Mass Spectrometer for *In-Situ* Analysis of Organics in Martian Samples

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Overview

The Mars Organic Molecule Analyzer (MOMA) is part of the 2018 ExoMars rover led by the Max Planck Institute in Germany (PI: Dr. Fred Goesmann). A NASA-Goddard-based team contributes the core ion-trap mass spectrometer and electronics. MOMA's top objective is to seek signs of past and present life Mars. The main requirement of the mass spectrometer is to support the analysis of molecules of interest from both GC and laser sources. Two types of ion traps are under investigation.

1] **3D Ion Trap** (First approach)
2] **2D Linear Ion Trap** (New approach)

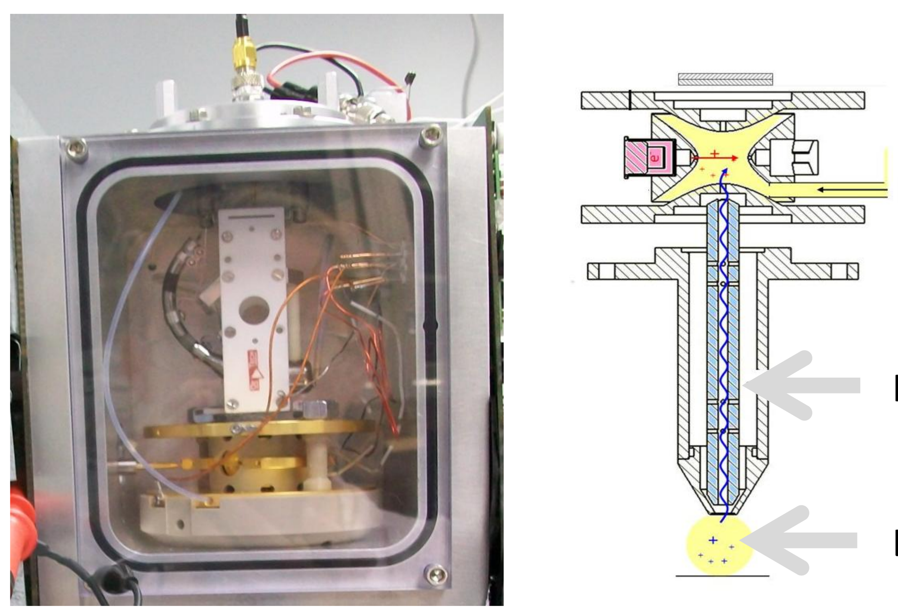
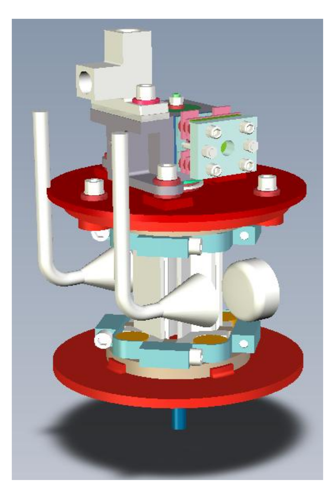


Figure 1. The MOMA 3D ion-trap test setup.



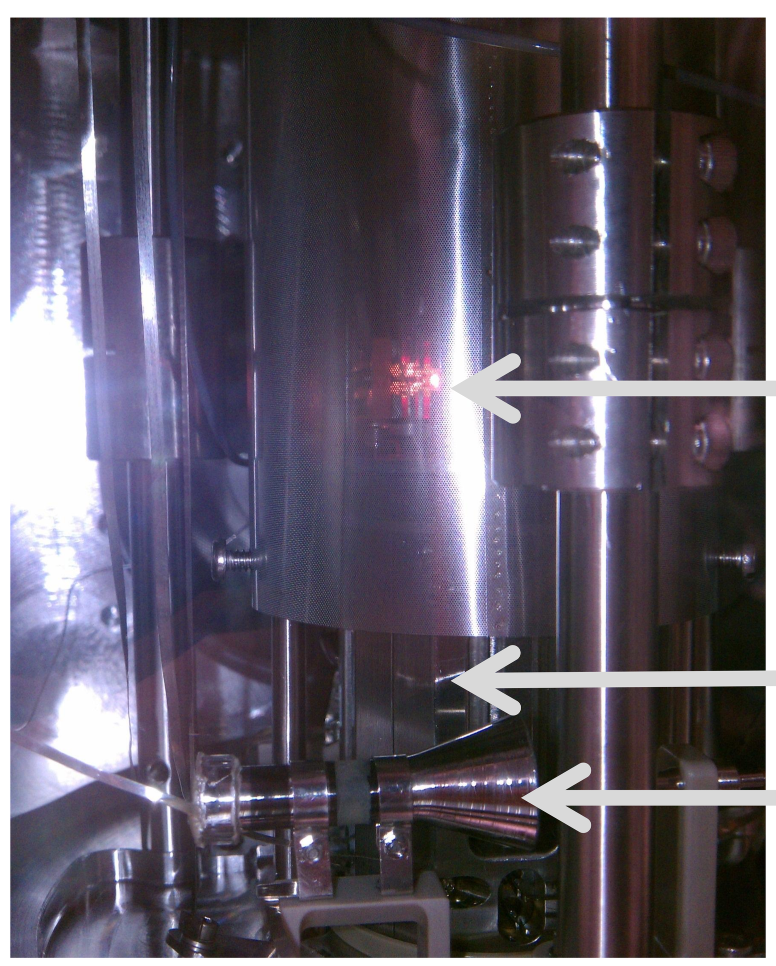


Figure 2. MOMA 2D ion trap

3D ion trap VS 2D ion trap

In addition to permitting dual ion sources, the LIT configuration supports a larger capacity for ions.
The LIT also supports 2 detectors for system redundancy.

Results prior to 2D ion trap

Acceptable performance, in terms of mass resolution and sensitivity, was achieved with an RF frequency down to 500 kHz.

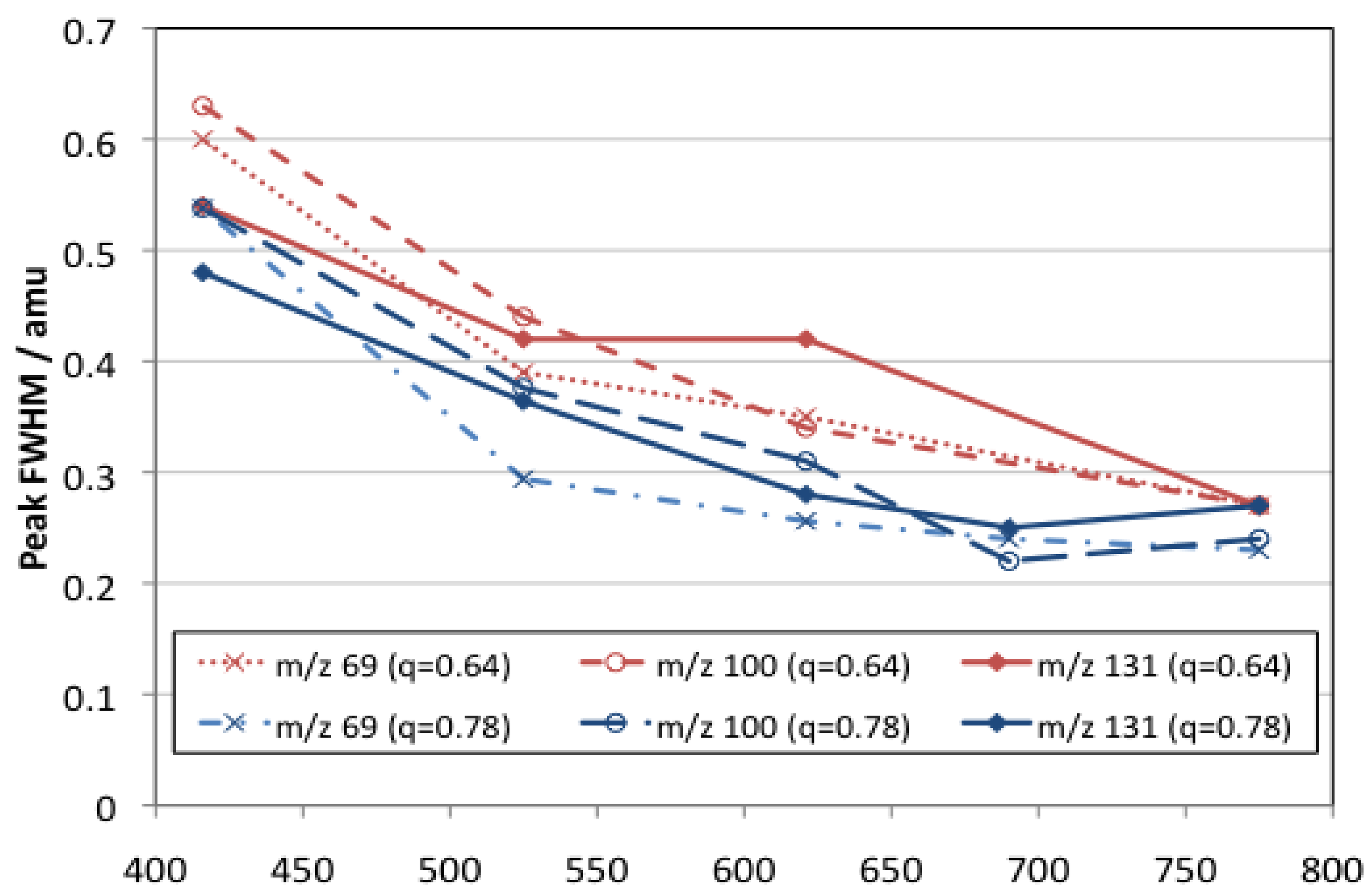


Figure 3. Mass resolution measured for different fundamental frequencies of the ion trap.

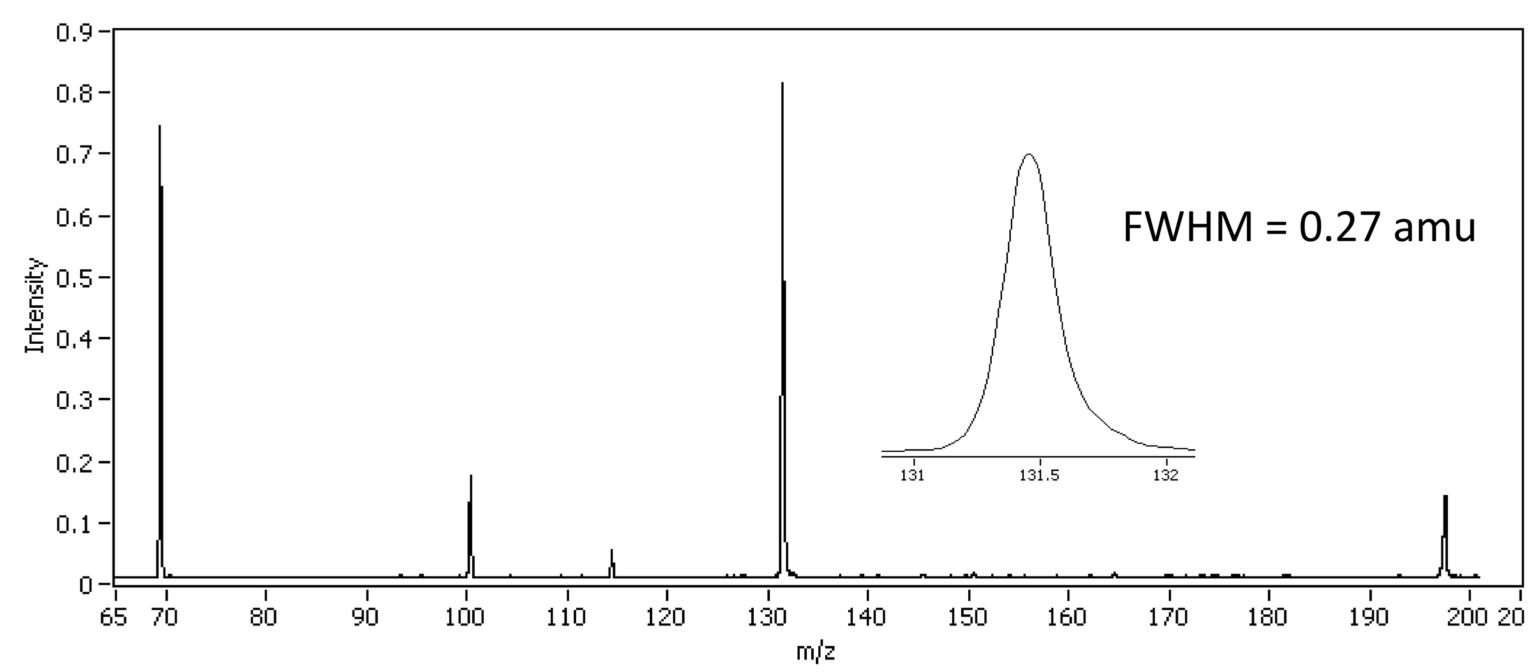


Figure 4: PFTBA spectrum from 3D ion trap: Ω = 775 kHz, q_{eject} = 0.85

2D ion trap parameters

Trapping and ejection parameters of the LIT. An analytical scan includes ionization and transfer of ions into the trap, trapping and cooling, and ejection of ions to the detector.

Parameter	Definition	Value
r	internal radius	3 mm
V_{pp}	main RF voltage	1.2 kV
f	main RF frequency	700 kHz
V_{aux}	aux. RF voltage (pp)	0-10 V
f_{aux}	aux. RF frequency	15-350 kHz
V_{DC}	DC end plate bias	0-100 V
q_{eject}	trap ejection point	0.64

2D ion trap

Preliminary data of a 4 mm Thermo Finingan 2D linear trap identical to our scaled down 3 mm 2D ion trap design.

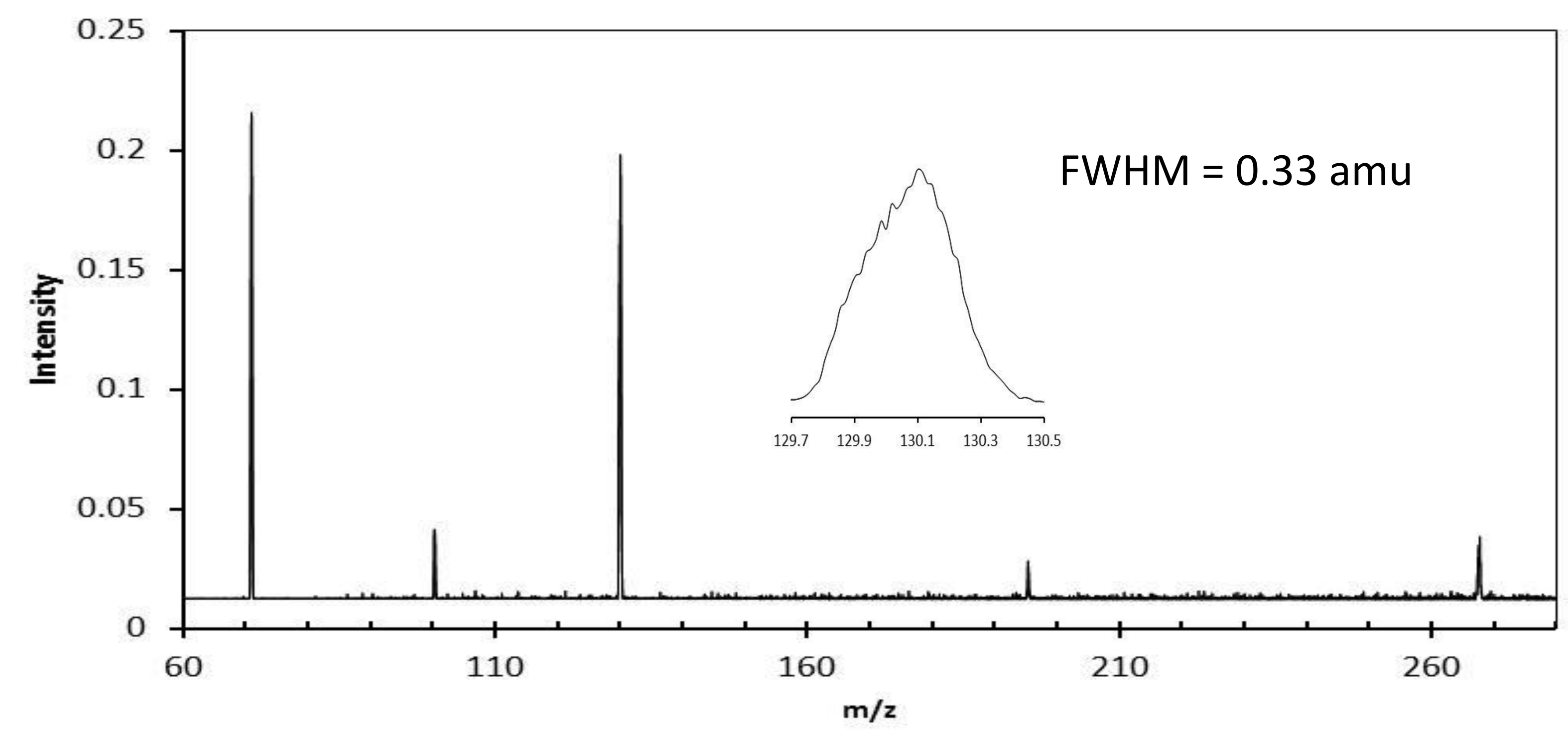


Figure 5. PFTBA spectrum of a 4 mm 2D ion trap: Ω = 840 kHz, q_{eject} = 0.85

Pulse counting

Pulse-counting has advantages over analog detection: Avoidance of analog noise and drift by digitization; performance degradation can be modeled and remotely diagnosed; low power and small PCB signature. Pulse counting experiments were performed on the 3D ion trap to investigate linearity.

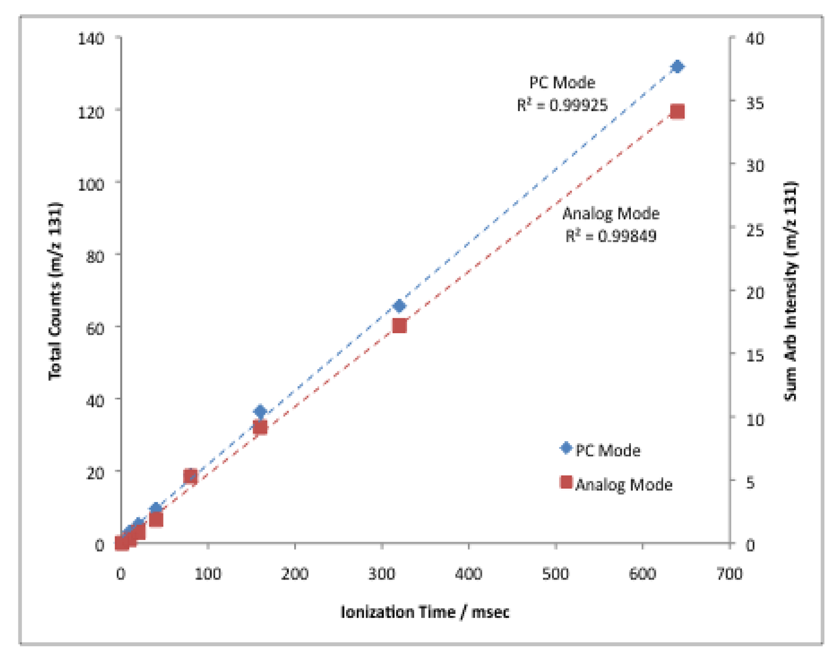


Figure 4. Linearity of the analog system compared with the pulse counting system. The pulse counting system has better linearity.

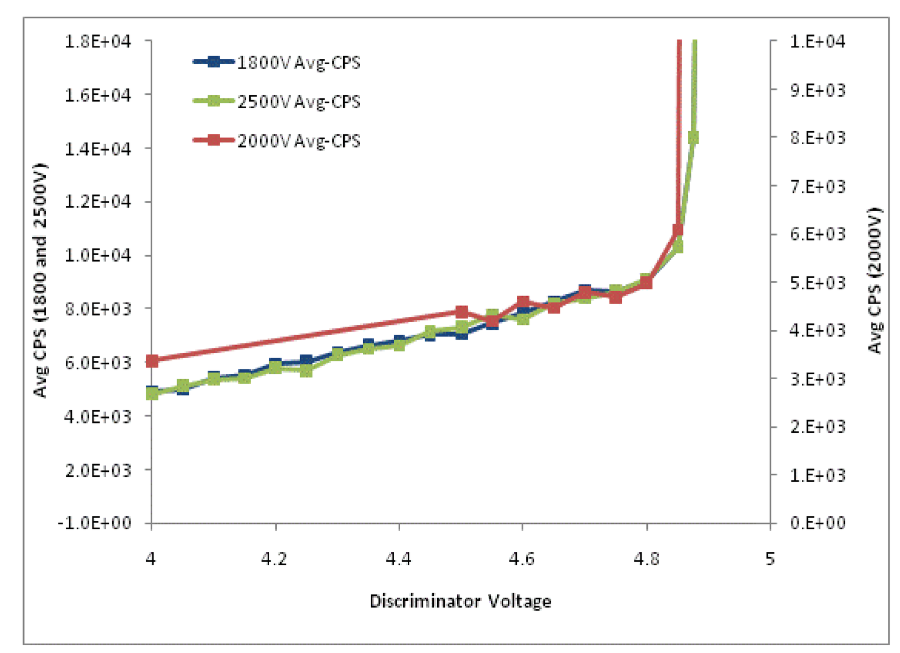


Figure 5. Pulse height distribution measured for different detector voltages.

Conclusions

The MOMA mass spectrometer requirements are met with a linear ion trap design that supports introduction and analysis of ions from laser desorption and GC/EI modes. The radial ejection of ions to a dynode and electron multiplier and detection pulse-counting electronics permits MOMA to achieve high analytical performance in a very compact and low-power instrument.

Acknowledgment

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