Space Simulation Unit – Centro de Astrobiología - INTA

We study different aspects of the space simulation.
Currently studies:
*Interstellar space and planet surfaces.
*Planetary simulation for probing effect of radiation
*MARS simulation chamber to probe devices, biosensors in Mars environmental conditions, their outgassing and DHMR protocol for planetary protection.

We have three topics to be discussed in relation with the ultimate factors limiting the pressure, and how the pressure is measured accurately on planet surfaces.

- Factors limiting pressures below 1E-11mbar
  - The scope of ISAC machine is the study of ice in interstellar space
- How to measure vacuum accurately in different working conditions
  - REMS (Rover Environmental Monitoring Station) studies the atmospheric conditions (pressure, gas composition, temperature and radiation) on Mars.
- Outgassing of special plastic materials
  - IE3C and PPC chambers studies the outgassing of different devices and the bacteriological contamination, in real time using a mass spectrometer

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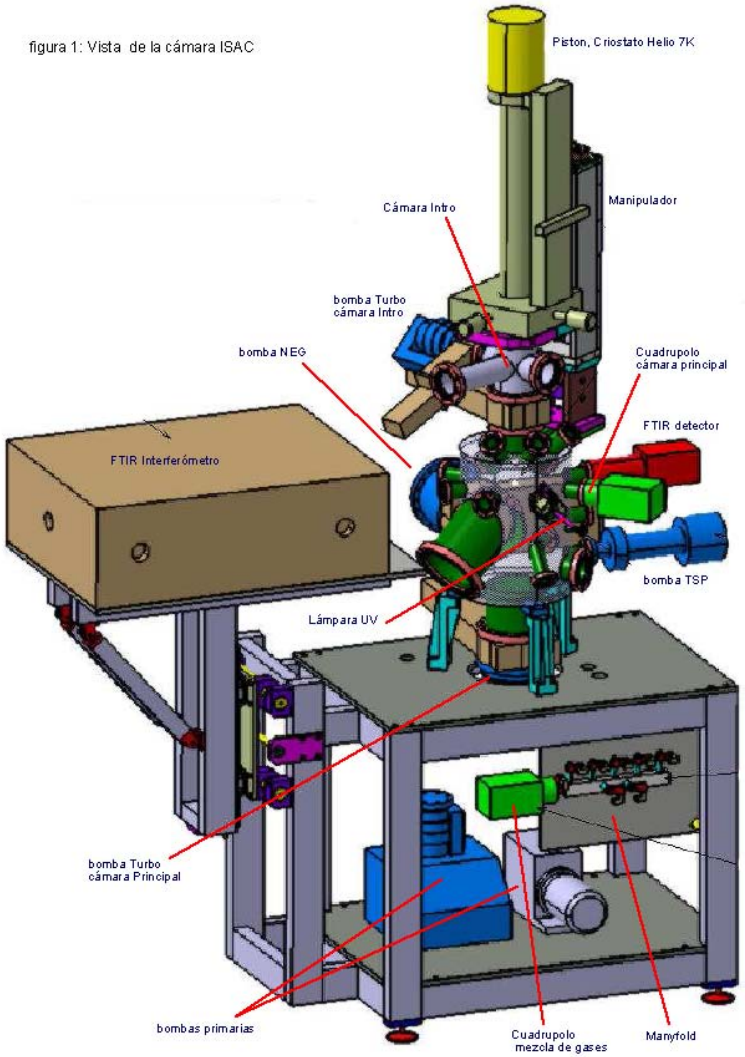
- Factors limiting pressures below 1E-11mbar
  - The scope of ISAC machine is the study of ice in interstellar space



Pumps
- TMP (Pfeiffer)
- NEG (SAES)
- TSP (Gamma Vacuum)

Gauges
- Bayard-Alpert (Leybold)
- Mass spectrometer (Pfeiffer)

- Bakeout of delicate instruments: cryostat (Max 80ºC)
- Need of use hot filaments (B-A, TSP, QMS), outgassing, and Methane formation
- Outgassing of NEG in UHV operating conditions.
- Stainless Steel Chamber. Desorption and permeability
- Limit of measured pressure with B-A extractor

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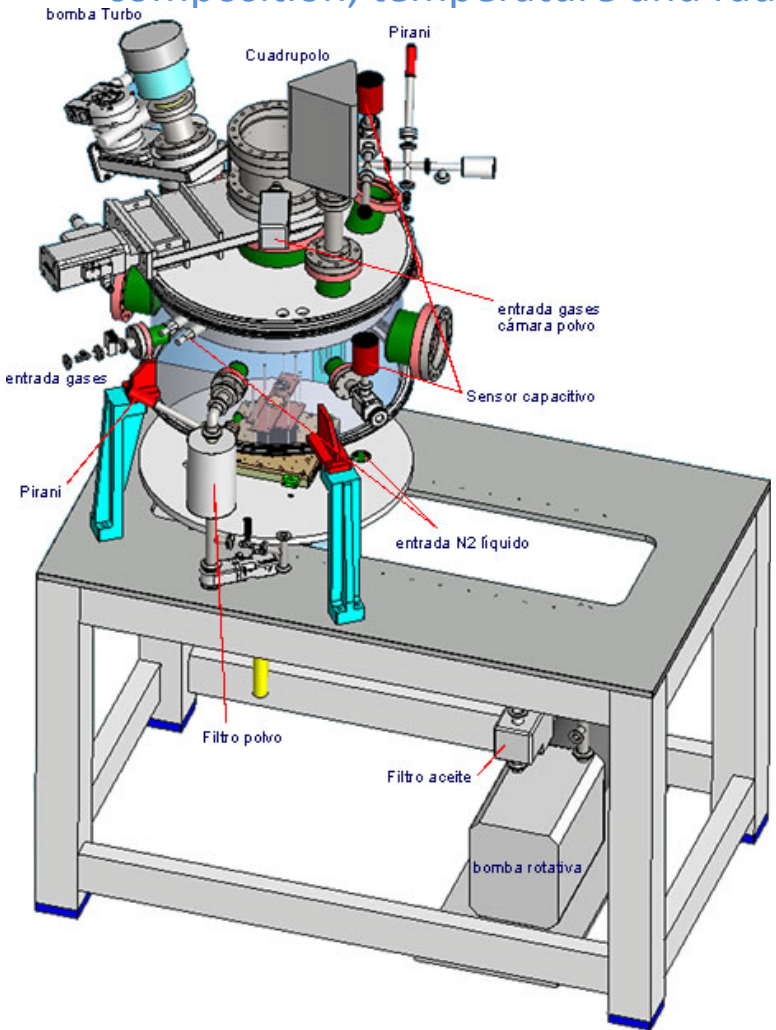
- How to measure vacuum accurately in different working conditions
  - REMS (Rover Environmental Monitoring Station) studies the atmospheric conditions on MARS. MARS chamber simulates the different environmental conditions (pressure, gas composition, temperature and radiation).



On Mars surfaces, the atmosphere gas composition depends on temperature and the pressure.
In the polar regions, the CO_2 (main gas in the MARS atmosphere, around 95%) is ice “dry ice”.
We suppose that the ice contains other gases and solids, e.g. H2O, N and Ar. We performed TDS experiments with QMS.
The real pressure measured by the ROVER vehicle is locally modified by the heat generated by its systems.

We need to know the thermal environment of the sensor to calibrate it.

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Objectives

Testing instruments and devices in Mars atmosphere and similar climate conditions, including powder generator. Space qualification of instrumentation. DHMR, and outgassing control in planetary protection procedures.

Environmental conditions

- Temperature range: From 80K to 450K in sample holder computer controlled.
- Temperature in the atmosphere range from 200K to 400K
- Atmosphere: vacuum base pressure 10^{-7} mbar by Turbo pump. Pressure stable until 3 mbar.
- Irradiation: Deuterium lamp, and 6 halogen lamps to simulate sun illumination at different azimuths

Technical parameters

- Powder storm module (Fe particles)
- Rotary and Turbo pumps
- Cooling by lN2, and heating by conduction and radiation
- Sample size: should fit on a 205mm x 205mm optical table. Maximum height 400mm
- Modular chamber, possible to modified the volume in two hours
- Easy to connect electronic components.

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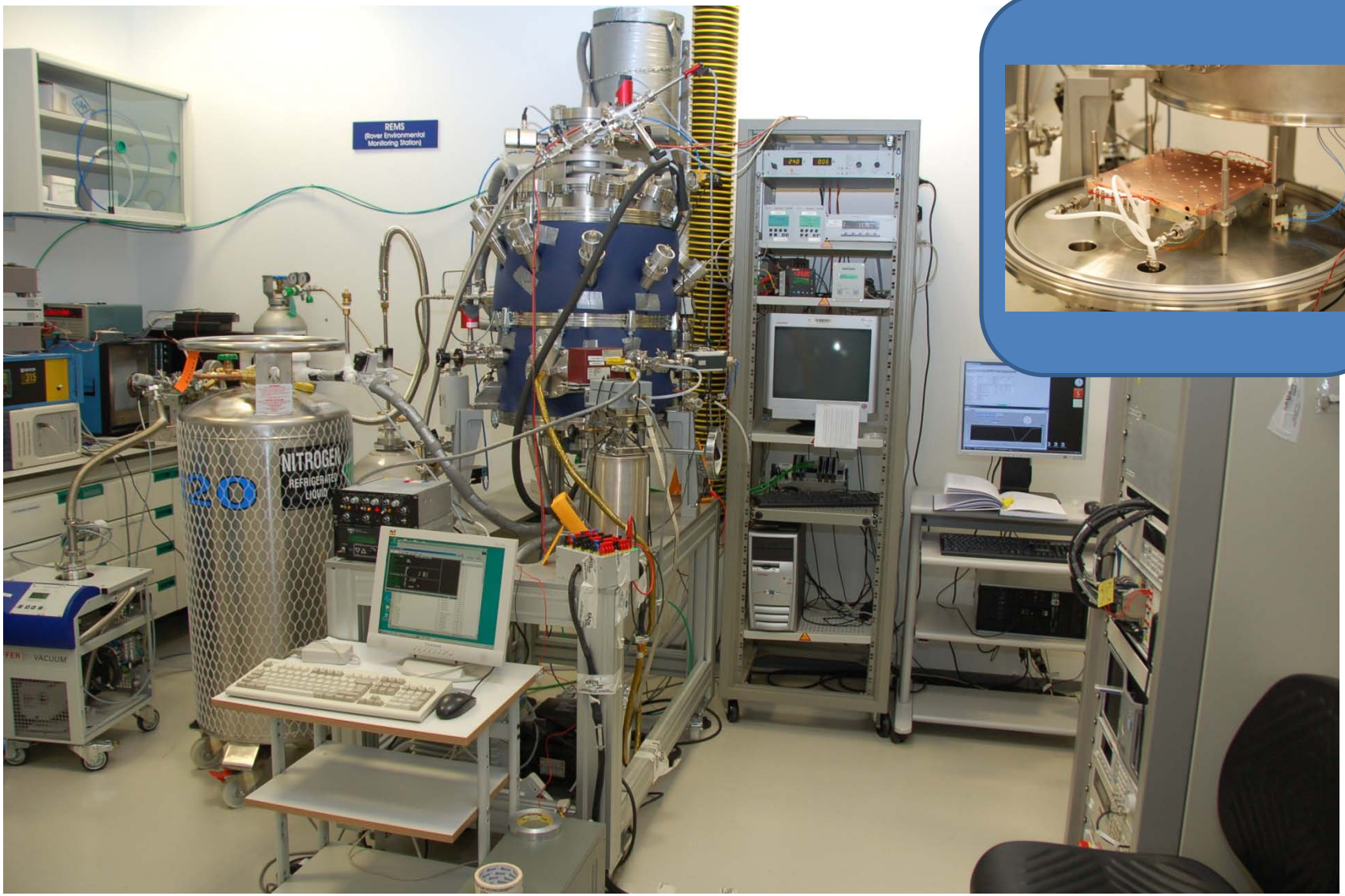

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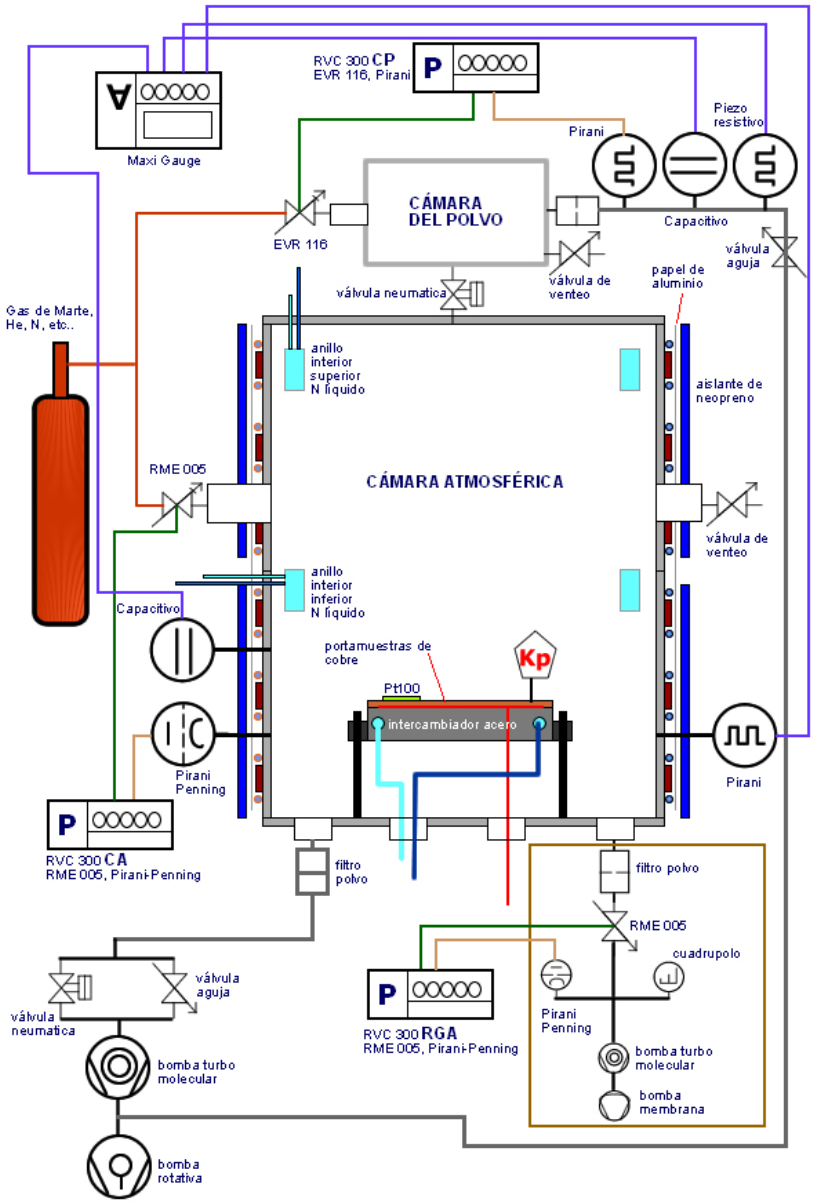

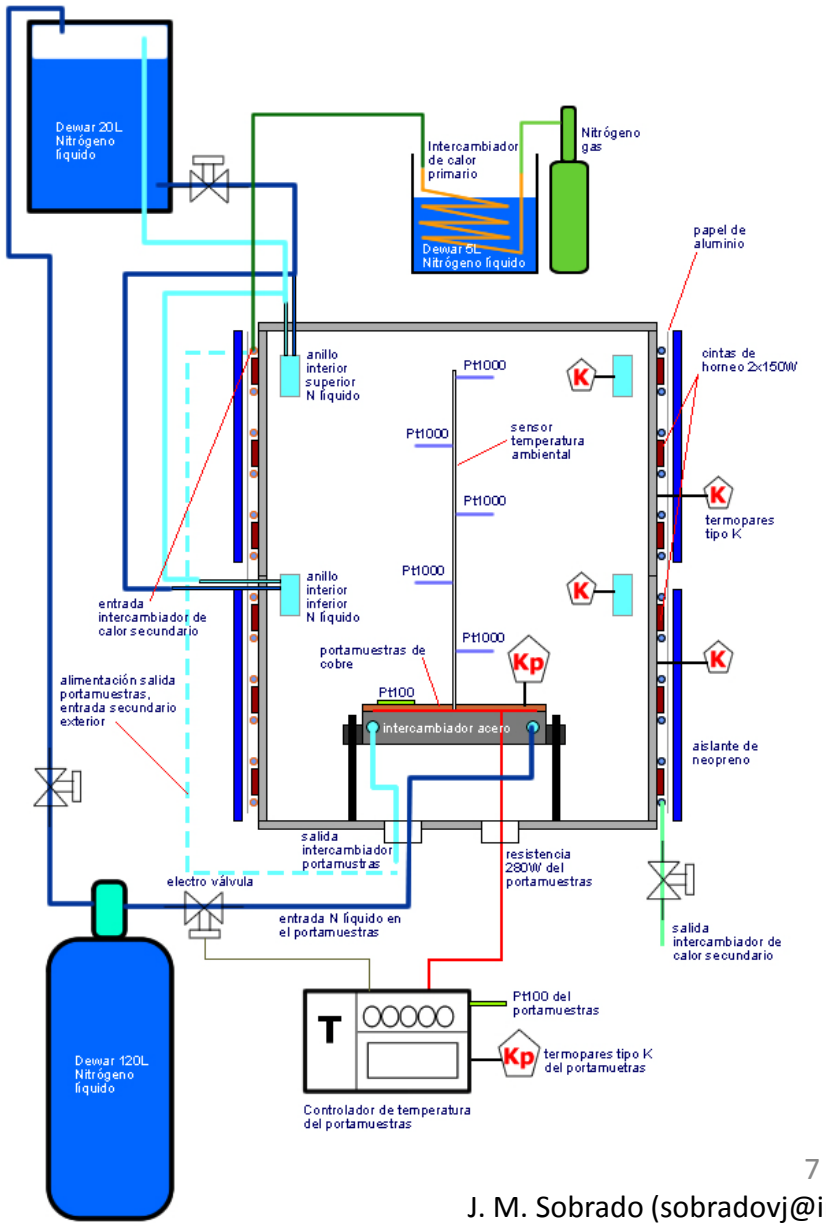

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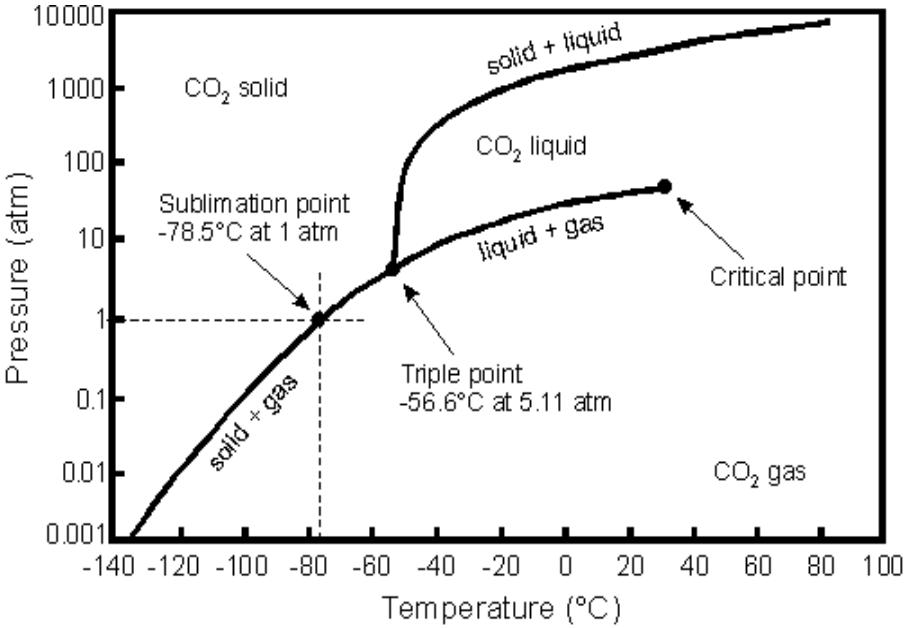

Pressure-Temperature phase diagram for CO_2.

The pressure sensor will be located inside the rover body and connected to the external atmosphere via a tube. The tube exits the rover body through a small opening with protection against dust deposition. Its measurement range goes from 1 to 1150 Pa with an end-of-life accuracy of 20 Pa (calibration tests give values around 3 Pa) and a resolution of 0.5 Pa. As this component will be in contact with the atmosphere, a HEPA filter will be placed on the tube inlet to avoid contaminating the Mars environment.

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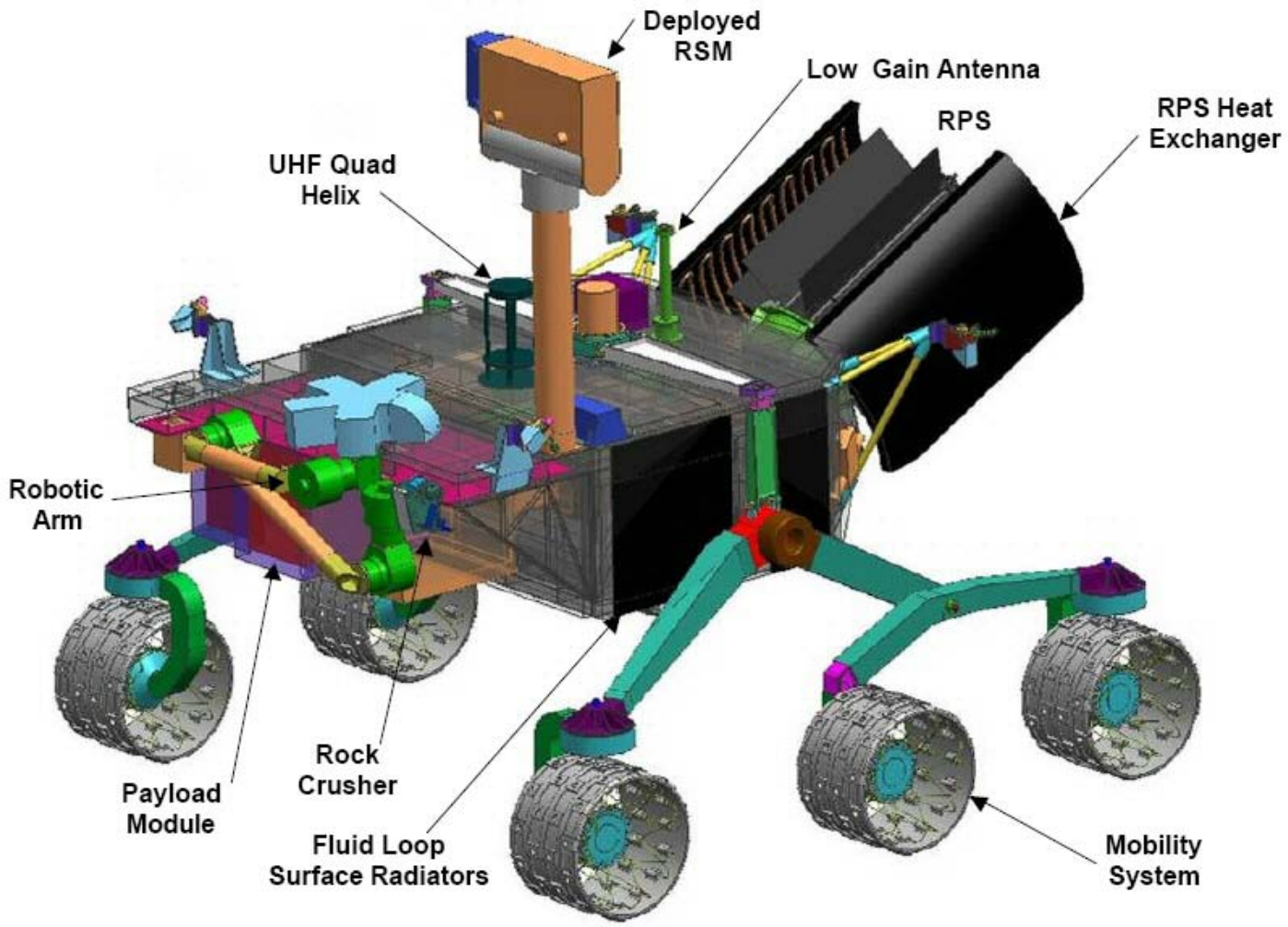

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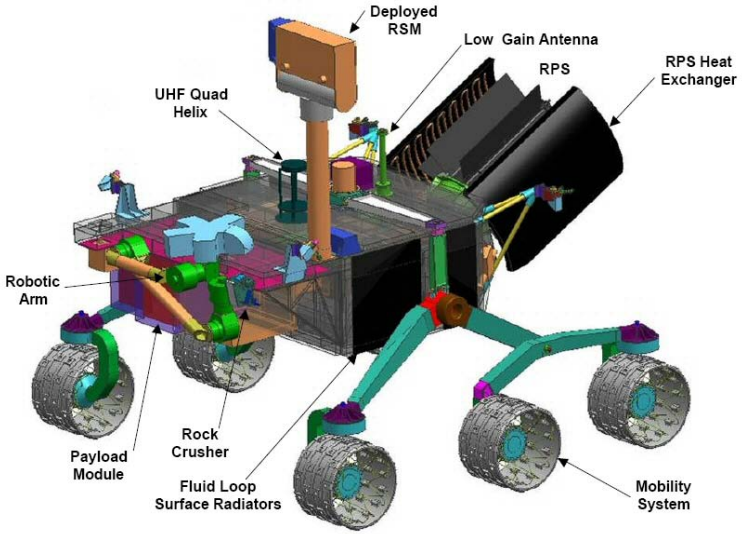

Radioisotope power systems (RPS) with specific power of ~ 3 W/kg are currently used in deep-space missions beyond ~ 4 AU, or for planetary surface missions where there is limited sunlight. JPL has long used RPS for deepspace missions, including Voyager, Galileo, and Cassini, and will be using RPS for MSL, the next Mars rover. Future deep-space missions require advanced RPS with long-life capability (> 20 years), higher conversion efficiency (> 10%), and higher specific power (> 6 W/kg). Some deep-space missions require the ability to operate in high radiation environments. Advanced thermoelectric radioisotope generators are under development at JPL for future space missions. The capabilities of smaller RPS are being explored for future exploration missions. The development of small RPS enables smaller landers at extreme latitudes or regions of low solar illumination, subsurface probes, and deep-space microsatellites.

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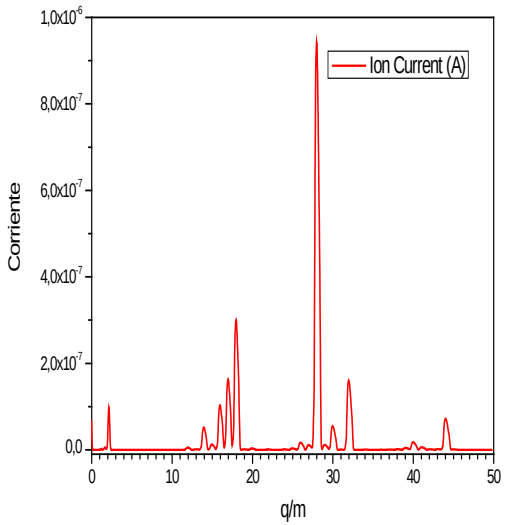
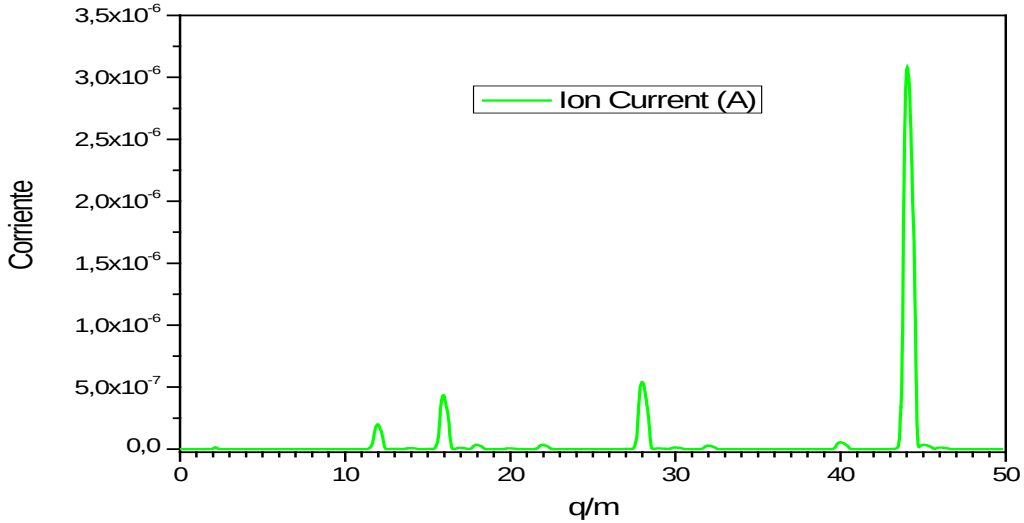
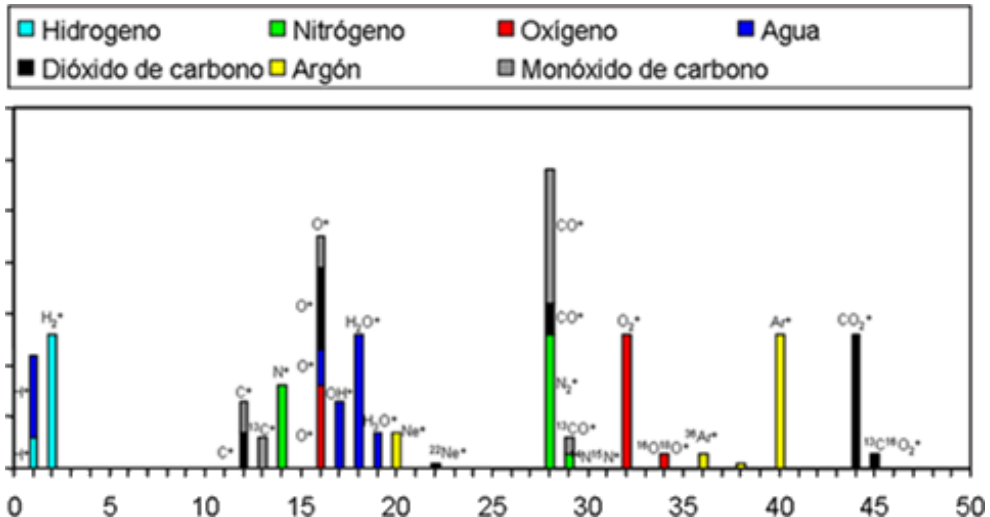
RGA of atmospheric vacuum chamber, 1E-3mbar (7E-7mbar in the mass spectrometer chamber), at 22ºC and 35% Hr.



RGA of atmospheric vacuum chamber, 17mbar, with MARS gas composition (1E-5mbar in the mass spectrometer chamber), at 22ºC and 35% Hr.





MARTE

Ar 1,6%
CO_2 95%
H_2O 0,6%
N_2 2,7%

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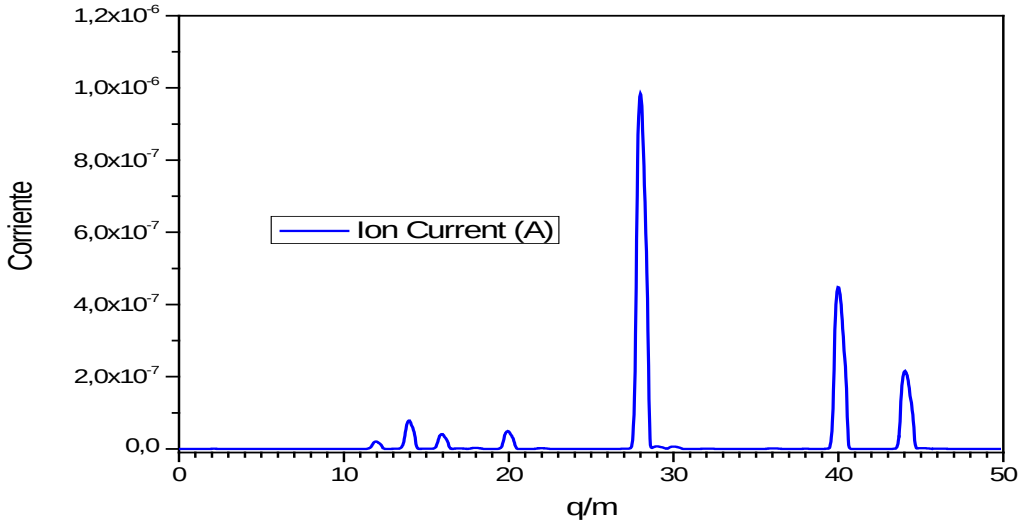
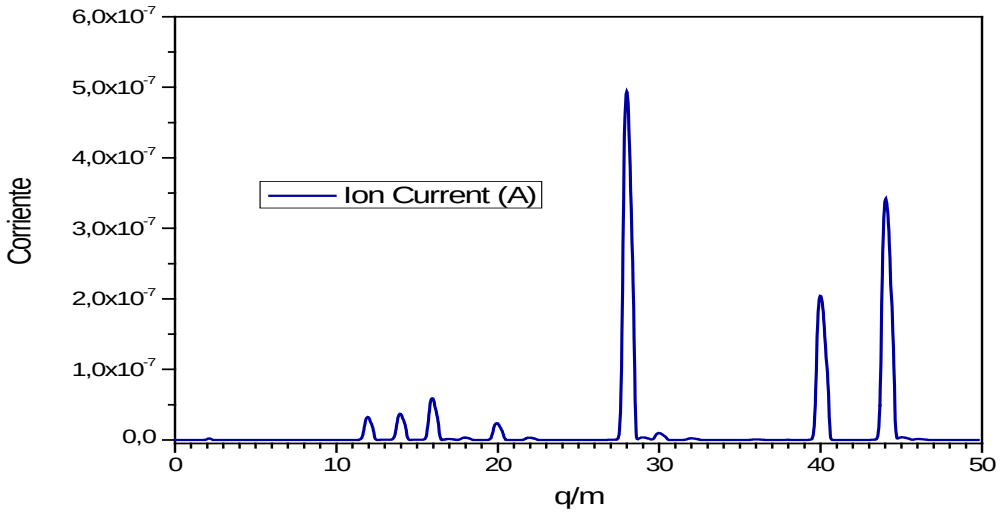


RGA of atmospheric vacuum chamber, 7mbar, with MARS gas composition. (-80ºC in sample holder with inside rings LN2) (1E-5mbar in the mass spectrometer chamber), at 22ºC and 35% Hr.



RGA of atmospheric vacuum chamber, 3.67mbar with Pirani and 5.7mbar with capacitive gauge, with MARS gas composition. (-120ºC in sample holder) (1E-5mbar in the mass spectrometer chamber), at 22ºC and 35% Hr.

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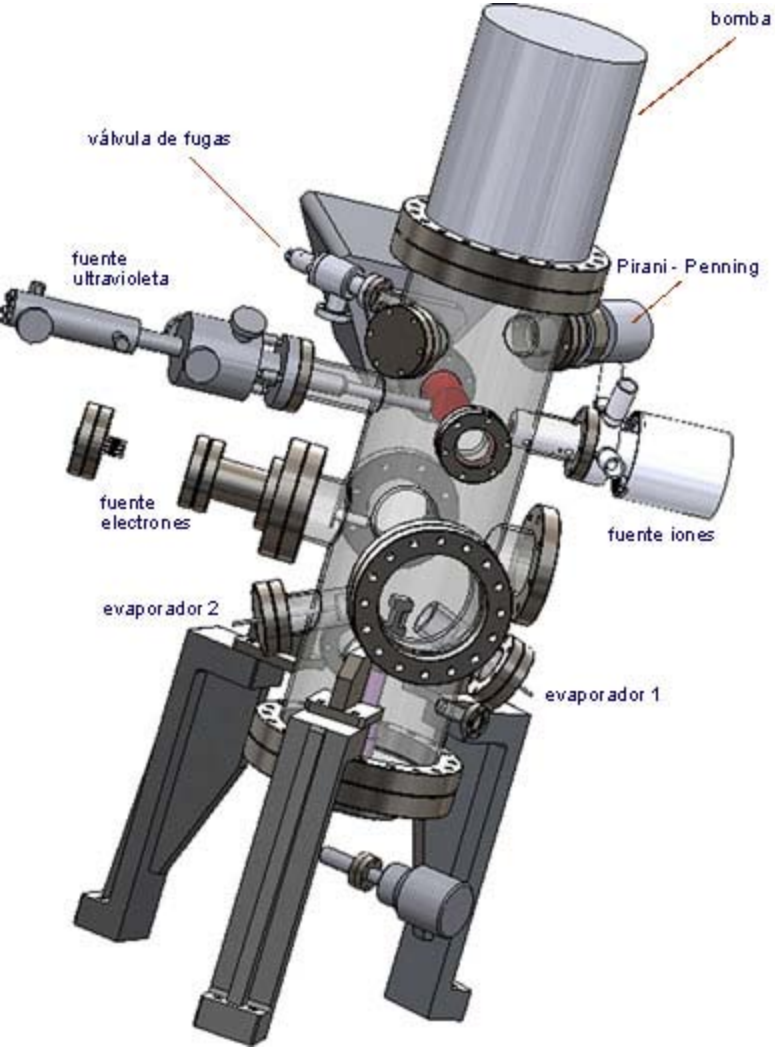
  - IE3C and PPC chambers studies the outgassing of different devices and the bacteriological contamination in real time using a mass spectrometer



In new devices of the next generation of biological instrumentation are employed biosensors and various detectors of single molecules (investigation of the origin of life). It is very important to decontaminate all the instruments and to calibrate the outgassing in real time. The plastic, silicone and other vacuum-compatible materials should be probed in the simulated conditions of the space mission.

Normally the rate of outgassing depends on the temperature and compounds, and modifies the partial pressure and could be responsible for contamination of the biosensors.

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Thanks for your patience and attention

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