UK PP Community & LSST

Edinburgh (Clarke)

Imperial (Colling, Egede)

Lancaster(Love, Jones)

Liverpool (Barrett, Bowcock, Mehta)

Manchester(Pilkington, Price)

Open (Skottfelt, Stefanov, Holland)

Oxford (Azfar, Shipsey*, Tseng)

Swansea (Tasinato, Zavala)

UCL (Korn)

* LSSTUK:PP Spokesperson

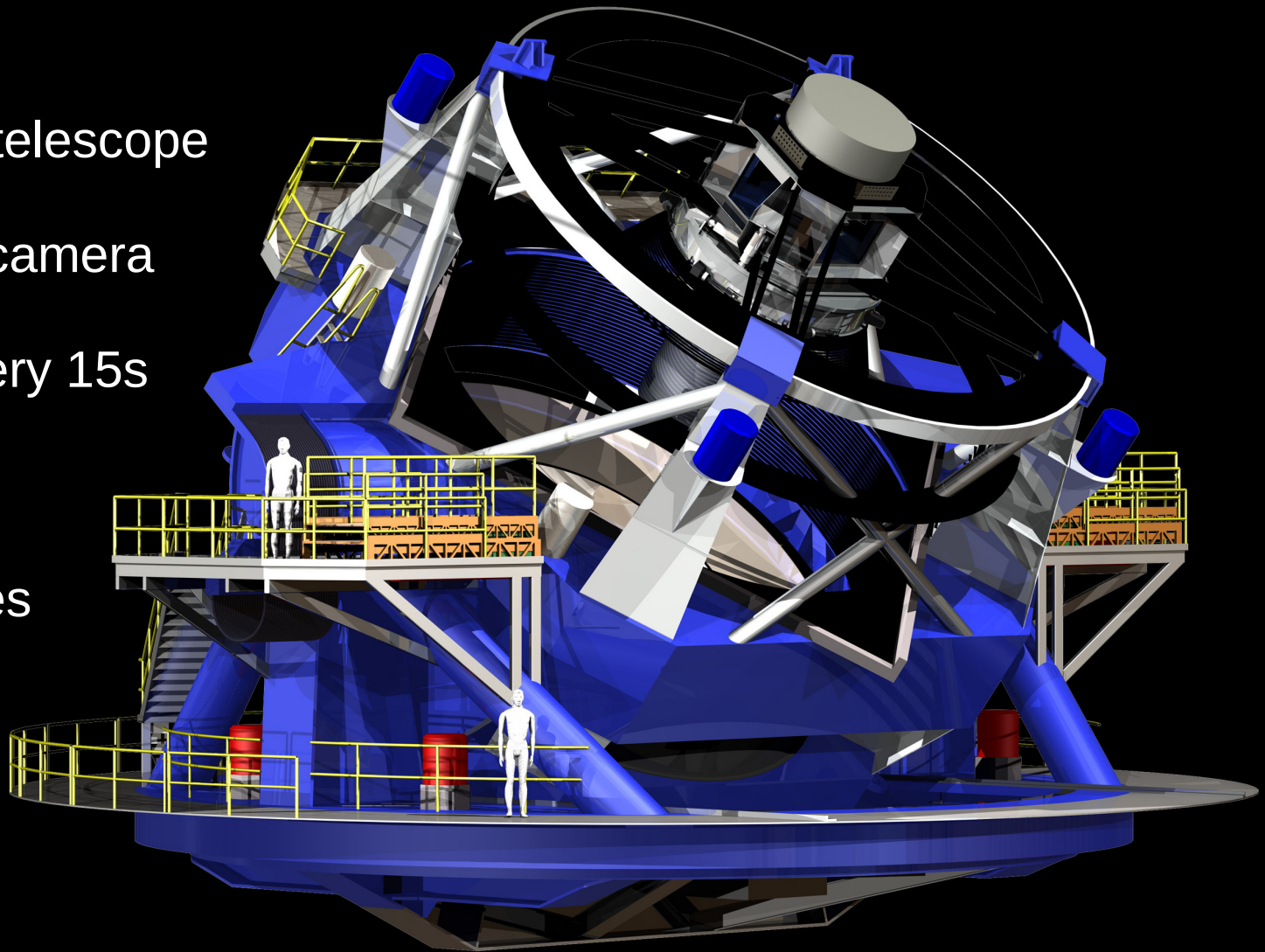
Andreas Korn (UCL)

The Large Synoptic Survey Telescope in a nut shell

Synoptic = Big Picture

LSST: an integrated survey system designed to conduct a decade long, deep, wide & fast time domain survey of the optical sky

- 8 m wide field ground based telescope
- 3.2 GigaPixel camera
- new image every 15s
- >15 TB/night
- 5 million images
- > 100 PB

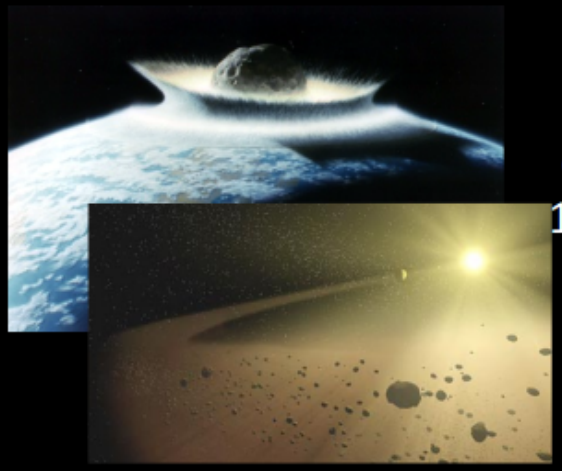


LSST 4 Science Missions

Dark Energy-Dark Matter

Multiple investigations into the nature of the dominant components of the universe

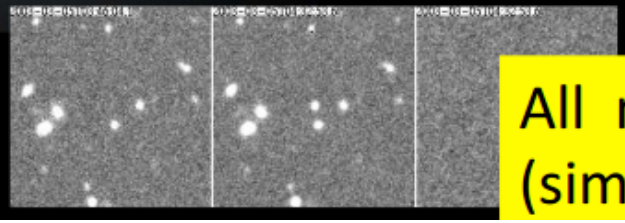
Inventory of the Solar System



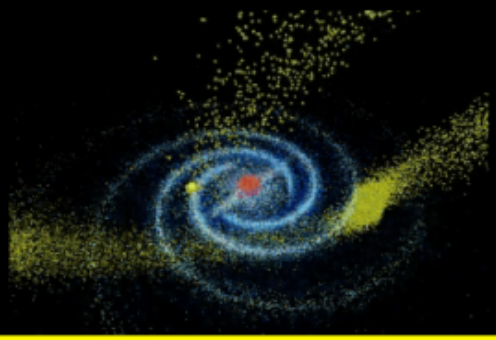
Find 82% of hazardous NEOs down to 140 m over 10 yrs & test theories of solar system formation

"Movie" of the Universe: time domain

Discovering the transient & unknown on time scales days to years



Mapping the Milky Way



Map the rich and complex structure of the galaxy in unprecedented detail and extent

All missions conducted in parallel
(similar to a general purpose expt @ LHC)

UK participation in LSST

LSST: UK Consortium
(All UK astro groups)

+9 particle physics groups

UK largest national group after the US

ROYAL ASTRONOMICAL SOCIETY

YOU ARE HERE: Home > Event Details

RAS@200

The Large Synoptic Survey Telescope

Time	Title	Speaker
10.45	LSST project status	Beth Willman (LSST) & Ian Shipsey (Oxford), presented by Andy Lawrence (Edinburgh)
11.20	Solar System	Wes Fraser (QUB)
11.40	Transients and Variable Stars	Mark Sullivan (Southampton)
12.00	Stars, Milky Way and Local Volume	Phil Lucas (Herts)
12.20	Galaxies	Sugata Kaviraj (Herts)
12.40	Active Galatic Nuclei	Carole Mundell (Bath)
13.00	Lunch	
14.00	Dark Energy Science	Benjamin Joachimi (UCL)
14.20	Informatics and Statistics	Jason McEwen (UCL)
14.40	Synergies with Euclid and SKA	David Bacon (Portsmouth)
14.55	Follow-up with Liverpool Telescope 2	Chris Copperwheat (Liverpool JMU)
15.10	LSST and UK particle physics	Ian Shipsey (Oxford)
15.25	Wrap-up	

PP becoming well-integrated

LSST RAS Specialist meeting
May 12, 2017
Well attended by PP members who played a prominent role in the meeting

PP interests in LSST & expertise

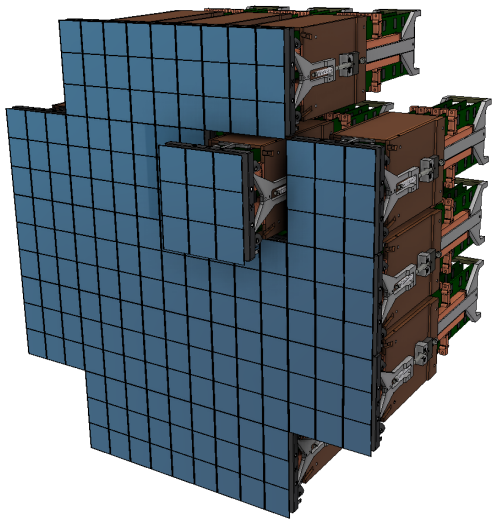
- Science
  - PP Standard Model describes only 5% of the universe
  - Open question: nature of dark matter & dark energy
  - LSST probes DM, dark energy & neutrino masses
- Technical expertise
  - Complex detectors (sensors, DAQ)
  - Big Scale Computing (GridPP, UK data access centre)
  - Big Data handling & analysis (data bases, simulation)
  - Algorithms

→ Skills well matched to LSST

  - In the US: significant fraction of particle physicists on the LSST project (¼ of construction funds from DOE)
  - UK PP adds complementary value to UK AST LSST contributions → helps secure UK science leadership

Oxford

Sensor characterisation



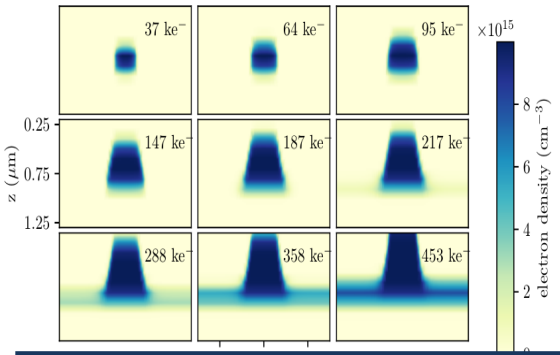
LSST CCD Camera (3 Gpix) largest ever constructed for astronomy

Thick 100 micron red-sensitive full depletion CCDs grew out of SSC silicon work in 1990's.

Raft construction underway at BNL. 1st rafts now complete.

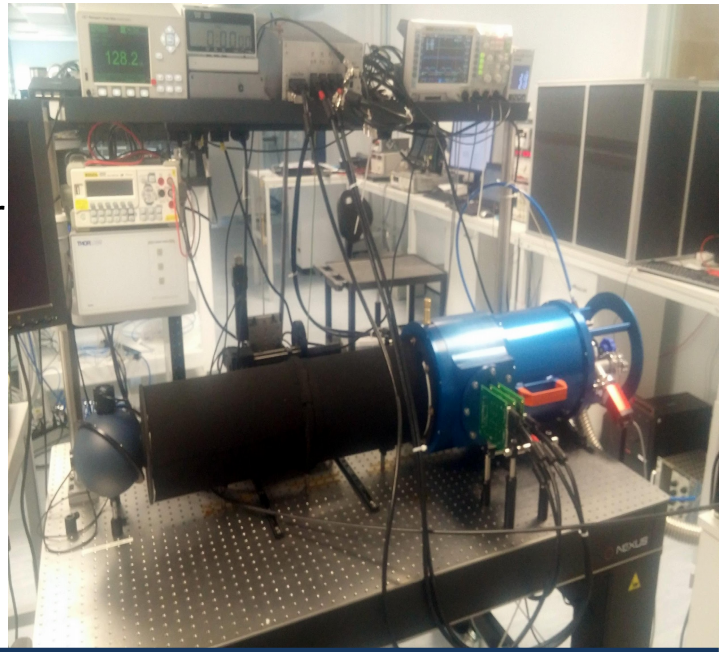
Optical test stand built in Oxford lab, assisting in detailed characterization of sensor performance.

Currently investigating sensor full well over large parameter space of operating conditions



Charge storage simulation (Weatherill et al JINST 2017)

Working on sensor simulation effort – particularly on charge storage in pixels



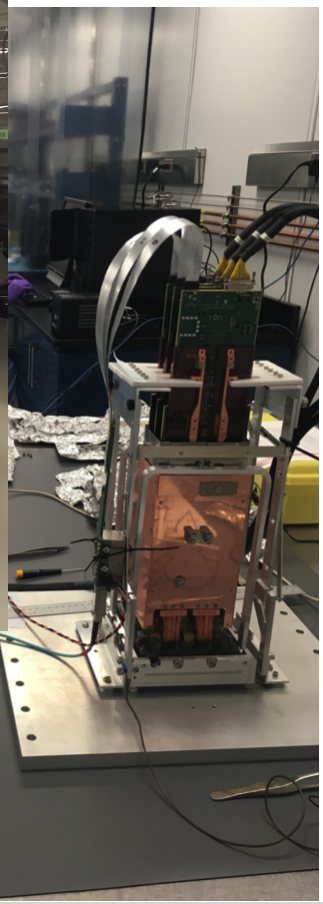
Optical test stand in Oxford lab

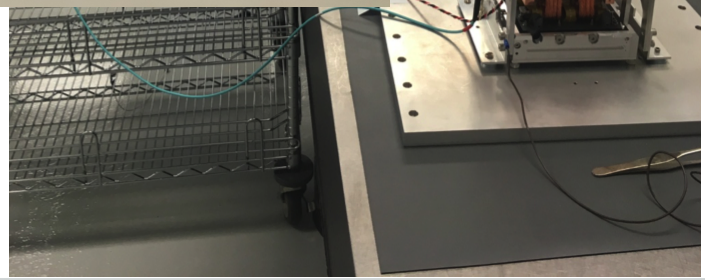
Oxford

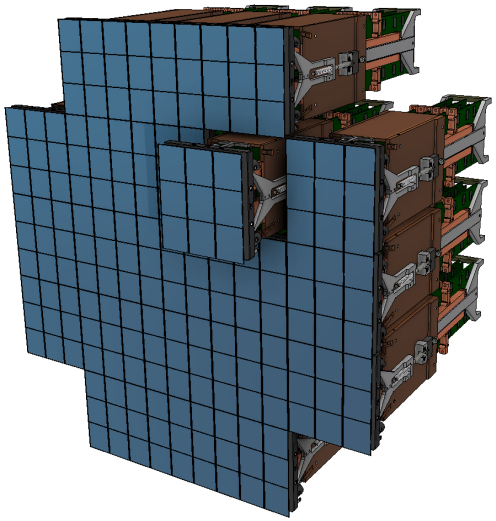
Weatherill

Building Camera Rafts at BNL

part of the BNL team, with
Dan Weatherill (LSST UK postdoc)







First raft delivered to SLAC!

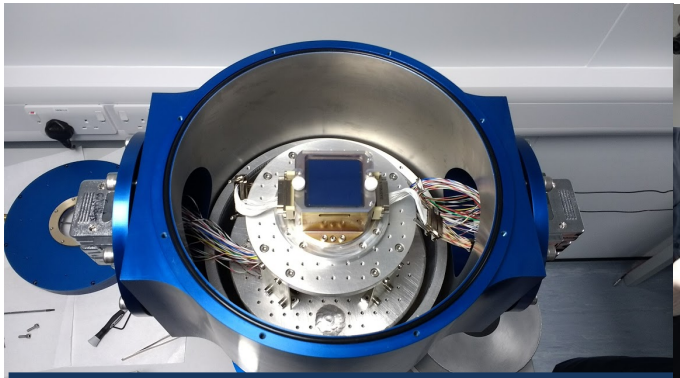
Sensor characterisation

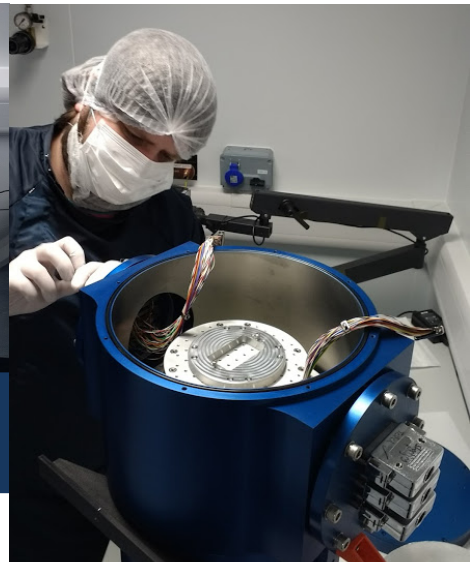
Oxford

Hardware testing individual sensors in cleanroom at OPMD facility in Oxford

Contributing expertise and testing to optimisation of readout sequence for LSST CCD
– critical for best performance.

Collaboration:BNL, Davis, Paris & SLAC.



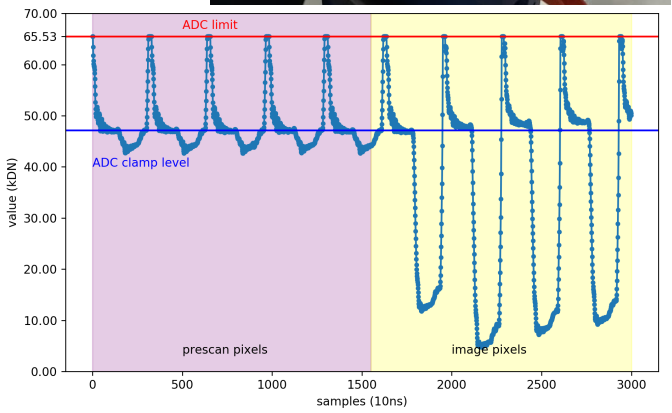


Installation of Teledyne e2v CCD in cryostat at Oxford

Oxford Stand Is uniquely low-noise, low-vibration

Oxford test system can illuminate CCD with monochromatic flat field, projected spot optical light or Fe-55 source X-rays.

Fe-55 clusters incident on Teledyne e2v CCD



CCD pixel raw output

Sensor modelling from TCAD

Open U.

(Skottfelt, Stefanov, Holland

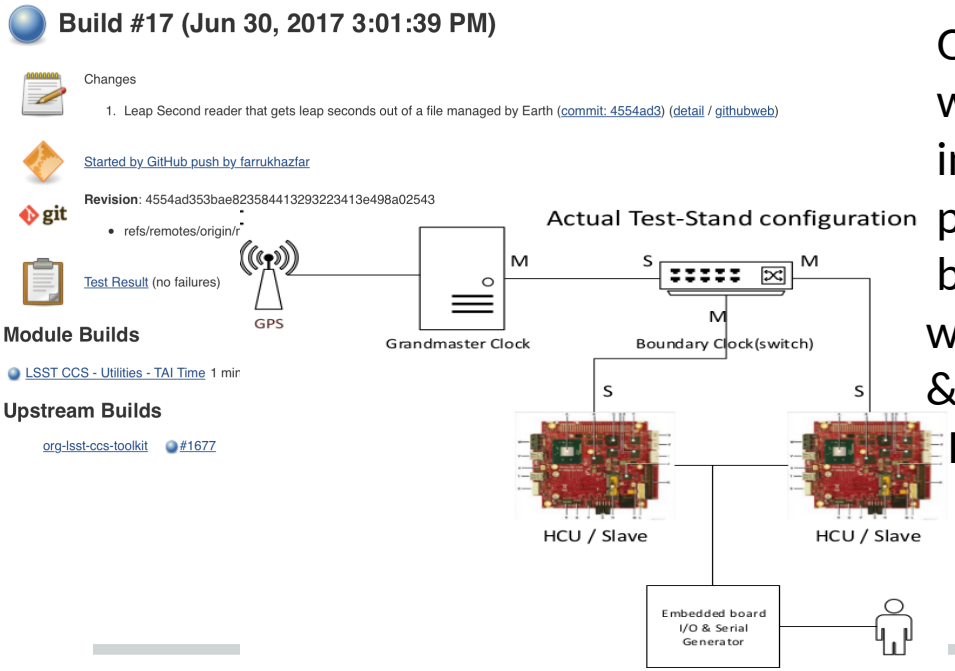
- Impact of sensor effects on cosmic shear estimates is not fully understood
  - More work is needed to develop a reliable estimate of the additive bias from sensor effects (including anisotropy and chromaticity)
- Brighter-fatter effect models may need a factor of 10 improvement in accuracy
- Present models don't include detailed sensor parameters such as doping profiles
- Proposed work to include detailed CCD information based on manufacturing input
  - Collaboration between the Centre for Electronic Imaging (CEI), Teledyne e2v and Oxford
  - Goal is a BF model accurate to ~1%, using FEA electrostatic modelling in 3D TCAD and single electron tracing
  - The model will describe both the amplitude and the statistical behaviour of the charge collection process, and will be validated experimentally
- The long-standing collaboration agreement between the CEI and Teledyne e2v gives access to proprietary device information not available to competitor institutions, and crucial for this work.
- The CEI would also be able to contribute to the optimisation of the CCD operation

Oxford

Camera Control System (CCS)

Abi, Azfar

- Precise time synching (Babak Abi, Farrukh Azfar):
- CCS actions must be time stamped across all platforms and users to ms accuracy using **Temps Atomique International (TAI) time** (GPS & a grandmaster clock & master PC to distribute time), A test stand in Oxford will help evaluate, setup and benchmark the system
- Requisite software interface and classes (Java) complete and ready for use by final system
- Observatory Control System (OCS) software & CCS exist as separate entities
- OCS must provide users a way to control CCS seamlessly
- A “bridge” is needed to translate and communicate commands



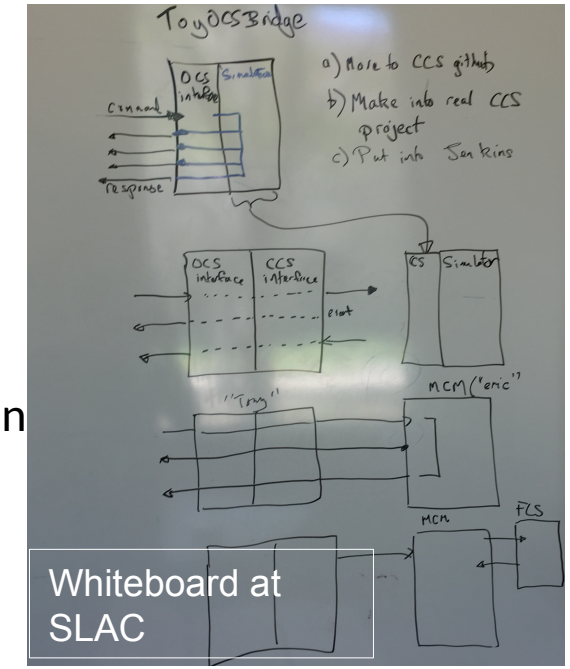
Oxford has begun work on a simulated implementation to produce the OCS-CSS bridge in collaboration with U.Paris Diderot & SLAC

People :

Oxford : F. Azfar

Paris : Eric Aubourg,

SLAC: Tony Johnson

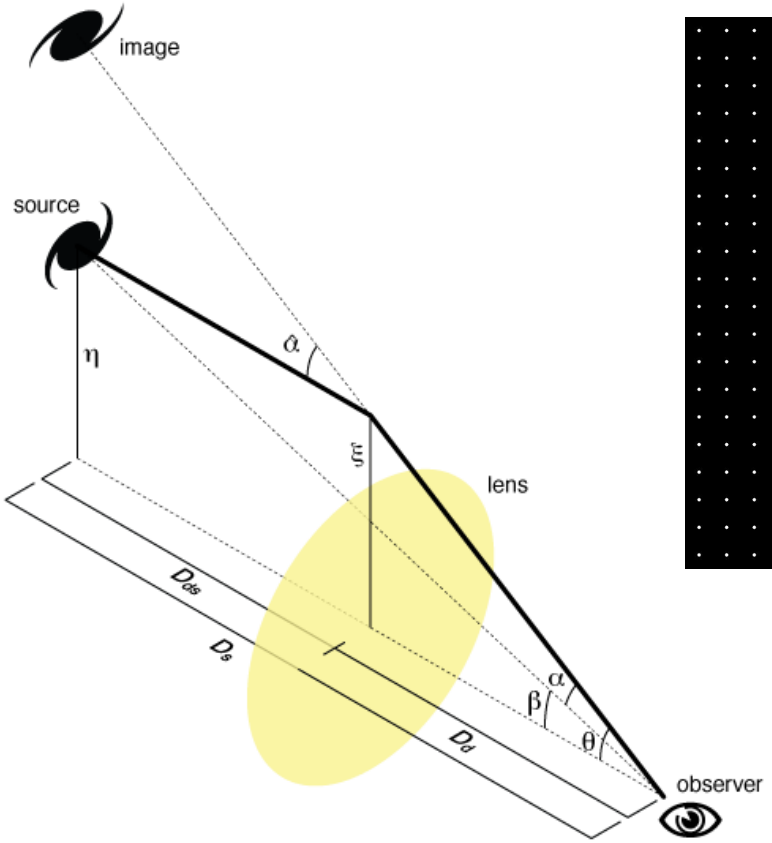


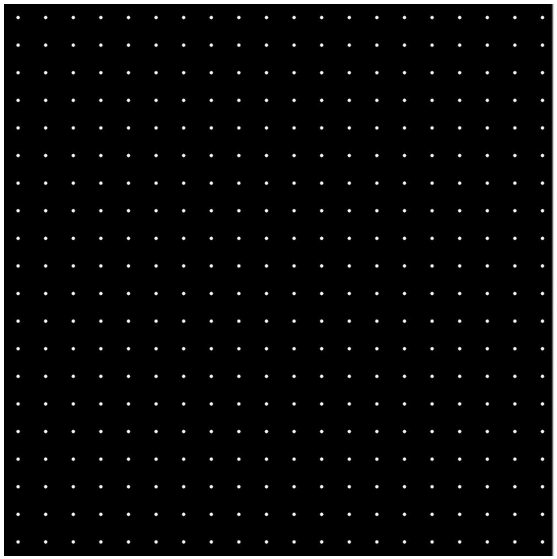
Astro & PP Synergies @ UCL

UCL

- Cooperate with a strong LSST Astro group at UCL:
  - Benjamin Joachimi, Hiranya Peiris, Ofer Lahav, Jason McEwen, Tom Kitching
- Relevant HEP expertise at UCL:
  - Dark matter
  - Data Acquisition
    - Strong group at UCL (electrical engineers)
    - LSST COB/RCE platform exists at UCL
  - Big Data Analysis (multivariate analysis, grid)
  - Centre for Doctoral Training in data intensive science
- Physics Interest:
  dark matter from lensing, online corrections/computations
- PhD student:
  Constance Mahony, co-supervised by B. Joachimi and A. Korn

Weak lensing magnification vs shear





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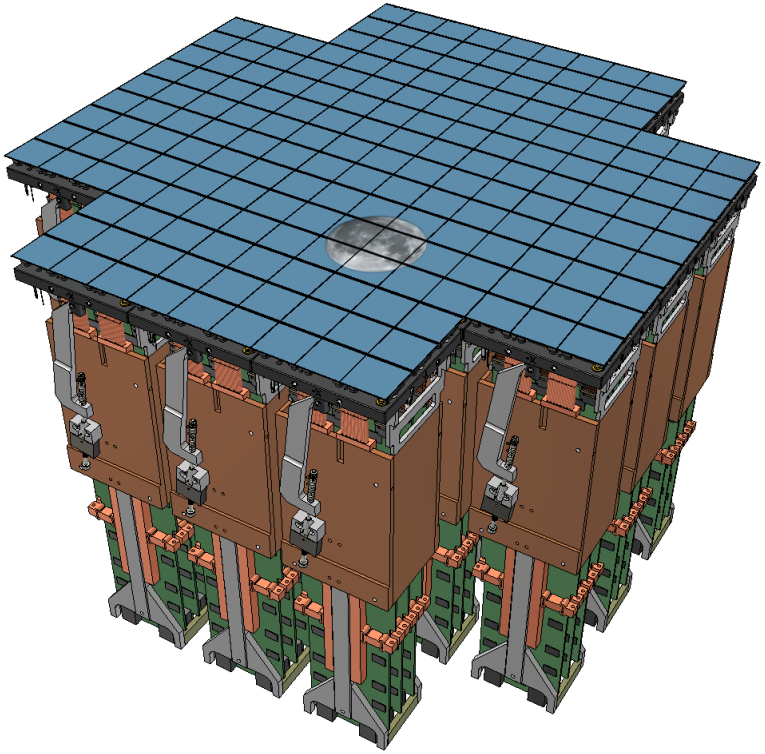
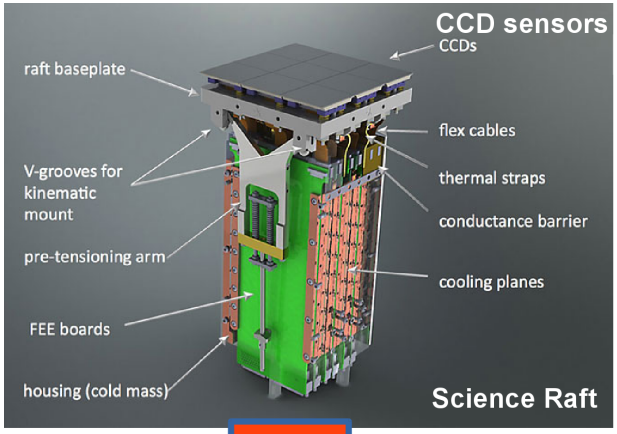
LSST Data Acquisition (DAQ)

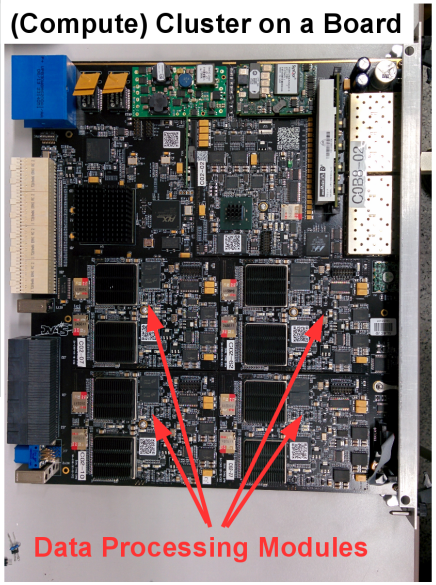
UCL
Oxford

Cluster on a Board (COB) used to route and preprocess LSST data
Toolkit planned to be used in ATLAS and DUNE
Test stands at Oxford & UCL allow development and testing of online processing software





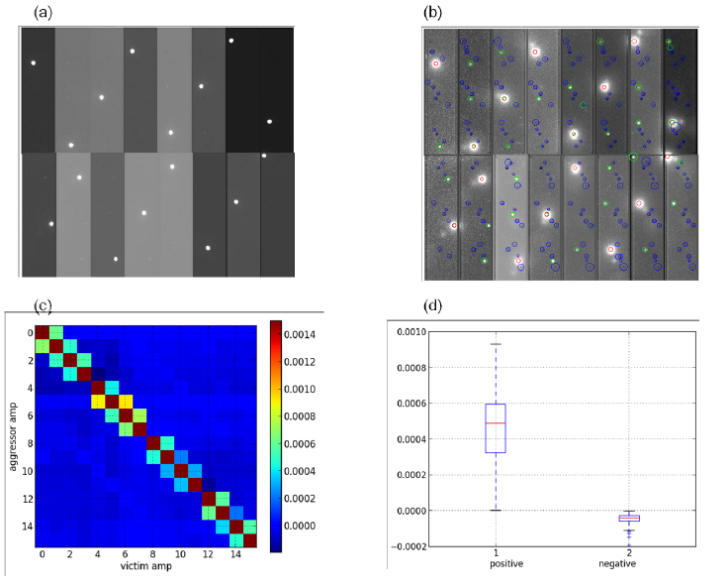
(Compute) Cluster on a Board



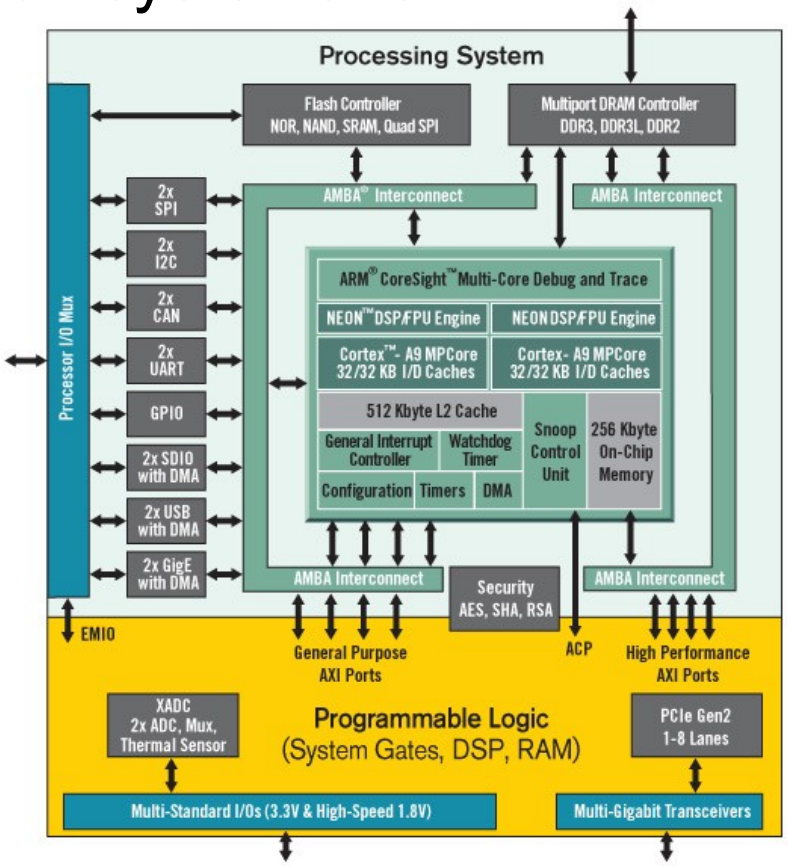
Connecting HW & physics

UCL

- UCL (Korn) contact with M. Huffer and G. Thayer at SLAC
- Plan: contribute to online cross talk correction on the COB → CCD performance: magnification systematic
- Use ZYNQ NEON co-processor on the RCE



From P. O'Connor arXiv 1501.04137

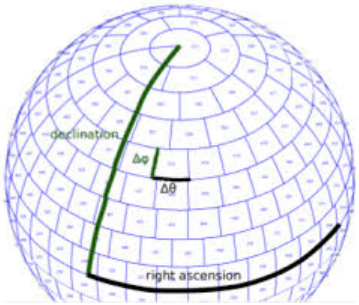


Oxford

Data management

Tseng, Gallas

LSST is developing *qserv* for managing multi-PB, distributed offline data products for trillions of detections



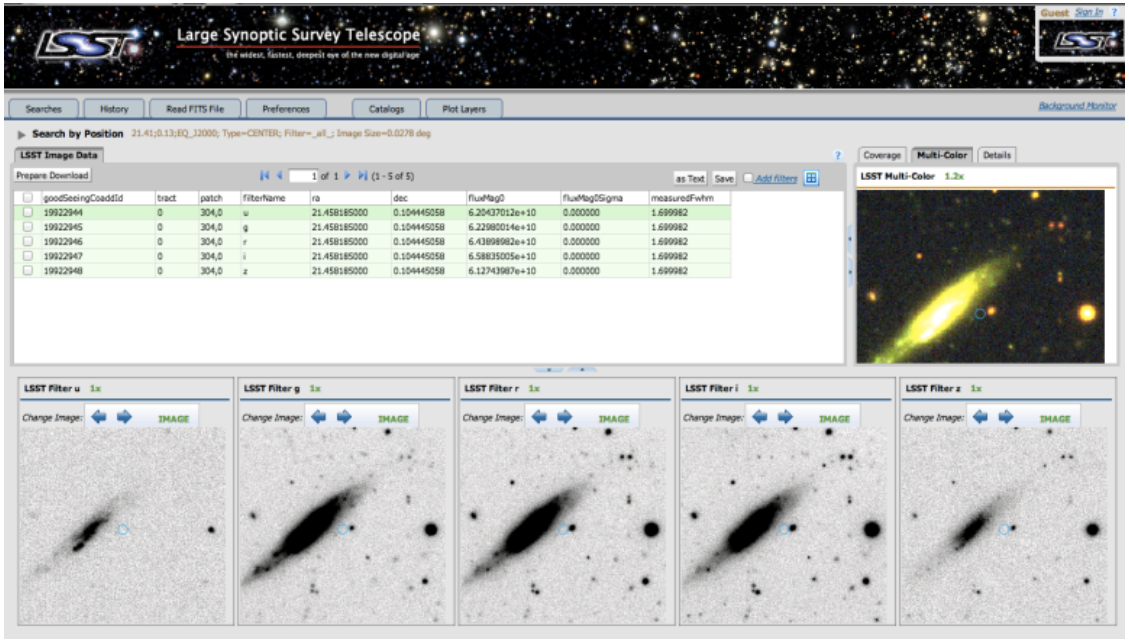
- Focus on SQL-like random access queries
- Oxford investigating query performance, construction
  - Mostly Tseng, small part of Gallas (ATLAS)
- Learning from past surveys and analyses
  - Historical SDSS queries, expected common LSST queries
  - Talking with astrophysics colleagues about past analyses for cosmology, large-scale structure, transients
    → improve understanding of actual analysis needs
- Currently focusing on how qserv transforms queries into workflows
  - Opportunities for optimization, and catch “bad” queries

GridPP for LSST

A joint LSST/GridPP technical post is in place, paid 50% by LSST to transfer expertise and technology. Working on developing the LSST UK Data Access Centre

A successful pilot (processing galaxy shears) has been developed as collaboration between Manchester astronomers (Zuntz, Bridle) and GridPP groups at Manchester, Imperial and Edinburgh

LSST-UK has requested GridPP to provide support for LSST-DESC at modest level (~ 2% resources). This has been possible using leveraged resources at collaborating sites.



Edinburgh/ Imperial

UK Tier 0

Clarke, Egede

Is an attempt to use the diverse landscape of existing STFC Computing resources (GridPP, DiRAC etc) in a more coherent manner to better serve the expanding range of STFC science.

So far unfunded so progress is slow and on a best effort basis.

If LSST is going to be able to exploit the science in the data there will need to be a considerable investment in computing, either as part of GridPP or a wider UK Tier 0

Workflow management & tools

Lancaster

Lancaster has expertise in the workload management and data flows, and are the UK experts on the Panda and BigPanda systems used by some of the LSST community in the US, and also working in the general on workload/job management. Lancaster also have expertise in resource predication and computing models.

Manchester

LSST @ Manchester

Manchester astronomers heavily involved in DES and LSST

Manchester Particle Physicists heavily involved in ATLAS, LHCb, DUNE, all of which are data-intensive projects

New collaborative efforts to focus on joint computing efforts efforts between the astronomy and particle physics groups

- Use of GridPP resources for DES/LSST analysis was initially developed by A. Forti, S. Bridle and J. Zuntz
- Similar effort for SKA by A.McNab and A.Scaife

New Centre for Doctoral Training in Data Intensive Science means opportunity for interdisciplinary research, focussing on

- *New analysis of existing data*
- *Developing advanced statistical data analysis techniques*
- *Improving the theoretical modelling of the dark universe*

LSST @ Liverpool

Liverpool

Barrett Bowcock Mehta

- Working closely with astronomers from LJMU
- Two LSST students starting 2017
- Looking at Software and Physics topics
- School is investing in Dark Energy/ Dark Matter
- Collaboration with Theory

Swansea Particle Physics Group: expertise for LSST

Swansea

Swansea particle physics group includes *theoretical cosmologists*, *particle physics/string theorists*, *experts in computational physics* applied to lattice QCD

- Theoretical cosmology: work on **dark energy** and **dark matter** model building, **modified gravity**, and **evolution of cosmological perturbations**

Expertise on **formulating DE and DM theoretical models** aimed to explain cosmological data, and provide theoretical interpretation to new findings.

- modified gravity with screening mechanisms:
  model building and evolution of cosmological perturbations
- analysis of cosmological perturbations in non-linear regimes
  to be applied to Large Scale Structure formation and dynamics

Expertise on embedding DE, inflation, DM scenarios in **broader particle physics and string theory contexts**.

Swansea Particle Physics Group: expertise for LSST

Swansea

- **Computational Physics**

  Research facilities for Big Data and High Performance Computing: the new **Swansea Academy for Advanced Computing**: Collaboration with Computer Science and Mathematics

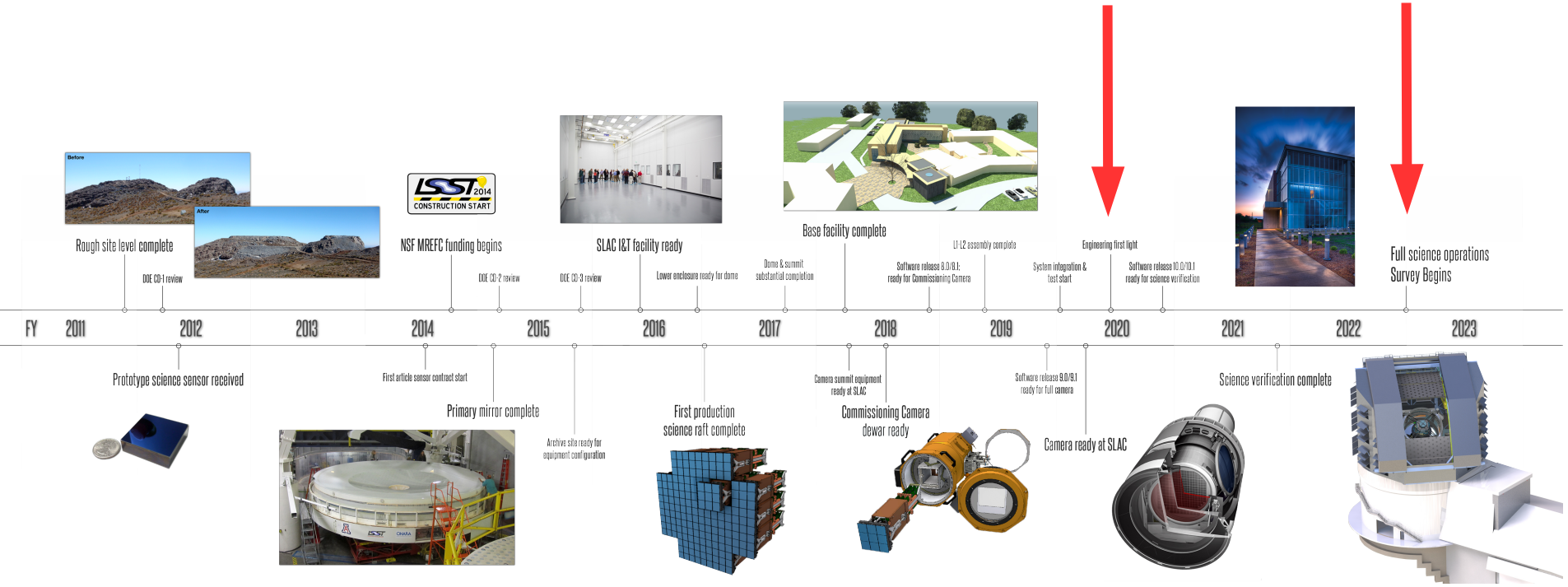
  - Cutting edge hardware facilities, and existing expertise in scientific image analysis and big data astrophysics: astronomical data sets are a welcome application

- **Centre for Doctoral Training Data-Intensive Science**

  Consortium with Universities of Bristol and Cardiff. First aim: train PhD students in Data Intensive and High Performance Computing. New collaborations with these institutions will develop also on LSST Physics.

Direct contact between theoretical cosmologists and computational physicists with particle physics background is a bonus of our group

Project Construction Schedule



Project on track for first light in 2020 and first science October 2022

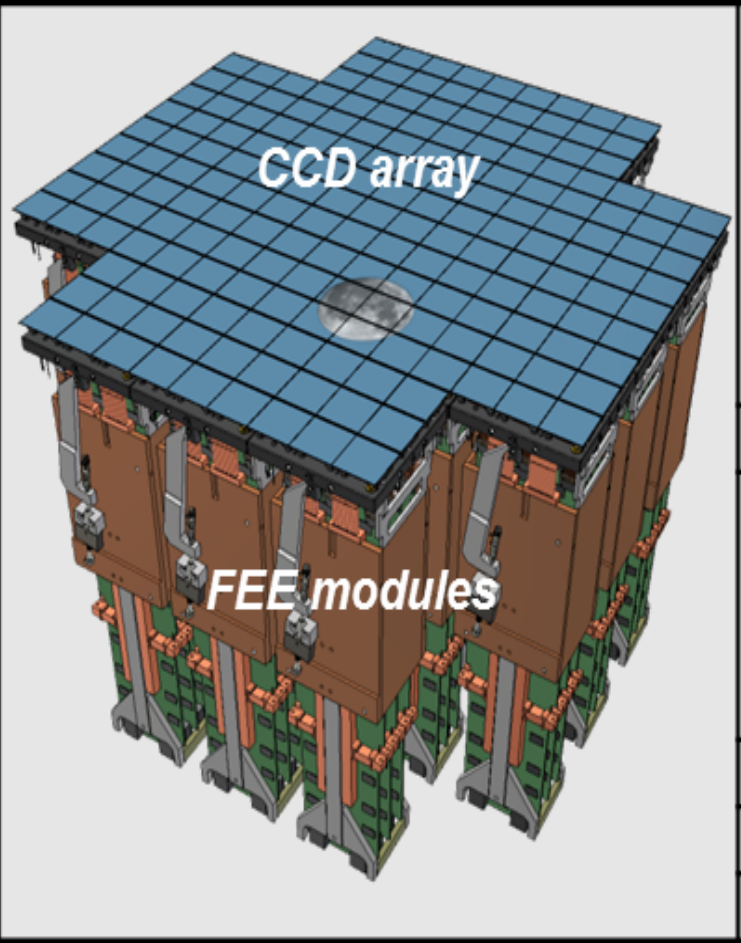

July, 2017

Summary

- Many UK Particle Physicists starting in LSST
  - Camera & sensors, DAQ, control systems, data handling & management, UK data access centre, GridPP, …. & Dark Physics!
- Particle Physics Technical expertise
  - Complex detectors (sensors, DAQ)
  - Big Scale Computing (GridPP, UK data access centre)
  - Big Data handling & analysis (data bases, simulation)
  - Algorithms

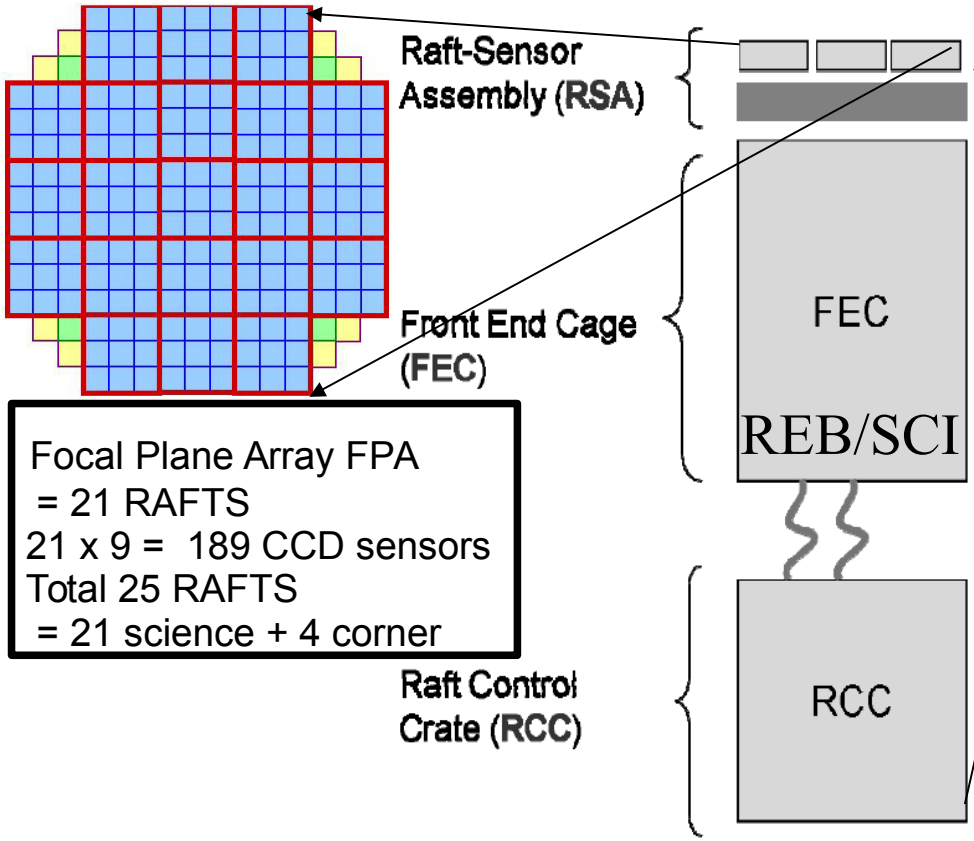
  → well received by LSST community
  - UK PP adds complementary value to UK AST LSST contributions → helps secure UK science leadership
- Many opportunities for more PP community members to get involved

Additional Slides



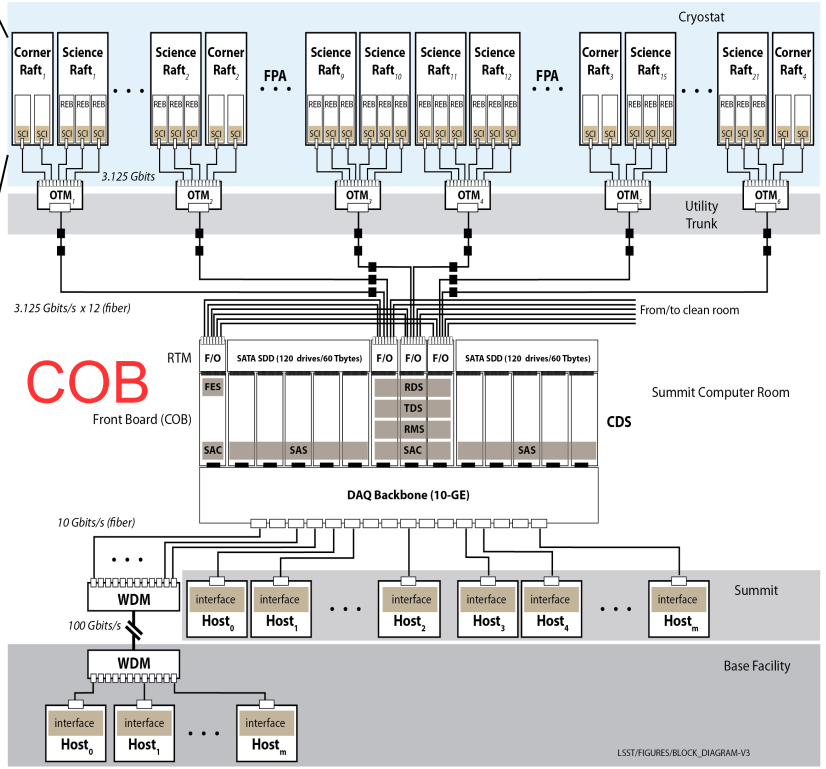
CCD Technology	Fully-depleted 100μm thick silicon, ≥ 10kΩ/cm resistivity 10μm pixel pitch 4Kx4K full-frame format 16 outputs/CCD
Science focal plane	189 CCDs, 3.024 Gpixels
Trace pitch: Silicon Ceramic package Flex cable	 5mm 0.4mm (6 layers) 0.64mm (2 layers)
PCB area/channel	8.8cm^2 (full signal chain)
Pixel rate	550Kpix/s
Power budget	350mW/channel total

LSST DAQ



Focal Plane Array FPA
= 21 RAFTS
21 x 9 = 189 CCD sensors
Total 25 RAFTS
= 21 science + 4 corner

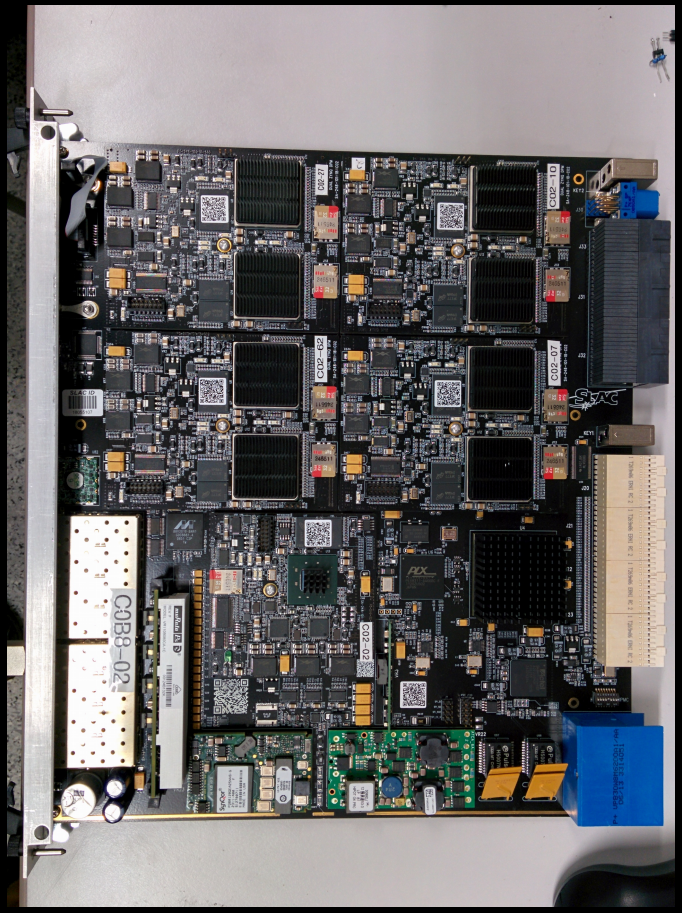
21 x 3 + 4 x 2 = 71 REB/SCI Raft-Electronic-Boards/ Source Communication Interfaces



14 Cluster on a Board COBs:
- 3 to service Focal Plane Arrays
- 1 data emulation
- 10 data storage

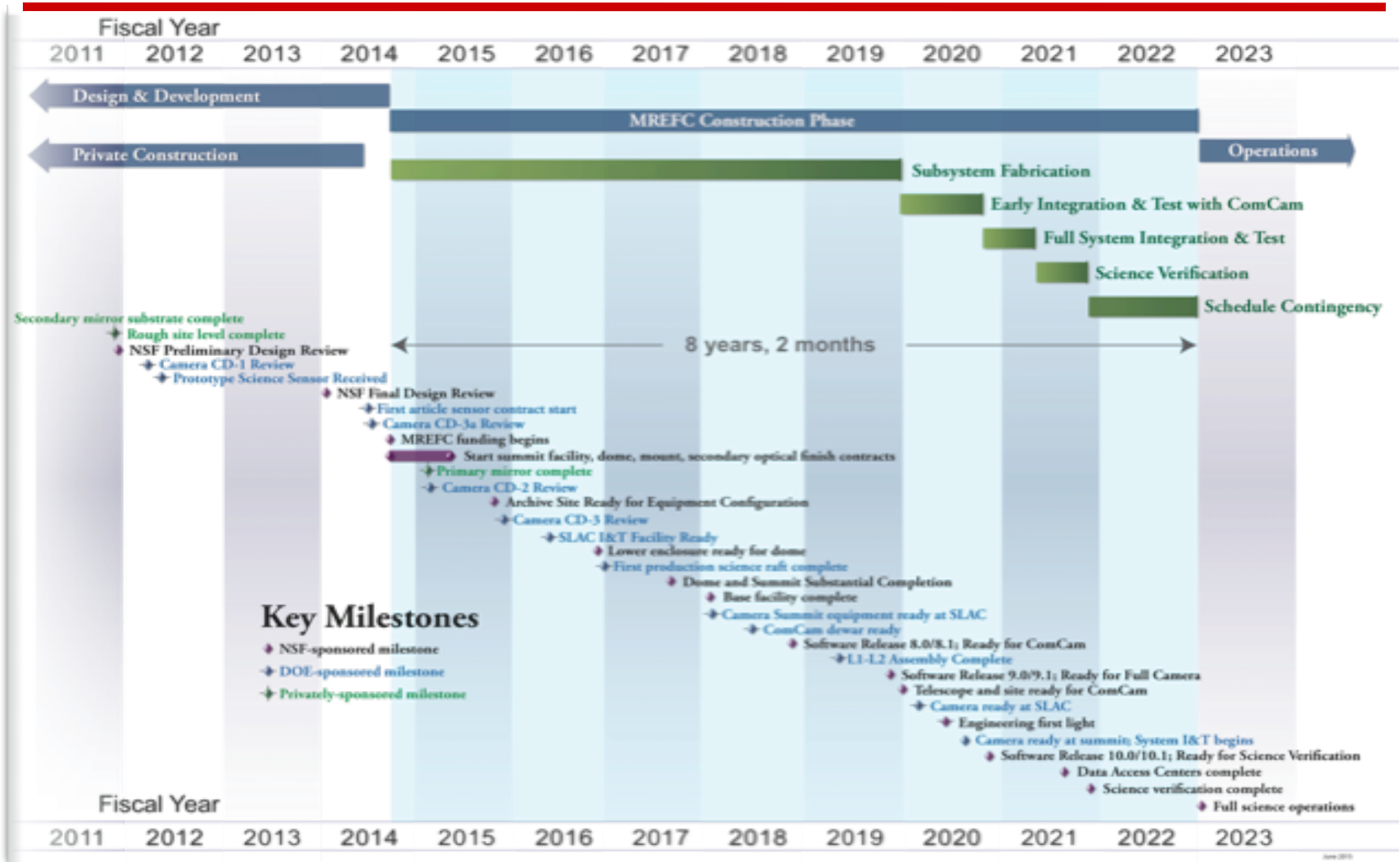
12 Source Communication Interface SCI per Optical Transition Module OTM

COB/RCE at UCL



(also at Oxford)

Project Construction Schedule



Project on track for first light in 2020 and first science October 2022

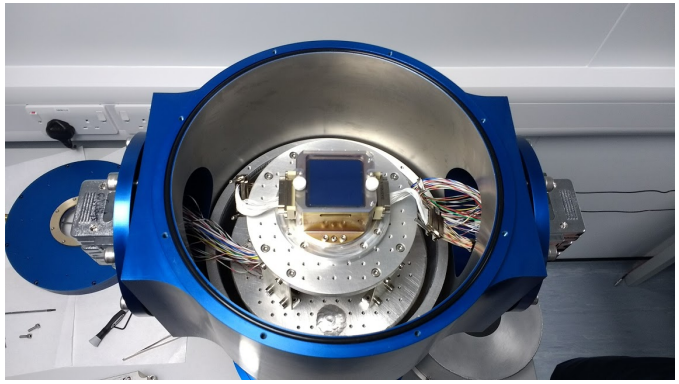
Sensor characterisation

Oxford

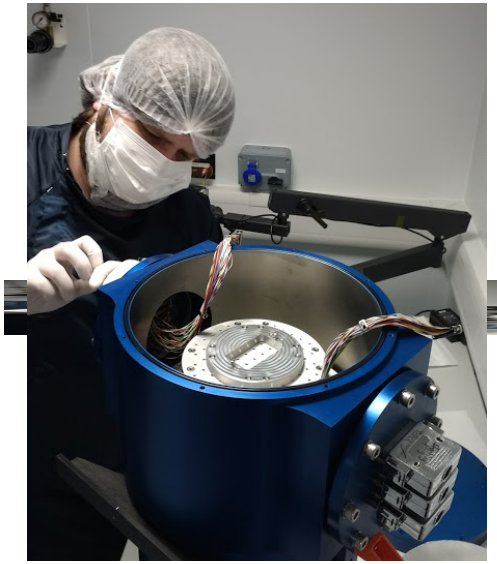
Hardware testing on individual sensors takes place in cleanroom at OPMD facility in Oxford

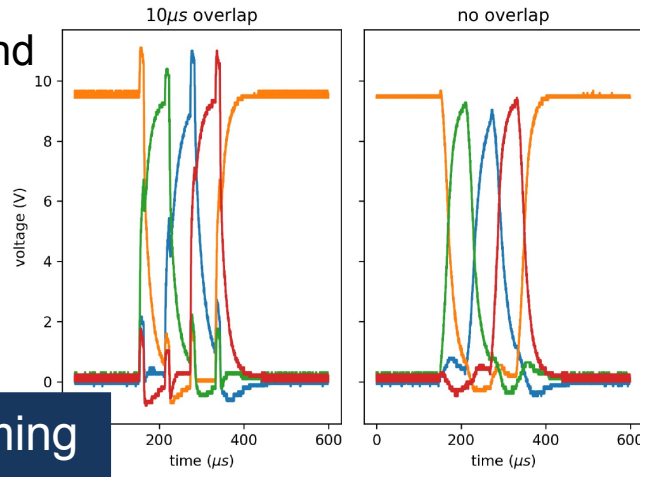
Contributing expertise and testing to optimisation of readout sequence for LSST CCD – critical for obtaining best performance.

Collaboration with BNL, David, Paris and SLAC. Oxford Stand Is uniquely low-noise, low-vibration

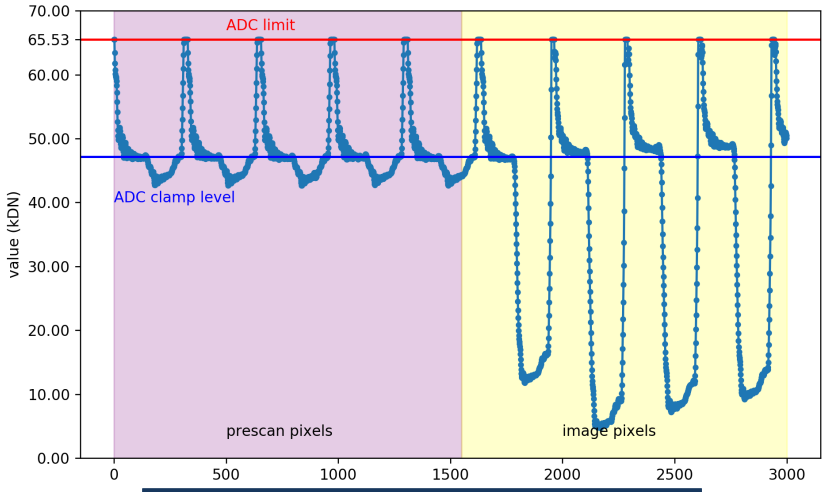


Installation of Teledyne e2v CCD in cryostat at Oxford





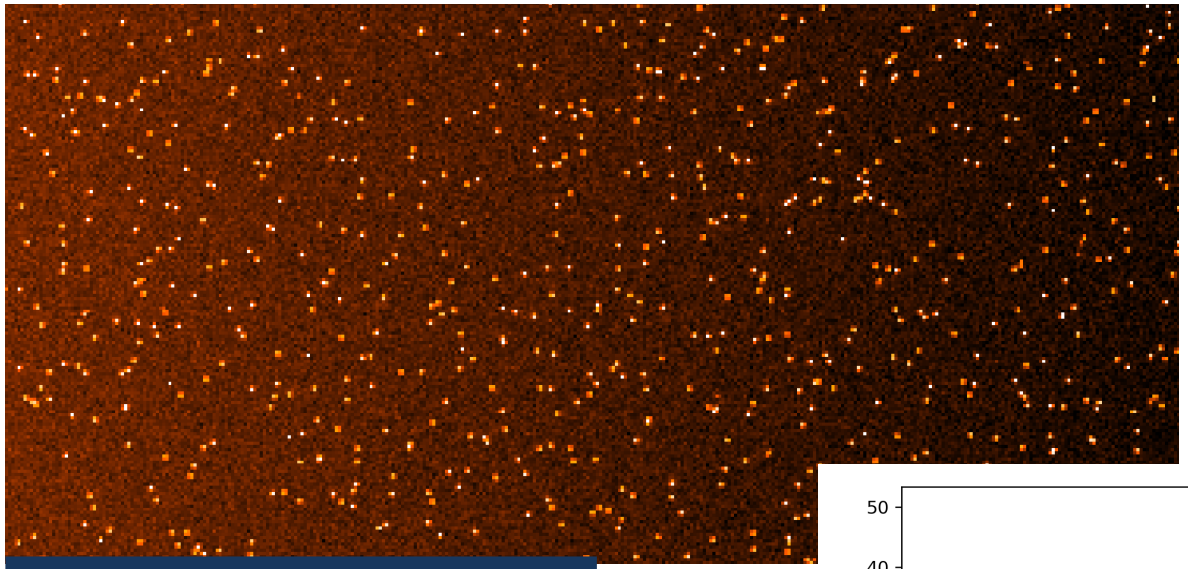
Testing overlap timing of image clocks



CCD pixel raw output

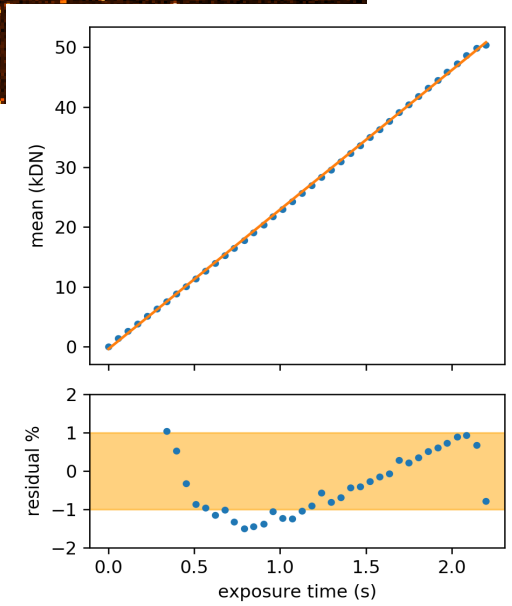
Sensor characterisation

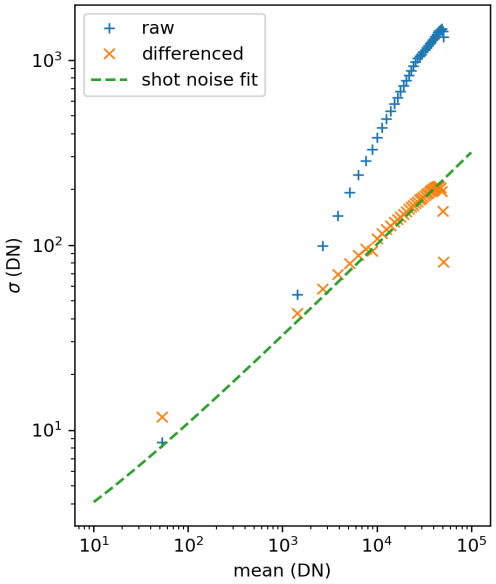
Oxford



Fe-55 clusters incident on Teledyne e2v CCD

Oxford test system can illuminate CCD with monochromatic flat field or projected spot optical light or X-rays from Fe-55 source.





Photon Transfer Curve used to calculate gain and full well of a CCD output channel

Oxford

CCS Precise time synching

Abi, Azfar

Camera Control System (CCS)

actions must be time stamped across all platforms and users to millisecond accuracy using **Temps Atomique International (TAI) time, platforms must be synchronised !**

Use GPS & a grandmaster clock and a master PC to distribute time

-A test stand in Oxford will help evaluate, setup and benchmark the system
-Requisite software interface and classes (Java) complete and ready for use by developers final system

(Babak Abi, Farrukh Azfar)

Build #17 (Jun 30, 2017 3:01:39 PM)

Changes

1. Leap Second reader that gets leap seconds out of a file managed by Earth (commit: 4554ad3) (detail / githubweb)

Started by GitHub push by farrukhazfar

Revision: 4554ad353bae82358441329322341e498a02543

- refs/remotes/origin/master

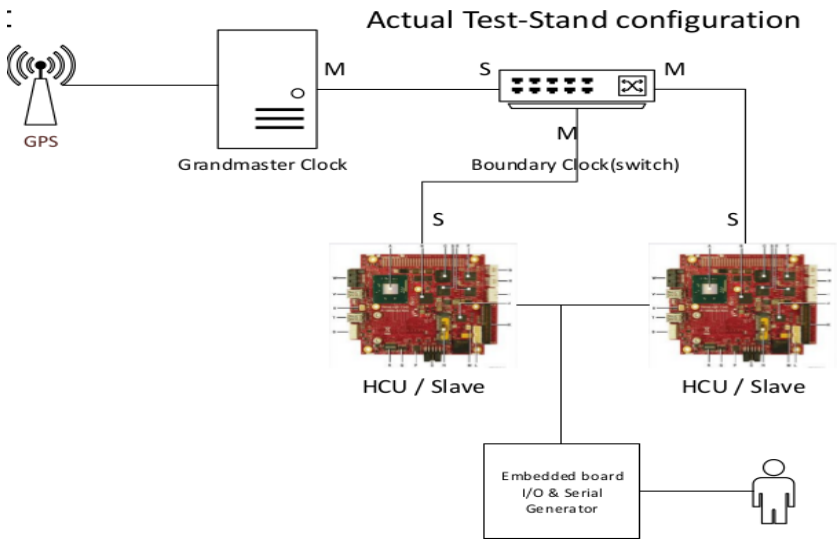
Test Result (no failures)

Module Builds

LSST CCS - Utilities - TAI Time 1 min 29 sec

Upstream Builds

org-lsst-ccs-toolkit #1677



Oxford

Azfar

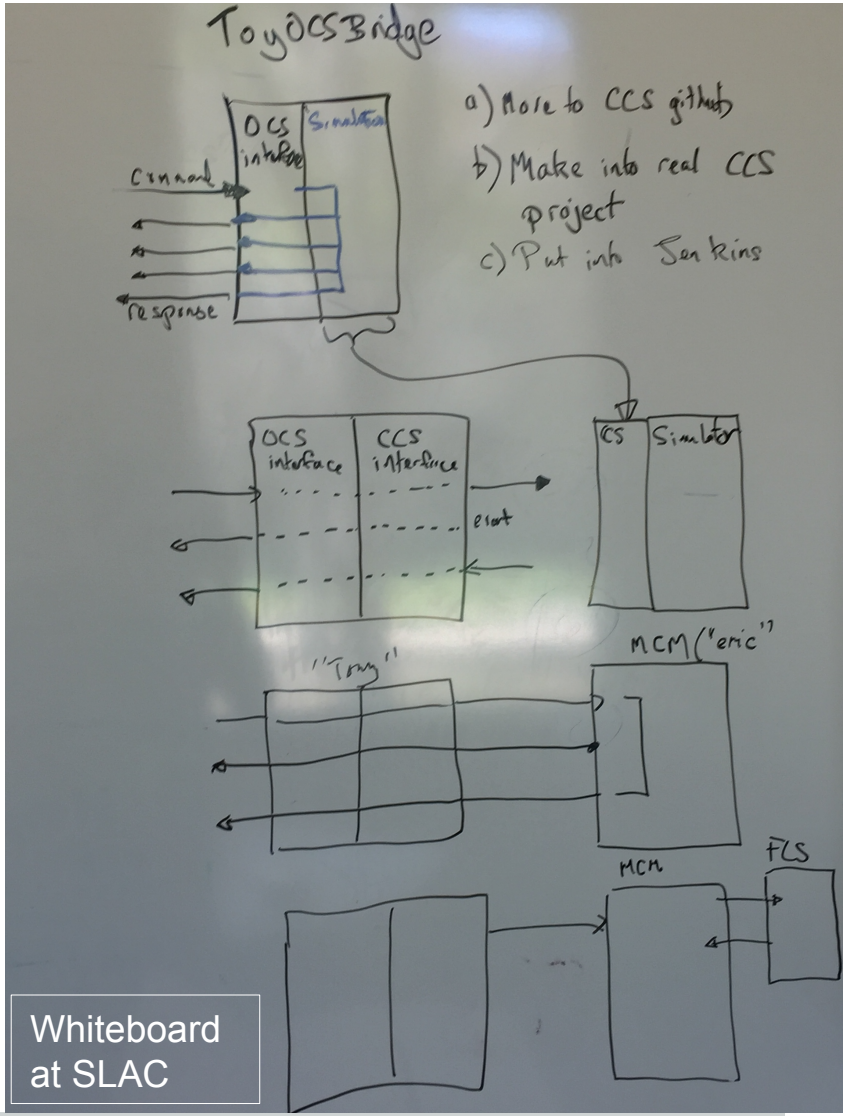
OCS-CCS Software Bridge

Observatory Control System (OCS) software & Camera Control System Software (CCS) exist as separate entities

OCS must provide users a way to control CCS seamlessly

A “bridge” is needed to translate and communicate commands

Oxford has begun work on a simulated implementation to produce the bridge in collaboration with
U. Paris Diderot and SLAC
(People : Oxford : Farrukh Azfar
Paris : Eric Aubourg, + Tony Johnson SLAC)



Whiteboard at SLAC