Mars Atmosphere and Volatile EvolutioN (MAVEN) Mission

MAVEN SCIENCE COMMUNITY WORKSHOP

December 2nd, 2012

Neutral Gas and Ion Mass Spectrometer (NGIMS)

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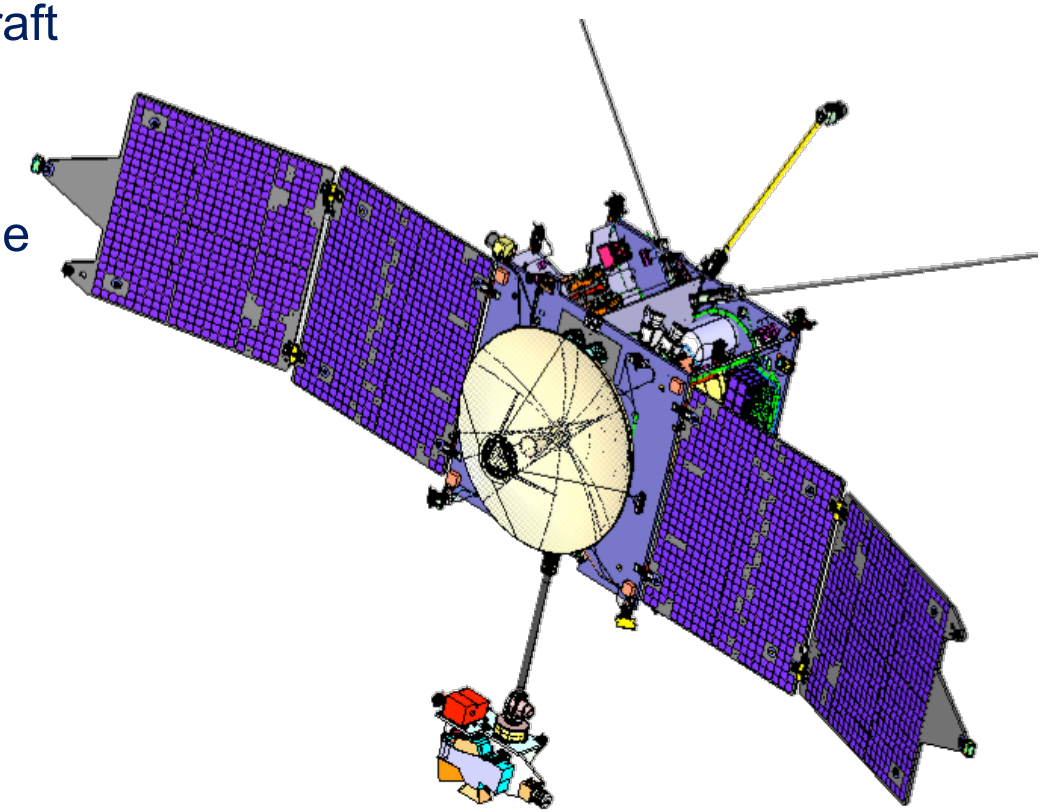


Science Goals

NGIMS science goals

- establish structure & composition of upper **NEUTRAL** atmosphere
- measure **ISOTOPE** ratios
- measure thermal and supra thermal **IONS**

Measurement focus

- every orbit **below ~500 km**
  → altitude profiles from the homopause to above the exobase
- over mission duration
  → changes in atmosphere with perturbations from above and below

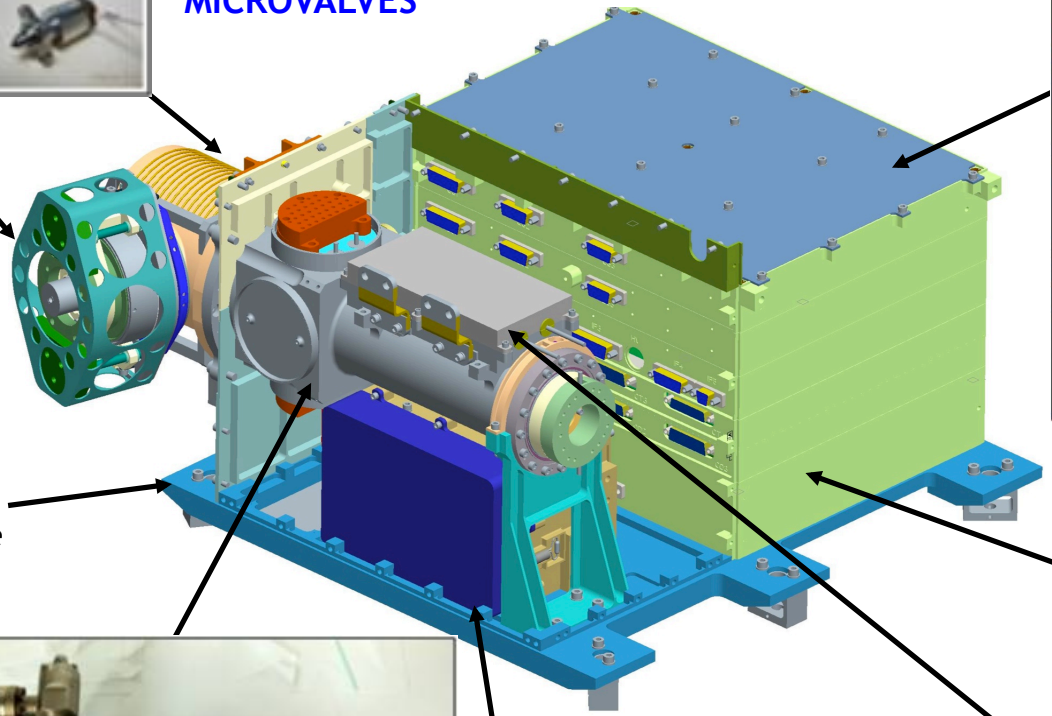
Relationship to MAVEN science goals

- state of upper atmosphere established for neutrals, ions, and isotopes
- response to solar perturbations established
- **NGIMS measurements in concert with other MAVEN data sets provide a basis for models of present and past atmospheric loss and a better understanding of the history of Martian climate**

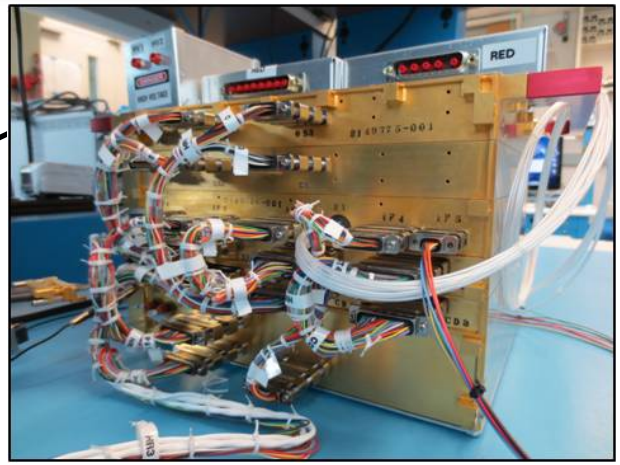
NGIMS Overview

MICROVALVES

Breakoff Assembly



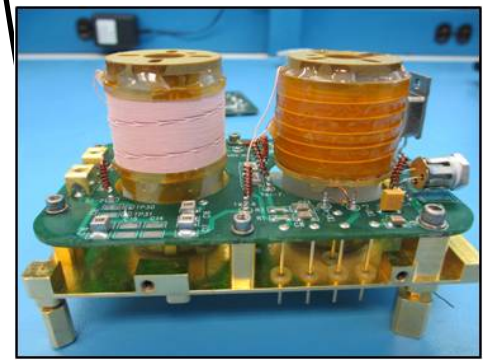
NGIMS Baseplate



MEB AND HARNESSES

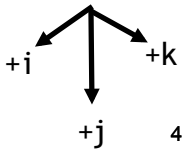
Thermal Radiator and Blankets

QMS SENSOR

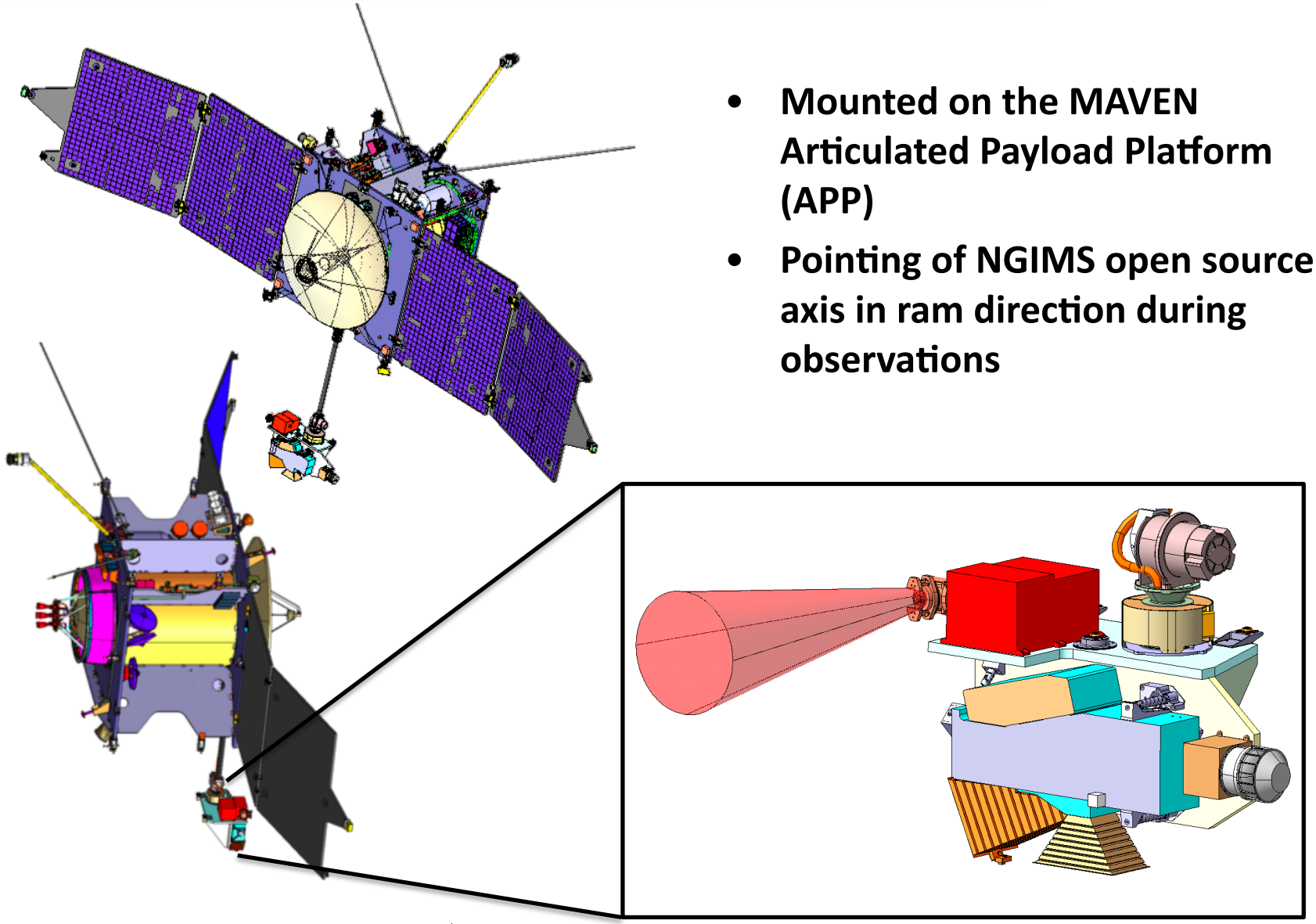


RF ELECTRONICS

DET ELECTRONICS



Accommodation on the Spacecraft



- Mounted on the MAVEN Articulated Payload Platform (APP)
- Pointing of NGIMS open source axis in ram direction during observations

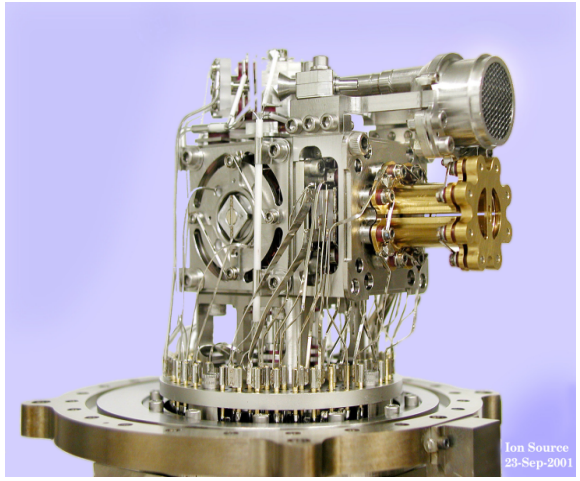
NGIMS Top Level Requirements

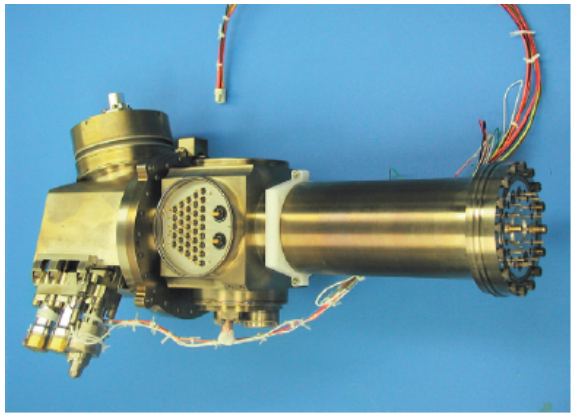
NGIMS measurement requirements:

- Profiles of He, N, O, CO, N_2, NO, O_2, Ar, and $CO_2$and their major isotopes
  - From the homopause up to one scale height above the exobase (130 km for He, ~12 km for CO_2)
  - Vertical resolution of one half scale height for each species
  - 25% accuracy
- Profiles of thermal O_2^+, CO_2^+, NO^+, O^+, CO^+, C^+, N_2^+, OH^+, and N^+
  - From the ionospheric main peak (~120 km) up to the nominal ionopause (~400 km)
  - Vertical resolution of one half O_2^+ scale height
  - 25% accuracy.

The combination of NGIMS sampling performance and spacecraft and attitude and orbit give:

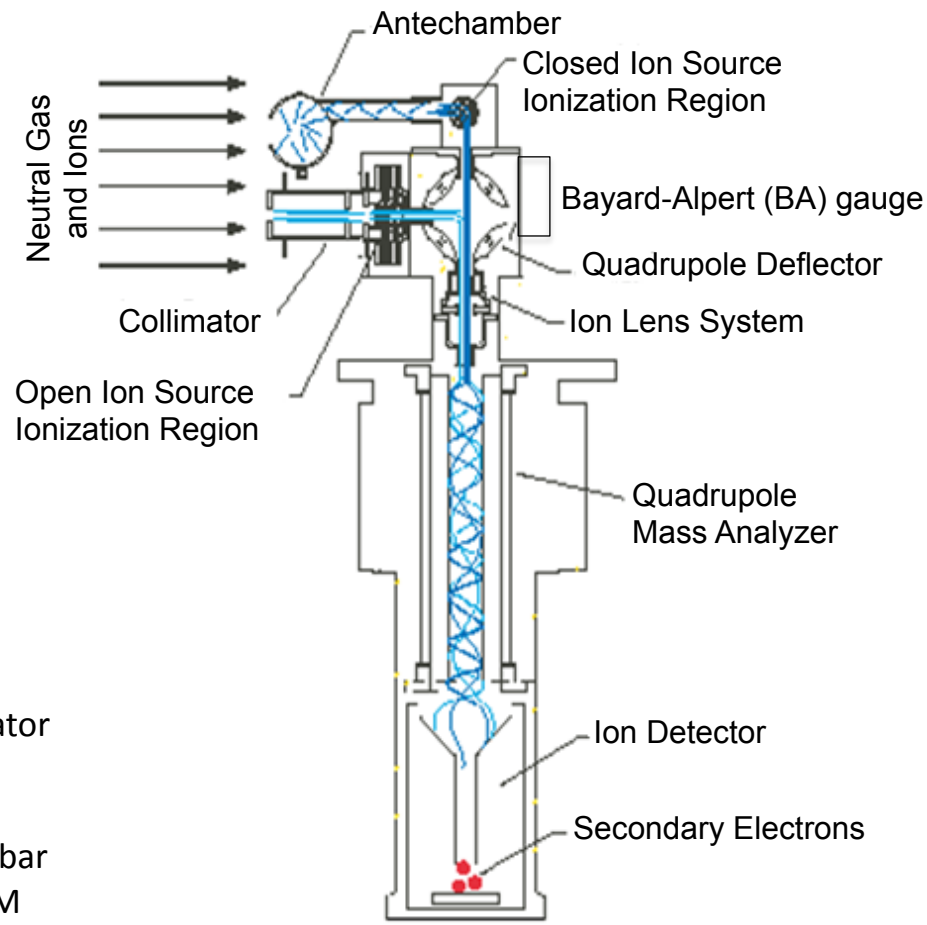
- Required profiles of neutral and ion species
- Neutral temperature from scale height.
- Isotopes: ($^{13}C/^{12}C$, $^{18}O/^{16}O$, $^{15}N/^{14}N$, $^{40}Ar/^{36}Ar$, $^{38}Ar/^{36}Ar$)





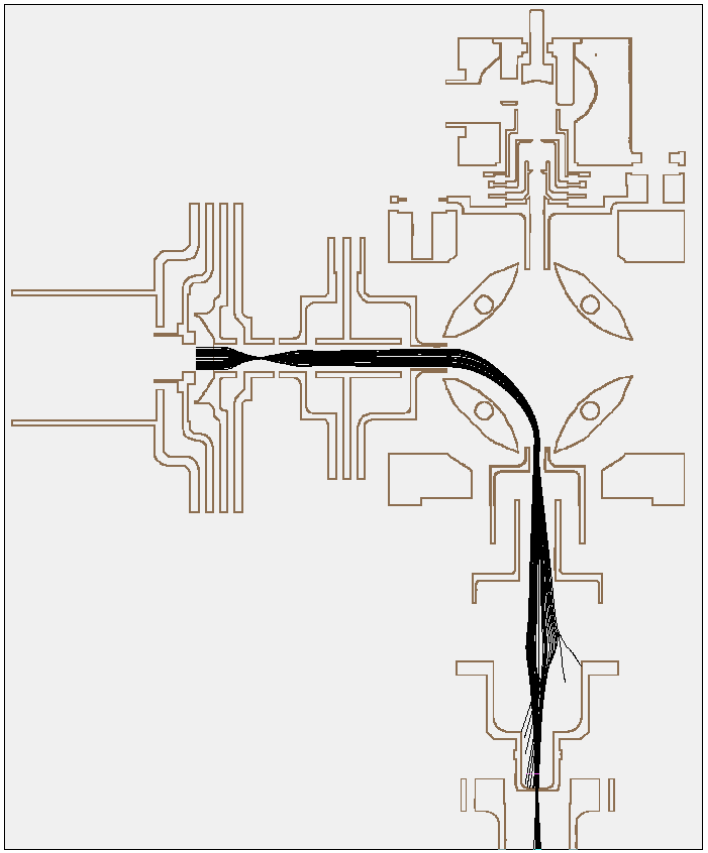
Instrument Characteristics

- **Neutral Gas Sampling:**
  (1) closed source (non wall reactive species)
  (2) open source (wall reactive species)
- **Positive Ion Sampling:**
  thermal and suprathermal (< 30 eV)
- **Ion Source:** electron beam ionization
- **Electron Energy:** 75 eV
- **Mass Range**: 2 to 150 amu (H_2 to Xe)
- **Quadrupole Radio Frequencies:** 2
- **Resolution/Crosstalk:** 10^{-6} for adjacent masses
- **Detector System:**
  redundant pulse counting multipliers
  sample period 30 ms, integration period 27 ms
  dynamic range 10^8
- **Scan Modes:**
  (1) programmed mass or mass band scan
  (2) survey (scan in 1/10 or 1 amu steps)
- **Electrical Interfaces**: RS-422, power, heater, PRT, actuator
- **Deployment Mechanism:**
  jettisoned metal ceramic break-off cap
- **Internal Bayard-Alpert Pressure Gauge**: 10^{-8} to 10^{-3} mbar
- **Inheritance:** CONTOUR NGIMS, Cassini INMS, MSL SAM

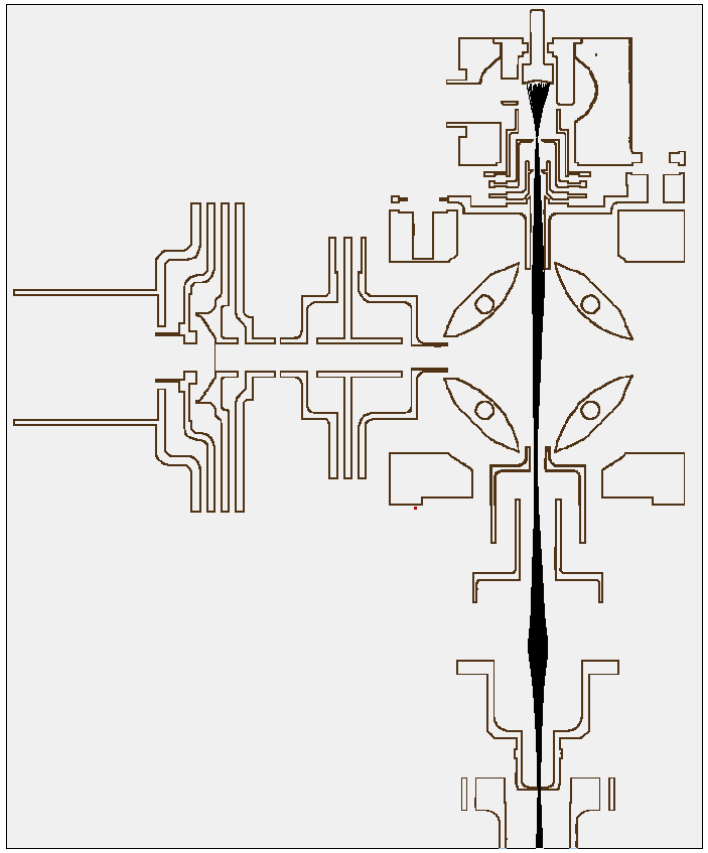


Ion Optics and Focusing Scheme

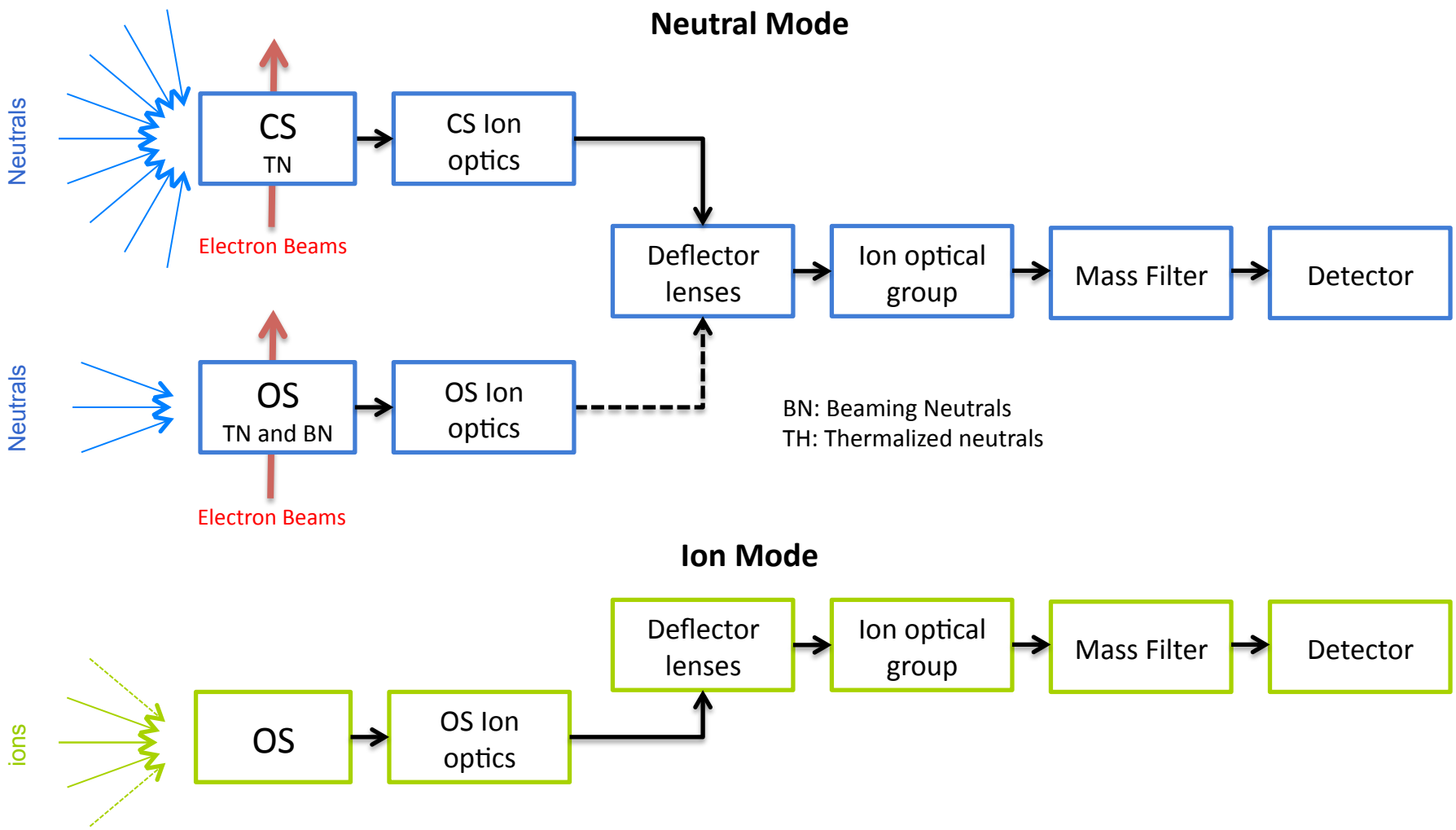
Open Source Mode



Closed Source Mode

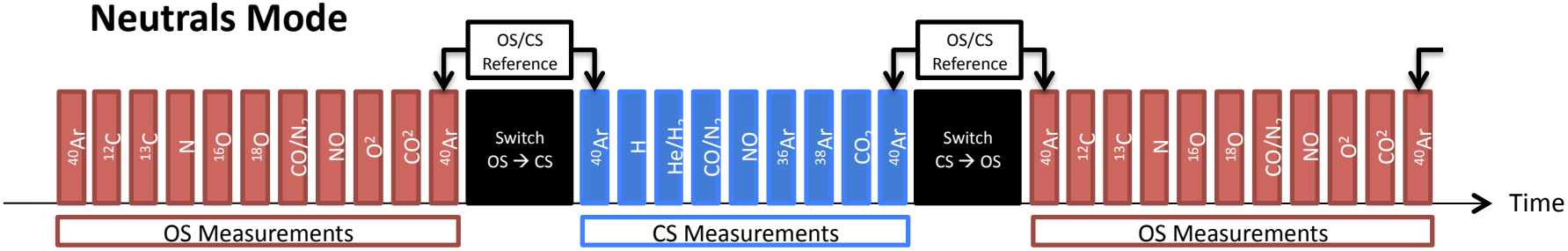


Measurement Modes

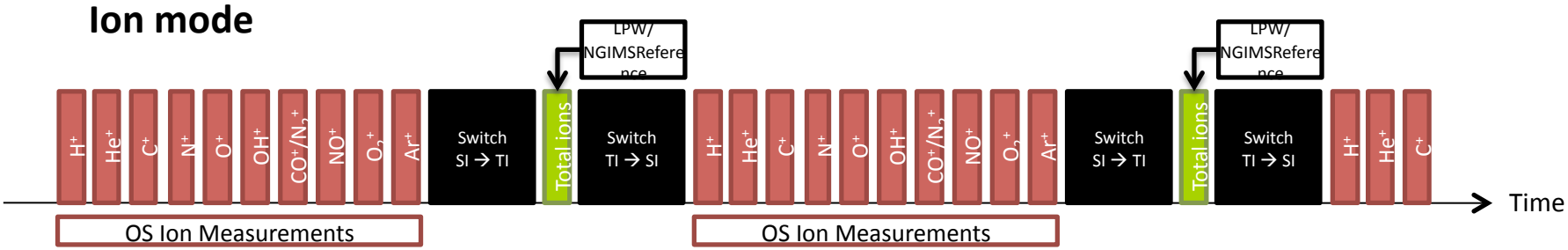


Measurement Sequences

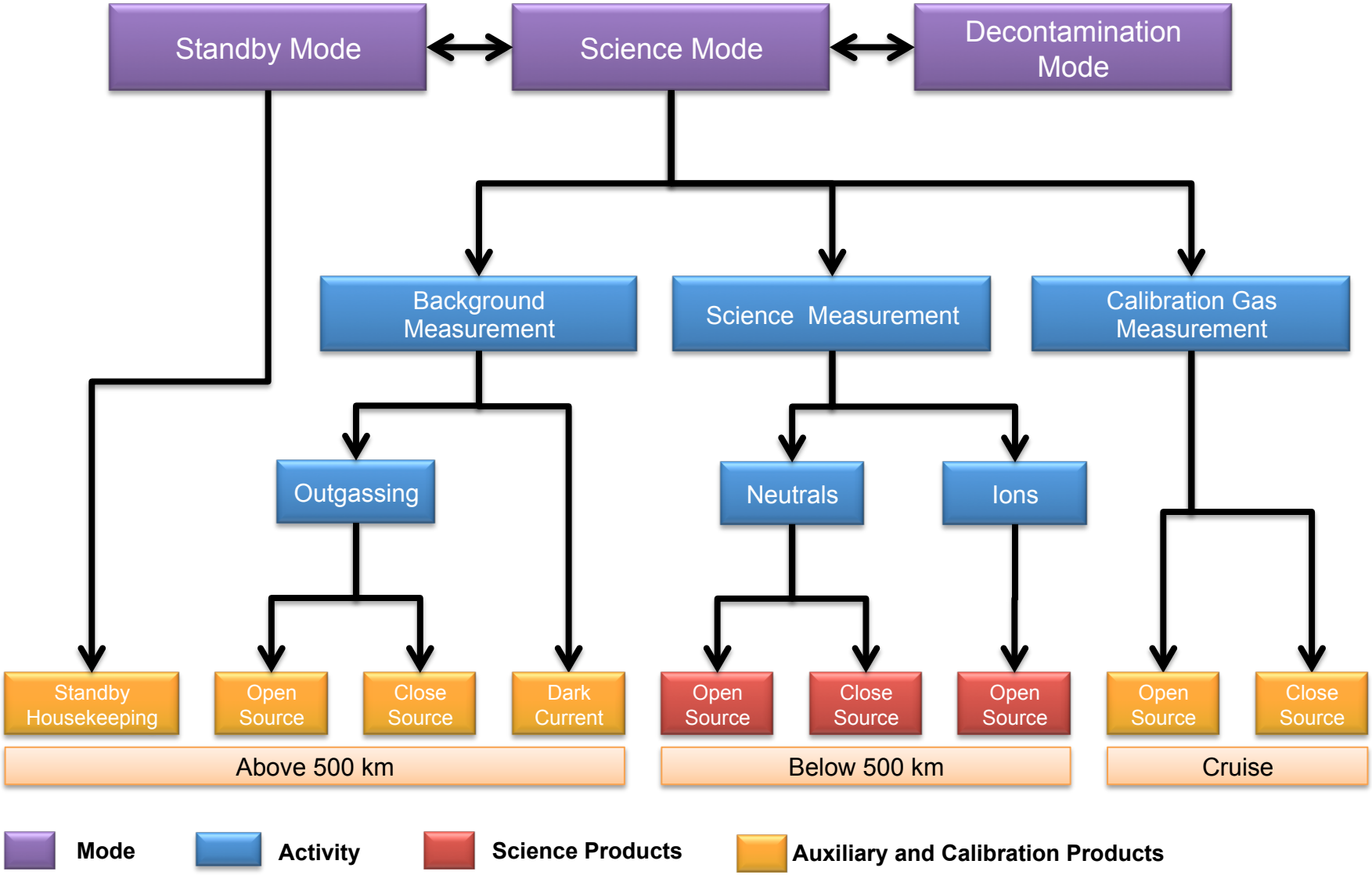
Neutrals Mode



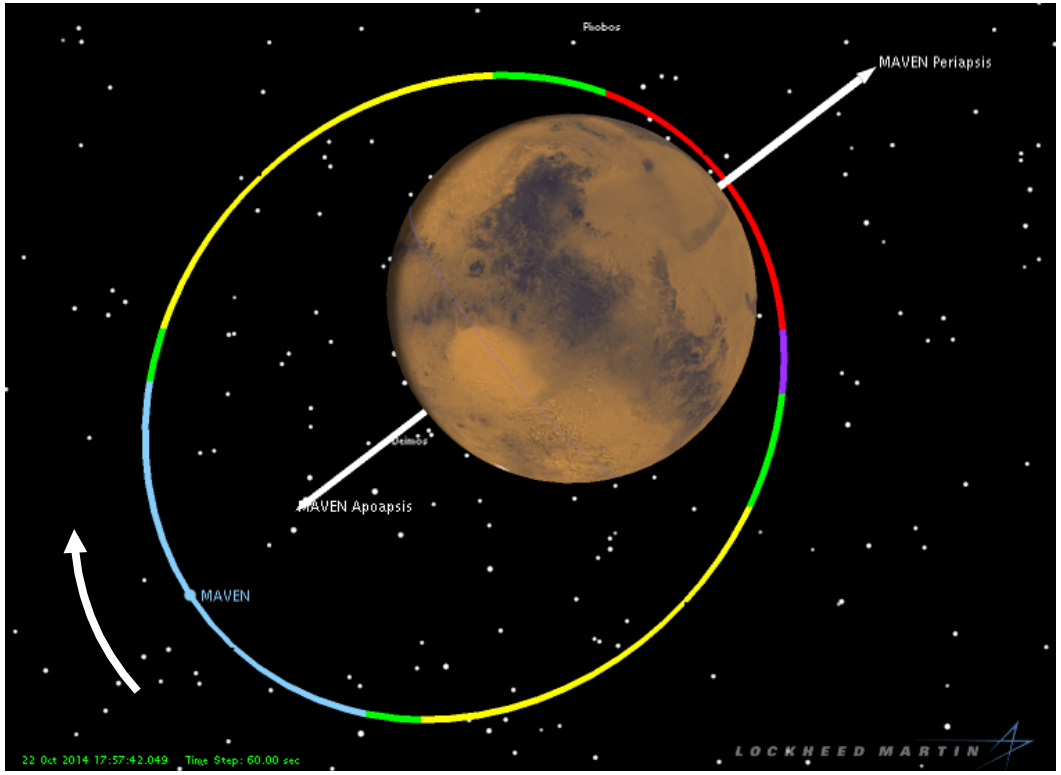
Ion mode



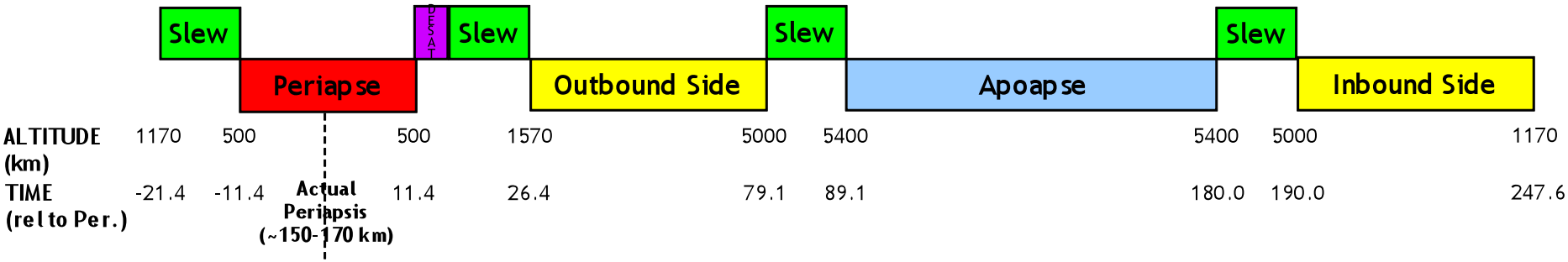
Mode of Operations



Segment Allocations



- Most of science operations are done at periapse.
- Apoapse segment is used for calibrations and decontaminations.
- Campaign relies on repeatable measurements to determine atmospheric behaviors and variability.
- No difference in instrument commanding during Deep Dip operations.



Instrument Commanding

- Nominal instrument commanding is accomplished through the execution of scripted commands (code written in Basic):
  - high heritage from past missions.
  - provide all the flexibility needed to accomplish the science goals.
- Scripts are parameterized to allow flexibility and minimize file uplinks.
- Scripts are stored:
  - on the instrument to be executed when needed,
  - on the spacecraft memory, to be loaded to NGIMS and executed when needed.
- During the execution of scripts the FSW generates message logs and housekeeping telemetry that come to supplement the science telemetry.

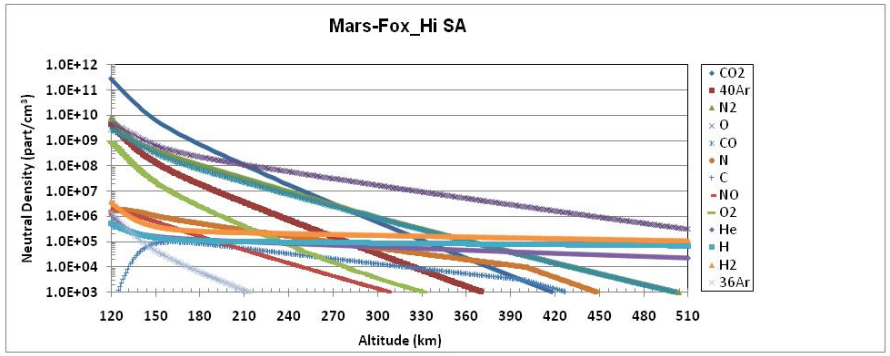
Instrument Scripts

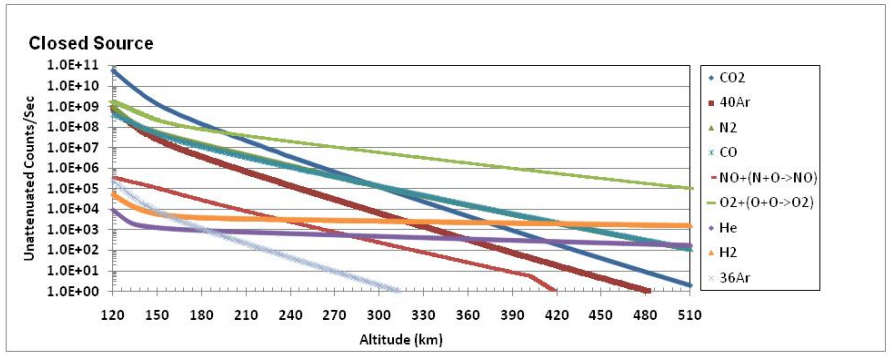
- The instrument executes typically one of these operations:

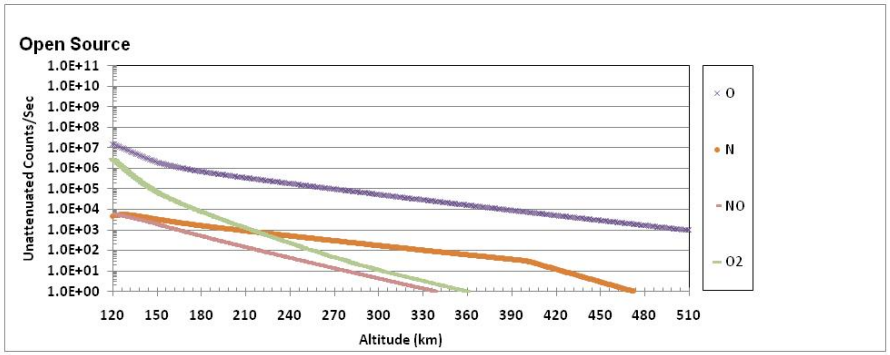
Operation	Exec. by	Description	S/C requirement	Duration (min)
Aliveness Test (AT)	NGIMS	▪ Power level check ▪ C&DH basic functions check	None	15
Electrical Baseline Test (EBT)	NGIMS	▪ BA gage pressure check ▪ RF circuit check ▪ Electrodes voltage check ▪ Current, voltage and monitors check ▪ Energy scans for each electrode ▪ Background scans for each source ▪ Pulse height distribution for each detector ▪ Variable integration period scans	None	60
Background Scans (BScan)	NGIMS	▪ Instrument background for each source	Above 1000 km Off-ram pointing Off S/C pointing Away from thruster firing times	60
Calibration Scans (CScan)	NGIMS	▪ Closed source scan with calibration gas	Above 1000 km Off ram pointing Off S/C pointing Away from thruster firing times	60
Neutral Mode Science (NMS)	NGIMS	▪ Predefined closed source scans	Ram pointing	35 (nominal)
Ion Mode Science (IMS)	NGIMS	▪ Predefined open source scans	Ram pointing	35 (nominal)
Break-off Cover Deployment	MAVEN	▪ Bellows fired by S/C while NGIMS is off	Anti-ram pointing Apoapse	NA
Decontamination	MAVEN	▪ Heaters enabled by S/C while NGIMS is off	Outside periapse	NA

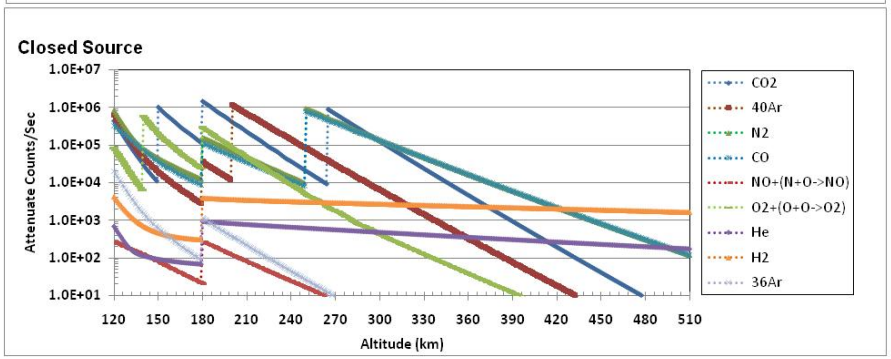
Measurement Predicts (1)

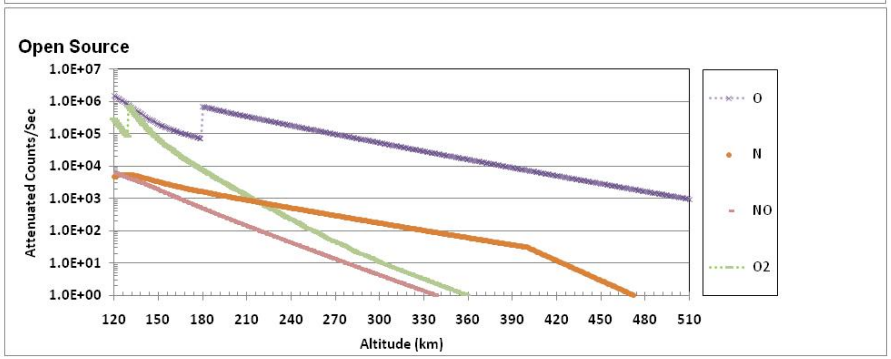
Predicted NGIMS counts/sec from Jane Fox model – High solar activity





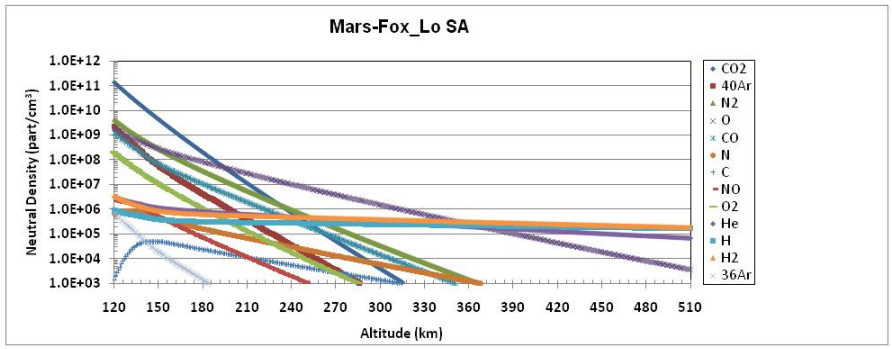


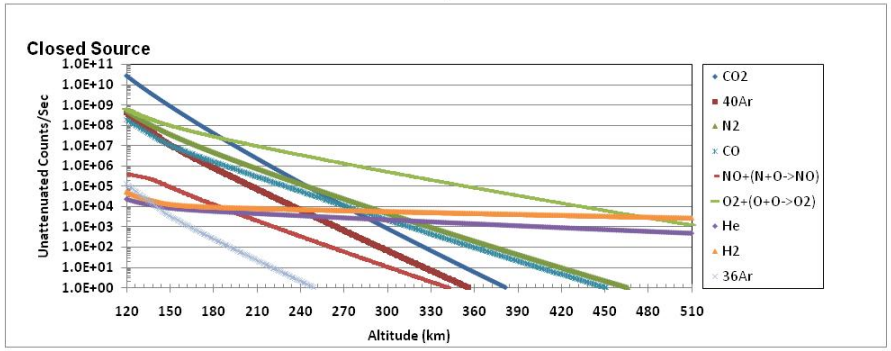


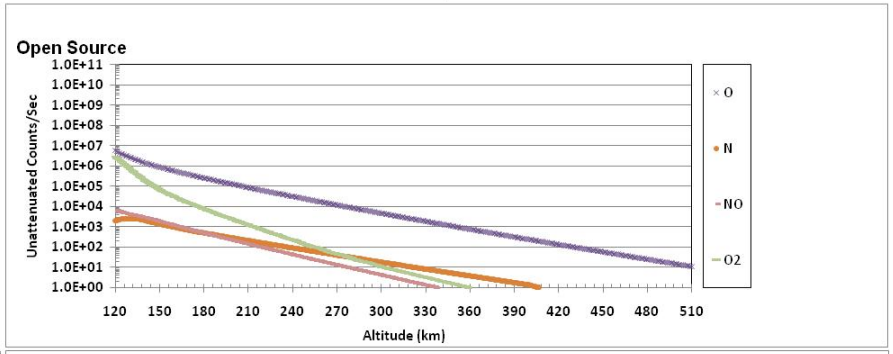


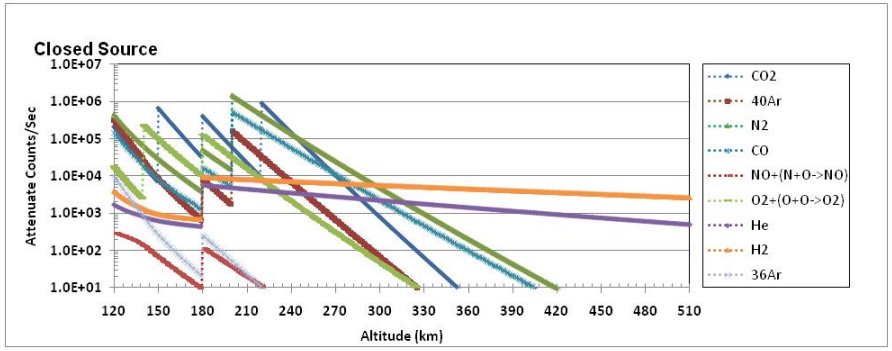
Measurement Predicts (2)

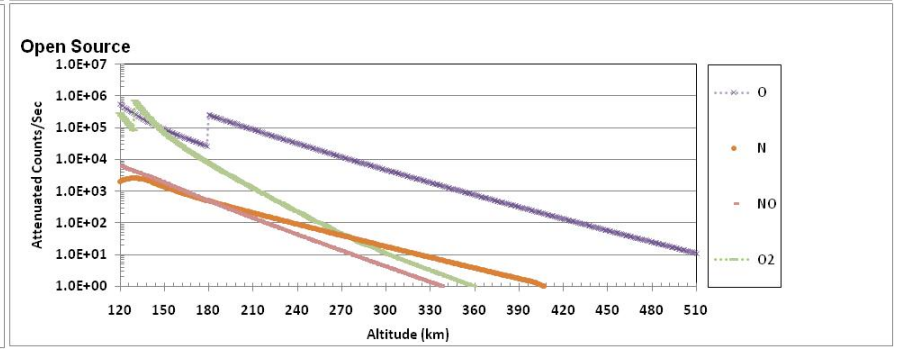
Predicted NGIMS counts/sec from Jane Fox model – Low solar activity











Data Products

NGIMS Data Products	
Data Level	**Description**
0	Files of Binary packets as produced by the instrument.
1	Calibrated Data Record: Time and altitude stamped spectra (counts per second per unit mass and bands) separated by mode (ion or neutral) and source (close or open) and calibrated for detector response.
2	Derived Data Record: Single species abundance vs. time or single species energy distribution vs. time corrected for background, pointing and ram effects
3	Re-sampled Data Record: Altitude re-sampled abundances and energy distributions.

- Level 0 ⇨ Quicklook & Level 1:

  Level 0 packets will be separated by measurement mode and ionization source to generate the Neutral Close Source (NCS), the Neutral Open Source (NOS), and the Ion Open Source (IOS) data sets. These data will be checked for anomalies, time and altitude stamped (using reconstructed ephemerides) and calibrated for detector response then merged with their relevant housekeeping information in engineering units to form Level 1 files. Quicklooks will be generated in the same fashion by the SDC using predicted ephemerides.

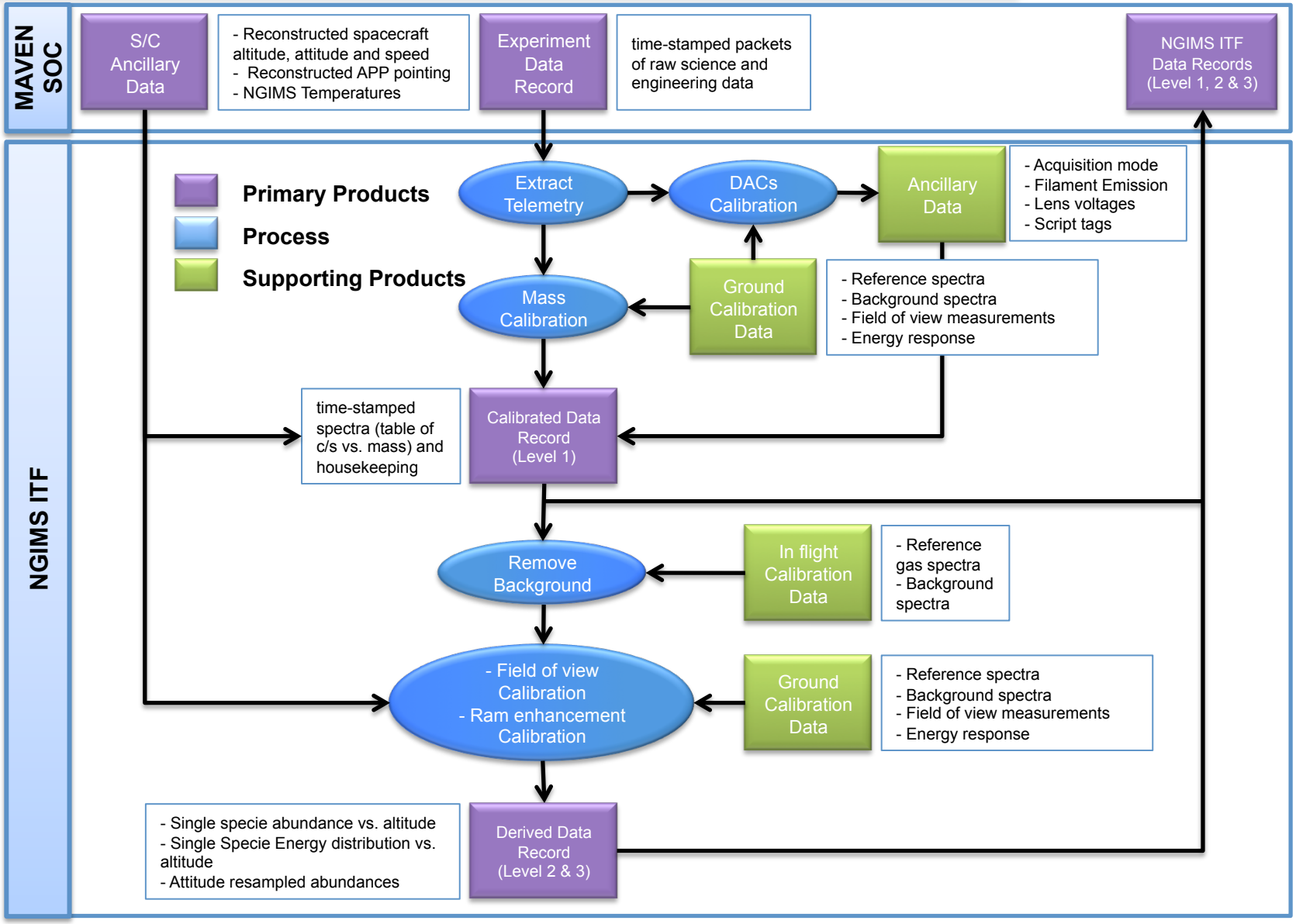
- Level 1 ⇨ Level 2:

  Single species information (counts/energy band/time) will be extracted from the Level 1 data and reprocessed into physical units (abundances in particles/cc, and energy in eV) by correcting for background, pointing direction, and ram enhancement corrections due to the spacecraft motion during deep dips.

- Level 2 ⇨ Level 3:

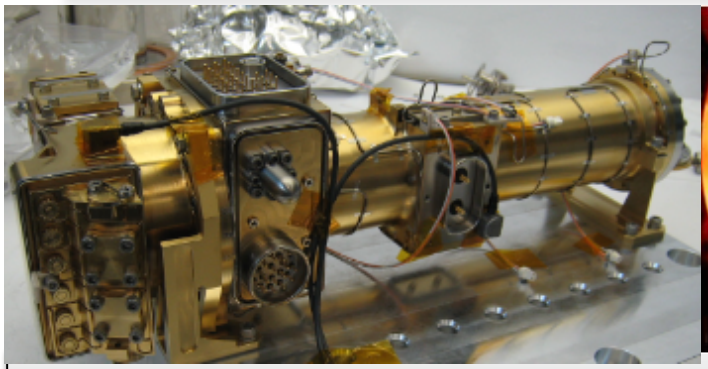
  Level 2 data will be resampled into iso-altitudes for all the measured species using spacecraft reconstructed trajectory profile.

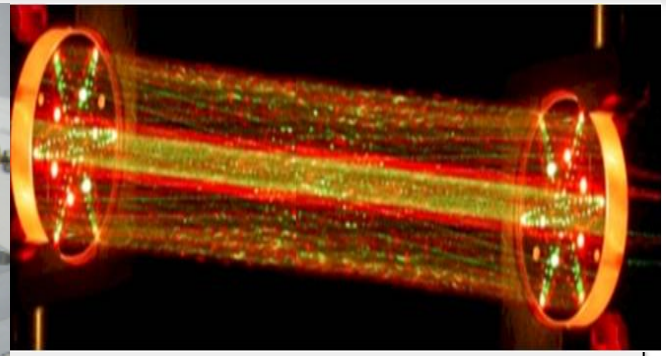
Data Reduction Flow



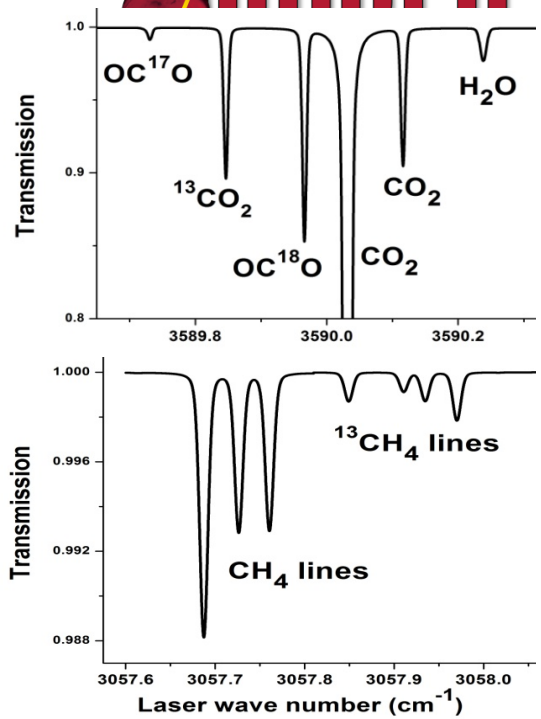
Synergy with atmospheric composition and isotopic data from the SAM investigation on the Curiosity Mars Science Laboratory rover

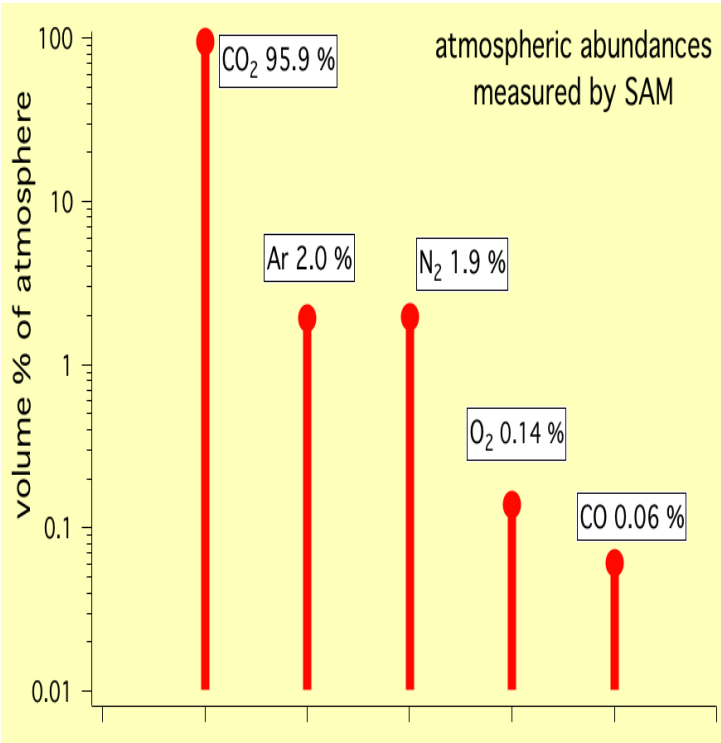
Synergy with Curiosity/SAM atmospheric composition and isotopic data

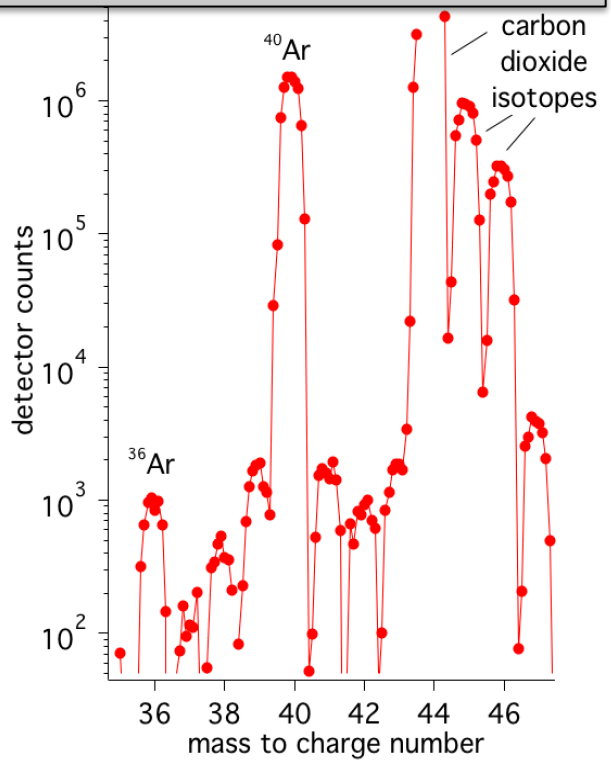




QMS provides, to date, significant updates from Viking and Phoenix for mixing ratios, C, O, N, and Ar isotope abundances







TLS provides, to date, significant updates from Viking, Phoenix and ground based remote sensing for C and and O isotopes in CO2
AND
Methane volume mixing ratio upper limits