

A Gigapixel commercially-manufactured cryogenic camera for the J-PAS 2.5m survey telescope

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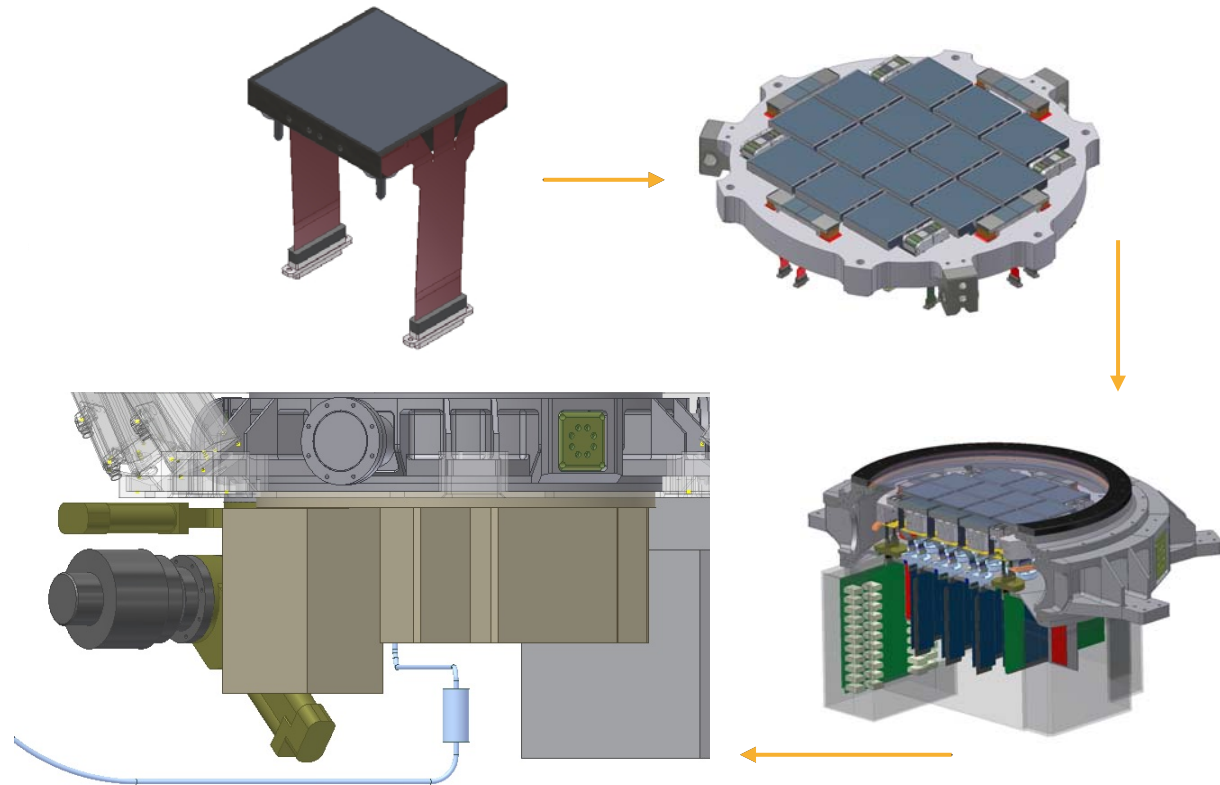
SPIE AS12

Conference 8453

Contents

J-PAS 2.5m camera

- Introduction
- Summary of requirements
- CCDs
- Focal Plane Assembly
- CCD electronics
- Cryostat and cooling
- Camera System
- Challenges
- Summary
- Acknowledgements



Main purpose is Dark Energy survey through BAO measurements

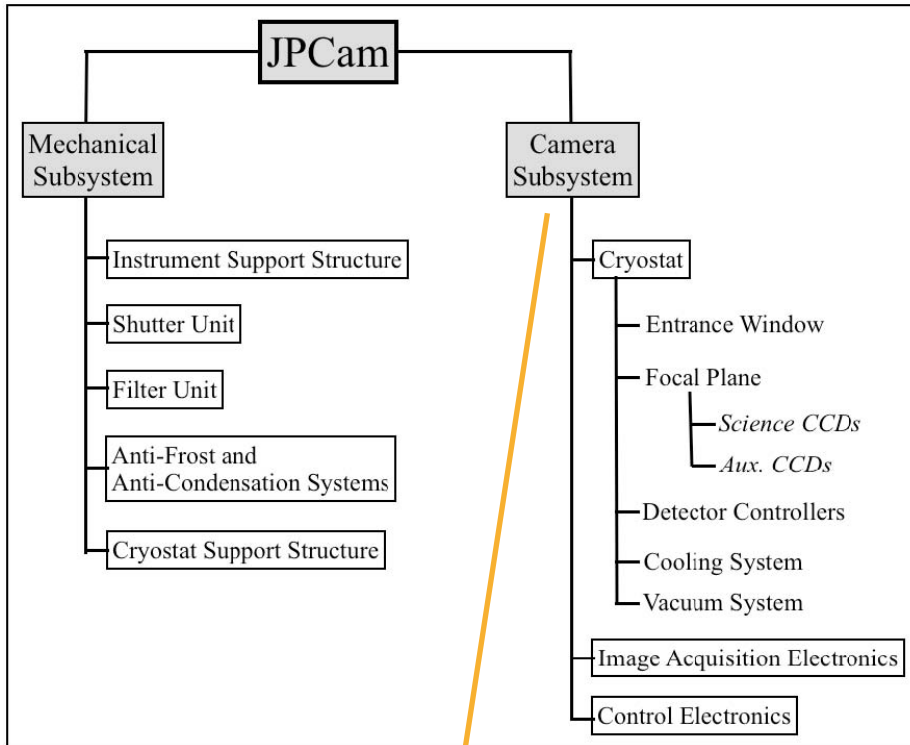
Cryogenic camera system for J-PAS 2.5 m telescope
Javalambre Physics-of-the-Accelerating-Universe Astrophysical Survey

Concept design of the camera is described-

- Science, Autoguide, & WFS CCDs integrated into precision focal plane
- Integrated pumping, LN2 cooling, vacuum cryostat, and control system
- Custom local electronics designed for 4 e- read-noise from 224 science channels
- Digital signal sampling [DCDS] and 1.2 G-pix science data frames

Shutter, filters, camera mounting to telescope not included

Summary of Requirements



e2v provides “Camera Subsystem”

Primary Requirements

- 14 Science CCDs; 3° FOV; 476 mm Φ
- 9216 X 9216 10 um pixel science CCDs
- Low read-noise and < 10 s readout time
- 12 aux. CCDs for guiding & image quality
- Control electronics & multiple modes
- Volume & mass limits for camera specified
- Design for reliability & 10 year (min.) use
- Precision focal plane location & flatness
- Cryogenics, vacuum and thermal control

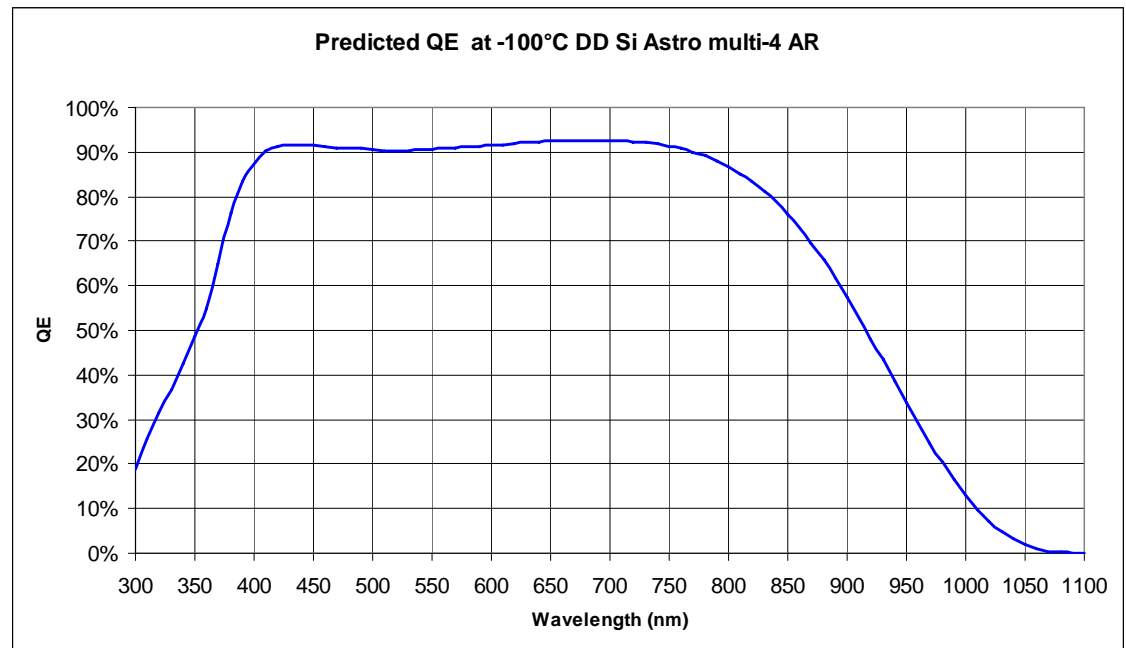
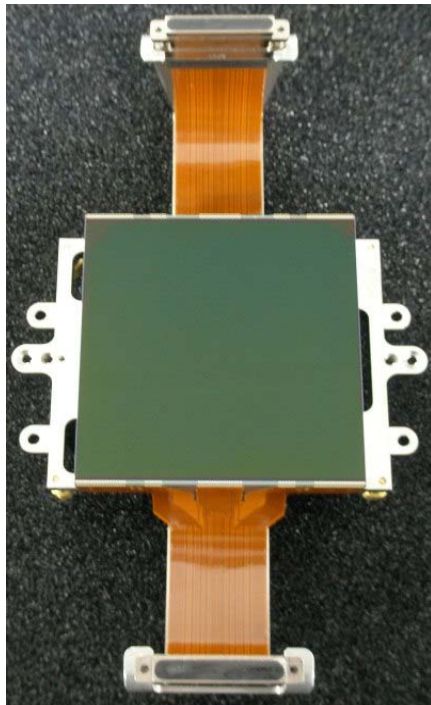
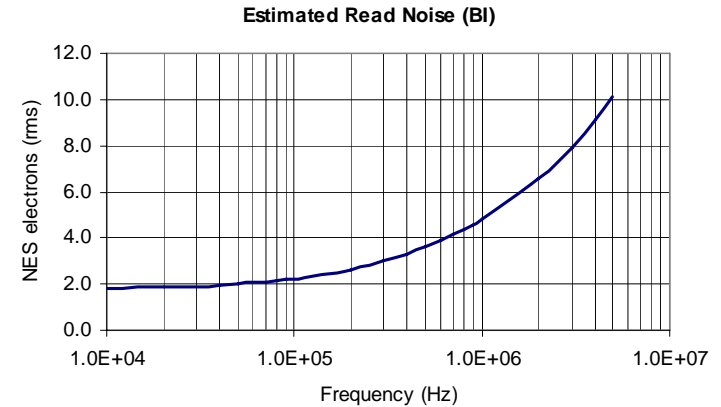
Camera has interfaces to Cryostat Support Structure, filter/shutter unit, telescope

CCDs -1

CCD290-99 Fourteen Science CCDs

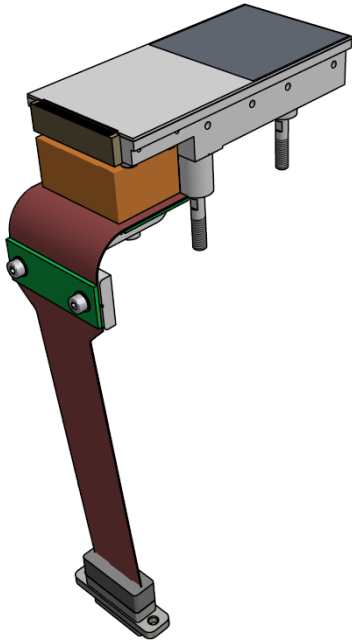


- 9216 X 9216 10 um pixels
- 92 X 92 mm size
- 16 outputs
- 10 second readout at 500 kHz
- Backthinned; deep depletion; multi-4 AR coating
- 2 e- read noise floor [single output; 50 kHz]
- Precision flatness, SiC buttable package



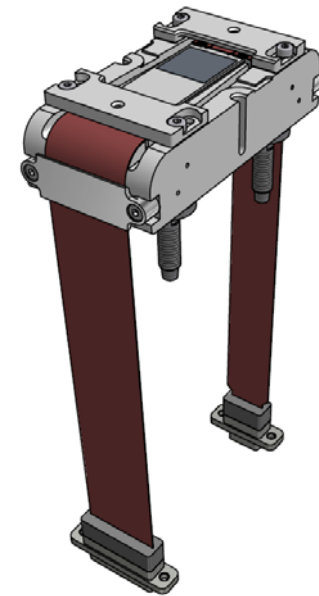
CCDs -2

CCD44-82 (image quality) and CCD47-20 (guiders)



Both types-

- Custom packages
- Flex cable connectors
- Low noise [5 e- goal]
- Differential outputs used



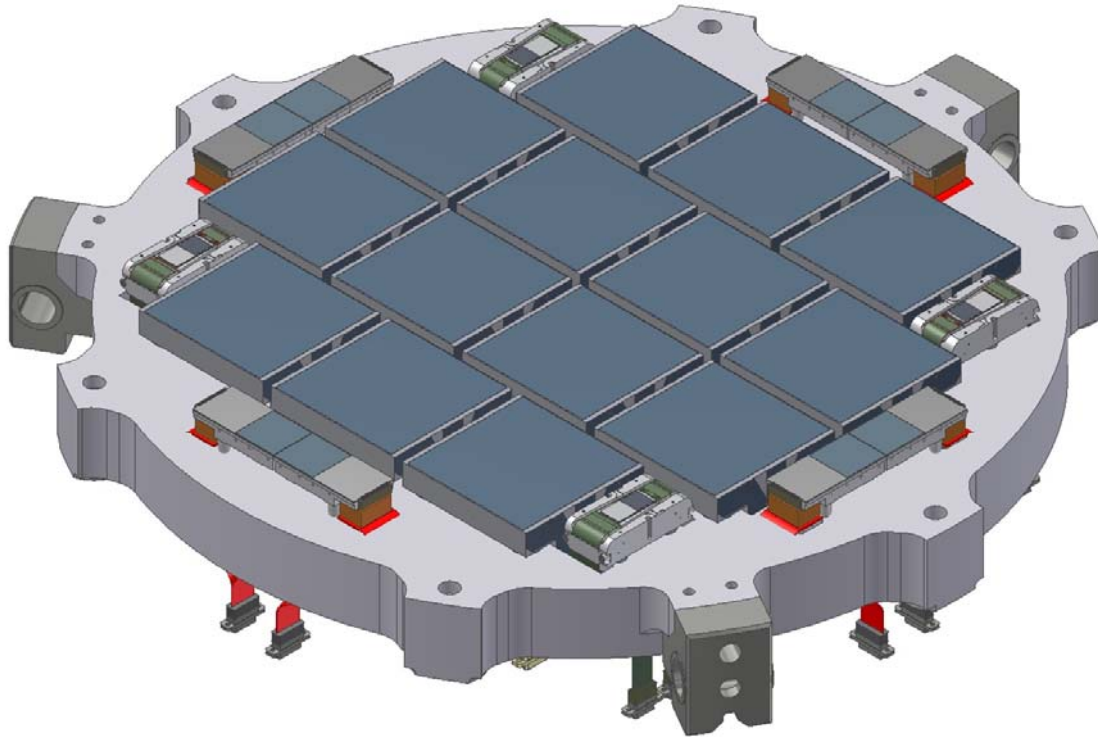
Wavefront sensors- CCD44-82

- 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

Focal Plane Assembly- 1

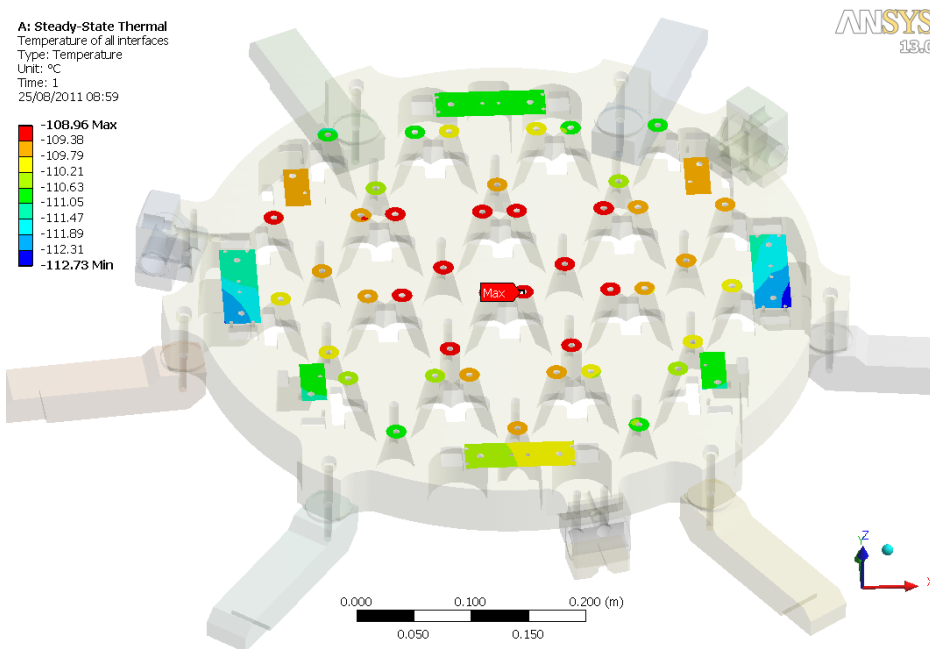


14 science CCDs (9k9k)
4 guide CCDs (1k1k FT)
8 WFS CCDs (2k2k FT)

40 um p-v flatness overall
173K nominal operation
Height/tilt adjusted in cryostat

500 mm Φ assembled cold plate with CCDs

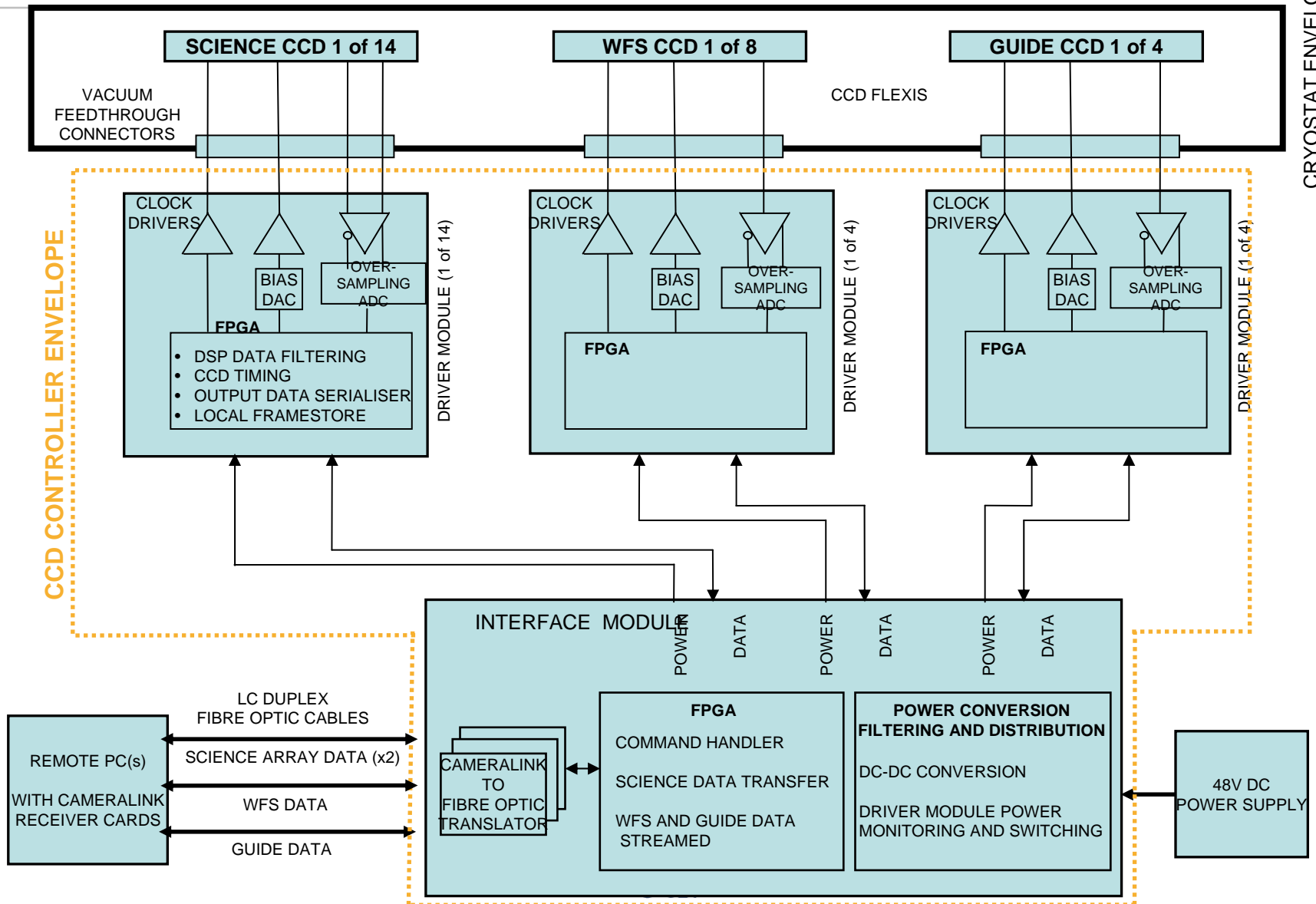
Thermal/structural FEA modelling \leftrightarrow detailed design \leftrightarrow customer agreement



- Concept design
- Modelling
- Detailed design
- Manufacture
- Assemble
- Test, including Metrology
- Iterate (we hope not!)

CCD electronics- 1

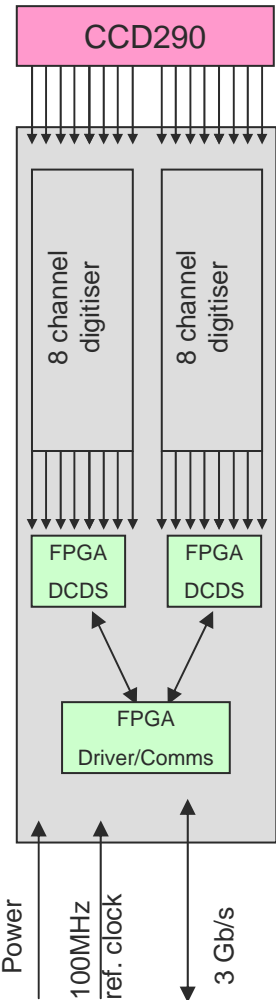
The CCD system- controller architecture



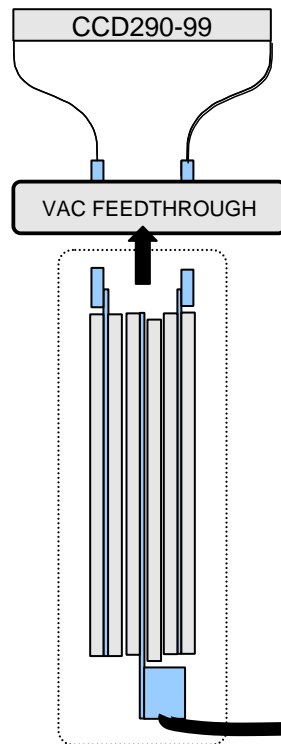
CCD electronics- 2

Drive module

CCD DRIVE MODULE COMPONENTS (1 of 22)



CCD DRIVE MODULE LAYOUT (1 of 22)



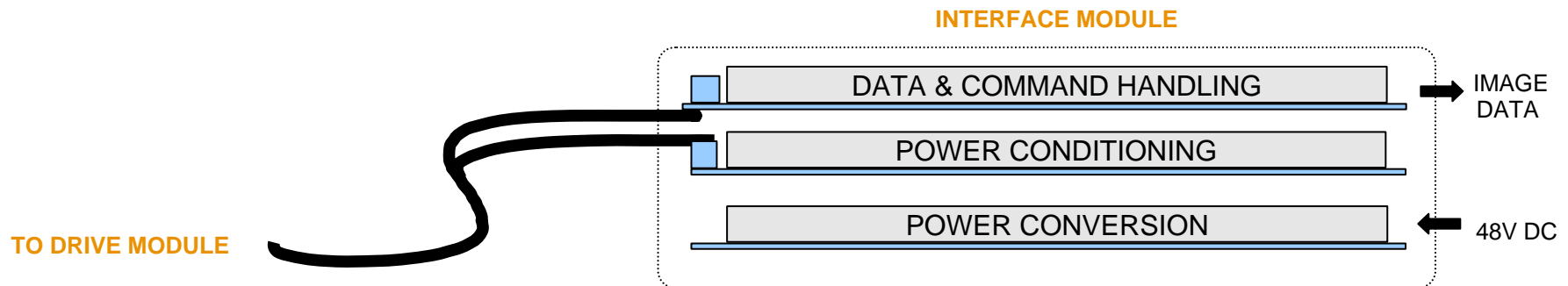
Drive Module

- One for each science CCD; one will drive two WFS CCDS
- Drives and processes the analogue video from one CCD290-99
- Power dissipation 35W; water cooled
- 8-channel digitiser card- designed by RAL
- Bridge board designed by e2v (timing, clock driving, framestore)
- Includes data and power connections to the Interface Module

See RAL reference later for DCDS system

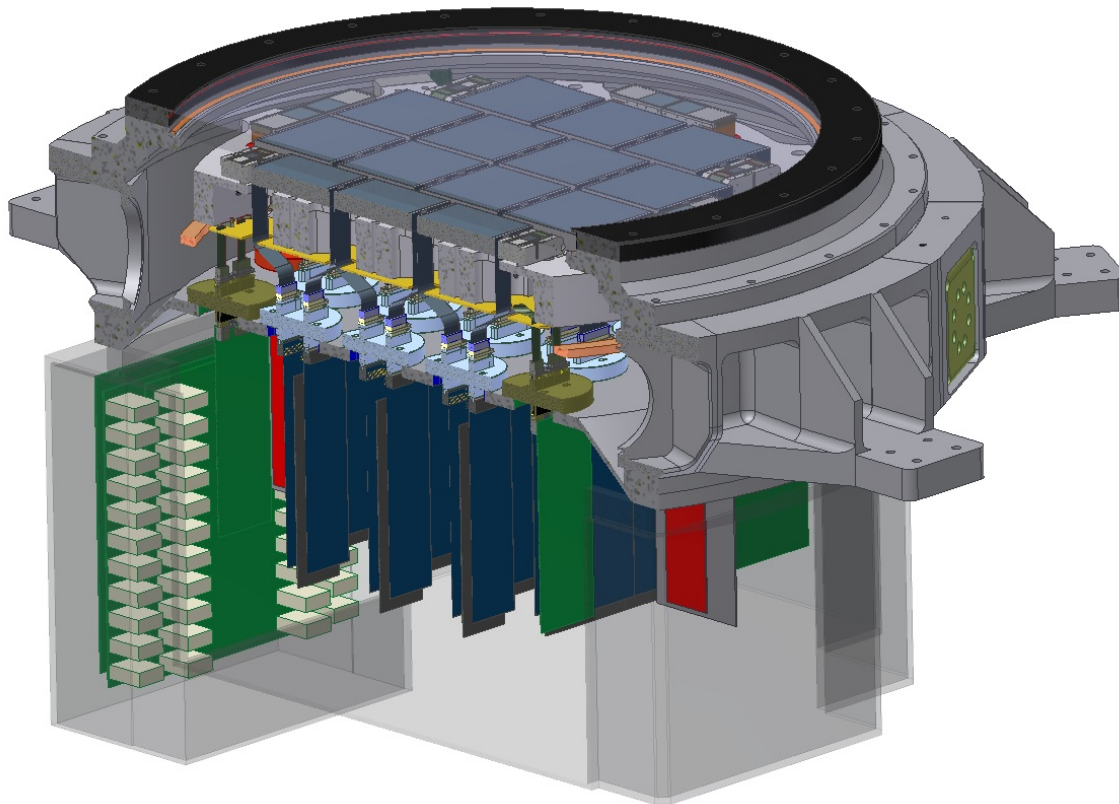
Interface Module

- Hub for CCD data & transfer to control PCs
- Generates multiple voltage rails from incoming 48V
- System monitoring



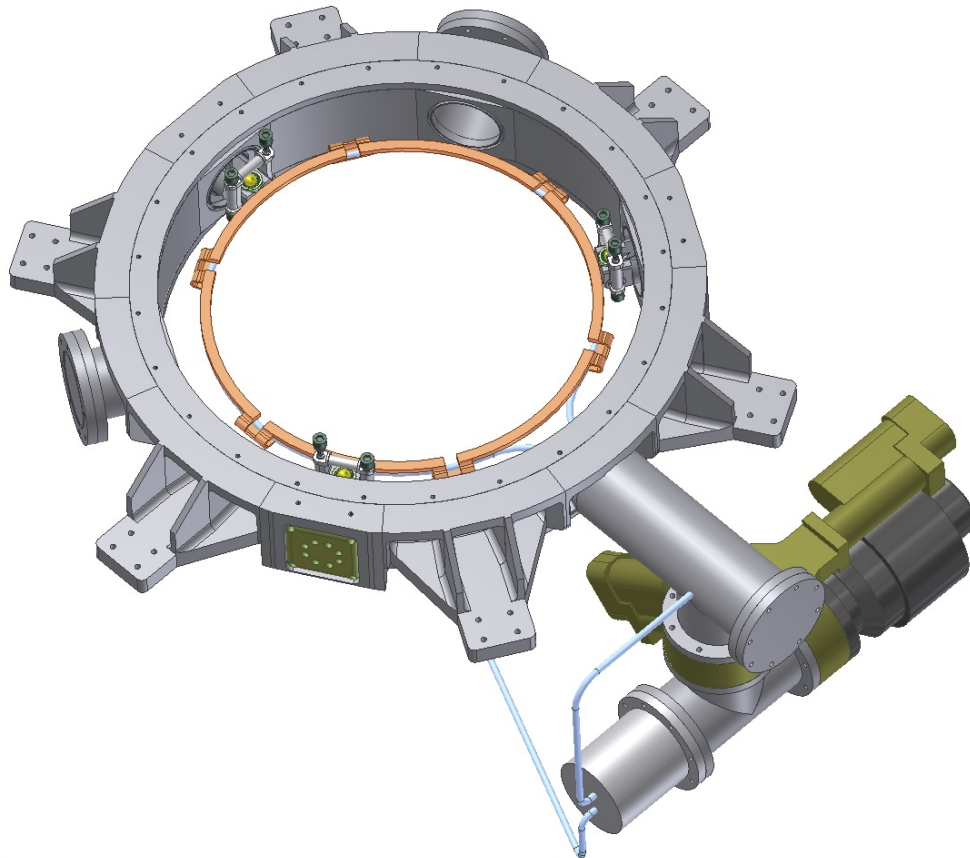
CCD electronics- 3

Mechanical layout



Main features

- Short flex cables in vacuum-
From CCD to vac. conn.
- One vac. connector per CCD-
All mounted to sealing plate
- Multiple drive modules with
one interface module-
At ambient & water cooled
- Simple connections externally-
Power and fibres only



Liquid nitrogen cooling

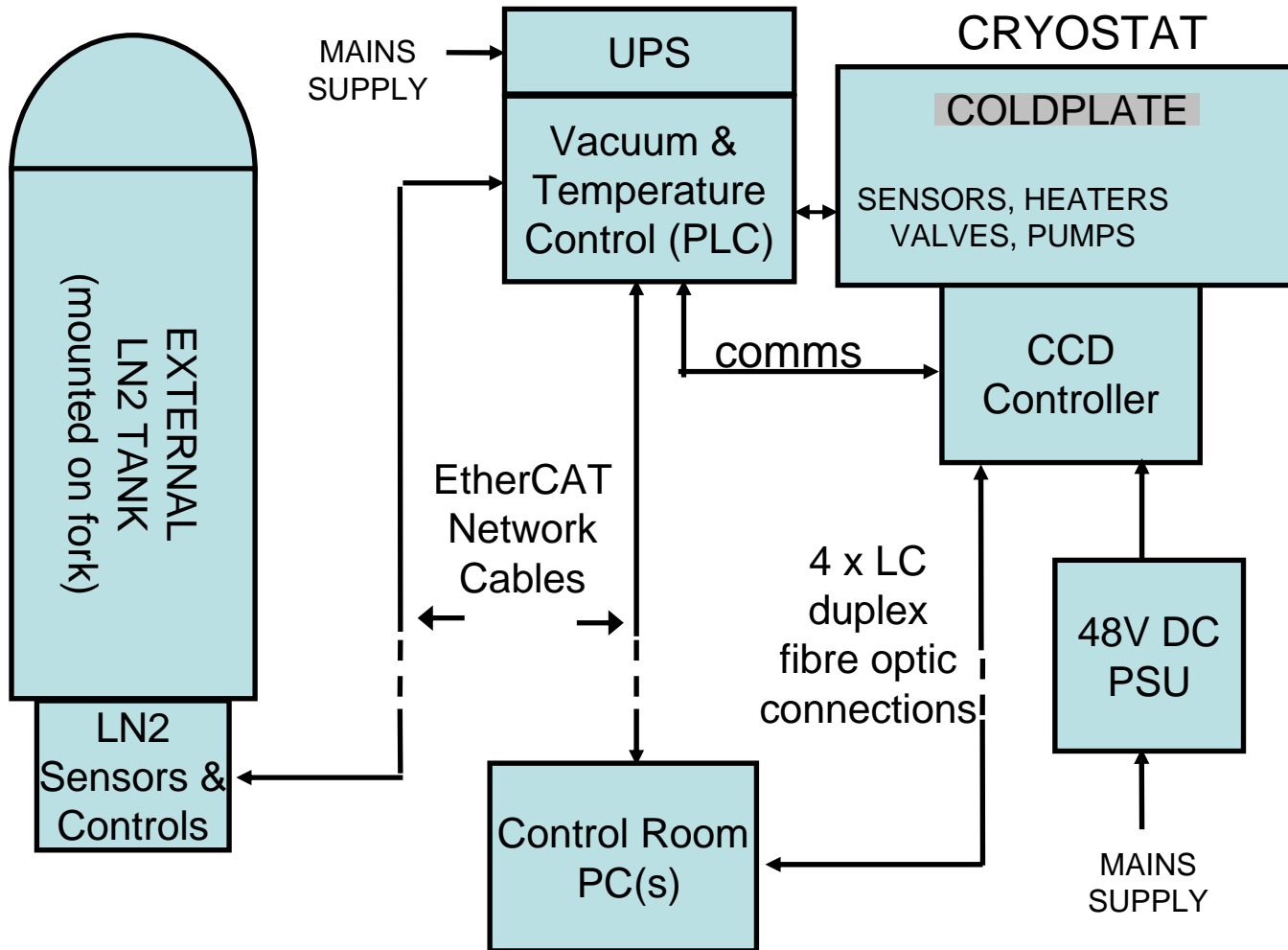
- Liquid/gas piped from remote LN2 Dewar
- Two rotary couplings for cryogen
- Cryogen passes through sorption pump into chamber
- Cryogen cools copper ring which attaches to focal-plane plate

Vacuum-

Turbo pump & gate valves for sorb isolation during regeneration

The camera system-1

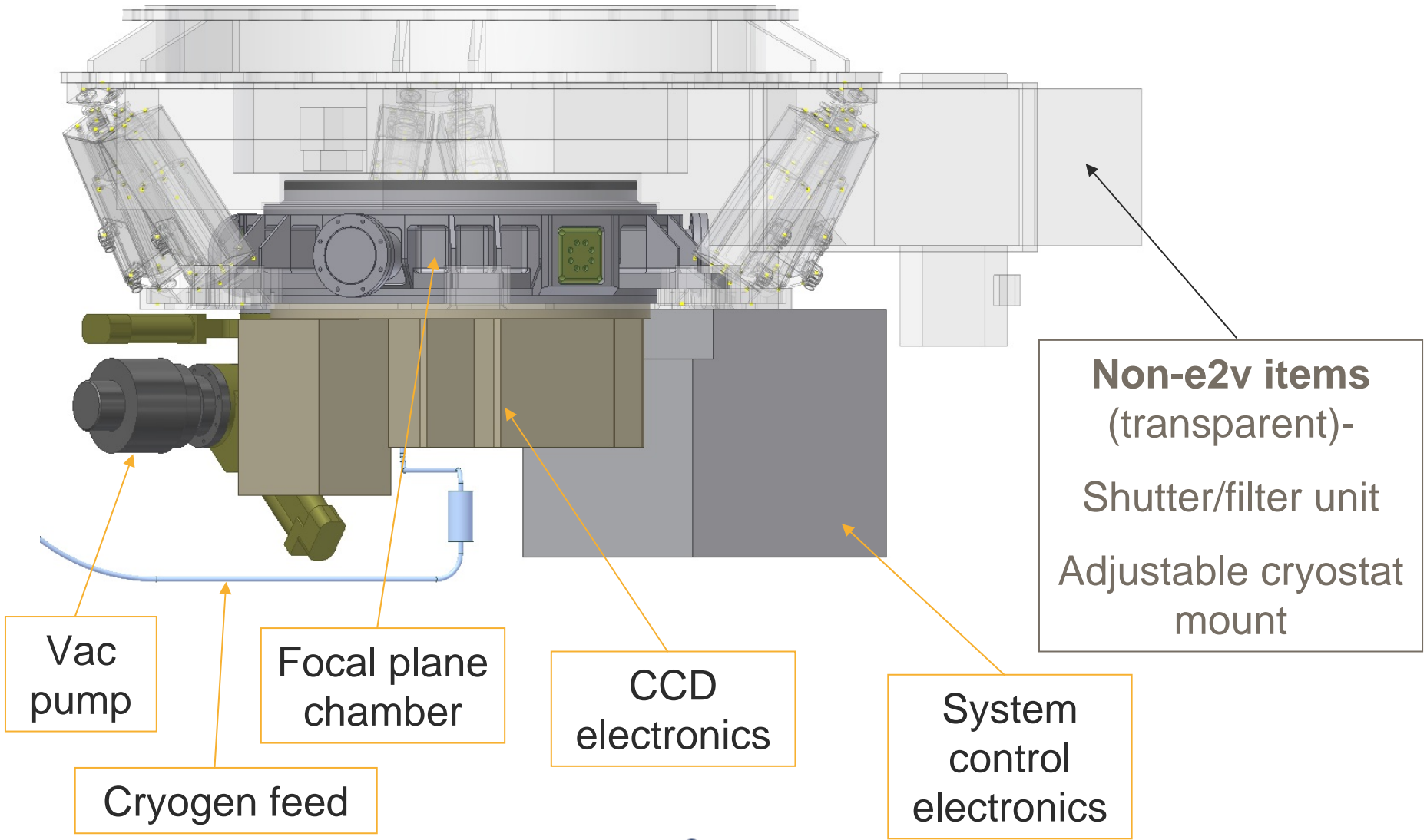
System components



- Custom LN2 cooling system
- Thermal control of focal plane
- Vacuum control
- CCD electronics
- Designed for telescope operation

The camera system- 2

Mechanical layout



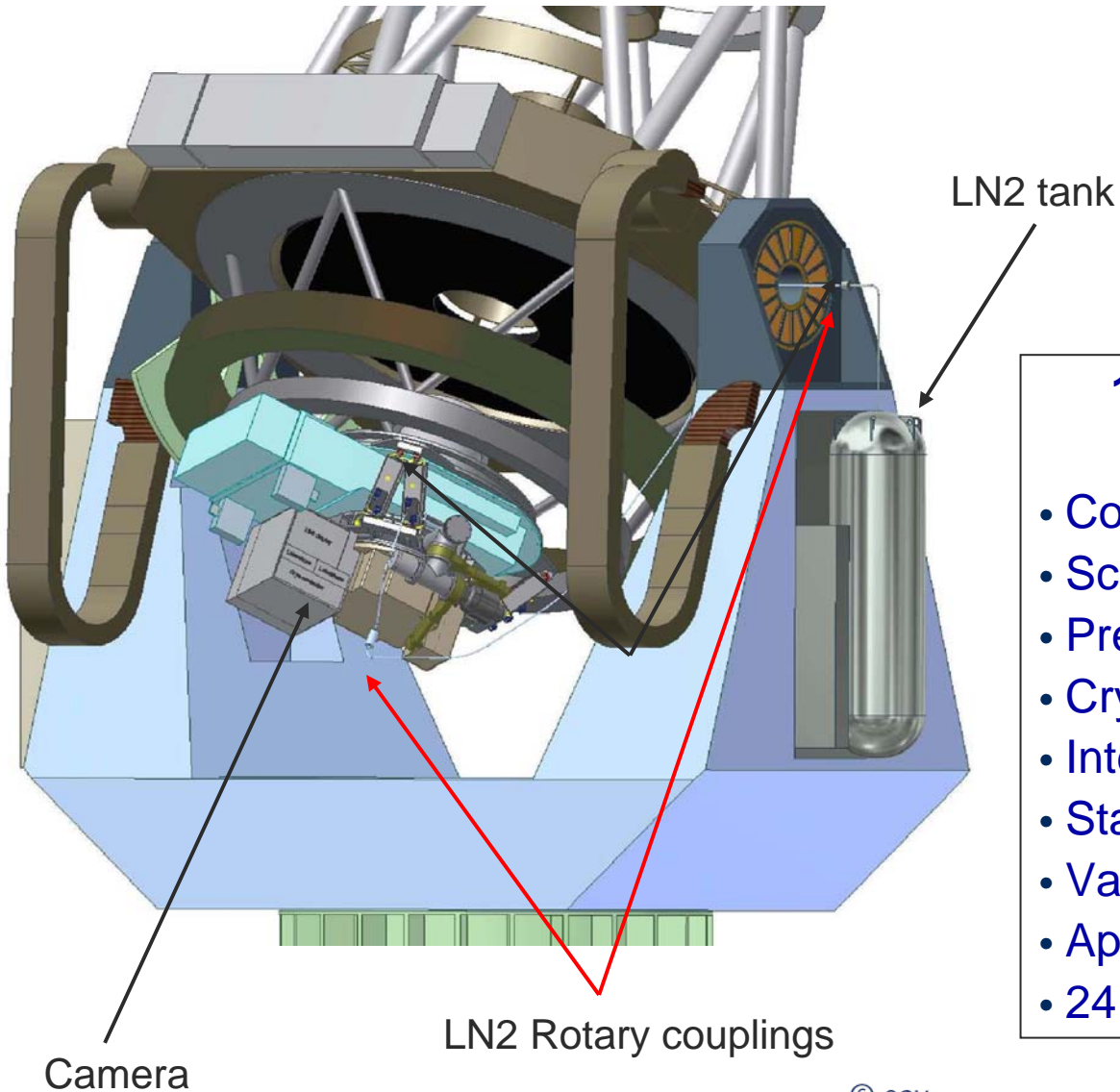
Challenges

- Set of wafer-size CCDs; high performance and guaranteed specifications
- Design and make precision FPA; assemble very carefully!
- Design and make a 224-channel low-noise electronics system
- Lots of data handling, throughput, and storage
- Design & make a novel large cryogenic camera- with high stability in use
- Handling a large heavy structure in clean room conditions

Lots of customer interfaces

- AMOS \ telescope mounting, cabling, services, access
- CEFCA \ Observatory coordination & telescope specifications
- Other J-PAS members or sub-contractors (design & manufacture)
\ Shutter & Filter unit, Cryostat support unit, etc

J-PCAM on 2.5 m telescope



1.2 GPix camera summary

- Complete astronomical camera
- Science, Guide, & WFS CCDs
- Precision Focal Plane Assembly
- Cryogenic FPA cooling included
- Integrated CCD electronics
- State-of-the-art performance
- Vacuum system included
- Approx 600 kg weight
- 24 month programme

J-PAS collaboration-

- Centro de Estudios de Física del Cosmos de Aragón (CEFCA), IAA-CSIC, IFCA
- Universidade de São Paulo (USP), Observatorio Nacional de Río de Janeiro (ON)
With funding agencies in Brazil and Spain.

Others organisations involved-

- AMOS, CEFCA, RAL

Thanks to-

- Numerous e2v colleagues associated with J-PAS project
- Numerous members of J-PAS & associated organisations (as above)
- Jean-Louis Lizon (ESO) for advice

Other references-

- M Clapp, RAL, “Development of DCDS readout system..”, 8453-49, this conference
- Taylor et al, “JPCAM...”, 8446-36 this meeting, 2012. Other AS12 J-PAS papers also
- www.e2v.com
- <http://j-pas.org/>
- See also Atwood et al, 8446-246, KMTNet large format CCD camera