NIC-FPS Preliminary Design Review

Instrument Overview,

Management/Schedule

Jon Morse

(CU-CASA)

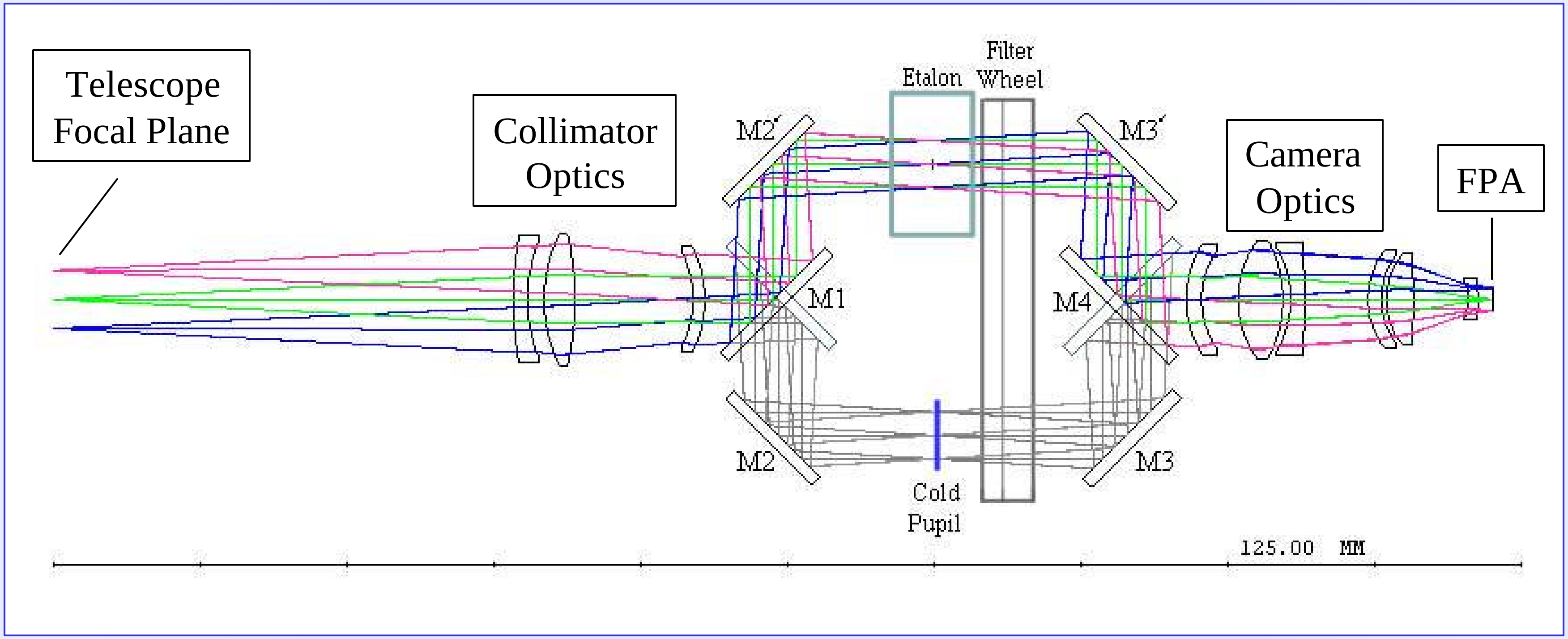
12 April 2002

CASA-ARL

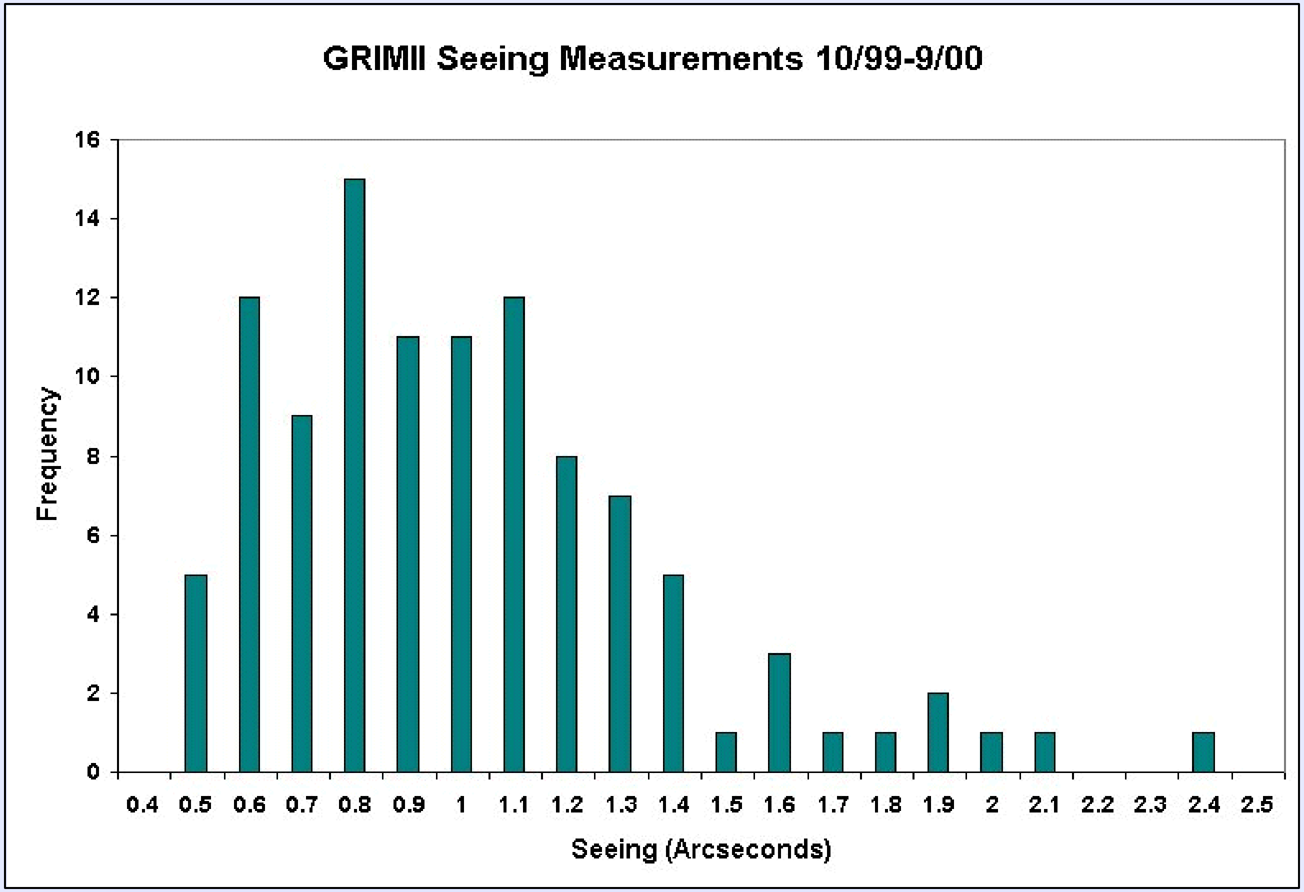
Boulder, CO

- Brief history of the Near-Infrared Camera and Fabry-Perot Spectrometer (NIC-FPS):
  - Original IRFP concept by G. Cecil (UNC) and P. Hartigan (Rice) to be used in conjunction with CIRIM 256^2 IR camera on CTIO 4m
  - Cryogenic IR F-P etalon purchased by Hartigan from QI in 1996 for $62k (50 mm clear aperture; R ~ 10,000; operates at 77K; 1 of only 5 constructed by QI)
  - 90% of components (dewar, optics, bench) fabricated but IRFP never fully assembled (CU contributed ~$10k to dewar fab)
  - CU joined ARC in July 2001; $450k instrument obligation presents opportunity to fulfill unique science of cryogenic IR F-P while simultaneously upgrading ARC near-IR imaging capability
  - Summer 2001: Investigated compatibility of existing IRFP hardware for NIC-FPS, but Cass focus IRFP design not adaptable for Nasmyth mount
  - Fall 2001: Investigated 2k × 2k imager feasibility, but cost beyond CU+ARC present resources
  - January 2002: 1k × 1k approach adopted; detailed design begins

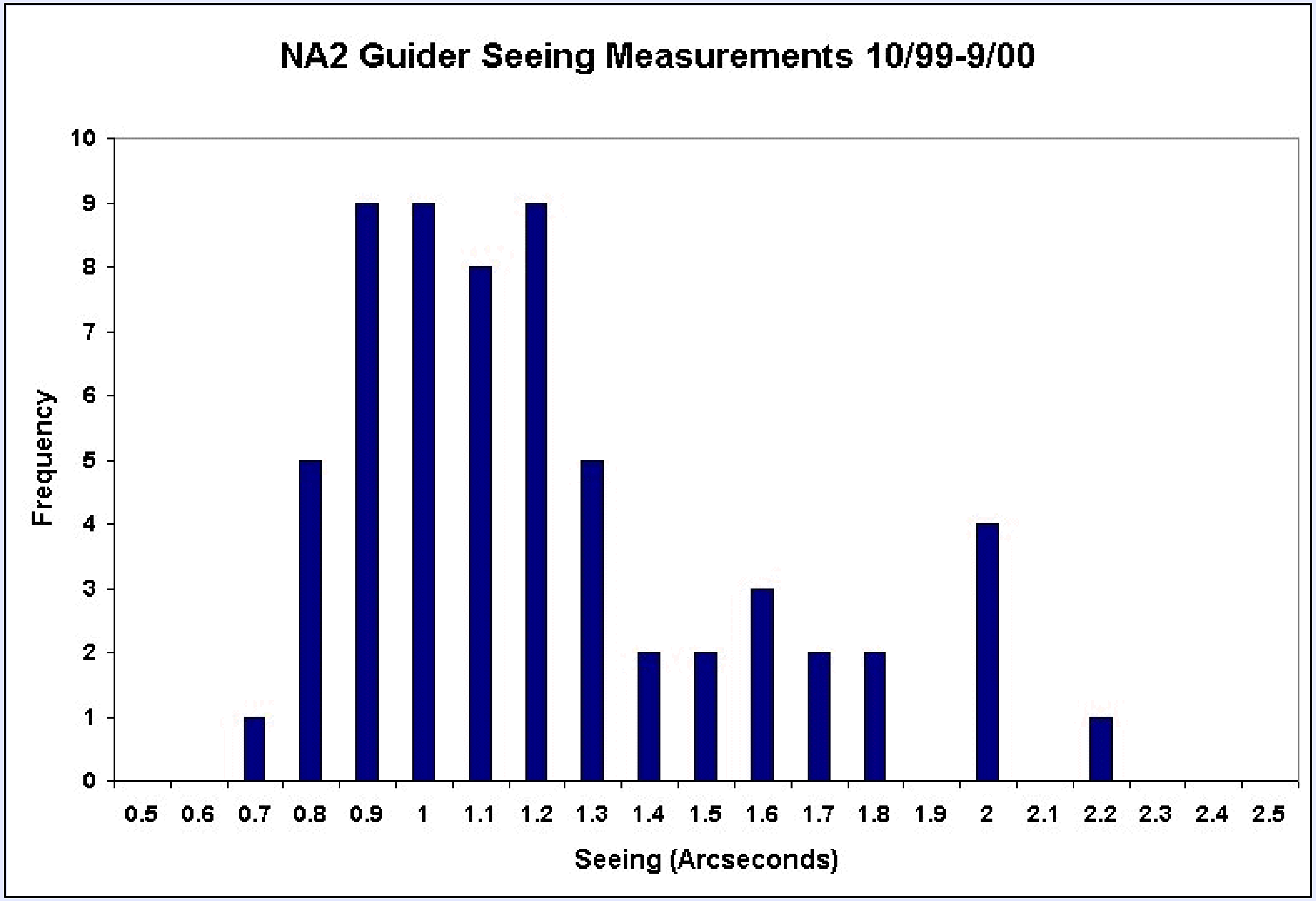
Instrument Concept Overview



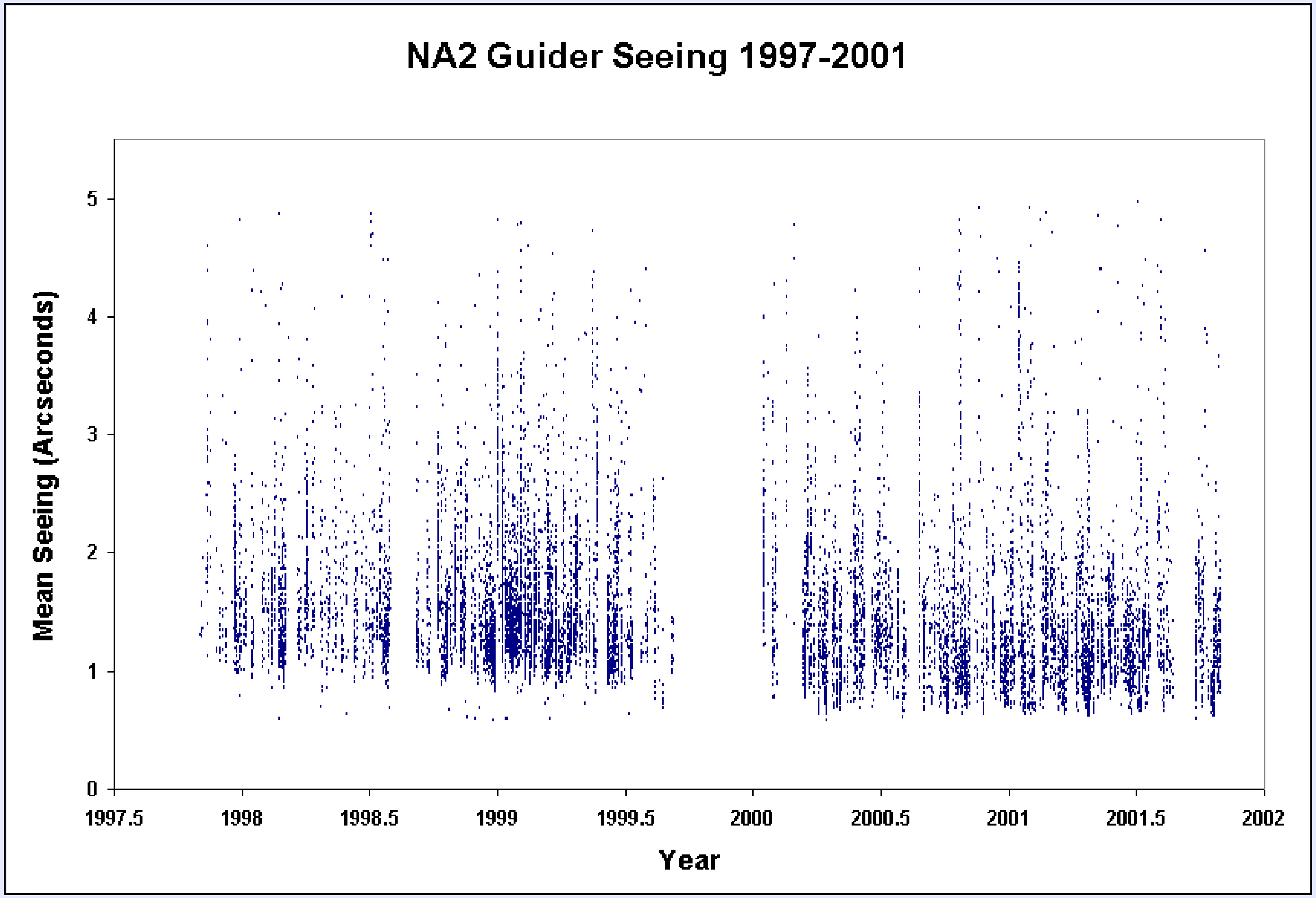
- **Wavelength range:** 0.85 to 2.5 μm
- **Pixel Scale and Field of View:** single image scale
  - Pixel scale of 0.28 ±0.02 arcsec/pixel for Hawaii 1 1024×1024 HgCdTe detector with 18.5μm pixel pitch
  - Field of View of 4.8′×4.8′ (6.75′ across diagonal)
- **Optics**
  - High intrinsic Strehl to take advantage of best seeing conditions
  - Minimized and well-characterized image distortion to allow accurate astrometry
  - High throughput (> 60% at 2 microns)
  - F-P etalon of 50mm clear aperture filled by collimated beam to nominally >80%
  - Cold optics and Lyot stop to reduce background levels in K-band
  - Minimize scattered light and ghost images when viewing point and extended sources
  - Separate beam paths for direct imaging and F-P etalon



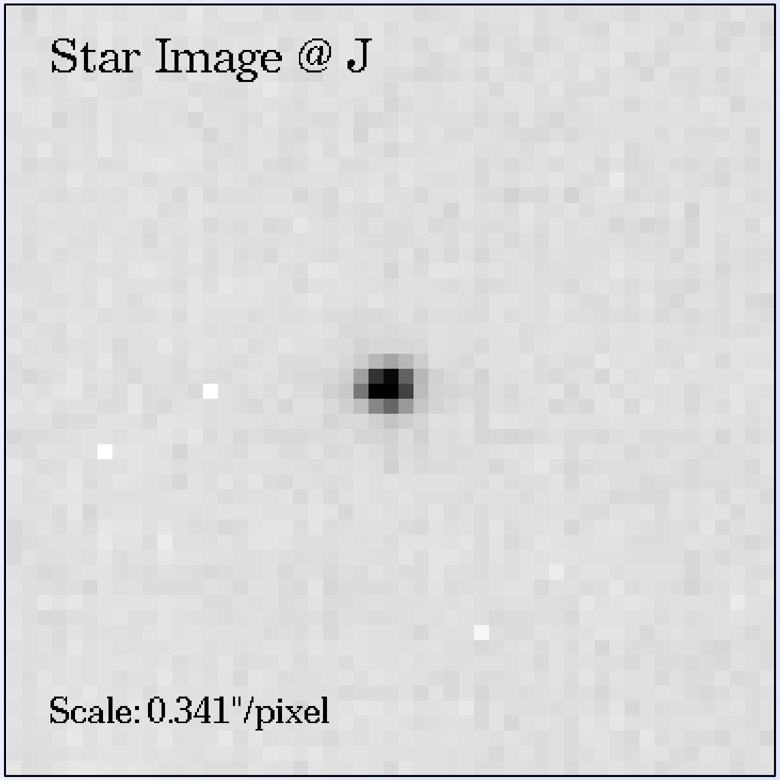
- 1999-2000 GRIM II 2-micron median FWHM seeing is 0.93 arcsec (Barentine, 2002).
- Seeing better than 0.8 arcsec occurs about one night in four.
- 0.5 arcsec seeing occurs about once a month.

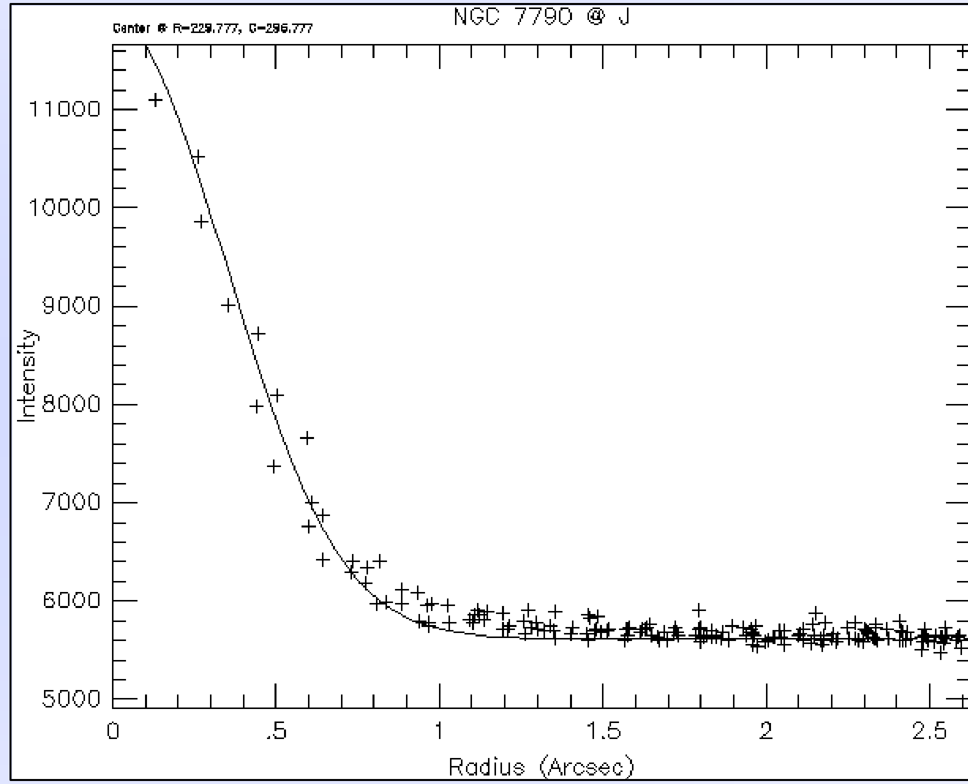


- NIR seeing ~20% better than optical seeing

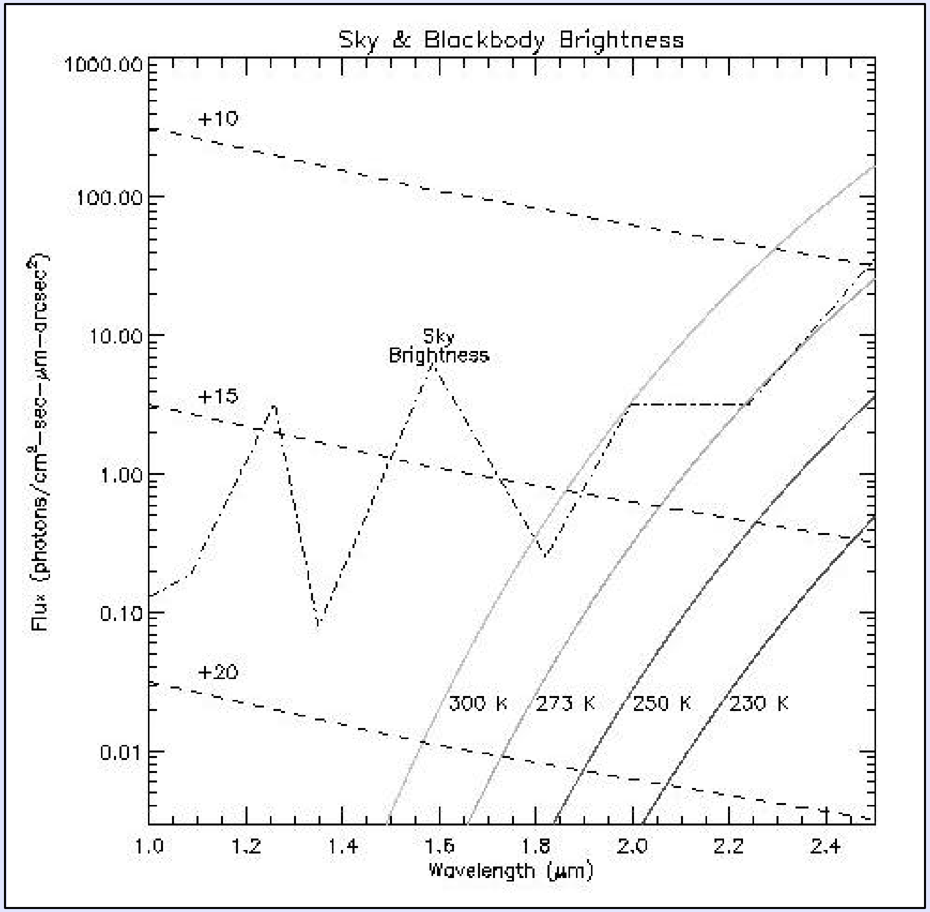


NA2 Guider Seeing 1997-2001
Mean Seeing (Arcseconds)
0
1
2
3
4
5
1997.5
1998
1998.5
1999
1999.5
2000
2000.5
2001
2001.5
2002
Year





- Approximate image quality (Example: OSU MOSAIC on KPNO 2.1m)



- Cooling optics to < 220K mitigates intrinsic thermal background in H, K bands

- **Dewar & optical bench**
  - "Access architecture" for alignment and maintenance
  - Cool detector to ~77K using LN2
  - Cool optics to <220K to reduce background
  - Cool optics to ~77K with LN2 for ease of implementation and to reduce thermal gradients/mechanical distortions
  - Cryogen hold time >24 hours (goal of >48 hours)
  - Minimal vibration environment for etalon
  - Baseline mounting to Nasmyth port 2
  - Internal calibration sources (pending ARC input)
- **Cryo Mechanisms (minimum set)**
  - 2 motorized filter wheels with 10 slots each in collimated beam
    - Filter wheels serve both beam paths (direct imaging, F-P mode)
  - 2 motorized turning flats to choose science mode (direct imaging or F-P)

NIC-FPS Personnel

CU-CASA

Jon Morse, PI
Mark Vincent, Instrument Scientist
Fred Hearty, Dewar design
Stéphane Béland, Software
Bob Sarrazin, Detailed drawings

Science & Technical Advisory Group

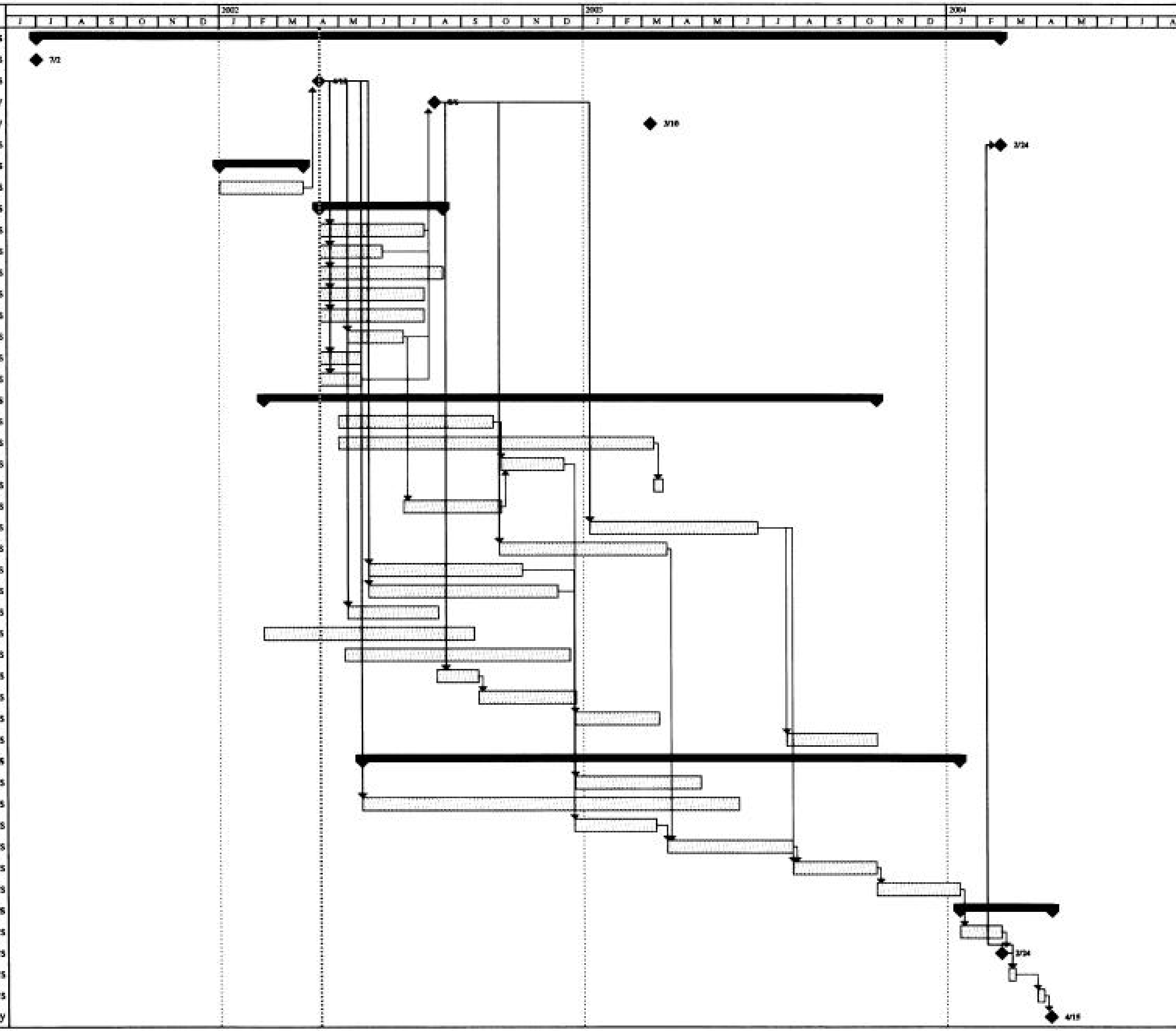
John Bally (CU-CASA)
Erica Ellingson (CU-CASA)
Erik Wilkinson (CU-CASA)
Al Betz (CU-CASA)
Pat Hartigan (Rice U.)
Jon Holtzman (NMSU/ARC)
John Barentine (ARC Instr Liaison)

Ball Aerospace

David Fischer, Systems engineering
Chris Stewart, Optical design
Gary Emerson, Opto-mechanical/thermal

NIC-FPS DEVELOPMENT SCHEDULE

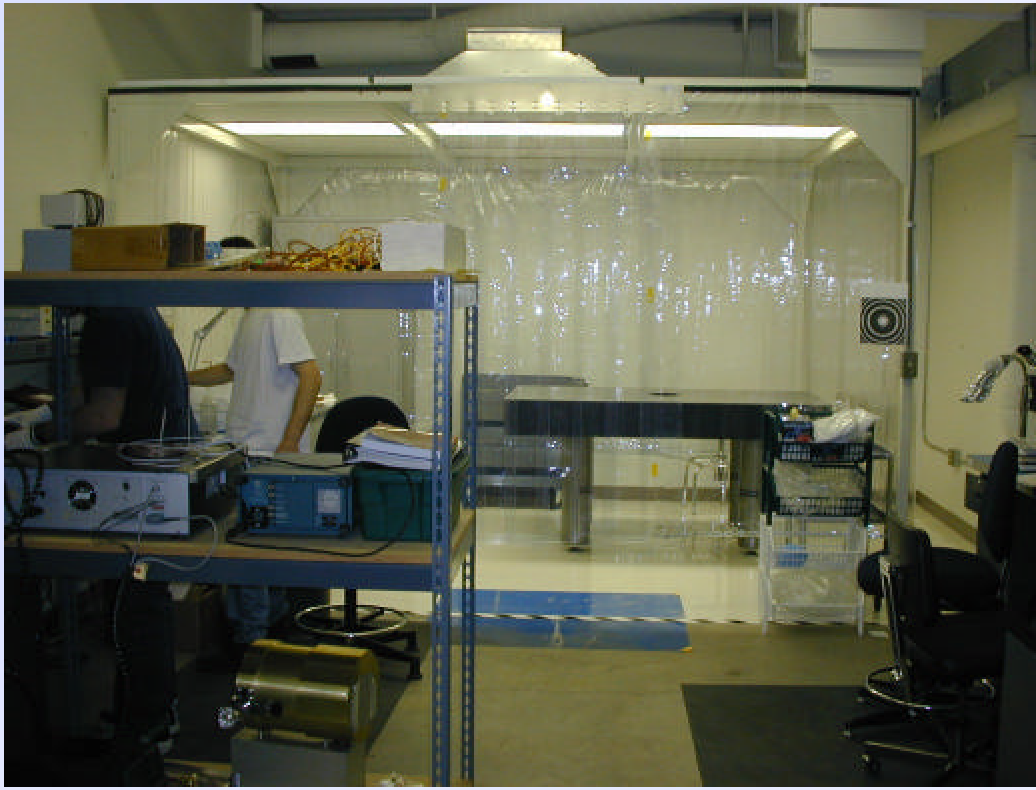
Task Name	Duration
Milestones	**692 days**
Project Initiation	0 days
Preliminary Design Review	0 days
Critial Design Review	1 day
Year 1 Review	1 day
Delivery to Apache Point Observatory	0 days
NIC-FPS Definition	**60 days**
Requirements Definition	60 days
Engineering Design	**88 days**
Preliminary Opto-Mechanical System Desi	75 days
Structural & Thermal Analysis	45 days
Dewar & Optical Bench Design	88 days
Filter Wheel Assembly Design	75 days
Lens & Filter Mount Design	75 days
Detector Housing	40 days
Preliminary NIC-FPS to Telescope Interfac	30 days
Preliminary Electronics Design	30 days
Procurement, Fabrication, and Assembly	**439 days**
Procure Rockwell Hawaii 1 Eng. Array	111 days
Procure Rockwell Hawaii 1RG Sci. Array	226 days
Package Engineering-grade Array (Rockwe	45 days
Swap & Test Science-grade Array (Rockwe	7 days
Detector Lab Dewar Fabrication / Modific	70 days
Dewar Fabrication	120 days
Optical Bench Fabrication	120 days
Lens & Filter Mount Fabrication	110 days
Procure Optics	136 days
Filter Wheel Assembly Fab	65 days
Procure JHK Filters, MKO consortium & I	151 days
Procure Narrowband Filters	162 days
Procure Calibration Lamps	30 days
Calibration Lamp Unit Design & Fab	70 days
Fabricate Electronics Cabling	60 days
Fabricate NIC-FPS to Telescope Interface	65 days
Integration, Alignment, and Test	**428 days**
Lab Test Etalon and Controller Software	90 days
NIC-FPS Control Software Development	270 days
Integrate Optics into Optical Mounts	60 days
Integrate Optical Bench & Align Optics	90 days
Integrate Detector & Final Alignment	60 days
Final Test & Verification	60 days
Commissioning & Field Tests	**67 days**
Schedule Float	30 days
Delivery to APO	0 days
Commissioning Run #1	5 days
Commissioning Run #2	5 days
Begin Science Operations	1 day



CASA Facilities and Equipment

- NIC-FPS assembly and test to be done at CASA's Astrophysical Research Lab
- A NIC-FPS instrument area has been allocated for the duration of the program

Electronics bench and test area



Class 10,000 clean tent (10'x12') with I&T table

Detector choices:

1. Rockwell/Hawaii-1 PACE 1024×1024 HgCdTe
   - Well-understood fabrication, performance, and operations
   - Some undesirable features (e.g., image latency, not-so-great QE)
   - Cost estimate $210k; schedule risk low-to-moderate
2. Rockwell/Hawaii-1RG MBE 1024×1024 HgCdTe
   - NGST prototype with several enhancements over Hawaii 1, such as reference pixels and selectable postage-stamp readout
   - Under development (with NGST providing significant funding); some devices delivered to NGST Project
   - Rockwell in-house testing indicates excellent QE, read noise, and dark current performance
   - Cost estimate ~$300k +; schedule risk moderate-to-high
3. Raytheon VIRGO SWIR 1024×1024 HgCdTe
   - Raytheon prototype device to enter HgCdTe market
   - Raytheon in-house testing indicates excellent performance
   - Under development (none exist with our performance requirements)
   - Cost estimate ~$225k +; schedule risk high

Rockwell Hawaii-1
Packaged in CFHTIR

2.1.3 Focal Plane Assembly

The FPA will be a Rockwell 1k x 1k HAWAII HgCdTe array[6], featuring 18.5 µm pixels and 4 output readout. The HAWAII FPA is mounted in an IRLabs IRLF25A Fanout Board and positioned on a thermally controlled stage at the camera focal plane. The focal plane assembly provides the requisite thermal and electrical connection to the FPA. The IRL25A is configured for differential video output for noise rejection issues. The IRLF25A uses a pair of discrete JFETs configured as source followers for each video output. One JFET buffers the BUS output of the FPA (bypassing the on chip source follower), while the second JFET buffers the BIASGATE signal. All electrical connection to the fanout board is through the fanout flex circuit assembly detailed above. The fanout board and internal dewar wiring are designed for FPA-limited performance during 4-quadrant simultaneous readout. The FPA will be temperature controlled through the use of an internal 35 Ohm, 5W heating element. FPA temperature will be monitored using both an RTD and a temperature-sensing diode.

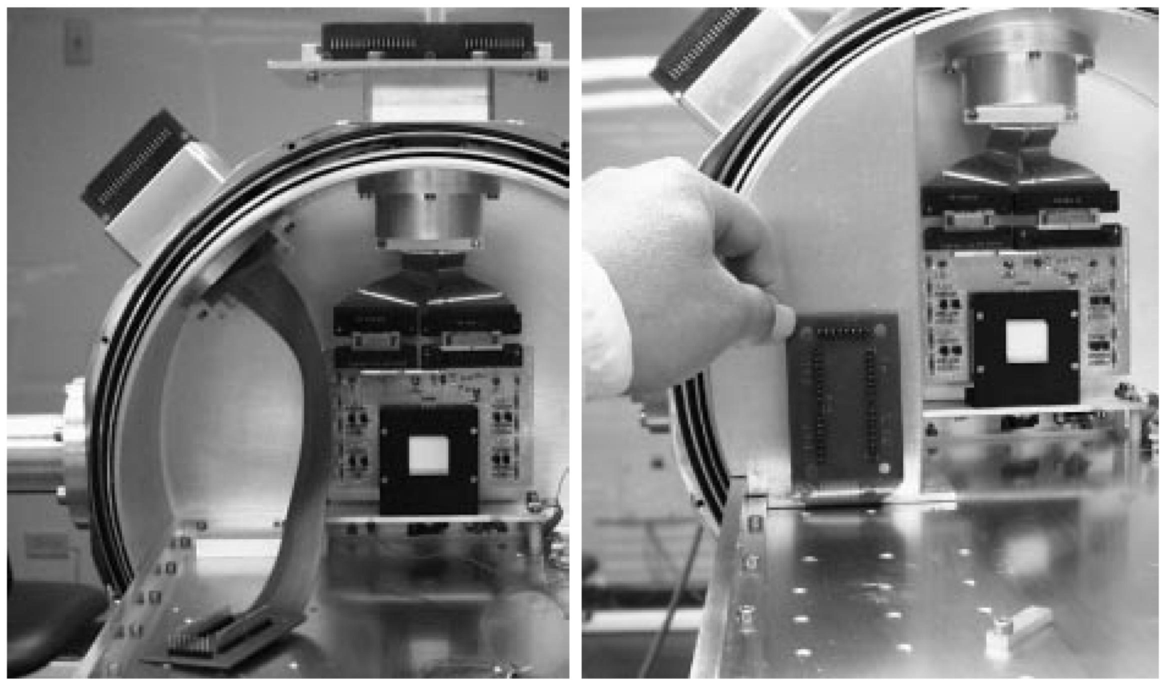
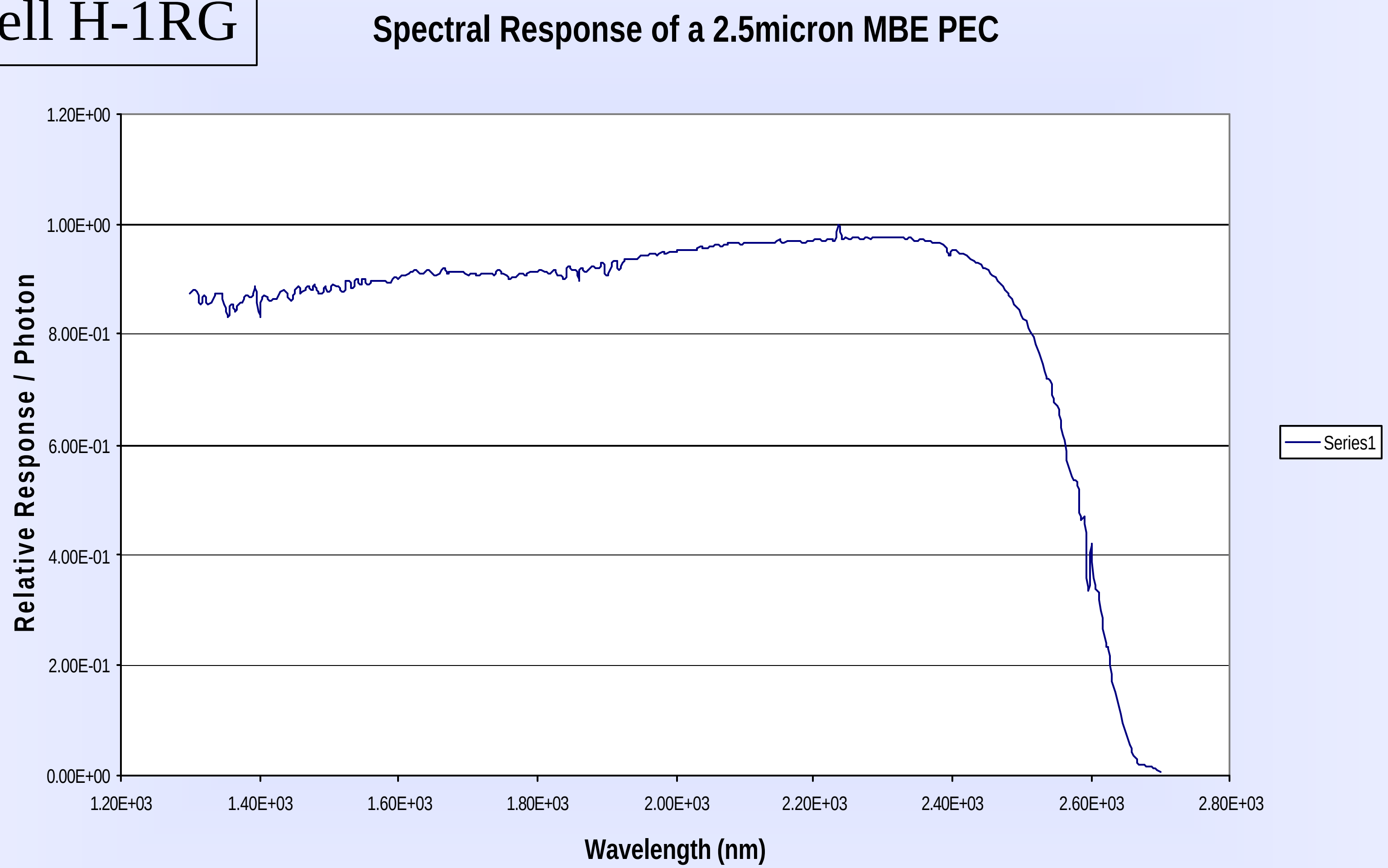


Figure 5. Focal Plane Assembly. *Picture on left shows the FPA Fanout Board and thermal mount, along with the two flexprint circuits to outside mating connectors. The picture on right shows the final mounting location of the internal Utility fanout board.*

NIC-FPS Preliminary Design Review

Rockwell H-1RG



• With appropriate AR coating, peak QE is > 80%