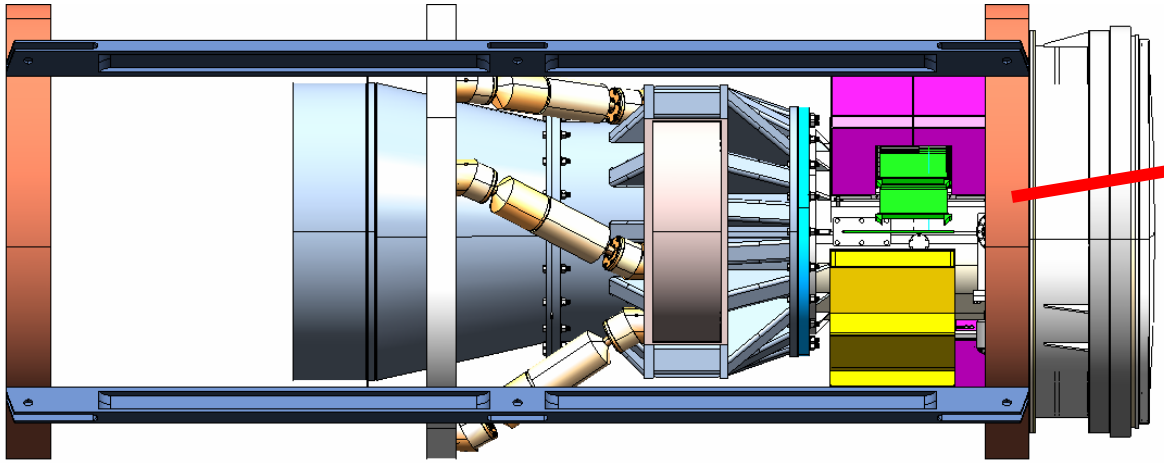
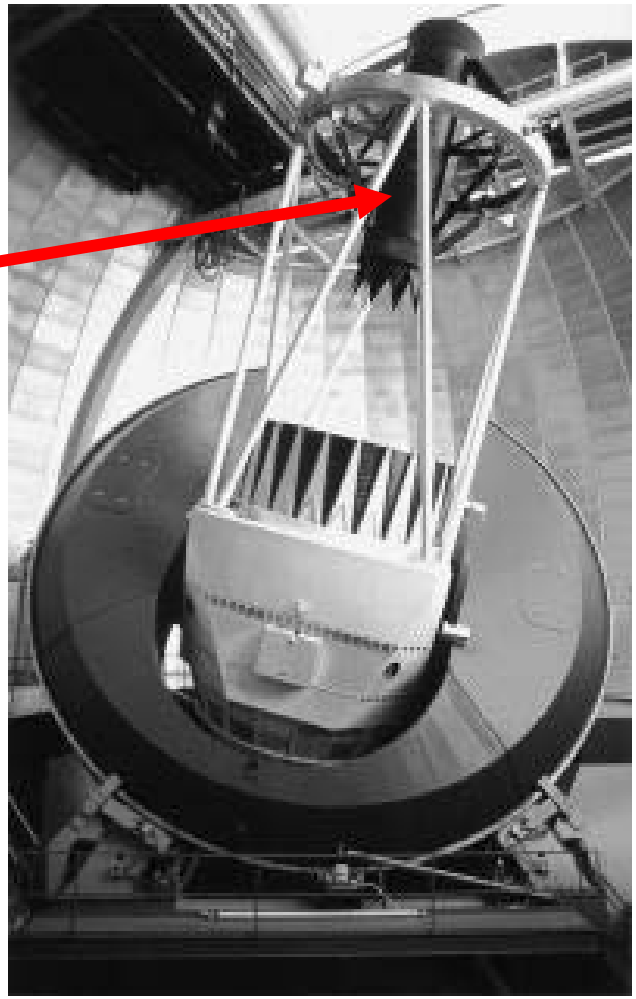
The Dark Energy Survey Camera: DECam

DARK ENERGY SURVEY

DECam will replace the prime focus cage





DECam Project Structure

1.1 Management
1.2 Focal Plane Detectors
1.3 Front End Electronics
1.4 Optics
1.5 Opto-Mechanics
1.6 Survey Image Processing System (SISPI)
1.7 Survey Planning
1.8 CTIO Integration

DES: DECam

DARK ENERGY SURVEY

DECam will have a 3 sq. deg. Field of View

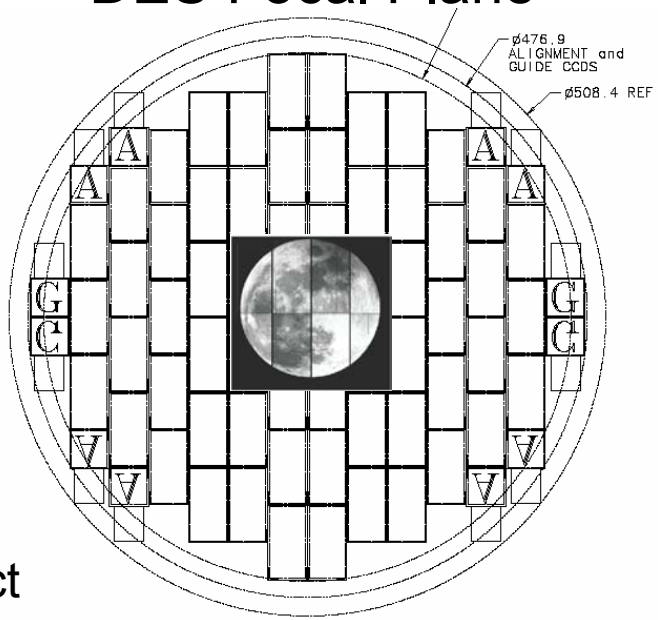
Each image:

- ~ 20 Galaxy clusters
- ~ 200,000 Galaxies

Each night ~ 300 GB

Entire survey ~ 1 PB

DES Focal Plane



DECam provides simulated and
real data to the DES Data Management Project

62 2kx4k Image CCDs: 520 MPix
8 2kx2k focus, alignment CCDs
4 2kx2k guide CCDs

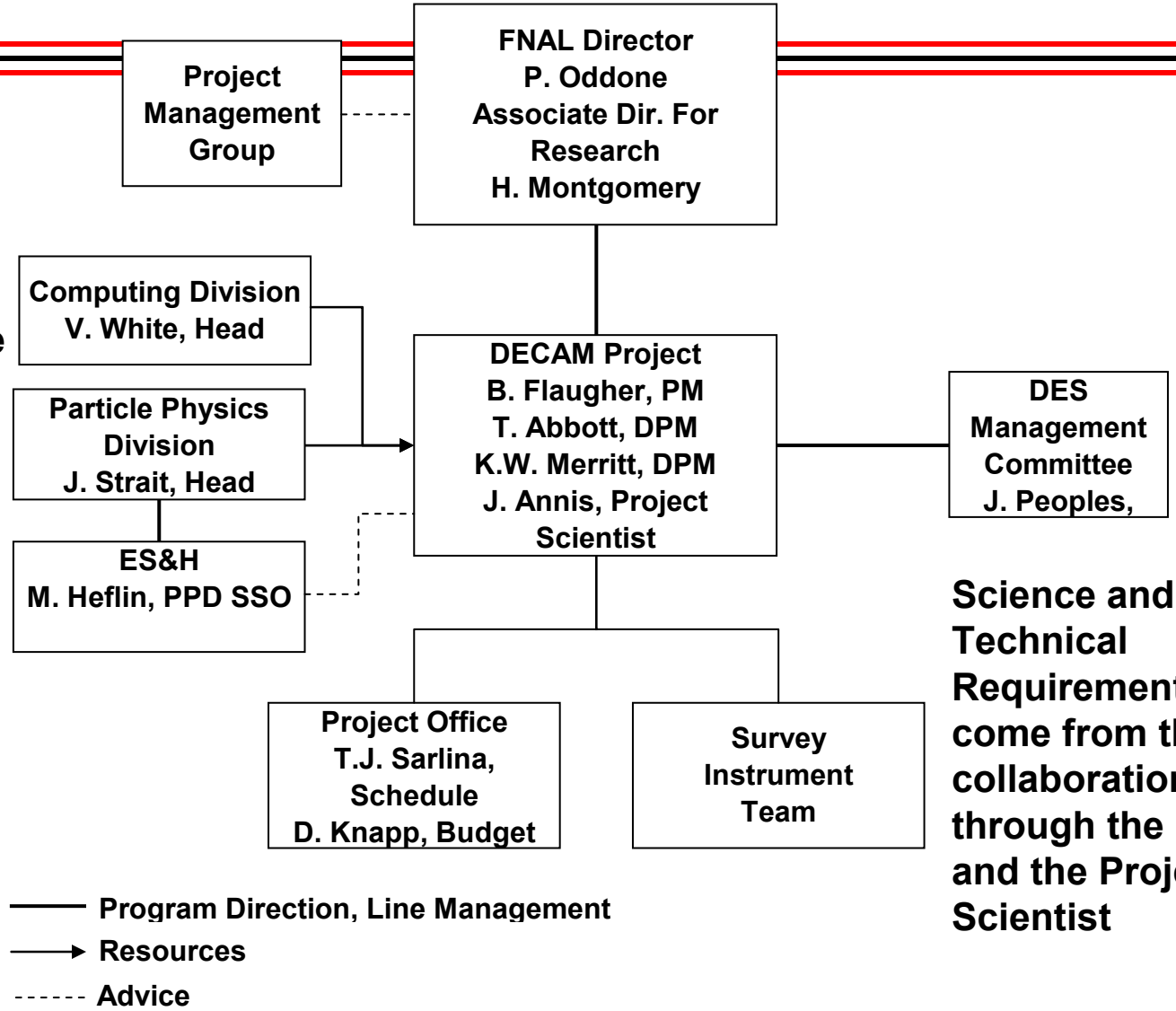
OUTLINE of this talk

- DECam
  - project description
  - cost and schedule
  - critical paths

DOE/Fermilab Dark Energy Camera (DECam) Organization

DARK ENERGY SURVEY

The Experimental Astro-physics Group in CD has the astrophysics experience and are also involved in SDSS and SNAP



PPD is host division for DECam and provides most of the technical resources and management support

Science and Technical Requirements come from the DES collaboration through the MC and the Project Scientist

DECam Project Management Roles

DARK ENERGY SURVEY

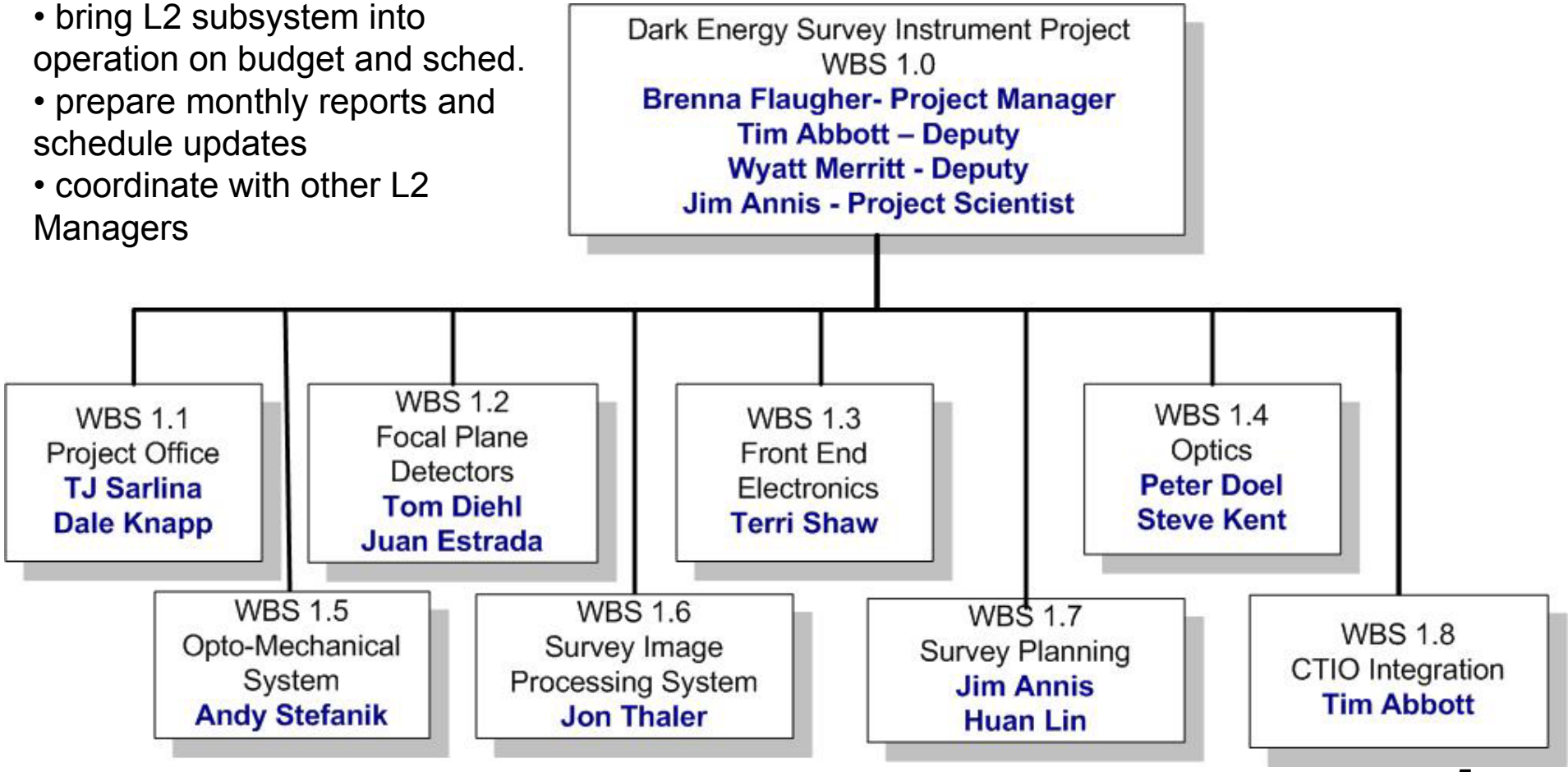
- Two Deputy Project Managers
  - Both help with all aspects of the project management
  - **Fermilab DPM: Wyatt Merritt**
    - DOE Documents, Risk Management, ES&H
    - Signature and decision authority in absence of PM
  - **CTIO DPM: Tim Abbott**
    - Primary point of contact with CTIO
    - Authors documents on Integration and Acceptance of DECAM at CTIO
- Project Scientist: Jim Annis
  - Science and Technical Requirements
  - With CTIO DPM, defines acceptance tests that ensure DECam will meet the requirements
- Mechanical Integration Coordinator (MIC) : Andy Stefanik
- Electrical Integration Coordinator (EIC): Terri Shaw
- Documentation Coordinator: Liz Buckley-Geer
- Budget Officer: Dale Knapp
- Scheduler: TJ Sarlina

DECam Work Breakdown Structure

DARK ENERGY SURVEY

Level 2 Managers:

- bring L2 subsystem into operation on budget and sched.
- prepare monthly reports and schedule updates
- coordinate with other L2 Managers



DES CCDs (WBS 1.2.1)

Natalie Roe (LBNL) is L3 project manager

DARK ENERGY SURVEY

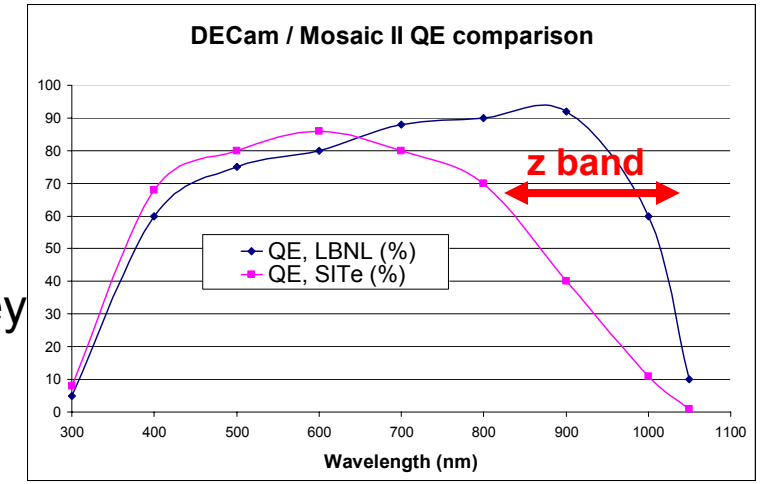
LBNL CCDs in use on WIYN telescope. From S. Holland et al, LBNL-49992 IEEE Trans. Elec. Dev. Vol.50, No 1, 225-338, Jan. 2003

LBNL Design: fully depleted 2kx4k CCDs

- QE> 50% at 1000 nm, 250 microns thick
- 15 μm pixels, 0.27”/pixel
- readout 250 kpix/sec, readout time ~17sec

LBNL CCDs are much more efficient than the SITE CCDs in Mosaic II at high wavelengths

To reach redshifts of ~1.3 DES will spend 46% of survey time in z –band



DES is the 1st production quantity application for LBNL CCDs

DES CCD design has already been used on telescopes in small numbers (3)

SNAP CCDs are the next generation, optimized for space

CCD Fabrication, Packaging and Testing (WBS 1.2)

DARK ENERGY

Follow LBNL business model developed for SNAP:

- Foundry delivers partially processed wafers to LBNL (~650 microns thick)
- LBNL finishes wafers (250 microns thick), tests, dices (production rate 5 wafers/month)

FNAL builds up the CCD packages and tests CCDs – will match CCD delivery rate

Preconceptual R&D (FY06):

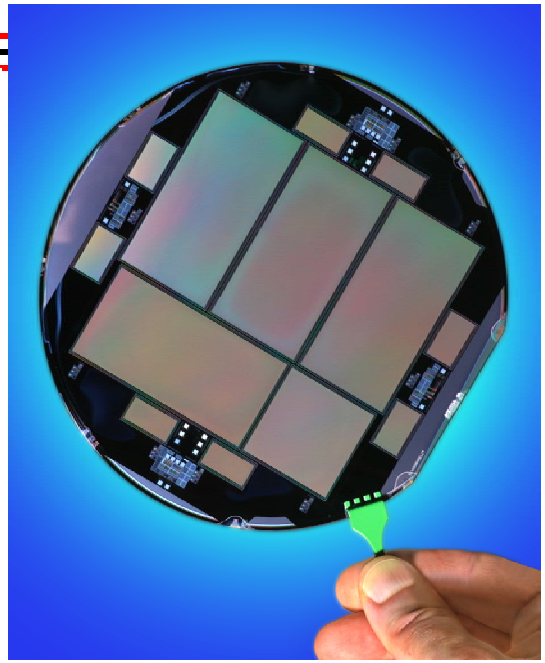
- 44 Eng. grade 2kx4k CCDs in hand
- used to develop focal plane packages, characterize CCD performance, test CCD readout electronics
- Expect 16 more in Sept. 06

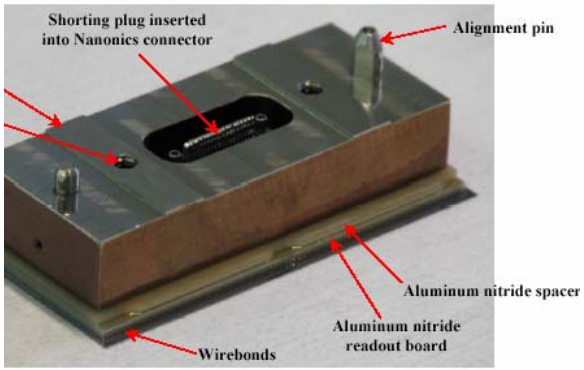
Potential Science grade devices expected in Nov. 06

FY07: establish CCD processing and packaging yield

- preliminary est. 25% yield (SNAP devices)
- implies 18 months and $1.6M for 70 good devices
- CCD yield is a cost and schedule driver (will say more when discussing the critical paths)

DES Wafers – June 2005!





Front End Electronics WBS 1.3

FNAL, Barcelona, Madrid, UIUC

DARK ENERGY SURVEY

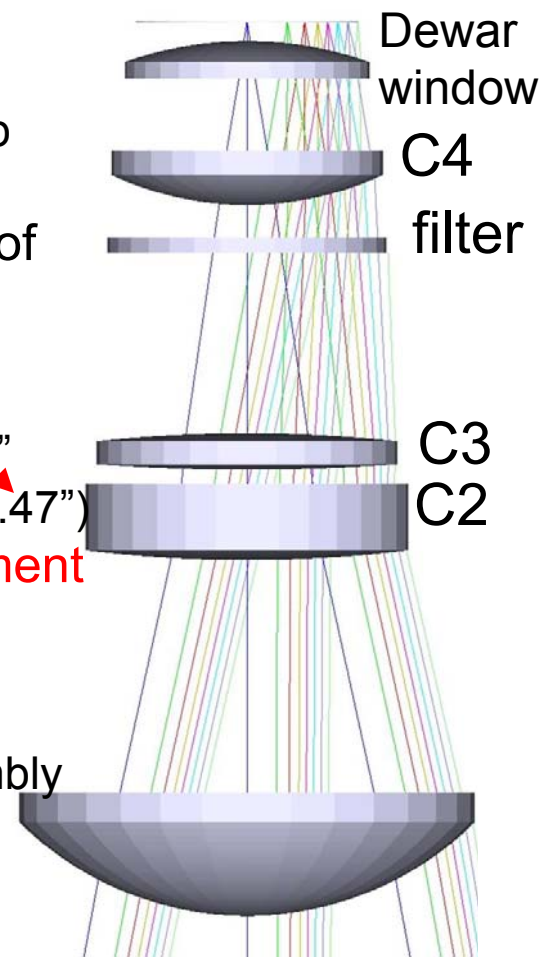
- We chose the Monsoon CCD readout system developed by NOAO for our CCD testing and characterization efforts.
  - Monsoon: designed to be compact and low power for large mosaic cameras
  - 3 types of boards: Master Control board, Clock board and Acquisition board
- For the PF cage we need higher density:
  - Need a 12 channel instead of 8 channel Acquisition card (Fermilab)
  - Need more clock signals and buffers (Spain)
  - Master control board – convert optical link to S-link (Spain)
  - Compact, low noise power supplies, thermally controlled crates (UIUC)
- Internal Collaboration review panel (led by Manel Martinez from Barcelona) investigated other options and this is their recommended path (their report is on the web)
- Spanish consortium plans to provide all the production FEE boards
- Their proposal to their funding agencies was approved (~$1M).
- UIUC is developing the thermally controlled housings for the crates and testing prototype power supplies

Optical Corrector WBS 1.4

5 elements, fused silica

DARK ENERGY SURVEY

- 2005: added collaborators with optics experience
  - University College London, and their Optical Science Lab
  - University of Michigan
- Feb. 2006: DES director's Preliminary Design Review of the Optical Design (Report and presentations on the web)
- Preliminary Design ~complete (UMich lead, FNAL, UCL)
  - PSF from the telescope, instrument, and other factors exclusive of the site seeing shall be no greater than 0.55"
  - Est. for current DES corrector design: fwhm ~ 0.33" (0.47")
- March 06 the UK proposal to PPARC for the procurement of the optics was conditionally approved
  - 1.47 M pounds to cover cost of polishing, mounting, and alignment of the lenses in the barrel
  - P. Doel (UCL-OSL) will manage procurement and assembly
- Additional UK funding ($0.5M) available through Portsmouth (SRIF3): ~60% of the blanks
- US University funding could cover the rest.
- Procurement of the optics is ~2 years
- CRITICAL PATH



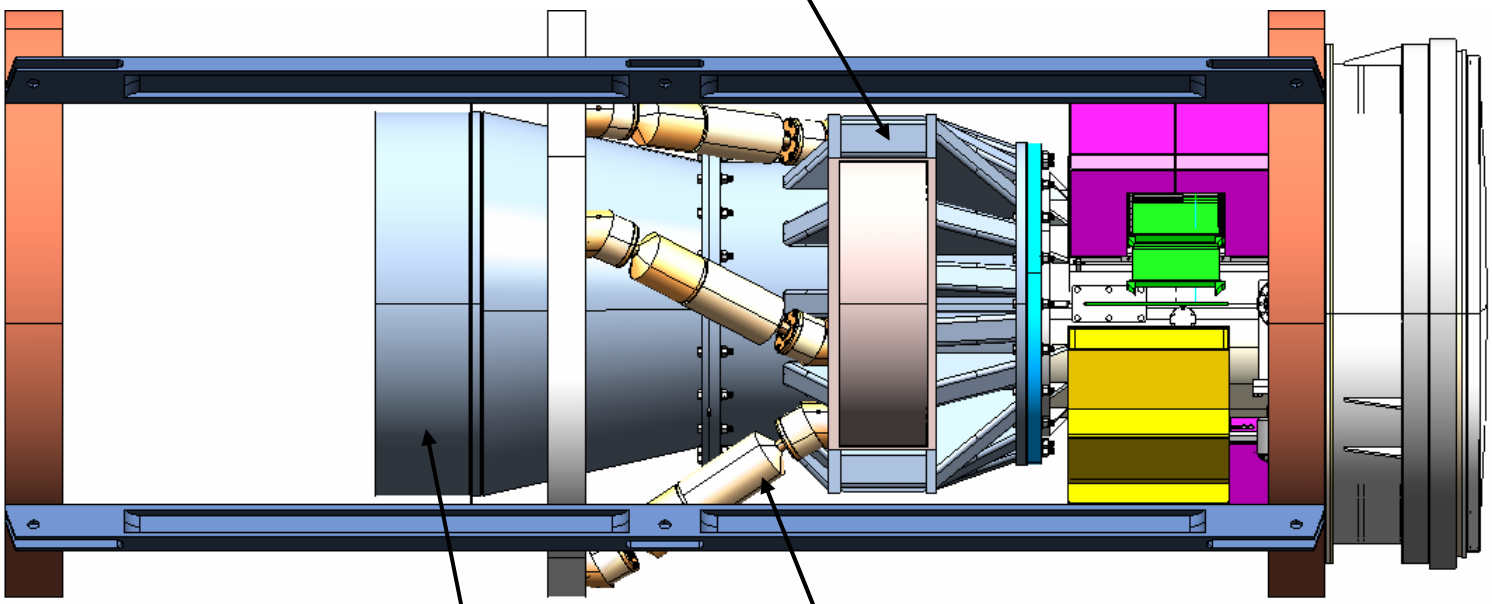
C1 diameter 940 mm

Opto-Mechanical Systems (WBS 1.5)

DARK ENERGY SURVEY

Opening for filter changer and shutter. Shutter is installed directly in front of C4. UMichigan is designing the combined shutter/filter changer unit. It will house the four DES filters plus at least two community filters

Prime Focus Camera



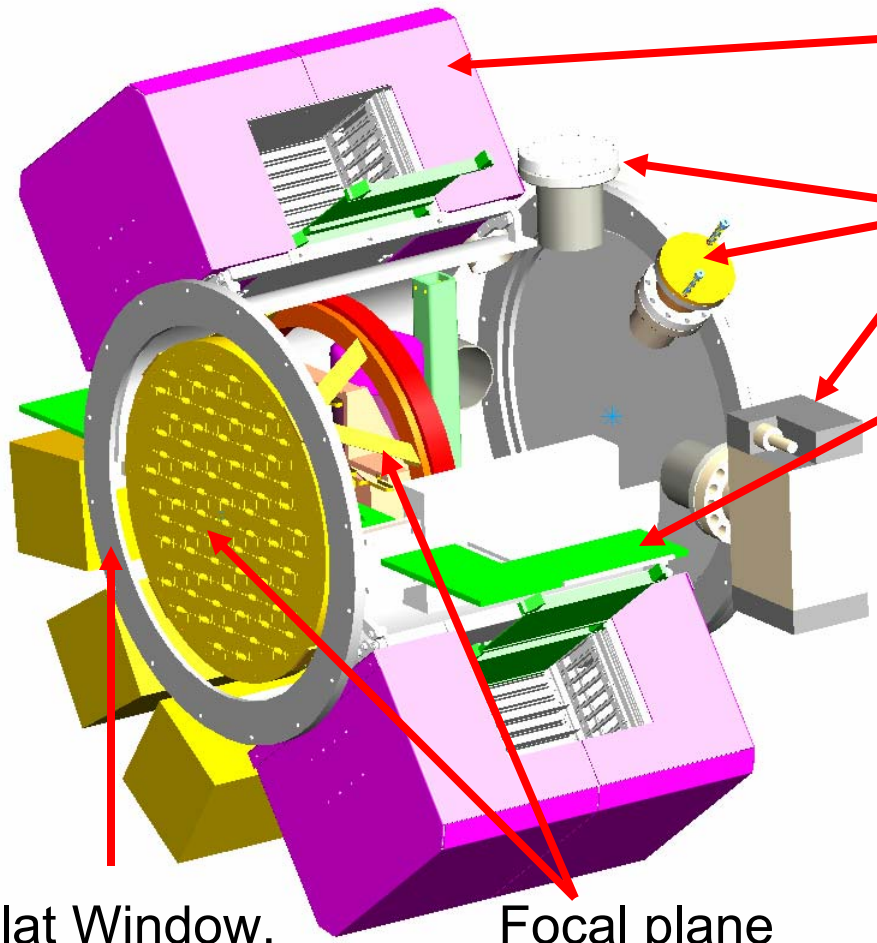
Will reuse F/8 mirror and some mounting hardware

Cover and baffles

Hexapod alignment system

Camera Vessel Prototype (WBS 1.5.3)

DARK ENERGY SURVEY



10 slot thermally controlled crate for CCD readout electronics

Cryo and Vacuum controls

Feed-through board for CCD signals

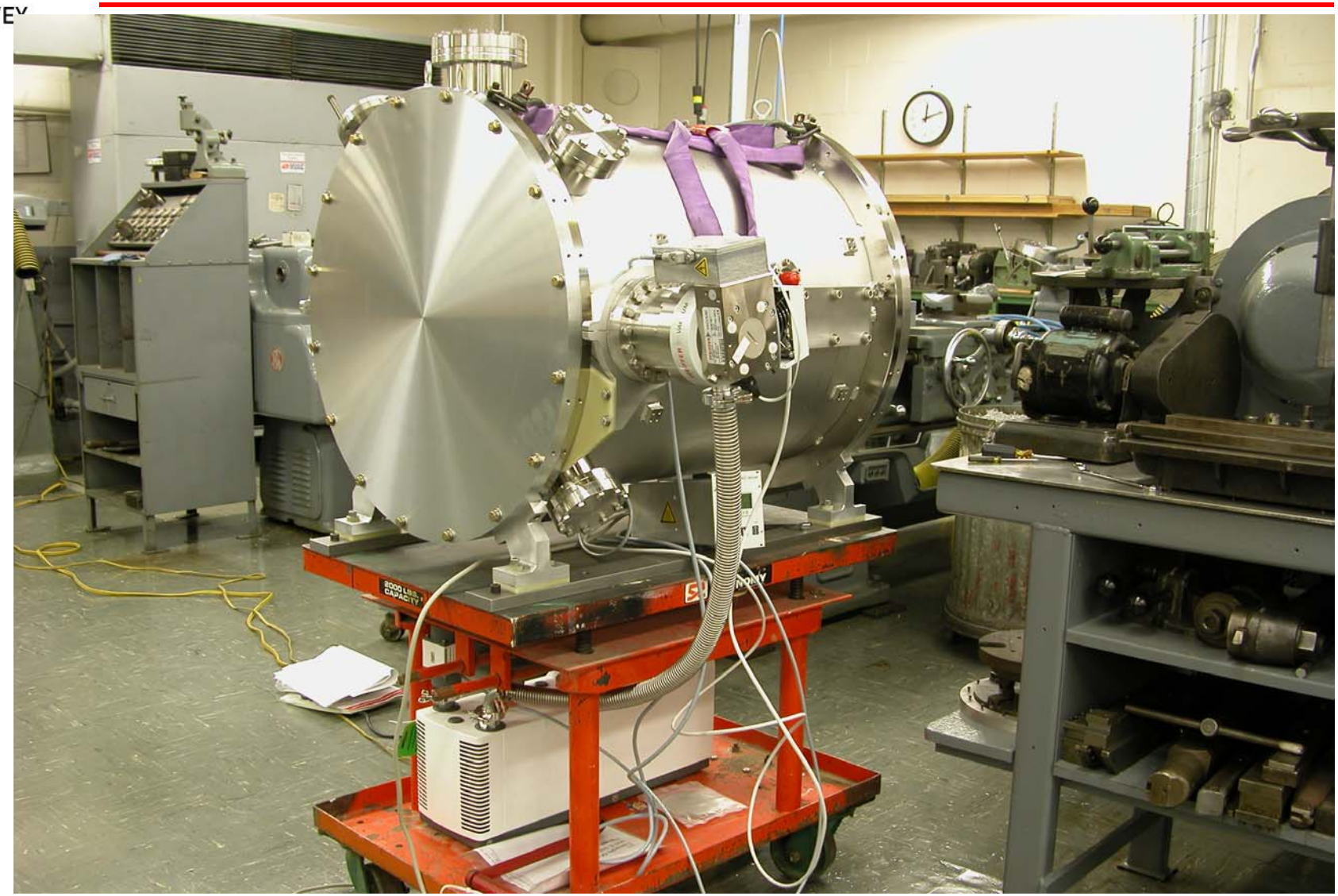
Primary goal is to test multi-CCD readout
Also tests concepts for Focal Plane supports, C5 Cell, Vacuum and cooling

Flat Window, prototype C5 Cell

Focal plane and supports

Designed at Fermilab (Cease), Built by UChicago (in-Kind) arrived at Fermilab last week

DARK ENERGY SURVEY

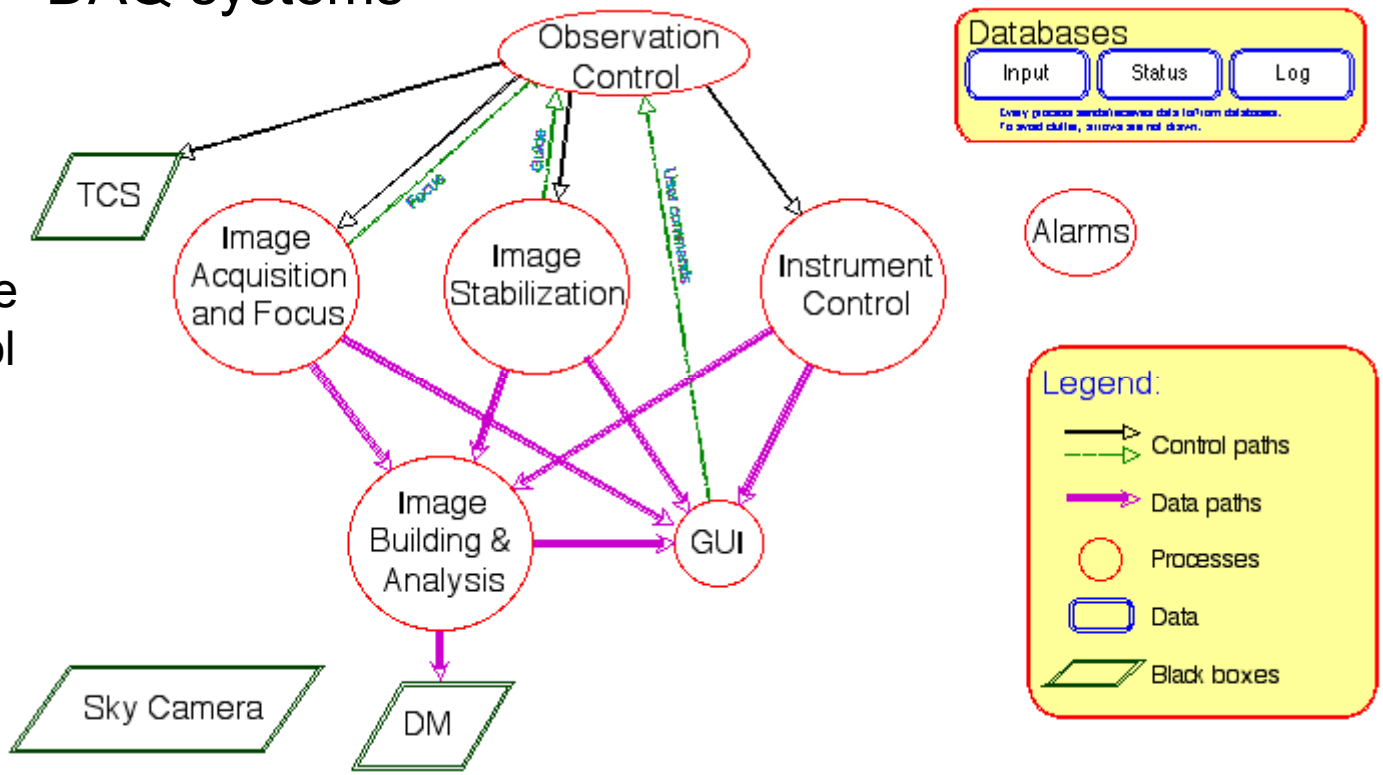


Survey Image System Process Integration (SISPI) WBS 1.6

DARK ENERGY SURVEY

U Illinois-HEP (J. Thaler) is leading the SISPI development - similar to HEP-DAQ systems

CTIO will upgrade the Telescope Control System (TCS)



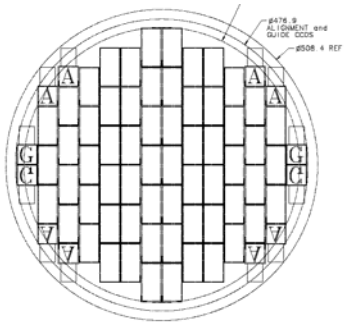
Data Management (DM): U. Illinois-Astro/NCSA

Survey Planning (WBS 1.7)

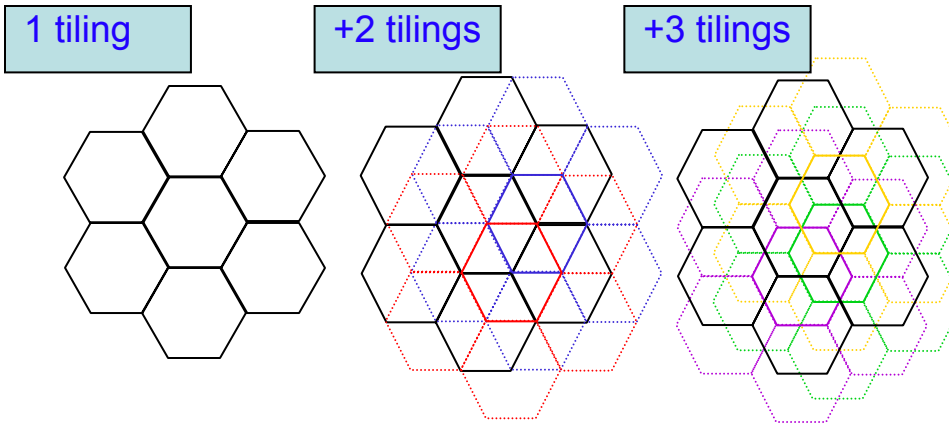
DARK ENERGY SURVEY

Led by Scientists in the CD-EAG group

- Determination (simulation) of an efficient observing strategy
  - Optimize for excellent photometric calibrations
- Simulation of mock raw DECam survey images, including galaxies and stars, and instrumental effects
  - Used to optimize photo-z calibrations – key goal for DES
- Produce simulated data to support the annual Data Challenges in the Data Management Project: Each year the simulations grow in complexity and size



DECam 3 deg^2 field of view (= 1 hex = 1 tile)



DES "tiles" 5000 deg^2 of sky at a rate of 2 times per year in each of 4 filters

Integration at CTIO (WBS 1.8)

DARK ENERGY SURVEY

DECam design is tailored to match the capabilities of the Blanco, the site, and where possible (with no cost increase) needs of the community.

- Main point of contact is DECam Deputy project manager (Tim Abbott)
  - Participates in weekly meetings on all aspects of the project
  - Provides critical on-telescope experience

Examples:

- DES and CTIO upgrades will bring the delivered PSF (currently 0.9”) closer to the site PSF (0.65”): CTIO will upgrade mirror supports, DES will have focus and alignment sensors on FP, active focus and position control (hexapods), cooled electronic crates
- CTIO upgraded TCS will reduce the slew time to match the CCD readout
- DES filter system will include positions for at least 2 community filters to minimize handling of all filters and allow safe filter swaps for additional filters

Three documents will define the interfaces:

- **DECam Integration Plan**
- **DECam Installation Plan**
- **DECam Operations and Maintenance**

Proposed DECam DOE Critical Decision Schedule

DARK ENERGY SURVEY

- Generic CD0 Granted in Nov. 05
- FY06 R&D; CD1 Paper review Sept.06
  - Conceptual Design report, Science and Technical Requirements Document
  - Cost and schedule ranges
  - Preliminary DOE Documents: Acquisition Strategy, Project Execution Plan, Hazard analysis
  - Project Management Plan
- FY07 R&D, CD2 Review March 07
  - Technical Design Report
  - Lehman Review: Cost and Schedule are baselined
- Sept. 07, CD3 Paper Review
- FY08 MIE Construction start (Schedule assumes funds available in Nov. 07)
- FY08-10: Assemble and test camera vessel and corrector
  - Ship to Chile, reassemble and perform acceptance tests
  - DECam Project activities complete when acceptance tests are satisfied (Sept. 2010)
  - Installation on the Blanco is scheduled by the CTIO Director
- March 2011 – CD4: DECam project close-out documentation complete
- Survey Oct. 2010 - March 2015

DECam Cost and Schedule

DARK ENERGY SURVEY

- Cost and Schedule are captured in a Microsoft Project file
- Will use Cobra to interface the schedule file to the Fermilab general ledger and monitor project progress
  - matches budgeted cost of work performed to the schedule and to the progress reported by the L2 mangers through monthly updates to the schedule file
- Level 2 managers and engineers participate in the construction of the schedule file
- When estimating the cost and schedule the L2 managers were instructed to be realistic – not overly conservative or aggressive – so contingency can be explicitly identified for both cost and schedule. Estimates are discussed and reviewed by Project management.
- Progress will be reported monthly to the ADR and the Federal Project Director through written reports and meetings of the Project Management Group
- Milestones of different levels (next slides) are used to define critical events and to monitor progress

Reviews (in addition to the DOE CD reviews)

DARK ENERGY SURVEY

- The DES Directors (of NOAO, FNAL, NCSA) will periodically review the DECam project, typically annually, to monitor the progress

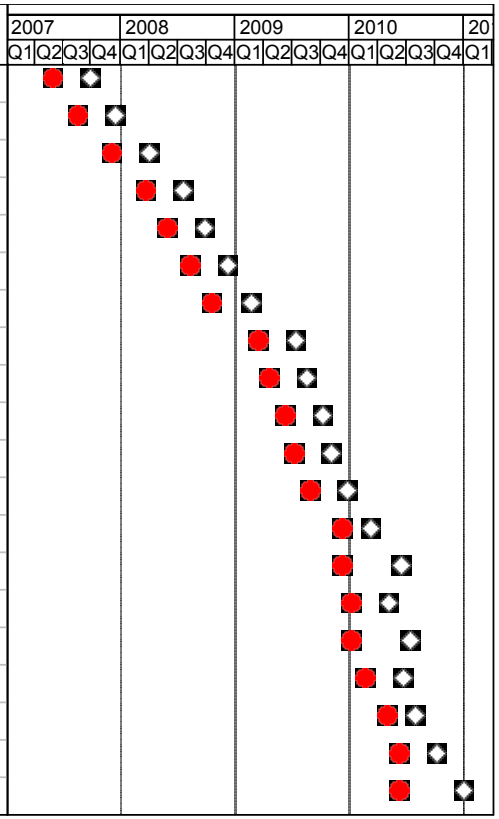
- Each L2 system will undergo a technical review to optimize the design, minimize cost and risk. The DES Project Director and Project Manager will appoint a committee of experts within and external to the DES Collaboration – An example of such a review is the Preliminary Design review of the Optics (Feb. 2006)

- The schedule includes multiples stages of development. Typically:
  - Prototypes are called version V1
  - V2 includes modifications to V1 but is not final (preproduction)
  - V3 is the production version
- Internal DECam reviews are scheduled before major procurements and before launching in to each development stage. May include reviewers external to the collaboration
- Safety Reviews:
  - PPD ES&H group will review each L2 system
  - PPD ES&H Committees will conduct Operational Readiness Reviews prior to operation of major systems

Level 1 and 2 Milestones

DARK ENERGY SURVEY

WBS Level	Name	Forecast Start	Baseline Start	Variance
1.3	L2 - CCD readout review - go ahead for V2	3/2/07	6/30/07	-16.8 wks
1.4	L2 - Corrector Element Polishing Contract Awarded	5/18/07	9/15/07	-16 wks
1.2	L2 - CCD Processing and Packaging (v2) Review Complete	9/5/07	1/3/08	-15 wks
1.5	L2 - Design Review of Camera and Cooling Complete	12/21/07	4/19/08	-15 wks
1.3	L2 - Production Electronics Review Complete	2/26/08	6/25/08	-16.8 wks
1.4	L2 - Ready To Install Cells On Lenses at UCL	5/13/08	9/10/08	-16.2 wks
1.2	L2 - 30 production wafers delivered to FNAL	7/22/08	11/19/08	-16.8 wks
1.4	L2 - Barrel and C5 Cell Arrive At UCL From Fermilab	12/15/08	4/14/09	-15.2 wks
1.2	L2 - Final CCDs at FNAL	1/19/09	5/19/09	-17.2 wks
1.6	L2 - Final SISPI Software Testing Complete	3/10/09	7/8/09	-16.8 wks
1.2	L2 - Production CCD testing complete	4/9/09	8/7/09	-16.8 wks
1.3	L2 - DES Front End Electronic Production Complete	5/26/09	9/23/09	-16.6 wks
1.5	L2 - Camera testing complete	9/9/09	12/8/09	-12.4 wks
1.5	L1 - Camera testing complete	9/9/09	3/15/10	-26 wks
1.4	L2 - Corrector Alignment and Testing Complete	10/7/09	2/4/10	-16.8 wks
1.4	L1 - Corrector Alignment and Testing Complete	10/7/09	4/14/10	-26.4 wks
1.7	L2 - Survey Strategy Complete	11/20/09	3/22/10	-16.8 wks
1.8	L2 - Acceptance Testing Ready To Begin	1/29/10	4/29/10	-12.8 wks
1.8	L2 - Acceptance Testing Complete	3/12/10	7/10/10	-17 wks
1.8	L1 - Acceptance Testing Complete	3/12/10	9/30/10	-28.6 wks



Schedule contingency is built into the Level 1 and Level 2 milestones
Level 3 and 4 milestones are driven by the tasks
If the tasks slip we will see the variance (contingency) go down

Change Control: Schedule

DARK ENERGY SURVEY

Formal change control procedures will track technical, schedule, and cost changes in the project. Each change requires the preparation of a Project Change Request (PCR) form and approval depending on the size.

Milestone Definitions and Change Control thresholds:

- Level 4 Milestones are owned by the Level 2 managers. They define significant points in schedule – no contingency, no change control
- Level 3 Milestones are monitored by the DECam Project manager Typically contain ~ 4 weeks of contingency.
  - A change of >2 wks triggers preparation of a PCR and requires approval of the DECam PM
  - A change of > 12 wks requires approval of the ADR
- Level 2 Milestones are monitored by DECam Federal Project Director. Contingency is ~ 16 weeks. Any change to these requires approval of the FPD.
- Level 1 are the highest level. Any change requires approval of the DOE Acquisition Executive. Contingency is ~ 6 months.

Cost

	Total Base w/Ind. & Esc.					
	FY06	FY07	FY08	FY09	FY10	Total
R&D	2.30	4.63	1.00	0.00	0.00	7.93
MIE	0.00	0.00	5.93	5.90	3.78	15.61
Total	2.30	4.63	6.93	5.90	3.78	23.54

This matches the straw-man funding guidance from the ADR

- At the P5 meeting (April 06)
  - the R&D total was $4.1M, now it is $7.9M
    - Revised direct (unburdened or escalated) costs went up ~$0.1M
    - The P5 estimate did not include FY06; plus it assumed FY06 budget would be $2.8M, which is more than the project is receiving: adds $2.8M
    - Did not include the new Organizational Overhead: adds ~ $0.9M
  - The MIE total was $12.6M, now it is $15.6M
    - Revised direct costs went up $0.5M Labor (11%) and $0.5M in M&S (8%)
    - The new overhead on the MIE adds an additional $2M

Cost Contingency

DARK ENERGY SURVEY

- MSP Schedule file contains columns to indicate a contingency factor separately for the M&S and the labor cost
- Typical contingency assigned to each task:
  - Labor is 50%
  - M&S is 40%.
- If we have a reliable quote or direct experience the M&S contingency factor is 20%
- For the CCDs we have 20% on the CCD fabrication (LBNL and Dalsa costs have been right on so far) and also have included the cost of procurement and processing of an additional 24 wafer lot ($485k)
- As the risk analysis becomes more sophisticated, the factors will be adjusted to reflect the risks
- The contingency on each task is calculated in the MSP file and included in the MIE cost of the project. Total is ~ 35% of the total (R&D+MIE)

Cost Range

DARK ENERGY SURVEY

- For DOE Critical Decision 1 we need a cost and schedule range
- The range should bracket the estimated cost and schedule of the project
- Further analysis and feedback will transform the ranges into the project baseline cost and schedule for the CD2 Review (~March 07)

How we derived the ranges:

- For the high end we assumed we have to repeat FY09. This would add $6M to the MIE: $29.5M
- For the low end we assumed we only need half the contingency (for example if we could determine the CCD yield was 50% rather than 25%): The DOE MIE would be $20.4M
- For the schedule range we take the low end as the finish from the schedule without contingency (March 2010) . For the high end we add one year to the earliest finish (March 2011)
- This will be a topic for discussion in the management breakout

Costs at Level 2

DARK ENERGY SURVEY

- DOE Base costs R&D+MIE (this is what the L2 project managers talks will use: no escalation or burdening)
- M&S $6.5M Labor $5.6M
- With contingency these become M&S $8.5M Labor $7.5M
- Below shows the costs at Level 2 burdened and escalated
- In Kind contributions at Level 2 are also shown

	Total DECam DOE Costs w/Ind. & Esc.				In Kind	Total
	M&S	**Labor**	**M&S cont.**	**Labor Cont.**		
DECAM Total	**7.67**	**9.57**	**2.77**	**3.66**	**3.92**	**27.59**
Management	0.33	0.79	0.04	0.17	0.58	1.91
Focal Plane Detectors	2.75	2.44	1.16	0.81	0.03	7.20
Front End Electronics	0.72	2.37	0.17	1.01	0.73	5.01
Optics	0.88	0.09	0.36	0.04	2.15	3.52
Opto-Mechanical	2.68	3.50	0.91	1.46	0.42	8.98
SISPI	0.13	0.00	0.05	0.00	0.01	0.19
Survey Planning	0.19	0.06	0.08	0.03	0.00	0.35
CTIO Integration	0.00	0.30	0.00	0.13	0.00	0.44

In-Kind Contributions

DARK ENERGY SURVEY

- Memoranda of Understanding (MOU) between each institution and Fermilab define overall contribution to DECam and institutional roles
- Annual Statements of Work (SOW) specify
  - funding and commitments for the next Fiscal Year,
  - the in-kind contributions of the institution to the DECam project,
  - the resources provided by Fermilab to the institution,
  - the responsibilities of key personnel from Fermilab and the institution,
  - schedule and milestones for completion of the tasks.
- The collaborating institution intend to cover the full cost of the components that are identified as in-kind contributions.
- Each institutional proposal includes contingency
- Each institution has also identified contributions to the DECam "Common Fund". These contributions will be used through consultation of the DES PD, the DECam PM and the relevant Institution and can function as additional contingency on the institutional in-kind contribution.

In-Kind Contributions

DARK ENERGY SURVEY

- Proposed changes to the in-kind deliverables will be reviewed by the DES Project Director and the DECam Project Manger and the Project Scientist
- If the technical performance, cost or schedule changes affect the DECam L2 milestones it will be brought to the attention of the PMG and the Change Control Board for action and the institutional DECam MOU will be revised.

Change Control Thresholds: Technical and Cost

DARK ENERGY SURVEY

- Level 4 : any change to the technical scope and any use of contingency funds must be approved by the DECam Project Manager

- Level 3 : Requires approval by the FNAL Associate Director of research
  - Any change that affects the technical performance or baseline, or ES&H requirements
  - Any use of DOE contingency that would take the contingency as a percentage of the DOE MIE Estimated cost To Complete (ETC) below 25-30% (TBD)

- Level 2 :Requires Approval of the Federal Project Director:
  - Any use of DOE contingency that would take the contingency as a percentage of the DOE MIE ETC below 25-30% (TBD)

- Level 1: Requires approval of the DOE Acquisition Executive
  - Any change in scope that affects the mission need requirements
  - Any increase in the DOE MIE

DECam critical paths: CCDs & Optics

DARK ENERGY SURVEY

CCDs:

- LBNL can deliver CCDs at a rate of 20/month after 3 month startup
- We need 70 CCDs for the FP including spares
- Preliminary yield estimate of 25% implies ~18 months
- Cost is ~$23k/wafer, 25% yield implies $1.6M
- Construction start of Nov. 07 implies last CCD is finished April ’09
- Install last CCD and test full camera ~ 5 months
- Ready to ship to Chile ~ Sept. 09 → March 2010 acceptance tests complete
- Level 2 Milestone on July 2010 includes 4 months contingency

Optics:

- Blanks ~ $0.9M , 8 month delivery,
- Polishing ~ $1.5M, 18 month delivery
- Assembly and alignment into corrector ~ 6 months
- Ready to ship to Chile ~ 2.75 yrs after procurement begins
- Feb. 07 blank procurement → Oct. 09 delivery to CTIO → March 2010 acceptance tests complete
- Level 2 Milestone in July. 2010 includes 4 months contingency

Peter Doel will discuss the Optics in his talk, the next few slides discuss the CCD procurement

CCD procurement and Yield

DARK ENERGY SURVEY

- CCDs are ordered from Dalsa in Lots of 24 wafers
- 3 out of the 24 are used by Dalsa to control/monitor the processing. These are finished at Dalsa, functional but 650 microns thick
- Testing occurs at multiple stages
  - Dalsa tests control wafers; provides first estimate of success
  - LBNL tests the control wafers on a cold probe station (-45 C)
    - Can find bad RO channels, and other gross effects
    - estimate of the cosmetic defects (some will freeze out)
  - After thinning and processing at LBNL, cold probing of the 2kx4k devices provides preliminary estimate of yield and is used to determine the order of packaging at FNAL
  - After packaging, the CCDs are tested at FNAL at operating temp. (-100C) (talk by Juan Estrada)

CCD procurement

DARK ENERGY SURVEY

- Yield can vary between lots but is fairly uniform within a lot
- When Dalsa gets started – processing can proceed quickly (8-12 weeks) but sometimes we are not their highest priority
- Processing at LBNL takes 12 weeks for the first 5 wafers and then can sustain a rate of 5 wafers/month.
- Processing at Dalsa is ~ 5k/wafer, processing at LBNL is $17.5k/wafer

R&D Plans:

- Develop a mask with four 2kx4k CCDs to minimize processing costs
- Order 1 Lot for development of packaging and testing procedures: Lot 1
- Order 4 lots of 24 wafers with potential for focal plane CCDs (Lots 2A-D)
- Process 5 wafers per lot at LBNL to determine Lot yield

Production (once MIE funds are approved):

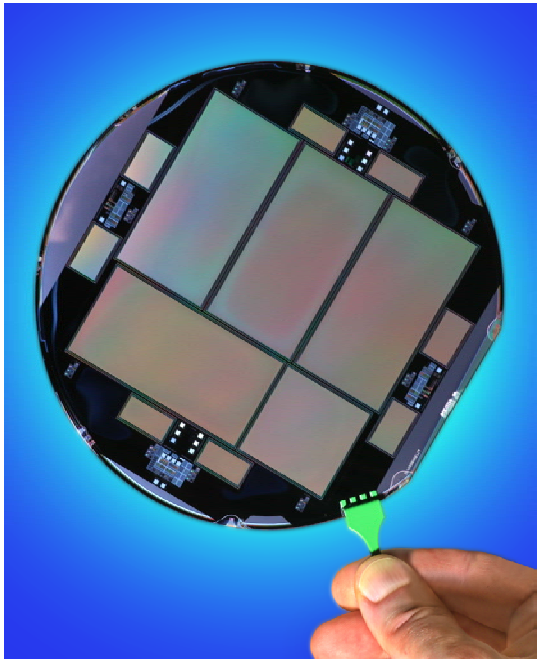
- Order another lot if yield is < 25%
- Initiate processing at LBNL of remaining wafers (schedule assumes Nov 07 start) ~18 months

R&D program status

DARK ENERGY SURVEY

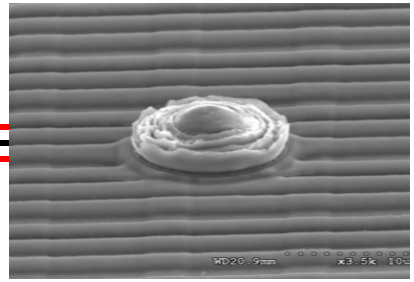
DES Wafers – June 2005!

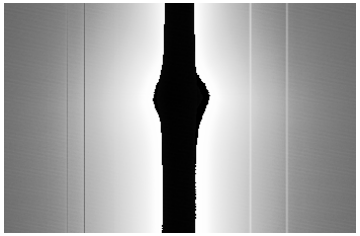
- June 2005 Control wafers delivered to LBNL – DES mask design proven successful!



- Lot 1A
  - High particulate count, Dalsa delivered for free
  - LBNL processed and delivered 5 wafers in Nov.
  - High incidence of defects related to particulate count.
- Lot 1B
  - Lower particulate count
  - Foundry delivered wafers to LBNL in Sept. 05
  - LBNL processed 5 wafers (Lot 1B.1)
  - Still found high incidence defects
- LBNL visited Dalsa
  - Traced high particulate count to new users of an oven at Dalsa that used to be only for the LBNL recipe

CCD Fabrication Update





- Particulates get deposited on front side during application of the ISDP backside gettering layer (ISDP)
- Subsequent application of FS layers fails at these points
- Sometimes produces “light bulbs” : device is unuseable

- As Feb.06 14 out of 36 (39%) delivered 2kx4k had no light bulbs based on cold probe data

- March, April 06: Processing at LBNL retuned

- June 06: LBNL delivered 2 Lot 1B wafers (8 die) with 0 light bulbs

CCD Fabrication Update

DARK ENERGY

- We are investigating two strategies to make the CCD processing less sensitive to particulate count
  - Re-polish the front-side of the wafers after ISDP (DES Lot 2A is following this path, estimated delivery to LBNL at the end of Aug.06)
  - Use a new wafer material (Poly Backseal) that already has the backside gettering layer. LBNL initiated an 18 wafers lot to investigate this option.
  - Initial results on Poly Backseal look good:
    - cold probe results on 8 thick 2k x 4k devices show no light bulbs
    - small test devices have been packaged and tested in dewar to measure dark current vs temp.
- If the Poly Backseal option works, it is the way to go, less risky and more efficient
- CCD Processing Review is planned for Dec. 2006

CCD Procurement Schedule

DARK ENERGY SURVEY

Task	Start	Duration	M&S
R&D on wafer Lots 2A and 2B (WBS 1.2.2)			**$175,000**
Process Lot 2a repolished wafers at Dalsa	6/21/06	8 wks	
Saw Lot 2 A Control wafers and deliver to FNAL	8/18/06	4 wks	
Determine lot yield for 5 repolished wafers (Lot 2A processing at LBN	8/18/06	12 wks	
Review of CCD processing results	11/14/06	4 wks	
Reinitiate Lot 2B wafers at Dalsa (polyback seal)	12/14/06	12 wks	
Submit requisition for processing 10 Lot 2B wafers at LBNL	12/14/06	8 wks	$175,000
Saw Lot 2B Control wafers and deliver to FNAL	3/22/07	4 wks	
L4 - Cold probe yield known for Lots 2A and 2B	4/18/07	0 wks	
Process 10 Lot 2B wafers at LBNL & determine lot yield and LBNL rat	3/22/07	16 wks	
R&D on wafer Lots 2C and 2D (WBS 1.2.3)	**4/19/07**	**26 wks**	**$415,000**
Lot 2C and 2D CCD processing at Dalsa- (48 wafers)	4/19/07	10 wks	$240,000
Get requisition in place for processing 10 Lot 2C + 2D wafers at LBNL	4/19/07	8 wks	$175,000
Saw control wafers and deliver to FNAL	6/29/07	4 wks	
Lot 2C,2D processing at LBNL 10 wafers: determine lot yields	6/29/07	16 wks	
L4 - Cold probe yield known for Lots 2C and 2D	10/24/07	0 wks	
Production CCD Processing At LBNL (WBS 1.2.4)	**10/31/07**	**58 wks**	**$980,000**
LBNL Process remaining 15 wafers	10/31/07	22 wks	$227,500
LBNL Process remaining 15 wafers	4/18/08	13 wks	$192,500
L3 - 30 production wafers delivered to FNAL	7/22/08	0 wks	
LBNL Process remaining 15 wafers	7/23/08	13 wks	$280,000
LBNL Process remaining 9 wafers	10/24/08	10 wks	$280,000
L4 - Final CCDs at FNAL	1/19/09	0 wks	

Information for Reviewers

DARK ENERGY SURVEY

- All the slides and documents are on the reviewer web page:

https://www.darkenergysurvey.org/the-project/decam/DECam-CD1-DR/

- Reviewer notebooks contain
  - Conceptual Design Report
  - Science and Technical Requirements Document
  - All the plenary talks
  - Responses to the June 2004 Director's review
- Management Breakout will have notebooks with all the CD1-DOE documents. All are preliminary: ACQ, PEP, PMP,NEPA, Hazard Analysis, Risk Management, Configuration Management and Value Management
- Breakout sessions: Each will have a Basis of Estimate Book with print-outs of the Schedule Gantt and Cost Chart.
  - Management (WBS 1.1)
  - Focal Plane Detectors (WBS 1.2) and Camera Vessel (1.5.3)
  - Front End Electronics (WBS 1.3) and SISPI (WBS 1.6)
  - Optics (WBS 1.4), Opto-Mechanical (WBS 1.5), Survey Planning (WBS 1.7) and Integration (WBS 1.8)

Conclusions

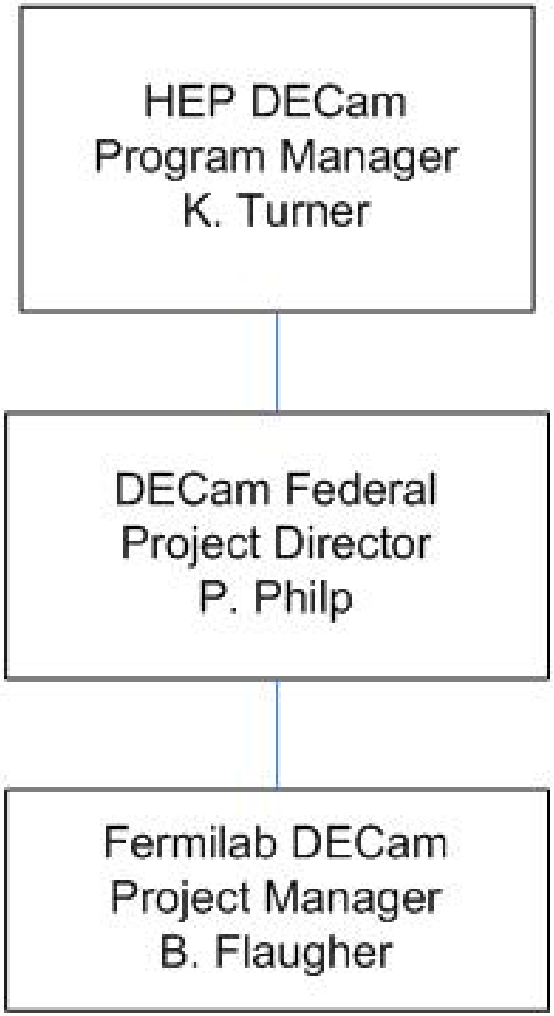
The DECam Project

- Builds on existing technology and infrastructure and project management experience at Fermilab, and capitalizes on collaboration's experience with optics, electronics, large DAQ systems, operating CCD cameras, and telescopes
- Realizes the potential of an excellent proven telescope and site
- Will place new constraints on Dark Energy and is well situated to make combined constraints with other projects such as the South Pole Telescope
- 3 deg^2 camera: x7 larger area and x7 faster readout than existing Mosaic camera on the Blanco – significant improvement for the user community
- Development and implementation of data analysis techniques for photo-z's, cluster masses, weak lensing, baryon oscillations, and supernovae are the next steps toward the science of the Stage IV projects of the future (LSST, SNAP)

EXTRA SLIDES

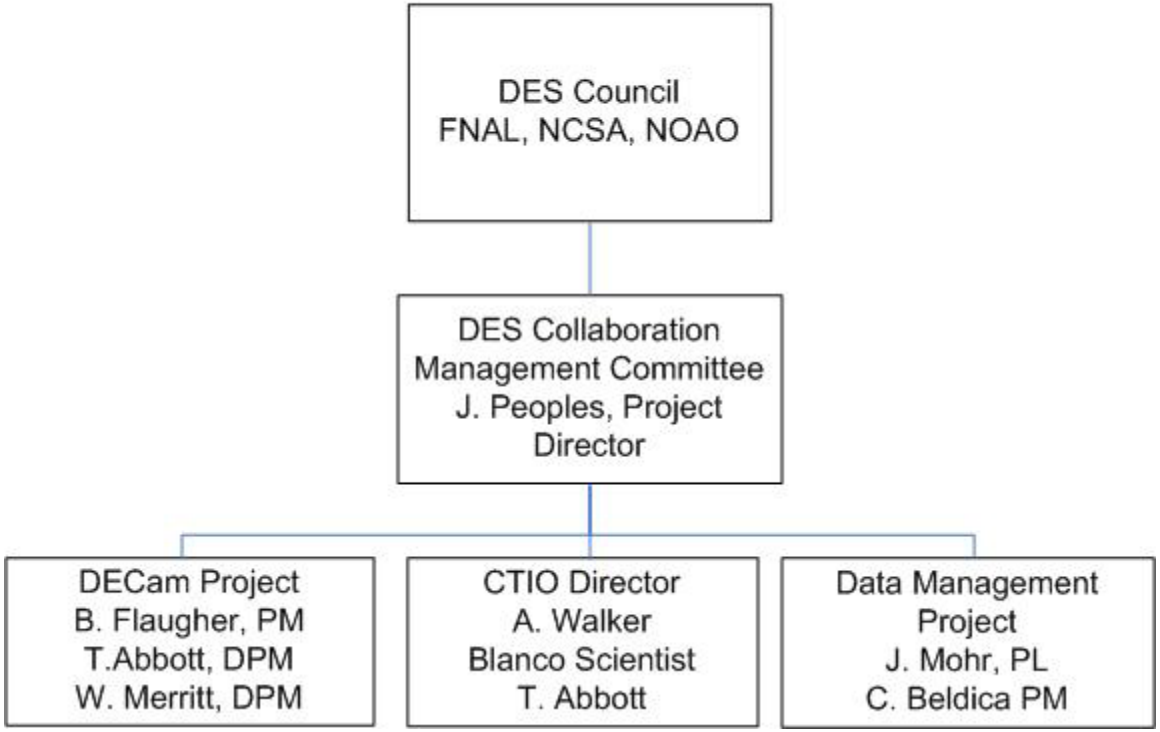
DARK ENERGY SURVEY

DECam Program Project Management Organization
(day to day working level interactions)



DARK ENERGY SURVEY

Dark Energy Survey Organization
(DES)



Change Control

- The July 2004 proposal serves as the reference design of DECam
- Since then we have developed
  - A separate Science and Technical requirements document that contains a more complete and detailed description
  - A conceptual design report which contains updated description of the science projections and an undated design for DECam that includes the design and experience in the last 2 years
- The Science Requirements document states the requirements of DECam and is under change control
- DECam design also responds to the needs of the community
- The Fermilab PMG serves as the change control board

End Game

- C5 Cell is fit to Barrel before barrel is shipped to UCL
- Corrector is shipped directly to CTIO from UCL
- Camera goes from FNAL to CTIO
- Will have a second barrel and a simulator of the top end flip ring at FNAL for testing the hexapod, the cooling and cable routing, Filter changer and shutter
- At CTIO the camera and corrector will be reassembled and tested in the clean room on the Mountain.
- Acceptances tests on the floor at CTIO define the end of the DECam project.
- CTIO Director decides when to disassemble the telescope and install DES.