CONTOUR (COmet Nucleus TOUR): A NASA Discovery Mission

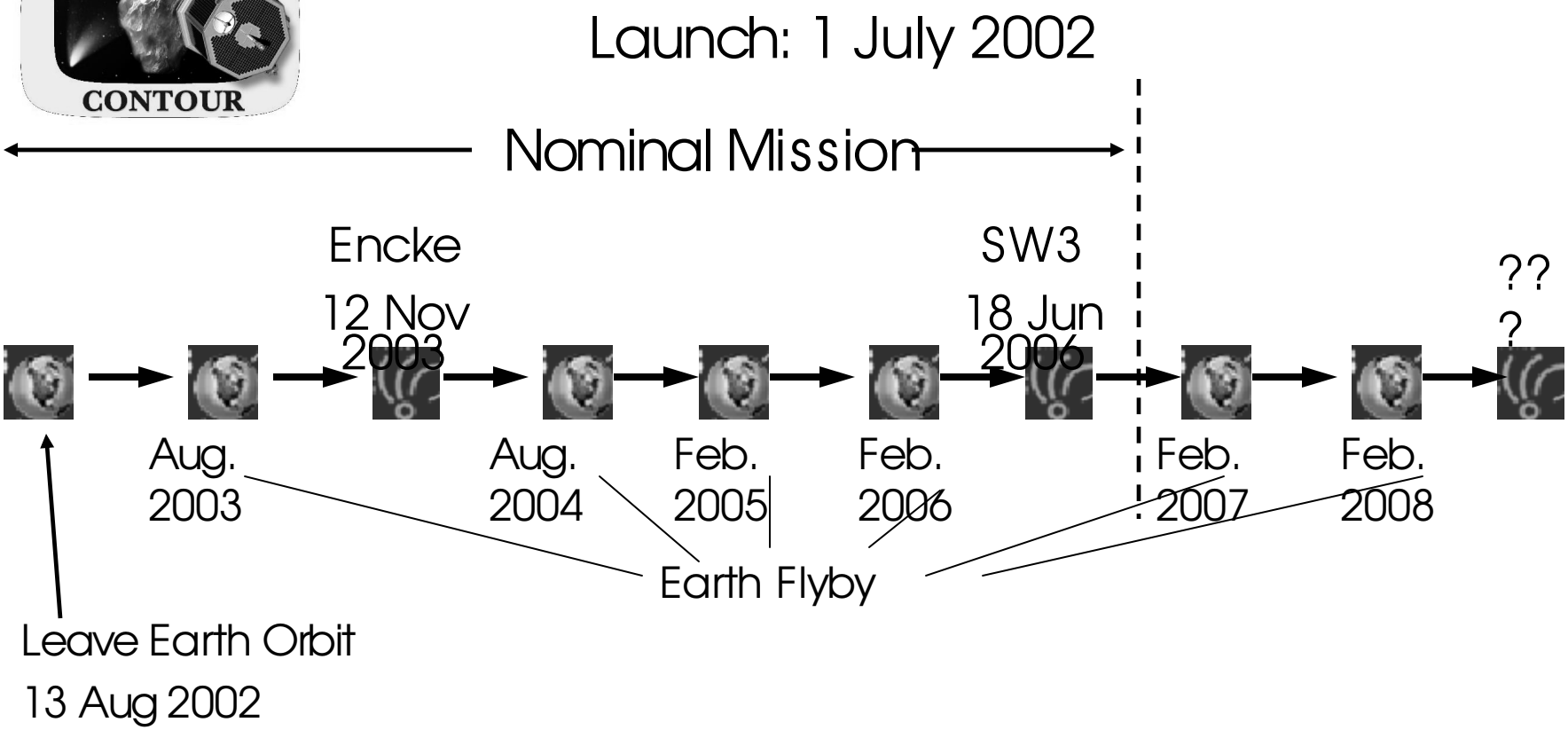
PI: Dr. Joseph Veverka (Cornell University)

Spacecraft built at Johns Hopkins University Advanced Physics Lab

GOALS

- To assess the diversity of comets by flying past and observing at least two comets.
  - Determine properties of the Nucleus.
  - Measure the composition of the gas and the dust.
  - Study the coma.

Mission Timeline



Encke: Flyby speed 28.3 km/sec; phase 12° ; R_h=1.07au; Δ=0.27au

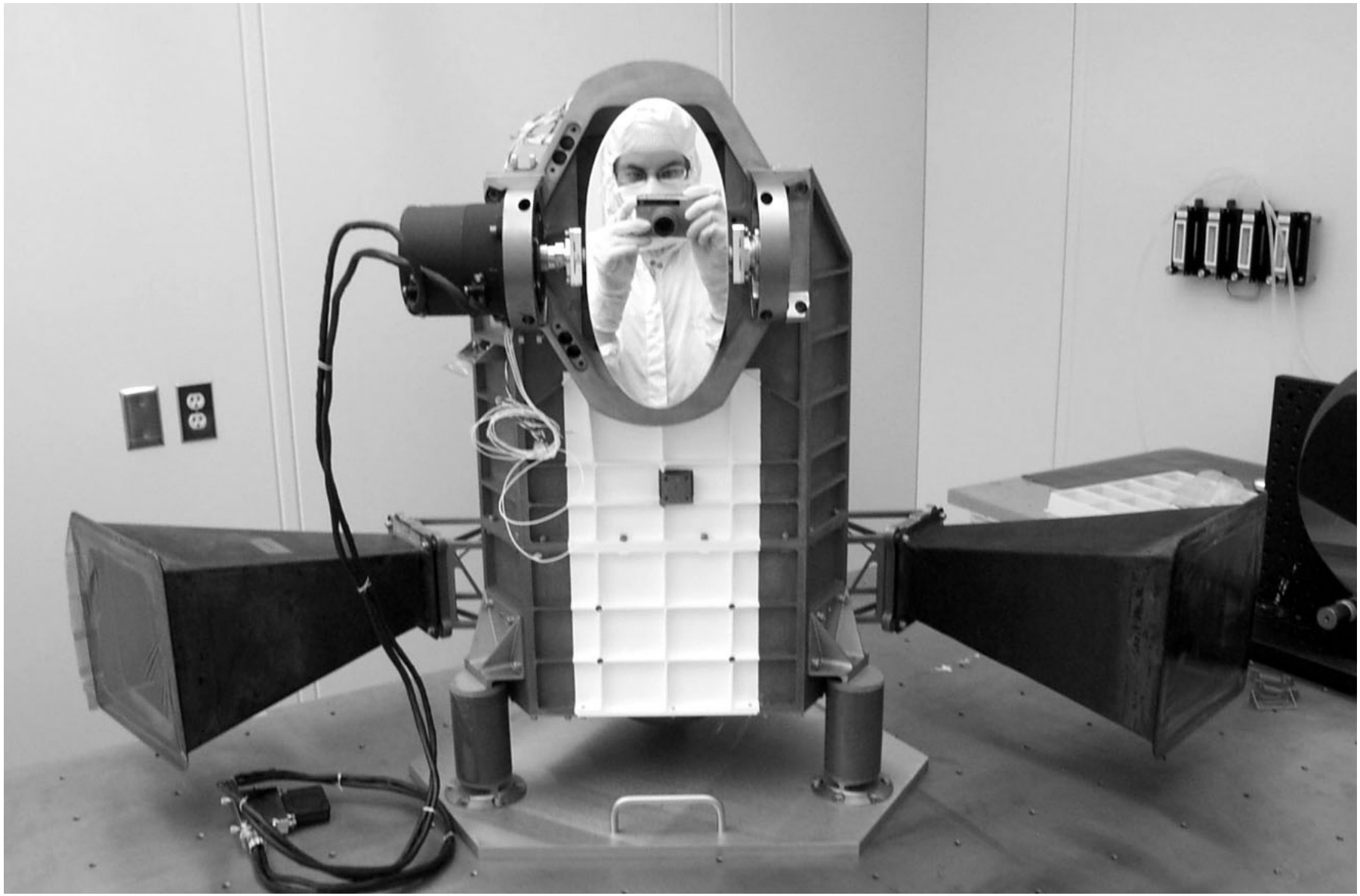
SW3: Flyby speed 14.0 km/sec; phase 100° ; R_h=0.95au; Δ=0.33au

Instrumentation

- The CONTOUR spacecraft carries four instruments:
  - **CRISP** = CONTOUR Remote Imaging SPectrograph
  - **CFI** = CONTOUR Forward Image
  - **NGIMS** = Neutral Gas and Ion Mass Spectrometer
  - **CIDA** = Comet Impact Dust Analyzer

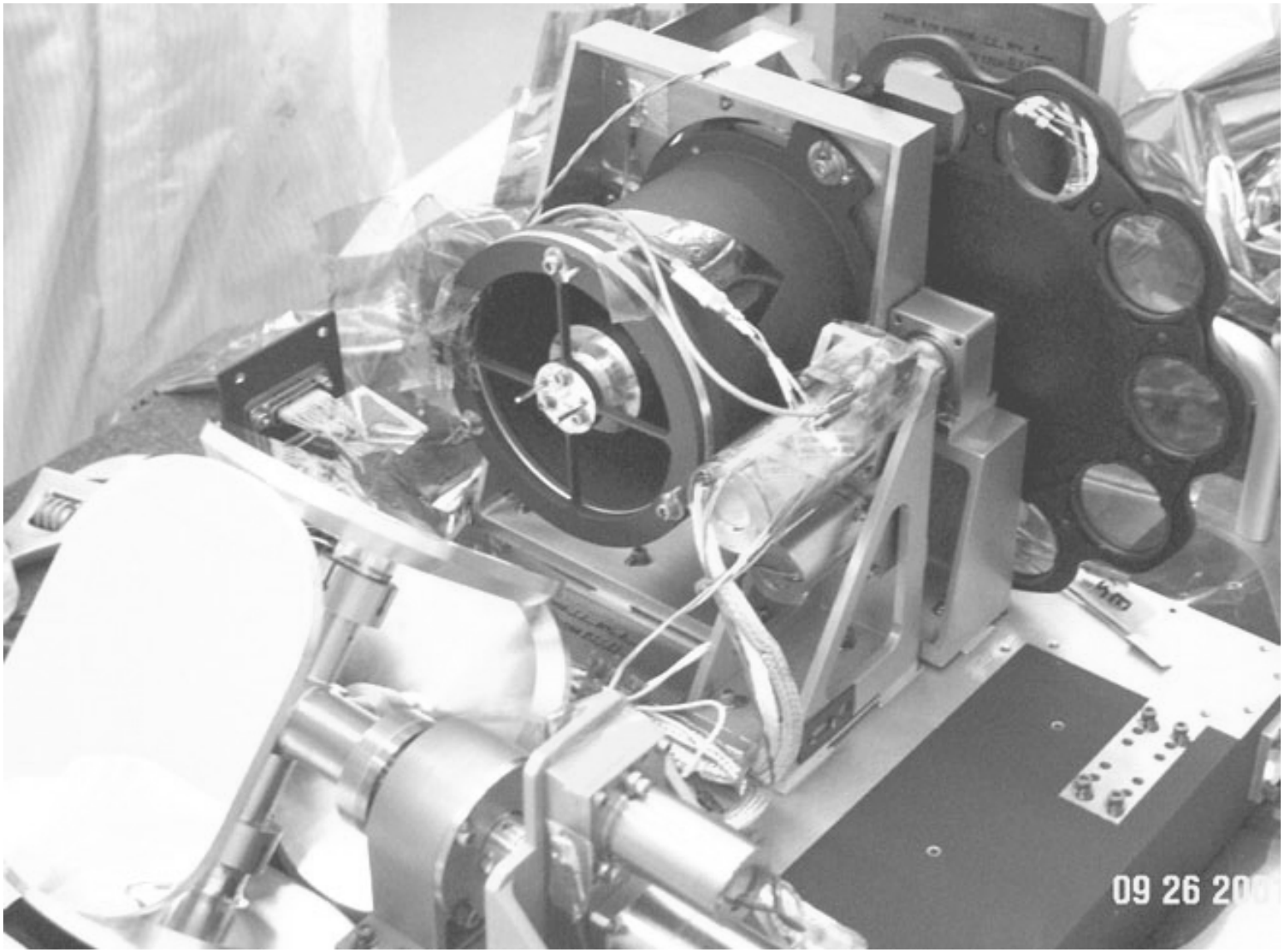
CRISP

- A narrow-angle optical (0.45 - 0.77 μm) camera and Near-IR (0.8 - 2.5 μm) spectrometer with readouts at up to 5Hz.
  - Imager:
    - FOV 1.2° X 1.2°
    - 10 filters (40 nm wide)
    - 1024 X 1024 pixels
  - Spectrometer:
    - FOV 0.86° X 0.003°
    - 256 spatial X 256 spectral channels



CFI

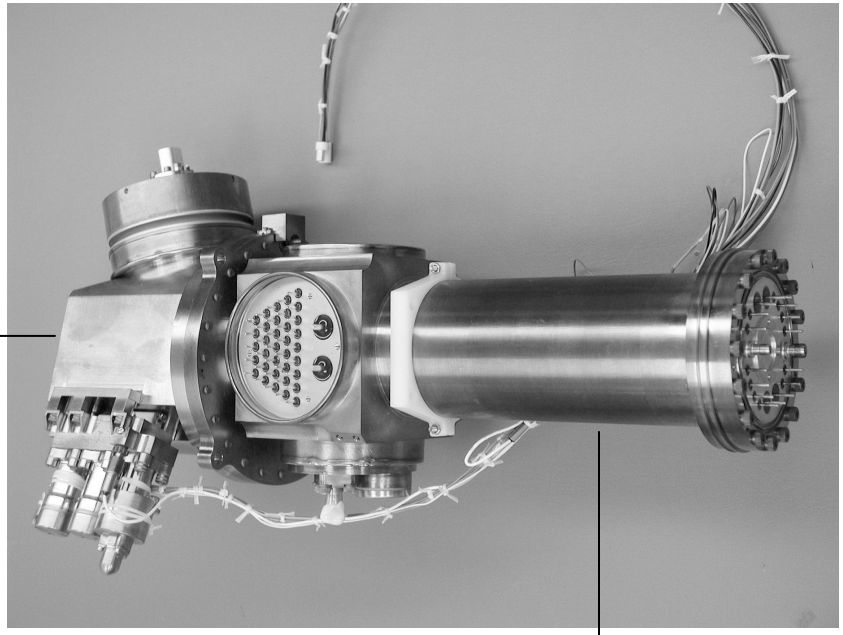
- A wide-angle optical (0.3-1.0 μm) camera.
- Top priority use is for optical navigation.
  - FOV 2.5° X 2.5°
  - 10 Filters, including 3 narrow coma gas filters (OH, CN, and C_2) and 2 narrow continuum filters
  - 1024 x 1024 pixel CCD


09 26 20

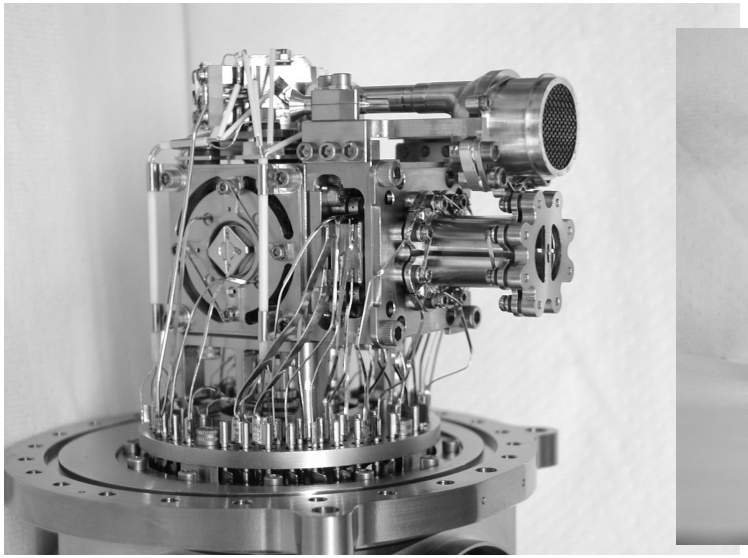
NGIMS

- Measurements from 1 - 300 AMU, with mass resolution of 1 AMU.
  - Uses a quadrupole mass analyzer at 3 fixed frequencies to cover the selected range.
  - Open ion source - measures ambient particle density directly.
  - Closed ion source - provides measurements of higher accuracy and sensitivity.

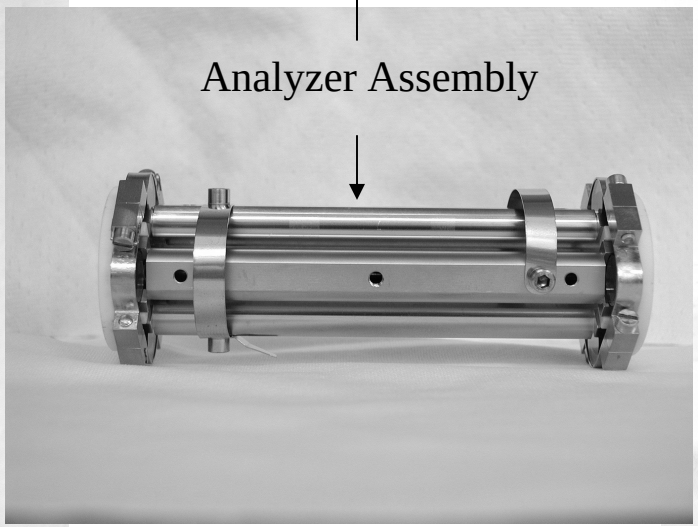
NGIMS - Sensor



Ion Source Assembly



Analyzer Assembly

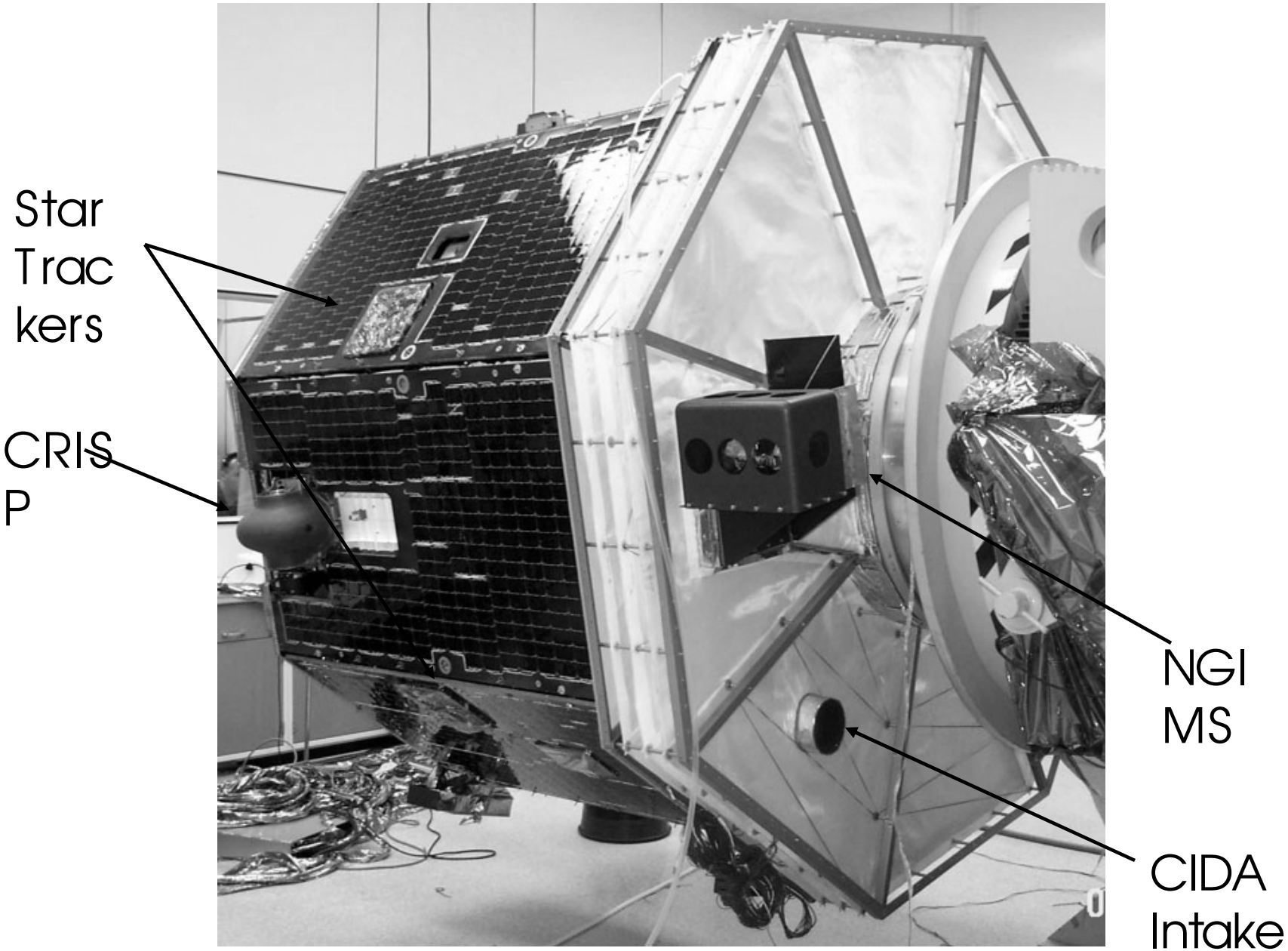


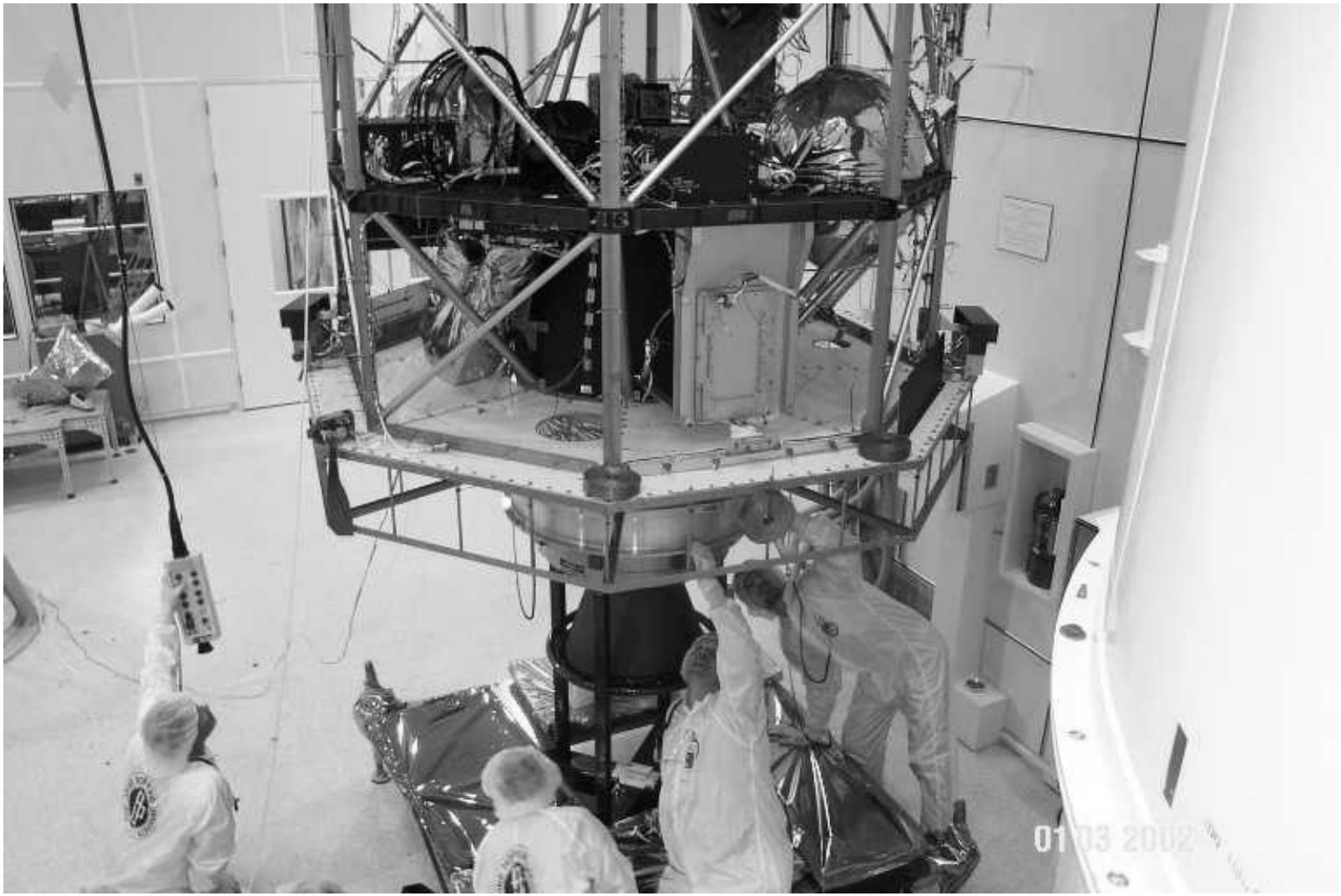
Ion Detector Assembly

CIDA

- The CONTOUR CIDA instrument is identical to the Stardust CIDA instrument.
  - Target size: 100 cm^2 (Halley missions: 5 cm^2).
  - Time resolution of 10 ns.
  - Full dynamic range of 5 decades.
  - Can measure dust grains of $2x10^{-16}$ to $3x10^{-9}$ g.

HOPKINS UNIVERSITY


Star Trac kers
CRIS P
NGI MS
CIDA Intake



Solid Rocket Motor
Integration

Nucleus Properties

- The top priority of the CONTOUR mission is to image the nuclei of at least two comets with a resolution of at least 10m/pixel.
  - The closest approach distance for comet Encke is 130 km.
  - The tracking accuracy is < 1.5 pixels for the shortest exposures (10 ms) with >100 km miss distance (CRISP) $\Rightarrow$ Smear is < 1.5 pixels for the highest spatial resolution image.
  - These images can be used to study small-scale morphology of the nucleus, surface roughness, craters, etc.

Nucleus (cont).

- *Multispectral imaging / hyperspectral maps* (CRISP, CFI): Correlation of spectral variations with morphology constrains jet formation and mass wasting processes; such maps provide evidence for spectral homogeneity.
  - 0.4 - 2.5 μm.
  - Covers the major likely ice and silicate absorptions.
  - Will detect 1% variations in band depth over a spot covering 1% of the surface.
  - Expected S/N of 125-300 over desired wavelength range.

Nucleus (cont.)

- *Moderate spatial resolution and lightcurves from approach imaging* (CRISP, CFI): yields a shape model and rotation state ⇒ provides evidence for any disturbing function.
  - Must detect comet at least 12 hours before closest approach and track brightness variations for > 6hrs.
  - <500 m/pixel images need for shape model

The Near-Nucleus Environment

- *Composition of the dust* (CIDA): Measure the composition of the dust and the variations in its properties as a function of distance from the nucleus.
  - Will distinguish silicate particles from CHON particles.
  - Most sensitive to H, C, N, O, Mg, Al, Si, S, Ca, Fe.
  - Will determine dust composition as a function of azimuthal and radial position with respect to the nucleus.

Near-Nucleus (cont.)

- *Multispectral imaging* (CFI) *of the inner coma and in situ measurement of gases and ions* (NGIMS): will allow the determination of the locations of degassing and volatile speciation.
  - Imaging maps of OH, CN, C_2 and dust place the *in situ* results within their broader context.
  - Will obtain detailed information on composition of the gas as a function of radial and azimuthal position with respect to the nucleus.
  - Can probe the nature of the jets and how they contribute to the coma.

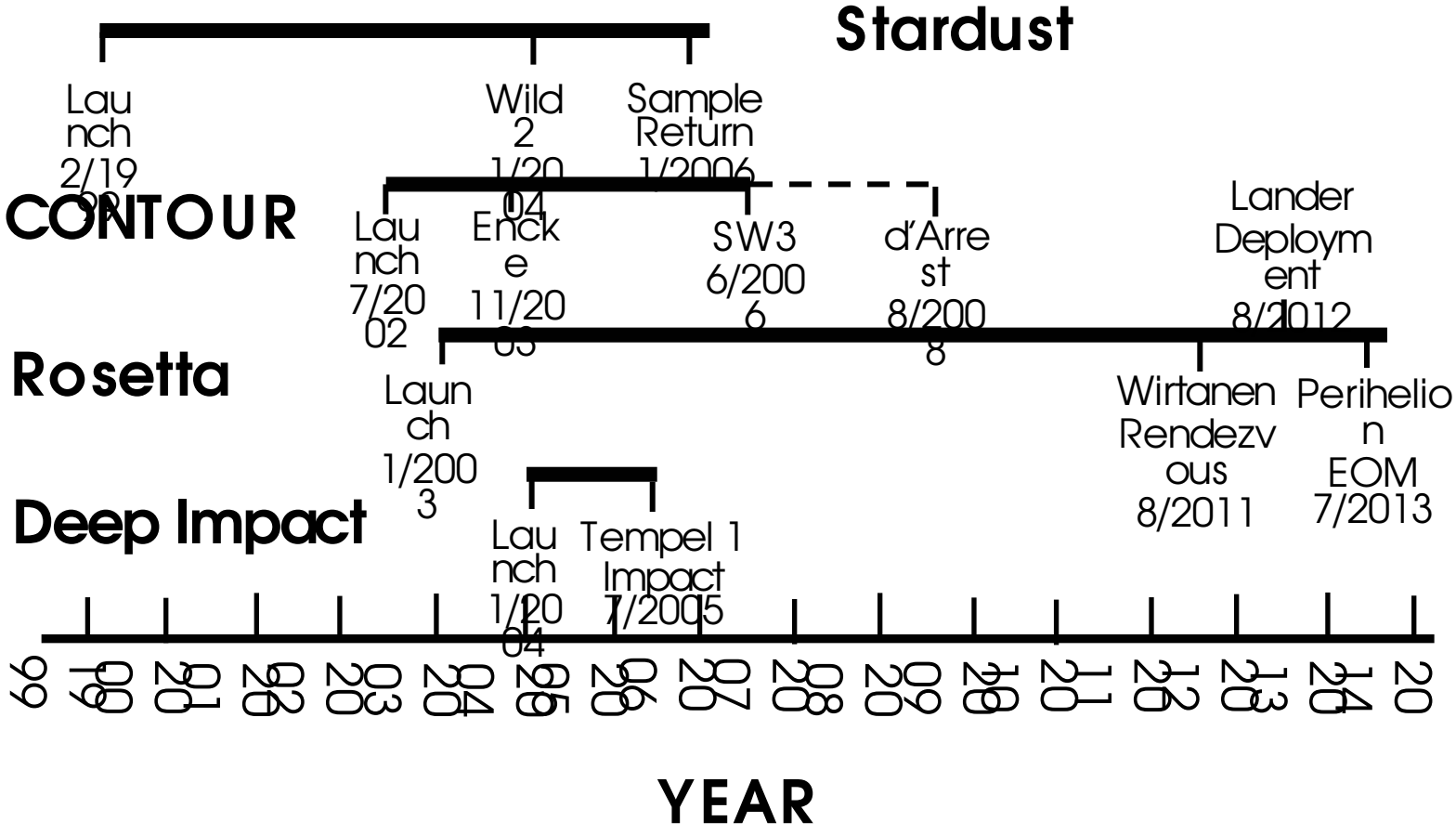
The Coma

- *Multispectral mapping* (CFI) *and mass spectrometry* (NGIMS): will help to assess the level of outgassing of the comet.
  - CFI images with OH, CN and C_2 filters will be used to obtain maps with S/N of 7-18.
  - Mass spectra will be obtained at distances from 100,000 to 100 km. An observing strategy will be used that will cycle between fine spatial sampling of key mass bins, more widely spaced sampling of other mass bins and searches for new species.

Diversity

- Nominal mission consists of flybys of two comets.
- Current targets are 2P/Encke and 73P/Schwassmann-Wachmann 3.
- The nominal mission allows for additional flybys of other comets (e.g. d'Arrest or Wirtanen).
- Could also retarget to observe a newly discovered (Oort cloud) comet. This is the only current mission with this capability.
- Repeated Earth swingbys give a large degree of flexibility.

Complementarity with Other Missions

- CIDA is the same as the instrument currently flying on Stardust and similar to experiments flown past Halley and to be flown on Rosetta.
- NGIMS is comparable to instruments on other missions.
- Imaging and spectral mapping comparable to other missions.
- Filter selection coordinated with Deep Impact.
- Coma filters compatible with ground-based Hale-Bopp filters.

Timelines for Comet Missions