Flexion in COSMOS

Measuring Higher Order Lensing Distortions

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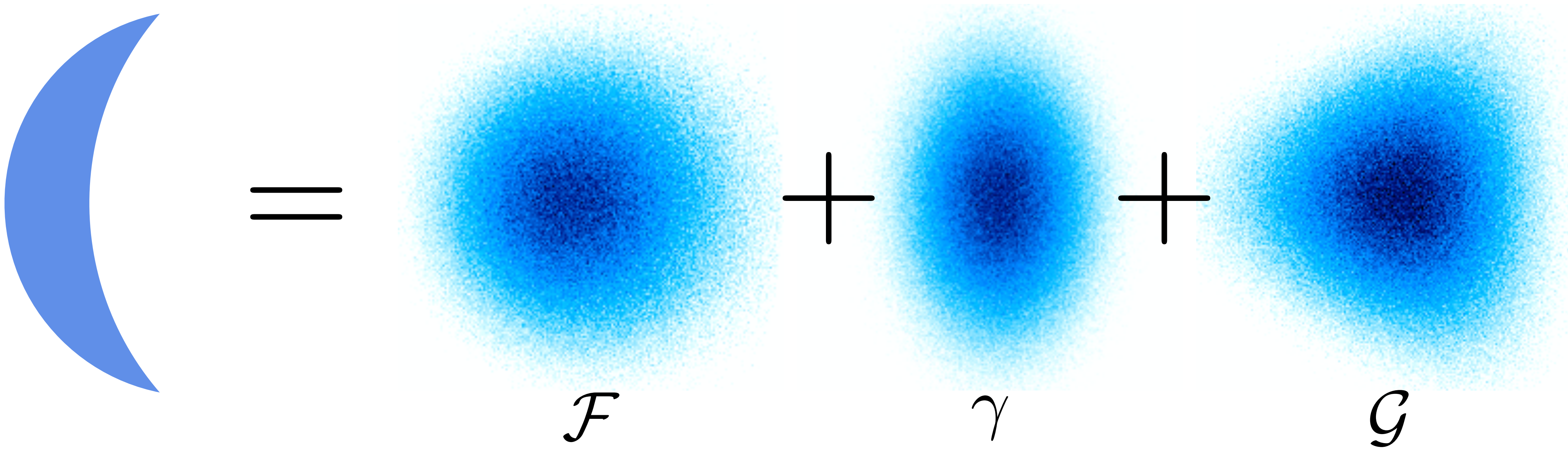
Why Flexion?

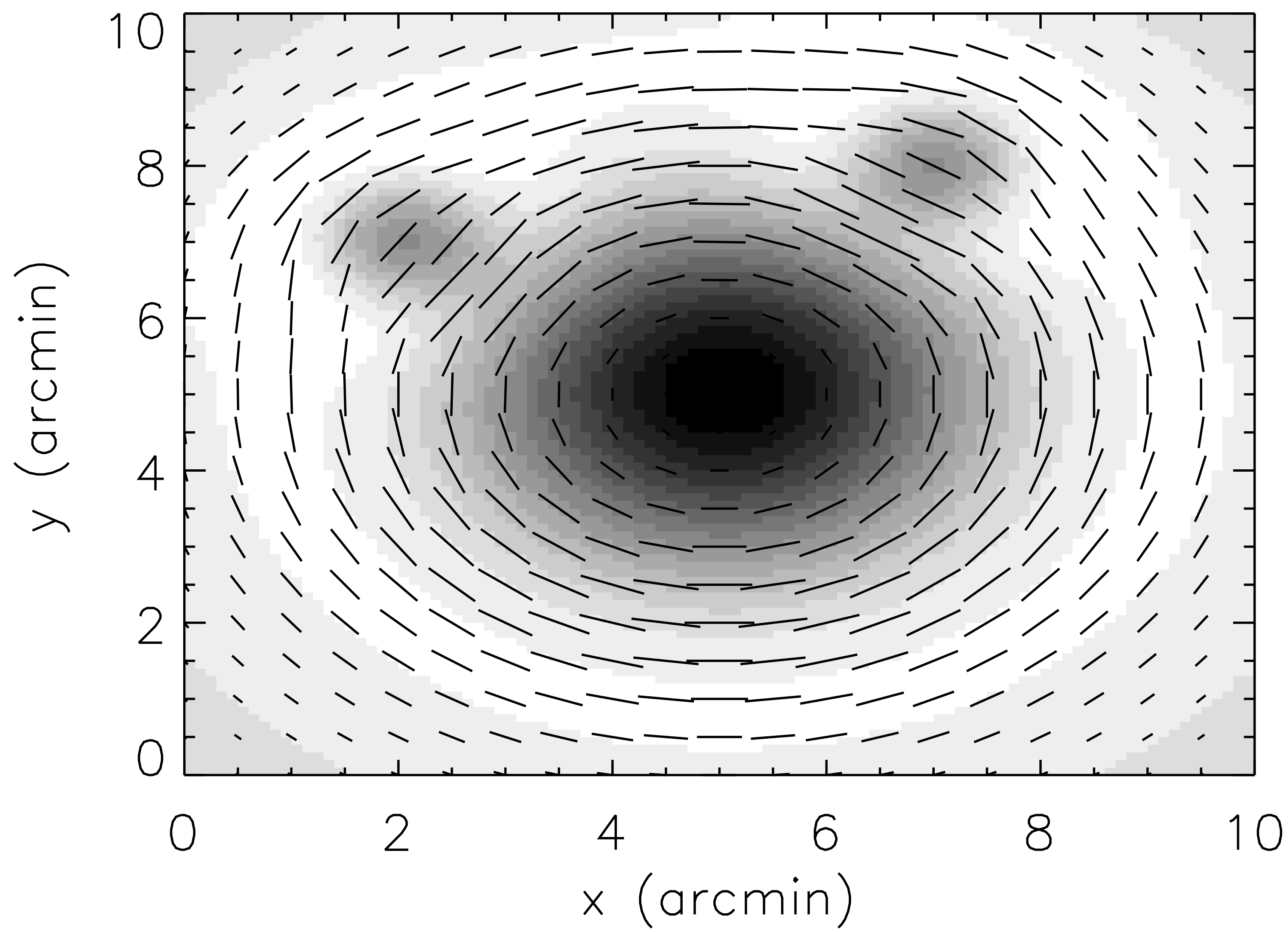
- Flexion is the *gradient* of shear
- Describes local distortions when the shear is not constant across a source image
- Adds more detail to mass reconstruction so improves e.g.
  - substructure detection (e.g. Bacon et al 2006)
  - halo shape determination (e.g. Hawken & Bridle 2009)

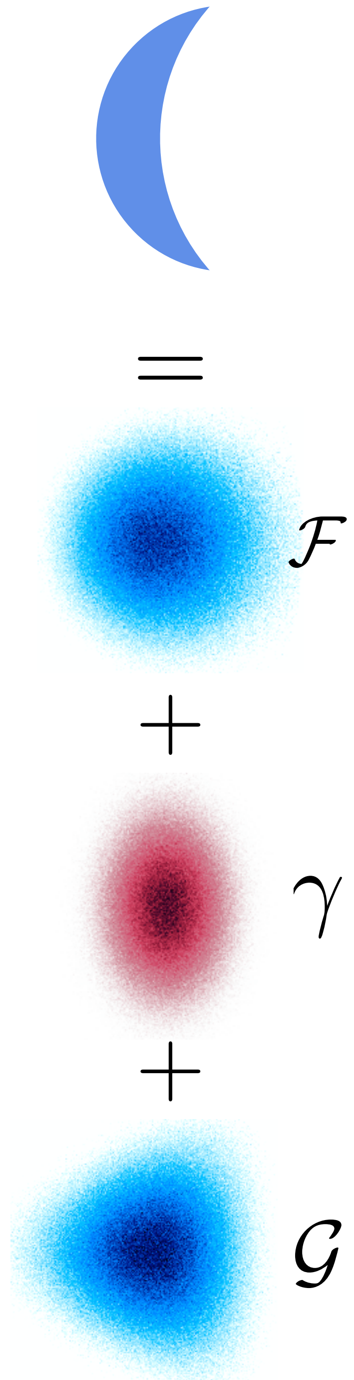
Shear



- $\mathcal{F}$: F Flexion
  γ: Shear
  $\mathcal{G}$: G Flexion
- See e.g. Goldberg & Bacon 2005, Bacon et al 2006, Massey et al 2007

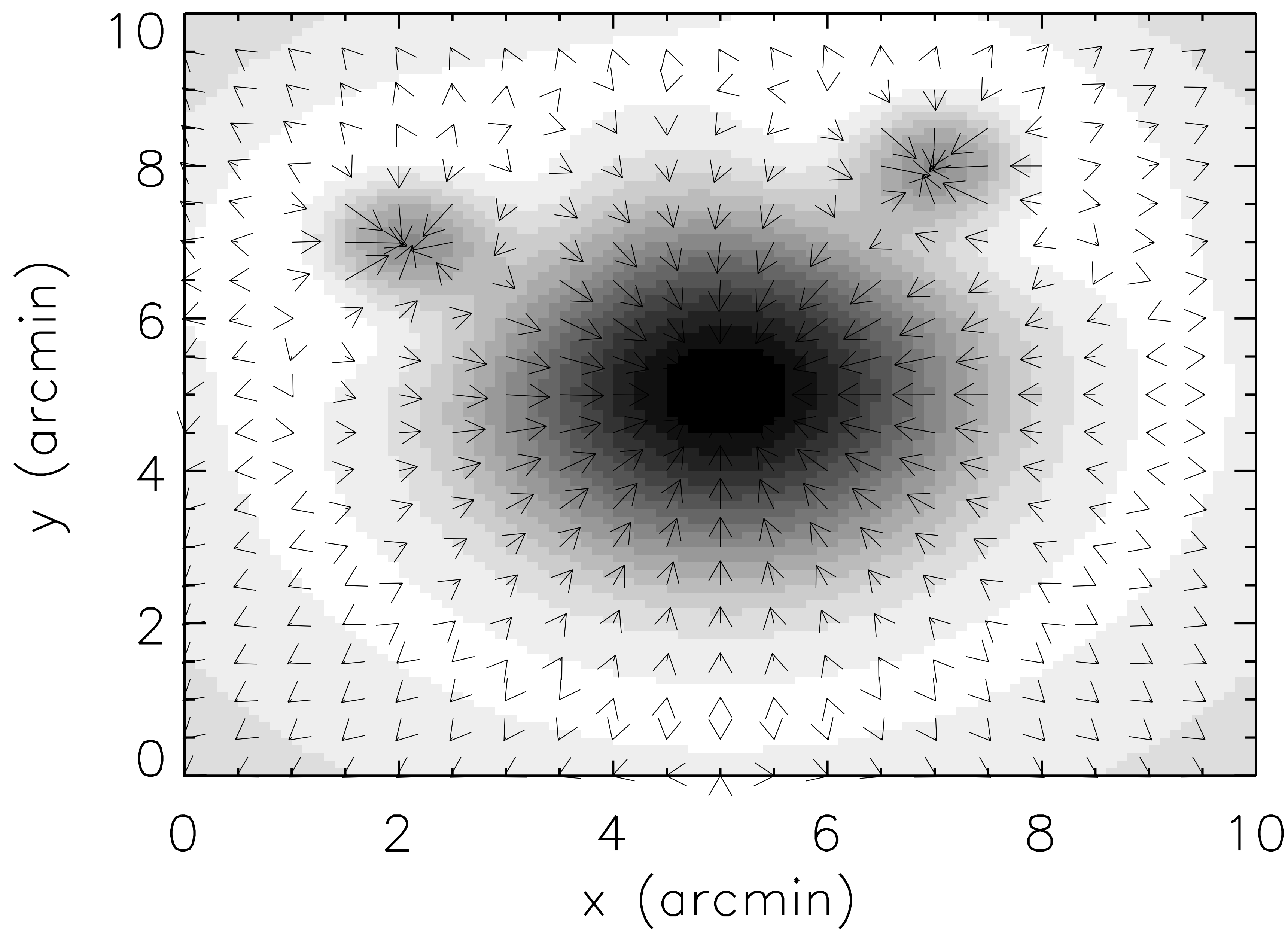
Shear

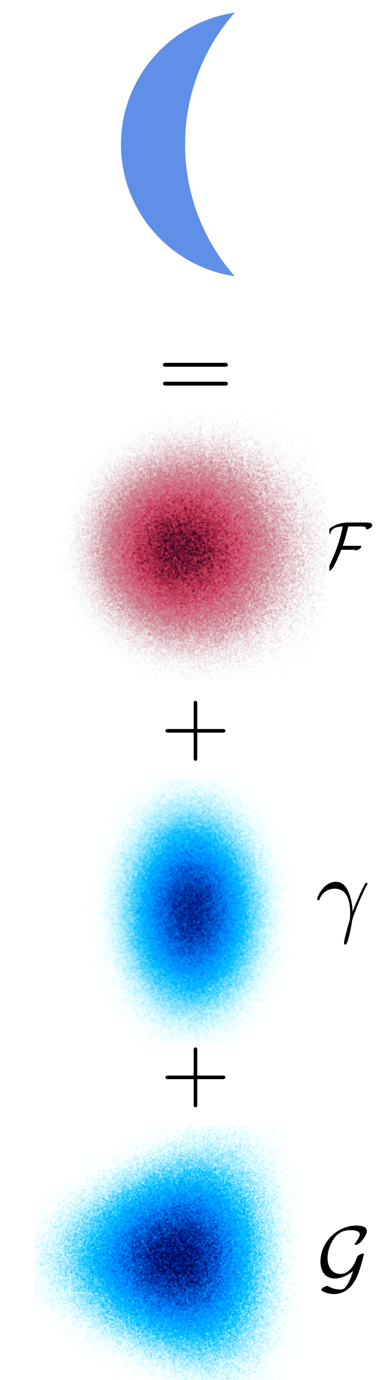




Bacon et al 2006

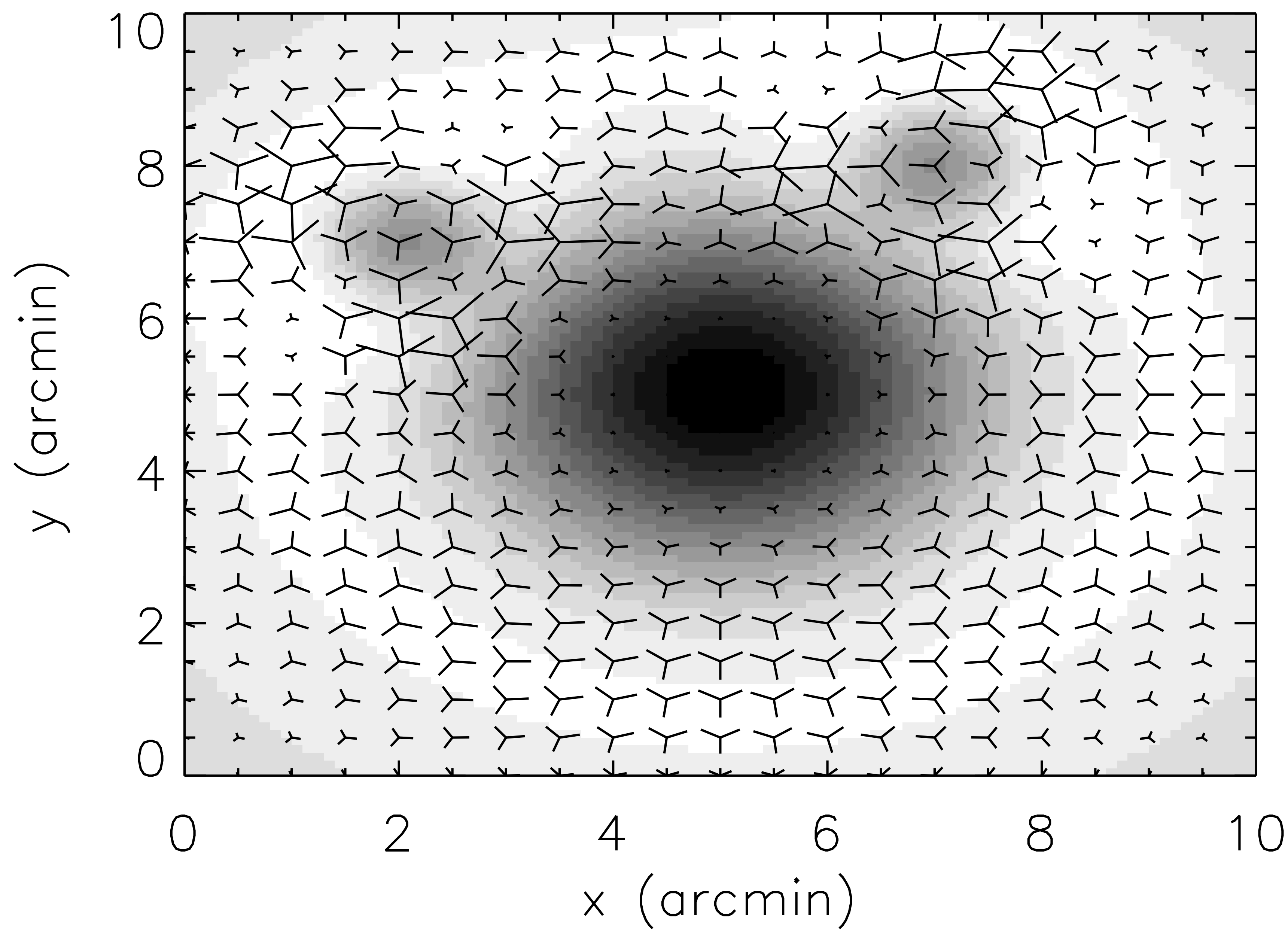
F Flexion

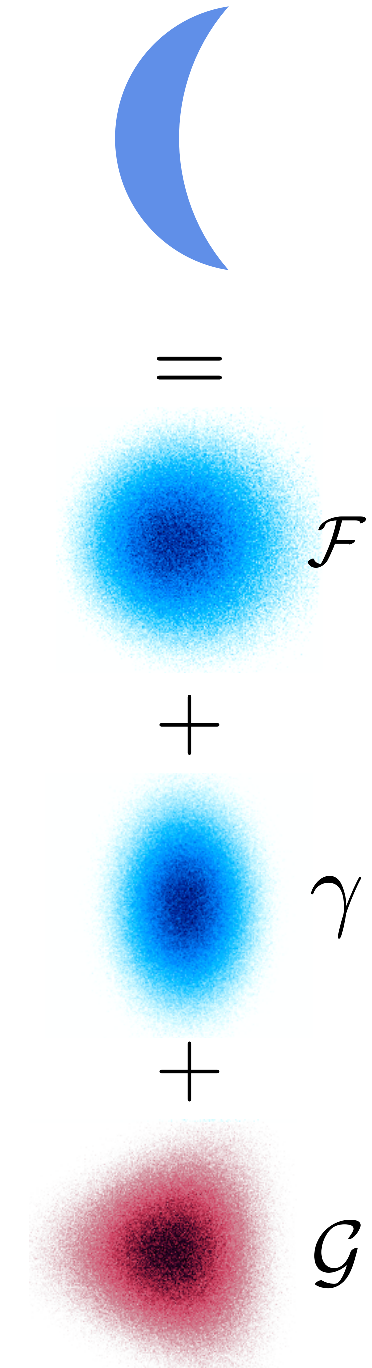




Bacon et al 2006

G Flexion

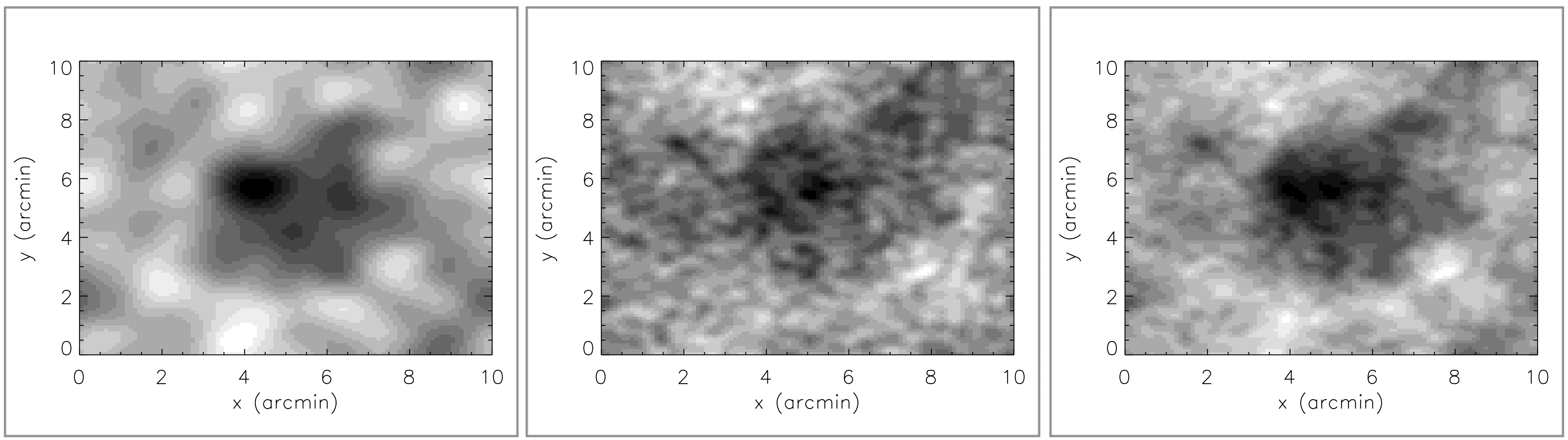




Bacon et al 2006

Mass Reconstruction

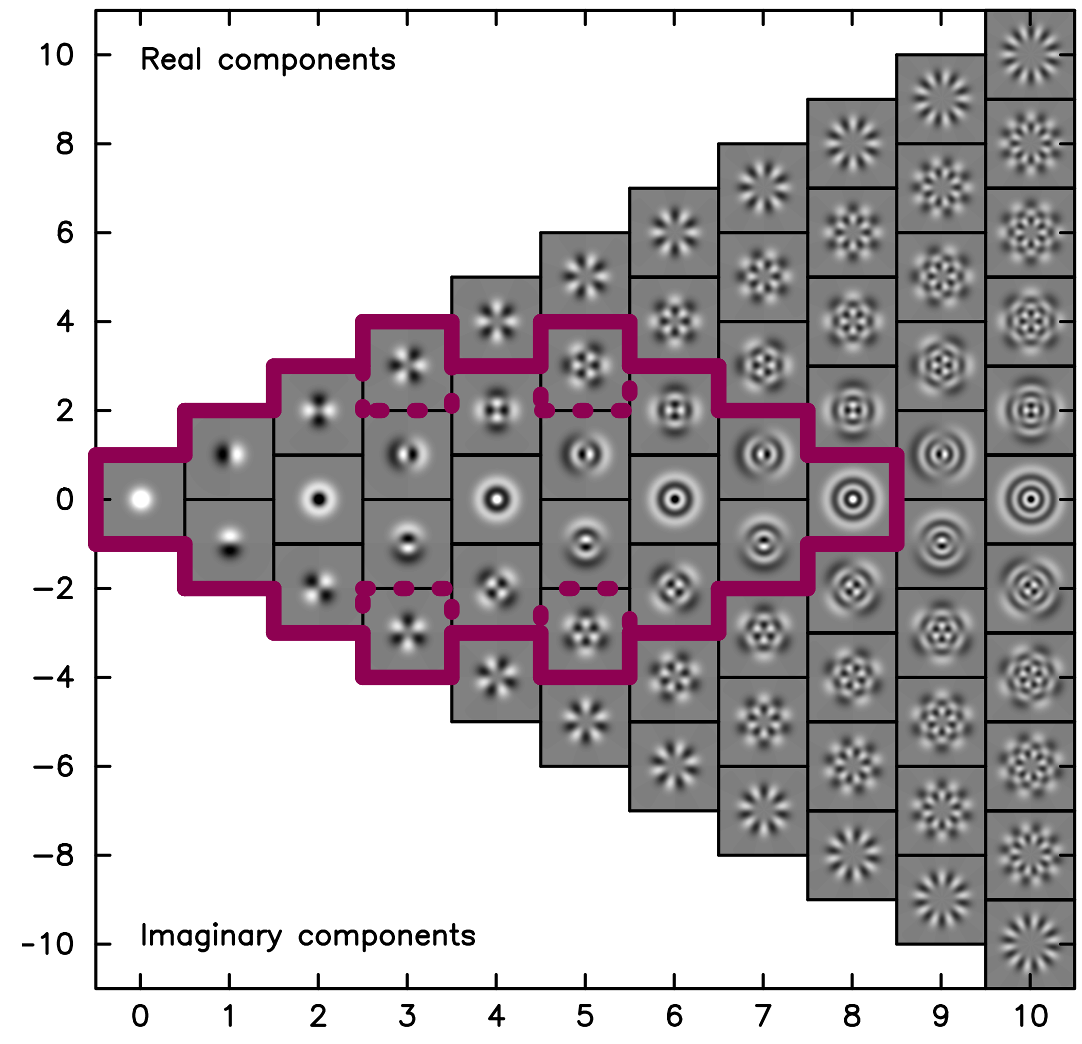
Shear only | Flexions only | Shear & Flexions



Bacon et al 2006

The MV Pipeline

- Decompose galaxy image into a series of *shapelets* (e.g. Refregier 2003, Refregier & Bacon 2003, Kuijken 2006)
- Create shapelet model of sheared and flexed galaxy
- Fit observed image to model to find amount by which it is sheared and flexed



Velander et al (in prep.)

FLASHES

- FLASHES: FLexion And SHEar Simulations
- Variations:
  - Intrinsic galaxy ellipticity
  - Galaxy profiles
  - SNR
  - PSF ellipticity

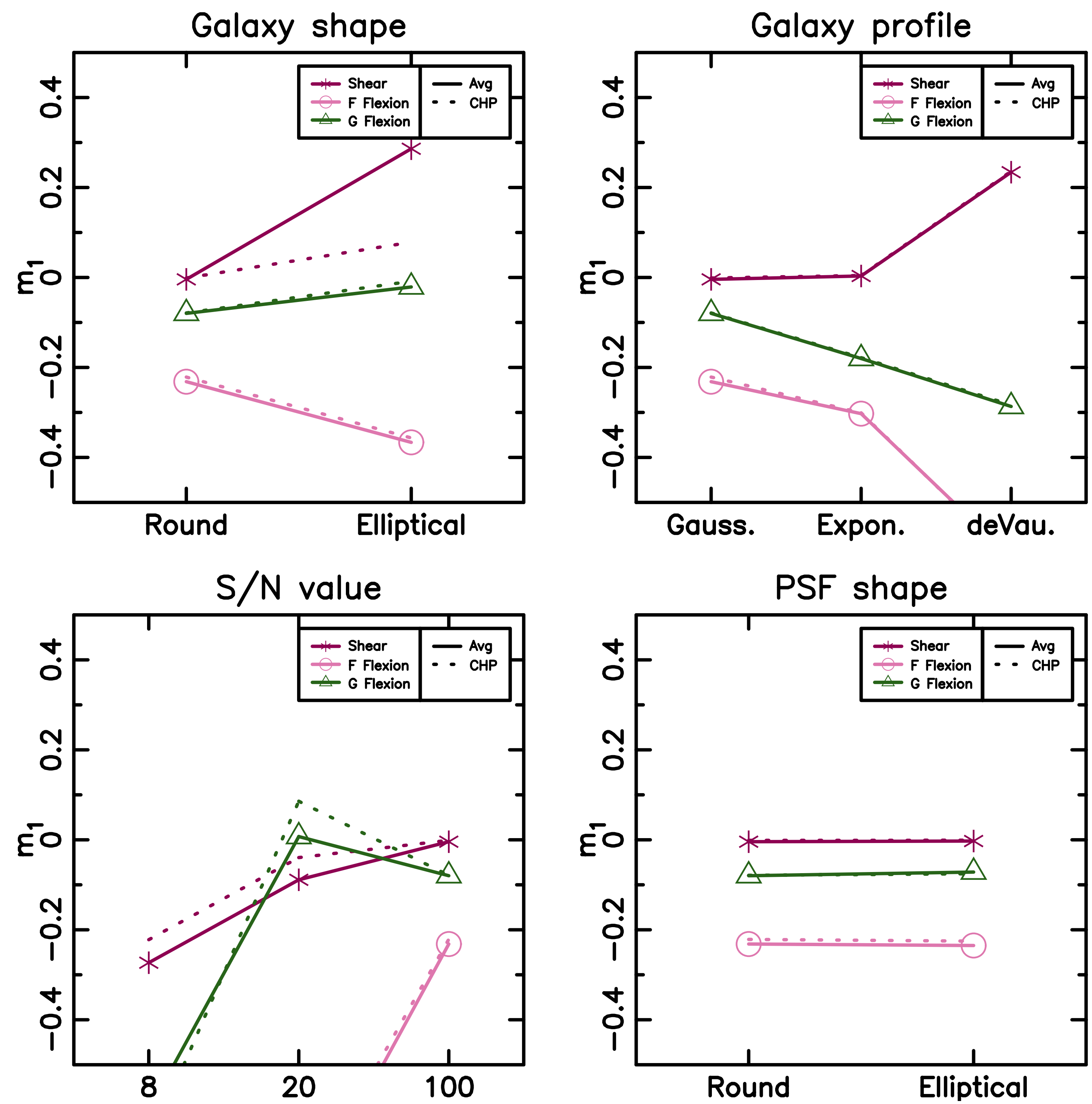
FLASHES

- STEP4/GREAT08-like
- 10000 galaxies per image
- One shear/flexion value across image
- Use STEP-parameterisation:
  - $\langle\gamma_i^{\rm measured}\rangle - \gamma_i^{\rm input} = m_i\gamma_i^{\rm input} + c_i$
  - m = multiplicative bias; c = additive bias

FLASHES Results

- Purple: shear
- Pink: F flexion
- Green: G flexion

- F flexion **underestimated** with a multiplicative bias of -0.2 at best



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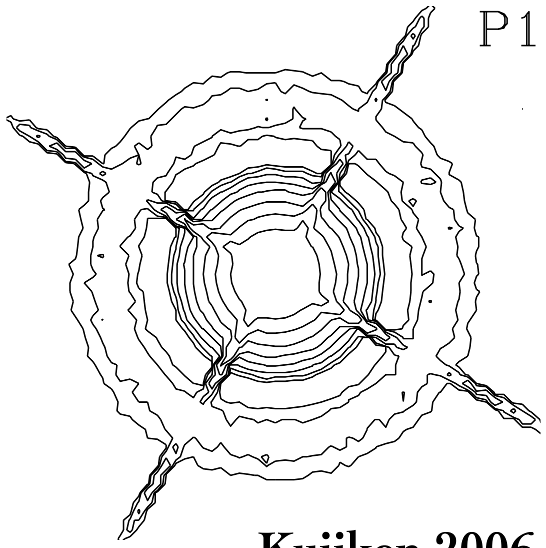
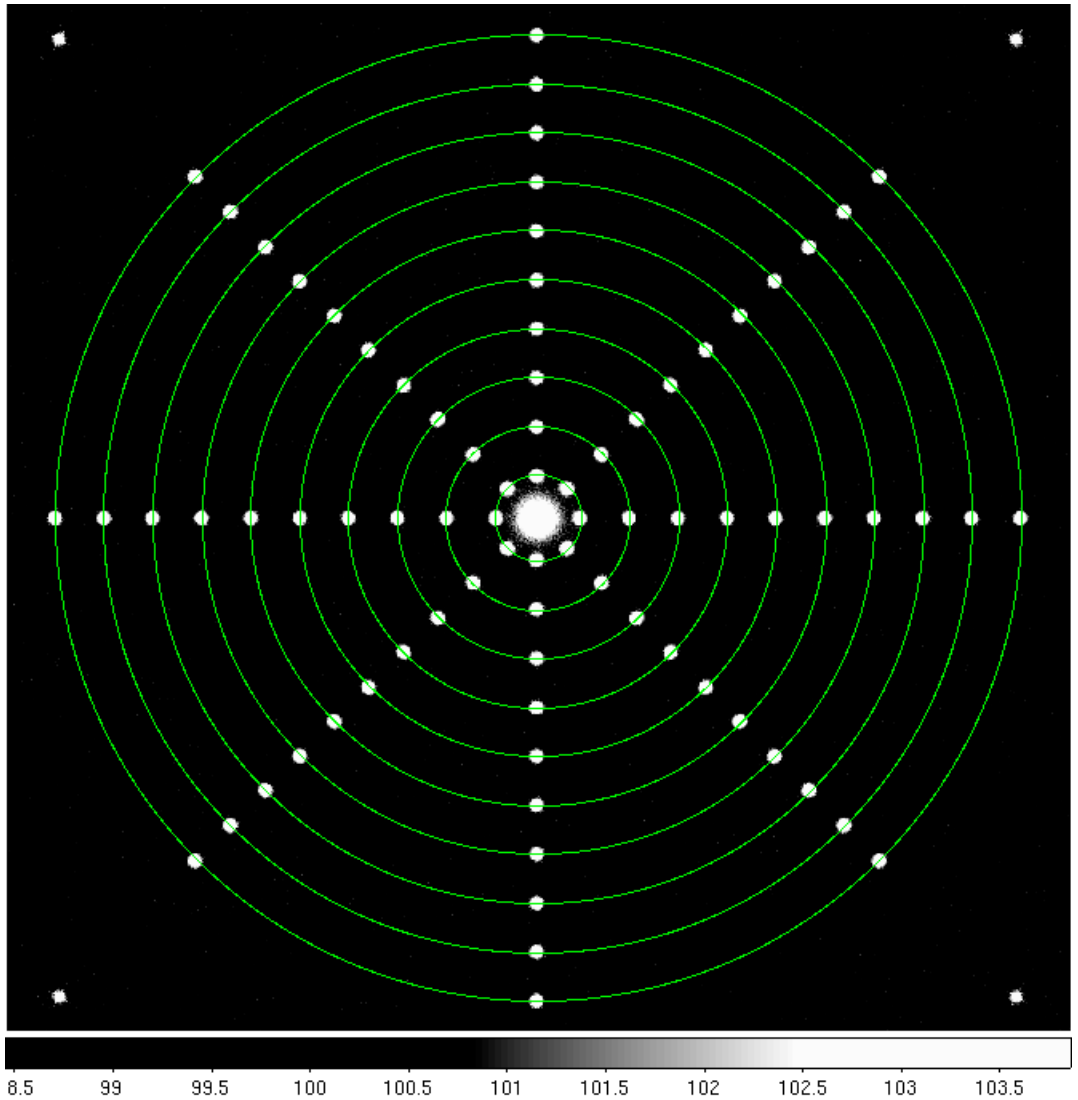
"Galaxy-galaxy" Simulations

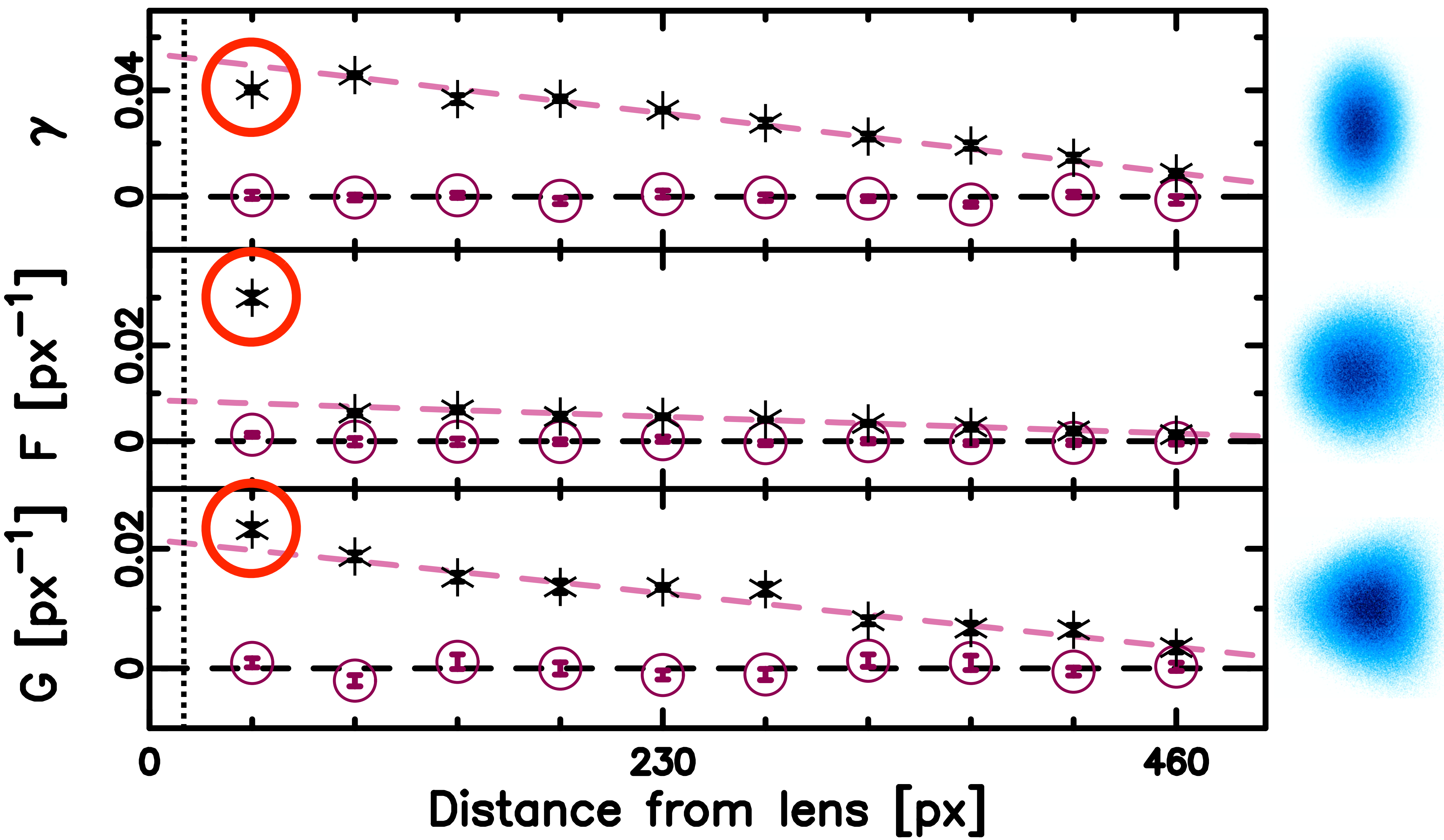


Kuijken 2006

- STEP4-like "galaxy-galaxy" simulations
- Central lens object has Sérsic index n = 1
- Gaussian sources placed in rings at evenly spaced distances from center
- SNR ~200
- PSF: Pseudo-Airy with 10% spikes



GG Simulation Results

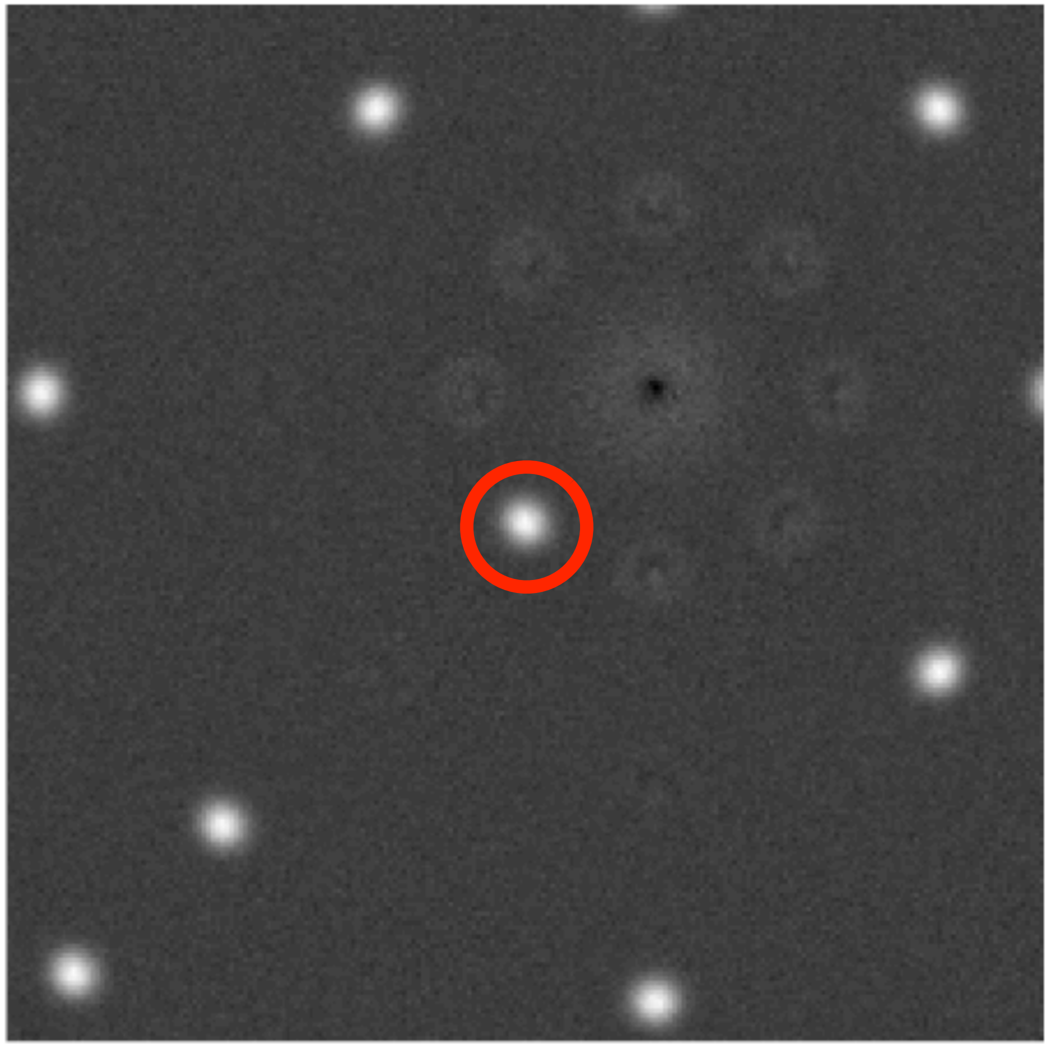


Light from nearby bright objects strongly affects the lensing signal!

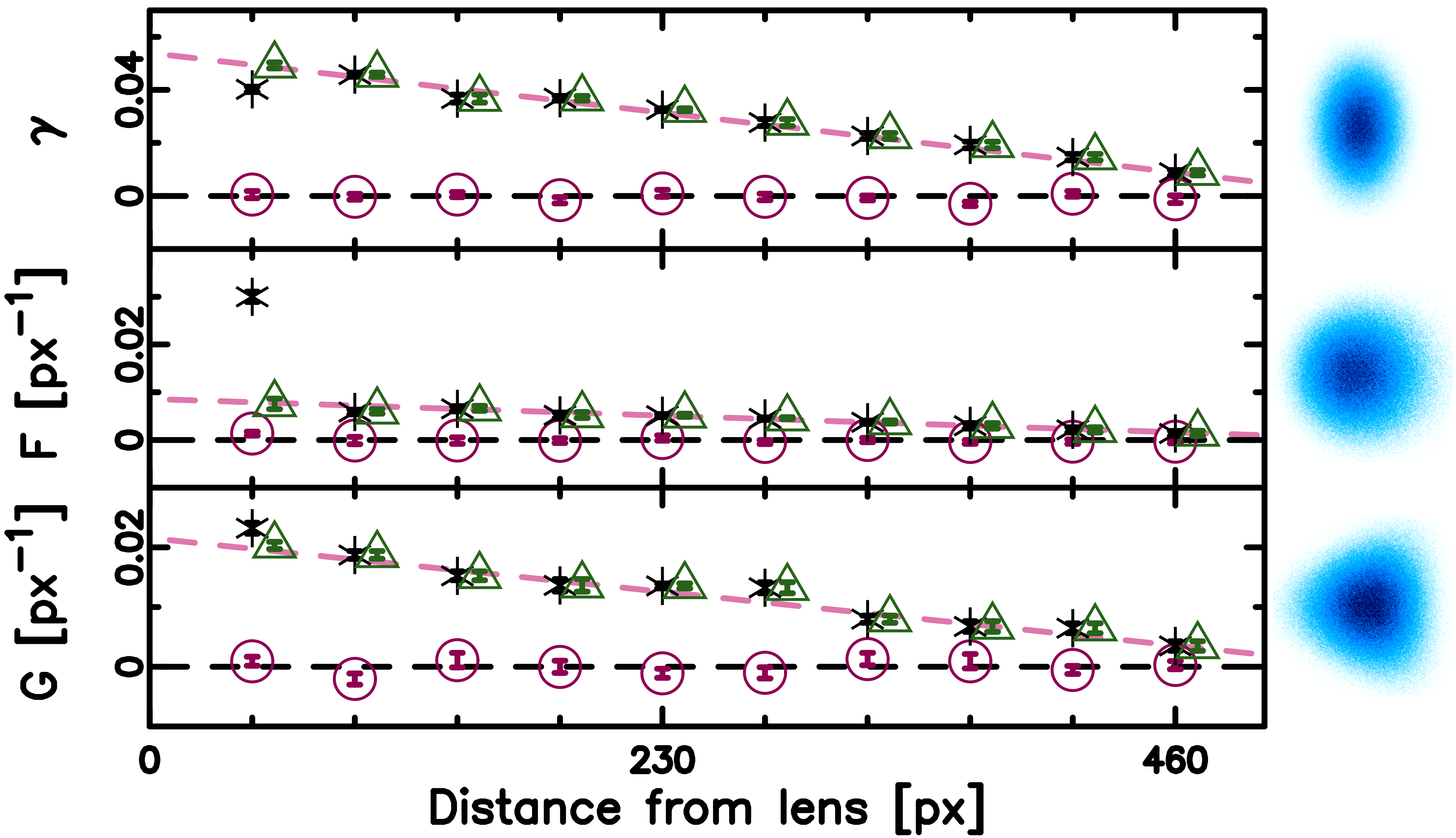
Velander et al. (in prep.)

Bright Object Removal

- Create Sérsic model of nearby object
- Subtract model from source postage stamp
- Remove nearby objects depending on brightness and distance from source



GG Simulation Corrected Results



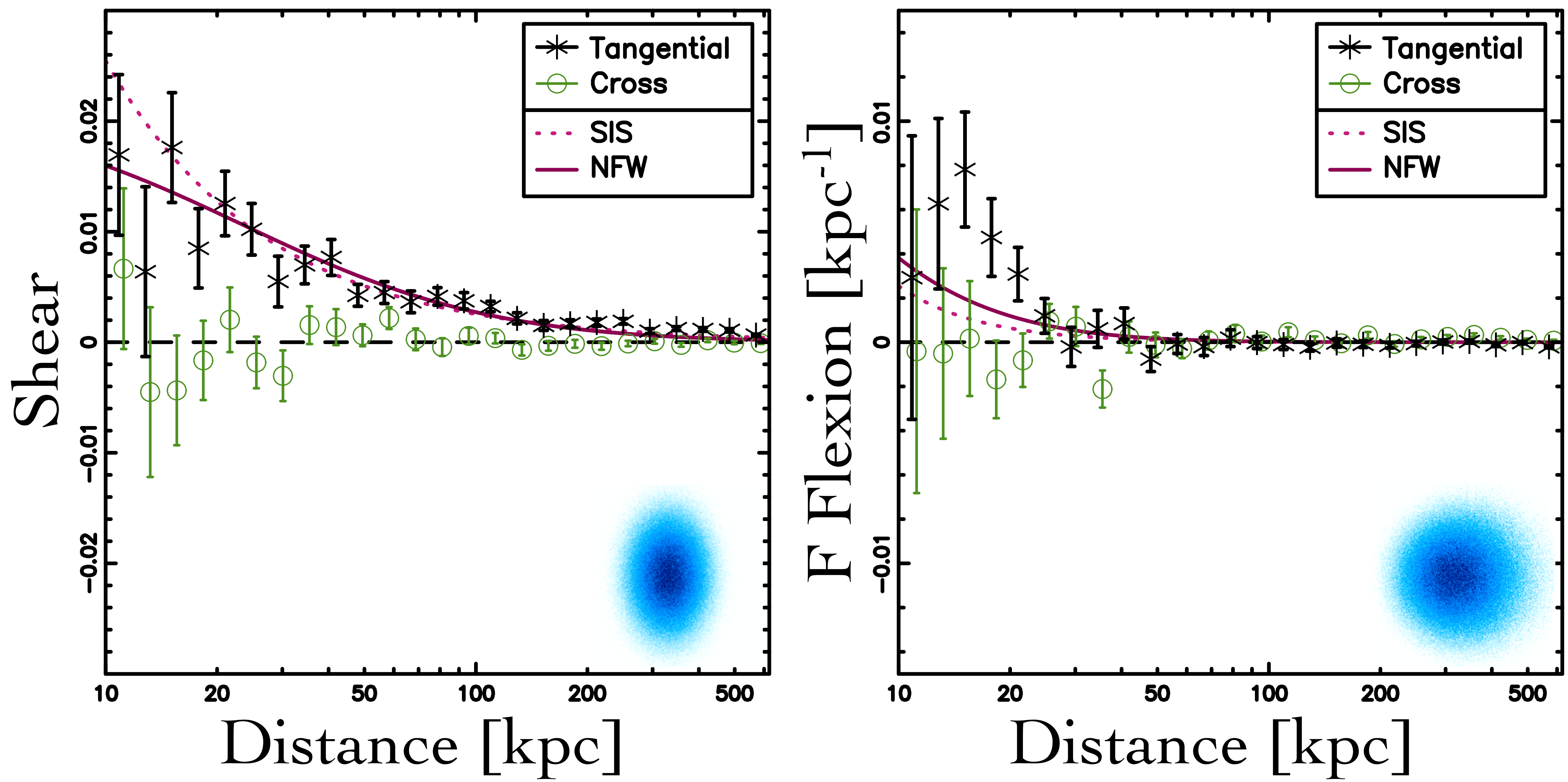
Velander et al (in prep.)

COSMOS Analysis

- Shear/flexion from MV pipeline
- Parametric CTI correction as in Schrabback et al 2010
- PSF correction done using PCA as in Schrabback
- Photo-z's from Ilbert et al 2009
- Galaxy-galaxy signal

COSMOS Results

Velander et al (in prep.)



...and the G Flexion

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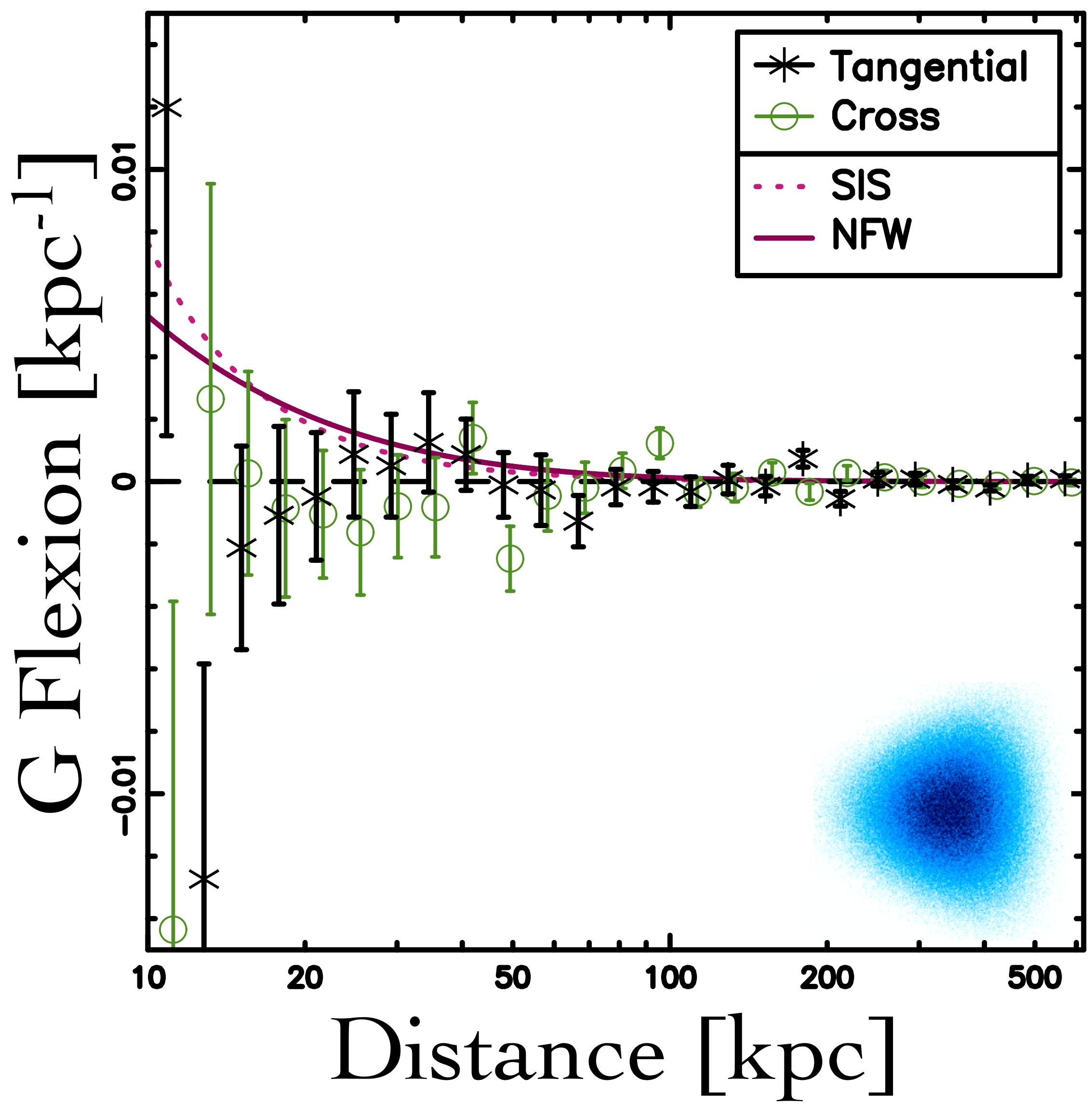
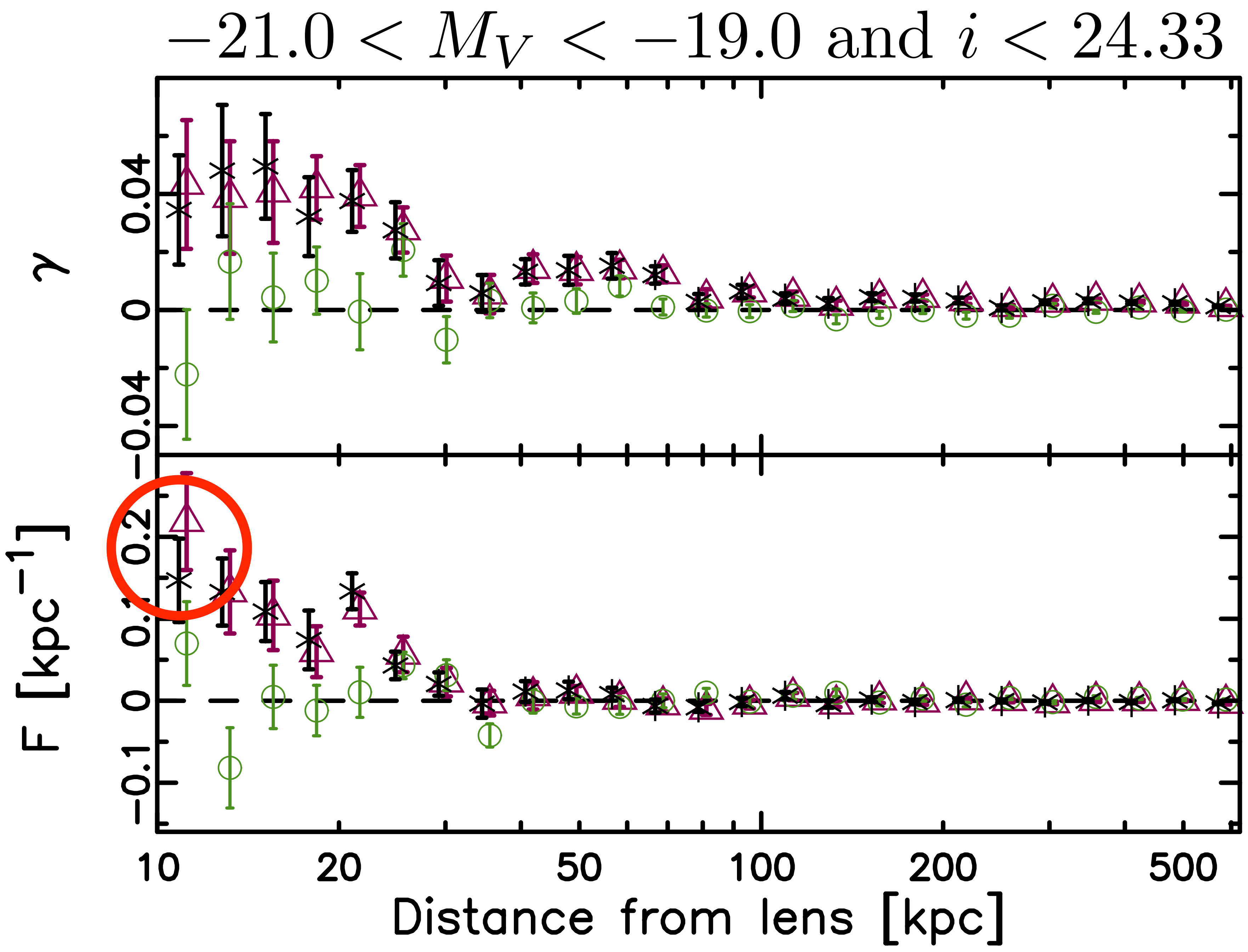


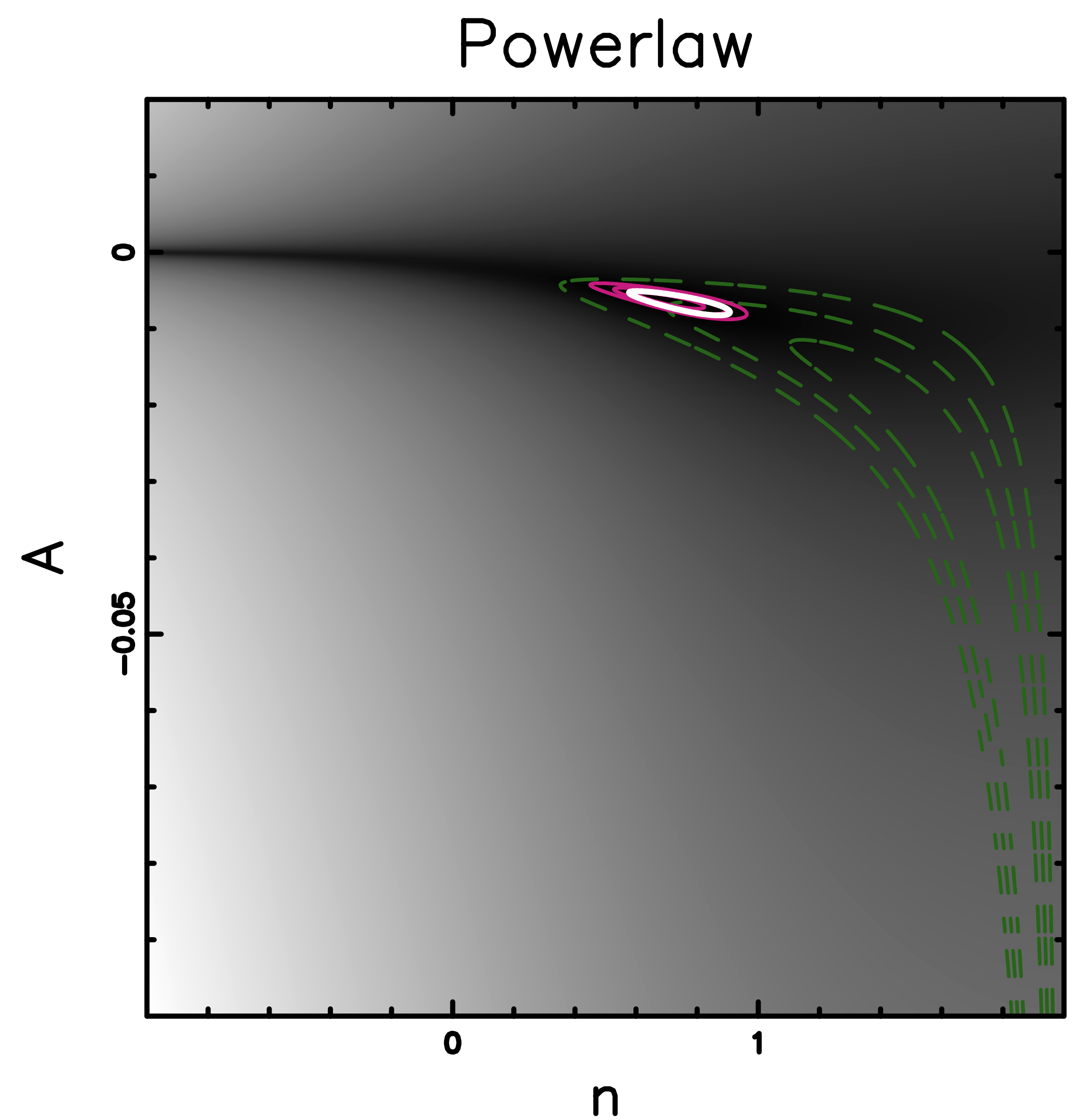
BOR Effect



Velander et al (in prep.)

Powerlaw Constraints

- Fit powerlaw to signals
  - $\gamma = -Ad^{-n}$
  - $\mathcal{F} = (n-2)Ad^{-n-1}$
- Purple: shear (1-3σ)
- Green: F flexion (1-3σ)
- White: combined 3σ
- Prefer $n < 1$



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Summary

- Flexion adds crucial information to halo shape measurements and substructure detection
- Galaxy-galaxy flexion has been detected in COSMOS but is still noisy and seems overestimated compared to shear
  - Could also indicate shear underestimation
- In future, try ground-based larger datasets (CFHTLS, RCS2, KiDS...)