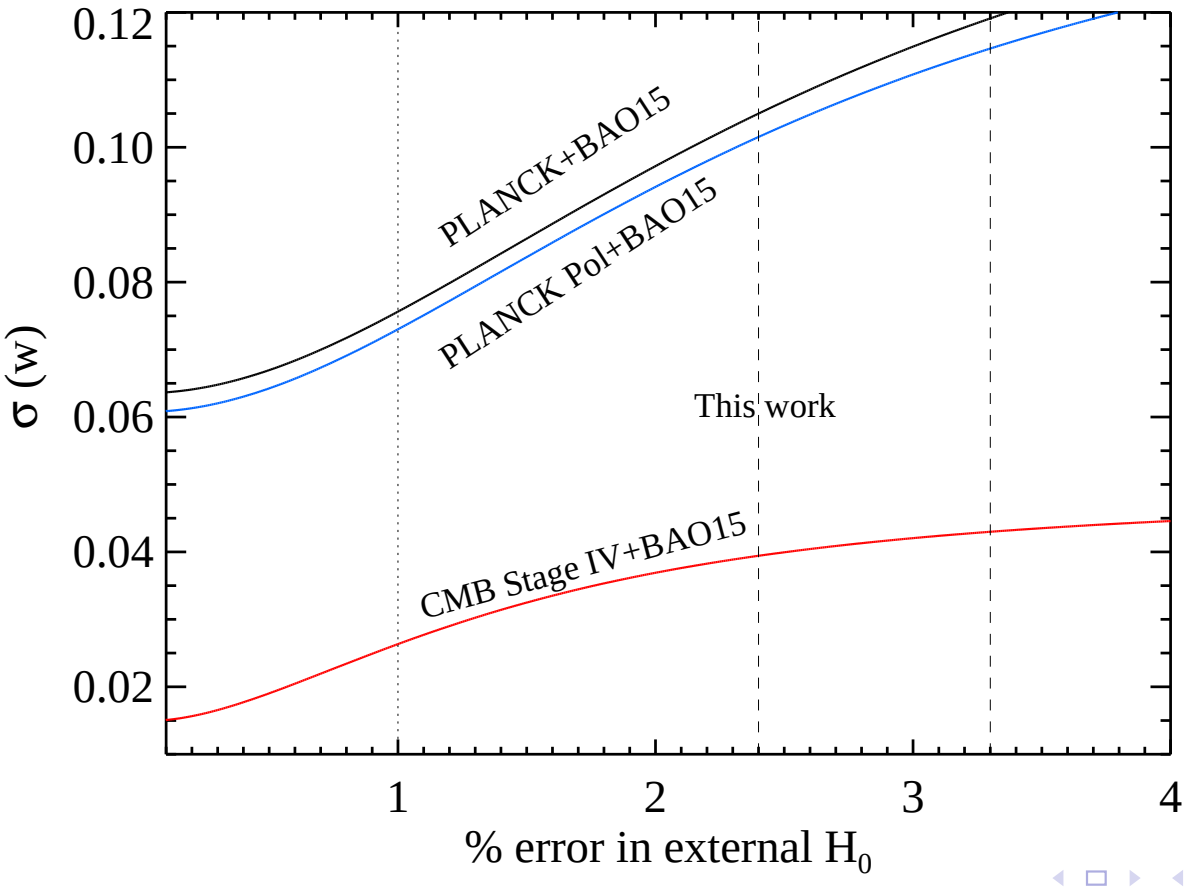
LSST16 at Pitts
Type II SNe as standard candles : review and LSST prospects

Nicolás Meza Retamal
Supervisor: Alejandro Clocchiatti

Insituto de Astrofísica (PUC), Instituto Milenio de Astrofísica (MAS)

Motivation

- We are not far from reaching $\sim 1\%$ precision in cosmological parameters (Riess et al. 2016)



Need of distance indicators

- Understanding systematics will be crucial if we aim to understand cosmic expansion in a greater detail.
- For this reason it is good to have independent measurements of the cosmological parameters.
- SN II distances have been proved to be useful and were not too far from Ia's (Using IR we have ~ 0.1 mag rms in the hubble diagram. Rodriguez Ósmar et al 2016 in prep)

Type II SNe

- The progenitors of type II-P SNe are trust-worthily asocciated to Red Supergiants ($\approx 8 - 16 M_{\odot}$).
- The physics of H dominated atmosphere are simpler to model ... but
- Great variety of observational properties explained from the diversity on the progenitors (+ probably interaction with CSM)

Type II are standarizable !

- Theoretichal aproaches : EPM (Kirshner-Swan, 1974) , SEAM (Baron 2006, Dessart-Hillier 2006)
- Empirical : SCM (Hamuy-Pinto, 2002) , PMM (Rodriguez 2014) , PCM (De Jaegger, 2015)

The basic idea

- The ejecta rapidly achieves homologous expansion
- Well defined photosphere in the optically thick phase
- Remember the Steffan Boltzmann law ... (Black body ? ... why not !)

$$\begin{aligned} \mathcal{F}_\lambda &= \left(\frac{R_{ph}}{d_L}\right)^2 I_\lambda(T(t)_{ph}, t) = \left(\frac{v_{ph}\cdot(t-t_0)}{d_L}\right)^2 I_\lambda \\ \rightarrow \mu_{\bar{\lambda}} &= \underbrace{m_{corr}}_{\text{rest frame, AKA corrected}} - \underbrace{\mathcal{M}_{\bar{\lambda}}(t)}_{\text{Photospheric Intensity}} - \underbrace{\mathcal{R}_{ph}(t)}_{\text{Size term}} \end{aligned} \tag{1}$$

Standard Candle Method (SCM)

- SCM is a Ia like calibration using the tight luminosity-velocity at the middle plateau (Originally from Hamuy-pinto) relation and a color term
- Already used at reasonable redshifts (up to $z \approx 0.1$ Nugent,D'andrea and Poznaski with SDSS-II sample)

$$M_{X,Y} = -\alpha \log v_{50} + \beta(Y - X) + M_0 \tag{2}$$

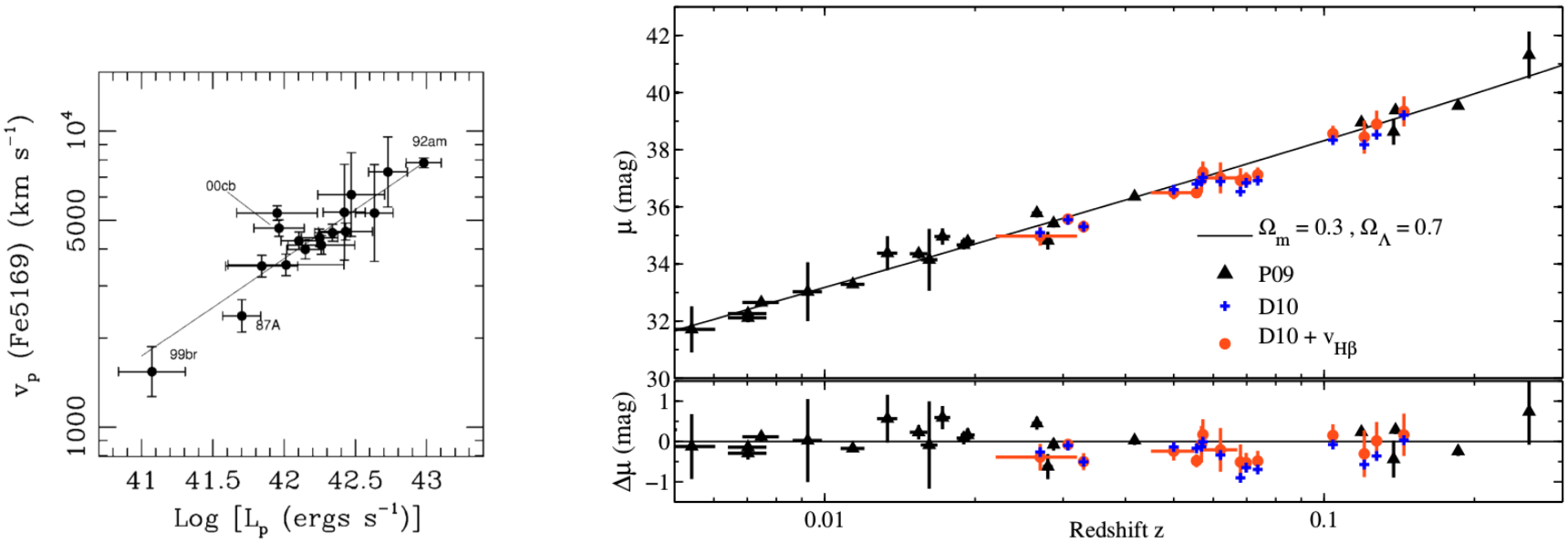
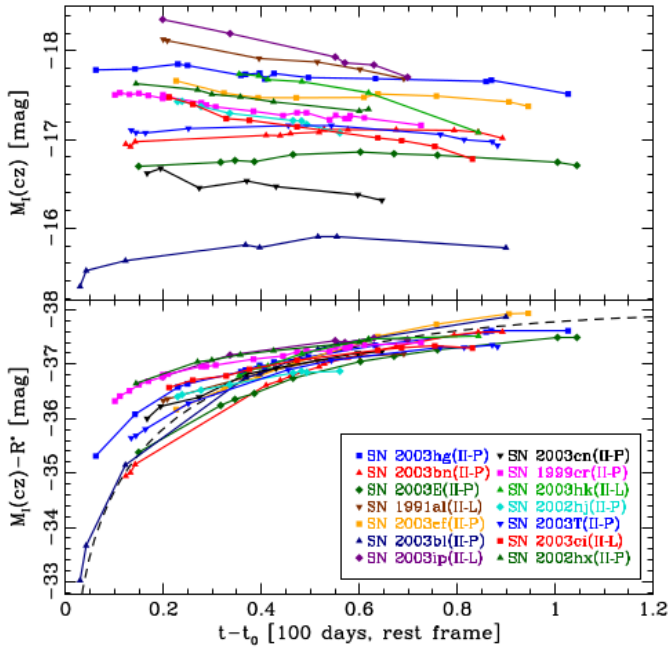


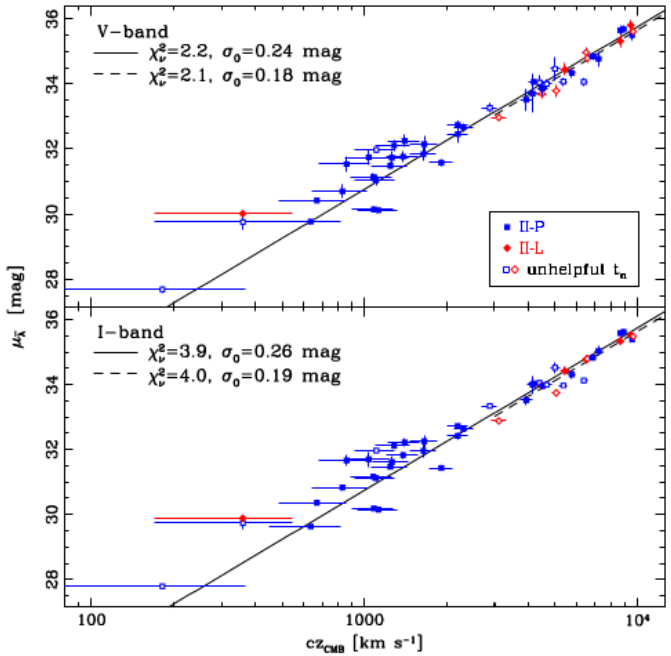
Figure : Left: L-v correlation. Right : Podznaski HD

Photospheric Magnitude Method (PMM)

- Time based standarization of the photospheric magnitude gives ≈ 0.2 dispersion in the HD.
- Distance can be measured at any time in the plateau given the explosion time and an expansion velocity.

$$\mu_{\bar{\lambda}} = \underbrace{m_{corr}}_{\text{rest frame, AKA corrected}} - \underbrace{\mathcal{M}_{\bar{\lambda}}(t)}_{\text{Photospheric Intensity}} - \underbrace{\mathcal{R}_{ph}(t)}_{\text{Size term}} \quad (3)$$

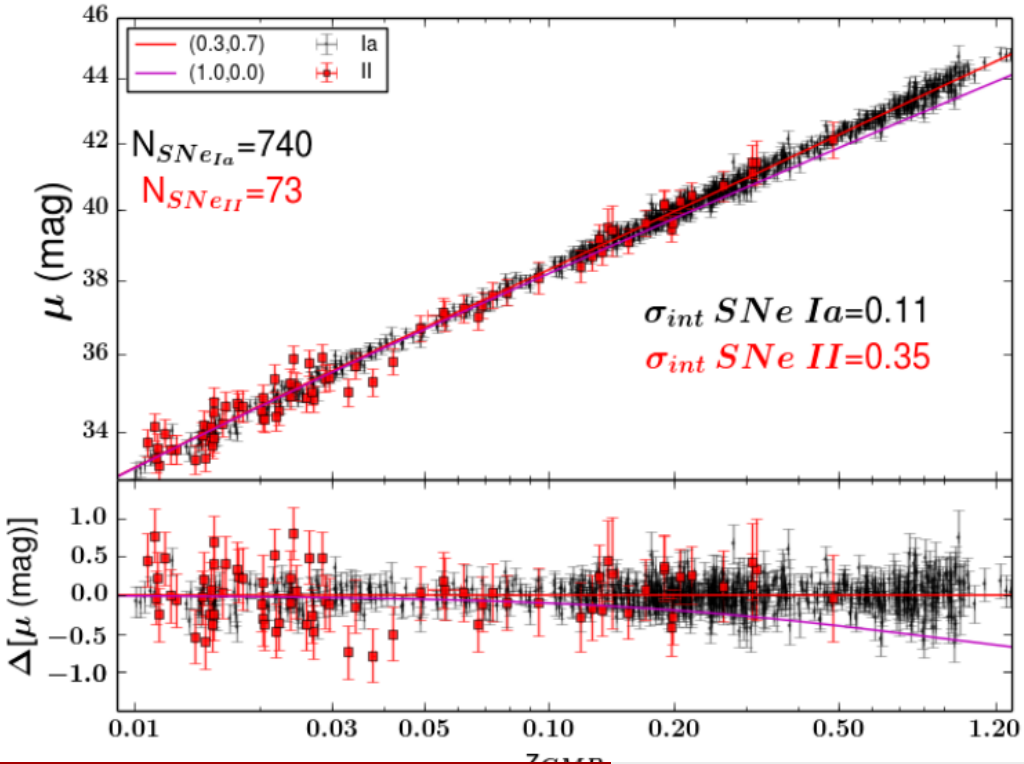




Do we need spectra ?

- We use spectra to get expansion velocities from optically thin lines.
- De Jaegger et al. (2016, soon to be sent to ApJ) recently showned the Photometric Colour Method (PCM) that relies on the plateau slope (s_2, see J. Anderson work) and got 0.35 mag dispersion versus 0.27 with SCM, up to $z = 0.2$ (CSP+SDSS+SNLS).

$$M_{X,Y} = -\alpha \log s_2 + \beta(Y - X) + M_0 \quad (4)$$



LSST prospects

- LSST **will** have thousands of type II SNe (type II covers the mayority of the fraction of all SNe)
- The larger time scale of a typical type II-P SNe would apparently be favorable for the LSST cadence (which we dont know yet !)
- type II-P are easily identifiable from their light curves versus their H-poor counterparts.
- Sadly we dont have the large sample that Ia's have and there's a lot to be done ! (K-corrections, Simulations)
- We need to do simulations to check the actual contribution of type II cosmology (redshift range of interest, number expected at each bin and follow-up posibilities).

Conclusions

- Type II SNe are standarizable and they promise to be a contribution to cosmology with LSST and the upcoming follow-up facilities.
- To get a live time follow up is best but we already have photometry-only methods to get type II distances.
- A lot of work needs to be done ! (Classification issues, Cosmological simulations) We need interest and advise from Ia people already working on this issues.

The End