Transients and Cosmic distance ladder

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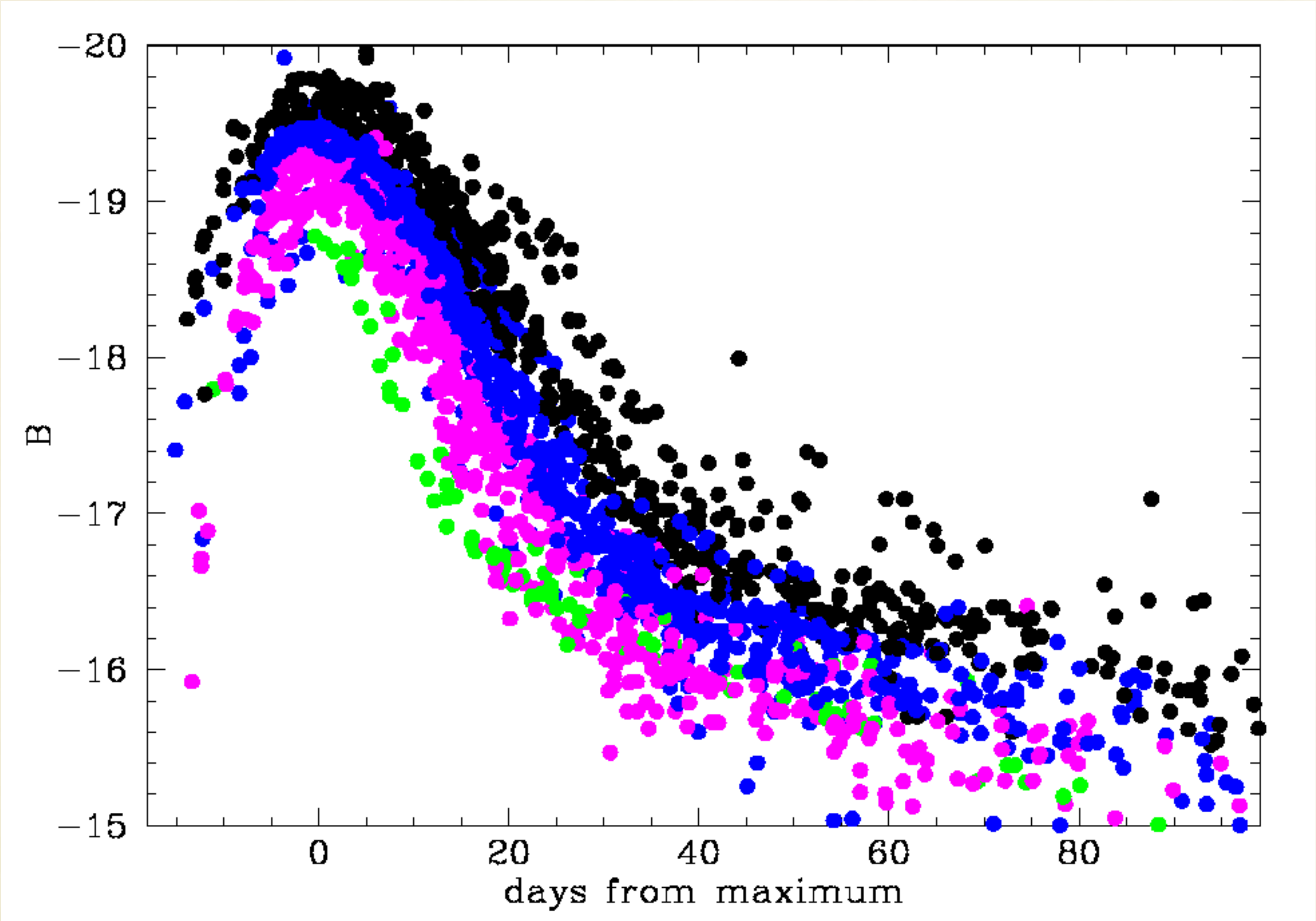
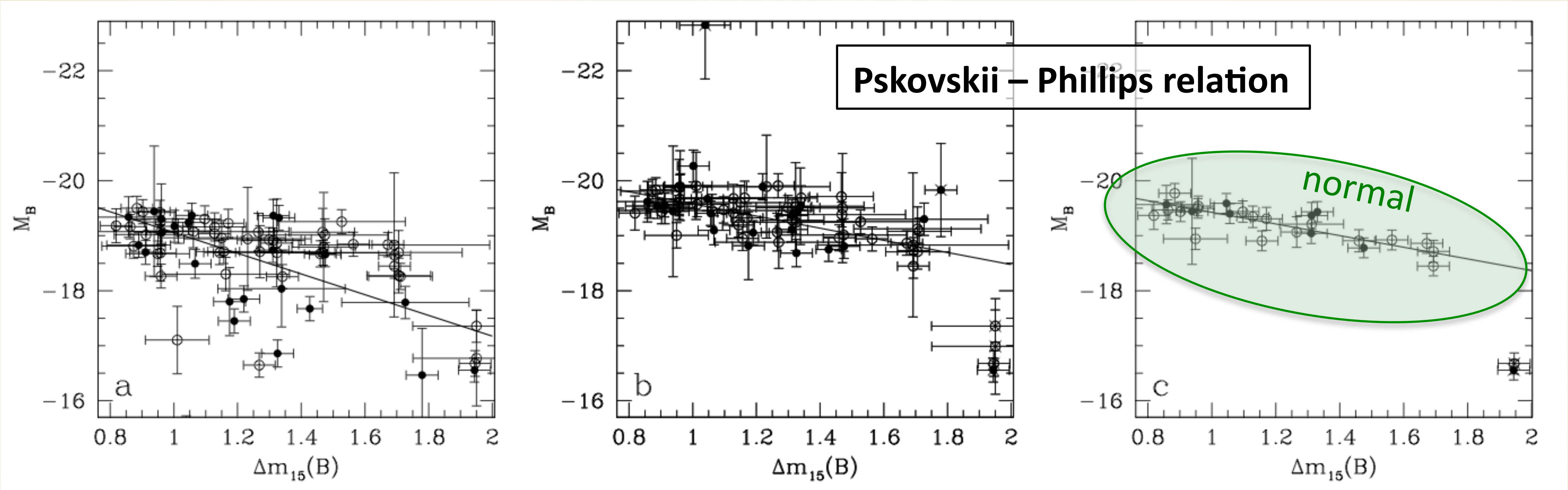
Bologna 16 June 2016

SNIa are the best!





Altavilla+ 2004

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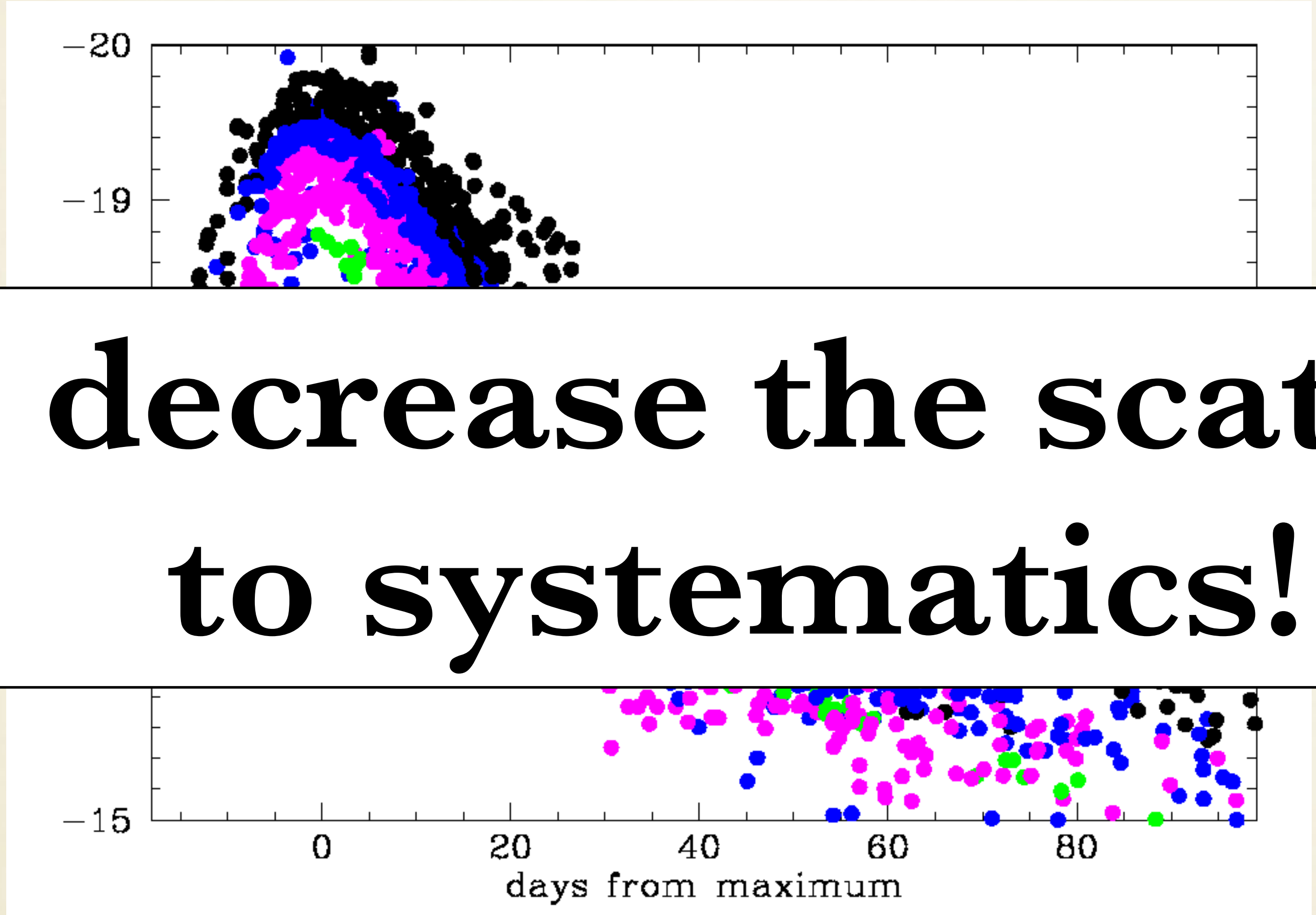
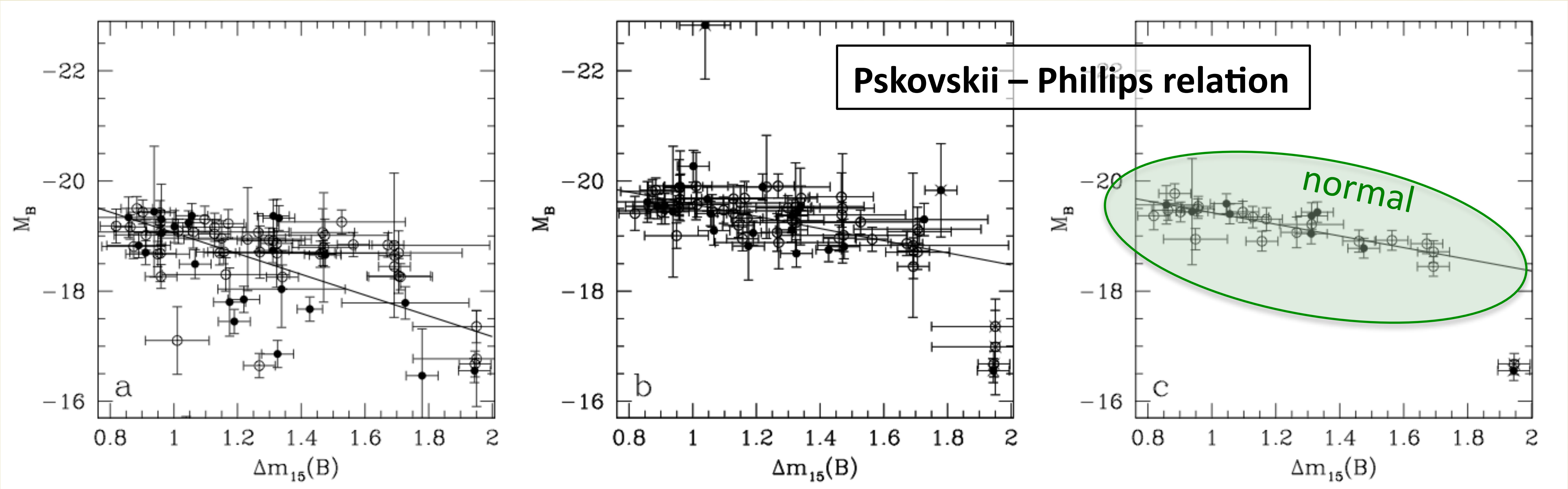
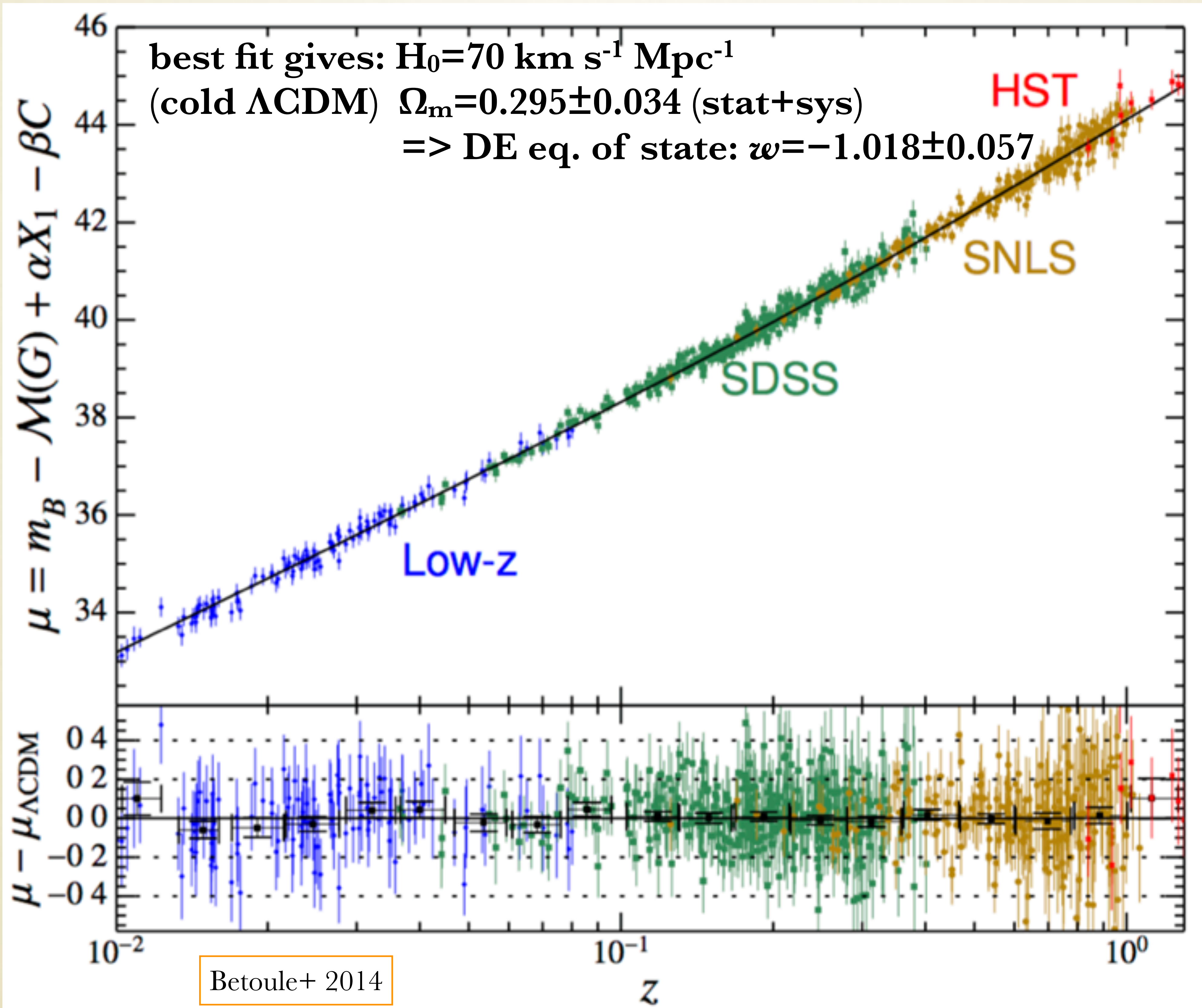


Goal: decrease the scatter due to systematics!



Altavilla+ 2004

Hubble diagram with SNIa



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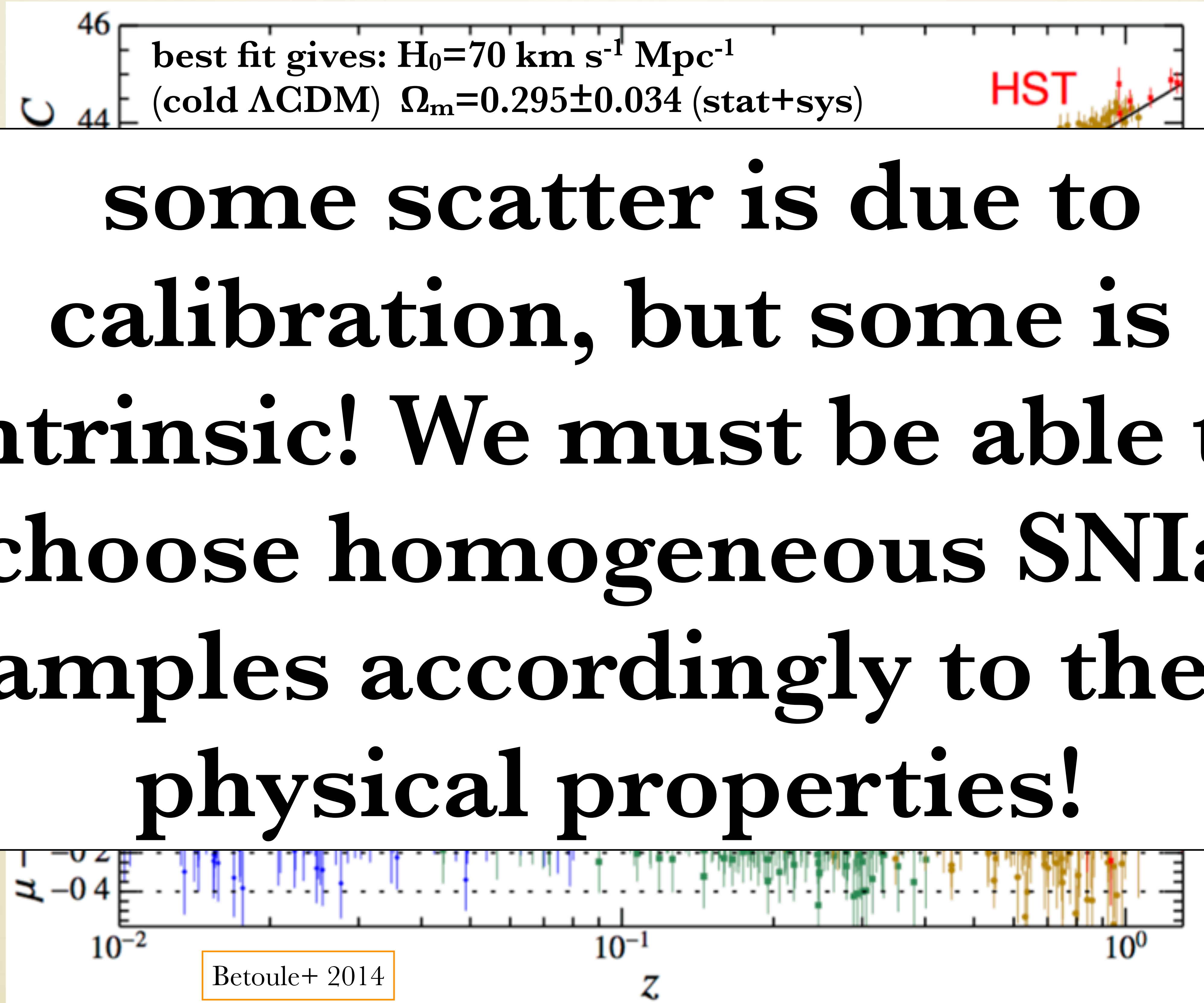

some scatter is due to calibration, but some is intrinsic! We must be able to choose homogeneous SNIa samples accordingly to their physical properties!

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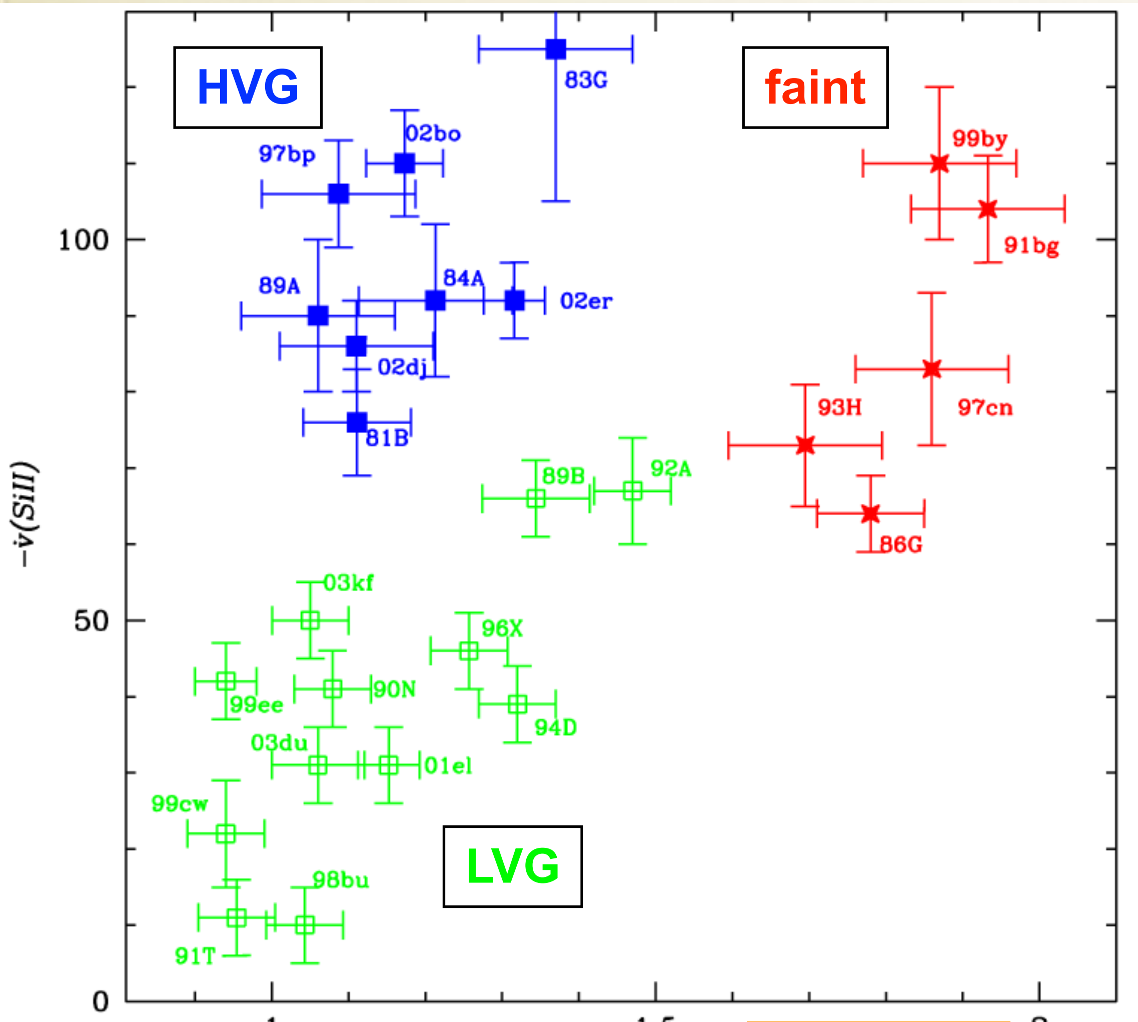
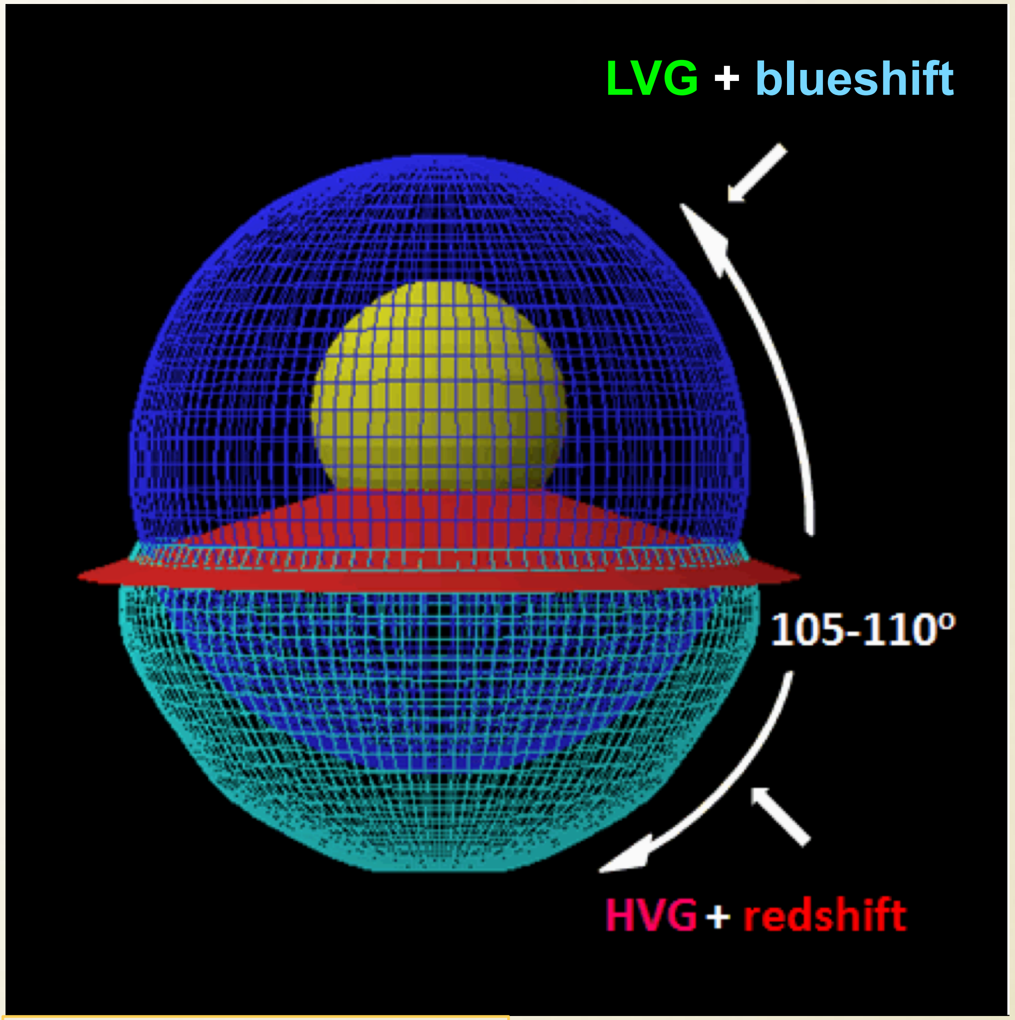
Early attempts: Understanding the physics with diversity



Benetti+ 2005



Maeda, Benetti+ 2010, Nature

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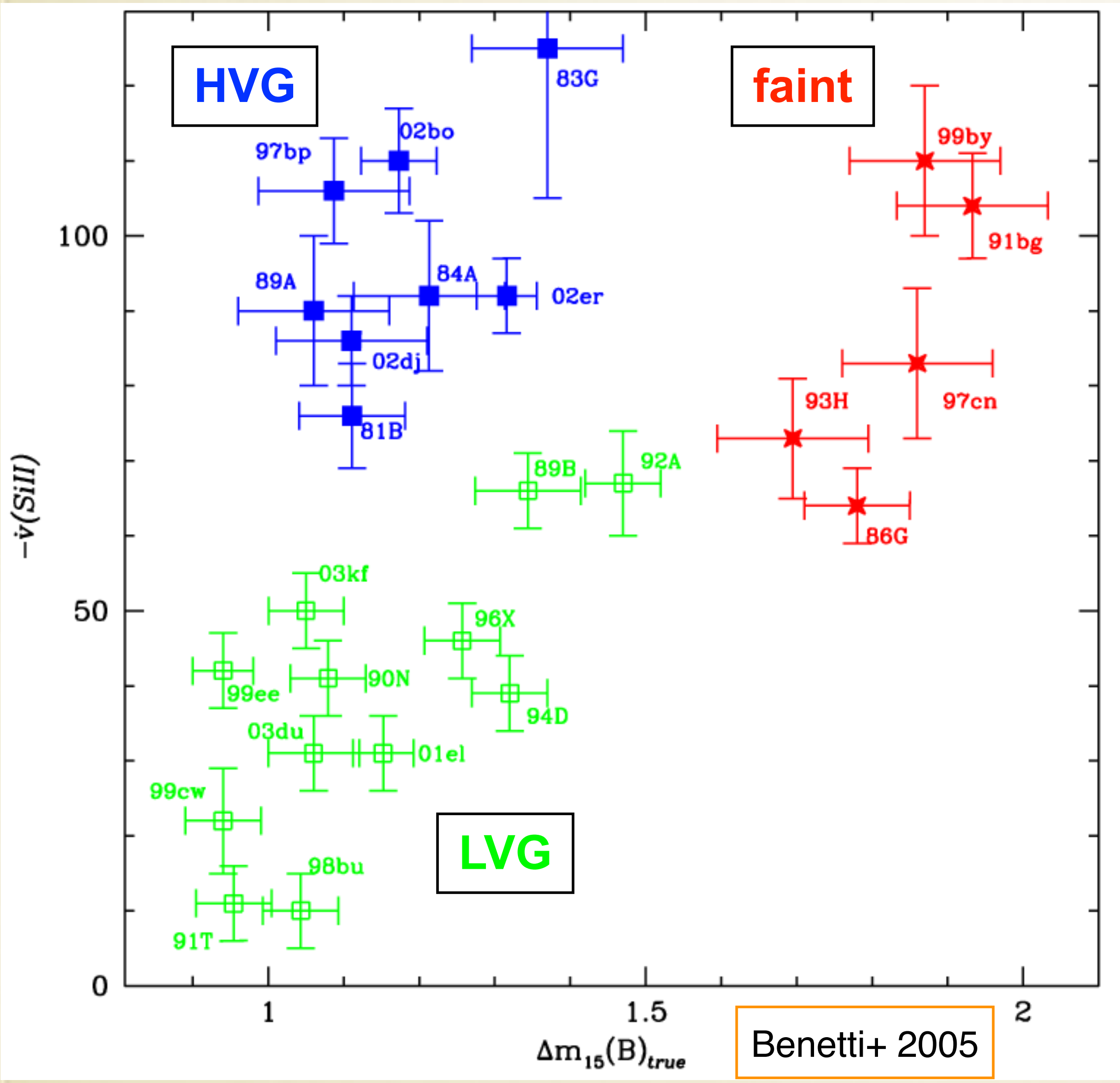

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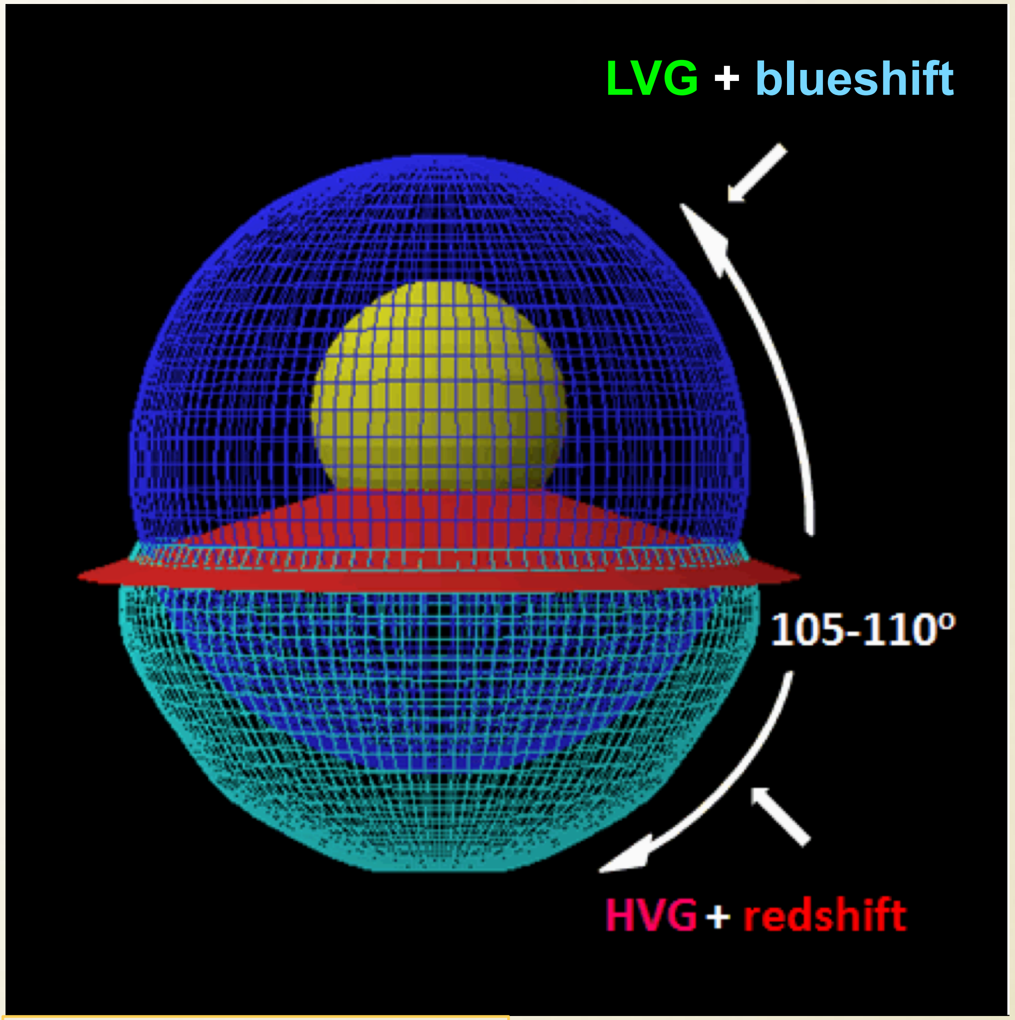

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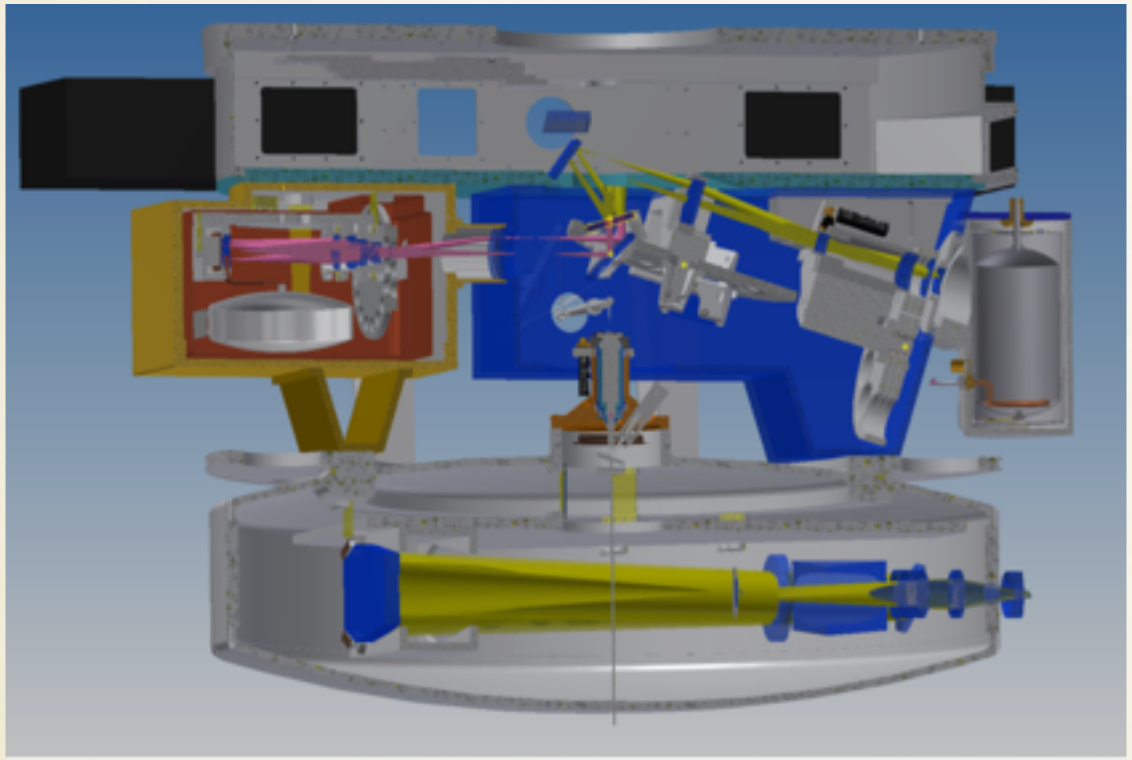
SNIa: DD explosions of Ch. mass C/O WDs seen from different directions!

Needs: follow nearby SNIa with higher resolutions and λ range!



SOXS PI S. Campana

After PESSTO we need:

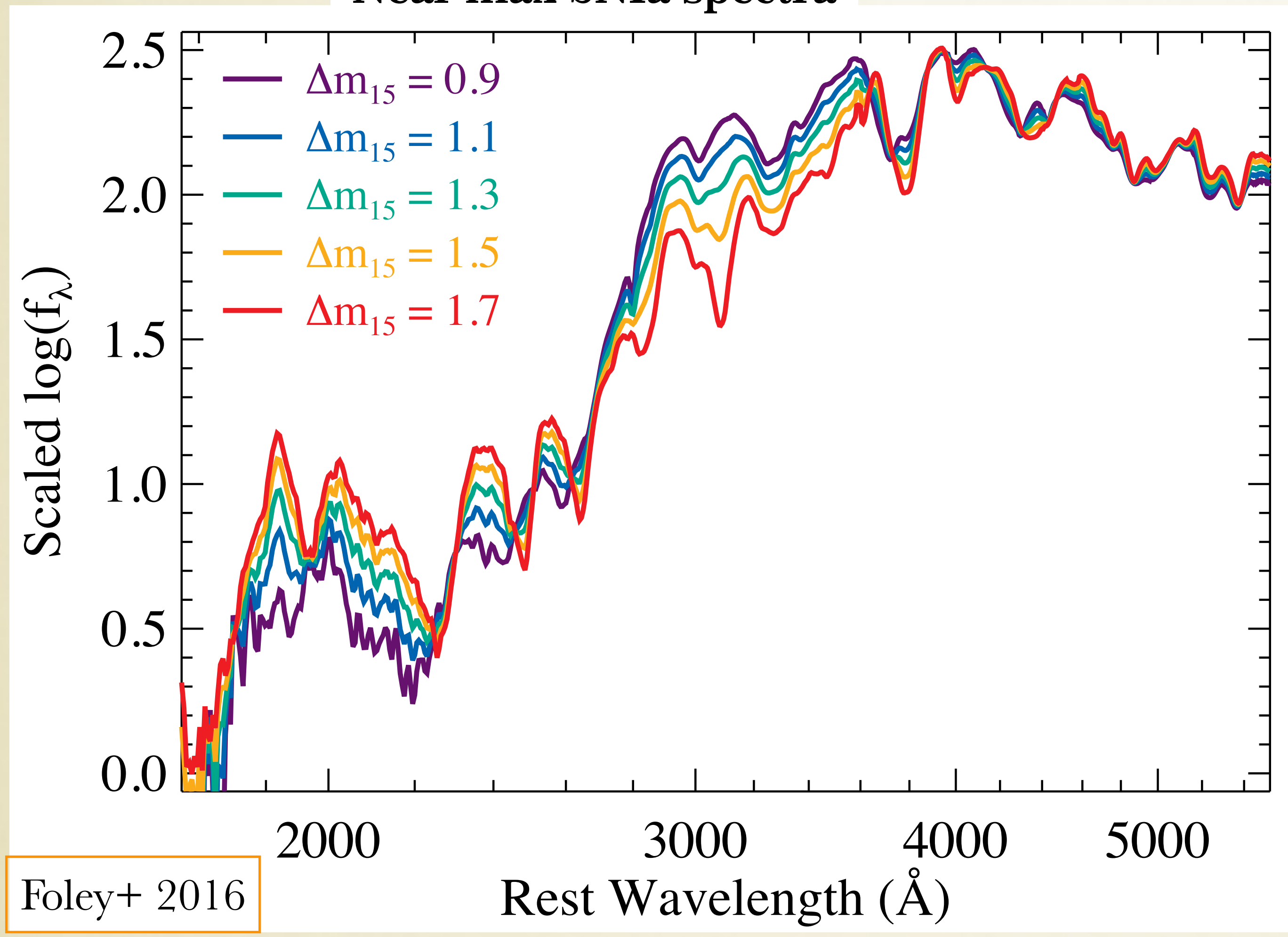
SOXS@NTT and NTE@NOT

to follow SNIa from t_{expl} to t_{neb}

Explosion models from t_{expl} to t_{neb}

UV is the key!

Near max SNIa spectra



Foley+ 2016

Very homogeneous in optical but not in UV! Diversity UV connect to progenitor chemistry and explosion physics

Improve the SNIa observed in UV:

1) **Use HST (very expensive)**
2) **Go to redshifts 0.15-0.5 (mag_{max}>20.5) => to have enough S/N => VLT or ELT better (also expensive!)**

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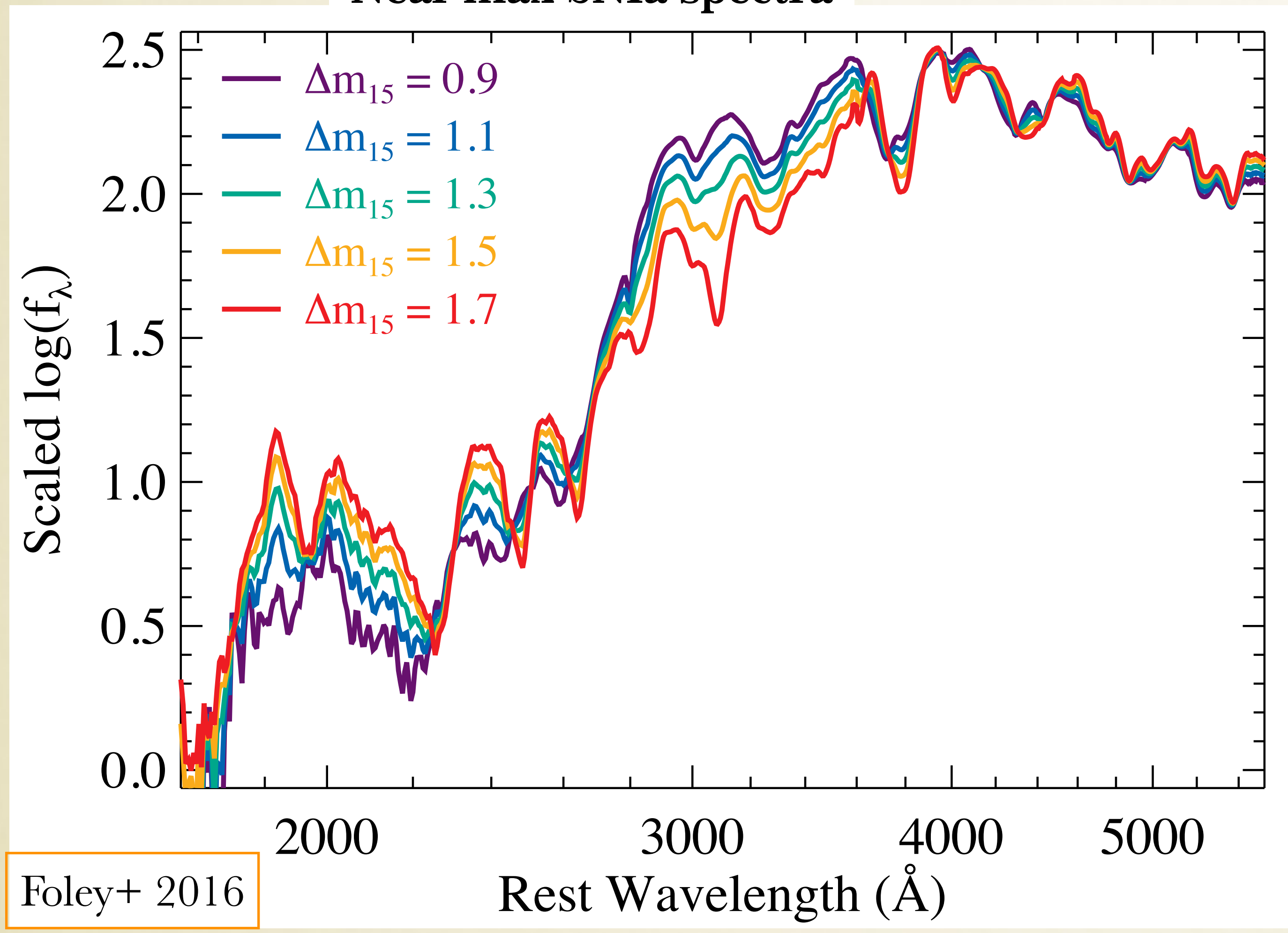

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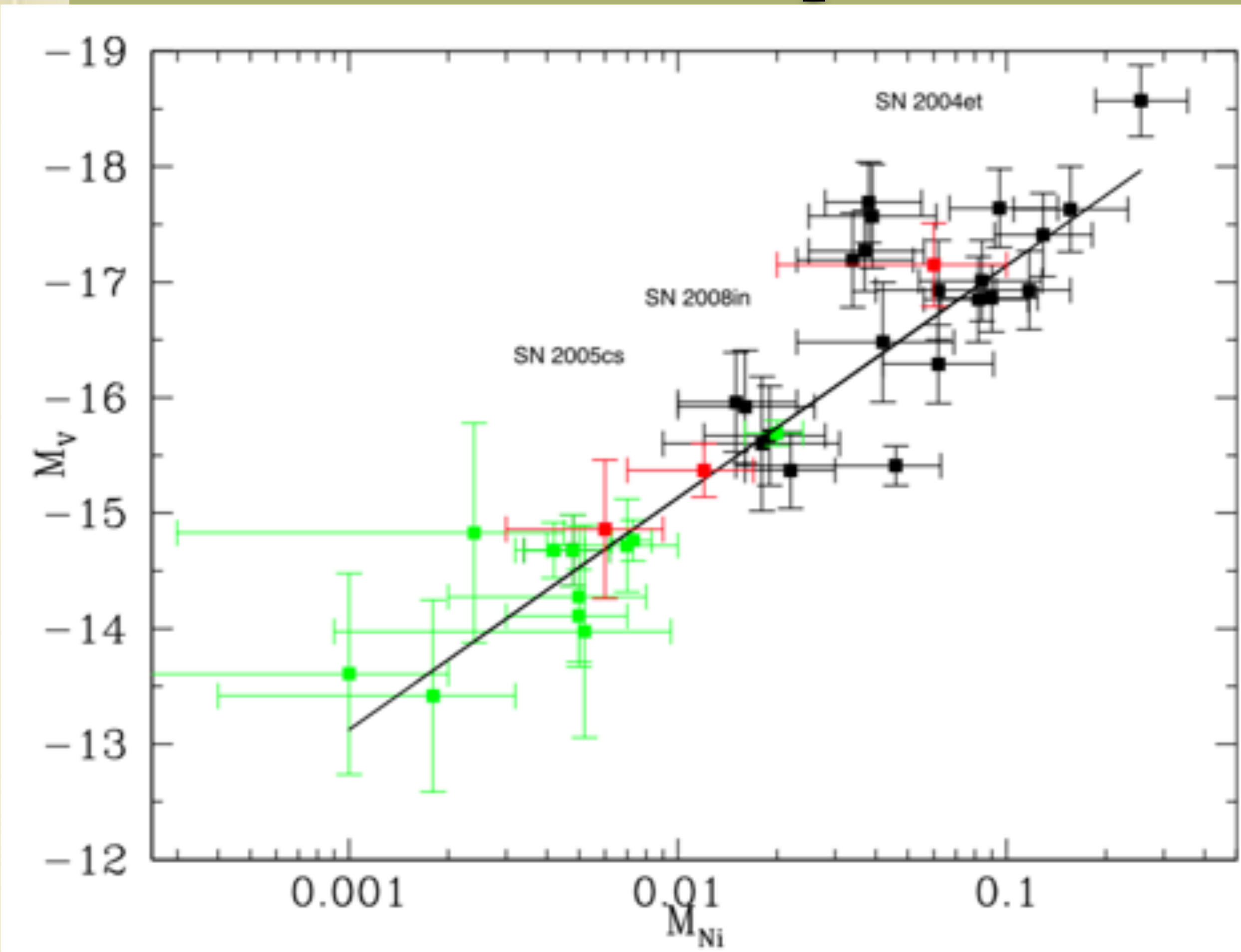
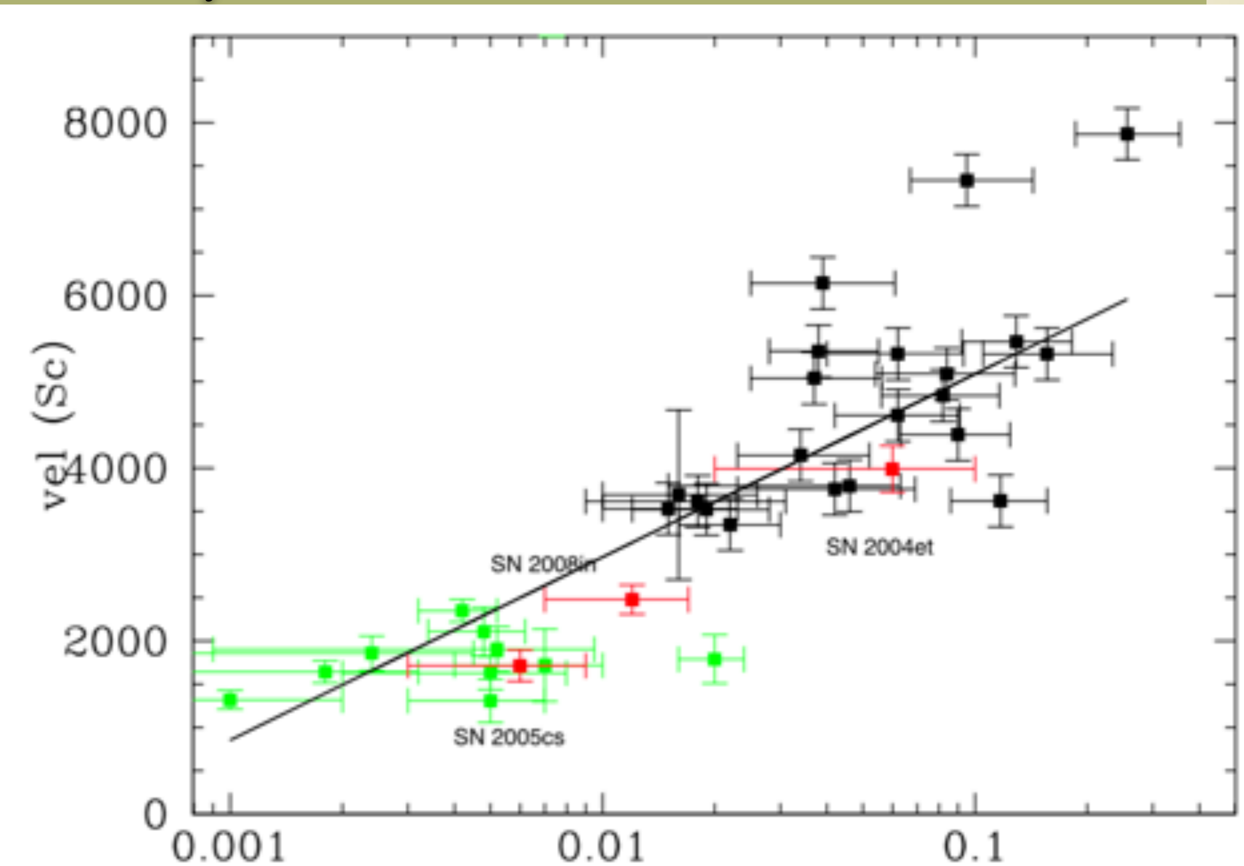
We need (LSST era) a spectroscopic survey (PESSTO-like) with VLT!

What about Core Collapse? SNIIP are the most common supernovae: are they useful?





Spiro+ 2014

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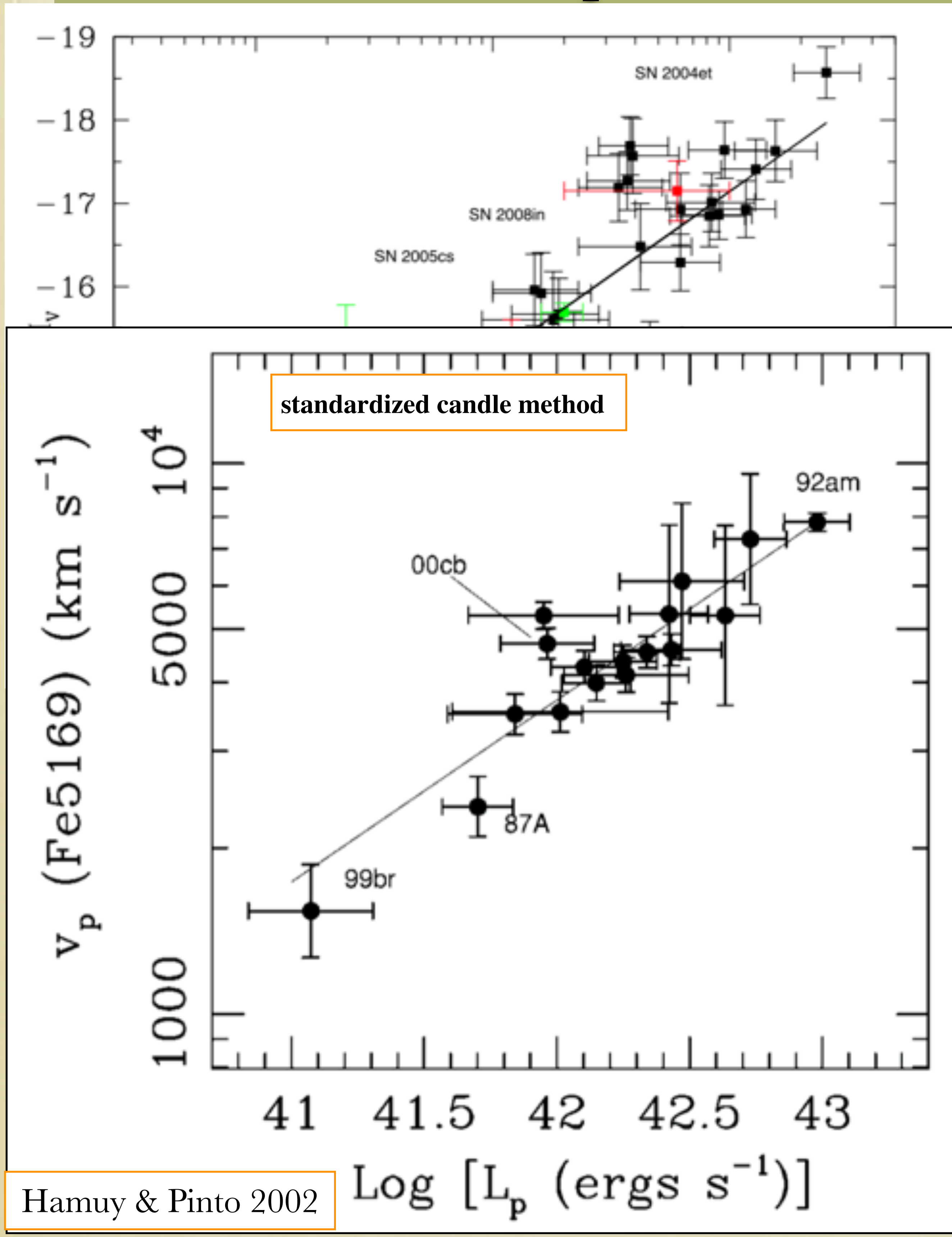
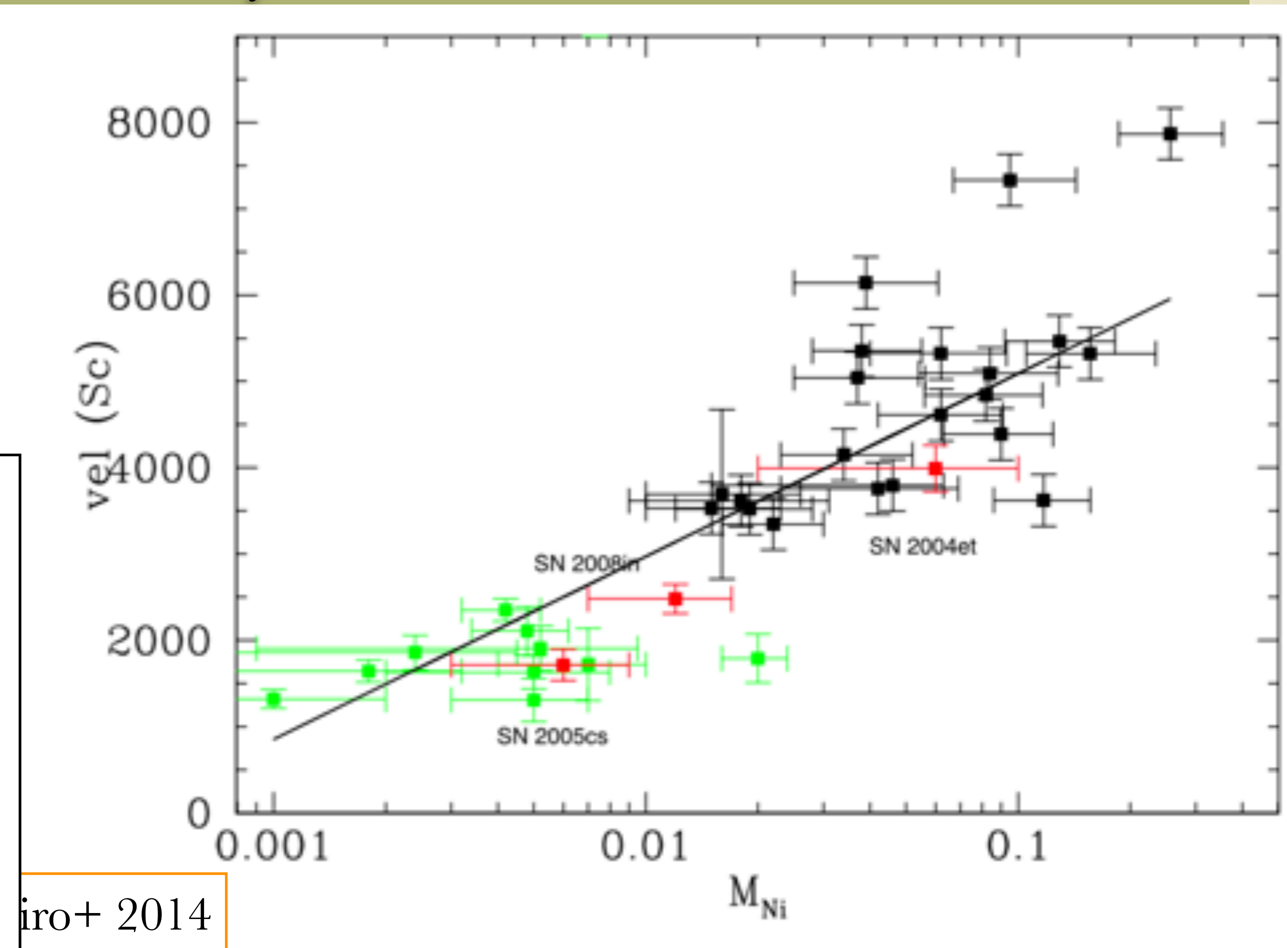


Hamuy & Pinto 2002



iro+ 2014

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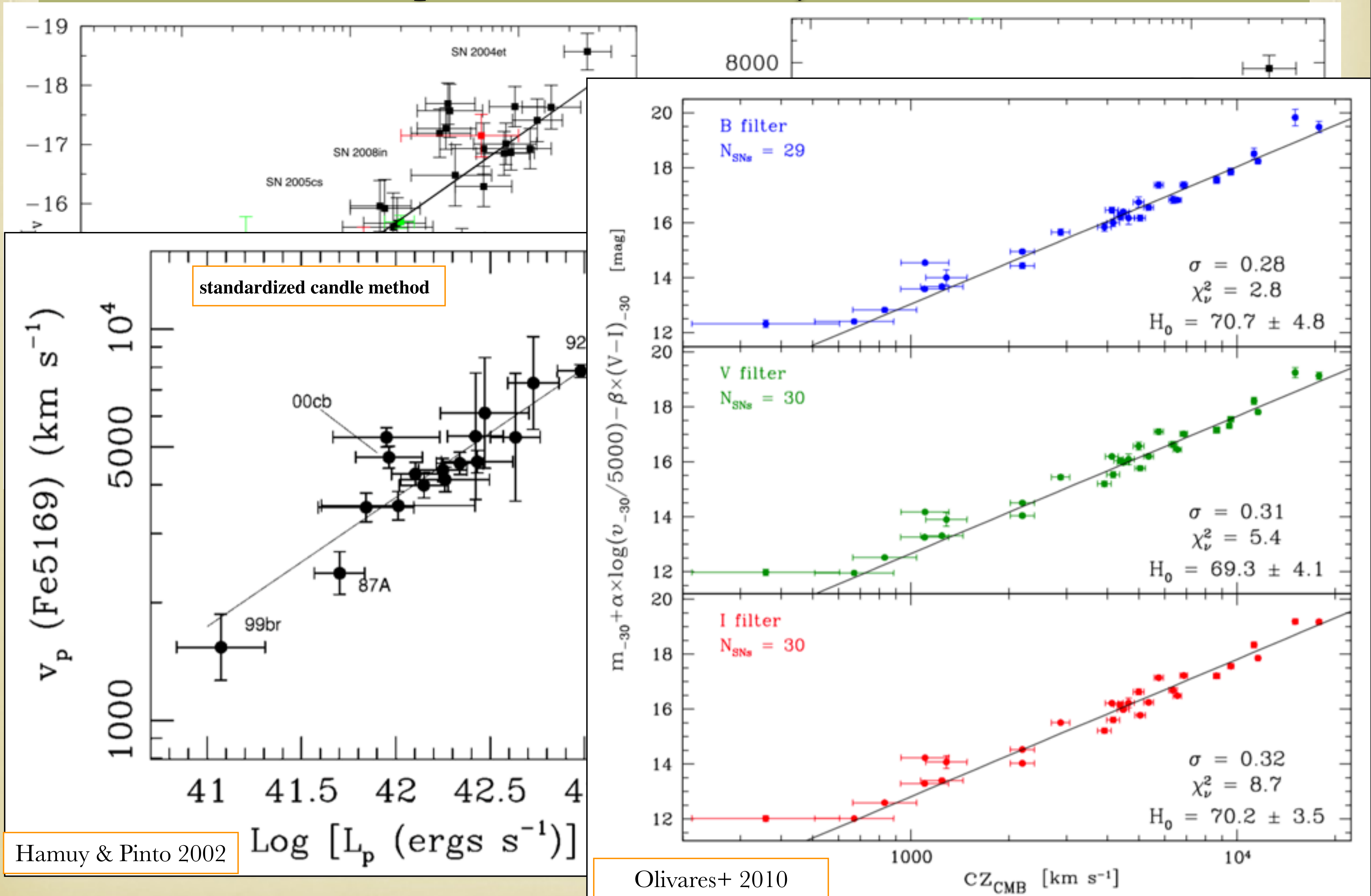

SNIIP & EPM (variant of the Baade–Wesselink method)

angular radius:

$$\theta = \frac{R}{D} = \sqrt{\frac{(1+z) f_\lambda}{\pi \zeta_{\lambda'}^2 B_{\lambda'}(T) 10^{-0.4[A(\lambda)+A'(\lambda')]}}}$$

but

$$R \approx \frac{v(t-t_0)}{1+z}$$

diluition factor is model dependent

$$\zeta_{\lambda'}^2 = \frac{L_{\lambda'}}{\pi B_{\lambda'}(T) 4\pi R^2}$$

$$\boxed{\frac{\theta_i}{v_i} \approx \frac{(t_i - t_0)}{(1+z)D}}$$

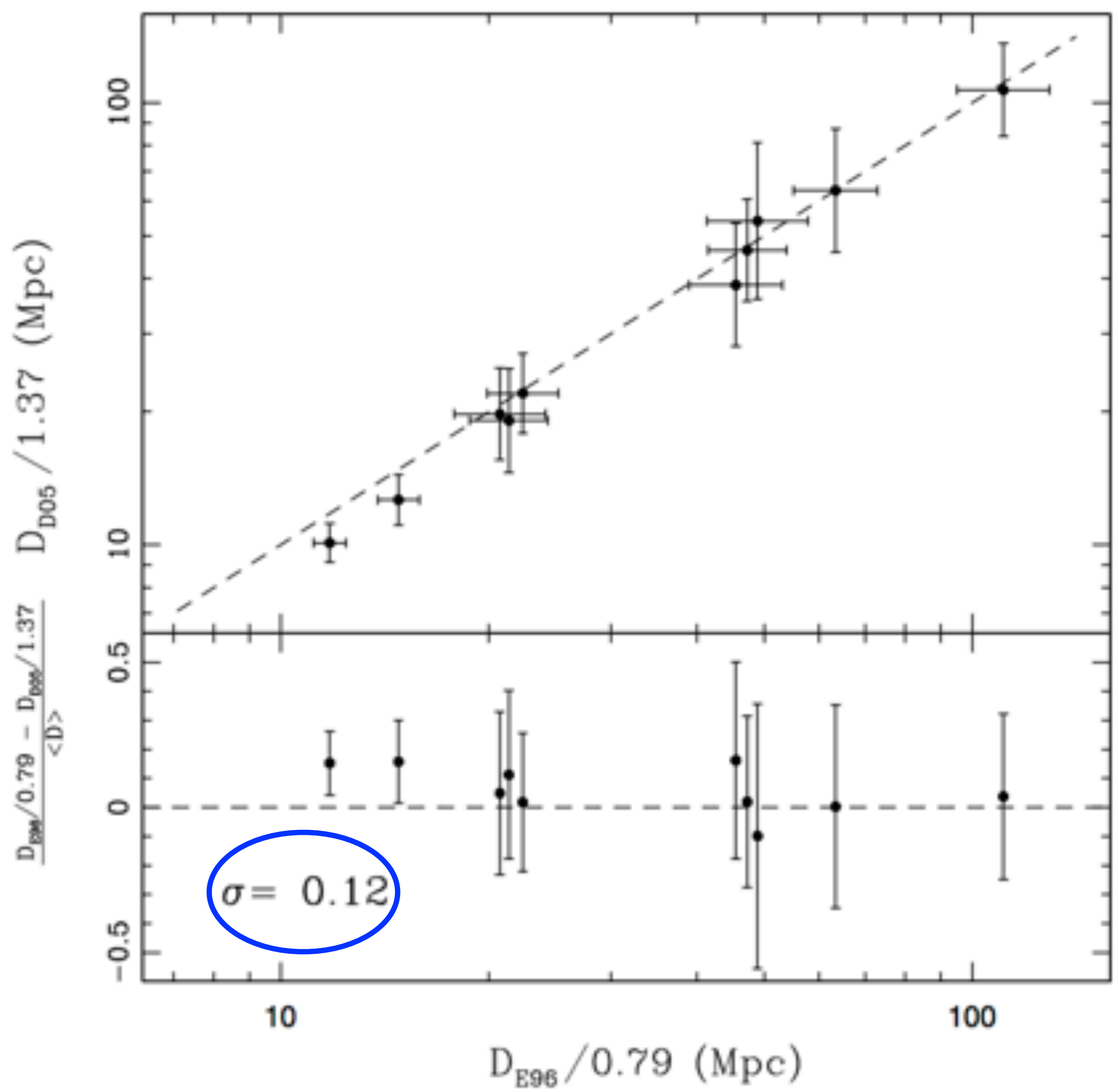

Figure 31. Top panel: D05 distances versus E96 distances corrected to the *HST Key Project* Cepheid scale. The dashed line shows slope unity. Bottom panel: differences between the corrected distances normalized to the average of the E96 and D05 corrected distances. The 12% scatter reflects the internal precision of the EPM.

Jones+ 2009

SNIIP & EPM (variant of the Baade–Wesselink method)

angular radius: $\theta = \dfrac{R}{D} = \sqrt{\dfrac{(1+z)f_\lambda}{\pi \zeta^2_{\lambda'} B_{\lambda'}(T) 10^{-0.4[A(\lambda)+A'(\lambda')]}}}$ **but** $R \approx \dfrac{v(t-t_0)}{1+z}$

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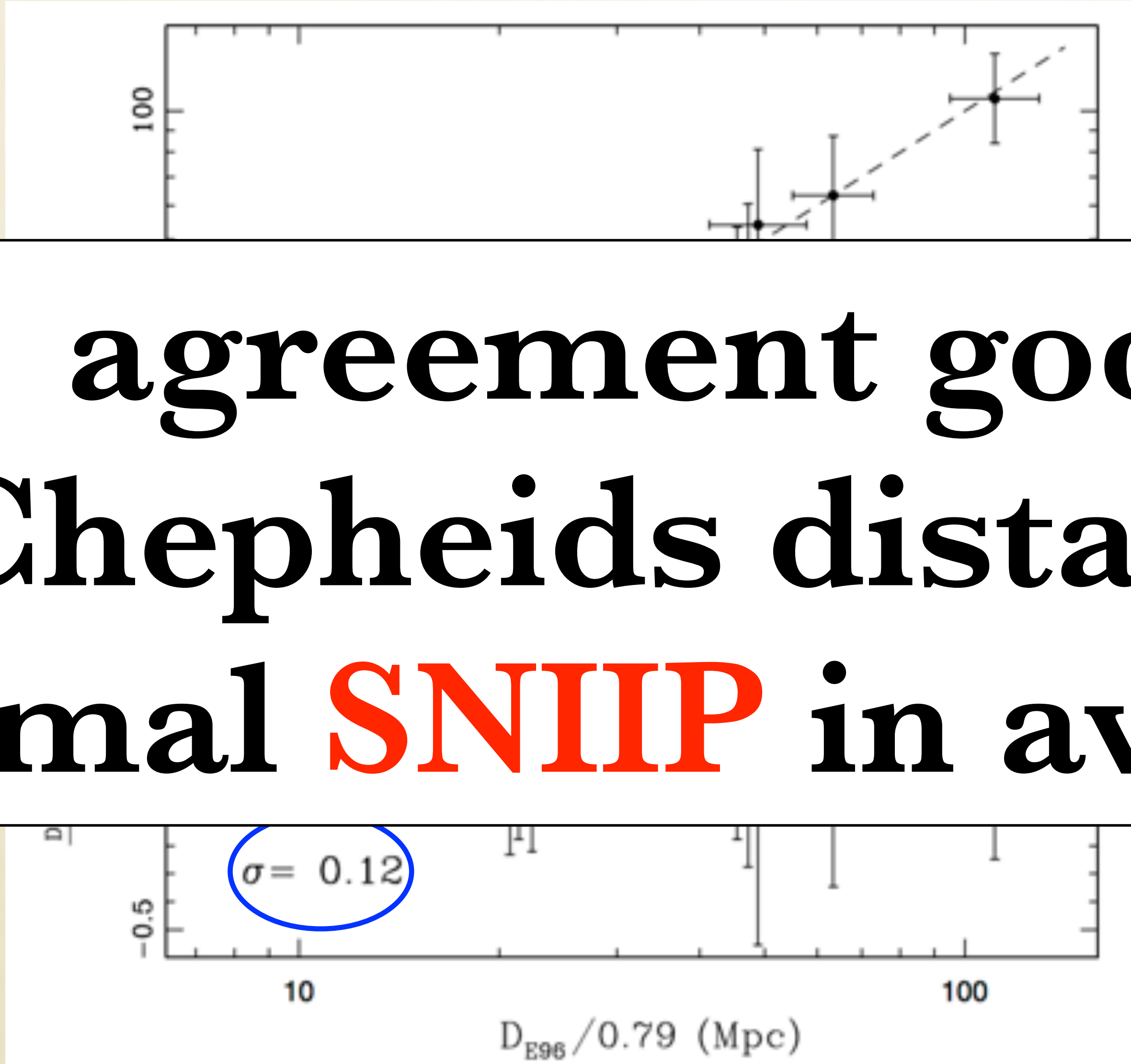

agreement good with Chepheids distances, but normal SNIIP in average faint!

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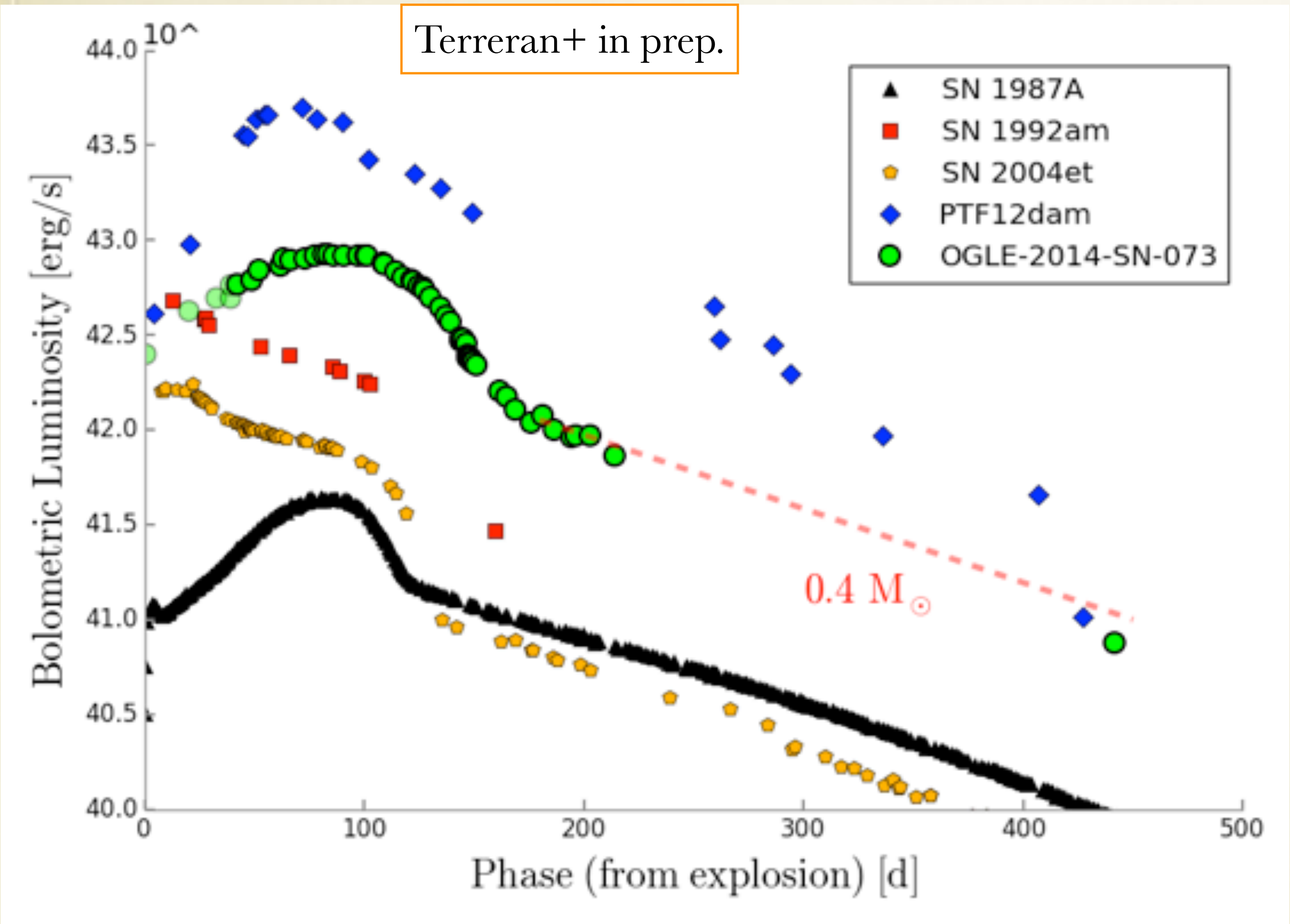
Jones+ 2009

Much more interesting if above methods are applied to luminous SNII: the case of **OGLE-2014-SN-073**



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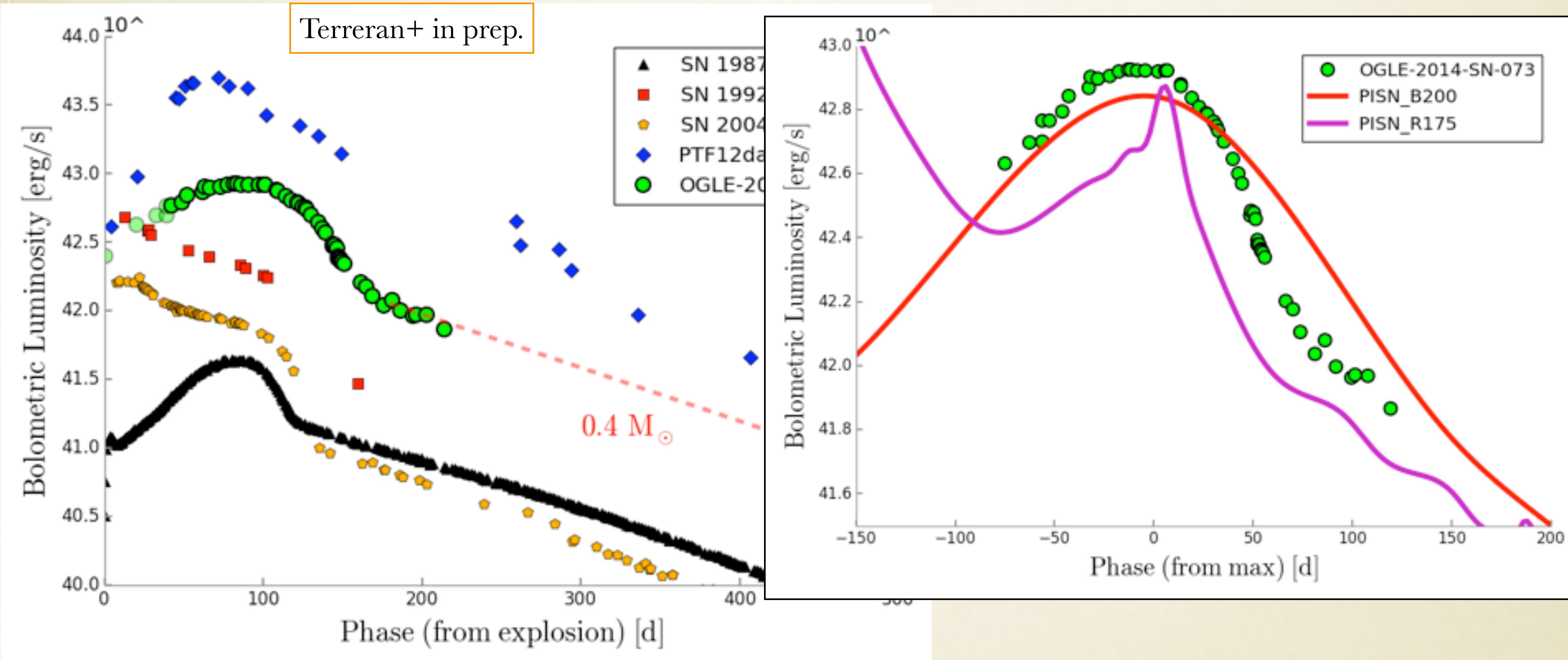

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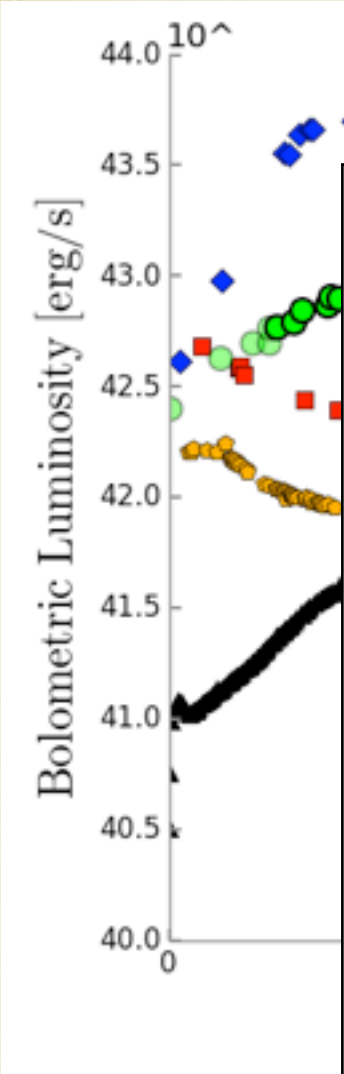
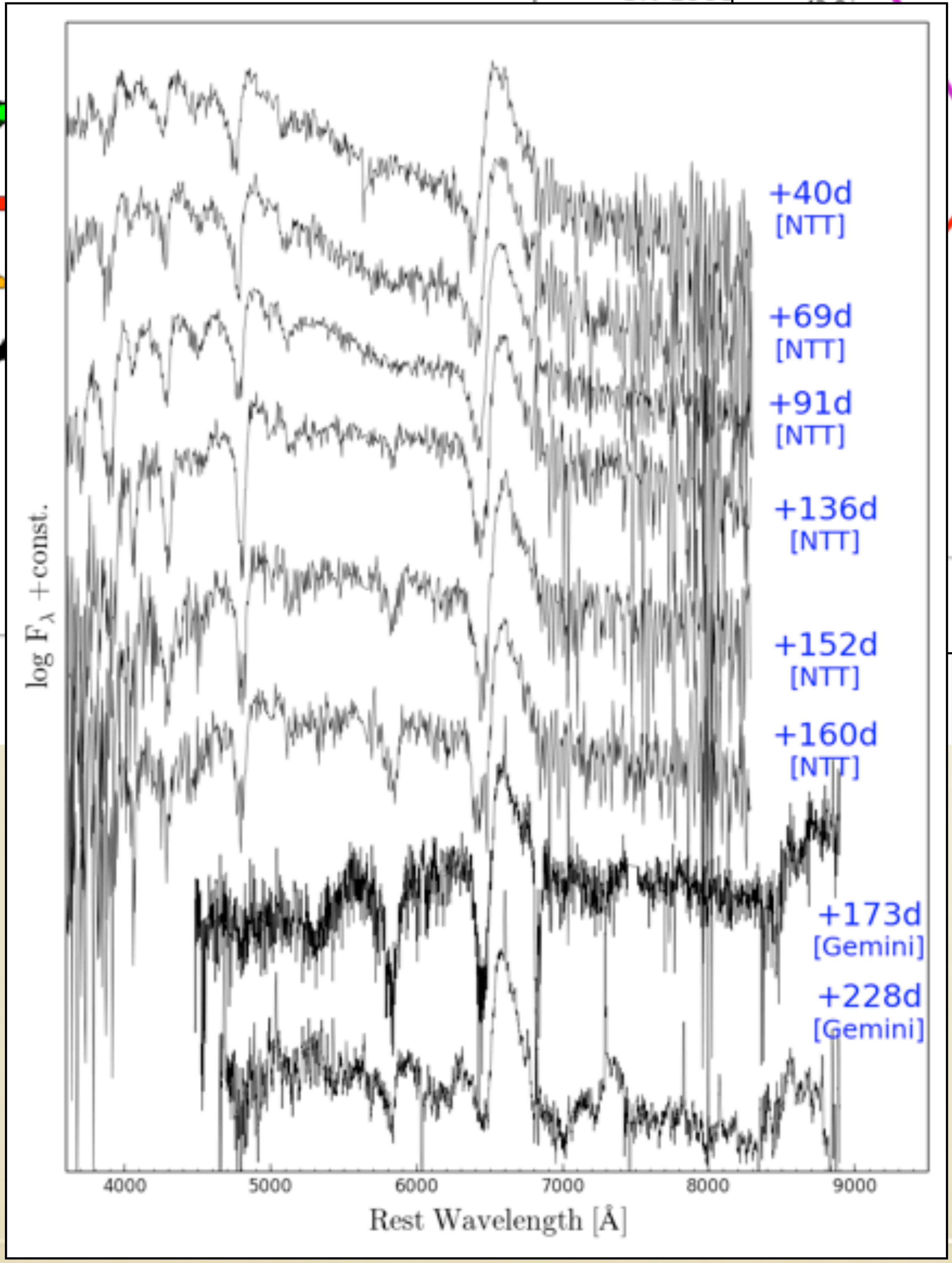
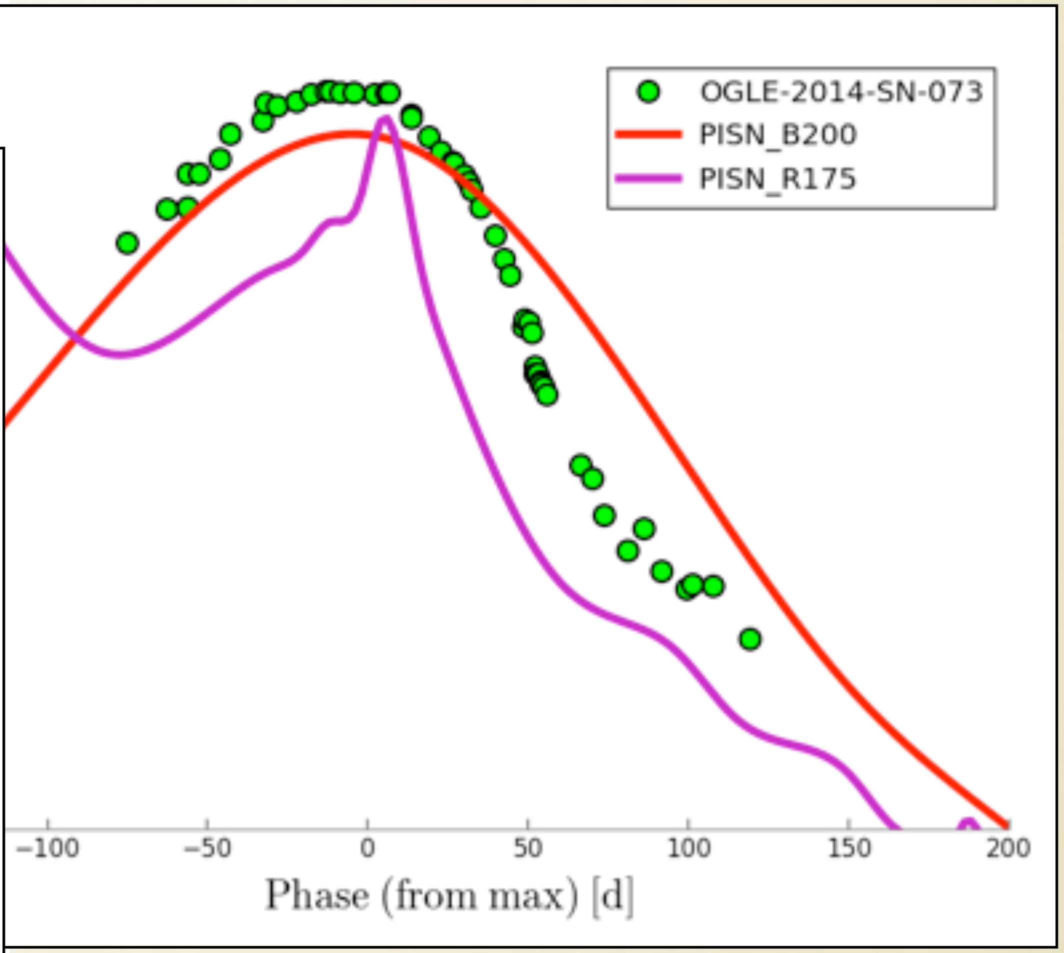
Terreran+ in prep.







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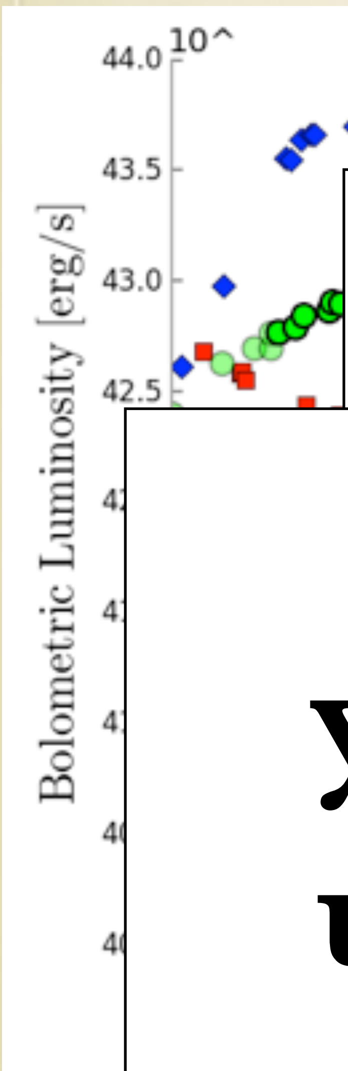
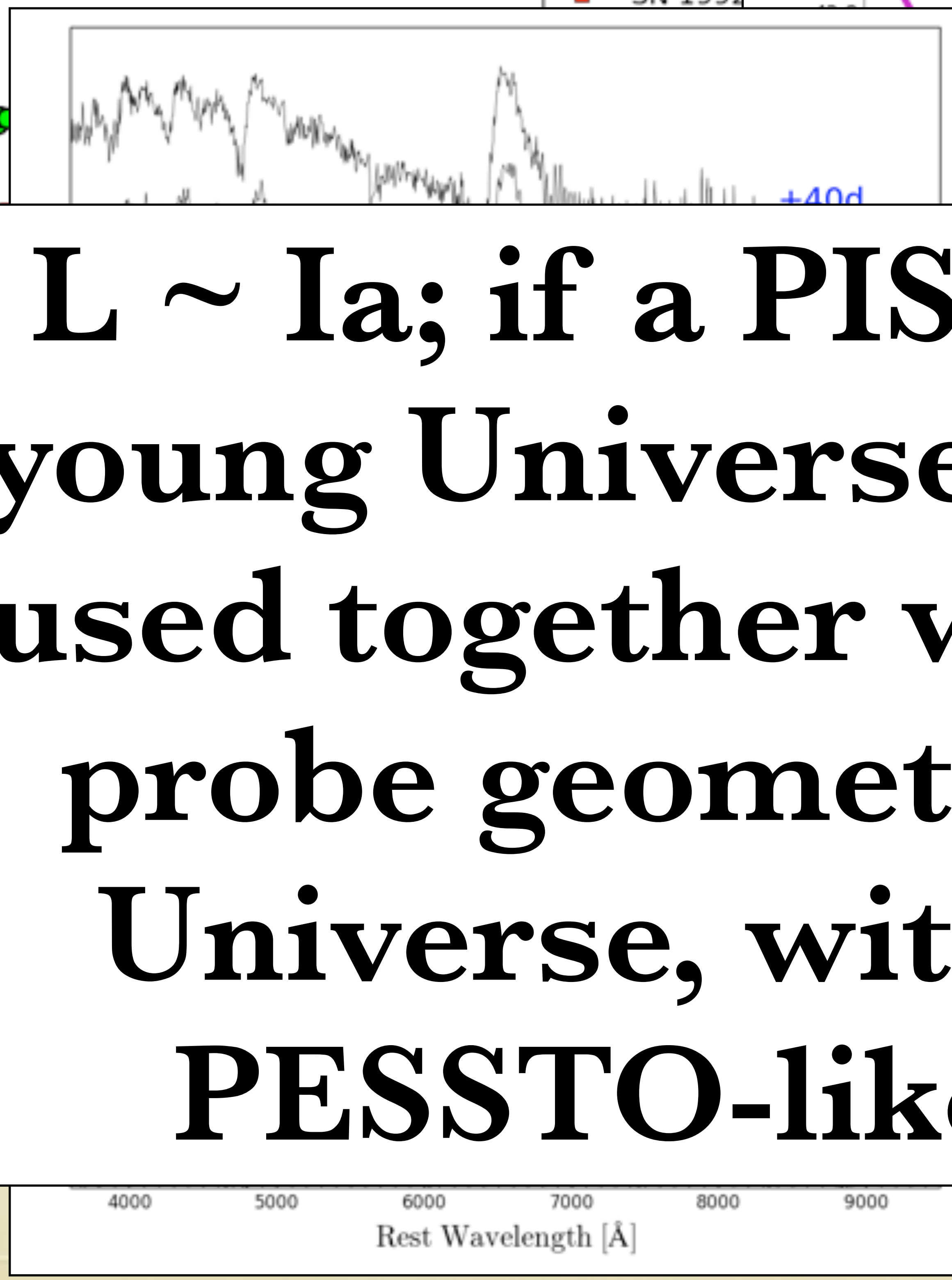
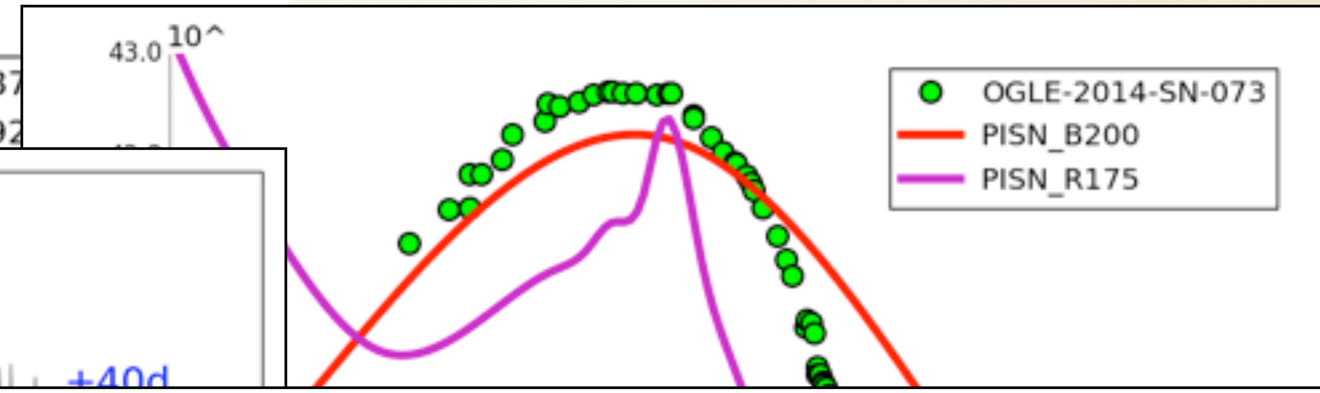


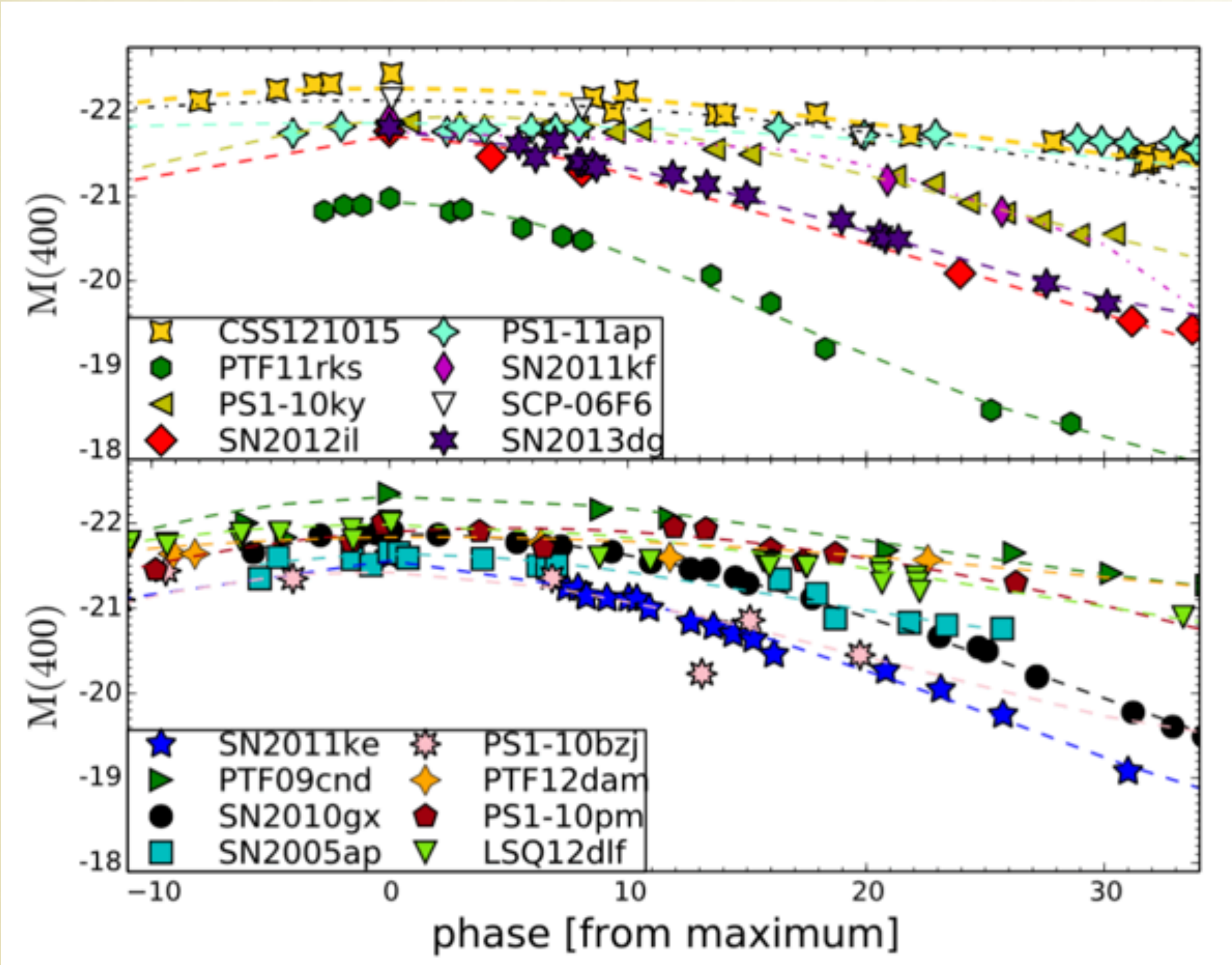




L ~ Ia; if a PISN, many in young Universe => may be used together with SNIa to probe geometry of early Universe, within a VLT PESSTO-like survey!

Superluminous SNe

Inserra & Smartt 2014



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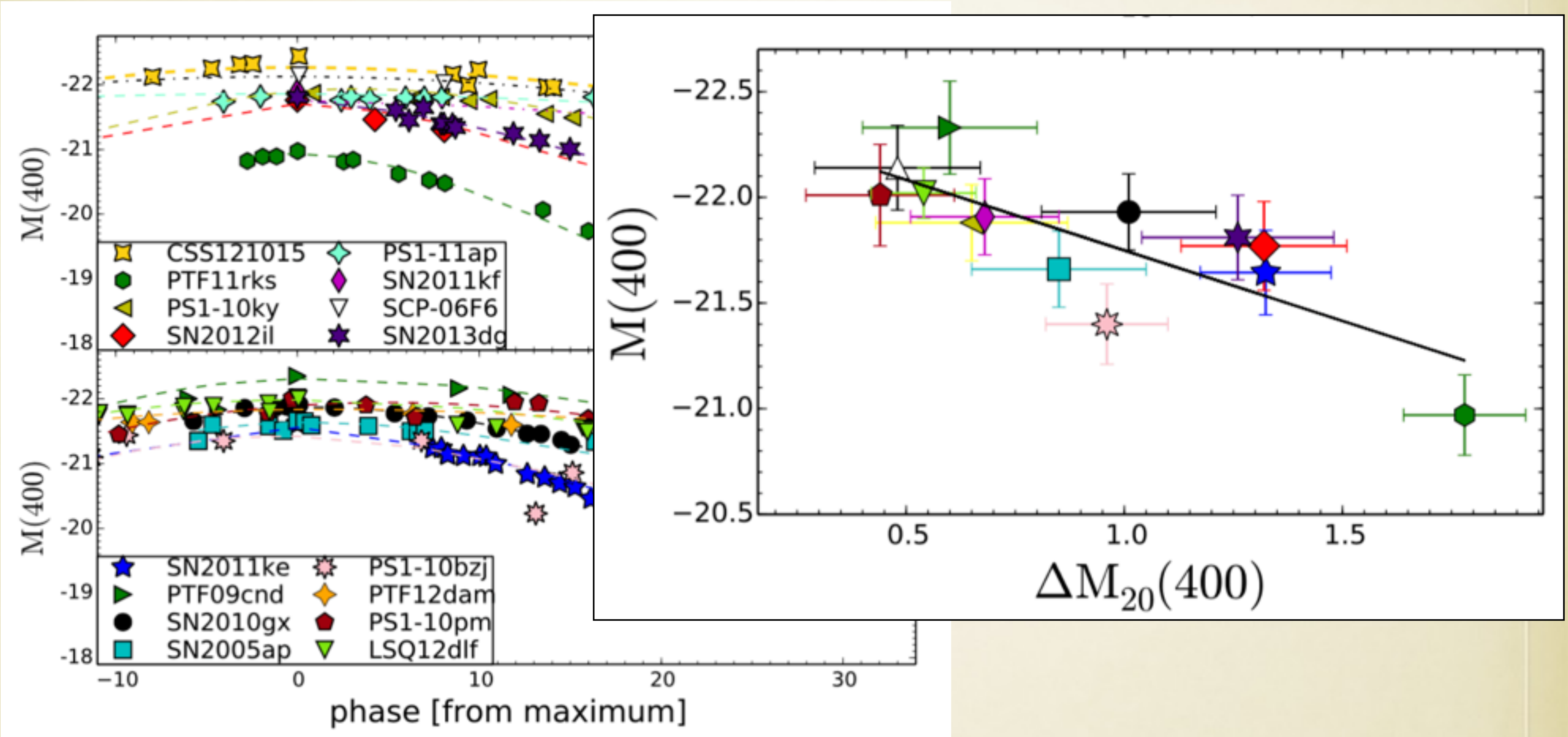

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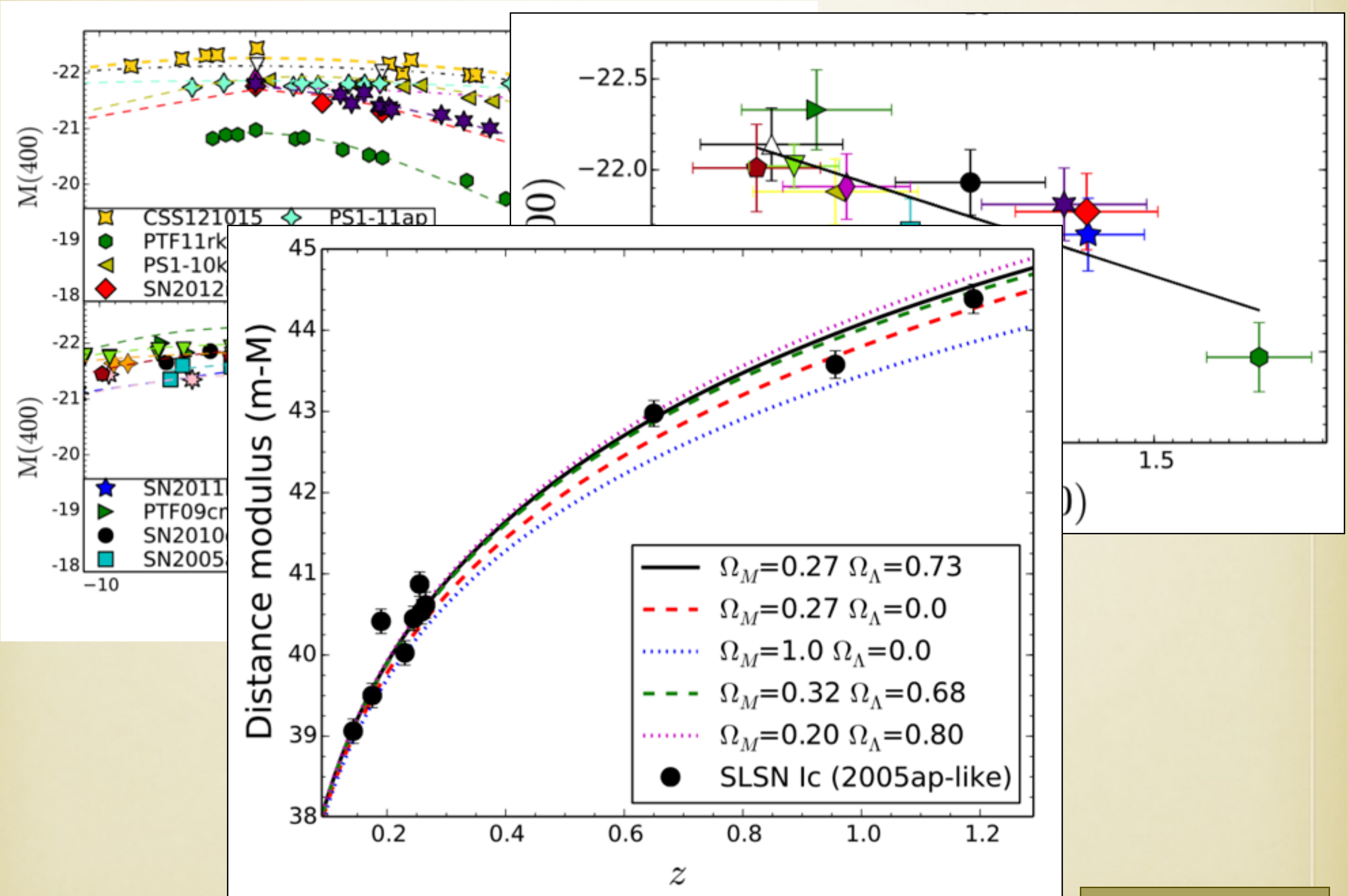

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Superluminous SNe, goals:

Check with "nearby (z<1)" SLSN if relation M(400) vs $DM_{20}(400)$ holds! Instruments needed: NTT +SOXS; NOT+NTE

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SLSN observable to $z\sim3$-4, but then 400 nm band shifts to NIR ($i_{max}\sim23.5$ at $z\sim3$) => ELT-IFU is needed!

In summary

Primary goal: **understand the nature of dark energy using supernovae as distance indicators!**

Immediate needs: **SOXS@NTT and NTE@NOT**
PESSTO-like survey @ VLT

Long term (LSST era): ELT-IFU/CAM