EARLY COMPOSITION, STRUCTURE, AND ISOTOPE MEASUREMENTS IN THE UPPER ATMOSPHERE OF MARS FROM MAVEN'S NEUTRAL GAS AND ION MASS SPECTROMETER (NGIMS). P. R. Mahaffy[1], M. Benna[2], M. Elrod[3], S. W. Bougher[4], R. Yelle[5], and B. Jakosky[6]. [1]NASA Goddard Space Flight Center, Code 699, Greenbelt, MD 20771, Paul.R.Mahaffy@nasa.gov, [2]CRESST, University of Maryland Baltimore County, Baltimore, MD 21228, [3]CRESST University of Maryland College Park, Greenbelt, MD 20742, [4]AOOS Dept., University of Michigan, Ann Arbor, MI 48189, [5]Department of Planetary Sciences, University of Arizona, Tucson, AZ 85721, [6]Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO 80303..

Introduction: MAVEN's mission goal is to advance the understanding of the evolution of the martian climate and surface environment by exploring processes that lead to atmospheric escape. MAVEN's Neutral Gas and Ion Mass Spectrometer is designed to characterize the source region for escaping atoms, with measurements of the neutral upper atmosphere and ionosphere. Typical altitudes for NGIMS measurements are between ~150-500 km although periodic excursions down to ~125 km are planned. Over the course of the mission a wide range of lattitudes, longitudes, and local times will be sampled. The elliptical orbit enables the space environment and the energy inputs into the upper atmosphere to be regularly measured with MAVEN instruments.

Previous direct in situ composition measurements at the lower altitudes sampled by NGIMS are limited to single point Viking entry aeroshell mass spectrometer and retarding potential analyzer data in 1976 [1].

NGIMS Capabilities and Early Measurements Sequences: NGIMS is a dual ion source mass spectrometer [2] derived from instruments developed at Goddard for more than a dozen space missions. It is a quadrupole analyzer mass spectrometer similar to instruments developed for the CONTOUR, Cassini, and LADEE missions but with more than an order of magnitude greater sensitivity than the Cassini INMS and a mass range of 2-150 Da. NGIMS can analyze neutral gas in a **closed source neutral (CSN) mode** to take advantage of the RAM density enhancement in the instrument or in an **open source neutral (OSN) mode** to measure surface reactive gases such as O, C, and N. The open source provides the collimated aperatures through which ambient ions are sampled. This mode is designated **OSION**.

In the first weeks of the mission the MAVEN periapse was on the day side at high latitudes. NGIMS alternated on sequential orbits during this period between a mode which rapidly switched from CSN to OSN every few seconds and a mode which also secured ambient ion measurements by switching from CSN to OSION modes for a selected set of m/z values completing a cycle every 2.4 seconds. Near periapse unit mass scans were implemented from 2-90 Da. Flexibility built into the NGIMS scripting language allows these sequences to be readily modified as new discoveries dictate.

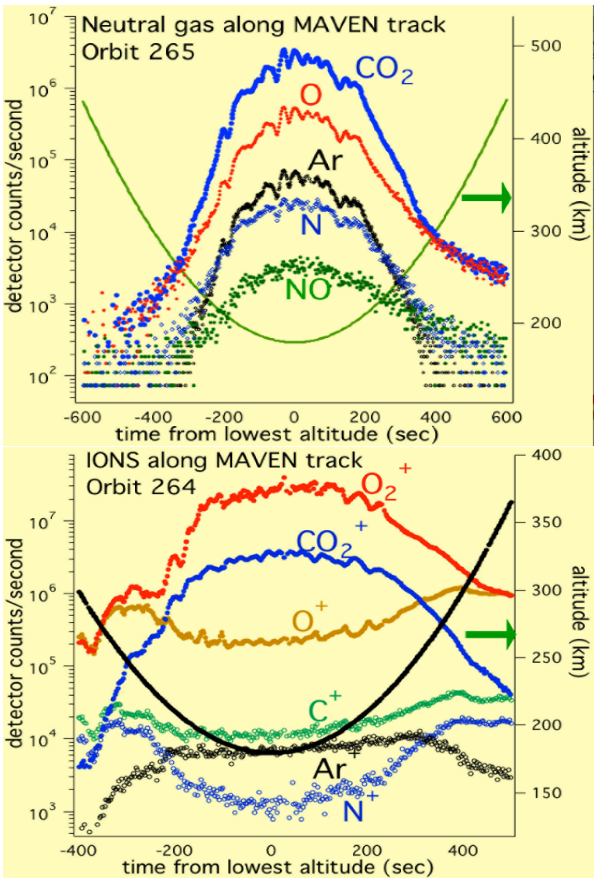

Figure 1. Neutral and ion measurements on MAVEN orbits 264 and 265 show (top) traces through periapse for the m/z channels 44, 16, 40, 14, and 30 in OSN mode and (bottom) traces from m/z channels 32, 44, 16, 12, 40, and 14 in OSION mode. In each case, major contributing species to these channels are labeled. These m/z channels are just a few of the several dozen sampled by NGIMS every 2-3 seconds during the CSN/OSN or CSN/OSION cycles. Processing to convert these counts into atmospheric ion and neutral densities is underway. Considerable structure is evident in both ions and neutrals along the orbital track.

First Observations from NGIMS: Figure 1 shows several of the neutral and ion species measured during a single orbital pass through periapse. Immediately evident is the substantial structure present in both neutral and ion densities over time periods of several 10's of seconds (30 sec is ~120 km along spacecraft track) with count variations 10's of percent within just a few seconds occurring on portions of orbits studied to date. The helium neutral CSN signals show an interesting asymmetry compared to the argon. Spectra secured near periapse are shown in Figure 2.

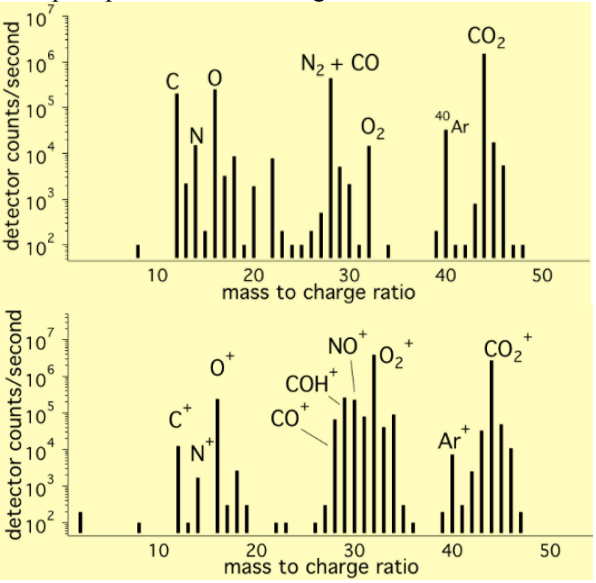

Figure 2. The spectrum for neutral gases measured (top) and ions (bottom) for the orbits shown in Figure 1 illustrates the range of molecular and atomic species that NGIMS will measure over the course of the mission. Variations in each of these species are traced over the orbital track below ~500 km by NGIMS

Siding Spring Signatures in the Martian Upper Atmosphere: The nucleus of comet Siding Spring passed by ~140,000 km from Mars on October 19, 2014 with a relative velocity of ~56 km/sec. Several MAVEN instruments including NGIMS were turned off during the closest approach but as soon as the comet passed by instruments were turned on to search for signatures of the cometary coma in the upper atmosphere of Mars. NGIMS operated in CSN/OSION mode on the orbits immediately before and after the comet encounter and discovered several metal ions that disappeared after several orbits [3]. The ion signal from cometary dust ablating in the atmosphere Figure 3 shows just one of these ions and an example of enhanced neutral density observed just above 200 km due to heating and expansion of the atmosphere with deposition of energy from cometary coma material.

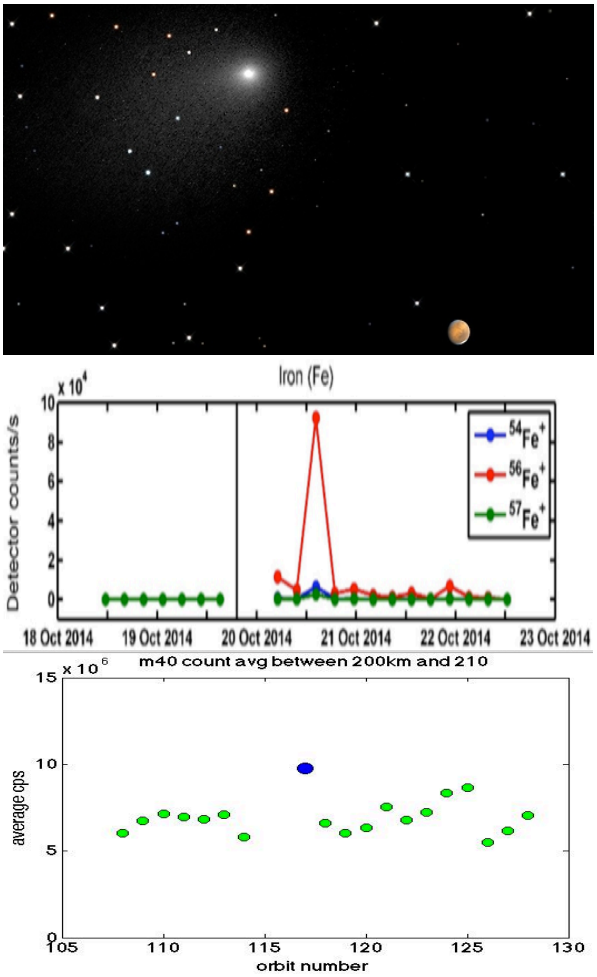

Figure 3. **Top frame** shows portions of a remarkable image captured by the hubble Space Telescope of Siding Spring passing by Mars (CR: NASA, ESA, PSI, JHU/APL, STScI/AURA). **Middle frame** shows iron ions measured by NGIMS during its periapse with each dot representing a separate orbit and the vertical line illustrating the time of the comet's closest approach. **Bottom frame** shows density enhancement observed in 40Ar between 200 and 210 km on the first orbit where NGIMS was turned on following the comet's passage (blue dot).

NGIMS Products to be Delivered to the PDS: Low level products to be delivered in a regular cadence to the PDS will be background subtracted and deadtime corrected counts for each mass value sampled along the spacecraft track. Higher level products will include densities for major neutral and ion species [4].

References: [1] Nier A. O. (1976) Science 193, 786 [2] Mahaffy P. R. et al. (2014) SSR, DOI 10.1007/s11214-014-0091-1 [3] Benna M. et al. in preparation [4] Elrod M et al. this meeting.