Cosmology with Type Ia supernovæ: environmental effects

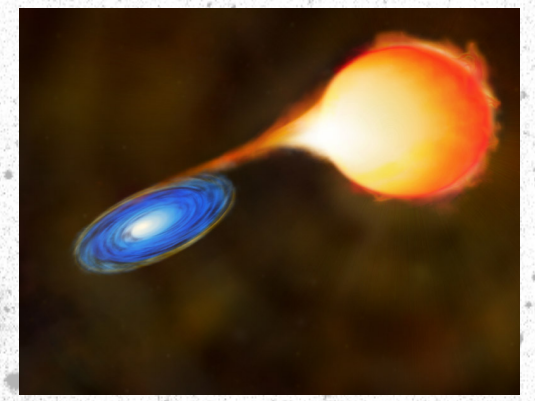
Matthieu Roman, Delphine Hardin, Marc Betoule

Standard candles

$$d_L(z) = (1+z)\frac{c}{H_0}\int dz \left(\Omega_m(1+z)^3 + \Omega_x \exp\left(\int_0^z dz' 3\frac{1+w(z')}{1+z'}\right)\right)^{-1/2}$$

Type Ia supernovæ

- ✓ Silicium features
- ✓ No helium, no hydrogen
- ✓ Single or double degenerate scenarios
- ✓ Rare: 1 per century per galaxy
- ✓ Short-lived: few months
- ✓ Luminous



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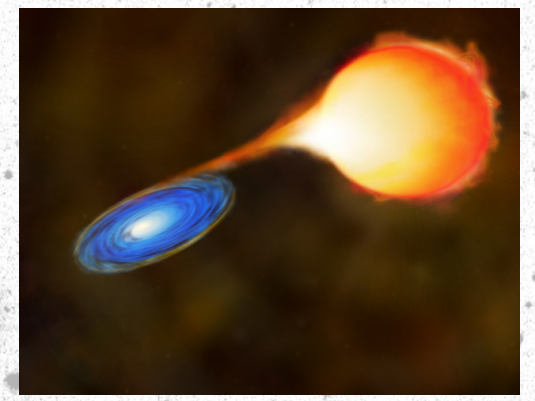
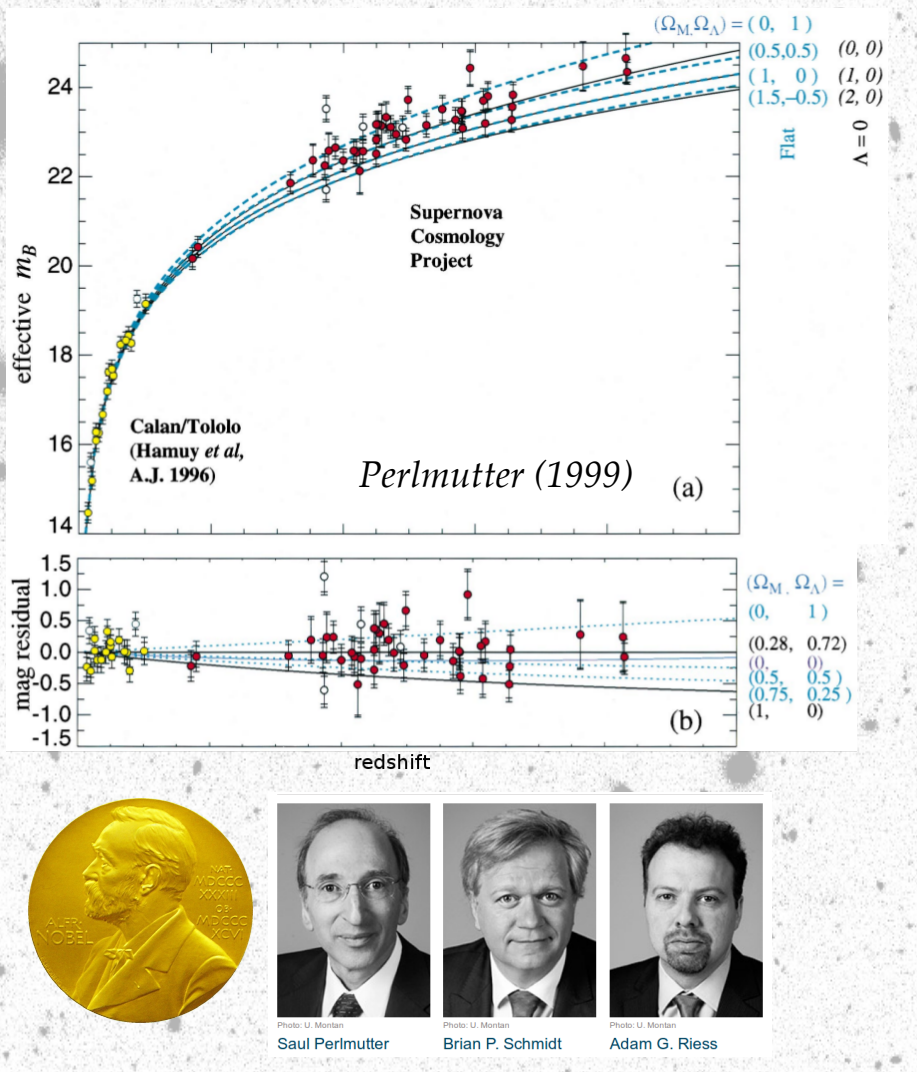
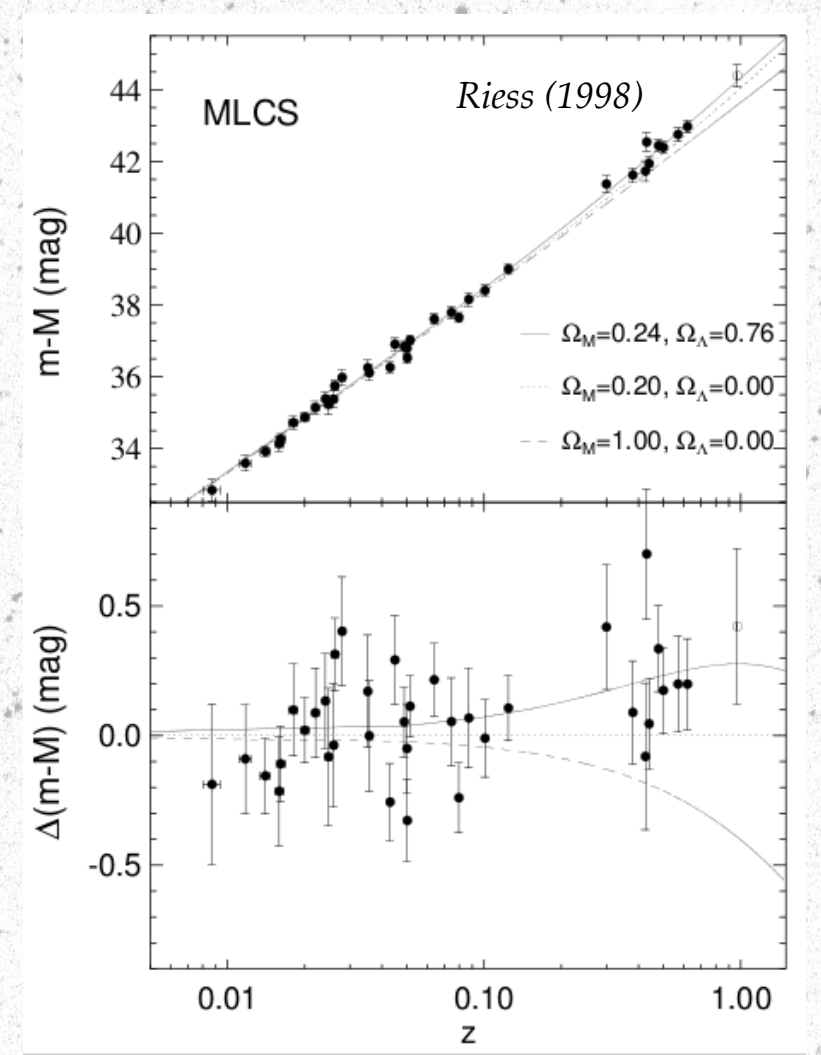


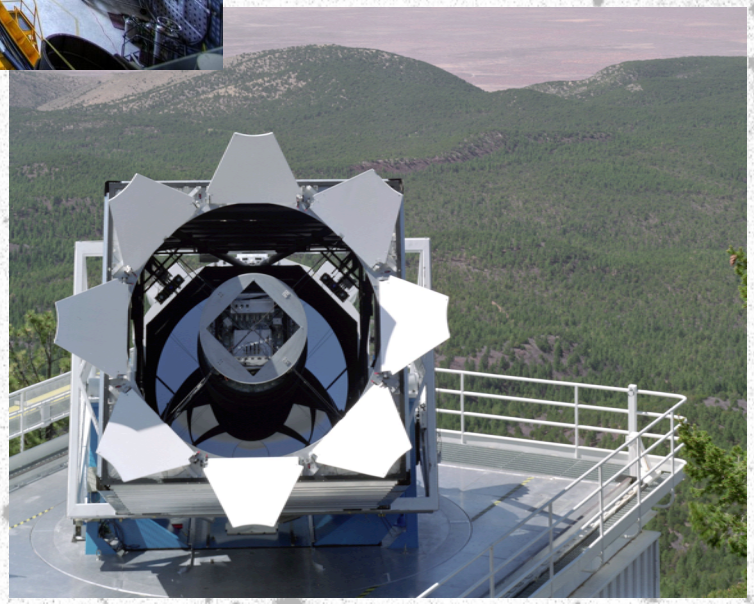
Flux measurement, calibration, unknown phenomenon, systematics

From SNIa to dark energy

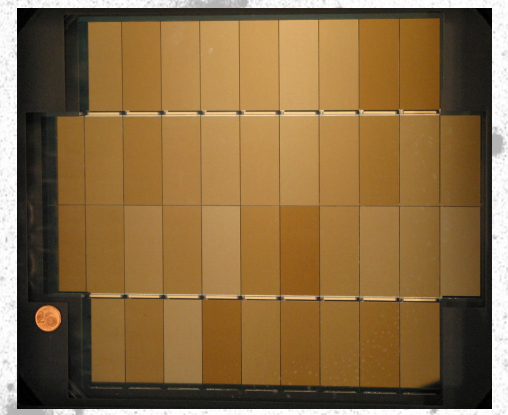




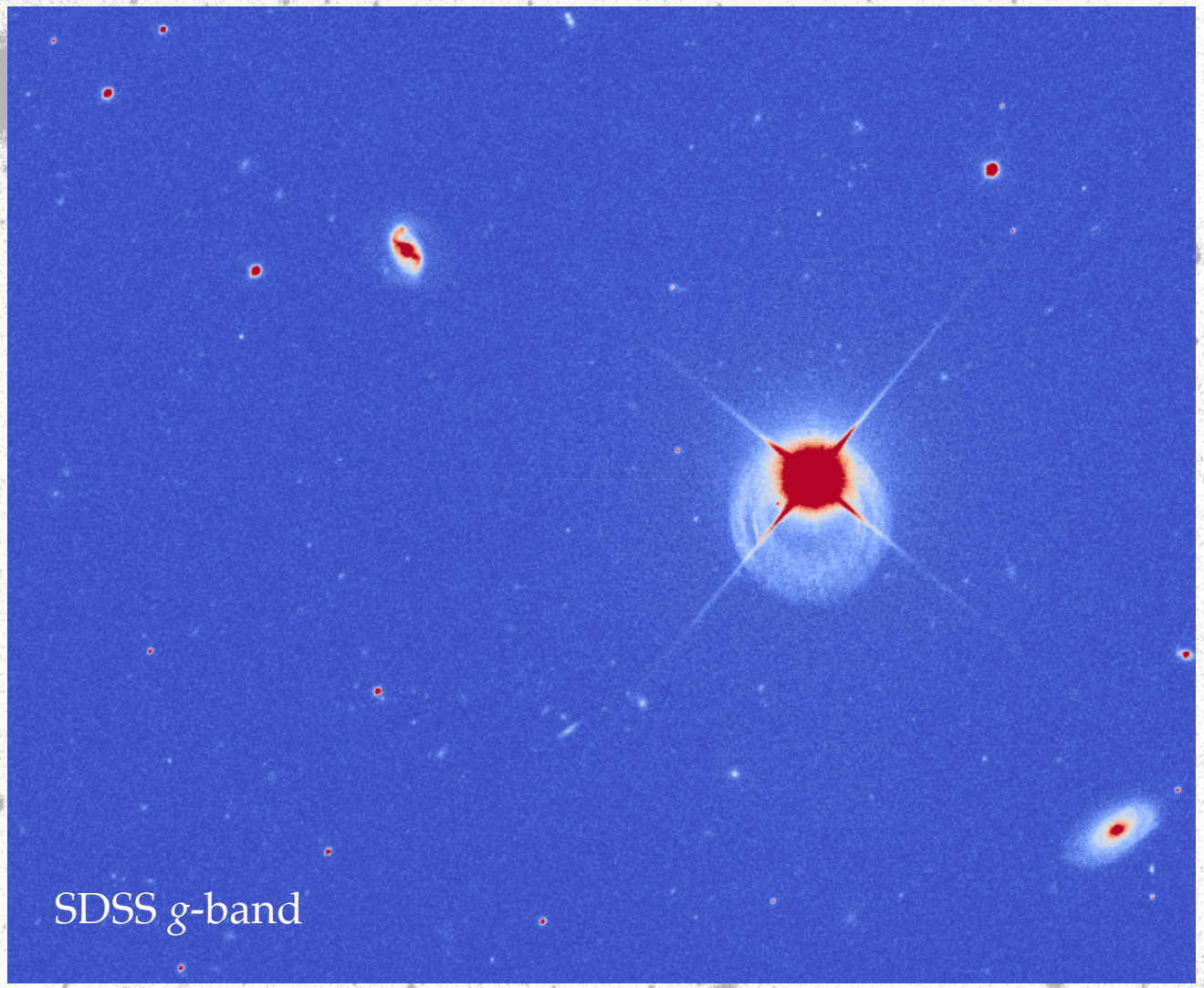
SNIa today



- Rolling search
- Matrices of CCDs
- SNLS
- SDSS



SNIa today



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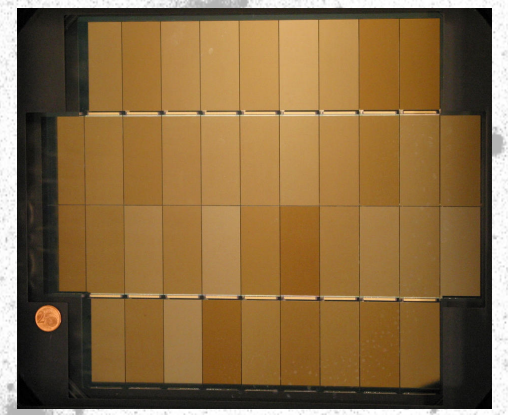

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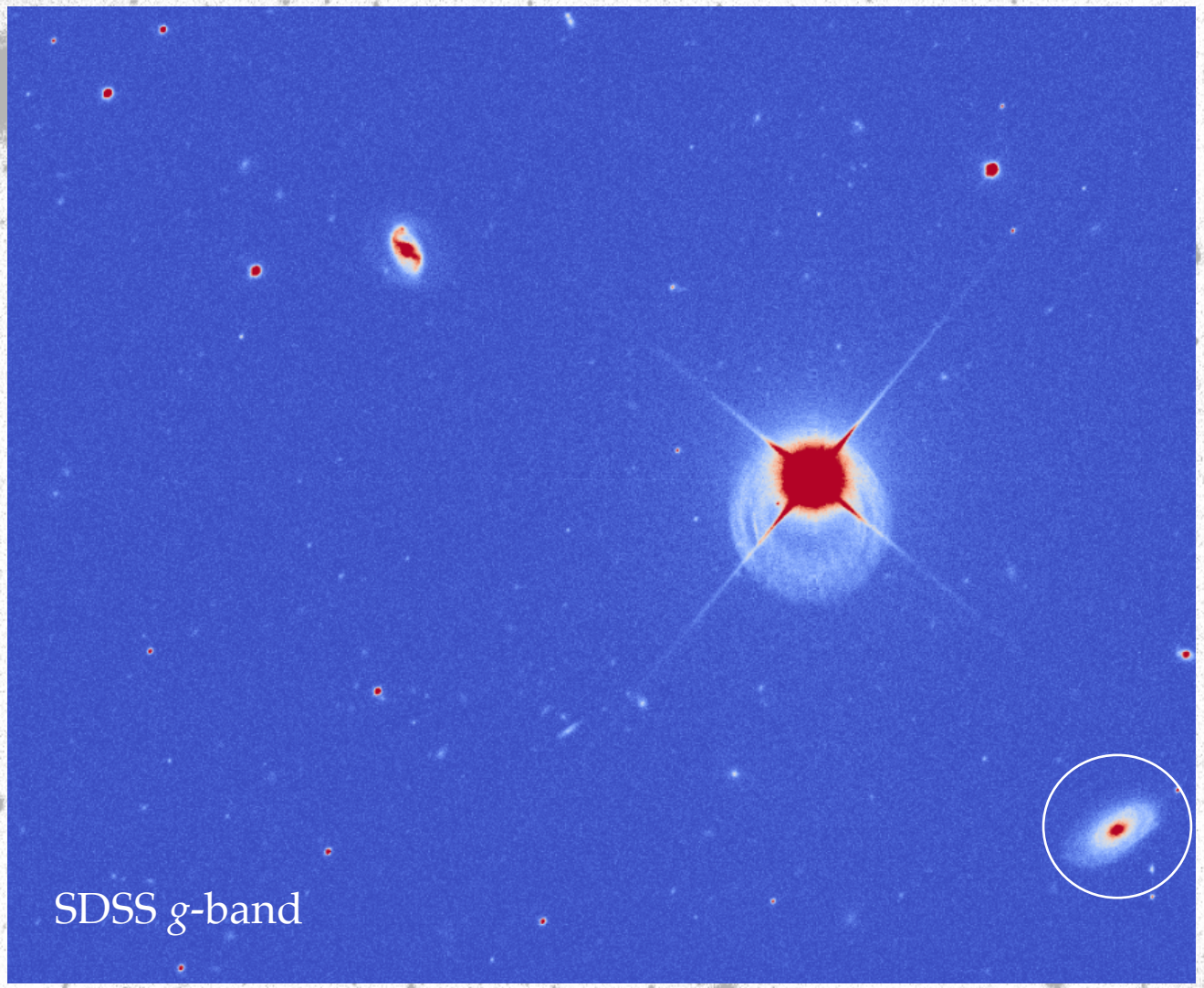

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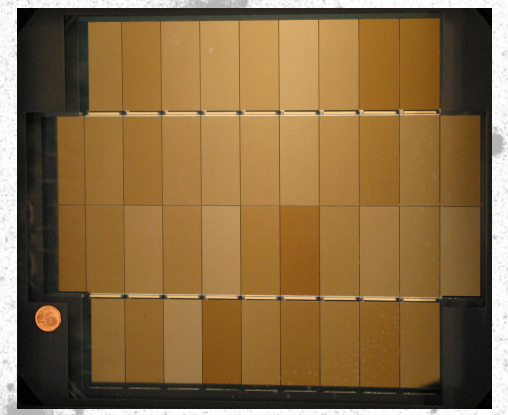

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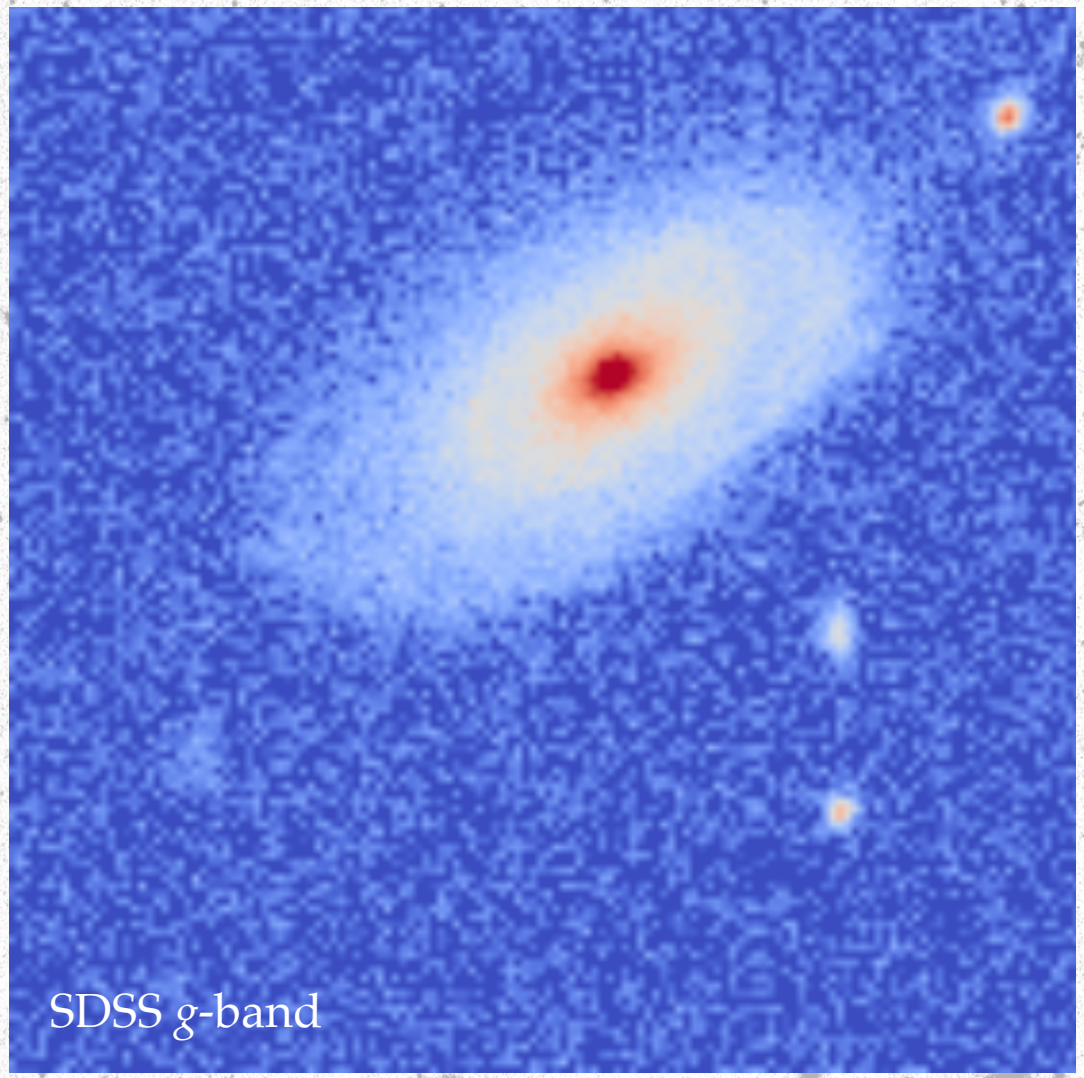

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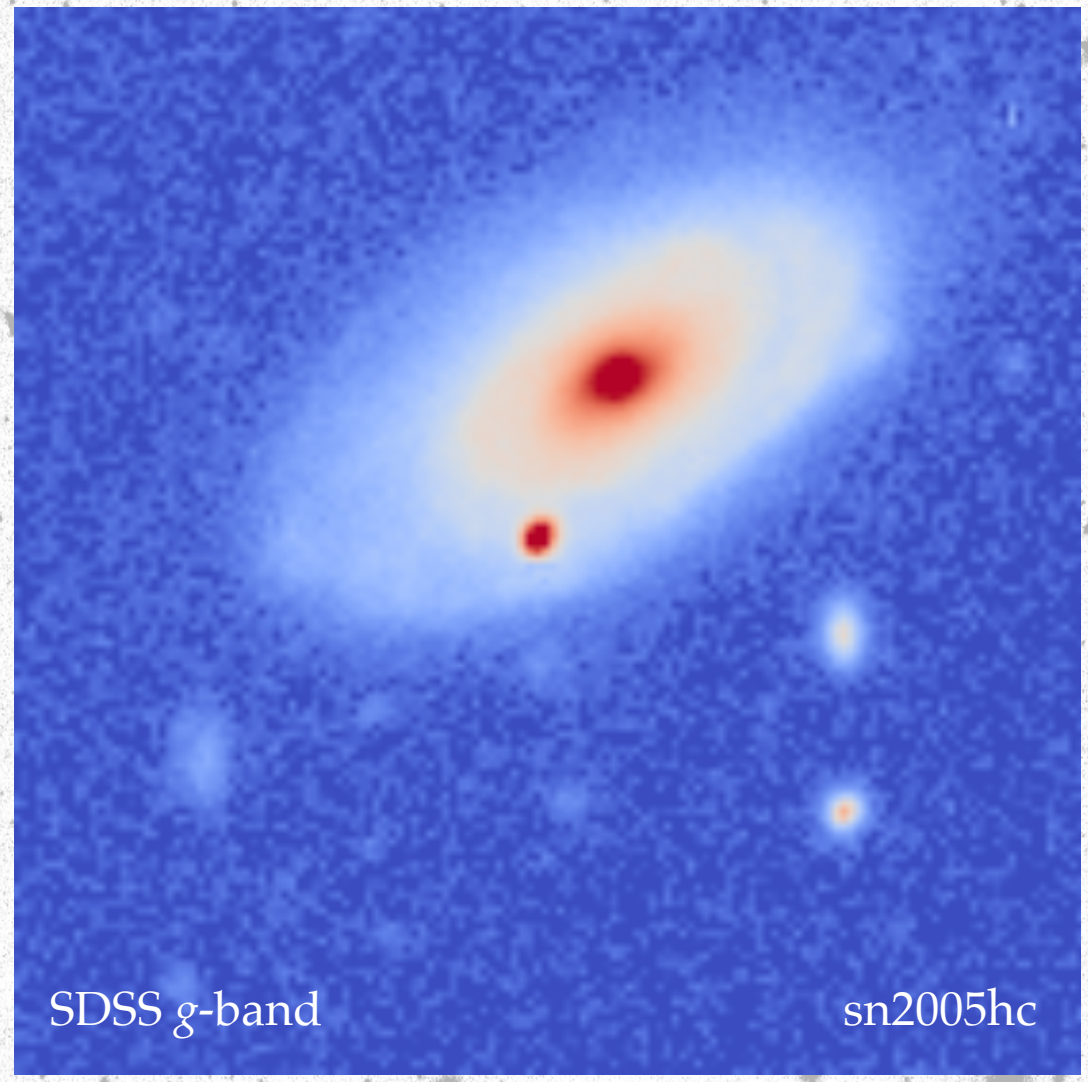
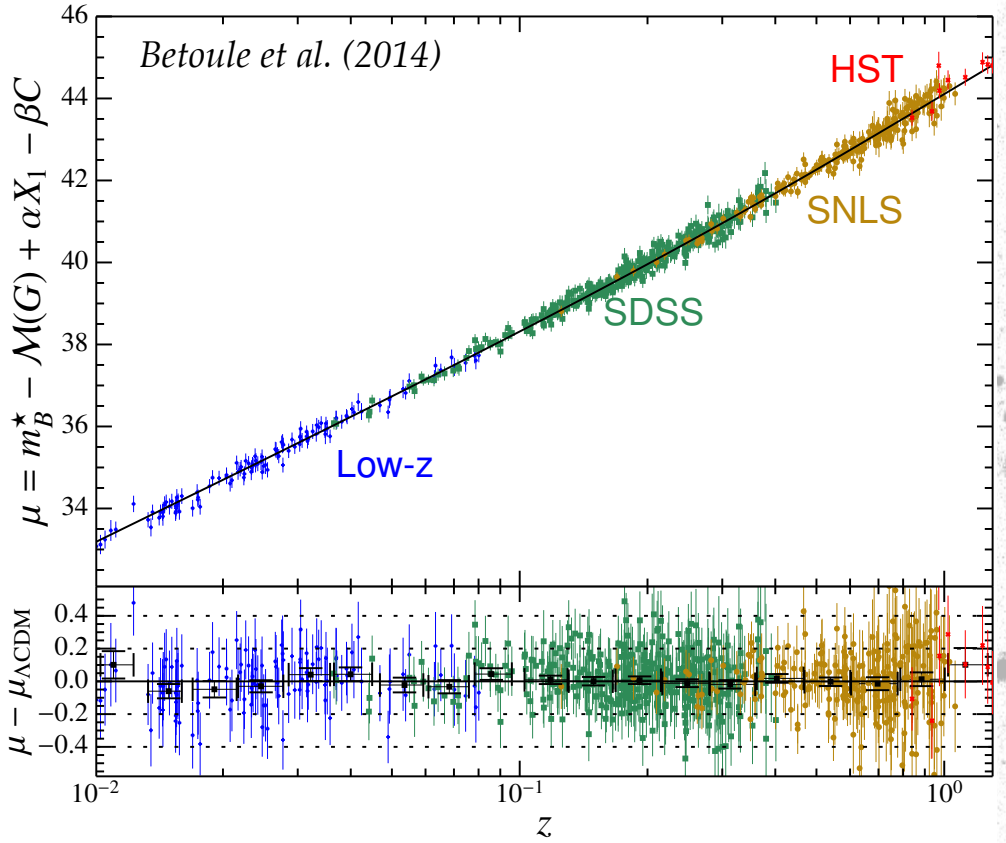


SNIa today

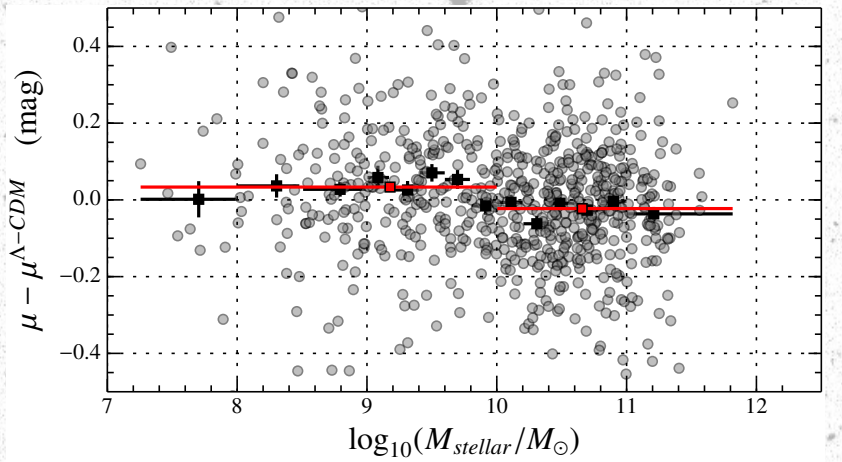
- Joint Light-curve Analysis (JLA)
- Improved calibration accuracy
- 0.15 mag dispersion
- 6% precision on w
- Going further in the standardization
  - SNIa environment
  - evolution



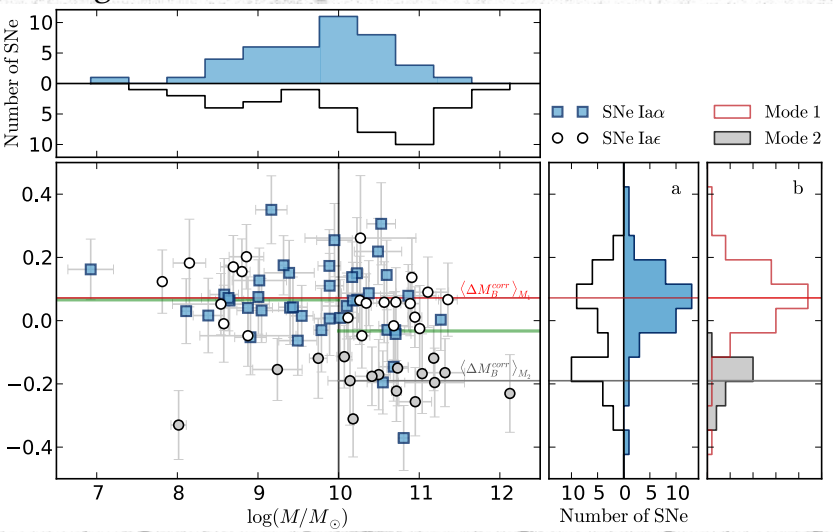
Global and local environment

- Stellar mass of the host galaxy
  - 5σ correlation with residuals
  - bimodality
- Local (1 kpc) H_α
  - traces stellar formation
  - can explain mass step

Betoule et al. (2014)

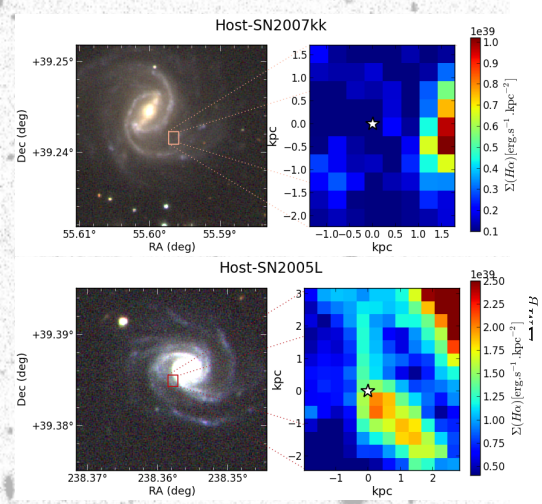


Rigault et al. (2013)

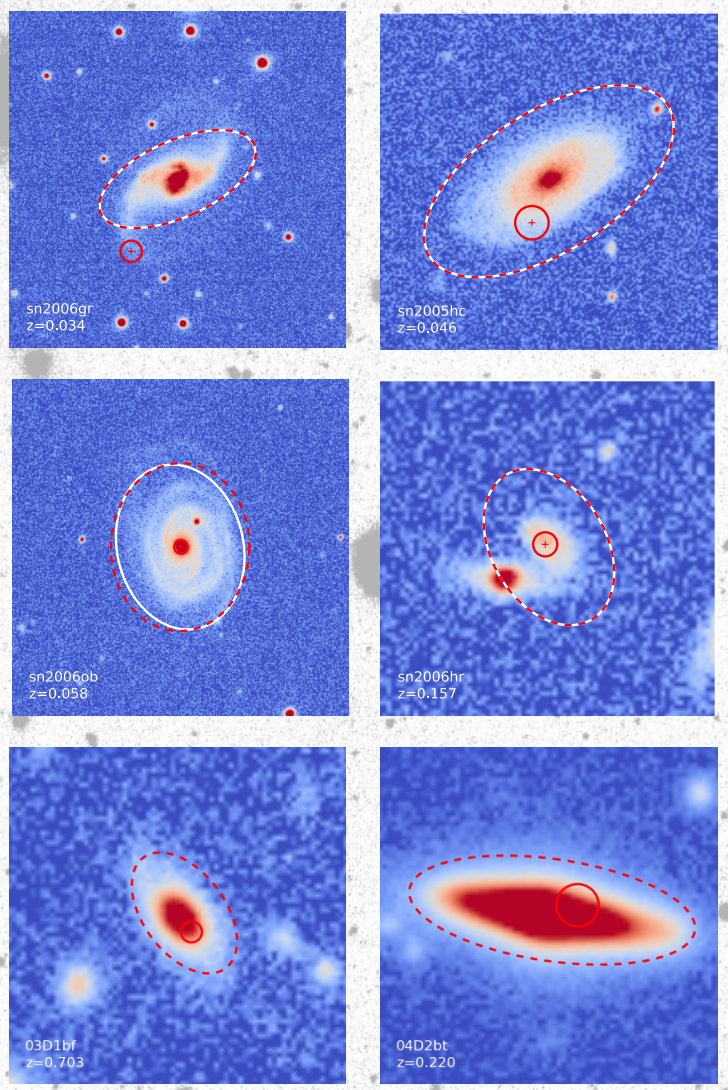


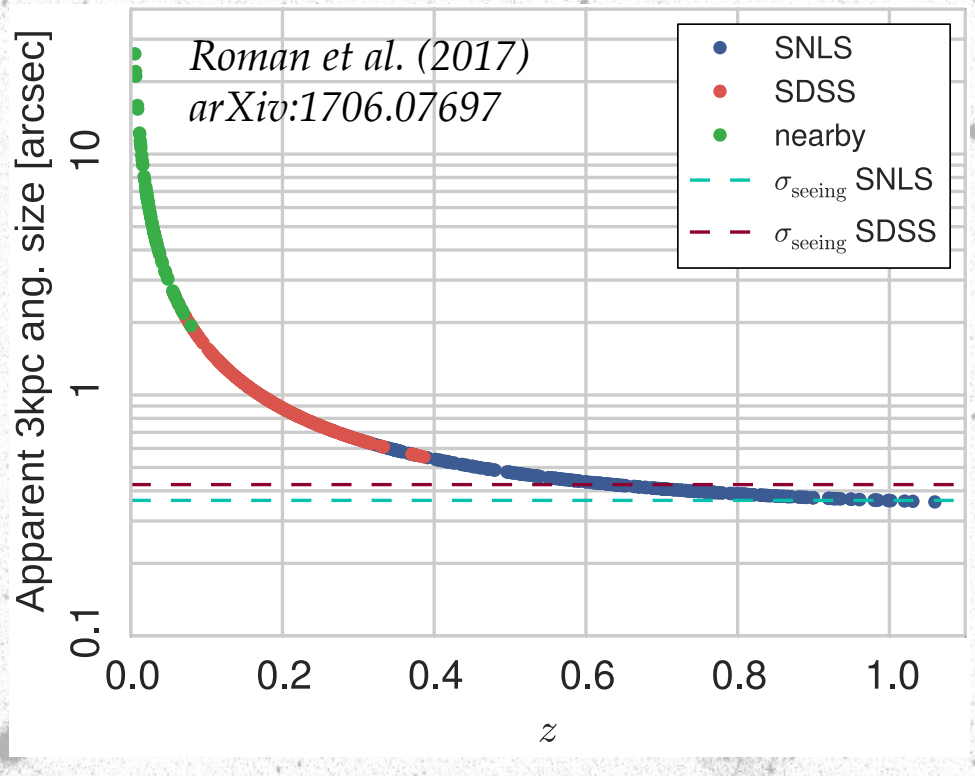
Supernova Factory
~60 low *z* SNIa

Rigault et al. (2013)



Local environment at ALL redshifts

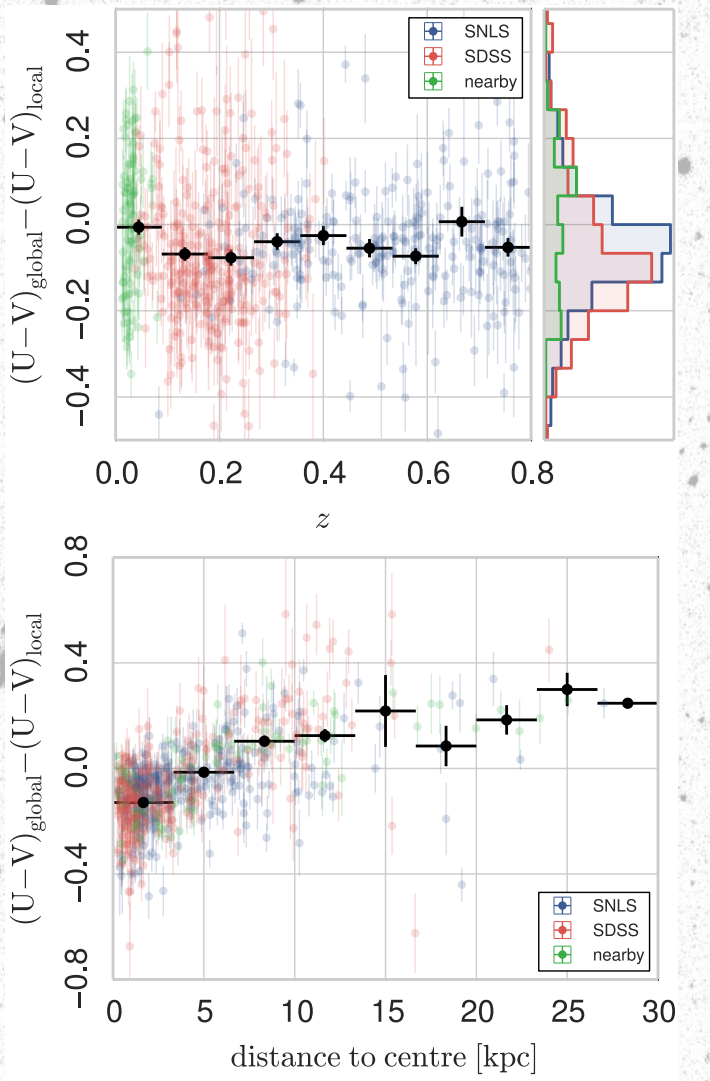




- Local and global photometry of 882 host galaxies of SNIa at ALL redshifts
- 3 kpc local radius
- rest-frame U-V colors by interpolating fluxes

Difference between global and local

- On average different than zero
  - changes with redshift
  - mostly comes from intermediate redshifts
- Link with distance to galactic centre
  - locally redder than host: close to centre
  - locally bluer: outskirst

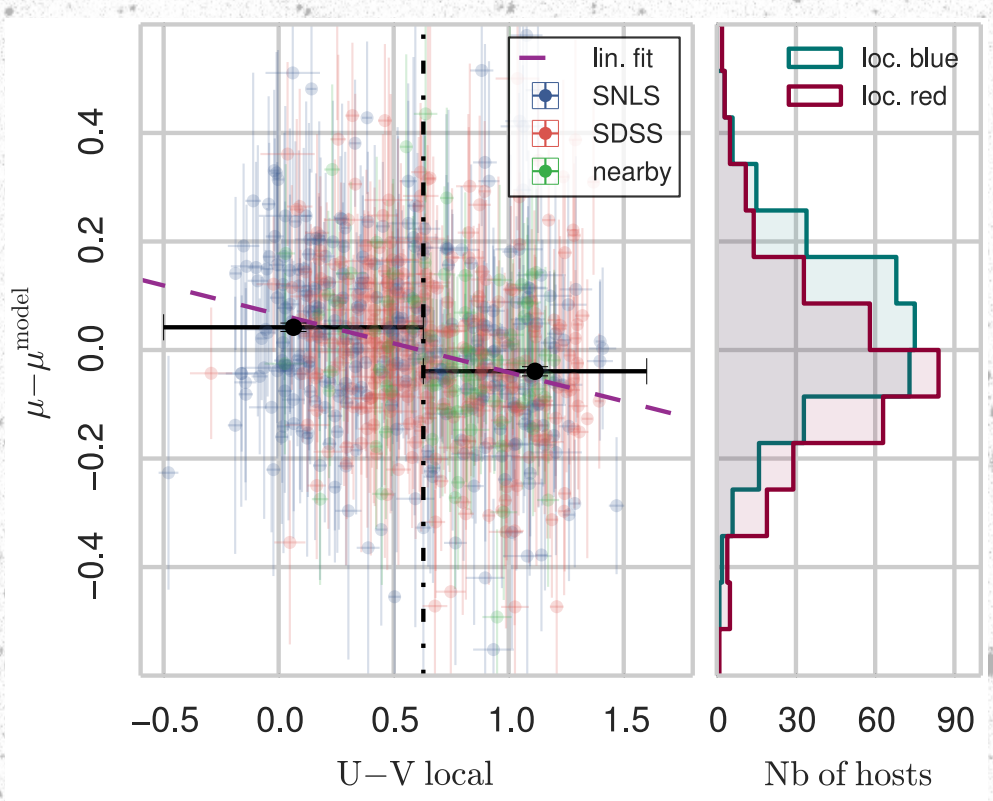


Roman et al. (2017)
arXiv:1706.07697

New standardization?

- Correlations with Hubble diagram residuals
  - bimodality
- Third standardization parameter
  - magnitude step of -0.091 ± 0.013 mag (7σ)
  - reduction of the dispersion: 0.14 mag
  - impact on dark energy: $\Delta w \sim 1\%$

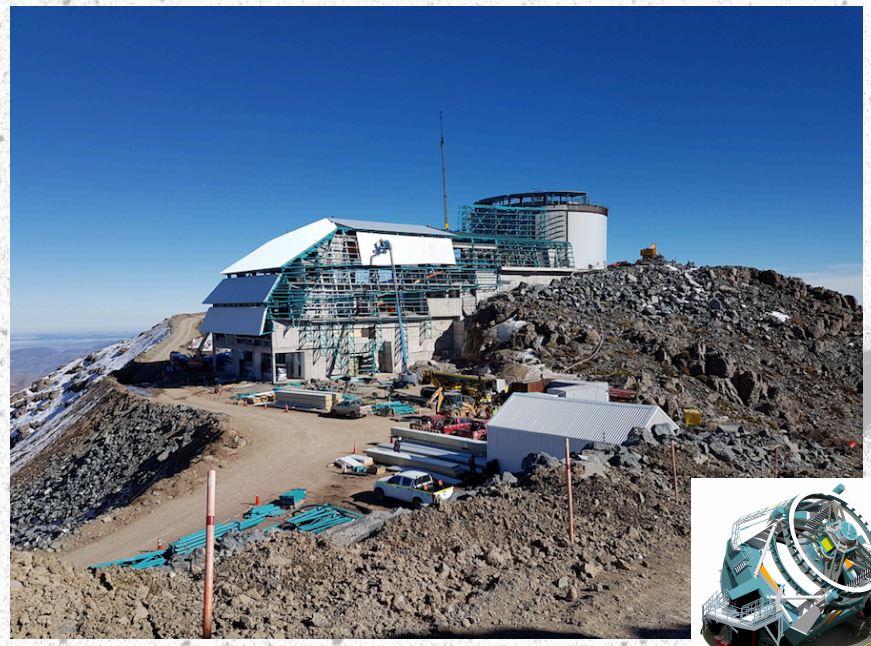
Roman et al. (2017)
arXiv:1706.07697



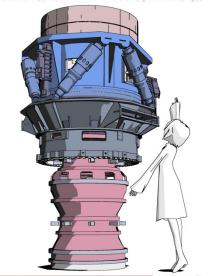
Perspectives

- Multiple surveys
- About 10^4 SNIa in 10 years
- Increasing analysis techniques
  - powerful probe of dark energy

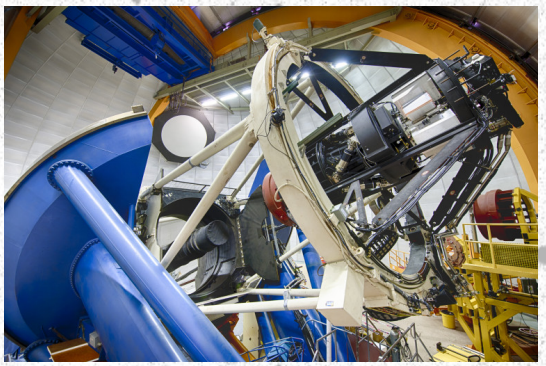
LSST



Subaru - HSC



Dark Energy Survey



ASAS SN

Pan-STARRS