

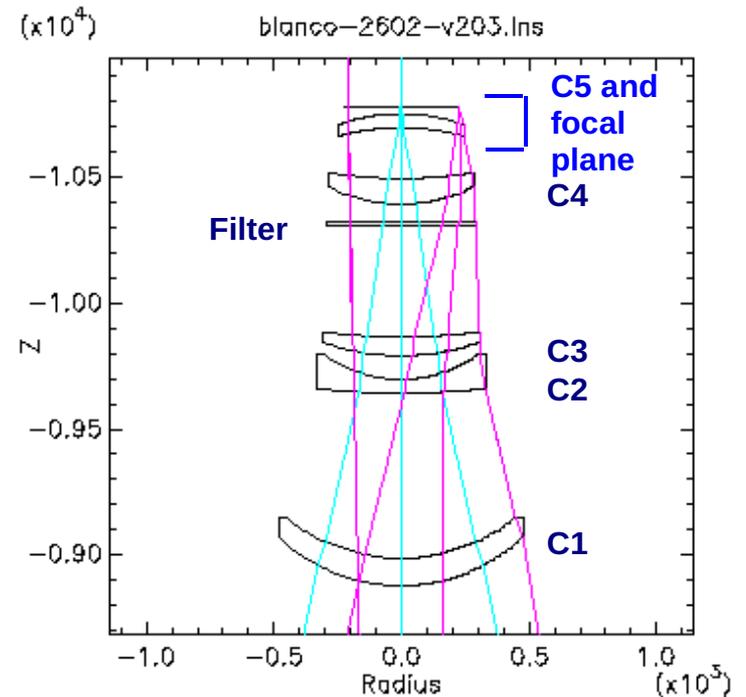


MS-DESI Optics

DARK ENERGY
SURVEY

- I. DECam lessons
- II. Requirements
- III. Blanco optical design
- despec11
 - Interchangeable camera & spectro configurations
- IV. Mayall optical design
- MS-DESI9
 - Combined optical/spectro
 - Allows swapping camera, fiber positioner between Mayall and Blanco

DECam Corrector and Camera





Lessons learned from DECam

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- **Keep optics as small as practical.**
 - **Easier to handle, coat, ...**
 - **E.G., C1 went from 1.1 to 0.9 m**
- **Maintain adequate thickness of elements**
 - **Easier for vendor to polish**
 - **More robust against mishandling**
- **Do not rely on vendor's quoted schedule or capabilities**
 - **Often overly optimistic**
 - **Coatings - SESO needed to outsource 2 lenses**



Notional Requirements - DESpec

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- Reuse C1-C4 of existing DECam corrector. Remove C5 and camera and replace with new optics and fiber positioner. Imager and fiber positioner must be swappable.
- Wavelength range
 - Required: $\lambda = 0.5 - 1.0\mu$
 - Goal: $\lambda = 0.35 - 1.0\mu$ [complete ELG redshift coverage $z = 0.0-1.7$ ($H\alpha$ or [OII]) plus QSOs]
- Maximum Airmass
 - $\sec(z) \sim 1.6$ ($\delta < +20^\circ$)
- Fiber size
 - $\sim 1.7''$ for $\text{mag}(i) = 23-24$, but exact value not critical
- PSF
 - FWHM of optics $< 0.6''$



despec11 (Will Saunders)

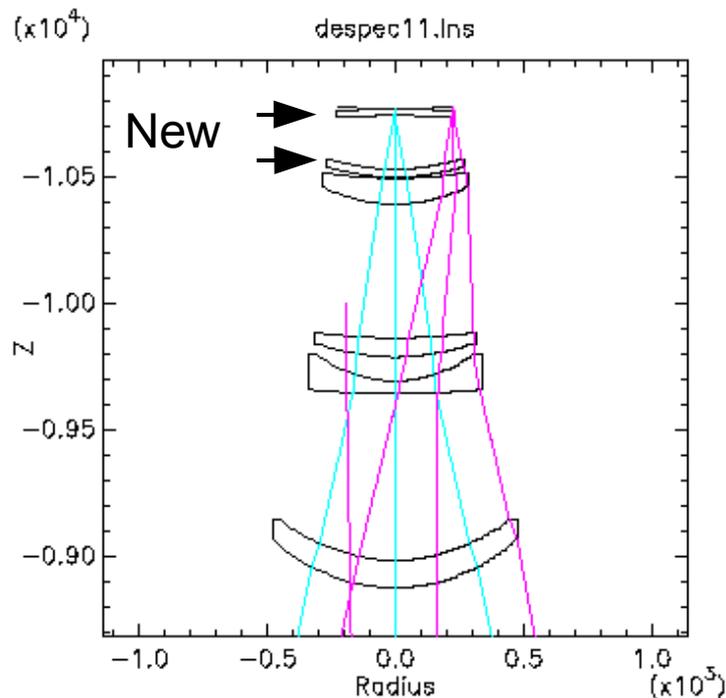
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- **Features**

- Replace DECam C5 with two lenses: C5, C6
- $\lambda = 0.35 - 1.05\mu$
- Modest asphere on C5
- Curved focal plane
- Nearly telecentric (max. tilt 0.2° - 0.5° depends on λ)
- Field diameter 2.2° (3.8 sq. deg area)
- Distortion: 1.5% peak

- **Limitation**

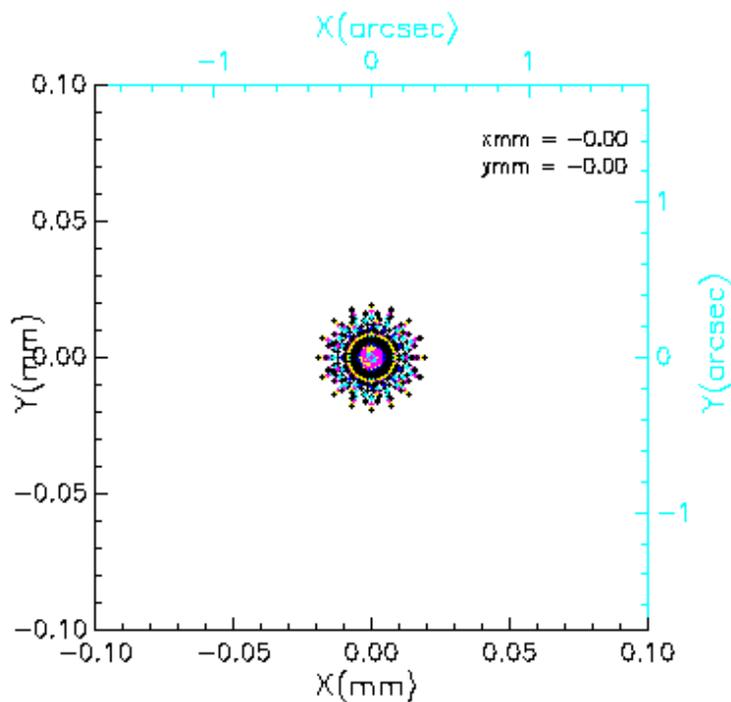
- No-ADC (too many compromises to make worthwhile)
- FWHM increases to $1.2''$ at $\sec(z) = 1.6$



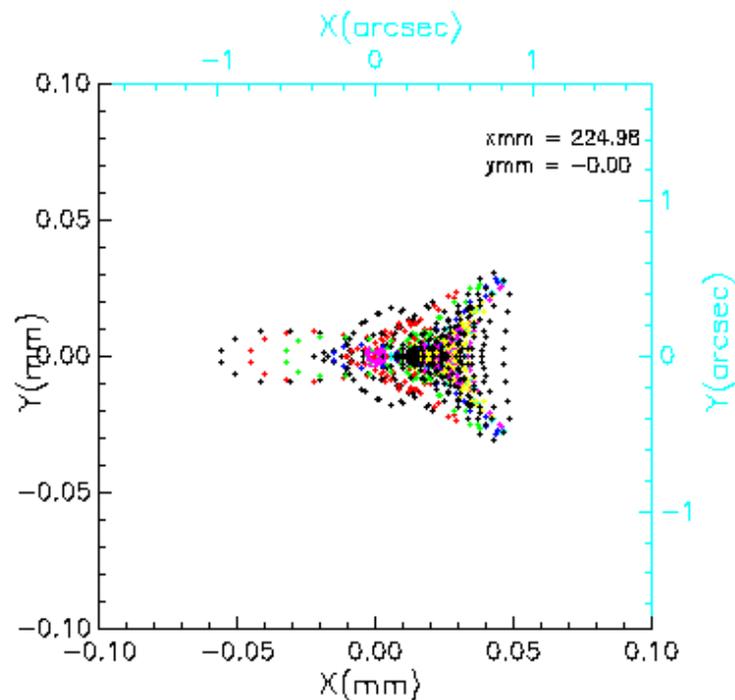


Performance

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Center: FWHM = 0.31"
 $\lambda = 0.35$ to 1.05μ

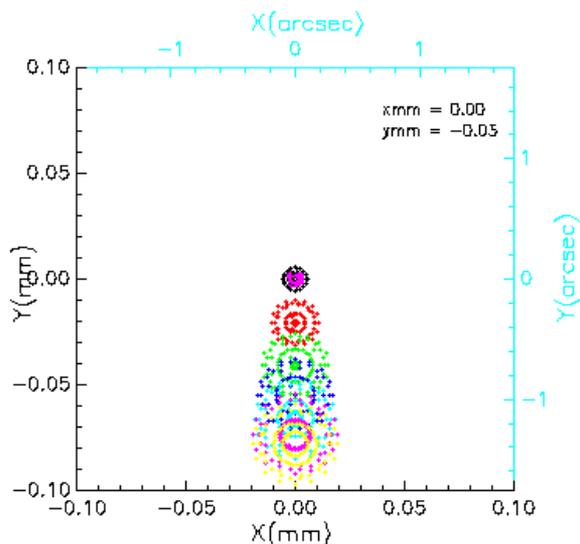


Edge: FWHM = 0.46" (worst-case 0.56")
 $\lambda = 0.35$ to 1.05μ

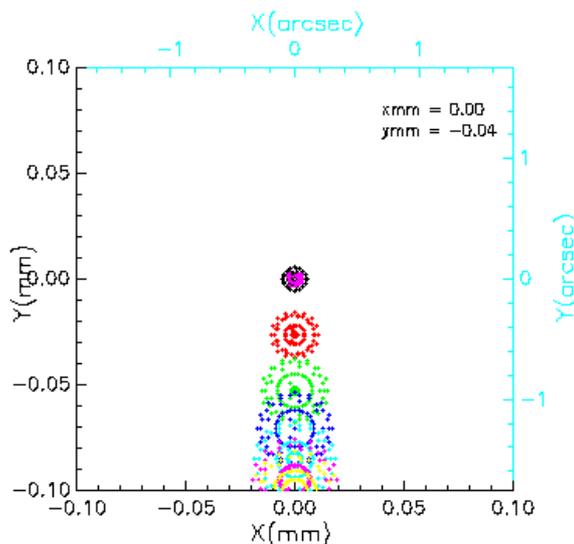


Atmospheric Dispersion

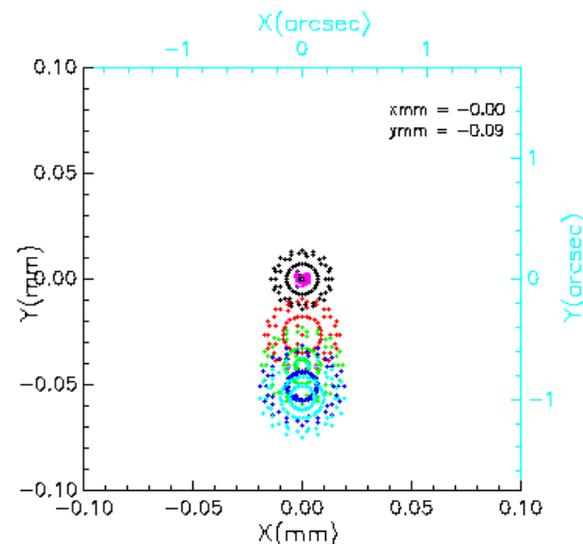
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$\lambda = 0.4 - 1.05 \mu$
 Airmass 1.4
 FWHM = 0.83"



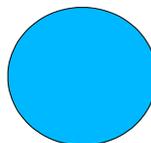
$\lambda = 0.40 - 1.05 \mu$
 Airmass 1.6
 FWHM = 1.00"



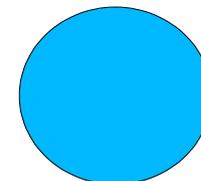
$\lambda = 0.50 - 1.05 \mu$
 Airmass 1.6
 FWHM = 0.70"

For high $\sec(z)$, one tunes the pointing to select a portion of the λ range, e.g., based on photo-z.

Fiber diameter 1.4"



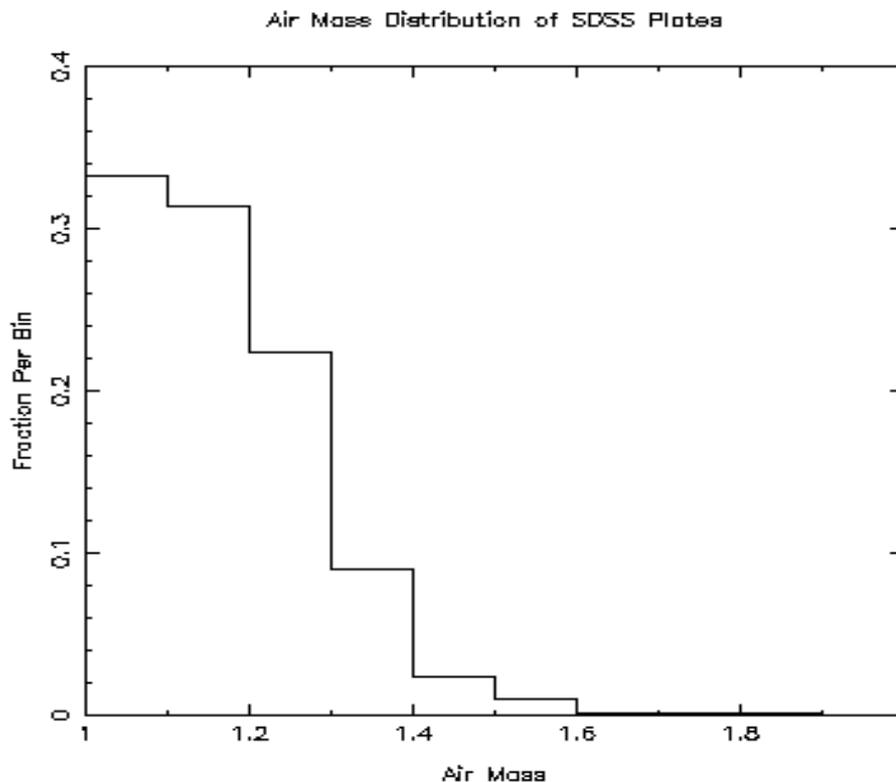
Fiber diameter 1.75"





SDSS Plate Coverage

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SDSS is an existing spectroscopic survey of ~10,000 sq. deg.
All plates (2880) airmass distribution
3% have $\sec(z) > 1.4$



MS-DESI9 (Will Saunders)

DARK ENERGY
SURVEY

- **Features**

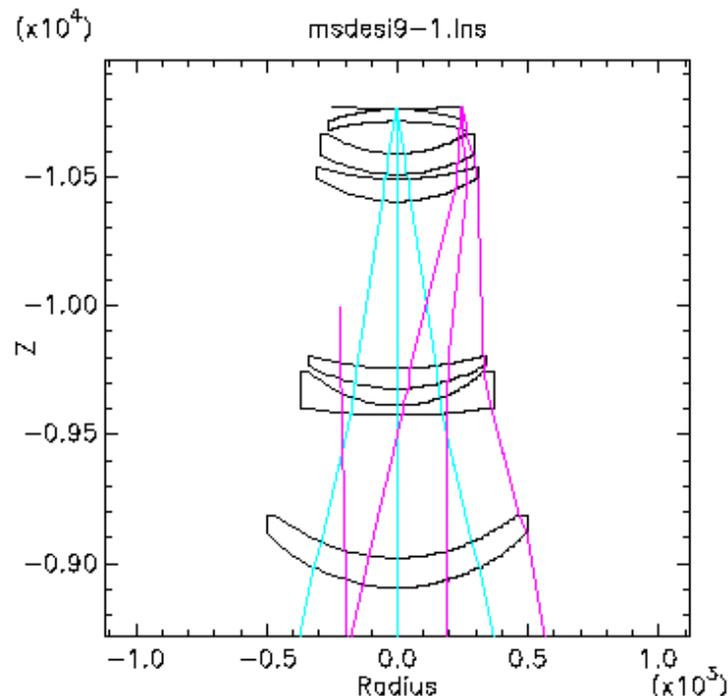
- **Two configurations: Imaging and spectroscopy.**
- **Six elements (same as despec11)**
- **Separate C5, C6 for each mode**
- **Two aspheres (C2, C5)**

- **Spectroscopic Mode**

- **Curved focal plane**
- **Nearly telecentric (max. tilt 0.2° - 0.5° depends on λ)**
- **Field diameter 2.5° (4.9 sq. deg area)**
- **$\lambda = 0.35 - 1.05\mu$**

Steve Kent (FNAL)

Spectroscopic Configuration

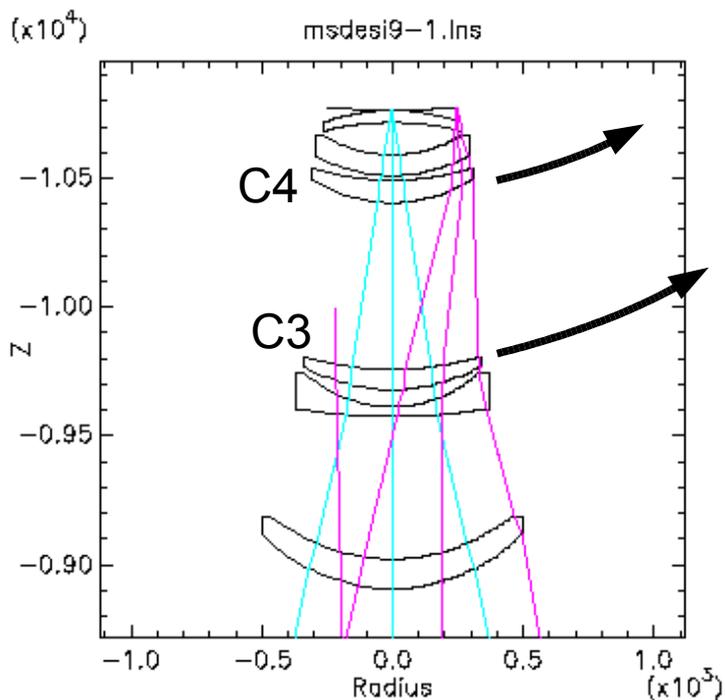


Distortion: 1.5% peak
Limitation
Focal plane is currently an asphere - not ideal (but soon to change)



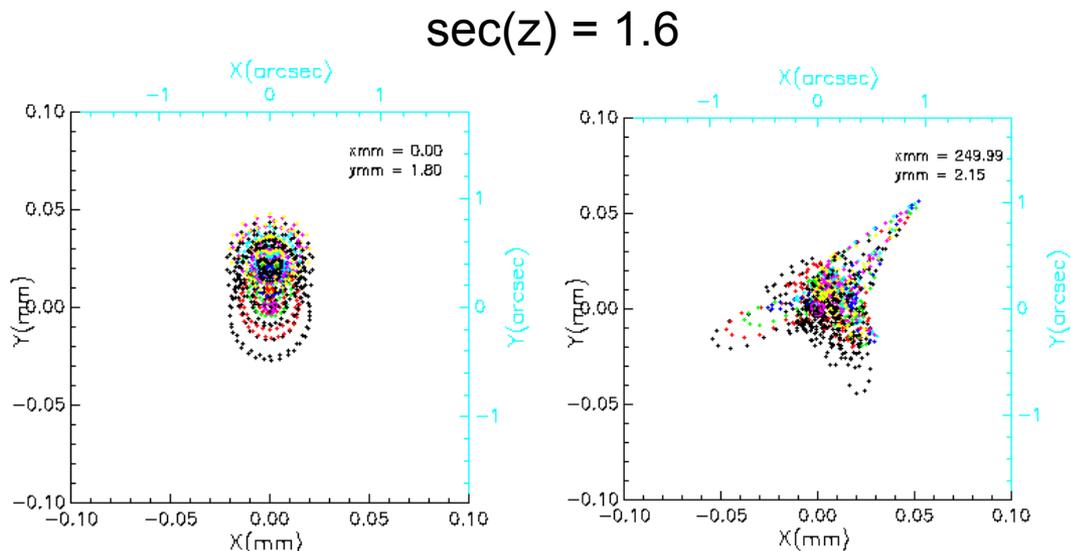
ADC Capability

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C3, C4 pivot to provide ADC capability

ADC action induces field translation; modifies distortion pattern.



**Field center
FWHM = 0.45"**

**Field edge
FWHM = 0.52"**

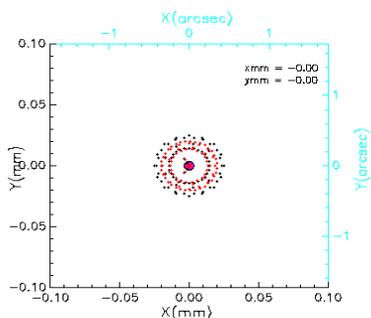


MS-DESI9

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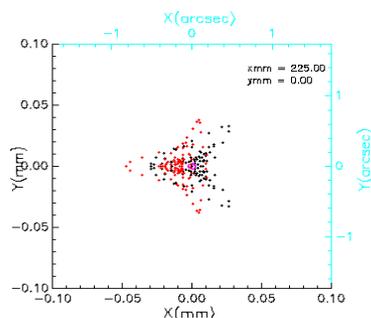
• Imaging Mode

- Flat focal plane
- Field diameter 2.2° (3.8 sq. deg area)
- No ADC action
 - Separate focus for each filter.
- $\lambda = 0.35 - 1.05\mu$



r band field center
FWHM=0.44"

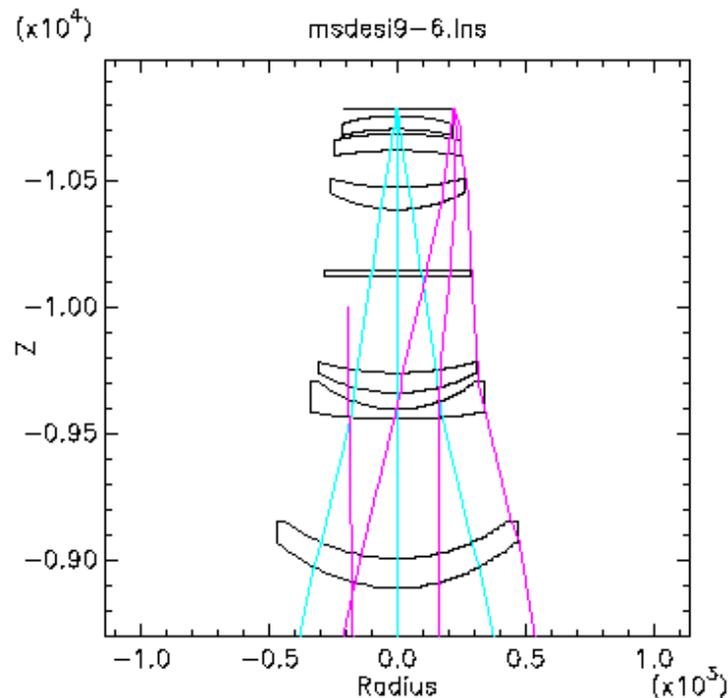
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r band field edge
FWHM=0.46"

MS-DESI Meeting (Mar 5, 2013)

Imaging Configuration



• Limitation

- Image quality not as good as DECam



Additional Issues for Wide-Field Spectroscopy

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- Time-dependent distortions across field - worse at high airmass
- Polar axis misalignment (field rotation)
- Community science
 - SMC: $\delta = -75^\circ$ $\sec(z) = 1.4@meridian; 1.6@ ha=4 \text{ hrs}$
 - May require short exposures with fiber position adjustment to deal with 1st two effects



Weight of Glass

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- **DESPEC11** **362 kg**
- **MS-DESI9** **429 kg**
- **Bigboss (old design)** **1100+ kg**



Summary

- **MS-DESI South**
 - **DESpec11 only realistic option**
 - Good wavelength coverage
 - No ADC - airmass coverage limited
- **MS-DESI North**
 - **BigBOSS**
 - Properties - see afternoon talk
 - **MS-DESI9**
 - Good wavelength coverage
 - ADC - will be interesting to implement
 - Can be used in imaging mode - swap instruments with Blanco
 - **DESpec11**
 - Probably cheapest and fastest



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Extra Slides



Target Selection Strategy

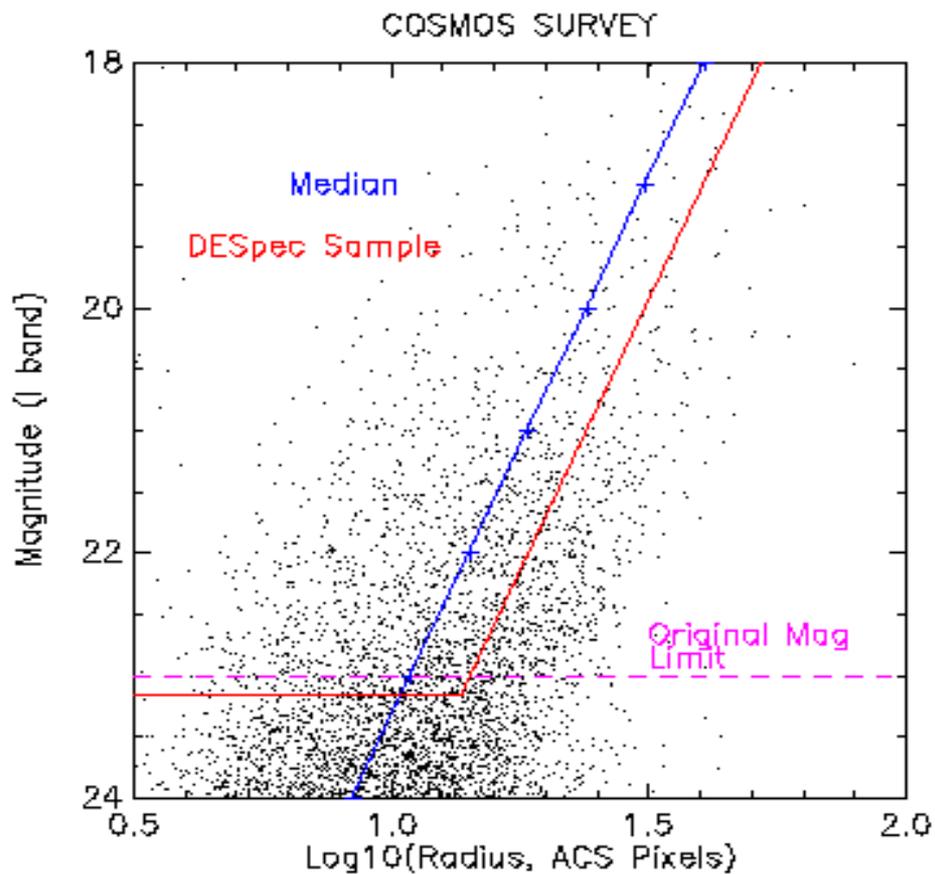
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- A) Select mag = m_{LIM} that achieves proper galaxy density
 - $m_{LIM} \approx 23$
- B) Go fainter by Δm and select galaxies with $r < r_{CRIT}$ such that density is unchanged. We expose to reach $S/N = (S/N)_{CRIT}$ for $m = m_{LIM} + \Delta m$, $r = r_{CRIT}$
- C) For each Δm , compute rate for collecting redshifts v. r_{FIBER}
- D) Pick Δm , r_{FIBER} that maximizes rate.
 - $\Delta m = 0.15$
 - $r_{FIBER} = 0.85''$ to $0.9''$ (diameter = $1.7''$ to $1.8''$)
 - We exclude $\sim 30\%$ of galaxies with $r_{1/2} > 0.41''$
- NOTE: Rate changes slowly as we move away from optimal
 - e.g., rate declines by 5% at $r_{FIBER} = 0.73''$ (BigBOSS value)



Radius-Mag Relation

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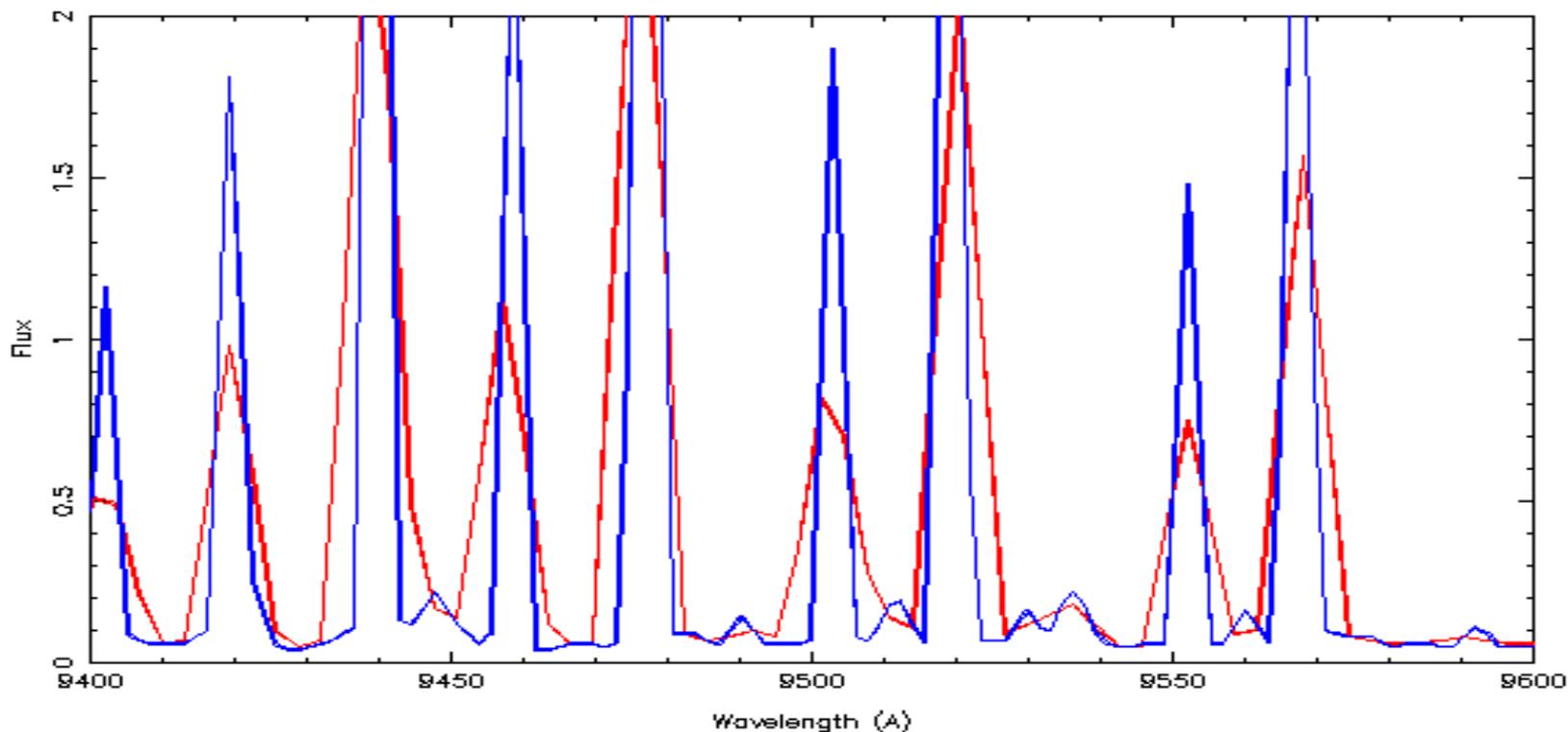
Night Sky Spectrum v. Resolution

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R=1500

R=3000

OH Night Sky Spectrum (Hanuschik 2003)



Signal
~ 0.04

1/4 BAO Cycle



Clear Pixels v. Resolution and Wavelength Range

