



Update of the STA1600 10560 x 10560 pixel high-resolution CCD

SPIE Astronomical Telescopes and Instrumentation

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Introduction



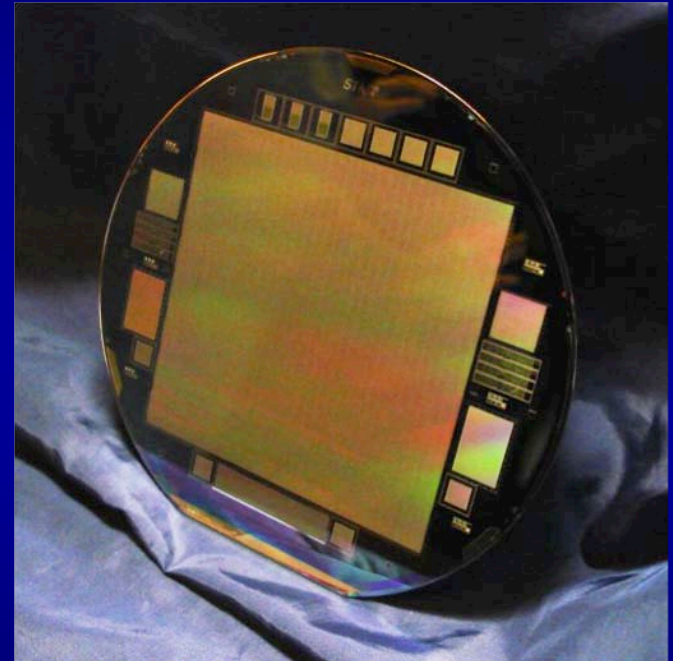
- Semiconductor Technology Associates provides imaging industry with custom charge-coupled device design, fabrication, characterization and operation
- Update of our current work on a 10k x 10k (Wafer scale Imager).
- Description of recently developed deep depletion devices of interest for the astronomical community.



STA1600B 111Mega pixel imager



- Full 6" wafer imager
- 10560 x 10560 pixels
- 9 micron pixel
- 111,513,600 pixels per frame
- 16 dual stage high speed outputs
- Backside thinned available
- Acquisition speeds up to 1 frame/sec
- Designed for US Naval Observatory





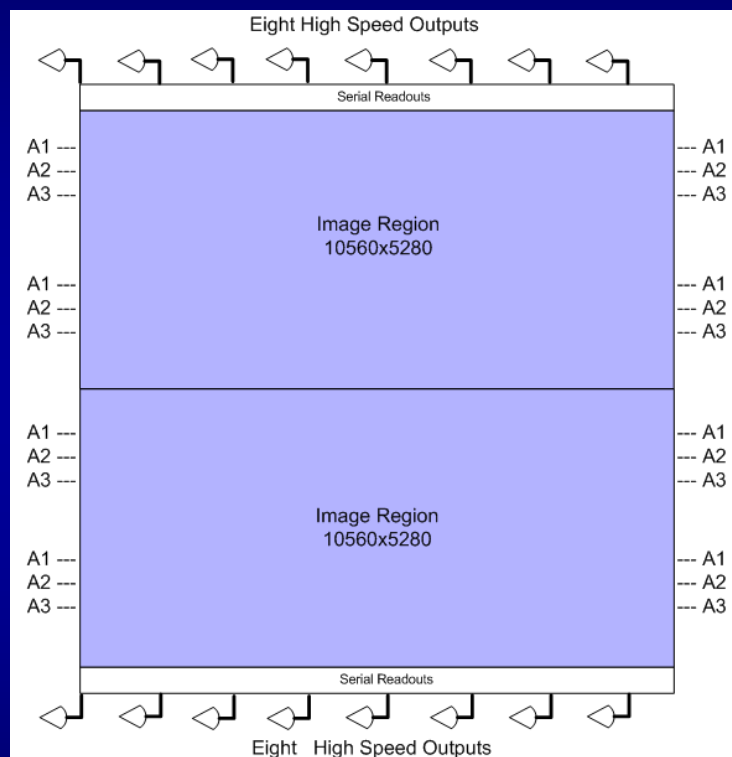
STA1600 Themes and Variations



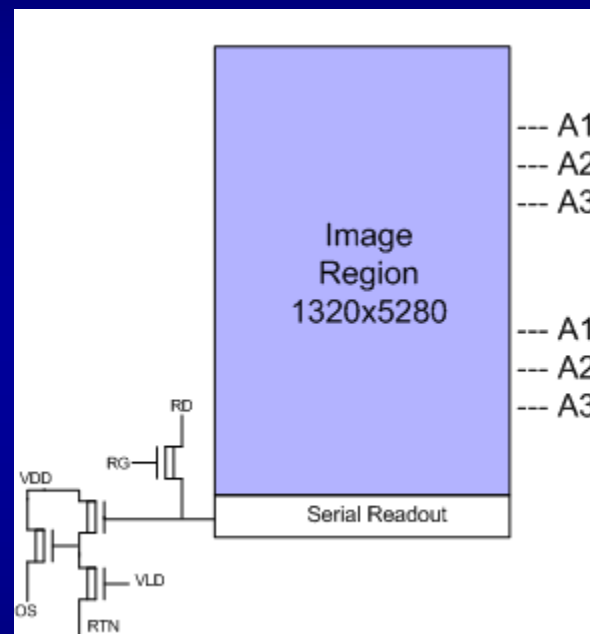
- STA1600
 - Standard device with dual stage high speed outputs
 - Full frame imager
- STA1600 MPP
 - Frontside illuminated low dark current
- STA1600 LN
 - 16 single stage low noise outputs.
- STA1600 FT
 - Frame transfer operation
- STA1600 DD
 - Deep depletion



STA1600 Schematic



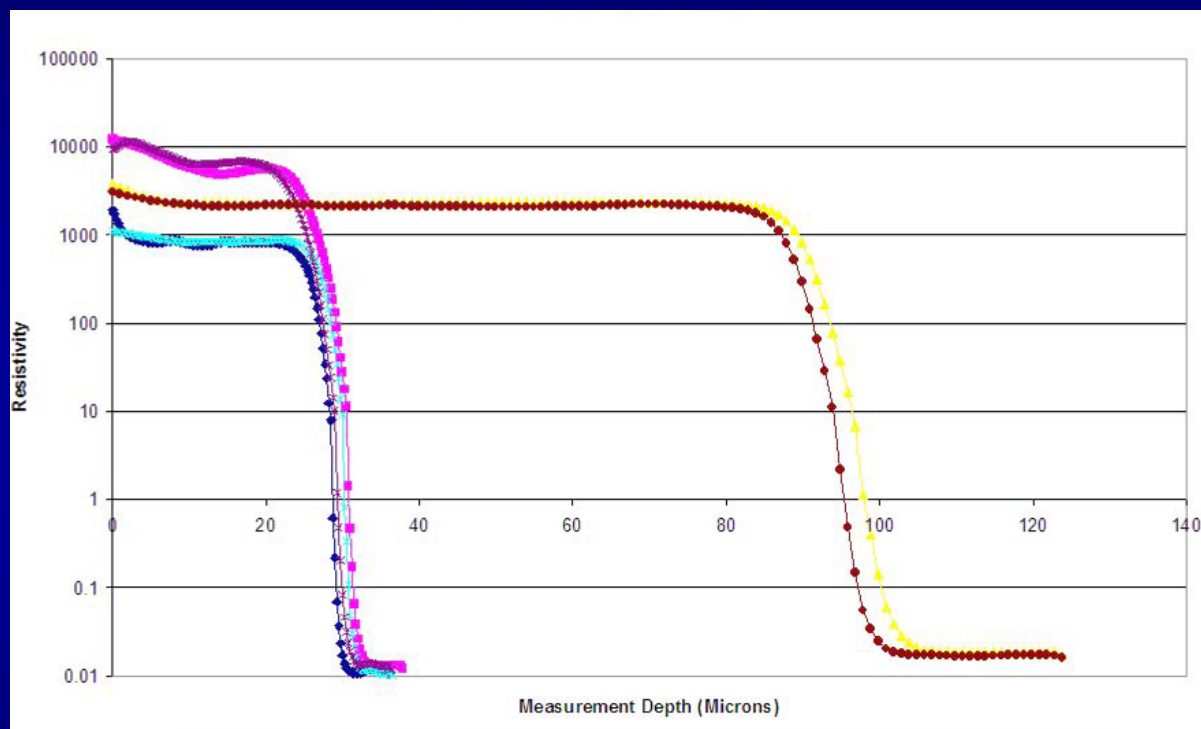
STA1600 Full Frame Imager



STA1600 Output Section



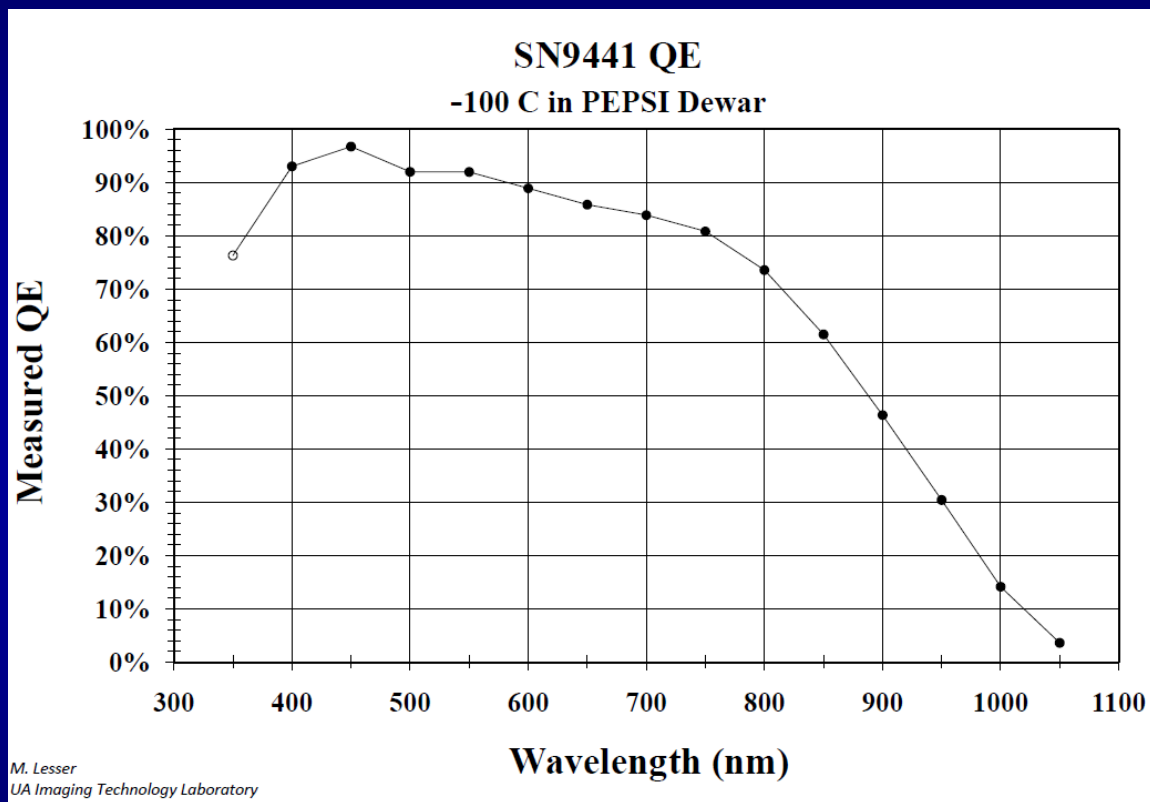
STA1600A Epitaxial Material



- Material cross section measurement of the Epitaxial Doping
- Two materials: 30 um/ >1000 Ohm-cm and 100 um/ >4000 Ohm-cm



Backside QE



- Blue optimized coating



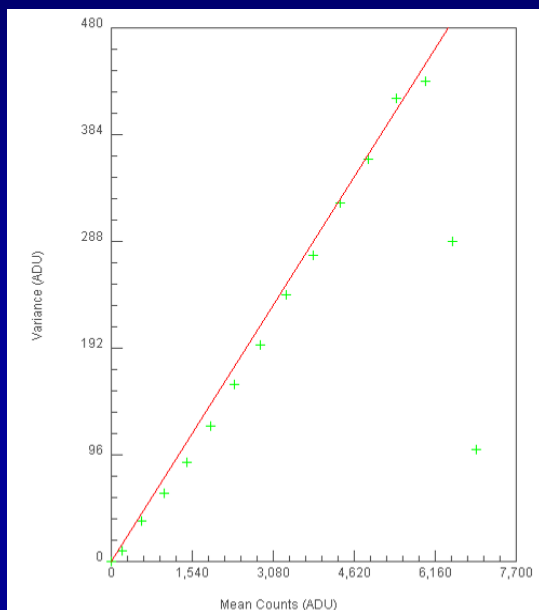
STA1600 Baseline Performance



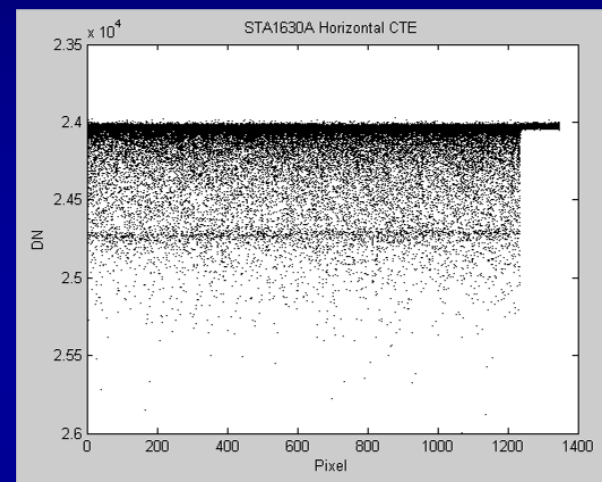
- 7.0-9.0 electrons noise @ 1.0 MHz
- 5.0 electrons @ 100 kHz
- Full well > 80,000 electrons non-MPP
- 16 amplifiers
 - 8 & 16 channel full frame readout
- Capable of readout rates up to 40MHz



STA1600 Performance



Photon Transfer Curve

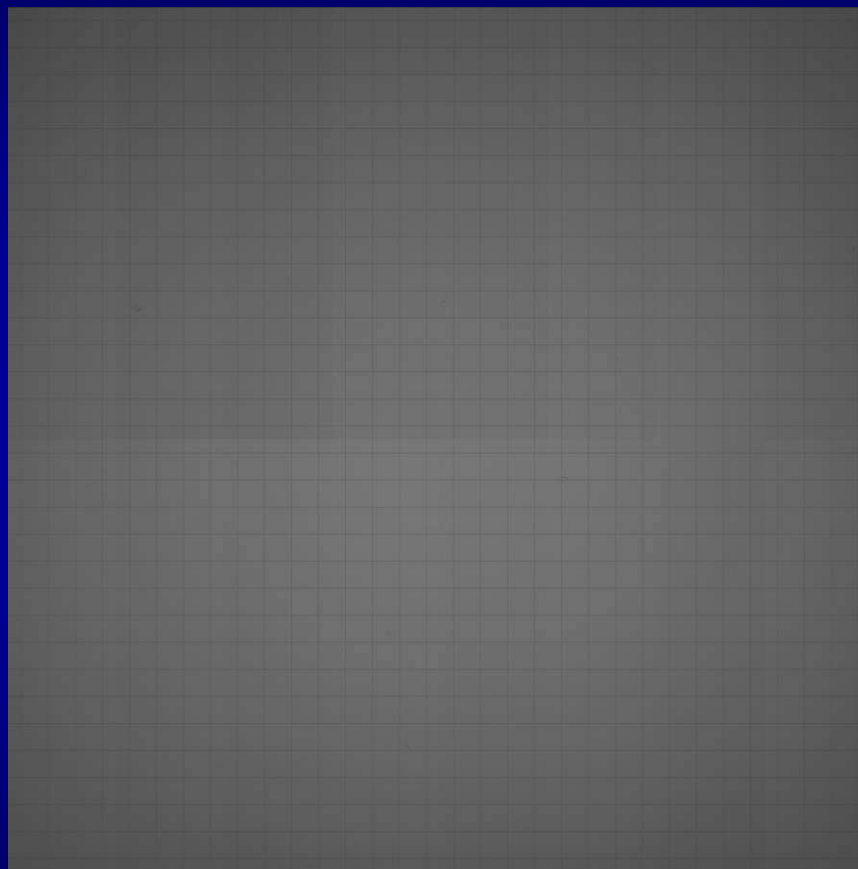


Charge Transfer Efficiency

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



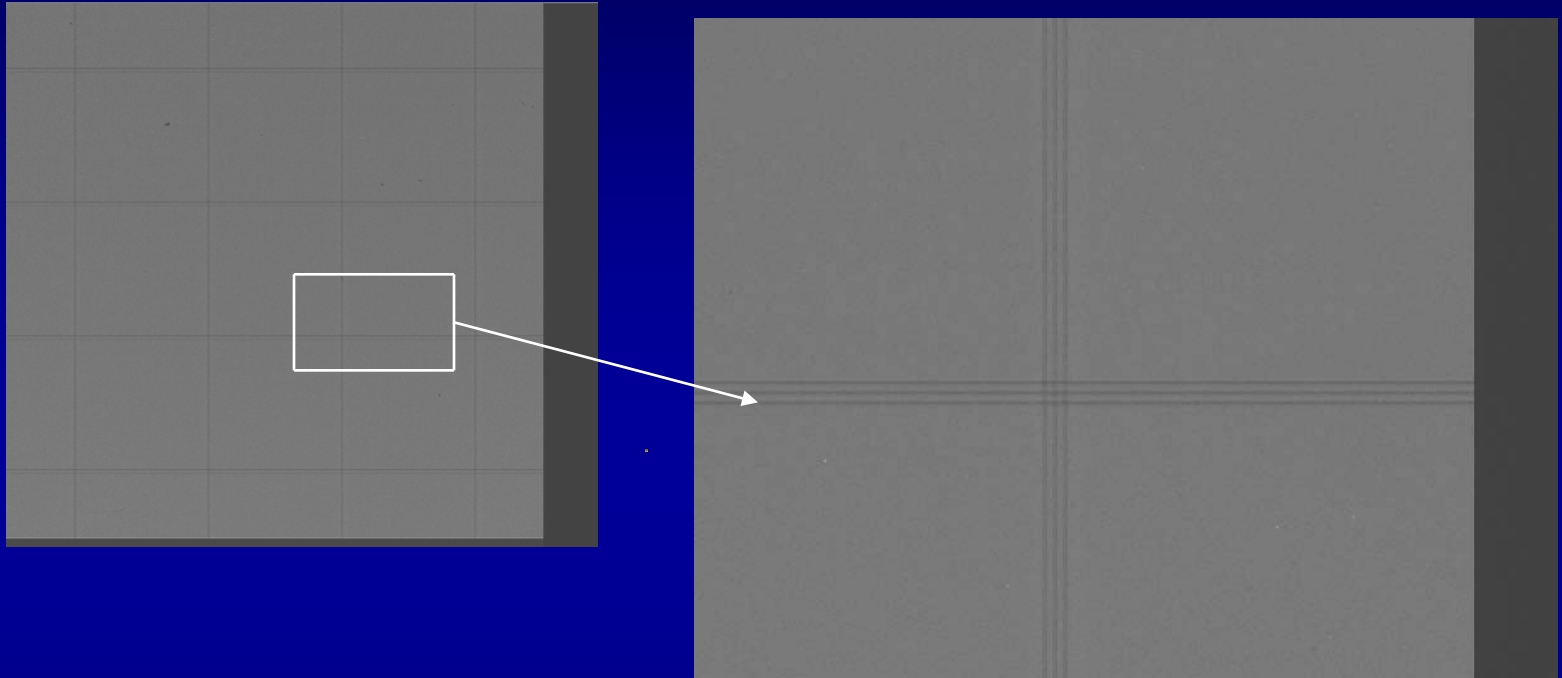
STA1600A Performance



Uncorrected STA1600A Image. Each output section shown is 1320 pixels X 5280 pixels.
PRNU = 9.2% over a 4k x 4k area located at the center of the device. Wavelength is 650nm.



STA1600 Performance Enhancement



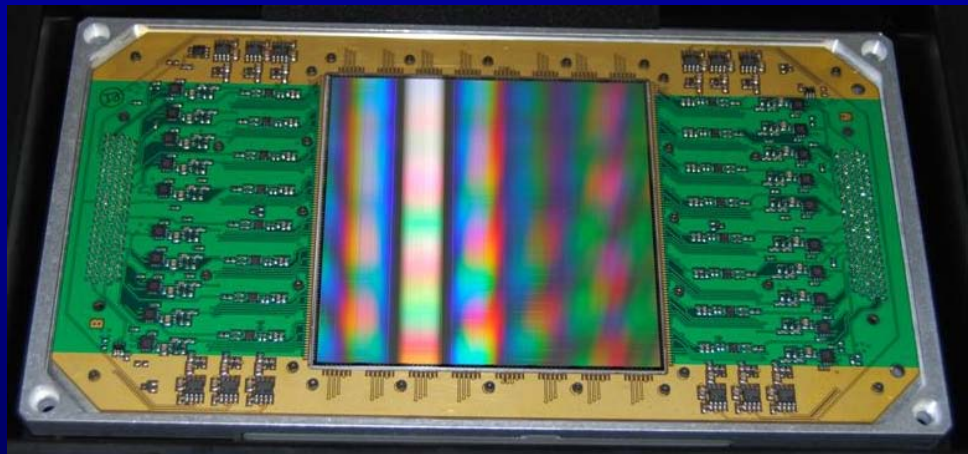
- These frontside images exhibit the on chip strapping necessary to reduce vertical gate time constant.
- As a result the device can be driven at enhanced data rates without degradation of CTE or increased image smear.
- All versions incorporate this feature



STA1600MPP

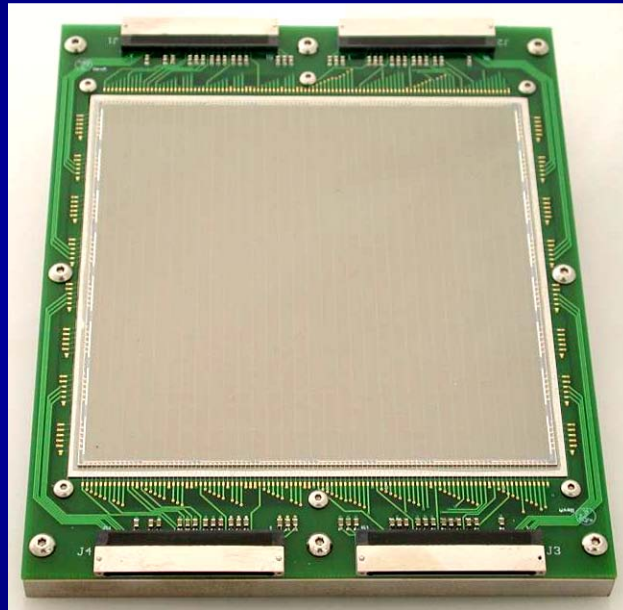


- High speed performance
 - Serial registers readout as fast as 40 Mhz
 - Parallel clock rates > 100kHz
 - Full well 30k e-
 - Better than 1 FPS





STA1600 Single chip Package

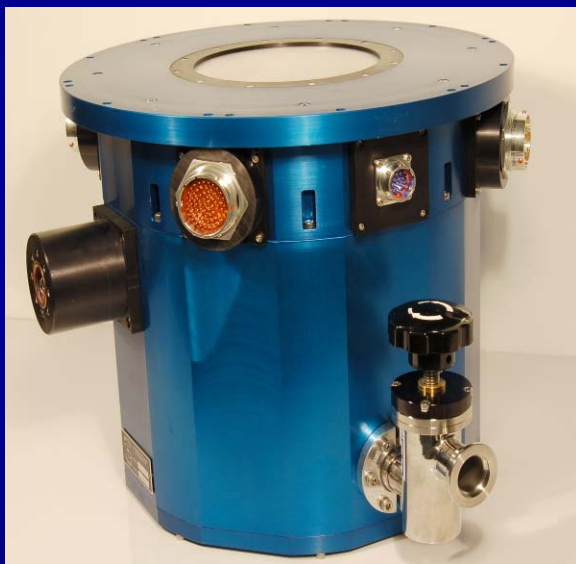


- Substrate fabricated on invar for good thermal matching to silicon, which allows the device to be cooled to -120°C
- Can mount front or backside devices

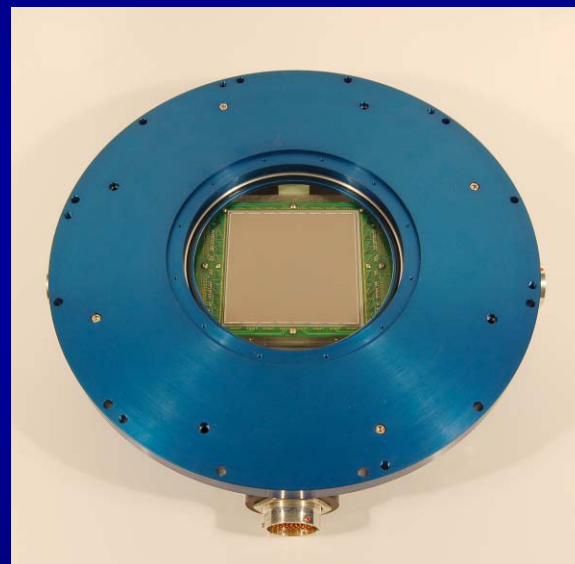
STA1600 Frontside Package



STA1600 USNO Dewar Assembly



Dewar 61 Pin I/O and
18 Pin Temp Connectors



Demonstration Unit



USNO Robotic Astrometric Telescope URAT

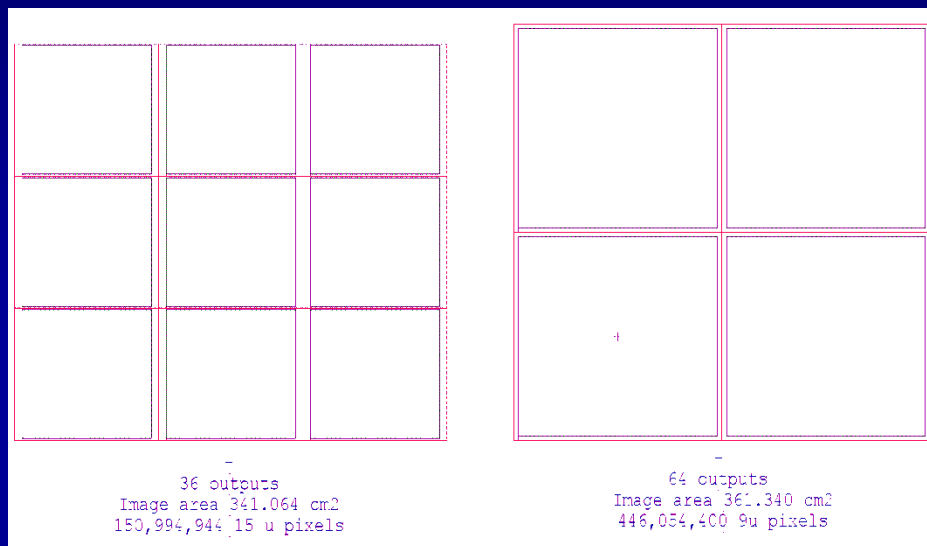


- 8 inch Refracting Telescope for Astrometry
- Upgrade initiated to a 2x2 array by Dr Norbert Zacharias for an all sky survey - URAT
- STA is providing complete system including
 - Dewar – Window – Bonn Shutter
 - Four BI STA1600 CCDs – Three STA 3000 Guiders
 - Five Aura cameras with software
 - Telescope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





Large Focal Plane Efficiency



4kx4k CCD adjacent to STA1600

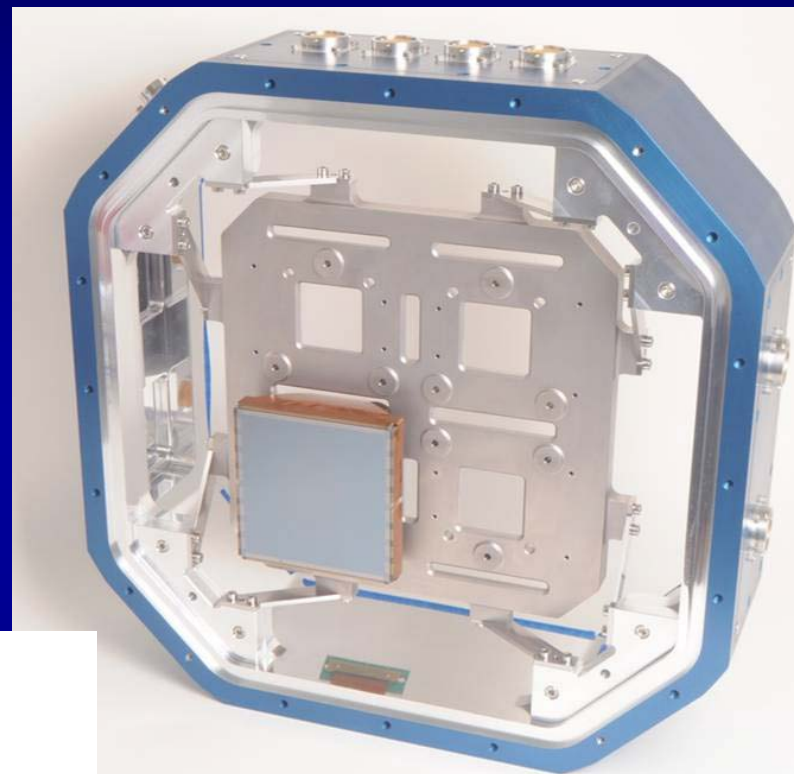
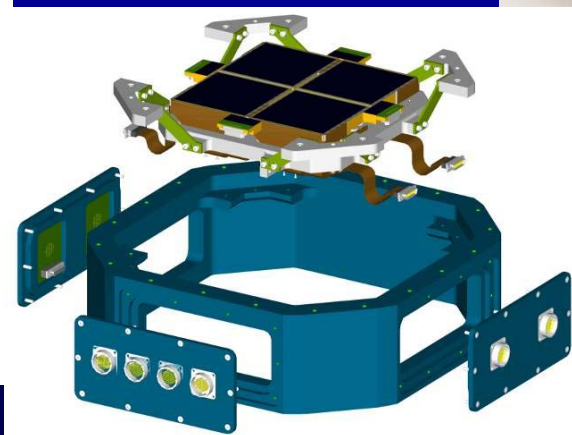
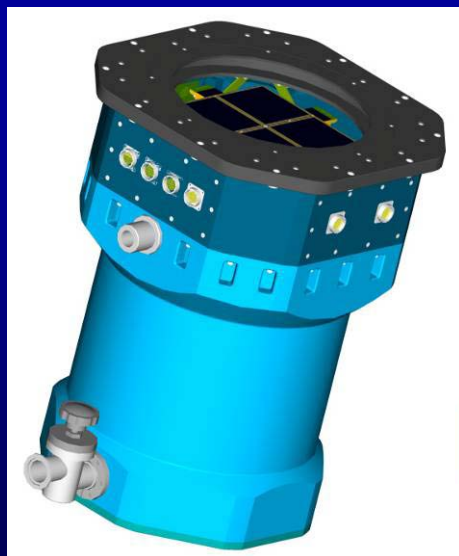
- Four 10ks provide more active image area than nine 4k imagers
- 91% Active area for 4k imager
- 95% Active area for 10k imager



URAT 2x2 Focal Plane



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





Aura Camera



- One of five cameras for URAT system
- There is a FPGA programmable timing core
- 16 ADC channels each have low noise fully differential AC-coupled preamps with high and low gain
- CCD clock signals are generated from 60Mhz DACs

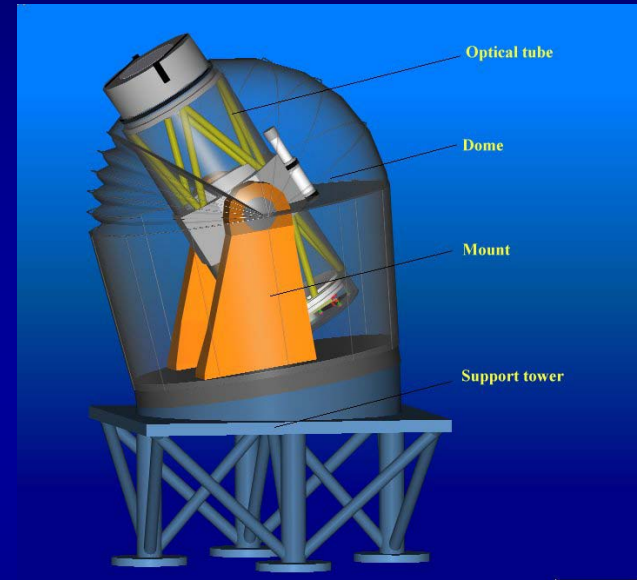




Antarctica Schmidt Telescopes (AST3)



- 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: STA1600FT
- Working mode: frame transfer

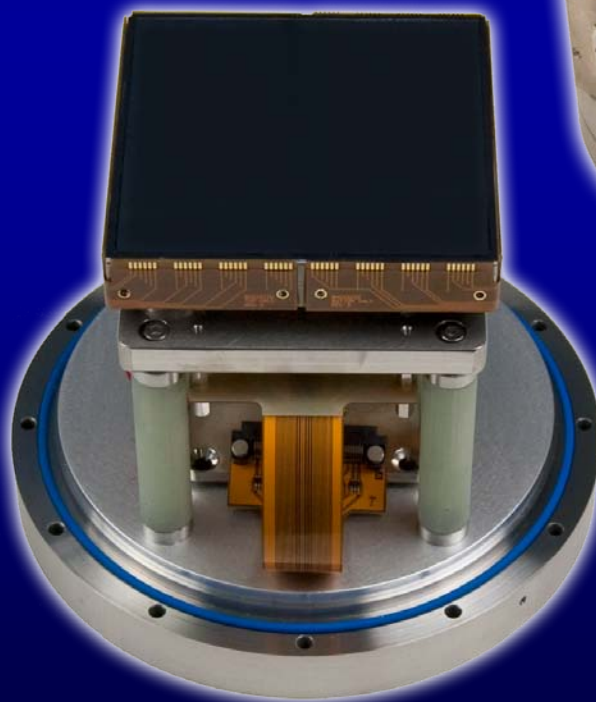




AST3 System STA1600FT



- Small 180 mm dewar system
- TE Cooling for operation at -80C
 - Average outdoor temperature -50C
- STA1600FT Split frame store operation





Reflex Camera



- Reflex Camera System
 - 11" x 9" x 5.5" (6-slot chassis)
- Flexible Modular Features
 - 8-ch 120 Mhz 16-bit A-D
 - 12-ch 500 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





STA1600 LN



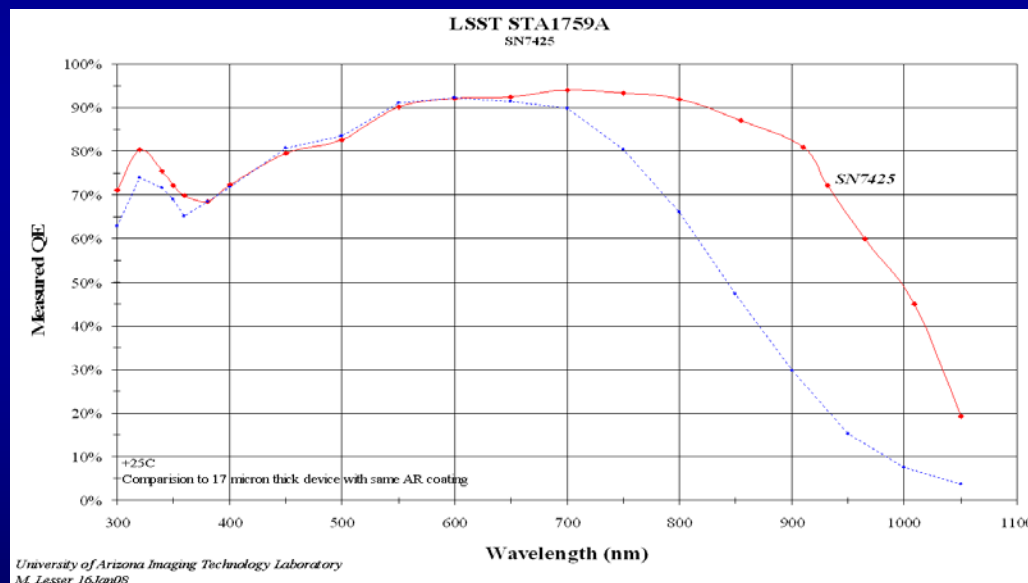
- Low noise version of STA1600
- 16 dual stage outputs are replaced with single stage low noise outputs
- Noise < 3 electrons
- Sensitivity 4-5 $\mu\text{V}/e^-$
- Identical pinout
- Available Fall 2010



STA1600 DD

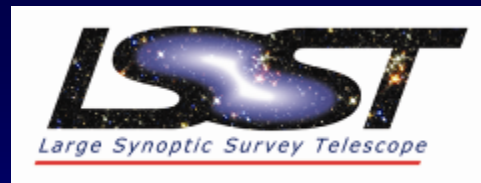


- Deep depletion for optimum red response
- STA1600DD would have similar performance
- 93 μm thickness
- >50% QE @ 1 μm
- Available 2011

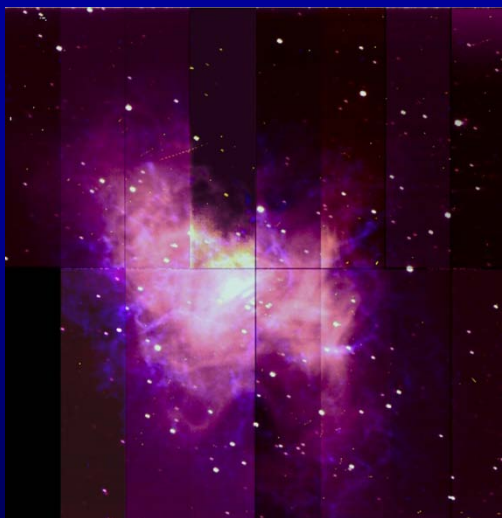




STA1920A LSST



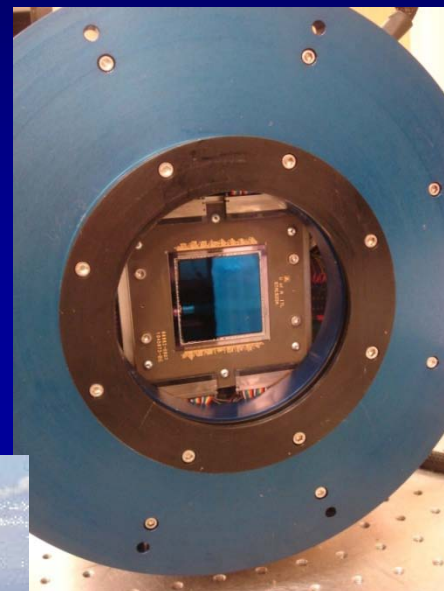
- Study contract device
- 100 μm thick, high resistivity bulk silicon, capable of overdepletion
- 4K x 4K, 10 μm pixels, 16 outputs



Crab Nebula shows chip segmentation



1.2 m Calypso Telescope at Kitt Peak

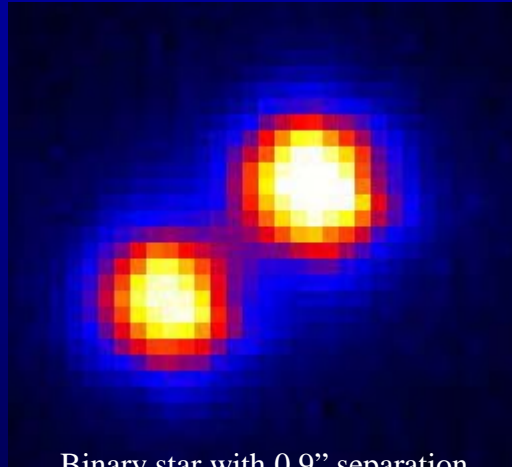




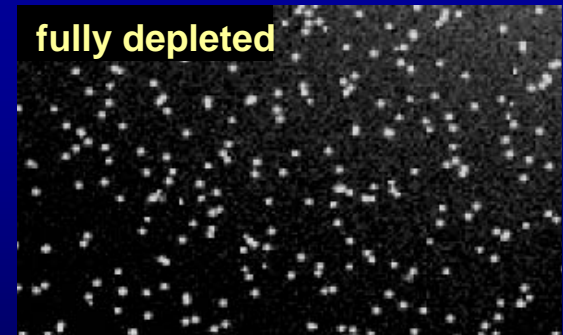
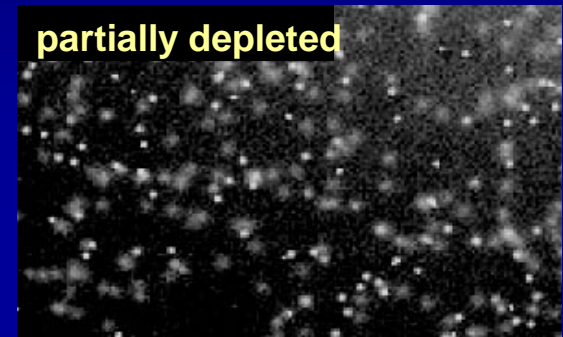
Substrate bias control of charge diffusion



- ^{55}Fe x-rays generate compact charge clusters within $\sim 30\text{ }\mu\text{m}$ of silicon surface.
- Fully depleting the silicon restores the PSF



Binary star with 0.9" separation

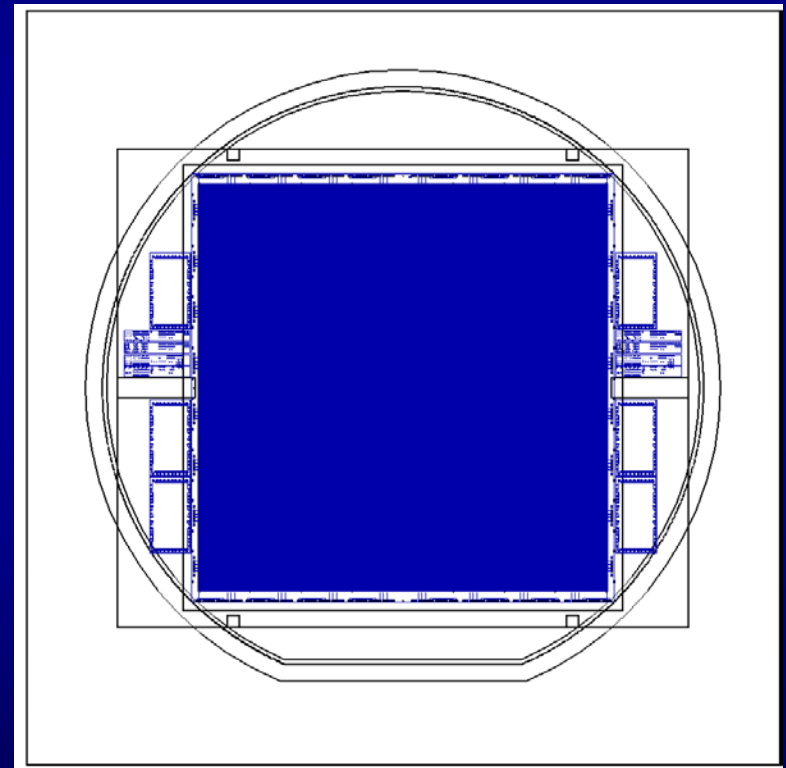




STA3200 Extreme Deep Depletion Imager



- Designed for direct X-Ray detection
- 4000 x 4000 24 micron pixels
- 20,000 ohm-cm p-type starting material
- Full depletion of 600 μm silicon at 120V
- Expect 90% QE at 1 μm

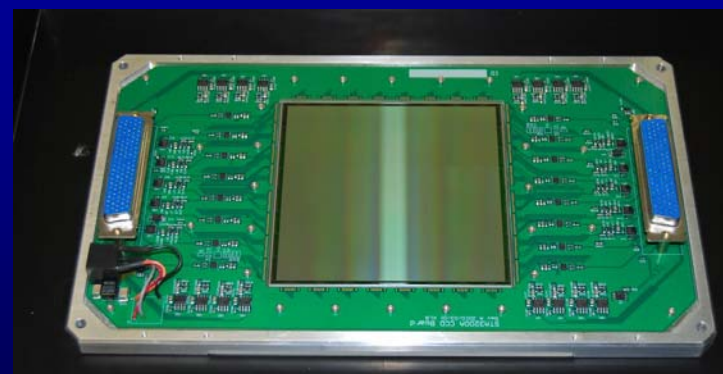
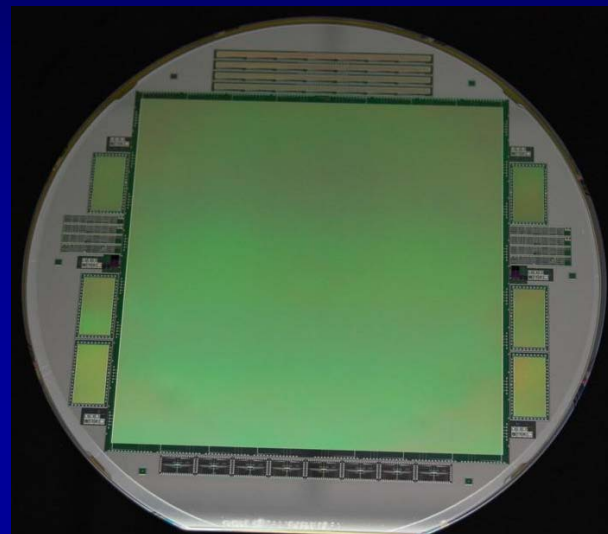




STA3200A CCD Layout



- Chip imaging dimensions 96 mm x 96 mm.
- 16 Separate outputs
 - Each output reads out a subsection of 500 x 2000 pixels when using all 16
 - Possible to readout complete array to top or bottom 8 outputs.





Summary



- The STA1600 variations are a result of the evolutionary growth of scientific imager requirements.
- The STA1600 greatly decreases the number of devices necessary for large focal plane arrays.
- The high resolution, along with high speed low noise capabilities, makes STA1600 appealing to a variety of large area imaging applications
- Thank you for your attention.