Overview of the HICO Instrument

HICO Users' Meeting

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HICO Build Schedule

- Requirements Finalized, Mechanical Design Begun in June 2007
- CDR in November 2007
- Hardware Build and Vibration Testing Complete July 2008
- Optical Calibration and Characterization August 2008
- Delivery for Integration into HREP September 2008
- HICO had to Meet NASA Manned Spacecraft Specifications
- Software had to Interface to NASA Systems and be Simple
- COTS Parts Used to Maximum Extent Possible
  - Camera, Spectrometer, Rotator
  - All Non-COTS Parts Are Straightforward Machine Work
  - PC-104 Computer, Windows OS for Camera Drive Software

Thermal Design Issue

Thermo-Electric Cooler in Camera Needs ≈ 80 wt Power

- Continuous Operation Would Require Heat Pipe to Remove Power, Not Within Program resources
- Camera's Duty Cycle < 1%

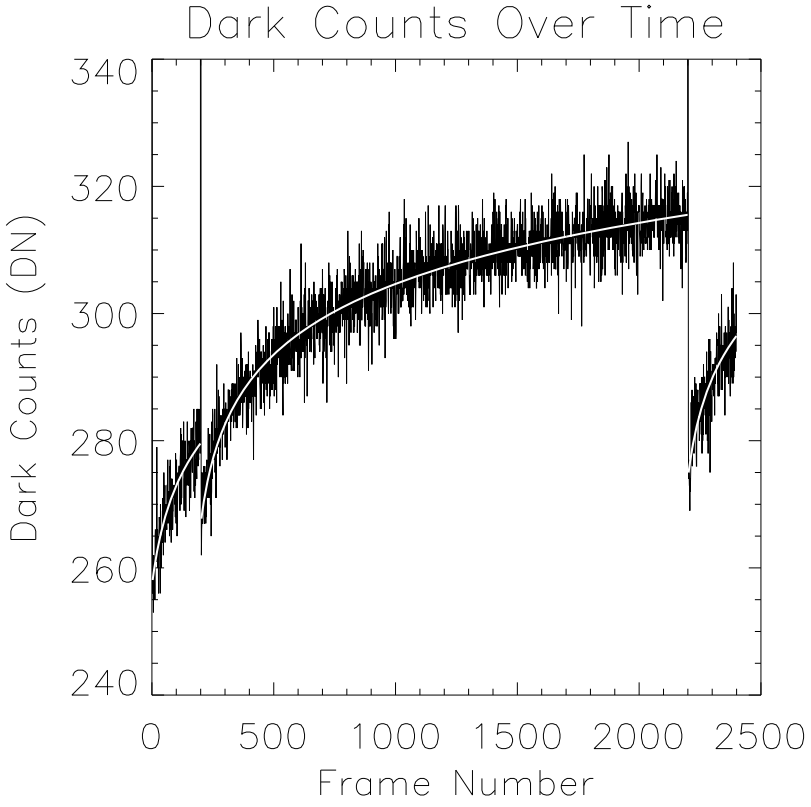
- Cooler NOT Used, CCD Temperature NOT Constant

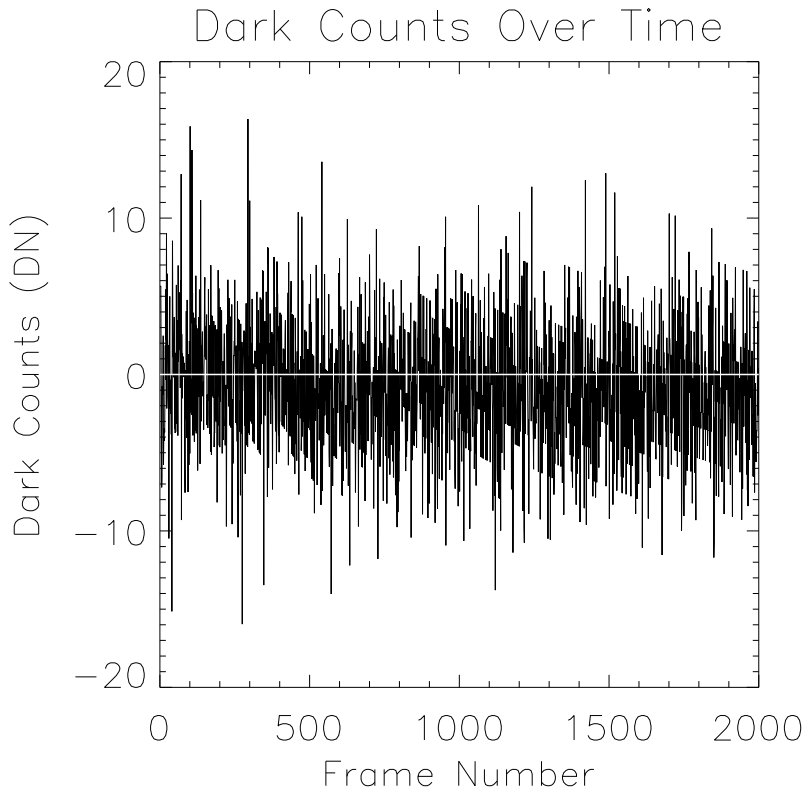
- One Scene Observation:
  - 200 dark frames, 8 min interval, 2,000 scene frames, 8 min interval, 200 dark frames
  - CCD warms during frame acquisition, cools during intervals
  - Dark Count Rate Changes

- Special Data Processing Required to Correct

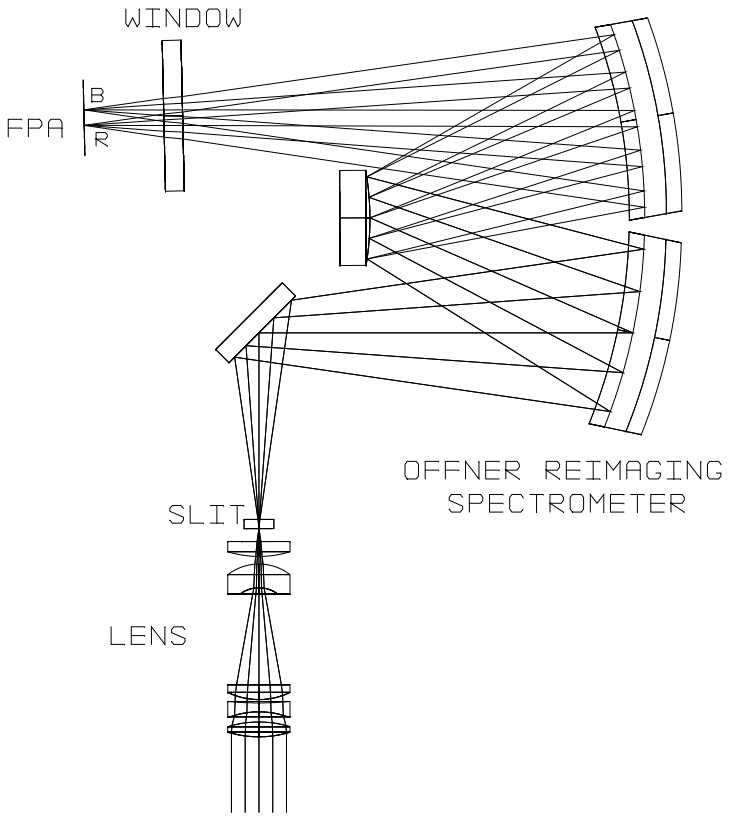
Correcting Dark Counts

- Left figure shows 1 pixel's output for 200 dark, 2,000 scene, 200 dark frames
- Right figure shows dark count subtraction
- Smooth curve is theoretical fit: use dark frame fits to infer dark counts in scene

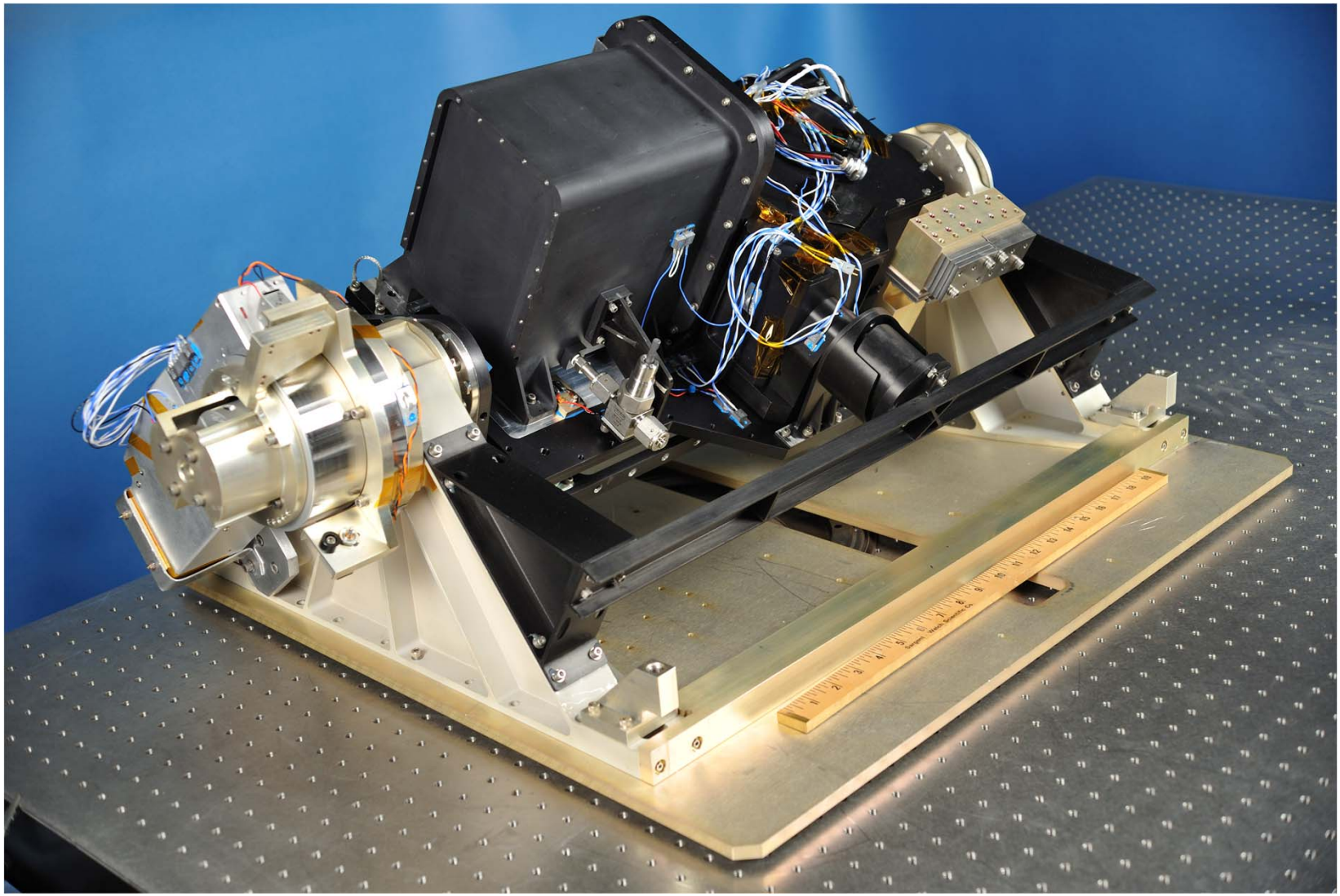




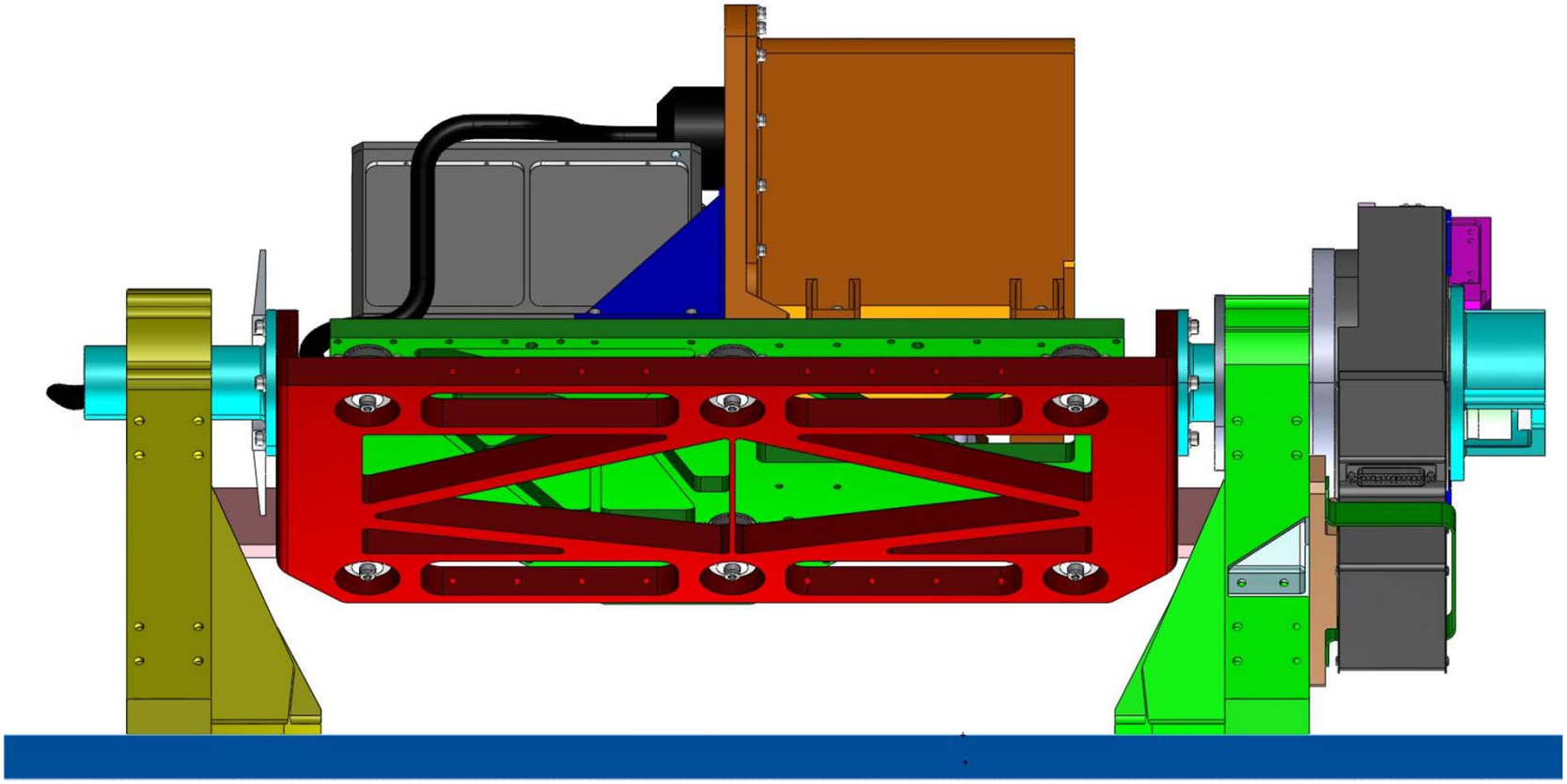
Optical Layout



Sensor Package



Back View of Assembly



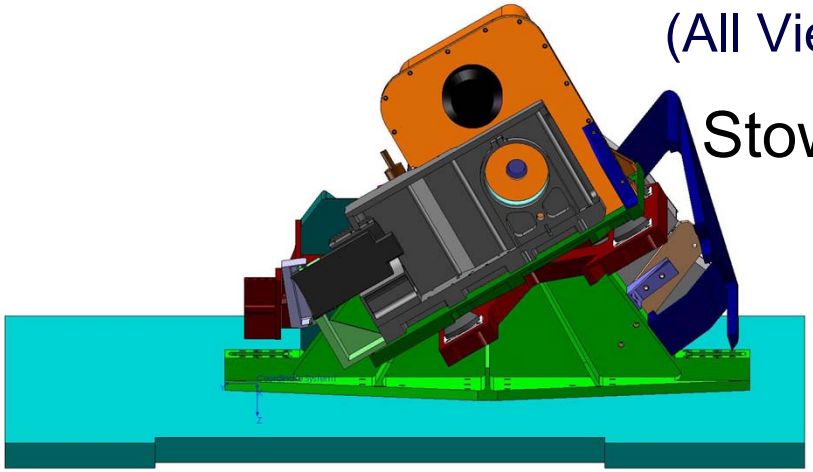
Field Of Regard (FOR)

FOV is 6.9°

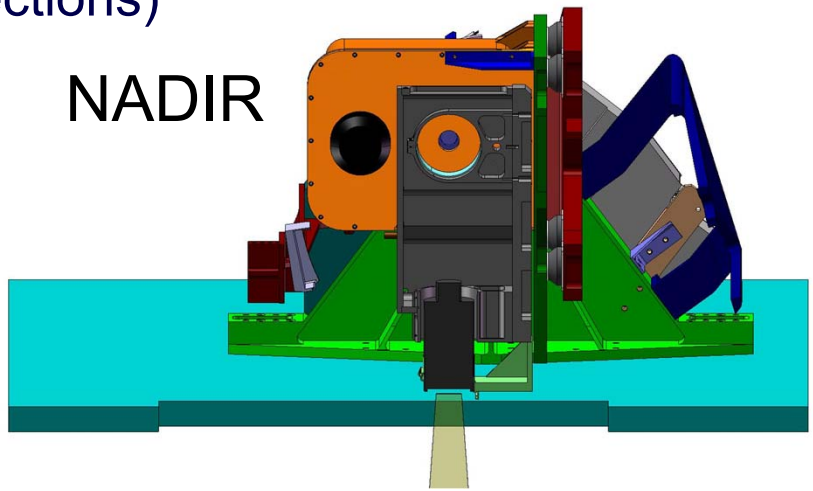
FOR is +45°/ -30° off NADIR (75° Total)

(All Views are Sections)

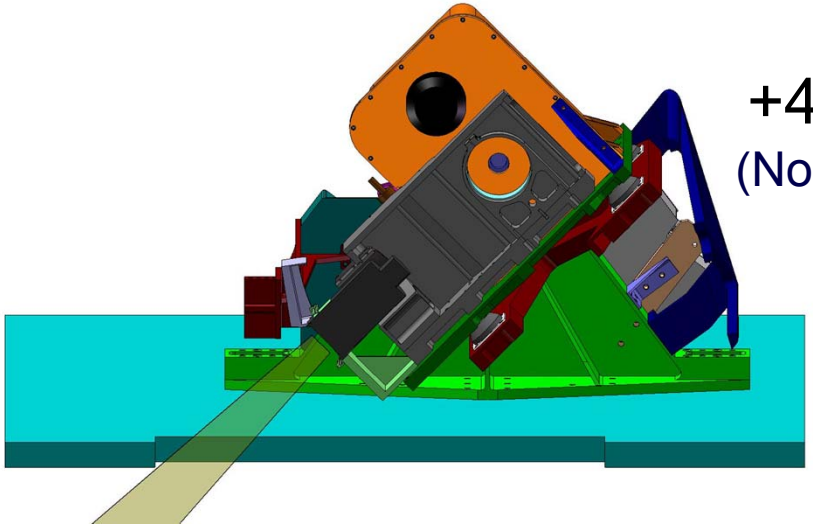
Stowed



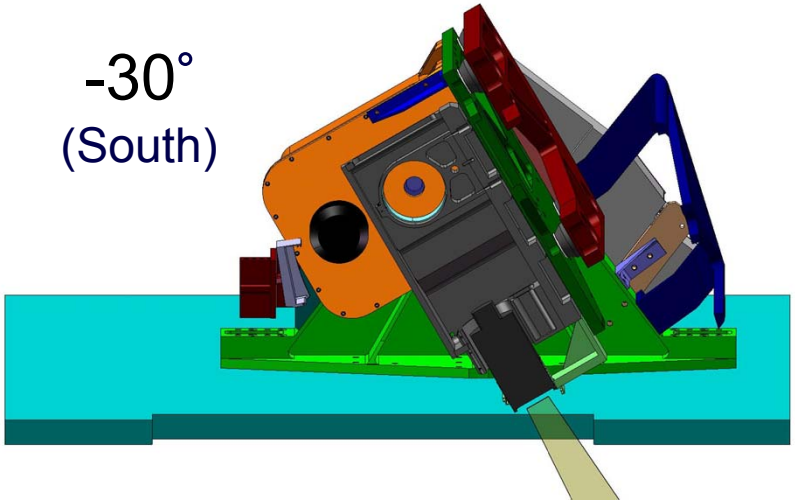
NADIR



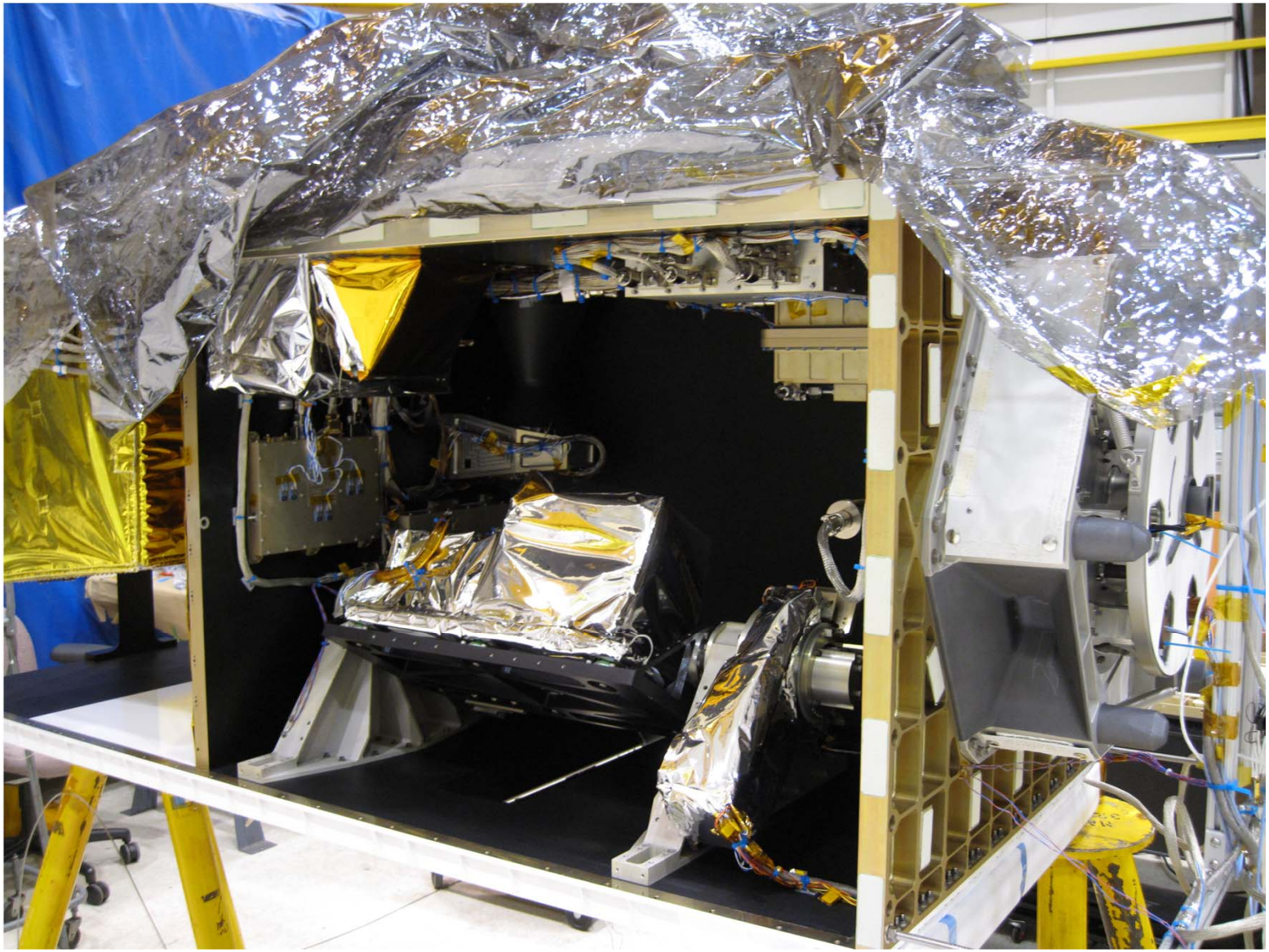
+45°
(North)



-30°
(South)



HICO in HREP



HICO Program

- HICO has Operated Successfully for 1 yr & 5 mo to Date
- Designed for 1 – 3 year Mission
- 2700 Images Returned so far
- Minor Optical Alignment Effects from Launch
  - Image Shifted Slightly ⇒ Small Change in Wavelength Calibration
  - Focus Still Sharp
  - On-Orbit Radiometric Calibration Not Same as Laboratory
    - Sensitivity Loss ≈ 25%, Cause Unknown

    (So Signal is 3/4 of Expected Value, Multiply by 4/3 to Correct)
- Mechanical Functioning has been Perfect
- Computer Locks Up Twice a Week on Average
  - Typical Rate on ISS for PC104 Running Windows OS

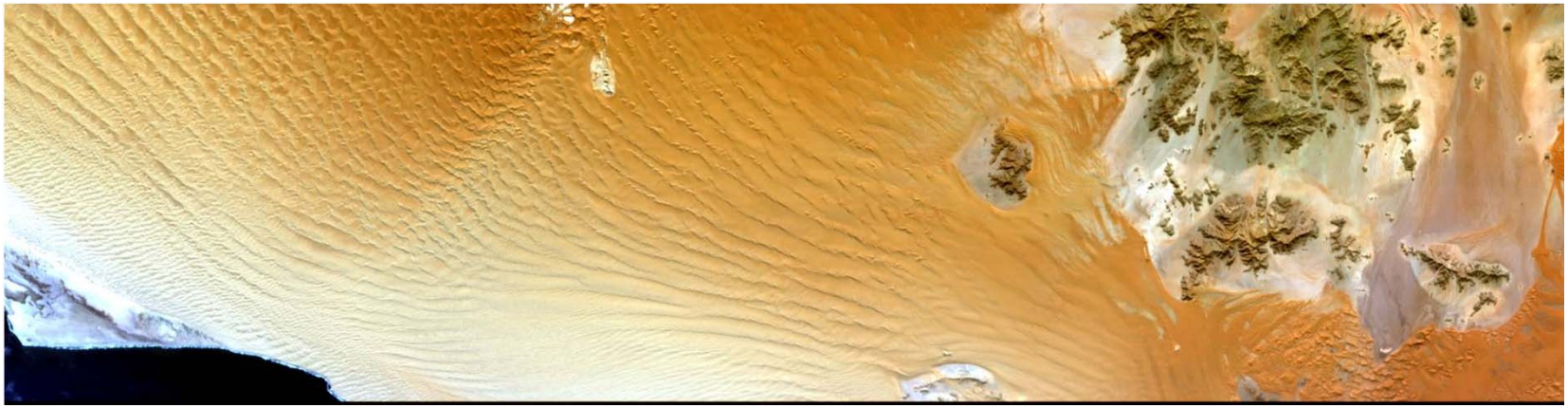
Images 1

Newport, Oregon

Kerch Strait, between Black Sea (bottom) and Sea of Azov (top)

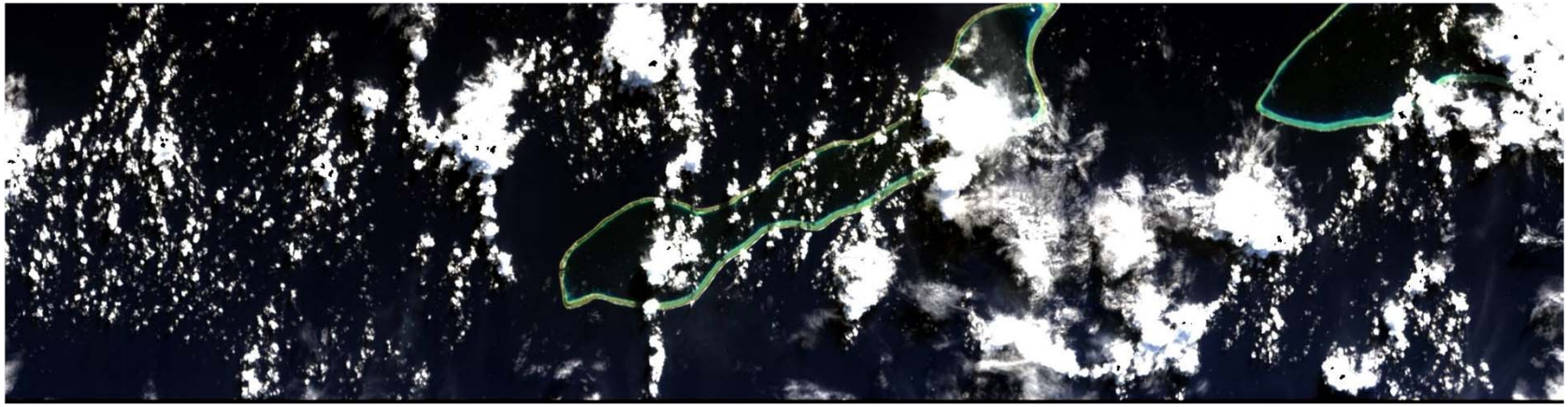
Images 2

Danube Delta



Namibia Desert

Images 3

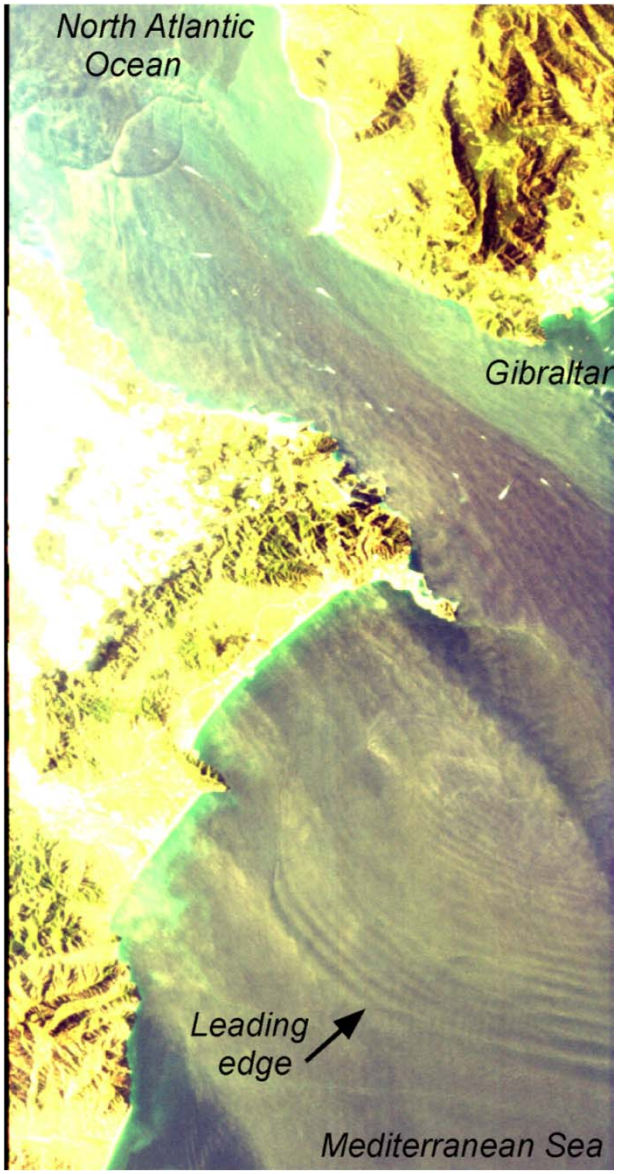


Makemo, French Polynesia

Barreal Blanco, Argentina

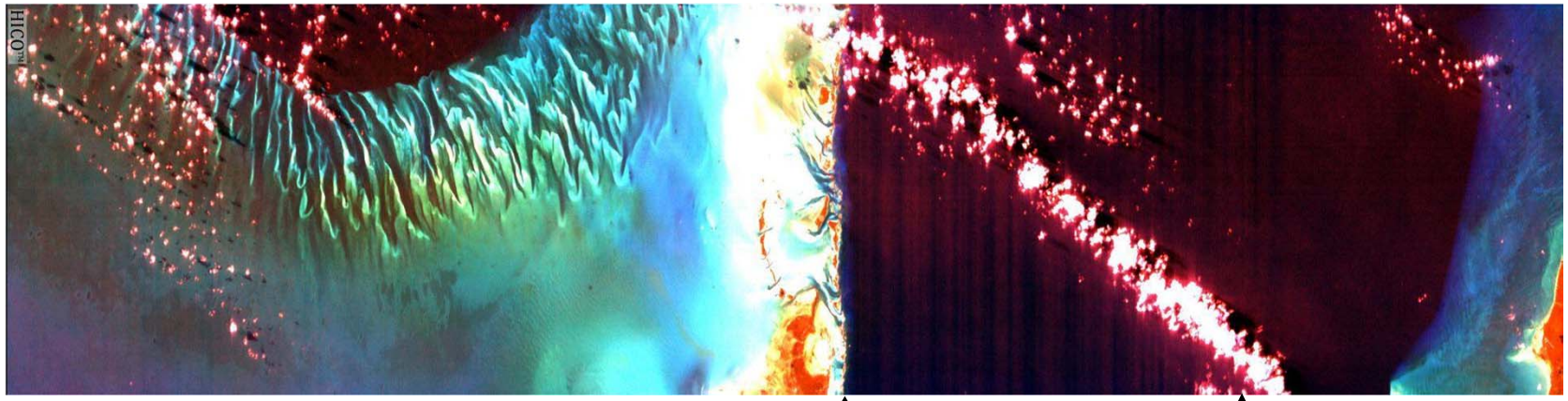
Ocean Internal Waves

- Ocean internal waves in HICO imagery
- Packets of large-amplitude ocean internal waves (IWs) occur in many littoral areas
- Important for vertical mixing and in acoustic variability
- Observed in SAR and sunglint imagery because IWs spatially modulate sea-surface roughness
- Recent studies suggest IWs also appear in ocean color imagery by modulating the chlorophyll maximum layer



Artifacts

- Bahamas with contrast stretch shows low-level artifacts



- deep-water drop-off
- cloud band

History Lesson

WE'VE INVENTED IT, SAM!

In WWII, photographic aerial reconnaissance couldn't determine the water depth and bottom type of the approaches to a beach, so swimmers had to be trained to gather intelligence on near-shore conditions before an invasion. Addressing this point, naval historian Samuel Eliot Morison wrote

> Among the many lessons learned at Tarawa* was the need for close pre-landing reconnaissance of beaches and their approaches, since no photographic process yet invented could indicate depth of water.
>
> – *History of United States Naval Operations in World War II*, vol. VIII, p. 166

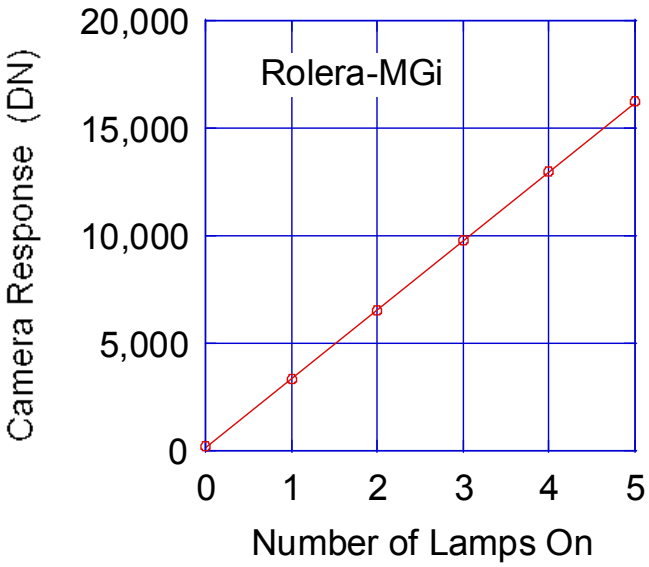
*The presence of a coral reef around Tarawa was known, but in the invasion many of the landing craft and amphibious vehicles couldn't cross it and Marines had to wade ashore through chest-deep water in the teeth of the Japanese machine guns. Hundreds died.

Back-Up Slides

Commercial Camera

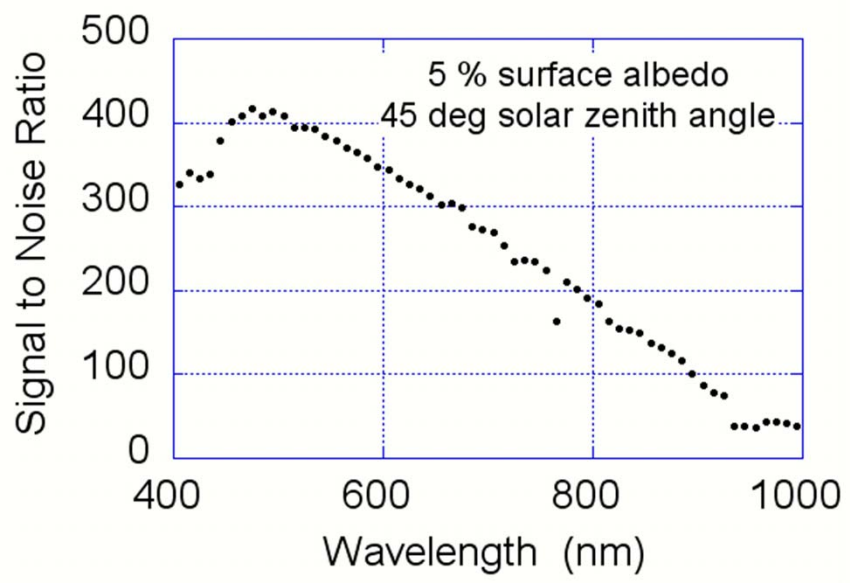
Tested QImaging Rolera-MGi camera:

- Measured conversion gain (26 e^- / DN)
- Measured pixel well depth (150 $ke^{-)}$
- Measured binning register well depth (>400 ke^-)
- Measured noise level (3.3 DN)
- Confirmed desired on-chip binning (3 V x 1 H)
- Confirmed readout rate at desired Region of Interest
- Confirmed linearity over desired range
- Confirmed operation with cryocooler disabled
- Confirmed stability under intermittent operation
- Wrote C++ code to operate camera
- Quantum efficiency not measured
- Selected all camera operating parameters



Commercial Spectrometer

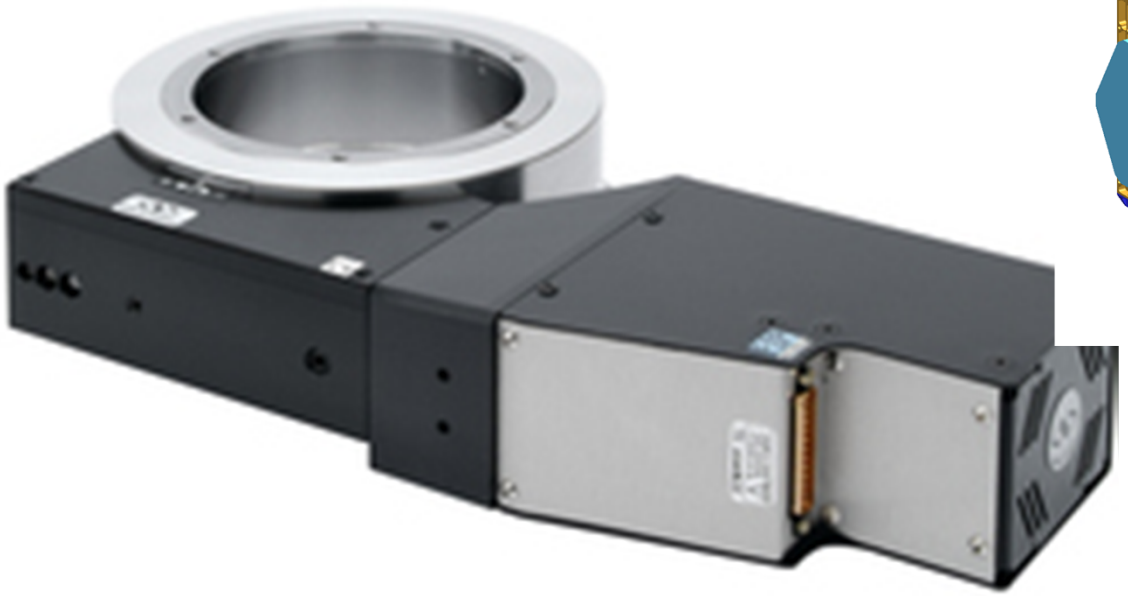
- Selected Brandywine Photonics model 3035 Spectrometer
- Offner spectrometer, high-efficiency grating
- Athermalized

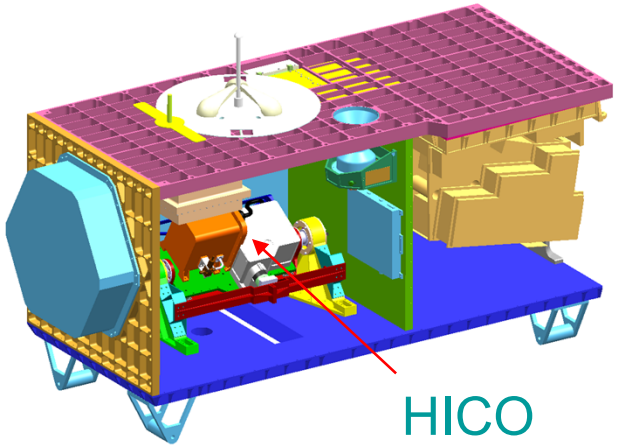


Brandywine Optics 3035 spectrometer (two shown)

Commercial Pointing Mechanism

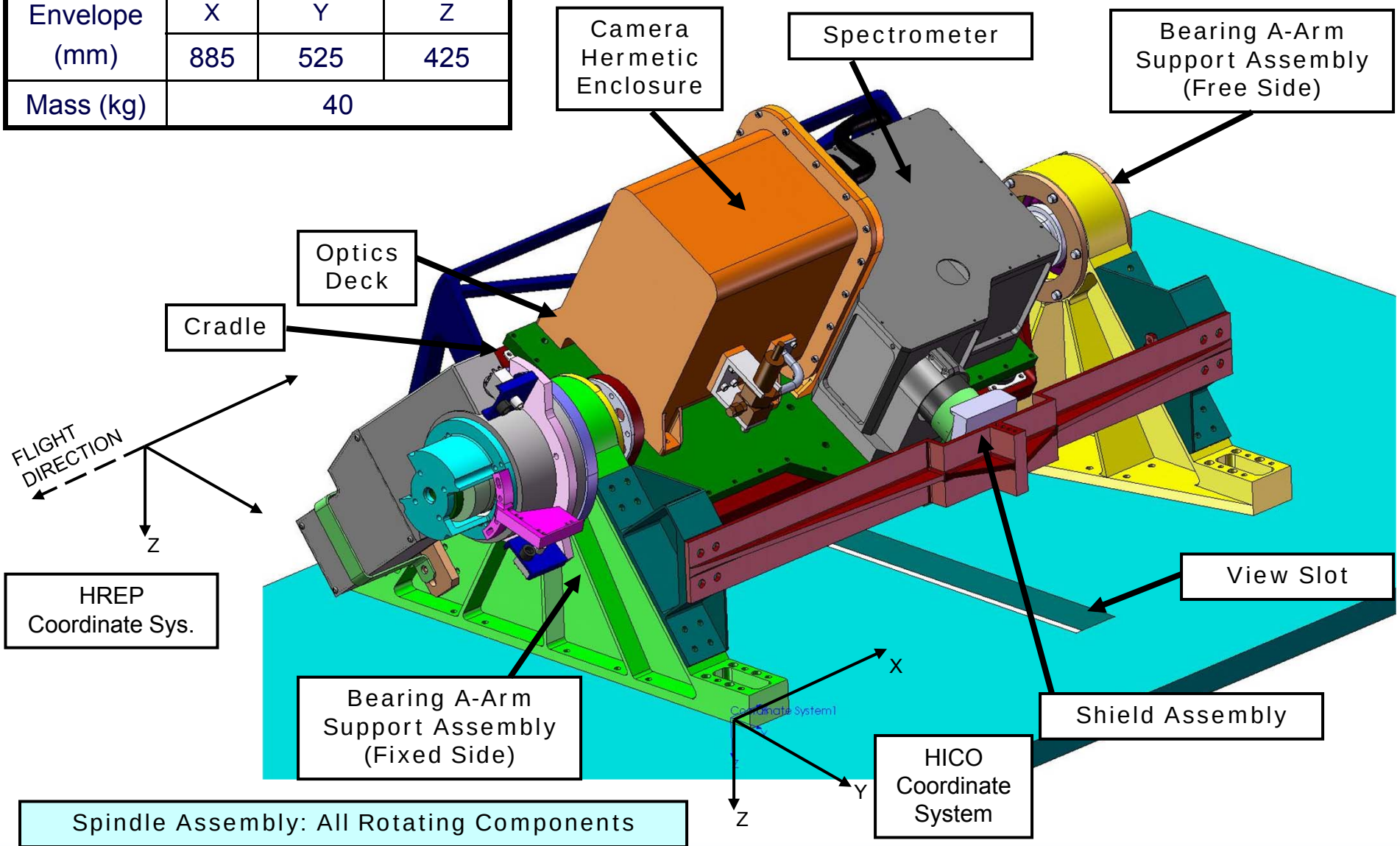
- One-dimensional rotary mechanism to point HICO line of sight in cross-track direction
- Newport Research model RV120PEV6 rotation stage
- Vacuum compatible
- Two units purchased: flight and spare





Rotating Sensor Assembly

Envelope (mm)	X	Y	Z
	885	525	425
Mass (kg)	40		



Spindle Assembly: All Rotating Components

HICO in HREP