# Adaptation of a commercially available Residual Gas Analyzer for use onboard the International Space Sation ISS

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## Abstract (1)

A residual gas analyzer (RGA) was developed for the Material Science Laboratory - Vacuum Gas System (MSL-VGS) onboard the International Space Station ISS to determine krypton leakage in sealed cartridges before and during vacuum metallurgy experiments. Krypton leakage is an indication of rupture of the cartridges which may contain dangerous chemicals such as arsenic and thus the RGA is a central safety component of the metal processing facility. The RGA also allows composition analysis of off-gases and by products prior to release to the ISS vacuum lines.

## Abstract (2)

A commercially available RGA (Pfeiffer Vacuum PRISMA QMS 200) was selected and adapted as it offers several advantages e.g.:

- Due to the large number of systems manufactured already (several thousands), all problems that may show up with more prototype like systems have been overcome,
- based on a standard system, the instrument could be developed at a reasonable price,
- the instrument had flown on a previous shuttle mission and several parabolic flights.

# Abstract (3)

The adaptations of the standard units for use in space included special mounting of all mechanical parts and larger, more robust electronics parts to withstand the enormous forces during launch on board the space shuttle, replacement of flammable and dangerous components and special coating of all electronics boards. For mounting, transportation, dust tightness, depressurization and heat management a special housing was designed.

## Description of experiment (1)

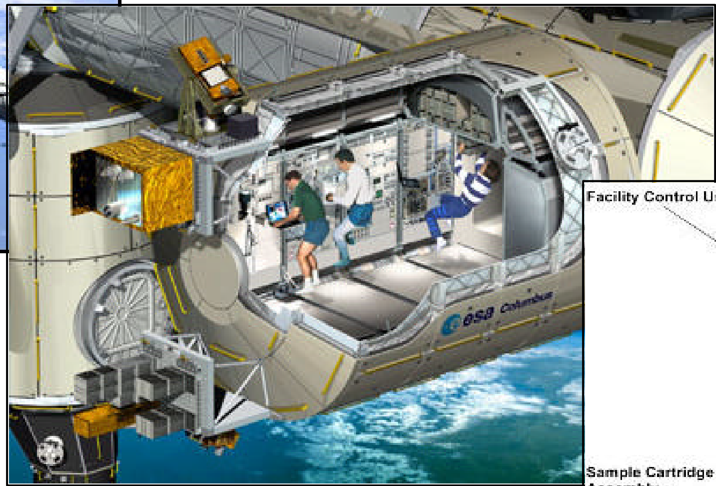
The Vacuum Gas System (VGS) is a unit of the Material Science Laboratory (MSL). Its main function within the MSL is the establishment and maintenance of a stable atmosphere within a metallurgical process chamber. In addition it allows the determination of the quality of  this atmosphere. By including a tracer gas, Krypton, in the sample cartridges and an RGA in an analytical loop it is possible to use the VGS as a hazard detection and isolation facility.

## Description of experiment (2)

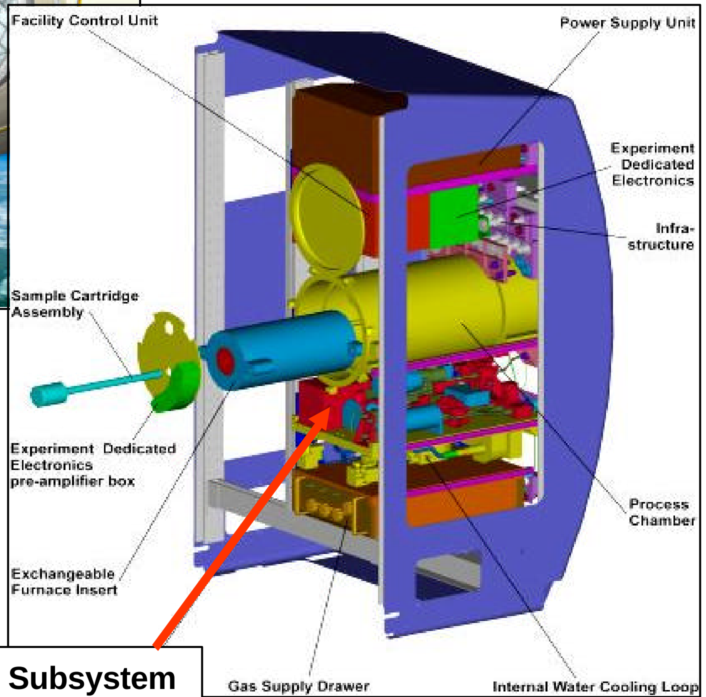
Astronauts on board the ISS will feed a sealed cartridge into the furnace and monitor the melting and cristallization process. The cartridge has been filled with Krypton. If hair cracks were to appear during the heating phase to 1800°C the gas would escape through them and reach the buffer volume in the analytical loop. This volume has been sized so as to allow 90 minute operation without opening the upstream valves. A leak valve allows a pressure drop of 5 decades between the buffer volume and RGA sensor. By continous monitoring of the gas in the loop it is possible to ascertain if hair cracks ocurred and thus whether gases have escaped. In this case and if the sample contained toxic components such as arsenic the unit will be sealed by the upstream valves and removed from the ISS.

# Description of experiment (3)

International Space Station



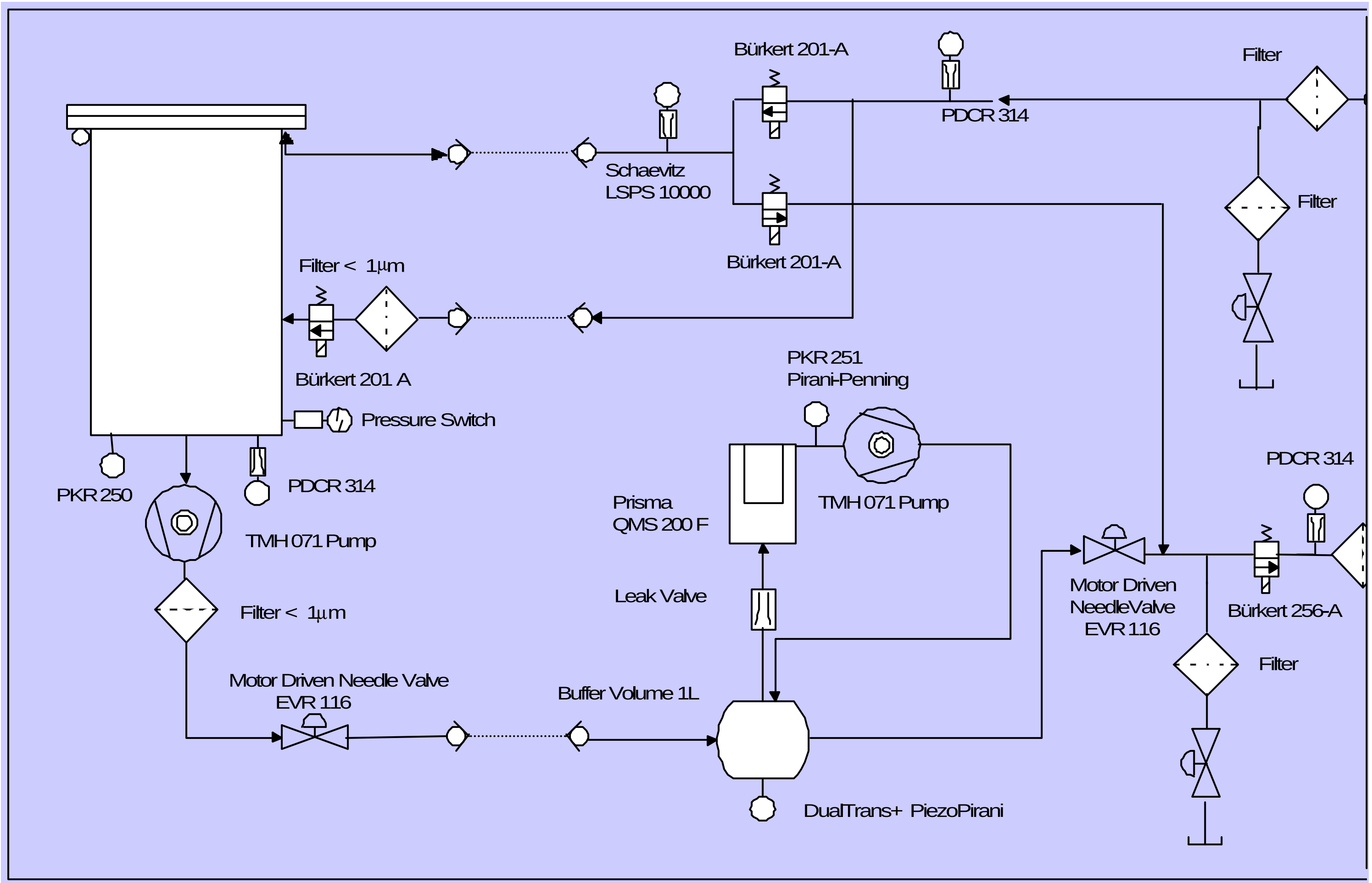

Module Columbus




Material Science Laboratory

**Vacuum Gas Subsystem**

# Description of experiment (4)



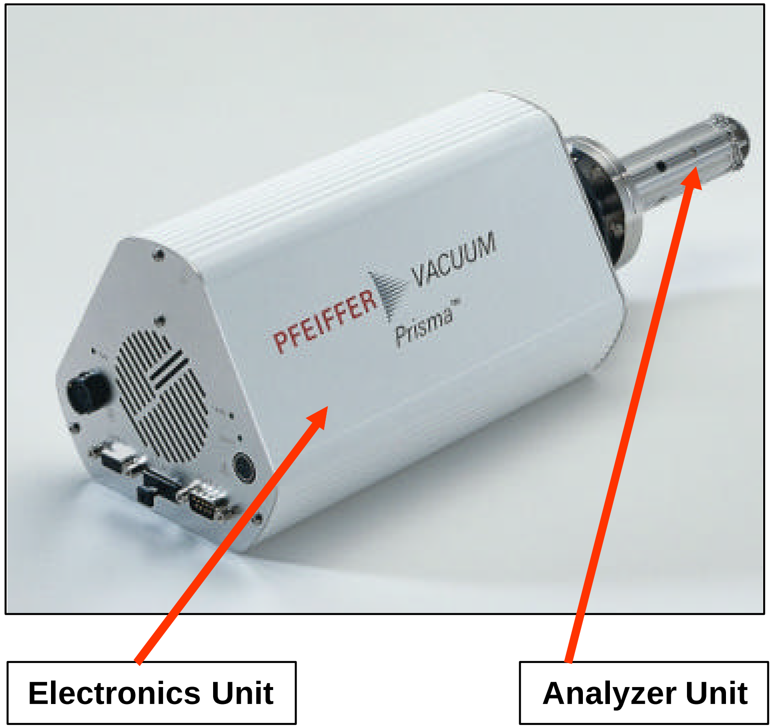

**Block diagram of the Vacuum Gas System**

## Adaptations

The Pfeiffer Vacuum Prisma QMS 200 was the basic instrument for the development of the RGA system of the MSL-VGS.

The Prisma is a highly sensitive quadrupole mass spectrometer featuring a double filament open ion source.

The electronics consisting of boards for the quadrupole controller, the ion source supply, the radio frequency supply and the electrometer amplifier is mounted in triangular form and directly attached to the analyzer.

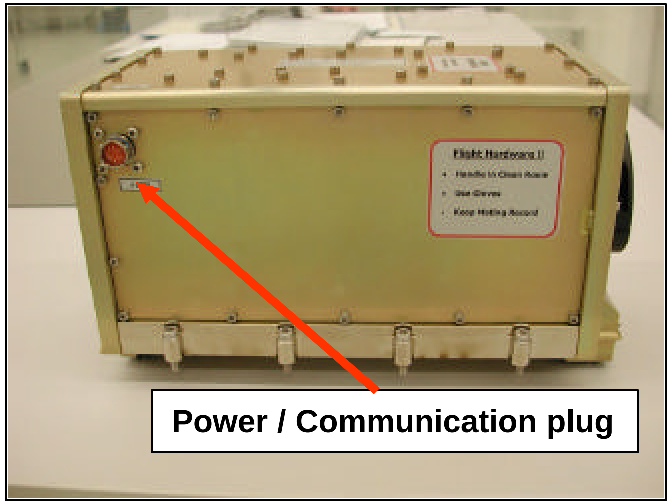


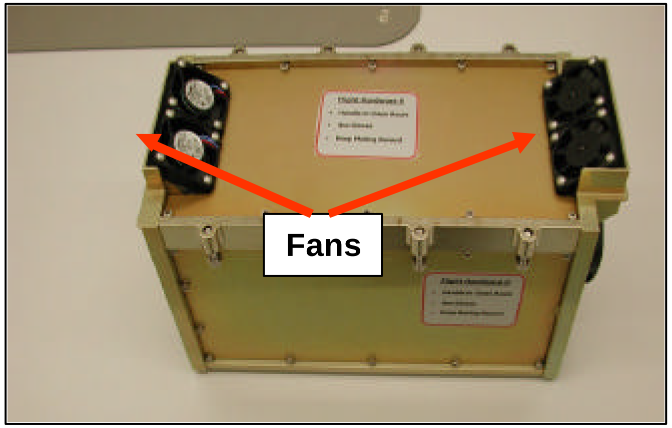

Minor changes had to be realized on the analyzer with the aim to withstand the vibrations during the launch of the Space Shuttle.

## Adaptations of the housing (1)

On the other hand the electronics had to undergo major adaptations:

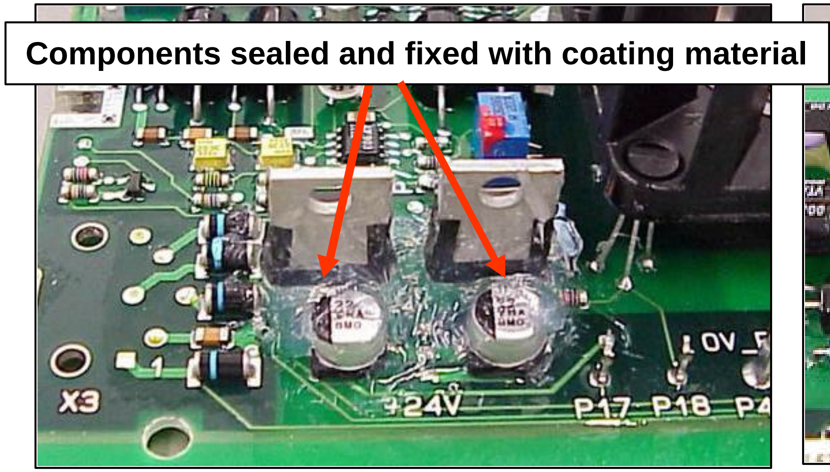
- Design of a robust, gas tight metallic housing with fans
- Manufacturing of larger circuit boards for rail- mounting
- Replacement of electrolytic capacitor by Tantalum-capacitors
- Stabilization of larger mechanical and electronic components with special fixtures and coating material
- Coating of the entire circuit board to prevent outgassing

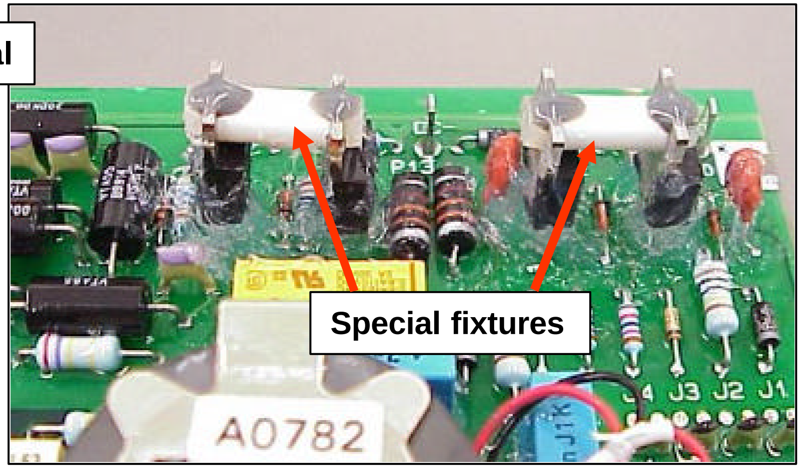


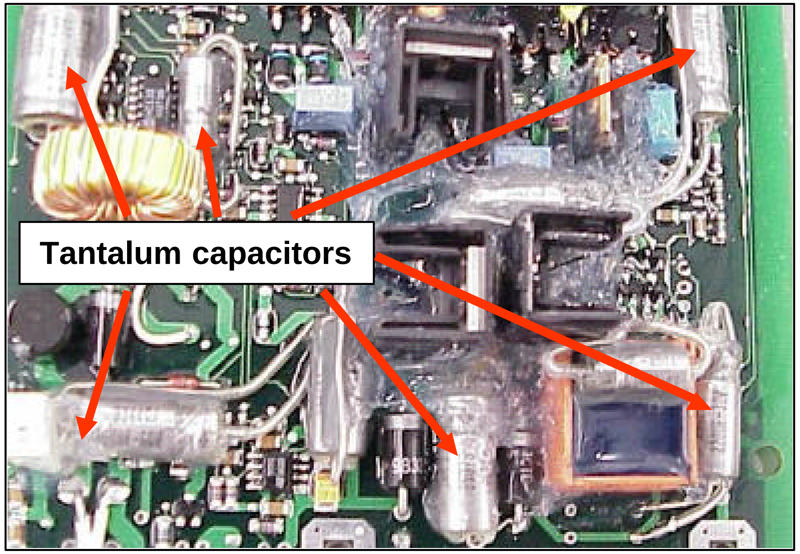

Side and bottom view of the adapted electronics box

# Adaptations of boards (1)

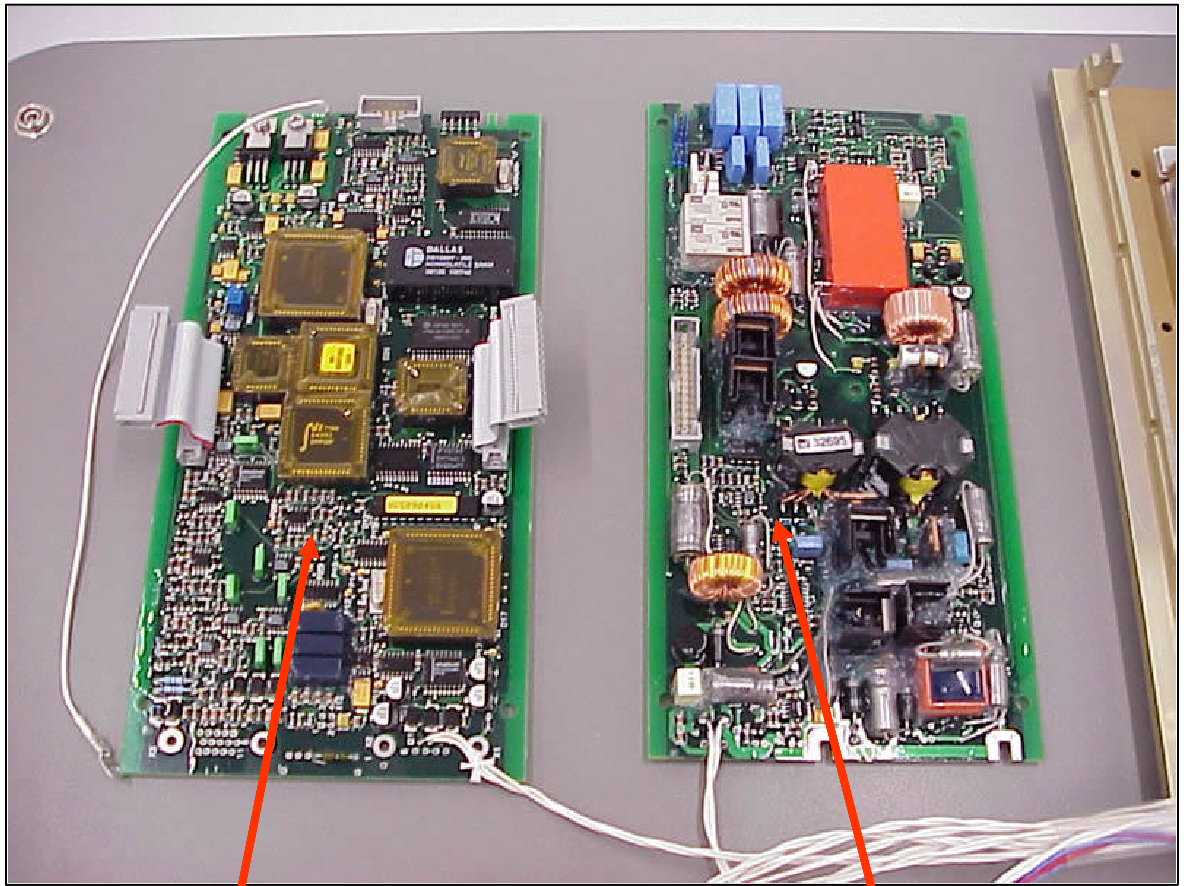



Details of the different prints showing electronics components mounted with special plastics and plastic screws and coating material. Figure to the right shows newly installed and safely mounted larger Tantalum capacitors.

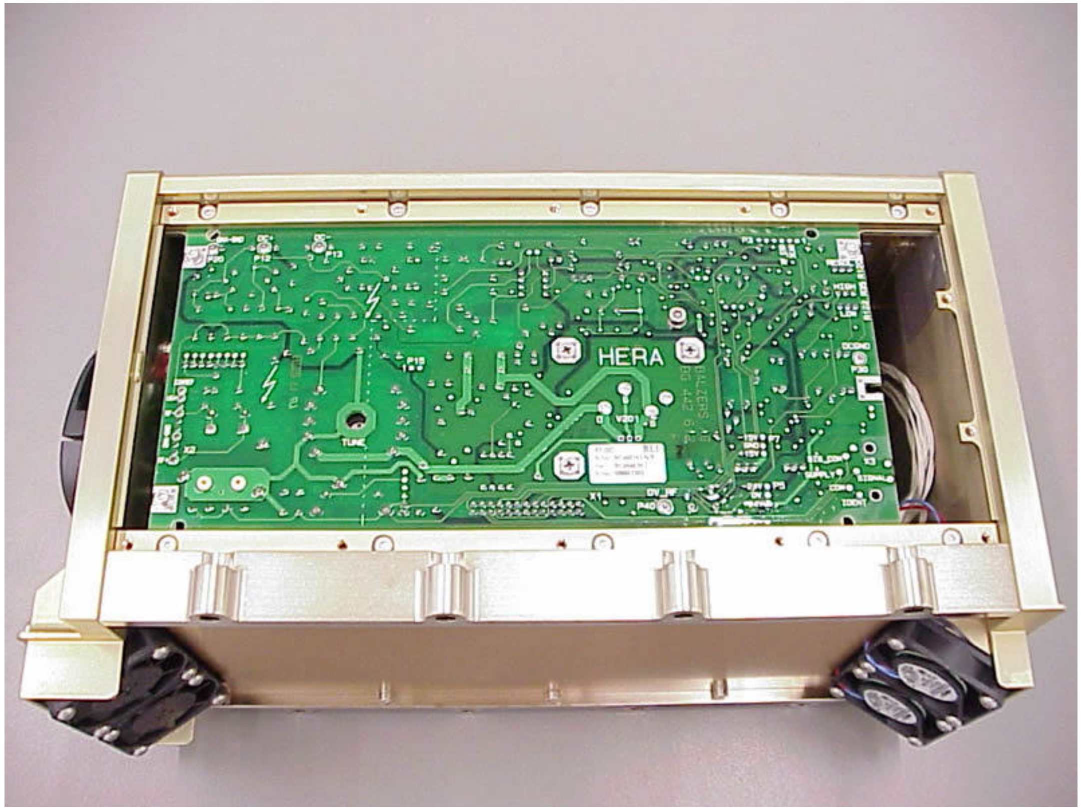


# Adaptations of boards (2)



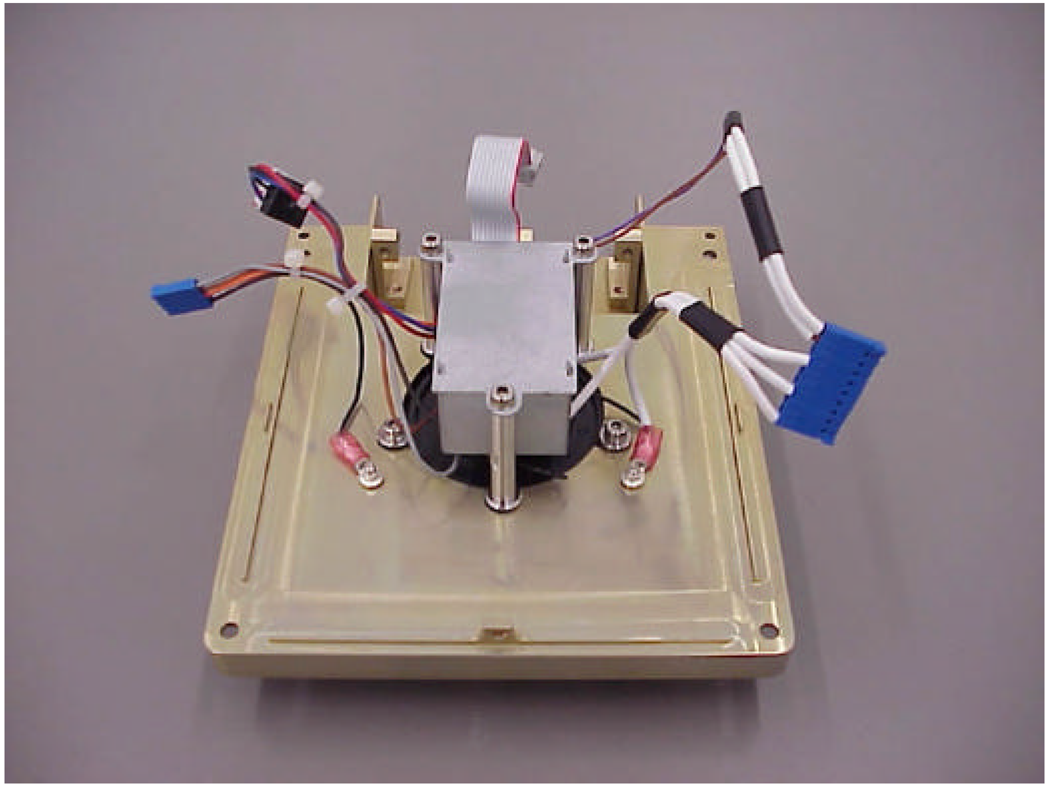
Controller circuit board and ion source supply circuit board after being entirely coated

## Adaptations of boards (3)



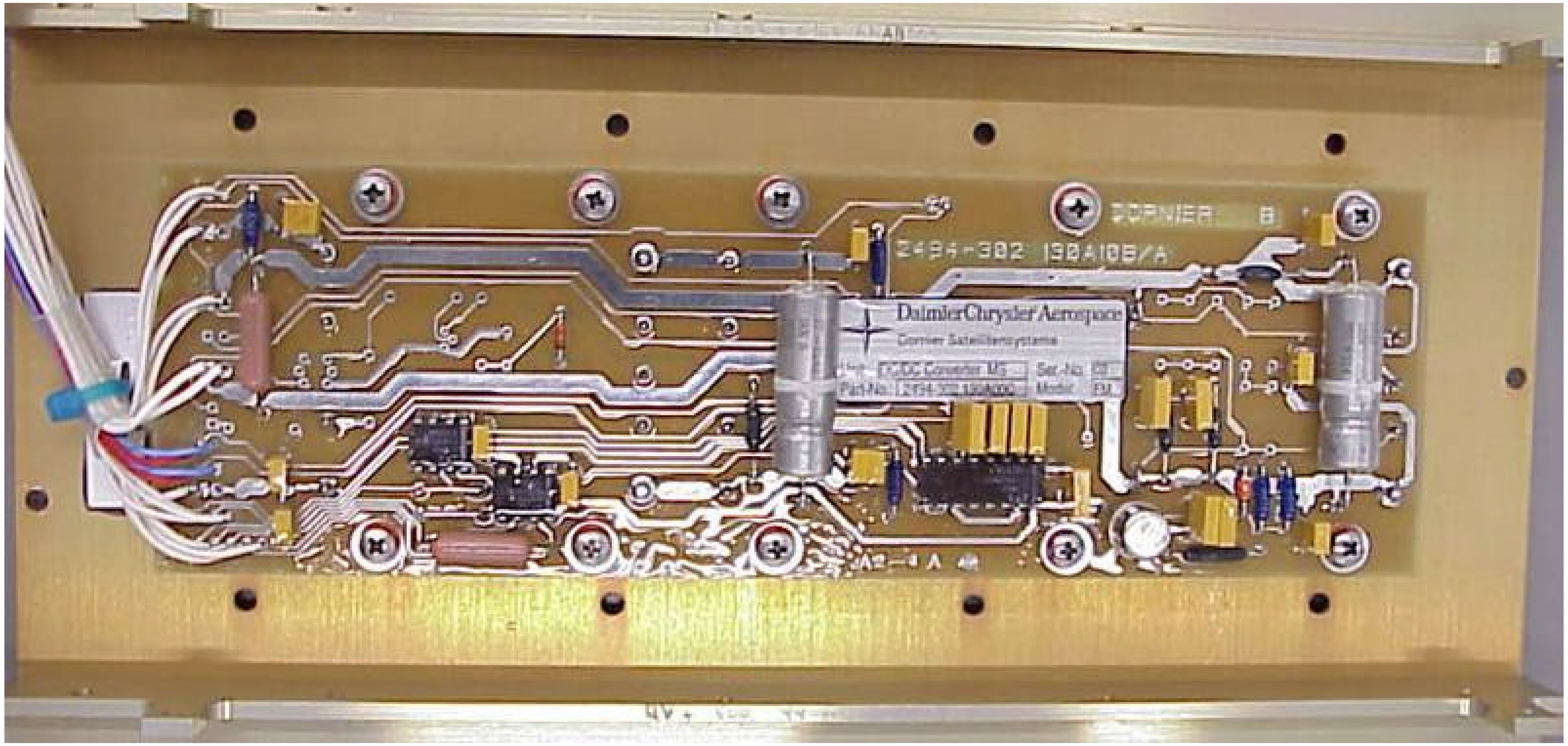

Ion source supply circuit board mounted in the electronics box. The circuit board is fixed within hinged rails on top and bottom

## Adaptations of boards (4)



The electrometer amplifier is encapsulated in a box to protect it from electrical and mechanical noise. This allows for the measurement of currents down to 1E-15A.

# Adaptations of boards (5)

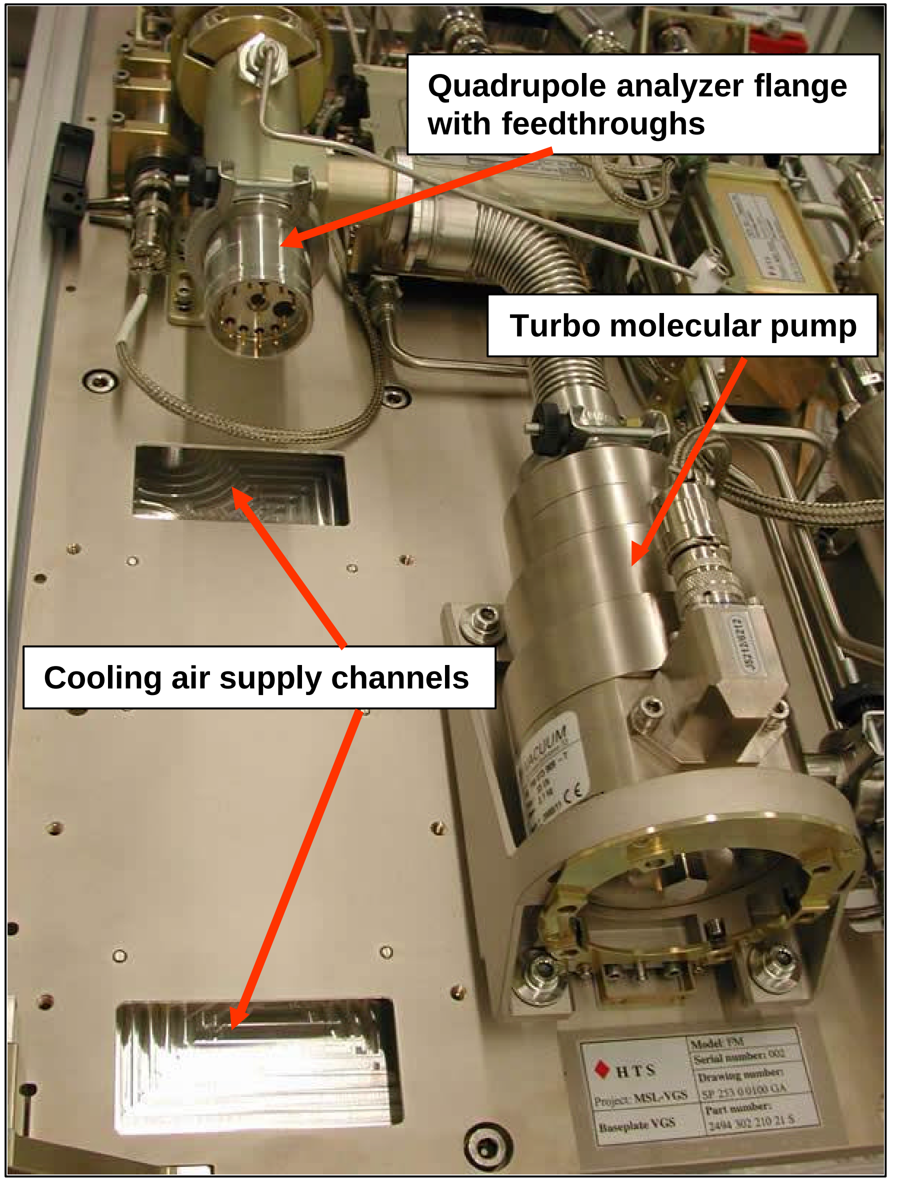



The only board developed completely new for this project has three functions

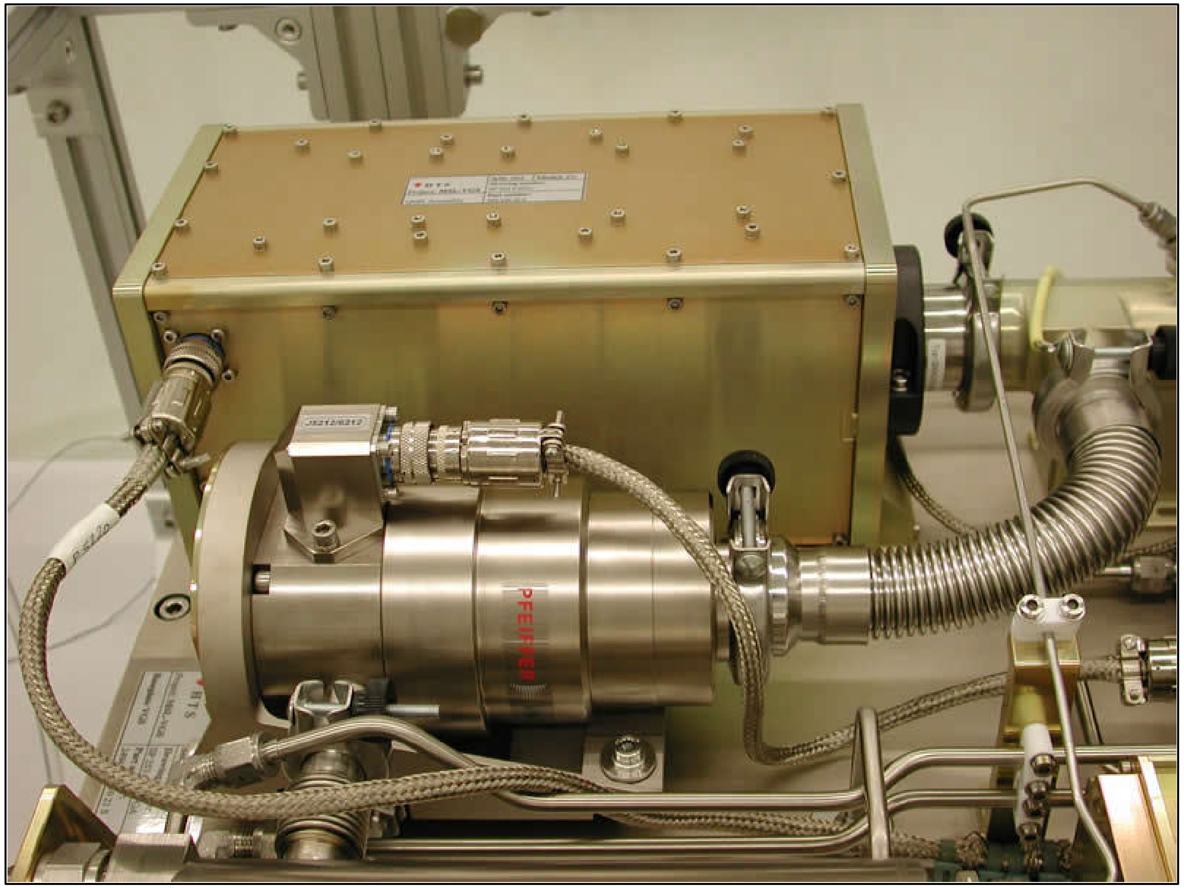
- Transform the 28 VDC supply to 24 VDC using a DC-DC converter
- Convert the Prisma RS 232 communication line into RS 422
- Control the fans of the electronics box

## Assembly (1)

Mounting position of the electronics on the baseplate of the VGS. The ***Pfeiffer Vacuum*** turbo molecular pump as well as the quadrupole analyzer are installed already, the cooling air supply channels for the electronics can be seen

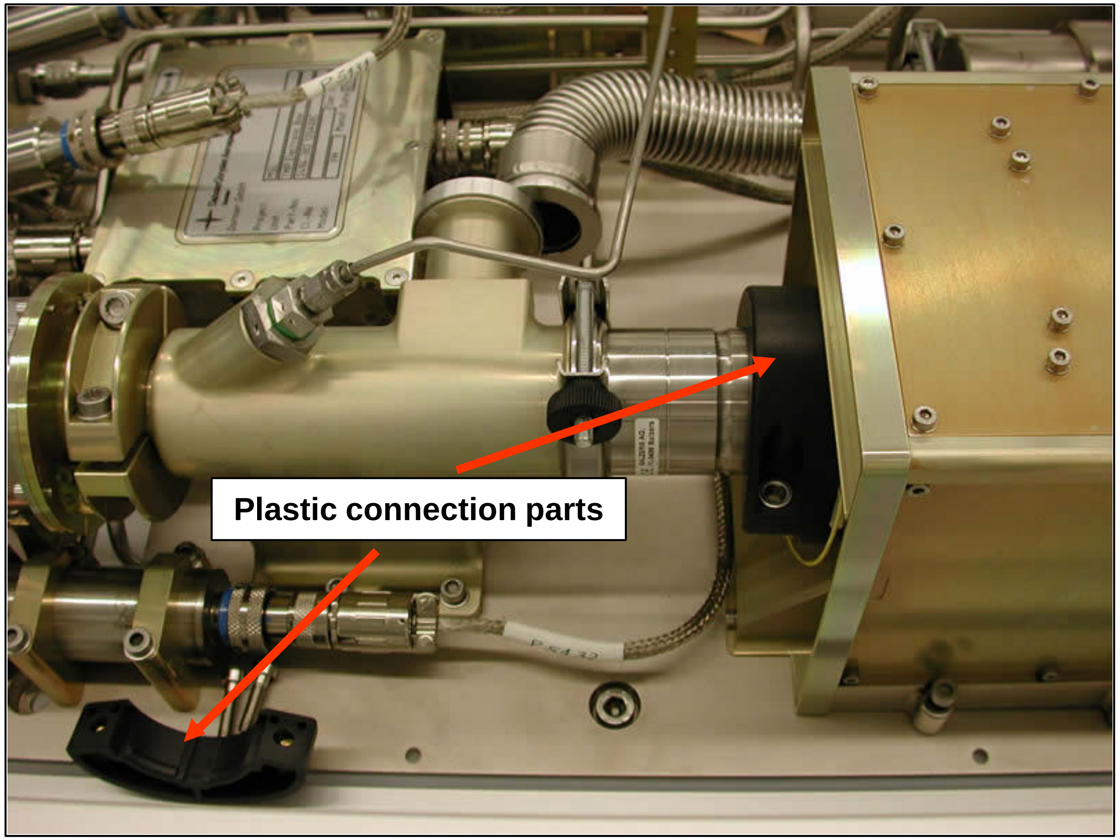


## Assembly (2)



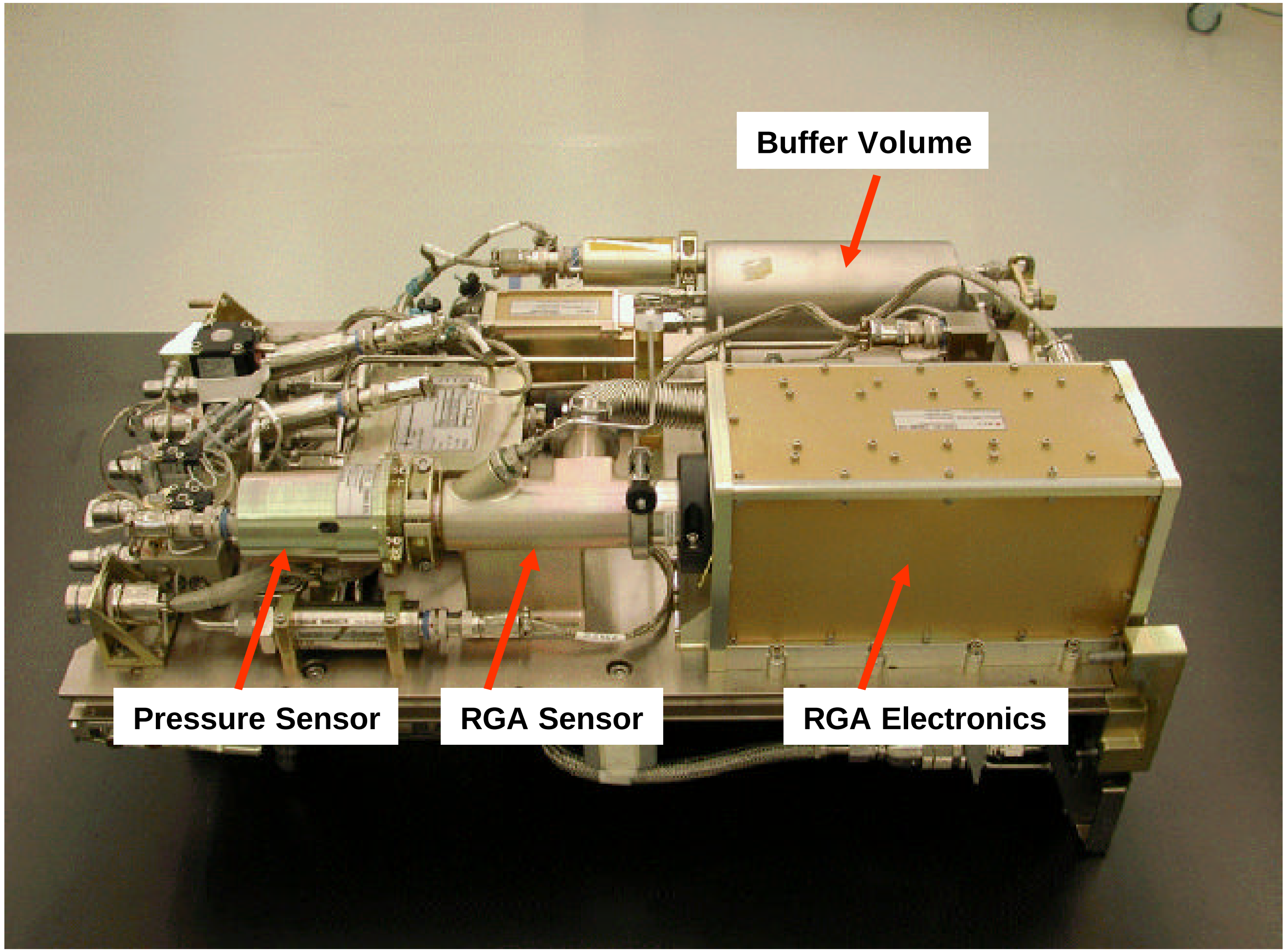

Electronics box mounted on the baseplate of the VGS. Supply power and communication line are within the same cable.

## Assembly (3)



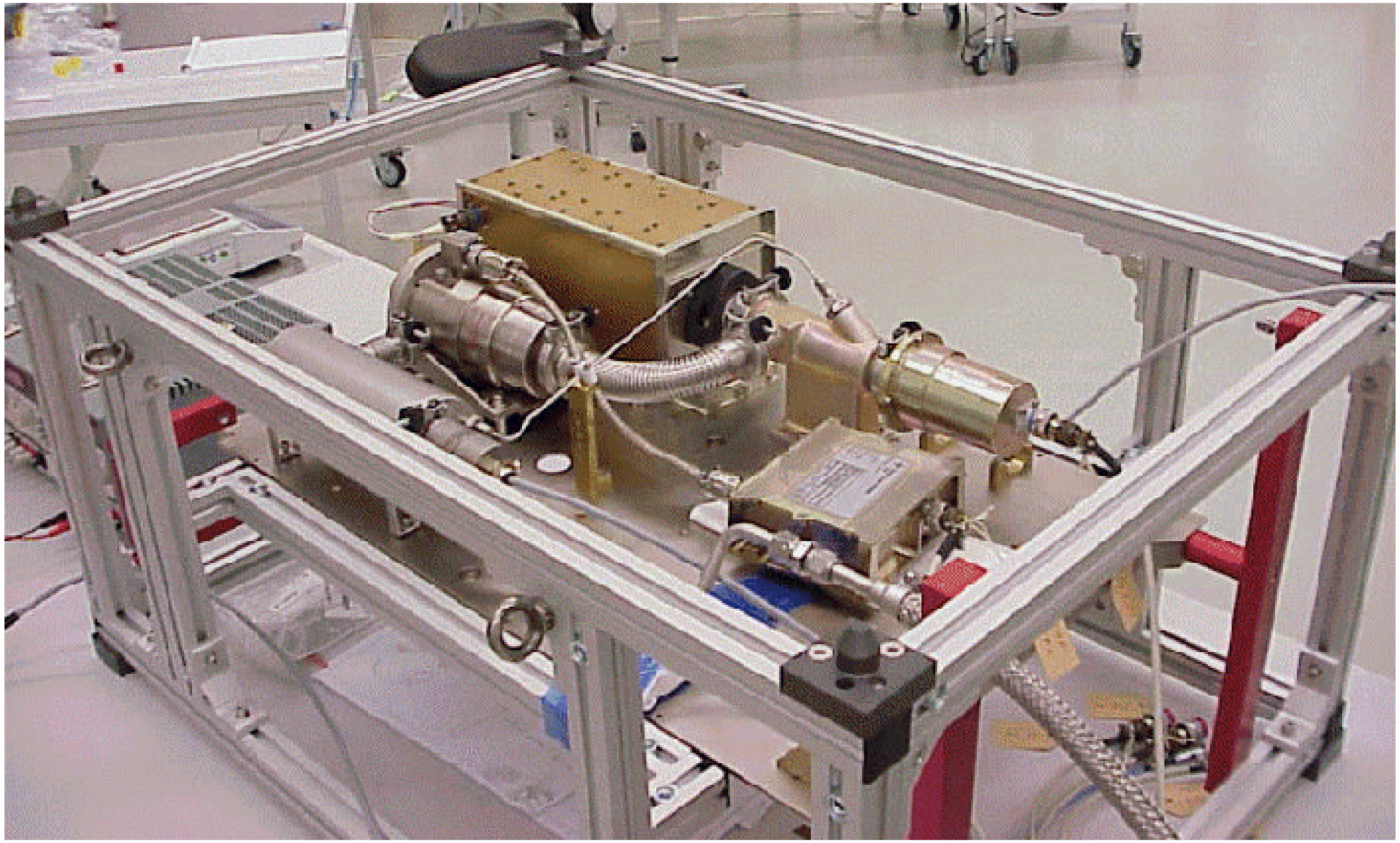

Electronics box connected to the quadrupole analyzer. The plastic connection parts assure a firm coupling of the analyzer to the electrometer amplifier to avoid vibration and an elevated noise level.

# Assembly (4)



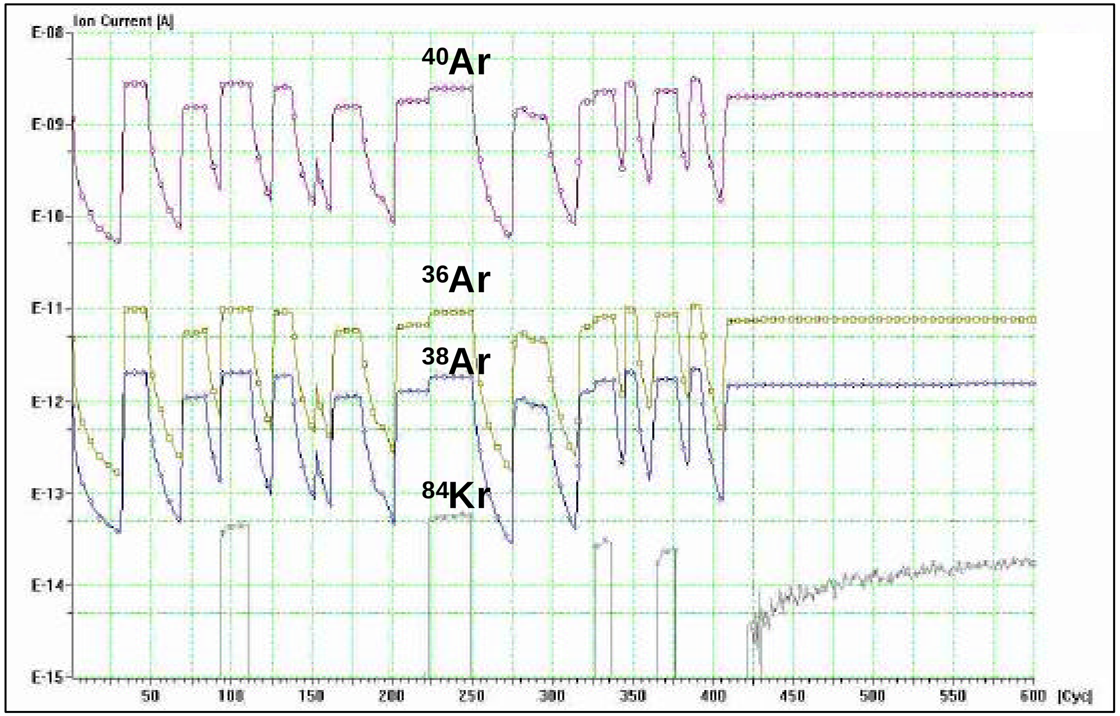

**Side view of the Vacuum Gas System drawer**

# Assembly (5)



**Analytical Loop Components in Assembly Structure**

## Verification Test (1)




Verification test on minimum detectable partial pressure:
The test has been performed using a low concentration (100 ppm) of Krypton in Argon. This mixture was admitted to the buffer volume of the VGS at different pressures and introduced into the mass spectrometer via the leak valve resulting in a pressure of approx. 1E-5 mbar. Krypton could be detected down to a partial pressure in the E-10 mbar range as required.

## Verification Test (2)

The RGA was subject to following mechanical and heat tests:

- Vibration test using the launch spectra of the Shuttle
- Microgravity disturbance testing of its cooling fan system
- Resistance to radiation (Synchrotron radiation testing of CMOS)
- Heat soaking 168 hours at 50°C
- Convection cooling in a closed loop

In addition following analysis were performed

- Structural, shock and fracture control analysis
- Housing resistance to sudden depressurization
- Failure modes and effects and criticality analysis
- Life cycle analysis

## Summary / Status

The RGA adapted for use on board the ISS fulfills all requirements.

Analytical

- It is capable of detecting Krypton at partial pressures of $10^{-10}$ mbar.

Heat and mechanical

- All vibration and heat tests were passed.
- Analysis showed that the unit will withstand all foreseeable critical situations

The expected lifetime is 10 years with 3-4 landings/take-offs.

Status March 2002: Flight and test systems are completed and final tests have been performed so that the units can be transported to and installed in the International Space Station.