Are the subluminous Ia's Sub-Chandra?

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Frustrations of an observer

What do we know from observations about

- **total mass ?**
- **energy source, i.e. amount of fuel ?**
- **explosion energy ?**
- **density ?**
- **element distribution ?**

Stritzinger & Leibundgut, 2005, A&A, 431, 423
Stritzinger, Leibundgut, Walch & Contardo, 2006, A&A, 450, 241
Blinnikov, et al., 2006, A&A, 453, 229
Stritzinger, Mazzali, Sollerman & Benetti, 2006, A&A, 460, 793

Usual procedure

Take explosion model

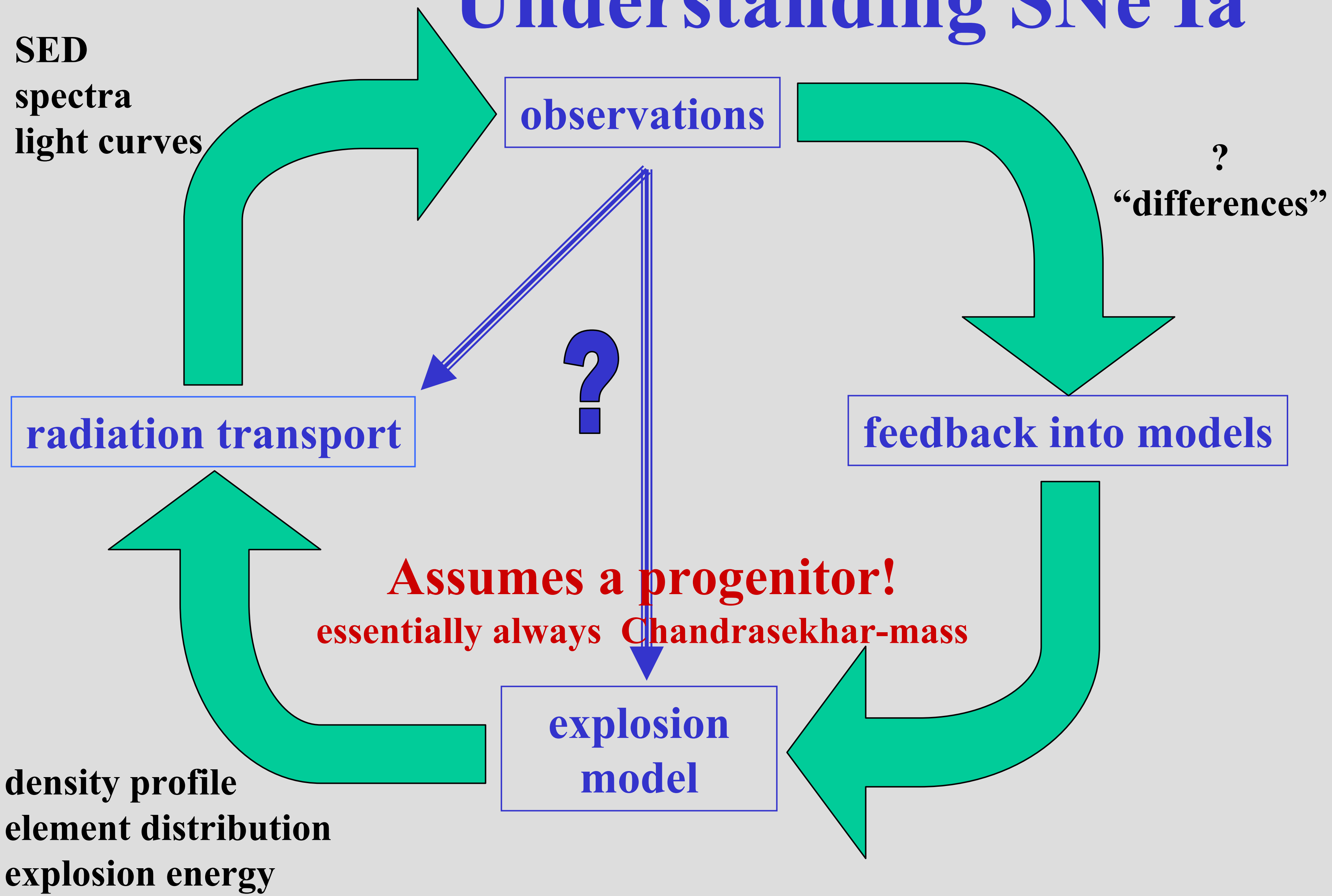
density and element distribution and explosion energy

and calculate the emerging spectrum and SED

→ always assume that you know the progenitor

usually Chandrasekhar mass T=0 white dwarf

Understanding SNe Ia



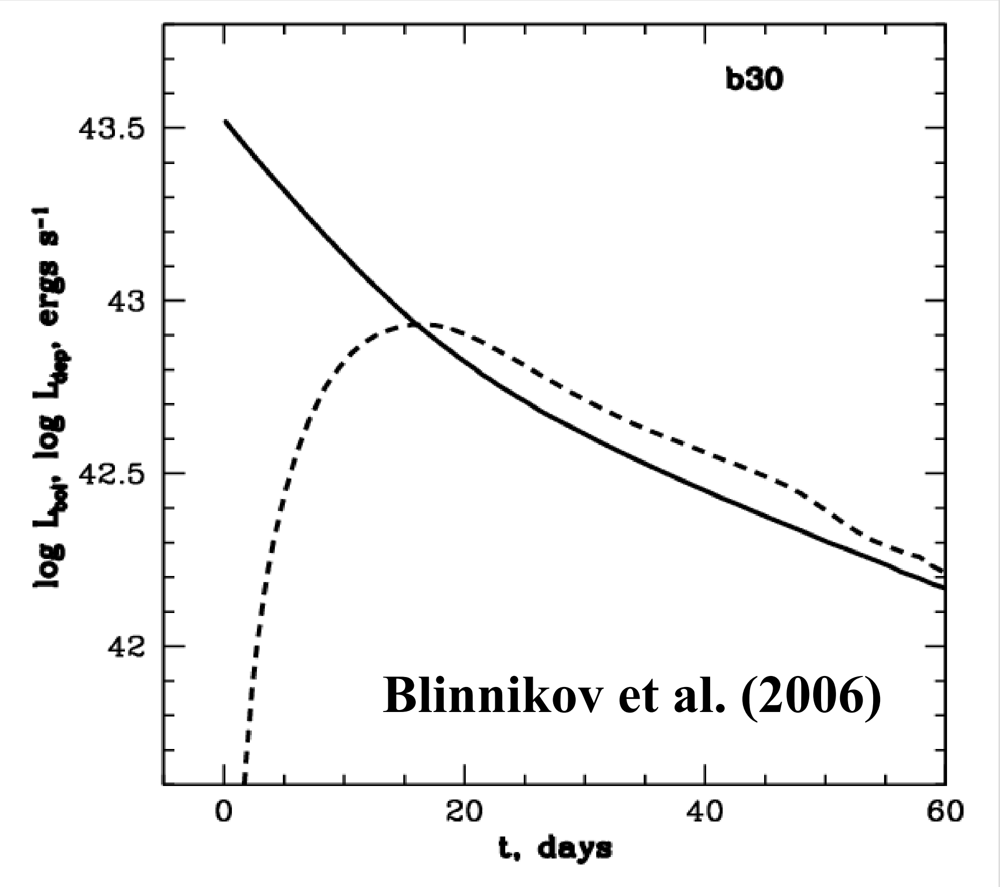
Can we do better?

Determine ^{56}Ni from the peak luminosity

Arnett's law

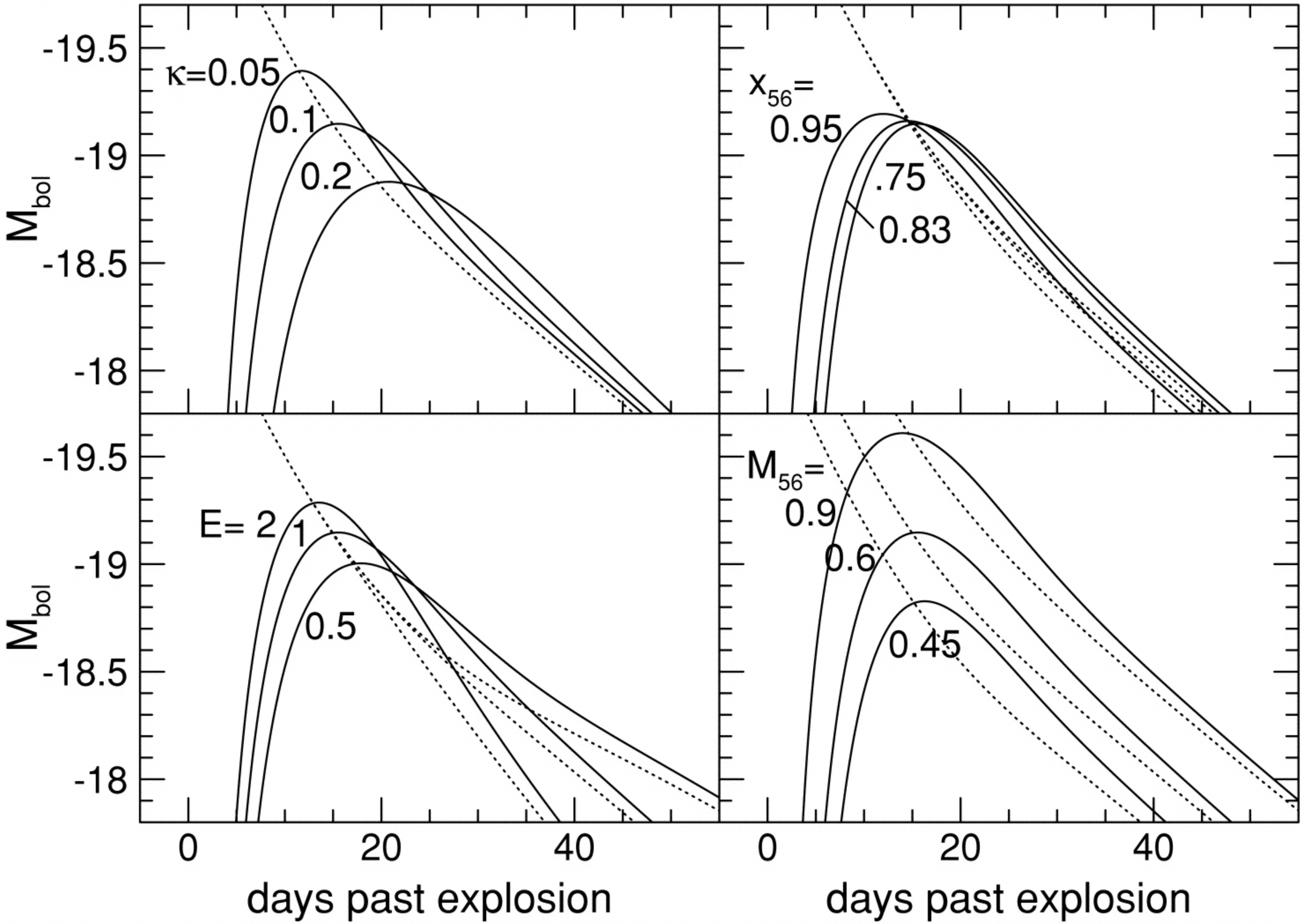
Requires a bolometric luminosity

- **multi-filter observations**
- **distance**

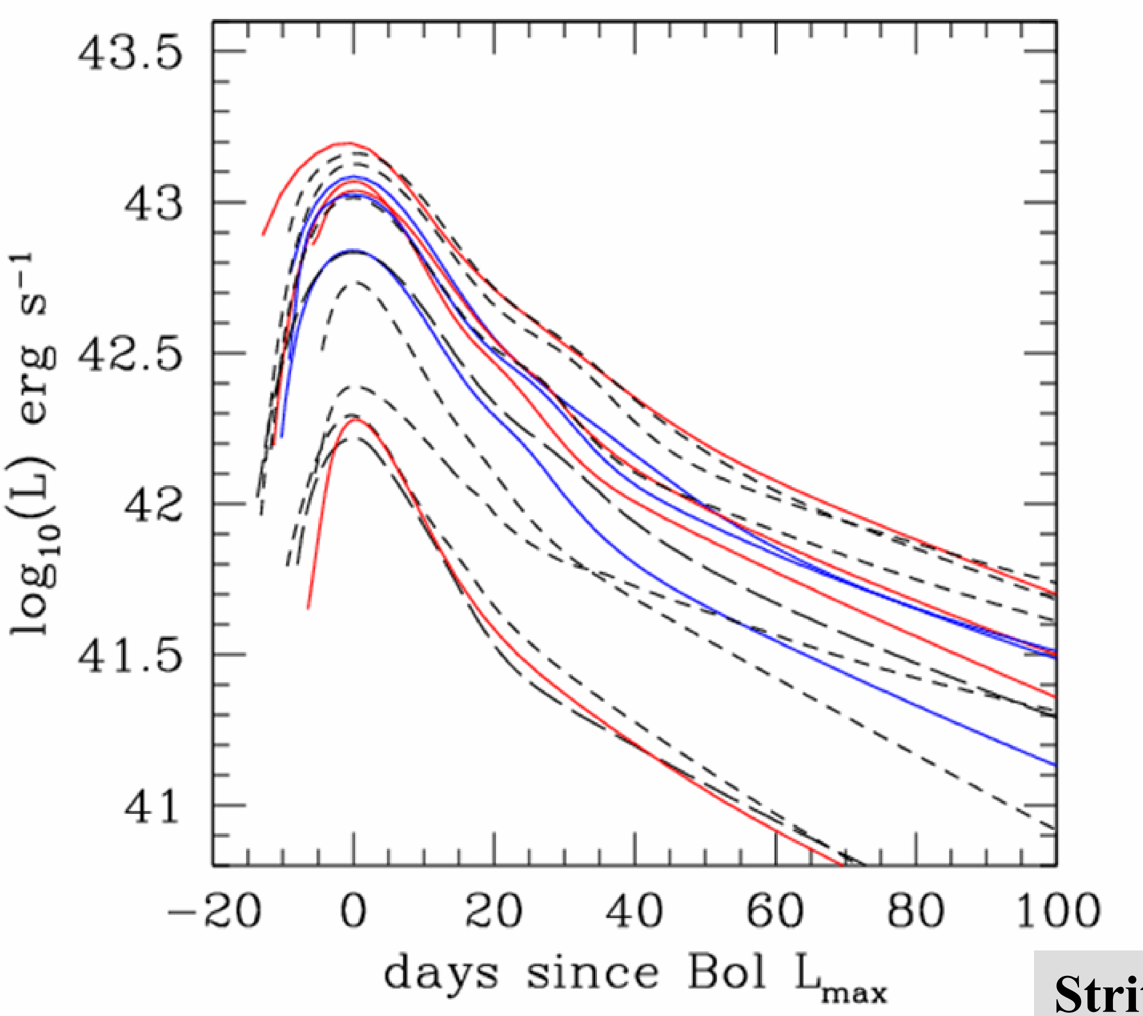


Arnett's rule must apply

Pinto & Eastman 2000

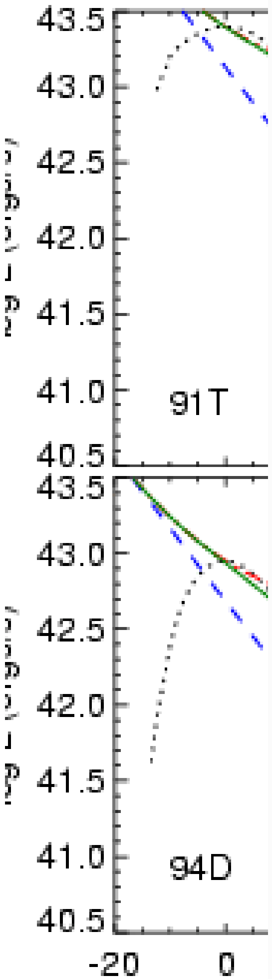


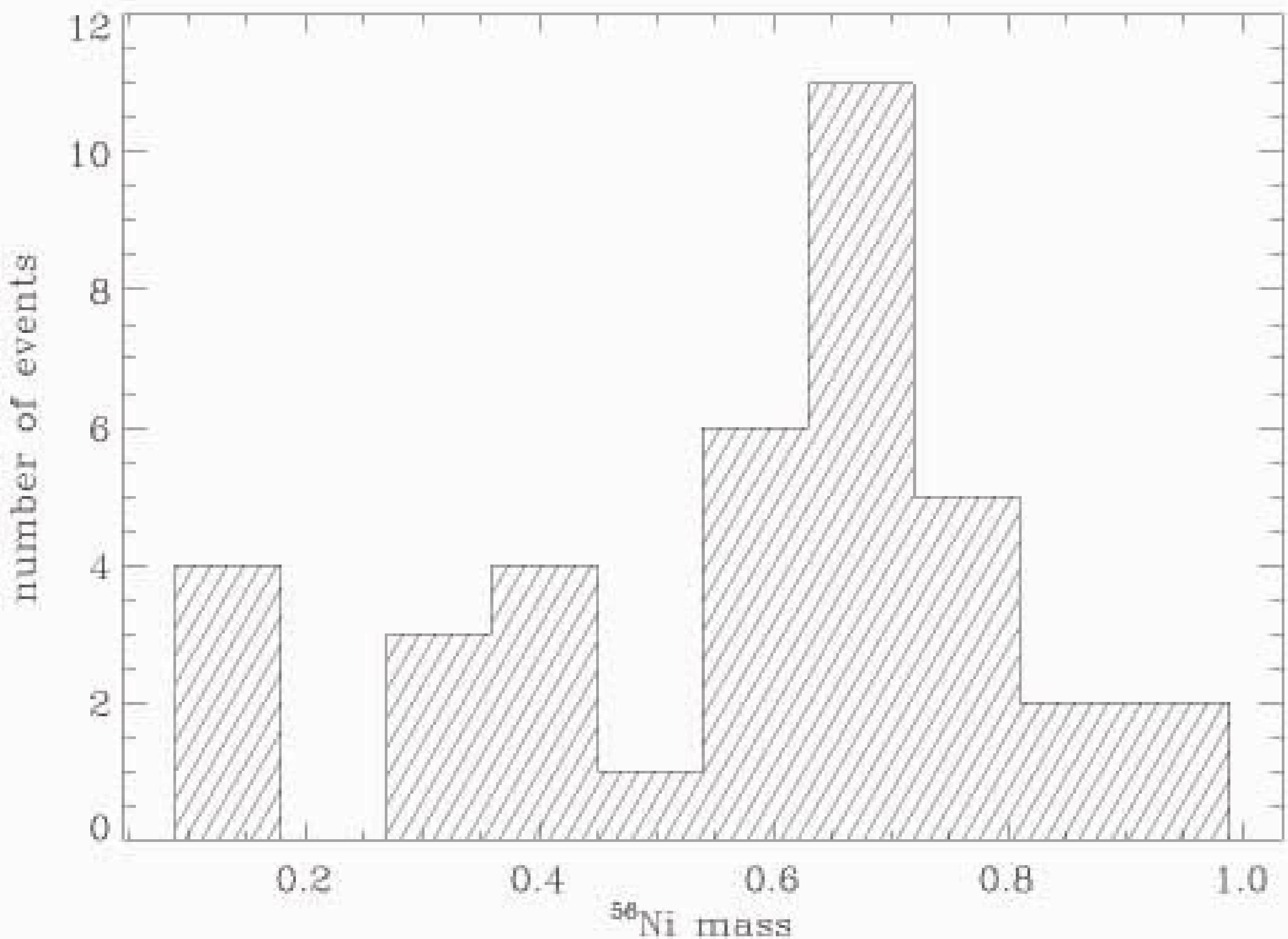
Bolometric light curves



Stritzinger

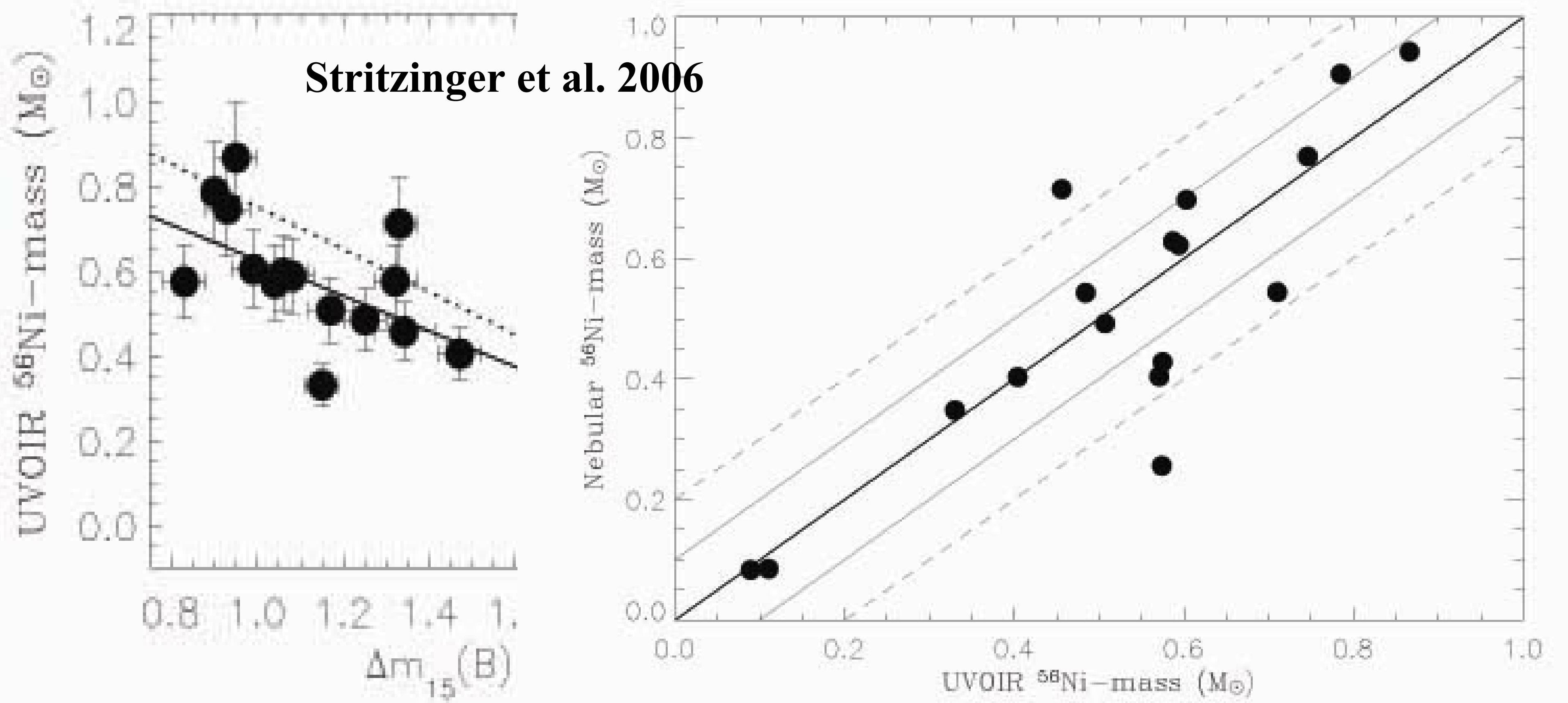
Ni masses from light curves





Check with a different method

Ni masses from the emission line in nebular spectra (t~300 days)



Stritzinger et al. 2006

Check with models

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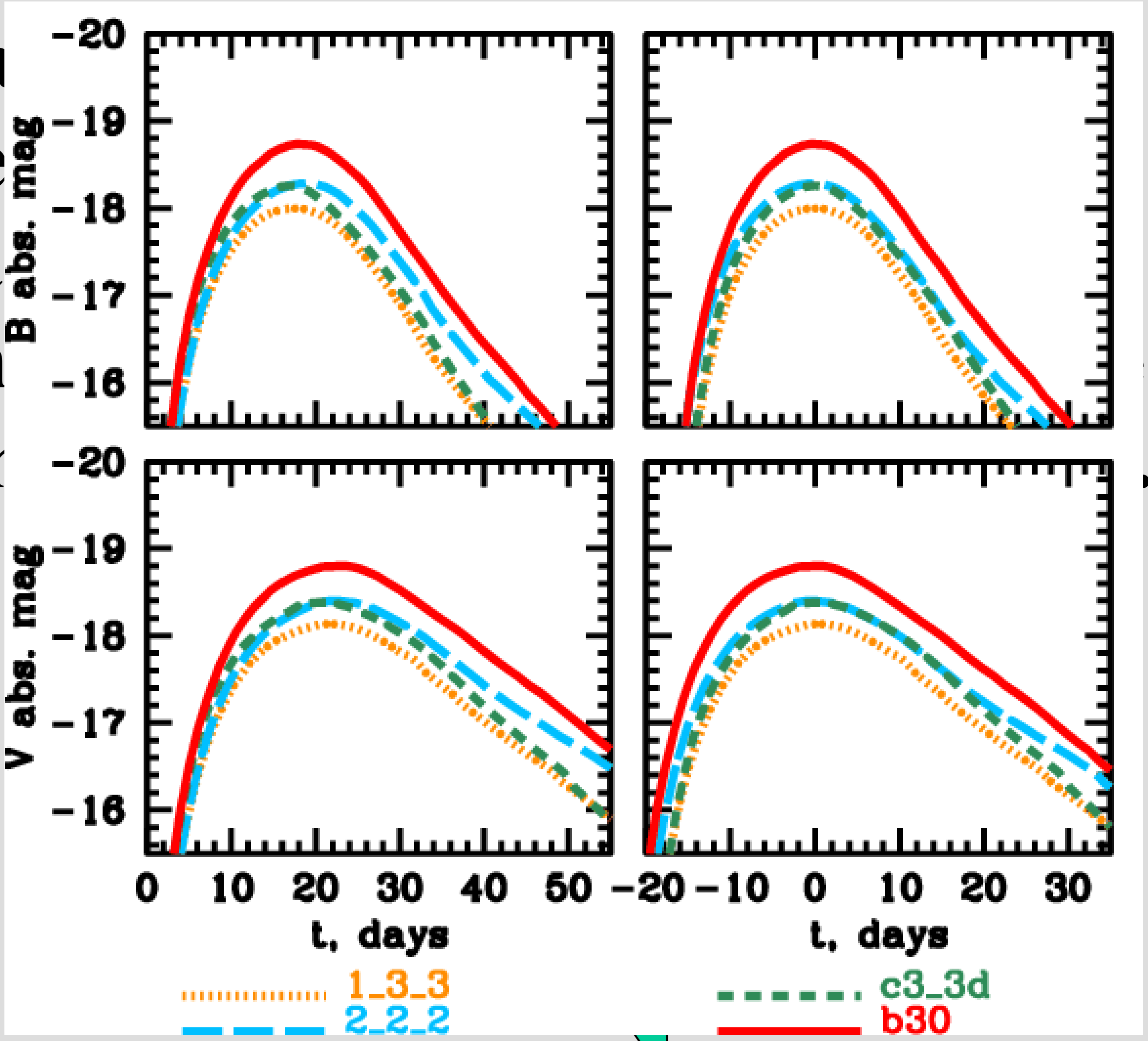
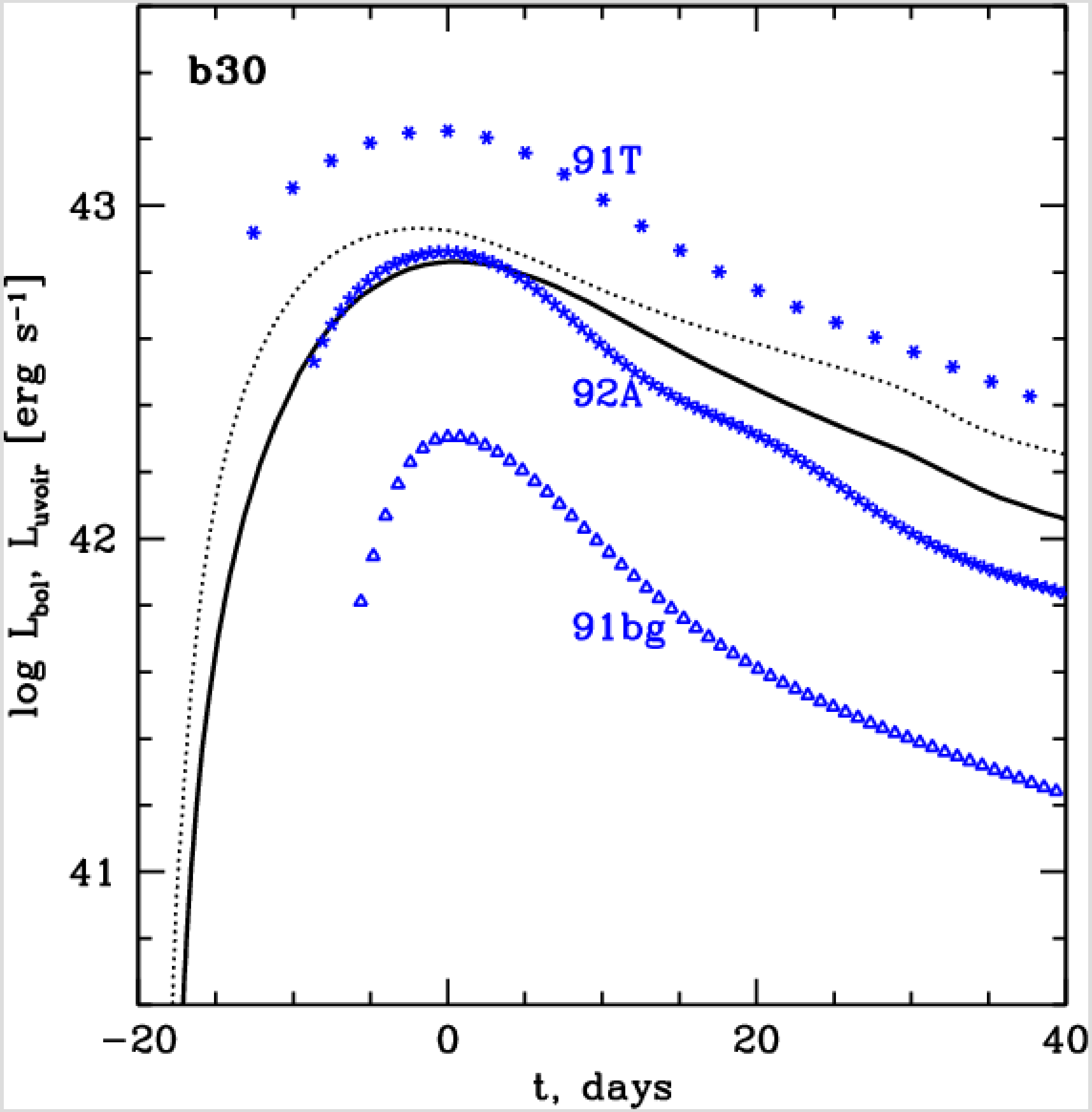


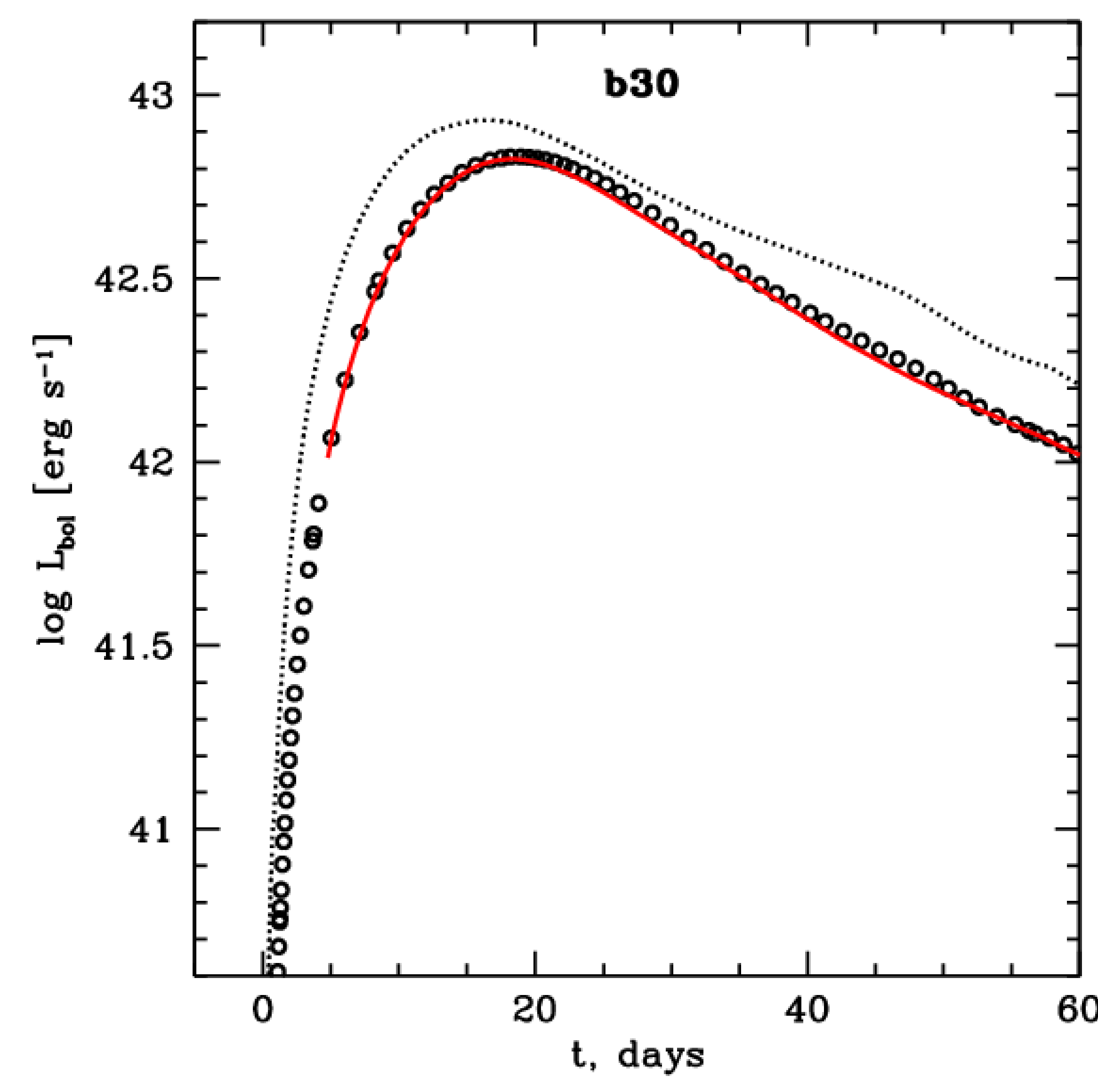
Comparison with real data



Check …

UVOIR light curve reproduced very well – validation of procedure in Stritzinger & Leibundgut

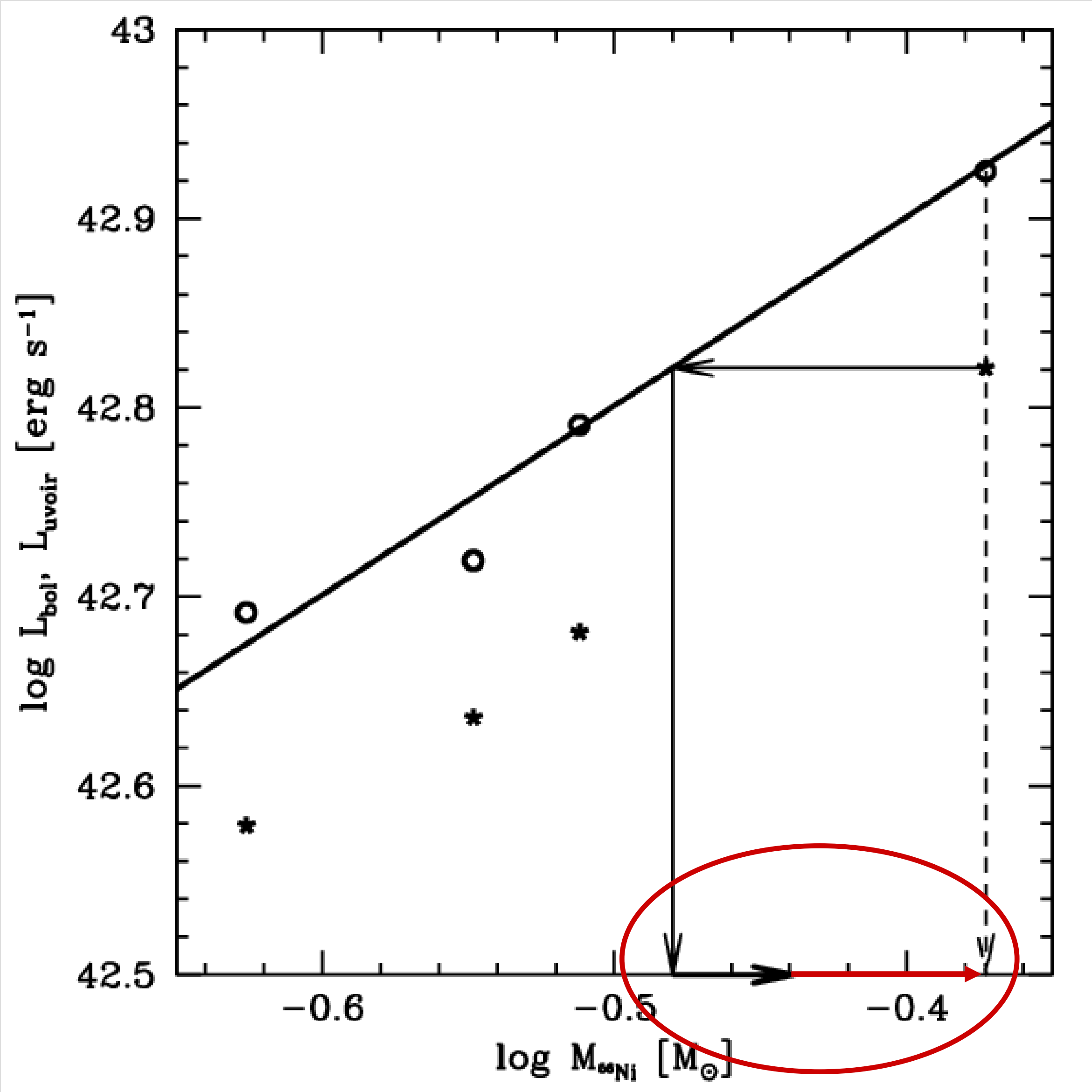
True bolometric light curve offset by about 15%



Not quite right …

‘Correction’ in SL05 insufficient

→ **total Ni mass underestimated by about 15-20%**



Using some simple physics

Deposition from the Ni-Co decay

$$E_{dep} = E_{Ni} + E_{Co,e^+} + (1 - e^{-\tau})E_{Co,\gamma}$$

$$= N_{Ni,0}\lambda_{Ni}Q_{Ni}e^{-\lambda_{Ni}t}$$

$$+ N_{Ni,0}\frac{\lambda_{Ni}\lambda_{Co}}{\lambda_{Ni} - \lambda_{Co}}\left\{e^{-\lambda_{Co}t} - e^{-\lambda_{Ni}t}\right\}\times[Q_{Co,e^+} + Q_{Co,\lambda}\{1 - e^{-\tau}\}]$$

$$\tau = \frac{M_{ej}\kappa q}{8\pi v_e t^2}$$

Ejecta masses from light curves

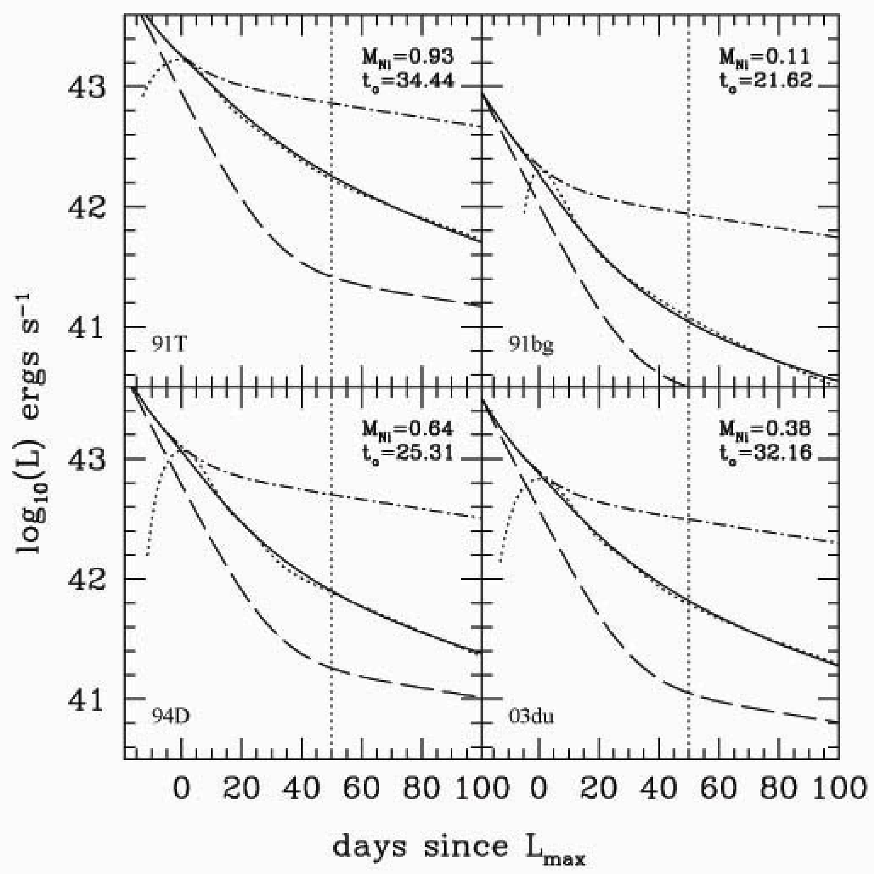
γ-ray escape depends on the total mass of the ejecta

$$M_{ej} = \frac{8\pi}{\kappa q} t_0^2 v^2 \propto \frac{v^2}{\kappa q}$$

***v*: expansion velocity**

***κ*: γ-ray opacity**

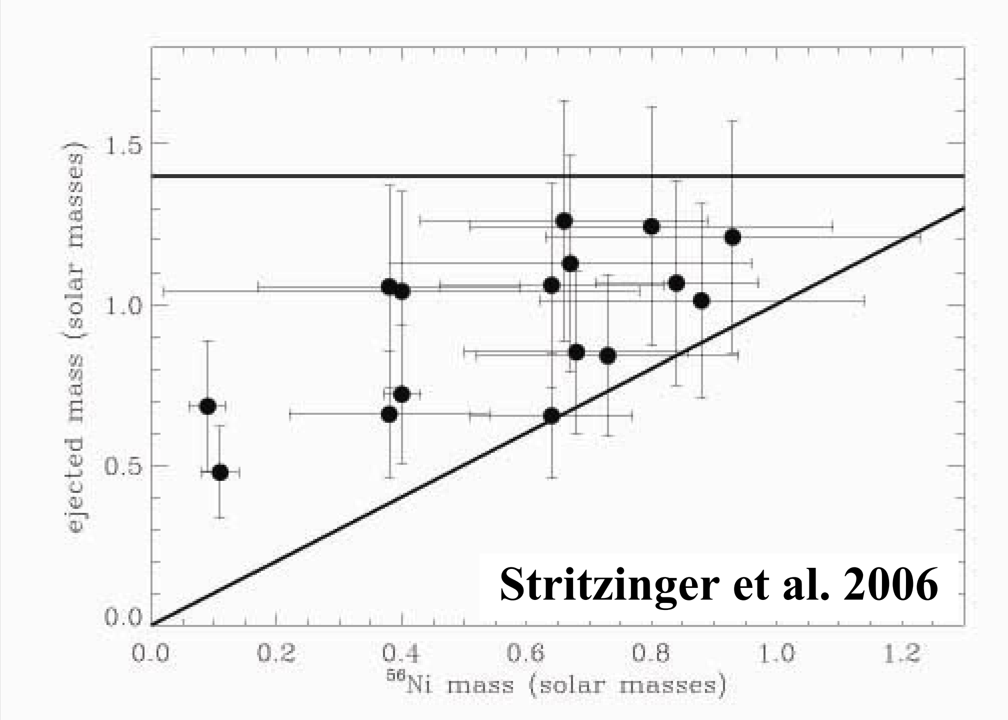
***q*: nickel distribution**



Ejecta masses

Large range in nickel and ejecta masses

- no ejecta mass at 1.4$M_\odot$
- factor of 2 in ejecta masses
- some rather small differences between nickel and ejecta mass
- according to Blinnikov et al. 2006 the nickel and ejecta masses need to be increased



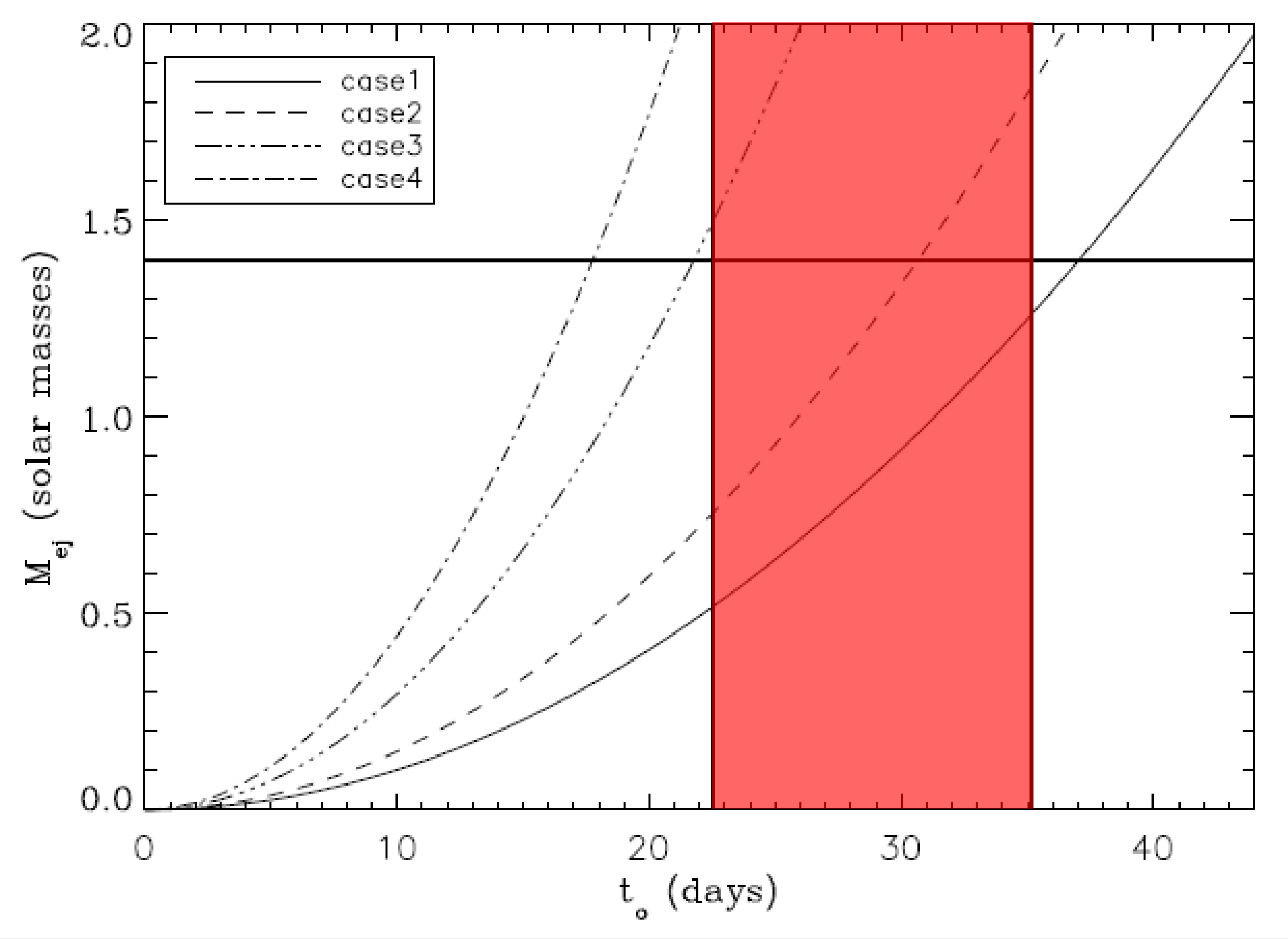
Dependence on explosion parameters

case 1: (fiducial)
v=3000 km/s),
κ=0.0025 cm/g and
q=1/3

case 2:
v=3625 km/s

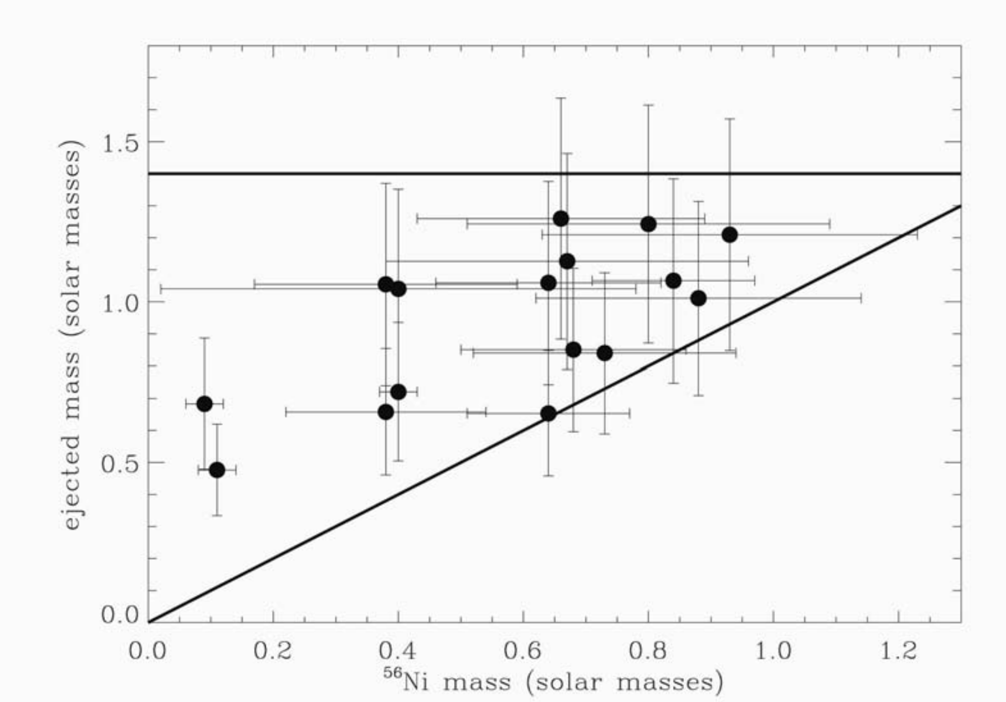
case 3:
v=3625 km/s,
κ=0.0084 cm/g and
q=1/2

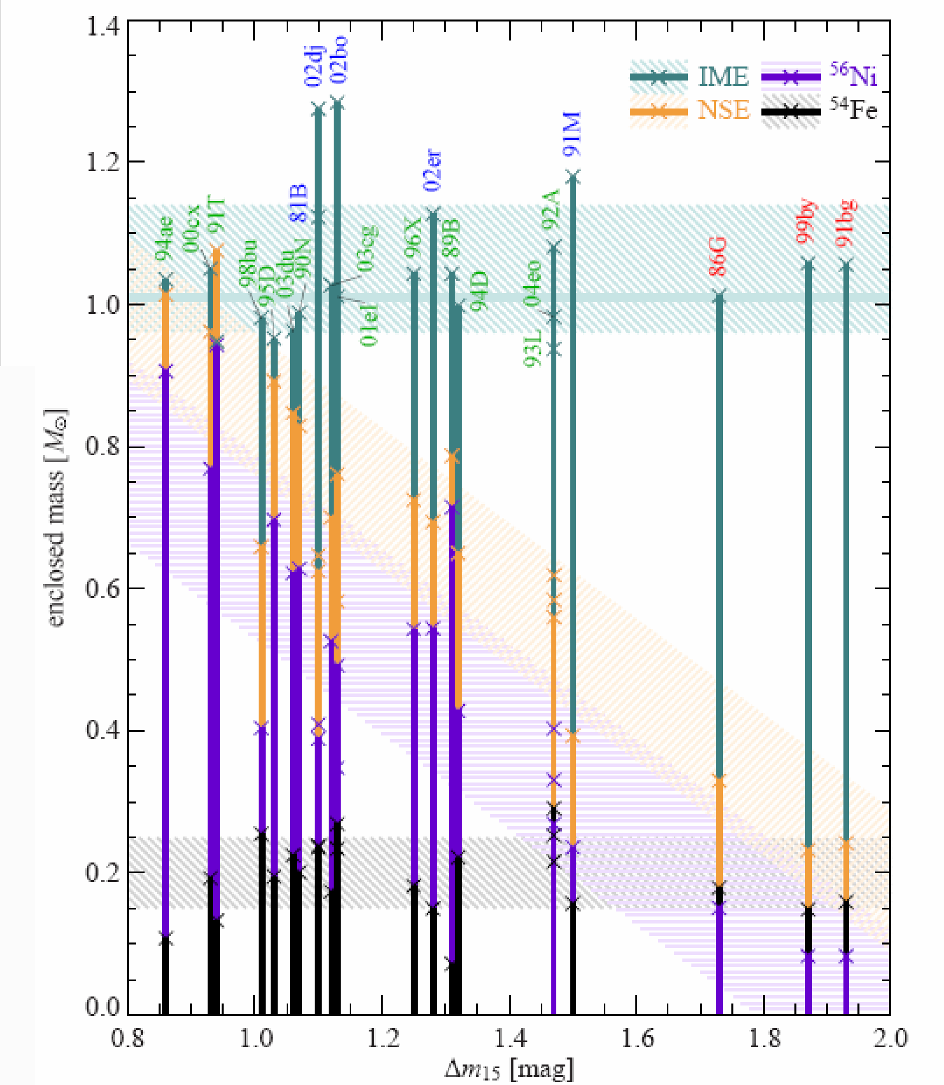
case 4:
v=3625 km/s,
κ=0.0084 cm/g and
q=1/3



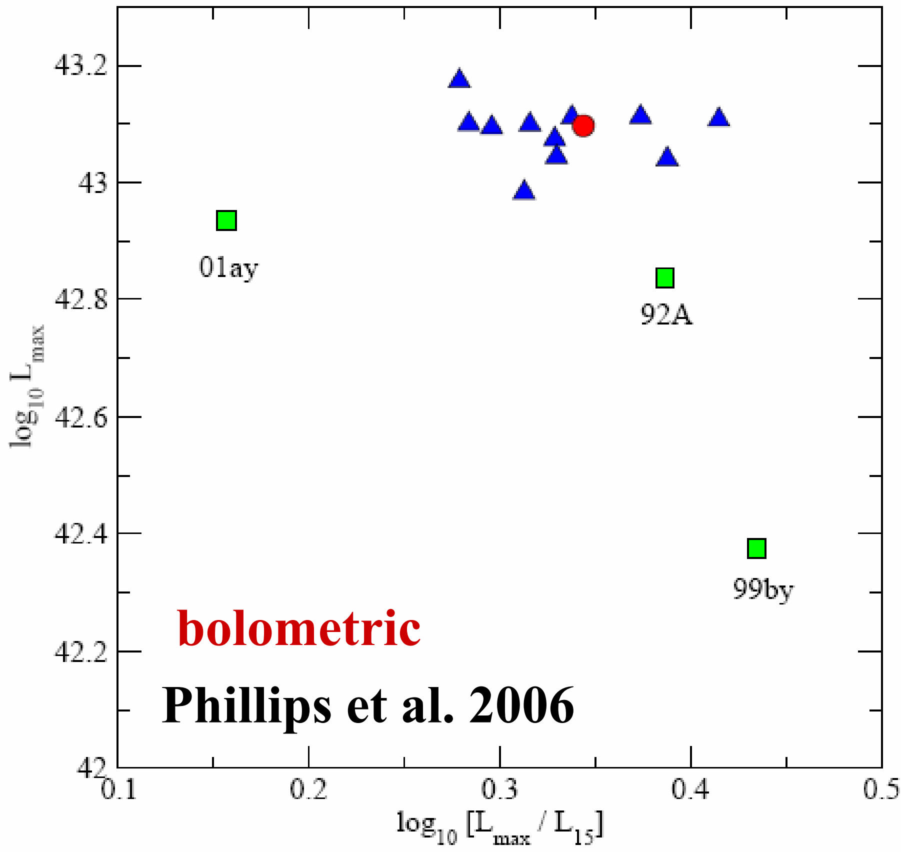
Is this true?

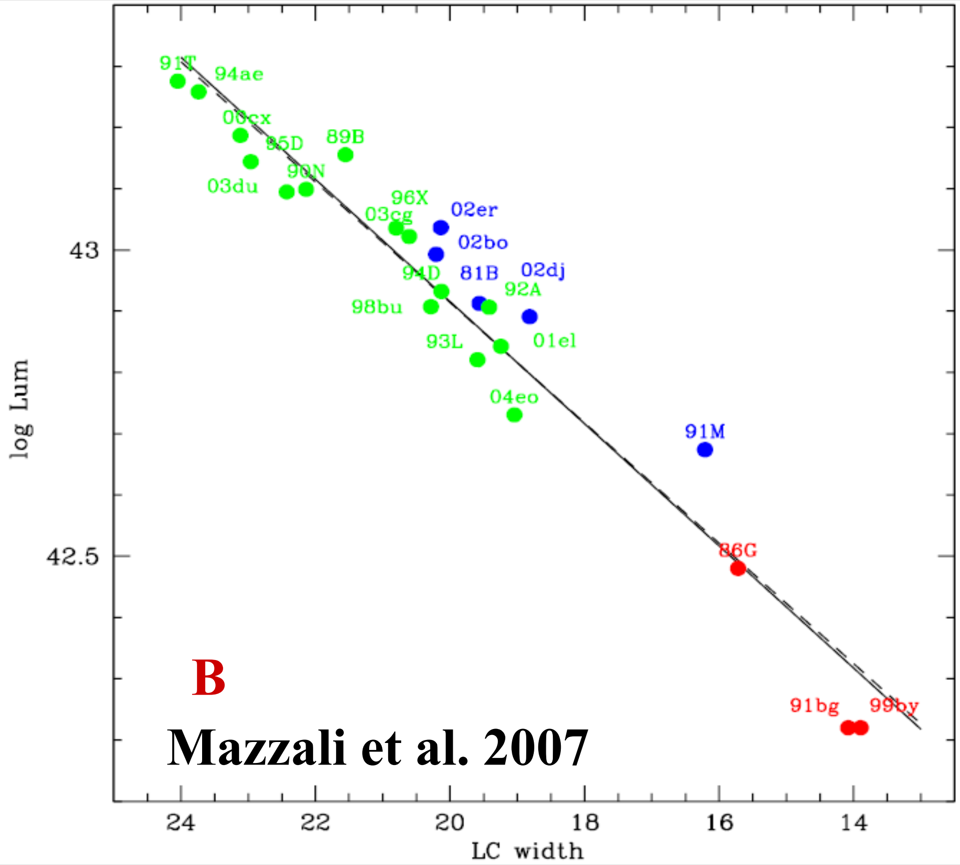
Claim that all SNe are from Chandrasekhar-mass progenitors





What's wrong here?





Summary

The ejecta mass of SNe Ia remains undetermined

- →**significant differences between the explosions (or the progenitors?)**
  - →luminosities, velocities, light curve shapes, colors

Considerable scatter among the measured ejecta masses

- →**implications for progenitors?**
- →**model too simple → how can we improve?**

Summary (cont.)

How can we infer properties of the progenitors and the explosions from the observations?