Cosmic Shear Review

Journées LSST France, Nov. 2020

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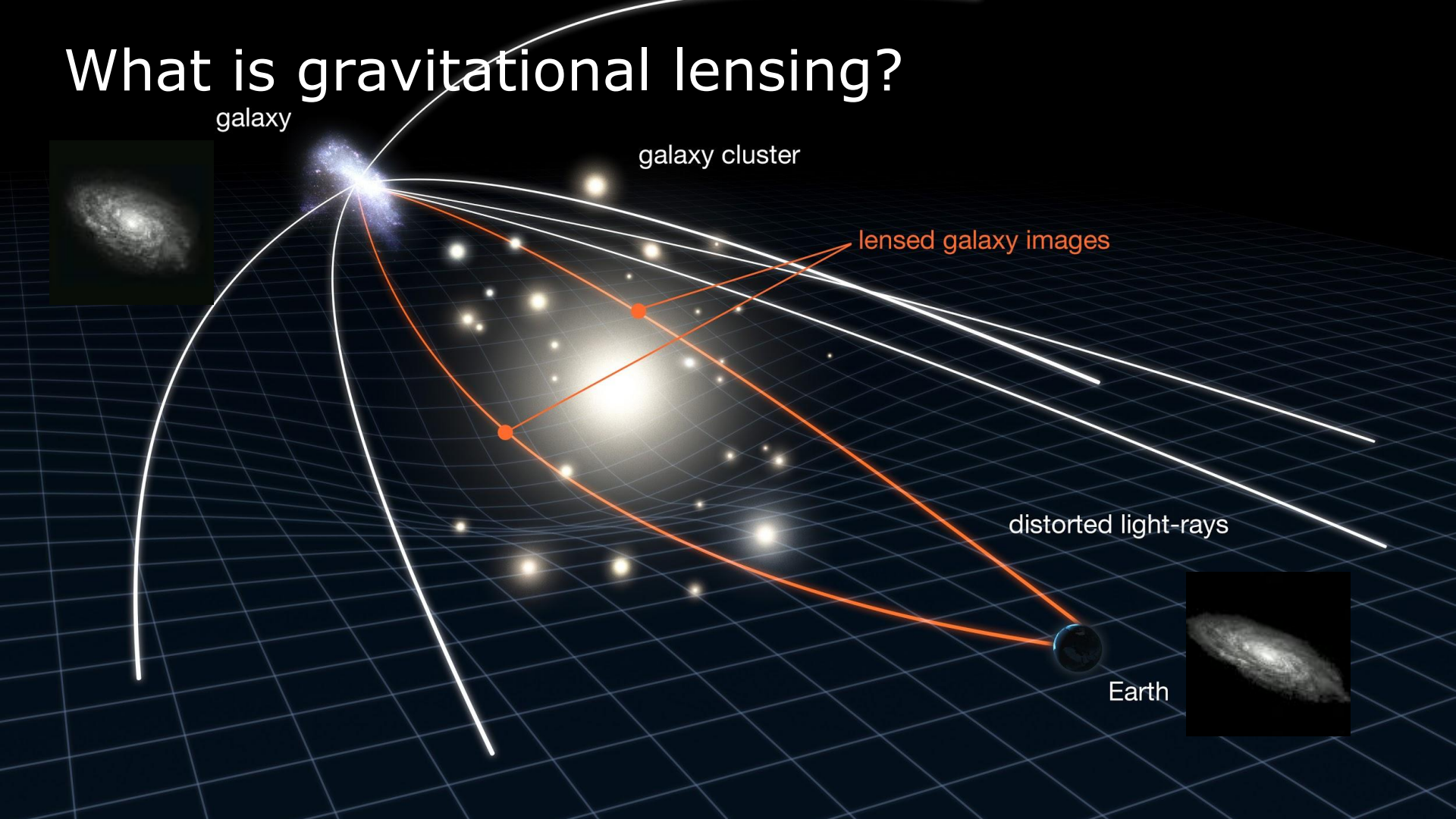
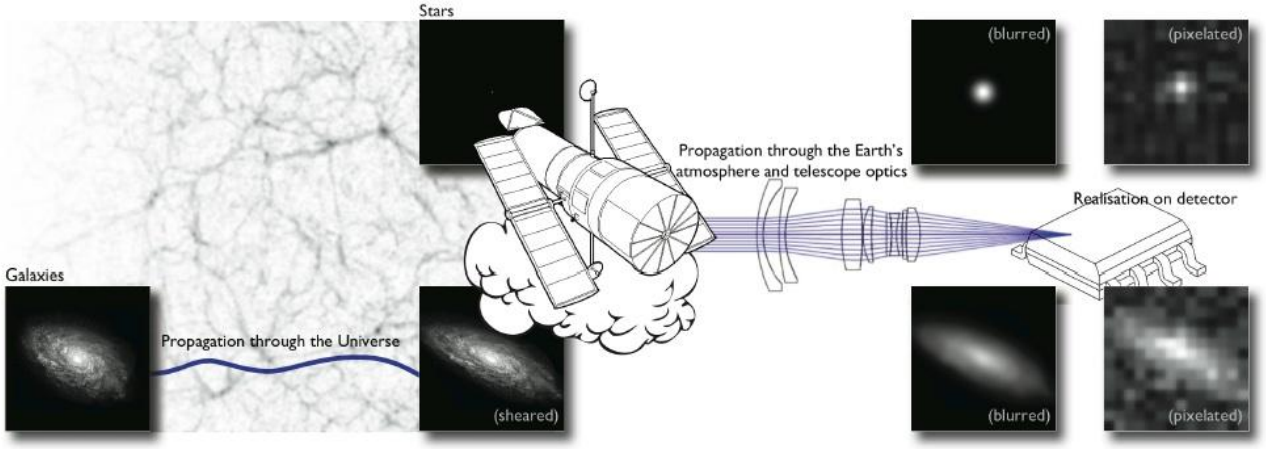
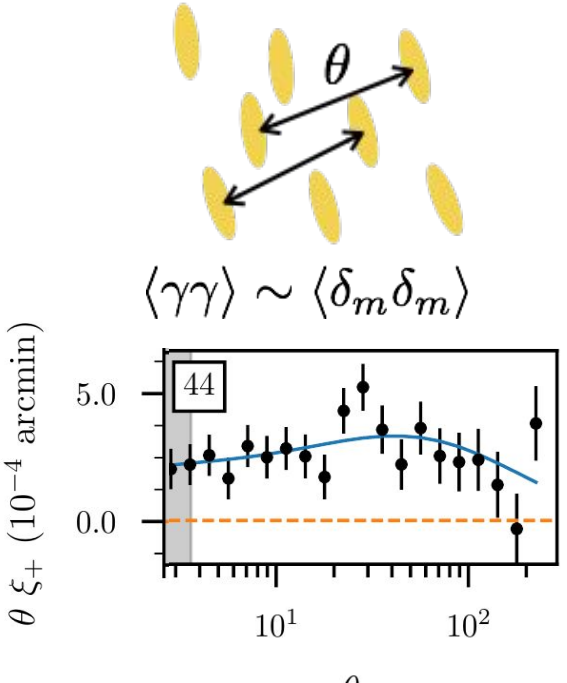
AIM/CNRS

What is gravitational lensing?



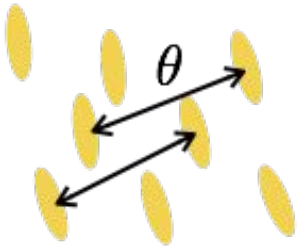
Cosmic Shear: Lensing by the Large Scale Structure

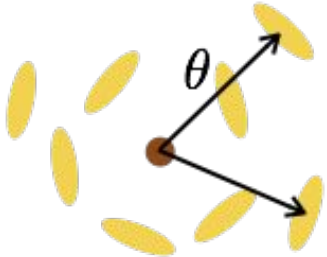


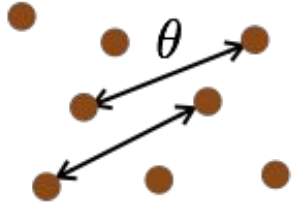


Abbott et al. 2018

Beyond Cosmic Shear: the 3x2pt ar







Cosmic shear

$$\langle \gamma\gamma \rangle \sim \langle \delta_m \delta_m \rangle$$

Galaxy-galaxy lensing

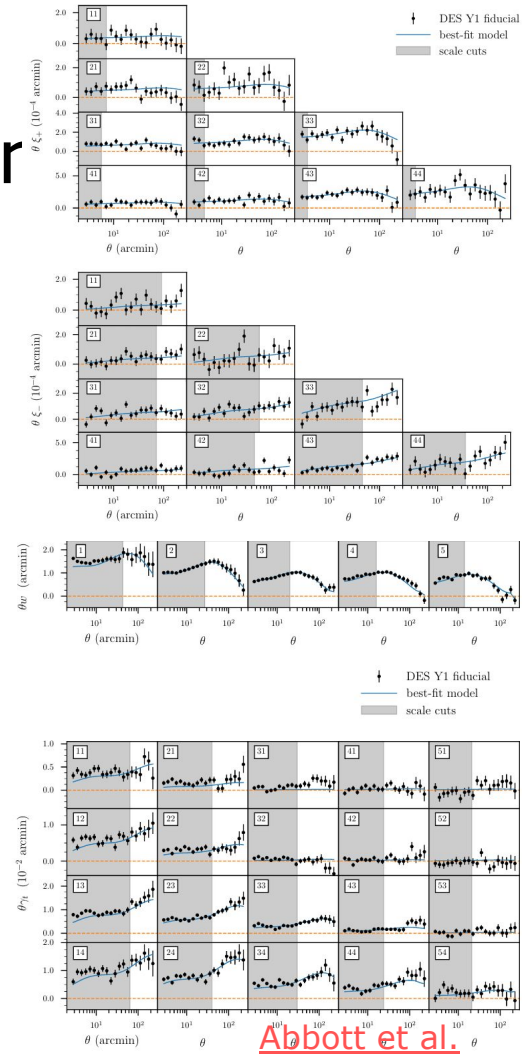
$$\langle \delta_g \gamma \rangle \sim \langle b \delta_m \delta_m \rangle$$

Galaxy clustering

$$\langle \delta_g \delta_g \rangle \sim \langle b^2 \delta_m \delta_m \rangle$$

3 different ways to probe the matter distribution

->Break degeneracies when combining all 3!

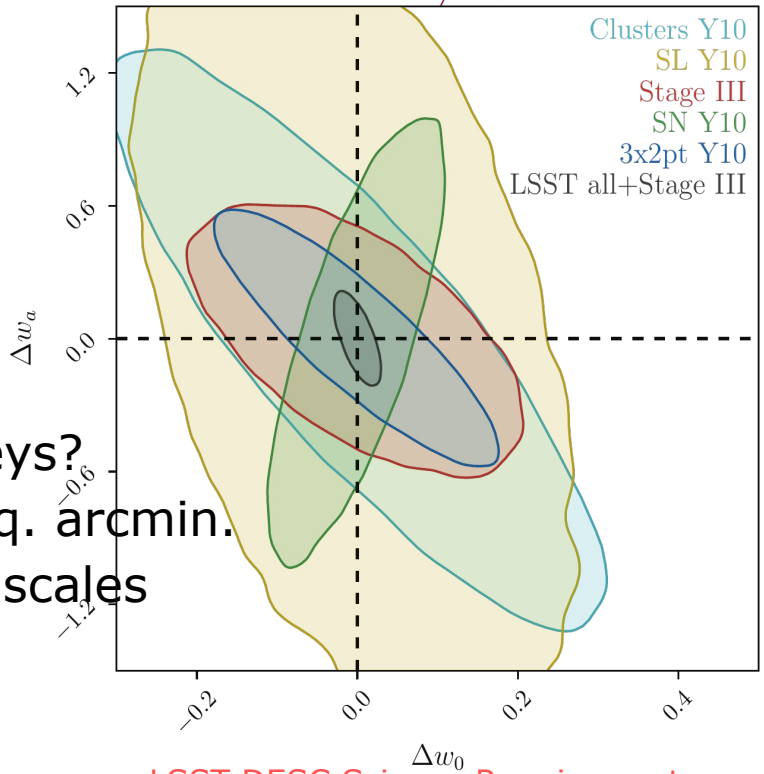


Abbott et al. 2018

Why is this probe so interesting?

- The most promising probe of Dark Energy
  - Most powerful single probe

- How does LSST compare to existing surveys?
  - Greater depth -> more galaxies per sq. arcmin.
  - Larger area -> more statistics, larger scales



LSST DESC Science Requirements Document, Mandelbaum et al. 2018

Going from Stage III to Stage IV

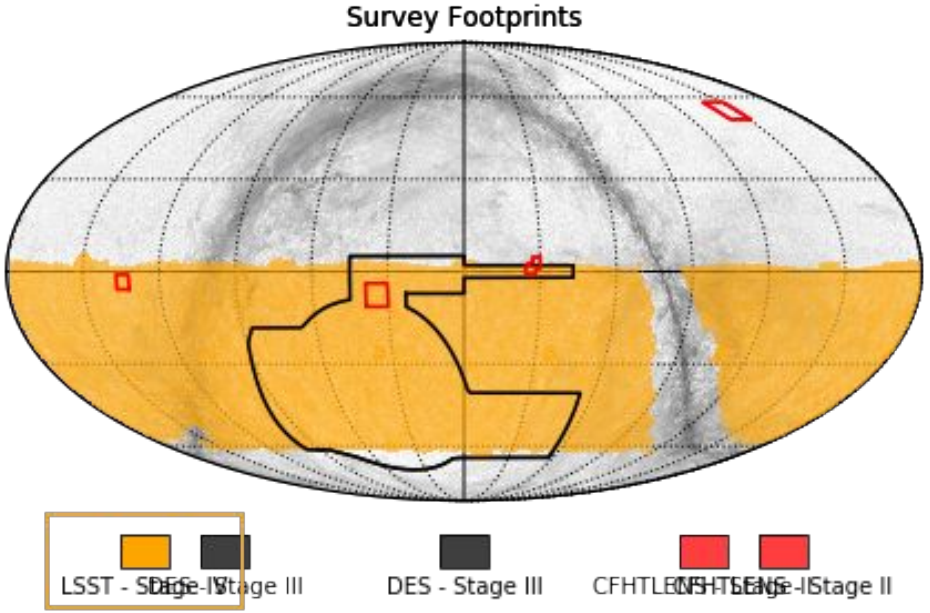
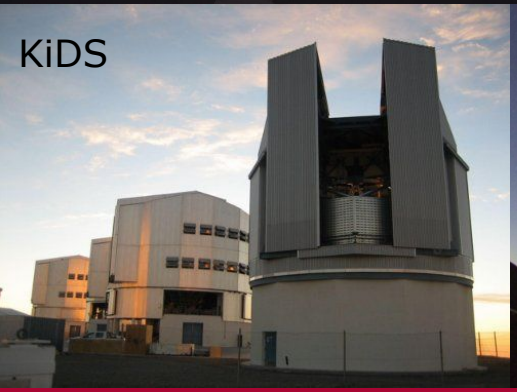
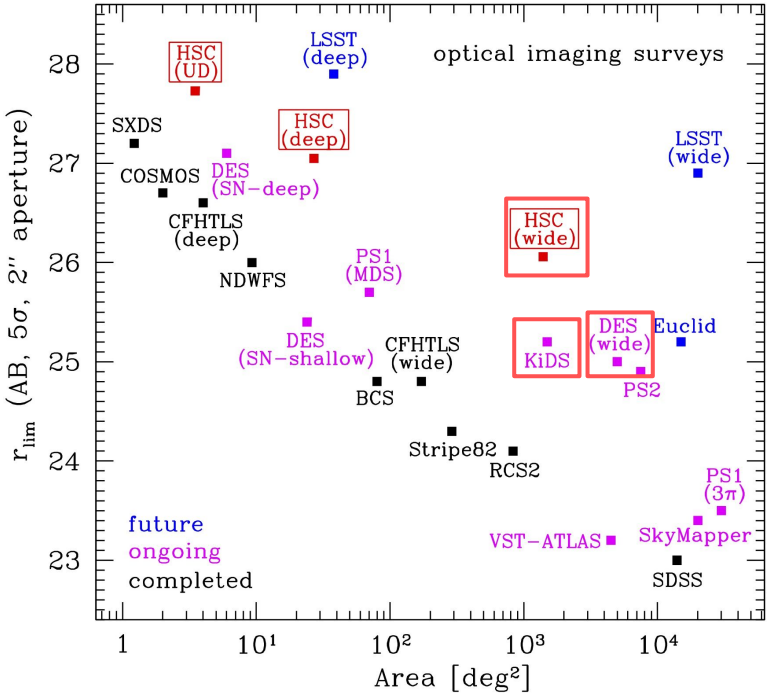


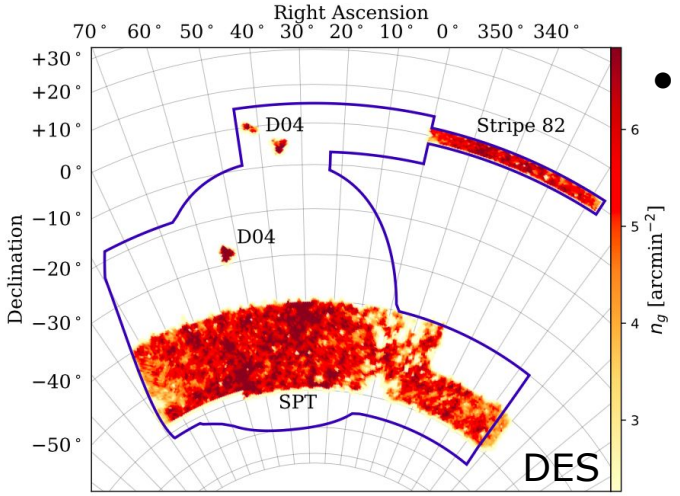
Image courtesy:
Peter Melchior

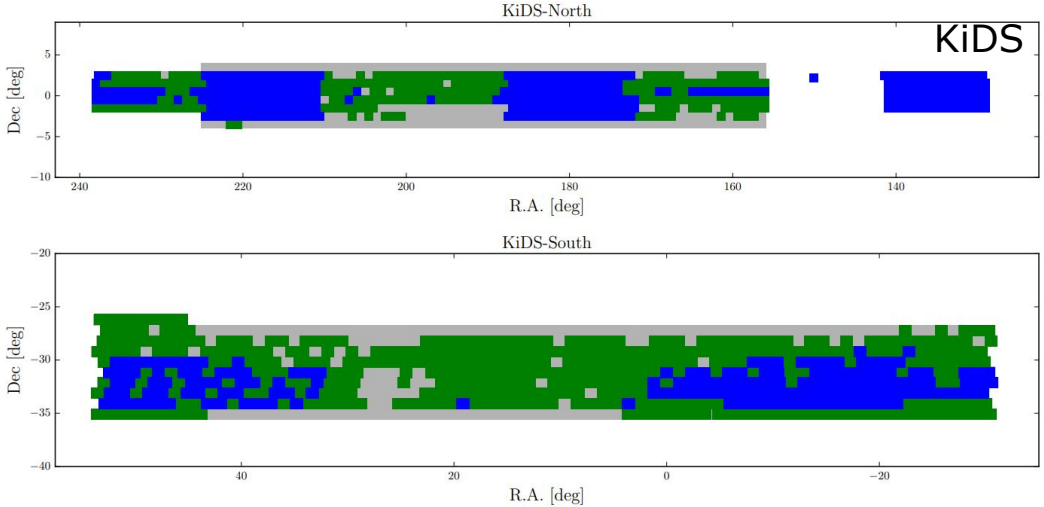
What are the current Stage III surveys?

- Dark Energy Survey (DES)
  - 5000 sq. deg.
- KiloDegree Survey (KiDS)
  - 1500 sq. deg.
- Hyper Suprime-Cam

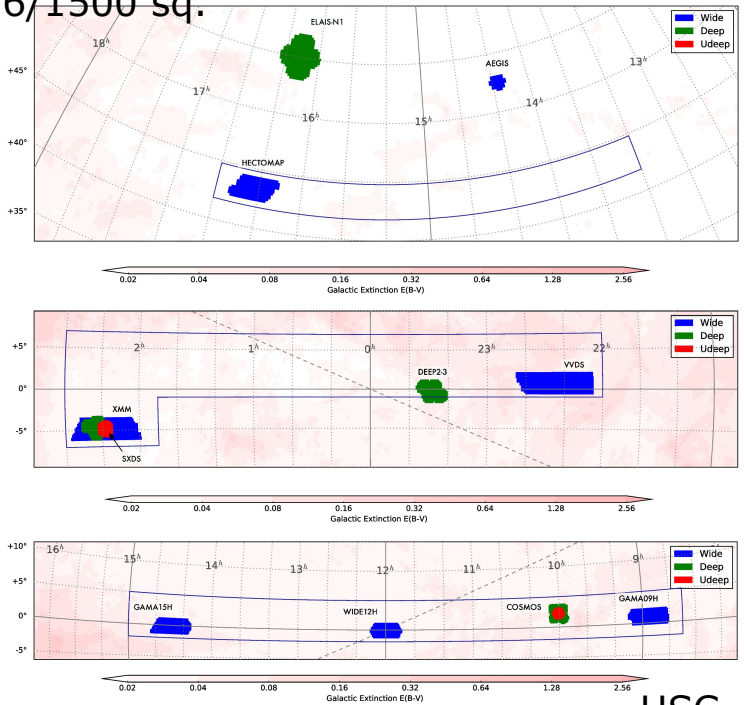




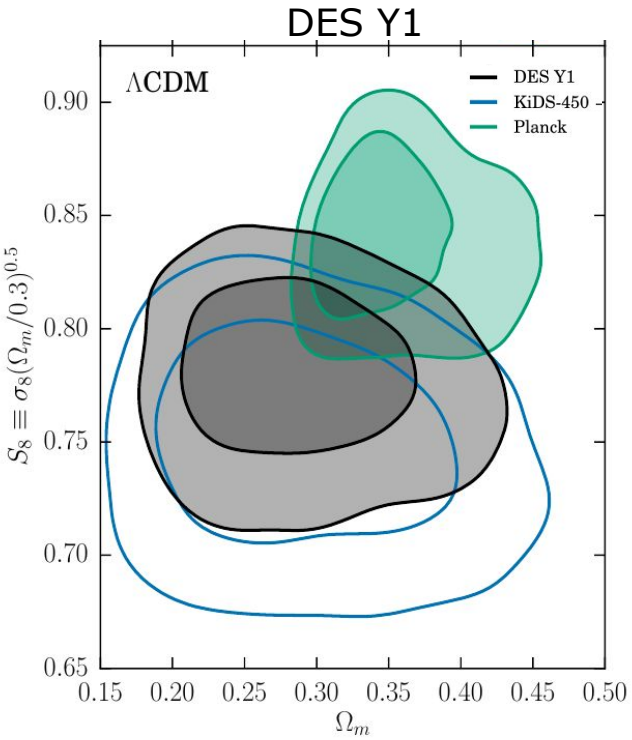




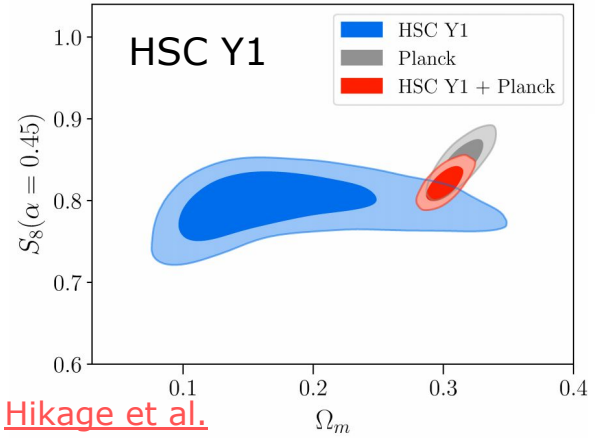
- Current results (Nov. 2020) are based on partial data releases.
  - DES Y1 -> 1321/5000 sq. deg.
  - HSC Y1 -> 137/1400 sq. deg
  - KiDS-1000 -> 1006/1500 sq. deg.



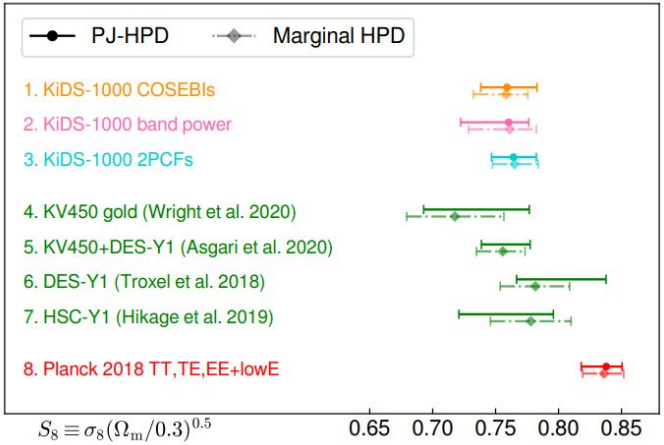
Cosmology constraints from Cosmic Shear

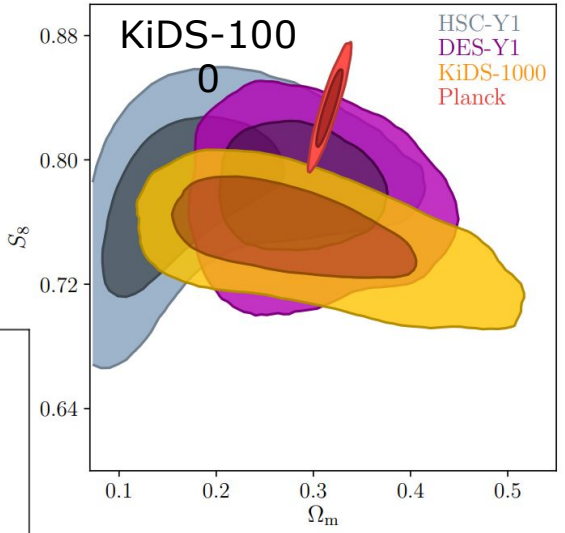


Troxel et al. 2018



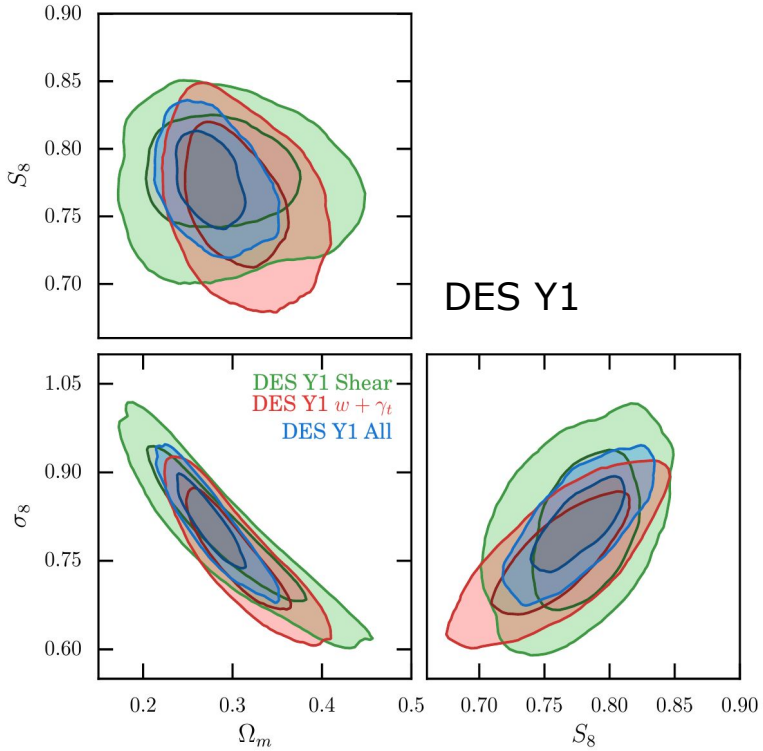
Hikage et al.



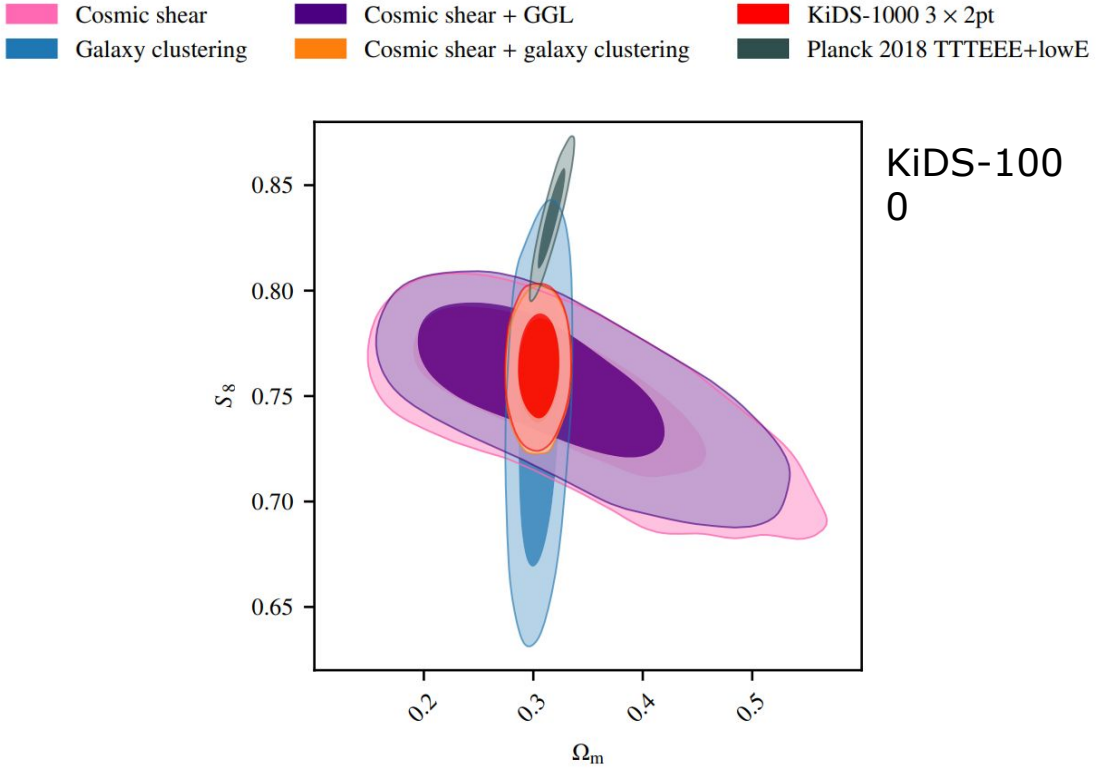


Asgari et al. 2020

3x2pt:Adding galaxy-clustering information



DES Y1

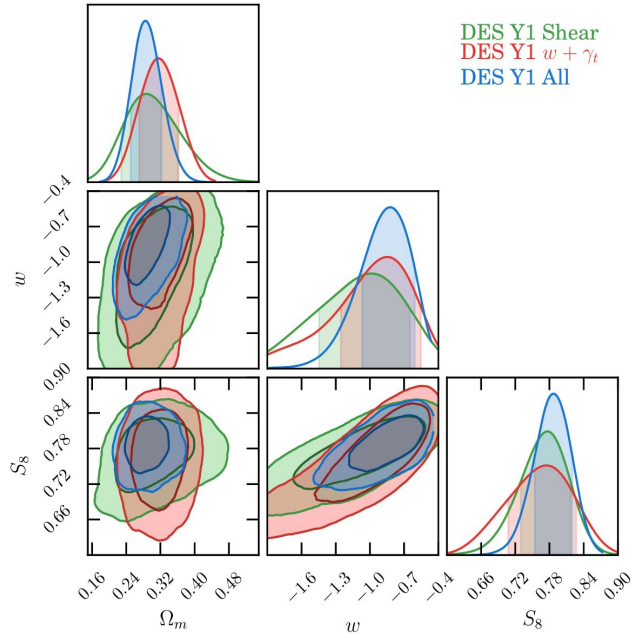


KiDS-1000

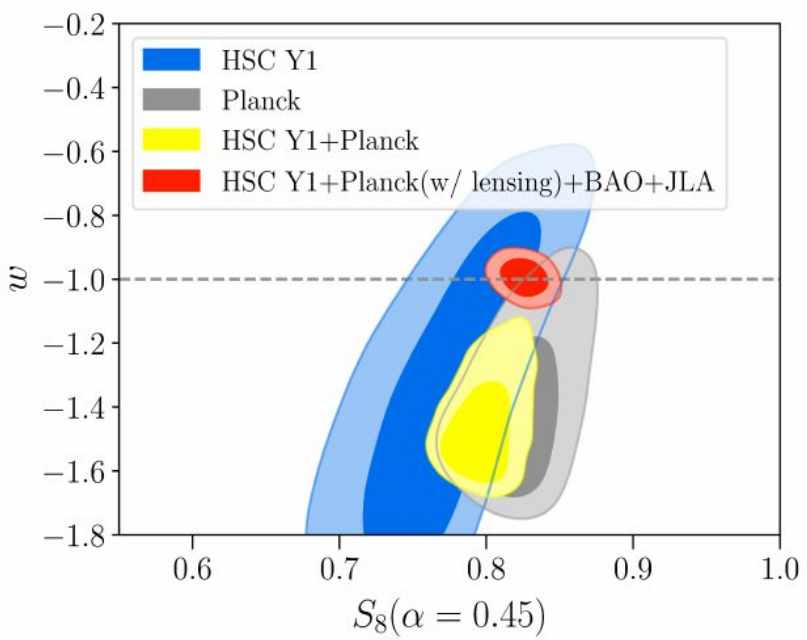
Abbott et al. 2018

Heymans et al. 2020

What about Dark Energy ?



Abbott et al. 2018

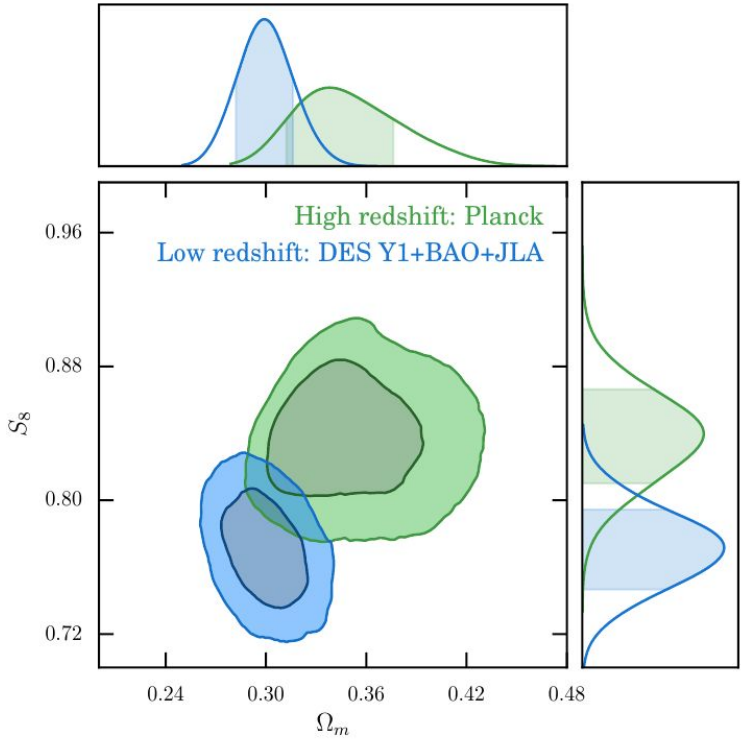


Hikage et al. 2019

Current state of affairs

- All surveys broadly agree with each other, but seem to exhibit a slight tension with Planck constraints, i.e. high redshift probe.

- Significant open challenges on systematics and modeling.
  - Shape measurement, photometric redshifts...
  - Non-linear scales, intrinsic alignments...



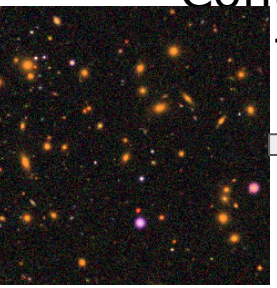
Abbott et al. 2018

What about LSST DESC in this picture?

DESC Weak Lensing Working Group Activities

<u>WG focus:</u> Science verification readiness with end-to-end processing pipeline

- Integration of shape measurement algorithms into the Rubin DM stack
- Implementation of 3x2pt analysis pipeline
- Control of sources of systematics with close integration with LSS, TJP, P



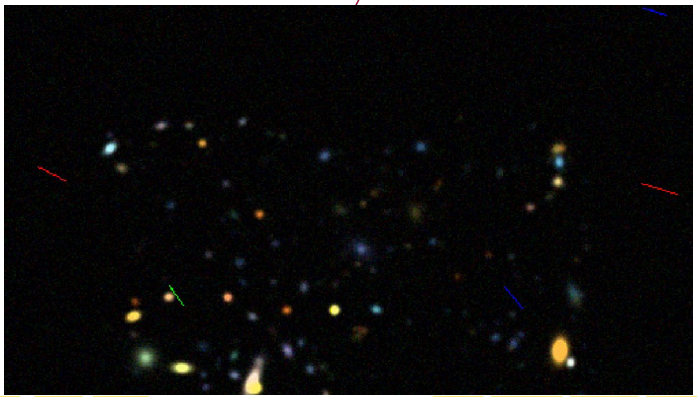
```
import GCRCatalogs
cat = GCRCatalogs.load_catalog('dc2_object_run2.2i_dr3_with_metacal')
cat.get_quantities(['mcal_g1', 'mcal_g2',
                    'mcal_g1_1m', 'mcal_g1_1p', 'mcal_g1_2m', 'mcal_g1_2p',
                    'mcal_g2_1m', 'mcal_g2_1p', 'mcal_g2_2m', 'mcal_g2_2p'])
```

DC2 Image, courtesy of Dominique Boutigny

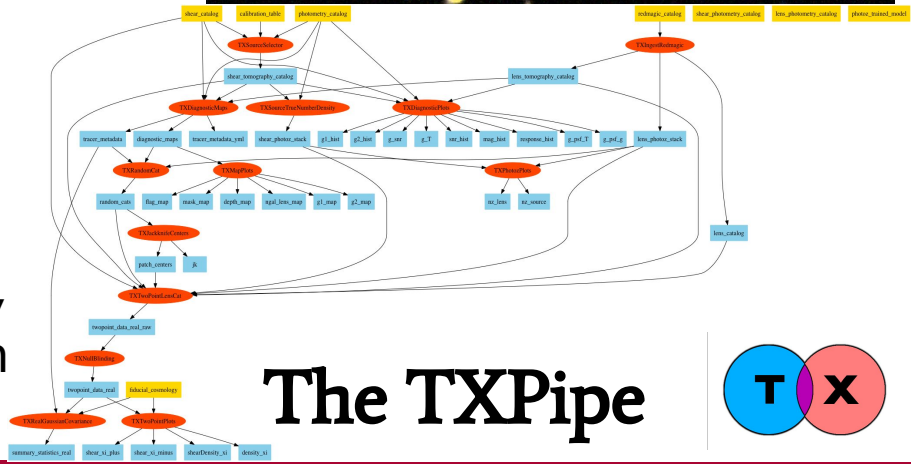
Access to shape catalog from DC2 image simulations, thanks to many people, special mention to Johann Cohen-Tanugi

Pipeline development: From Pixels to Measurements

- Development and validation of next generation shape measurement: MetaDetection
  - Fast image simulation tools
  - Implementation into DM infrastructure

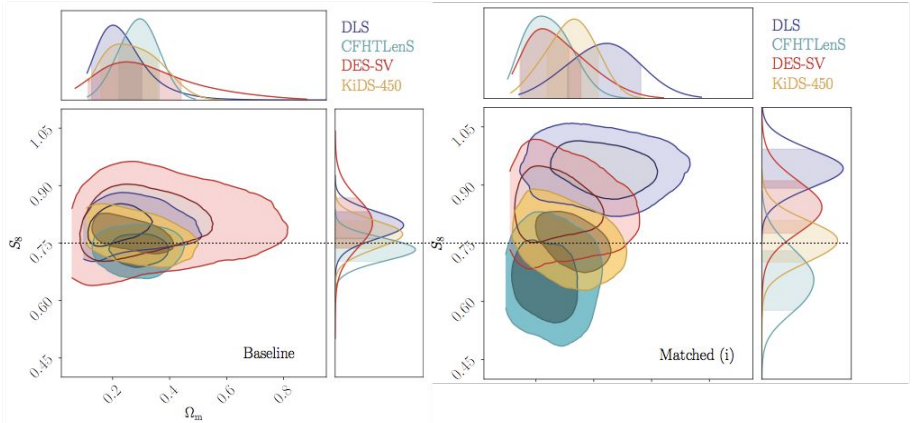


- Development of 3x2pt measurement pipeline
  - Integration of Data Management, sample selection, metacalibration photometric redshifts, real and

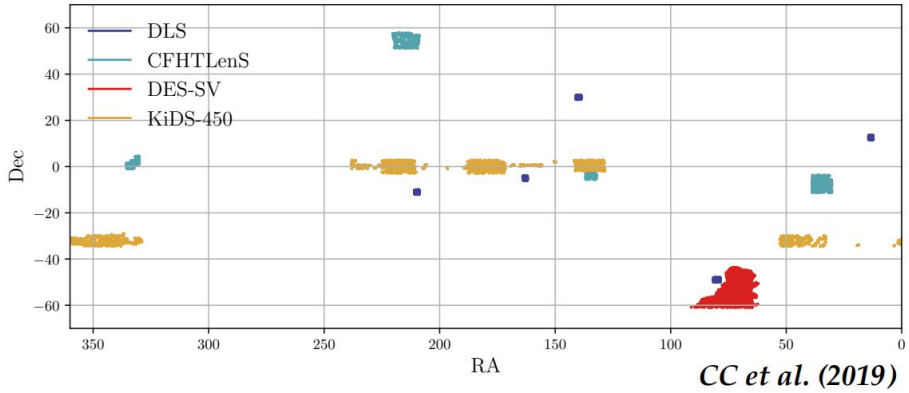


Before data: Reanalysis and comparison projects

- Chang et al. 2019: Reanalysis of Stage II surveys (DLS, CFHTLenS, DES-SV, KiDS-450)
  - Huge need to improve transparency and reproducibility of analyses



- Ongoing DESC reanalysis projects:
  - Real-space cosmic shear reanalysis of DES Y1, HSC Y1, KiDS-450
  - Harmonic-space 3x2pt analysis of HSC Y1 (new!)
  - Pixel-level reanalysis of HSC Y1 with metacalibration (new!)



Take away message

- Stage III surveys are rapidly nearing completion, stay tuned for new results.
  - They all seem to show slight tensions with high redshift probes (Planck)

- Plenty of challenges that can already be investigated by DESC on Stage III data.

- Exciting times to get involved in Cosmic Shea


DESC Hack Week 2016

Advertisement:
The **DESC Sprint Week** will take place next month (online, Nov 30-Dec 4), **perfect opportunity** to get involved in DESC and in lensing related projects (TXPipe, photometric redshifts, shape measurement, etc.).
Don't hesitate to reach out to me (@flanusse on slack) with any