How to achieve the best-ever cosmological constraints from weak lensing

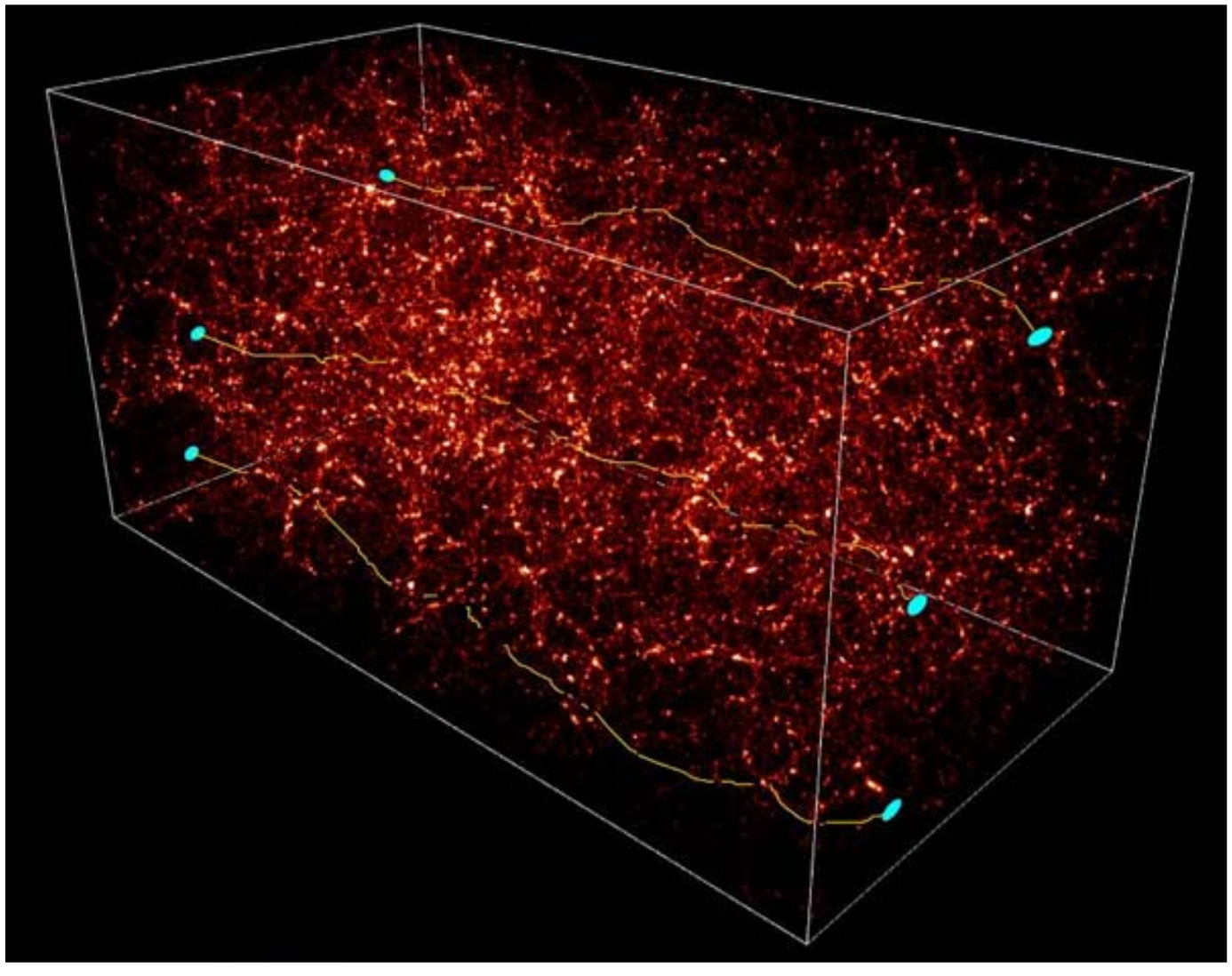

Image: S Colombi (IAP), CFHT

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Institute for Astronomy

University of Edinburgh

with

Catherine Heymans

Alan Heavens

Tom Kitching

Michael Brown (IoA, Cambridge)

CFHTLenS

Weak lensing and cosmic shear

For weak lensing regime, $|\gamma| \ll 1$, and observed ellipticity ~ intrinsic ellipticity + shear:

$$\epsilon_i \simeq \epsilon_i^s + \gamma(\theta_i)$$

Shear correlation functions:

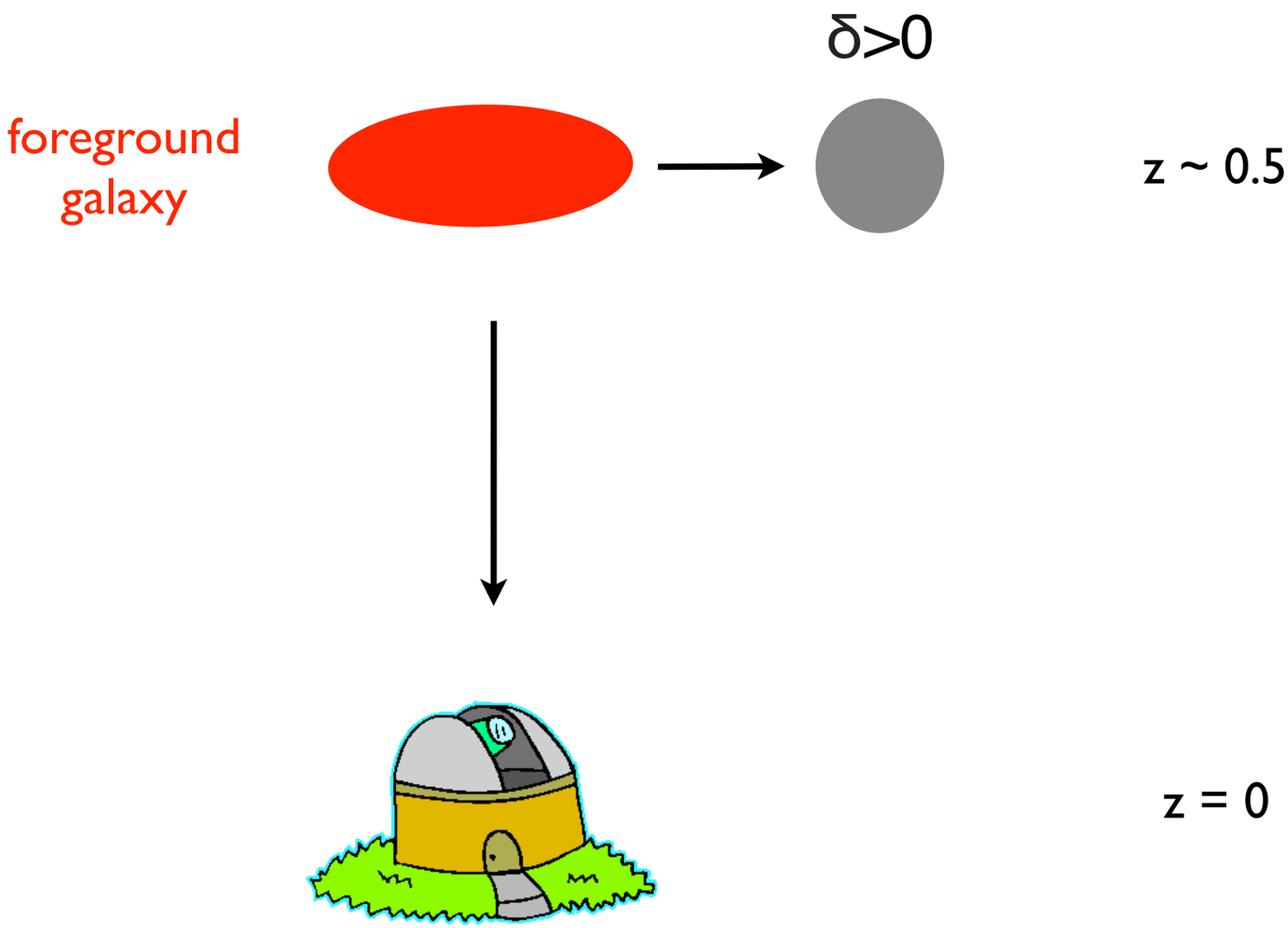
$$\xi_\pm = \langle \gamma_\mathrm{t}\gamma_\mathrm{t} \rangle \pm \langle \gamma_\mathrm{x}\gamma_\mathrm{x} \rangle$$

We measure:

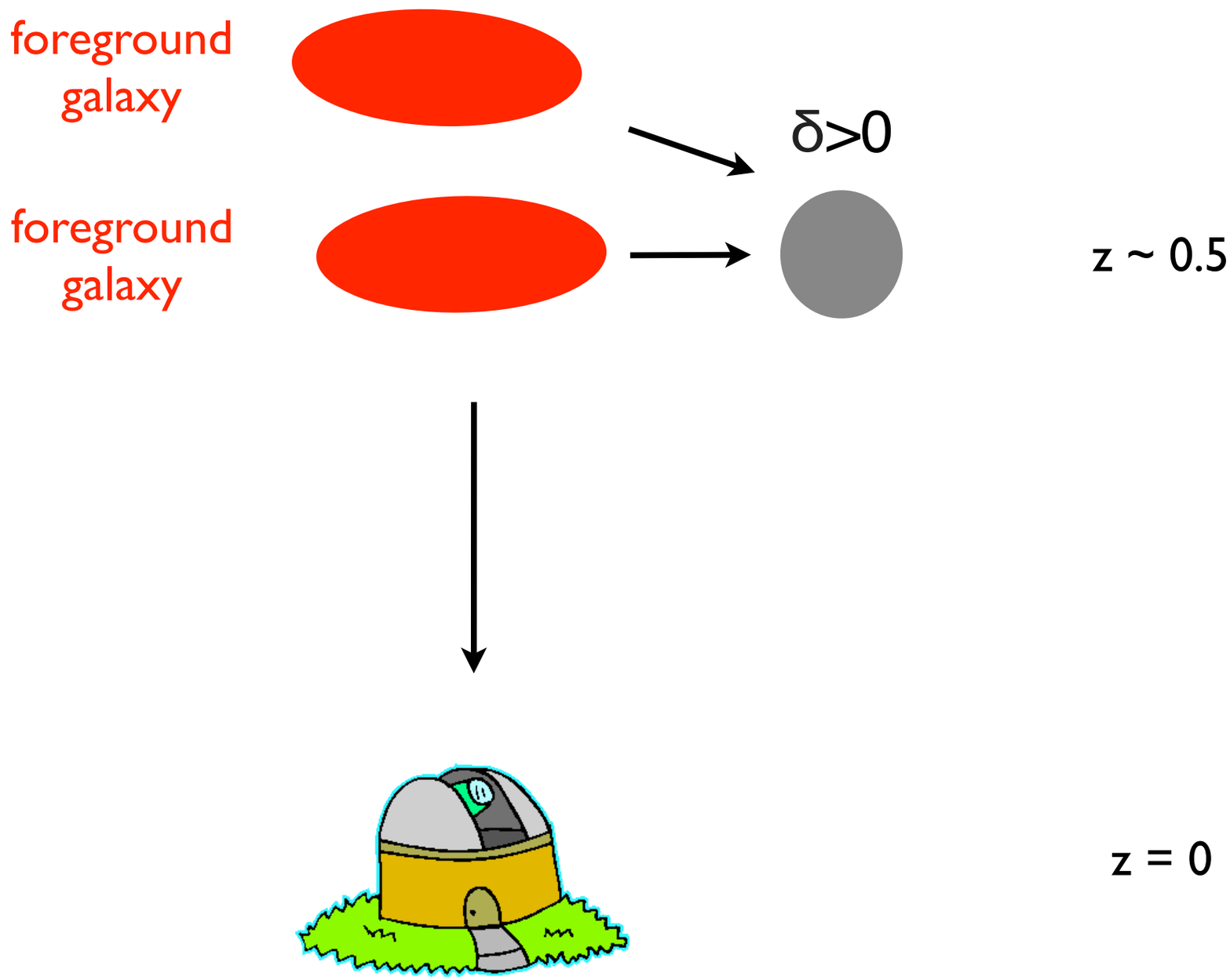
$$\langle \epsilon_i \epsilon_j^* \rangle = \underbrace{\langle \gamma_i \gamma_j^* \rangle}_{\mathrm{GG}} + \underbrace{\langle \epsilon_i^\mathrm{S} \epsilon_j^{\mathrm{S}*} \rangle}_{\mathrm{II}} + \underbrace{\langle \gamma_i \epsilon_j^{\mathrm{S}*} + \epsilon_i^\mathrm{S} \gamma_j^* \rangle}_{\mathrm{GI}}$$

and we can measure shear by measuring galaxy shapes over different angular scales!

Intrinsic-Intrinsic (II)



Intrinsic-Intrinsic (II)

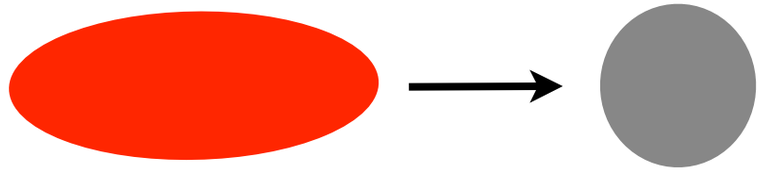


Gravitational-Intrinsic (GI)

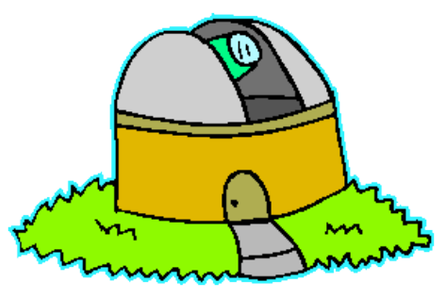
z ~ 1.0

δ>0

foreground galaxy

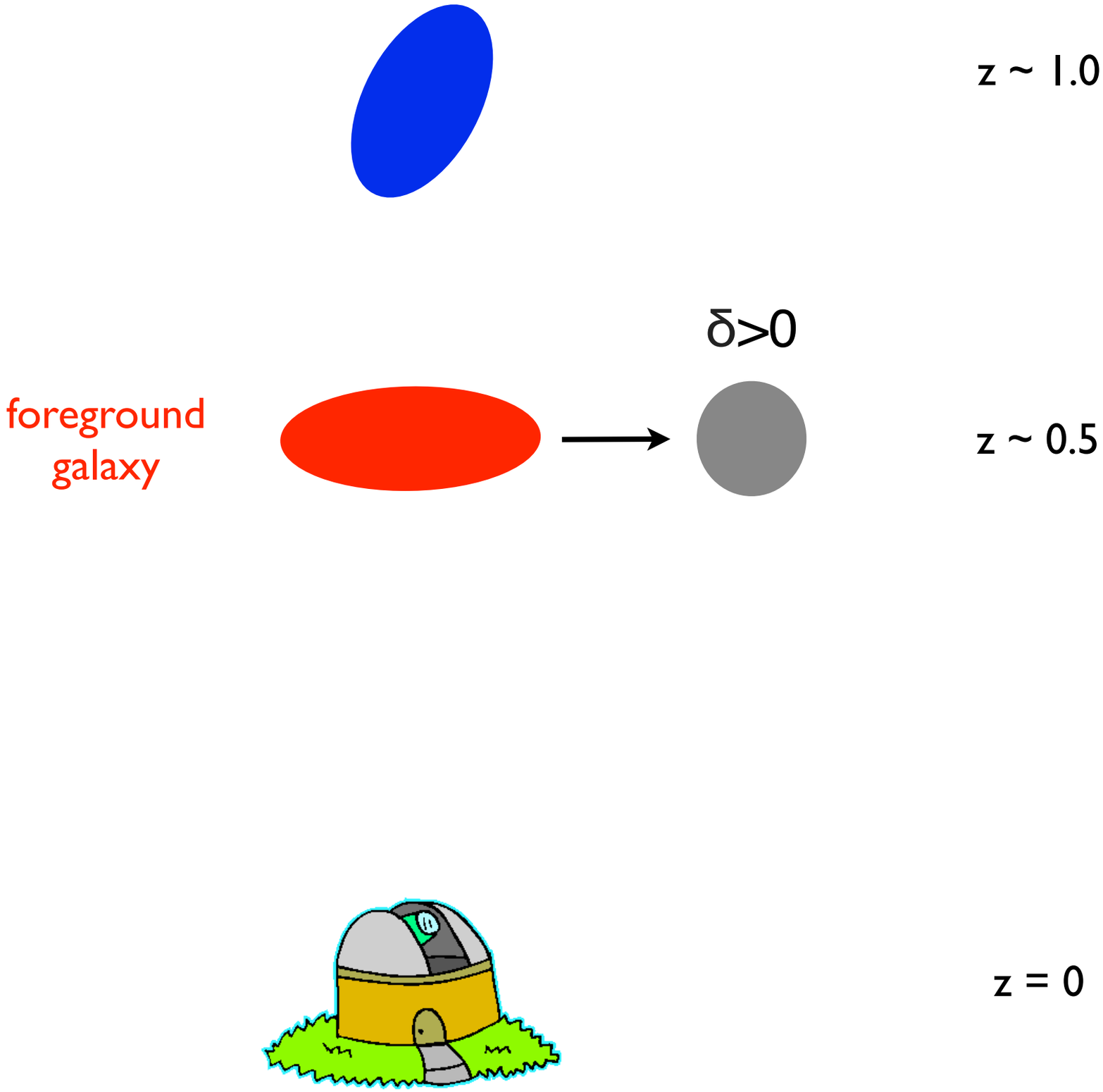


z ~ 0.5



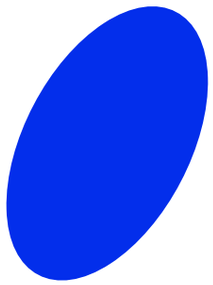
z = 0

Gravitational-Intrinsic (GI)



Gravitational-Intrinsic (GI)

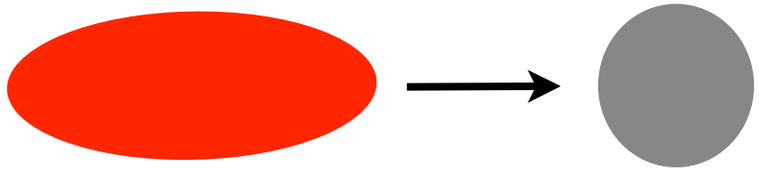
background galaxy



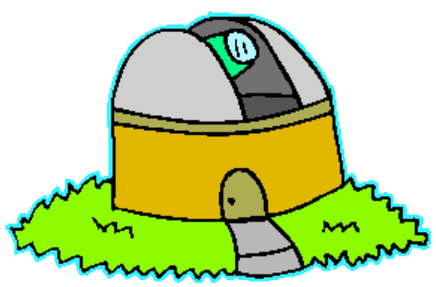
z ~ 1.0

δ>0

foreground galaxy



z ~ 0.5



z = 0

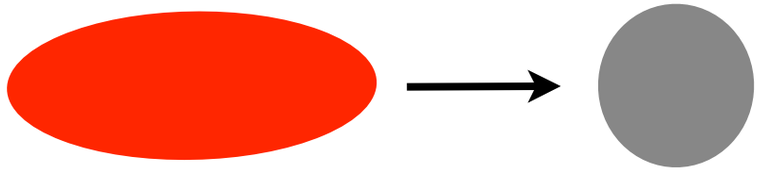
Gravitational-Intrinsic (GI)

background galaxy

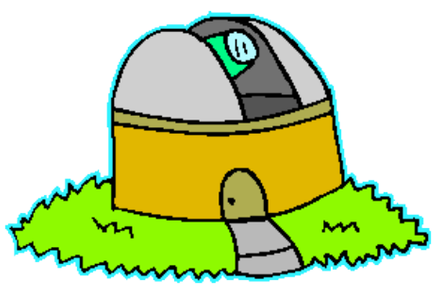
z ~ 1.0

δ>0

foreground galaxy



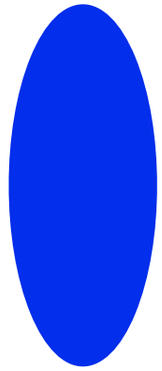
z ~ 0.5



z = 0

Gravitational-Intrinsic (GI)

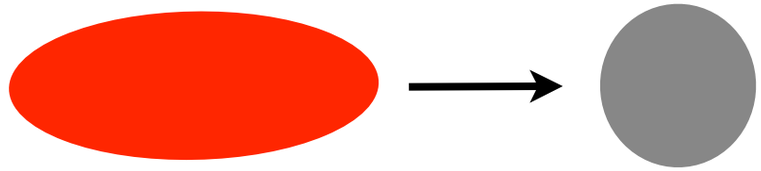
background galaxy



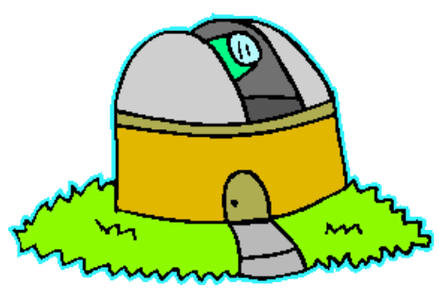
z ~ 1.0

δ>0

foreground galaxy



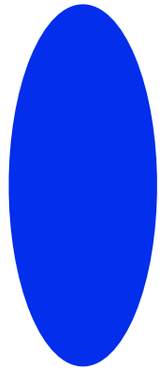
z ~ 0.5



z = 0

Gravitational-Intrinsic (GI)

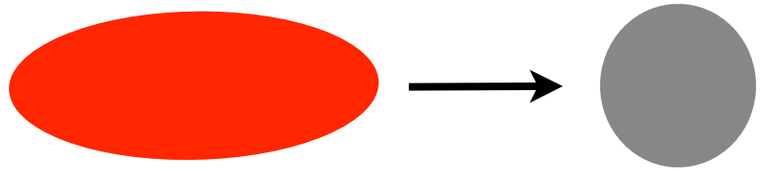
background galaxy



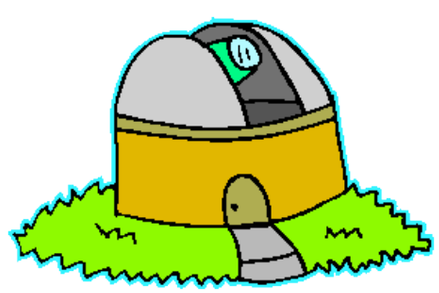
z ~ 1.0

δ>0

foreground galaxy



z ~ 0.5



z = 0

Tomography and Photometric Redshift Errors

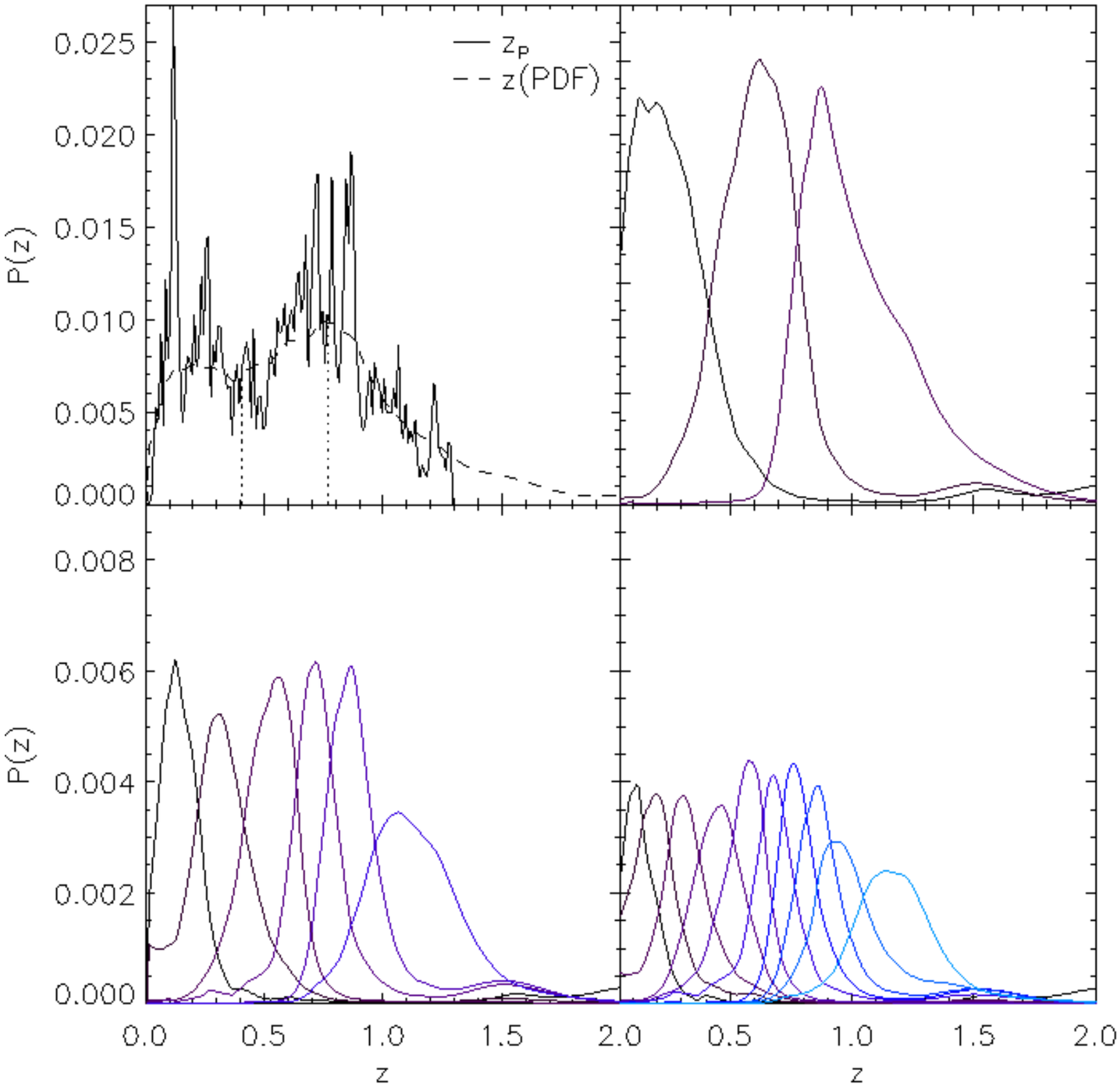
Tomography = binning by redshift

- Can help remove contamination from intrinsic alignments.
- 10 x tighter constraint on Ω_Λ (for 4-bin tomography, Simon et al. 2004).

Photo-zs

- Routinely available for every survey galaxy, use subsample of spec-z measurements for calibration.
- Typical scatter of $\Delta z \sim 0.1$ plus catastrophic outliers which can degrade parameter constraints.
- When combined with intrinsic alignments, photo-z errors could have a devastating effect on parameter constraints if not correctly accounted for.

Photometric Redshift Errors



Grocutt et al. 2012 in prep

Simulations

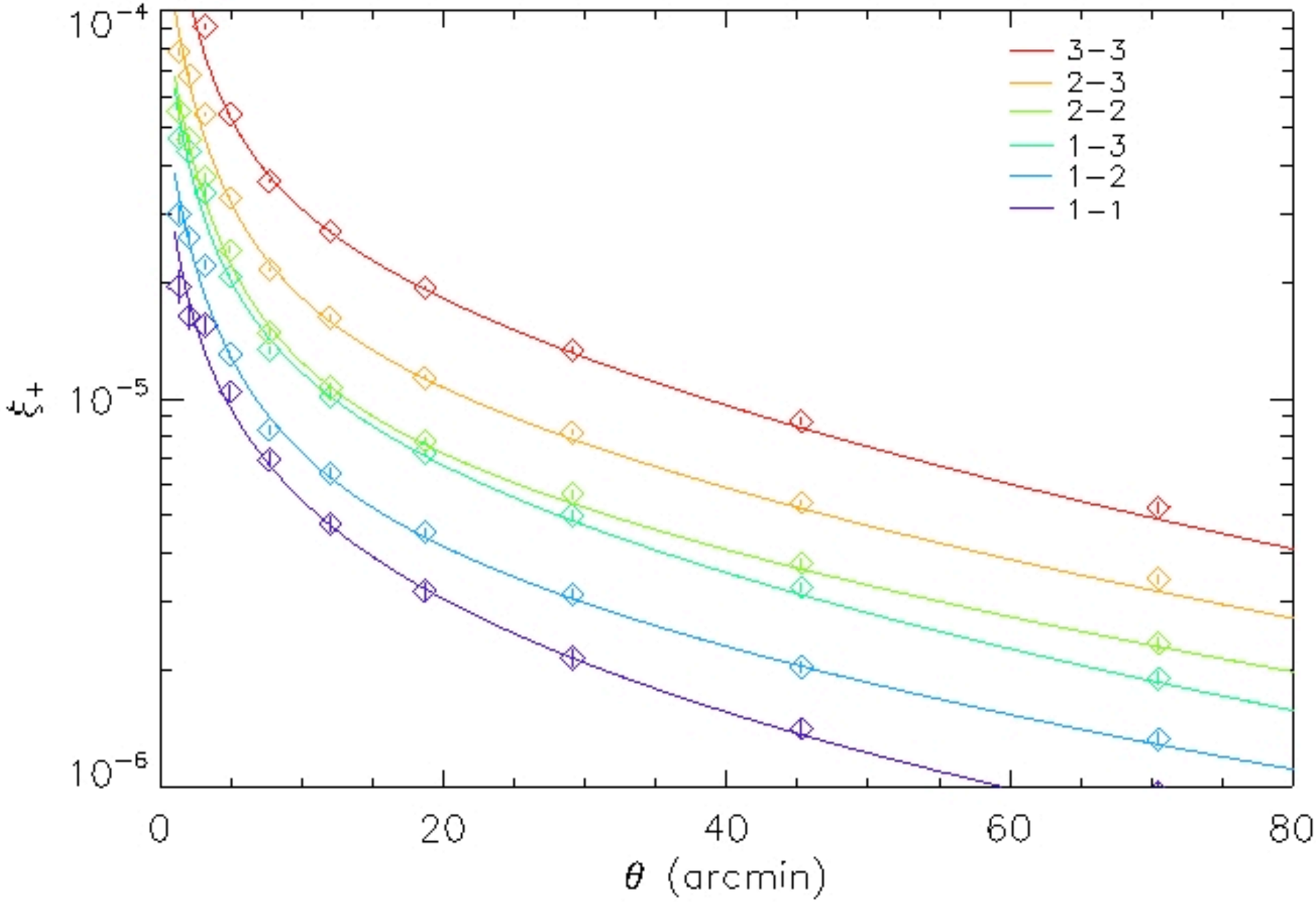
- Aim: find optimal tomographic and angular bin combination to minimise size of $\Omega_m - \sigma_8$ contour.
- Gaussian shear simulations of Brown & Battye 2011.
- 1600 semi-independent lines of sight of 18.2 sq. deg.
- Theoretically motivated linear alignment model (Hirata & Seljak 2004), with non linear power spectrum.
- Using n(z) and galaxy density from CFHTLenS.
- WMAP 7 cosmological priors.
- Shear and IA fields for $1 < n_{\rm tomo} < 10$ tomographic bin combinations, measuring ξ_+ over $3 < n_\theta < 15$ angular scales.

Likelihood Analysis

- Using publicly-available *nicaea* code[1] to extract shear correlation functions.
- MCMC algorithm used to find likelihood contours.
- Running over GG, and GG+II+GI case to see if optimisation varies.
- Investigating effect of incorrect n(z) and of ignoring intrinsic alignments.
- Incorporates full, scaled covariance matrix estimated from all lines of sight (Schneider et al. 2002, Hartlap et al. 2007).
- Constraining $\Omega_m, \sigma_8, h_0, w_0$ and A (amplitude of the alignment model).

[1] Martin Kilbinger, http://www2.iap.fr/users/kilbinge/athena/

Simulated correlation functions



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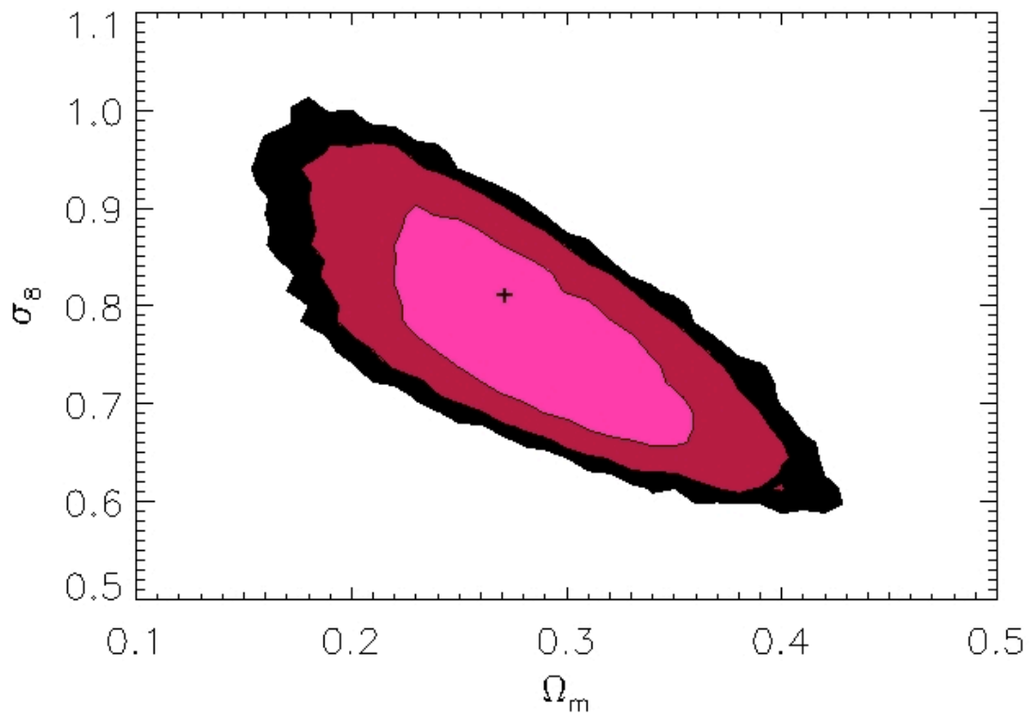
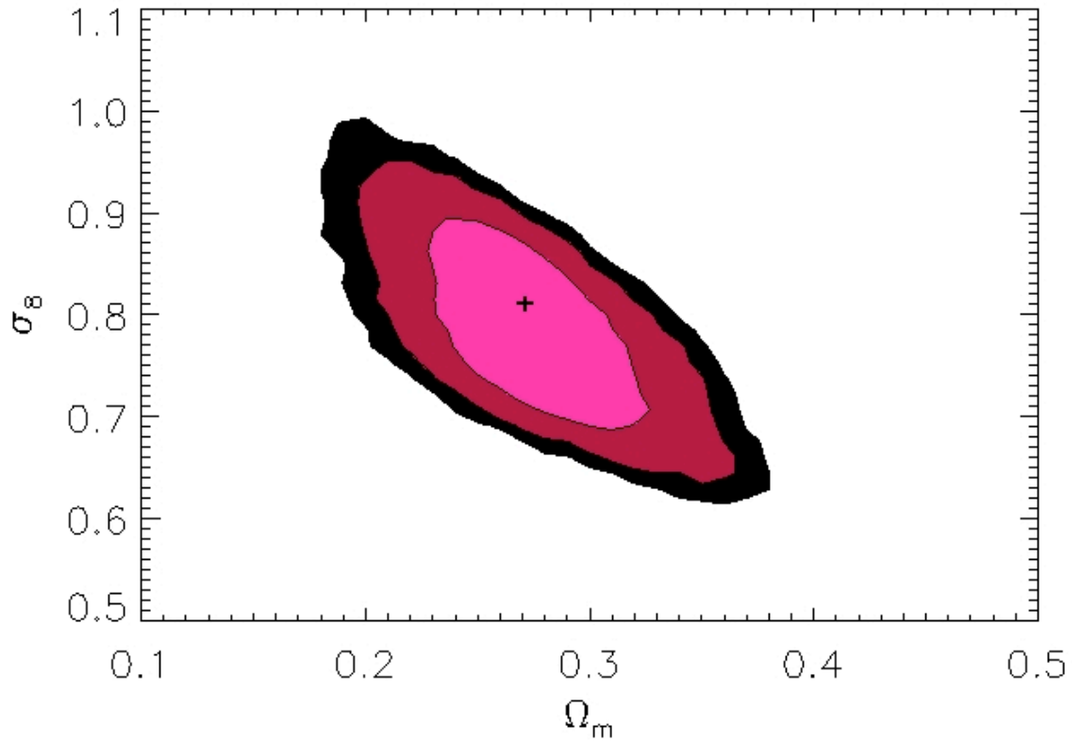
Results

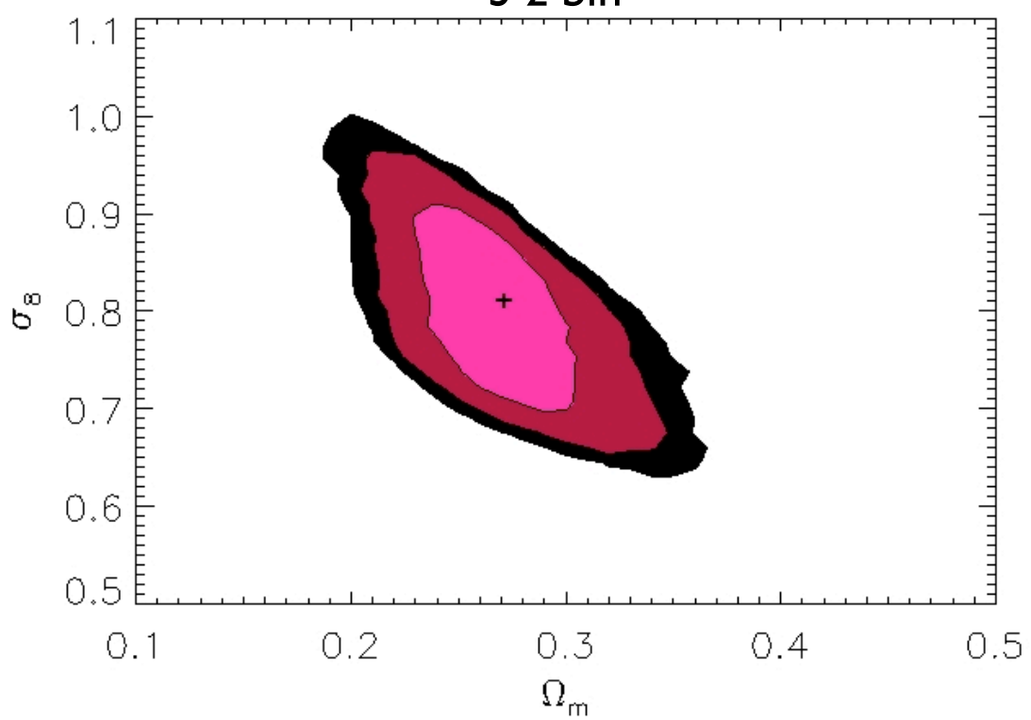
1 z bin



2 z bin



3 z bin

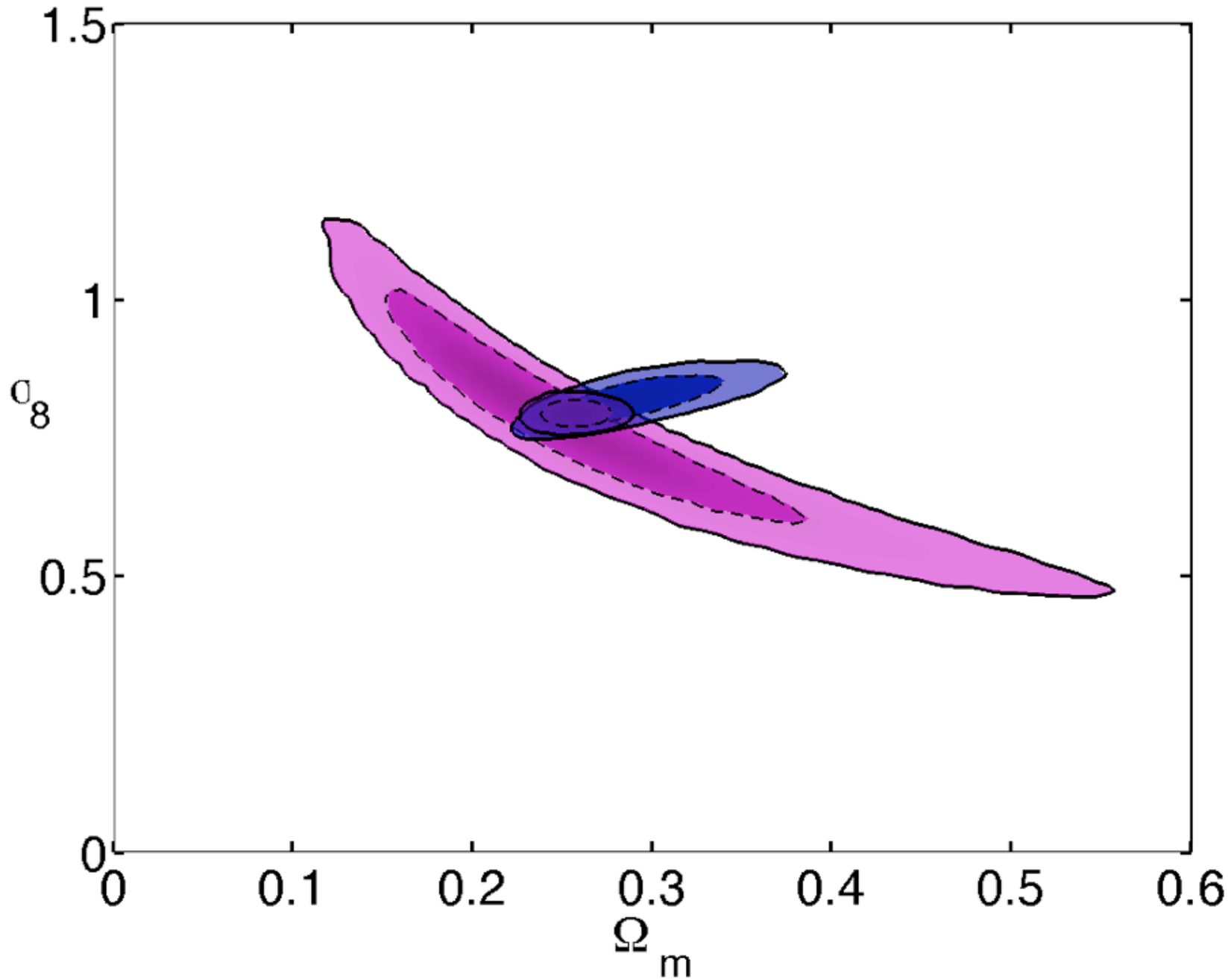


ξ_+ measured between $5' \leq \theta \leq 85'$

$n_\theta = 3$

Grocutt et al. 2012 in prep

CFHTLenS 2-bin tomography



Thank you