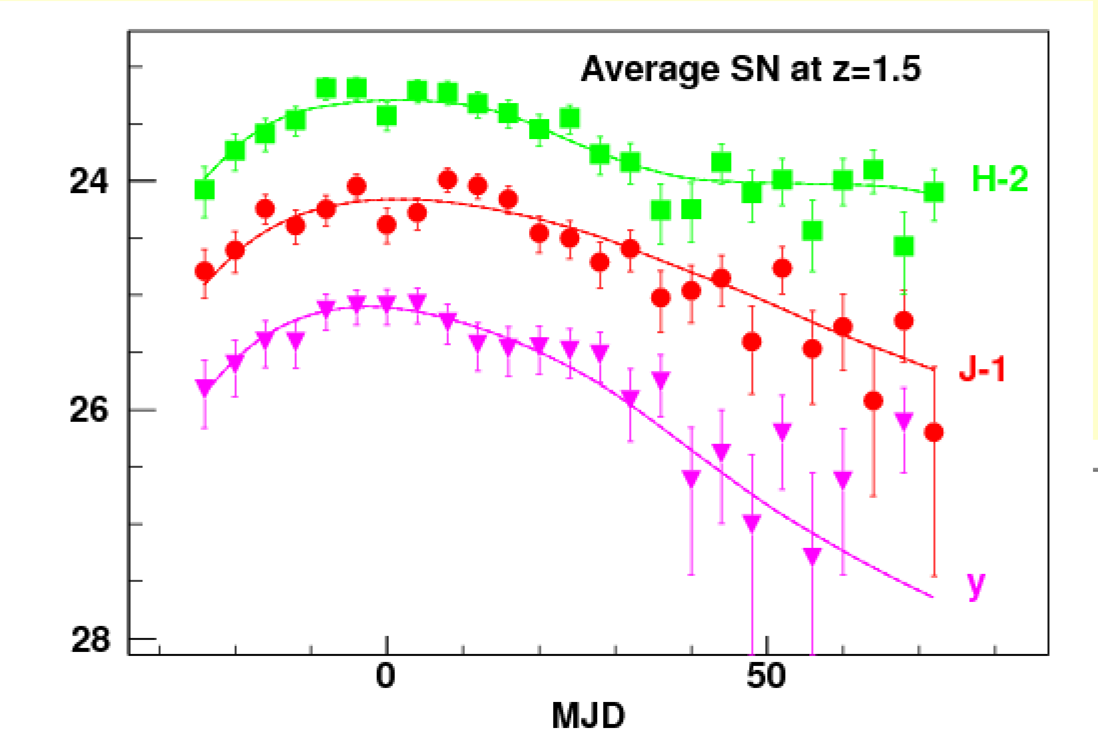
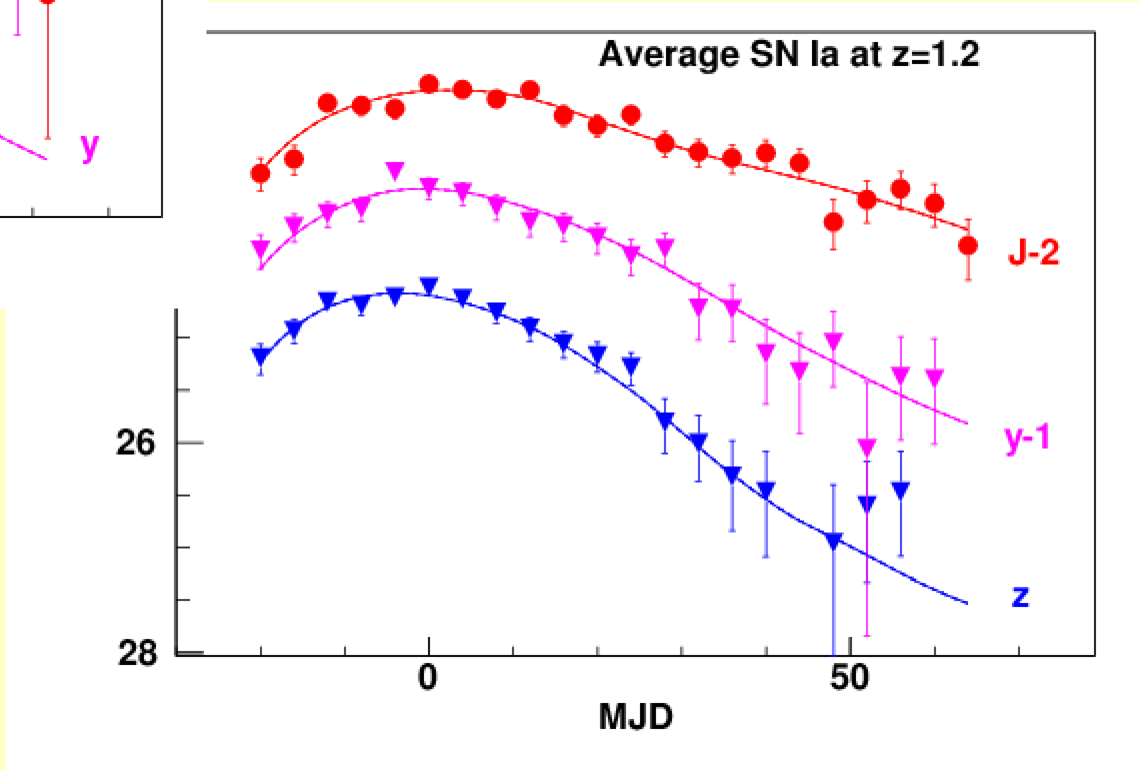
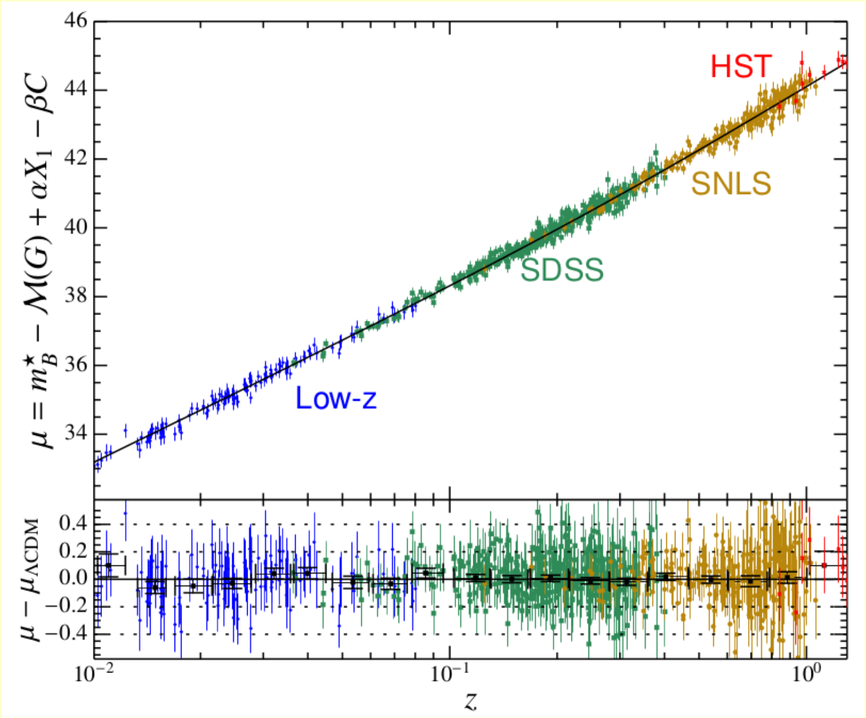
Supernova distances with LSST and Euclid

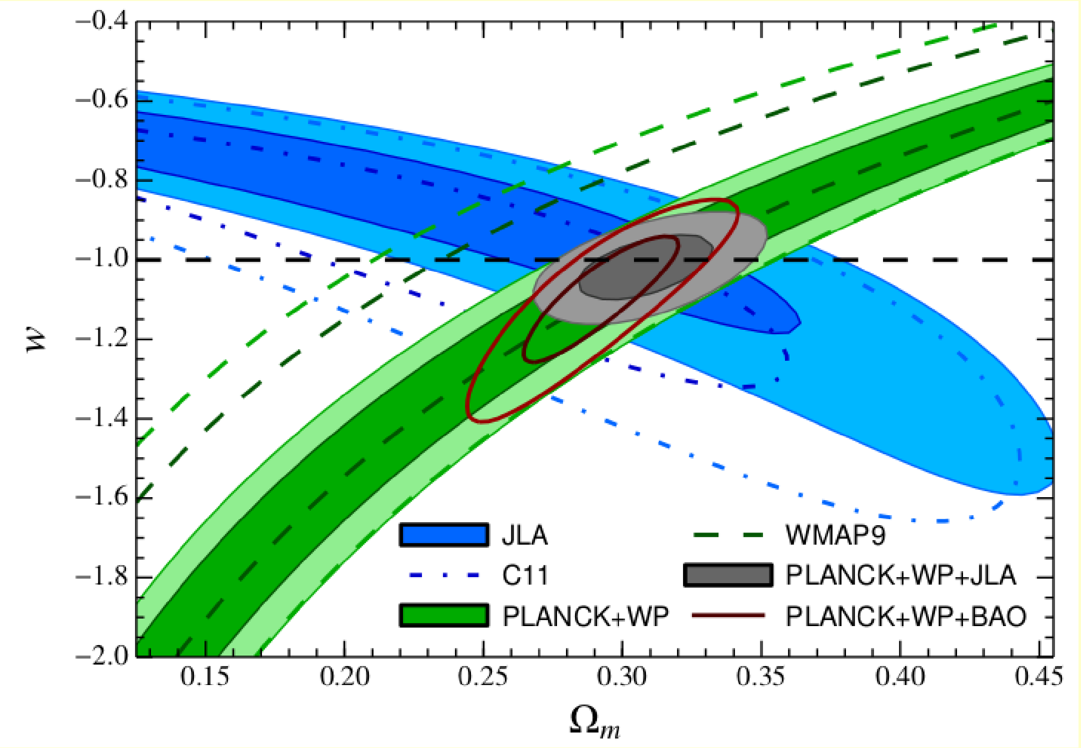




Pierre Astier
(LPNHE)

Supernovae : present and near future





- More than 700 events
- ΛCDM is a fair description of data

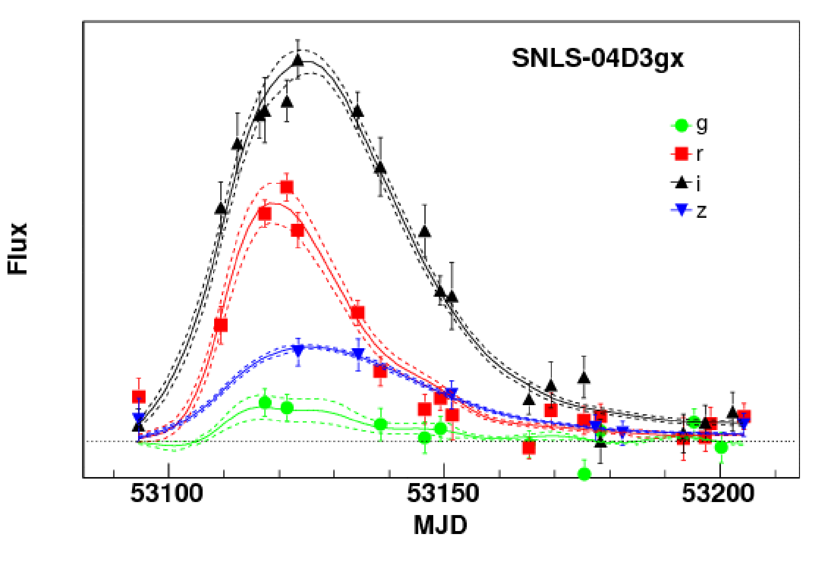
Contours with systematics :
Planck+SN : w = -1.018 +/- 0.057

From now to 2020: DES
- 2000-4000 events
- z<~ 1

Betoule et al (2014)

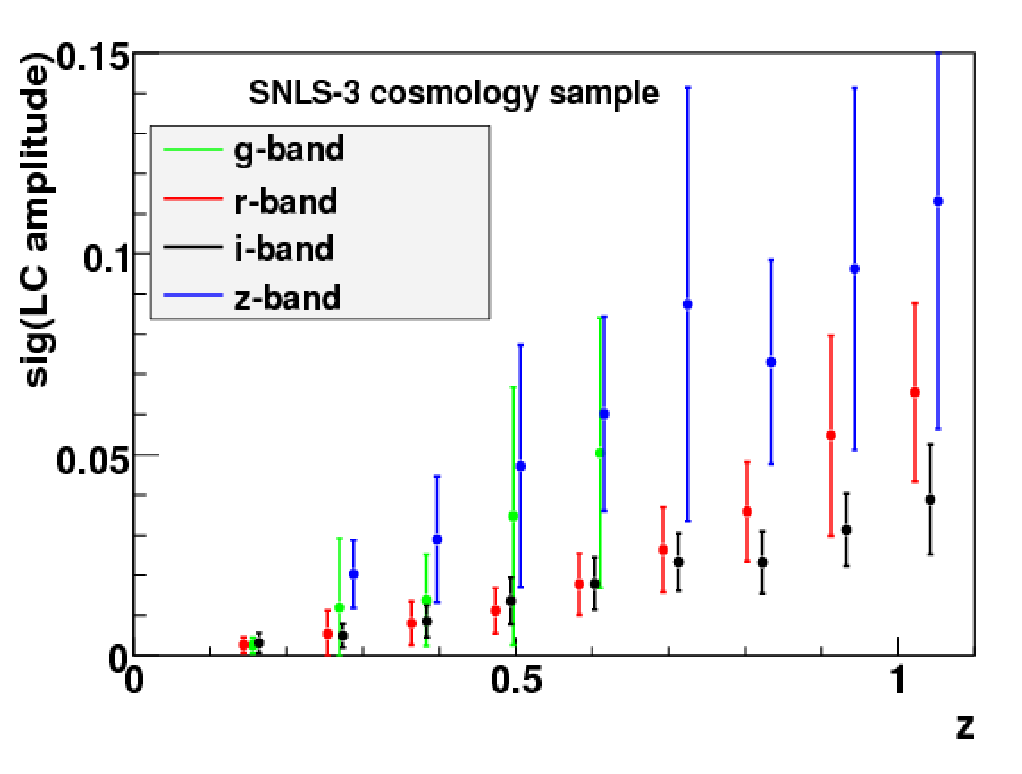
P. Astier . LSST.fr (2014)

Photometric quality for distances



Distance indicator
- directly
- via colour

SNLS: amplitude precision per band



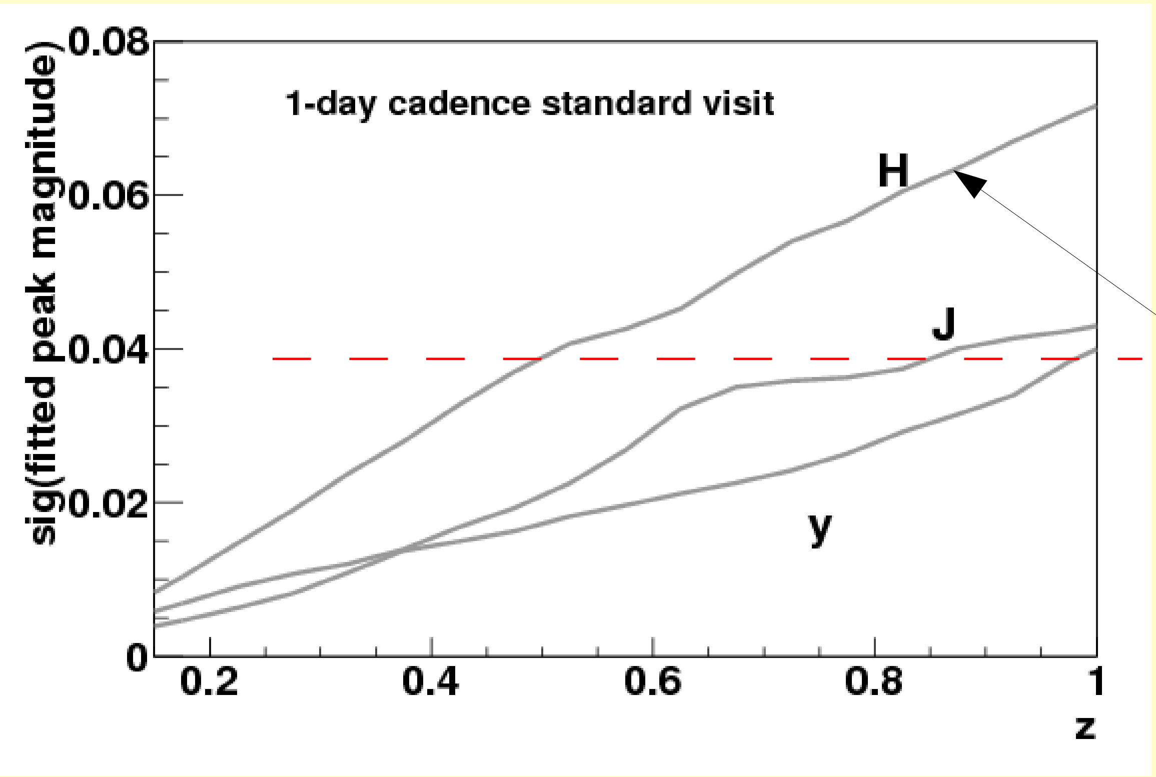
Photometric quality of distances (2)

- Measurement precision requirements
  - 3 bands
  - 2 bands at < 0.04, 1 band at < 0.06
  - $>$ colour to 0.03 mag
- Spectral coverage
  - Similar at all redshifts (minimal dependence to the SN model)
  - $\lambda_{mean} > 3800$ nm for the bluest band

Photometric quality of distances (3)

- You can often read that LSST will discover 10^5-10^6 SNe
- Discovering is not measuring a distance.....
- Now, collecting more poorly measured distances is useless for cosmology.
- With the current observing plan in the LSST wide survey, there are essentially no usable SNe light curves for distances.
- But the cadence in the wide survey does not have to be even over 10 years, within the same total allocation.

Standard Euclid visits?



Standard visit:

m_{AB}=24 (5 σ point source)

This is the one that matters.
at the highest z.

Assume one visit a day and per pointing:

- 10 deg^2 (full time).
- z<1 (in fact z<0.4 ou 0.8)
- 180 visits (= 6 months full time)

→ 500 SNe (z<1) → not interesting

The SN project for 2020+

- A lot : O(10000) events. Well measured !
- Z max : as large as possible (aim at z>1)

  → IR imaging, faint objects

  → Space.

- Photometric quality : at least as good as SNLS : resolution of 0.03 (integrated per band)
- Similar (restframe) bands at all z.

Redshift slices

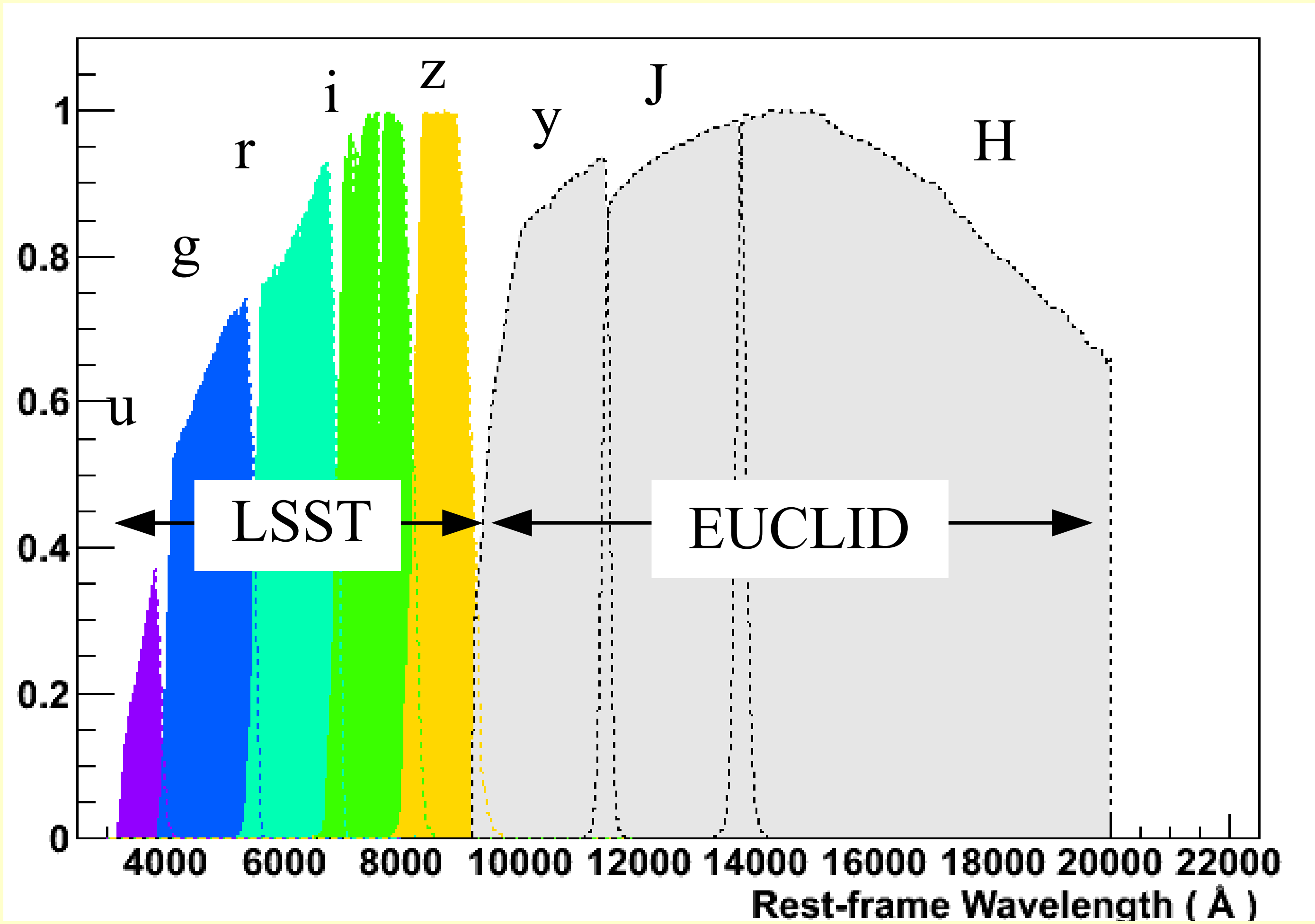
Low z : (u) gri (z) bands → $z<0.35$
Ground

Mid z : griz bands → $z<0.95$
Ground

High z : i z y J H bands
$0.75<z<1.5$
Ground +Euclid.

Ground = LSST
LSST can do the low z part, thanks to its fast read out.
LSST already has the mid z part in its schedule (deep drilling fields)

LSST+Euclid : visible & IR photometry

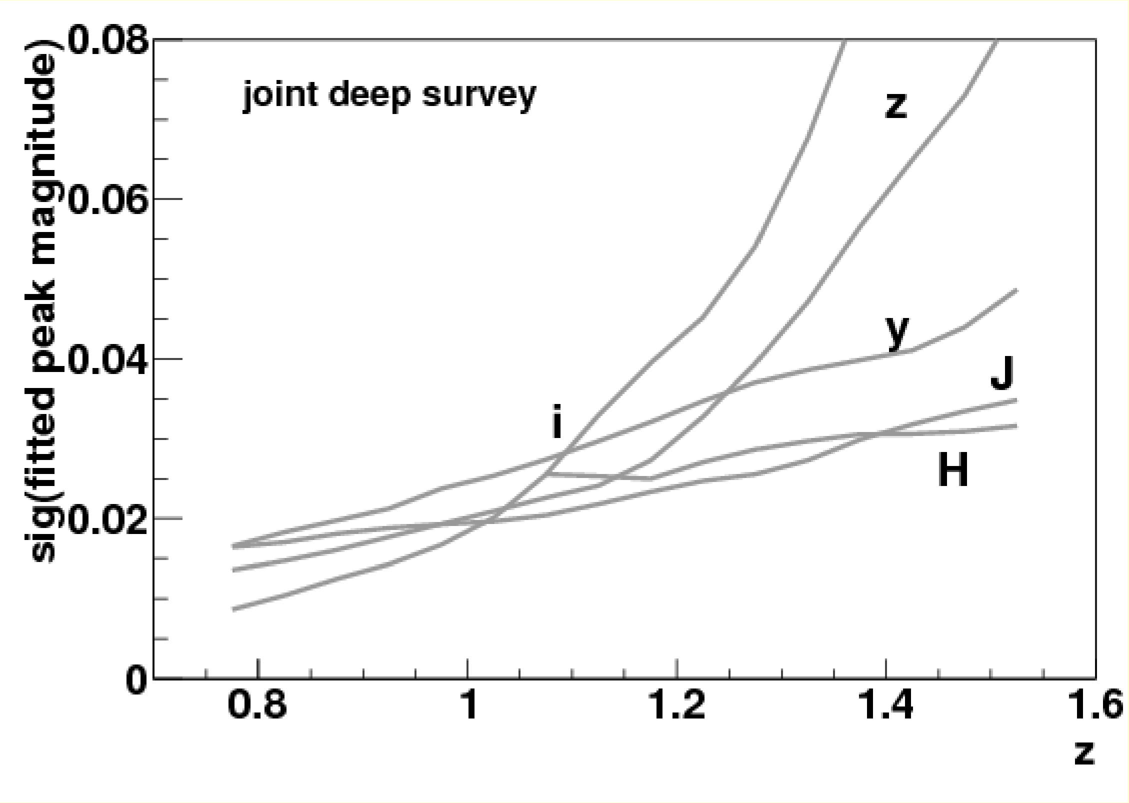


z<0.35

z<0.95

0.75<z<1.55

Getting distances to high-z events



Hypotheses :
Cadence = 4 jours
Survey LSST – Euclid

		m5	
LSST	i	26.05	700 s
LSST	z	25.65	1000 s
Euclid	Y	25.50	1200 s
Euclid	J	25.85	2100 s
Euclid	H	26.05	2100 s

- The wavelength cvoerage is widder than the redshift range
  i at z=0.8 → 420 nm
  H at z=1.5 → 660 nm

How much time on Euclid

Working hypothesis : 6 months (dedicated).

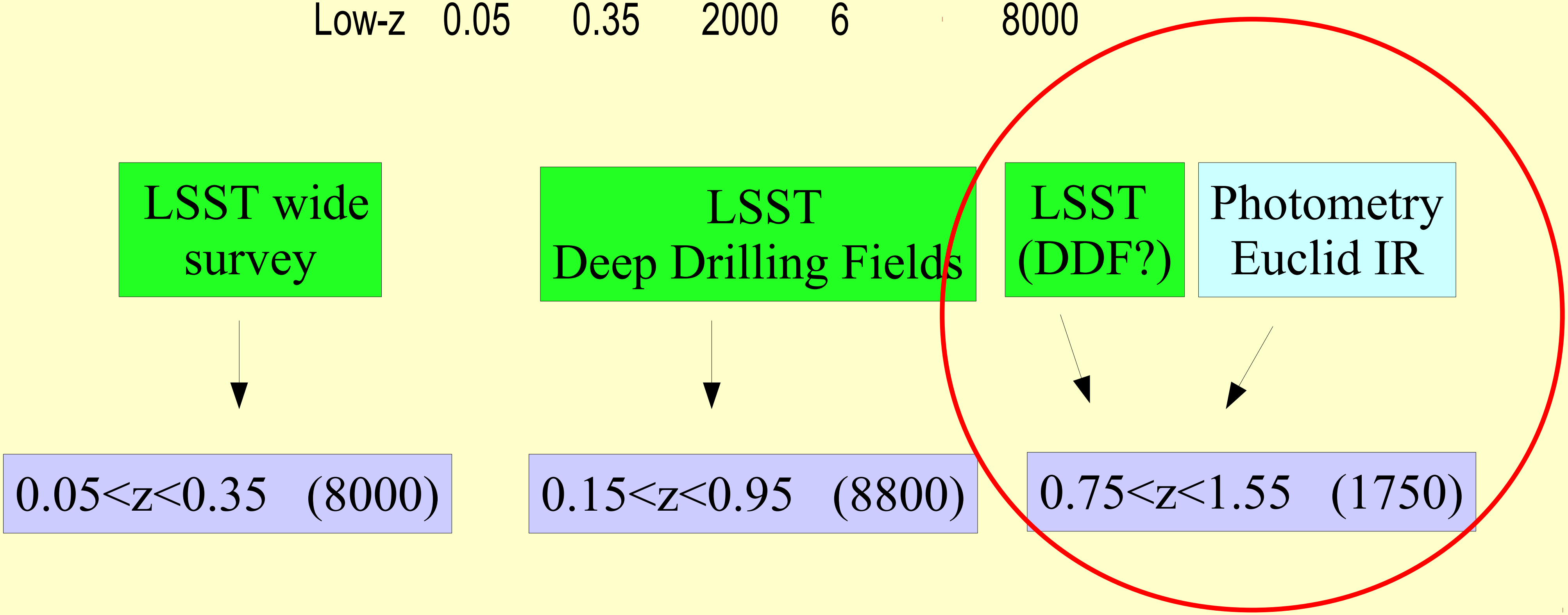
→ 20 pointings = 10 deg^2

→ imaged 2 times 6 months (half of the observing time)

→ 90 visits → final depth m >~28

Euclid & LSST

	z min	z max	area	duration	statistics
Hi-z	0.75	1.55	10	2x6	1740
Mid-z	0.15	0.95	50	18	8800
Low-z	0.05	0.35	2000	6	8000



Code name : DESIRE

Simulations and cosmological constraints

Astier, Guy, Pain, Balland (2010)

Uncertainty sources :

- Shot noise (sky plus object)
- Statistical uncertainty of the SN model
- Calibration systematic uncertainty (0.01)
  - Direct
  - Through the SN model training
- Colour smearing of SNe : amplitudes fluctuate by 0.025.
- Intrinsic scatter : 0.12 (beyond colour smearing).
  $\rightarrow$ 0.15 at best.
- Systematic distance error (correlated at all z)

- Current state of the art : no wild extrapolation

Results

Summary :

	z min	z max	area	duration	statistics
Hi-z	0.75	1.55	20	6	1740
Mid-z	0.15	0.95	50	18	8800
Low-z	0.05	0.35	2000	6	8000

Redshift limited surveys!

Cosmological constraints with R measured to 0.36 % (Planck) + flat universe

	sig(w_0)	sig(w_a)	FOM
3 surveys	0.022	0.25	203
low+mid	0.028	0.31	137
mid+high	0.031	0.40	82

- Euclid's contribution (hi-z) is important but it does not dominate.

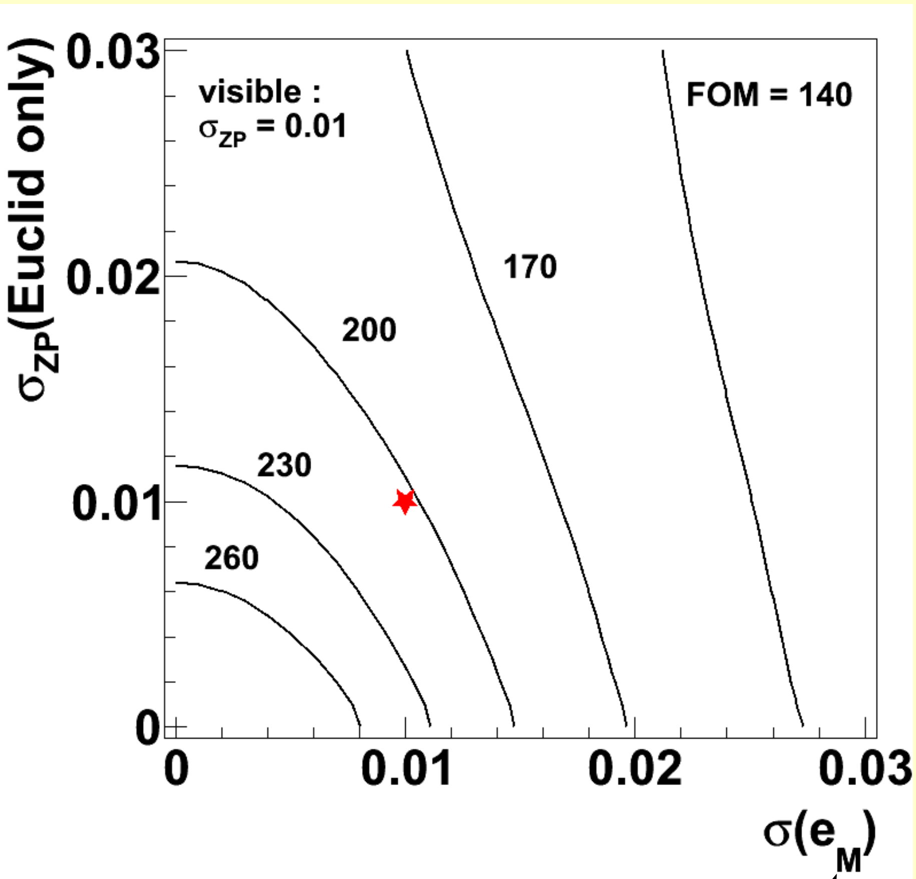
Redshifts

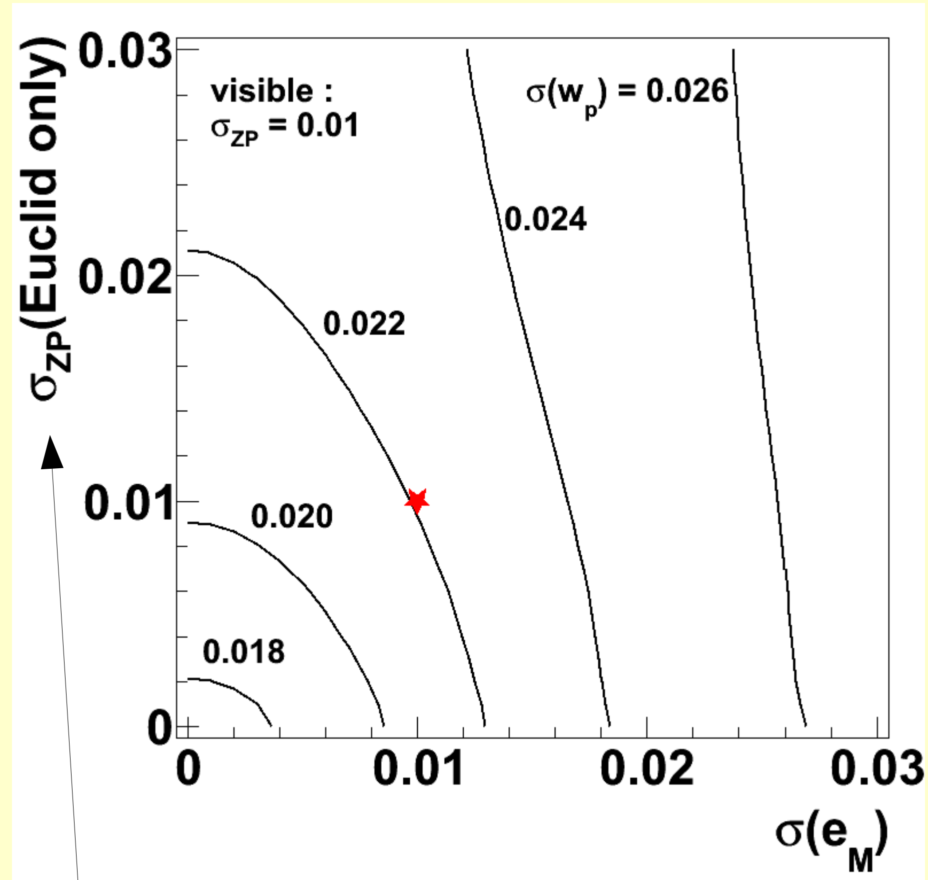
Get the host redshifts with a (fiber-fed) MOS
(Lidman et al 2012) e.g. 4Most, DESI
A few pointing , integrations of 100 -1000 ks

Contamination

Clipping outliers in the Hubble diagram seems to work
(e.g. P.A. et al 2011)
Light curve shapes and colours are a bonus.

Varying hypotheses





FOM

$\sigma(w_p)$

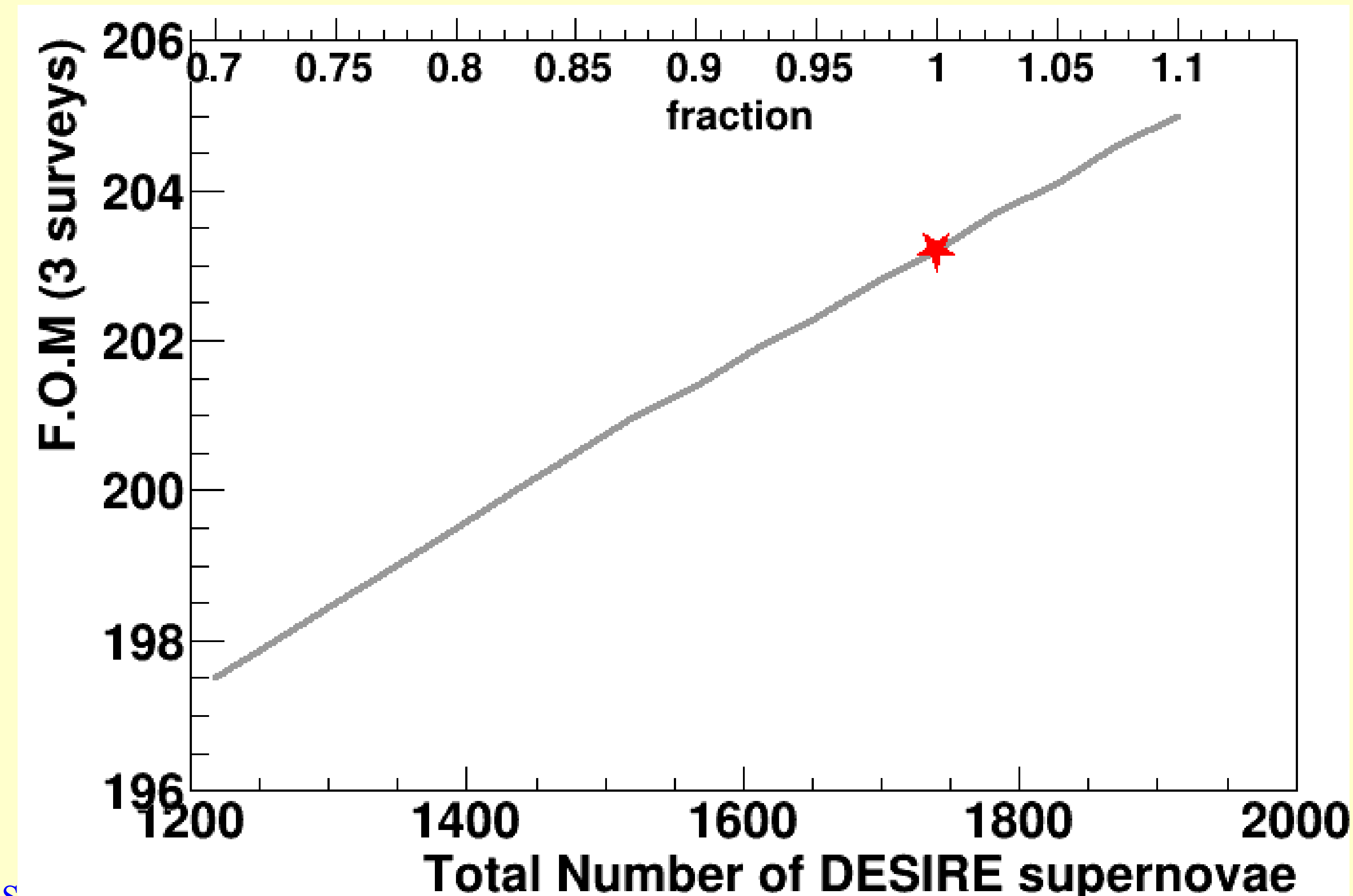
NIR ZP accuracy

Irreducible distance error

P. Astier . LSST.fr (2014)

Varying hypotheses

Number of high-z events



Project status

- This is the SN-cosmology project in Euclid.
- It depends on the observing time on Euclid being allocated. We are said that this should happen in 2015. I understand “not before 2015”.
- The project was adopted by the LSST and Euclid SN working groups.
- The outcome without Euclid is already interesting. It is much more interesting with Euclid.

Conclusions

- In the present landscape, we can sketch a compelling Hubble diagram of SNe Ia using LSST&Euclid.
  - Euclid alone cannot do much for distances to SNe
  - Euclid is the key to reach $z>1$.
- The combined performance is good, using current systematics
- A paper is submitted.