Studies of peculiar transients with TNG

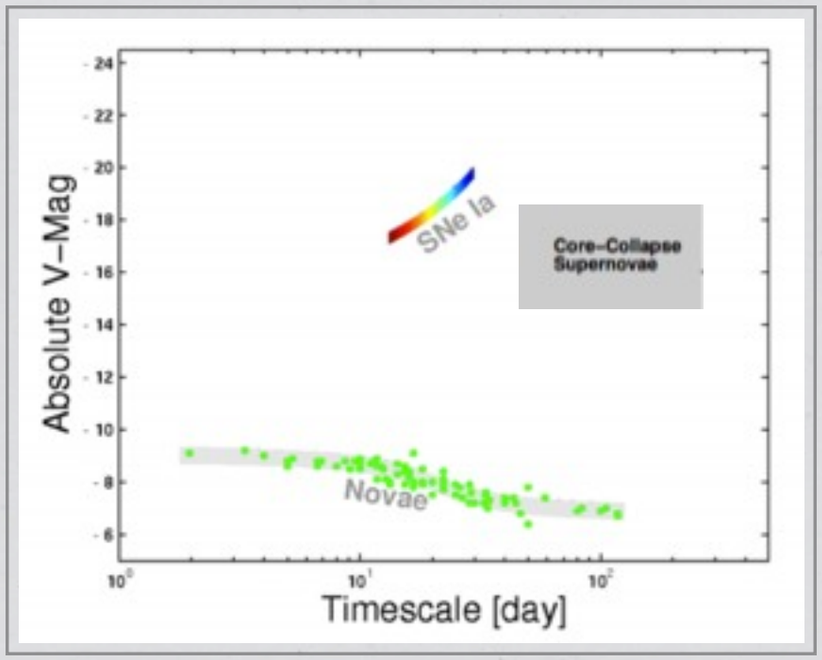
Past results and future perspectives

ANDREA PASTORELLO (INAF-OAPd)

Padova, 2017 March 1-3

TNG Workshop

New types of stellar transients

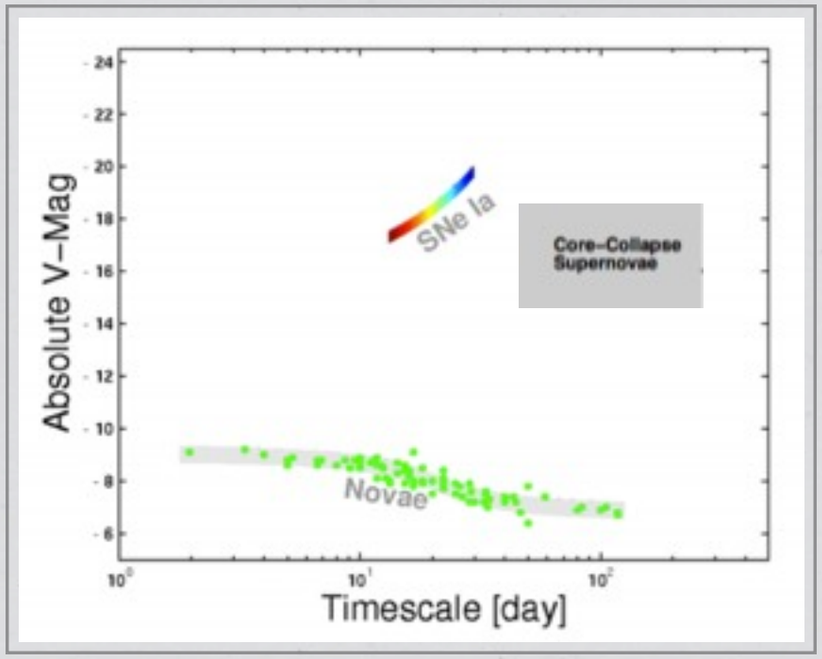


The transient sky

(past decade)

Credits: S. Kulkarni's team

New types of stellar transients



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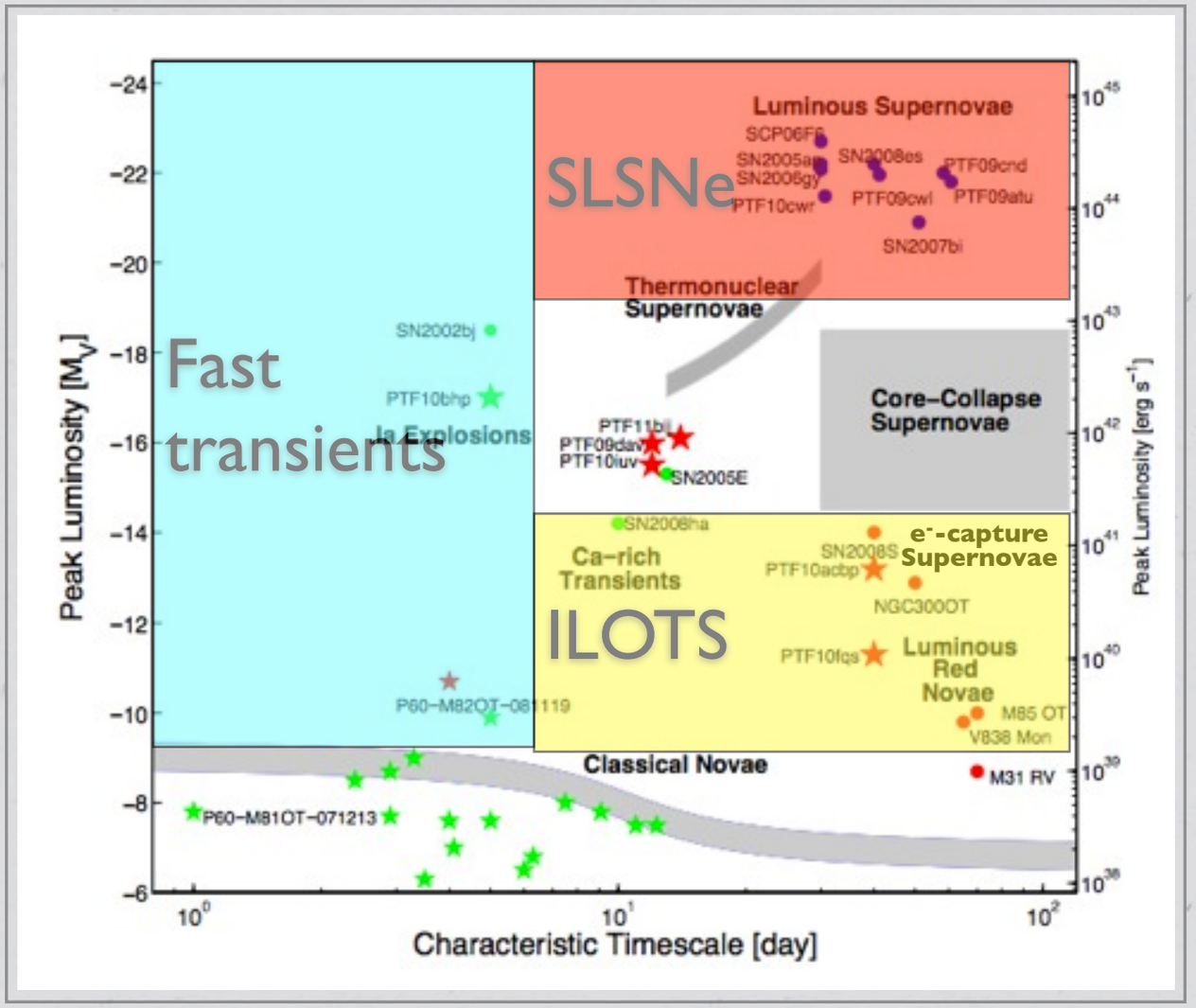
The current transient sky: populating the phase diagram with new stellar transients

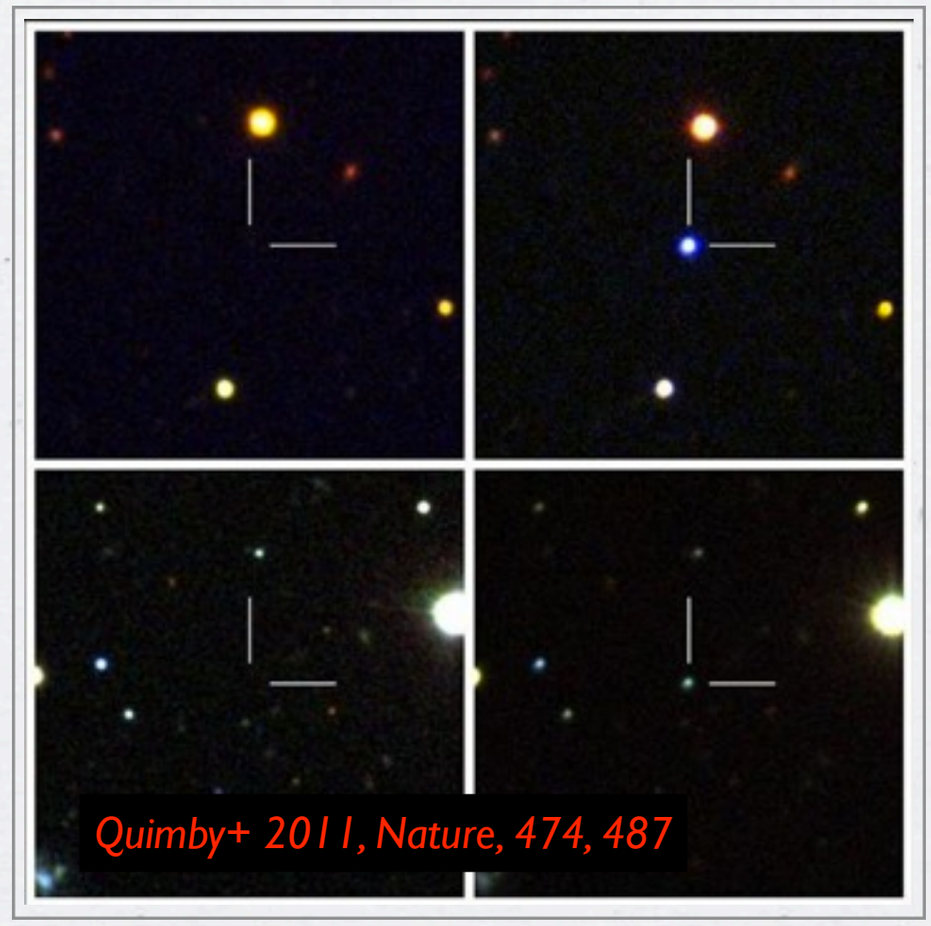
The transient sky
(past decade)

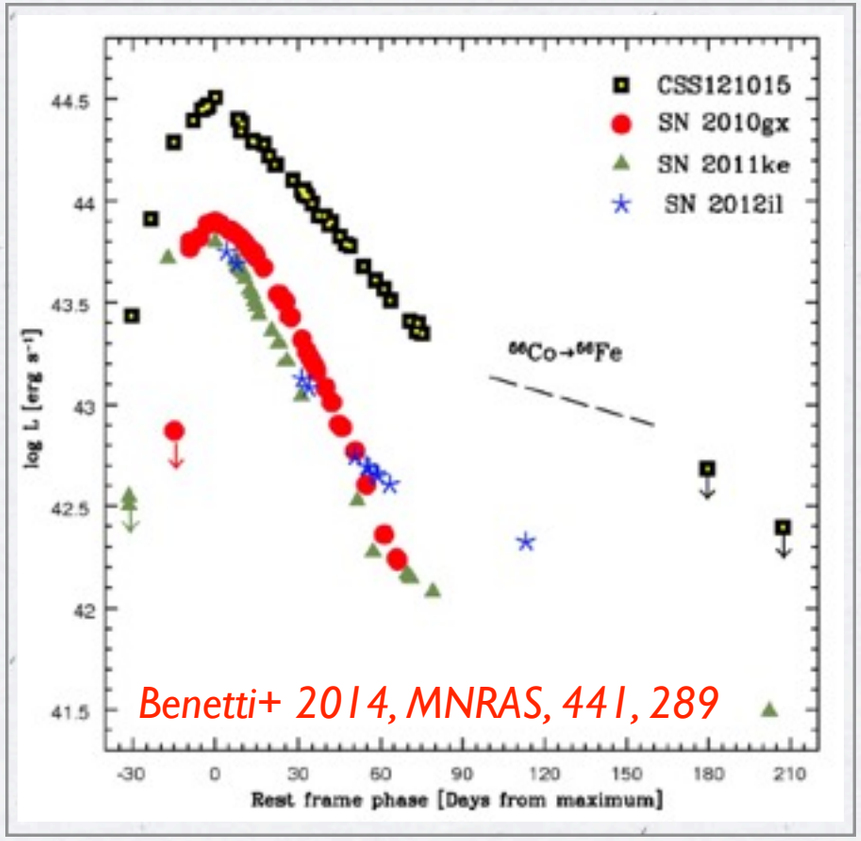
A challenge for the next few years

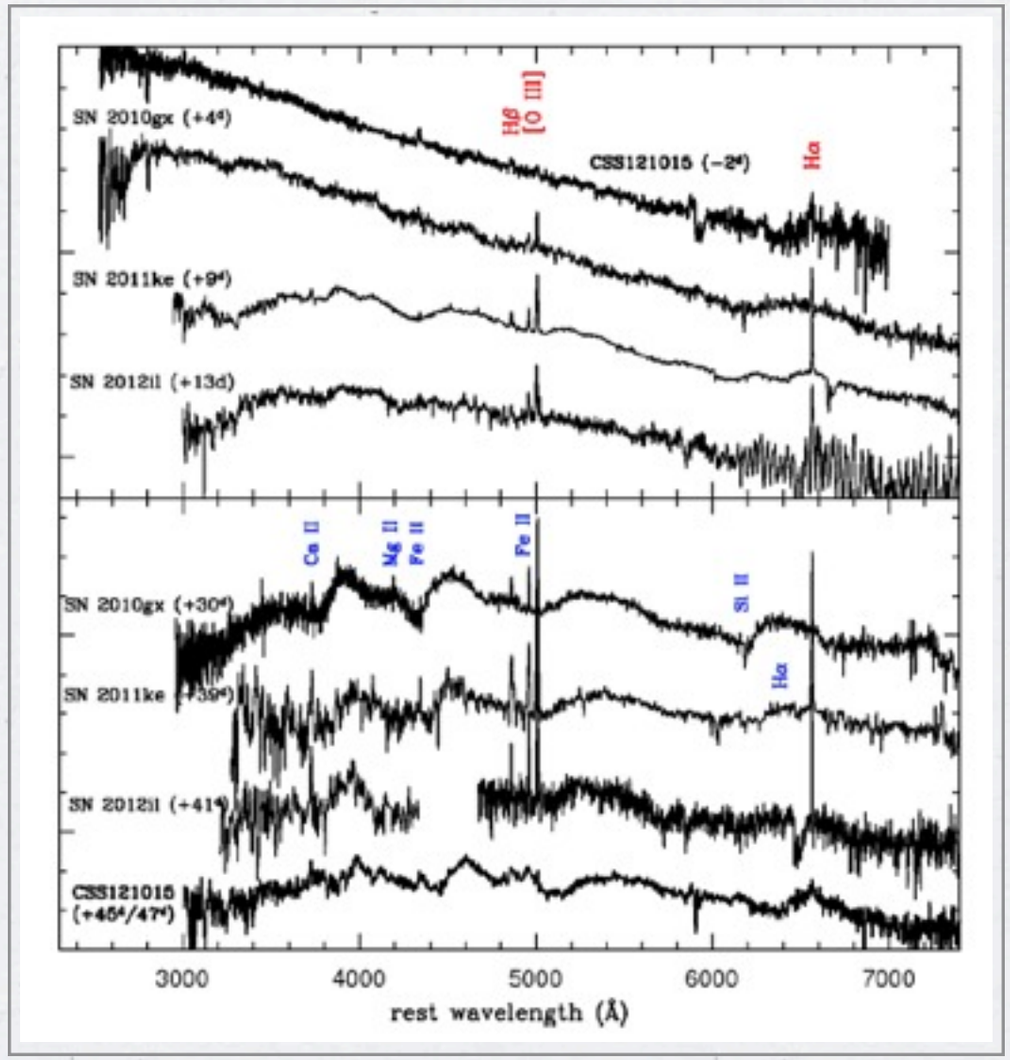


Super-luminous SNe

- ^{56}Ni-powered pair-production SN?
- Pulsational pair-instability events?
- Magnetar-powered CCSNe?
- Ejecta-CSM interacting CCSNe?
- A combination of above scenarios?







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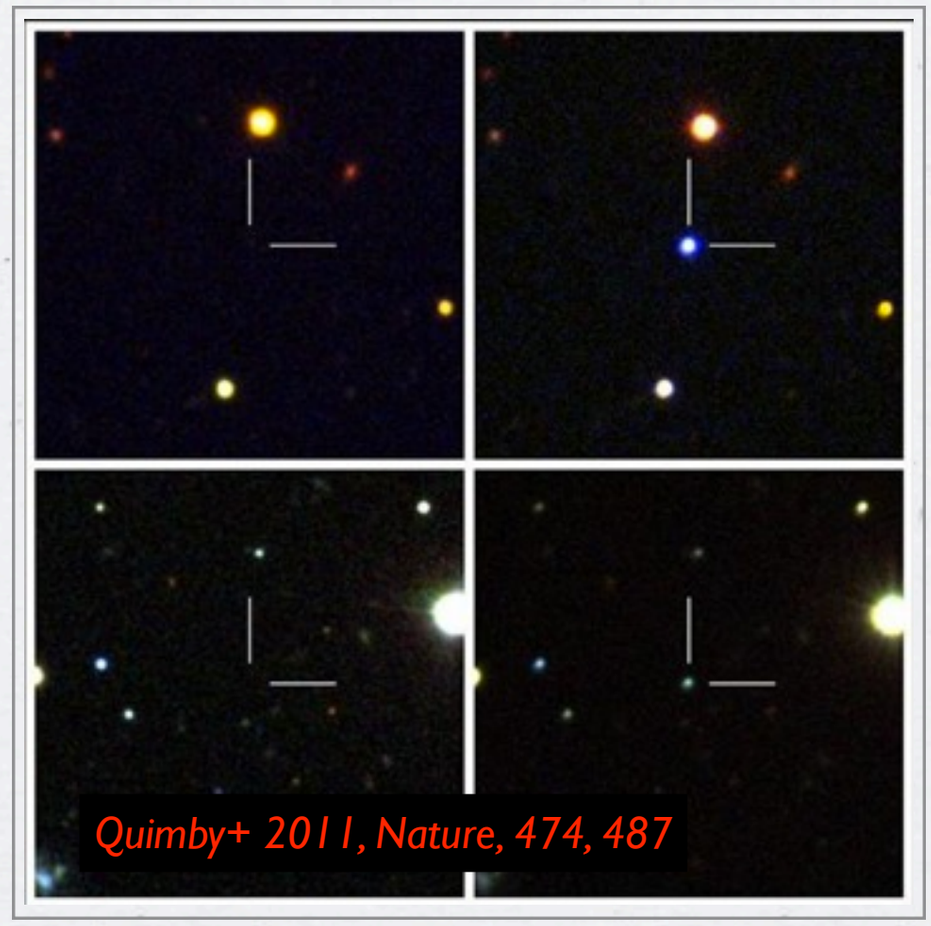
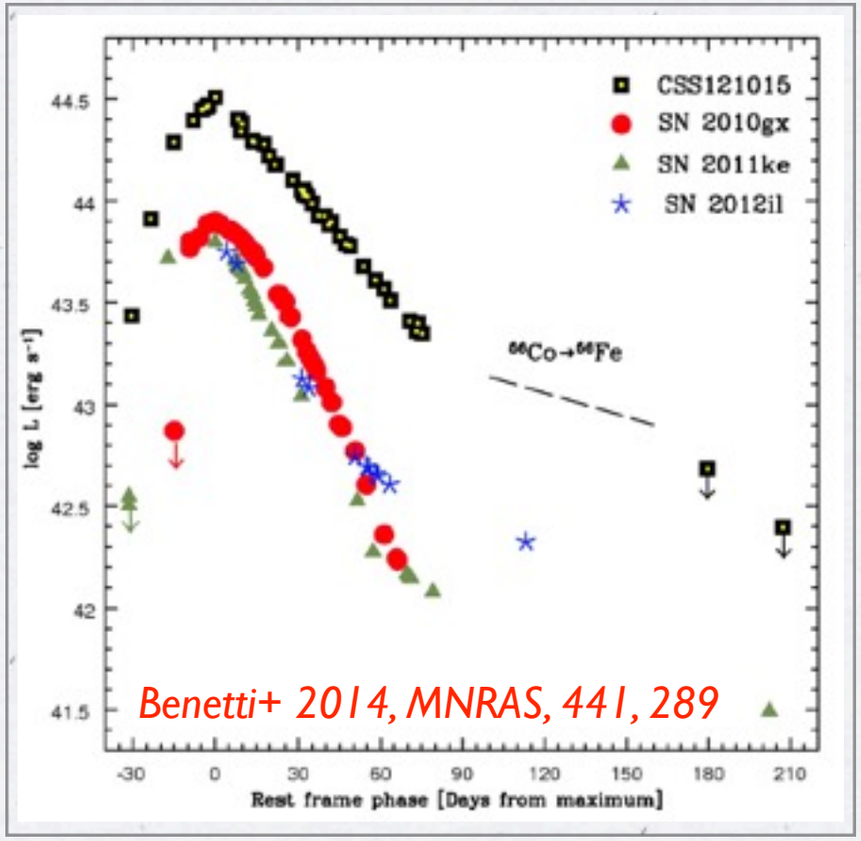
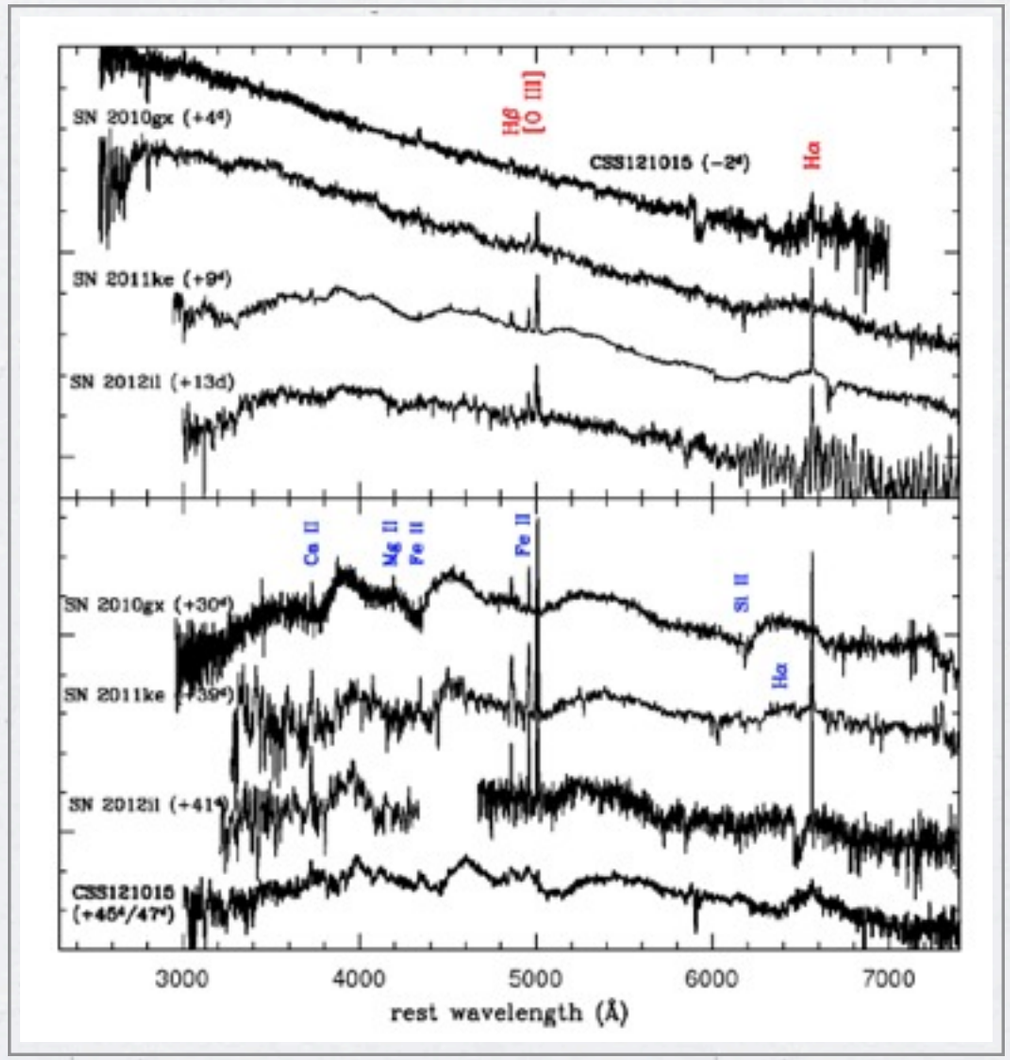
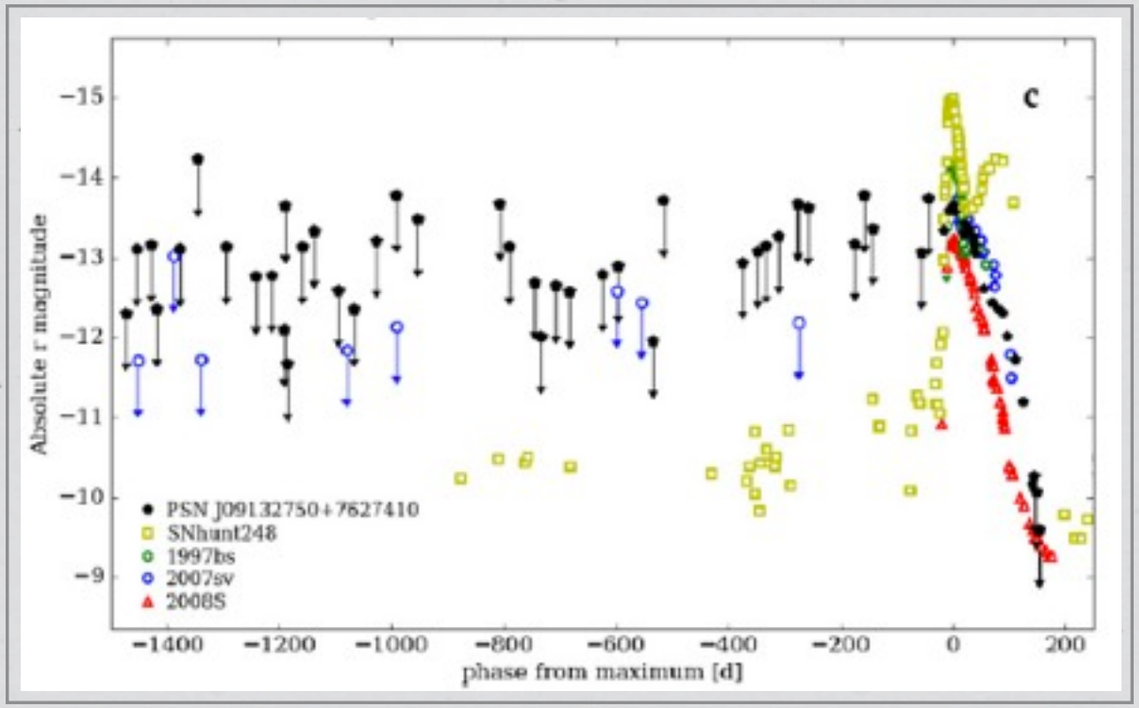
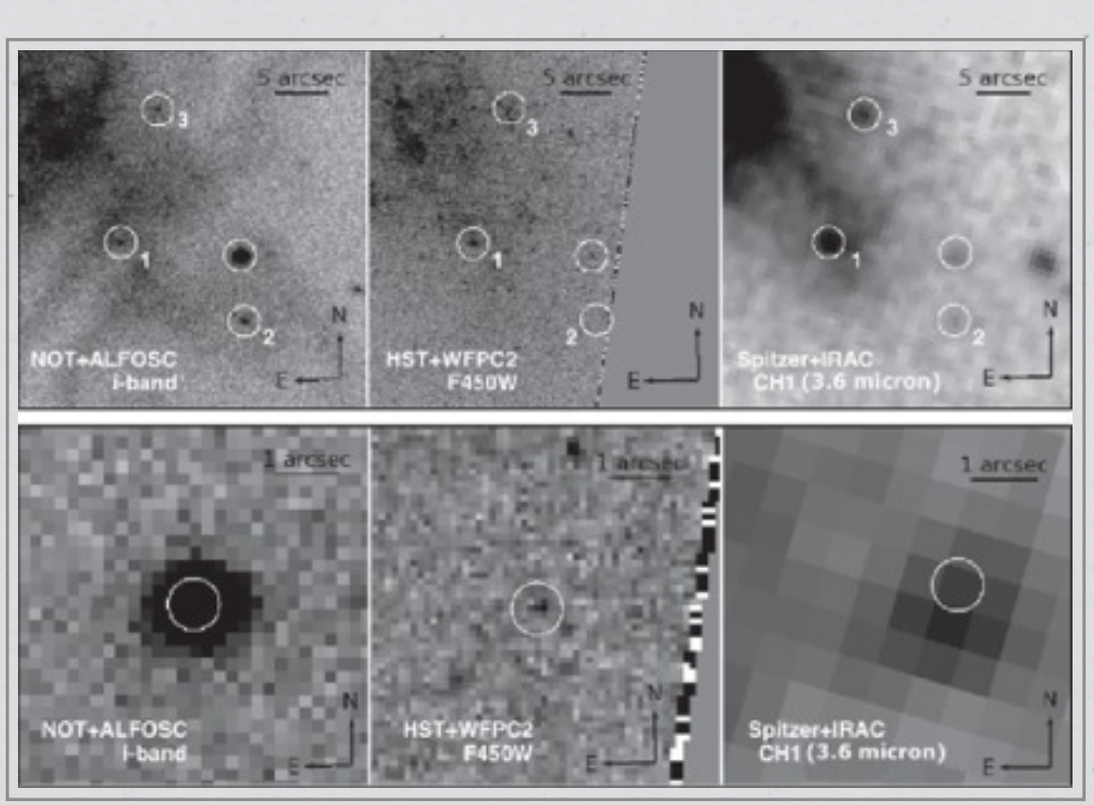




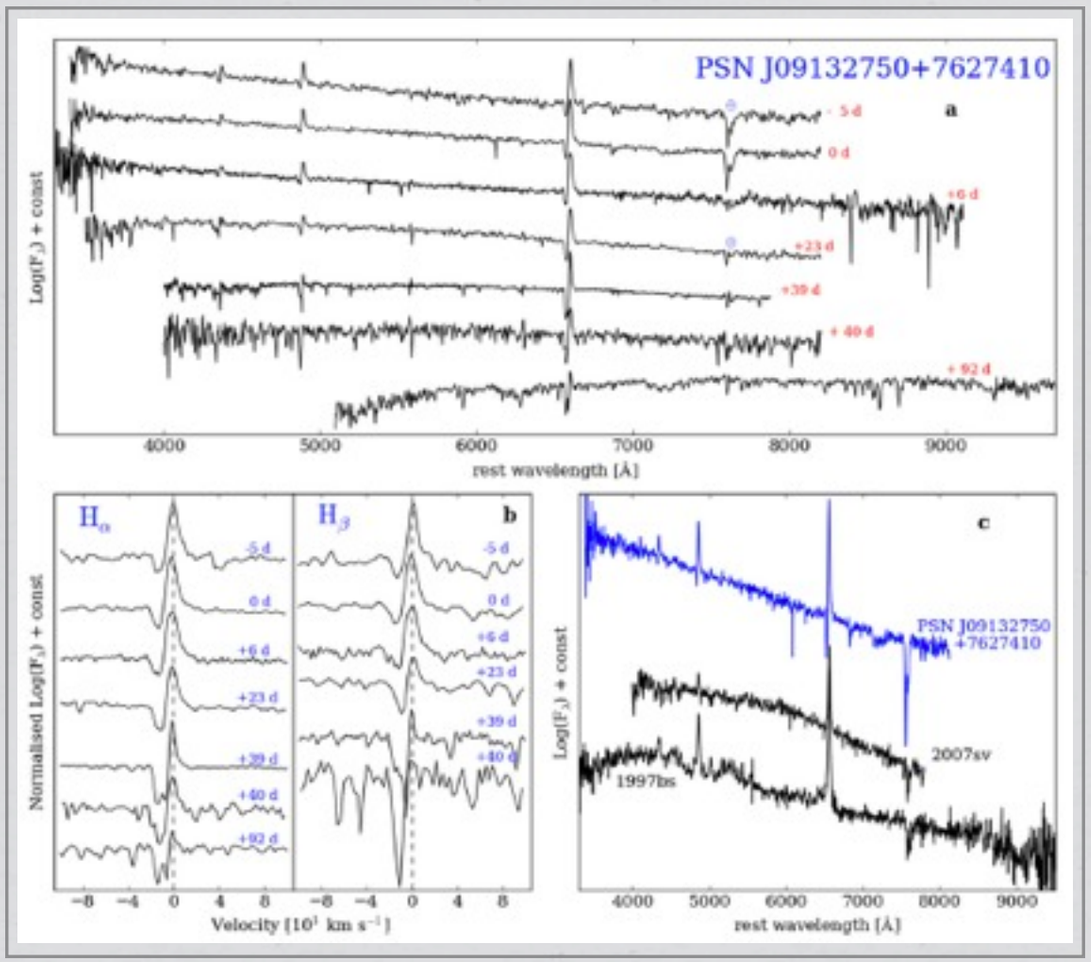


SN impostors: giant stellar eruptions





Tartaglia et al. 2016, ApJ, 823, L23



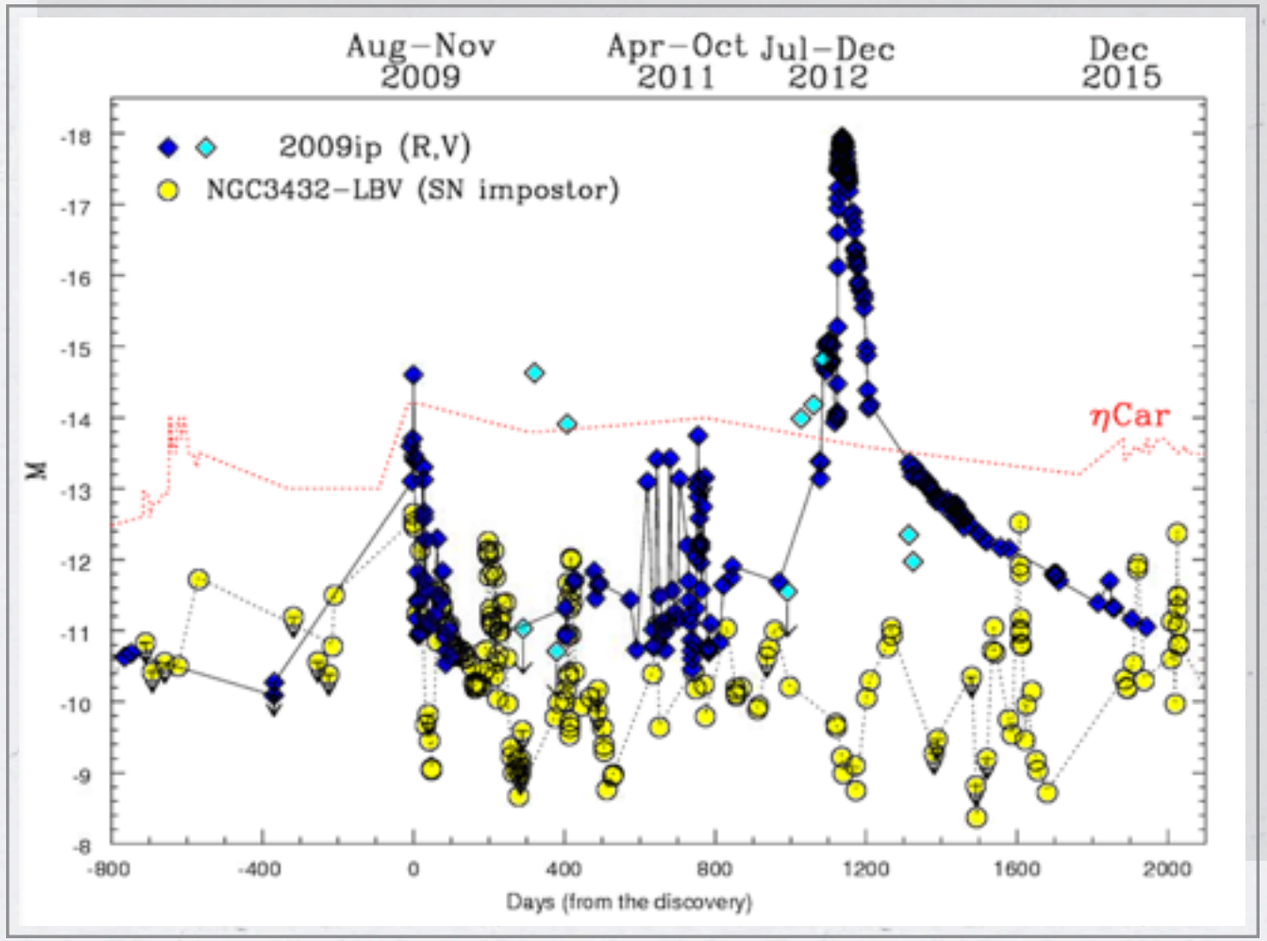
Pre-SN stellar instabilities

SN impostors => SNe

* < *Early 2012* => major LBV eruption

* *July 2012* => Type II SN explosion

* > *Late September 2012* => Strong ejecta-CSM interaction (SN IIn)



Adapted from
Pastorello+ 2012;
Fraser+ 2013,2015;
Margutti+ 2015

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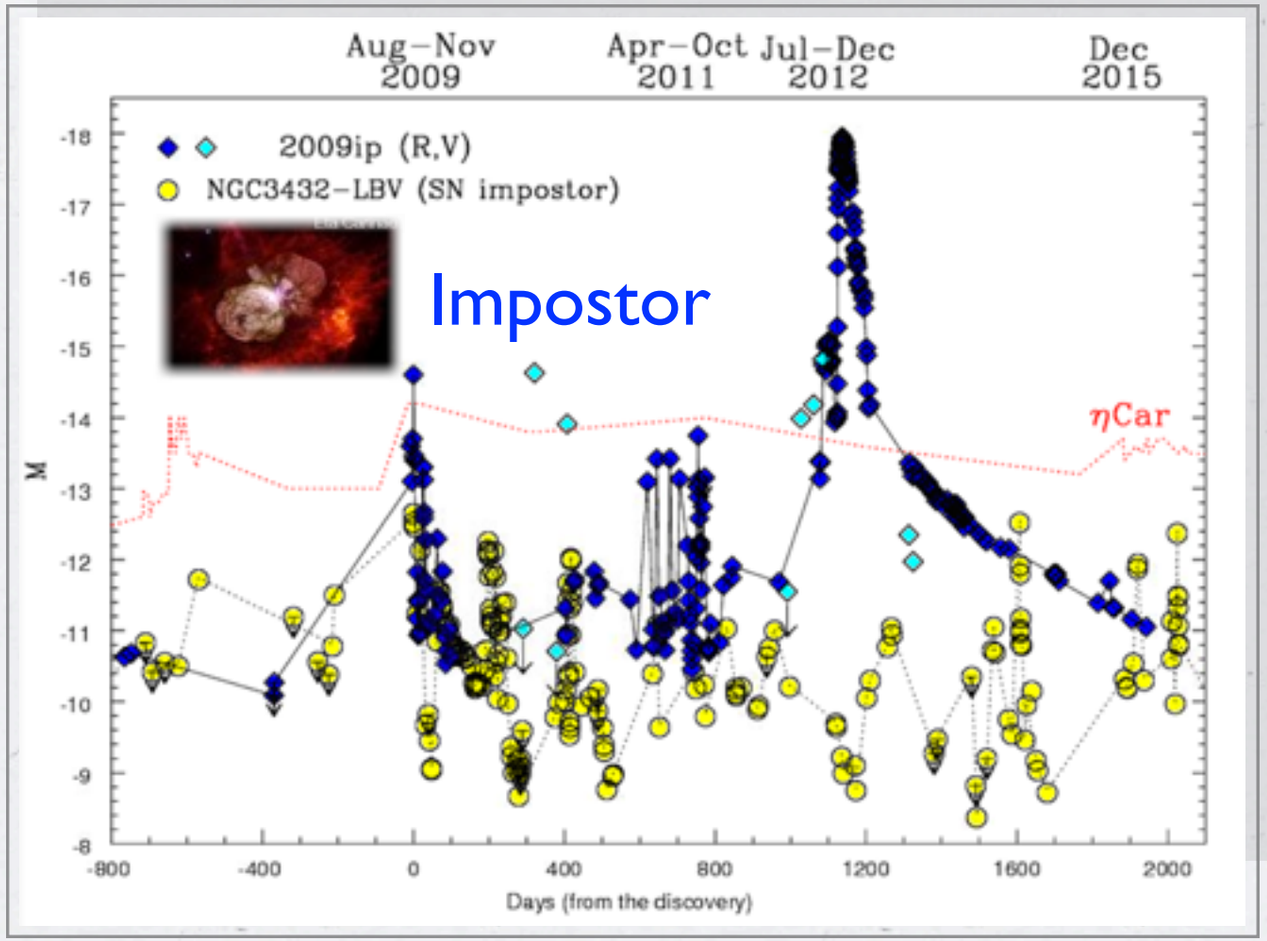

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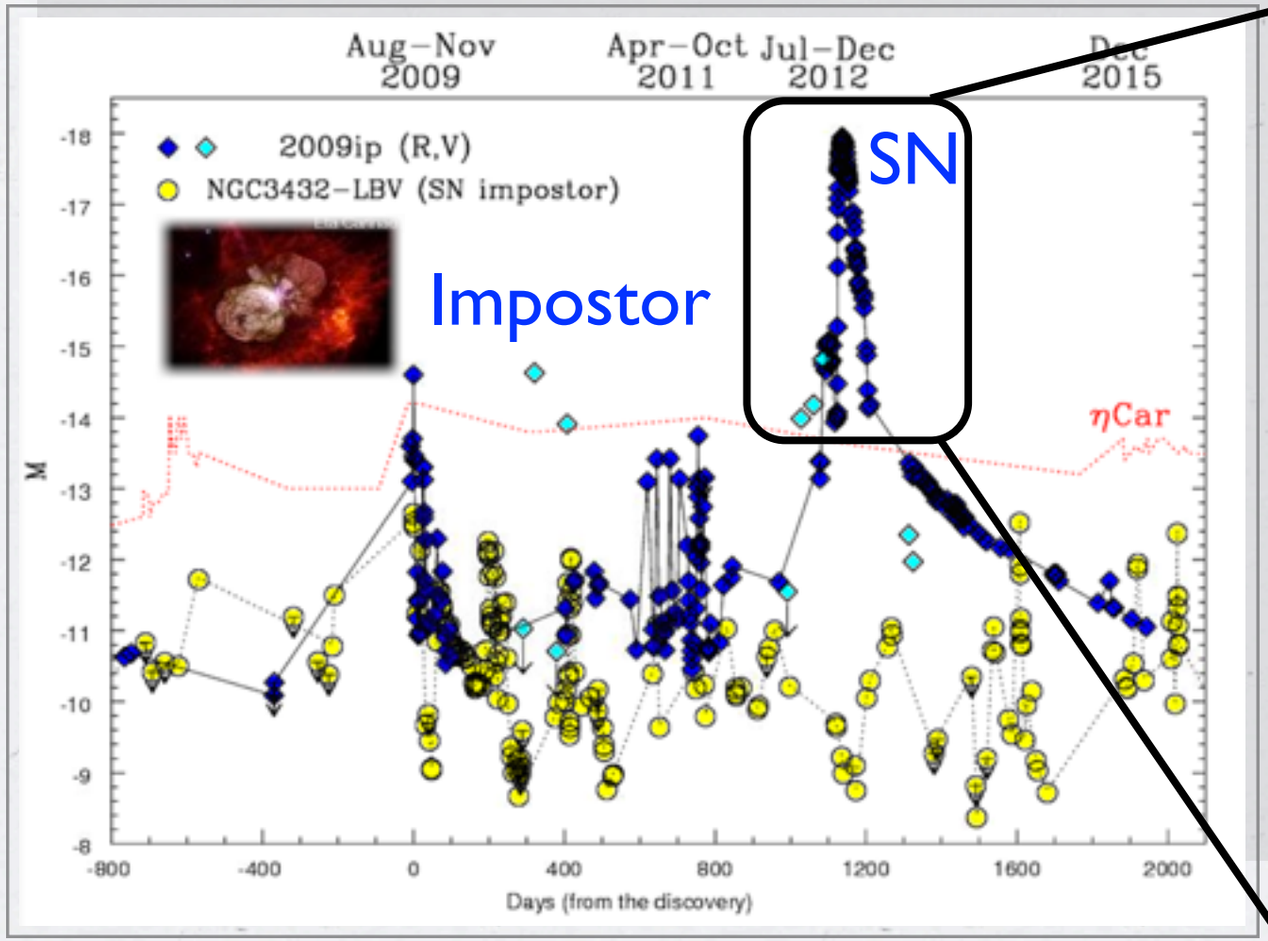

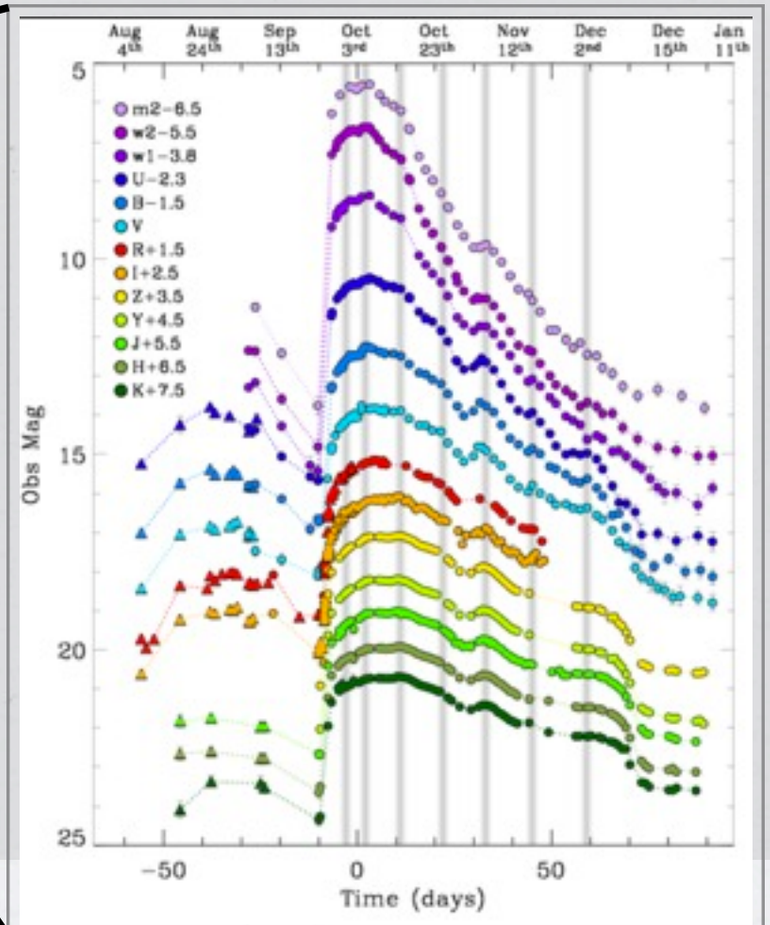

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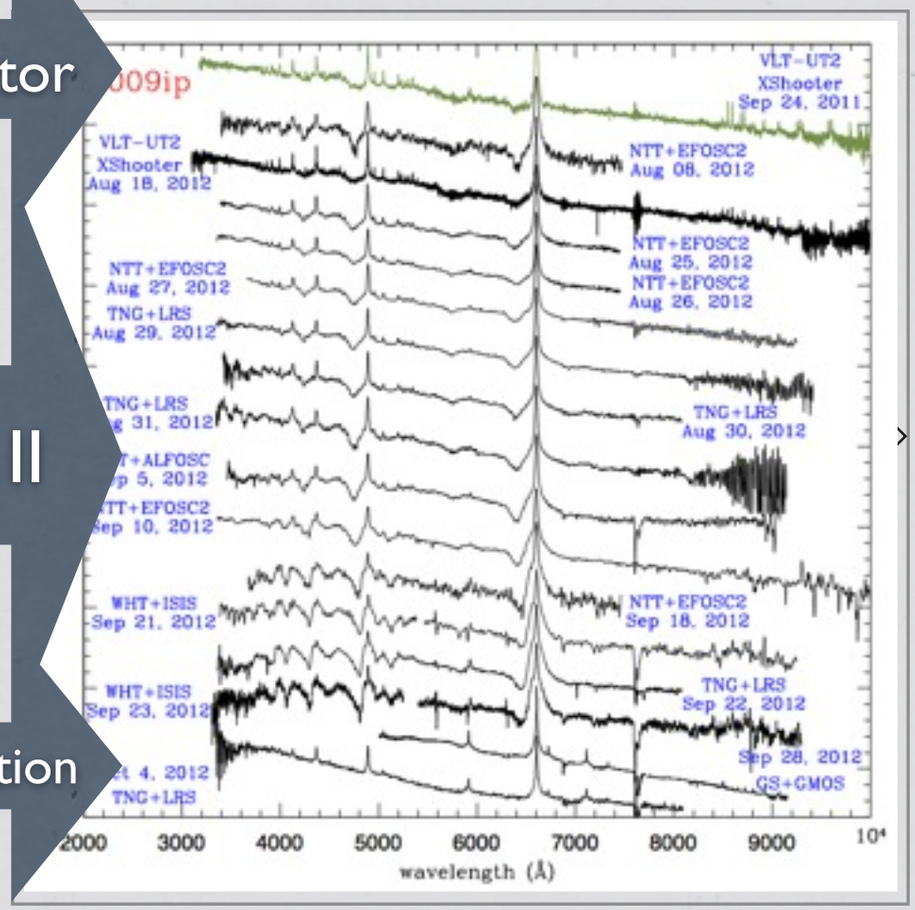
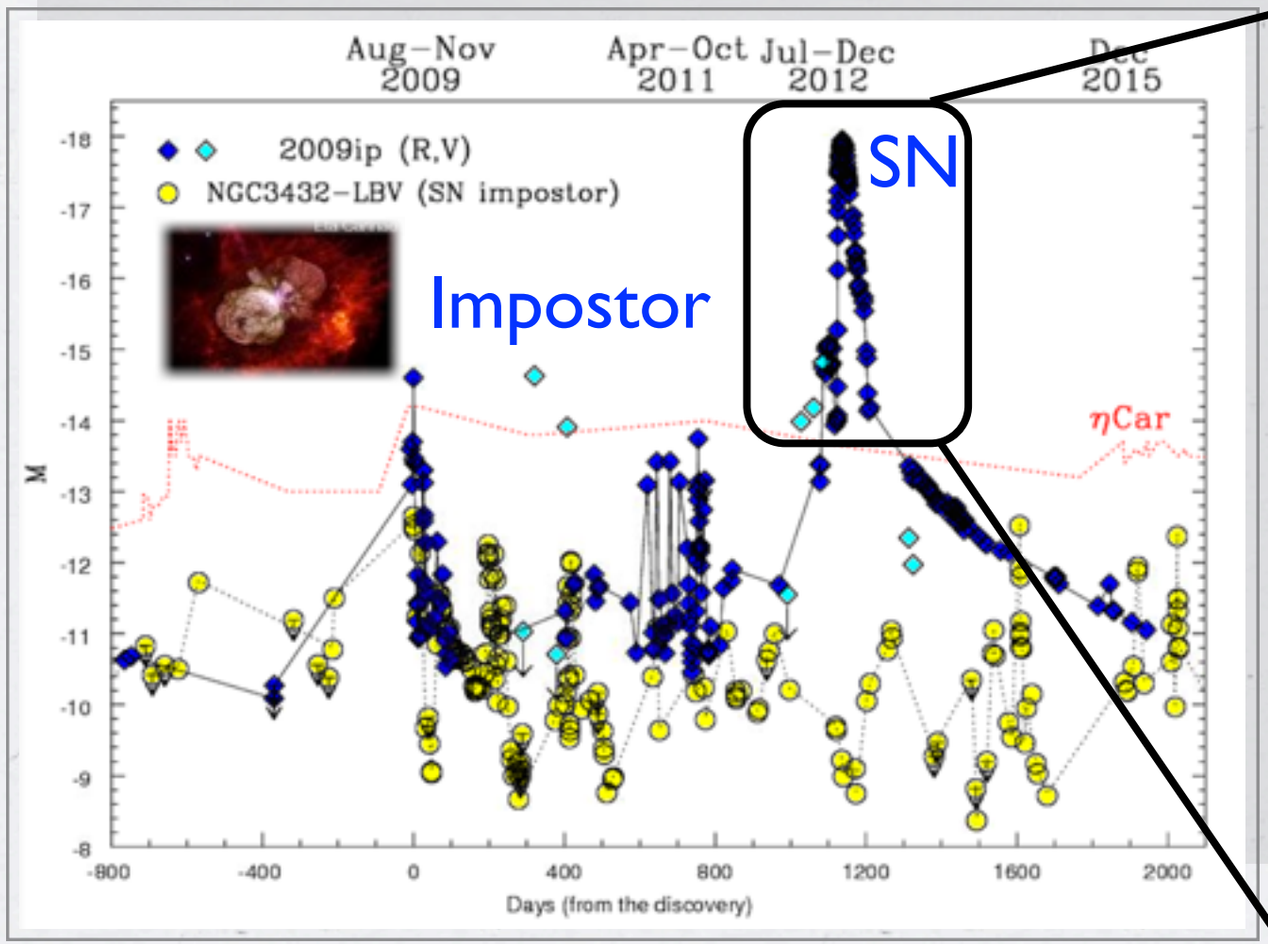
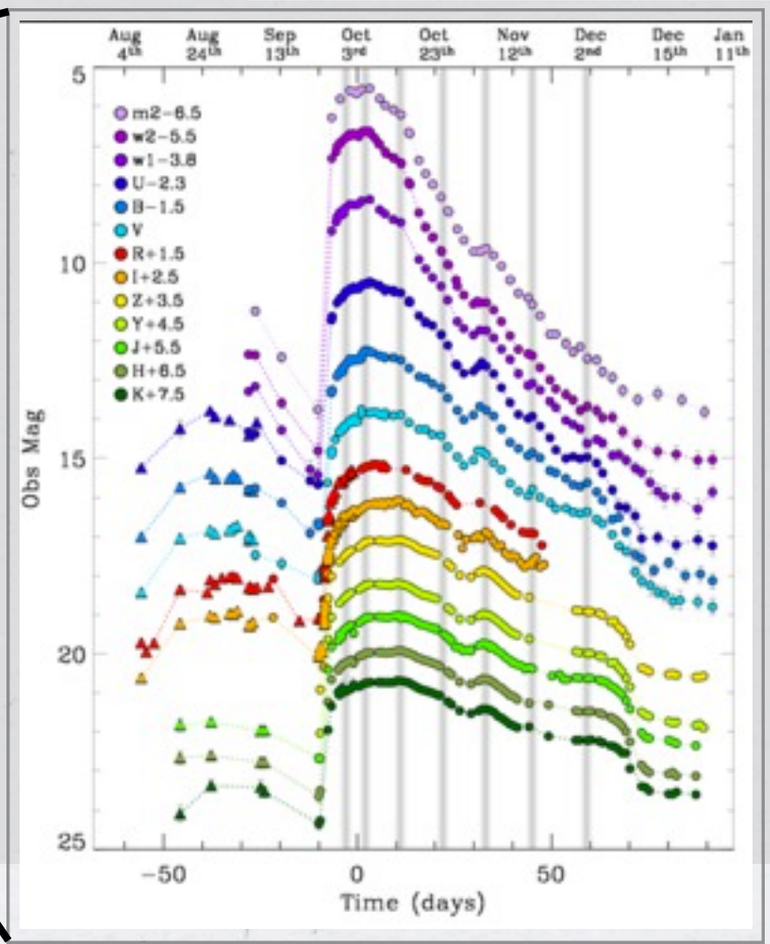
impostor

SN II

interaction







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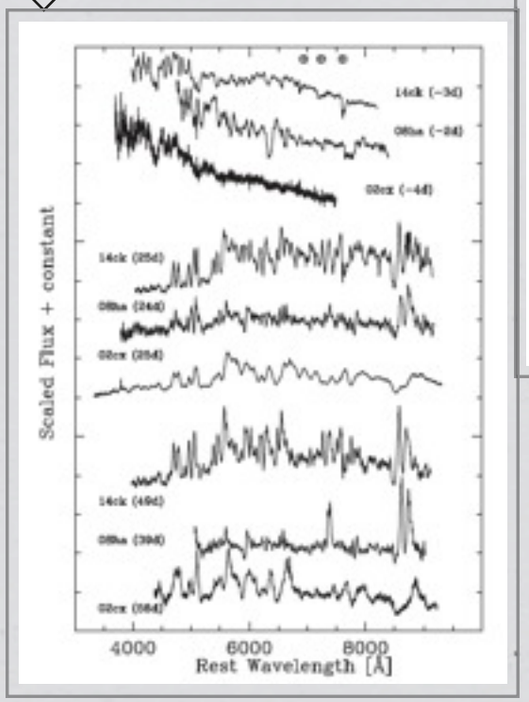
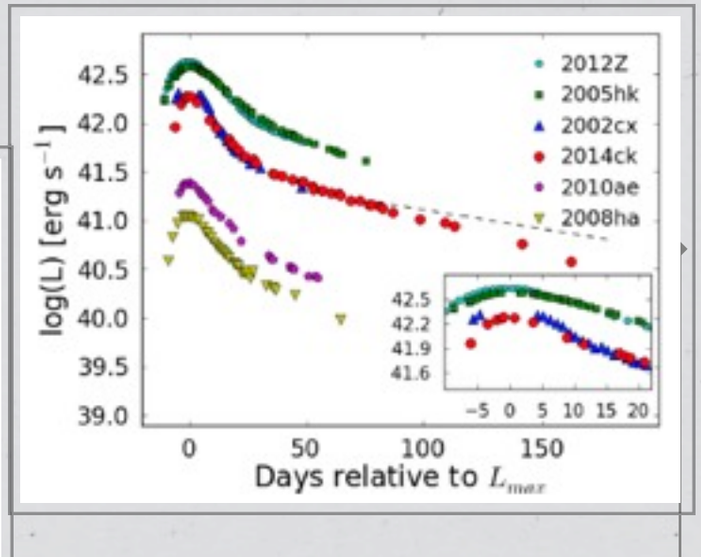
Intermediate luminosity optical transients





Tomasella et al. 2016, MNRAS, 459, 1018

Faint (likely) thermonuclear SNe

- SNe Iax: sub- or canonical Chandrasekhar mass WD explosions?
- Ca-rich spectra, fast & faint, type I SNe - no star forming hosts: He-shell detonation or faint core-collapse?

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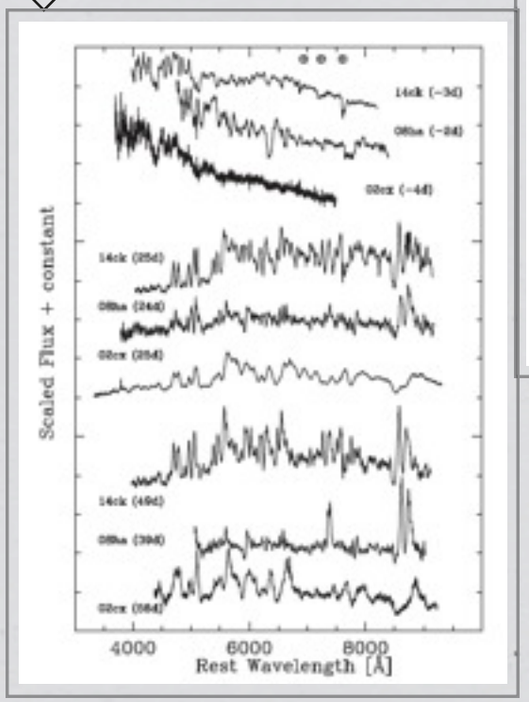

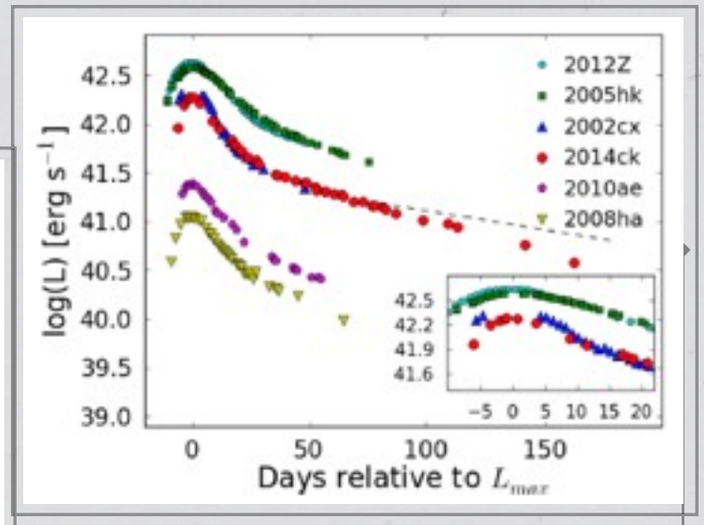

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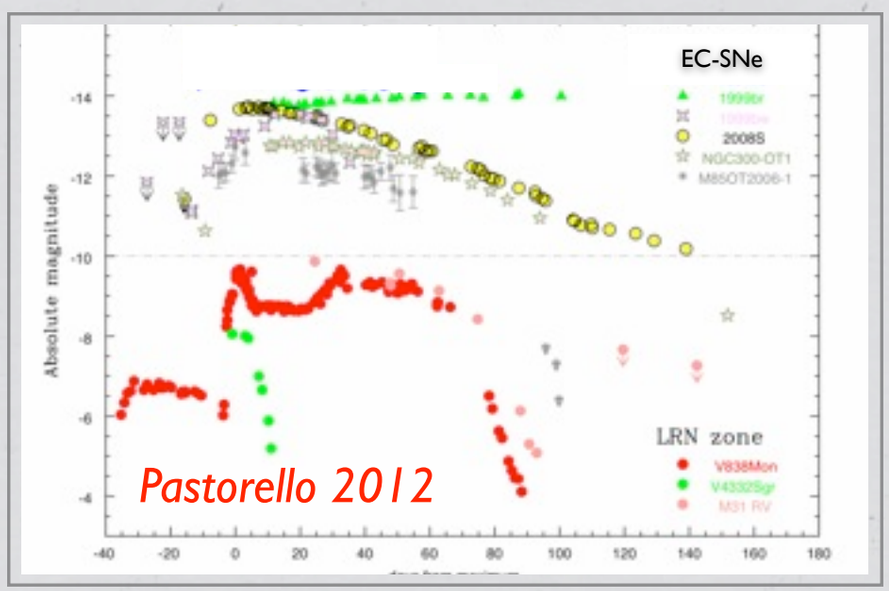

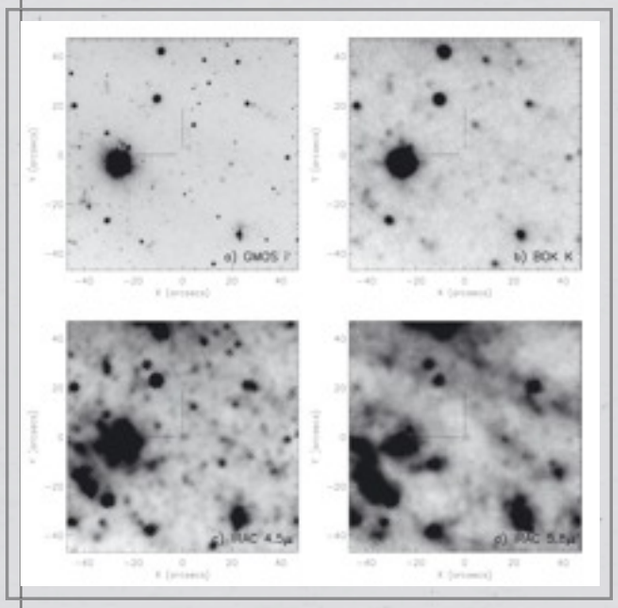

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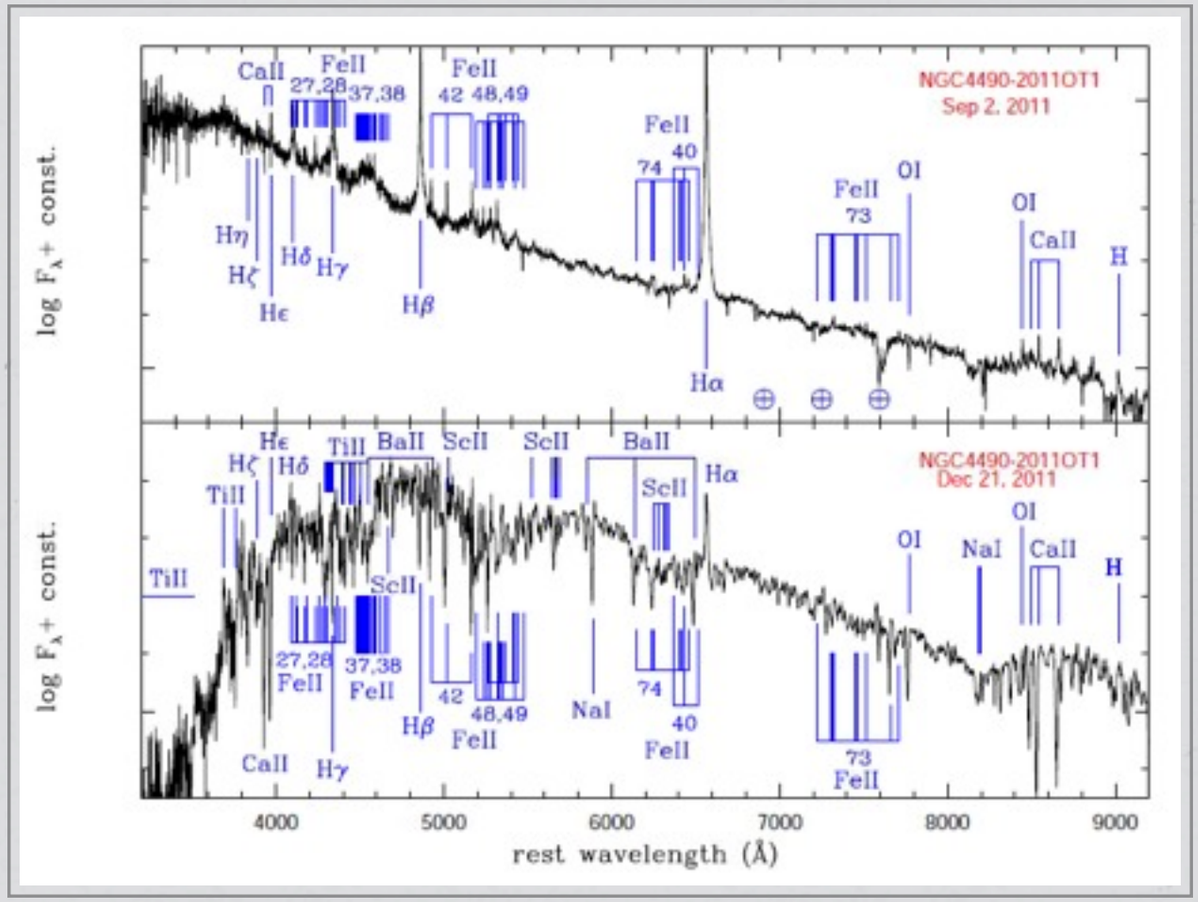
* Ca-rich spectra, fast & faint, type I SNe - no star forming hosts: He-shell detonation or faint core-collapse?
* ILRT: Faint SNe IIn, light curve decline following the ^{56}Co decay; dusty massive (8-10Mo) progenitors; EC-SNe of S-AGBs?

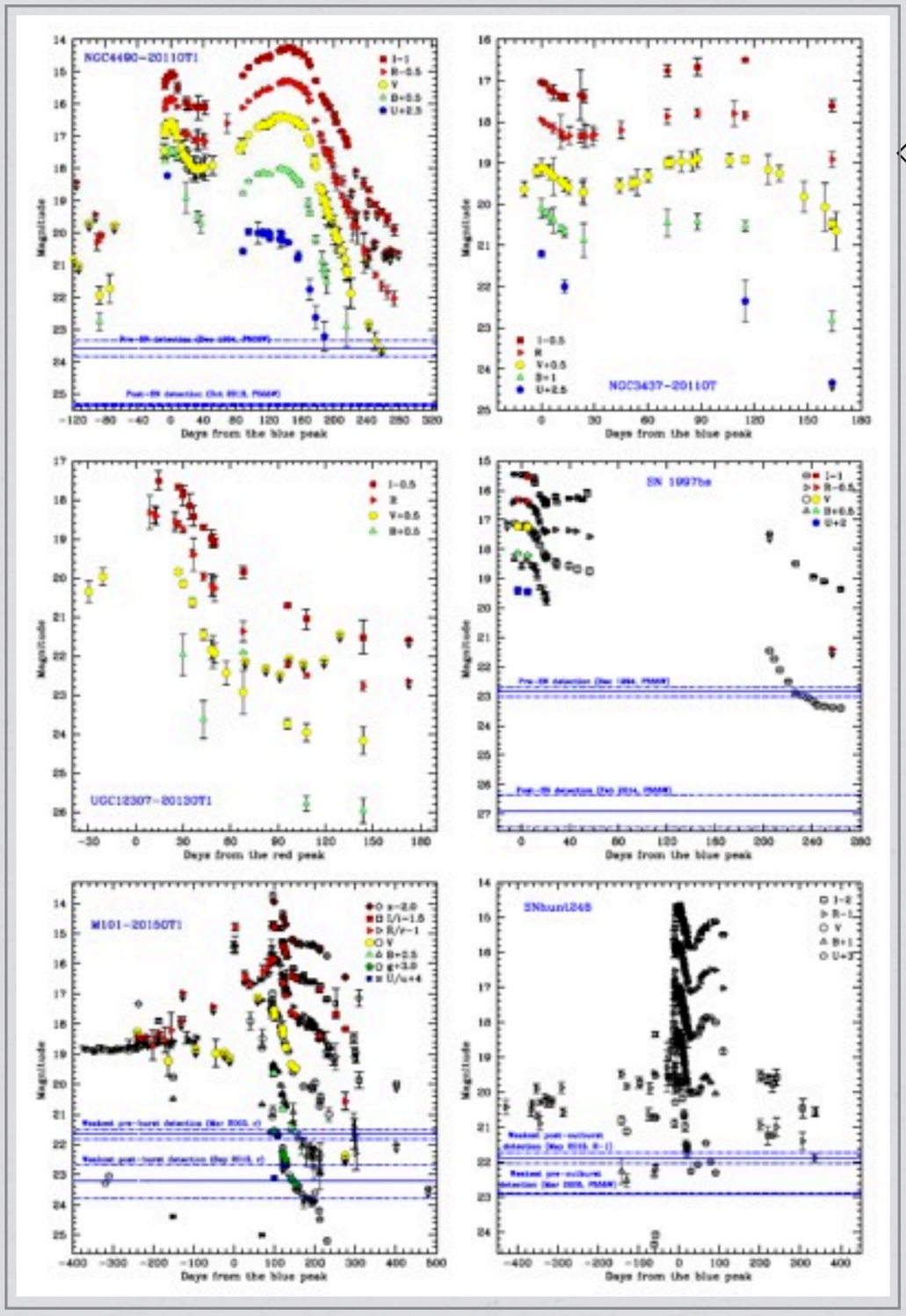
Botticella et al. 2010, MNRAS, 398, 1041

Massive stellar mergers

* Weaker Luminous Red Novae have M > -10, multiple-peaked lightcurves - mergers of low-moderate mass stars? (V1309Sco, *Mason et al. 2011*; V838 Mon, *Munari+ 2002*)

* NGC4490-2011OT1 and similar (M < -14) : scaled-up V838 Mon analogous - massive stellar mergers? (*Pastorello+ in prep.*)





Studies of Supernovae with TNG

- Fair access at TNG until 2011 through an LP, PI Benetti (about **100 hrs/semester**)
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- 2012B to 2014A: PI Walker (wide collaboration); **72 hrs/semester**
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Large contribution of TNG (15-30% of data) in most cases; minor TNG contribution in 20% of papers. Crucial for late-time and NIR observations.

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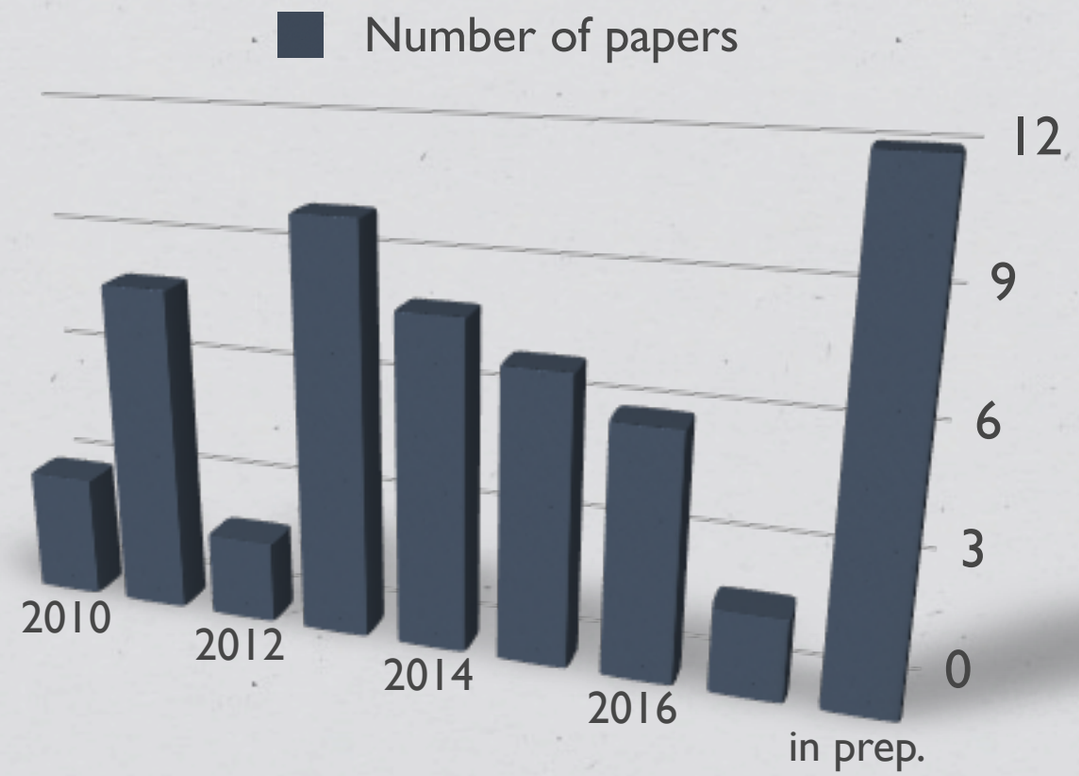

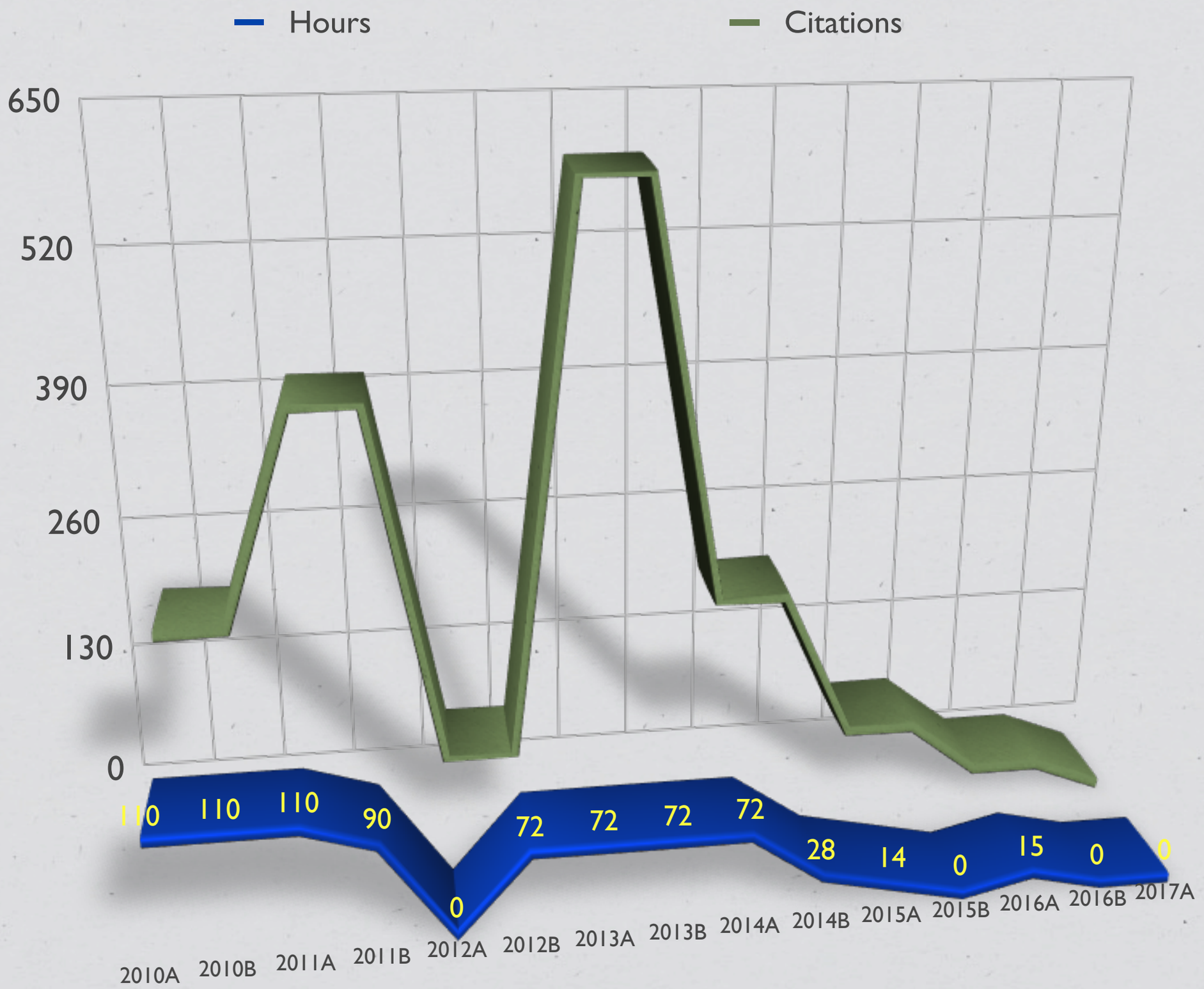
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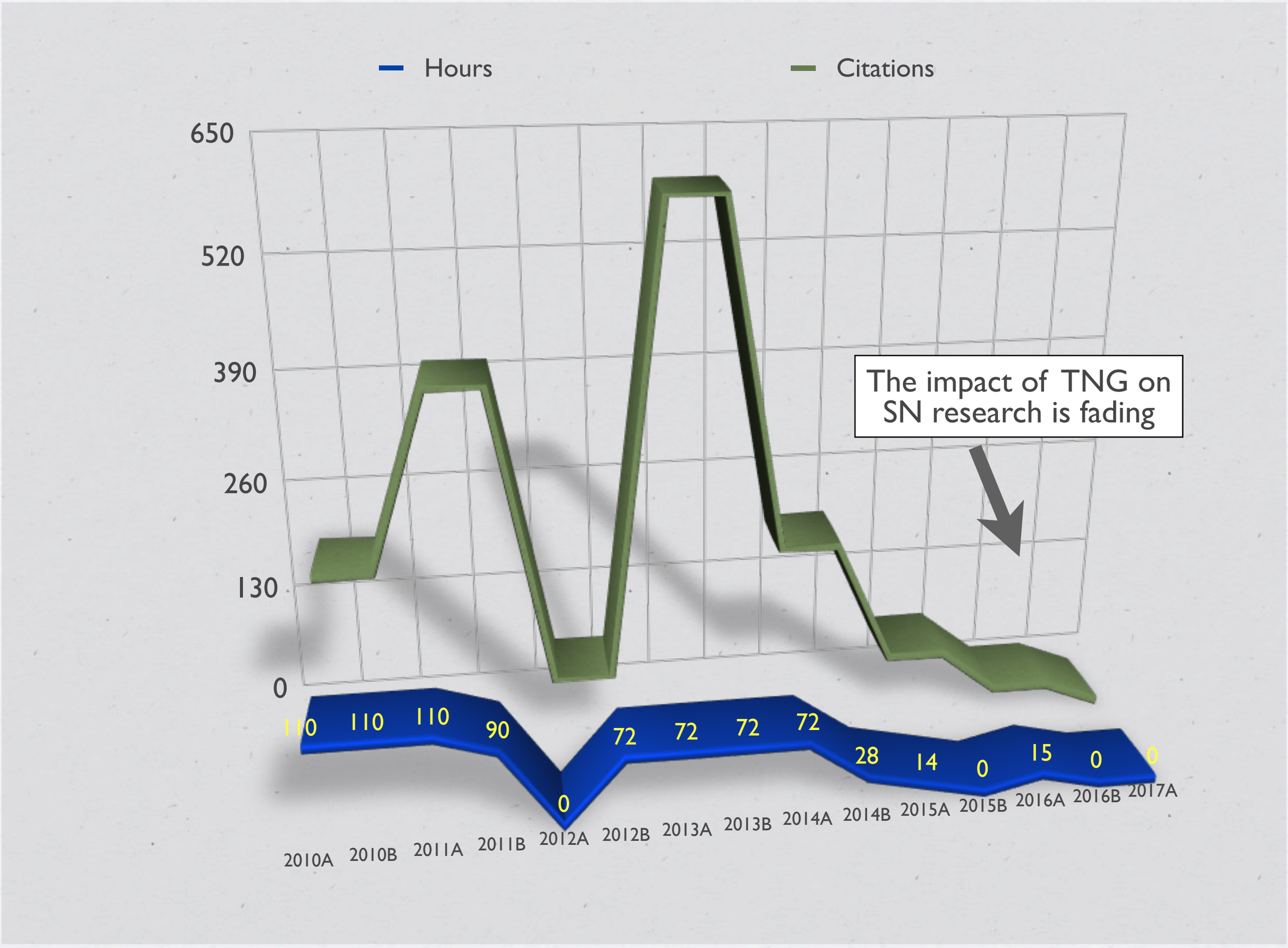
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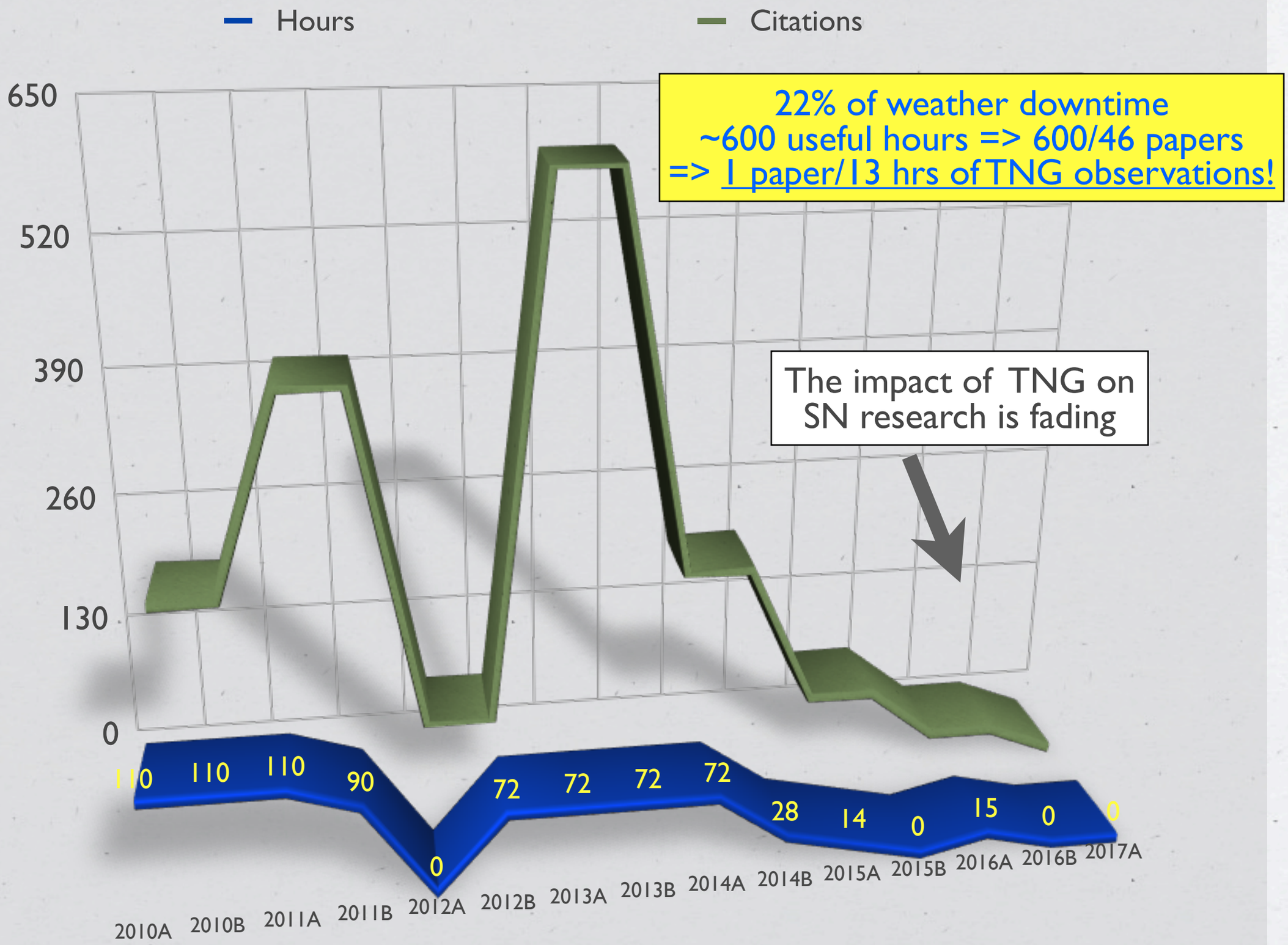
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22% of weather downtime
~600 useful hours => 600/46 papers
=> 1 paper/13 hrs of TNG observations!
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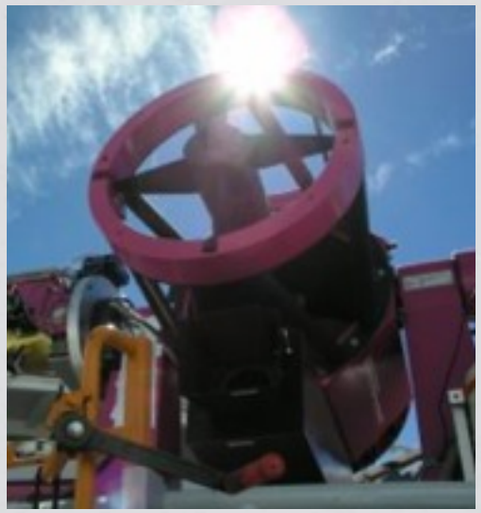
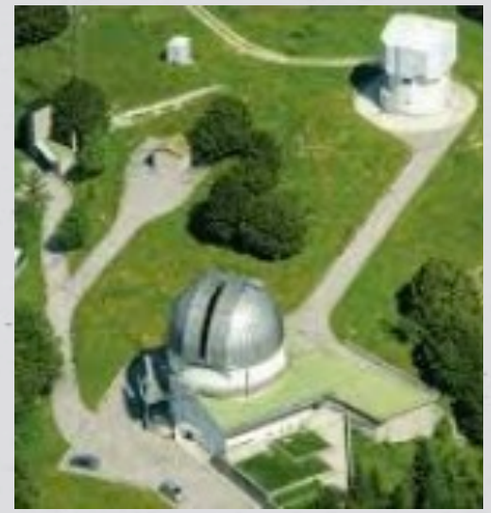
Problems

- A lot of competition for a VERY limited amount of time (much easier access to other facilities, incl. ESO, LCOGT, LT, GTC...)
- Discontinuous time awards at TNG (our proposals are alternatively rejected and approved) - deleterious for long-term projects
- Distribution of limited amount time in fixed night windows - no control on timing (e.g. our targets may not be observable in the assigned night fraction)
- High impact of technical problems (e.g. REM, TNG LRS/NICS)

INAF/Italian facilities





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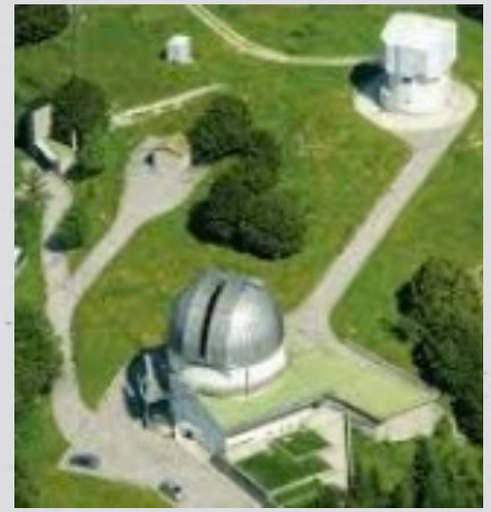


Our current facilities

- **Southern hemisphere**: a large program (PESSTO/ePESSTO) at the NTT (optical and NIR) plus wide access to supporting low sized facilities (LCOGT, GROND…)

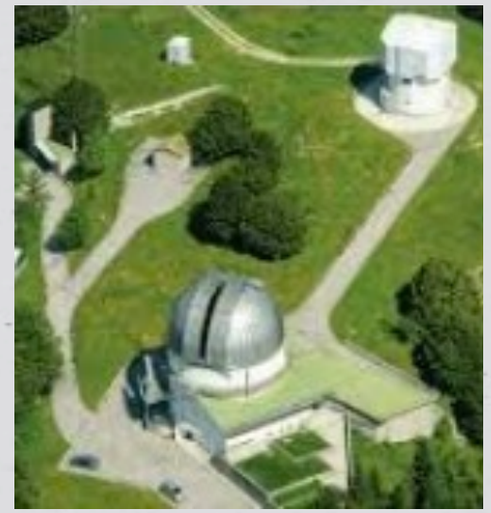
- **Northern hemisphere**:

  - A NOT large program (NUTS; 70 hr in ToO mode + 18 half-nights in queue per semester) with ALFOSC/ NOTCam, joined with North Europe researchers for studying early phases.

  - A large program with the Asiago Telescopes for classification and bright SN phases.

  - 24 hrs per year at GTC for studying narrow-lines, faint SN impostors and other focused projects.

INAF/Italian facilities



However, TNG would be important for us

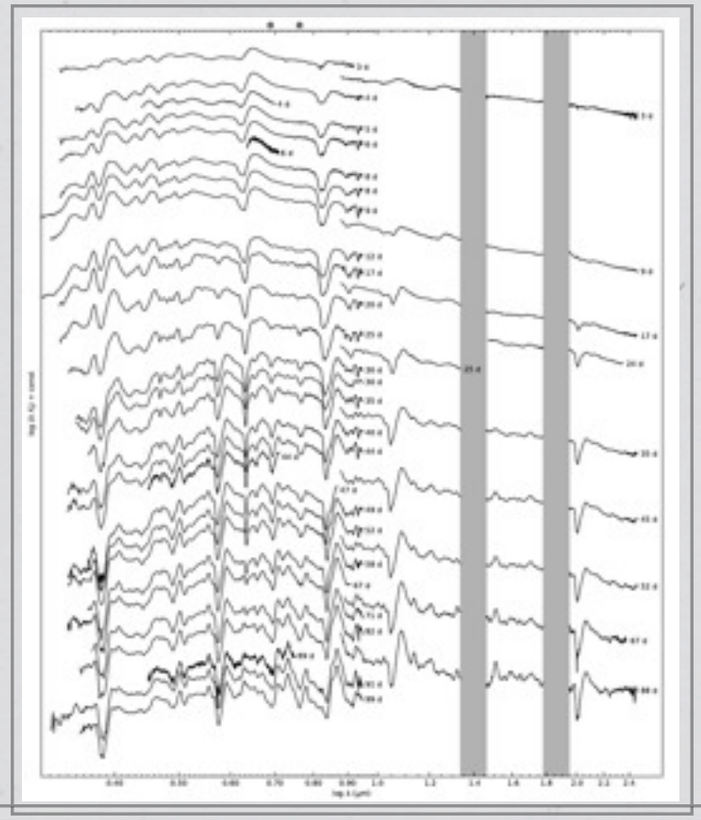
* Southern hemisphere - we have access to NTT (via PESSTO); no 3-4m class telescopes in the Northern hemisphere

* **NICS**: NIR photometry to complement our NOTCam light curves, and NIR spectroscopy (now totally missing).

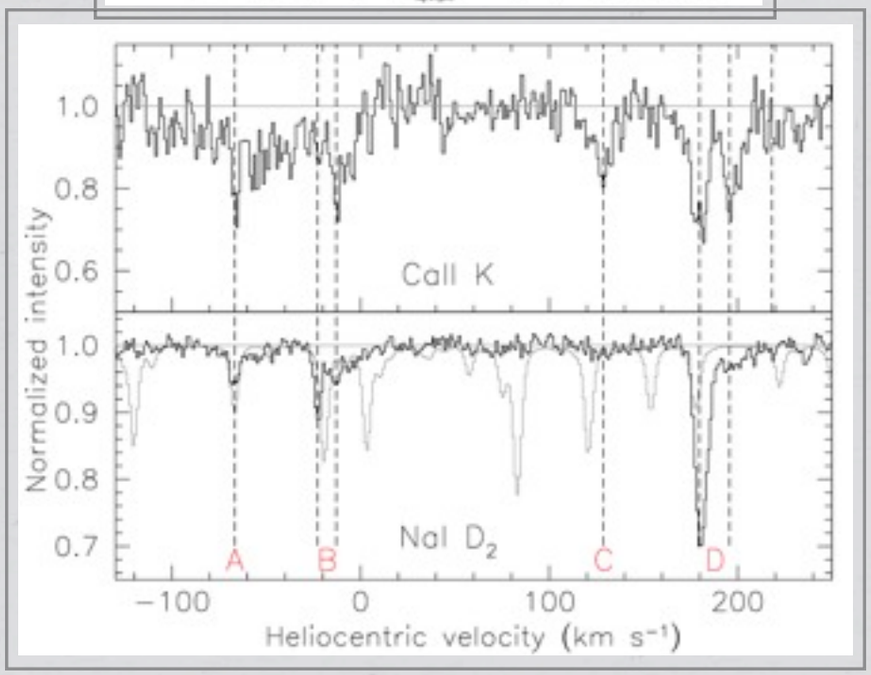
* **LRS:** Optical spectroscopy of intrinsically faint transients (e.g. ILOTS) and nebular spectra of more canonical SNe (see **Giacomo's talk**).

* **LRS:** fast reaction in ToO mode to classify (few) urgent targets (flash spectroscopy)

* **HARPS-N/GIANO(?):** Occasionally (< once per year), high-res spectroscopy.



Ergon+ 2014



SARG, Patat+ 2013

Proposed solutions

(depending on the future INAF choices for TNG)

Option 1

* A major increase of the fraction of time allocated for LRS & NICS

* More flexibility in the night scheduling (fixed temporal windows during the service nights are inconvenient for SN studies)

* Frequent use of ToO triggers

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Option 2

* Excellent experience with the NOT campaigns, which will become more crucial if/when NTE will be operative => increase the amount time available for Italy-Nordic countries joint proposals

* This favours coordination in the observational campaigns and successful wide international collaborations (e.g. NUTS; 40 researchers involved)

* More flexibility - via ToO time

* Future NTE will have broad wavelength coverage and fair spectral resolution

Conclusions

* TNG was a major resource for us until 2014, but its impact on our studies has significantly decreased with time.

* Great benefit for TNG in terms of publication (43 from 2010), citations (over 1600) with our TNG observations. High productivity (1 paper with TNG data per < 13 hrs of observations).

* TNG can still be used as a filler in the observational campaigns, but is more appealing for projects requiring fast reaction (ToO mode), NIR observations or deep spectroscopy for faint targets (see Terreran's talk).

* If TNG will still remain a high-res facility, a fair alternative for us would be increasing the Italian-Nordic countries time exchange, hence the slot available at the NOT for the Italian community.