Polarimeter to Unify the Corona and Heliosphere

NFI Instrument Status Overview

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NFI Instrument Lead

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PUNCH 6 Science Meeting
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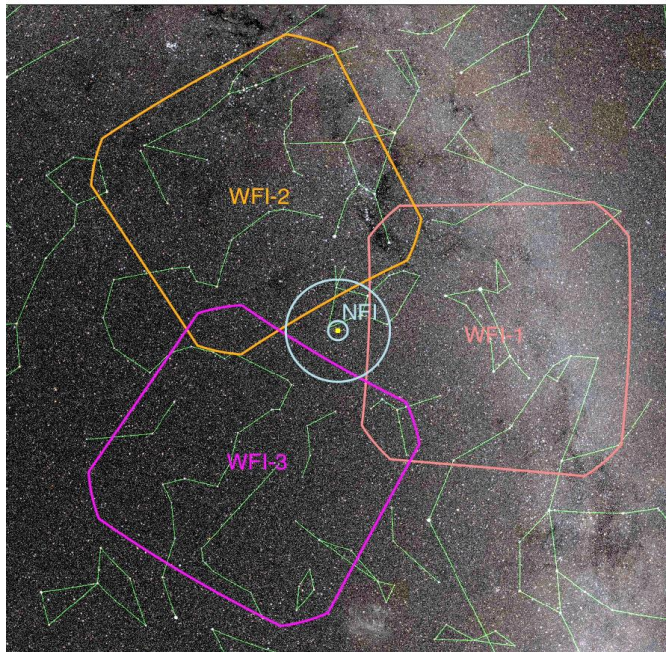
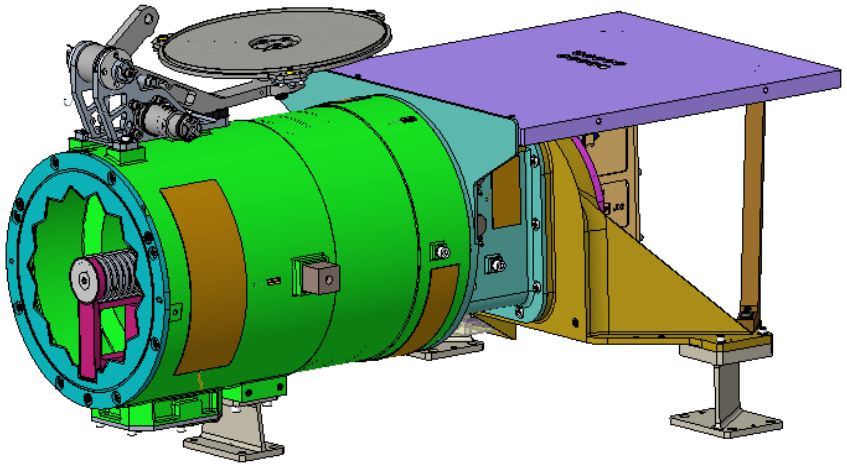
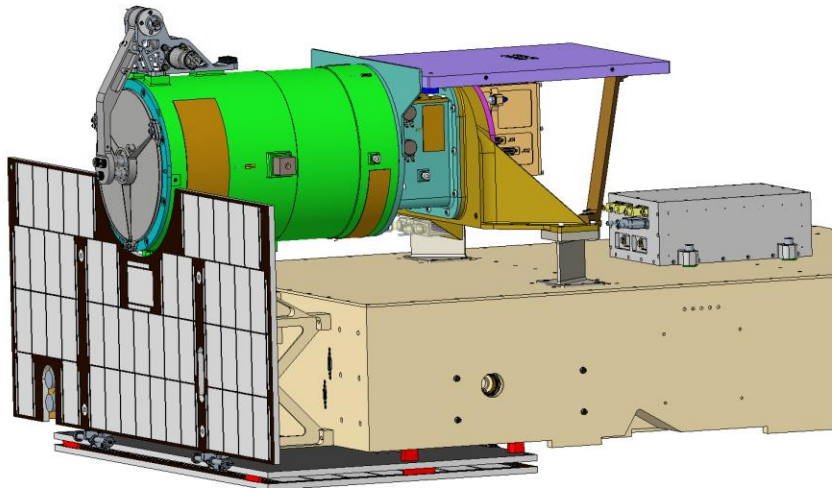
NFI Overview

- Combined NFI & WFI FOV provide first:
  - Wide-field, polarimetric, high resolution views of corona-solar wind transition
  - NFI: 6 -30 $R_\odot$, WFI: 20-180 $R_\odot$
- Provides high spatial/temporal resolution in the inner FOV
  - 1 observatory in polar orbit
  - Continuous 4 min observing cadence



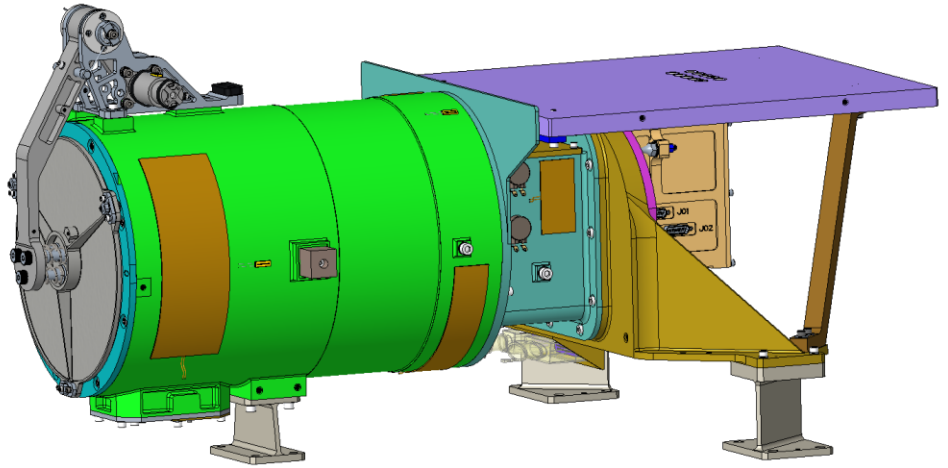


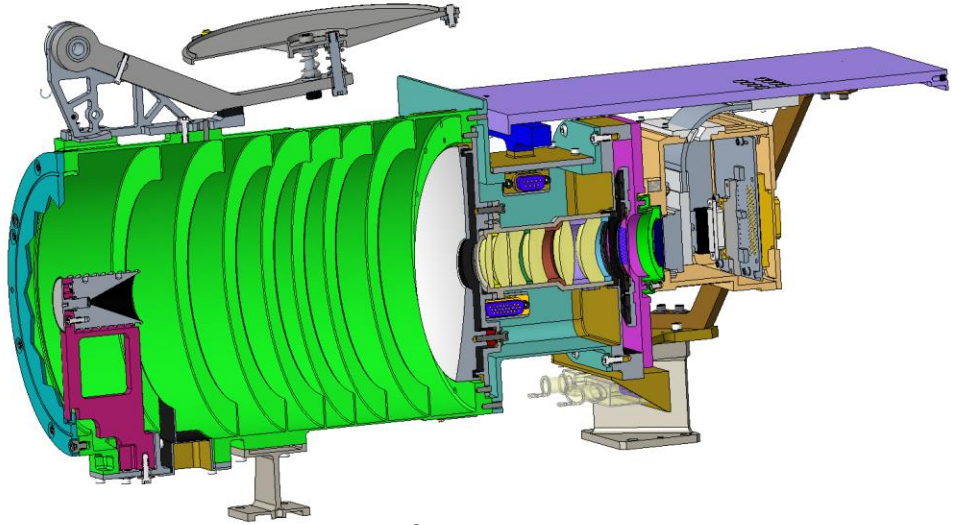


U.S. NAVAL RESEARCH LABORATORY

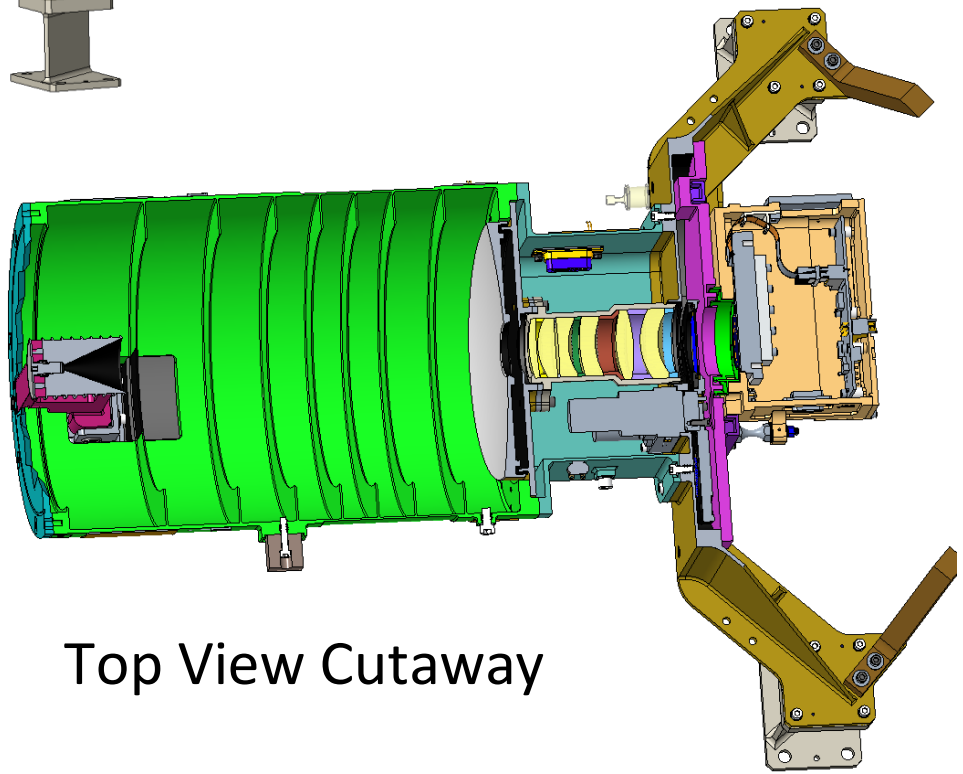
NFI Instrument Layout

Side View



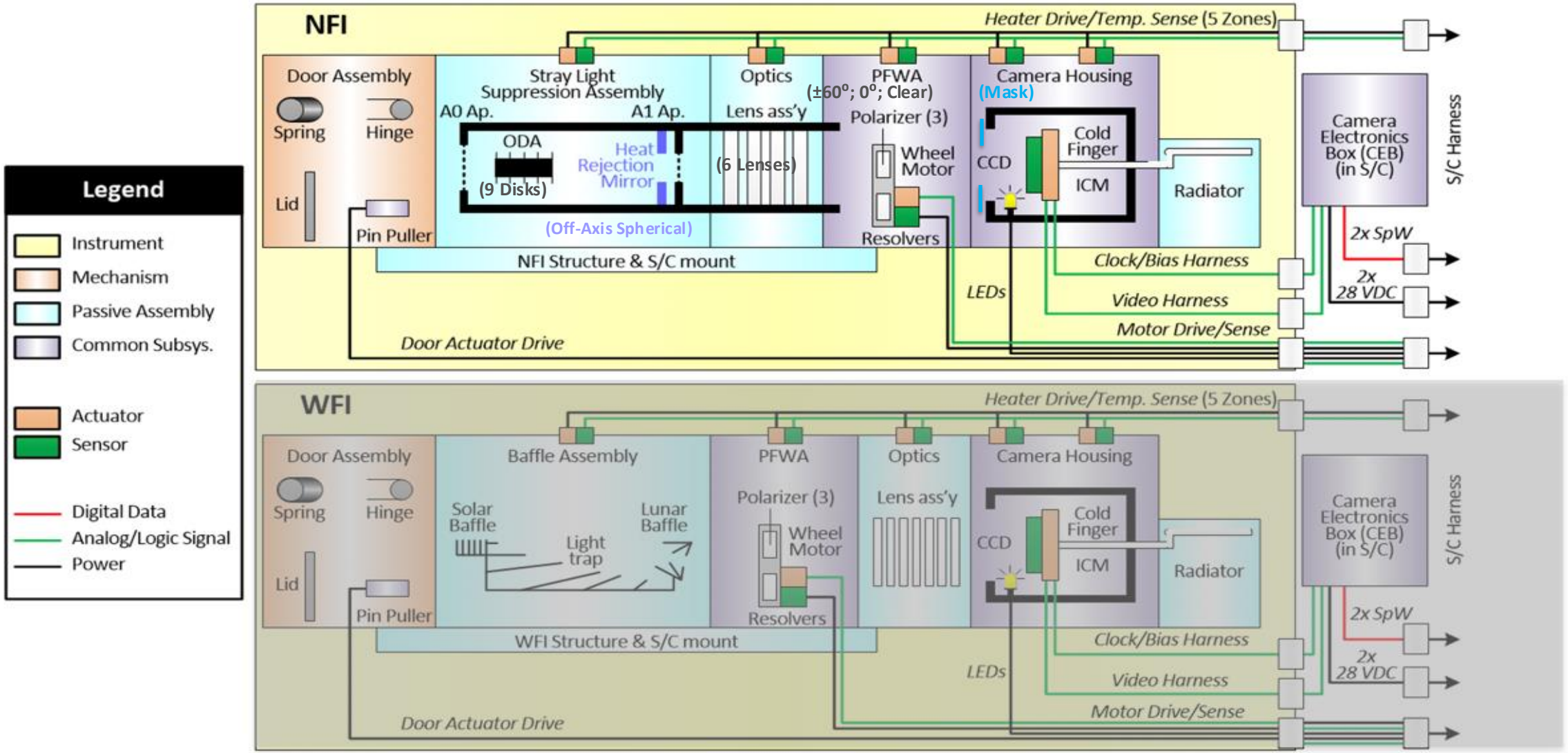


Side View Cutaway



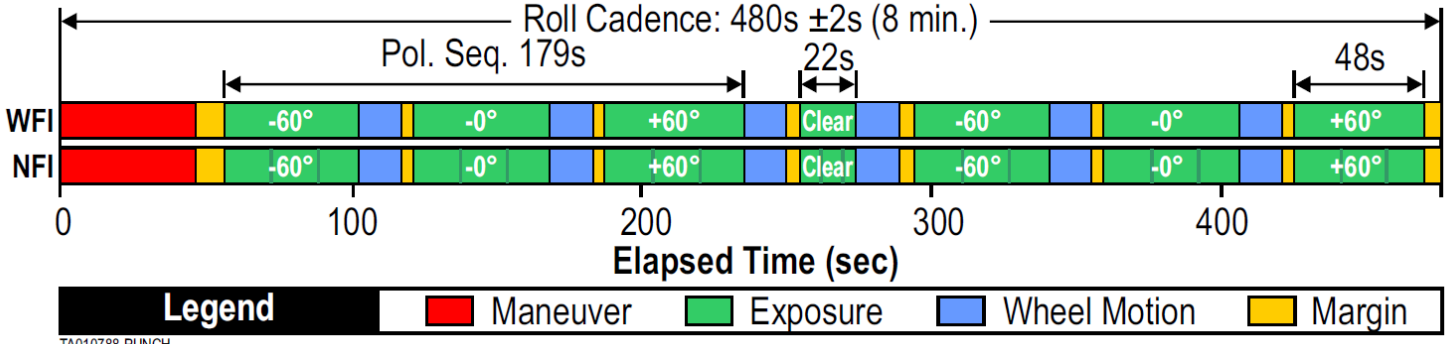
Top View Cutaway

NFI Physical Block Diagram



NFI Observing Plan

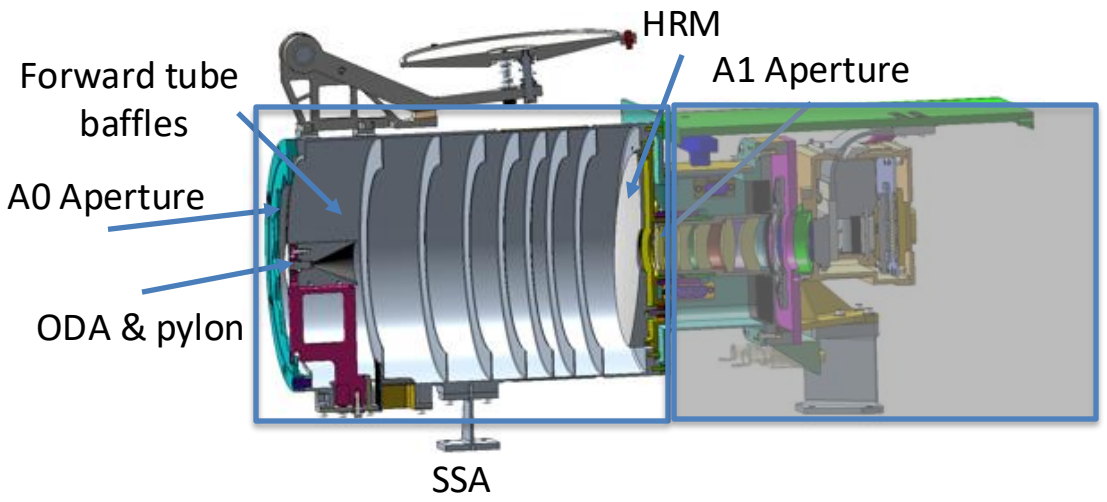
- Conops common to WFI & NFI
- Two sets of polarization sequences per 8 min roll cadence
- Each image a summation of 3 exposures

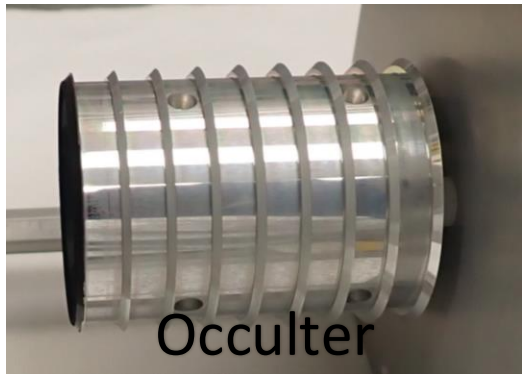


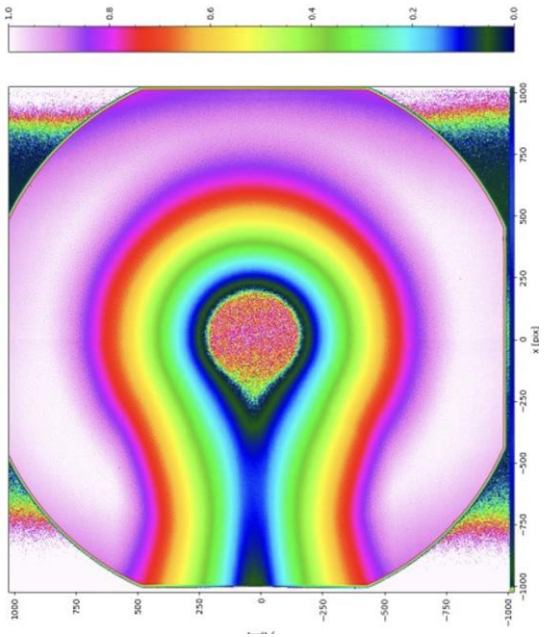
PUNCH Observing Sequence Schedule			
Time (s)	Length + margin	NFI Action	WFI Action
0	47+4	Roll & set PFW to -60°	Roll & set PFW to -60°
51	48+1(*)	Expose 3x13s at -60°	Expose 45s at -60°
98	15+5	Set PFW to 0° & settle	Set PFW to 0° & settle
118	48+1(*)	Expose 3x13s at 0°	Expose 45s at 0°
165	15+5	Set PFW to 60° & settle	Set PFW to 60° & settle
185	48+1(*)	Expose 3x13s at 60°	Expose 45s at 60°
232	15+5	Set PFW to CL & settle	Set PFW to CL & settle
252	22+1(*)	Expose 3x5s at CL	Expose 19s at CL
273	15+5	Set PFW to -60° & settle	Set PFW to -60° & settle
293	48+1(*)	Expose 3x13s at -60°	Expose 45s at -60°
340	15+5	Sep PFW to 0° & settle	Sep PFW to 0° & settle
360	48+1(*)	Expose 3x13s at 0°	Expose 45s at 0°
407	15+5	Set PFW to 60° & settle	Set PFW to 60° & settle
427	48+1(*)	Expose 3x13s at 60°	Expose 45s at 60°
474	1 to 11	Sync for next roll	Sync for next roll
(*) 2-second overlap with following event			

NFI Stray-Light Suppression Assembly (SSA)

- SSA design has:
  - Occulter Disk Assembly (ODA) & pylon
  - Forward tube baffles
  - Front aperture A0
  - Heat Rejection Mirror (HRM)
  - Entrance aperture A1
- Vignetting from the ODA ends at 21.9 $R_{\odot}$
  - Optimized for the coronal brightness gradient and overlap with the WFI FOV

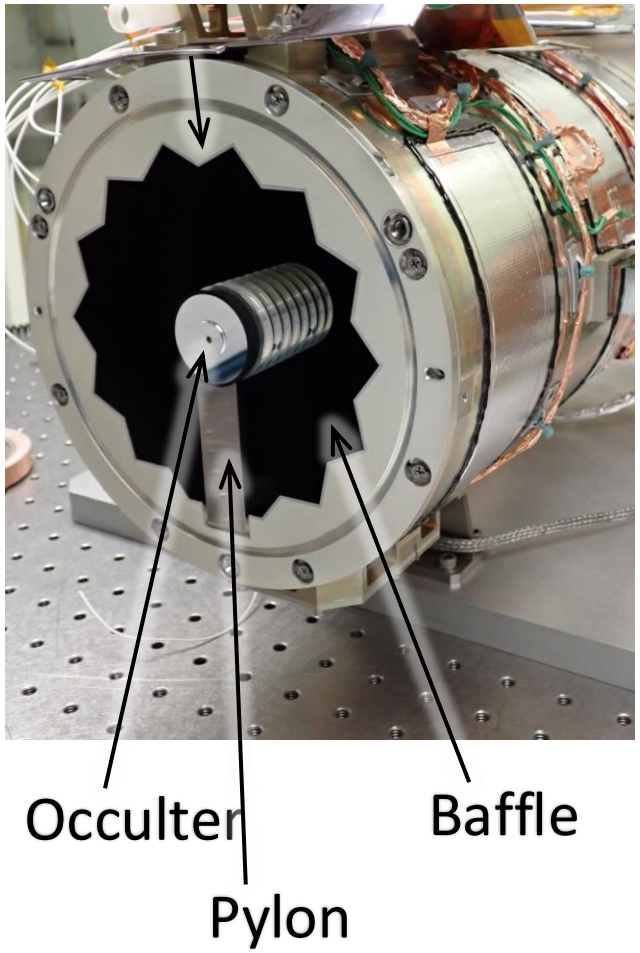






Normalized Measured Vignetting

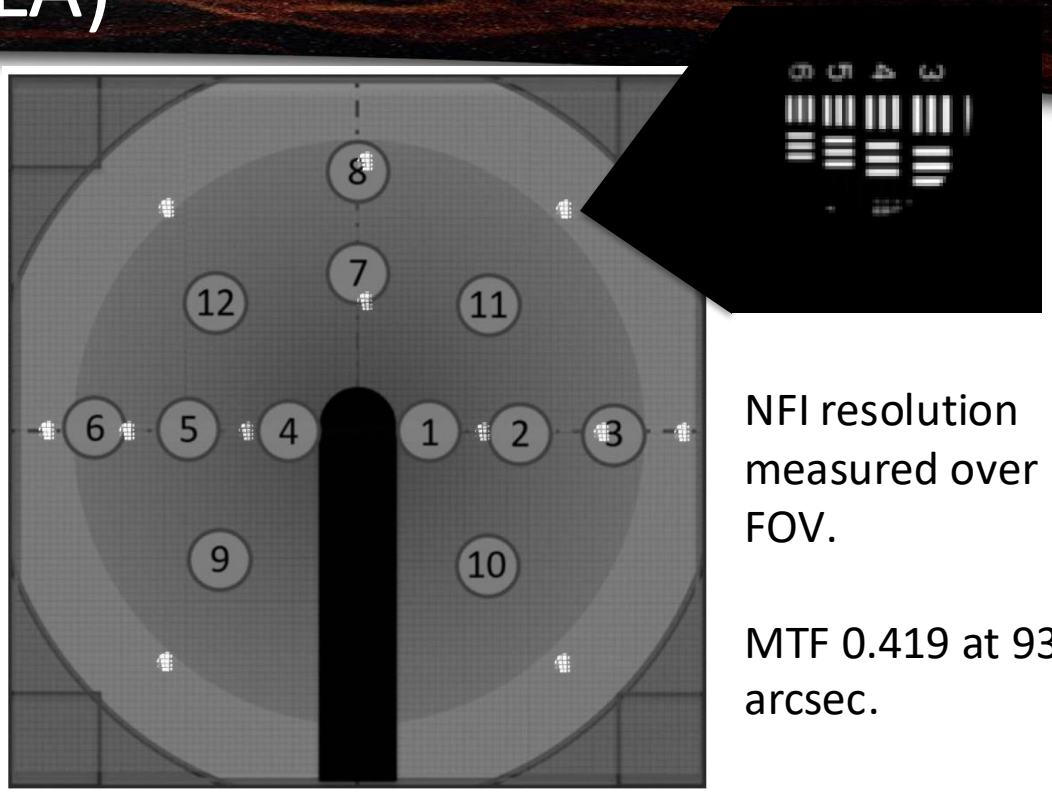
A0 Aperture



NFI Optical Lens Assembly (OLA)

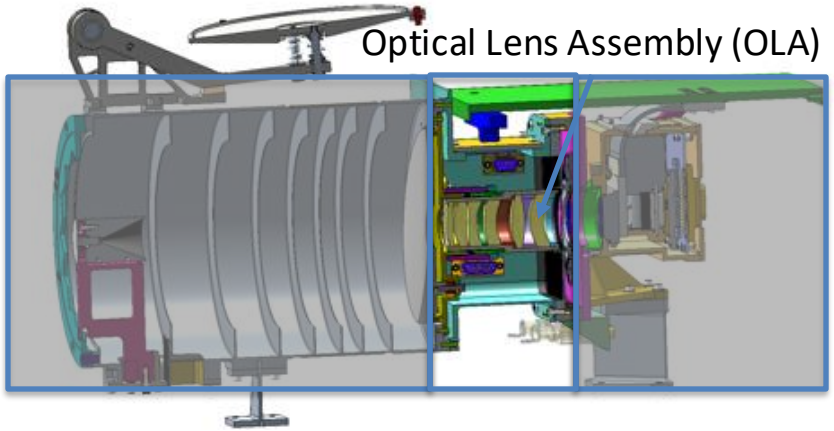
NFI Optical Parameters

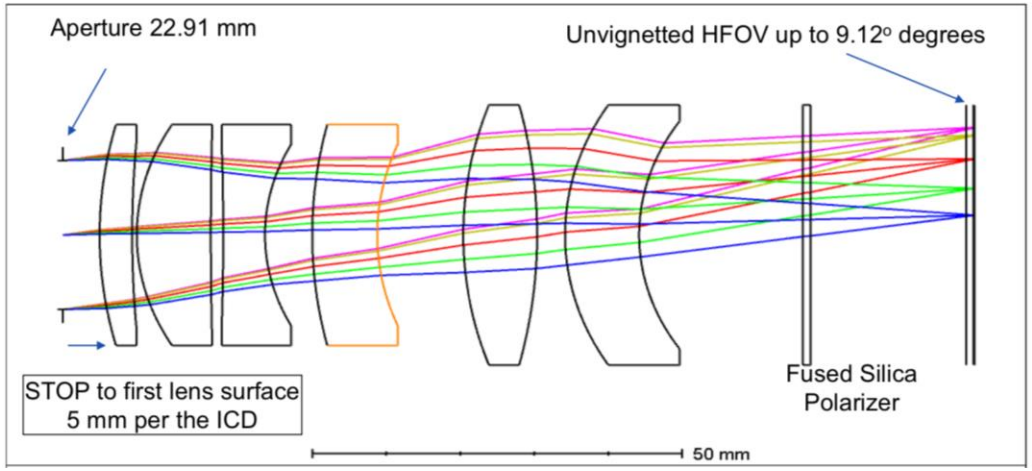
Parameter		units
FOV	6.0 - 36	$R_\odot$
Number of lenses	6	elements
Aperture	22.91	mm
Focal length	103.08	mm
Plate scale	0.55	mm/deg
f/#	4.5	
Spectral range	447 - 764	nm
Resolution	93	arcsec



NFI resolution measured over FOV.

MTF 0.419 at 93 arcsec.

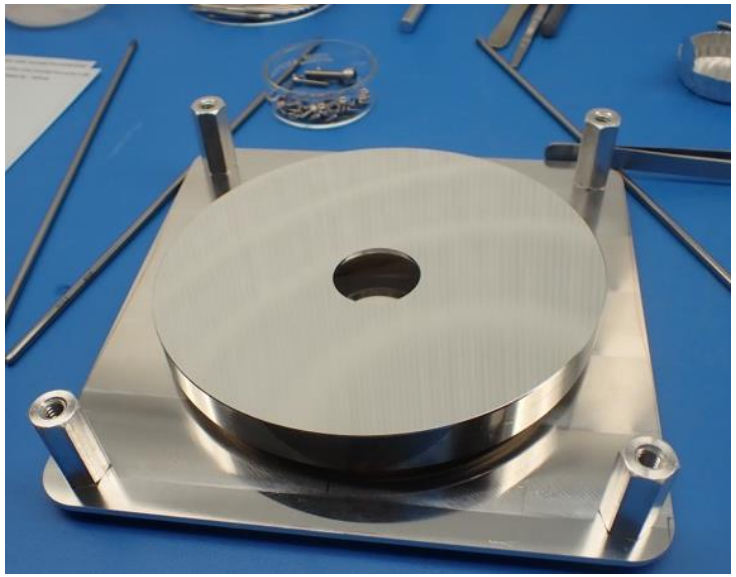


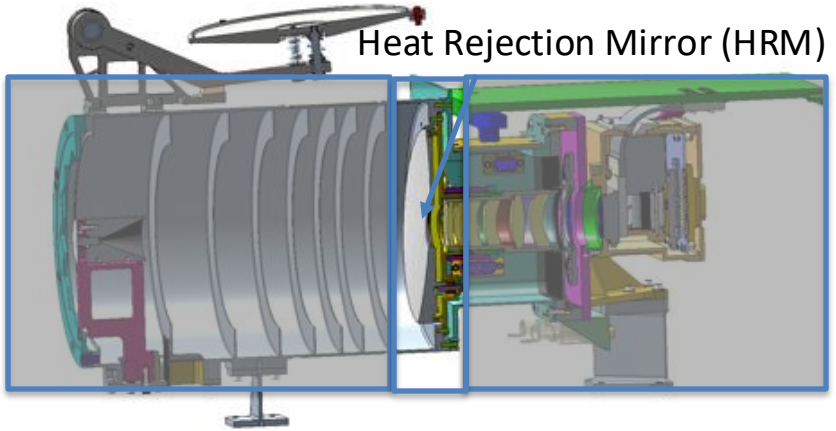


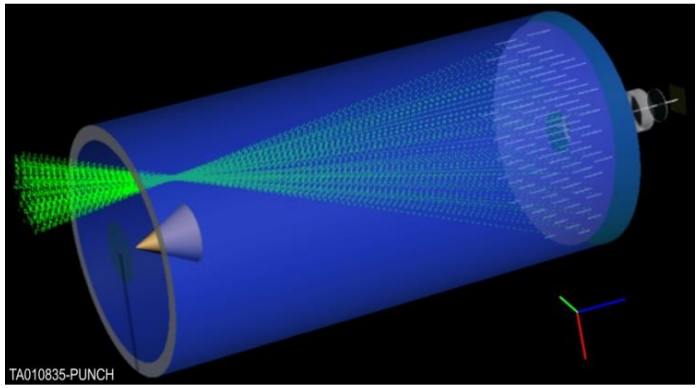
NFI Heat Rejection Mirror

- Minimizes scattered light in SSA and heating of instrument
  - Off-centered, parabolic mirror
  - 255-mm focal length
  - Creates an image of the Sun opposite the occulter pylon
  - Scatter due to surface imperfections 8.8×10^{-12} CBE+C

HRM





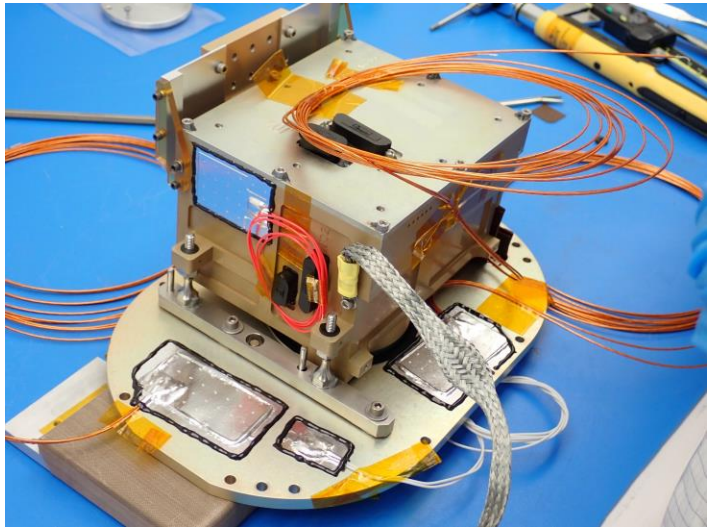


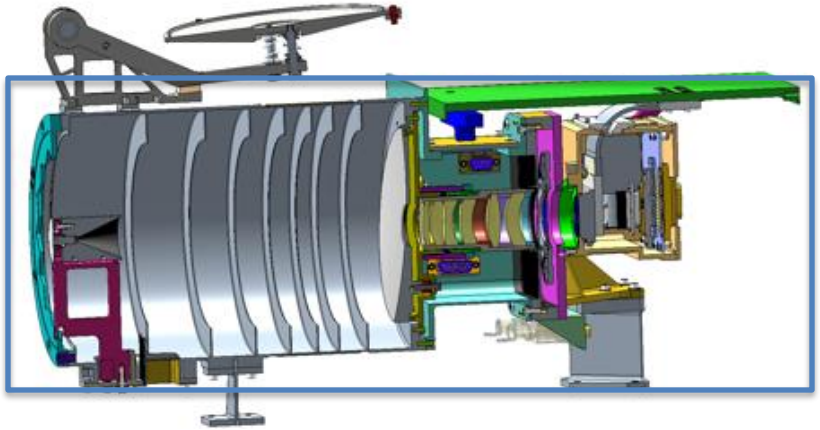
HRM Focal Point

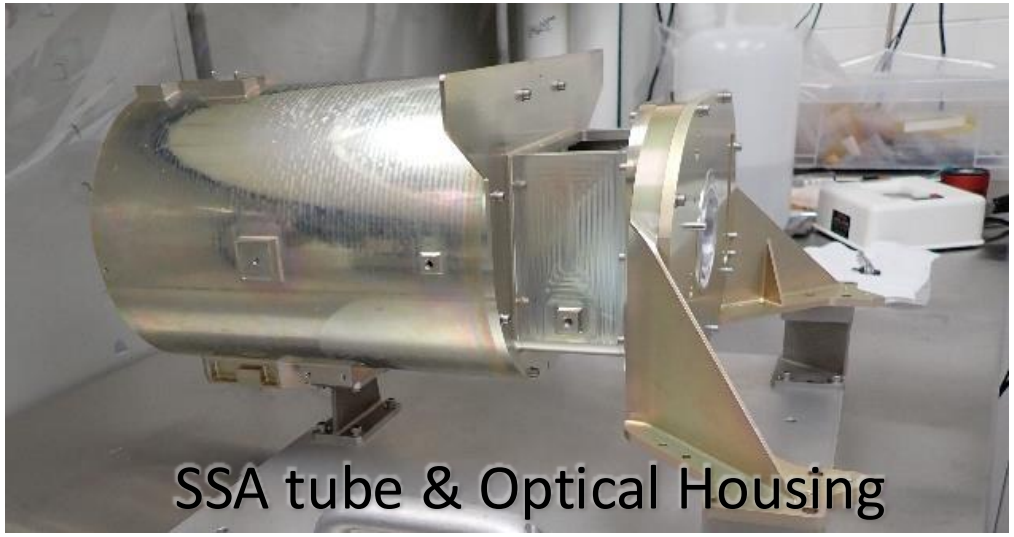
NFI Structure

- Aluminum tube construction
- Three piece design
  - SSA tube, optical housing, camera box
- Alignment determined by shims at the interfaces
- NFI Structure mounts to S/C via 3-point Ti kinematic mount
  - Thermally isolated from S/C
  - Provides alignment with S/C

FM camera box

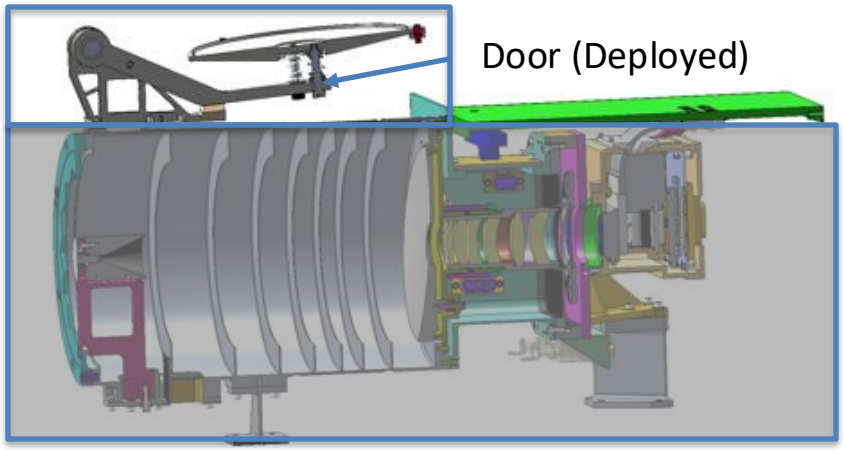




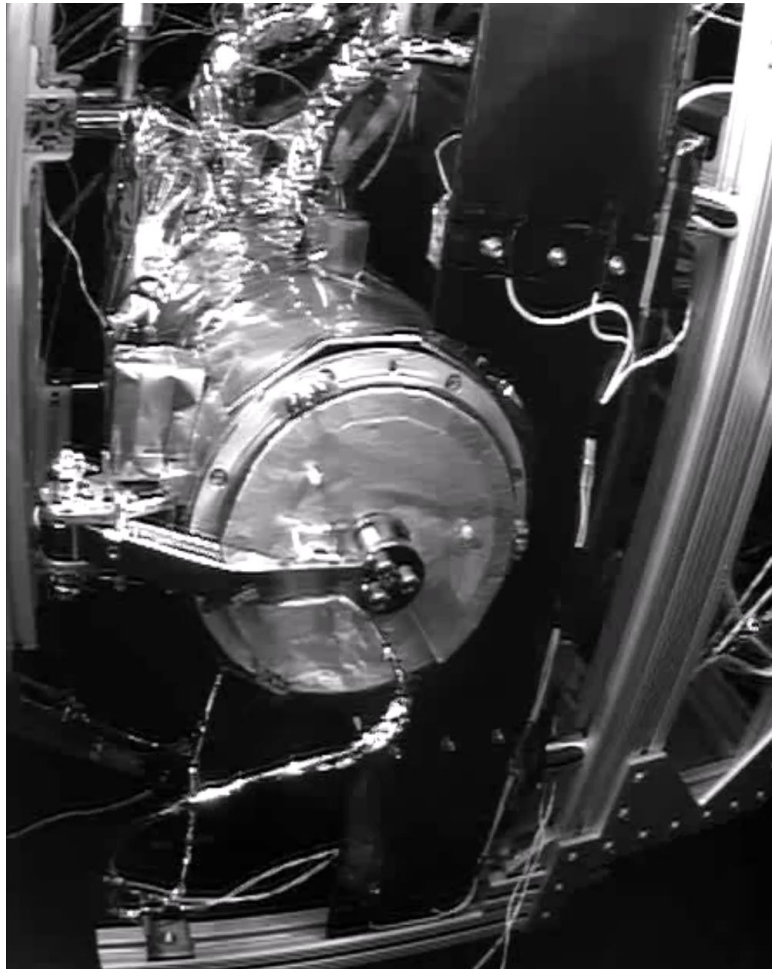


NFI Door

- Single one-time-open door
  - Provides contamination protection during S/C I&T, launch and early operations
  - All elements behind A0 for clear 180° field of regard
- Paraffin Wax Resettable Pin-Puller
  - Common to NFI and WFI

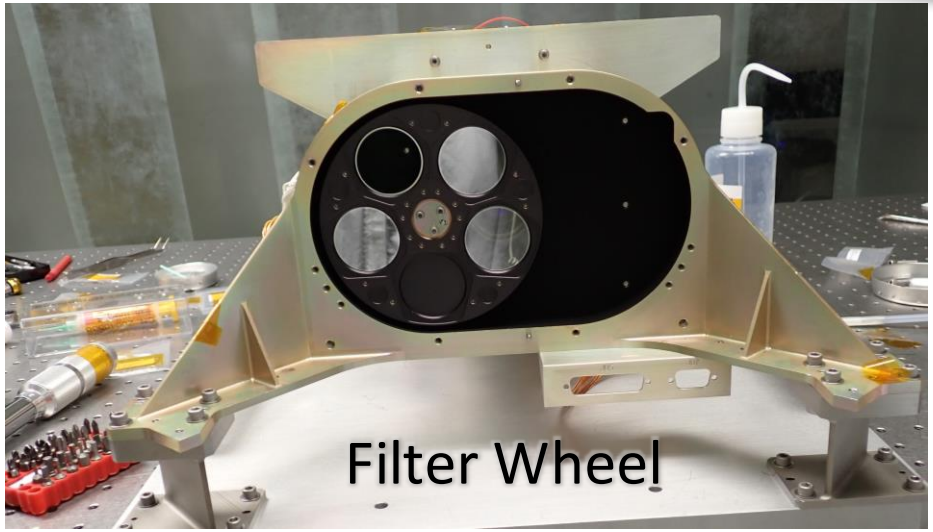


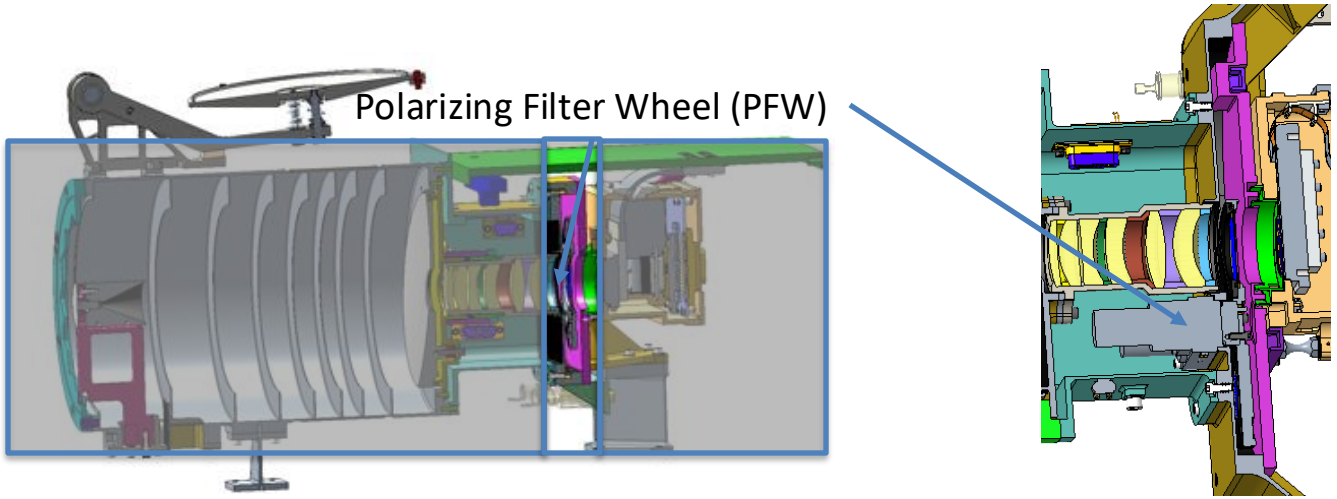
Door TVAC Test

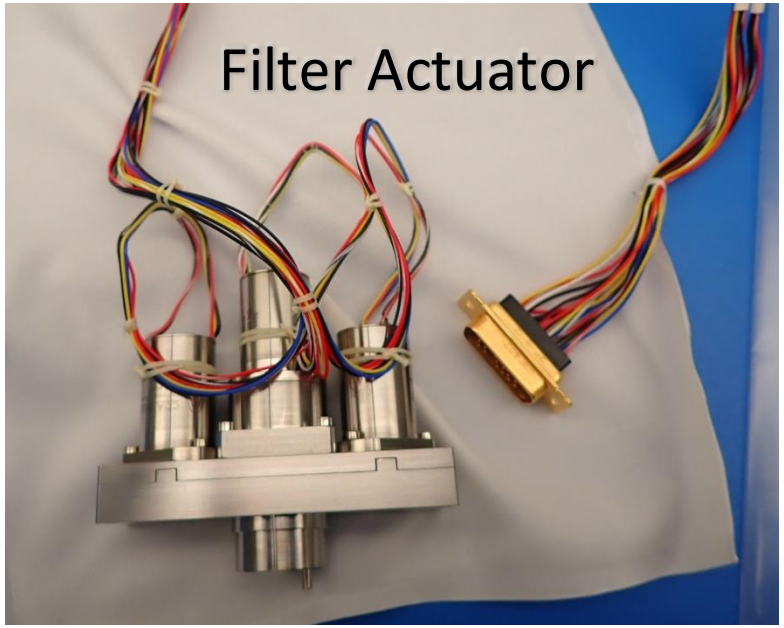


Polarizing Filter Wheel (PFW)

- PFW is common to WFI & NFI
- Provided by NRL to NFI & WFI
- 5-position filter wheel
  - Filters: -60°, 0°, +60° linear polarizers
  - Clear glass (optical focus consistency)
  - Blank (for Safing, Stim LED lamp)
- Linear Polarizers
  - Al nanowire lithographically applied to glass
  - Superior contrast ratio (>1000:1) and transmittance (>85%)



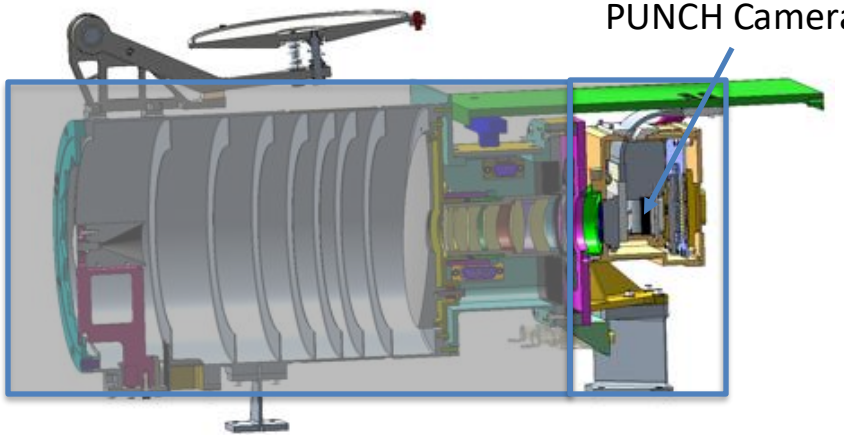


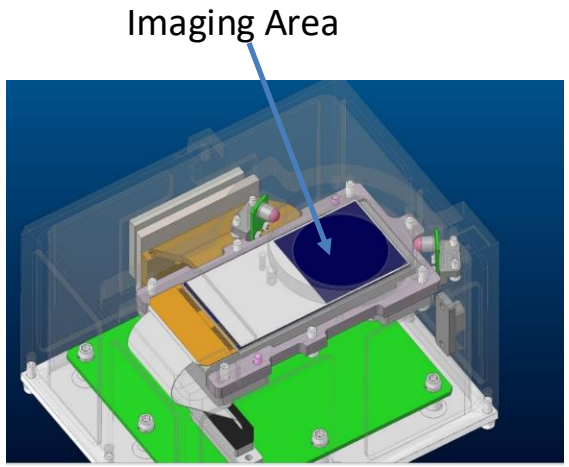


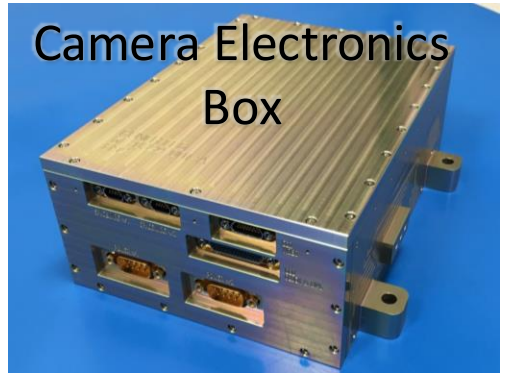
PUNCH Camera

- Camera system identical in WFI & NFI
- Build by RAL, STEREO Heritage
- Teledyne-E2V CCD
  - 2k x 2k Imaging Area
  - 2k x 4k pseudo-charge-transfer CCD

PUNCH EM CCD - full-frame readout with frame-transfer storage area 4200 x 2148 pixels

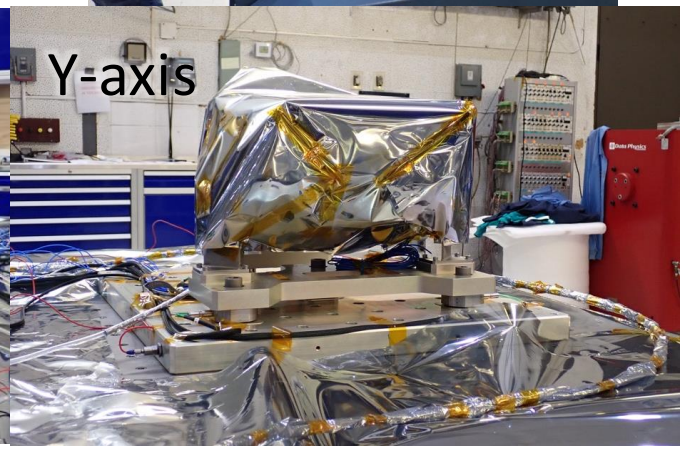




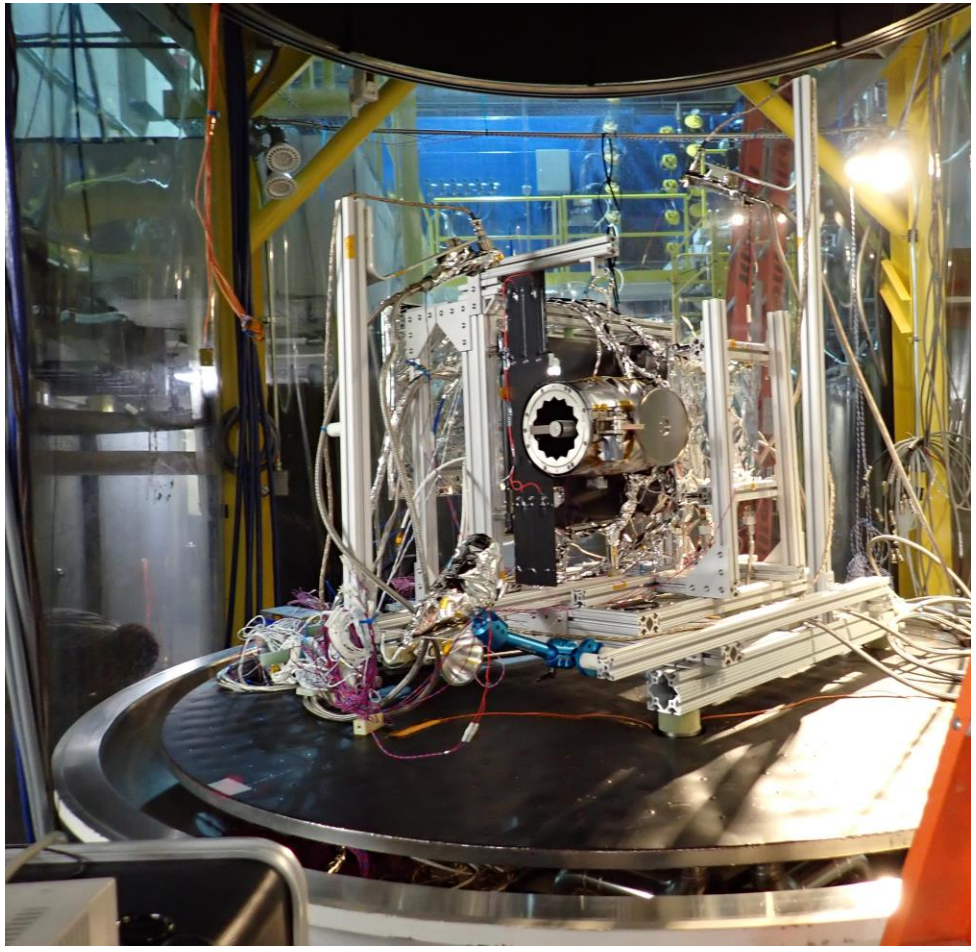


Environmental Testing

- Vibration Testing
  - Simulates vibrations seen at launch
  - Each axis of the instrument is tested independently

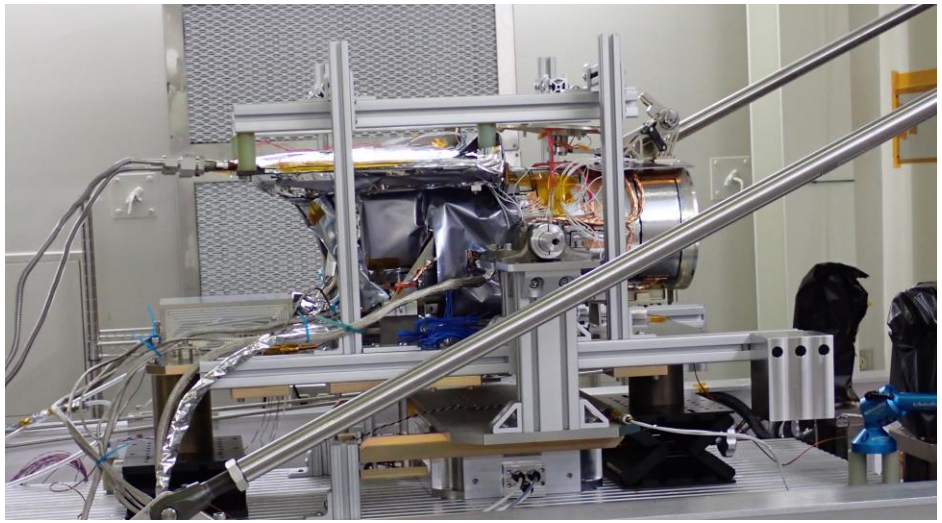


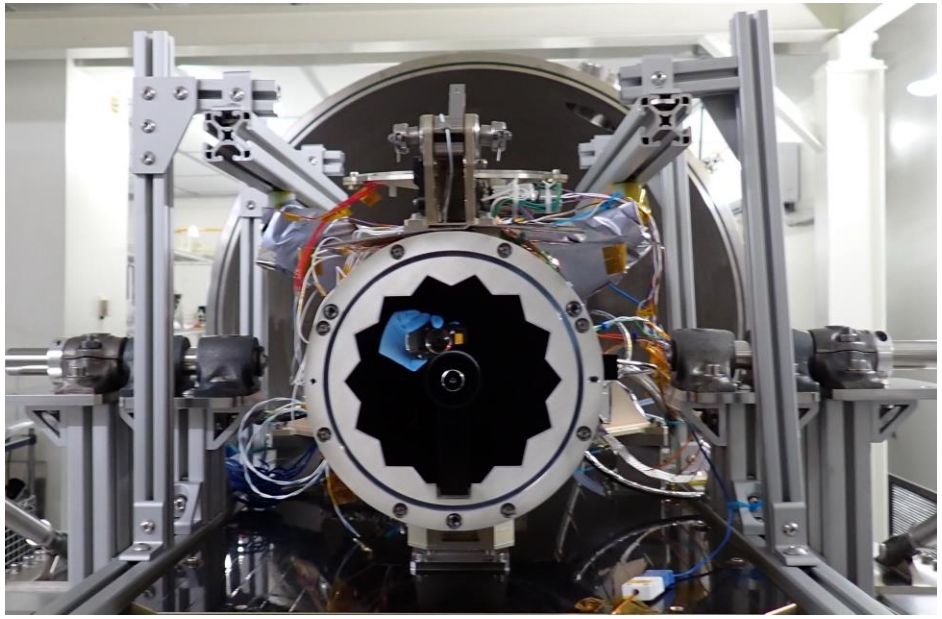
- Thermal Vacuum Testing
  - Simulates the temperatures seen on-obit in vacuum



Pre- & Post-Environmental Testing: SCOTCH Testing

- Optical Testing of Complete instrument
  - In vacuum at operational temperatures
  - Solar simulator provides collimated light

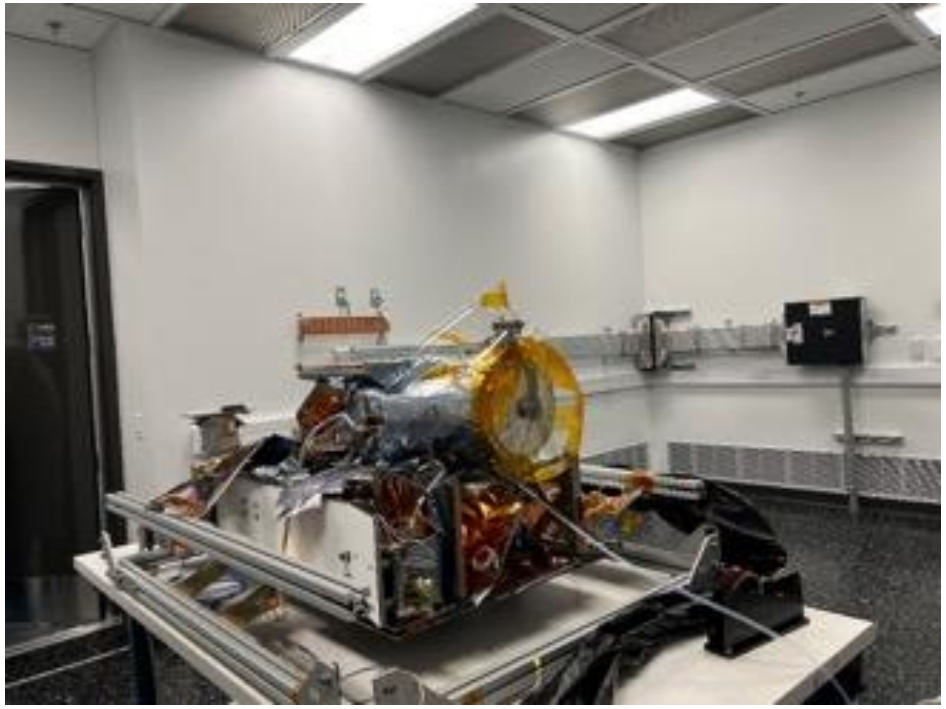




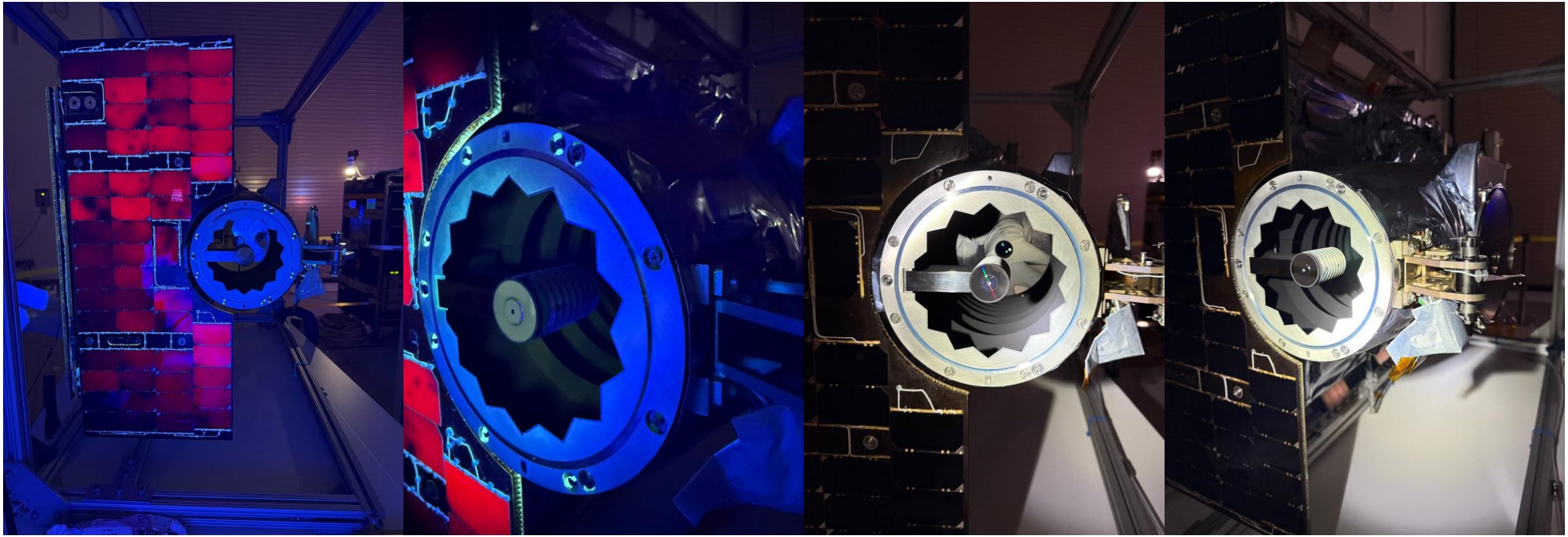
Instrument Delivery SwRI San Antonio

NFI Spacecraft Integration

- NFI was integrated onto a PUNCH Spacecraft
- PUNCH-NFI-Spacecraft successfully completed Vibration, Shock and Acoustic testing
- PUNCH-NFI-Spacecraft is in Thermal Vacuum (TVAC) testing



Launch Site Contamination Inspection



Summary

- NFI meets the driving requirements and Science Objectives
- NFI was successfully delivered to the PUNCH mission for Spacecraft integration and environmental testing
- NFI is ready for launch!

GO NFI
GO PUNCH