Using Clusters to Measure Intrinsic Alignments

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DUEL 2010

Collaborators
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Outline

- Why is studying the intrinsic alignment of galaxies interesting?
- What do simulations to tell us?
- What other studies are there?
- Our sample of galaxy clusters, and how it fits in.

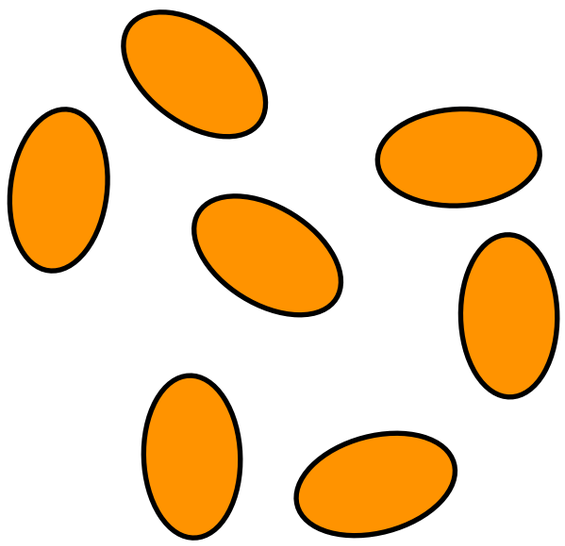
Intrinsic alignment

- Common weak lensing assumption: galaxy orientations are intrinsically random

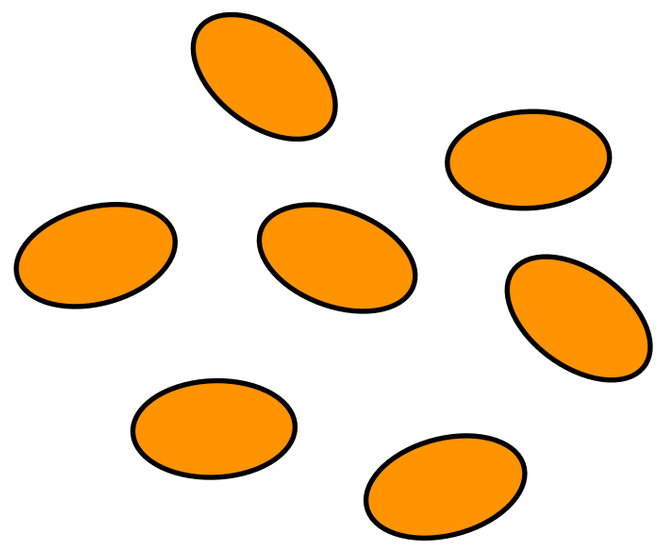
- "$e_{\text{observed}} = e_{\text{gravitational}} + e_{\text{intrinsic}}$"

- Correlations in galaxy alignments can mask/mimic gravitational lensing

- $\langle e_{\text{intrinsic}} \rangle = 0$



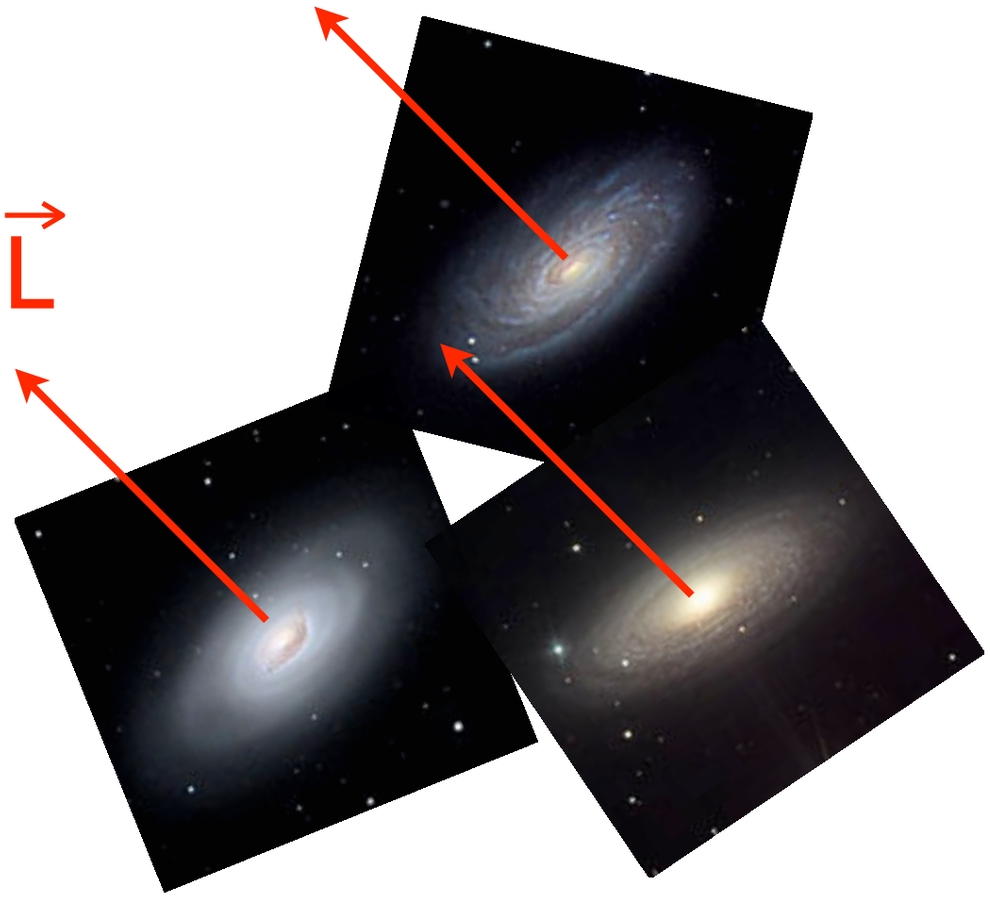
- $\langle e_{\text{intrinsic}} \rangle \neq 0$



Intrinsic Alignment Mechanisms

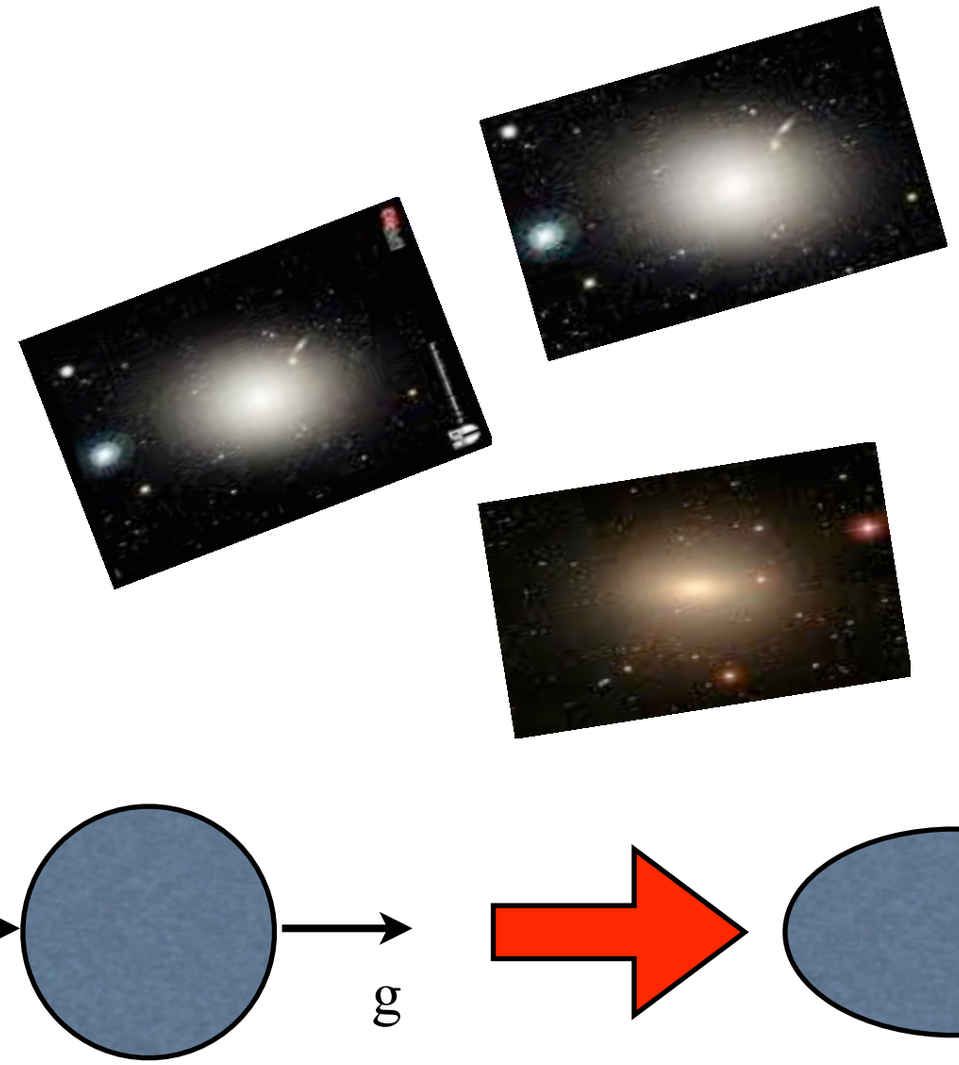
Torquing:

- Alignment of spin axes for galaxies that formed in the same initial tidal field
- Expected to be dominant for spiral galaxies
- Expected to be small



Stretching:

- Coherent stretching of galaxy shapes due to gravitational potential
- Expected to be important for elliptical galaxies
- Detectable



Intrinsic Alignment: Scales

Larger scales: $\gamma_I \propto (\nabla_x^2 - \nabla_y^2 , 2\nabla_x \nabla_y)\, S[\Psi]$

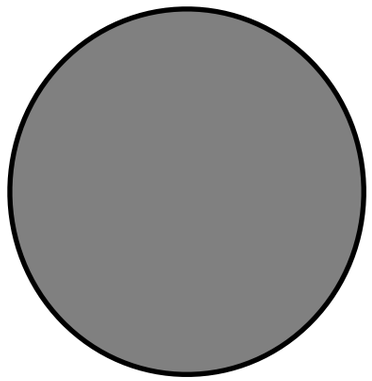
$S[\Psi]$: Newtonian potential at formation, smoothed on small scales

Catelan, Kamionkowski, Blandford, Mon. Not. Roy. Astron. Soc. 320, L7 (2001).

Smaller (group/cluster) scales:

Constrained by observations/simulations

- Satellites tend to be oriented toward center of host halo
- Satellites tend to be aligned with central galaxy



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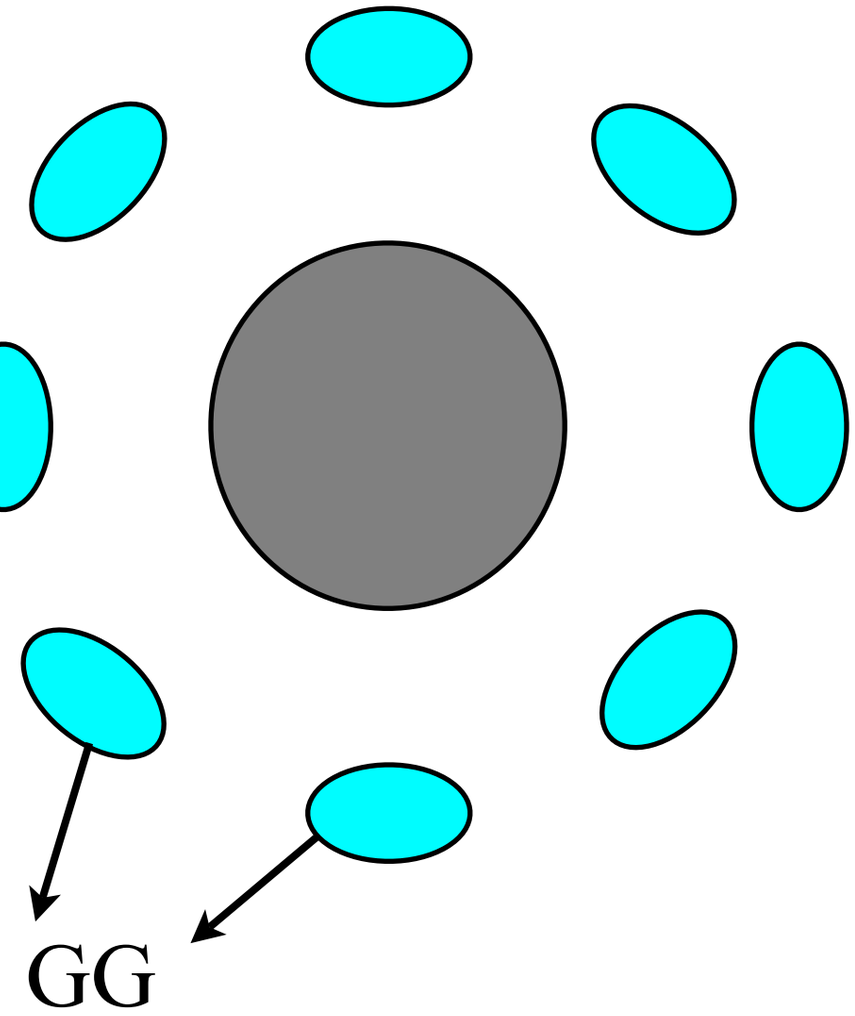
"GG" : Cosmic Shear



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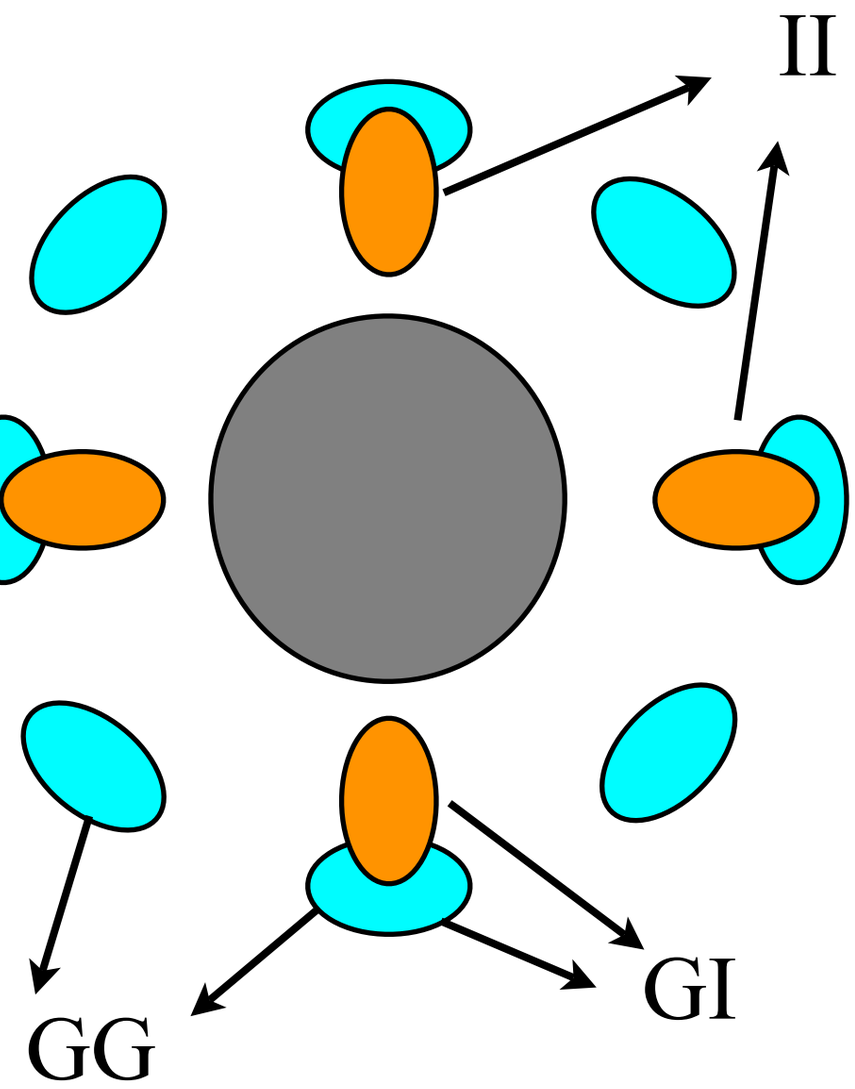
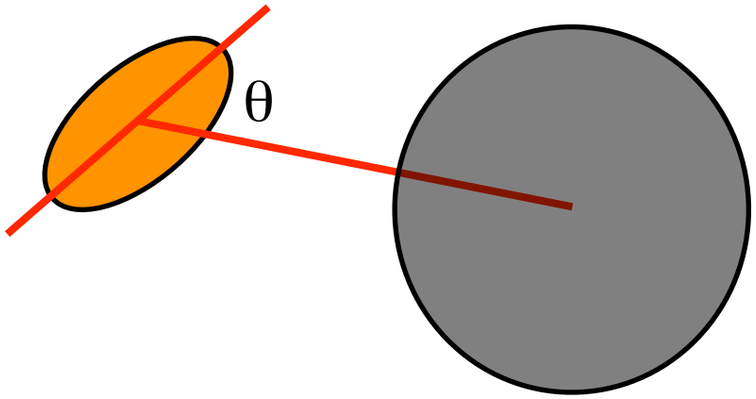


"GG" : Cosmic Shear

"II" : Intrinsic Correlation

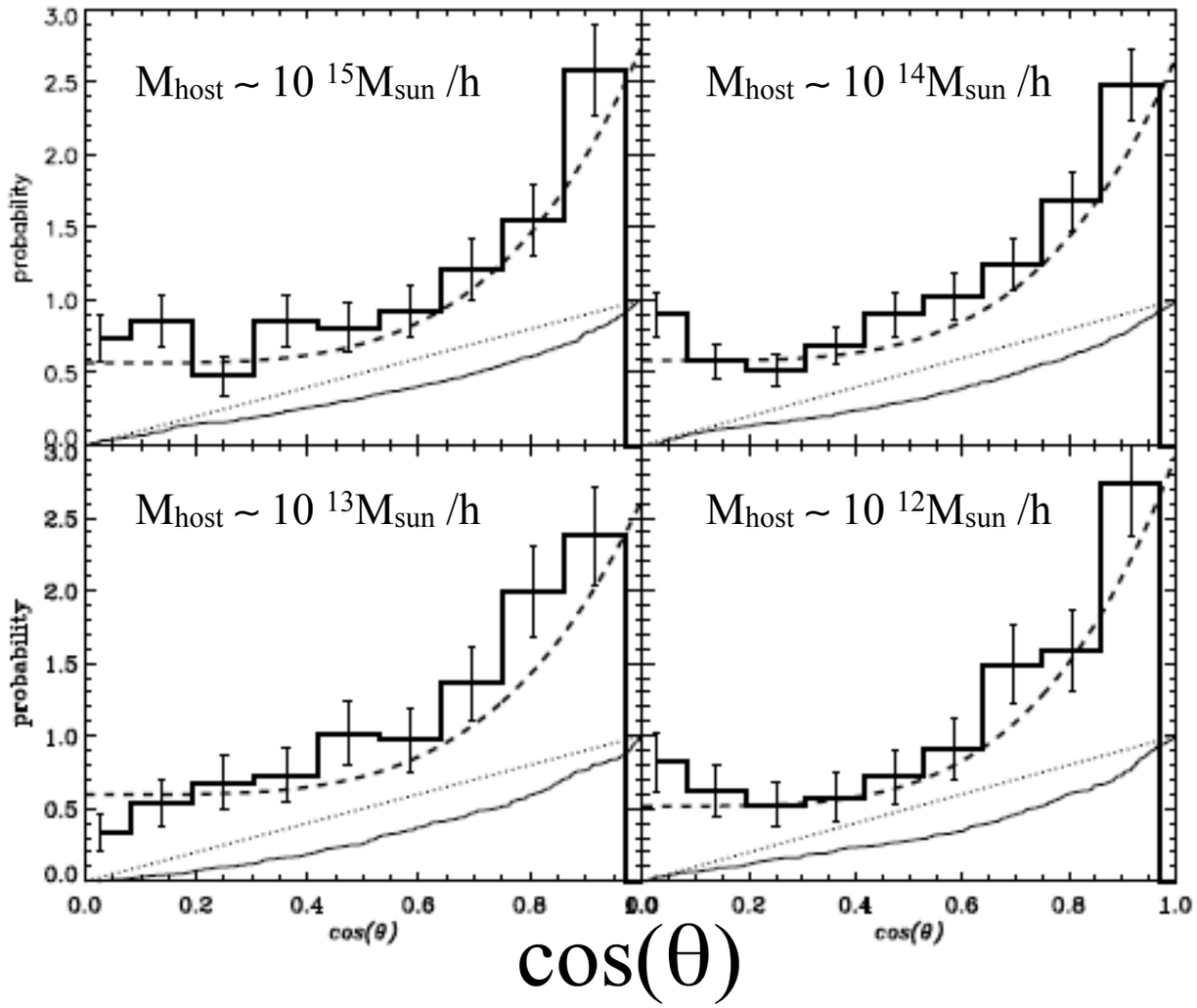
"GI" : Cross correlation

Simulations



- Series of dark matter halo simulations spanning a range of masses (10^{12} - 10^{15} M_{sun} /h)
- Radial alignment of subhaloes and host independent of mass.
- From galaxy to cluster scales
- $P(\cos\theta) \propto A\,(\cos\theta)^4 + B$

Knebe et al. (2008)



Knebe, et al., MNRAS Letters 386 L52 (2008)
Pereira, et al., ApJ 672, 825 (2008)
Ciotti and Dutta, MNRAS 270, 390 (1994).

Several Measurements: Orientation of Satellite Galaxies

- "Distribution of Observed Orientations of Galaxies"
  - Hawley and Peebles, Astronomical Journal 80 (1975).
    - Coma Cluster

- "Radial Alignment of Cluster Galaxies"
  - Pereira and Kuhn, ApJ 627, L21 (2005)
    - 85 Clusters in SDSS (eBCS)

- "Large–Scale Intrinsic Alignment of Galaxy Images"
  - Agustsson and Brainerd, Astrophysical Journal Letters 644, L25 (2006). Brainerd, et al arXiv:0904.3095
    - SDSS

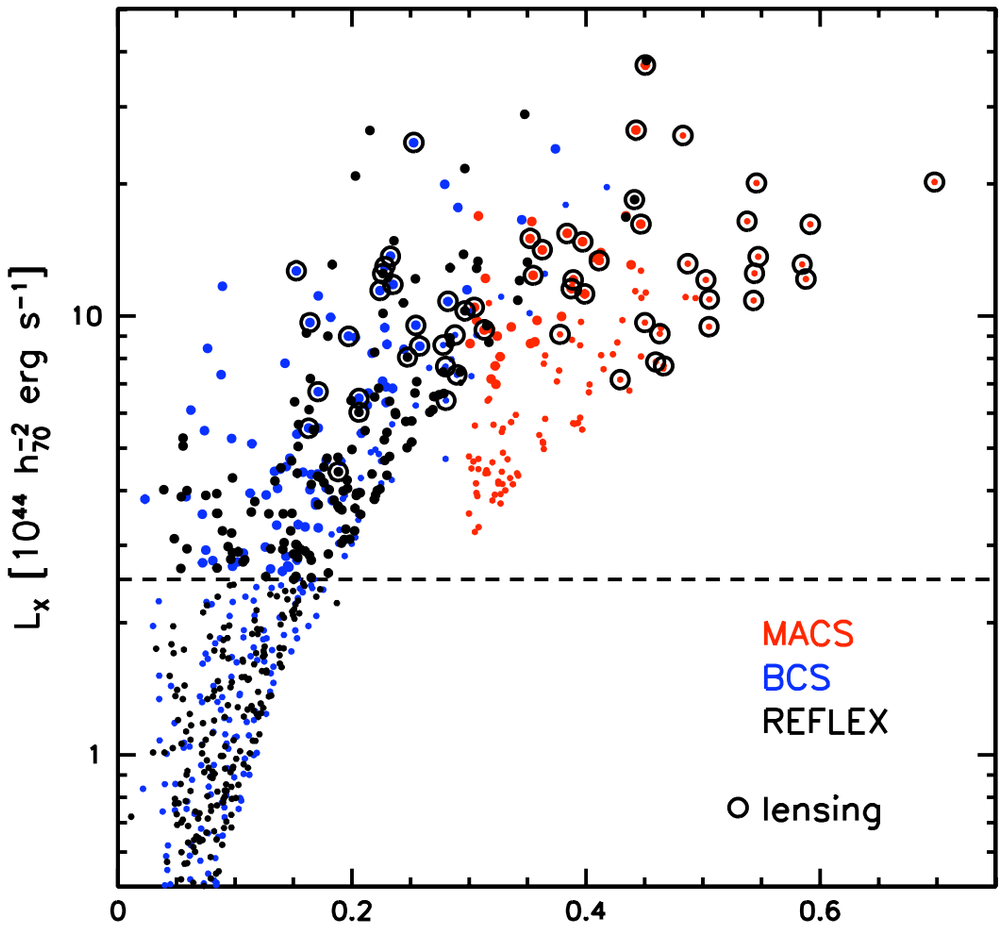
- "Alignment between galaxies and large-scale structure"
  - Faltenbacher, et al, Res. in Astron.and Astrop., V 9, 1, pp. 41-58 (2009).
    - SDSS

- (Several More)

Our Sample

MACS Clusters + lower redshift ,
less massive clusters
-(See Anja von der Linden's talk)

-Suprime Cam + Megaprime data
- ~50 clusters with ≥ 3 filters
- Large masses ~ 10^{15} M_{sun}
- Higher redshift: 0.2-0.6
- Clusters X-ray selected
- Cluster members photometrically selected



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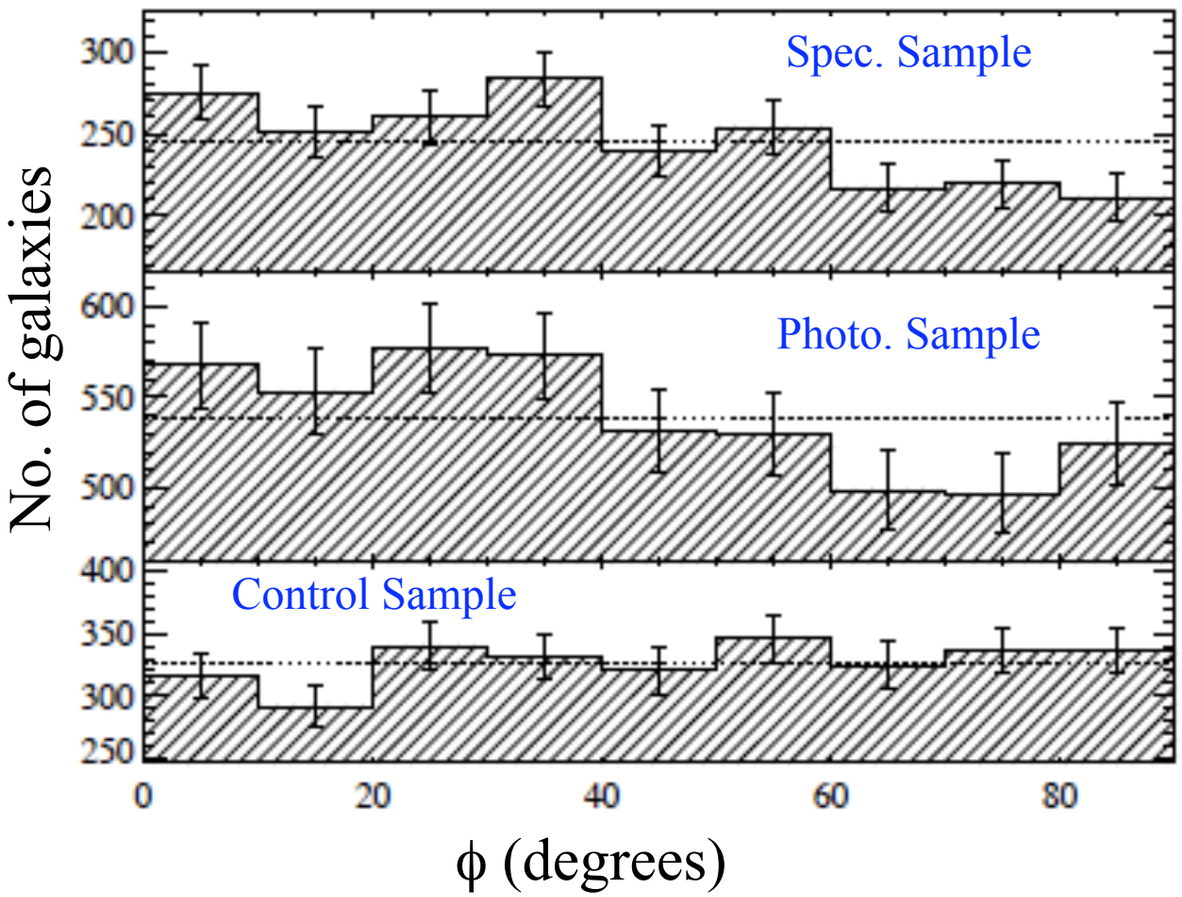
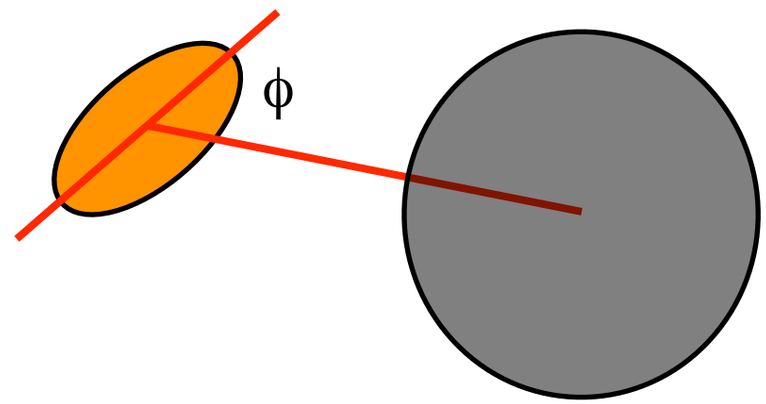
Intrinsic Alignment in Clusters

Pereira and Kuhn (2005)

85 eBCS clusters in SDSS
z = 0.02 - 0.23



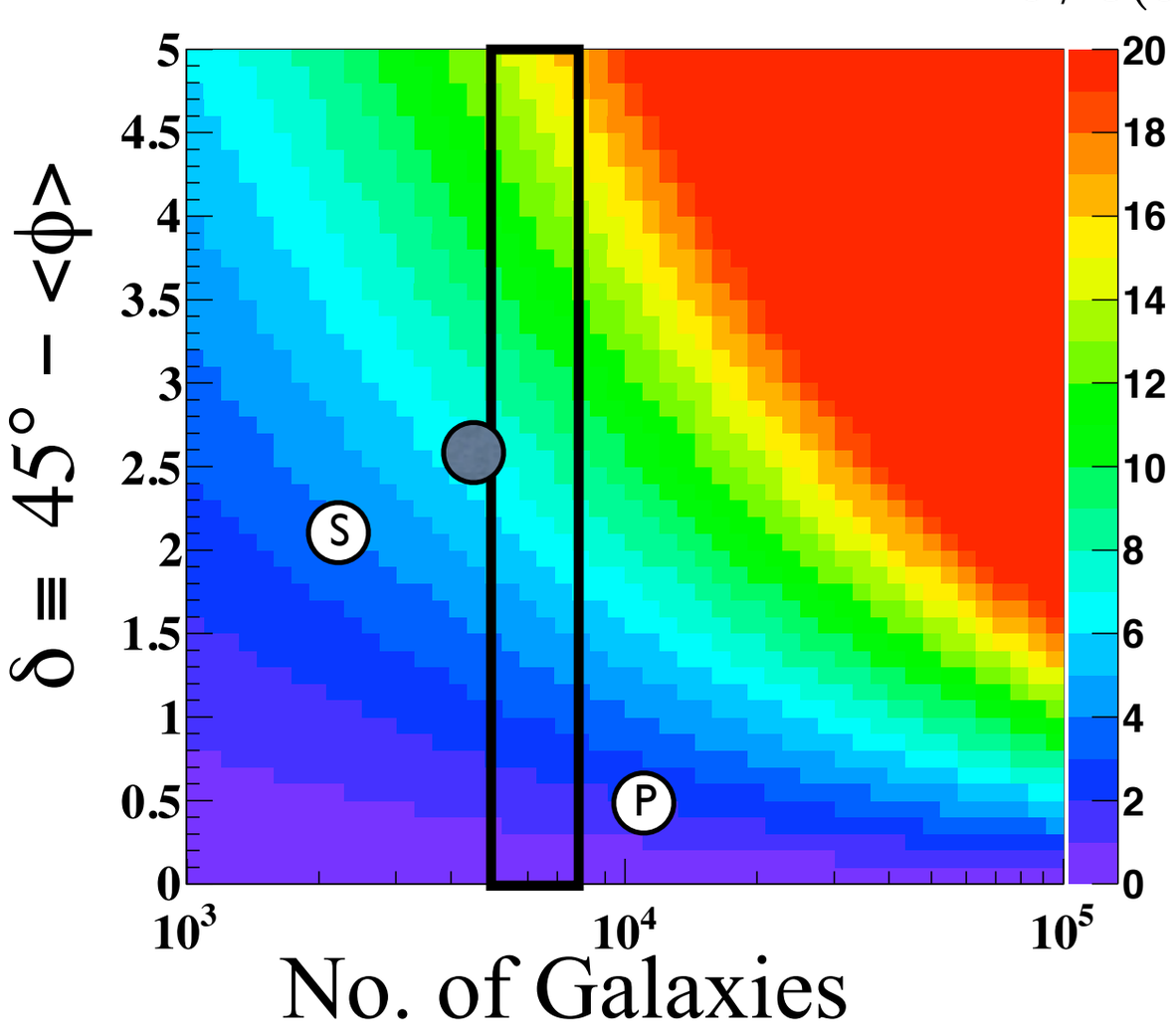


$\delta \equiv 45° - \langle\phi\rangle = 2.21° \pm 0.55°$ (Spec. Sample)

$\delta \equiv 45° - \langle\phi\rangle = 0.48° \pm 0.25°$ (Photo. Sample)

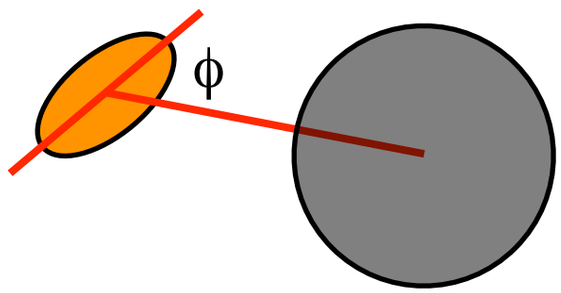
$\delta \equiv 45° - \langle\phi\rangle = -0.30° \pm 0.30°$ (Control Sample)

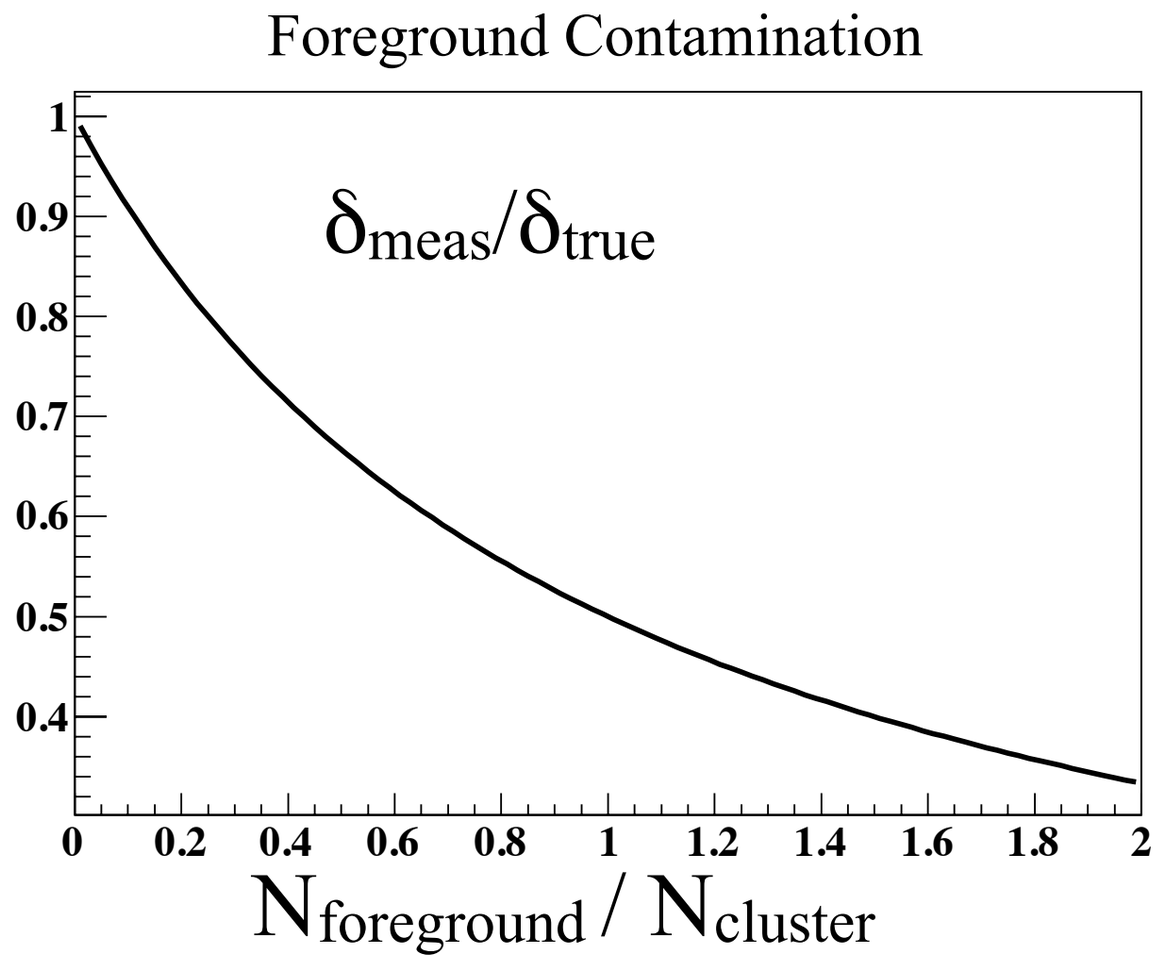
Still Blind...



Pereira and Kuhn (2005)

Agustsson and Brainerd (2006)



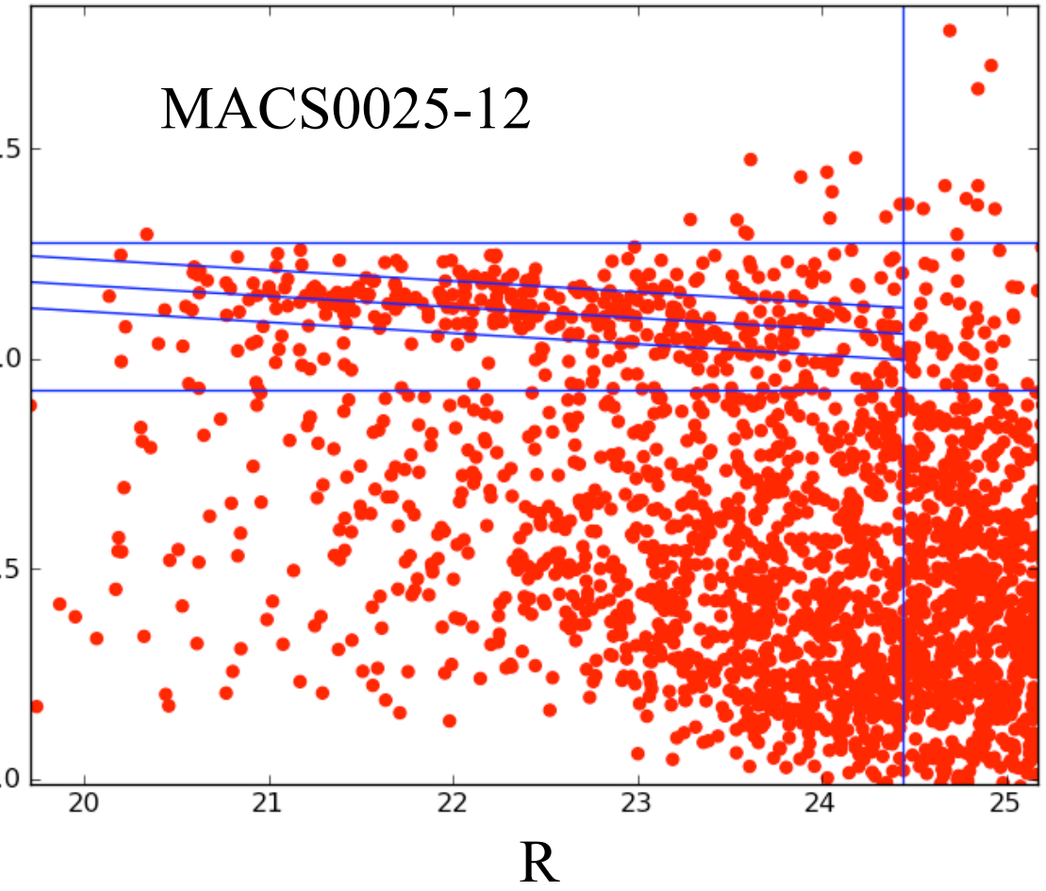


- Measurement error on the orientation angle has a similar effect

Work in progress

Things to check/understand before we unblind:

- Center of Cluster (Xray, lensing, BCG...)
- Backgrounds
    - Understand rate of foreground galaxies
    - Rate of background (lensed/anti-aligned.)
- Cluster member selection.
- Selection effects
    - Bright galaxies saturated
- Shape Measurements
    - Orientation angle / Ellipticity

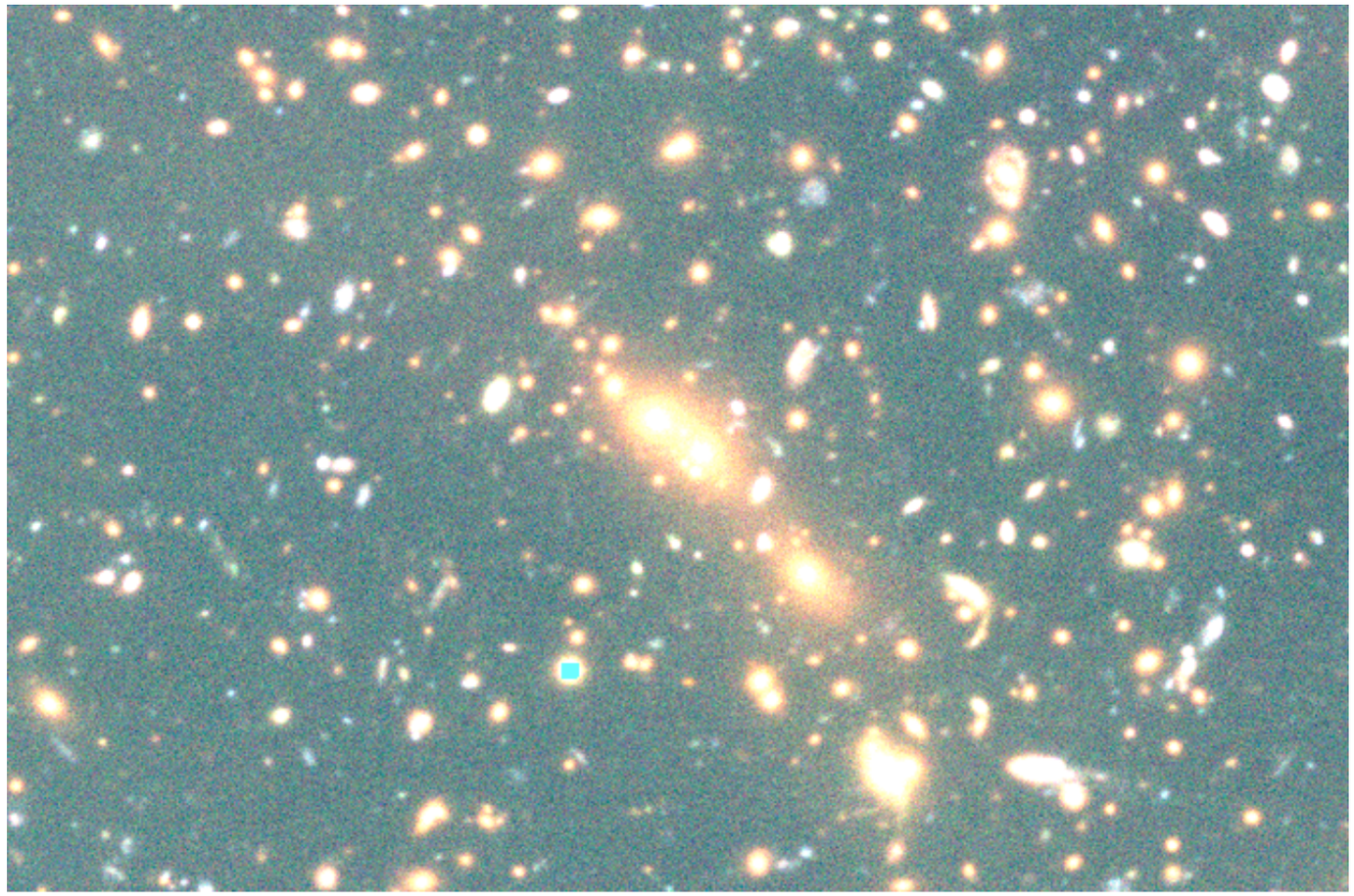


Conclusion

- Understanding intrinsic alignments important for weak lensing surveys

- Cluster galaxies can be used to study intrinsic alignments

- Results soon.



Simulations: II

Pereira, et al (2008)