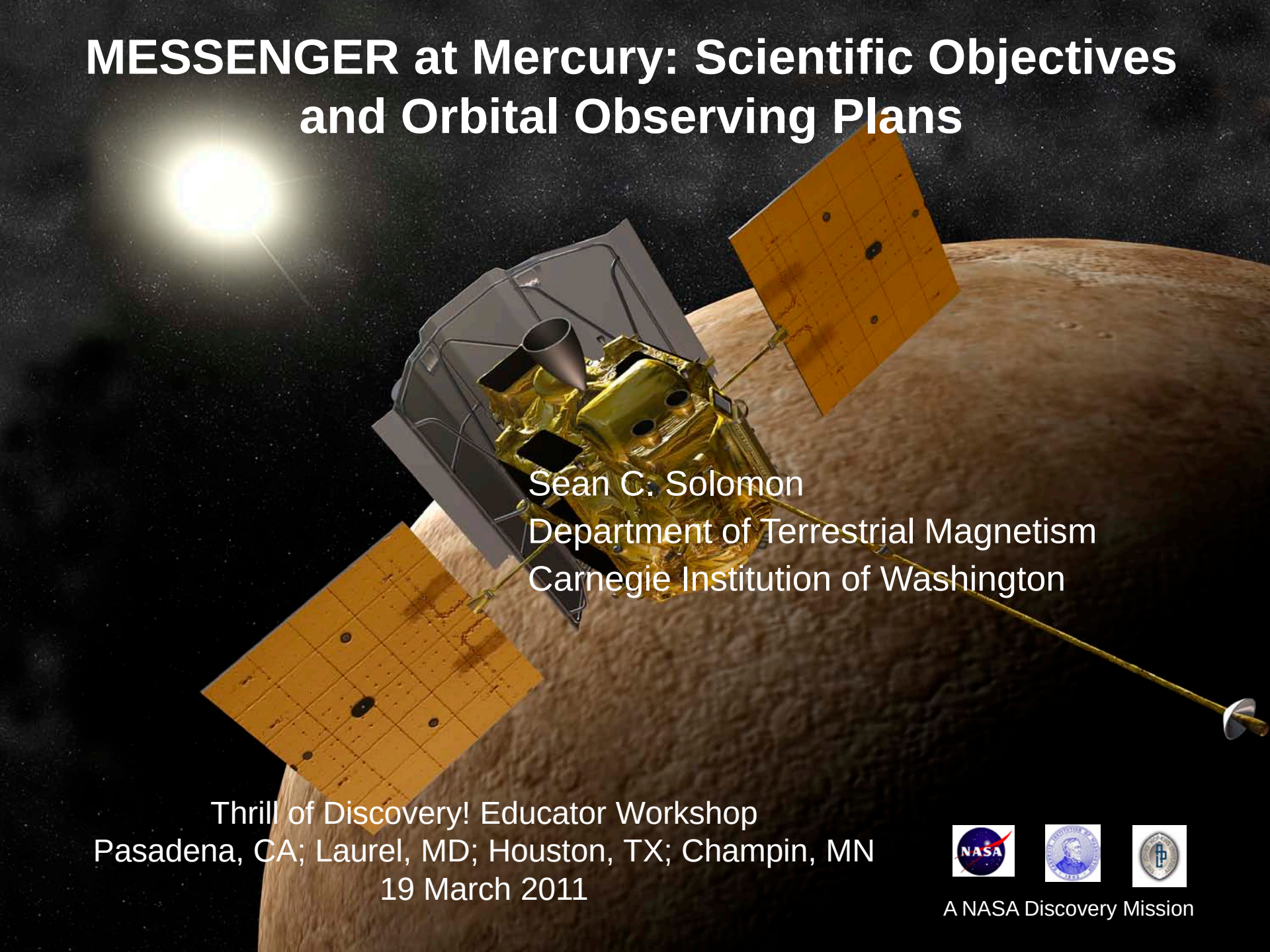
MESSENGER at Mercury: Scientific Objectives and Orbital Observing Plans



Sean C. Solomon
Department of Terrestrial Magnetism
Carnegie Institution of Washington

Thrill of Discovery! Educator Workshop
Pasadena, CA; Laurel, MD; Houston, TX; Champin, MN
19 March 2011

A NASA Discovery Mission

MESSENGER

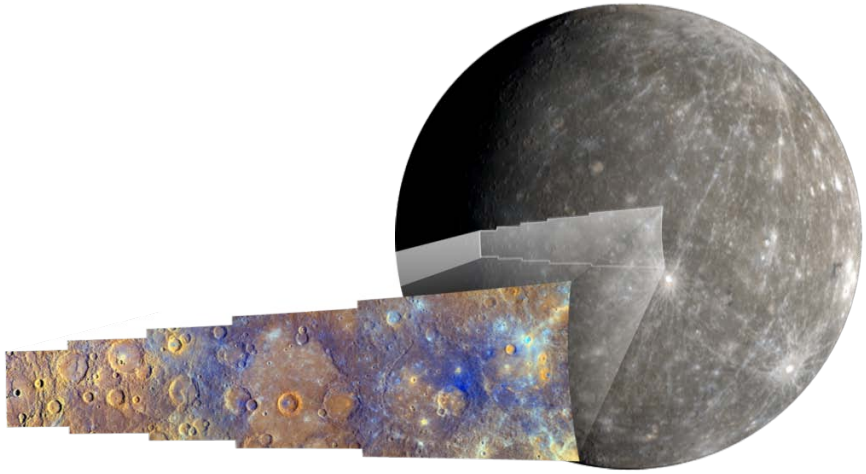
Guiding Science Questions

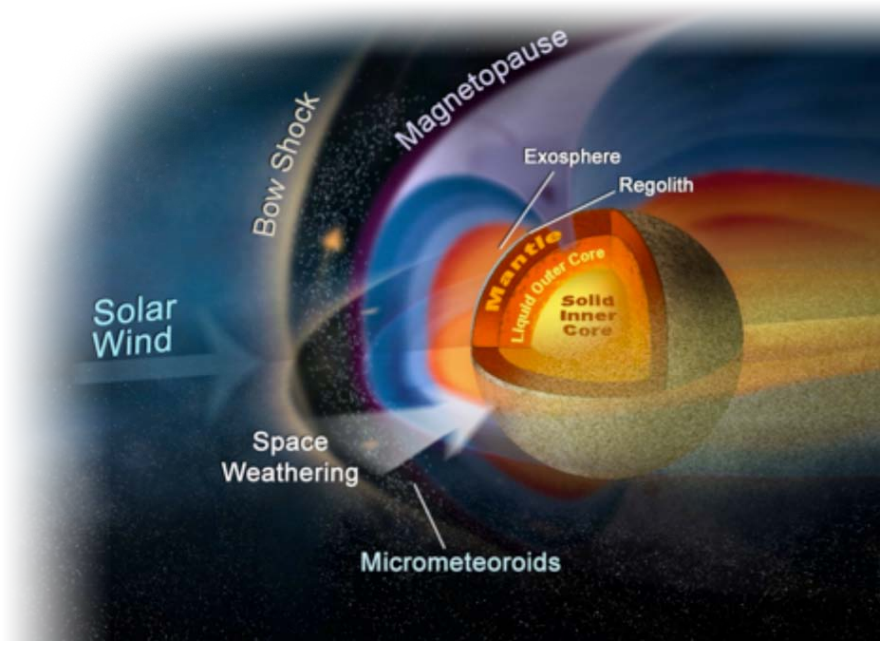
MESSENGER issue, 1 May 2009

What planetary formational processes led to the high metal/silicate ratio in Mercury?
What is the geological history of Mercury?
What are the nature and origin of Mercury's magnetic field?
What are the structure and state of Mercury's core?
What are the radar-reflective materials at Mercury's poles?
What are the important volatile species and their sources and sinks on and near Mercury?

MESSENGER
Measurement Objectives

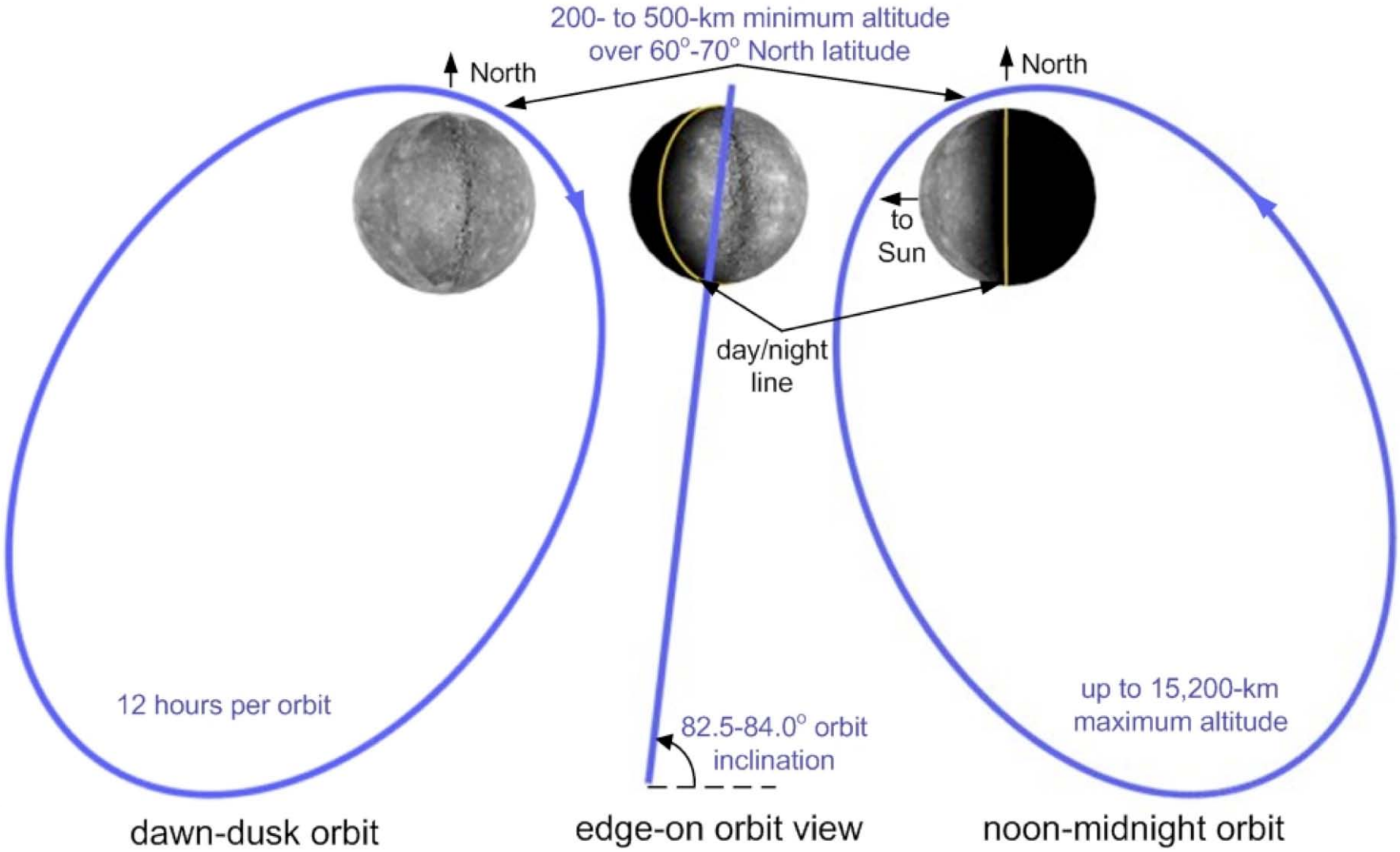
- **Global imaging**: color, higher-resolution monochrome, and targeted ultra-high resolution
- **Reflectance spectroscopy**: ultraviolet to near-infrared
- **Elemental remote sensing**: X-rays, gamma rays, and neutrons
- **Topography**: laser ranging and stereo
- **Gravity field**: Doppler and ranging
- **Exosphere**: multi-species assay versus space and time
- **Magnetic field**: internal field, magnetospheric structure, and dynamics
- **Charged particles**: plasma and energetic particle transport





MESSENGER

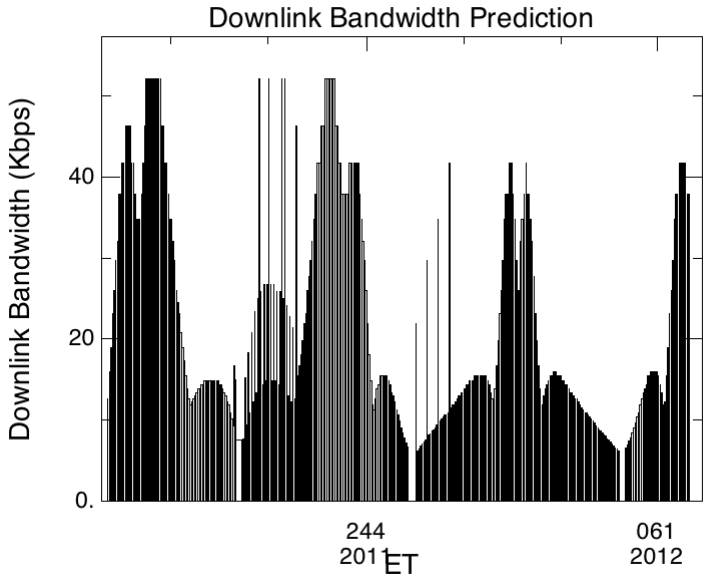
Orbit Geometry

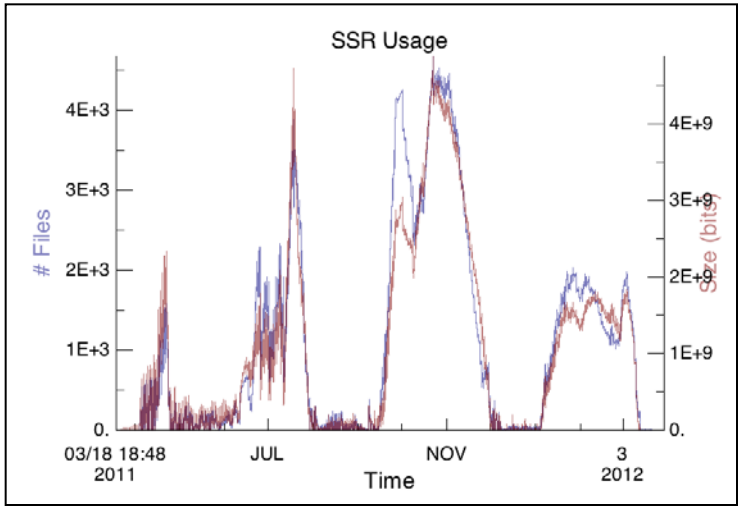


MESSENGER

Operational Constraints

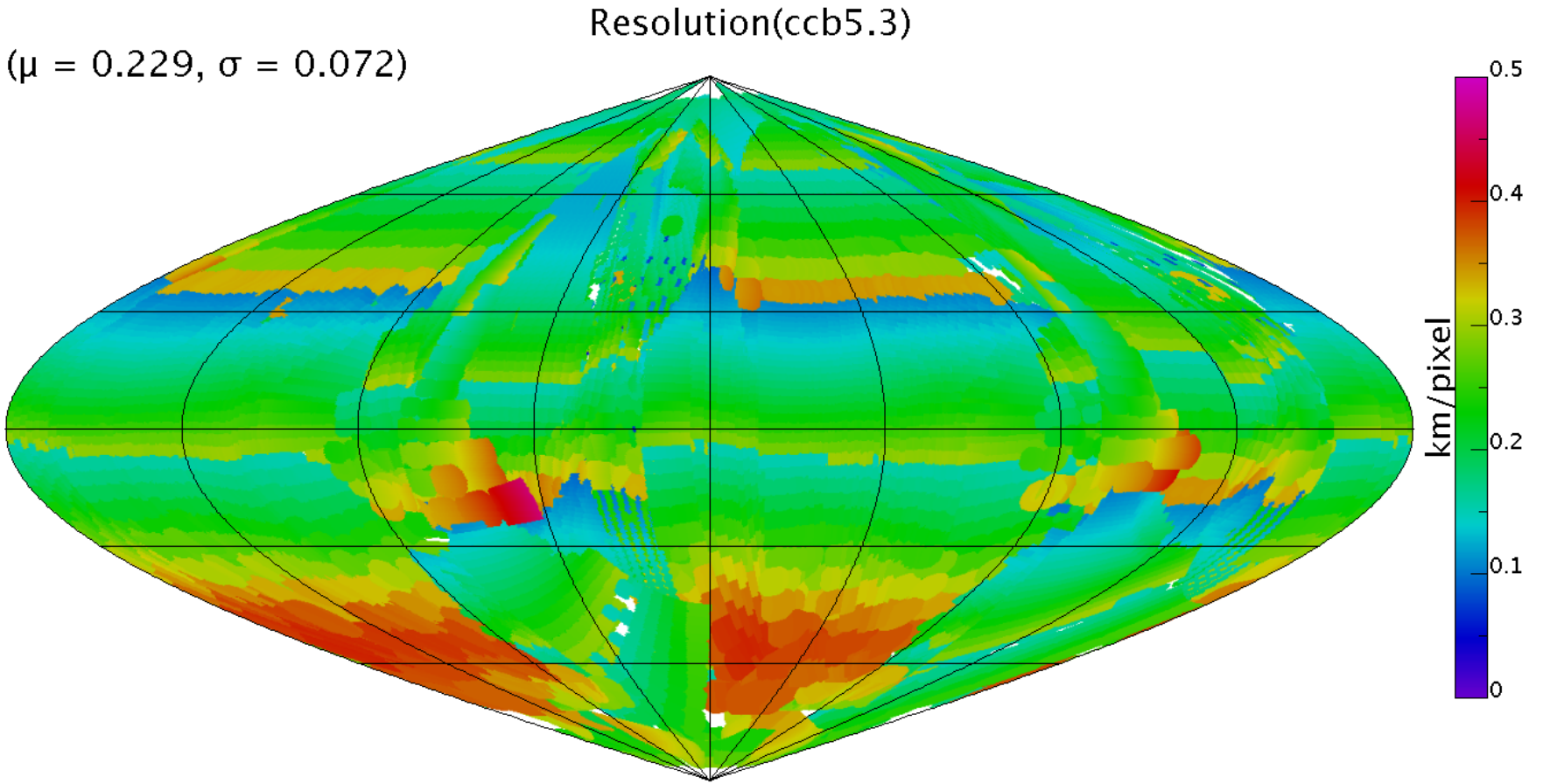
- Instrument pointing demands
- Sun keep-in limits
- Hot-pole keep-out limits
- Limited and variable downlink rate
- Limited capacity for onboard data storage





MESSENGER

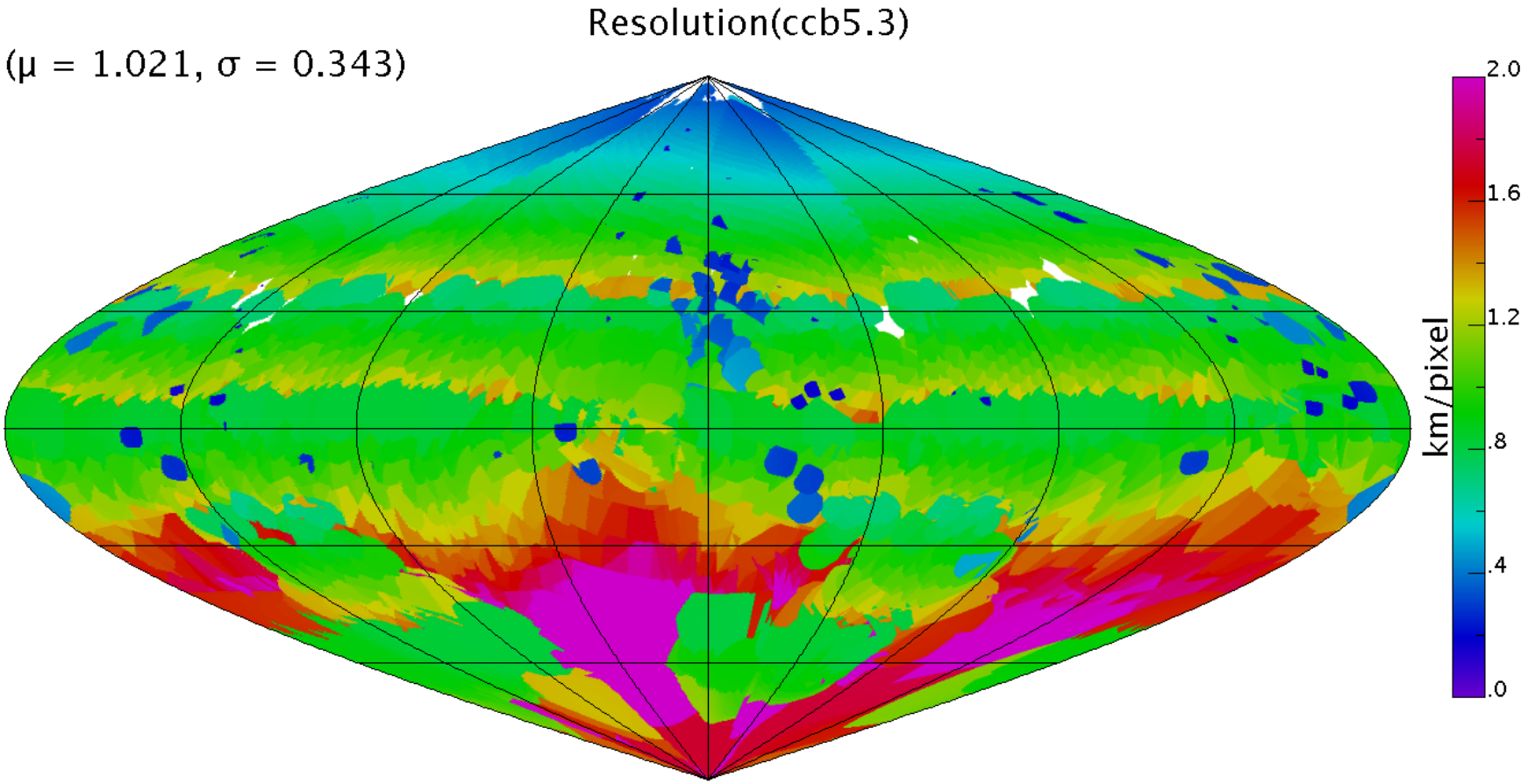
Monochrome Base Map



~13,000 images, > 99% coverage, 227 m/pixel average resolution

MESSENGER

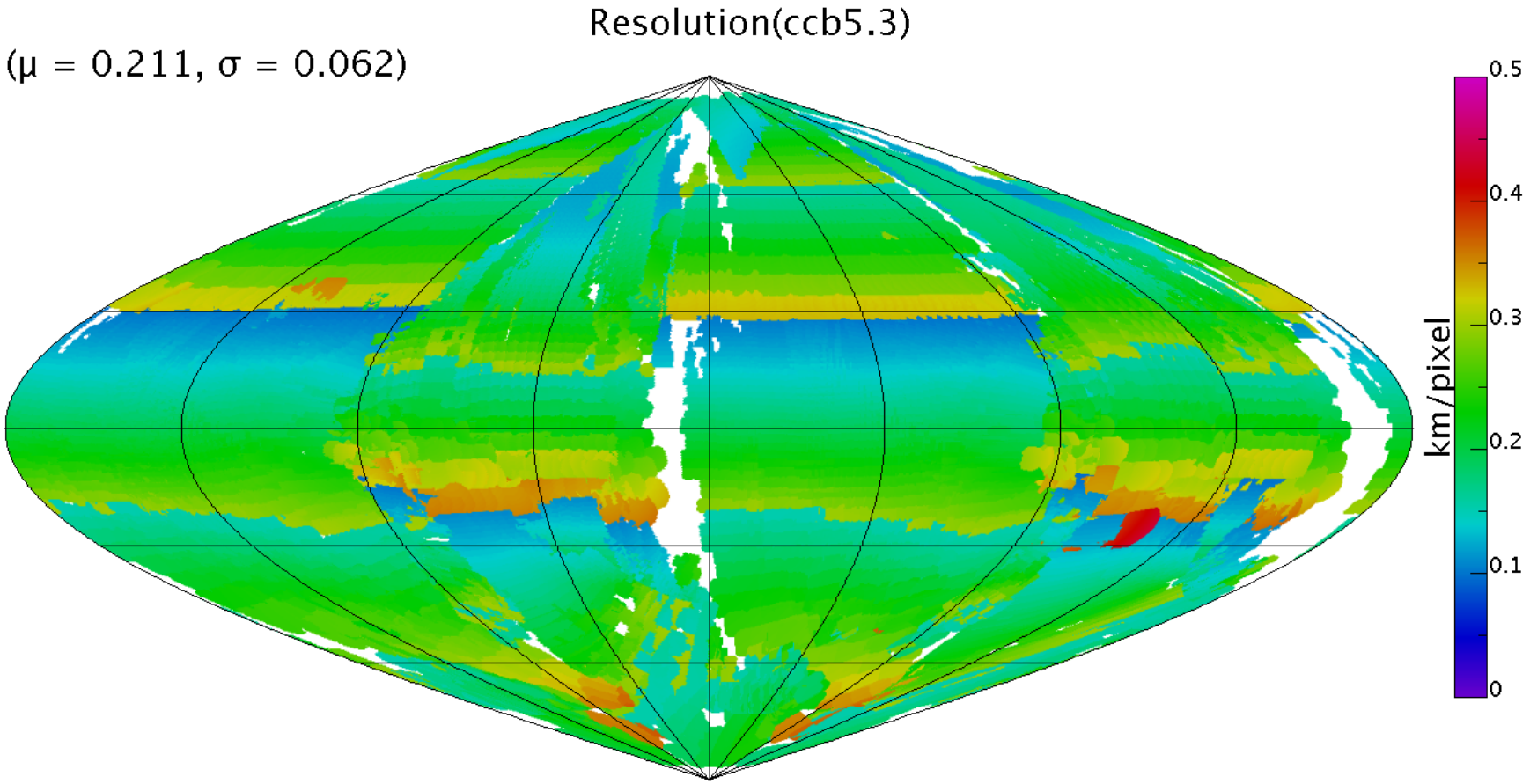
Color Base Map



~40,000 8-color images, 95% coverage, 1 km/pixel average resolution

MESSENGER

Stereo Base Map

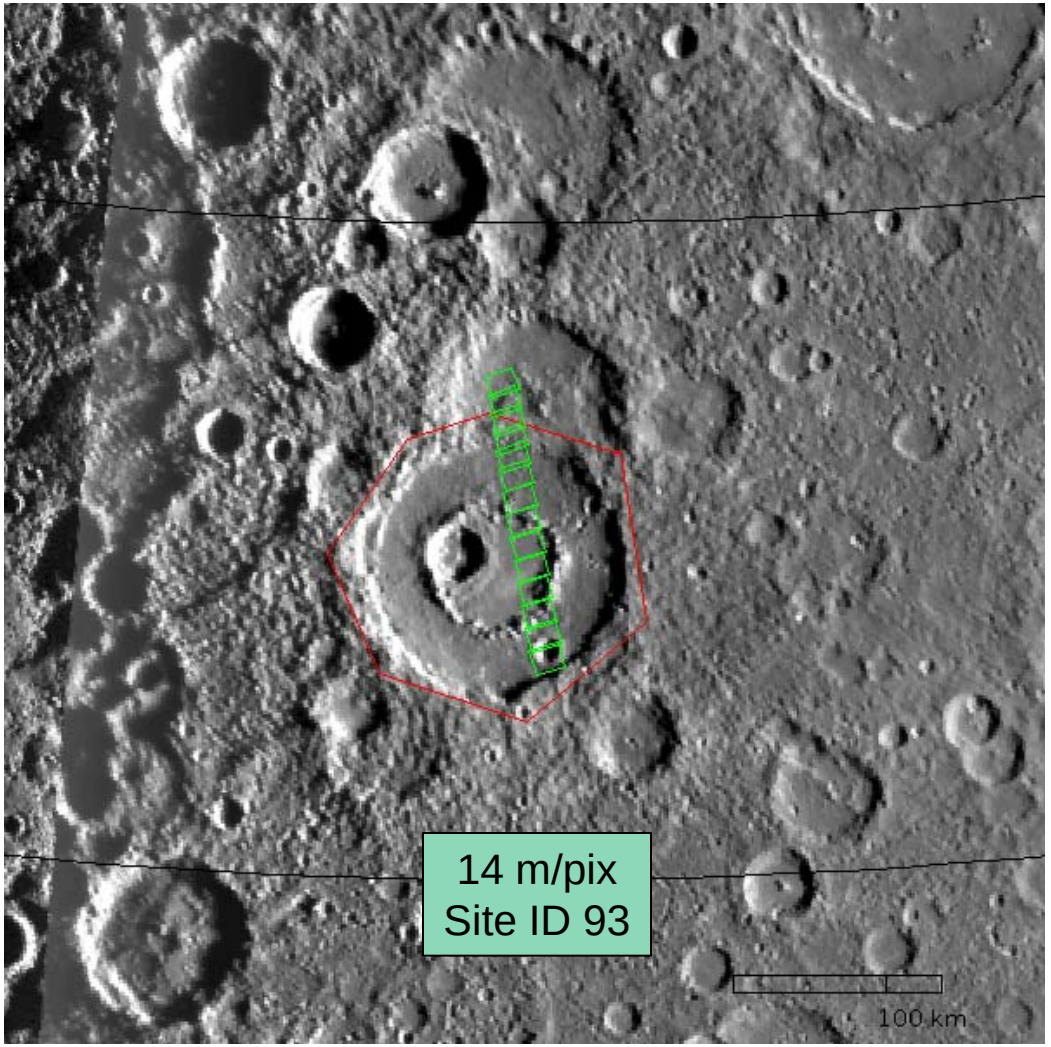


~19,000 images, 95% coverage, 210 m/pixel average resolution

MESSENGER

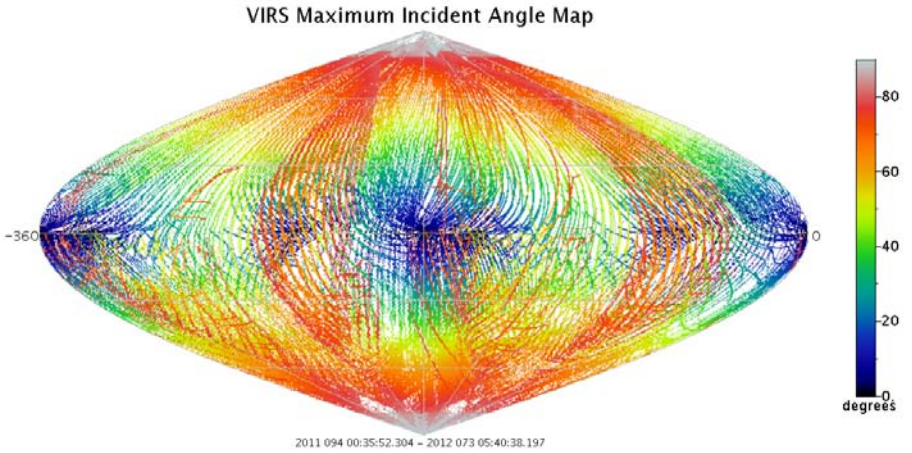
Targeted High-Resolution Images

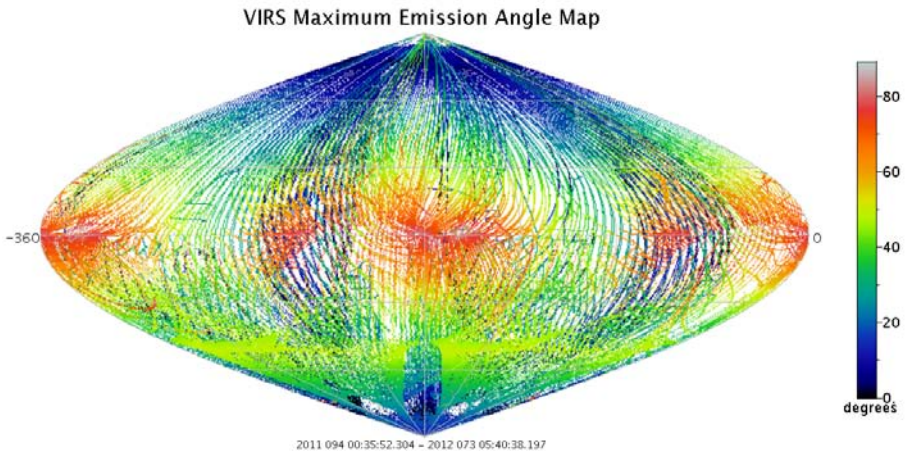
- ~2200 science targets
  - High-resolution NAC: ~1100
  - High-resolution 8-color WAC: ~1000
  - High-resolution NAC stereo: ~70
  - NAC+VIRS: ~70



MESSENGER

MASCS Orbital Operations

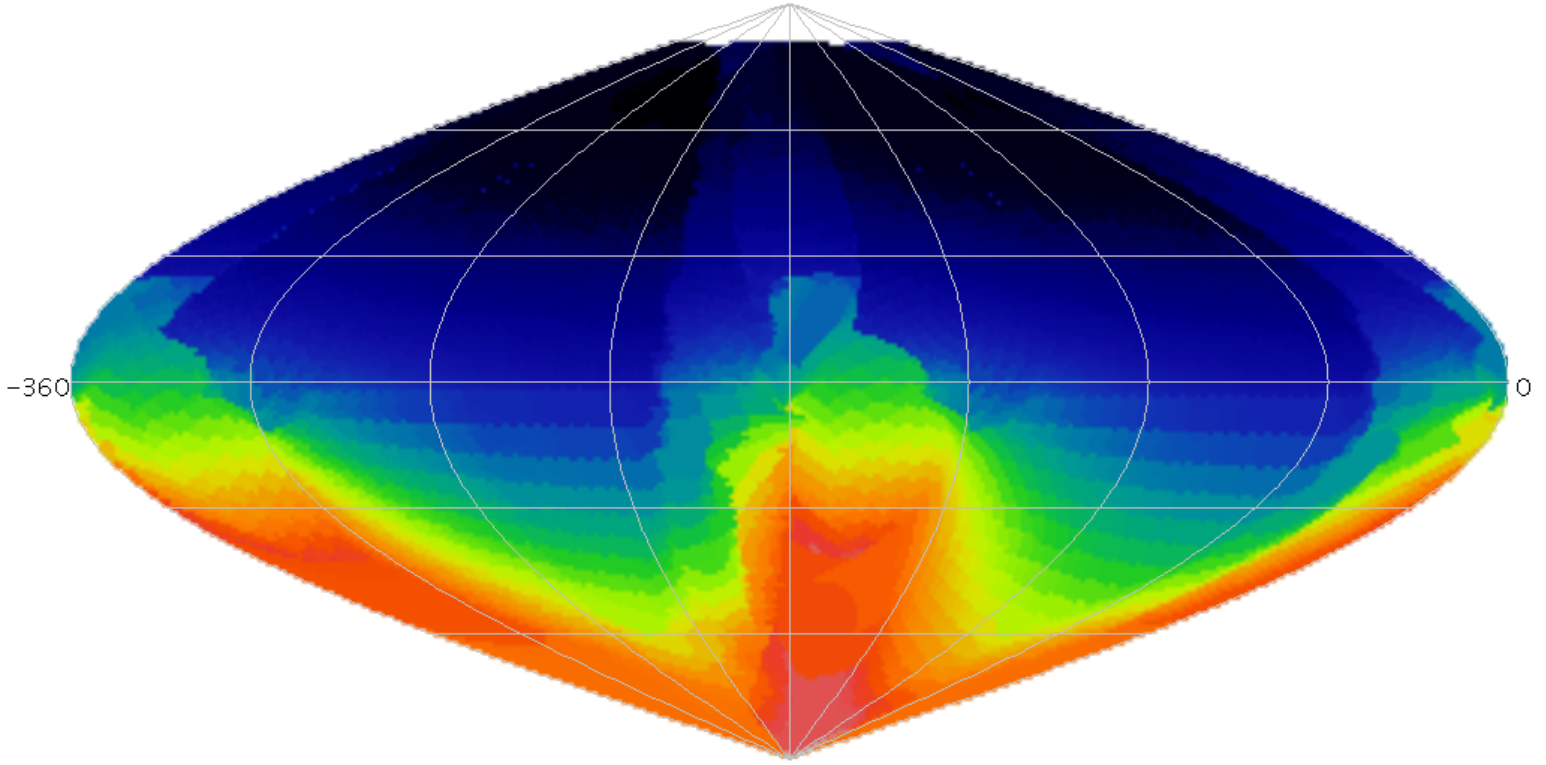




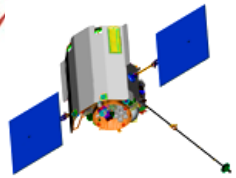
- **Global survey of reflectance spectra with VIRS (300–1450 nm).**
- **95% spatial coverage at ~20-km scale poleward of ± 20°N.**
- **Observations at a range of *i* and *e* to derive photometric corrections.**
- **A variety of geological targets have been selected for full UVVS and VIRS spectra (115–1450 nm).**

MESSENGER

XRS Orbital Operations



- XRS will be on continuously except for some maneuvers and long eclipses.
- Measurements will be generally photon limited.
- Spatial resolution will be sharply enhanced during solar flares.
- Coverage will be uneven, especially for higher-Z elements that require flare activity to provide sufficient signal.

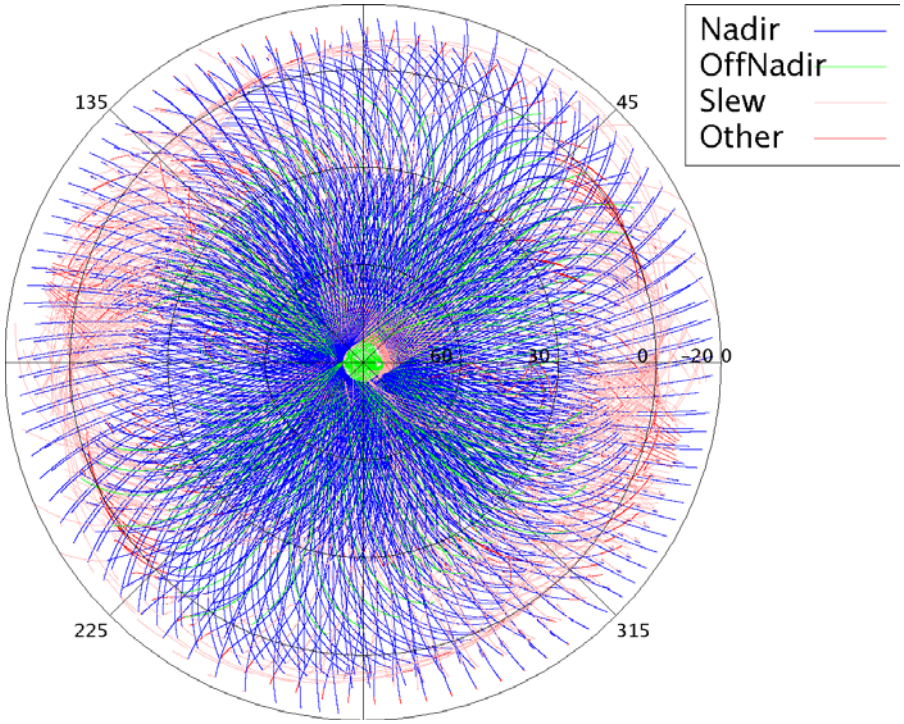


MESSENGER

MLA Orbital Observations

- MLA controls spacecraft pointing when slant range to the surface is less than 1,500 km.
- MLA points to nadir, or as close to nadir as possible, given the Sun keep-in limits (except near the north pole).
- For 1 orbit out of 7, pointing slews toward the north pole.
- No other targeted observations are planned for the primary mission.

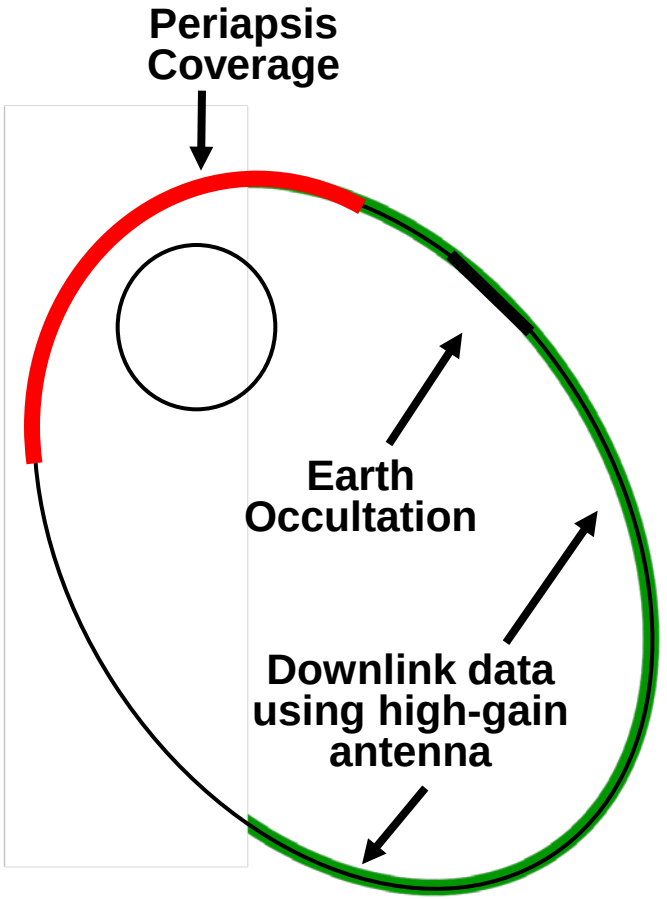
MLA coverage in northern hemisphere



MESSENGER

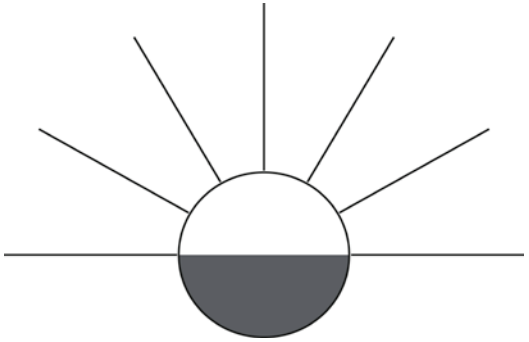
Radio Science Orbital Observations

- Doppler signals during 8-hour data downloads with high-gain antenna (HGA).
- Doppler signals during one of every two daily periapsis passes with low-gain antenna (LGA).
- Occultation ingress and egress times when possible, with LGA .
- When geometry is favorable, capture Doppler for the second daily periapsis pass.

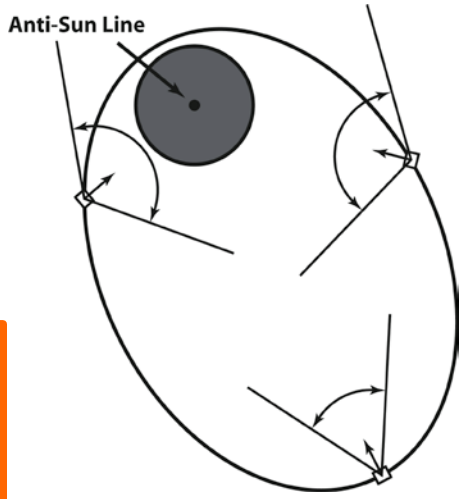


MESSENGER

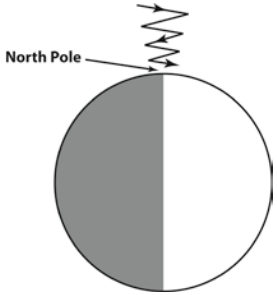
Exosphere Orbital Observations



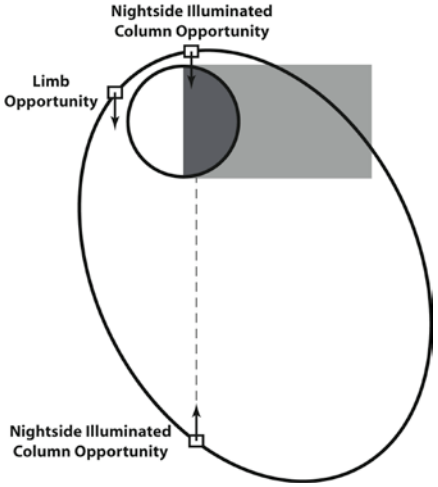
Dayside radial limb scans provide full local time coverage and probe important dawn/dusk asymmetries.



Mapping scans at high altitudes provide spatial coverage on day and night sides.



Polar scans probe regions over both poles during each dawn-dusk orbital season.

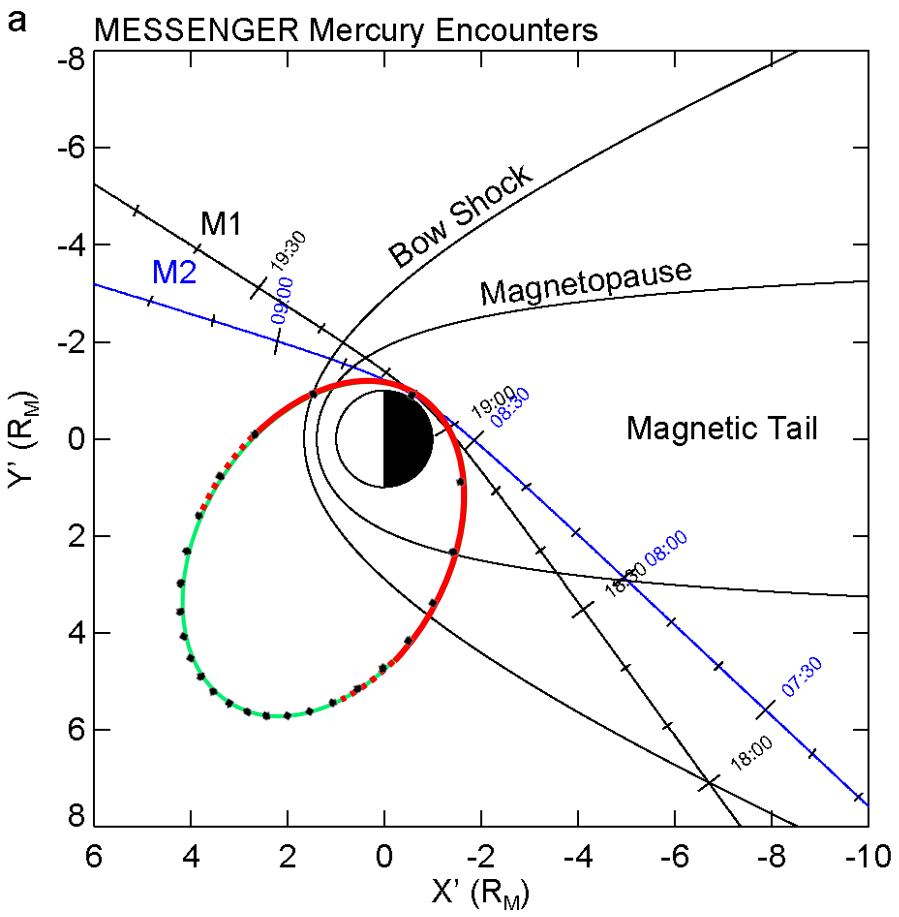


Ride-along intervals offer opportunities for further measurements.

MESSENGER

MAG Orbital Observations

- **The magnetic field will be sampled at the highest rate (20 samples/s) for as much of every magnetosphere transit as possible (e.g., red portion of orbit at right).**
- **When continuous high-rate sampling is not possible, three-hour windows with triggered 8-minute bursts of high-rate sampling adjacent to the continuous high-rate zone will capture magnetospheric boundaries.**



Mapping phase begins 4 April