Weak Lensing in the GAMA Field

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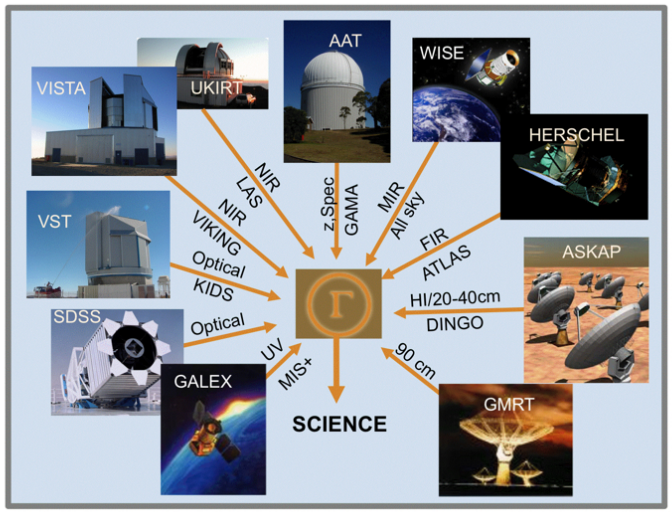
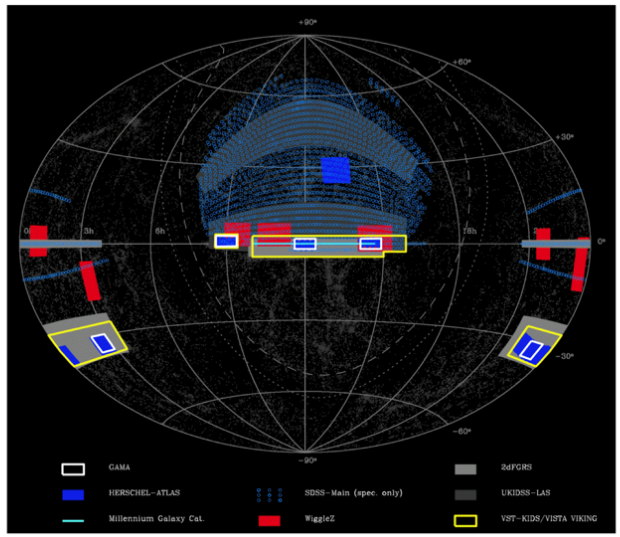
Galaxy And Mass Assembly (02/2008 $\sim$.)

- Survey
  - spectroscopic and multi-wavelength
  - wide ($\sim 250 deg^2$) and deep ($r_{pet} \leq 19.8, z < 0.5$)
  - uniform and high completeness (98%)
  - spectral($4.6\AA$) and spatial resolution (0.7")
- Science
  - Probe CDM paradigm: HMF,GSMF,Merger Rates
  - Galaxy structure and evolution





Constrain Group Mass

- Methods
  - Dynamical Mass

    $$M \propto \sigma_v^2 R$$

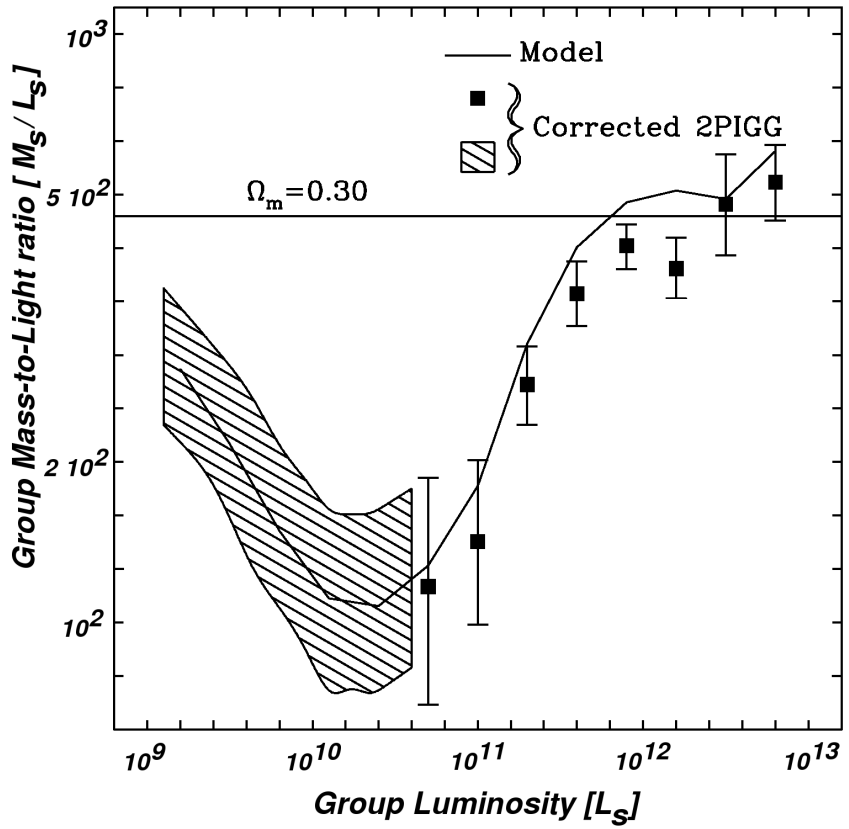
  - Luminosity Mass

    $$M \sim L$$

  - Weak Lensing Mass

    $$M \sim \textit{distortion}$$

- Application
  - Model Mass Calibration
  - M/L constraints
  - HOD constraints



Weak Lensing Mass Reconstruction

- Linking shape and mass
  - Observable: Ellipticity (galaxy shape)
    $e = \frac{1-(b/a)^2}{1+(b/a)^2}$
  - Bridge: shear (in distortion matrix) γ
    In linear regime (*weak* lensing): $e \approx 2\gamma$
  - Gravity defines how shear is related to the mass $\Sigma = \bar{\rho}\int \delta_m dl$ along l.o.s

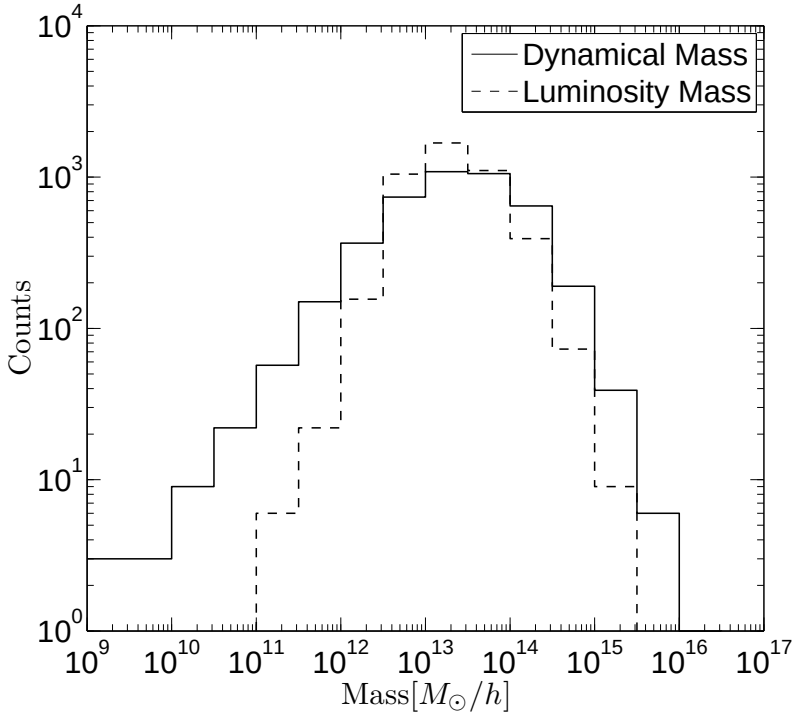
$$\langle \gamma_t \rangle = \kappa(<\theta) - \langle \kappa(\theta) \rangle = \frac{\Delta\Sigma}{\Sigma_{crit}}$$

- Mass/Density Estimators
  - Surface Over-density Profile $\Delta\Sigma(r) = \frac{\sum_i w_i e_{t,i} \Sigma_{crit,i}}{2\mathscr{R}\sum_i w_i}$
  - 3D Density Profile(Johnston+,07) $\Delta\rho = \frac{1}{\pi}\int_r^\infty dR \frac{-\Sigma'(R)}{\sqrt{R^2-r^2}}$
  - Aperture Mass $M_\zeta = \pi(D_l\theta)^2 \sum_i Q_i \epsilon_{t,i} \Sigma_{crit,i}/n$
  - Improved $\Delta\Sigma$ and M_ζ

Data

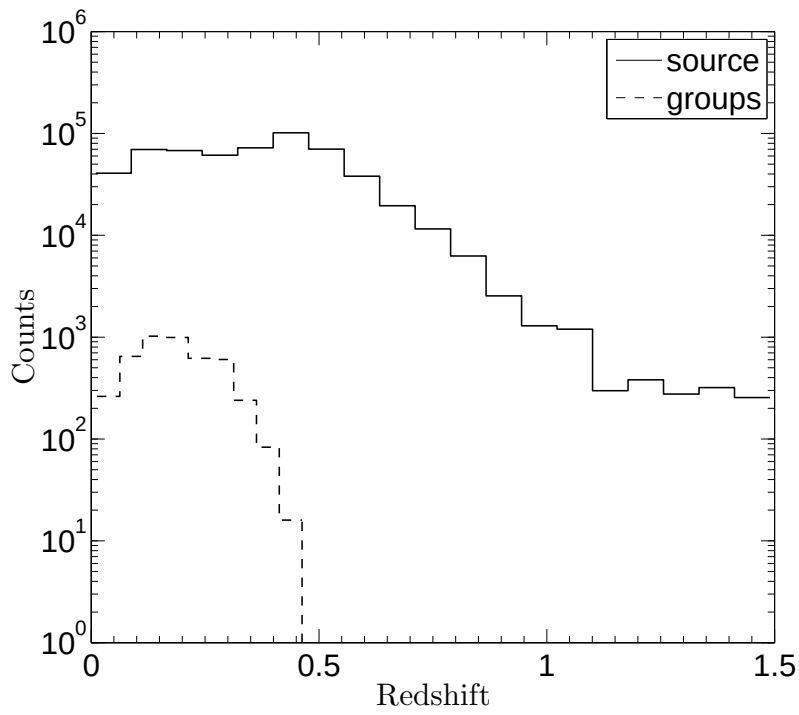
GAMA FoF groups

- 4.5k groups with Mult>2
- Median-unbiased mass calibration
- Mostly $10^{13} - 10^{14}\mathrm{M}_{\odot}\mathrm{h}^{-1}$



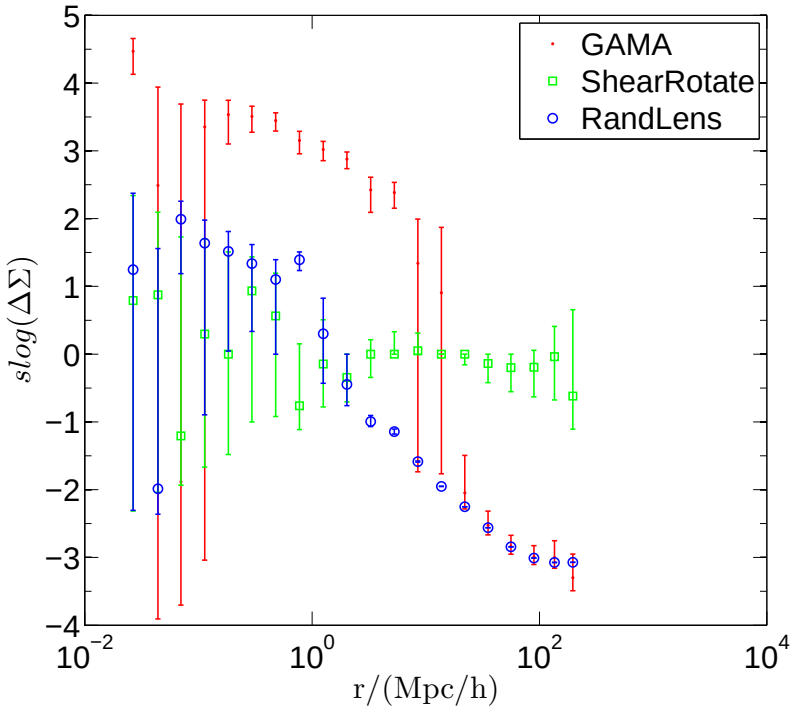
SDSS source galaxies

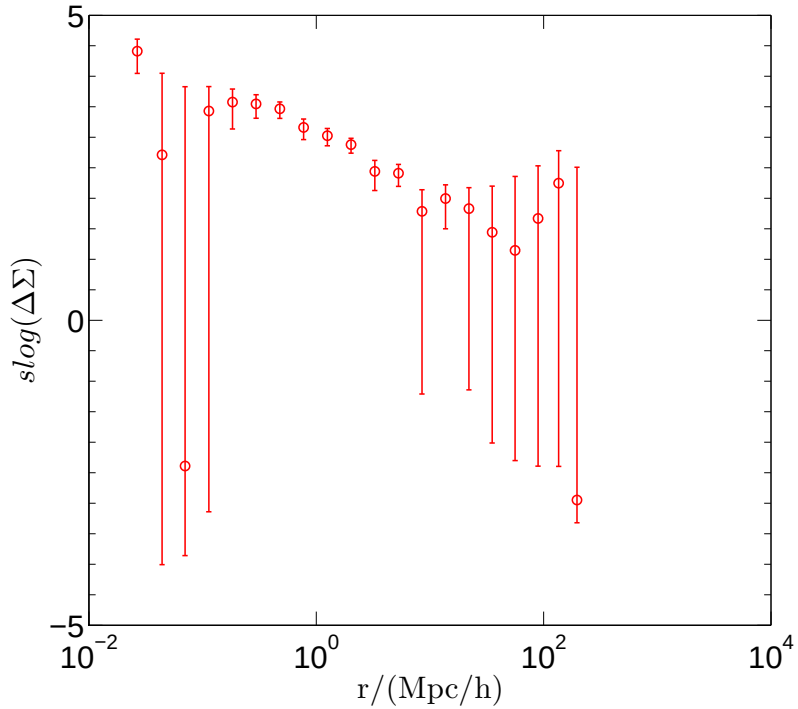
- Re-Gaussianization shape measurements
- ZEBRA photo-z
- $1/\mathrm{arcmin}^2$



Correction:Systematic Shear

- Ideally, no signal with randomly placed lenses.
- In practice, some systematic residual exists for random lenses.
- Need to be subtracted.





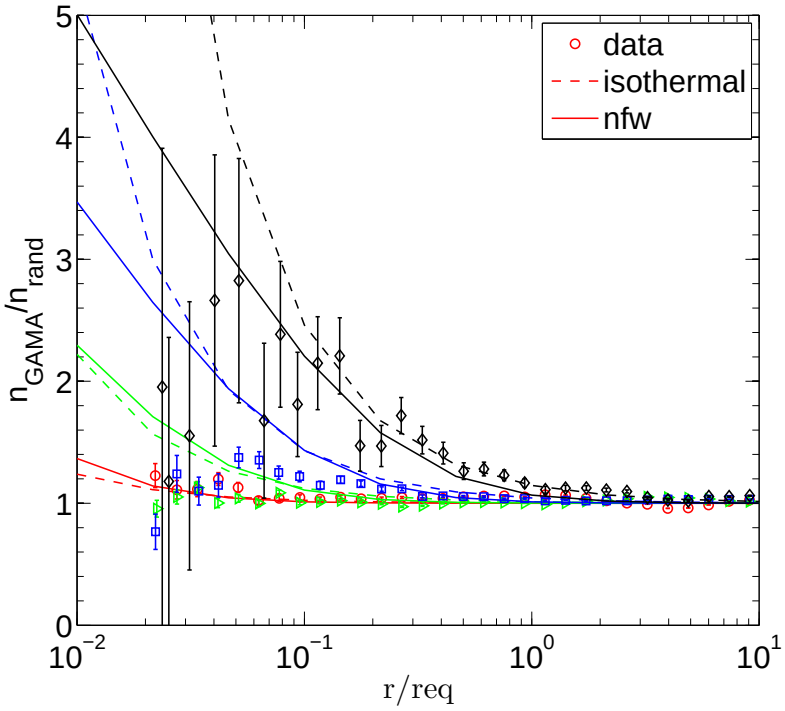
$$slog(x) \equiv \begin{cases} \log(x) & \text{if } x > 1 \\ 0 & \text{if } |x| < 1 \\ -\log(-x) & \text{if } x < -1 \end{cases}$$

Correction: Photo-Z Dilution

- Foreground galaxies misidentified as background galaxies due to photo-z error.
- Misidentified galaxies carry no distortion, but dilutes the average signal.
- Alleviated by requiring $z_s - z_l > 0.1$, with $\Sigma_{crit}^{-2} \propto D_{ls}^2$ weighting in the shear estimator to suppress close pairs.
- Further correct for this by checking lens-source correlation.

Correction: Photo-Z Dilution–A Toy Model

1. Assume galaxies follow DM.
   - Consider one-halo term only.
2. Photo-z uncertainty $\rightarrow$ PSF in z, with PSF size $>>$ halo size.
   $\delta z = 0.1 \sim \delta D = 300\mathrm{Mpc}$
   - After PSF convolution, halo profile takes the shape of the PSF in the z direction.
3. The fraction of galaxies above given flux limit as a function of redshift is extracted from the data.
   - $P \approx e^{-8.8z}$



$$n(r)/n_{rand}(r) - 1 = \alpha(\sigma_z)\frac{H(z_c)}{c}\Sigma(r)$$

Other Systematics

- Photo-z Calibration Bias. Compare against representative spectro-z source samples to calibrate the bias. $1\% sim 10\%$.
- Center mis-alignment. Yet to be checked with more complete mock catalogs.
- Non-weak shear.
- Intrinsic alignment.
- ...

Error Estimation and Comparison

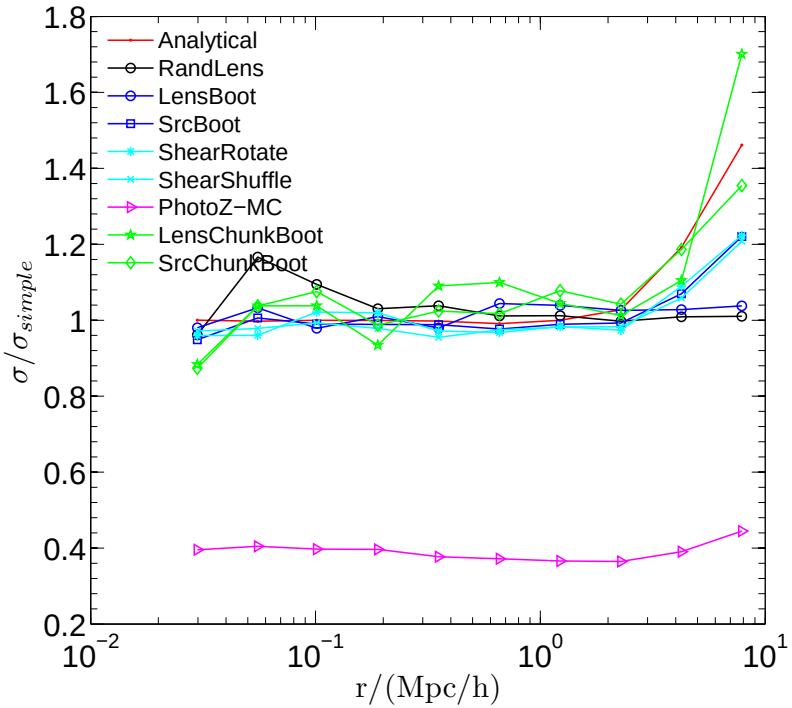
- Simple Error Estimation

$$\sigma^2_{\Delta\Sigma} = \frac{\sum_i w_i^2 \Sigma^2_{crit} \sigma_i^2}{(\sum_i w_i)^2}$$

- Covariance considering multiple source count

$$C_{IJ} = \frac{\sum_s \sum_{is\in I} \sum_{js\in J} w_{is} \Sigma_{crit,is} w_{js} \Sigma_{crit,js} Cov(e_{t,is}, e_{t,js})}{(\sum_s \sum_{is\in I} w_{is})(\sum_s \sum_{js\in J} w_{js})}$$

- Mento-Carlo Estimations
- Photo-z uncertainty induced error



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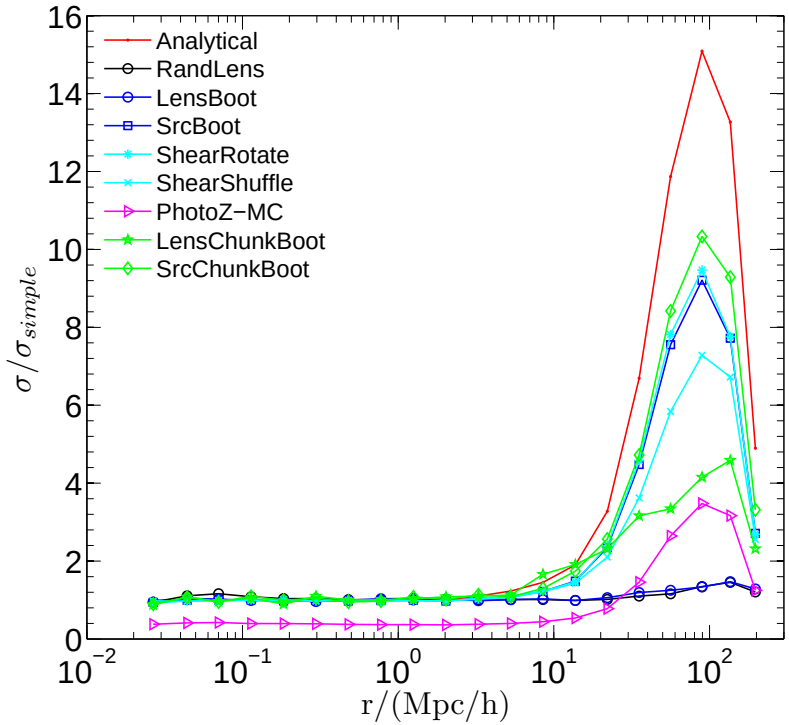
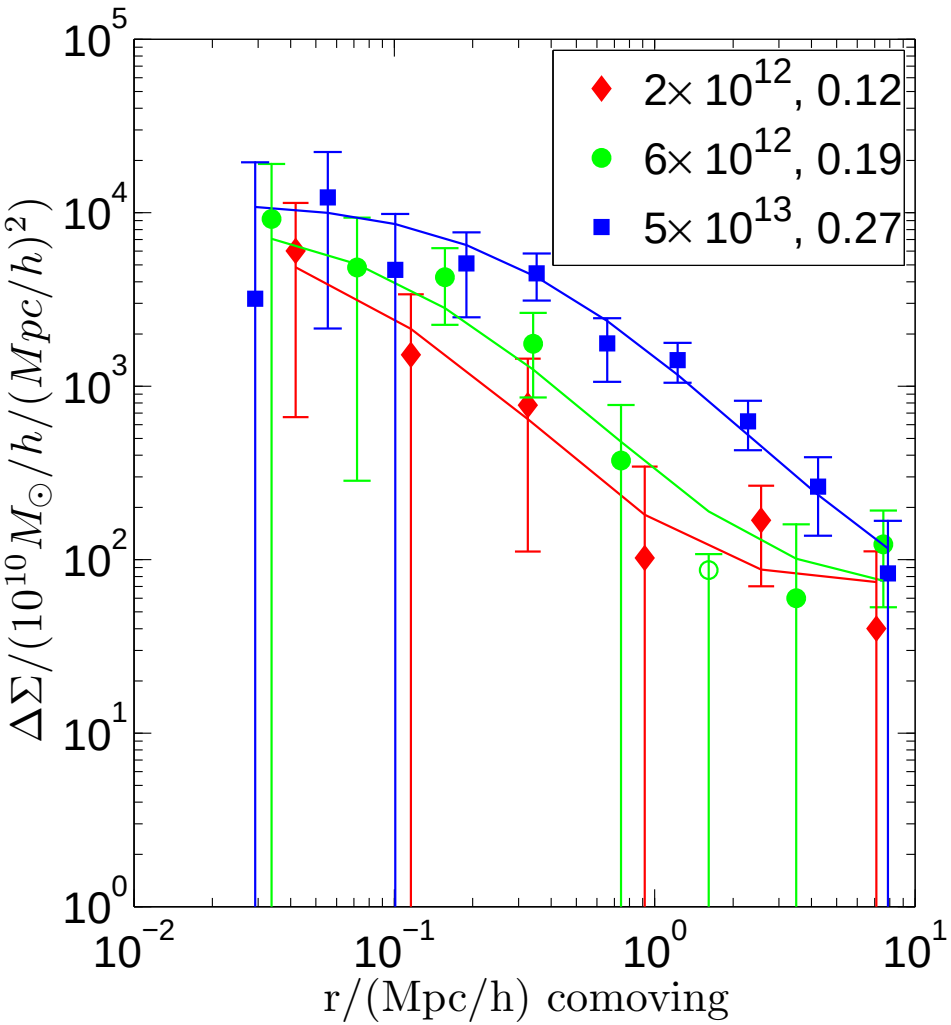


Density Profile

Surface over density profile for three LuminosityMass bins:



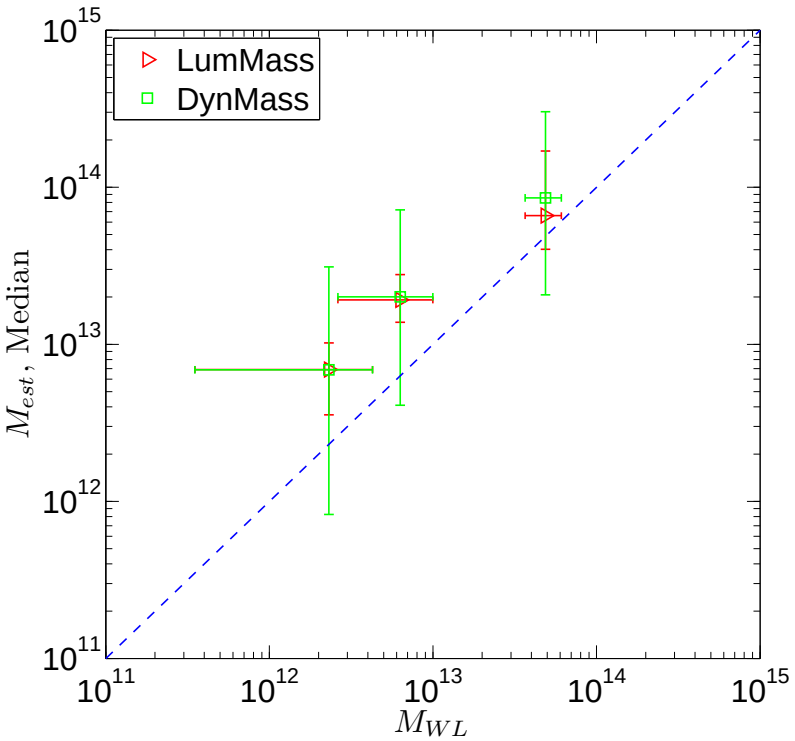
Two param fitting

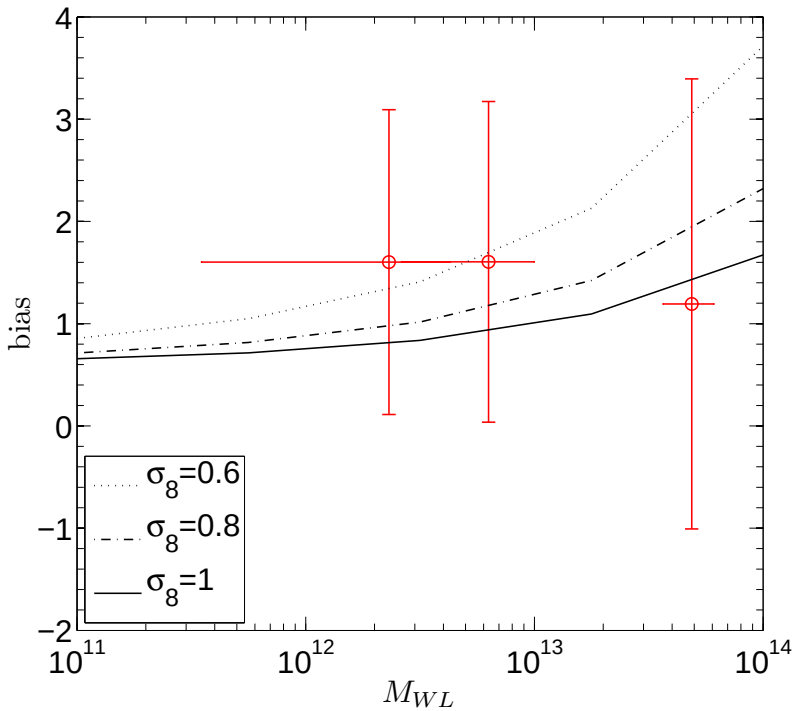
(Preliminary) : NFW profile (mass) + linear bias

Mass and biasm (Preliminary)

Mass:

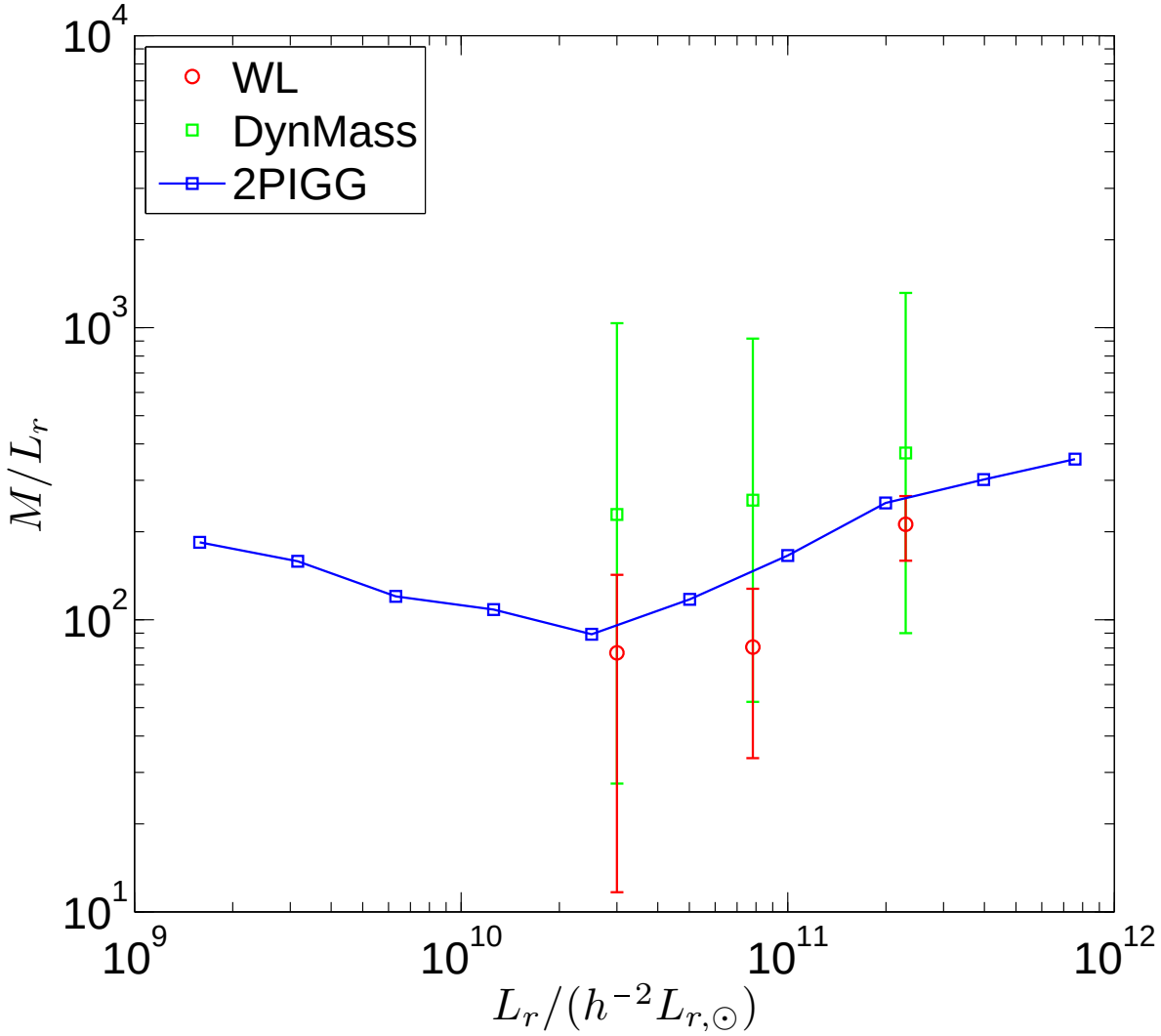
Linear Bias:





Possible reasons for bias: profile model; averaging and weighting; selection function; mass proxy bias;...

Mass to Light ratio



Summary

- Stacked weak lensing analysis on GAMA groups, using SDSS shear maps
- Density profile measurement down to $10^{12}\mathrm{M}_{\odot}\mathrm{h}^{-1}$ groups
- Density profile fitted by NFW+linear bias model reasonably well
- Priliminary result suggests overestimated luminosity/dynamical mass
- More systematics in the fitting need to be addressed before a fair comparison with other mass observables
- Though with better quality small groups, still no significant improvement over previous measurements, due to limited sample size.
- No large scale signal for large groups due to limited survey area, and systematic shear on large scales.
- Galaxy-galaxy lensing may help utilizing the rich multiwavelength information to link against DM