Gravitational Lensing and the Yale ODI survey

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Yale Survey Meeting,
October 2, 2009

Executive Summary

- Why is ODI Yale Survey good for gravitational lensing?
- What projects do we already think we're going to do?
- What else might be done?
- Caution! What extra complications are we in for with OTAs?

Why ODI is a good camera for lensing?

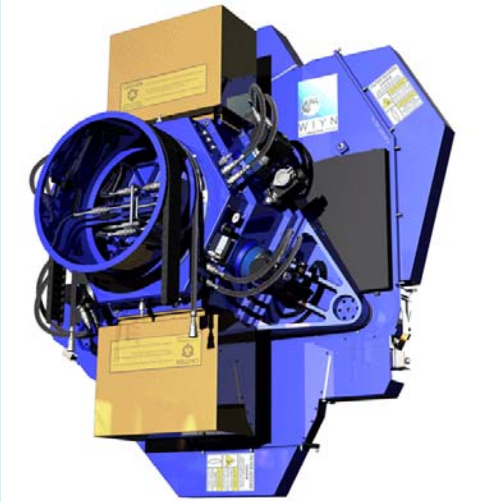
- **Wide area with very good sampling.**

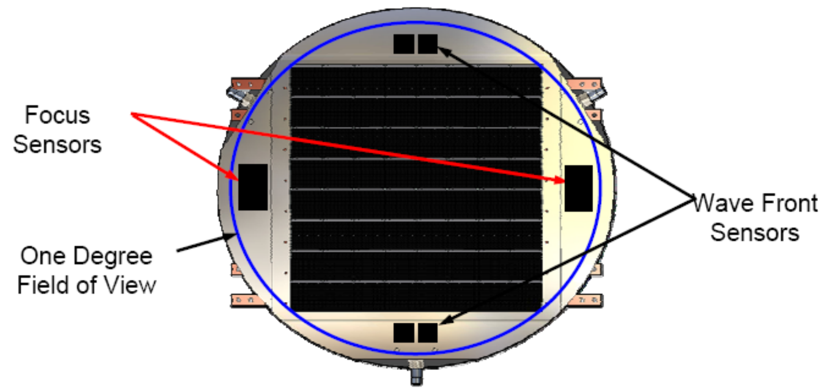
64 OTA detectors, each with 0.11” pixels, spanning one degree (1 gigapixel camera).

- **The telescope and camera optics are designed to provide excellent image quality**

Mode of i-band seeing ~0.5-0.55”

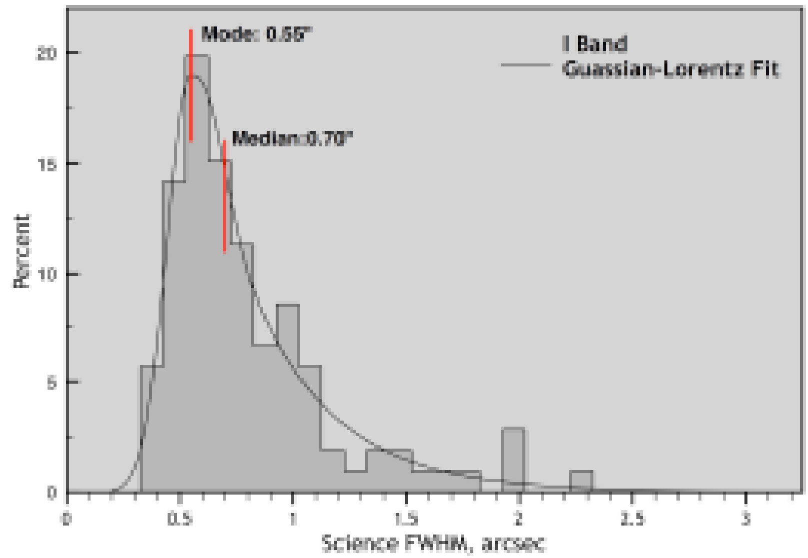
- **Orthogonal transfer (OT) capability of the OTAs can improve seeing by another ~5-10%**



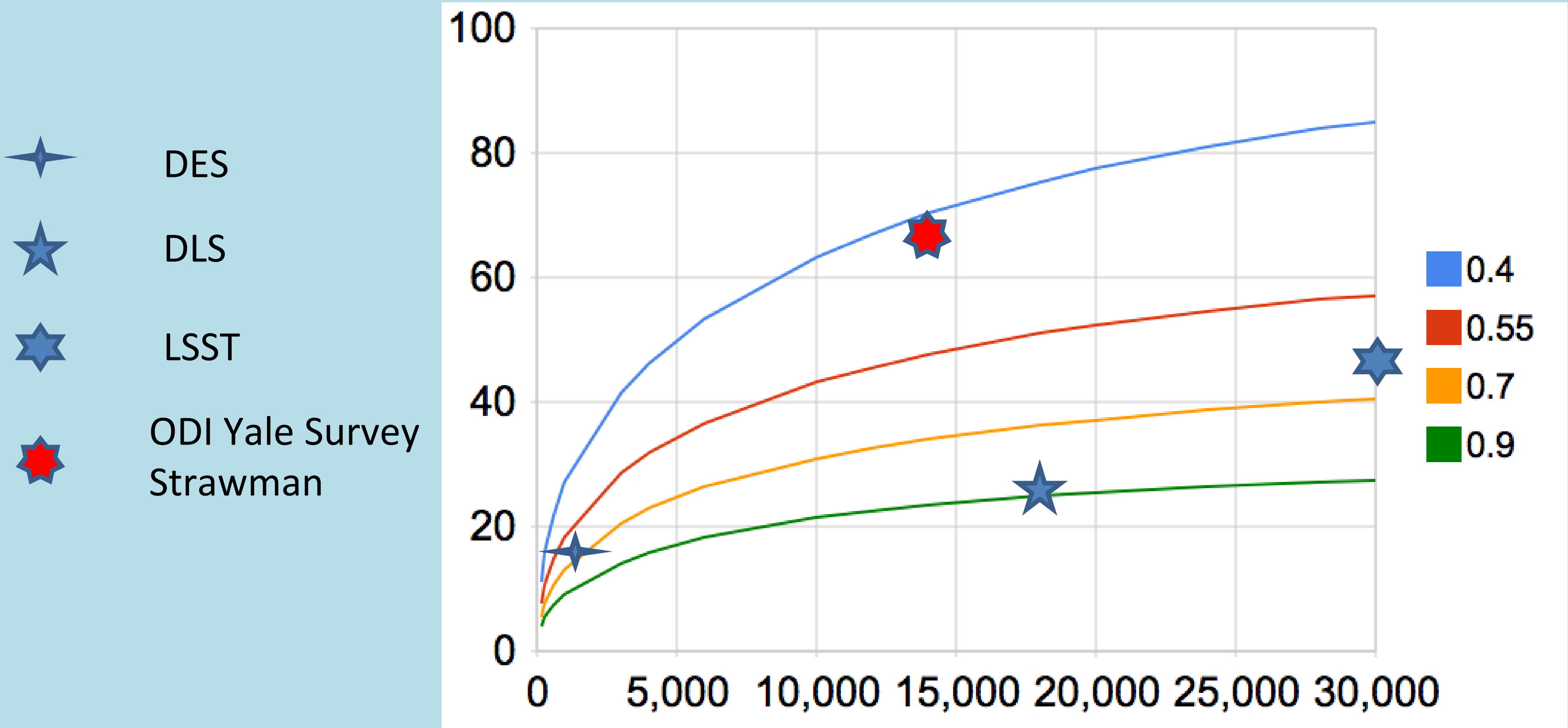


ODI (2009) → 32K x 32K Array -- Uses 64 OTAs

Diagonal ~22.5 inches; Corrector ~26 inches diameter



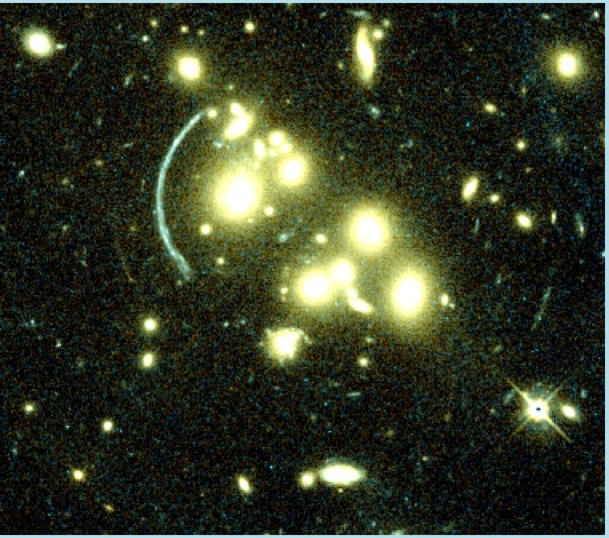
The Bottom line (weak lensing)



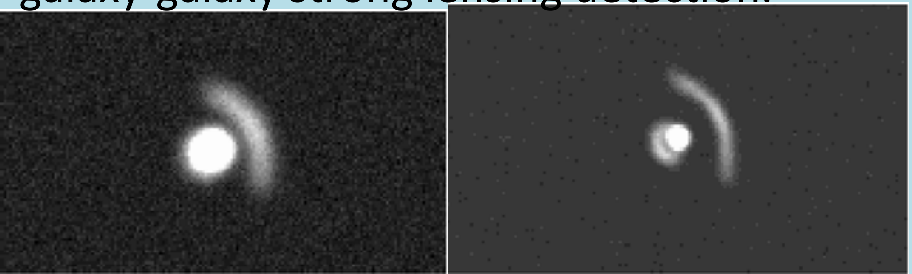
A plot of the effective number of galaxies resolved per square arcminute as a function of exposure time. As the seeing improves, you detect more objects, resolve more objects, and each object is “less smeared” – it has a higher weight.

The bottom line: strong lensing.

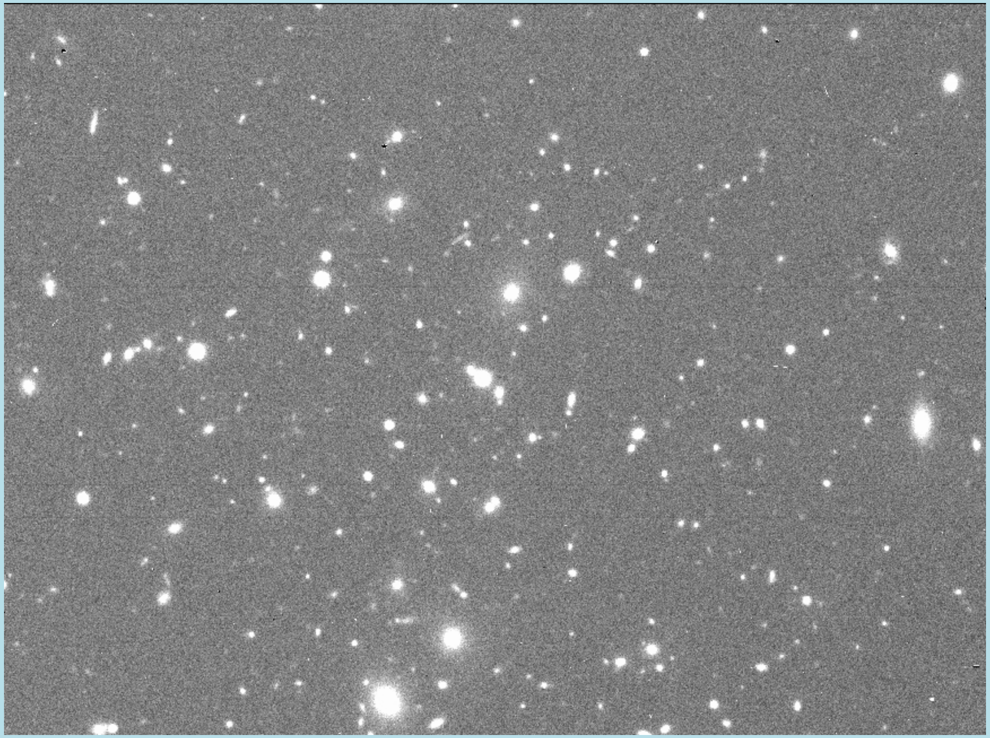
Improved image quality increases the number of detected arcs (arc width is less than the seeing for most ground-based conditions).



Top:CL2244, WFPC2; bottom: effect of seeing on galaxy-galaxy strong lensing detection.

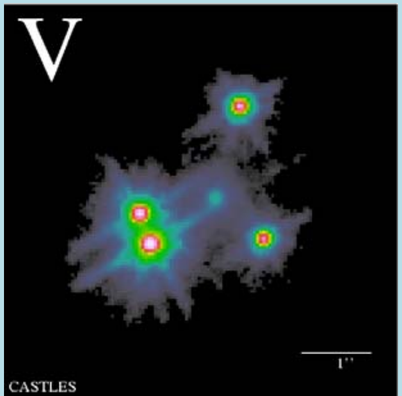


Abell 781 in <0.5" seeing from Optic



Improved seeing makes lensed QSOs and galaxies easier to detect.

CASTLES



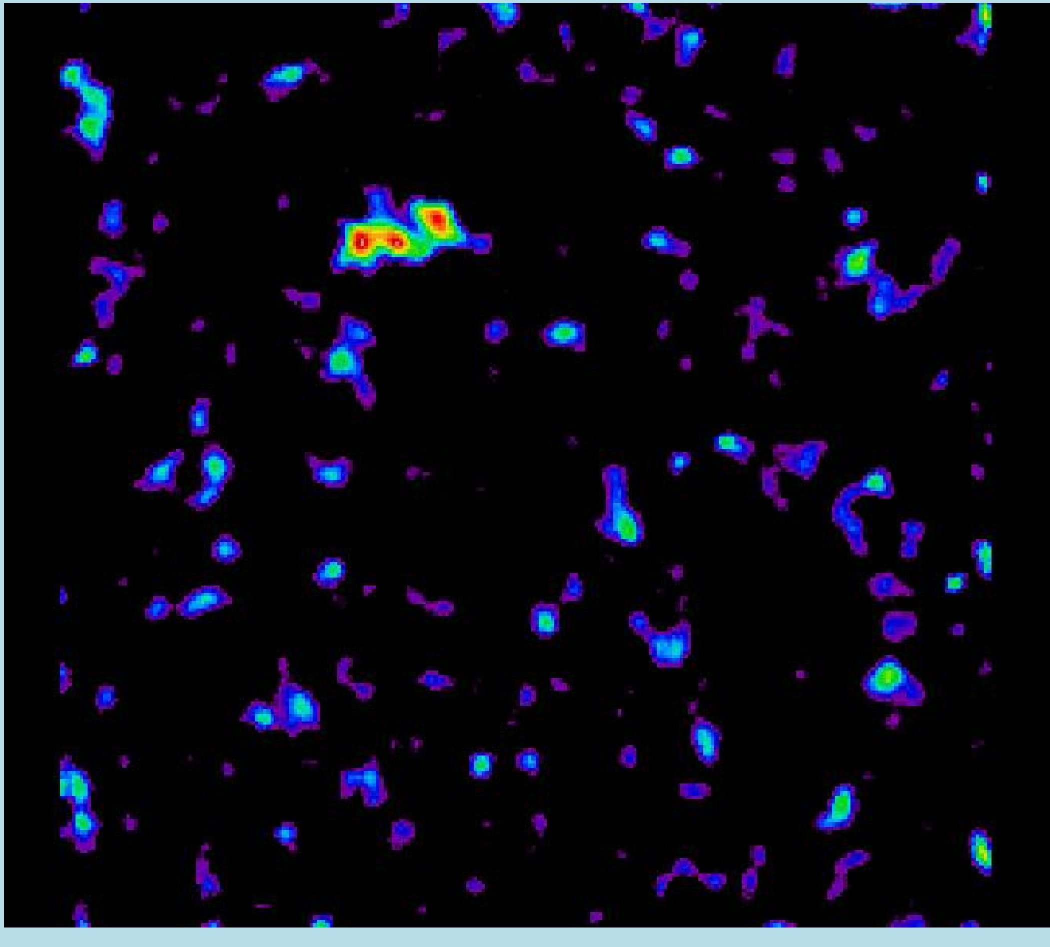
Planned projects—1:Survey of clusters of galaxies in the Yale Survey fields

Many upcoming surveys plan to use "stacks" of clusters to measure the WL signal as a normalization of mass-observable relations.

ODI is the one public instrument that can detect the individual clusters to be stacked.

Expect 200-250 clusters to be detected in WL.

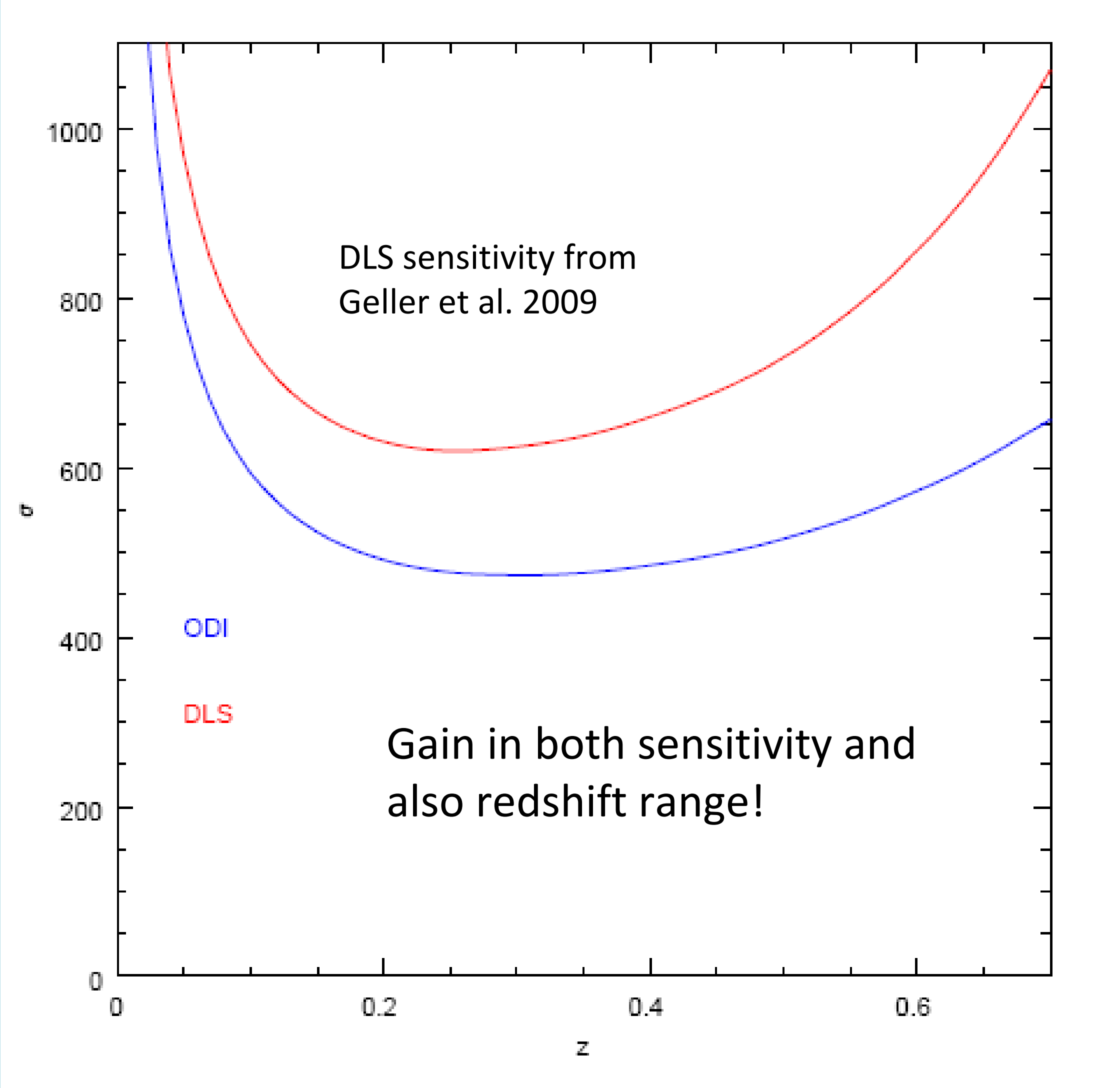
DLS map of F2—4 ODI fields to 1/3 ODI depth…



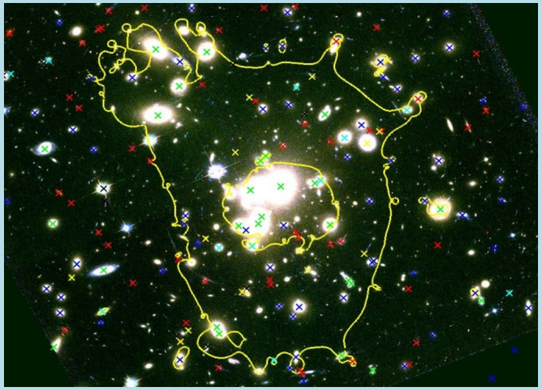
Sensitivity versus redshift…

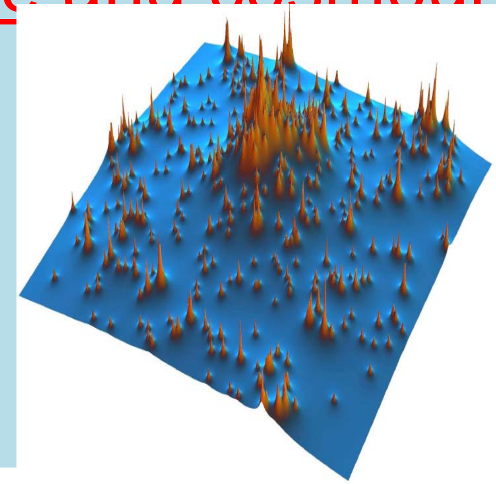
- ODI opens the possibility of detecting more abundant low-mass clusters
- Can use ODI to study mass substructure in high-mass clusters.
- Cluster selection via photometric redshifts, red sequence or possibly SZ (if a field can overlay the ACT fields)

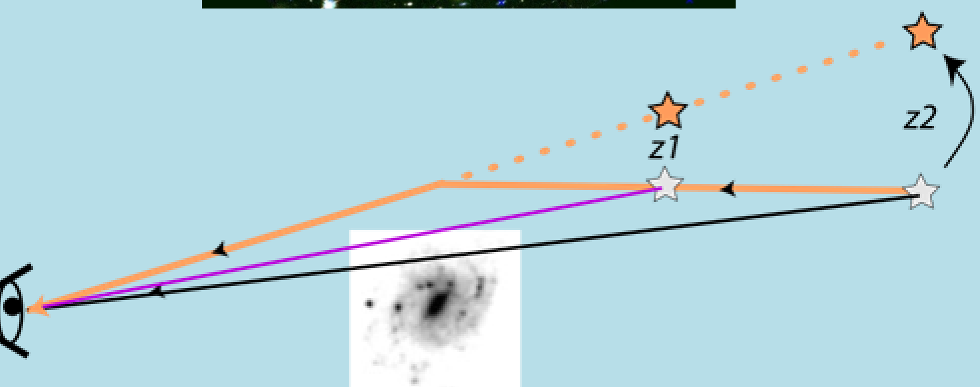
Curves are 3.5σ detection limits

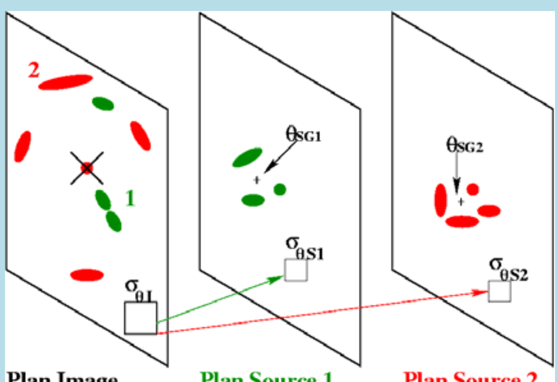


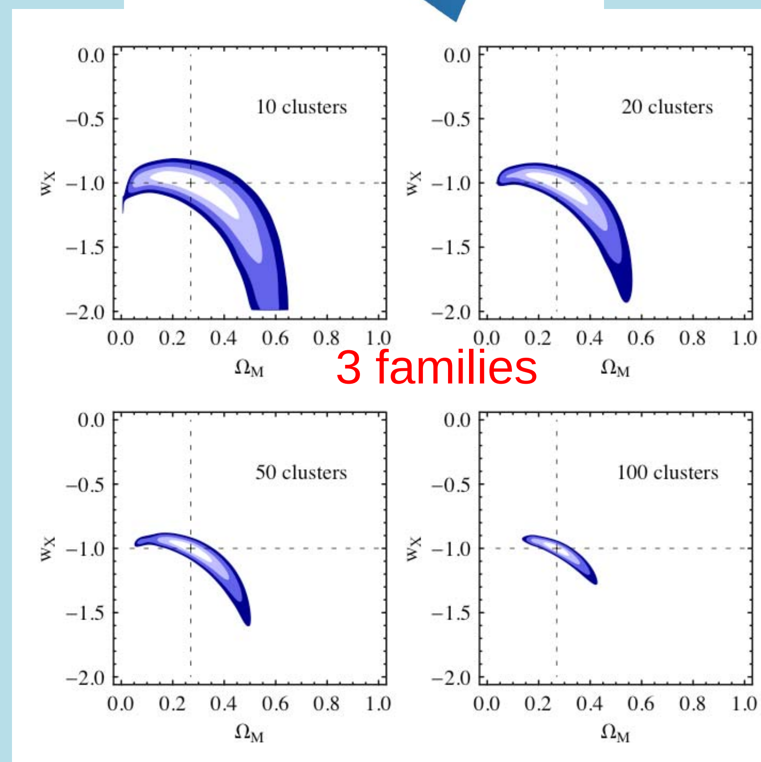
Cluster strong lensing: substructure and cosmography











3 families

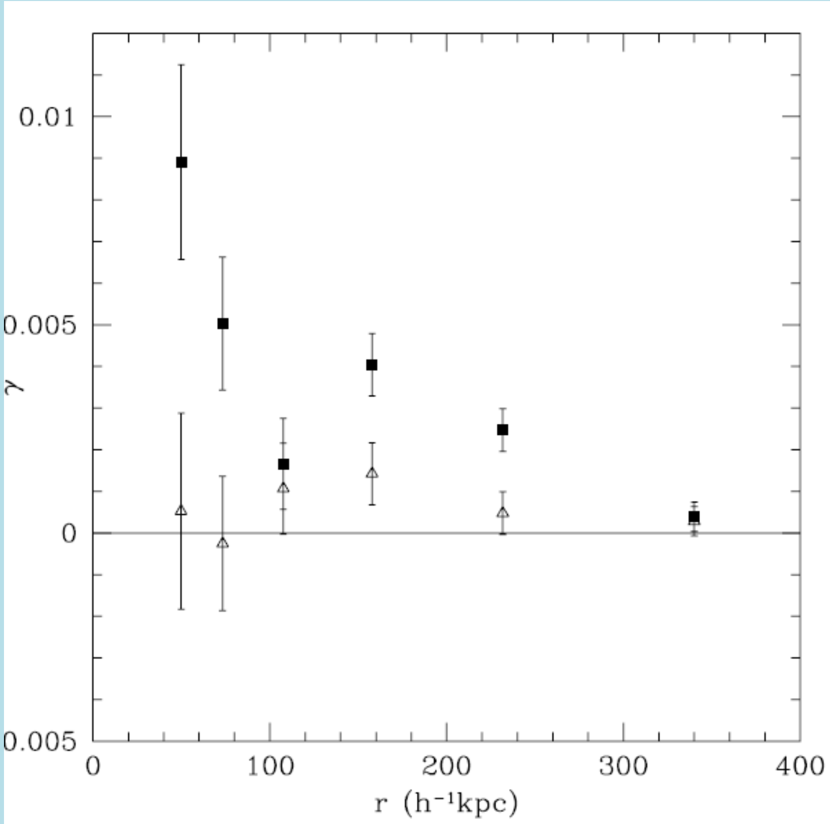
Allows constraining dark energy out to z_{source}

D’Aloisio &PN; Gilmore & PN 09

Planned Projects– 3:Galaxy-Galaxy Lensing

The Yale ODI survey will detect the average galaxy-galaxy lensing signal of massive red galaxies. Combined with measures of local clustering, this will allow us to trace the evolution of these galaxies and their dark matter environments.

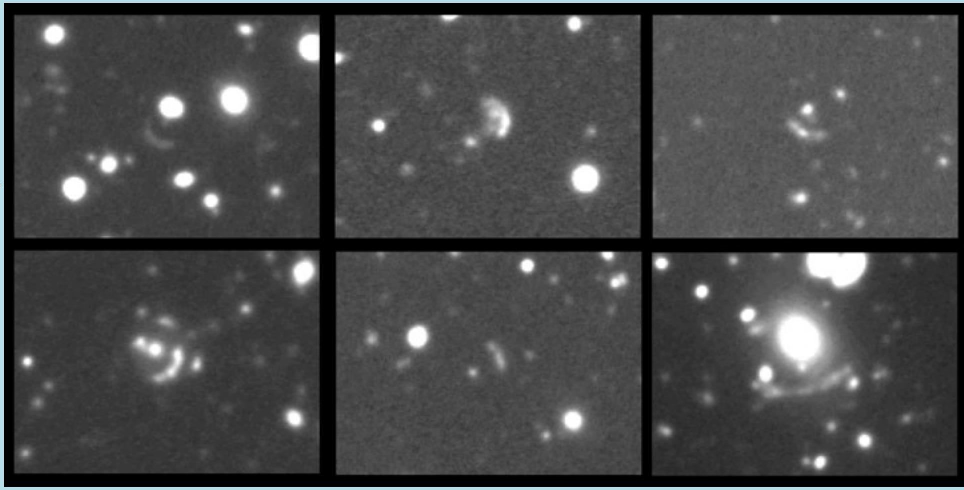
Tangential shear vs projected radius



Combined shape and photometric redshift measurements for ~6 million galaxies allow galaxy-galaxy shape cross-correlations to be calculated in multiple (5?) redshift shells. Can be used to measure the mass, radial mass profile, and flattening of the DM halos around galaxies at 0<z<0.3.

Other project examples—strong and weak lensing:

- At 0.45” seeing, we will detect ~5 galaxy-galaxy strong lenses per square degree. Could use them to probe structure in lens galaxies.



- Weak lensing by Large-Scale Structures?

- Higher order shape statistics?

Many more interesting things to be done!

Problems with OT guiding.

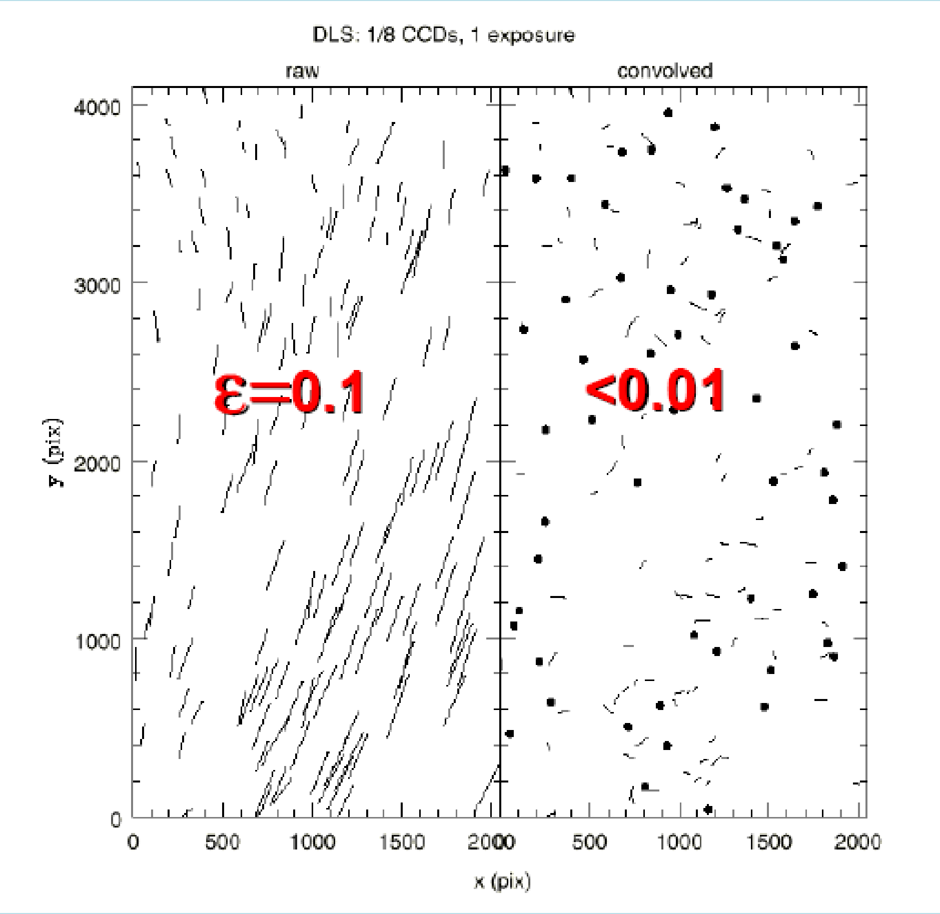
T guiding alters the PSF shapes—this can introduce systematic errors in the weak lensing reconstruction. Two questions are currently being investigated:

) What is the induced ellipticity and how does it vary exposure-by-exposure it both local and coherent OT guided mode?

) How smooth is the spatial variation of OT-induced ellipticity?

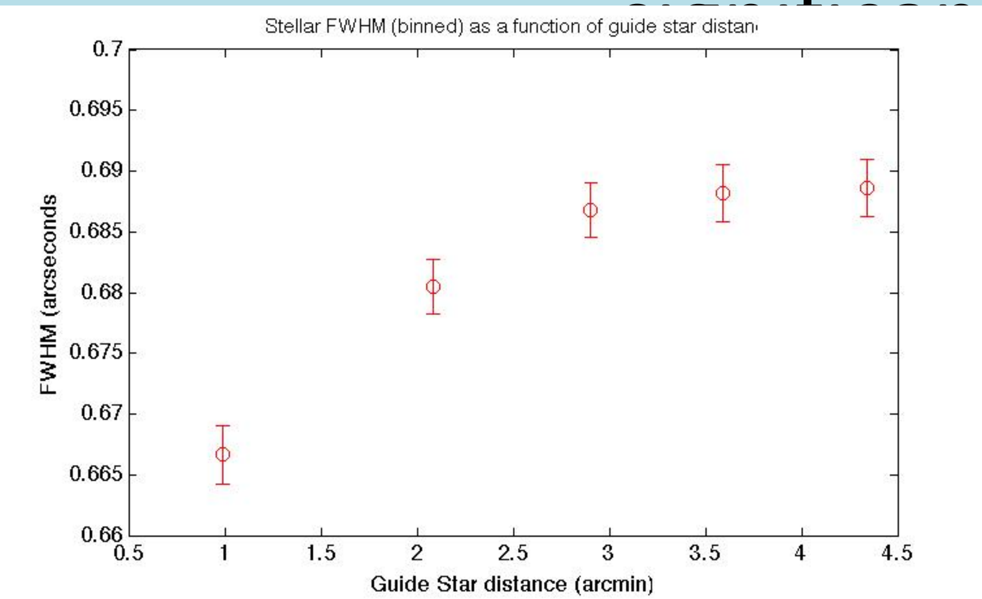
) What is the lower limit of the ellipticity error on ~arcminute scales in the case of many exposures?

ot yet clear whether <0.1% level can be reached—perhaps not a cosmic shear machine?



Can this be done for OT arrays?

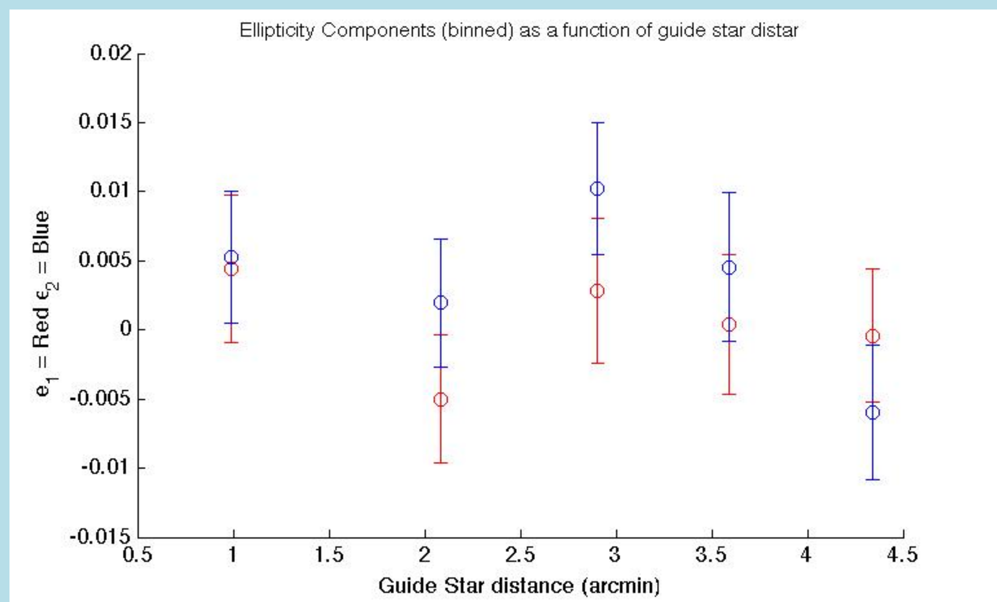
The good news—ellipticities in OT mode do not appear to be altered as significantly!



60second successive images taken with coherent OT guiding and with no OT guiding, kindly provided by Daniel Harbeck in July, 2009

OT guiding decreases PSF size.

Difference between the e1 and e2 components for the guided vs. unguided image, as a function of the distance from the OT guide star.



Needs for gravitational lensing

- Deep, best-seeing imaging in one band (i’?)
- Imaging in multiple bands for photometric redshifts (griz for cluster lensing, u is most useful for the galaxy-galaxy lensing project)

NB: Lensing does not require uniform exposure time/filter. Depth in the seeing band should be ~50-100% greater than in other bands.

- Large area coverage for significant samples (minimum is ~30 square degrees)
- Contiguous areas for efficiency