Modeling the Orion Air Monitor

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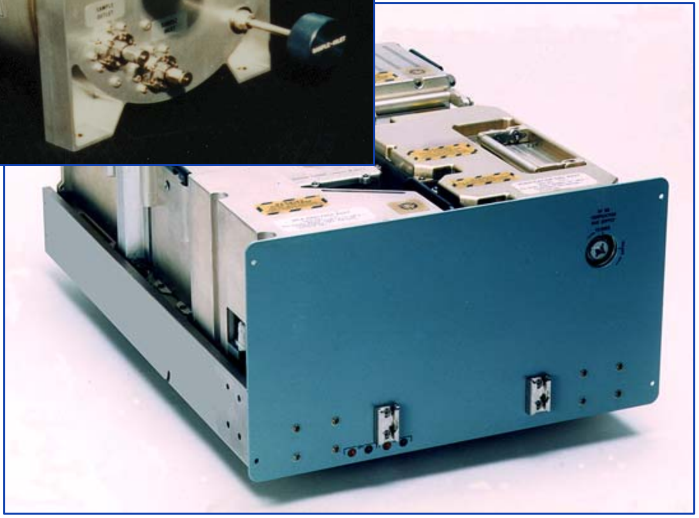
Orion Air Monitor Heritage

OAM derived from three on-orbit analyzers

- Skylab Air Monitor
- ISS Major Constituent Analyzer (MCA)
- Spacelab Metabolic Gas Analyzer Mass Spectrometer (GAMS)

Challenges

- Drive mass to ~½ Skylab sensor mass
- Higher mechanical loads



Air Monitor Performance Requirements

The OAM monitors major constituents in CEV air:

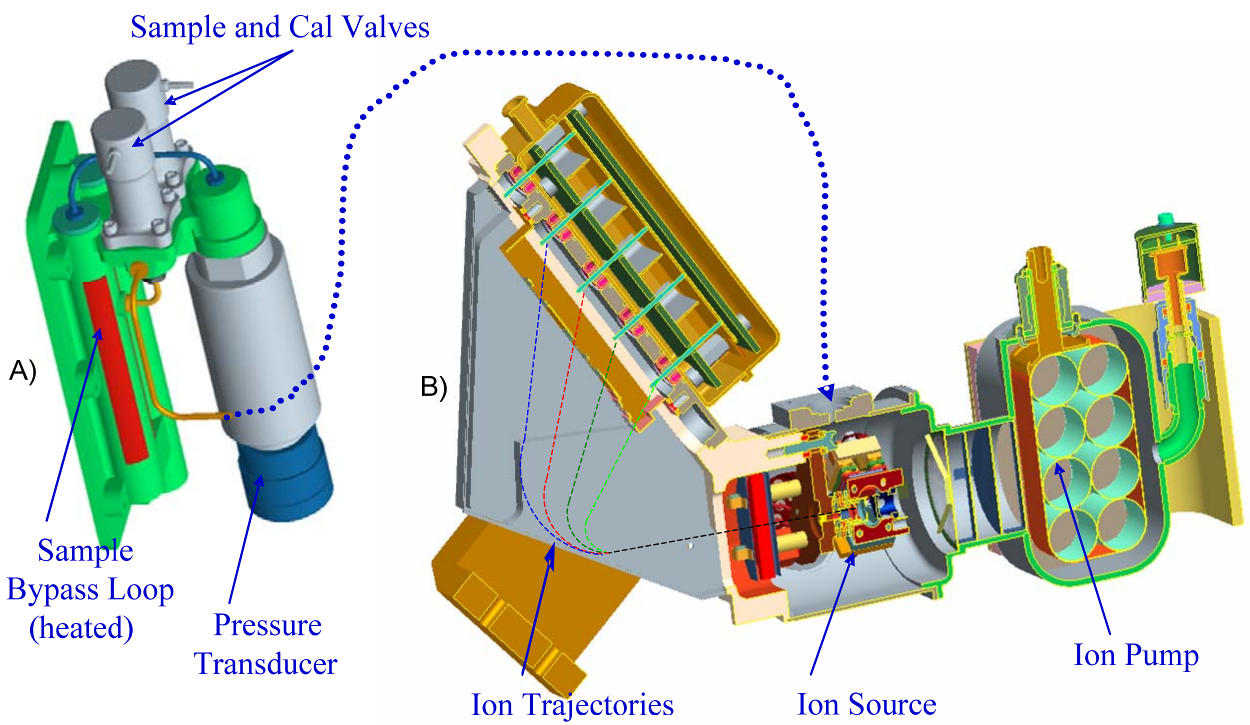
- Supports cabin and suit loop operation
- Provides feedback for swing bed and pressure control system operation

Analyte	Pressure Range /psia	Accuracy at Nominal Concentration /psi	Response Time /sec
Oxygen	0 – 24	0.1	10
Nitrogen	0 – 13	0.1	10
Carbon Dioxide	0 – 0.5	0.005	10
Water Vap	0 – 0.5	0.01	15

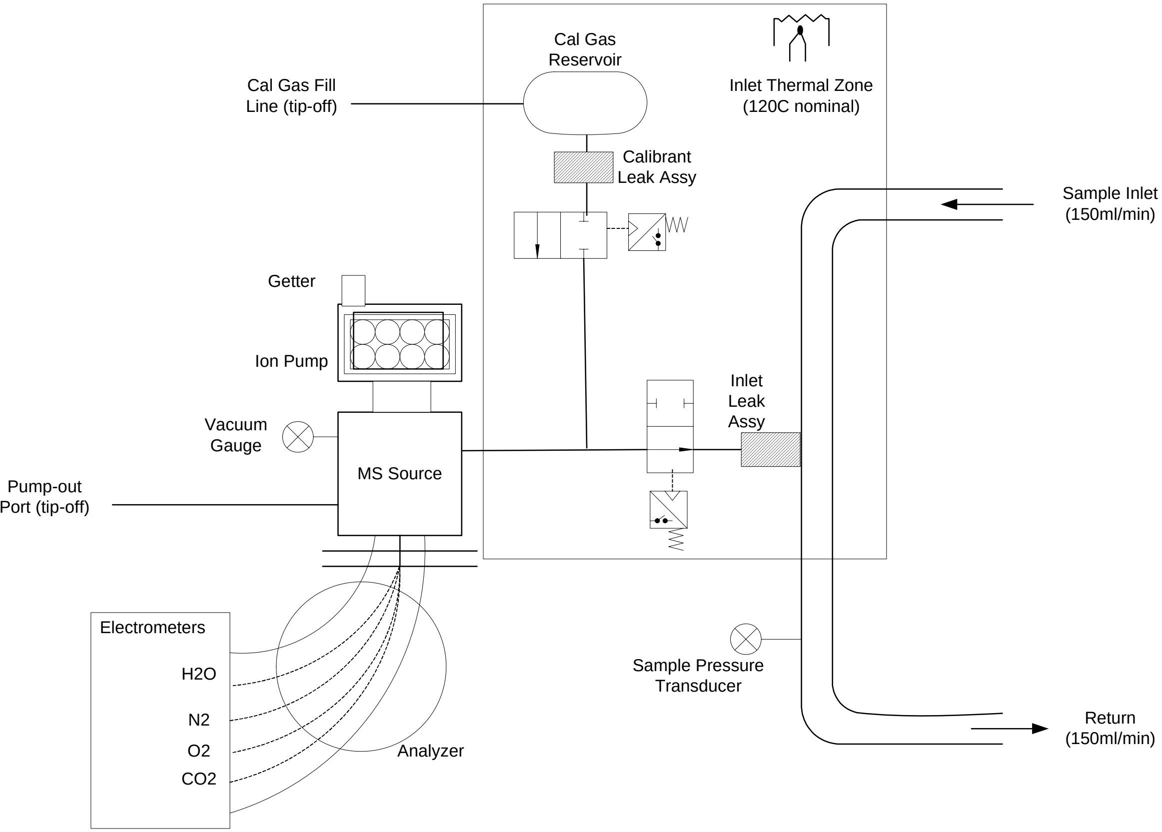
Parameter	Specification	Performance Target
Weight	18.6 lbs	15.6 lbs
Power	120V, 25 W	17 W (nominal)
Communications	RS422	460kbs

Analyzer core

- Small ‘sensor class’ magnetic sector mass spectrometer
- Flight heritage
- Minimized mass, optimized response time, for CEV application



OAM Pneumatic Block Diagram



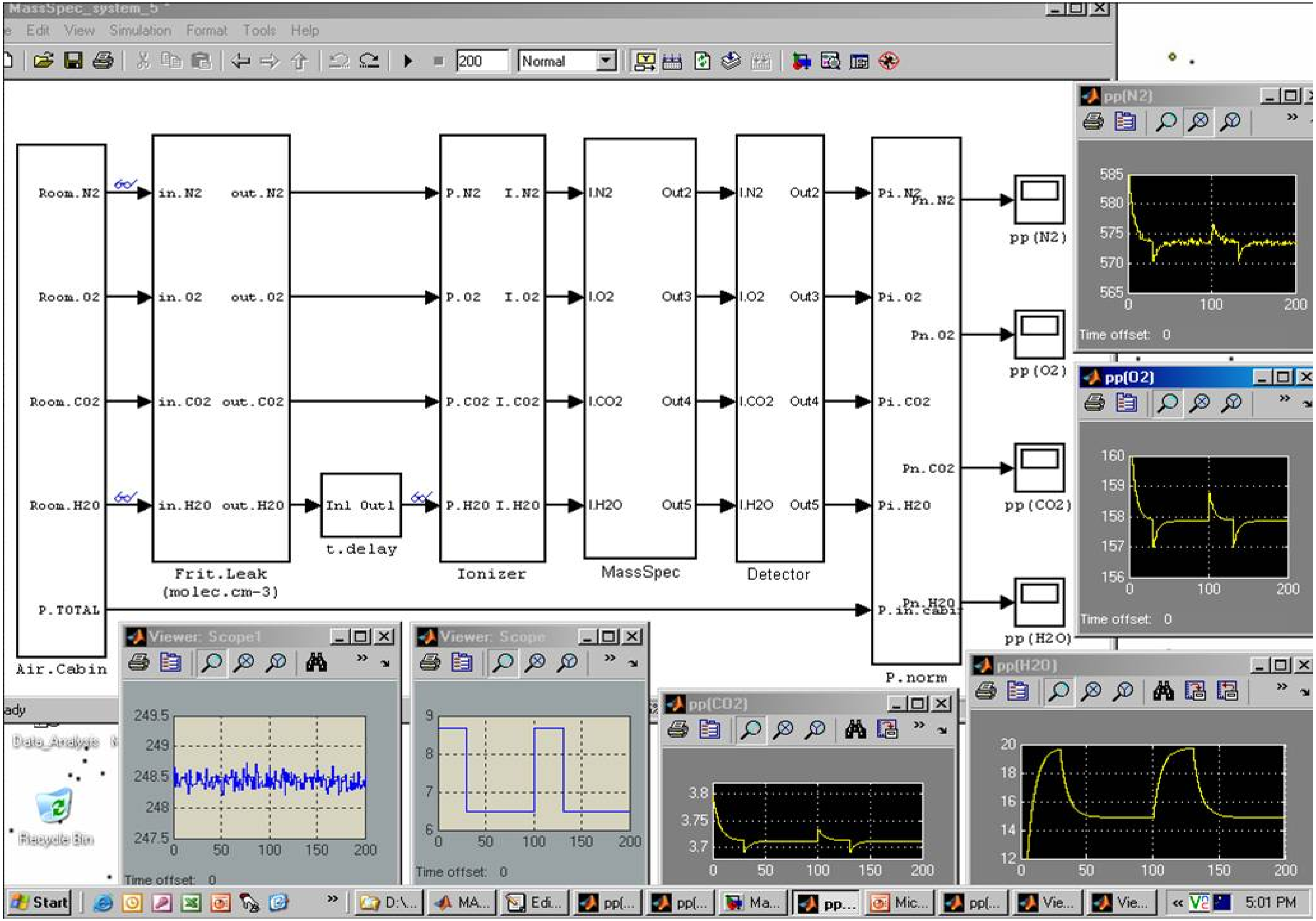
Sample is provided by a 150 cc/min bypass in the suit loop

Instrument sips 1E-5 stdcc/s air

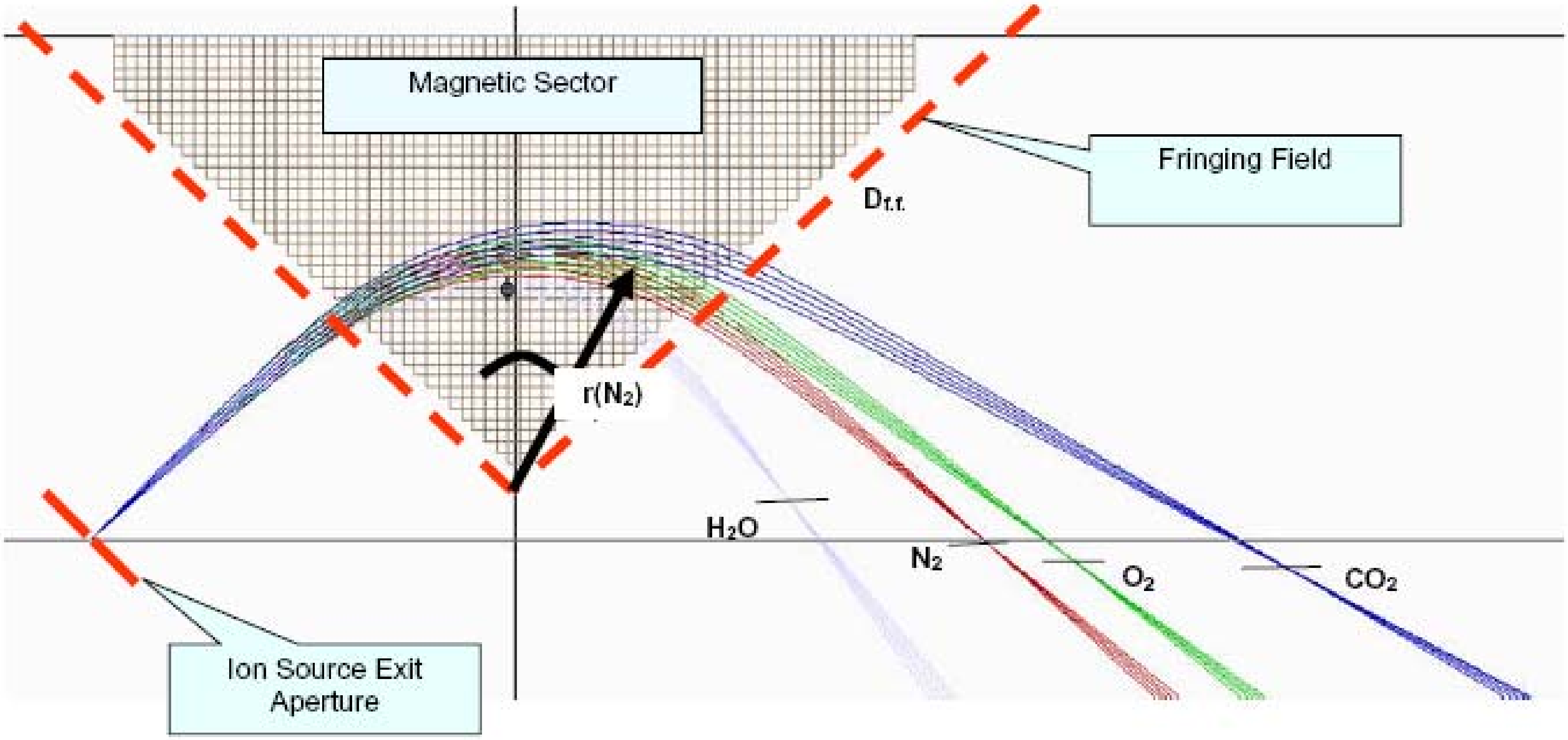
High Reliability design:

- Two moving parts (valves); can go an entire mission without actuation.
- On-orbit calibration provides measurement accuracy verification
- Analyzer maintained with low power ion pump/getter.

Top-Level OAM Simulink® Model

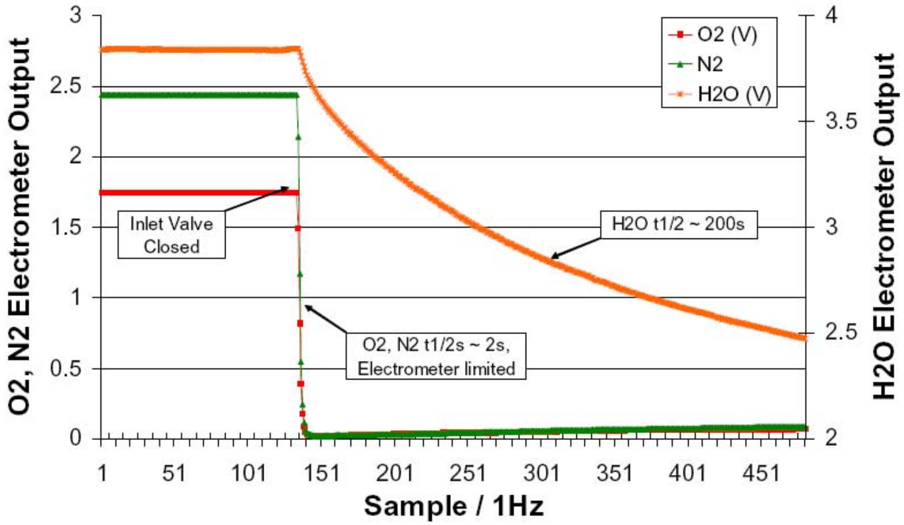


Simion® Model of a Magnetic Sector Mass Spectrometer

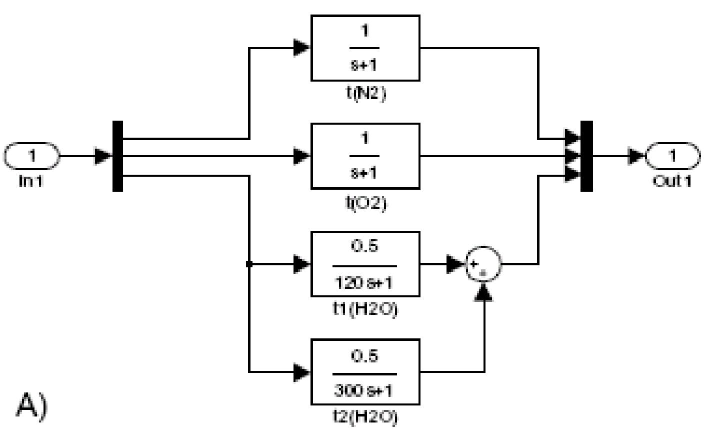


A single sector analyzer can simultaneously detect these four analytes, and more, with dedicated Faraday collectors.

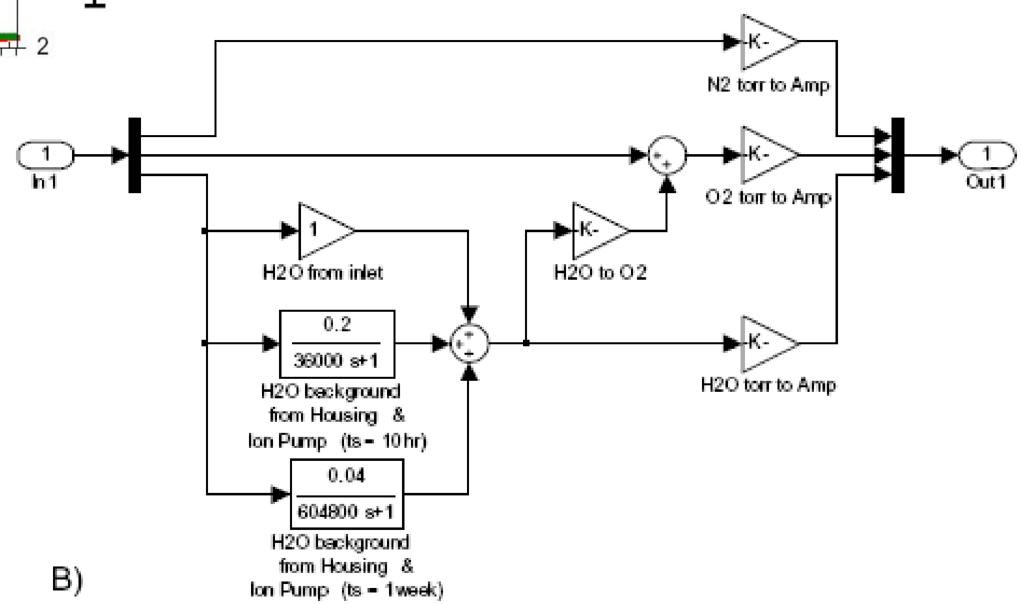
ISS MCA Components for Water Response



Short-time (minutes) response is dominated by the analyzer's inlet. However, the analyzer vacuum system has two small terms that provide significant background drift.



A)



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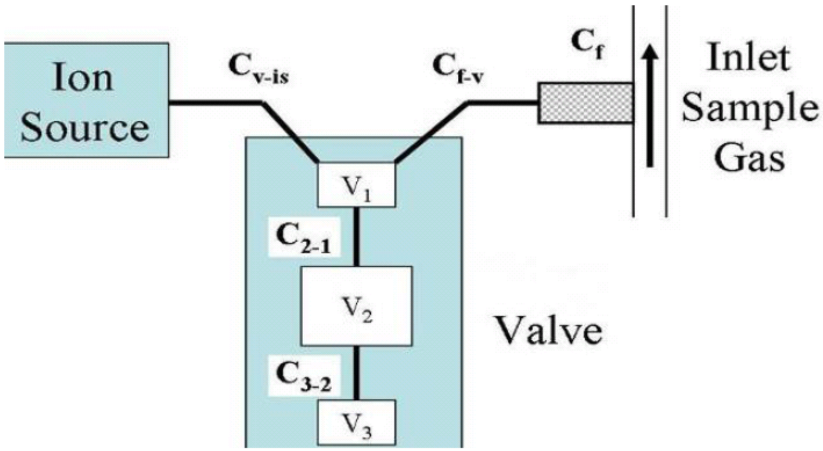
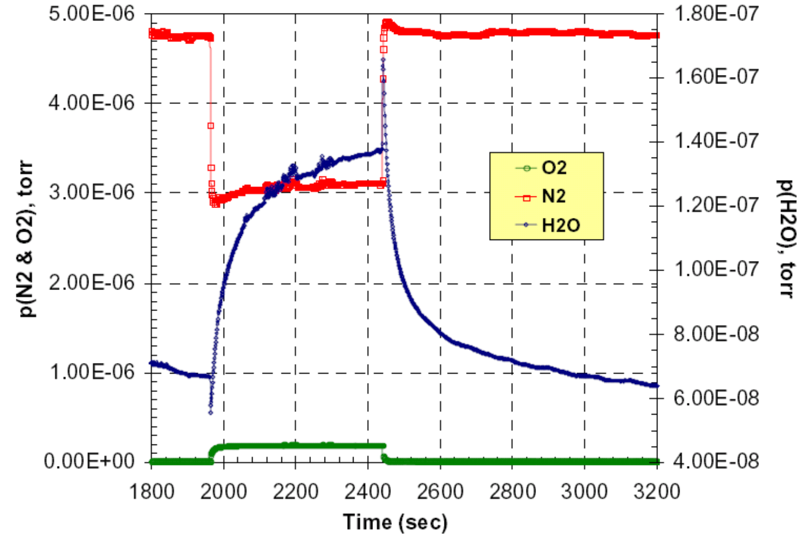
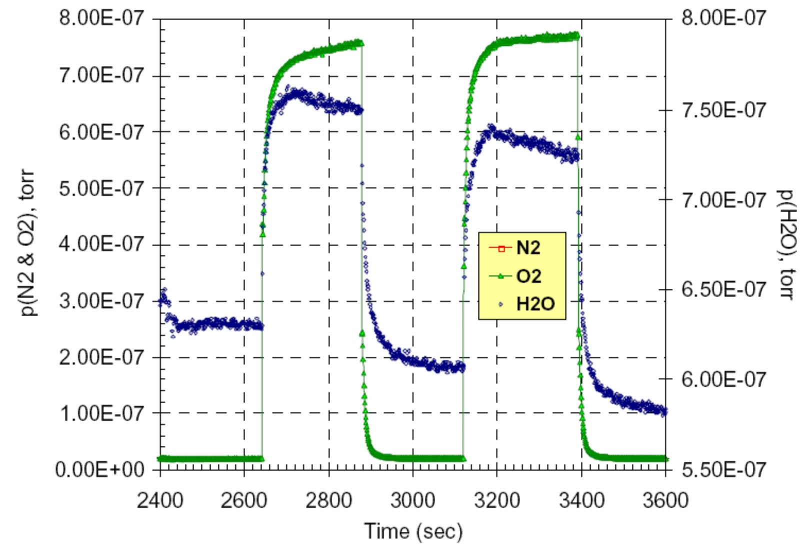
Elements of the Inlet Water Response Time

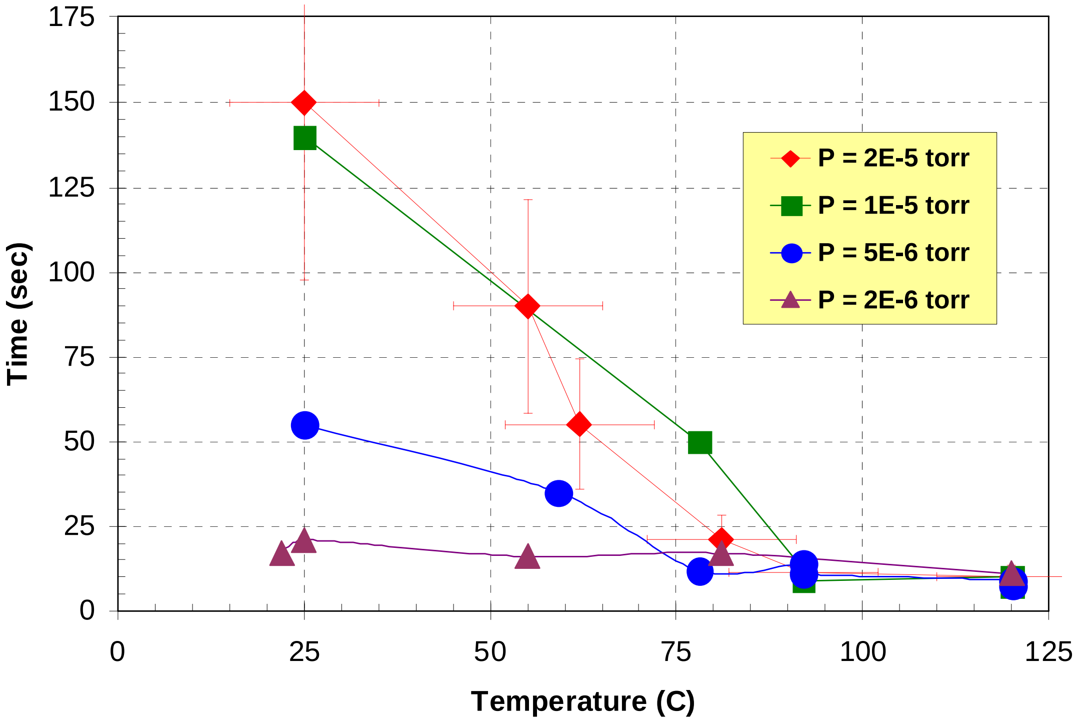






Improving water response time for the CEV application requires opening up the diameter of one line (Cv-is), eliminating the complex inner volumes of the sample valve, and heating the inlet to > 90C.

OAM H_2O Response vs Inlet Temperature and Pressure



The Skylab / ISS-based analyzer can easily meet CEV response time requirements

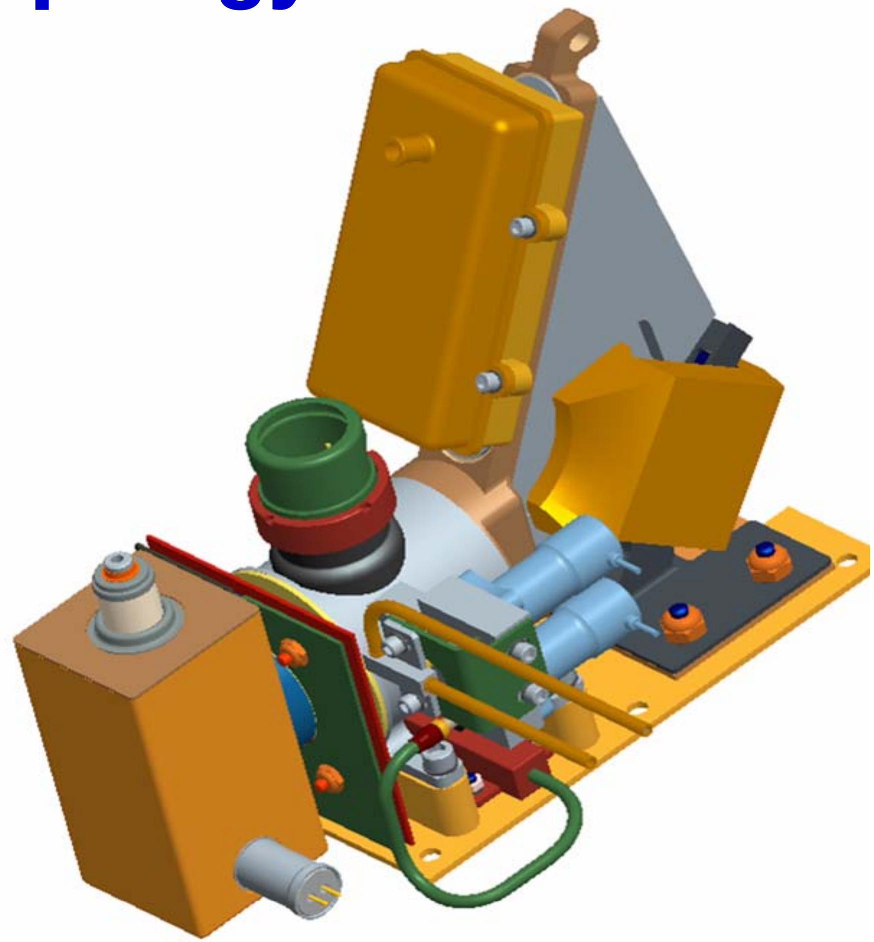
Improvements required:

- **Heat inlet > 90C**
- **Modify inlet valve for improved conductance**
- **Modify conductance to the source to minimize pressure in the inlet**

Other improvements noted:

- **New inlet valve allows elimination of support equipment**
- **Lining the analyzer with a passivating layer can reduce the background amplitude**

Optimized CEV OAM Topology



Envelope Dimensions:
10.895 W X 11.838 L X 7.50 H

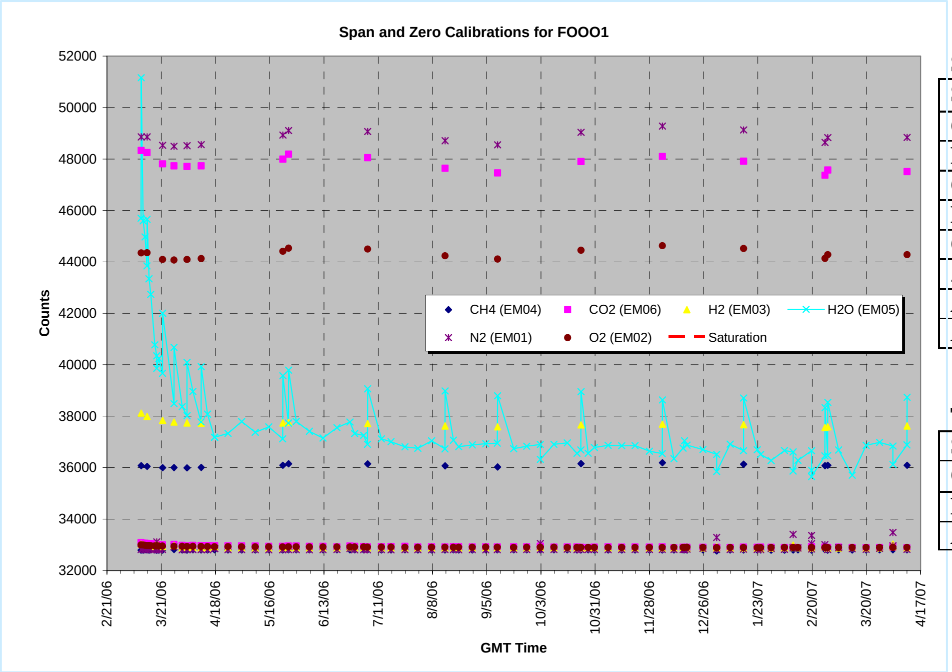
The OAM is optimized for power, weight, and response time. The instrument relies on the ECLS ARS for sample flow, and gets response time down with improved inlet conductance and heated inlet components.

Vacuum System Blow-down

ISS analyzer water background shows two long timeconstant terms

Traced to water binding, and dissociating, on vacuum system surfaces

Mitigated by heating analyzer or passivating surfaces



Stabilization Energies for Water Bound to Clean Metal Surfaces [Thiel]

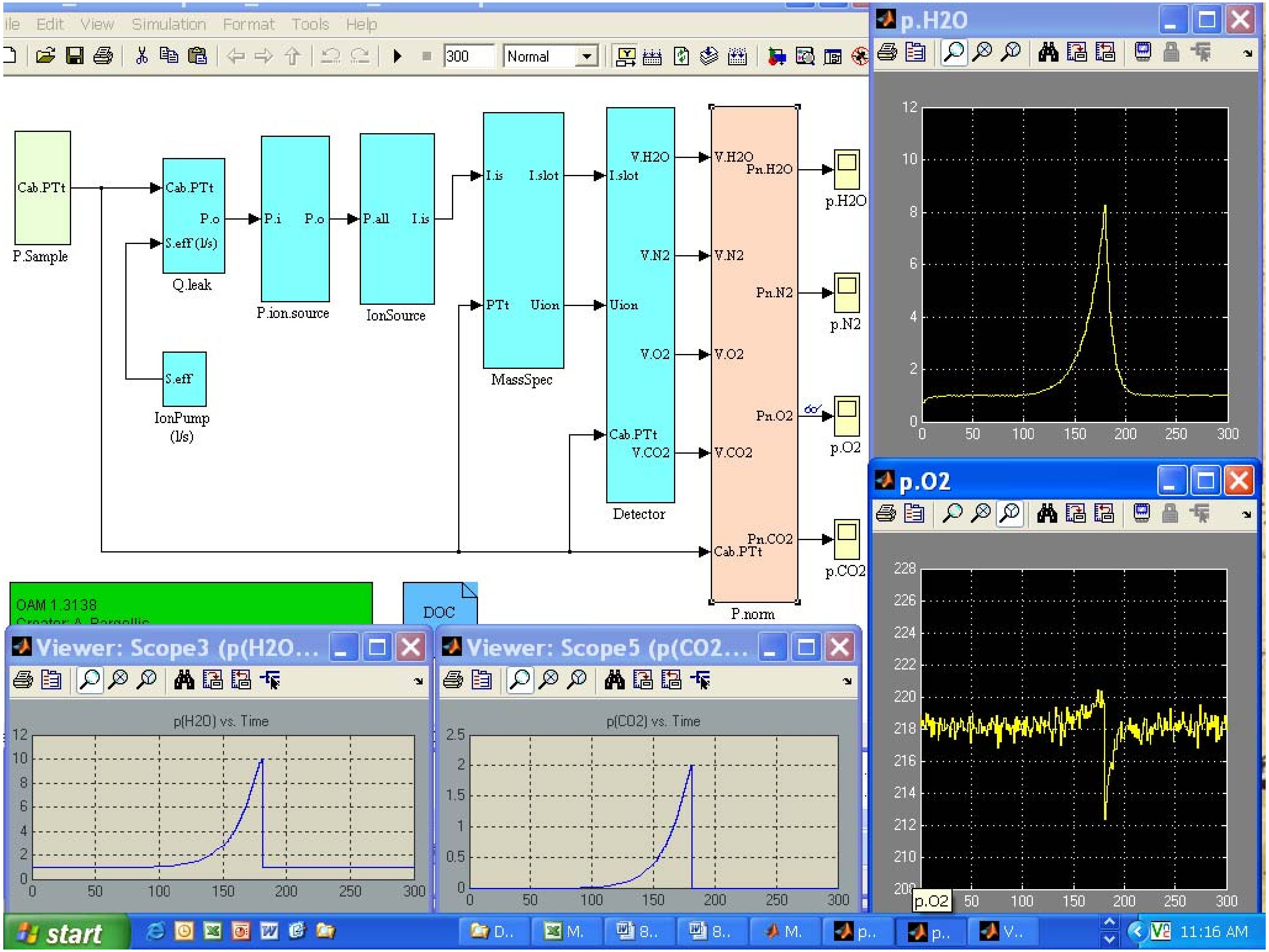
Surface	ΔH_s / kJ/mol	ΔH_1 / kJ/mol	ΔH_2 / kJ/mol
Cr	-50	-205	-324
Fe	-50	-59	-163
Co	-50	-72	-113
Ni	-50 (-42)	-53	-93
Cu	-50	+10	-44
Zn	-50	-123	-201
Ag	-50	+69	+131
Au	-50 (-4)	+51	+170

Thermal Desorption Temperatures for Water on Selected Metal Oxides

Surface	Bare Metal TDS /K	Oxide or O_2-doped TDS /K
Cu	175	290
Ni	370, 270, 235, 170	360-380
Ag	150	320

P. A. Thiel and T. E. Maddey. 1987. *The Interaction of Water With Surfaces: Fundamental Aspects.* Surface Science Reports, v. 7, p. 211-385.

Integration with CEV: Modeled behavior through a Swing Bed cycle.



Summary

- The OAM was modeled in Simulink and SIMION
  - Fidelity of the models verified against ISS MCA
  - Used to define model-based tuning
  - Evaluated requirements to meet water response time
- Optimization of water response
  - Inlet passivation, heating, and conductance
  - Analyzer inner surfaces passivated
- Characterized analyzer/algorithm behavior in CEV application