CryoCam – the 1.2 GPix Camera for JPAS

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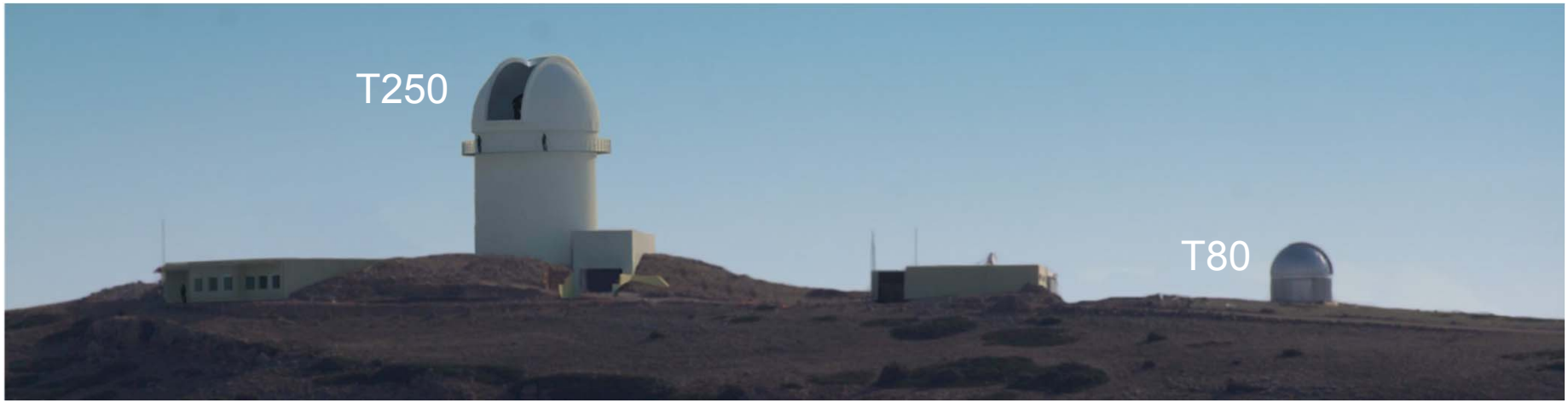
Talk Outline

1. **Introduction and project overview**
2. CCD290 -99 and auxiliary CCDs
3. Detector Control Electronics
4. Focal Plane Array

What is JPAS?

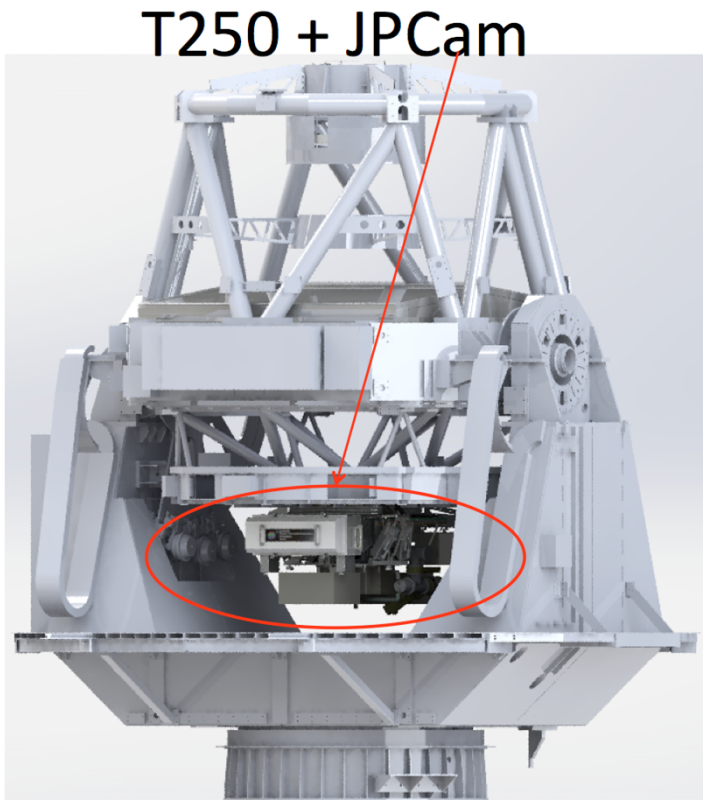
- **JPAS** - **J**avalambre **P**hysics of the accelerating universe **A**stronomical **S**urvey

- JPAS is a 5 year **wide-area astrophysical mapping survey** which primarily aims to explore dark energy in the universe
- A new, dedicated 2.5 m telescope (called the T250) is being built in Spain to carry out the survey
- This telescope will use **56 narrow band optical filters** to build up a 3-D map of the universe by studying red-shifts
- e2v are supplying the 1.2 GPixel camera which is mounted to the back of the T250 telescope

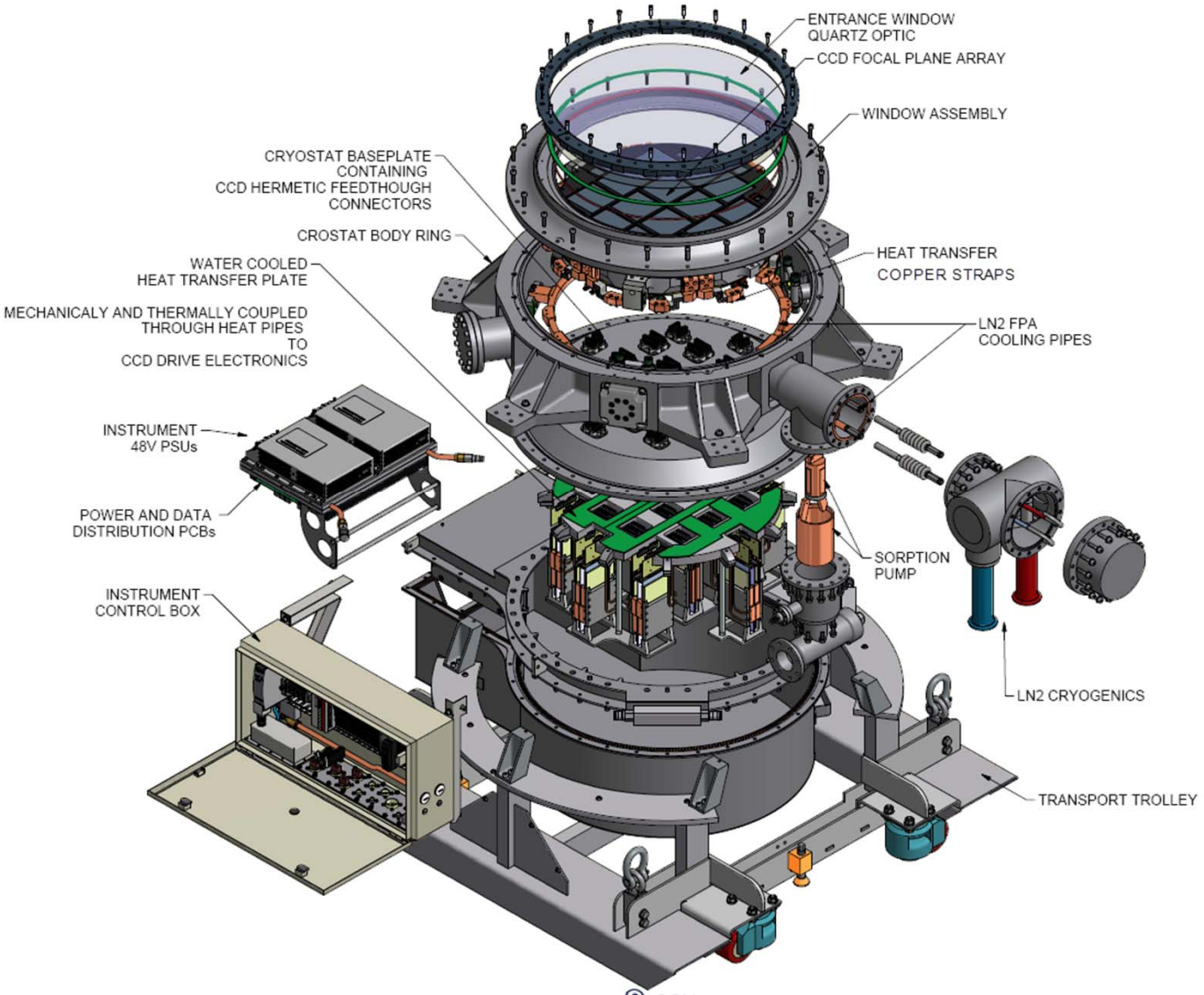


The Telescope – T250

- 2.5 m Cassegrain telescope
- Camera (JPCam) is mounted at the Cassegrain focus



CryoCam


ENTRANCE WINDOW
QUARTZ OPTIC
CCD FOCAL PLANE ARRAY
WINDOW ASSEMBLY
CRYOSTAT BASEPLATE
CONTAINING
CCD HERMETIC FEEDTHOUGH
CONNECTORS
CROSTAT BODY RING
HEAT TRANSFER
COPPER STRAPS
WATER COOLED
HEAT TRANSFER PLATE
MECHANICALY AND THERMALLY COUPLED
THROUGH HEAT PIPES
TO
CCD DRIVE ELECTRONICS
LN2 FPA
COOLING PIPES
INSTRUMENT
48V PSUs
POWER AND DATA
DISTRIBUTION PCBs
SORPTION
PUMP
INSTRUMENT
CONTROL BOX
LN2 CRYOGENICS
TRANSPORT TROLLEY

CryoCam Highlights

- 1.2 GPix Camera
- Includes three types of CCD:
  - 14 x CCD290–99 (Science CCDs)
  - 8 x CCD44–82 (Wavefront Sensors)
  - 4 x CCD47–20 (Autoguider CCDs)
- Camera includes readout electronics for all the CCDs
  - 22 CCD drive modules
  - Power and data handling electronics
  - Over 50 FPGAs to handle the 2.4 GBytes of data per frame
  - Digital CDS (Correlated Double Sampling) readout
  - Designed for < 5 e^- noise performance
- Camera is cryogenically cooled using a mixed phase LN2 cooling system
- Camera also includes PLC (Programmable Logic Computer) control electronics for the cooling and vacuum systems

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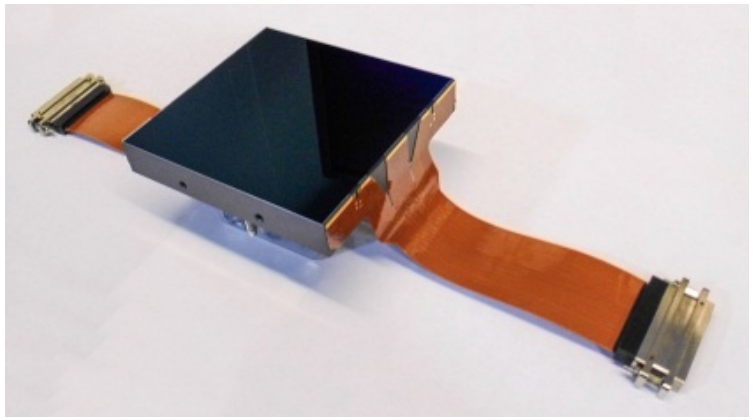
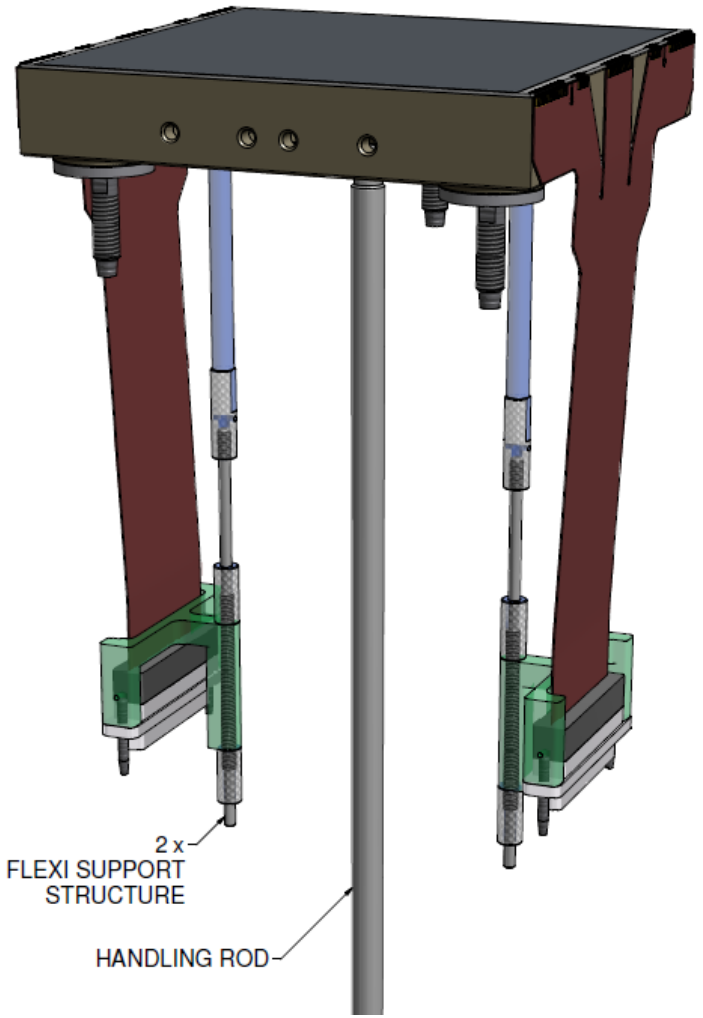
CCD290-99 Overview

CCD290-99 science device assembly with central handling rod and flexi support structures awaiting integration





9216 X 9232 format, 10 µm pixels
92 X 92 mm image area

14 devices to form the science array

CCD290 performance

- Non-inverted, Full frame, Deep depletion, Astro multi-2
- Precision Silicon Carbide package 20.0 mm height; 40 µm p-v flatness
- Flexi-cables; two 51W micro-D connectors
- 16 outputs for low readout time

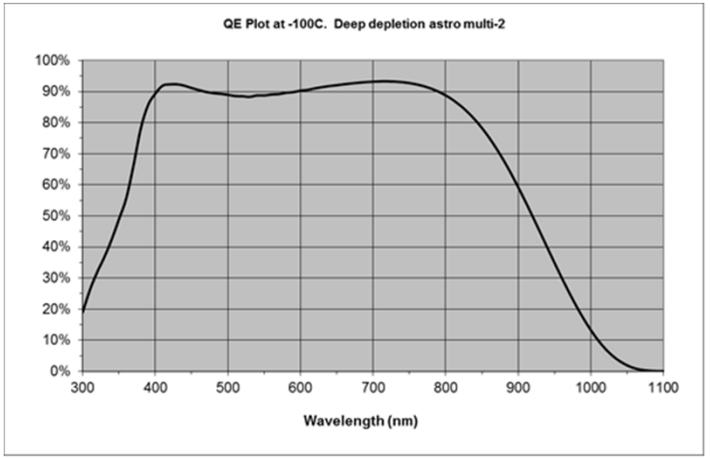
>90% Peak QE; wide spectral range

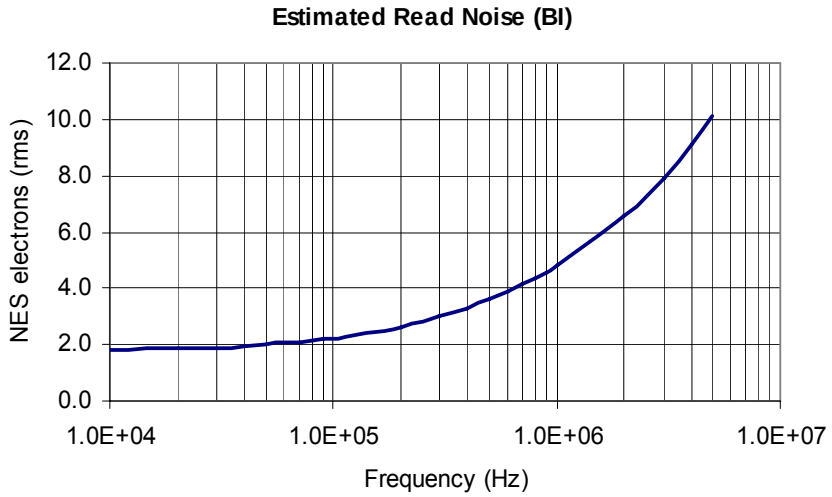
< 5 e- Read-noise at 500 kHz

Differential outputs available

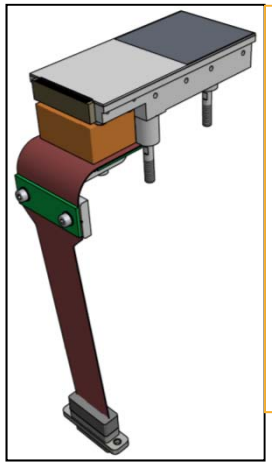
Low output impedance

>99.9990% CTE



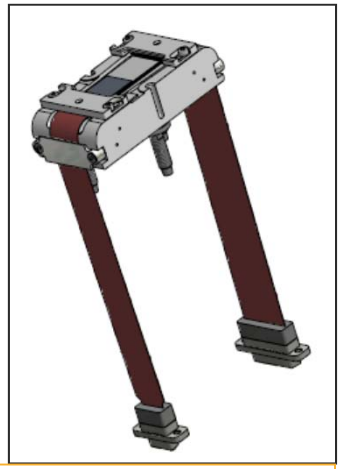


Auxiliary CCDs



Wavefront sensors- CCD44-82

- 4 pairs of sensors in focal plane
- 2048 X 2048 Frame-transfer
- 500 X 500 window at 4 sec read time
- +/- 1 mm intra/extra focal planes



Guiders- CCD47-20

- Four sensors in focal plane
- 1024 X 1024 Frame-transfer
- 50 X 50 window at 5 fps
- Co-planar with science CCDs

General features

- Non-inverted, frame transfer (with store shield), deep depletion, astro multi-2
- Same Spectral response as science sensors
- Low noise [5 –e goal]; differential outputs used
- Established device type; customised for this focal plane application
- Custom Invar package: 20.0 mm precision height to match science sensors
- Custom flexi-cables; micro-D connectors

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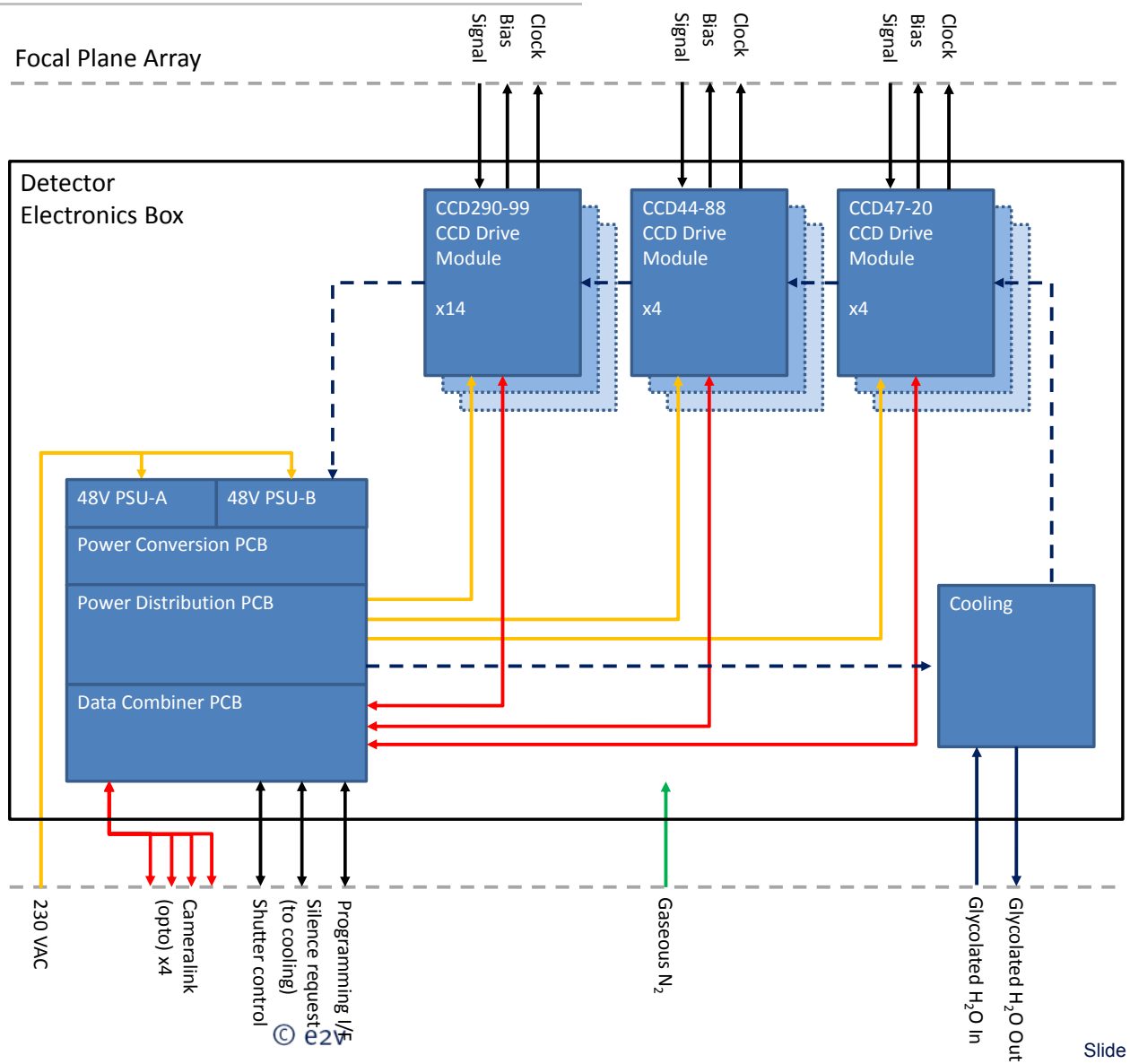
Detector Electronics

22 CCD drive modules for 26 CCDs

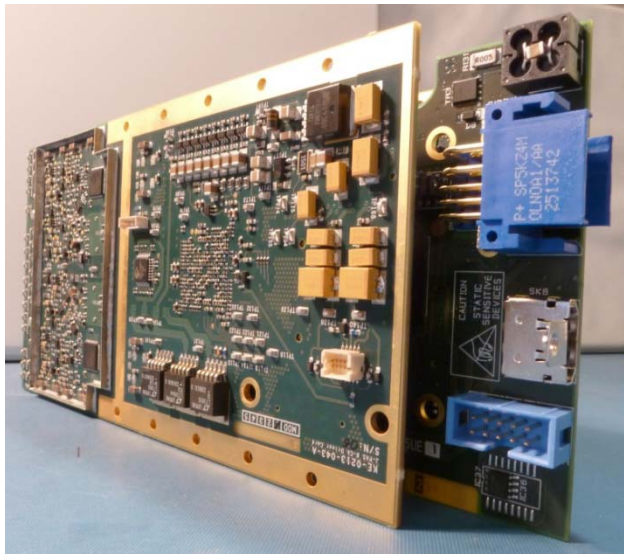
4 Optical CameraLink interfaces to camera for command and data telemetry

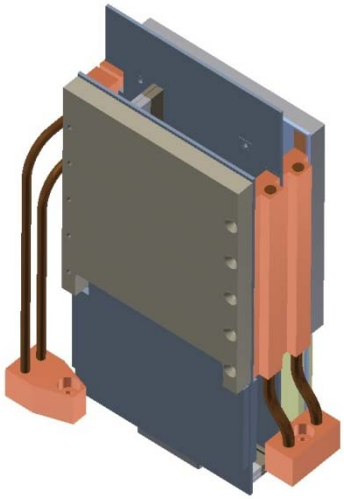
Mains powered with local power conversion

Glycolated water cooling system



CCD Drive Modules

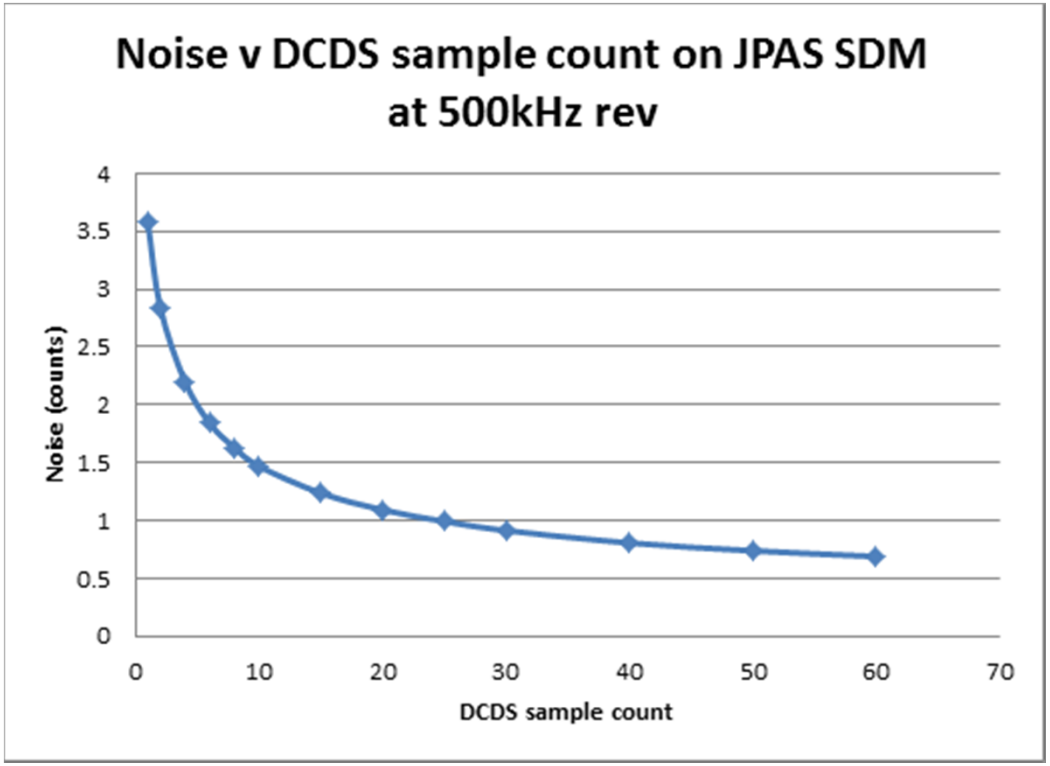




- Drives 1 x CCD290-99 Science CCD **or** 1 x CCD47-20 Auto-Guide **or** 2 x CCD44-82 Wavefront CCDs
- 16 x low noise 16bit 100MHz DCDS analogue input chains
- Stores the 81 MPixel image data in on-board DDR2 SDRAM Framestore.
- Provides low noise bias voltages to the CCDs.
- Performs clock waveform generation
- Outputs the reconstructed image via a single high speed serial LVDS link (carried over HDMI cables).
- Heat pipe thermal management system for removing excess heat
- Wide variety of diagnostic

DCDS performance

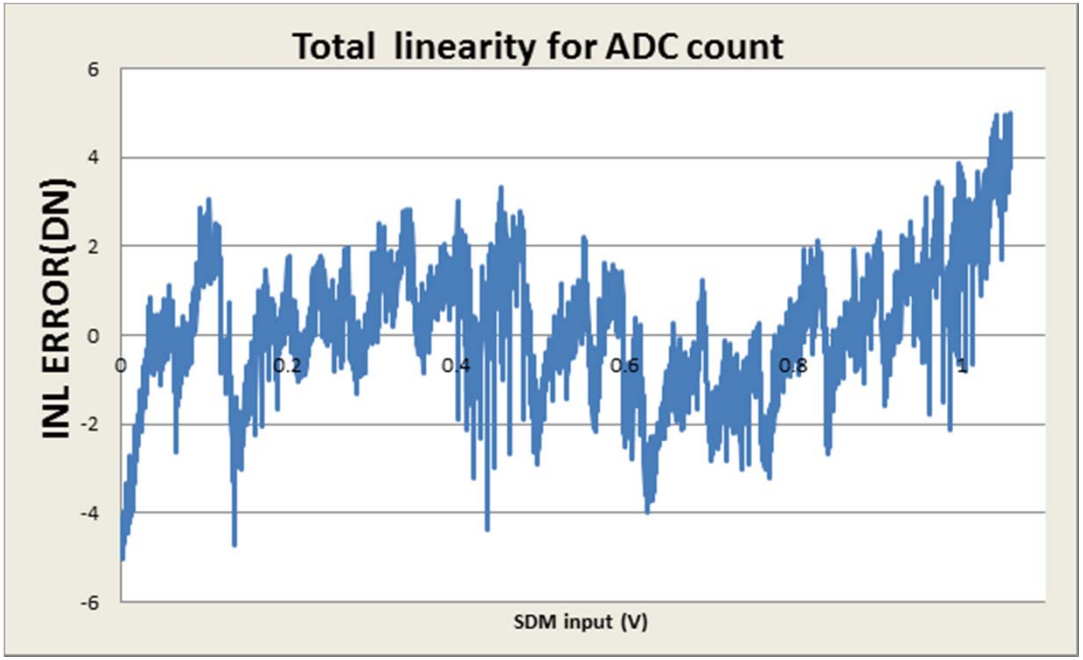
- Right shows measured DCDS system noise performance as a function of sample count
- Noise approaches the limit of a traditional CDS circuit with high numbers of samples
- Characterisation carried out on JPAS CCD drive module system
- 1 count = 2.18 e-



Noise Performance

- Measured noise performance at 500 kHz of drive module is 1.6 e^-
- When operating the CCD290 in a differential mode this yields an average measured noise for the system of 4.7 e^-
- Number of DCDS samples is ~50 in this regime

- Graph to the right shows system non linearity
- Non-linearity is dominated by the ADC specification (± 2 DN)



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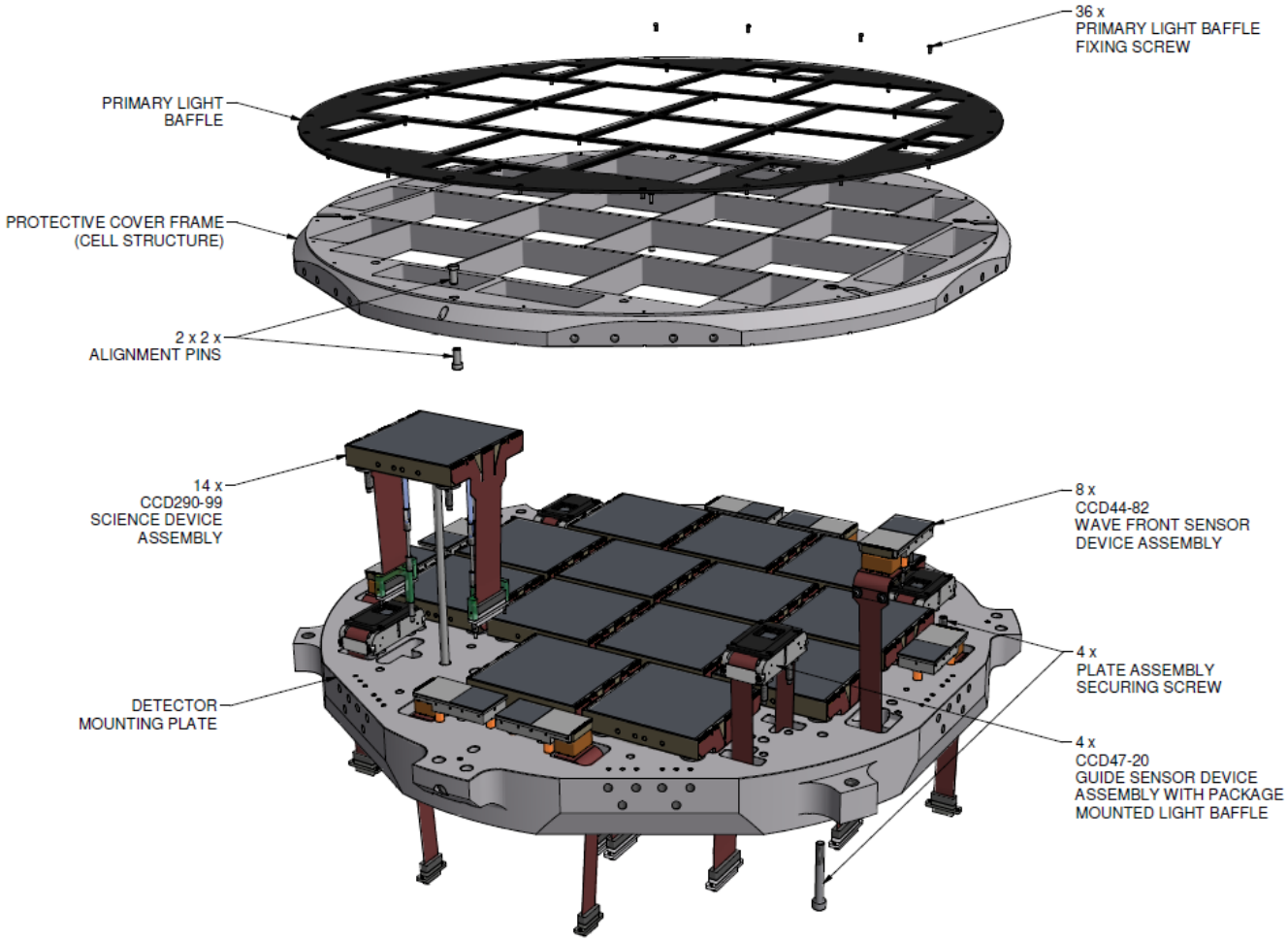
The focal plane array

Lapped 600 mm diameter Aluminium cold plate

FPA will be flat to <40 µm over the science array

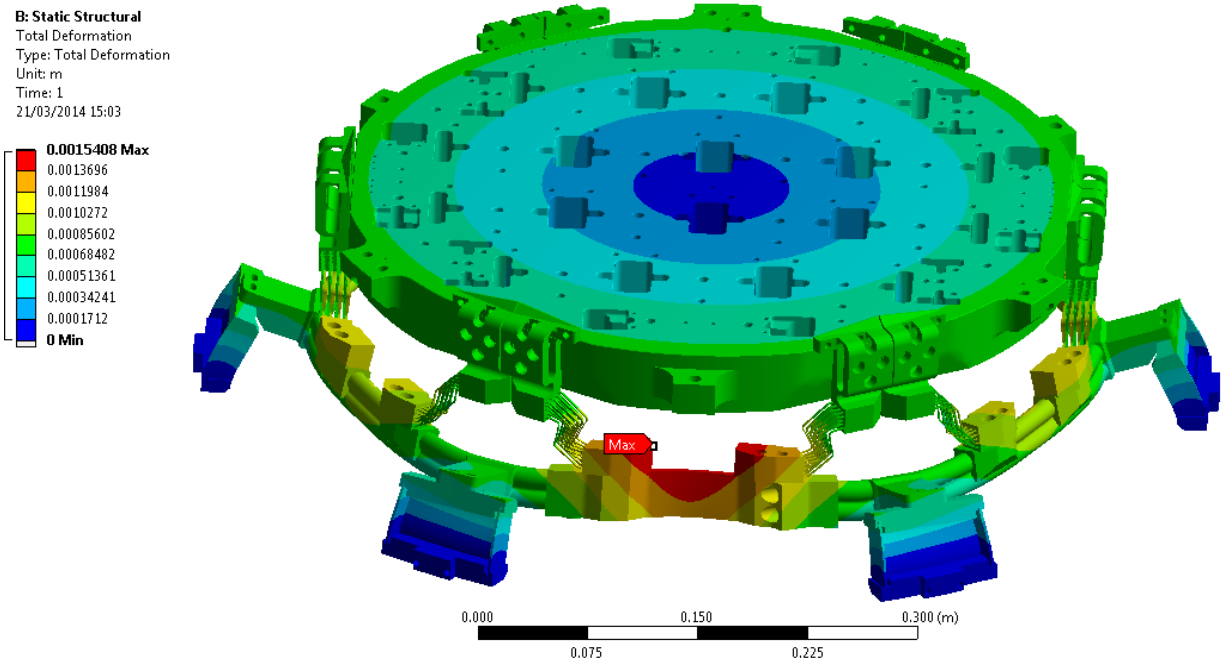
Includes 14 Science CCD290-99 plus 8 CCD44-82 (wavefront) and CCD47-20 (auto-guide)

Integrate light baffles



Focal Plane Mechanical Performance

- Comprehensive FEA analysis has been carried out on the Focal Plane Array
- Predicting < 7.5 micron distortion to FPA when in operation
- When combined with 5 micron plate flatness and 24 micron device height P-V yields a total predicted flatness of < 40 microns



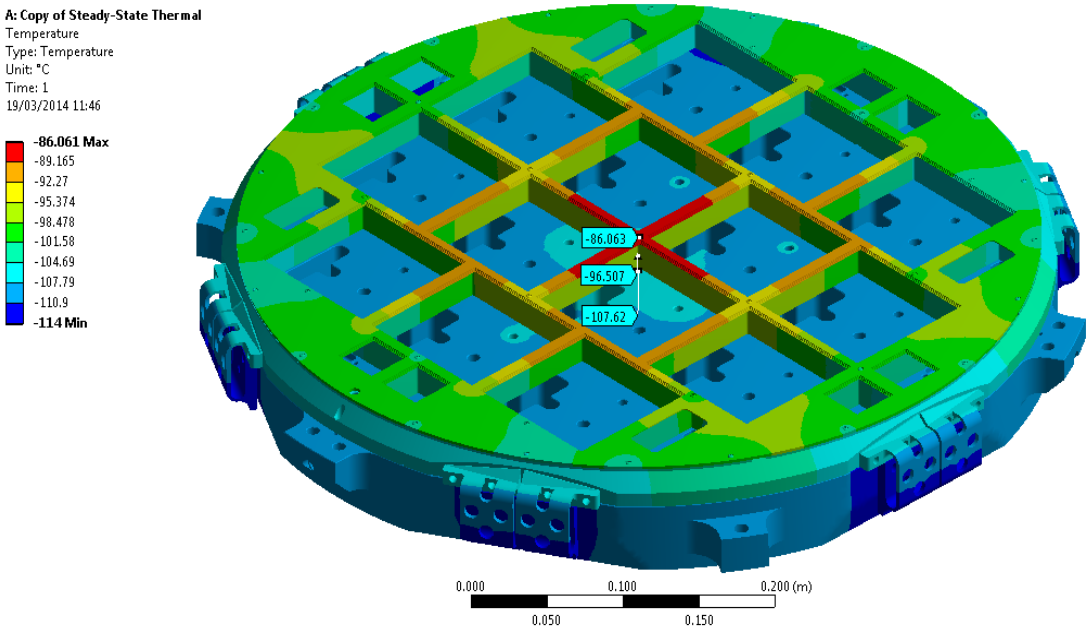
FEA analysis result showing deformation of plate

Blue = 0 micron deformation

Green = 6.8 micron deformation

Focal Plane Thermal Performance

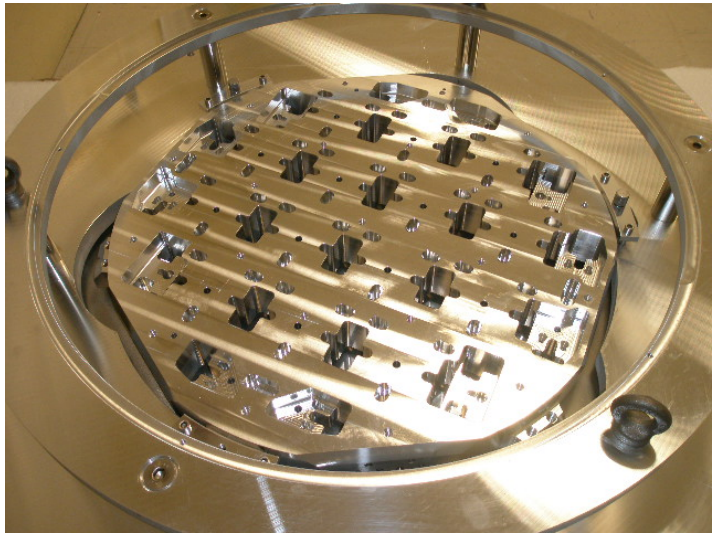
- Operates at -100 °C with ±1 °C stability
- Cooled via phase change LN2 cooling system
- Gradient of < 4°C over cold plate
- Three point kinematic mounts to allow for thermal expansion of plate

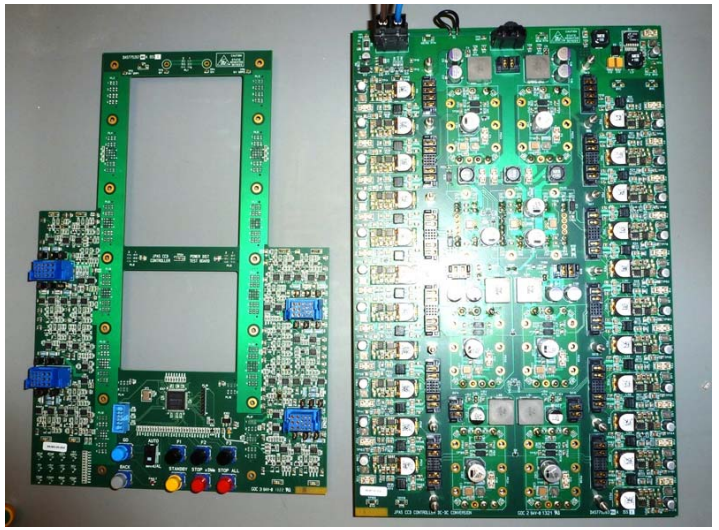


FEA analysis result showing thermal gradient across plate assembly

Programme Status

- First engineering model cold plates have been delivered and are undergoing final processing
- Prototyping of electronics is largely complete, procurement of main items about to begin
- Mechanical CDR is imminent, procurement of main mechanical assemblies will begin shortly
- CCD manufacture is under way with devices being prepared for assembly
- Camera completion planned for June 2015





Acknowledgements & References

Acknowledgements

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