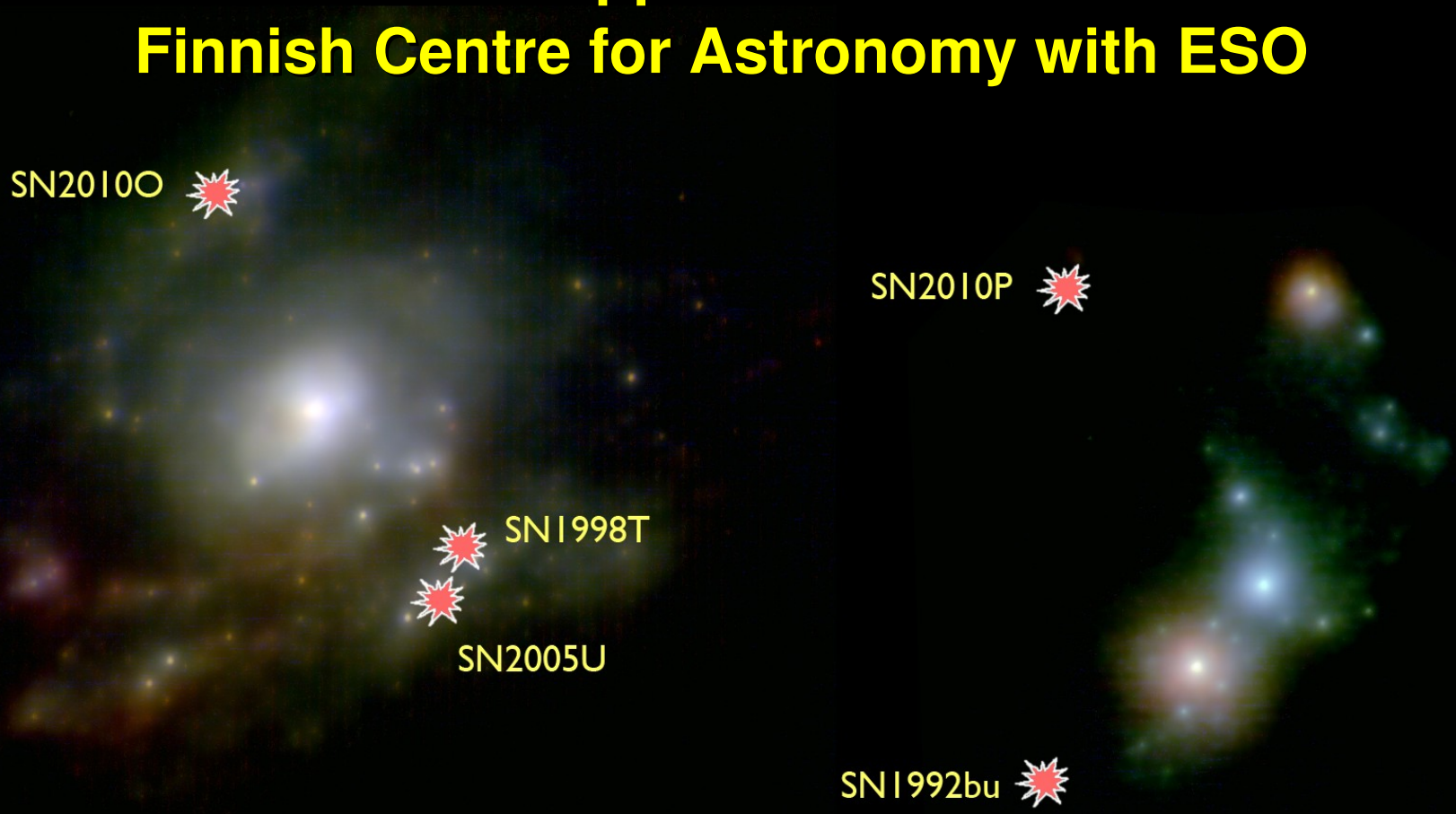
Studies of core-collapse SNe with NOT

Seppo Mattila
Finnish Centre for Astronomy with ESO



Studies of core-collapse SNe with the NOT

(in Stockholm, Turku, Århus)

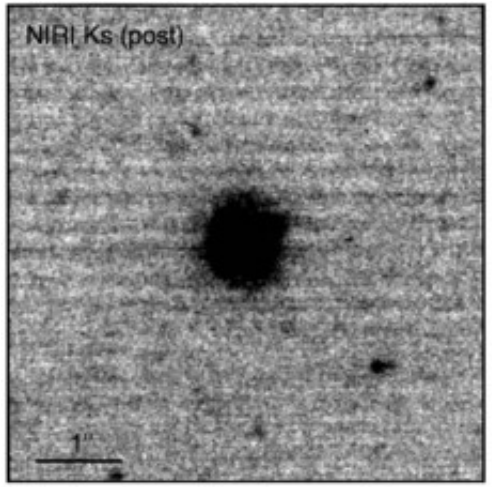
- Follow-up of SNe with identified progenitors
- SNe interacting with CSM
- Follow-up of rare types of SNe
- SN rates and SNe missed in dusty galaxies
- Dust formation in SNe

SNe with identified progenitors

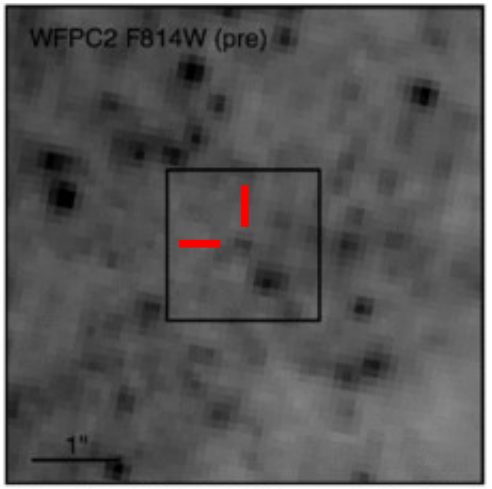
SN 2009md: another faint supernova from a low-mass progenitor

Fraser et al. (incl. Ergon, Sollerman, Mattila) 2011, MNRAS, 417, 1417

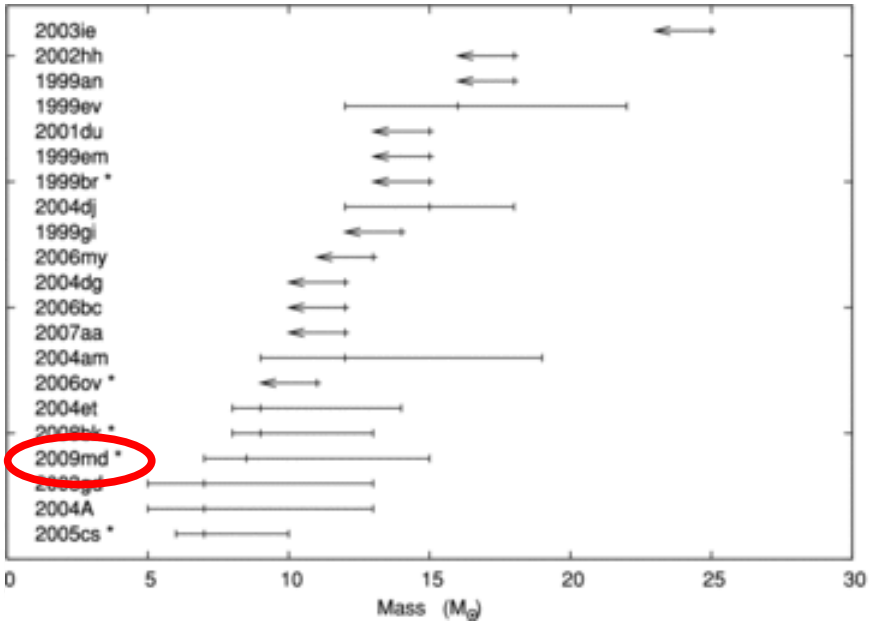
- Adaptive optics used to pinpoint the progenitors (PI: M. Fraser, QUB)
- Provides a fundamental test of stellar evolution theory
- SN 2009md progenitor a red supergiant with M = 7 - 15 $M_{\odot}$
- Close to the lowest end of the mass range producing a core-collapse
- SN follow-up crucial for relating progenitors with SN properties



(a) Section of Gemini NIRI post-explosion image, centered on the SN.



(b) Section of HST WFPC2 pre-explosion image, centered on the SN location. A blow up of the central region (indicated by a black square is shown in panel (c).



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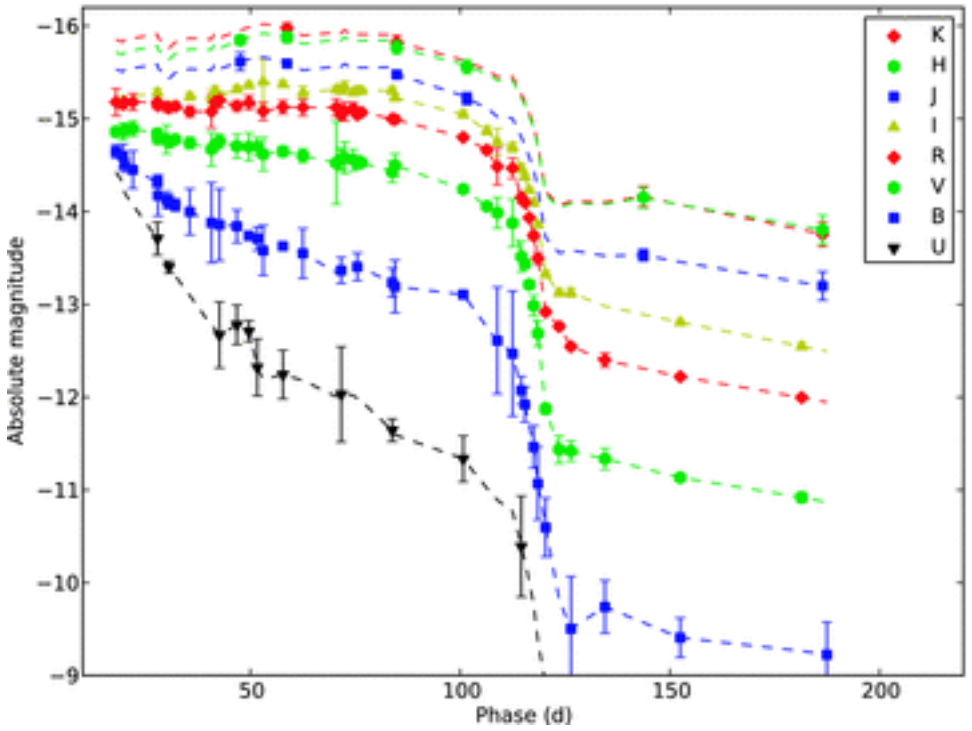
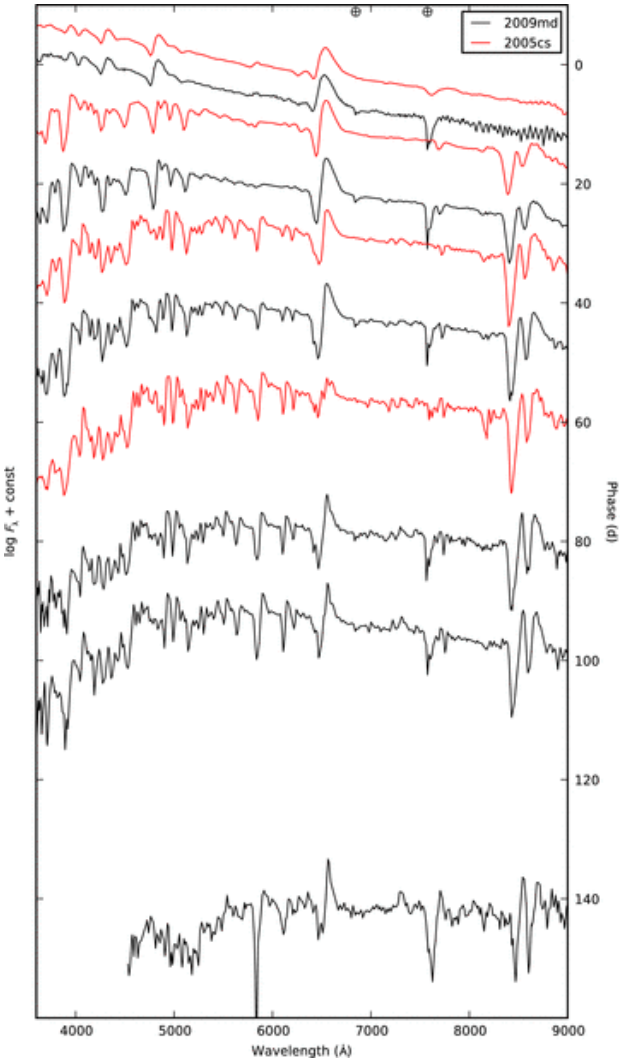
- NOT provided SN follow-up in most progenitor studies recently
- SN 2009md was a subluminous Type II-P SN
- Low mass of ^{56}Ni ejected in the explosion
- Third time a low-mass progenitor was detected for a low energy, low ^{56}Ni mass SN!



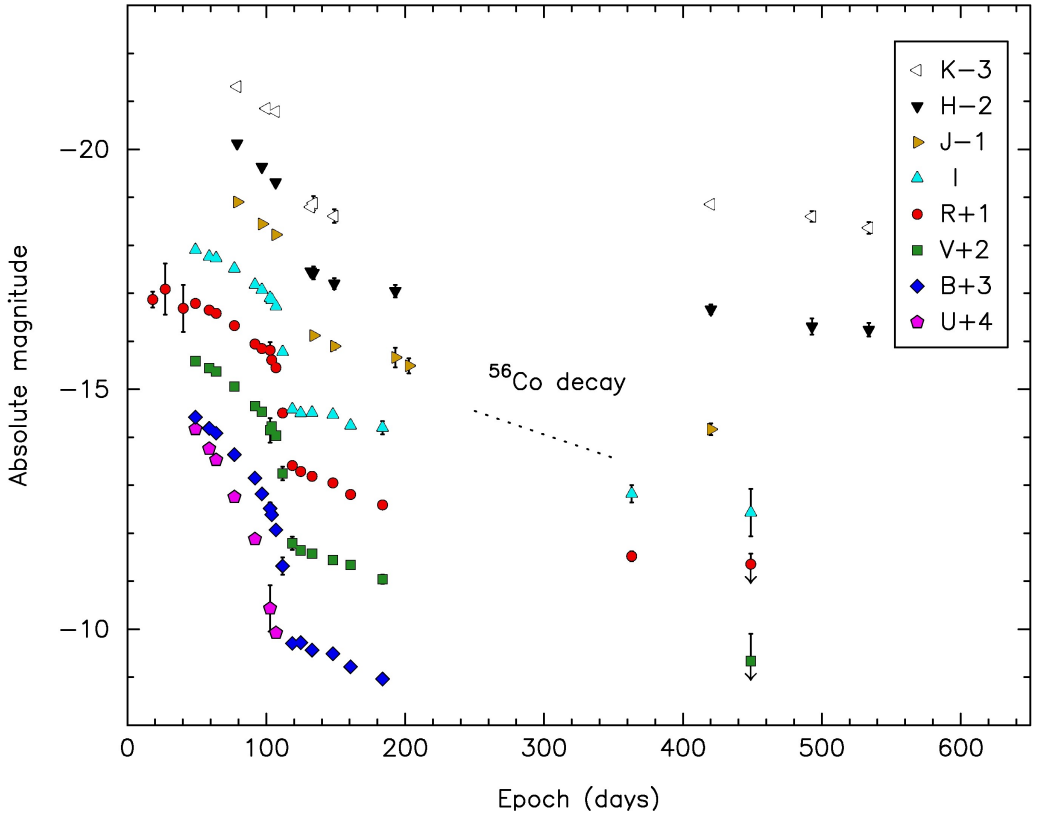


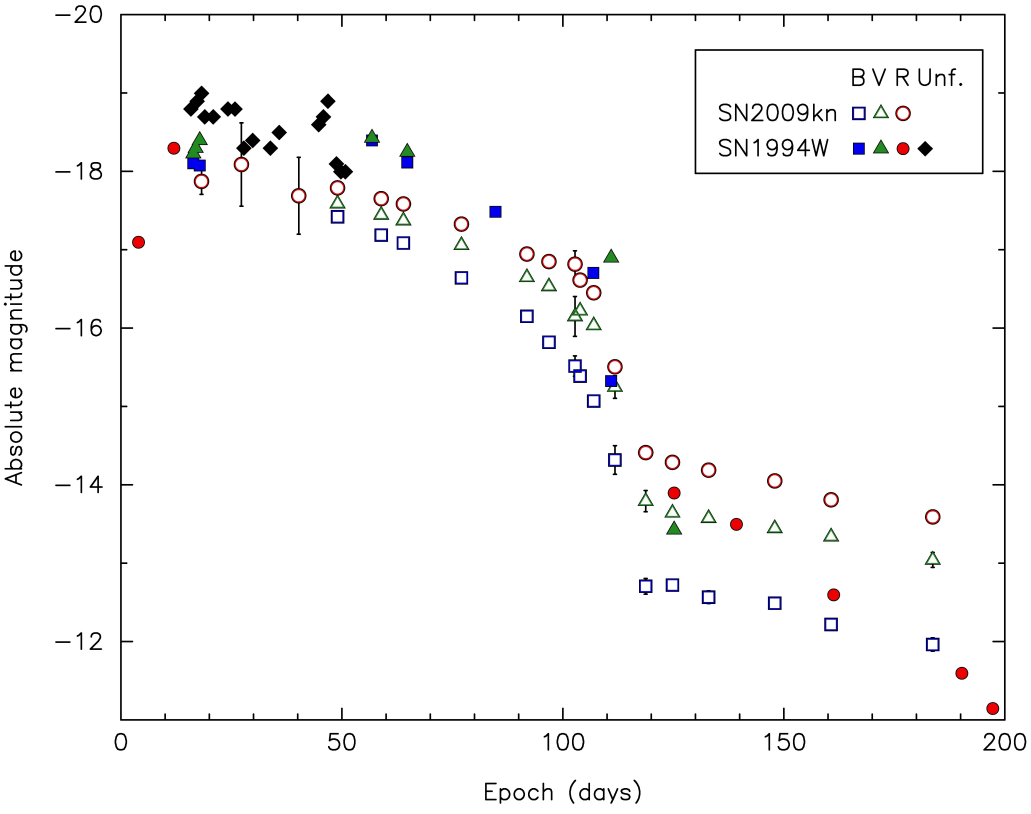
SNe interacting with CSM

SN 2009kn: the twin of the Type IIn supernova 1994W

Kankare et al. (incl. Mattila, Sollerman, Stritzinger) 2012, MNRAS, 424, 855

- SN targets followed together with the large European SN collaboration
  - ESO NTT Large Programme (PI: S. Benetti): P84-P89
  - **P**ublic **E**SO **S**pectroscopic **S**urvey of **T**ransients **O**bjects (PI: S. Smartt)
- Detailed follow-up of the Type IIn SN 2009kn (lead by Turku)
- Extensive follow-up for SNe 2009kr, 2010jl, 2011dh (lead by Stockholm)

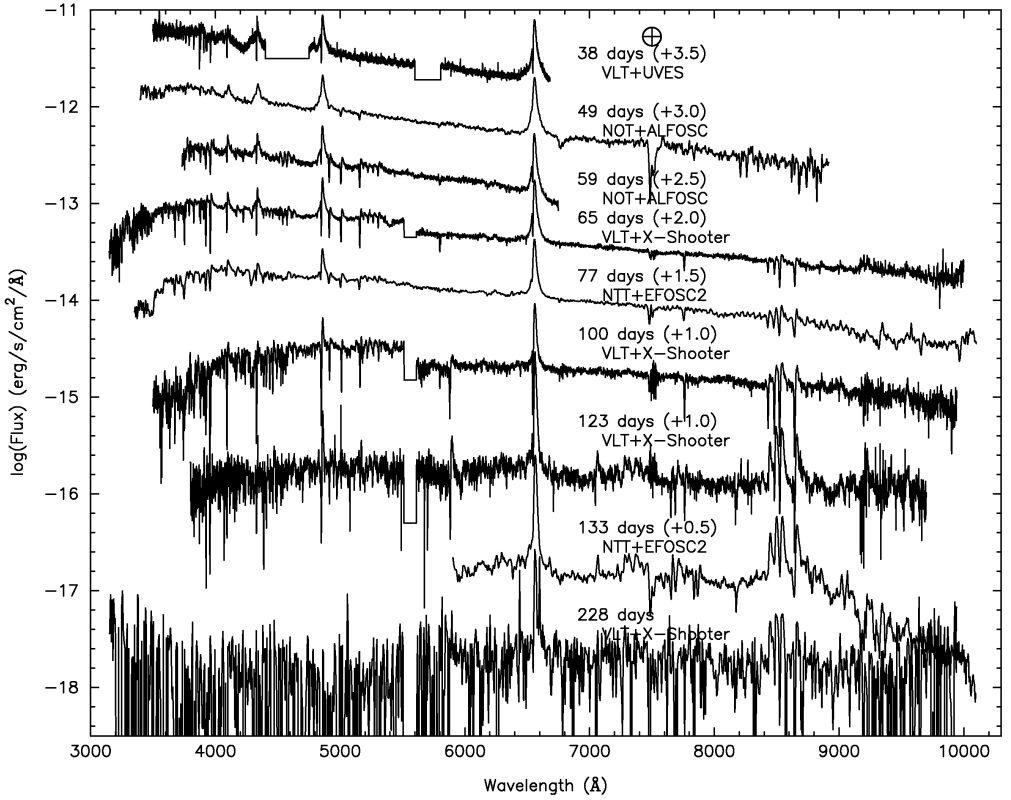


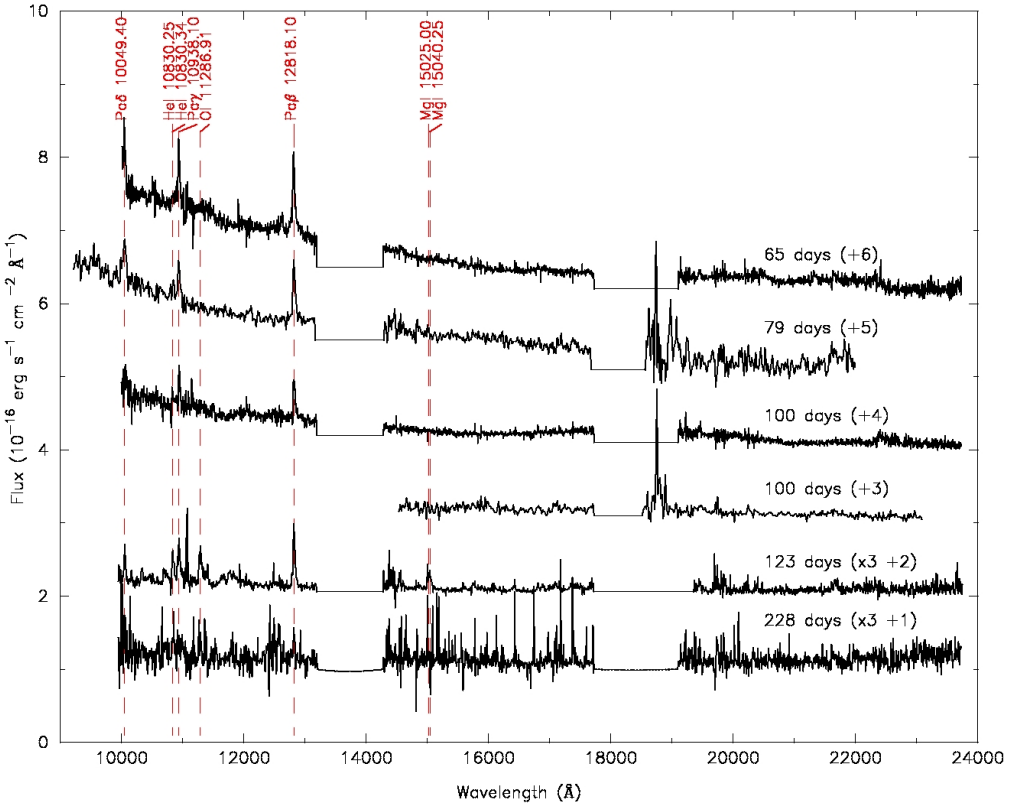


SN 2009kn: the twin of the Type IIn supernova 1994W

Kankare et al. (incl. Mattila, Sollerman, Stritzinger) 2012, MNRAS, 424, 855

- Spectroscopy and imaging of SN 2009kn from several telescopes incl. NOT
- SN 2009kn an example of a rare class of Type IIn supernovae
- Origin in an electron capture SN from an S-AGB star close to 8 $M_{\odot}$?



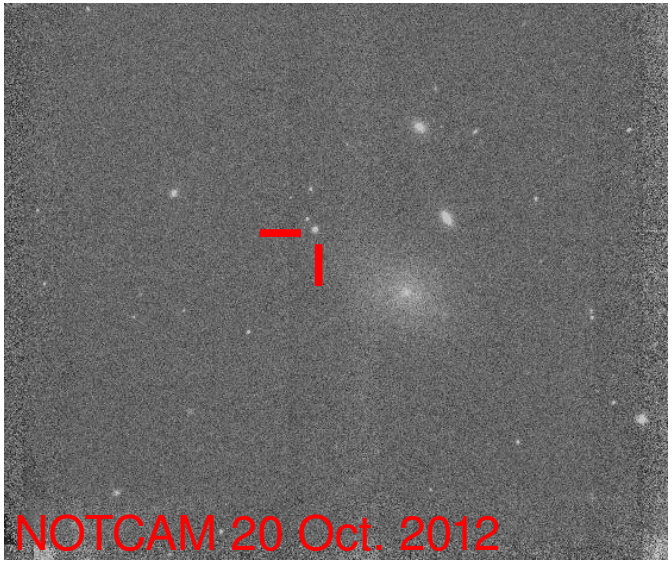


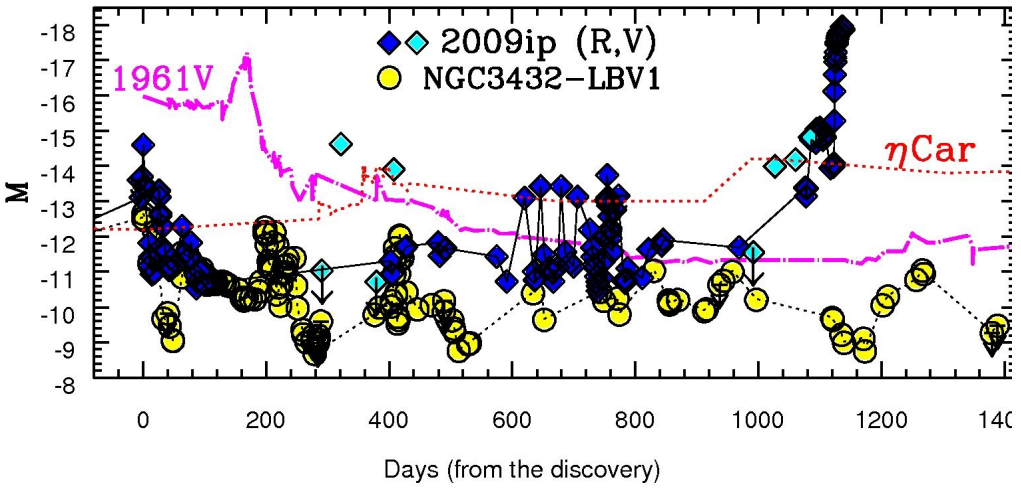
Rare types of SNe

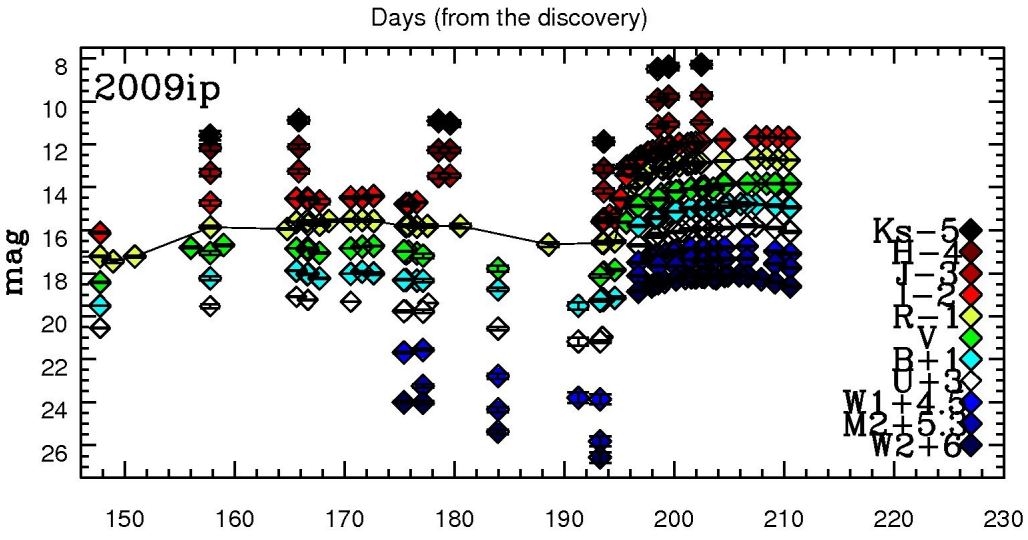
Interacting Supernovae and SN Impostors - SN 2009ip, is this the end?

Pastorello et al. (incl. Ergon, Kankare, Mattila) et al. 2012, ApJ, submitted

- A 'restless' Luminous Blue Variable in NGC 7259
- Designated SN 2009ip in a giant 2009 outburst
- Strong brightening on 24 Sept. 2012 onwards
- NOTCAM obs. 27, 28 Sept and 1, 20 Oct.
- Reached a SN-like absolute magnitude of -18







Interacting Supernovae and SN Impostors - SN 2009ip, is this the end?

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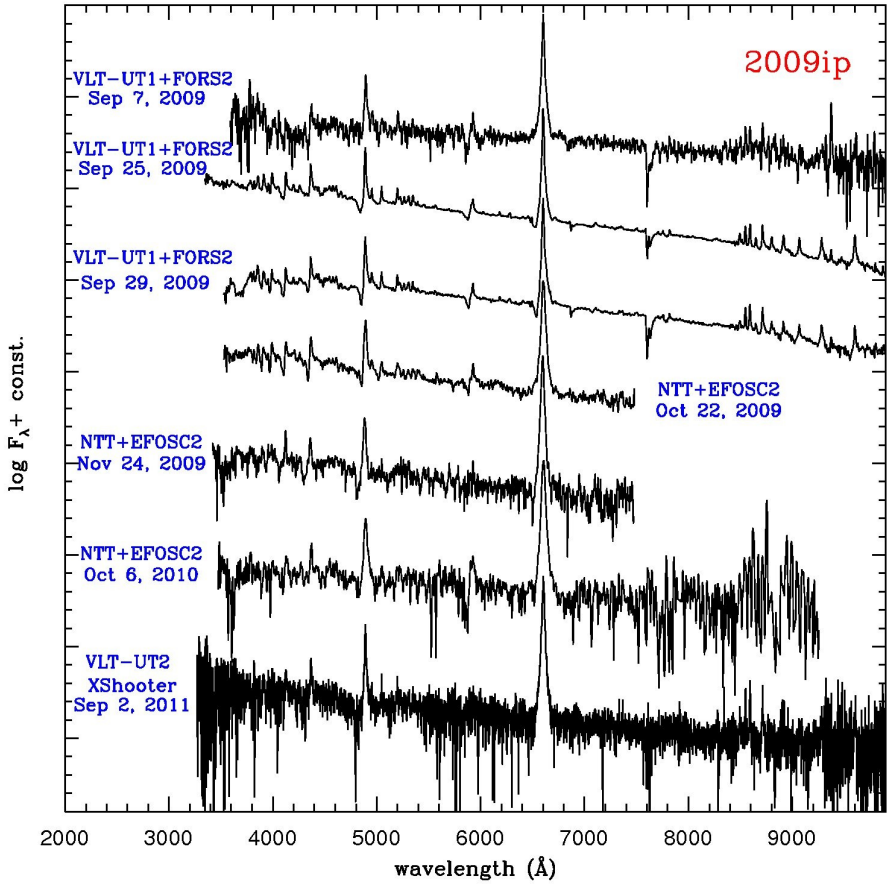
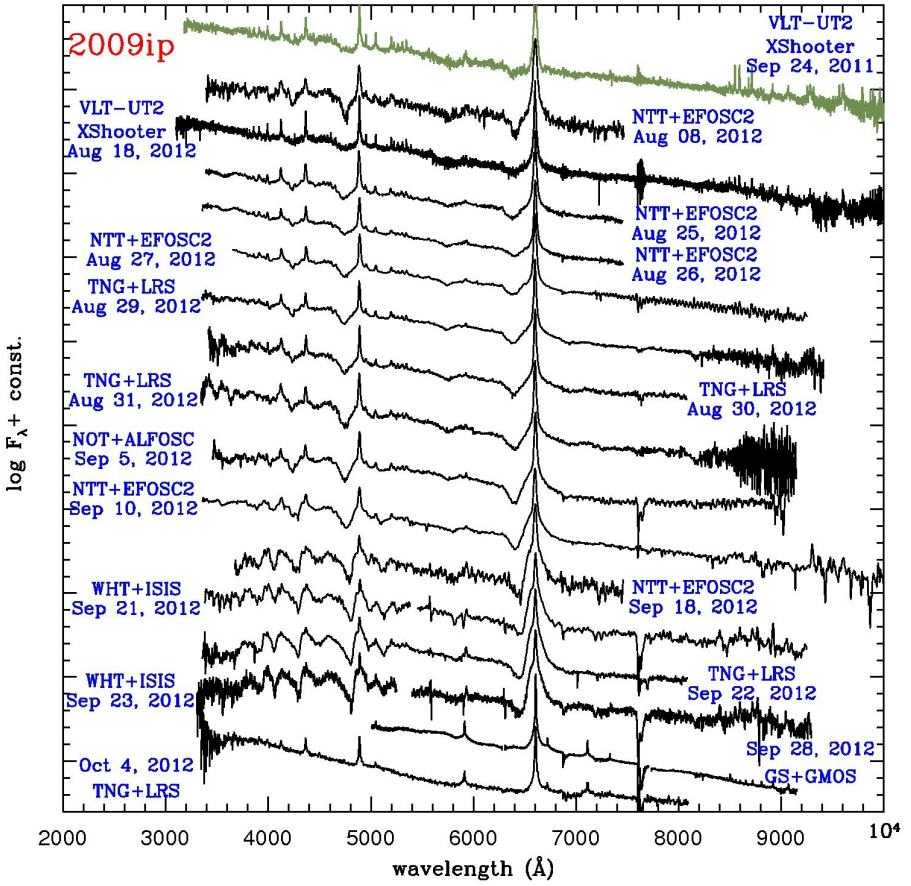
- Broad spectral lines already before Sept. 2012!
- Origin in a pulsational pair-instability event?
- Did the progenitor survive the latest outburst?
- More rare SN discoveries from the wide-field SN searches (PS1, PTF ...)



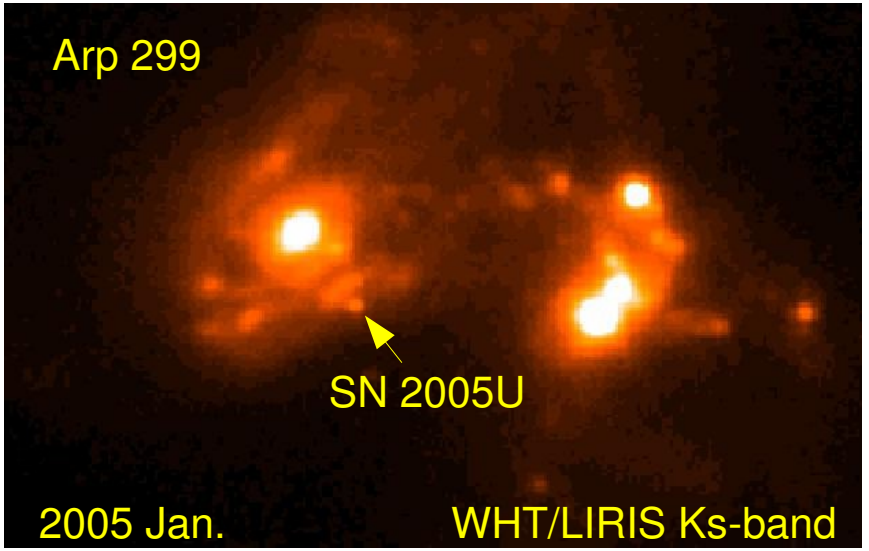


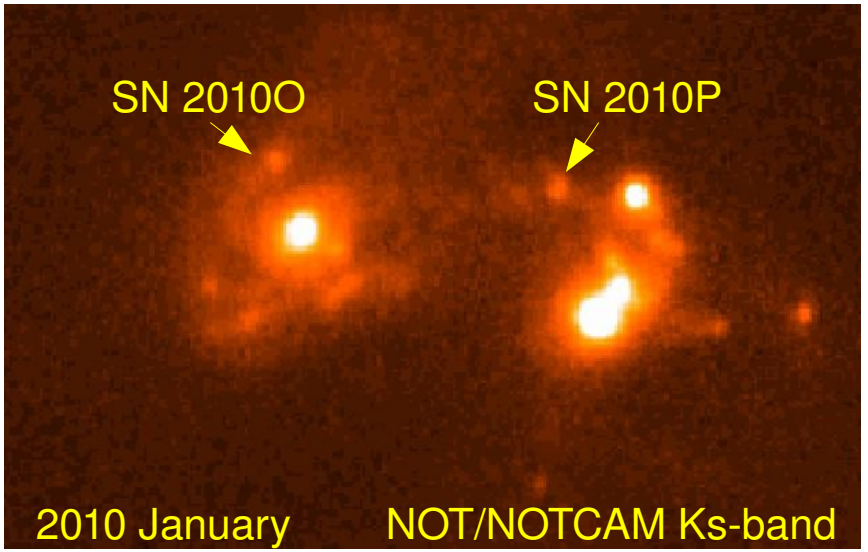
Dust obscured SNe

Core-collapse SNe Missed by Optical Surveys

Mattila (incl. Melinder, Östlin from Sthlm) et al. 2012, ApJ, 756, 111

- Detect and study SNe in luminous infrared galaxies
  - Characterise the nature of SNe within the LIRG nuclear regions
  - Estimate how many SNe missed in dusty regions of galaxies
- Adaptive Optics programmes at VLT (PI: Mattila) Gemini (PI: Ryder)
- NOTCAM used to detect and follow-up SNe in our nearest targets
- K-band with strongly reduced extinction crucial!
- Systematic monitoring of Arp 299 (>20 NOTCAM epochs)

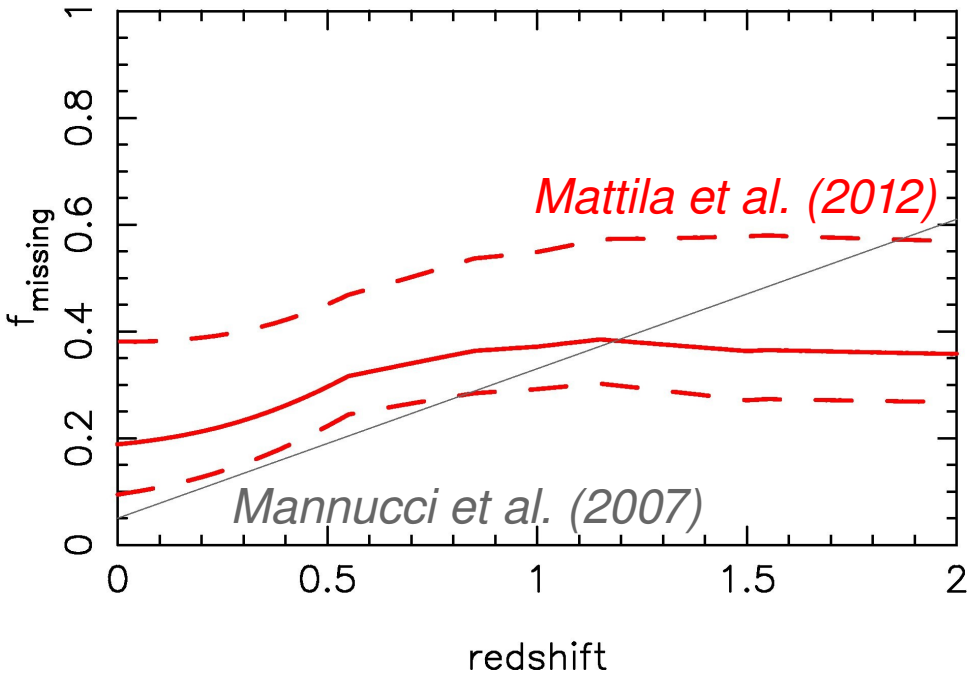


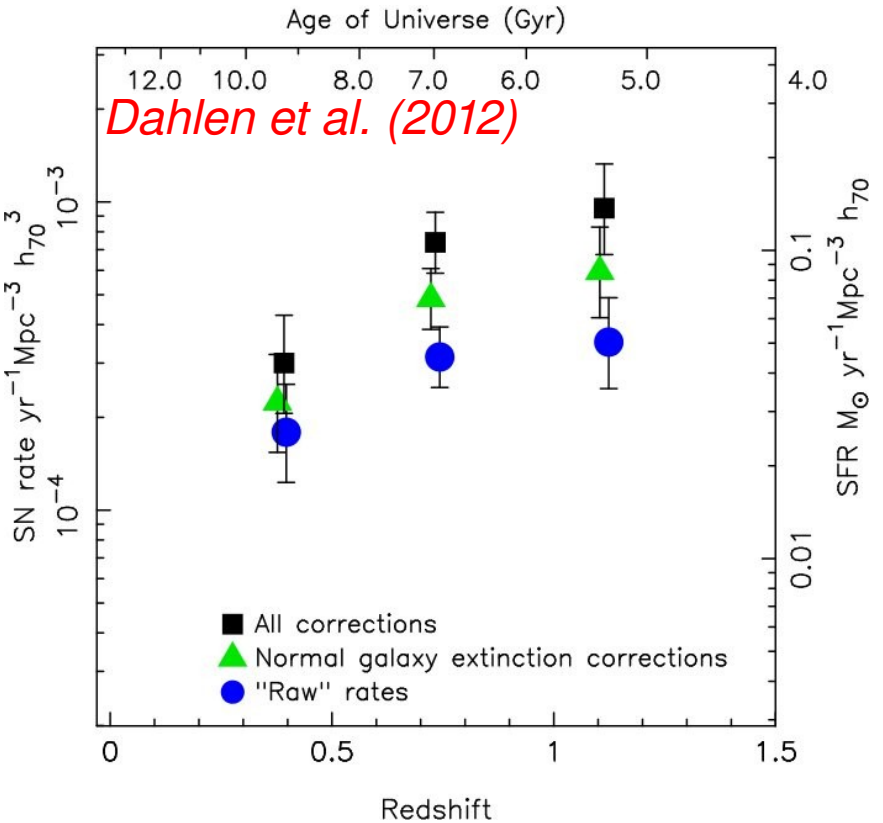


Core-collapse SNe Missed by Optical Surveys

Mattila (incl. Melinder, Östlin from Sthlm) et al. 2012, ApJ, 756, 111

- CCSNe missed by rest-frame optical surveys in dusty environments:
- **~5-35%** in 'normal' host galaxies and **~70-90%** in local U/LIRGs
  - The missing fraction increases from local **~20%** to **~38%** at z ~ 1.2
- Accurate correction for dust obscuration crucial for CCSN rate studies
- After correction CCSN rates consistent with expectations from the SFRs





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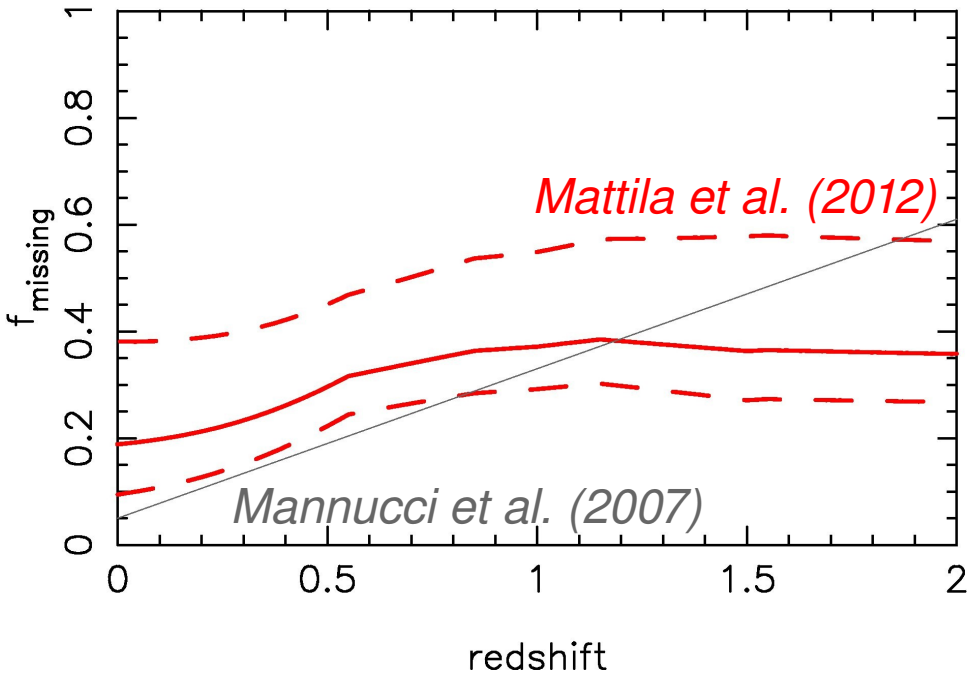
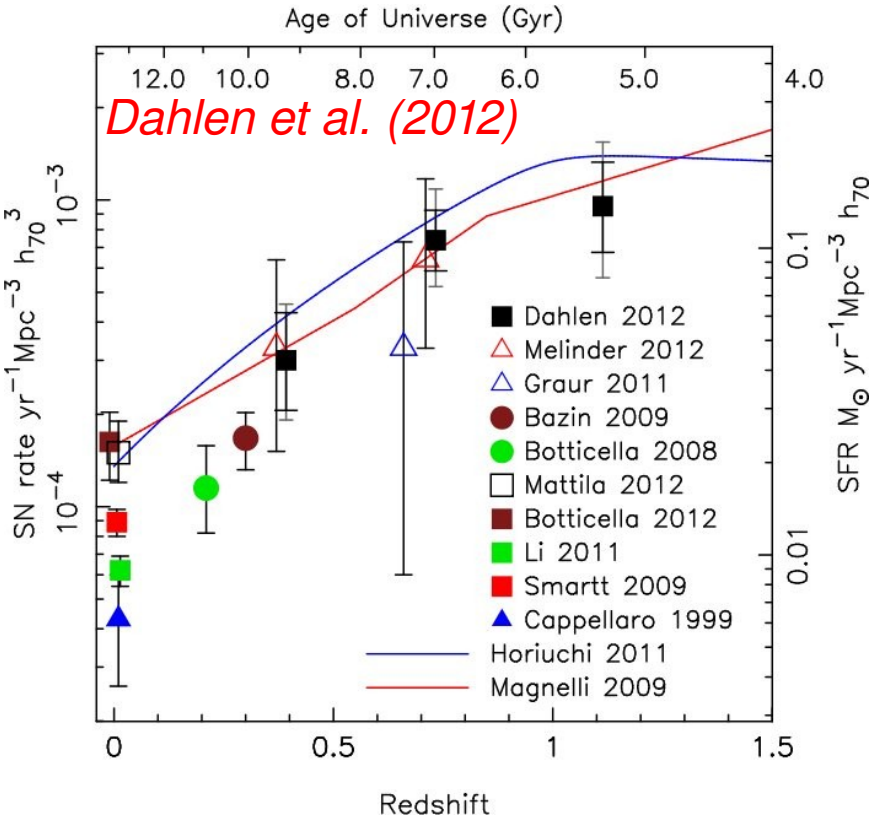
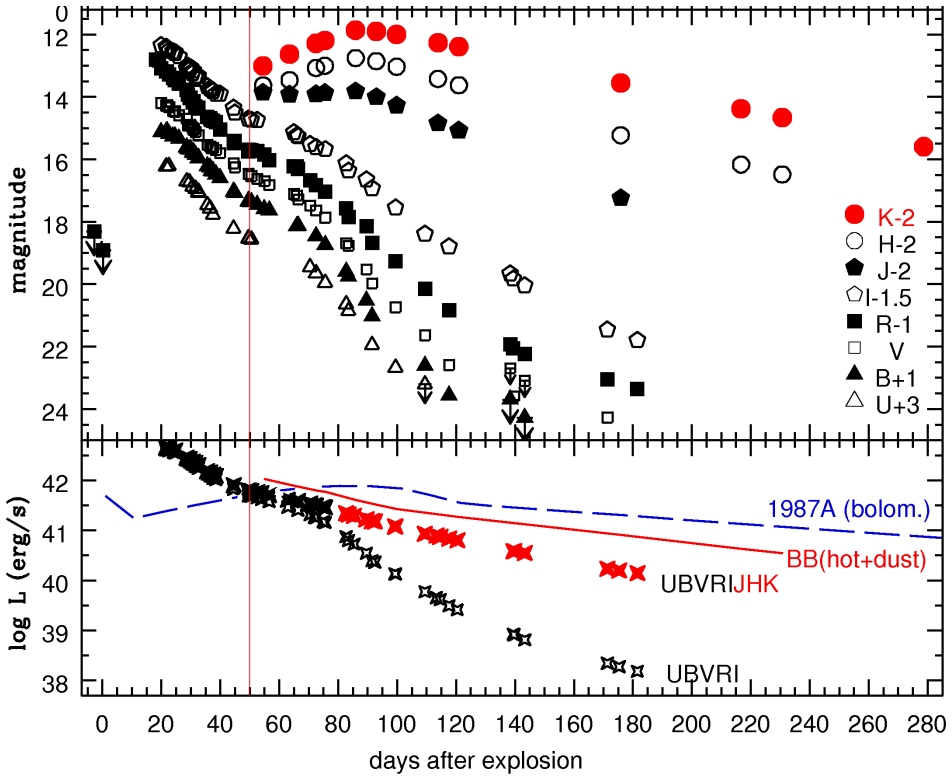


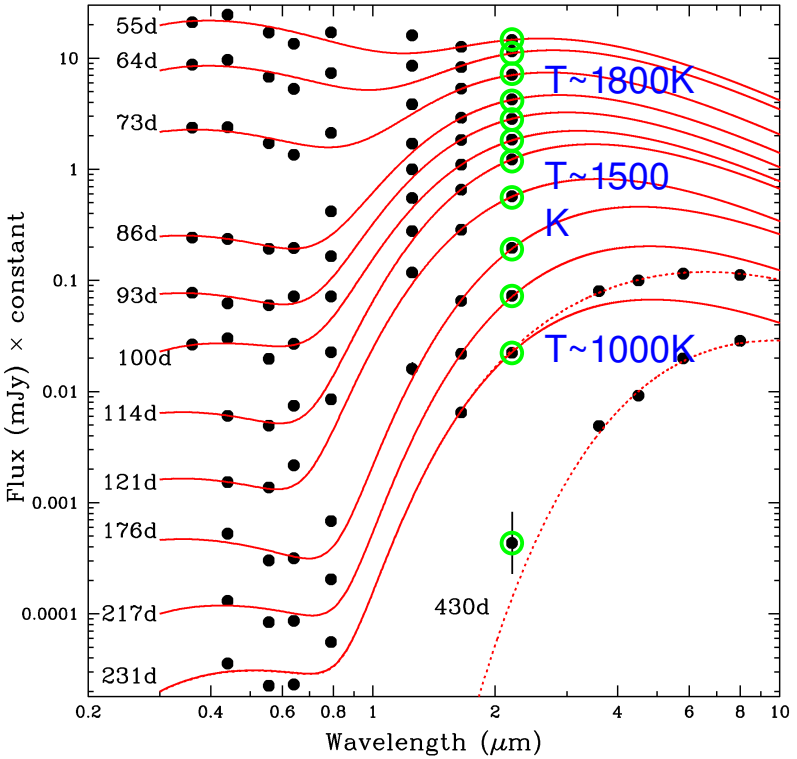


Dust formation in SNe

SN 2006jc: IR echoes from new and old dust in the progenitor CSM

Mattila et al. 2008, MNRAS, 389, 141





- NTE including also K-band allows extending the SED to the *thermal* IR
- Allows studies of CCSNe with pre-existing/newly-formed dust
- The rare Type Ib SN 2006jc observed with UKIRT+Spitzer
- Dust condensed in a cool dense shell produced by ejecta-CSM interaction

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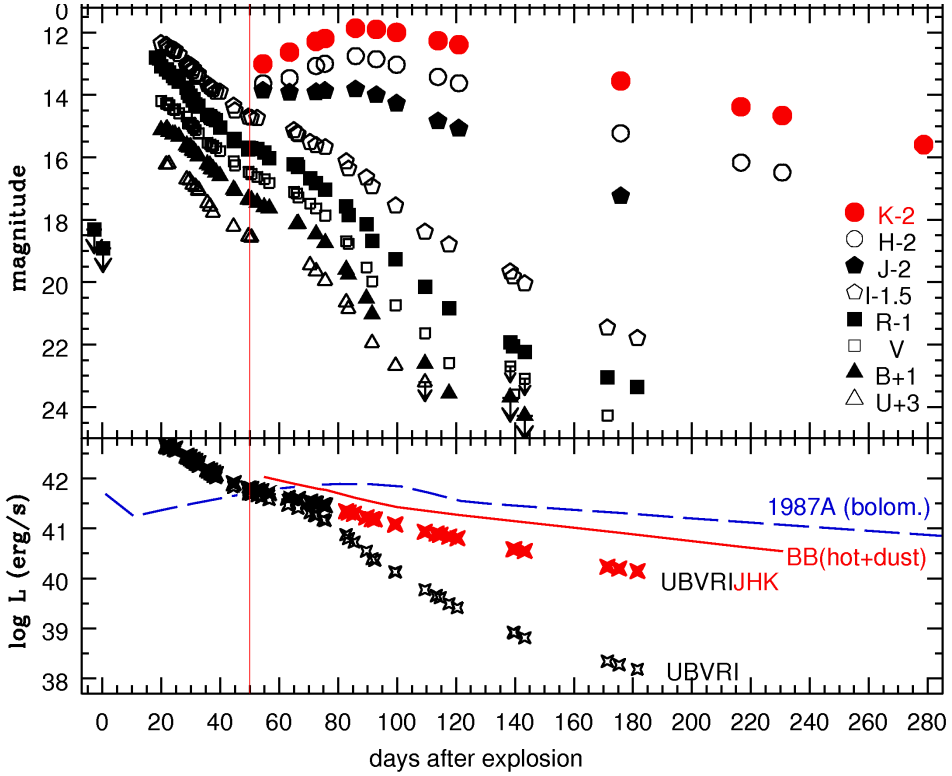

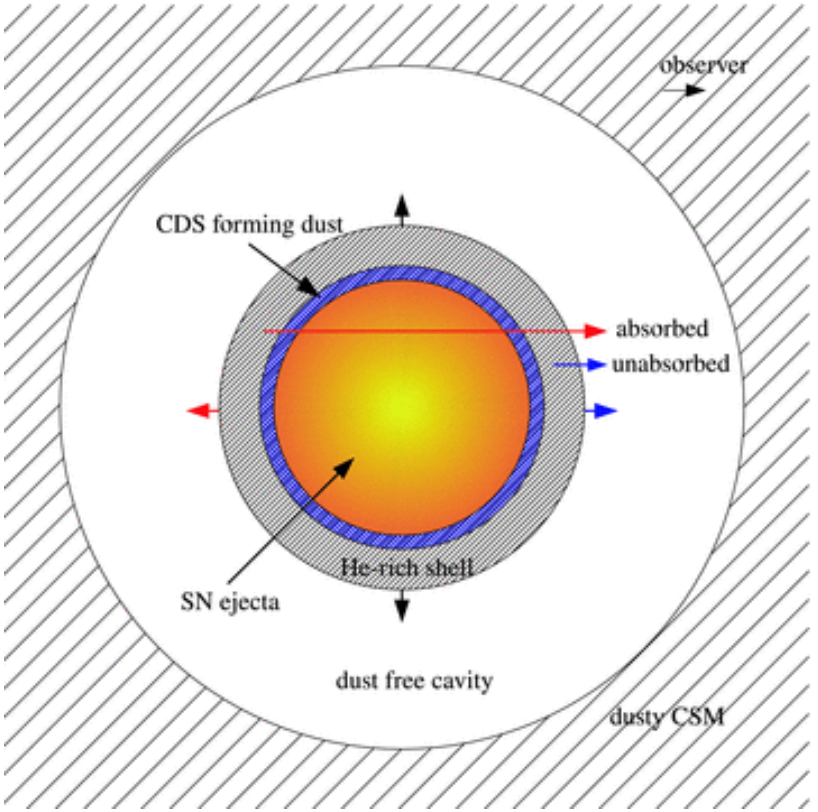

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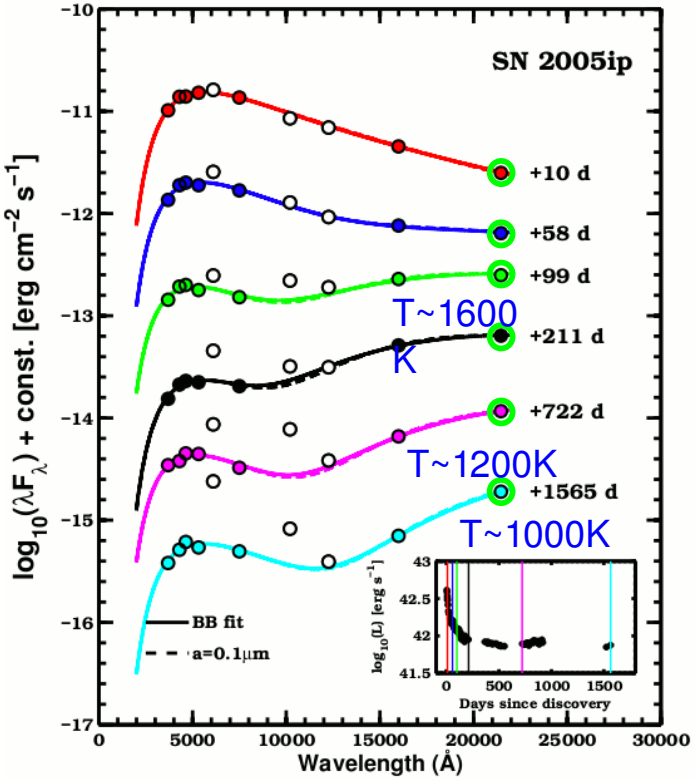
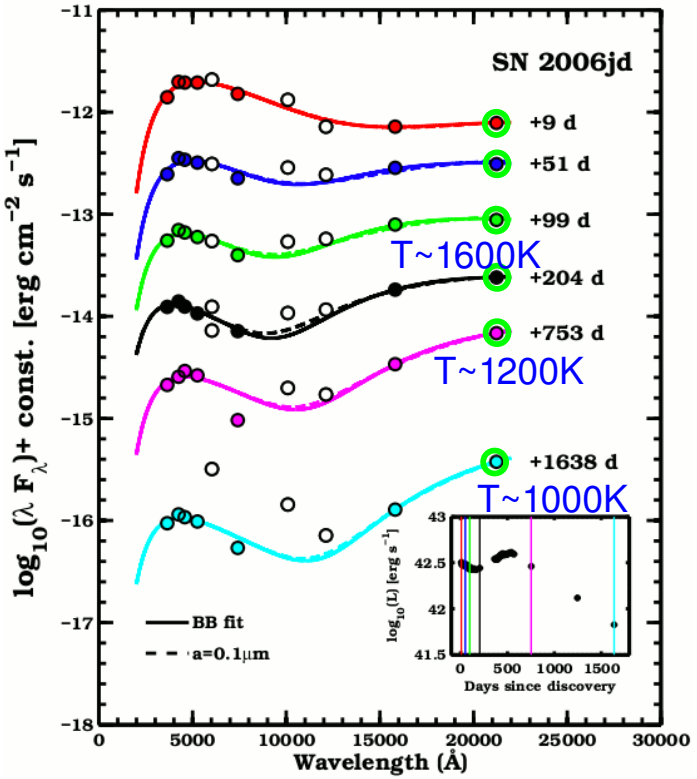
The Enduring Type IIn SNe 2005ip and 2006jd

Stritzinger (Århus), Taddia (Stockholm) et al. 2012, ApJ, 756, 173





- The two SNe observed with 1-2.5m telescope at Las Campanas + Spitzer
- Late time spectroscopy for SN 2005ip from ALFOSC
- Evidence for warm (newly formed) and cool (pre-existing) dust

Core-collapse SN follow-up with the NTE

- Observations in the optical + near-IR on the same night!
- Intermediate resolution (R ~ 4000) optical spectroscopy
- Optical + near-IR (JHKs) imaging
- Near-IR spectroscopy for brightest targets?