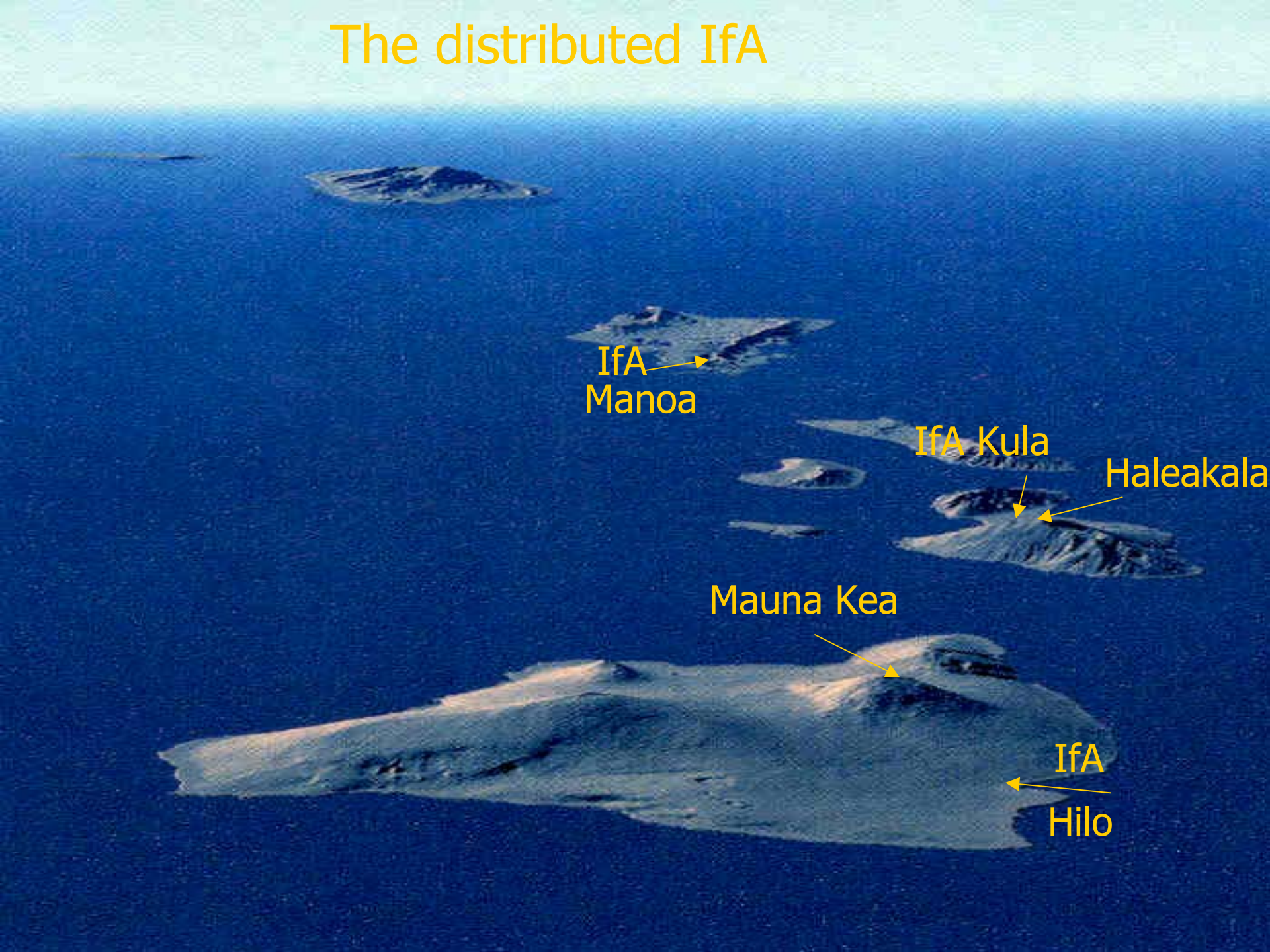
Institute for Astronomy

Instrumentation Capabilities and Recent Projects

Klaus Hodapp

for the IfA Instrumentation Division

The distributed IfA



Mauna Kea Observatory

Haleakala High Altitude Observatory Site

Institute for Astronomy

- **280 staff, 80 scientists**
- **40 tenure track faculty**
- **35 PhD students**
- **1000 undergraduate students/yr in Manoa**
- **2 observatory sites: Mauna Kea and Haleakala**
- **base facilities distributed over 3 islands**

IfA Technical Staff

- 7 Instrument P.I.s
- 4 Project Managers
- 6 Mechanical Engineers
- 12 Electronics Engineers
- 4 Software Engineers
- 6 Machinists
- 18 Technicians

The IfA technical staff is organized in the JOS system, allowing flexible assignment to projects.

IfA Expertise

- Infrared Detector Arrays (Hall, Hodapp, Onaka, Rayner)
- Optical CCDs (Tonry, Luppino)
- Controllers (Onaka, Hall, Tollestrup, Jacobson, Sousa)
- Wavefront Sensors (Tonry, Chun, Hodapp, Hall)
- Optics (Rayner, Hodapp, Kuhn, Lin)
- Curvature AO Systems (Ftaclas, Chun)
- Cryo Mechanisms (Tokunaga, Rayner, Hodapp)
- Site Testing (Chun)
- Telescope Operations (2.2m and IRTF) (Tokunaga, Tollestrup, Aspin)
- Data Processing, Pan-STARRS (Magnier, Heasley, Jedike, Chambers)
- Observing Condition Forecast (Businger)

HAWAII Heritage

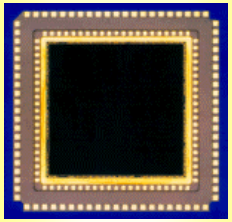
On-chip butting

Reference pixels

Guide mode & read/reset opt.

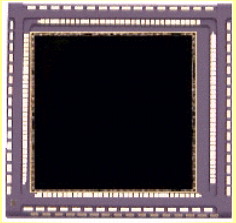
Stitching

HAWAII - 1
1994



1024 x 1024 pixels
3.4 million FETs
0.8 µm CMOS
18 µm pixel size

HAWAII - 2
1998

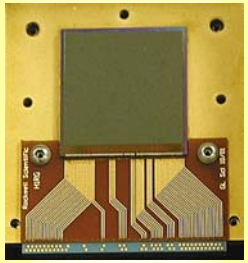


2048 x 2048 pixels
13 million FETs
0.8 µm CMOS
18 µm pixel size

HAWAII - 1R
2000

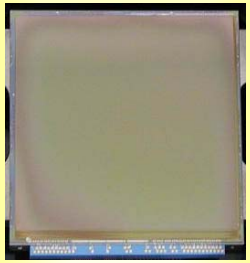
1024 x 1024 pixels
3.4 million FETs
0.5 µm CMOS
18 µm pixel size

HAWAII - 1RG
2001



1024 x 1024 pixels
7.5 million FETs
0.25 µm CMOS
18 µm pixel size

HAWAII - 2RG
2002



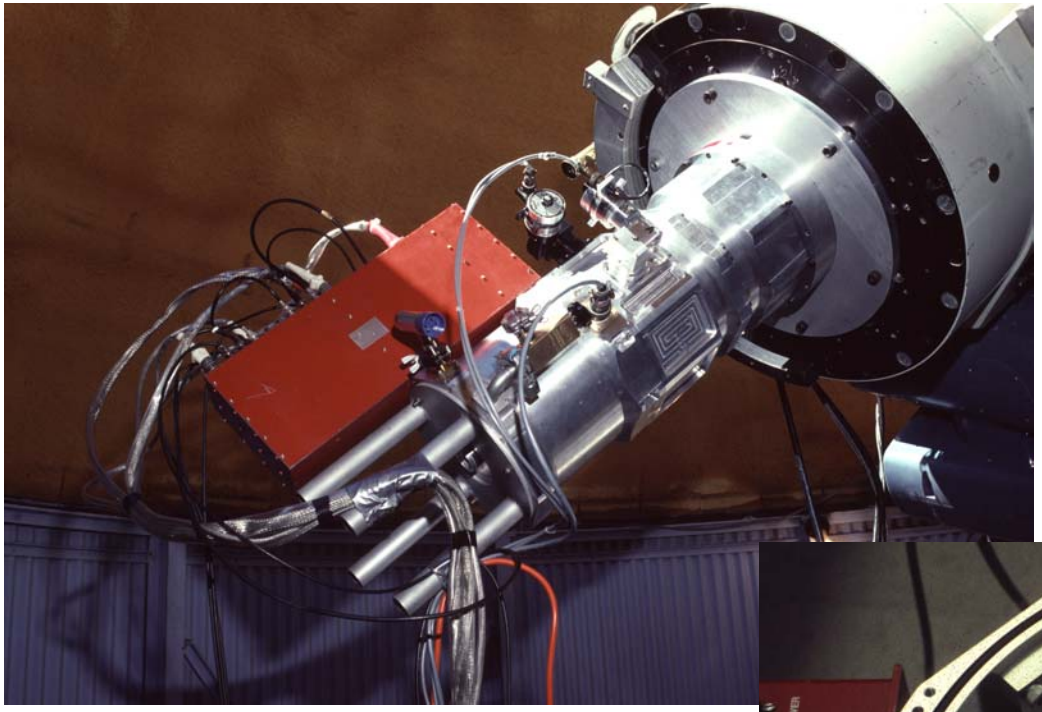
2048 x 2048 pixels
29 million FETs
0.25 µm CMOS
18 µm pixel size

Smaller pixels,
Improved flexibility
& performance,
Scalable resolution

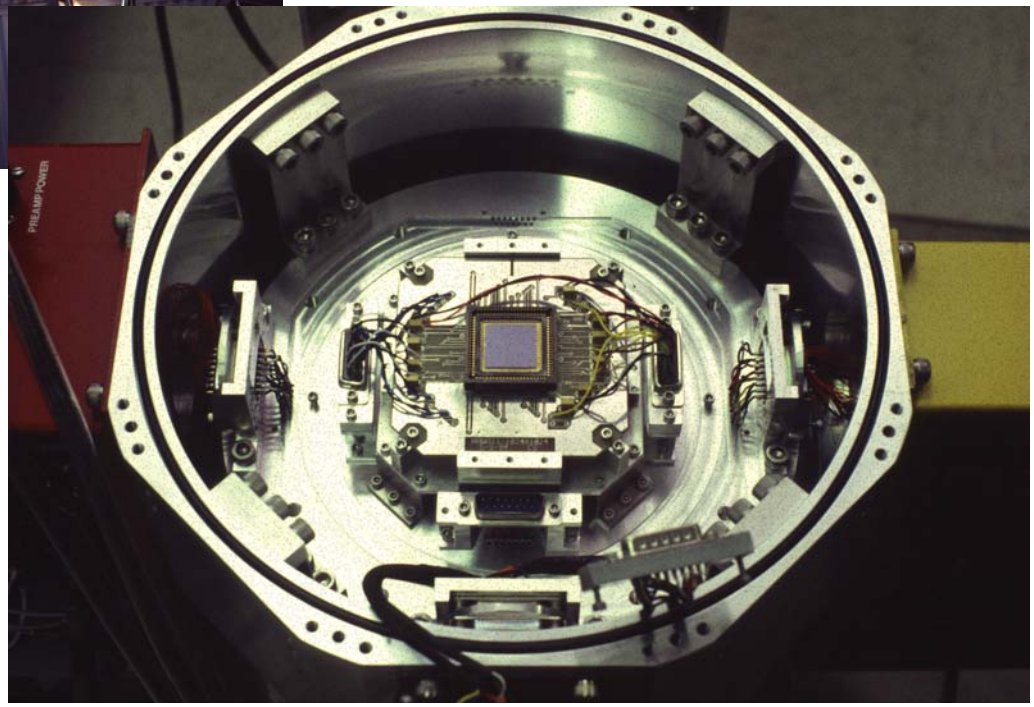
HAWAII - 4RG Family
2004

4096 x 4096
120 million FETs
0.16 µm CMOS
15 µm pixel size

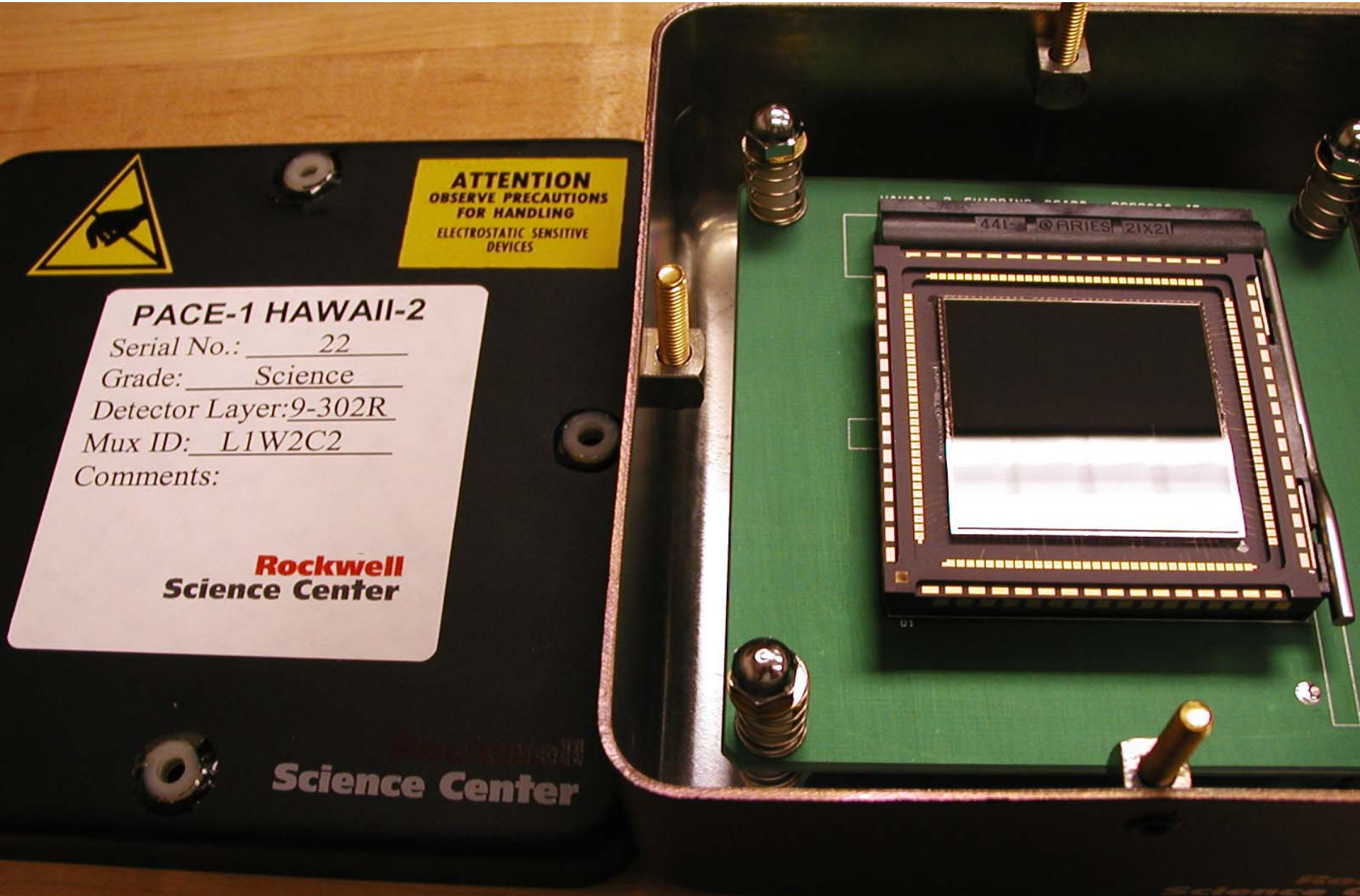
8192 x 8192
420 million FETs
0.25 µm CMOS
9 µm pixel size



UH NICMOS-3 Camera
(1990) NASA

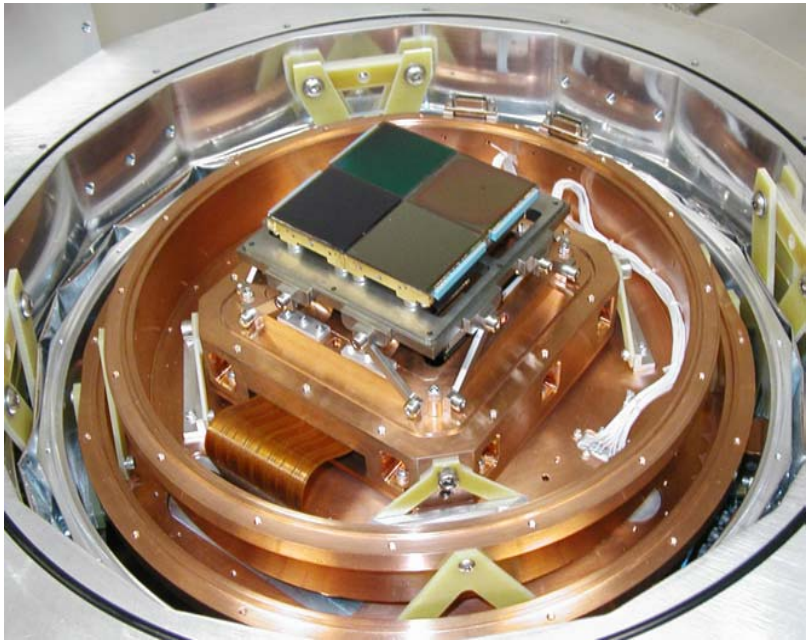


QUIRC (HAWAII-1)
(1994) AFRL

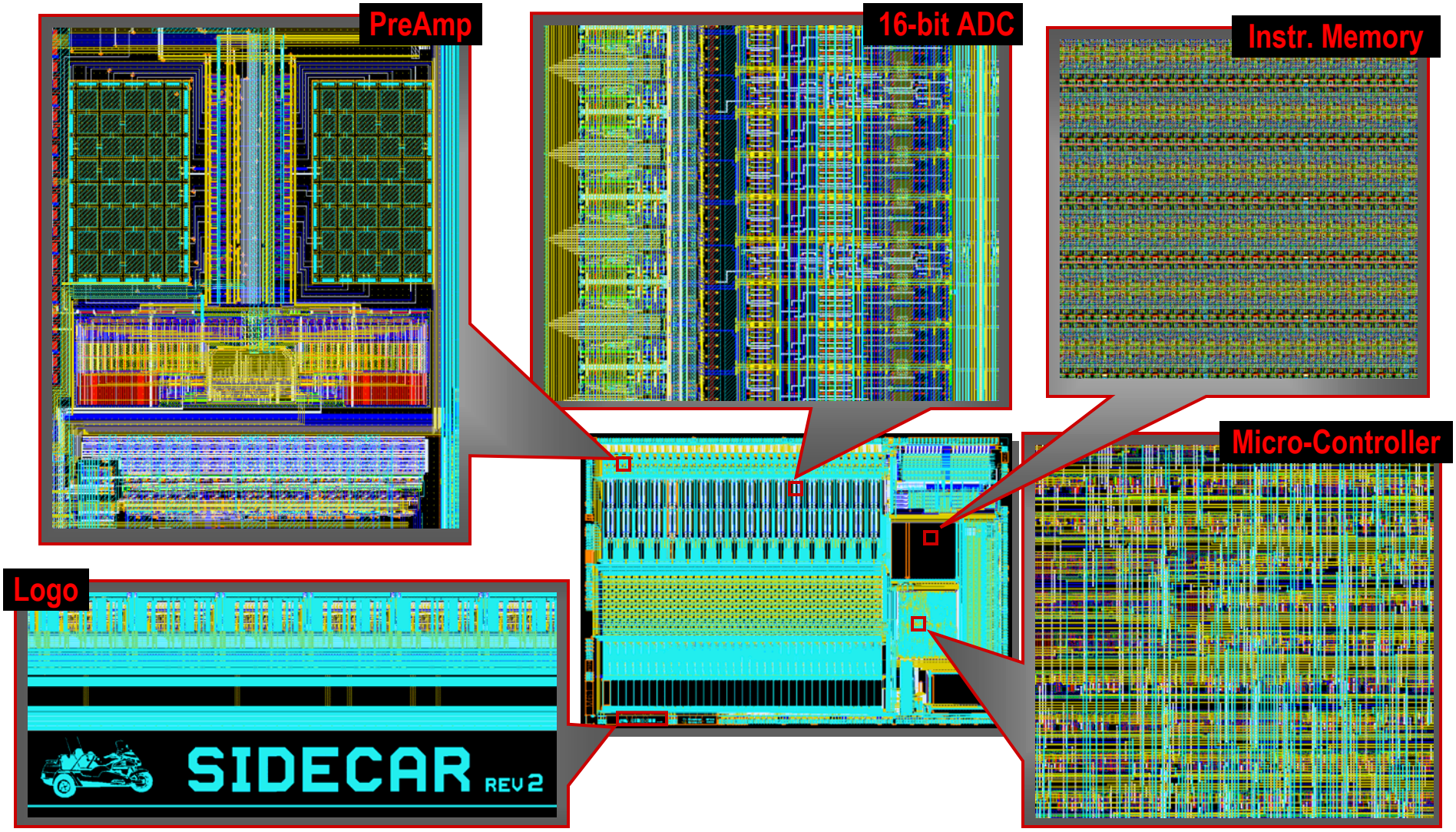


HAWAII-2 IR Arrays, K. Hodapp,

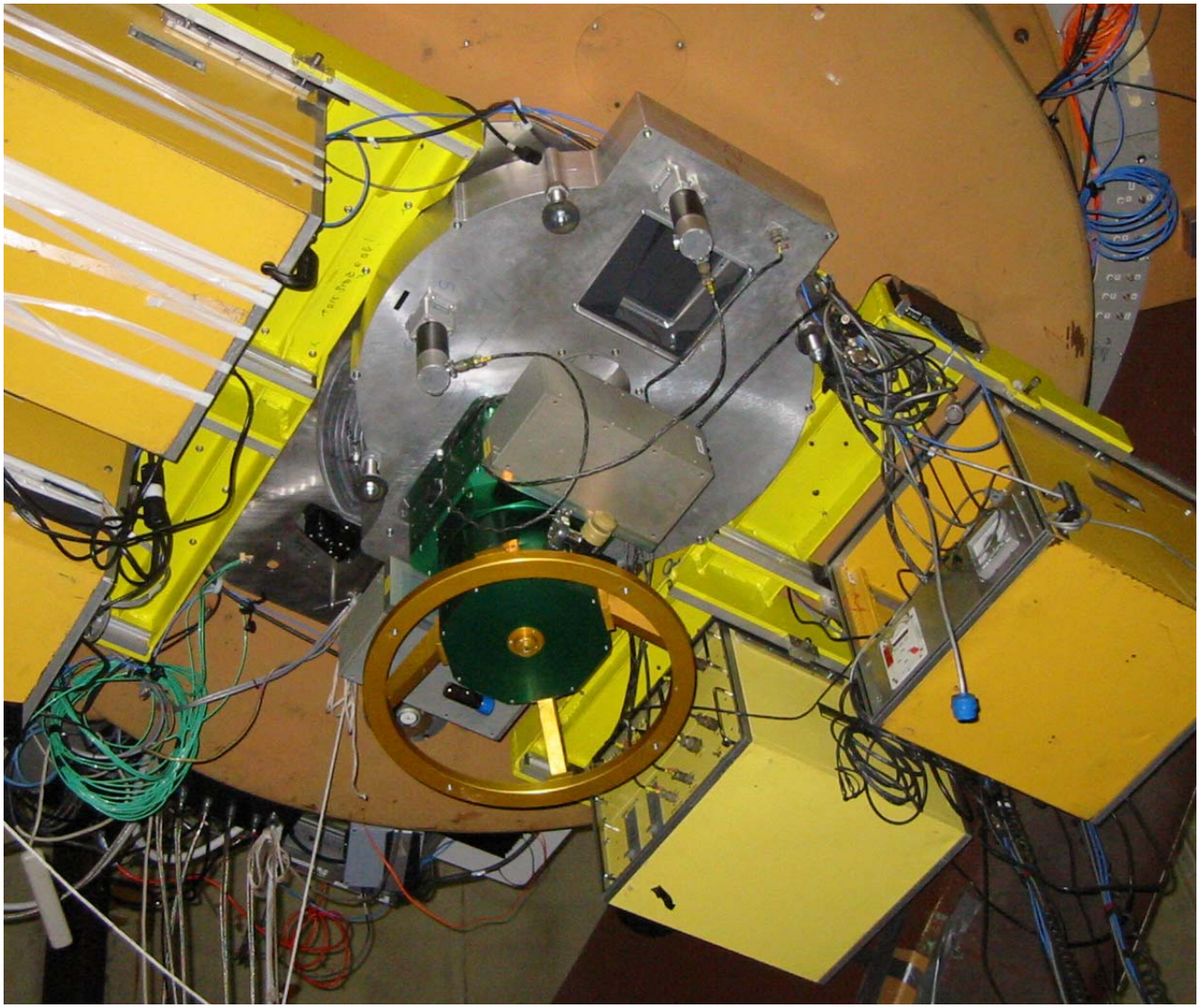
Ultra-Low Background Test Camera (ULB), 2003, NASA
P.I. Don Hall



Rockwell Sidecar ASIC (D. Hall, NASA funding)

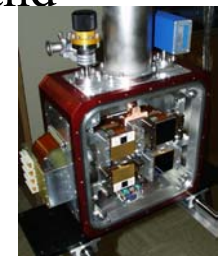


UH Wide Field Imager (UHWFI) with upgraded UH 8K CCD (K. Hodapp, G. Luppino, NSF ATI funding)

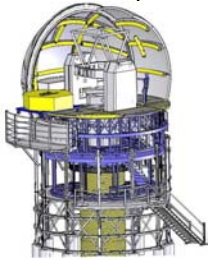


Pan-STARRS Development Schedule

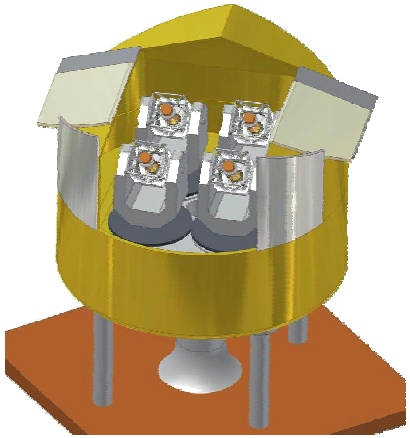
- Development, infrastructure, and testing (2003-2006)



- Pan-STARRS1 (2006-2009)



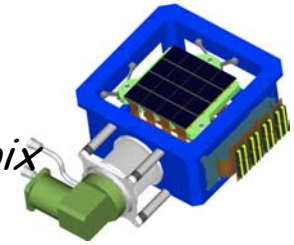
- Pan-STARRS2 (2010+)
- Pan-STARRS3
- Pan-STARRS4



- Test Cameras 1-2

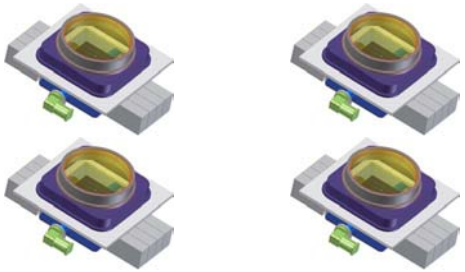
90 Mpix

360 Mpix



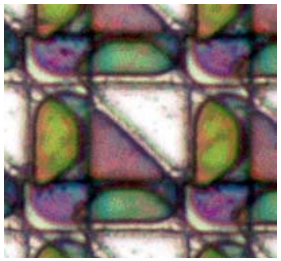
- Test Camera 3
- Gigapixel Camera 1

- Gigapixel Camera
- Gigapixel Camera
- Gigapixel Camera 4

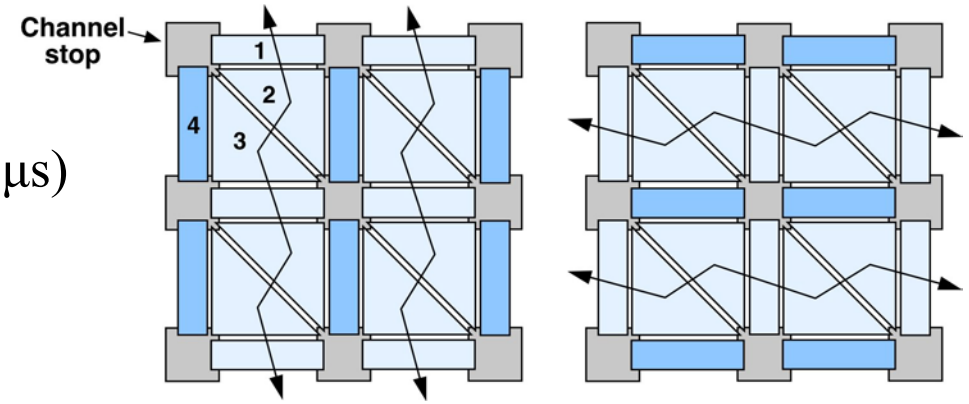


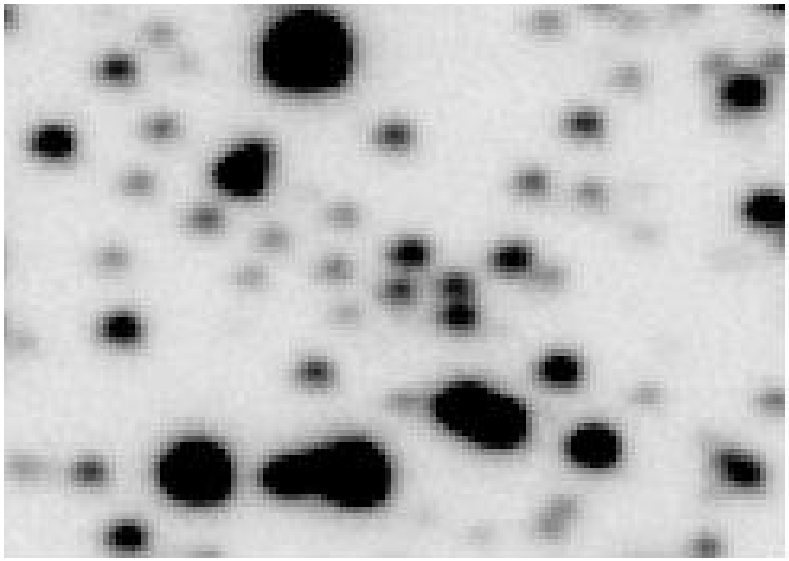
5.5 Gpix

Orthogonal Transfer CCD

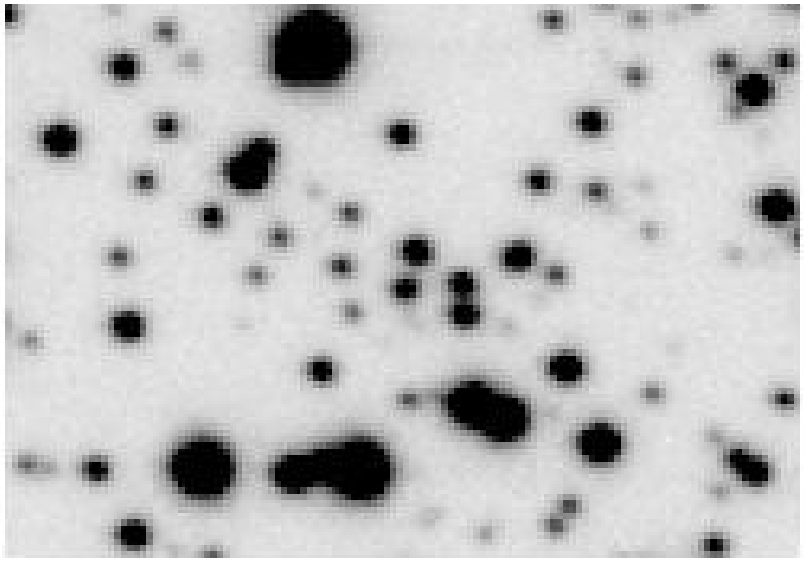


- Orthogonal Transfer CCD
  - Pixel design which can noiselessly remove image motion at high speed (~10 μs)



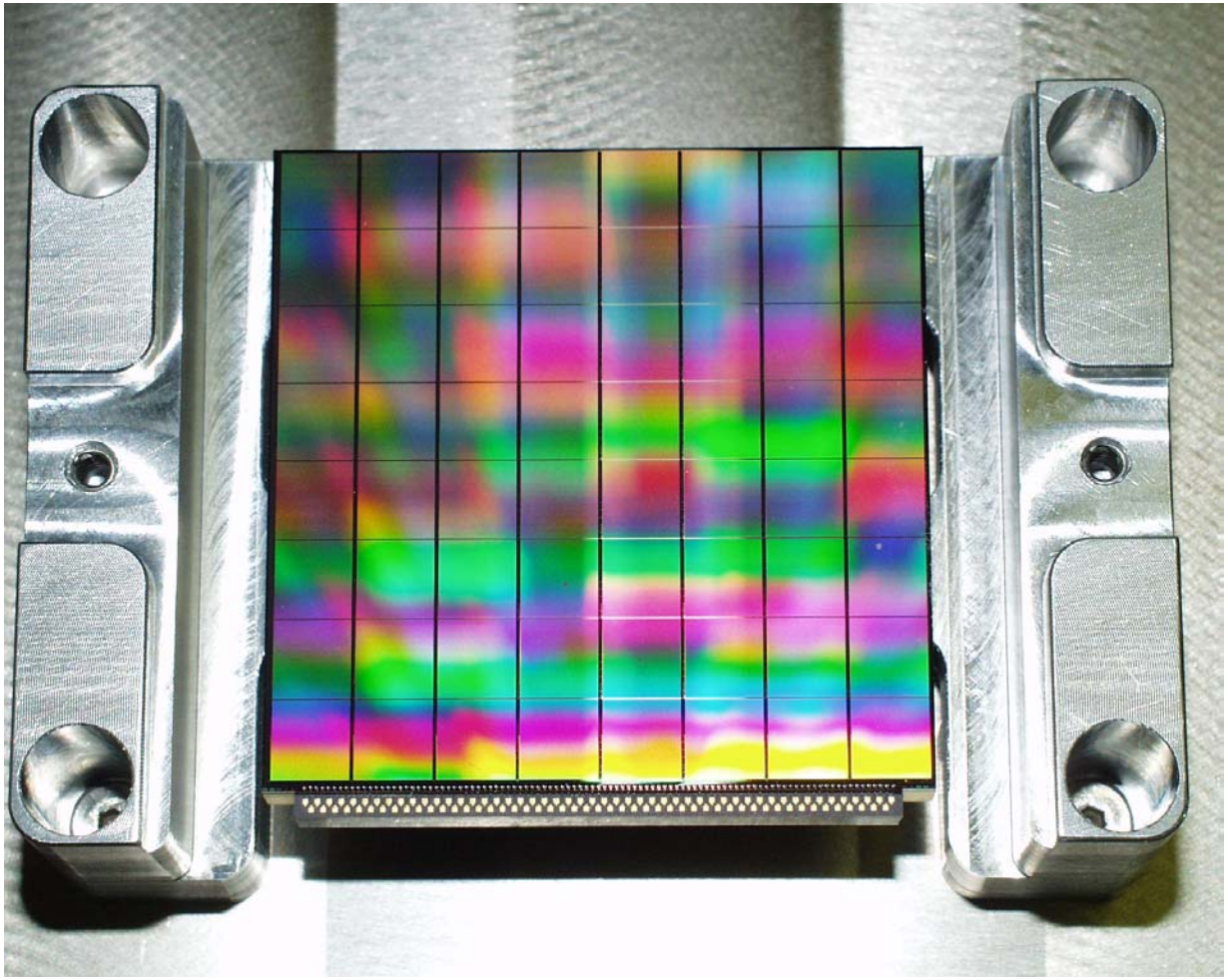


Normal guiding (0.73")



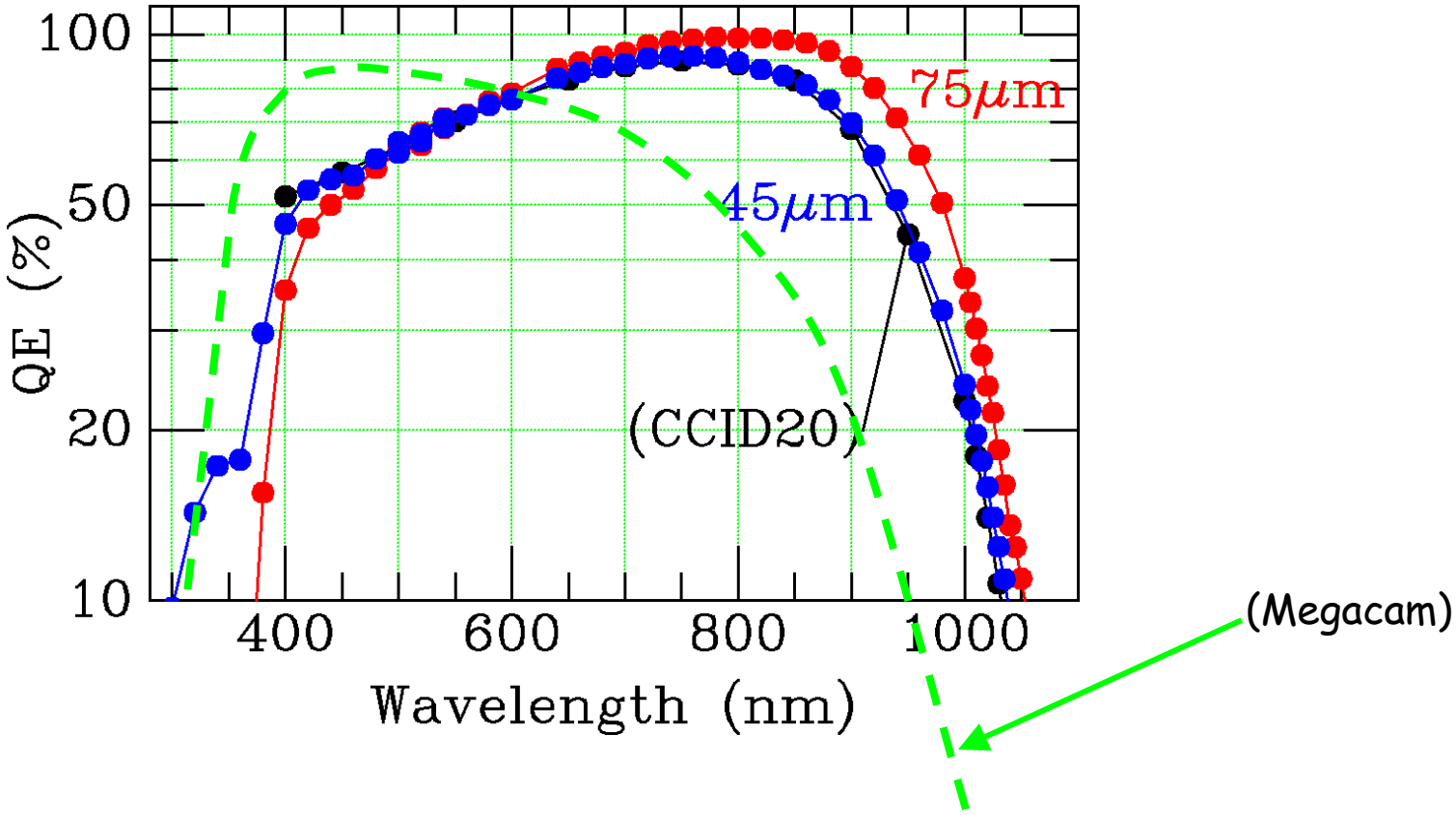
OT compensation (0.50")

Frontside Orthogonal Transfer Array (OTA)



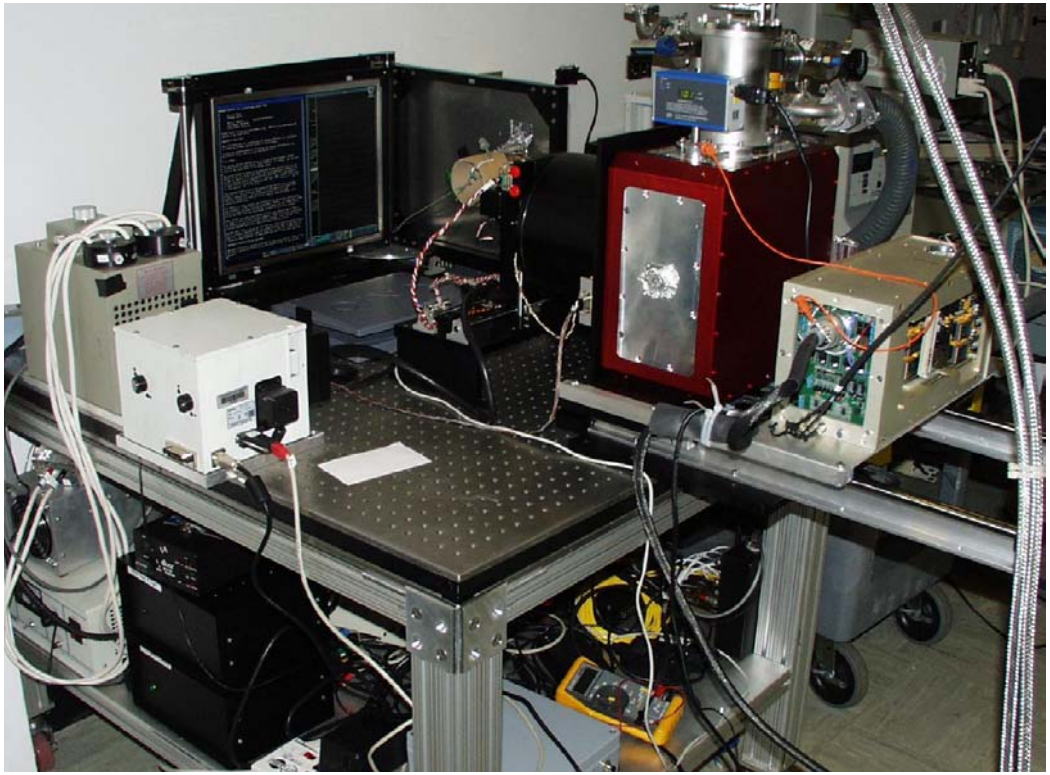
OTA Quantum Efficiency

- OTAs demonstrate expected QE (-65ºC)
  - 45μm thick device is virtually identical to CCID20
  - 75μm thick device has 50% enhanced QE at 1μm

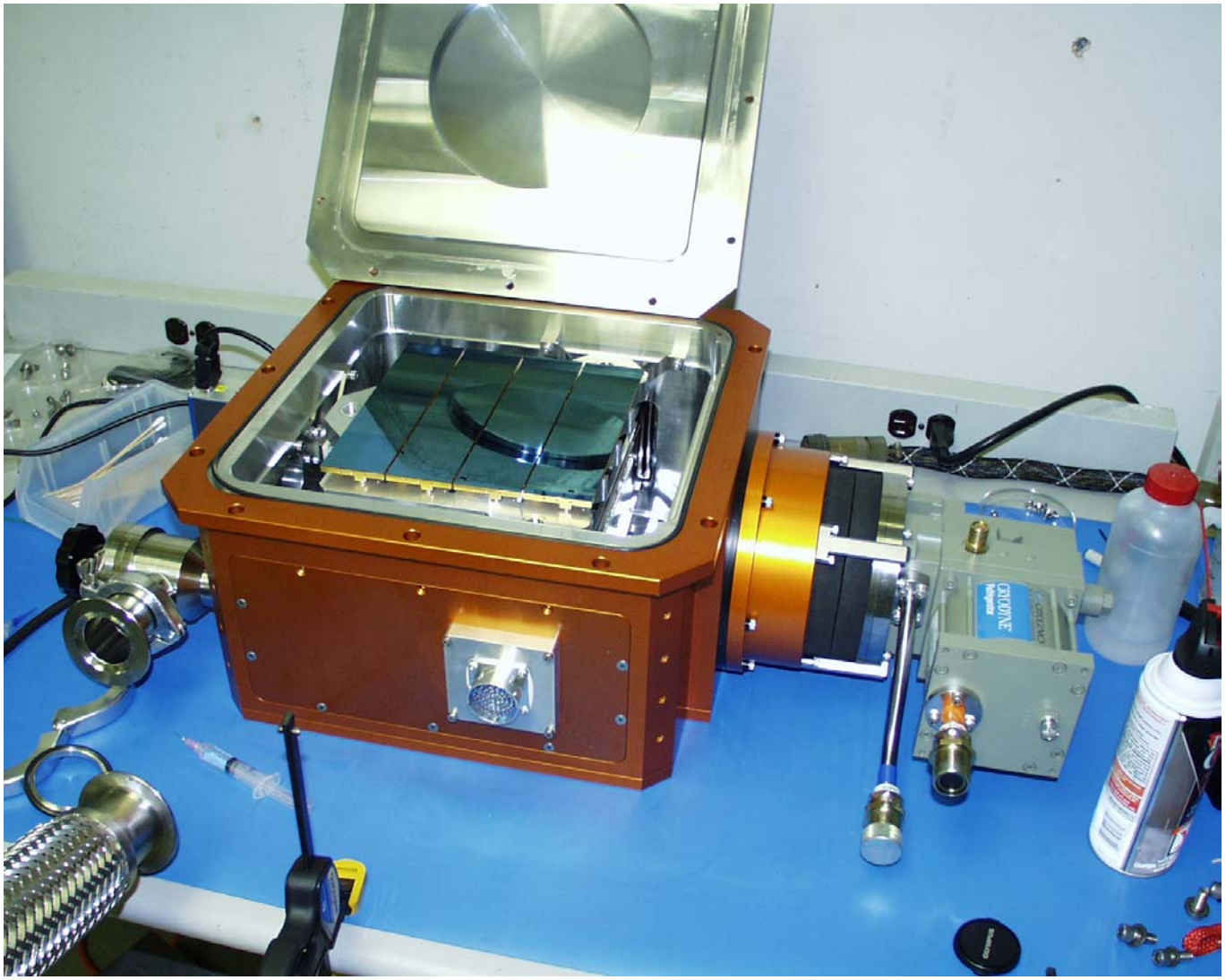


Test Cryostat #1 and Test Bench

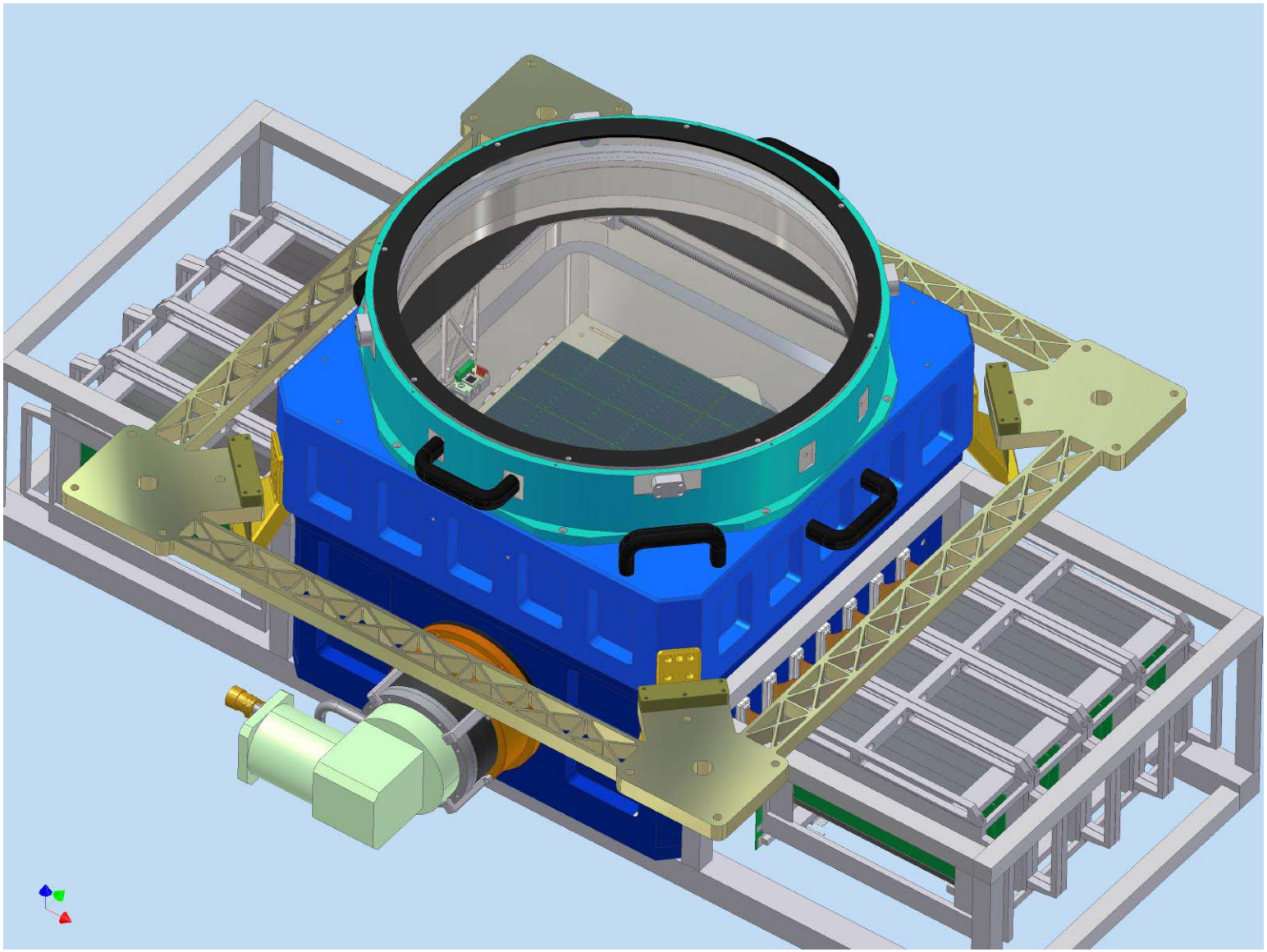
- Workhorse for OTA testing, completely automated
  - Server architecture interfaces to multiple clients
  - Simultaneously tests 4 devices
- Computer scripts exhaustively explore parameter space



Test Camera 3 (TCS3)

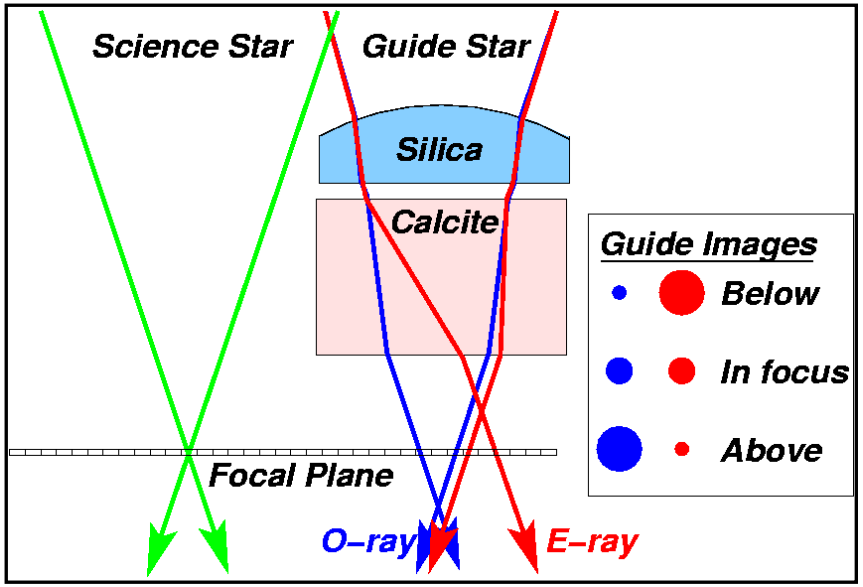


Pan-STARRS Gigapixel Camera

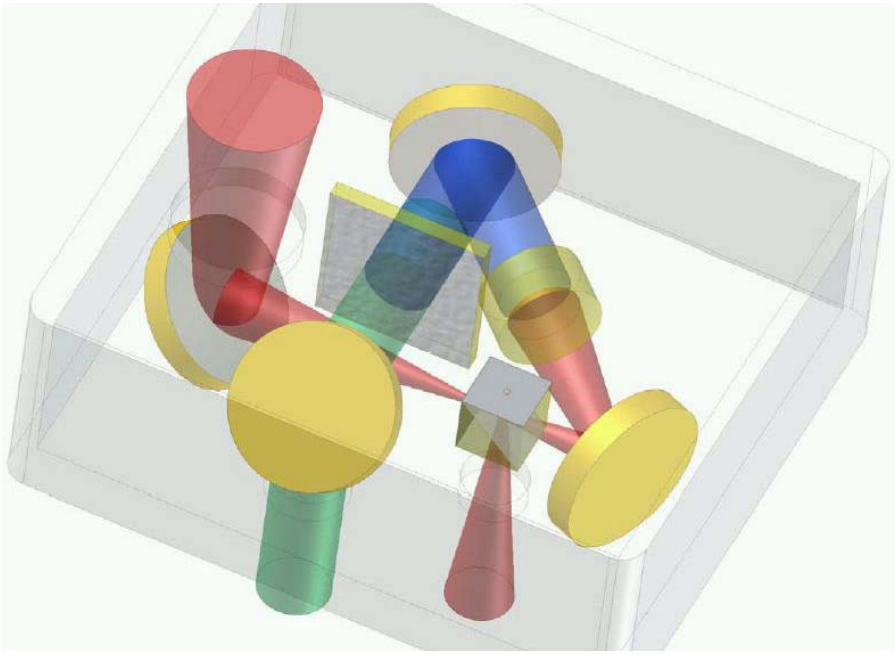


Pan-STARRS Curvature Wavefront Sensing

- Curvature sensing design
  - 2—4 locations, above focal plane but outside 3 deg FOV
  - Converging lens and block of calcite
- Two images of every star provide above and below focus donuts
  - Difference is quite sensitive to wavefront aberrations
  - Operates automatically and continuously with every exposure, no special pointing or overhead.
  - Results available within 30 sec.

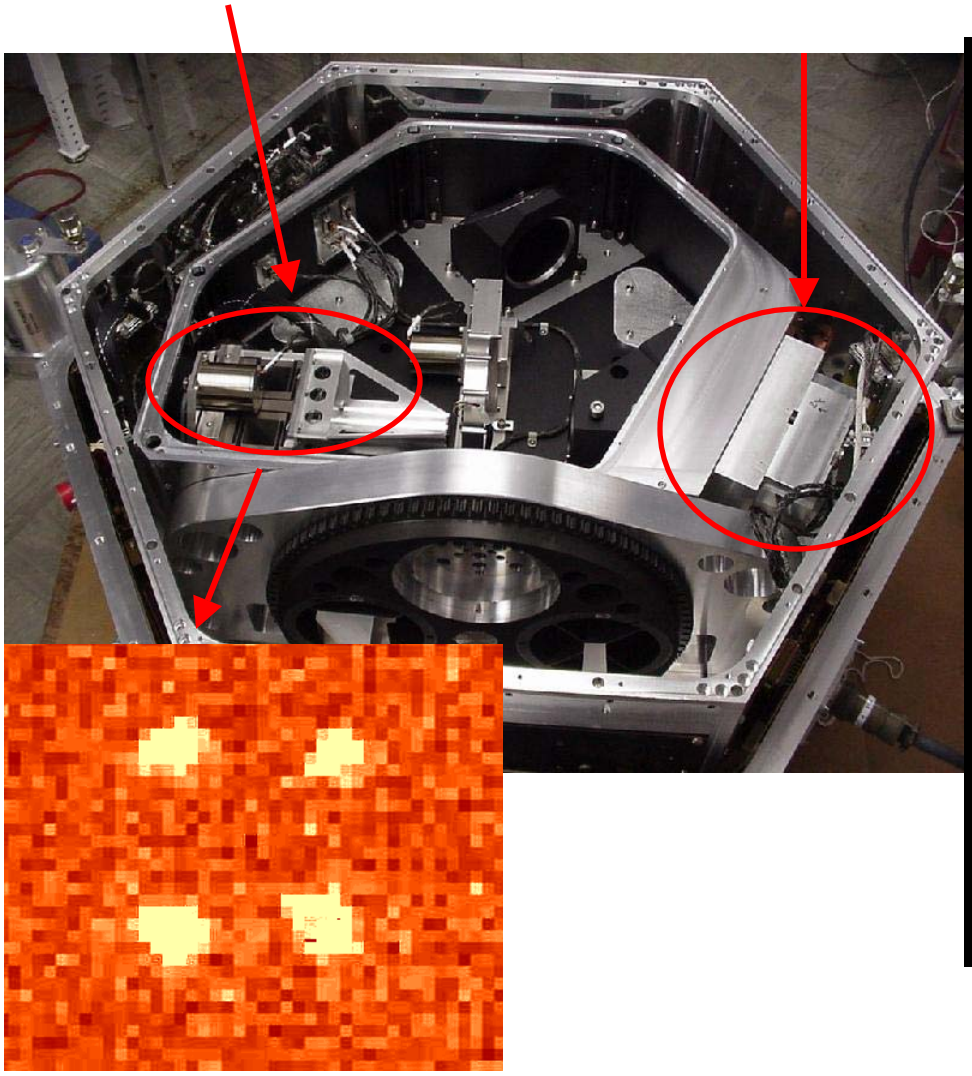


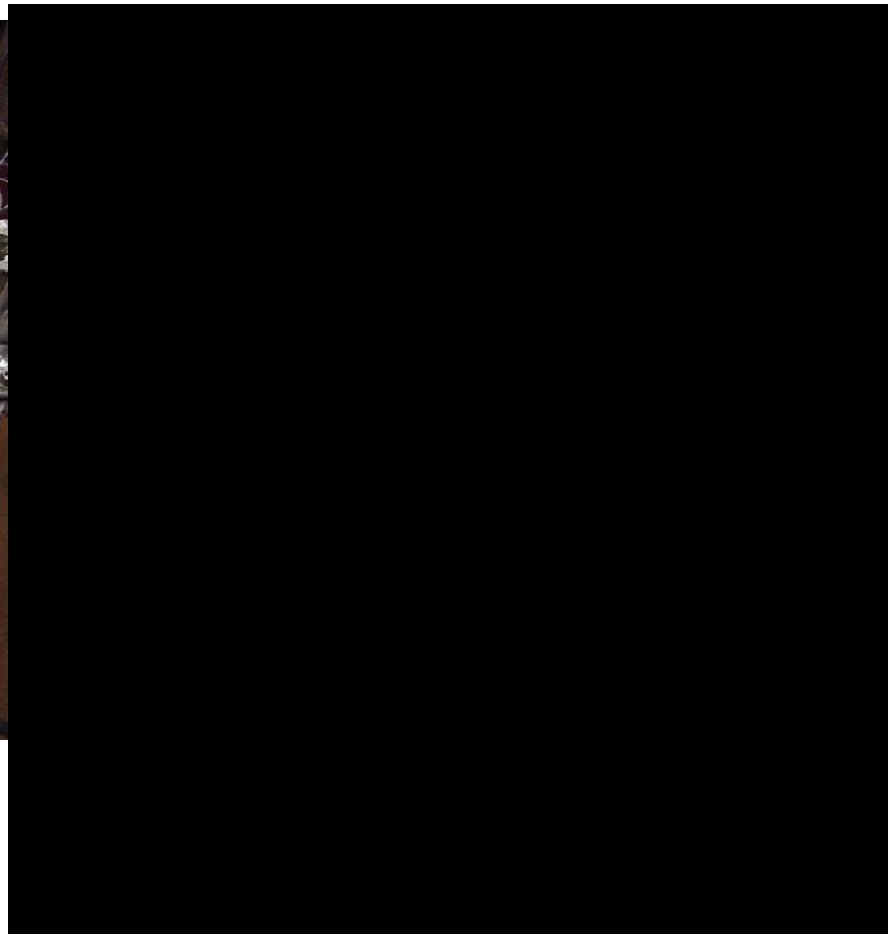
Pan-STARRS SH Wavefront Sensing



- Deployable WFS located in antechamber of camera extends out over focal plane to pick off a star for analysis
- Lenslet images and pupil images are parfocal with normal telescope images
- S-H sensor parked out of field of view for normal operations

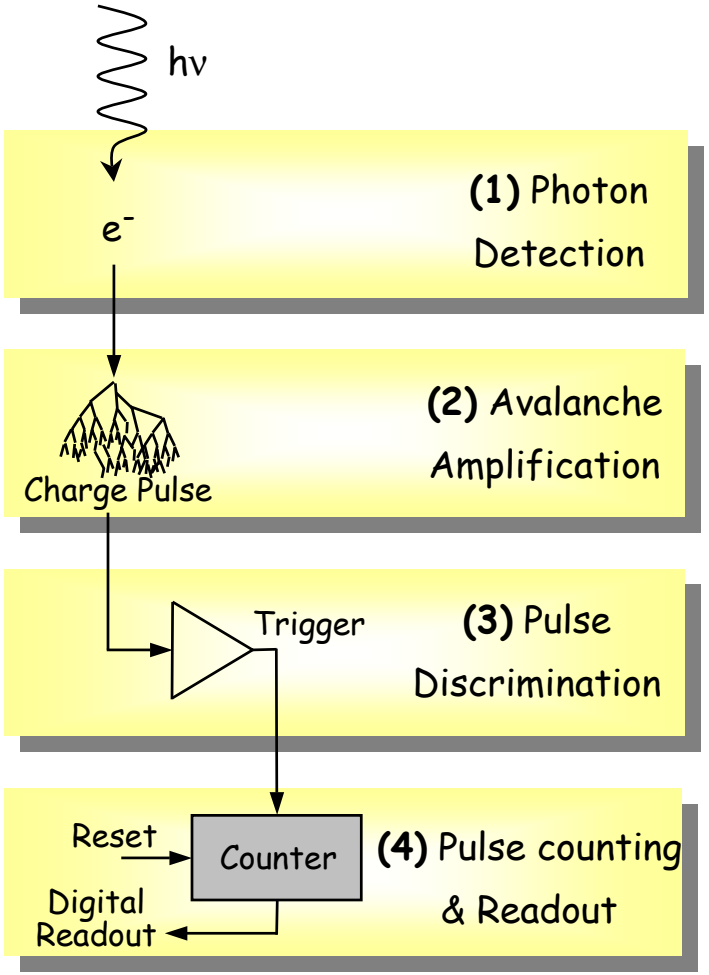
Near-infrared Imager (NIRI)



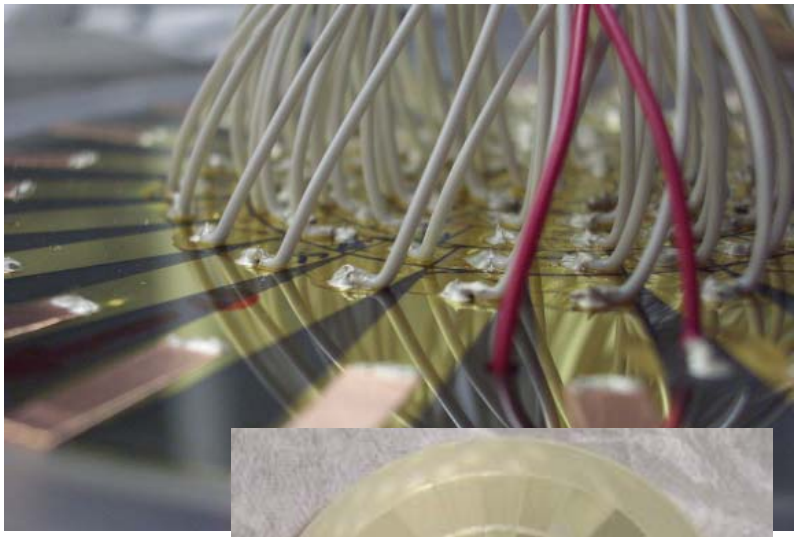


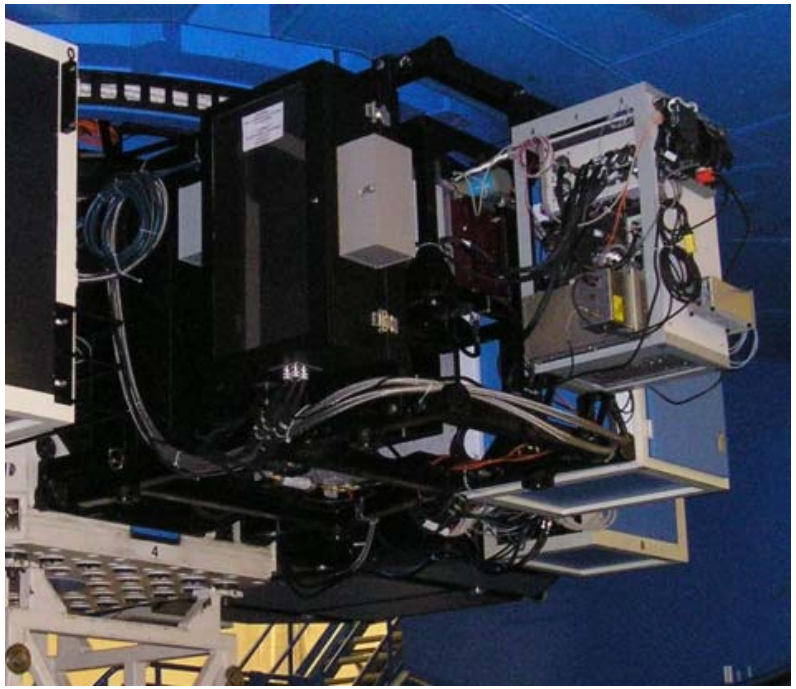
Geiger APD Sensor Architecture

- **Four main parts**
  1) Photon detection
  2) Avalanche amplification (pulse generation)
  3) Pulse discrimination
  4) Photon counting and readout circuitry
- **CMOS circuit used for (3) and (4)**
- **For (1) and (2) - two options:**
  - Part of CMOS circuit
  - Put APD into detector material and hybridize to CMOS circuitry



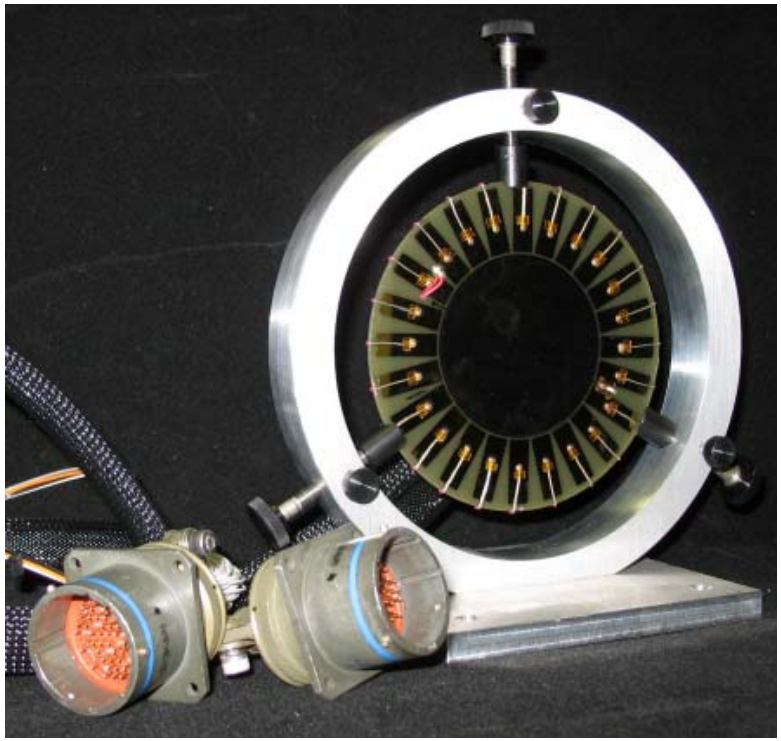
Curvature Adaptive Optics
at the IfA
(C. Ftaclas, M. Chun)

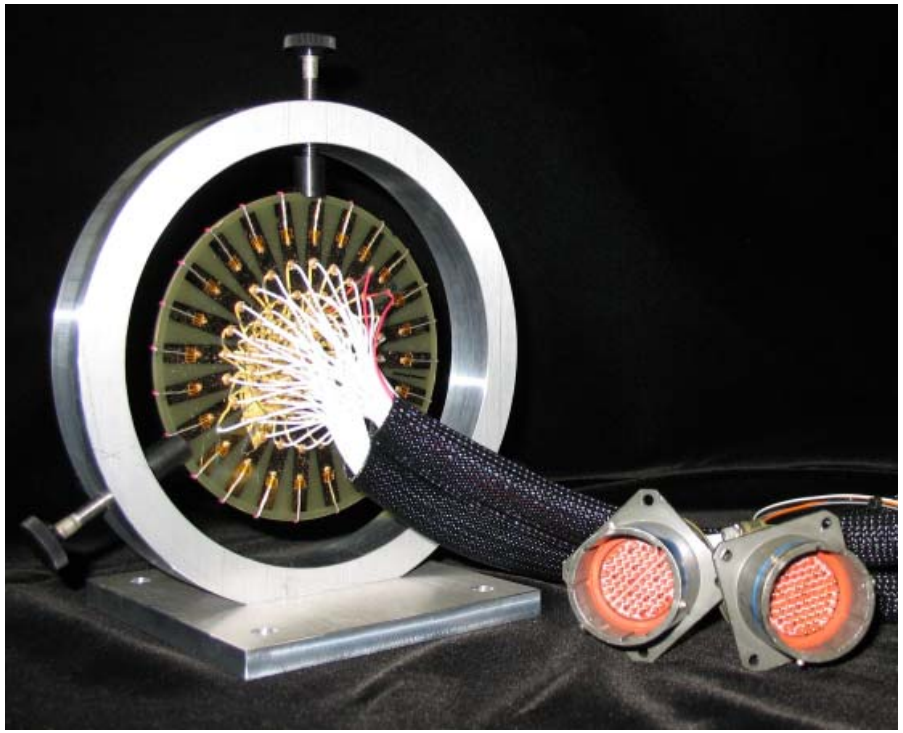




Systems and
Components

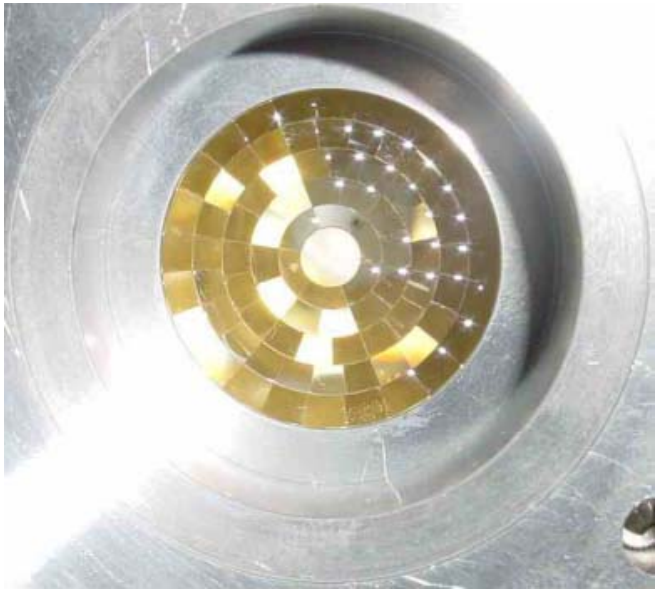
Curvature AO Components: Deformable Mirror





Minimum Bend Radius = 10m
Resonant Frequency > 680Hz
Bimorph Edge Benders
Front Focus Electrode

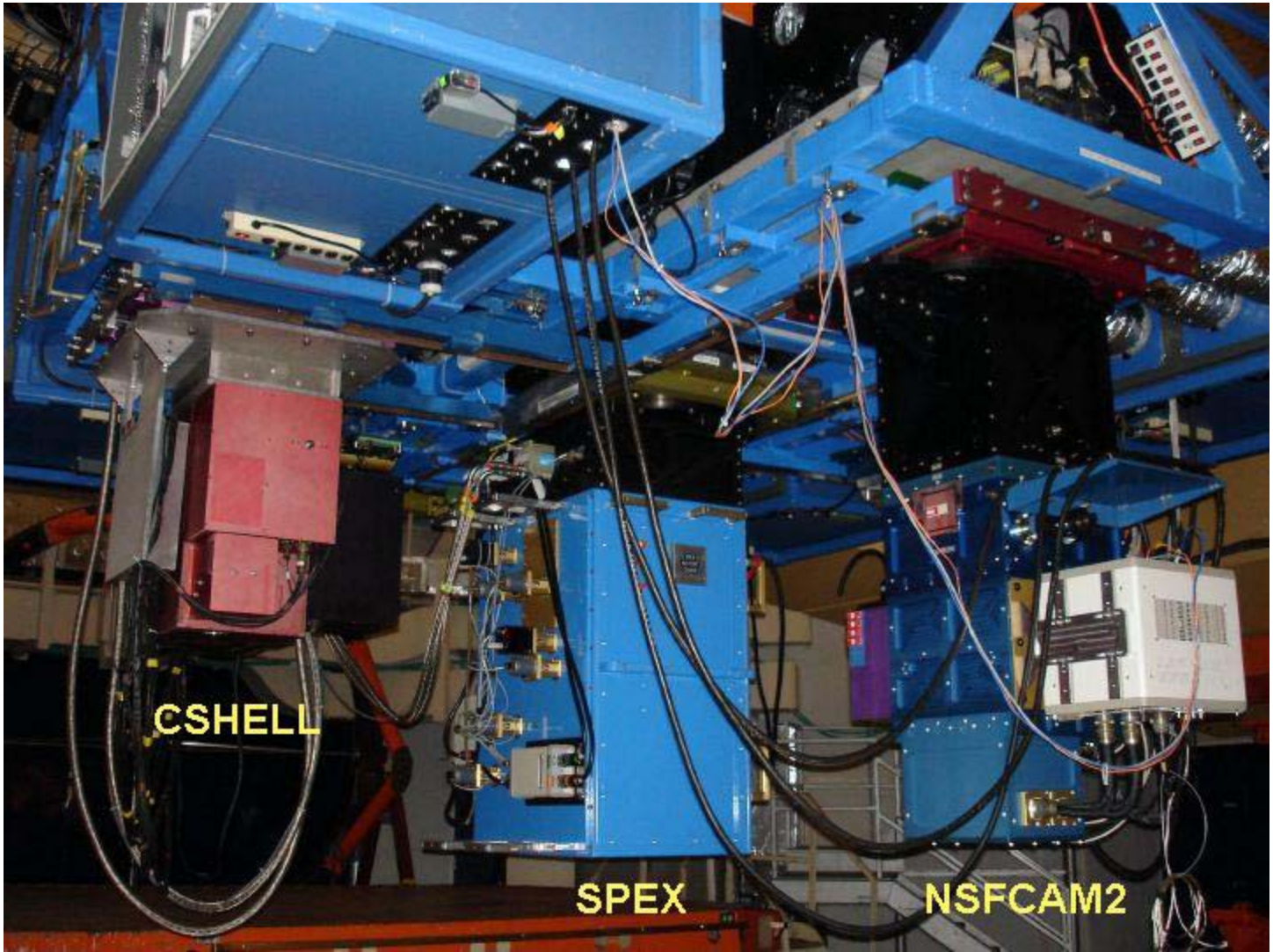
Curvature AO Components: Lenslet array

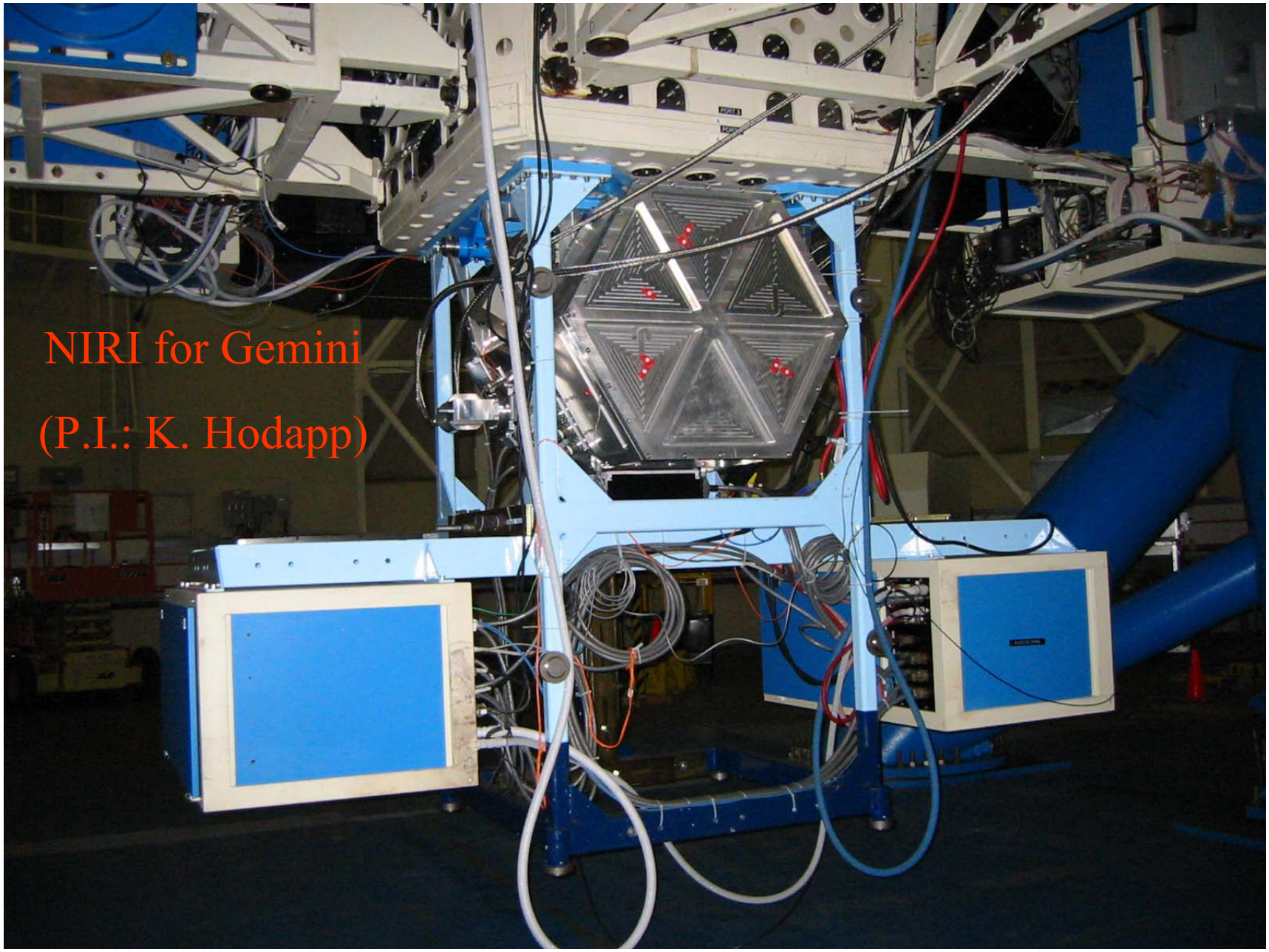


Fiber Coupled
Achromatized 0.4 to 1 micron

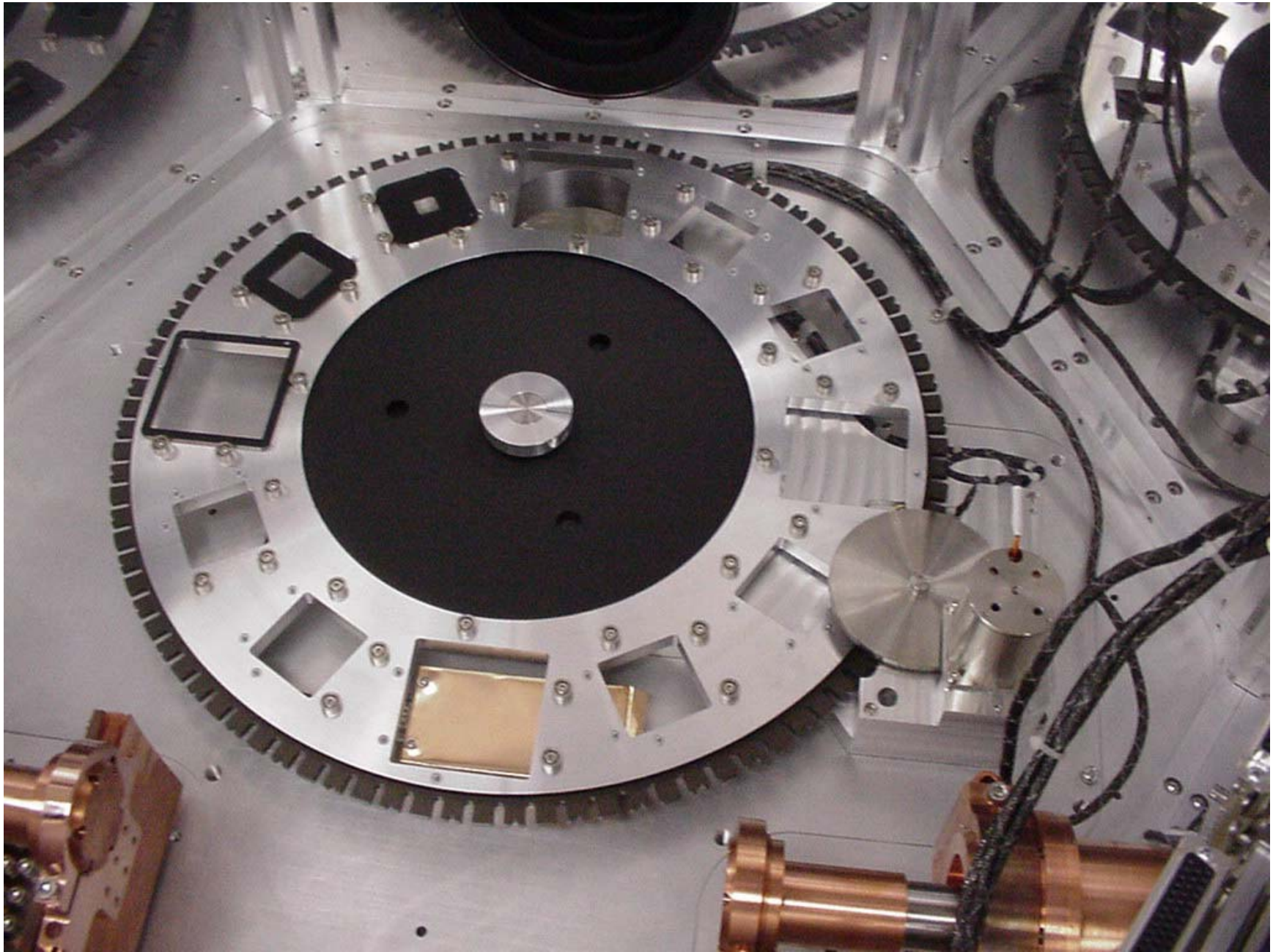
IRTF Instruments: CSHELL (A. Tokunaga), SPEX (J. Rayner), and NSFCAM-2 (E. Tollestrup)

Funded by NSF ATI



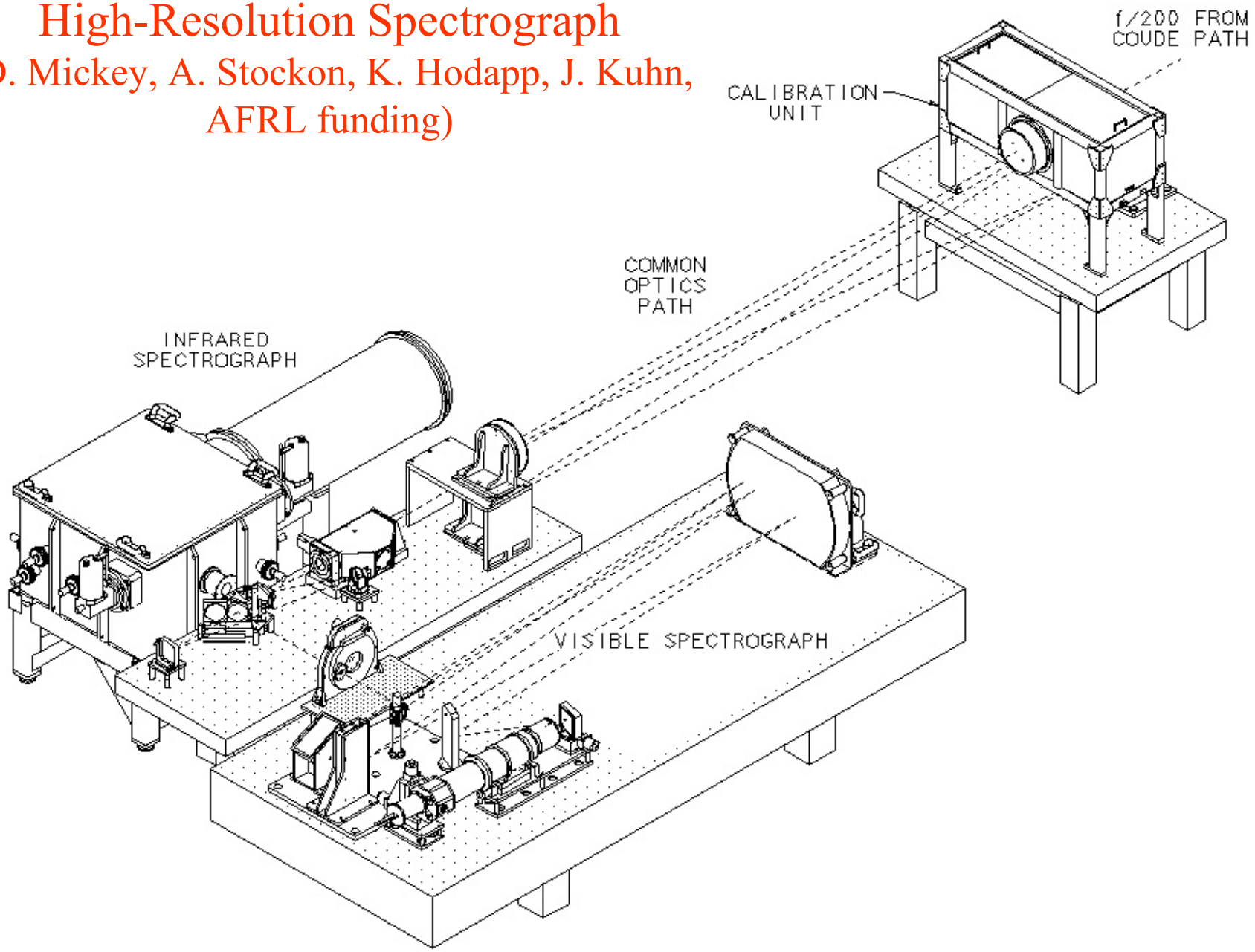

NIRI for Gemini
(P.I.: K. Hodapp)

Large Cryogenic Mechanisms: NIRI Focal Plane Mask Wheel

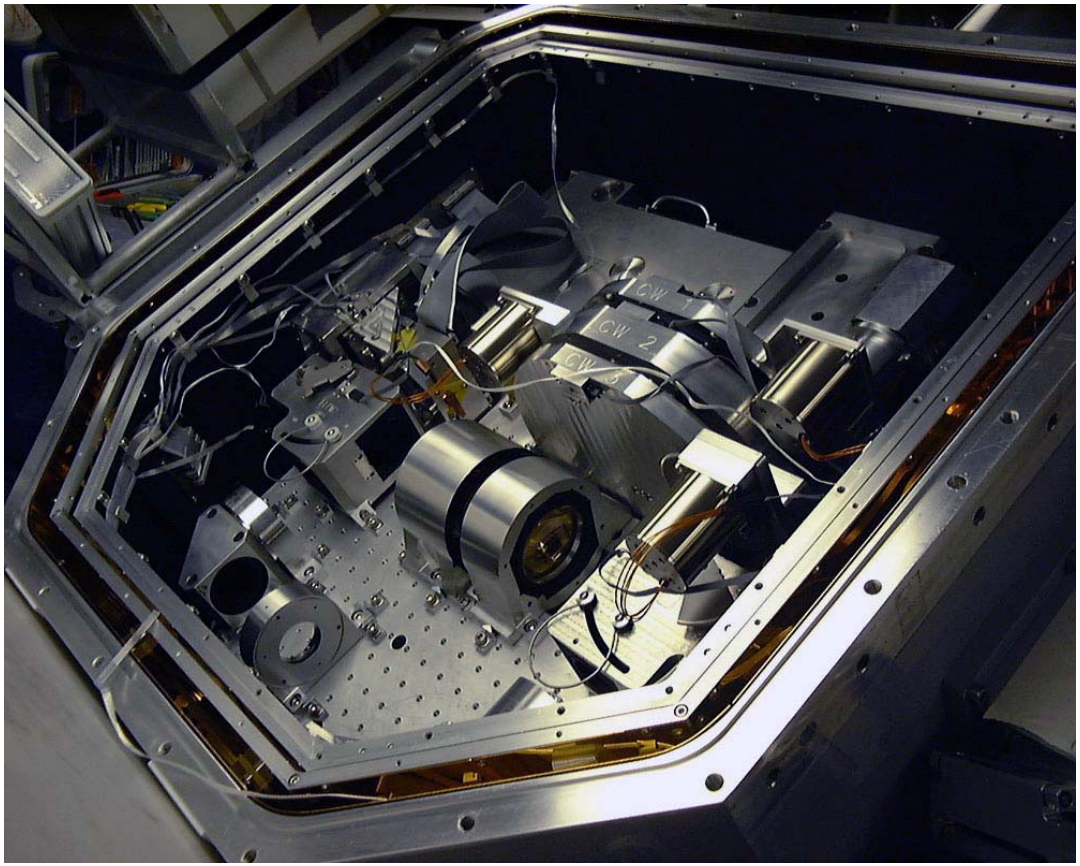


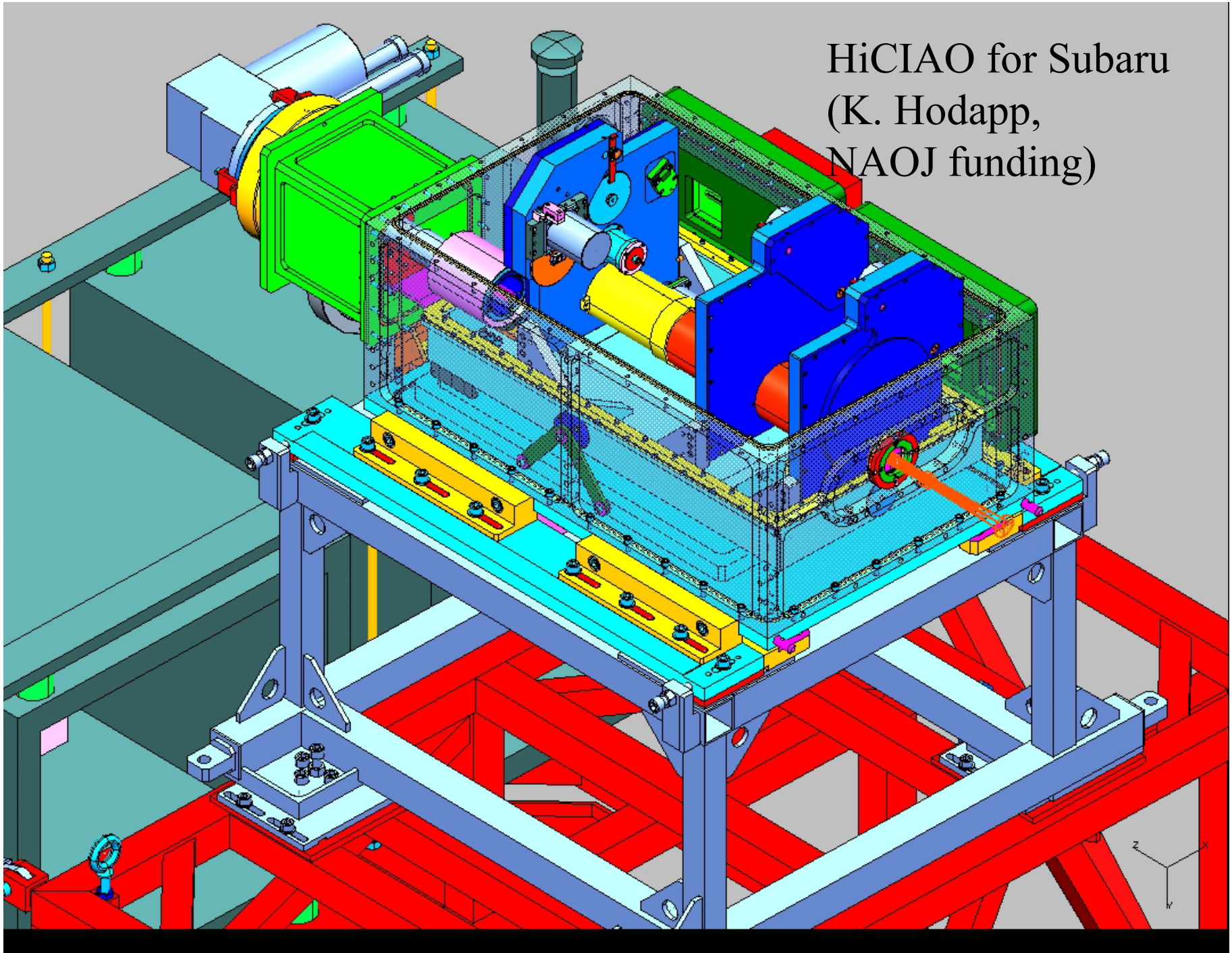
AEOS Optical and Infrared High-Resolution Spectrograph

(D. Mickey, A. Stockon, K. Hodapp, J. Kuhn, AFRL funding)

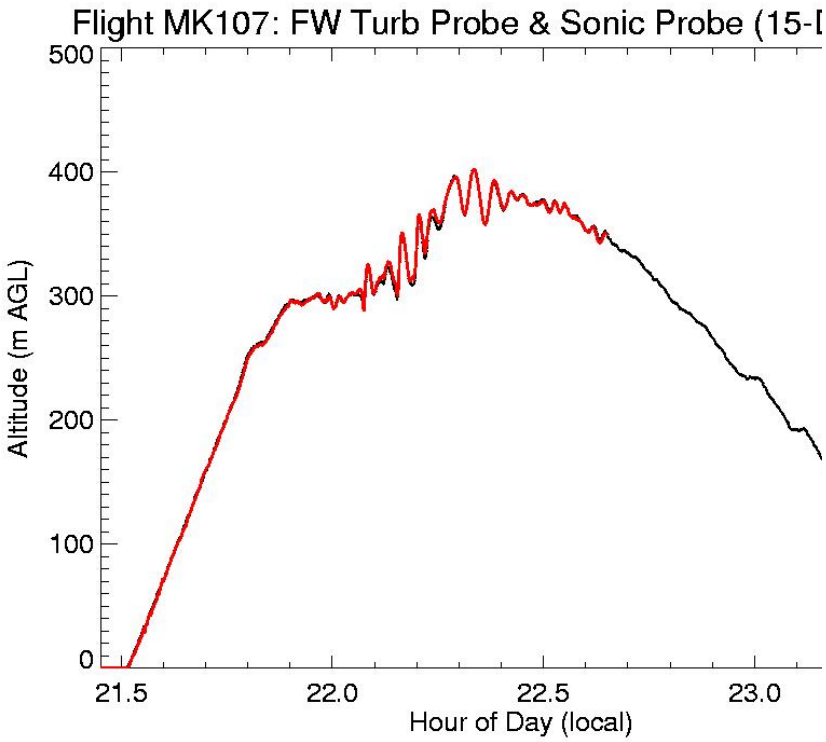


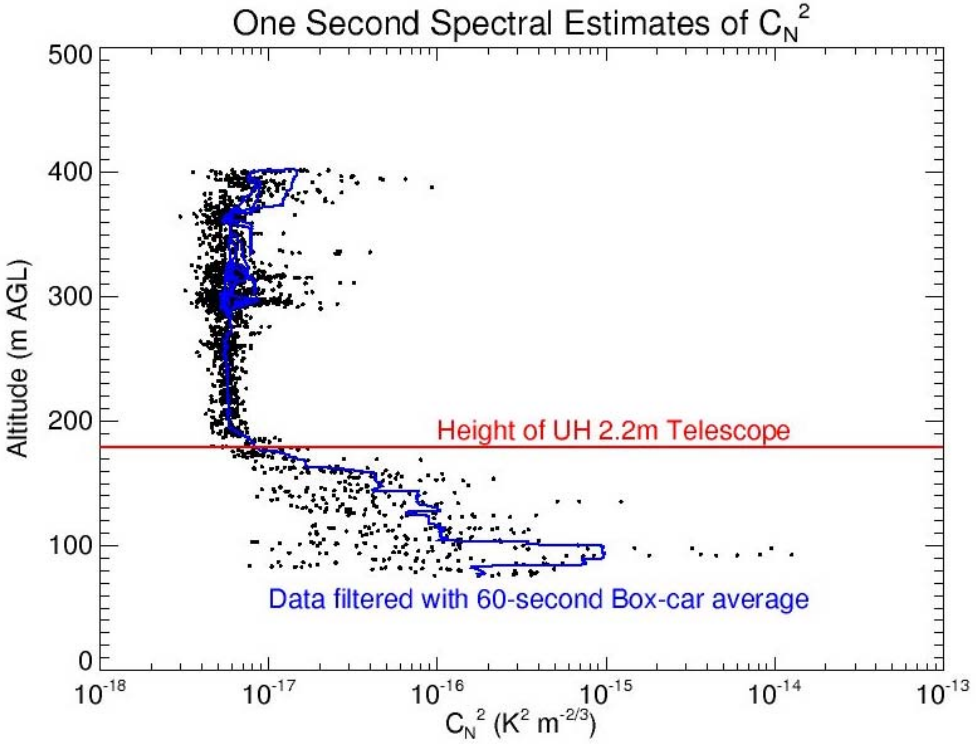
Infrared Camera and Spectrograph (IRCS) for Subaru
(P.I. A. Tokunaga)




HiCIAO for Subaru
(K. Hodapp,
NAOJ funding)

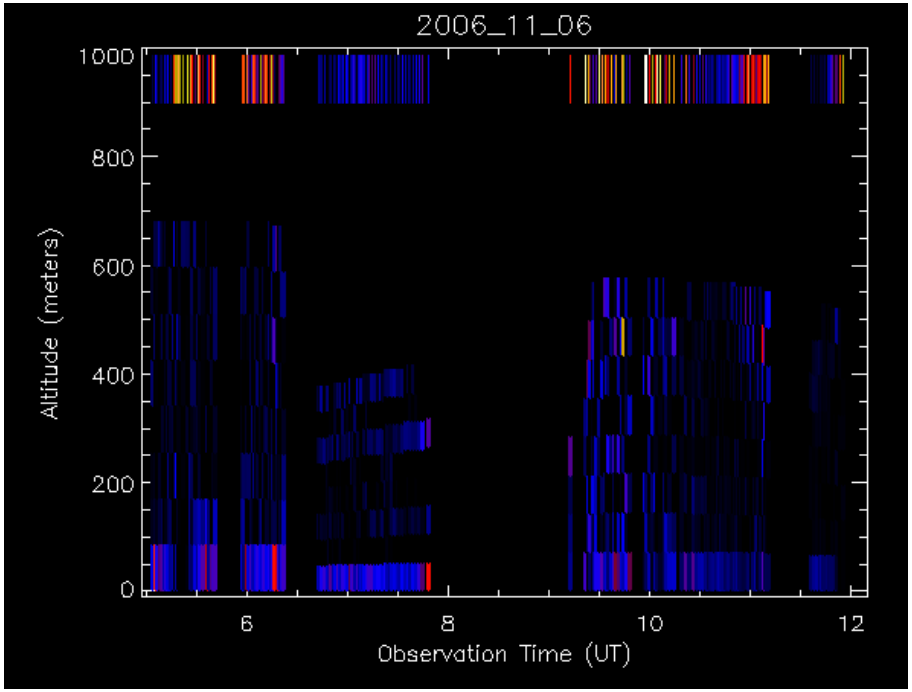
Studies of the boundary layer (M. Chun)

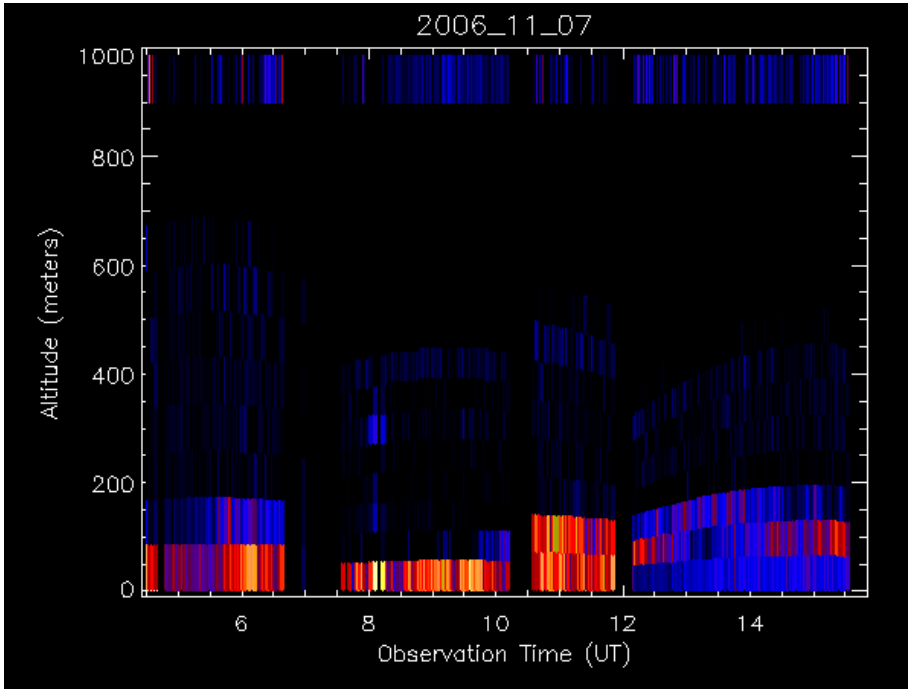




Current activities: Ground-layer characterization (M. Chun)

- New optical turbulence profiler based based on the correlations of the optical wavefront gradients and amplitude fluctuations from double stars.
- Collaboration with University of Durham and UNAM
  - SLODAR: Slope detection and ranging
  - LOLAS: Low-layer SCIDAR.





Mauna Kea Observing Condition Forecast
(S. Businger, UH Meteorology)