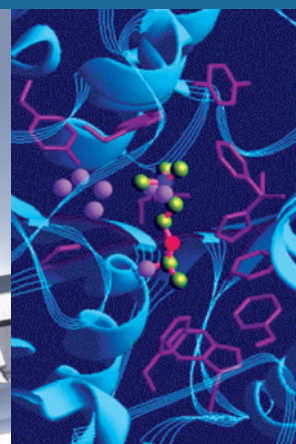
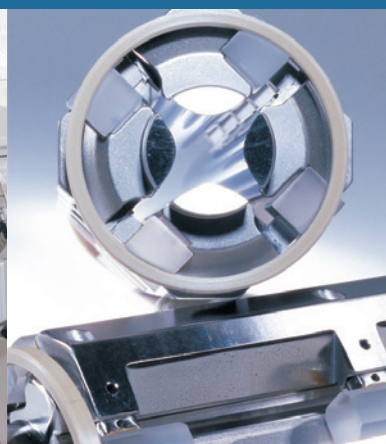


Thermo Fisher Scientific  
**LTO Orbitrap Velos™**  
Hardware Manual

Revision A - 1250580



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Release History: Revision A released in October 2009.

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**EG-Konformitätserklärung gemäß ISO/IEC 17050-1:2004**  
**EC Declaration of conformity according to ISO/IEC 17050-1:2004**

**Name des Herstellers:** Thermo Fisher Scientific  
manufacturers name

**Adresse des Herstellers:** Hanna-Kunath-Strasse 11  
manufacturers address 28199 Bremen  
Germany

**Der Hersteller erklärt, dass das Produkt**  
The manufacturer declares that the following product

**Name des Produkts:** Mass Spectrometer  
product name

**Modell:** LTQ ORBITRAP VELOS  
model number

**Produktoptionen:** inkl. / incl. ETD  
product options

**mit den folgenden EG Richtlinien und harmonisierten Standards übereinstimmt:**  
is in conformity with the following EC Directives and harmonized standards

<b>EMV-Richtlinie</b> EMC Directive 2004/108/EG	EN 55011 (11.2007)	EN 61000-4-5 (06.2007)
	EN 61000-3-2 (10.2006)	EN 61000-4-6 (04.2008)
	EN 61000-3-3 (06.2006)	EN 61000-4-11 (02.2005)
	EN 61000-4-2 (12.2001)	EN 61326-1 (10.2006)
	EN 61000-4-3 (12.2006)	+ Corr. (06.2008)
	EN 61000-4-4 (05.2005)	

**Niederspannungsrichtlinie** EN 61010-1 (08.2002)  
Low Voltage Directive  
2006/95/EG

**Ergänzende Informationen:** -  
Complementary information

Bremen, Germany, 24. April 2009



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### LTQ Velos/ETD System (November 2008)

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EN 61326-1: 2006

EN 61000-4-4: 2004

EN 55011: 2007

EN 61000-4-5: 2005

EN 61000-3-2: 2006

EN 61000-4-6: 2007

EN 61000-3-3: 2005

EN 61000-4-11: 2004

EN 61000-4-2: 2001

FCC Part 15: 2007

EN 61000-4-3: 2006

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# Read This First

Welcome to the Thermo Scientific LTQ Orbitrap Velos™ system! The LTQ Orbitrap Velos is a member of the family of LTQ™ mass spectrometer (MS) hybrid instruments.

All information in this guide concerning the LTQ Orbitrap Velos also applies to the LTQ Orbitrap Velos ETD™ system where the ETD Module is physically coupled to the back of the LTQ Orbitrap Velos.

## About This Guide

This *LTQ Orbitrap Velos Hardware Manual* contains a description of the modes of operation and principle hardware components of your LTQ Orbitrap Velos instrument. In addition, this manual provides step-by-step instructions for cleaning and maintaining your instrument.

## Who Uses This Guide

This *LTQ Orbitrap Velos Hardware Manual* is intended for all personnel that need a thorough understanding of the instrument (to perform maintenance or troubleshooting, for example). This manual should be kept near the instrument to be available for quick reference.

## Scope of This Guide

This manual includes the following chapters:

- [Chapter 1: “Functional Description”](#) describes the principal components of the LTQ Orbitrap Velos.
- [Chapter 2: “Basic System Operations”](#) provides procedures for shutting down and starting up the LTQ Orbitrap Velos.
- [Chapter 3: “User Maintenance”](#) outlines the maintenance procedures that you should perform on a regular basis to maintain optimum instrument performance.
- [Chapter 4: “Replaceable Parts”](#) lists the replaceable parts for the MS detector and data system.
- [Appendix A: “Fluoranthene”](#) describes properties of the reagent that is used in the ETD Module portion of the LTQ Orbitrap Velos ETD.

## Related Documentation

In addition to this guide, Thermo Fisher Scientific provides the following documents for LTQ Orbitrap Velos and LTQ Orbitrap Velos ETD:

- *LTQ Orbitrap Series Preinstallation Requirements Guide*
- *LTQ Orbitrap Velos Getting Started Guide*
- LTQ Velos manual set

You can access PDF files of the documents listed above from the data system computer. The software also provides Help.



## Contacting Us

There are several ways to contact Thermo Fisher Scientific.

### Assistance

For technical support and ordering information, **visit us on the Web:**

[www.thermo.com/advancedms](http://www.thermo.com/advancedms)

### Customer Information Service

[cis.thermo-bremen.com](http://cis.thermo-bremen.com) is the Customer Information Service site aimed at providing instant access to

- latest software updates
- manuals, application reports, and brochures.

**Note** Thermo Fisher Scientific recommends that you register with the site as early as possible. ▲

To register, visit [register.thermo-bremen.com/form/cis](http://register.thermo-bremen.com/form/cis) and fill in the registration form. Once your registration has been finalized, you will receive confirmation by e-mail.

### Changes to the Manual

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- Please send your comments (in German or English) to:

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You are encouraged to report errors or omissions in the text or index. Thank you.

## Typographical Conventions

This section describes typographical conventions that have been established for Thermo Fisher Scientific manuals.

### Data Input

Throughout this manual, the following conventions indicate data input and output via the computer:

- Messages displayed on the screen are represented by capitalizing the initial letter of each word and by italicizing each word.
- Input that you enter by keyboard is identified by quotation marks: single quotes for single characters, double quotes for strings.
- For brevity, expressions such as “choose **File > Directories**” are used rather than “pull down the File menu and choose Directories.”
- Any command enclosed in angle brackets < > represents a single keystroke. For example, “press <F1>” means press the key labeled *F1*.
- Any command that requires pressing two or more keys simultaneously is shown with a plus sign connecting the keys. For example, “press <Shift> + <F1>” means press and hold the <Shift> key and then press the <F1> key.
- Any button that you click on the screen is represented in bold face letters. For example, “click on **Close**”.

### Topic Headings

The following headings are used to show the organization of topics within a chapter:

## Chapter 1 Chapter Name

### Second Level Topics

#### Third Level Topics

#### Fourth Level Topics

## Safety and EMC Information

In accordance with our commitment to customer service and safety, this instrument has satisfied the requirements for the European CE Mark including the Low Voltage Directive.

Designed, manufactured and tested in an ISO9001 registered facility, this instrument has been shipped to you from our manufacturing facility in a safe condition.

This instrument must be used as described in this manual. Any use of this instrument in a manner other than described here may result in instrument damage and/or operator injury.

### Notice on Lifting and Handling of Thermo Scientific Instruments

For your safety, and in compliance with international regulations, the physical handling of this Thermo Scientific instrument *requires a team effort* for lifting and/or moving the instrument. This instrument is too heavy and/or bulky for one person alone to handle safely.

### Notice on the Proper Use of Thermo Scientific Instruments

In compliance with international regulations: If this instrument is used in a manner not specified by Thermo Fisher Scientific, the protection provided by the instrument could be impaired.

### Notice on the Susceptibility to Electromagnetic Transmissions

Your instrument is designed to work in a controlled electromagnetic environment. Do not use radio frequency transmitters, such as mobile phones, in close proximity to the instrument.

## Safety and Special Notices

Make sure you follow the precautionary statements presented in this guide. The safety and other special notices appear different from the main flow of text. Safety and special notices include the following:



**Warning** Warnings highlight hazards to human beings. Each Warning is accompanied by a Warning symbol. ▲

**Caution** Cautions highlight information necessary to protect your instrument from damage. ▲

**Note** Notes highlight information that can affect the quality of your data. In addition, notes often contain information that you might need if you are having trouble. ▲

## Identifying Safety Information

The *LTQ Orbitrap Velos Hardware Manual* contains precautionary statements that can prevent personal injury, instrument damage, and loss of data if properly followed. Warning symbols alert the user to check for hazardous conditions. These appear throughout the manual, where applicable. The most common warning symbols are:



**Warning** This general symbol indicates that a hazard is present that could result in injuries if it is not avoided. The source of danger is described in the accompanying text. ▲



**Warning** High Voltages capable of causing personal injury are used in the instrument. The instrument must be shut down and disconnected from line power before service is performed. Do not operate the instrument with the top cover off. Do not remove protective covers from PCBs. ▲



**Warning** Treat heated zones with respect. Parts of the instrument might be very hot and might cause severe burns if touched. Allow hot components to cool before servicing them. ▲



**Warning** Wear gloves when handling toxic, carcinogenic, mutagenic, or corrosive/irritant chemicals. Use approved containers and procedures for disposal of waste solution. ▲

In addition to the above described, every instrument has specific hazards. So, be sure to read and comply with the precautions described in the subsequent chapters of this guide. They will help ensure the safe, long-term use of your system.

## General Safety Precautions

Observe the following safety precautions when you operate or perform service on your instrument:

- Before plugging in any of the instrument modules or turning on the power, always make sure that the voltage and fuses are set appropriately for your local line voltage.
- Only use fuses of the type and current rating specified. Do not use repaired fuses and do not short-circuit the fuse holder.
- The supplied power cord must be inserted into a power outlet with a protective earth contact (ground). When using an extension cord, make sure that the cord also has an earth contact.

- Do not change the external or internal grounding connections. Tampering with or disconnecting these connections could endanger you and/or damage the system.
- The instrument is properly grounded in accordance with regulations when shipped. You do not need to make any changes to the electrical connections or to the instrument's chassis to ensure safe operation.
- Never run the system without the housing on. Permanent damage can occur.
- Do not turn the instrument on if you suspect that it has incurred any kind of electrical damage. Instead, disconnect the power cord and contact a Service Representative for a product evaluation. Do not attempt to use the instrument until it has been evaluated. (Electrical damage may have occurred if the system shows visible signs of damage, or has been transported under severe stress.)
- Damage can also result if the instrument is stored for prolonged periods under unfavorable conditions (e.g., subjected to heat, water, etc.).
- Always disconnect the power cord before attempting any type of maintenance.
- Capacitors inside the instrument may still be charged even if the instrument is turned off.
- Never try to repair or replace any component of the system that is not described in this manual without the assistance of your service representative.
- Do not place any objects – especially not containers with liquids – upon the instrument. Leaking liquids might get into contact with electronic components and cause a short circuit.

## **Safety Advice for Possible Contamination**

### **Hazardous Material Might Contaminate Certain Parts of Your System During Analysis.**

In order to protect our employees, we ask you to adhere to special precautions when returning parts for exchange or repair.

If hazardous materials have contaminated mass spectrometer parts, Thermo Fisher Scientific can only accept these parts for repair if they have been properly decontaminated. Materials, which due to their structure and the applied concentration might be toxic or which in publications are reported to be toxic, are regarded as hazardous. Materials that will generate synergetic hazardous effects in combination with other present materials are also considered hazardous.

Your signature on the **Repair-Covering letter** confirms that the returned parts have been decontaminated and are free of hazardous materials.

The Repair-Covering letter can be ordered from your service engineer or downloaded from the **Customer Information Service (CIS)** site. Please register under <http://register.thermo-bremen.com/form/cis>.

Parts contaminated by radioisotopes are not subject to return to Thermo Fisher Scientific – either under warranty or the exchange part program. If parts of the system may be possibly contaminated by hazardous material, please make sure the Field engineer is informed before the engineer starts working on the system.

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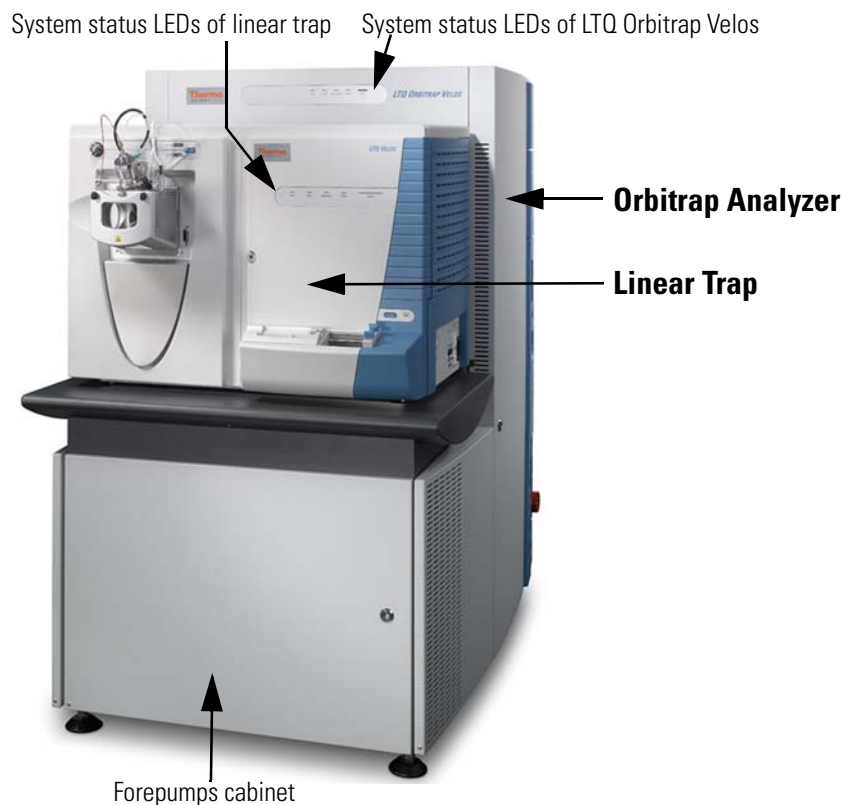
# Chapter 1 Functional Description

This chapter provides an overview of the functional elements of the LTQ Orbitrap Velos. It contains the following topics:

- “General Description” on page 1-2
- “Control Elements” on page 1-5
- “Linear Ion Trap” on page 1-12
- “Orbitrap Analyzer” on page 1-13
- “ETD System” on page 1-19
- “Vacuum System” on page 1-30
- “Gas Supply” on page 1-37
- “Cooling Water Circuit” on page 1-42
- “Printed Circuit Boards” on page 1-44

## General Description

LTQ Orbitrap Velos is a hybrid mass spectrometer incorporating the LTQ Velos™ dual cell linear trap and the Orbitrap™ analyzer. [Figure 1-1](#) shows a front view of the instrument.



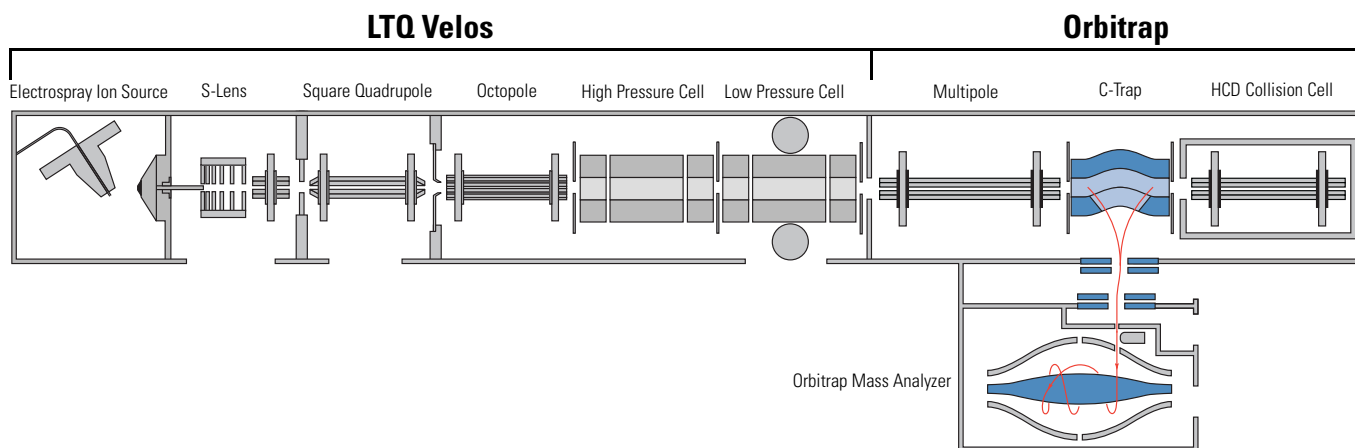
**Figure 1-1.** LTQ Orbitrap Velos front view

The LTQ Orbitrap Velos consists of four main components (See [Figure 1-2](#) on [page 1-3](#).), which are described in the following topics:

- A dual cell linear ion trap (Thermo Scientific LTQ Velos) for sample ionization, selection, fragmentation, and AGC™.
- An intermediate storage device (curved linear trap) that is required for short pulse injection.
- An Orbitrap analyzer for Fourier transformation based analysis.
- A collision cell for performing higher energy CID experiments.

The LTQ Orbitrap Velos ETD has an additional reagent ion source for enabling post-translational modification analyses of peptides by Electron Transfer Dissociation (ETD). See [“ETD System”](#) on [page 1-19](#).





**Figure 1-2.** Schematical view of the LTQ Orbitrap Velos

## Mechanical Characteristics

Wheels at the bottom side of the instrument facilitate positioning the LTQ Orbitrap Velos at the intended place in the laboratory.

The mains inlet as well as a power outlet for peripheral devices are located at the right side of the instrument. The forepumps for the vacuum system of the linear trap and the Orbitrap are hidden under the linear trap and accessible from the front. The forepump for the ETD Module is accessible after removing the bottom panel of the rear side. The left side panel and the front panel of the MS portion are mounted on hinges and the right side panel is removable. The top lid of the MS portion opens upwards to allow easy access for Field Engineers from the top. See [Figure 1-3](#).

In the LTQ Orbitrap Velos ETD, after removing the cables the top lid of the ETD Module is also removable to allow accessing its electronic components.



**Figure 1-3.** Top lid of MS portion opened

A stand-alone recirculating water chiller is delivered with the instrument. It is connected to the right side of the instrument.

## Specifications

The LTQ Orbitrap Velos has the following measuring specifications:

<b>Resolution</b>	60 000 (FWHM) @ $m/z$ 400 with a scan repetition rate of 1 second Minimum resolution 7500, maximum resolution 100 000 @ $m/z$ 400
<b>Cycle Time</b>	1 scan at 60 000 resolution @ $m/z$ 400 per second
<b>Mass Range</b>	$m/z$ 50–2000; $m/z$ 200–4000
<b>Mass Accuracy</b>	<3 ppm RMS for 2 h period with external calibration using defined conditions, <1 ppm RMS with internal calibration
<b>Dynamic Range</b>	>10 000 between mass spectra, >5000 between highest and lowest detectable ion signal in one spectrum
<b>MS/MS</b>	MS/MS and $MS^n$ scan functions

## Control Elements

The LTQ Orbitrap Velos is mainly operated from the desktop computer (data system). Some control elements for important system functions are located directly on the instrument. They are described in the following sections.

### System Status LEDs

Figure 1-4 shows the system status LEDs at the front of the instrument. Five LEDs indicate the main functions of the system. (See also [Figure 1-5 on page 1-6](#).) The Power LED is directly controlled by the 3 × 230 V input and all other LEDs are controlled by the power distribution board (See [“Power Distribution Board” on page 1-53](#)). Table 1-1 explains the function of the various LEDs.



**Figure 1-4.** System status LEDs

The system status LEDs at the front panel of the linear ion trap are described in the *LTQ Series Hardware Manual*.

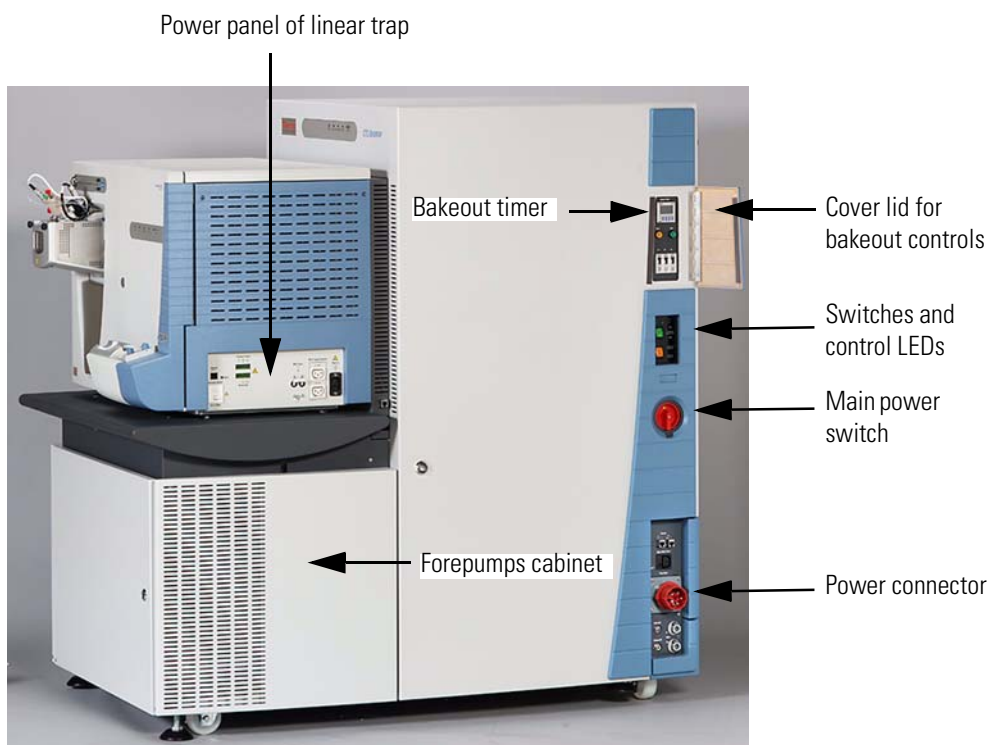
**Table 1-1.** System status LEDs of the LTQ Orbitrap Velos

LED	Status	Information
Power	Green	Main switch on
	Off	Main switch off
Vacuum*	Green	Operating vacuum reached
	Yellow	Insufficient vacuum or Vacuum Pumps switch off
Communication	Green	Communication link between instrument and data system established
	Yellow	Communication link starting up or Vacuum Pumps switch off
System*	Green	System ready
	Yellow	FT Electronics switch off or Vacuum Pumps switch off
Detect	Blue	Orbitrap scanning
	Off	Orbitrap is not scanning

\*These LEDs are flashing when a system bakeout is performed. See [“Baking Out the System” on page 3-4](#).

## Control Panels

Figure 1-5 shows the right side of the LTQ Orbitrap Velos. Located here are the control panels, switches, and the ports for the external connections (mains supply, gases, Ethernet communication, and cooling water).



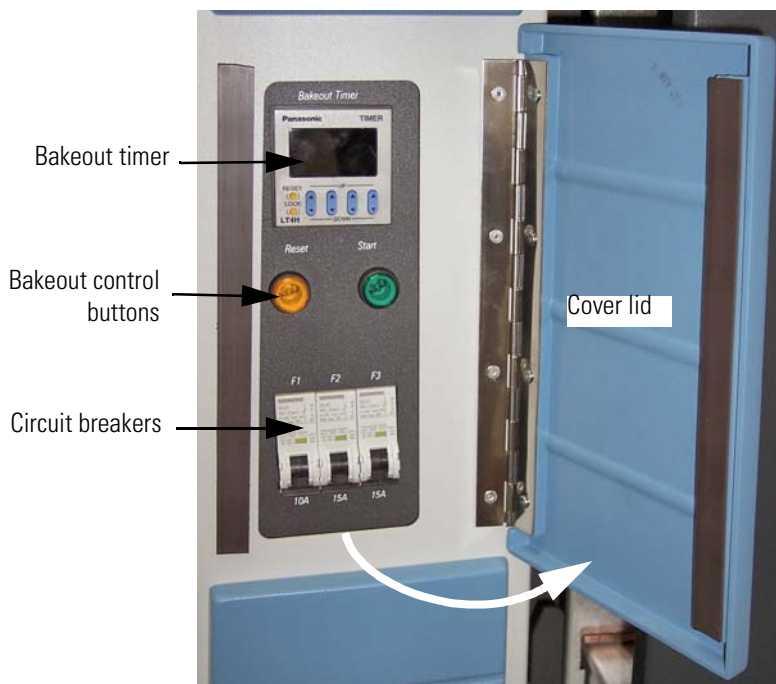
**Figure 1-5.** Right side of the LTQ Orbitrap Velos

For more information about the external connections, see “[External Connections](#)” on [page 1-9](#).

### Upper Control Panel

The upper instrument control panel comprises the bakeout timer, the bakeout control buttons, and three circuit breakers. To access the upper control panel, swing open the small lid (opens from left to right). See [Figure 1-5](#) and [Figure 1-6](#) on [page 1-7](#).

The timer allows setting the duration for the bakeout of the system. After the duration is set, the bakeout procedure is started by pressing the green button on the right. A running bakeout procedure can be stopped by pressing the orange button on the left side. For instructions about performing a bakeout, see “[Baking Out the System](#)” on [page 3-4](#).



**Figure 1-6.** Upper control panel

**Note** The buttons themselves have no indicator function. A running bakeout procedure is indicated by flashing Vacuum and System LEDs at the front side of the instrument. See [Figure 1-4](#) on [page 1-5](#). ▲

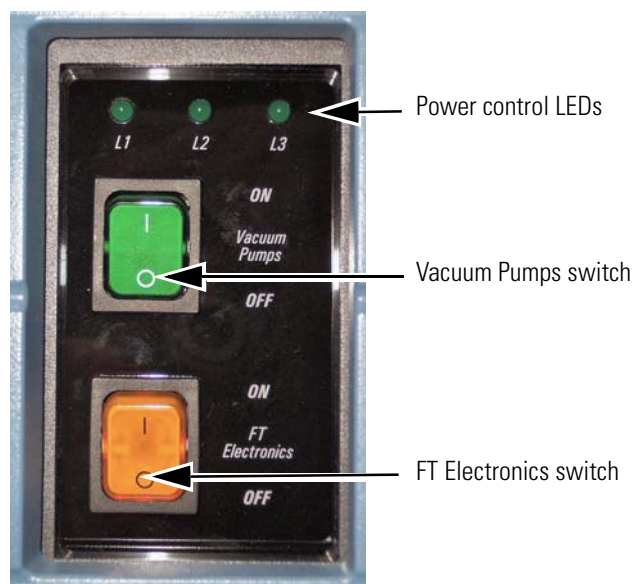
Three circuit breakers are located at the bottom of this control panel. [Table 1-2](#) shows the parts of the LTQ Orbitrap Velos that are protected by the respective circuit breaker. The proper function of each circuit breaker is signaled by a dedicated LED in the power control panel (for example, F1 corresponds to L1).

**Table 1-2.** Circuit breakers of the LTQ Orbitrap Velos

Circuit breaker	Ampere	LED	Instrument parts
F1	10	L1	Power Distribution
F2	15	L2	Linear ion trap
F3	15	L3	Multiple socket outlets (Peripherals, LC, heater, etc.)

## Power Control Panel

In addition to the system status LEDs at the front side (see [Figure 1-4](#) on [page 1-5](#)), the LTQ Orbitrap Velos has three power control LEDs above the Vacuum Pumps switch at the right side. See [Figure 1-7](#). They indicate whether the corresponding circuit breaker is closed and the respective parts of the instrument have power. (See [Table 1-2](#) on [page 1-7](#).)



**Figure 1-7.** Power control panel with power control LEDs and switches

The use of the switches below the power control LEDs changes the working mode of the power distribution. (See [“Working Modes of the Power Distribution”](#) on page 1-48.)

The Vacuum Pumps switch can be set into the positions **ON** or **OFF**. When the switch is in the **OFF** position, everything but the multiple socket outlet is switched off.

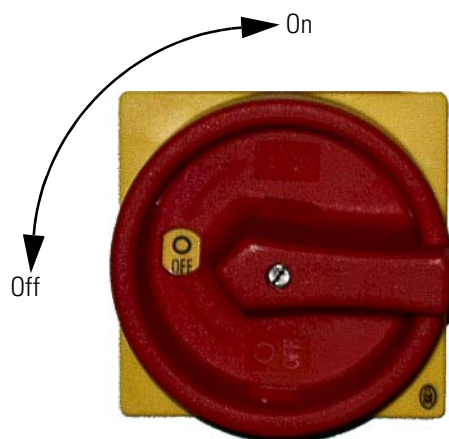
The FT Electronics switch can be set into the operating position (**ON**) or into the service position (**OFF**). When the switch is in the service position, all components are switched off with exception of the following:

- Fans
- Heater control
- Power distribution (See [“Power Distribution Board”](#) on page 1-53)
- Pumps (See [“Vacuum System”](#) on page 1-30)
- Temperature controller (See [“Temperature Controller Board”](#) on page 1-62)
- Vacuum control

The linear ion trap also remains on because it has a separate Service switch.

## Main Power Switch

The main power switch must be turned 90° clockwise/anti-clockwise to switch on/off the instrument (see [Figure 1-8](#)). Placing the main power switch in the Off position turns off all power to the LTQ Orbitrap Velos, the linear ion trap, and the vacuum pumps. In the LTQ Orbitrap Velos ETD, power to the ETD Module is also turned off.



**Figure 1-8.** Main power switch

**Note** When the main power switch is in the Off position, you can secure it with a padlock or a cable tie (to prevent unintended re-powering when performing maintenance, for example). ▲

## External Connections

[Figure 1-9](#) on [page 1-10](#) shows the lower right side of the instrument with the external connections for mains supply, gases, cooling water, and Ethernet communication.

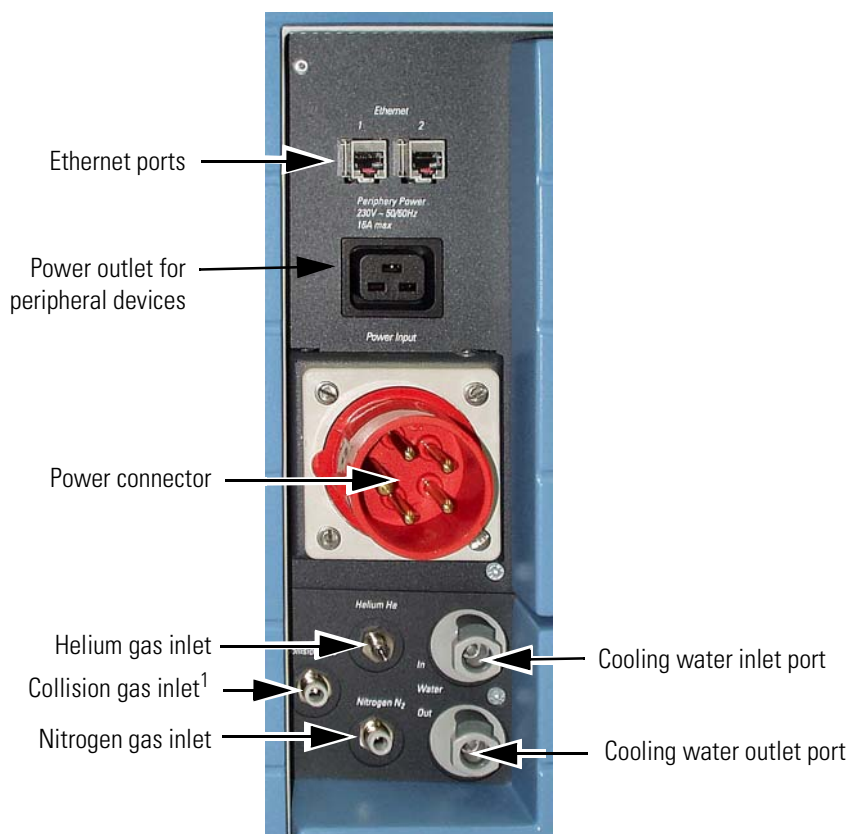
Located at the top are two ports for Ethernet cables for connecting the LTQ Orbitrap Velos and the linear ion trap via an Ethernet hub with the data system computer.

The power outlet for peripheral devices is located below the Ethernet ports. In the LTQ Orbitrap Velos, the outlet provides the mains supply for the data system. In the LTQ Orbitrap Velos ETD, the outlet provides the mains supply for the ETD Module whereas the data system is connected to a wall outlet.

The power connector for the mains supply is located at the center. The LTQ Orbitrap Velos instrument is designed to operate at a nominal voltage of 230 V ac, 50/60 Hz. Line voltages can vary between a minimum of 207 V ac and a maximum of 253 V ac.



**Caution** Systems installed in areas with 208 V power experience voltage sags during high use periods that might place the line voltage below the operating parameters discussed in this section. In this case, you must protect your instrument by using a buck/boost transformer to ensure that power is within the specified parameters at all times. ▲



**Figure 1-9.** External connections to the LTQ Orbitrap Velos

The cooling water ports are located below the power connector. (See also “Cooling Water Circuit” on page 1-42.)

The port for nitrogen gas allows connecting a Teflon® hose from the gas supply of the laboratory to the instrument. The required gas pressure for nitrogen is  $690 \pm 140$  kPa ( $6.9 \pm 1.4$  bar,  $100 \pm 20$  psi). Helium ( $40 \pm 10$  psi [ $275 \pm 70$  kPa], 99.999% [ultra-high] purity) enters the instrument through a 1/8 inch port. Metal tubing from the helium gas supply must be terminated with 1/8 inch, female, Swagelok-type connectors. See “Gas Supply” on page 1-37 for information about connecting the gas supplies to the instrument.

<sup>1</sup>The port named Collision Gas is not used in the LTQ Orbitrap Velos.



**Caution** Do not connect other gases than nitrogen or helium to the LTQ Orbitrap Velos! The maximum pressure for the nitrogen gas inlet is 830 kPa (8.3 bar, 120 psi); the maximum pressure for the helium inlet is 345 kPa (3.45 bar, 50 psi). ▲

In the LTQ Orbitrap Velos ETD, the ETD reagent carrier gas supply of the laboratory is connected via metal tubing to an 1/8 inch inlet port at the rear side of the instrument. Metal tubing from the gas supply must be terminated with 1/8 inch, female, Swagelok-type connectors. The required gas pressure is  $690 \pm 140$  kPa ( $6.9 \pm 1.4$  bar,  $100 \pm 20$  psi). See “Gas Supply of the Reagent Ion Source” on page 1-40.

The exhaust hose from the rotary pumps comes out the back of the instrument, and connects the pumps to the exhaust system in the laboratory.

## Linear Ion Trap

The LTQ Orbitrap Velos system can utilize a variety of ionization techniques such as ESI, APCI, or APPI. Maintenance of the Ion Max API source, as well as switching between ionization methods, is vent-free. Ions are transferred by octapole and “square” quadrupole lenses into an ion trap that is optimized for axial ion ejection into the curved linear trap. (See [Figure 1-2](#) on [page 1-3](#).)

The linear ion trap is an independent MS detector (Thermo Scientific LTQ Velos), which can store, isolate, and fragment ions and then send them either to the Orbitrap for further analysis or to an SEM detector. The linear ion trap is a unique ion preparation and injection system for Orbitrap MS, because it has greater ion storage capacity than conventional 3D ion trap devices. The linear ion trap is completely described in the *LTQ Series Hardware Manual*.

All the ion handling, selection and excitation capabilities of the ion trap can be used to prepare ions for analysis in the Orbitrap. These features include storage and ejection of all ions, storage of selected masses or mass ranges, as well as ion isolation. Isolated ions can be excited and then fragmented as necessary for MS/MS and MS<sup>n</sup> experiments. The patented Automatic Gain Control (AGC) provides extended dynamic range and insures optimized overall performance of the ion trap and Orbitrap MS.

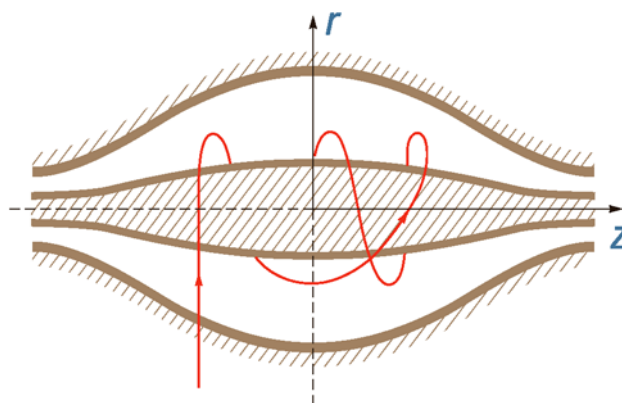
The application of a supplementary RF voltage on the end lenses of the linear trap allows ions of opposite polarity to be trapped in the same space at the same time (charge-sign independent trapping – CSIT). This allows performing ion-ion reactions of previously isolated precursor cations with ETD reagent anions.

The linear ion trap and the transfer chamber are mounted on a table. See [Figure 1-1](#) on [page 1-2](#). The table also serves as a housing for the forepumps. See [Figure 1-26](#) on [page 1-33](#). The LTQ Orbitrap Velos provides power for the linear ion trap. The LTQ Orbitrap Velos ETD also provides the power for the ETD Module.

The linear ion trap is delivered with power connector, gas lines (He, N<sub>2</sub>, and collision gas), and vacuum tube lines extending to the ESI source. On the rear side of the LTQ Velos ion trap is a flange with an O-ring seal. When the flange is removed, the Orbitrap transfer chamber is mounted to the flange of the linear ion trap. The transfer chamber is held with supports on the table. The components of the ion optics and the Orbitrap are fixed to the transfer chamber.

## Orbitrap Analyzer

This section describes the basic principle of the Orbitrap™ mass analyzer. The heart of the system is an axially-symmetrical mass analyzer. It consists of a spindle-shaped central electrode surrounded by a pair of bell-shaped outer electrodes. See Figure 1-10. The Orbitrap employs electric fields to capture and confine ions.

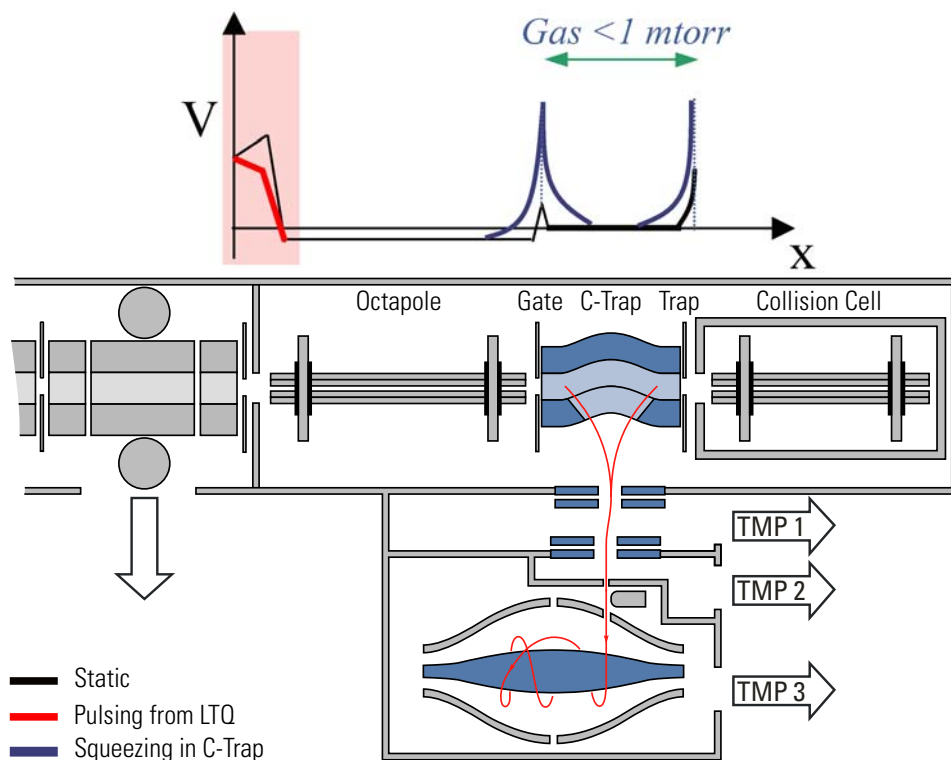


**Figure 1-10.** Schematic view of the Orbitrap cell and example of a stable ion trajectory

## Curved Linear Trap

On their way from the linear trap to the Orbitrap, ions move through the gas-free RF-only octapole into the gas-filled curved linear trap (C-Trap). See Figure 1-11 on page 1-14. Ions in the C-Trap are returned by the trap electrode. Upon their passage, the ions lose enough kinetic energy to prevent them from leaving the C-Trap through the gate. The collision gas (bath gas) is used for dissipating the kinetic energy of injected ions and for cooling them down to the axis of the curved linear trap.

Voltages on the end apertures of the curved trap (trap and gate apertures) are elevated to provide a potential well along its axis. These voltages may be later ramped up to squeeze ions into a shorter thread along this axis. The RF to the C-Trap (“Main RF”) is provided by the CLT RF main board. (See page 1-63.) Trap and gate dc voltages as well as RF voltages to the octapole are all provided by the ion optic supply board. (See page 1-59.) High voltages to the lenses are provided by the high voltage power supply board. (See page 1-66.)

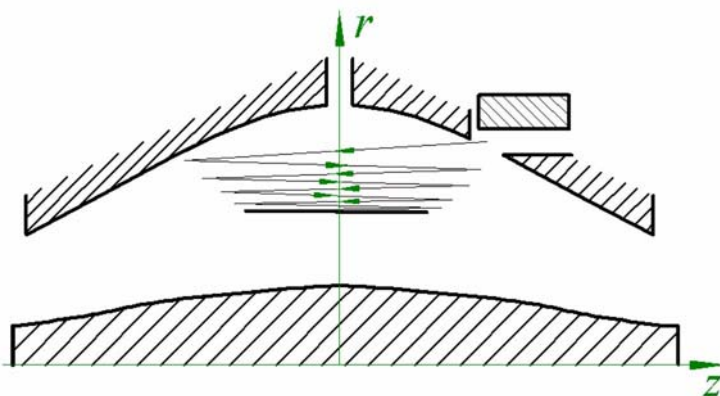


**Figure 1-11.** Layout of the LTQ Orbitrap Velos, also showing the applied voltages

## Extraction of Ion Packets

For ion extraction, the RF on the rods of the C-Trap is switched off and extracting voltage pulses are applied to the electrodes, pushing ions orthogonally to the curved axis through a slot in the inner hyperbolic electrode. Because of the initial curvature of the C-Trap and the subsequent lenses, the ion beam converges on the entrance into the Orbitrap. The lenses form also differential pumping slots and cause spatial focusing of the ion beam into the entrance of the Orbitrap. Ions are electrostatically deflected away from the gas jet, thereby eliminating gas carryover into the Orbitrap.

Owing to the fast pulsing of ions from the C-Trap, ions of each mass-to-charge ratio arrive at the entrance of the Orbitrap as short packets only a few millimeters long. For each mass-to-charge population, this corresponds to a spread of flight times of only a few hundred nanoseconds for mass-to-charge ratios of a few hundred Daltons/charge. Such durations are considerably shorter than a half-period of axial ion oscillation in the trap. When ions are injected into the Orbitrap at a position offset from its equator (See [Figure 1-12.](#)), these packets start coherent axial oscillations without the need for any additional excitation cycle.



**Figure 1-12.** Principle of electrodynamic squeezing of ions in the Orbitrap as the field strength is increased

The evolution of an ion packet during the increase of the electric field is shown schematically on [Figure 1-12](#). When the injected ions approach the opposite electrode for the first time, the increased electric field (owing to the change of the voltage on the central electrode) contracts the radius of the ion cloud by a few percent. The applied voltages are adjusted to prevent collision of the ions with the electrode. A further increase of the field continues to squeeze the trajectory closer to the axis, meanwhile allowing for newly arriving ions (normally, with higher  $m/q$ ) to enter the trap as well. After ions of all  $m/q$  have entered the Orbitrap and moved far enough from the outer electrodes, the voltage on the central electrode is kept constant and image current detection takes place.

## Measuring Principle

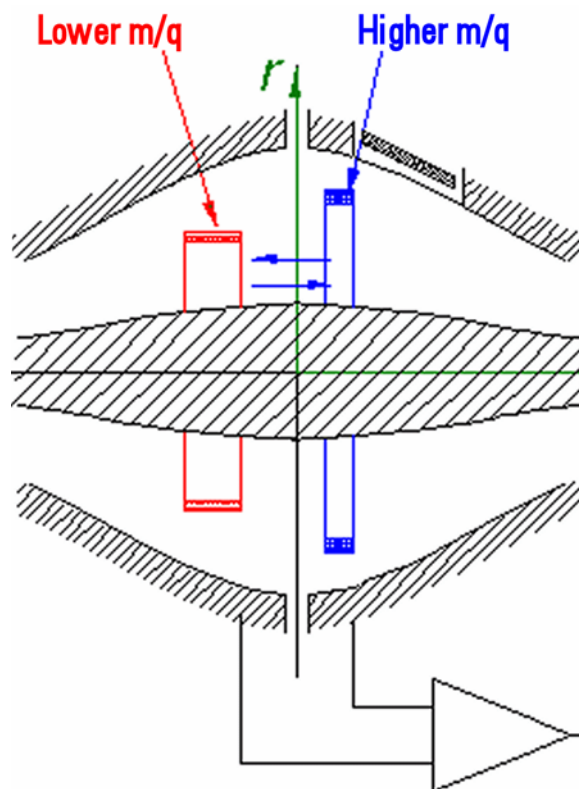
In the mass analyzer shown in [Figure 1-10](#) on [page 1-13](#), stable ion trajectories combine rotation around an axial central electrode with harmonic oscillations along it. The frequency  $\omega$  of these harmonic oscillations along the  $z$ -axis depends only on the ions' mass-to-charge ratios  $m/q$  and the instrumental constant  $k$ :

$$\omega = \sqrt{\frac{q}{m} \times k}$$

Two split halves of the outer electrode of the Orbitrap detect the image current produced by the oscillating ions. By Fast Fourier Transformation (FFT) of the amplified image current, the instrument obtains the frequencies of these axial oscillations and therefore the mass-to-charge ratios of the ions.

## Ion Detection

During ion detection, both the central electrode and deflector are maintained at very stable voltages so that no mass drift can take place. The outer electrode is split in half at  $z=0$ , allowing the ion image current in the axial direction to be collected. The image current on each of half of the outer electrode is differentially amplified and then undergoes analog-to-digital conversion before processing using the fast Fourier transform algorithm.



**Figure 1-13.** Approximate shape of ion packets of different  $m/q$  after stabilization of voltages

As mentioned above, stable ion trajectories within the Orbitrap combine axial oscillations along the  $z$ -axis with rotation around the central electrode and vibrations in the radial direction. (See [Figure 1-10](#) on [page 1-13](#).) For any given  $m/q$ , only the frequency of axial oscillations is completely independent of initial ion parameters, whereas rotational and radial frequencies exhibit strong dependence on initial radius and energy. Therefore, ions of the same mass/charge ratio continue to oscillate along  $z$  together, remaining in-phase for many thousands of oscillations.

In contrast to the axial oscillations, the frequencies of radial and rotational motion will vary for ions with slightly different initial parameters. This means that in the radial direction, ions dephase orders of magnitude faster than in the axial direction, and the process occurs in

a period of only 50–100 oscillations. After this, the ion packet of a given  $m/q$  assumes the shape of a thin ring, with ions uniformly distributed along its circumference. (See [Figure 1-13](#).) Because of this angular and radial smearing, radial and rotational frequencies cannot appear in the measured spectrum. Meanwhile, axial oscillations will persist, with axial thickness of the ion ring remaining small compared with the axial amplitude. Moving from one half outer electrode to the other, this ring will induce opposite currents on these halves, thus creating a signal to be detected by differential amplification.

## Active Temperature Control

Active temperature control is achieved by monitoring temperature directly on the Orbitrap assembly and compensating any changes in ambient temperature by a thermoelectric cooler (Peltier element) on the outside of the UHV chamber. A dedicated temperature controller board is used for this purpose. See [page 1-62](#).

## Peltier Cooling

To allow stable operating conditions in the UHV chamber, it can be cooled or heated (outgassing) by means of a Peltier element located on the outside. A second Peltier element is located on the back of the CE power supply board. See [Figure 1-43](#) on [page 1-59](#).

The Peltier cooling is based on the Peltier Effect, which describes the effect by which the passage of an electric current through a junction of two dissimilar materials (thermoelectric materials) causes temperature differential (cooling effect). The voltage drives the heat to flow from one side of the Peltier element to the other side, resulting in cooling effects on one side and heating effects on the other side.

To remove the heat from the hot side of the Peltier elements, they are connected to the cooling water circuit of the LTQ Orbitrap Velos. See [“Cooling Water Circuit”](#) on [page 1-42](#) for further information.

## HCD Collision Cell

The HCD collision cell consists of a straight multipole mounted inside a metal tube, which is connected in direct line-of-sight to the C-Trap. It is supplied with a collision gas to provide increased gas pressure inside the multipole. See “Gas Supply” on [page 1-37](#) for details. The ETD Ion Optic Supply board provides the voltages for the HCD collision cell. (See [page 1-46](#).)

For HCD (Higher Energy Collisional Dissociation), ions are passed through the C-Trap into the HCD collision cell. The offset between the C-Trap and HCD is used to accelerate the parent ions into the gas-filled collision cell. A potential gradient is applied to the collision cell to provide fast extraction of ions, such that it transmits ions at a reliable rate.

The fragment spectra generated in the HCD collision cell and detected in the Orbitrap show a fragmentation pattern comparable to the pattern of typical triple quadrupole spectra. See the *LTQ Orbitrap Velos Getting Started* manual for more information.

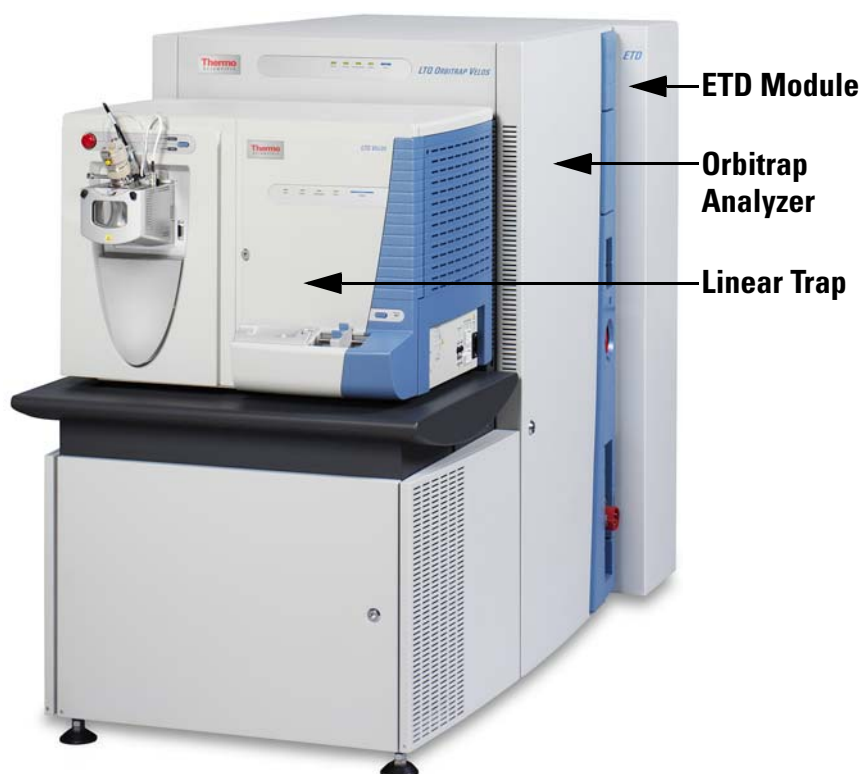
## HCD and ETD

In the LTQ Orbitrap Velos ETD, ETD reagent anions can efficiently pass through the high pressure region of the HCD cell. This is an important prerequisite to allow for a fast switching (i.e. scan to scan) between HCD and ETD fragmentation, thus making comparative measurements possible. When compared with the standard LTQ Orbitrap Velos, HCD performance is not in any way compromised by the addition of the ETD Module.



## ETD System

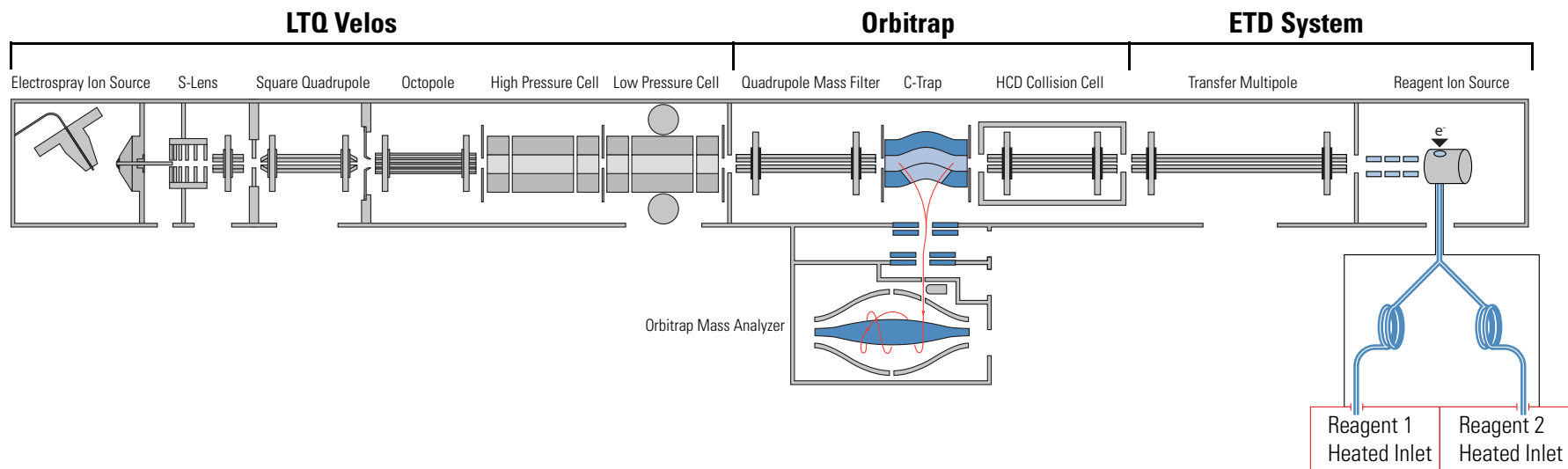
In the LTQ Orbitrap Velos ETD, an ETD Module is physically coupled to the back of the LTQ Orbitrap Velos. See [Figure 1-14](#). A quadrupole mass filter replaces the octapole of the LTQ Orbitrap Velos. See [Figure 1-2](#) on [page 1-3](#). The linear trap provides the voltages for the quadrupole mass filter. A tube, which contains the transfer multipole, connects the HCD housing to the ETD Module. See [Figure 1-23](#) on [page 1-30](#). The ETD Ion Optic Supply board is mounted on top of the data acquisition unit on the right side of the instrument. See [Figure 1-35](#) on [page 1-47](#).



**Figure 1-14.** LTQ Orbitrap Velos ETD front view

Protein or peptide analyte ions may also be fragmented in the linear trap by negatively charged reagent ions (fluoranthene radical anions) from the reagent ion source (ETD Module). These negatively charged ions deliver electrons to protein or peptide analyte ions and cause them to fragment at their peptide bonds to produce c and z type fragments (versus the y and b type fragments produced by CID). The resulting analyte fragment ions provide another way of analyzing these molecules as compared to CID and PQD. Electron Transfer Dissociation (ETD) improves the identification of important post-translational modification (PTM) for characterization.

**Note** The ETD system is also available as an upgrade on new and existing LTQ Velos and LTQ Orbitrap XL systems. The ETD system is not available for LTQ Orbitrap Discovery or LTQ Orbitrap systems. ▲



**Figure 1-15.** Schematical view of the LTQ Orbitrap Velos ETD

## Principle of Operation

During a typical ETD MS/MS scan, analyte cations are injected into the linear trap for subsequent precursor cation isolation. Then, ETD reagent anions are generated in the CI ion source and are transferred into the linear trap via RF-only ion guides (transfer multipoles), the gas-filled HCD collision cell, and the C-Trap. (See [Figure 1-15](#) on [page 1-20](#).)

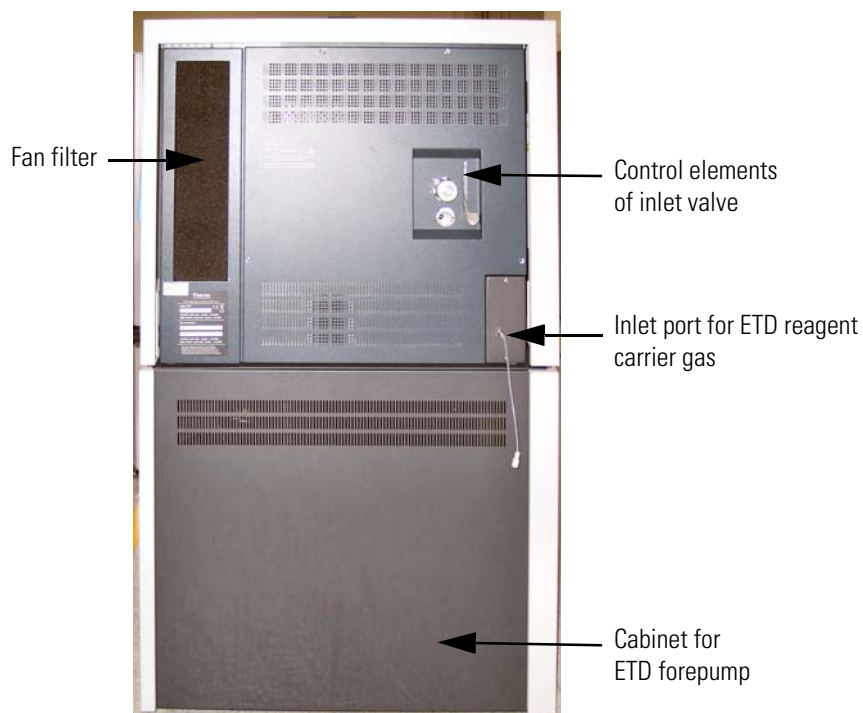
The reagent ions pass a quadrupole mass filter between C-Trap and linear trap. This ion guide works as a low pass mass filter to remove the adduct of the fluoranthene radical and molecular nitrogen at  $m/z$  216. This adduct favors proton transfer reactions instead of electron transfer.

The application of a supplementary RF voltage on the end lenses of the linear trap allows ions of opposite polarity to be trapped in the same space at the same time (charge-sign independent trapping – CSIT).

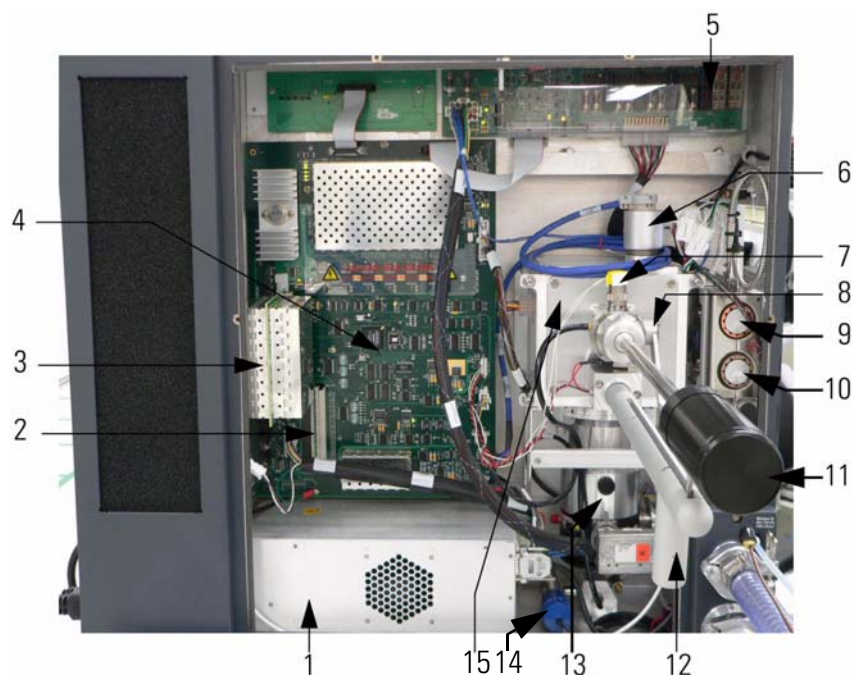
During ion-ion reactions in the linear trap, electrons are transferred from the reagent anions to the precursor cations. The resulting product ions are mass-to-charge ( $m/z$ ) analyzed in either the linear trap (if speed and sensitivity are important) or the Orbitrap (if mass resolution and accuracy are important).

## ETD Module

[Figure 1-16](#) on [page 1-22](#) shows the rear side of the ETD Module. It consists of the reagent ion source, ETD Module electronics, ETD Module power supply, ETD Module forepump, and the hardware that connects the ETD Module to the mass detectors.

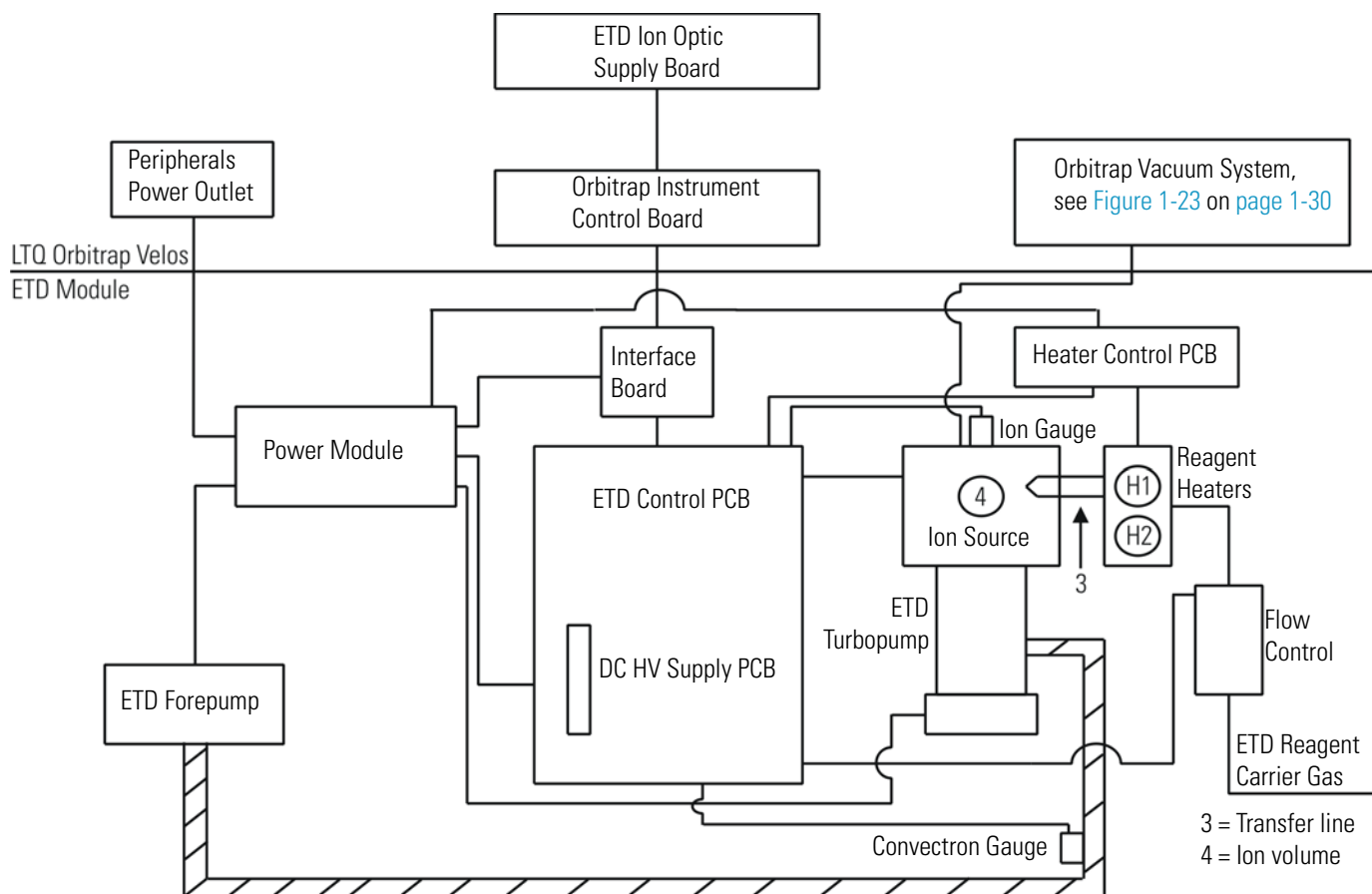


**Figure 1-16.** LTQ Orbitrap Velos ETD, rear side



Labeled components: 1=power module, 2=connector to Interface Board (Interface Board is behind the ETD Control PCB, item #4), 3=DC HV Supply PCB, 4=ETD Control PCB, 5=Heater Control PCB, 6=ion gauge, 7=inlet valve solenoid, 8=inlet valve lever in closed (down) position, 9=reagent heater 1, 10=reagent heater 2, 11=ion volume tool handle, 12=guide bar, 13=turbopump, 14=Convectron gauge, 15=vacuum manifold (contains ion source and ion volume)

**Figure 1-17.** Rear view of the ETD Module, with major component locations



**Figure 1-18.** ETD Module functional block diagram

The following sections describe the major ETD Module components that are shown in [Figure 1-17](#) on [page 1-22](#) and [Figure 1-18](#).

## ETD Power Module

The ETD power module (item #1 in [Figure 1-17](#)) receives 220 V, 10 A, from the peripherals power outlet. See [Figure 1-9](#) on [page 1-10](#). It distributes appropriate voltages and currents to the ETD components. It also contains DC power supplies.

## ETD Module Power Panel

The external receptacles and switches for the power module are located on the ETD power module panel at the right side of the ETD Module. See [Figure 1-19](#).



Figure 1-19. Right side of the LTQ Orbitrap Velos ETD

Figure 1-20 shows a close up picture of the ETD Power Module panel. Power In is connected to the peripherals power outlet of the MS portion. See Figure 1-9 on page 1-10. Forepump is a receptacle to power the ETD forepump (220 V AC, 5 A).

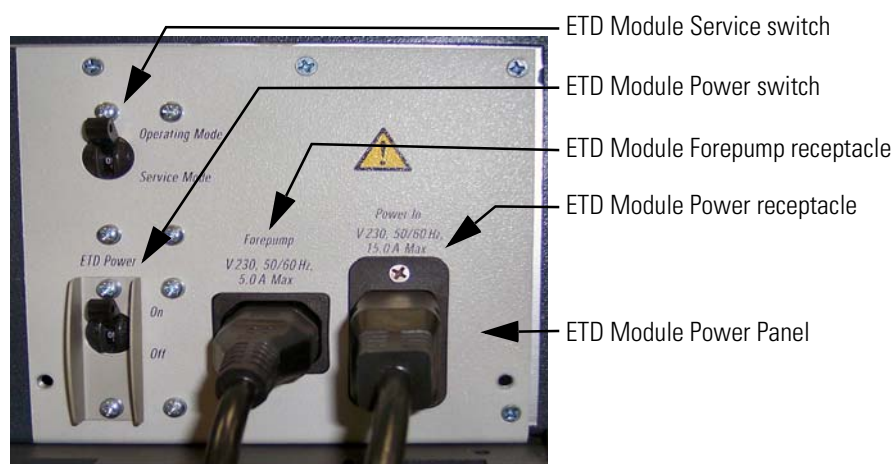


Figure 1-20. ETD Power Module panel

The ETD power module panel contains the main breaker and the service switch for the ETD Module. During normal operation, the ETD Power switch is left On and the service switch is left in the Operating Mode position. As a safety feature, both components of the LTQ Orbitrap Velos ETD system (the MS detector and the ETD module) are shut down with one set of switches, the MS detector switches. When you perform maintenance on components inside the ETD module as described in “[Maintenance of the ETD Module](#)” on [page 3-12](#), you set the MS detector’s service switch to the Service position. The service switch turns On or Off power to all ETD Module components except the turbopump and forepump.

## ETD Module Interface Board

The ETD Module Interface board (item #2 in [Figure 1-17](#) on [page 1-22](#)) provides an electronic interface between the ETD Module and the MS. This board also allows the power to both the MS and the ETD Module to be controlled by the MS power control panel switches:

- The MS Main Power switch controls the power supply to all components in both the MS and the ETD Module.
- The MS FT Electronics switch controls the power supply to all mass spectrometer and ETD Module components except the pumps that are connected to the MS and the ETD Module.

**Note** The ability to control the power to both components of the LTQ Orbitrap Velos ETD at one point (the power control panel switches of the MS) is a safety feature. ▲

## ETD Control PCB

The ETD Control PCB (item #4 in [Figure 1-17](#)) controls most of the ETD Module functions. The ETD Control PCB consists of circuits that control:

- ETD Module operating logic
- Ion source (filament, ion source heater, lenses)
- Heater temperature and readback logic (for reagent heaters, transfer line heater, and the restrictor oven heater)
- Reagent gas flow
- Oven cooling gas control
- Ion gauge
- Convectron gauge



The DC HV Supply PCB (item #3 in [Figure 1-17](#) on [page 1-22](#)) is plugged in to the ETD Control PCB.

## **ETD Heater Control PCB**

The ETD Module Heater Control PCB (item #6 in [Figure 1-17](#)) contains the power source and temperature sensing circuitry for the four heaters in the reagent ion source. The heaters are H1 and H2 (the two reagent heaters, [Figure 1-18](#) on [page 1-23](#), and items #9 and #10 in [Figure 1-17](#)), the transfer line heater (#3 in [Figure 1-17](#)), and the restrictor oven heater (not shown in [Figure 1-17](#)). The Heater Control PCB reports temperature information to the heater temperature and readback logic on the ETD Control PCB. The heater temperature and readback logic controls how the Heater Control PCB applies power to the ETD Module heaters.

## **Reagent Carrier Gas Flow Control for ETD**

The ETD Module contains a digital flow control for the chemical ionization (CI) gas/reagent carrier gas provided by the ETD Control PCB (See [Figure 1-17](#) on [page 1-22](#).) and an electronic pressure regulator. The gas serves two functions in the ETD Module:

- As a carrier gas, the nitrogen sweeps the reagent (fluoranthene) from the vial to the ion source where the reagent radical anions are formed.
- As a chemical ionization (CI) vehicle, the nitrogen undergoes collisions with 70 eV electrons from the filament in the ion volume. These 70 eV electrons from the filament knock electrons off of the nitrogen molecules (nitrogen ions are created). The secondary electrons resulting from these collisions have near thermal kinetic energies. These thermal electrons are captured by the fluoranthene to form reagent radical anions that react with the analyte.

Thermo Fisher Scientific strongly recommends a mixture of 25% helium and 75% nitrogen. The helium in this mixture serves as a tracer gas to enable leak checking of gas connections using conventional thermal conductivity-based leak detectors, which are widely used to check leaks in gas chromatography equipment. See [“Gas Supply of the Reagent Ion Source”](#) on [page 1-40](#) for detailed information.

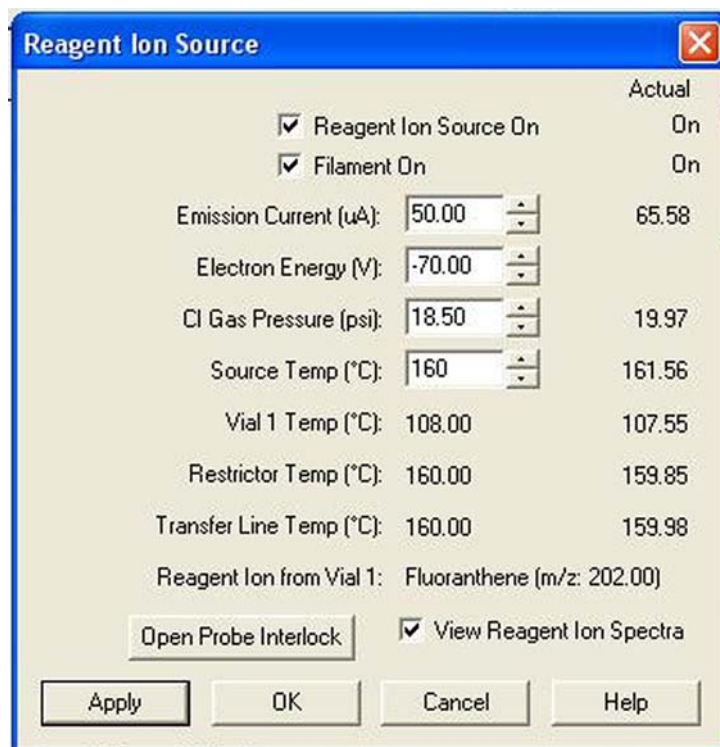
The reagent carrier gas supply in the laboratory is connected to the ETD reagent carrier gas port at the rear side of the ETD Module. See [Figure 1-31](#) on [page 1-40](#).



## Reagent Heaters

The reagent heaters (items #9 and #10 in [Figure 1-17](#) on [page 1-22](#), H1 and H2 in [Figure 1-18](#) on [page 1-23](#)) heat the reagent to obtain a sufficient amount of reagent vapor in the carrier gas. The reagent heaters are powered by the Heater Control PCB which, in turn, is controlled by the ETD Control PCB.

The reagent heaters are turned on by selecting the Reagent Ion Source On check box in the Reagent Ion Source dialog box. See [Figure 1-21](#).



**Figure 1-21.** Reagent Ion Source dialog box

When you deselect the Reagent Ion Source On check box, the reagent heaters and filament immediately turn off and the reagent ion source goes into Standby mode.

When the reagent ion source is placed in Off mode, cooling nitrogen (high-purity nitrogen) will turn on. This is confirmed by an audible rush (hissing noise) of nitrogen from the reagent ion source area in the back of the ETD Module. This is normal operation. See also [“Turning Off the Reagent Ion Source: What to Expect”](#) on [page 2-14](#).



**Warning Burn Hazard.** When the reagent ion source is in Off mode, restrictor oven, transfer line, and ion source remain at 160 °C. ▲

The nitrogen cooling gas turns off when the reagent heaters reach 70 °C. If it is necessary to install or replace the reagent vials, follow the procedure in “Changing the Reagent Vials” on page 3-47.

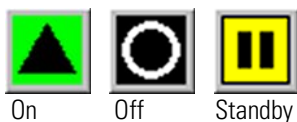
**Note** The rushing or hissing noise of the nitrogen coming from the back of the ETD Module will stop when the cooling nitrogen turns off. ▲



**Warning Burn Hazard.** Do not attempt to handle the vials or vial holders when the cooling nitrogen stops. They are still too hot to handle when the cooling nitrogen stops at a vial temperature of 70 °C. Follow the procedures in “Changing the Reagent Vials” on page 3-47 if it is necessary to install or replace the reagent vials. ▲

When the reagent heaters are in Standby mode, they are immediately turned on by selecting the Reagent Ion Source On check box (Figure 1-21 on page 1-27). When starting from room temperature, it takes up to ten minutes for the reagent heaters and vials to stabilize at 108 °C and reagent to delivered to the ion source.

**Note** When you switch on a cold reagent ion source, the Tune Plus software warns you that the vial temperature is not sufficient. The filament is automatically switched on after the temperature has stabilized. ▲



When you click the **Standby** button in the Tune Plus window (shown in the left margin), you initiate a Standby process. It delays turning off the reagent heaters and the start of nitrogen cooling for one hour after the system is placed in Standby. This method of placing the system in Standby permits a quick return to operation after a break (lasting one hour or less) rather than waiting up to ten minutes for the heaters to return to temperature and reagent delivery to be fully restored.

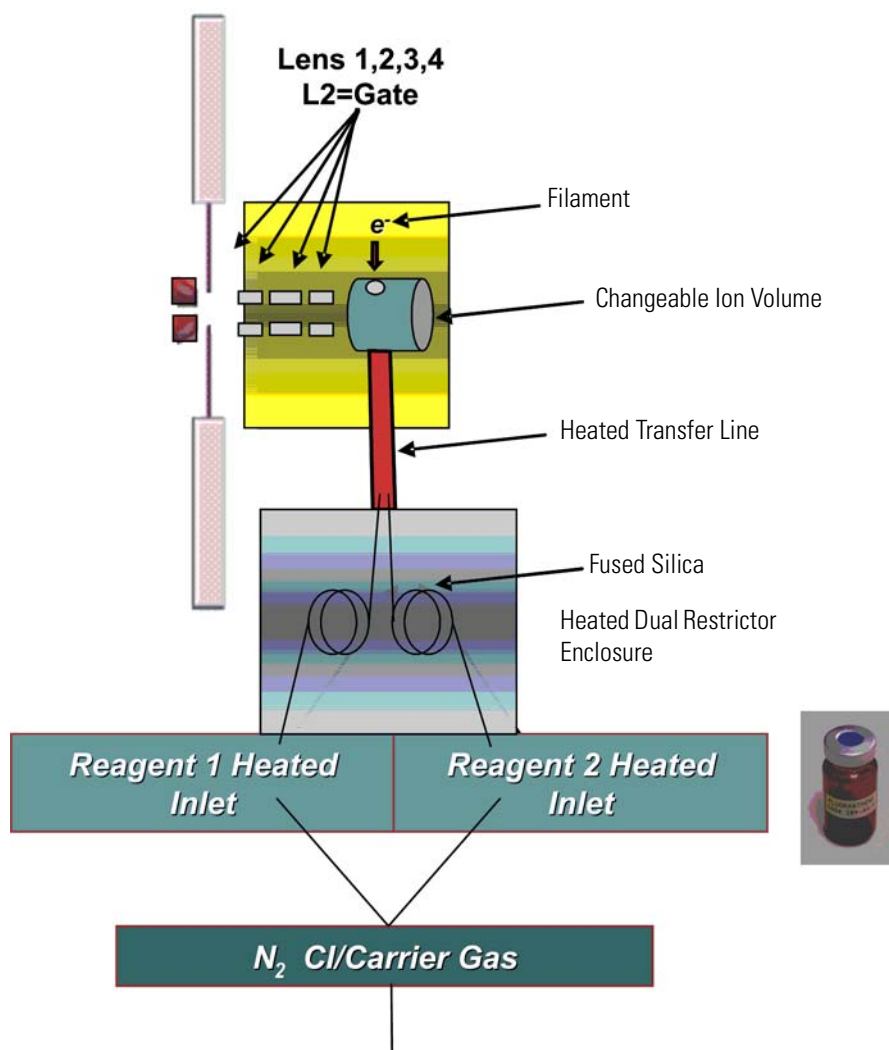
In summary:

- The reagent heaters turn off immediately when the Reagent Ion Source On check box is deselected in the Reagent Ion Source dialog box. (See Figure 1-21 on page 1-27.)
- The reagent heaters turn off one hour after the system is placed in Standby by clicking the Standby button in the Tune Plus window.

## Reagent Ion Source

The ion source (Figure 1-17 on page 1-22 and inside of the vacuum manifold, see item #14 in Figure 1-17) is where the reagent ions are formed. The ion source contains the filament, the reagent ion volume, and the ion source heater. The filament is the source of electrons that

react with the reagent to form reagent ions. The reagent ion volume is the space where this reaction takes place. See [Figure 1-22](#). The ion source heater is controlled by the ETD Control PCB.

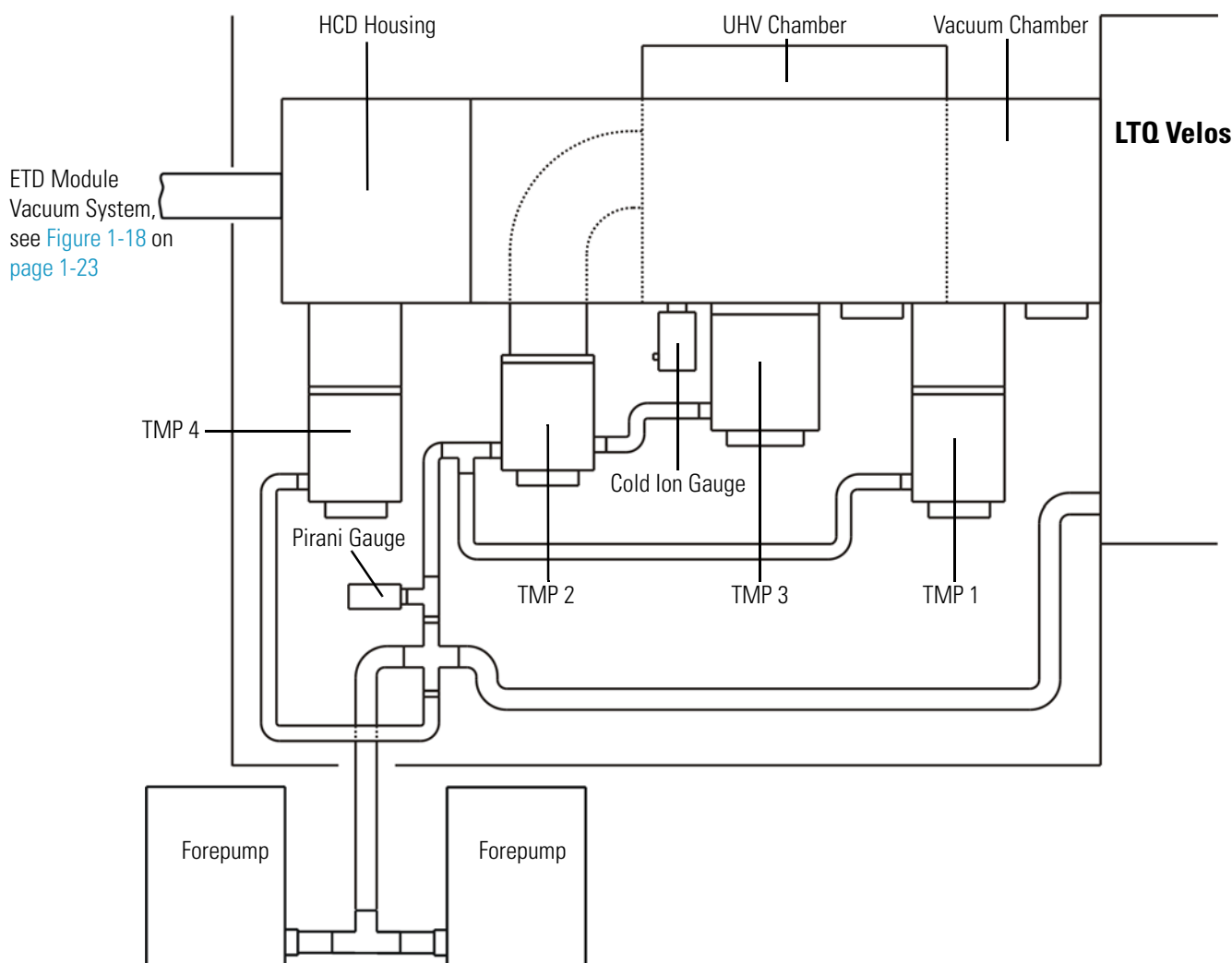


**Figure 1-22.** Reagent ion source schematics

The reagent ion source contains two reagent vials, CI/carrier gas (nitrogen) handling hardware and flow restrictors, ion volume and filament, ion optics, and heaters for these components. The flow restrictors keep the internal pressure of the reagent vials below atmospheric pressure. This prevents the contents of the reagent vials from being expelled to the laboratory atmosphere.

## Vacuum System

Figure 1-23 shows a schematical overview of the Orbitrap vacuum system.



**Figure 1-23.** Schematical view of Orbitrap vacuum system (CLT compartment and Orbitrap chamber not shown)\*

\*For an abridged version of the parts list, see Table on page 4-3.

The LTQ Orbitrap Velos has the following vacuum compartments:

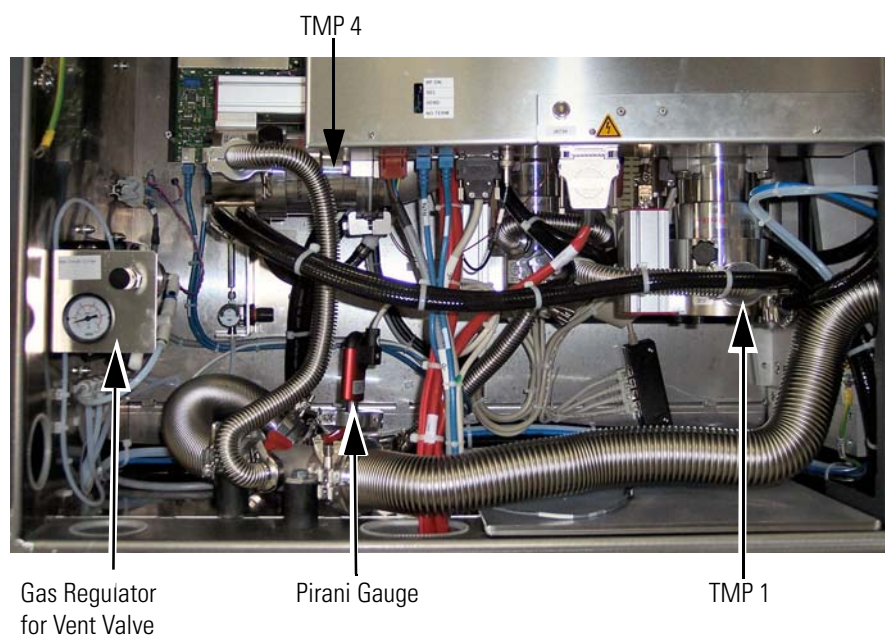
- **CLT compartment in the aluminum vacuum chamber** (pumped by the same pump as the linear trap)
- **Vacuum chamber** (pumped by a water-cooled 60 L/s – for N<sub>2</sub> – turbomolecular pump TMH 071, *TMP 1*, manufacturer: Pfeiffer)
- **Ultra high vacuum chamber** (UHV chamber, pumped by a water-cooled 60 L/s turbomolecular pump TMH 071, *TMP 2*, manufacturer: Pfeiffer)

- **Orbitrap chamber** (pumped by a 210 L/s – for N<sub>2</sub> – water-cooled turbomolecular pump TMU 262, *TMP 3*, manufacturer: Pfeiffer)
- **HCD housing** (pumped by a water-cooled 60 L/s turbomolecular pump TMH 071, *TMP 4*, manufacturer: Pfeiffer)

The forepumps of the linear trap provide the forevacuum for the turbomolecular pumps TMP 1 to TMP 4.

## Turbomolecular Pumps

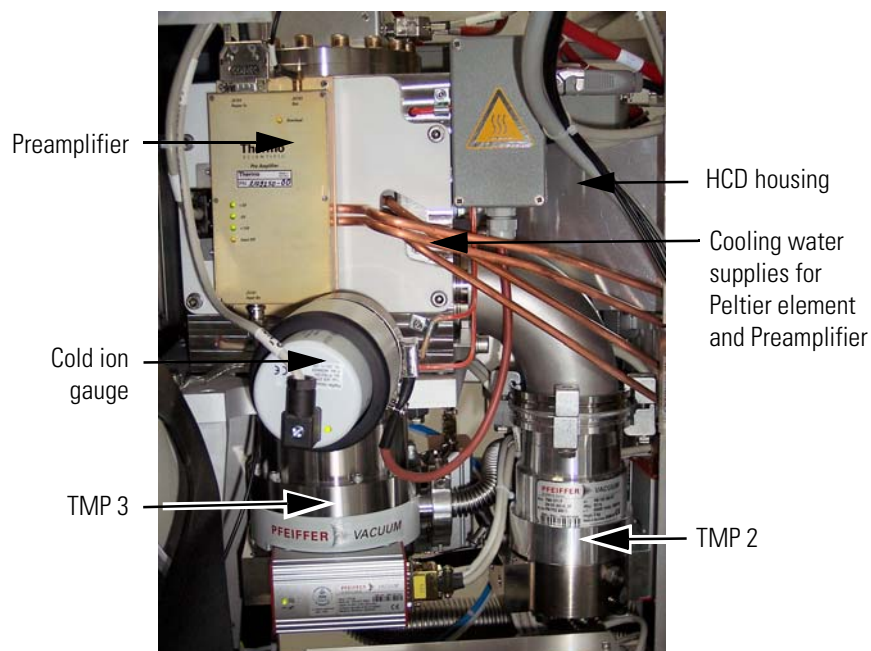
All parts of the system except for the Orbitrap analyzer are mounted in a aluminum vacuum chamber that is evacuated by a 60 L/s turbomolecular pump (TMP 1, see [Figure 1-24](#)). The rotary vane pumps of the linear trap (see [page 1-33](#)) provide the forevacuum for this pump. This chamber is bolted to a stainless steel welded UHV chamber, which accommodates Orbitrap, lenses, and corresponding electrical connections.



**Figure 1-24.** Vacuum components on the left instrument side

The UHV chamber is evacuated down to  $10^{-8}$  mbar pressure range by a 60 L/s UHV turbomolecular pump (*TMP 2*, see [Figure 1-25](#) on [page 1-32](#)). The Orbitrap itself is separated from the UHV chamber by differential apertures and is evacuated down to  $10^{-10}$  mbar by a 210 L/s turbomolecular pump (*TMP 3*, see [Figure 1-25](#)). The HCD housing is evacuated by a 60 L/s UHV turbomolecular pump (*TMP 4*, see [Figure 1-24](#)) that is mounted to its bottom via an elbow. This dedicated pump for the HCD cell protects the low pressure cell of the linear trap from gas overload.

In the LTQ Orbitrap Velos ETD, a tube that contains the transfer multipole (flatapole) connects the HCD housing to the ETD Module.



**Figure 1-25.** Vacuum components on the right instrument side

All turbomolecular pumps are equipped with TC 100 control units (manufacturer: Pfeiffer). A 24 V switch mode power supply provides the electric power for all four turbomolecular pumps of the system.

### Linear Trap Turbomolecular Pump

A separate turbomolecular pump provides the high vacuum for the linear ion trap. It is mounted to the bottom of the vacuum manifold of the linear ion trap. For more information, refer to the *LTQ Series Hardware Manual*.

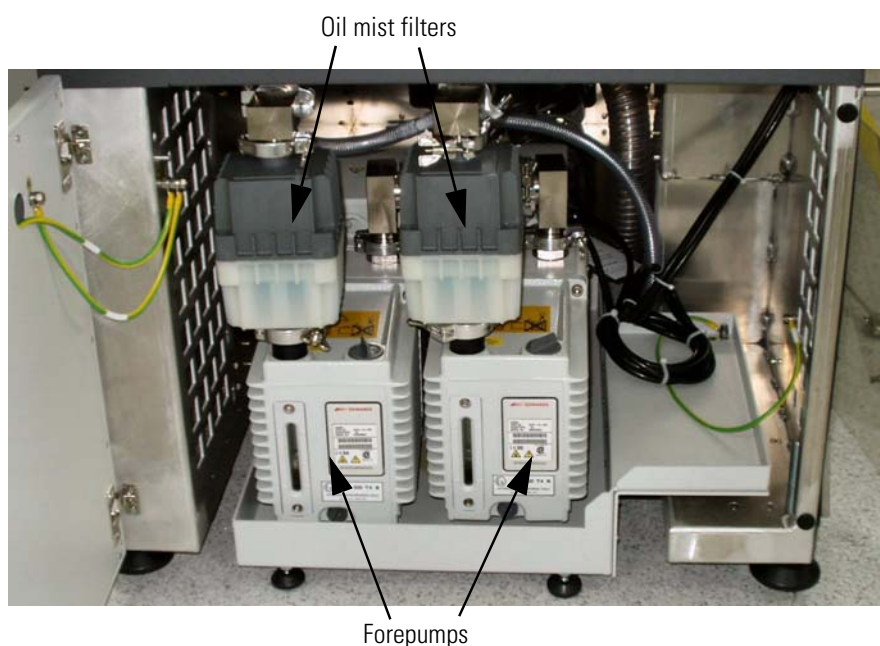
### ETD Module Turbomolecular Pump

In the LTQ Orbitrap Velos ETD, a separate turbomolecular pump (BOC Edwards EXT75DX) provides the high vacuum for the ETD reagent ion source. See [Figure 1-17](#) on [page 1-22](#). It is backed up by a dedicated rotary vane pump at the bottom of the ETD Module. See [Figure 1-27](#) on [page 1-34](#). This air-cooled turbomolecular pump contains no user-serviceable parts.



## Forepumps of the Linear Trap

The rotary vane pumps from the linear trap serve as forepumps for the three smaller turbomolecular pumps (TMP 1, TMP 2, and TMP 4). The exhaust hose from the forepumps is led to the back of the instrument and connects them to the exhaust system in the laboratory. The forepumps are located on a small cart in the forepumps cabinet below the linear trap. See [Figure 1-26](#).



**Figure 1-26.** Forepumps cabinet

To minimize the ingress of pump oil into the exhaust system, the outlets of the forepumps are fitted to oil mist filters. See [page 3-11](#) on instructions about returning the collected oil to the forepumps.

The forepumps of the linear trap are powered by the power panel of the linear ion trap.



**Warning** Hazardous materials may be present in the effluent of the forepumps. The connection to an adequate exhaust system is mandatory! ▲

Leave the switches of the forepumps always in the On position to provide the control from the vacuum control panel. Before starting the pumps, however, make sure that:

- The forevacuum pumps are filled with oil,
- They are connected to the power supply, and
- The gas ballast is shut.

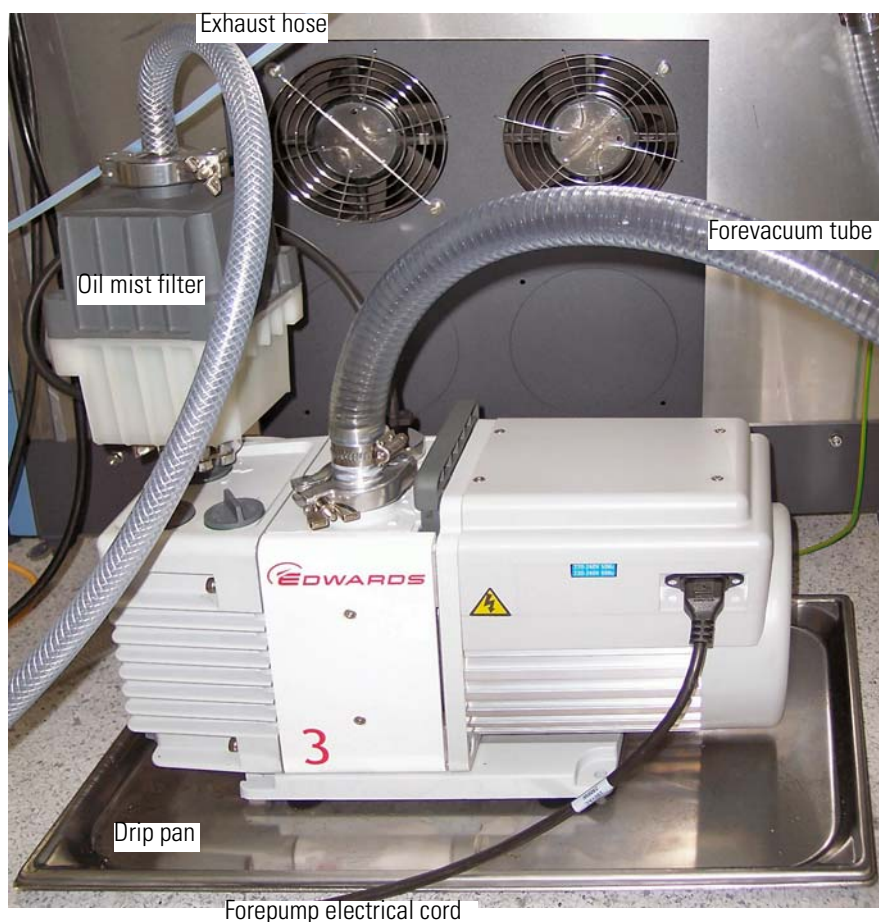
For a detailed description of the forepumps, refer to the handbook of the manufacturer.

## Forepump of the ETD Module

In the LTQ Orbitrap Velos ETD, a rotary vane pump (BOC Edwards RV 3) provides the forevacuum for the ETD turbomolecular pump. (See “[ETD Module Turbomolecular Pump](#)” on [page 1-32](#).) It is located in a cabinet at the bottom of the ETD Module. The ETD forepump is equipped with an oil mist filter and stands on a drip pan. See [Figure 1-27](#) on [page 1-34](#).

An exhaust hose connects the forepump to the exhaust system in the laboratory. A forevacuum tube connects the ETD forepump to the ETD TMP. The forepump electrical cord is plugged into the Forepump receptacle on the ETD Module power panel. See [Figure 1-20](#) on [page 1-24](#).

For maintenance instructions for the ETD forepump, see “[Maintenance of the ETD Forepump](#)” on [page 3-5](#) and the manual that came with the forepump.



**Figure 1-27.** Forepump for ETD Module



## Vacuum System Controls

The power distribution board controls all turbopumps via voltage levels. See “[Power Distribution Board](#)” on page 1-53. An interface for RS485 data via the instrument control board connects the turbopumps with the linear ion trap. (See “[Instrument Control Board](#)” on page 1-52.) The turbomolecular pump of the linear ion trap and the ETD turbomolecular pump have individual controllers.

## Vacuum Gauges

Several vacuum gauges monitor the vacuum within the instrument:

- The forevacuum of the LTQ Orbitrap Velos is monitored by an Active Pirani gauge (TPR 280, manufacturer: Pfeiffer) connected to the LTQ Orbitrap Velos forevacuum line. See [Figure 1-24](#) on page 1-31.
- The high vacuum of the LTQ Orbitrap Velos is monitored by a Cold Ion Gauge (IKR 270, manufacturer: Pfeiffer) connected to the UHV chamber. See [Figure 1-25](#) on page 1-32. Because the gauge would be contaminated at higher pressures, it is turned on only when the forevacuum has fallen below a safety threshold ( $<10^{-2}$  mbar).
- The linear ion trap vacuum is monitored by a Convectron® gauge and an ion gauge. Refer to the *LTQ Series Hardware Manual* for more information.
- In the LTQ Orbitrap Velos ETD, two dedicated vacuum gauges monitor the vacuum in the ETD Module. A Convectron gauge (see [Figure 1-17](#) on page 1-22 and [Figure 1-18](#) on page 1-23) monitors the pressure in the ETD forevacuum line and an ion gauge (see [Figure 1-17](#)) monitors the pressure in the reagent ion source. [Table 1-3](#) shows typical pressure readings in the ETD Module.

**Table 1-3.** Typical pressure readings in the ETD Module

Conditions	Convection Gauge Reading	Ion Gauge Reading
Cl gas pressure set to 20 psi	0.1–0.01 Torr	20–35×10 <sup>-5</sup> Torr

The vacuum gauges of the LTQ Orbitrap Velos are connected to the power distribution board that directly responds to the pressure values. (See “[Power Distribution Board](#)” on page 1-53.) The analog values are digitized by the instrument control board. (See “[Instrument Control Board](#)” on page 1-52.) They are then sent as readout values to the data system.

## Switching on the Vacuum System

When the vacuum system is switched on, the following occurs:

1. After the Vacuum Pumps switch is switched On, the pumps of the linear ion trap and the LTQ Orbitrap Velos are run up. The Pirani gauge (see above) controls the LTQ Orbitrap Velos low vacuum pressure as well as the pressure at the forevacuum pumps. Within a short time, a significant pressure decrease must be observed. The goodness of the vacuum can be estimated by means of the rotation speed of the turbopumps (e.g. 80% after 15 min.).
2. If the working pressure is not reached after the preset time, the complete system is switched off. At the status LED panel of the power distribution board, an error message (Vacuum Failure) is put out (see below).
3. The Cold Ion Gauge is only switched on after the low vacuum is reached. It is then used to monitor the vacuum in the Orbitrap region.

## Vacuum Failure

In case the pressure in the LTQ Orbitrap Velos or the linear ion trap exceeds a safety threshold, the complete system including linear ion trap, electronics, and pumps is switched off. However, the power distribution is kept under current and puts out an error message at the LED panel. (See “[Power Distribution Board](#)” on [page 1-53](#).) It can be reset by switching the main power switch off and on. (See “[Main Power Switch](#)” on [page 1-9](#).)

Upon venting, the vent valves of the turbopumps on the Orbitrap detector stay closed. Only the vent valve of the linear ion trap is used. (See “[Vent Valve of the Linear Ion Trap](#)” on [page 1-39](#).)

## Vacuum System Heating during a System Bakeout

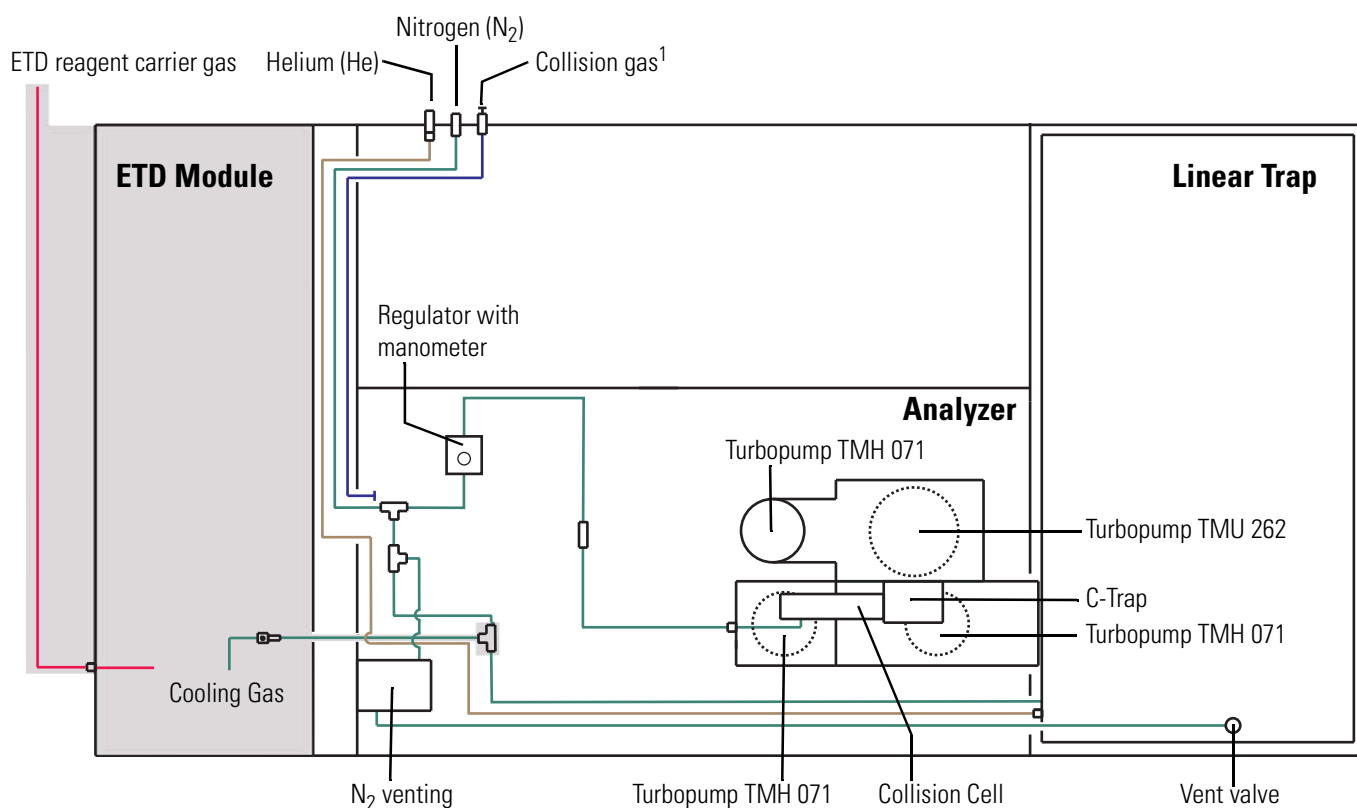
After the system has been open to the atmosphere (e.g. for maintenance work), the vacuum deteriorates due to contaminations of the inner parts of the vacuum system caused by moisture or a power outage. These contaminations must be removed by heating the vacuum system: a system bakeout. See “[Baking Out the System](#)” on [page 3-4](#).

## Gas Supply

This section describes the gas supplies for the mass analyzers of the LTQ Orbitrap Velos and the reagent ion source of the LTQ Orbitrap Velos ETD.

### Gas Supply for the Mass Analyzers

Figure 1-28 shows a schematical view of the gas supply for the instrument. The gas supply of the ETD system is highlighted in gray.



**Figure 1-28.** Schematical view of gas supply for LTQ Orbitrap Velos ETD<sup>\*</sup>

<sup>\*</sup>For parts lists of the gas supply, see [page 4-4](#) and [page 4-5](#).

### Gas Inlet Ports of the Instrument

On its right side (See [Figure 1-9](#) on [page 1-10](#).), the instrument provides three gas inlet ports for the gas supply of the mass analyzers:

- **Nitrogen:** The linear trap requires high-purity (99%) nitrogen for the API sheath gas and auxiliary/sweep gas. The required gas pressure is  $690 \pm 140$  kPa ( $6.9 \pm 1.4$  bar,  $100 \pm 20$  psi).

<sup>1</sup>The port named Collision Gas is not used in the LTQ Orbitrap Velos.

In the LTQ Orbitrap Velos ETD, the ETD system uses the high-purity nitrogen for cooling the reagent vials when the reagent ion source is turned off.

- **Helium:** The linear trap requires ultra-high purity (99.999%) helium for the collision gas. The required gas pressure is  $275 \pm 70$  kPa ( $2.75 \pm 0.7$  bar,  $40 \pm 10$  psi).



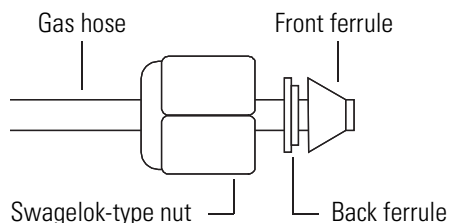
**Warning Danger of Asphyxiation.** Accumulation of nitrogen gas could displace sufficient oxygen to suffocate personnel in the laboratory. Ensure that the laboratory is well ventilated. ▲

❖ **To connect the nitrogen source to the LTQ Orbitrap Velos**

1. Connect an appropriate length of Teflon™ tubing to the nitrogen source in the laboratory. The Installation Kit contains 6 m (20 ft) of suitable Teflon tubing (OD 6 mm, P/N 0690280). The connection for the Teflon hose to the nitrogen gas supply is not provided in the kit; you have to supply this part.
2. Connect the opposite end of the Teflon tubing to the press-in fitting labeled Nitrogen, which is located at the right side of the instrument. See [Figure 1-9](#) on [page 1-10](#). To connect the tubing, align the Teflon tubing with the opening in the fitting and firmly push the tubing into the fitting until the tubing is secure.

❖ **To connect the helium source to the LTQ Orbitrap Velos**

1. Connect an appropriate length of 1/8-in ID copper or stainless steel tubing with a brass Swagelok-type 1/8-in nut (P/N 00101-15500) and a 2-piece brass 1/8-in ID ferrule [P/N 00101-08500 (front), P/N 00101-2500 (back)] to the Helium gas inlet. See [Figure 1-29](#) for the proper orientation of the fitting and ferrule.
2. Connect the opposite end of the tubing to the helium gas source, using an appropriate fitting.

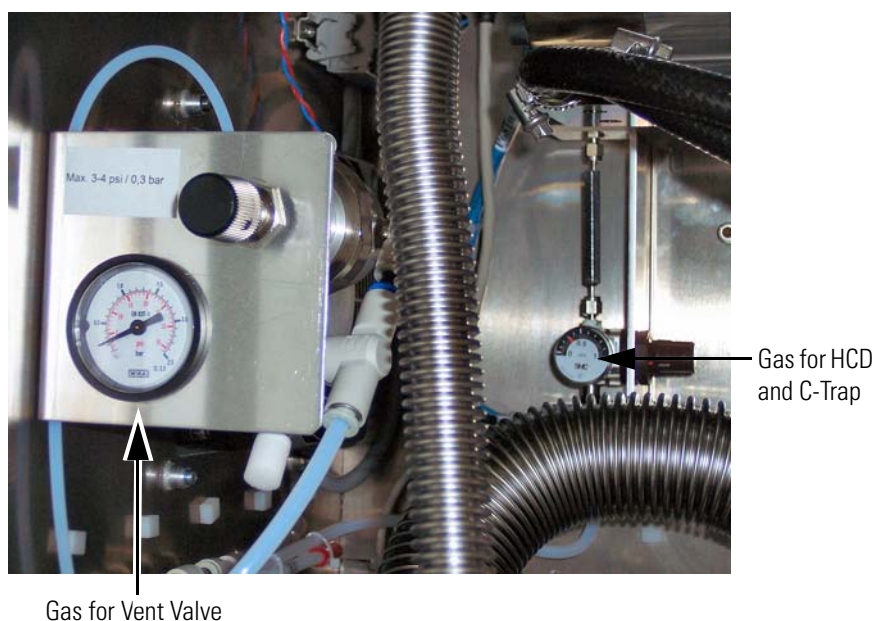


**Figure 1-29.** Proper orientation of the Swagelok-type nut and two-piece ferrule

## Gas Distribution Within the Instrument

Helium gas is led from the helium port through a stainless steel capillary to the right rear side of the linear trap. See [Figure 1-28](#) on [page 1-37](#). High purity nitrogen gas is led from the nitrogen port via Teflon tubing to the right side of the LTQ Orbitrap Velos. Here, two T-pieces divide the nitrogen gas flow into three parts.

The first part of the high purity nitrogen gas flow is directed through Teflon tubing via a pressure regulator to the vent valve of the linear trap. (See [Figure 1-30](#) on [page 1-39](#).) The second part of the nitrogen flow is directed through Teflon tubing to the API source. The third part of the nitrogen flow enters a gas regulator with manometer, which keeps the gas pressure to the C-Trap and HCD collision cell constant. (See [Figure 1-30](#), background.) From the regulator, the collision gas is led through *red* PEEKSil™ tubing (100 mm ID silica capillary in 1/16 inch PEEK tubing) to the collision octapole next to the curved linear trap (flow rate: ~0.5 mL/min). The nitrogen gas leaking from the HCD collision cell (3–5 mbar) is used for ion trapping and cooling in the C-Trap.



**Figure 1-30.** Gas regulators

In the LTQ Orbitrap Velos ETD, nitrogen is also directed through Teflon tubing to the ETD Module to be used for cooling the reagent vials when the reagent ion source is turned off.

## Vent Valve of the Linear Ion Trap

If the system and pumps are switched off, the system is vented. The vent valve is controlled by the linear ion trap. The *LTQ Series Hardware Manual* contains further information about the vent valve.

## Functional Description

### Gas Supply

The instrument is vented with high purity nitrogen from the same tubing that supplies the LTQ Velos sheath gas. See [Figure 1-28](#) on [page 1-37](#). The vent valve of the LTQ Velos is supplied via a pressure regulator that is set to a venting pressure of 3–4 psi. The pressure regulator is located at the left side of the LTQ Orbitrap Velos. (See [Figure 1-30](#), front.)

## Gas Supply of the Reagent Ion Source

In addition to high purity nitrogen for cooling, the reagent ion source of the LTQ Orbitrap Velos ETD uses a mixture of 25% helium and 75% nitrogen gas as carrier gas and chemical ionization (CI) vehicle. This gas mixture must be ultra high-purity (minimum purity 99.999%) with less than 3.0 ppm each of water, oxygen, and total hydrocarbons. The required gas pressure is  $690 \pm 140$  kPa ( $6.9 \pm 1.4$  bar,  $100 \pm 20$  psi). The ETD carrier gas supply of the laboratory is connected via metal tubing to the inlet port at the rear side of the instrument. See [Figure 1-31](#).



**Figure 1-31.** ETD reagent carrier gas port at the ETD Module

The helium in this mixture serves as a tracer gas to enable leak checking of gas connections using conventional thermal conductivity-based leak detectors, which are widely used to check leaks in gas chromatography equipment.

**Note** If the helium/nitrogen mixture is not available, then use a nitrogen supply that is ultra high-purity (99.999%) with less than 3.0 ppm each of water, oxygen, and total hydrocarbons. ▲

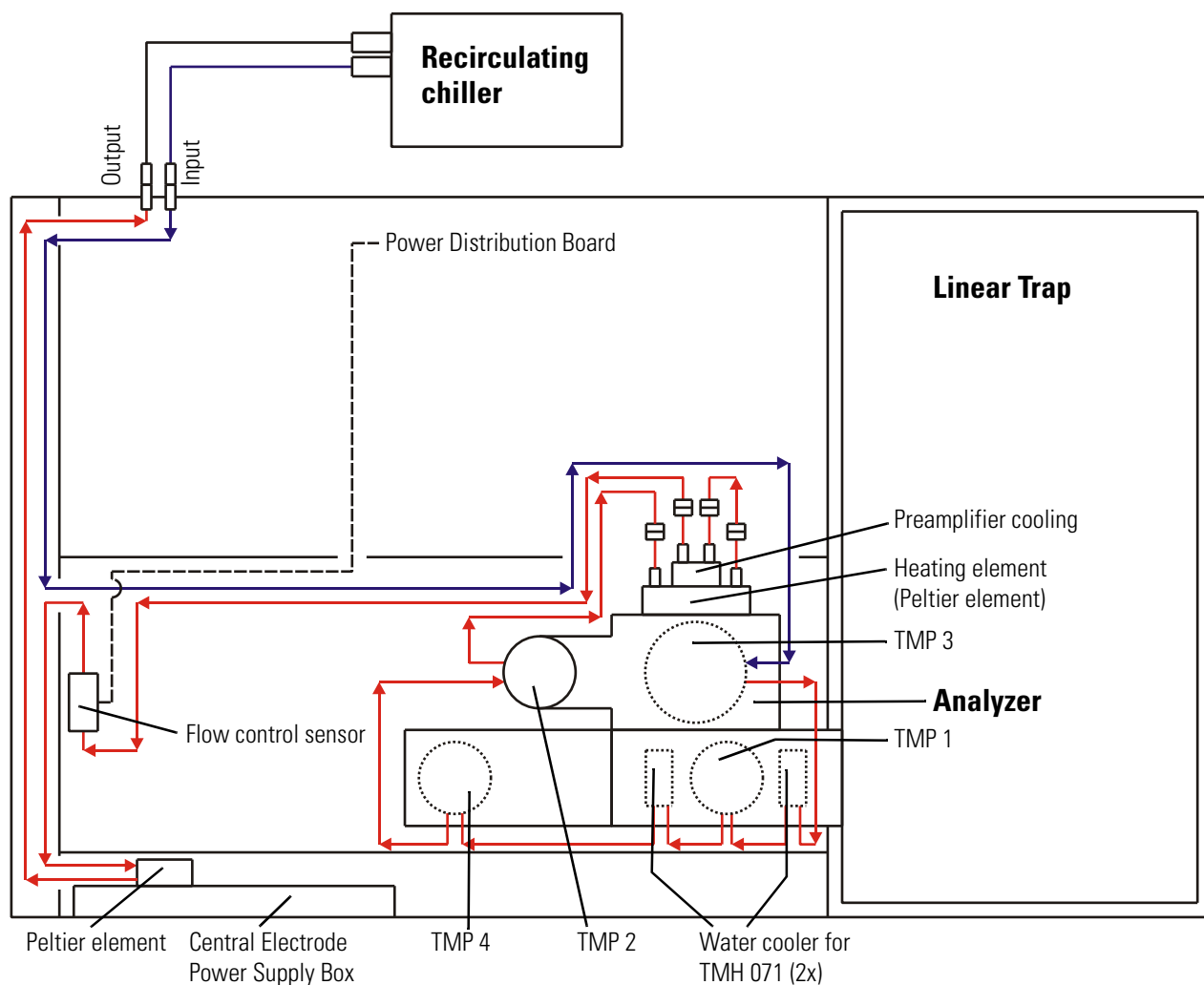
## **Triple Gas Filter**

A triple (oxygen/water/hydrogen) gas filter is installed between the regulator on the reagent carrier gas source and the ETD module to ensure that the reagent carrier gas (either nitrogen or helium/nitrogen) is better than 99.999% pure with much less than 1 ppm of oxygen, water, and hydrocarbons.

Refer to the filter manufacturer's instructions for information about how to monitor the color changes in the filters that indicated when the filters need to be replaced, as well as information about where to order new filters. If there are no leaks in the reagent carrier gas plumbing, you can expect the filters to last a year or more. Thermo Fisher Scientific strongly recommends that a Thermo Fisher Scientific Field Service Engineer replace the gas filters.

## Cooling Water Circuit

Figure 1-32 on page 1-42 shows a schematical view of the cooling water circuit in the LTQ Orbitrap Velos. Cooling water at a temperature of 20 °C enters and leaves the instrument at the bottom of the right side. See Figure 1-9 on page 1-10. First, the fresh water passes through the turbomolecular pumps in the order TMP 3 → TMP 1 → TMP 4 → TMP 2. Then it passes through the heating element (Peltier element) that maintains ( $\pm 0.5$  °C) the preset temperature of the analyzer. After that, the cooling water passes through the preamplifier cooling unit. Before it leaves the instrument, the water passes through the other Peltier element at the back of the central electrode power supply board.



**Figure 1-32.** Schematical view of cooling water circuit\*

\* For a parts list of the cooling water circuit, see Table on page 4-4.

A flow control sensor is connected to the power distribution board and allows displaying the current flow rate of the cooling water in the software.



## Recirculating Chiller

A recirculating chiller (NESLAB ThermoFlex™ 900) is delivered with the instrument, making the LTQ Orbitrap Velos independent from any cooling water supply. A wall receptacle provides the electric power for the chiller. Two water hoses (black), internal diameter 9 mm, wall thickness 3 mm, length approx. 3 m (~10 ft) are delivered with the instrument.

For instruction about performing maintenance for the chiller, see “Maintenance of the Recirculating Chiller” on page 3-57. See also the manufacturer’s manual for the chiller.

## Properties of Cooling Water

The water temperature is not critical, but should be in the range of 20 to 25 °C (68 to 77 °F). Lower temperatures could lead to a condensation of atmospheric water vapor. It is recommended to use distilled water rather than de-ionized water due to lower concentration of bacteria and residual organic matter.

The water should be free of suspended matter to avoid clogging of the cooling circuit. In special cases, an in-line filter is recommended to guarantee consistent water quality.

The cooling water should meet the following requirements:

Hardness:	<0.05 ppm
Resistivity:	1–3 MΩ/cm
Total dissolved solids:	<10 ppm
pH:	7–8



**Warning Burn Hazard.** If the water circuit fails, all parts of the water distribution unit may be considerably heated up. Do not touch the parts! Before disconnecting the cooling water hoses, make sure the cooling water has cooled down! ▲

## Printed Circuit Boards

The LTQ Orbitrap Velos is controlled by a PC running the Xcalibur™ software suite. The software controls all aspects of the instrument. The main software elements are the communication with the linear ion trap, the control of ion detection, and the control of the Orbitrap mass analyzer.

The following pages contain a short overview of the electronic boards in the MS portion of the LTQ Orbitrap Velos. For each board, its respective location and function are given. If applicable, the diagnostic LEDs on the board are described. For a description of the printed circuit boards in the ETD Module, see “[ETD Module](#)” on [page 1-21](#).

The electronics of the LTQ Orbitrap Velos contains complicated and numerous circuits. Therefore, only qualified and skilled electronics engineers should perform servicing.

A Thermo Fisher Scientific Service Engineer should be called if servicing is required. It is further recommended to use Thermo Fisher Scientific spare parts only. When replacing fuses, only use the correct type. Before calling a Service Engineer, please try to localize the defect via errors indicated in the software or diagnostics. A precise description of the defect will ease the repair and reduce the costs.



**Warning Electrical Shock Hazard.** Parts of the printed circuit boards are at high voltage. Shut down the instrument and disconnect it from line power before performing service. Opening the electronics cabinet is only allowed for maintenance purposes by qualified personal. ▲

**Note** Many of the electronic components can be tested by the LTQ Orbitrap Velos diagnostics, which is accessible from the Tune Plus window. ▲

## Linear Ion Trap Electronics

The linear ion trap is connected to the LTQ Orbitrap Velos main power switch. The linear ion trap has a sheet metal back cover. [Figure 1-33](#) shows the electronic connections at the rear side of the linear trap.



**Figure 1-33.** Electronic connections to linear trap

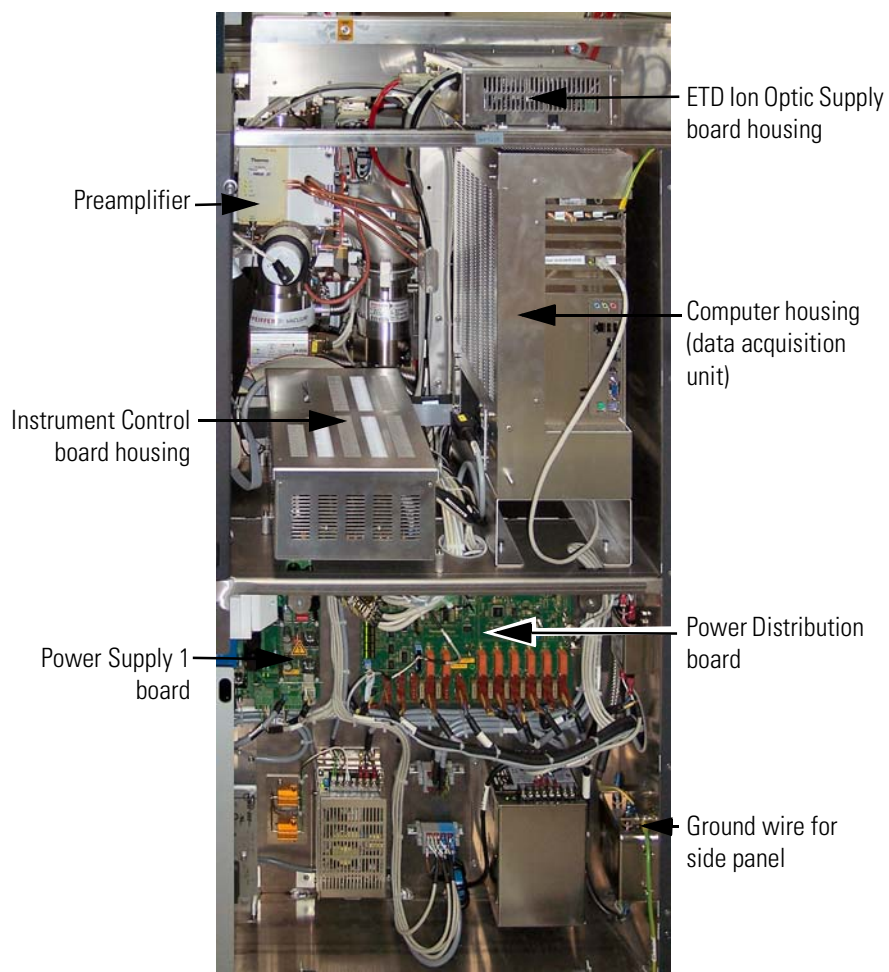
The linear ion trap electronics has two connections with the LTQ Orbitrap Velos electronics:

- Data communication with the internal computer of the LTQ Orbitrap Velos. See [“Electronic Boards at the Right Side of the Instrument”](#) on [page 1-46](#).
- Signal communication (SPI bus) with supply information for the instrument control board. See [“Instrument Control Board”](#) on [page 1-52](#).

For further information about the linear ion trap electronics, refer to the *LTQ Series Hardware Manual*.

## Electronic Boards at the Right Side of the Instrument

Figure 1-34 shows the parts of the instrument when the right side panel is opened. A transparent cover protects the lower part.



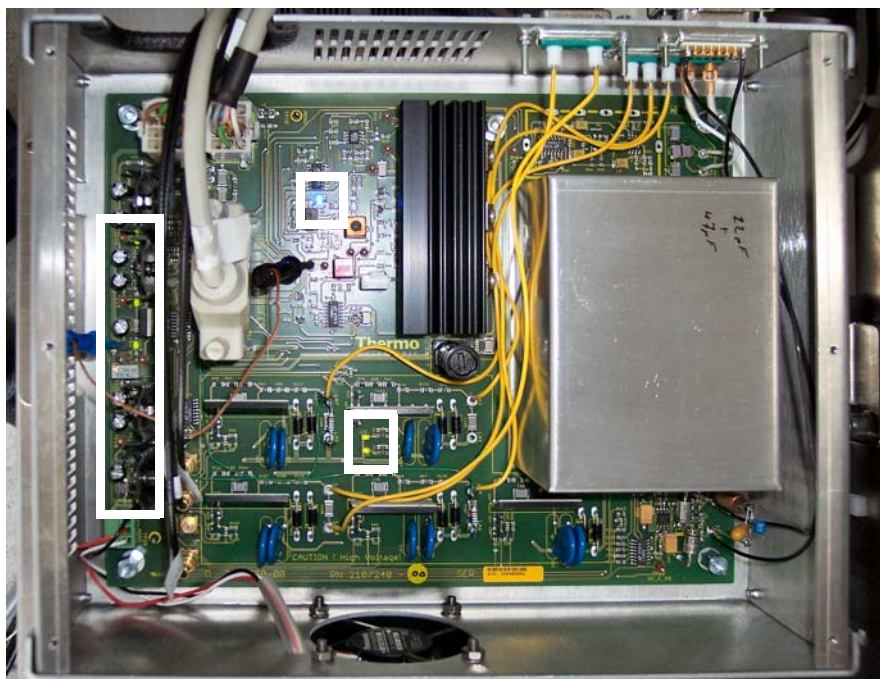
**Figure 1-34.** Electronic boards on the right side of the LTQ Orbitrap Velos



The side panel is connected to the instrument frame by two green/yellow ground wires. See bottom of Figure 1-34. The connectors on the panel are labeled with green-yellow PE (for **P**rotective **E**arth) signs. See photo left. Do not forget to reconnect them before closing the panel!

### ETD Ion Optic Supply Board

The ETD Ion Optic Supply board is mounted on top of the data acquisition unit. See Figure 1-35. It supplies the voltages for the HCD collision cell. In the LTQ Orbitrap Velos ETD, this board also supplies the RF voltage and the dc voltages for the ETD Module: an RF voltage with dc offset, three dc voltages with  $\pm 250$  V, and a dc voltage with  $\pm 12$  V.



**Figure 1-35.** ETD Ion Optic Supply board

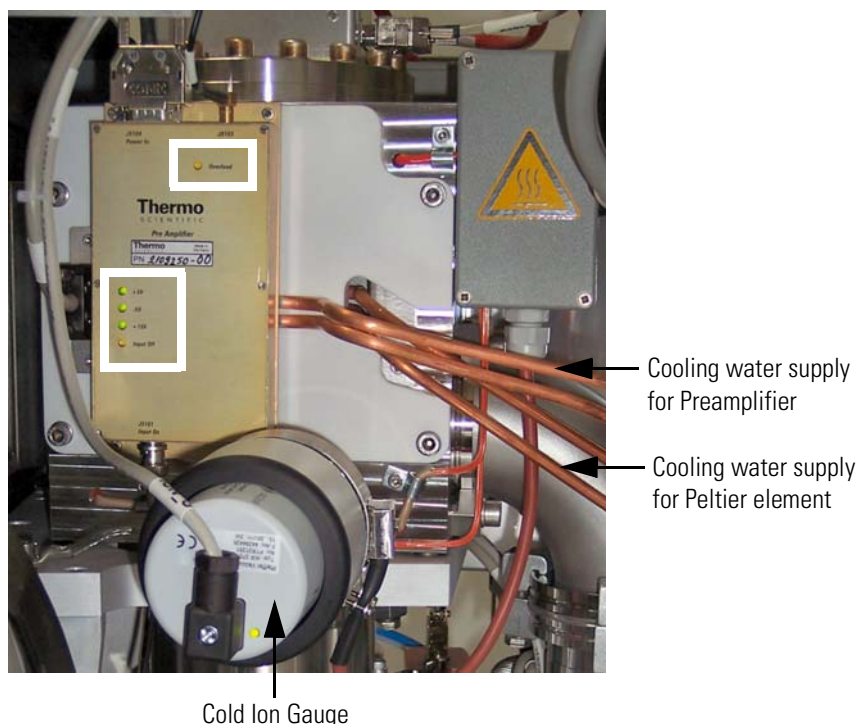
The diagnostic LEDs on the ETD ion optic supply board are listed in [Table 1-4](#) on [page 1-47](#). The positions of the diagnostic LEDs on the board are indicated by white rectangles in [Figure 1-36](#).

**Table 1-4.** Diagnostic LEDs on the ETD Ion Optic Supply board

No.	Name	Color	Description	Normal Operating Condition
LD1	+275 V	Green	+275 V input voltage present	On
LD2	-275 V	Green	-275 V input voltage present	On
LD3	RF Supply	Green	RF input voltage (22 V) present	On
LD4	+24 V	Green	+24 V input voltage present	On
LD5	+15 V	Green	+15 V input voltage present	On
LD6	-15 V	Green	-15 V input voltage present	On
LD7	RF1_ON	Blue	RF-generator switched on	On/Off, depending on active application

## Preamplifier

The preamplifier is located in a housing next to the Cold Ion Gauge. See [Figure 1-36](#). It is water cooled to protect it during a system bakeout.



**Figure 1-36.** Preamplifier board

This board is a broadband preamplifier with differential high-impedance inputs. It serves as a detection amplifier and impedance converter for the image current created by the oscillating ions. The output current is transferred to the data acquisition board. It has an amplification factor of about 60 dB and covers the frequency range from 15 kHz to 10 MHz.

The diagnostic LEDs on the preamplifier are listed in [Table 1-5](#) on [page 1-48](#). The positions of the diagnostic LEDs on the board are indicated by white rectangles in [Figure 1-36](#).

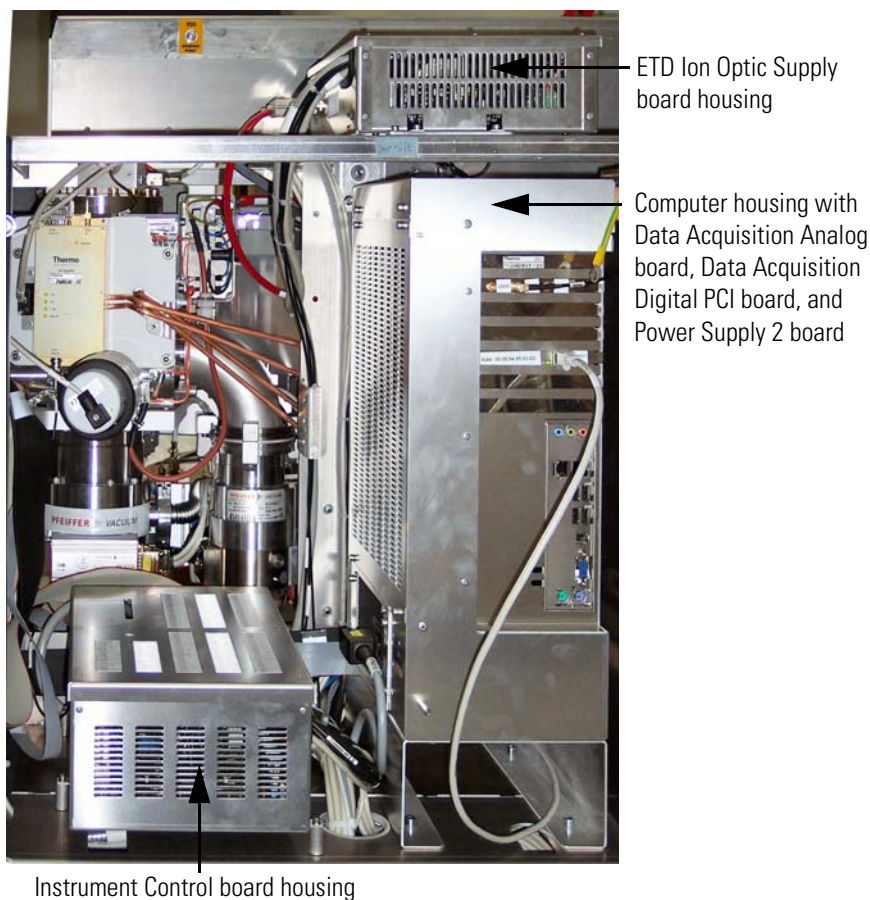
**Table 1-5.** Diagnostic LEDs on the Preamplifier board

No.	Name	Color	Description	Normal Operating Condition
LD1	Overload	Yellow	RF output is overloaded	Off
LD2	+5 V	Green	+5 V input voltage present	On
LD3	+15 V	Green	+15 V input voltage present	On
LD4	-5 V	Green	-5 V input voltage present	On
LD5	Input off	Yellow	RF inputs are shortened (protection)	On, off during Detect



## Internal Computer

Figure 1-37 shows the components of the data acquisition unit. The unit is mounted in a housing located at the right side of the instrument.

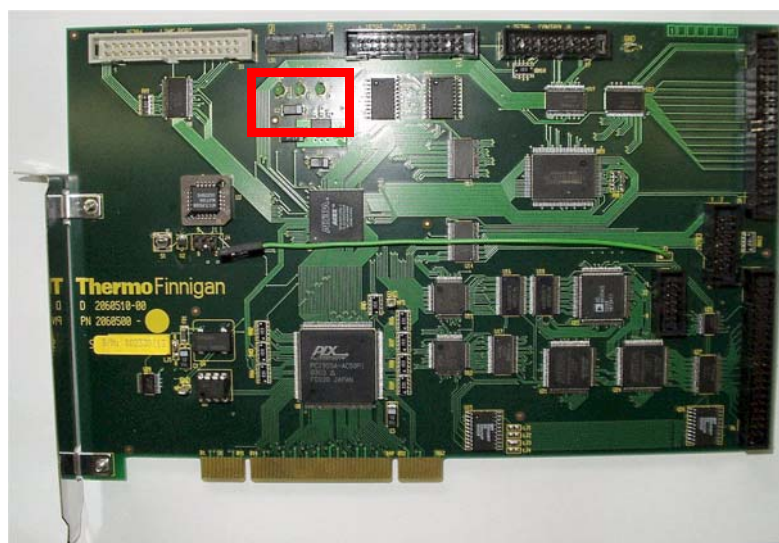


**Figure 1-37.** Data Acquisition unit

The internal computer contains a computer mainboard with an ATX power supply. The data acquisition digital PCI board is directly plugged into the mainboard. The data acquisition analog board is mounted on top of the computer mainboard.

## Data Acquisition Digital PCI Board

Figure 1-38 shows the data acquisition digital PCI board. It is an add-on board to the internal computer. (See Figure 1-37 on page 1-49.)



**Figure 1-38.** Data Acquisition Digital PCI board

This board is used to convert detected ion signals to digital form and to interface to the computer mainboard. The board has two 16 bit parallel connections to the DAC and the ADC on the data acquisition analog board, which are used for controlling and reading-back signals. A high-speed link port channel is also on the board that is used to communicate with the electronics in the linear ion trap.

Precision timing is derived from the data acquisition analog board and events with lower requirements use the timer in the internal computer. This timer is used to check at regular intervals whether the foreground process works as expected.

Communication takes place not only between the linear ion trap and the internal computer of the LTQ Orbitrap Velos system, but also between the linear ion trap and the data system computer. For further information about the data system, refer to the *LTQ Series Hardware Manual*.

The diagnostic LEDs listed in Table 1-6 show the status of the board. The position of the LEDs on the board is indicated by a red rectangle in Figure 1-38.

**Table 1-6.** Diagnostic LEDs of the Data Acquisition Digital PCI board

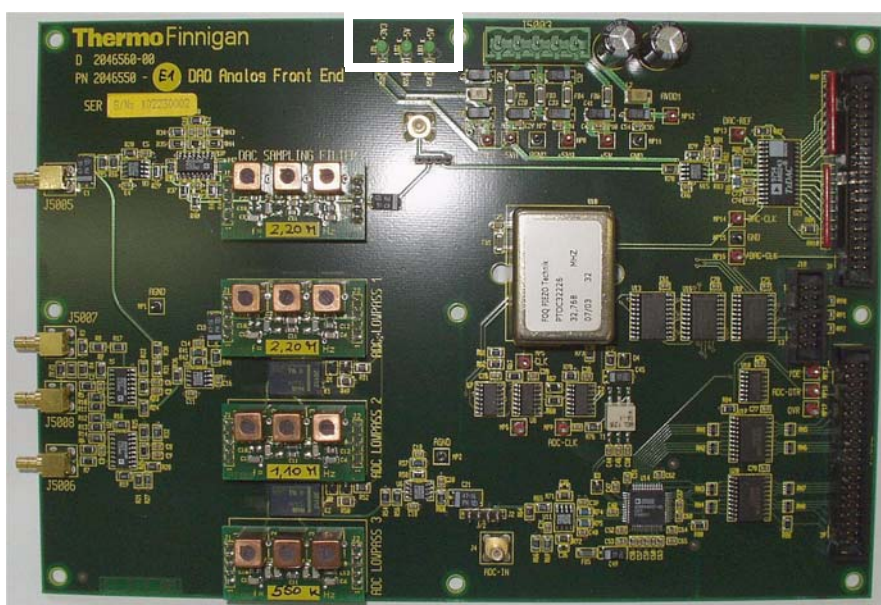
Name	Color	Description	Normal Operating Condition
+5 V	Green	+5 V voltage present	On
+3.3 V	Green	+3.3 V voltage present	On
+2.5 V	Green	+2.5 V voltage present	On



## Data Acquisition Analog Board

Figure 1-39 shows the data acquisition analog board. This board is an add-on board to the mainboard of the internal computer. See Figure 1-37 on page 1-49. It is used to convert analog to digital signals for Orbitrap experiments, especially for detecting the ions. The board contains an ADC for the detection of the transient signal, with a frequency range from 10 kHz to 10 MHz. Three anti-aliasing filters for the low, middle and high mass range are automatically selected by the software.

The data acquisition board provides precision timing to control the acquisition. Events with lower timing requirements on accuracy are controlled by the linear ion trap.



**Figure 1-39.** Data Acquisition Analog board

The diagnostic LEDs listed in Table 1-7 on page 1-51 show the status of the voltages applied to the board. The position of the LEDs on the board is indicated by a white rectangle in Figure 1-39.

**Table 1-7.** Diagnostic LEDs of the Data Acquisition Analog board

Name	Color	Description	Normal Operating Condition
+5 V	Green	+5 V voltage present	On
-5 V	Green	-5 V voltage present	On
+3.3 V	Green	+3.3 V voltage present	On

## Power Supply 2 Board

The power supply 2 board provides the supply voltages for the data acquisition analog board. It is mounted to the back inside the housing of the internal computer. See Figure 1-37 on page 1-49.

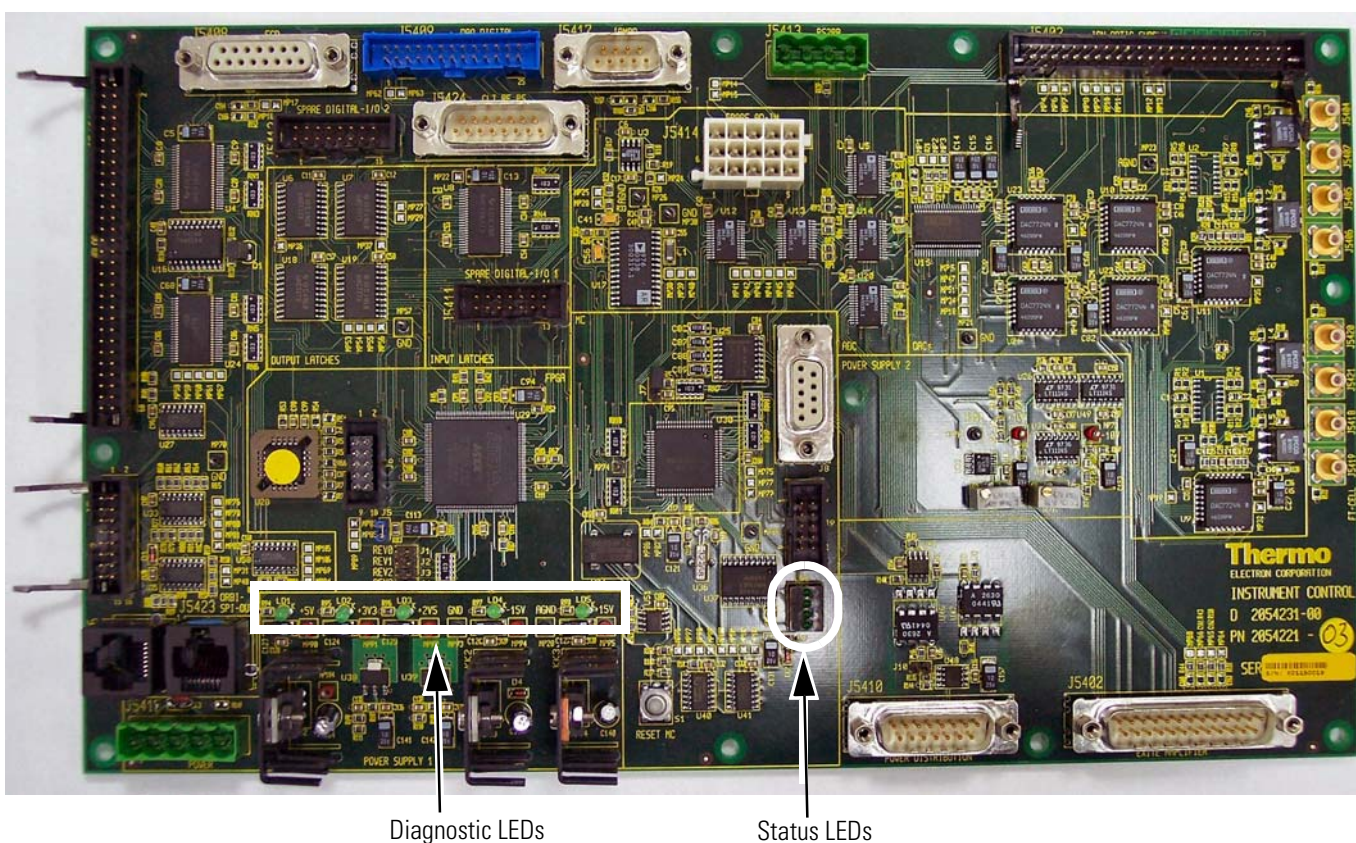
The diagnostic LEDs listed in [Table 1-8](#) show the status of the voltages applied to the board.

**Table 1-8.** Diagnostic LEDs of the Power Supply 2 board

Name	Color	Description	Normal Operating Condition
+5.1 V	Green	+5.1 V voltage present	On
-5.1 V	Green	-5.1 V voltage present	On
+3.3 V	Green	+3.3 V voltage present	On

### Instrument Control Board

[Figure 1-40](#) shows the instrument control board. The instrument control board is located in a housing next to the internal computer. It is connected to the LTQ Orbitrap Velos main power.



**Figure 1-40.** Instrument Control board

The instrument control board is used to interface the LTQ Velos control electronics to the Orbitrap control electronics. Three signal lines are passed from the LTQ Velos: a digital, parallel (DAC) bus, a serial SPI bus, and a Link Port Signal line. The instrument control board contains a micro controller, digital and analog converters, and serial port connectors.

On the instrument control board, analog signals from vacuum gauges are converted to digital signals and passed to the data system as well as to the power distribution board. (See [page 1-53](#).) Turbopumps (See “[Vacuum System](#)” on [page 1-30](#).) are attached to a serial port connector and this is connected via the signal lines to the linear ion trap.

The diagnostic LEDs listed in [Table 1-9](#) show the status of applied voltages to the board. The position of the diagnostic LEDs on the board is indicated by a white rectangle in [Figure 1-40](#) on [page 1-52](#).

**Table 1-9.** Diagnostic LEDs of the Instrument Control board

No.	Name	Color	Description	Normal Operating Condition
LD1	2.5 V	Green	2.55 V Input voltage present	On
LD2	3.3 V	Green	3.3 V Input voltage present	On
LD3	5 V	Green	5 V Input voltage present	On
LD4	-15 V	Green	-15 V Input voltage present	On
LD5	+15 V	Green	+15 V Input voltage present	On

Additionally, the board has four green LEDs that are directly connected to the micro controller. They indicate the state of the micro controller and possible error bits and can be used for software debugging. See [Table 1-10](#). The position of the status LEDs on the board is indicated by a white oval in [Figure 1-40](#) on [page 1-52](#).

**Table 1-10.** Software status LEDs of the Instrument Control board

No.	Description	Normal Operating Condition
6.1	Micro controller is working properly	Permanent flashing of LED
6.2	CAN bus connection to power distribution board enabled	On
6.3	Connection to internal computer and LTQ Velos SPI bus enabled	On
6.4	Orbitrap SPI bus enabled	On Flashing on error

## Power Distribution Board

[Figure 1-41](#) on [page 1-54](#) shows the power distribution board. It is located at the bottom of the right side of the instrument.

The power distribution board controls the vacuum system and the system power supplies, including the linear ion trap. Depending on the quality of the vacuum and the status of the turbo molecular pumps, it switches the vacuum gauges, the pumps, and the 230 V relays. It controls external relays with 24 V dc connections. In case of a vacuum failure, it initiates an automatic power down of the instrument.



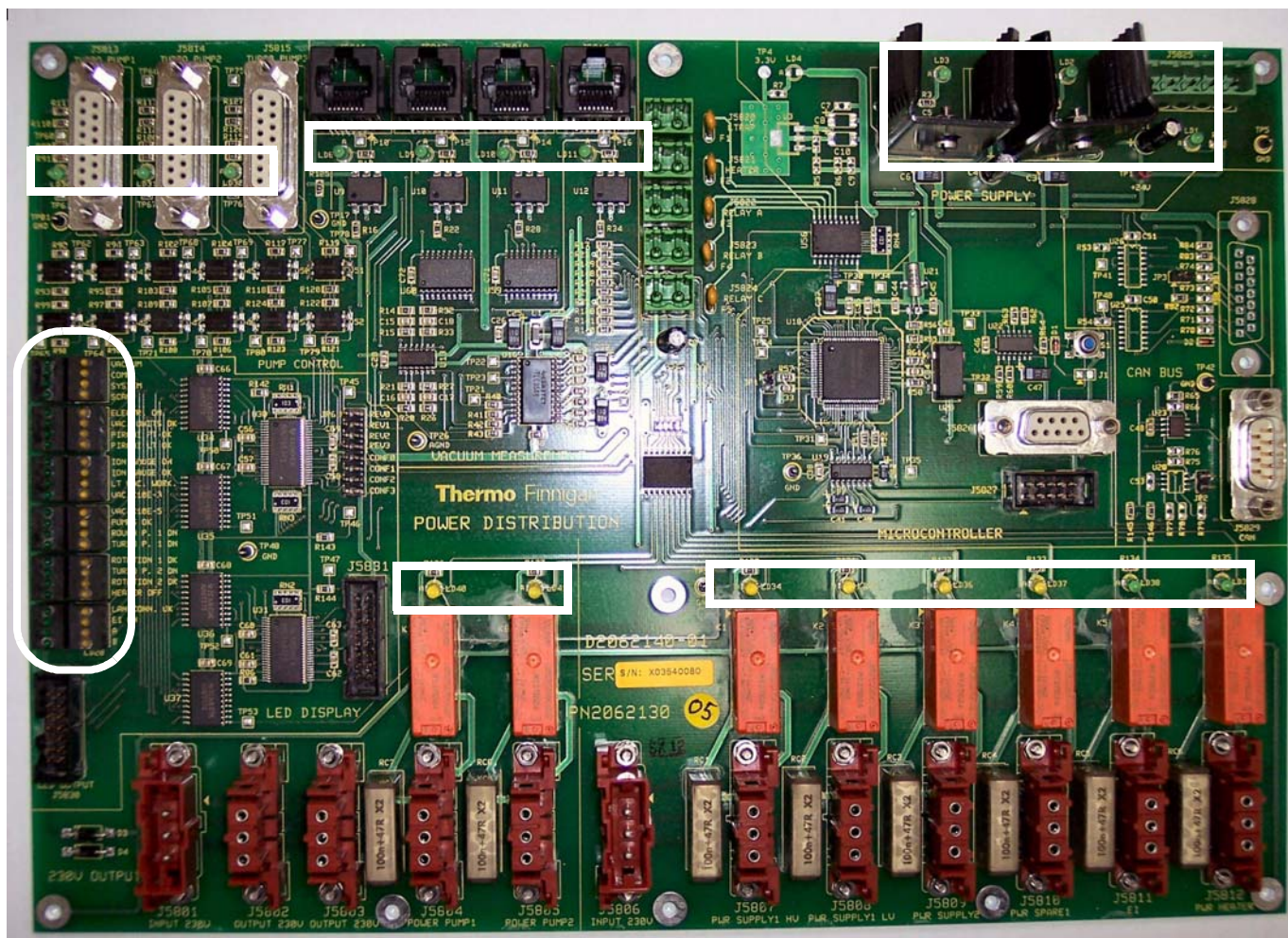


Figure 1-41. Power Distribution board

The power distribution board indicates all system states and error messages by status LEDs (See [Table 1-11](#) on [page 1-55.](#)) in the middle of the left side of the board. A green LED indicates that the status is OK. An orange LED indicates a status that differs from normal. The position of the LEDs on the board is indicated by a white oval in [Figure 1-41.](#)

The system status LEDs on the front side of the instrument (See [Figure 1-4](#) on [page 1-5.](#)) are controlled by the power distribution board. The information partially comes from external boards (for example, the Communication LED is controlled by the instrument control board). (See “[Instrument Control Board](#)” on [page 1-52.](#))

Diagnostic LEDs show the status of voltages applied from the board to other devices. The positions of the diagnostic LEDs on the board are indicated by white rectangles in [Figure 1-41.](#)

**Table 1-11.** Status LEDs of the Power Distribution board

LED green	LED orange	Information given by orange LED
Vacuum	High vacuum failure	High vacuum pressure > 10 <sup>-8</sup> mbar
Comm.	No communication with instrument control board	CAN bus problem or instrument control board not working
System	System is not ready	FT Electronics switch off or Vacuum Pumps switch off
Scan		Instrument is not scanning
Electr. On	Service mode	FT Electronics switch off
Vac. Units OK	Vacuum measurement failure	Vacuum gauge defective
Pirani Orbitrap OK	No function, at present	
Pirani LT OK	Pirani LTQ Velos failure	Control signal < 0.5 V
Ion Gauge On	Penning LTQ Orbitrap Velos Off	Forevacuum > 10 <sup>-2</sup> mbar
Ion Gauge OK	Penning LTQ Orbitrap Velos failure	Control signal < 0.5 V
LT Vacuum Work	LTQ Velos vacuum failure	Vacuum forepump LTQ Velos >10 <sup>-1</sup> mbar
Vac. <10 <sup>-3</sup>	Forevacuum failure	Forevacuum > 10 <sup>-3</sup> mbar
Vac. <10 <sup>-5</sup>	High vacuum failure	High vacuum > 10 <sup>-5</sup> mbar
Pumps OK	Pumps Off	Pump down; leakage
Rough P. 1 On	Forepump #1 failure	Forepump defective
Turbo P. 1 On	TMP 1 failure	Turbopump defective/error*
Rotation 1 OK	TMP 1 failure	80% rotation speed of turbopump not reached
Turbo P. 2 On	TMP 2 failure	Turbopump defective/error*
Rotation 2 OK	TMP 2 failure	80% rotation speed of turbopump not reached
Heater Off	Heater enabled	Heater enabled
LAN Conn. OK	LAN connection failure	LAN interrupted (Option)
EI On	No function, at present	
A	System reset	System reset has occurred
B		Micro controller idle

\* An error of TMP 3 is indicated by an LED directly located on the pump controller. An error of TMP 4 is indicated in the software.

Depending on user actions, the power distribution is switched to various working modes by the hardware. See [Table 1-12](#) on [page 1-56](#).

**Table 1-12.** Working modes of the Power Distribution board

Action	Consequences
a. Main switch off	Complete system including linear ion trap and multiple socket outlets (ETD Module, for example) are without power
b. Vacuum Pumps switch off	Everything is switched off
c. FT Electronics switch off	All components are switched off with exception of the following ones: <ul style="list-style-type: none"> <li>• Heater control</li> <li>• Multiple socket outlets</li> <li>• Power distribution board</li> <li>• Pumps</li> <li>• Vacuum control</li> <li>• LTQ Velos (has a separate Service switch)</li> </ul>

Table 1-13 shows the possible operating states of the power distribution.

**Table 1-13.** Operating states of the Power Distribution board

Action	Consequences
1. Main switch on, Vacuum Pumps switch off	Everything is switched off
2. Vacuum Pumps switch on and FT Electronics switch on	System starts up: pumps and electronics switched on
3. Check linear ion trap and LTQ Orbitrap Velos forevacuum pumps: $10^0$ mbar after 30 s.	If not ok: switch off system and light error LED <sup>*</sup> ; power distribution remains switched on
4. After the system has started, the Pirani gauge returns a vacuum $< 10^{-2}$ mbar and both turbopumps reach 80% rotation speed	Switch on Penning gauge
5. Vacuum and 80% rotation speed of turbopumps not reached after preset time ( $< 8$ min, otherwise the pumps automatically switch off).	Switch off system (including linear ion trap) and light error LED <sup>*</sup> ; power distribution remains switched on
6. One or more vacuum gauges defective (control signal $< 0.5$ V).	Light error LED only, otherwise ignore
7. After the operating status is reached, the pressure at one gauge exceeds the security threshold for more than the preset time period: <ul style="list-style-type: none"> <li>• Pirani gauge LTQ Orbitrap Velos <math>&gt;10^{-1}</math> mbar</li> <li>• Penning gauge LTQ Orbitrap Velos <math>&gt;10^{-3}</math> mbar</li> <li>• Pirani gauge LTQ Velos forepump <math>&gt;10^{-1}</math> mbar</li> </ul>	System is shut down with exception of power distribution (light error LED).  Rebooting of the system by switching off/on of the main switch.

**Table 1-13.** Operating states of the Power Distribution board, continued

Action		Consequences
8.	Rotation speed of a turbopump falls below 80%	Shut down system (see 7.); light LED* of corresponding pump.
9.	Service switch linear ion trap off	Linear ion trap electronics switched off, pumps keep on running; LTQ Orbitrap Velos without data link, keeps on running
10.	FT Electronics switch LTQ Orbitrap Velos off	LTQ Orbitrap Velos electronics switched off, pumps keep on running; LTQ Orbitrap Velos without data link, keeps on running
11.	Failure of linear ion trap or LTQ Orbitrap Velos (e.g. fuse is opened).	If the vacuum in one part deteriorates, the complete system is shut down.
12.	Mains failure	System powers up after the electricity is available again. All devices reach the defined state. Linear ion trap and internal computer must reboot.

\*After the shutdown, the LED flashes that represents the reason for the shutdown.

## Power Supply 1 Board

Figure 1-42 shows the power supply 1 board. This board is located next to the power distribution board. It provides the power for the ion optic supply board (See “Ion Optic Supply Board” on page 1-59.) and the instrument control board. (See “Instrument Control Board” on page 1-52.)



**Figure 1-42.** Power Supply 1 board





**Warning Electrical Shock Hazard.** Parts of the power supply 1 board are at high voltage. Shut down the instrument and disconnect it from line power before performing service. ▲

The diagnostic LEDs listed in [Table 1-14](#) show the status of the voltages applied to the board. The position of the LEDs on the board is indicated by the white rectangles in [Figure 1-42](#).

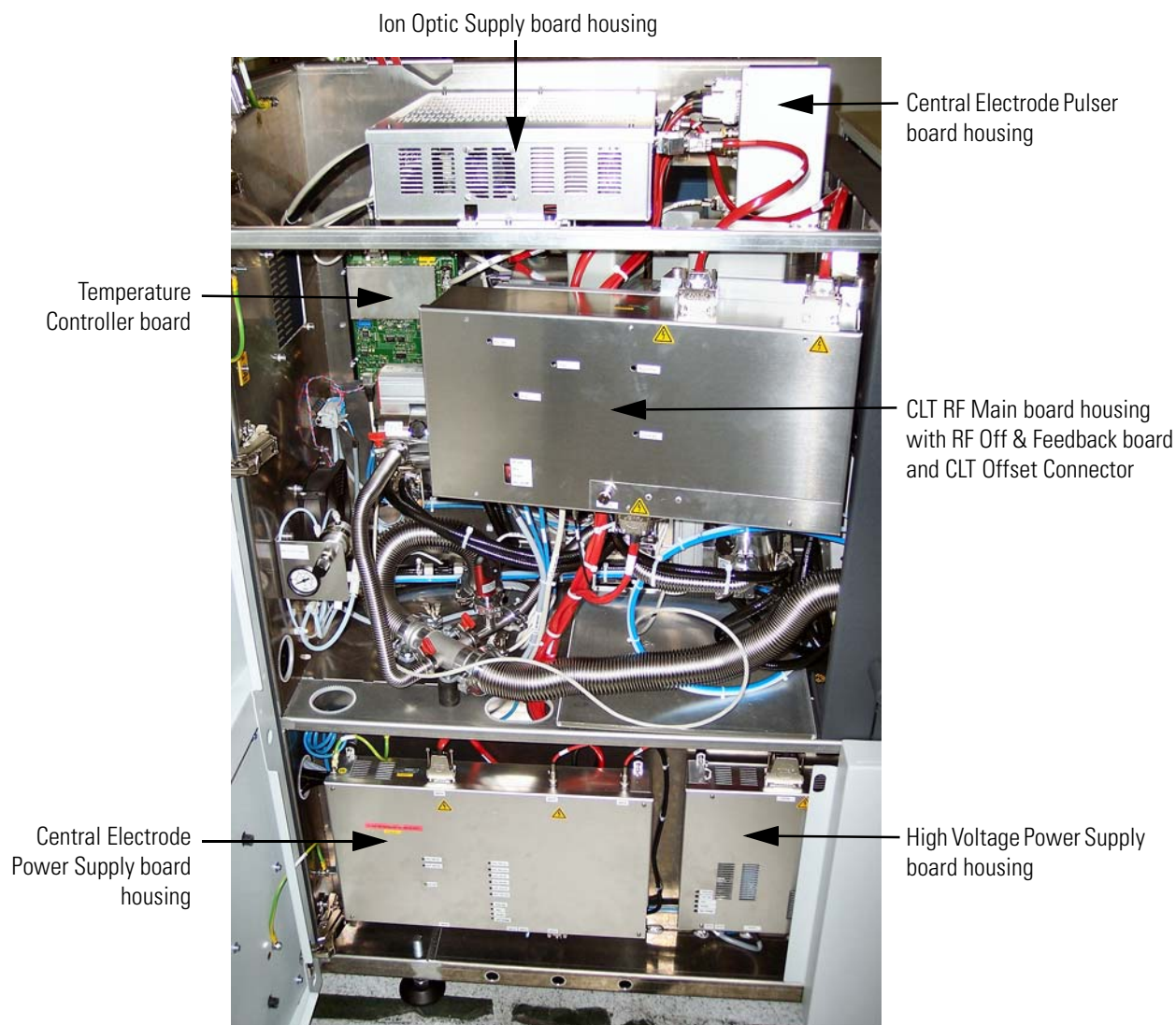
**Table 1-14.** Diagnostic LEDs of the Power Supply 1 board

Name	Color	Description	Normal Operating Condition
+285 V	Green	+285 V Output voltage present	On
-285 V	Green	-285 V Output voltage present	On
Over Current +285 V	Red	LED lit dark red: $I_{out} > 80$ mA LED lit bright red: output is short-circuited	Off
Over Current -285 V	Red	LED lit dark red: $I_{out} > 80$ mA LED lit bright red: output is short-circuited	Off
+18 V	Green	+18 V Output voltage present	On
-18 V	Green	-18 V Output voltage present	On
+8.5 V	Green	+8.5 V Output voltage present	On



## Electronic Boards on the Left Side of the Instrument

Figure 1-43 shows the left side of the instrument with the panel opened. This side of the instrument contains mostly boards that are part of the Orbitrap control.



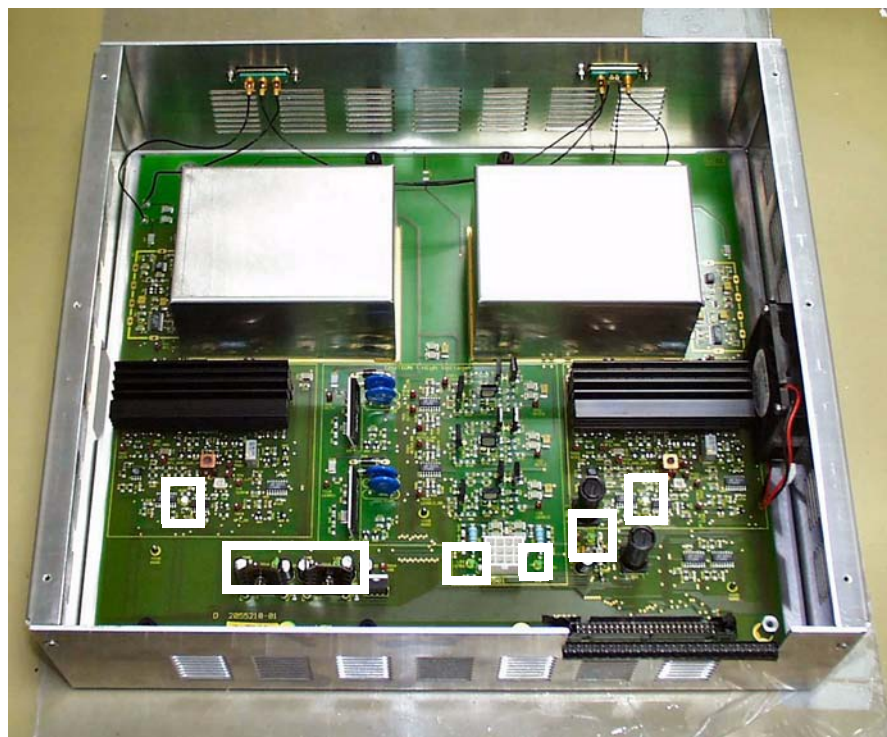
**Figure 1-43.** Electronic boards on the left side of the instrument

The main components on this side are described starting from the top.

### Ion Optic Supply Board

Figure 1-44 on page 1-60 shows the ion optic supply board. The board is located in a housing on top of the left instrument side of the instrument. This board supplies the voltages and the radio frequency for the ion guides and interoctapole lenses of the LTQ Orbitrap Velos. It has an RF detector for the RF output control. The board also provides

the trap voltage, the gate voltage, and the reflector dc voltages as well as the RF voltages to the octapole of the Orbitrap. See “Orbitrap Analyzer” on page 1-13 for further information.



**Figure 1-44.** Ion Optic Supply board

The diagnostic LEDs listed in Table 1-15 show the status of applied voltages to the board. The position of the LEDs on the board is indicated by white rectangles in Figure 1-44.



**Warning Electrical Shock Hazard.** Parts of the board are at high voltage. Shut down the instrument and disconnect it from line power before performing service. ▲

**Table 1-15.** Diagnostic LEDs of the Ion Optic Supply board

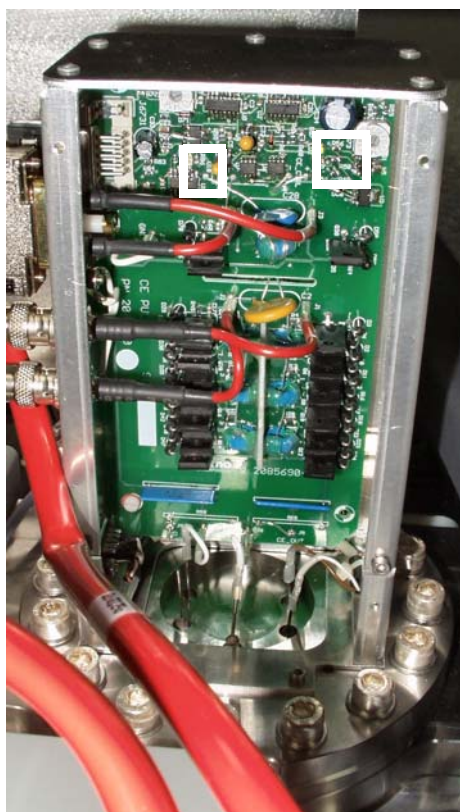
No.	Name	Color	Description	Normal Operating Condition
LD1	+275 V	Green	+275 V Input voltage present	On
LD2	-275 V	Green	-275 V Input voltage present	On
LD3	+29 V	Green	+29 V Input voltage present	On
LD5	+15 V	Green	+15 V Input voltage present	On
LD6	-15 V	Green	-15 V Input voltage present	On

**Table 1-15.** Diagnostic LEDs of the Ion Optic Supply board, continued

No.	Name	Color	Description	Normal Operating Condition
LD7	RF1_ON	Blue	RF1 generator switched on	depending on application; LED flashes during scanning
LD8	RF2_ON	Blue	RF2 generator switched on	depending on application; LED flashes during scanning

## Central Electrode Pulser Board

The central electrode pulser board is located in a housing that is mounted to the flange of the UHV chamber. See [Figure 1-45](#).



**Figure 1-45.** Central Electrode Pulser board

The board switches the injection and measurement voltages for the central electrode and the detection electrodes of the Orbitrap. Resistor-capacitor circuits on the board convert the switching pulse into a smooth transition between the voltages.

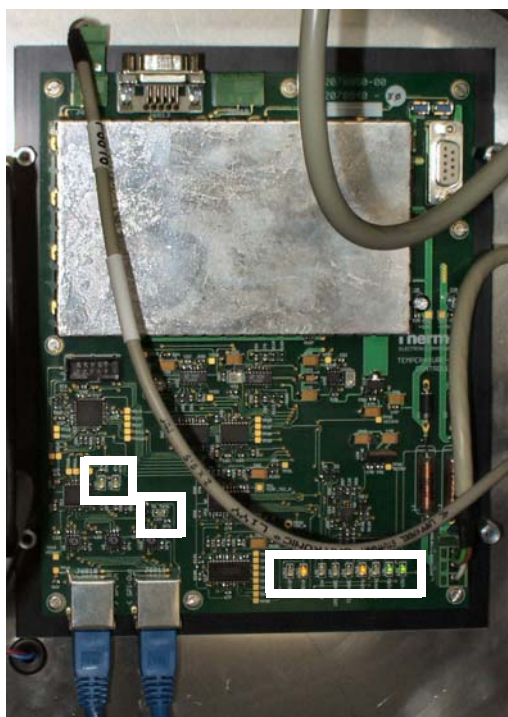
The diagnostic LEDs listed in [Table 1-16](#) on [page 1-62](#) show the status of the voltages applied to the board as well as some operating states. The position of the LEDs on the board is indicated by the white rectangles in [Figure 1-45](#).

**Table 1-16.** Diagnostic LEDs of the Central Electrode Pulser board

No.	Name	Color	Description	Normal Operating Condition
LD1	TRIG	Green	Trigger signal indicator	Flashing when scanning
LD2	PS	Green	24V Power Supply is OK	On

## Temperature Controller Board

The temperature controller board is located on the top left side of the instrument, next to the CLT RF main board. See [Figure 1-43](#) on [page 1-59](#). The temperature controller board keeps the temperature of the analyzer chamber to a preset value. A Peltier element that can be used for heating as well as for cooling is used as an actuator. Activation is done via the serial SPI (Serial Peripheral Interface) bus.



**Figure 1-46.** Temperature Controller board

The diagnostic LEDs listed in [Table 1-17](#) on [page 1-63](#) show the status of the voltages applied to the board as well as some operating states. The positions of the LEDs on the board are indicated by the white rectangles in [Figure 1-46](#).



**Table 1-17.** Diagnostic LEDs of the Temperature Controller board

No.	Name	Color	Description	Normal Operating Condition
LD1	+15 V	Green	+15 V Input voltage present	On
LD2	-15 V	Green	-15 V Input voltage present	On
LD3	TEC >60C	Yellow	Temperature of cold side Peltier element above 60 °C	Off
LD4	Unit >60C	Yellow	Temperature of UNIT heat sink above 60 °C	Off
LD5	Reg Off	Yellow	Control switched off	Off
LD6	No Term	Yellow	SPI bus termination board missing	Off
LD7	SDT enable	Green	Interface has been addressed and sends/receives data	Flashing on SPI bus data transfer
LD8	SEL	Green	Board has been addressed	Flashing on SPI bus data transfer
LD9	Heating	Yellow	Peltier element is heating	Depending on system state
LD10	Cooling	Yellow	Peltier element is cooling	Depending on system state
LD11	UR>0	Yellow	Summation voltage controller >0 V	Off when adjusted
LD12	UR<0	Yellow	Summation voltage controller <0 V	Off when adjusted

## CLT RF Unit

The CLT RF unit comprises the CLT RF main board and the RF off & feedback board. The unit operates the curved linear trap (CLT) with four phases RF voltage and three pulsed dc voltages (PUSH, PULL, and OFFSET).

The CLT RF main board is located in a housing in the center of the left side of the instrument. See [Figure 1-43](#) on [page 1-59](#). This board provides an RF voltage (“Main RF”) for the curved linear trap. It allows switching off the RF and simultaneous pulsing of each CLT electrode. See “[Orbitrap Analyzer](#)” on [page 1-13](#) for further information. The board communicates with the instrument control board via an SPI bus.



**Figure 1-47.** CLT RF unit (cover removed)

The diagnostic LEDs listed in Table 1-18 show the status of the voltages applied to the board as well as some operating states. The position of the LEDs on the board is indicated by the white rectangles in Figure 1-47.

**Table 1-18.** Diagnostic LEDs of the CLT RF Main board

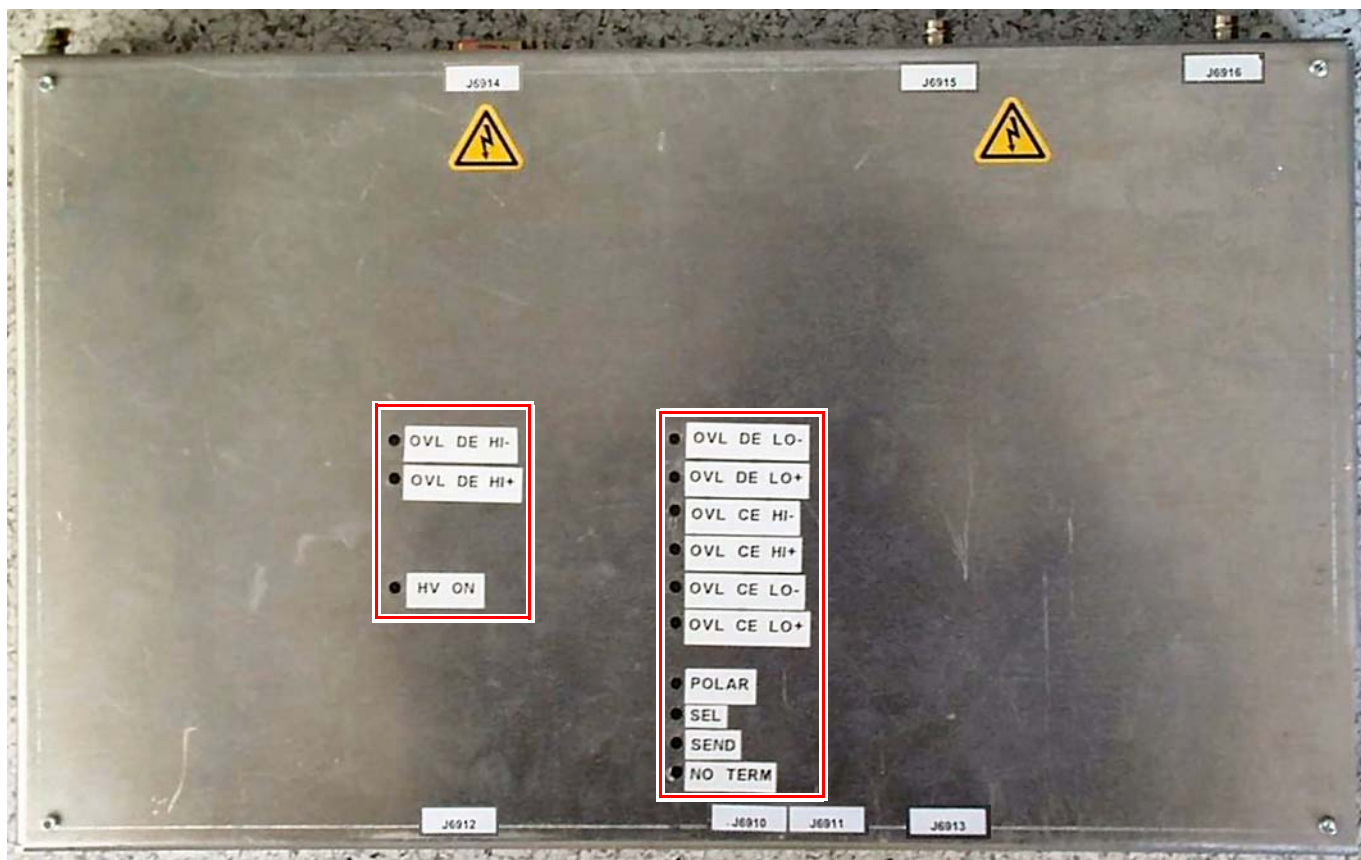
No.	Name	Color	Description	Normal Operating Condition
LD1	NO TERM	Yellow	SPI bus termination board missing	Off
LD2	SEND	Yellow	Interface has been addressed and sends/receives data	Flashing on SPI bus data transfer
LD3	SEL	Green	Board has been addressed	Flashing on SPI bus data transfer
LD4	RF ON	Green	RF voltage on	On
LD5	NO LOCK	Yellow	PLL has been not locked	50% intensity
LD6	OVL	Yellow	RF Amplifier overload	Off
LD7	OVHEAT	Red	Heatsink temperature > 73 °C	Off

The RF off & feedback board is an add-on board to the CLT RF main board. It is located in the same housing. See Figure 1-47 on page 1-64.

The CLT Offset connector, which removes interfering signals from the circuit, is also mounted in the housing.

## Central Electrode Power Supply Board

The central electrode power supply board is mounted in a housing on the bottom left side of the instrument. See [Figure 1-48](#).



**Figure 1-48.** Central Electrode Power Supply board

The board supplies four dc voltages to the Orbitrap:

- Two central electrode (CE) voltages: CE HIGH and CE LOW.
- Two deflector electrode (DE) voltages: DE HIGH and DE LOW.

For positive ions, the CE voltages are negative and the DE voltages are positive. The maximum CE voltage is 3 kV and the maximum DE voltage is 1 kV. The board communicates via the SPI bus.

In addition to a ventilator on the bottom right side, a water-cooled Peltier element on the rear side of the board serves as means of heat dissipation.

The diagnostic LEDs listed in [Table 1-19](#) show the status of the voltages applied to the board as well as some operating states. The position of the LEDs on the board is indicated by the red rectangles in [Figure 1-48](#) on [page 1-65](#).

**Table 1-19.** Diagnostic LEDs of the Central Electrode Power Supply board

No.	Name	Color	Description	Normal Operating Condition
LD1	OVL DE HI-	Yellow	Negative side of Deflector High Supply has been overloaded	Off when HV is switched on
LD2	OVL DE HI+	Yellow	Positive side of Deflector High Supply has been overloaded	Off when HV is switched on
LD3	No Term	Red	SPI bus termination board missing	Off
LD4	Send	Yellow	Interface has been addressed and sends/receives data	Flashing on SPI bus data transfer
LD5	Sel	Green	Board has been addressed	Flashing on SPI bus data transfer
LD6	Polarity	Blue	Positive/negative ion mode	Off (positive mode)
LD7	OVL CE LO+	Yellow	Positive side of Central Electrode Low Supply has been overloaded	Off when HV is switched on
LD8	OVL CE LO-	Yellow	Negative side of Central Electrode Low Supply has been overloaded	Off when HV is switched on
LD9	OVL CE HI+	Yellow	Positive side of Central Electrode High Supply has been overloaded	Off when HV is switched on
LD10	OVL CE HI-	Yellow	Negative side of Central Electrode High Supply has been overloaded	Off when HV is switched on
LD11	OVL DE LO+	Yellow	Positive side of Deflector Low Supply has been overloaded	Off when HV is switched on
LD12	OVL DE LO-	Yellow	Negative side of Deflector Low Supply has been overloaded	Off when HV is switched on
LD13	HV ON	Green	High voltage switched on	On when HV is switched on

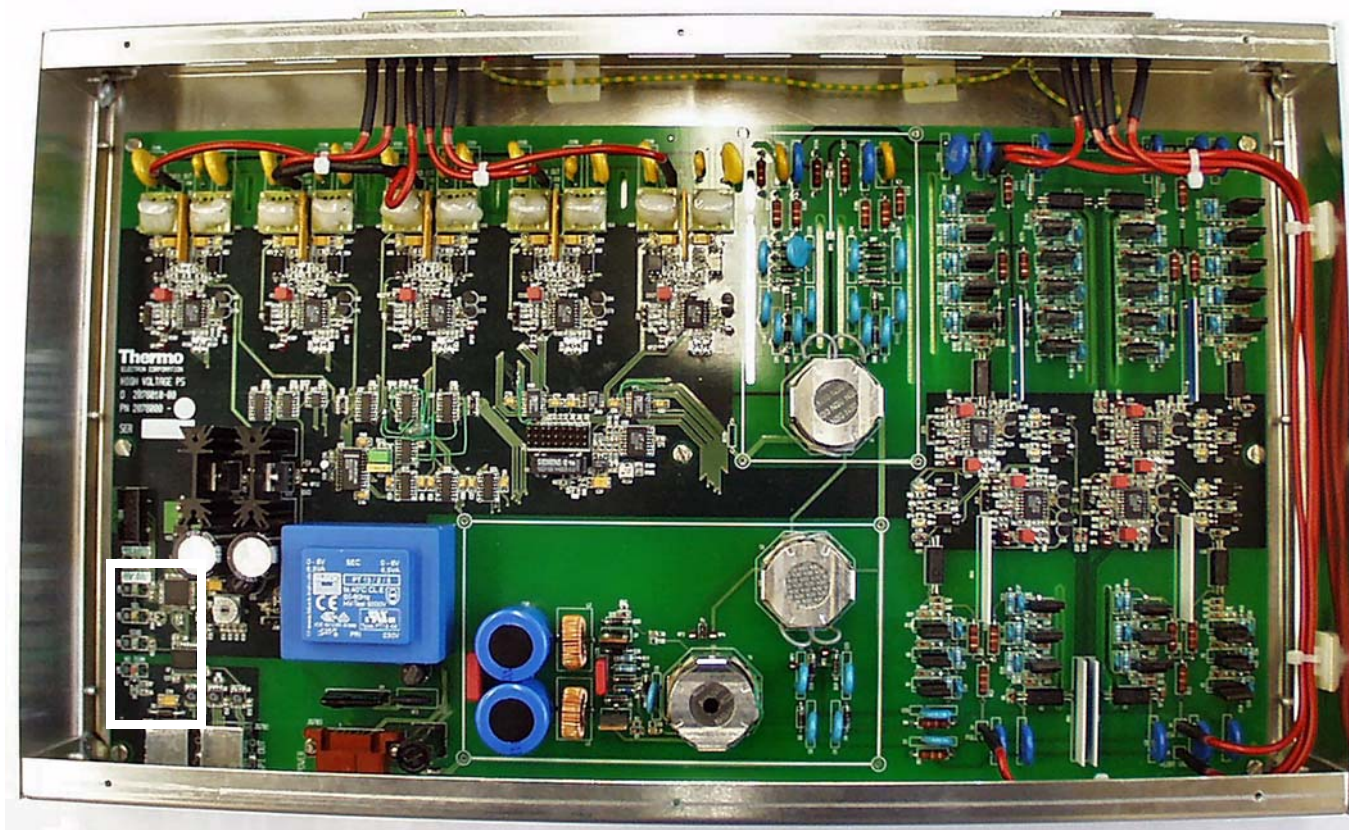
## High Voltage Power Supply Board

The high voltage power supply board is mounted in a housing on the bottom left side of the instrument. See [Figure 1-43](#) on [page 1-59](#). This board provides five dc voltages for the ion optics of the LTQ Orbitrap Velos. Two voltages supply the lenses of the instrument. Three voltages are applied to the RF CLT main board to be used as focusing potentials for the curved linear trap. See [“Orbitrap Analyzer”](#) on [page 1-13](#) for further information. The board communicates via the SPI bus.





**Warning Electrical Shock Hazard.** The high voltage power supply board creates voltages up to 3.5 kV! Shut down the instrument and disconnect it from line power before performing service. ▲



**Figure 1-49.** High Voltage Power Supply board (cover removed)

The diagnostic LEDs listed in [Table 1-20](#) on [page 1-67](#) show the operating states of the board. The position of the LEDs on the board is indicated by the white rectangles in [Figure 1-49](#).

**Table 1-20.** Diagnostic LEDs of the High Voltage Power Supply board

No.	Name	Color	Description	Normal Operating Condition
LD1	NO TERM	Red	SPI bus termination board missing	Off
LD2	SEND	Yellow	Interface has been addressed and sends/receives data	Flashing on SPI bus data transfer
LD3	SEL	Green	Board has been addressed	Flashing on SPI bus data transfer
LD4	HV ON	Green	High voltage is switched on	On
LD5	POLARITY	Green	Positive/negative ion mode	Off (positive mode)

## SPI Bus Termination Board

Various boards communicate via the SPI bus, a serial RS485-based bus system. The SPI Bus Termination board reduces unwanted signal reflections. The boards indicate a missing termination (after maintenance, for example) by LEDs.

The SPI Bus Termination board is located below the High Voltage Power Supply board, at the bottom left side of the instrument. See [Figure 1-50](#).



SPI bus termination board

**Figure 1-50.** High Voltage Power Supply board with SPI Bus Termination board

## Chapter 2 Basic System Operations

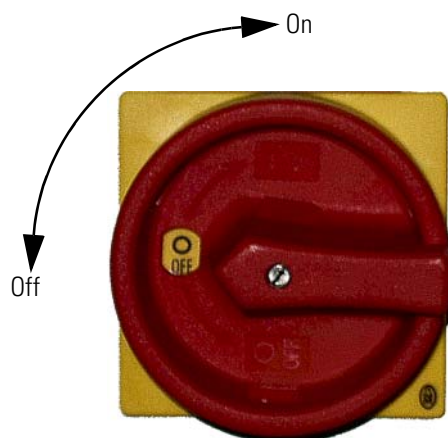
Many maintenance procedures for the LTQ Orbitrap Velos system require that the MS detector be shut down. In addition, the LTQ Orbitrap Velos system can be placed in Standby condition if the system is not to be used for 12 h or more.

The following topics are discussed in this chapter:

- “Shutting Down the System in an Emergency” on page 2-2
- “Placing the Instrument in Standby Condition” on page 2-4
- “Shutting Down the LTQ Orbitrap Velos Completely” on page 2-7
- “Starting Up the System after a Shutdown” on page 2-9
- “Resetting the System” on page 2-12
- “Resetting the Tune and Calibration Parameters to their Default Values” on page 2-13
- “Turning Off the Reagent Ion Source: What to Expect” on page 2-14

## Shutting Down the System in an Emergency

If you need to turn off the MS detector in an emergency, place the main power switch (located on the power panel at the right side of the LTQ Orbitrap Velos) in the Off (0) position. This turns off all power to the instrument, including the linear ion trap, multiple socket outlets, and the vacuum pumps. The main power switch must be turned 90° anti-clockwise to switch off the instrument. See [Figure 2-1](#).



**Figure 2-1.** Main power switch in Off position

The instrument is automatically vented by the vent valve of the linear ion trap. The vent valve vents the system 30 s after power is switched off.

Although removing power abruptly will not harm any component within the system, this is not the recommended shutdown procedure to follow. See [“Shutting Down the Instrument”](#) on [page 2-7](#) for the recommended procedure.

**Note** To separately turn off the recirculating chiller or computer in an emergency, use the On/Off switches on the chiller and computer, respectively. ▲

## Behavior of the System in Case of a Main Failure

A main power failure has the same consequence as switching off via the main power switch. If the power is available again, the system starts up automatically: the pumps are switched on and the instrument is pumped down. If the system has been vented during the mains failure, it is necessary to bake out the system to obtain the operating vacuum. See [“Baking Out the System”](#) on [page 3-4](#).

It is not possible to check whether the system was vented. The log file of the data system indicates a reboot of the system. In case of frequent but short power failures we recommend installing an uninterruptible power

supply (UPS). If main power failures occur frequently while the system is not attended (e.g. in the night), we recommend installing a power fail detector.

**Note** The intentional venting of the system is performed with the vent valve of the linear ion trap. ▲



## Placing the Instrument in Standby Condition

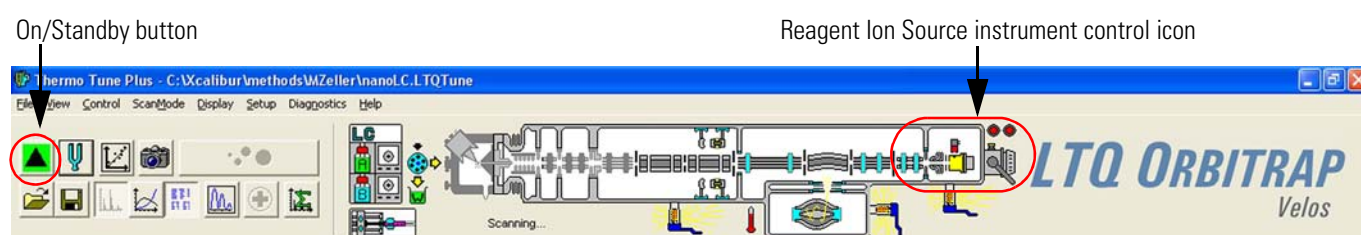
The LTQ Orbitrap Velos system should not be shut down completely if you are not going to use it for a short period of time, such as overnight or over the weekend. When you are not going to operate the system for 12 hours or more, you can leave the system in Standby condition.

In case of an LTQ Orbitrap Velos ETD, first place the ETD Module in Standby condition. Then place the mass spectrometer in Standby condition according to the procedures described in the following topics.

### Placing the ETD Module in Standby Condition

❖ **To place the ETD Module in Standby condition**

1. If the Tune Plus window is not already open, choose **Start > Programs > Thermo Instruments > LTQ > LTQ Tune** from the taskbar. The Tune Plus window will open.



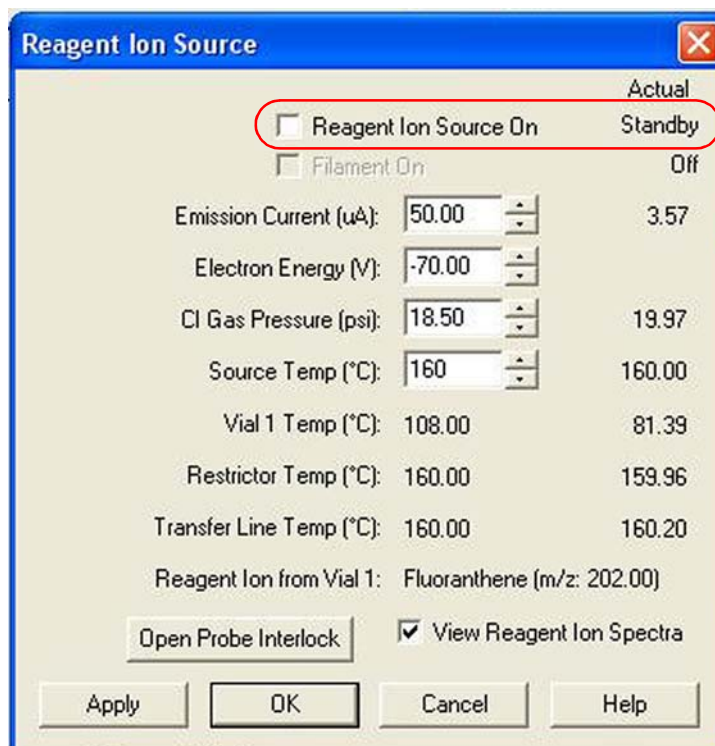
**Figure 2-2.** Tune Plus window, toolbar



You can determine the state of the MS detector by observing the state of the On/Off/Standby button on the Control/Scan Mode toolbar. See [Figure 2-2](#). The three different states of the On/Standby button are shown at the left.

2. Click the Reagent Ion Source portion of the instrument control graphic at the top of the Tune Plus window. (See [Figure 2-2](#).) The Reagent Ion Source dialog box appears. (See [Figure 2-3](#).)
3. In the Reagent Ion Source dialog box, clear the Reagent Ion Source On box to place the Reagent Ion Source in Standby condition. See [Figure 2-3](#) on [page 2-5](#). This places the Reagent Ion Source in Standby condition as indicated by the Actual condition shown to the right of the Reagent Ion Source On box.

When the reagent ion source is placed in Standby condition, the filament and vial heaters turn off. Simultaneously, a valve opens to allow the nitrogen gas to cool the reagent vials. This cooling nitrogen runs until the reagent vials reach 70 °C. The audible rush (hissing noise) of nitrogen from the reagent ion source area in the back of the ETD Module is normal operation.



**Figure 2-3.** Reagent Ion Source dialog box with Reagent Ion Source On box and Actual condition circled

If the reagent ion source is on when you place the LTQ Orbitrap Velos ETD in Standby mode, the filament turns off immediately. In contrast, the vial heaters stay on for 60 minutes before they turn off and the cooling gas begins. Because the filament is turned off, you can perform minor maintenance procedures on the ETD Module without cooling the reagent inlet.



**Warning Burn Hazard.** Install or exchange the reagent vials by following the procedure in “Changing the Reagent Vials” on page 3-47. The reagent vials will be too hot to touch after the cooling nitrogen turns off at 70°C. Verify that the reagent vials are cool to the touch before handling them. ▲

More information about turning on and off the reagent heaters is given in “Reagent Heaters” on page 1-27.



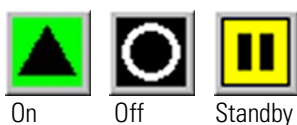
**Warning Burn Hazard.** The restrictor, the transfer line, and the ion source heater operate at 160 °C. Do not attempt to touch them unless the LTQ Orbitrap Velos is shut down (See “Shutting Down the LTQ Orbitrap Velos Completely” on page 2-7.) and these heaters have had sufficient time to cool down to room temperature. ▲

## Placing the MS in Standby Condition

❖ **To place the LTQ Orbitrap Velos system in Standby condition**

1. Wait until data acquisition, if any, is complete.
2. Turn off the flow of solvent from the LC (or other sample introduction device).

**Note** For instructions on how to operate the LC from the front panel, refer to the manual that came with the LC. ▲



3. From the Tune Plus window, choose **Control > Standby** (or click on the **On/Standby** button to toggle it to Standby) to put the instrument in Standby condition. The consequences of this user action are described in the *LTQ Series Hardware Manual*. The System LED on the front panel of the LTQ Velos is illuminated yellow when the system is in Standby condition.
4. Leave the LC power on.
5. Leave the autosampler power on.
6. Leave the data system power on.
7. Leave the LTQ Orbitrap Velos main power switch in the On position.



## Shutting Down the LTQ Orbitrap Velos Completely

The LTQ Orbitrap Velos does not need to be shut down completely if you are not going to use it for a short period of time, such as overnight or over weekends. Shut down ETD Module and MS system completely only if you do not want to use them for an extended period or if you want to perform a maintenance or service procedure.

### ❖ To shut down the instrument completely

1. Place the ETD Module in Standby condition as described in [“Placing the ETD Module in Standby Condition”](#) on page 2-4.
2. Shut down the instrument as described in [“Shutting Down the Instrument”](#) below. This also shuts down the ETD Module because its power controls are linked to the LTQ Orbitrap Velos power controls through the ETD Module Interface board. See [“ETD Module Interface Board”](#) on page 1-25.

## Shutting Down the Instrument

### ❖ To shut down the LTQ Orbitrap Velos system

1. Wait until data acquisition, if any, is complete.
2. Turn off the flow of solvent from the LC (or other sample introduction device).

**Note** For instructions on how to operate the LC from the front panel, refer to the manual that came with the LC. ▲

3. From the Tune Plus window, choose **Control > Off** to put the instrument in Off condition. When you choose **Control > Off**, all high voltages are shut off, as are the flows of the sheath gas and the auxiliary gas.
4. Put the FT Electronics switch to the Off position. See [Figure 1-7](#) on page 1-8.
5. Put the Vacuum Pumps switch to the Off position. See [Figure 1-7](#). When you place the switch in the Off position, the following occurs:
  - a. All power to the instrument, including the turbomolecular pumps and the rotary-vane pumps, is turned off.
  - b. After 30 s, power to the vent valve solenoid of the ion trap is shut off. The vent valve opens and the vacuum manifold is vented with nitrogen to atmospheric pressure through a filter. You can hear a hissing sound as the gas passes through the filter.

## Basic System Operations

### Shutting Down the LTQ Orbitrap Velos Completely

6. Leave the main power switch of the LTQ Orbitrap Velos in the On position.
7. During service or maintenance operations that require opening the vacuum system of the LTQ Velos or the LTQ Orbitrap Velos, always put the main switch (main circuit breaker) to the Off position. You can secure the main switch with a padlock or tie-wrap to prevent unintended re-powering.



**Warning Burn Hazard.** Allow heated components to cool down before you service them (the ion transfer tube is operated at about 300 °C, for example). ▲

**Note** If you are planning to perform routine or preventive system maintenance on the LTQ Orbitrap Velos only, you do not need to turn off the recirculating chiller, LC, autosampler, or data system. In this case, the shutdown procedure is completed. However, if you do not plan to operate your system for an extended period of time, you might want to turn off the recirculating chiller, LC, autosampler, and data system. ▲

## Starting Up the System after a Shutdown

To start up the LTQ Orbitrap Velos after it has been shut down, you need to do the following:

1. Start up the instrument.
2. Set up conditions for operation.

## Starting Up the Instrument

**Note** The recirculating chiller and data system must be running before you start up the instrument. The instrument will not operate until it has established a communication link to the data system. ▲

### ❖ To start up the LTQ Orbitrap Velos

1. Start up the (optional) LC and autosampler as is described in the manual that came with the LC and autosampler.
2. Start up the data system and the chiller.
3. Turn on the flows of helium and nitrogen at the tanks, if they are off.
4. Make sure that the main power switch of the LTQ Velos is in the On position and the electronics service switch of the LTQ Velos is in the Operating position.
5. Place the main power switch at the right side of the LTQ Orbitrap Velos in the On position.
6. Put the Vacuum Pumps switch to the On position. See [Figure 1-7](#) on [page 1-8](#). The rotary-vane pumps and the turbomolecular pumps are started.

**Note** Pumping the system after a complete shut down takes hours and requires overnight baking of the system. ▲

7. Put the FT Electronics switch to the On position. See [Figure 1-7](#). When you place the FT Electronics switch to the On position, the following occurs:
  - a. Power is provided to all electronic boards. (The electron multiplier, conversion dynode, 8 kV power to the API source, main RF voltage, and quadrupole RF voltage remain off.)
  - b. The internal computer reboots. After several seconds, the Communication LED on the front panel is illuminated yellow

to indicate that the data system has started to establish a communication link.

- c. After several more seconds, the Communication LED is illuminated green to indicate that the data system has established a communication link. Software for the operation of the instrument is then transferred from the data system to the instrument.
- d. After three minutes, the System LED of the ion trap is illuminated yellow to indicate that the software transfer from the data system is complete and that the instrument is in Standby condition.

**Note** The Vacuum LED on the front panel of the LTQ Velos is illuminated green only if the pressure in the vacuum manifold is below the maximum allowable pressure ( $5 \times 10^{-4}$  Torr in the analyzer region, and 2 Torr in the capillary-skimmer region), and the safety interlock switch on the API source is pressed down (that is, the API flange is secured to the spray shield). ▲

8. Press the Reset button on the LTQ Velos to establish the communication link between LTQ Velos and internal computer.

If you have an LC or autosampler, start it as is described in the manual that came with the LC or autosampler. Then, proceed to [“Setting Up Conditions for Operation”](#). If you do not have either, go to the topic directly.

## Setting Up Conditions for Operation

### ❖ To set up your LTQ Orbitrap Velos for operation

1. Before you begin data acquisition with your LTQ Orbitrap Velos system, you need to allow the system to pump down for at least eight hours. Operation of the system with excessive air and water in the vacuum manifold can cause reduced sensitivity, tuning problems, and a reduced lifetime of the electron multiplier.

**Note** The vacuum in the analyzer system can be improved by an overnight baking of the system. See [“Baking Out the System”](#) on [page 3-4](#). ▲

2. Ensure that the gas pressures are within the operational limits:
  - Helium:  $275 \pm 70$  kPa ( $2.75 \pm 0.7$  bar,  $40 \pm 10$  psi),
  - Nitrogen:  $690 \pm 140$  kPa ( $6.9 \pm 1.4$  bar,  $100 \pm 20$  psi).

In case of an LTQ Orbitrap Velos ETD, also check the pressure of the reagent carrier gas:  $690 \pm 140$  kPa ( $6.9 \pm 1.4$  bar,  $100 \pm 20$  psi).

**Note** Air in the helium line must be purged or given sufficient time to be purged for normal performance. ▲

3. Click the **Display Status View** button in the Tune Plus window. Check whether the pressure measured by the ion gauge is  $\leq 5 \times 10^{-9}$  mbar, and the pressure measured by the Pirani gauge is around 1 mbar. Compare the values of the other parameters in the status panel with values that you recorded previously.
4. In case of an LTQ Orbitrap Velos ETD, start up the ETD Module as described in “Starting the ETD Module After a Complete Shutdown”. In case of an LTQ Orbitrap Velos, continue to set up for ESI or APCI operation as described in *LTQ Orbitrap Velos Getting Started*.

## Starting the ETD Module After a Complete Shutdown

### ❖ To start up the ETD Module after a complete shutdown

1. Start the LTQ Orbitrap Velos ETD according to the start up procedures given in “Starting Up the System after a Shutdown” above. This also turns on the ETD Module as the ETD Module power controls are linked to the MS power controls (see “ETD Module Interface Board” on page 1-25).
2. If the Tune Plus window is not already open, choose **Start > Programs > Thermo Instruments > LTQ > LTQ Tune** from the taskbar. The Tune plus window will open.



You can determine the state of the MS detector by observing the state of the On/Off/Standby button on the Control/Scan Mode toolbar. (See Figure 2-2 on page 2-4.) The three different states of the On/Standby button are shown at the left.

3. Click the **Display Status View** button in the Tune Plus window.  
Check the reagent vacuum parameters:
  - Reagent ion gauge pressure:  $20$  to  $35 \times 10^{-5}$  Torr
  - Reagent Convectron gauge pressure:  $< 0.08$  Torr
  - Reagent turbomolecular pump speed :  $> 90\%$
4. Continue to set up the instrument for operation as described in *LTQ Orbitrap Velos Getting Started* manual.

## Resetting the System

If the communication link between LTQ Orbitrap Velos and data system computer is lost, it may be necessary to reset the system using the Reset button of the LTQ Velos.

The procedure given here assumes that the LTQ Orbitrap Velos and data system computer are both powered on and are operational. If the instrument, data system computer, or both are off, see [“Starting Up the System after a Shutdown”](#) on [page 2-9](#).

To reset the LTQ Orbitrap Velos, press the Reset button of the LTQ Velos. See the *LTQ Series Hardware Manual* for the location of the Reset button. When you press the Reset button, the following occurs:

1. An interrupt on the mainboard of the internal computer causes the internal computer to reboot. All LEDs on the front panel are off except the Power LED.
2. After several seconds, the Communication LED is illuminated yellow to indicate that the data system and the instrument are starting to establish a communication link.
3. After several more seconds, the Communication LED is illuminated green to indicate that the data system and the instrument have established a communication link. Software for the operation of the instrument is then transferred from the data system to the instrument.
4. After three min, the software transfer is complete. The System LED is illuminated either green to indicate that the instrument is functional and the high voltages are on, or yellow to indicate that the instrument is functional and it is in Standby condition.

## Resetting the Tune and Calibration Parameters to their Default Values

You can reset the LTQ Orbitrap Velos system tune and calibration parameters to their default values at any time. This feature may be useful if you have manually set some parameters that have resulted in less than optimum performance.

### ❖ To reset the LTQ Orbitrap Velos tune and calibration parameters

In the Tune Plus window,

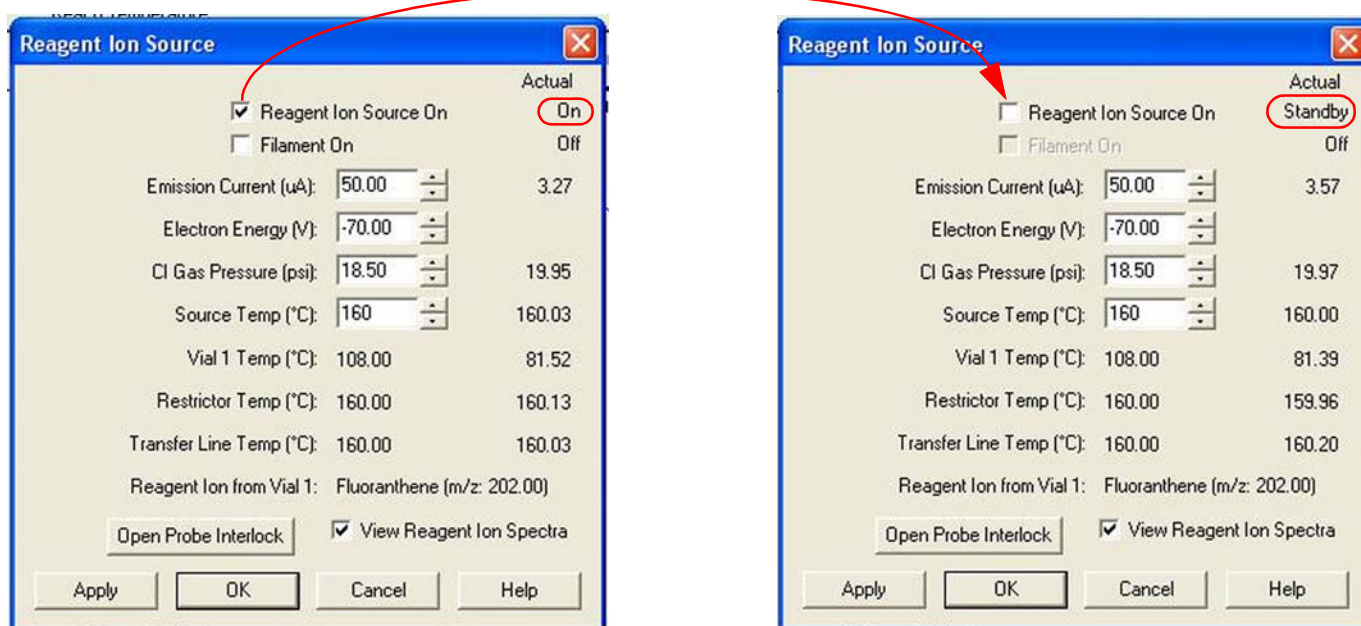
- Choose **File > Restore Factory Calibration** to restore the default calibration parameters, or
- Choose **File > Restore Factory Tune Method** to restore the default tune parameters.

**Note** Make sure that any problems you might be experiencing are not due to improper API source settings (spray voltage, sheath and auxiliary gas flow, ion transfer capillary temperature, etc.) before resetting the system parameters to their default values. ▲



## Turning Off the Reagent Ion Source: What to Expect

In the LTQ Orbitrap Velos ETD, the reagent ion source controls can be accessed as described in “Placing the ETD Module in Standby Condition” on page 2-4. When you deselect the Reagent Ion Source On check box in the Reagent Ion Source dialog box (See Figure 2-4.), the ETD source and reagent heaters are placed in Standby condition.



**Figure 2-4.** Placing the reagent ion source in Standby condition

When the ETD Module is placed in Standby condition, the filament and vial heaters are turned off. Simultaneously a valve opens to allow nitrogen gas to cool the reagent vials. This cooling nitrogen runs until the vials reach 70 °C. The audible rush (hissing noise) of nitrogen from the reagent ion source area in the back of the ETD Module is normal operation.



**Warning Burn Hazard.** The reagent vials are too hot to handle after the cooling nitrogen turns off at a vial temperature of 70 °C. Verify that the reagent vials have cooled down to a safe temperature before handling them. This can take up to 90 minutes after the cooling nitrogen has turned off. ▲

Other conditions that will cause the ETD Module to remain in Standby:

- Attempting to turn on the reagent ion source when the restrictor heater, transfer line heater, and the source heater are not at their target temperatures.

- Whenever either the mass spectrometer or the ETD Module goes into Standby mode. Reagent vial nitrogen cooling will turn on if the vials are at an elevated temperature.



**Exception:** If the LTQ Orbitrap Velos ETD is placed in Standby by clicking the Standby button in Tune Plus (see Standby icon in the margin), there is an hour delay before the cooling nitrogen turns on. ▲

- Whenever the pressure in the mass spectrometer or the ETD Module exceeds its protection limit. Reagent vial nitrogen cooling will turn on if the vials are at an elevated temperature.
- Whenever the abundance of reagent ions becomes insufficient as determined by the AGC setting. When this occurs, the LTQ Orbitrap Velos ETD completes the Xcalibur Sequence step in progress before going into Standby mode.



## Chapter 3 User Maintenance

This chapter describes routine maintenance procedures that must be performed to ensure optimum performance of the LTQ Orbitrap Velos.

For instructions on maintaining the LTQ Velos linear trap, refer to the *LTQ Series Hardware Manual*. For instructions on maintaining LCs or autosamplers, refer to the manual that comes with the LC or autosampler.

**Note** It is the user's responsibility to maintain the system properly by performing the system maintenance procedures on a regular basis. ▲

The following topics are described in this chapter:

- “General Remarks” on page 3-2
- “Baking Out the System” on page 3-4
- “Maintenance of the Vacuum System” on page 3-4
- “Maintenance of the ETD Module” on page 3-12
- “Maintenance of the Recirculating Chiller” on page 3-57

## General Remarks

Preventive maintenance must commence with installation, and must continue during the warranty period to maintain the warranty. Thermo Fisher Scientific offers maintenance and service contracts. Contact your local Thermo Fisher Scientific office for more information. Routine and infrequent maintenance procedures are listed in Table 3-1.

**Table 3-1.** User maintenance procedures

MS Detector Component	Procedure	Frequency	Procedure Location
Analyzer	System bakeout	If necessary (e.g. after performing maintenance work on the vacuum system)	<a href="#">page 3-4</a>
Rotary-vane pumps	Add oil	If oil level is low	Manufacturer's documentation
	Change oil	Every three months or if oil is cloudy or discolored	Manufacturer's documentation
Turbomolecular pumps	Exchange lubricant reservoir	Once a year	Manufacturer's documentation <a href="#">page 3-11</a>
Recirculating chiller	Check cooling fluid level	See manufacturer's documentation	Manufacturer's documentation <a href="#">page 3-57</a>
	Check cooling fluid filter		
	Check air inlet filter		
ETD Module	Clean the ion volume	As needed*	<a href="#">page 3-21</a>
	Replace the inlet valve components	As needed*	<a href="#">page 3-44</a>
	Clean the ion source lenses	As needed*	<a href="#">page 3-33</a>
	Clean the ion source	As needed*	<a href="#">page 3-39</a>
	Replace the ion source filament	As needed*	<a href="#">page 3-41</a>
	Check the rotary-vane pump oil and add when needed	Every month	<a href="#">page 3-8</a>
	Change the rotary-vane pump oil	Every four months	<a href="#">page 3-9</a>
	Clean the rear cooling fans	Every four months	<a href="#">page 3-56</a>

\* As needed depends on how close the component is to the electron transfer reagent introduction point. For example, the ion volume is closer to the fluoranthene introduction point than any other component and requires the most frequent cleaning.

To successfully carry out the procedures listed in this chapter, observe the following rules:

- Proceed methodically.
- Always wear clean, lint-free, and powder-free gloves when handling the components of the API source, ion optics, mass analyzer, and ion detection system.

Thermo Fisher Scientific recommends the following gloves: white nitrile clean room gloves (Fisher Scientific P/N 19-120-2947B [size medium] or P/N 19-120-2947C [size large]; Thermo Scientific P/N 23827-0008) [size medium] or P/N 23827-0009 [size large]).

- Never re-use gloves after you remove them because the surface contaminants on them will re-contaminate clean parts.
- Always wear protective eye wear when you clean parts.
- Always place the components on a clean, lint-free, and powder-free surface.
- Always cover the opening in the top of the vacuum manifold with a large, lint-free tissue whenever you remove the top cover plate of the vacuum manifold.
- Never overtighten a screw or use excessive force.
- Dirty tools can contaminate your system. Keep the tools clean and use them exclusively for maintenance and service work at the LTQ Orbitrap Velos.
- Never insert a test probe (for example, an oscilloscope probe) into the sockets of female cable connectors on PCBs.

## Returning Parts

To protect our employees, we ask you for some special precautions when returning parts for exchange or repair to the factory. Your signature on the [Repair Covering letter](#) confirms that the returned parts have been de-contaminated and are free of hazardous materials. See ["Safety Advice for Possible Contamination"](#) on [page viii](#) for further information.

## Cleaning the Surface of the Instrument

Clean the outside of the instrument with a dry cloth. For removing stains or fingerprints on the surface of the instrument (panels, for example), slightly dampen the cloth (preferably made of microfiber) with distilled water.

**Caution** Prevent any liquids from entering the inside of the instrument. ▲

## Maintenance of the Vacuum System

This section contains instructions for performing a system bakeout and for performing pumps maintenance.

### Baking Out the System

Collected or remaining gases and molecules as well as moisture can lead to an increased number of collisions with sample ions in the high vacuum region of the instrument. The bakeout procedure removes these contaminations. Therefore, we recommend to bake out the instrument if the high vacuum decreases noticeably during routine operation.

Bakeout is mandatory after maintenance or service work is performed in the analyzer region where the system is vented.

**Note** Pumping down the system after venting takes at least eight hours, and usually requires overnight baking of the system. ▲

In case the system has been vented during a power failure, it is necessary to bake out the system to obtain the operating vacuum. See “[Behavior of the System in Case of a Main Failure](#)” on [page 2-2](#).

### Bakeout Procedure

#### ❖ To perform a system bakeout

1. Place the system in Standby condition as described in “[Placing the Instrument in Standby Condition](#)” on [page 2-4](#).
2. Put the FT Electronics switch at the power control panel into the On position.



**Figure 3-1.** Bakeout timer



3. Set the bakeout time by entering the desired time (hh:mm) with the up/down keys of the bakeout timer. See [Figure 3-1](#) on [page 3-4](#).



4. Start the bakeout procedure by pressing the green start button on the right. The LTQ Orbitrap Velos indicates a running bakeout procedure by the flashing Vacuum and System LEDs on the front side of the instrument. See [Figure 1-4](#) on [page 1-5](#).



You can stop a running bakeout procedure by pressing the orange reset/stop button on the left side. Also press this button after you have changed the preset bakeout time.

5. The bakeout procedure is terminated because of two reasons:
  - The preset duration has expired, or
  - The vacuum has risen above a preset value.

The termination of the baking process is indicated by the status LEDs (System and Vacuum) on the front side that have stopped flashing.

## Maintenance of the Forepumps

Rotary-vane pumps require minimal maintenance. All that is required to maintain the rotary-vane pump is to inspect, add, purge, and change the pump oil.

For maintenance of the forepumps of the MS portion, refer to the *LTQ Series Hardware Manual* or the pump manufacturer's manual.

**Note** The manuals of the pump manufacturers give detailed advice regarding safety, operation, maintenance, and installation. Please note the warnings and precautions contained in these manuals! ▲

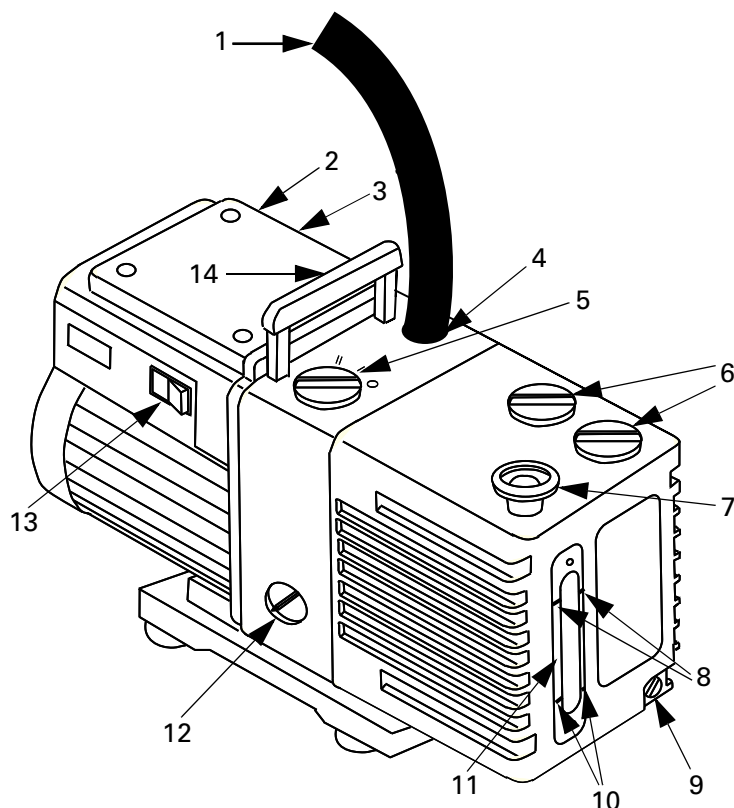
## Maintenance of the ETD Forepump

Rotary-vane pump oil (P/N A0301-15101) is a translucent light amber color and it should be checked often. During normal operation, oil must always be visible in the oil level sight glass between the MIN and MAX marks. If the oil level is below the MIN mark, add oil. If the oil is cloudy or discolored, purge the oil to decontaminate dissolved solvents. If the pump oil is still discolored, change it. You should change the pump oil every 3000 hours (about four months) of operation.

The rotary-vane pump major components are shown in [Figure 3-2](#) on [page 3-6](#).

## User Maintenance

### Maintenance of the Vacuum System



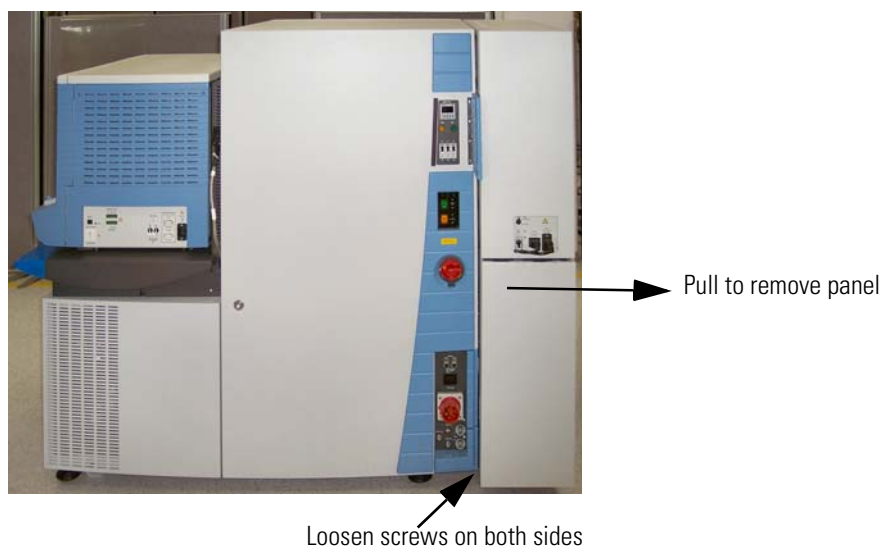
Labeled components: 1=Foreline Vacuum Hose, 2=Electrical Inlet Connector, 3=Voltage Indicator, 4=Inlet Port, 5=Gas Ballast Control, 6=Oil Filler Plugs, 7=Outlet Port, 8=MAX Marks, 9=Oil Drain Plug, 10=MIN Marks, 11=Oil Level Sight Glass, 12=Mode Selector, 13= On/Off Switch, 14=Lifting Handle

**Figure 3-2.** Schematic of ETD forepump

**Note** During normal operation, the mode selector switch is set to high-vacuum mode (turned fully clockwise) and the gas-ballast control is closed (0). ▲

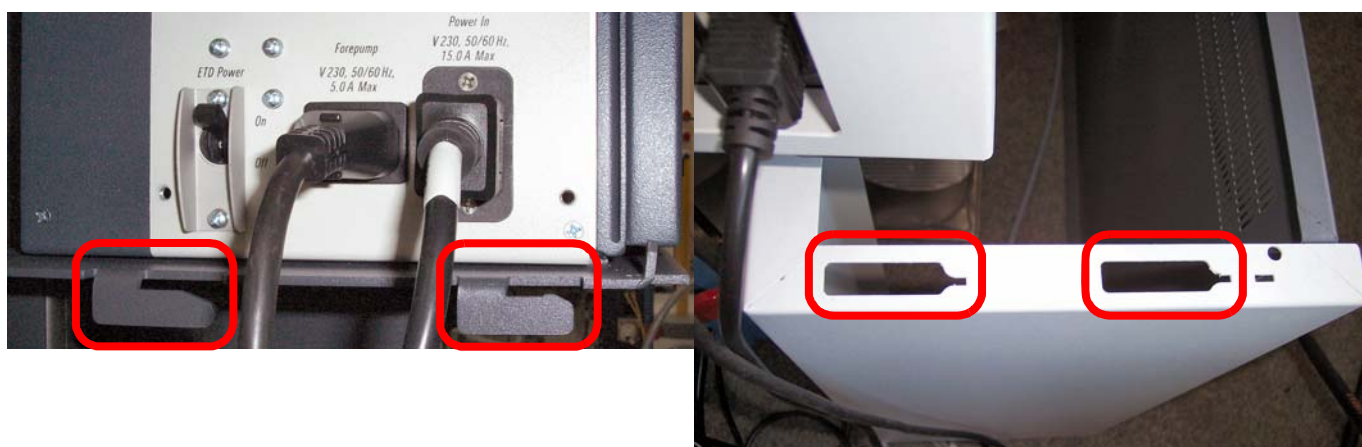
### Accessing the ETD Forepump

As described in “[Forepump of the ETD Module](#)” on [page 1-34](#), the ETD forepump is located in a cabinet at the bottom of the ETD Module. To access the ETD forepump you have to remove the lower panel as indicated in [Figure 3-3](#) on [page 3-7](#).



**Figure 3-3.** Accessing the ETD Forepump: Removing the panel

Two pairs of hooks under the top panel hold the bottom panel. They mount into corresponding openings at the top side of the bottom panel. [Figure 3-4](#) shows the details for the right side of the instrument. The panel hangs on the hooks and comes off if lifted up a little and getting pulled on into the backwards direction.



**Figure 3-4.** Hooks (left) and top side of detached bottom panel (right)

On the bottom of the rear side of the MS portion, two Allen screws fix the panel to the instrument frame by means of fork-like extensions (lugs). See [Figure 3-5](#) on [page 3-8](#).



**Figure 3-5.** Lugs for fixing the bottom panel

❖ **To remove the panel**

1. Use a 6 mm Allen wrench to loosen the screws that fix the bottom panel. Take care not to loosen the screws completely.
2. Pull the panel horizontally away from the instrument until it comes clear from the hooks.
3. Remove the panel from the instrument and store it at a safe place.

To reattach the panel, proceed in the reverse order.

**Adding Oil to the ETD Forepump**

The pump oil level must be between the MIN and MAX marks on the oil level sight glass for the pump to operate properly. Pump oil (P/N A0301-15101) is added as needed when the oil level is below the MIN mark on the oil level sight glass.

You can check the oil level by looking at the oil level sight glass, which is shown in [Figure 3-2](#) on [page 3-6](#). If the ETD forepump oil level is low, follow these steps to add more oil.

❖ **To add oil to the ETD forepump**

1. Shut down and vent the LTQ Orbitrap Velos ETD.

**Caution** Shut down and unplug the instrument before adding oil. ▲

2. Remove the lower panel at the rear side of the ETD Module as described on [page 3-8](#).
3. Remove one of the oil filler plugs from the rotary-vane pump.

**Caution** To maintain optimal performance and prevent damage to the ETD forepump, only use factory-approved rotary-vane pump oil. ▲

4. Add fresh oil to the reservoir until the oil is half way between the MIN and MAX level marks. If the oil level goes above the

MAX level mark, remove the drain plug and drain the excess oil into a suitable container.

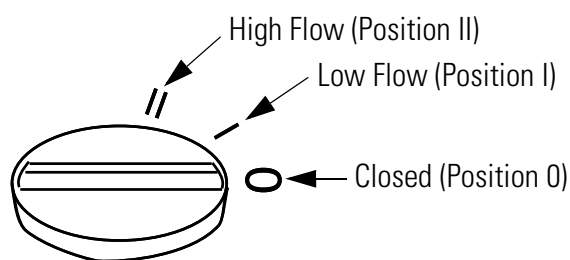
5. Insert the oil filler plug back into the rotary-vane pump.
6. Reattach the lower panel at the rear side of the ETD Module.
7. Plug in the instrument.
8. Restart the system.

### **Purging the Rotary-Vane Pump Oil**

When the rotary-vane pump oil becomes cloudy or discolored, purge the oil. Purging (or decontaminating) the oil removes dissolved gases and low boiling-point liquids. You can purge the oil without interrupting system operation, but do not purge it during an acquisition or while the electron multiplier or filament is powered on.

#### **❖ To purge the rotary-vane pump oil**

1. Remove the lower panel at the rear side of the ETD Module as described on [page 3-8](#).
2. Set the gas ballast control (See [Figure 3-2](#) on [page 3-6](#).) to Low Flow (I).
3. Operate the pump for 10 minutes or until the oil is clear. If the oil remains cloudy or discolored after 10 minutes, replace the oil.
4. Set the gas ballast control to Closed (0), as shown in [Figure 3-6](#).



**Figure 3-6.** Gas ballast control positions

5. Reattach the lower panel at the rear side of the ETD Module.

### **Changing the Rotary-Vane Pump Oil**

You should change the ETD forepump oil every four months (about 3000 hours of operation).

Supplies needed for changing the ETD forepump oil:

- Rotary-vane pump oil (P/N A0301-15101)
- Suitable container for removing spent or excess oil

**Note** For best results, change the oil while the ETD forepump is still warm after operation. Be careful, however, as the oil can still be very hot at this time. ▲



**Warning Burn Hazard.** Handle hot pump oil carefully to avoid being burned or injured. ▲

❖ **To change the ETD forepump oil**

1. Shut down and vent the LTQ Orbitrap Velos ETD.

**Caution** Shut down and unplug the instrument before adding oil. ▲

2. Remove the lower panel at the rear side of the ETD Module as described on [page 3-8](#).
3. Disassemble the rotary-vane pump.
  - a. Disconnect the foreline vacuum hose. (See [Figure 3-2](#) on [page 3-6](#).)
  - b. Disconnect the exhaust vacuum hose.
  - c. Place the rotary-vane pump on a bench.



**Warning Lifting Hazard.** Use the proper lifting technique to lift the ETD forepump. It weighs approximately 50 pounds (22.7 kg). ▲

4. Drain the spent oil.
  - a. Remove one of the oil filler plugs.
  - b. Remove the oil drain plug and allow the oil to drain into a suitable container.
  - c. Dispose of the spent oil according to local environmental regulations.
  - d. Replace the oil drain plug.
5. Add fresh oil.
  - a. Add oil into oil filler reservoir half way between the MIN and MAX level marks.
  - b. If the oil level goes above the MAX level mark, remove the drain plug and drain the excess oil from the pump.

6. Reassemble the rotary-vane pump.
  - a. Replace the oil filler plug.
  - b. Return the rotary-vane pump to the floor.
  - c. Reconnect the foreline vacuum hose to the rotary-vane pump.
  - d. Reconnect the exhaust vacuum hose to the rotary-vane pump.
  - e. Plug in the rotary-vane pump.
7. Reattach the lower panel at the rear side of the ETD Module.
8. Plug in the instrument.
9. Restart the system.

## Maintenance of the Turbopumps

The turbopumps in the MS portion of the LTQ Orbitrap Velos need maintenance work that is briefly outlined below. In contrast, the turbopump in the ETD Module of the LTQ Orbitrap Velos ETD contains no user-serviceable parts.

**Note** The manuals of the pump manufacturers give detailed advice regarding safety, operation, maintenance, and installation. Please note the warnings and precautions contained in these manuals! ▲

### Exchanging the Lubricant Reservoir of the Turbopumps

**Note** For all manipulations at the pumps, note the advice, warnings, and cautions contained in the pump manuals! ▲

For the turbopumps, we recommend exchanging the lubricant reservoir once per year. At each exchange procedure, the complete lubricant reservoir must be exchanged!

**Note** The storage stability of the lubrication oil is limited. The specification of durability is given by the pump manufacturer. (Refer to the manuals for the turbopumps.) ▲

Replacements for the turbopump lubricant reservoirs (TMH 071 P: P/N 0172350; TMU 262: P/N 1050160) are available from Thermo Fisher Scientific.

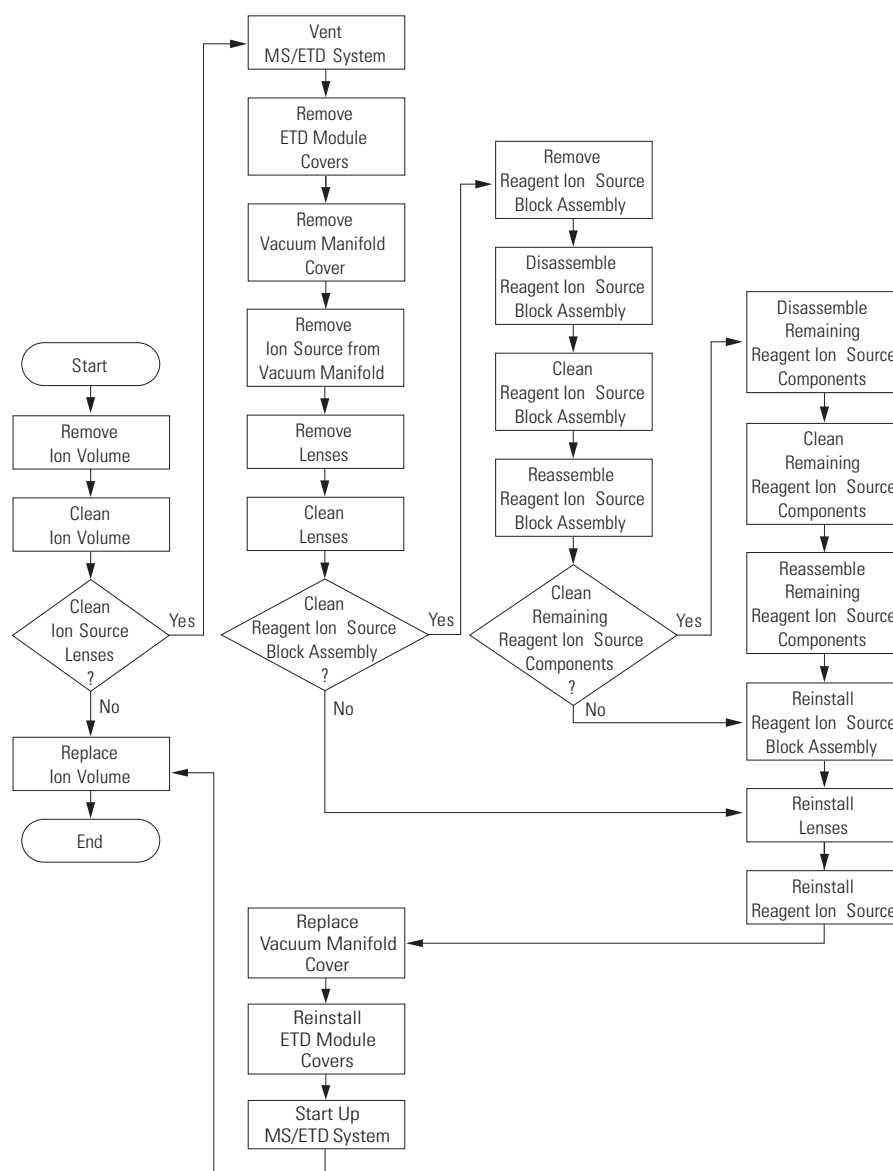
The disposal of used oil is subject to the relevant regulations.



## Maintenance of the ETD Module

This section describes routine ETD Module maintenance procedures that must be carried out to ensure optimum performance of the system. Some of the procedures describe how to clean components of the ETD Module. Others involve replacing components or replenishing the electron transfer reagent. See also the *ETD Module Hardware Manual* for additional information.

Figure 3-7 illustrates the sequence in which to perform routine maintenance on the ETD system.



**Figure 3-7.** Routine maintenance sequence for ETD system

Table 3-2 on page 3-13 gives advice for correcting frequent problems with the ETD system.

**Table 3-2.** Indications requiring maintenance of the ETD system

Symptom	Cause	Fix
No ions at $m/z$ 202 with the emission current at the correct level.	The $m/z$ 202 is outside the mass range.	Set the starting mass lower.
The $m/z$ 202 signal intensity drops slowly over several days when the emission current is at the correct level.	The ion volume needs to be cleaned or replaced.	Clean or replace the ion volume when the injection time is over 100 ms. See <a href="#">page 3-21</a> .
A system error message advising that the maximum injection time has been reached for the ETD AGC.	The AGC target has not been reached within the specified time limit. The ion volume needs to be cleaned or replaced.	Clean the ion volume. Increase the maximum injection time limit.
Sudden and complete drop of $m/z$ 202 level, low emission current.	The filament may just have blown out.	Check the filament. Replace it if necessary. See <a href="#">page 3-41</a> .

## Handling and Cleaning Reagent Ion Source Parts

A large part of maintaining your reagent ion source consists of making sure that all the components are clean. Use the cleaning procedures listed in this section to clean stainless steel and non-stainless steel parts. However, use caution when doing so, because some components can be damaged by exposure to liquids.

How often you clean the reagent ion source depends on the amount of reagent introduced into the system. In general, the closer a component is to where the reagent ion is introduced, the more rapidly it becomes dirty (see the footnote in [Table 3-1](#) on [page 3-2](#)). For example, the ion volume needs to be cleaned more often than other parts.

Many parts can be removed and disassembled by hand. Make sure you have all the necessary tools before carrying out a procedure. See below for a list of the tools and supplies generally needed for maintenance of the reagent ion source. Tools should be used only for the maintenance of the reagent ion source and be free of grease or other residues. Handle parts in a manner that maintains their cleanliness.

**Note** It is crucial that the cleanliness of the parts be maintained when they are handled. Wear gloves and place the parts on surfaces that are clean if the parts are not returned directly to the instrument. If clean surfaces are not available, place the parts on fresh lint free wipes or cloths or aluminum foil that has not been used for any other purpose. ▲

The following tools and supplies are needed for reagent ion source maintenance:

- Clean, dry gas (air or nitrogen)
- New, white nitrile clean room gloves (Fisher Scientific P/N 19-120-2947B [size medium] or P/N 19-120-2947C [size large]; Thermo Scientific P/N 23827-0008 ) [size medium] or P/N 23827-0009 [size large])
- Lint-free cloth or paper
- Nut driver, 5.5 mm
- Protective eyewear
- Screwdriver, Phillips #2
- Screwdriver, flat blade
- Wrench, adjustable
- Wrench, Allen, 2 mm, 2.5 mm, 3 mm, 4 mm, 5/32-in, 5/64-in, 1/16-in
- Wrench, open-ended, 1/4-in, 5/16-in, 7/16-in (2), 1/2-in, 9/16-in
- Wrench, socket, 1/2-in

## **Cleaning Stainless Steel Parts**

The reagent ion source, ion volume assembly, ion source block, and lenses are made from stainless steel. To clean these parts, follow the procedure described in this topic. Use this procedure with caution because some components can be damaged when exposed to liquids.

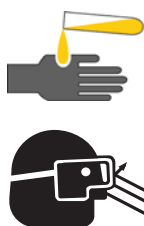
The following tools and supplies are needed for cleaning stainless steel parts in the reagent ion source:

- Acetone, analytical grade (or other suitable solvent)
- Aluminum oxide abrasive, number 600 (P/N 32000-60340)
- Applicators, cotton-tipped
- Beaker, 450 mL
- Clean, dry gas
- De-ionized water
- Detergent (Alconox<sup>®</sup>, Micro, or equivalent)
- Dremel<sup>®</sup> rotary tool or equivalent (recommended)

- Foil, aluminum
- Forceps
- New, white nitrile clean room gloves
- Glycerol, reagent grade
- Lint-free cloth
- Protective eyewear
- Tap water
- Toothbrush, soft
- Ultrasonic cleaner

**Caution** Do not use this procedure to clean ceramic, aluminum, or gold plated parts. See page 3-17 for the method for cleaning ceramic, aluminum, or gold plated parts. ▲

**Caution** Follow the subsequent instructions precisely. If done wrong, the cleaning procedure could damage the ion source lenses. ▲



**Warning Hand and Eye Hazard.** Wear impermeable laboratory gloves and eye protection when performing these cleaning procedures. ▲

❖ **To clean reagent ion source stainless steel parts**

1. Remove contamination from the surfaces being cleaned.
  - a. Use a slurry of number 600 aluminum oxide in glycerol and a cleaning brush or cotton-tipped applicator. Contamination often appears as dark or discolored areas, but may not be visible. The heaviest contamination is usually found around the apertures, such as the electron entrance hole on the ion volume.
  - b. Clean each part thoroughly, even if no contamination is visible.
  - c. Use the wooden end of an applicator that is cut at an angle to clean the inside corners.
  - d. Use a Dremel® tool with the polishing swab at its lowest speed. This will increase the cleaning efficiency and decrease the time required to clean the part.



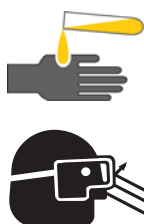
**Warning Injury Hazard.** To prevent personal injury, be sure to keep the Dremel tool away from possible hazards, such as standing water or flammable solvents. ▲

2. Rinse the parts with clean water.
3. Use a clean applicator or toothbrush to remove the aluminum oxide slurry. Do not let the slurry dry on the metal because dried aluminum oxide is difficult to remove.
4. Place the parts in a warm detergent solution in an ultrasonic bath and sonicate them.
  - a. Make a solution of detergent and warm tap water in a 400 mL glass beaker.
  - b. Using forceps, place the parts in a beaker containing the warm detergent solution.
  - c. Place the beaker and contents in an ultrasonic bath for five minutes.
  - d. Rinse the parts with tap water to remove the detergent.
5. Sonicate the parts in deionized water.
  - a. Using forceps, place the parts in a beaker containing deionized water.
  - b. Place the beaker and contents in an ultrasonic bath for five minutes.
  - c. If the water is cloudy after sonicating, pour off the water, add fresh water, and place the beaker and its contents in a ultrasonic bath again for five minutes. Repeat until the water is clear.
6. Sonicate the parts in acetone.
  - a. Using forceps, place the parts in a beaker containing fresh acetone.
  - b. Place the beaker and contents in an ultrasonic bath again for five minutes.
7. Blow-dry the parts immediately. Use clean, dry gas (air or nitrogen) to blow the acetone off the parts.
8. Complete the drying process, doing one of the following:
  - Using forceps, place the parts in a 500 mL glass beaker, cover the beaker with aluminum foil, and put the beaker in an oven set at 100 °C for 30 minutes.

- Lay the parts on clean aluminum foil (dull side up) and allow to dry for 30 minutes.
9. Allow the parts to cool before reassembling them.

## Cleaning Non-Stainless Steel or Hybrid Parts

To clean the stainless-steel portion of hybrid parts, follow [step 1](#) and [step 2](#) of the instructions on [page 3-15](#). Perform these steps only on the stainless-steel surfaces of hybrid parts. Do not allow the aluminum oxide slurry to contact the aluminum, ceramic, or gold plated portions of these parts.



**Warning Hand and Eye Hazard.** Wear impermeable laboratory gloves and eye protection when performing these cleaning procedures. ▲

The reagent ion source heater ring, filament spacer, lens holder, and spacers are non-stainless steel parts that are made from aluminum, ceramic, or are gold plated.

### ❖ To clean the non-stainless-steel portions of hybrid parts

1. Scrub all of the parts with a warm detergent solution.
  - a. Make a solution of detergent and warm tap water in a 500 mL glass beaker.
  - b. Dip a clean cotton-tipped applicator in the detergent mixture and use the applicator to scrub the parts.

**Note** Do not soak or sonicate the parts in detergent. ▲

- c. Using forceps, rinse the parts thoroughly with tap water to remove the detergent.

**Caution** Do not leave aluminum parts, such as the heater ring, in the detergent. Basic solutions, like detergent, damage the surface of aluminum. ▲

2. Rinse the parts in deionized water. Using forceps, dip the parts in a beaker of deionized water. Change the water if it becomes cloudy. Do not soak or sonicate the parts.

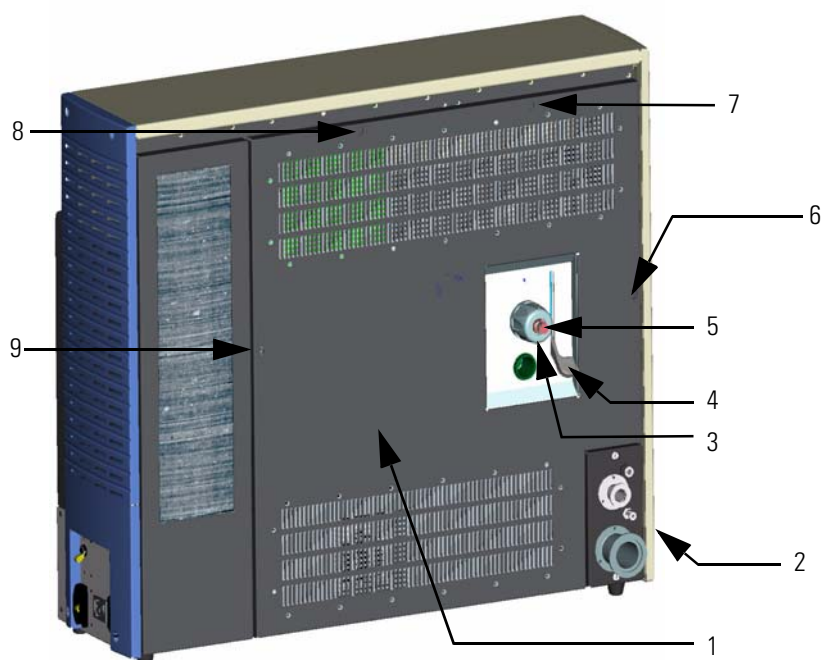
## User Maintenance

### Maintenance of the ETD Module

3. Rinse the parts with acetone. Using forceps, dip the parts in a beaker of acetone. Change the acetone if it becomes cloudy. Do not soak or sonicate the parts.
4. Blow-dry the parts immediately. Use clean, dry gas (air or nitrogen) to blow the acetone off the parts.

## Removing the Access Panels

During some ETD Module maintenance activities, it is necessary to remove either the ETD main access panel, or the side access panel, or both (see [Figure 3-8](#)). Follow the subsequent procedures to remove these panels.



Labeled components: 1=ETD main access panel, 2=side access panel, 3=inlet valve knob, 4=inlet valve lever (down is closed, up is open), 5=inlet valve plug, 6, 7, 8, 9=panel fasteners.

**Figure 3-8.** Rear view of the ETD Module

## Removing the ETD Main Access Panel

### ❖ To remove the ETD main access panel

1. Place the ETD Module to Service mode as directed in [“Placing the Instrument in Off Condition and Service Mode”](#) on [page 3-47](#).



**Note** In Service mode, all power to the LTQ Orbitrap Velos ETD electronics is turned off. There are no user accessible components that carry a voltage in this mode. However, the vacuum pumps continue to operate. ▲



**Warning Burn Hazard.** The reagent vial heaters can be 108 °C (or set point); the transfer line, the restrictor, and the ion source can be at 160 °C. These components may be too hot to touch. Verify that all of these components are safe to touch before handling them. ▲

**Note** The ETD main access panel is interlocked with the ETD Module power. When the ETD main access panel is removed, all power to the ETD Module will be turned off. However, the mechanical pump and turbo pump will continue operating. ▲

2. Remove the inlet valve lever (item 4 in [Figure 3-8](#) on [page 3-18](#)) by pulling it down and away from the ETD Module main access panel. Do not rotate the lever upwards. It must remain in its down (closed) position to avoid catastrophic venting of the system.

**Caution** Rotating the inlet valve lever upwards (to the open position) without the inlet valve plug (item 5 in [Figure 3-8](#)) or the ion volume tool in place will cause a catastrophic venting of the system. ▲

3. Unscrew the inlet valve knob (item 3 in [Figure 3-8](#)) and remove the inlet valve plug (item 5 in [Figure 3-8](#)), the inlet valve knob, and the internal ferrule.
4. Loosen the four panel fasteners (items 6, 7, 8, and 9 in [Figure 3-8](#)).
5. The top panel rests on hooks pointing into the upward direction. Tilt the top panel towards you and lift it up and away from the ETD Module.

## Removing the ETD Side Access Panel

### ❖ To remove the ETD side access panel

1. If it is not already in Service mode, place the ETD Module in Service mode as directed in [“Placing the Instrument in Off Condition and Service Mode”](#) on [page 3-47](#).

**Note** In Service mode, all power to the LTQ Orbitrap Velos ETD electronics is turned off. There are no user accessible components that carry a voltage in this mode. However, the vacuum pumps continue to operate. ▲



**Warning Burn Hazard.** The reagent vial heaters can be at 108 °C (or set point); the flow restrictor, the transfer line heaters, and the ion source heater can be at 160 °C. These components may be too hot to touch. Verify that all of these components are safe to touch before handling them. ▲

**Note** The ETD side access panel is interlocked with the ETD Module power. When the ETD side access panel is removed, all power to the ETD Module will be turned off. However, the mechanical pump and turbopump will continue operating. ▲

2. Using an Allen wrench, loosen the captive screws at the top and remove the screws at the bottom of gray plastic side panel and remove the panel.
3. Using a #2 Phillips screwdriver, loosen the three captive screws on the metal side access panel (item 2 in [Figure 3-8](#) on [page 3-18](#)) and remove the panel.



**Warning Burn Hazard.** Reagent vial heaters, ion source heater, flow restrictor, and transfer lines are accessible under the ETD side access panel. These are heated components. Verify that they are safe to touch before handling them. ▲

Replace the panels by following the above steps in reverse order and reversing the instructions in each step.

## Maintenance of the Reagent Ion Source

The reagent ion source consists of an ion volume, filament, and ion source lenses. Because the ion volume is exposed directly to samples introduced into the reagent ion source, it requires the most frequent cleaning. You can access the ion volume assembly with or without an inlet valve.

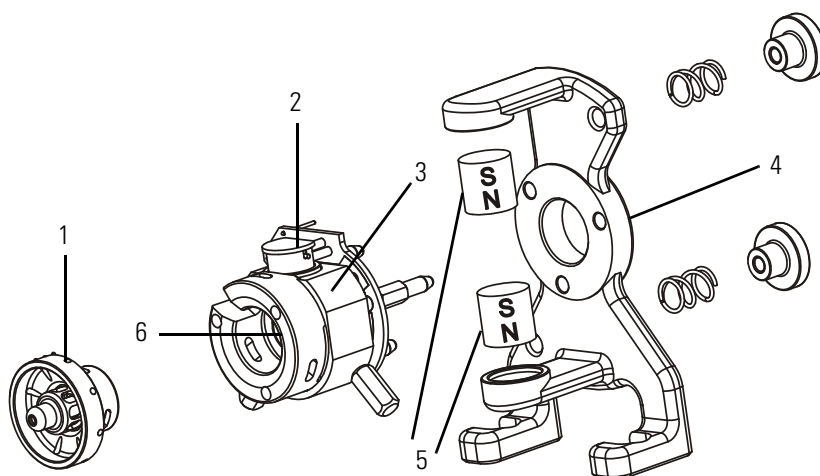
To restore system performance, always clean the ion volume first, then the ion source lenses. If cleaning either of these components does not restore system performance, try cleaning the entire reagent ion source.

This section contains these maintenance procedures:

- “Cleaning the Ion Volume With an Inlet Valve” on [page 3-21](#)
- “Cleaning the Ion Source Lens Assembly” on [page 3-33](#)
- “Cleaning the Ion Source Block” on [page 3-39](#)
- “Replacing the Ion Source Filament” on [page 3-41](#)

- [“Replacing Inlet Valve Components”](#) on [page 3-44](#)

The ion source, the ion trap, and their components are shown in [Figure 3-9](#).



Labeled components: 1=ion source lenses, 2=filament assembly, 3=ion source block, 4=magnet support, 5=magnets, 6=ion volume (inside the ion source block, 3)

**Figure 3-9.** Ion source components (left view)

## **Cleaning the Ion Volume With an Inlet Valve**

The ion volume is where molecules interact with energetic electrons to form ions. Because the ion volume is exposed directly to reagents introduced into the reagent ion source, you will have to clean it more frequently than other parts. How often you have to clean the ion volume assembly will depend on the types and amounts of reagents used.

For cleaning the ion volume with an inlet valve, the following tools and supplies are needed:

- Cleaning supplies for stainless steel parts (See [“Cleaning Stainless Steel Parts”](#) on [page 3-14](#).)
- Gloves (clean, lint-free, and powder-free)
- Ion volume tool and guide bar
- Lint-free cloth

Using the ion volume tool allows you to access the ion volume by entering the vacuum manifold through the inlet valve without venting the instrument.

## User Maintenance

Maintenance of the ETD Module

### ❖ To clean the ion volume with an inlet valve

1. Click the On/Standby button in the Tune Plus window to place the LTQ Orbitrap Velos ETD in Standby mode. See [Figure 3-10](#).

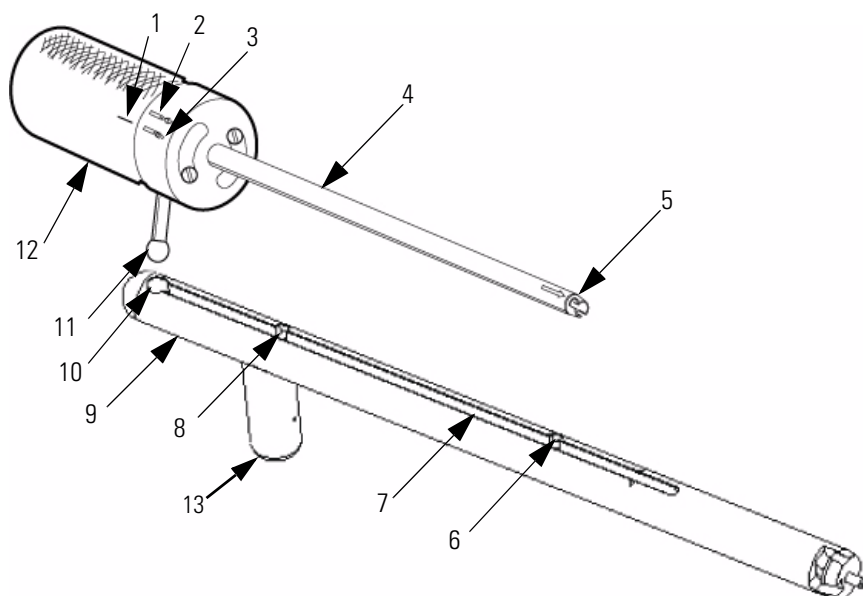
The screenshot shows the Thermo Tune Plus software interface. At the top left, there are three buttons labeled 'On', 'Off', and 'Standby'. The 'On' button is a green triangle, 'Off' is a black circle, and 'Standby' is a yellow rectangle with two vertical bars. Below these buttons, an arrow points to the 'On/Standby button' in the software's toolbar. Another arrow points to the 'Reagent Ion Source instrument control icon' in the software's toolbar. The main window displays a mass spectrum plot with 'Relative Intensity' on the y-axis and 'm/z' on the x-axis. A prominent peak is labeled at m/z 201.9. To the right of the plot is a 'Status View' panel with a table of instrument parameters.

Label	Value
ESI Source	
✓ Spray Voltage (kV):	3.80
✓ Spray Current (µA):	8.00
✓ Sheath Gas Flow Rate:	8.00
✓ Aux Gas Flow Rate:	-0.01
✓ Sweep Gas Flow Rate:	-0.01
✓ Capillary Temp OK:	Yes
✓ Capillary Voltage (V):	35.10
✓ Capillary Temp (°C):	274.91
✓ Tube Lens (V):	108.73
Vacuum	
✓ Vacuum OK:	Yes
✓ Ion Gauge Pressure OK:	Yes
✓ Ion Gauge:	On
✓ Ion Gauge (E-5 Ton):	1.38
✓ Convection Pressure OK:	Yes
✓ Convection Gauge (Ton):	0.93
FT Vacuum	
✓ FT Penning Pressure OK:	Yes
✓ FT Penning Gauge (E-10 ...):	0.62
✓ FT Pirani Gauge 1 (Ton):	0.87
✓ FT Pirani Gauge 2 (Ton):	0.00
Turbo Pump	
Status:	Running
Life (hours):	19851
Speed (Hz):	800
Power (Watts):	73
Temperature (°C):	63
FT Turbo Pump 1	
Status:	Running
Life (hours):	19505
Speed (Hz):	1500
Power (Watts):	15
FT Turbo Pump 2	
Status:	Running
Life (hours):	19505
Speed (Hz):	1500
Power (Watts):	14

**Figure 3-10.** Tune Plus window



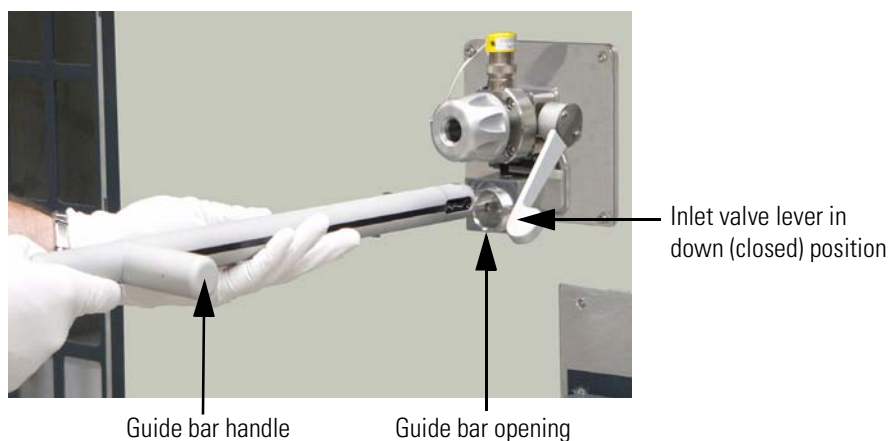
2. Open the Reagent Ion Source dialog box ([Figure 3-17](#) on [page 3-26](#)) in Tune Plus by clicking the Reagent Ion Source instrument control icon.
3. Place the guide bar handle (item 13 in [Figure 3-11](#) on [page 3-23](#)) to the 3 o'clock position ([Figure 3-12](#) on [page 3-23](#)).



Labeled components: 1=alignment line, 2=lock position, 3=unlock position, 4=ion volume tool, 5=bayonet lock, 6=second stop, 7=guide ball track, 8=first stop, 9=guide bar, 10=guide ball hole, 11=guide ball, 12=ion volume tool handle, 13=guide bar handle

**Figure 3-11.** Ion volume tool components

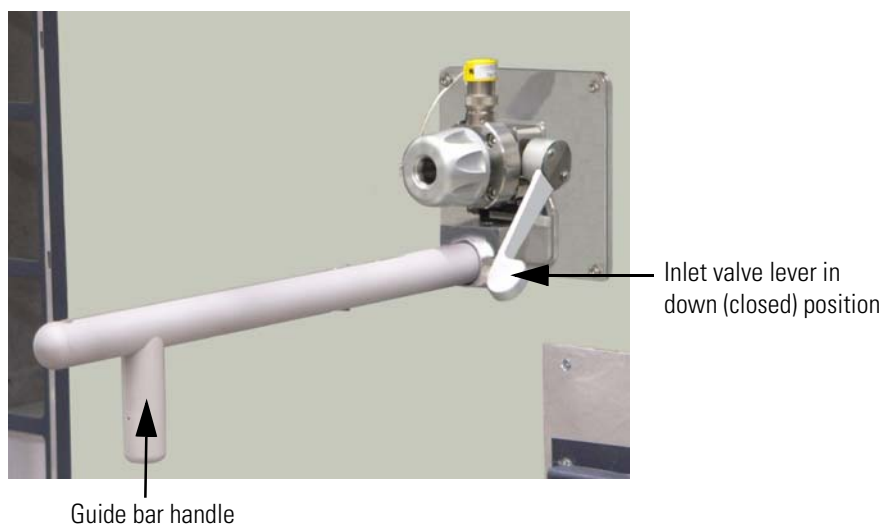
4. Insert the guide bar (item 9 in [Figure 3-11](#)) into the guide bar opening in the back of the ETD Module ([Figure 3-12](#)).



**Figure 3-12.** Guide bar being inserted into guide bar opening\*

\* Guide bar handle is facing to the right. The inlet valve is closed when the inlet valve lever is in the down position and open when it is in the up position.

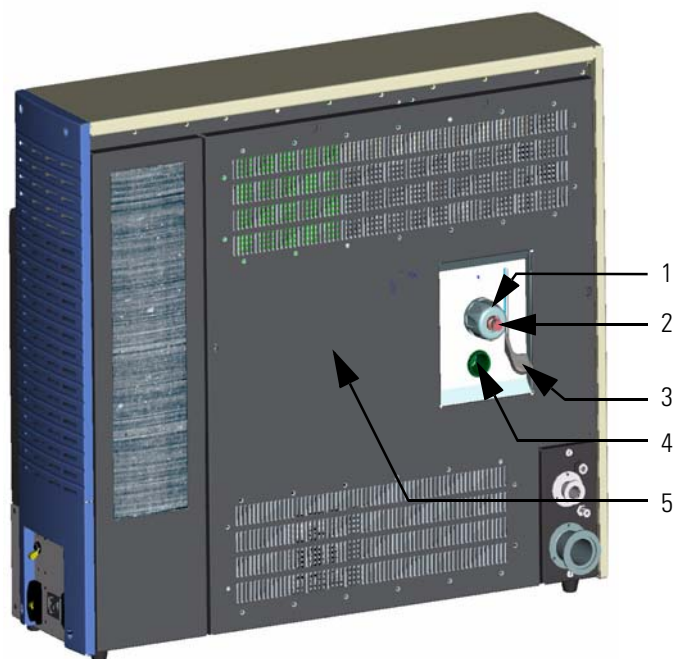
5. Push the guide bar in as far as it will go, then rotate it 90° clockwise to lock in the guide bar ([Figure 3-13](#) on [page 3-24](#)). The guide bar handle faces the floor at the completion of this step.



**Figure 3-13.** Guide bar insertion complete\*

\* Guide bar handle is facing the floor. The inlet valve is closed when the inlet valve lever is in the down position and open when it is in the up position.

6. Prepare the inlet valve and ion volume tool for insertion.



Labeled components: 1=inlet valve knob, 2=inlet valve plug, 3=inlet valve lever (down is closed, up is open), 4= guide bar opening, 5=main access panel

**Figure 3-14.** Rear view of the ETD Module, showing the inlet valve

Make sure the inlet valve is closed (inlet valve lever is down, as shown in [Figure 3-13](#)) and remove the inlet valve plug (item 2 in [Figure 3-14](#)). Do this by rotating (loosening) the inlet valve knob

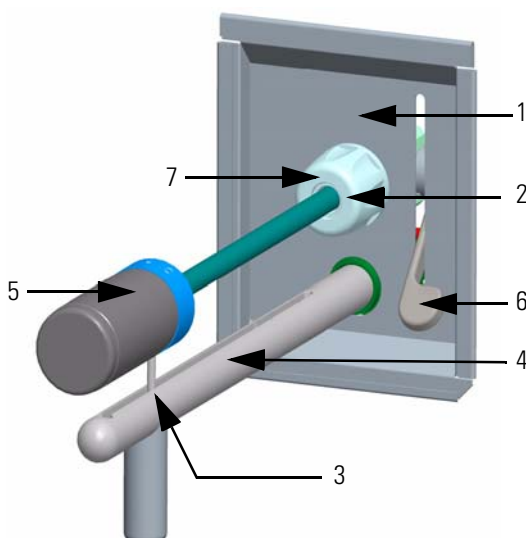
(item 1 in [Figure 3-14](#) on [page 3-24](#)) until the inlet valve plug will slide out easily. The inlet valve plug prevents air from entering the vacuum manifold in case the inlet valve is inadvertently opened.

7. Turn the ion volume tool handle to the unlock position, which indicates that the ion volume tool is in position to accept the ion volume. See [Figure 3-15](#).



**Figure 3-15.** Ion volume tool handle in the unlock position

8. Insert the ion volume tool and evacuate the inlet valve:
  - a. Insert the guide ball into the guide ball hole.

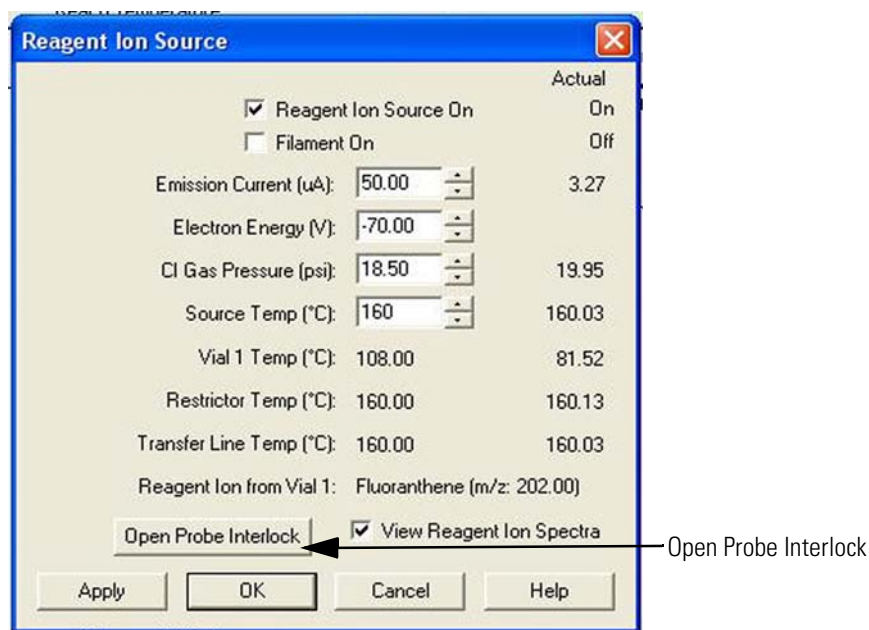


Labeled components: 1=ion volume tool entry housing, 2=inlet valve opening, 3=first stop, 4=guide bar, 5=ion volume tool, 6=inlet valve lever, 7=inlet valve knob

**Figure 3-16.** Ion volume tool guide bar first stop



- b. Slide the ion volume tool forward in the guide bar track until the guide ball is at the guide bar's first stop, which is shown in [Figure 3-11](#) on [page 3-23](#) and [Figure 3-16](#) on [page 3-25](#).
- c. Slide the ion volume tool so the guide ball is in the groove at the first stop ([Figure 3-11](#) and [Figure 3-16](#)). This prevents the probe from being pulled forward when the inlet valve is evacuated.
- d. Tighten the inlet valve knob ([Figure 3-16](#)) to ensure that a leak-tight seal is made.
- e. Click **Open Probe Interlock** in the Reagent Ion Source dialog box ([Figure 3-17](#)). A message box appears stating that the probe interlock is being pumped down. The target pressure is <0.1 mTorr. If a pressure of 0.1 mTorr or less is not obtained, replace the inlet valve seal as described in [“Replacing Inlet Valve Components”](#) on [page 3-44](#). When the target pressure is achieved, a message appears stating that the ball valve can be opened ([Figure 3-18](#)).

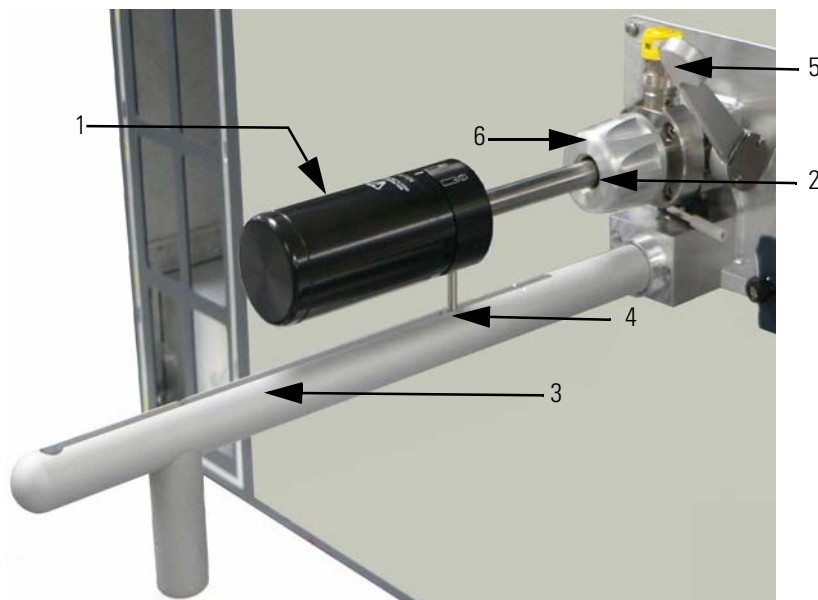


**Figure 3-17.** Reagent Ion Source dialog box, Open Probe Interlock button.



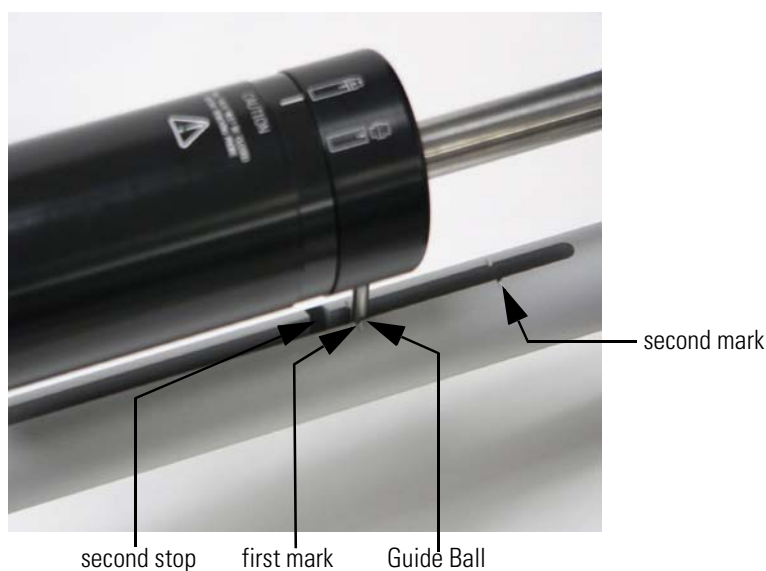
**Figure 3-18.** Instrument Message box: The Ball Valve can now be opened

- f. Once evacuation is complete, push up the inlet valve lever to open the inlet valve (Figure 3-19).
9. Remove the ion volume:
- a. Slide the ion volume tool into the vacuum manifold until the tip of the ion volume tool is fully inserted into the ion volume holder, as shown in Figure 3-19.



Labeled components: 1=ion volume tool, 2=inlet valve opening, 3=guide bar, 4=second stop, 5=inlet valve lever in open (up) position, 6=inlet valve knob

**Figure 3-19.** Ion volume tool inserted into the inlet valve



**Figure 3-20.** Detail of ion volume tool fully inserted into the inlet valve

You will know that the ion volume tool is fully inserted into the ion volume holder because the guide ball (item #11, [Figure 3-11](#) on [page 3-23](#)) will be just past the first mark on the guide bar as shown in [Figure 3-20](#) on [page 3-27](#).

- b. Turn the ion volume tool handle counterclockwise to the lock position, See [Figure 3-21](#). Listen for a click indicating that the handle is fully engaged in the lock position and is holding the ion volume.



**Figure 3-21.** Ion volume tool handle in the locked position

- c. Withdraw the ion volume tool (the ion volume is attached) until the guide ball reaches the first stop (see [Figure 3-11](#) on [page 3-23](#) and [Figure 3-16](#) on [page 3-25](#) for the first stop position).
- d. Close the inlet valve by pushing the lever down.

**Caution** Do not withdraw the ion volume tool beyond the point where the guide ball reaches the first stop in the guide bar. Close the inlet valve before withdrawing the ion volume tool past the first stop. Otherwise, the system will vent to the atmosphere and cleaning the components that are under vacuum will be required. ▲

- e. Loosen the inlet valve knob ([Figure 3-19](#) on [page 3-27](#)).
- f. Continue withdrawing the ion volume tool completely from the inlet valve by sliding the ion volume tool through the guide ball track in the guide bar.

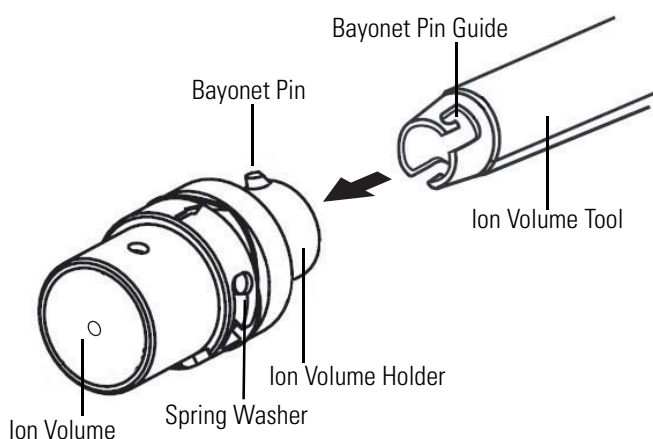


**Warning Burn Hazard.** The ion volume will be too hot to touch. Let it cool to room temperature before handling it. ▲

10. Clean the ion volume:

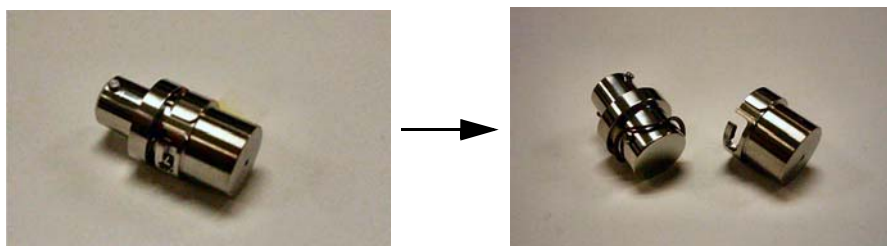


- a. Turn the ion volume tool handle to the unlock position (Figure 3-15 on page 3-25). The ion volume tool handle unlock position icon is shown at the left.
- b. Remove the ion volume from the ion volume tool. Using clean gloves, press the ion volume into the tip of the ion volume tool and rotate it to disconnect the bayonet pins from the pin guides. Pull the ion volume out of the ion volume tool, as illustrated in Figure 3-22.



**Figure 3-22.** Ion volume assembly

- c. Press the ion volume into the ion volume holder and rotate the ion volume to remove it from the ion volume holder See Figure 3-23.



**Figure 3-23.** Separating ion volume and ion volume holder

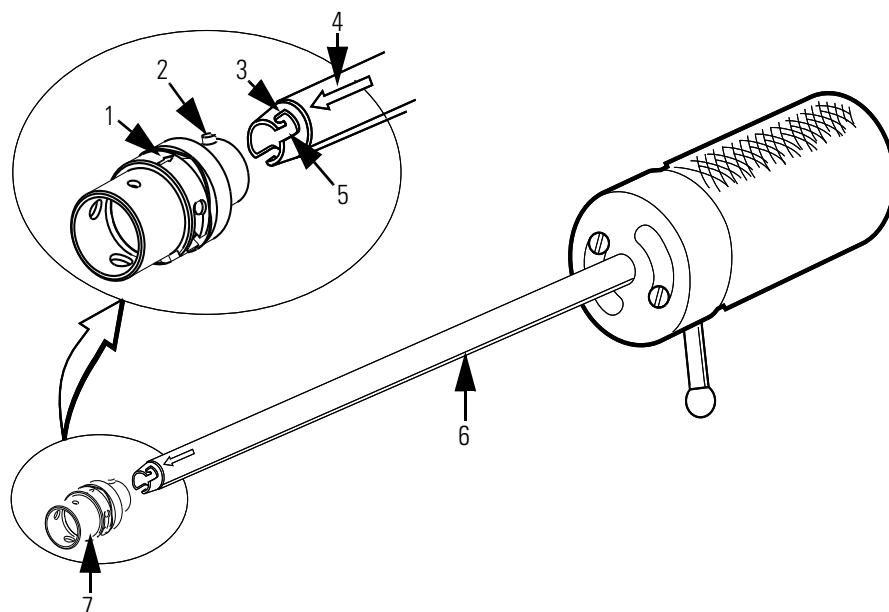
- d. Clean ion volume and ion volume holder according to the instructions in “Cleaning Stainless Steel Parts” on page 3-14.

❖ **To reinsert the ion volume**

1. Press the ion volume into the ion volume holder and rotate the ion volume to secure it to the ion volume holder.

2. Place the clean ion volume on the ion volume tool:
  - a. Place the ion volume into the bayonet lock located on the ion volume tool. Make sure that the alignment arrows on the ion volume and ion volume tool are facing each other. See [Figure 3-24](#).

**Caution** To avoid damage to the ion source, ensure that the arrows on the ion volume tool and ion volume are aligned. ▲



Labeled components: 1=ion volume alignment arrow, 2=bayonet pin, 3=bayonet lock, 4=ion volume tool alignment arrow, 5=bayonet guide, 6=ion volume tool, 7=ion volume

**Figure 3-24.** Placing the ion volume on the ion volume tool

**Note** Wear clean, lint-free, and powder-free gloves when you handle parts inside the vacuum manifold. ▲

- b. Turn the ion volume tool handle to the lock position. (See [Figure 3-21](#) on [page 3-28](#).)
3. Insert the ion volume tool and evacuate the inlet valve:
  - a. Insert the guide ball into the guide ball hole and slide the ion volume tool forward in the guide bar track until the guide ball is at the guide bar's first stop (see [Figure 3-11](#) on [page 3-23](#) and [Figure 3-16](#) on [page 3-25](#)).
  - b. Turn the ion volume tool so that the guide ball is in the groove at the first stop ([Figure 3-16](#) on [page 3-25](#)). This prevents the

probe from being pulled forward when the inlet valve is evacuated.

- c. Tighten the inlet valve knob to ensure a leak-tight seal (Figure 3-19 on page 3-27).
  - d. Click **Open Probe Interlock** in the Reagent Ion Source dialog box (Figure 3-17 on page 3-26). A message box will appear stating that the probe interlock is being pumped down. The target pressure is <0.1 mTorr. If a pressure of 0.1 mTorr or less is not obtained, the inlet valve seal must be replaced as described in “Replacing Inlet Valve Components” on page 3-44. When the target pressure is achieved, a message will appear stating that the ball valve can be opened. See Figure 3-18 on page 3-26.
  - e. Once evacuation is complete, push the inlet valve lever up to open the inlet valve. See Figure 3-19 on page 3-27.
4. Reinsert the ion volume:
- a. Slide the ion volume tool into the vacuum manifold, as illustrated in Figure 3-19.
  - b. Listen for a click indicating that the ion volume has connected with the ion source block. The guide ball will be slightly beyond the second stop on the guide bar. See Figure 3-20 on page 3-27.
  - c. Turn the ion volume tool handle to the unlock position. See Figure 3-25.



**Figure 3-25.** Ion volume tool handle in the unlock position

- i. Withdraw the ion volume tool away from the ion volume about 2.5 cm (1 in) and turn the ion volume tool handle to the lock position. See Figure 3-26 on page 3-32.
- ii. Slide the ion volume tool back into the vacuum manifold until the end of the ion volume tool just touches the ion volume.

- iii. If the ion volume tool does not go into the inlet valve completely, the ion volume is not seated properly.
- d. Withdraw the ion volume tool until the guide ball reaches the first stop (see [Figure 3-11](#) on [page 3-23](#) and [Figure 3-16](#) on [page 3-25](#)).



**Figure 3-26.** Ion volume tool handle in the locked position

- e. Close the inlet valve by pushing down on the inlet valve lever ([Figure 3-14](#) on [page 3-24](#)).

**Caution** Do not withdraw the ion volume tool beyond the point where the guide ball reaches the first stop in the guide bar. Close the inlet valve before withdrawing the ion volume tool past the first stop. Otherwise, the system vents to the atmosphere. ▲

- f. Loosen the inlet valve knob (item 6 in [Figure 3-19](#) on [page 3-27](#)).
  - g. Continue withdrawing the ion volume tool completely from the inlet valve by sliding the ion volume tool through the guide ball track in the guide bar.
5. Remove the ion volume tool and guide bar from the vacuum manifold:
    - a. Remove the guide bar by rotating it 90 degrees counter-clockwise and sliding it out of the entry housing.
    - b. Replace the inlet valve plug and tighten the inlet valve knob (item 6 in [Figure 3-19](#) on [page 3-27](#)).
    - c. Click **Close** in the message stating that the ball valve can be opened. (See [Figure 3-18](#) on [page 3-26](#).)
  6. Re-tune the MS detector.



**Note** Tune Plus provides an evaluation procedure for CI gas pressure under **Diagnostics > Diagnostics > Tools > System evaluation > Reagent CI gas pressure evaluation**. Thermo Fisher Scientific recommends performing this procedure after replacing the filament and/or the ion volume. ▲

## Cleaning the Ion Source Lens Assembly

If cleaning the ion volume did not restore system performance, try cleaning the ion source lens assembly. The ion source lens assembly comes in direct contact with reagent ions introduced into the ETD Module and needs to be cleaned periodically (though not as often as the ion volume).

### ❖ To clean the ion source lens assembly

1. Prepare the ETD Module for maintenance:
  - a. Prepare a clean work area by covering the area with a clean lint-free cloth.
  - b. Shut down and vent the ETD Module. (See “[Shutting Down the Instrument](#)” on [page 2-7](#).)

**Caution** Shut down and unplug the LTQ Orbitrap Velos ETD before proceeding with the next steps of this procedure. ▲

**Note** Wear clean, lint- and powder-free gloves when you handle parts inside the vacuum manifold. ▲



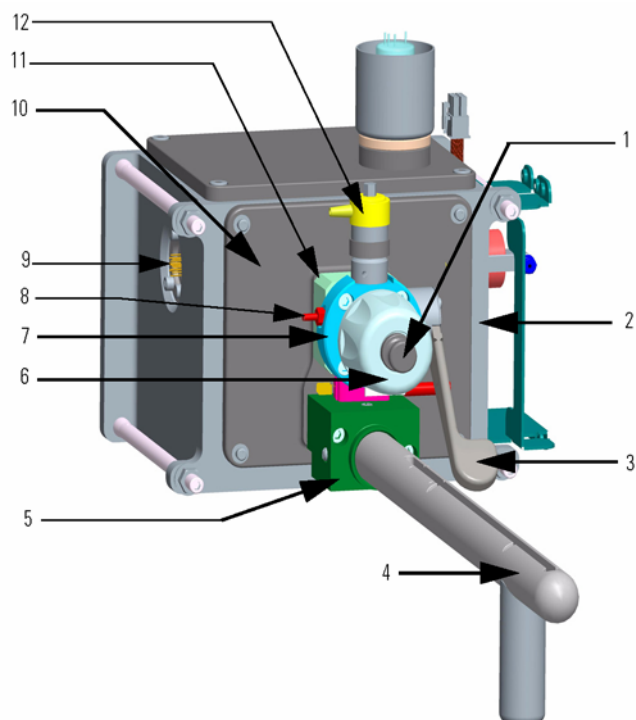
**Warning Burn Hazard.** The ion source may be too hot to touch even if the cooling nitrogen has completed its cycle. Be sure that the ion source has cooled to room temperature before handling it. ▲

2. Remove the ion source assembly:
  - a. Remove the main access panel of the ETD Module (item 1 in [Figure 3-8](#) on [page 3-18](#)). Follow the procedures in “[Removing the ETD Main Access Panel](#)” on [page 3-18](#).

**Caution** It is good practice to keep the inlet valve lever in the down (closed) position whenever it is not explicitly required to be in the up position (open), even if the vacuum manifold is at atmospheric pressure. This is to be consistent with maintenance procedures that rely on the inlet valve lever being closed at the appropriate step to prevent the accidental loss of vacuum. If the vacuum is accidentally lost the system may be damaged. At a minimum, the components that were under vacuum might have to be cleaned. ▲

## User Maintenance

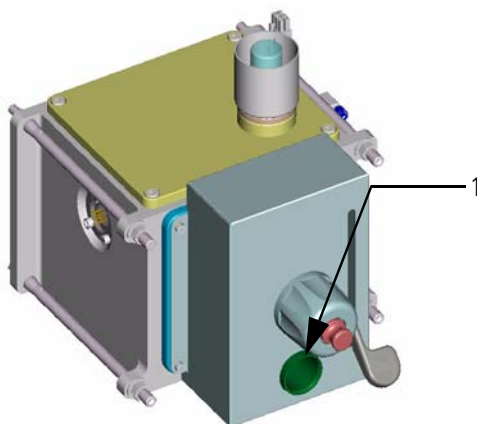
### Maintenance of the ETD Module



Labeled components: 1=inlet valve plug, 2=vacuum manifold, 3=inlet valve lever, 4=guide bar, 5=entry housing, 6=inlet valve knob, 7=inlet valve block, 8=foreline hose connection, 9=12 pin feedthrough, 10=vacuum manifold probe plate, 11=ball valve housing, 12= inlet valve solenoid

**Figure 3-27.** Inlet valve components (ion volume tool not shown)

- b. Remove all connectors between the components on the vacuum manifold probe plate (item #10, [Figure 3-27](#) on [page 3-34](#)) and the ETD Control PCB ([Figure 1-17](#) on [page 1-22](#)).
- c. Remove the valve shield from the vacuum manifold probe plate ([Figure 3-28](#)) by loosening the four screws at the corners of the shield.



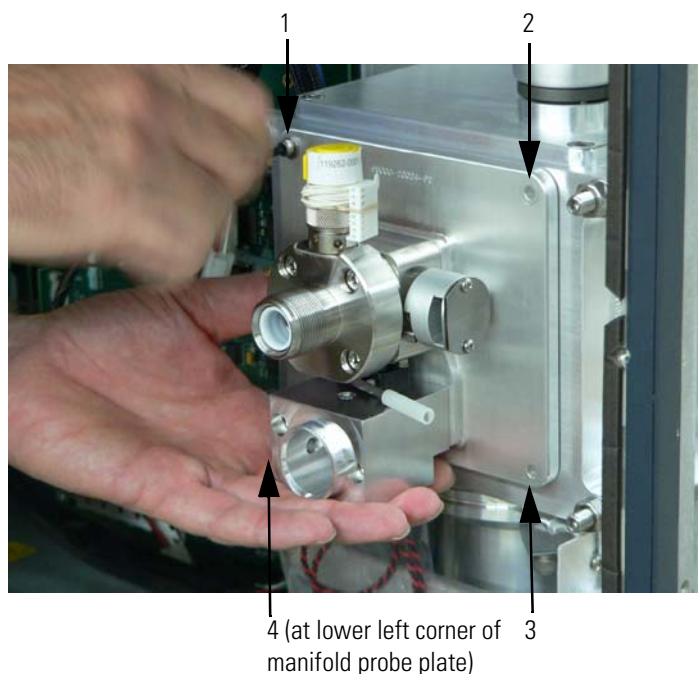
**Figure 3-28.** Valve shield (1) covering the vacuum manifold probe plate

- d. Remove the foreline hose on the source from its connection (Figure 3-29 and item 8 in Figure 3-27).



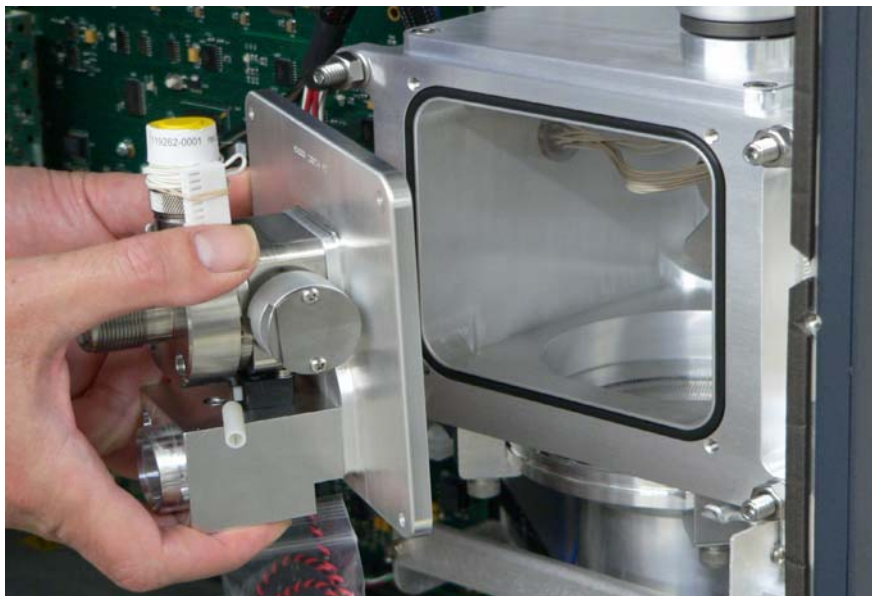
**Figure 3-29.** Removing the foreline hose from its connection

- e. Remove the four screws holding the vacuum manifold probe plate (Figure 3-30 and item 10 in Figure 3-27 on page 3-34). Support the plate with your hand as shown in Figure 3-30. Arrows point to the four hex screw locations (items 1–4).



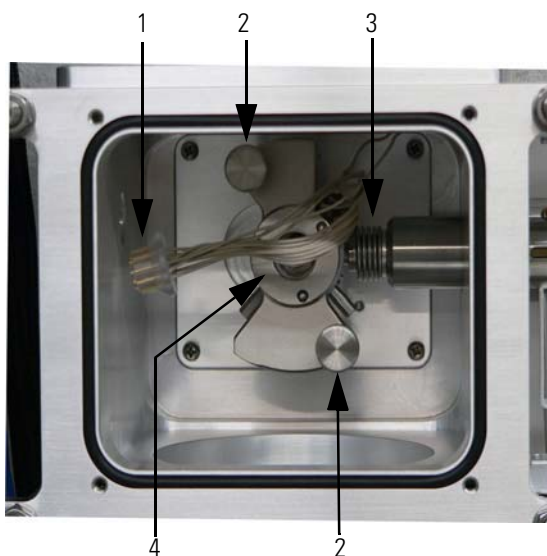
**Figure 3-30.** Unscrewing the vacuum manifold probe plate

- f. Remove the vacuum manifold probe plate (Figure 3-31 on page 3-36).



**Figure 3-31.** Removing the vacuum manifold probe plate

- g. Unplug the 12-pin feedthrough harness from the feedthrough (Figure 3-32).



Labeled components: 1=unplugged 12 pin feedthrough, 2=thumbscrews, 3=transfer line bellows, 4=ion source assembly

**Figure 3-32.** Interior of vacuum manifold

- h. Remove the ion source assembly from the vacuum manifold (Figure 3-33 on page 3-37) by first loosening the ion source thumbscrews (item 2 in Figure 3-32).
- i. Second, as you remove the ion source assembly (item 1 in Figure 3-33) gently shift it to the left (arrow 2 in Figure 3-33) before and while pulling it out. This will allow the ion source

assembly to disengage from the transfer line bellows (item 3 in [Figure 3-33](#)) as it is removed. Alternatively, gently depress the transfer line bellows ([Figure 3-32](#) on [page 3-36](#)) to disengage it from the ion source assembly.



**Figure 3-33.** Removing the ion source assembly from the vacuum manifold\*

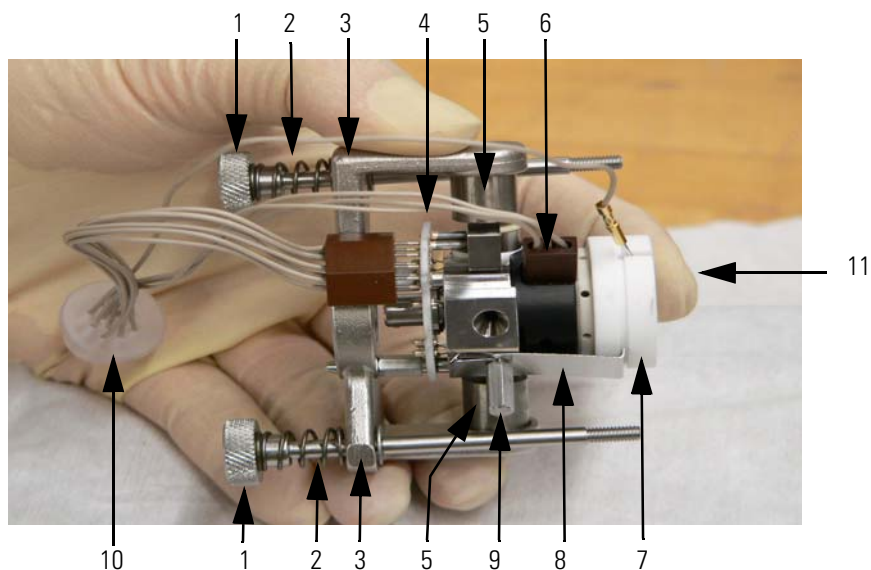
\*The ion source assembly (item 1) is gently shifted to the left (arrow 2) to allow the ion source assembly to disengage from the transfer line bellows (item 3) as it is removed.

The ion source assembly is held together with a clip (item 8 in [Figure 3-34](#) on [page 3-38](#)). However, it is necessary to keep the tips of your gloved fingers on both the front edge of the ceramic lens holder (item 11 in [Figure 3-34](#)) and the back of the magnet yoke (item 3 in [Figure 3-34](#)) when you handle the ion source assembly. This prevents unsecured components inside of the ceramic lens holder from falling out.

**Caution** When handling the ion source assembly, it is important to handle it with gentle finger pressure on each end (as instructed above) to keep unsecured components from falling out of the assembly. ▲

## User Maintenance

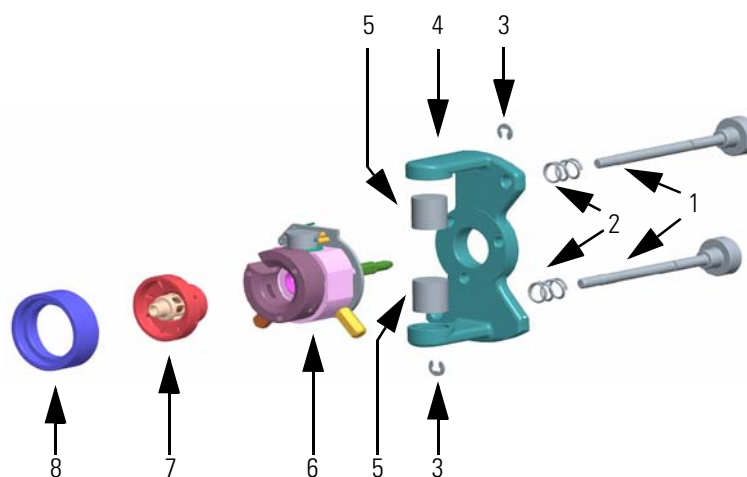
### Maintenance of the ETD Module



Labeled components: 1=thumbscrew, 2=springs, 3=magnet yoke, 4=Ion Source PCB, 5=magnets, 6=ion source block, 7=ceramic lens holder, 8=spring clip, 9=spring clip thumb screw, 10=12 pin feedthrough harness, 11=finger over front edge of ceramic lens holder to keep unsecured components from falling out of the ion source assembly.

**Figure 3-34.** Ion source assembly

An exploded view of the ion source assembly is shown in [Figure 3-35](#).



Labeled components: 1=thumbscrews, 2=springs, 3=E-clips, 4=magnet yoke, 5=magnets, 6=ion source, 7=ion source lens assembly, 8=ceramic lens holder

**Figure 3-35.** Ion source assembly exploded view

3. Separate the magnet yoke and the ion source.
4. Remove the ion source lens assembly from the ceramic lens holder ([Figure 3-35](#)).



5. Clean the ion source lens assembly according to the procedure in [“Cleaning Stainless Steel Parts”](#) on [page 3-14](#). Pay particular attention to the areas inside the tube and around the holes in the lens assembly.
6. Replace the ion source assembly:
  - a. Insert the lens assembly into the ceramic lens holder.
  - b. Reassemble the ion source assembly.
  - c. Reinstall the ion source assembly into the vacuum manifold by following [step 2](#) in reverse order.
7. Restore the ETD Module to operational status. See [“Starting Up the System after a Shutdown”](#) on [page 2-9](#).

## Cleaning the Ion Source Block

If cleaning the ion volume and ion source lens assembly does not restore system performance, you might need to clean the ion source block. Generally, you need to clean the ion source block no more than once every six months.

Supplies needed for cleaning the ion source:

- Cleaning supplies
- Gloves (clean, lint-free, and powder-free)
- Lint-free cloth

### ❖ To clean the ion source block

1. Prepare the ETD Module for maintenance:
  - a. Prepare a clean work area by covering the area with lint-free cloth.
  - b. Shut down and vent the LTQ Orbitrap Velos ETD. (See [“Shutting Down the LTQ Orbitrap Velos Completely”](#) on [page 2-7](#).)

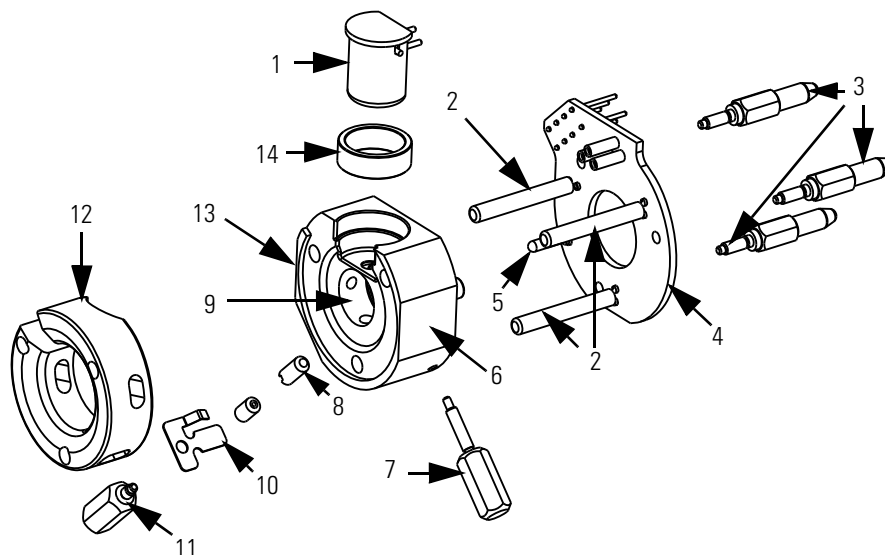
**Caution** Shut down and unplug the LTQ Orbitrap Velos ETD before proceeding with the next steps of this procedure. ▲

- c. Remove the ion source assembly by following the procedures in [step 2](#) in [“Cleaning the Ion Source Lens Assembly”](#) on [page 3-33](#).

**Note** Wear clean, lint- and powder-free gloves when you handle parts inside the vacuum manifold. ▲



2. Disassemble the ion source assembly (Figure 3-34 on page 3-38 and Figure 3-35 on page 3-38), remove and disassemble the ion source (Figure 3-36).
  - a. Remove the magnet yoke and the ion source block with the ion source lens assembly.
  - b. Remove the ion source lens assembly.
  - c. Remove the ion source.



Labeled components: 1=ion source filament, 2=cartridge heaters, 3=base studs (3×), 4=Ion Source PCB, 5=temperature sensor, 6=ion source block, 7=ion volume key thumbscrew, 8=ion volume pin, 9=ion volume, 10=spring clip, 11=spring clip thumb screw, 12=heater ring, 13=sample inlet aperture (in side of item 6), 14=ceramic spacer

**Figure 3-36.** Ion source, exploded view

- d. Remove the three base studs (item 3 in Figure 3-36). Be careful not to damage the leads on the Ion Source PCB (item 4 in Figure 3-36).
- e. Gently remove the Ion Source PCB (item 4 in Figure 3-36) from the ion source by loosening the spring clip thumbscrew (item 11 in Figure 3-36) and the spring clip (item 10 in Figure 3-36) and sliding the three cartridge heaters and the temperature sensor (items 2 and 5 in Figure 3-36) off the ion source and pulling the filament (item 1 in Figure 3-36) straight away from the three filament connectors on the Ion Source PCB. Do not bend or twist the cartridge heaters or temperature sensor.
- f. Remove the filament and ceramic spacer (items 15 and 1 in Figure 3-36) from the ion source block (item 6 in Figure 3-36).

- g. Remove the ion volume key thumbscrew (item 7 in [Figure 3-36](#) on [page 3-40](#)).

**Note** It is not necessary to remove the ion volume pin (item 8 in [Figure 3-36](#)). If you remove it, you should reinsert it just far enough so the ball will keep an ion volume (item 9 in [Figure 3-36](#)) from falling out. If the ball extends too far, the ion volume will be difficult to remove. ▲

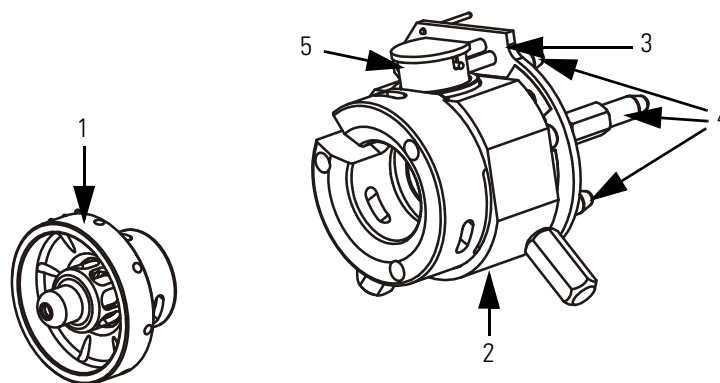
3. Clean the ion source parts and replace the ion source assembly:
  - a. Clean each component of the ion source, as described in “[Cleaning Stainless Steel Parts](#)” on [page 3-14](#) and “[Cleaning Non-Stainless Steel or Hybrid Parts](#)” on [page 3-17](#).
  - b. Reassemble the ion source block.
  - c. Reassemble the ion source assembly.
  - d. Reinstall the ion source assembly into the vacuum manifold by following [step 2](#) of “[Cleaning the Ion Source Lens Assembly](#)” on [page 3-33](#) in reverse order.
4. Restore the ETD Module to operational status. See “[Starting Up the System after a Shutdown](#)” on [page 2-9](#).

## Replacing the Ion Source Filament

The number of ions produced in the ion source is approximately proportional to the filament emission current. If you notice that ion production is low, this might indicate that the filament has failed and needs to be replaced. If the measured emission current is substantially less than the value that the emission current is set to, or if the measured emission current is decreasing over time, then the filament has failed or is failing and needs to be replaced. The ion source filament assembly is shown in [Figure 3-37](#) on [page 3-42](#).

Supplies needed for replacing the ion source filament:

- Filament Assembly DSQ II (P/N 120320-0030)
- Gloves, clean, lint-free, and powder-free
- Protective eyewear
- Lint-free cloth
- Forceps or dental pick



Labeled components: 1=ion source lens assembly, 2=ion source block, 3=Ion Source PCB, 4=base studs (3x), 5=ion source filament

**Figure 3-37.** Ion source lens assembly and ion source

❖ **To replace the ion source filament**

1. Prepare the ETD Module for maintenance.
  - a. Prepare a clean work area by covering the area with lint-free cloth.
  - b. Shut down and vent the LTQ Orbitrap Velos ETD. (See “Shutting Down the LTQ Orbitrap Velos Completely” on page 2-7.)

**Caution** Shut down and unplug the LTQ Orbitrap Velos ETD before proceeding with the next steps of this procedure. ▲

- c. Remove the ion source assembly by following the procedures in step 2 in “Cleaning the Ion Source Lens Assembly” on page 3-33.

**Note** Wear clean, lint- and powder-free gloves when you handle parts inside the vacuum manifold. ▲

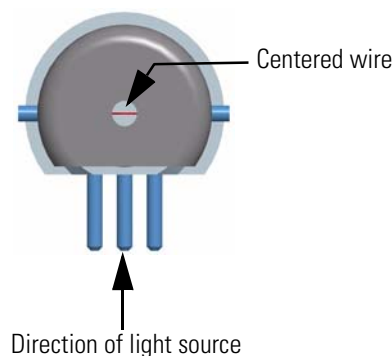
2. Disassemble the ion source assembly (Figure 3-34 on page 3-38 and Figure 3-35 on page 3-38), remove and disassemble the ion source (Figure 3-36 on page 3-40).
  - a. Remove the ion source lens assembly (item 1 in Figure 3-37).
  - b. Remove the three base-studs (item 3 in Figure 3-36, item 4 in Figure 3-37).
  - c. Remove the filament assembly (items 1 and 15 in Figure 3-36, item 5 in Figure 3-37) and ion source block (item 2 in Figure 3-37) from the three filament connectors and cartridge heaters (item 2 in Figure 3-36) on the Ion Source PCB (item 4

in Figure 3-36) according to the procedure in step e of “Cleaning the Ion Source Block“ on page 3-40 .

**Note** Now is a good time to clean the ion volume and ion source lenses. ▲

3. Inspect and install a new filament assembly:
  - a. Turn the filament assembly over and, using a strong light and a magnifying glass, verify that the filament wire is centered in the electron lens hole. If necessary, carefully use forceps (or a dental pick) to adjust the filament wire. Figure 3-38 shows the centered filament wire as seen from the bottom of the filament through the electron lens hole.

**Note** A bent filament can lead to a low or absent anion signal. If the filament wire is bent, not centered, or otherwise damaged, you must replace the filament assembly. ▲



**Figure 3-38.** Filament wire as seen from the bottom of the filament through the electron lens hole

- b. Insert the filament into the ceramic spacer of the ion source block (item 14 in Figure 3-36 on page 3-40).
  - c. Align the filament leads with the Ion Source PCB connectors and gently press the leads into the connectors. Normally, there is a small gap (about 0.020 in or 0.50 mm) between the filament and the connectors. The gap allows the ceramic filament centering ring (spacer) to properly position and align the electron lens hole with the ion volume.
  - d. Reinstall the three base-studs (item 3 in Figure 3-36, item 4 in Figure 3-37 on page 3-42).
4. Reassemble ion source and ion source assembly.
5. Insert the ion source assembly into the vacuum manifold.

- Restore the ETD Module to operational status. See “Starting Up the System after a Shutdown” on page 2-9.

**Note** Tune Plus provides an evaluation procedure for CI gas pressure under **Diagnostics > Diagnostics > Tools > System evaluation > Reagent CI gas pressure evaluation**. Thermo Fisher Scientific recommends performing this procedure after replacing the filament and/or the ion volume. ▲

## Replacing Inlet Valve Components

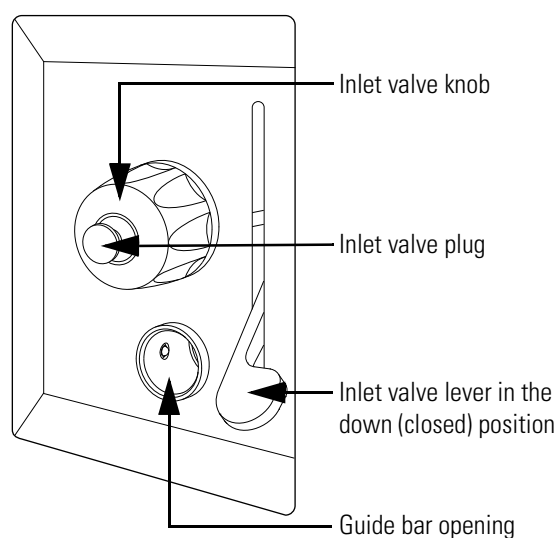
This topic provides the procedure for replacing inlet valve components. Perform this procedure when the inlet valve seal or the inlet valve is being replaced.

Tools and supplies needed for replacing inlet valve components:

- Inlet Valve Seal Kit (P/N 119265-0003)
- Lint-free cloth
- Wrench, open-ended, 5/16-in
- Wrench, Allen, 4 mm

### ❖ To replace inlet valve components

1. Pull down the inlet valve lever to close the inlet valve. See [Figure 3-39](#).



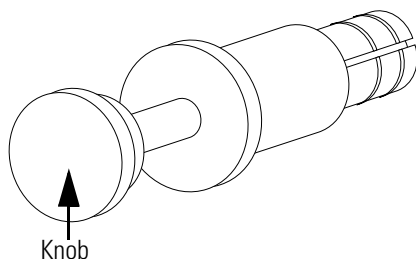
**Figure 3-39.** Inlet valve components

2. Rotate the inlet valve knob counter-clockwise until you can easily remove the inlet valve plug.

3. Continue to rotate the valve knob until you can remove it.

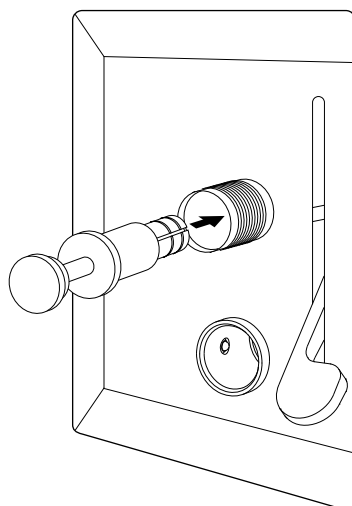
The inlet valve knob has a stainless-steel ferrule inside. Keep the inlet valve knob and ferrule together.

4. Pull out the knob on the inlet valve seal tool (P/N 119283-0001)<sup>1</sup>, so that the knob is loose. See [Figure 3-40](#).



**Figure 3-40.** Inlet valve seal tool

5. Insert the tool straight into the inlet valve. See [Figure 3-41](#).



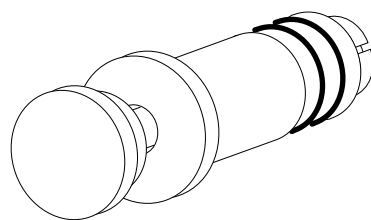
**Figure 3-41.** Inlet valve seal tool inserted in the inlet valve

**Caution** Do not scratch the surface of the seal. Use only the inlet valve seal tool to remove or install an inlet valve seal. ▲

6. Press in the knob on the tool until it stops.
7. Remove the tool. The inlet valve seal should be on the tool. See [Figure 3-42](#) on [page 3-46](#).

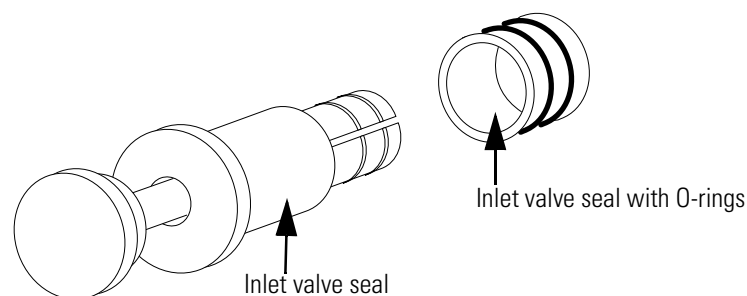
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<sup>1</sup>Item contained in Inlet Valve Seal Kit (P/N 119265-0003).



**Figure 3-42.** Inlet valve seal on the inlet valve seal tool

8. Loosen the knob to disengage the seal. See [Figure 3-43](#).



**Figure 3-43.** Inlet valve seal disengaged from tool

9. Discard the seal with its O-rings in place.
10. Place one O-ring (P/N 3814-6530)<sup>1</sup> into each of the two slots on the inlet valve seal (P/N 119683-0100)<sup>1</sup>.
11. Place the new inlet valve seal onto the inlet valve seal tool.
12. Insert the inlet valve seal tool into the inlet valve into it stops.
13. Remove the tool. The O-rings on the valve seal secure the inlet valve seal in the opening.
14. Reinstall the ferrule, knob, and plug into the inlet valve opening.

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<sup>1</sup>Item contained in Inlet Valve Seal Kit (P/N 119265-0003).



## Changing the Reagent Vials

A significant drop of the  $m/z$  202 signal within one hour with the mission current at the correct level indicates a low reagent supply. In this case, you should replace the fluoranthene vial.

Changing the reagent vials requires that the LTQ Orbitrap Velos ETD be placed in Service mode after the vials have cooled. (Vial cooling is done in Off condition.) See the following sections for procedures to be used to change the reagent vials:

- [“Placing the Instrument in Off Condition and Service Mode”](#) on page 3-47
- [“Installing/Exchanging the Reagent Vials”](#) on page 3-50

The ETD reagent vials are designed to keep the ETD reagent out the lab environment. Removal and replacement of the ETD reagent vials when they are not empty causes excessive puncturing of the septums and reduces their integrity. This could result in ETD reagent (fluoranthene) entering the lab environment. Prevent this from occurring by removing and replacing the ETD reagent vials only when they are empty.

**Caution** To preserve the integrity of the ETD reagent vial septums, remove and replace the ETD reagent vials only when they are empty. Do not reinstall used vials. ▲

**Note** Store and handle all chemicals in accordance with standard safety procedures. The Material Safety Data Sheet (MSDS) describing the chemicals being used should be freely available to lab personnel for them to examine at any time. Material Safety Data Sheets (MSDSs) provide summarized information on the hazard and toxicity of specific chemical compounds.

MSDSs also provide information on the proper handling of compounds, first aid for accidental exposure, and procedures for cleaning spills or dealing with leaks. Producers and suppliers of chemical compounds are required by law to provide their customers with the most current health and safety information in the form of an MSDS. Read the MSDS for each chemical you use. Dispose of all laboratory reagents in the appropriate manner (see the MSDS). ▲

Safety information about fluoranthene is given in [Appendix A: “Fluoranthene”](#).

## Placing the Instrument in Off Condition and Service Mode

The power switches control power to the LTQ Orbitrap Velos ETD (MS and ETD Module). The ETD Module power switches control the power to the ETD Module only. When the LTQ Orbitrap Velos ETD is

fully operational (all systems On), the MS Main Power switch is in the On position and the FT Electronics switch is in the operating (On) position.

Normally, the ETD Module Power and Service switches remain On. Use the FT Electronics switch on the MS unit to place the LTQ Orbitrap Velos ETD in Service mode. Turn On and Off the instrument (both ETD Module and MS) with the MS Main Power switch.

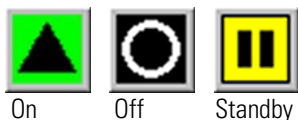


**Warning Burn Hazard.** When mass spectrometer and ETD Module system are turned On, the flow restrictor, the transfer line heaters, and the ion source heater can be at 160 °C. The vial heaters can be at 108 °C (or set point). Do not attempt to replace reagent vials or to service heated components until you have determined that they have cooled to a safe temperature for handling. ▲

**Note** The instructions that follow assume that no analyte is flowing into the API source. ▲

❖ **To place the LTQ Orbitrap Velos ETD in Off Condition and Service mode and to verify that the vials are safe to handle**

1. If the Tune Plus window is not already open, choose **Start > Programs > Thermo Instruments > LTQ > LTQ Tune** from the taskbar. The Tune Plus window appears. (See [Figure 3-10](#) on page 3-22.)



You can determine the state of the MS detector by observing the state of the On/Standby button on the Control/Scan Mode toolbar. The three different states of the On/Standby button are shown at the left.

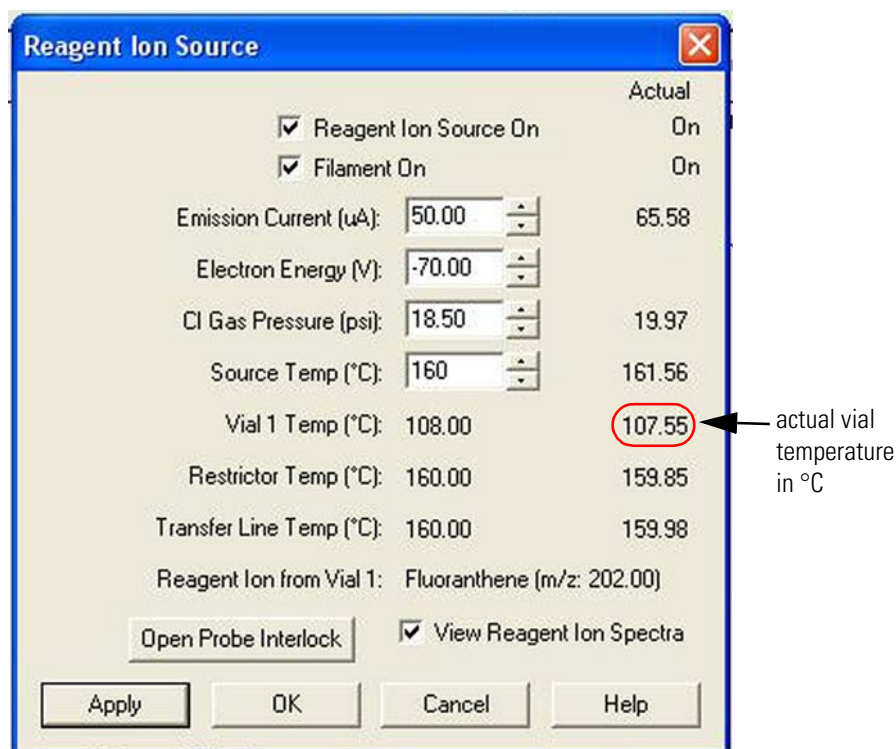
2. Choose **Control > Off** from the Tune Plus pull-down menu to place the system in Off condition. When the MS detector is in Off condition, the LTQ Orbitrap Velos ETD turns off the ion source sheath gas, auxiliary gas, high voltage, and all of the ETD Module heaters.

**Note** It is important to choose **Control > Off** from the Tune Plus pull-down menu in order to shut down all of the ETD Module heaters. ▲



3. Click the reagent ion source portion of the instrument control icon at the top of the Tune Plus window. The Reagent Ion Source dialog box appears ([Figure 3-44](#)).

Observe the temperature of Vial 1 in the Actual column of the Reagent Ion Source dialog box (Figure 3-44). Nitrogen cooling gas will flow until the vial reaches 70 °C. (See “Turning Off the Reagent Ion Source: What to Expect” on page 2-14.) Allow up to 90 minutes for the vial temperature to reach ambient temperature (about 30 °C).



**Figure 3-44.** Reagent Ion Source dialog box



**Warning Burn Hazard.** Do not attempt to handle the vials or vial holders when the cooling nitrogen stops. They are still too hot to handle when the cooling nitrogen stops at a vial temperature of 70 °C. Allow the vials to cool to about 30 °C (allow up to 90 minutes after the cooling gas stops) before proceeding with the next step and handling the vials. ▲

4. Toggle the FT Electronics switch to Service mode (Off) when the vial has reached a temperature that is safe for handling (about 30 °C). Toggling the FT Electronics switch to Service mode turns off all components except the turbopumps and the forepumps in both the mass spectrometer and the ETD Module.

**Note** Do not place the ETD Module Service switch into its Service mode (Off) position while the MS switches are left in their On positions. This could cause communication problems between the MS and the ETD Module. The ability to control the Service mode for both the MS and the ETD Module at one point (at the FT Electronics switch) is a safety feature. ▲



**Warning Burn Hazard.** Do not place the system in Service mode until the vials reach a safe temperature (about 30 °C). System temperature monitoring will stop when the system is placed in Service mode. Do not attempt to handle the vials, the vial holders, or the heater assembly until a safe temperature is reached (about 30 °C). ▲

The LTQ Orbitrap Velos ETD is now in Service mode and the vials are at a safe temperature for handling.

## Installing/Exchanging the Reagent Vials

After the reagent vial heaters have cooled to room temperature, the reagent vials are ready to be installed or exchanged.

### ❖ To install or exchange the reagent vials

1. Remove the back panel from the ETD Module. (See “[Removing the ETD Main Access Panel](#)” on [page 3-18](#).) This exposes the reagent inlet source heating unit, which has its own cover ([Figure 3-45](#) on [page 3-51](#)).

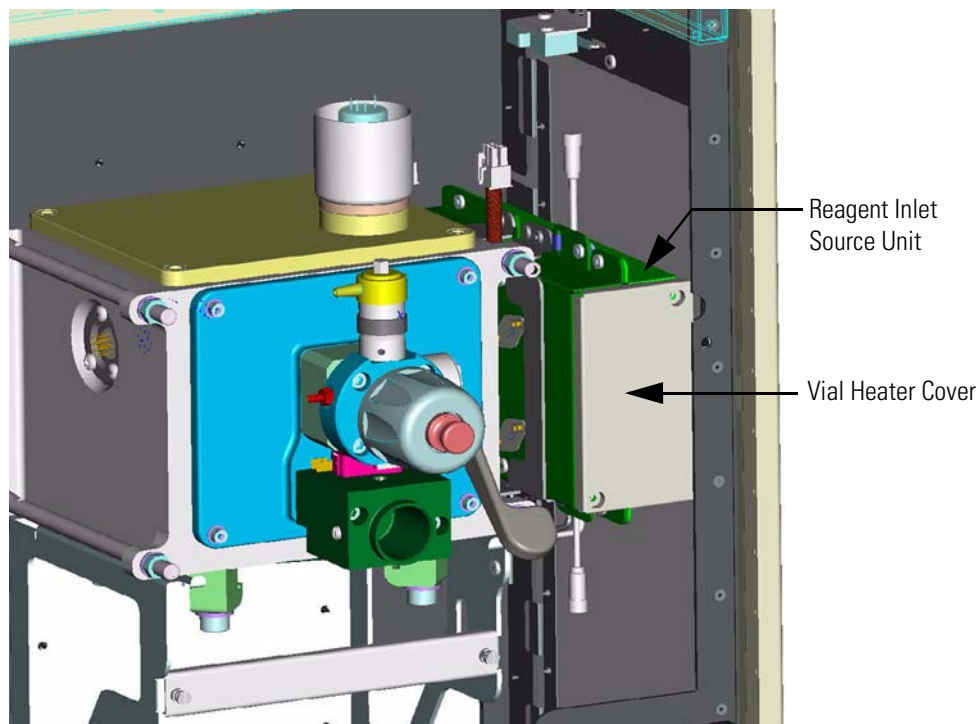


**Warning Burn Hazard.** Follow the procedures described in “[Placing the Instrument in Off Condition and Service Mode](#)” on [page 3-47](#) before removing the back panel of the ETD Module. Removing the back panel before the system is placed in Service mode will open the panel electrical interlocks and stop all system activity including temperature monitoring. In the absence of temperature monitoring, you might attempt to handle the vials before it is safe to do so. ▲

2. Make sure that the vial heater cover is cool to the touch.



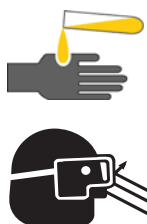
**Warning Burn Hazard.** The vial heaters can be at 108 °C (or set point). Allow sufficient time for the vials to cool (up to 90 minutes) and then place the system in Service mode. (See “[Placing the Instrument in Off Condition and Service Mode](#)” on [page 3-47](#).) Verify that the vial heater cover is safe to handle before attempting to remove the vial holders and reagent vials. ▲



**Figure 3-45.** ETD Module with back panel removed

3. Put on a pair of new, white nitrile clean room gloves and protective eye wear.
4. Using a Phillips screwdriver, remove the screws in the vial heater cover. The vial heater cover is located on the right side of the ETD Module as you view it from the back of the LTQ Orbitrap Velos ETD (Figure 3-45).
5. Remove the vial holder by gently pulling it out of the vial heater.
6. Remove the empty vial if it is present. The vial holder is a cylindrical tube with a handling knob at one end and ribs along its length. See Figure 3-46. These ribs prevent the vial holder from rotating once it is placed into the vial heater. Figure 3-47 on page 3-52 shows the tab and ribs of a vial holder in the vial heater.

**Note** Dispose of an empty fluoranthene vial in accordance with its MSDS. ▲

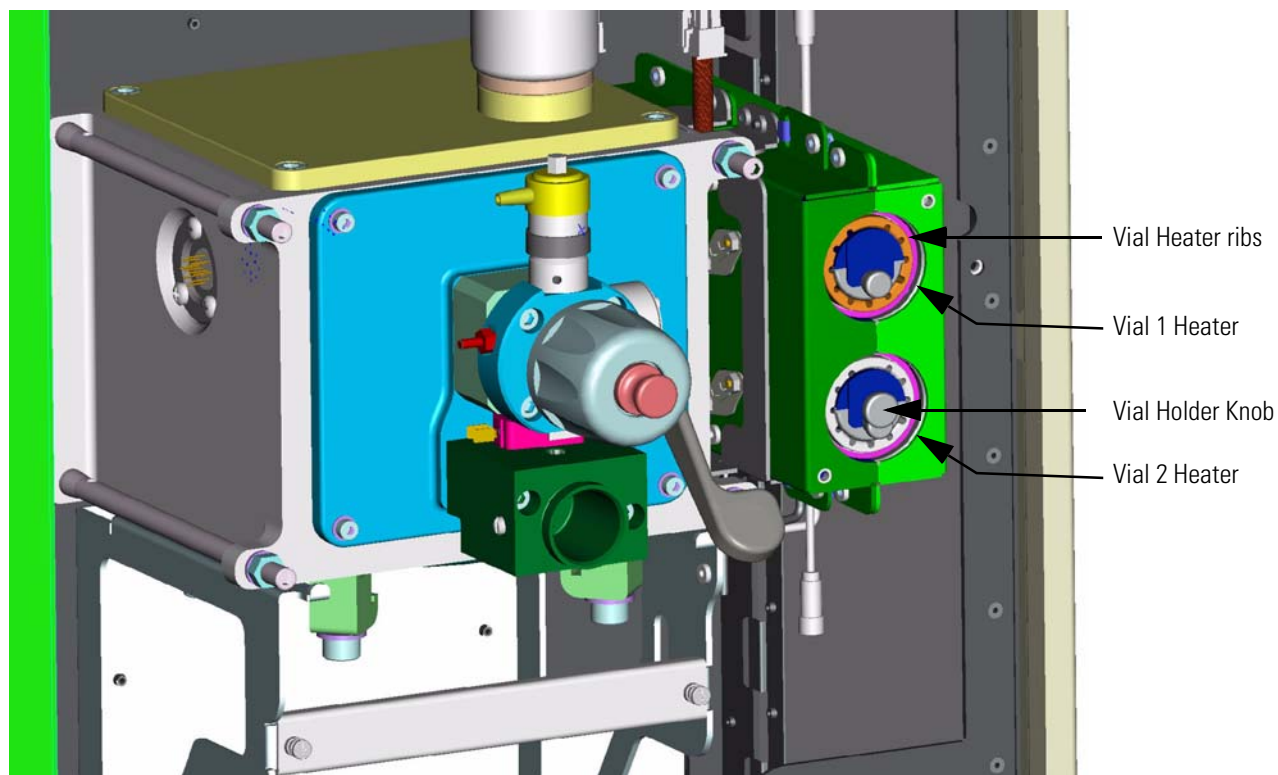


**Warning** Avoid exposure to potentially harmful materials. Always wear protective gloves and safety glasses when you handle solvents or corrosives. Also contain waste streams and use proper ventilation. Refer to your supplier's Material Safety Data Sheet (MSDS) for proper handling of a particular compound. ▲



**Figure 3-46.** Reagent vials with holders

7. Take a vial containing the ETD reagent (fluoranthene) from its box and remove the aluminum tab from the top of the vial's crimp seal.
8. Put the vial into a vial holder.



**Figure 3-47.** ETD Module with vial heater cover removed



9. Place this ETD reagent vial and its vial holder into the Vial 1 heater (top vial heater). Gently slide the vial holder into the vial heater.
10. Place the empty vial from the box into the other vial holder if an empty vial is not already installed.
11. Place this empty vial and its vial holder into the Vial 2 heater (bottom vial heater) if an empty vial is not already installed.



**Warning** The empty vial in the Vial 2 heater is an integral part of the carrier/CI gas system. It is necessary to keep the carrier/CI gas system closed to the laboratory. If no vial is placed in the Vial 2 heater:

- The carrier/CI gas containing the reagent might escape to the laboratory causing a safety problem.
- The ETD Module will not operate correctly and the filament will burn out. ▲

12. Reinstall the vial heater cover over the vial heaters.
13. Reinstall the back panel of the ETD Module. See “[Removing the ETD Main Access Panel](#)” on [page 3-18](#). The ETD Module will not turn on unless the back panel is installed.
14. Start the system:
  - a. Toggle the FT Electronics switch to the On position. The system will boot to Standby mode. Then ion source heater, flow restrictor, and transfer line heaters will start heating. Monitor these temperatures in the Status View on the right side of the Tune Plus window. (See [Figure 3-10](#) on [page 3-22](#).) They will have green check marks when they have reached their operating temperatures.
  - b. Select the Reagent Ion Source On check box in the Reagent Ion Source dialog box when the ion source heater, flow restrictor, and transfer line heaters are at their operating temperatures. (See [Figure 3-44](#) on [page 3-49](#).)

The LTQ Orbitrap Velos ETD is now ready for use.

## Changing the Reagent Ion Source Flow Restrictors

### ❖ To change the reagent ion source flow restrictors

1. Shut down completely the instrument according to the procedures in “[Shutting Down the LTQ Orbitrap Velos Completely](#)” on [page 2-7](#).





**Warning Burn Hazard.** The reagent vial heaters can be 108 °C (or set point), the flow restrictor, the transfer line heaters, and the ion source heater can be at 160 °C. These components may be too hot to touch. Verify that all of these components are safe to touch before handling them. ▲

2. Remove the ETD side access panel according to the instructions in “Removing the ETD Side Access Panel” on page 3-19.

**Caution** The ETD side access panel is interlocked with the ETD Module power. When the ETD side access panel is removed, all power to the ETD Module will be turned off. ▲

3. Remove the four screws that hold the reagent inlet cover in place.



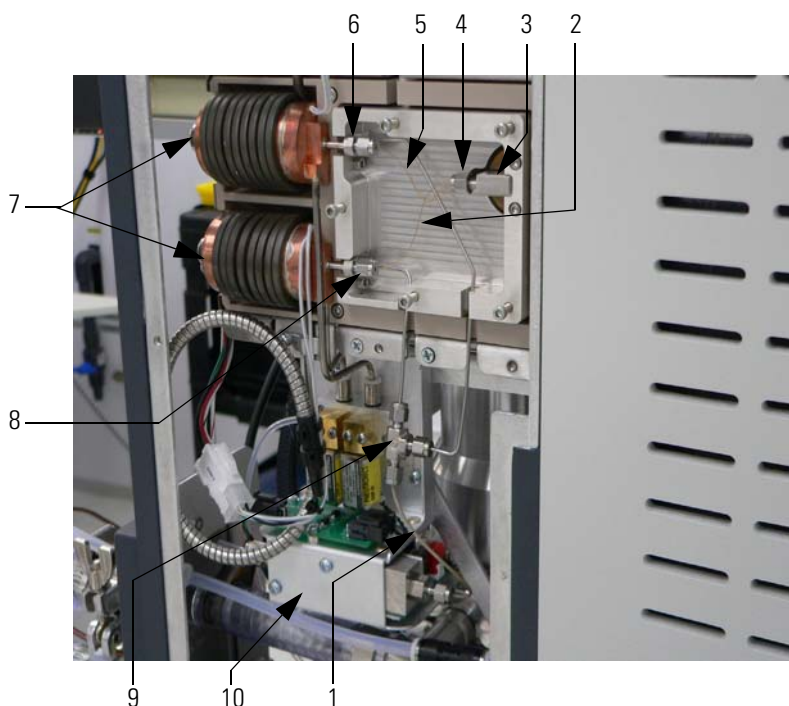
**Warning Burn Hazard.** The reagent inlet cover may be too hot to touch. Verify that the reagent inlet cover is at or near room temperature before handling it. ▲

4. Remove the five screws that hold the restrictor oven cover in place.



**Warning Burn Hazard.** The restrictor oven cover may be too hot to touch. Verify that the restrictor oven cover is at or near room temperature before handling it. ▲

5. Replace both fused silica restrictors and their ferrules by removing their Swagelok® nuts. See [Figure 3-48](#).



Labeled components: 1=PEEKsil<sup>®</sup> tubing, 2=fused silica tubing from lower oven, 3=transfer line inlet, 4=Swagelok fitting with two hole ferrule, 5=fused silica tubing from upper oven, 6=upper oven Swagelok fitting with a single hole ferrule, 7=vial 1 (upper) and vial 2 (lower) heaters, 8=lower oven Swagelok fitting with a single hole ferrule, 9=Tee below reagent inlet assembly, 10=gas valves

**Figure 3-48.** Reagent inlet assembly

6. Thread two pieces of fused silica tubing (P/N 98000-20060) into the two hole ferrule (P/N 00101-08-00006) from the Installation Kit for the Reagent Inlet Module (P/N 98000-62006). Place a Swagelok fitting over the ferrule.
7. Insert the two hole ferrule and Swagelok fitting from [step 6](#) onto the transfer line inlet (item 3 in [Figure 3-48](#)) and tighten the Swagelok fitting.
8. Thread the opposite end of one of the pieces of fused silica tubing into a single hole ferrule. Place a Swagelok fitting over the ferrule.
9. Insert the ferrule and Swagelok fitting from [step 8](#) on to one of the oven outlets (items 6 or 8 in [Figure 3-48](#)) and tighten the Swagelok fitting.

**Caution** Do not overtighten the ferrules. The ferrules may loosen after they are first heated. If this occurs retighten them if necessary. ▲

10. Repeat [step 9](#) for the other oven.

11. Replace the restrictor oven cover and reagent inlet cover removed in [step 3](#) and [step 4](#).
12. Loosen the Swagelok fitting connecting the PEEKsil® tubing (item 1 in [Figure 3-48](#)) to the Tee below the reagent inlet assembly (item 9 in [Figure 3-48](#)) and from the gas valves (item 10 in [Figure 3-48](#)).
13. Replace the old PEEKsil tubing with new PEEKsil tubing (P/N 00109-02-00020) from the Installation Kit for the Reagent Inlet Module (P/N 98000-62006).
14. Close the ETD Module and restart the instrument. Follow the procedures given in [“Starting Up the System after a Shutdown”](#) on [page 2-9](#).

## Cleaning the Fan Filters of the ETD Module

You need to clean the fan filters every four months. The fan filters are located at the rear of the ETD Module on the left side (as viewed from the back of the ETD Module). See [Figure 3-49](#).



**Figure 3-49.** ETD Module, top panel

### ❖ To clean the fan filters of the ETD Module

1. Remove the fan filter from the rear of the ETD Module by pulling it out of the fan filter bracket.
2. Wash the fan filters in a solution of soap and water.
3. Rinse the fan filters with tap water.
4. Squeeze the water from the fan filters and allow them to air dry.
5. Reinstall the fan filter in the fan filter bracket.

## Maintenance of the Recirculating Chiller

For the NESLAB ThermoFlex™ 900 recirculating chiller, the checks described in this section should be carried out on a regular basis.

**Note** For further information and maintenance instructions, refer to the manufacturer's manual supplied with the instrument. ▲

### Reservoir

Periodically inspect the fluid inside the reservoir. If cleaning is necessary, flush the reservoir with a cleaning fluid compatible with the circulating system and the cooling fluid.

The cooling fluid should be replaced periodically. Replacement frequency depends on the operating environment and amount of usage.



**Warning Burn Hazard.** Before changing the operating fluid make sure it is at safe handling temperature. ▲

### Fluid Bag Filter

The ThermoFlex 900 recirculating chiller installed in the cooling circuit of the instrument is equipped with a fluid bag filter, which needs to be replaced on a regular basis. Replacement bags are available from Thermo Fisher Scientific.

### Condenser Filter

To prevent a loss of cooling capacity and a premature failure of the cooling system, clean the condenser filter regularly. If necessary, replace it.



## Chapter 4 Replaceable Parts

This chapter contains part numbers for replaceable and consumable parts for the MS detector, data system, and kits. To ensure proper results in servicing the LTQ Orbitrap Velos system, order only the parts listed or their equivalent.

**Note** Not all parts are available for purchase separately. Some parts may only be available for purchase as part of a kit or assembly. ▲

For information on how to order parts, see “[Contacting Us](#)” in the front section of this guide.

## **Ion Sources**

ESI probe, for Ion Max source . . . . .	OPTON-20011
Low flow metal needle for API 2 probes . . . . .	OPTON-30004
Nanospray II Ion Source . . . . .	OPTON-20050
Static Nanospray . . . . .	OPTON-20051
Dynamic Nanospray . . . . .	OPTON-97017
APCI probe . . . . .	OPTON-20012
APPI probe . . . . .	OPTON-20026
HESI-II Probe Kit . . . . .	OPTON 20037
High-flow needle insert assembly . . . . .	OPTON-53010
Low-flow needle insert assembly . . . . .	OPTON-53011



## Parts for the Basic System

### Orbitrap Installation Kit

Tube, 1/8" × 2.1- 1.4301 . . . . .	.0261000
Ferrule, stainless steel; R. 1/8" . . . . .	.0520950
Ferrule, stainless steel; V. 1/8" . . . . .	.0522520
Cap nut, stainless steel; 1/8" . . . . .	.0520890
Fitting KJH06-00. . . . .	.1221620

### Pumping System

For a schematical overview of the pumping system, see [Figure 1-23](#) on [page 1-30](#).

T-piece 13 mm . . . . .	.0512360
Hose 13 × 3.5; PVC . . . . .	.0690720
Turbomolecular pump TMU262; modified . . . . .	.1184340
Turbomolecular pump; TMH 071 P . . . . .	.1141500
UHV gauge IKR 270; short . . . . .	.1181380
Compact Pirani Gauge TPR280. . . . .	.1156400
Water cooling for TMH 262 . . . . .	.1149140
Water cooling for TMH 071 P. . . . .	.0794742
PVC hose, with steel helix; ID=45 mm, L=1.6 m. . . . .	.1184330
Hose nipple, DN 40, ISO-KF-45. . . . .	.1159230
Venting flange; DN 10, KF-G1/8" . . . . .	.1184400
Splinter shield for turbopumps, with DN 100 CF-F flange . . . . .	.1198590
Centering ring, with integrated splinter shield; DN 63 ISO . . . . .	.1198600
Anti-magnetic cover for IKR 270 . . . . .	.1181390
Gasket; NW 100 CF, copper . . . . .	.0552440
Hose, metal; KF16-KF25 - 250mm . . . . .	.1154130
Gasket; copper, NW 35 . . . . .	.0550480
Metal tube, KF NW16×250. . . . .	.0524260
KF Tee piece; NW 16 KF, stainless steel . . . . .	.0524230
Centering ring with o-ring; DN 16, Viton . . . . .	.0522140
Centering ring with o-ring; DN 25, Viton . . . . .	.0522150
Centering ring; NW 16/10, aluminum-Viton . . . . .	.0522200
Clamping ring; NW 10/16, KF . . . . .	.0521830
Clamping ring; NW 20/25, KF . . . . .	.0521560
Reducing cross piece; DN40/DN16 KF. . . . .	.1184310
Metal tube; DN40x500 . . . . .	.1184350
Metal tube; DN40x750 . . . . .	.1181290
Hose clamp; NW 40 . . . . .	.1181320
Centering ring; NW 40 KF, aluminum-Viton . . . . .	.0522260
Tension ring; NW 32/40 KF . . . . .	.1181250
Clamping screw; DN63-100 ISO, aluminum. . . . .	.1042670
Flexible metal hose KF NW 16x500. . . . .	.0534500

## Water Supply

For a schematical overview of the gas supply, see [Figure 1-28](#) on [page 1-37](#).

Quick coupling insert; 9.6 mm	1141640
Quick coupling body; 9.6 mm.	1138960
Hose; 9 x 3, black, PVC	1049540
Hose; 6 x 1, Teflon	1042660
Quick coupling insert; Delrin Acetal, NW 6.4	1185030
Quick coupling body; Delrin Acetal, NW 6.4.	1185020
Clamping piece 8/16	0370130
Adaptor hose nipple; male, 1/2 x 10	1185840
Flow control sensor	1191740

## Gas Supply

For a schematical overview of the cooling water circuit, see [Figure 1-32](#) on [page 1-42](#).

Bulkhead union; 1/16", for hose 4 x 1 (for P/N 069 1130)	1153660
Bulkhead union; 1/8" x 1/8"	0523450
Hose; 4 x 1, Teflon	0690280
Hose; 4 x 1, polyurethane, blue	0691130
Capillary 1/16" ID-SS	0605470
Plug-in T-piece; 3 x 6mm	1128140
Regulator + manometer f. Orbitrap	1257670
Capillary; 1/16" x 0.13 x 400mm (red), PEEK	1253830
Coupling; 1/16", SS-100-6	0524340
Ferrule; 1/16" GVF 16-000	1121110
Reducer Swagelok; 1/8" x 1/16", stainless steel	0662880
Ferrule; 1/16" GVF/16	0674800
Connector 1/8", for hose OD 4 mm	1128680
Cap nut; 1/16", stainless steel	0520880
Hose; 2 x 1, PTFE	1091650
Sleeve; Ø 6 mm	1047320
Capillary; PEEKsil, 1/16", 0.1 x 500 mm	1223420
Plug, KQ2P-06	1185620
Cap, KQ2C-06	1258220

## Parts Lists for the ETD System

This section contains parts lists for the components of the ETD System of the LTQ Orbitrap Velos ETD.

Quadrupole Orbitrap, complete . . . . .	1239200
Housing HCD/ETD . . . . .	1231740
Separating plate HCD/ETD . . . . .	1231770
Screw M 4 x 8 DIN912 . . . . .	1044420
O-ring 129 X 4 A Viton . . . . .	1240520
Lid HCD/ETD . . . . .	1231760
Screw-in connector; 1/16" . . . . .	1186150
Gasket; NW 63 ISO, aluminum/Viton . . . . .	0554060
Blank flange; stainless steel, NW 63 . . . . .	0652620
Clamping screw; DN63-100, aluminum . . . . .	1028380
Washer 8.4; stainless steel . . . . .	0470070
Screw, hexagonal; M 8 x 35, stainless steel . . . . .	0454400
Washer 8.4 x 11 x 1.5, stainless steel . . . . .	0470860
Screw M8 x 35; stainless steel . . . . .	0454250
Centering ring NW 16 Viton . . . . .	0522140
Feedthrough; 8-fold 1,5kV DN16KF . . . . .	1231750
O-ring; 118 X 5 A, Viton . . . . .	1168240
Box f. feedthrough; KF16 / Sub-D9 . . . . .	1231800
Cylindrical Screw ISO4762-M6X12-A4 . . . . .	0453300

### Vacuum system ETD

Flange clamp; KF16 . . . . .	1145860
Turbopump TMH 071 P . . . . .	1141500
Splinter guard, DN_63_ISO . . . . .	1198600
Water cooling, for TMH 071 P . . . . .	0794742
Metal hose, DN 16 ISO-KF x500 . . . . .	1181410
Centering ring with o-ring; DN 16, Viton . . . . .	0522140
Clamping ring; NW 10/16, KF . . . . .	0521830
Hose flange; NW 25 KF . . . . .	1042330
Centering ring, with o ring; DN 25, Viton . . . . .	0522150
Clamping ring, DN 25 . . . . .	0521560
Flange, KF16 - hose OD 19 . . . . .	1239340
Reducer; DN 16/DN 25, aluminum . . . . .	0522160
PUMP, ROTARY VANE, EDWARDS RV3 . . . . .	00108-01-0008
KIT, ACCESSORY, MECHANICAL PUMP, RV3 . . . . .	98000-620007

### Gas Supply ETD

Plug-in T-piece; 3 x 6mm . . . . .	1128140
Sleeve 6 mm . . . . .	1047320
Reducing hose connector, 3.2->6 . . . . .	1239220
Hose cutter . . . . .	1239280
T-piece 13 mm . . . . .	0512360
Hose 9 X 3; PVC, black . . . . .	1049540

## Replaceable Parts

Parts Lists for the ETD System

Clamping piece 8/16 . . . . .	0370130
Hose; 4 X 1, Teflon . . . . .	0690280
Clamping ring; stainless steel, NW10/16. . . . .	1149200
PEEK capillary; 1/16" x 0.040. . . . .	1245940
Ferrule, 1/16", for GVF/16 . . . . .	0674800
Ferrule 1/16" - CTFE, collapsible . . . . .	1224700

## Electronic Parts ETD

Cable Y-ADAPTER/T.PUMP . . . . .	2108630
Coupling; RJ45 BU/2BU . . . . .	2075210
Patch cable; 0.51MT RJ45 gray SFTP . . . . .	2080870
Cable POWER DIS./T-PUMP . . . . .	2081200
Cable CLT-OFFSET-A . . . . .	2108710
Cable IOS ETD/ION OPTIC-S . . . . .	2108820
UNIT_ION OPTIC SUPPLY ETD . . . . .	2108920
PCB LTQ CABLE DRIVER. . . . .	2097780
PCB ORBITRAP CABLE RECEIVER. . . . .	2097830
PCB ETD CABLE RECEIVER . . . . .	2097800
Cable ETD/LTQ/ORBITRAP-INTERCONNECT 60 . . . . .	2108940
Cable ETD/LTQ/ORBITRAP-INTERCONNECT 36 . . . . .	2108950
Cable ETD/LTQ/ORBITRAP-INTERCON SUPPLY . . . . .	2108960
Coaxial cable; ETD IOS/ANALOG CTRL, J5554 . . . . .	2108990
Coaxial cable; ETD IOS/ANALOG CTRL, J5555 . . . . .	2109000
Coaxial cable; ETD IOS/ANALOG CTRL, J5556 . . . . .	2109010
Cable ANALOG CTRL / ETD IOS . . . . .	2108970
Cable ETD IOS/HCD multipole . . . . .	2108980
Extension cable; 16A C20-C19 2M . . . . .	2097050
ADAPTER_IOS/MULTIPOLE-HCD . . . . .	2100410

## Reagent Inlet Module

ASSY, TOOL, ION VOLUME INSERTION/REMOVAL . . . . .	98000-60028
TUBING, PEEKsil, 1/16" OD, 100mm LONG, RoHS. . . . .	00109-02-00020
FRLE, 1HOLE, 1/16 OD, 0.4mm ID, VESP/GRPHT, RO .00101-08-00005	
FRLE, 2HOLS, 1/16 OD, 0.4mm ID, VESP/GRPHT, RO .00101-08-00006	

## Inlet Valve Seal Kit. . . . . 119265-0003

Inlet valve seal removal tool. . . . .	119283-0001
Spool inlet valve seal . . . . .	119683-0100
O-ring Viton, 0530 ID x 0.082 W . . . . .	3814-6530

## ETD Reagent Kit

<b>ETD Reagent Kit</b> .....	<b>.98000-62008</b>
Angiotensin I, 1mg .....	00301-15517
Fluoranthene, 150mg .....	00301-01-0013

The fluoranthene in your ETD Reagent Kit is Sigma/Aldrich Supelco #48535. The fluoranthene MSDS is obtained from the MSDS link at:

[www.sigmaaldrich.com/catalog/search/ProductDetail/SUPELCO/48535](http://www.sigmaaldrich.com/catalog/search/ProductDetail/SUPELCO/48535)

Thermo Fisher Scientific supplies fluoranthene as a two vial kit. One vial contains 150 mg of fluoranthene and the other is the required empty vial.

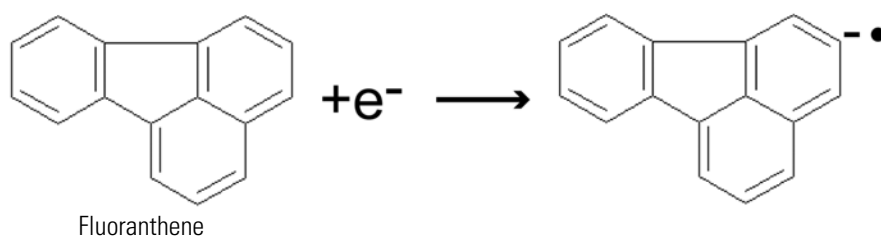
The angiotensin I in your ETD Reagent Kit is Angiotensin I human acetate hydrate (Sigma/Aldrich #A9650). Angiotensin I is potentially hazardous. Handle it in accordance with its MSDS. The angiotensin I MSDS is obtained from the MSDS link at:

[www.sigmaaldrich.com/catalog/search/ProductDetail/SIGMA/A9650](http://www.sigmaaldrich.com/catalog/search/ProductDetail/SIGMA/A9650)



## Appendix A Fluoranthene

Fluoranthene is used as the Electron Transfer Dissociation (ETD) reagent in the ETD Module portion of the LTQ Orbitrap Velos ETD. The fluoranthene radical anion is generated according to the reaction shown in Figure A-1.



**Figure A-1.** ETD Reagent (fluoranthene radical anion) generation from fluoranthene

Fluoranthene is potentially hazardous. Use it in accordance with its Material Safety Data Sheet (MSDS).

**Note** Store and handle all chemicals in accordance with standard safety procedures. The MSDS describing the chemicals being used should be freely available to lab personnel for them to examine at any time. Material Safety Data Sheets (MSDSs) provide summarized information on the hazard and toxicity of specific chemical compounds. The MSDS also provides information on the proper handling of compounds, first aid for accidental exposure, and procedures for cleaning spills or dealing with leaks. Producers and suppliers of chemical compounds are required by law to provide their customers with the most current health and safety information in the form of an MSDS. Read the MSDS for each chemical you use. Dispose of all laboratory reagents in the appropriate way (see the MSDS). ▲

The fluoranthene contained in the ETD Reagent Kit (P/N 98000-62008, see [page 4-7](#)) is Sigma/Aldrich Supelco #48535. The fluoranthene MSDS is obtained from the MSDS link at:

[www.sigmaaldrich.com/catalog/search/ProductDetail/SUPELCO/48535](http://www.sigmaaldrich.com/catalog/search/ProductDetail/SUPELCO/48535)

Thermo Fisher Scientific supplies fluoranthene as a two vial kit. One vial contains 150 mg of fluoranthene and the other is the required empty vial.





# Glossary

This section lists and defines terms used in this manual. It also includes acronyms, metric prefixes, symbols, and abbreviations.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

- A**
- A** ampere
- ac** alternating current
- ADC** analog-to-digital converter
- adduct ion** An ion formed by the joining together of two species, usually an ion and a molecule, and often within the ion source, to form an ion containing all the constituent atoms of both species.
- AGC™** See [Automatic Gain Control™ \(AGC\)](#).
- APCI** See [atmospheric pressure chemical ionization \(APCI\)](#).
- APCI corona discharge current** The ion current carried by the charged particles in the APCI source. The voltage on the APCI corona discharge needle supplies the potential required to ionize the particles. The APCI corona discharge current is set; the APCI corona discharge voltage varies, as required, to maintain the set discharge current.
- See also [corona discharge](#) and [APCI corona discharge voltage](#).
- APCI corona discharge voltage** The high voltage that is applied to the corona discharge needle in the APCI source to produce the APCI corona discharge. The corona discharge voltage varies, as required, to maintain the set APCI spray current.
- See also [APCI spray current](#).
- APCI manifold** The manifold that houses the APCI sample tube and nozzle, and contains the plumbing for the sheath and auxiliary gas.
- APCI needle, corona discharge** A needle to which a sufficiently high voltage (typically  $\pm 3$  to  $\pm 5$  kV) is applied to produce a chemical ionization plasma by the corona discharge mechanism.
- See also [chemical ionization \(CI\)](#), [chemical ionization \(CI\) plasma](#), [atmospheric pressure chemical ionization \(APCI\)](#), and [corona discharge](#).
- APCI nozzle** The nozzle in the APCI probe that sprays the sample solution into a fine mist.
- See also [atmospheric pressure chemical ionization \(APCI\)](#).
- APCI sample tube** A fused silica tube that delivers sample solution to the [APCI nozzle](#). The APCI sample tube extends from the sample inlet to the APCI nozzle.
- See also [atmospheric pressure chemical ionization \(APCI\)](#), and [API stack](#).
- APCI source** Contains the APCI probe assembly, APCI manifold, and API stack.
- See also [atmospheric pressure chemical ionization \(APCI\)](#), [APCI manifold](#), and [API stack](#).
- APCI spray current** The ion current carried by the charged particles in the APCI source. The [APCI corona discharge voltage](#) varies, as required, to maintain the set spray current.
- APCI vaporizer** A heated tube that vaporizes the sample solution as the solution exits the sample tube and enters the atmospheric pressure region of the APCI source.
- See also [atmospheric pressure chemical ionization \(APCI\)](#).

**API** See [atmospheric pressure ionization \(API\)](#).

**API atmospheric pressure region** The first of two chambers in the API source. Also referred to as the spray chamber.

**API capillary-skimmer region** The area between the capillary and the skimmer, which is surrounded by the tube lens. It is also the area of first-stage evacuation in the API source.

**API heated capillary** A tube assembly that assists in desolvating ions that are produced by the ESI or APCI probe.

See also [API heated capillary voltage](#).

**API heated capillary voltage** The dc voltage applied to the heated capillary. The voltage is positive for positive ions and negative for negative ions.

See also [API source](#) and [API heated capillary](#).

**API ion transfer capillary** A tube assembly that assists in desolvating ions that are produced by the ESI, NSI, or APCI probe.

See also [API ion transfer capillary offset voltage](#) and [API ion transfer capillary temperature](#).

**API ion transfer capillary offset voltage** A dc voltage applied to the ion transfer capillary. The voltage is positive for positive ions and negative for negative ions.

See also [API source](#) and [API ion transfer capillary](#).

**API ion transfer capillary temperature** The temperature of the ion transfer capillary, which should be adjusted for different flow rates.

See also [API source](#) and [API ion transfer capillary](#).

**API source** The sample interface between the LC and the mass spectrometer. It consists of the API probe (ESI or APCI) and API stack.

See also [atmospheric pressure ionization \(API\)](#), [ESI source](#), [APCI source](#), [ESI probe](#), and [API stack](#).

**API spray chamber** The first of two chambers in the API source. In this chamber the sample liquid exits the probe and is sprayed into a fine mist (ESI or NSI) or is vaporized (APCI) as it is transported to the entrance end of the ion transfer capillary.

**API spray shield** A stainless steel, cylindrical vessel that, in combination with the ESI or APCI flange, forms the atmospheric pressure region of the API source.

See also [atmospheric pressure ionization \(API\)](#).

**API stack** Consists of the components of the API source that are held under vacuum and includes the [API spray shield](#), [API ion transfer capillary](#), [API tube lens](#), [skimmer](#), the ion transfer capillary mount, and the tube lens and skimmer mount.

See also [atmospheric pressure ionization \(API\)](#) and [API source](#).

**API tube lens** A lens in the API source that separates ions from neutral particles as they leave the ion transfer capillary. A potential applied to the tube lens focuses the ions toward the opening of the skimmer and helps to dissociate adduct ions.

See also [API tube lens offset voltage](#), [API source](#), [API ion transfer capillary](#), and [adduct ion](#).

**API tube lens and skimmer mount** A mount that attaches to the heated capillary mount. The tube lens and skimmer attach to the tube lens and skimmer mount.

**API tube lens offset voltage** A DC voltage applied to the tube lens. The value is normally tuned for a specific compound.

See also [API tube lens](#), [adduct ion](#), and [source CID](#).

**APPI** See [Atmospheric Pressure Photoionization \(APPI\)](#).

**ASCII** American Standard Code for Information Interchange

**atmospheric pressure chemical ionization (APCI)** A soft ionization technique done in an ion source operating at atmospheric pressure. Electrons from a corona discharge initiate the process by ionizing the mobile phase vapor molecules. A reagent gas forms, which efficiently produces positive and negative ions of the analyte through a complex series of chemical reactions.

See also [electrospray ionization \(ESI\)](#).

**atmospheric pressure ionization (API)** Ionization performed at atmospheric pressure by using [atmospheric pressure chemical ionization \(APCI\)](#), [electrospray ionization \(ESI\)](#), or [nanospray ionization \(NSI\)](#).

**Atmospheric Pressure Photoionization (APPI)** A soft ionization technique in which an ion is generated from a molecule when it interacts with a photon from a light source.

**Automatic Gain Control™ (AGC)** Sets the ion injection time to maintain the optimum quantity of ions for each scan. With AGC on, the scan function consists of a prescan and an analytical scan.

**auxiliary gas** The outer-coaxial gas (nitrogen) that assists the sheath (inner-coaxial) gas in dispersing and/or evaporating sample solution as the sample solution exits the APCI, ESI, or H-ESI nozzle.

**auxiliary gas flow rate** The relative rate of flow of [auxiliary gas](#) (nitrogen) into the API source reported in arbitrary units.

**auxiliary gas inlet** An inlet in the API probe where auxiliary gas is introduced into the probe.

See also [auxiliary gas](#) and [atmospheric pressure ionization \(API\)](#).

**auxiliary gas plumbing** The gas plumbing that delivers outer coaxial nitrogen gas to the ESI or APCI nozzle.

**auxiliary gas valve** A valve that controls the flow of auxiliary gas into the API source.

## B

**b** bit

**B** byte (8 b)

**baud rate** data transmission speed in events per second

**BTU** British thermal unit, a unit of energy

## C

**°C** degrees Celsius

**CE** central electrode (of the Orbitrap)

**cfm** cubic feet per minute

**chemical ionization (CI)** The formation of new ionized species when gaseous molecules interact with ions. The process can involve transfer of an electron, proton, or other charged species between the reactants.

**chemical ionization (CI) plasma** The collection of ions, electrons, and neutral species formed in the ion source during chemical ionization.

See also [chemical ionization \(CI\)](#).

**CI** See [chemical ionization \(CI\)](#).

**CID** See [collision-induced dissociation \(CID\)](#).

**CLT** curved linear trap

**cm** centimeter

**cm<sup>3</sup>** cubic centimeter

**collision gas** A neutral gas used to undergo collisions with ions.

**collision-induced dissociation (CID)** An ion/neutral process in which an ion is dissociated as a result of interaction with a neutral target species.

**consecutive reaction monitoring (CRM) scan type** A scan type with three or more stages of mass analysis and in which a particular multi-step reaction path is monitored.

**Convectron™ gauge** A thermocouple bridge gauge that is sensitive to the pressure as well as the thermal conductivity of the gas used to measure pressures between X and Y.

**corona discharge** In the APCI source, an electrical discharge in the region around the corona discharge needle that ionizes gas molecules to form a chemical ionization (CI) plasma, which contains CI reagent ions.

See also [chemical ionization \(CI\) plasma](#) and [atmospheric pressure chemical ionization \(APCI\)](#).

**CPU** central processing unit (of a computer)

**CRM** See [consecutive reaction monitoring \(CRM\) scan type](#).

**C-Trap** curved linear trap

**<Ctrl>** control key on the terminal keyboard

## D

*d* depth

**Da** dalton

**DAC** digital-to-analog converter

**damping gas** Helium gas introduced into the ion trap mass analyzer that slows the motion of ions entering the mass analyzer so that the ions can be trapped by the RF voltage fields in the mass analyzer.

**data-dependent scan** A scan mode that uses specified criteria to select one or more ions of interest on which to perform subsequent scans, such as MS/MS or ZoomScan.

**dc** direct current

**divert/inject valve** A valve on the mass spectrometer that can be plumbed as a divert valve or as a loop injector.

**DS** data system

**DSP** digital signal processor

## E

**ECD** See [electron capture dissociation \(ECD\)](#).

**EI** electron ionization

**electron capture dissociation (ECD)** A method of fragmenting gas phase ions for tandem mass spectrometric analysis. ECD involves the direct introduction of low energy electrons to trapped gas phase ions.

See also [electron transfer dissociation \(ETD\)](#) and [infrared multiphoton dissociation \(IRMPD\)](#).

**electron multiplier** A device used for current amplification through the secondary emission of electrons. Electron multipliers can have a discrete dynode or a continuous dynode.

**electron transfer dissociation (ETD)** A method of fragmenting peptides and proteins. In electron transfer dissociation (ETD), singly charged reagent anions transfer an electron to multiply protonated peptides within the ion trap mass analyzer. This leads

to a rich ladder of sequence ions derived from cleavage at the amide groups along the peptide backbone. Amino acid side chains and important modifications such as phosphorylation are left intact.

See also [fluoranthene](#).

**electrospray ionization (ESI)** A type of atmospheric pressure ionization that is currently the softest ionization technique available to transform ions in solution into ions in the gas phase.

**EMBL** European Molecular Biology Laboratory

**<Enter>** Enter key on the terminal keyboard

**ESD** electrostatic discharge

**ESI** See [electrospray ionization \(ESI\)](#).

**ESI flange** A flange that holds the [ESI probe](#) in position next to the entrance of the heated capillary, which is part of the API stack. The ESI flange also seals the atmospheric pressure region of the API source and, when it is in the engaged position against the spray shield, compresses the high-voltage safety-interlock switch.

**ESI probe** A probe that produces charged aerosol droplets that contain sample ions. The ESI probe is typically operated at liquid flows of 1 µL/min to 1 mL/min without splitting. The ESI probe includes the ESI manifold, sample tube, nozzle, and needle.

**ESI source** Contains the ESI probe and the API stack.

See also [electrospray ionization \(ESI\)](#), [ESI probe](#), and [API stack](#).

**ESI spray current** The flow of charged particles in the ESI source. The voltage on the ESI spray needle supplies the potential required to ionize the particles.

**ESI spray voltage** The high voltage that is applied to the spray needle in the ESI source to produce the ESI spray current. In ESI, the voltage is applied to the spray liquid as it emerges from the nozzle.

See also [ESI spray current](#).

**ETD** See [electron transfer dissociation \(ETD\)](#).

**eV** electron volt

**external lock mass** A lock that is analyzed in a separate MS experiment from your sample. If you need to run a large number of samples, or if accurate mass samples will be intermingled with standard samples, you might want to use external lock masses. These allow more rapid data acquisition by eliminating the need to scan lock masses during each scan.

See also [internal lock mass](#).

## F

**f** femto ( $10^{-15}$ )

**°F** degrees Fahrenheit

**.fasta file** extension of a SEQUEST® search database file

**ft** foot

**Fast Fourier Transform (FFT)** An algorithm that performs a Fourier transformation on data. A Fourier transform is the set of mathematical formulae by which a time function is converted into a frequency-domain function and the converse.

**FFT** See [Fast Fourier Transform \(FFT\)](#).

**fluoranthene** A reagent anion that is used in an [electron transfer dissociation \(ETD\)](#) experiment.

**firmware** Software routines stored in read-only memory. Startup routines and low-level input/output instructions are stored in firmware.

**forepump** The pump that evacuates the foreline. A rotary-vane pump is a type of forepump.

**Fourier Transform - Ion Cyclotron Resonance Mass Spectrometry (FT-ICR MS)** A technique that determines the mass-to-charge ratio of an ion by measuring its cyclotron frequency in a strong magnetic field.

**fragment ion** A charged dissociation product of an ionic fragmentation. Such an ion can dissociate further to form other charged molecular or atomic species of successively lower formula weights.

**fragmentation** The dissociation of a molecule or ion to form fragments, either ionic or neutral. When a molecule or ion interacts with a particle (electron, ion, or neutral species) the molecule or ion absorbs energy and can subsequently fall apart into a series of charged or neutral fragments. The mass spectrum of the fragment ions is unique for the molecule or ion.

**FT** Fourier Transformation

**FT-ICR MS** See [Fourier Transform - Ion Cyclotron Resonance Mass Spectrometry \(FT-ICR MS\)](#).

**FTMS** Fourier Transformation Mass Spectroscopy

**full-scan type** Provides a full mass spectrum of each analyte or parent ion. With the full-scan type, the mass analyzer is scanned from the first mass to the last mass without interruption. Also known as single-stage full-scan type.

**FWHM** Full Width at Half Maximum

## G

**g** gram

**G** Gauss; giga ( $10^9$ )

**GC** gas chromatograph; gas chromatography

**GC/MS** gas chromatography / mass spectrometer

**GUI** graphical user interface

## H

**h** hour

**h** height

**handshake** A signal that acknowledges that communication can take place.

**HCD** Higher Energy Collision Induced Dissociation

**header information** Data stored in each data file that summarizes the information contained in the file.

**H-ESI source** Heated-electrospray ionization (H-ESI) converts ions in solution into ions in the gas phase by using [electrospray ionization \(ESI\)](#) in combination with heated [auxiliary gas](#).

**Glossary:** high performance liquid chromatography (HPLC)

### **high performance liquid chromatography (HPLC)**

Liquid chromatography in which the liquid is driven through the column at high pressure. Also known as high pressure liquid chromatography.

**HPLC** See [high performance liquid chromatography \(HPLC\)](#).

**HV** high voltage

**Hz** hertz (cycles per second)

## **I**

**ICR** ion cyclotron resonance

**ID** inside diameter

**IEC** International Electrotechnical Commission

**IEEE** Institute of Electrical and Electronics Engineers

**in** inch

**infrared multiphoton dissociation (IRMPD)** In infrared multiphoton dissociation (IRMPD), multiply charged ions consecutively absorb photons emitted by a infrared laser until the vibrational excitation is sufficient for their fragmentation. The fragments continue to pick up energy from the laser pulse and fall apart further to ions of lower mass.

See also [electron capture dissociation \(ECD\)](#).

**instrument method** A set of experiment parameters that define Xcalibur operating settings for the autosampler, liquid chromatograph (LC), mass spectrometer, divert valve, syringe pump, and so on. Instrument methods are saved as file type .meth.

**internal lock mass** A lock that is analyzed during the same MS experiment as your sample and is contained within the sample solution or infused into the LC flow during the experiment. Internal lock masses provide the most accurate corrections to the data.

See also [external lock mass](#).

**I/O** input/output

**ion gauge** Measures the pressure in the mass analyzer region (high vacuum region) of the vacuum manifold.

**ion optics** Focuses and transmits ions from the API source to the mass analyzer.

**ion source** A device that converts samples to gas-phase ions.

**IRMPD** See [infrared multiphoton dissociation \(IRMPD\)](#).

## **K**

**k** kilo ( $10^3$ , 1000)

**K** kilo ( $2^{10}$ , 1024)

**KEGG** Kyoto Encyclopedia of Genes and Genomes

**kg** kilogram

## **L**

**l** length

**L** liter

**LAN** local area network

**lb** pound

**LC** See [liquid chromatography \(LC\)](#).

**LC/MS** See [liquid chromatography / mass spectrometry \(LC/MS\)](#).

**LED** light-emitting diode

**LHe** liquid helium

**liquid chromatography (LC)** A form of elution chromatography in which a sample partitions between a stationary phase of large surface area and a liquid mobile phase that percolates over the stationary phase.

**liquid chromatography / mass spectrometry (LC/MS)** An analytical technique in which a high-performance liquid chromatograph (LC) and a mass spectrometer (MS) are combined.

**LN2** liquid nitrogen



**lock mass** A known reference mass in the sample that is used to correct the mass spectral data in an accurate mass experiment and used to perform a real-time secondary mass calibration that corrects the masses of other peaks in a scan. Lock masses with well-defined, symmetrical peaks work best. You can choose to use [internal lock mass](#) or [external lock mass](#).

**log file** A text file, with a .log file extension, that is used to store lists of information.

## M

**μ** micro ( $10^{-6}$ )

**m** meter; milli ( $10^{-3}$ )

**M** mega ( $10^6$ )

**M<sup>+</sup>** molecular ion

**MALDI** See [matrix-assisted laser desorption/ionization \(MALDI\)](#).

### matrix-assisted laser desorption/ionization

**(MALDI)** Ionization by effect of illumination with a beam of laser generated light onto a matrix containing a small proportion of analyte. A mass spectrometric technique that is used for the analysis of large biomolecules.

**MB** Megabyte (1 048 576 bytes)

**MH<sup>+</sup>** protonated molecular ion

**min** minute

**mL** milliliter

**mm** millimeter

**MRFA** A peptide with the amino acid sequence methionine–arginine–phenylalanine–alanine.

**MS** mass spectrometer; mass spectrometry

**MS** MS<sup>n</sup> power: where n = 1

**MS scan modes** Scan modes in which only one stage of mass analysis is performed. The scan types used with the MS scan modes are [full-scan type](#) and [selected ion monitoring \(SIM\) scan type](#).

**MSDS** Material Safety Data Sheet

**MS/MS** Mass spectrometry/mass spectrometry, or tandem mass spectrometry is an analytical technique that involves two stages of mass analysis. In the first stage, ions formed in the ion source are analyzed by an initial analyzer. In the second stage, the mass-selected ions are fragmented and the resultant ionic fragments are mass analyzed.

**MSn scan mode** The scan power equal to 1 to 10, where the scan power is the power *n* in the expression MS<sup>n</sup>. MS<sup>n</sup> is the most general expression for the scan mode, which can include the following:

- The scan mode corresponding to the one stage of mass analysis in a single-stage full-scan experiment or a selected ion monitoring (SIM) experiment
- The scan mode corresponding to the two stages of mass analysis in a two-stage full-scan experiment or a selected reaction monitoring (SRM) experiment
- The scan mode corresponding to the three to ten stages of mass analysis (n = 3 to n = 10) in a multi-stage full-scan experiment or a consecutive reaction monitoring (CRM) experiment.

See also [MS scan modes](#) and [MS/MS](#).

**multipole** A symmetrical, parallel array of (usually) four, six, or eight cylindrical rods that acts as an ion transmission device. An RF voltage and dc offset voltage are applied to the rods to create an electrostatic field that efficiently transmits ions along the axis of the multipole rods.

**m/z** Mass-to-charge ratio. An abbreviation used to denote the quantity formed by dividing the mass of an ion (in u) by the number of charges carried by the ion. For example, for the ion C<sub>7</sub>H<sub>7</sub><sup>2+</sup>, m/z=45.5.

## N

**n** nano ( $10^{-9}$ )

**nanospray ionization (NSI)** A type of electrospray ionization (ESI) that accommodates very low flow rates of sample and solvent on the order of 1 to 20 nL/min (for static nanospray) or 100 to 1000 nL/min (for dynamic nanospray).

**NCBI** National Center for Biotechnology Information (USA)

**NIST** National Institute of Standards and Technology (USA)

**NMR** Normal Mass Range

**NSI** See [nanospray ionization \(NSI\)](#).

**octapole** An octagonal array of cylindrical rods that acts as an ion transmission device. An RF voltage and dc offset voltage applied to the rods create an electrostatic field that transmits the ions along the axis of the octapole rods.

## O

**OD** outside diameter

**OT** Orbitrap

**OVC** outer vacuum case

$\Omega$  ohm

## P

**p** pico ( $10^{-12}$ )

**Pa** pascal

**PCB** printed circuit board

**PDA detector** Photodiode Array detector is a linear array of discrete photodiodes on an integrated circuit chip. It is placed at the image plane of a spectrometer to allow a range of wavelengths to be detected simultaneously.

**PE** protective earth

**PID** proportional / integral / differential

**P/N** part number

**p-p** peak-to-peak voltage

**ppm** parts per million

**PQD** pulsed-Q dissociation

**psig** pounds per square inch, gauge

**PTM** posttranslational modification

## Q

**quadrupole** A symmetrical, parallel array of four hyperbolic rods that acts as a mass analyzer or an ion transmission device. As a mass analyzer, one pair of opposing rods has an oscillating radio frequency (RF) voltage superimposed on a positive direct current (dc) voltage. The other pair has a negative dc voltage and an RF voltage that is 180 degrees out of phase with the first pair of rods. This creates an electrical field (the quadrupole field) that efficiently transmits ions of selected mass-to-charge ratios along the axis of the quadrupole rods.

## R

**RAM** random access memory

**raw data** Uncorrected liquid chromatograph and mass spectrometer data obtained during an acquisition. Xcalibur and Xcalibur-based software store this data in a file that has a .raw file extension.

**resolution** The ability to distinguish between two points on the wavelength or mass axis.

**retention time (RT)** The time after injection at which a compound elutes. The total time that the compound is retained on the chromatograph column.

**RF** radio frequency

**RF lens** A multipole rod assembly that is operated with only radio frequency (RF) voltage on the rods. In this type of device, virtually all ions have stable trajectories and pass through the assembly.

**RF voltage** An ac voltage of constant frequency and variable amplitude that is applied to the ring electrode or endcaps of the mass analyzer or to the rods of a multipole. Because the frequency of this ac voltage is in the radio frequency (RF) range, it is referred to as RF voltage.

**RMS** root mean square

**ROM** read-only memory

**rotary-vane pump** A mechanical vacuum pump that establishes the vacuum necessary for the proper operation of the turbomolecular pump. (Also called a roughing pump or forepump.)

**RS-232** An accepted industry standard for serial communication connections. This Recommended Standard (RS) defines the specific lines and signal characteristics used by serial communications controllers to standardize the transmission of serial data between devices.

**RT** An abbreviated form of the phrase *retention time* (*RT*). This shortened form is used to save space when the retention time (in minutes) is displayed in a header, for example, RT: 0.00-3.75.

## S

s second

**selected ion monitoring (SIM) scan type** A scan type in which the mass spectrometer acquires and records ion current at only one or a few selected mass-to-charge ratio values.

See also [selected reaction monitoring \(SRM\) scan type](#).

**selected reaction monitoring (SRM) scan type** A scan type with two stages of mass analysis and in which a particular reaction or set of reactions, such as the fragmentation of an ion or the loss of a neutral moiety, is monitored. In SRM a limited number of product ions is monitored.

**SEM** secondary electron multiplier

**Serial Peripheral Interface (SPI)** hardware and firmware communications protocol

**serial port** An input/output location (channel) for serial data transmission.

**sheath gas** The inner coaxial gas (nitrogen), which is used in the API source to help nebulize the sample solution into a fine mist as the sample solution exits the ESI or APCI nozzle.

**sheath gas flow rate** The rate of flow of sheath gas into the API source. A measurement of the relative flow rate (in arbitrary units) that needs to be provided at the sheath gas inlet to provide the required flow of [sheath gas](#) to the ESI or APCI nozzle.

**sheath gas inlet** An inlet in the API probe where [sheath gas](#) is introduced into the probe.

**sheath gas plumbing** The gas plumbing that delivers [sheath gas](#) to the ESI or APCI nozzle.

**sheath gas pressure** The rate of flow of sheath gas (nitrogen) into the API source. A measurement of the relative flow rate (in arbitrary units) that needs to be provided at the sheath gas inlet to provide the required flow of inner coaxial nitrogen gas to the ESI or APCI nozzle. A software-controlled proportional valve regulates the flow rate.

See also [sheath gas](#).

**sheath gas valve** A valve that controls the flow of [sheath gas](#) into the API source. The sheath gas valve is controlled by the data system.

**signal-to-noise ratio (S/N)** The ratio of the signal height (S) to the noise height (N). The signal height is the baseline corrected peak height. The noise height is the peak-to-peak height of the baseline noise.

**SIM** See [selected ion monitoring \(SIM\) scan type](#).

**skimmer** A vacuum baffle between the higher pressure capillary-skimmer region and the lower pressure region. The aperture of the skimmer is offset with respect to the bore of the ion transfer capillary.

**source CID** A technique for fragmenting ions in an [atmospheric pressure ionization \(API\)](#) source. Collisions occur between the ion and the background gas, which increase the internal energy of the ion and stimulate its dissociation.

**SPI** See [Serial Peripheral Interface \(SPI\)](#).

**SRM** See [selected reaction monitoring \(SRM\) scan type](#).

**sweep gas** Nitrogen gas that flows out from behind the sweep cone in the API source. Sweep gas aids in solvent declustering and adduct reduction.

See also [sweep gas flow rate](#).

**sweep gas flow rate** The rate of flow of sweep gas into the API source. A measurement of the relative flow rate (in arbitrary units) to provide the required flow of nitrogen gas to the sweep cone of the API source.

See also [sweep gas](#).

**syringe pump** A device that delivers a solution from a syringe at a specified rate.

## T

**T** Tesla

**target compound** A compound that you want to identify or quantitate or that a specific protocol (for example, an EPA method) requires that you look for. Target compounds are also called analytes, or target analytes.

**TIC** See [total ion current \(TIC\)](#).

**TMP** See [turbomolecular pump](#).

**Torr** A unit of pressure, equal to 1 mm of mercury and 133.32 Pa.

**total ion current (TIC)** The sum of the ion current intensities across the scan range in a mass spectrum.

**tube lens offset** The voltage offset from ground that is applied to the tube lens to focus ions toward the opening of the skimmer.

See also [source CID](#).

**Tune Method** A defined set of mass spectrometer tune parameters for the ion source and mass analyzer. Tune methods are defined by using the Exactive Tune, Tune Plus (LCQ Series, LXQ, and LTQ), or Tune Master (TSQ Quantum) window and saved as the file type .mstune, .LCQTune, .LTQTune, or .TSQTune, respectively.

A tune method stores tune parameters only. (Calibration parameters are stored separately, not with the tune method.)

**tune parameters** Instrument parameters whose values vary with the type of experiment.

**turbomolecular pump** A vacuum pump that provides a high vacuum for the mass spectrometer and detector system.

**TWA** time weighted average

## U

**u** atomic mass unit

**UHV** ultra high vacuum

**Ultramark 1621** A mixture of perfluoroalkoxycyclotriphosphazenes used for ion trap calibration and tuning. It provides ESI singly charged peaks at  $m/z$  1022.0, 1122.0, 1222.0, 1322.0, 1422.0, 1522.0, 1622.0, 1722.0, 1822.0, and 1921.9.

**UMR** Universal Mass Range

## V

**V** volt

**V ac** volts alternating current

**V dc** volts direct current

**vacuum manifold** A thick-walled, aluminum chamber with machined flanges on the front and sides and various electrical feedthroughs and gas inlets that encloses the API stack, ion optics, mass analyzer, and ion detection system.

**vacuum system** Components associated with lowering the pressure within the mass spectrometer. A vacuum system includes the vacuum manifold, pumps, pressure gauges, and associated electronics.

**vent valve** A valve that allows the vacuum manifold to be vented to air or other gases. A solenoid-operated valve.

**vol** volume

## W

**w** width

**W** watt

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