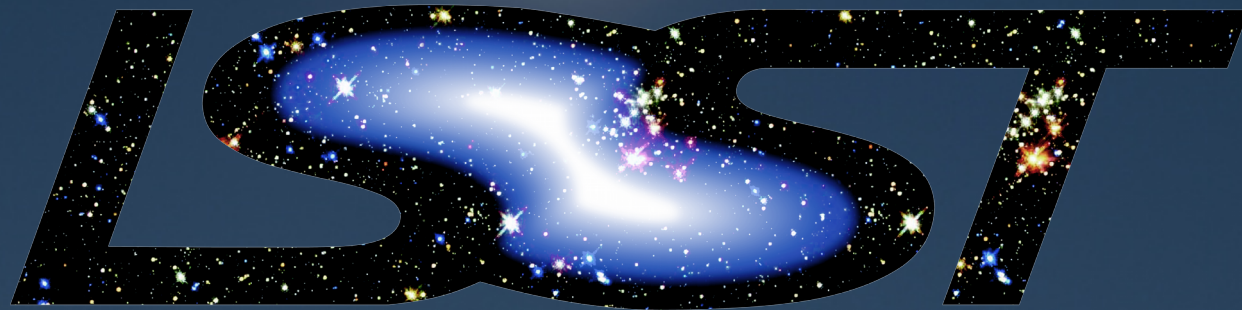
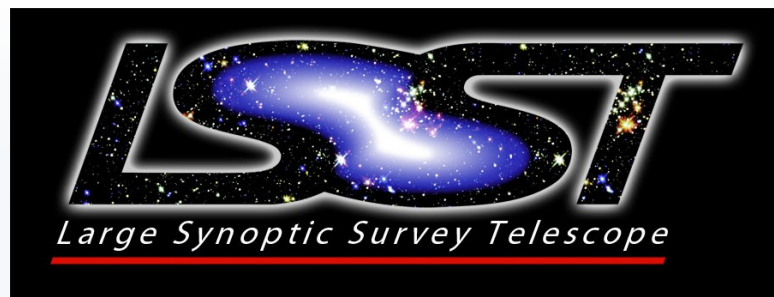


News from



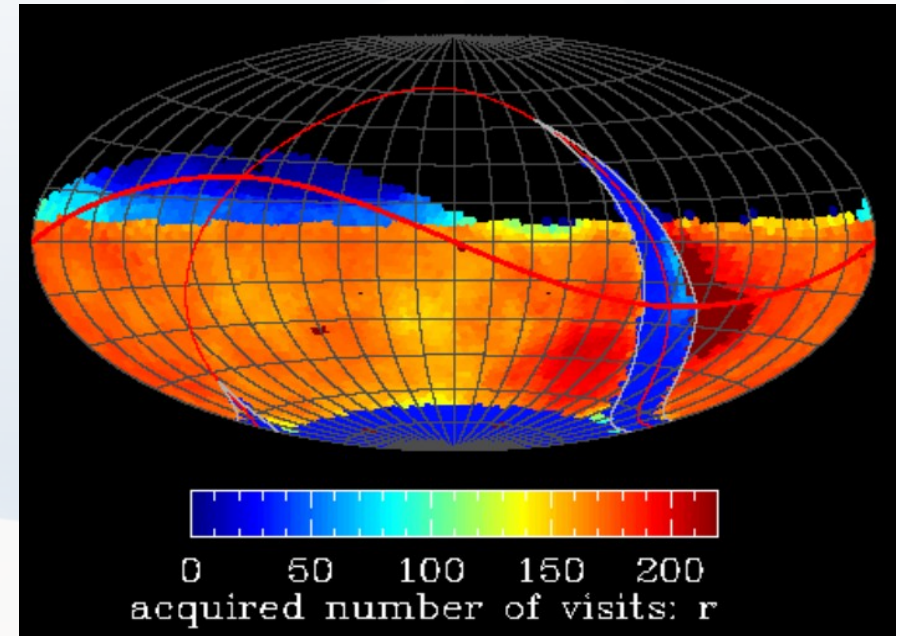
Large Synoptic Survey Telescope

Emmanuel Gangler – LPC – Clermont-Ferrand (France)

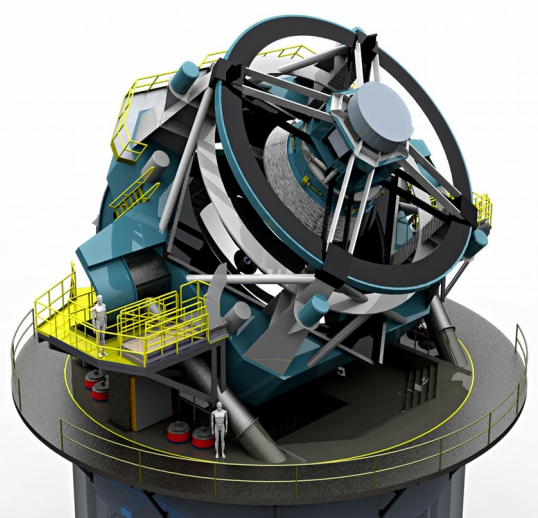


summary :

- A stage-IV survey :
 - 8.4 (6.7) m telescope
 - Cerro Pachon (Chili)
 - 3.2 Gpix 9.6° FoV camera
 - $0.2''$ pixel / $0.7''$ median FWHM
 - First light 2021, Survey 2022



- All visible sky in 6 bands (ugrizy) ($\sim 18000^\circ$)
- 1x30 s exposure, 1 visit / 3 days
r ~ 24.4 / visit
- During 10 years !
→ ~ 825 visits (all bands)
- 20TB/day 60 PB/10 years

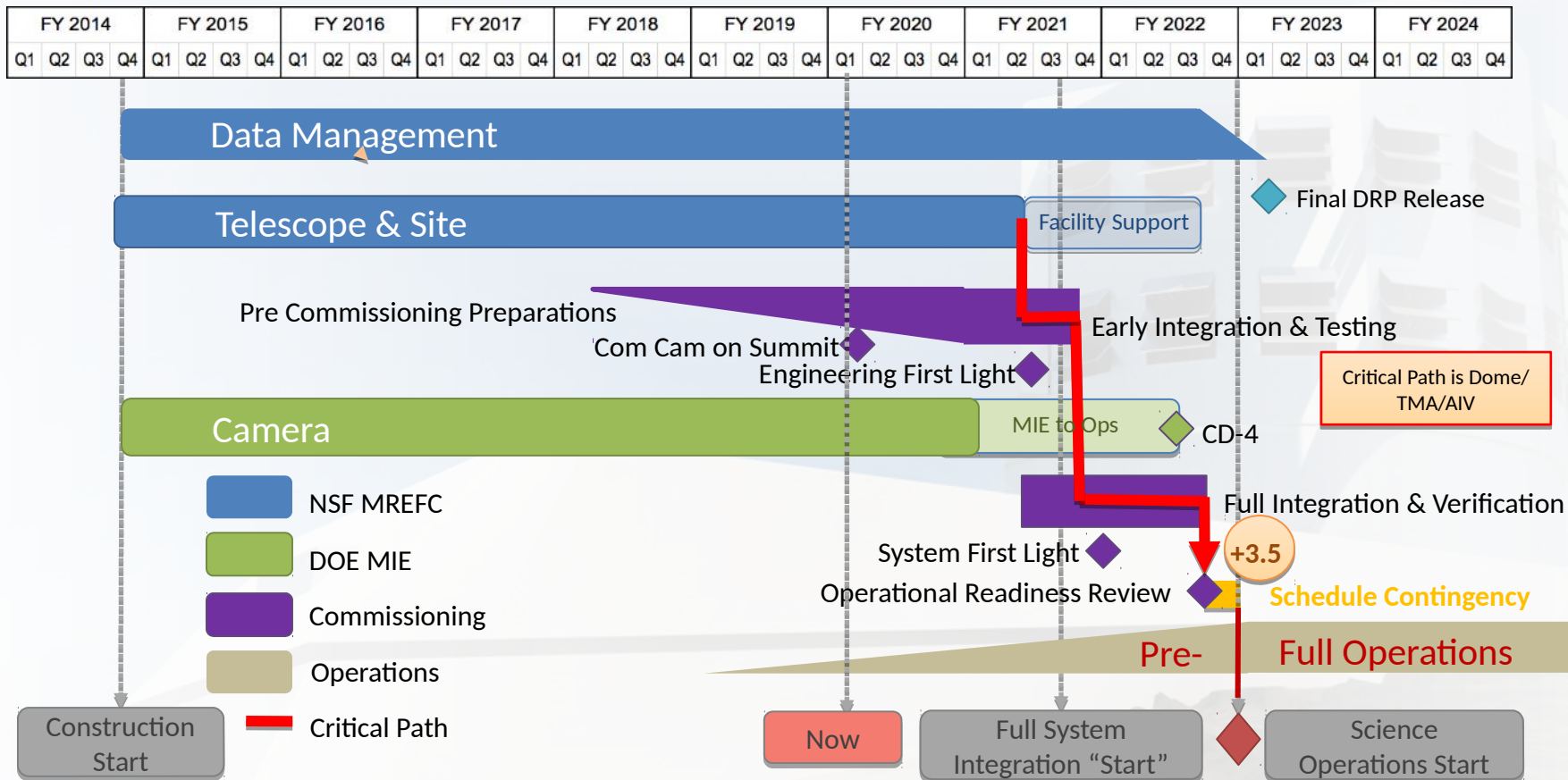


LSST project and Science:



- **LSST covers 4 major scientific themes**
 - Dark Energy, Dark matter
 - Mapping Milky Way
 - Transient optical sky
 - Solar system
- **Scientific analysis is not part of the project**
 - Conducted by independent collaborations
 - LSST delivers reduced data, scientists analyze them

LSST Timeline



Commissioning is happening NOW !

- **AuxTel (=1CCD):** First light with spectrograph 2019 (Chile)
- **ComCam (=1 Raft/9 CCDs):** integration 2019 (Tucson), First light in 2021 (Chile)
- **Full Focal Plane:** 9/25 Rafts integrated (SLAC, Oct 2019), Completion (summer 2020), First light fall 2021 (Chile)

The dream is coming true !

Sep. 2019



2012 rendering

Telescope at manufacturer Facility
→ being mounted at Summit



Summit Facility is complete
while Dome is constructed



M1M3 mirror on site



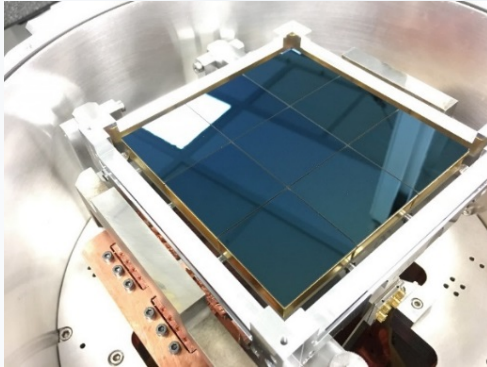
Emmanuel

Filter exchange System:

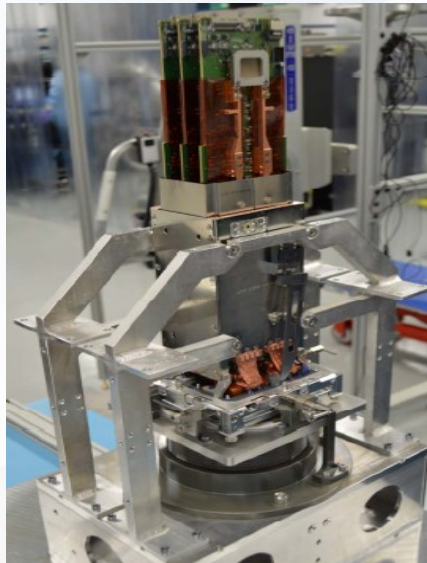
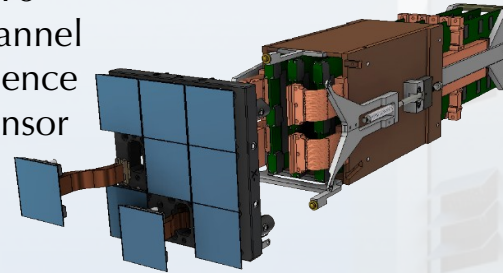
- **Fast filter exchange (<2 minutes swap time)**
- **Successful collaboration between 5 labs in France**
- **5 filters within the camera** for automatic switching + **1 filter swapped** out depending on moon phase
- Delivered at SLAC oct. 2019, *under integration within the camera*
- **Video on the Journal du CNRS**



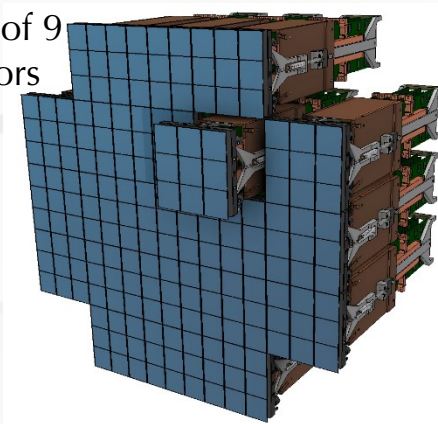
Focal plane: 63 cm and 3.2 Gpix



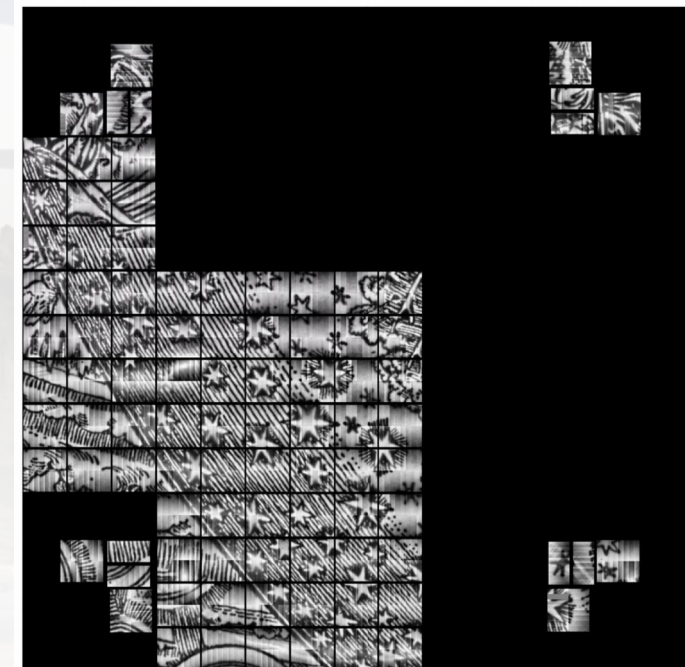
4K x 4K
16
Channel
Science
Sensor



189 sensors
packed in 21
rafts of 9
sensors



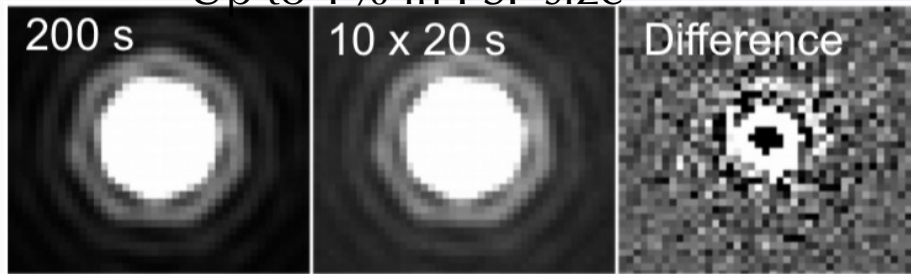
All 21 Rafts
have been
assembled



Brighter-Fatter effect

Size of star spots depends on flux

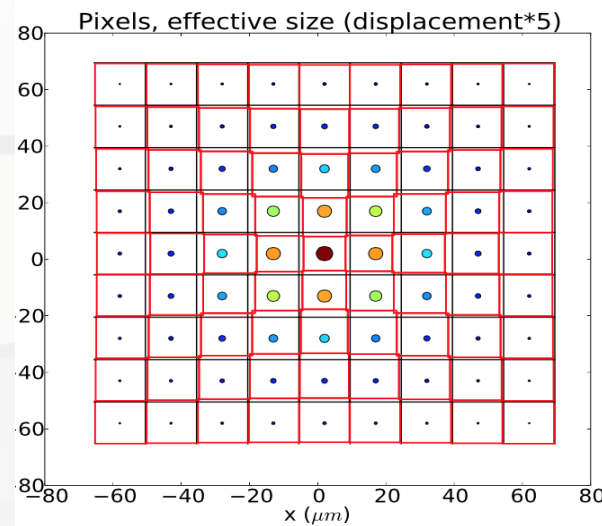
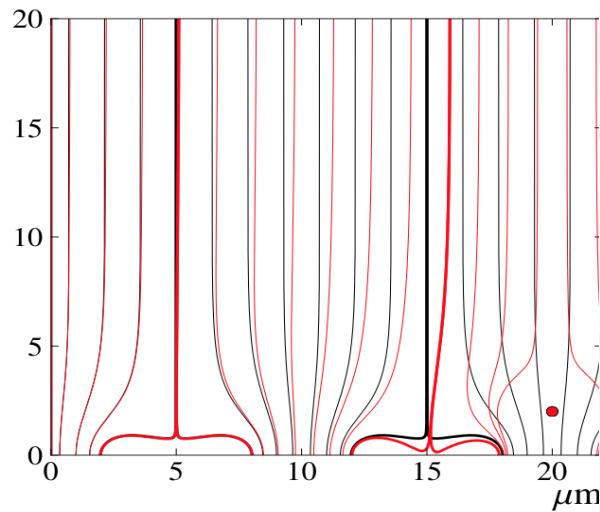
→ Up to 1% in PSF size



Different in x and y !

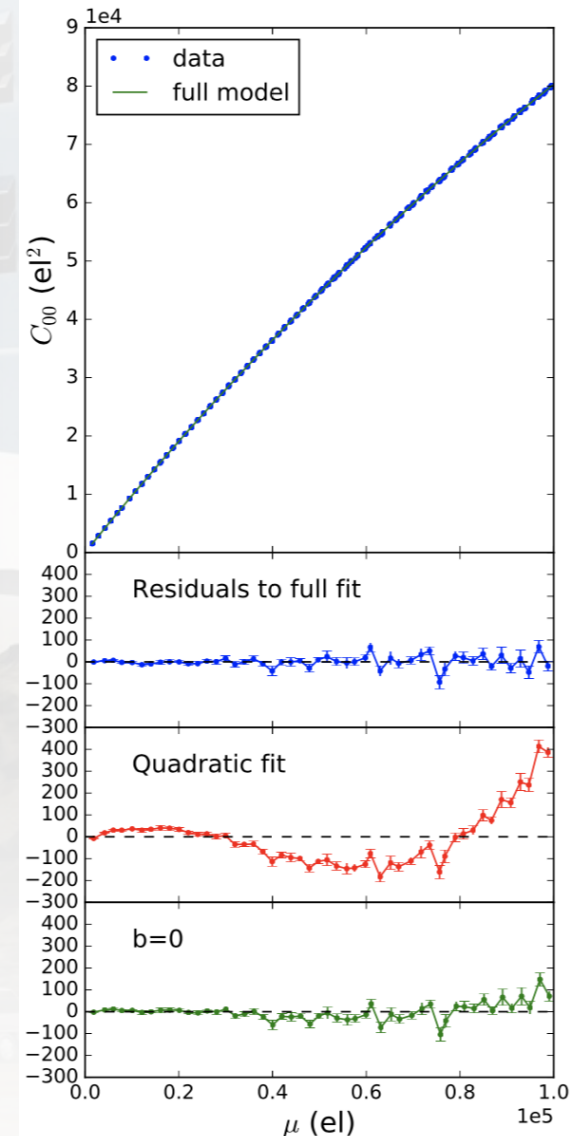
→ induces an **anisotropic shape distortion depending on flux**

This is electrostatics...



→ we now have an Analytical model

Astier 2019



LSST data flow

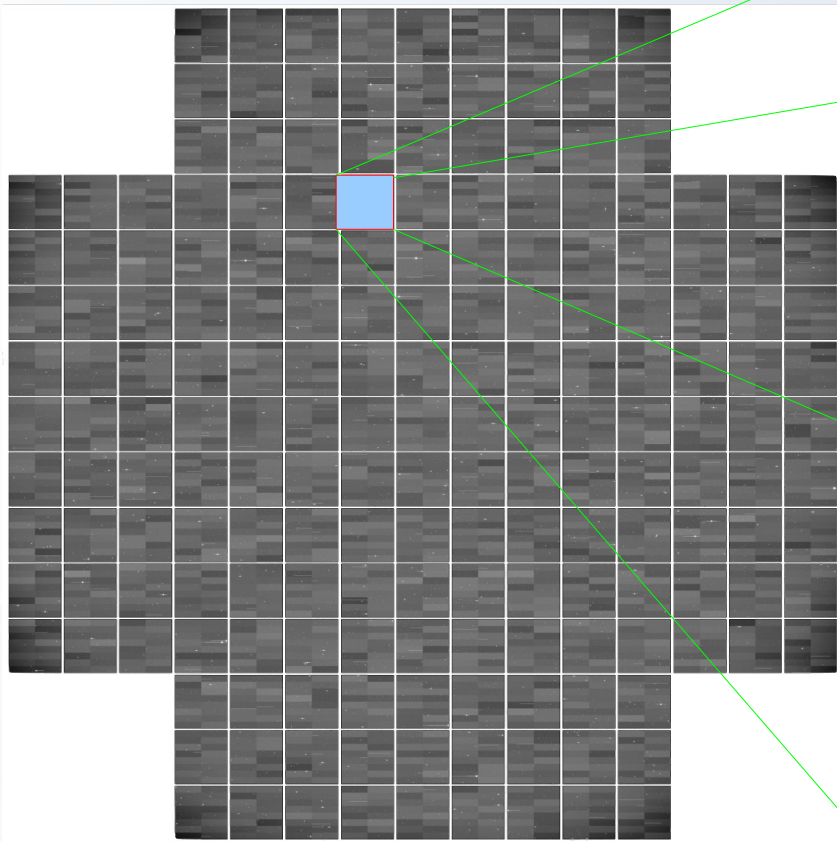
Camera : 189 CCD (16 Mpix) read in parallel

→ 3,2 G pixels !

~ 6 Gbyte / 17 seconds

→ 20 TB / night

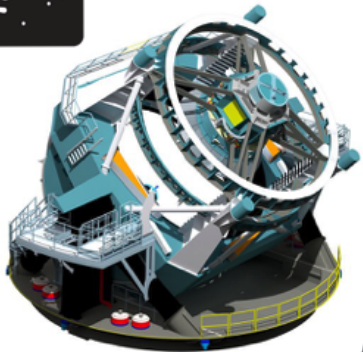
~ 1/1 000 000 000 des données LSST !



LSST Data Management

Raw Data: 20TB/night

Sequential 30s images that cover the entire visible sky every few days.



Prompt Data Products

Alerts: up to 10 million per night

Results of Difference Image Analysis (DIA): transient and variable sources

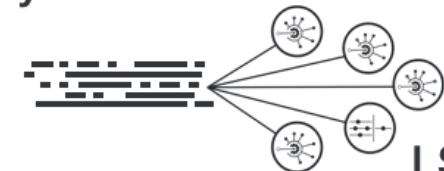
Solar System Objects: ~6 million by year 10

Data Release Data Products

Final 10 year Data Release
images: 5.5 million x 3.2 Gpx
catalogs: 37 billion objects, 15PB

50% of data processed at CCIN2P3 + Full Archive

via nightly alert streams



Community Brokers

LSST Alert Filtering Service



via Prompt Products Database

LSST DACs (Chile & NCSA)

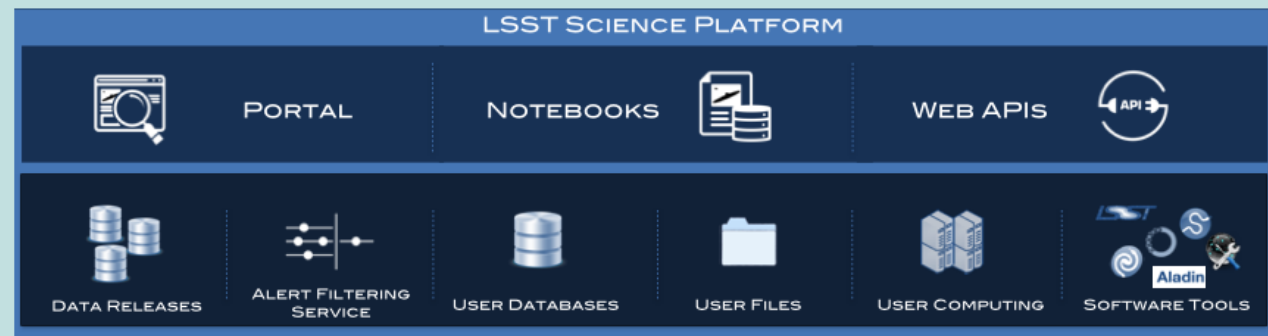
Independent DACs (iDACs)



via Data Releases

LSST Science Platform

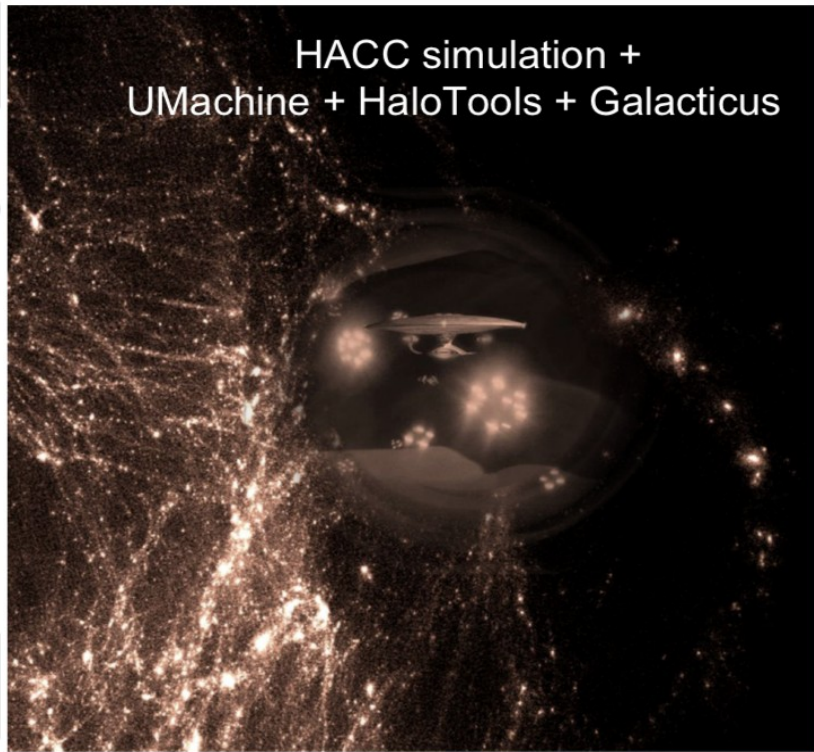
Provides access to LSST Data Products and services for all science users and project staff.



Ramping up for data processing: DC2

State of the art simulation

HACC simulation +
UMachine + HaloTools + Galacticus



Extra-galactic catalog generation
5000 sq. degree

PhoSim and ImSim

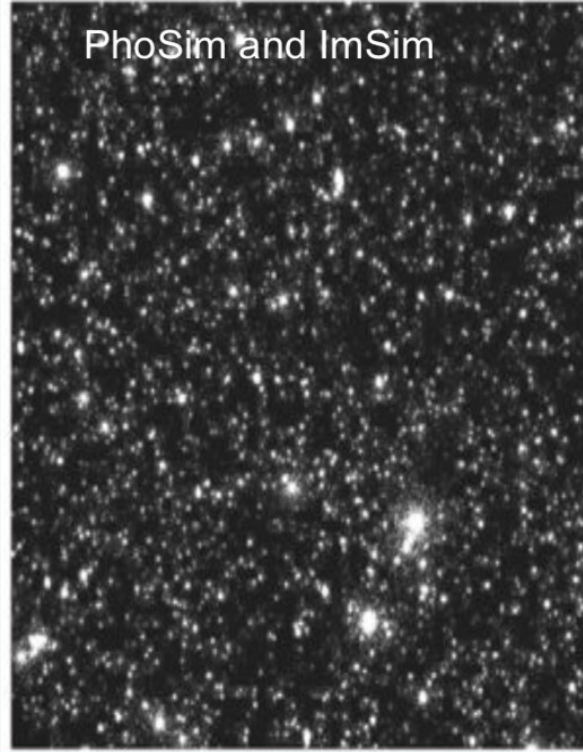
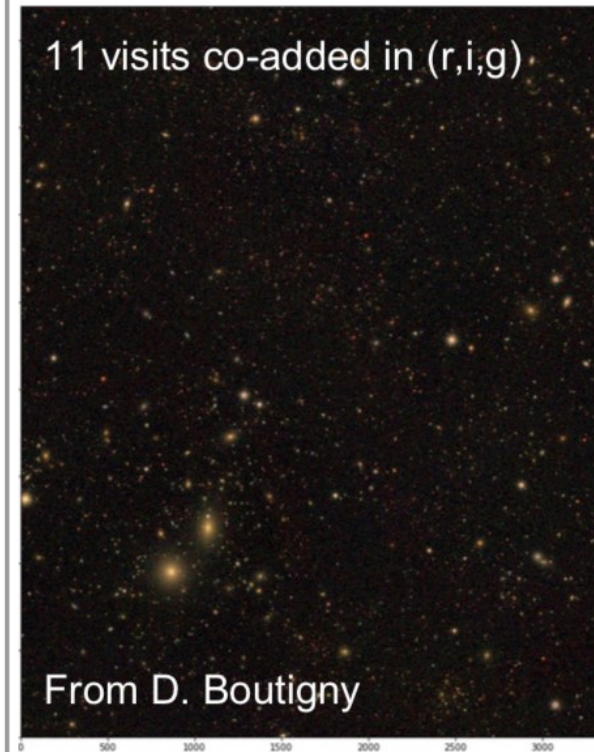


Image simulations
300 sq. degree
10 years

11 visits co-added in (r,i,g)



From D. Boutigny

DM processing

Ramping up for data processing: DC2

State of the art simulation

End-to-end validation

Extra-galactic catalog generation

5000 sq. degree

Image simulations

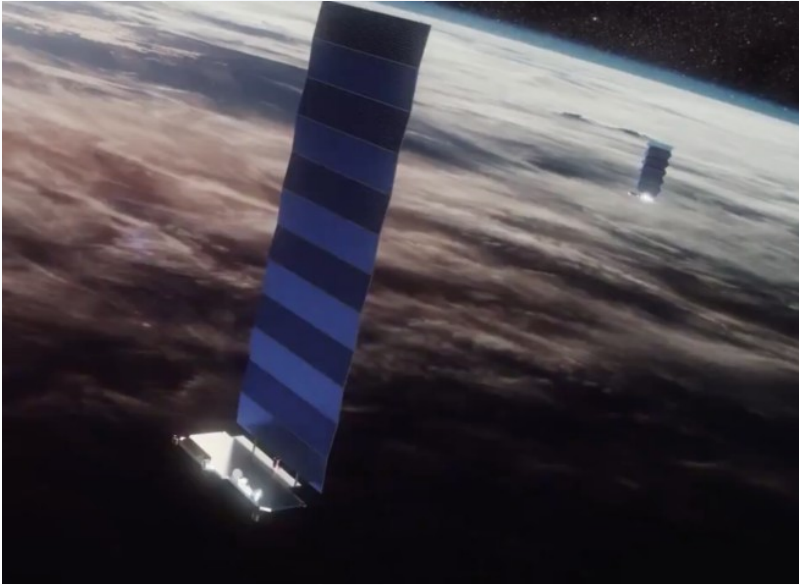
300 sq. degree

10 years

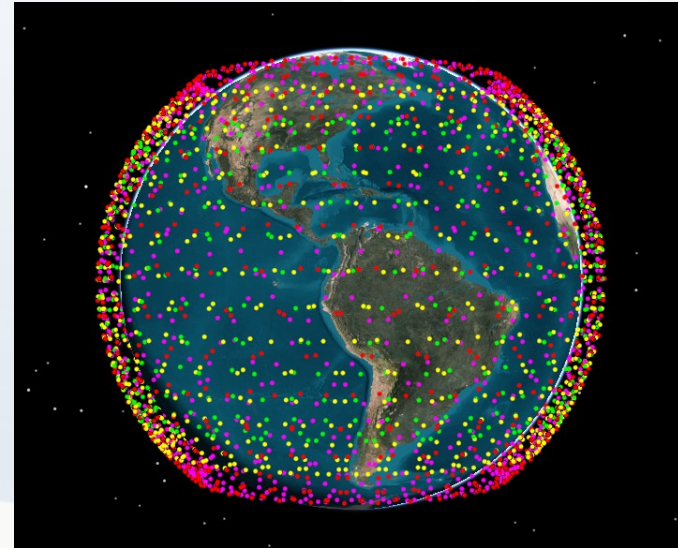
DM processing

But StarLink ...

62 satellite already deployed



4820 planned: Starlink, Kuiper,

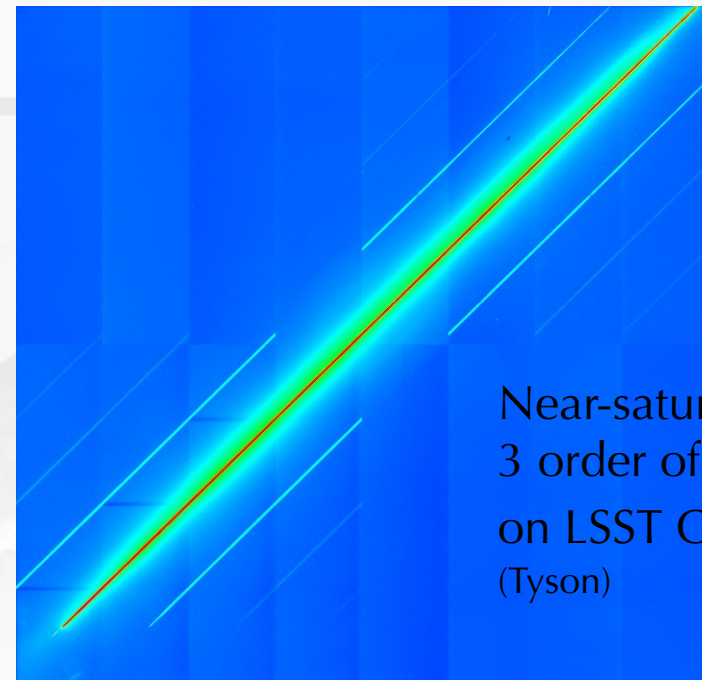


Starlink constellation:

Impact under study
~4-10 satellites visible at night
4 mag above LSST saturation

Mitigation

- Black painting for next ones
+3.5 mag
- LSST repeatability



Near-saturation trail:
3 order of cross-talk
on LSST CCD
(Tyson)

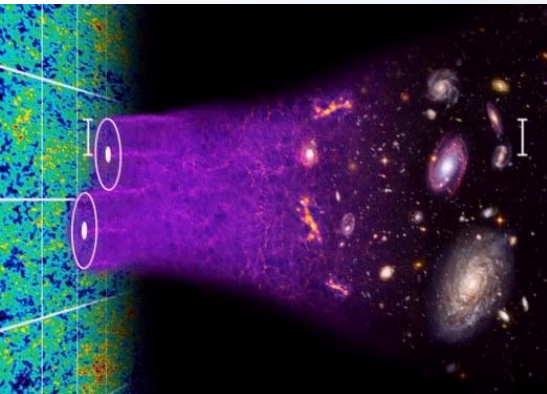


Preparing for the science

DESC: the Dark Energy Science collaboration

5 Dark Energy Probes

Large Scale Structures



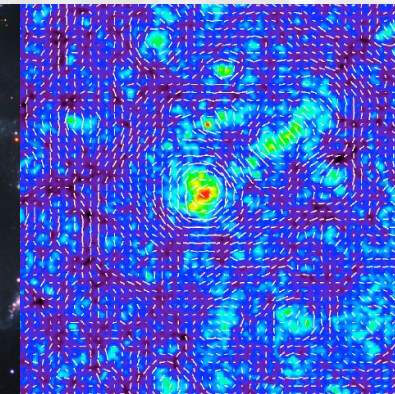
Strong Lensing



Supernovae



Weak Lensing

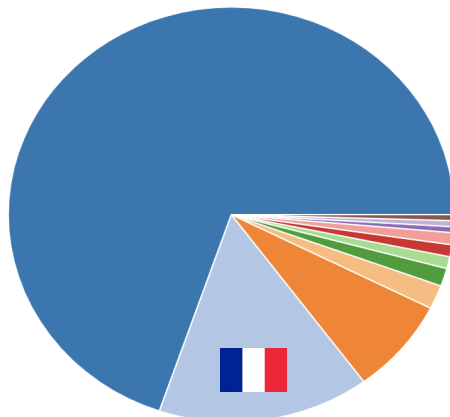


Clusters



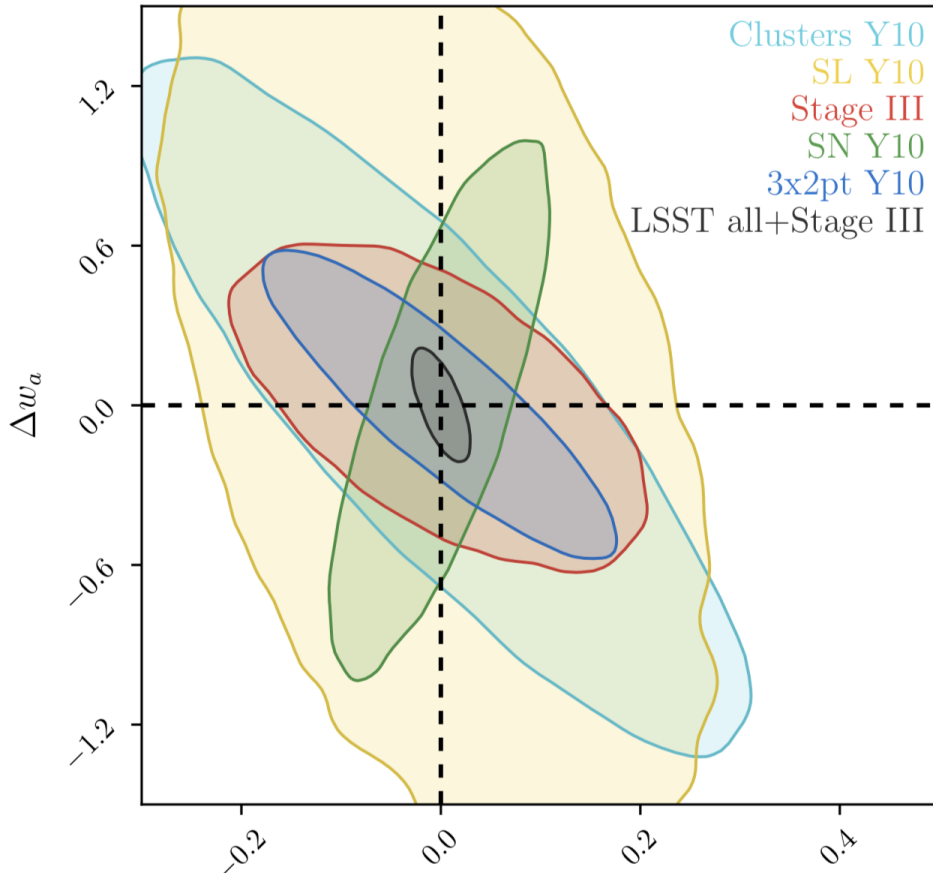
949 Members – 215 Full Members

Full members by country



ArXiv 1809.01669

10 year forecasts



- Forecasts for 1 and 10 yr
- Full review of **known systematics**
 - Calibratable and self-calibrated
- **Target: FoM of 500** for 10yr
 - **Calibratable systematics should not dominate statistics**
- Requirements for each probe

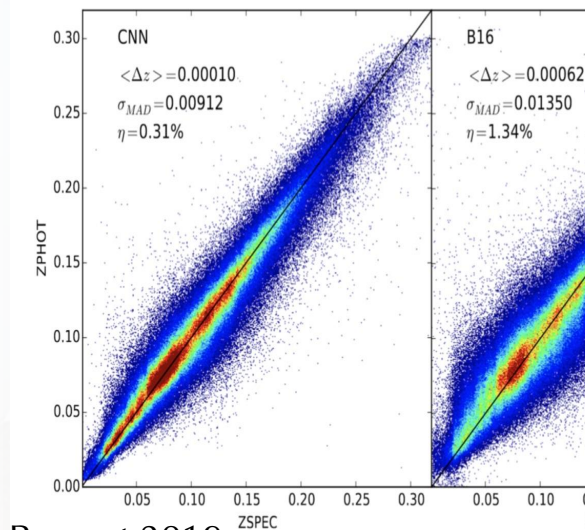
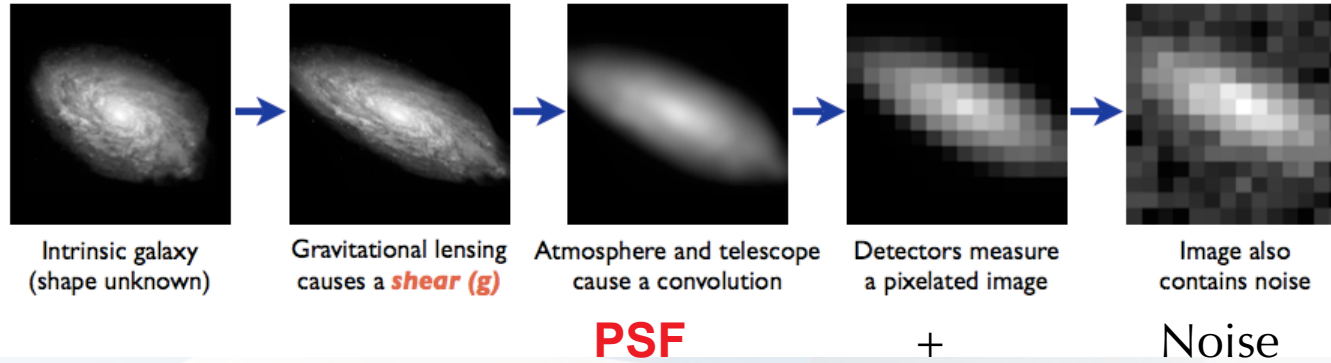
DESC Roadmap

		LSST DESC Pre-commissioning Activities																				LSST System Commissioning											
		FY16				FY17				FY18				FY19				FY20				FY21				FY22							
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4				
LSST DESC Pre-commissioning Activities	Data Challenge 1 (DC1)	RQ	Production			Analysis																											
	Data Challenge 2 (DC2)					RQ				Production				Production & Analysis				Analysis															
	Science Readiness (SR)																	Collection of SR Activities															
LSST DESC Commissioning	ComCam Analysis SV Analysis																									ComCam Analysis				SV Analysis			
LSST Facility Commissioning	Early Commissioning, ComCam LSSTCam Commissioning																					I&T				Obs							
																										I&T				Obs			

Shear challenges

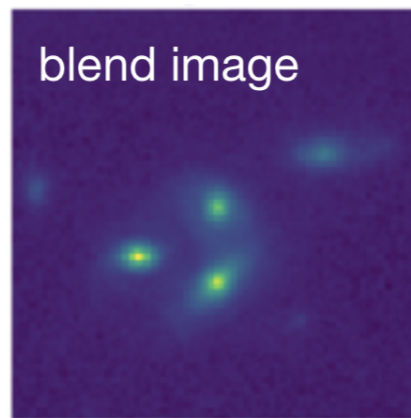
The Forward Process.

Galaxies: Intrinsic galaxy shapes to measured image:

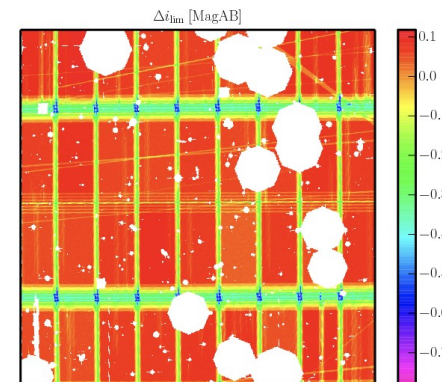


Pasquet 2019

Photo-z



Blending

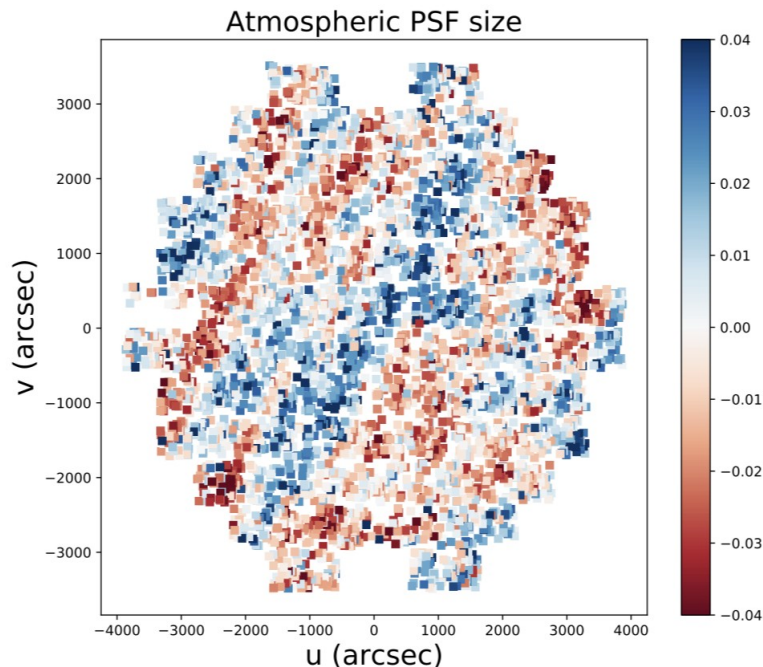


Masks, sensor effects

+ Astrophysics : intrinsic alignments, baryons feedback...

PSF improvement

PSF within a DES image



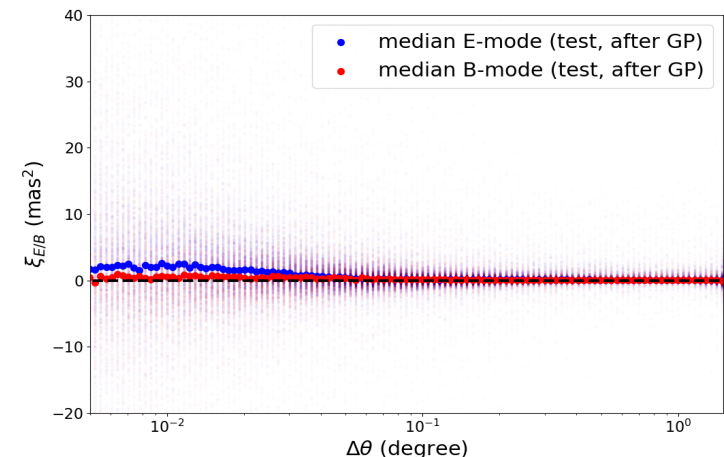
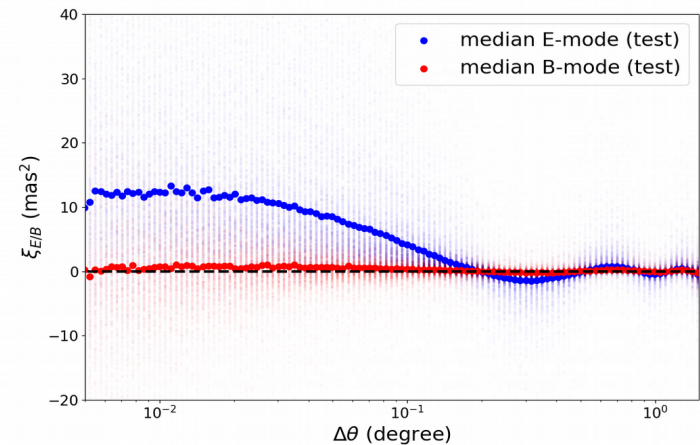
PSF size is correlated across full focal plane

→ this is the effect of Atmosphere

- Single CCD treatment insufficient
- Full FoV model :
 - optical model (Zernike)
 - Von Karman atmospheric correlations

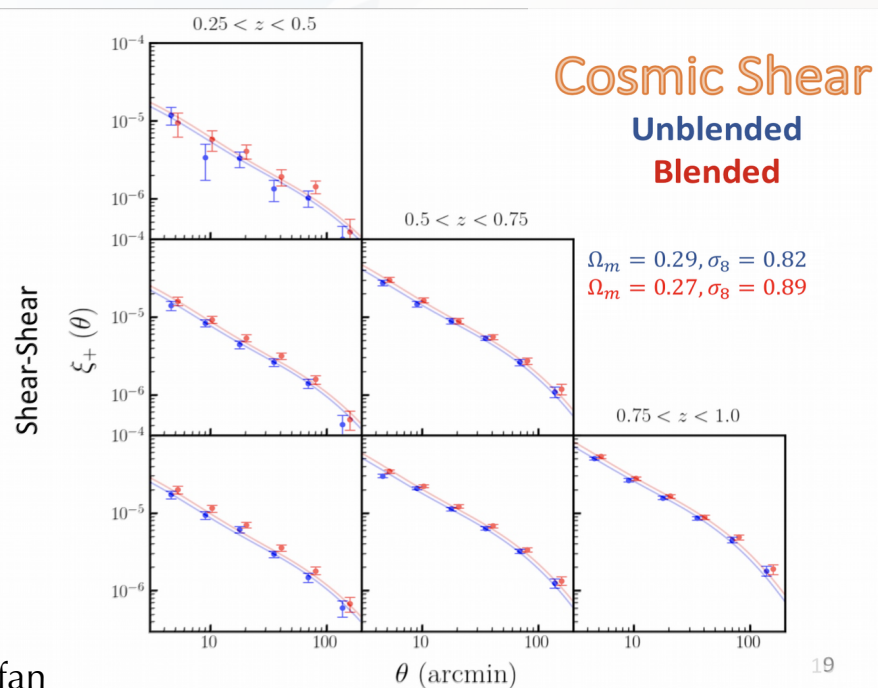
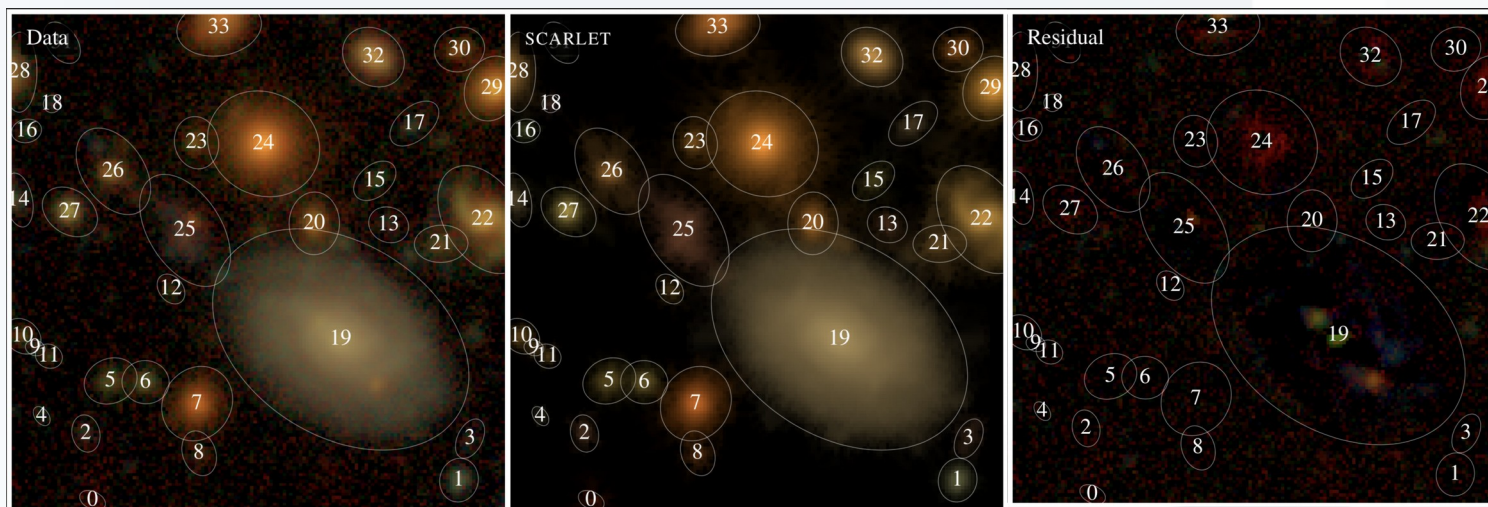
• Gaussian processes

PSF ellipticities



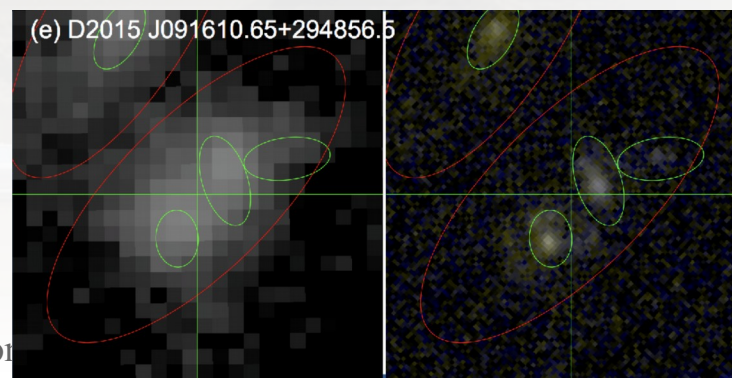
Léget in prep.

Deblending is an issue !



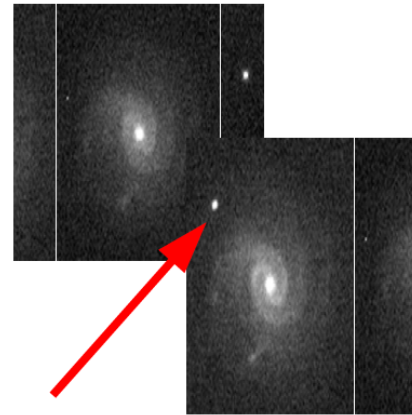
- Assess current algorithm performance
- Develop new approaches (Deep learning)
- Synergies with other data
 - Space-based (Euclid)
 - Other filter set (HSC)

Dawson 2016



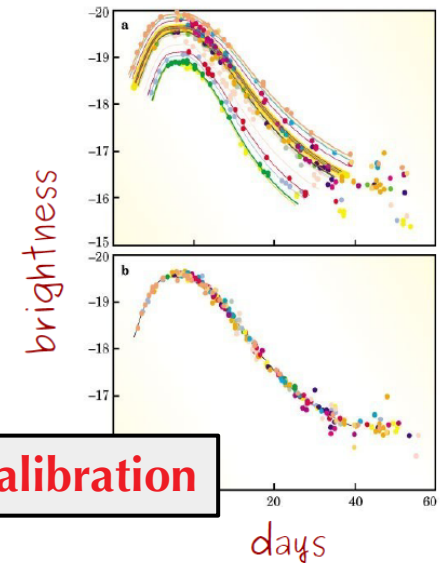
Supernova challenges

1. detection



Survey strategy

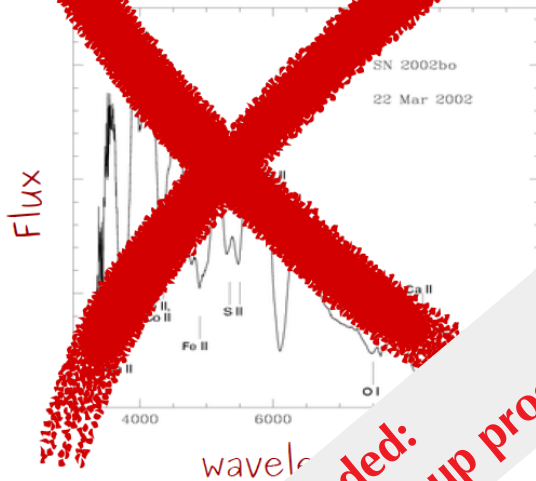
2. photometry



Calibration

Identification

3. spectroscopy

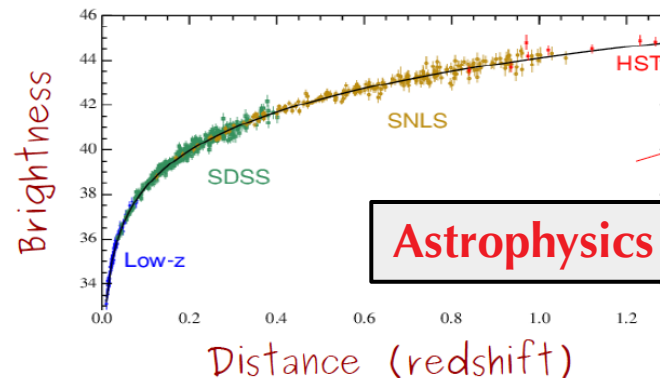


**Needed:
Follow-up program**

Distance (redshift) identification

Cf A. Moller presentation

4. standardization + cosmological fit



Astrophysics

year	Number of supernova
1998	42
2014	740
2025	> 10 000

Hubble Diagram

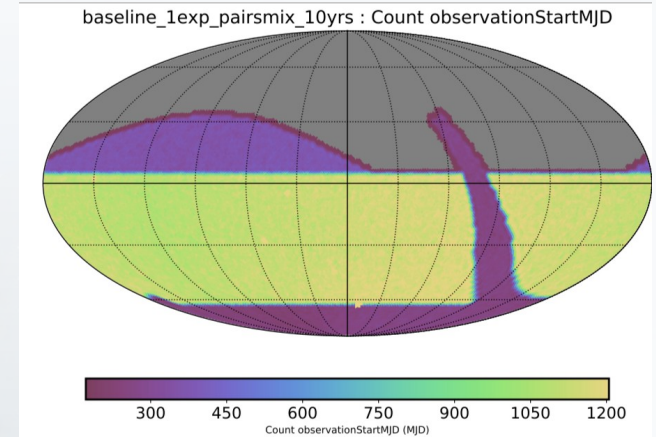
Peculiar velocities

Observing Strategy (Cadence)

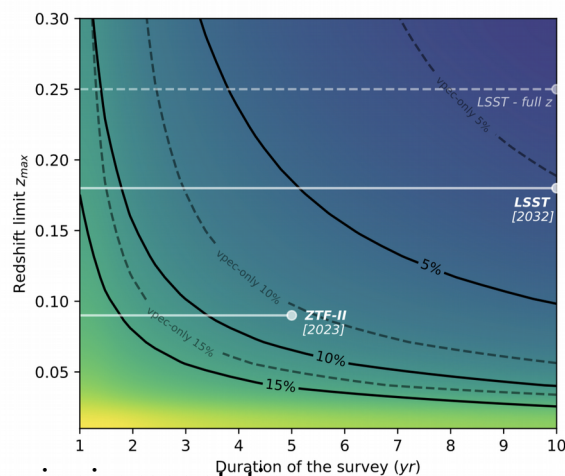
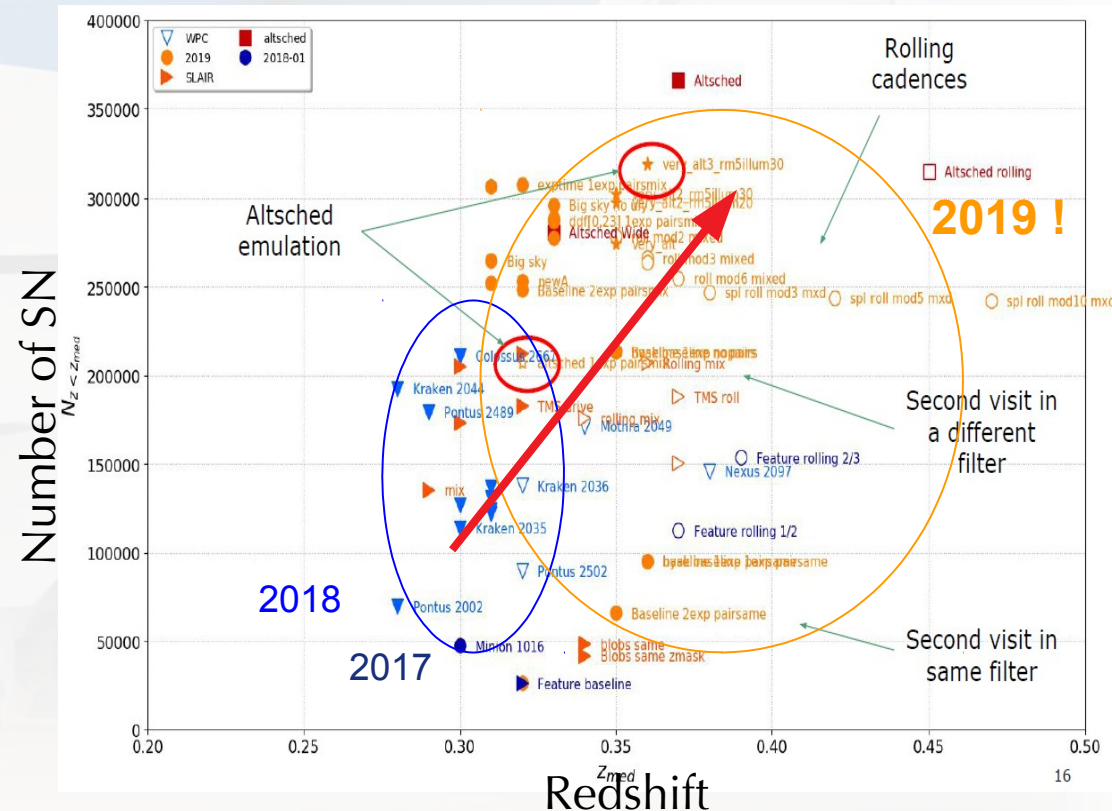
Two white papers on cadence in 2019

- Custom optimization in 2020
- Decision in 2021

- **Wide Fast Deep:** 90% of observing time
 - Baseline bad for SN program
 - Move toward **rolling cadence**
- **Deep Drilling Fields:** 5% of obs. time
 - From 12 to 28 kSN $z \sim 1,0$
 - SN and AGN are competing
 - Ongoing optimization
- **More SN means more science**
 - → Peculiar velocities



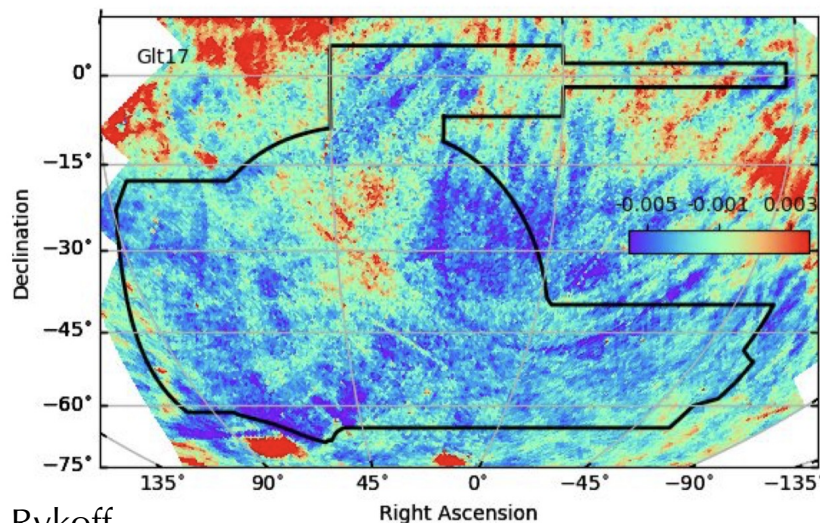
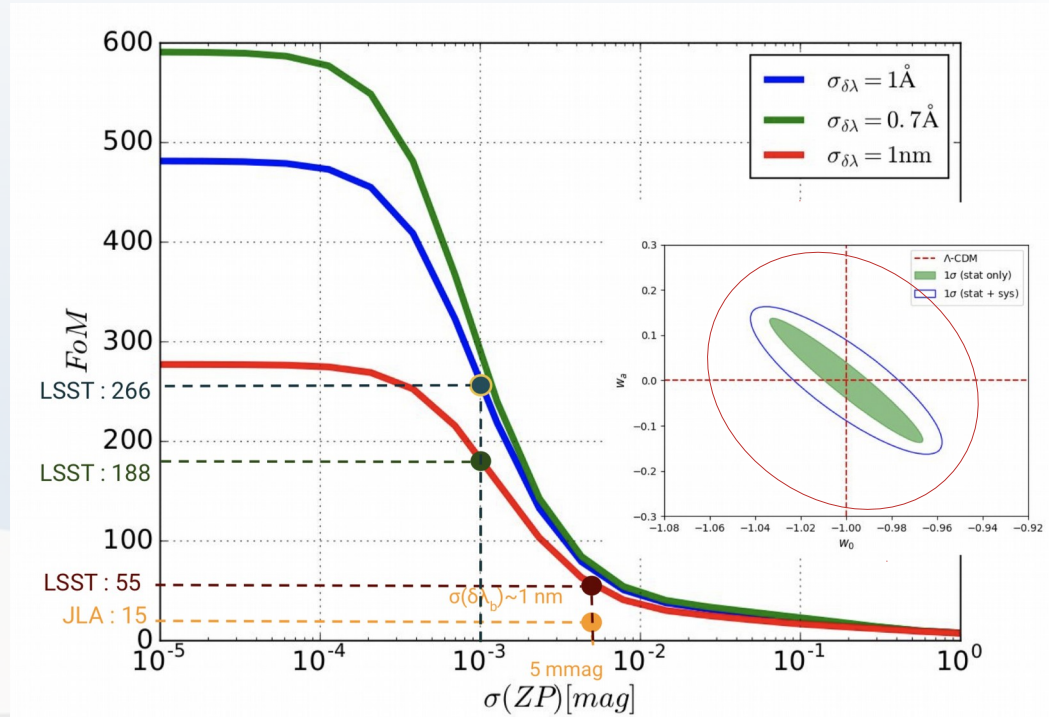
Forecast for various strategies



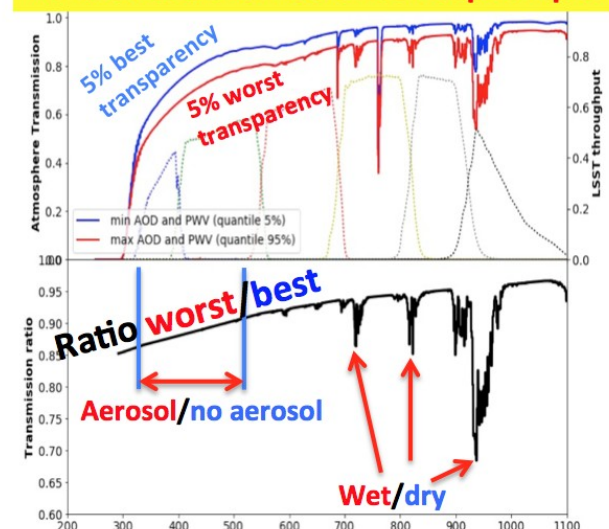
Calibration

Hazenberg

- Calibration is a **limiting systematics**
 - 1 mmag needed
- Improvement for LSST:
 - Primary flux measurements*
 - Stars → NIST metrology
 - Survey uniformity*
 - Use GAIA as a reference
 - Survey throughput*
 - Filter transmission and bandpass
 - Atmospheric transmission

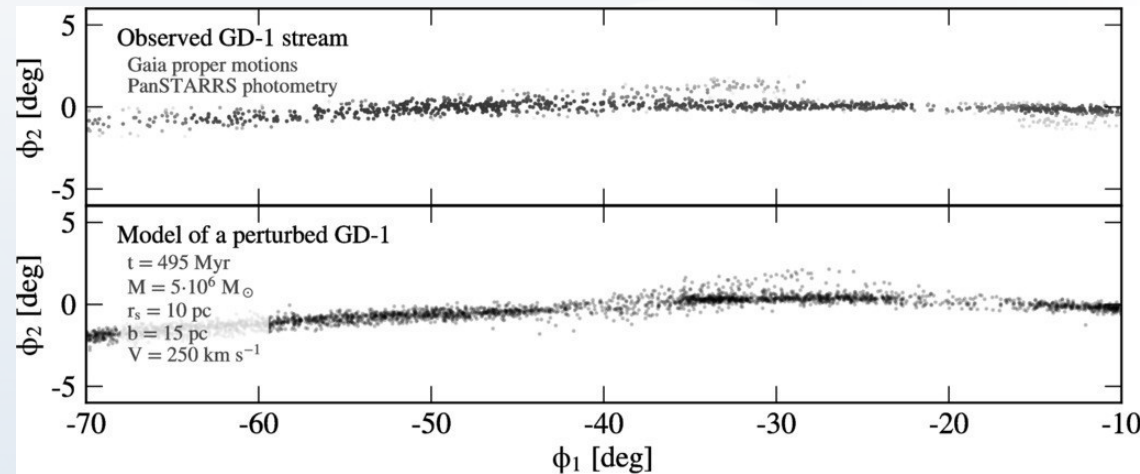


Variabilité transmission atmosphérique

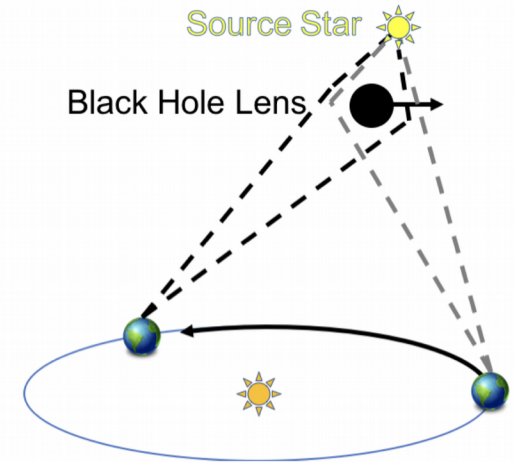
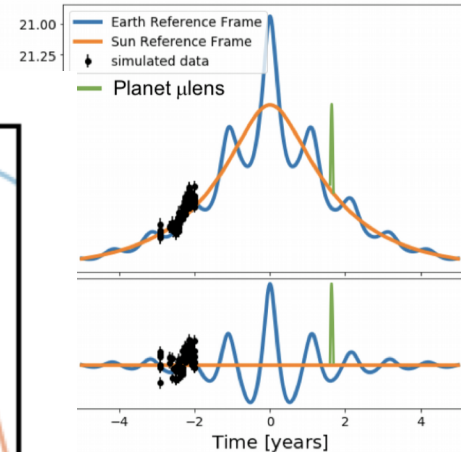
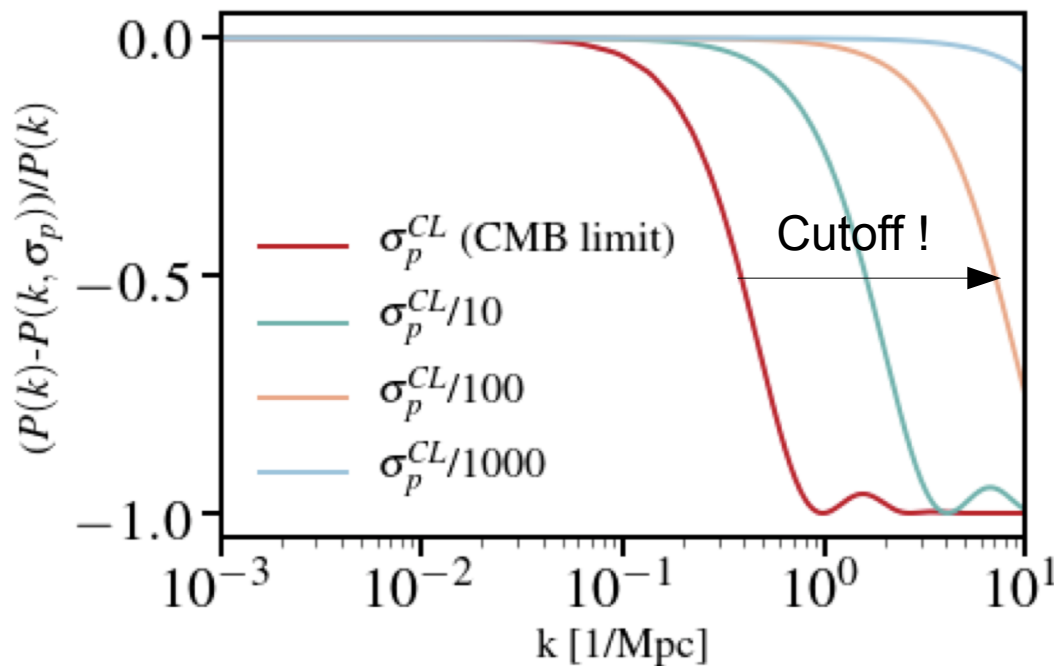


DESC and dark matter

- ArXiv:1902.01055
 - Minimum halo masses
 - Halo profiles
 - Microlensing
 - Anomalous energy loss
 - Large scale structure



Stellar stream gaps (Bonaca 2018)



Matter power spectrum is sensitive to Dark Matter microphysics !

Conclusion:

- Project-Wise:
 - **Computing** is a major deliverable
 - **Commissioning** is demanding new resources
- Dark Energy-Wise:
 - **Shear**: wide effort on systematics
 - **Supernovae**: photometry, anisotropy science
 - **Clusters**: calibrate the mass function
 - **Strong lensing**: GR tests + H_0 measurement
- But also:

FINK ! optical counterparts of transients

Dark matter, neutrinos... many other topics

→ *Exciting times to come !*