# Pushing the envelope of lensing with resolved kinematics

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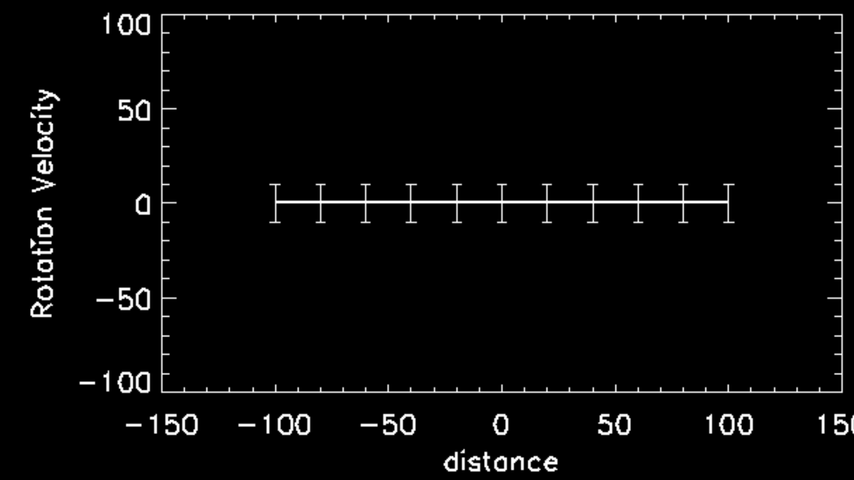
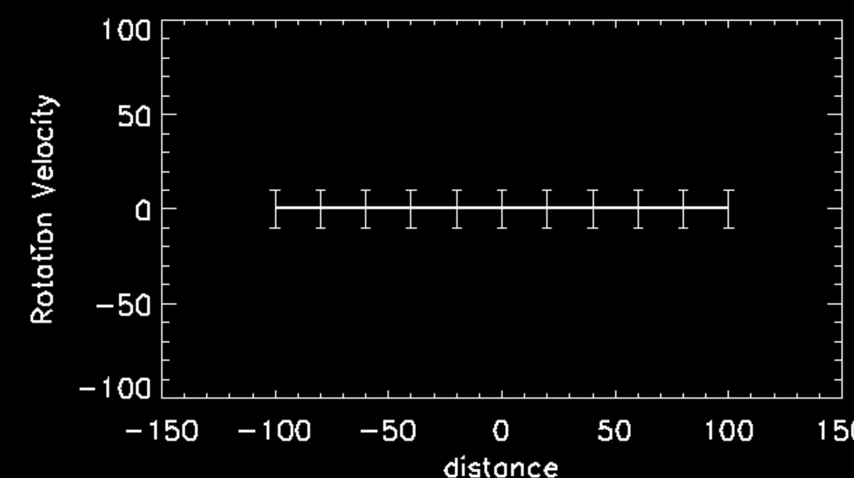
# Kinematics break degeneracy between shape and shear

<u>image</u> <u>rotation curve</u>

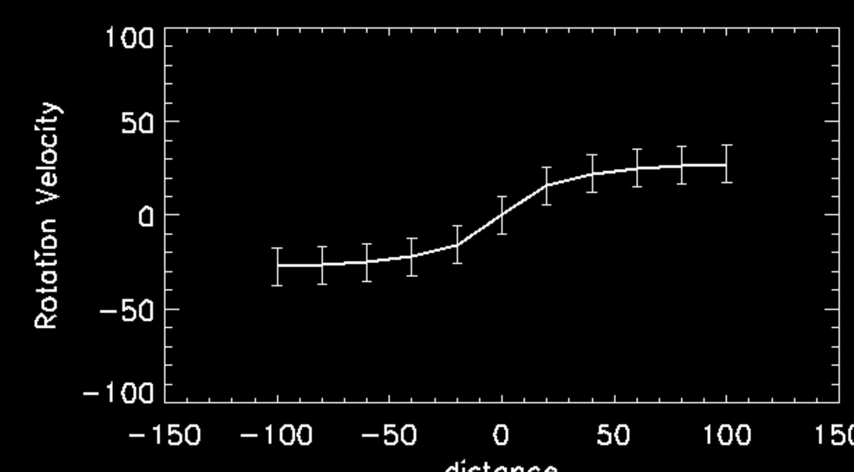
face-on



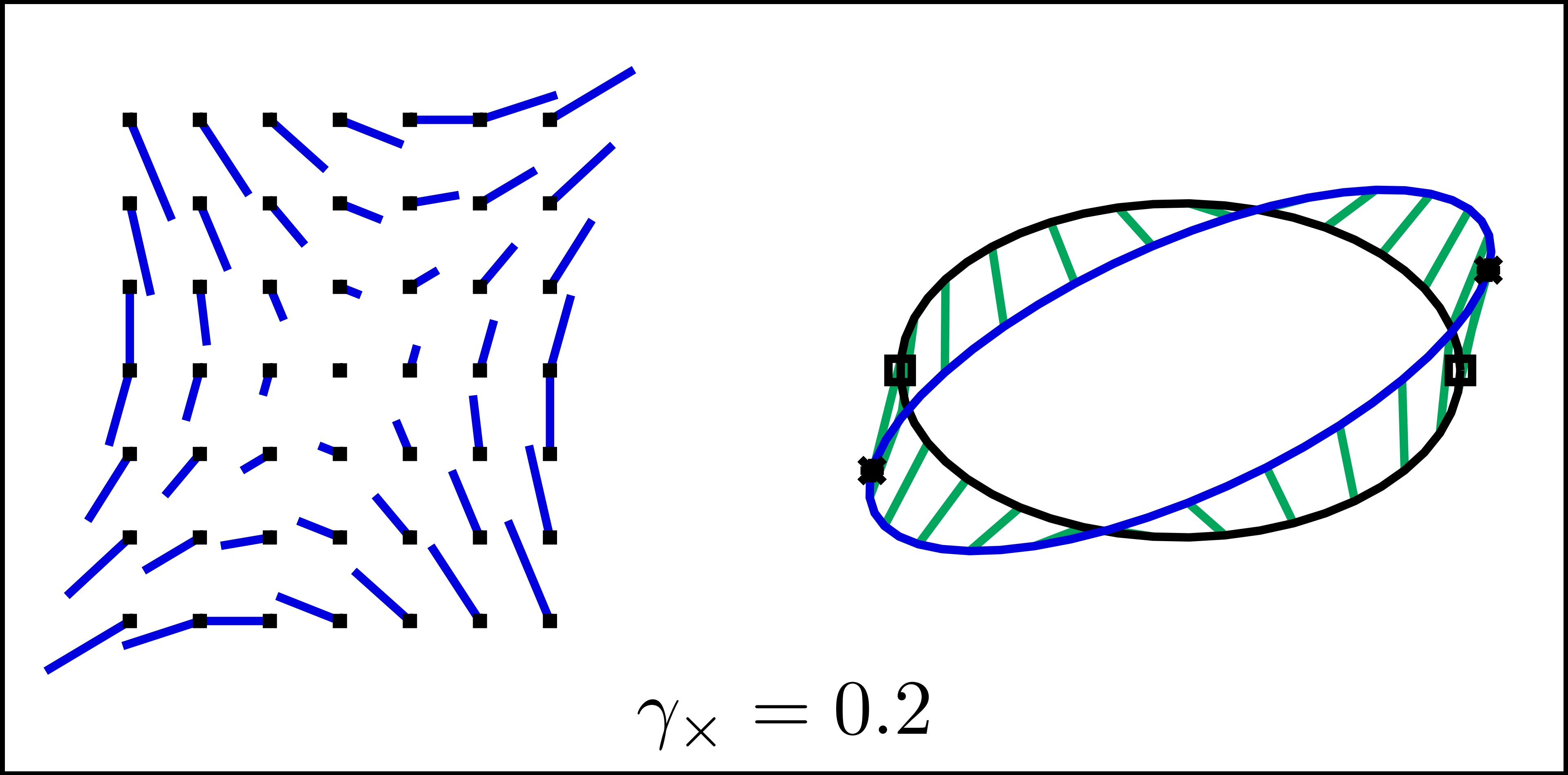

face-on, but sheared




inclined, but not sheared

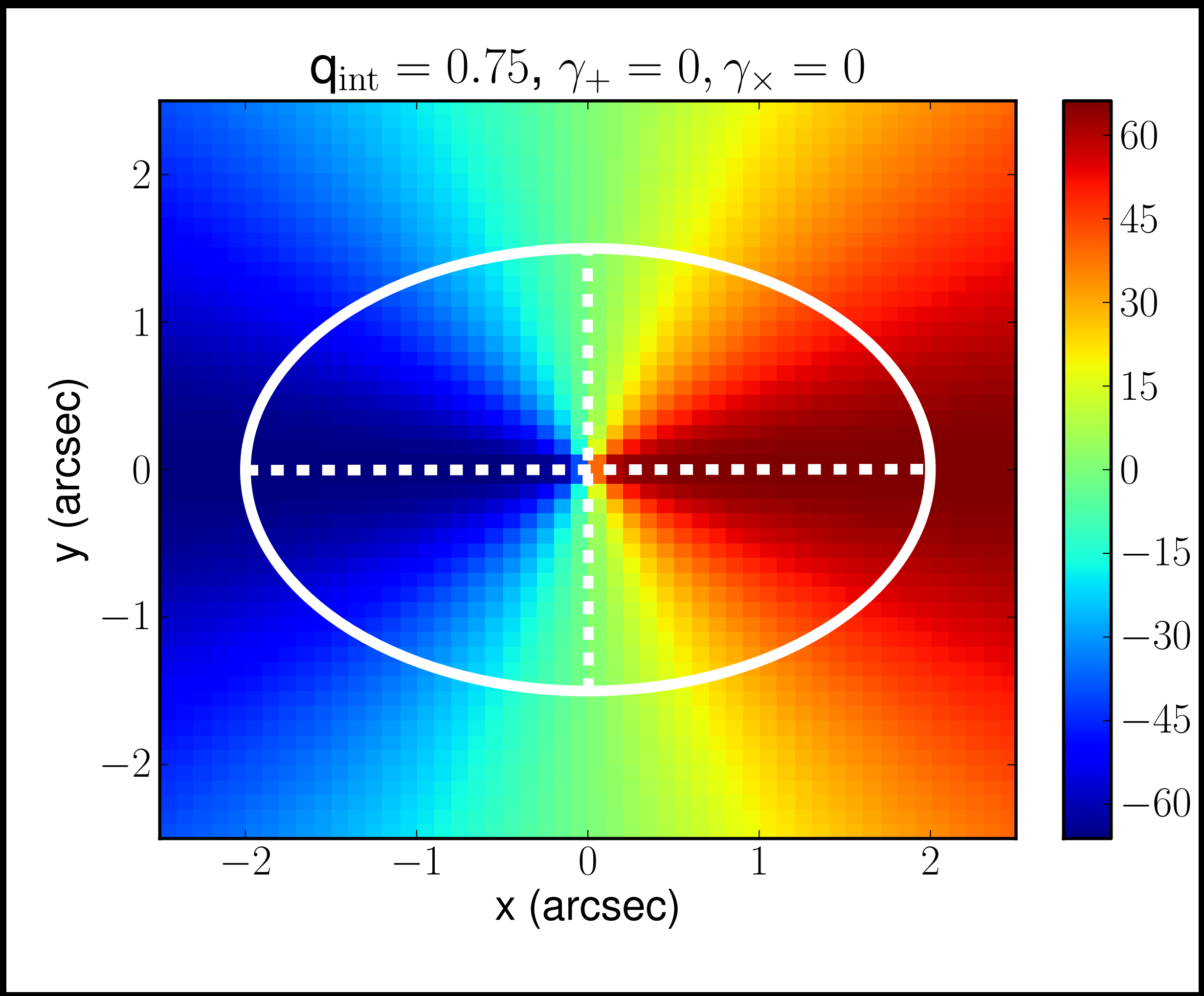


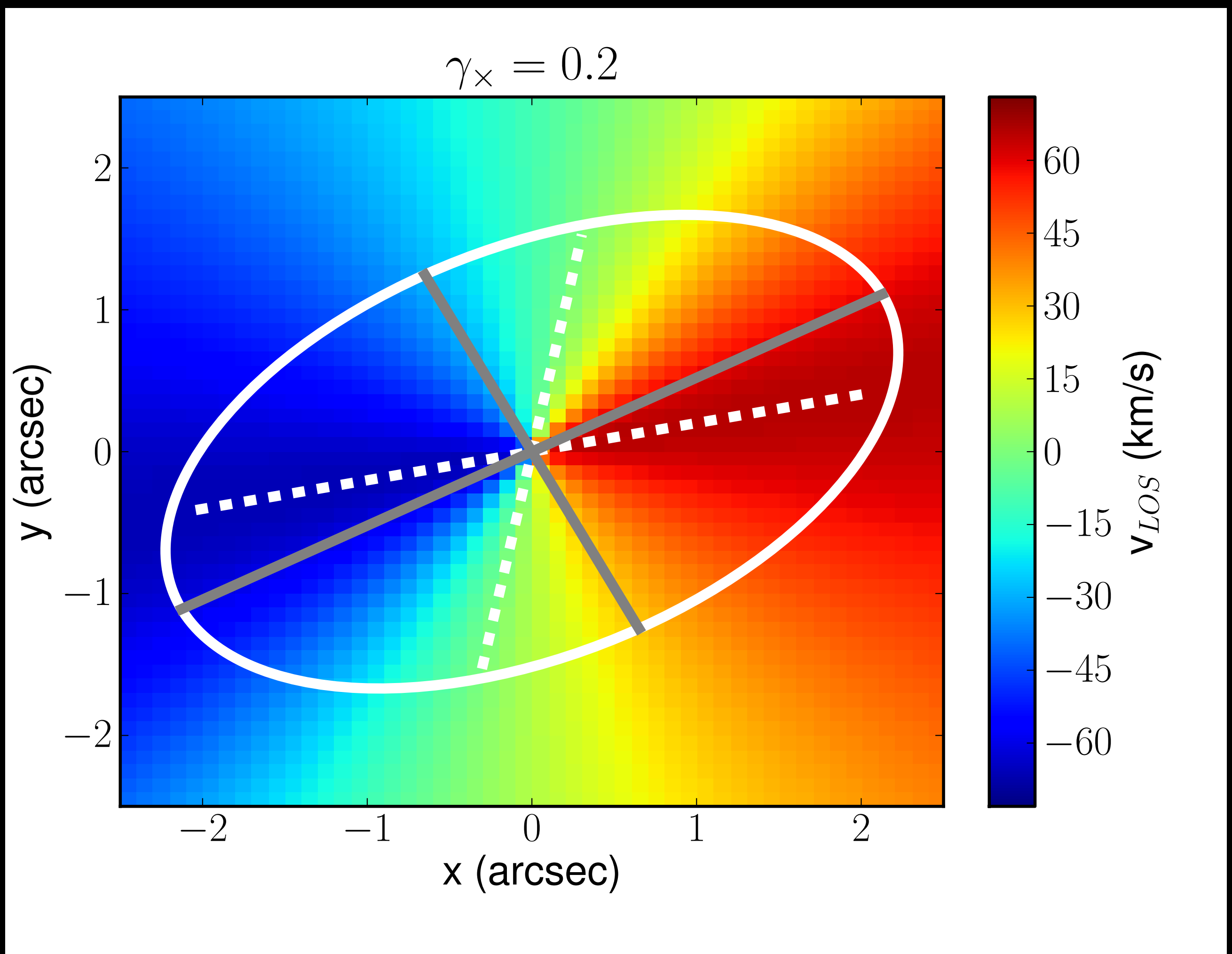
# Shear changes the orientation of an ellipse




But shear has no solid-body rotation component.

# Lensing *mis-aligns* the kinematic and photometric axes



# Consider the Tully-Fisher relation.

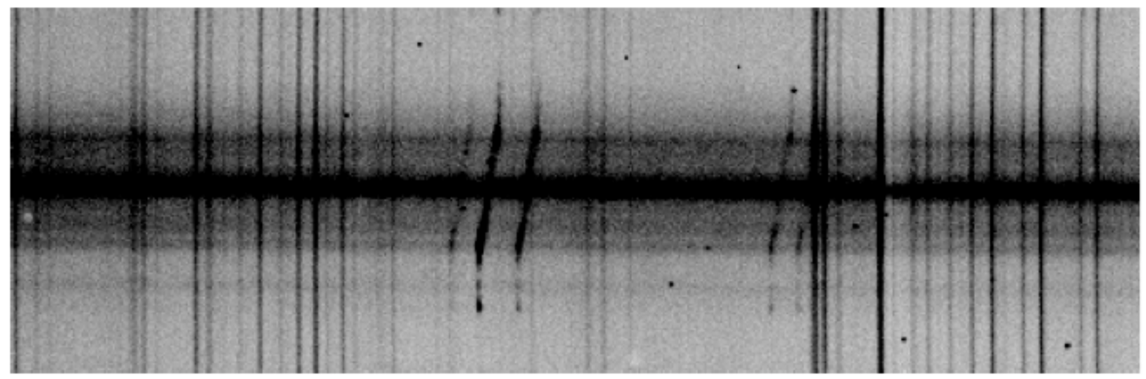
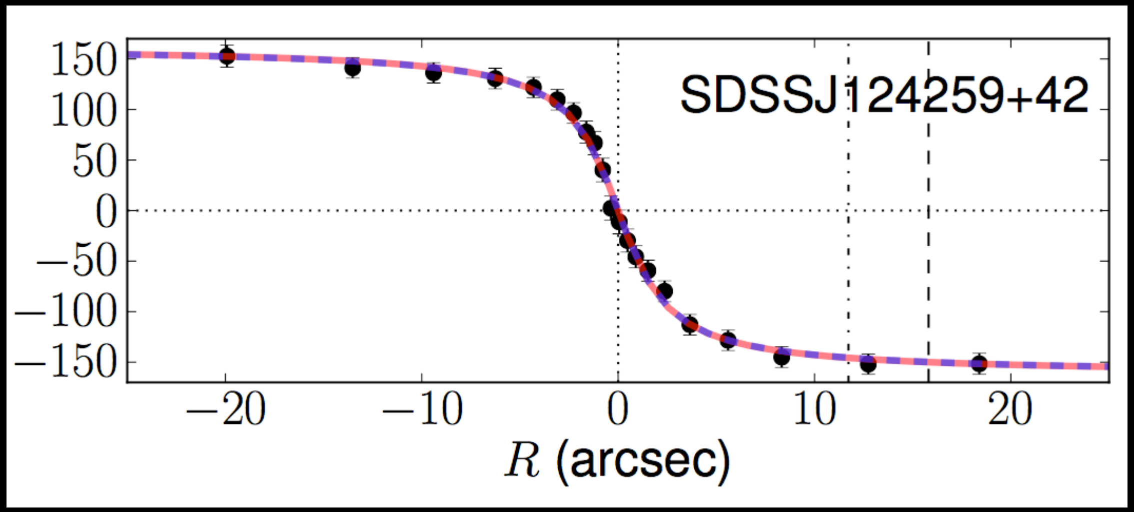
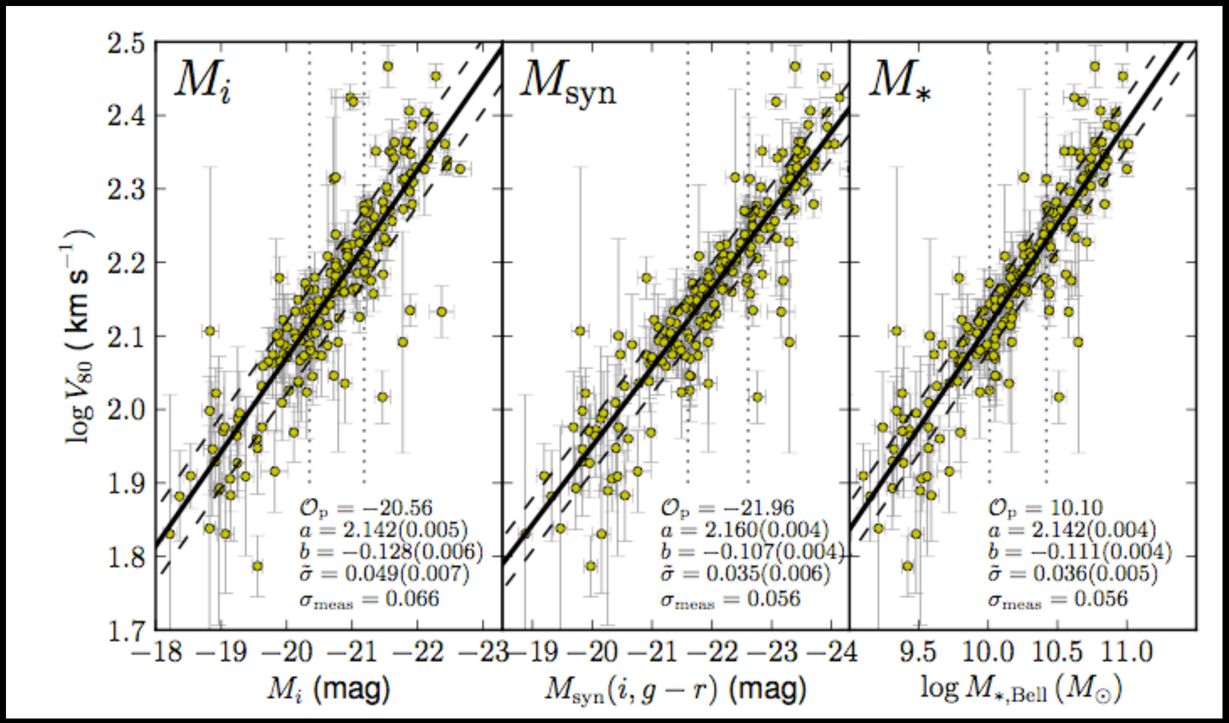


Figure 4.1: Raw 2D spectrum for IRAS 2214+4115

Schlegel (private comm.)



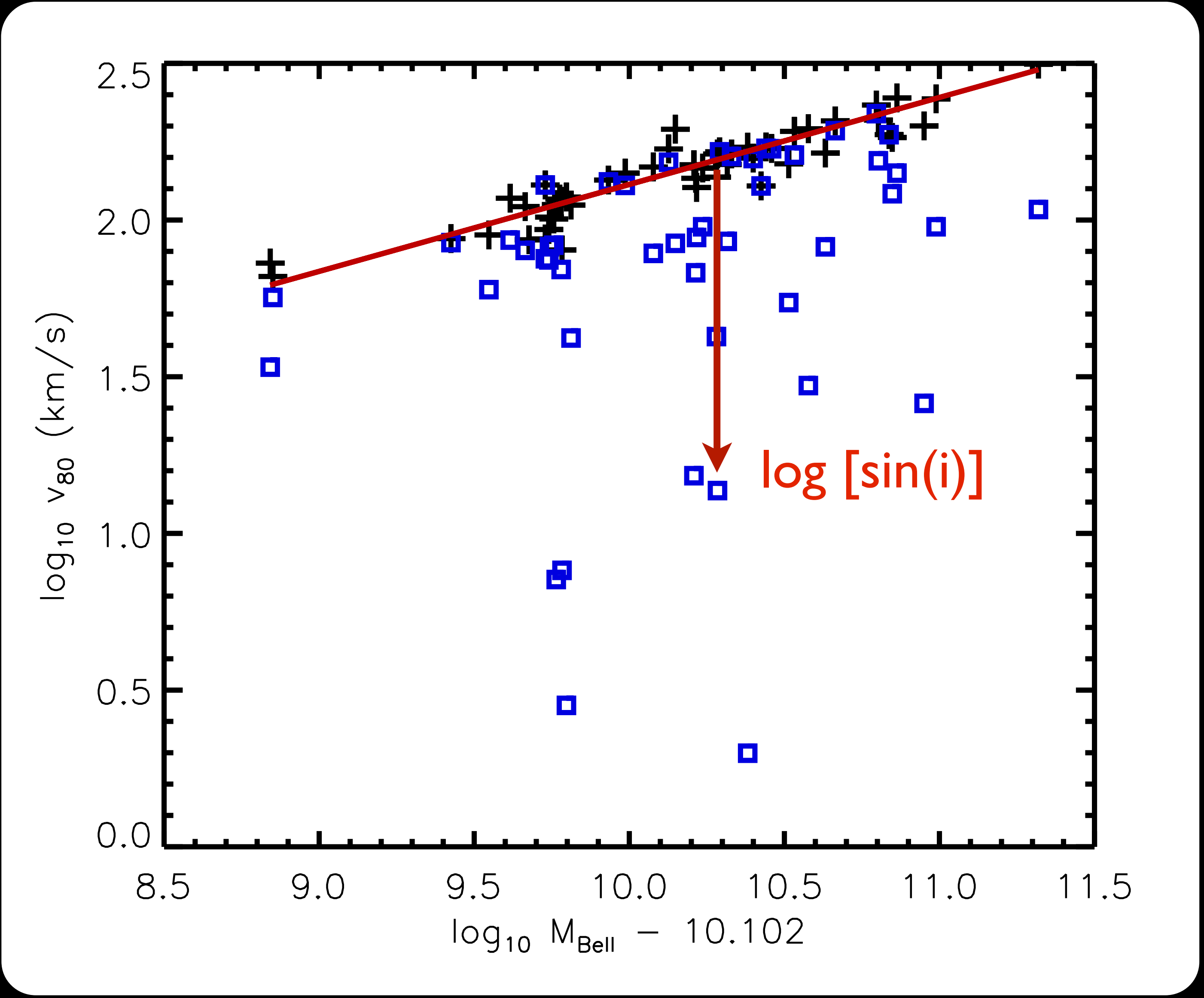

Reyes et al 2011




Reyes et al 2011

# With spectroscopy, the Tully-Fisher relation tells us the inclination angle.

<u>Blue points:</u>
not corrected for inclination




<u>Red trendline:</u>
TF relation, which we treat as given

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

# Shear messes up the inclination correction.

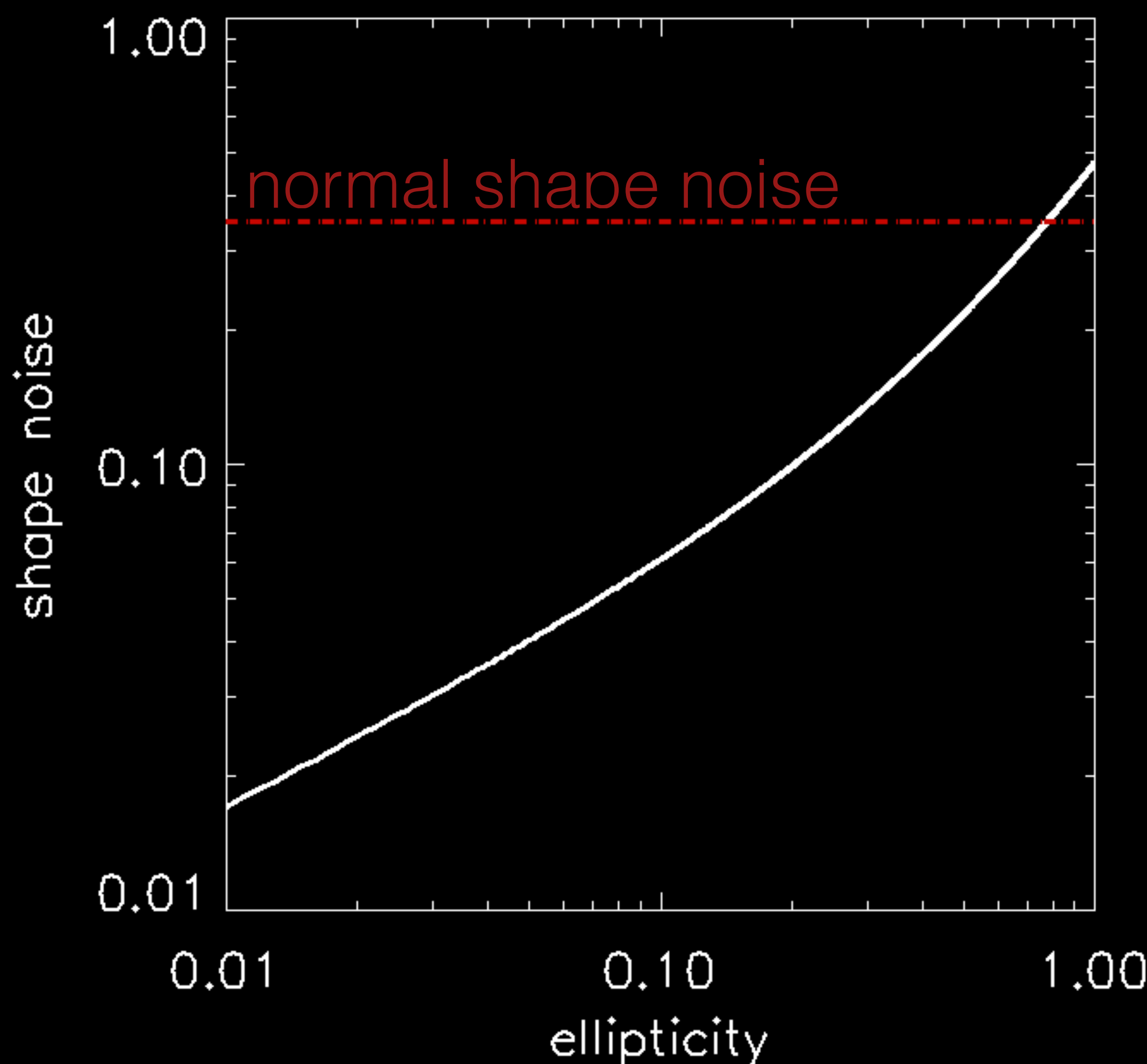
Tully-Fisher: $v_{\text{obs}} = v_{\text{TF}}\ \sin(i) + \sigma_{\text{TF}}$

For a disk: $\sin(i) = \left(\dfrac{2e}{1+e}\right)^{\frac{1}{2}}$

The effect of a shear: $e \mapsto e + \gamma$

$$\sin(i)|_{\gamma} = \sin(i)|_{\gamma=0} + \frac{\gamma}{2\sqrt{e(1+e)^3}}$$

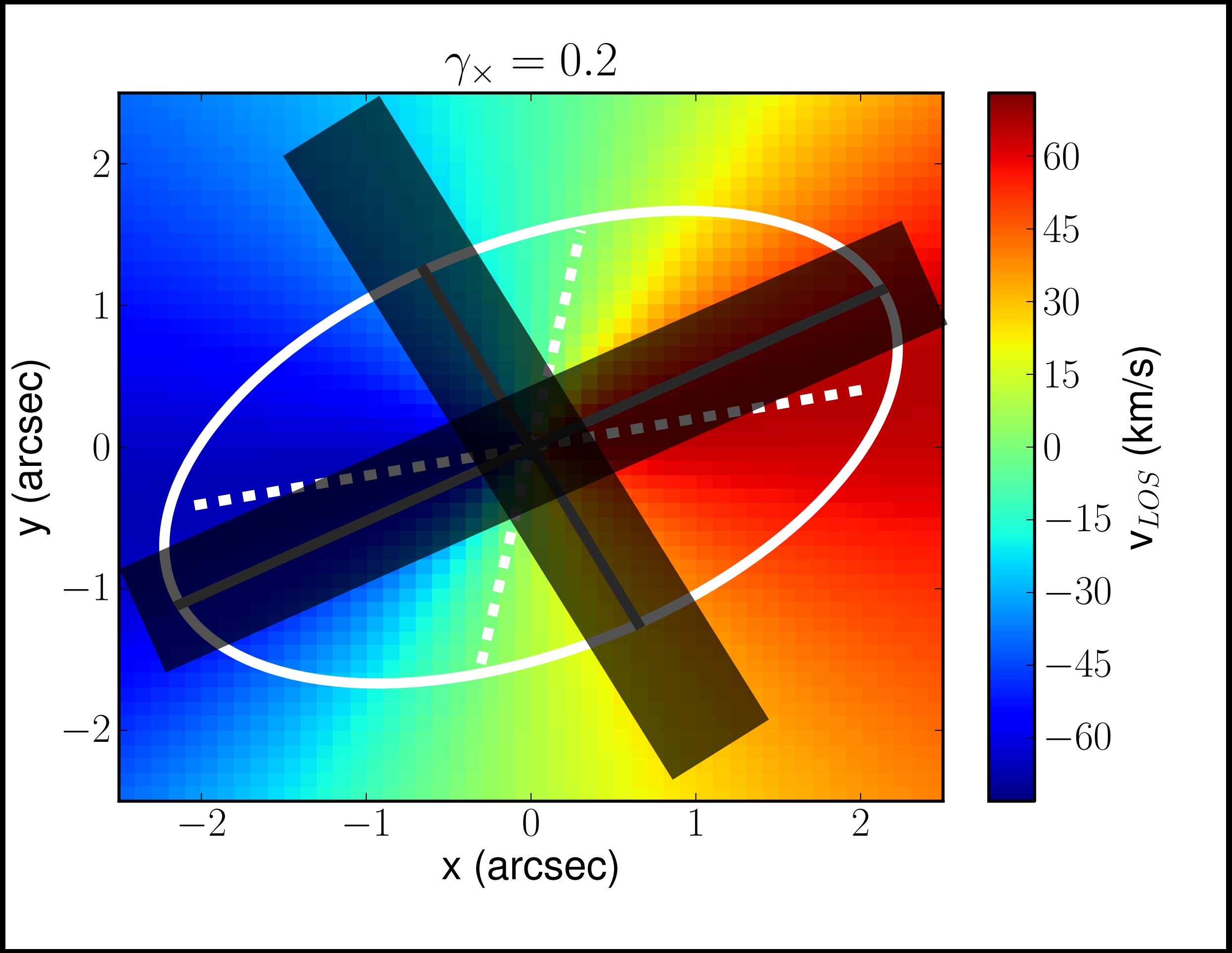
# The reduction in shape noise can be very large…



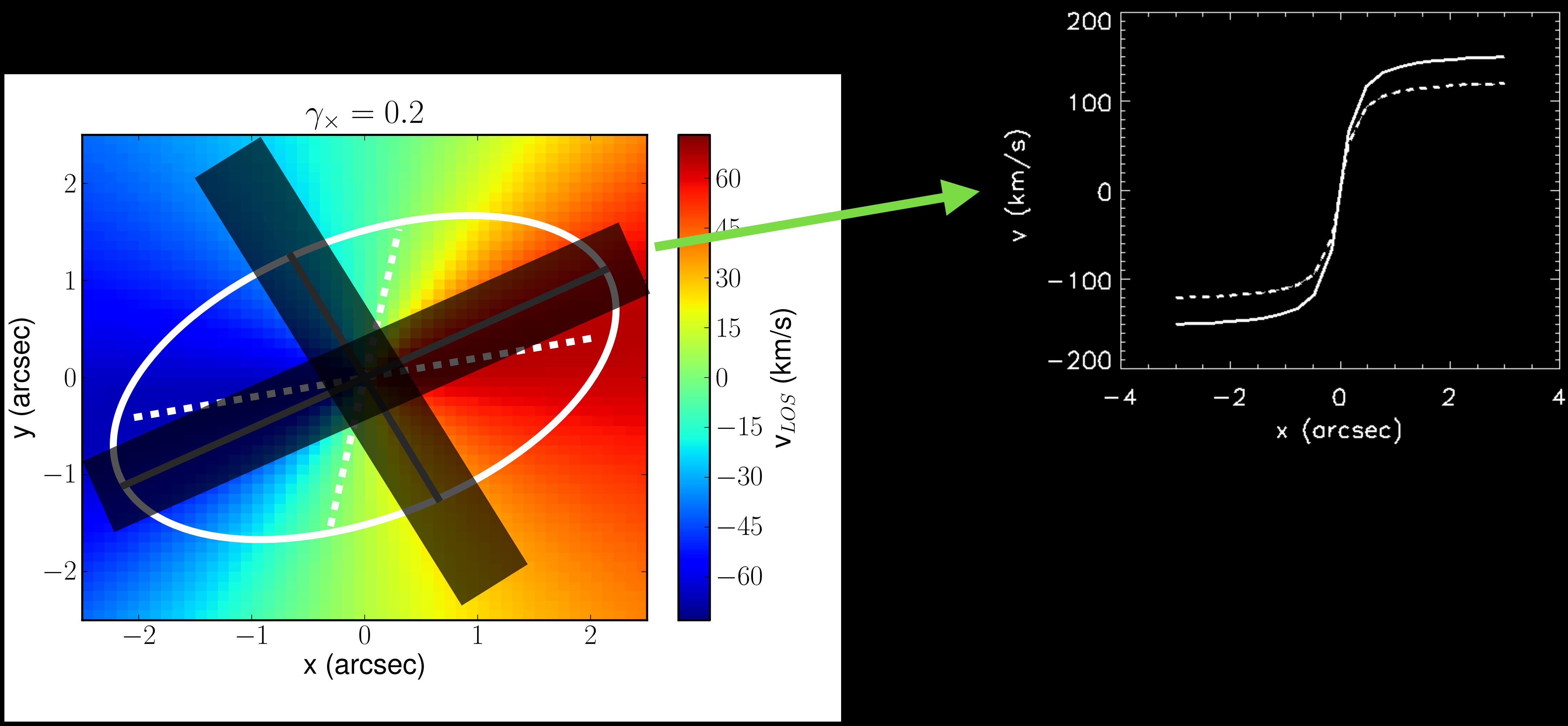

$$\sigma_{eff} = 4.4\sqrt{e(1+e)^3}\sigma_{\rm TF}$$

…For face-on disks, factors of 10.

# A spectroscopic weak lensing measurement with slit spectroscopy

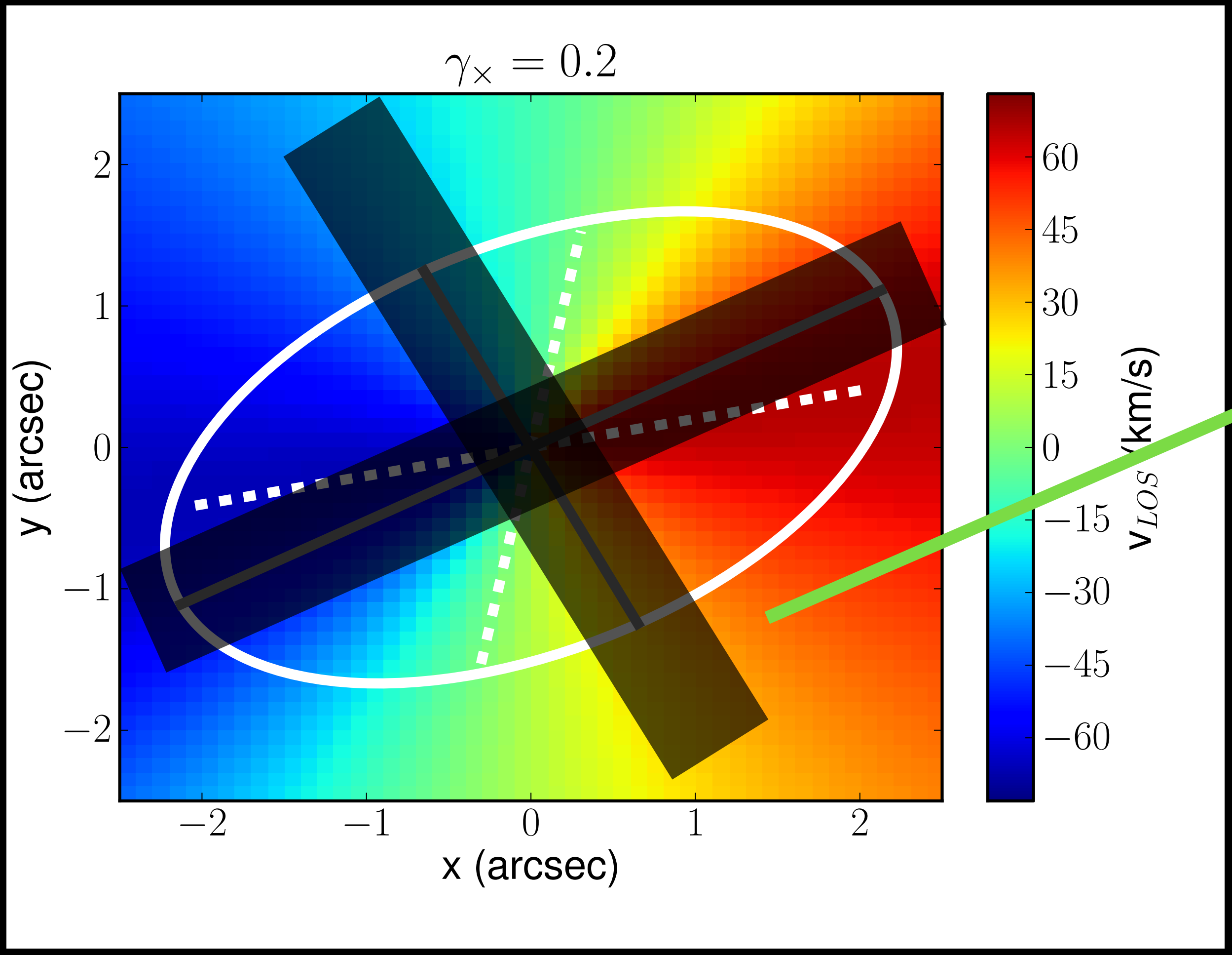


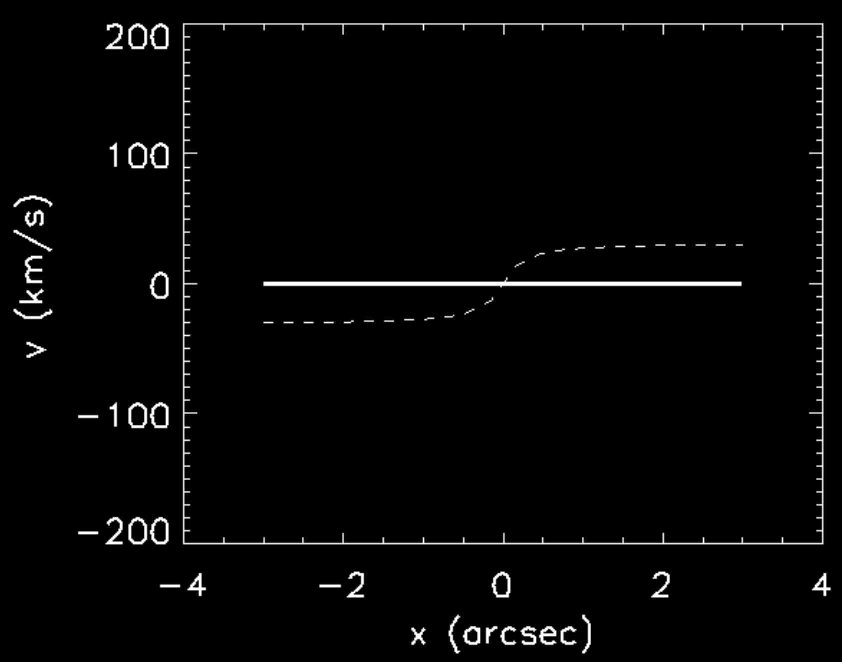
# A spectroscopic weak lensing measurement with slit spectroscopy




Less rotation along the major axis than TFR would predict

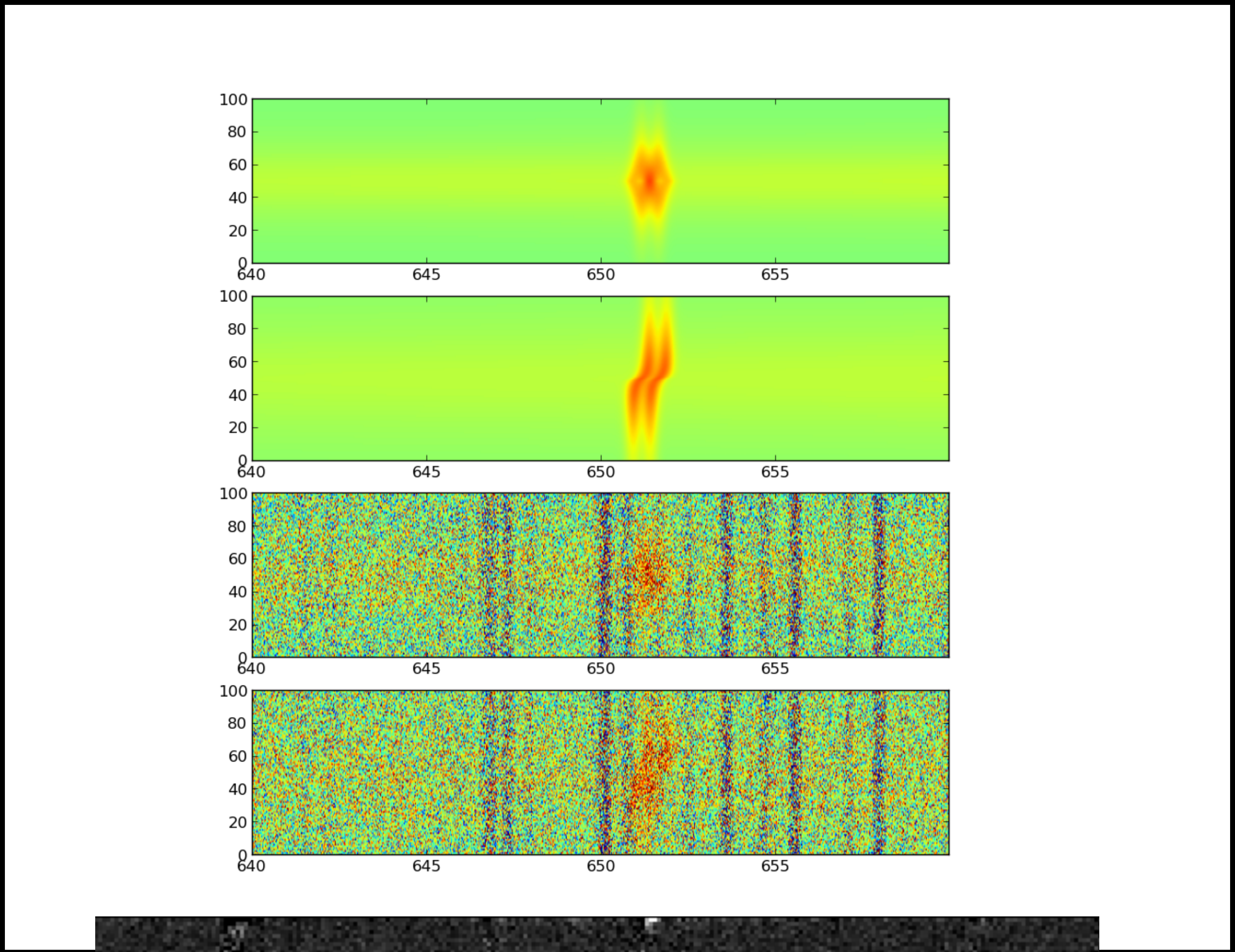
# A spectroscopic weak lensing measurement with slit spectroscopy

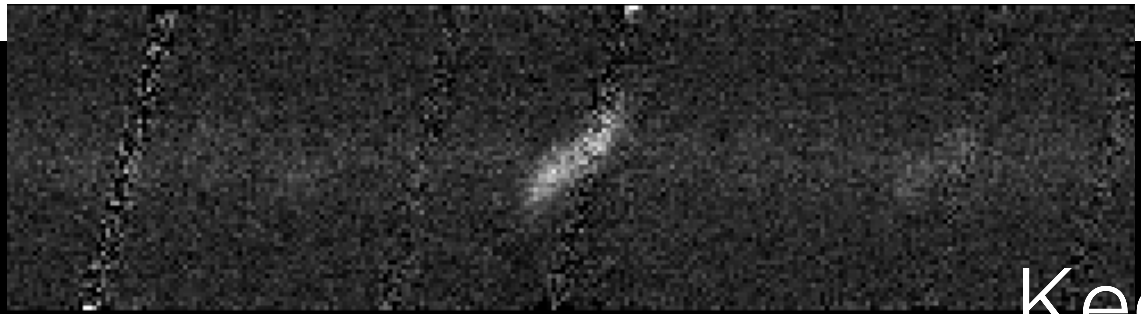



More rotation along the minor axis than TFR would predict

# Simulating the measurement: Slit Spectroscopy



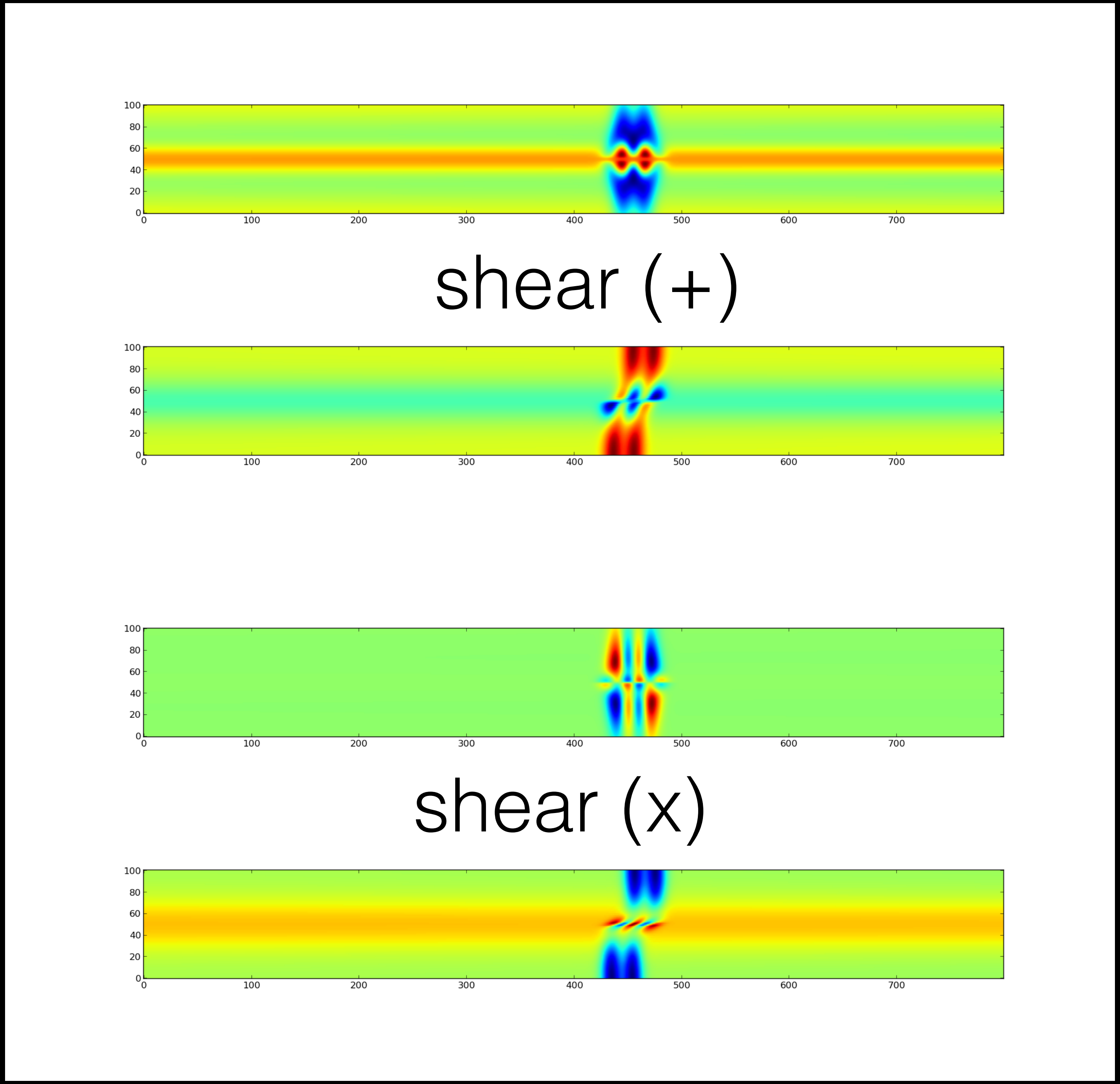



simple galsim-based simulation

consistent with DES/BigBOSS estimates

Keck-DEIMOS June 30, 2014

# Simulating the measurement: Slit Spectroscopy




**extremely crude**

<u>Fisher estimate:</u>

- 8m telescope
- 1000 s
- Paranal sky, atm

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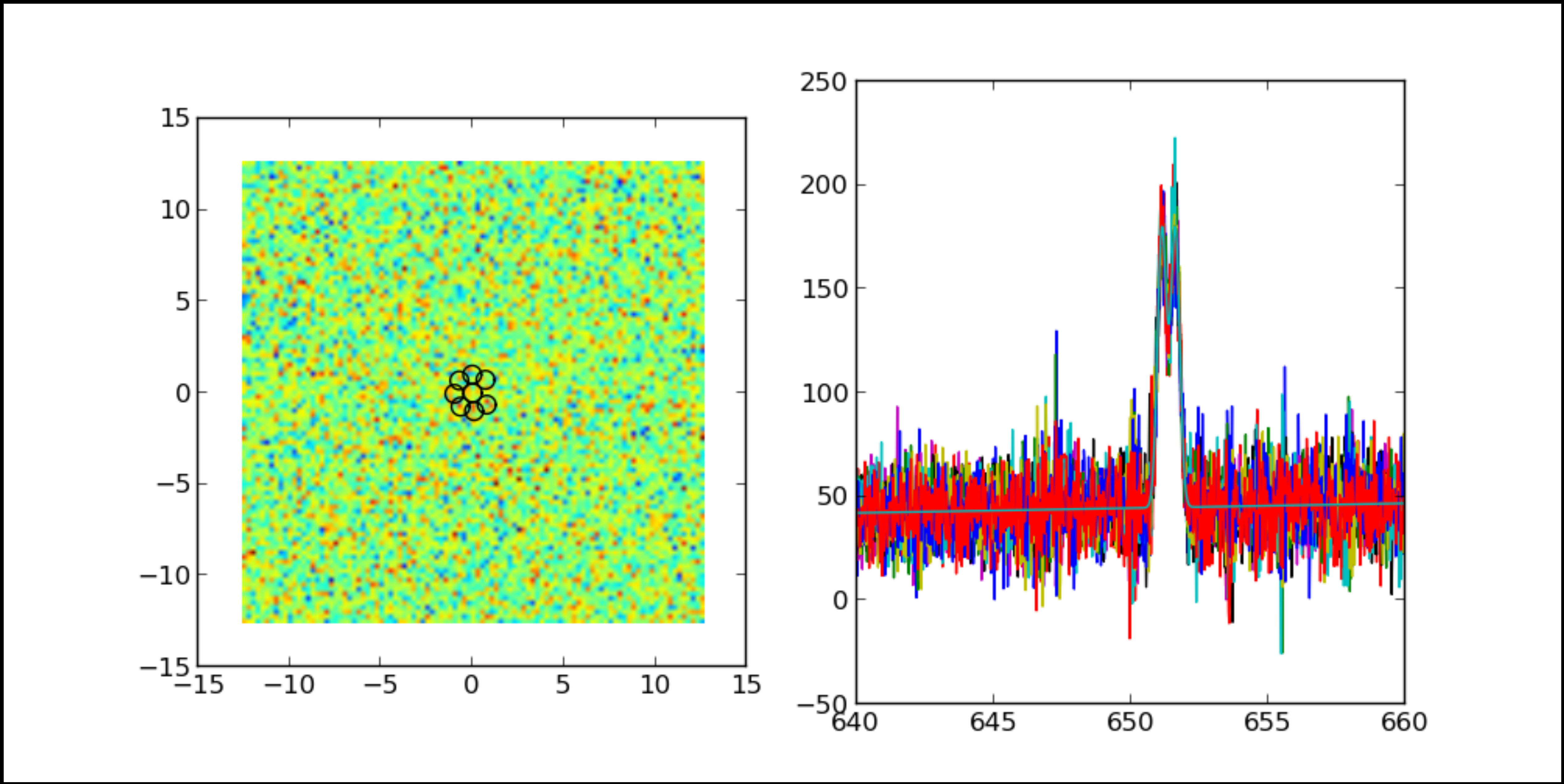
gain factor of ~30 measurement precision over shapes alone

# Simulating the measurement: fiber Spectroscopy




(work ongoing)

# For this level of per-galaxy shape noise:

Shape noise: $\propto \dfrac{\sigma_e}{\sqrt{n_{\rm gal}}}$

For LSST: $n_{\rm gal} \approx 25 \, {\rm gal \, arcmin}^{-2}$

$\sigma_e \approx 0.2$

For kinematic lensing, equivalent shape noise with:

$\sigma_e \approx 0.025$

$n_{\rm gal} \approx .25 \, {\rm gal \, arcmin}^{-2}$

$$n_{\rm gal} \approx .25 \, {\rm gal \, arcmin}^{-2}$$

$$\sim 10^3 \, {\rm deg}^2$$

$$\implies 10^7 \, {\rm spectra}$$

This is achievable with SuMIRe/PFS or DESI

# None of the usual lensing systematics matter

- Photo-z's
- Intrinsic alignments
- Shear measurement
- PSF correction

We'll have spectra for every source galaxy

# None of the usual lensing systematics matter

- ~~Photo-z's~~
- $\boxed{\text{Intrinsic alignments}}$
- Shear measurement
- PSF correction

Intrinsic alignments don't contribute (at ~leading order) to the kinematic signal

# None of the usual lensing systematics matter

- ~~Photo-z's~~
- ~~Intrinsic alignments~~
- Shear measurement
- PSF correction

Low $\bar{n}_{\rm gal}$ means we can target bright, resolved galaxies