Toward a Near-Infrared SN Ia Cosmology

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The problem

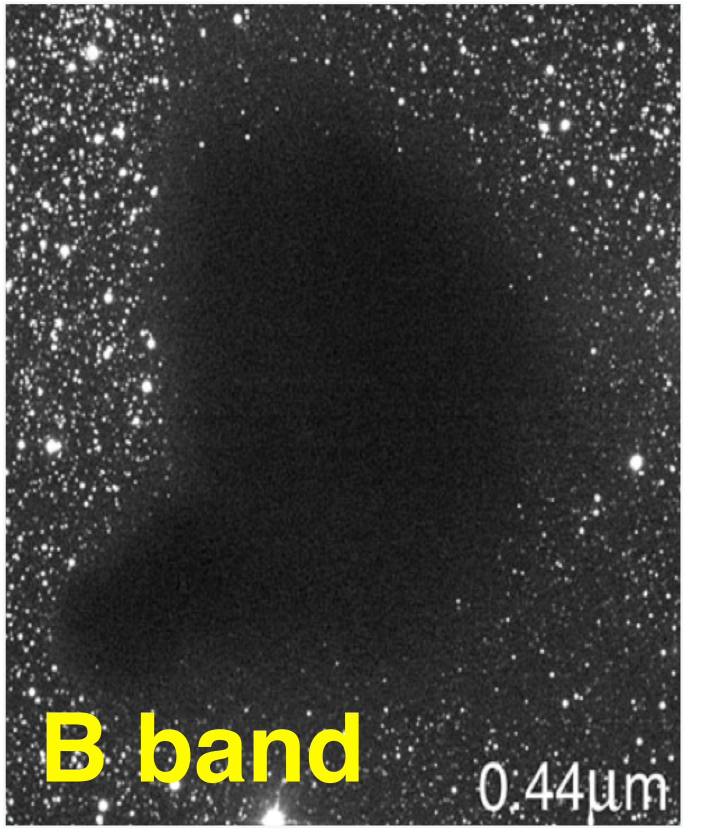
Optical samples of SN Ia for cosmology have reached their limit to constrain the nature of the dark energy (DE) because of the systematic uncertainties.

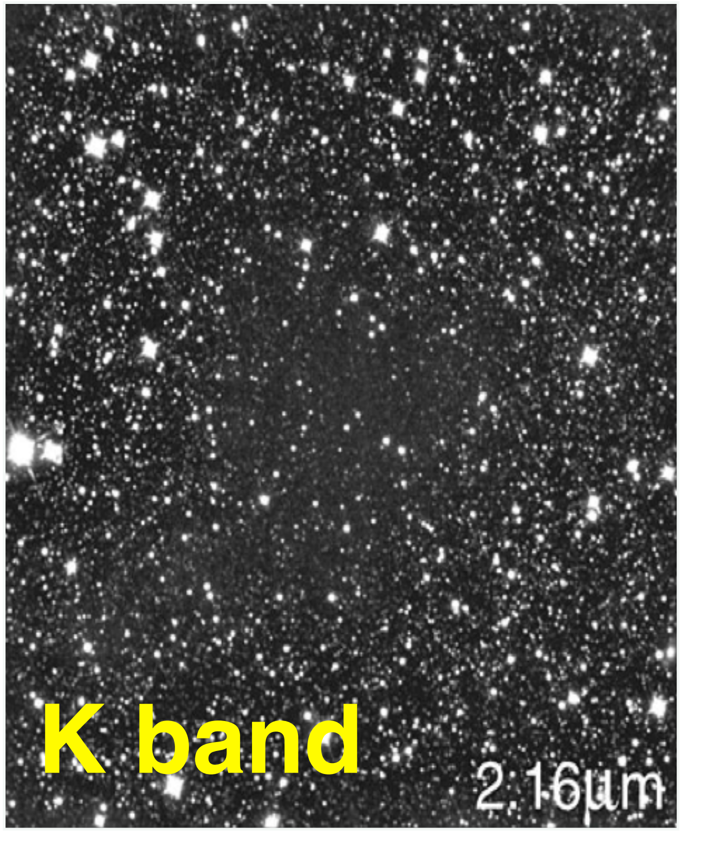
- More optical data *doesn't* mean better DE constraints.

- **Optical** light is **dimmed** and **reddened** by **dust** in the host galaxy, the Milky Way, and the extragalactic medium.

A solution: NIR observations!

- Near infrared (**NIR**) light is much **less sensitive to dust** than the optical wavelengths. Then the systematic uncertainty due to dust is reduced.



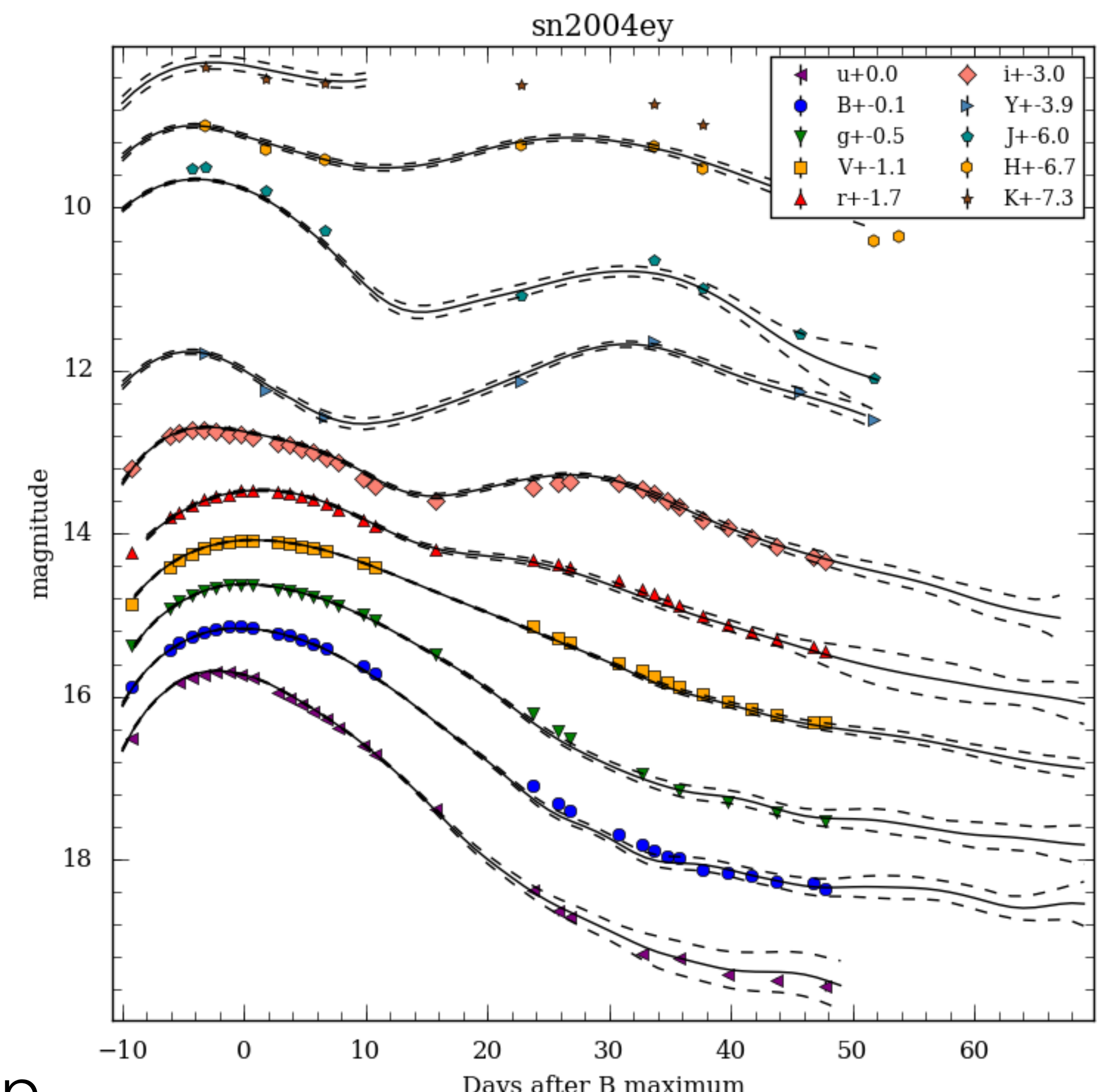


A solution: NIR observations!

- Near infrared (**NIR**) light is much **less sensitive to dust** than the optical wavelengths. Then the systematic uncertainty due to dust is reduced.

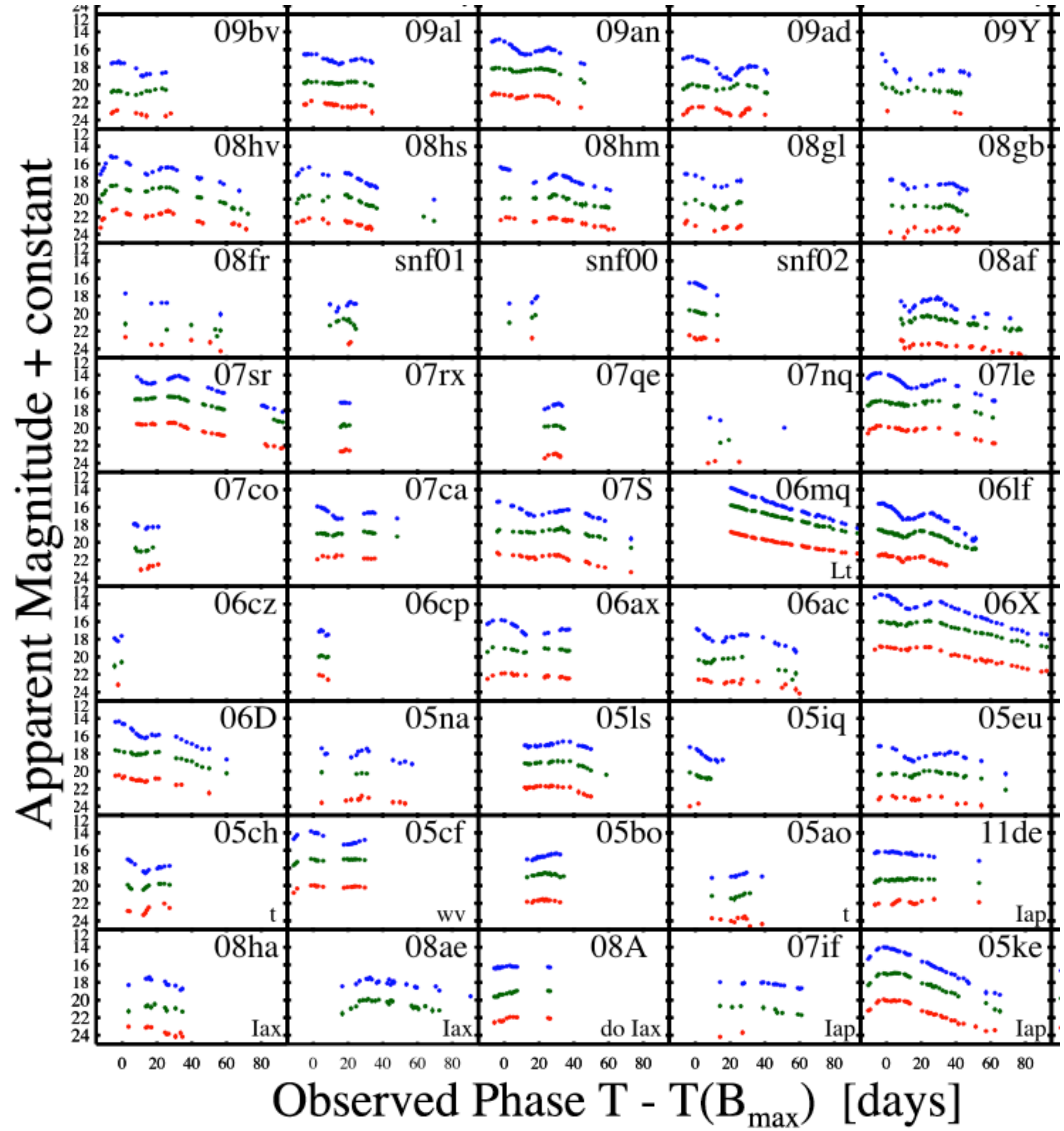
- SN Ia observed in **NIR** are much **more standard candles** than in optical wavelengths.

- **NIR** light curves have a **second maximum** that allow to have a **brighter SN for longer** compared with the optical bands and can help in **photometric classification.**



Low-z NIR sample

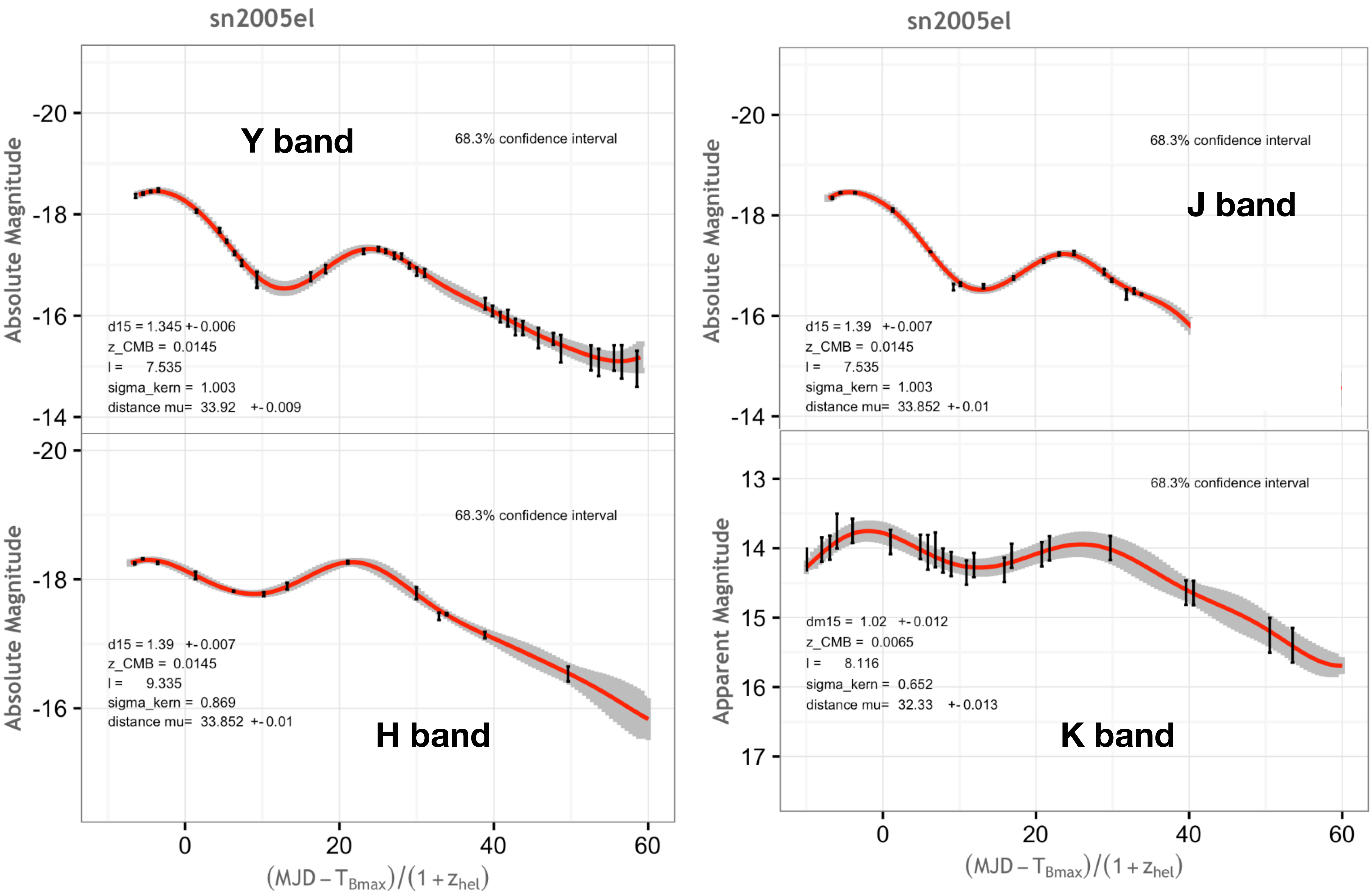
Friedman+2015



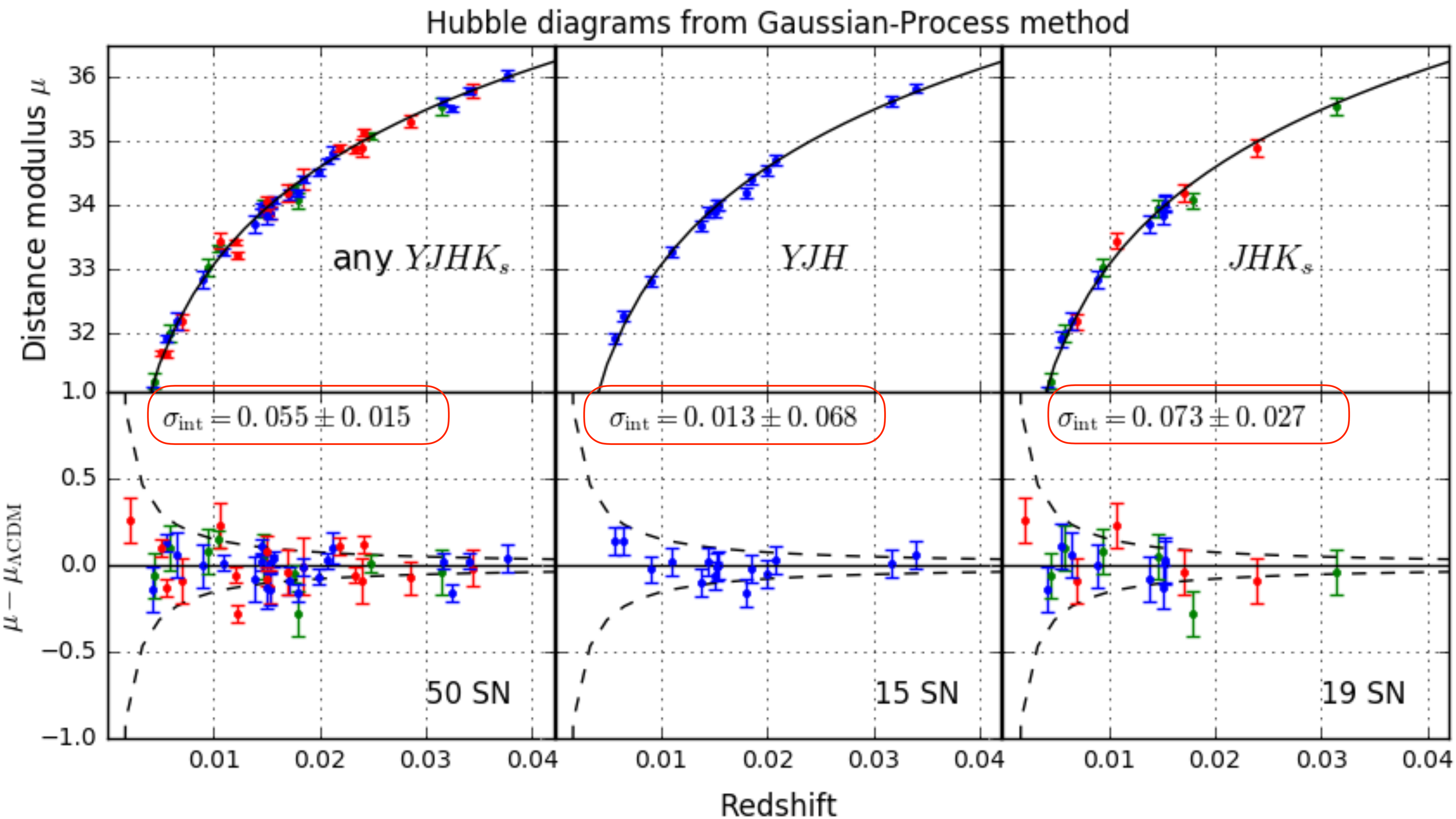
Compiled by **Andrew Friedman** (UCSD):

- CfA, CSP, Krisciunas
- 154 SN Ia with optical + NIR (YJHK) light curves

Gaussian-Process Method



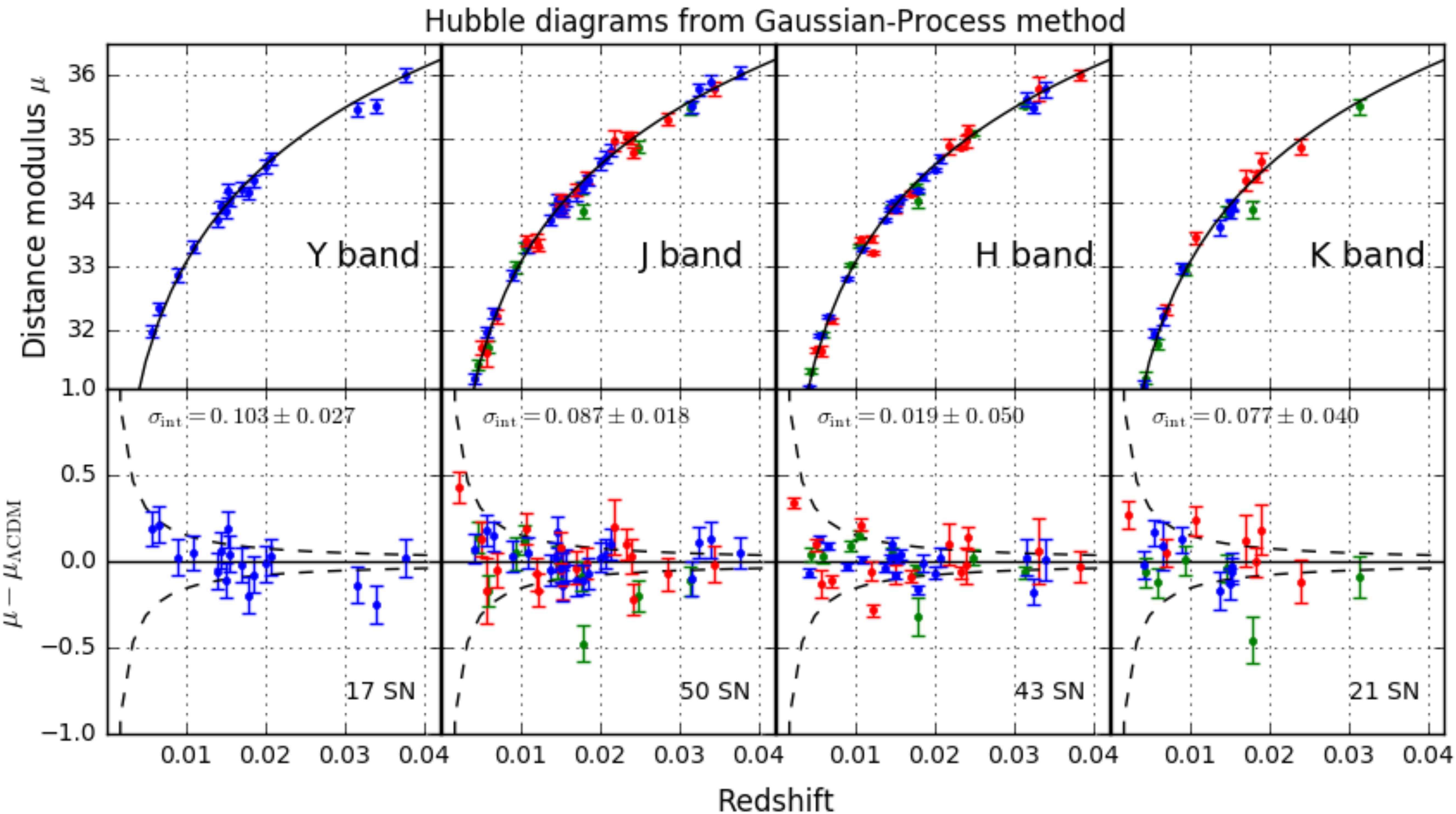
Gaussian-Process Method



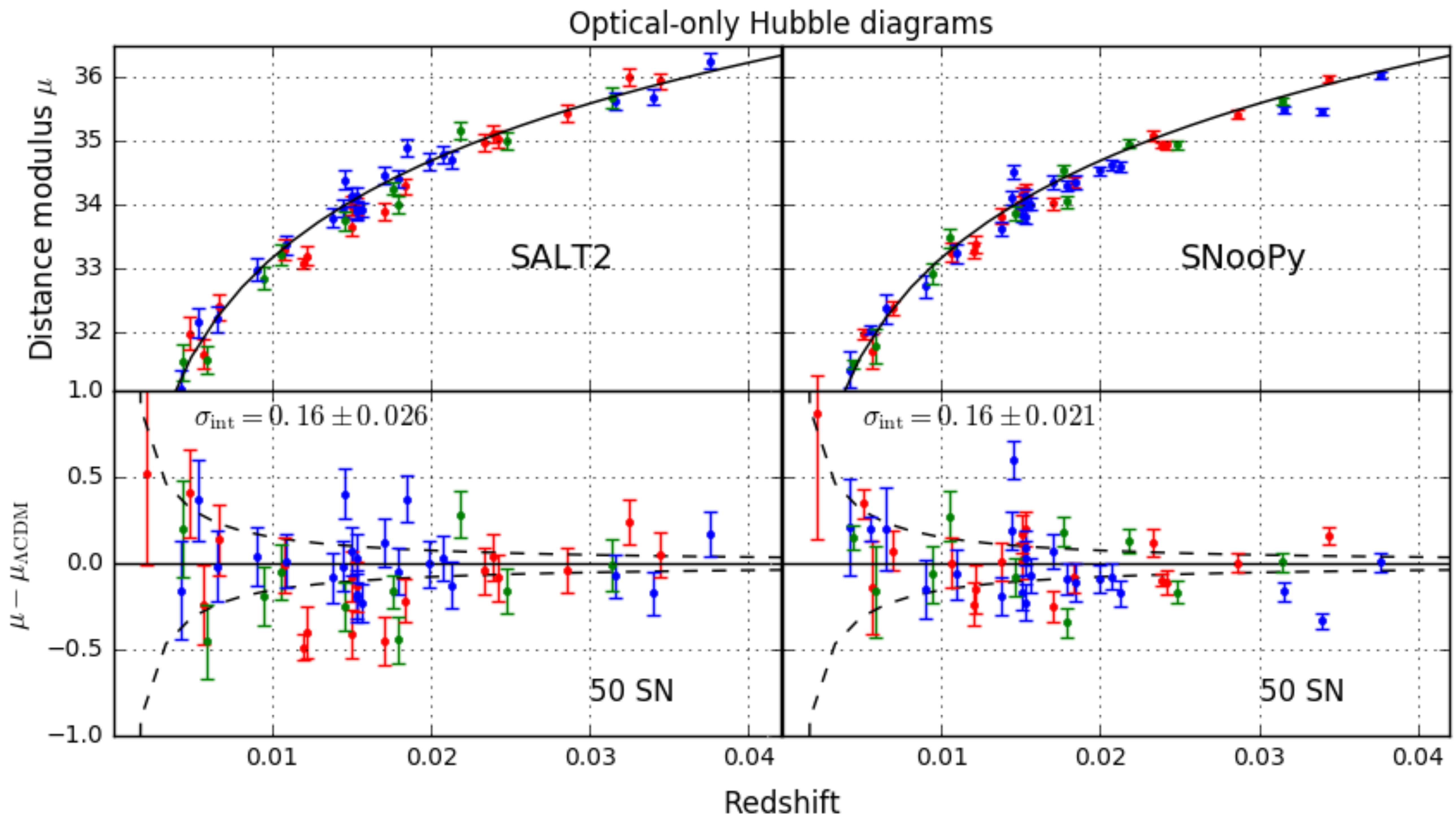
Determination of the intrinsic dispersion $\sigma_{\rm int}$:

$$-2\ln\mathcal{L}(\sigma^2_{\rm int}) = \sum_s^{N_{\rm SN}} \left[\ln\left(\sigma^2_{\rm int} + \sigma^2_{\mu_{{\rm pec},s}}\right) + \frac{\delta\mu_s^2}{\sigma^2_{\rm int} + \sigma^2_{\mu_{{\rm pec},s}}} \right]$$

Gaussian-Process Method



Optical-only Hubble diagrams



Intrinsic dispersion and wRMS summary

Band	Method	σ_{int}	wRMS (mag)
Y	GP	0.103 ± 0.027	0.128
J	GP	0.087 ± 0.018	0.125
H	GP	0.019 ± 0.050	0.099
K	GP	0.077 ± 0.040	0.144
any $YJHK_s$	GP	0.055 ± 0.015	0.096
YJH	GP	0.013 ± 0.068	0.074
JHK_s	GP	0.073 ± 0.027	0.114
optical	SALT2	0.160 ± 0.026	0.220
optical	SNooPy	0.156 ± 0.021	0.170

RAISIN = SN IA in the IR

Tracing cosmic expansion with SN Ia in the Near Infrared

RAISIN-1

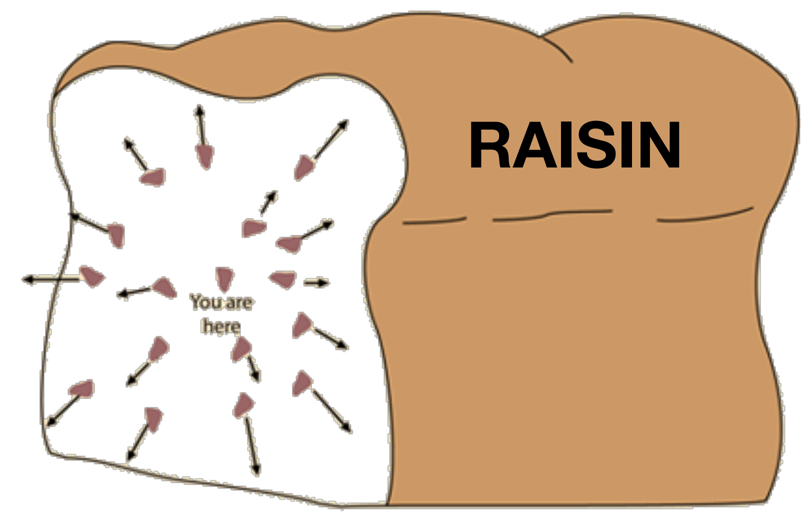
- 23 SN Ia with redshift ~ 0.3
- Spectroscopic classification and redshift from Magellan, MMT and Gemini.
- Optical (griz) photometry from PanSTARRS.
- Near-infrared photometry from HST (F125W, F160W)

RAISIN-2

- 24 SN Ia with redshift ~ 0.5
- Spectroscopic classification and redshift from Magellan, MMT and Gemini.
- Optical (griz) photometry from DES.
- Near-infrared photometry from HST (F125W, F160W)

Take away

- NIR SN Ia are very good standard candles compared with the optical-only observations.



- Very promising for cosmology when combining low-z & high-z of optical+NIR observations: **RAISIN** program, WFIRST.