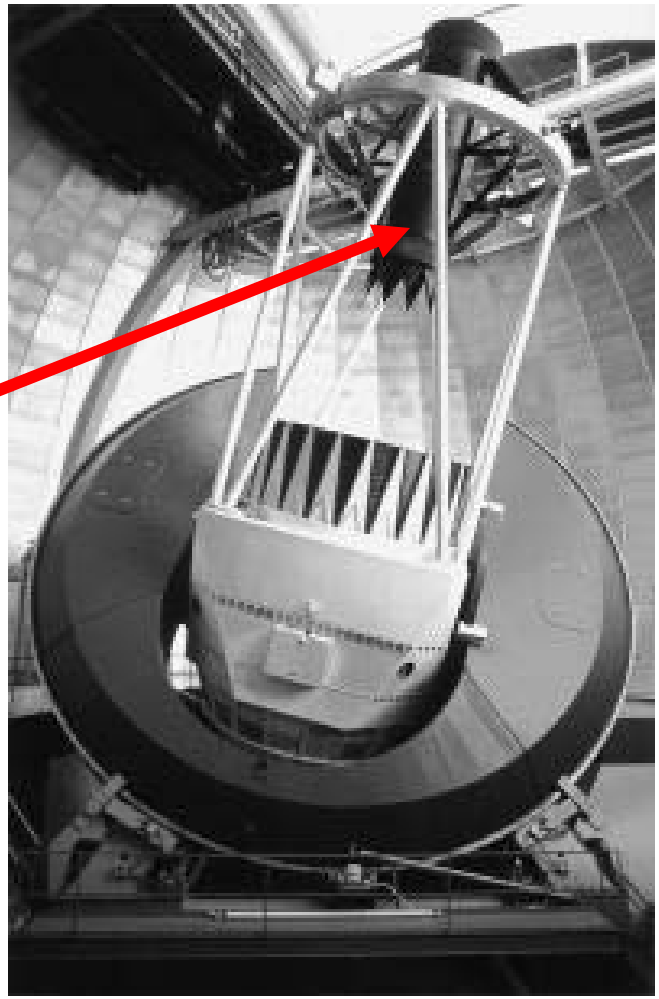
Dark Energy Survey Technical Progress, Cost and Schedule

DARK ENERGY SURVEY

- 5000 sq-deg in the South Galactic Cap in 30% of 5 years (’09 –’14)
  - 300 million galaxies, 30,000 clusters, 2000 SN- Ia
  - 3 sq-degree camera with ≥ 2.2 deg FOV
  - SDSS g,r,i,z filters covering 400 to 1100nm
- Prime Focus Cage of the Blanco Telescope
- We plan to replace this and everything inside it



- Outline
- Approval/Funding Status
- R&D progress
- Cost,schedule

DES: Fermilab, U Illinois, U Chicago, LBNL, CTIO/NOAO, Barcelona, UCL, Cambridge, Edinburgh

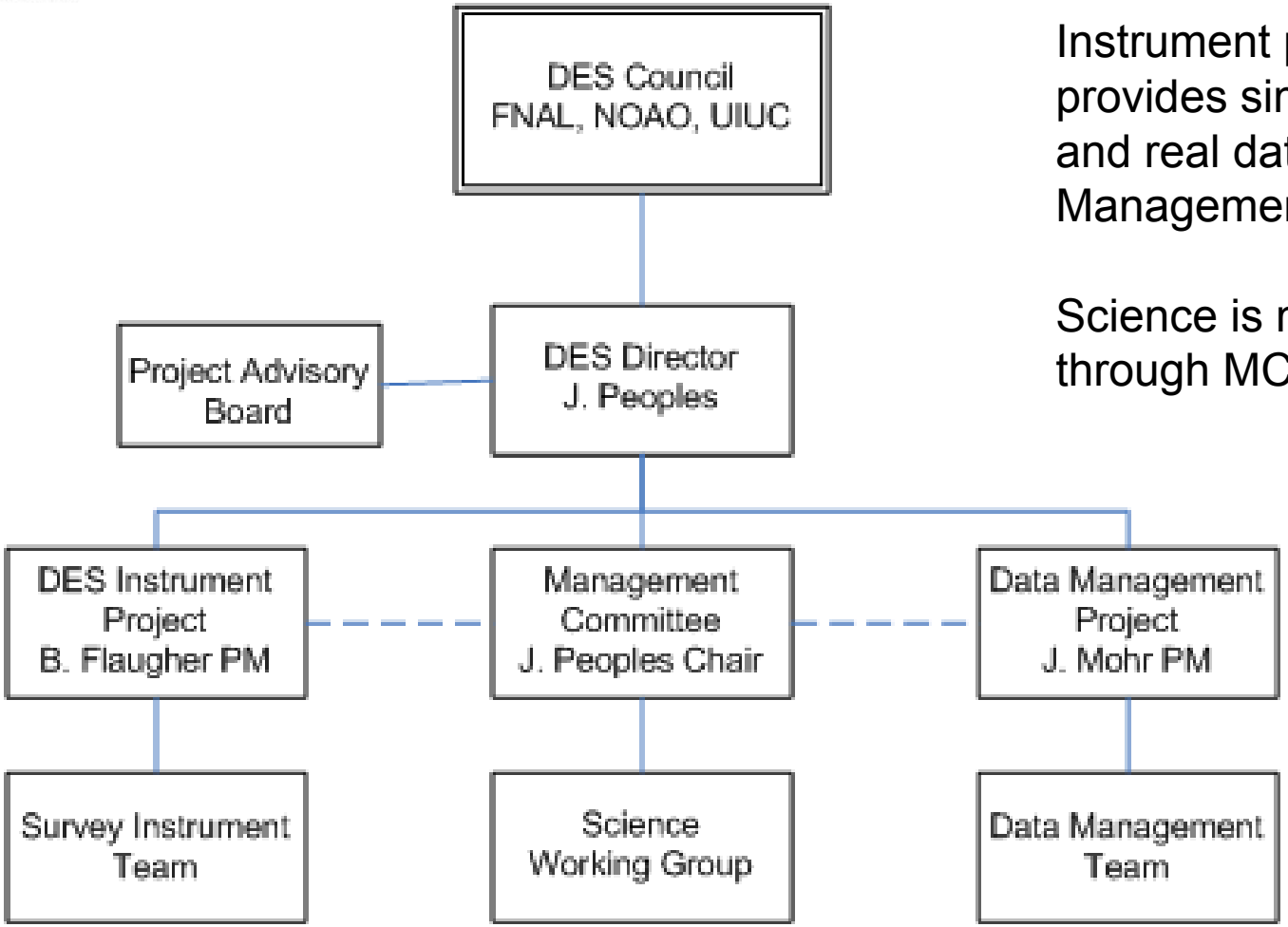
DARK ENERGY SURVEY

DES Status

- Aug/Sept 04: reviewed and accepted by NOAO – DES was awarded 30% of the telescope time (525 nights) in exchange for the new instrument and Data Management systems
- UC, UIUC and Fermilab contributed money for R&D
- Fermilab and UIUC are contributing engineering now, potential new collaborators could contribute soon
- FY05 and 06 are R&D years
  - CCDs: establish yield, learn to test CCDs, demonstrate packaging
  - Optics: finalize design, develop firm cost estimate
  - Front End Electronics – develop system design, begin prototyping, testing
  - Firm up the cost estimate and prepare for DOE review process
- Hope to be in the FY07 budget – need this to stay on schedule

DES Organization

DARK ENERGY SURVEY

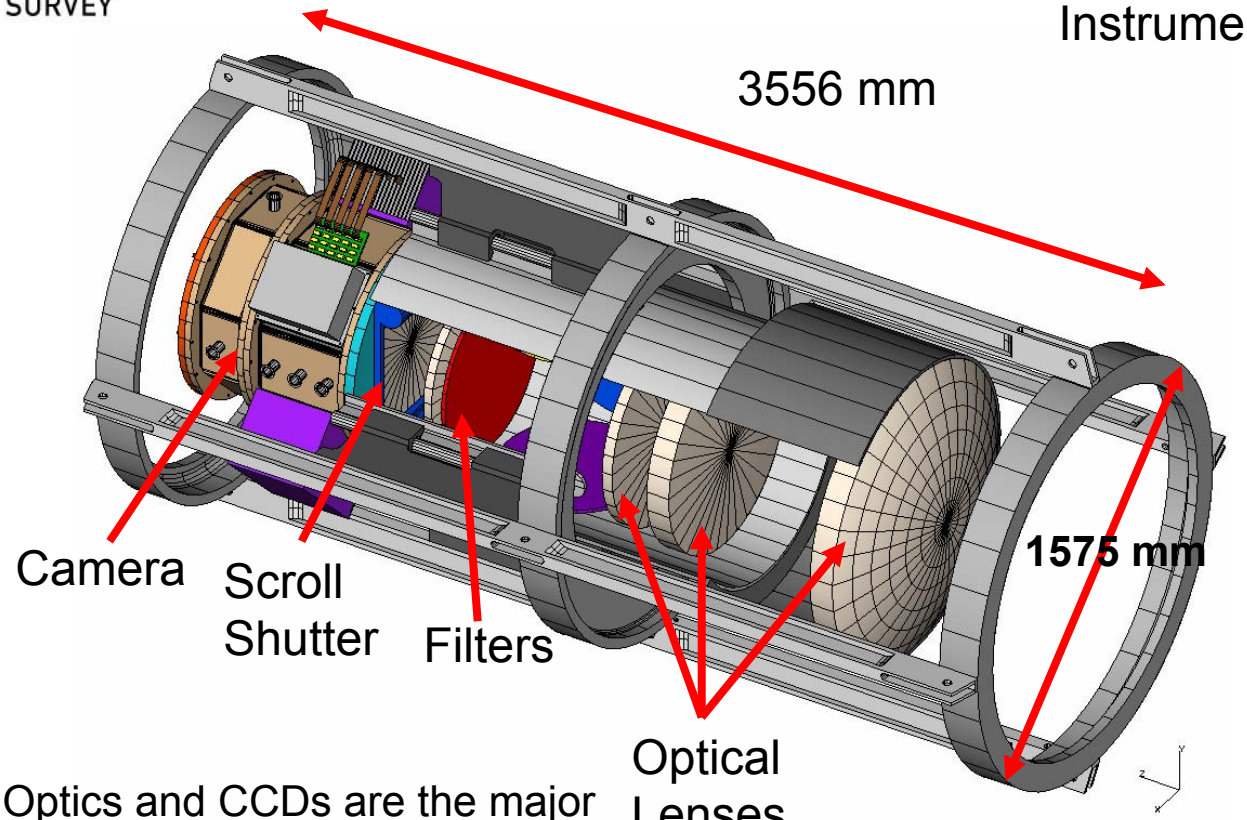


Instrument project provides simulated and real data to Data Management project

Science is managed through MC.

DES Instrument Reference Design

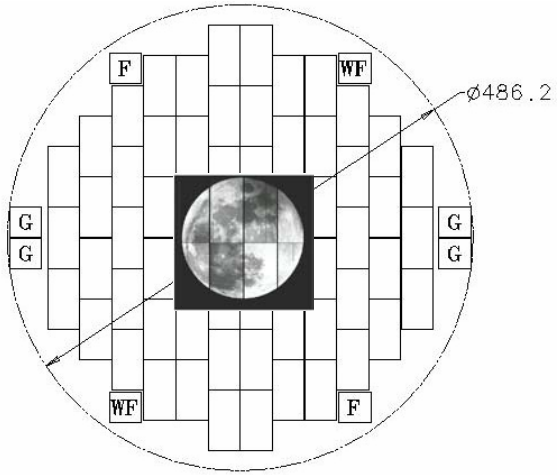
DARK ENERGY SURVEY



Optics and CCDs are the major cost and schedule drivers
Optics Total ~ $2M + $1M cont.
CCD Total ~ $2M + $1M cont.

Instrument Construction Organization

1.2.1 CCDs
1.2.2 CCD Packaging
1.2.3 Front End Electronics
1.2.4 CCD Testing
1.2.5 Data Acquisition
1.2.6 Camera Vessel
1.2.7 Cooling
1.2.8 Optics
1.2.9 Prime Focus Cage
1.2.10 Auxiliary Components
1.2.11 Assembly and Testing



Progress on the CCDs

DARK ENERGY SURVEY

Preproduction wafer design submitted to Dalsa on Mar. 3rd.

April 5th: Masks have been made and are ready to use.

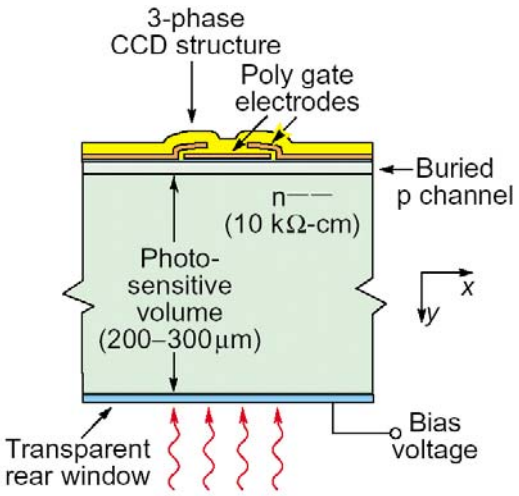
April 7th: Wafers have started working their way through the process steps at Dalsa!!

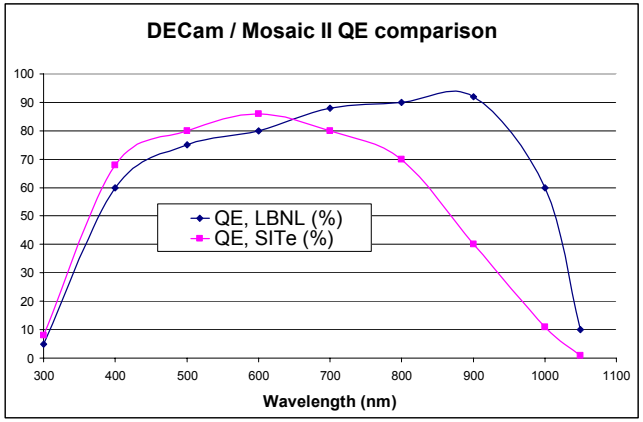
LBNL helped us to get the wafer order started early – combined with a SNAP order

SNAP recent wafer processing was very fast:

- Lot 105868 - 28 working days from 1st mask step to delivery
- Lot 107409 – is mid processing, and is 6 days faster.

Could have 1st devices in May or June!





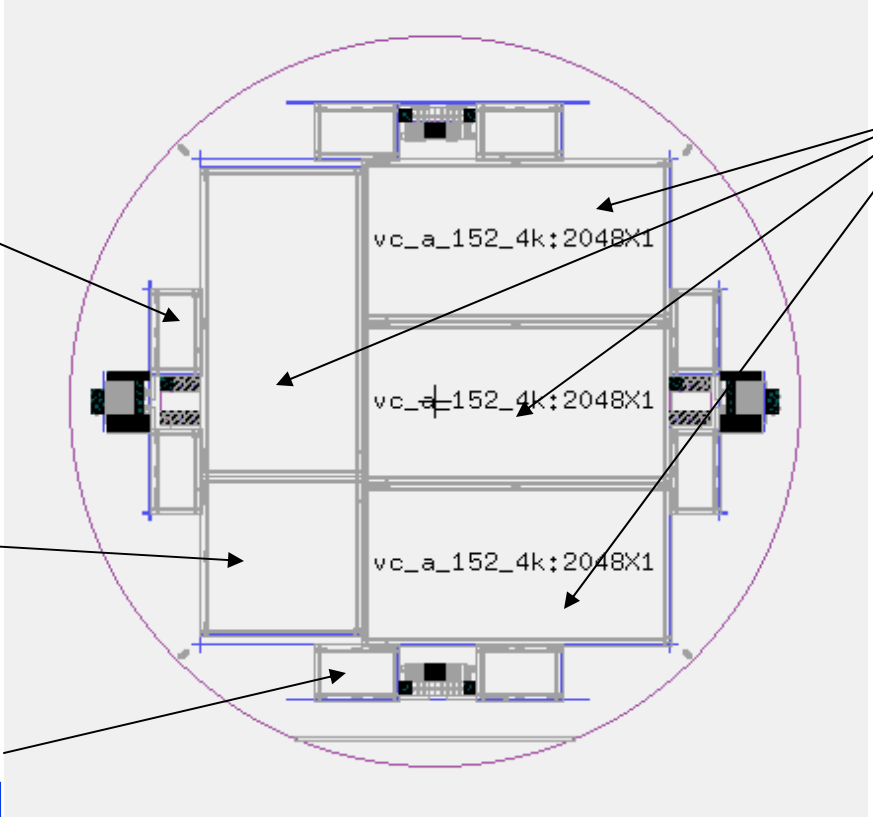
Wafer layout

DARK ENERGY SURVEY

1024 x 512
15 μm pixel
4 per wafer
for tests

2048 x 2048
15 μm pixel
Guide, focus,
WF CCD

1024 x 588
15 μm pixel
4 per wafer



2048 x 4096
15 μm pixel
Image CCDS

1st devices will be 650 um thick – can discover if masks worked and get preliminary est. of maximum raw yield

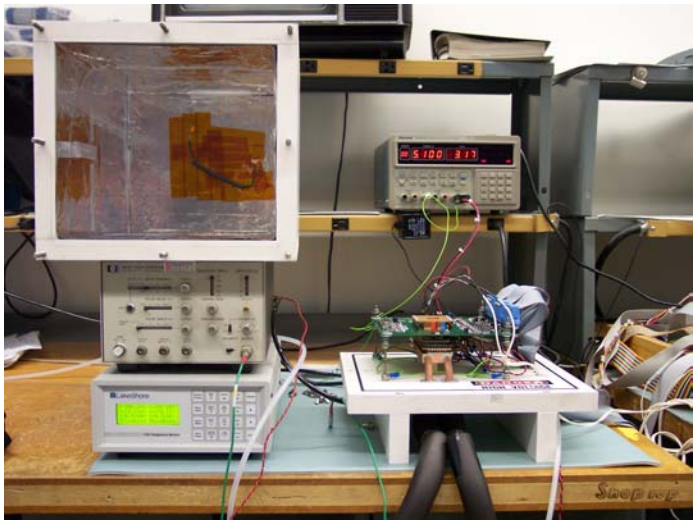
Have submitted requisition to cover cost of thinning and processing 5 wafers at LBNL ~ 8-12wks, $24k/wafer

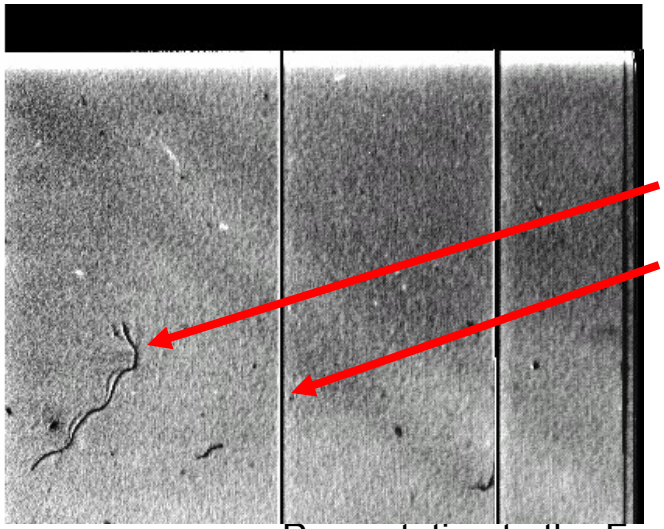
Should have estimate of fully processed yield by mid summer '05
CCD yield is one of the large uncertainties in the cost estimate

Progress in CCD Testing

DARK ENERGY SURVEY

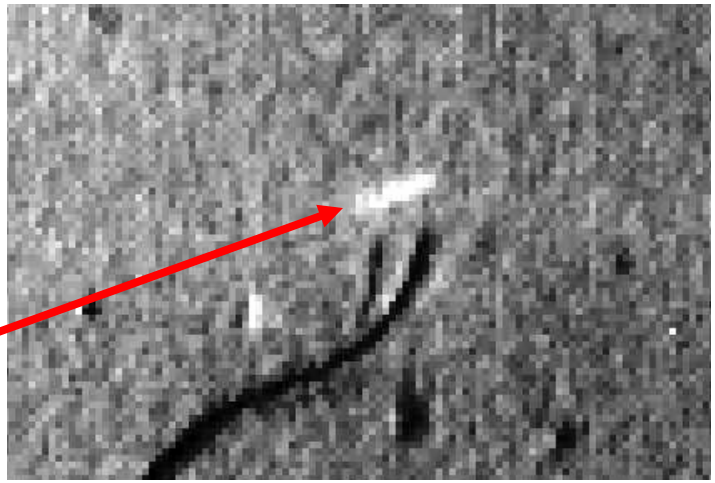
- Borrowed readout system and CCD from Tom Droege Sept. 04
- Juan Estrada and co. got it working last yr.
- built a “cool” box for preliminary tests (-25 deg. C)
- LBNL gave us 1.5 working CCDs to start
- built LBNL CCD adapter cards, cables, etc,
- 1st CCD read out successfully in early Feb.!





Corner of CCD,
dust,
dead columns

Cosmic Ray!!



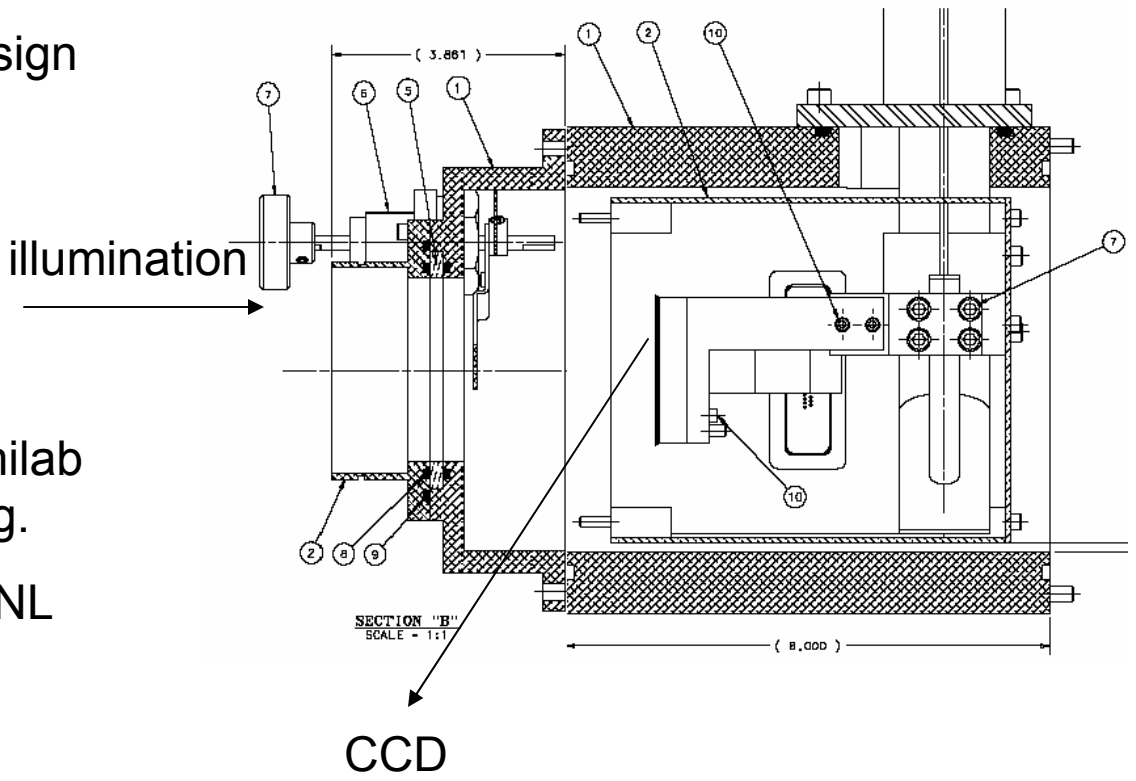
Next steps: CCD @ -100 C

DARK ENERGY SURVEY

- A testing box (deCube) has been built and is being tested now.
- Vacuum vessel, CCD cooled with LN2
- Learning to control temp with heaters, LN2 feeds and vents

Liquid Nitrogen

Design followed LBNL design for SNAP



In total we need 5 at Fermilab for production CCD testing.

Should be reading out LBNL CCD in deCube with TD system next week!

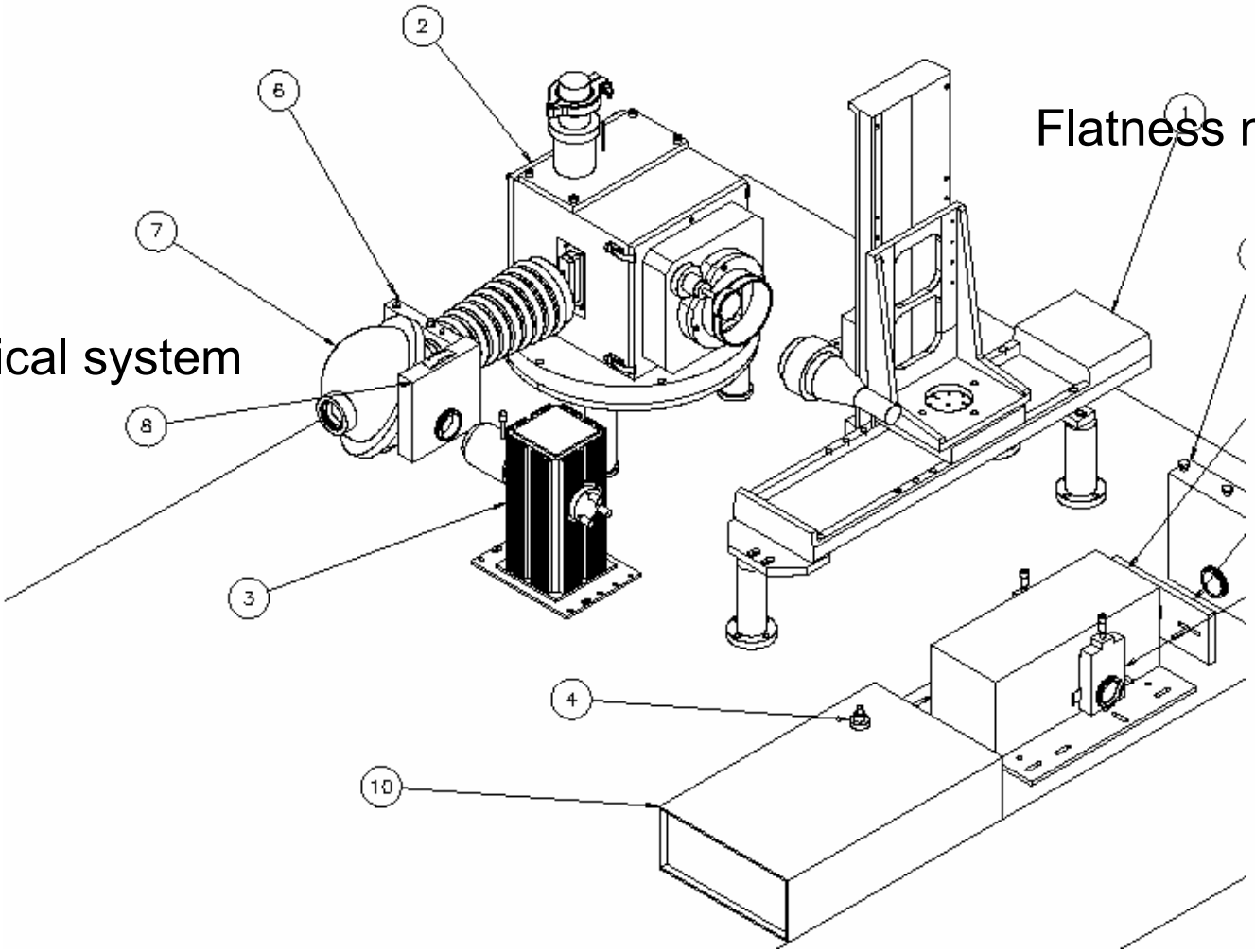
Complete CCD testing setup

DARK ENER(
SURVEY

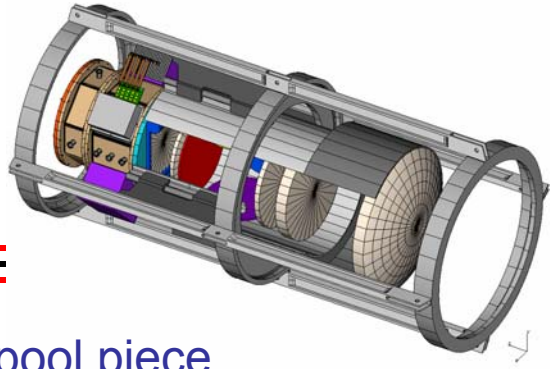
deCube

Flatness measurement

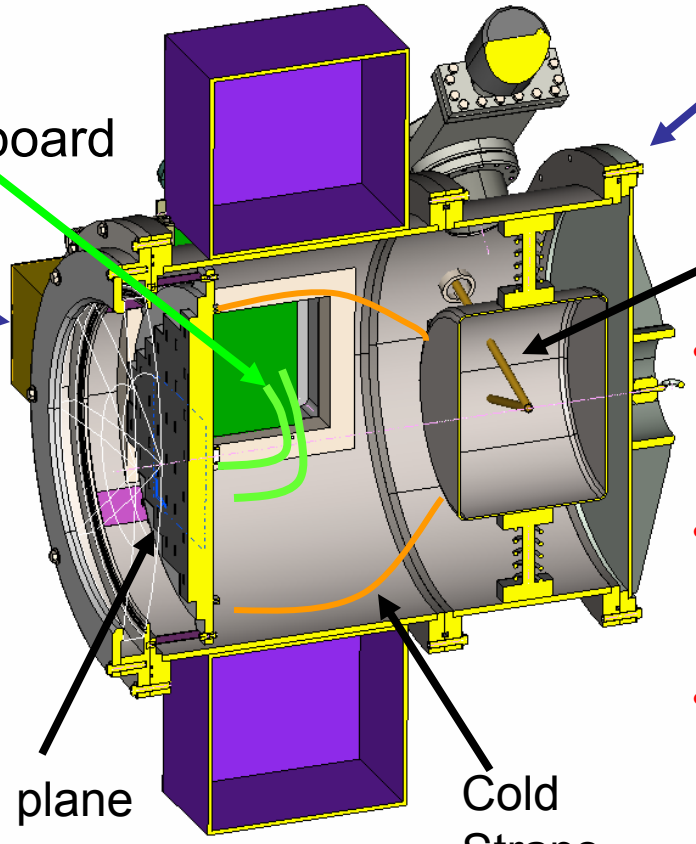
Optical system



Camera Vessel –Inside



DARK ENERGY SURVEY



Planning to build full scale prototype this fall to test multiple CCDs in real environment

- Large focal plane implies long cables between CCD and electronics crates
- may need to have preamps close to CCDs – inside camera or on feed through boards
- Goals for readout:
  - noise < 5 e-
  - linearity <0.25%
  - readout rate of 250 kpix/sec

DARK ENERGY SURVEY

Front End Electronics and DAQ

- NOAO has almost completed development of a FEE-DAQ system called Monsoon.
- We decided to adopt this as the basis for our reference design
  - capitalize on engineering and software already developed
  - DES will need higher density cards (12 channel instead of 8). Design has started at FNAL, expect prototype by Sept. 05.
  - Plan to use default Monsoon for initial CCD testing setups
- Time scale is Short:
- Need individual CCD testing stations (5) ready for CCD production testing and as similar to final FEE configuration as possible – Jan 07
- Final FEE system: ready to use during commissioning of the full focal plane with CCDs – March '08.
- Adopting Monsoon allows us to get a big jump start!

Monsoon System

DARK ENERGY SURVEY

•Monsoon system at Fermilab Mar. 14th!

•UIUC has similar system operating

•Hope to be reading out the CCD in deCube with Monsoon by mid May

PF cage implementation plan:

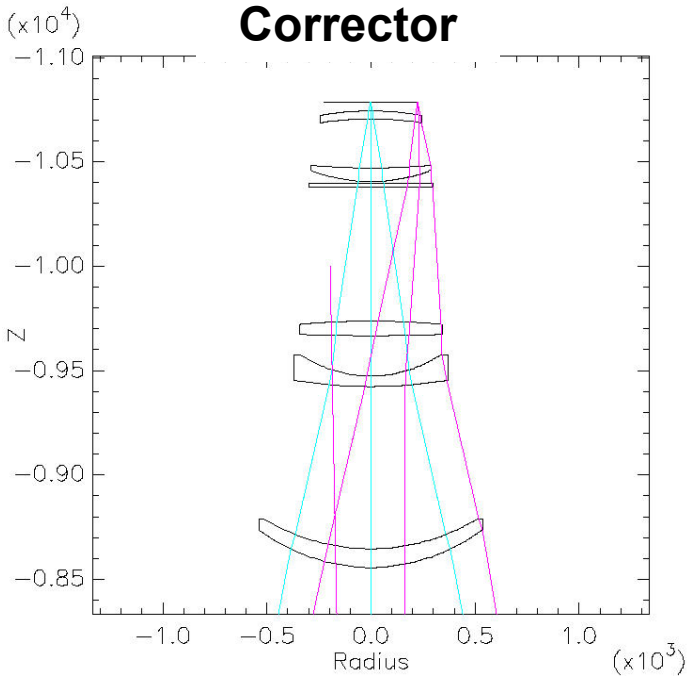
Two 6-slot cPCI backplanes can be put into a single crate

Image CCDs can be read out by 2 of these electronics crates. The guide CCDs will have their own small crate.

Progress on Optics Procurement

DARK ENERGY SURVEY

- UCL and the Optical Science Center
  - UK group has been provisionally admitted to the DES collaboration.
  - UCL has experience with both procurement and fabrication of optical systems. Richard Bingham designed the Mosaic II corrector.
  - UCL submitted proposal to PPARC March 1. It was reviewed April 5,6. We should hear back in early May.
  - UCL is obtaining quotes from vendors and investigating cost saving options



2.2 deg. FOV Corrector (Kent, Gladders)
5 powered elements (Fused Silica)
one aspheric surface (C4)
four filters – griz

DARK ENERGY SURVEY

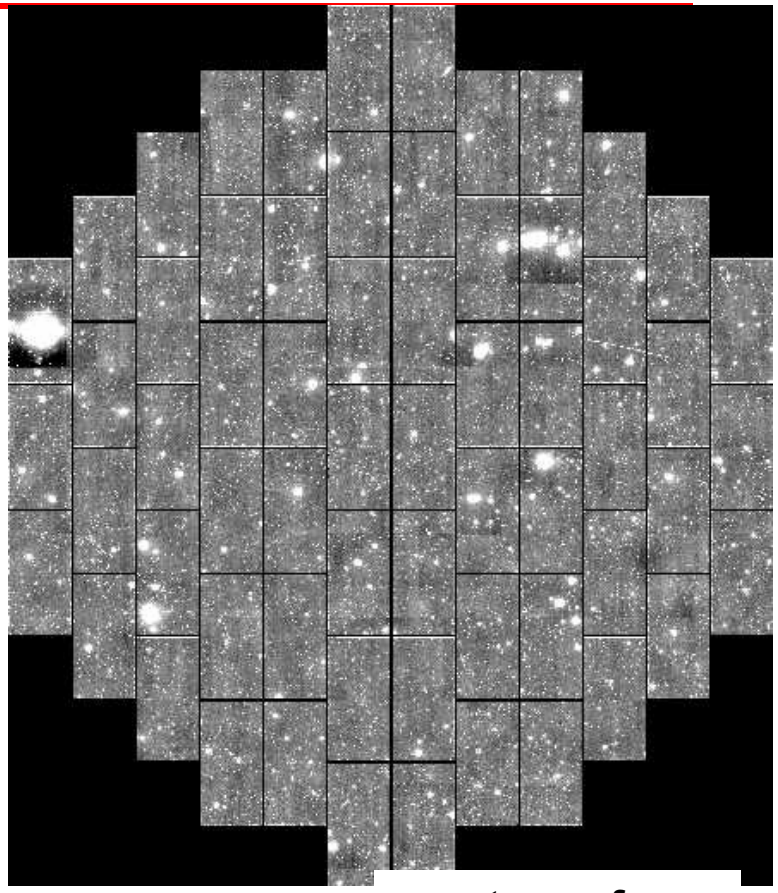
Optics Design Progress

- Steve Kent is modeling anisotropic patterns in the Blanco data (BTC, and Mosaic II weak lensing data)
- Shows that PSF shape (e.g. the WL signal) is sensitive to horizontal offsets between corrector and mirror
- Other factors that affect PSF
  - Thermal: Focus, Mirror distortion (astigmatism)
  - Gravity: Mechanical motions (coma, astigmatism)
  - Atmosphere: Seeing (image size; spatial changes?)
  - Earth rotation: Tracking & guiding errors
- working with CTIO to understand mechanical stability of the mirror and telescope:
  - Will try to survey relative motion of cage and mirror
  - Will instrument mirror to detect motion
- DES improvements will be important for WL analysis:
  - active focus control
  - possible WF sensor system to detect changes in PSF
  - investigating active horizontal motion system for corrector
  - thermal control of exterior of the electronics crates

Data Simulation and Data Management

DARK ENERGY SURVEY

- FNAL + NOAO used SDSS data to simulate data:
  - read noise, gain and bias variations between amplifers, unflattened, gaps
  - sky levels, pupil images (ghosts)
- Fed data to DM systems at UIUC and at NOAO
- Results compared to original. Bugs found, fixed!
- DM Development will be mapped by yearly data challenges
  - Data Challenge 1 (Oct '05):
    - Grid-processing framework, image data archive, astronomy modules
  - Data Challenge 2 (Oct '06):
    - All of the above plus catalog database, automated quality assessment, global photometric calibration and archive replication
  - Data Challenge 3 (Oct '07):
    - All of the above with stress test (full year)
  - Data Challenge 4 (Oct '08):
    - Test refinements for archive & pipelines, add Observing tools



courtesy of F. Valdes/NOAO

Costs and Funding (then yr $M, no overhead)

DARK ENERGY SURVEY

Cost Estimate has not changed, but profile has been smoothed

Stays on schedule for June 09 completion and installation on the telescope

COST	FY05	FY06	FY07	FY08	FY09	Total
M&S	1.0	2.6	3.3	1.2	0.2	8.3
M&S Contingency	0.0	0.0	0.3	2.0	0.8	3.1
Total M&S	1.0	2.6	3.6	3.2	1.0	11.4

FUNDING M&S						
Total potential outside sources goal	0.5	1.0	1.1	1.2	0.2	4.00
Total M&S Req. from FNAL/DOE	0.5	1.6	2.5	2.0	0.8	7.4
Technical Labor	1.0	1.2	1.2	1.0	0.4	4.8
Labor Contingency			1.0	1.0	0.4	2.4
Total Labor Cost	1.0	1.2	2.2	2.0	0.8	7.2

Outside sources include UC, UIUC funding – already in MOUs = $0.9m

UK and Barcelona have submitted proposals to their funding agencies

We anticipate applications from several universities

DARK ENERGY SURVEY

Conclusions

- R&D program is well underway and is addressing critical aspects of the DES design
- Have adjusted schedule to better match possible anticipated funding profile – still finish in June ‘09
- CCDs wafers have been ordered and are expected in May/June 05, ~ 2 months ahead of schedule!
- Optics design is progressing, getting better understanding of telescope, mirror and environment
- FEE schedule is aggressive, but we have a good start
- Simulations of the DES data are underway and the 0^{th} version of the DES Data Management systems has been successfully tested
- We have expanded the collaboration to include groups from the UK and Barcelona. They bring expertise and expand our funding possibilities. We are also talking with several university groups who are interested in the DES science and in contributing to the collaboration.