FERMILAB-SLIDES-20-041-PPD

LSST in 10 minutes

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New Perspectives 2020

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Introduction

- **What is LSST?**
  - The **L**egacy **S**urvey of **S**pace and **T**ime is a photometric survey that will be carried at the [Vera C. Rubin Observatory](#) at Cerro Pachón (Chile). Planned to start in 2022.

Status of the site on Apr 14th 2020. Image credits: lsst.org/ Google Maps

LSST: Key Numbers

- It uses the 8.4-m mirror Simonyi telescope.
  - Using the LSST Camera 3.2 Gpix. 189 CCD 4096x4096 pixel sensors.
  - Field-of-view ~9.6 square-degrees (approx 40 full moons).
  - 10 year survey in 6 different bands (filters): u, g, r, i, z, y.
  - 37 billion stars and galaxies.
  - 10 million transient alerts (supernovae, meteorites, planets, things that are variable in the sky)
  - 20 TB of data every night! Expected ~15 PB database for the final data release.

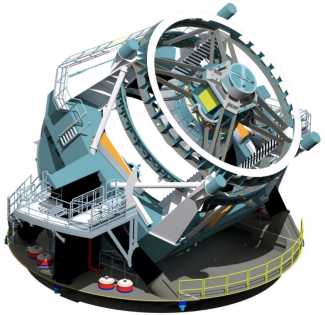
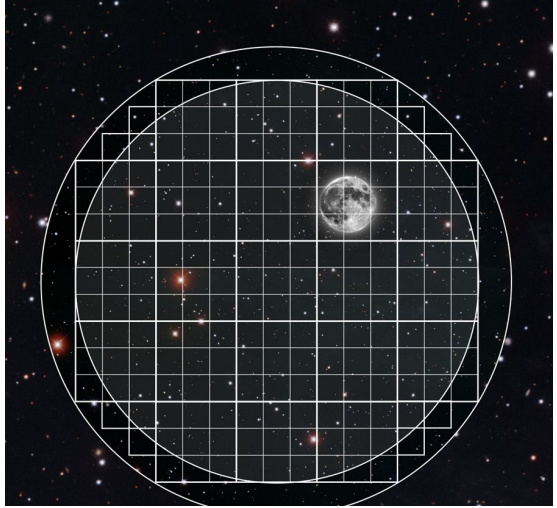
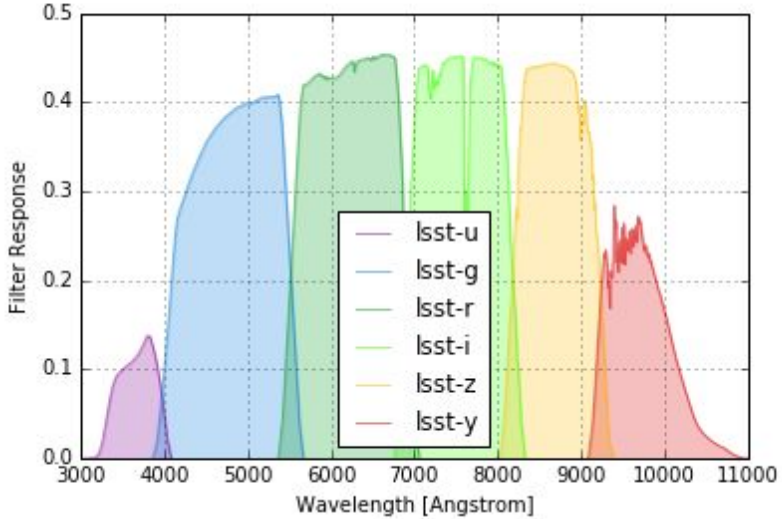


Image credits: LSST/ NSF/ AURA

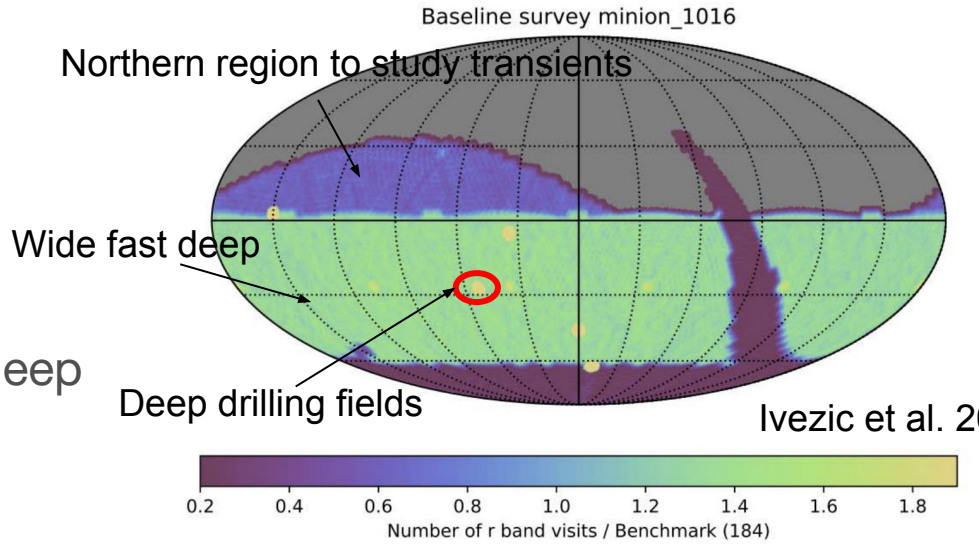
Filters from speclite





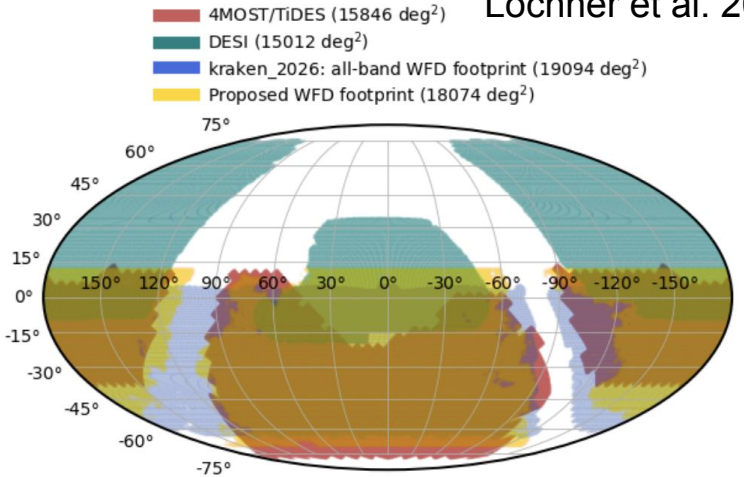
LSST: Science

- 8 science collaborations.
- Map 30,000 square-degrees total.
- 90% of survey time to map uniformly ~18,000 square-degrees (wide-fast-deep survey).
- Main science drivers:
  - Dark matter and dark energy.
  - Solar system.
  - Transients/variable objects.
  - Milky way.



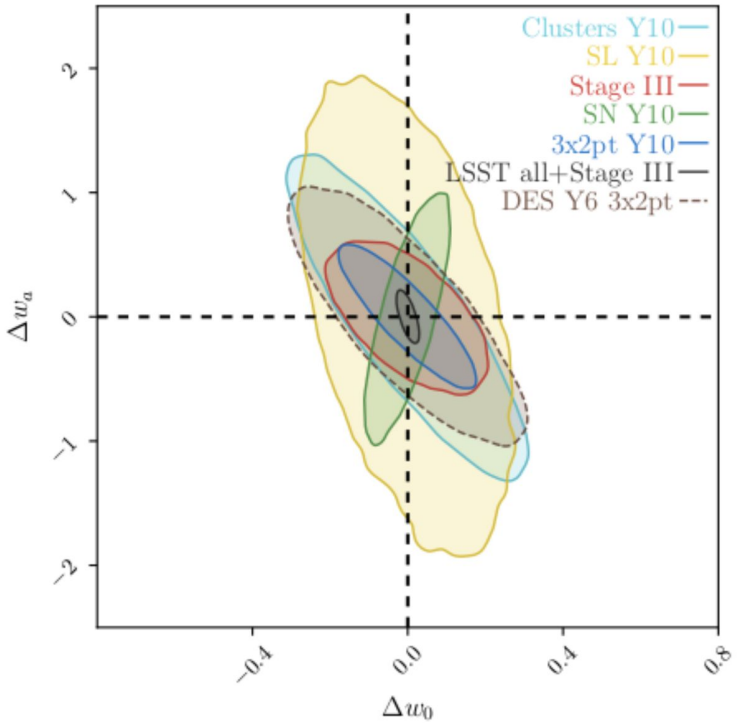
Ivezic et al. 2019

Lochner et al. 2018



Dark Energy Science with LSST

- Dark Energy probes:
  - **Weak gravitational lensing.**
  - Baryon Acoustic Oscillations and galaxy clustering.
  - Clusters of galaxies.
  - Strong gravitational lensing.
  - Supernovae.



Lochner et al. 2018

Weak Lensing: Intro

- Gravity bends light.
- Object shapes appear sheared to us due to the presence of matter.
- Measuring shapes we can get information about the (mostly dark) matter distribution.
- We repeat this at different cosmic times (tomography).

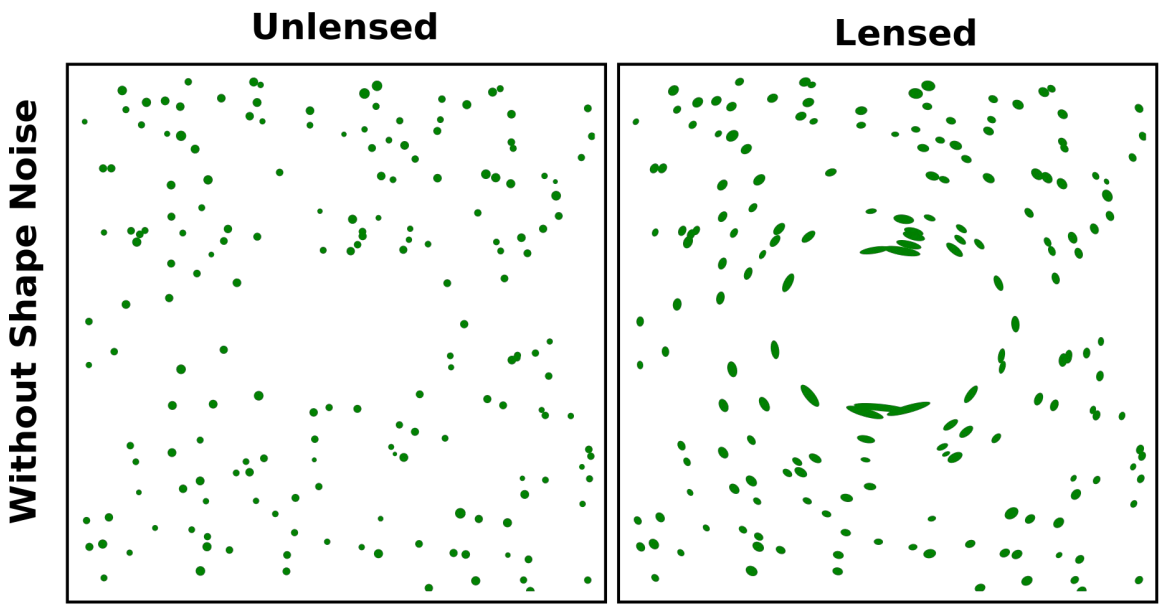


Image credit: Wikipedia

Weak Lensing: Challenges

- Galaxies aren't round.
- Shapes are random at first order.
- We can still get information but we have noise due to the intrinsic variance in the shapes (shape noise).
- We need a lot of galaxies since the shear effect is typically 3-300 times smaller than the intrinsic shape.

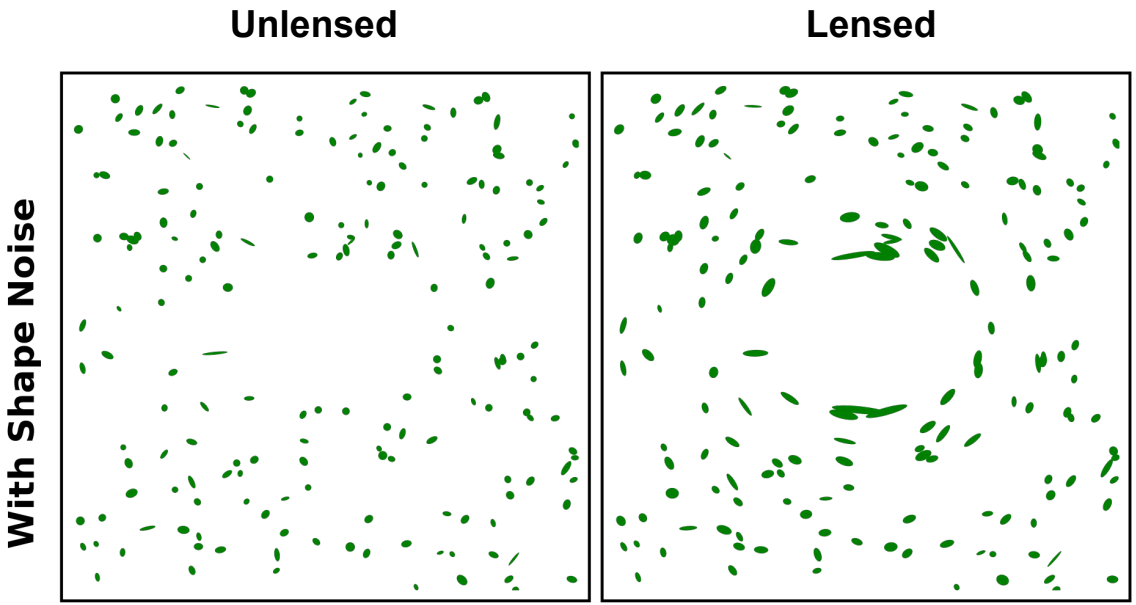
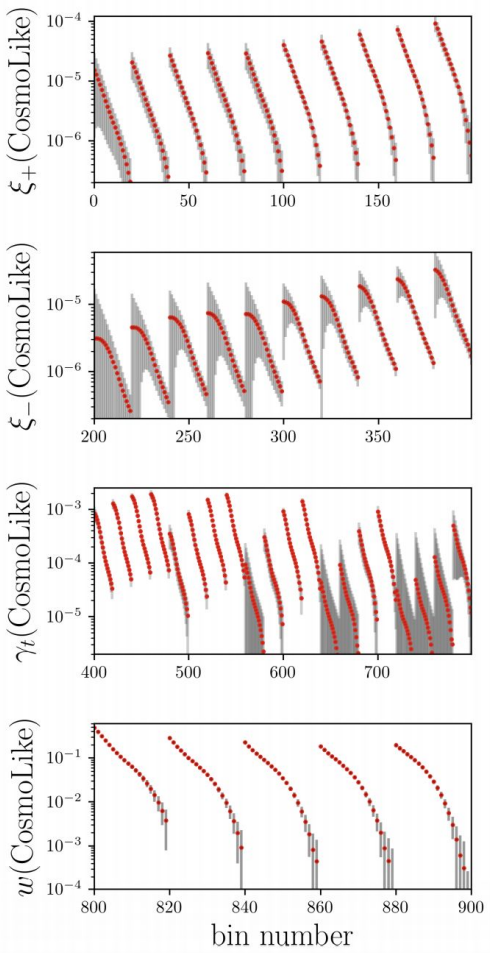


Image credit: Wikipedia

3x2pt analysis

- Cosmic shear is one of the dark matter density tracers. But galaxies are also dark matter density tracers.
- Initial density fluctuations are close to Gaussian. 2-point statistics can fully determine the field.
- Combining 3 different (although correlated) 2 point statistics we can improve cosmological constraints:
  - Shear-shear (cosmic shear).
  - Shear-galaxy (galaxy-galaxy lensing).
  - Galaxy-galaxy (galaxy clustering).

Error-bars for LSST should be ~10 times smaller.



DES Y1. Krause et al. 2018

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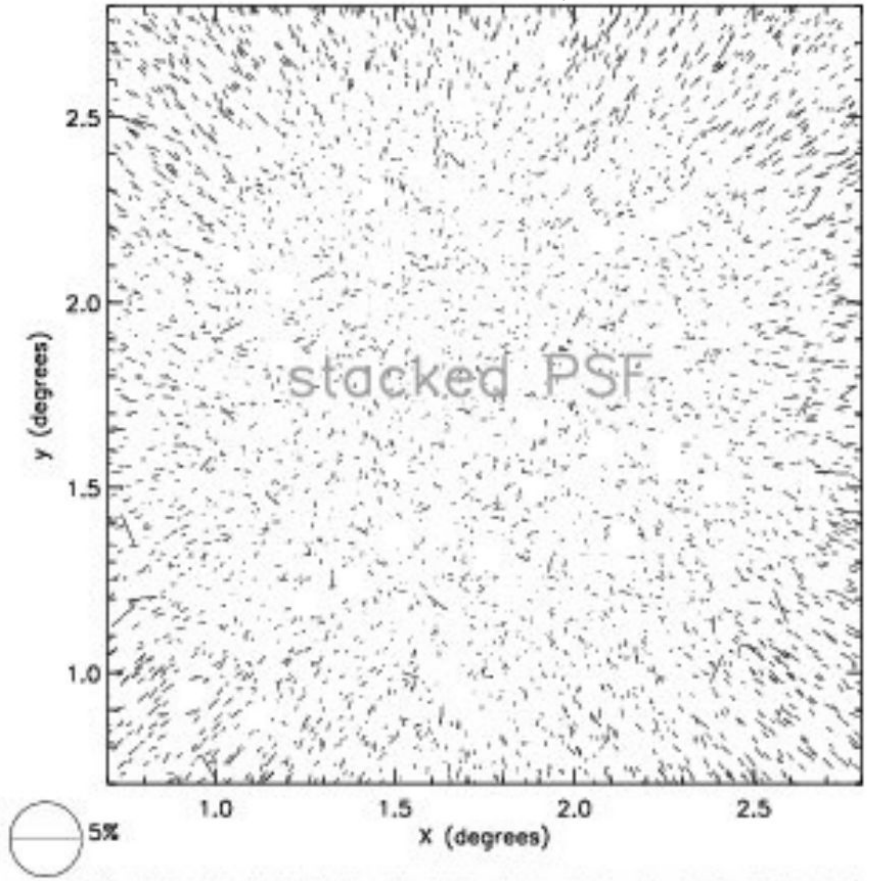
3x2pt analysis challenges

- LSST will accurately determine shapes for 2 billion objects.
- This means that it will be systematics limited!
- Atmosphere and optics can introduce spurious shears.
- This imposes very strict requirements in image quality and the knowledge/determination of the point-spread-function (PSF).

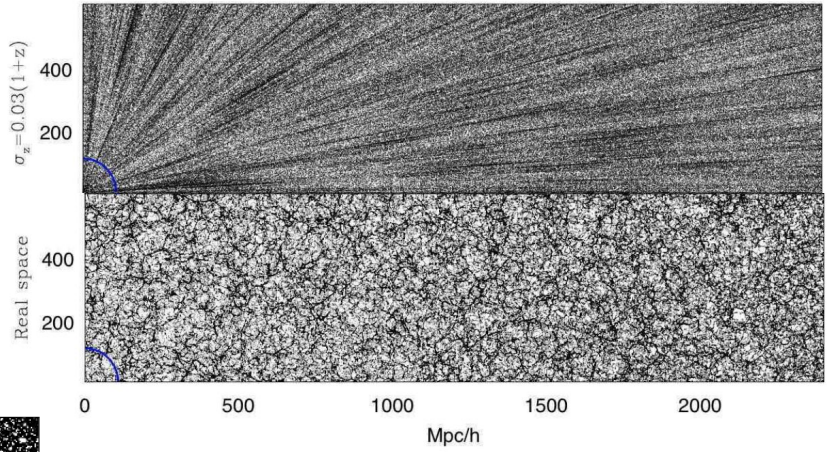
PSF ellipticity



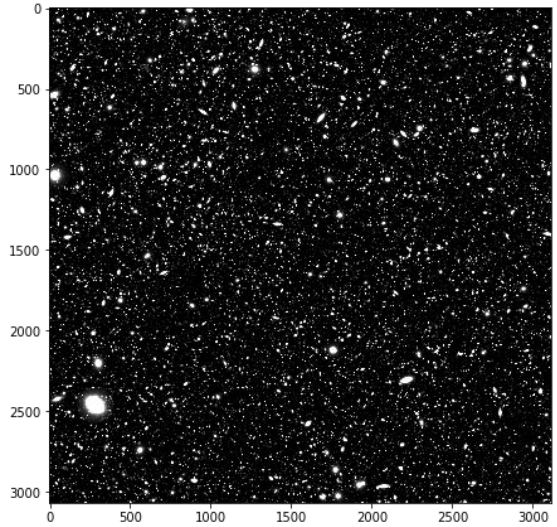
Jee & Tyson 2011

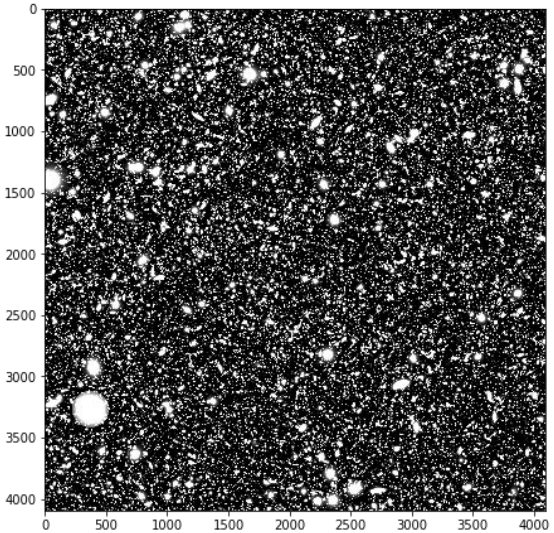
3x2pt analysis challenges

- LSST will perform “low-resolution” tomography.
- More objects in the field, increases the probability of overlaps: Blending.



Benítez et al. 2009





Left: DES Y6
Right: LSST Y10

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LSST @FNAL

- FNAL involved in Rubin Observatory project and different LSST Science Collaborations.
- Key Roles in Rubin/LSST Operations: Observatory operations, data production and data performance.
- Heavy involvement in LSST DESC:
  - Survey Simulations: Image Simulations (Montecarlo), ++
  - Dark Matter studies: Preparation for the search of Low Surface Brightness objects, ++
  - Cluster studies.
  - Strong Lensing studies.
  - Galaxy clustering/weak lensing/3x2pt: Contributions to analysis pipeline.
  - Blending studies: Forecasting of impact of blending and mitigation with overlapping observations.
  - Cross-correlations with CMB experiments: SPT, CMB-S4.
  - Transient/Gravitational wave follow-up.
  - And many others!