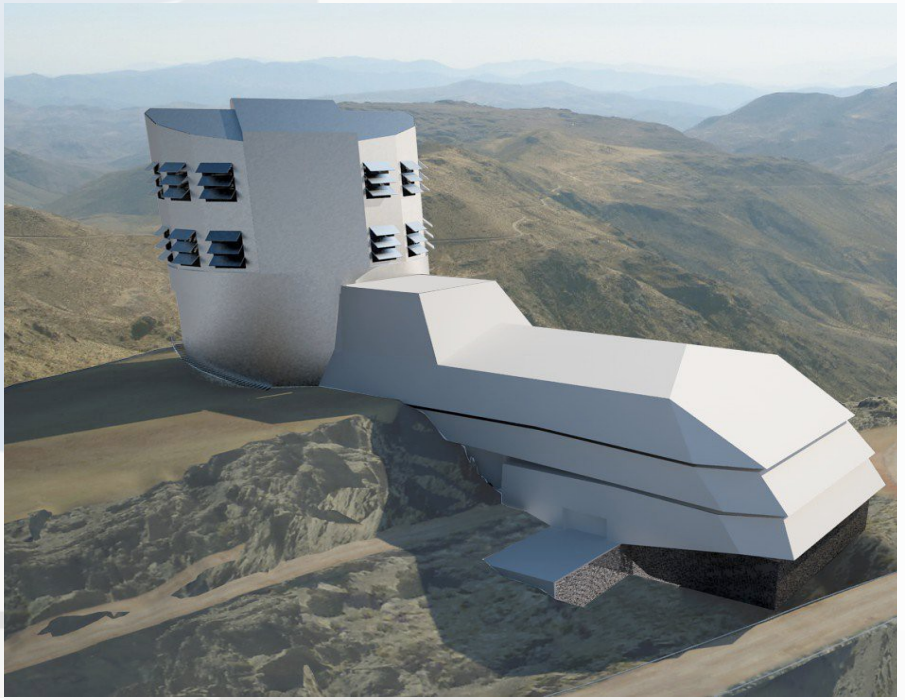
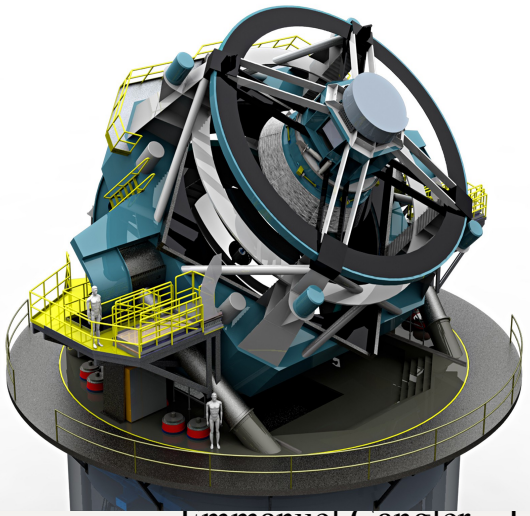
STATUS

Emmanuel Gangler – LPC – Clermont-Ferrand (France)

In short :

- A stage-4 survey :
  - 8.4 m telescope
  - Cerro Pachon (Chili)
  - (Very) wide-field astronomy
  - 9,6□ camera
  - 0.2 '' pixel / 0.7 '' seeing





- All visible sky in 6 bands (ugrizy) (~20000□)
- 15 s exposure, 1 visit / 3 days
- During 10 years !
- 60 Pbytes of raw data

LSST survey requirements

Survey Property	Performance
Main Survey Area	18000 sq. deg.
Total visits per sky patch	825
Filter set	6 filters (ugrizy) from 320 to 1050nm
Single visit	2 x 15 second exposures
Single Visit Limiting Magnitude	u = 23.9; g = 25.0; r = 24.7; I = 24.0; z = 23.3; y = 22.1
Photometric calibration	< 2% absolute, < 0.5% repeatability & colors
Median delivered image quality	~ 0.7 arcsec. FWHM
Transient processing latency	< 60 sec after last visit exposure
Data release	Full reprocessing of survey data annually
Astrometry	10 mas on single individual exposure

The LSST consortium

Institutional Members

Adler Planetarium
Argonne National Laboratory
Brookhaven National Laboratory (BNL)
California Institute of Technology
Carnegie Mellon University
Chile
Columbia University
Cornell University
Drexel University
Fermi National Accelerator Laboratory
George Mason University
Google, Inc.
Harvard-Smithsonian Center for Astrophysics
Institut de Physique Nucleaire et de Physique des Particules (IN2P3)
Johns Hopkins University
Kavli Institute for Particle Astrophysics and Cosmology (KIPAC) - Stanford University
Las Cumbres Observatory Global Telescope Network, Inc.
Lawrence Livermore National Laboratory (LLNL)
Los Alamos National Laboratory (LANL)
National Optical Astronomy Observatory*
National Radio Astronomy Observatory
Northwestern University
Princeton University
Purdue University
Research Corporation for Science Advancement*
Rutgers University
SLAC National Accelerator Laboratory
Space Telescope Science Institute
Texas A & M University
The Institute of Physics of the Academy of Sciences of the Czech Republic**
The Pennsylvania State University
The University of Arizona*
University of California at Davis
University of California at Irvine
University of Illinois at Urbana-Champaign
University of Michigan
University of Oxford
University of Pennsylvania
University of Pittsburgh
University of Washington*
Vanderbilt and Fisk Universities

LSSTc : Non-profit organization

- 41 institutions, with major US contribution
  - SLAC, UWashington, Google, …
  - Non-US : Chilean Republic, France/IN2P3
- Expect **~900 scientists involved** (~50% US)

Funding :

- NSF/DOE/Private donors : **~670 M$**
- France : in kind contribution
- Others : 200000$/PI/ 10years (covering 30% of running costs)

In Europe

- France : **100 PI** (60-75 in kind camera, 30-45 in kind computing)
- UK : 100 PI (proposal submited to STFC, anwser expected 2015)
- Czech, Croatia, Hungaria, Poland, Serbia : 30-50 PI

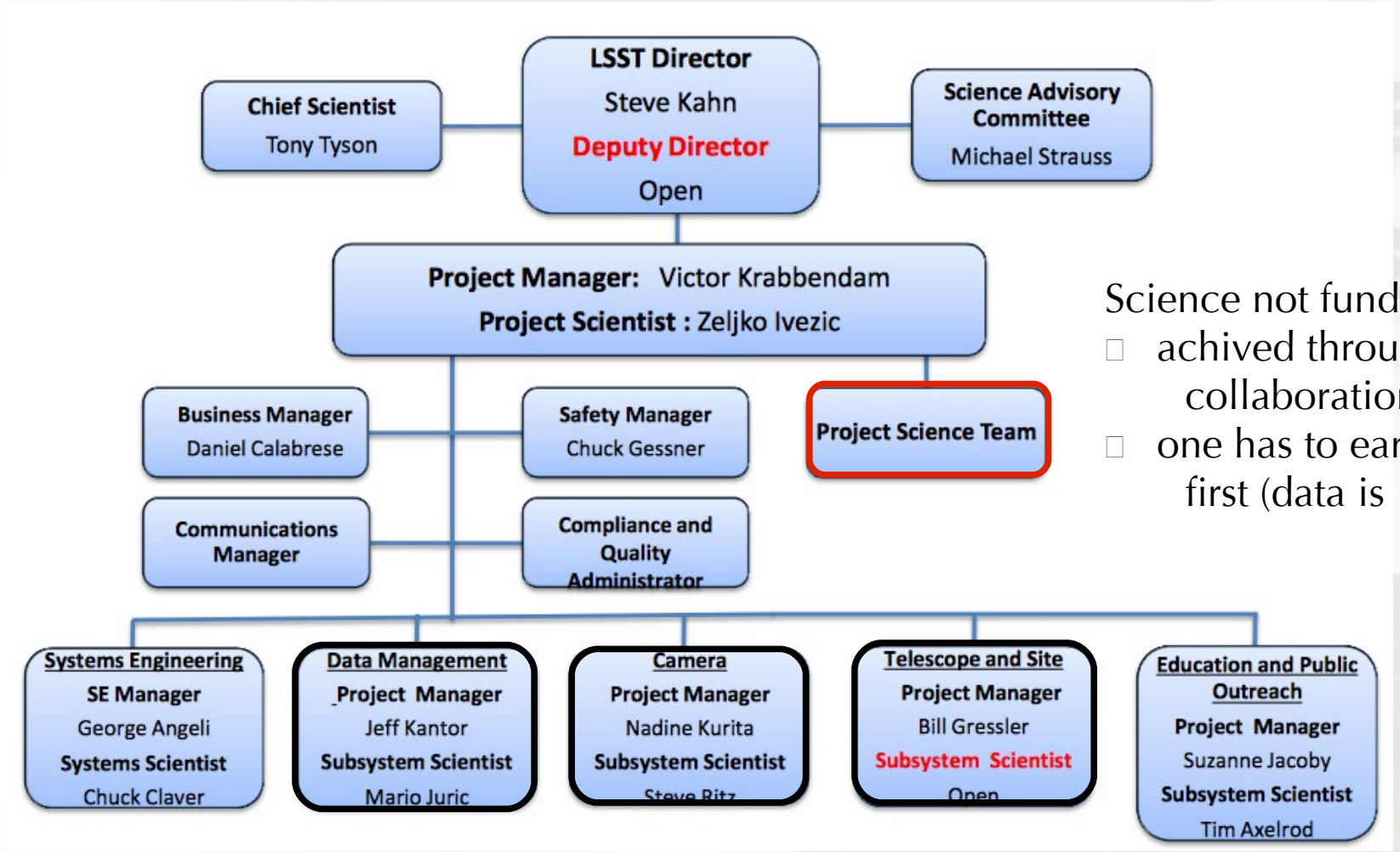
Rest of the world

- Brazil : situation unclear, forseen in kind (network)
- Australia, China, India, New Zealand (>100 PI) MoA in discussion

We are looking for partners, we are not selling data!

(S. Kahn)

Organization chart



Science not funded by the project

- achived through science collaborations
- one has to earn LSST data access first (data is « public but...»)

NSF DOE / SLAC NSF Donors

LSST 2014
CONSTRUCTION START

National Science Foundation
WHERE DISCOVERIES BEGIN

Press Release 14-095
TAKING ASTRONOMY TO THE NEXT LEVEL

Large Synoptic Survey Telescope gets funding to begin construction

LSST was the highest-ranked ground-based large initiative in NAS' 2010 decadal survey.
Credit and Larger Version

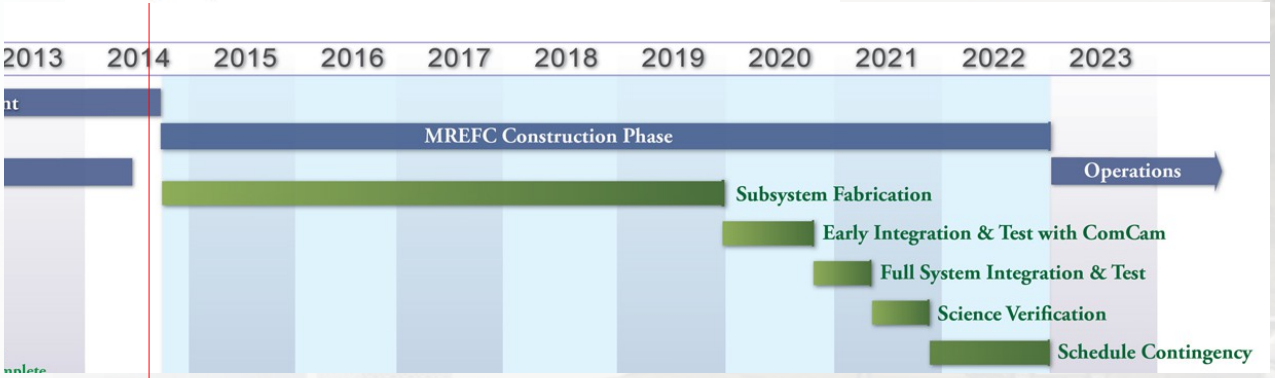
August 7, 2014

LSST funded for construction !

- NSF MREFC approval
- DOE CD-2 (cost and schedule)
- 49 M$ in president's budget 2014
- 115 M$ in president's budget 2015

France / IN2P3

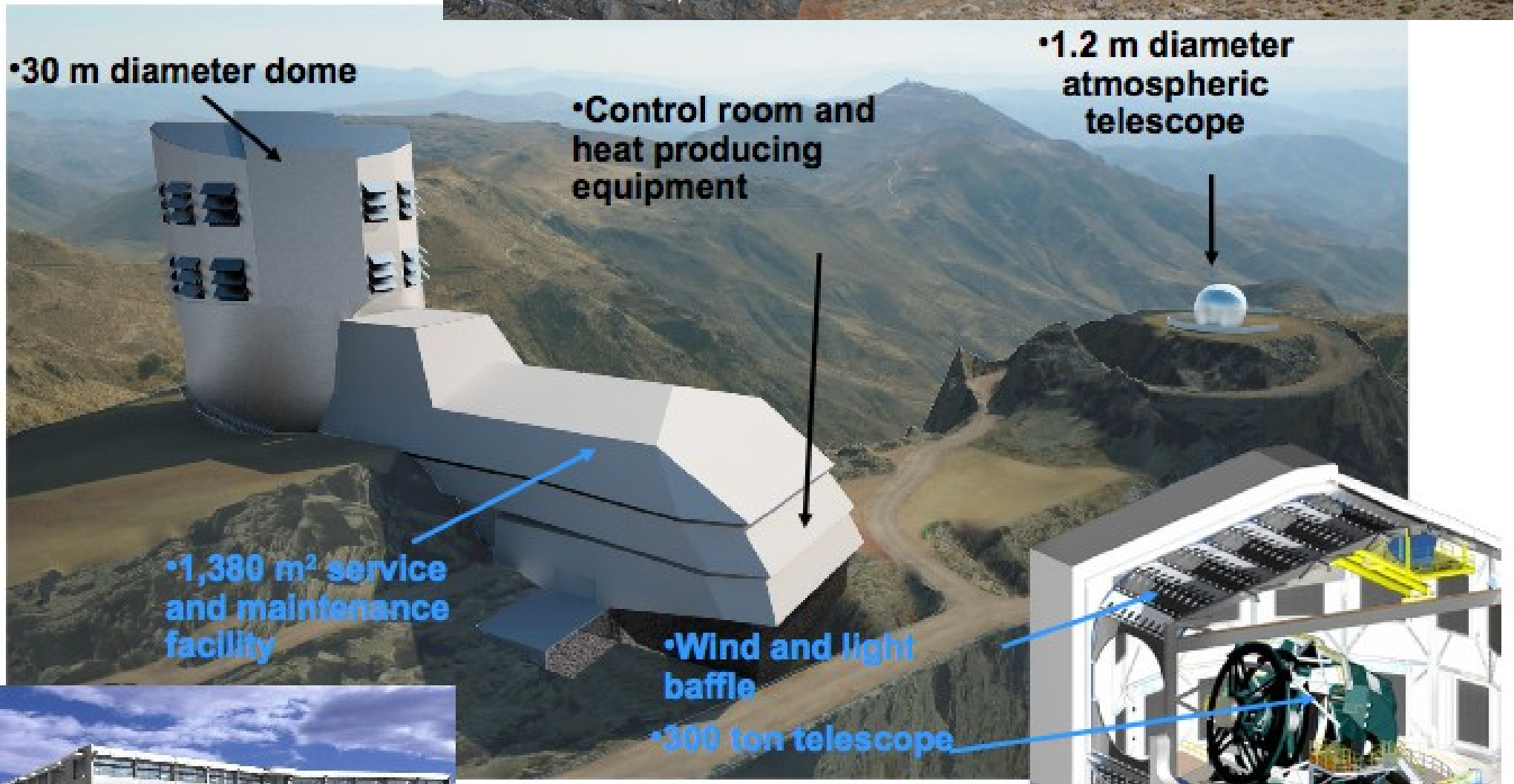
- 9 laboratories, 46 scientists, 56 engineers
- 10% of the camera construction (MoA under signature)
- 50% of LSST computing (MoA forseen 2015)



R&D Construction Operations

The Cerro Pachon site

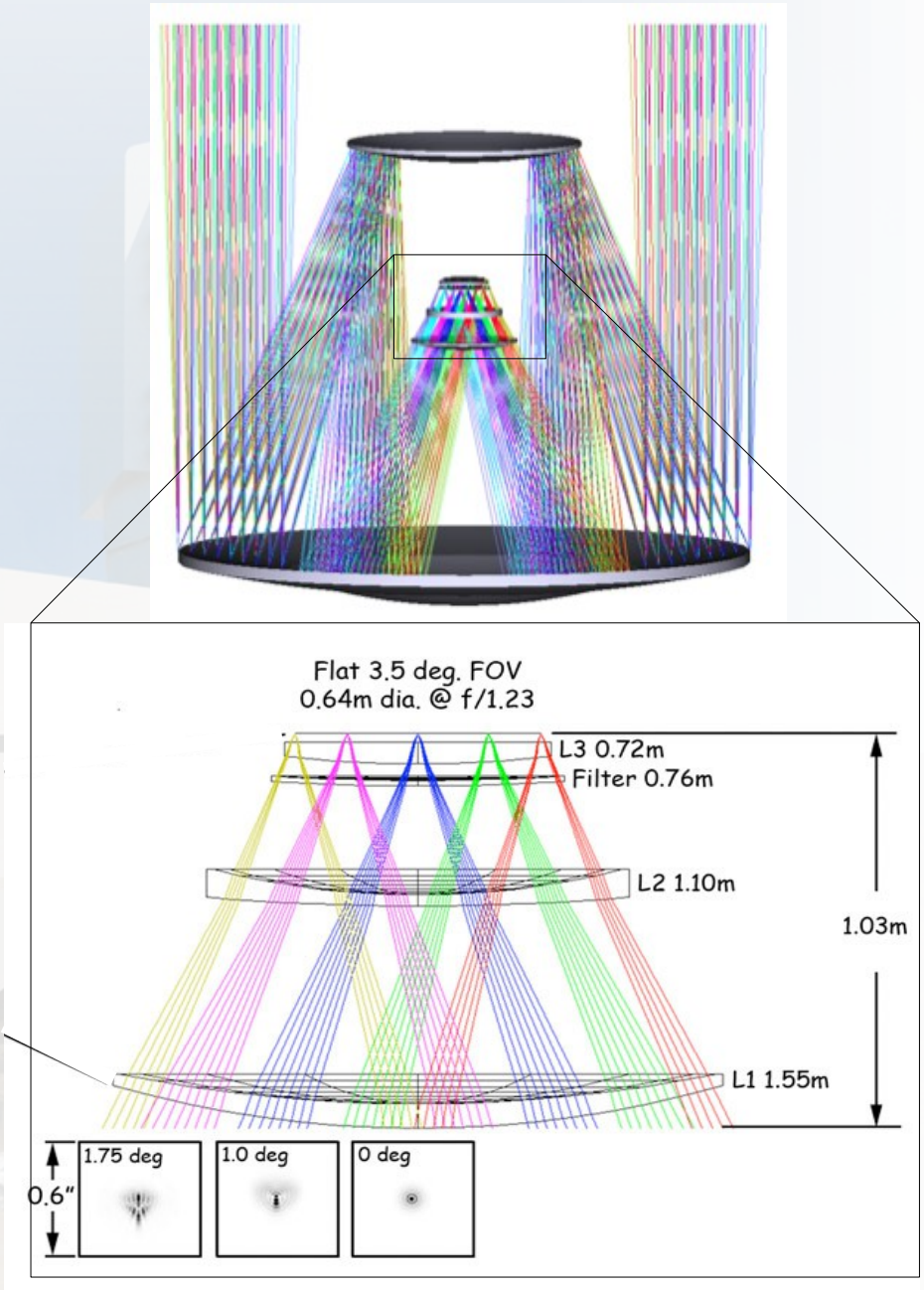
Site ready for construction



•Base Facility in La Serena

Optical solution

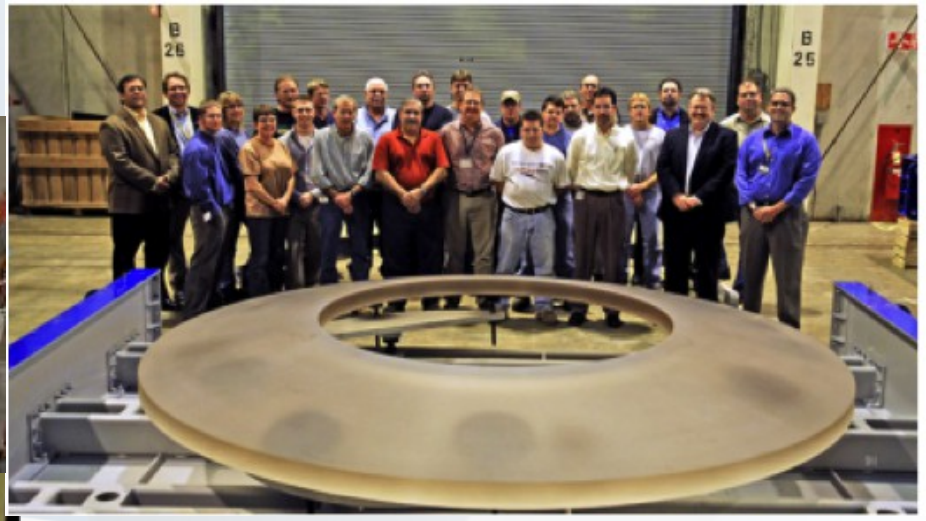
- Median seeing : 0.6'' □ 0.2'' pixel
- Minimum pixel size 10µm
- Plate scale □ 10.3m focal length
- Depth requirement : aperture 6.5m
  - □ focal ratio <1.5
- FOV 3.5°
  - □ 3.2 Gpix,
  - □ 63cm ø focal plane
- Fast slew (5°/sec) □ Compact design



Mirrors

M1 – M3 fabricated as a single monolith
M1 polished (23 nm)
M3 polishing underway (40 nm □ 20 nm)

M2 substrate ready for polishing

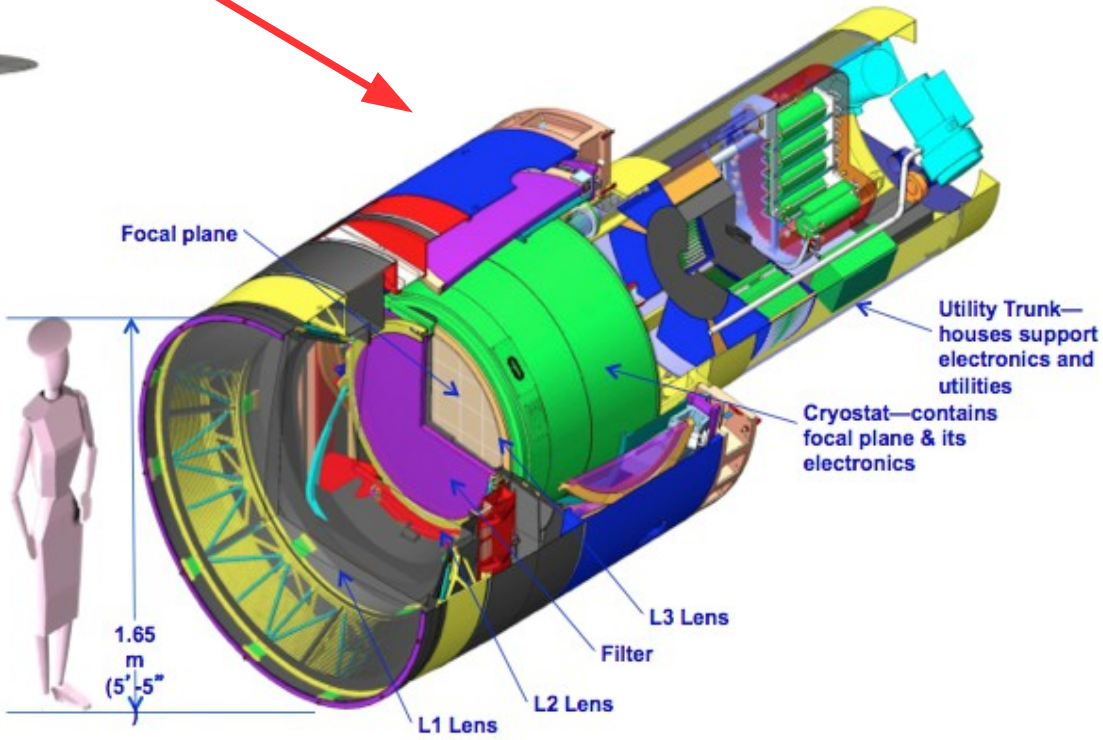


Calypso telescope relocation

The camera

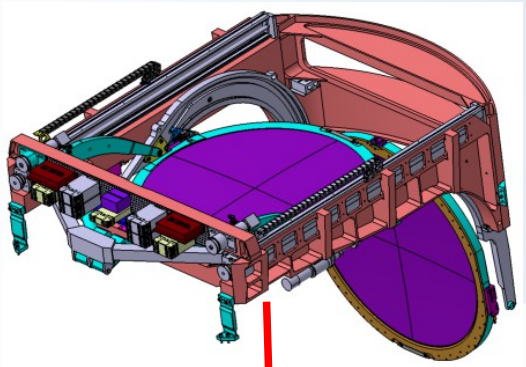
- Camera is located in the telescope beam
- Constraints on
  - Enveloppe (ø<1.6m)
  - Mass (3t)
  - Heat dissipation
  - Lifetime (10 yr) and maintenance

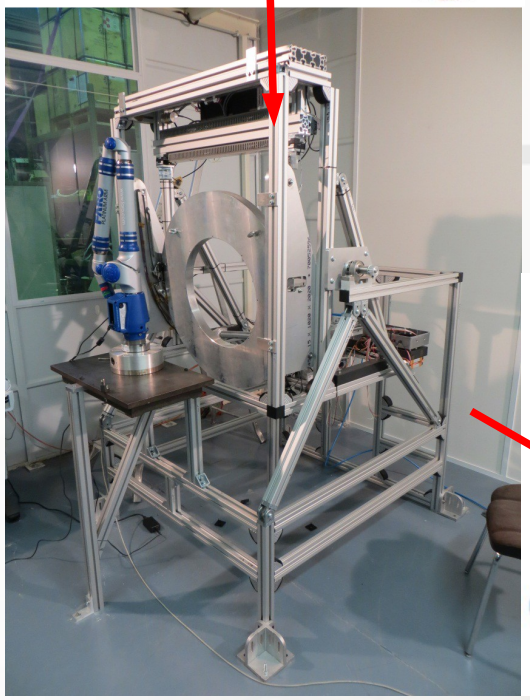
France/IN2P3 involved in
- Filter R&D
- Filter exchange system
- CCD qualification and readout
- Camera optical characterization

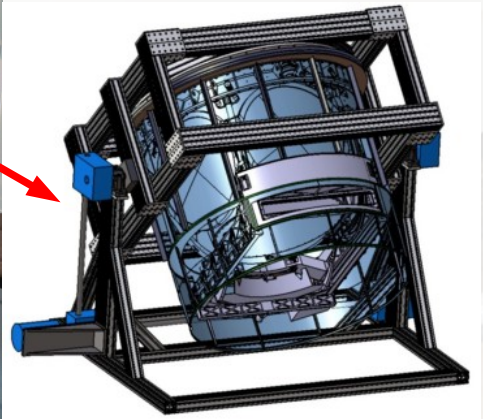


Protyping and construction

Filter exchange system :
Towards a full-scale prototype



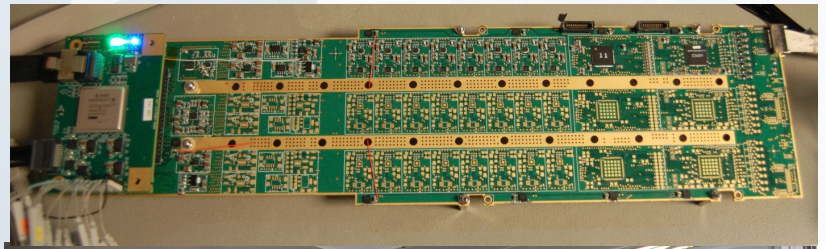


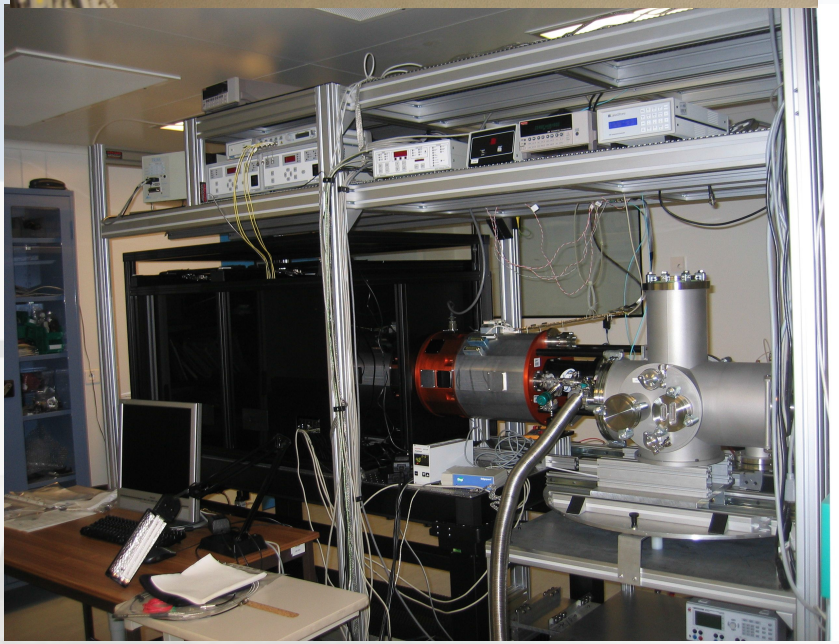


Multi-lab project :

- Clermont-Ferrand (LPC)
- Grenoble (LPSC)
- Marseille (CPPM)
- Montpellier (LUPM)
- Lyon (CC)
- Paris (APC,LPNHE)

CCD readout electronics

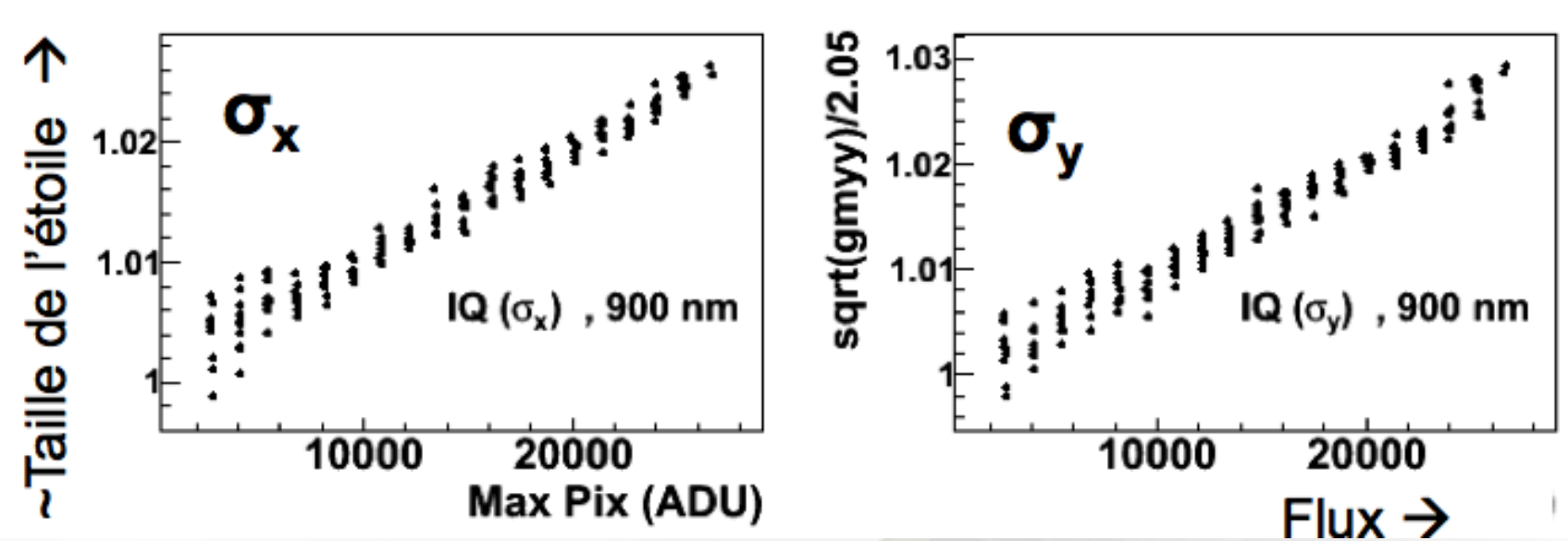




CCD qualification test bench

CCD qualification

- Revealed a new effect : brighter-fatter



- Confirmed by SNLS, SDSS, HSC
- Serious impact for analysis (especially lensing)

LSST data flow

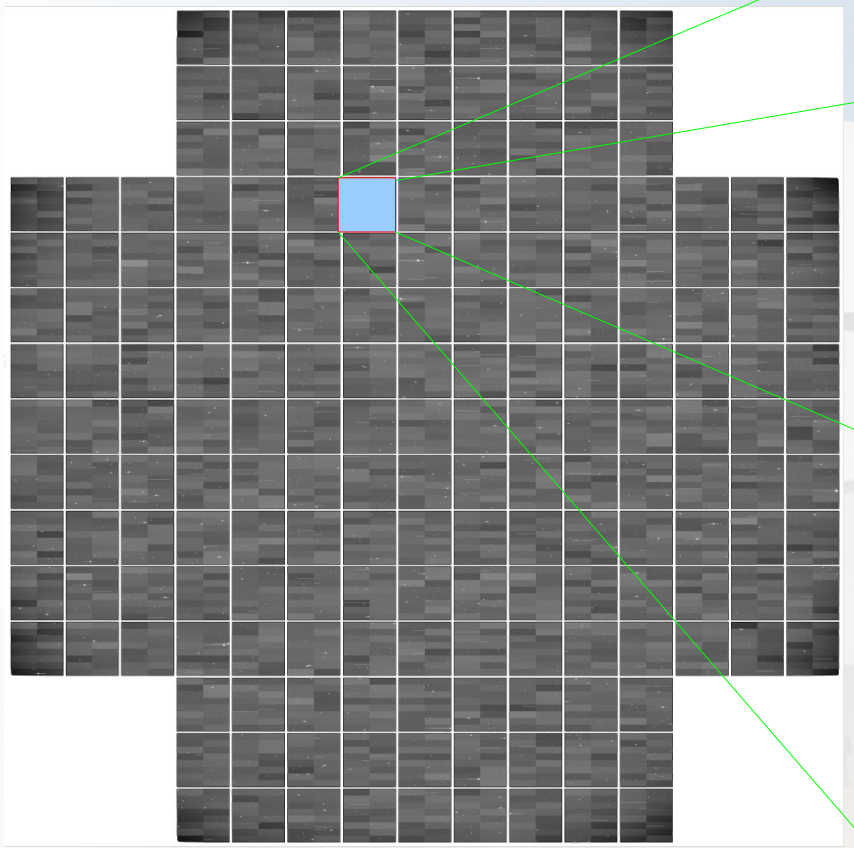
Camera : 189 CCD (16 Mpix) read in parallel

- 3,2 G pixels !

~ 6 Gbyte / 17 seconds

- 15 TB / night

~ 1/1 000 000 000 des données LSST !

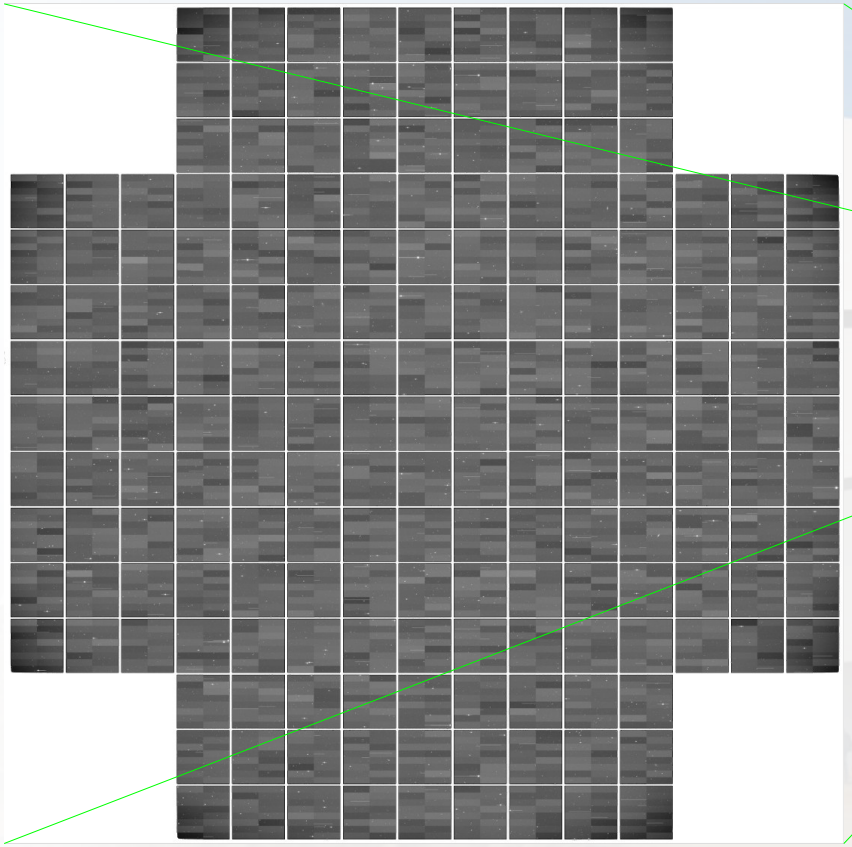


LSST data flow

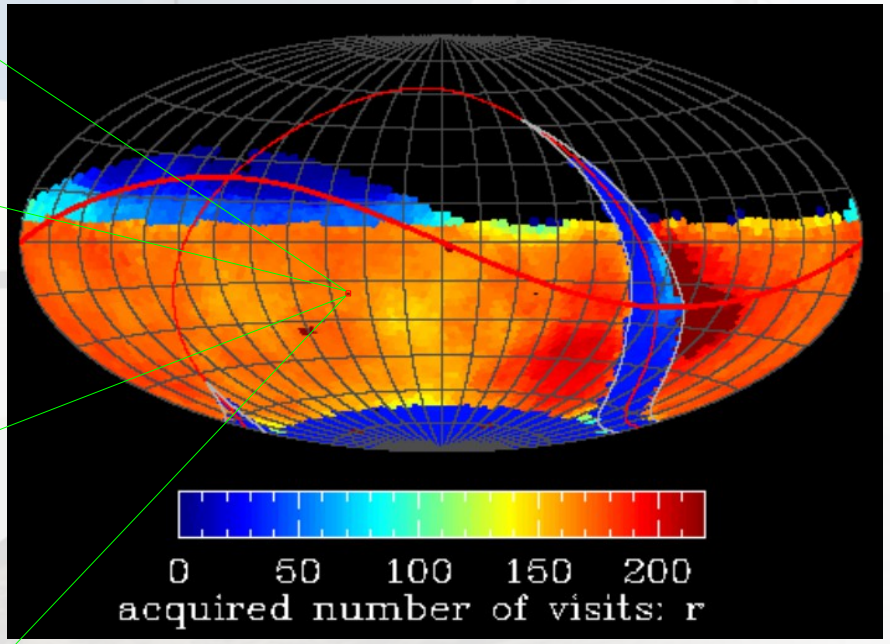
Camera : 198 CCD (16 Mpix) read in parallel

- 3,2 G pixels !
- ~ 6 Gbyte / 17 seconds
- 15 TB / night

During 10 years !



- ~ 800 visits per field
- opens the time domain



~ 500 PB at end of the project

This is Big Data !

Data Management Sites and Centers

HQ Site
HQ Facility
Observatory Management
Science Operations
Education and Public Outreach

AURA

LSST Corporation

Archive Site
Archive Center
Alert Production
Data Release Production
Calibration Products Production
EPO Infrastructure
Long-term Storage (copy 2)
Data Access Center
Data Access and User Services

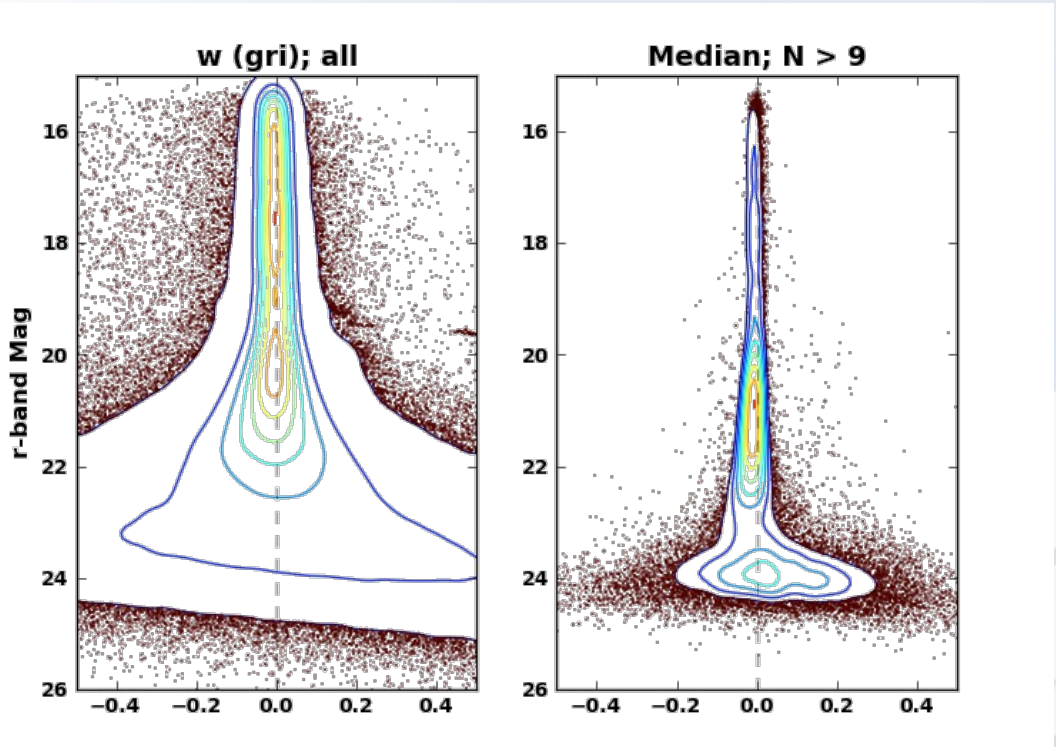
French Site
Processing Center
Data Release Production

Summit Site
Summit Facility
Telescope and Camera
Data Acquisition
Crosstalk Correction

Base Site
Base Facility
Long-term storage (copy 1)
Data Access Center
Data Access and User Services

LSST@Europe Meeting, Cambridge, UK September 9-12, 2013 15

LSST reduction pipeline already enables scientific analysis

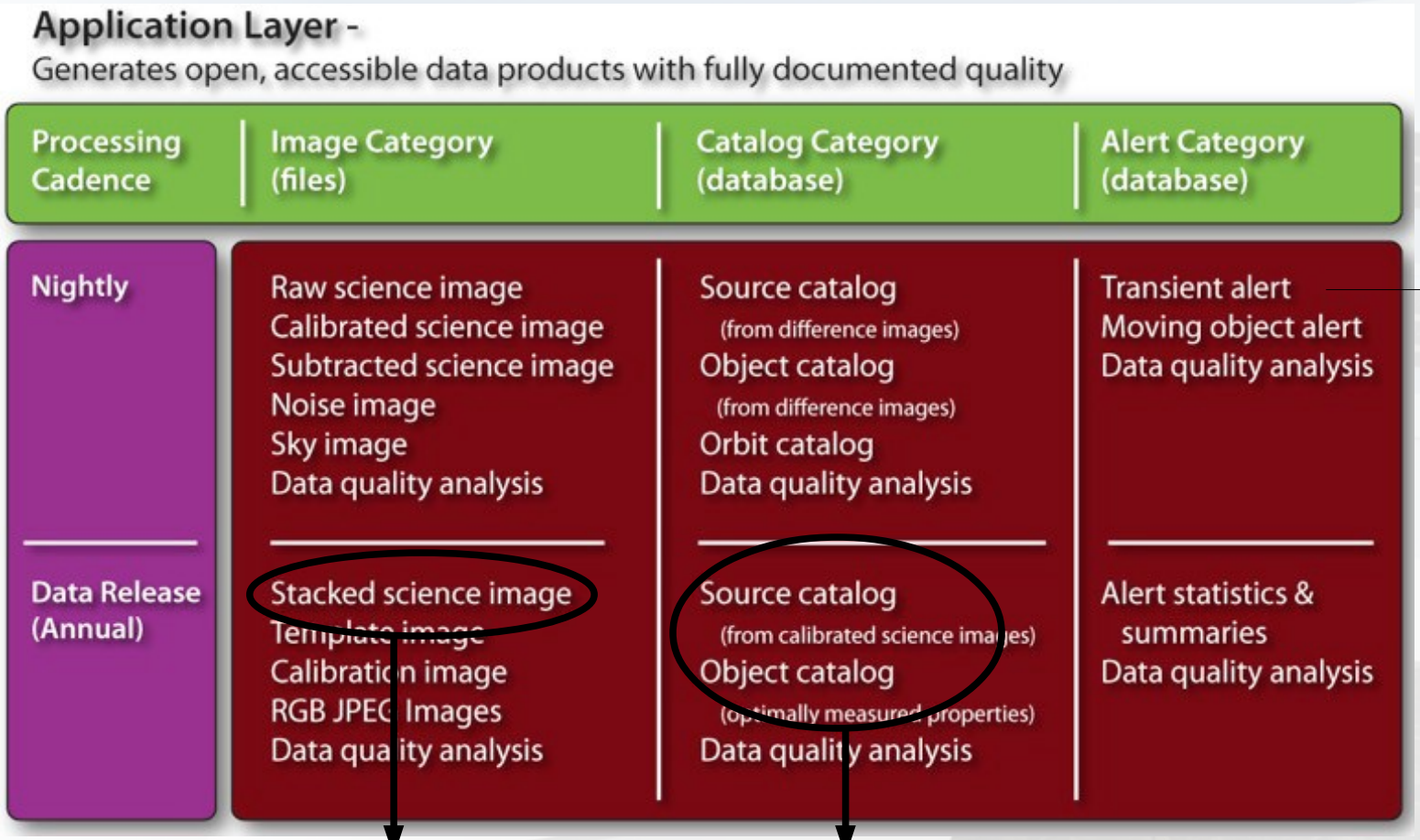


Photometry from SDSS stripe 82
reprocessed with LSST software
(split processing NCSA/CCIN2P3)

$5^{\square}$ coadded image near M2
Diffuse structures are preserved

Ongoing (France) :
reprocessing of CFHTLS data

Data products:



10^6 (within 60s.)

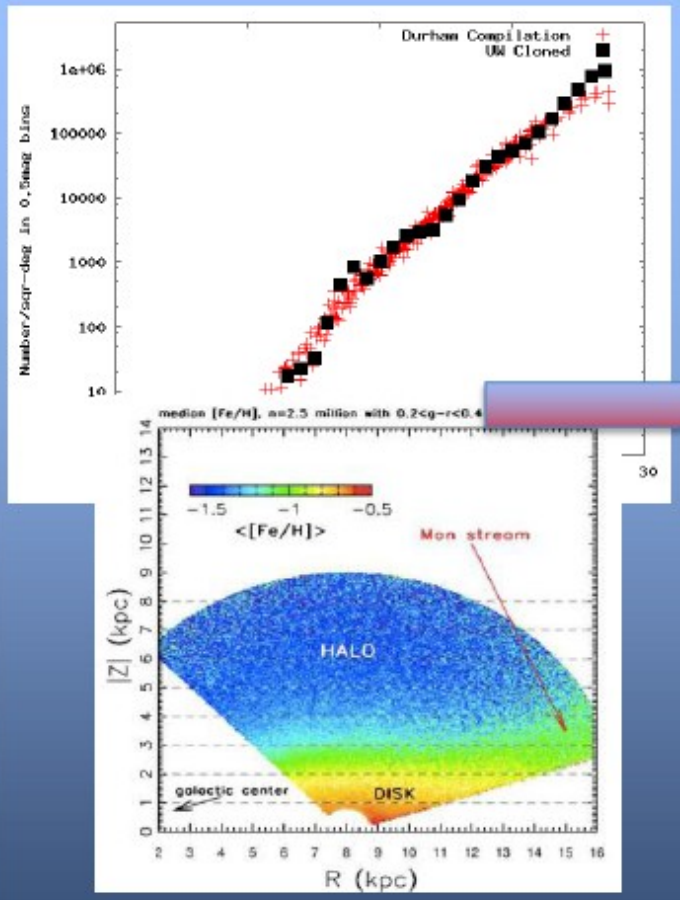
Static: 80 TB image
In 6 bands
(all visible sky)
Dynamic: 60 PB

Relation 1-Many
Object (40 10^9 x 500)
Sources (5 10^{12} x 120)
Catalogs : 5 PB

France : test of distributed DB
300 nodes, 15TB

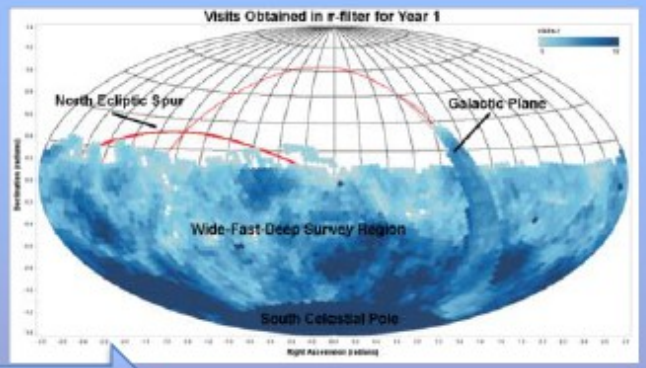
System simulation and performance evaluation

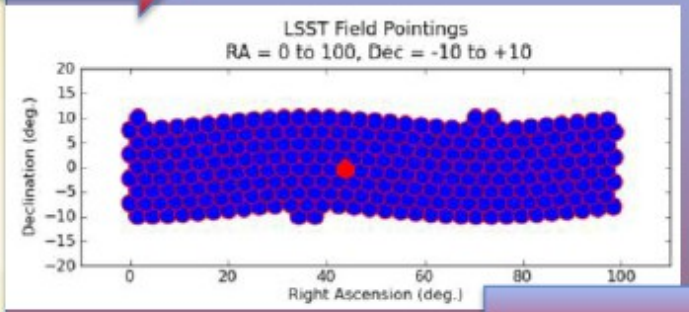
A simulated sky



Galaxies (de Lucia et al 2006)
Stars (Juric et al 2008)
Asteroids (Grav et al 2007)

Observing an LSST simulation

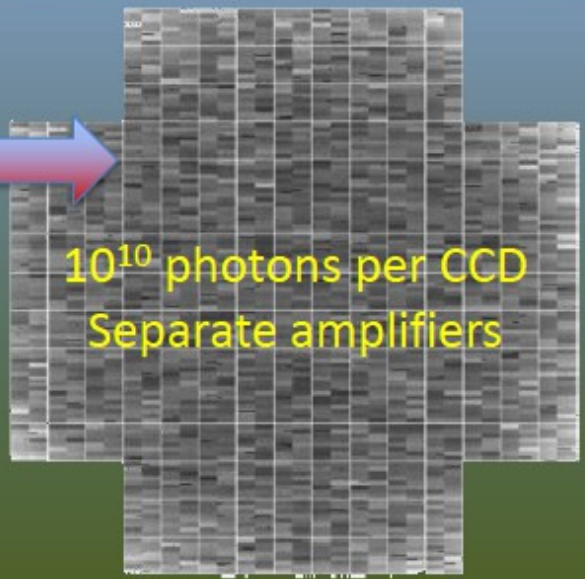




Pointing, Filter, Airmass, Time and Atmosphere from Op Sim

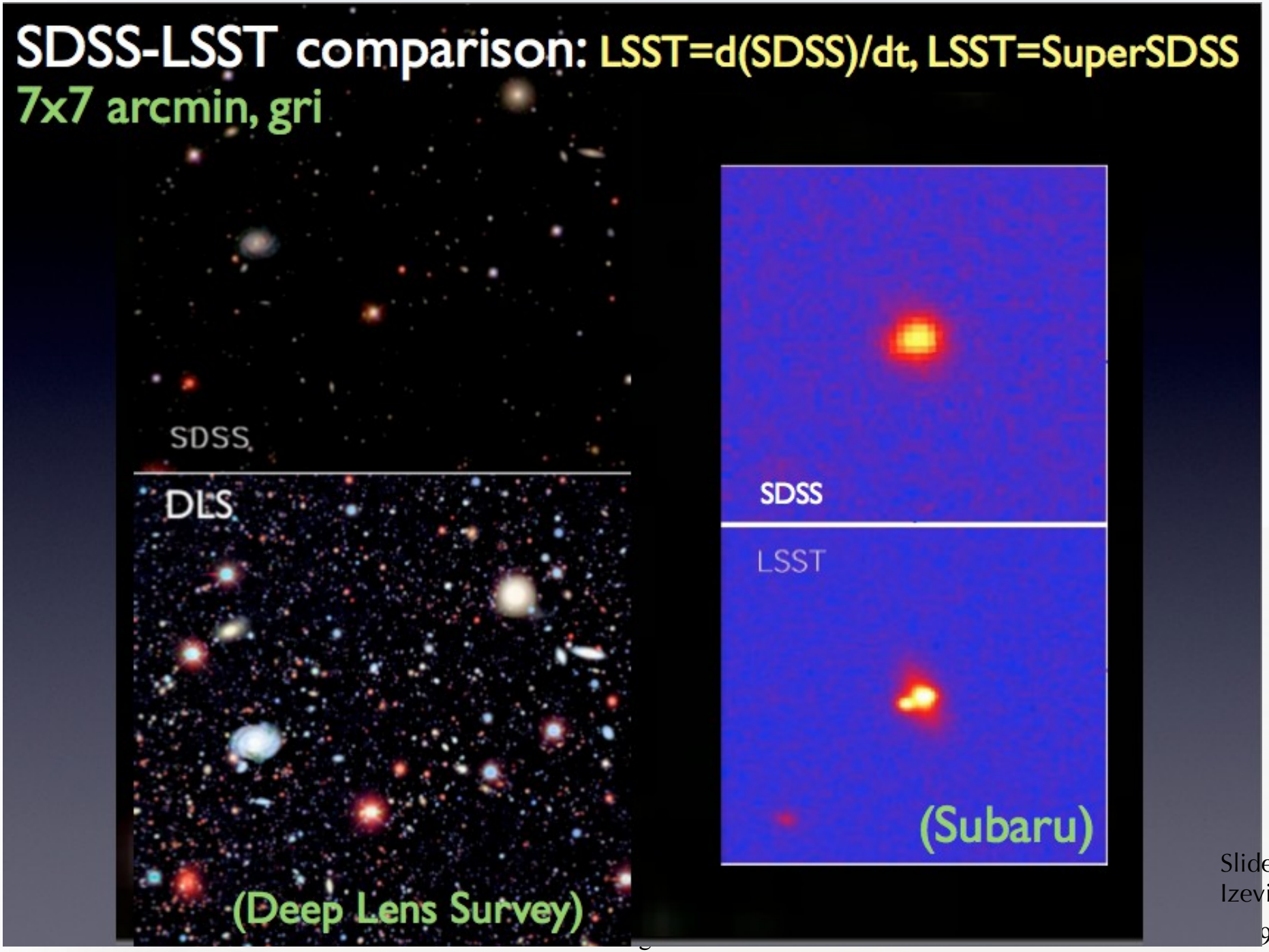
Custom instance of field of view

Producing a simulated image



10^{10} photons per CCD
Separate amplifiers

Which science will LSST address ?



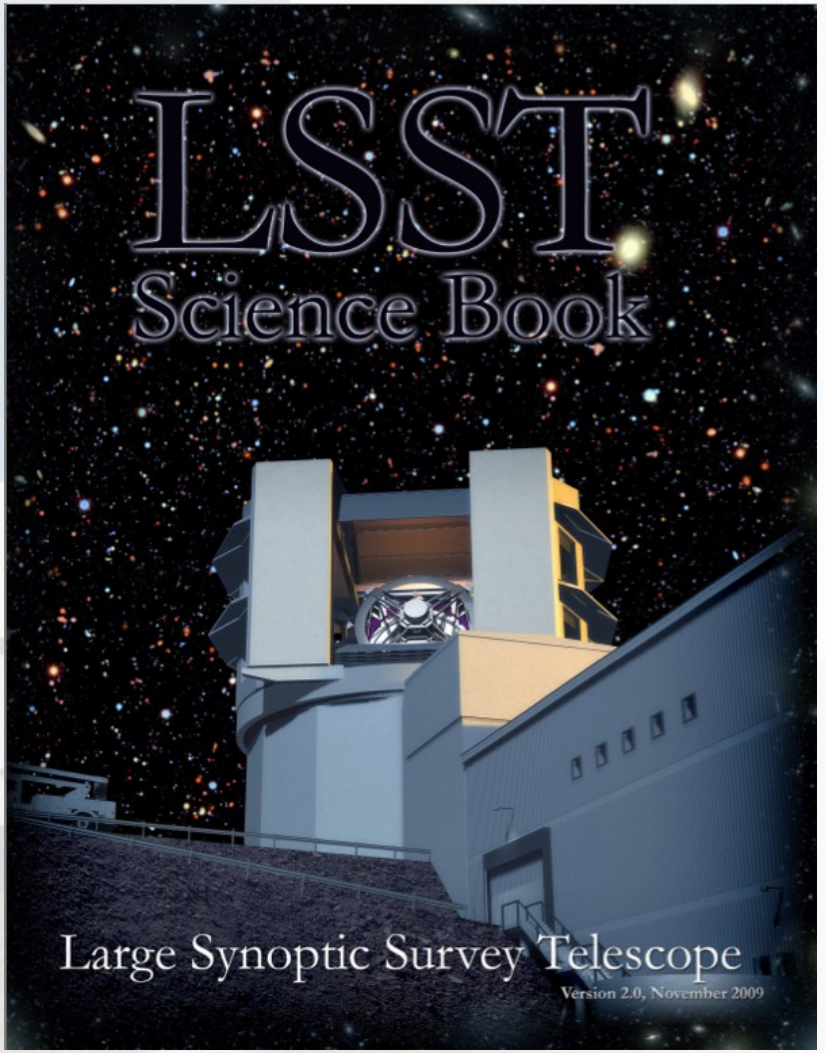
Slide from Ivezic

The LSST science book

- 4 major themes
  - Dark Energy, Dark matter
  - Mapping Milky Way
  - Transient optical sky
  - Solar system
- 11 science collaborations
  - Weak Lensing
  - BAO
  - Supernovae
  - Strong lensing
  - Galaxies
  - AGN
  - Milky way and the local volume structure
  - Stellar populations
  - Transient/variable stars
  - Solar system
  - Informatics and statistics

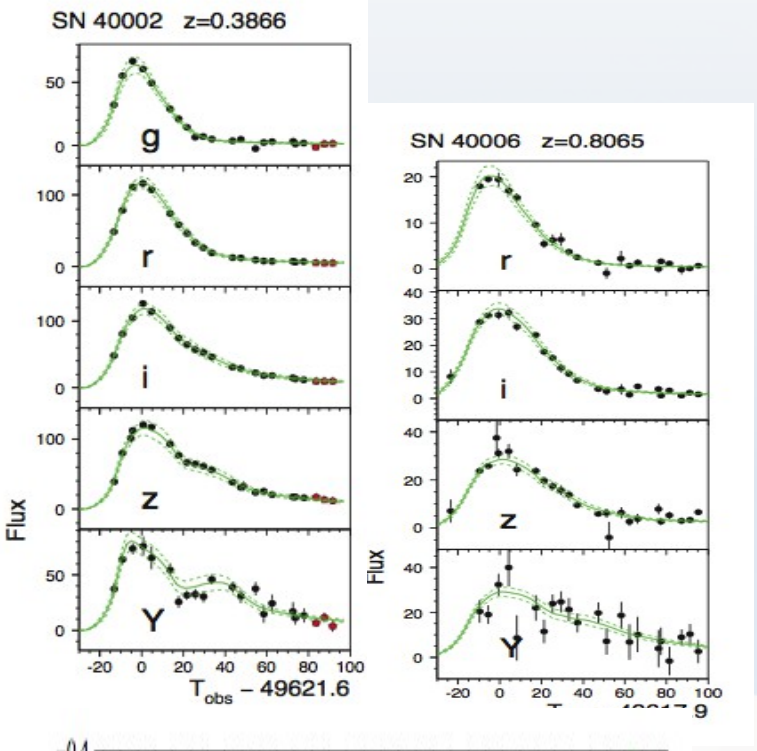
LSST DESC Dark Energy Science Collaboration

ArXiv 1211.0310



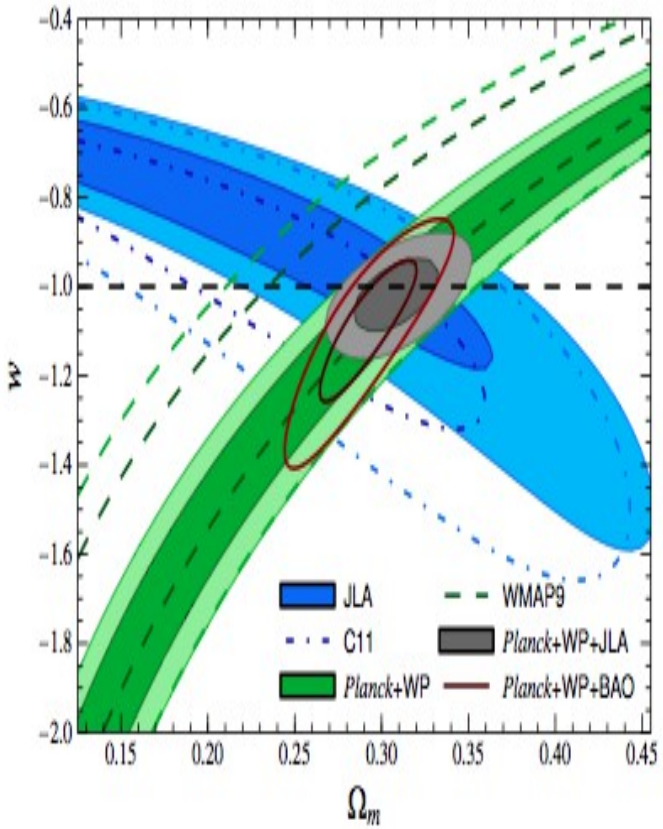
arXiv:0912.0201

SN in LSST

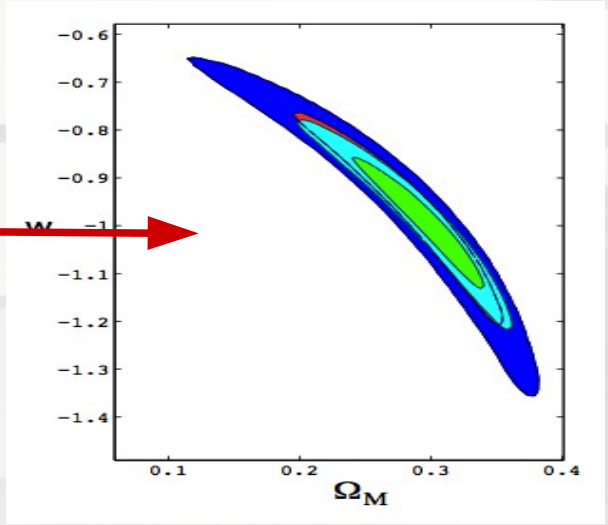


- *10 000 well sampled SN/year*
- Systematics dominated (short in IR)
- No spectroscopy (for now…)
- Redshift from external measurement

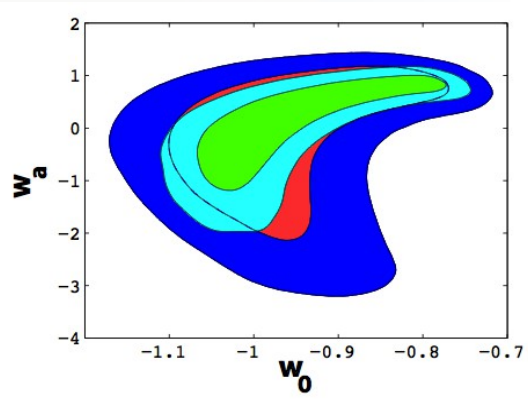
Huge improvement still !



Bétoule 2014



LSST 10 000 SN



LSST 50 000 SN

A combined Euclid/LSST SN program :

A&A 572 80 (2014)

Extending the supernova Hubble diagram to $z \sim 1.5$ with the Euclid space mission

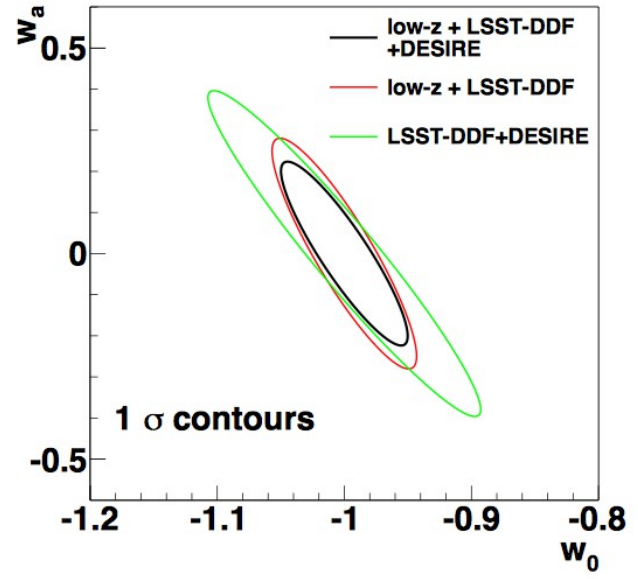
P. Astier[1], C. Balland[1], M. Brescia[2], E. Cappellaro[3], R. G. Carlberg[4], S. Cavuoti[5], M. Della Valle[2,6], E. Gangler[7], A. Goobar[8], J. Guy[1], D. Hardin[1], I. M. Hook[9,10], R. Kessler[11,12], A. Kim[13], E. Linder[14], G. Longo[5], K. Maguire[9,15], F. Mannucci[16], S. Mattila[17], R. Nichol[18], R. Pain[1], N. Regnault[1], S. Spiro[9], M. Sullivan[19], C. Tao[20,21], M. Turatto[3], X. F. Wang[21], and W. M. Wood-Vasey[22]

DESIRE survey :

2x 6-month seasons

45 visits / season

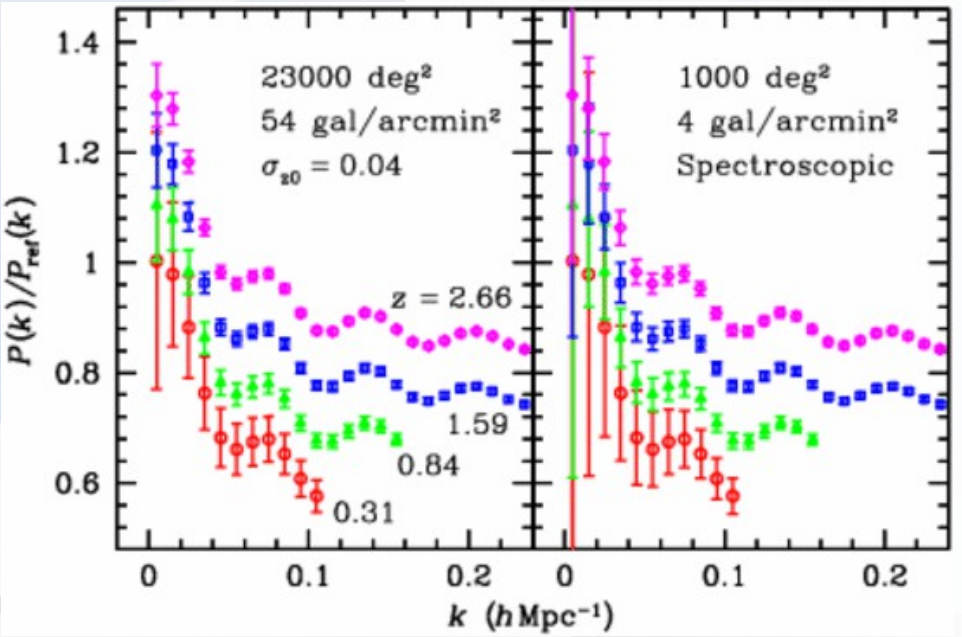
	z_{min}	z_{max}	area (deg^2)	duration (months)	events
DESIRE	0.75	1.55	10	2x6	1740
LSST-DDF	0.15	0.95	50	4x6	8800
Low z	0.05	0.35	3000	6	8000

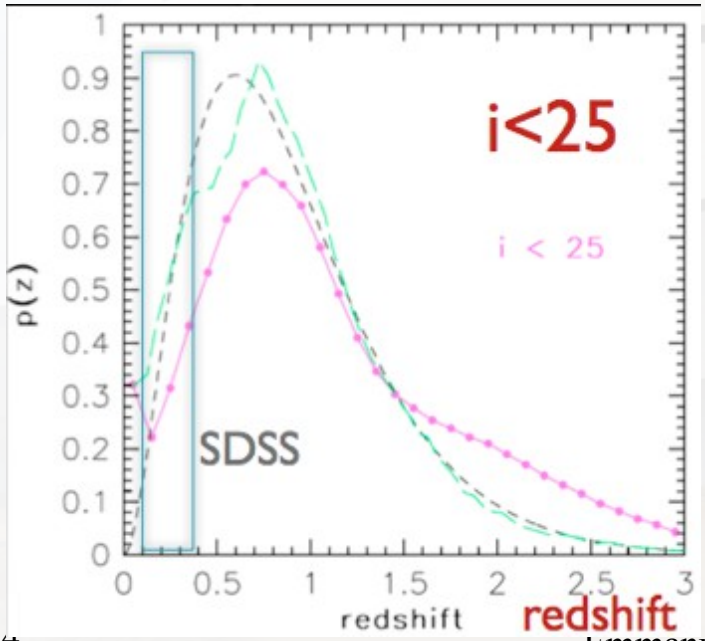


LSST galaxy census :

- 10 10^9 galaxies in 20000□
  - 4 10^9 in gold sample (i<25.3)
  - Up to z < 2.5
    - Structure growth
    - Redshift tomography
    - Galaxy evolution
    - ...

BAO





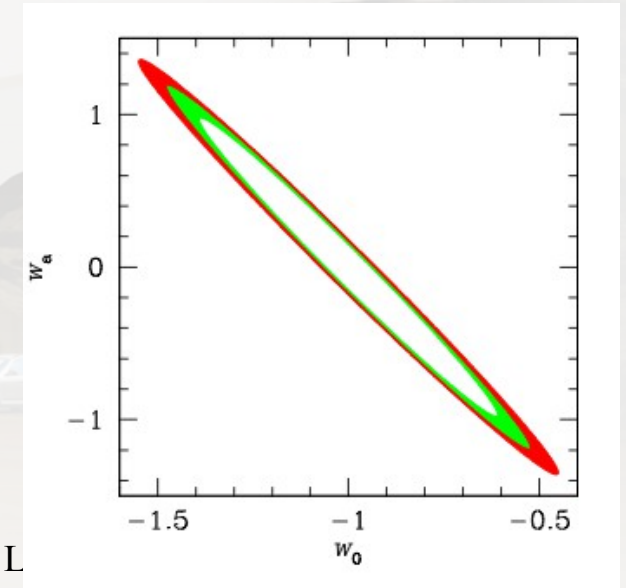
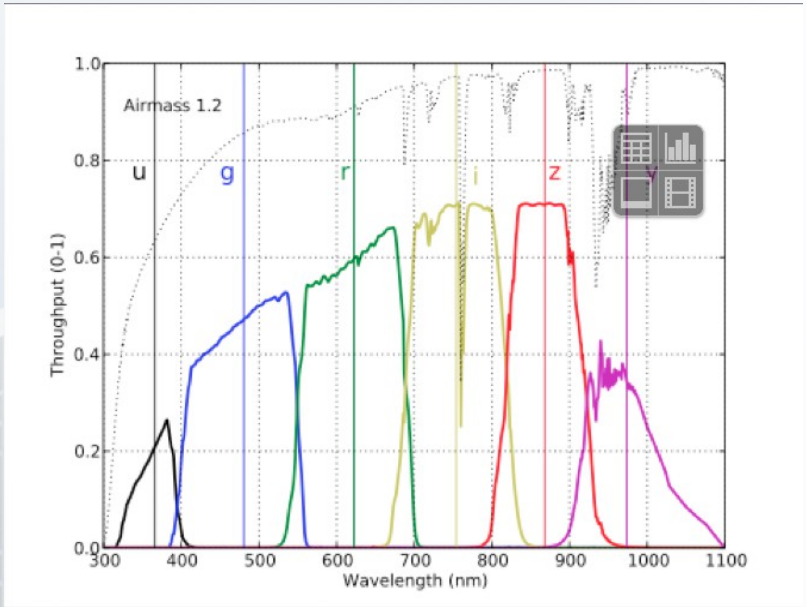
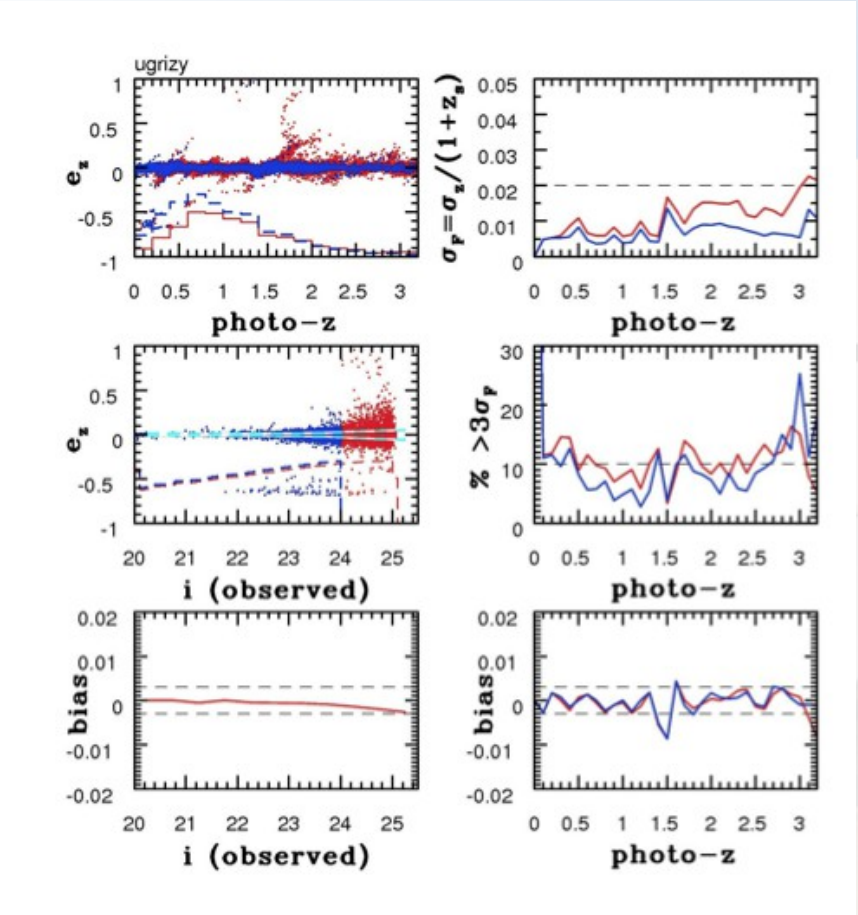


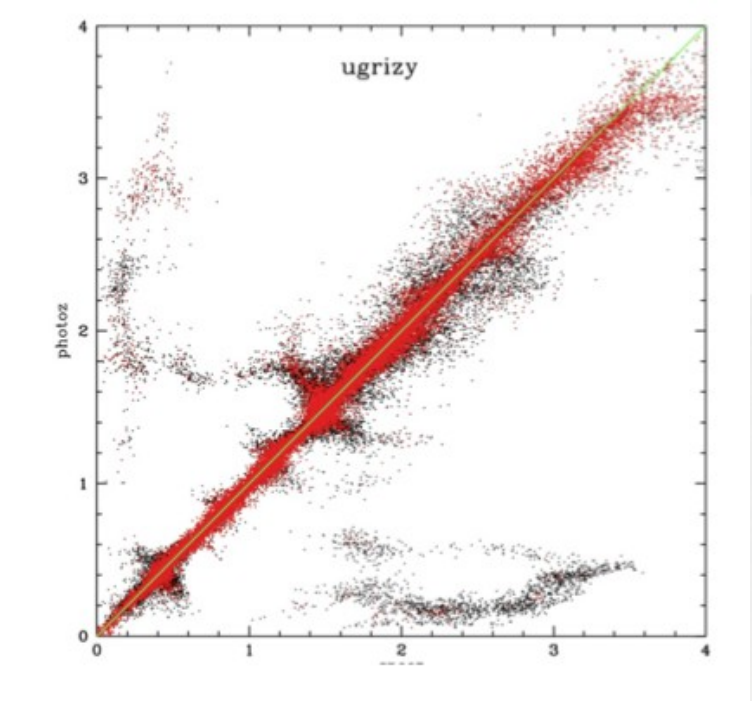
Photo-z

LSST requirements on 1+z

- 0.02 random error
- <0.003 bias
- <10% 3-σ outliers
  - primary driver for LSST main survey







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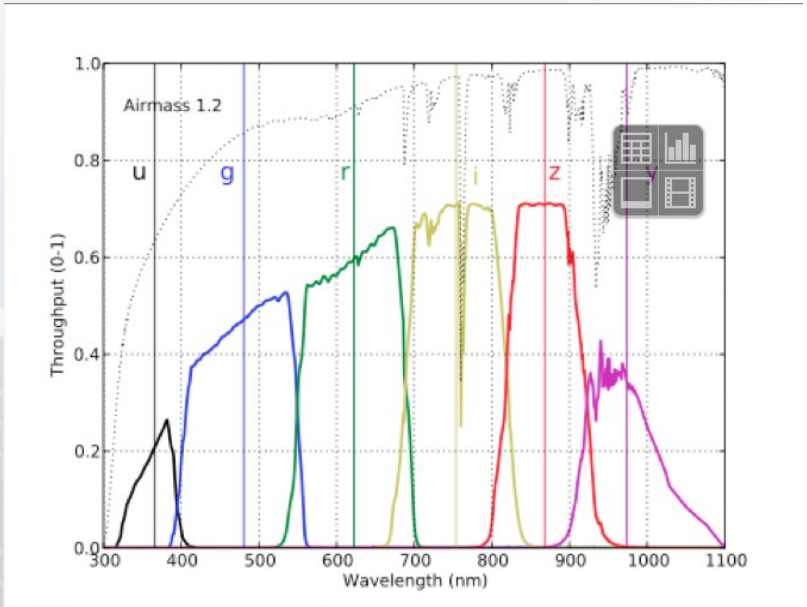
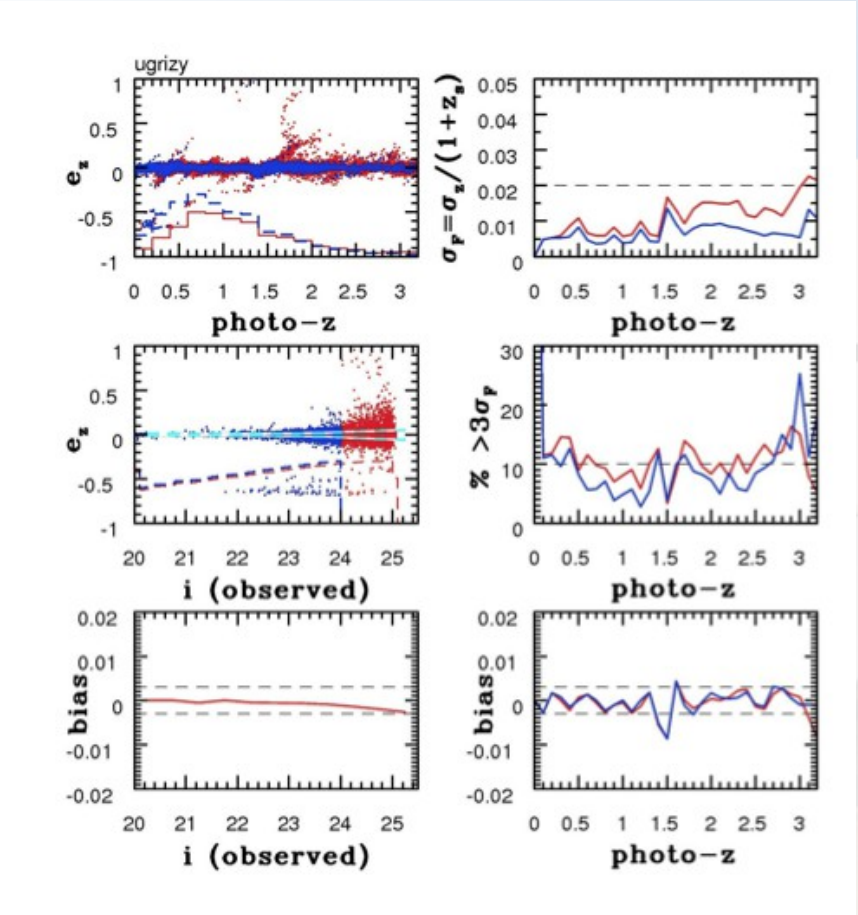
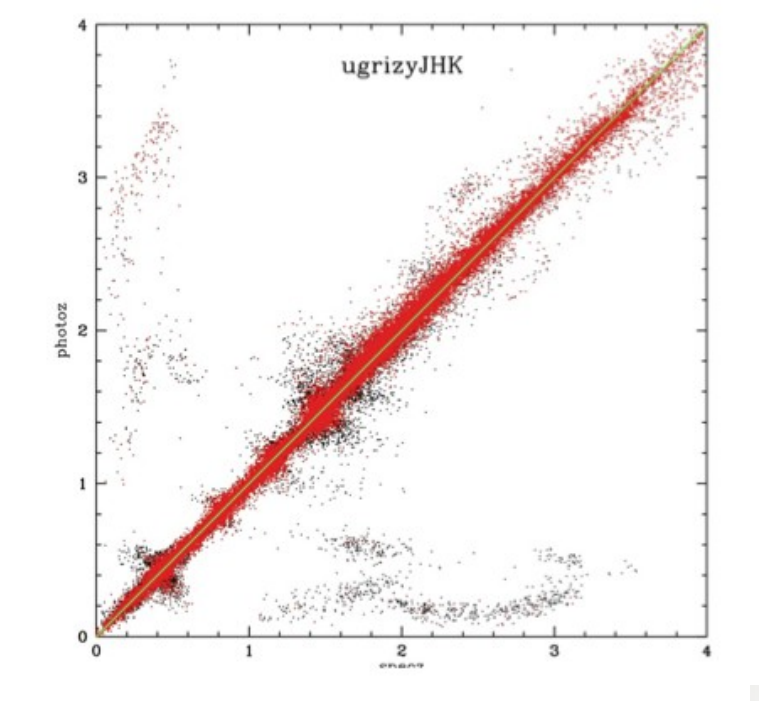






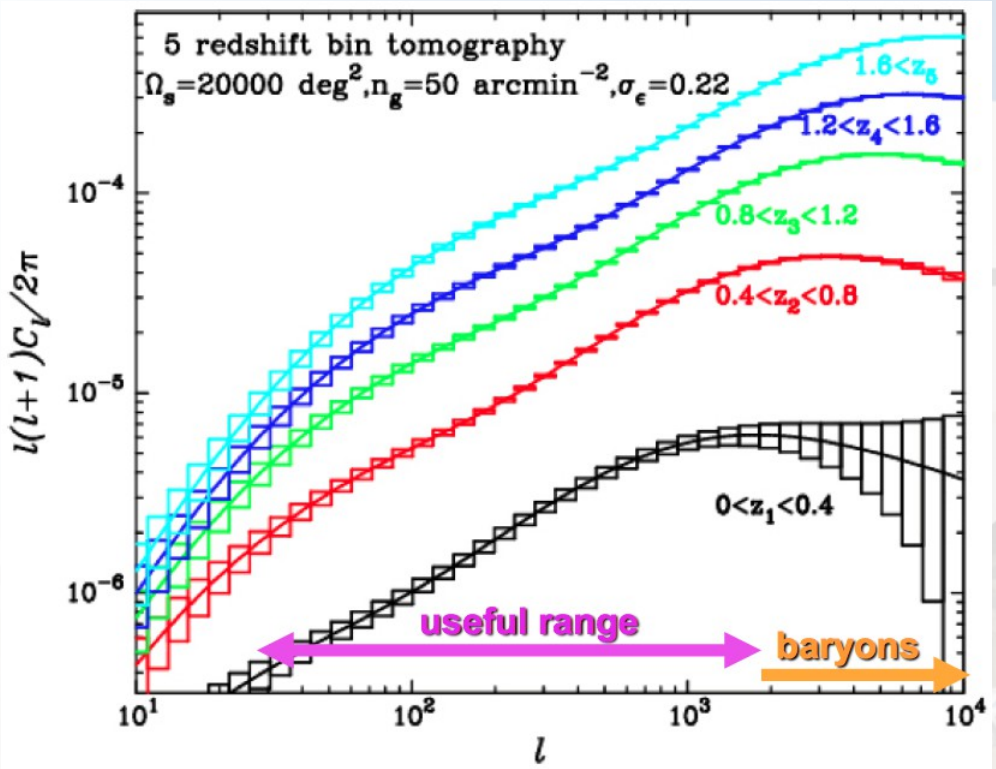
Dramatic improvement with IR

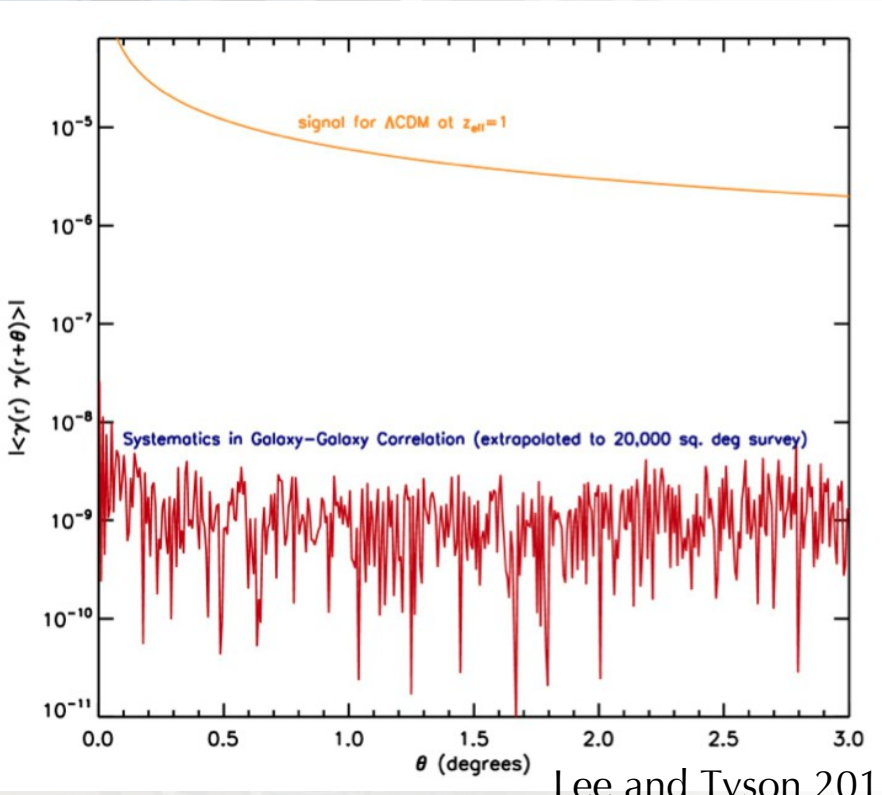
Lensing with LSST

Lensing is sensitive to all dark matter components, including neutrinos

10 redshift bins: 55 auto and cross-spectra

~100 visits will reduce the systematic shear correlations below the shot noise





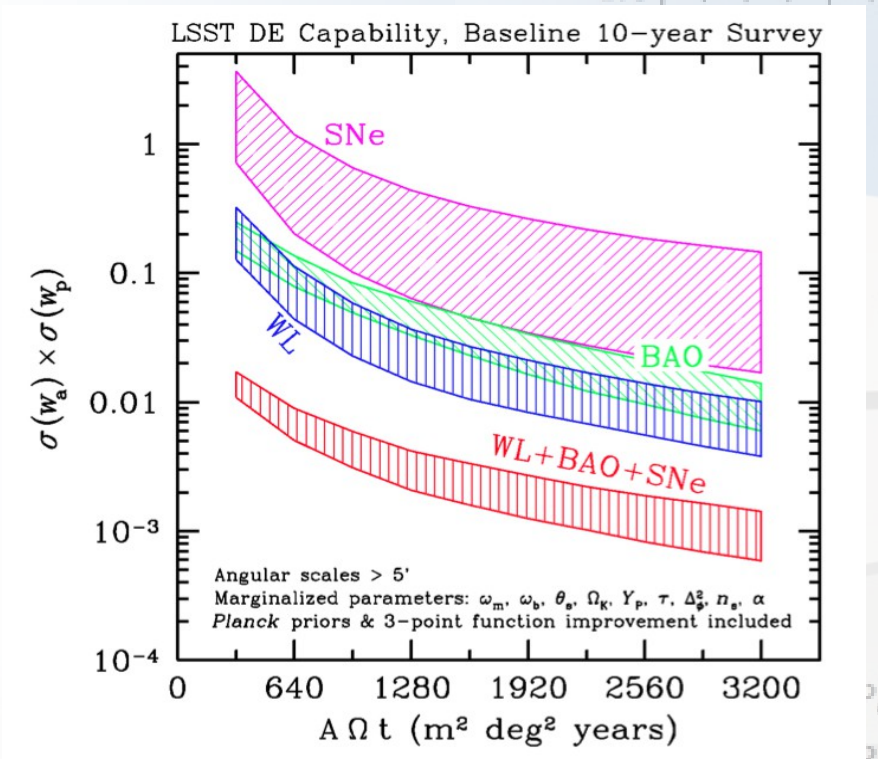
Lee and Tyson 2011

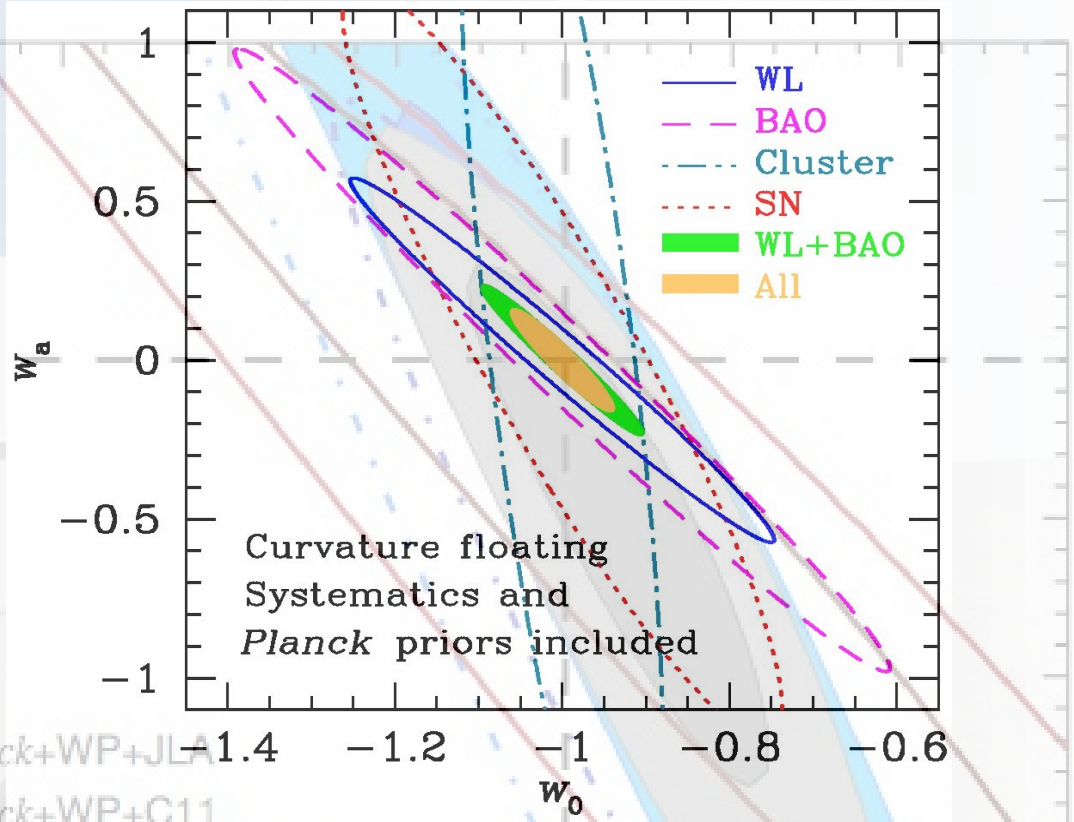
- Expected to be most precise probe with LSST

LSST Dark Energy constraints

Multi-probe approach

- precise determination of equation of state.
- control of systematics





Errors will be systematics dominated !

Conclusions

- **LSST will provide unprecedented data : Wide, Fast, Deep**
  - Multi-probe approach for Cosmology
  - … and offers a LOT of scientific opportunities
- **France has a privilegied access to LSST data**
  - Early construction member (IN2P3)
  - 50% of LSST processing

    Adds ~30 French PI
- **Complementarity with Euclid**
  - ~5000□ in common, different bands
    - Room for joint analysis (SN, Galaxies …)