AST3 Cameras, a Status Update

Astronomy & Astrophysics in Antarctica

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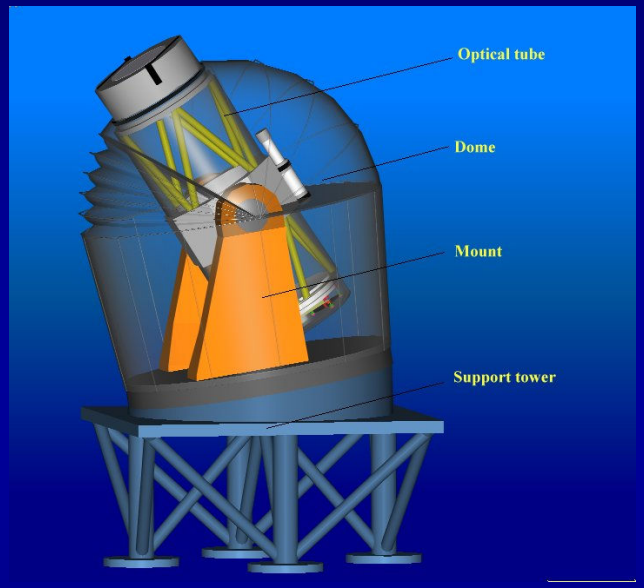
Introduction

- Semiconductor Technology Associates provides the imaging industry with custom charge-coupled device design, fabrication, characterization and operation
- Update of our current work on a CCD camera system for the AST3 telescopes.
- Description of recently developed CCD devices of interest for the astronomical community.

Antarctica Schmidt Telescopes (AST3)

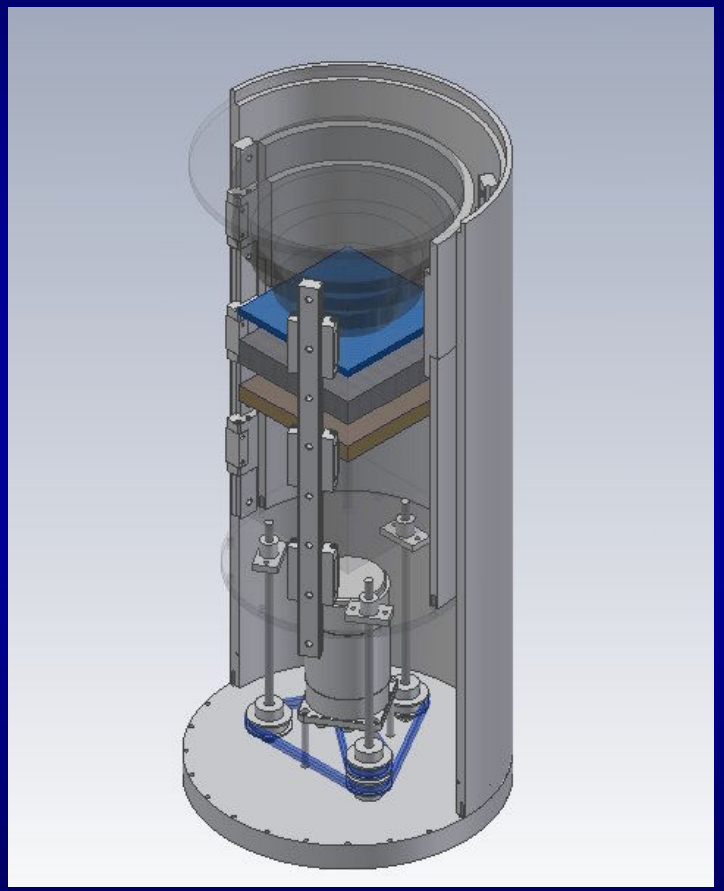
- Location Dome: A Antarctica
- Clear aperture: 50cm
- FOV: 4.2°
- Wave Band: 400nm-900nm
  (g, r, i filters for 3 telescopes)
- Scale:1 arcsec/pixel



- Image quality: 80% energy encircled in one pixel
- Type: STA1600-FT Charge Coupled Device
- Working mode: frame transfer

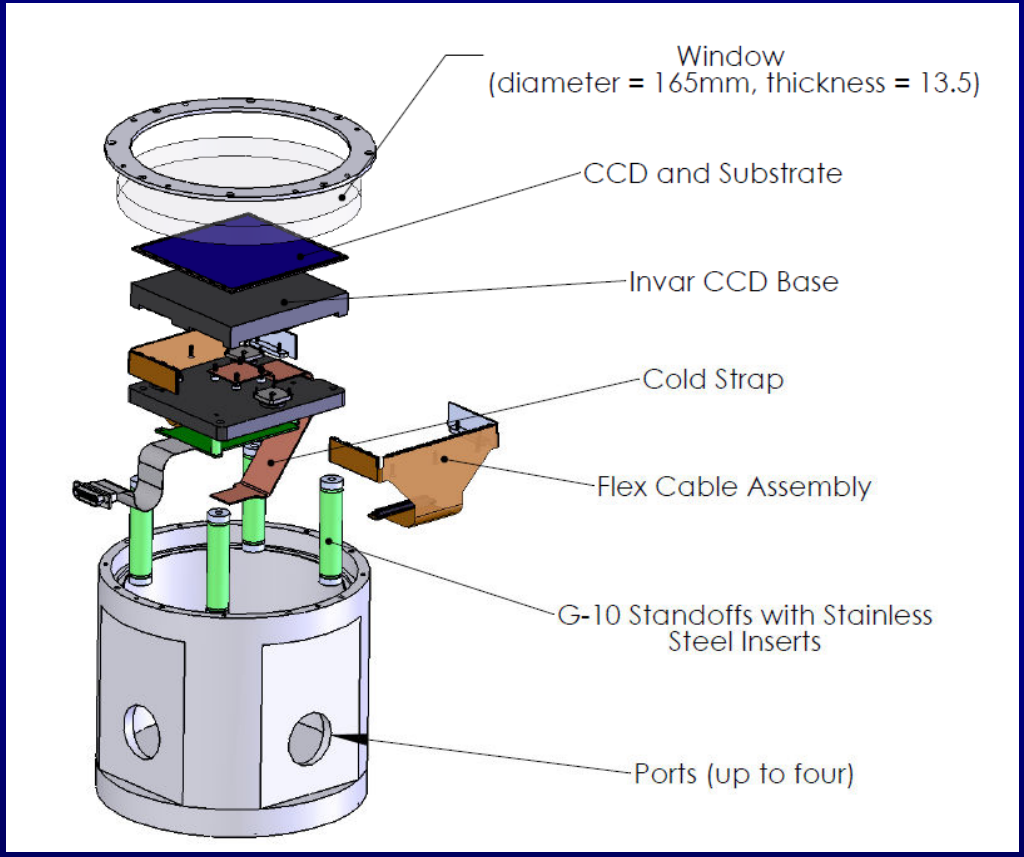
AST3 Camera Assembly

- Camera assembly mounted within tube for fine focusing.



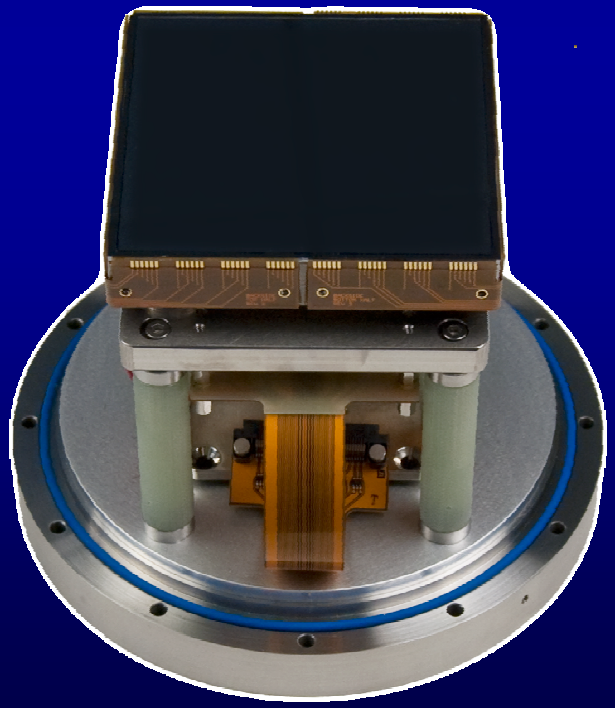
AST3 Dewar Housing

- 180mm diameter stainless steel dewar
- TE Cooling for operation at -80C
  - Average outdoor temperature -50C



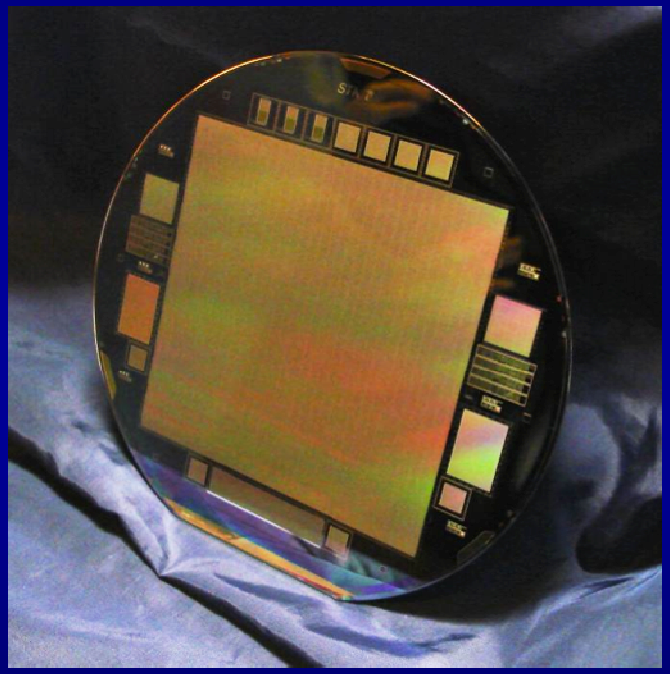
AST3 Dewar System

- STATUS: Dewar
  - Three housings have been completed
  - Presently undergoing cold testing



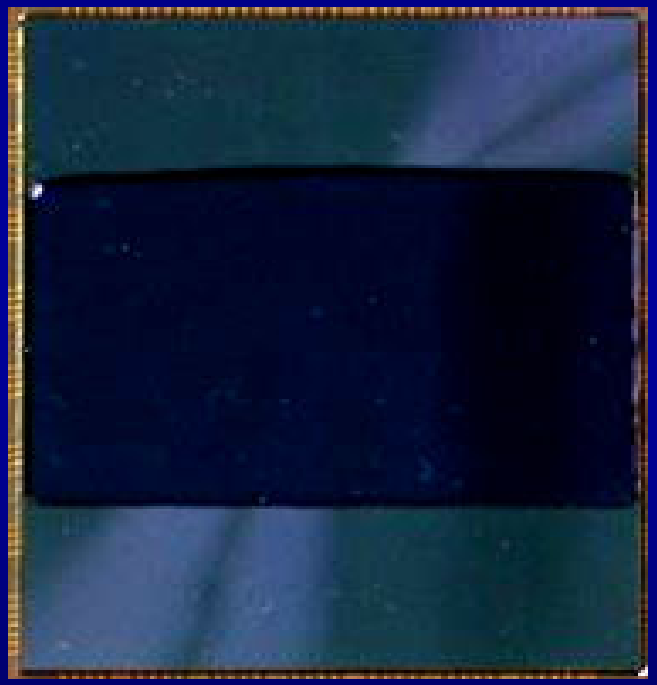
STA1600 111Mega pixel imager

- Full 6” wafer imager
- Image area 95 mm x 95 mm
- 10560 x 10560 pixels
- 9 micron pixel
- 111,513,600 pixels per frame
- Backside thinned for high QE
- Acquisition speeds up to 1 frame/sec
- Originally designed for US Naval Observatory - Astrometry



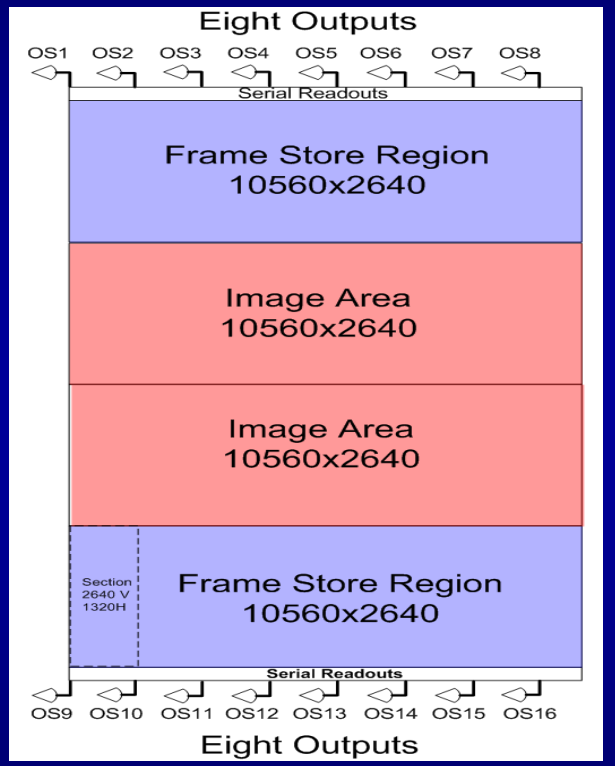
STA1600-FT Performance

- Image area 95 mm x 47.5 mm
- 16 dual stage high speed outputs
- 7.0-9.0 electrons noise @ 1.0 MHz
- 5.0 electrons @ 100 kHz
- Full well > 80,000 electrons non-MPP



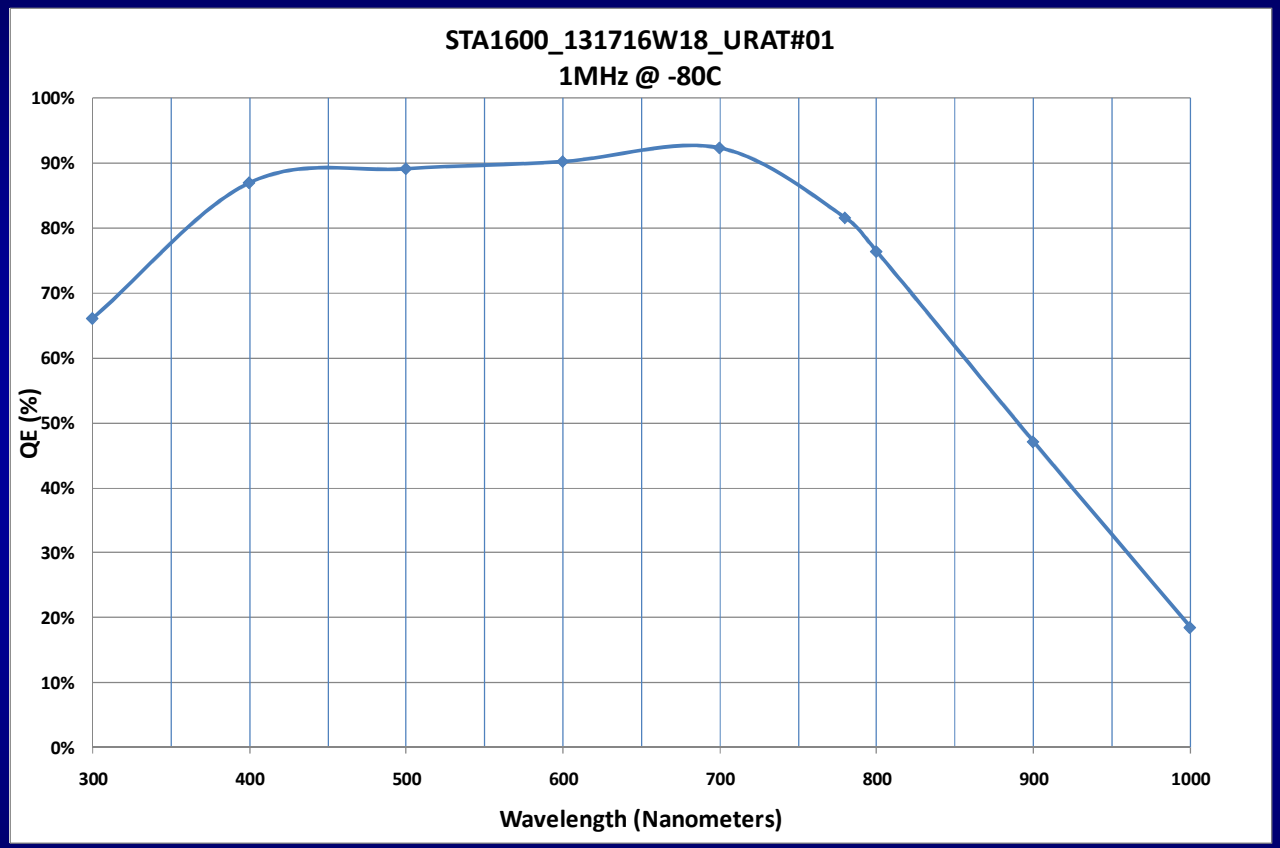
STA1600-FT CCD

- Modified for split frame transfer operation
- Additional metal strapping achieves frame transfer rate of 100 Khz
- Design modifications expressly for AST3 operation
- STATUS: STA1600-FT CCD
  - CCD fabrication run completed
  - CCDs out to be thinned this month



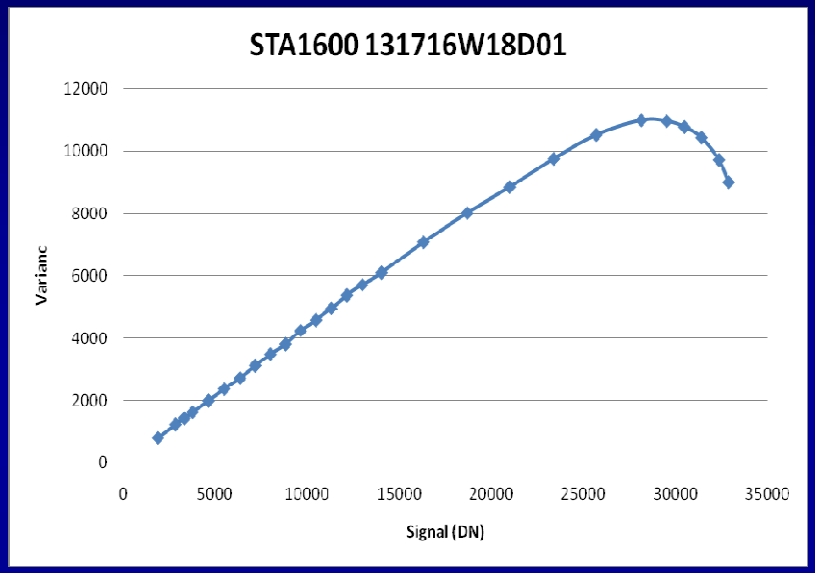
STA1600-FT Frame Transfer Imager

Typical Backside QE

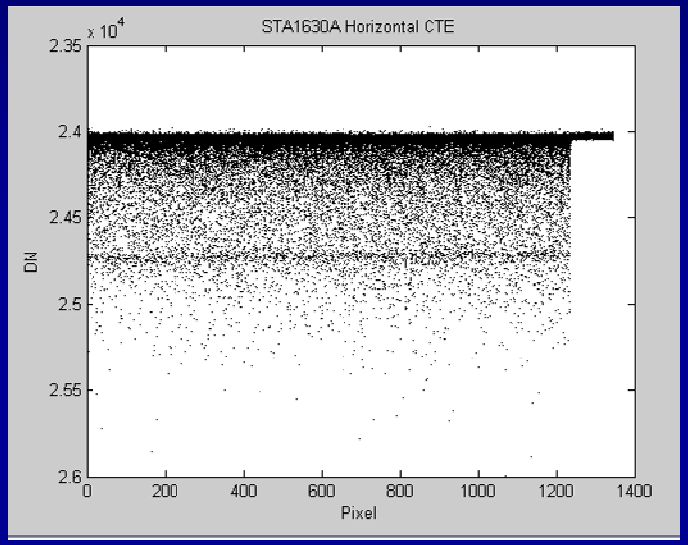


- Coating optimized for broadband response
- Measured QE for 30 micron silicon epitaxial layer

STA1600 Performance



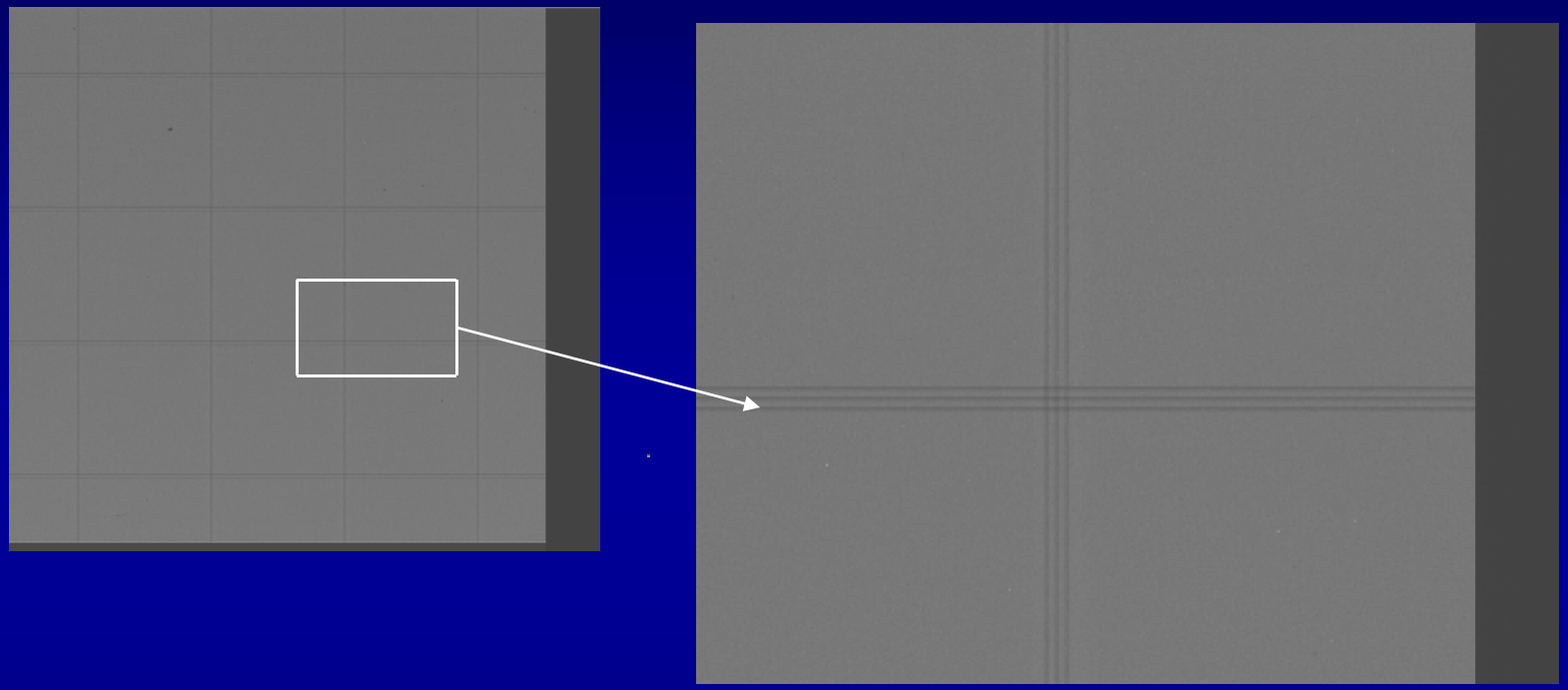
Photon Transfer Curve



Charge Transfer Efficiency

- HCTE and VCTE > 0.999998
- Less than 1% non-linearity between 200 e- and 80ke-

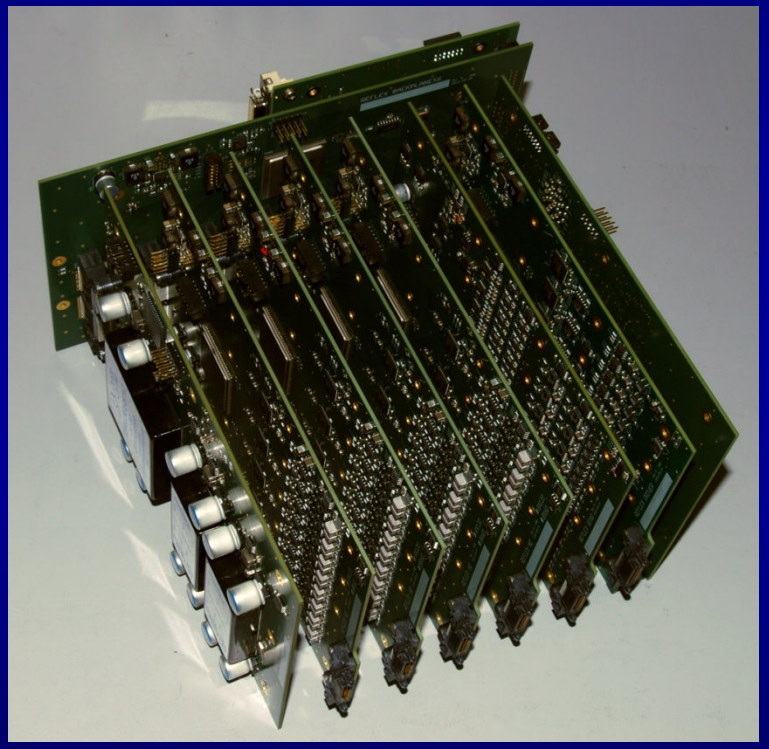
STA1600 Performance Enhancement



- These frontside images exhibit the on chip strapping necessary to reduce vertical gate time constant.
- As a result the device can be driven at enhanced data rates without degradation of CTE or increased image smear.
- Allows for high speed parallel transfer from frame store operation

Reflex Camera

- Reflex Camera System
  - 11” x 9” x 5.5” (6-slot chassis)
- Flexible Modular Features
  - 8-ch 100 Mhz 16-bit A-D
  - 12-ch 200 Mhz 16-bit clock driver
    - +/- 12V (Programmable slew)
  - 16-ch 16 bit DC bias
    - Voltage and current monitoring
    - Programmable current limit
  - Full cameralink interface
    - Swappable for custom, gigabit ethernet, firewire.
  - Single 12 V DC power supply



Internal board set

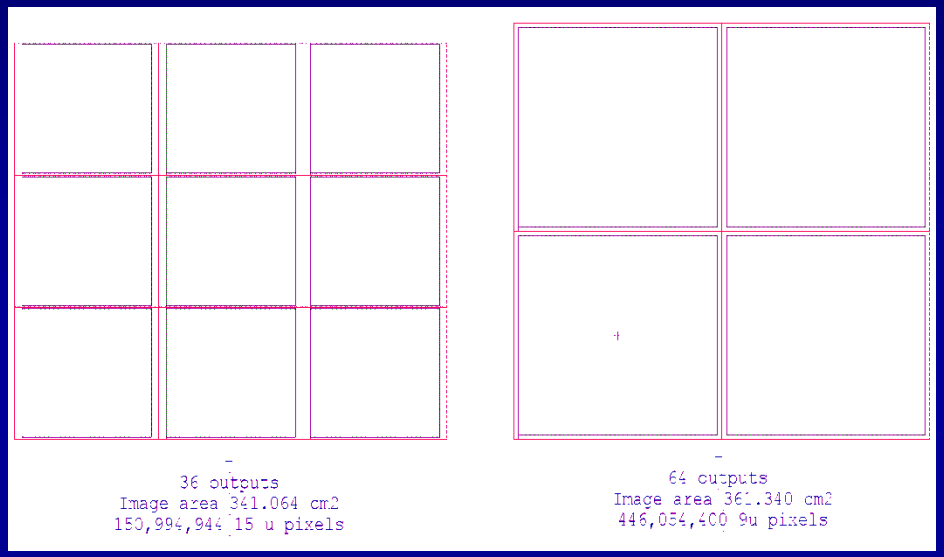
Reflex Camera

- There is a FPGA programmable timing core
- Sixteen 16-bit ADC channels each have low noise fully differential AC-coupled preamps
- CCD clock drive signals are generated from 200 Mhz DACs
- STATUS: Three cameras completed for AST3

STA1600 Themes and Variations

- STA1600
  - Standard device with dual stage high speed outputs
  - Full frame imager
- STA1600 MPP
  - Frontside illuminated low dark current
- STA1600 LN
  - 16 single stage low noise outputs.
- STA1600 FT
  - Frame transfer operation
- STA1600 DD
  - Deep depletion

Large Focal Plane Efficiency

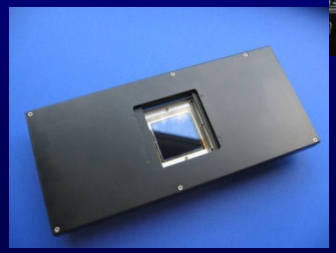


4kx4k CCD adjacent to STA1600

- Four 10ks provide more active image area than nine 4k imagers
- 91% Active area for 4k imager
- 95% Active area for 10k imager

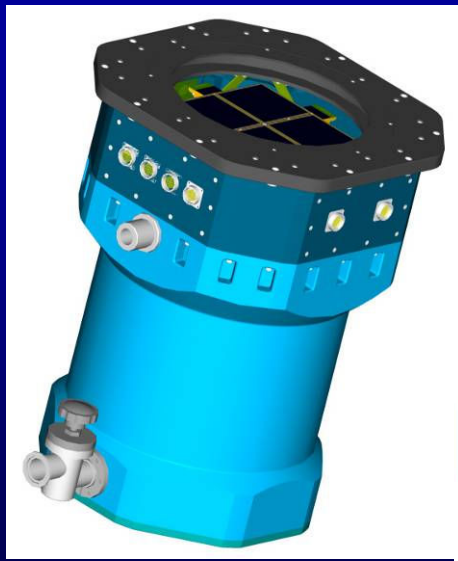
USNO Robotic Astrometric Telescope URAT

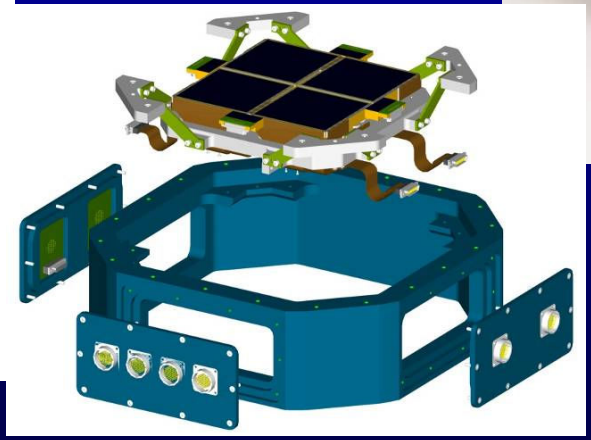
- 8 inch Refracting Telescope for Astrometry
- Upgrade initiated to a 2x2 array by Dr Norbert Zacharias for an all sky survey - URAT
- STA is providing complete system including
  - Dewar – Window – Bonn Shutter
  - Four BI STA1600 CCDs – Three STA 3000 Guiders
  - Five Aura cameras with software
  - Telescope robotic control software

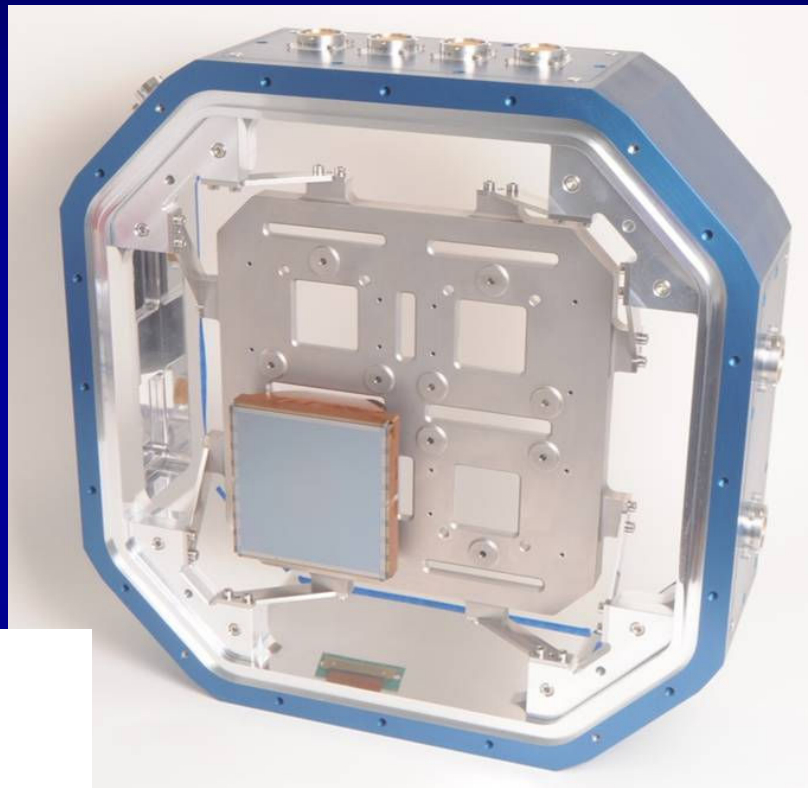


URAT 2x2 Focal Plane

- Next generation astrometry focal plane
  - 1 Frame = 1 Gigabyte of data
- Incorporates buttable package version of STA1600
- GL Scientific Dewar

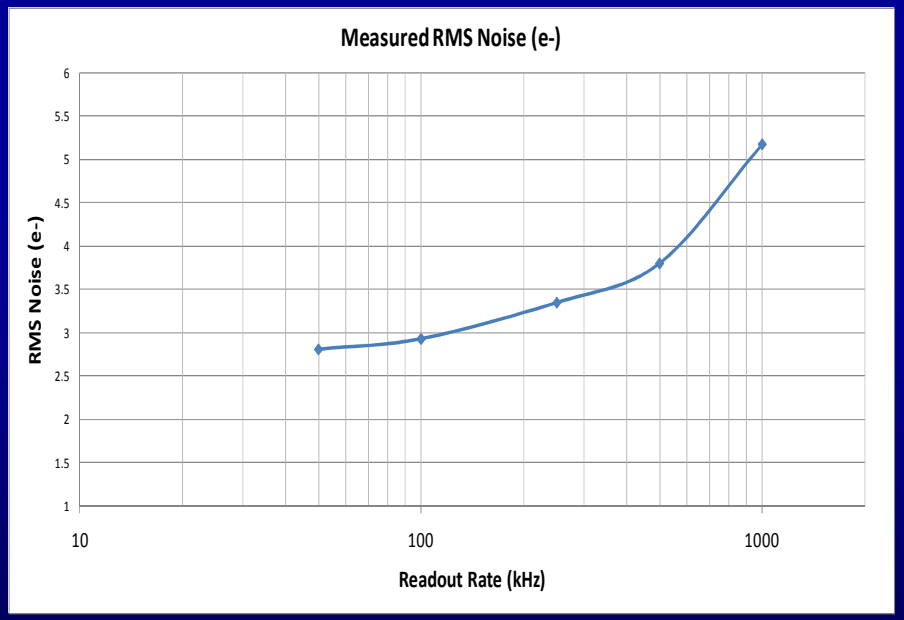






STA1600 LN

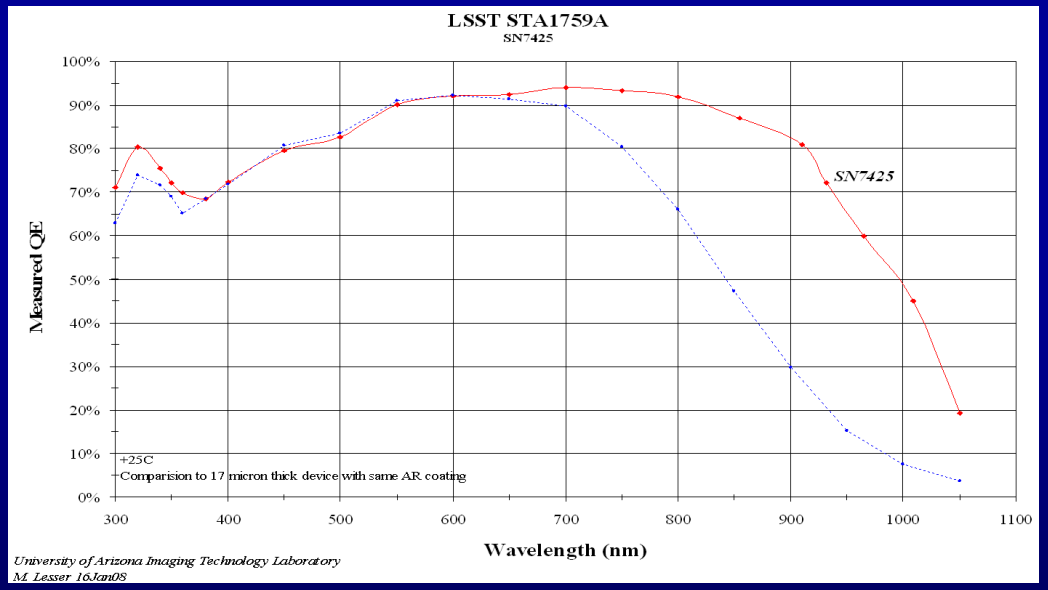
- Low noise version of STA1600
- 16 dual stage outputs are replaced with single stage low noise outputs
- Noise < 3 electrons
- Sensitivity 4-5 µV/e-
- Identical pinout
- Available Fall 2010



Measured on backside thinned STA0510

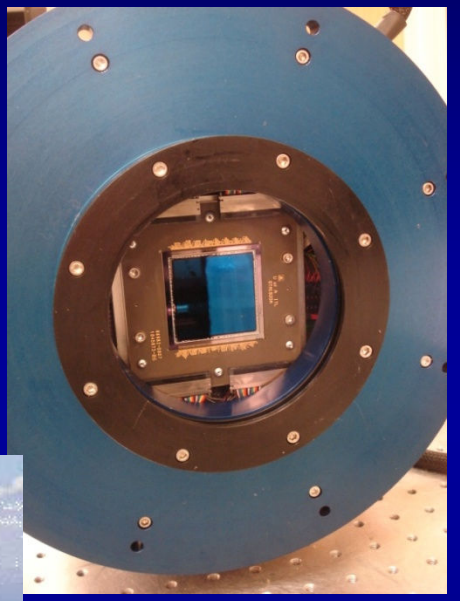
STA1600 DD

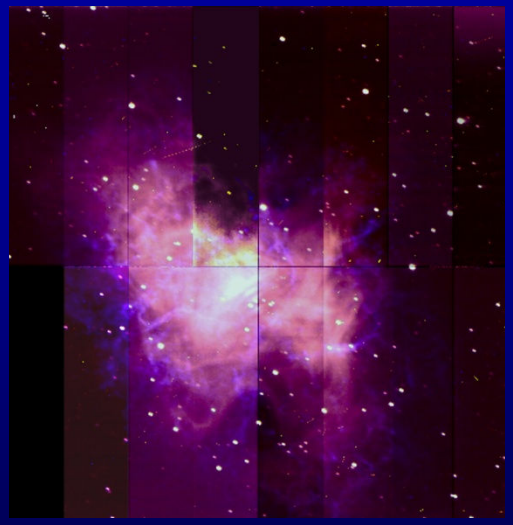
- Deep depletion for maximum red response
- STA1600DD would have similar performance
- 93 µm thickness
- >50% QE @ 1 µm
- Available 2011



STA1920A LSST

- Study contract device
- 100 µm thick, high resistivity bulk silicon, capable of overdepletion
- 4K x 4K, 10 µm pixels, 16 outputs



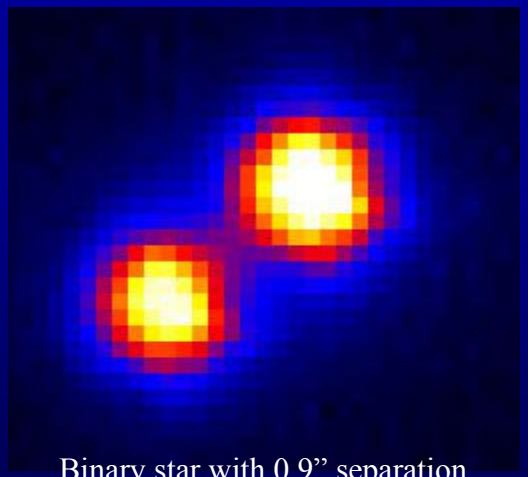


Crab Nebula shows chip segmentation

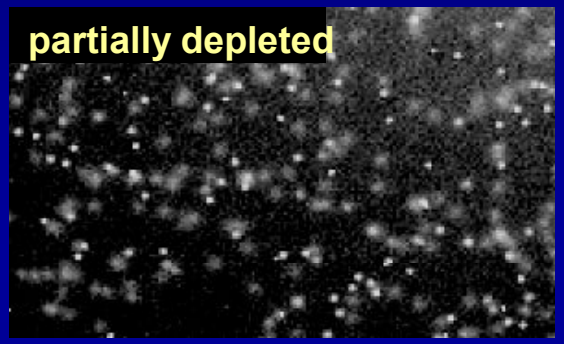
1.2 m Calypso Telescope at Kitt Peak

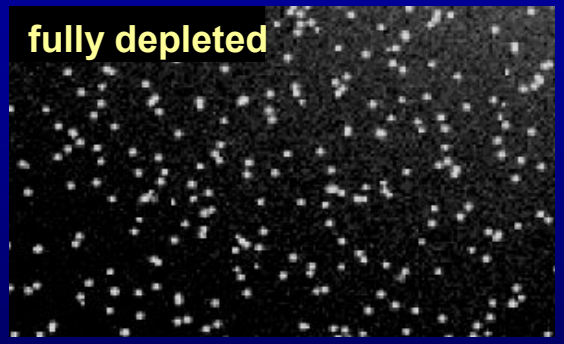
Substrate bias control of charge diffusion

- ^{55}Fe xrays generate compact charge clusters within ~30 μm of silicon surface.
- Fully depleting the silicon restores the PSF



Binary star with 0.9” separation





Summary

- The AST3 camera system is making very good progress
- The STA1600-FT CCDs have been fabricated and are out for backside thinning
- The AST3 dewars are complete and undergoing cold testing.
- The AST3 Camera electronics are complete.
- Thank you for your attention.