Near-IR Hubble Diagrams of SNe II

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Motivation

Redshift-independent distances allow us to compute:

- Properties of astrophysical objects at $z<0.01$
  - Brightness (SN Iax 2014dt @ $z=0.005$)
  - Mass (N6946-BH1 @ $z=0.0001$)

- Properties of the Universe
  - Expansion rate ($0.01\text{-}0.02<z<0.15$)
  - Deceleration parameter ($z>0.3$)

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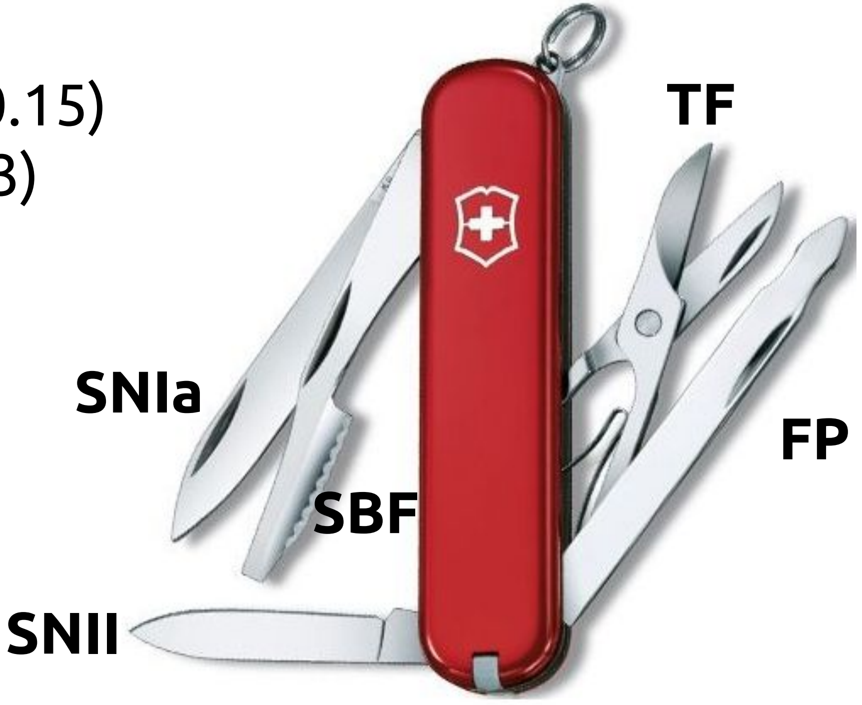
Swiss army knife
for extragalactic distances



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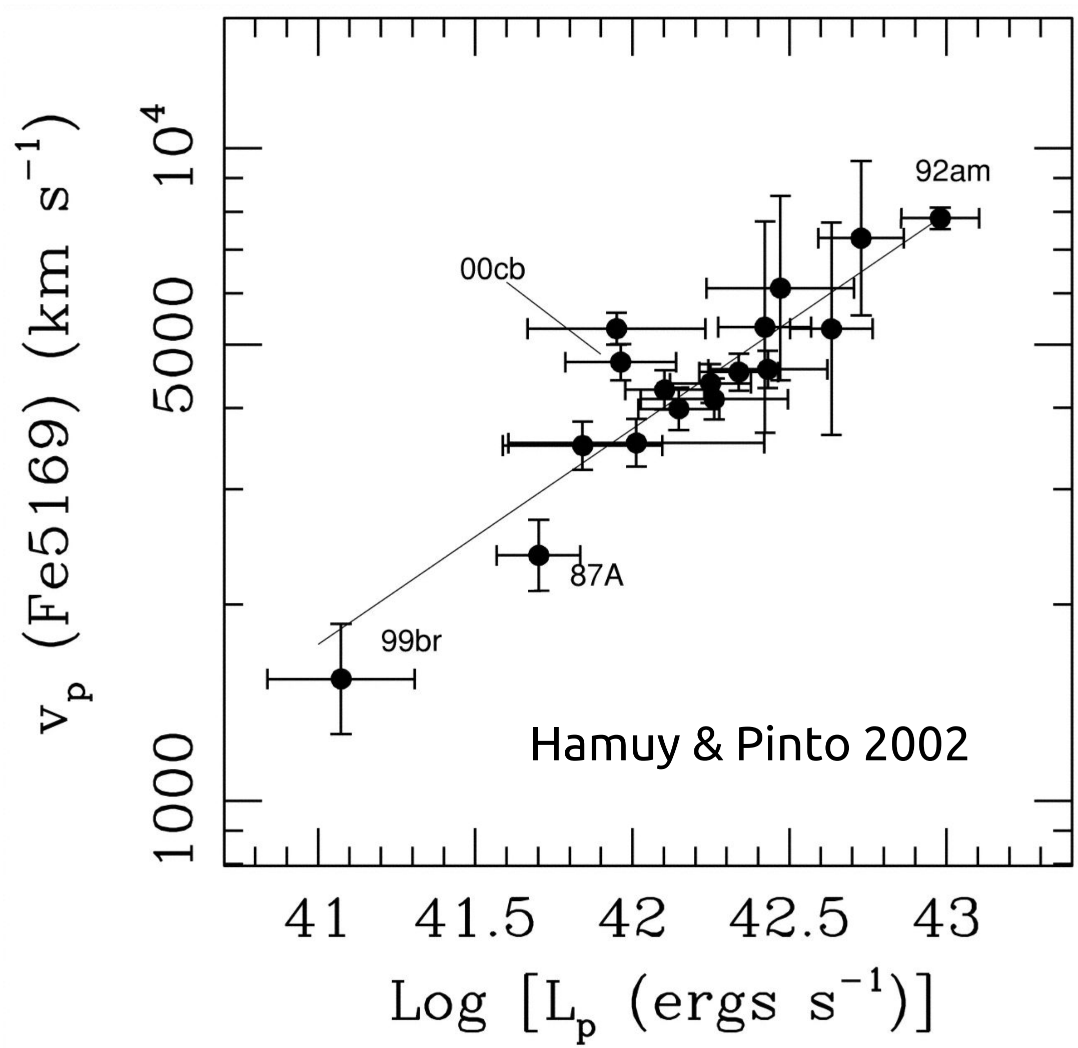
My objective: improve this tool → SNII

Methods to measure SN II distances

Standardized candle method (SCM)



$$M_{50d} = a + b \log(v_{ph,50d})$$

SCM not only at 50 days:

- 45 days (de Jaeger+17)
- -30 days (Olivares+10)

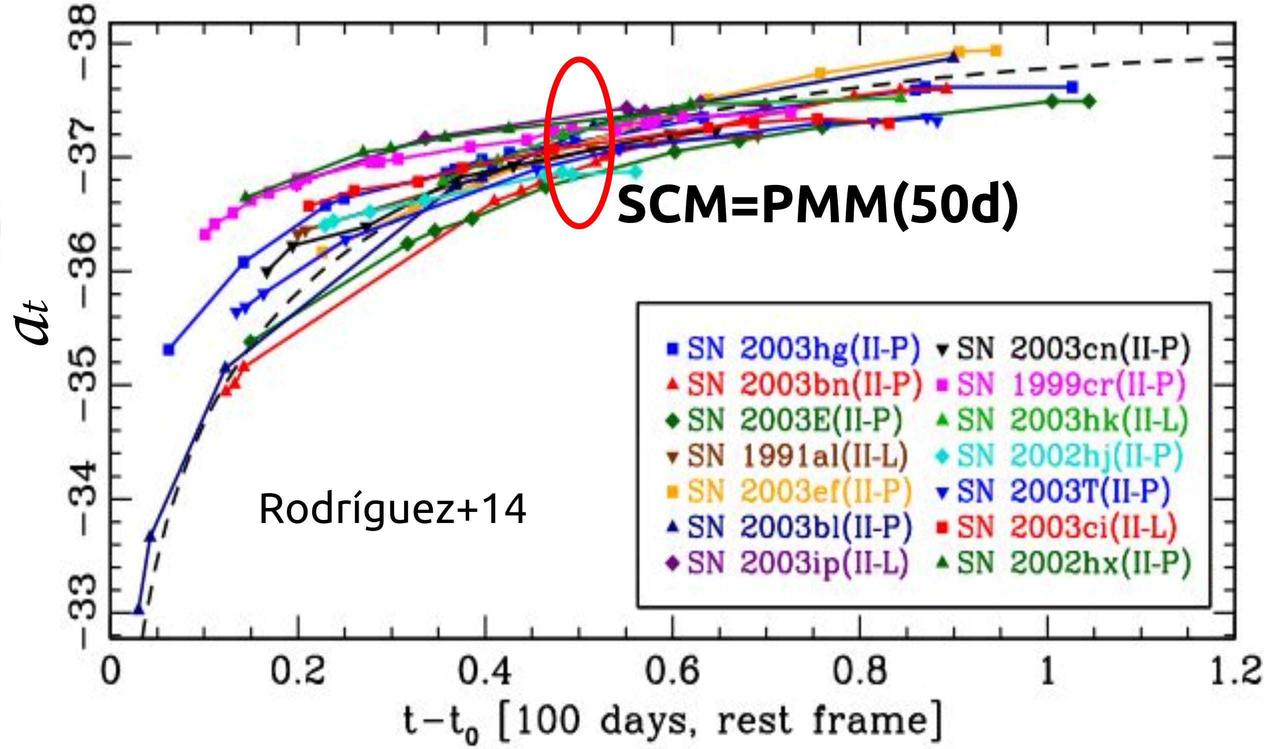
Photospheric Magnitude Method (PMM)

SCM:

$$M_{50d} = a + b\log(v_{ph,50d})$$

PMM:

$$M_t = a_t + 5\log(v_{ph,t})$$



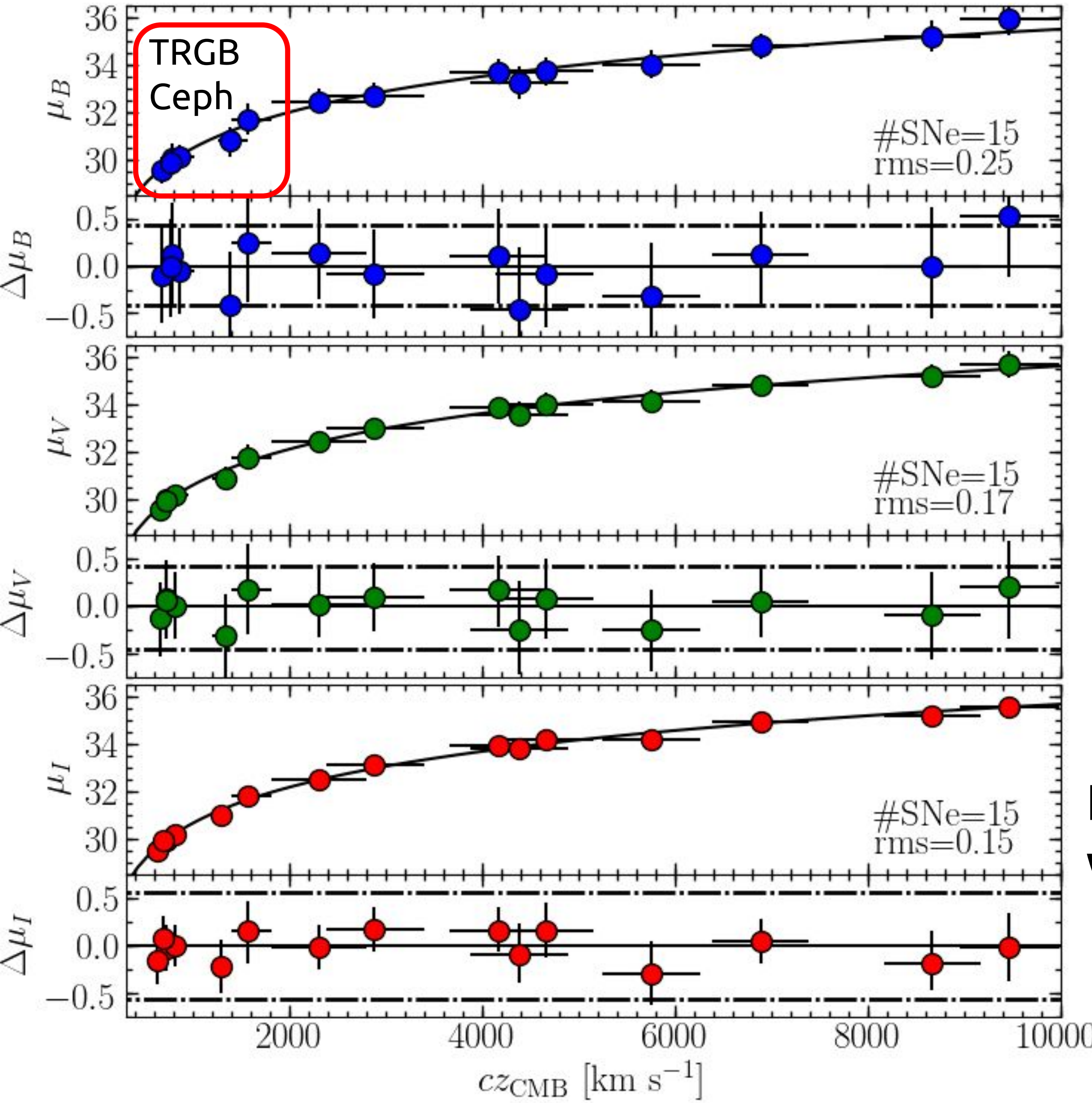
To measure a PMM distance, we need:

- one v_{ph} measurement at “any” epoch
- photometry

PMM does not work at <30 d

* Error on explosion epoch
* CSM interaction

Optical SN II Hubble diagrams



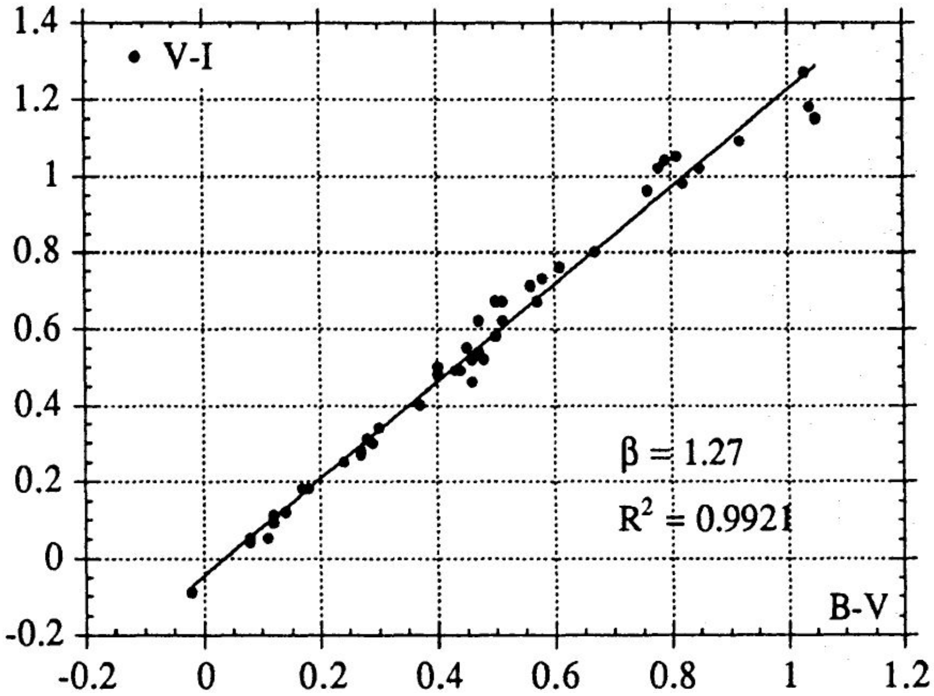
Rodríguez (+Nidia)+18 (submitted)

HD rms decreases as wavelength increases

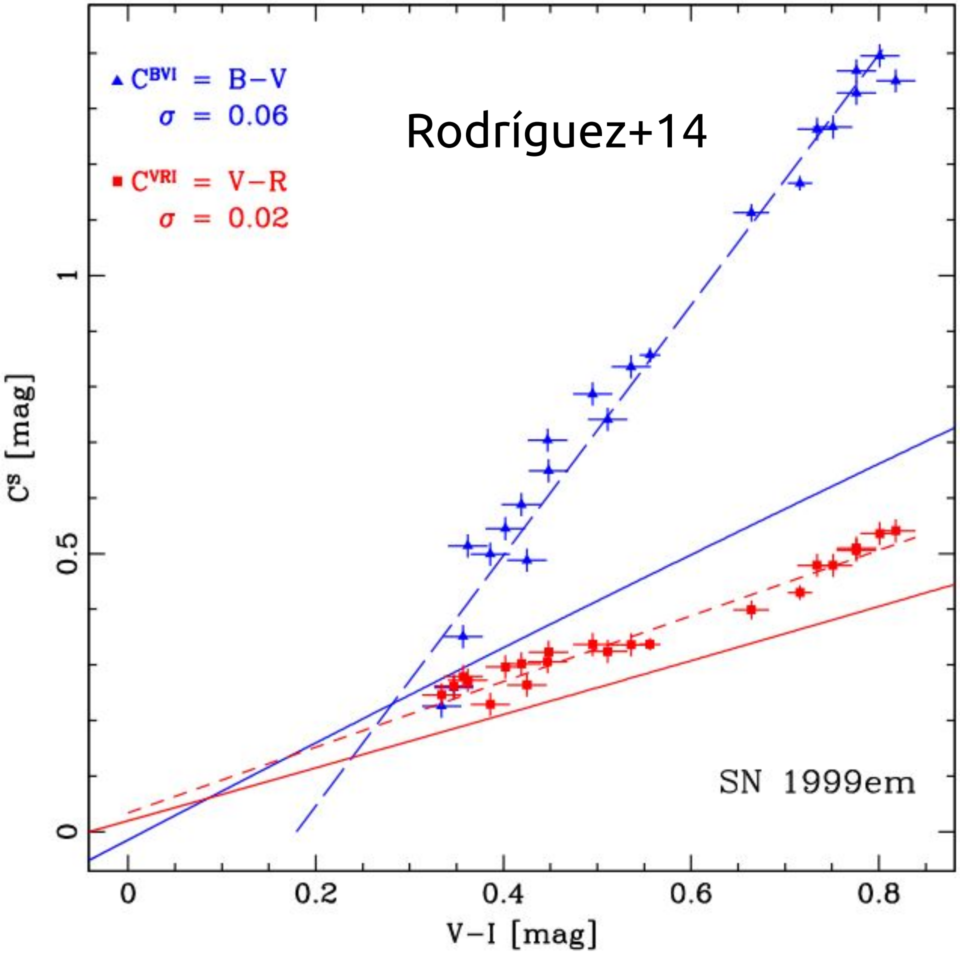
Host galaxy extinction

Methods to measure Av(host) are still not well-established
(e.g., NaID EW, Poznanski+11; Color curve, Olivares+10)

We use the color-color analysis

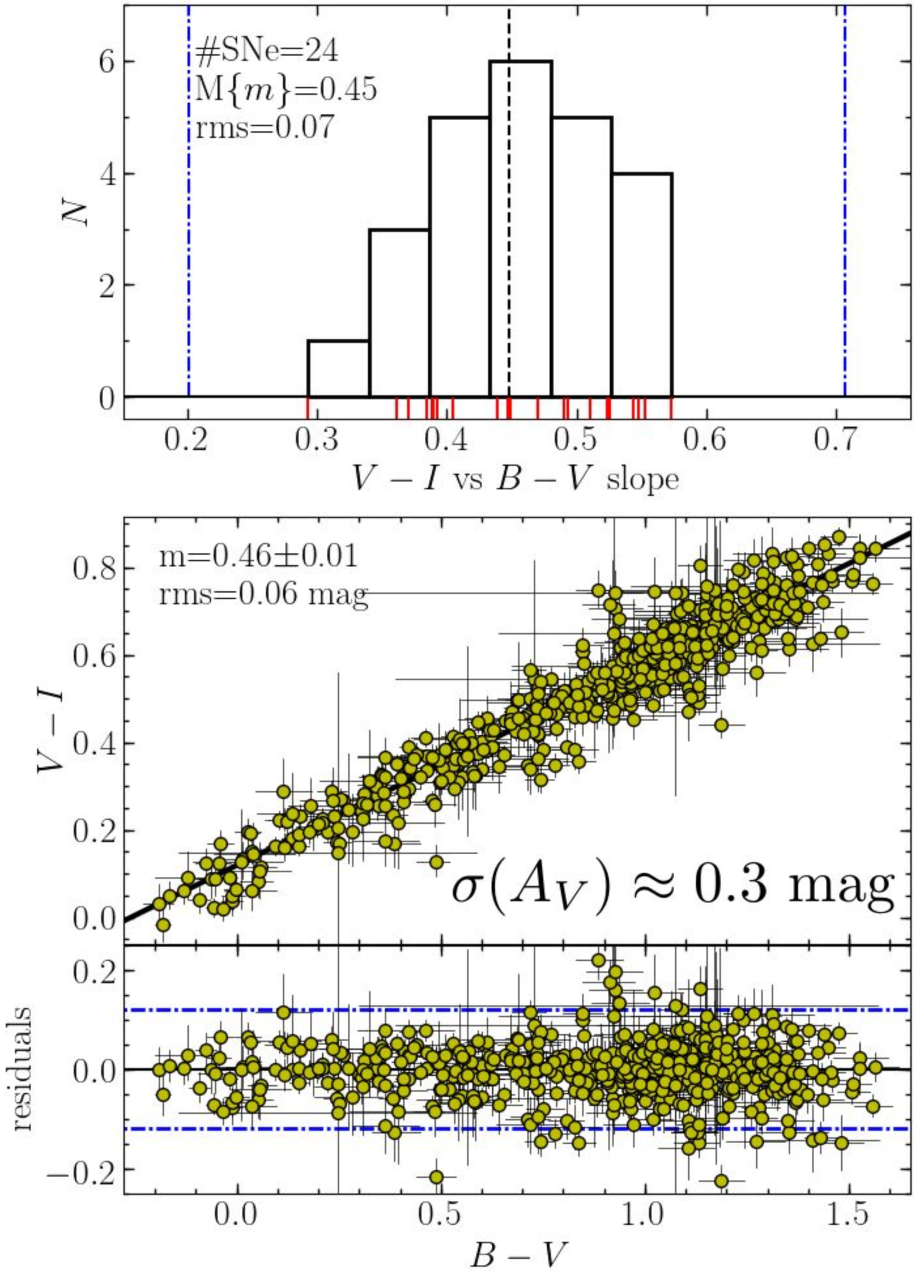


Natali+94

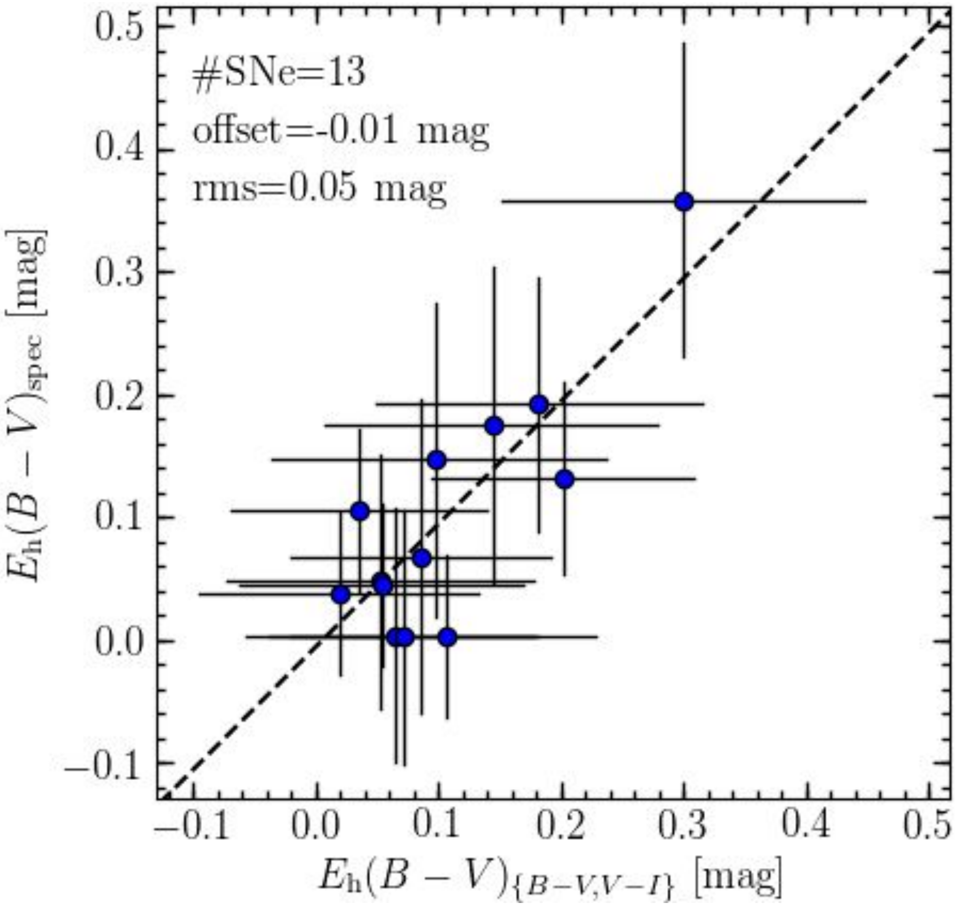


Rodríguez+14

Host galaxy extinction



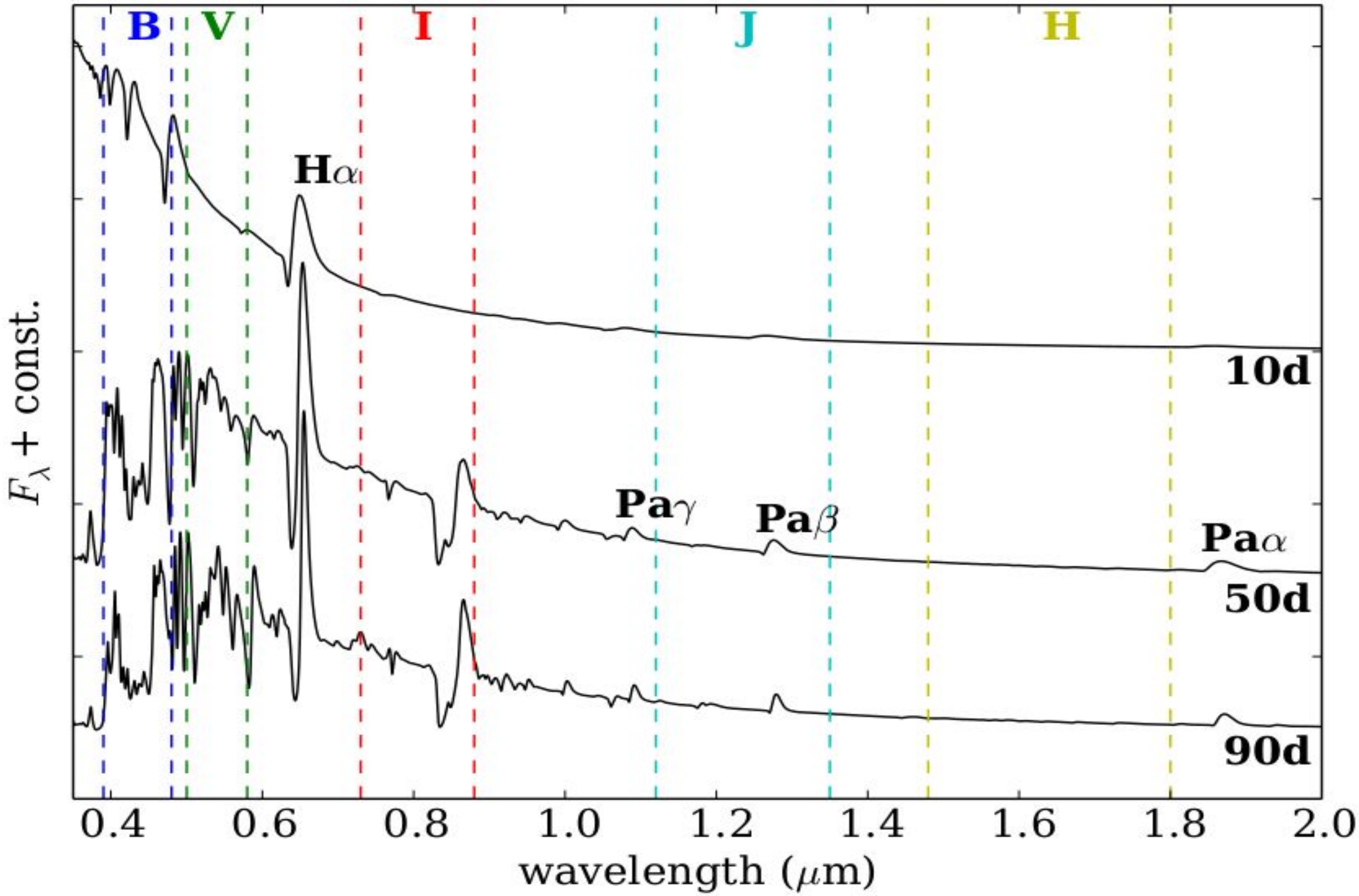
Rodríguez+18



SNe II at near-IR wavelengths

Observing at near-IR has two clear benefits:

1) Near-IR light less affected by dust
2) SNe II: few and weak spectral lines at near-IR bands



Error Budget

μ statistical errors:

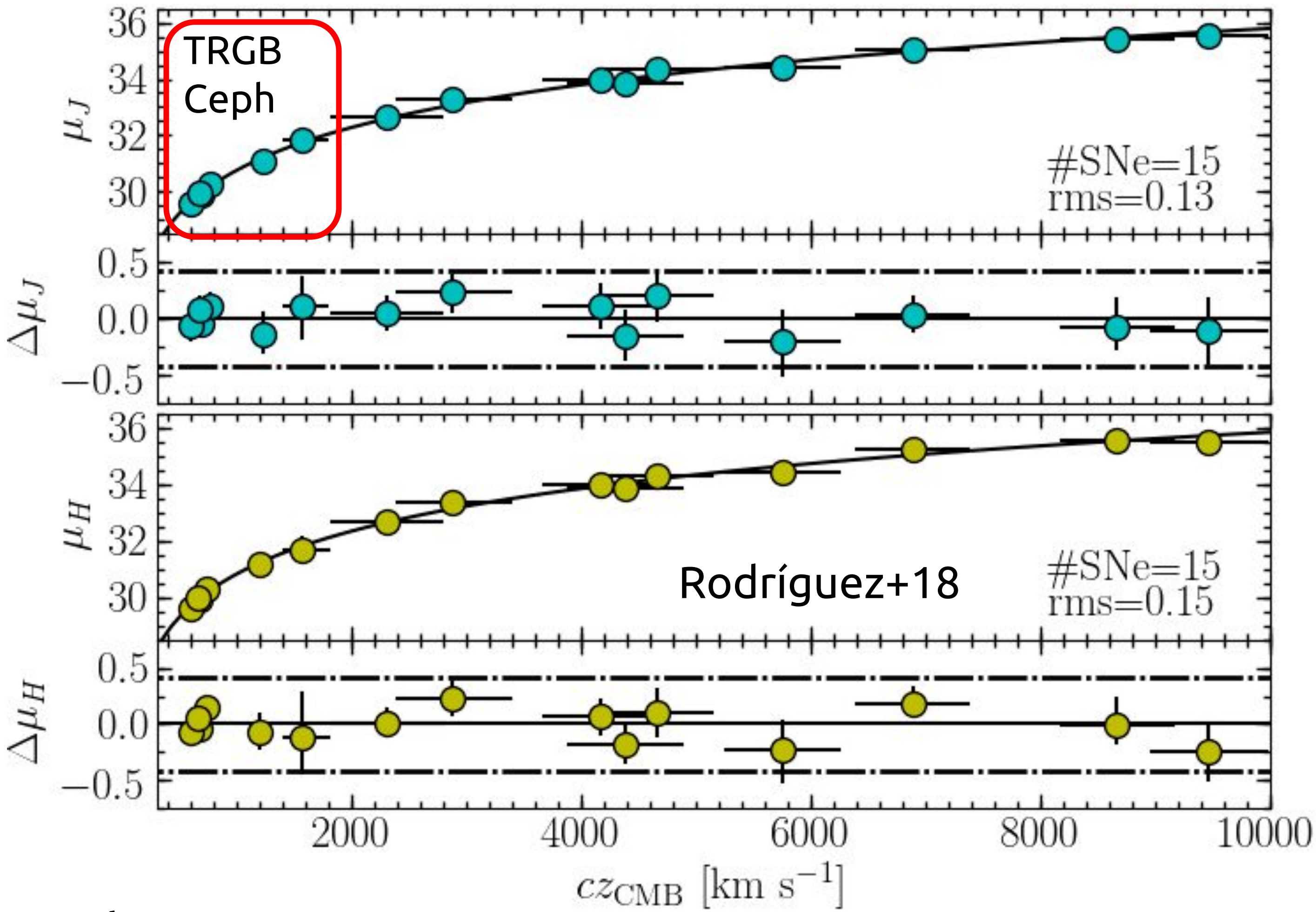
Rodríguez+18

Term	Typical rms	rms(μ_J)	% of total error
Av(host)	0.3 mag	0.079	42.1%
t_0	2.6 d	0.064	27.6%
m_J	0.048 mag	0.048	15.5%
v_{ph}	60 $\mathrm{km\,s^{-1}}$	0.042	11.9%
cz_{hel}	29 $\mathrm{km\,s^{-1}}$	0.020	2.7%
K_J	0.003 mag	0.003	0.1%
$E_{\mathrm{G}}(B-V)$	0.004 mag	0.003	0.1%
	Total	0.122	100.0%

μ errors are dominated by Av(host) errors, even in the J-band (maybe we are overestimating the Av(host) error)

We need an accurate method to measure Av(host)!!!

Near-IR SN II Hubble diagrams



Main results:

1) #SNe=15, rms(HD,J)=0.13 mag

2) We cannot discard a true rms(HD) of 0.23 mag (99% CL)

-> It is necessary to increase the # of SNe II observed at near-IR

Optical/near-IR follow-up

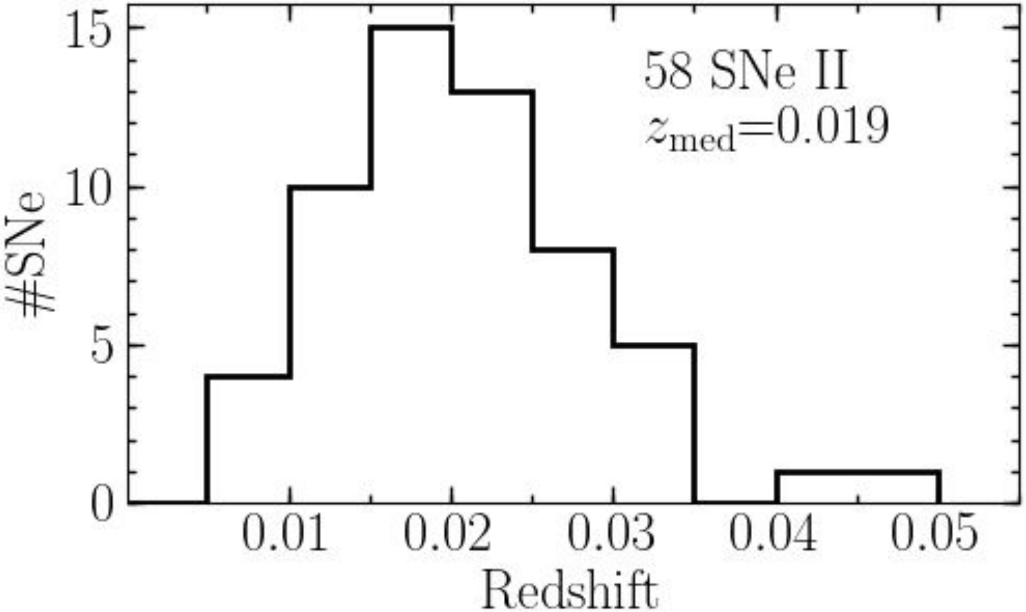
In 2015B, we started and observational campaign to observe SNe II at optical and near-IR

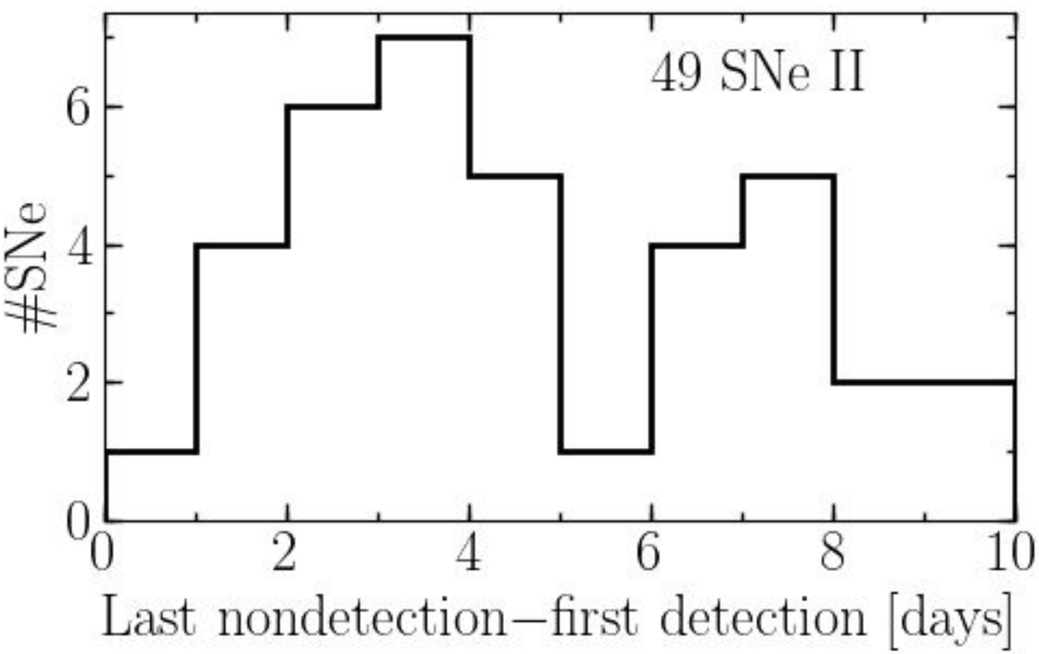
Targets:
- SNe II at z > 0.01
- Explosion epoch constrained within a week

We collected:
- **Near-IR photometry** during the first three months.
- **Optical spectroscopy** to measure the expansion velocity.
- **Optical photometry** to estimate Av(host).

Telescope	Mirror
REM	0.6 m
TRAPPIST-S	0.6 m
IRIS	0.8 m
LCO 1.0	1.0 m
SMARTS 1.3	1.3 m
FTN/FTS	2.0 m
MPG	2.2 m
du Pont	2.5 m
NTT	3.6 m
SOAR	4.1 m
Clay	6.5 m
Gemini-S	8.1 m

Optical/near-IR follow-up



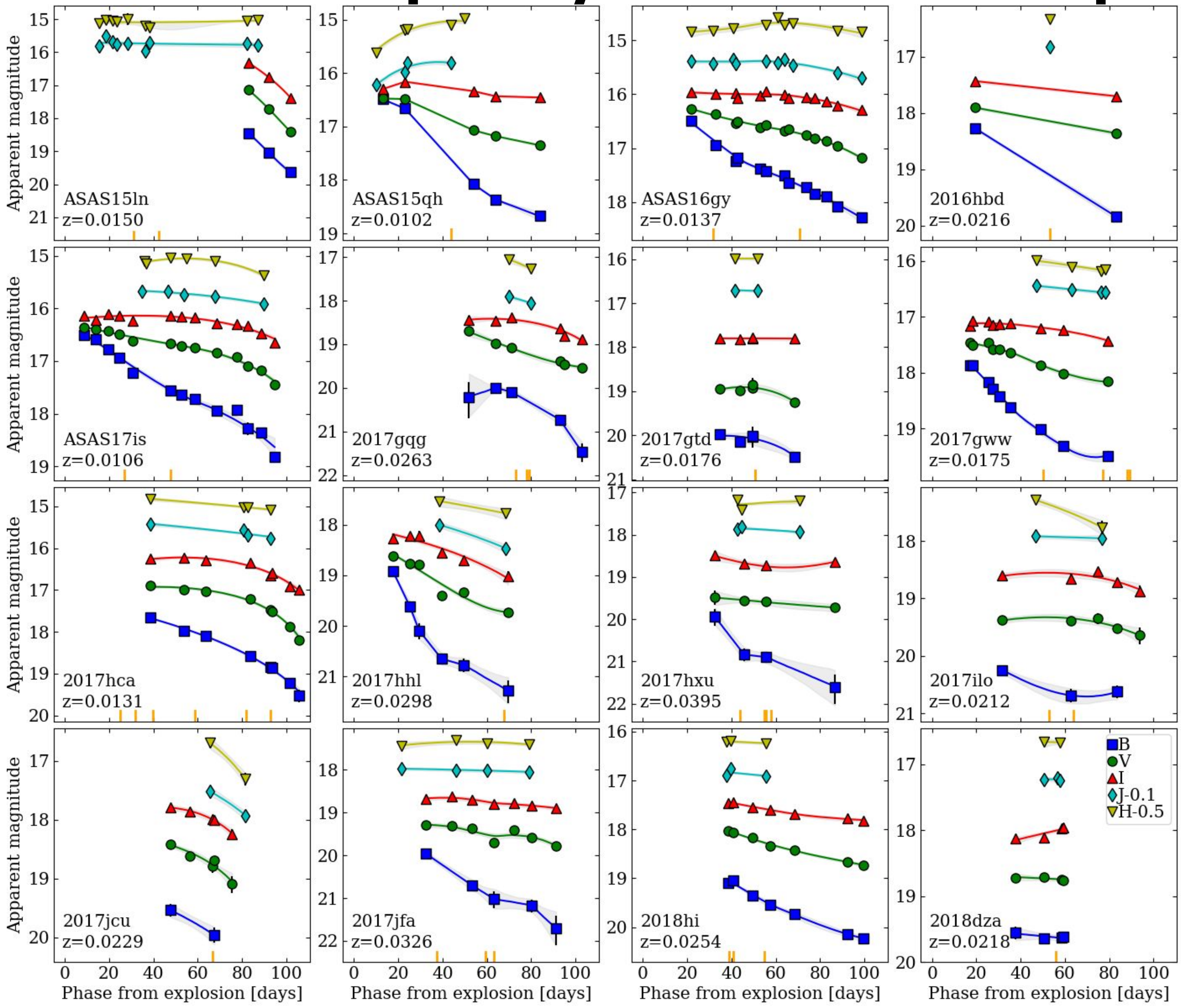


SNe II discovered by

ATLAS
ASASSN
OGLE
GAIA
PanSTARRS

(ATLAS, ASASSN, OGLE: cadence of 1-5 days)

Optical/near-IR follow-up



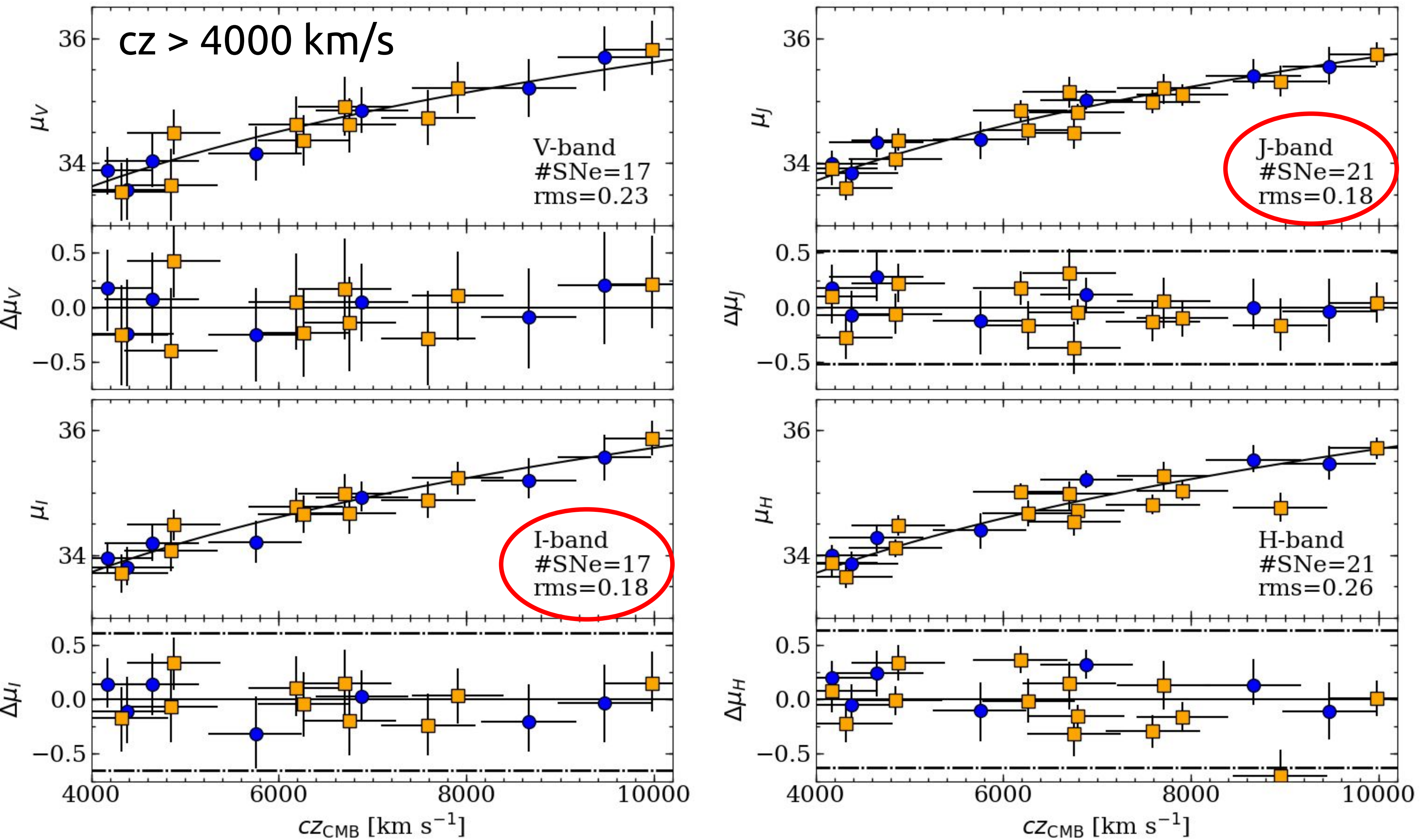
PSF photometry

Optical seq: PanSTARRS

Near-IR seq: 2MASS

We are taking templates for gal-subtraction

Optical vs near-IR SN II HD



rms=0.18 mag
-> PMM distance precision <11% (95% CL)

$H_0(I)=71.9 +- 3.4$
$H_0(J)=72.2 +- 3.1$

Summary

- We collected new optical/near-IR data of SNe II, which are useful to measure distances with the PMM

- We construct Hubble diagrams with SNe II at cz>4000 km/s, obtaining a rms of 0.18 mag for I- and J-band

- From the J-band HD, we obtained H_0 = 72.2+-3.1 Mpc/km/s