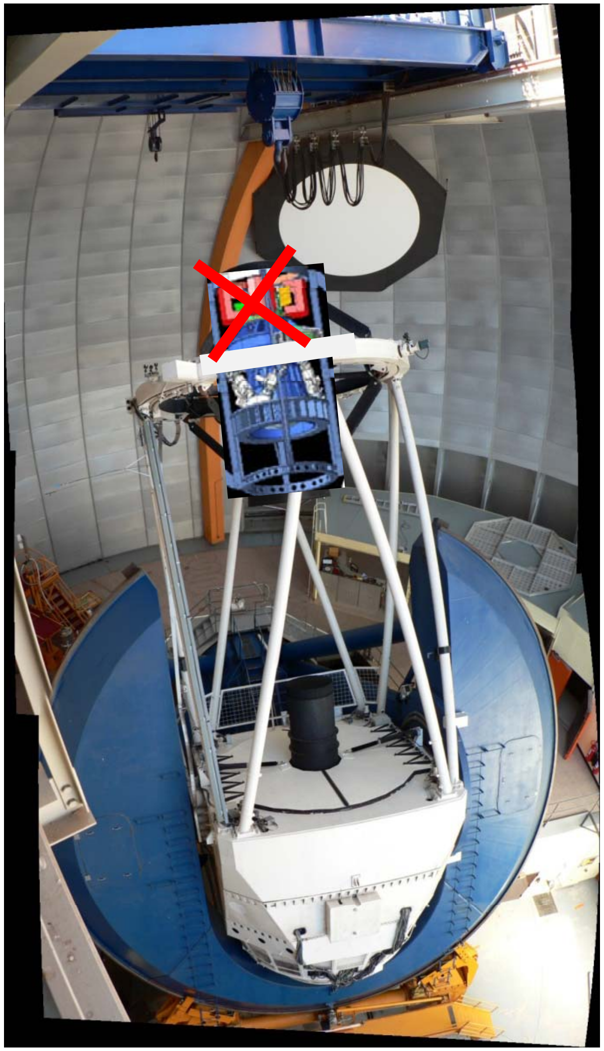
DESpec

Outline

- Concept
- Technical Components
  - Optics: corrector and ADC
  - Fiber Positioner
  - Fibers & Spectrographs
  - CCD & RO
  - Instrument Swap
- Instrument Simulation
- Summary



Tom Diehl, DESpec Meeting at KICP May 2012

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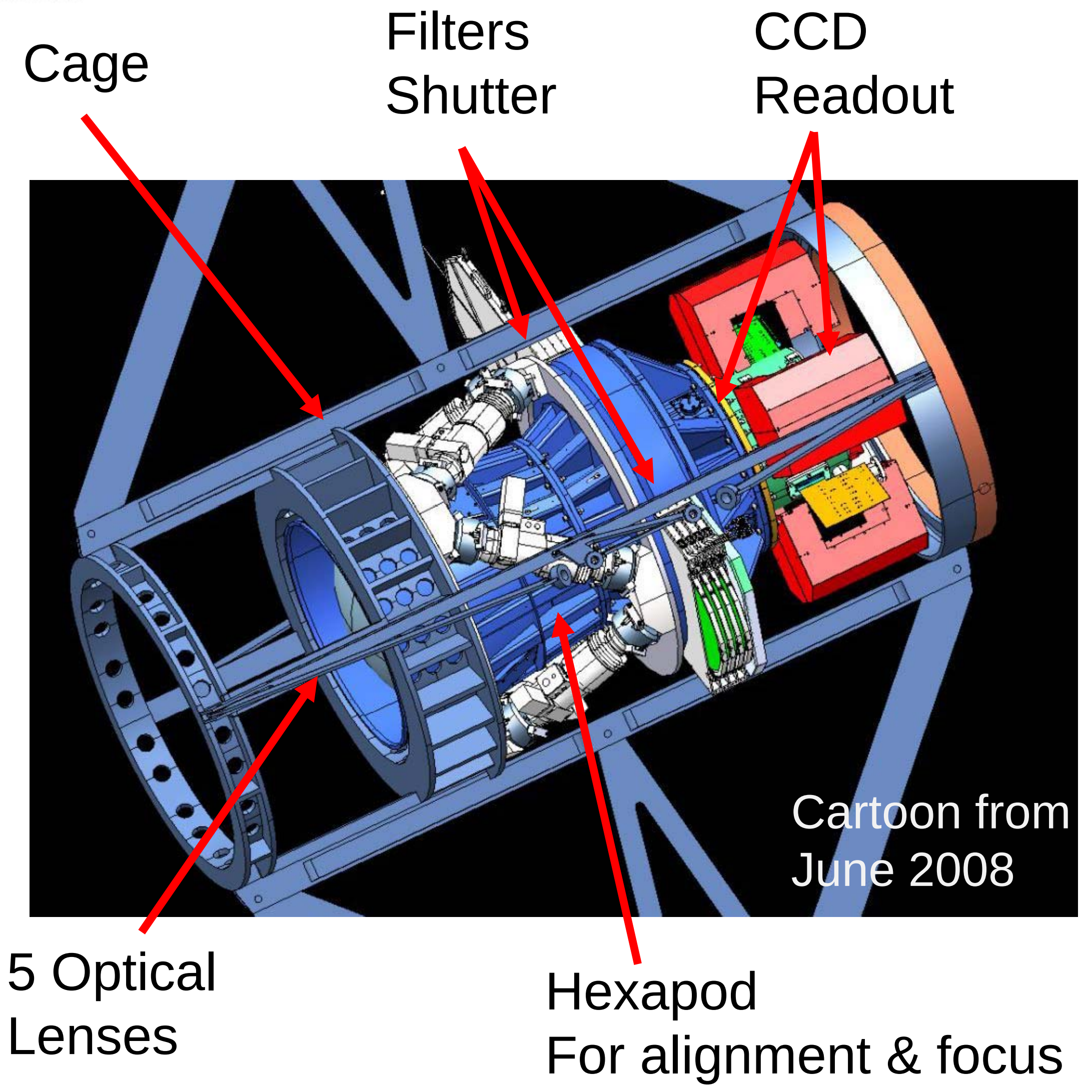
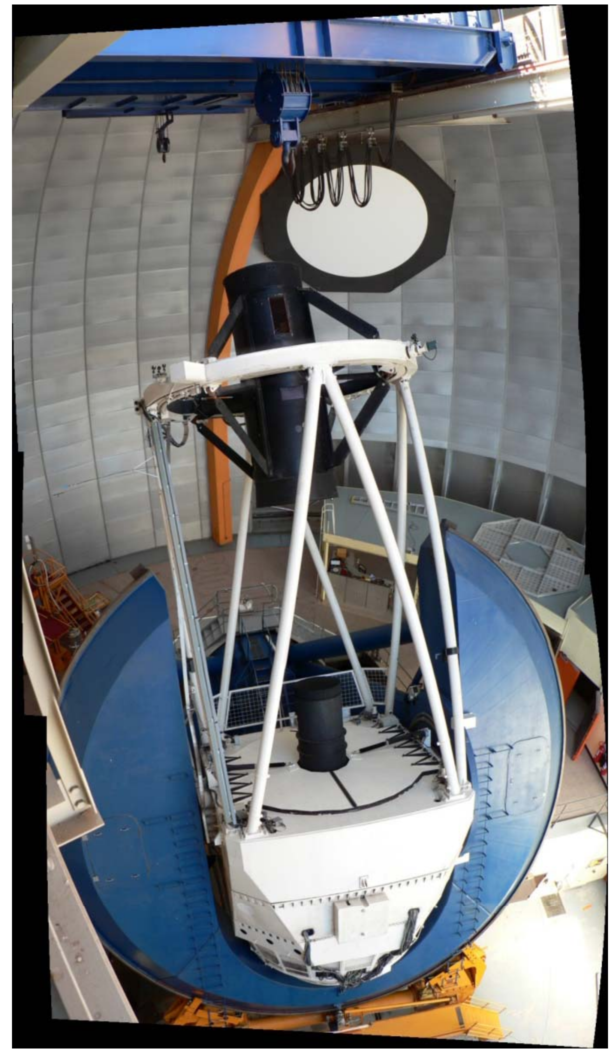
DECam => the Blanco Telescope @ CTIO





DESpec Instrument Notion

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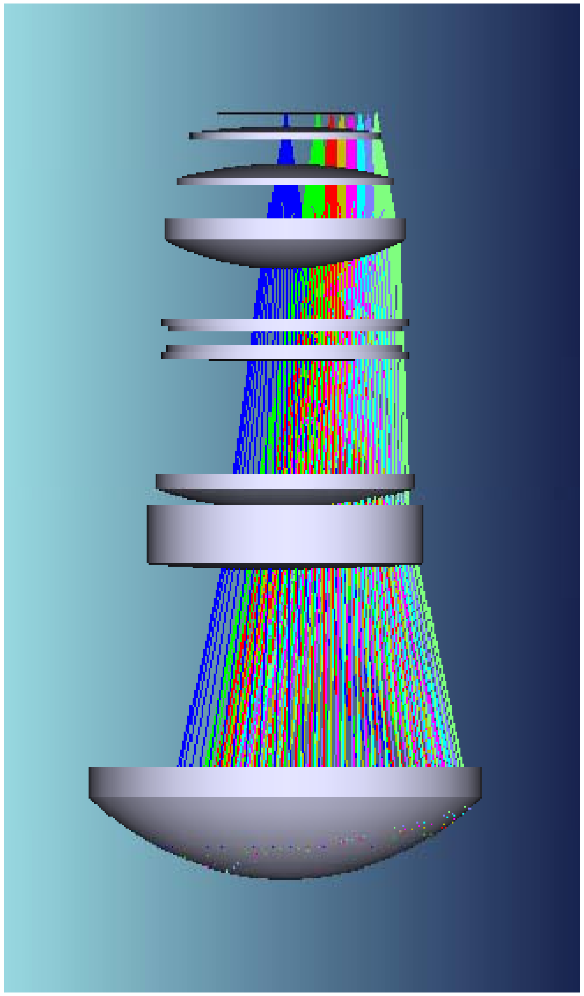
- Build an instrument to perform spectroscopic follow-up of millions of targets identified in DES data, taking advantage of the DECam strengths (red-sensitivity).
- It's necessary that the instrument can be inter-changed with DECam in a reasonably short time.
- An instrument that can be built at about the same cost and schedule as DECam (ready by the end of DES) is desired.
- Identify existing or planned components at other instruments for technical feasibility and to minimize the cost

DESpec Optics

Version SK-V3C
by Steve Kent

- Reuse the DECam optics C1-C4 (focal ratio f/2.9)
- The DECam Dewar needs its window (C5) as the cover. SK designed C5' and C6 made from fused silica. C5' has an asphere on the concave side.
  - Spot size (RMS radius) 0.26" at center, 0.52" at worst, 0.44" at edge.
  - Focal surface has a slight curvature. radius of curvature is -8047 mm.
  - Worst chief ray (edge) comes in at 0.45 deg angle of incidence.
- Steve & David Brooks will talk about the optics in more detail



FP FoV has Radius = 225.54 mm

Atmospheric Dispersion Compensator Example from WYIN

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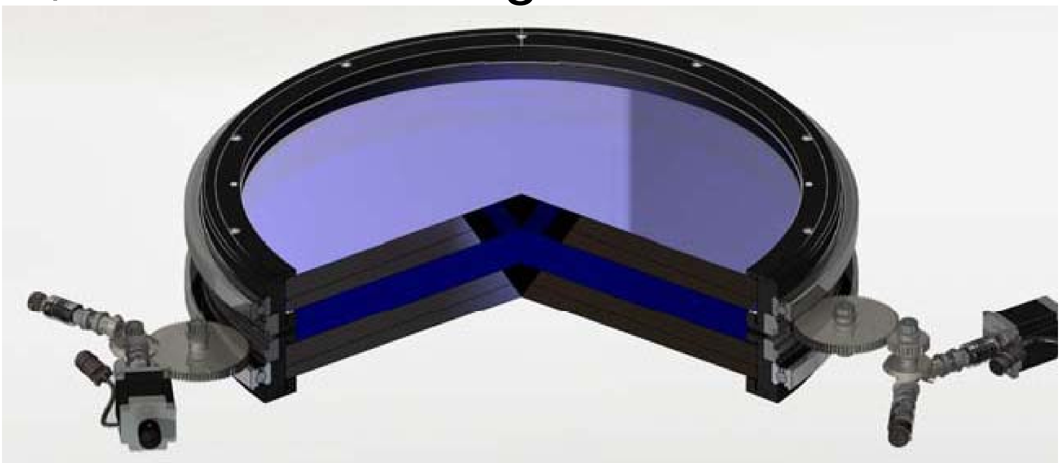
- When not at zenith the sky acts as a prism.
- The ODI ADC has diameter 635 mm. The prisms are rotated using a pair of encoded stepper motors.
- Two prisms each made from two wedge-shaped pieces of different glass materials.
- Issues include optical alignment and position (movement) tolerance and backlash, introduction of ghosts
- ODI ADC is very close to size required for DESpec



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ADC or Not ADC

- In the white paper we plan to provide an ADC.
- The technical justification for the D.E. science needs to be worked-out so that the question (ADC or not) isn't a matter of guesswork. Quantify:

Reasons For (Default)

- Better Spot Size especially at 50+ deg from zenith
  - Better signal-to-noise
  - Faster measurements
  - Fainter objects
- Provides a more useful Instrument to astronomical users. That could be required in an AO.

Reasons Against

- Cost $800k to $1000k
- Increases time to change instrument by 2-4 hours?

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Optical Fiber Positioners

- Precisely hold the tip of optical fibers on the desired RA & DEC of the galaxy
  – Premium on small (7 mm) spacing between actuators (pitch)
  – ± 0.14” (± 1/2 pixel on DECam) position accuracy corresponds to ±7.5 um.
  – 60” target separation is ~3.2 mm spacing between fiber tips
  – Fast reconfiguration time: 90 seconds or less
  – Maximum throughput, highly reliable …
- Tilting Spines and Twirling Posts
  – A kind of Twirling Posts (Cobra) design is being planned for Sumire. (See Mike Seiffert’s talk).
  – A Tilting Spines design is battle-tested on FMOS. See Will Saunders’ Talk

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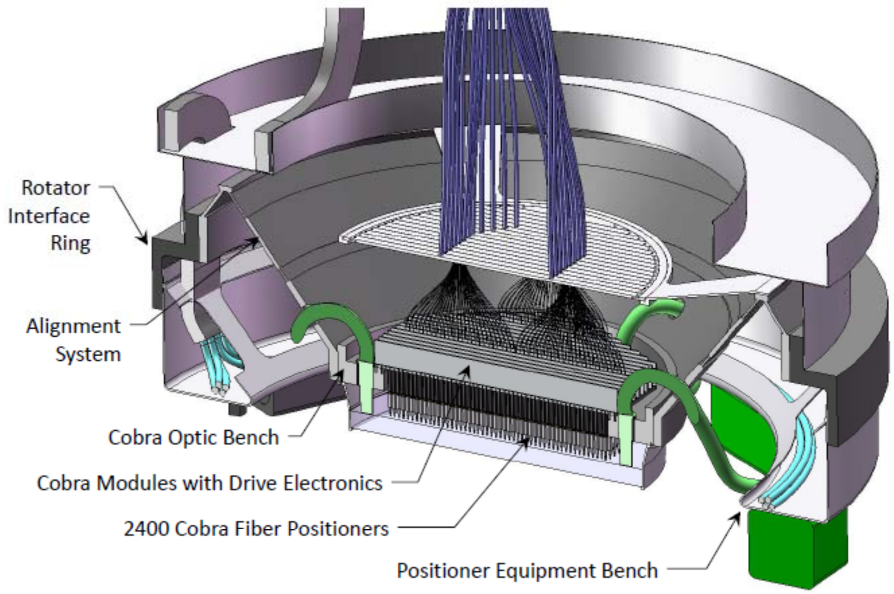
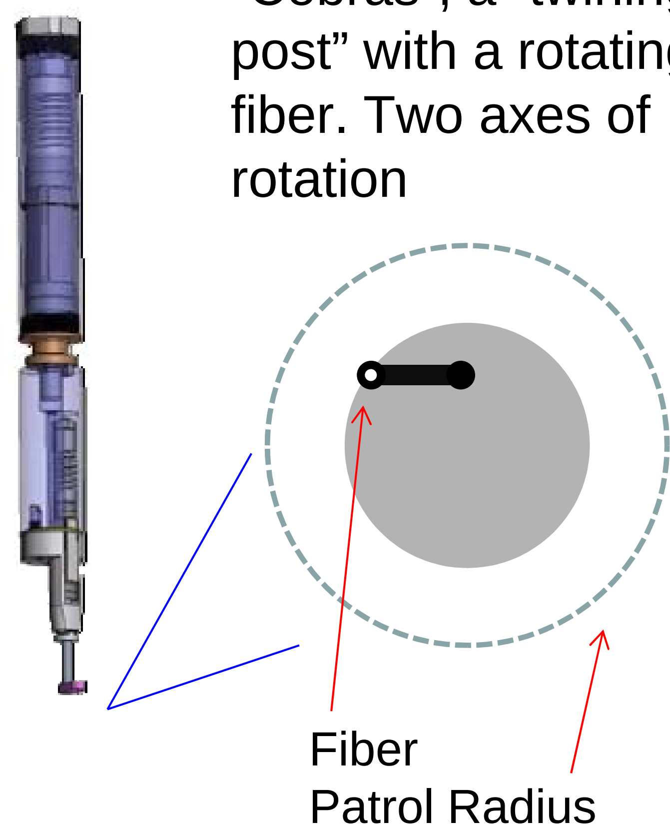
Example “Twirling Post”

WFMOS “Cobra”



M. Seiffert (JPL) presentation at P.U. 11/09

- Here, a FP with 2400 “Cobras”, a “twirling post” with a rotating fiber. Two axes of rotation



Example “Tilting Spines”

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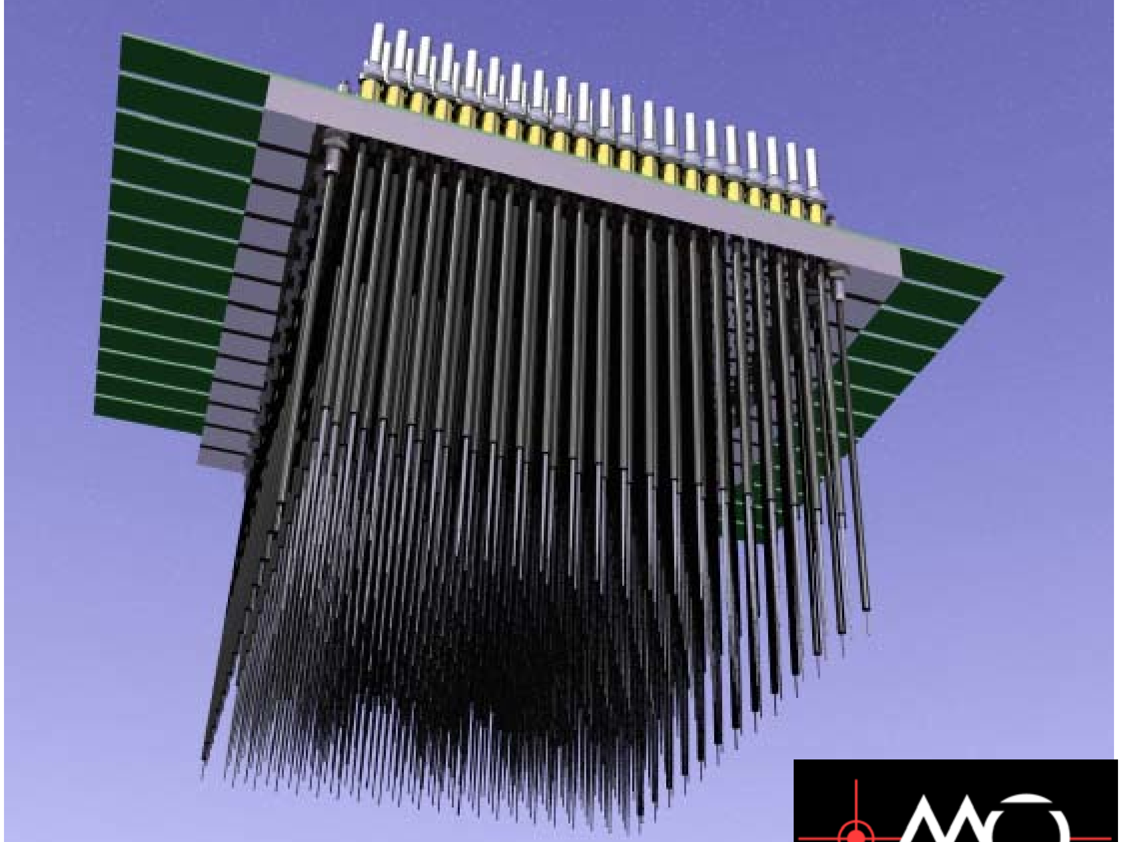

FMOS Echidna on the Subaru

Also was a wfmos proto

- Echidna: an Australian marsupial with flexible spines
- Also an operating fiber-positioner from AAT with ~400 fibers.
- Spines pivot from mounts near the bases
- Naturally handles a varying target density because the tips are small. Min. sep. < 0.7 mm
- configuration time can be taken to < 60s (W.S.)

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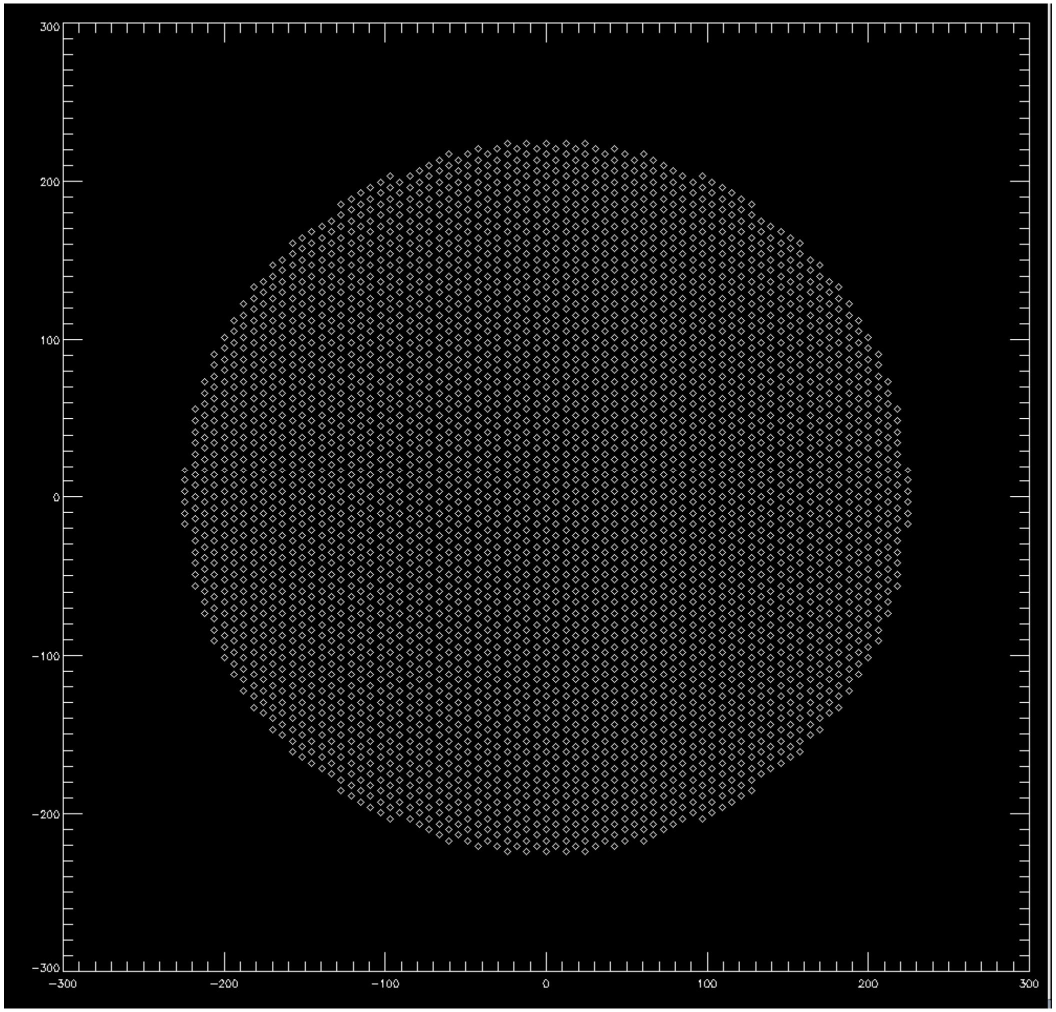
Fibers & “Pitch”

- Distance between centers of the positioners == “pitch”
- Here we show 3781 positions on a FP with R=22.554 mm using a 7 mm pitch.
- If pitch was 6.3 mm we get 4675 positioners on the FP.
- # fibers is a basic cost driver.



Fiber R&D Topics

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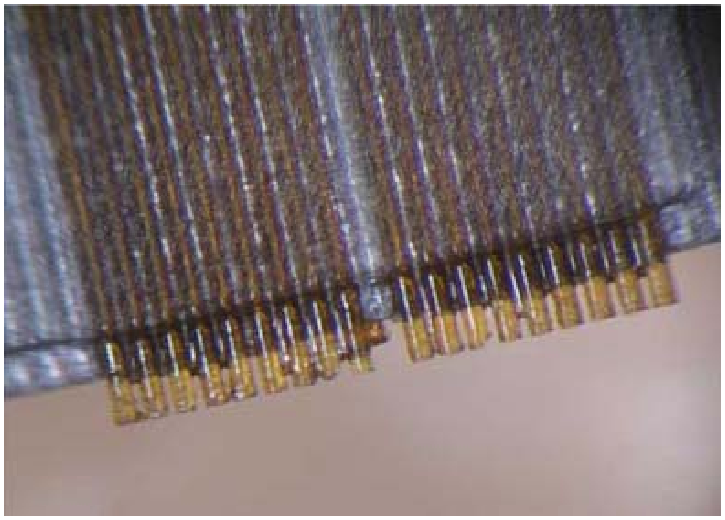


- F/3 is ideal for injection into fibers
- Justify fiber width
- Fibers run to where?
  - Coude Room (75m?)
  - "Plate Development Lab" (less?)
  - Horseshoe (less)
  - Truss (<10m?), Above the truss?
- Throughput vs length. J-P's data from Polymicro for a 100m fiber (100 microns?):
  - <70% throughput at 500nm
  - ~83% throughput at 600nm
  - ~96% throughput at 850nm (peak)

Some fiber chemistries are better in the blue (red) than others.

- Connections at FP or anywhere else cost 2-5% light?
- Backlight mechanism for fiber positioner tips!

Spectrographs

- There's trade offs and limitations between the following design parameters
  - wavelength range – want to take advantage of the red imaging
  - spectral resolution – need R >3000 at λ = 950 nm
  - # pixels on CCD – we can get the as big as 2kx4k
  - Fiber size – S/N vs throughput
  - f/# of the spectrograph optics – hard to make them f/1.3, easier to make them f/1.6
  - Cost

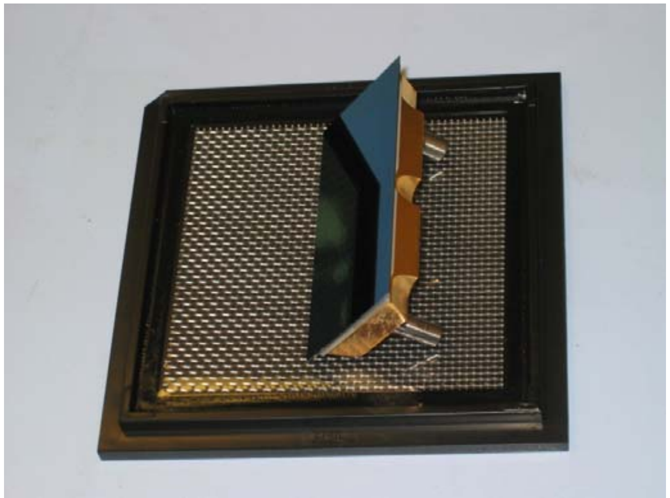
Options: 2 arm (above) 1 arm (below)

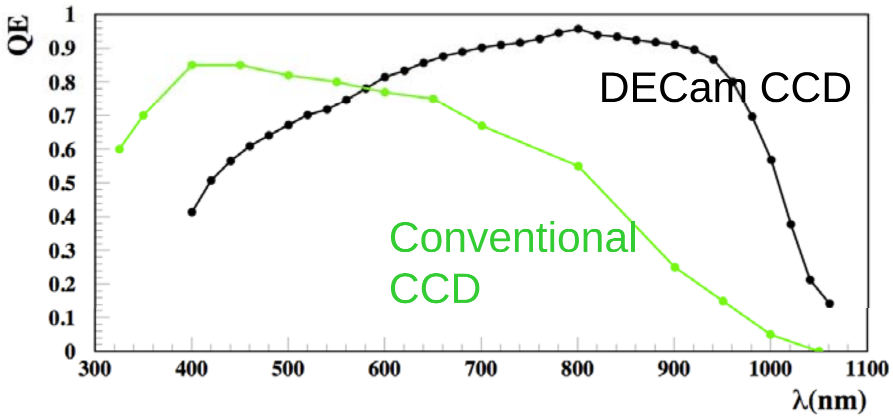
Parameter	**Blue Side**	**Red Side**
Fiber Diameter	100 μm	
Wavelength Range	500<λ<760	760<λ<1050
CCD	E2V or DECam 2kx4k	DECam 2kx4k
Resolution(Δλ nm/pixel) (use 4000 pixels)	0.065	0.0725
# pixels/fiber	5	4
Camera f/#	f/2.2	f/1.7
Spectral Resolution	1923 @ 625 nm	3276 @ 950 nm 3621 @ 1050 nm
Camera Type	Reflective or refractive	

Parameter	**Single-Arm Spectrograph (B)**
Fiber Diameter	80 μm
Wavelength Range	600<λ<1000
CCD	DECam 2kx4k
Resolution(Δλ nm/pixel) (use 4000 pixels)	0.1
# pixels/fiber	3
Camera f/#	f/1.6
Spectral Resolution	3334 @ 1000 nm
Camera Type	VIRUS

CCDs

- DECam CCD is well-matched to either the 1-arm ccd or the red side of the 2-arm spectrograph
  - We have some spares, probably enough
- DECam CCD is not ideal for the blue side of the 2-arm spectrograph
  - What are we going to do? A blue-sensitive LBNL device?
  - Or use a CCD vendor such as Hamamatsu or E2V?





CCD Readout

- DESpec CCD readout can use DECam readout electronics, probably repackaged
- For a 2-arm spectrograph with a blue-sensitive side, we need to adapt the controller
  - Straightforward, but we don't yet know the CCD
- DECam is getting 7 e^- RMS in 250 khz (17s) readout
  - Low (<0.5 e^-) noise is nice but not necessary
  - Readout speed could be a little slower than DECam to get improved noise

Interchangeable w/ DECam

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- To install DESPec 1st stow DECam off-telescope
  - We are providing hardware to install/remove DECam as part of that project (see right)
- Then pick up DESpec, and using similar hardware, install it on the end of the barrel.
- In reverse, either store DESpec on the telescope or produce a convenient way to connect/disconnect the fibers.

- We bring this into the design ab initio so that the process can be done quickly and easily.
- Probably .LE. 2 work days and can use f/8 in between

Instrument Simulation I

- Model the effect on survey completeness and spectral success
- Targeting Efficiency (can we put a fiber on the galaxy?)
  - Fiber pitch
  - Patrol radius
  - Minimum fiber-tip spacing
  - # fibers needed for sky background over the FOV
- Throughput
  - Spot size vs wavelength with and w/o ADC
  - Diameter and type of optical fiber
  - Length of optical fiber and # connections
  - Effect due to the small non-telecentricity vs radius
  - Tilt-defocus (or not) from a fiber-positioner
  - Spectrographs vs wavelength

Instrument Simulation II

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- A good instrument simulation will allow us to optimize the targeting strategy
  - Costs 60 seconds to retarget
  - CCD Readout and telescope pointing time is less than that
- Results in MORE galaxy spectra
- A good instrument simulation will allow us to simulate more science

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Cost

- In July 2010 we made a top-down cost estimate based on our experience with DECam including separate estimates for
  - Management, CCDs, CCD Readout Electronics, “SISPI”, optics with ADC, Fiber Positioner with Fibers, Spectrographs, Mechanical Integration, Survey Planning & Simulation
  - MIE Cost = $39M, counting the in-kind contributions of equipment, and including 50% contingency
- We’ve refined this since, still including the cost of in-kind contributions. It’s still generally top-down
  - 2-ARM design: $28M with ADC without contingency
  - 1-ARM design: $22M with ADC without contingency
- Next step is to reevaluate bottoms-up and redo using actual vendor quotes. We’ll see that from David Brooks.

Summary

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- We've just done a round of science & survey requirements based on the anticipated range of technical capabilities. The result is the white paper.
  - It's not the final answer. Not yet.
- The present need is to
  - Make a bottoms-up cost estimate.
  - Identify R&D necessary to make this a technical reality as well as resources available (some R&D is underway).
  - Improve the instrument simulation to allow more definitive trade studies
- & To begin to put together a consistent science –> survey –> technical requirements trail
  - How do we organize this? How do we "be a Collaboration"?

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