MAVEN

Mars Atmosphere and Volatile EvolutioN (MAVEN)

MAVEN Community Meeting
IUVS: The Imaging UltraViolet Spectrograph

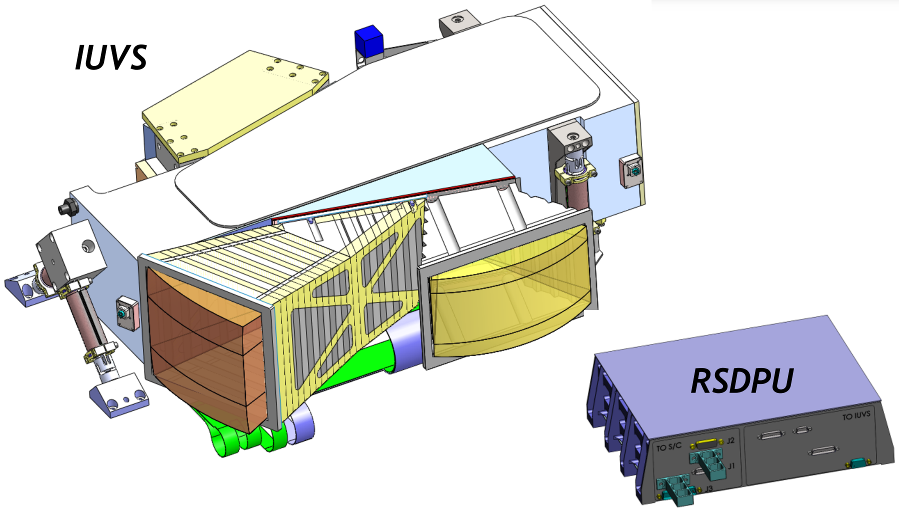
December 2, 2012

Nick Schneider
IUVS Science Lead
nick.schneider@lasp.colorado.edu

Outline

- The Big Picture - Requirements
- Instrument Overview
- Observing Modes
- Science data processing

MAVEN Remote Sensing (IUVS)



Imaging Ultraviolet Spectrograph

Wavelength range

FUV: 110 – 190nm

MUV: 180– 340nm

Detectors: Image-intensified 2-D active pixel sensors

Mass ~27kg, Dimensions 71x33x15cm

Laboratory for Atmospheric and Space Physics (LASP) University of Colorado

Science Lead: Nick Schneider

Instrument Lead: Bill McClintock

Project Manager: Mark Lankton

Science Team: Ian Stewart, Greg Holsclaw, Erik Richard, Justin Deighan, Franck Montmessin (LATMOS), Jean-Yves Chaufray (LATMOS), John Clarke (BU), Roger Yelle (UA)

Observations

- Limb scans near periapsis
- Disk maps near apoapsis
- D/H and O coronal mapping
- Stellar occultations

IUVS Requirements

Composition and structure mapped over planet:

- Neutral Atmosphere & Corona: Profiles and column abundances of H, C, N, O, CO, N_2, and CO_2 from the homopause up to two scale heights (H~750 km for coronal H and O, H~12 km for CO_2) above the exobase with a vertical resolution of one scale height for each species and 25% accuracy.
- Ionosphere: Profiles and column abundances of C^+, CO^+, and CO_2^+ from the ionospheric main peak up to the nominal ionopause (~ 400 km) with one O_2^+ scale height (H~60 km) vertical resolution and 25% accuracy.
- Isotopes: D/H ratio above the homopause with sufficient accuracy (~30%) to capture spatial/temporal variations (factor of 2) and compare with measured D/H in bulk atmosphere.
- Lower Atmosphere: CO_2 profiles of lower atmosphere using stellar occultations.

IUVS Roles in MAVEN

MAVEN
Mars Atmosphere and Volatile Evolution Mission
CU/LASP • GSFC • UCB/SSL • LM • JPL

IUVS provides global 3D models of major molecules, atoms, ions and isotopes in the atmosphere & corona, with derived properties such as exobase and ionosphere altitudes. IUVS also provides major constraints on escape processes and measures the lower atmosphere.

- Vertical profiles to characterize composition & structure
  - Multispecies periapsis limb scans
- Global images to characterize spatial distribution & variability
  - Multispectral 2-dimensional apoapsis Images
- Coronal Scans
  - Deuterium/Hydrogen ratio vs. altitude to constrain escape processes
  - "Hot Oxygen" vertical profile to quantify a major escape process
- Vertical CO_2 profile to characterize the underlying atmosphere
  - Stellar Occultations

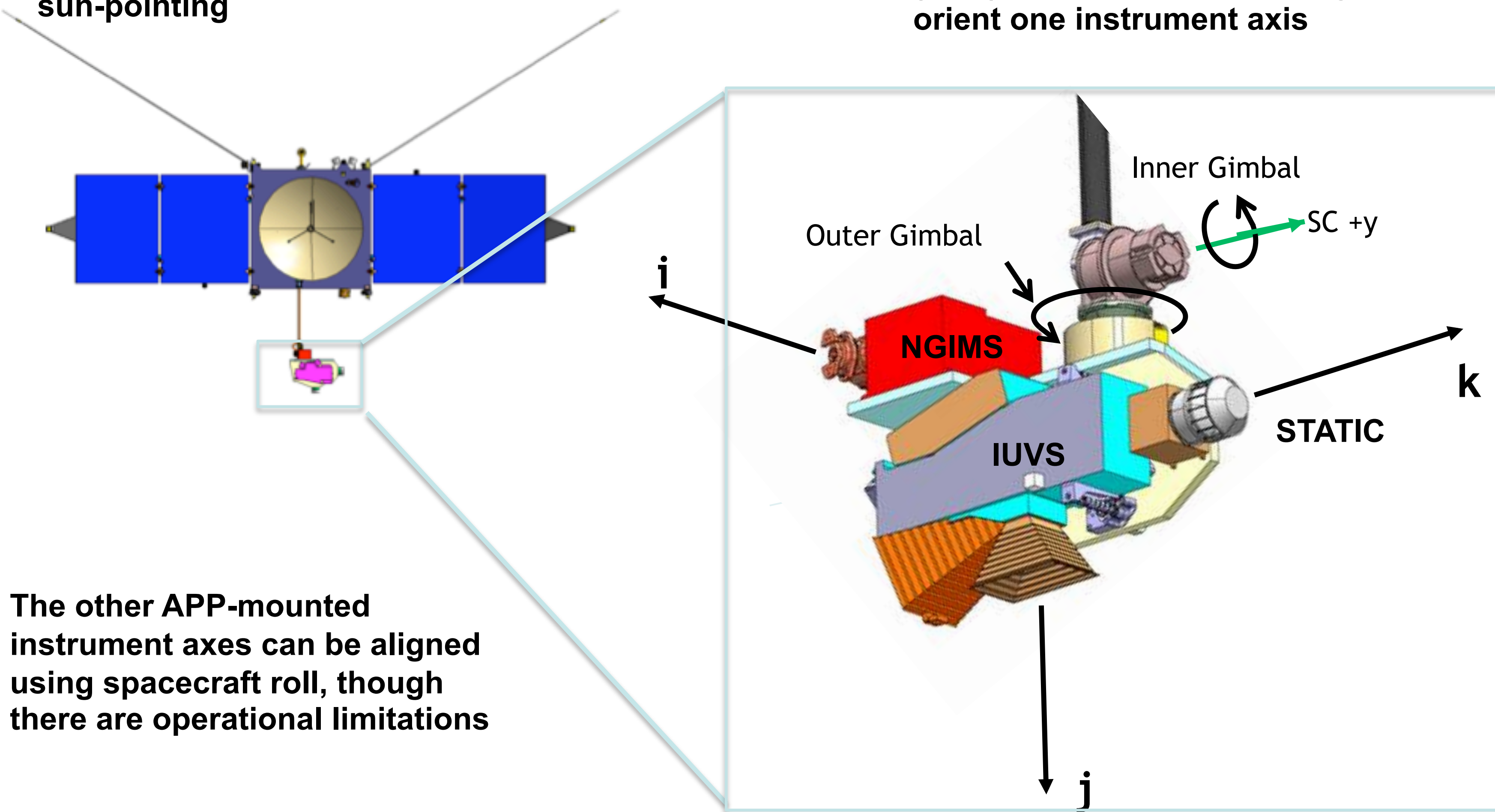
The IUVS approach uses <u>fixed observing sequences</u> which depend only spacecraft pointing capabilities through the mission (e.g., power constraints and pointing control singularity avoidance)

Instrument Overview

IUVS Accommodation & Pointing Capability

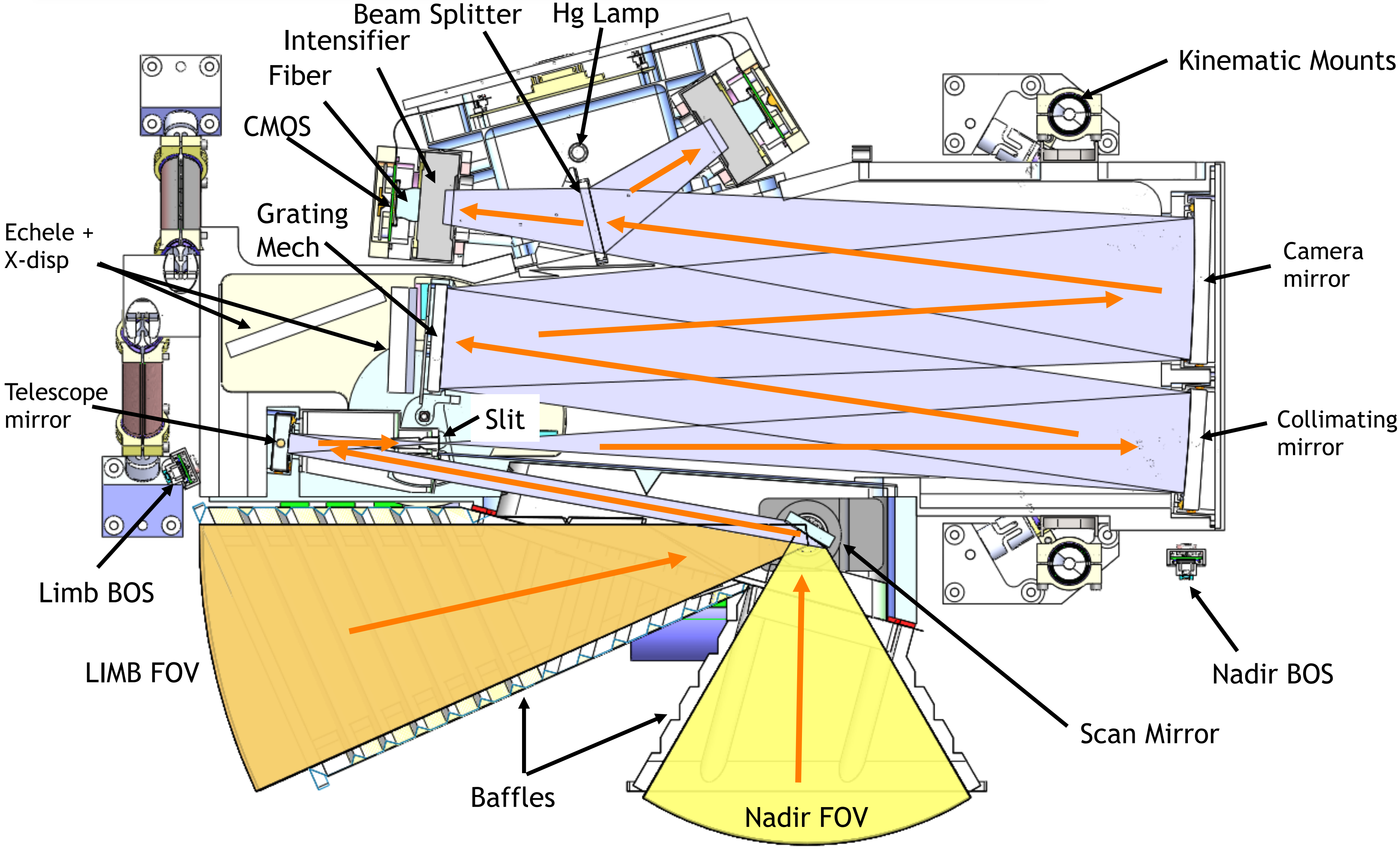
During most normal operations, the spacecraft flies with solar arrays and body-mounted instruments exactly sun-pointing

IUVS, NGIMS and STATIC are located on the Articulated Payload Platform (APP) which uses uses two gimbals to orient one instrument axis



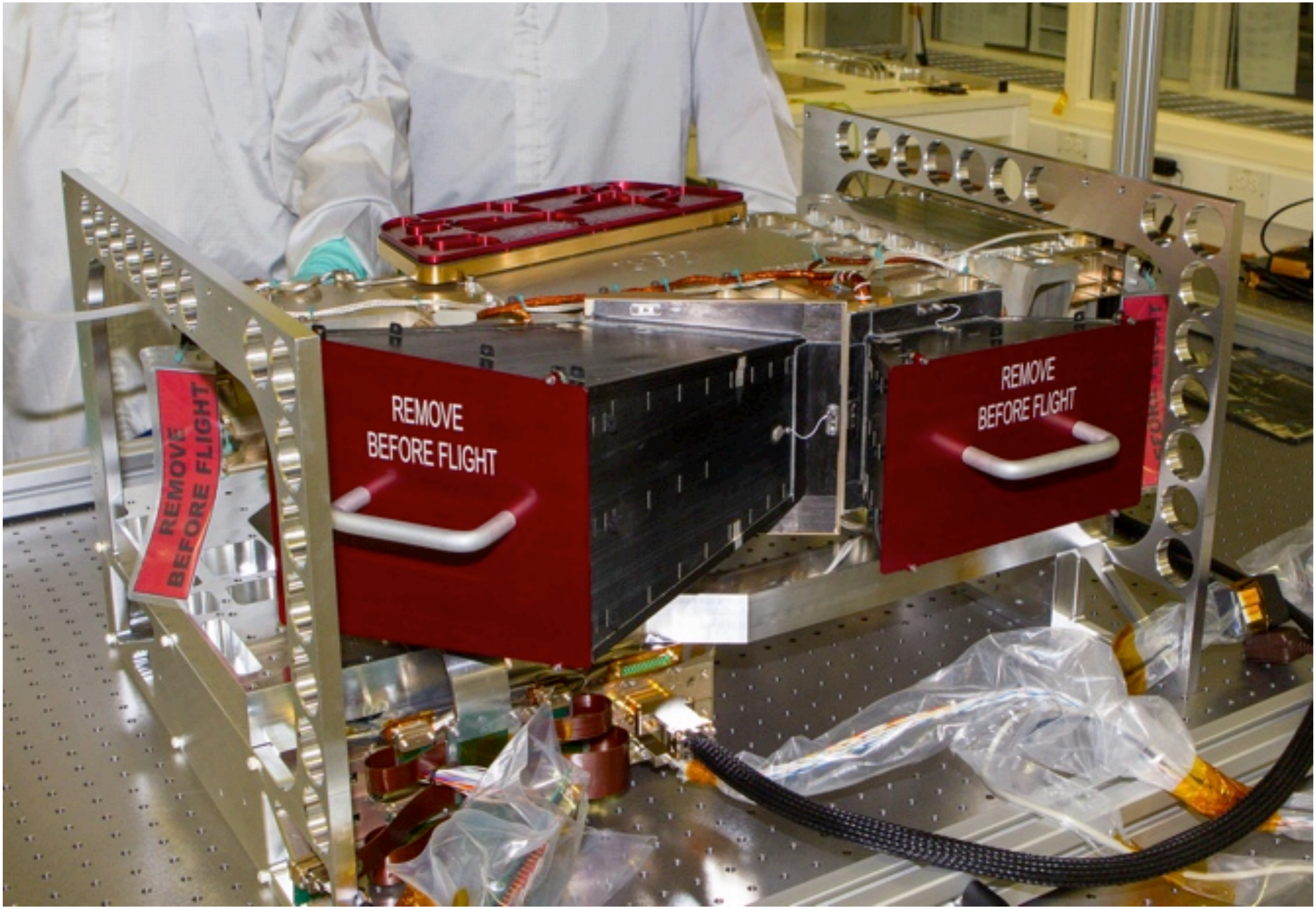
The other APP-mounted instrument axes can be aligned using spacecraft roll, though there are operational limitations

IUVS – Cross Section



IUVS: Key Features

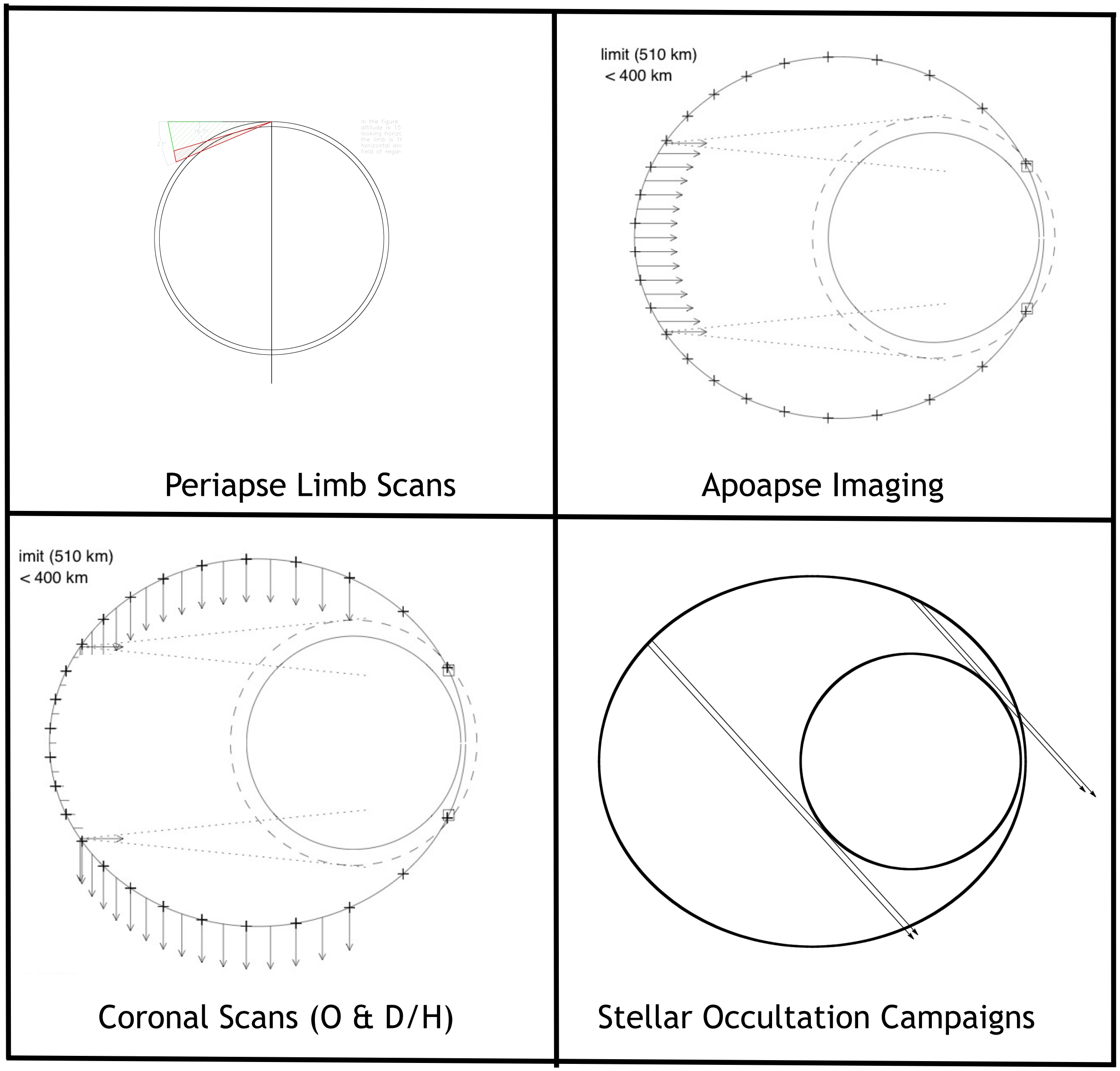
- UV imaging spectrograph
  - 10x0.06 degree slit with occultation apertures at ends
  - FUV: 110 – 190nm at 0.6nm resolution
  - MUV: 180 – 340nm at 1.2nm resolution
- Instrument mounted on APP for continuous planet-pointing
- Two fields-of-regard for nadir or limb viewing
- Scan mirror for constructing altitude profiles or disk images
- Selectable high- or low-resolution grating for full-spectrum observations or Lyman Alpha spectrum for D/H ratio
- Separate MUV and solar-blind FUV sensors for optimal sensitivity and stray light rejection
- Data binned in spectral and spatial dimensions to fit in downlink bandwidth



IUVS was delivered to Lockheed Martin shortly before Thanksgiving, on time and under budget

Observing Modes

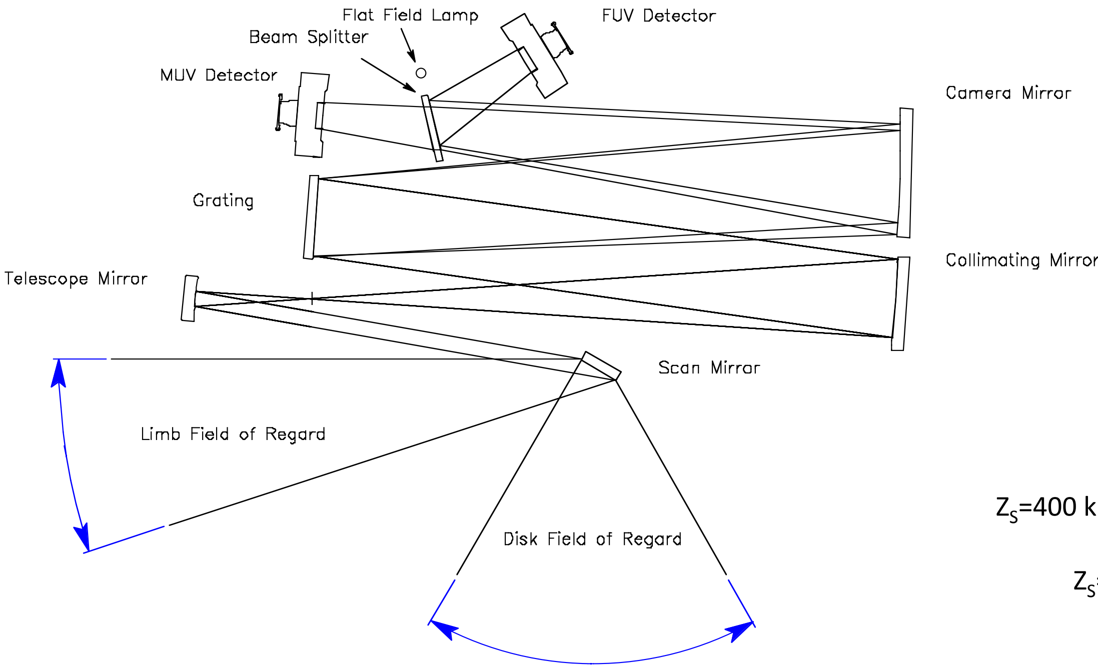
IUVS' Four Observing Modes

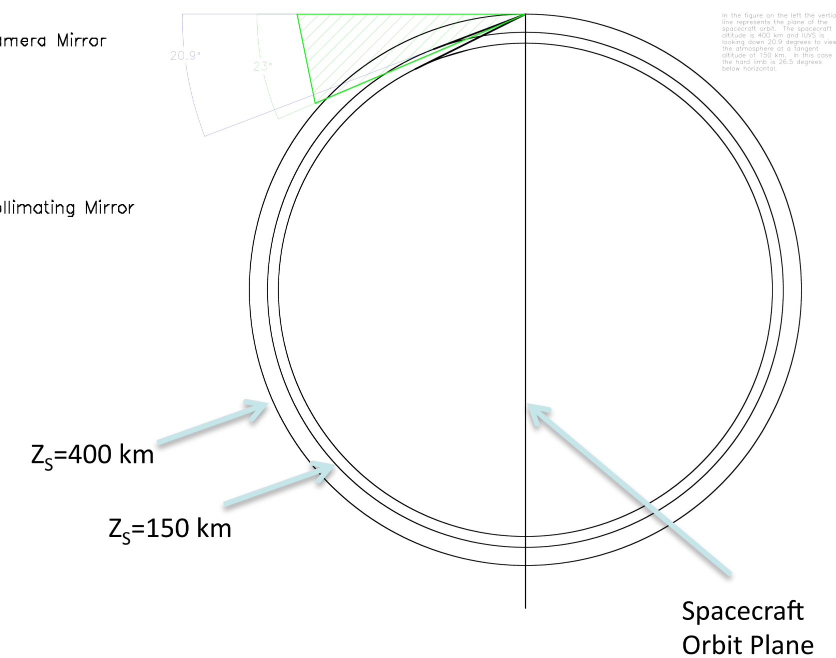


- Each mode has specific pointing strategies, optical and detector settings
- Periapse Imaging and Coronal Scans alternate with orbits STATIC and NGIMS at a pre-determined cadence.
- Coronal Scans for O and D/H use identical pointing (inwards on the ascending leg, outward on the descending leg)
- Stellar Occultations occur during dedicated 1-day campaigns

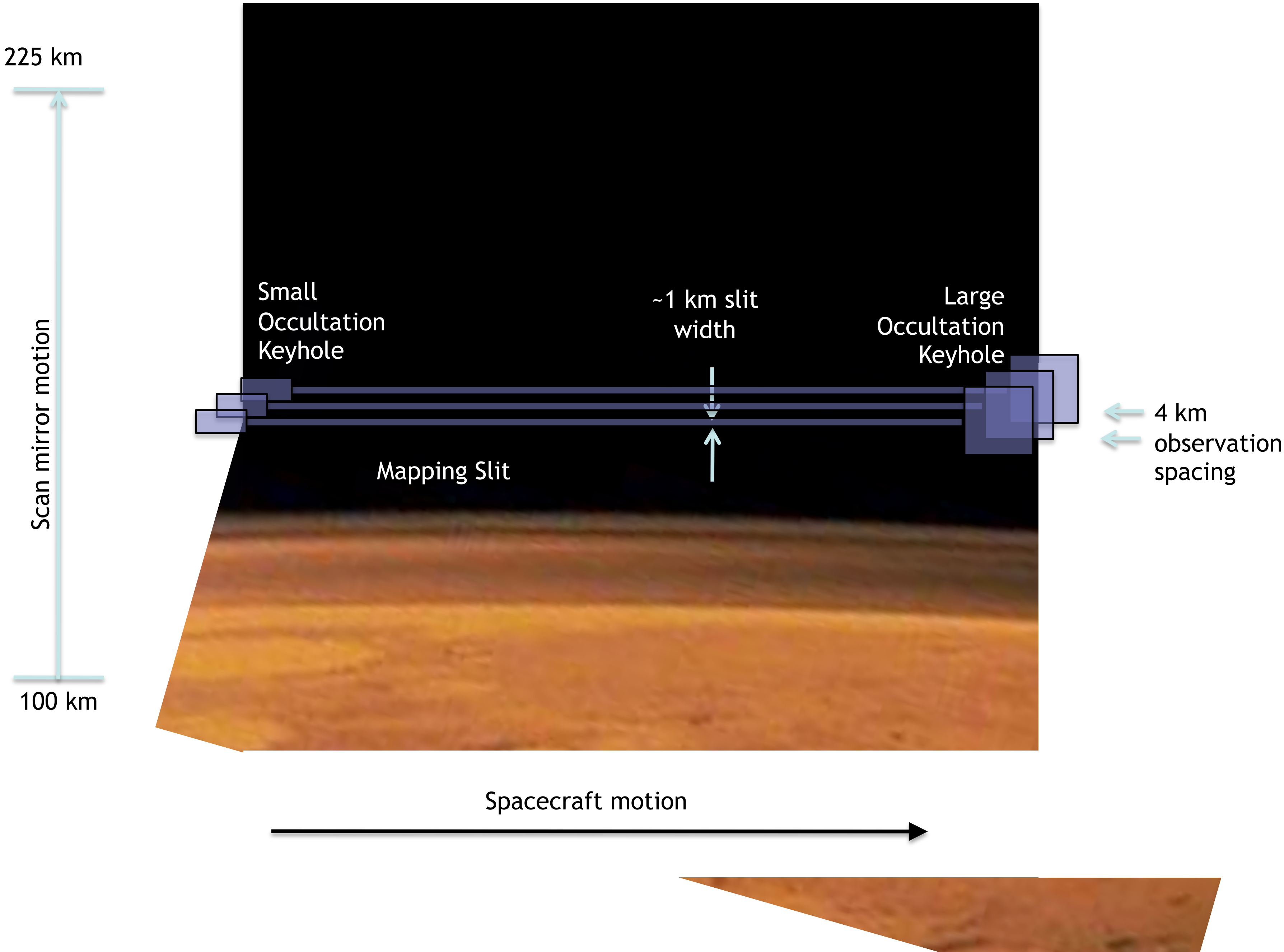
1: Periapse Limb Scans: Overview

- Periapse scans are acquired looking sideways out our Limb Field-of-Regard (FOR)
- Observation goals include FUV, MUV airglow altitude profiles





1: Periapsis Limb Scans: Scan Construction



1: Periapse Limb Scan: Spectral/Spatial Req'ts

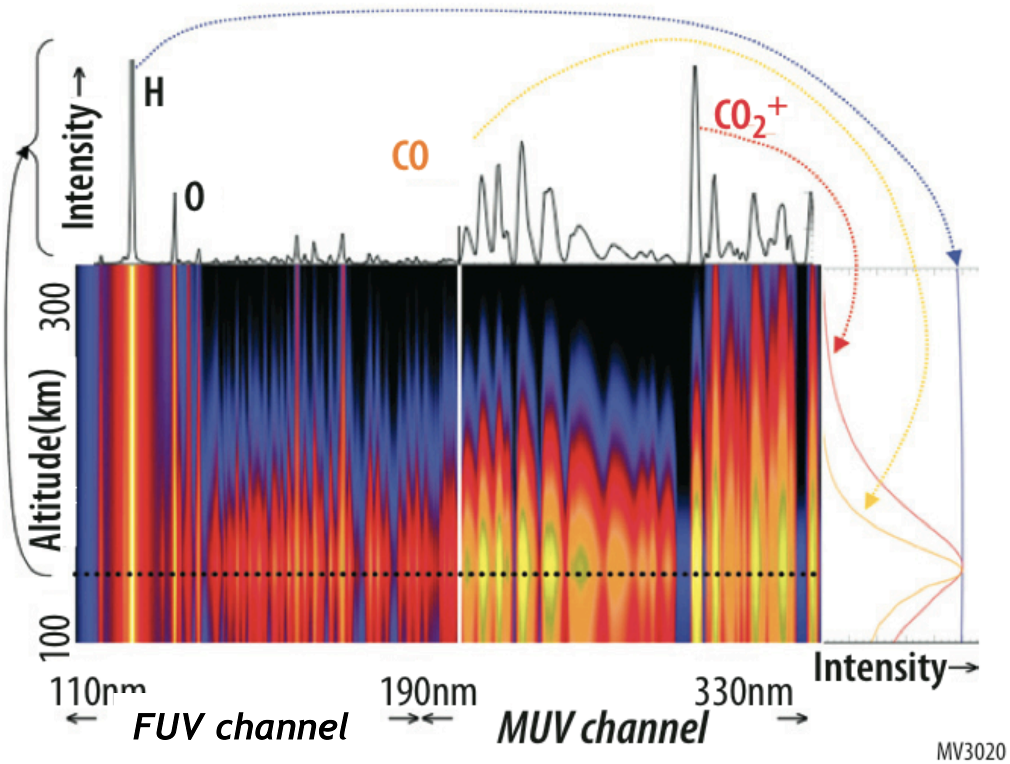
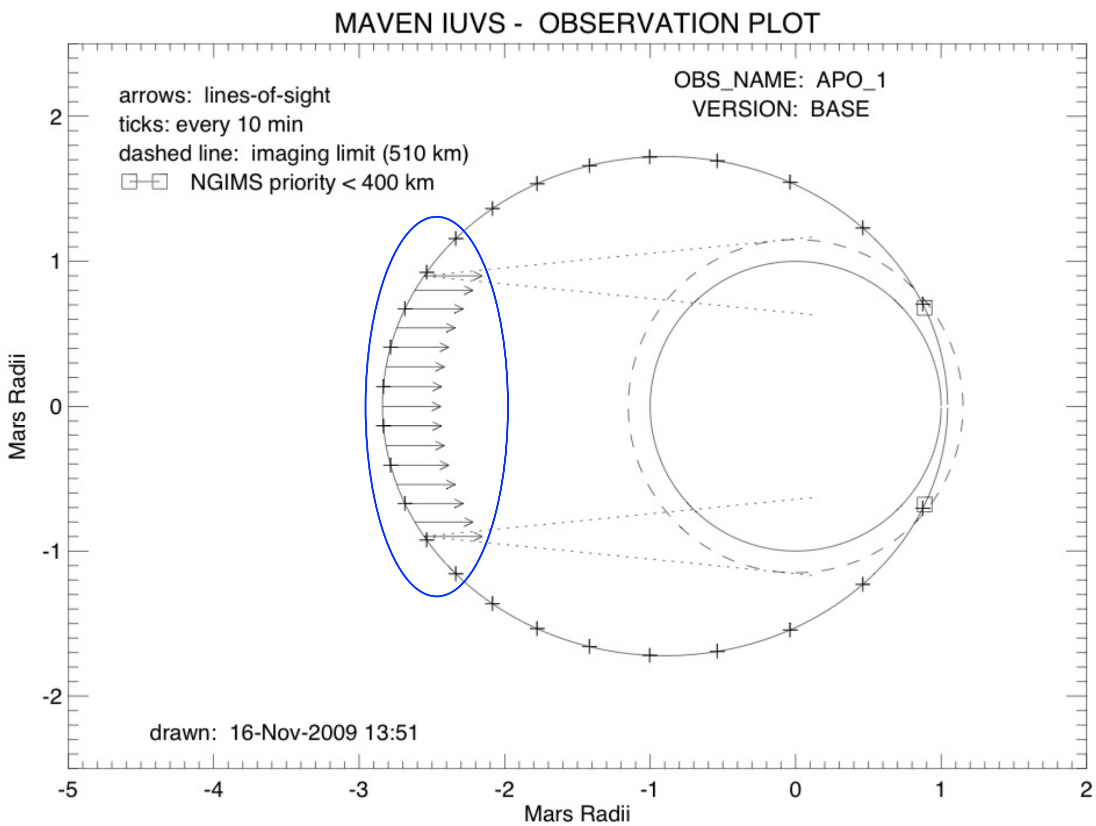


Figure E.2–2: The tremendous capability of the IUVS is shown in this simulated limb scan, which provides spectra for each limb altitude (sample spectrum at top) and derived vertical profiles for H, CO, CO_2^+ (at right).

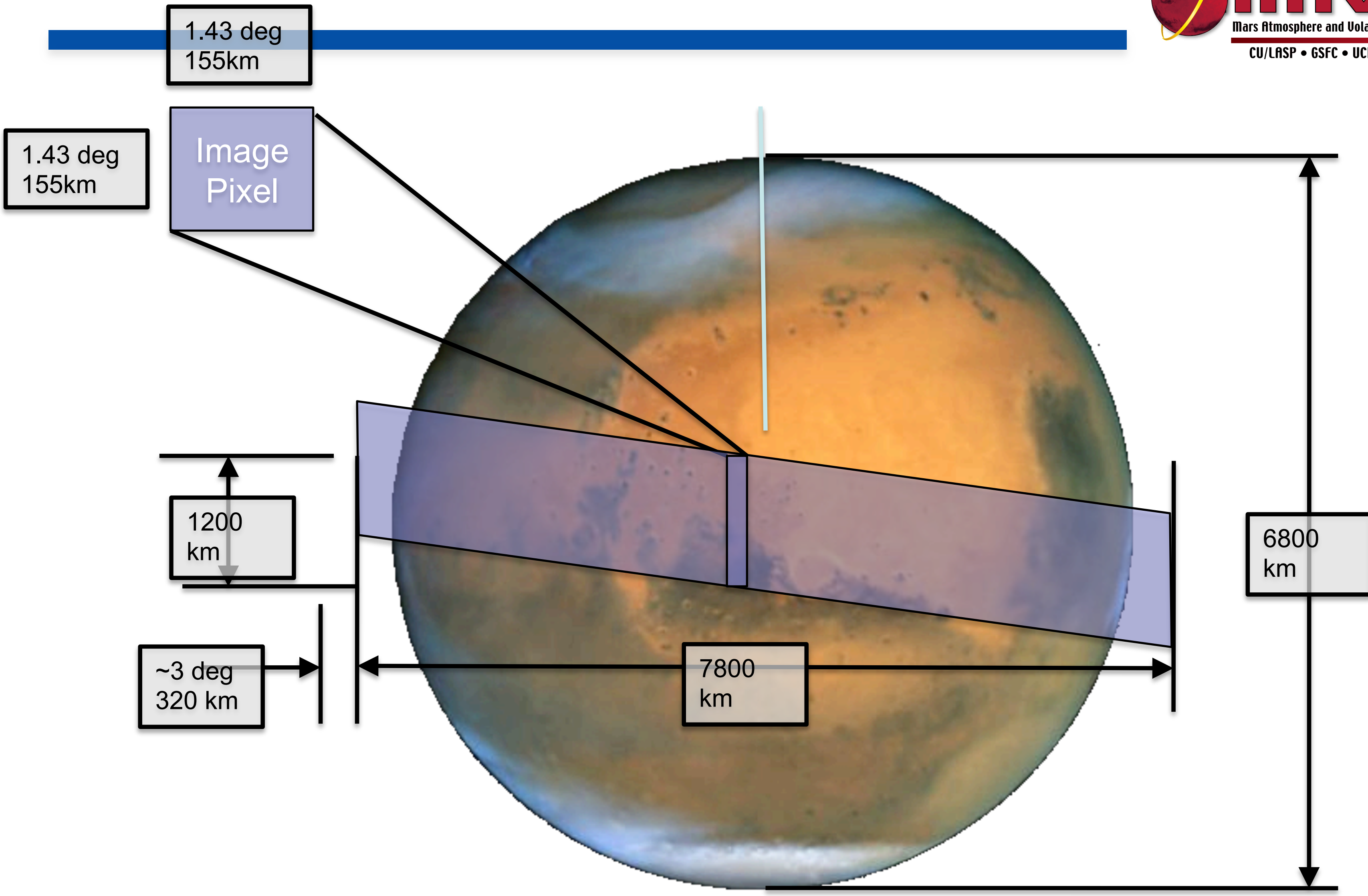
- The figure shows a simulated high-level data composite assembled from a full vertical scan
- Spectral coverage requirement flows from list of atmospheric species to measure
- Spectral resolution requirement flows from the need to separate emissions from different species
- Spatial coverage requirement flows from altitude range of detectable emissions
- Spatial resolution requirement flows from need to independently sample each atmospheric scale height

2: Apoapsis Images: Overview

- IUVS apoapsis images are acquired using inertial pointing & nadir FOR
- Science goals include FUV airglow and MUV reflected sunlight (ozone, dust, clouds)

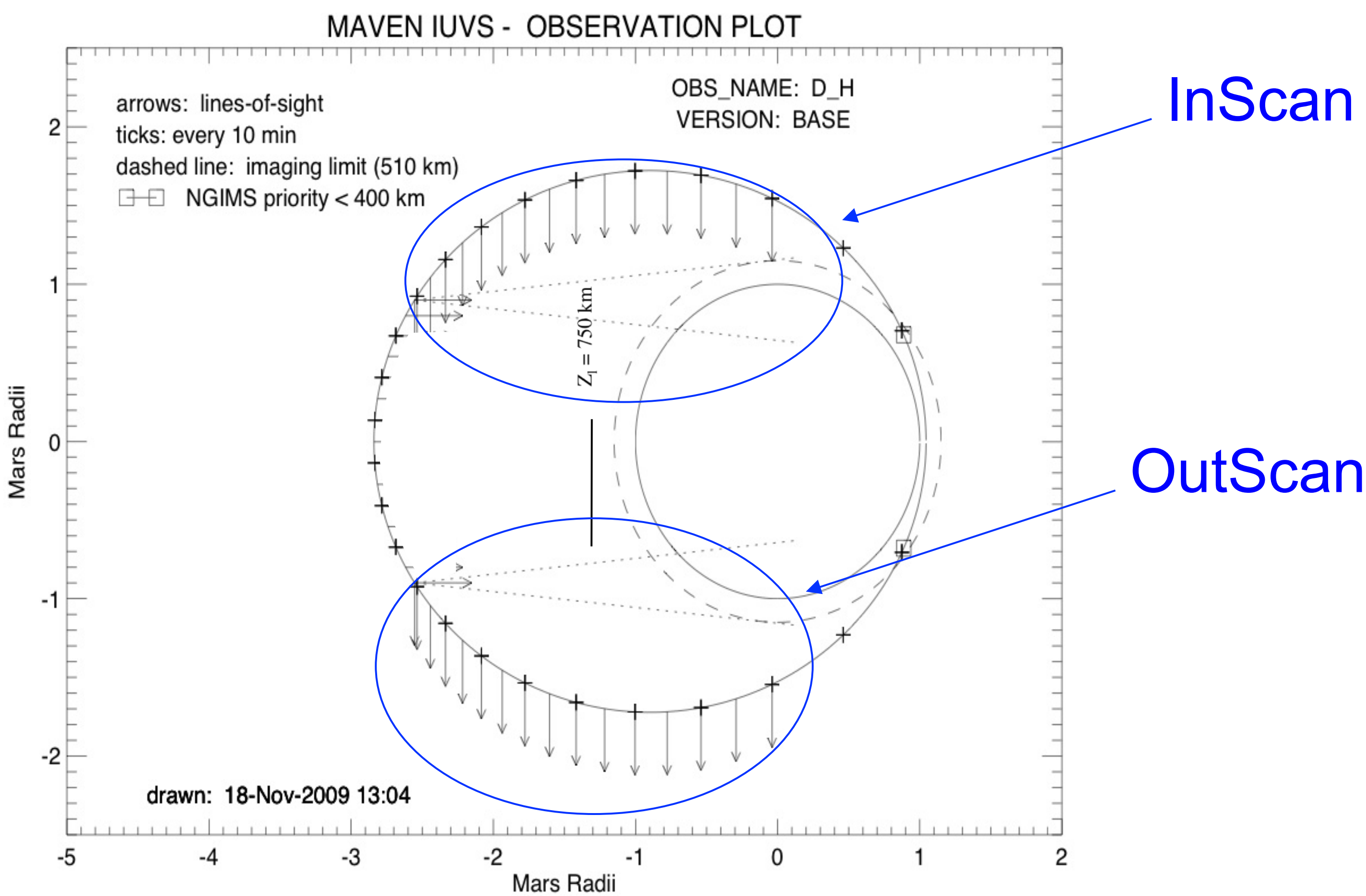


2: Mars Apoapsis Images: Image construction



3: Coronal Scans: Overview

- “InScan” measures corona + interplanetary background, “OutScan” measures background alone. Same pointing plan used for O and D/H coronal scans
- Science goals include D/H and Hot O (related to photochemical escape)



3: D / H Coronal Scans: Spectral Req' ts

- Spectral resolution requirement flows from need to minimize intensity in wings of the bright H Lyman alpha line at the position of D Lyman alpha

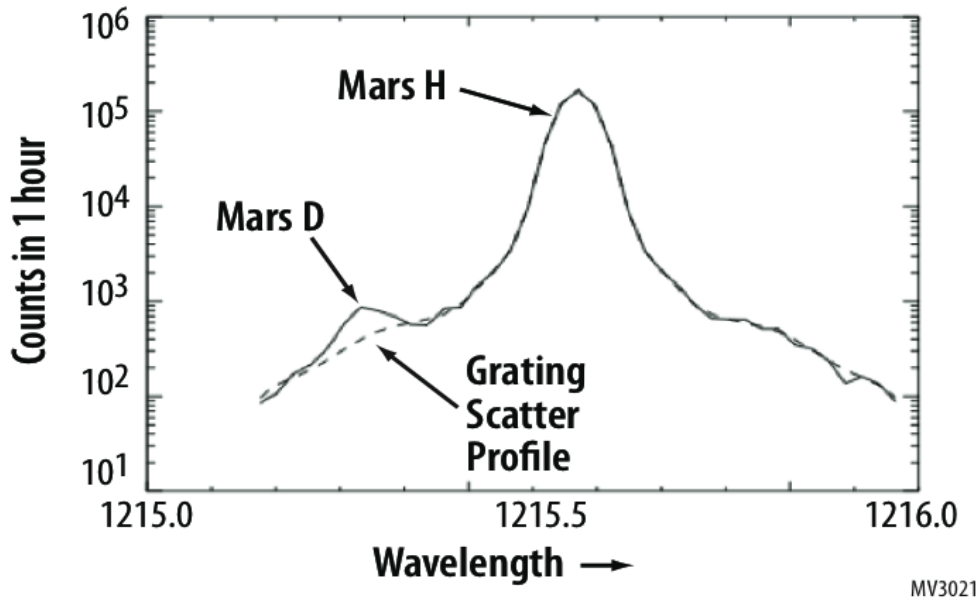
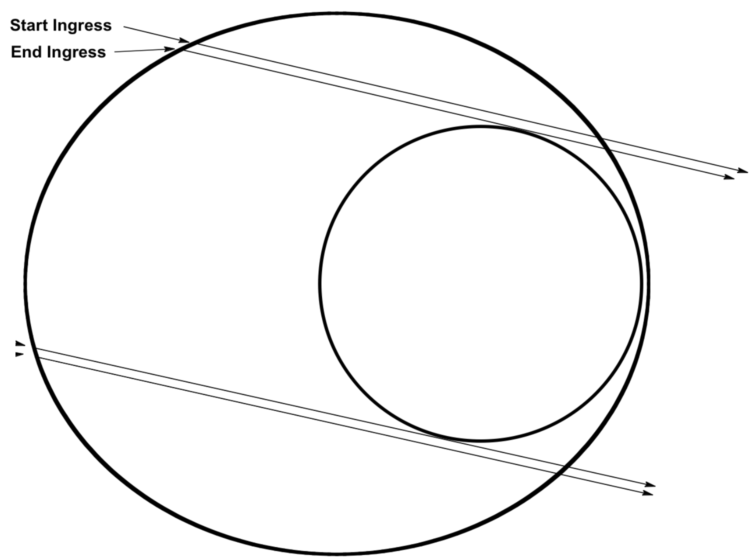
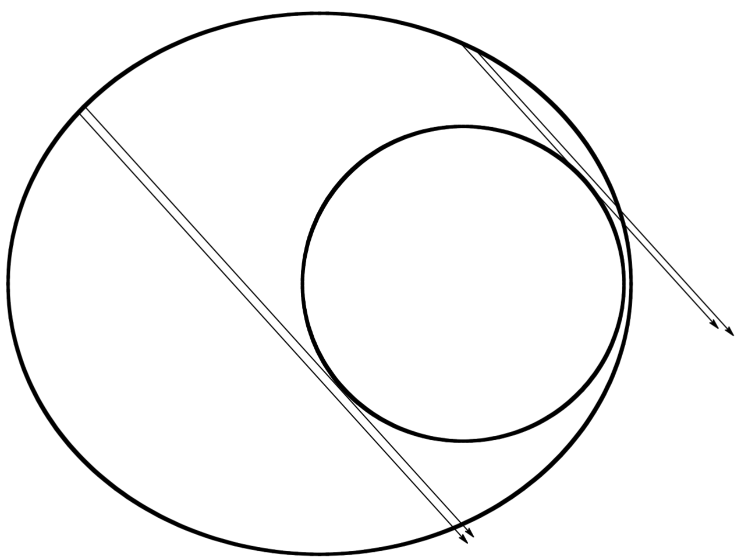


Figure E.2–3: Simulated observation of H and D Lyman-α emissions in 222nd order. The lines are well-resolved yielding SNR~10 in <1 hr. The dominant noise source is photon noise in the grating-scatter wings of H. Simulation includes noise and uses actual STIS measurements of the scatter from the grating to be used.

4: Stellar Occultations: Overview

- IUVS will perform occultation campaigns lasting 5 consecutive orbits occurring every ~2 months. Selected stars will vary campaign-to-campaign but will be observed repetitively during the 5 consecutive orbits.
- Of order 15 events per orbit will be observed, maximizing coverage in latitude and local time.
- Mars completes one rotation during 5 orbits, giving full longitude coverage.
- Science goals include measurement of CO_2, O_3, dust, clouds below the spacecraft altitude





Science data processing and products

Science Data Products 1

MAVEN
Mars Atmosphere and Volatile Evolution Mission
CU/LASP • GSFC • UCB/SSL • LM • JPL

IUVS will provide global 3D models of major molecules, atoms, ions and isotopes in the atmosphere & corona, with derived properties such as exobase and ionosphere altitudes

- Periapsis Limb Scans
  - Multispecies vertical profiles, multiple profiles along-track per pass
- Apoapsis Images
  - Multispectral 2-D images, one set per apoapse
- D / H & O Coronal Scans
  - 1-D Deuterium, Hydrogen, Oxygen vertical profiles, single profile per orbit
- Stellar Occultations
  - Vertical CO_2 profile; single profile per occultation

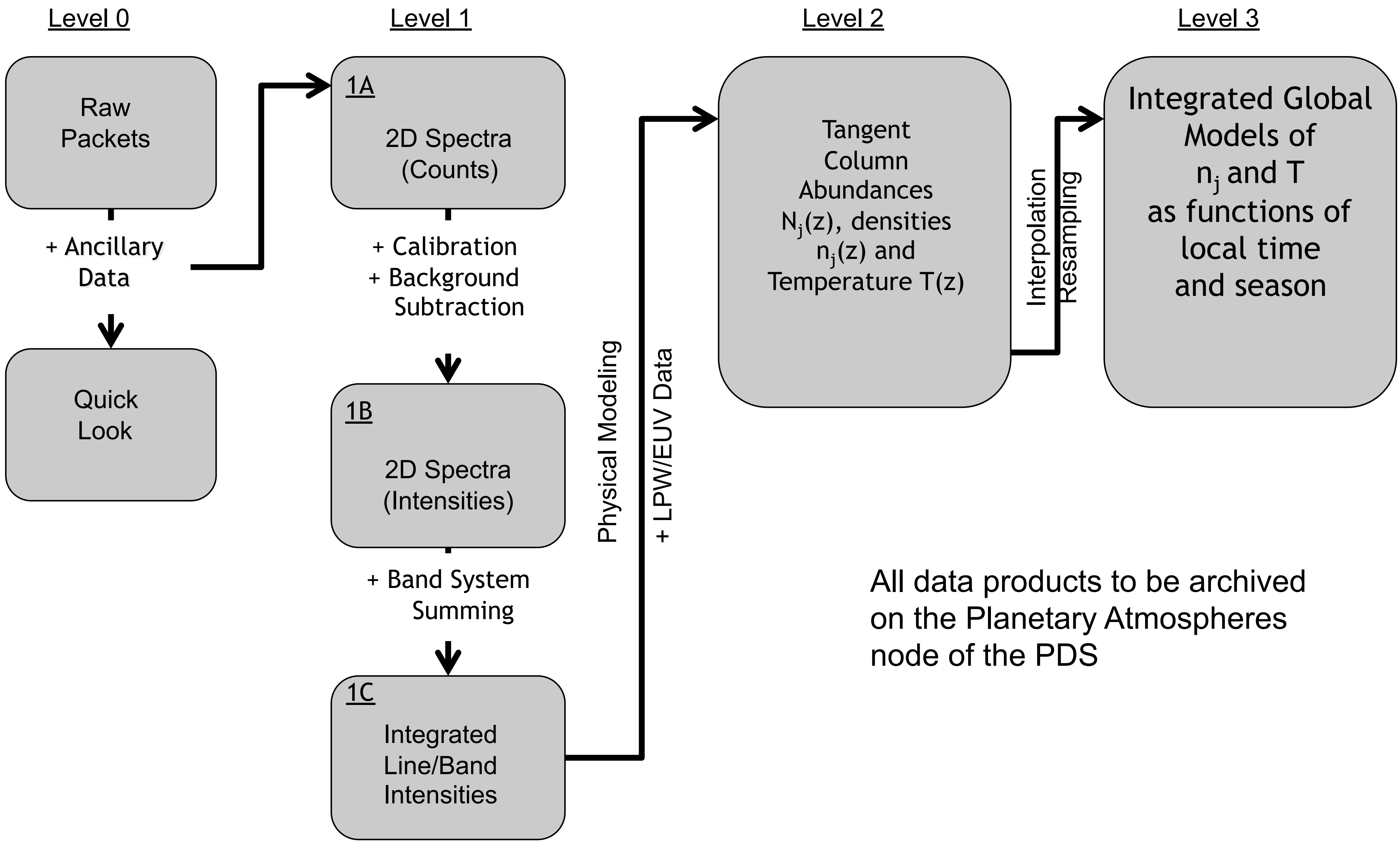
IUVS provides critical global descriptions essential for the interpretation of *in situ* data

Science Data Products – All Modes

- Periapsis Limb Scans
  - Level 1A/B: two-dimensional spectra in counts/intensities
  - Level 2A: tangent column abundances $N_i(z)$ (adjacent to periapse track)
  - Level 2B: densities $n_i(z)$, and temperatures $T(z)$
  - Level 3: integrated global models of n_i, T as functions of local time, season, time
- Apoapsis Images
  - Level 1A/B: images in counts/intensities for multiple emissions
  - Level 2: vertical column abundance maps
  - Level 3: integrated global models as functions of local time, season, time
- Coronal Scans
  - Level 1A/B: two-dimensional spectra in counts/intensities
  - Level 2A/B: D, H, O tangent column abundances, densities & temperatures (radially from planet)
  - Level 3: integrated global models as functions of local time, season, time
- Stellar Occultations
  - Level 1A/B: raw absorption spectrum in counts/normalized intensity spectrum
  - Level 2: atmospheric density profile
  - Level 3: integrated global model as functions of local time, season, time

MAVEN requires high-level derived geophysical quantities within days to weeks of data receipt. Pipeline processing must be in place before orbit insertion!

IUVS Science Data Flow (Periapse Data Example)



All data products to be archived on the Planetary Atmospheres node of the PDS

Data Products from Periapse Limb Scans

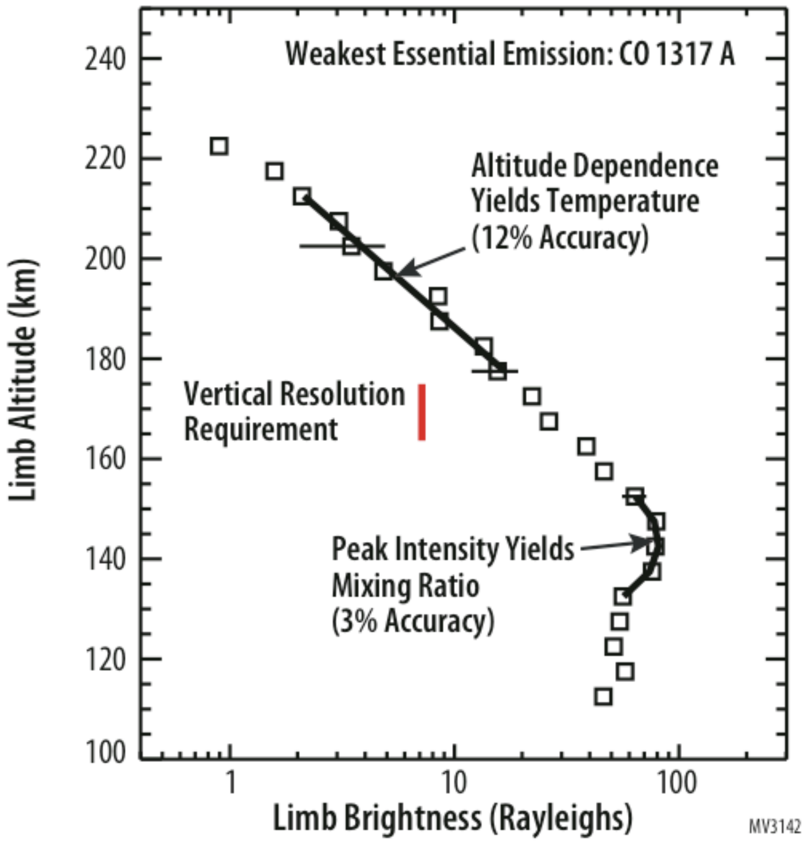


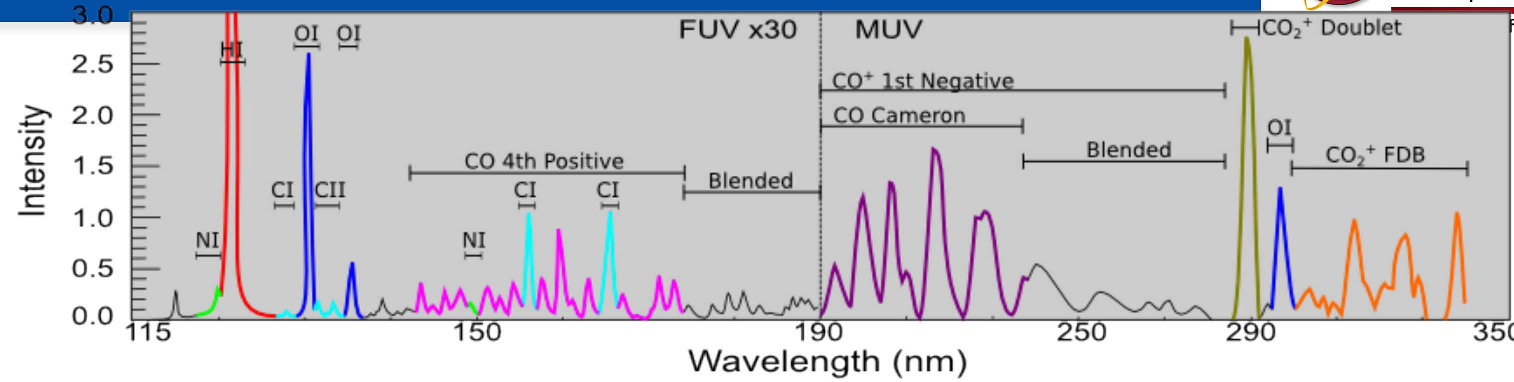
Figure F.5–2: IUVS limb profiles will allow accurate determination of critical atmospheric properties, even for the weakest essential emissions.

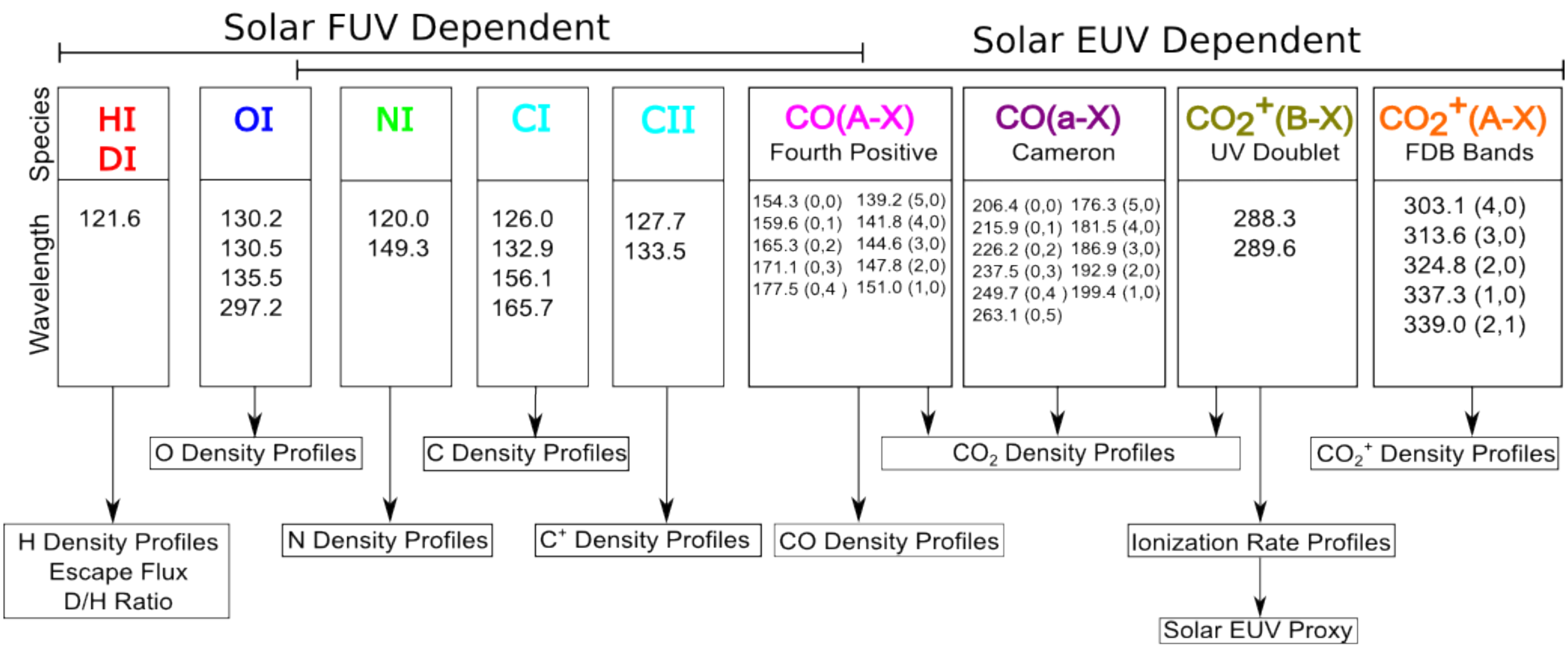
Single Emission Example

- Counts maps will be converted to intensity maps based on instrument calibrations
- Intensity maps will be converted to limb column abundances using computer models and inputs from other instruments (e.g., LPW/EUV)
- Column abundance maps will be converted to vertical density profiles n(z) and temperature profiles T(z)
- Local profiles will be integrated into global profiles vs. local time, season, time

Periapse Data: From Emissions to Derived Quantities

MAVEN
Mars Atmosphere and Volatile Evolution Mission
FC • UCB/SSL • LM • JPL





Other potentially observable features include the N_2 V-K band system, CO^+(B-X), and the 131.7nm feature of CO(A-X).
Spectral regions marked in grey are blended emissions and will not by used in pipeline processing.

Summary

- IUVS offers UV capabilities never before used at Mars
- The instrument's four modes address fundamental science in the upper atmosphere, ionosphere, corona and middle atmosphere
- The instrument will obtain an unprecedented dataset of consistently mapped UV data spanning at least one Earth year
- Pipeline processing will produce extensive high-level data in geophysical units (densities, temperatures)
- The data, when combined with MAVEN's other instruments, will address the current state of the atmosphere, ongoing escape processes, and the integrated loss to space over time