How **Weak Lensing** Can Help Us Understand **Galaxy Physics**

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How **Galaxy Physics** Can Help Us Understand **Weak Lensing**

Eric Huff via Eric Suchyta
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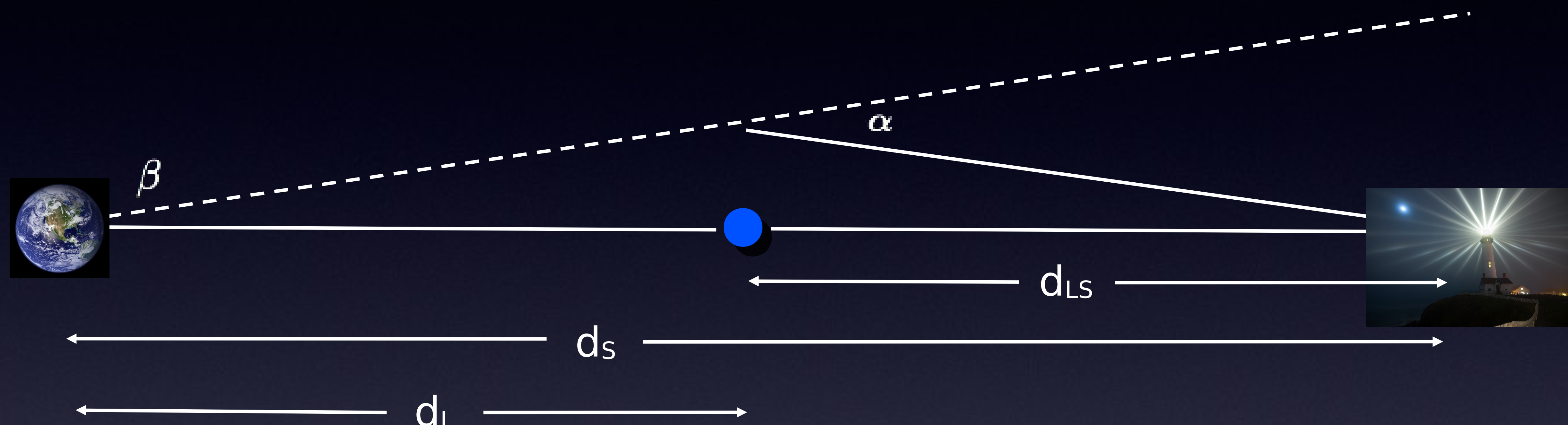
Lensing is the distortion of background images by foreground mass:

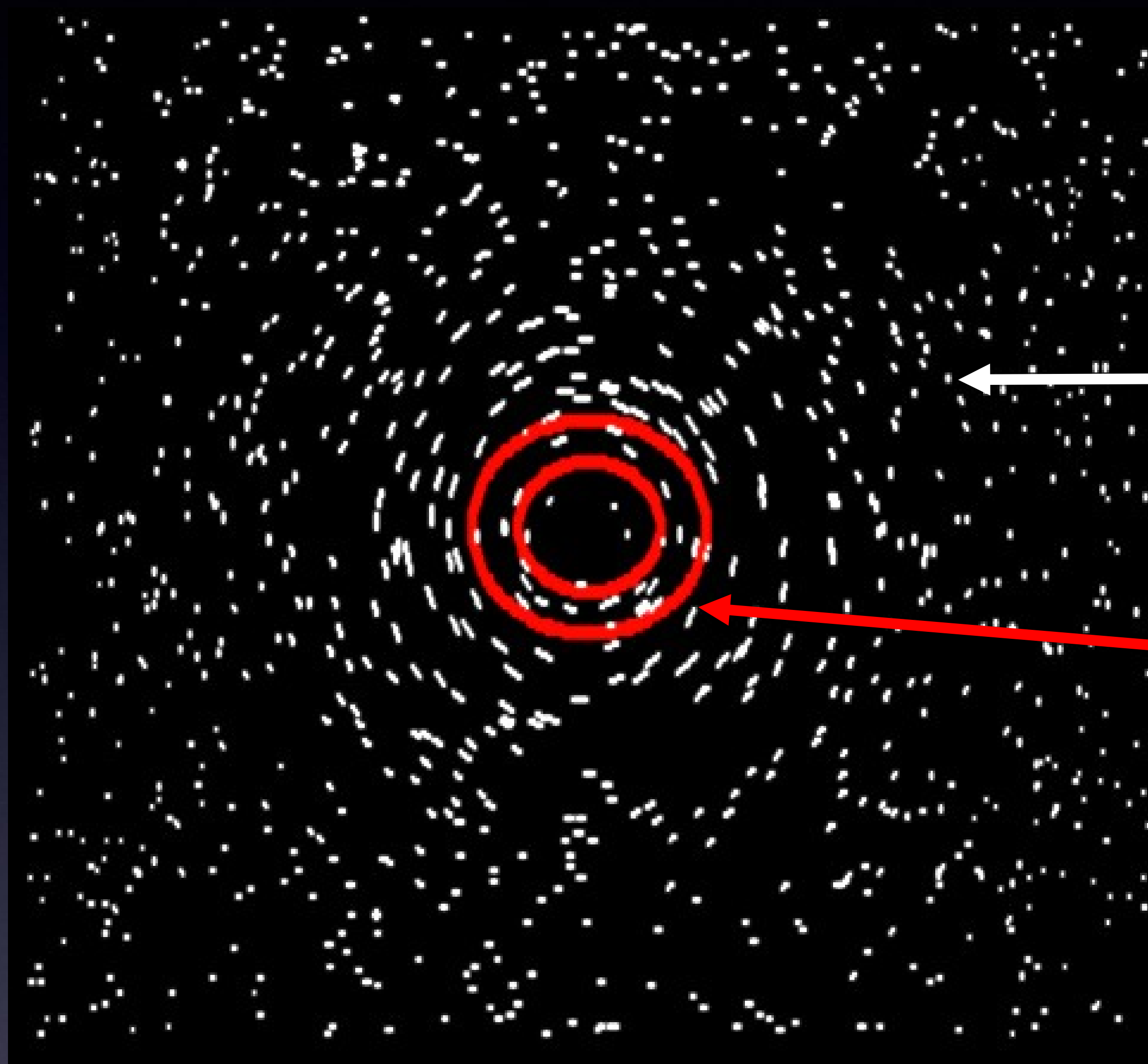


$$\kappa\left(\bar{\theta}\right) = \int_0^{z_s} \frac{c}{H_0}\frac{dz}{a}\frac{\rho_m\left(z\right)}{\Sigma_{\mathrm{crit}}}$$

$$\Sigma_{\mathrm{crit}} = \frac{3H_0^2}{8\pi G}\frac{d_S}{d_L\,d_{LS}}$$

Sensitive to geometry and lens mass

what weak lensing measures:



$$\gamma_t \propto \Delta\Sigma = \bar{\Sigma}(< r) - \Sigma(r)$$

$$\kappa \propto \Sigma(r)$$

Foreground mass shears and magnifies background galaxies.

Weak lensing is weak.

The signal-to-noise is very small.

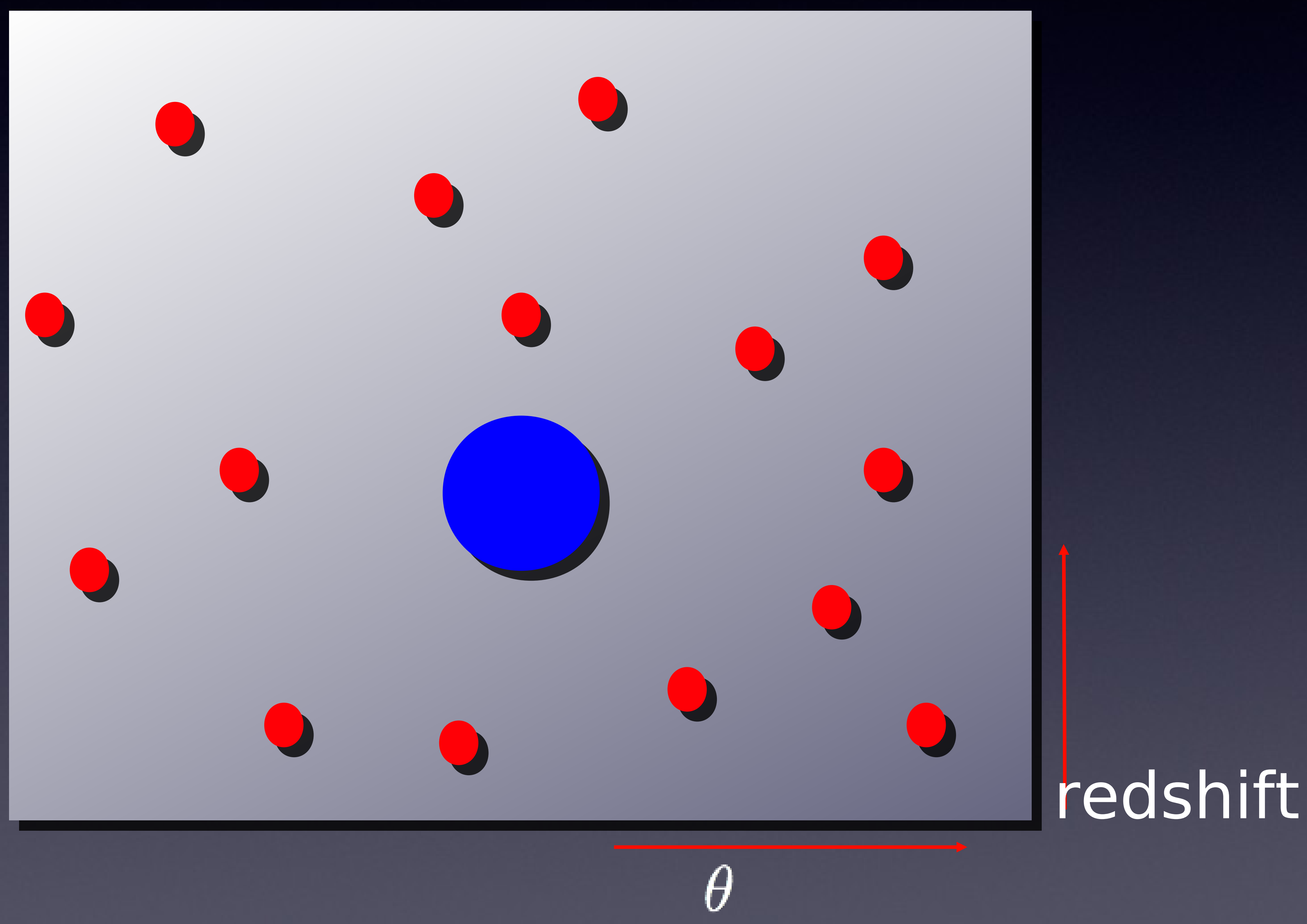
$$< \gamma > \sim 0.001 - 0.01$$

Especially compared to the random noise from intrinsic galaxy shapes

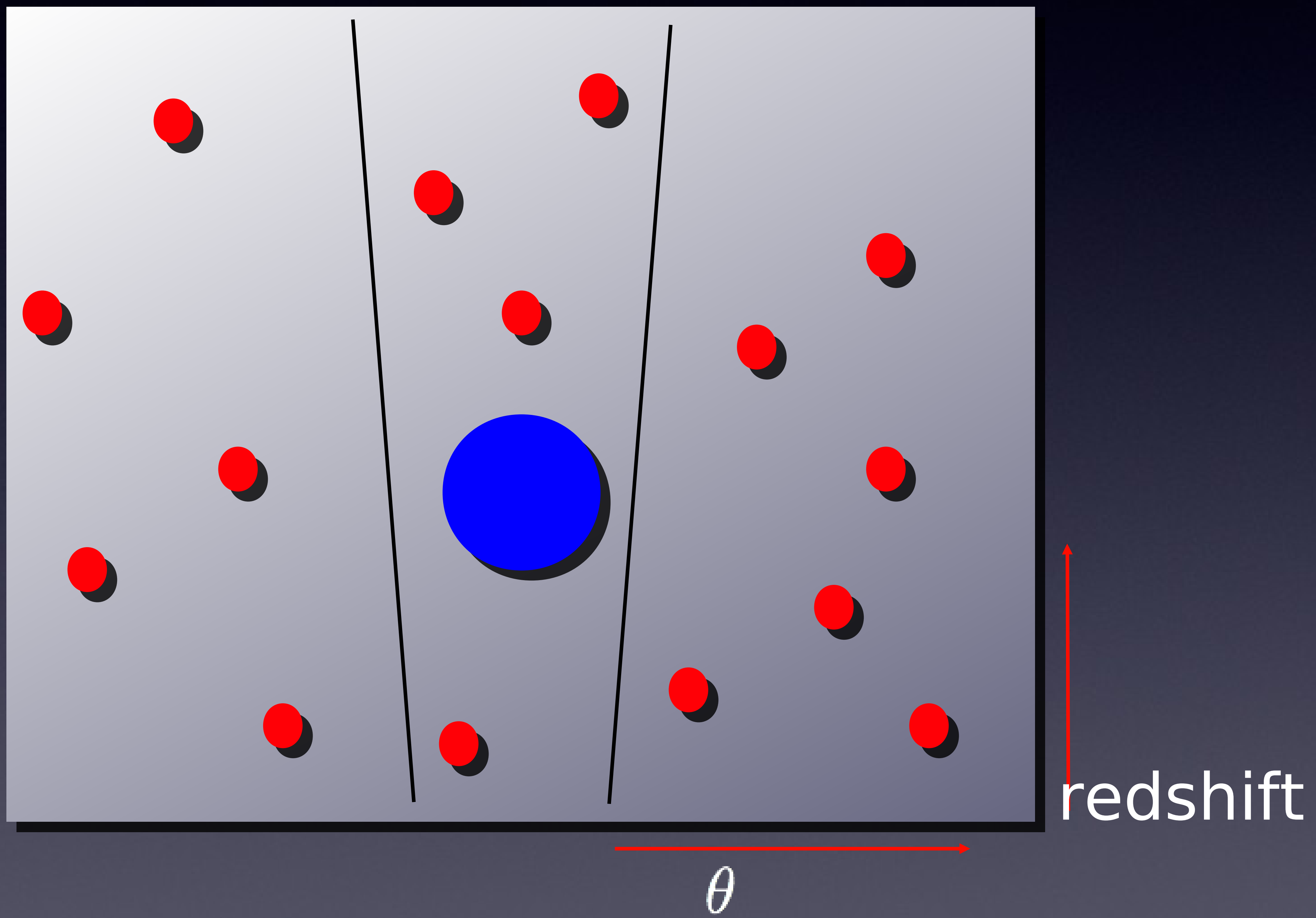
$$\sigma_\gamma = 0.2$$

Consider magnification.

The Effect of Magnification on galaxy sizes and luminosities



The Effect of Magnification on galaxy sizes and luminosities



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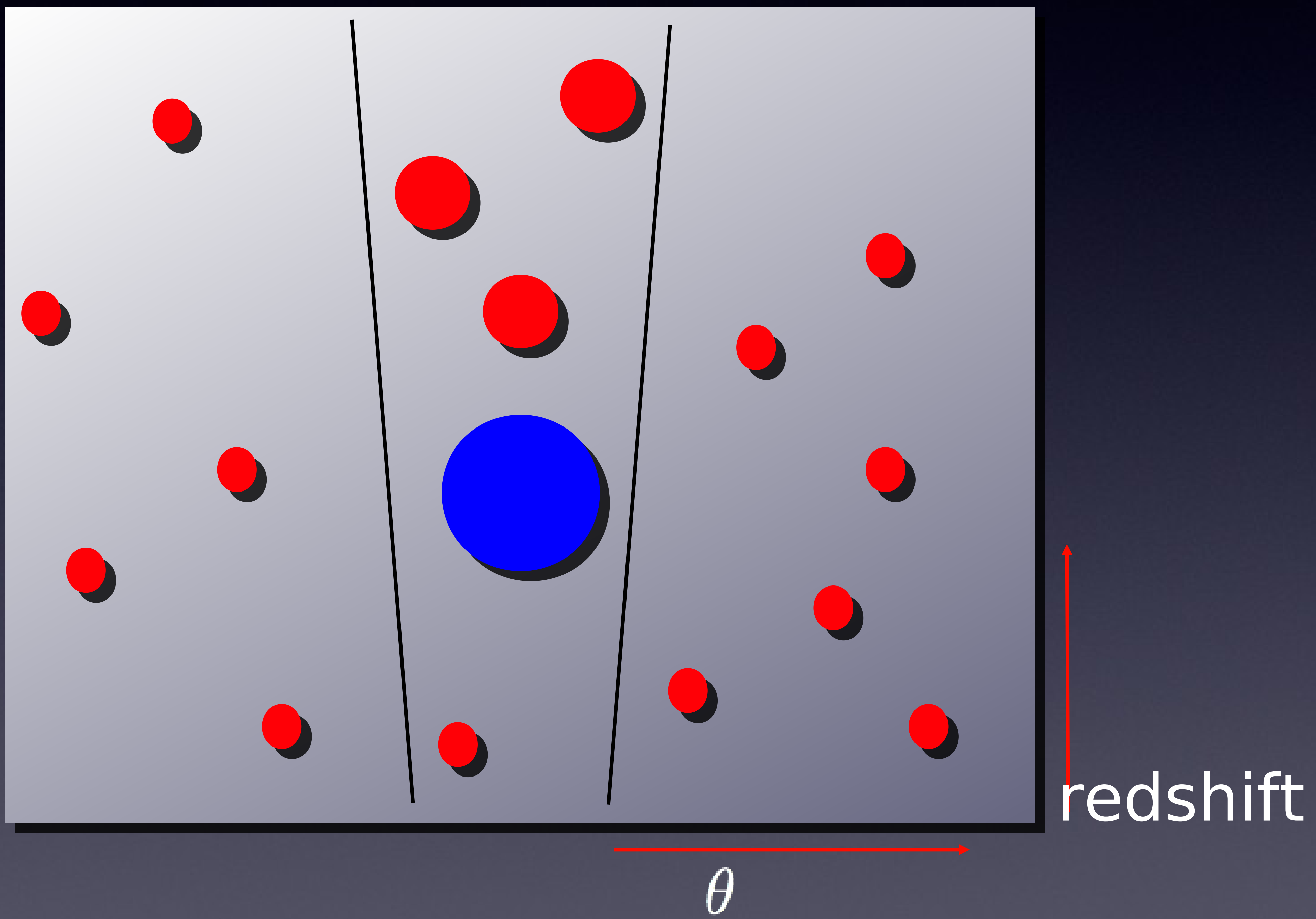
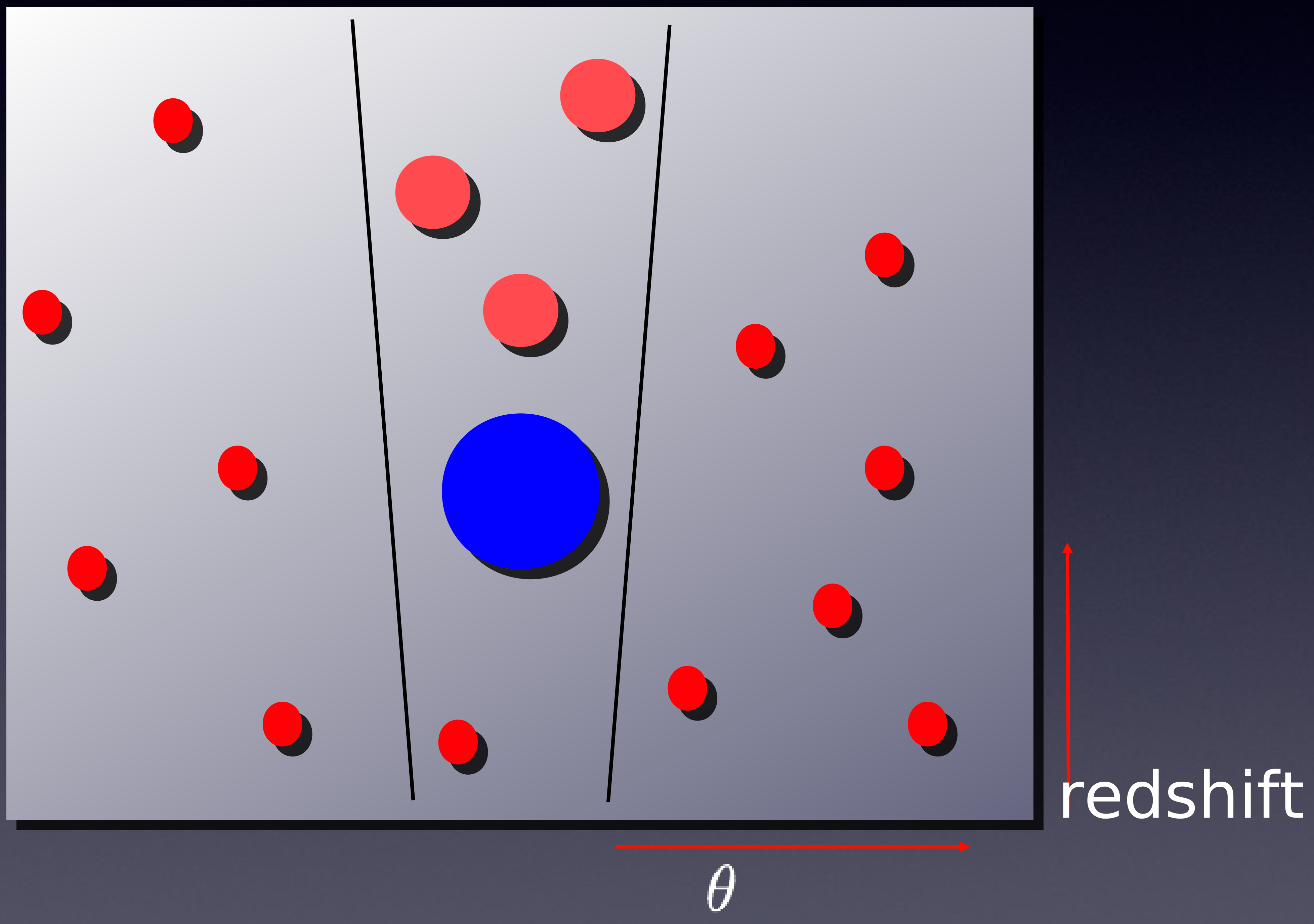
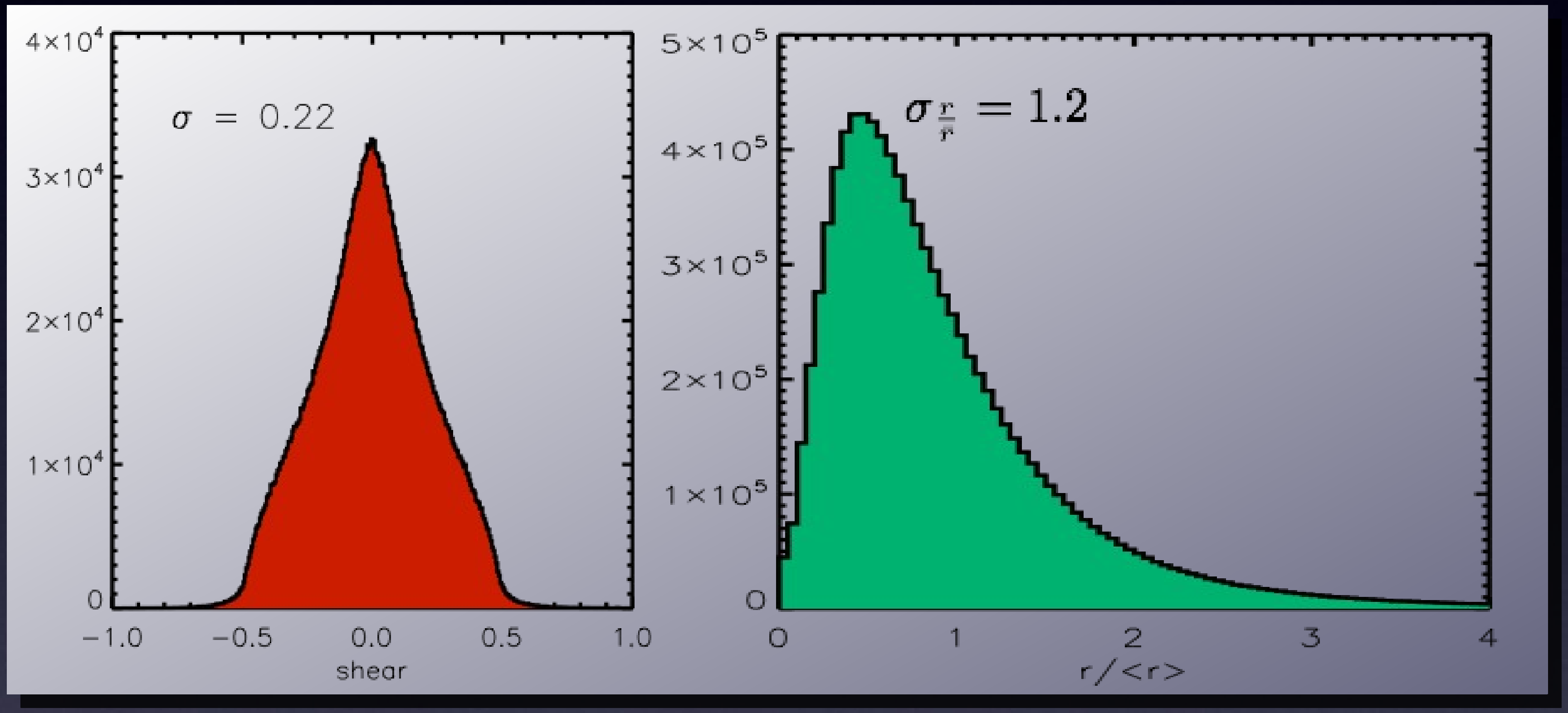


The Effect of Magnification on galaxy sizes and luminosities



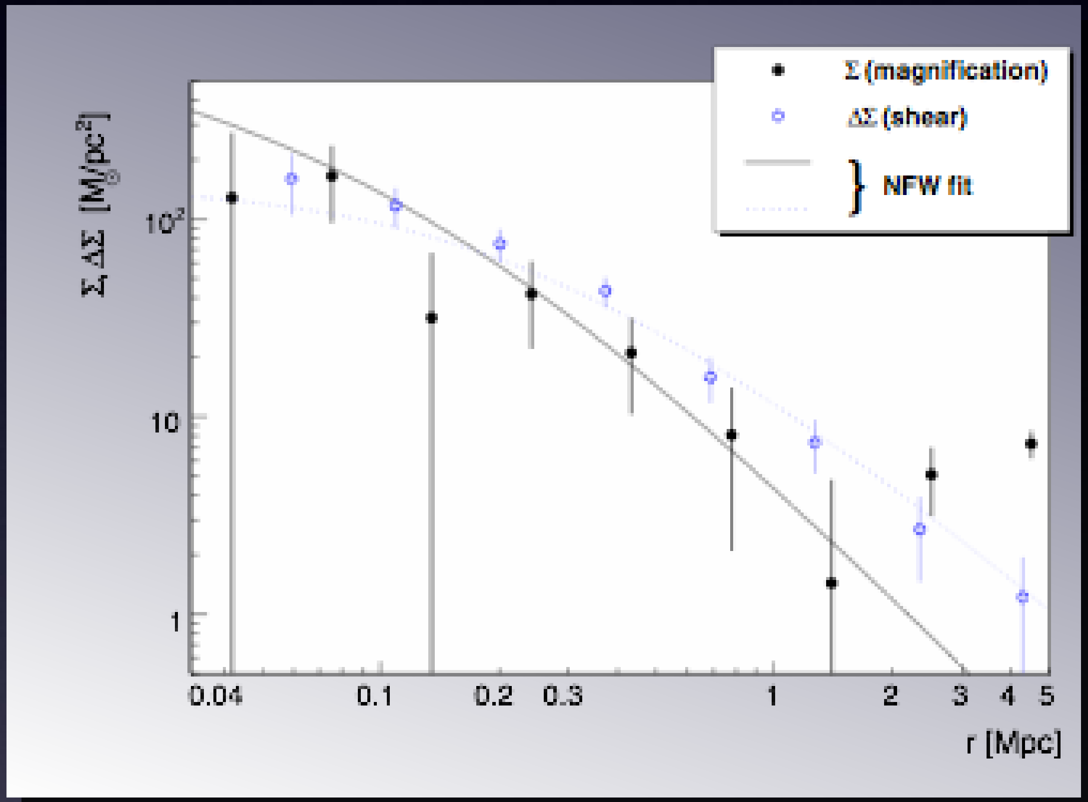
Traditionally, magnification measurements are much noisier than shear



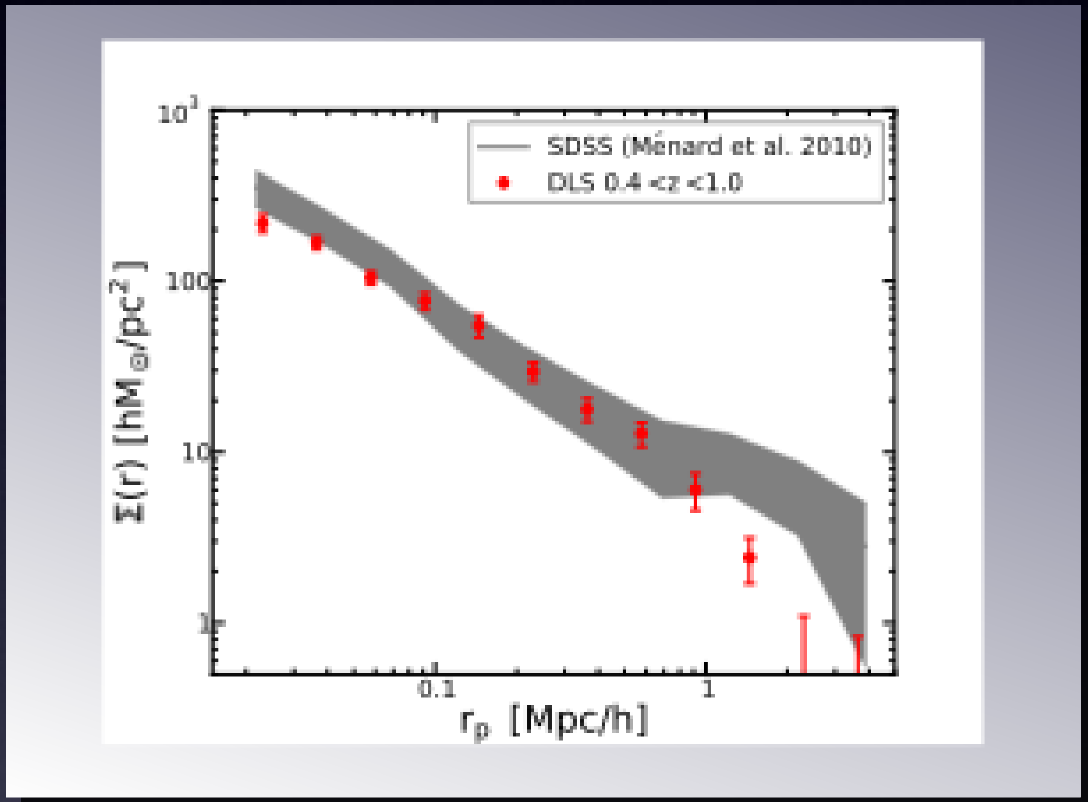
shapes sizes

This is because the intrinsic scatter in magnified properties is much larger than that in shapes.

Very recently, there have been several successful measurements.



Schmidt et al. 2012



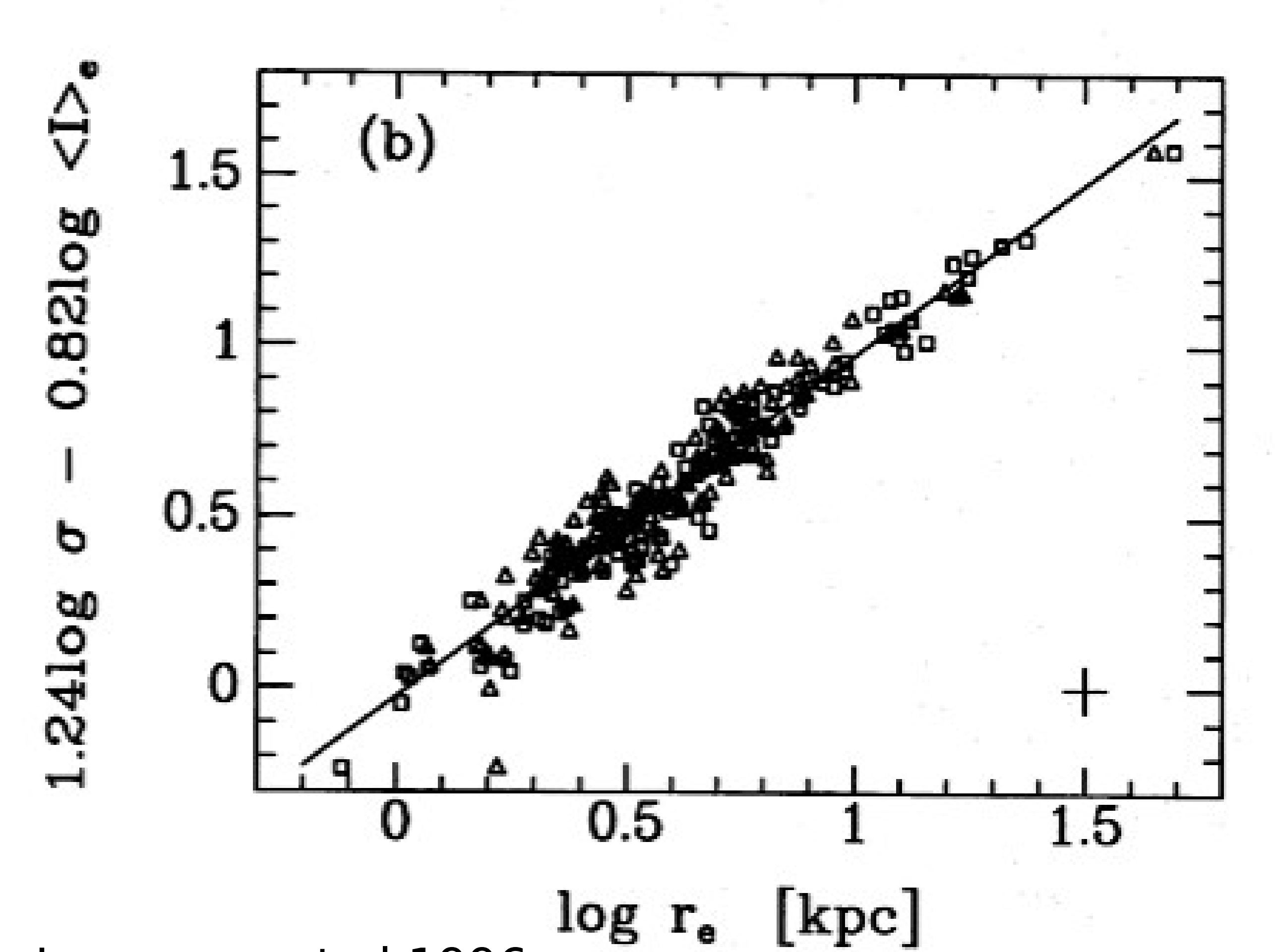
Morrison et al. 2012

but the signal-to-noise is still far below that of shear.

There is unexploited signal here

to use it, remember that the source galaxies are more than just a size and a shape...

The Fundamental Plane of Early Type Galaxies



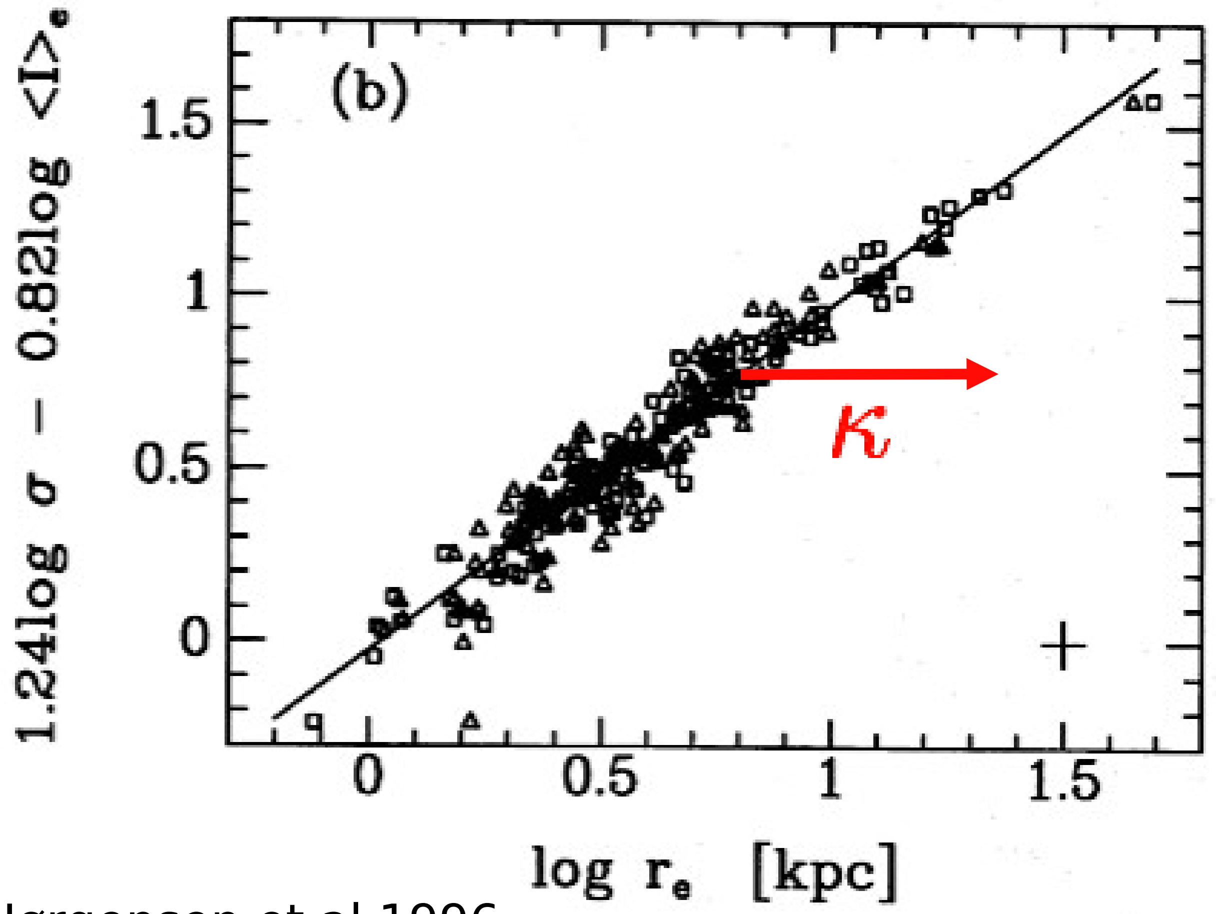
Jørgensen et al 1996

~15% intrinsic scatter

no* significant variation with environment

*maybe

The Fundamental Plane of Early Type Galaxies



Jørgensen et al 1996

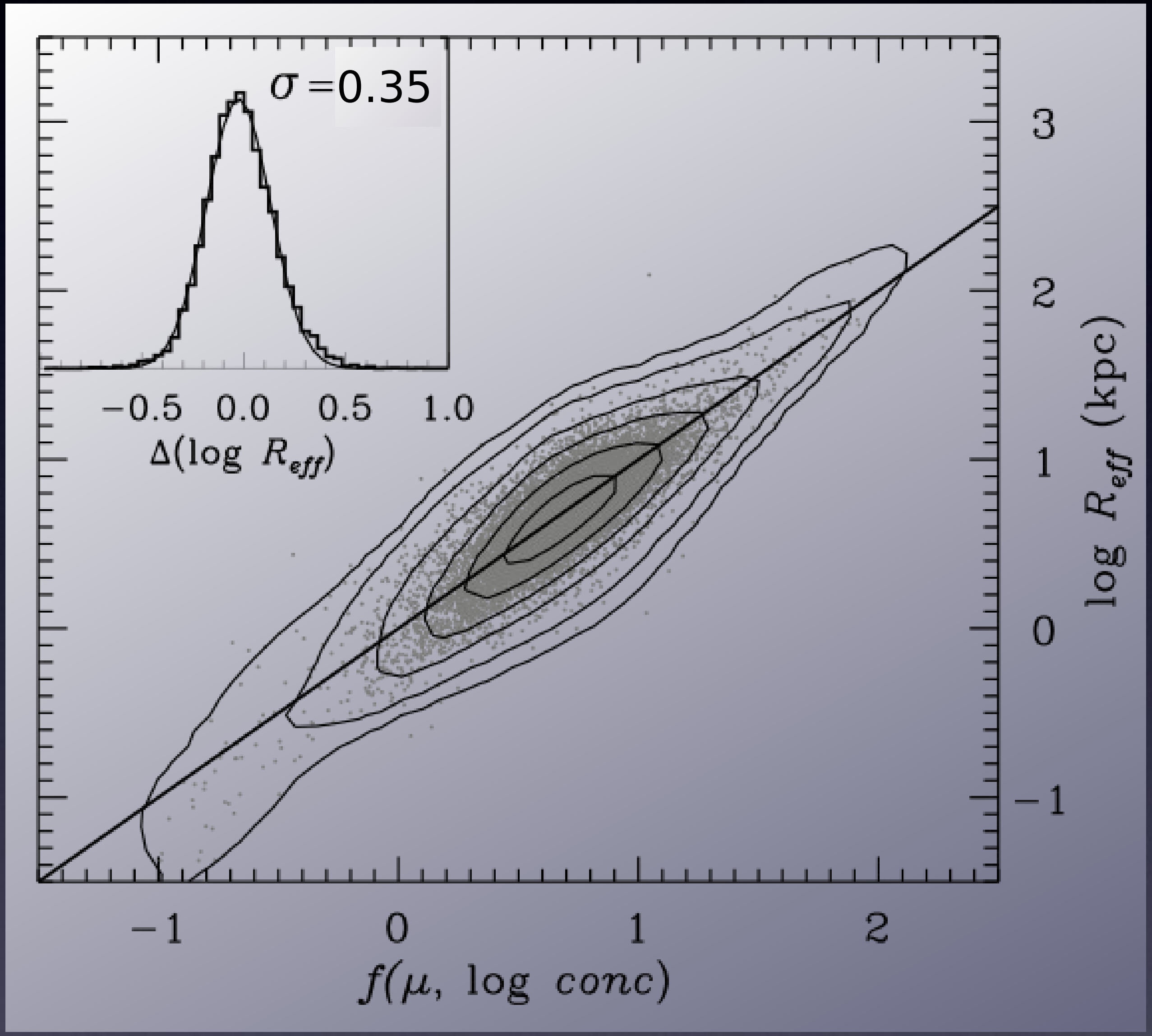
~15% intrinsic scatter

no* significant variation with environment

But we cannot get spectra for enough galaxies to do weak lensing this way.

*maybe

There is a photometric FP analogue



$$\kappa = \log\left(R_{eff}\right) - f\left(\mu, \log conc\right)$$

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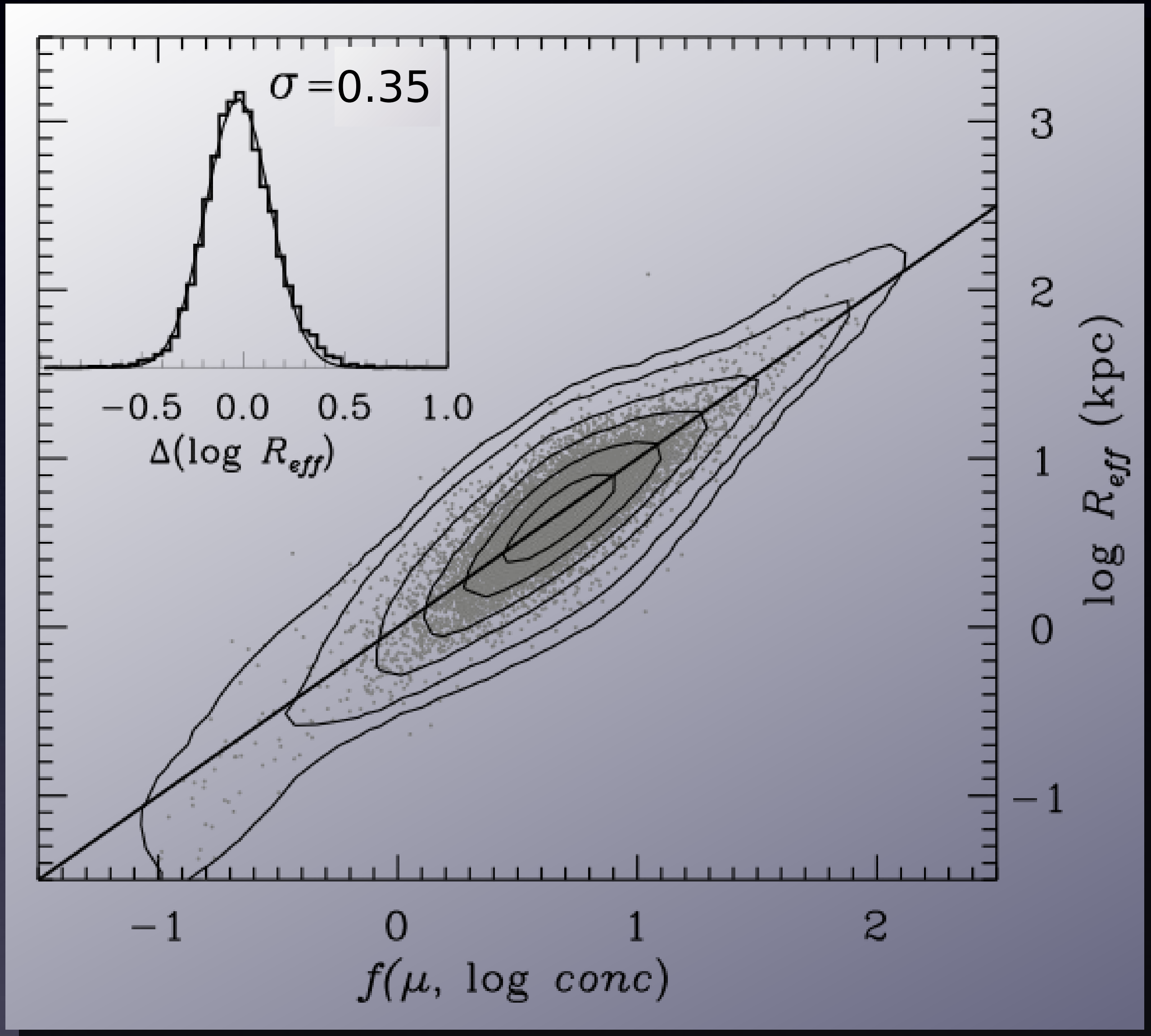
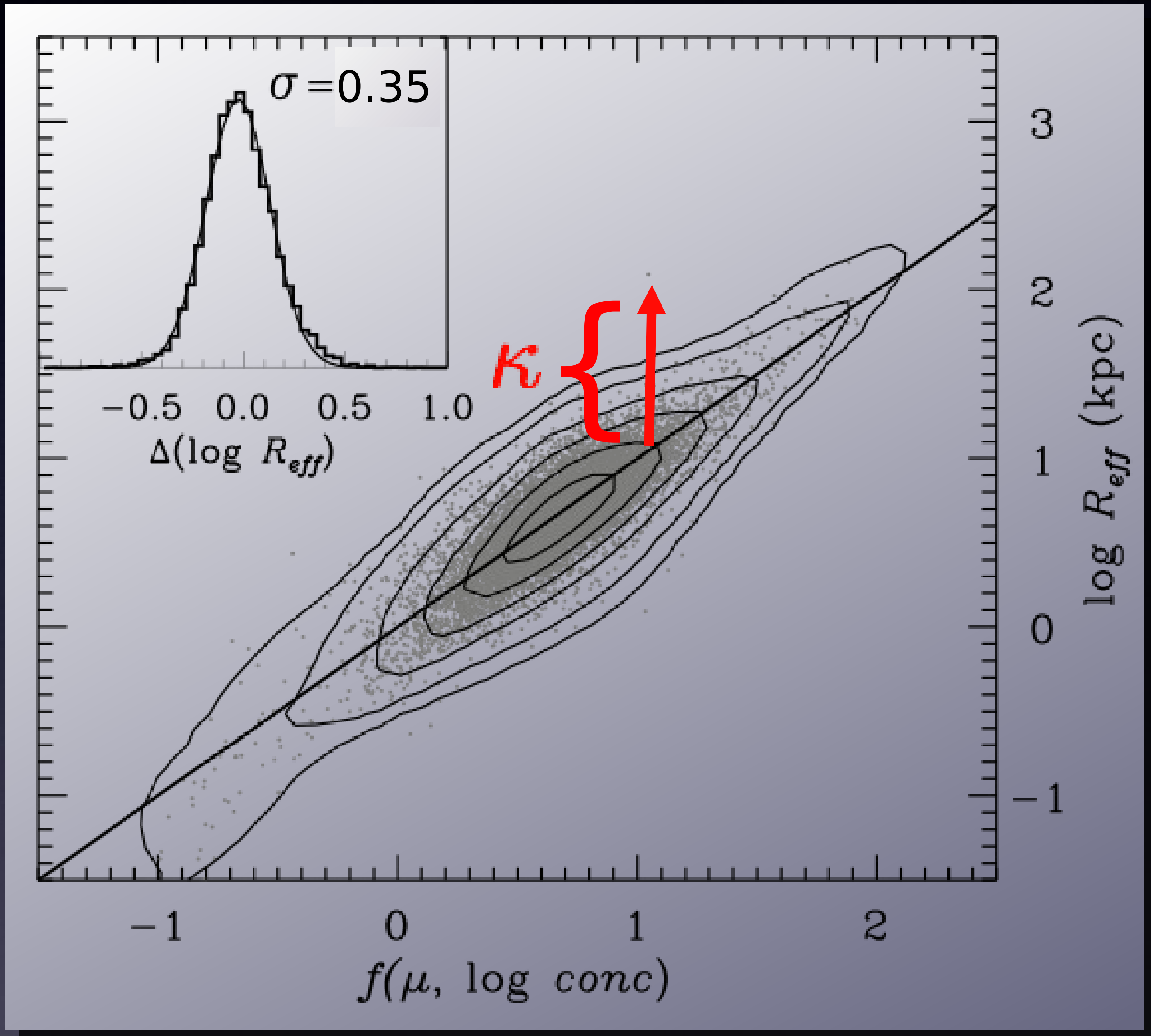


$$\kappa = \log\left(R_{eff}\right) - f\left(\mu, \log conc\right)$$

This is what it looks like in SDSS.

There is a photometric FP analogue



$$\kappa = \log\left(R_{eff}\right) - f\left(\mu, \log conc\right)$$

This is the result of a small magnification.

Constructing a magnification source sample using SDSS

60,000 Lenses:
- log (stellar mass) > 11.0
- 0.2 < z < 0.4

10 million Sources:
- resolved galaxies
- early-type SEDs (35%)

Why this is not an easy measurement:

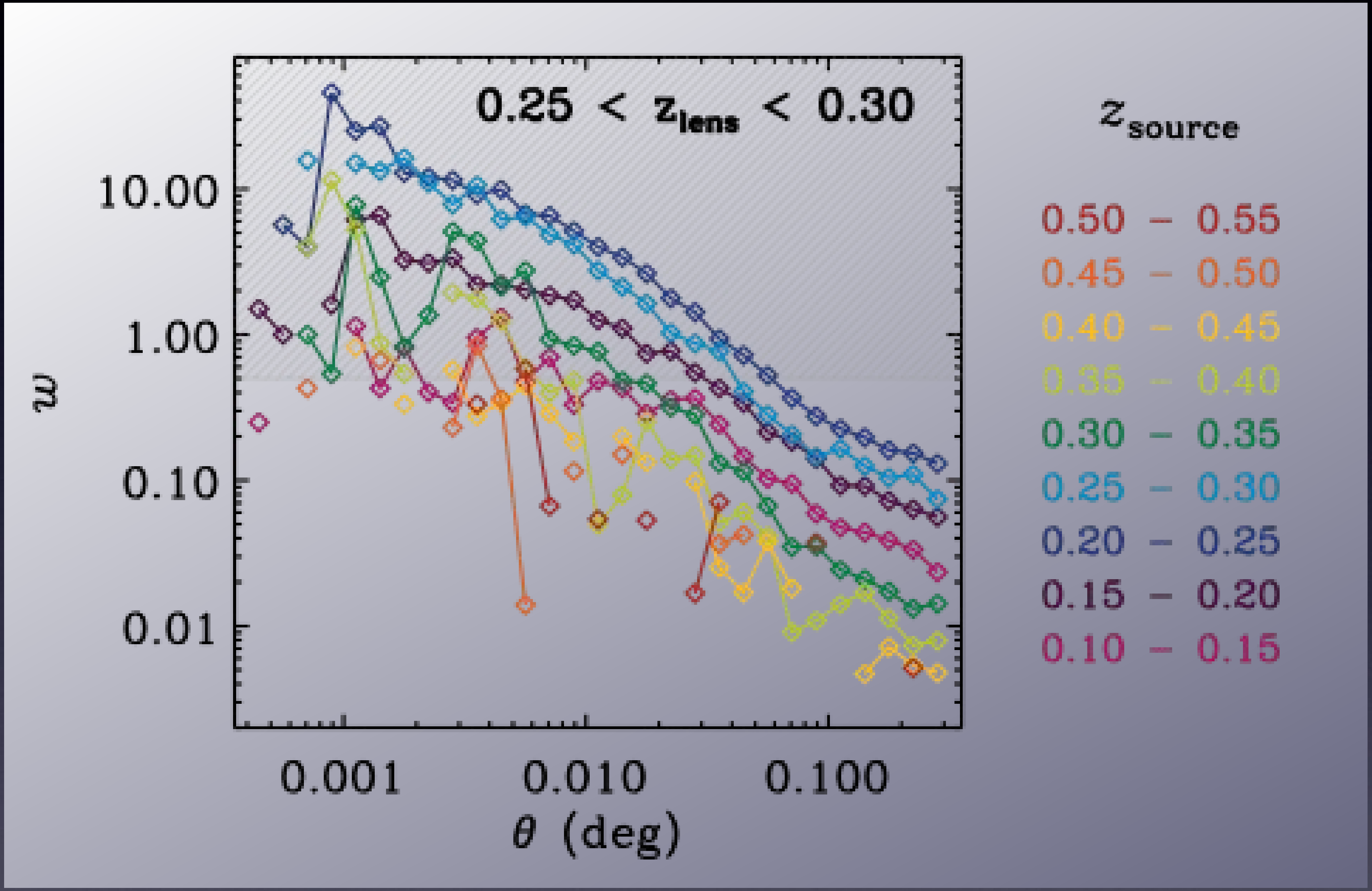
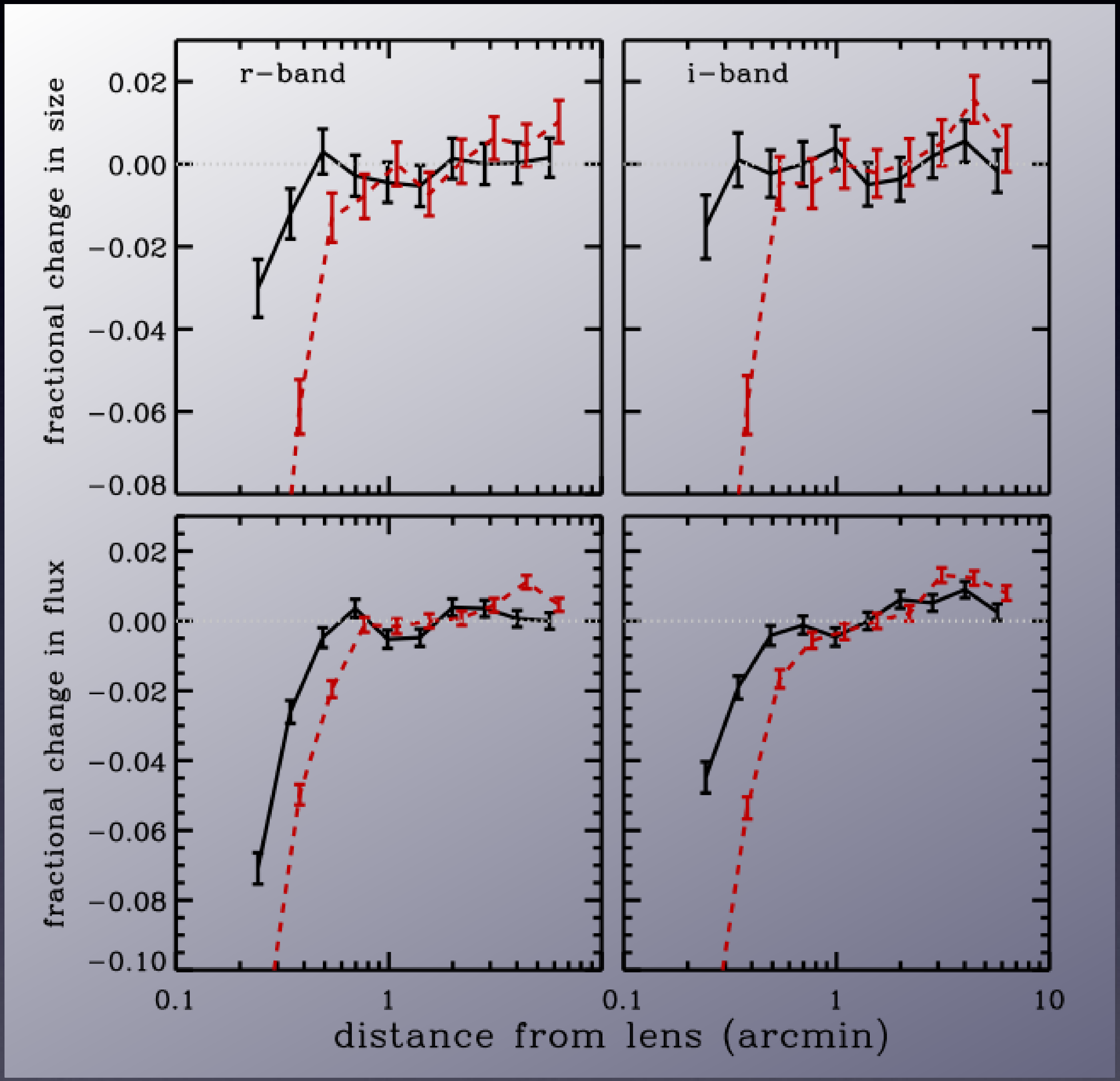


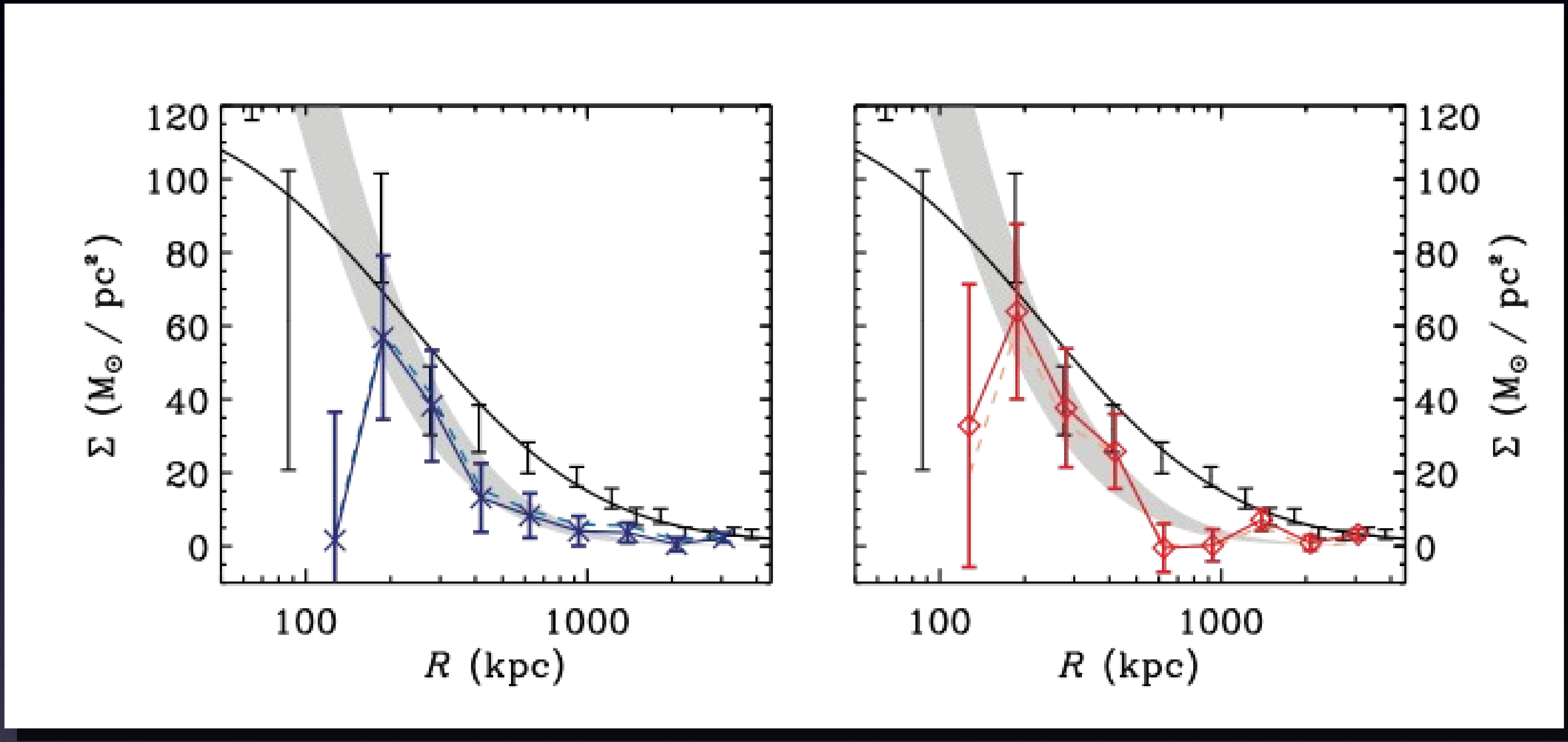
photo-z’s and clustering produce spurious signal

Why this is not an easy measurement: all existing photometric pipelines are flawed



Lenses bias the measurement of faint source properties.

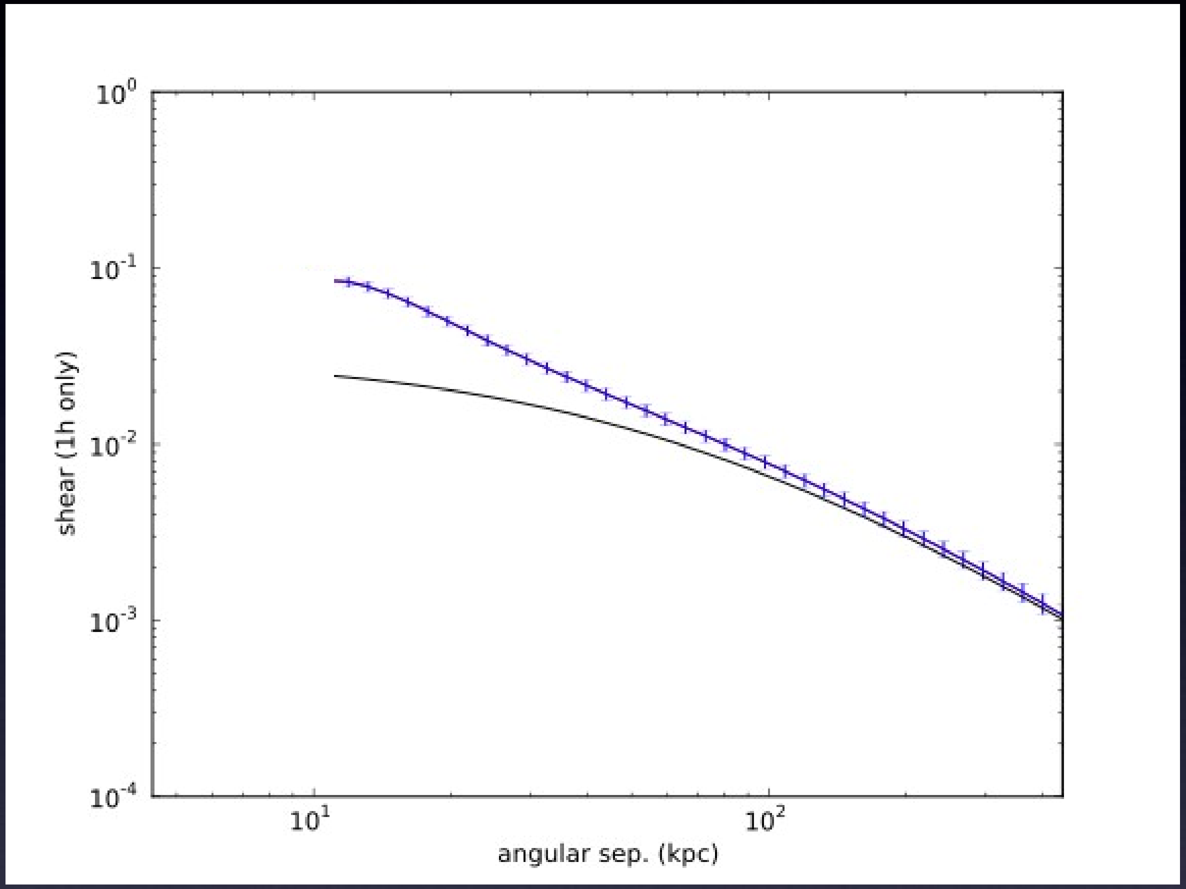
SDSS Magnification Results

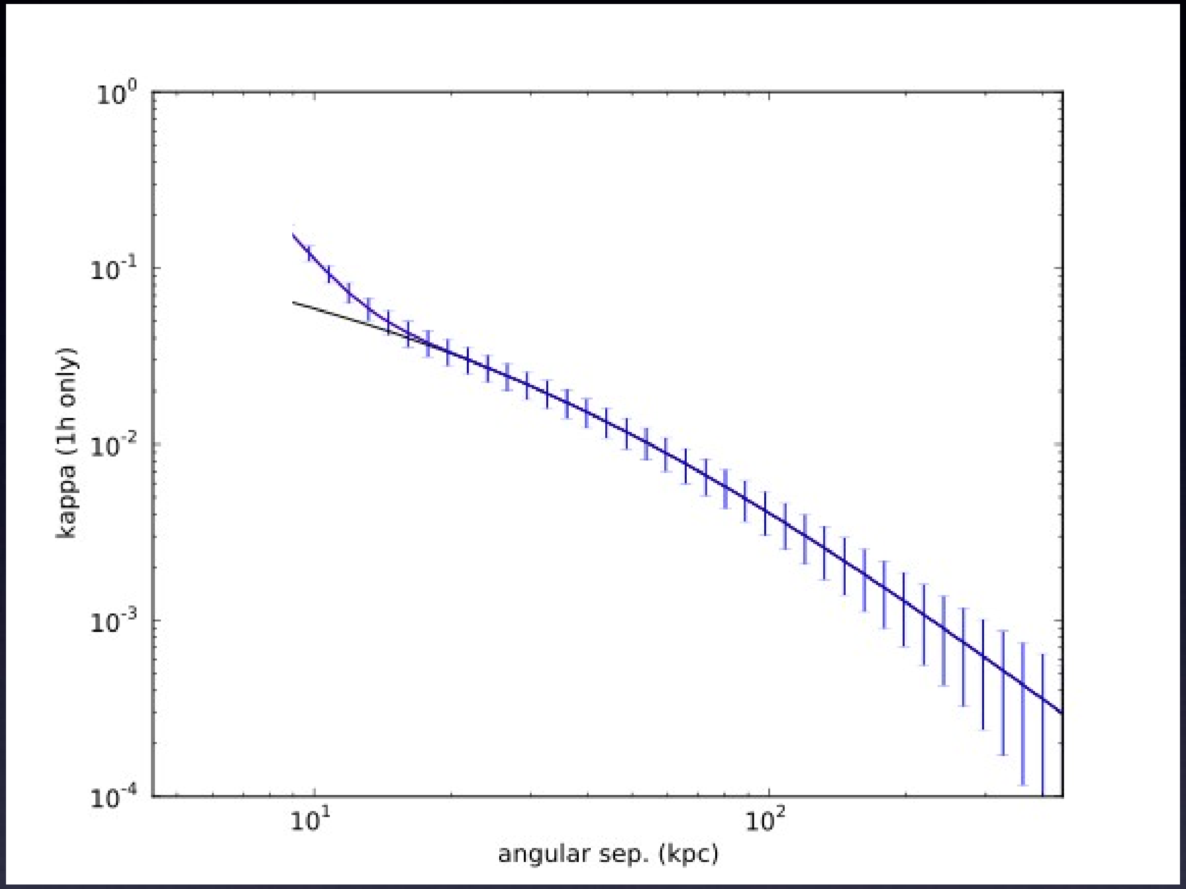


Errors ~ 1.5-2x those of shear,

(but there is room for improvement)

What we gain from combining shear and magnification:





shear

magnification

A novel combination of kinematics and lensing using the Tully-Fisher relation

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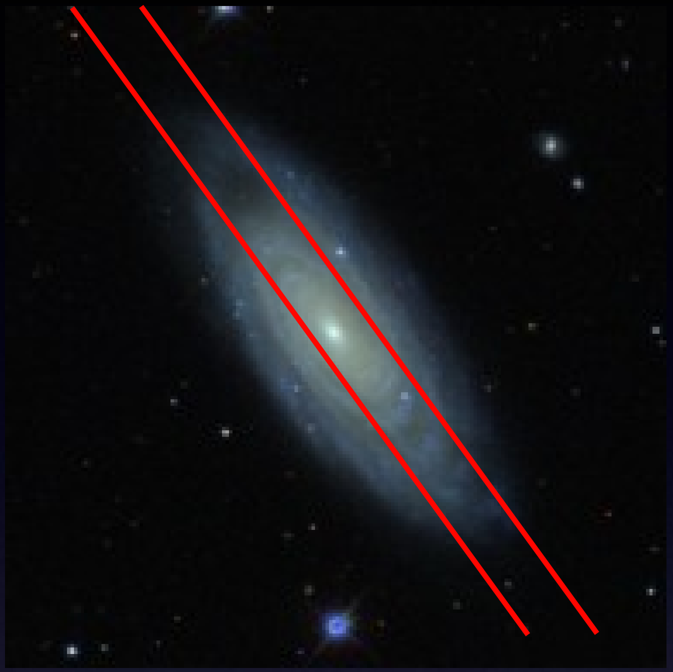
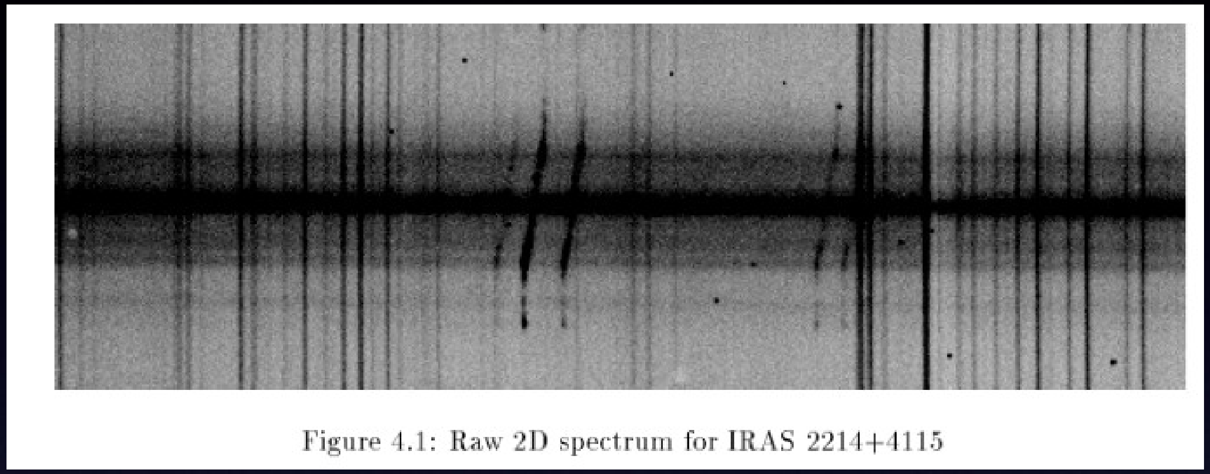
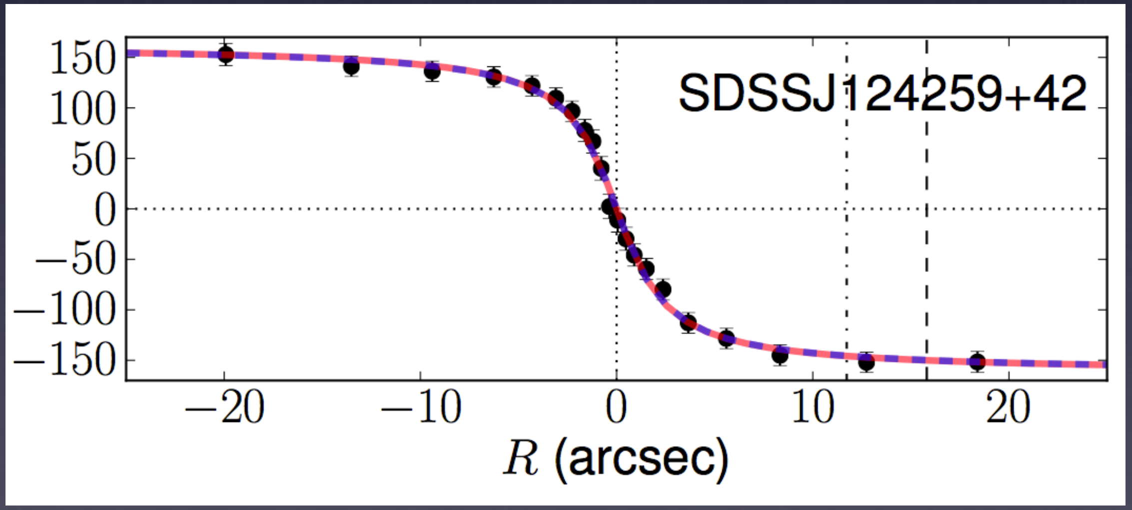
$$\sigma_\gamma = 0.2$$

A novel combination of kinematics and lensing using the Tully-Fisher relation

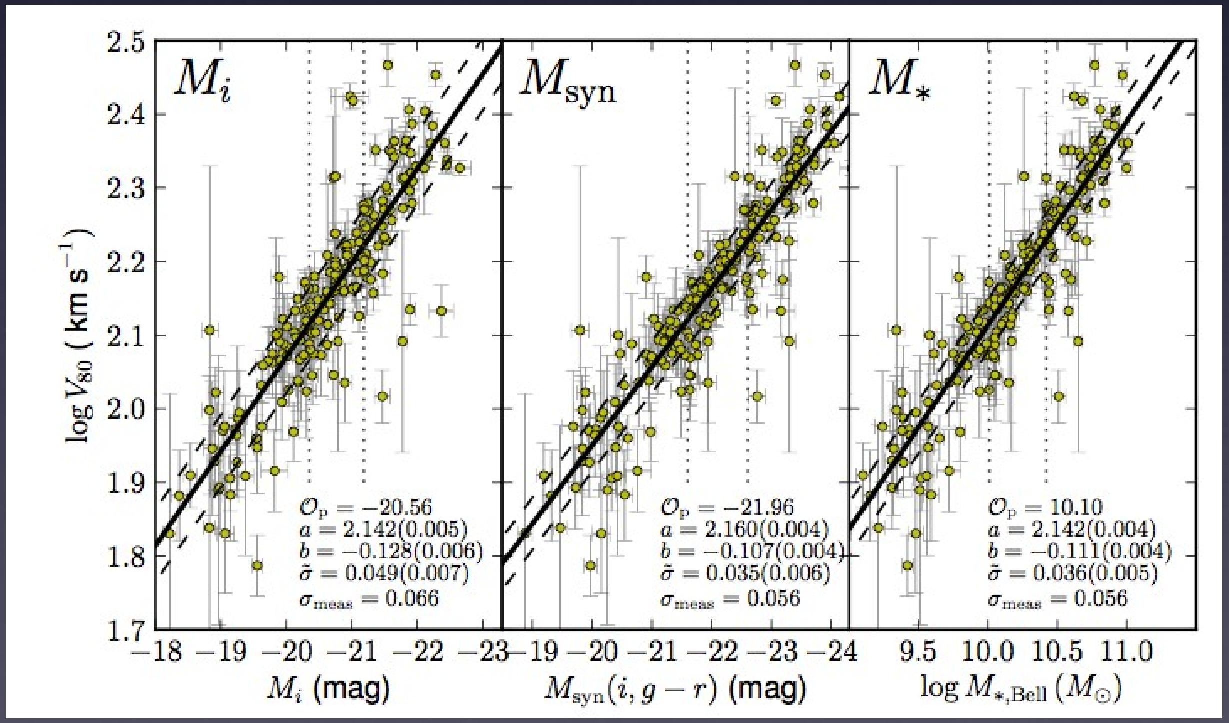




Schlegel (private comm.)

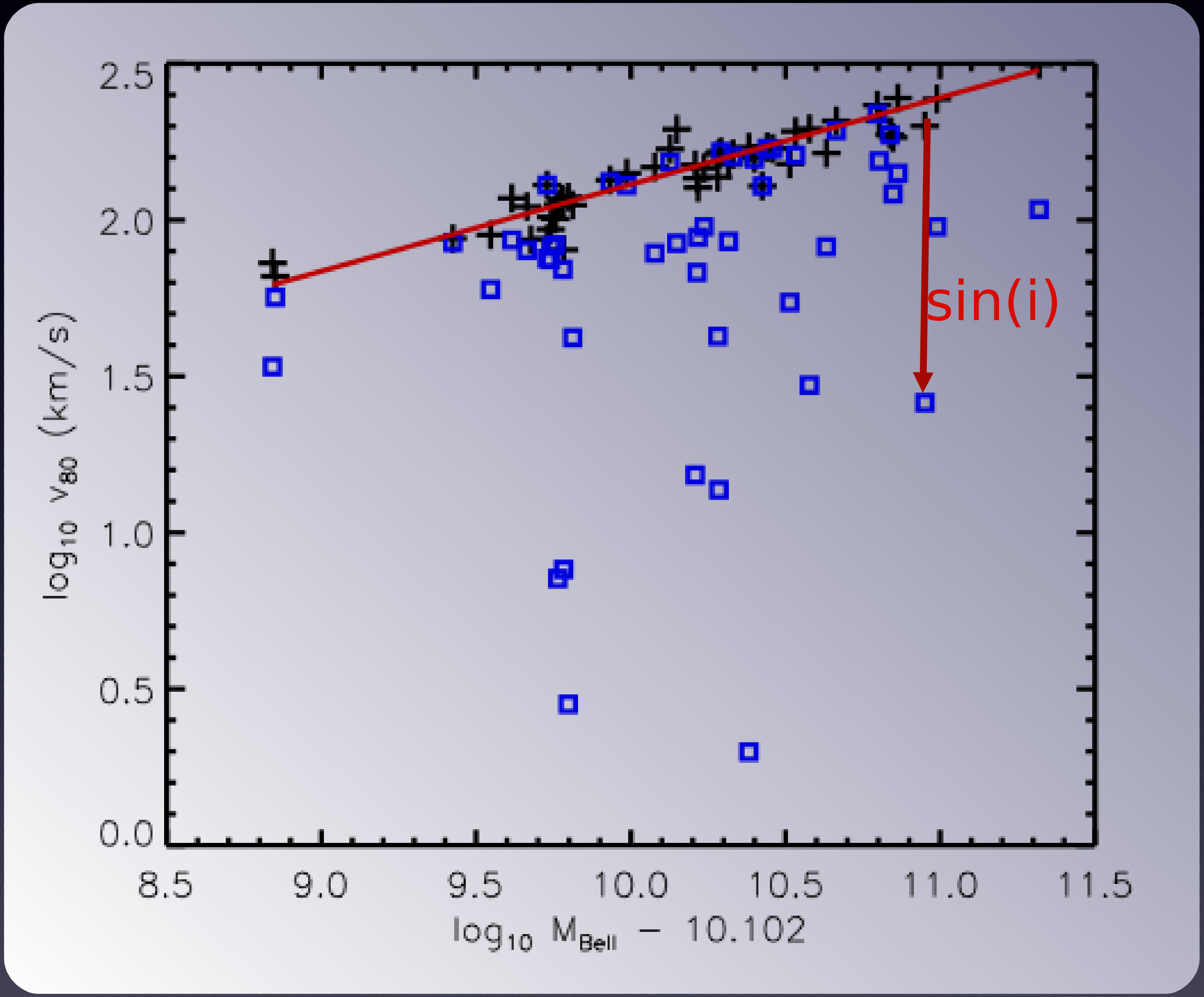


Reyes et al 2011



Reyes et al 2011

If we know TF, we can use rotation curves to estimate the ellipticities independently



Red trendline:
TF relation, which we
treat as given

Blue points:
not corrected
for inclination

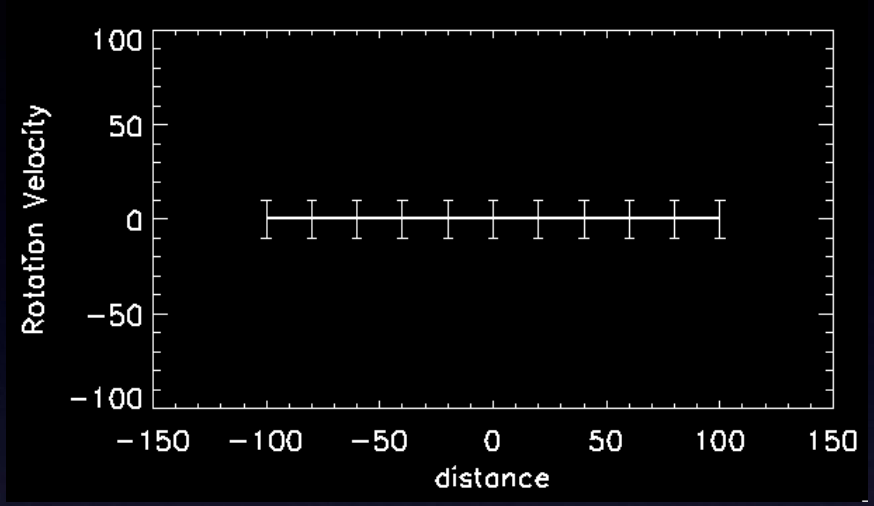
For a disk, sin(i) tells us what ellipticity we should measure in the absence of lensing.

Cartoon: How TF improves lensing signal.

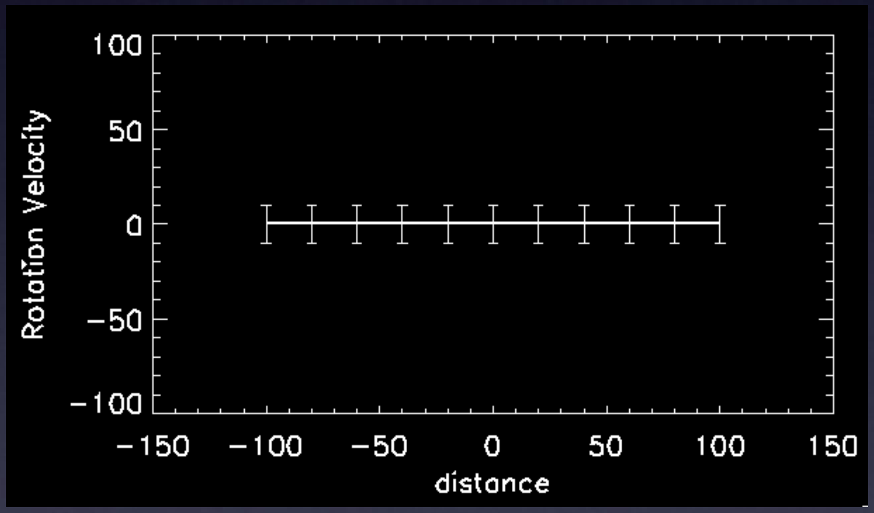
image

rotation curve

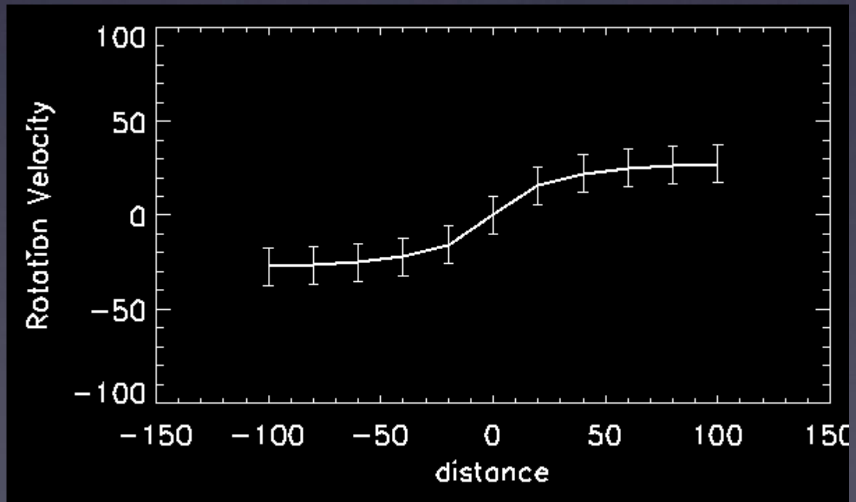
face-on



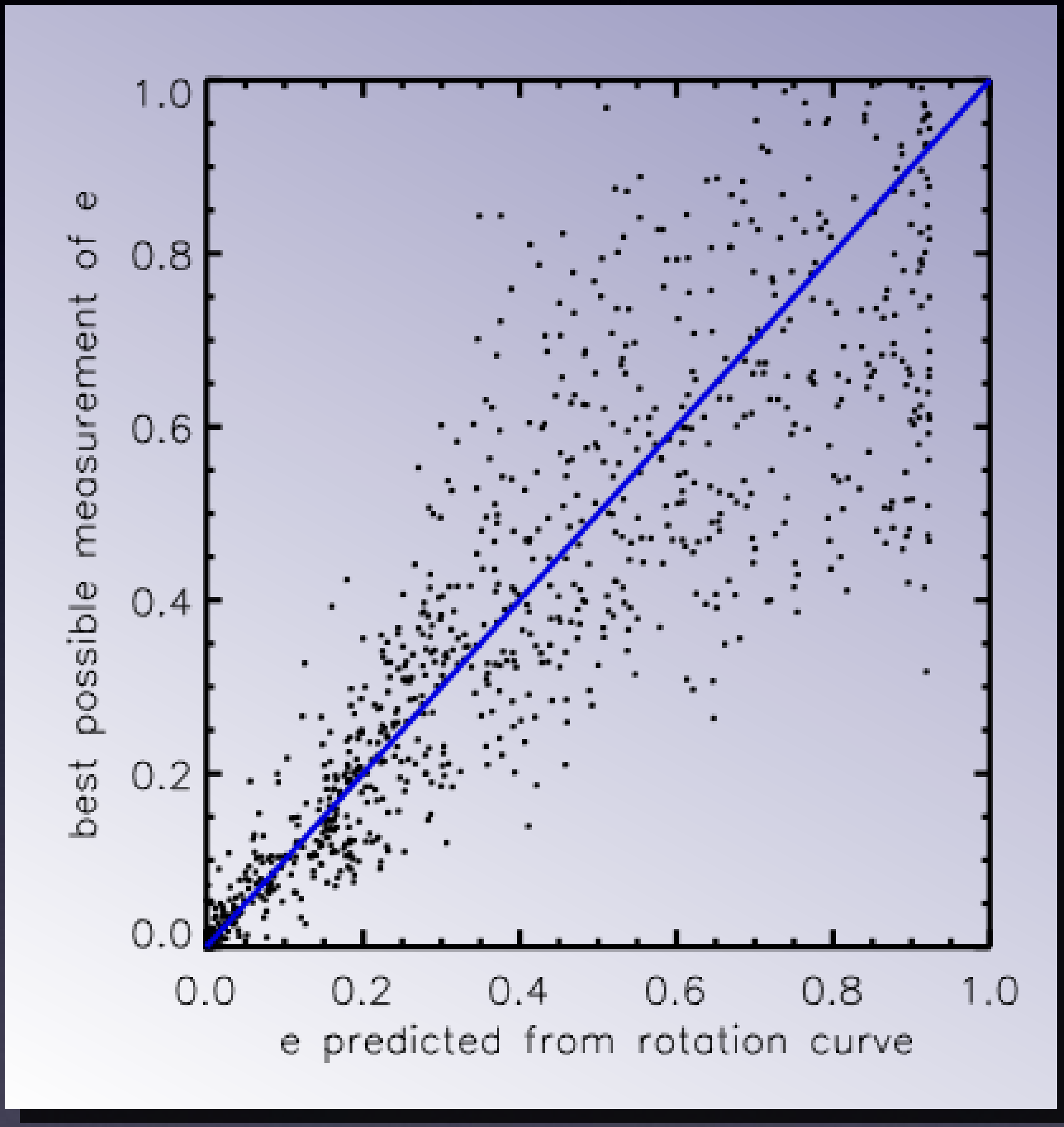
face-on, but sheared



inclined, but not sheared



This controls for much of the shape noise.



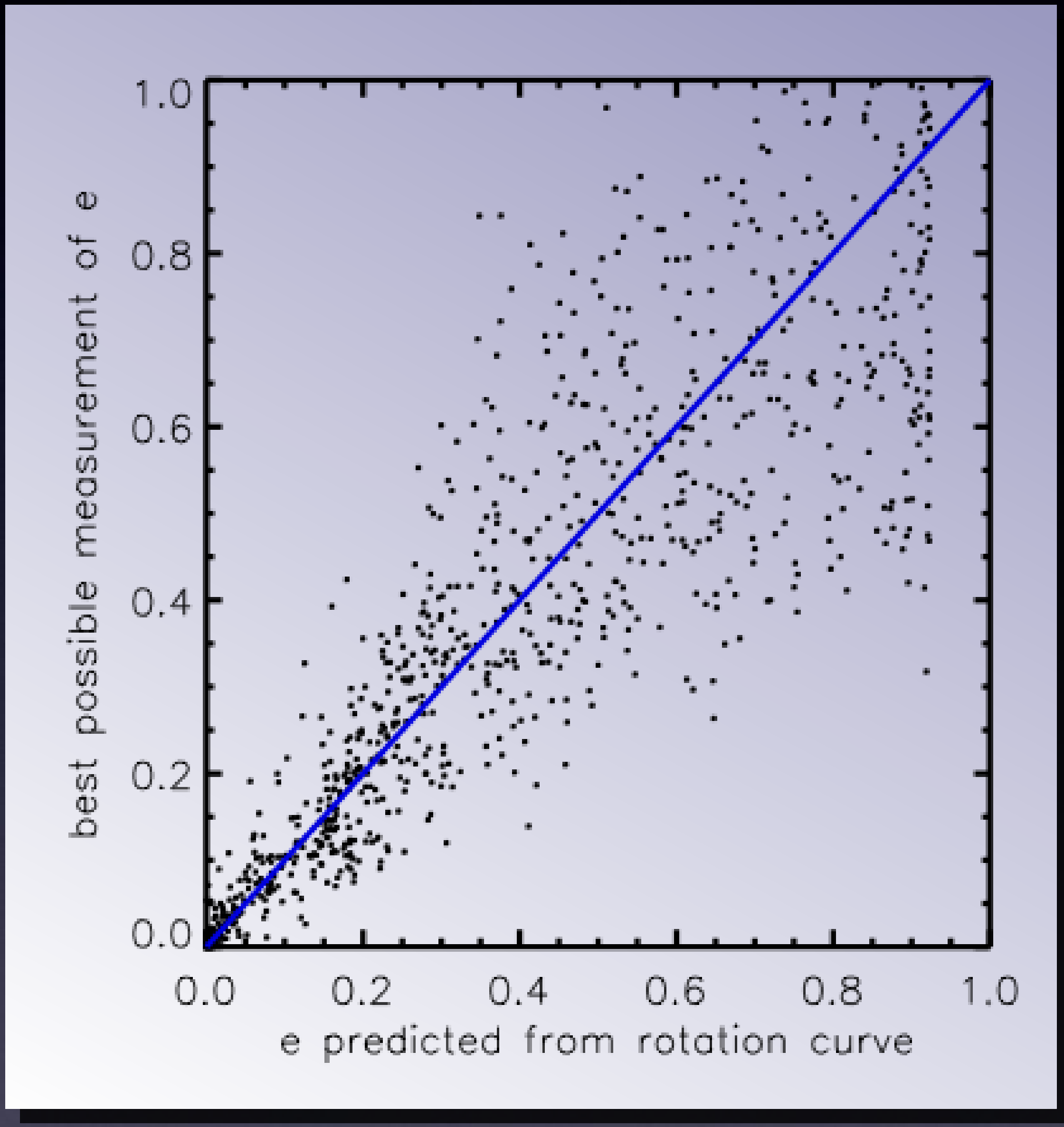
$\sigma_\gamma = 0.02$

LSST weak lensing:
37 galaxies per sq. arcmin

equivalent S/N to 0.5
Tully-Fisher galaxies per sq. arcmin

a **major** reduction in certain systematic errors

This controls for much of the shape noise.



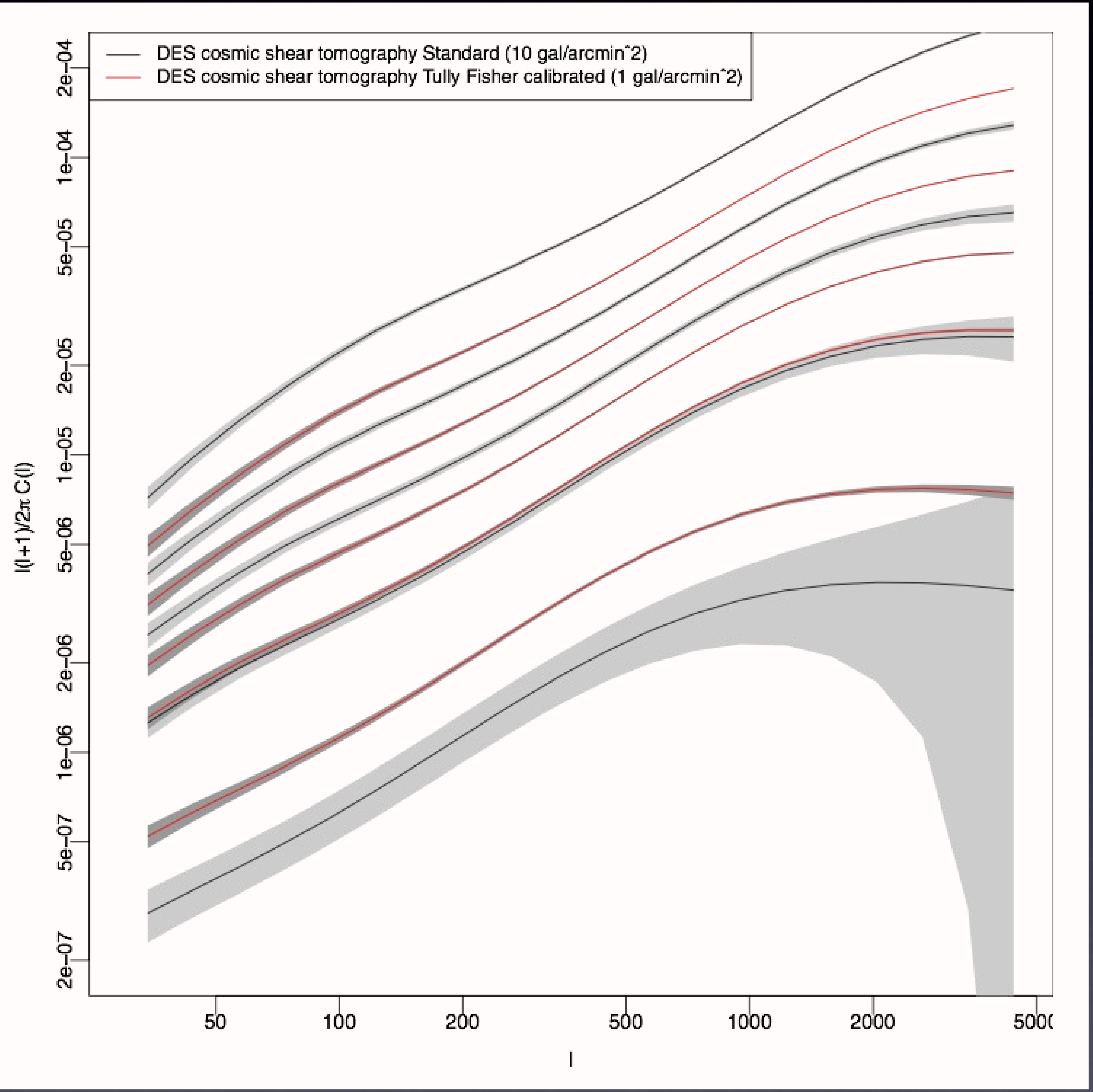
$\sigma_\gamma = 0.02$

a **major** reduction in certain systematic errors:

no photo-z's

brighter, better resolved galaxies drastically reduce psf correction, shear calibration issues

And allows for dramatic improvements to the cosmological constraints



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