



The KMTNet 340 Megapixel focal planes

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OSU

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**THE OHIO STATE
UNIVERSITY**

Korea Micro-lensing Telescope Network (KMTN)- focal planes

- Three 1.6-m southern-hemisphere telescopes.
- Continuous monitoring of micro-lensing events in the galactic bulge.
- Each telescope equipped with a 340 megapixel camera.

- OSU designs and builds the three cameras with electronics

- e2v designs and builds the three focal planes with sensors
 - Custom-designed precision cryogenic detector mounting plates
 - Optimised custom sensors

CONTENTS

KMTN project

CCD camera overview

Plate design and layout

FEA modelling of plate

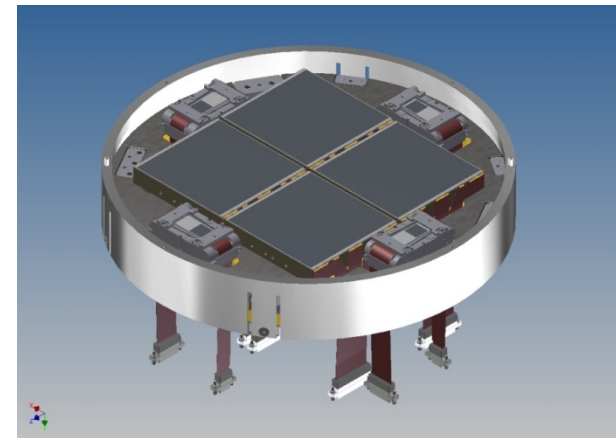
Science sensors

Guide sensors

Plate assembly

Status

Summary



The Korea Microlensing Telescope Network

Discovering extrasolar planets using microlensing

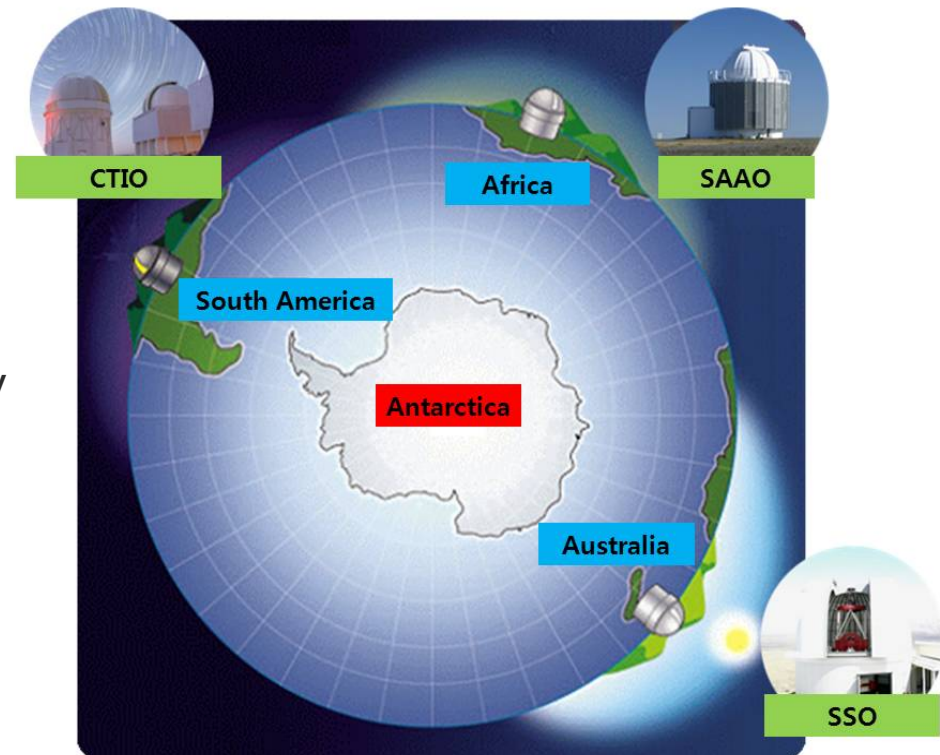


Planet searches with microlensing have mostly been done with wide field surveys to find candidates and then follow-up observations with a heterogeneous data set to get the required temporal coverage.

KMTNet will have one primary data set covering 16 square degrees.
Continuous 24 hour coverage of >100 million objects in the galactic bulge. Light curves for objects down to magnitude 20.

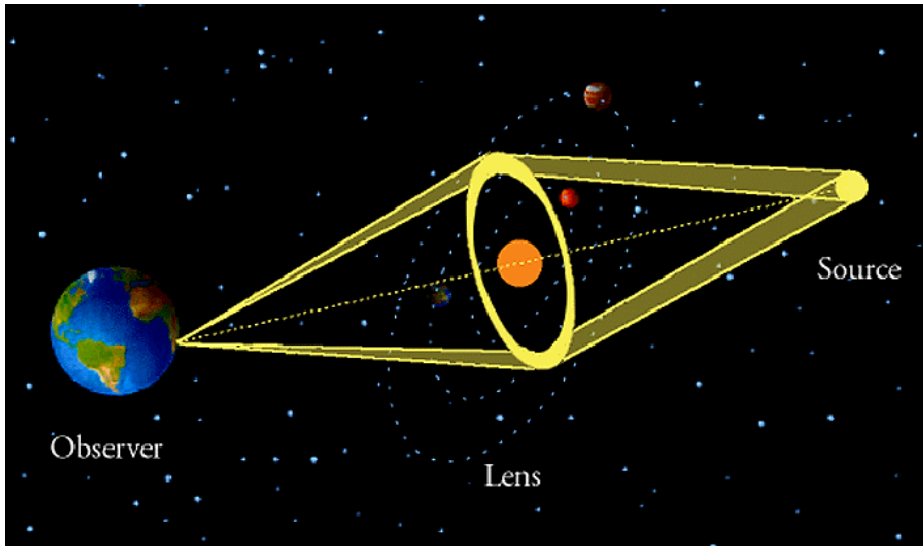
Southern Hemisphere KMTNet sites:
Cerro Tololo Inter-American Observatory
South African Astronomical Observatory
Siding Springs Observatory

Three 1.6m telescopes
Each with a 340 megapixel camera
e2v sensors → OSU cameras



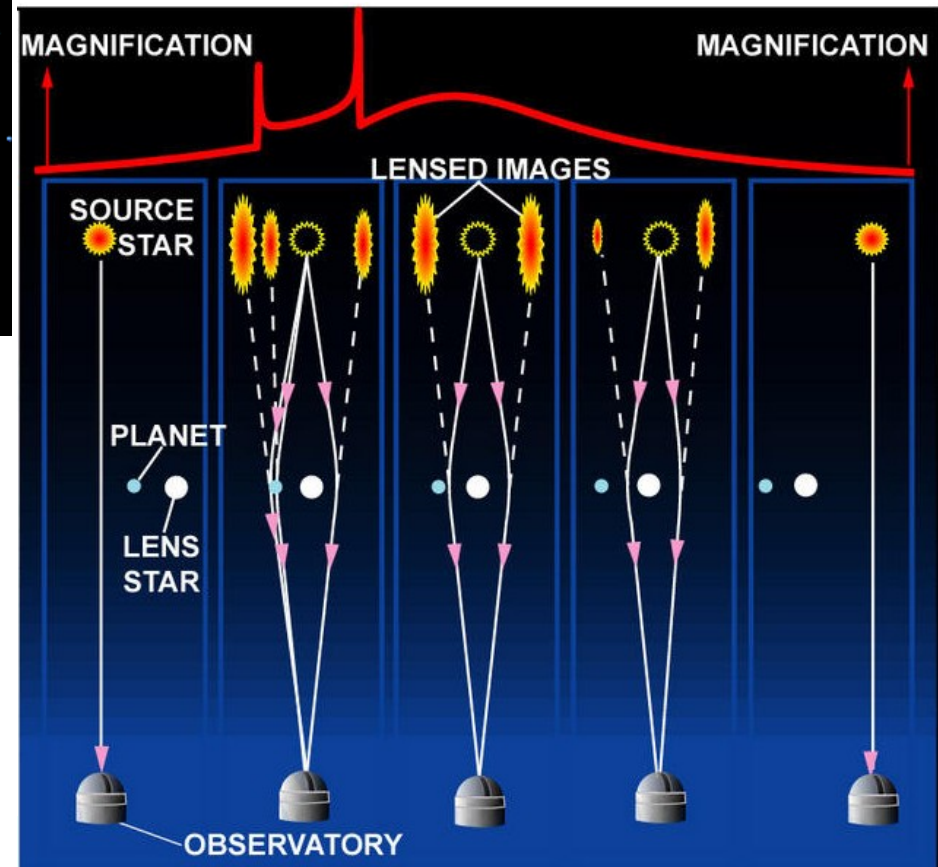
The Korea Microlensing Telescope Network

The microlensing technique



Matter in nearby object bends light (gravitational lens) of distant source

Source is magnified and extrasolar planets can be detected.
KMTNet measures light curves to detect planets efficiently.
Planetary systems and variable objects explored.



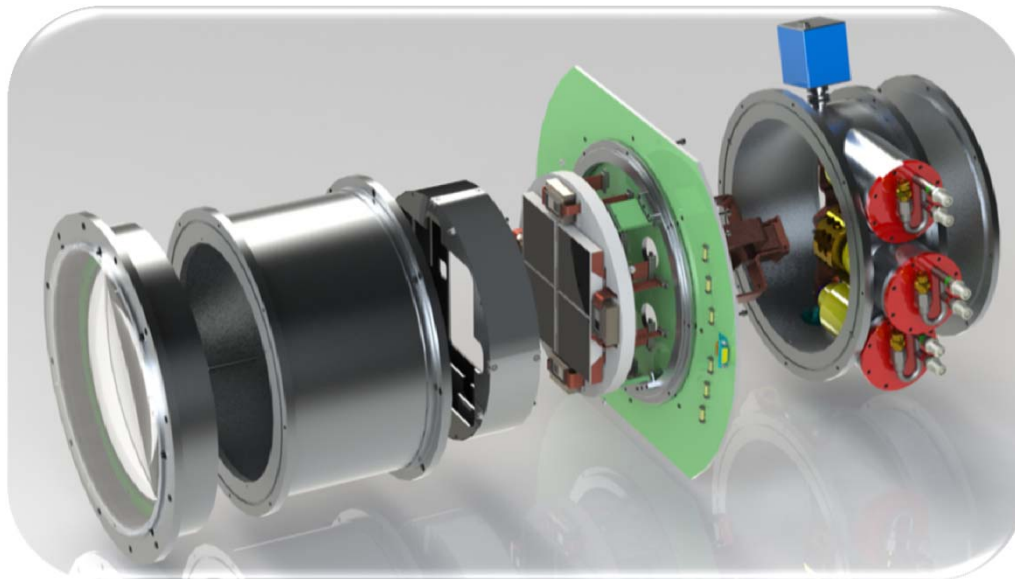
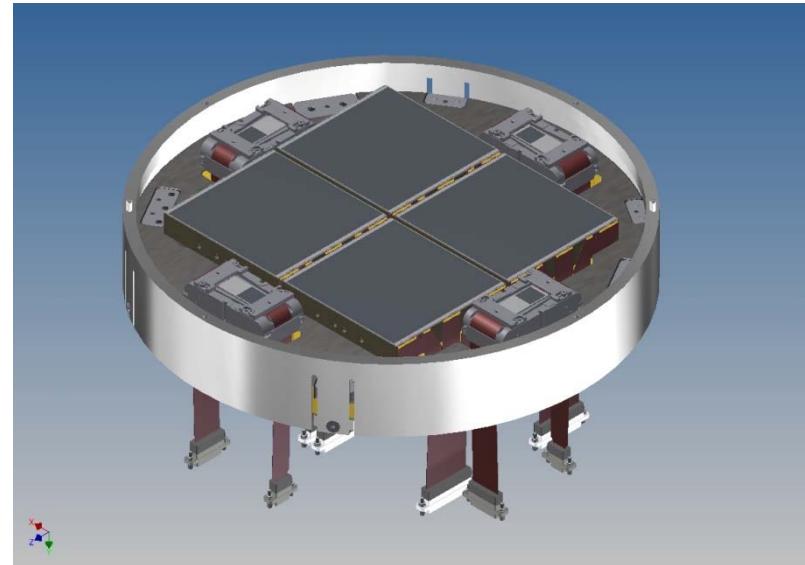
CCD Camera overview

Cryogenic focal plane assembly



- Four 9k x 9k Science CCDs
- Four 1k x 1k FT Guide CCDs
- Closed Cycle Cooling System

e2v detector mounting plate

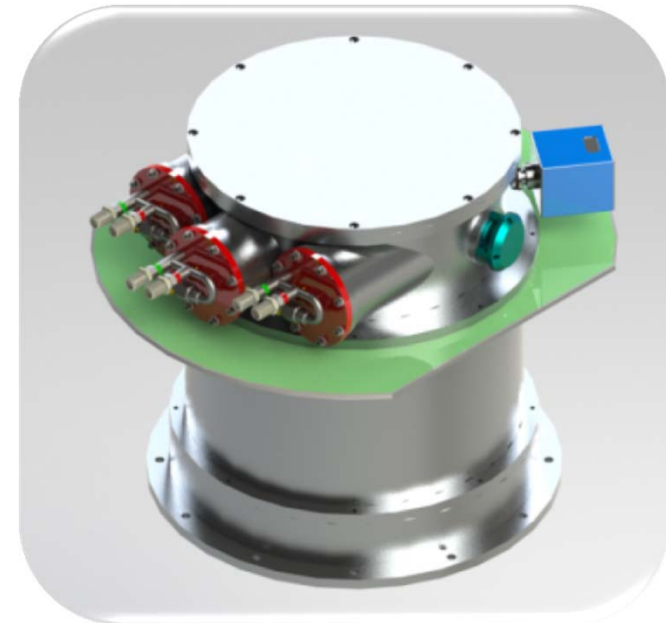
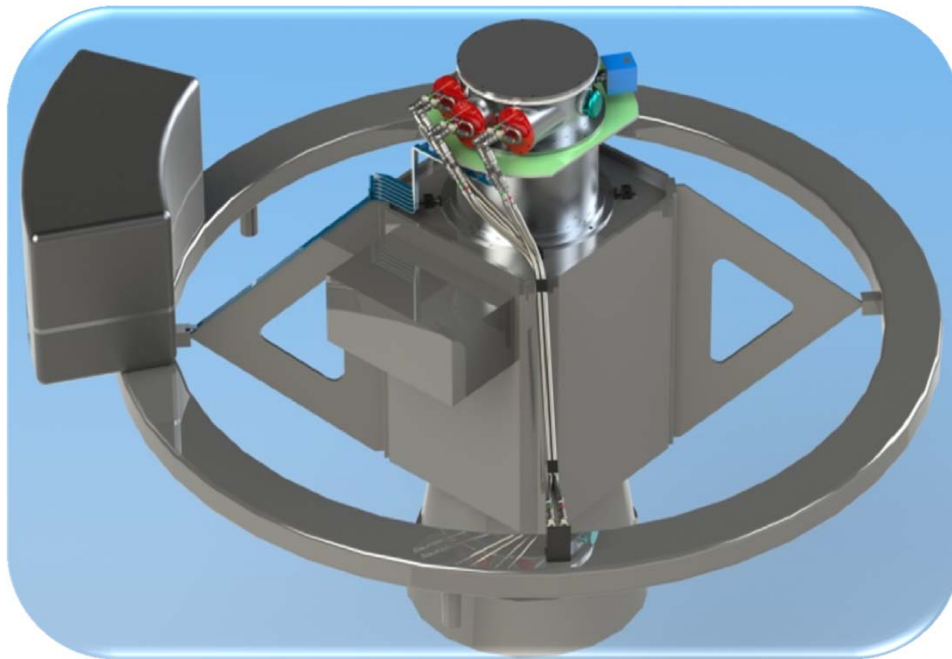


OSU cryogenic camera

CCD Camera overview



- OSU Camera System
- 4 Element Prime Focus Corrector
- Closed Cycle Cooling System
- Three systems under construction



Camera at prime focus

Detector Mounting Plate (DMP) Design

Key Features



- Material: Silicon Carbide
- Size: 320mm diameter x 20mm thick
- Low emissivity gold sputtered on lower surface and side walls
- Mounting holes/plates for science sensors
- Mounting holes/plates for guide sensors
- Provision for guide rods and support of flex-cables
- Features to facilitate device assembly
- Annular side ring for protection
- Provision for temporary glass cover during handling
- Mounting fixtures for plate heaters
- Mounting fixtures for temperature sensors
- Fixtures for cold strap attachment
- Fixtures for plate mechanical fixing to camera
- Provision for retention in handling ring during assembly

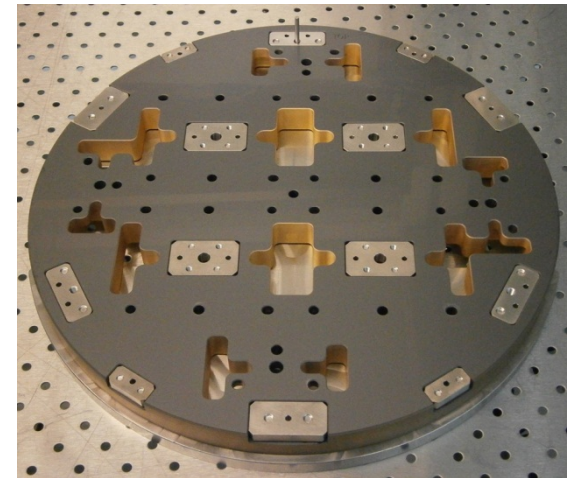
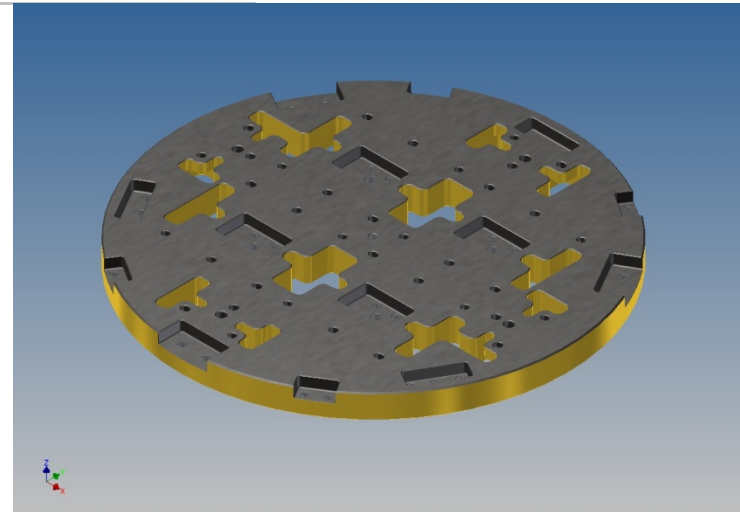


Plate with Invar fixtures

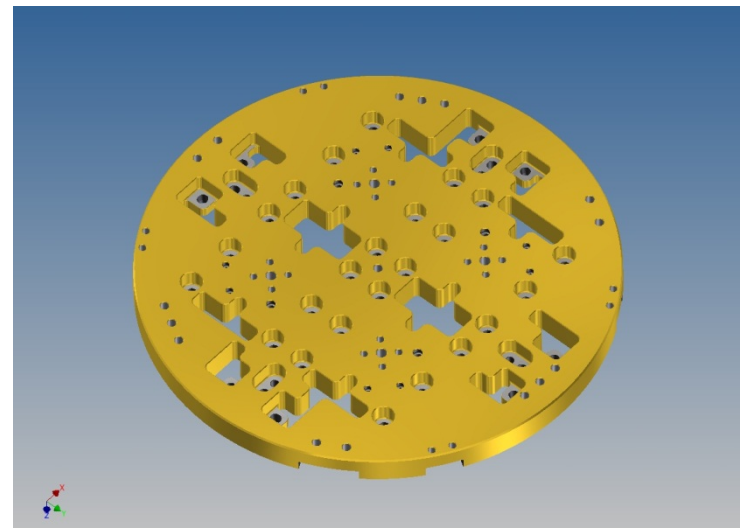
Detector Mounting Plate (DMP) Design



- Finish: Lapped to within 5 μ m flatness on top and bottom faces, and 50 μ m parallelism
- Features on top surface:
 - Holes to control alignment of devices
 - Pockets to retain Invar plates used to assemble components
- Features on bottom surface:
 - Blind holes to accept Invar threaded inserts to assemble components
 - Pockets to allow clearance around device assembly fasteners
- Other Features:
 - Slots to allow access of Flexi Connectors and assembly tools
 - Holes to allow access of device handling tools
 - Clearance holes for component assembly screws



Top and lower plate views



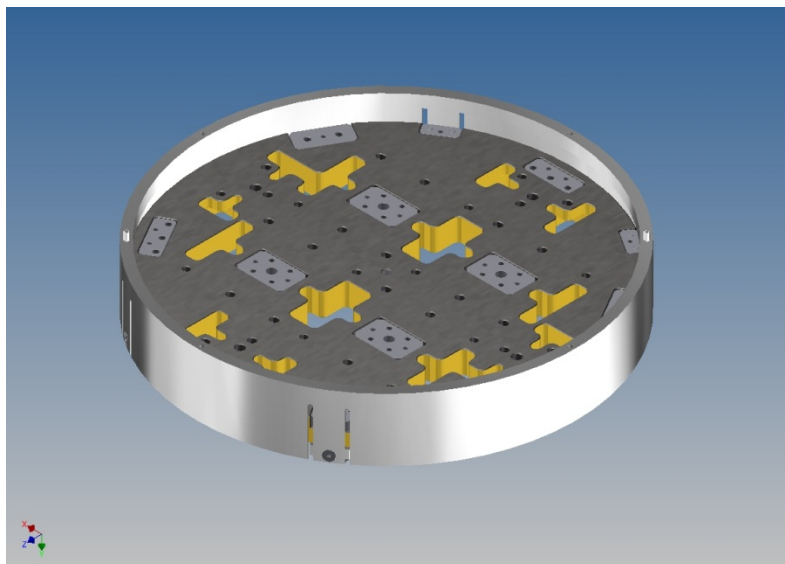
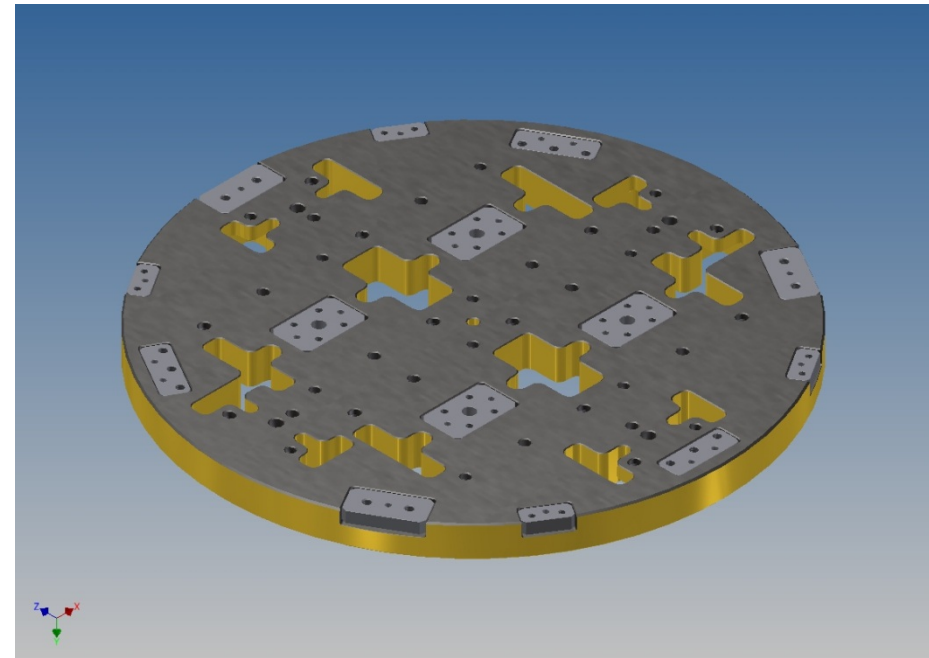
Detector Mounting Plate (DMP) Design



DMP with Invar parts attached

Invar plates are used to assemble:

- Protection Ring assembly
- Support Jig during device assembly
- Copper Heat Blocks (for OSU)
- Support Web Assemblies (for OSU)
- Thermal Resistors (for OSU)
- Temperature Sensors (for OSU)

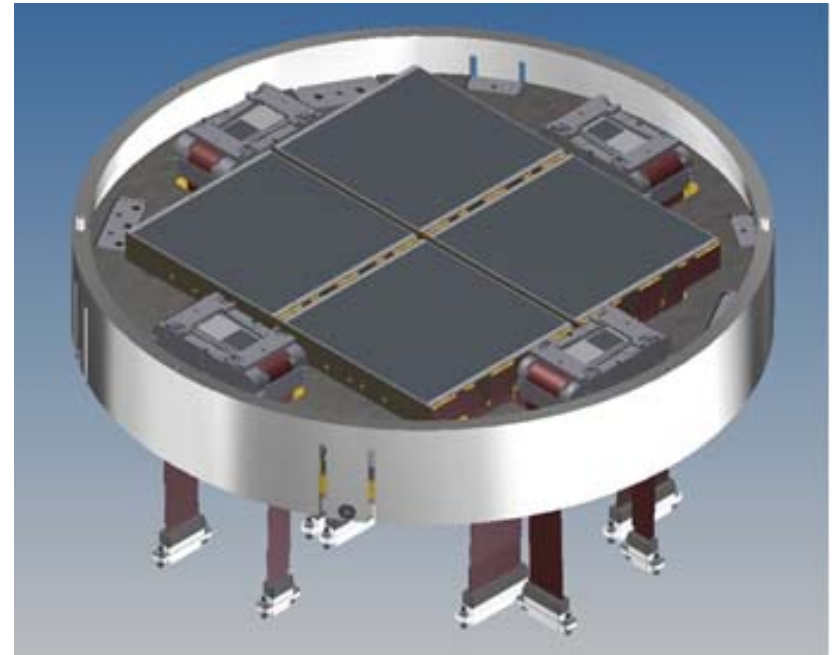


DMP with Protection Ring attached

DMP layout



- Four CCD290-99 Image Sensors;
92.16 x 92.32 mm image area each
- Specified dead space between science image sensor areas <math>< 34 \text{ cm}^2</math> (90% fill factor);
93% achieved
- Four CCD47-20 Guide Sensors;
13.32 x 13.33 mm image area each; centre-lines of image areas align with centre-lines of Detector Mounting Plate $\pm 0.45 \text{ mm}$



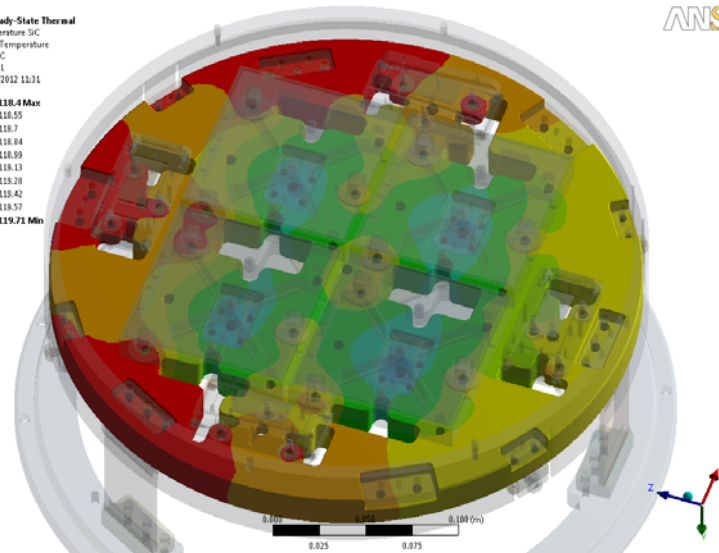
- Each Sensor's image area is 20.00 mm above the plate mounting surface
- The flatness of all image surfaces fall within a peak to valley range of $40 \mu\text{m}$

DMP FEA modelling

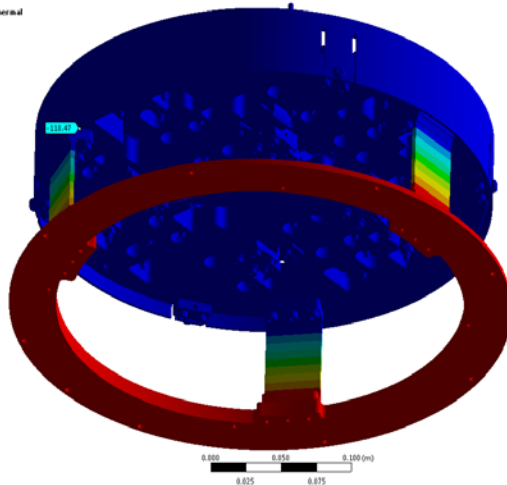


- Temperature plots obtained through thermal analysis
- G10 struts used to insulate plate from warm cryostat mounting ring
- The entire plate has a temperature delta of 1.3K (analysis includes radiation heat input)
- Temperature of the CCD devices can be studied with particular focus on the image areas

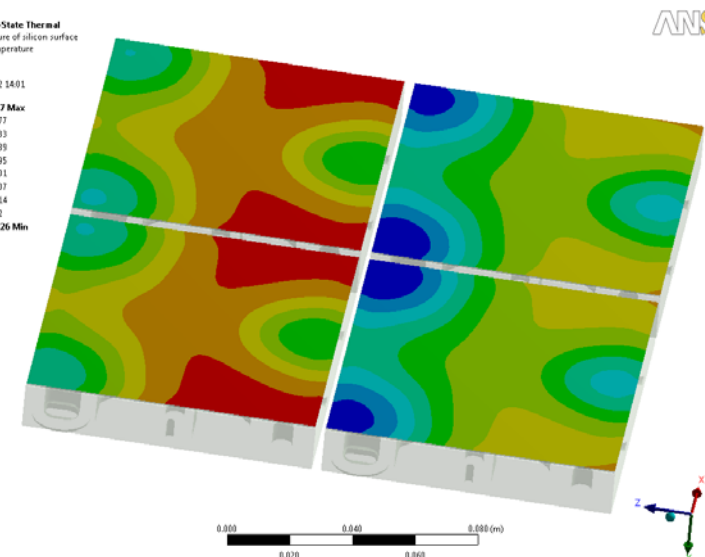
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Temperature SIC
Type: Temperature
Unit: °C
Time: 1
09/09/2012 11:31



A: Steady-State Thermal
Temperature
Type: Temperature
Unit: °C
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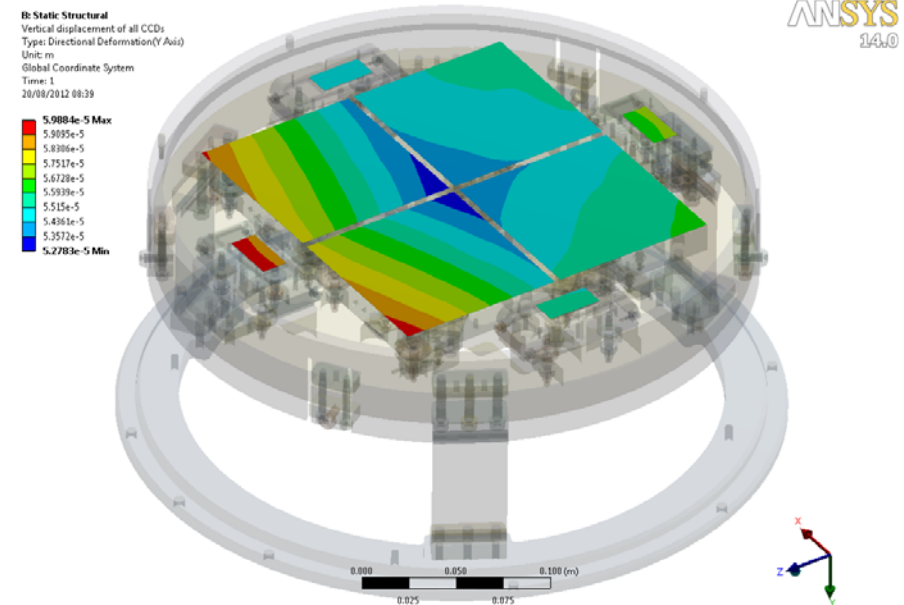
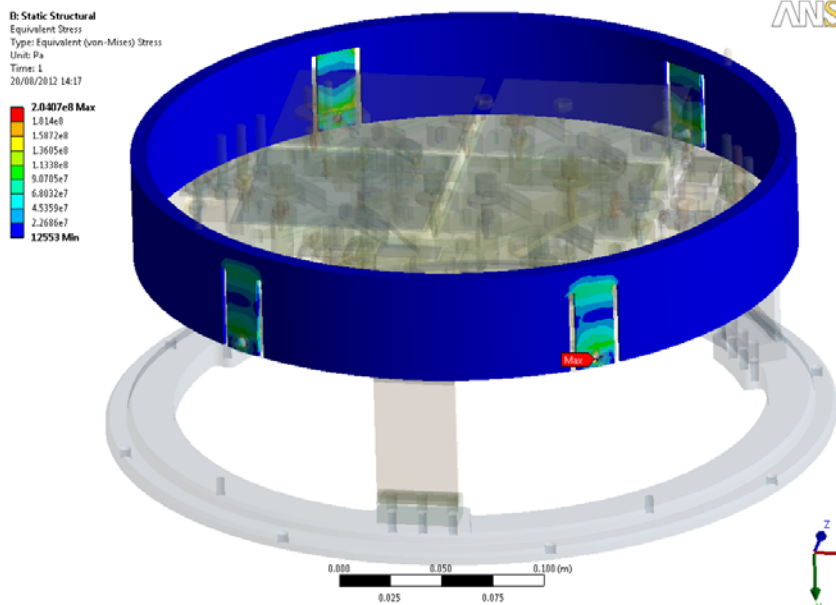
A: Steady-State Thermal
Temperature of silicon surface
Type: Temperature
Unit: °C
Time: 1
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DMP FEA modelling



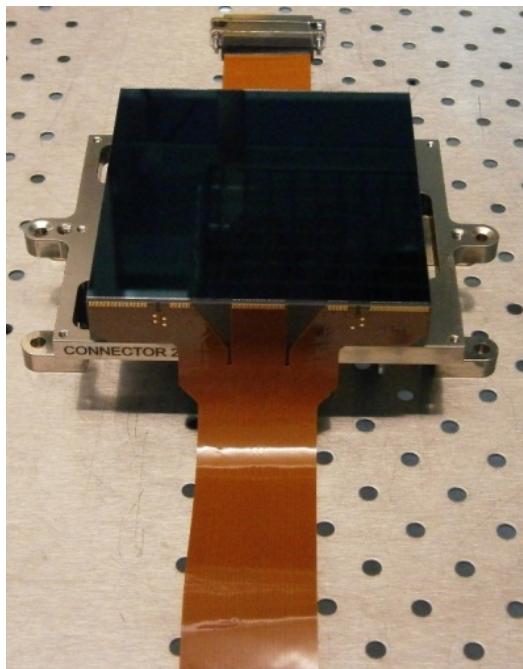
- Thermal results are fed into the structural analysis to deduce stresses and non-flatness of the array
- The Al alloy protective ring and the G10 struts were engineered so that the thermal expansion mis-match of the ring and the mounting plane had a minimal effect on the flatness of the plate.
- Non-flatness of the entire CCD array due to thermal contraction is predicted to be $7.1 \mu\text{m}$



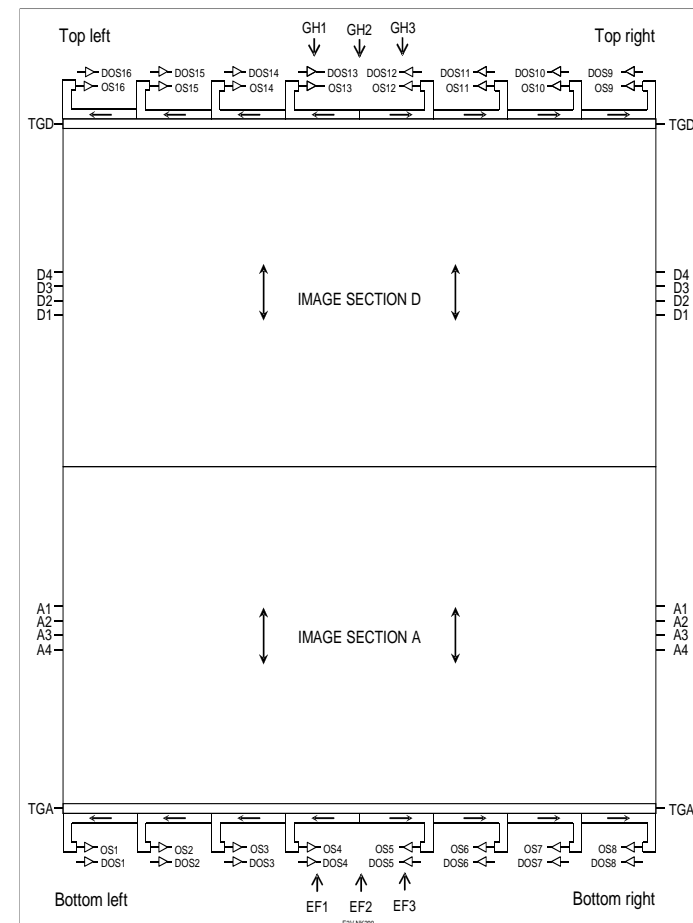
Science CCD sensors CCD290-99



- Non-inverted, Full frame, Deep depletion, Astro multi-2
- Silicon Carbide package (20.0 mm height)
- Flexi-cables; two 51W micro-D connectors
- 9216 X 9232 10 μm pixel image area
- 16 outputs for low readout time



CCD290-99 **replace?**

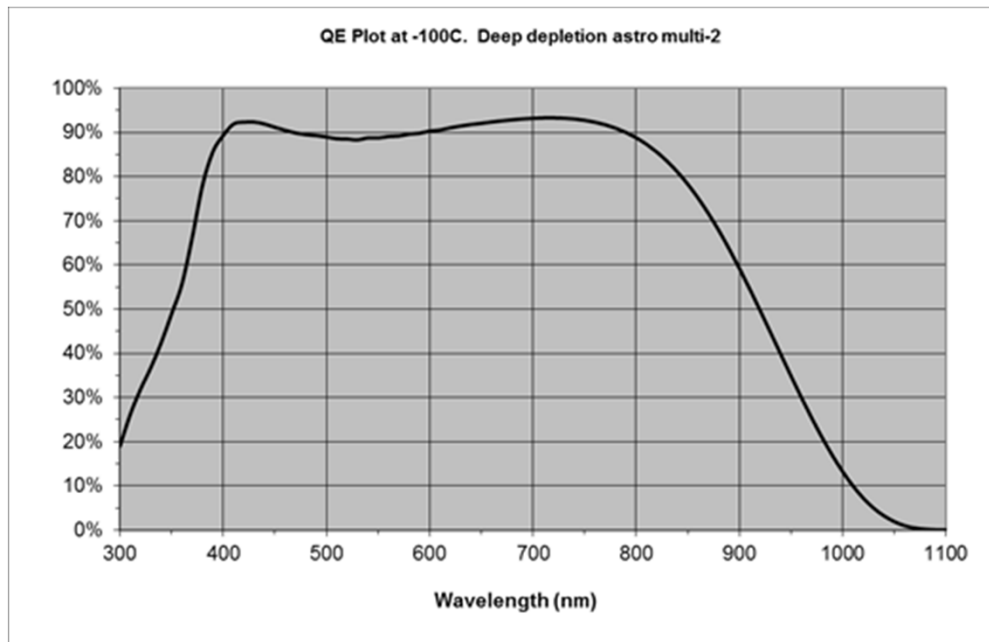
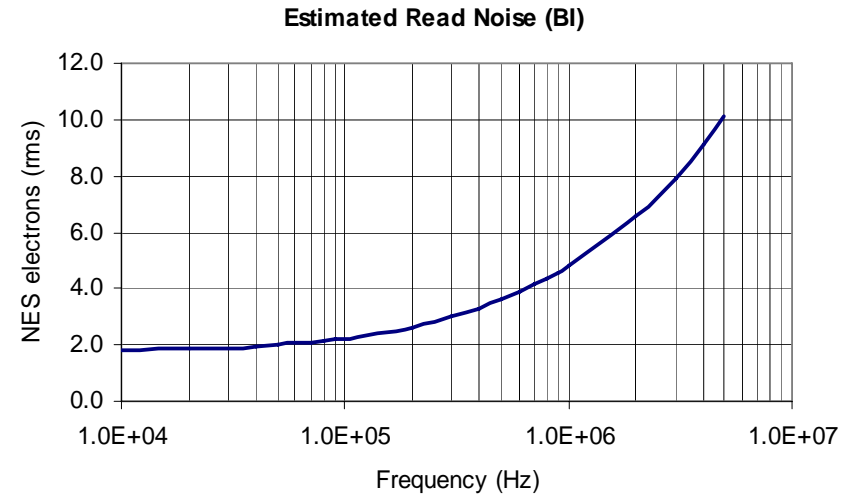


Device Architecture

Science CCD sensors



- >90% Peak QE; wide spectral range
- < 5 e- Read-noise at 500 kHz
- Differential outputs available
- Low output impedance
- >99.9990% CTE
- 40 μm flatness; precision height package

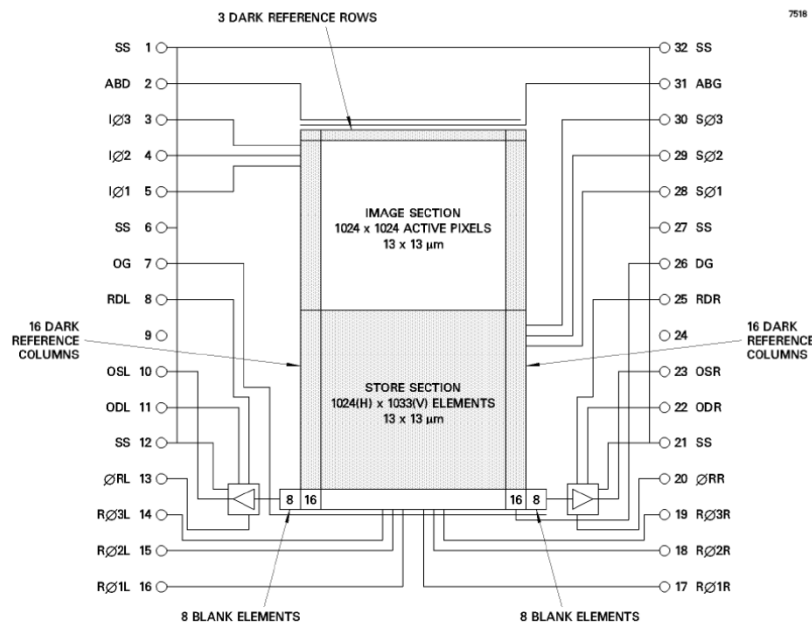


Guide CCD sensors

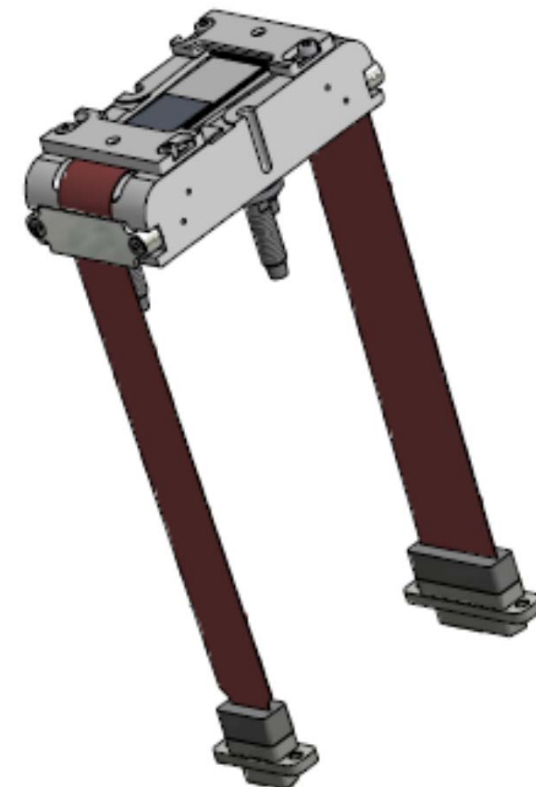
CCD47-20



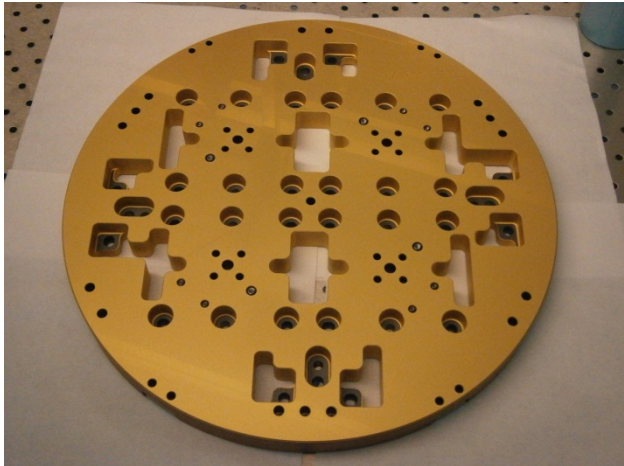
- Non-inverted, frame transfer (with store shield), deep depletion, astro multi-2
- Established device type; customised for this focal plane application
- Custom Invar package (20.0 mm precision height including shims)
- Custom flexi-cables; two micro-D connectors
- 1024 X 1024 13 μm pixel image area
- Same Spectral response as science sensors



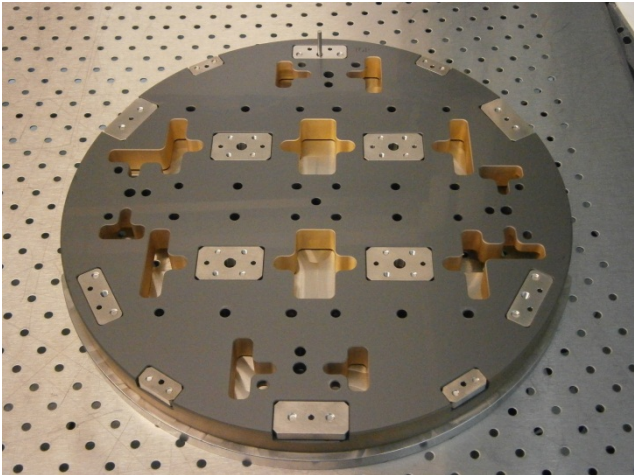
Device Architecture;
ignore pin numbers



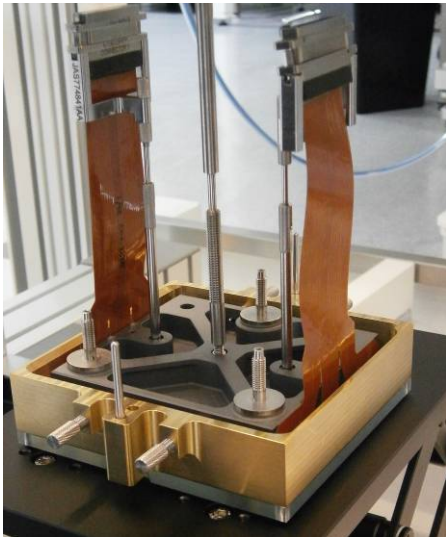
DMP assembly pictures



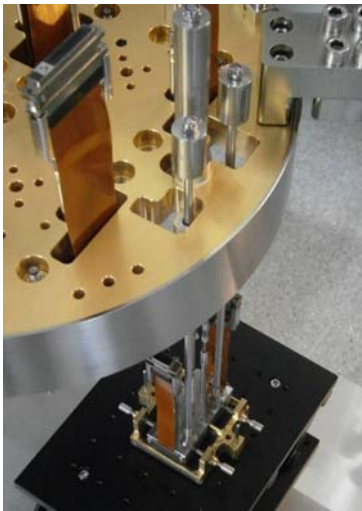
Gold-plated Silicon Carbide plate (lower surface)



Top surface of plate

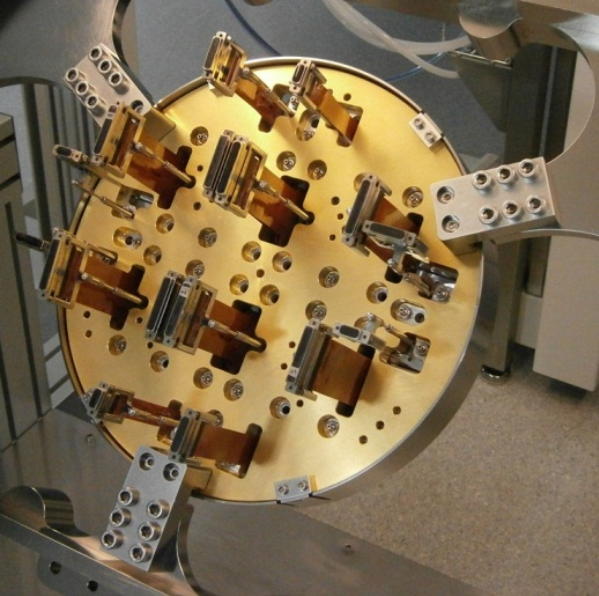


CCD290 prepared for insertion

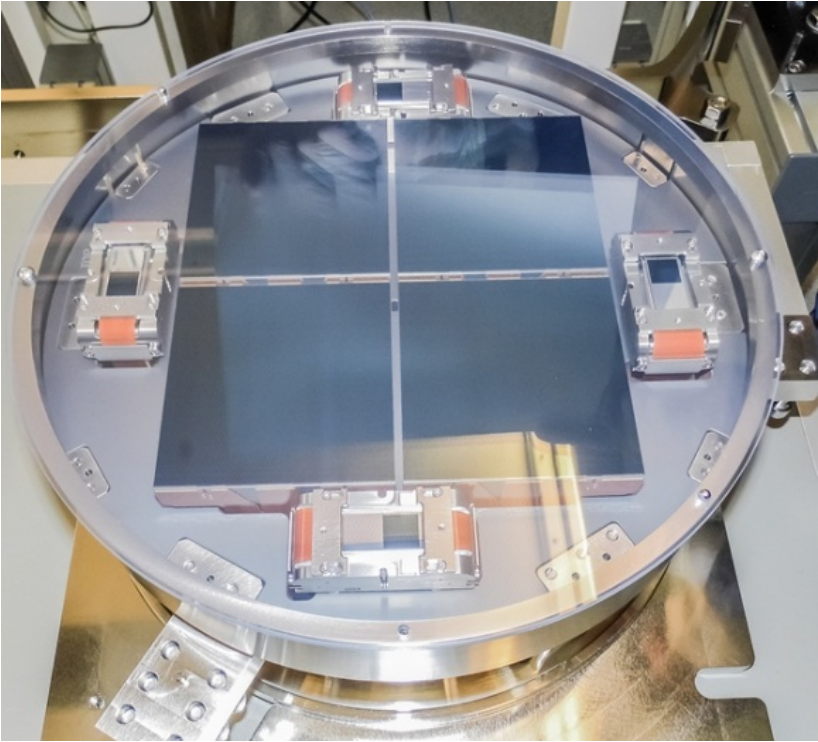


CCD47 being inserted

DMP assembly pictures



Underside of plate with sensors installed



All sensors assembled onto plate



It fits in the metrology machine!

- Plate design complete
- Plate procurement complete (3), including gold coating (in-house)
- Trial plate fully assembled with dummy devices
- First deliverable DMP assembled with all fixtures and sensors
- CCDs in progress for following two DMPs
- Custom transport box designed and manufactured
- Packing crate and transport box have been drop & vibration tested
- Delivery of first DMP – Due Oct 2013
- Delivery of following DMPs- Due Jan 2014 & March 2014

- Installation in OSU camera and cryogenic tests to follow

KMTNet detector mounting plates

- Plate design meets specification
- Science CCDs- designed, manufactured, and fitted to first plate
- Guide CCDs- designed, manufactured and fitted to first plate
- Plate assembly- jigs and fixtures complete

e2v Generic capability

- Optimised sensor designs (science and guide)
- Custom plate design for cryogenic use
- Detailed FEA model; thermal & mechanical
- Precision plate manufacture
- Precision assembly and metrology

- Other shapes & sizes

- Electronics and cryogenic camera capability [**J-PAS paper SPIE 8453-20**]

Acknowledgements



- Many members of the teams at Ohio State University and e2v technologies contributed to the work presented here.
- The detailed design was done at e2v but with multiple constructive dialogues with OSU.
- The design and manufacture of a precision plate with high performance (flatness etc) relies on well defined interface definition.
- **A plug for 2014 SPIE Montreal-**
e2v also does large-area backthinned CMOS. Look for-
 - TAOS. 2k4k science sensors; 20 fps with ~ 100 ROI's. Prototype results in 2014.
 - NGSD. ~800X800 WFS, 700 fps. [Mark Downing; Wed am,] Prototype results in 2014.
- **4k4k FT EMCCD >5 fps photon counting chip. Doug Jordan. Wed. am.**

Thanks for your attention