Local environment of SNLS5 Type Ia supernovæ

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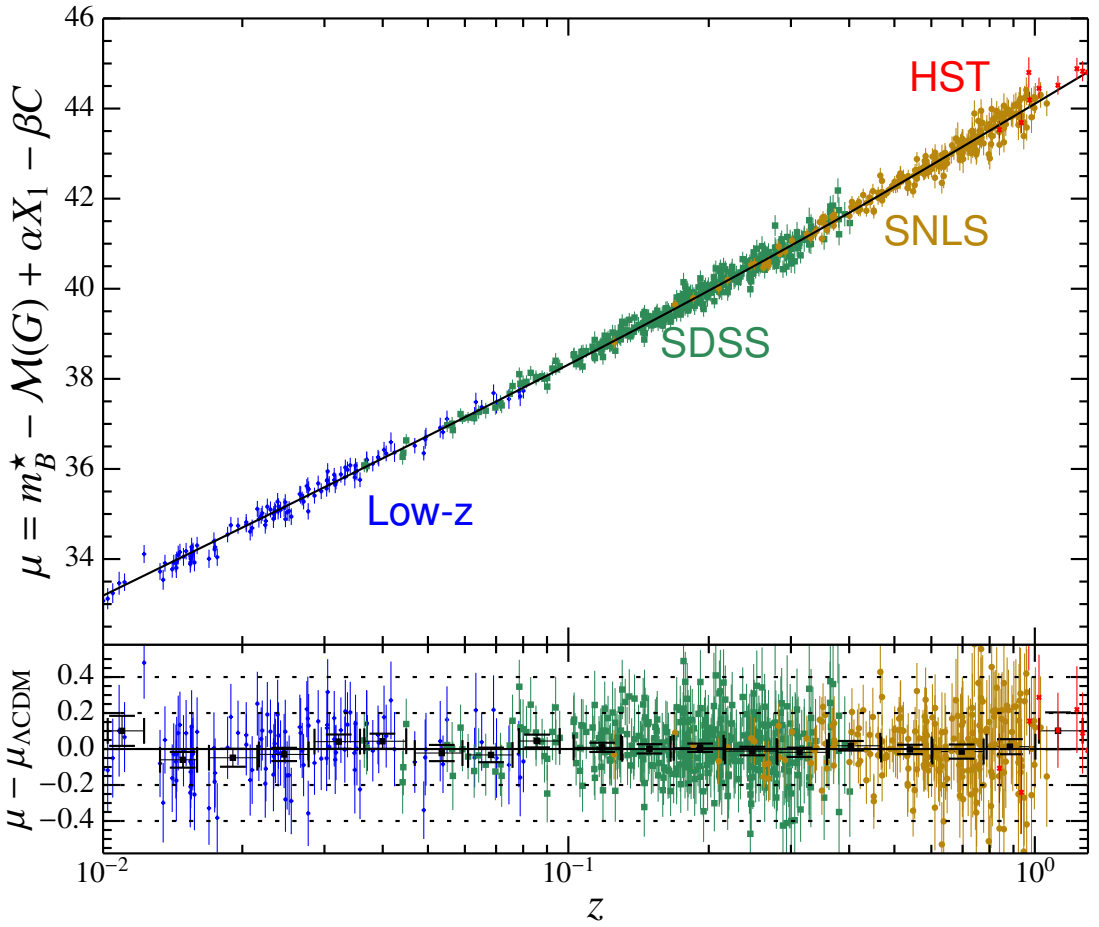
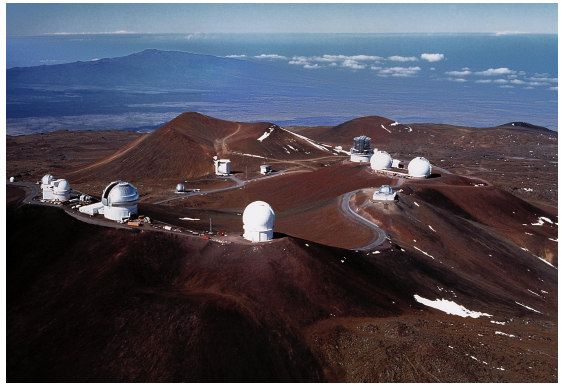
Joint Light-Curve Analysis (JLA)

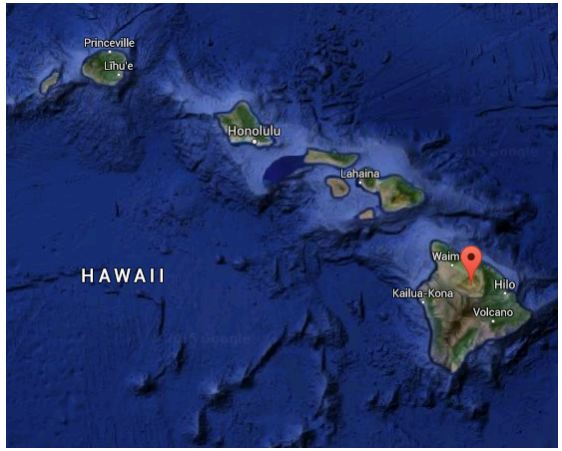
- Collaboration btw SNLS, SDSS and low-redshift surveys
  - improved calibration accuracy
  - statistic-limited Hubble diagram

Betoule et al. (2014)



SNLS 5: The Canada-France-Hawaï Telescope (CFHT) instrument





3.6m diameter
4200m high

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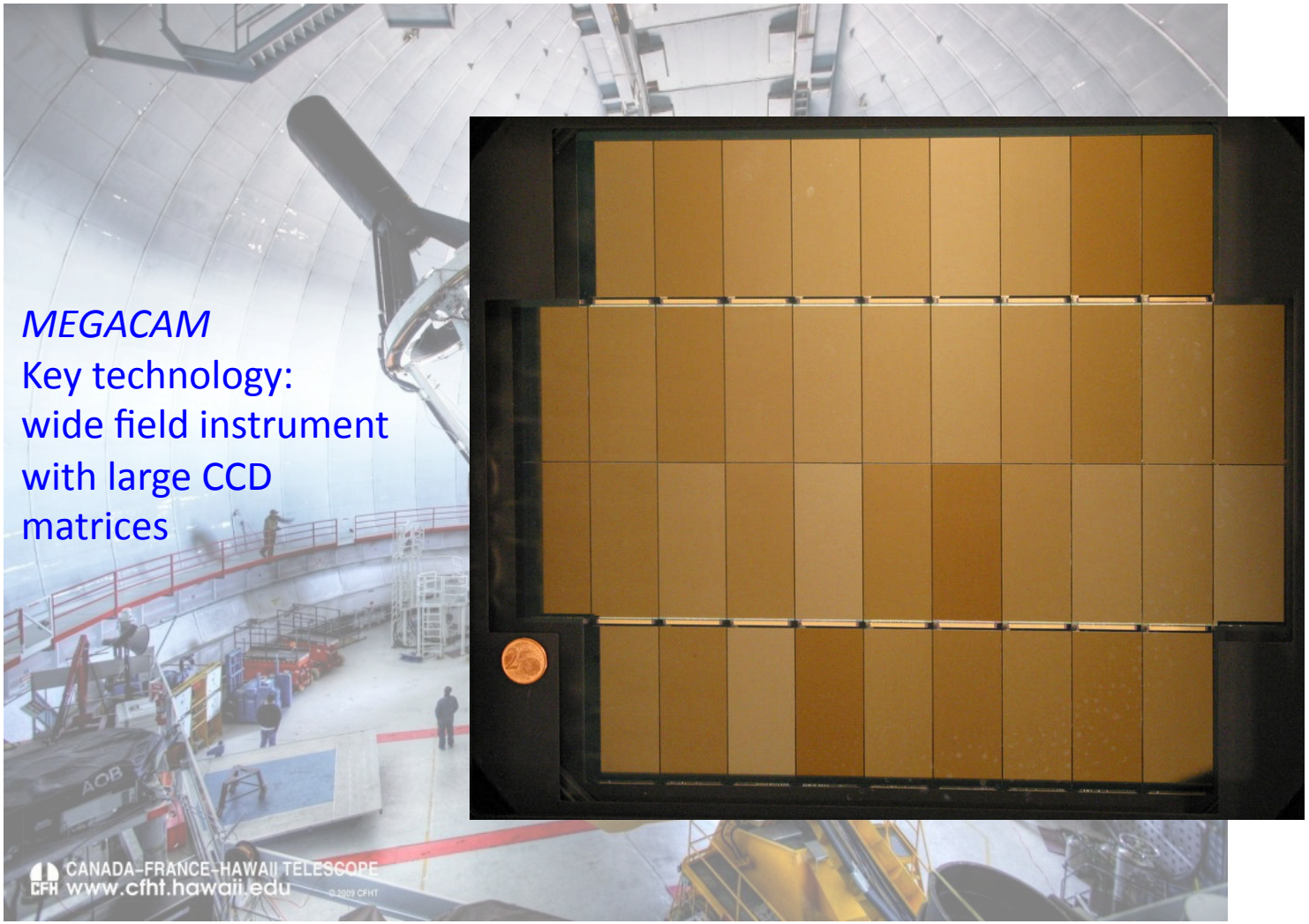
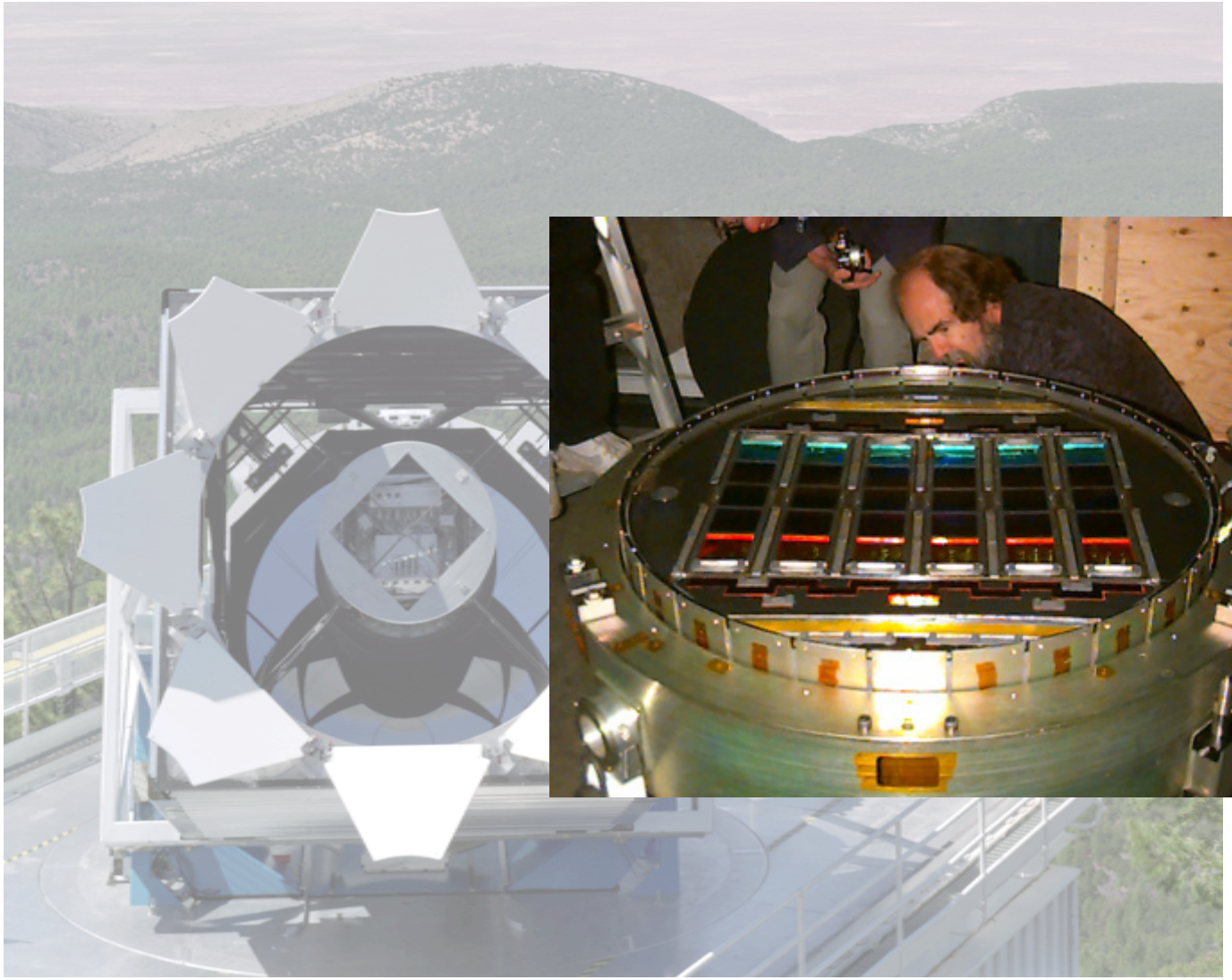


36 CCDs
340M pixels
fov 1 deg²
30s readout
1 star over 3pix

392 SNIa

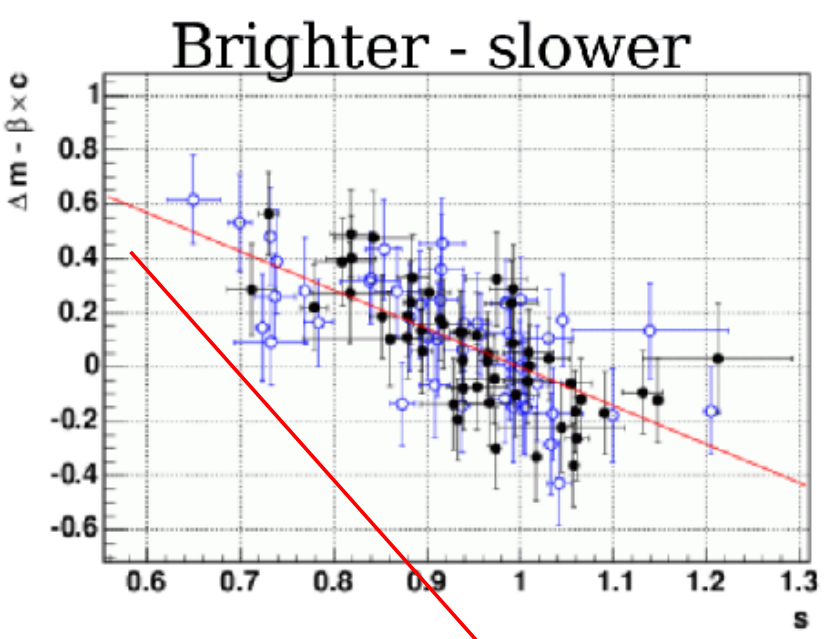
SNLS5: The SDSS instrument

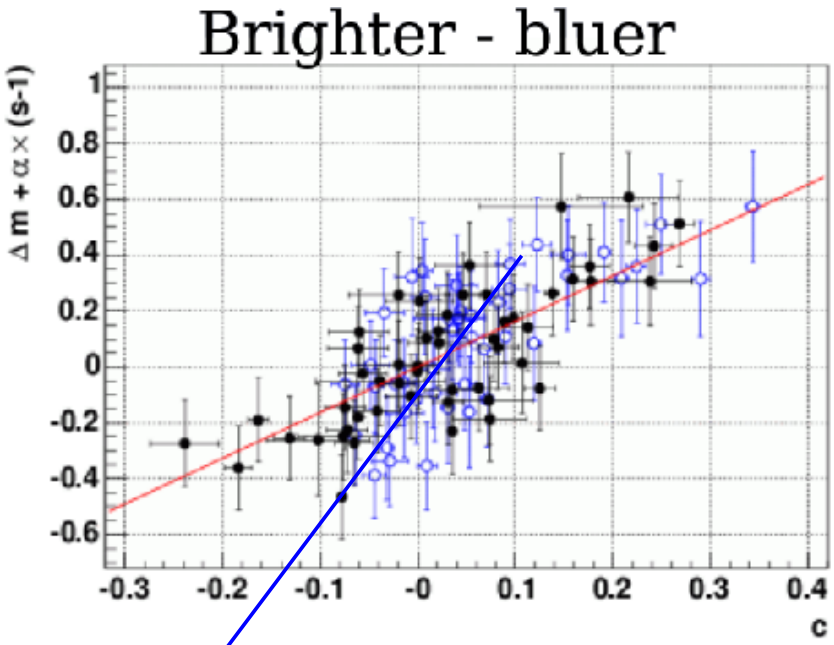


+ low-redshift SNIa

330
+137 SNIa

Standardization of the distance modulus





$$\mu_B = m_B^\star - \mathcal{M}_B + \alpha \times stretch - \beta \times color$$ + ??

El-Hage (2014)

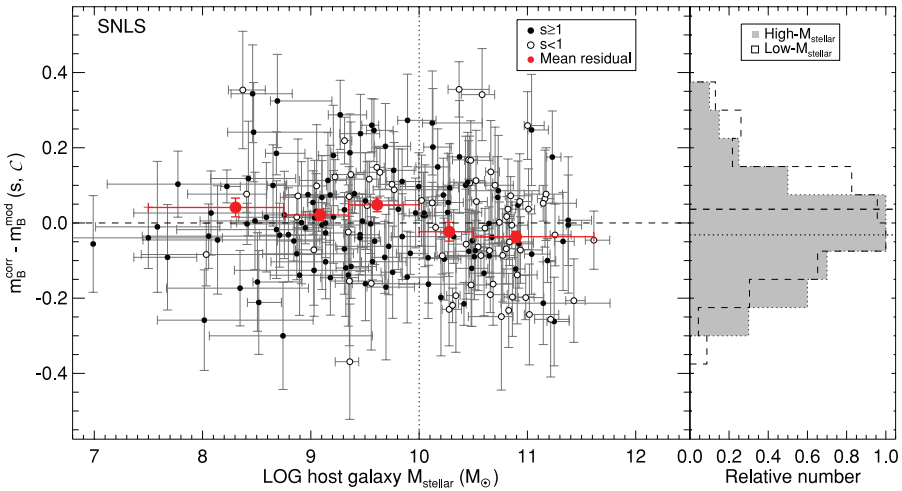

GLOBAL properties of host galaxies

Going further in the standardization

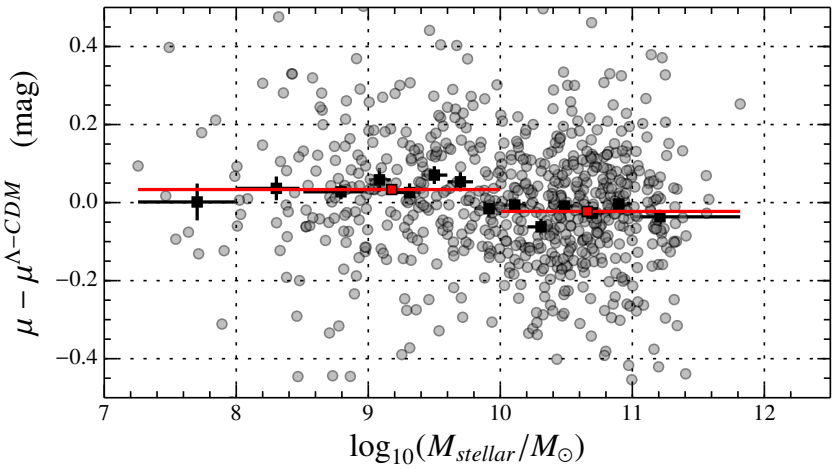
- Environment of supernovæ evolve with redshift
- The host stellar mass can directly be estimated from galaxy luminosity
- It strongly correlates to HR residuals (JLA: 5σ)
- Mass-step for absolute magnitude
- The standardization is not better and the physical meaning remains unclear

$$M_B = \begin{cases} M_B^1 & \text{if} \quad M_{\text{stellar}} < 10^{10}\, M_\odot\,, \\ M_B^1 + \Delta_M & \text{otherwise.} \end{cases}$$

Sullivan et al. 2010



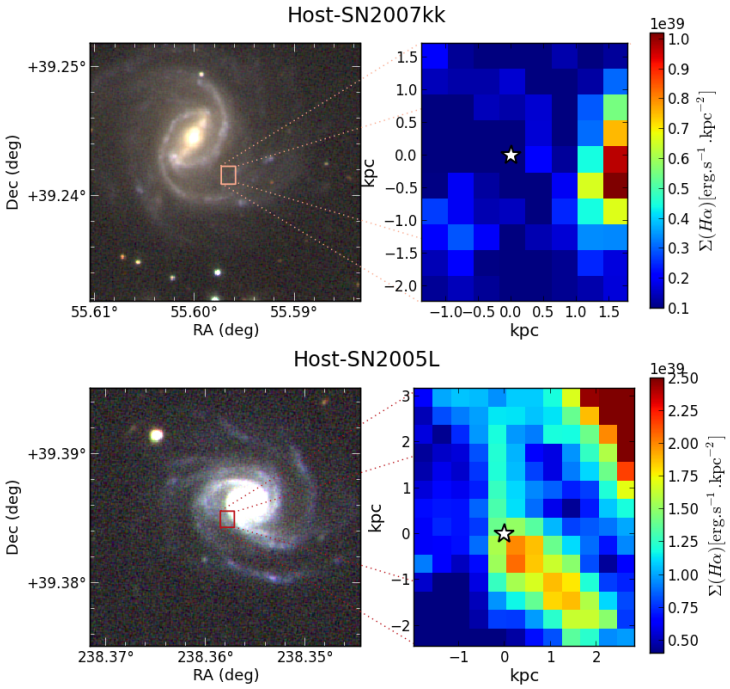
Betoule et al. (2014)



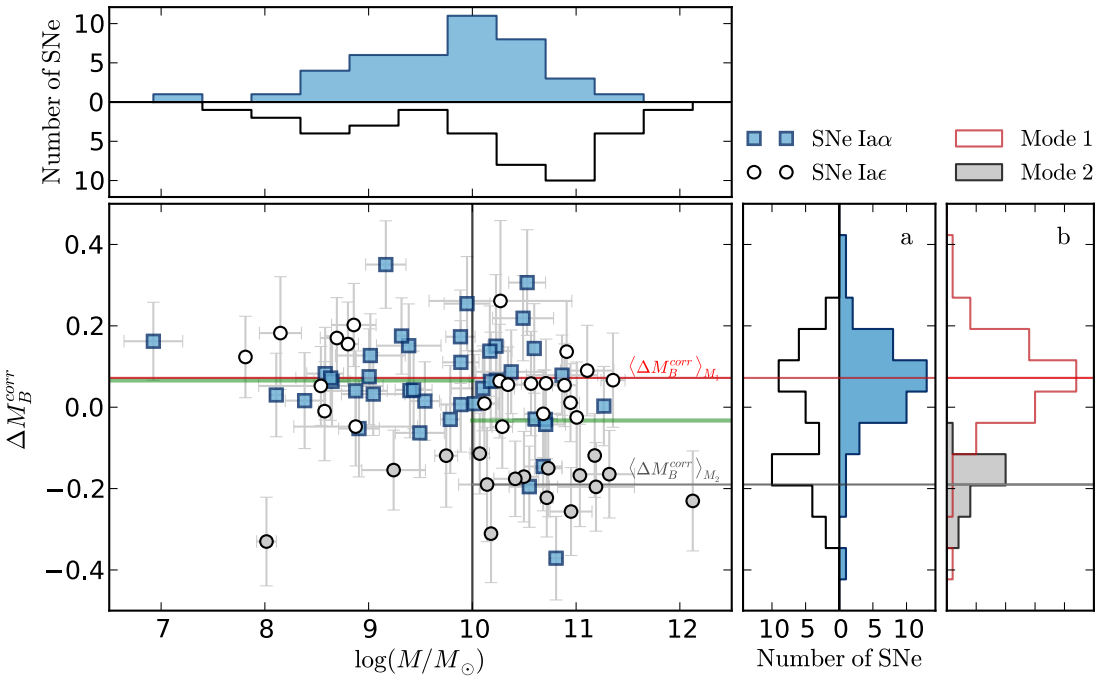

LOCAL properties of host galaxies

A first look at local host properties

- Hα as a tracer of stellar formation
- SNIa in locally active regions are brighter



Rigault et al. 2013



$\mathcal{O}(80)$ SNe

Nearby Supernova Factory


Let's build a new tracer of local SN properties at ALL redshifts!

SNLS5 final data sample: hosts photometry

- we have global host galaxy photometry for most of the sample (83%)

	# SN	# Host photometry	Reference	Filters/Instrument
SNLS	392	346	Hardin et al. (in prep.)	$ugriz$/MegaCam
SDSS	330	291	Sako et al. 2014	$ugriz$/SDSS
low-z	137	117	SIMBAD	$ugriz$/SDSS & JHK/2MASS
Total	**859**	**754**	–	–

http://simbad.u-strasbg.fr/simbad

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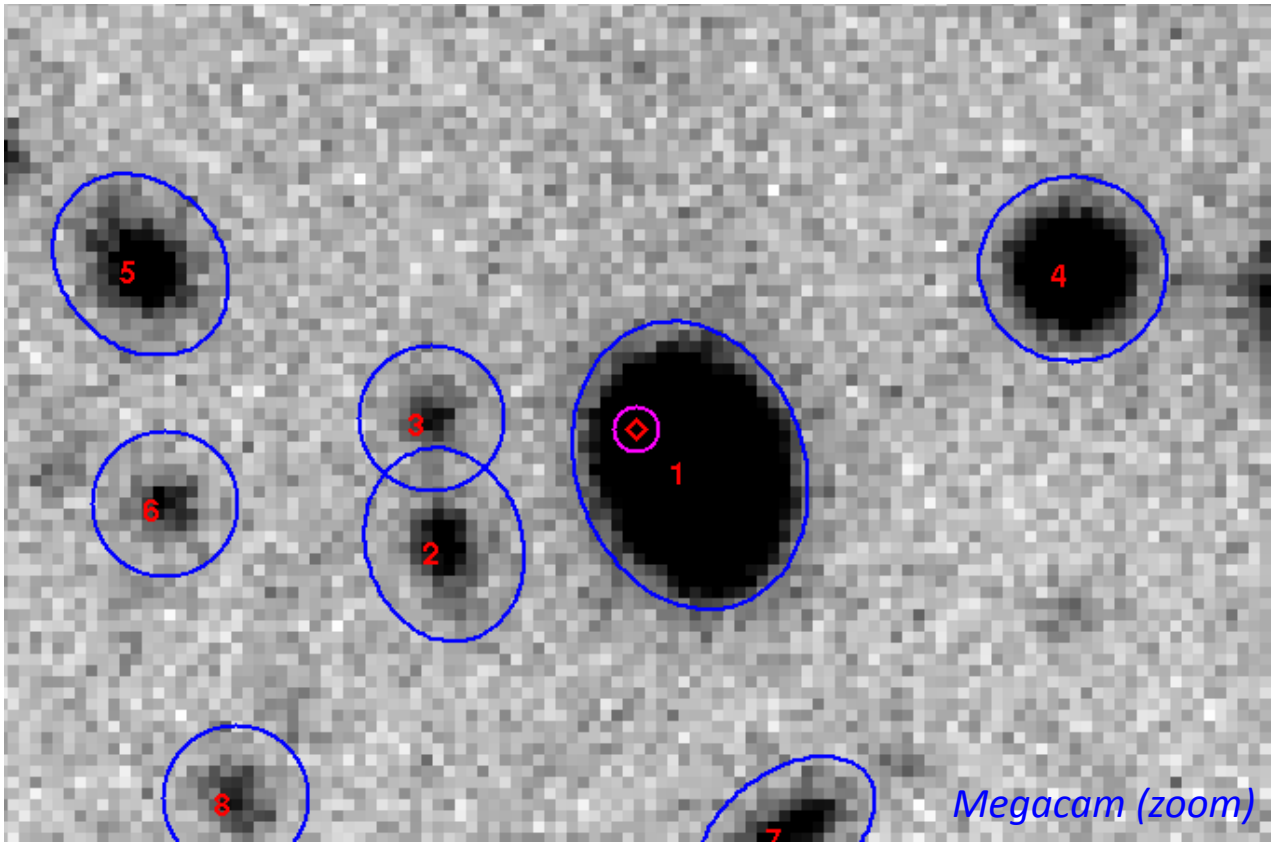
	# SN	# *z* match	# in SDSS	# in 2MASS	# only 2MASS	no photo
CSP	18	16	8	16	8	0
CfAIII	79	68	46	59	19	3
CfAIV	40	38	24	33	12	2
Total	**137**	**122**	**78**	**108**	**39**	**5**

369 SNe

Host photometry for SNLS

- Local: circular photometry with fixed radius (3 kpc) at SN position (violet circle)
- Global: corresponding host ellipse (blue)



Two kinds of SDSS images

- single-epoch images (DR12)
- coadded images of Stripe 82 (before fall 2005)

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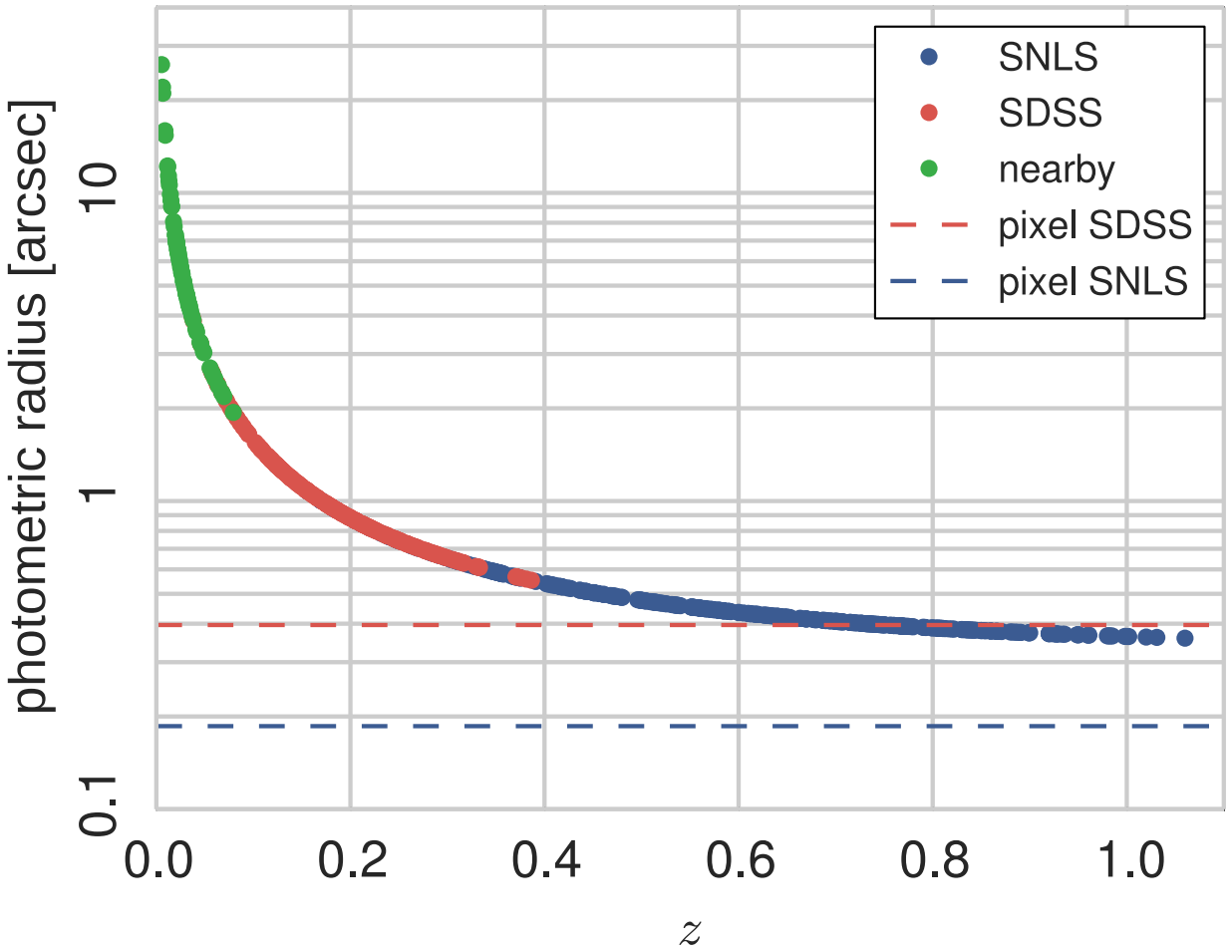
Photometric radius

- we probe regions of radius 3kpc at all redshifts



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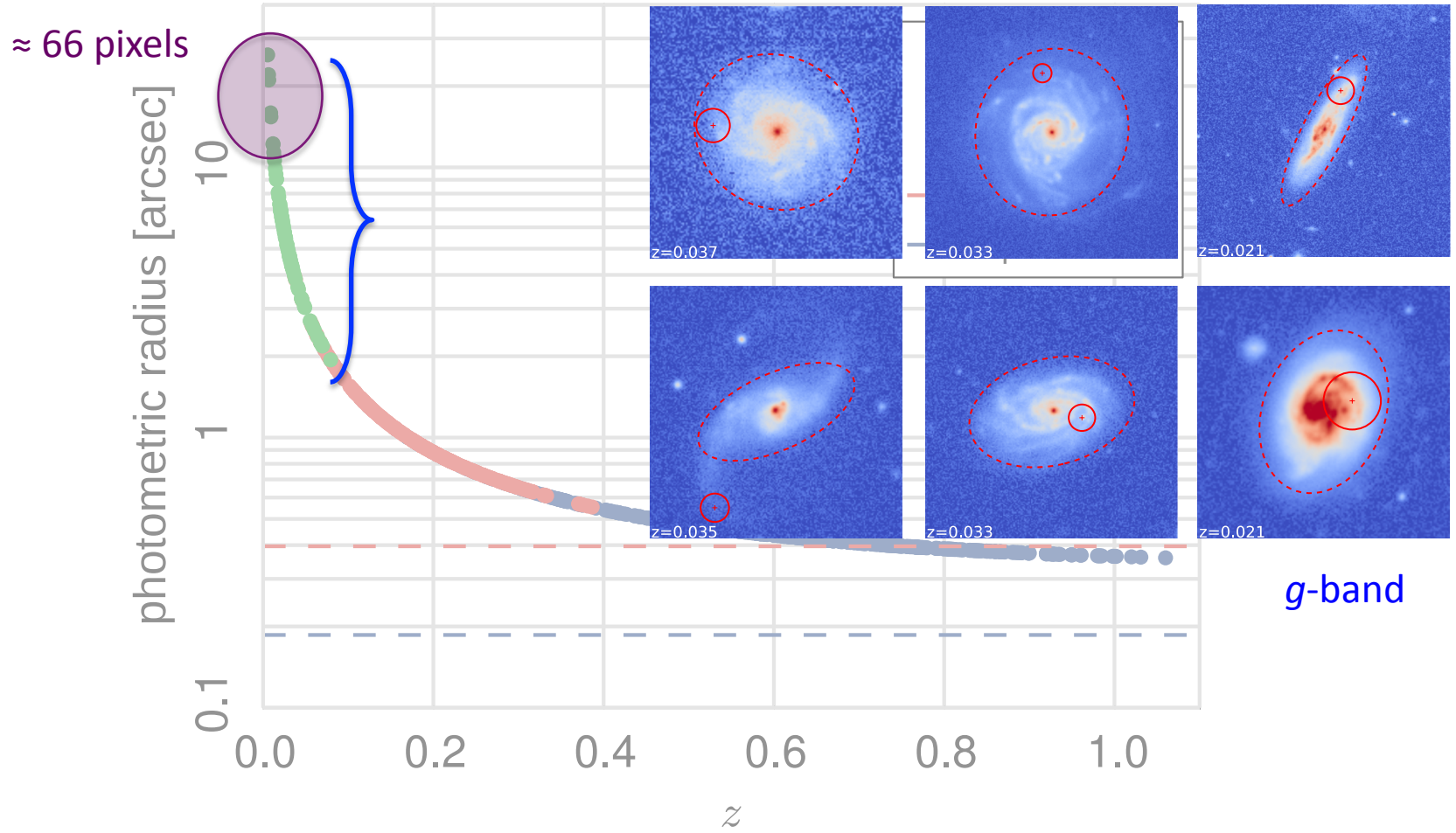

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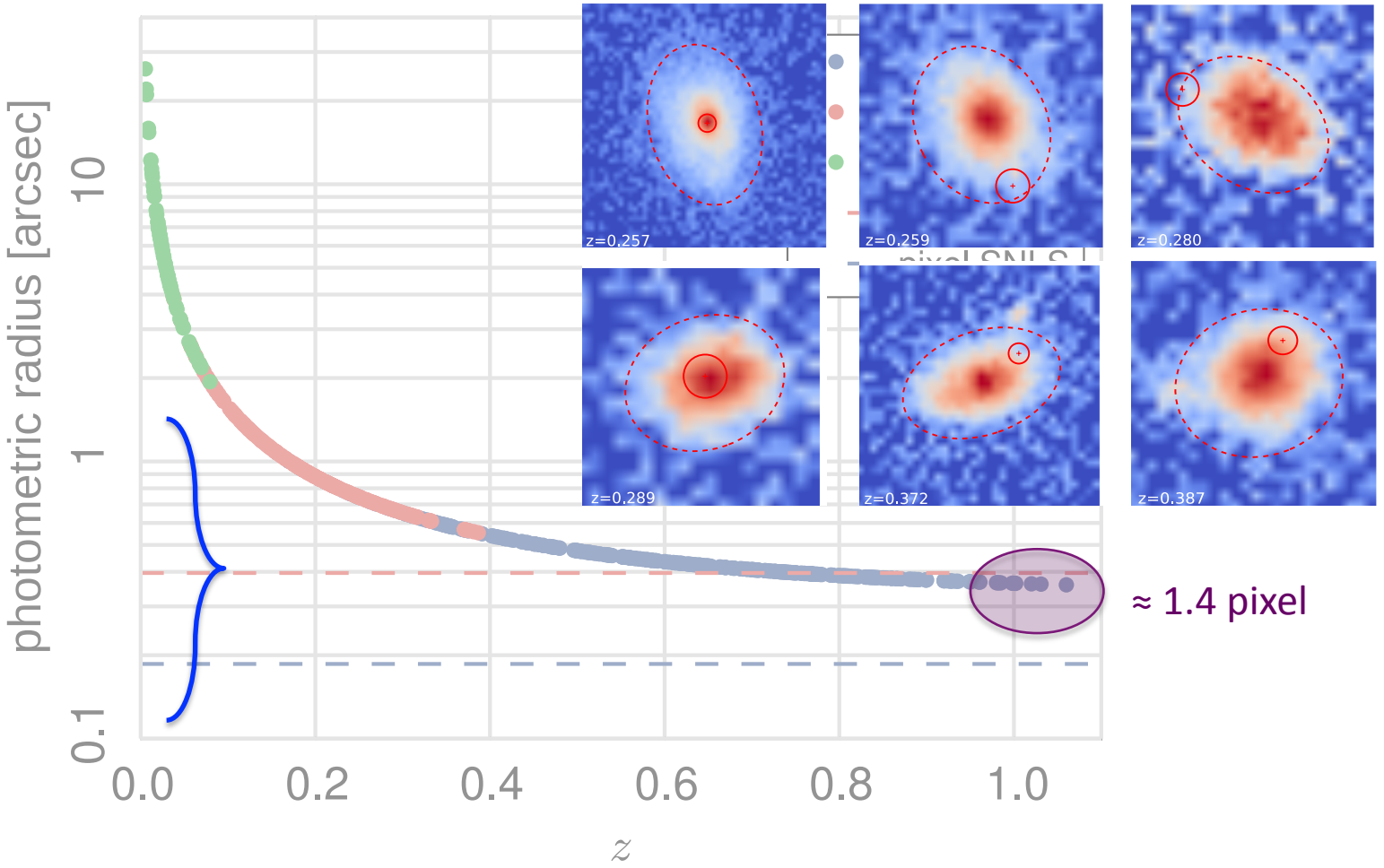
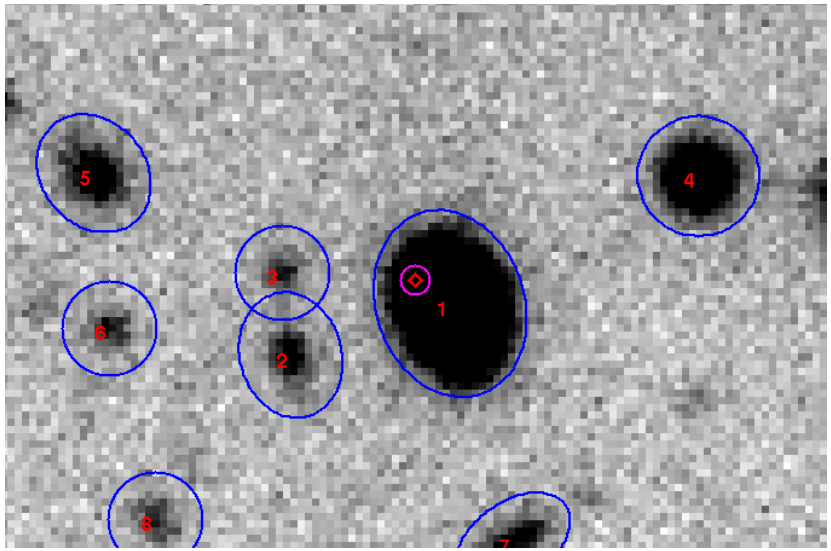
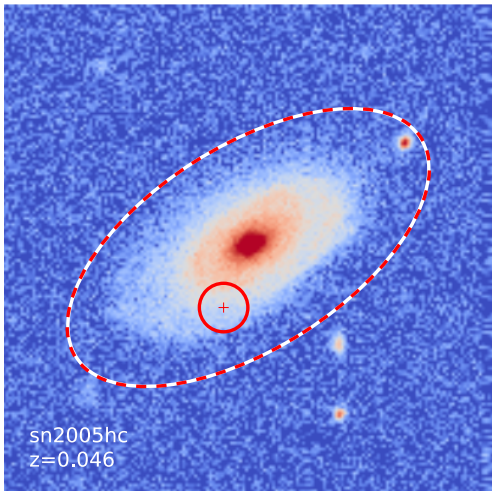


Local environment of SNIa at all redshifts

- The measurement:
  - perform the local and global photometry of more than 700 host galaxies of SNIa from SNLS, SDSS and low-redshift surveys
  - probe the same size (≈3 kpc) at all redshifts
  - compute *rest-frame U-V* colours from *observed* magnitudes (fitting of galaxy spectral energy distribution)

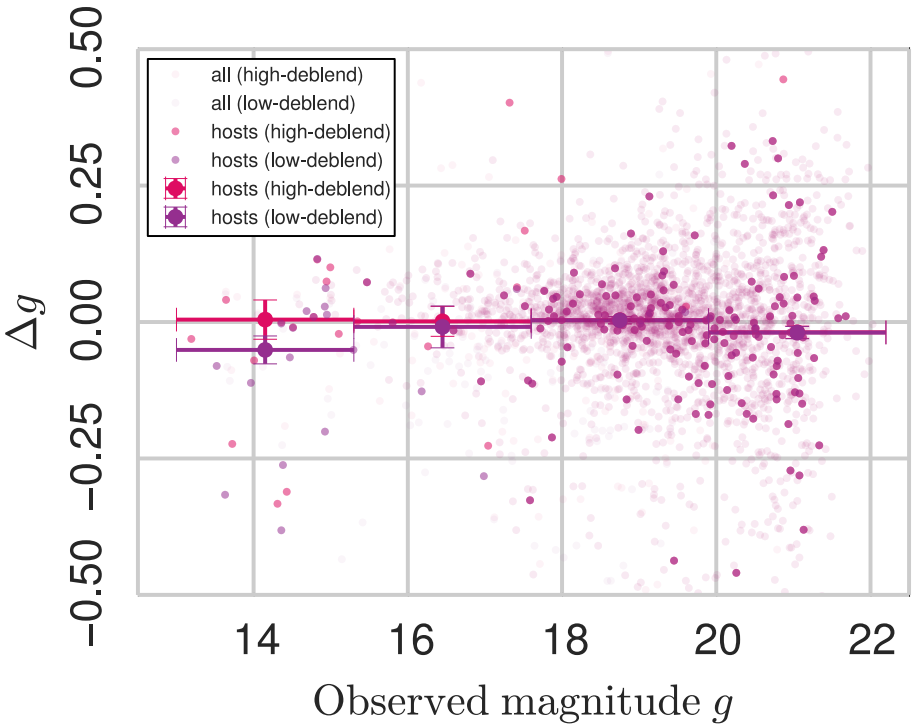


SNLS



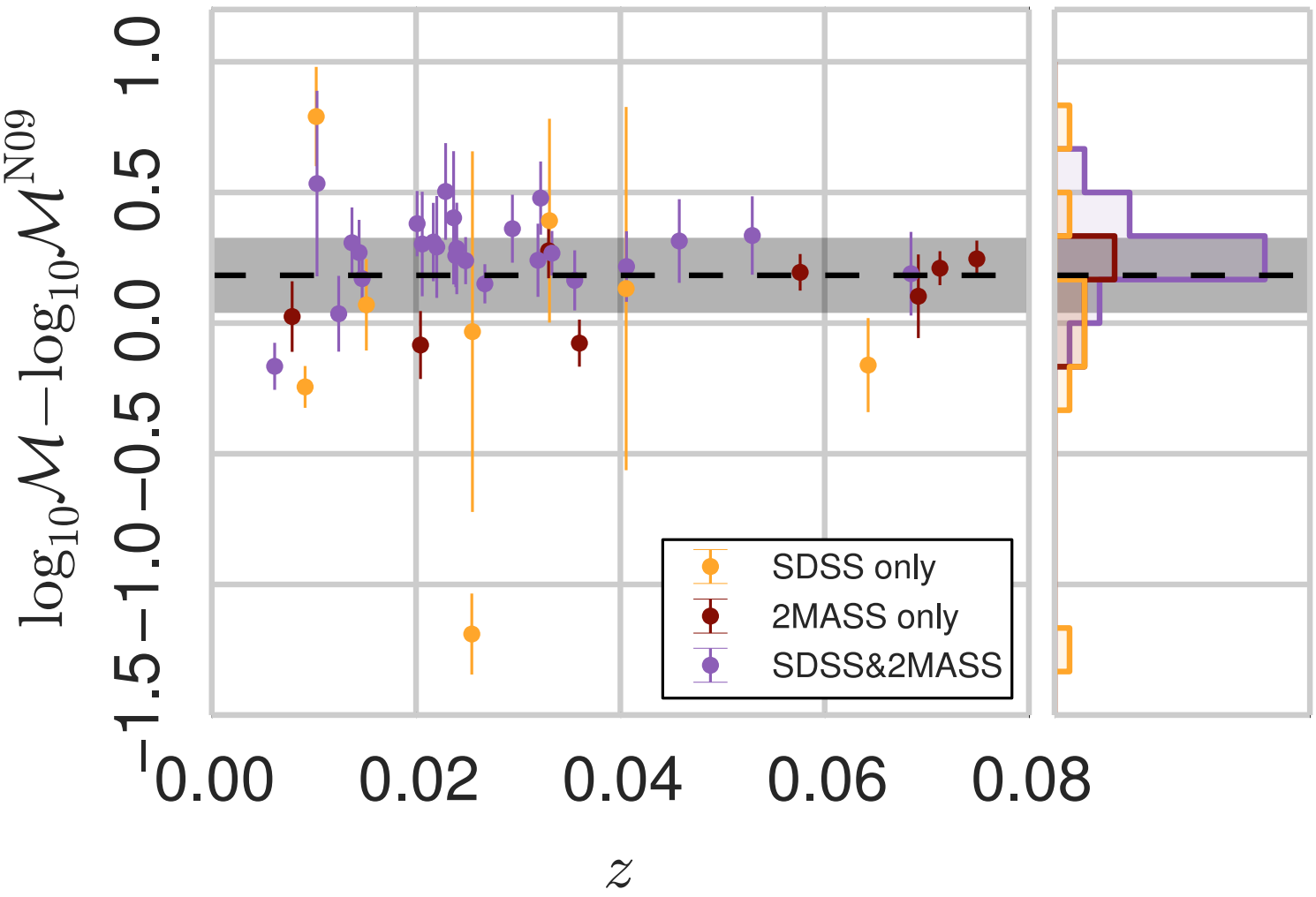
SDSS
r-band

Comparison of global measurements: SDSS DR12

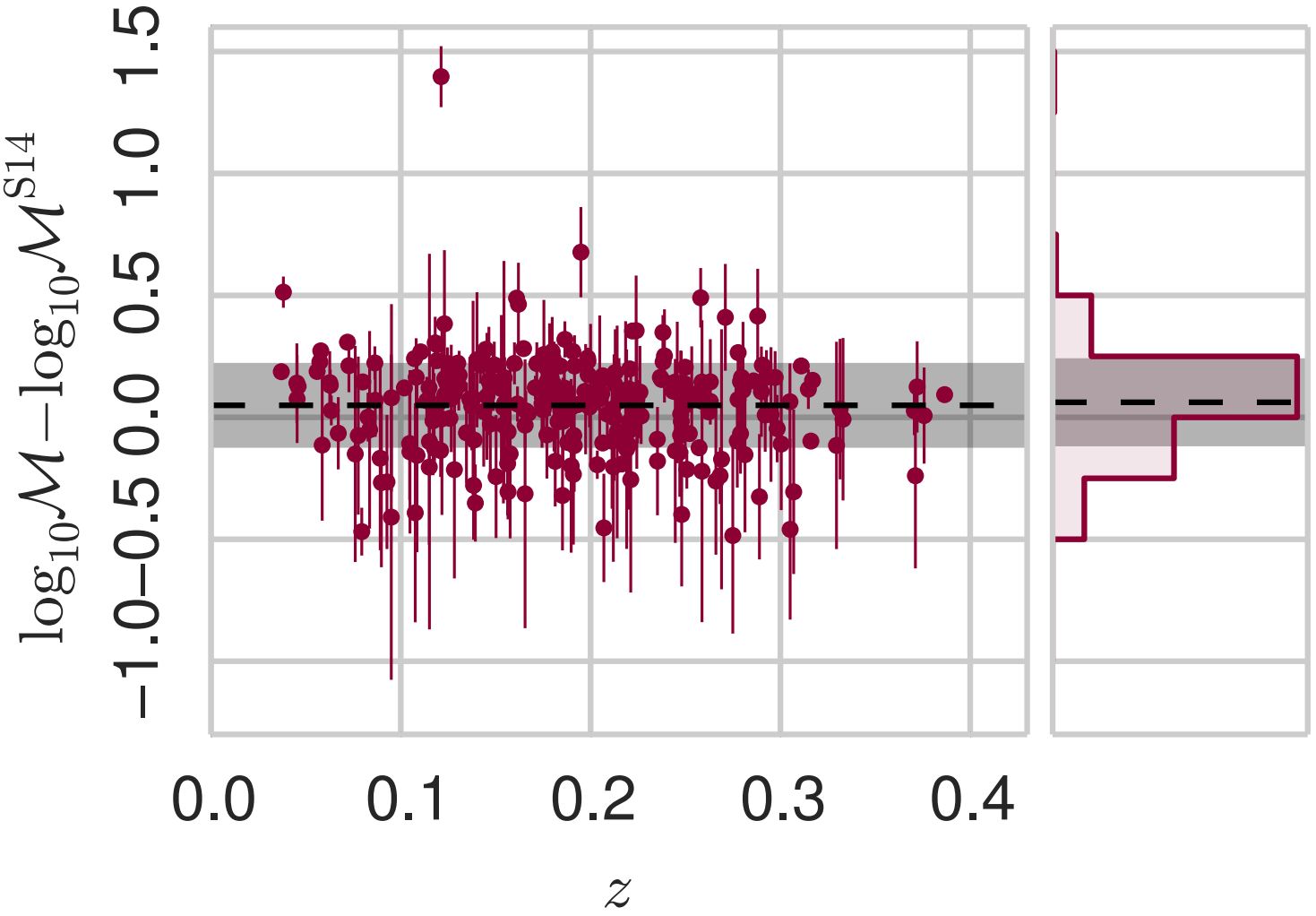


	low-deblending	
Band	Field galaxies	Host galaxies
u	-0.029 ± 0.309	-0.048 ± 0.307
g	0.007 ± 0.079	-0.003 ± 0.077
r	0.019 ± 0.077	0.014 ± 0.060
i	0.013 ± 0.086	0.009 ± 0.080
z	-0.004 ± 0.125	-0.027 ± 0.123

Comparison of global properties: Neill et al. 2009



Comparison of local variables: Sako et al. 2014



Local environment of SNIa at all redshifts

- Correlations between local colour of SN explosion regions and Hubble diagram residuals

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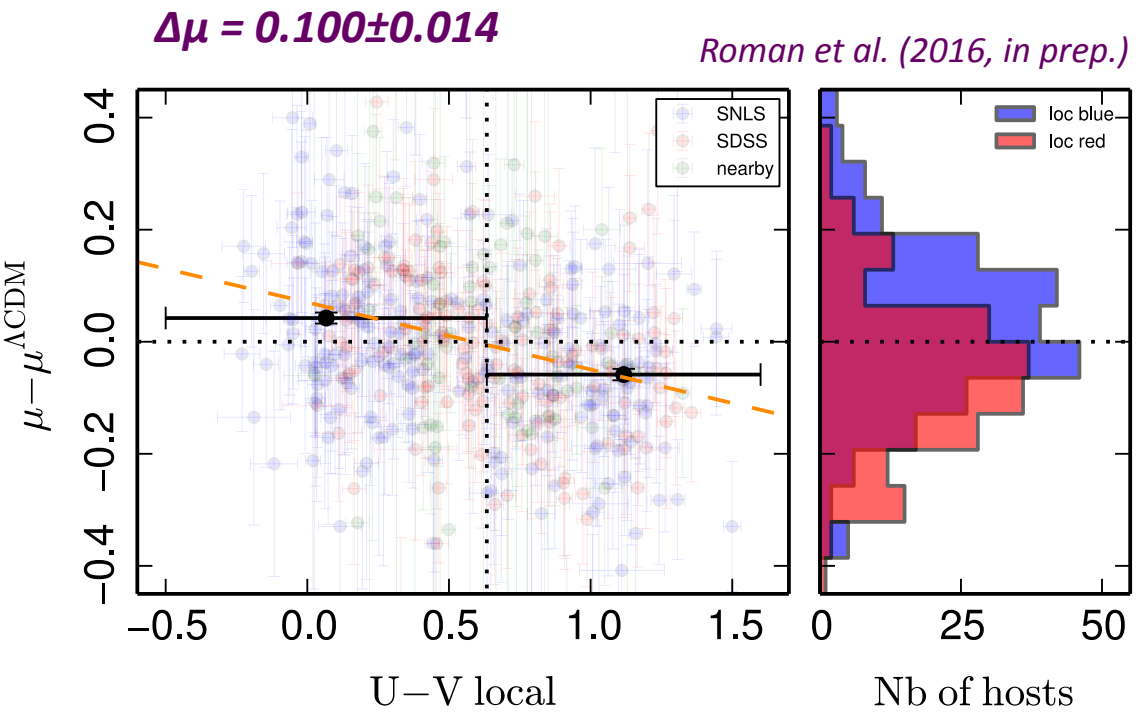
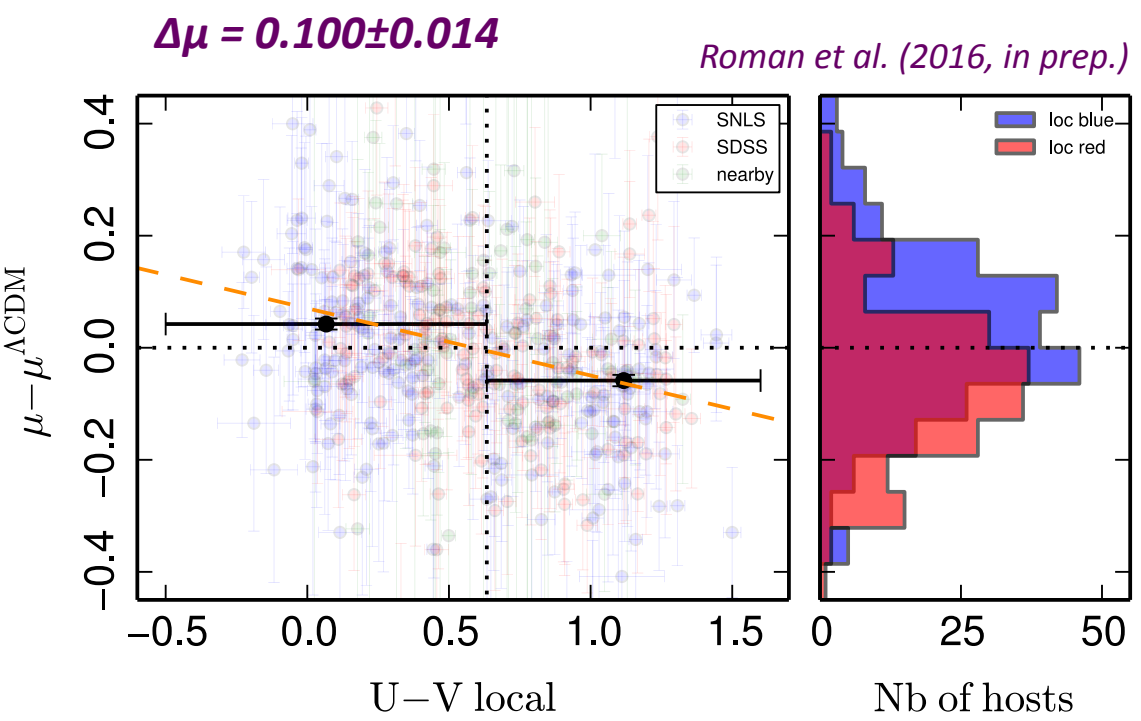
  - 7σ significance assuming a bimodal distribution



Local environment of SNIa at all redshifts

- Correlations between local colour of SN explosion regions and Hubble diagram residuals
  - 7σ significance assuming a bimodal distribution
  - more significant than stellar mass and galaxy colour (5σ)
  - valid for high and low redshift ranges



Conclusions

- First analysis of local environment at all redshifts and for a large sample
- Strong hint that luminosity variations can be reduced
- Impact on *w*
- Type Ia supernovæ can become a major cosmological probe again: dark energy, expansion rate
- Subaru, LSST