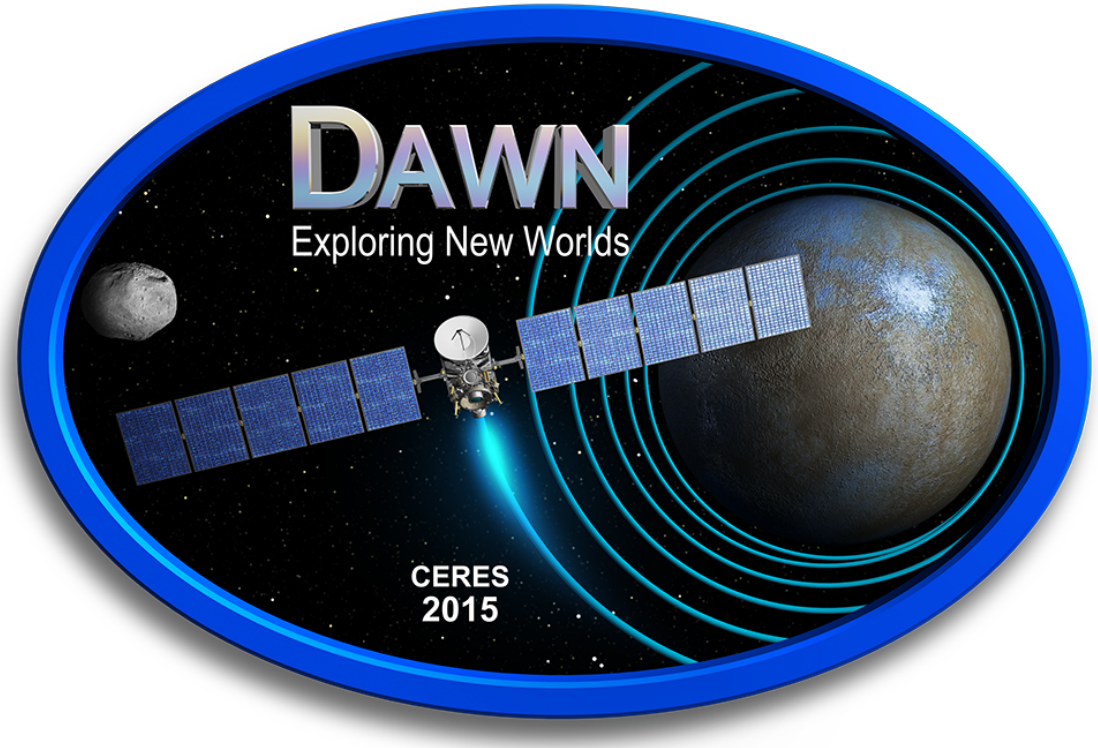
Dawn Status Report

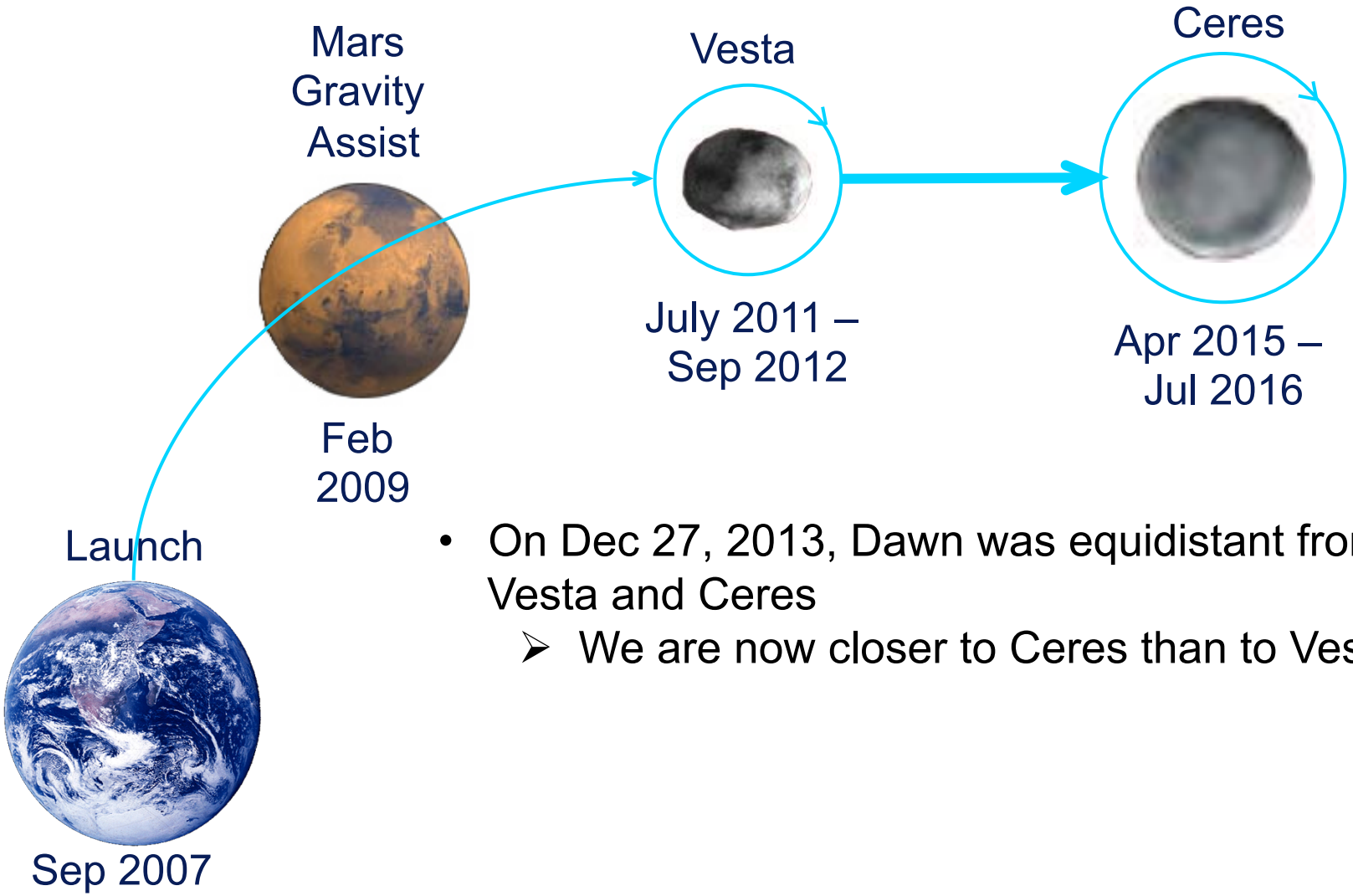


Small Bodies Assessment Group

C. Raymond, JPL

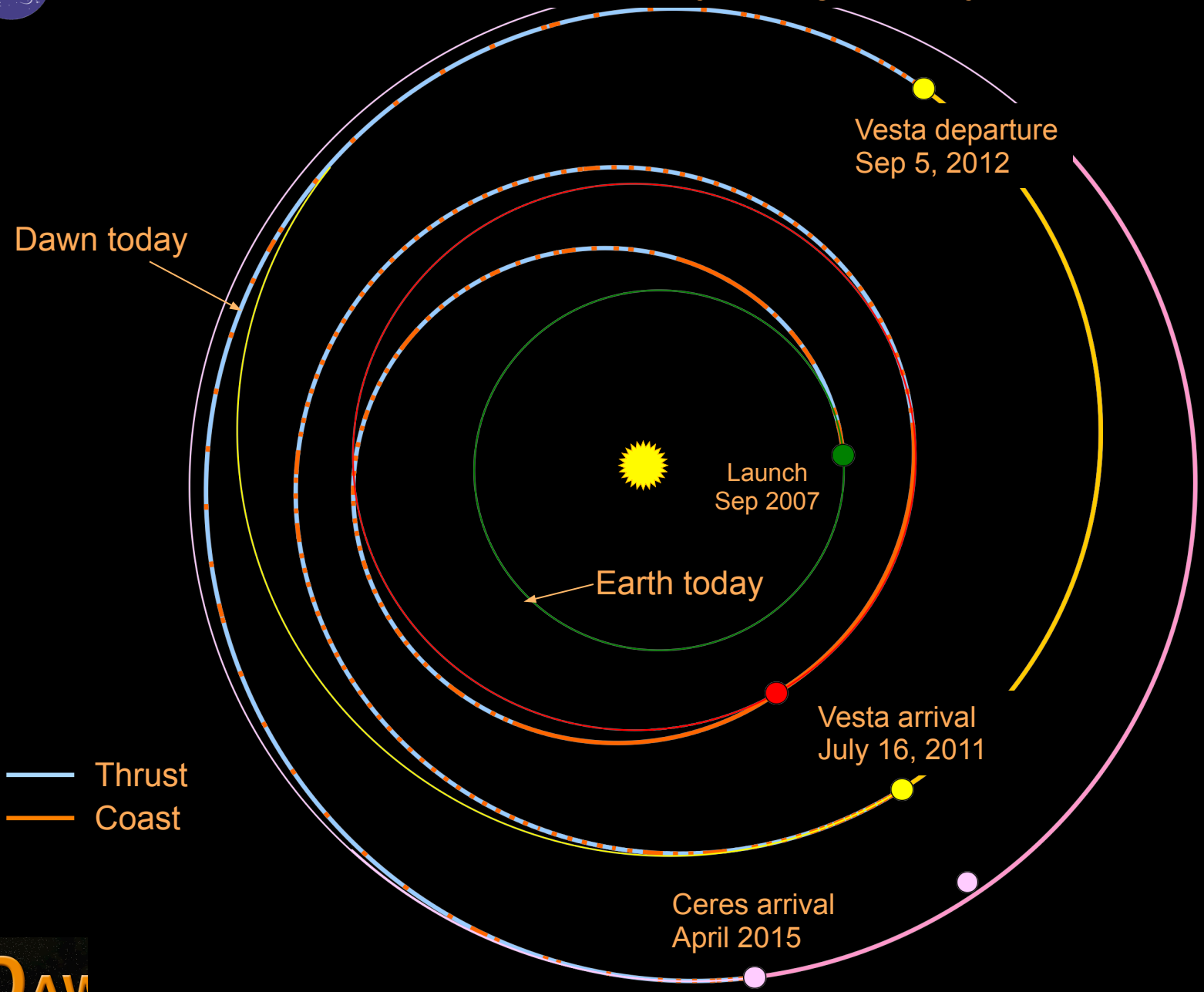
9 Jan 2014

Mission Itinerary

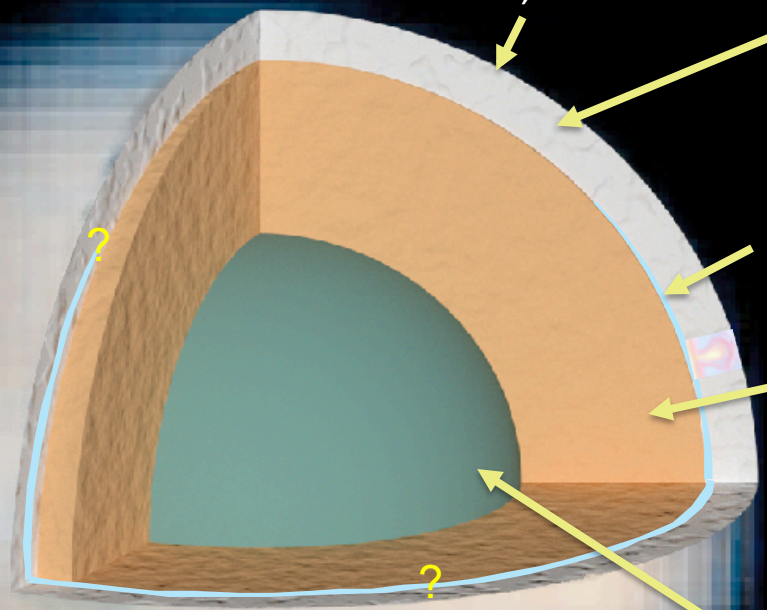


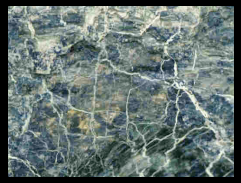
- On Dec 27, 2013, Dawn was equidistant from Vesta and Ceres
  - ➢ We are now closer to Ceres than to Vesta

Interplanetary Trajectory



Ceres Interior Model





Castillo-Rogez and McCord, 2010

Constraints on Ceres Mission

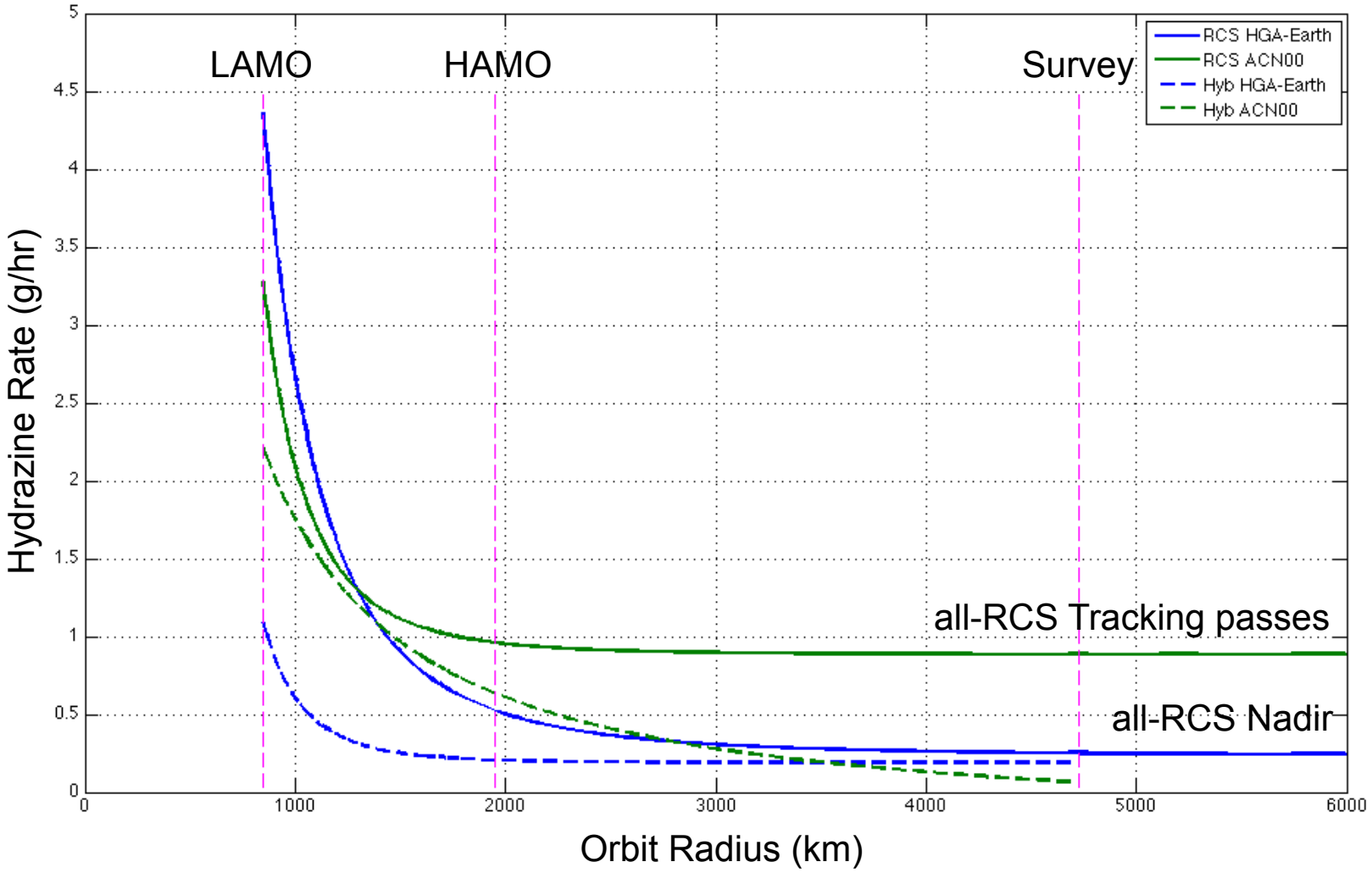
- Vesta mission was constrained primarily by time
  - Time allocations were tracked and carefully managed
- Dawn lost a second (of four) reaction wheel at the end of the Vesta mission. This presented a challenge to planning the Ceres mission
  - Dawn has hybrid capability (2-wheels plus Reaction Control System – RCS thrusters or jets)
  - Can also use all-RCS (jet) attitude control
- Ceres mission is constrained by hydrazine and time

Reaction Wheel Loss Mitigation

- An all-RCS (jet) Ceres mission that does not sacrifice science objectives or Level-1 requirements was adopted as a conservative goal
  - Strategy was driven by the assumption that the remaining two reaction wheels are unreliable and their use would have negligible contribution to improving the Ceres mission at higher altitudes
  - Focus was placed on preserving hydrazine by reducing the number of spacecraft turns and minimizing orbit transfer durations
    - Reduced spacecraft turns by more than a factor of 5 from the Vesta mission
    - Increased efficiency of orbit transfers to reduce coast time (coasting costs)

- Baseline plan includes use of hybrid control in the last science orbit phase (LAMO) when reaction wheels have the greatest impact on increasing the science return and lowest impact on operational complexity

Hydrazine Use Rate with Orbit Radius



Impact of All-RCS Pointing on Science

- Science pointing is more uncertain in jet control
- Primary impact is uncertainty in the position of images or spectra
  - Since Dawn is a mapping mission, the position of any individual image or spectra is not important
  - Planned image overlap was increased to mitigate gaps (this also adds to science return)
- Pointing error rate of 70 microrad/sec during RCS thrusting results in less than 1 pixel smear for the exposure time of most imaging
  - Comparable to the RWA jitter requirement of 75 microrad/sec
  - RCS pointing will not result in additional smearing
- Tracking accuracy for gravity is degraded due to the thruster perturbations but does not prevent achieving the Level-1 requirement
  - Thruster firing causes acceleration that is two orders of magnitude lower than the gravitational acceleration of Ceres at degree n=5 (L-1 requirement of 300 km half-wavelength)

Hydrazine Available

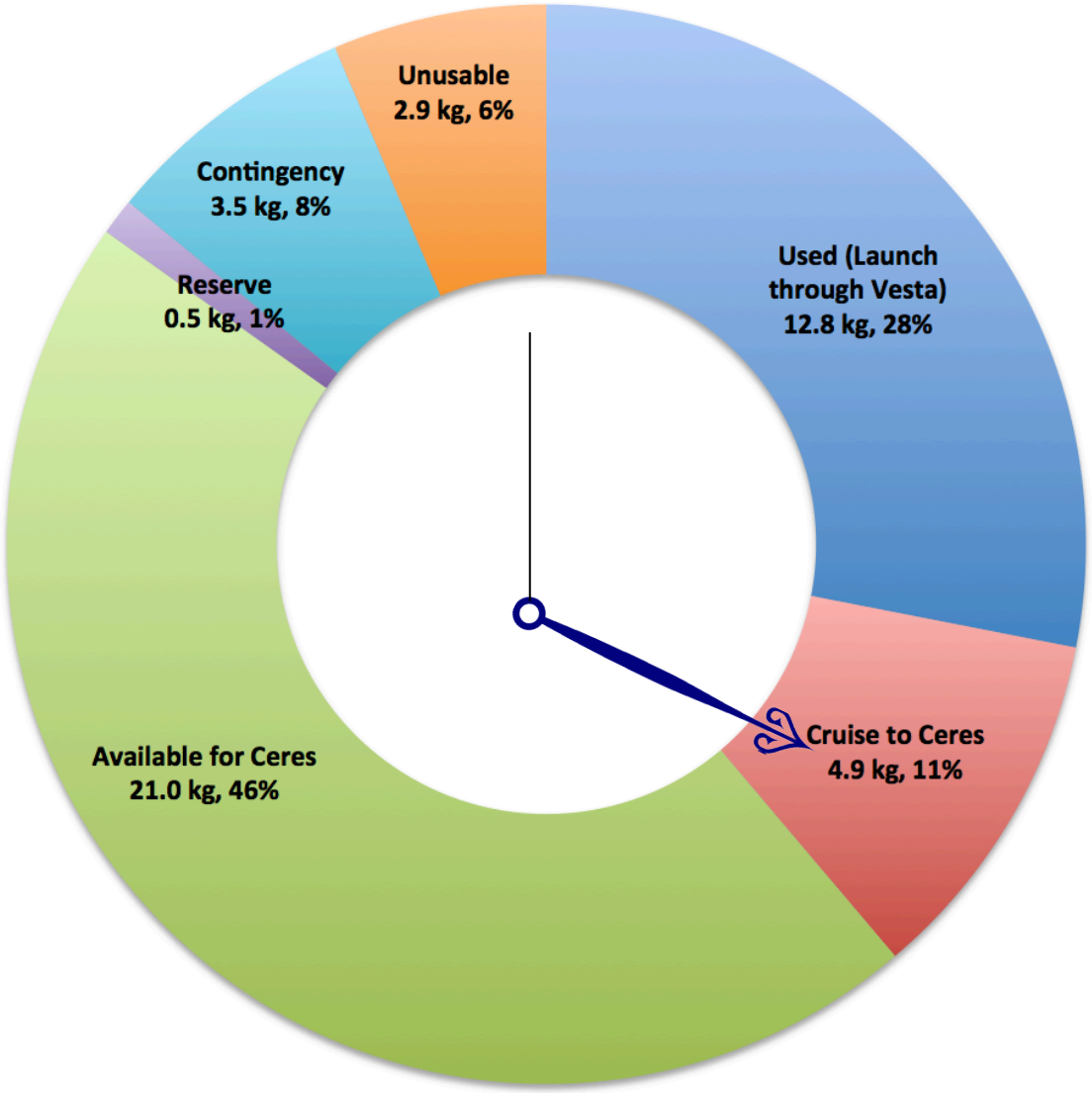
Post-Vesta, ~30 kg of hydrazine available to complete the mission

~5 kg needed to get to Ceres

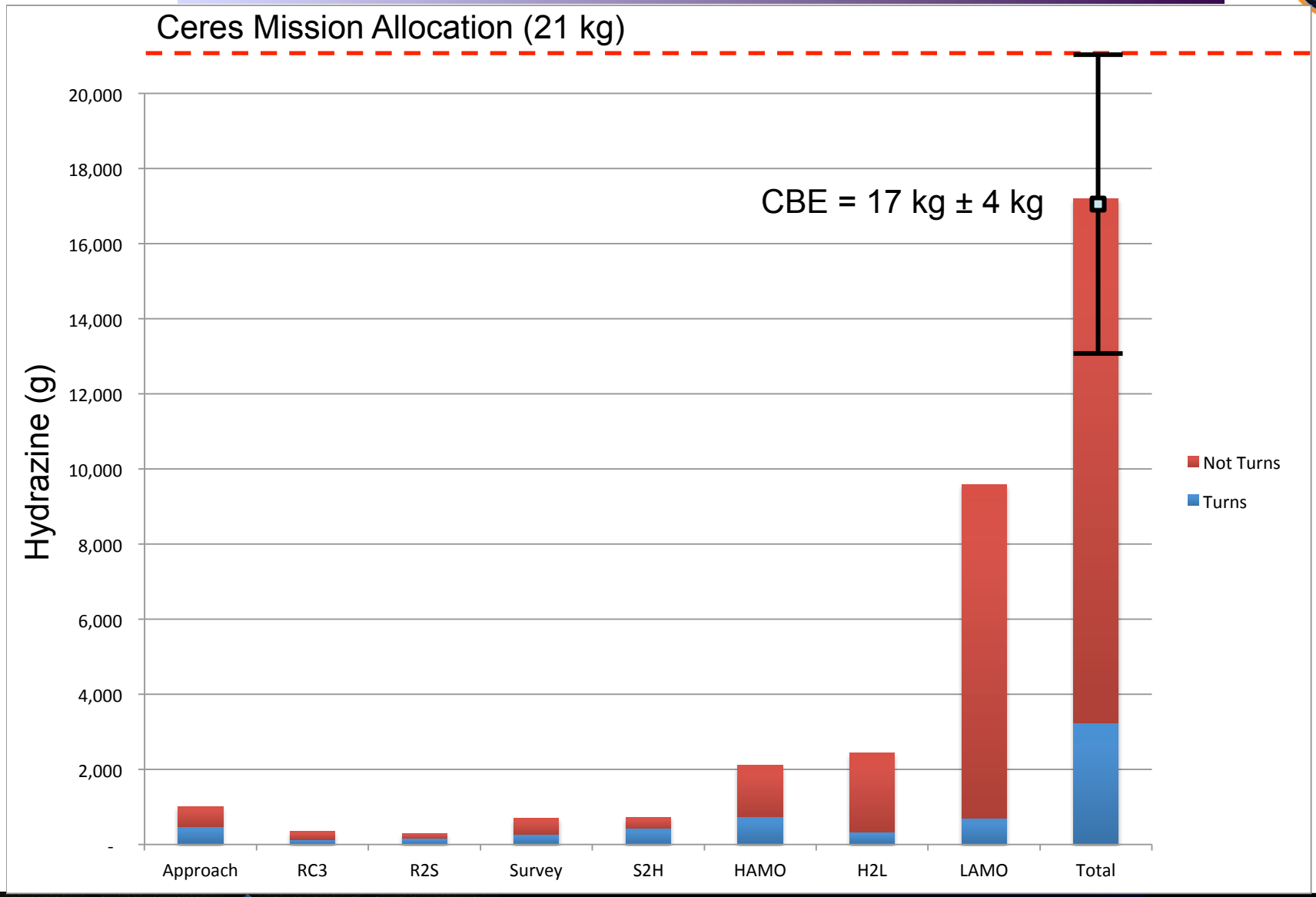
Project is holding 3.5 kg as Contingency (to accommodate potential future anomalies)

Set aside 0.5 kg as Management Reserve for Ceres Planning

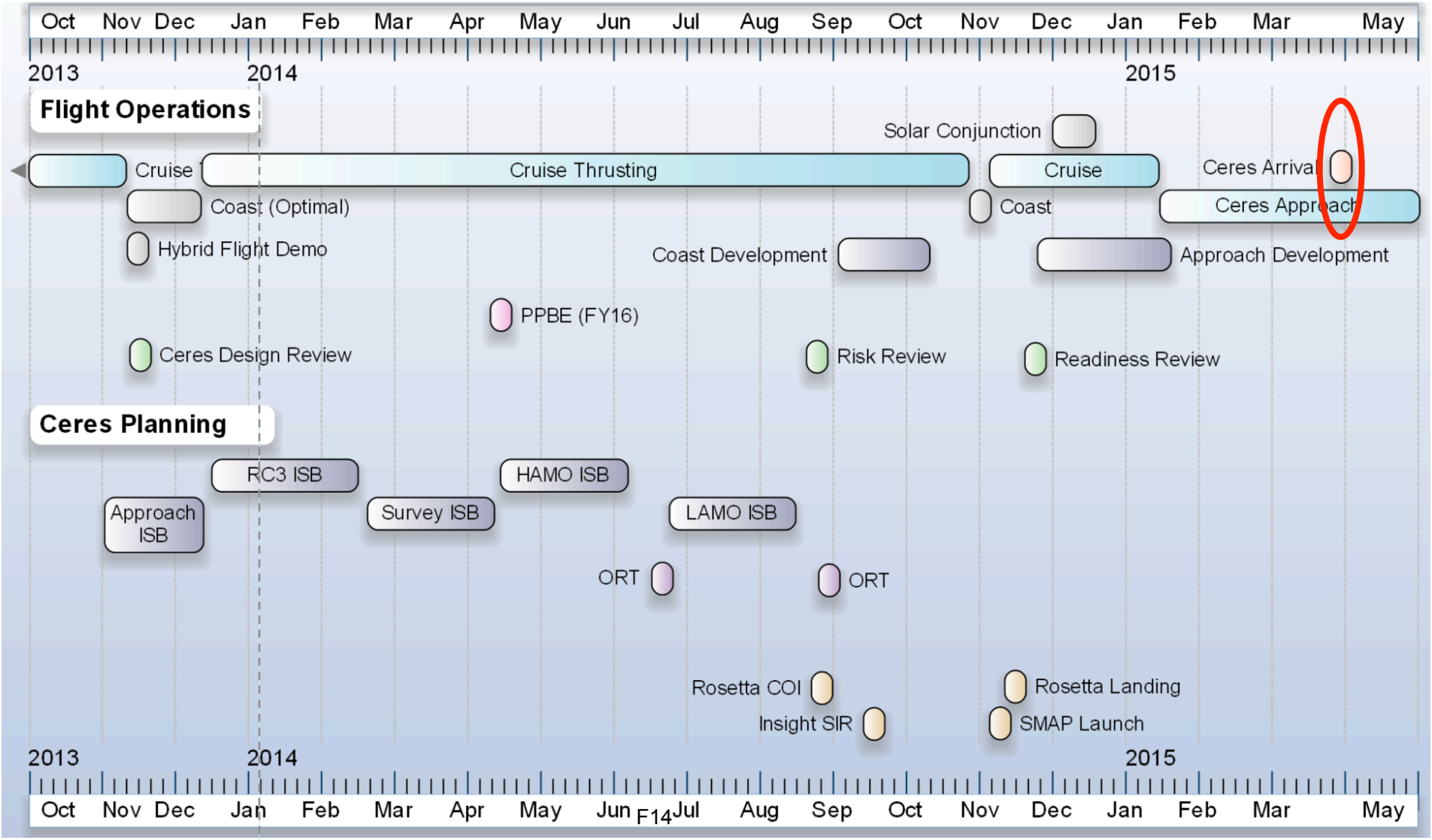
Leaving 21 kg available to accomplish the Ceres mission



Ceres Hydrazine Estimate

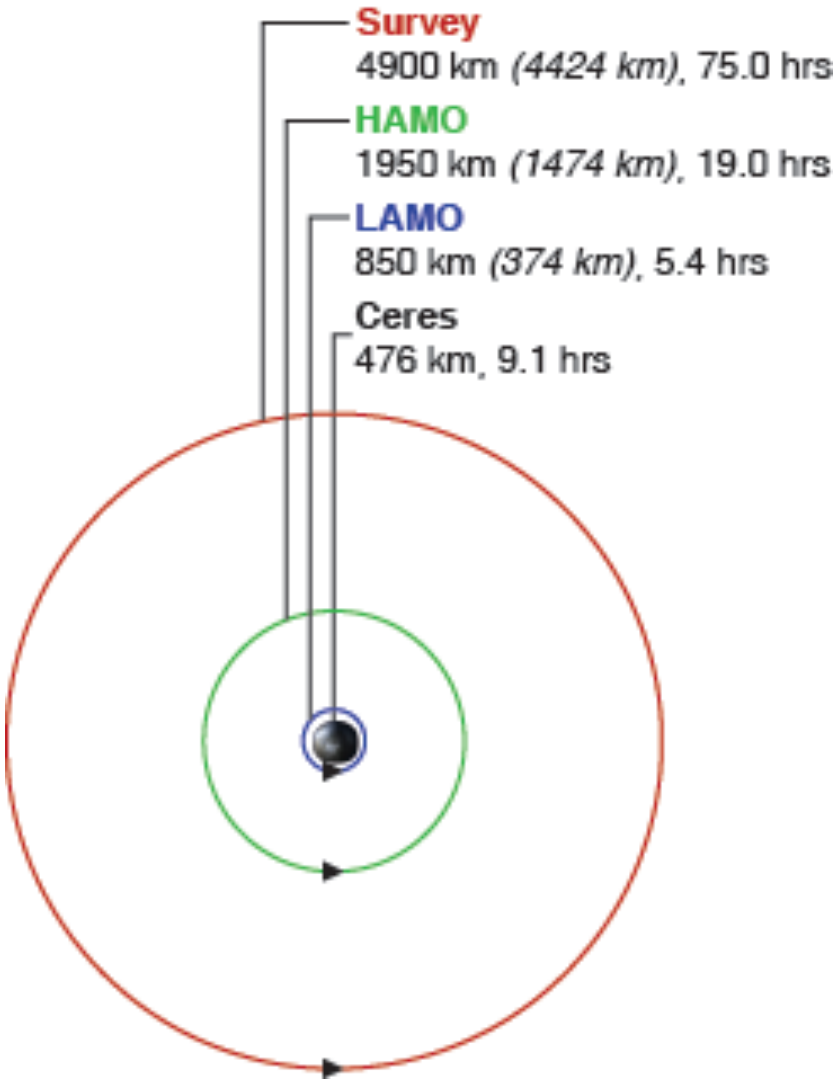


Ceres Preparation Timeline



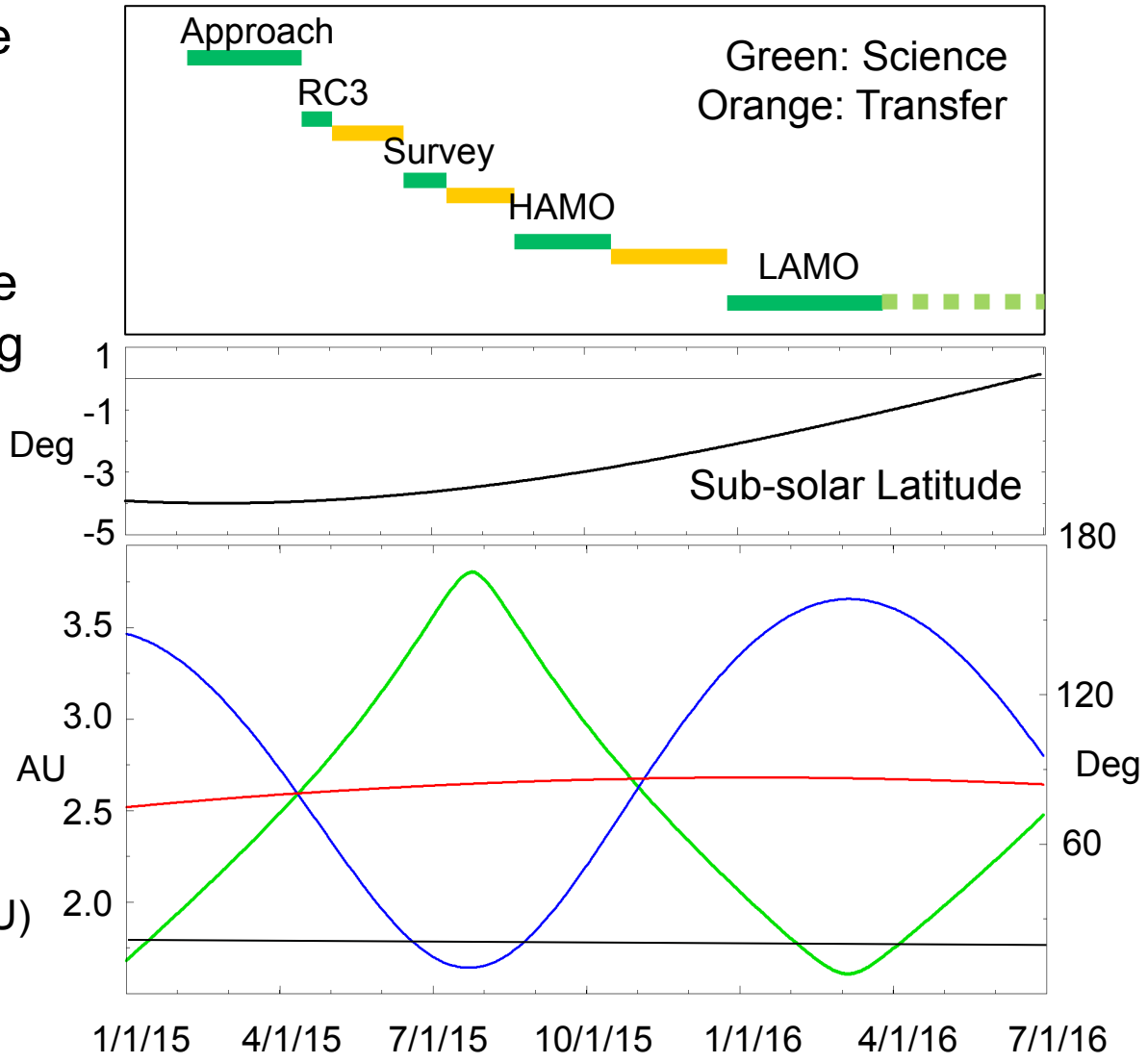
Ceres Science Orbits

- 406 days of operations are planned at Ceres
  - Primarily constrained by hydrazine
- **RC3**
  - Phase angle = varying
  - Duration 1 orbit (20 days)
  - Nadir rotation movies, high phase observations.
- **Survey Orbit:**
  - Beta angle = 10-25º drifting, Incl. = 90º
  - Duration 7 orbits (22 days)
  - Nadir mapping, limb observations
- **High Altitude Mapping Orbit (HAMO):**
  - Beta angle = 27-37º drifting, Incl. = 90º
  - Duration 70 orbits (56 days)
  - Nadir and fixed off-nadir mapping
- **Low Altitude Mapping Orbit (LAMO):**
  - Beta angle = 45-50º, Incl. = 90º
  - Duration 404 orbits (92 days)
  - Nadir pointed for GRaND
  - HGA-on-Earth for gravity (some LGA tracks)



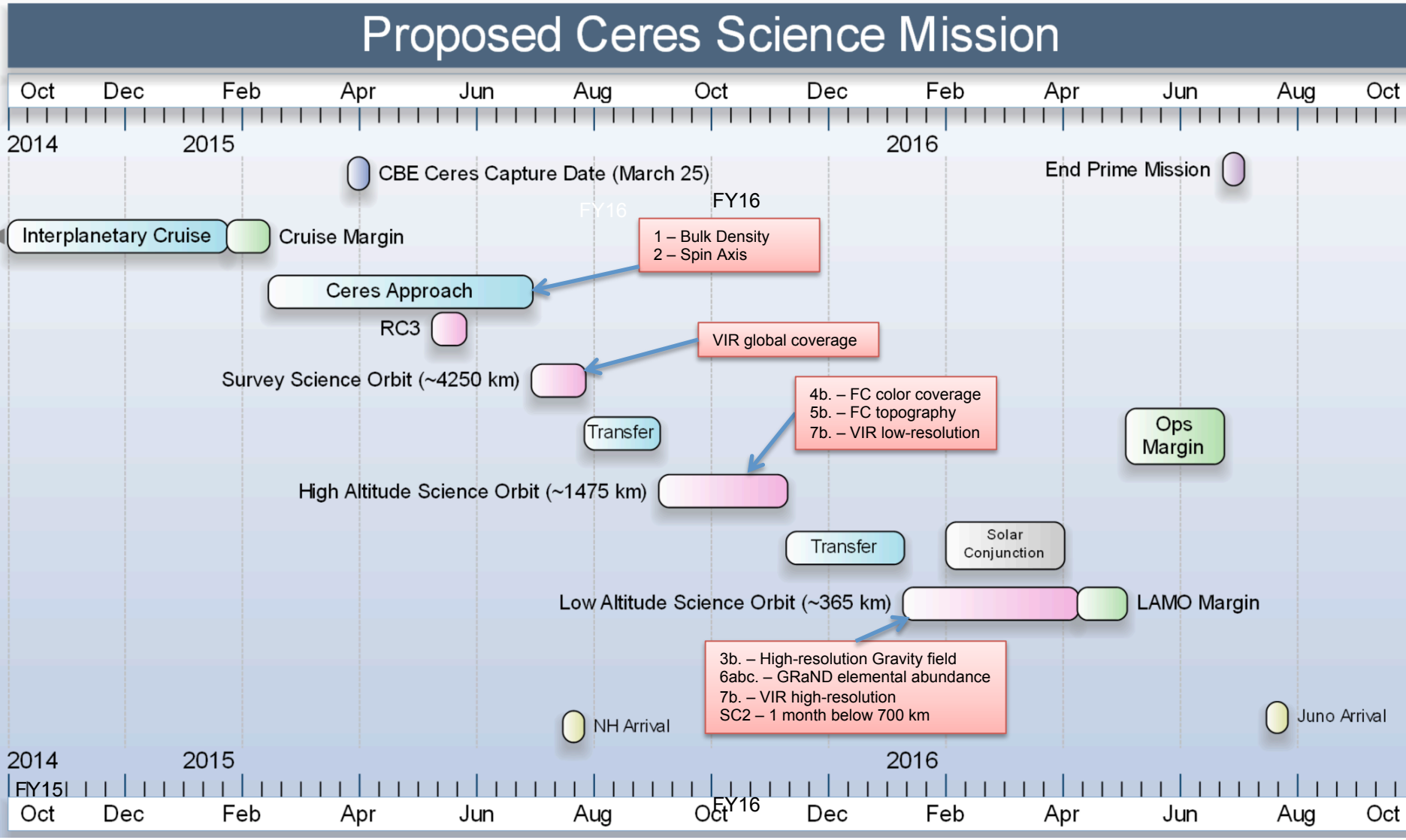
Ceres Lighting Conditions

- Lighting conditions are fairly constant during the Ceres encounter
- Sun Earth Probe angle drops below 20° during Feb - Mar

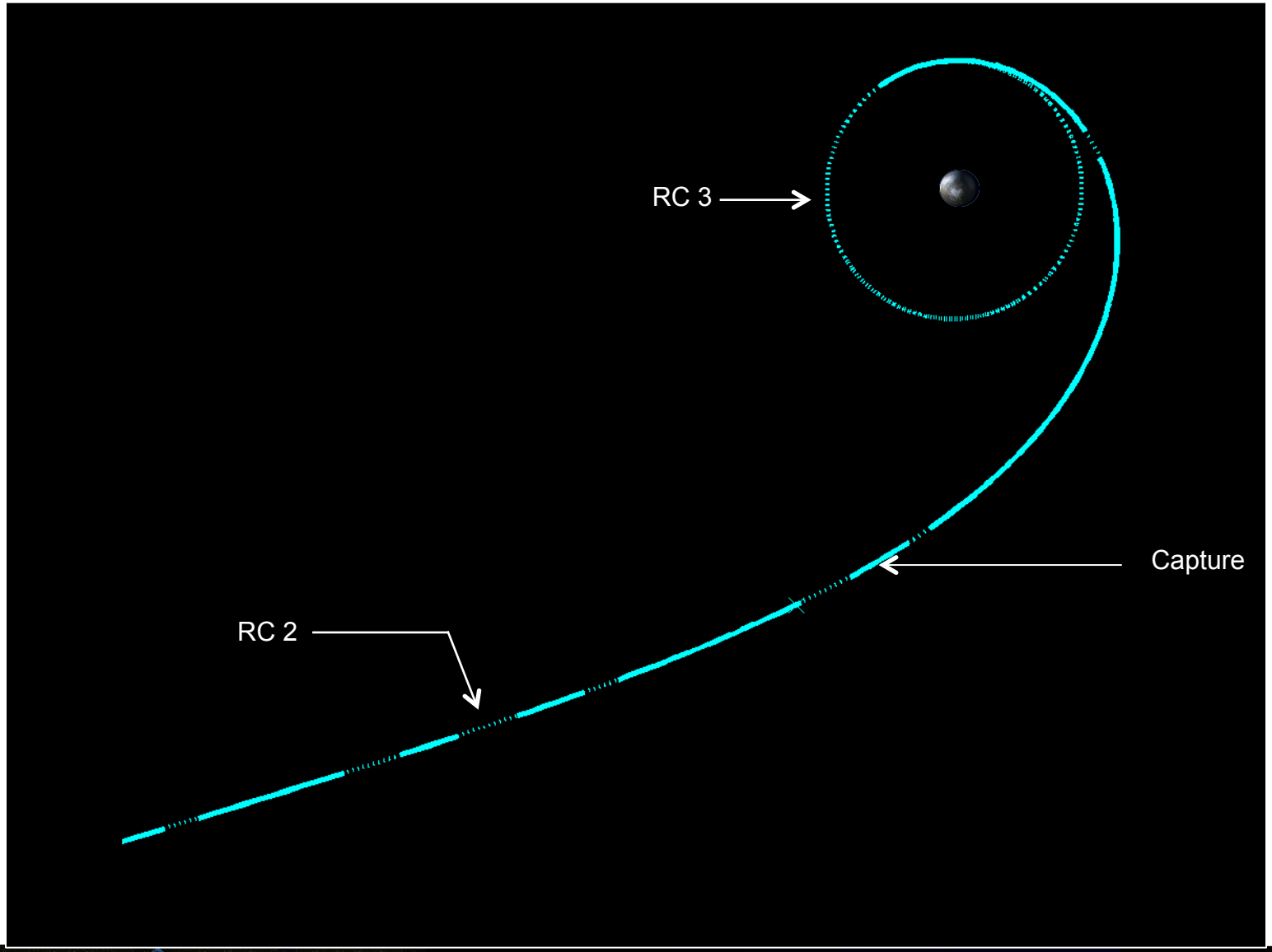


Bottom
Red: Sun-Dawn Range (AU)
Blue: Earth-Dawn Range (AU)
Green: SEP angle (Deg)

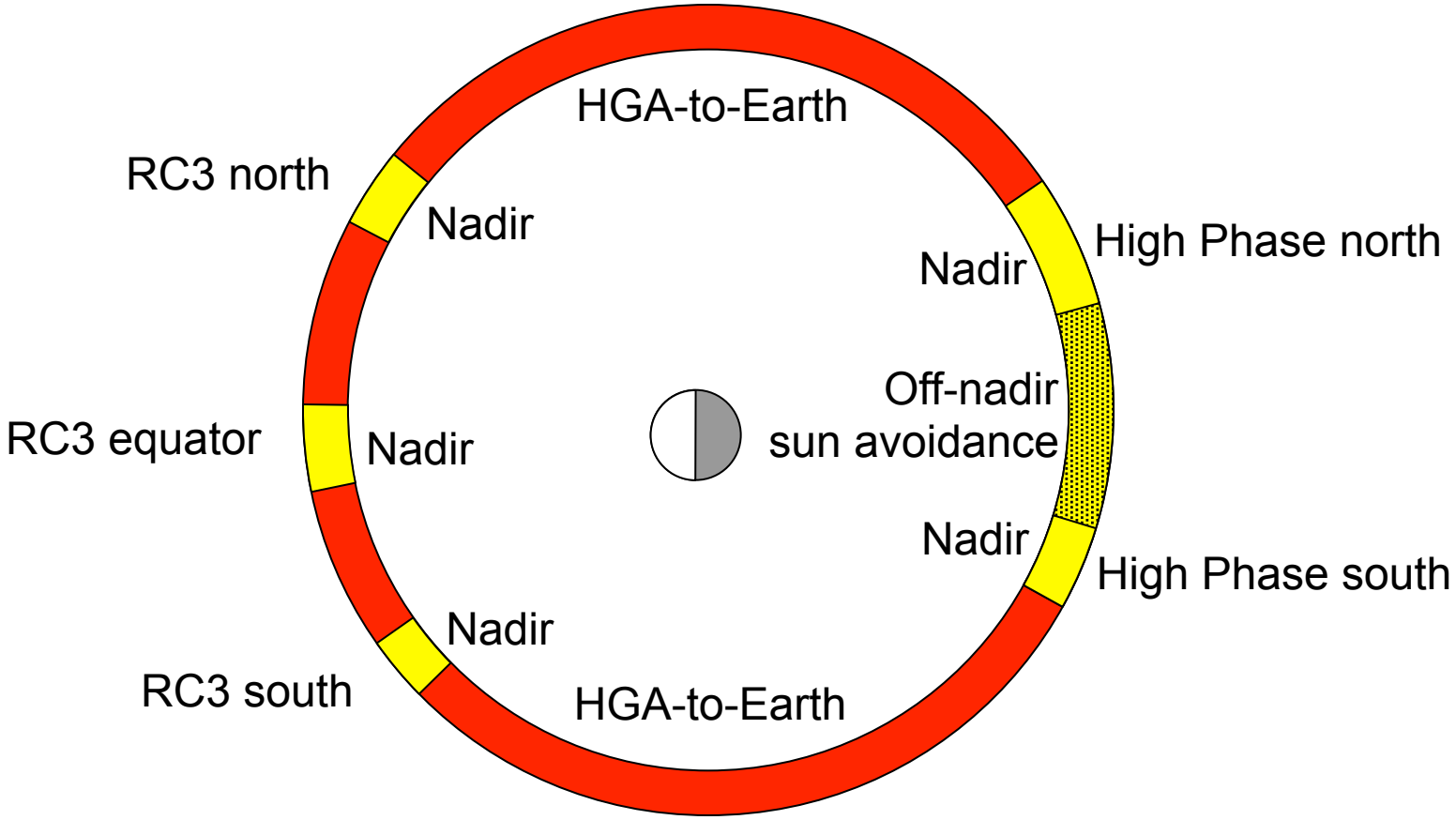
Ceres Mission Timeline



Ceres Late Approach and Capture

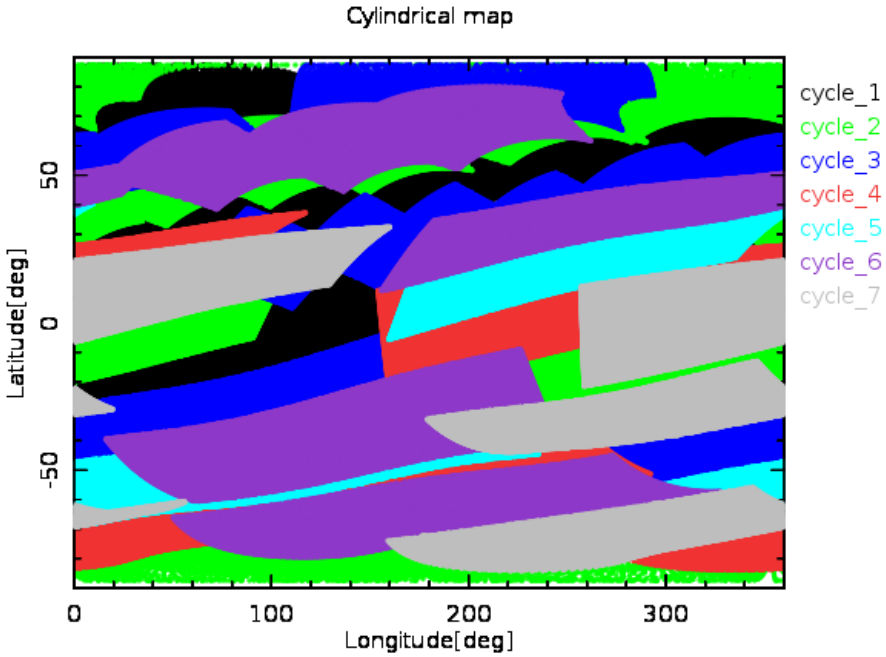


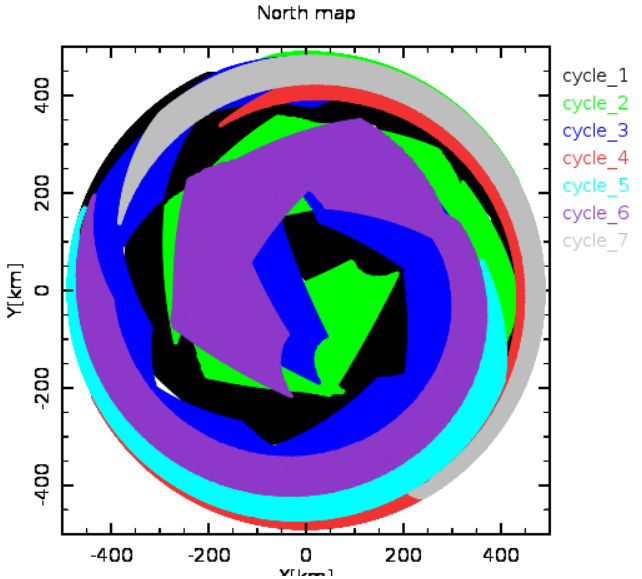
RC3 Observation Placement

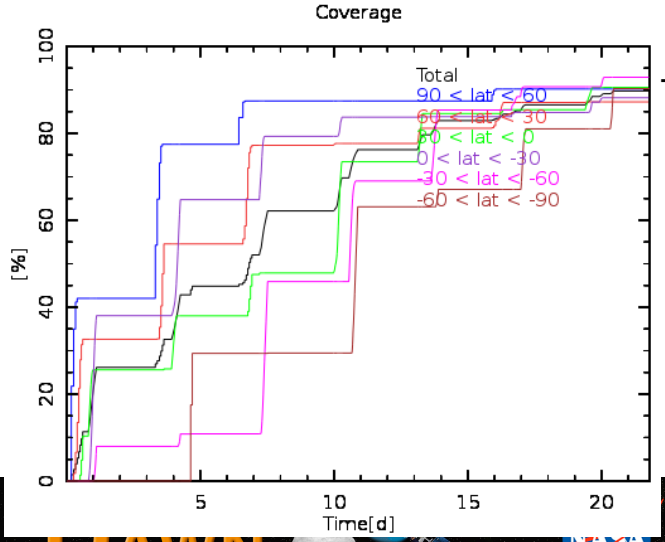


- Final order of observations will be determined during approach
  - Flexibility to re-order the observations keeps the phase duration to approximately one orbit period

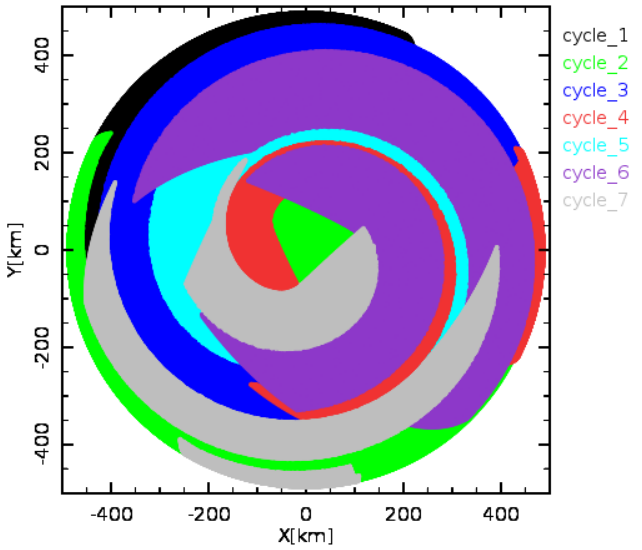
VIR Survey Orbit Coverage





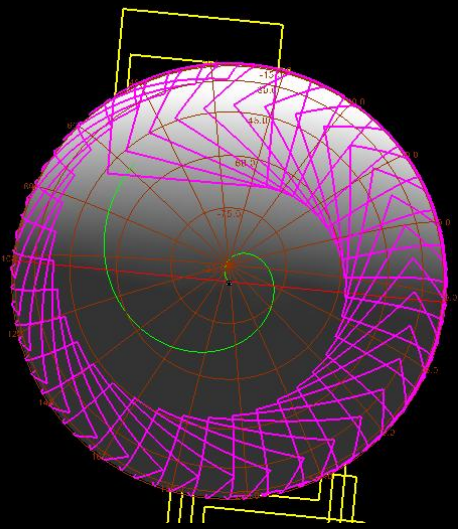


Total coverage ~ 90% (black)

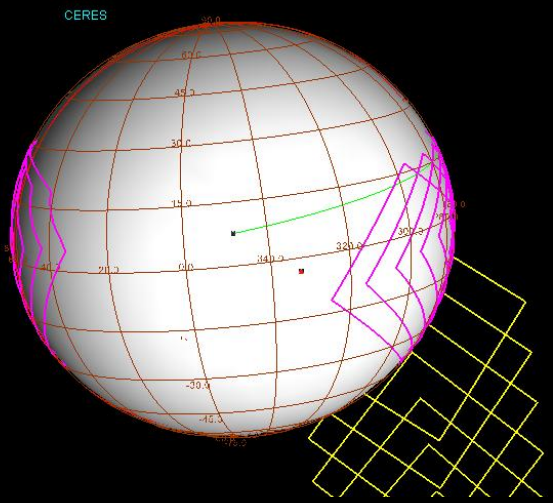


FC Survey Orbit Observation Examples

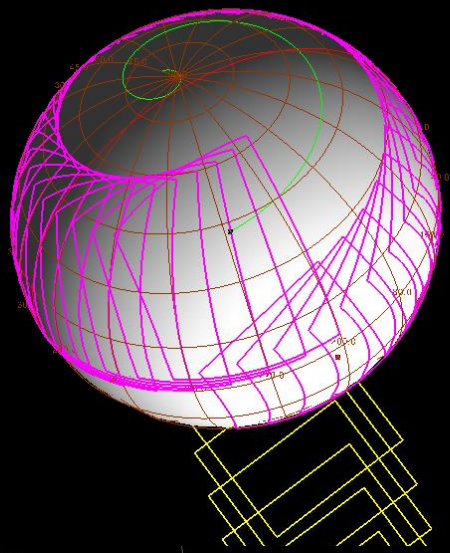
C1 limb from the south



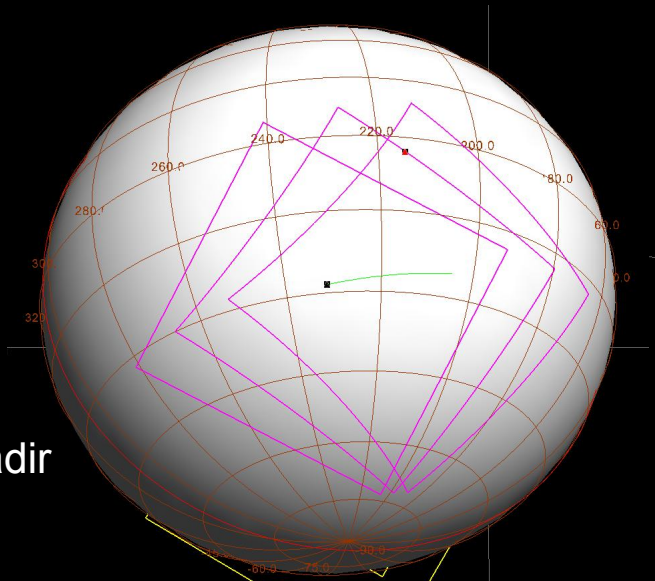
C2 limb from the equator

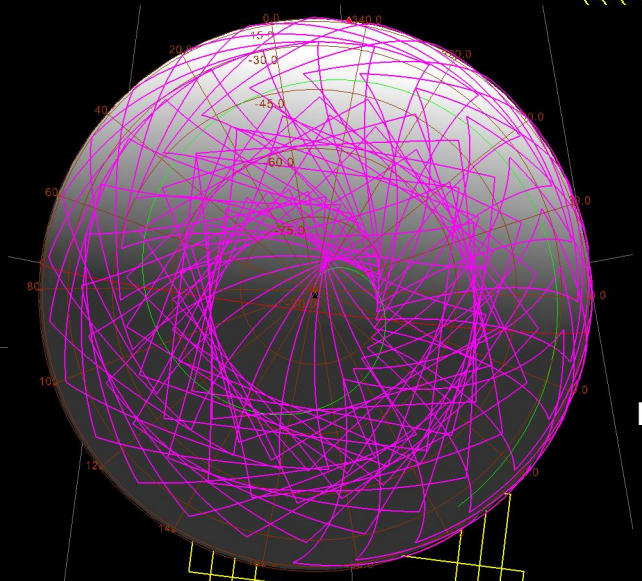


C4 limb from the north



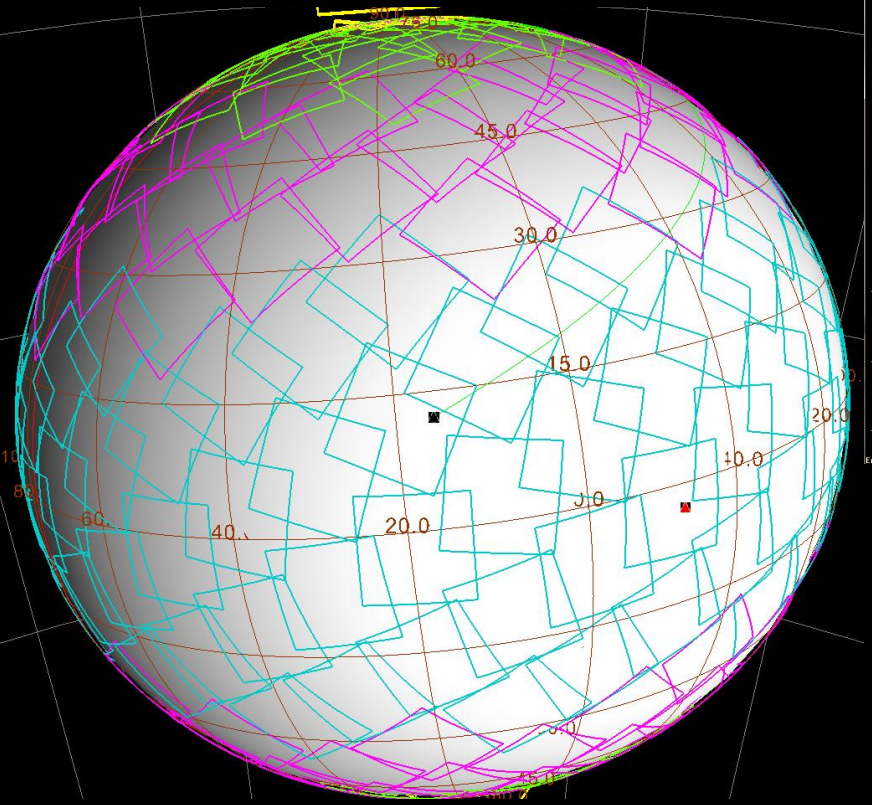
3 sample nadir FOV

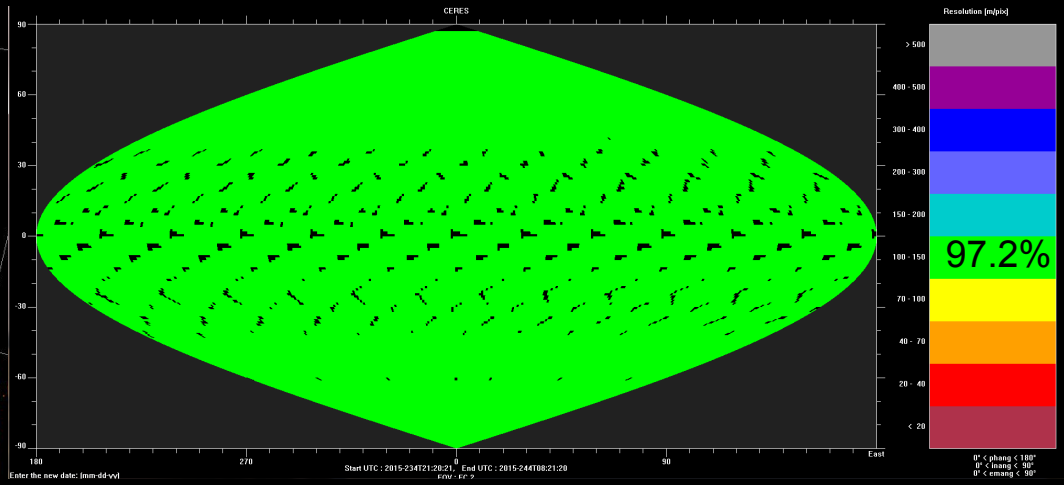




nadir coverage of the south pole

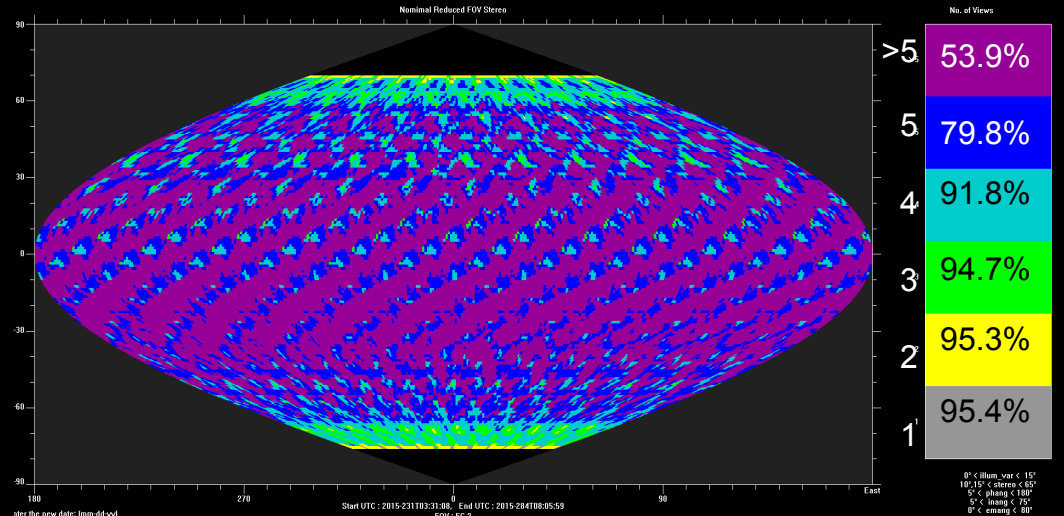
HAMO Imaging Coverage





Clear and Color coverage for the nadir cycle
(Conservative modeling with reduced FC FOV)

Planned topography coverage exceeds requirements



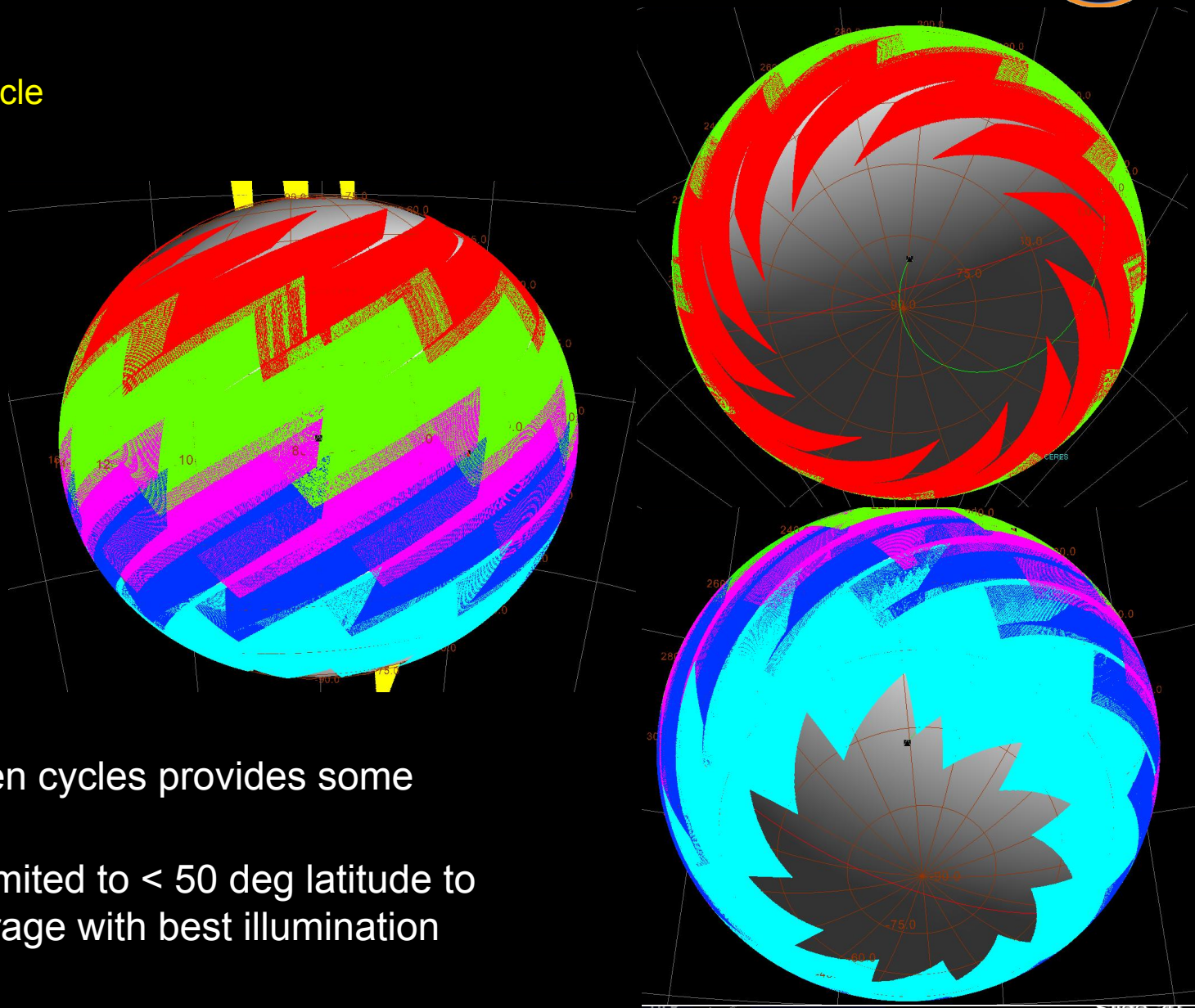
Mapping of 80% of the surface at 200m/pixel is required for both color imaging and topography

- HAMO resolution is < 140 m/pixel

VIR HAMO Coverage

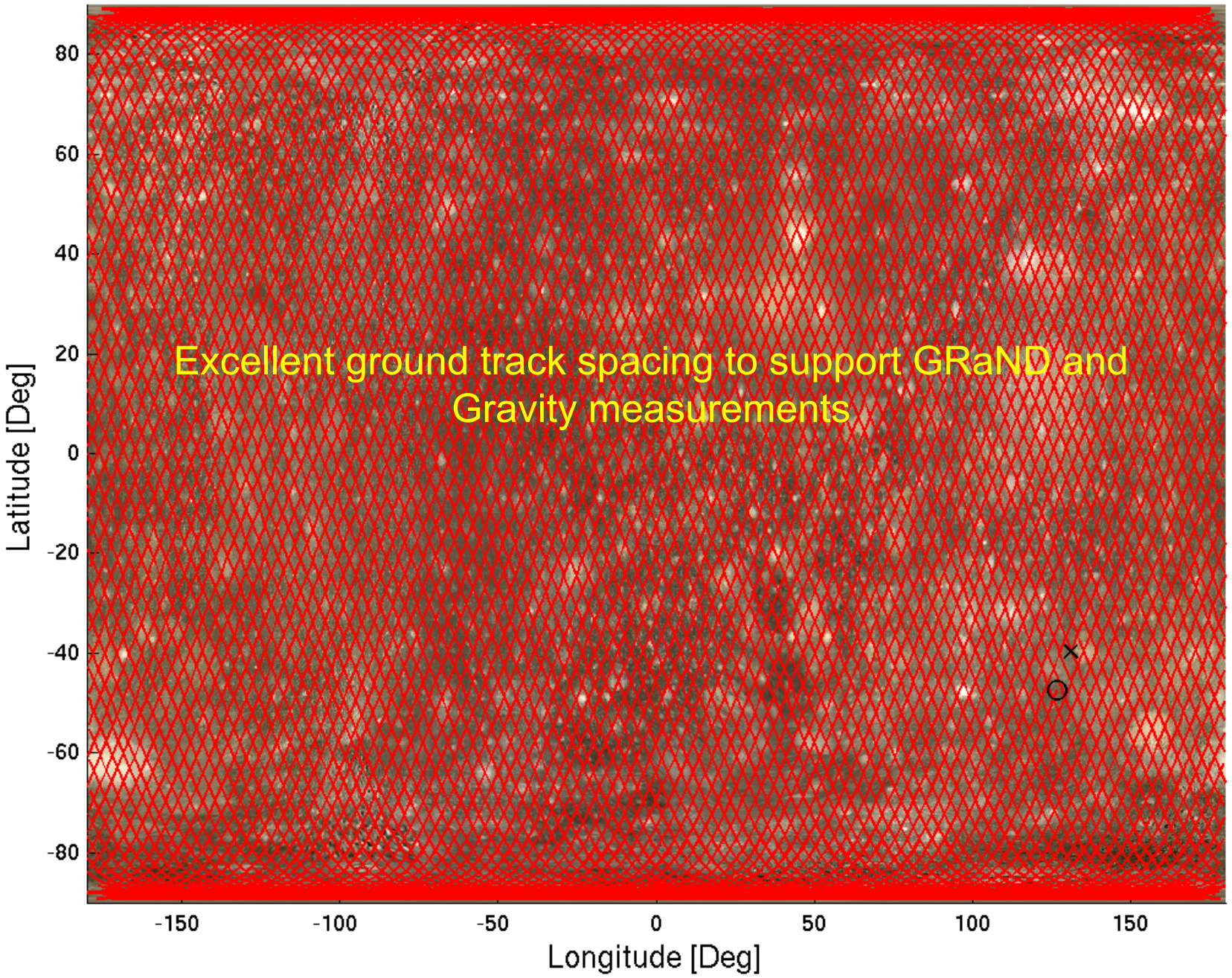
VIR coverage by cycle

- C1: Magenta
- C2: Cyan
- C3: Green
- C4: Orange
- C5: Blue



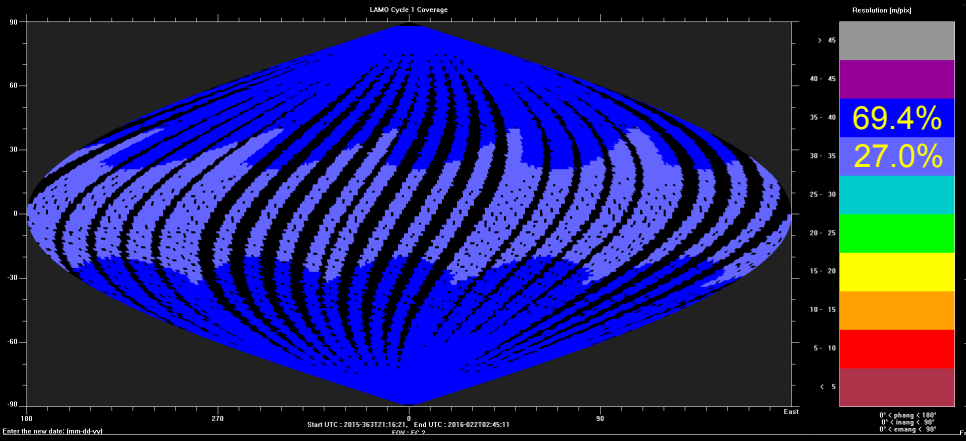
- Overlap between cycles provides some redundancy
- Observations limited to < 50 deg latitude to maximize coverage with best illumination conditions

LAMO: Ceres Latitude and Longitude

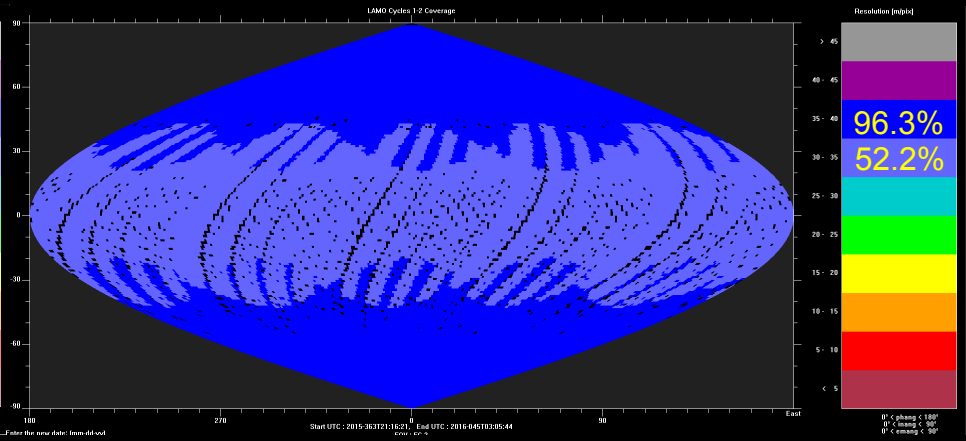


Nearly complete imaging coverage at 30-35m/pixel after 2 cycles at LAMO

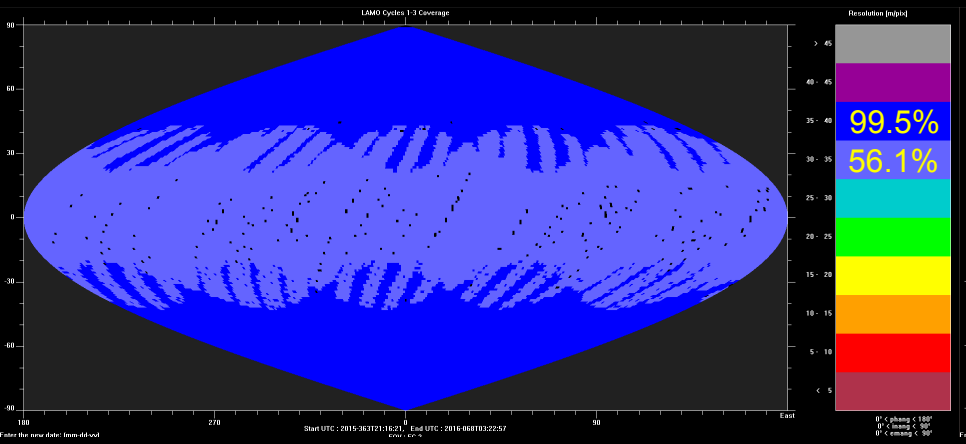
Cycle 1



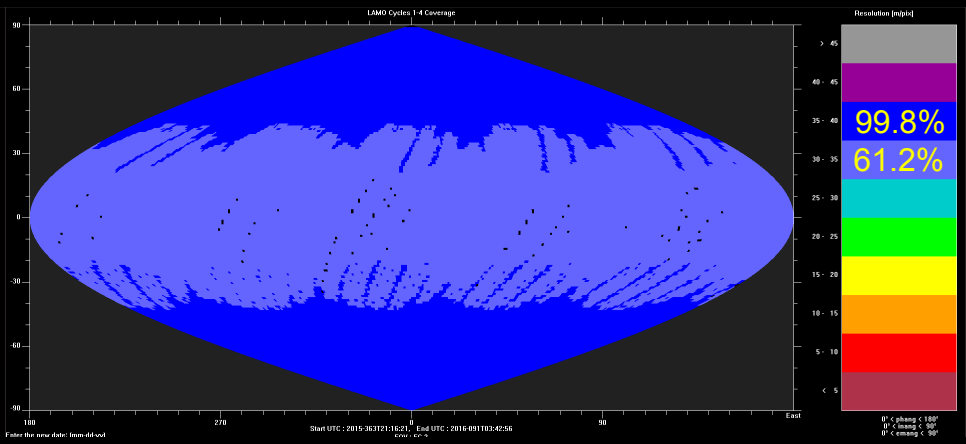
Cycles 1 - 2



Cycles 1 - 3



Cycles 1 - 4



Summary

- Despite the loss of two reaction wheels, Dawn will achieve all its objectives at Ceres
  - Team has worked diligently to recover the full science mission
  - Plan meets all requirements
- Ceres mission plans are complete and derive heritage from the Vesta mission
  - Results are planned to be similar to the Vesta results