Accurate weak lensing shear measurement with LensMC (for Euclid)

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[in prep. 2018]

19th Apr 2018
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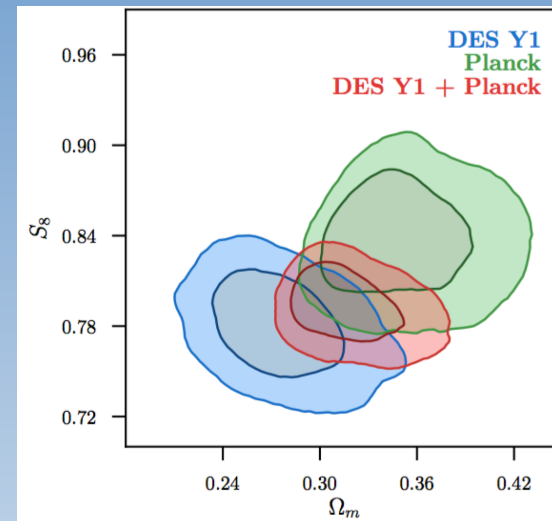
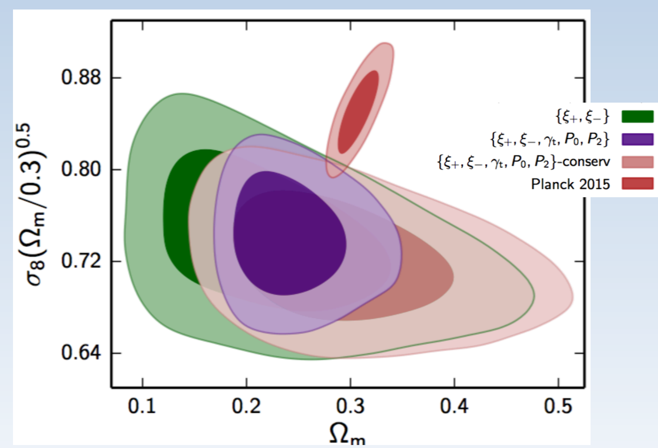
Motivation

- In the era of <u>percent precision cosmology</u>, the focus naturally shifts to <u>measurement accuracy</u>
- Particularly tricky is the weak lensing shear measurement
- Need <u>accurate methods</u> that deal with a wealth of real data effects at small scales
- For Euclid, we need to reach an accuracy of:
  - Total of 0.1% on 1% distortion
  - 0.01% owing only to the shear measurement method

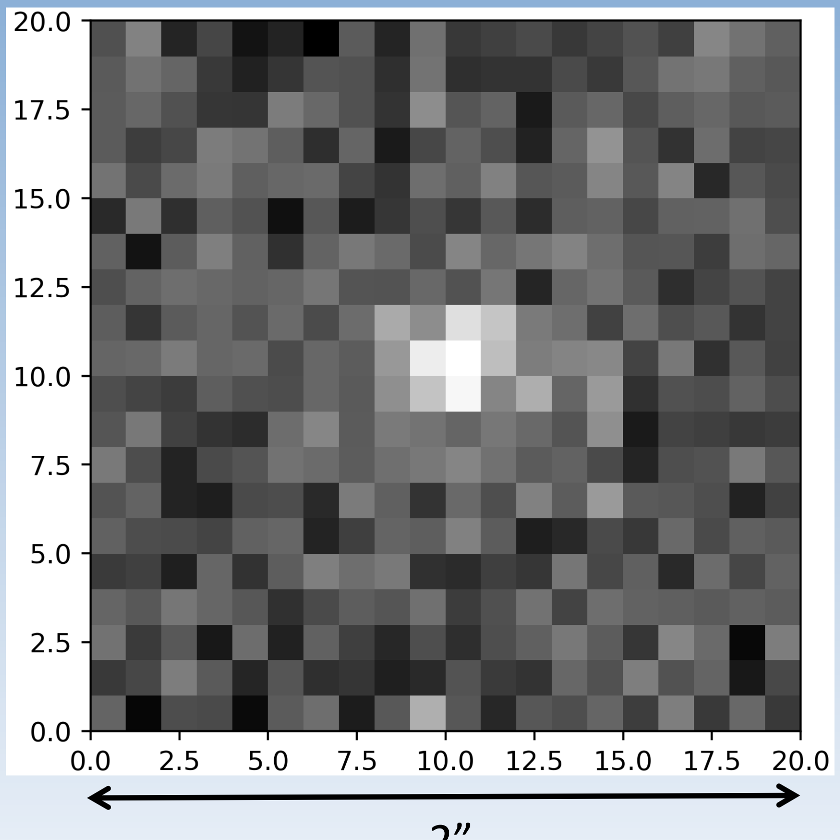


DESy1 (1.3k deg^2), Abbott *et al* (2017)



KiDS450, Joudaki *et al* (2017)

Shear measurement: the (statistical) challenge



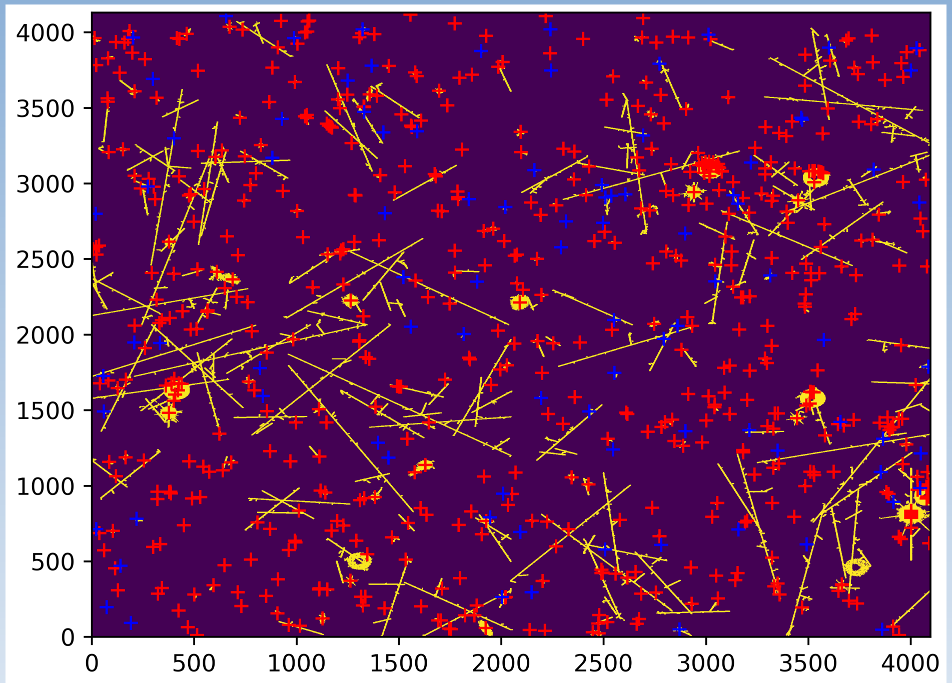
pixel = 0.1″
PSF_{FWHM} = 0.2″

- Typical Euclid galaxy: e~0.3, r_e~0.3″, S/N~20, B/T~0.3
- Can we measure its shape?
- Can we measure its shear to less than:

$$\hat{g} = (1+m)g + c \qquad \sigma_m < 2\times10^{-3} \qquad \sigma_c < 3\times10^{-4}$$

- Can we do this consistently for $1\text{x}10^9$+ galaxies?

Shear measurement: the (statistical) challenge



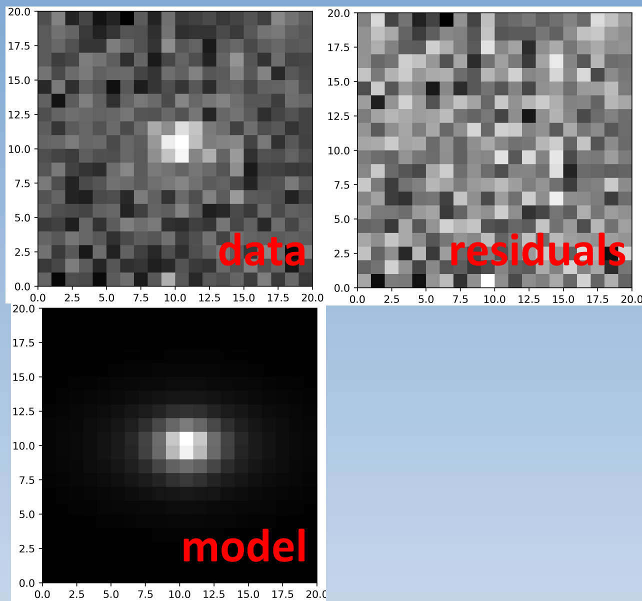
LensMC segmentation map of a raw CCD (out of 36 that make a Euclid exposure, Science Challenge 3)

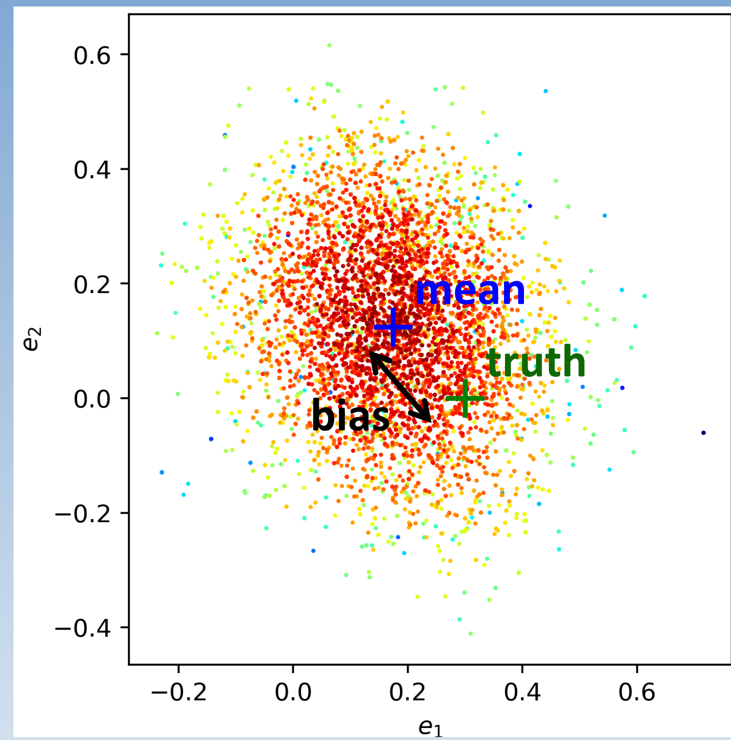
- Can we measure the shapes in this environment?
- We expect a number of <u>potential systematics</u>:
  - Cosmic rays
  - Star ghosts
  - Blending and meta-blending
  - PSF spatial and colour variation
- <u>Low S/N</u> regime
- No cuts to data to avoid <u>selection biases</u> and loss in statistical power
- Huge data volume: 25k deg^2 ➔ runtime and data storage

LensMC

- Galaxy model fitting and Bayesian inference
  - Efficient MCMC sampling and marginalisation
  - Analytical marginalisation whenever possible
- Meets Euclid accuracy requirements on shear
- Runtime = 3 sec/gal/core ➔ can process 2×10^8 gal/week on the Euclid:UK cluster in Edinburgh (1,000 cores)

LensMC





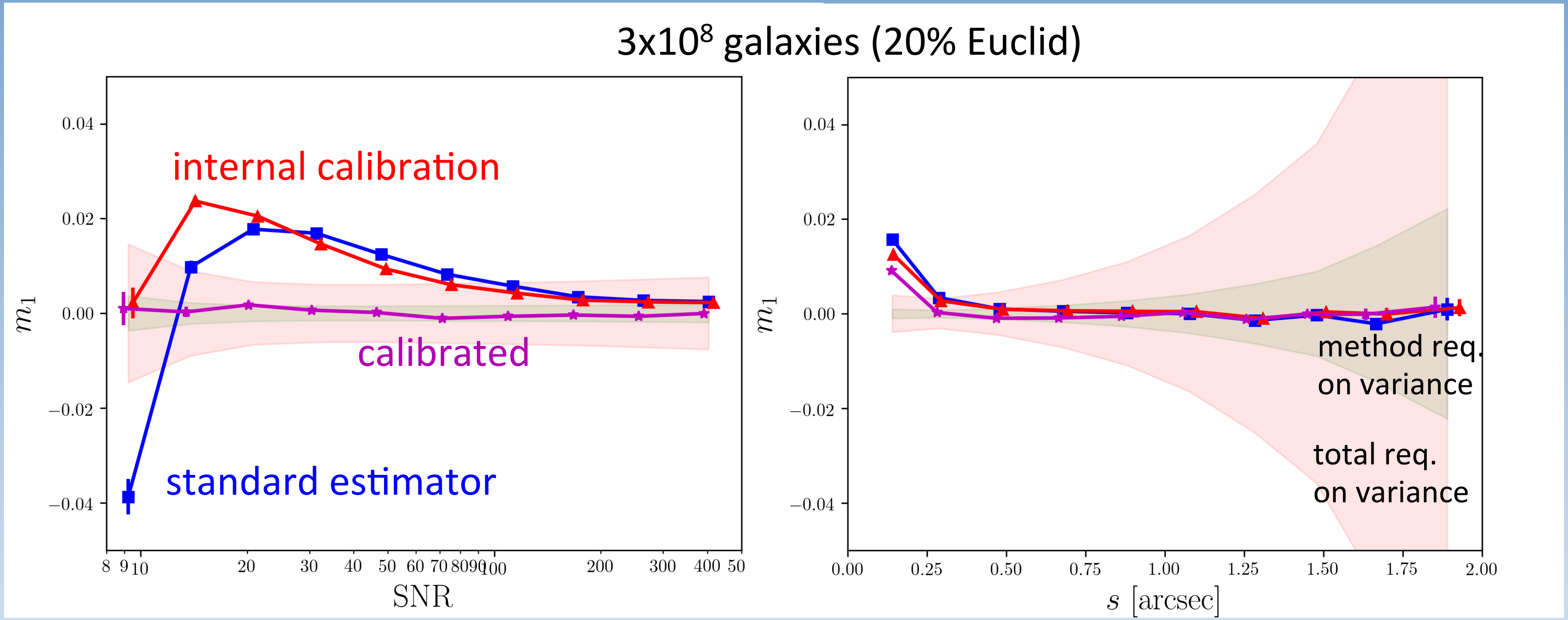
$$e' = \frac{1+g}{1+e^{*}g}$$

ellipticity posterior (marginalised over nuisance)

LensMC <u>internal calibration</u> strategy to mitigate shear bias:

- improved self-calibration [Fenech-Conti *et al* (2017)]
- custom meta-calibration [Huff & Mandelbaum (2017)]

LensMC



- Minimal (if any) assumptions in the fit
- Robustness to a variety of galaxy properties; flexibility to accommodate more complex galaxy models, if needed
- Systematics generally under control (e.g. real data features, PSF, colour gradients, etc.)
- Total shear bias within requirements!

GC+ (2018) in prep.