

Parallel Imager for Southern Cosmological Observations: A Multiband Imager for Magellan

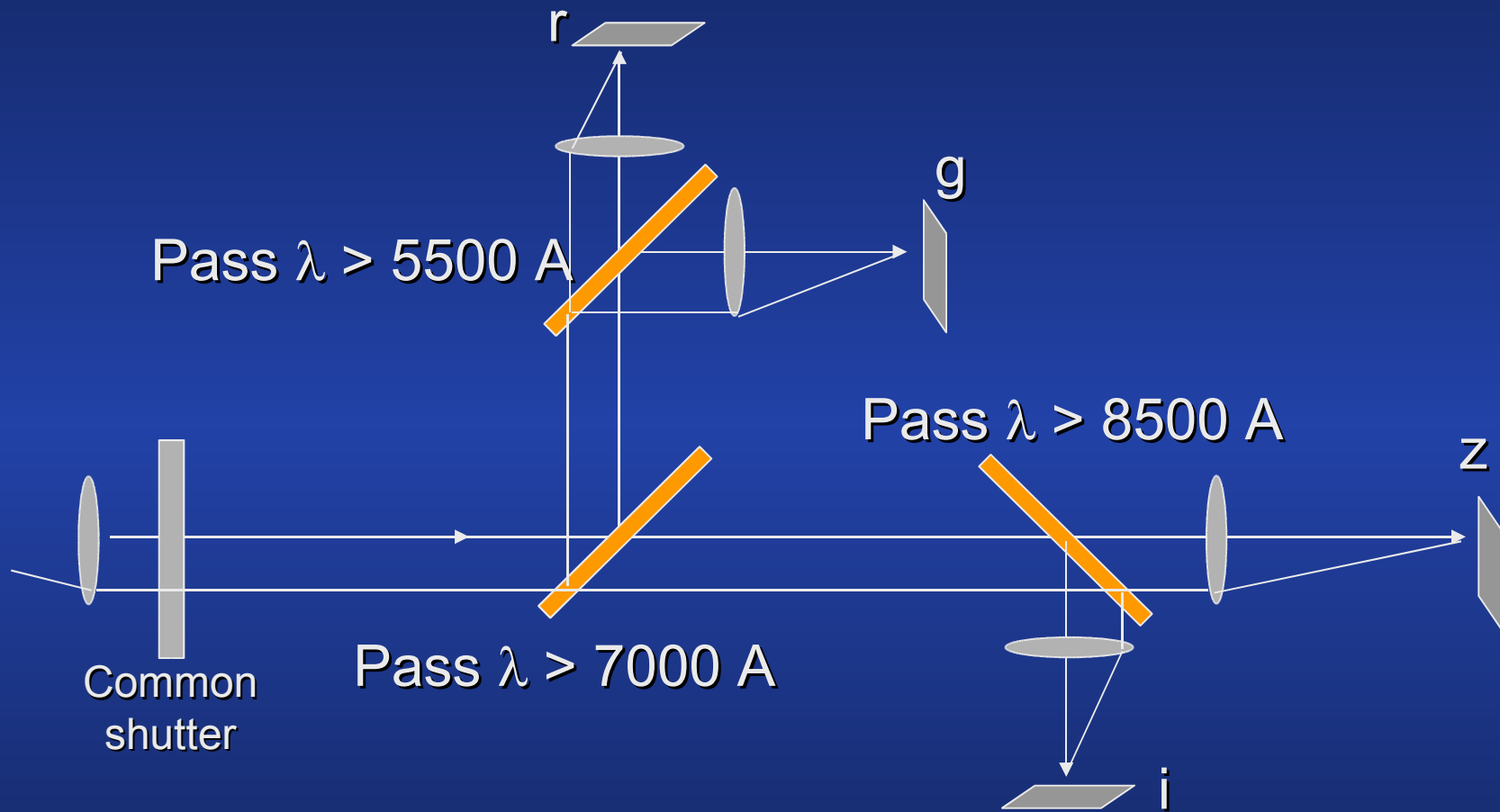
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A PI Instrument for Magellan at f/11



Collaborators

- Christopher Stubbs, CfA & Harvard Physics
- Melissa Franklin, Harvard Physics Dept
- Tony Stark, CfA
- John Geary, CfA
- Tim Axelrod, Univ. of Arizona

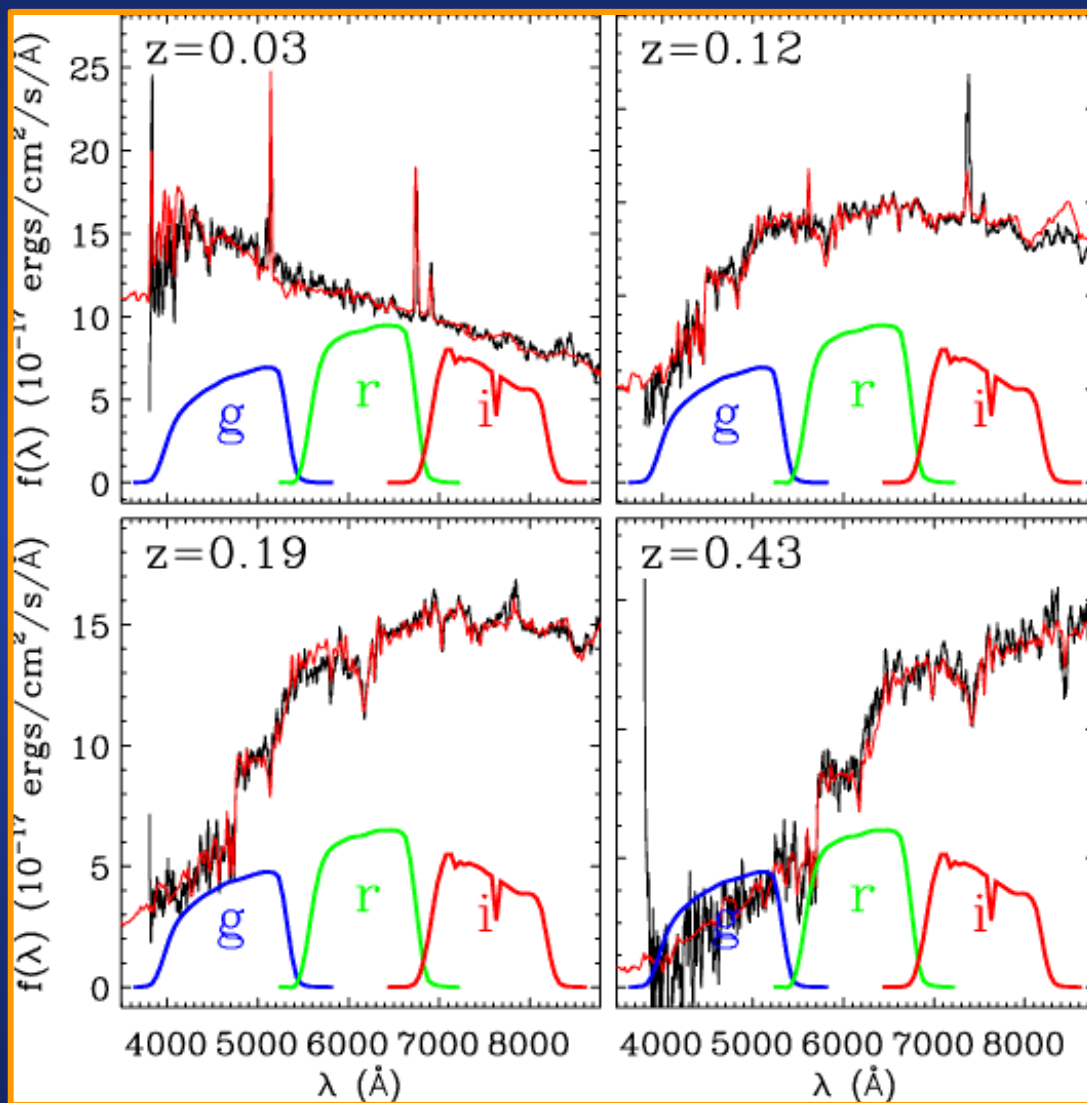
- South Pole Telescope/Dark Energy Survey collaboration: J. Carlstrom, J. Mohr...

Our thanks to Alan Uomoto (Magellan), who has been very supportive and informative.

Science Opportunities

- **Supernova followup observations**
 - Type Ia and type II SNe as cosmological probes
 - Requires multiband images, multiple epochs
- **Photometric redshifts of clusters**
 - 4 band imaging over modest field
- **Transient followup**
 - Evolution of SED for GRBs
 - Microlensing light curves
- **Planetary occultations**
 - Multiband data useful for discrimination

Photometric Redshifts in SDSS bands



Photometric Redshift for Clusters

- Photo-z's for individual galaxies tend to have scatter of $\sigma_z/(1+z) \sim 0.03$, but with a few “catastrophic” outliers.
- Combination of morphology, magnitude, color and location can be used to establish cluster's redshift.
- Robust statistics can be used to eliminate “outliers”.

Time (sec) to reach SNR=10

Extended source, ABmag in 2.2 arcsec aperture

Dark time, 0.8 arcsec, airmass=1.2, scaled to Magellan and high- ρ

<http://rpm.cfht.hawaii.edu/~megacam/diet/DIET.rpm>

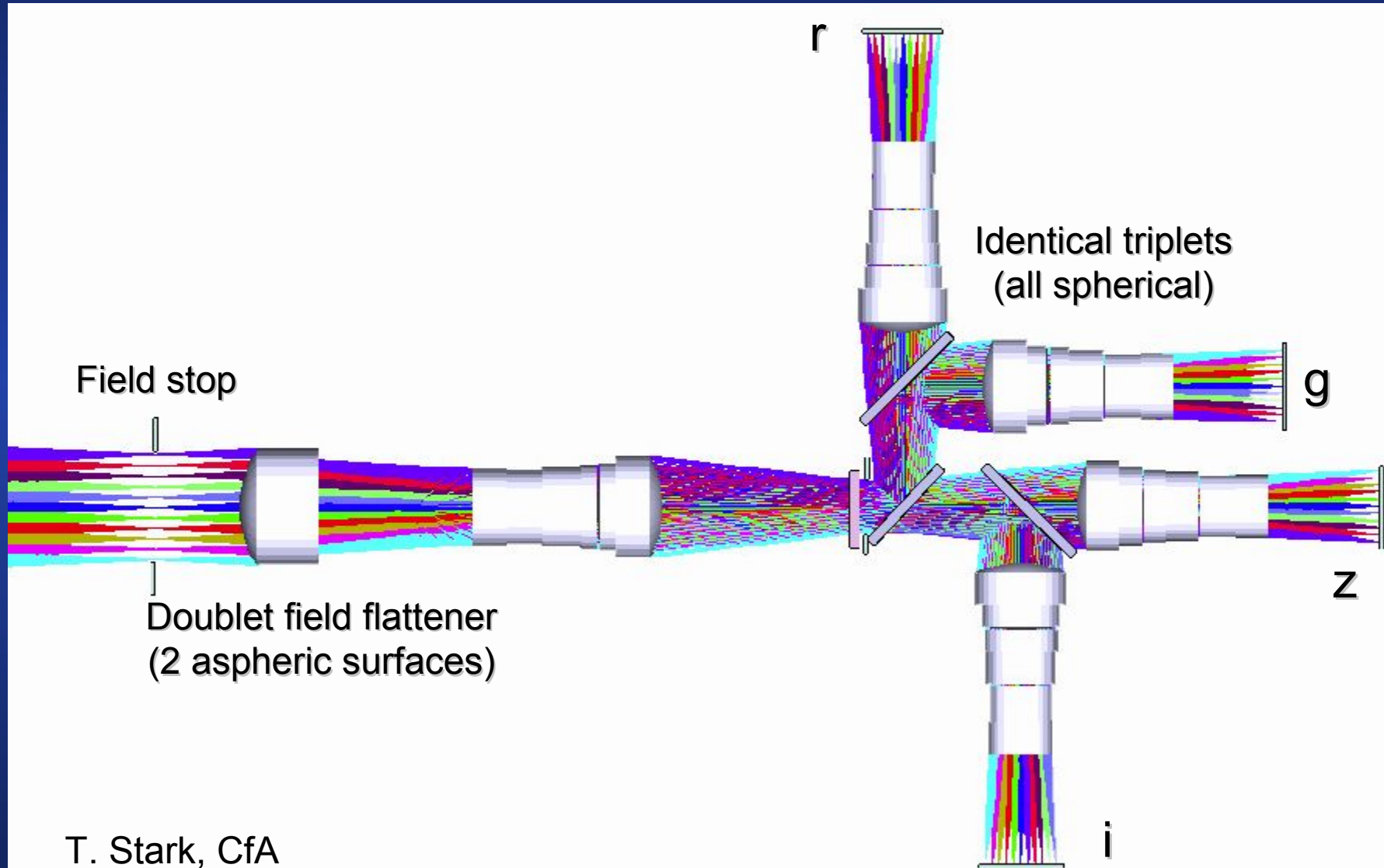
m AB	g	r	i	z	Median redshift (r mag)
23	35	86	320	870	0.52 to 23 rd
23.5	78	210	800	2200	0.73
24	180	500	1900	5500	0.85
24.5	450	1200	4900	13000	1.01

Galaxy colors roughly follow contours of constant integration

Shaded boxes are DEC target 10σ magnitudes.

7 We should get $\frac{1}{2}$ the clusters (those with $z < 0.5$) in 60 sec

Conceptual Optical Design



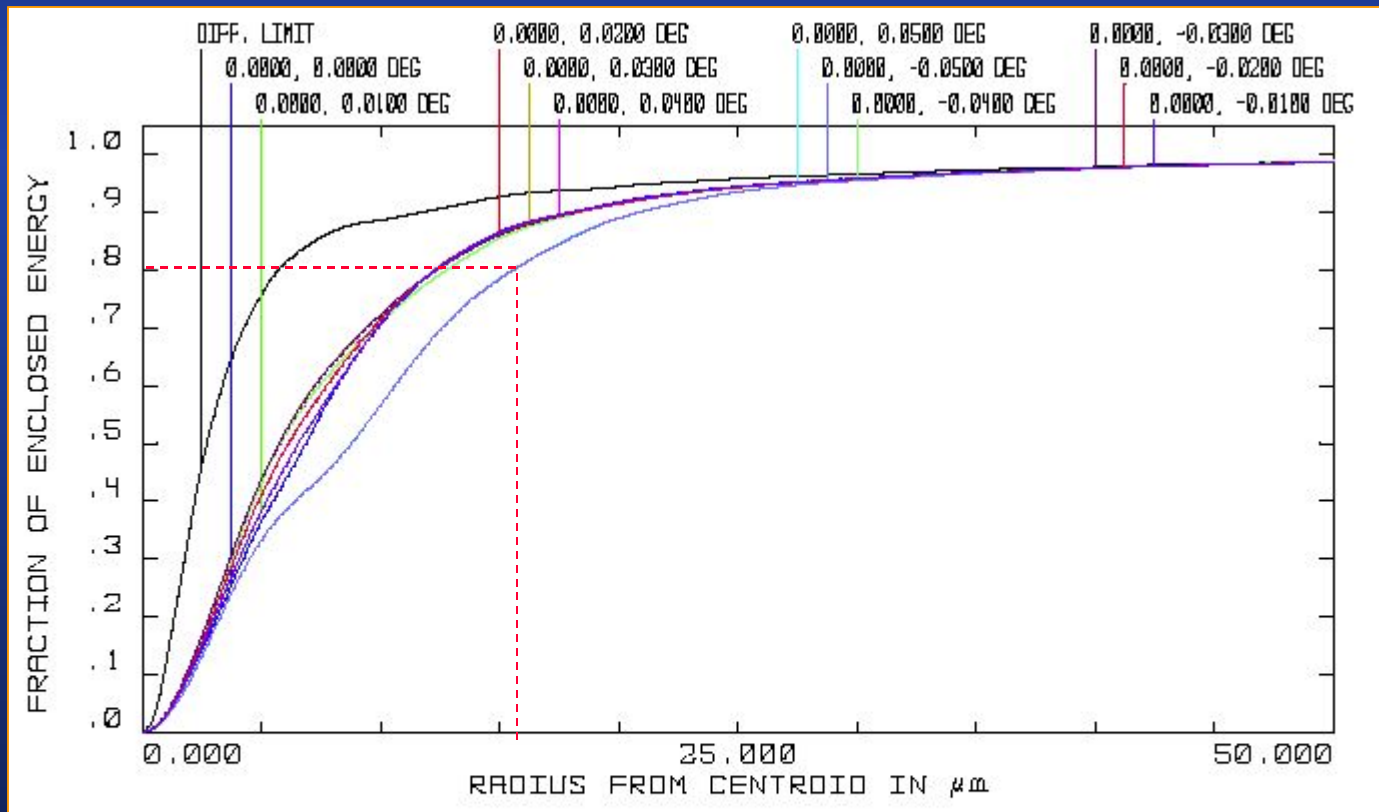
T. Stark, CfA

Optical Performance

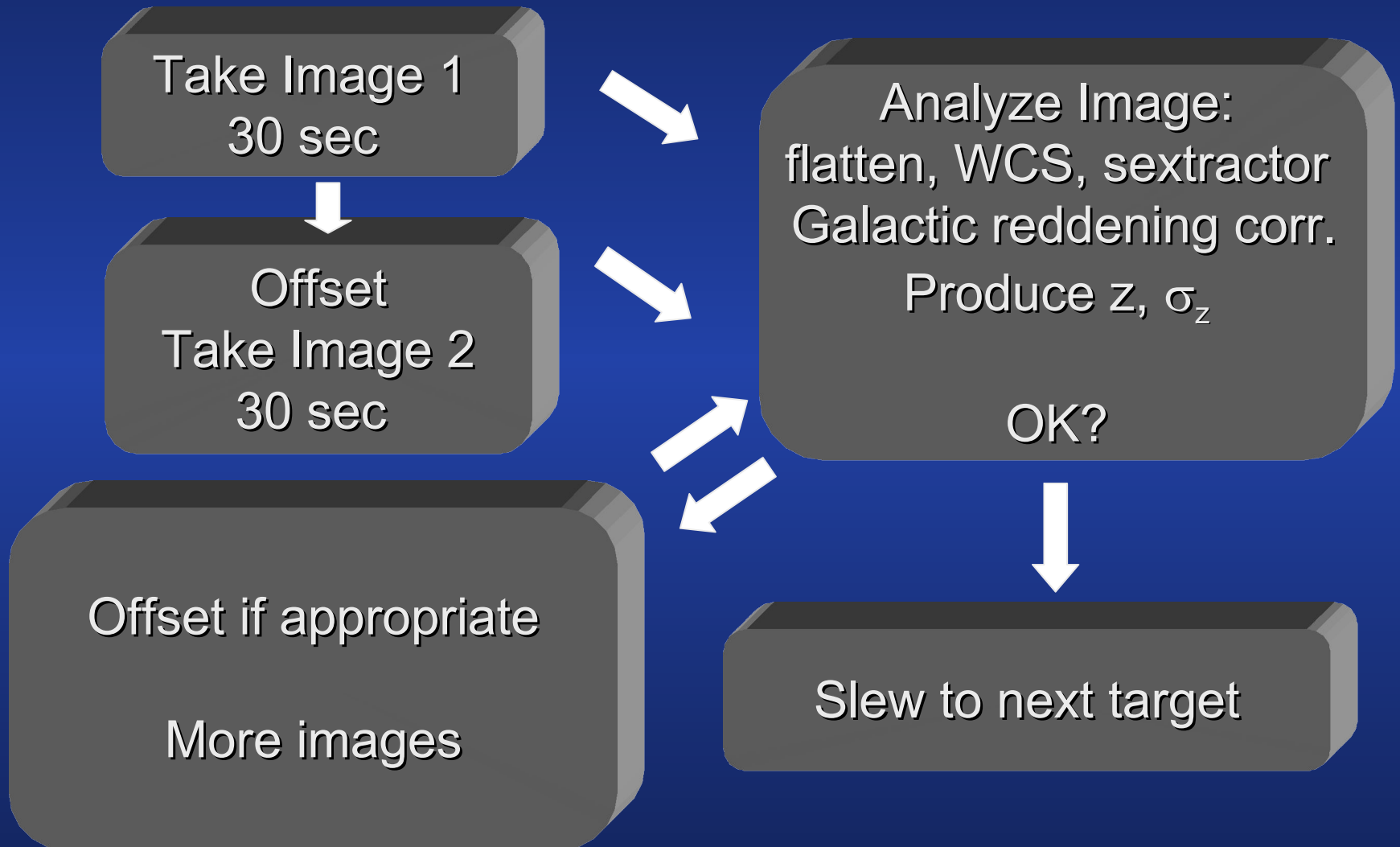
Plate scale is 0.062 arcsec per 15 μm pixel

FOV is 4.1 x 4.1 arcminutes (~ 700 kpc at $z=0.3$)

80% encircled energy in ~ 0.15 arcsec:



Tightly coupled software/observing



Rapid Readout and High Efficiency

Integrated SW reduces wasted time

Binning 2x2 gives

- 0.124 arcsec/pix,
- Single amplifier output per 2K x 4K chip

8 sec readout @ 250Kpix/sec

Effective telescope time multiplier:

- For “balanced” exposures, sequential images take

$$T_{\text{series}} = 4(t_{\text{exp}} + t_{\text{readout}}) \times N_{\text{frames}}$$

- Parallel imager takes (with 0.8 throughput degradation)

$$T_{\text{parallel}} = (t_{\text{exp}}/0.8 + t_{\text{readout}}) \times N_{\text{frames}}$$

For $t_{\text{exp}} \gg t_{\text{readout}}$ total time is reduced by a factor of ~ 3

Controlling Systematics

- Our design is readily baffled
 - Can use both field stop and pupil stop
 - Suppresses stray and scattered light
 - Better flatfielding
- Single common shutter near pupil
 - Reduced shutter artifacts
- Flux ratios with a single pointing and 2-3 exposures, under all conditions!
 - Even with patchy cloud cover, get Poisson-limited colors.

Status

- Rough conceptual design done
- Proof-of-concept optical design done
- Detectors are in hand
 - Lincoln labs 2K x 4K, 15 μm pixels
 - Some epitaxial, some high-resistivity
- Readout electronics require replication
 - MegaCam architecture and board set
- Machine shop capacity available

Task list

- **Modeling**
 - Slew vs. expose tradeoffs vs. redshift and richness
 - Photo-z determination
- **Hardware**
 - Finish design work, order optics
 - Mechanical design, fabrication
 - Electronics and detector optimization
 - System integration, testing...
- **Software**
 - Scripts that connect Sextractor to photoz codes
 - Test with SDSS and IMACS data
 - Integrate with instrument
- **Proposals**
 - Plan is to submit NSF ATI proposal Nov 1.

Interface with Magellan

- Stubbs has experience providing new capabilities to observatories:
 - CCD imager for Apache Point 3.5m
 - Data reduction pipeline & cluster computing hardware for CTIO surveys
 - Upgrades to various Apache Point systems
- We are engaging in this conversation early in the instrument conceptual design, to receive feedback and suggestions.
- Open issues include:
 - Rotator/WFS/guider
 - Software aspects: TCS interface, etc.
 - Best policy on use by others
 - Timing and constraints
 - Budget for costs at the interfaces

Summary

- Our team is hoping to construct this device in the next 18 months, as a “PI” instrument on Magellan.
- Science drivers are compelling
- Design needs to be refined, and optimal observing strategy devised
- Your comments welcome!