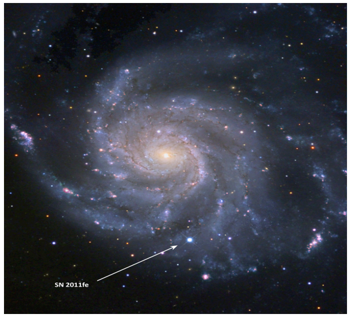
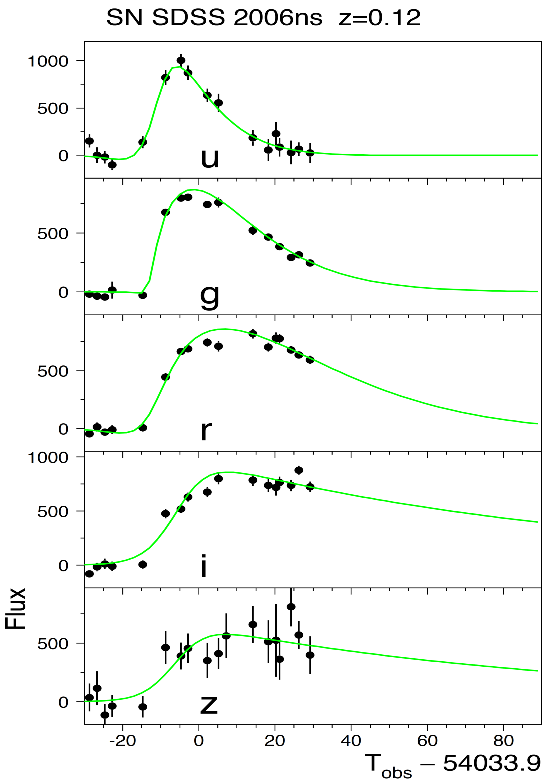
Supernovae @ LSST-France

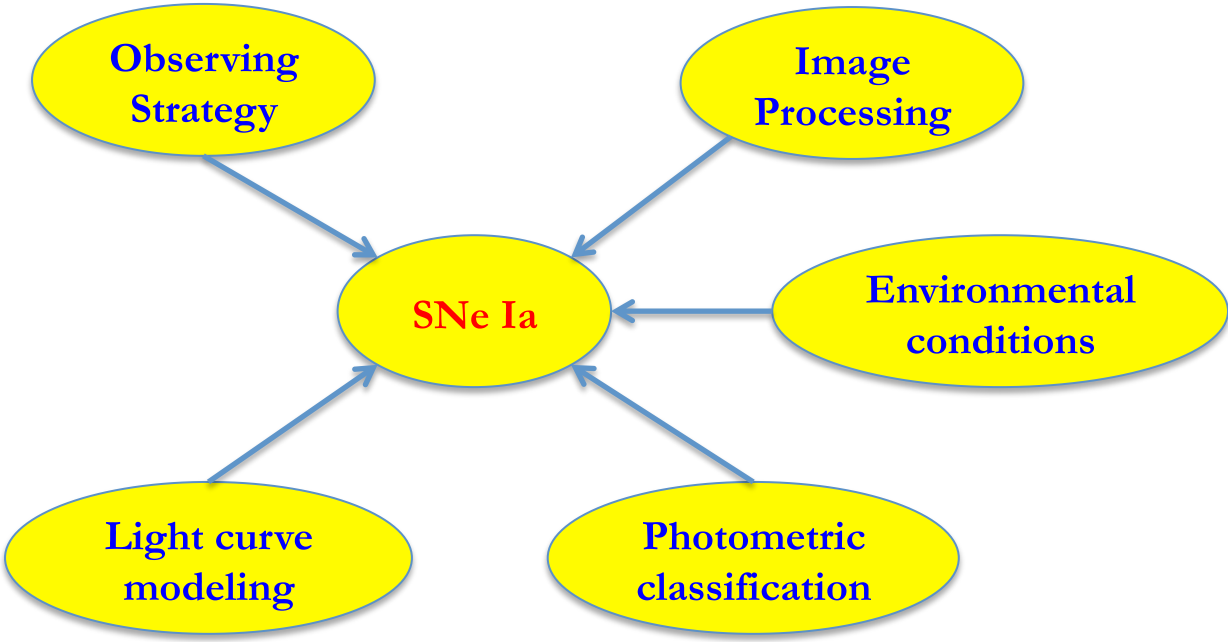
Ph.Gris on behalf of the LSST-France Supernovae WG
Laboratoire de Physique de Clermont
IN2P3/CNRS

Supernovae in LSST

- Supernovae (Ia) :
  - objets transitoires (~ 80 jours)
  - très lumineux ~ 10 milliards $L_{\odot}$ au pic de luminosité)
  - "chandelles standard" -> mesures de distance -> cosmologie
- LSST : SNe identification/characterisation from photometric light curves

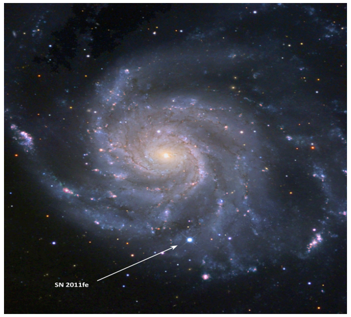


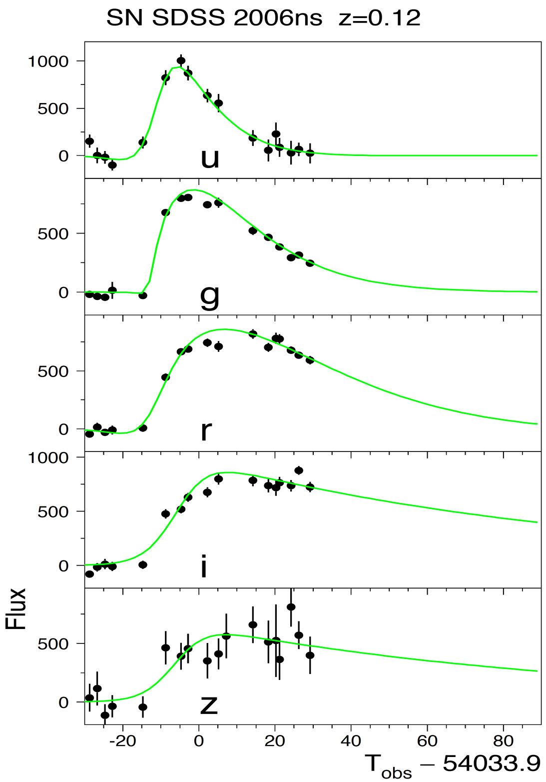


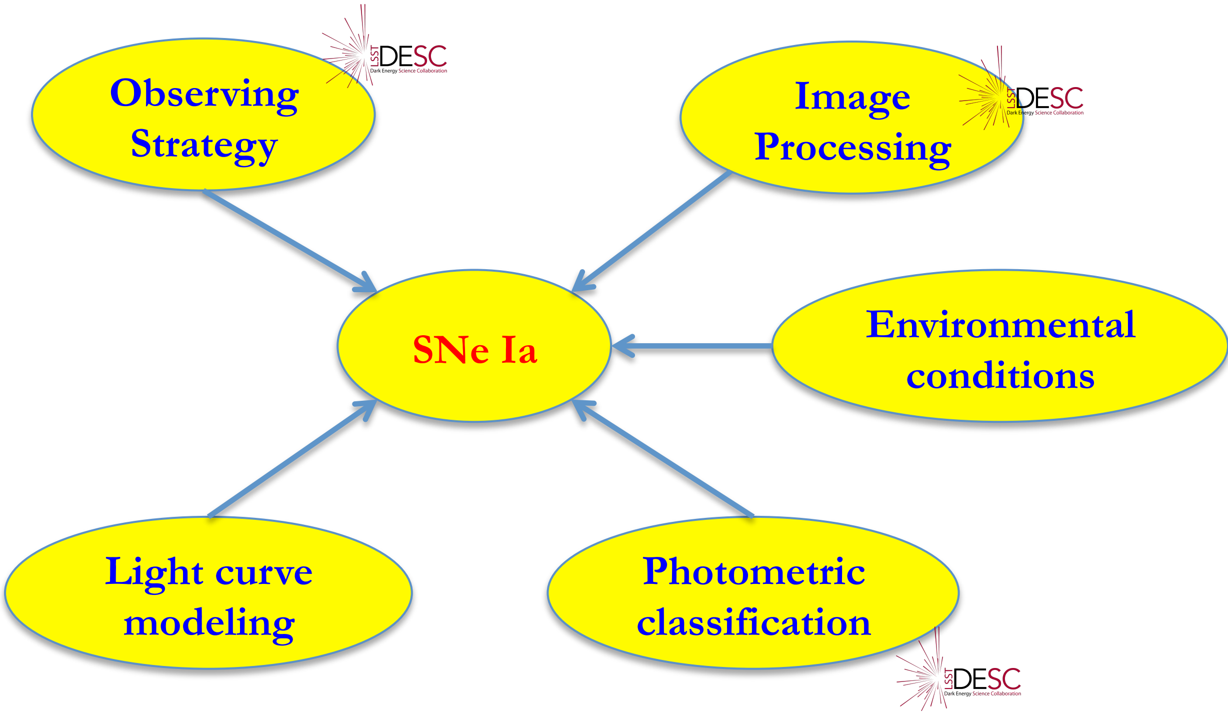


Supernovae in LSST

- Supernovae (Ia) :
  - objets transitoires (~ 50 jours)
  - très lumineux ~ 10 milliards $L_{\odot}$ au pic de luminosité)
  - “chandelles standard” -> mesures de distance -> cosmologie
- LSST : SNe identification/characterisation from photometric light curves

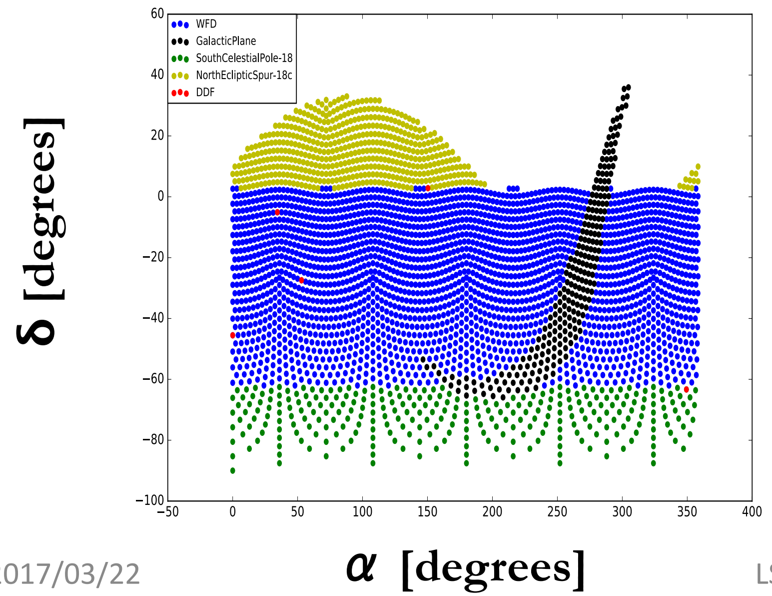






Current LSST Observing strategy

Cadencing	Sky region	Physics
Universal (uniform) "main survey"	south hemisphere	stellar parallax, proper motion, asteroids
Reduced number of repeat observations "mini surveys"	low Galactic latitudes	
	South Celestial Cap	Magellanic Clouds
	Ecliptic Plane (northern)	+ Near-Earth Asteroids, Main Belt Asteroids
Deep Drilling	5 fields	Variable objects

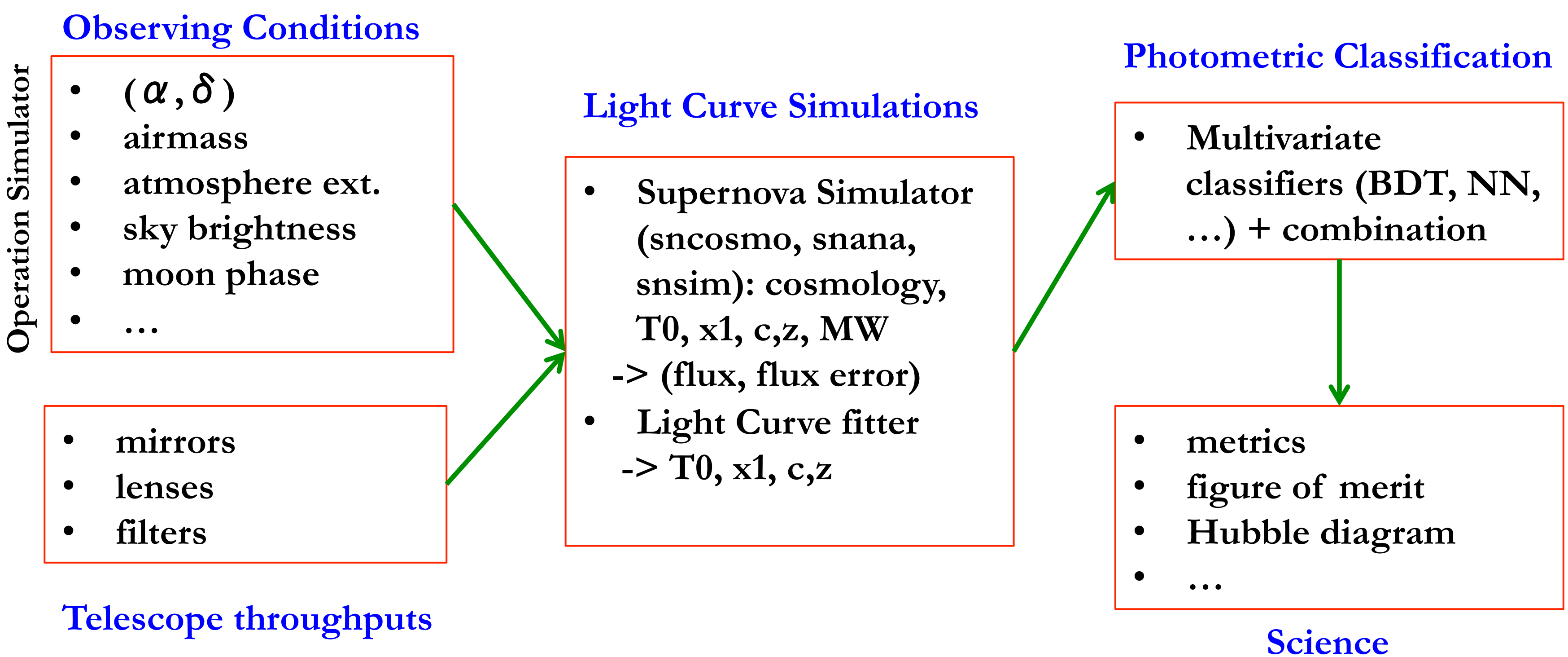


Survey	Mean number of visits per field over ten years
Main	~200
Low Galactic	30
South celestial	30
Ecliptic plane	90
Deep Drilling	> 1000

Total number of visits : 2,448,282

Observing Strategy and Supernovae

- With the current baseline, we would like (or we probably need) to estimate the number of Supernovae (Ia) that LSST will collect after ten years of observations.
- This number will depend both on the cadence and on quality criteria -> "useful" sample of SNe Ia (-> Hubble diagram)
  - Is the current baseline satisfactory wrt SNe Ia science ?
  - Would it be possible to have a more suitable cadence ?
- We are currently using a simulation pipeline to estimate the performance:



SN and Observing Strategy in LSST

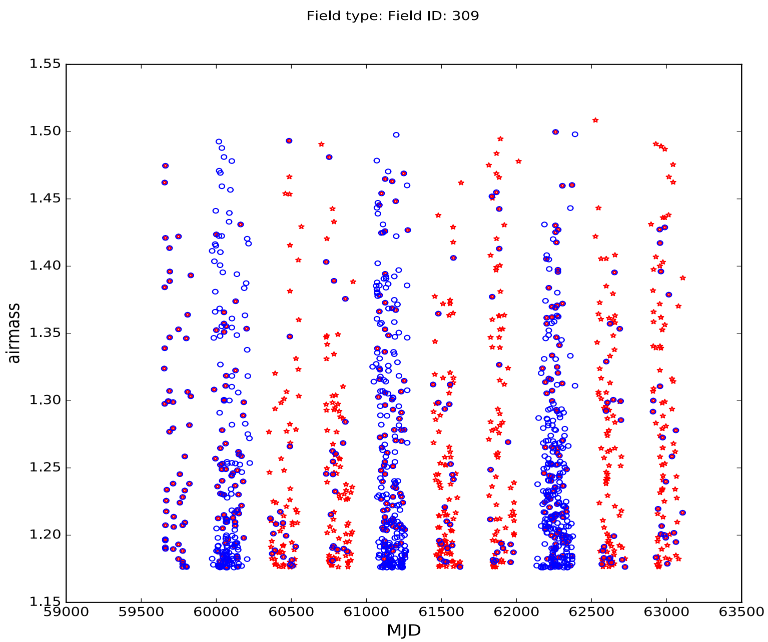
- **Ongoing work**

-> setup of a full simulation chain

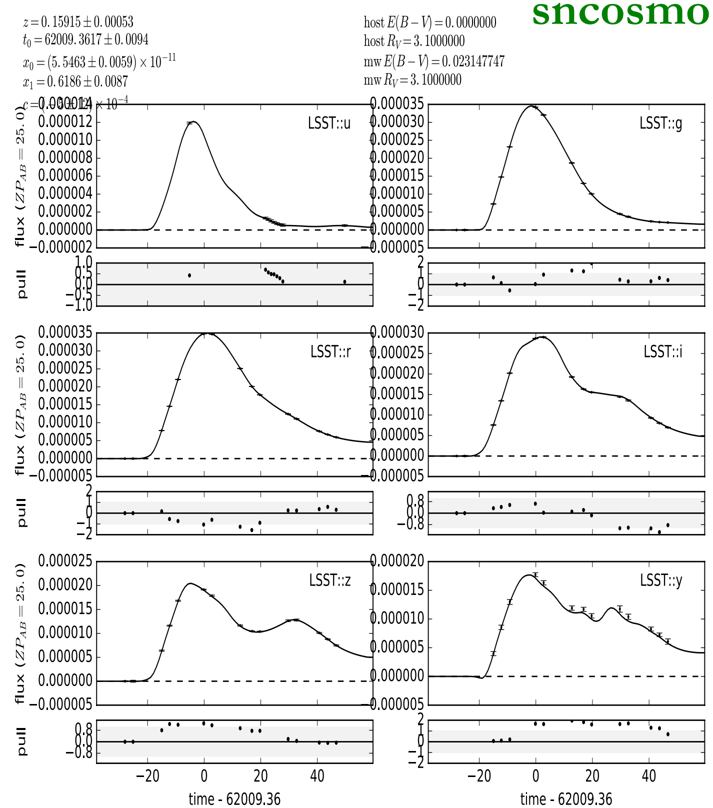
-> Estimation of the number and quality of SNe Ia with the current baseline (DDFs)

-> Optimisation of the cadence:

  - **DDFs : 5 fields -> 10 fields**
  - **in the Wide : "Rolling Cadence"**



sncosmo



Cadencing per band, number of measurements per night, combination of filters

Observing Strategy – (Official) Schedule

Observing Strategy white paper

- by september 2017 : With OpSim 4 : generation of a new set of observing strategy, including "a rolling cadence"
- september – end of 2017 : redefinition of the Deep Drilling Fields and associated cadence
  (5 DDFs -> 10 DDFs)
- End of april 2018 : The Science Advisory Council will be asked to make a recommandation to the project on which DDFs and cadences should be used
- September 2018 : the project will issue a request to the community to update the Observing Strategy white paper (MAF+FOMs) for the WDF+mini-surveys
- July 2019 :
  - the project will establish a committee, the Survey Strategy Committee (SSC) to :
    - evaluate competing survey proposals
    - propose a survey strategy for commissionning and operation of the full LSST camera
  - SSC : chaired by the LSST Project Scientist and comprised of project and non-project personnel
  - The SAC will be asked to make recommandations for committee memberships
  - the SCC will report to the LSST Director until the end of LSST construction and commissionning
- December 2019 : based on the recommandation made by the SSC : announcement of an initial survey strategy and publication of a baseline simulation that reproduces this strategy.

Data reprocessing : from pixels to light curves

Level 1
Raw images
+corrections (bias, dark, flat)

Level 2

ProcessCcd

jointcal(simultaneous astrometry)

Coaddition

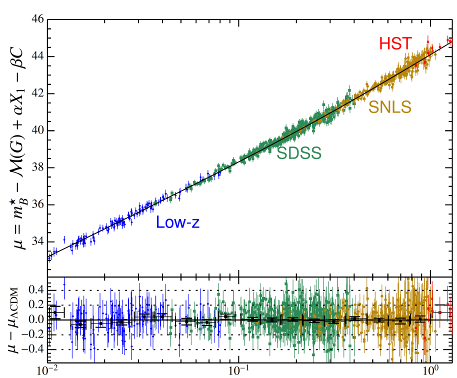
ForcedPhotometry

Image Subtraction

Level 3

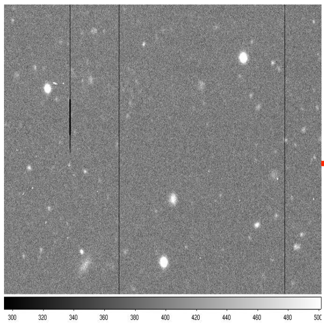
SN light curves

Cosmology

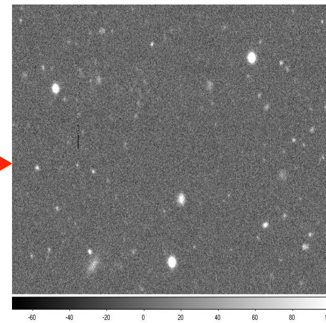


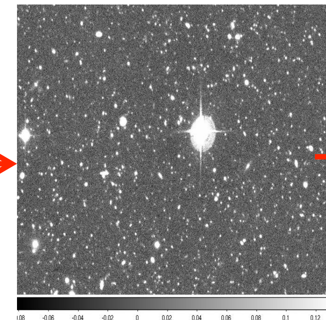
LSST : du pixel à la courbe de lumière

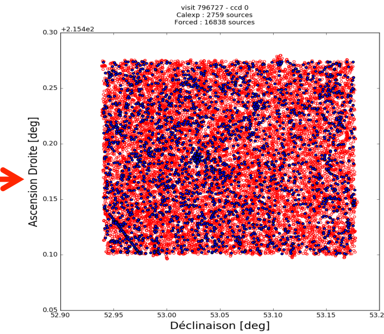
- Reprocessing of the CFHT D3 field



Bad pixels
Astrometry
Photometry





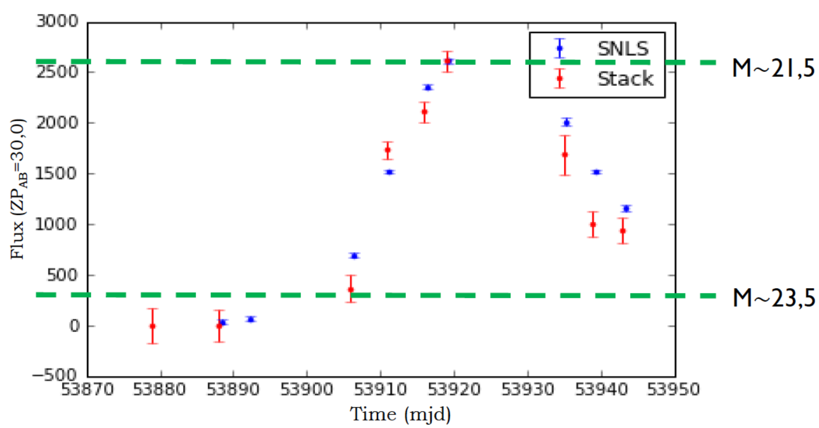


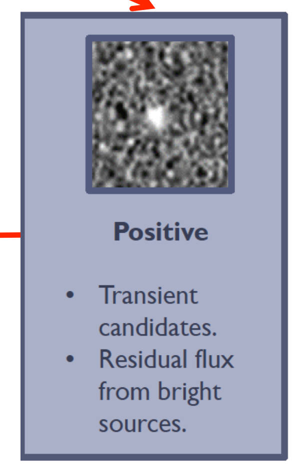
Initial image

calibrated exposure

coadded image

Forced photometry





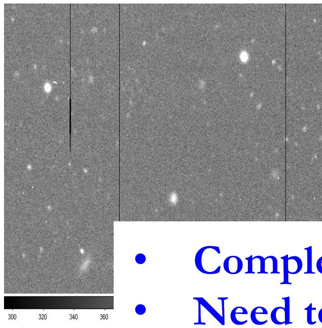
Juan-Pablo Reyes

Light curves

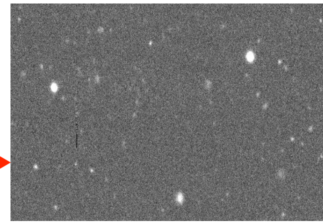
Image subtraction

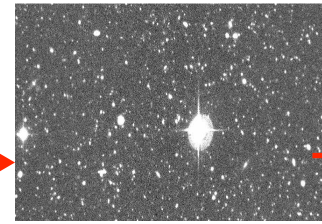
LSST : du pixel à la courbe de lumière

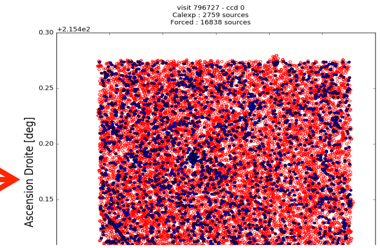
- Reprocessing of the CFHT D3 field



Bad pixels
Astrometry
Photometry

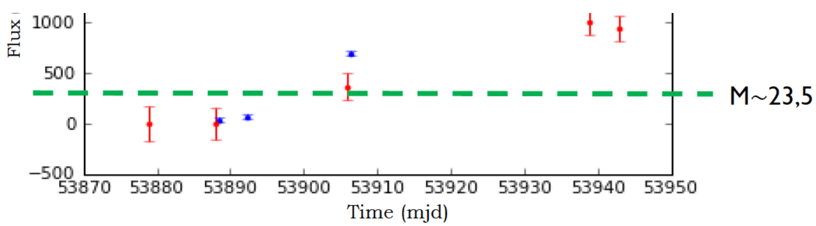


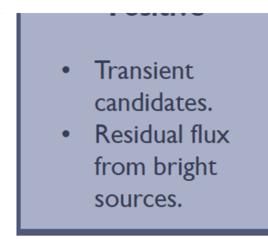




Init

- Complete L2 chain exercised but in a rather hand-made way
- Need to automate the processing (common goal with the Cluster group in France -> coordination)
- Systematic studies (and reference plots) of the performance (photometry, astrometry) of the stack image processing (at each step of the chain)
- Image subtraction optimisation
- Are we able to detect SN light curves observed by the CFHT ? Precision level ? Limiting factors ?
- What about the Level3 ?





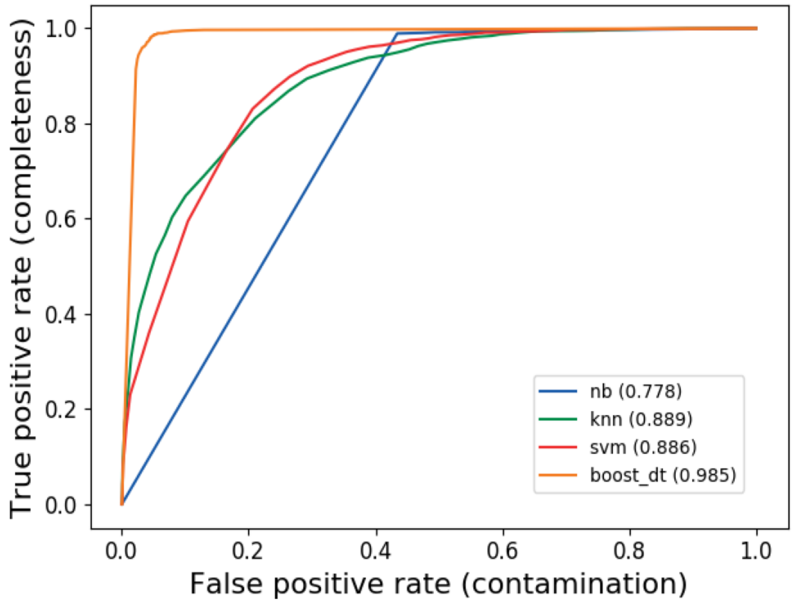
Juan-Pablo Reyes

Light curves

Image subtraction

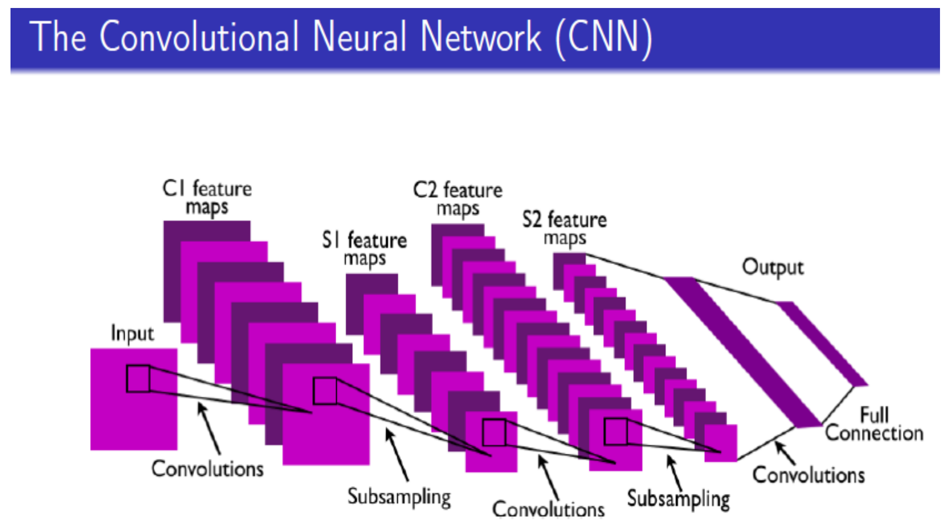
Photometric classification of SNe Ia

- **Goal : optimise the fraction of collected SNe Ia (wrt core-collapse SN) which will be used for cosmology using light curve parameters (x1, c, …)**
- **Mean : machine learning methods (supervised) rather sophisticated**



Emille Ishida

Photometric Classification Data Challenge in DESC-SN on july 2017



Johanna Pasquet

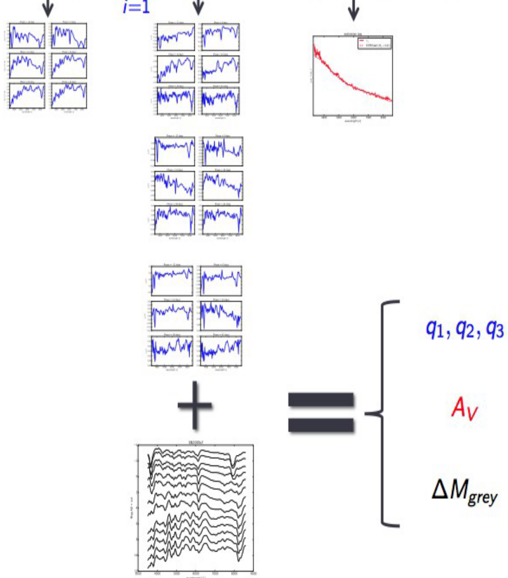
Empirical modeling of SNe Ia

- Why is a new model needed?
  - SNe peak B-band magnitudes have ~15% dispersion after correction (~10% intrinsic dispersion)
  - Intrinsic dispersion indicates the presence of un-modeled processes.
  - This will lead to bias if the processes change with redshift or sample selection.

Soutenance de Thèse 28 Septembre 2016 P-F Léget (LPC-Clermont) 68

SUGAR results: fit SUGAR parameters

$$M(t;\lambda) = M_0(t;\lambda) + \sum_{i=1}^{i=3} \alpha_i(t;\lambda) q_i + A_V f(R_V;\lambda) + \Delta M_{grey}$$

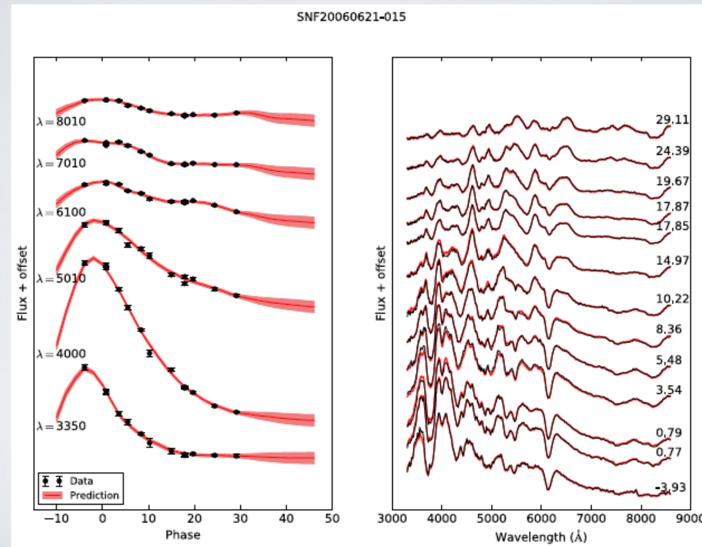


Correction scheme :
- stretch
- color
+ velocities
+ detached Ca

Improves SED fitting
And standardization

Mas step still there

GAUSSIAN PROCESSES



Clare Saunders

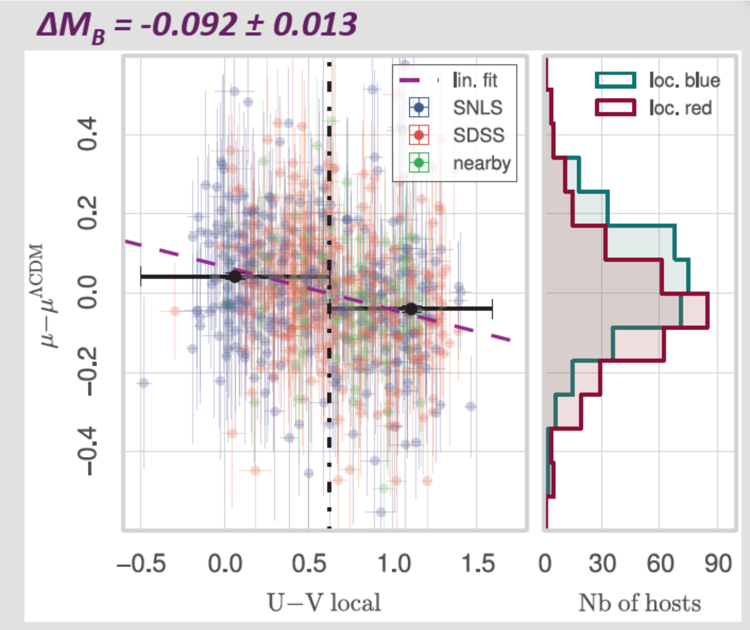
-> Understand and correct for some of the remaining sources of variability
-> more parameters to model SNe Ia spectra
-> integration in SN simulator

Pierre-François Léget / Emmanuel Gangler

Environmental dependence of supernova

- Goal : study and characterize environmental conditions where SNe Ia are detected
  -> impact on cosmology

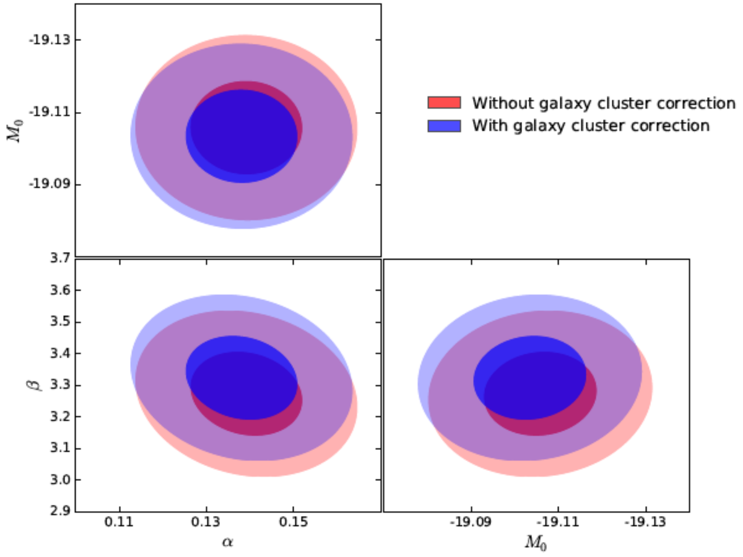
Correlation brightness-environment



- Local color as a third standardization parameter
- 7σ significance of the magnitude step

Matthieu Roman

Impact of peculiar velocities on distance measurements



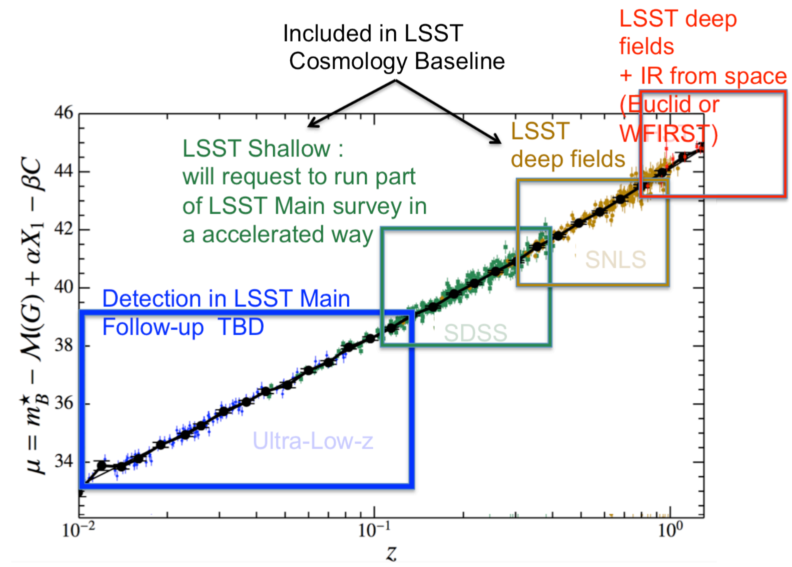
Maria Pruzhinskaya

Environmental conditions of SNe Ia are to be taken into account at the standardisation level and for cosmology.

Follow-up of nearby Supernovae with LSST

Supernovae collection in LSST:

- 0.6-0.5 ≤ z ≤ 1 : DDFs
- 0.1 ≤ z ≤ 0.4-0.5 : "rolling" cadence
- z ≤ 0.1 – 0.2 : dedicated follow-up needed



Pierre Antilogus

- The (very) low redshift domain
  - is important for cosmology (H_0 measurements using cepheids)
  - may only be studied with supernovae
  - is difficult (poor number of SNe Ia collected : few hundreds after ten years)

-> other experiments (ZTF, DES, PanStarrs, SNFactory) will probably not do the job before LSST.

-> LSST follow-up : photometric ? spectroscopic ?

Study -> White book "LSST nearby SN Ia"
-> z < 0.05, 0.1, 0.2
-> optimisation of distance measurements
-> possible setup

Thank you for your attention