Analysis of a select group of Type II-P SNe

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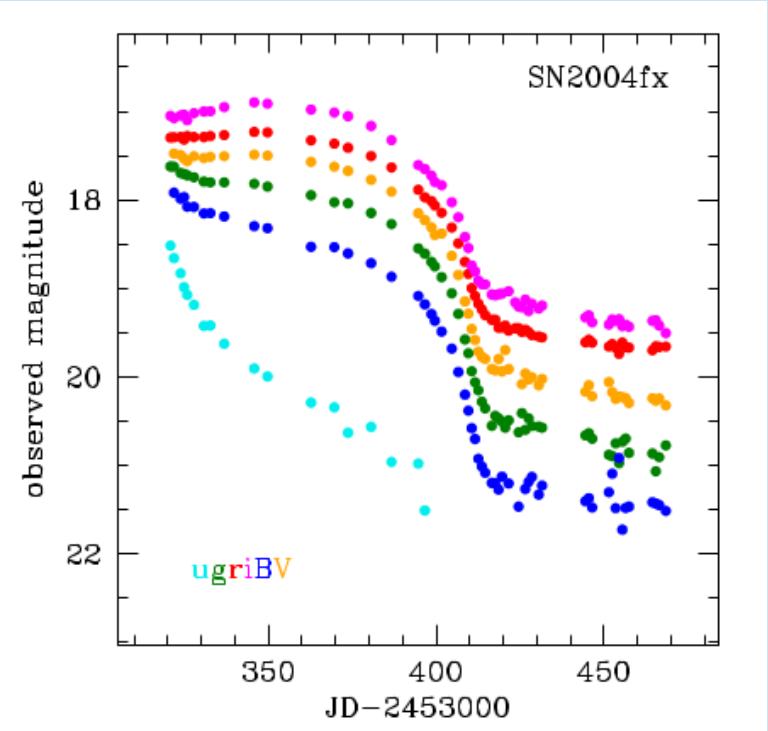
Type II-P SNe

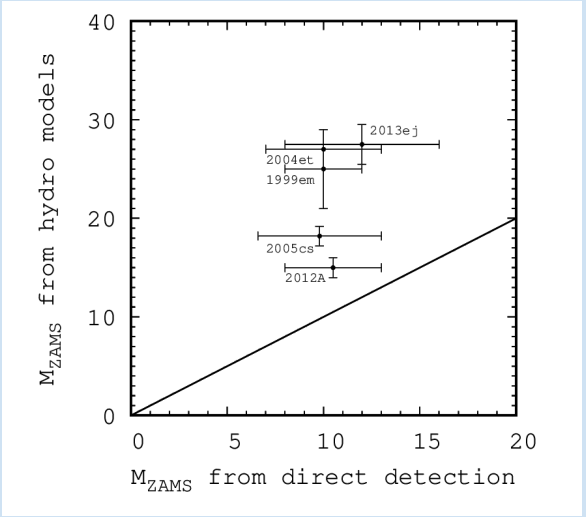
- Prominent H lines in their spectra and a phase of nearly constant luminosity (~ 100 days) in their optical photometry (but see Anderson+14)
- Hydrodynamical models show that a RSG progenitor with an extensive H-rich envelope is necessary to reproduce the plateau.
- Direct detections of progenitors proved that they arise from RSG stars with $M_{ZAMS} \lesssim 18\text{-}19\ M_{\odot}$. (Van Dyk+03, 12, Smartt+15, Davies & Beasor 2018)



CSP - Hamuy et al. (2006)

Mass discrepancy

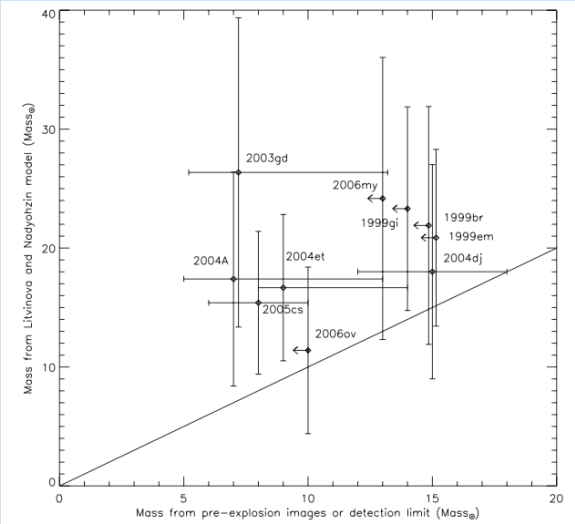
Mass estimation from hydrodynamical models **(M_{hydro})** is usually larger than pre-SN imaging.



Results from Utrobin (2007), Utrobin & Chugai 08, 09, 13, 15, 17

Goals

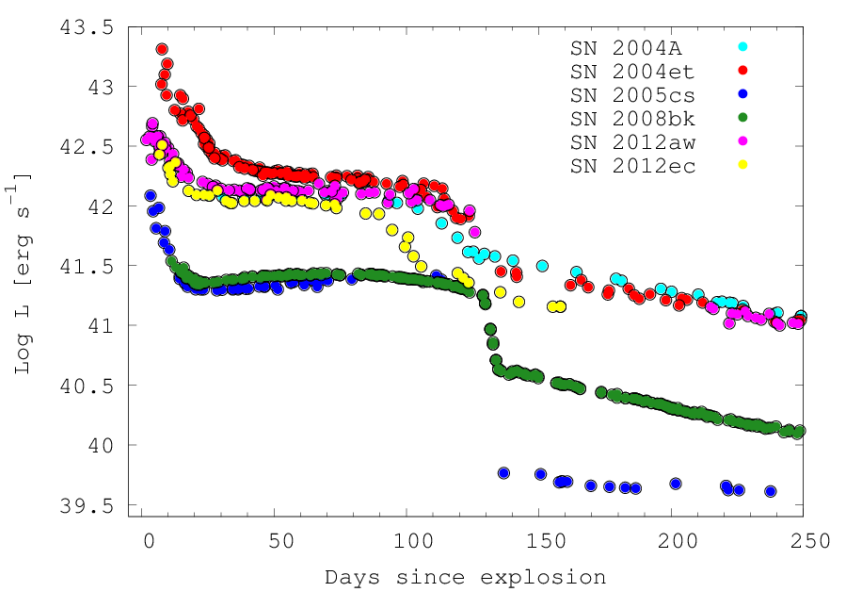
- Determine physical parameters (mass, radius, explosion energy, amount of nickel) from hydro modeling of a select group of SNe II-P.
- Study if there are systematic differences between hydrodynamic masses and those obtained by direct detections in pre-explosion images, as found in the literature.

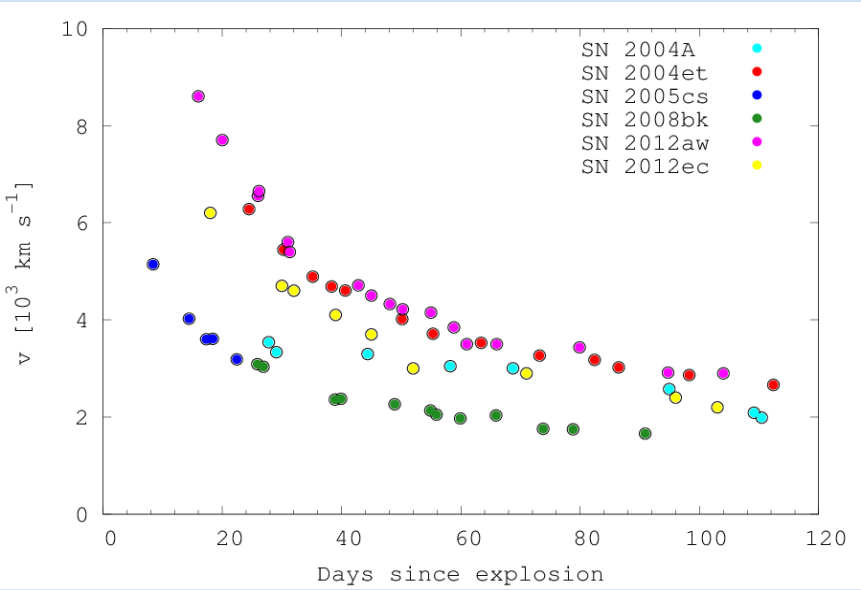


Maguire+10

Selected sample

- Good photometric and spectroscopic monitoring.
- Pre and post-explosion images confirming the disappearance of the progenitor.

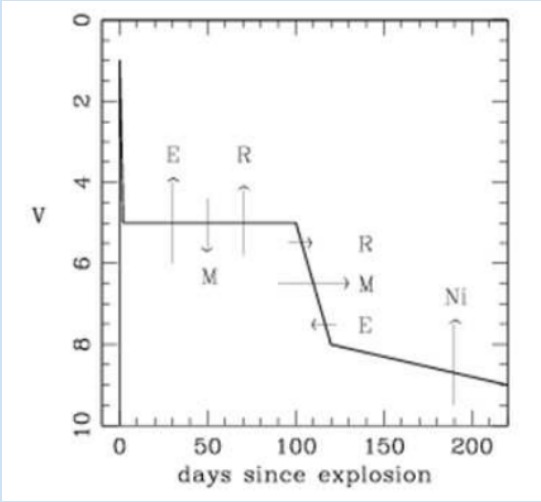




SN 2004A, SN 2004et, SN 2005cs, SN 2008bk, SN 2012aw, SN 2012ec

Hydrodynamic models

- Physical parameters (M, R, E and ^{56}Ni mass) determine the shape of the light curve (LC).
- We use a hydrodynamic code that simulates the explosion of the SN and provides bolometric LC and photospheric velocities (Bersten, Benvenuto & Hamuy 2011) to derive the physical parameters.
- Double polytropic models used as pre-SN models.

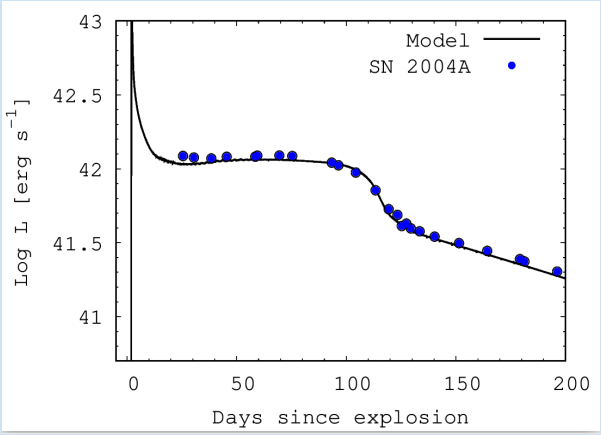


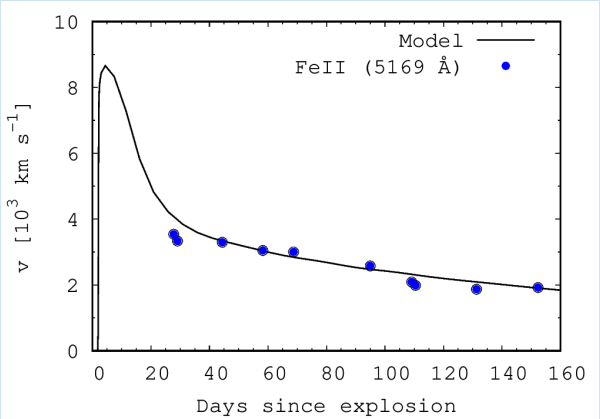
BUT

- LCs need to model together with the photospheric velocity (v_{ph}) to reduce the degeneracy between M, R and E.
- We use R derived from direct detection (when it was possible) to further reduce the degeneracy.

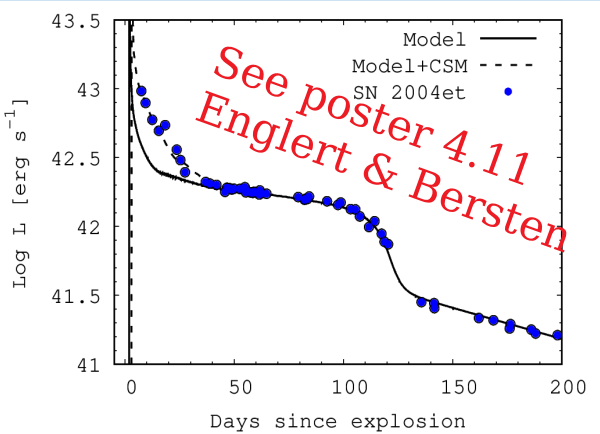
Results

SN 2004A

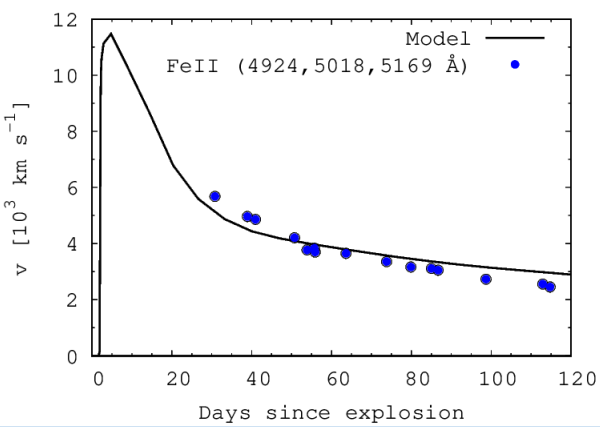




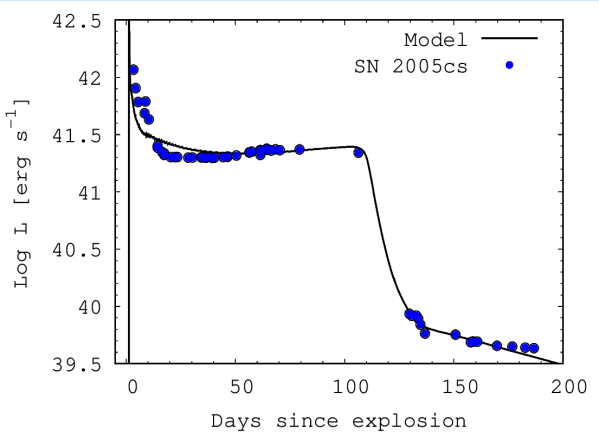
SN 2004et

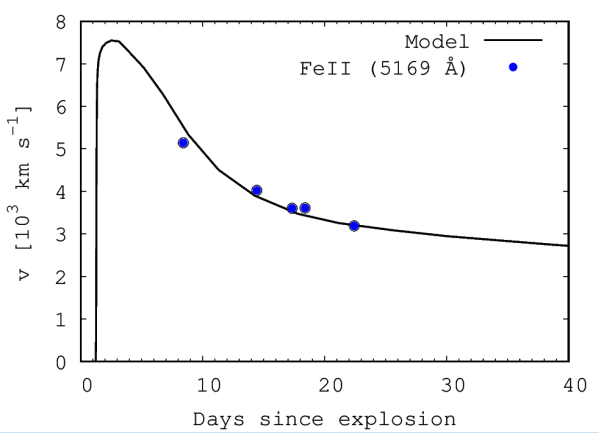


See poster 4.11
Englert & Bersten

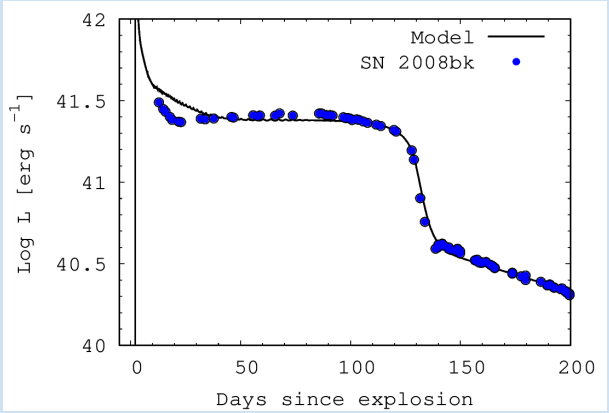


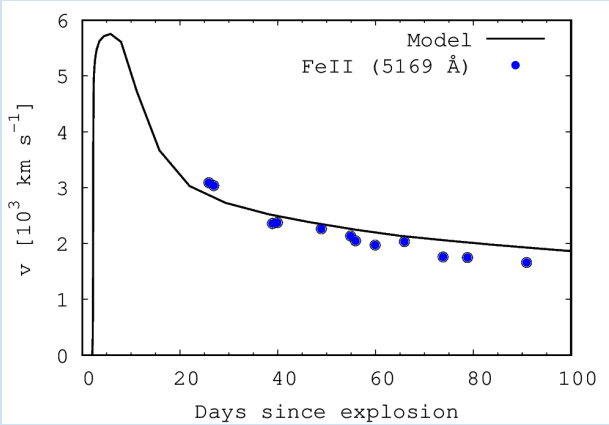
SN 2005cs



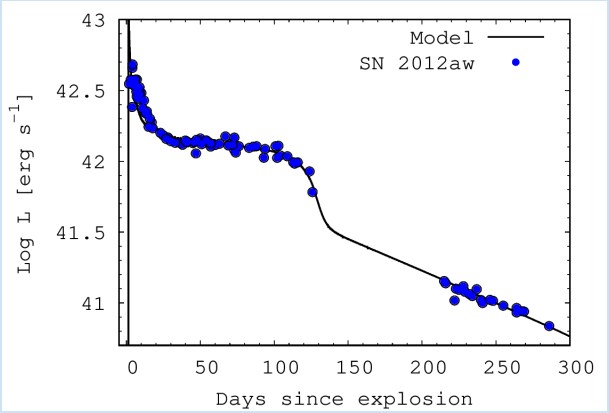


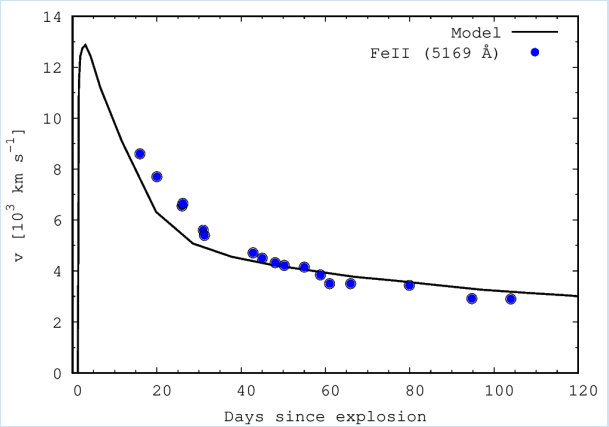
SN 2008bk



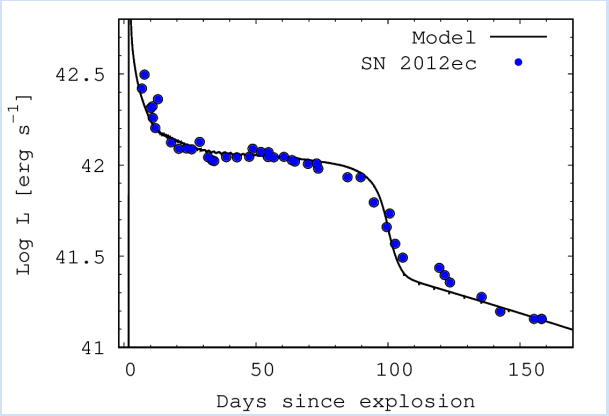


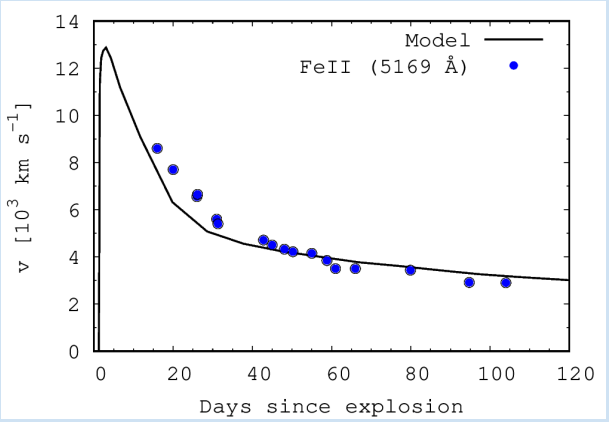
SN 2012aw





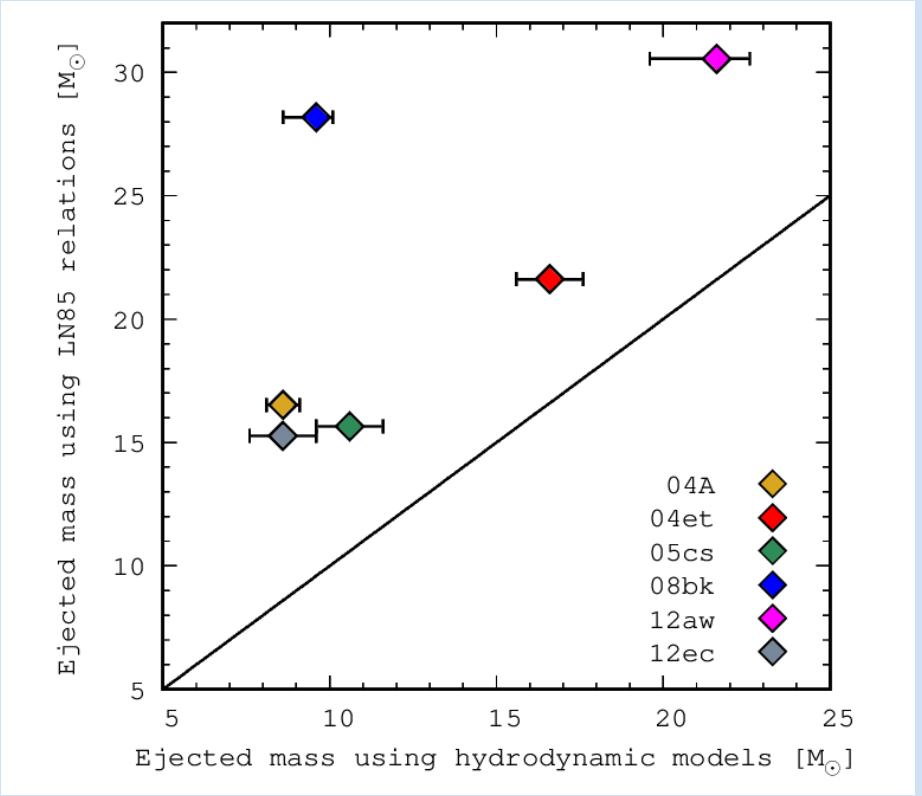
SN 2012ec





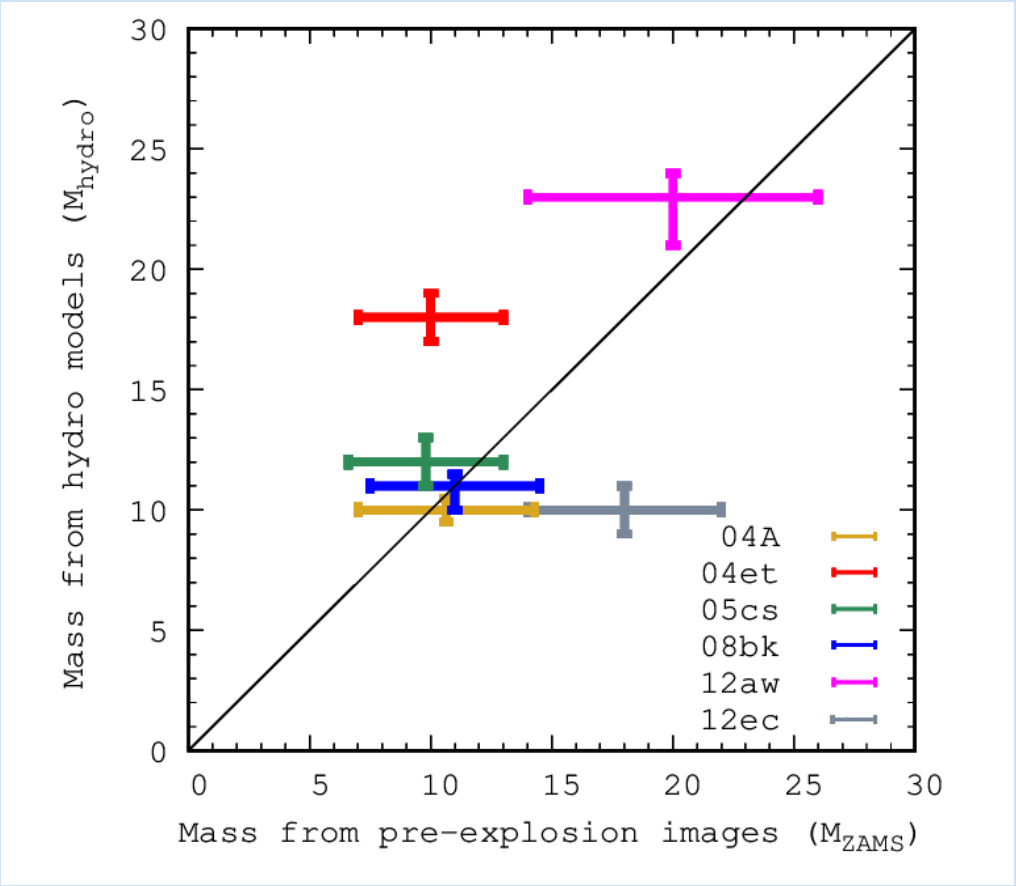
Comparison with physical-observed parameter relations

- Litvinova & Nadëzhin 1985, (LN85) proposed some relations between certain observables (M_V, $v_{exp,}$ Δt_p) and physical parameters (M_{ej}, R, E).
- These relations, widely used in the literature, allows to derive easily those physical parameters.
- Significant differences between our results and those from LN85 relations.
- LN85 models don't include the effect of heating due to ^{56}Ni decay and used single polytropic models, among others.
- **These relations do not seem to be giving reliable results.**



M_{ej} using LN85 are larger than ours

Hydro masses vs pre-explosion masses



Study if there are systematic differences between M_{hydro} and those obtained by direct detections in pre-explosion images.

- M_{ZAMS} from direct detections.
- M_{hydro} from hydrodynamic models.
- $M_{hydro} \leq M_{ZAMS}$ due to mass loss.

Masses estimated by hydrodynamic models are not systematically larger than those estimated by the analysis of pre-explosion images.

Summary

- We derived physical parameters for a select sample of SNe II-P through hydrodynamical modeling of their LCs and photospheric velocity evolution:
  - M_{hydro} = 10 - 23 $M_{\odot}$
  - R = 400 - 1250 $R_{\odot}$
  - E = 0.2 - 1.4 x 10^51 erg
  - M_{Ni} = 0.0015 - 0.085 $M_{\odot}$
- LN85 relations do not seem to be giving reliable results.
- Our masses estimation are not systematically larger than those using pre-explosion images.
- This is the first step in an analysis of a large sample of SNe II.

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Thanks!