ADVANCING THE TECHNICAL READINESS OF THE MOMA MINIATURE LINEAR ION TRAP MASS SPECTROMETER.

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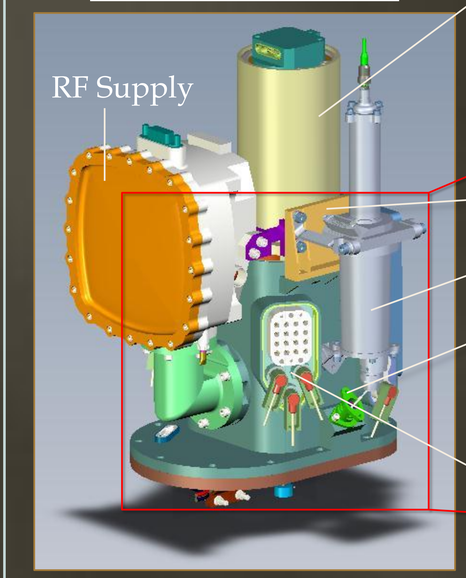
INTRODUCTION

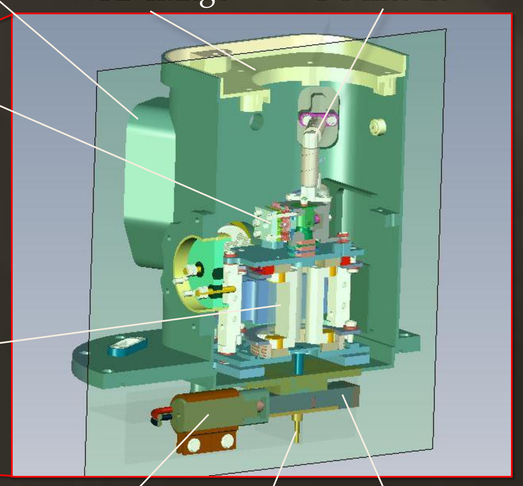
The primary science goal of the joint ESA-Roscosmos-NASA ExoMars Program is to search for and identify signs of past or present life on Mars through a chemical investigation of the martian atmosphere (via an orbiter to be launched in 2016) and surface (via a rover to be launched in 2018). The Mars Organic Molecule Analyzer (MOMA), a dual-source, mass spectrometer-based instrument capable of both pyrolysis-gas chromatography (pyr-GC) and laser desorption/ionization (LDI), is a key instrument on the Pasteur Payload of the ExoMars 2018 rover. When combined with the unprecedented two-meter depth sampling capability of the current rover, MOMA affords a uniquely broad and powerful search for organics over a range of preservational environments, volatility, and molecular weight. In addition to enabling mission science, MOMA critically informs strategies for both sampling and *in situ* analysis for Mars Sample Return (MSR).

The NASA contribution to the MOMA instrument comprises the mass spectrometer (MS) subsystem, including the following components shown below.

MOMA Instrument



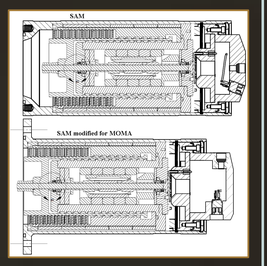
MS Subsystem (NASA)



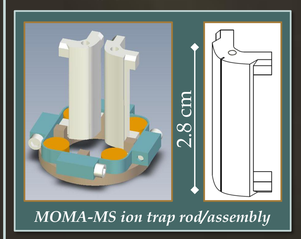
HERITAGE (HIGH-MATURITY) HARDWARE COMPONENTS

(Based on SAM/LADEE/MAVEN designs)

1. *RF Supply, Housing, and Electrical Headers/Feedthroughs*
2. *Creare 100k RPM Wide-Range Pump*
3. *Electron Ionization Source*
4. *Hyperbolic Rods*

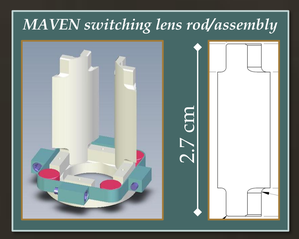


SAM vs. MOMA-MS 100k rpm WRPs
(NOTE: this is a backup option for MOMA-MS, as the baseline is currently a 200k rpm pump that requires qualification)

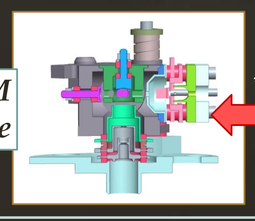


MOMA-MS ion trap rod/assembly

MAVEN switching lens rod/assembly

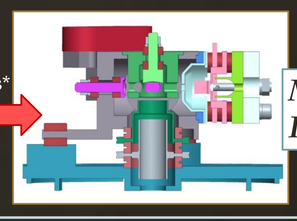


SAM/MOMA-MS High-Voltage and Multipin Headers

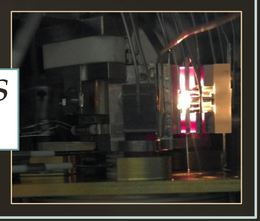


SAM Ion Source

Dual E-Guns
Modified Optics
HERITAGE DESIGN

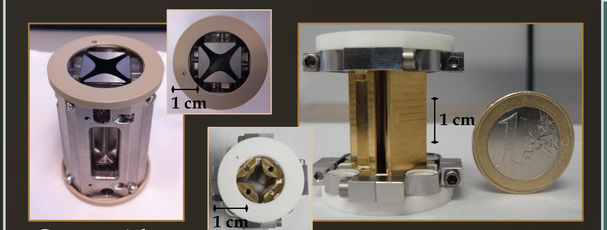


MOMA-MS Ion Source



NEW TECHNOLOGY: LINEAR ION TRAP MASS SPECTROMETER

The heart of MOMA-MS is a linear (or 2-D) ion trap mass analyzer. Compared to 3-D varieties, linear ion traps are particularly suited for FLT as they provide: a symmetrical interface to two distinct ion sources (e.g., pyr-GC and LDI modes); increased dynamic range; improved ion trapping capacity and efficiency; redundant detector/dynode assemblies; and, an analyzer design based on a set of four hyperbolic rod electrodes, similar to GSFC heritage quadrupole mass filters/lenses (SAM/LADEE/MAVEN).



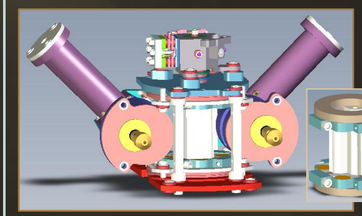
Commercial trap (r_0 = 4 mm)

Custom trap (heritage design) (r_0 = 3 mm)

Evolution of MS "Guts"

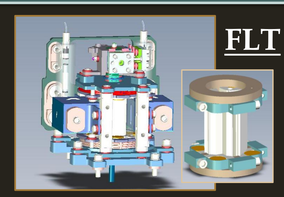
GB1: Breadboard demonstrated proof-of-concept and allowed evaluation of trade space for system performance

- Commercial r_0 = 4 mm ion trap
- Shielded single-gun EI source
- Competing CEM detectors
- Shielded rod assembly



GB2: FLT-like instrument dedicated to demonstrating TRL-6 performance requirements under environmental conditions

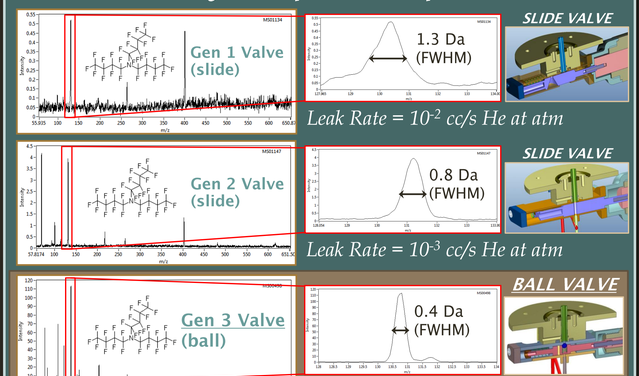
- Custom miniaturized r_0 = 3 mm ion trap
- Shielded detector/dynode assemblies
- Brassboard RF and DET electronics
- Heated ion trap and EI lenses
- Dual gun EI source



FLT

Laser desorption/ionization (LDI) mass spectrometry with the MOMA-MS linear ion trap is supported at Mars ambient pressures by the implementation of an LDI inlet consisting of an aperture valve and ion guide.

Low Maturity Component: Aperture Valve

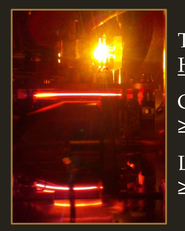


MOMA-MS TRL-6 PERFORMANCE REQUIREMENTS

Across a defined range of martian surface conditions (i.e., P = 5 to 7 torr, T = -40°C to +20°C), the integrated MOMA-MS subsystem (including constituent high- and low-maturity components) must meet the following performance specifications to ensure the full science return over the 180 sol operational lifetime of the mission:

Performance Specification	MOMA-MS pyr-GC mode	MOMA-MS LDI mode
Sensitivity	≤1 nmol (SNR ≥ 10) of PFTBA	≤1 pmol (SNR ≥ 3) of Rhodamine 6G and Angiotensin II
Mass Range	50 – 500 amu	50 – 1000 amu (Goal: up to 2000 amu)
Resolution (FWHM)	≤1 amu over mass range	≤1 amu (50 – 500 amu) ≤2 amu (501 – 1000 amu)
Analytical Drift	<0.4 amu per experiment	<0.4 amu per experiment
Mass Accuracy	<0.4 amu over mass range	<0.4 amu over mass range
Dynam Range	≥100	≥100

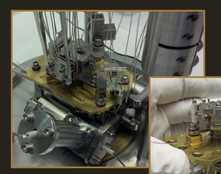
GB2 Instrument

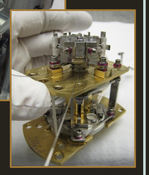


Trap Heating

GC-mode ≥75°C

LDI-mode ≥50°C





These performance metrics have been demonstrated on the GB2 prototype instrument, under FLT-like conditions and with active heating of the ion trap mass analyzer (see Pinnick et al. poster).

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