Higher Order Weak Lensing Statistics (Howl's)

Kick-off telecon - October 9th

HOWL’S Project

- Joint project:
  - WP Mass Mapping (Sandrine Pires, Nicolas Martinet)
  - WP Higher Order Statistics (Vincenzo Cardone, Ismael Tereno)
  - Simulations (Carlo Giocoli)
- Goals:
  - Compare different HOS of the mass maps: e.g. peaks, minkowski functionals, …
  - Quantify the effects of the reconstruction on these statistics

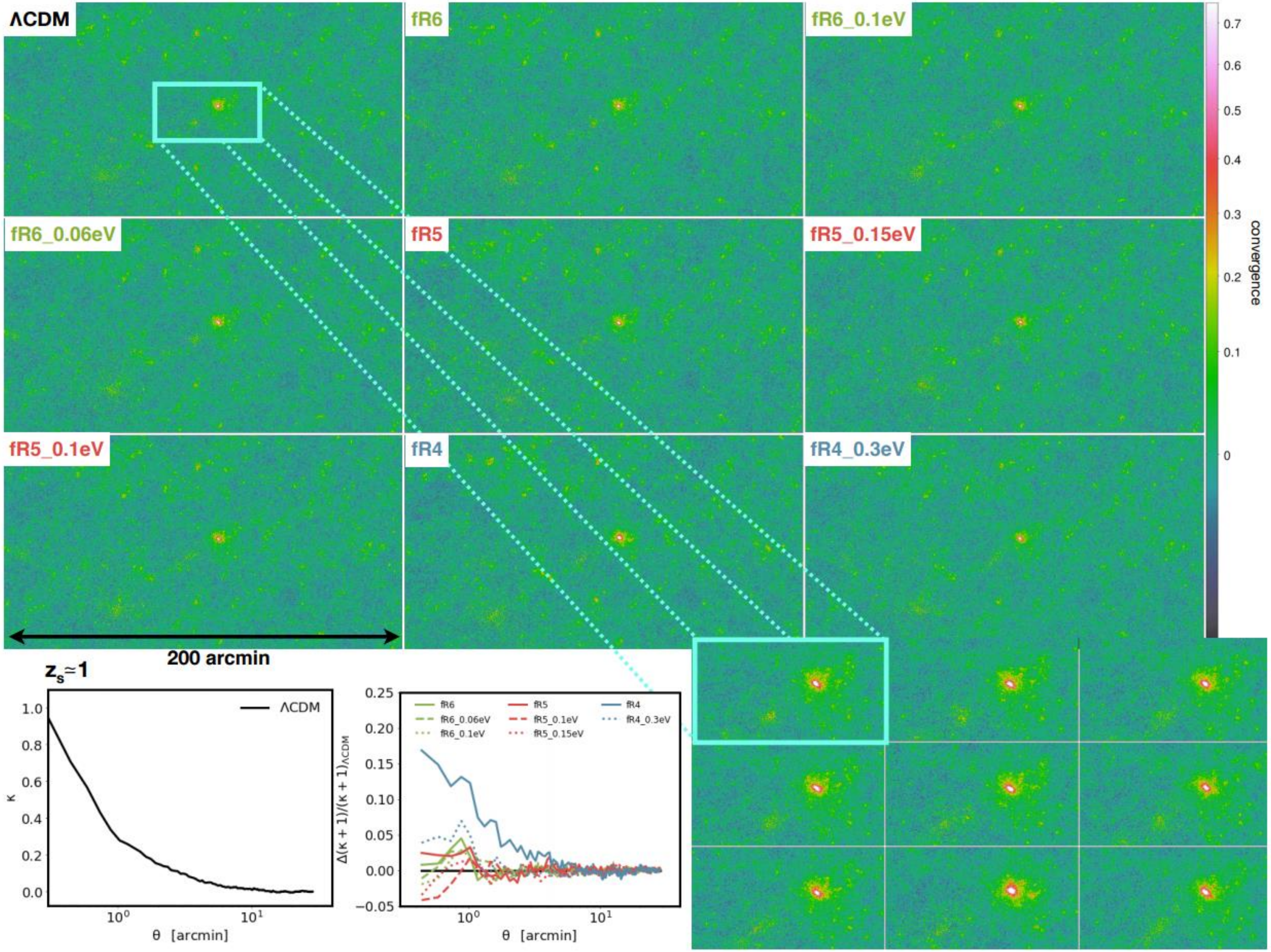
➢ Common set of mass maps!

Simulations

- DUSTGRAIN-pathfinder simulations (Giocoli et al. 2018)
- Parameters:

N. part	Box-size	M_{DM}
768^3	750 Mpc/h	$8.1 \times 10^{10} M_{sun}/h$

- LCDM + f(R) modified gravity + various neutrino masses

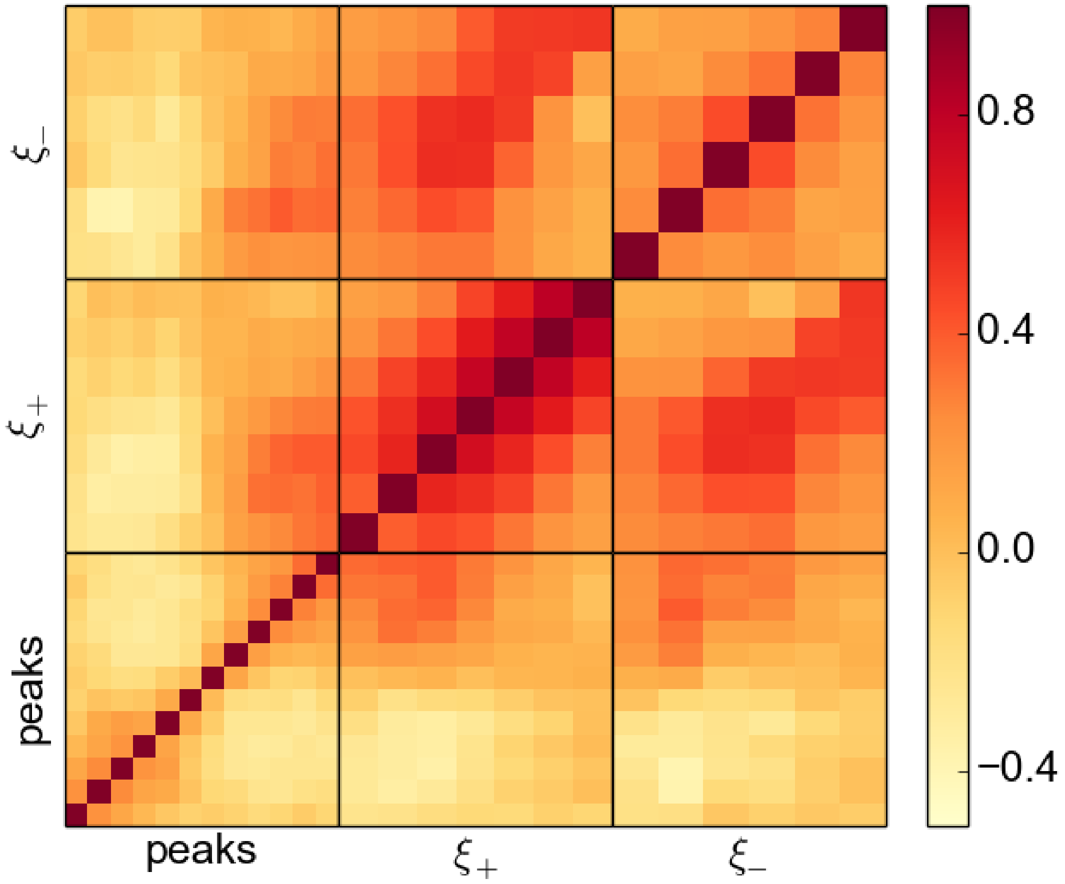


First step: input

- LCDM simulations
- 256 noiseless convergence maps
  - Input convergence map from simulations
  - 5° x 5°
  - 2048 x 2048
  - Redshift distribution : $z_s = 2$
- 256 noisy convergence maps
  - $n_g = 30$ gal/arcmin2, σ_e/component = 0.3
  - Gaussian noise with zero mean and $\sigma_\kappa = \sigma_e/\sqrt{n_g \cdot \text{pixel\_area}}$

First step: output

- Data vectors for every statistics
- How correlated are the different statistics?
- Answer at the WL+GC SWG meeting in Milan (3-6 Dec)



Joint peaks/2pcf correlation matrix for KiDS-450 simulations (Martinet et al. 2018)

Next steps

- Use reconstructed convergence maps (KS93, inpainting, Map,…)
- Compare data vectors for various cosmologies
- Propagate to cosmological constraints
- Test various mass map reconstruction effects (masks, boundaries)
- Allow participants to test there own reconstruction

Estimators (add your name)

Peaks: Sandrine, Austin, Dipak

Minkowski functionals: Martina, Dipak

HO moments: Sandrine, Martina, Austin, Dipak

Shear 2pcf: Martin

Convergence 2pcf: Sandrine, Carolina, Dipak

Kappa power spectrum and bispectrum - halo model : Matteo Rizzato, Dipak, Fabien

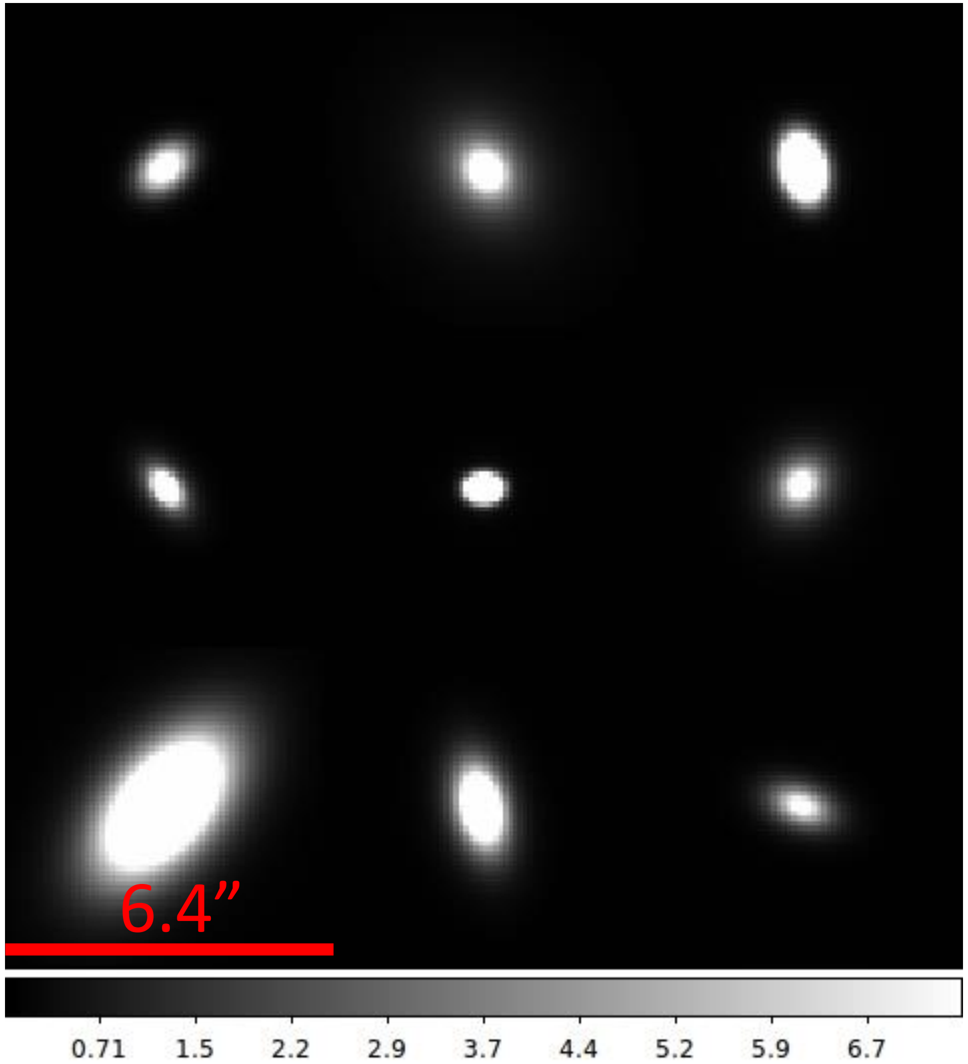
Machine Learning: Austin, Julian

- 18 project members
- 9 participants
- 7 statistics

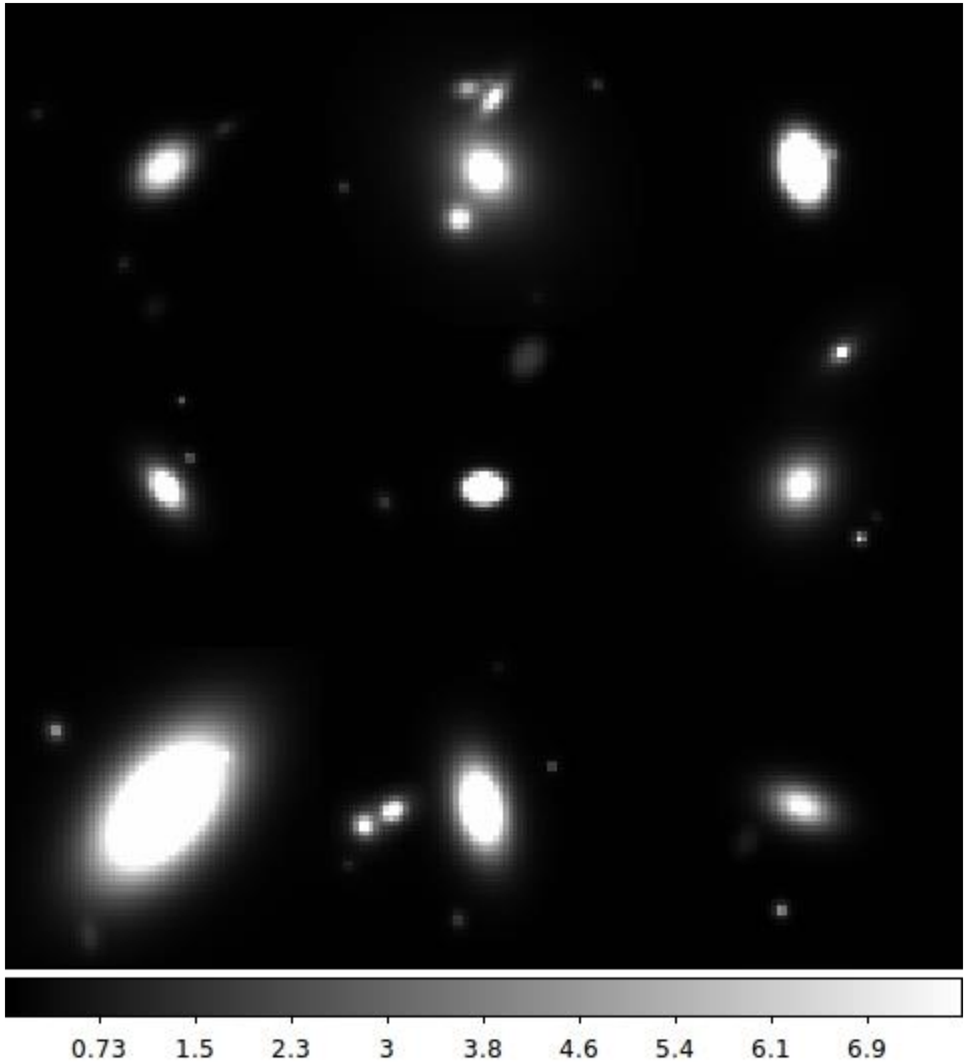
Do we need to include galaxies below Euclid VIS detection limit in the calibration simulations?

Martinet, Schrabback, Hoekstra, Tewes, Herbonnet, Schneider, Hernandez, et al.
to be revised by OU-SHE/SWG-WL

Simulations without noise

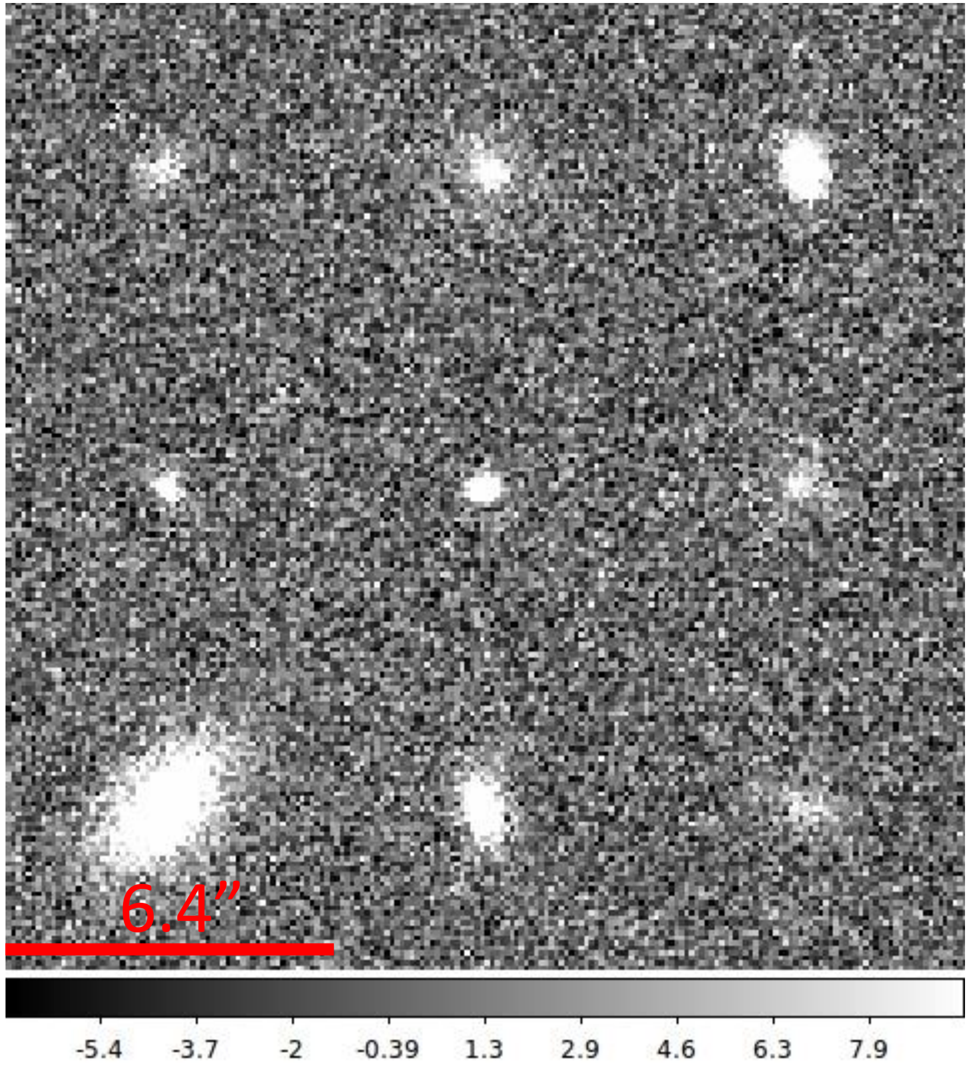


Bright gal (mag<24.5)



Bright gal (mag<24.5) & faint gal (24.5<mag<29)

Simulations with noise



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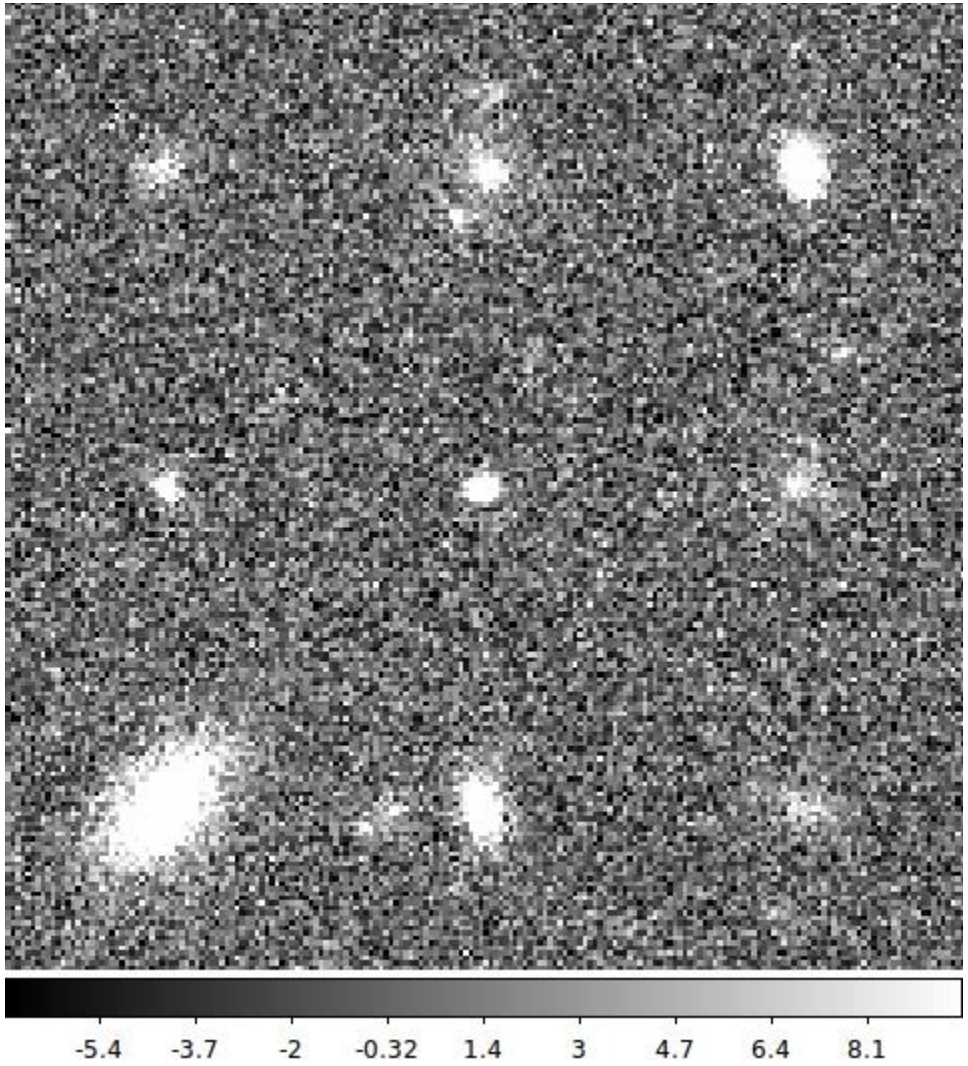


Bright gal (mag<24.5) & faint gal (24.5<mag<29)

Defining Euclid-like simulations (see also Tewes et al. 2018)

Galaxies flux:

$$F^{\mathrm{ADU}} = \frac{t_{\mathrm{exp}}}{gain} 10^{-(mag - ZP)/2.5}$$

Gaussian noise:

$$F_{\mathrm{sky}}^{\mathrm{e^-/pixel}} = l^2 t_{\mathrm{exp}} 10^{-(sky_{\mathrm{bkg}} - ZP)/2.5}$$

$$\sigma_{\mathrm{bkg}}^{\mathrm{e^-/pixel}} = \sqrt{F_{\mathrm{sky}}^{\mathrm{e^-/pixel}} + \sigma_{\mathrm{readout}}^2}$$

Sky background noise

CCD readout noise

t_{exp} = 3 x 565 s (Laureijs et al. 2011)

l = 0.1 arcsec (Laureijs et al. 2011)

$gain$ = 3.1 electrons.ADU^{-1} (Niemi et al. 2015)

sky_{bkg} = 22.35 mag.arcsec^{-2} (Refregier et al. 2010)

$\sigma_{\mathrm{readout}}$ = 4.2 electrons (Cropper et al. 2016)

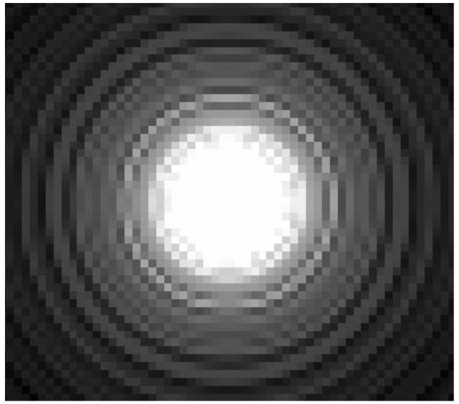
ZP adatpted so that a galaxy with mag=24.5 has a SNR of 10 (Cropper et al. 2016)

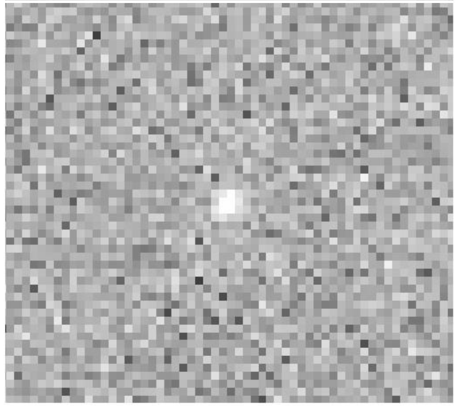
ZP = 24.0

PSF and galaxy properties

PSF

- Sum of three Airy PSF (diameter=1.2m, obscuration=0.3m), with λ=[600nm, 700nm, 800nm]





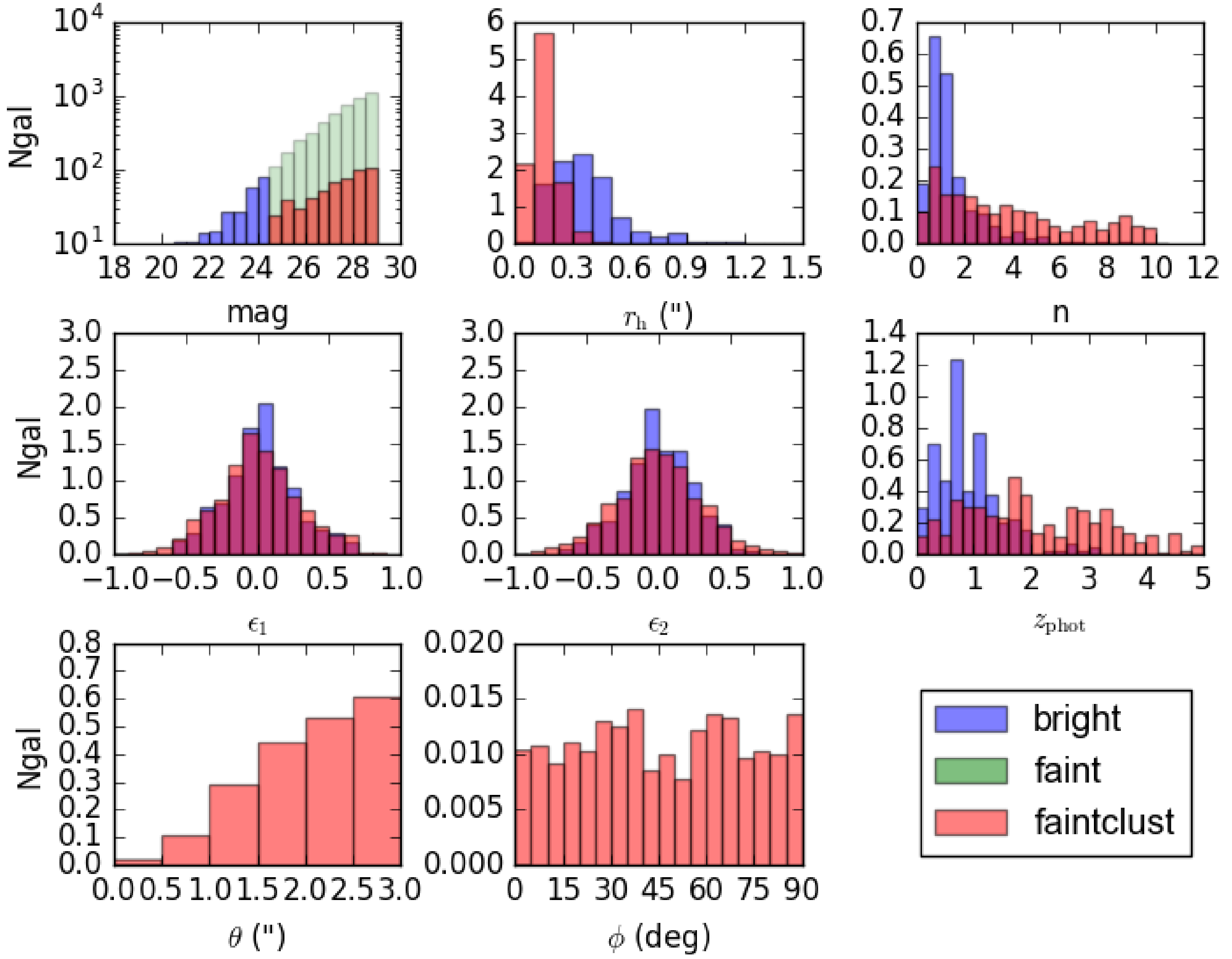
GALAXIES

- Galaxy properties and clustering measured on UDF data (12 arcmin^2)
- Single Sersic profiles
- Bright galaxies 20.5<mag<24.5, faint galaxies 24.5<mag<29
- Galaxy patch size: 6.4“x6.4“

NUMBER OF GALAXIES

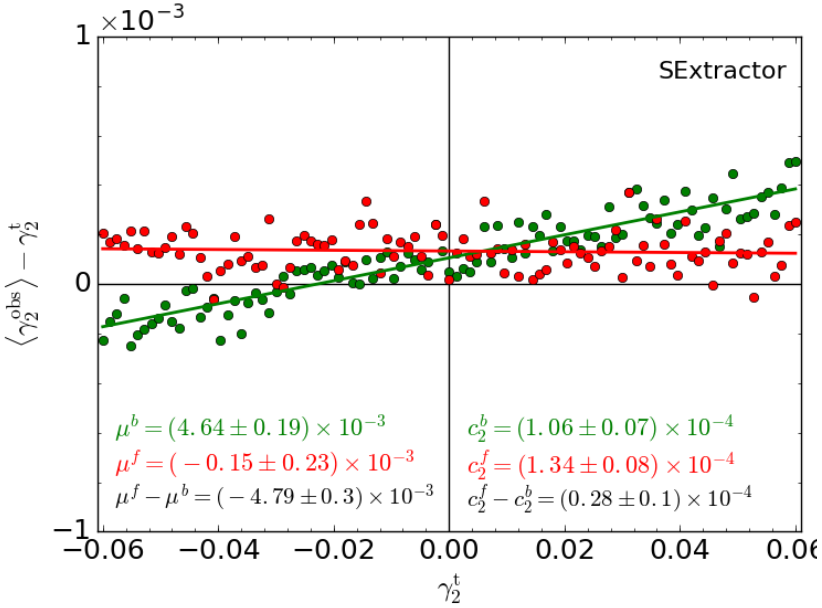
- $N = \left(\frac{\sigma_\varepsilon}{|g| * \sigma_\mu}\right)^2$
- σ_ε=0.26, $|g|$=0.03, σ_μ=2x10^{-4} -> 1.9x10^{9} galaxies
- A few 10ms/galaxy -> a few 10 000 hours (+ shape measurement)
- Some tricks to reduce the number of galaxies (shape noise and sky noise cancellation)

Observed galaxy properties (UDF)

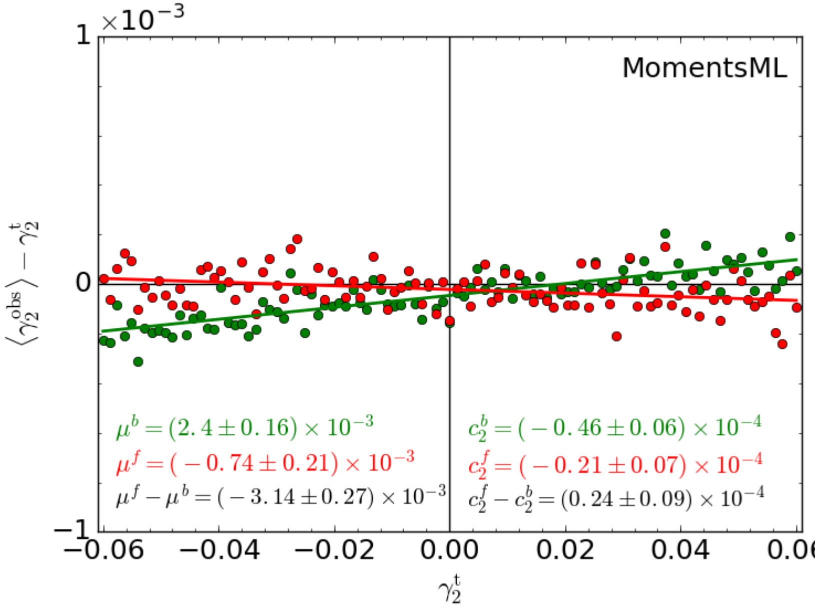


Results for 20 million shear estimates

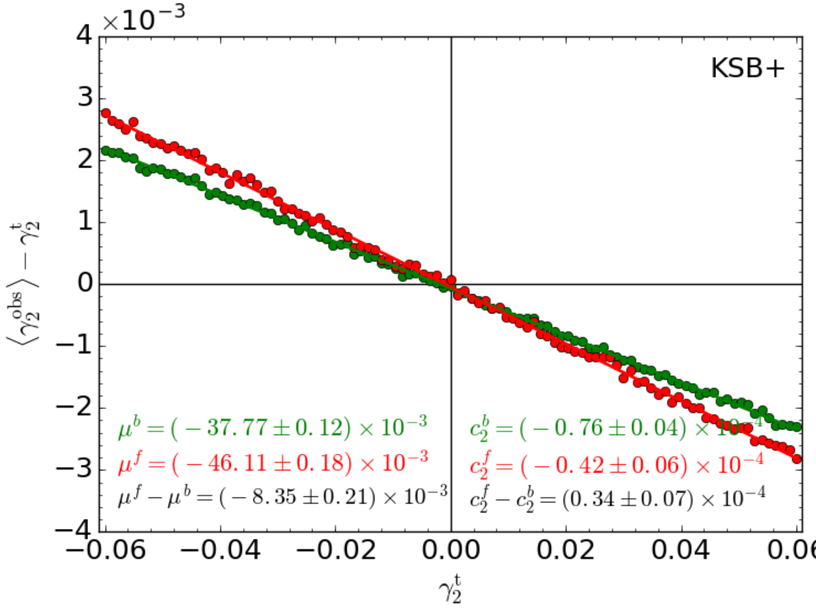
Sextractor+PSFEx



MomentsML

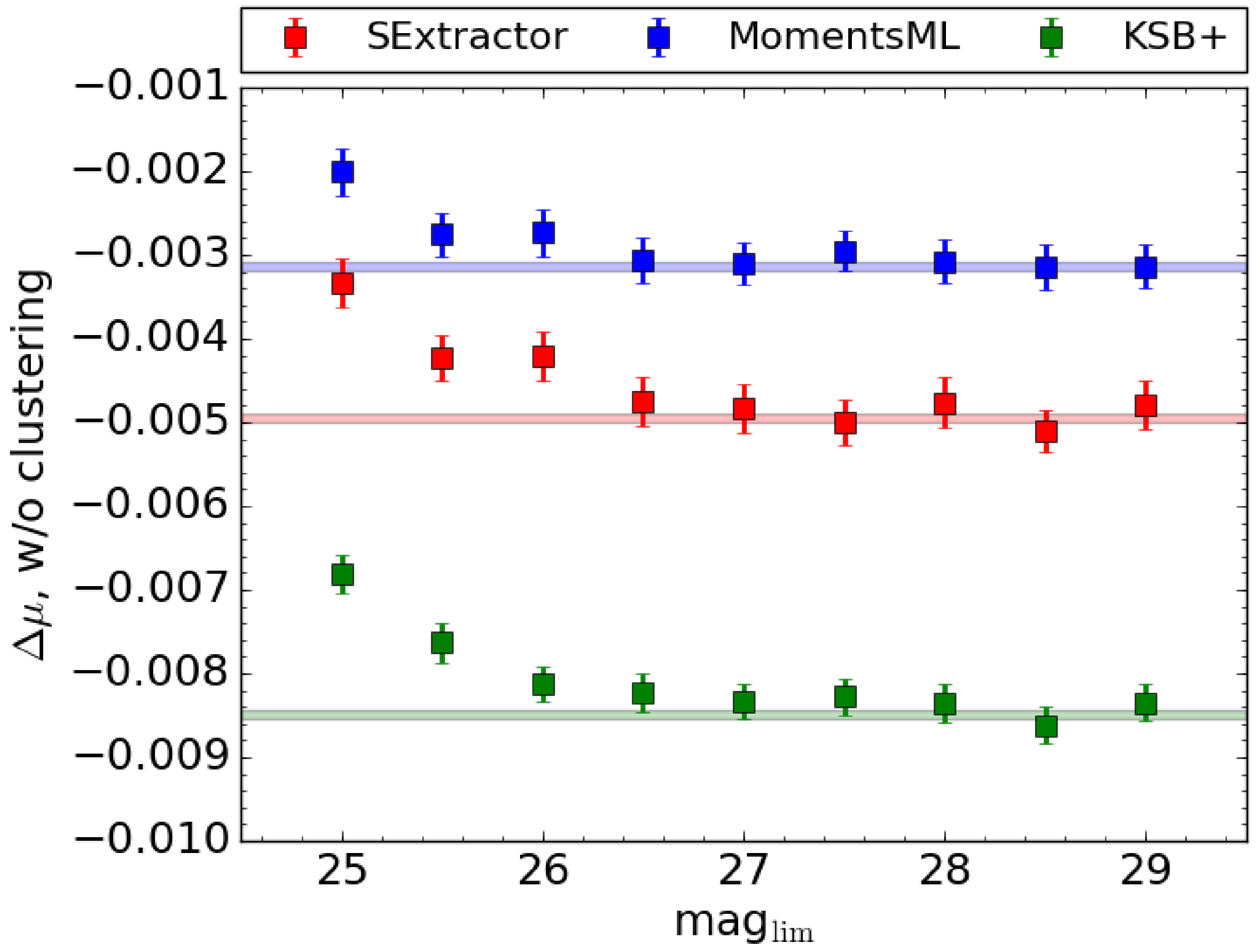


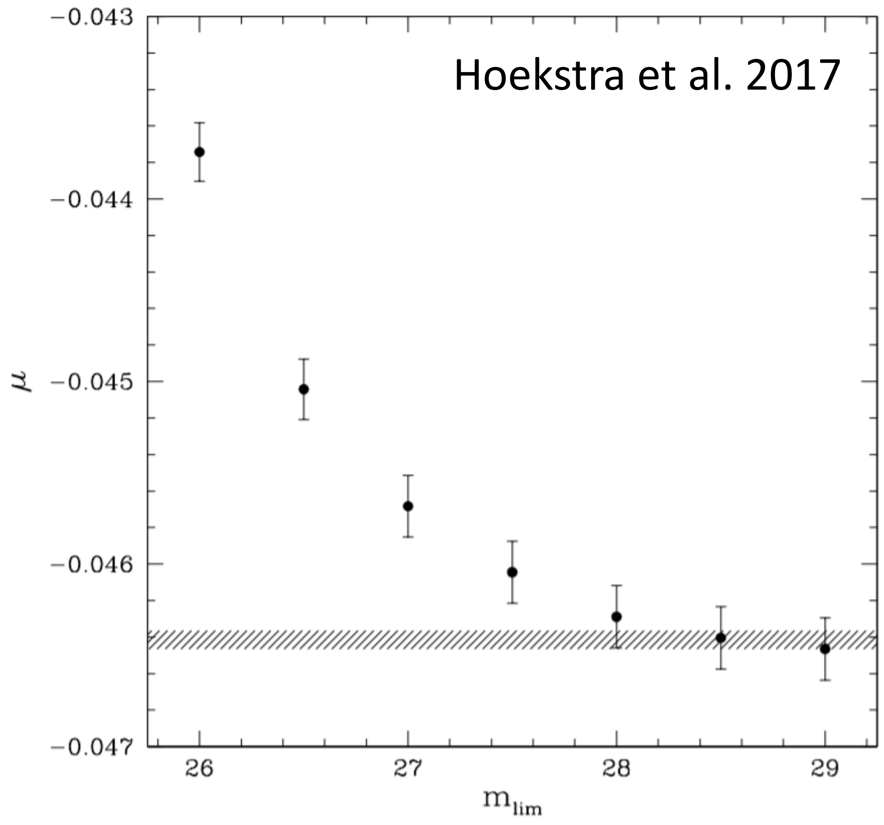
KSB



- $< \gamma^{obs} > - \gamma^{true} = \mu \times \gamma^{true} + c$
- Every method is affected by galaxies below the detection limit
- Up to which magnitude do we need to include these galaxies?

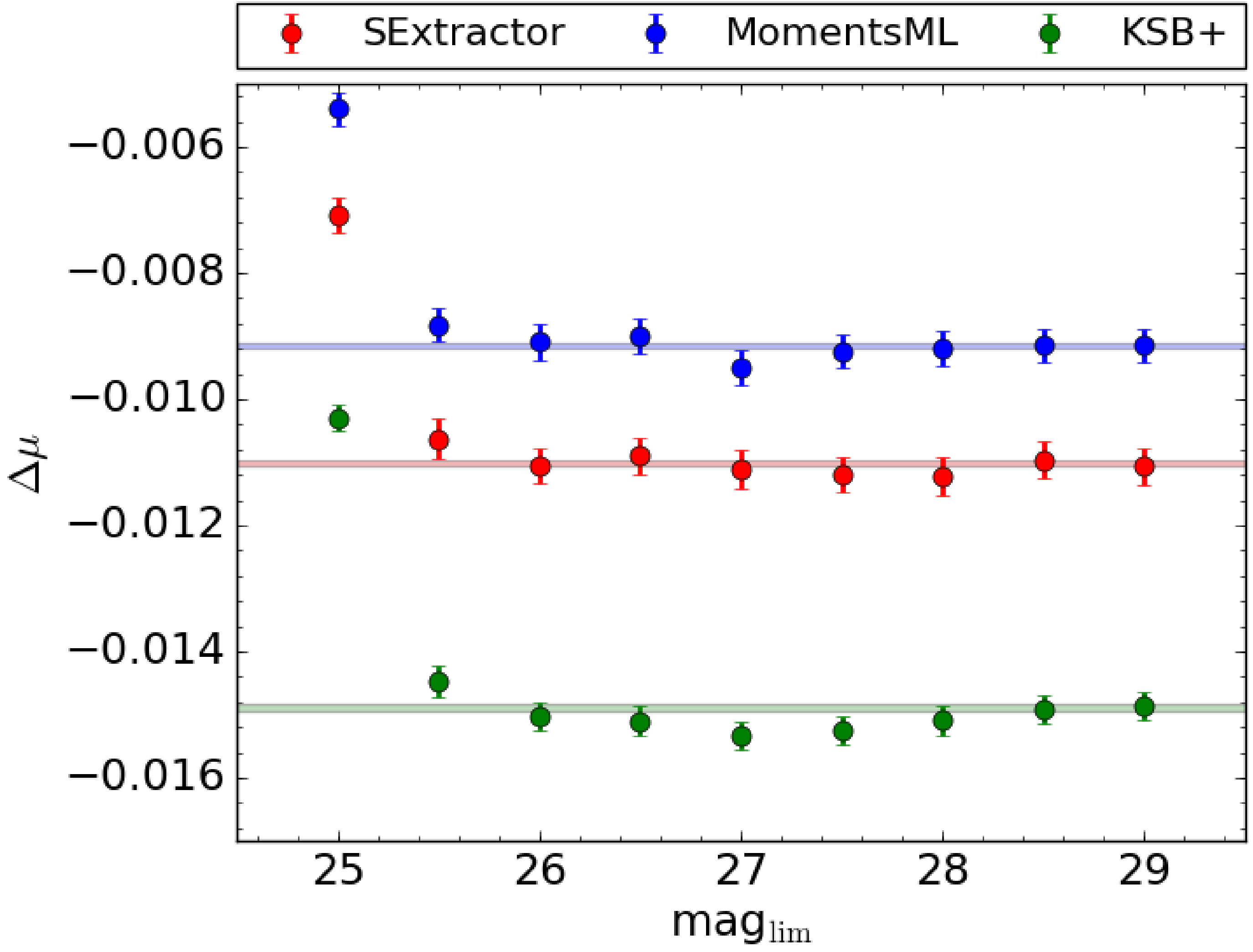
Results for random faint galaxy positions





- Effect of a few 10^{-3} up to magnitude ~26.5-27
- Affects all shape measurement algorithms!

Results with clustering of faint galaxies



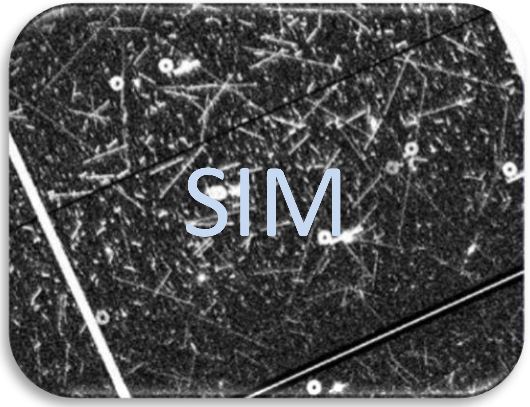
- Effect of clustering quite dramatic: ~10^{-2} up to mag 27-28
- Mostly driven by faint galaxies with mag < 26.5
- Affects all shape measurement algorithms

- Need to accurately include faint galaxy clustering in simulations

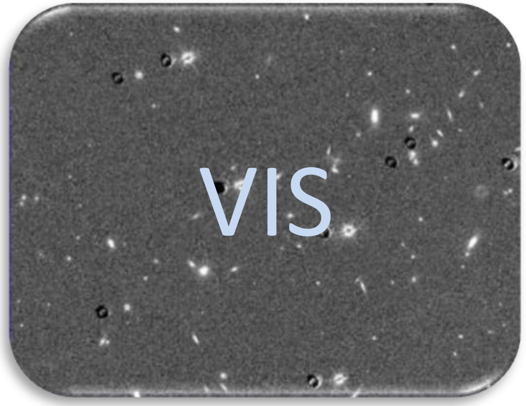
Conclusions

- Galaxies below the detection limit must be included in the Euclid calibration simulations
- Bias of ~10-3 with random faint galaxy position
- Bias of ~10-2 with clustering of faint galaxies
- Most of the effect due to galaxies with $24.5 < mag < 26.5$
- Test with clustering up to mag 26 and random position for fainter galaxies gives similar results as full clustering (at 1-5x10^{-4}) -> possibility to use positions from Flagship for clustered population but cosmology dependence of the calibration
- Magnification effects negligible
- Dependence on the deblending strategy but faint galaxy clustering always significant
- Possible statistical bias due to the small observed area with magnitude depth of 29

Bypass SIM-SHE



Production of simulated images with observational artifacts



Reduction of the simulated images

SHE

Galaxy shear measurement on VIS reduced images

Bypass:

Production of simulated images tailored for specific SHE measurements

- Faster interaction between SIM and SHE for validation
- Possibility to switch on/off particular biases

- Maybe direct simulation of corrected biases (e.g. CTI)