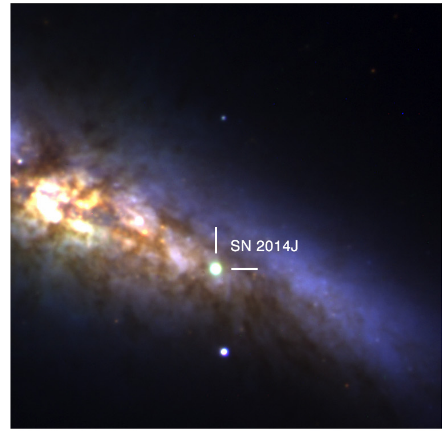
Update on SN2014J

Early rise time and high-cadence observations from KELT

Ariel Goobar

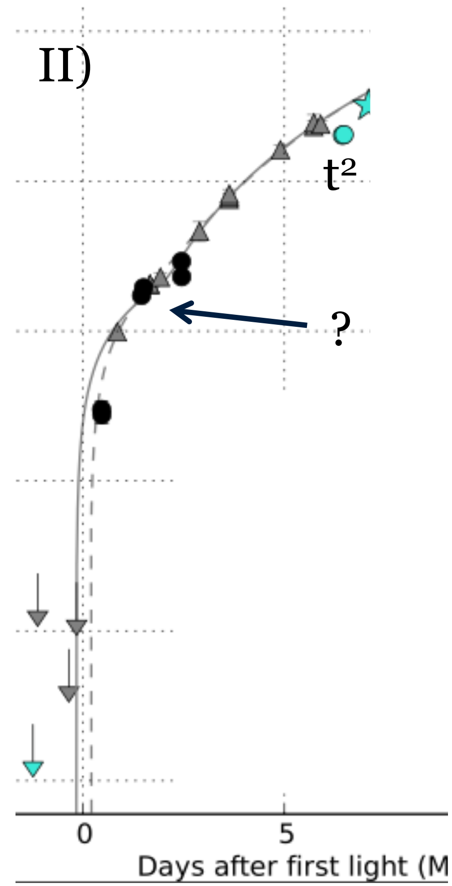
Main collaborators: Markus Kromer (OKC)

& Robert Siverd (Vanderbilt)



I) <1hr cadence observations of SN2014J

II)



The Kilodegree Extremely Little Telescope (KELT)

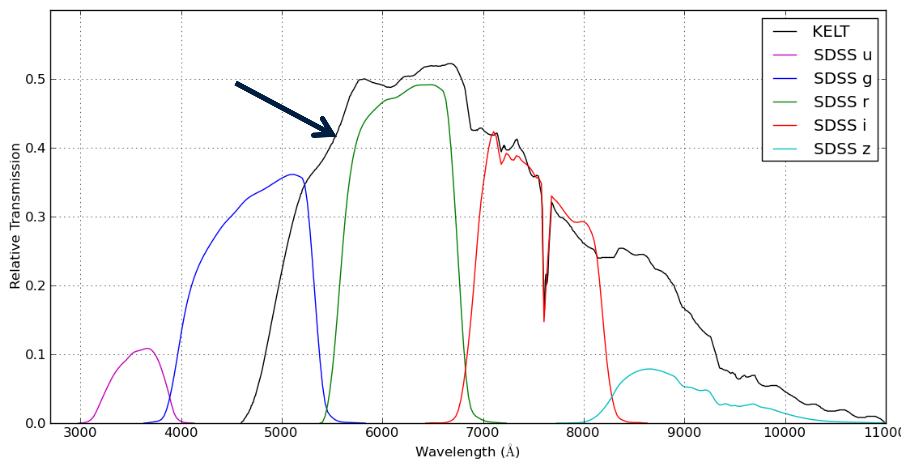
- Monitoring M82 since October 2013

~10-30 visits/night searching for exoplanet transits.

The KELT-North survey telescope is located at Winer Observatory in Arizona. The telescope is a wide-field, small aperture system optimized for imaging bright stars.

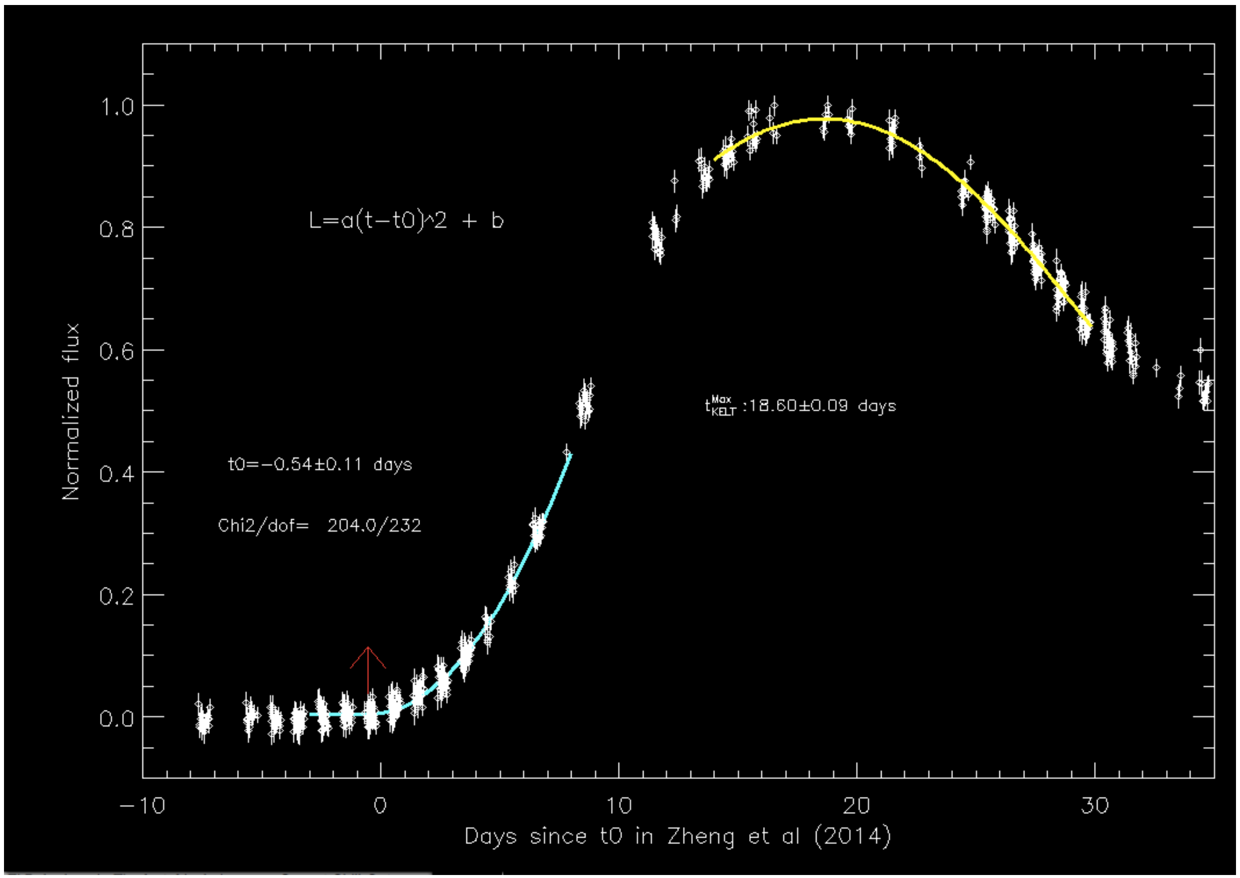
Lens:	Mamiya 645 80mm f/1.9
Aperture:	42.0 mm
CCD:	4096 x 4096 Apogee AP16E
Pixel Size:	9.0 microns
Field of View:	26.0 x 26.0 degrees
Plate Scale:	23.0 arcsec/pixel
Mount:	Paramount ME

- Open filter redwards of 5000Å



Collaborators: Rob Siverd, Keivan Stassun, Joshua Pepper (Vanderbilt)

The early KELT LC (preliminary version)



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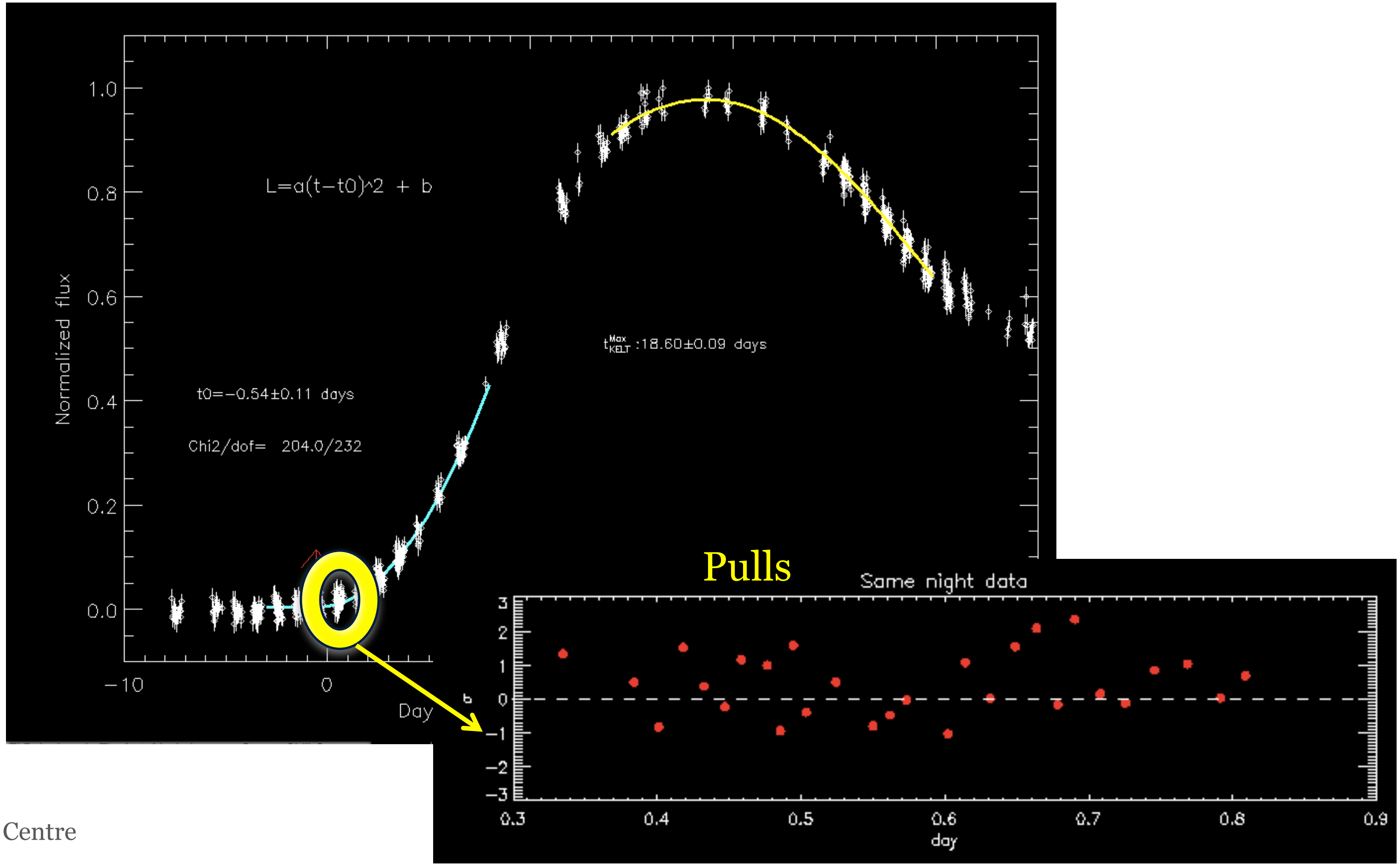
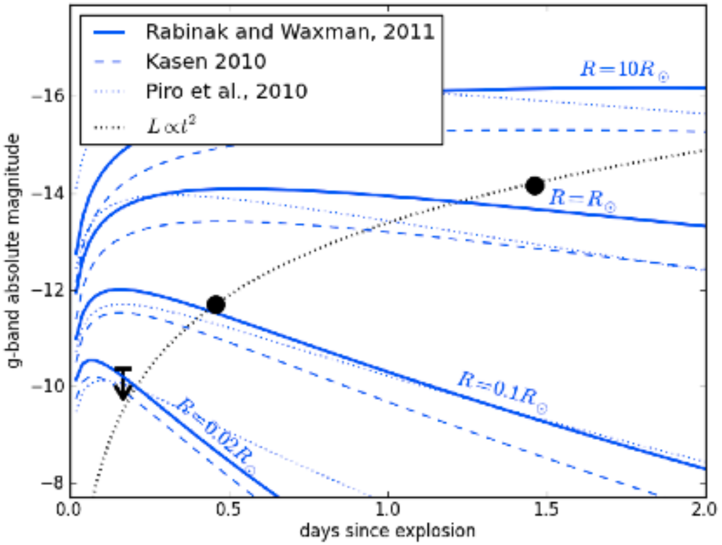
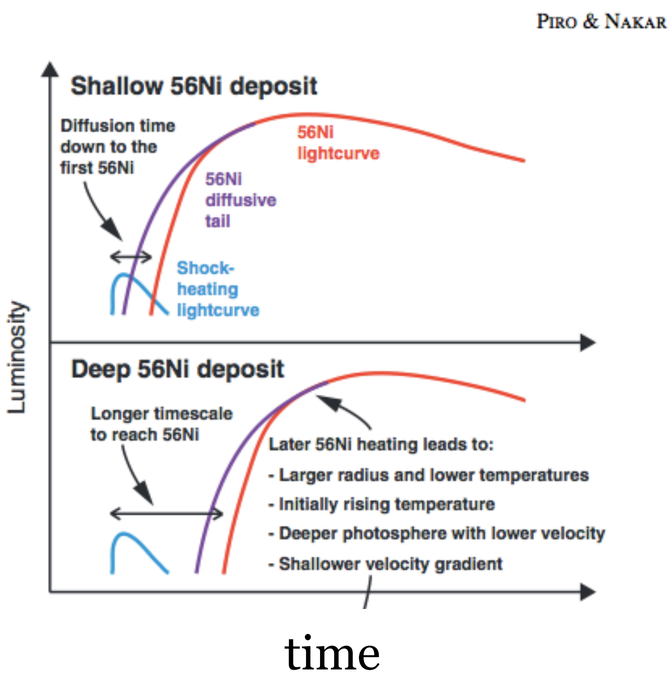


Progenitor size



- Nugent et al 2011, Bloom et al 2012 derived upper limit on progenitor of SN2011fe ($<0.02R_\odot$) from the early rise data.

Powering of early lightcurve



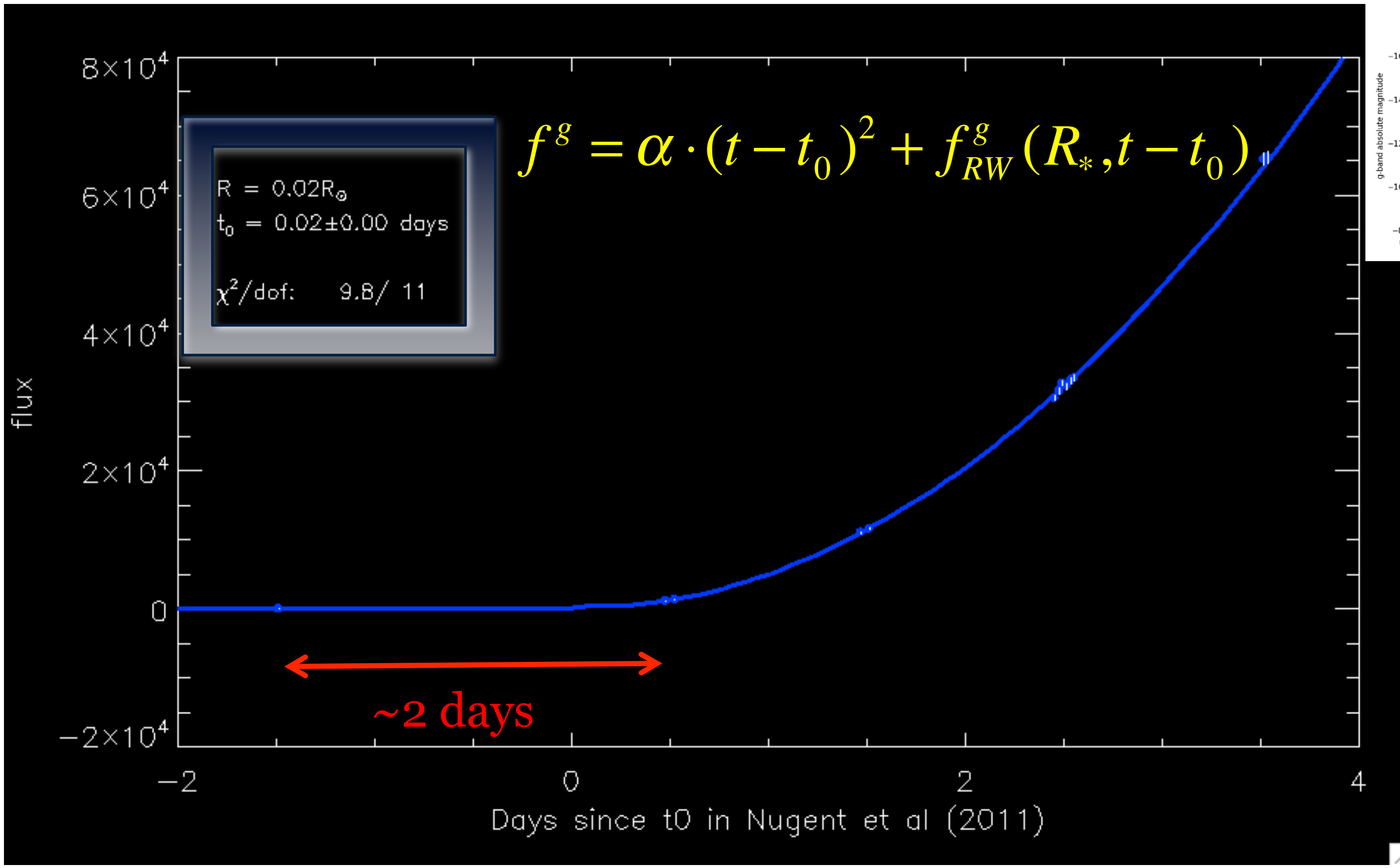
- Piro & Nakar 2013, Mazzali et al 2014: ”dark phase” between the moment of explosion and the first observed light emitted once the shallowest layers of ^{56}Ni are exposed + ”diffusive tail”.
- Time of explosion not well-constrained.
- Other effects that could generate ”bump”

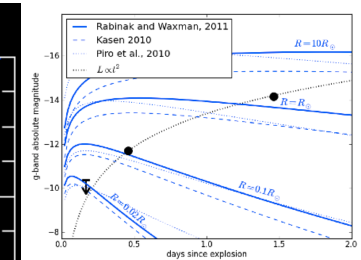
I. Cooling of shock heated ejecta.

II. Shock heating of donor star (Kasen 2010).

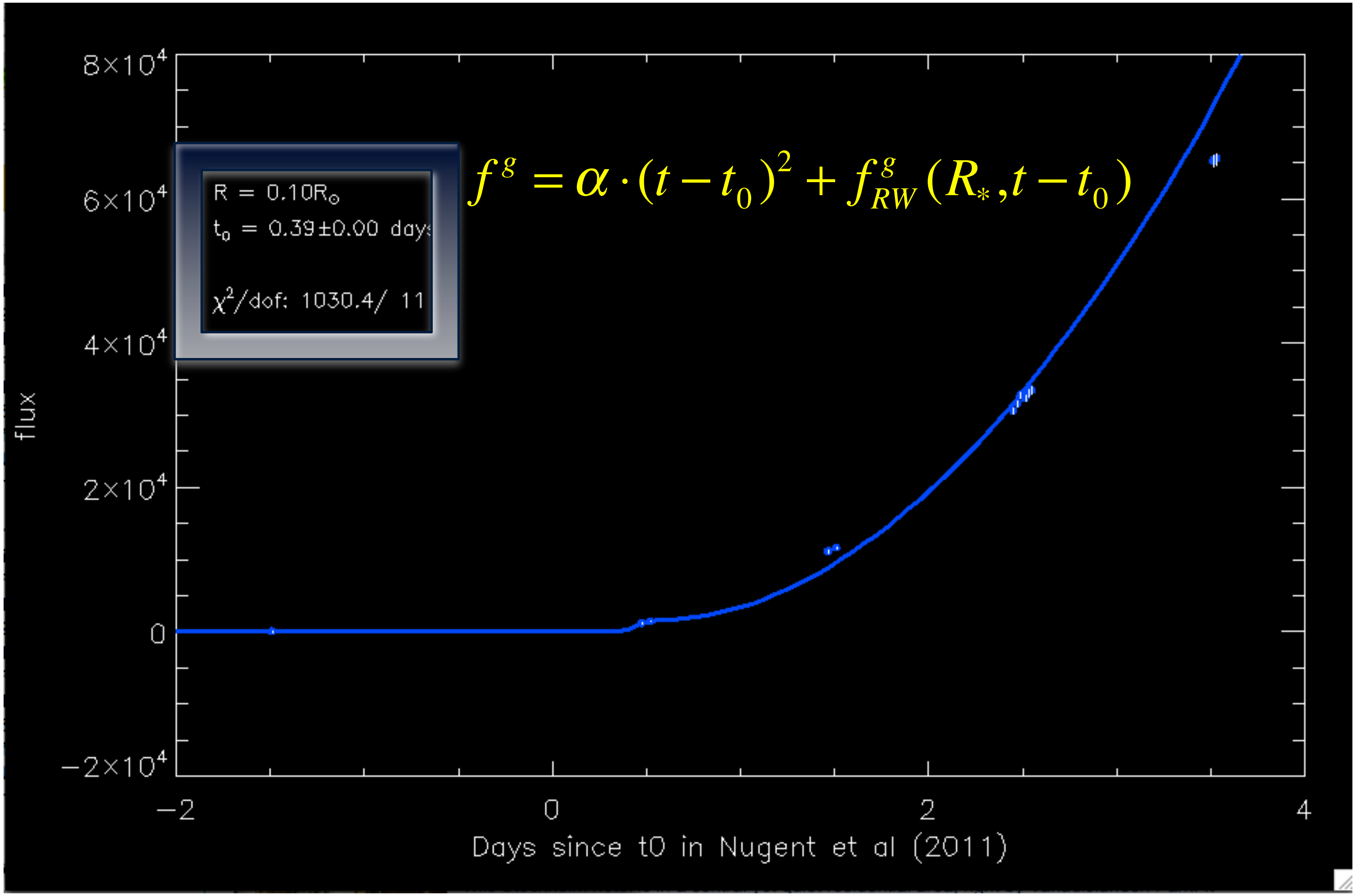
III. Depending on the distribution of ^{56}Ni and other short-lived radioactive isotopes close the surface (e.g., double detonation).

SN2011fe: fitting *flux* by a sum of two components "fireball" + shock heated ejecta (g-band)





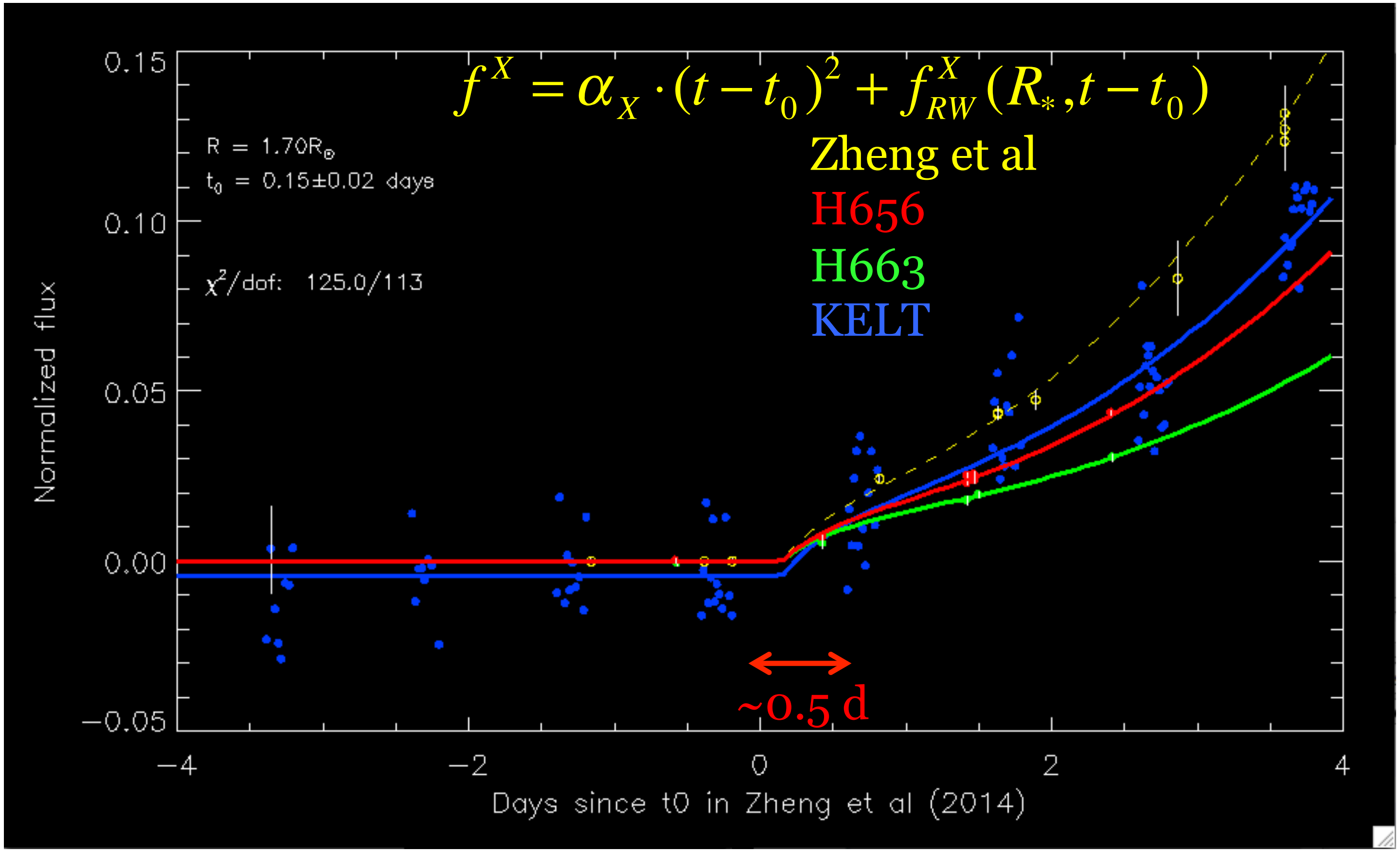
Larger progenitor radii give really bad fits for SN2011fe!



$$f^g = \alpha \cdot (t - t_0)^2 + f^g_{RW}(R_*, t - t_0)$$

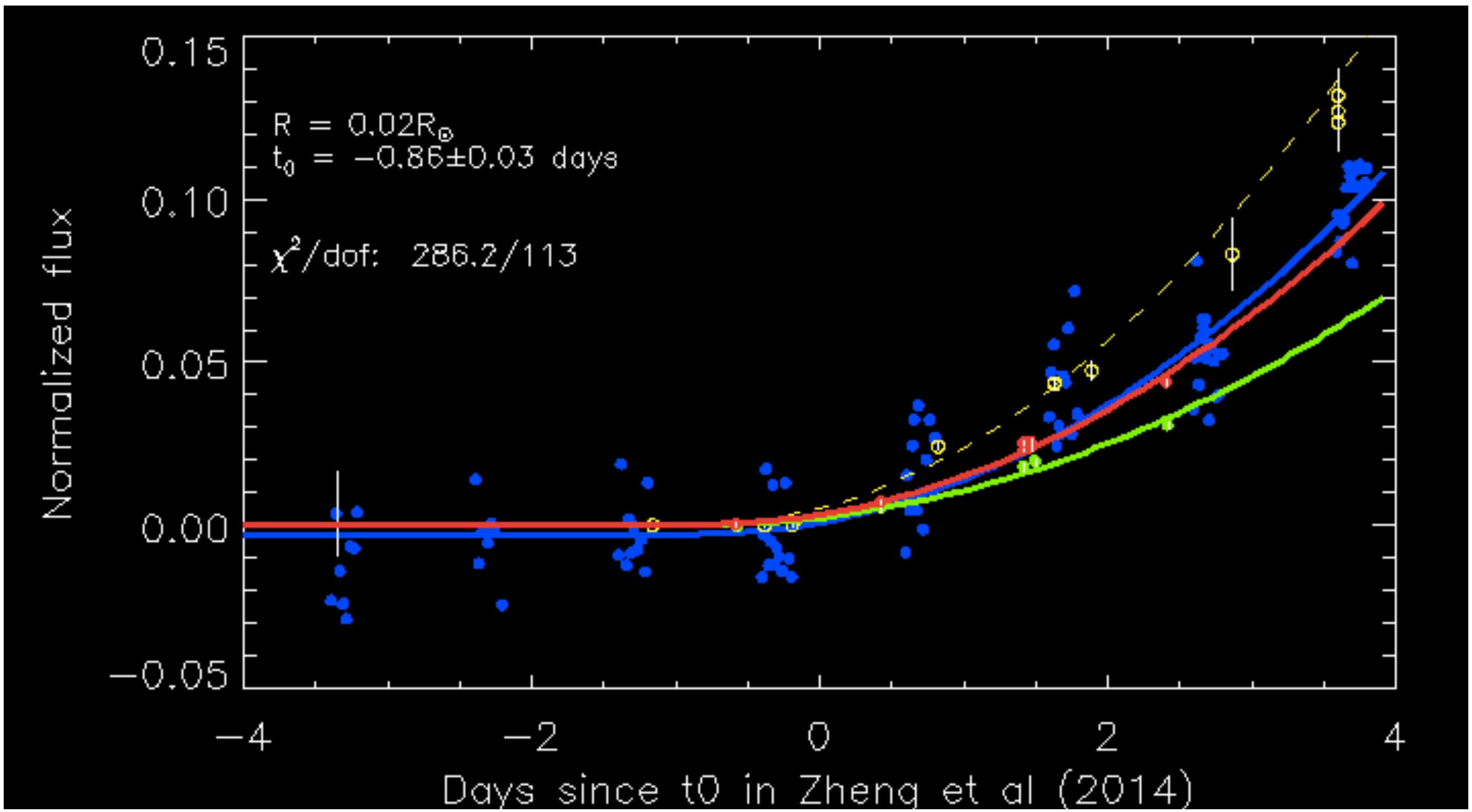
Same procedure for SN2014J using KAIT+2 H-alpha filters + *"riz"* KELT

(The Kilodegree Extremely Little Telescope)



P=0.21

Compact progenitor gives significantely worse fit for SN2014J



$P<10^{-5}$

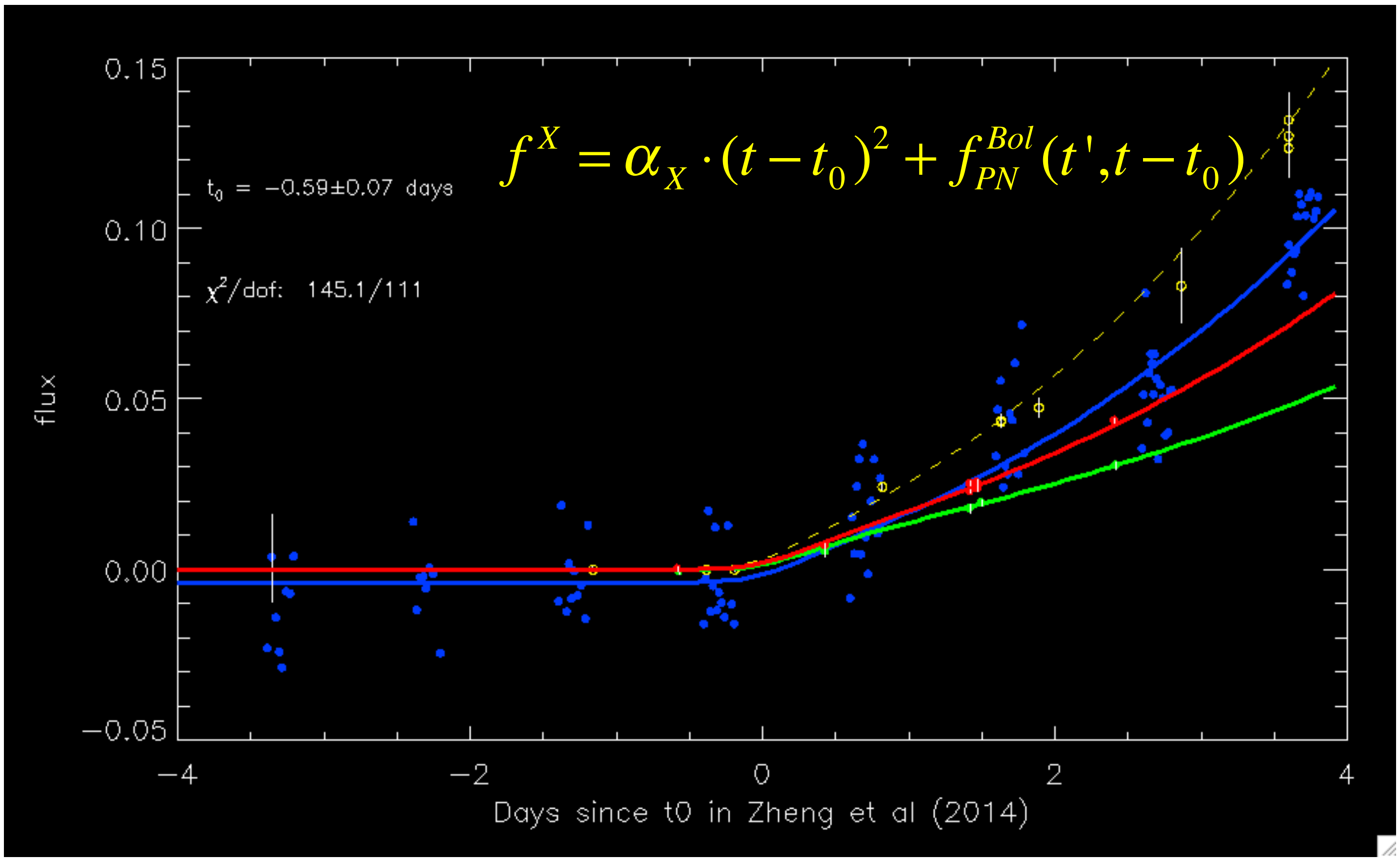
Other interpretations

- Not compatible with expectations from compact progenitor.
- Interaction with companion? (Kasen 2010)

Assuming Roche-lobe overflowing: companion star with $R=5\text{-}150\ R_{\odot}$ (Work in progress). But no radio detection.

- Contribution from short lived isotopes?
- Possibly compatible with picture in Piro & Nakar (2012) involving a steep gradient of ^{56}Ni near surface.

"Diffusive tail" picture in P&N13: $0.001 M_\odot$ of ^{56}Ni in outer layer (1% of mass) provides acceptable fit.



P=0.02

Assumption: filter data proxy for bolometric LC

Summary

- Unique set of high-cadence data for SN2014J, unfortunately not as deep as earliest data of SN2011fe.
- Compatible with t^2, *except for first 48 hs*.
  - Shock heating of progenitor/companion provide good fits, but give uncomfortably large radii.
  - Model with radioactive elements near surface (a modified version of Piro & Nakar 2013) provides acceptable fits. Note that this treatment would give smaller X_{56} for SN2011fe than derived in Piro 2012. (Piro 2012≠ Piro & Nakar 2013).
  - Short-lived isotopes remains an intriguing untested hypothesis. To be studied next.
  - Implications for SNIa models?