

Orbitrap Exploris
480
Service Manual

ThermoFisher S C I E N T I F I C	Service Manual	Rev. 00
	Orbitrap Exploris 480	

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Revision History

Revision	Created by	Changes
00	Nicole Zehethofer	Initial Release

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Legal Notices

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Safety



Electrical Shock. While the main power is connected, parts of the instrument may carry live voltage. Always disconnect any electrical connections to the instrument before removing the covers. Never operate the instrument with the covers removed. Take appropriate measures to keep the instrument free of electrical potential while working on the open instrument. Reinstall the covers before reconnecting power.



Electromagnetic Radiation. The UHV ion gauge emits electromagnetic radiation even if the electronics switch is turned off. This radiation can interfere with the operation of cardiac pacemakers and implanted heart defibrillators, possibly causing death or serious injury. If you wear these devices, keep at least 10 cm away from the UHV ion gauge.



Electrical Shock. Electronic components, especially capacitors, can carry residual potential after the power lines have been connected. Wait at least 5 minutes after powering down before working on the equipment. Be careful not to touch any components on the printed circuit boards to keep the risk as low as possible.



Suffocation Hazard. The instrument is vented with nitrogen, which continues to flow until the external gas supply is turned off. Ensure that the room is well ventilated.



Hazardous Chemicals. Samples and solvents may contain toxic, carcinogenic, mutagenic or corrosive/irritant chemicals. Avoid exposure to contaminated parts of the instrument. Always wear protective clothing, safety glasses and gloves when handling sample facing parts of the instrument.



Hot surface. Touching parts of the forepump might cause burns. Forepump in function is hot and some surfaces could reach a temperature higher than 80 °C (176 °F). Switch off the pump and let it cool down before any intervention or take appropriate precautions. Always wear heat protective gloves when working on a pump that is still warm from operation.



Hot Surface. Touching hot parts of the ion source interface might cause severe burns. During operation of the mass spectrometer, ion transfer capillary and sweep cone might reach temperatures of up to 450 °C. To cool the ion transfer capillary, set the

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capillary temperature to 25 °C or place the electronics service switch in the Service Mode position. Wait until the ion source has cooled down to room temperature (for approximately 60 minutes) before you begin working on it. Do not leave the instrument unattended when the housing is not mounted to the source.



Sharp edges. The instrument chassis can have sharp edges. In particular the EMD shielding has sheet metal springs that are very sharp and can lead to injury if not handled carefully. Wear protective clothing.



Heavy Object The instrument is heavy and cause back injury during transportation. See operating manual for lifting instructions



Crushing Hazard The lid on the analyzer chamber might crush your hands when the lid is not in the resting position. Keep your hands clear when the lid is open.

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1. Scope and Overview

The following Orbitrap Exploris 480 instruments are covered in this manual:

Instrument	Orbitrap Exploris 480
Mass accuracy	< 3 ppm with external calibration (under defined conditions) < 1 ppm using internal standard, lock masses (under defined conditions)
Mass Range	m/z 40-6000 (8000 with BioPharma option)
Resolutions and Scan Speeds	7,500 at 40 Hz 15,000 at 22 Hz 30,000 at 12 Hz 60,000 at 7 Hz 120,000 at 3 Hz 240,000 at 1.2 Hz 480,000 at 0.7Hz
Fragmentation	in-source CID HCD
Dynamic Range within one scan	> 5000 within a single scan
Polarity Switching	1 scan in each polarity within 1 second @60,000 resolution setting
Isolation	40 < m/z ≤ 400: > 0.4 amu 400 < m/z ≤ 700: > 0.7 amu 700 < m/z ≤ 1000: > 1.0 amu 1000 < m/z ≤ 2000: > 2.0 amu 2000 < m/z ≤ 2500: > 3.0 amu 2500 < m/z : No ion selection.
Available Options	Biopharma, FAIMS, Easy IC
Sensitivity	MS/MS: 50 fg reserpine on column S/N 100:1 SIM: 50 fg reserpine on column S/N 150:1
Main Application Areas	Proteomics

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2. Common Tasks

2.1 Installing the instrument

The Orbitrap Exploris 480 mass spectrometer and other devices shipped have to be installed by a Thermo Fisher Scientific field service engineer. Only employees of Thermo Fisher Scientific or personnel who act on behalf of Thermo Fisher Scientific are allowed to install the power cables for the instrument. The installation must not be performed if the installation requirements are not met.

2.2 Personal Protective Equipment

Appropriate safety clothing must be worn at all times while you move and handle instrument parts. This manual can only give general suggestions for personal protective equipment (PPE), which protects the wearer from hazardous substances. Refer to the Material Safety Data Sheets (MSDSs) of the chemicals handled in the laboratory for advice on specific hazards or additional equipment.

Eye Protection

The type of eye protection required depends on the hazard. For most situations, safety glasses with side shields are adequate. Where there is a risk of splashing chemicals, goggles are required.

Protective Clothing

When the possibility of chemical contamination exists, protective clothing that resists physical and chemical hazards should be worn over street clothes. Lab coats are appropriate for minor chemical splashes and solids contamination, while plastic or rubber aprons are best for protection from corrosive or irritating liquids.

Gloves

For handling chemical compounds and organic solvents, the use of white nitrile clean room gloves from [Fisher Scientific](#) or [Unity Lab Services](#) is recommended. For handling hot objects, gloves made of heat-resistant materials (for example, leather) should be available.

2.3 Moving the instrument

The Orbitrap Exploris 480 instrument has eight recessed grips at its underside— two at the front side and three at each the left side and the right side. The grips become accessible after the filter brackets are removed.

Caution: Heavy Load. Because of its weight of about 120 kg, handling the instrument alone might cause muscle strain and back injury. Lifting and moving the instrument requires the effort of at least *four persons* to keep the individual load below acceptable limits (maximum 40 kg for men or 15 kg for women for a duration of 5 seconds). The carriers must be trained in how to carry loads properly (for example, by rising from the knees with a straight back). It is recommended to use a pallet jack to lift the mass spectrometer to the height of the workbench.

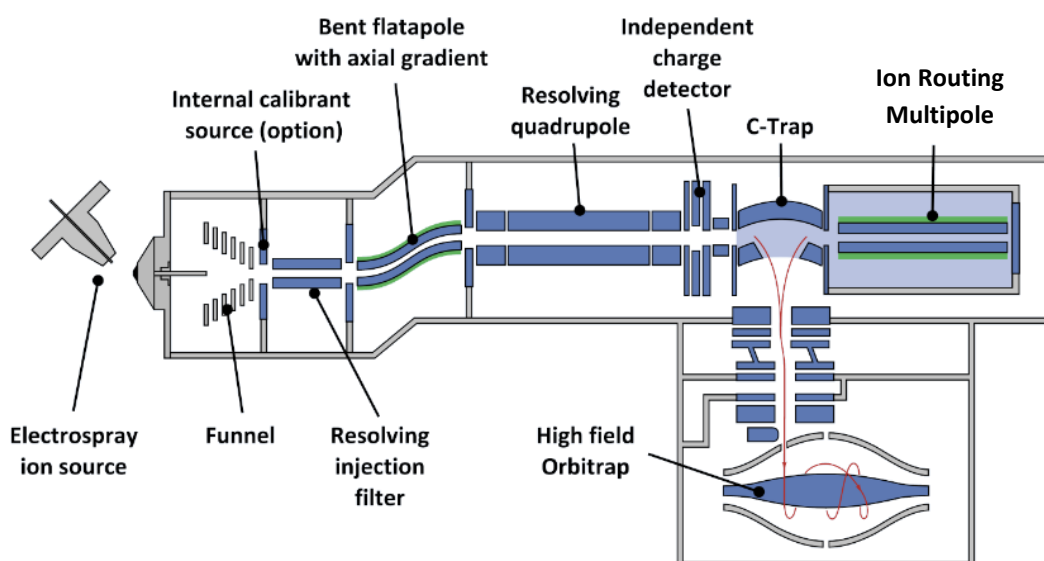
Step-by-step guide: How to move the instrument

1. Gather four persons and appoint one person that takes command and gives instructions to the remaining people.

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- Lift the instrument to the height of the working bench with the pallet jack.
- Remove the filter brackets on the sides of the instrument. The lifting handles come into view.
- On command, all four carriers lift the instrument simultaneously—to prevent them from experiencing an uneven load distribution. Place the instrument onto the bench.
- Only two persons are necessary for moving the instrument into its final position on a bench. The rear row of the support points below the instrument consists of synthetic material that has a low frictional resistance and should easily slide above the surface of your workbench. The front row of the support points below the instrument consists of synthetic material that has a high frictional resistance and should keep the instrument safely in position.

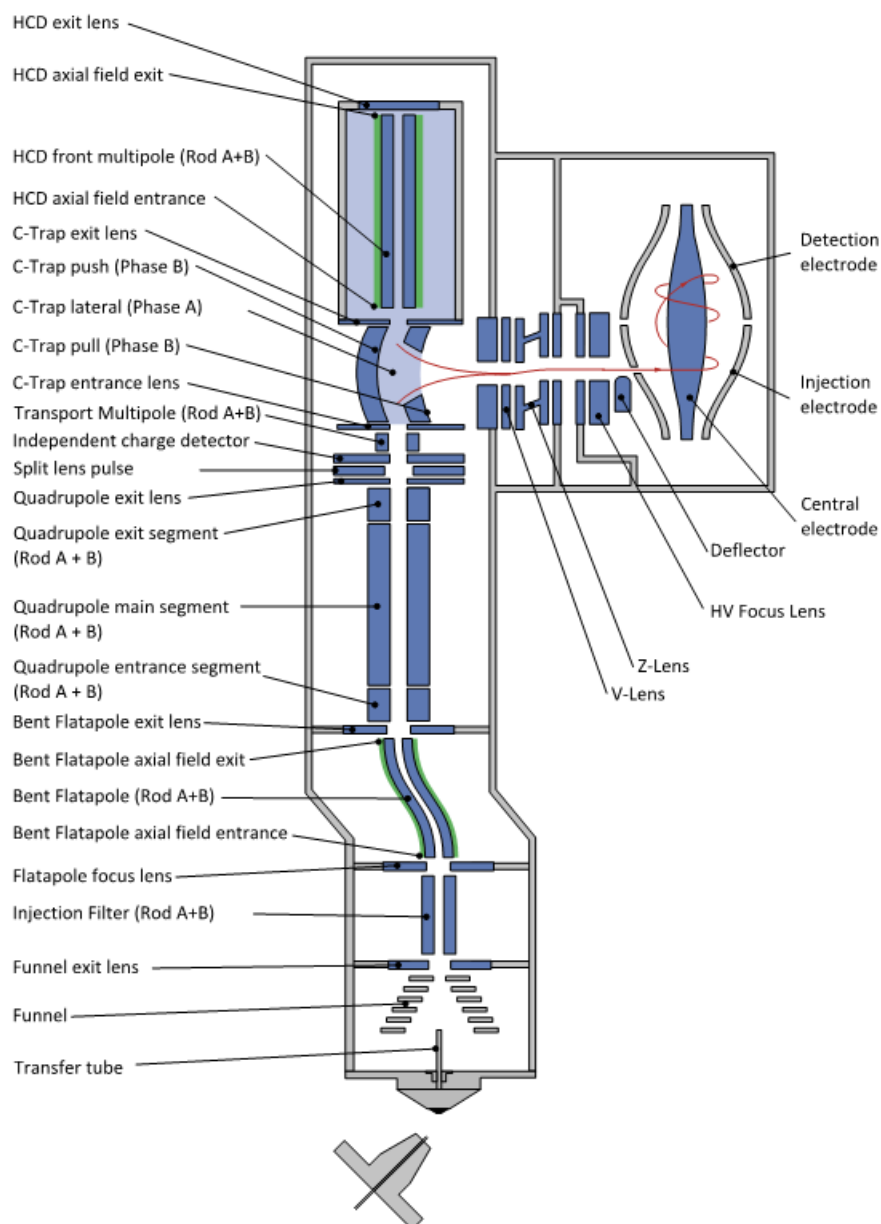
2.4 Description of the instrument design



2.5 Functional overview of PCBs

Boards in Exactive Series	Corresponding board on Merkur
Source Board	Source Board, Instrument Control Board
Ion Optics DC and RF	Ion Optics Supply
Quadrupole Electronics	Quadrupole Supply
C-Trap RF (with inputs from CEHV)	C-Trap Supply
CEHV + Pulser	Orbitrap Supply
FT adapter + Vacuum Control	Instrument Control
FT DAQ	FT DAQ
Preamp	Preamp

2.6 Lenses: Name conventions



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2.7 Venting the instrument

1. Wait until data acquisition, if any, is complete.
2. Turn off the flow of sample solution from the LC (or other sample introduction device).
3. In the Tune software window, put the instrument in Off condition. All high voltages are shut off, as are the sheath and auxiliary gas.
4. Put the electronics switch of the mass spectrometer in the Off position.
5. Put the main power circuit breaker switch of the mass spectrometer in the Off position.
6. Wait 10 min for the instrument to vent before beginning any maintenance.
7. Once maintenance is complete, pump down the instrument and run the bakeout procedure after venting. This can be found in the Service Diagnostics Tool in the status tree [ST]:

[ST] Procedures > By Sequence > By Functionality > General > Bake-out

2.8 Turn off electronics

Most of the electronic PCBs can be replaced without venting the instrument by switching the electronics switch to the “Off” position. Please note that the following parts are **not** in a voltage-free state when only the electronics switch is turned “Off”:

Instrument control PCB, power supplies, pumps

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3. Troubleshooting

The individual diagnostics between instruments can differ and will evolve over time. In this guide shared diagnostics are covered and a general approach to narrow down on an issue provided.

The instructions will differentiate between internal problems, i.e. mechanics and electronics, and external problems, e.g. control PC, software and LC. The main part will cover internal problems in detail, while the external problems will be summarized and pointers to additional information given.

3.1 General Remarks

Many of the calibrations and evaluations are interdependent and most of them are strongly dependent on the signal quality.

- ⇒ Do not take a single calibration failure as an indicator of a specific problem.
- ⇒ First look and think about causes and symptoms before starting to take countermeasures.
- ⇒ Take a step backwards and look at the whole picture.

A simple example would be:

There is no way to calibrate the mass accuracy if no calibrant peaks are visible. So the failure of the mass calibration does not actually indicate anything. You need to find out why there are no calibrant peaks.

3.2 Defining the problem

Try to collect and gather as much information as possible before starting to modify parts.

- Keep the instrument in a failure state as long as it takes to get an idea what the root cause is.
- What is the problem description by the customer?
- Verify the description (e.g. wrongly quoted error messages or calibrations).
- Analyze and capture logfiles.
- Take screenshots or photos.
- If complaint is about sample results: Gather rawfiles (good and bad).
- Make your own decision if the customer's description is correct.

Further steps depend on the type of problem.

Typically at this point a categorization should be possible into:

- Instrument hardware problem, e.g.
 - Error messages about wrong voltages
 - Communication breakdowns
 - Complete loss of signal
 - Vacuum leaks

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- Instrument performance issues, e.g.
 - Low intensities with calibration solution
 - Failing Calibration/Evaluations
 - Bad measurement results
- Peripheral problems, e.g.
 - Liquid chromatography

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3.3 Is the instrument working as specified?

Bad measurement results can very often be caused by just a minor loss of performance.

A quick check to test the overall performance of the system is to run the quick health check, which can be found here:

[ST] > Instrument > Procedures >By Sequence > Service > Quick health check (pos)

[ST] > Instrument > Procedures >By Sequence > Service > Quick health check (neg)

3.4 Troubleshooting Steps for some typical failures

Troubleshooting steps are provided as simple list below. If a step does not provide a solution or points out a failure, proceed with the following step. If it does, fix whatever the procedure or test identifies.

3.4.1 No connection to the instrument

- ☐ Ping the instrument: 172.16.0.200
- ☐ Connect an external monitor to the embedded PC, reboot the instrument, check if the boot up process finishes without error messages
- ☐ Check the network switch/network cable connections

3.4.2 Complete Loss of Signal

- ☐ Run all diagnostics, which can be found under [ST] > Instrument > Procedures >By Sequence > Service > Troubleshooting > By Symptom > No ion signal
- ☐ Check Transients (Windows-Transient in Tune) for anything suspicious, e.g. spikes
- ☐ Measure the capacitances at the feedthroughs according to the training materials.
- ☐ Exchange the Orbitrap Supply.
- ☐ Exchange the C-Trap Board.

3.4.3 Troubleshooting ion generation and transfer

- ☐ Check the spray current (should be at least 0.3µA) and capillary temperature.
- ☐ Make sure there is no blockage in the lines
- ☐ Run all diagnostics, which can be found under [ST] > Instrument > Procedures > By Sequence > Service > Troubleshooting > By Symptom > Low MS1 intensity
- ☐ If everything appears to work, vent the system, inspect all ion optics connections and clean them if necessary.

3.4.4 Bad MS2 spectral quality

- ☐ Run all diagnostics, which can be found under [ST] > Instrument > Procedures > By Sequence > Service > Troubleshooting > By Symptom > Low MS2 intensity

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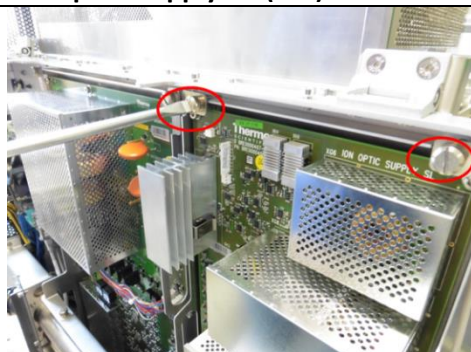
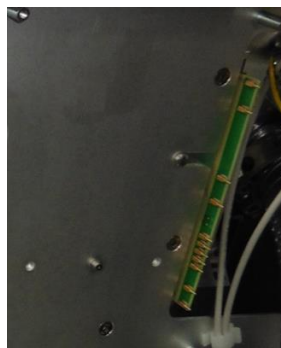
3.4.5 Identifying chromatography issues

- ☐ Open a good and a bad rawfile in QualBrowser
- ☐ Set the “pin” on the chromatogram view
- ☐ Right-Click chromatogram view → Ranges...
 - Set “Plot Type” to “Base Peak”
 - Set “Scan Filter” to “ms”
 - Create another chromatogram plot by clicking on the list
 - Set the same for “Plot Type” and “Scan Filter” but select the other rawfile under “Rawfile:”.
 - Click “OK”
- ☐ Right-Click chromatogram view → Display Options ... → Labels → Enable Basepeak
- ☐ Now localize a chromatographic peak that has the same basepeak label in both files. For both files:
 - Click onto the top of the peak.
 - In the spectrum view, zoom in onto the basepeak and click on it to create the XIC.
- ☐ Now compare the two XICs for:
 - Retention Time
 - FWHM and peak shape
 - Absolute intensity

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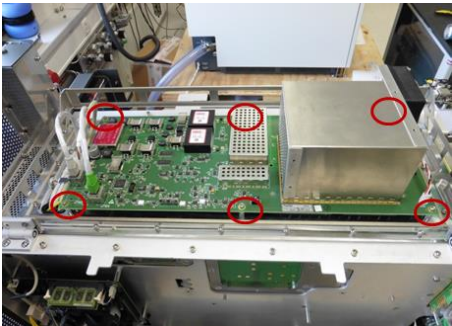
4. Electronics

4.1 Ion Optics Supply FU (IOS)

Component	Part Number	Used In	Previous Part Numbers
Ion Optics Supply FU (IOS)	BRE0019290		n/a
 	Supplies DC Voltages to the following ion optics: • Source DC offset • Funnel RF (RF1), Funnel RF offset, Funnel DC offset • Injection Filter DCs and RF (RF2) • Flatapole Focus Lens DC (DC2) • Bent Flatapole RF and DC (RF3) • Bent Flatapole Axial Field (DC3) • Bent Flatapole Exit Lens (DC4) Voltages are supplied through spring loaded contacts (pogo pins) Check pins free movement before (re-)installing the board. 		
Required Tools Slot screwdriver	Preparing Steps for Exchange/ Turn off electronics Remove instrument cover Remove left side EMC cover	Exchange Loosen 4 screws Tilt board Remove PCB	
Associated Problems	Calibrations/Evaluations that might fail	Diagnostics that detect problems Readback and Voltage Check	
Known Issues and History			

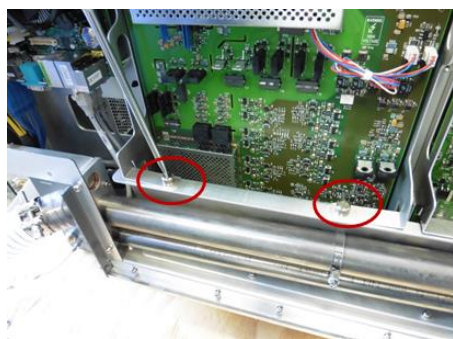
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4.2 Quadrupole Supply (QS)

Component Quadrupole Supply (QS)	Part Number BRE0013916	Used In	Previous Part Numbers n/a
 	Supplies: Quad end segment DC offset Quad main segment DC offsets Quad RF		
Required Tools 3 mm Hex	Preparing Steps for Exchange Turn off electronics Remove instrument cover Remove quad cover	Exchange Loosen 3 screws hidden under cover Loosen 17 screws outside cover Remove cover Disconnect cables Remove 4 screws below cover Remove PCB	
Associated Problems	Calibrations/Evaluations that might fail	Diagnostics that detect problems Readback and Voltage Check Quad RF calibration (no amplitude on one or both rod pairs) Isolation Shape Check	
Known Issues and History			

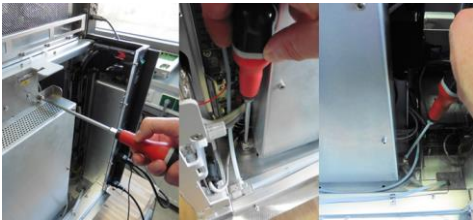
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4.3 C-Trap Supply (CTS)

Component	Part Number	Used In	Previous Part Numbers
C-Trap Supply (CTS)	BRE0013900		n/a
	Supplies: Independent Charge Detector (Beam Split) Quad Exit Lens Split Lens C-Trap Entrance Lens C-Trap Exit Lens C-Push and HV offset pulser Z-Lens Transfer Multipole DC HCD Axial Field Entrance HCD Axial Field Exit HCD Exit Lens C-Trap RF amplitude HCD RF Transfer Multipole RF C-trap RF frequency Analyzer Temperature These come from one coil ➔ only one setpoint		
Required Tools	Preparing Steps for Exchange		Exchange
Slot screwdriver	Turn off electronics Remove cover Remove left EMC cover		Loosen 4 screws Tilt Remove PCB
Associated Problems	Calibrations/Evaluations that might fail		Diagnostics that detect problems
			Readback and Voltage Check HCD evaluation
Known Issues and History			

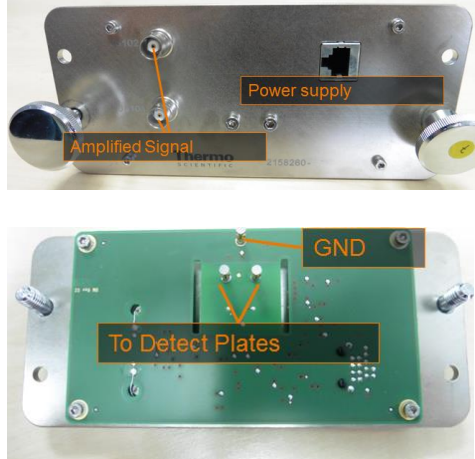
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4.4 Orbitrap Control (OTC)

Component	Part Number	Used In	Previous Part Numbers
Orbitrap Control (OTC)	BRE0013898		n/a
	Consists of Orbitrap Supply (OTS) and Orbitrap Pulser (OTP) Supplies: C-Trap Inject (HV offset high and low) HV Focus Lens V Lens Deflector Measure Central Electrode Inject Central Electrode Measure		
Required Tools	Preparing Steps for Exchange	Exchange	
Slot Screwdriver	Turn off electronics Remove cover Remove right EMC cover	Loosen all 4 bolts Tilt about 10 deg Pull up and out	
Associated Problems	Calibrations/Evaluations that might fail	Diagnostics that detect problems	
Mass drift Loss of ion signal Spectral Noise	eFT calibration Mass calibration	Readback and Voltage Check Long-term mass accuracy check Spectral Noise Check	
Known Issues and History			

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4.5 Preamplifier (PreAMP)

Component Preamplifier (PreAMP)	Part Number BRE0013892	Used In	Previous Part Numbers n/a
	Amplification of Orbitrap Signal		
Required Tools n/a	Preparing Steps for Exchange Turn off electronics Remove cover Remove right side EMC cover	Exchange Disconnect BNC and RJ45 cables Loosen 2 finger tight screws. Pull away from analyzer	
Associated Problems Bad sensitivity No signal	Calibrations/Evaluations that might fail eFT calibration Spectral mass calibration	Diagnostics that detect problems Second harmonics check Preamp check	
Known Issues and History n/a			

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4.6 Source Board (SB)

Component	Part Number	Used In	Previous Part Numbers
Source Board (SB)	BRE0013902		n/a
	Source controls: APCI Heater Capillary Heater Source Interlocks Internal Calibration Unit Heaters and high voltage Source gases Cover light sensor (right side) 8kV supply LED Panel Source ID N2 flow regulation		
Required Tools Pliers or similar to push quick fit release (gas tubing) Slot screwdriver	Preparing Steps for Exchange Turn off electronics Remove cover Remove right side EMC cover Turn off nitrogen supply	Exchange Disconnect all cables Disconnect gas tubings Loosen 4 screws Tilt and pull out	
Associated Problems	Calibrations/Evaluations that might fail	Diagnostics that detect problems Readback and Voltage Check Gas regulation test	
Known Issues and History			

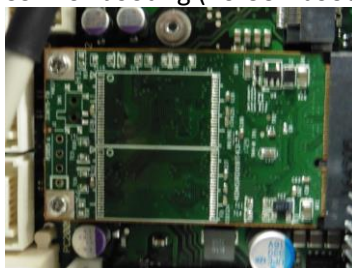
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4.7 DAQ Board (DAQ)

Component DAQ Board (DAQ)	Part Number BRE0013896	Used In	Previous Part Numbers -
	Analog to digital conversion of Preamplifier signal. Data transmitted via USB to embedded PC.		
Required Tools 3 mm hex	Preparing Steps for Exchange Turn off electronics Remove cover Remove right side EMC cover Remove Orbitrap Control	Exchange Unplug cables Remove 4 screws Remove PCB	
Associated Problems	Calibrations/Evaluations that might fail	Diagnostics that detect problems Manually check transients Second harmonic check	
Known Issues and History			

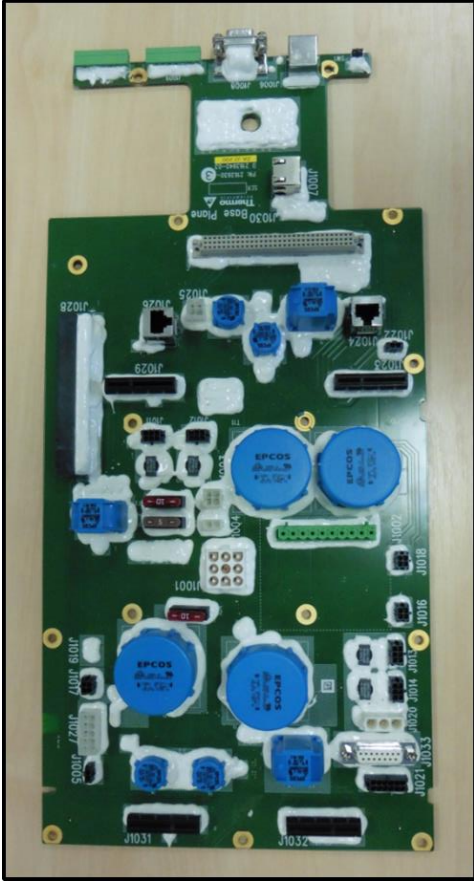
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4.8 Unit Embedded PCU

Component	Part Number	Used In	Previous Part Numbers
Unit Embedded PCU	BRE0013920		-
	Intel core i5, 4th generation SSD for booting (no USB bootstick anymore)  USB 2.0, 4GB RAM, 8GB SSD Memory Power from main power supplies Responsible for FFT and calculation of mass spectra		
Required Tools 3 mm hex	Preparing Steps for Exchange Turn off electronics Remove cover Remove left side EMC cover	Exchange Disconnect all cables Remove 4 screws Remove PCB	
Associated Problems No instrument connection	Calibrations/Evaluations that might fail	Diagnostics that detect problems	
Known Issues and History			

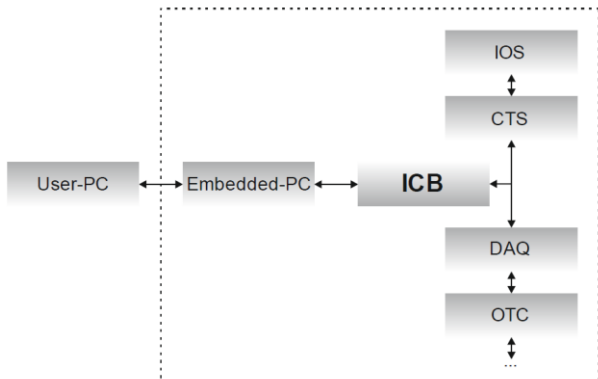
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4.9 Base Plane (BP)

Component	Part Number	Used In	Previous Part Numbers
Base Plane (BP)	BRE0013901		-
	Passive components only Bake out control PCB sits on BP		
Preparing Steps for Exchange Vent system All instrument PCBs have to be removed	Exchange See separate presentation for more details		
Associated Problems	Calibrations/Evaluations that might fail		Diagnostics that detect problems
Known Issues and History			

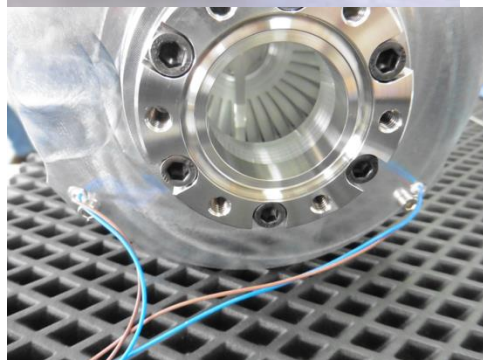
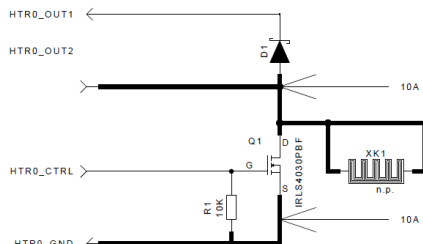
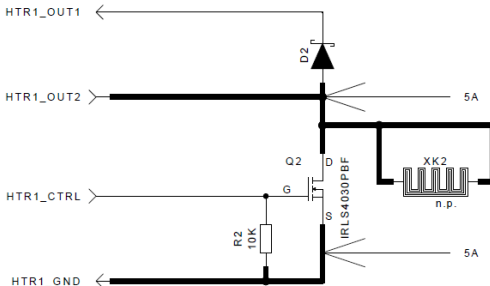
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4.10 Instrument Control PCB (ICB)

Component	Part Number BRE0013897	Used In	Previous Part Numbers -
Instrument Control PCB (ICB)	Connection between embedded PC and PCBs. It controls timings. OmniSPI Turbo Pump Vent valve Forepump Embedded PC reset Vacuum Gauges Temperature and Humidity Sensor Bakeout Fans Digital and Analog In/Out IO Panel		
 			
Required Tools 3 mm hex	Preparing Steps for Exchange Vent the instrument Remove cover Remove right side EMC cover Remove OTS	Exchange Disconnect USB Loosen 4 screws Slide out	
Associated Problems	Calibrations/Evaluations that might fail	Diagnostics that detect problems	
Known Issues and History			

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4.11 Bake out PCB (BO)

Component	Part Number	Used In	Previous Part Numbers
Bake out PCB (BO)	BRE0013919		n/a
  Bake out heater cables can be replaced after by unscrewing screws (3 mm hex required) after removal of cover, EMC cover and Orbitrap Supply PCB	Regulated bake out (8 h including 3 h cool down time) Bake out temperature ~ 105°C Heater 0  Heater 1 		
Required Tools 3 mm hex	Preparing Steps for Exchange Turn off electronics Remove cover Remove right side EMC cover		Exchange Loosen 1 screw Disconnect
Associated Problems	Calibrations/Evaluations that might fail		Diagnostics that detect problems
Known Issues and History			

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4.12 8 kV power supply

Component	Part Number	Used In	Previous Part Numbers
8 kV power supply	2106030		-
	Supplies ESI voltage (similar to the 8 kV power supply, which is used in Exactive series)		
Required Tools 3/32 inch hex	Preparing Steps for Exchange Turn off nitrogen supply Turn off electronics Remove cover Remove front cover Remove right side EMC cover	Exchange Remove 4 hex screws Disconnect nitrogen tubing and cables on Source PCB (to clear space) Loosen and move Source PCB as far as possible Pull out 8 kV supply	
Associated Problems	Calibrations/Evaluations that might fail	Diagnostics that detect problems	
Known Issues and History			

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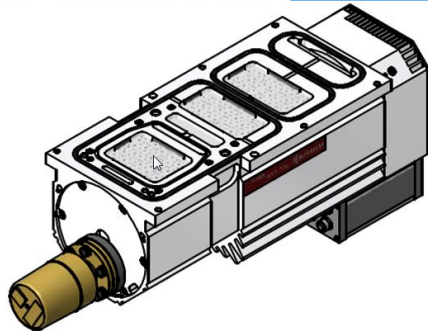
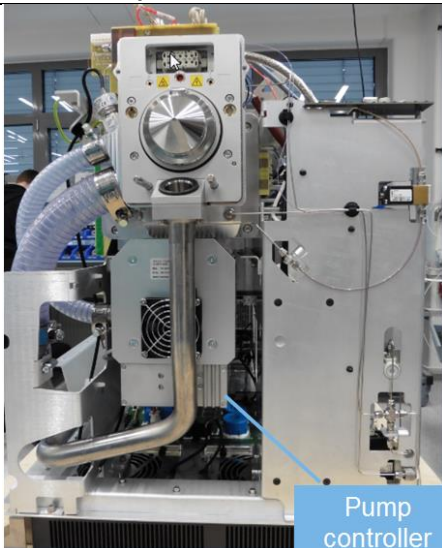
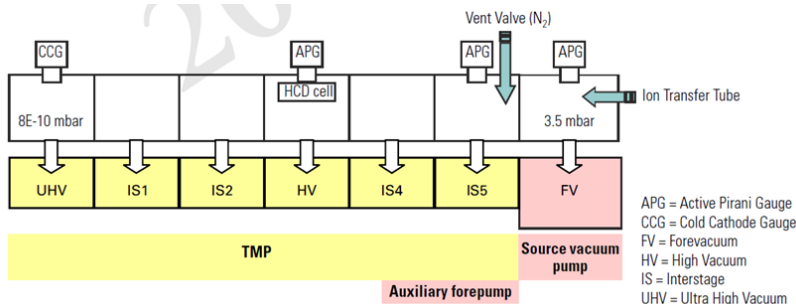
4.13 Power supplies

Component	Part Number	Used In	Previous Part Numbers
Power supplies	see description		-
 Turbopump 24V/25A	Different models are used: 24V/25A: P/N BRE0000349 12V/13A: P/N BRE0000350 +48V/6.3A: P/N BRE0000346 24V/12.5A: P/N BRE0000348		
 • Top 48V/6.3A • Middle 24V/12.5A • Bottom 12V/13A			
Required Tools 3, 8 and 10 mm hex PH1 or PH2 driver	Preparing Steps for Exchange Vent the instrument Remove cover Remove right side EMC cover	Exchange - remove 2 main wires (red one , labelled 1 and 2) and grounding wires from earth pin using 10 mm wrench - remove the 2 screws from the plate where all the power supplies are attached - remove plate from the instrument (careful: wires need to be taken off the secure clips) - for the 24 V turbo power supply (located on the bottom of the instrument) use 8mm wrench	
Associated Problems	Calibrations/Evaluations that might fail	Diagnostics that detect problems	
Check if voltages are provided with a DVM			
Known Issues and History			

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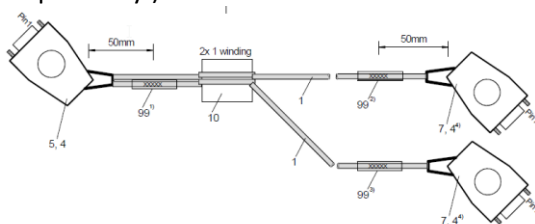
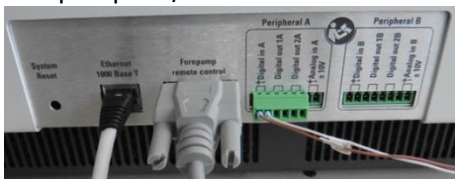
5. Mechanics

5.1 Turbo Pump

Component	Part Number	Used In	Previous Part Numbers
Turbo Pump	BRE0013937		n/a
	Pump controller (TC400) is included in pump Turbo pump including ion gauge and copper seal; BRE0013937 Pfeiffer Split Flow XL (6-stage pump) Pump weight is 20 kg 		
Required Tools	Preparing Steps for Exchange Orbitrap needs to be removed prior to pump exchange		Exchange See separate presentation. KIT for exchange contains Turbo pump, ion gauge and copper seal: P/N BRE0013938
Associated Problems	Calibrations/Evaluations that might fail		Diagnostics that detect problems
Known Issues and History			

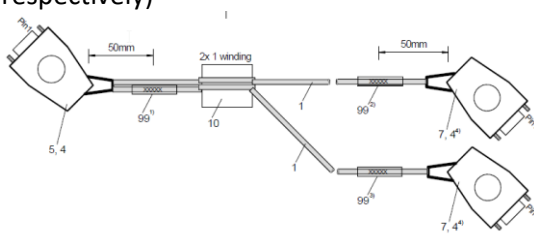
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5.2 Forevacuum pump 1

Component	Part Number	Used In	Previous Part Numbers
Forevacuum pump 1	BRE0015548		
	Leybold Sogevac 120 BI FC (Oerlikon Leybold Vacuum) - single-stage rotary vane pump - primary vacuum pump, which evacuates the funnel region of the vacuum manifold. Nominal pumping speed of ≥ 147 m³/h. 180-264V, 50 & 60 Hz Use Leybonol LV 700 oil only		
Forepump ON/OFF at pump	RS232 cable to Forepump ON/OFF outlet and Forepump 2 (pins 4&5 and pins 8&9 are connected to pin 8&9 and pin 8&9, respectively) 		
	98 kg on wheels to facilitate transport		
Forepump ON/OFF at instrument			
Required Tools n/a	Preparing Steps for Exchange Vent the instrument	Exchange	
Associated Problems	Calibrations/Evaluations that might fail	Diagnostics that detect problems	
Known Issues and History Pump will shut down when not connected. Bridge pin 8 & 9 to see if pump starts.			

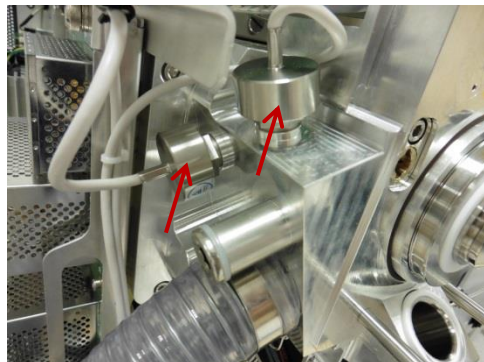
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5.3 Forevacuum pump 2

Component	Part Number	Used In	Previous Part Numbers
Forevacuum pump 2  Forepump ON/OFF at pump 	BRE0015547		
Pfeiffer DUO11: - two-stage rotary vane pump - supplies as auxiliary forepump the forevacuum for the TMP 115-240 V, 50-60Hz RS232 cable to Forepump ON/OFF outlet and Forepump 1 (pins 4&5 and pins 8&9 are connected to pin 8&9 and pin 8&9, respectively)  Use P3 oil only Ensure voltage switch is set correctly!			
Required Tools n/a	Preparing Steps for Exchange Vent the instrument	Exchange	
Associated Problems	Calibrations/Evaluations that might fail	Diagnostics that detect problems	
Known Issues and History Pump will shut down when not connected. Bridge pin 8 & 9 to see if pump starts.			

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5.4 Vacuum gauge (front)

Component	Part Number	Used In	Previous Part Numbers
Vacuum gauge (front)	BRE0013940		n/a
	Pirani-Gauge RPT010 - Pfeiffer		
	Monitors the forevacuum (top) and the pressure in the interflatapole region (bottom)		
Required Tools	Preparing Steps for Exchange	Exchange	
19 mm open wrench	Vent the instrument Remove cover	Disconnect cable Remove gauge	
Associated Problems	Calibrations/Evaluations that might fail	Diagnostics that detect problems	
Known Issues and History			

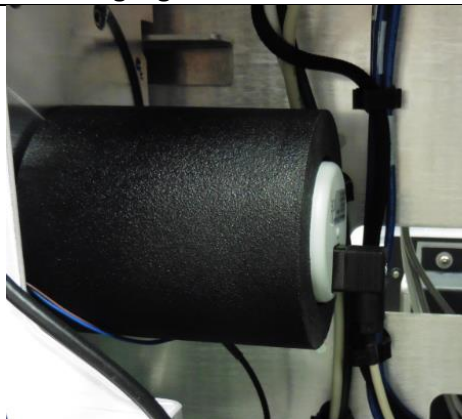
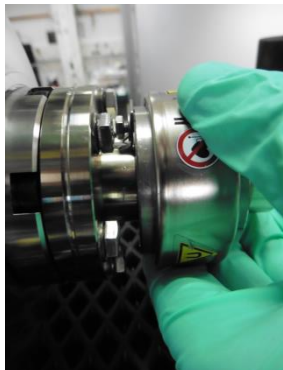
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5.5 Vacuum gauges (back)

Component	Part Number	Used In	Previous Part Numbers
Vacuum gauges (back)	BRE0013940		n/a
	Pirani-Gauge RPT010 - Pfeiffer Monitors pressure in the Ion Routing Multipole		
Required Tools 19 mm open wrench	Preparing Steps for Exchange Vent the instrument Remove cover Remove EMC cover Remove Orbitrap Supply PCB	Exchange Disconnect cable Remove gauge	
Associated Problems	Calibrations/Evaluations that might fail	Diagnostics that detect problems	
Known Issues and History			

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5.6 UHV ion gauge

Component	Part Number	Used In	Previous Part Numbers
UHV ion gauge	1181380		n/a
 	UHV IKR 270 Monitors pressure in the UHV region (uses RJ45 connector) Supplier: Pfeiffer, Edwards, Leybold und Inficon		
Required Tools 7 mm open wrench 5 mm hex Ratchet set	Preparing Steps for Exchange Turn off and vent the instrument Remove cover Remove EMC cover Remove Orbitrap Supply PCB	Exchange Move foam cover to the back to access the screws Disconnect cable Remove bolts Remove gauge	
Associated Problems	Calibrations/Evaluations that might fail	Diagnostics that detect problems	
Known Issues and History Metal screw is used to mount electronics since the instrument has active noise cancelling Always use new copper gasket (P/N 0550480) when exchanging UHV ion gauge A deviating version with old connector (Exactive Series style) was used for first batch of instruments.			

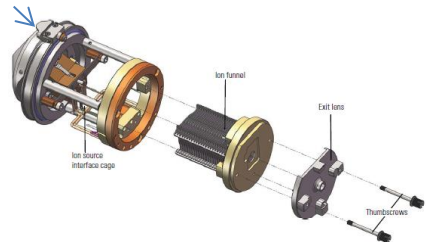
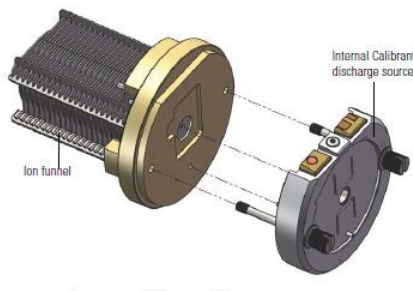
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5.7 Fan assembly

Component	Part Number	Used In	Previous Part Numbers
Fan assembly	2165900		
	Two fans are located below bent flatapole region, one is located below the orbitrap.		
Required Tools n/a	Preparing Steps for Exchange Turn off electronics Remove cover Remove front cover (front fans) Remove right EMC cover (fan below orbitrap)	Exchange Disconnect cable, undo plastic stud, push down and slide out.	
Associated Problems	Calibrations/Evaluations that might fail	Diagnostics that detect problems	
Known Issues and History			

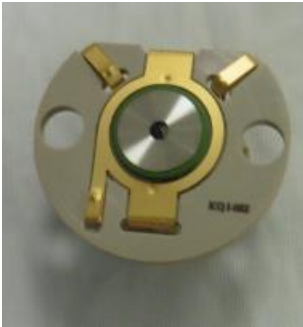
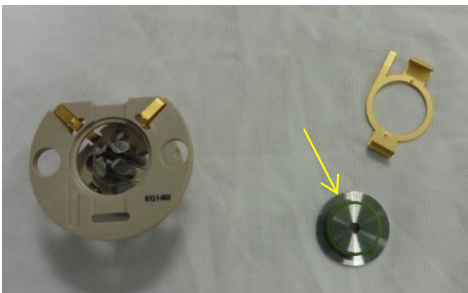
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5.8 API source interface

Component	Part Number	Used In	Previous Part Numbers
API source interface	BRE0018506 BRE0018507		
w/o internal calibration (IC) option PN BRE0018506  with IC option (PN BRE0018507) 	Funnel Cleaning: Step 1: Place into a beaker with 2% alkaline detergent in water with the PEEK holder facing down. Sonicate for 60 minutes. Step 2: Rinse the ion funnel thoroughly with tap water. Step 3: Sonicate the ion funnel in a 50:50 xOH/water solution for five minutes. If there are noticeable residues coming off the funnel in this stage, repeat steps 1-3 until this is not noticeable anymore. Step 4: Sonicate the ion funnel in xOH for 5 minutes. Step 5: Purge with N2 Funnel Exit Lens Cleaning: Step 1: Clean the flat surfaces with lint-free wipes that have been soaked in a 50:50 xOH:water solution. Step 2: Clean the inner surfaces with conical swabs that have been soaked in a 50:50 xOH/water solution. Step 3: Clean the flat surfaces with lint-free wipes that have been soaked in 100% xOH. Step 4: Clean the inner surfaces with conical swabs that have been soaked in xOH. Step 5: Purge with N2 Internal calibrant discharge source can be cleaned (see operating manual) xOH: (Methanol, Ethanol or iso-Propanol)		
Required Tools Slot screwdriver	Preparing Steps for Exchange Vent instrument	Exchange Lift up the release latch, grasp the API source interface with your fingers, and then carefully pull it out of the vacuum manifold Inspect o-ring (arrow) before re-installing	
Associated Problems	Calibrations/Evaluations that might fail	Diagnostics that detect problems	
Known Issues and History			

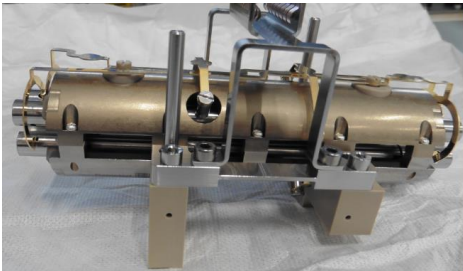
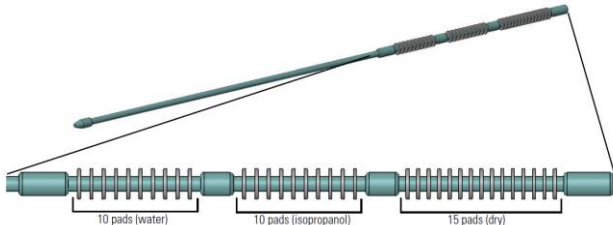
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5.9 Injection Filter + Flatapole Focus Lens

Component	Part Number	Used In	Previous Part Numbers
Injection Filter + Flatapole Focus Lens	BRE0013933		
 	Disassembly: Unhook one side of the clip from the PEEK assembly (upper side in this picture) Unhook the other side and remove clip and lens. Rods should not be removed from assembly. Injection Filter Cleaning: Step 1: Sonicate the injection filter in a 2% solution of an alkaline detergent in water for 5 minutes. Step 2: Clean the rod surfaces facing the ion beam with a lint-free swab soaked in a 2% solution of an alkaline detergent in water. Wipe each rod (from both sides) 20 times. Step 3: Sonicate in a 2% solution of alkaline detergent in water for 10 minutes. Step 4: Rinse thoroughly under warm tap water. Sonicate in 50:50 xOH/water for 5 minutes. Step 5: Sonicate in xOH for 5 minutes. Dry under a strong stream of nitrogen Flatapole Focus Lens Cleaning: Step 1: Use a conical swab soaked with a 50:50 xOH/water solution to clean the inside of the orifice. Step 2: Wipe the lens orifice from both sides with a lint-free wipe wetted with a 50:50 xOH/water solution. Step 3: Wipe the lens orifice from both sides with a lint-free wipe wetted with xOH. Step 4: Purge with N2 xOH: (Methanol, Ethanol or iso-Propanol)		
Required Tools Slotted screwdriver	Preparing Steps for Exchange Vent instrument	Exchange Lift up the release latch, grasp the API source interface with your fingers, and then carefully pull it out of the vacuum manifold Unscrew to screws to release inject flatapole	
Associated Problems	Calibrations/Evaluations that might fail Flatapole evaluation	Diagnostics that detect problems Flatapole Evaluation Charging Test Lens Connection Test	
Known Issues and History			

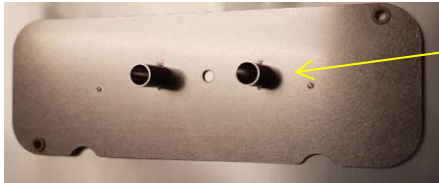
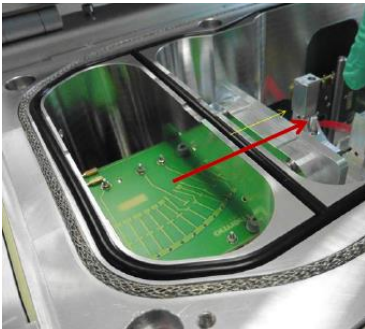
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Quadrupole

Component	Part Number	Used In	Previous Part Numbers
Quadrupole	BRE0018511		
 Remove holder (plastic before installing new quadrupole) 	Filters ions by their m/z charge ratio. Isolation width can be freely chosen. Also active in full scan experiments. Quadrupole rods are split into segments. Entrance and exit segment are run in RF-only mode and at lower RF amplitude than the center segments. Cleaning tool is used for quadrupole cleaning (5x, quadrupole has to be mounted on holder): 		
Required Tools 3 mm hex	Preparing Steps for Exchange Vent instrument Remove cover Open lid	Exchange Unscrew 4 screws Remove the holding brackets Lift the quadrupole straight up to remove it	
Associated Problems Low sensitivity Low MSMS sensitivity Charging	Calibrations/Evaluations that might fail Quadrupole Isolation calibrations.	Diagnostics that detect problems Quadrupole Transmission Check Quadrupole Transmission Endurance Check HCD evaluation	
Known Issues and History First few instruments have different orientation of the guide rods. Correct orientation of the quad is with the circular alignment holes facing the bent flatapole. Newer versions can only be mounted in one orientation.			

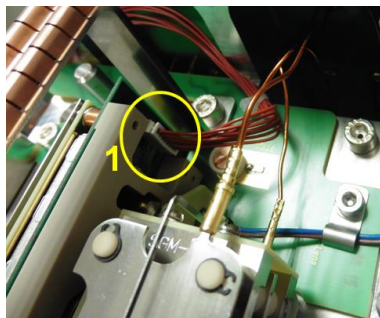
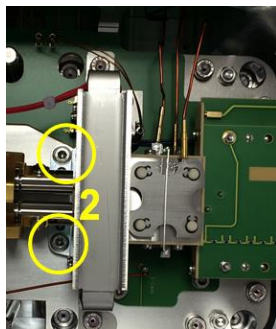
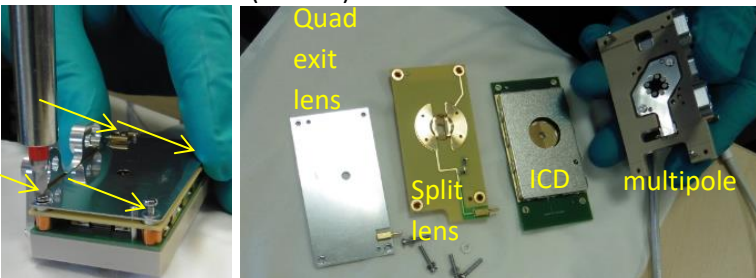
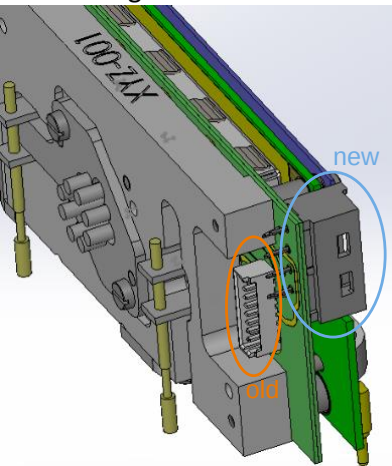
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Bent Flatapole

Component	Part Number	Used In	Previous Part Numbers
Bent Flatapole	BRE0013929		
	Lift the latches and rotate upwards to release the bent flatapole exit lens 		
	Cleaning: Bent Flatapole: Purge with N2 Bent flatapole exit lens:  Neutral contamination spot Step 1: Use a conical swab soaked soaked in 50:50 xOH:Water and clean the inside of the orifice. Step 2: Wipe off neutral spot from the lens with wet lint-free wipes soaked in 50:50 xOH:Water. Step 3: Wipe the lens orifice from both sides with a lint-free wipe wetted with a 50:50 xOH/water solution. Step 4: Wipe the lens orifice from both sides with a lint-free wipe wetted with xOH. Step 5: Purge with N2 xOH: (Methanol, Ethanol or iso-Propanol)		
			
Required Tools 4 mm hex 2 mm hex	Preparing Steps for Exchange Vent instrument Remove cover Remove Quad	Exchange Unscrew 2 screws Remove the holding bracket Pull out to the right	
Associated Problems	Calibrations/Evaluations that might fail	Diagnostics that detect problems	
Known Issues and History			

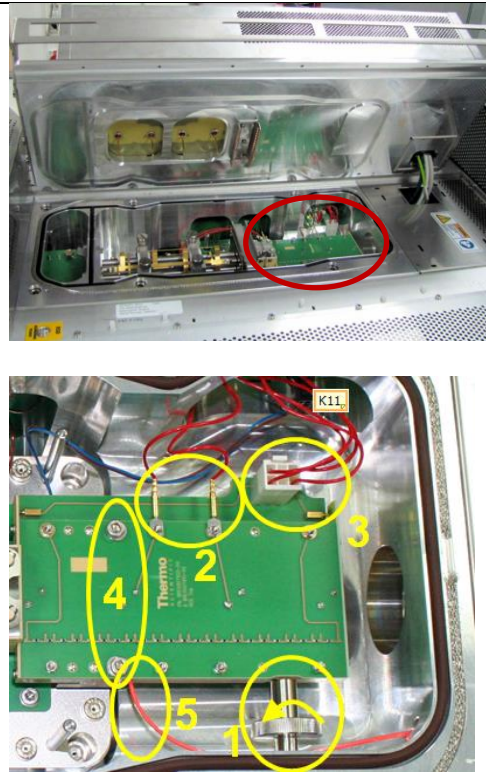
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5.10 Independent charge detector (ICD)/multipole

Component Independent charge detector (ICD)/multipole	Part Number BRE0013931	Used In	Previous Part Numbers
  	Remove four screws (slotted) to disassemble  Octapole cleaning: Refer to Disassembly and Cleaning Procedure document ICD: No cleaning → consumable  The latest version uses different connector, but both types are available on the ICD assembly.		
Required Tools 3 mm Hex Slotted screwdriver	Preparing Steps for Exchange Vent instrument Remove cover Remove Quad		Exchange Loosen the two screws and remove them (2), move the ICD to the left to facilitate cable removal (1) Disconnect the cable (1)
Associated Problems	Calibrations/Evaluations that might fail		Diagnostics that detect problems
Known Issues and History			

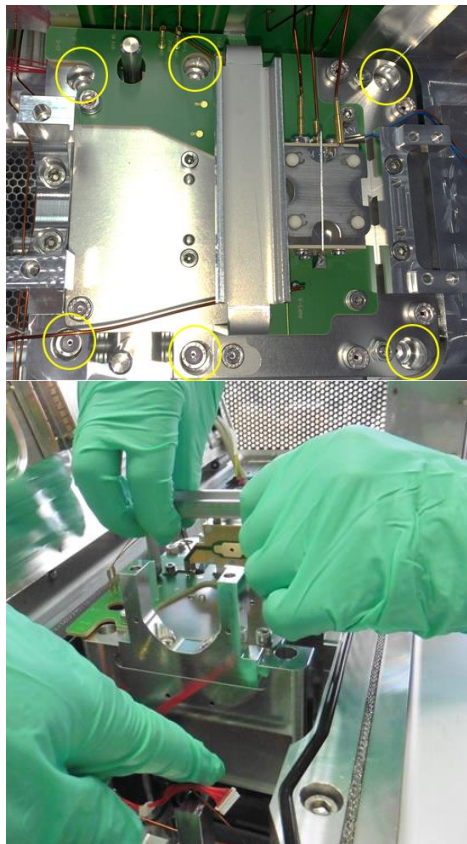
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5.11 Ion Routing Multipole

Component	Part Number	Used In	Previous Part Numbers
Ion Routing Multipole	BRE0013930 HCD cell Assy		
	Use “Ion Routing Multipole” term when communicating about it with customers!		
Required Tools 3 mm Hex	Preparing Steps for Exchange Vent instrument Remove cover	Exchange Retract the tube to the vacuum gauge by turning it counterclockwise (1) Disconnect the two RF wires (2) Unplug the DC connector (3) Loosen the two holding screws (4) Pull out the gas line – it is pushed in all the way in (5) Remove the HCD cell by lifting it upwards	
Associated Problems	Calibrations/Evaluations that might fail	Diagnostics that detect problems	
Known Issues and History Gas line needs to be pushed all the way in Tube to the vacuum gauge might get stuck -> lubricating with isopropanol will help			

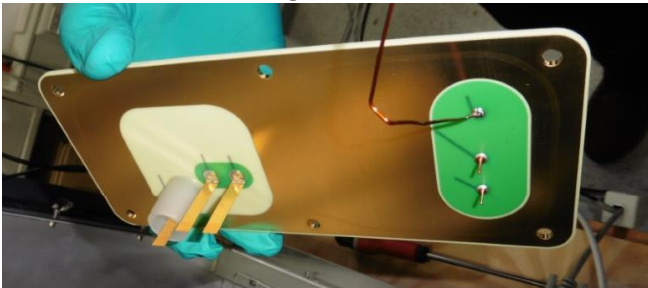
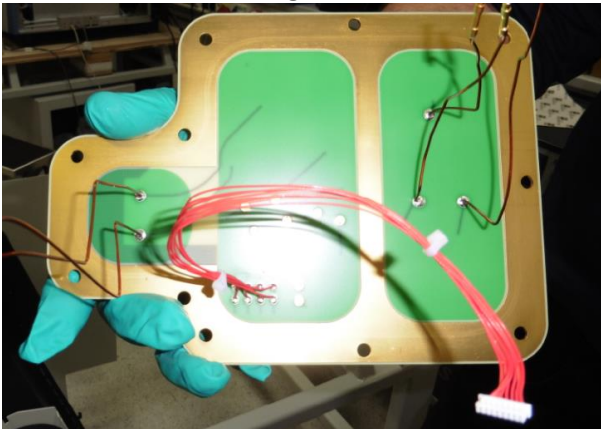
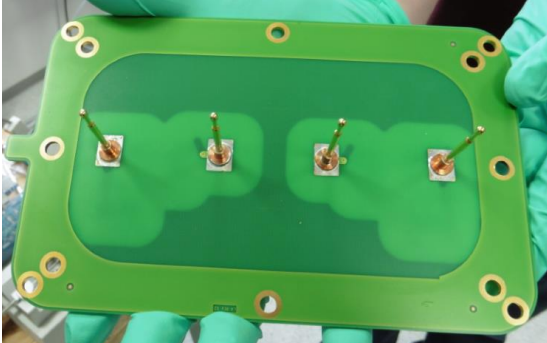
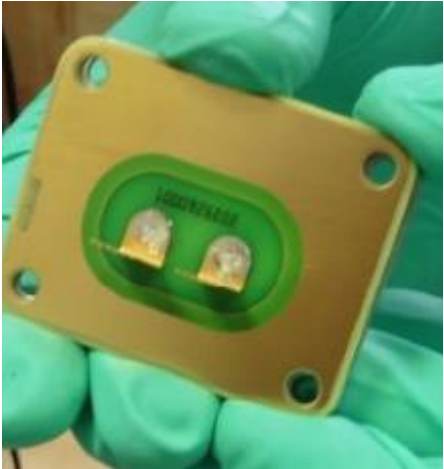
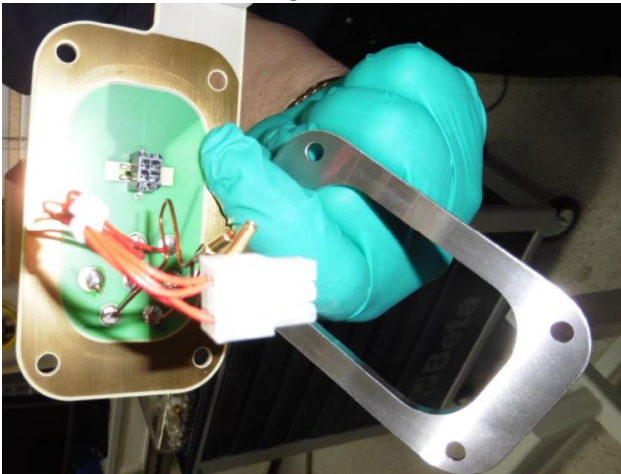
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5.12 C-trap/ Orbitrap assembly

Component	Part Number	Used In	Previous Part Numbers
C-trap/ Orbitrap assembly	BRE0013927		
	D20 orbitrap		
Required Tools Torque wrench (5 Nm to tighten orbi screws) To reach orbitrap bolts: flat head, no ball 	Preparing Steps for Exchange Vent instrument Remove cover Remove Quad Remove HCD Remove ICD	Exchange Remove cables at back (C-trap -> note which cable goes where) Disconnect V-lens Disconnect heater cable Loosen and remove all 6 screws (do not use ballhead allenkeys for this task due to the risk of damaging bolts) Grip the assembly by the handle and pull straight up carefully	
Associated Problems	Calibrations/Evaluations that might fail	Diagnostics that detect problems	
Known Issues and History			

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5.13 Feedthroughs

Component	Used In	Previous Part Numbers
Feedthroughs BRE0016960 Feedthrough Pulser ASSY 		BRE0018029 Feedthrough IOS/Source ASSY 
BRE0016964 Feedthrough CT ASSY 		BRE0017080 Feedthrough Quadrupole RF ASSY 
BRE0018025 Feedthrough Pre-amp ASSY 		BRE0016954 Feedthrough HCD ASSY 

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6. Maintenance

Before performing any maintenance on electronics boards or removing the EMC cover, put the electronics switch of the mass spectrometer in the Off position.

If hazardous materials have contaminated the instrument, the instrument has to be decontaminated prior to any exchange of equipment.

Before performing maintenance on the ion optics/ instrument control board, shut the instrument down according to the instructions below:

1. Wait until data acquisition, if any, is complete.
2. Turn off the flow of sample solution from the LC (or other sample introduction device).
3. In the Tune software window, put the instrument in Off condition. All high voltages are shut off, as are the sheath and auxiliary gas.
4. Put the electronics switch of the mass spectrometer in the Off position.
5. Put the main power circuit breaker switch of the mass spectrometer in the Off position.
6. Wait 10 min for the instrument to vent before beginning any maintenance.
7. Once maintenance is complete, pump down the instrument and run the bakeout procedure after venting. This can be found in the Service Diagnostics Tool in the status tree [ST]:

[ST] Procedures > By Sequence > By Functionality > General > Bake-out

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7. Preventive Maintenance

7.1 Steps to be performed during preventive maintenance of the system

1. Check the integrity of the forevacuum tubing
2. Check/clean the ion transfer tube
3. Clean the S-lens/ion funnel (see 4.8)
4. Clean the inject flatapole (see 4.9)
5. Clean the inject flatapole focus lens (see 4.9)
6. Clean the bent flatapole (see 4.13)
7. Clean the quadrupole (see 4.11)
8. Check the electrometer
9. Inspect the o-rings and contacts of outer cage before reinstalling the outer cage
10. Perform gas line leak check (as outlined in Operating manual)
11. Clean the fan filters (as outlined in Operating manual)

Perform the cleaning steps as indicated in the Cleaning Manual.

7.2 Checks to be performed before and after preventive maintenance of the system

▲ Procedures	
▷ Calibrant Masses	FlexMix
▷ Custom Masses	CalMix
▷ Pre-Conditions	
▲ By Sequence	1;;By Sequence
▷ User	1;;User
▲ Service	1;;Service
Vacuum Chamber Bake Procedure	1;;Vacuum Chamber Bake Procedure
▷ Installation Acceptance	1;;Installation Acceptance
▲ Preventive Maintenance	1;;Preventive Maintenance
▲ Pre-PM Procedures	1;;Pre-PM Procedures
▷ System Check	1;;System Check
▲ Post-PM Procedures	1;;Post-PM Procedures
▷ System Calibration	1;;System Calibration
▷ System Check	1;;System Check
▷ Troubleshooting	1;;Troubleshooting
▷ After Part Exchange	1;;After Part Exchange
▷ Alerts	
▷ IC Source	

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[ST] = Check needs to be run from the service diagnostics tool status tree

- Before starting a PM, run all procedures under
[ST] Instrument > Procedures > By Sequence > Service > Preventive Maintenance > Pre-PM Procedures > System Check (pos) and (neg)
The check includes these items:

eFT check

Spectral mass accuracy test

HCD evaluation

Quadrupole isolation check

Quadrupole mass resolution calibration

Cluster evaluation

Isotope ratio check
- Check for side bands.* This can be found in the Service Diagnostics Tool in the status tree [ST]:
[ST] Procedures > By Sequence > Service > Troubleshooting > By Topic > Ion Detection > Side Band Detection
- Lens connectivity test.* This can be found in the Service Diagnostics Tool in the status tree [ST]:

[ST] Procedures > By Sequence > Service > Troubleshooting > By Topic > Lens and multipole connectivity check
- Ion Optics Voltages Check.* This can be found in the Service Diagnostics Tool in the status tree
[ST] Procedures > By Sequence > Service > Troubleshooting > By Topic > Readback and voltage check
- Sensitivity and Orbitrap Transmission Check:* This can be found in the Service Diagnostics Tool in the status tree [ST]:
[ST] Procedures > By Sequence > Service > Troubleshooting > By Topic > Ion Detection > Signal to noise Evaluation
- After bake out check the UHV and HCD vacuum readings:
 - 5e-11mbar<UHV readback<8e-10
 - 1.00e-2mbar<HCD pressure<1.2e-2mbar

7. After PM completion and bake out, run all procedures under
 [ST] Instrument > Procedures > By Sequence > Service > Preventive Maintenance > Post-PM Procedures

The check includes these items:

eFT check

Spectral mass accuracy test

HCD evaluation

Quadrupole isolation check

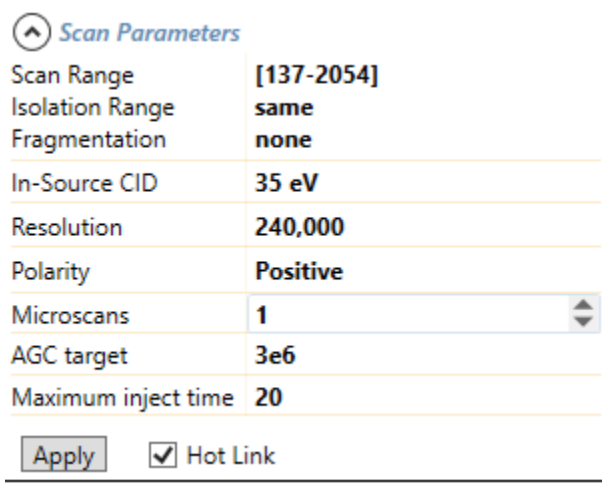
Quadrupole mass resolution calibration

Cluster evaluation

Isotope ratio check

8. Run all procedures described in points 2-6.
9. Verify that the Inject Times with the Calibration solution are < 1 ms. Adjust the source if necessary to achieve this.
10. Mass Range Transmission Check:

- Set the scan parameters as follows:



Scan Parameters	
Scan Range	[137-2054]
Isolation Range	same
Fragmentation	none
In-Source CID	35 eV
Resolution	240,000
Polarity	Positive
Microscans	1
AGC target	3e6
Maximum inject time	20
Apply ☒ Hot Link	

- Verify that the caffeine fragment 138.066 and the Ultramark peak 2021.04 peaks are both visible in the spectrum.

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7.3 Checks to be performed after venting the system

1. Once maintenance is complete, pump down the instrument and run the bakeout procedure. This can be found in the Service Diagnostics Tool in the status tree [ST]:

[ST] Procedures > By Sequence > Service > Vacuum Chamber Bake Procedure

2. After the bake out, run all procedures under

[ST] Instrument > Procedures > By Sequence > Service > Preventive Maintenance > After-PM Procedures > System Check (pos) and (neg)

The check includes these items:

eFT check

Spectral mass accuracy test

HCD evaluation

Quadrupole isolation check

Quadrupole mass resolution calibration

Cluster evaluation

Isotope ratio check