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** - Javalambre Physics of the accelerating universe Astronomical Survey

- 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 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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2. **CCD290 -99 and auxiliary CCDs**
3. Detector Control Electronics
4. Focal Plane Array
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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4. **Focal Plane Array**
The focal plane array

Lapped 600 mm diameter Aluminium cold plate

FPA will be flat to <40 \mu m 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
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

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References

