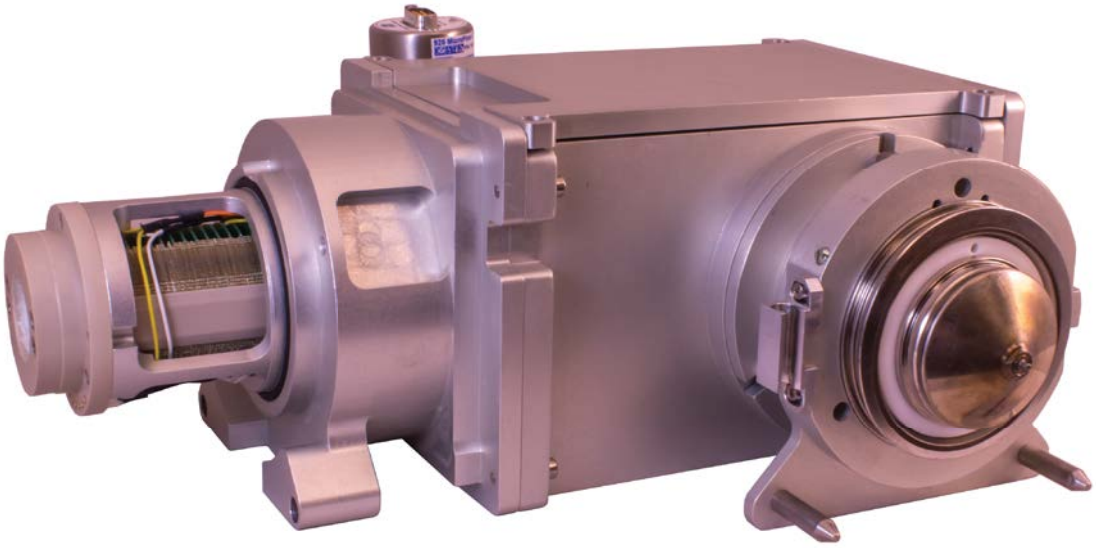
Two Stage Ion Funnel for Thermo Mass Spectrometers

(LTQ Ion Trap, LTQ Orbitrap, Orbitrap Elite, Velos, Velos Pro, Exactive, and Q Exactive, Orbitrap Fusion, TSQ Quantiva, TSQ Endura)

Installation, Operation, and Maintenance Manual



Warning

The heated capillary assembly cone inserted into the funnel's mouth is kept under 310-350 V voltage and should be handled with **extreme** care. Touching it with one's bare hand/fingers during funnel operation can result in electrical shock. One needs to take special measures to protect the heated capillary conical assembly from accidental touching.

For maintenance and/or repairs, please contact your sales agent or the manufacturer directly:

MASSTECH, INC.

6992 Columbia Gateway Dr.
Suite 160
Columbia, MD 21046 USA

Phone: (443) 539-1758
Fax: (443) 539-1759
E-mail: msms@apmaldi.com

Last revision: October 12, 2017

MassTech

Table of Contents

PREFACE

The following symbols are used in this manual to indicate material that should especially be noted because it relates to safety issues.

This symbol in the manual margin is used to emphasize the presence of important operating instructions related to safety; especially during installation, un-installation, maintenance, and troubleshooting.

This symbol in the manual margin is used to alert the operator to potential dangerous exposure to high voltage.

Operators are strongly encouraged to read this manual before installation, un-installation, operation, maintenance, or troubleshooting. Operators should pay special attention to paragraphs marked by  and  .

DO NOT ATTEMPT services or repairs that are not covered in the Troubleshooting Section, Section 8, of this manual. For services and repairs beyond those specifically provided in the Troubleshooting Section, contact the manufacturer:

MassTech Inc.
ATTN: Service Department
6992 Columbia Gateway Drive
Suite 160
Columbia, MD 21046
USA

Phone #: (443) 539-1758
E-Mail: msms@apmaldi.com

(This Page is left intentionally blank)

1 INTRODUCTION: TWO-STAGE ION FUNNEL: IMPROVING THE ION UPTAKE FOR MASS SPECTROMETERS WITH ATMOSPHERIC PRESSURE ION SOURCES

The Two-Stage Ion Funnel is designed to provide better transmission of ions of analytes over a very broad MW range produced in Atmospheric Ion Sources (ESI APSI, MALDI, *etc*) to the downstream (low vacuum) sections of Mass Spectrometer. The ions produced by the Atmospheric Source are carried with atmospheric air intake through the heated capillary to the chamber containing the high pressure (HP) ion funnel. There, the ions are declusterized, focused towards the exit for the HP funnel, and transmitted with very low loss to the second chamber containing the low pressure (LP) funnel. In this LP funnel, the ions can be either trapped for a time period up to a few hundred ms or can be transmitted directly to the downstream (RF "flatapole") section of Mass Spectrometer kept at low vacuum. The main advantages of using the Two -Stage Ion Funnel are as follows:

- The Two-Stage Ion Funnel is an assembly external to mass spectrometer. It is designed to easily accommodate a variety of ion sources such as the ESI, APCI, DART, MALDI, *etc*.

- The Two-Stage Ion Funnel allows one to reduce many-fold the ion loss in the subatmospheric section of mass spectrometer compared to the systems utilizing the nozzle-skimmer interface or S-lens. Contrary to

S-lens it allows simultaneous transmitting the ions of significantly broader m/z range. The heated capillary exploited in the two-stage ion funnel assembly has larger i.d., providing 4 times stronger intake. This allows one, for instance, to collect almost all the ions generated in the divergent plume of the nanoESI source. With the used of funnel, the interior low- and high-vacuum parts of the MS system are not exposed to contaminants containing in the sprayed solutions. The latter allows one to keep the interior of MS system clean for a long time. The Two-Stage Ion Funnel interface is equipped with a small external pump that aids in establishing low pressure in the HP funnel chamber. The pressure in this chamber can be established at approximately 7-20 Torr, which is beneficial for efficient declusterization of analyte ions. A detailed discussion of the Two-Stage Ion Funnel operation can be found in publications [1, 2].

- The Two-Stage Ion Funnel assembly is designed as an additional external interface to the mass spectrometer capable of not only transmitting the ions but also trapping the ions for an extended time. The trapped ions can be pulsed out toward the low-vacuum section of the mass spectrometer in a time of 100-200 microseconds. Thus, the ion funnel assembly can be used not only with Thermo instruments, but also with a variety of qTOF MS ones.

- The two-stage Ion Funnel utilizes a separate (from the MS system) fore-vacuum pump. Due to high-speed gas evacuation of the gas streaming from the heated capillary, the funnel can be used with FAIMS devices utilizing air-helium mixtures to attain a very high resolution. The FAIMS device provides information about molecular cross sections of the ions under MS analysis. The use of complementary gas phase separation technique such as FAIMS gives the opportunity to cover a broad range of problems in modern analytical chemistry.

1.1 QUICKSTART OPERATION

This section covers the basic operation of the two-stage Ion Funnel and iFunnel software.

Once the two-stage Ion Funnel is installed, according to Section 5 of this manual, the operation steps are as follows in the section below.

NOTE: All installation and uninstallation procedures **must** be done with the main power switch and electronic system switch on the mass spectrometers turned "OFF." (The order and timing for turning off main and electronic system rocker switches are described in corresponding Thermo's MS system manuals). Before proceeding, the operator is strongly urged to read the safety procedures in Section 4 of this manual.

1. Prepare the sample(s) according to Section 6 of this manual; the sample preparation procedures are similar to methods used for the conventional (vacuum) MALDI and ESI sources.
2. Pump down the HP section to 7-14 Torr by turning on power on the fore-vacuum pump and by slow opening the in-line valve on the vacuum hose. The gas pressure in the LP funnel should not exceed 1.5-1.6 Torr. One needs to operate within safe pressure limits in the "flatapole" section of MS located downstream of the LP funnel. One is required to read the corresponding Thermo MS system manual section to figure out the pressure limit in the "flatapole" section. If it starts to exceed the safe value, then one is required to change the fore-vacuum pump for the one with larger pumping speed.
3. Turn the unit "ON" (by toggling the black round rocker on the rare panel of the DC/RF Control unit), and wait for the unit to initialize (the green LED standing above Power sign on the front panel goes ON). Run the iFunnel software on the PC.

4. The Thermo Software (LTQ Tune, Tune, or Orbitrap Fusion etc.) is normally optimized for the electrospray source. Accordingly, using ESI source/Funnel combination, the operator must adjust the Tune software's parameters so that it is optimized for the ESI source.

In case of using LTQ or Velos (with or without Orbitrap), set the MS system software (Tune) to the following initial settings:
For ESI source, use the trapping time (LTQ part) 1-2 ms,
For AP-MALDI source, use the trapping time (LTQ part) 100-200 ms
Injection Time (for C-trap): 100-500ms

5. To turn the funnel OFF, the operator must click to Standby button in iFunnel software and then click Exit. Then one needs to put the mass spectrometer to the “Standby Mode”.

6. If the funnel’s fore-vacuum pump must be turned off by some reasons (MS system is in standby mode), turn OFF the power that is supplied to heat the capillary cone, wait for its temperature to drop below 50 C, and provide tight sealing to the capillary

2 THE TWO-STAGE ION FUNNEL BASIC PRINCIPLES

This section will focus on the description of operation of the Ion Funnel.

A schematic drawing of the two-stage Ion Funnel is shown in Fig. 2.1.

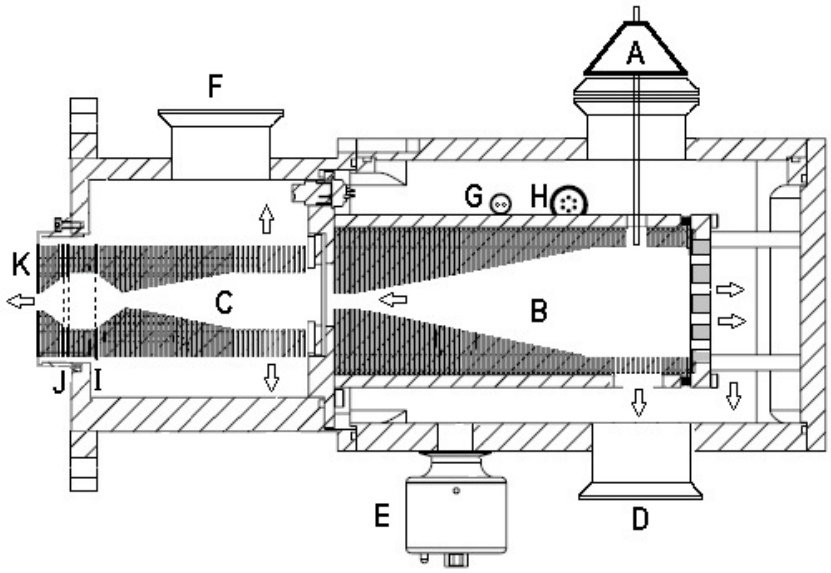


Fig 2.1. Schematic drawing of the two-stage Ion Funnel

The two-stage Ion Funnel assembly comprises: **A** - the inlet capillary heated cone, **B** - high pressure (HP) funnel, and **C**- low pressure (LP) funnel with ion trapping grids. Also are shown: D- NW40 port to evacuate gas from the HP funnel; E -Pirani gauge measuring gas pressure in the HP funnel (typically over 0.7-22 Torr range); F- NW40 port to evacuate (if necessary) gas from the LP funnel; G- RF voltage connector, H - DC voltage connector, I – entrance grid; J –trapping and exit grids; K – the exit electrode (DC only voltage). Arrows indicate gas evacuation routes.

The ions produced by the atmospheric ion source enter the capillary with the inrushing air. After passing the capillary, the ions are discharged into the HP funnel, declusterized and spread over the HP funnel volume. Then, the ions are directed to the LP funnel by the action of the electric field. The ions can be trapped for some time in the LP funnel. Eventually, the trapped ions are ejected by the electric field towards the downstream section of the MS system.

The ion trapping step can be omitted. In this case, after entering the LP funnel the ions are transferred without delay to the LP funnel exit by the joint action of the electric field and gas drag.

The ion trapping takes place in the cylindrical section of the LP funnel. The trapping field is provided by means of DC voltages applied across the entrance and trap fine mesh grids.

The gas from the HP funnel section is evacuated by the fore-vacuum (roughing) pump. The gas discharged by the capillary is pumped through gaps between the funnel plates opposite to capillary distal end. The Ion Funnel electrodes (plates) made from solid PCBs are separated by metal washers in a cylindrical part of the HP funnel Also, several dozen holes made in the first solid metal plate of the HP funnel (cover plate) offer an additional pumping route. Eventually, the gas is evacuated through the NW40 port. The conical part of the HP funnel is made gas-tight through the use of solid plastic spacers instead of washers.

The same or another pump can be used to evacuate the gas from the LP section through the NW40 port. The gas evacuation from the LP funnel is often not necessary because the gas from this section is also pumped by the fore-vacuum pump(s) of the Thermo MS instruments. The gas from LP funnel is pumped out through the gaps between the plates in its cylindrical part. The rest of the LP funnel is sealed through the use of solid plastic spacers.

The ions are kept from escaping from the HP and LP funnels by the action of the RF field produced between the adjacent electrodes.

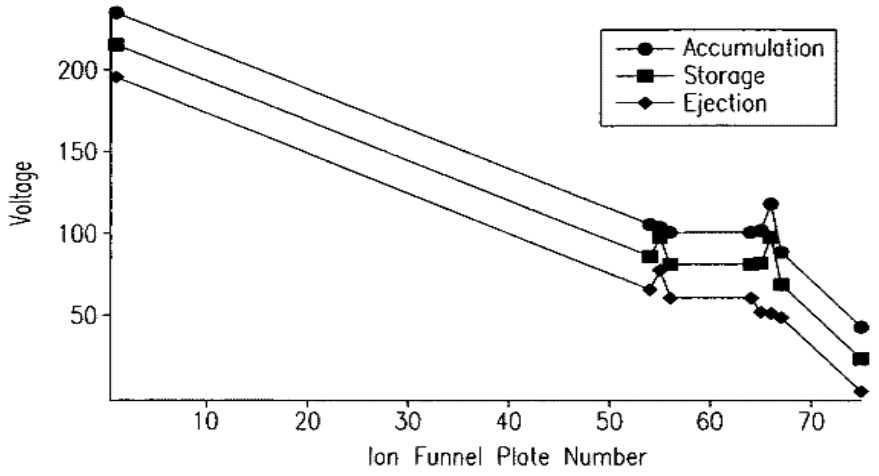


Fig 2.2 shows the sequence of ion accumulation, storage, and ejection events

During ion accumulation, storage, and ejection events, the DC voltages are kept constant. The only voltages to change are those applied across the grids. The timing for ion accumulation and storage depends on the intensity of the ion flow towards the LP ion funnel trapping volume. When using the ESI source, it can be as short as 1 to 5 ms, when using MALDI source it can exceed 200 ms. The trapped ions are ejected in 0.1 ms, typically.

4 SAFETY PROCEDURES WHILE USING THE SUB-AP/MALDI ION SOURCE

If operated properly, the ion funnel is safe. No special knowledge of electrical safety is necessary to operate it. However, there are one potentially hazardous factor connected with the funnel installation, operation, and maintenance/ troubleshooting:

1. High voltage up to 400 V DC applied to the heated cone
2. Hot surface of the heated cone

In order to insure the necessary safety measures, the manufacturer of this product has implemented protection measures for the users by limiting the current that can be produced by the 400 V DC source. Nevertheless the touching of the heated cone during funnel operation is hazardous. Also, turn all the voltages OFF or disconnect DC, RF as well as cone heating (if used) cables during installation/ uninstallation.

4.1 Safety Precautions

This section describes important precautions that must be observed during the ion funnel ***installation/un-installation, operation, and maintenance***. Appropriate precautions can be divided into the following stages:

- **Installing and Uninstalling:** The Ion Funnel is bolted to the MS system by means of two Socket Head Screws (supplied by MassTech). The screws are first inserted into the two holes on the top part of the LP funnel section. The screws are directed towards the opposite threaded holes on the front circular flange of Thermo's MS system. Before attaching the Ion Funnel, two original screws holding the top of the metal ring serving to attach the heated capillary cone must be removed. When the Ion Funnel is installed or uninstalled into the mass spectrometer, the mass spectrometer must be placed into the "Shutdown" mode. To switch the MS system into the Shutdown mode please read Thermo manual for corresponding MS instrument.

Never switch the power "ON" of the DC /RF box feeding the Ion Funnel before the source is completely installed.

As stated earlier, when uninstalling the device, make sure that the MS is in "Shutdown" mode. The operator must also turn OFF the DC/RF Control box. Then the operator may detach the Ion Funnel or start doing other disassembling operations.

The operation of the Ion Funnel with Thermo MS systems necessitates a use of custom-made "source closed" DB-15 connector interlock. The interlock is supplied by MassTech Inc and is inserted into DB-15 receptacle located on the Front panel of the MS system above the original position of the cone.
MassTech also provides the high voltage cable that can connect the high voltage input of the customer ESI source to the HV receptacle of Thermo MS instrument located on its front panel.

- **DC/RF Control unit: If t**he operator needs to open the Funnel (for instance, to make a clean up), it is mandated that the operator switch the MS instrument into OFF mode. Before doing that, the operator is mandated to click "Standby" and then "Exit" in the iFunnel software and then to turn OFF the DC/RF unit. If the Funnel is open and/or the pressure inside it is larger than 25 Torr, the iFunnel software automatically establishes the "Standby" mode and cannot be engaged into the "Continuous" mode. Keep the Pressure gauge cable terminated with two DB-9 always bolted to corresponding DB-9 receptacles.

- **Mass Spectra Recording:** During the data acquisition, the gas from the Ion Funnel's HP section must be pumped out. There is no safety interlock preventing automatic shutdown of the 300-370 V voltage supplied by the RF/DC control box to the heated cone under condition when the operator inadvertently touches the cone.

DO NOT ATTEMPT services or repairs that are not covered in the Troubleshooting Section, Section 8 of this manual. For services and repairs beyond those specifically provided in Section 8, contact the manufacturer:

MassTech, Inc.
6992 Columbia Gateway Drive, Suite 160
Columbia, MD, 21046, USA
Phone: +1 (443) 539-1758
Please ask to be directed to the MassTech Sales Department.

Remember:

Never attempt to open the DC/RF box during operation

- **Never power "ON" the Mass Spectrometer if the Ion Funnel is not properly bolted to the Mass Spectrometer.**

4.2 Operator Controls and Indicators

The two figures below illustrate the front and back plate of the DC/RF Control unit. When the unit is connected to the 110/220V power grid via power cord inserted into the power entry (see the Back panel) and the switch on the same Back panel is switched into ON (marked as "I") position, then the green LED (below Power label) on the Front panel goes ON. The yellow LED goes ON indicating the **Overload** when the RF part of the unit starts to consume more power than usual. With that happening, turn the unit OFF!

Figure 4.1. The DC/RF Control unit. **Front panel**

Figure 4.2 The DC/RF Control unit. **Back Panel**

5 SOURCE INSTALLATION

5.1 Checking that all Components have been received

Before the operator starts installing the Ion Funnel, the operator must ensure that all necessary parts and accessories have been delivered. Figures 5.1 through 5.5 (below) show these components and introduce some definitions as well as the part names used in the installation explanations.

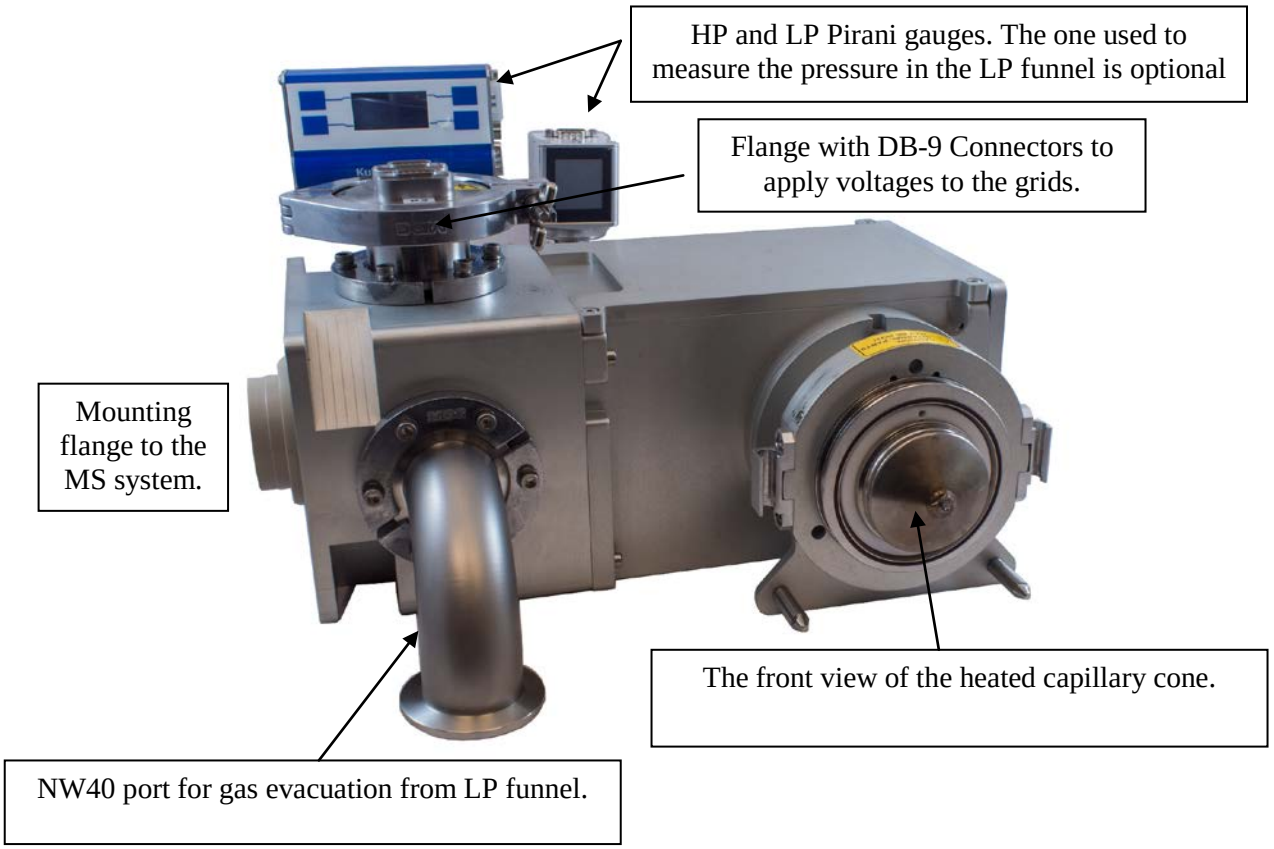


Figure 5.1. Side View of the two-stage Ion Funnel with the heated cone installed.

Figure 5.2. A view of the two-stage Ion Funnel. The heated capillary cone is not installed. In the heated cone mounting hole, one can see the wired PEEK segment connector with 7 pins. The pins should be inserted into opposite bronze receptacles in the inlet capillary cone taken from Thermo MS.

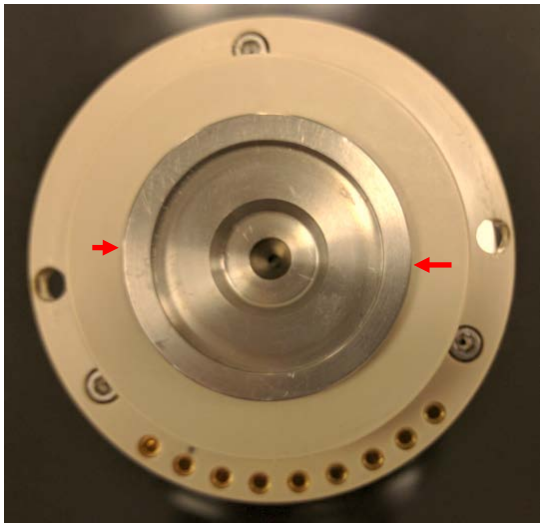


Figure 5.3. A rear view of heated capillary cone of LTQ MS system. Before inserting the cone into the Ion Funnel, one needs to remove the skimmer (stainless steel disk in the center). The skimmer can be removed by unscrewing two set screws. Positions of the set screws are shown with red arrows.

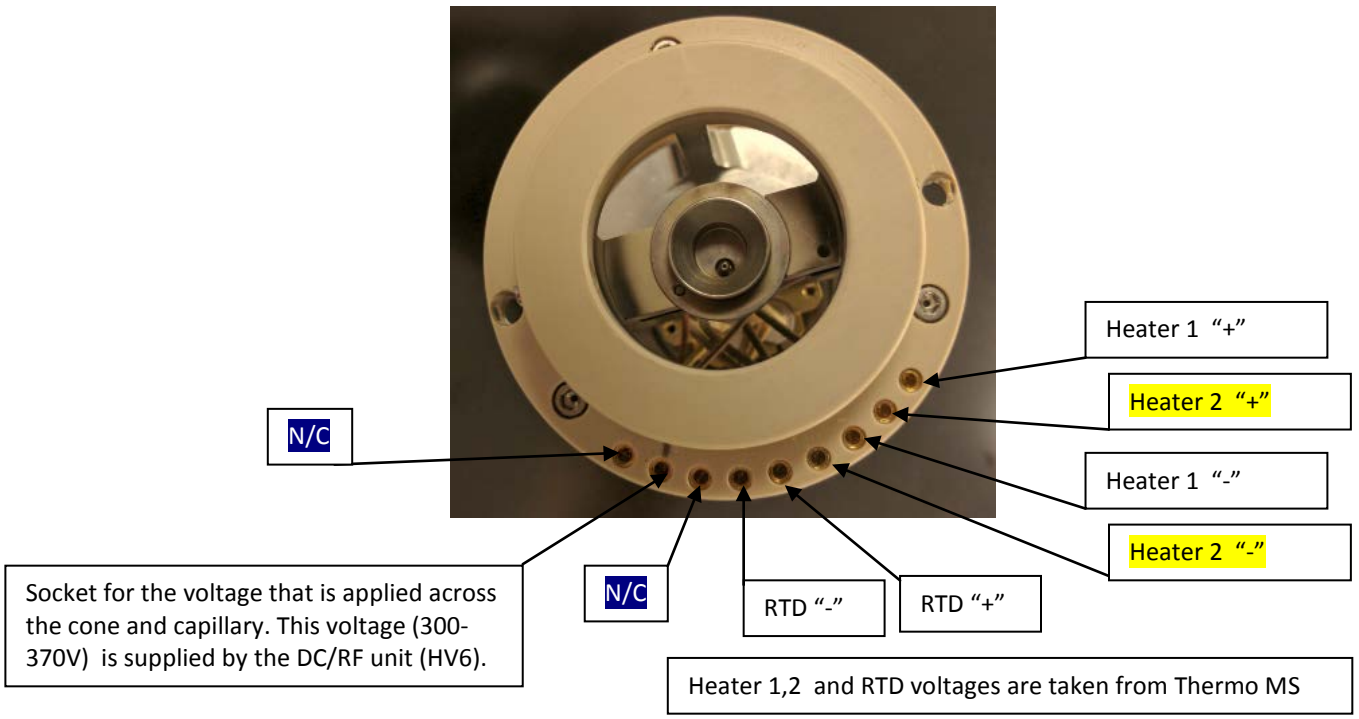


Figure 5.4. A rear view of the heated capillary cone of LTQ MS system with skimmer removed. Before inserting the cone into the Ion Funnel, one needs to <u>insert pins of the PEEK segment connector</u> into the corresponding bronze sockets in the PEEK flange in the rear of the heated cone. Attention must be made to the order of wiring for Heater 1 and Heater 2. Due to the fact the skimmer is removed, there is no need to apply any voltage across it, so a corresponding socket is <u>left not connected</u> (N/C). The same N/C state is kept for the socket connecting the voltage supplied from MS and the lens (the lens is seen as the thick disk surrounding the end of the metal capillary). The voltage across the cone metal body and capillary is supplied by the DC/RF unit (HV6). The opposite pin in the PEEK segment connector is soldered to the wire that is terminated at the 9-pin FISHER connector (pin #6).

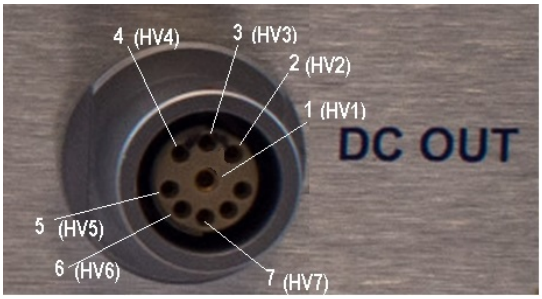


Figure 5.5. FISHER 9-pin female connector pinout utilized to connect the DC/RF with the Ion funnel electrodes. The same is pinout for the female FISHER connector on the Ion Funnel body.

Before the operator installs the heated cone into the Ion Funnel, the operator must remove (unscrew) the Skimmer or the S-lens from the heated cone assembly. Basically only the capillary (and the lens in case of LTQ MS or LTQ Orbitrap) must be retained in the space past the heated cone. The original Thermo capillary must be unscrewed and instead the new capillary (supplied by MassTech) must be screwed in its place.

In addition to the Ion Funnel and DC/RF unit, the following items are included into the shipment:

	Description		Quantity
1.	USB A to USB B cable	(3 ft)	1
2.	Fisher 9 pin cable	(3 ft)	1
3.	Fisher 3 pin cable	(3 ft)	1
4.	DB-9 male to female cable	(3 ft)	1
5.	MassTech DB-15 Plug Unit (required for MS to recognize the ion source)		1
6.	HV cable	(3ft)	1
7.	Power cable	(6ft)	1
8.	Extended Capillary		1
9.	Pirani gauge (MKS)		1

Optional items:

Additional Pirani gauge

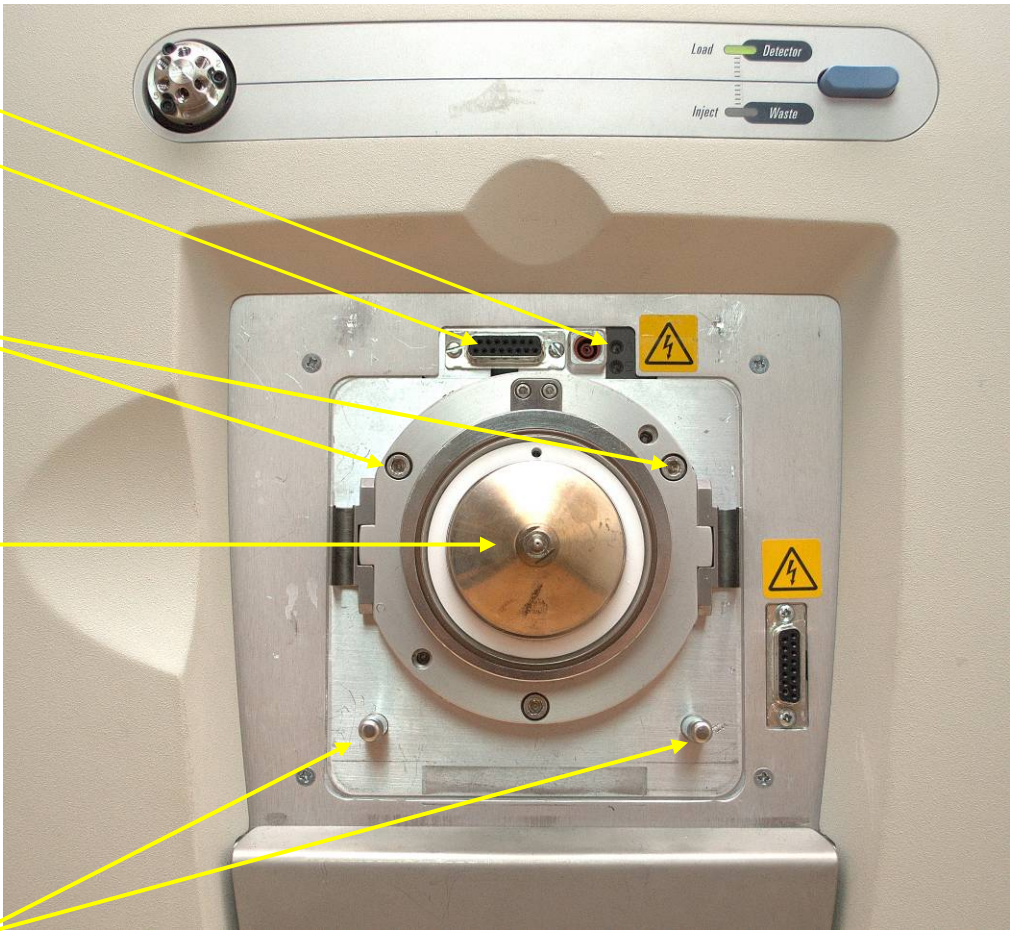
NW Flange with DB9 connectors mounted on the top of the LP funnel

5.2 Installation of the Source

Installing/Uninstalling: Before the source is installed, uninstalled, or replaced, the mass spectrometer must be in either the "Standby" or "Shutdown" mode. The same rules, as described in the mass spectrometer operator's manual regarding the replacement/repair of the heated cone in Thermo MS instruments, are applicable for the Ion Funnel.

> ***Never*** switch the power "ON" on the rear panel of the DC/RF Control box before the source is ***completely installed***.

The ion sweep cone must also be removed (CAUTION – the ion sweep cone may be hot). The mass spectrometer inlet typically looks like Fig. 5.6 when it is ready for the Ion Funnel installation.



HV socket

DB-15 connector

These two bolts must be unscrewed to install iFunnel

Capillary heating cone (inlet) with Ion Sweep Cone REMOVED. **The capillary heating cone can be removed (pooled out) by hands 30 minutes after the instrument is OFF. Beware, it can be still rather hot! Wait until it cools down.**

Support Pins

Fig 5.6. The Inlet of the Thermo LTQ/Velos Mass Spectrometer

Fig 5.7. The Ion Sweep Cone Must be Removed Prior to Source Installation

CAUTION: The ion sweep cone may be hot!

Next, insert the iFunnel part into the mass spectrometer while making sure to line up the holes on a bottom of iFunnel with the conical supports (see Fig. 5.6). Use the 2 bolts (M4x22 mm length) to firmly attach the iFunnel to the Mass Spectrometer. Only two upper threaded holes from which the original bolts have been removed are used for bolting the iFunnel while the bottom bolt is kept untouched. Also, the MassTech's Plug Unit (DB-15 plug in a metal shell) should be inserted into the 15-pin connector located above the Inlet of Mass Spectrometer. In Q Exactive, use MassTech's plastic insert to defeat the source interlock. .

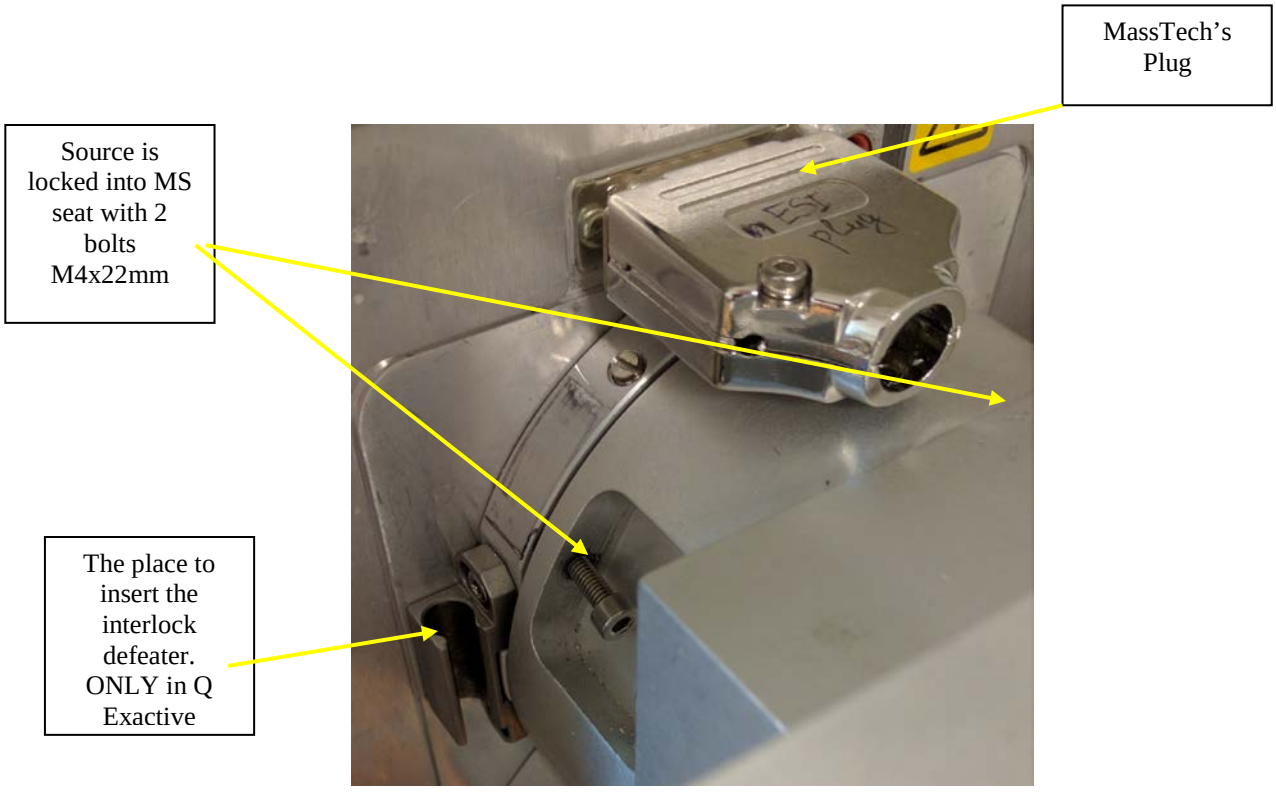


Figure 5.8. Installation Step for the iFunnel part into the Mass Spectrometer. To the left is a knob of manual vacuum shutter (gate).

5.3 Connecting cables

Control Unit cabling:

Connect the power cord to power entry of the RF/DC Control box (rear panel, Fig 4.2).

No adjustment is necessary for RF/DC Control unit. It can take power from ~110/~127/~220/~240V AC!

DC/RF box cabling:

Connect the USB (B) terminal of USB cable to the corresponding B type USB socket on the front plate of the Control unit (Fig. 4.1). Another (A) terminal of the USB cable should be inserted into the USB port of the customer PC. Connect 9-pin DC and 3-pin RF cables (the RF cable comprises two thin cables terminated with BNC connectors joined, on the other, end in one Fisher connector) to the corresponding DC and RF outputs located on the front panel of the DC/RF Control box. Connect the DB-9 connector of the pressure measurement cable to the 9-pin connector on the top-right corner of the DC/RF box (see Fig 5.9).

Figure 5.9. Connecting cables to DC/RF box

iFunnel and manifold cabling

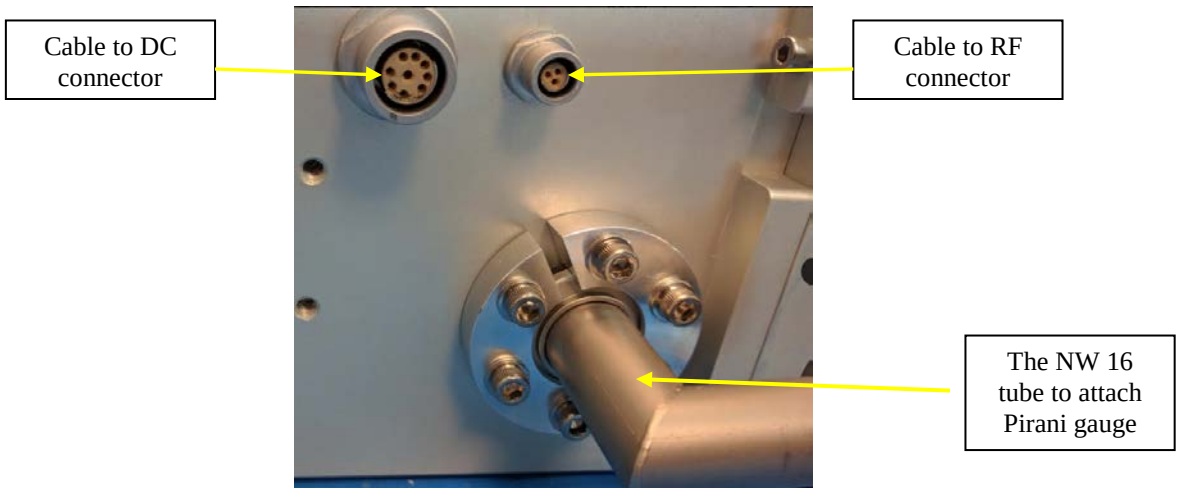


Figure 5.10. Connecting cables to the Ion Funnel

Connect the 9-pin DC cable to Fisher's DC connector on the side of the Ion Funnel part. Make sure that red dot on the receptacle is opposite to that on the jack. Connect the RF cable (the RF cable is terminated with a pair of BNC connectors and a single Fisher connector) to the 3-pin Fisher's RF receptacle on a side of the Ion Funnel part (see Fig. 5.9). Make sure that red dot on the receptacle is opposite to that on the jack. Connect the DB-9 connector of the pressure measurement cable to the 9-pin output of the Pirani gauge attached to the NW16 tube.

<u>Before Switching on the Power "On"</u>

1. Ensure that the connectors are firmly connected.
2. Now it is safe to turn on the Control unit.
3. Masstech DB-15 Plug is inserted into MS
4. The "source open" defeater (ONLY for Q Exactive) is inserted

5.5 Source Removal and Uninstallation

When the operator needs to remove the Ion Funnel in order to put another device on the MS, the operator must follow the steps below:

1. Set the MS Instrument to the “Standby” and then to “OFF” mode.
2. Turn the power OFF on the DC/RF Control unit.
3. Then, uninstall the source by reversing the installation procedure as described in Sections 5.1 , 5.2 and 5.3.

6 SAMPLE PREPARATION

The same sample preparation techniques and the same matrix used for the conventional MALDI vacuum can be used for the AP MALDI sample preparation. The main difference, is that the crystal size in AP MALDI has no direct influence on the spectrum quality. A typical molar ratio of a sample-to-matrix is between 1:100 and 1:10,000.

Prepare several standard samples for testing the AP MALDI source. The following steps below are deemed as a typical sample preparation procedure:

- Carefully clean the target plate surface
- For the standards test, a α-Cyano-4-hydroxycinnamic acid (α-CHCA) matrix is recommended and typical matrix concentration is 5 mg/mL (30% water/ 70% Acetonitrile, v/v).
- Mix matrix solution in a ratio 1:1 (v/v) with analyte solution composed of the standard peptides (Angiotensin II, Bradykinin 1-7, $P_{14}R$ and/or similar peptides) with a concentration of approximately 500-1000 fmole/µL (50% water/50% acetonitrile, 0.1% TFA) .
- Deposit a droplet of 0.5-2 µL of the mixture on the metal target surface and allow it to dry

Figure 6.1. Spotting of Several Standard Samples

Figure 6.1 shows the spotting of several standard samples on a target (sample) plate for testing by the AP/MALDI. The sample preparation procedure is similar to the vacuum MALDI experiments.

7. *Running iFunnel software*

Turn on the DC/RF box. Double click on the iFunnel icon. Go to File and select Settings. Filling Settings fields allows one to establish communication with PC.

Both Stellaris COM port and RF generator Serial Numbers as well as resonance RF frequency for any given DC/RF box are written on the internal surface of the DC/RF box top cover or on the bottom of the DC/RF box.

"Trapping mode ejection time" that control the simultaneous change of the voltages across the funnel electrodes (excluding grids) is typically disabled due to its low efficiency for QExactive and Velos/LTQ Orbitraps, though it can be use with stand along Velos, LTQ MS systems, or with custom ion mobility TOF MS systems. One needs to request this option separately from MassTech Inc.

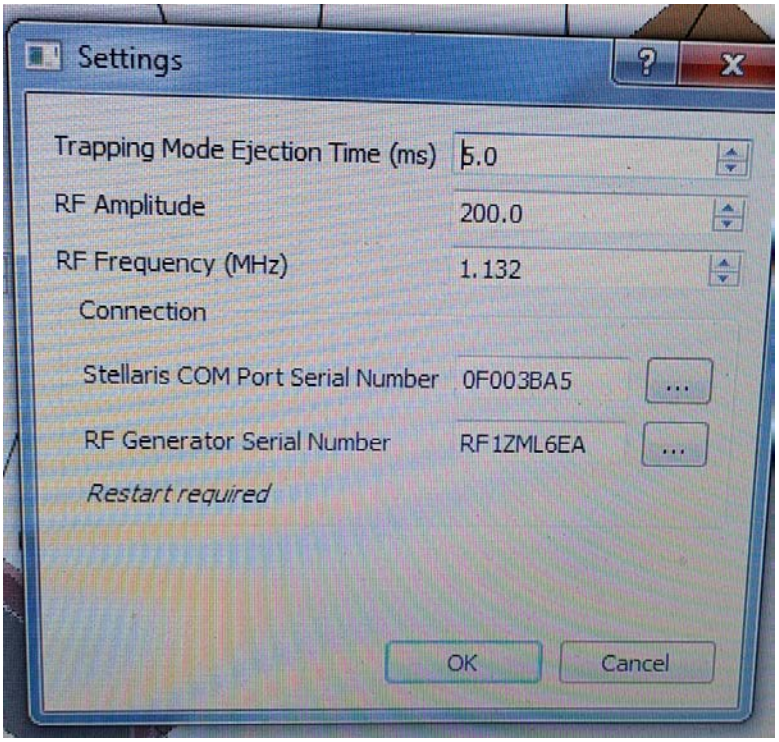
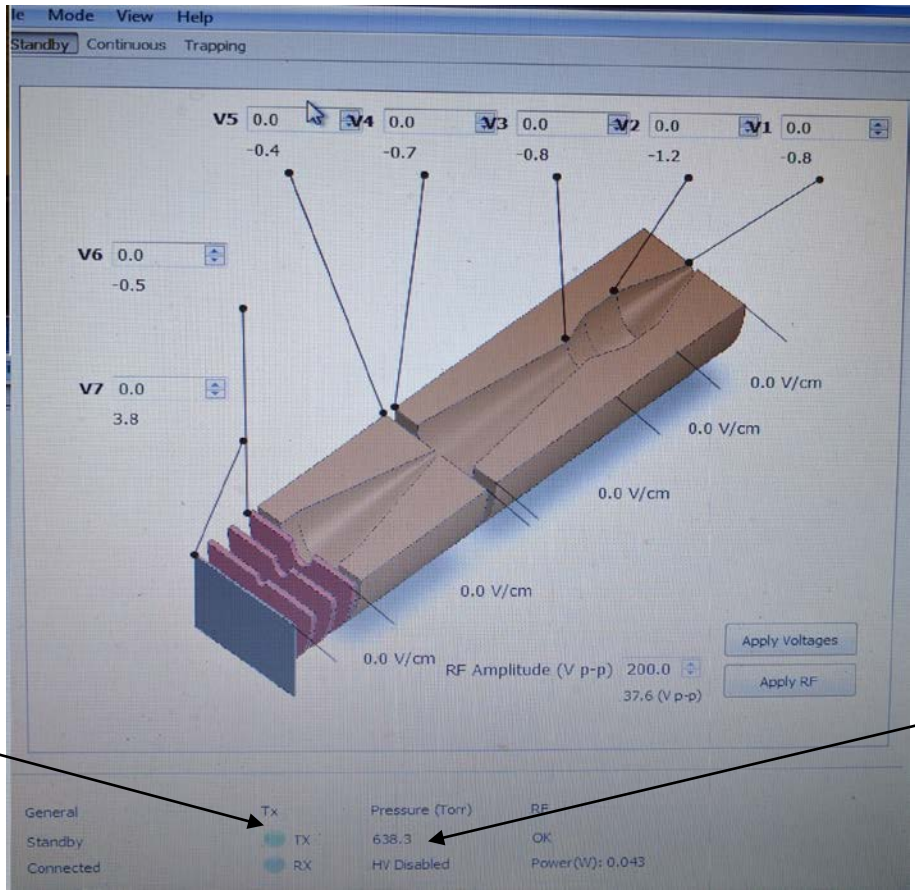


Figure 7.1. Computer screen when filling Settings fields with Serial Numbers and frequency during installation or after switching to a new PC computer – DC/RF box combination.

After filling all the fields click OK and then go to Exit thus closing the iFunnel software program. Then double click on the iFunnel icon to open it again.

When the communication is established, but the DC/RF box was turned OFF, then to operate the Funnel turn ON the DC/RF box by toggling the power switch on the rear panel of the DC/RF box. Then after green LED starts to shine, male a double click on the iFunnel icon. When the program starts, one must see 2 twinkling green buttons near TX and RX signs. If the source is open (atmospheric pressure inside the source and below pressure reading line, one sees "HV Disabled"), the applications of all the voltages is disabled. If one presses Continuous button, then nothing happens.



TX and RX buttons

Pirani gauge shows atmospheric pressure, so RF and DC outputs are disable. TX and RX buttons are twinkling

Figure 7.2. Computer screen when the pressure in the source is too high (>20 Torr). Continuous button is disabled and no DC/RF voltages is applied

When the small pump is pumping gas out of the Ion Funnel, then the pressure rapidly drops and, eventually, the Funnel Software becomes "active". Now, one may type in some DC and RF values in the corresponding voltage boxes. To apply voltages to the system electrodes one needs to click

Apply voltages button for DC and Apply RF button for RF and then click on the “Continuous” button. If one simply clicks the “Continuous” button without typing in, the system chooses the most recently used combination of DC and RF voltages. When operating in the “Continuous” mode, one can change the voltages “on-the-fly” by typing in the new numbers into the small voltage boxes and then click “Apply Voltages” button. The same can be done for the RF voltage. RF voltage selection is limited by 200 V peak-to-peak value.

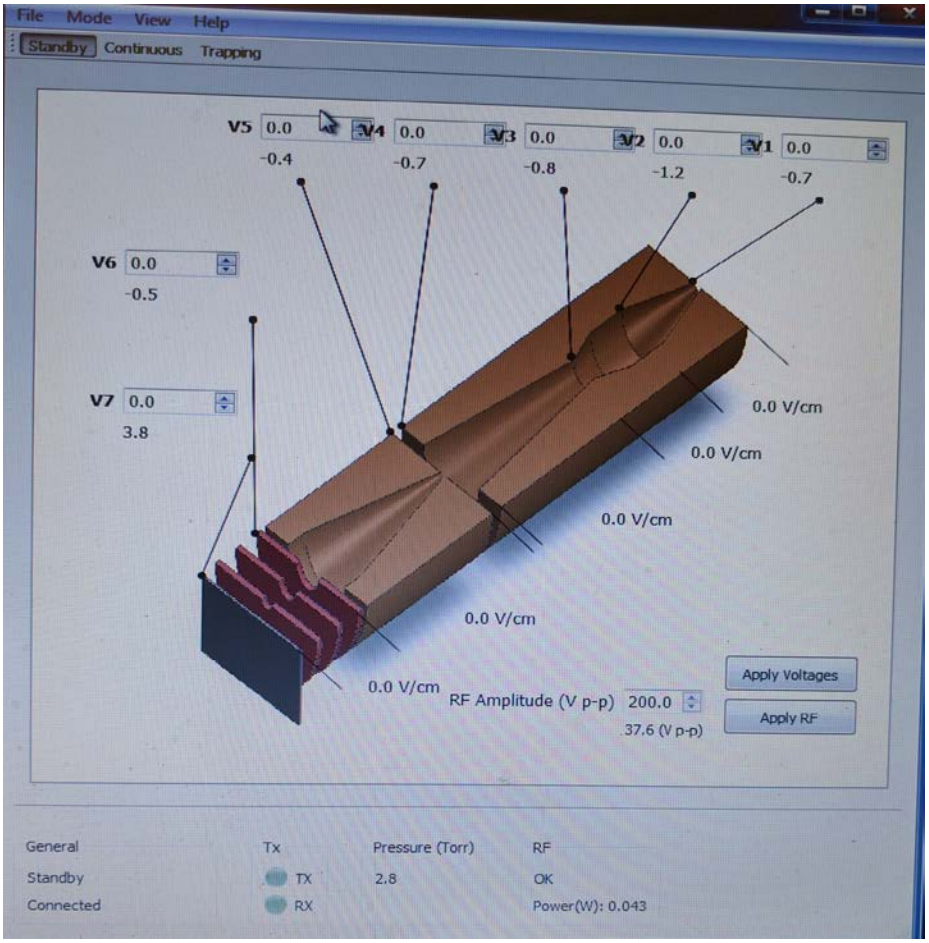
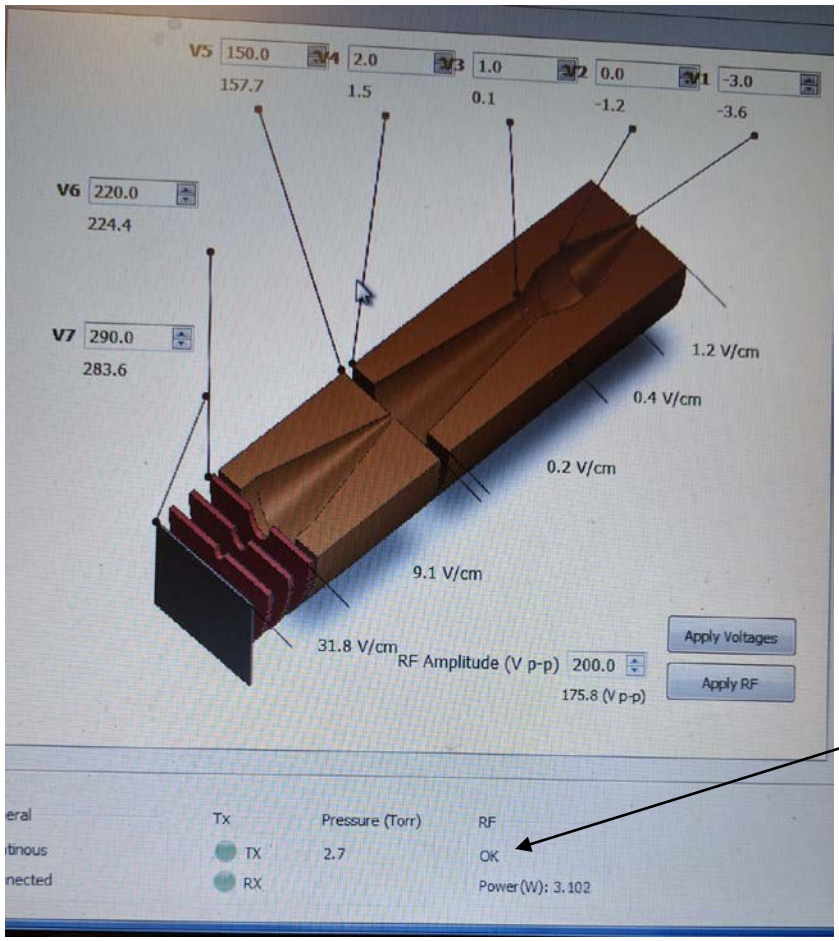


Figure 7.3. Computer screen when the pressure in the source is below 20 Torr. Continuous button is not yet engaged and no DC/RF voltages is applied.



"OK" indicates the connection is established between the RF subunit of the DC/RF Control box and PC

Fig. 7.4. Computer screen when the pressure in the source is below 20 Torr. The operator pressed Continuous button and voltages are applied. Below the voltage boxes one can see the read back DC and RF voltages. Along, on the bottom, the funnel image, one can see numbers that indicate the calculated electric field strength across different funnel sections.

To save current settings for DC and RF one clicks on "File" on the top line, then "Save as", and then types in the file name (see Fig 7.4). To open file with previously saved settings, when operating either in "Standby" or "Continuous" modes, one click on "File", then "Open", and then select the previously saved file and to open it. One needs to click "Continuous" to start DC/RF box operation with new settings (loading of new settings forces the system to go into Standby mode).

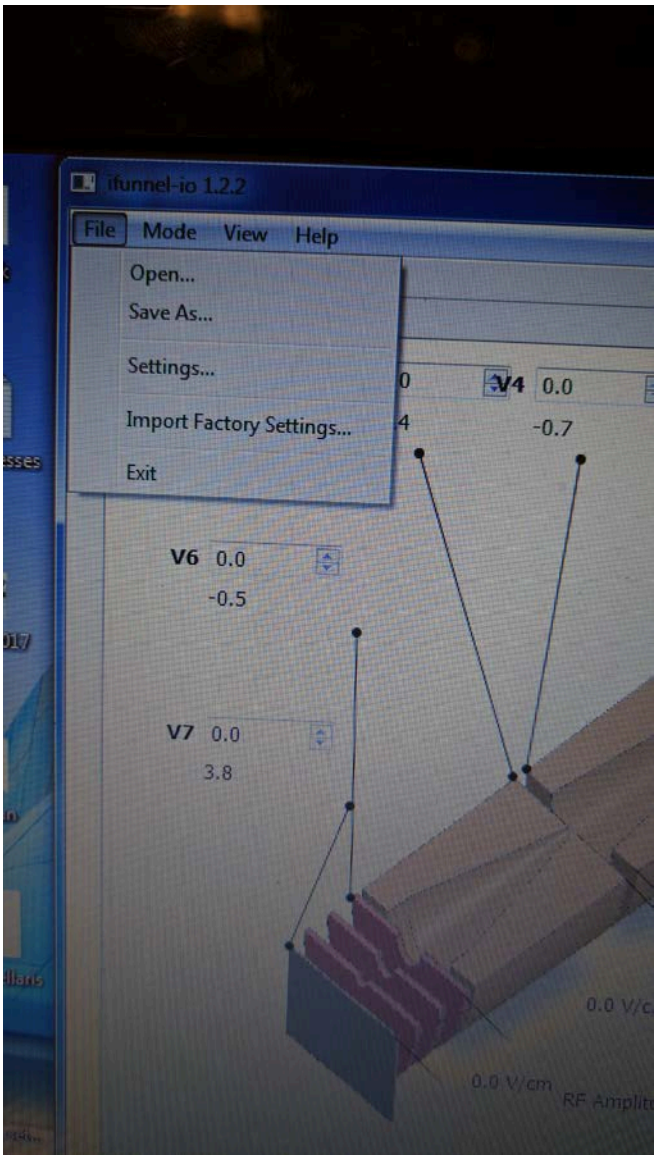


Figure 7.5. When the operator click on "File", several options appear. "Open" allows one to download the set file containing previously recorded voltages. "Save As" allows recording current voltage settings. "Setting"

8 MAINTENANCE —TROUBLESHOOTING THE SOURCE.

The **Ion Funnel** does not require regular maintenance.

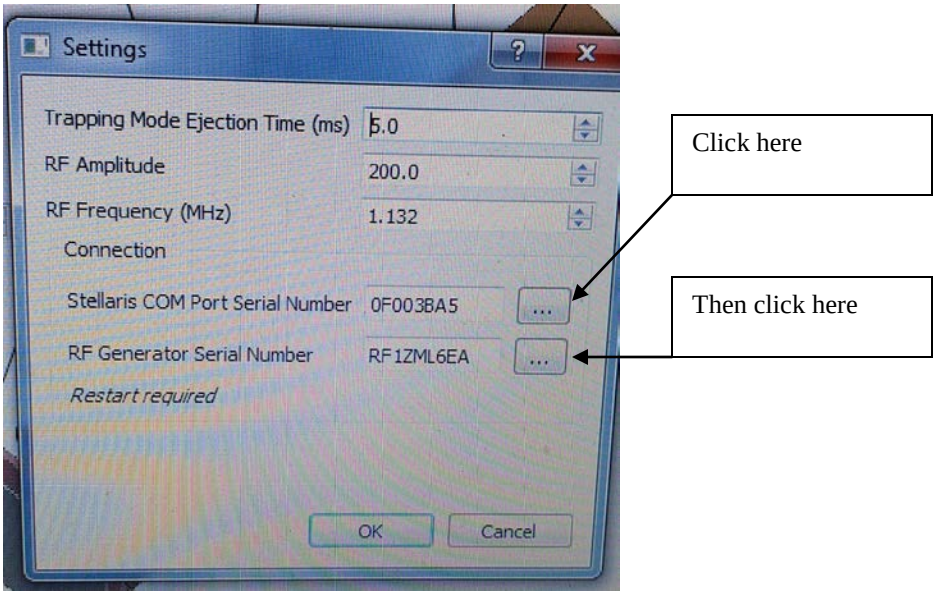
DO NOT ATTEMPT services or repairs that are not covered in the Troubleshooting Section. For services and repairs beyond those specifically provided in the Troubleshooting Section, contact the manufacturer:

MassTech Inc.
ATTN: Service Department
6992 Columbia Gateway Dr.
Suite 160
Columbia, MD, 21046
(443)539-1758

The Ion Funnel is shipped completely tuned and ready for operation. However, there are several reasons why the MS signal might decrease significantly or even disappear at times. The following sections describe possible symptoms with the machine's remedies.

8.1 PROBLEM: No PC communication with DC/RF box.

1. Open File and then Settings in the iFunnel software. Click on the three dots icons to the right of the Stellaris COM port and RF Serial numbers icons. One will see a list COM Ports and Serial numbers.



If you do not see the numbers against Serial ports then COM ports of the PC is not longer compatible with the USB controllers in the DC/RF box.

2. One is recommended to restart the computer, and start the iFunnel software again.
3. If you see the numbers, then copy the Stellaris and RF Serial numbers (one by one) using the mouse Copy function and then highlight the corresponding field (Stellaris or RF Serial Number) in Settings and Paste this number (again, one by one) instead of the old one.

8.2 PROBLEM: No pressure readings.

1. Check the connection of the DB-9 connectors of the pressure cable to corresponding DB-9 receptacles in the DC/RF box and on the MKS Pirani gauge.
2. When cable is totally disconnected, the pressure readings must be 0 Torr and the DC and RF voltages can be engaged, yet one is not recommended to do that because the pressure inside the funnel is not known.
3. If there is not PC communication with the RF subunit RF, one can see the sign Disconnected near the RF panel.

8.3 PROBLEM: Overload of the RF circuit (Yellow LED is ON)

1. Check the RF cable.

2. Reduce the RF voltage

3. Minimize the RF power at small RF voltage by changing the resonance frequency. For instance, select 10V setting for the RF amplitude, then go to Settings and use a slightly different resonance frequency (e.g., instead of 0.67 kHz, type 0.68 kHz), go to Continue mode, and watch changes in the RF power. If the RF circuit was by some reasons detuned, one can find new RF power consumption minimum by finding the new resonance frequency.

We are ready to provide you any technical assistance! Call us at (443) 539-1758 or e-mail the problem to: msms@apmaldi.com

9 LITERATURE

1. Kelly RT, Tolmachev AV, Page JS, Tang K, Smith RD. The ion funnel: theory, implementations, and applications. *Mass Spectrom Rev*. 2010; 29(2):294-312.

2. Ibrahim Y, Belov ME, Tolmachev AV, Prior DC, Smith RD. Ion funnel trap interface for orthogonal time-of-flight mass spectrometry. Anal Chem. 2007; 79(20):7845-52.

3. Ibrahim Y, Tang K, Tolmachev AV, Shvartsburg AA, Smith RD. Improving mass spectrometer sensitivity using a high-pressure electrodynamic ion funnel interface. J Am Soc Mass Spectrom. 2006; 17(9): 1299-305\

4. Gimelshein S, Lilly T, Moskovets E. Numerical Analysis of Ion-Funnel Transmission Efficiency in an API-MS System with a Continuum/ Microscopic Approach. Journal of The American Society for Mass Spectrometry. 2015, 26(11):1911–1922

5. Clowers BH, Ibrahim Y, Prior DC, Danielson WF, Belov M, Smith RD. Enhanced Ion Utilization Efficiency Using an Electrodynamic Ion Funnel Trap as an Injection Mechanism for Ion Mobility Spectrometry. Anal Chem. 2008; 80(3): 612–623.

10 Warranty Information – Six month limited warranty

MassTech, Inc. provides to the original purchaser the following limited warranty from date of invoice.

MassTech, Inc. warrants each AP/MALDI(ng) instrument and its components to be free from defects in material and workmanship. Liability under this warranty covers servicing of the instrument when returned from the customer's facility within the United States pre-paid to our factory. MassTech, Inc. will repair any component(s) or part(s) that it finds to be defective during the period of this limited warranty, which is six months from the date of invoice. Should a defect become apparent, the original purchaser must first notify MassTech, Inc. at (443) 539-1758 of the suspected defect and request a Return Merchandise Authorization number (RMA#). The instrument (or suspect components) should be carefully packaged in the original container (if the original shipping container has been lost, trashed, or damaged, another one must be purchased from MassTech, Inc. prior to shipping). Then, mark the original container with the RMA#, and ship prepaid to:

MassTech, Inc.
Attn: Service Dept.
6992 Columbia Gateway Dr.
Suite 160
Columbia, MD, 21046

The instrument will be repaired in the shortest possible time and returned prepaid by the same shipping method as received by the factory. During the warranty period, no charge will be made to you for parts, service, or labor.

This limited warranty is void if the instrument has been damaged by accident, misuse, negligence, act of God, or serviced by any other person not authorized by MassTech, Inc. The warranty also does not apply to units that have had the serial lot number altered, defaced or removed.

This limited warranty contains the entire obligation of MassTech, Inc. and no other warranties expressed, implied, or statutory are given. No representative or employee of MassTech, Inc. is authorized to assume any further liability or grant any further warranties except as set herein.

MassTech, Inc. disclaims liability for indirect, incidental or consequential damages. Exclusion or limitation of incidental or consequential damages are not permitted by some states and this limitation or exclusion may not apply to you. Warranty rights vary from state to state; and, therefore, you may have other rights in addition to those provided by this warranty.

APPENDIX A: WARNING AND IDENTIFICATION LABELS

Hot temperature sign (on the top of the flange accommodating heated capillary cone)

High Voltage sign (on the top of the flange accommodating heated capillary cone)

Serial number label (at the bottom of the DC/RF box)

CE sign (on the rear panel of the DC/RF box)