Mission to Catch Comet ISON

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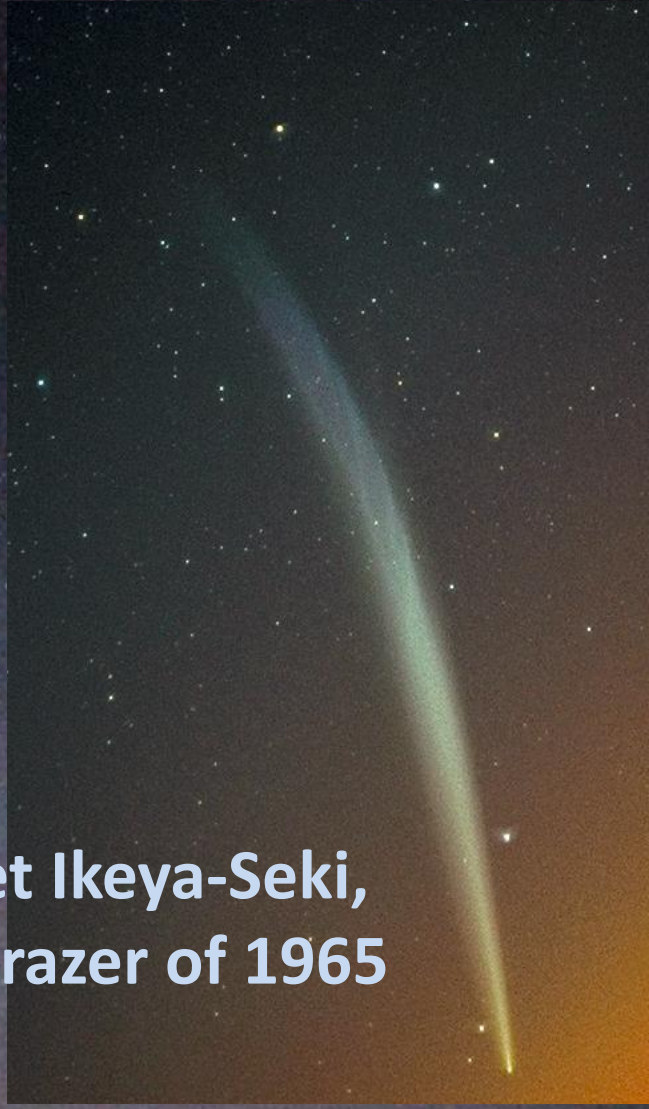
Comet ISON

- Comet ISON discovered September, 2012
  - An Oort Cloud comet believed to be making its first apparition
- ISON perihelion in November, 2013
  - A sun-grazer which may not survive perihelion passage intact
  - Observe the comet before perihelion
- An important target of opportunity
  - To study volatile-rich material from the epoch of planet formation
  - To learn how comets work

Oort Cloud Comets

- Provide clues to the origins of the Solar System
- Consist of pristine, icy material that was never heated in the inner solar system

In late 2013, ISON may become the brightest Oort Cloud comet to appear in decades

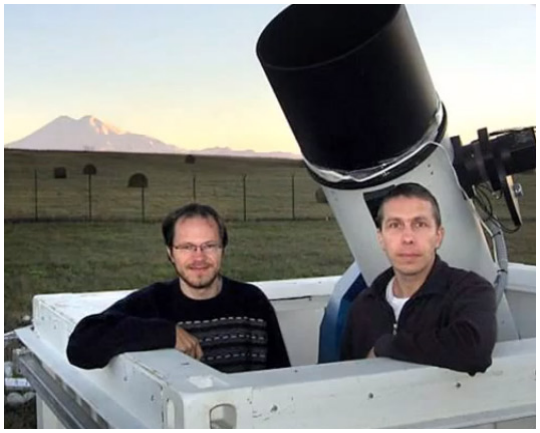


Comet Ikeya-Seki, sun-grazer of 1965

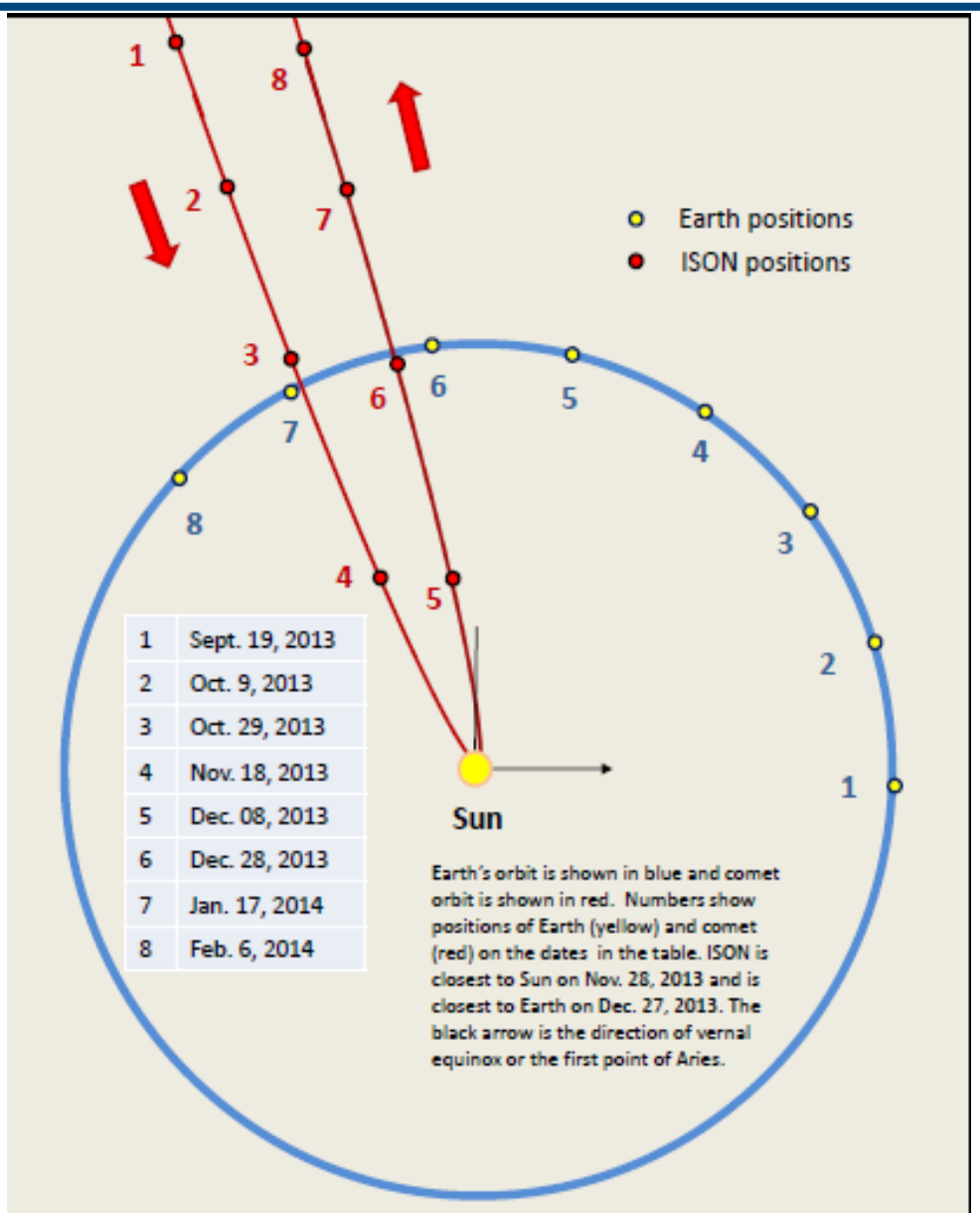
Comet McNaught in 2007

Comet ISON Observability

- Comet ISON is observable from the Northern Hemisphere, with solar elongation >40°, from September 15, 2013 through Nov 12, 2013
- ISON becomes steadily brighter through this period
- ISON may remain spectacularly bright after December, 2013

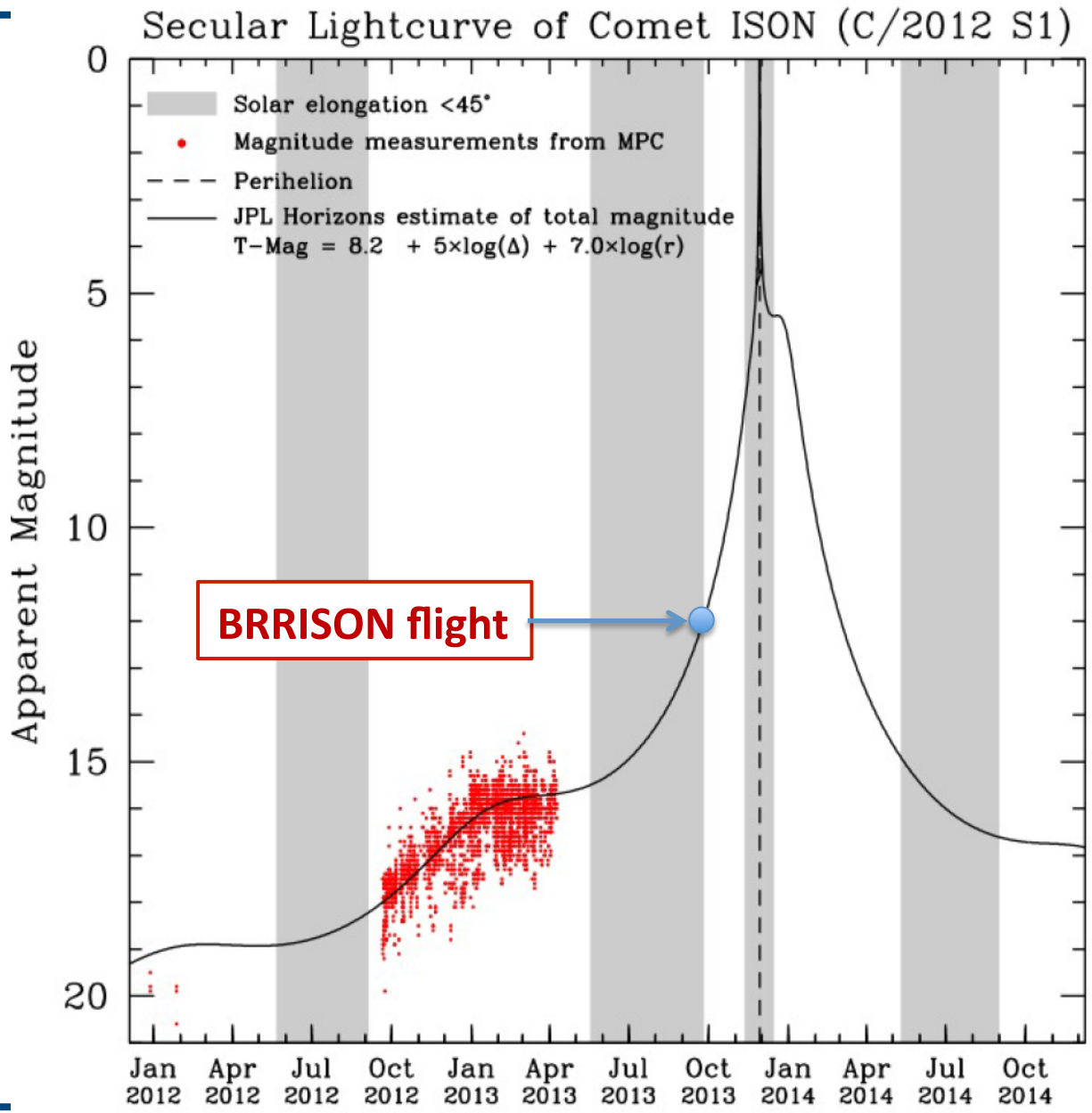


Vitali Nevski and Artyom Novichonok, discoverers (space.com)



Comet ISON Brightness

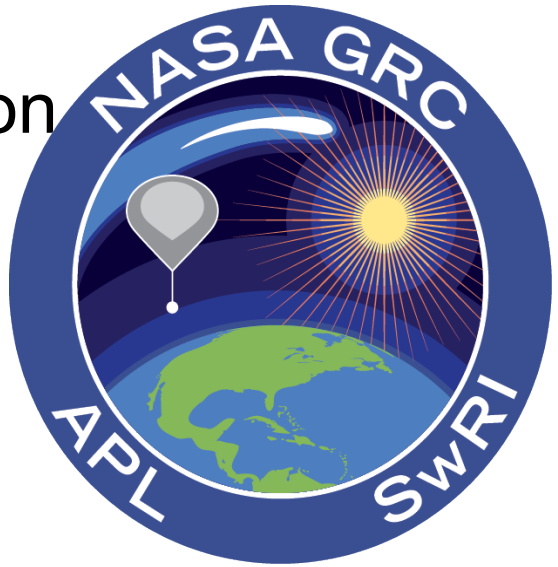
- Observations are consistent with V~12 at time of BRRISON flight
- Due to small solar elongation, additional observations prior to flight are not expected



CIOC web site,
sungrazer.nrl.navy.mil

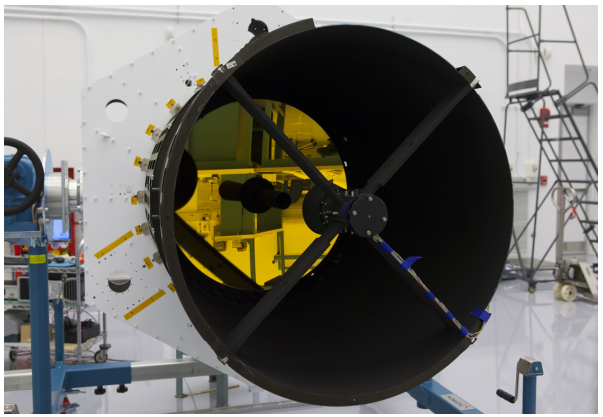
What is BRRISON?

- BRRISON = Balloon Rapid Response for the comet ISON
  - Goal is to observe the comet ISON from a balloon platform
  - Leverages the balloon study concepts
  - Coordinate the science measurements with the greater scientific community, including ground and space observations
  - 12 months from comet discovery to mission
- NASA Planetary Science Division Mission
  - NASA GRC (Program Management)
  - JHU/APL (Gondola, IR Camera)
  - SwRI (UVVis Imager)



BRRISON Objectives

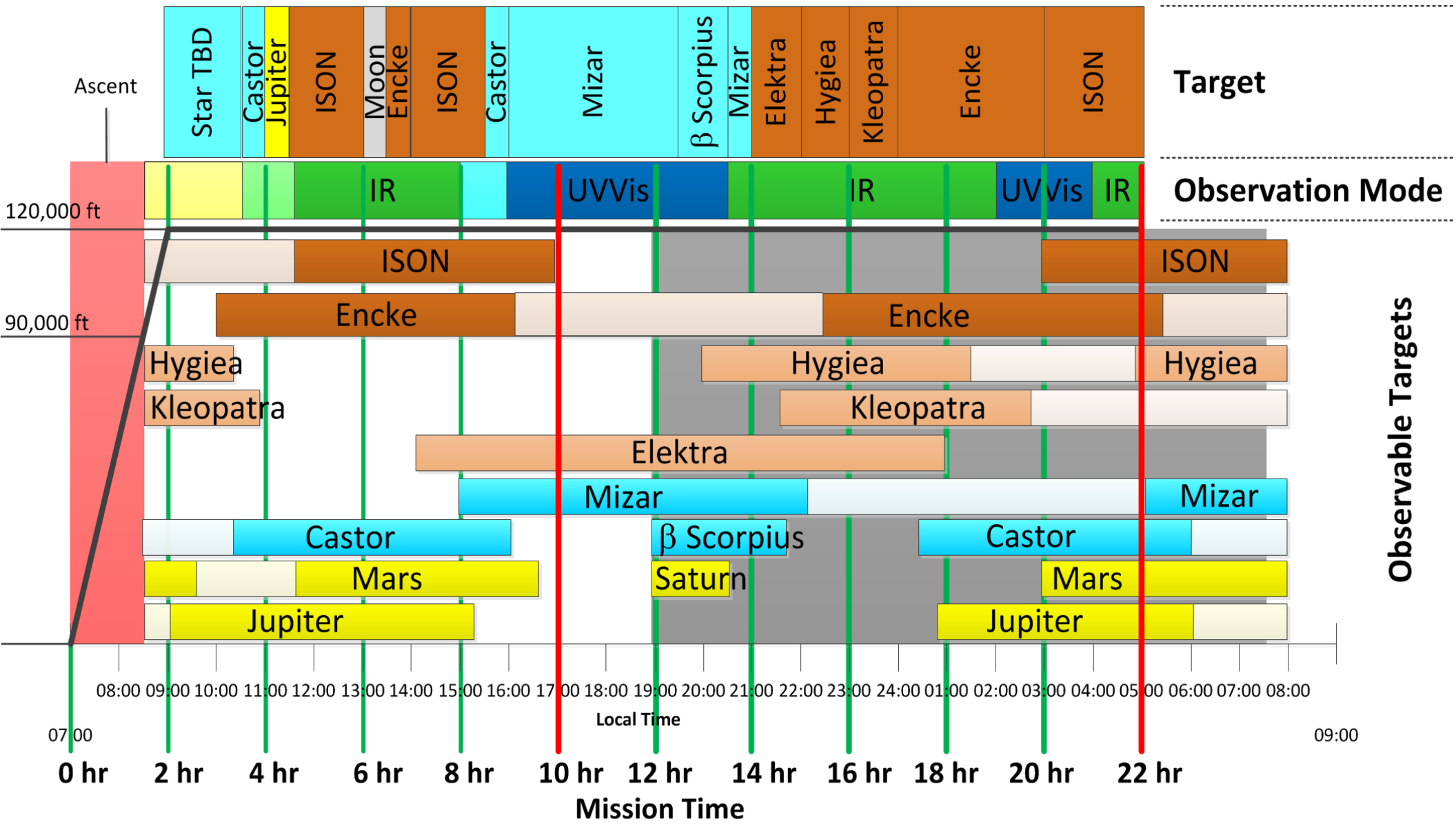
- Provide high-value science from Comet ISON
  - Measure CO_2 and H_2O and determine their ratio
- Develop and demonstrate gondola and payload systems for a balloon-borne platform designed to achieve planetary science decadal survey objectives
  - Payload systems: IR imaging of ISON; NUV/Vis imaging and operation of Fine Steering Mirror for obtaining sub-arcsec pointing stability
  - Gondola systems for platform capable of lifting a >1m aperture telescope to 120,000 feet



Launch from Fort Sumner, NM

- BRRISON launch from Fort Sumner
- Launch in September-October 2013
  - One day flight
- Columbia Scientific Balloon Facility at Fort Sumner
  - Balloon launch and recovery support
  - Range safety
  - Can accommodate 3 – 4 payloads
- Payload recovered typically within 3 or 4 days after landing

Mission Operations Timeline 22 Hours Flight Baseline

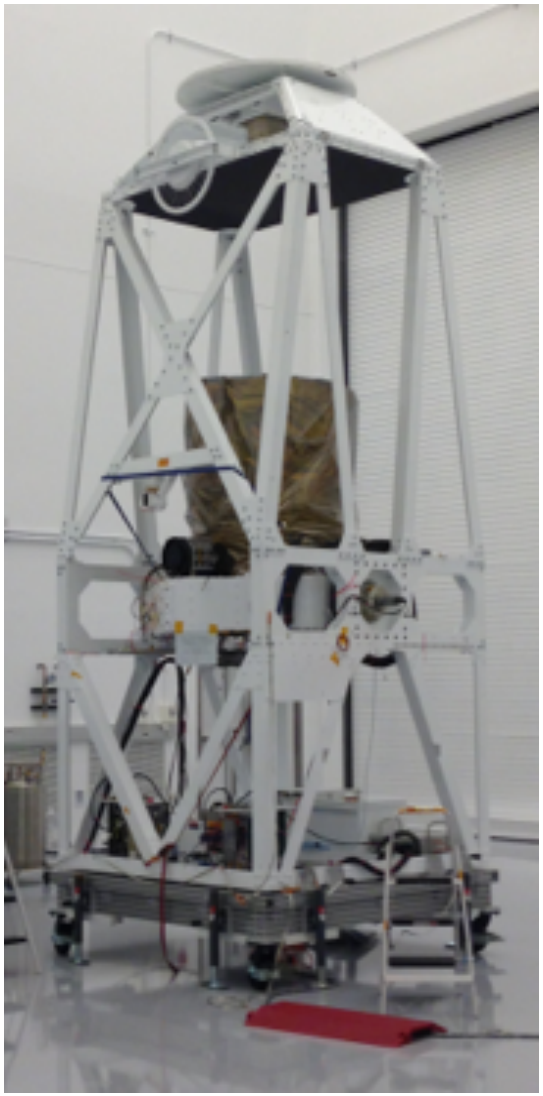


Decadal Survey Questions Addressed by BRRISON

- How does the composition of Oort Cloud comets compare to Kuiper Belt comets?
- What are the chemical routes leading to complex organic molecules in regions of star and planet formation?
- Were there systematic chemical or isotopic gradients in the early solar nebula?
- How did Earth get its water and other volatiles?

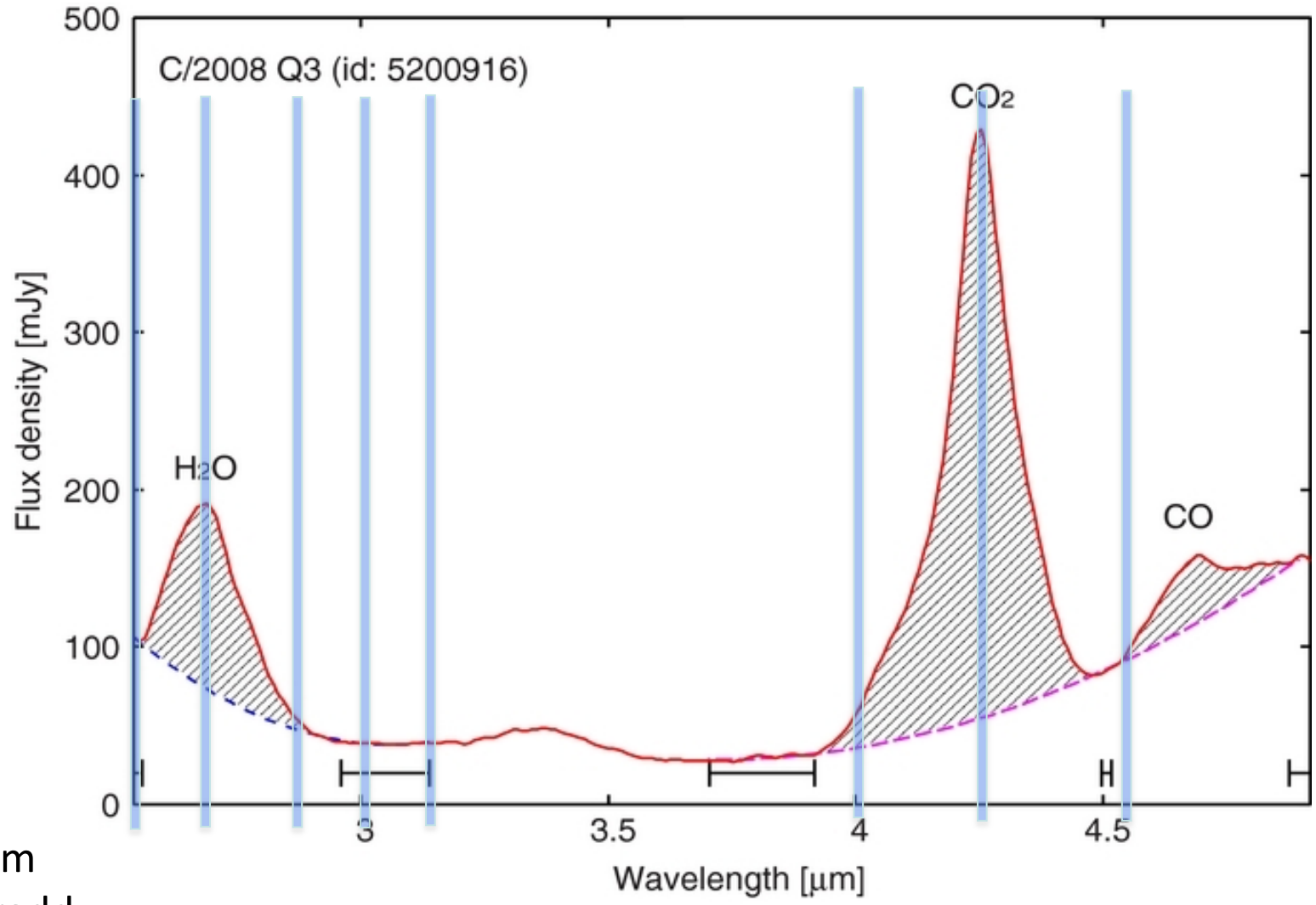
BRRISON Science Objectives

- Target list includes:
  - Comets ISON and Encke
  - Jupiter
  - Hydrated asteroids (Themis, Elektra, Kleopatra)
  - Multiple star systems (Castor and Mizar)
  - Moon if flight September 26 or later
- Measure terrestrial atmospheric transmission and emission (IR) and turbulence (UV/Vis).
- Study CO_2:H_2O ratios on comets ISON and Encke, constrain formation scenarios and parent populations
- Study water distribution (and possibly CO_2) in Jupiter's atmosphere to test exogenic source of stratospheric water on Jupiter
- Study surface effective temperatures, ices: hotspots and plumes on Io, CO_2 on Europa and Ganymede
- Study ices, aqueous alteration, minerals containing H_2O or OH on large main belt asteroids including a known binary asteroid
- Image lunar swirls to look for evidence of space weathering, state and abundance of mafic minerals



Measuring CO_2 and H_2O

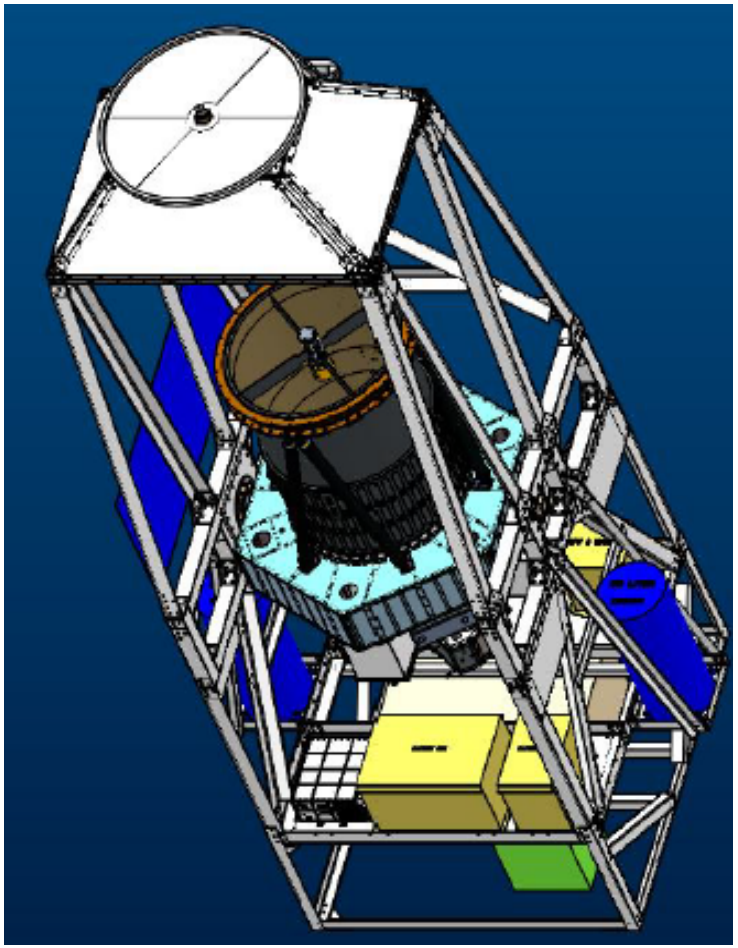
Continuum subtraction and ratio of CO2 to H2O emissions, using eight spectral filters



Comet Spectrum C/2008Q3 Garradd

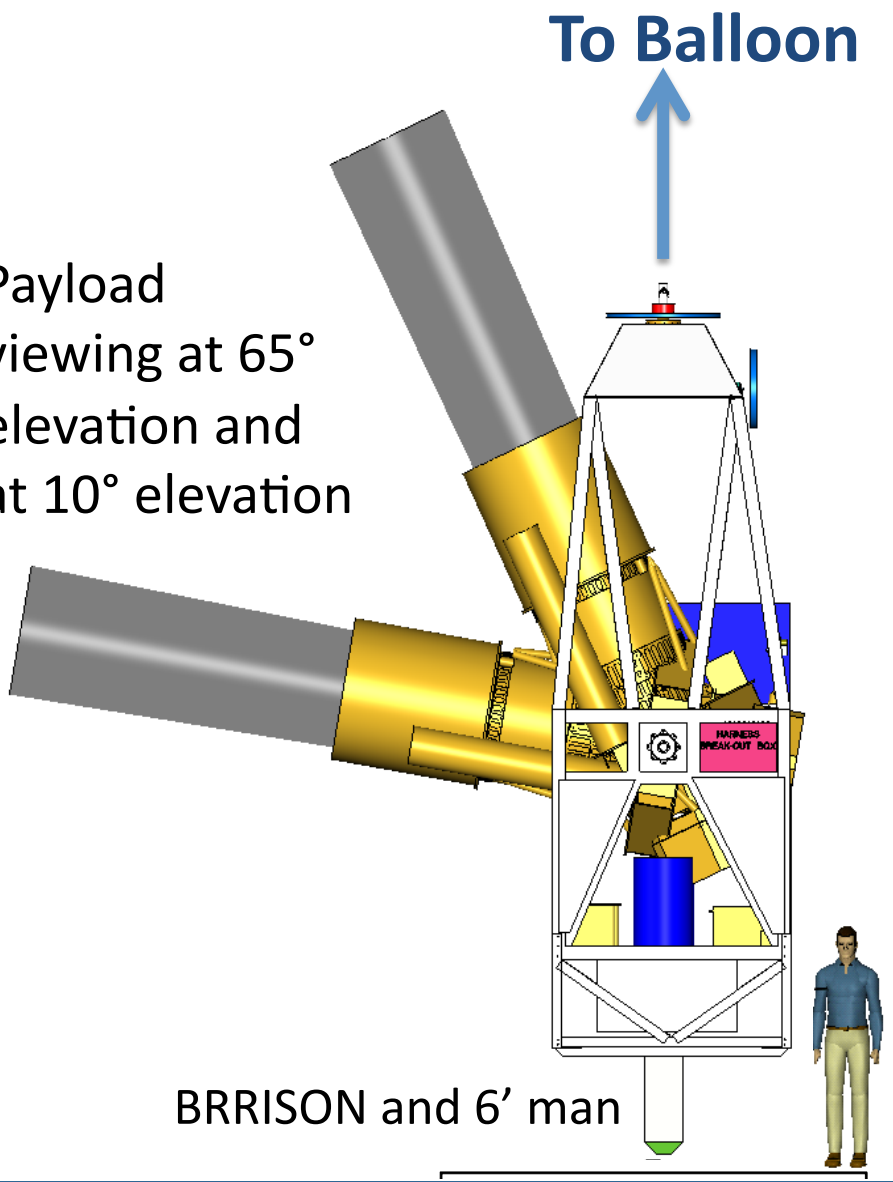
BRRISON Gondola

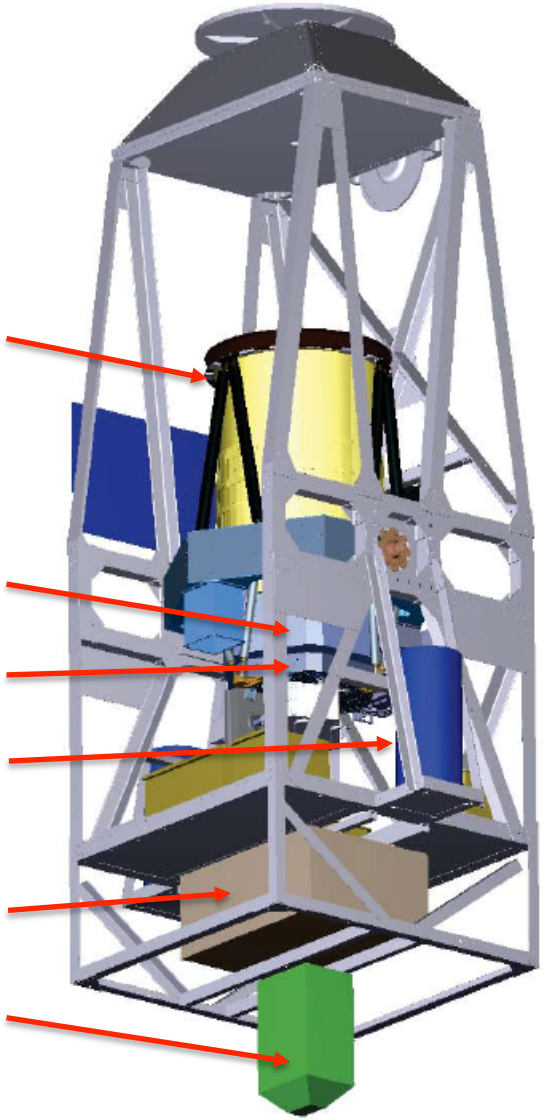
- Azimuth and Attitude stabilized gondola with 80-cm telescope
- Two instruments on separate optical benches:
  - **BRRISON IR Camera (BIRC)**, for imaging 2.5 μ to 5μ
  - **UVVis** camera with fast steering mirror and fine guidance system
  - Light is sent to either UVVis or BIRC (not both at once)
- Payload in stow position is enclosed within gondola frame



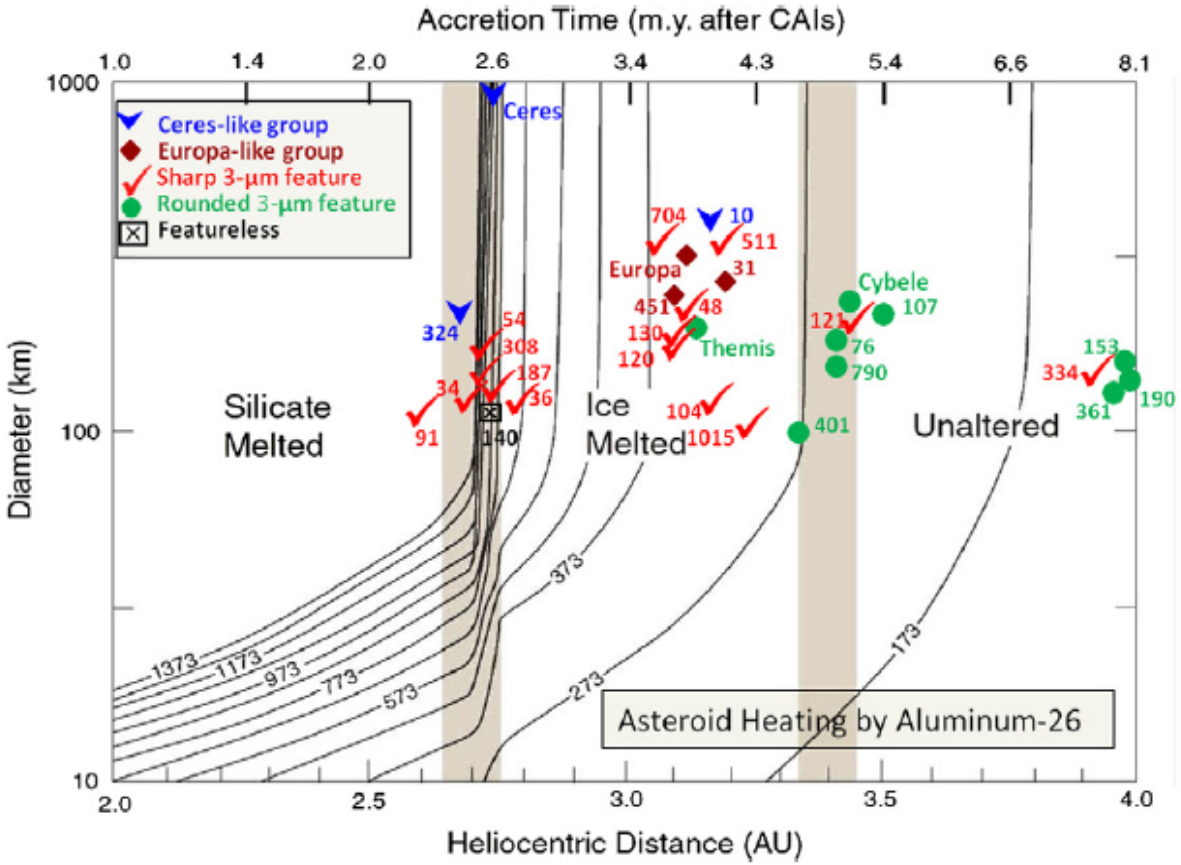
Payload in stow position
(baffle extension not shown)

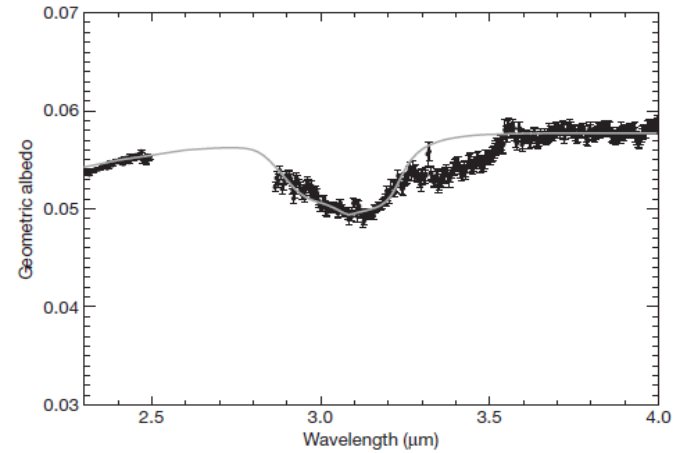
Putting BRRISON together

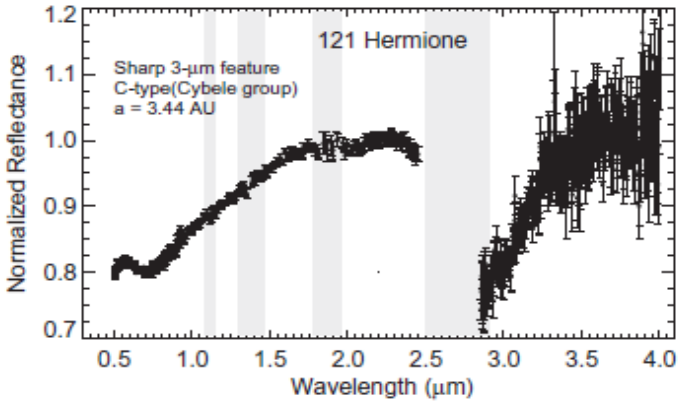




Hydrated Asteroid Diversity



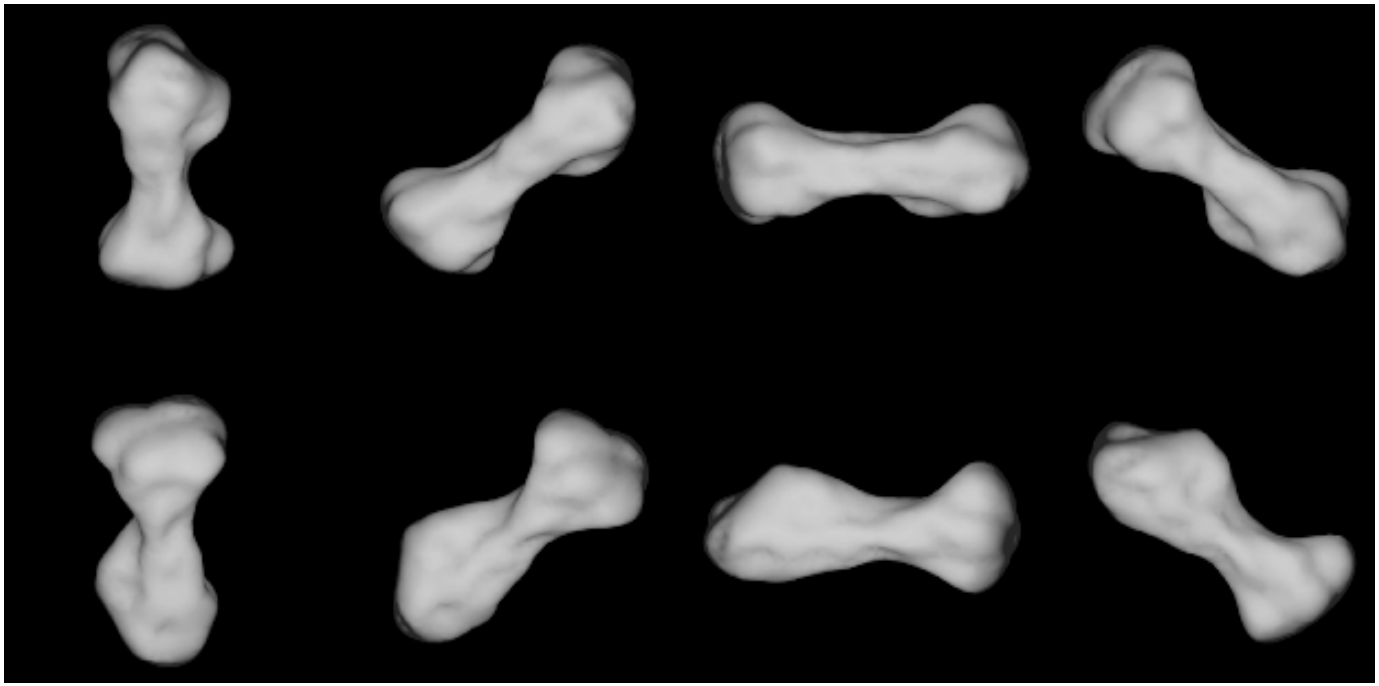




- Four groups of main belt asteroids distinguished by shape and center of 3µ feature
- BRRISON will observe two objects included above:
  - 24 Themis
  - 130 Elektra

Rivkin and Emery 2010
Takir and Emery 2012

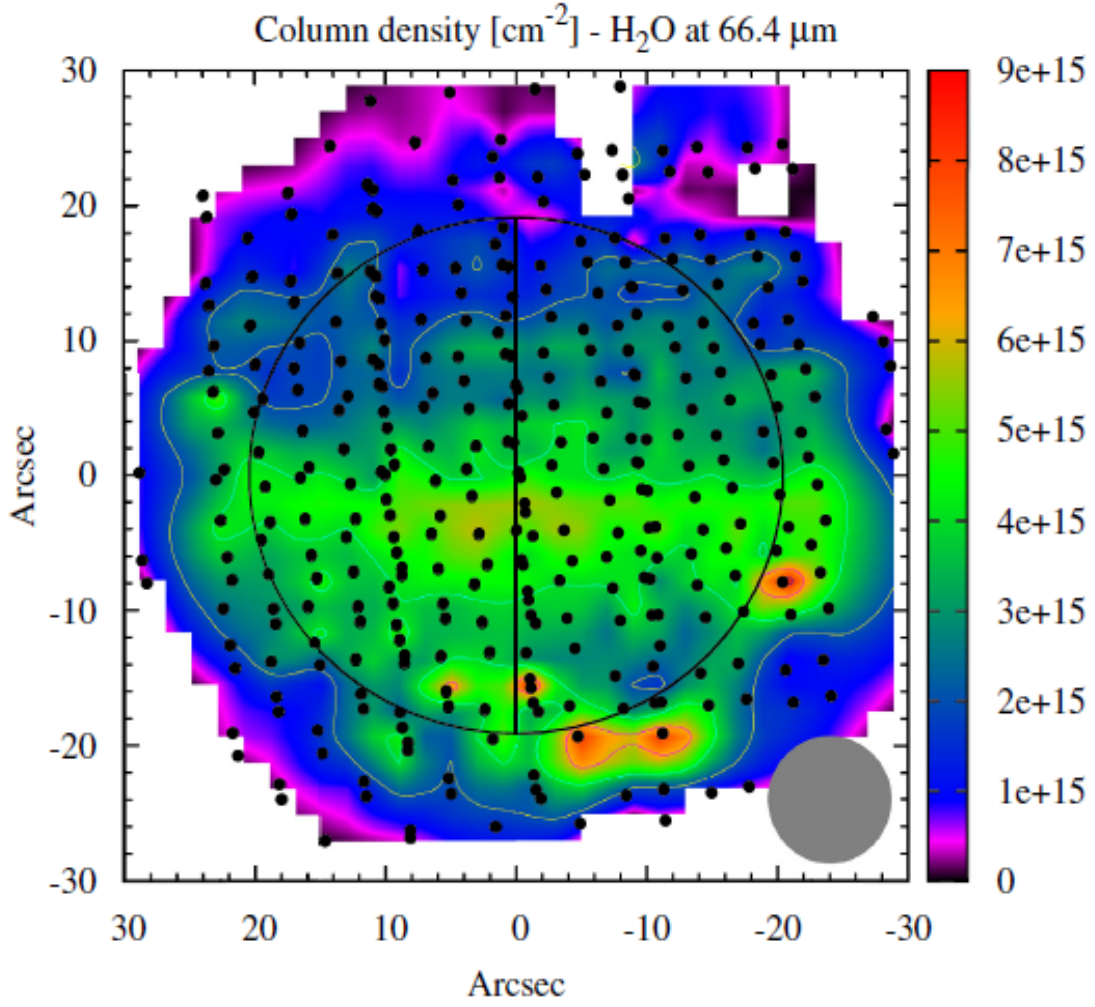
Asteroid 216 Kleopatra



- Shape model from radar data
- Size 217 km x 94 km x 81 km
- Two small satellites known
- Spectral type M or Xe

JPL PIA 02454

Water at Jupiter



- Herschel HIFI and PACS observations in sub-mm and far-IR of stratospheric water in Jupiter
- Hemispheric asymmetry consistent with delivery by SL-9 comet impact on Jupiter in July, 1994

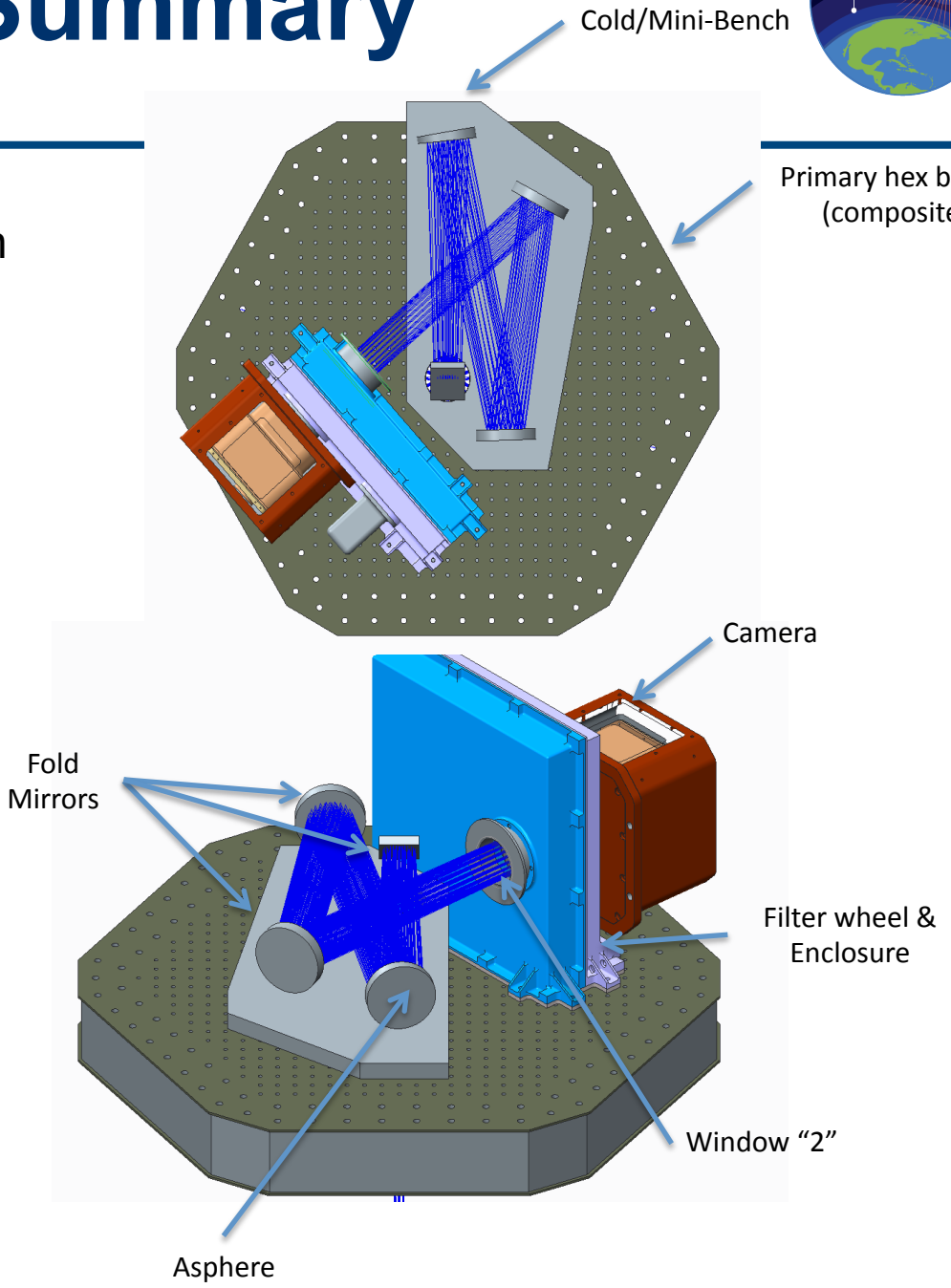
Cavalie et al. 2013. A&A 553 A21

BIRC Summary

- BIRC is a multispectral IR imager with cryogenic HgCdTe detector
- Cooled filter wheel and relay optics
- Filters at
  - 2.47 μm
  - 2.70 μm
  - 2.85 μm
  - 3.05 μm

  } water and continuum
  - 3.20 μm
  - 4.00 μm
  - 4.27 μm
  - 4.60 μm

  } CO_2 and continuum
  - R band (600 – 800 nm)
- FOV 3 arcmin
- 1.16 arcsec/pixel plate scale with 18 μm pixel pitch
- 12 bit images

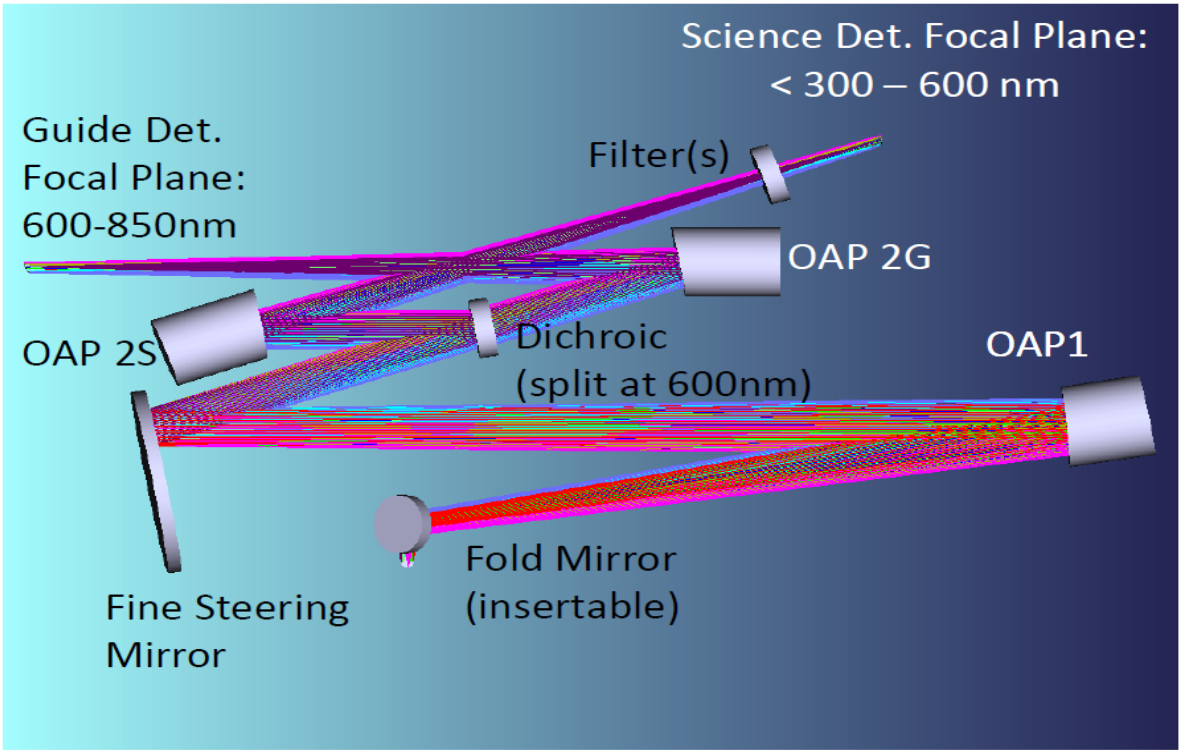


UVVis Overview

Science channel:
- 4 bandpass filters (300 – 450 nm)
- broad band (<300-600 nm)

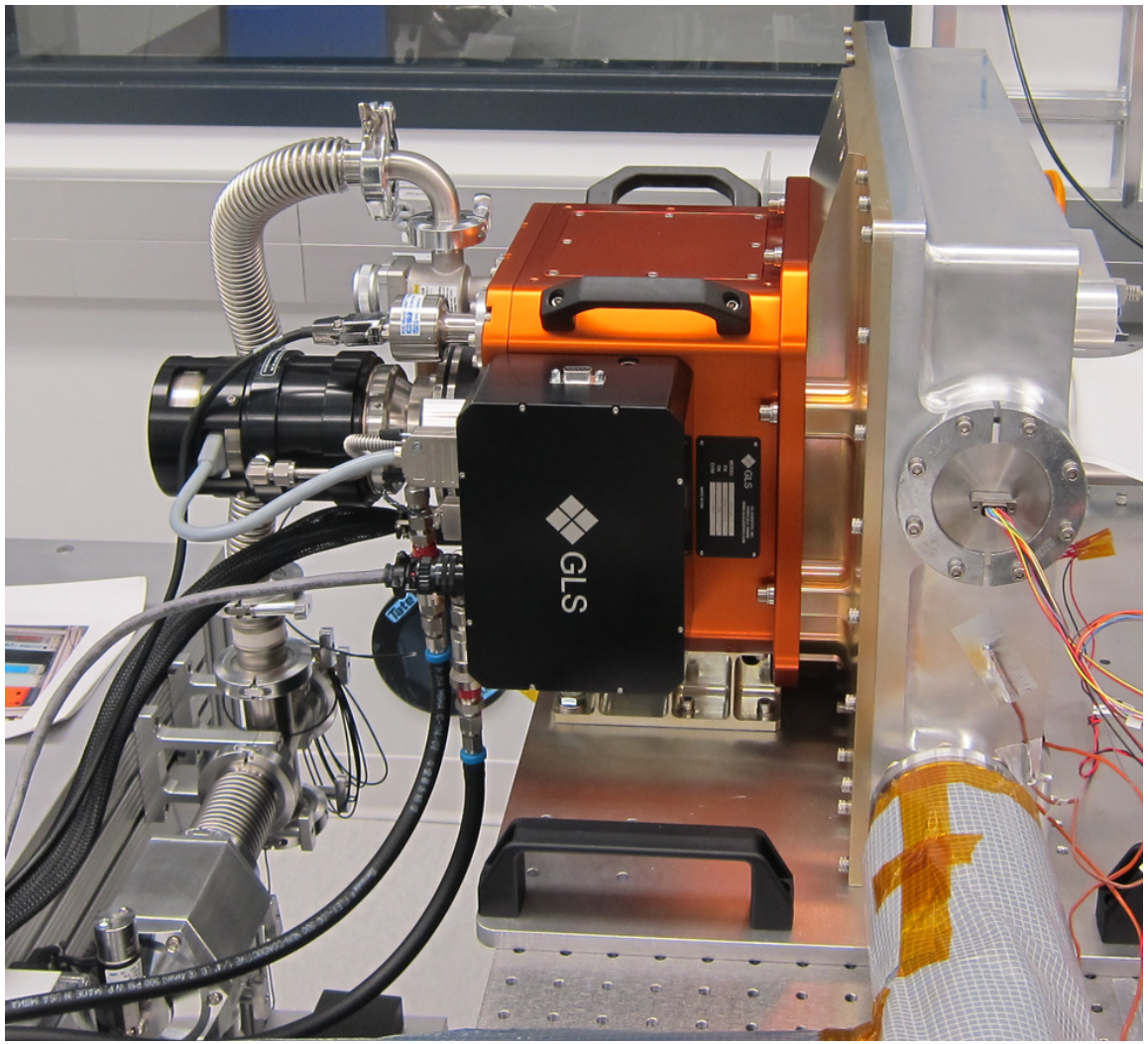
Guide channel:
- 600-850 nm broad band

Insert mirror
- fails open



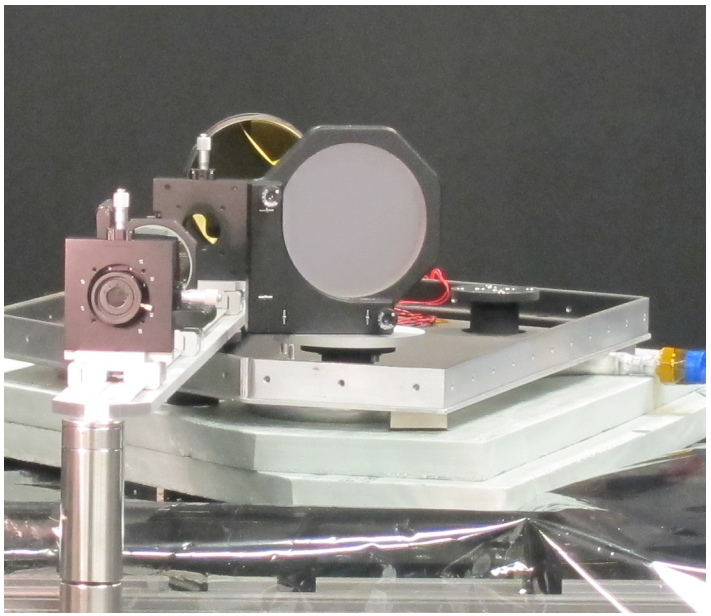
- **Science channel** is a CCD camera with filter wheel
  - Frame format 1024x1024 with optional EMCCD
  - Plate scale 0.19 arcsec/pixel with 13 μm pixel pitch
- **Guide channel** is a fast framing, CMOS imager
  - sCMOS detector with image format 2560x2160
  - Plate scale 0.096 arcsec/pixel with 6.5 μm pixel pitch

BIRC Integration

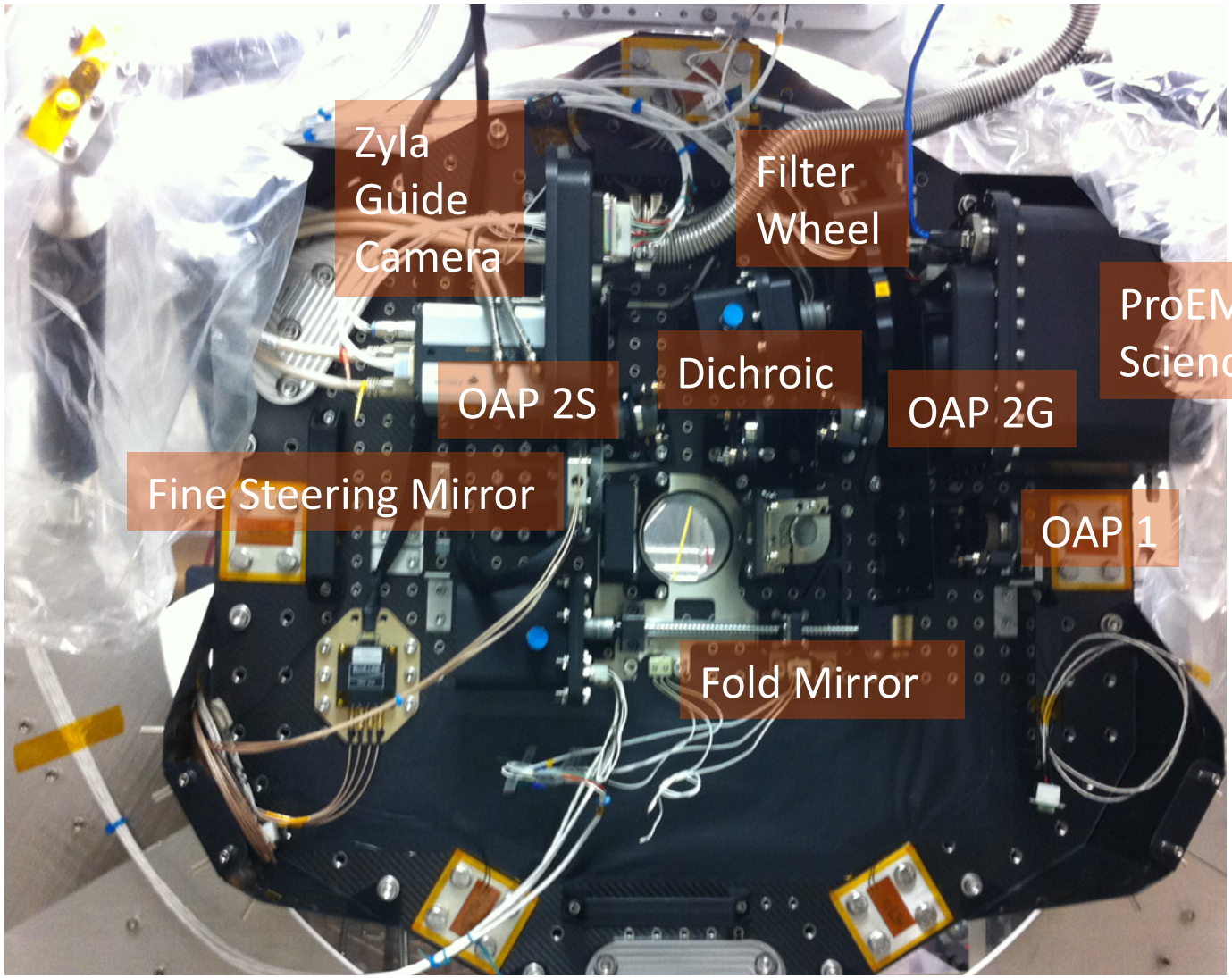


IR Camera and Filter Wheel

Relay Optics

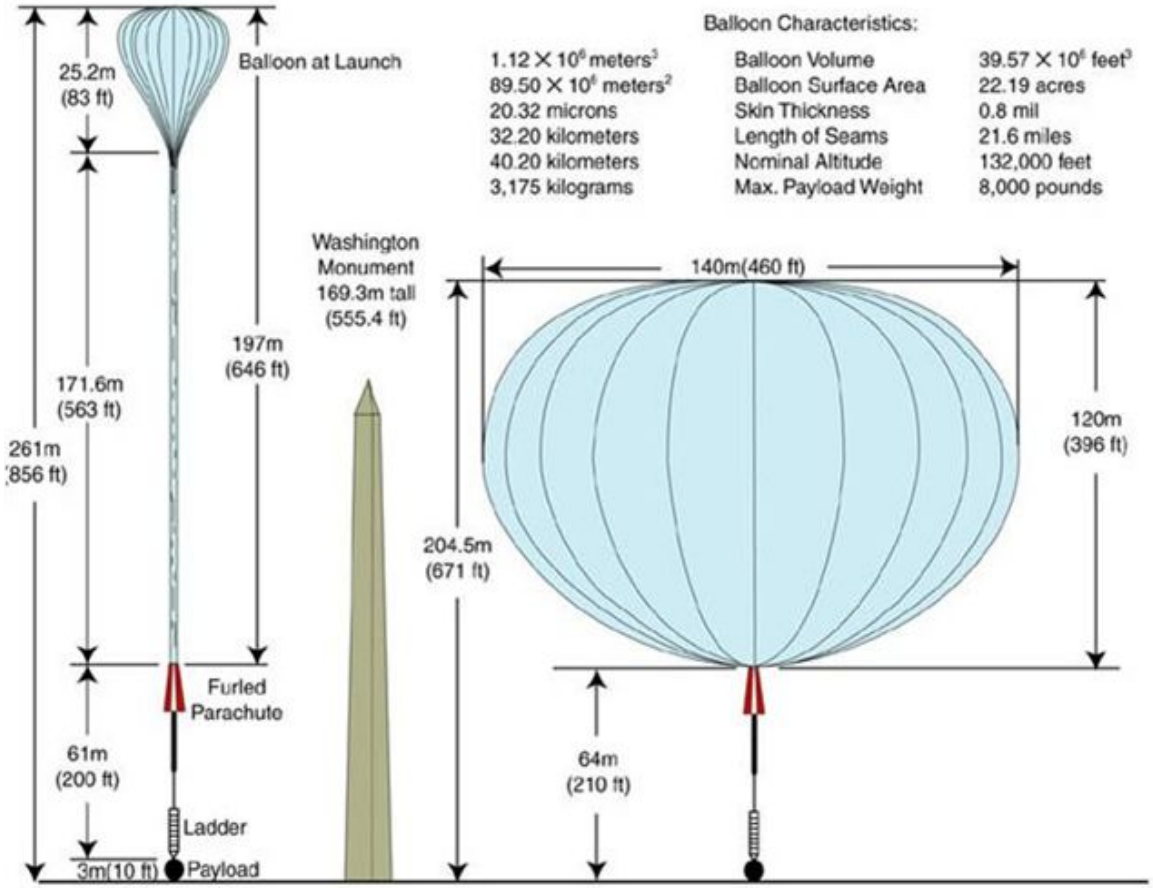


UVVis Bench

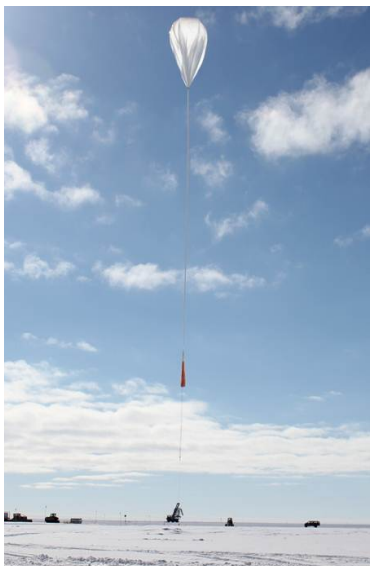

Zyla
Guide
Camera
Filter
Wheel
ProEM
Science Camera
Dichroic
OAP 2S
OAP 2G
Fine Steering Mirror
OAP 1
Fold Mirror

Stratospheric Scientific Balloons

- Large He-filled balloon
- 150 ft to 400 ft in diameter
- 12 to 60 M feet^3
- Carry up to 8000 lbs of payload
- Fly at 110,000 to 140,000 feet altitude



Stratospheric Balloon Launch



(above)
Flight train layout before launch

(below, from left)
Balloon release and ascent