
Lens galaxies and their environments
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ct 2006

Lens galaxies and their environments

Local

Not-so-local

(Very local)

Toward robust measurement of H_0 with gravitational lenses: dealing with the systematic effects

- Average over measurements made with lots of lens systems
  - Fine for beating down effects that are zero-mean
- Understand each lens system as well as you can
  - "excruciating detail"
  - Especially needed for correcting for effects that are not zero-mean

The local environment of lenses: groups and clusters

- The mass-sheet degeneracy (Falco et al., Gorenstein et al.)

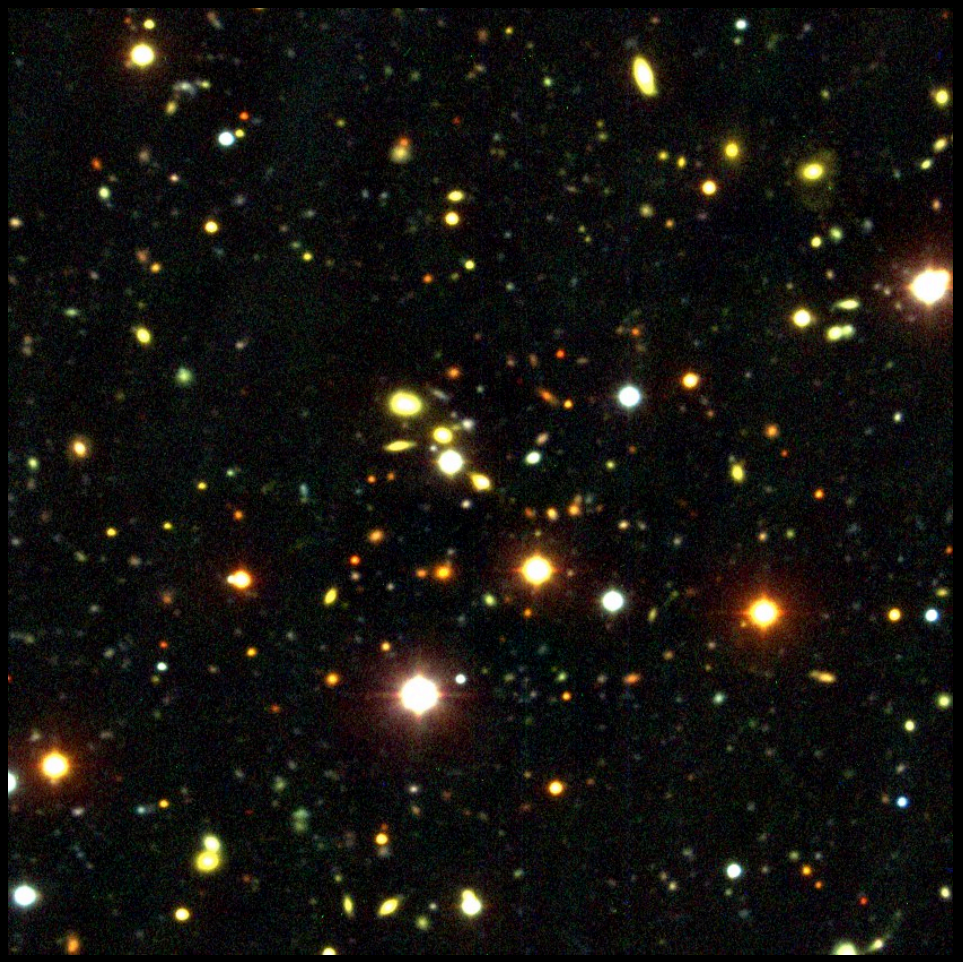
$$H_{0,true} = H_{0,meas} \, (1 - \kappa_{sheet})$$

Galaxy Groups as Mass Sheets?

- Groups are the most common galaxy environment in the local Universe
- Morphology-density relationship
- Theoretical studies predict 25% or more of lenses should be in groups (Keeton et al., Blandford et al., Oguri et al.).

Assessing the local environment

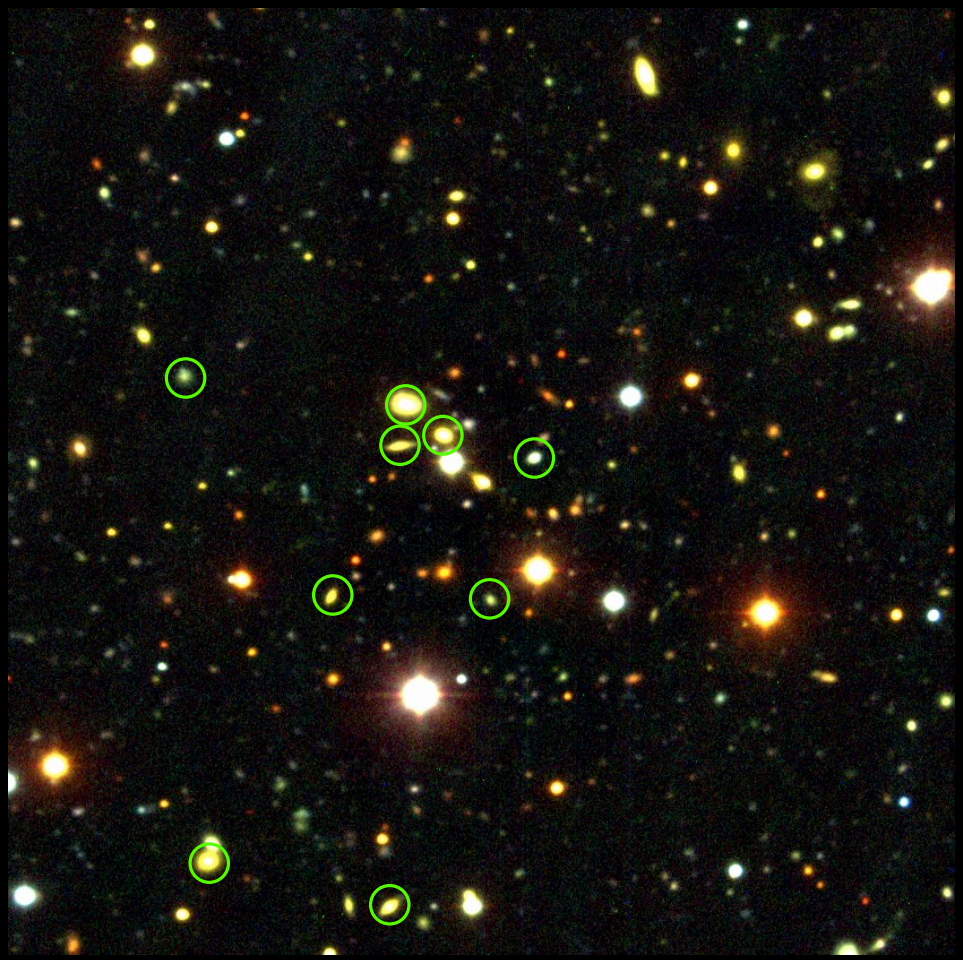
- Galaxy groups can be hard to find even if they are present



Keck BRI image of B0712+472 field

Assessing the local environment

- Galaxy groups can be hard to find even if they are present



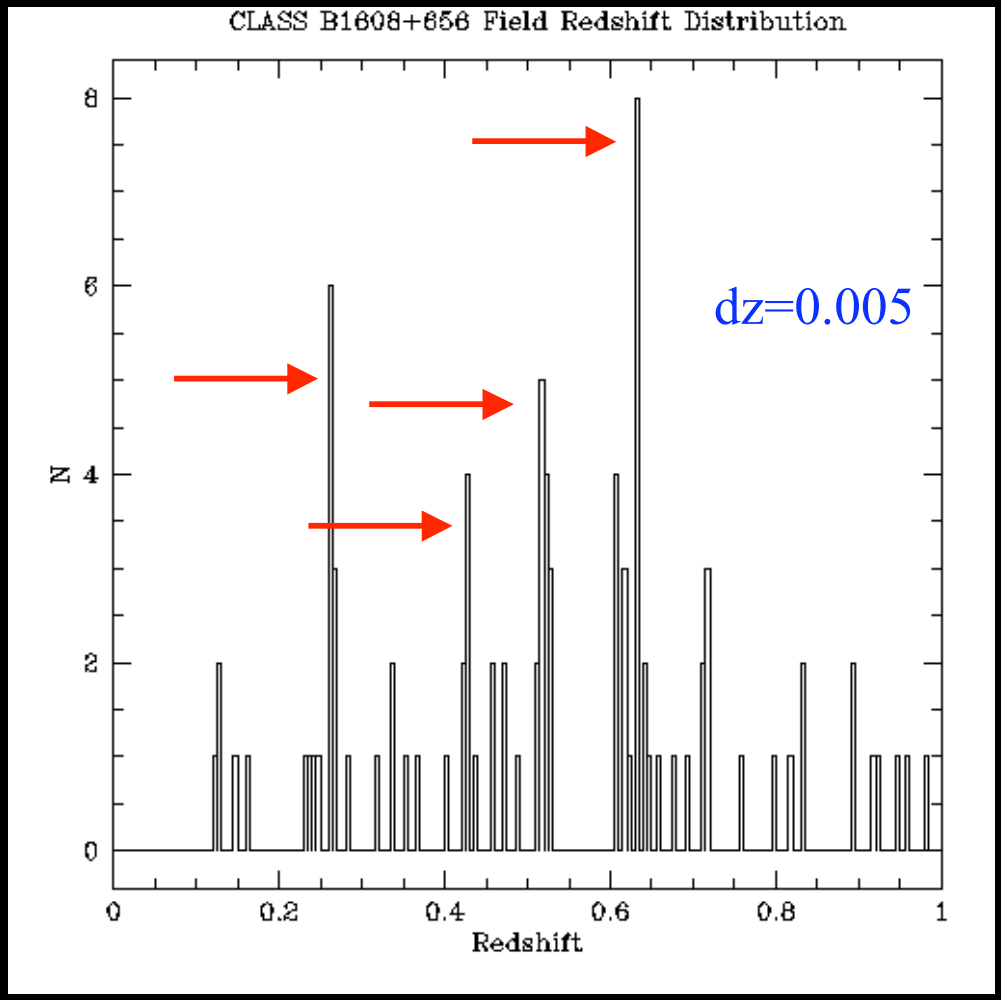
Fassnacht & Lubin 2002

Finding lens-group associations: Systematic spectroscopic surveys

- Use multi-band imaging to select targets
  - Palomar 60-Inch, Lick, Keck, HST
- Spectroscopic targets ($r < 23$) are prioritized by:
  - Color
  - Proximity to the lens system
- Multislit spectroscopic followup
  - Keck (LRIS) and Gemini (GMOS)
- Search for galaxy associations that are compact spatially and in redshift space
- Work with Matt Auger, Lori Lubin, Gordon Squires

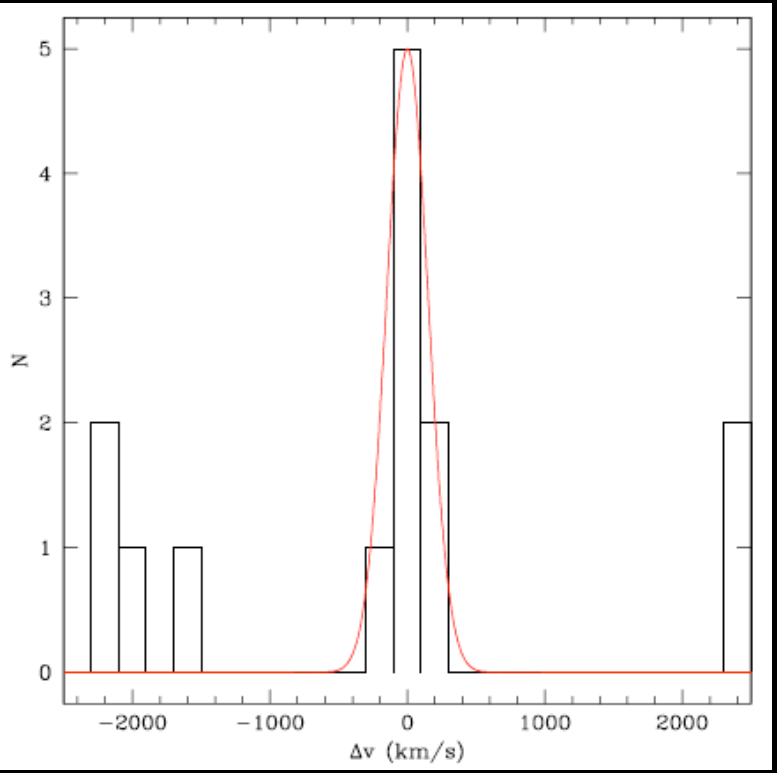
B1608+656: A complex LOS

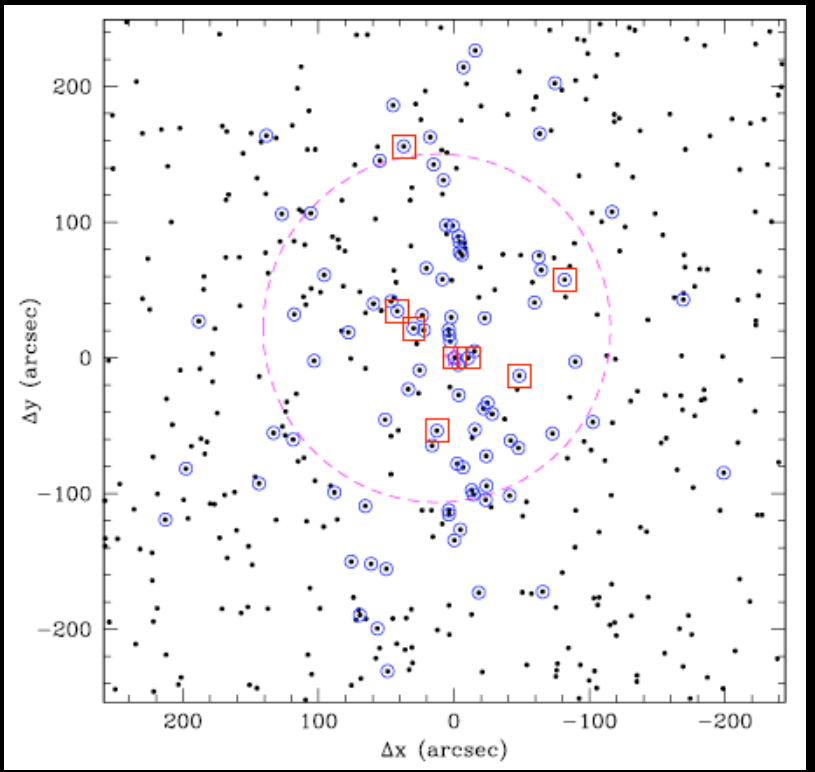
- Spectroscopic survey (~90 redshifts) shows at least 3 galaxy groups along line of sight.



Fassnacht et al. 2006a

B1608+656: The group at z=0.63

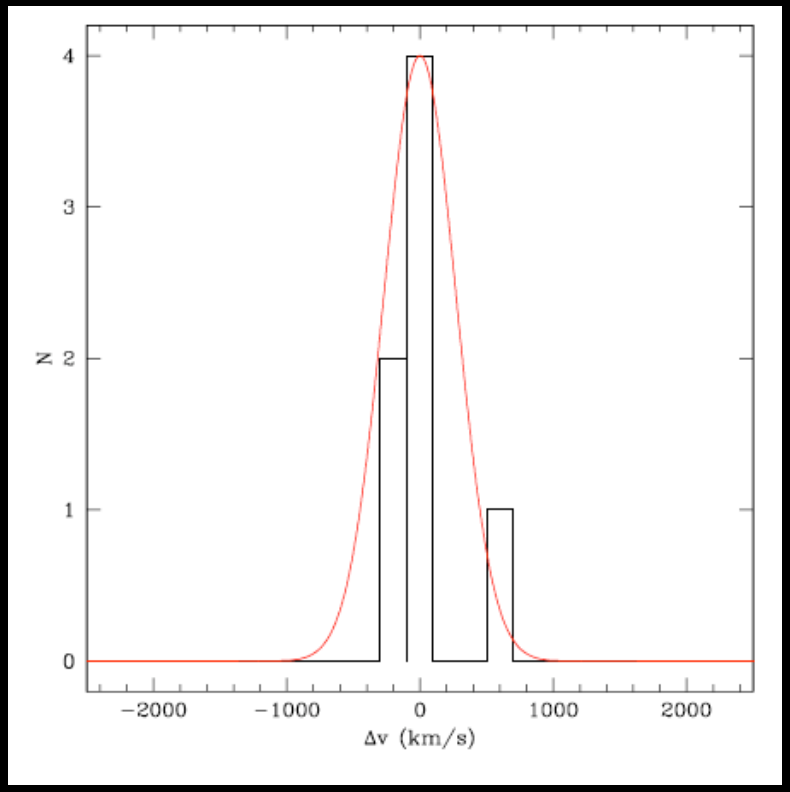


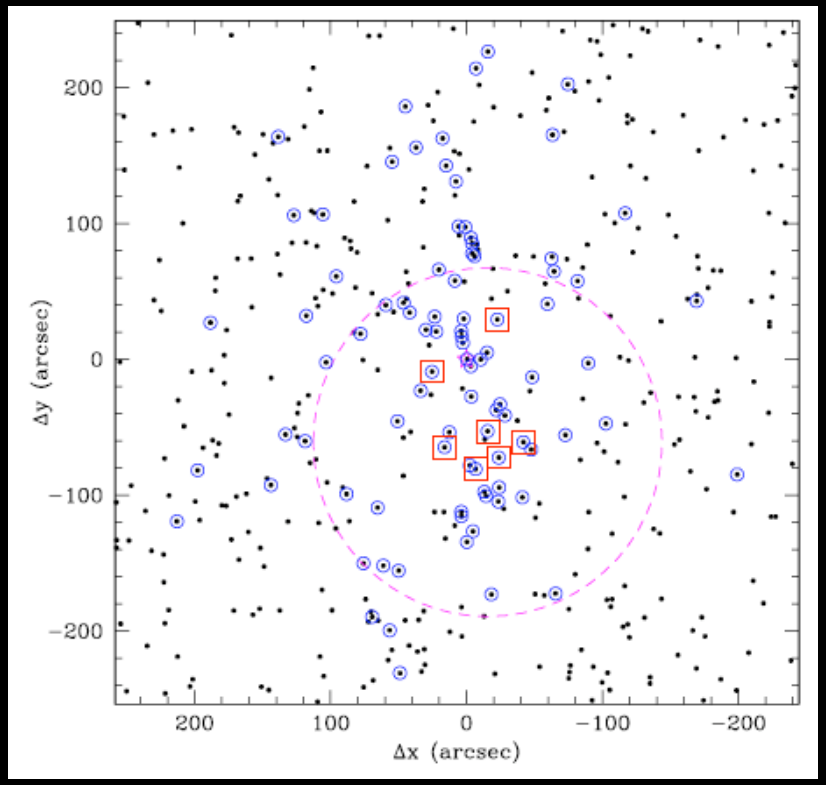


- 9 confirmed members
- σ ~ 150 km/s

8.3 arcmin

B1608+656: The group at z=0.43

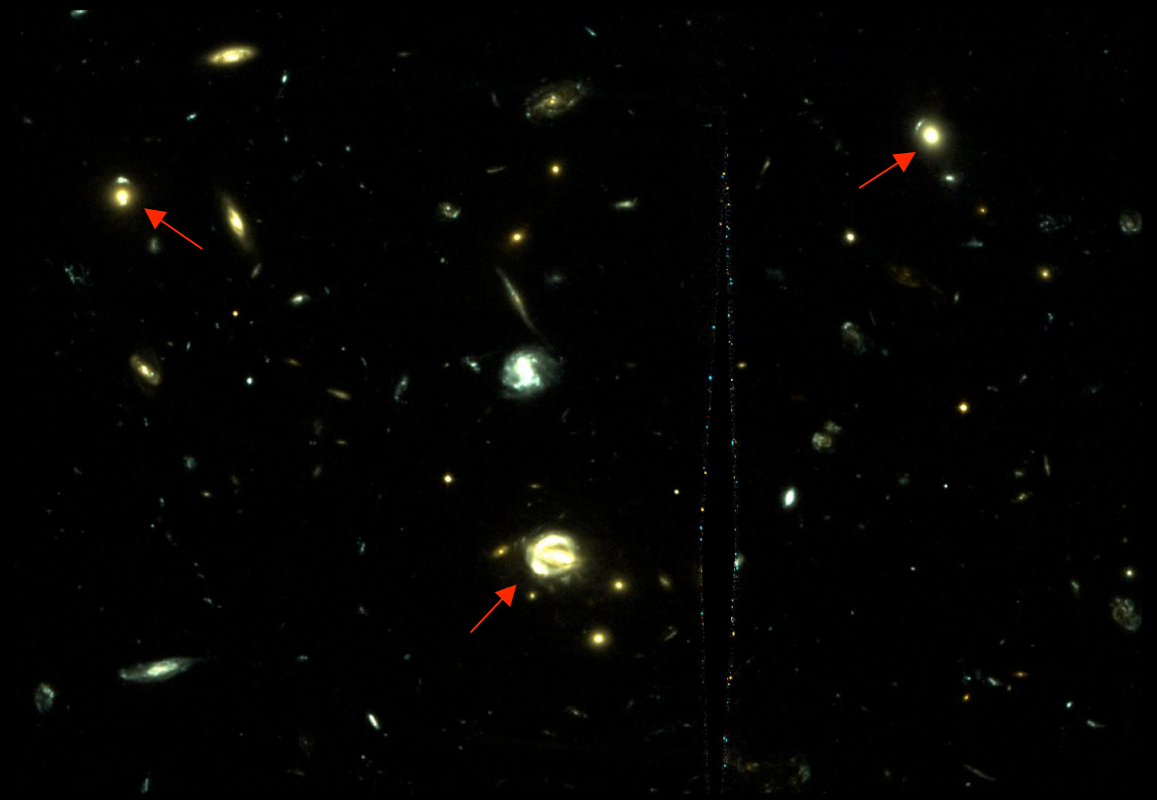




- 7 confirmed members
- σ ~ 270 km/s

A complex line of sight

- Two additional lens candidates found, each within 40 arcsec from B1608+656 (Fassnacht et al. 2006b)

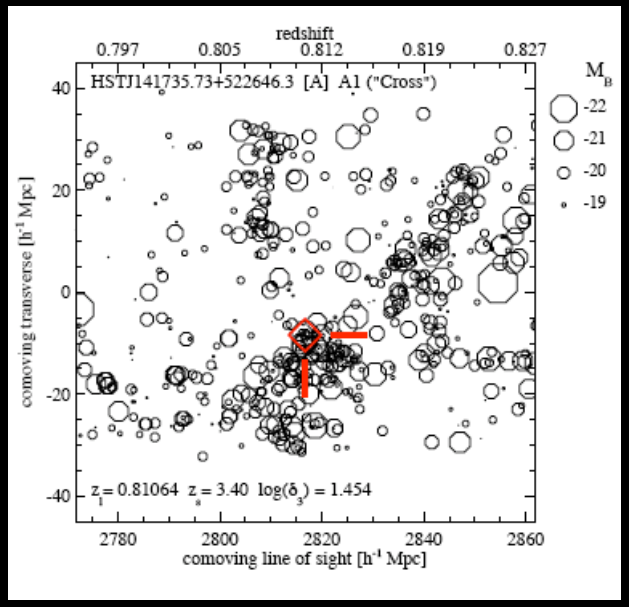


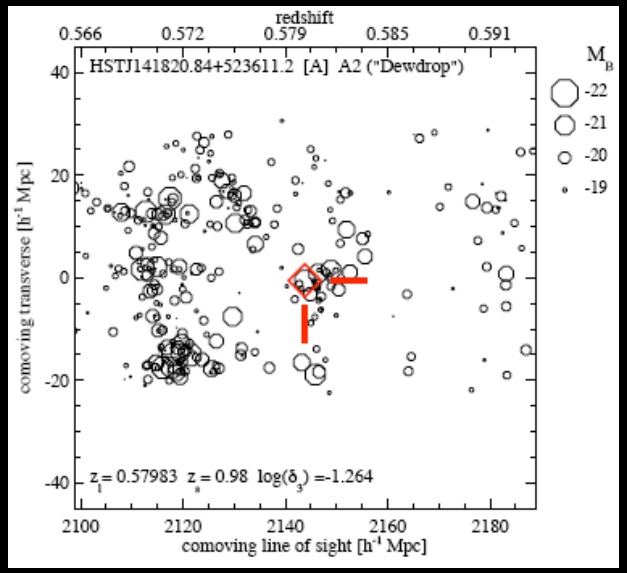
Results: Local Environments

- Several new lens-group associations found:
  - B0712+472 - Fassnacht & Lubin 2002
  - B1608+656 - Fassnacht et al. 2006
  - B1600+434 and B2319+051 - Auger et al. 2006
  - B2108+213 - McKean et al. in prep.
- Effects on H_0 of a few percent
- See Auger poster
- Also, follow-up Chandra observations of two groups

Other methods to evaluate lens environments

- Weak lensing analysis and photometry
  - e.g., Faure et al. 2004
  - Work with Lagattuta, Bradac
- Using existing data from large redshift surveys
  - Moustakas et al. 2006





The non-local environment of lenses: LSS

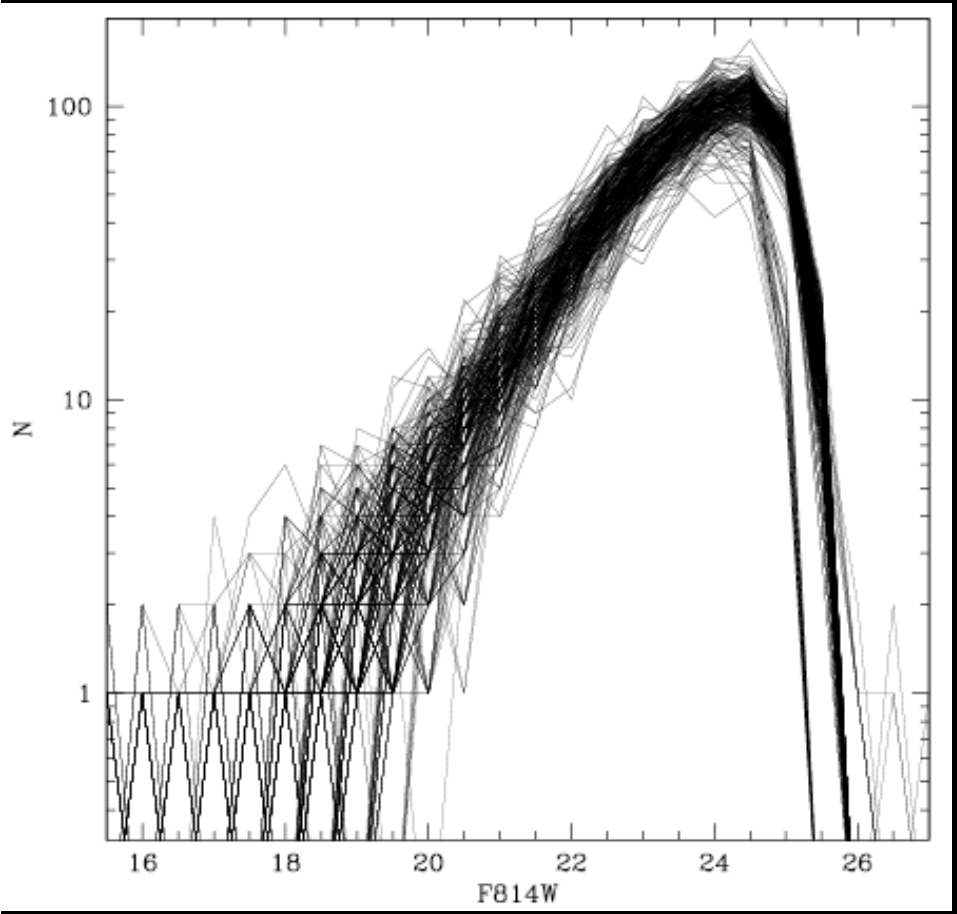
- LSS is expected to contribute a systematic error on H_0 from individual lenses at the few percent level
  - See Barkana, Seljak, Surpi et al.
- Assumption: this is a zero-mean effect
  - ==> Averaging over many lens systems will help.

Testing the zero-mean assumption

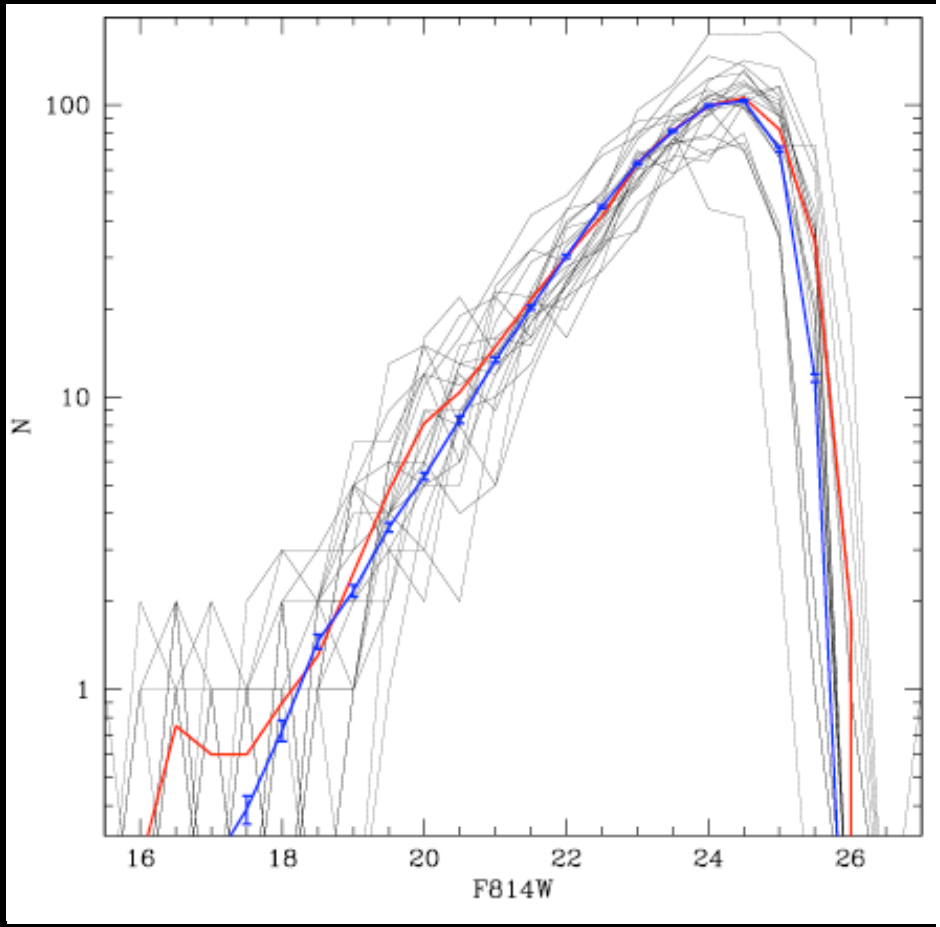
- Do the simplest possible thing -- look at number counts in lens fields
  - ACS imaging of lenses from CASTLES program (PI: Kochanek) + B1608+656 (PI: Fassnacht):
  - 20 fields - typical exposure time = 1300-2500 sec in F814W
- Control sample #1: COSMOS survey
  - Largest HST imaging survey (PI: Scoville)
  - Use first 1 square degree:
  - 257 ACS fields - typical exposure time = 2000 sec in F814W
- Work in progress, with Ken Wong and Leon Koopmans

Initial Results: Differential Counts

COSMOS fields

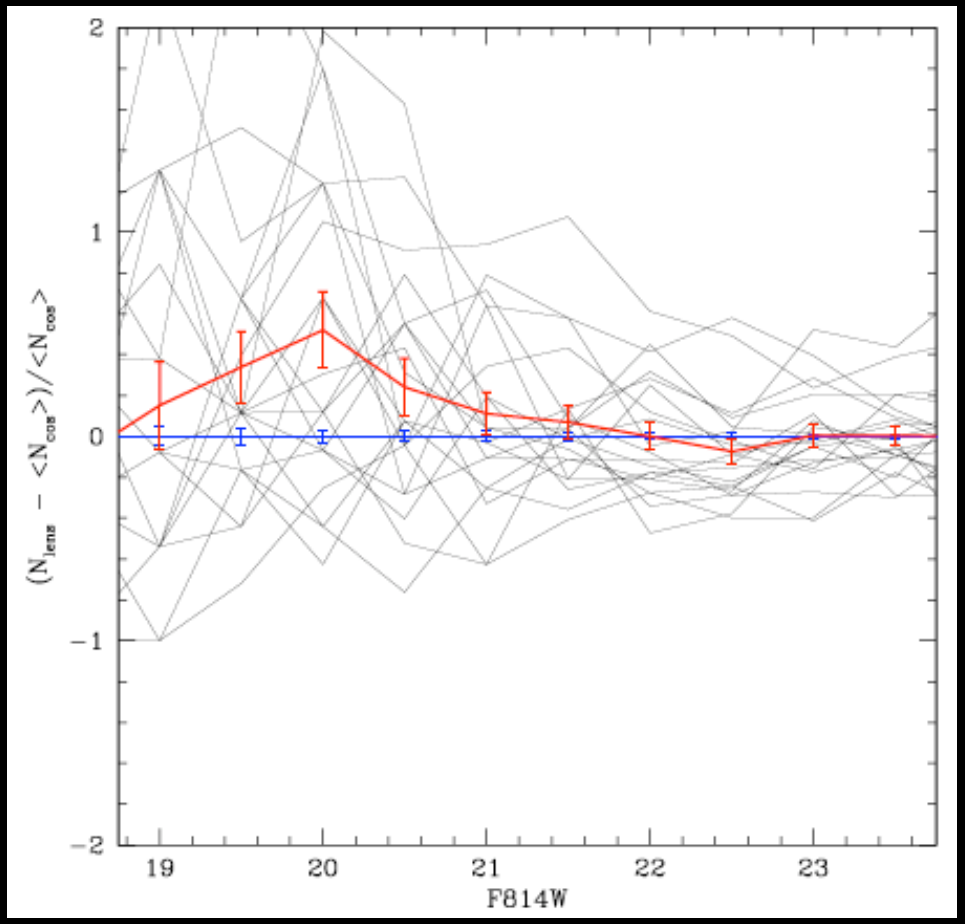


Lens fields



Fassnacht et al., in prep.

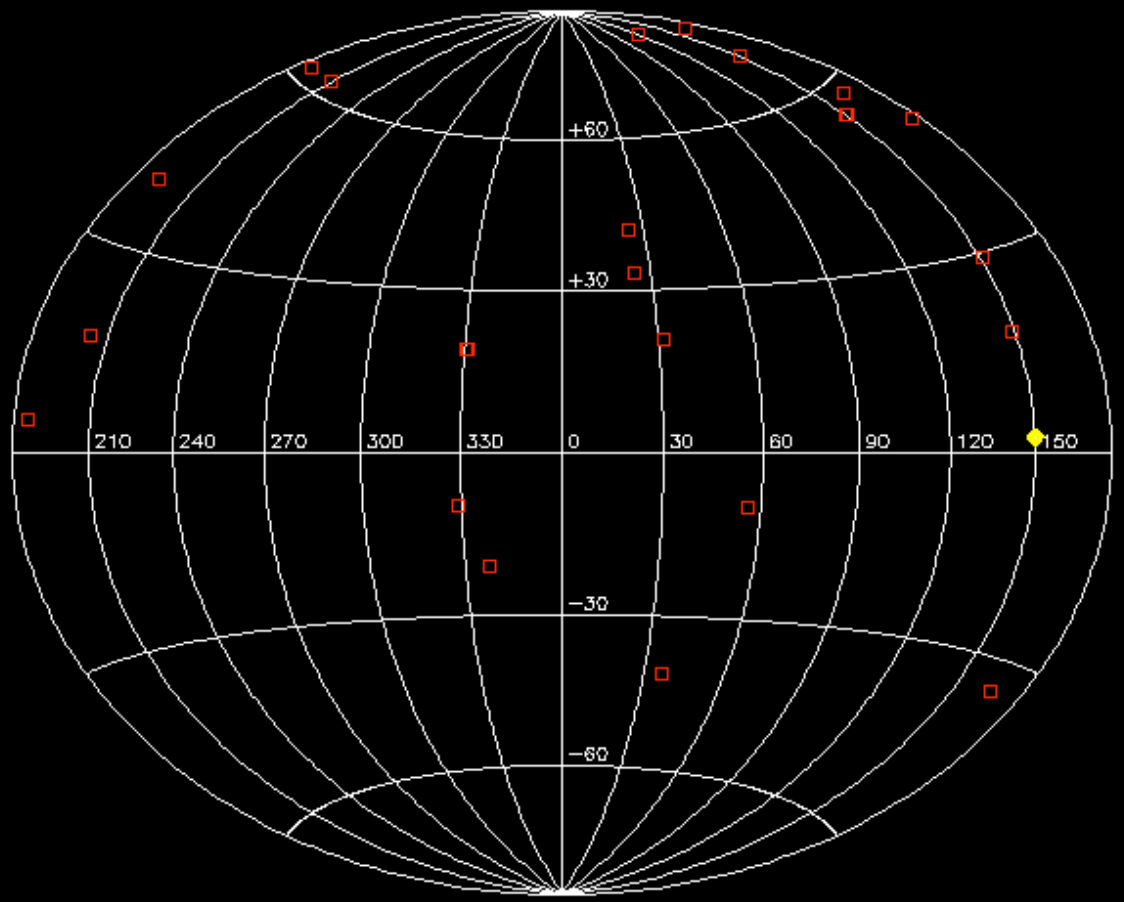
Initial Results: Fractional Differences



Differential

The need for a second control sample

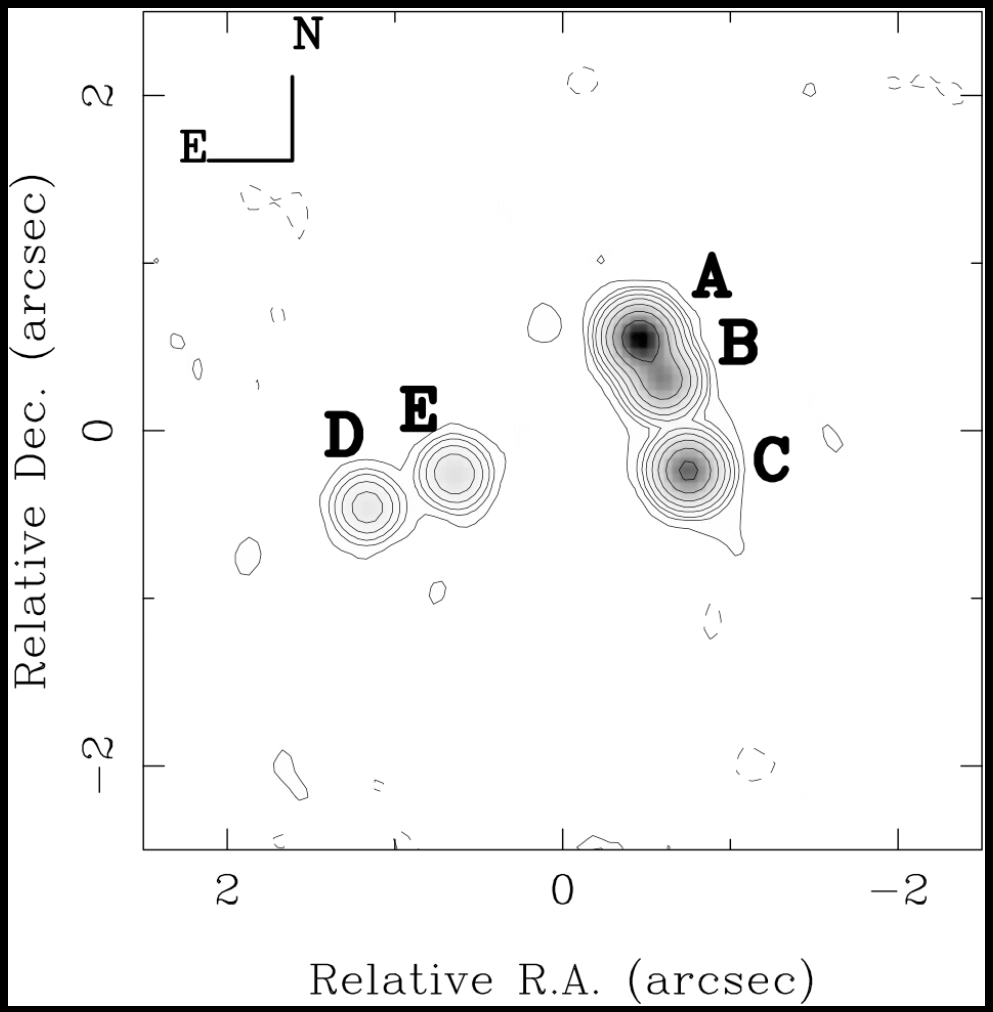
- Use Yan et al. ACS parallel data
- ~30 total fields
- Currently calibrating data with HAGGLES pipeline



Conclusions

- Initial analysis of LSS data indicate that lenses may lie along slightly biased lines of sight.
  - However, effects may be consistent with those due to the local environment
  - Therefore LSS effects could average out
- More lens fields are needed to improve the statistics for LSS analysis.
- Local environments do have to be investigated individually
  - Effects of a few percent on H_0 for the time-delay lenses in our sample

B2045+265

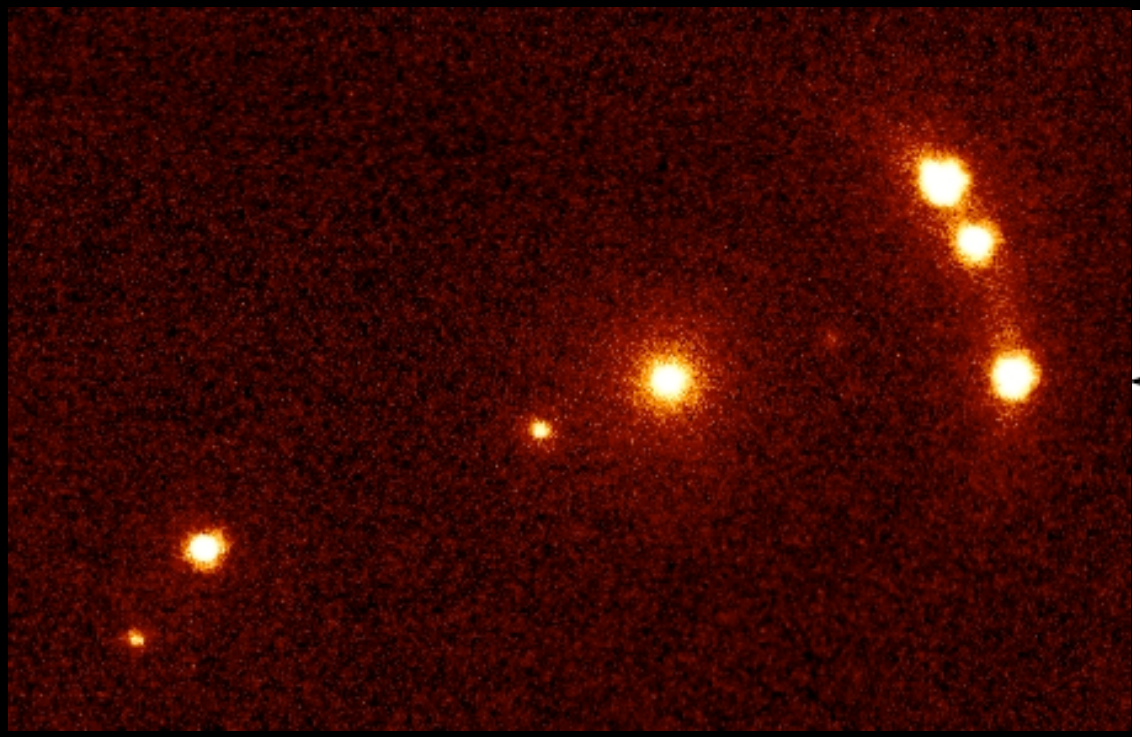


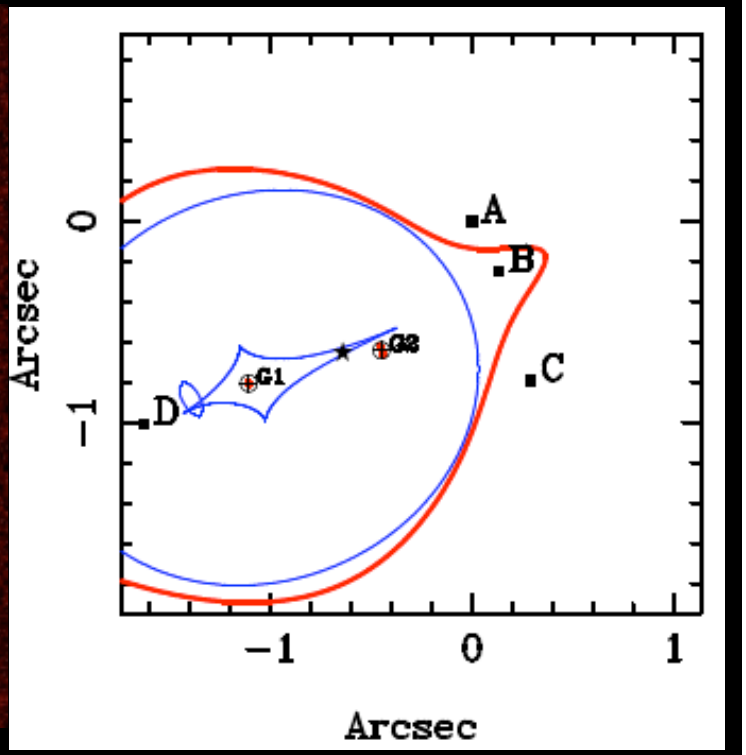
Fassnacht et al. 1999

2045+265

HST WFPC2 + NICMOS

2045+265





Keck AO K band -- McKean et al. in prep

FWHM ~ 80 mas, t_{exp} = 63 min