Performance of the e2v 1.2 GPixel cryogenic camera for the J-PAS 2.5m survey telescope

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J-PAS CryoCam

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Introduction

- J-PAS - Javalambre Physics of the accelerating universe Astronomical Survey
- J-PAS is a 5 year wide-area astrophysical mapping survey which primarily aims to explore dark energy in the universe
- The dedicated 2.5m telescope (built in Teruel, Spain) 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 on the back of the T250 telescope

http://www.j-pas.org/

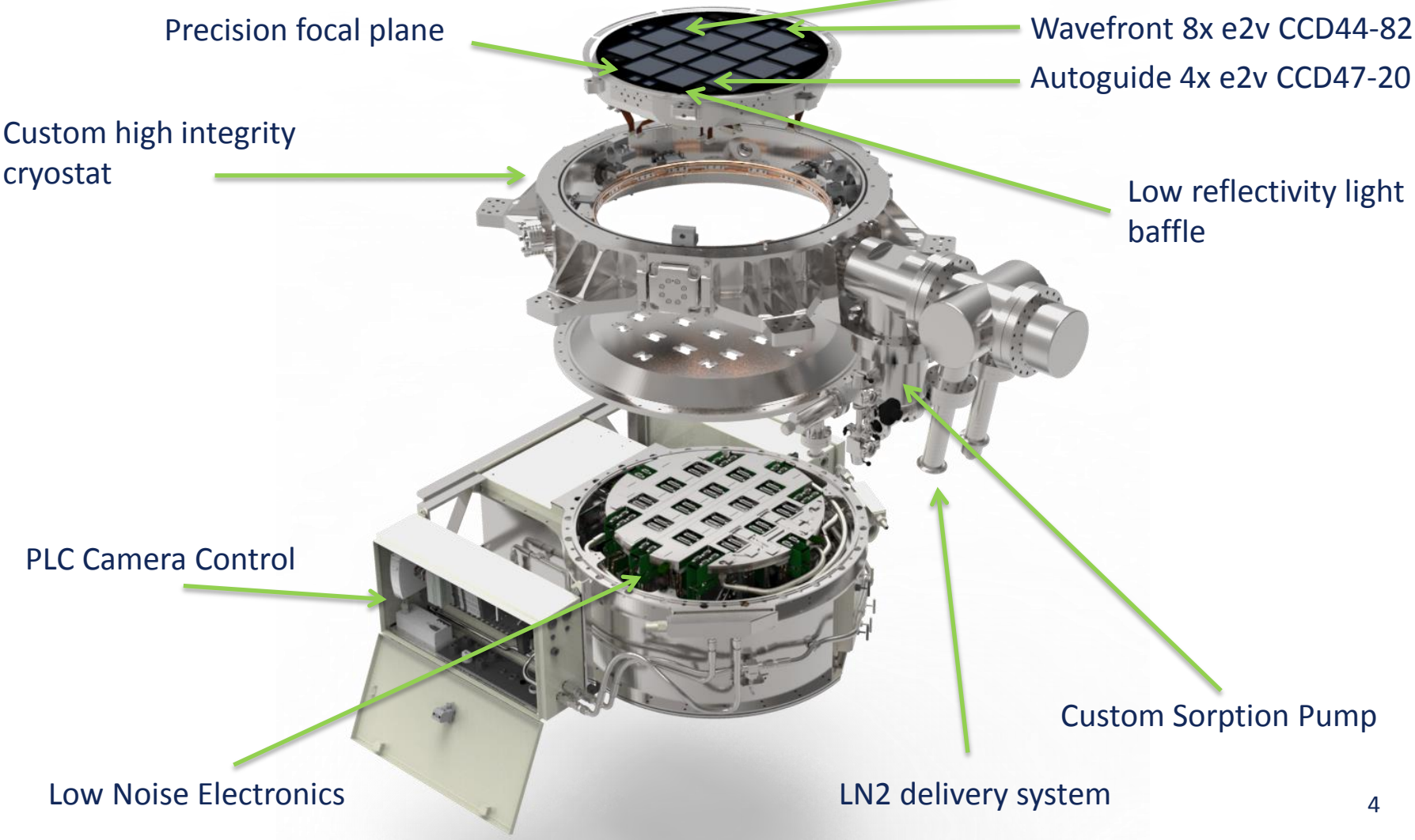
Overview

Presenting a review the factory performance of the e2v JPAS CryoCam following AIVT

- Overview of Cryocam
- The Opto-Mechanical Sub-System
  - Opto-Mechanical Description
  - Geometric Verification
- The Instrument Control and Support Sub-System
  - Sub-System description
  - Thermal Performance
  - Vacuum Performance
- Detector Control Sub-System
  - Electronics overview
  - Electrical Performance
    - CCD Level
    - Module Level
    - System Level
- Conclusion

J-PAS CryoCam

Overview of CryoCam



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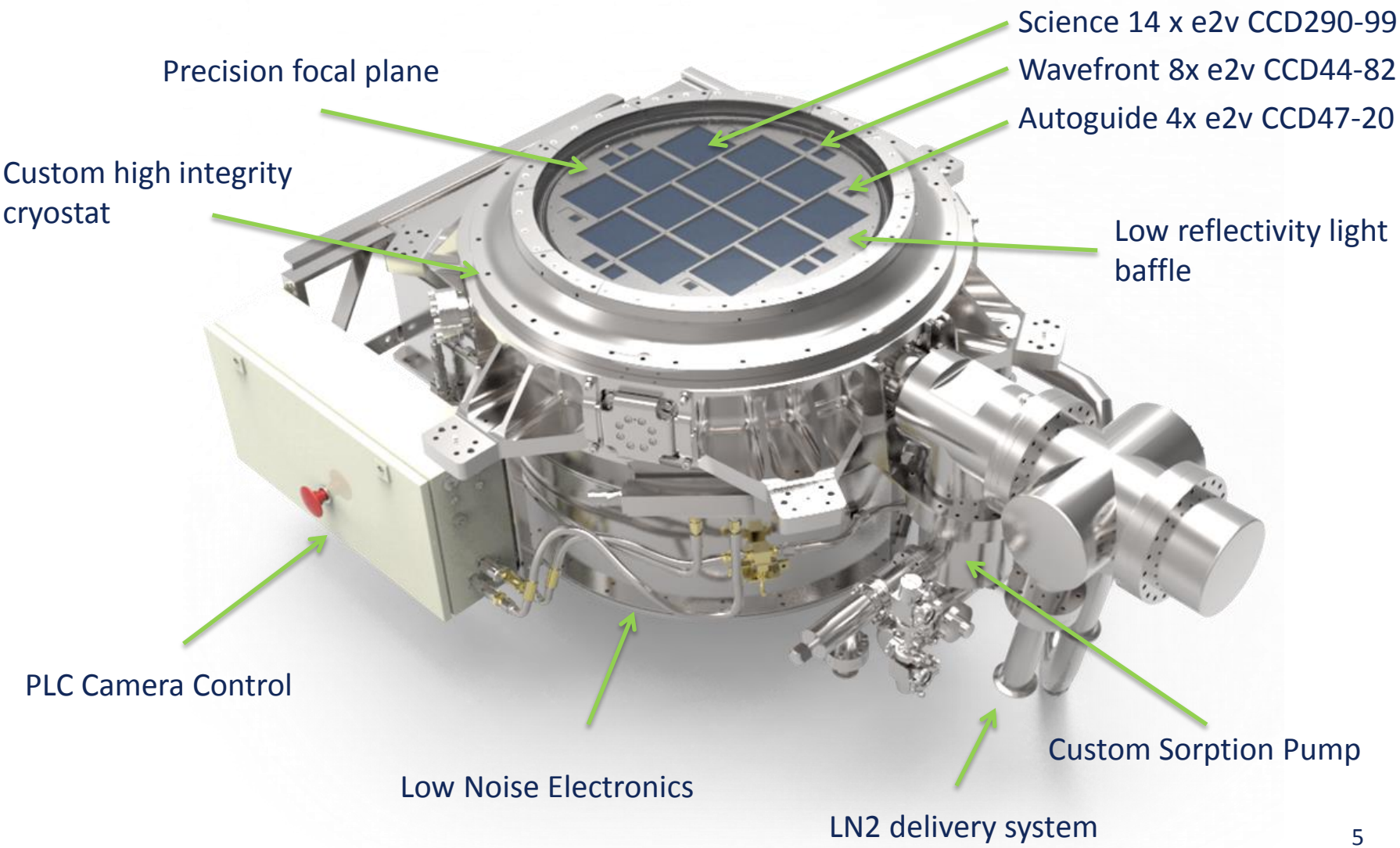
Overview of CryoCam



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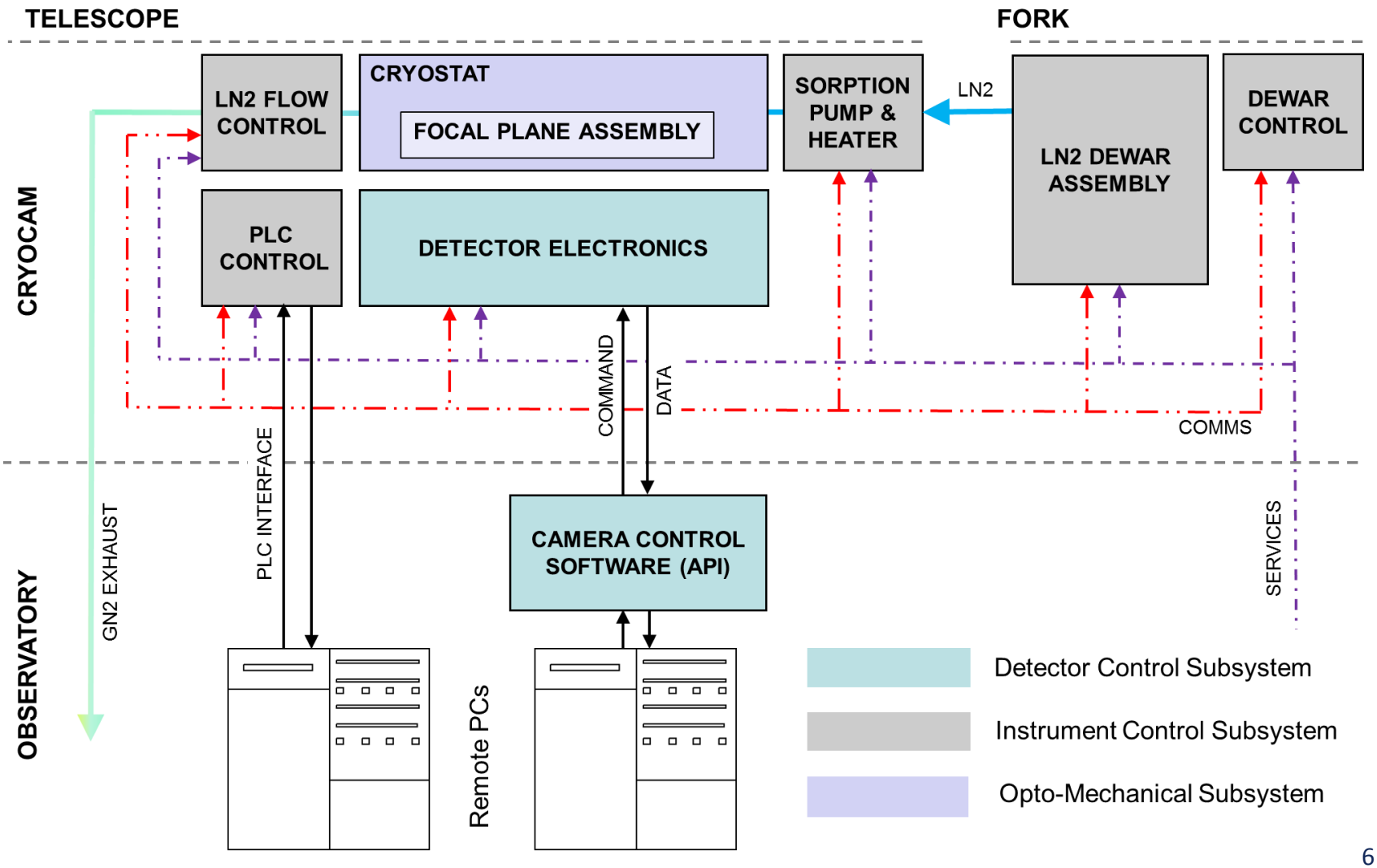
Overview of CryoCam



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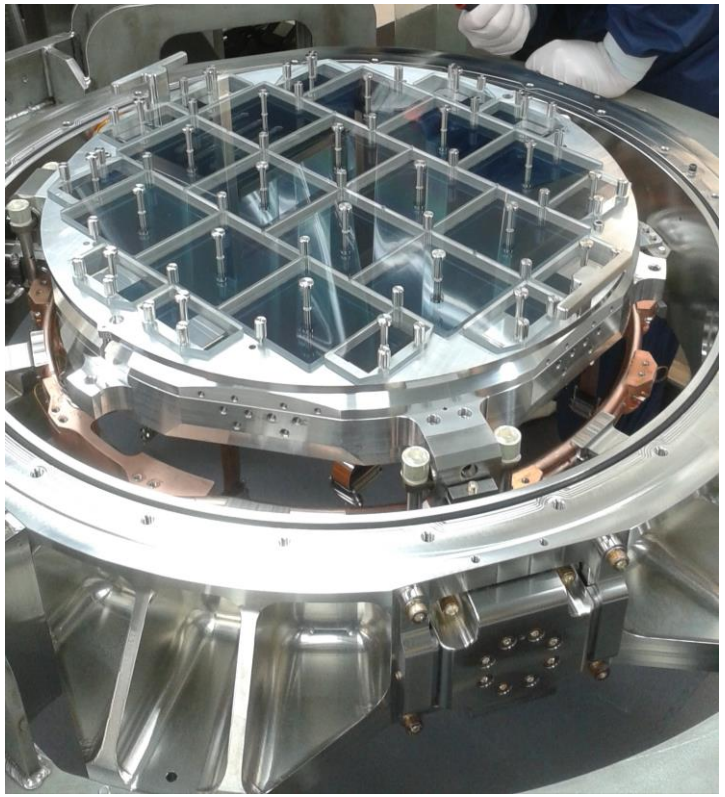
The Opto-Mechanical Sub-System

- Assembly housed within custom vacuum cryostat
- LN2 passed through a Cu ring and changes phase
- Cold plate attached to Cu ring with Cu straps
- Initially evacuated with a Turbo Pump
- Vacuum held with a sorption pump



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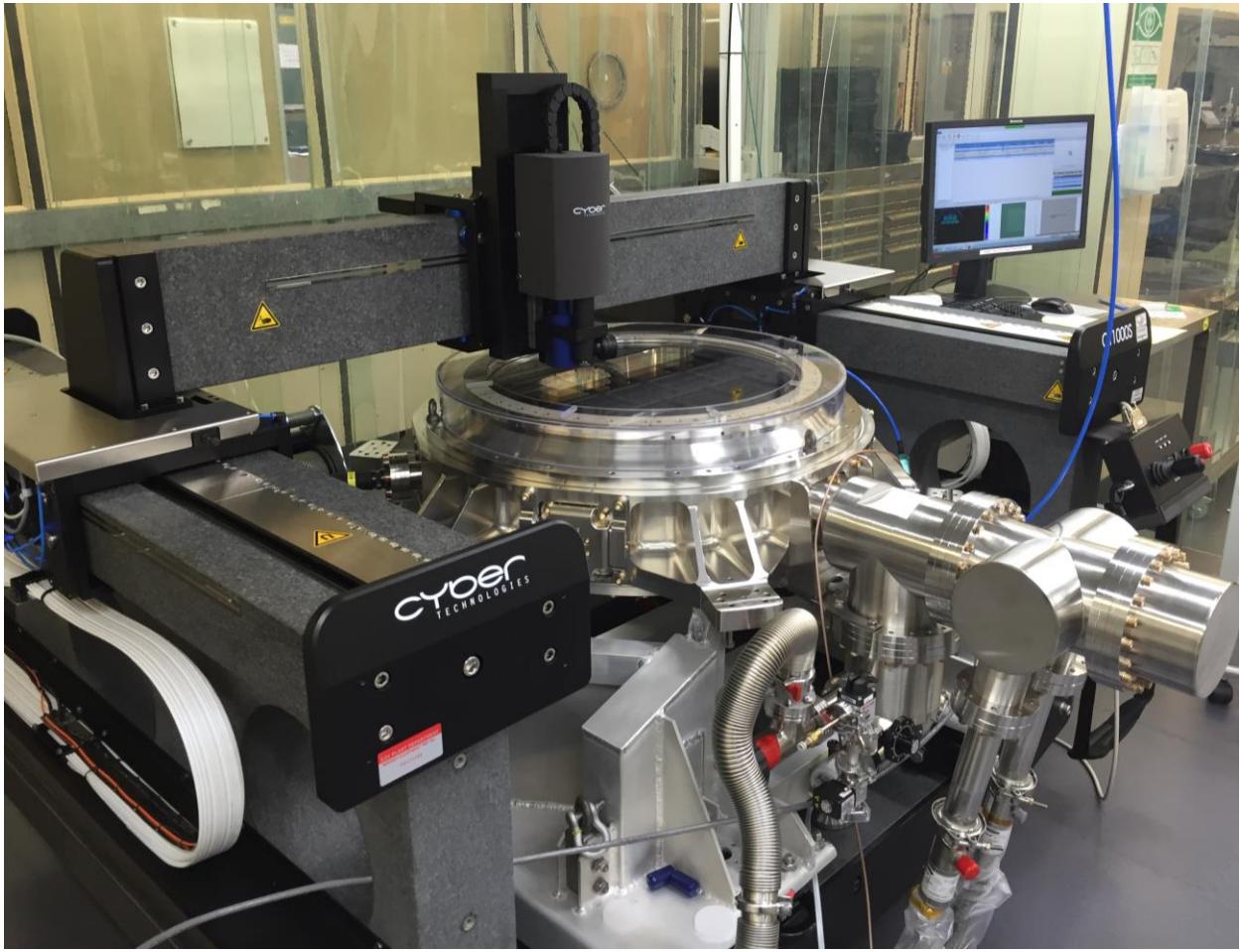
The Opto-Mechanical Sub-System – Geometric Verification



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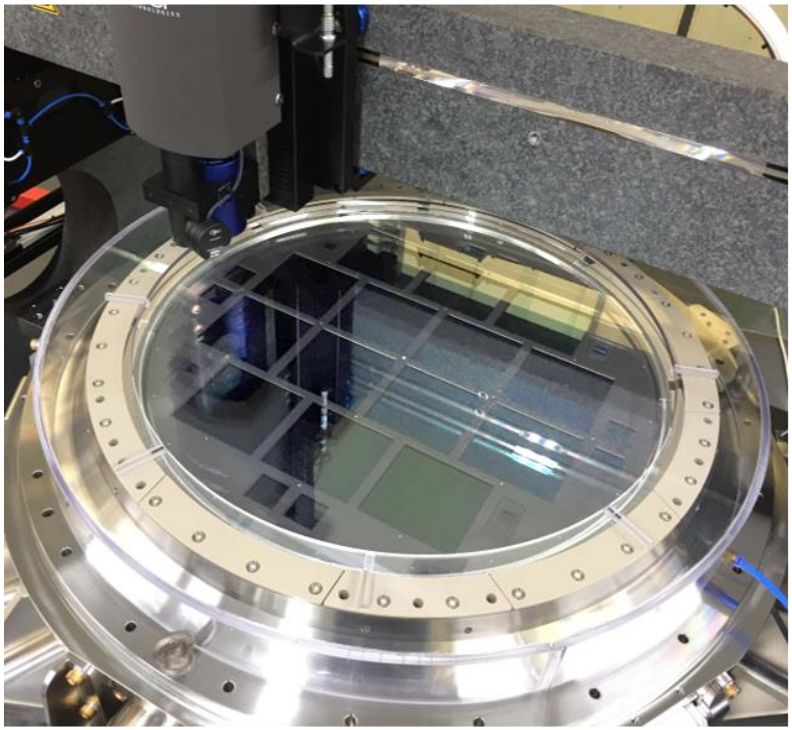
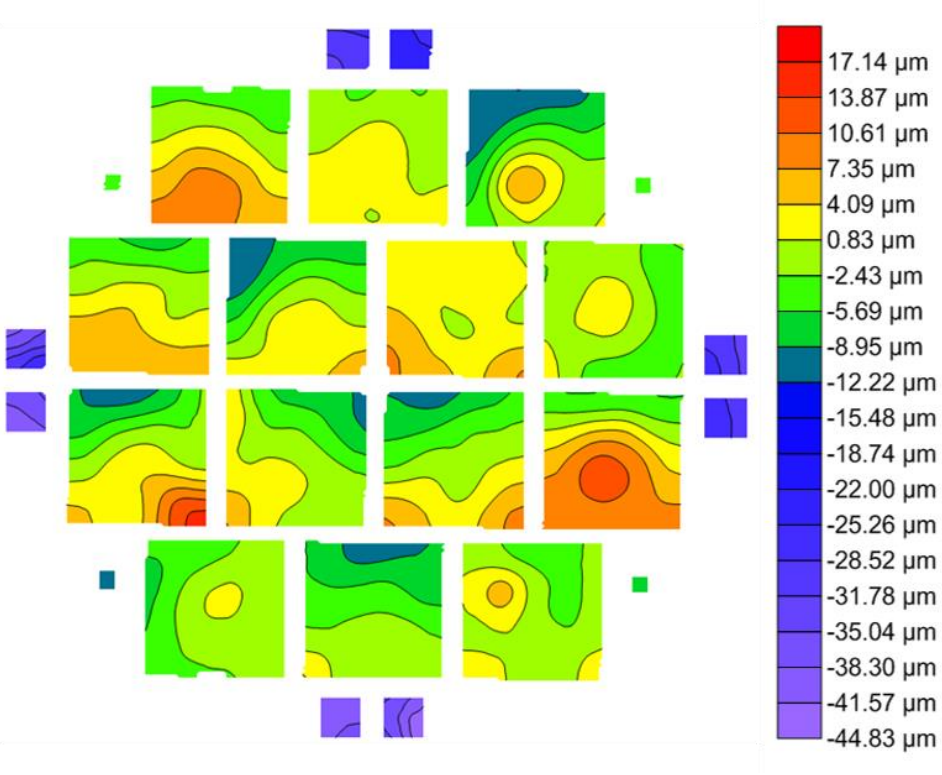
The Opto-Mechanical Sub-System – Geometric Verification





The focal plane inside the cryostat plane and flatness measurements made at -110 ^{o}C showing the 14 science devices, 8 wavefront and 4 autoguide CCDs.

Flatness achieved - **<u>27 µm peak to valley</u>** for (spec 40µm target 30µm)

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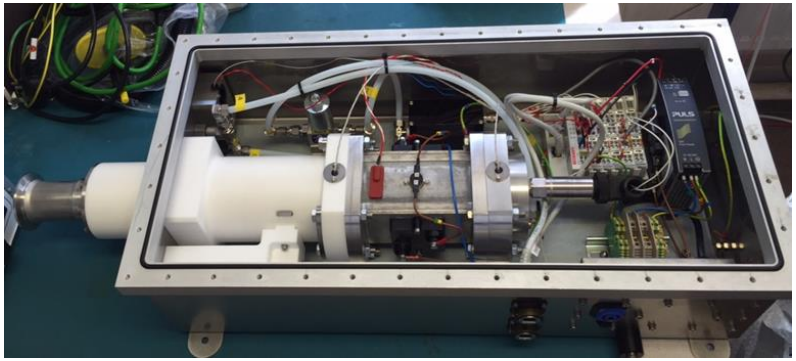
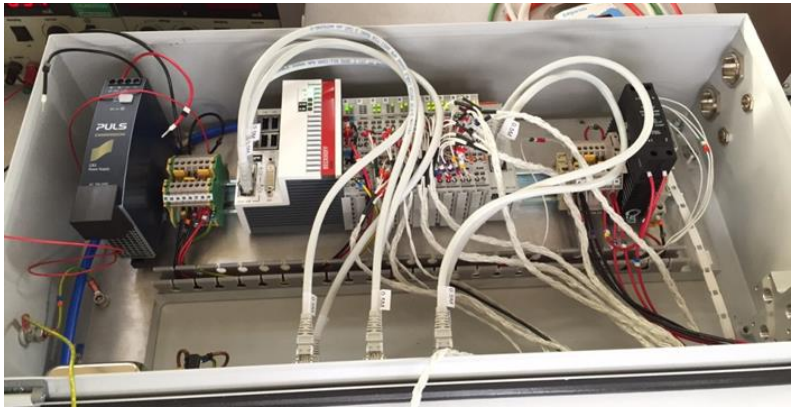
The Instrument Control and Support Sub-System

- Pair of LN2 Dewars mounted on telescope fork
- Temperature control implemented through PLC system
- Controls rate of flow of GN2 flowing from cryostat
- No heaters in cold plate assembly
- PID control employed
- Time constant ~3.5 hours





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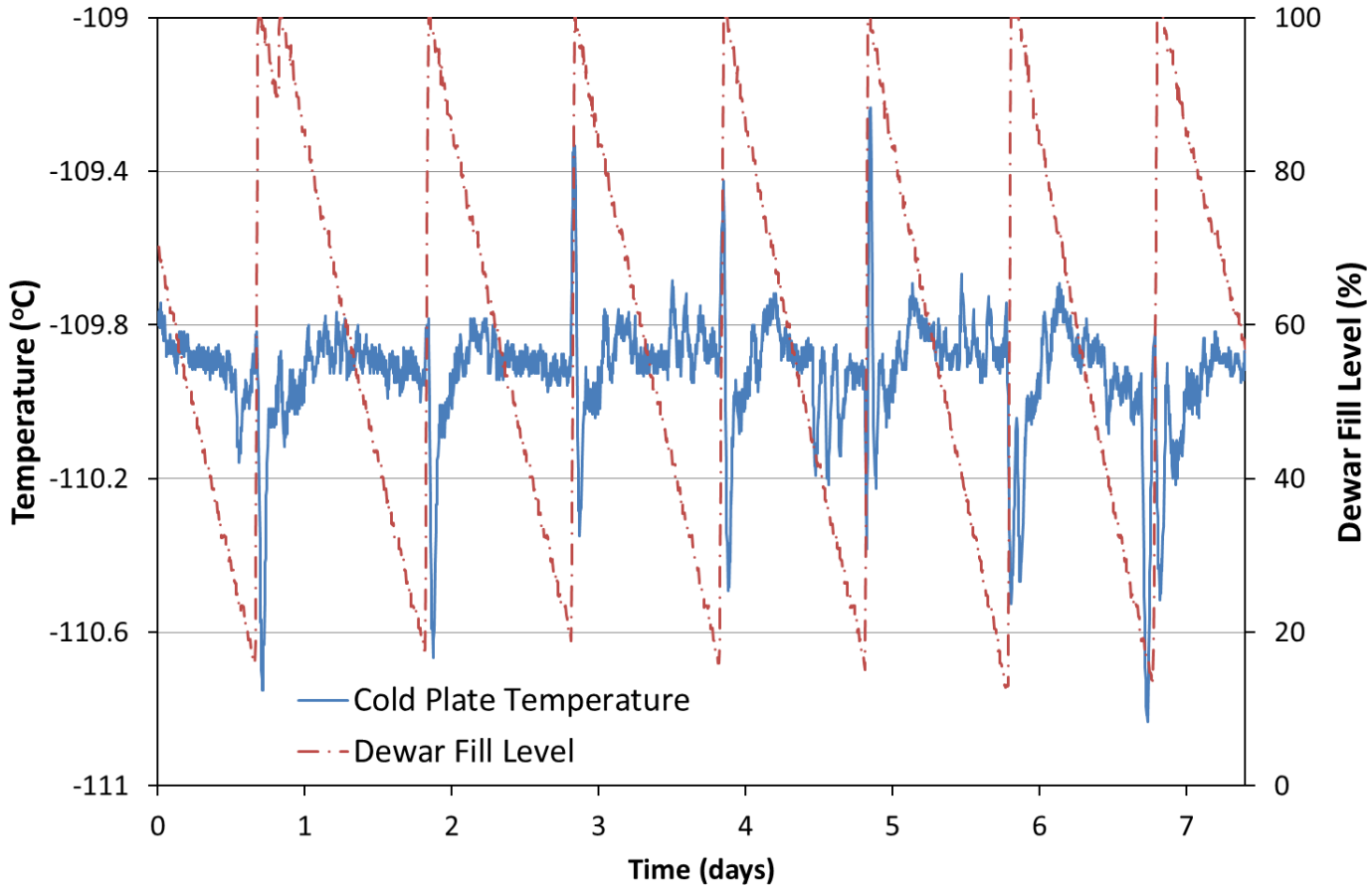
The Instrument Control and Support Sub-System – Thermal Performance



The control temperature and the Dewar fill level

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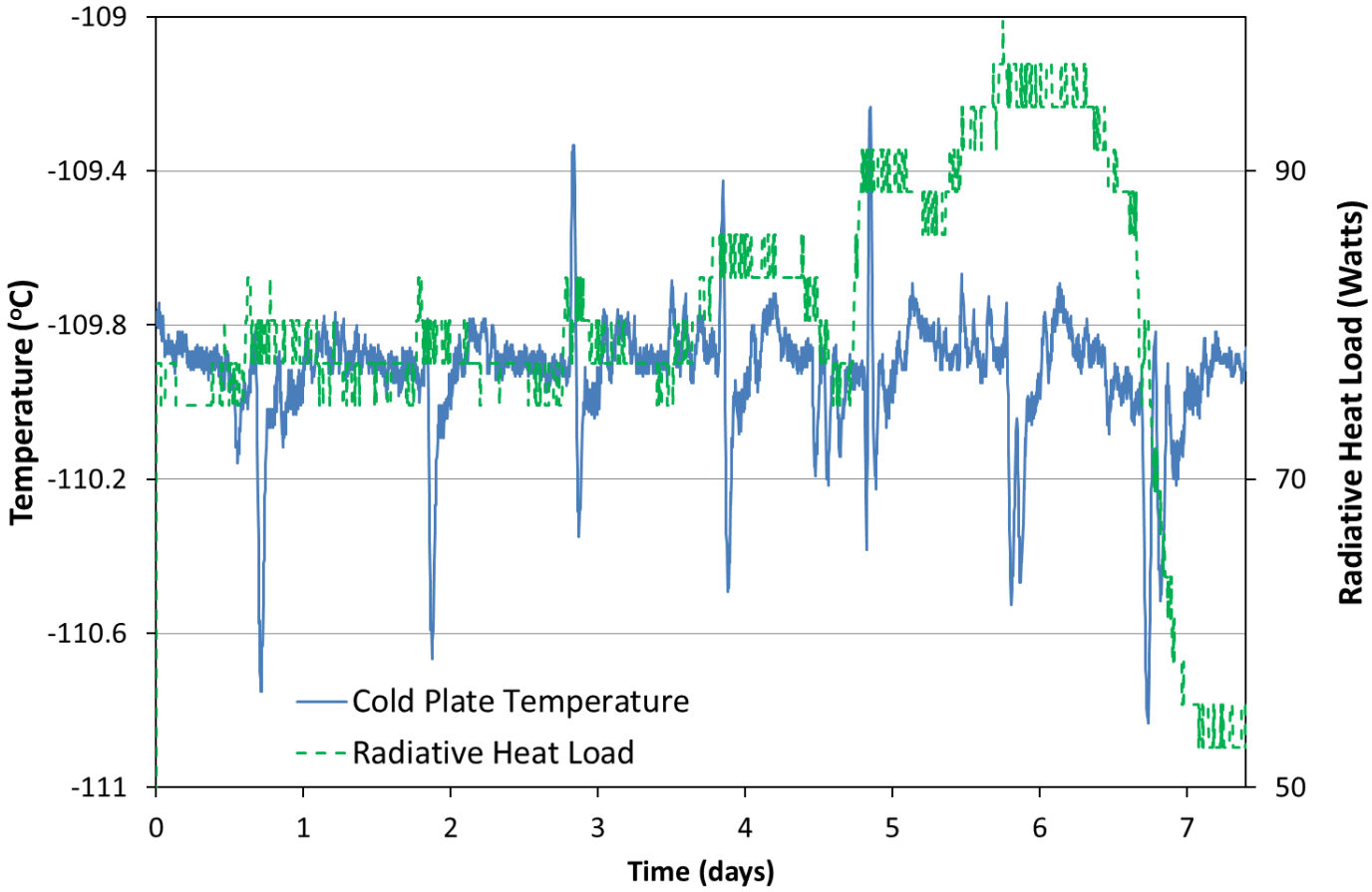
The Instrument Control and Support Sub-System – Thermal Performance



The control temperature and the radiative heat load on the cold plate

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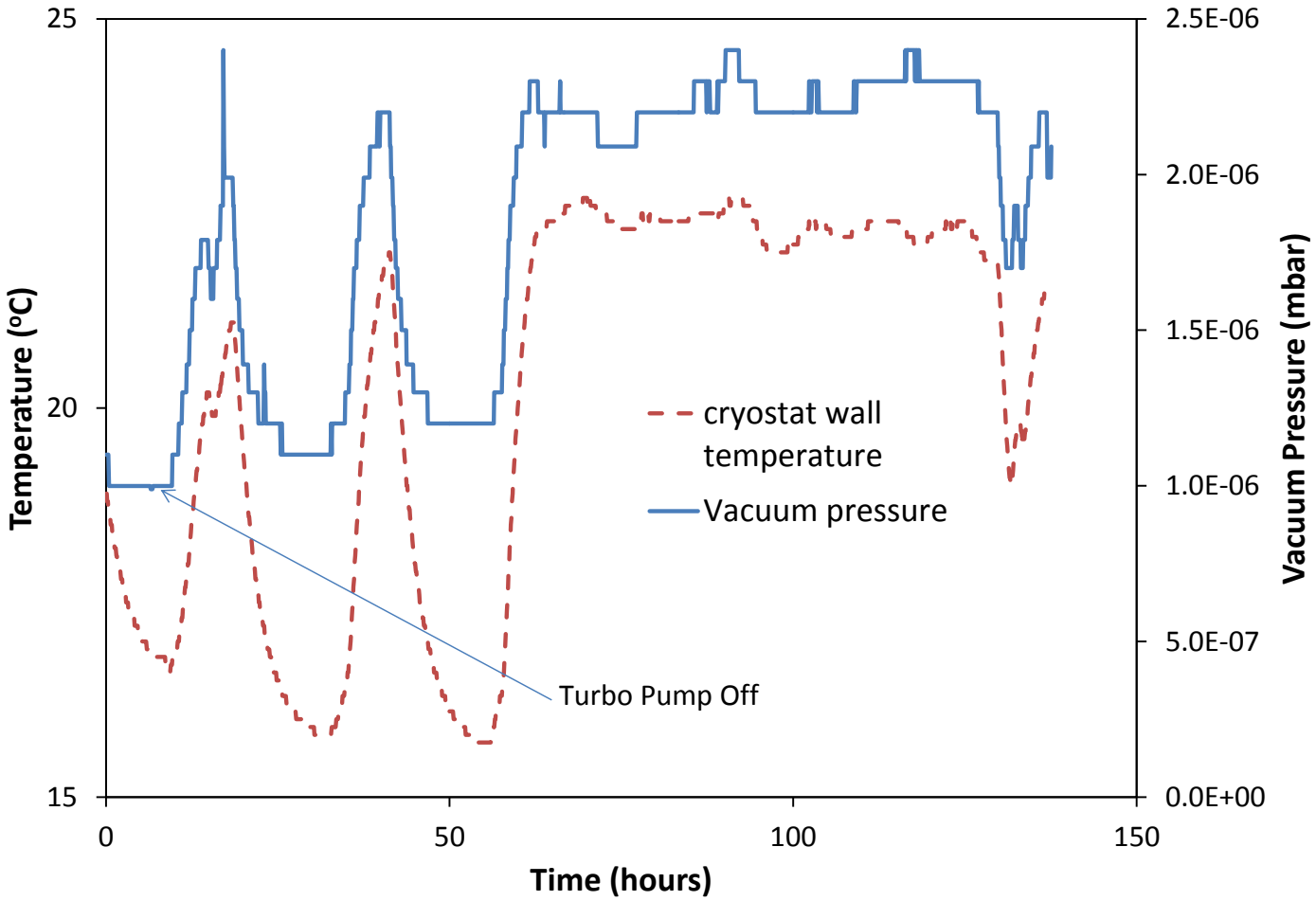
The Instrument Control and Support Sub-System – Vacuum Performance



Sorption pump only – no cryostat conditioning

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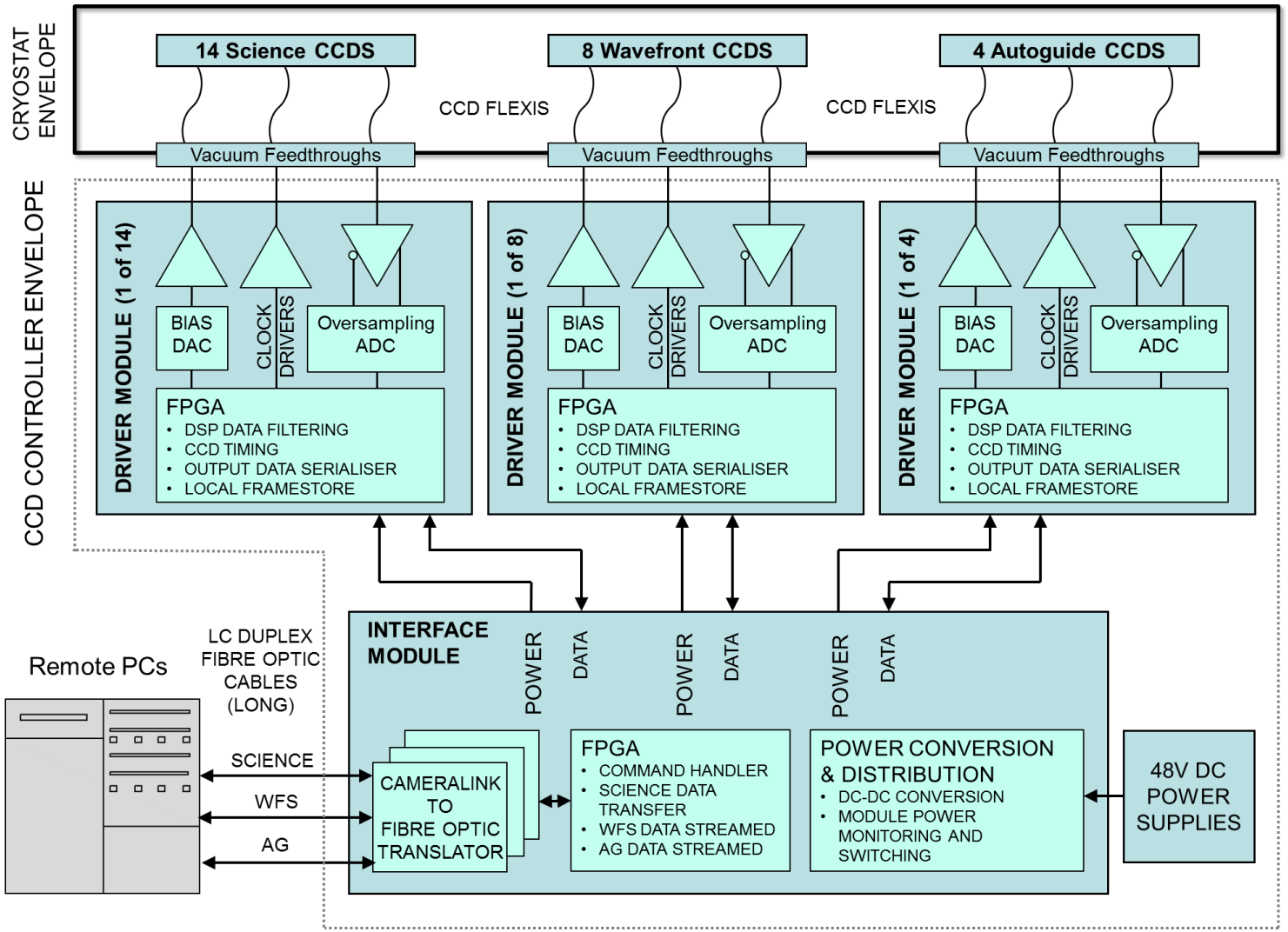
Detector Control Sub-System



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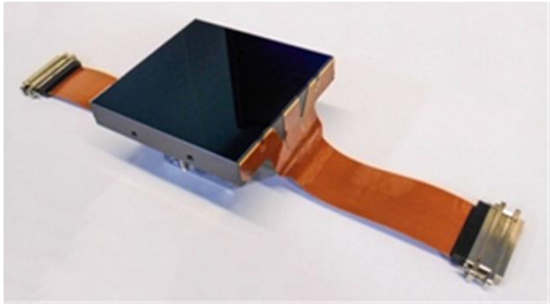
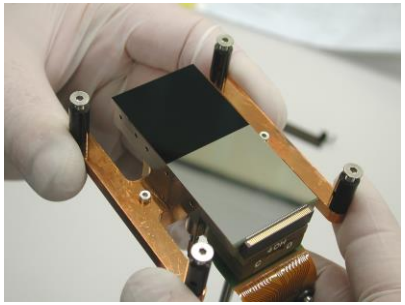
Detector Control Sub-System – CCD Level Performance

- The CCDs supplied as high grade devices
- All CCD testing undertaken using dedicated production test equipment
- CCDs tested for noise, responsivity, linearity, QE, CTE, dark signal, PRNU, DSNU, defects....

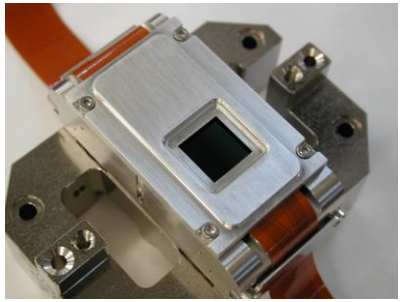
14xCCD290-99 Science Devices
9kx9k full frame
16 differential outputs
630 kHz and 400 kHz



8xCCD44-82 Wavefront
2kx2k frame transfer
100x100 window at 1 fps



4xCCD47-20 Autoguide
1kx1k frame transfer
50x50 window at 4 fps



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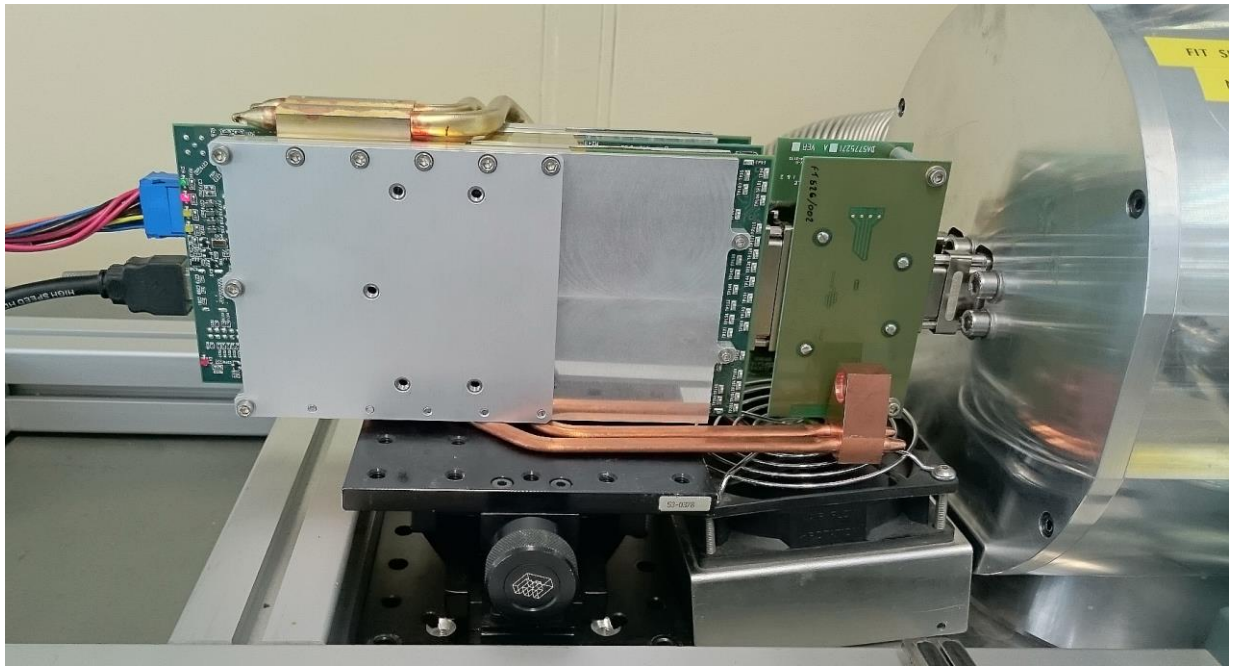
Detector Control Sub-System – Module Level Performance

- Each of the 22 electronics modules bench tested and tested with associated test devices.
- Test device is mounted in a “mini” cryostat
- Tested for functionality, noise, linearity, gain, CTE



A wavefront module being tested

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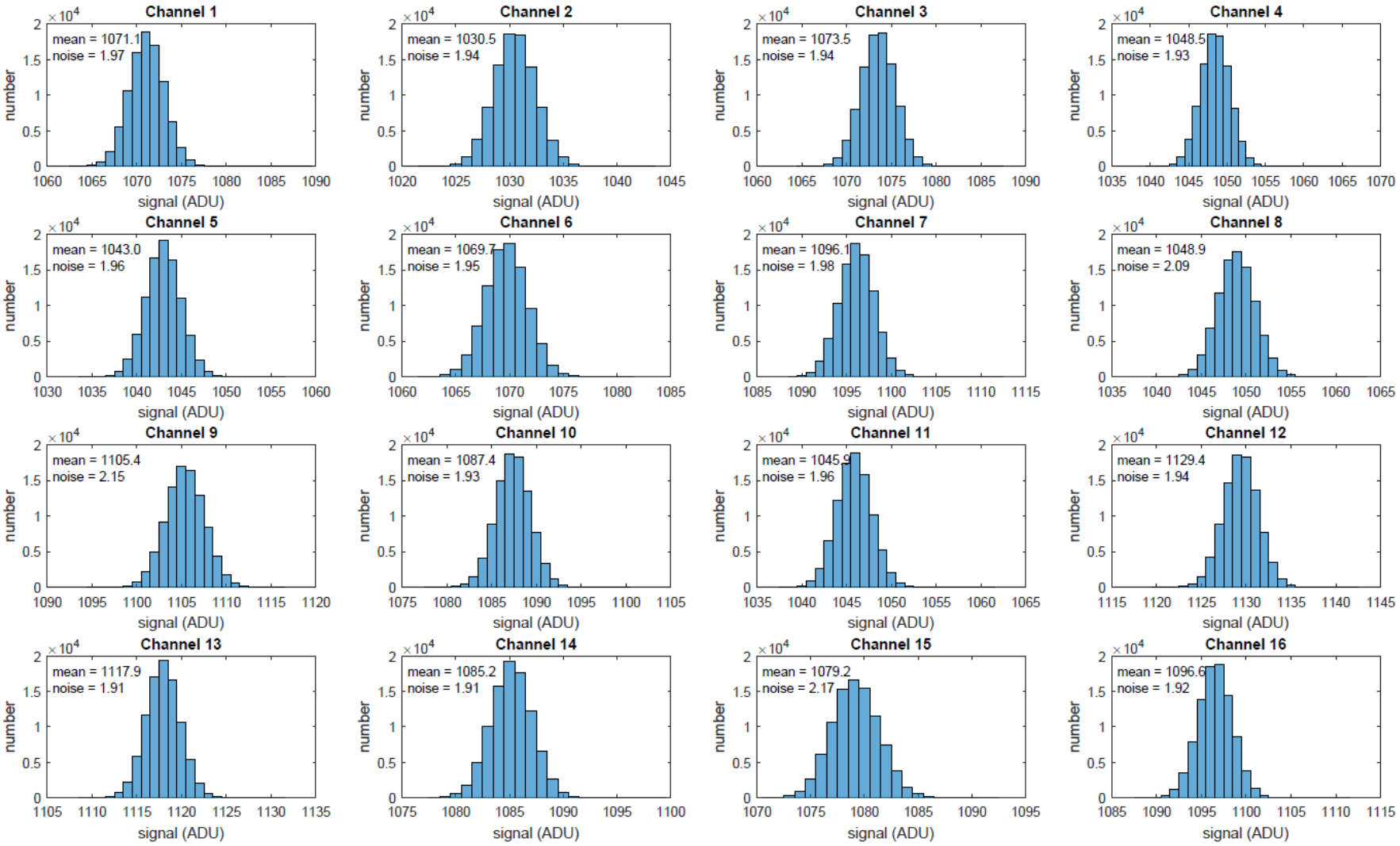
Detector Control Sub-System – Module Level Performance



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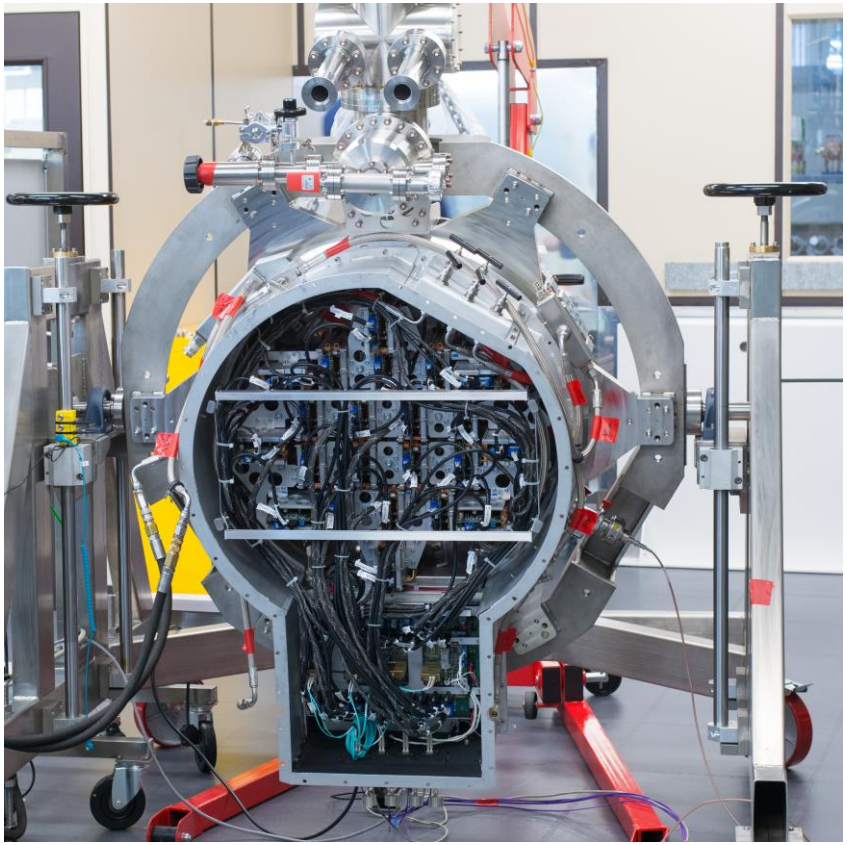
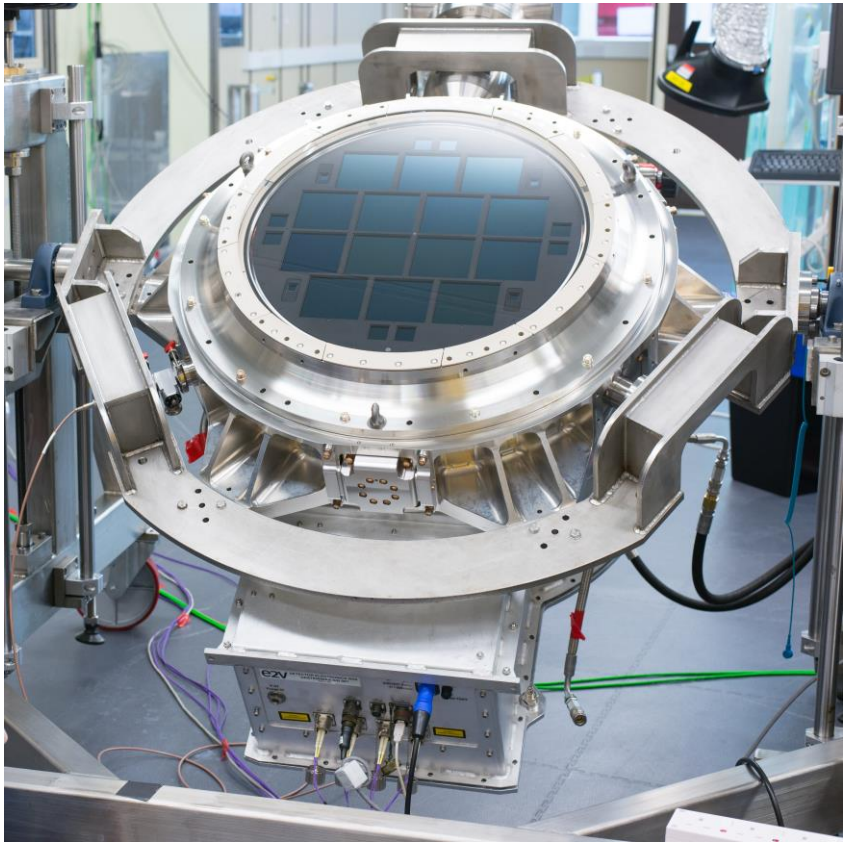
Detector Control Sub-System – System Level Performance

- System level performance assessed for noise, cross talk and functionality





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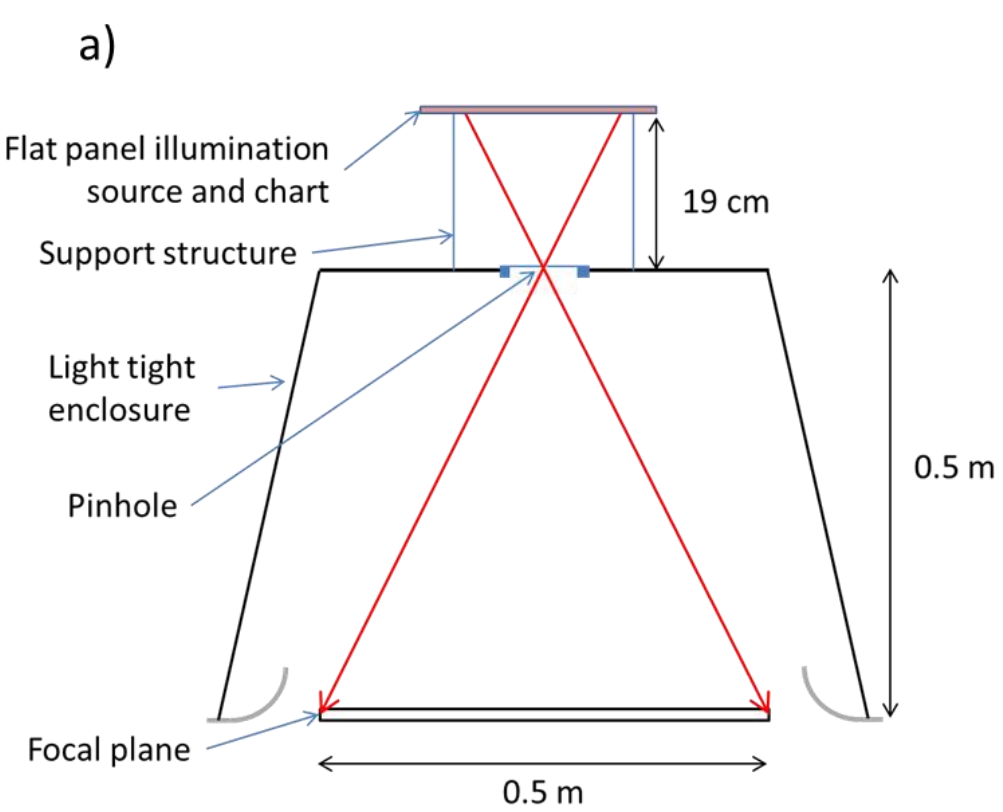
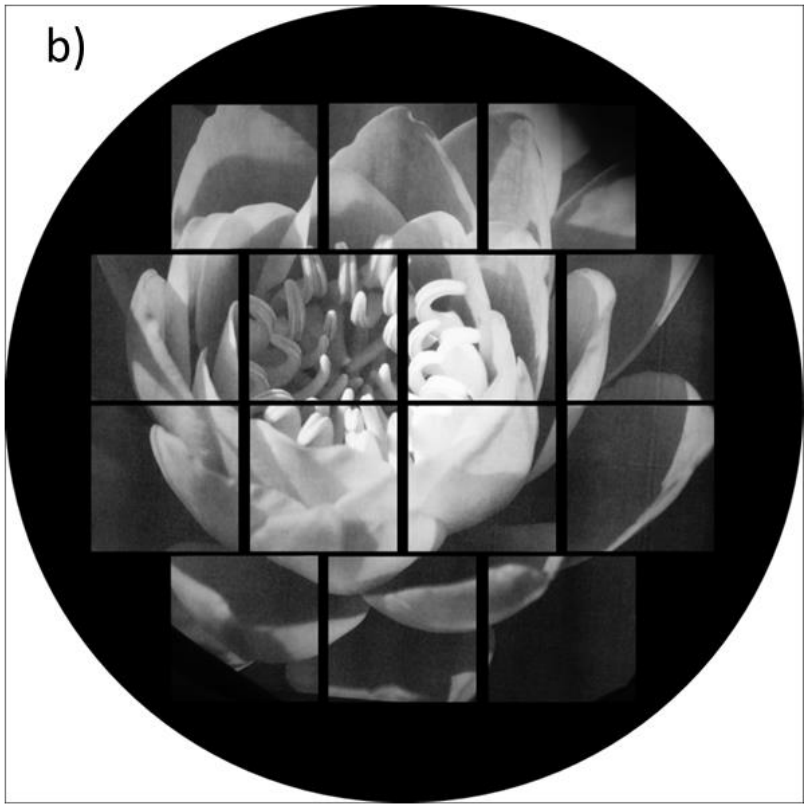
Detector Control Sub-System – System Level Performance





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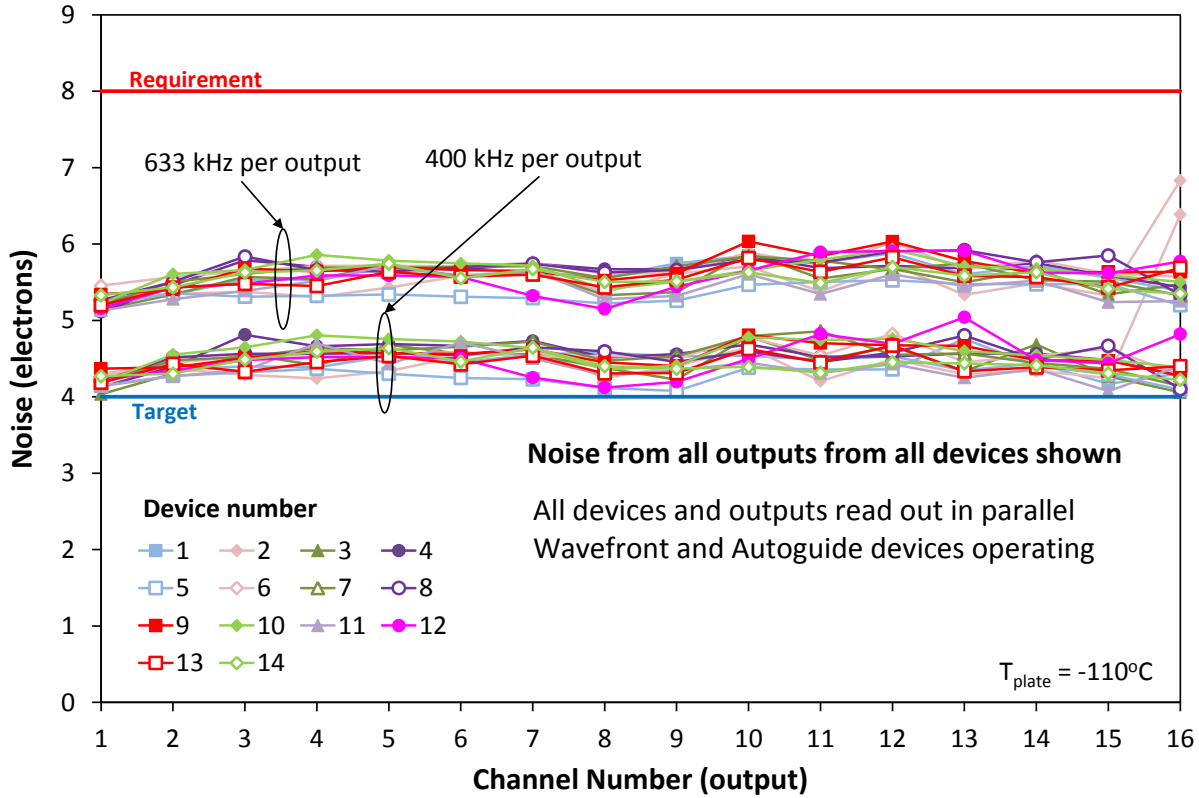
Detector Control Sub-System – System Level Performance

- The measured system level noise for all science devices operating in parallel.



- Inter channel and inter device cross talk less than 106 dB

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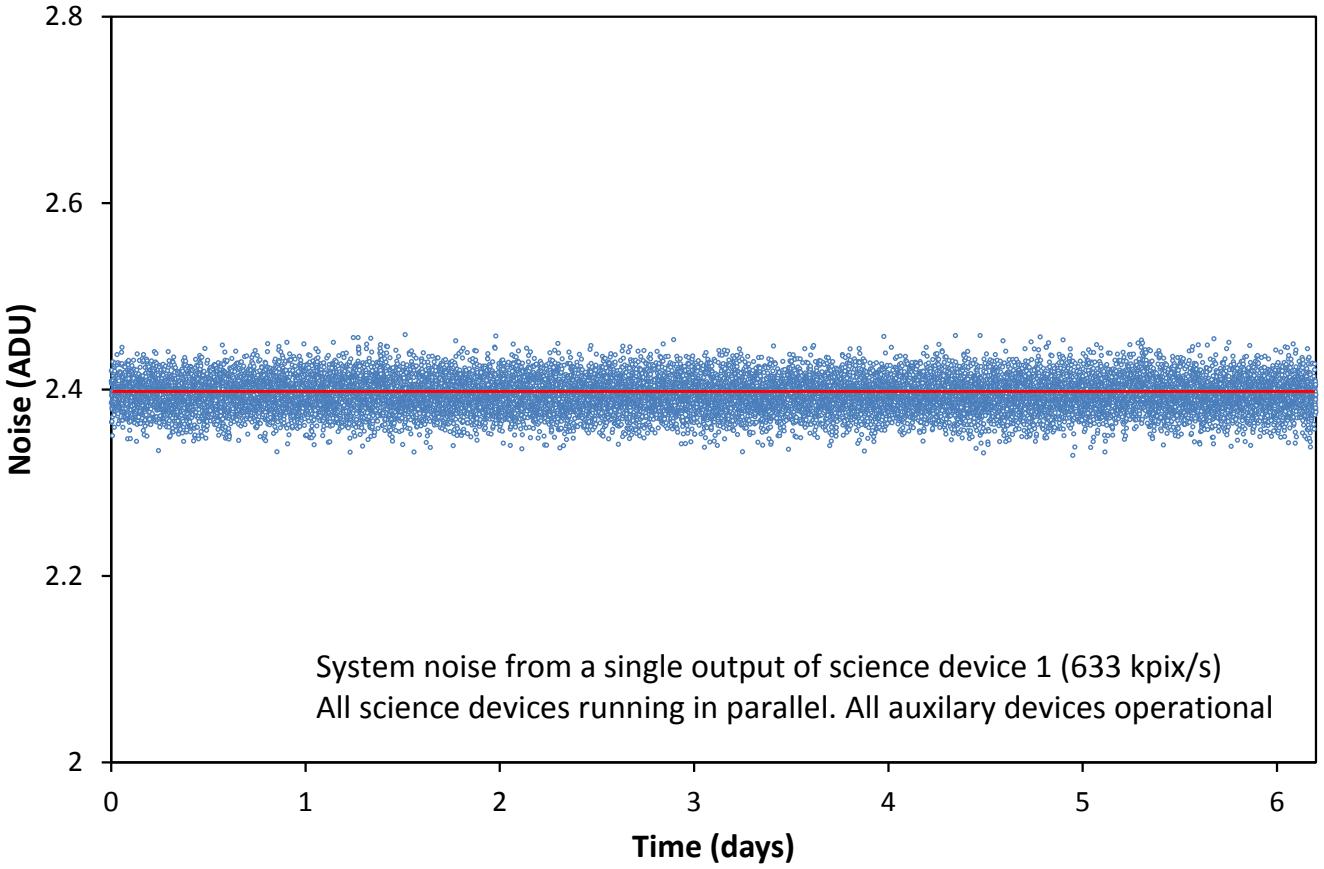
Detector Control Sub-System – System Level Performance



System noise from a single science output measured over a 6 day period.
All devices are operating and a noise measurement is made every 25 seconds.

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Conclusions

- The e2v CryoCam has completed factory acceptance tests and passed the System Acceptance Review ☺☺☺
- From the final critical design review it has taken 15 months to complete the complex AIVT phases of the programme.
- System level tests have verified performance against all key aspects of the customer requirements
- Key features include
  - Precision construction and metrology to meet geometrical/mechanical specifications
    - e.g. exceeding the focal plane flatness spec to achieve 27 um p-v cryogenic flatness
  - Validated differential digital correlated double sampling signal chain
    - providing read-noise that exceeded guaranteed specification
  - Custom cryogenic/vacuum system for reliable and low maintenance operation
- We have demonstrated that the supply of a complex, high performance camera system can be undertaken by a commercial organisation. This includes use of rigorous quality systems, delivering guaranteed performance levels, as well as being to an agreed price and schedule

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Acknowledgements

Many people at e2v, in addition to the core e2v J-PAS team, have contributed to the successful delivery of this program.

I would also like to thank the J-PAS collaboration and those supporting the collaboration for valuable interactions throughout the project.

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