

Next Decade of European SN Cosmology Workshop, Berlin, April 2016

Lessons learned from PESSTO (& PTF)



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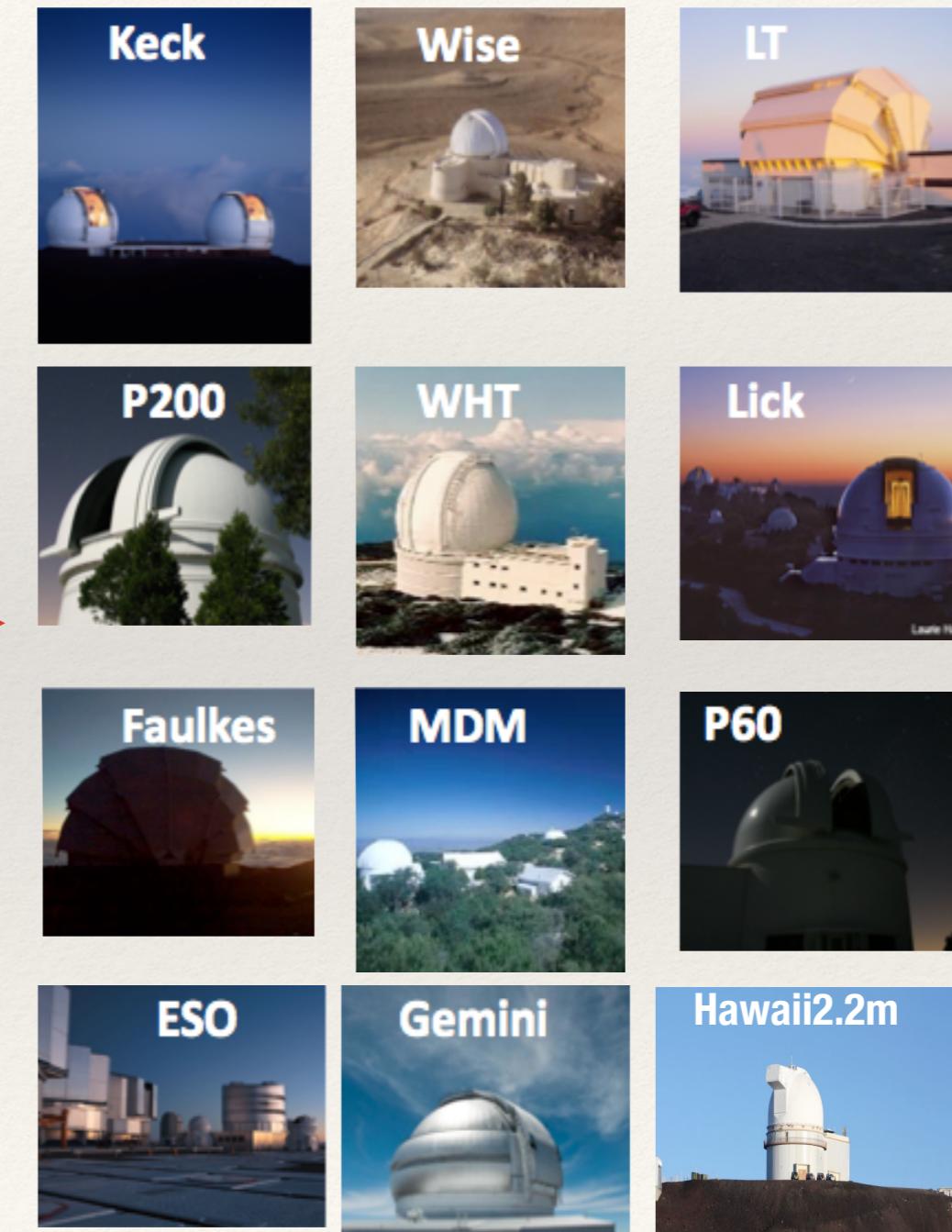
Palomar Transient Factory

Transient discovery

Palomar 48in

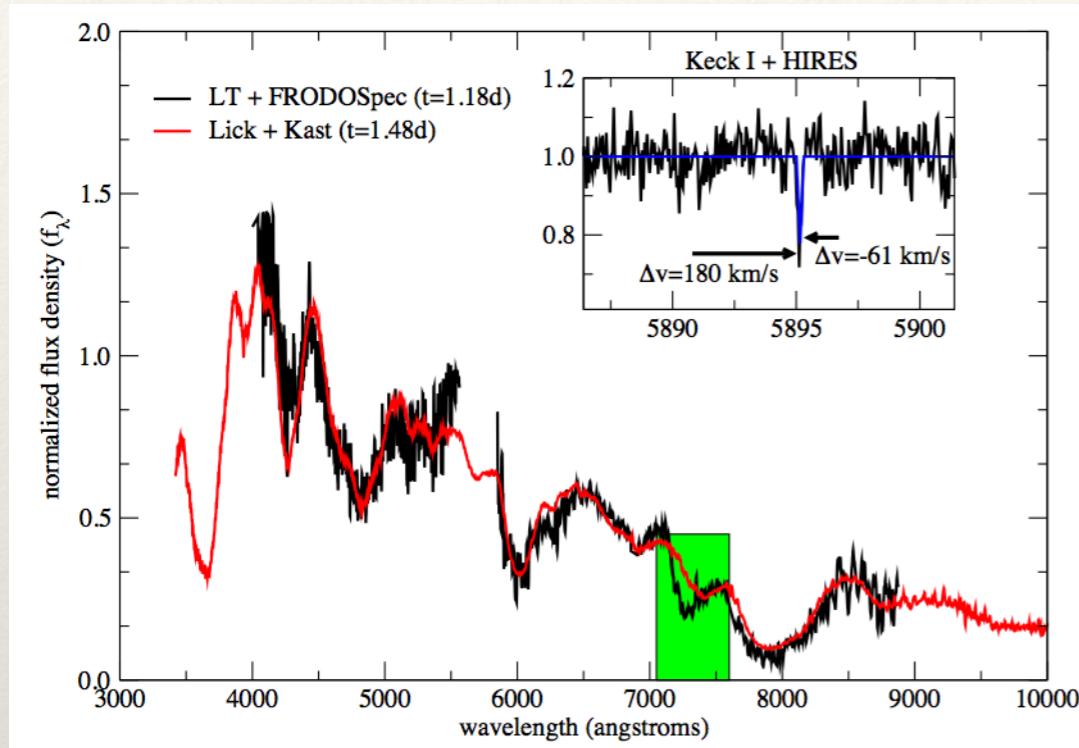


Rapid classification and follow-up



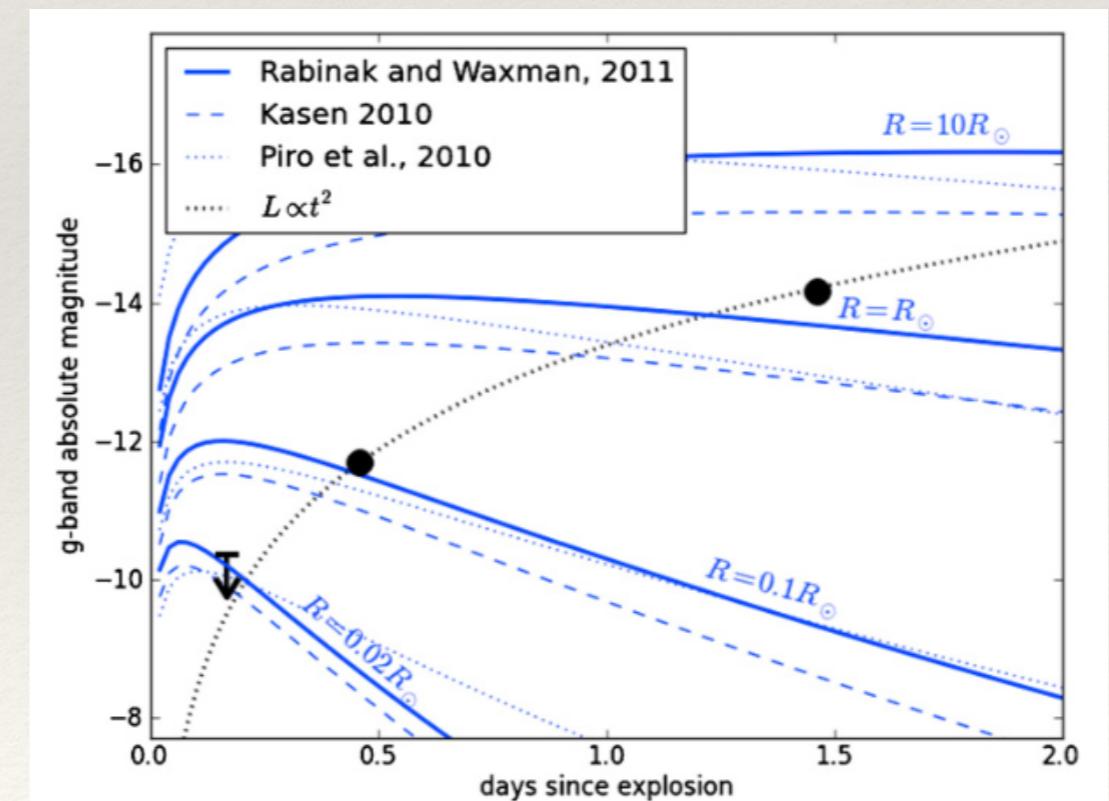
PTF Ia highlight - SN 2011fe

Nugent+ (2011)



- Degenerate star favoured ($R < 0.02 R_\odot$)

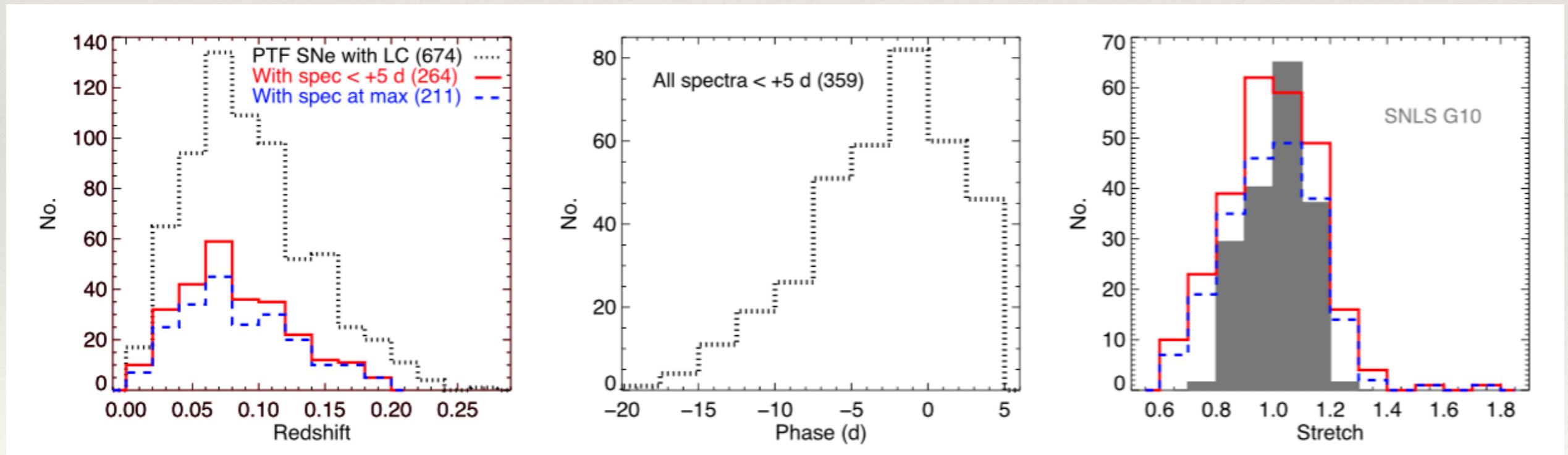
- SN Ia at 6.4 Mpc
- High-velocity O I (Nugent+ 2011)



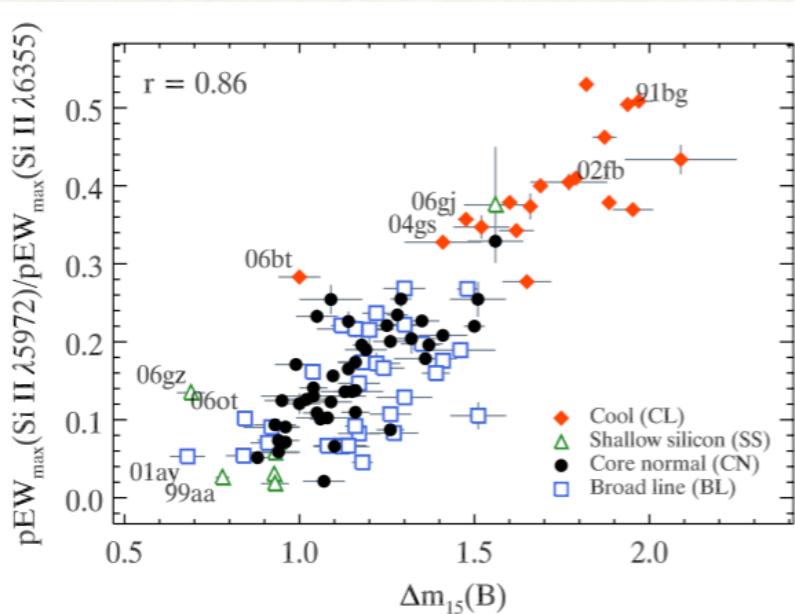
Bloom+ (2011)

PTF SN Ia sample

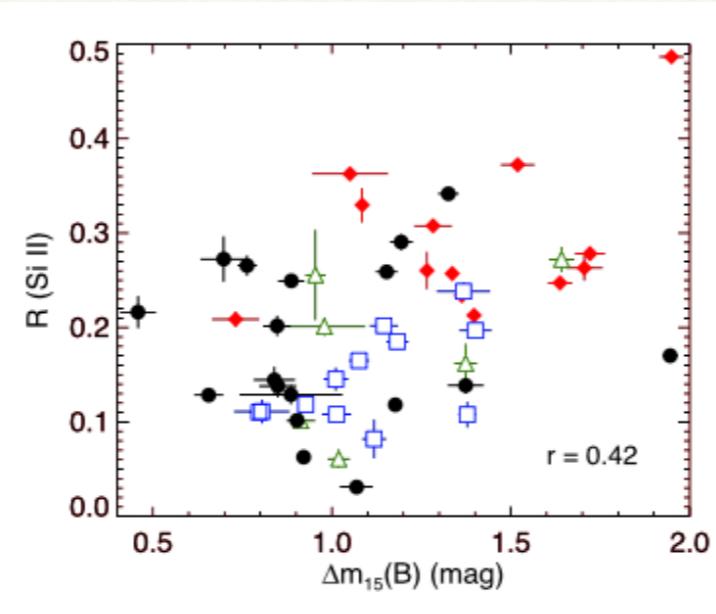
- 1200 spectroscopically confirmed SNe Ia
- 700 with ‘good’ P48 light curves
- 500 with ‘good’ LC and spectroscopic redshifts



PTF SN Ia sample



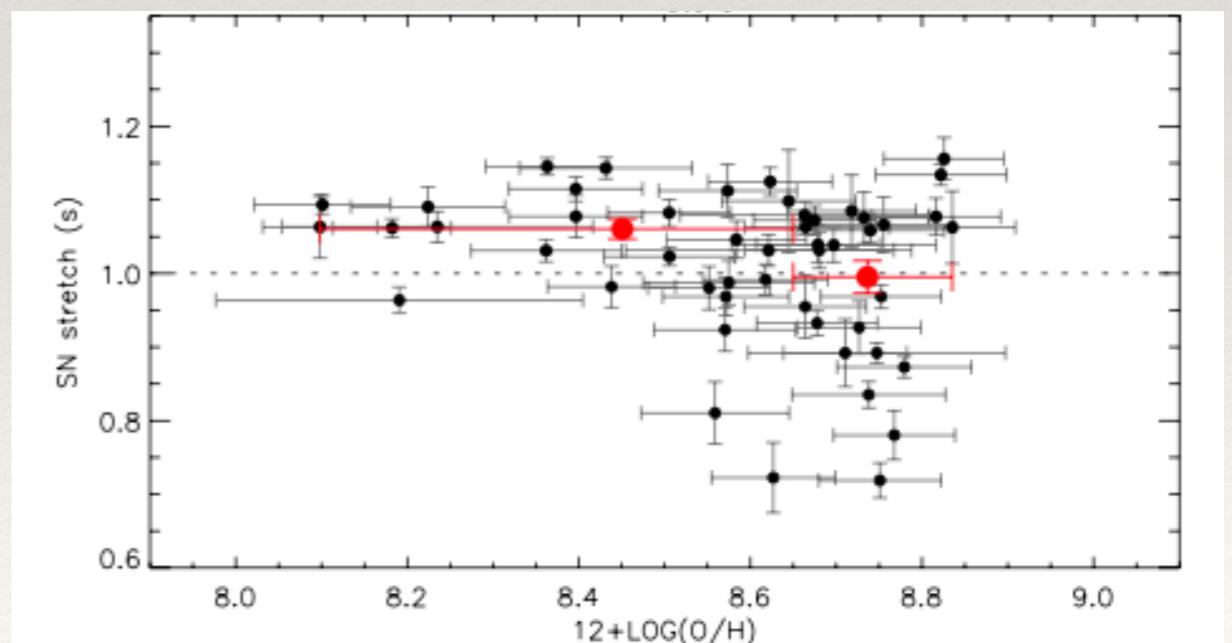
Blondin+ (2012)



Maguire+ (2014)

- Spectral luminosity indicators - $R(\text{Si II})$, pEW
- No significant correlation

Gas-phase metallicity

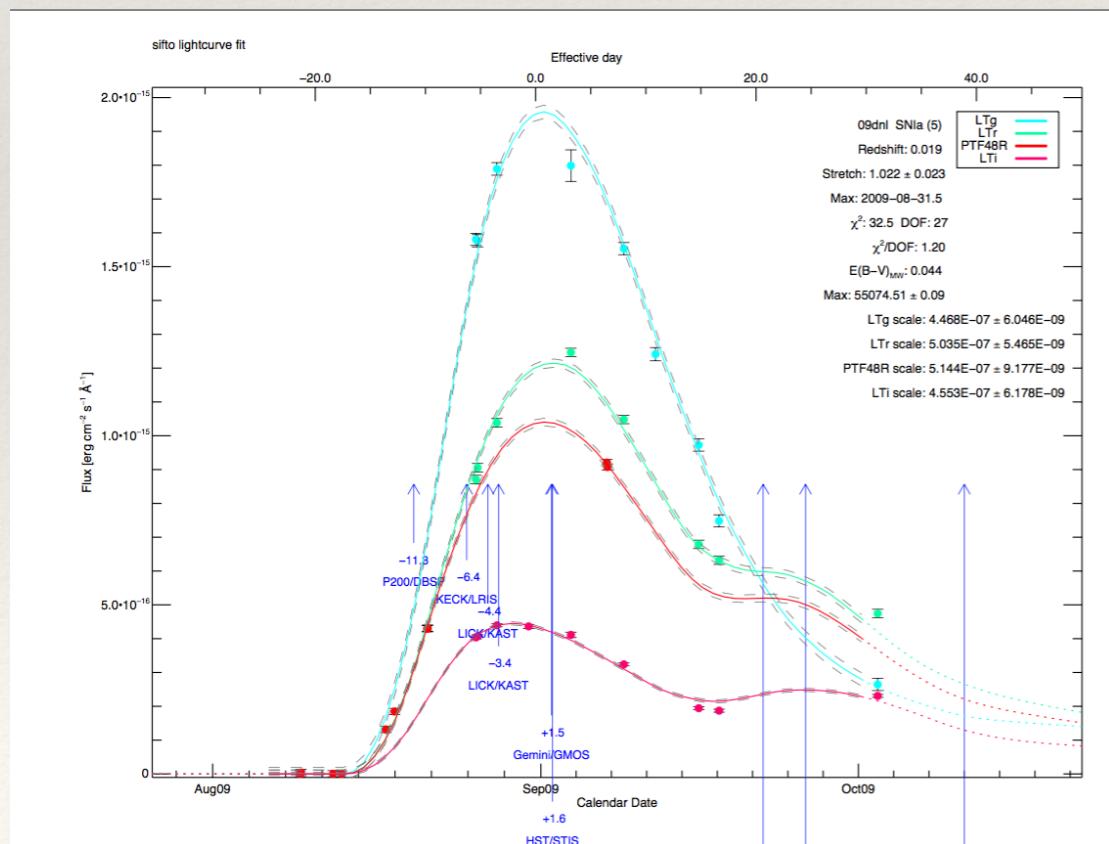


- Spectral and light curve properties - host galaxy dependence

Pan+ (2014, 2015)

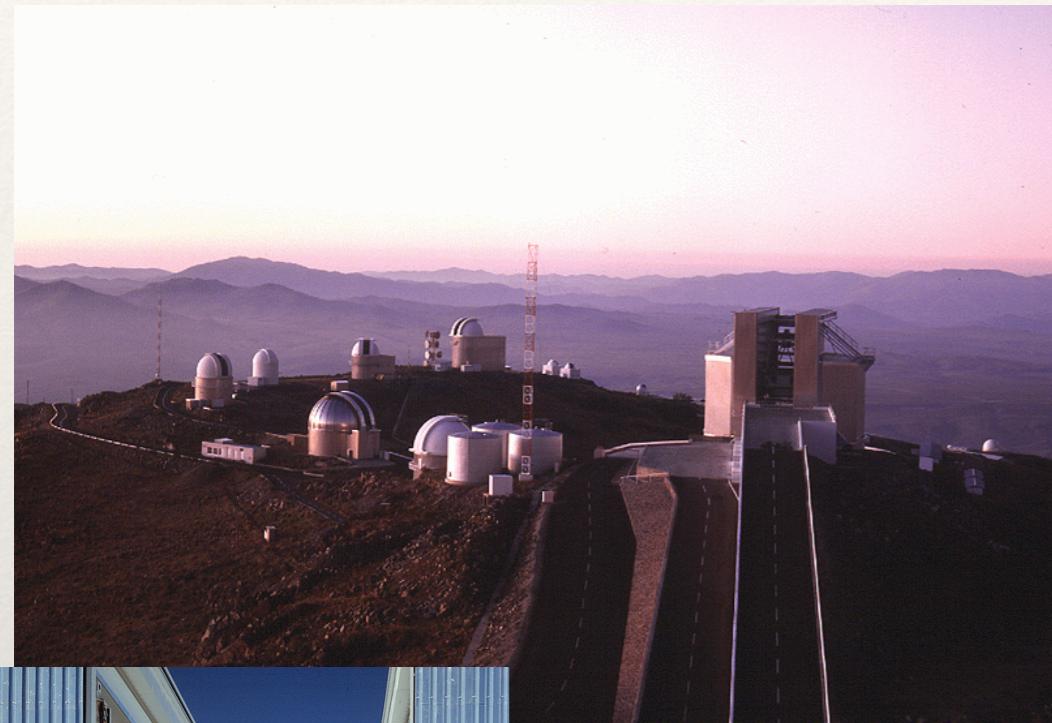
Multi-colour light curves

- 250 SNe Ia with multi-band (gri) light curves
- Robotic 2-m Liverpool telescope



- Reference images at >1 year after explosion
- RATCam (FOV: 4.6'x4.6'), IO:O (FOV: 10'x10')

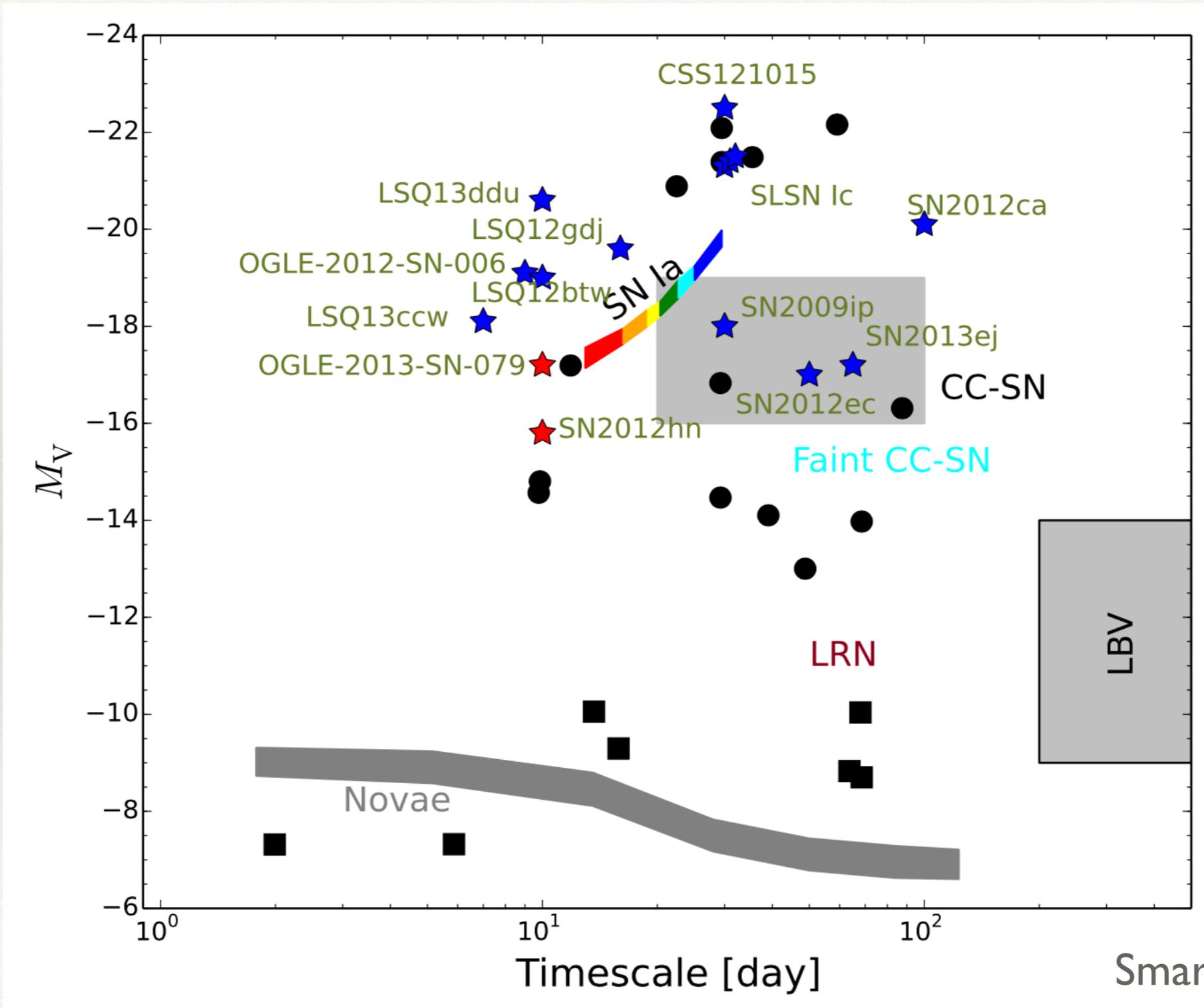
PESSTO



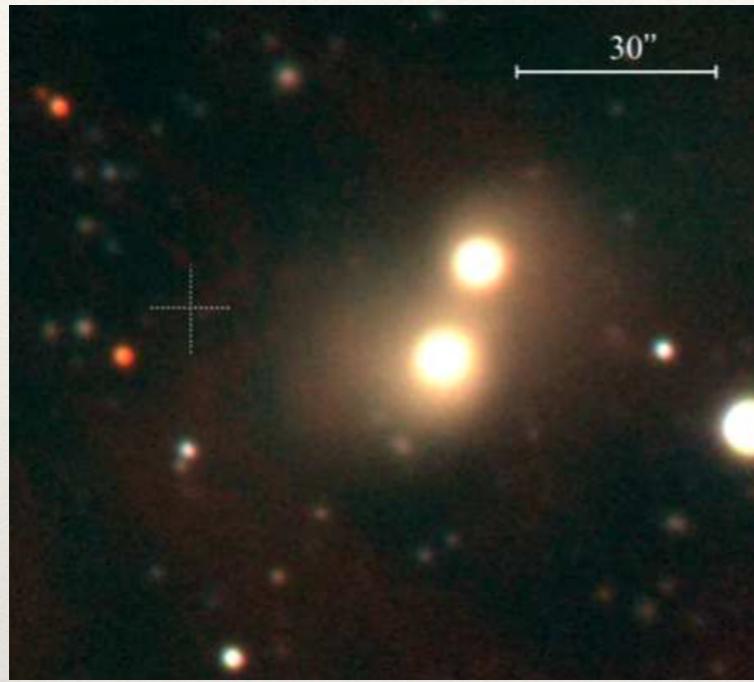
NTT, La Silla, Chile

- Public ESO survey 2012-2017 - Smartt+ (2015)
- 90 nights a year on the NTT
- Optical and NIR imaging and spectroscopy
- 186 registered members
- 22 key science projects
- 150 objects with full coverage

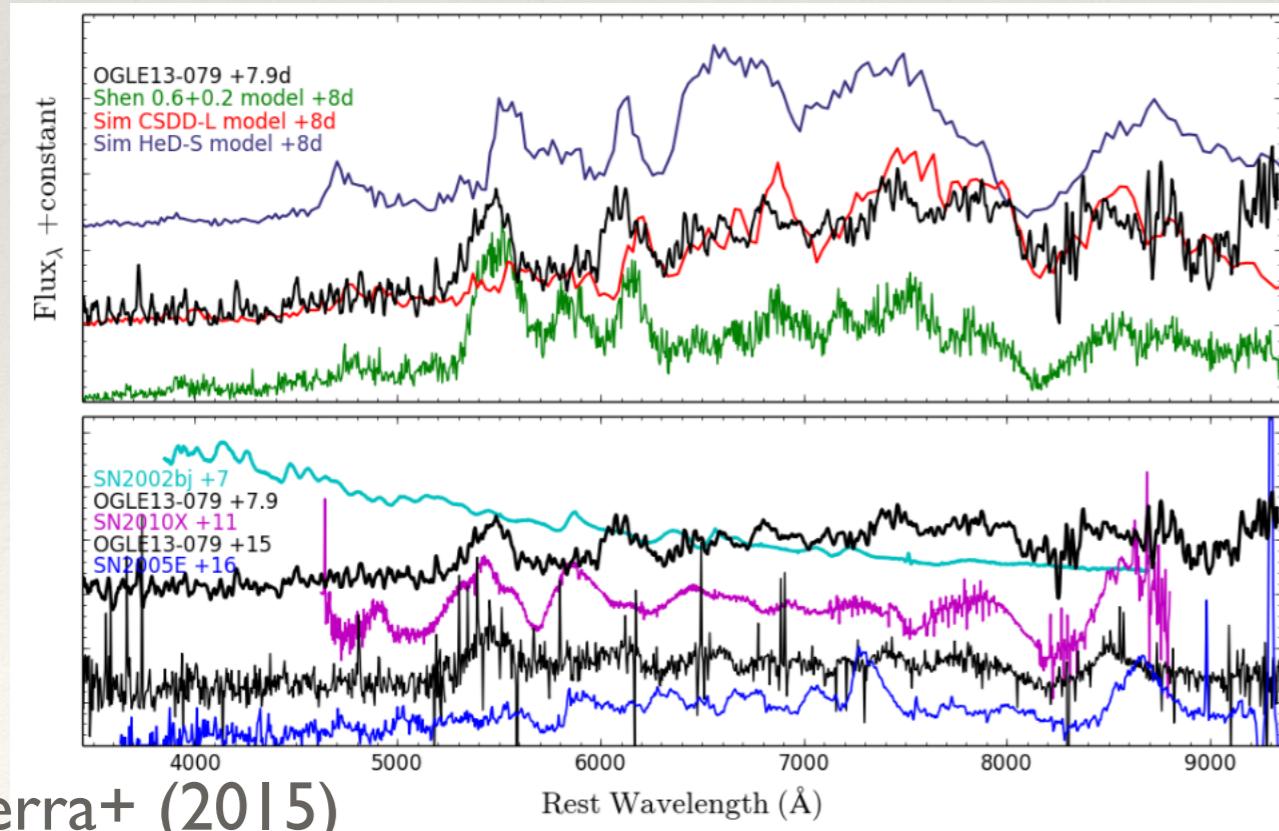
Extreme objects with PESSTO



Unusual SNe Ia in remote locations

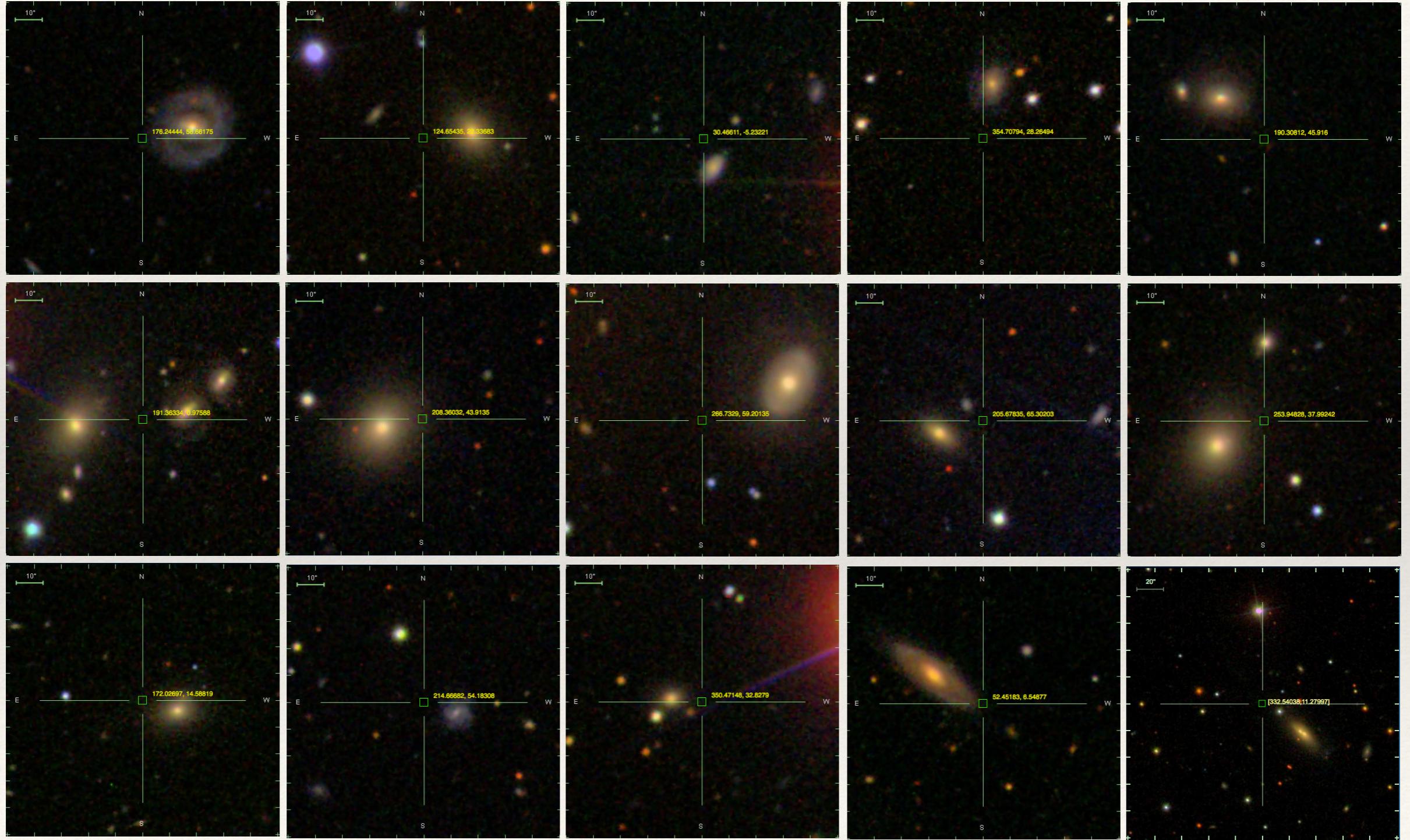


- OGLE-2013-SN-079 (Inserra+ 2015)
- 40 - 50 kpc from potential hosts
- Peak magnitude of -17.6



- Spectra dominated by Ti II / Ca II
- Match to He-shell detonations & double-detonations

SNe Ia in remote locations with PESSTO



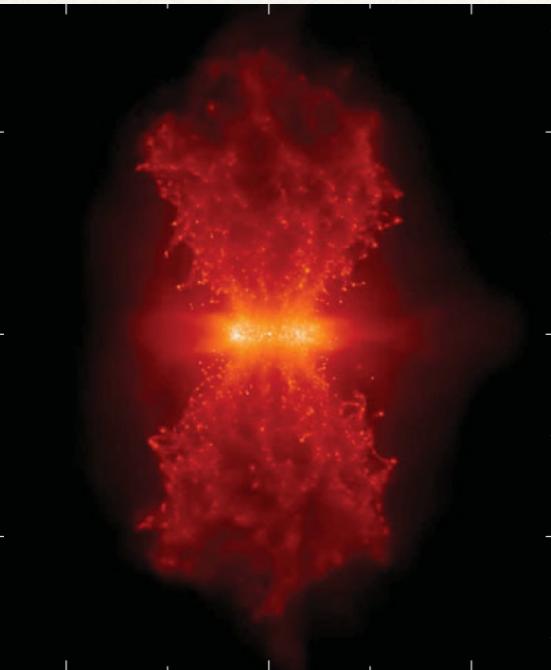
Lessons learned from PESSTO

- Different to PTF
- ESO public survey - all data is immediately available
- All data products released yearly
- Flexible science projects, open to new science ideas

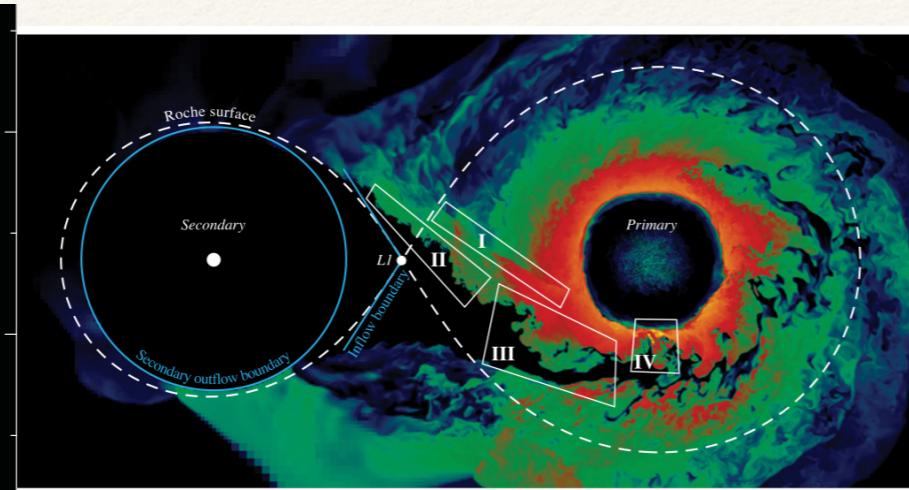
SN Ia progenitors

How can we distinguish explosion mechanisms?

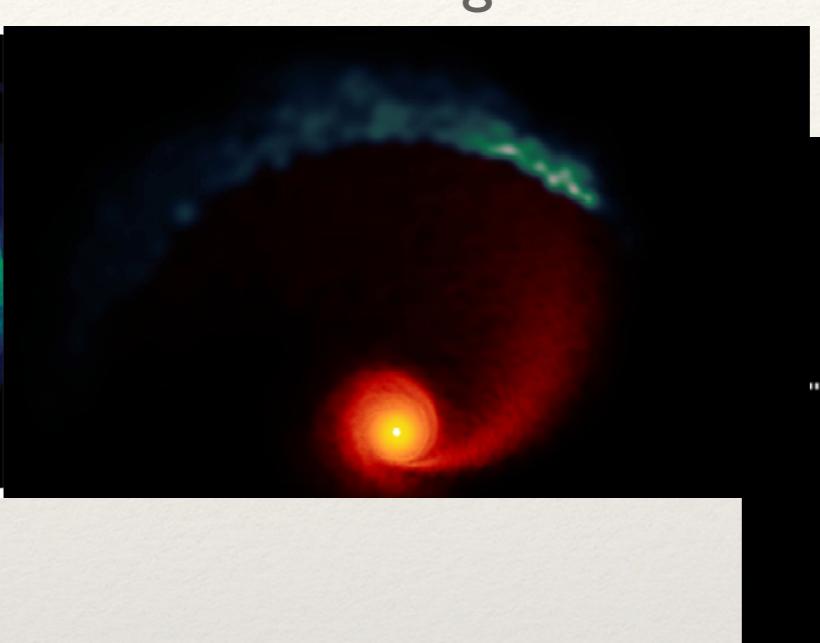
Single degenerate?



Double detonation?



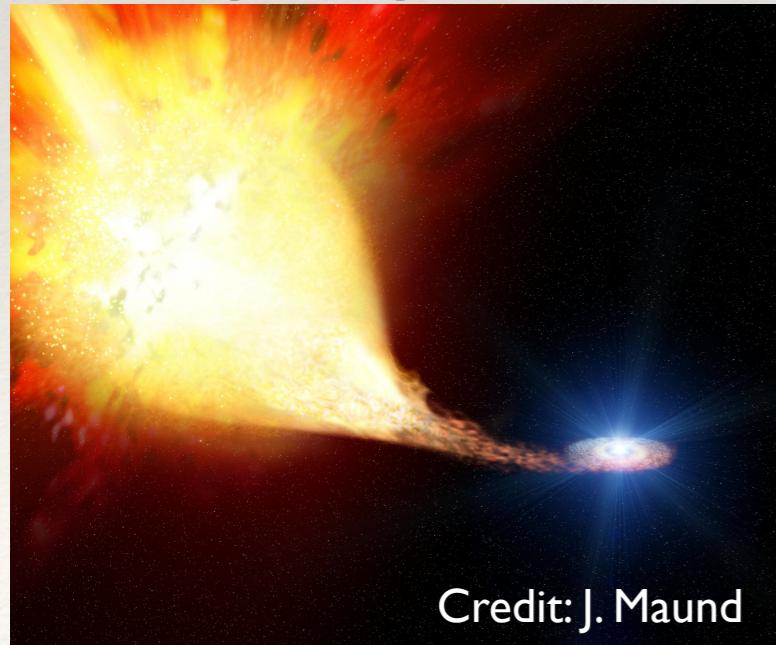
Merger?



Triple system?

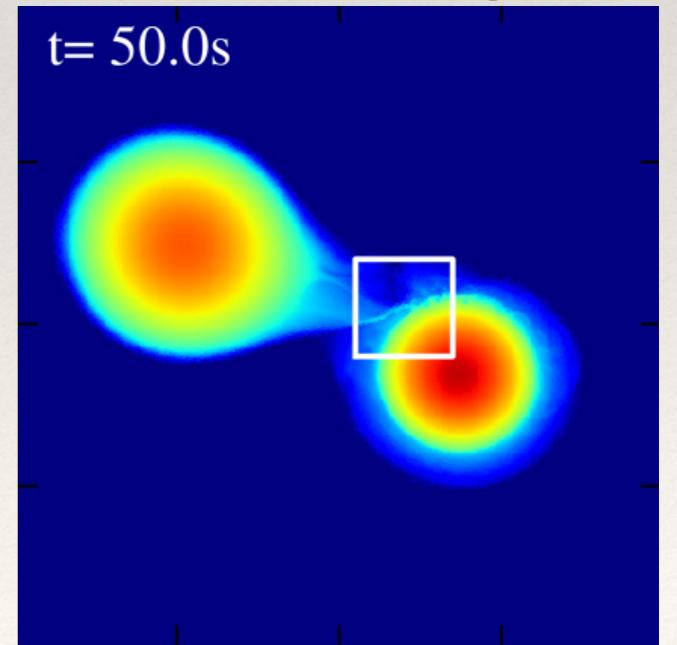


Single degenerate?

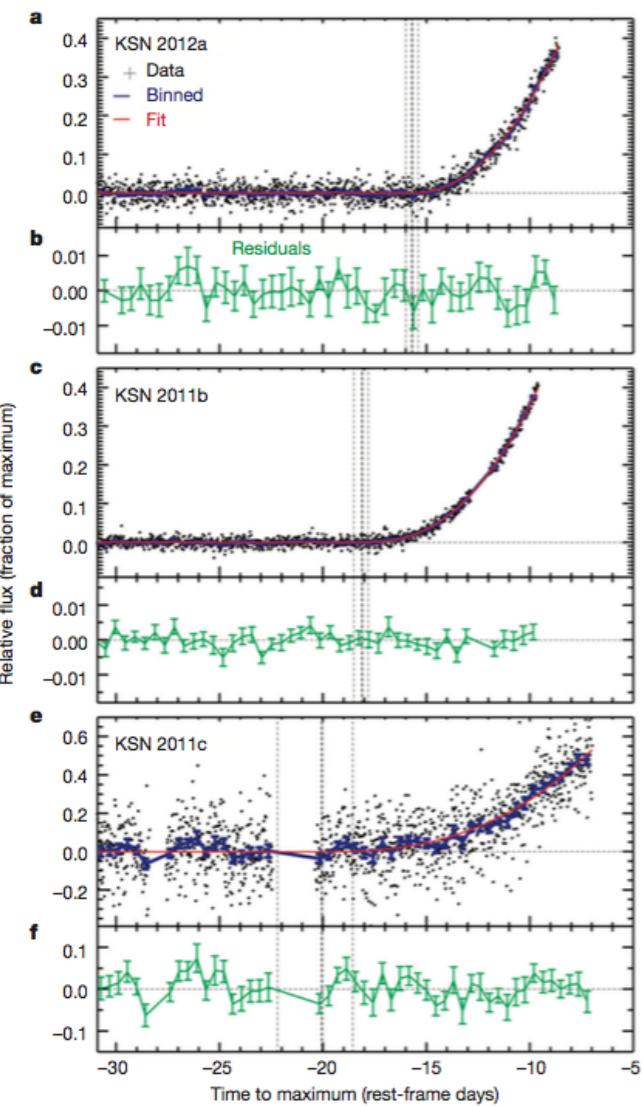


- Predict similar spectra
- Subtle signatures in SN Ia observations

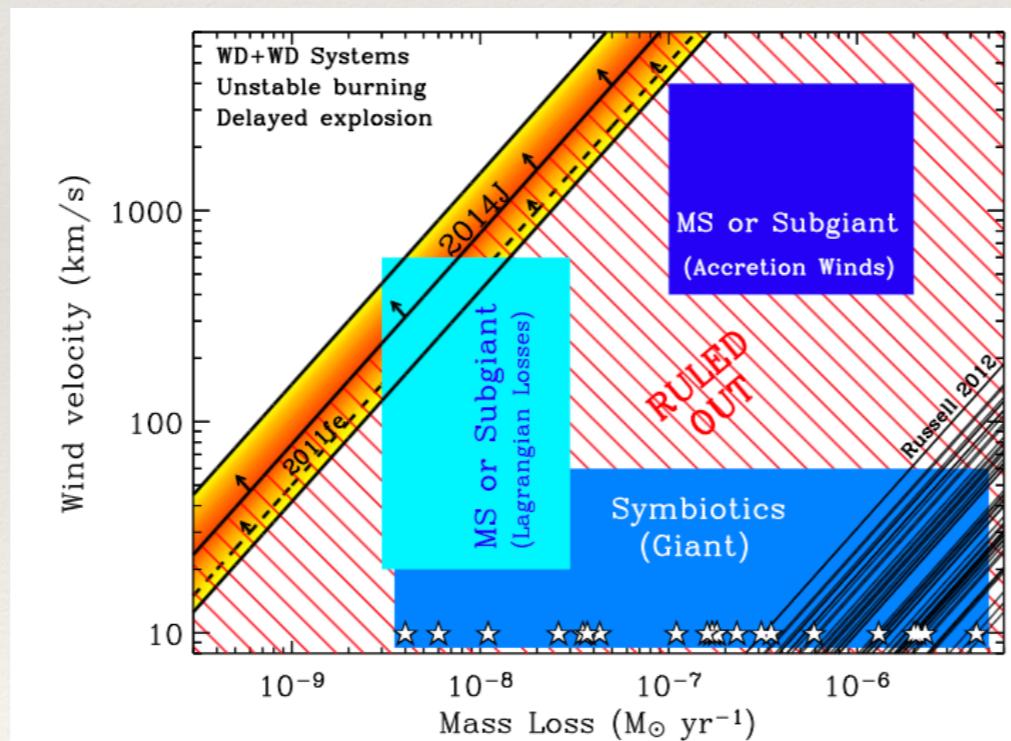
Violent merger?



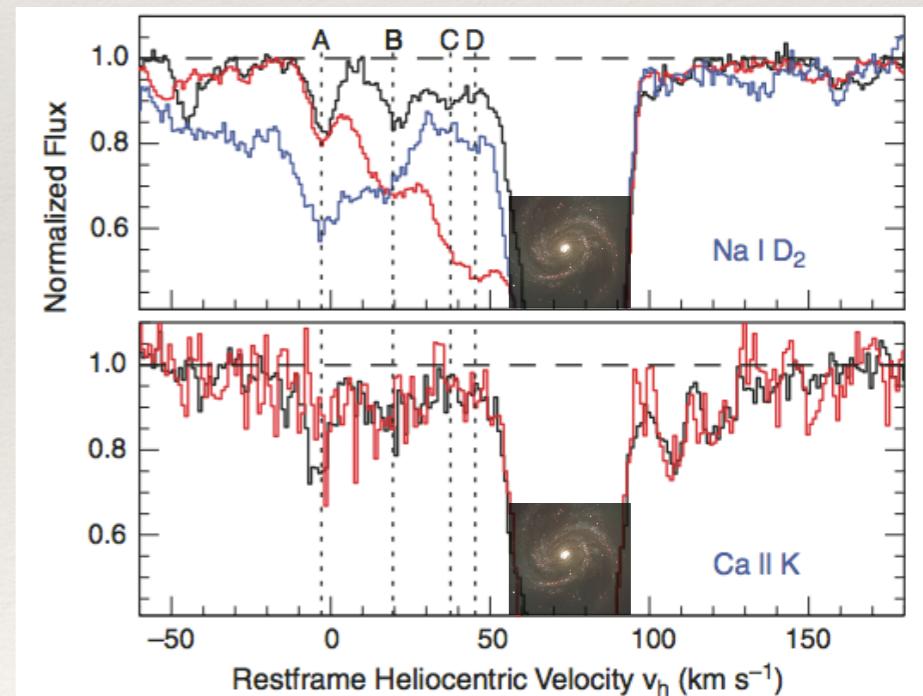
Progenitor signatures



- No early interaction with companion star
- No X-rays / radio emission
- No circumstellar material in 80% of SNe Ia



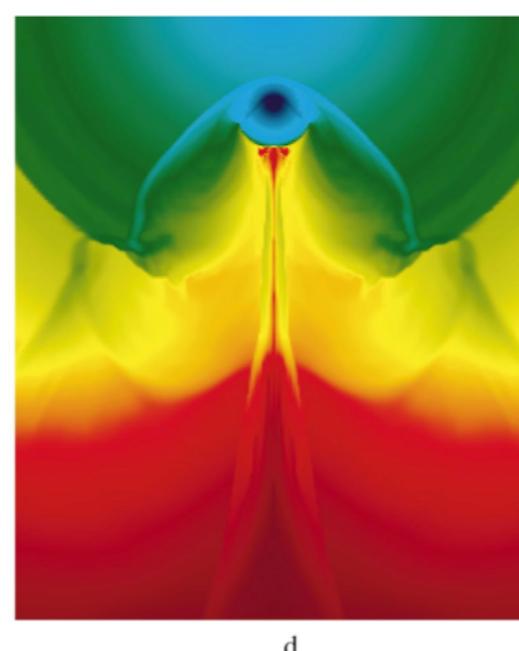
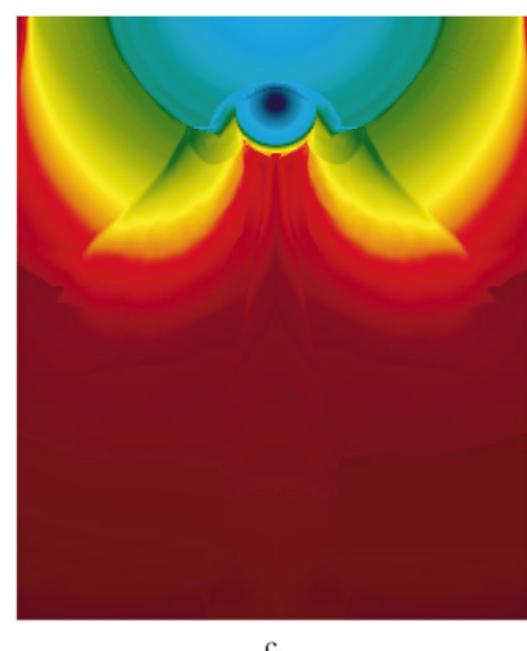
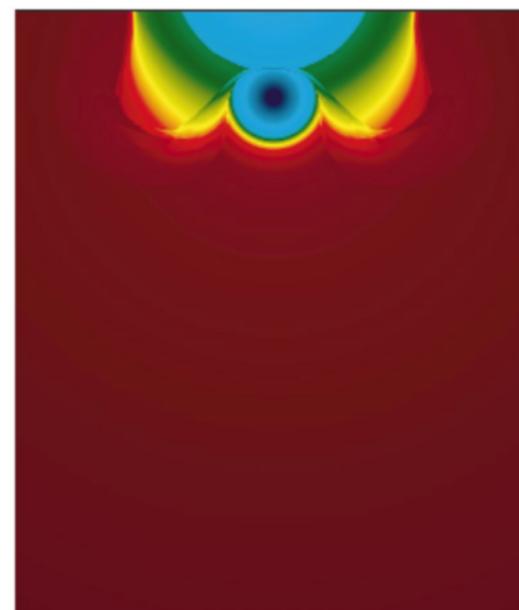
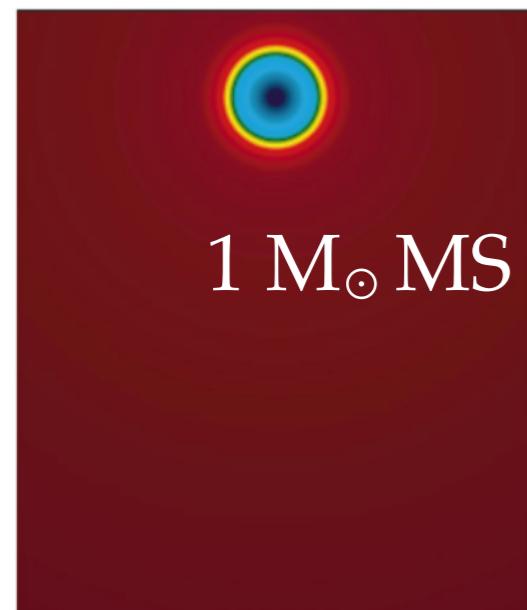
Margutti+ (2014)



Patat+ (2007)

Searching for companion material

SN



Marietta+ (2000)

- Stripping of material from companion (first: Wheeler+ 1975)
- Stripped masses of $0.05\text{-}0.3 M_{\odot}$ (Pan+ 2010, 2012; Liu+ 2013)
- $\text{WD+He} < \text{WD+MS} < \text{WD+RG}$

Little mass lost

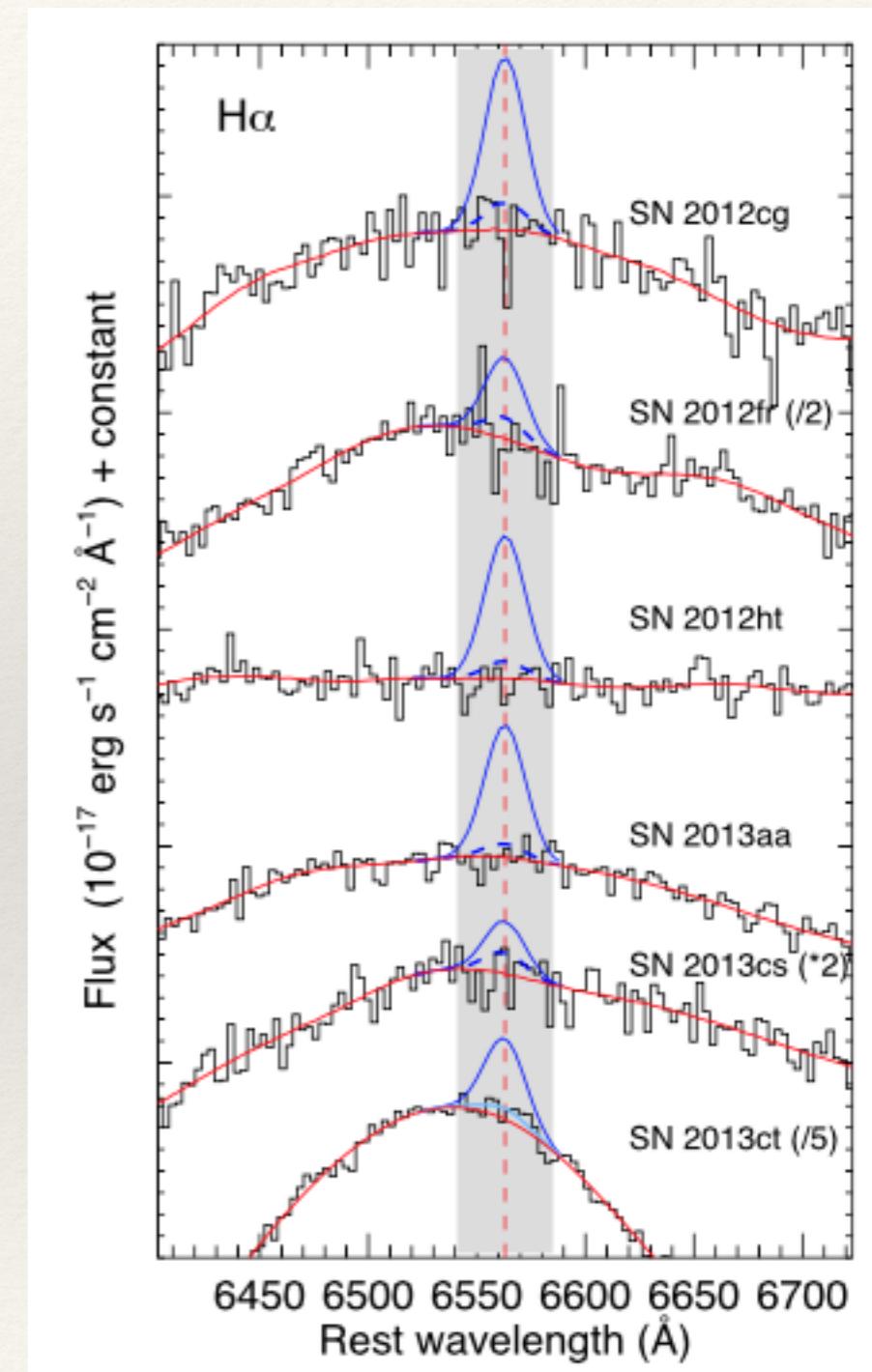


Nearly all envelope mass lost



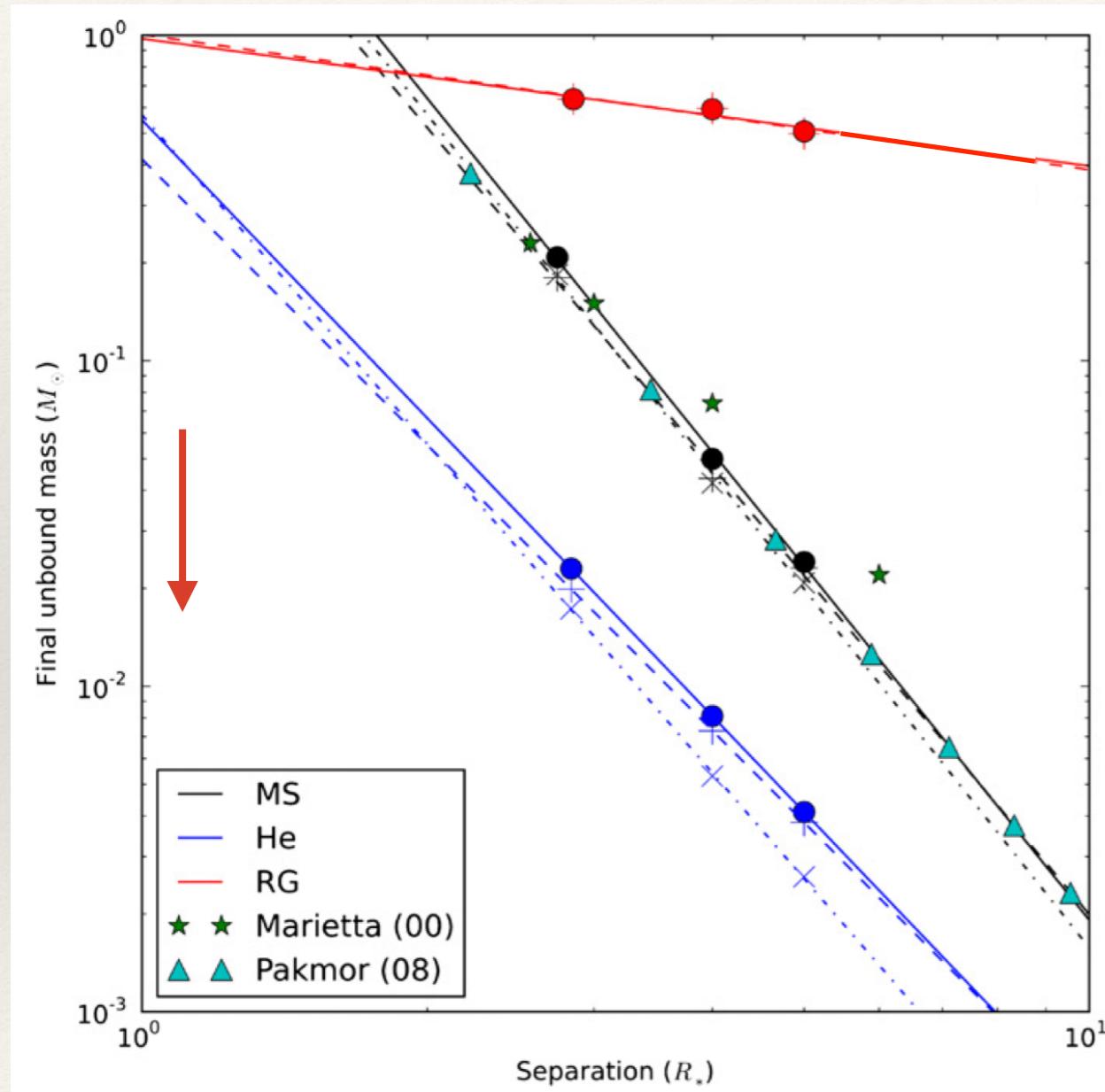
Non-detection of Hydrogen at late times

- Intermediate resolution searches at >200 d (Mattila+ 2005, Leonard 2007, Shappee+ 2012, Lundqvist+ 2013, Maguire+ 2016)
- 18 SNe Ia (11 new objects)
- Mattila+ (2005) models to estimate mass limits of H-rich material (limits < 0.001-0.06 M_{\odot} material)



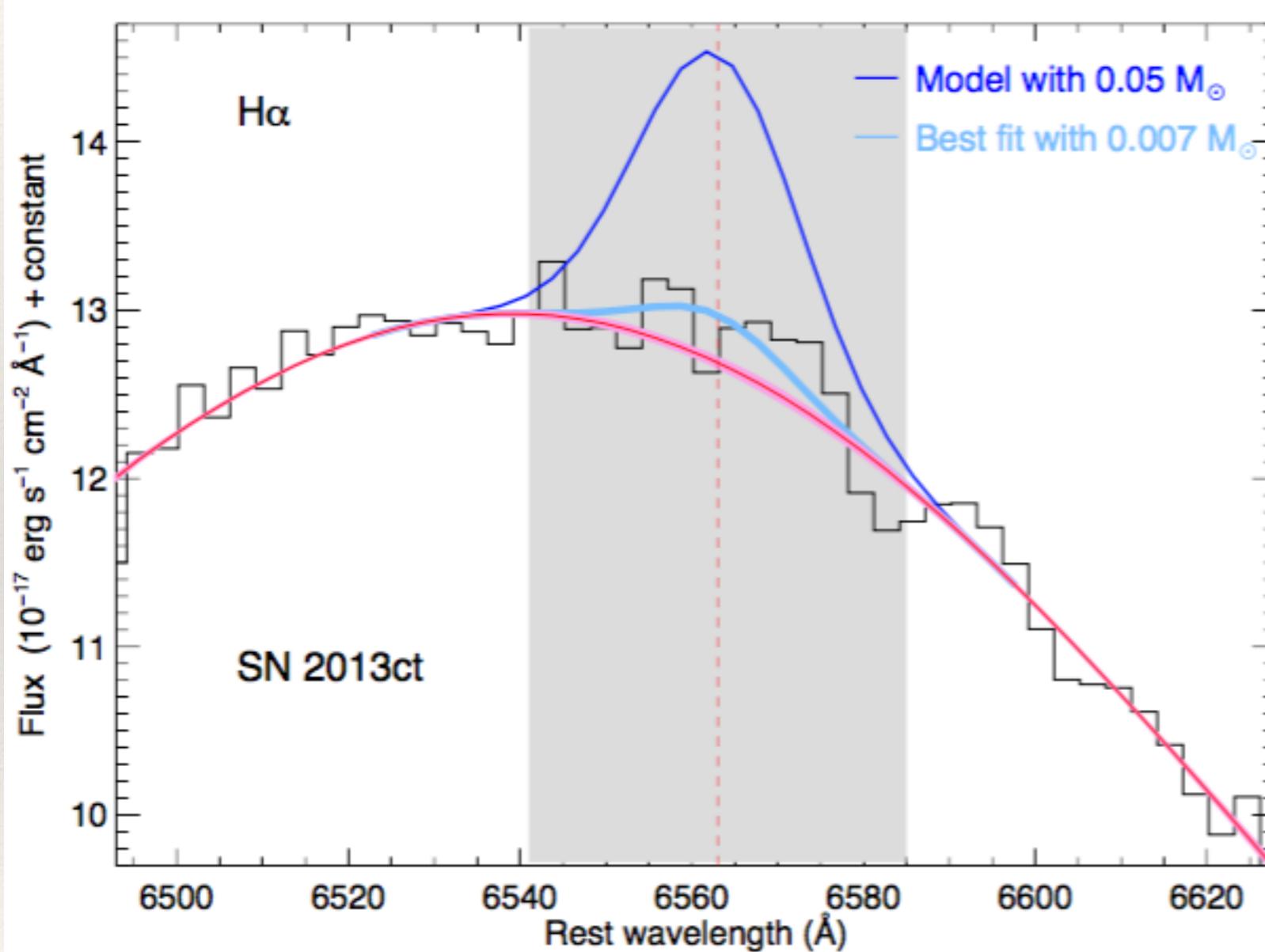
Maguire+ (2016)

What systems are ruled out?



- H-rich companion stars in RLOF ($\sim 3^*R$) ruled out
- 17 SNe Ia (limits $< 0.001\text{--}0.06 M_{\odot}$ material)
- If 20% come from SD, ~ 4 should have Hydrogen
- He companions?

Tentative detection of Hydrogen



- \sim 3.1-sigma detection of H in SN 2013ct
- $\sim 0.007 M_{\odot}$ H-rich material
- Suggests $>0.1 M_{\odot}$ of H-rich is present but not observed

Summary and open questions

- PTF - 250 SNe Ia with multi-colour light curves
- Spectral and host galaxy studies already released
- PESSTO - unusual transients
 - SNe Ia in remote locations
 - Differences with metallicity, age?
- SN Ia progenitor ‘problem’ - do we care for cosmology?