NASA's Dawn Mission to Asteroid 4 Vesta:

Lucy McFadden

GSFC IT Symposium

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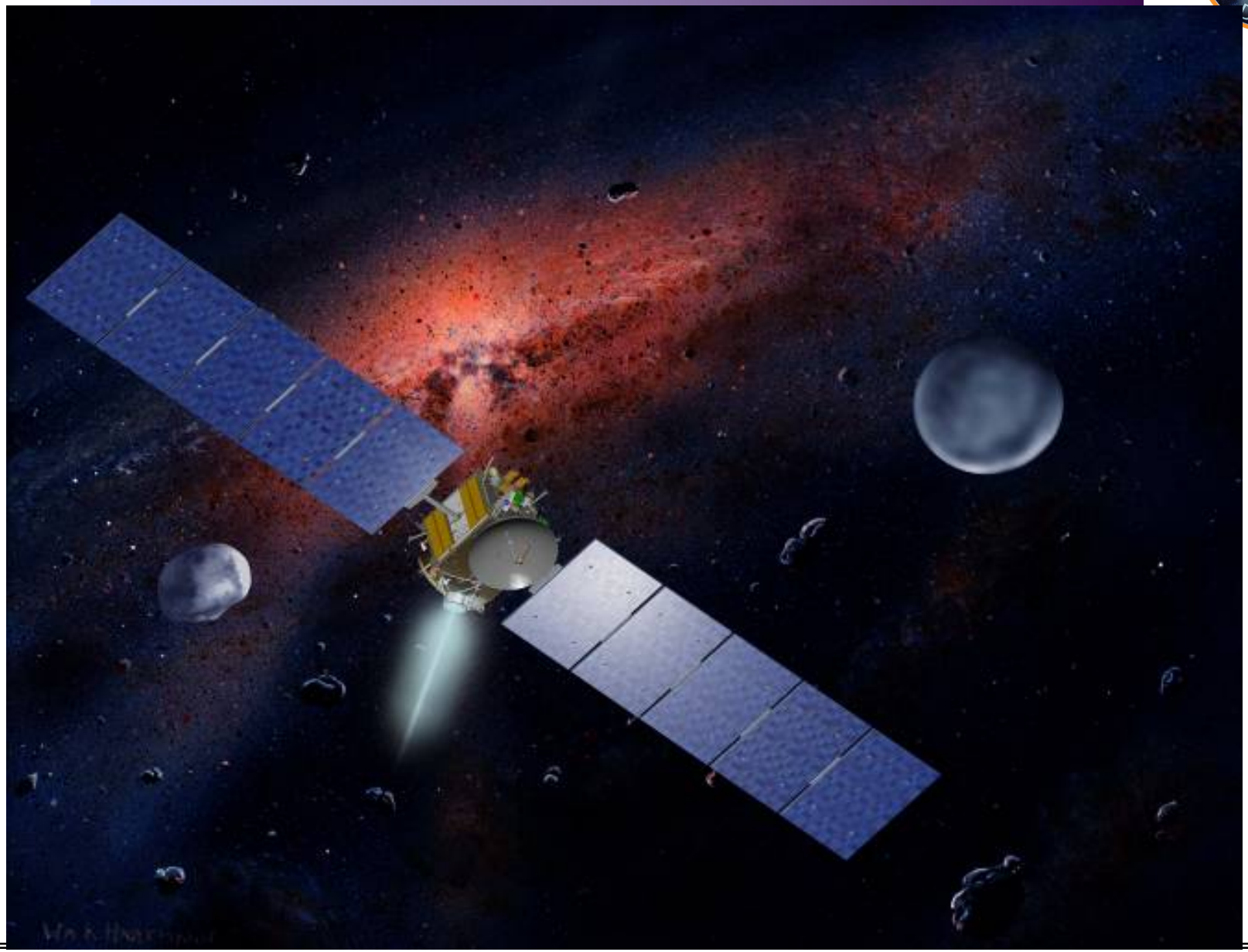
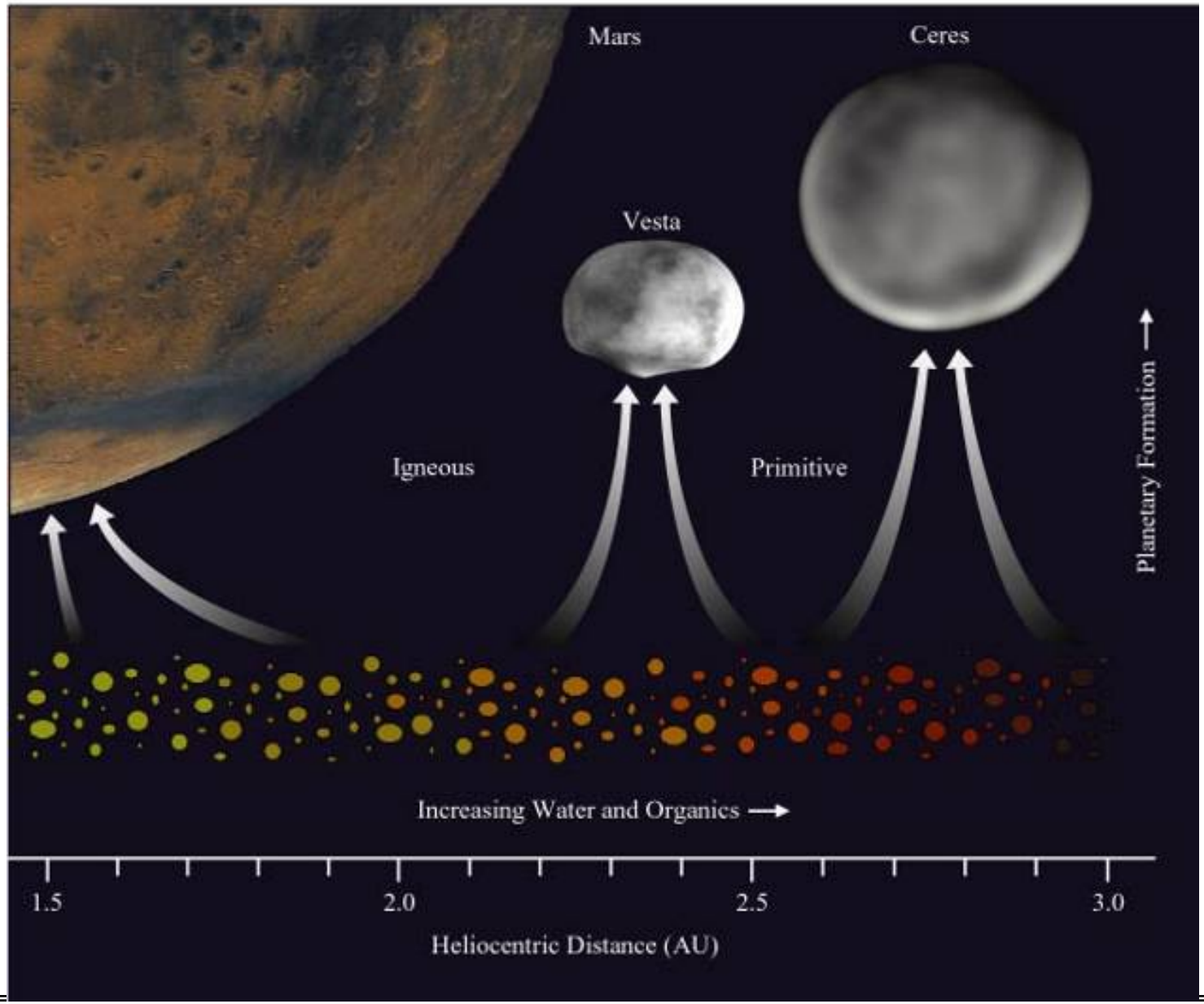
NASA's 9th Discovery Mission

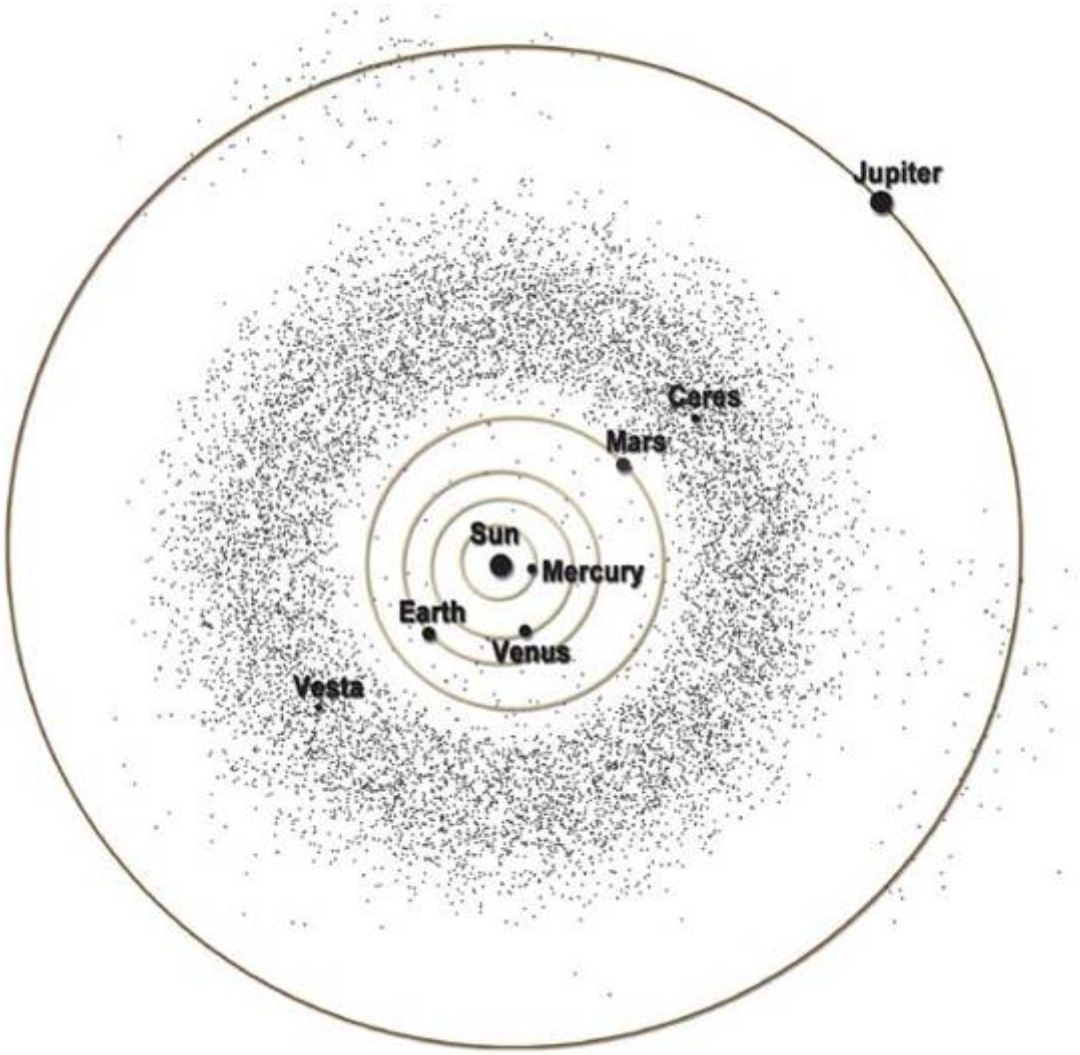


Traveling Back in Time

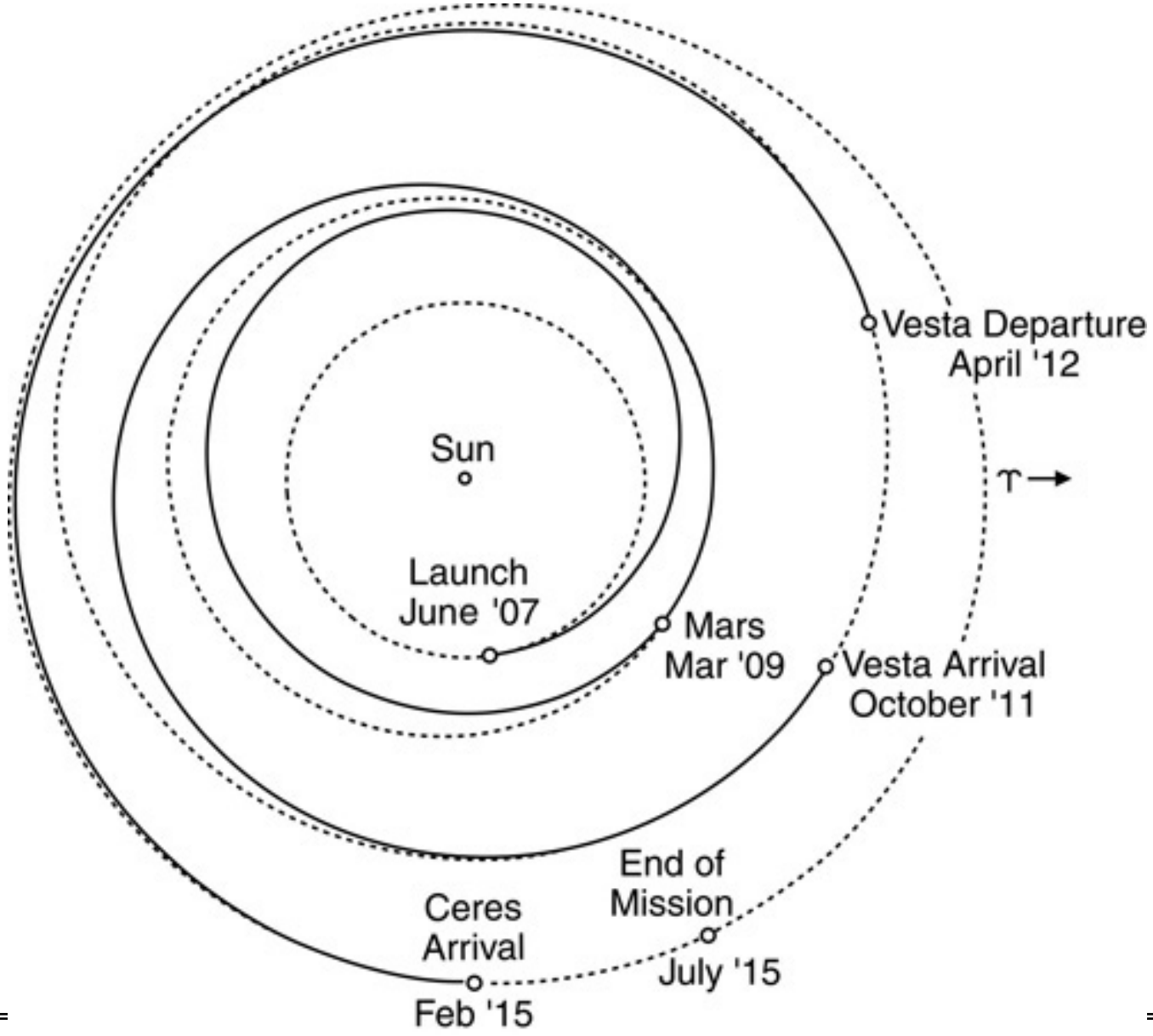
Planetary Perspective



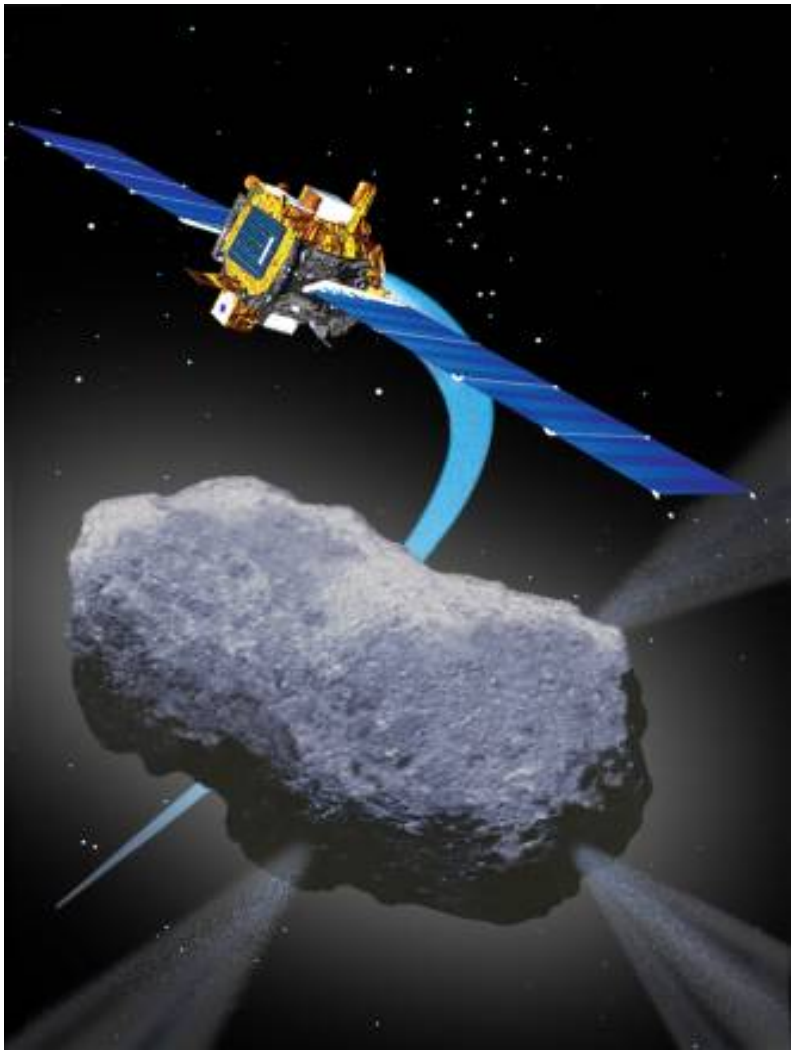
An Instantaneous View of the Main Asteroid Belt

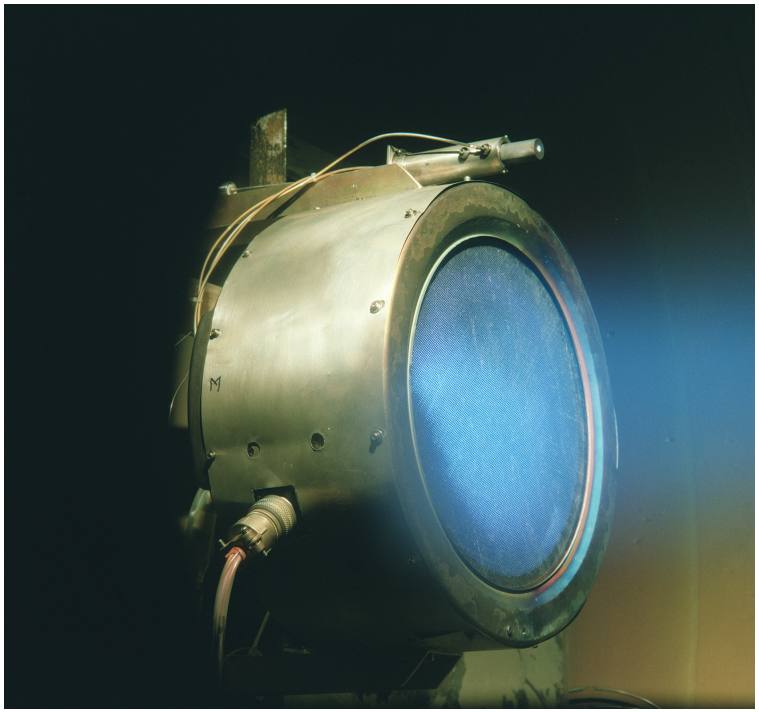


Dawn's Trajectory

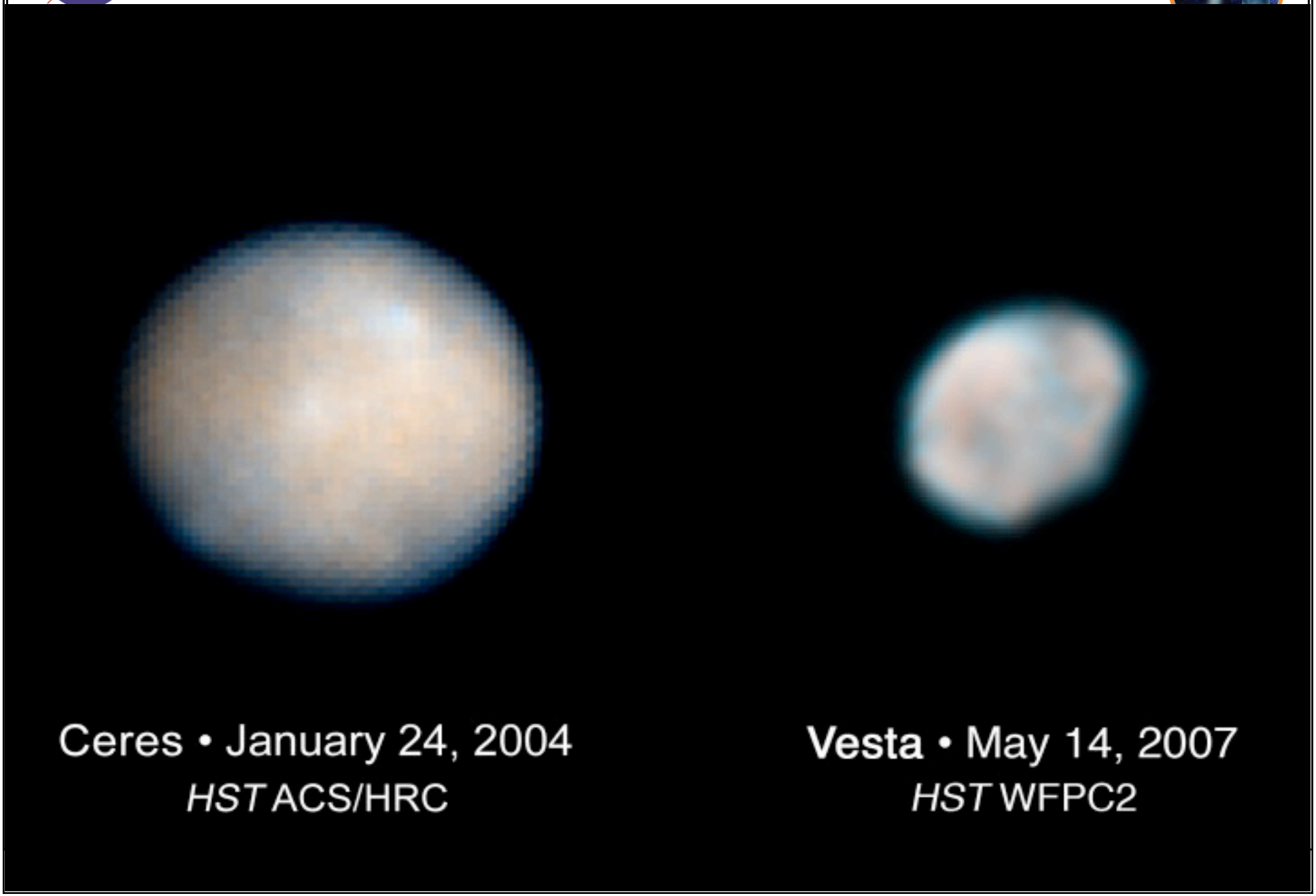


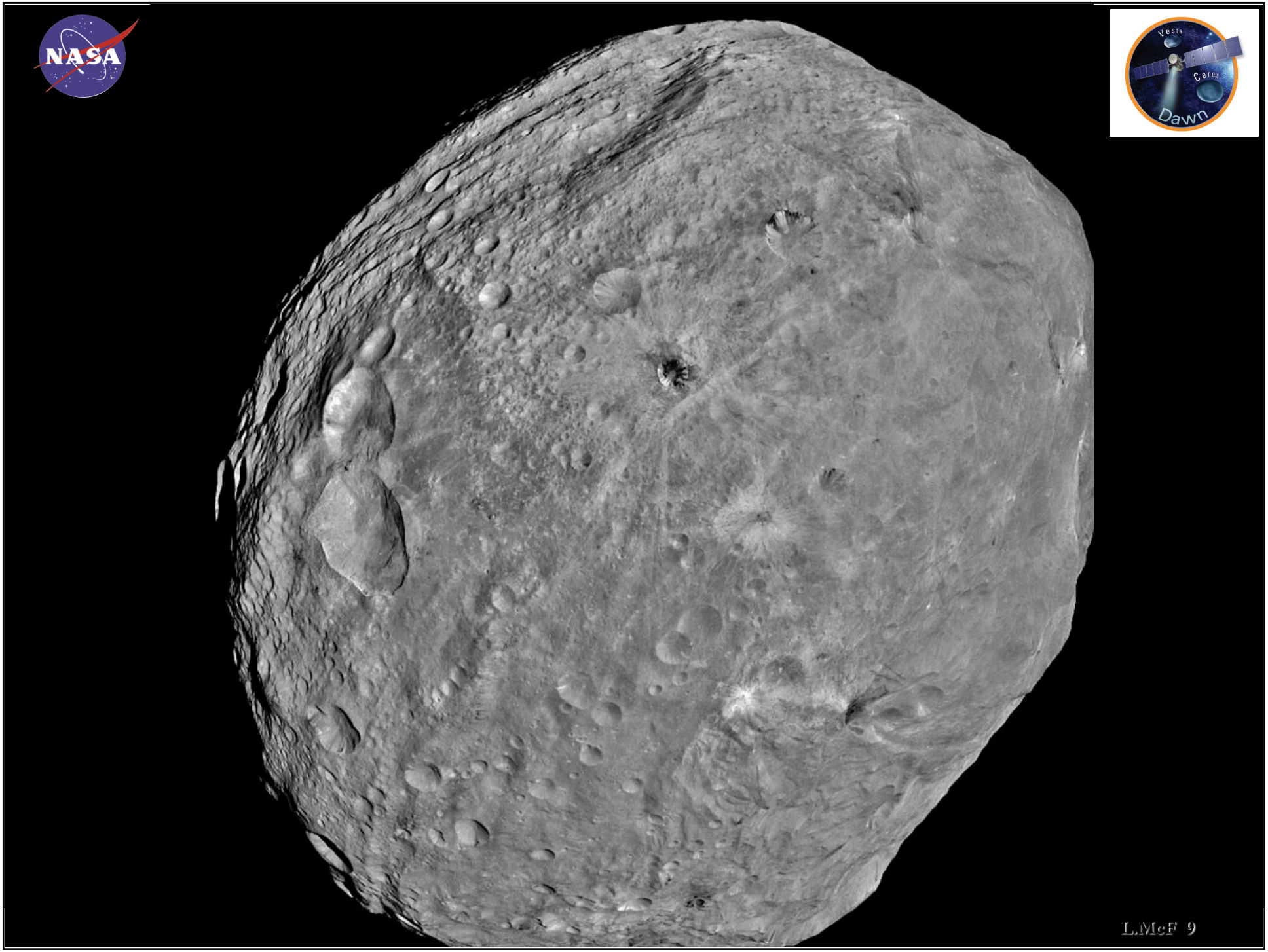
Computational Opportunity: Trajectory Prediction





Hubble Views

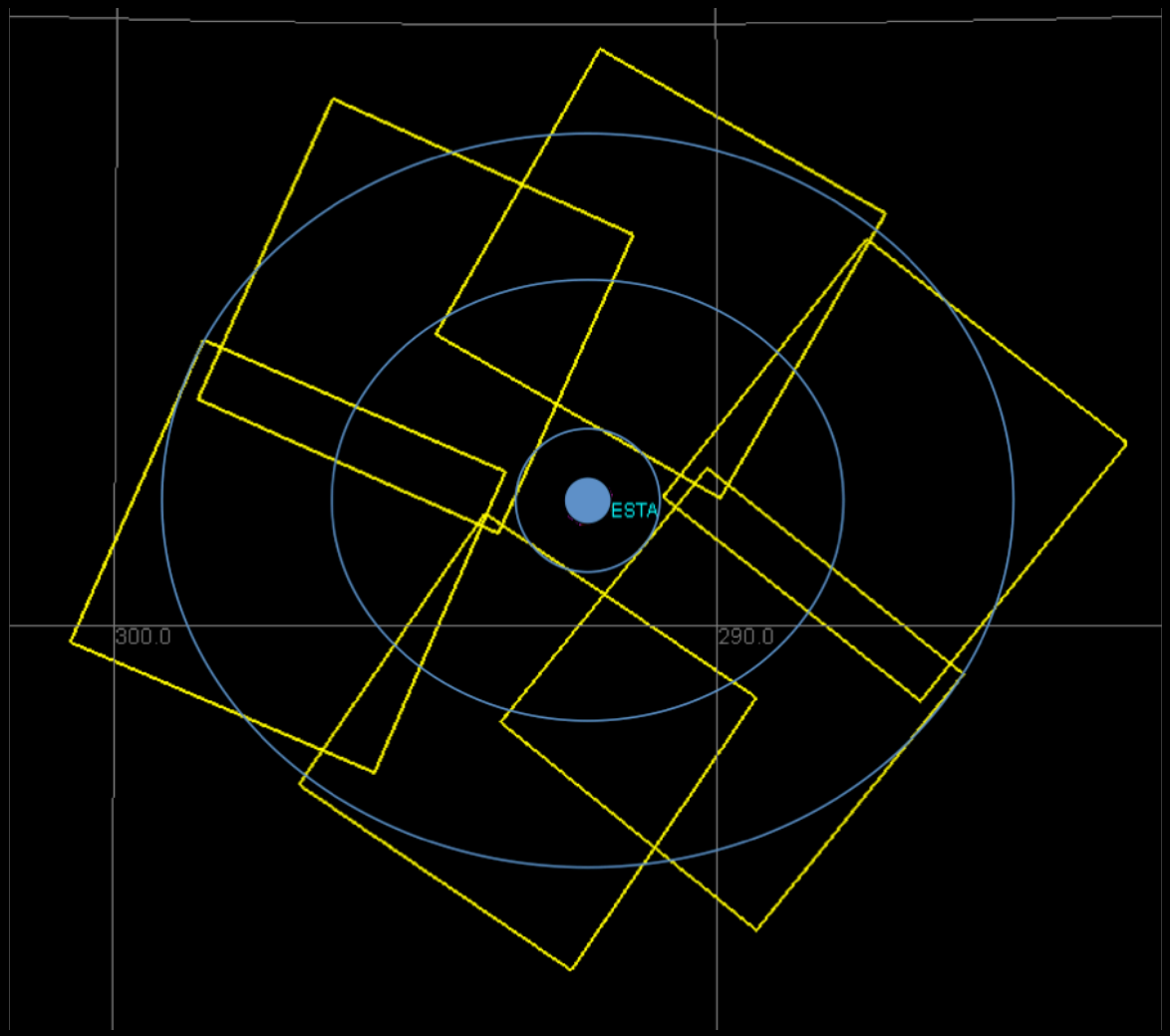



NASA
Vesta
Ceres
Dawn
L.McF 9

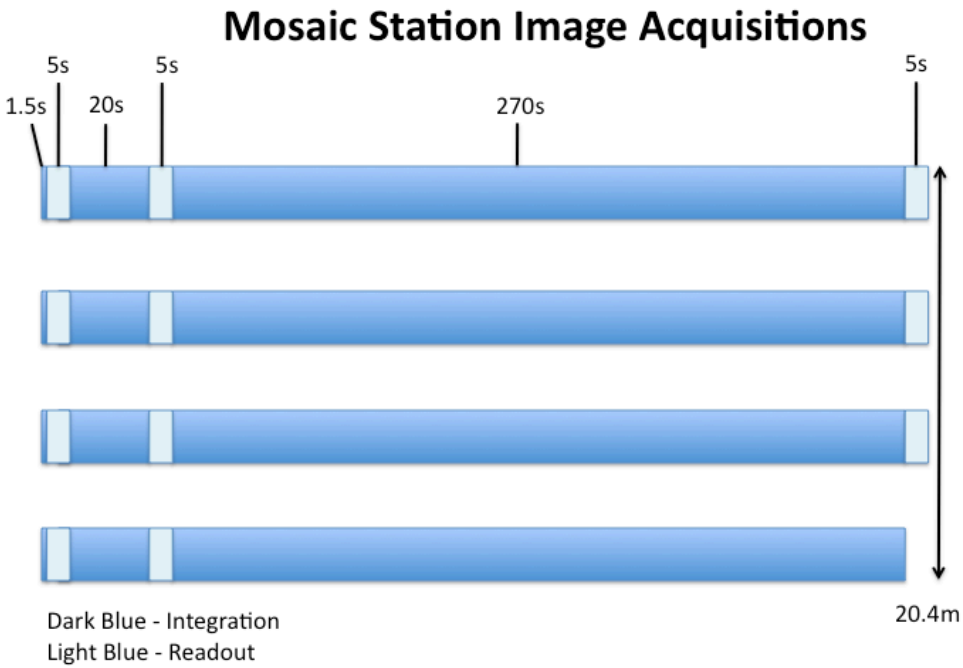
Satellite Search:

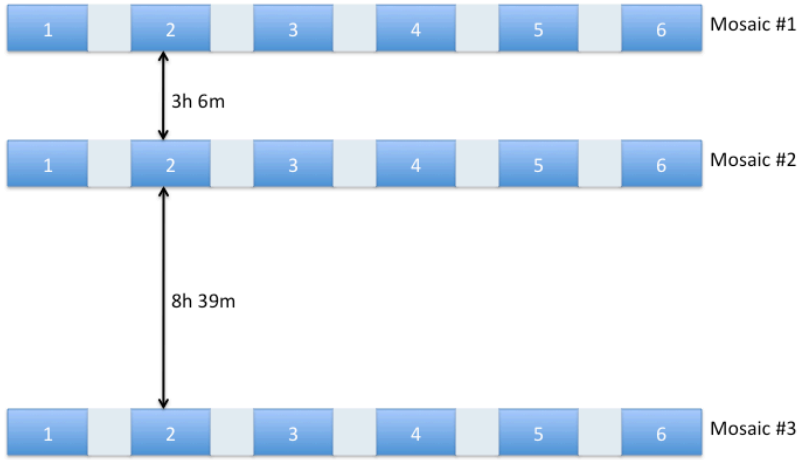
- Search for satellites of Vesta for
  - Spacecraft safety
  - Scientific interest related to dynamical history
- Approach: opnavs and sat search mosaics
  - Register, stack and blink opnav images
  - Difference images (OpNavs only)
  - High pass/unsharp mask filter
  - Determine astrometry
  - Identify asteroids in Vesta centric coordinates
  - Identify uncatalogued objects and register and stack

Mosaic Design



Spatial and Temporal Cadence





Orienting the Images in World Coordinate System

Thank you

Sam Roweis, Dustin Lang & Keir Mierle

University of Toronto

David Hogg & Michael Blanton

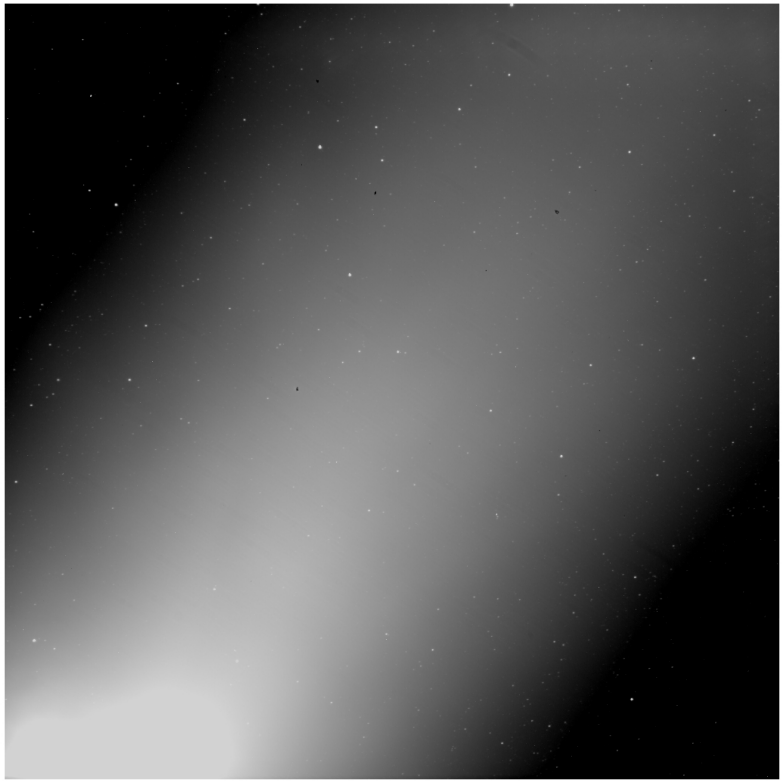
New York University

We start with a catalogue of stars in the sky,

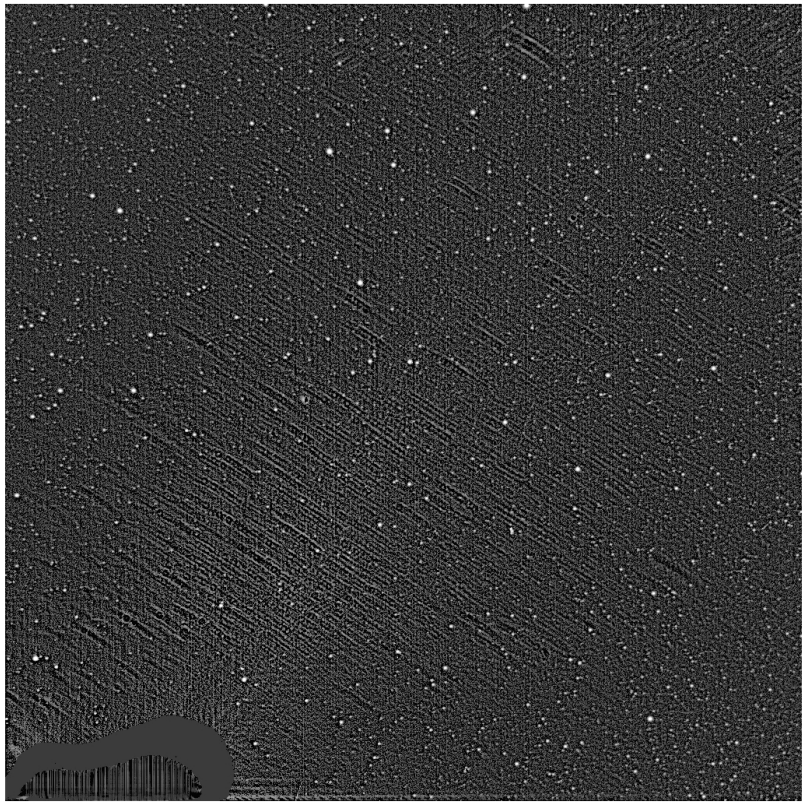
and from it build an index which is used to assist us in locating ('solving') new test images.

Image Processing

Long Exposure 270s

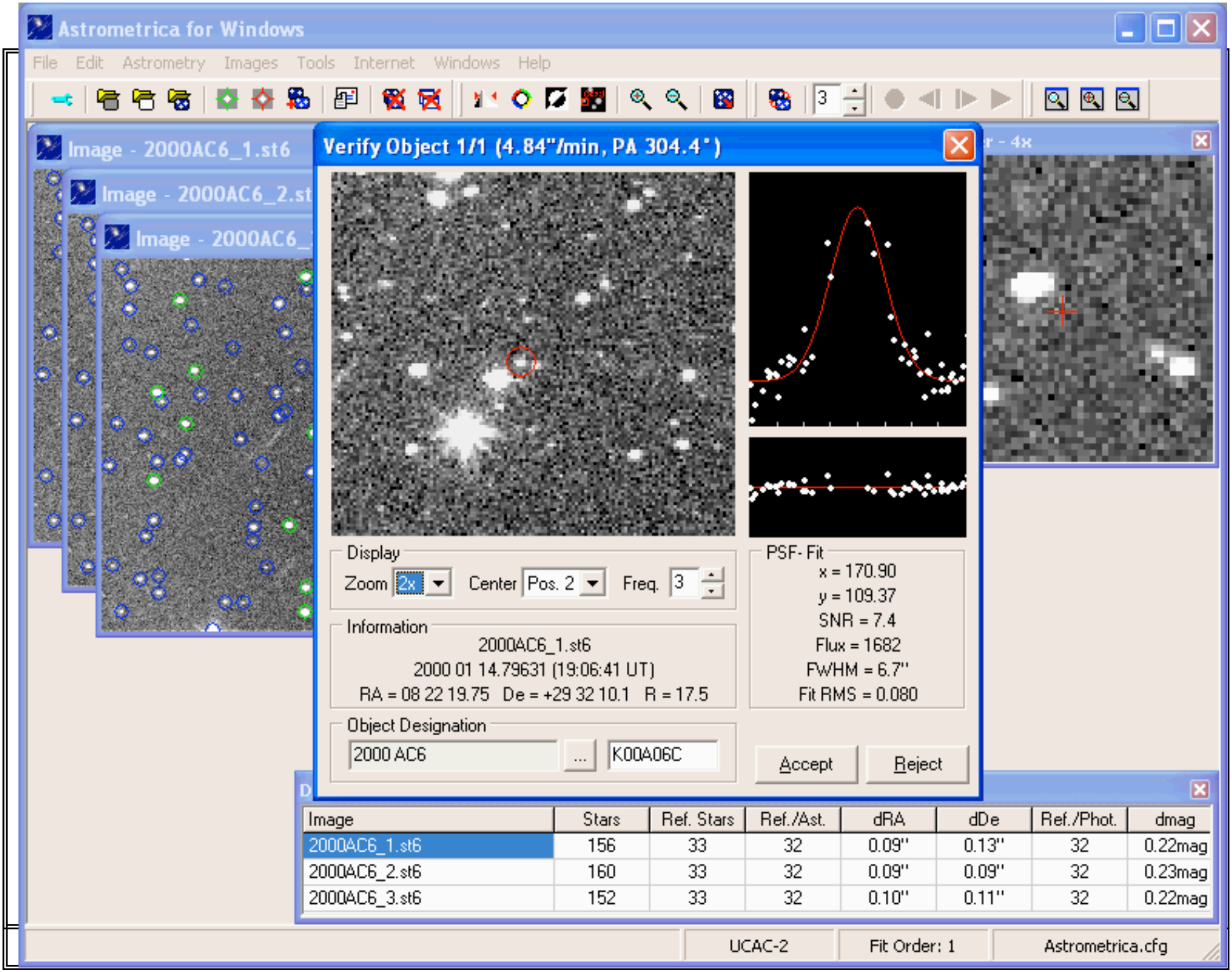


Unsharp Mask filter 9x9 box filter



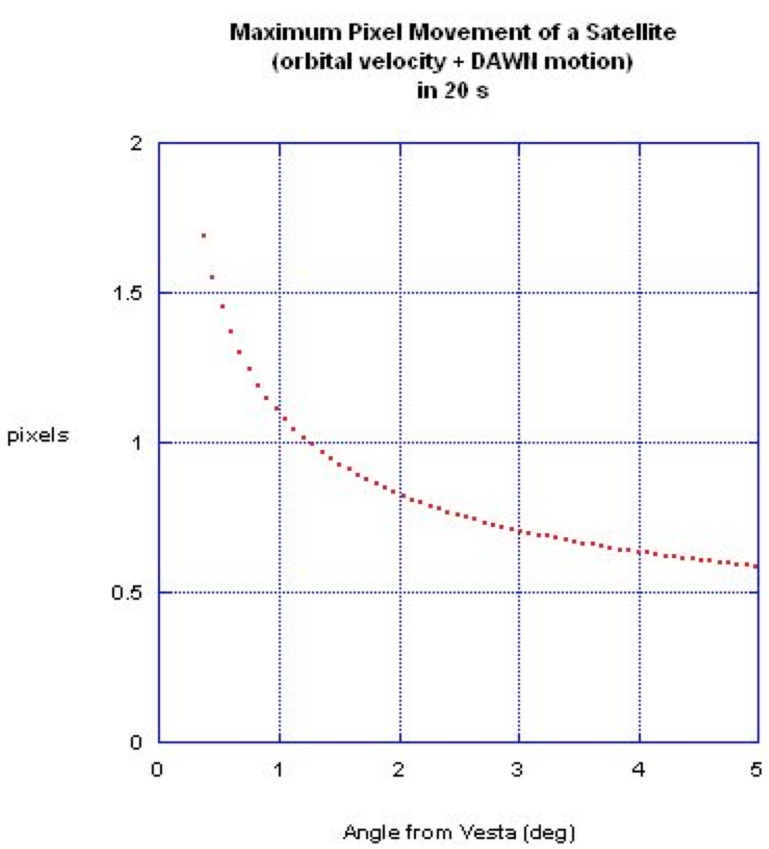
Astrometrica

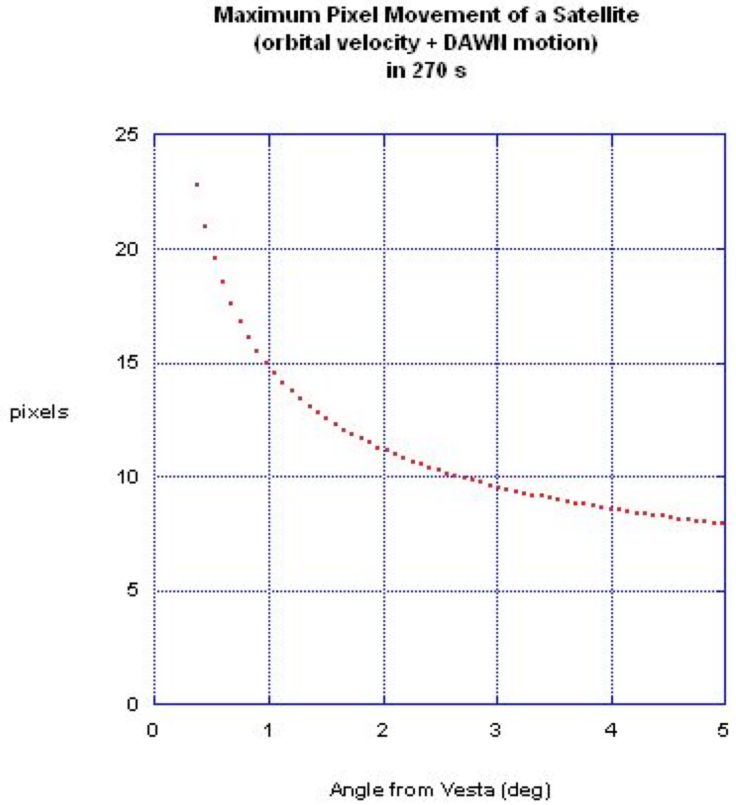
- http://www.astrometrica.at/
- Reads Fits format (8, 16 and 32 bit integer files).
- Image calibration (Dark Frame and Flat Field correction).
- Blinking with image registration.
- Zoom and 'Magnifying Glass' for close-up image inspection.
- Reference star identification, moving object detection and identification.
- Track and Stack' function to follow fast or very faint moving objects.
- Access to new-generation star catalogues (PPMXL, UCAC 3 and CMC-14).
- Dave Skillman asked the developer to insert Dawn's trajectory coordinates.
- Latest version is 4.6.5.389


Astrometrica for Windows
File Edit Astrometry Images Tools Internet Windows Help
Image - 2000AC6_1.st6
Image - 2000AC6_2.st
Image - 2000AC6_
Verify Object 1/1 (4.84"/min, PA 304.4°)
Display
Zoom 2x
Center Pos. 2
Freq. 3
Information
2000AC6_1.st6
2000 01 14.79631 (19:06:41 UT)
RA = 08 22 19.75 De = +29 32 10.1 R = 17.5
Object Designation
2000 AC6
K00A06C
PSF-Fit
x = 170.90
y = 109.37
SNR = 7.4
Flux = 1682
FWHM = 6.7"
Fit RMS = 0.080
Accept
Reject
Image Stars Ref. Stars Ref./Ast. dRA dDe Ref./Phot. dmag
2000AC6_1.st6 156 33 32 0.09" 0.13" 32 0.22mag
2000AC6_2.st6 160 33 32 0.09" 0.09" 32 0.23mag
2000AC6_3.st6 152 33 32 0.10" 0.11" 32 0.22mag
UCAC-2
Fit Order: 1
Astrometrica.cfg

Detectability

Fast moving objects will trail several pixels in 270 exposures





almost all possible satellites will stay in a single pixel during a 20s exposure, and almost all satellites will trail across multiple pixels on the 270s exposures.

Catalogue Comparison

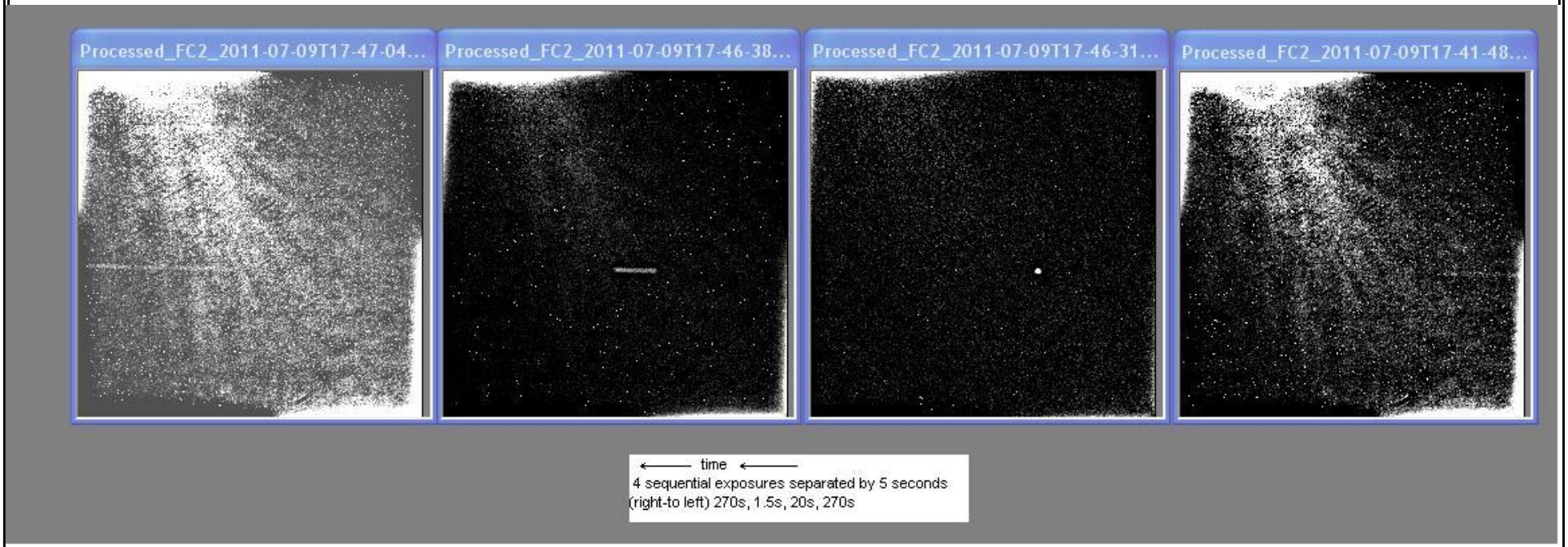
Detection limit ~10 m diameter

- Input
  - Raw FITS/LBL files (DSC)
  - WCS files from Astrometry.net processing (GSFC)
  - GSC/UCAC3 catalogs (STScI/ USNO)
- Image Processing
  - Run object detection algorithm
  - Match objects to catalogs
  - Perform image calibration with reference catalogs (mag<12)
    - Astrometry ~ 2-4” rms per axis
    - Photometry ~0.2-0.5 mag rms
  - Match objects between frames to reject cosmic ray hits and bad pixels from object list
  - Identify real detected objects that do not match catalogs for further investigation

- Output
  - Self-contained FITS files with useful keyword metadata
  - Mean/Median images from each observing sequence
  - Mean/Median dark frames
  - JPG images of each frame with matched and unmatched candidate objects
  - MP4 file of all frames in an observation sequence with candidate objects identified
  - Text files with details of candidate observations from each observing sequence

Findings

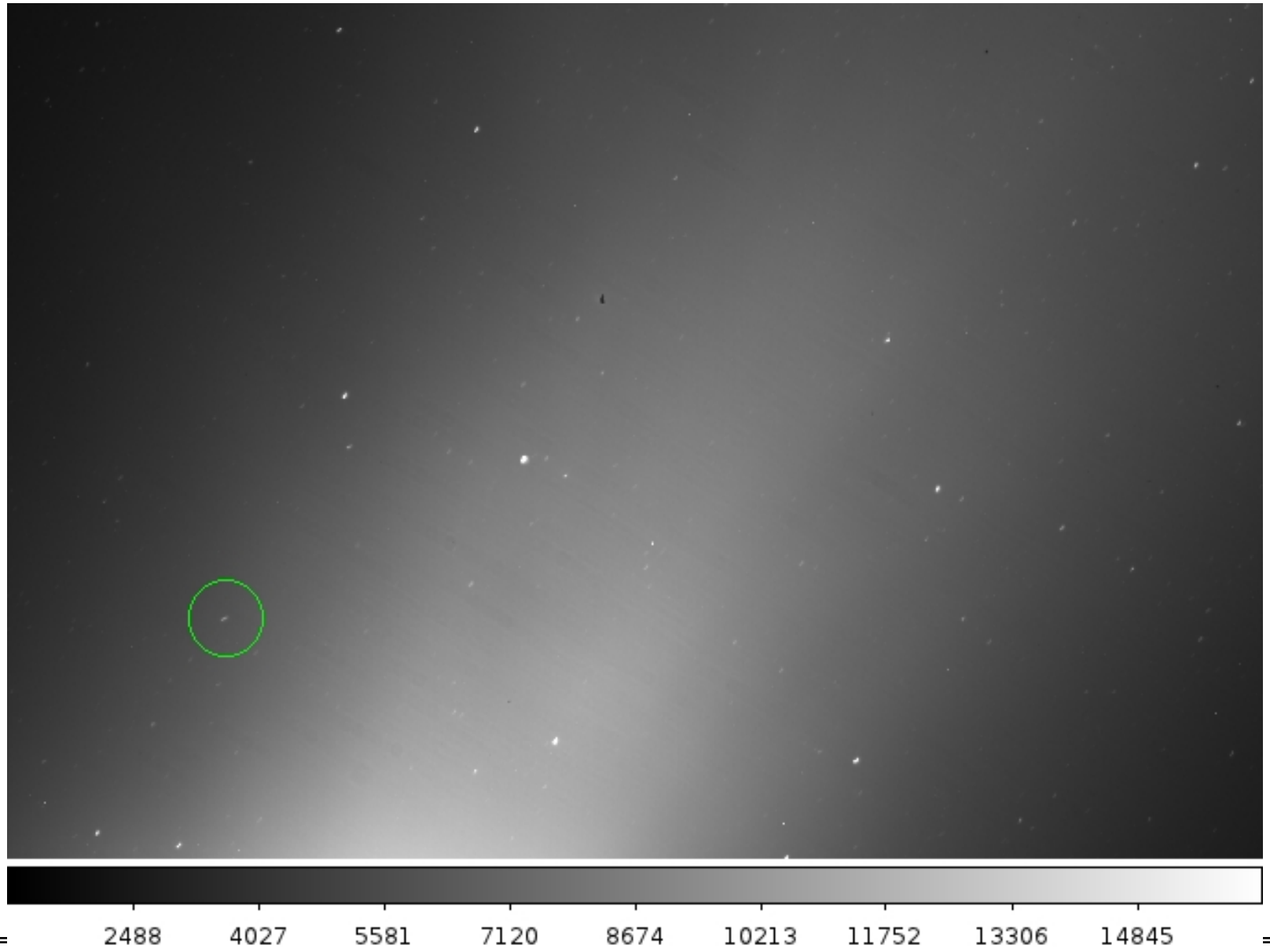
Almost Nothing



4 sequential exposures separated by 5 seconds

Right to left, 270 s, 1.5 s, 20 s, 270 s

Results



Thanks: Satellite Search Team

- Nargess Memarsadeghi, Dave Skillman, GSFC
- Max Mutchler, Brian McLean, STSci
- Mark Sykes, Pasquale Tricarico, Eric Palmer PSI
- Jian Yang Li, UMD
- Uri Carsenty, Stefano Mottola, DLR Berlin
- Steve Joy, Chris Russell, UCLA
- Andreas Nathues, Uwe Keller, MPI-Lindau
- Holger Sierks, Stefan Schroeder, Pablo Gutierrez and the FC team
- Carol Raymond, Carol Polansky, Marc Rayman, Stacy Weinstein-Weiss JPL

One Satellite of Vesta

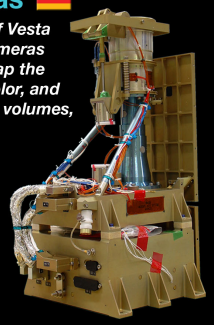
Dawn

A journey to the beginning of the solar system

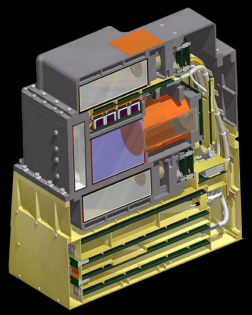
Framing Cameras

By imaging the surfaces of Vesta and Ceres, the framing cameras will enable scientists to map the topography, albedo and color, and to determine their shapes, volumes, and spin rates.

Holger Sierks
Framing Camera Lead, MPS

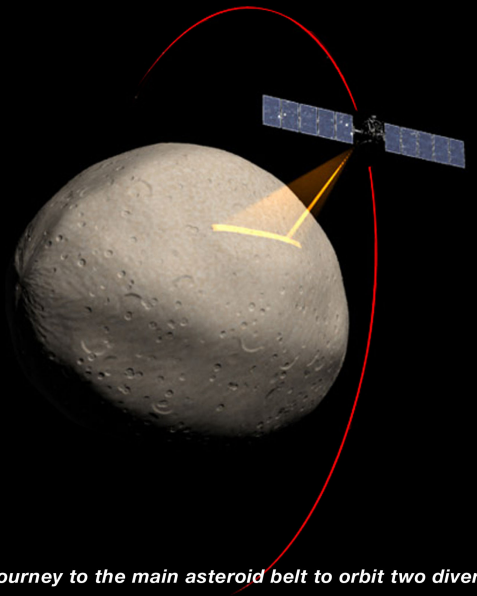


Gamma Ray Neutron Detector



GRaND *measures elemental abundances on the surfaces of Vesta and Ceres, offering insight into their respective formation and evolution*

Tom Prettyman
GRaND Team Lead, PSI

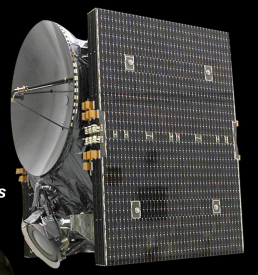


In its journey to the main asteroid belt to orbit two diverse protoplanets, Vesta and Ceres, Dawn is carrying a suite of sophisticated scientific instruments to collect data that will inform us about the early formation of our solar system.

http://dawn.jpl.nasa.gov

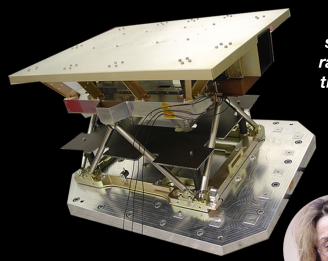
Gravity Science

Gravity science: *the spacecraft transmits a radio signal to Earth through its high gain antenna that changes in frequency as the spacecraft's speed changes when flying over areas of different densities. The collective set of information on the mass variations or concentrations is called the gravitational field of the body/planet.*



Sami Asmar
Gravity Science Lead, JPL

Visible & Infrared Spectrometer



VIR *measures reflected sunlight and emitted thermal radiation from the surfaces of the targets. Scientists extract and then map mineralogical signatures and thermal properties. These properties hold clues to the history and formation mechanisms of Vesta and Ceres.*

Angioletta Coradini,
VIR Team Leader, INAF