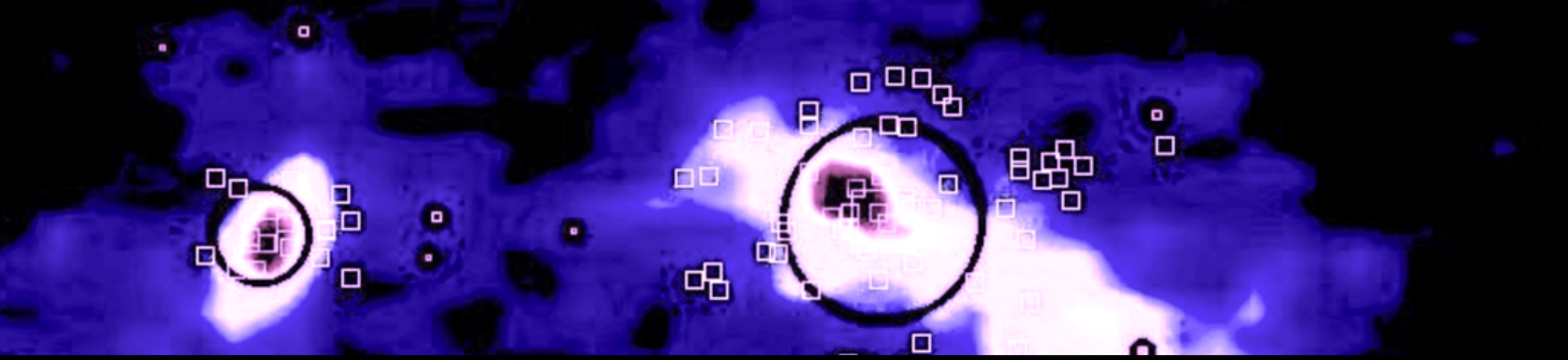


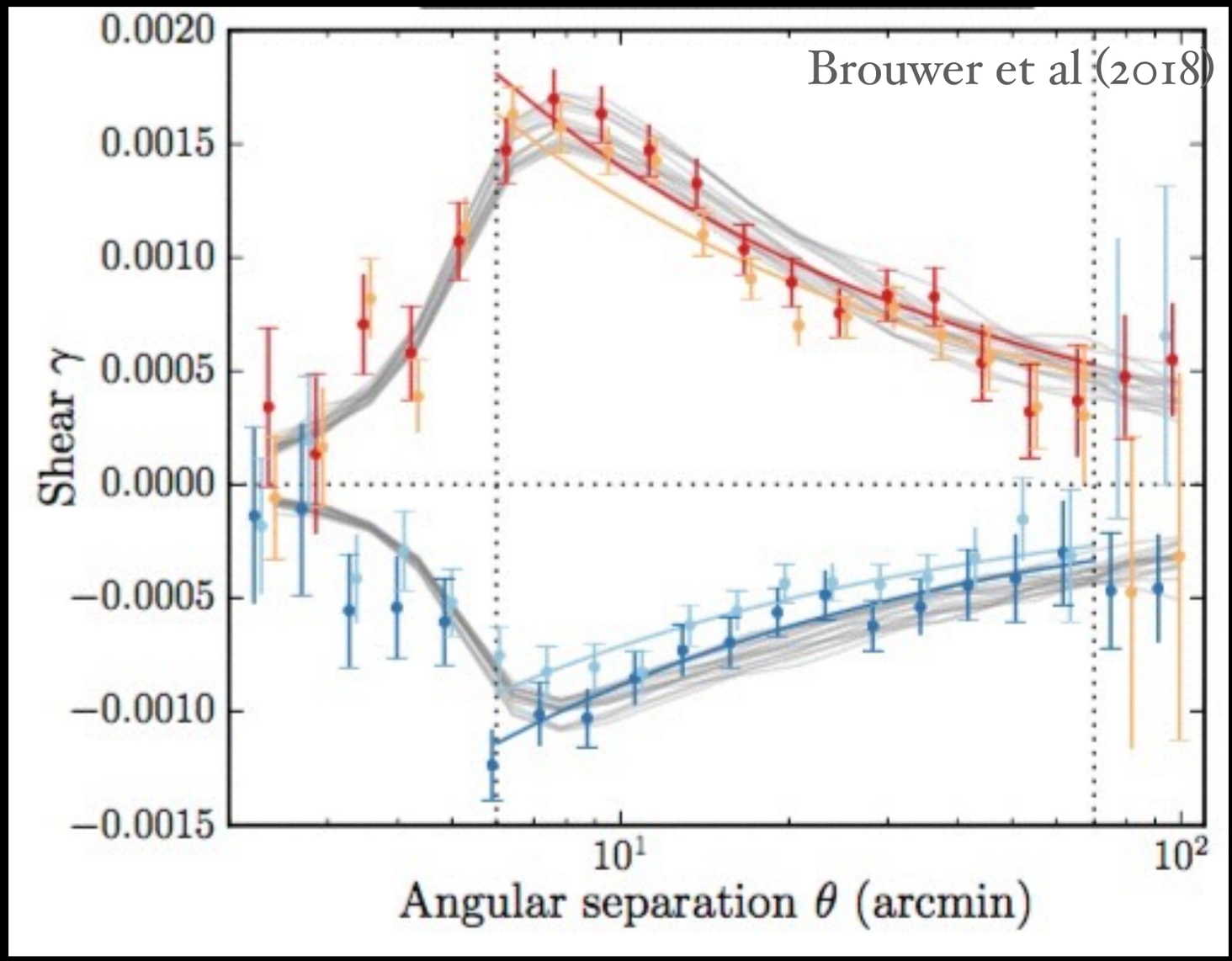
Weak lensing beyond 2-point statistics

Joachim Harnois-Déraps, University of Edinburgh

Accurate lensing in the era of precision cosmology, BCCP

European Research Council

Density Split Lensing



Get optimal! Ask more from the same data!

Get optimal! Ask more from the same data!

Get optimal! Ask more from the same data!

Need to investigate the same systematic effects as 2PCF:

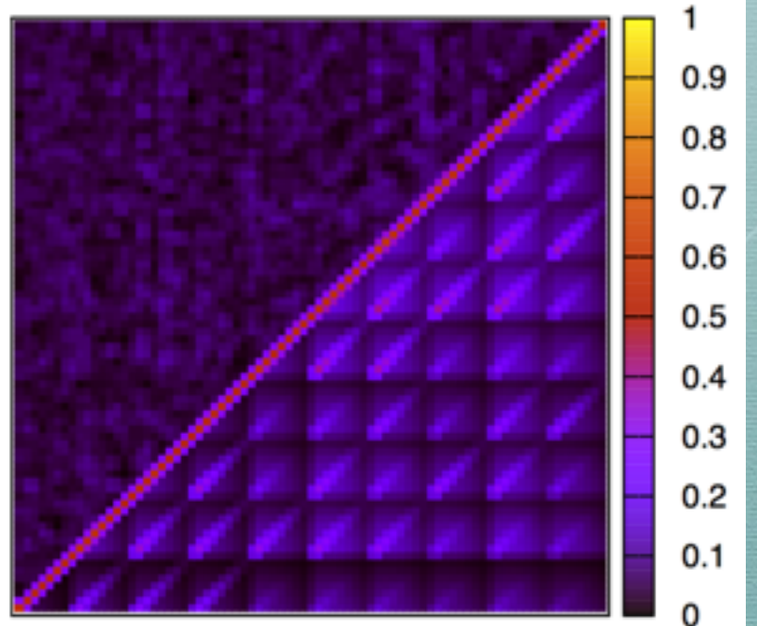
IA, baryons, masks, non-linearities, etc. (plus more?)

Analytical predictions partially or non-available for estimators beyond 2-points statistics

Analytical predictions partially or non-available for estimators beyond 2-points statistics

Also true for covariance

$$\chi^2_{\rm data} = \sum_{bb'} (\mathcal{C}_b^{\rm obs} - \mathcal{C}_b^{\rm model})[{\rm Cov}]^{-1}(\mathcal{C}_{b'}^{\rm obs} - \mathcal{C}_{b'}^{\rm model})$$



Science Goal

* Enable the extraction of weak lensing information beyond 2-point statistics
* Provide **public** weak lensing simulations that vary with cosmology

Needed

Adequate cosmological coverage

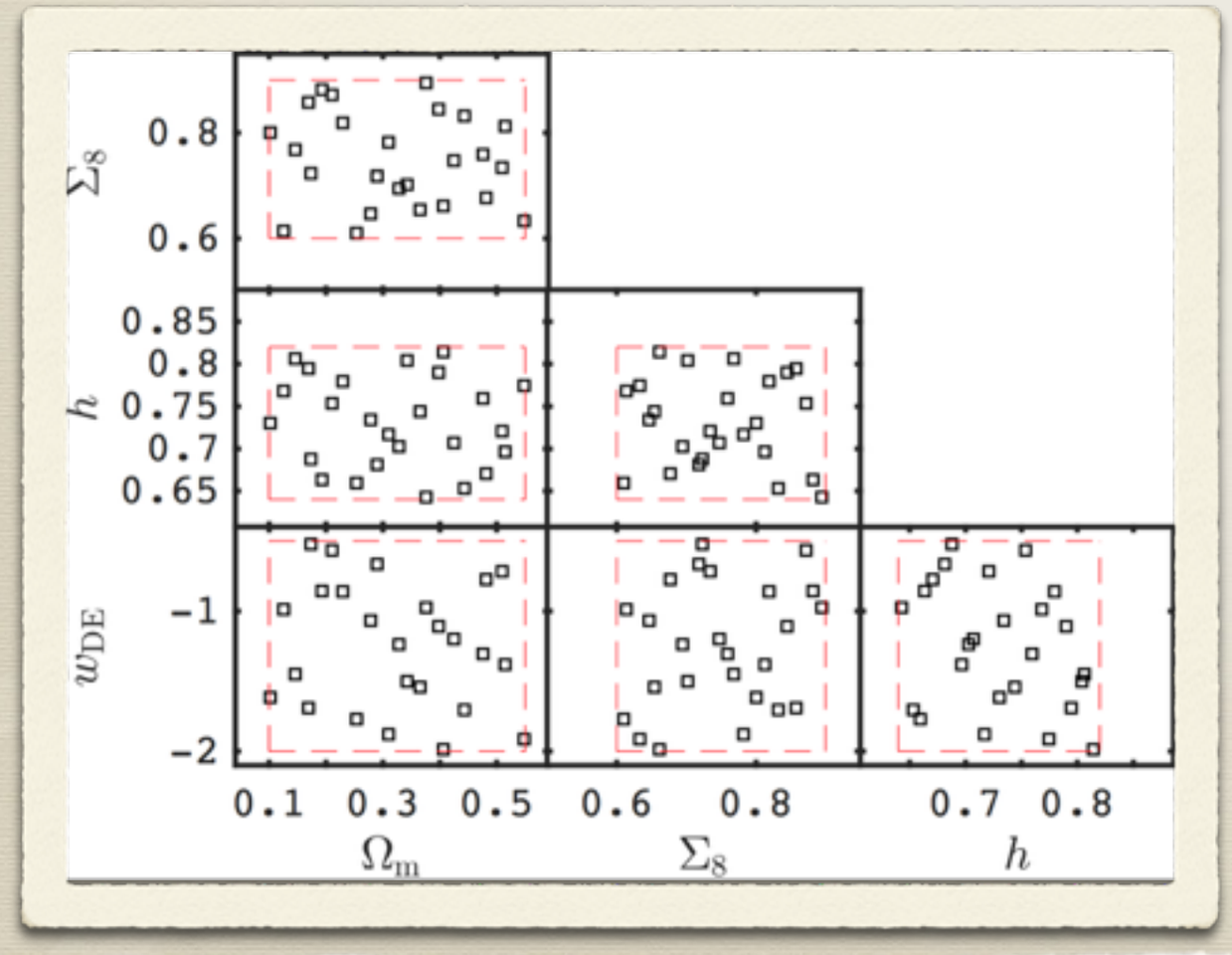
Lensing light cones data

In the bag

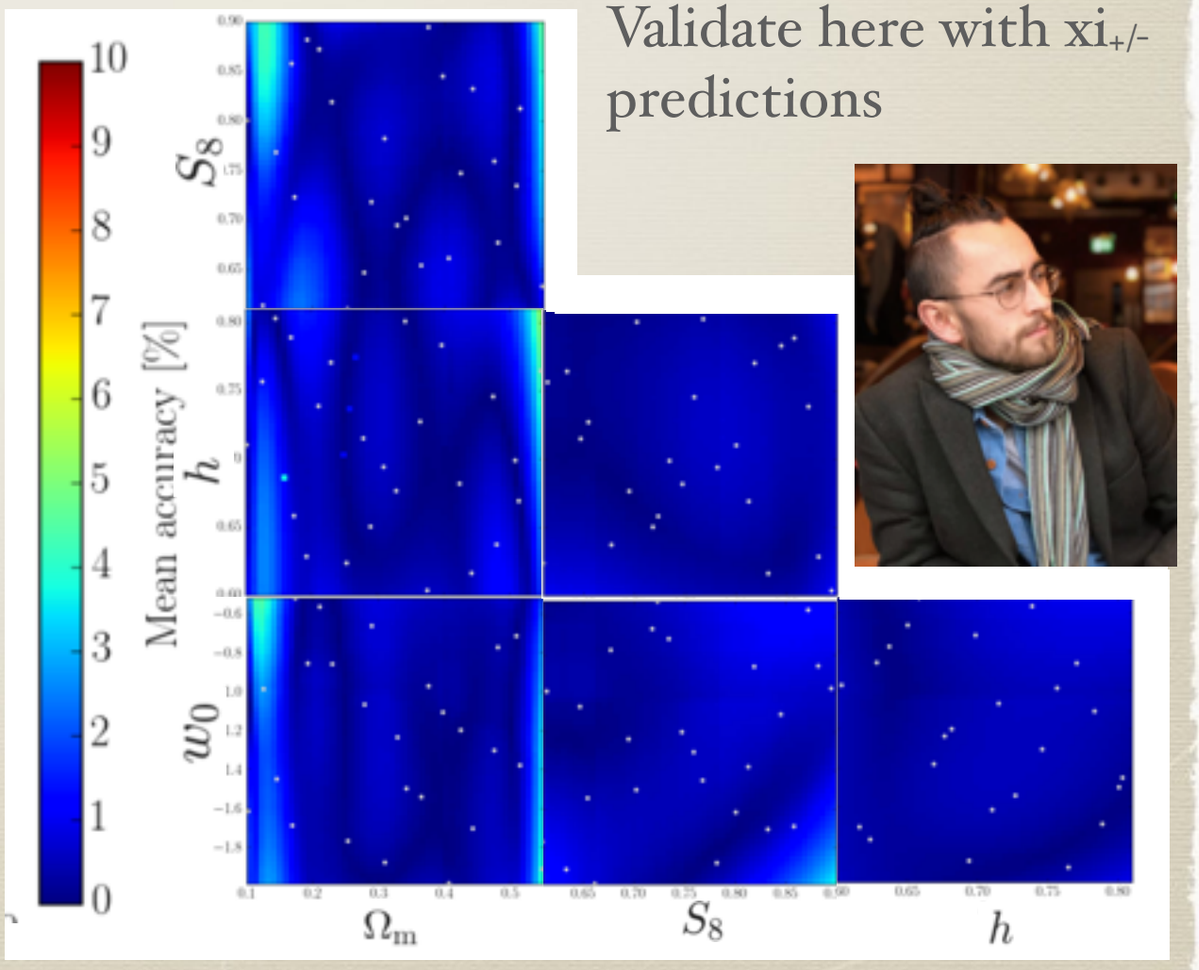
* Mira-Titan
* Aemulus
* Petri et al (2015)
* MassiveNu
* Dietrich and Hartlap (2010)
* DUSTGRAIN.

*cosmo-*SLICS

* Probe *w*CDM cosmology at 25 points
* Use a Gaussian Processes Emulator to interpolate at any cosmology within the range



Validate here with $xi_{+/-}$ predictions



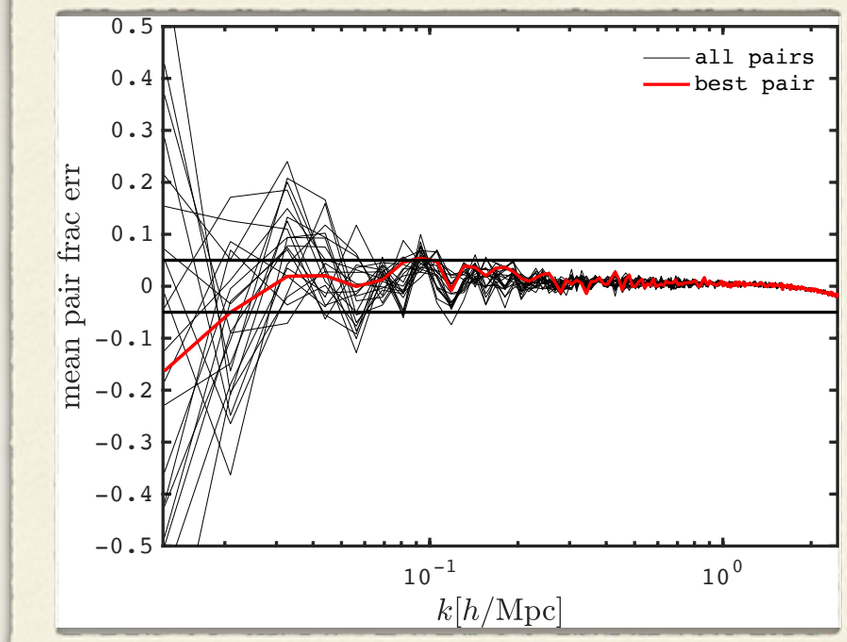
Credits: Ben Giblin

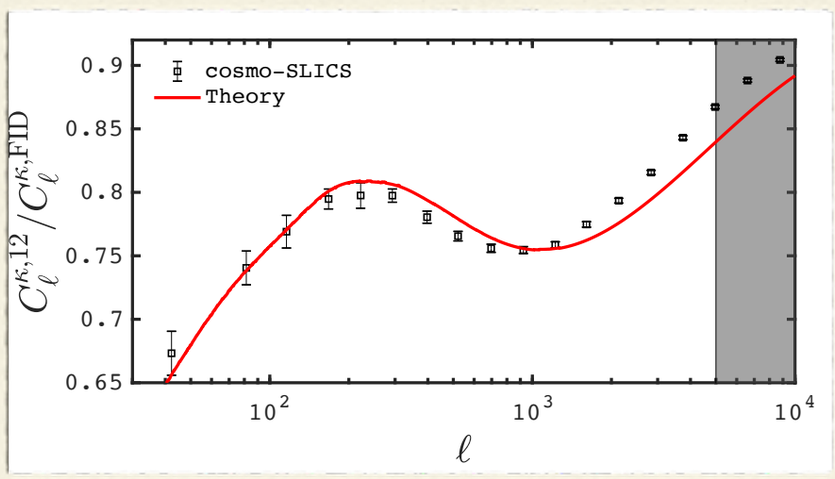
Simulation Setup

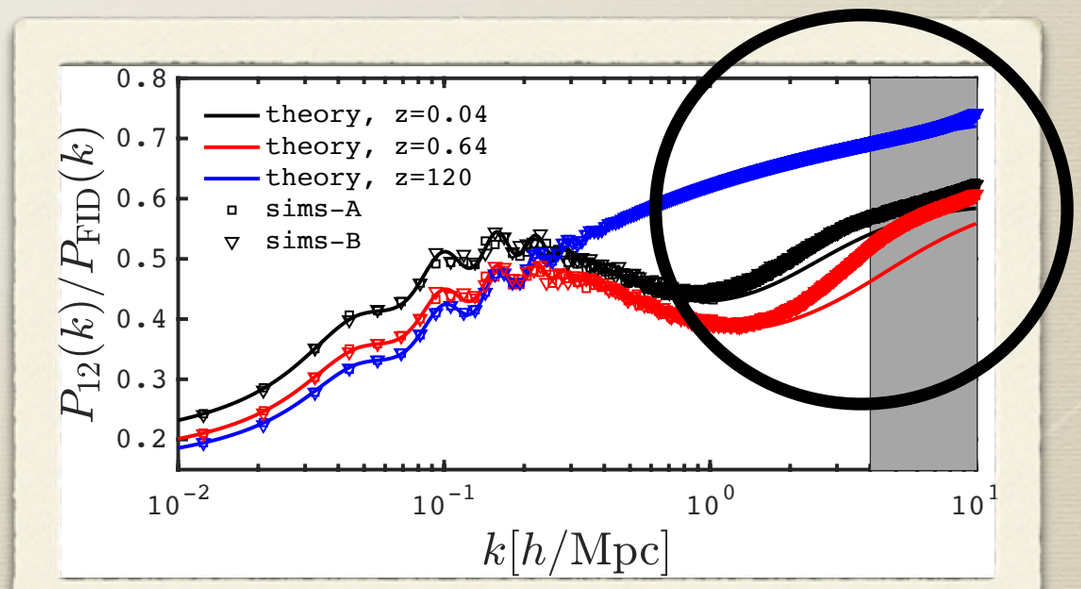
* Find pair of random seeds that minimise sampling variance (similar idea to Pontzen et al, 2016, but not quite the same)

* Run pair of *cosmo*-SLICS N-body simulations at every cosmology

* Ray-trace each run 400 times (=800 light cones per cosmology)



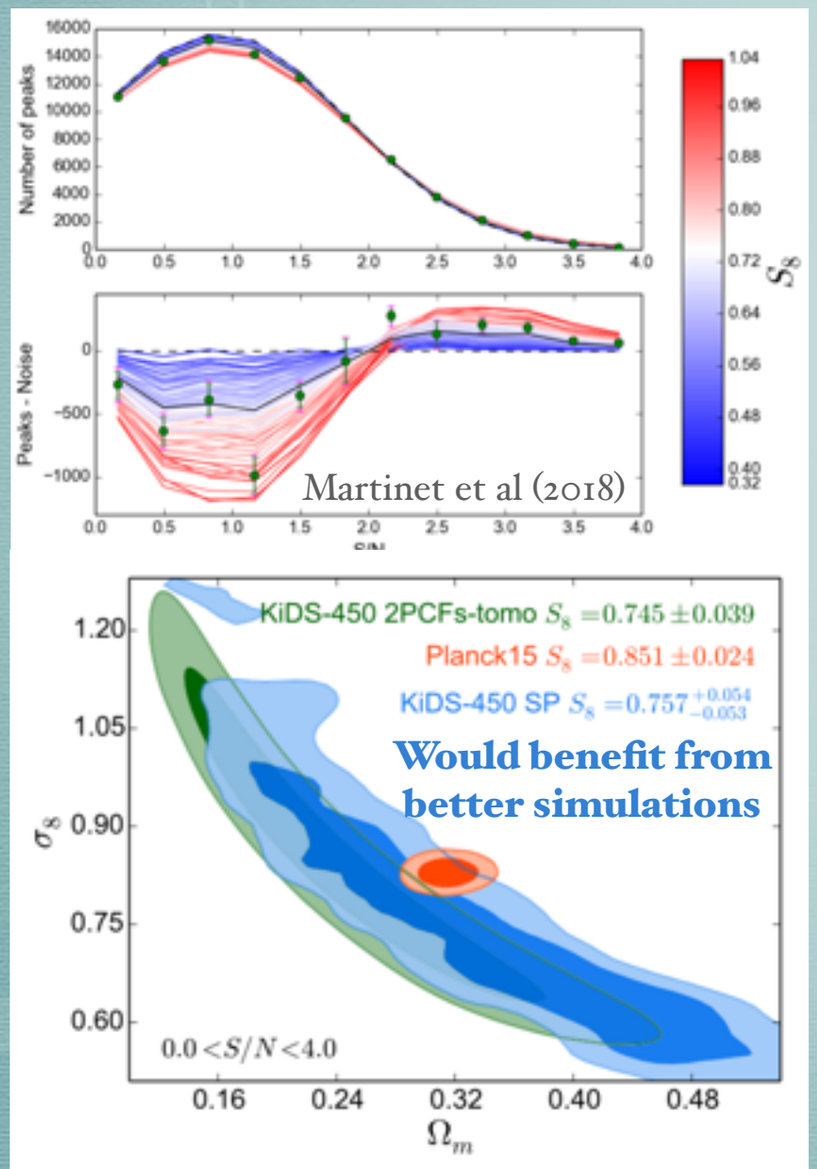


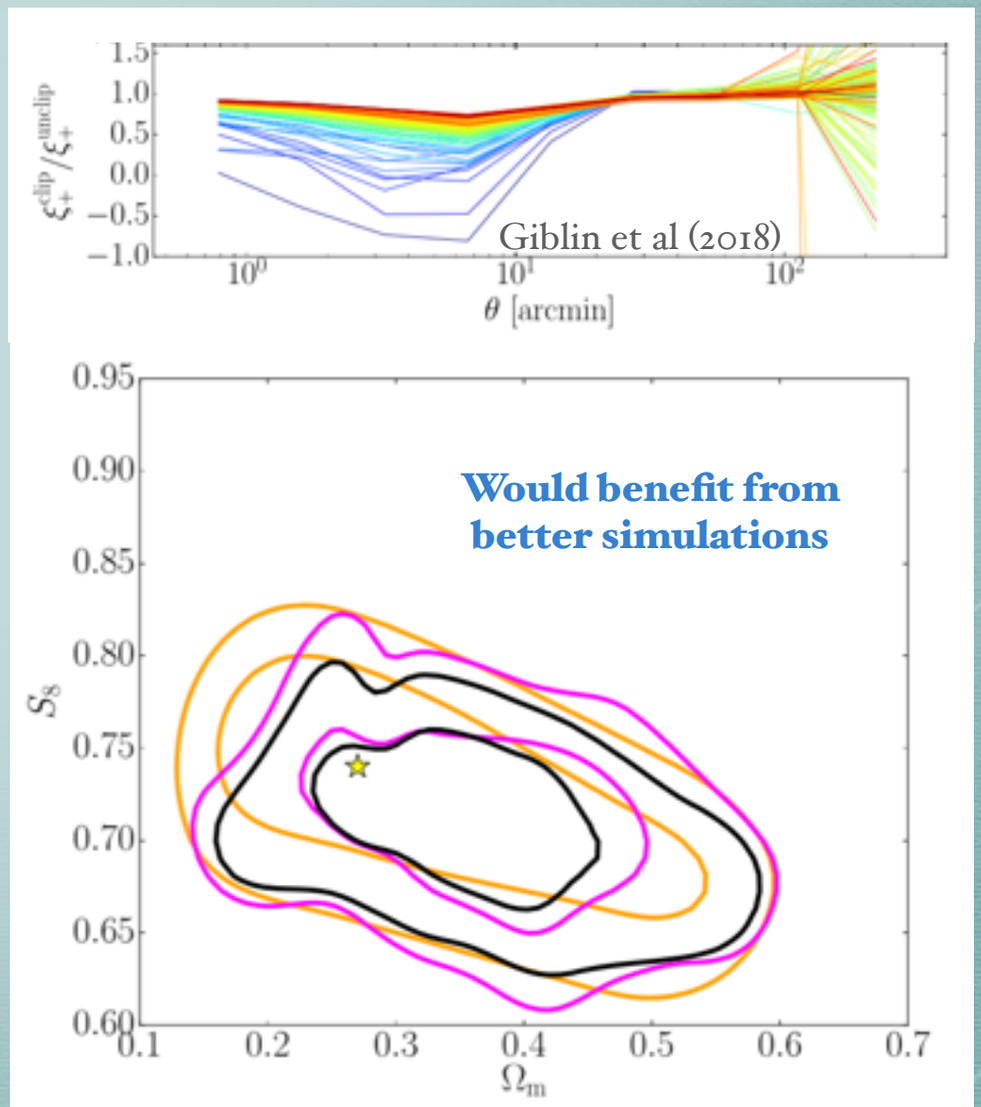


How to carry out data analyses with your new lensing estimator

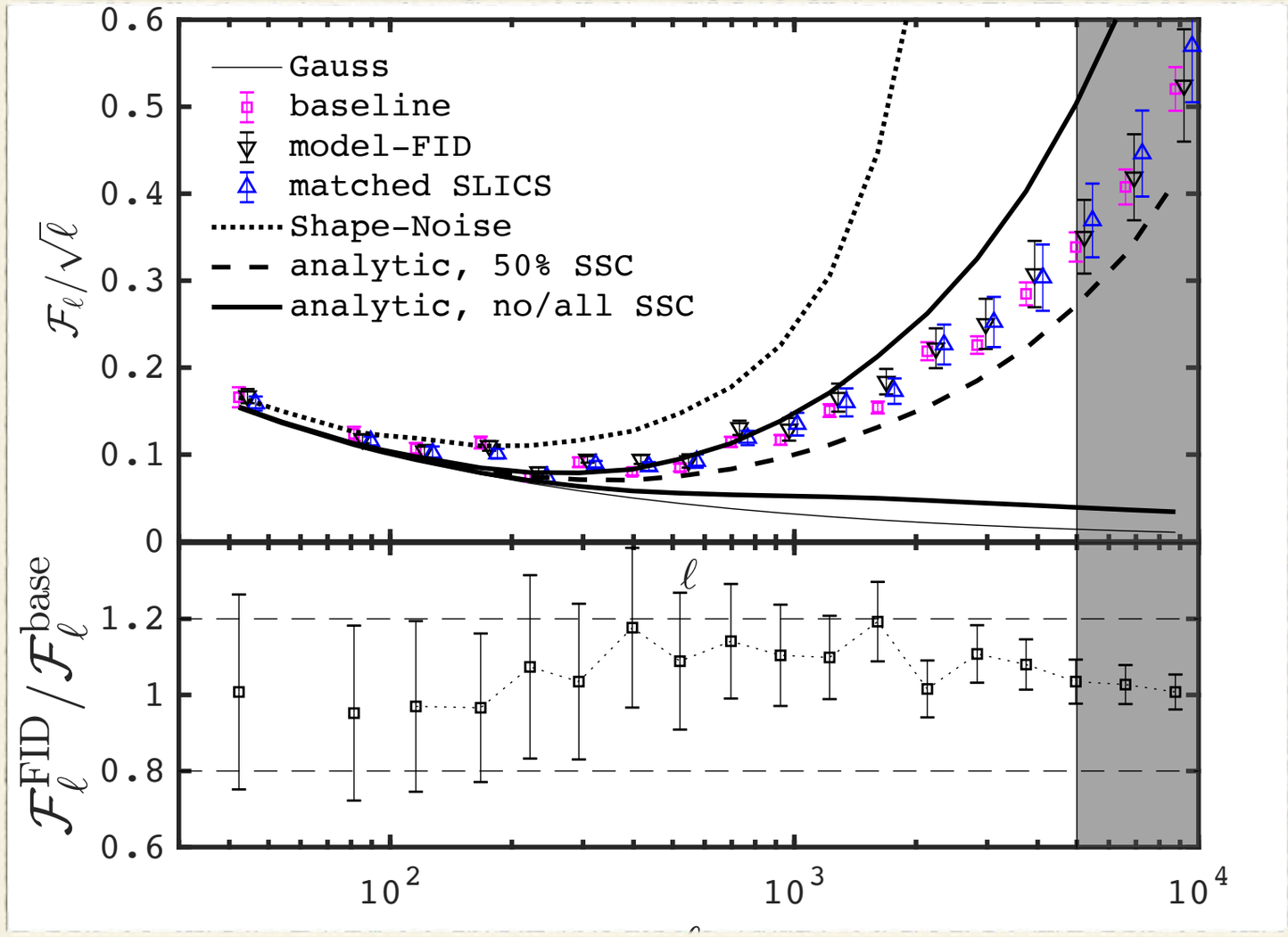
- ✦Measure your signal in the 25 cosmo-SLICS (peaks, 3-points, Minkowski, machine learning, see Jia Liu's talk...)
- ✦Train the GP emulator on your output
- ✦GP will give rapid predictions for any cosmology in the range
- ✦Insert this emulator in the signal segment of your MCMC pipeline

More examples



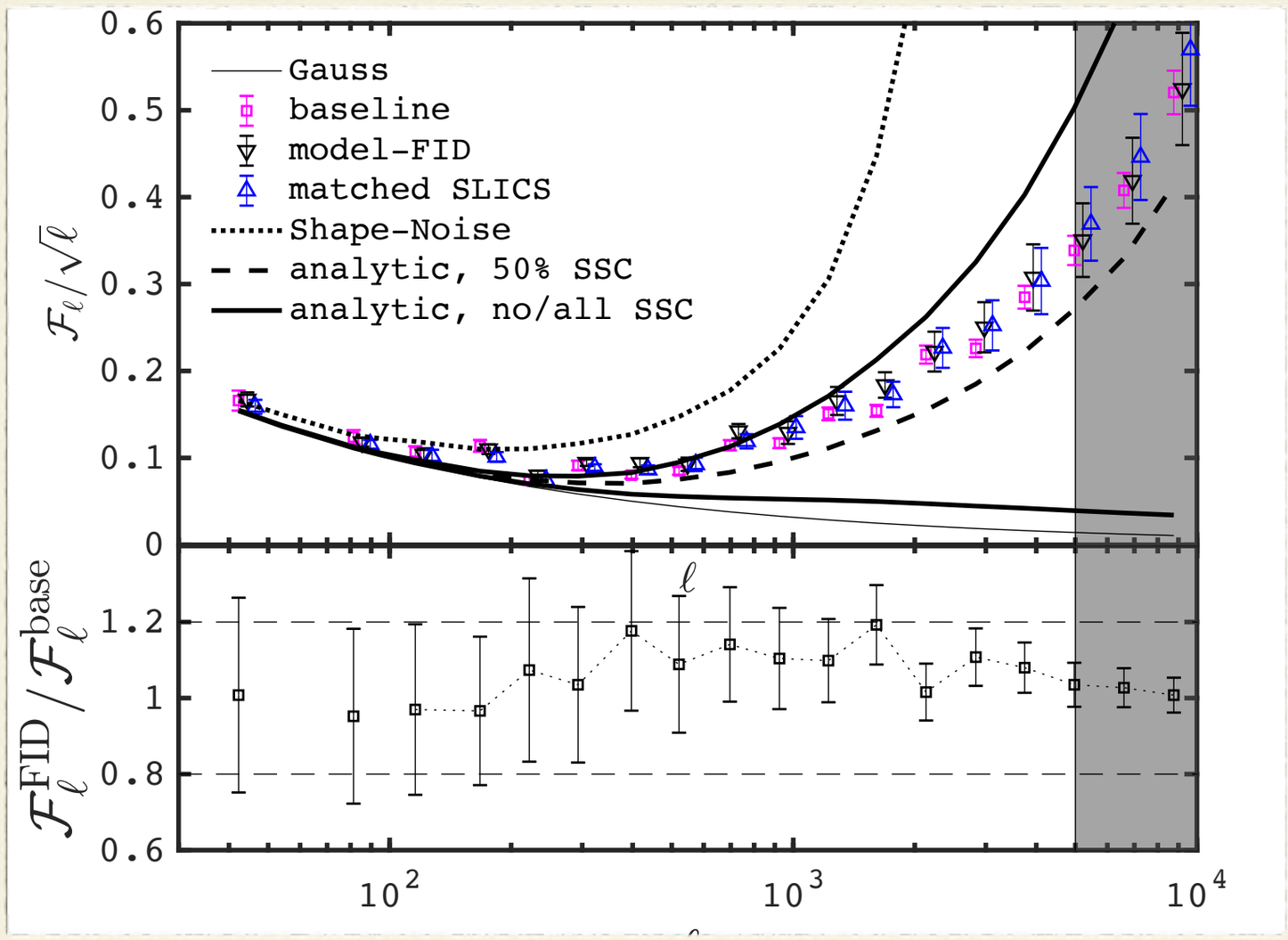


Covariance as a by-product?



$$\mathcal{F}_\ell \equiv \mathrm{diag}\left[\frac{\mathrm{Cov}^{\kappa}_{\rm tot}}{\mathrm{Cov}^{\kappa}_{\rm G}}\right]$$

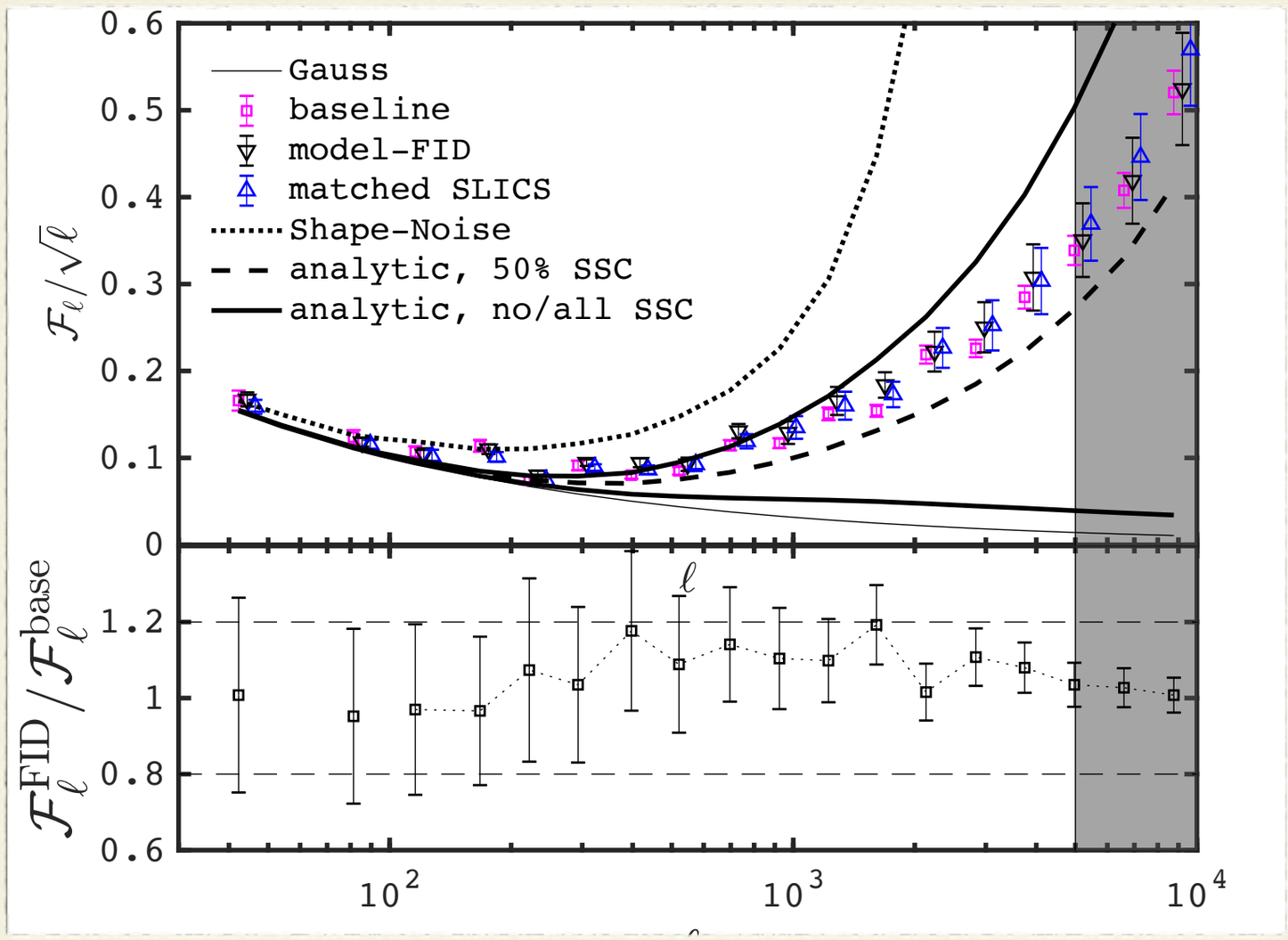
Covariance as a by-product?



Baseline from 800 fully independent N-body

$$\mathcal{F}_\ell \equiv \mathrm{diag}\left[\frac{\mathrm{Cov}^\kappa_{\rm tot}}{\mathrm{Cov}^\kappa_{\rm G}}\right]$$

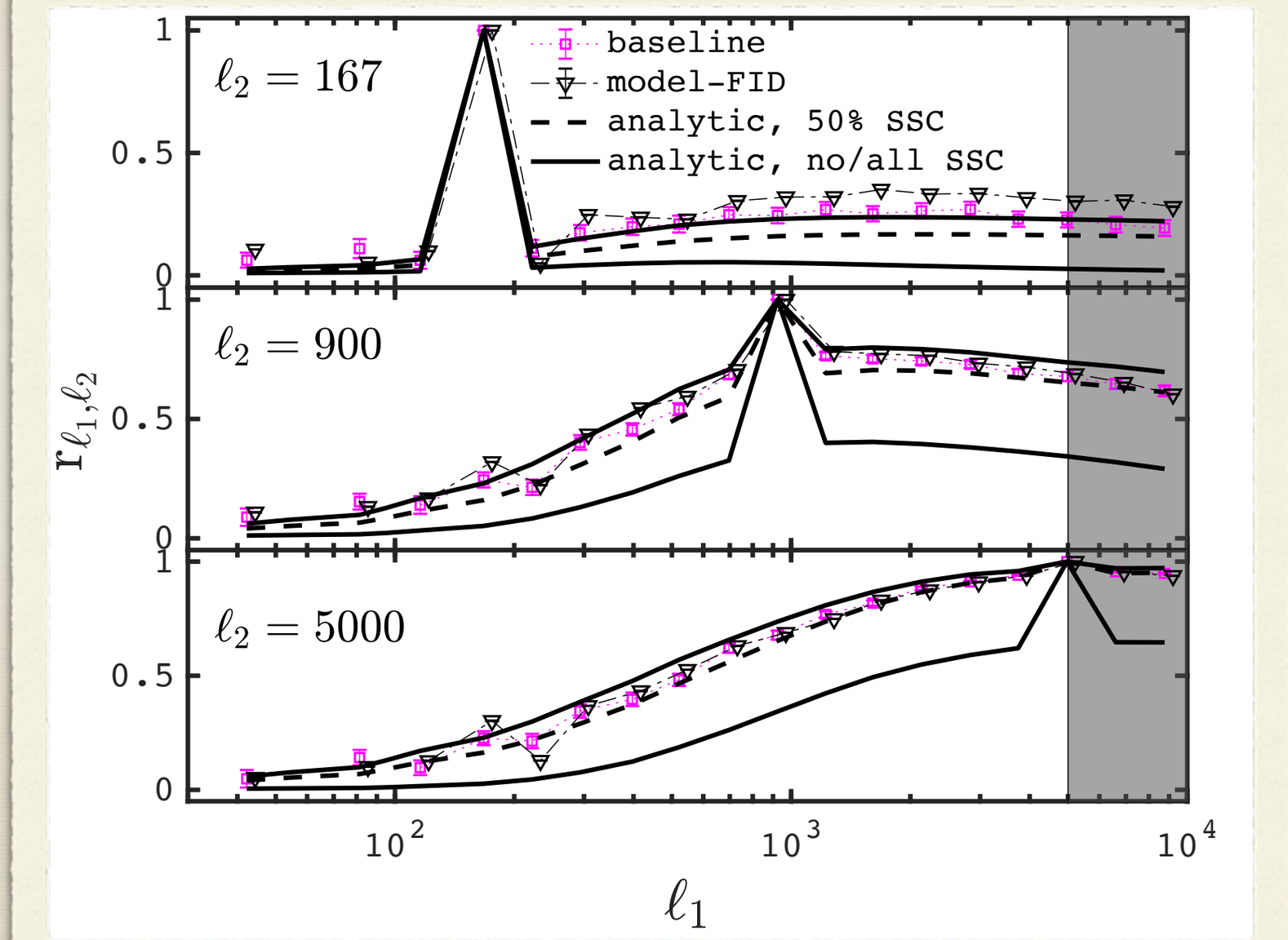
Covariance as a by-product?

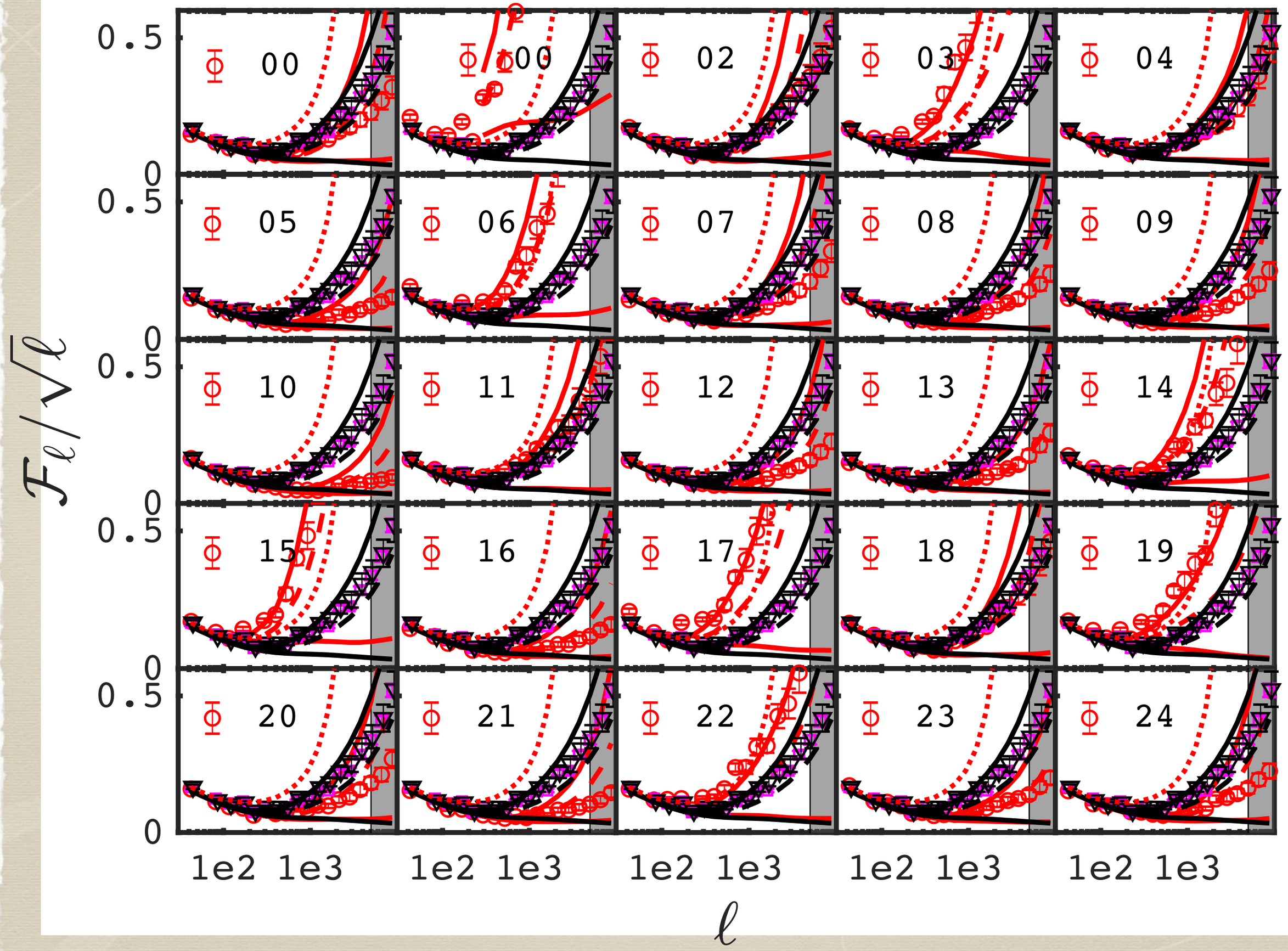


Baseline from 800 fully independent N-body model-FID from 2!

$$\mathcal{F}_\ell \equiv \mathrm{diag}\left[\frac{\mathrm{Cov}^\kappa_{\rm tot}}{\mathrm{Cov}^\kappa_{\rm G}}\right]$$

Off diagonals…




$\mathcal{F}_\ell/\sqrt{\ell}$
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Why does this work?

* Projection!!
* In some cases, inaccuracies in the covariance project out.
* Results would probably break in fine tomographic binning.

New questions

* How much can we trust trispectrum calculations away from LCDM?
* How much can we trust covariance from FLASK?
* Should we vary cosmology in the covariance matrix?
* What if we adopt a non-Gaussian Likelihood?

The road ahead

* Need to train estimators and models with the same level of scrutiny as we did for 2-point correlation function

* Need light cones repository (MassiveNu, MiraTitan, cosmo-SLICS, Amaelus) to mock *your* selected data and calibrate *your* measurement techniques

* What new simulations do we need? (more accurate? better cosmology coverage? More of them?)

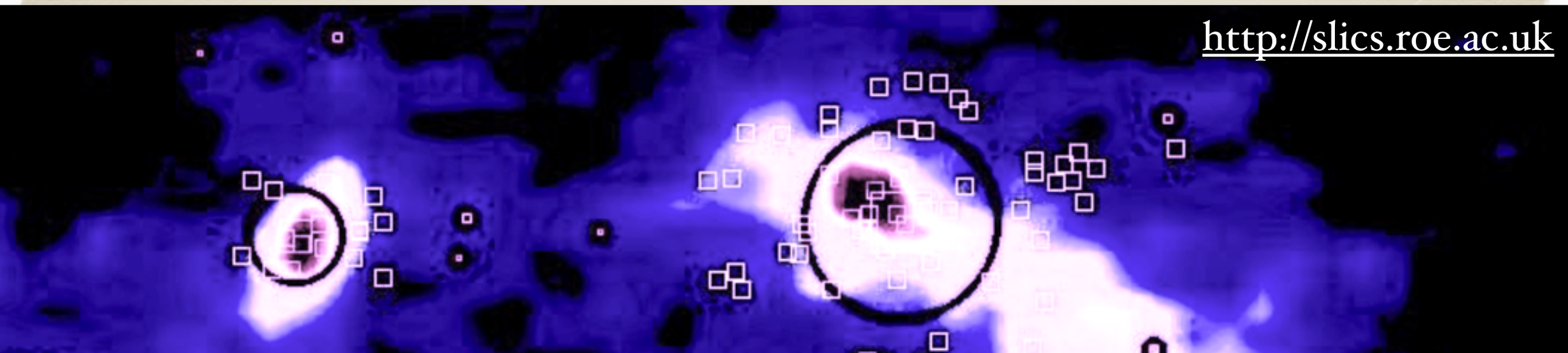
Summary

* The *cosmo*-SLICS are a great tool to train weak lensing estimators beyond 2-point statistics.
* They are designed for signal extraction combined with a Gaussian Processes Emulator (provided as well)
* Interpolation is accurate to ~1-2%
* Can also be used to estimate covariance matrices with varying cosmology for any estimator
* Preparing the public release in a few months but come talk to me now if in an emergency!!!

The ‘SLICS’

HD+, 2018, MNRAS, 481, 1337

* The Scinet LIght Cone Simulations are tailored for weak lensing+++ science
* Box = 505 Mpc/h, np = 1536^3, m_h=4.2x10^{11}M$_\odot$, fixed cosmology
* 800+ public simulations with many products (maps, BOSS/GAMA, CMB lensing...)
* Adjustable: can mock-up e.g. 6x2 LSST x DESI x SPT lensing...



http://slics.roe.ac.uk