

Super Luminous Supernovae with PESSTO

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What and How?

Gal-Yam 2012, Science

- Brighter than -21 (5 to 100 times brighter than classical SNe)
- ★ Rest-frame $g-r < 0-0.2$ (blue for 20-30 days also post max)
- ★ Spectroscopic peculiarities
- ★ Usually in faint galaxies (typically $M_g > -17$)

Chen 2014 Apj, Lunann 2014 Apj

Why?

- ★ Possible probes in the high-redshift universe (beyond $z > 2$; type Ia) Inserra & Smartt 2014, ApJ
- ★ chemical enrichment, stellar evolution (related to stripped envelope SNe) and feedback in galaxy formation Pastorello et al. 2010, ApJL
- ★ ideal target for current (e.g. PESSTO) and next generation surveys (e.g. LSST)

SLSNe: History Diversity Characteristic Energy Sources

Why?

54 + 15 papers
4 Nature
1 Science

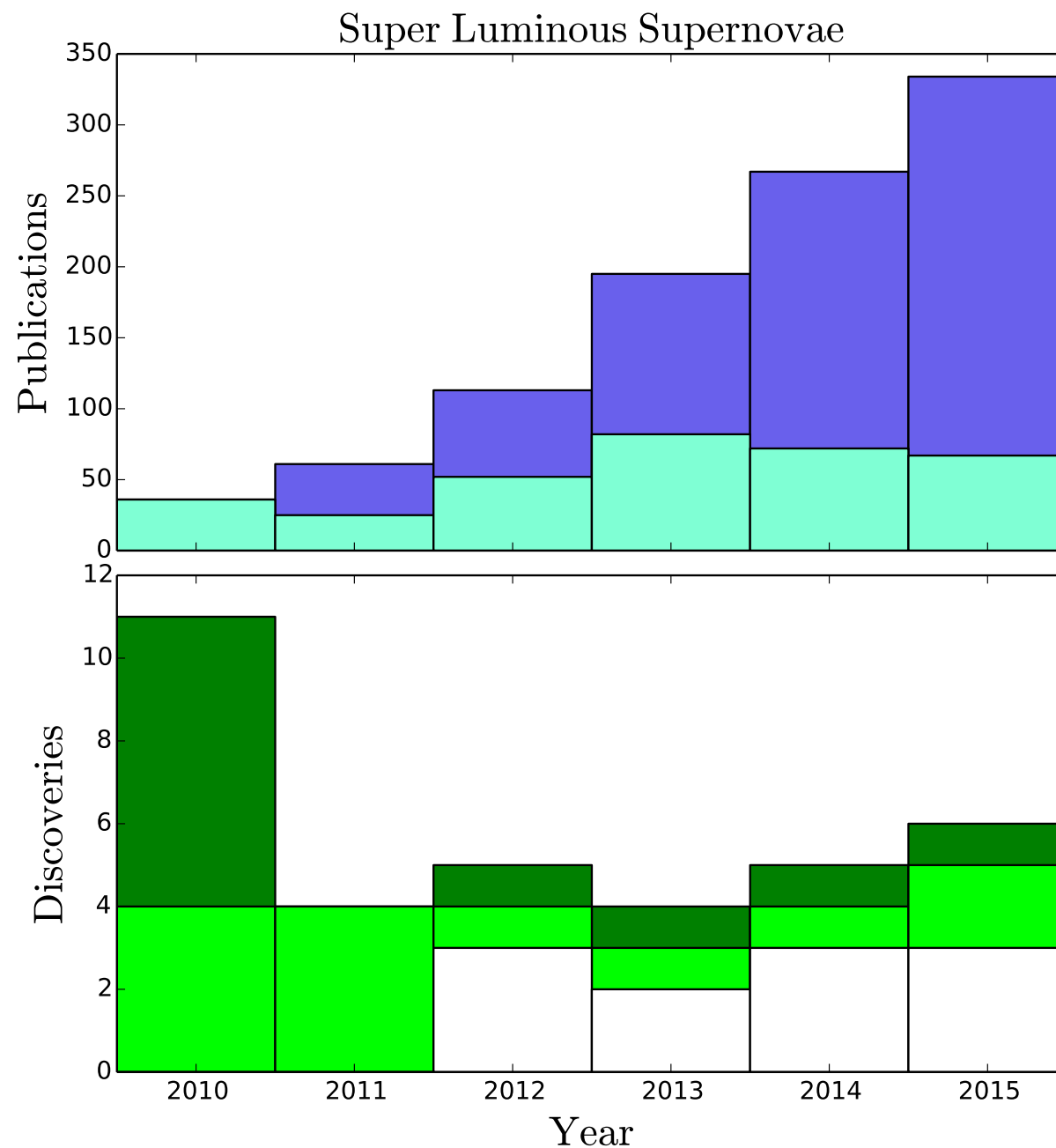
Cumulative
sources

Sources x year

Total

PESSTO
scientists

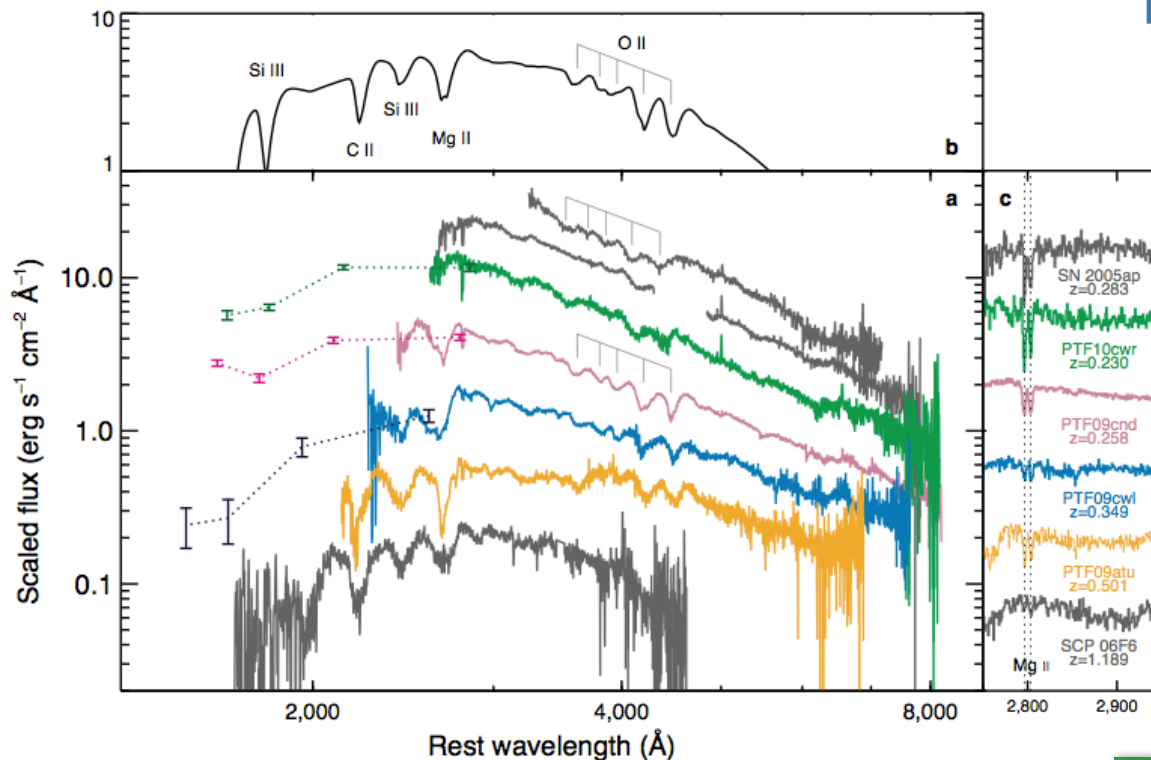
PESSTO



SLSNe: History Diversity Characteristic Energy Sources

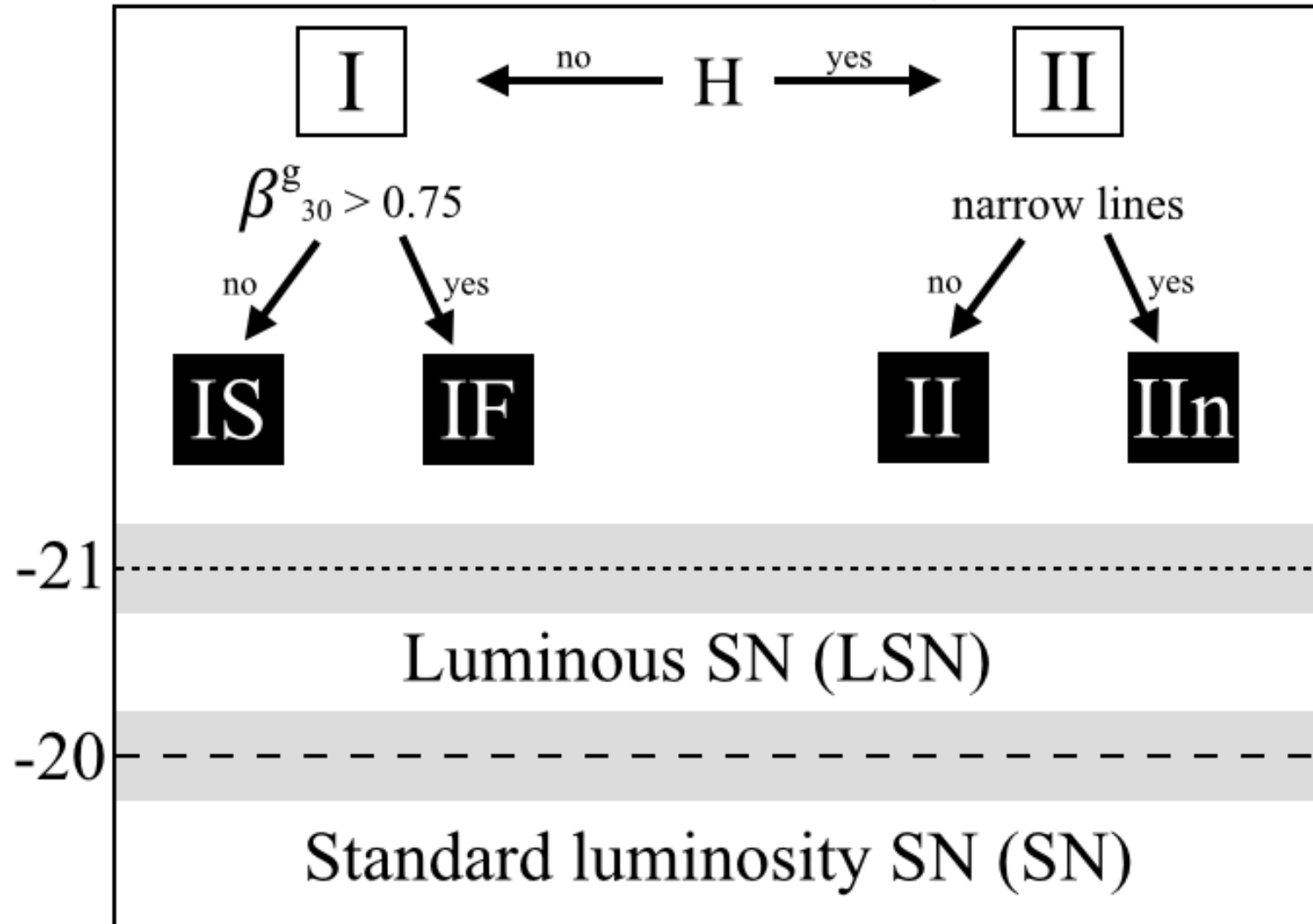
- Original Palomar Transient Factory (PTF) sample
- PanSTARRS1 objects up to $z \sim 1$ and at low redshift $z < 0.25$
- Supernova Legacy Survey (SNLS)
- Dark Energy Survey (DES)
- SN2007bi
- SN2010gx
-

Until now ~ 40
Only **half** well sampled



Quimby R. et al. 2011, Nature

SLSN Taxonomy

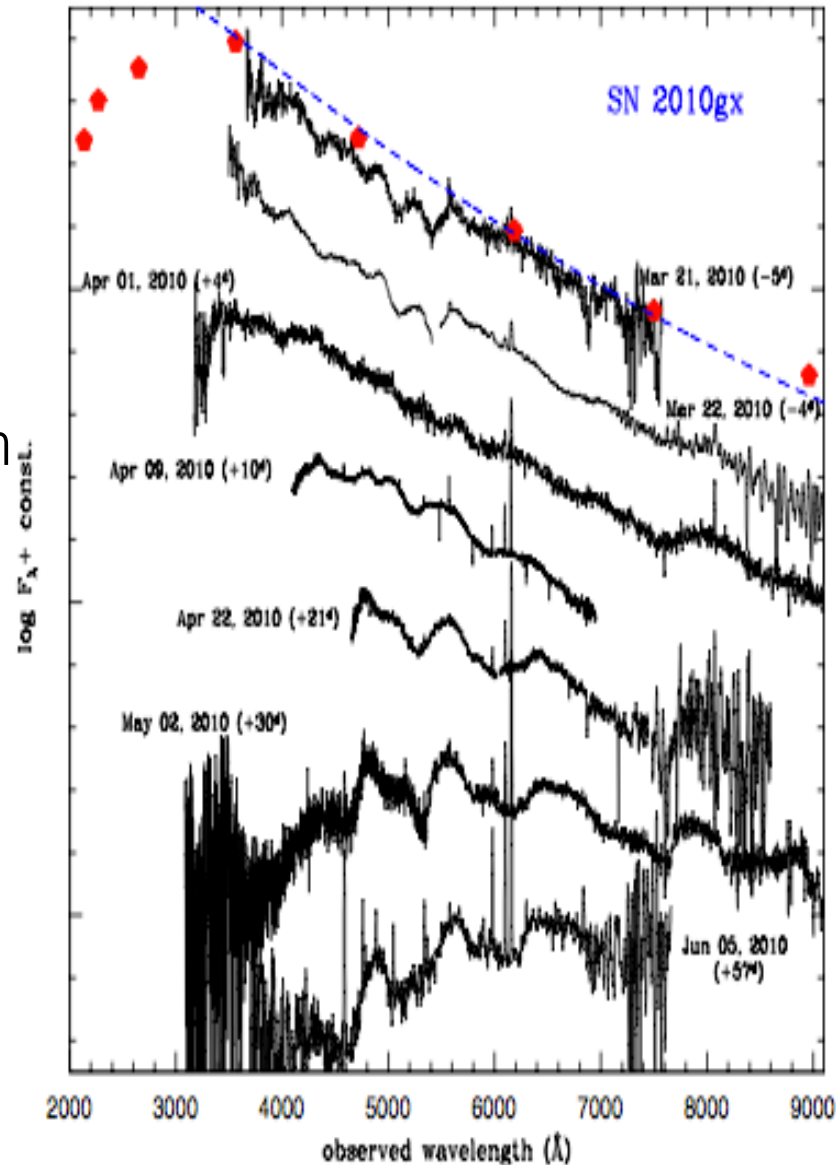
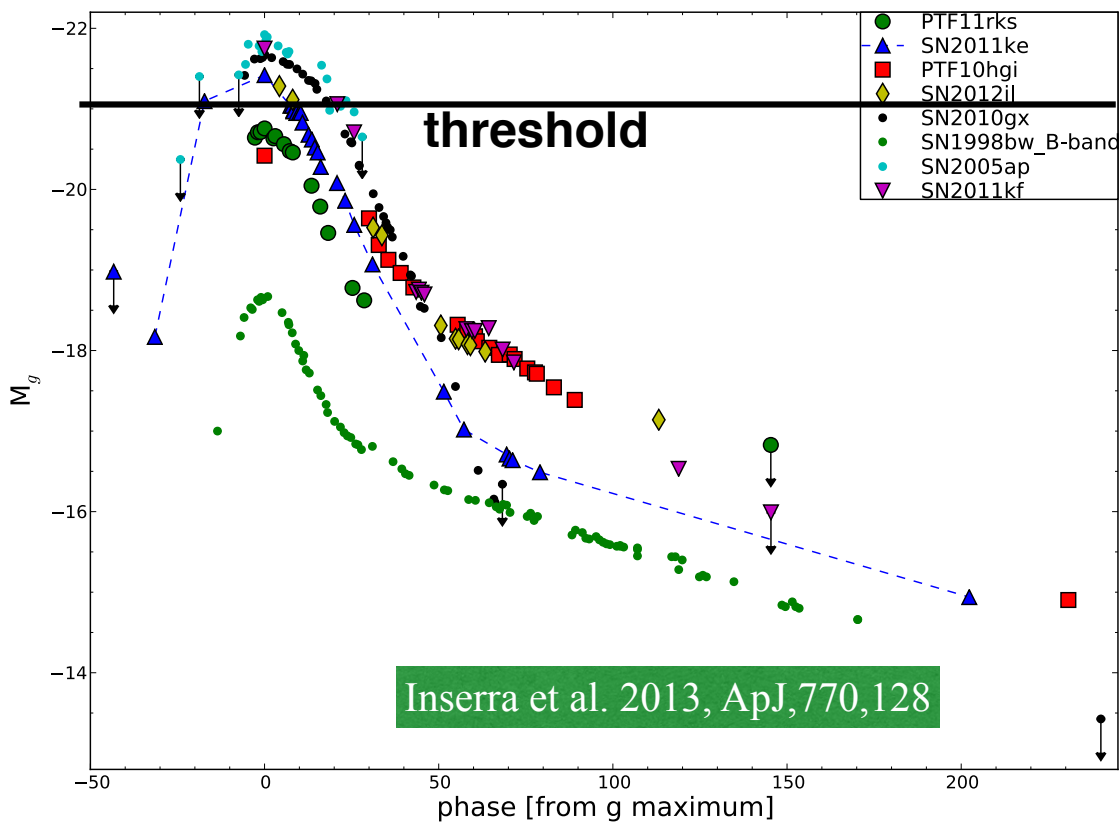


Inserra et al. 2015+ PESSTO community

SLSNe: History Diversity Characteristic Energy Sources

Type I

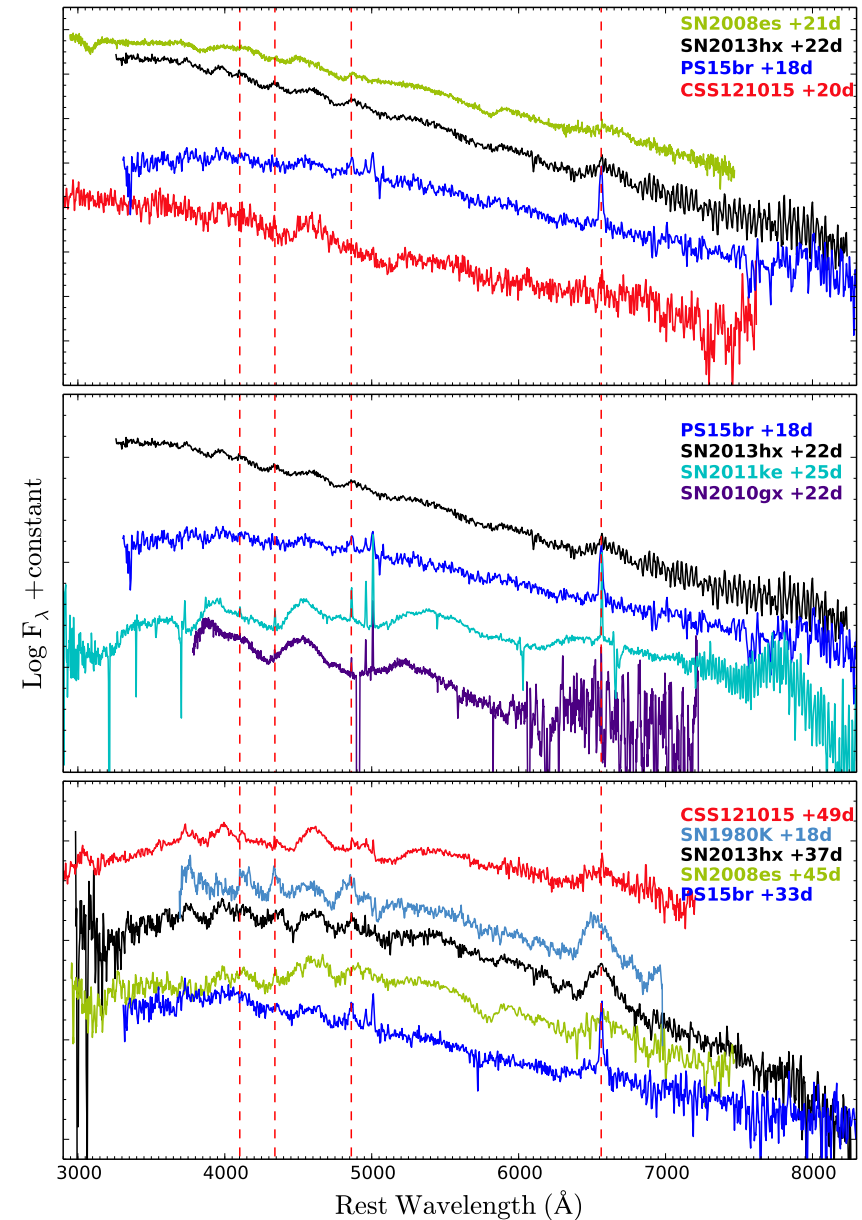
- $M_{\text{peak}} \leq -21$
- Blue featureless spectra
- OII $\sim 4200\text{-}4600\text{\AA}$
- $0.1 < z < 4.0$
- Resembling Type Ic at 30d past maximum



SLSNe: History Diversity Characteristic Energy Sources

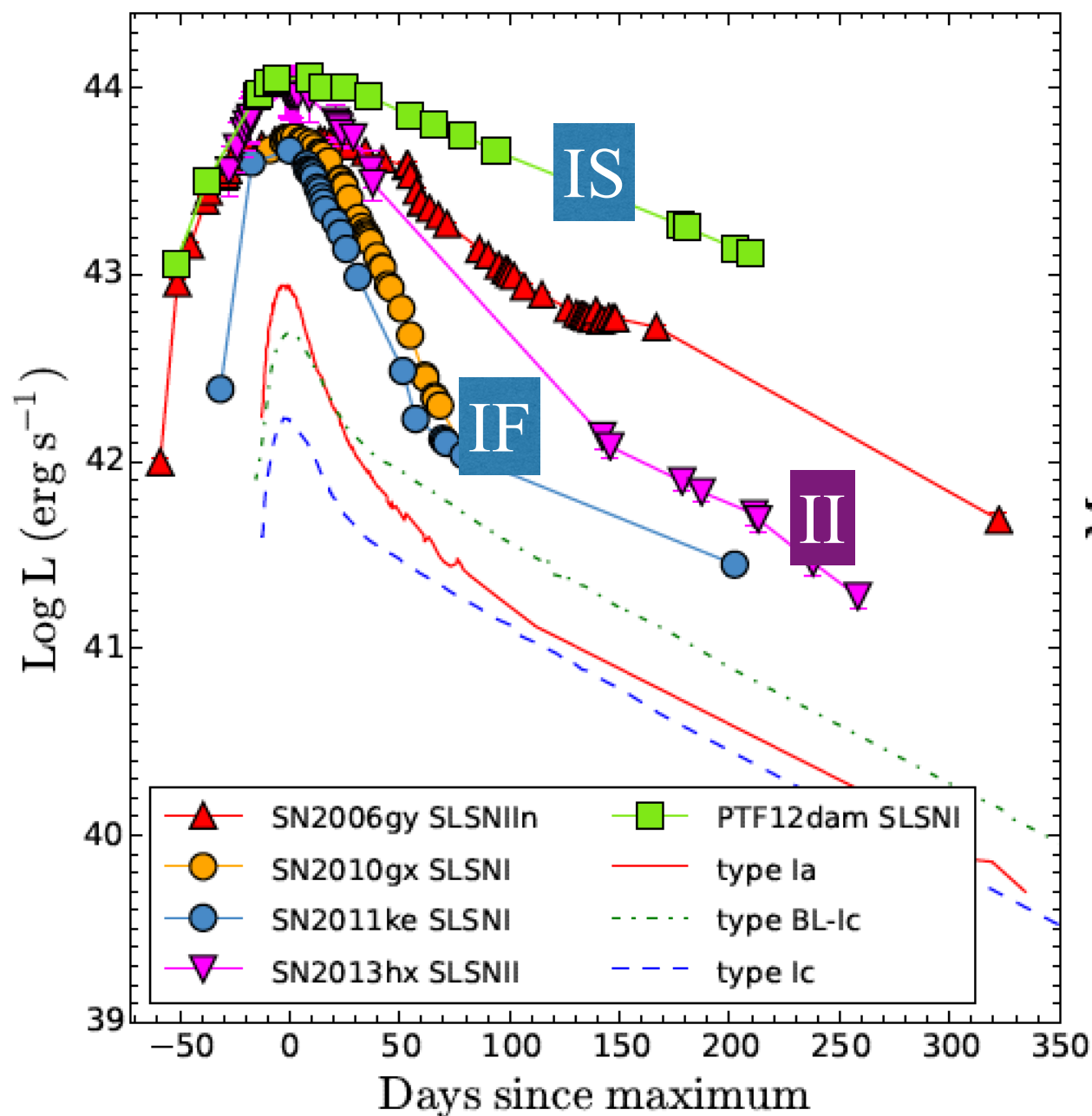
Type II

- $M_{\text{peak}} \leq -21$
- Blue featureless spectra
- HeII $\sim 4686\text{\AA}$
- $z < 0.21$
- Resembling Type II at 20-25d past maximum
- Similar behaviour of type IIL



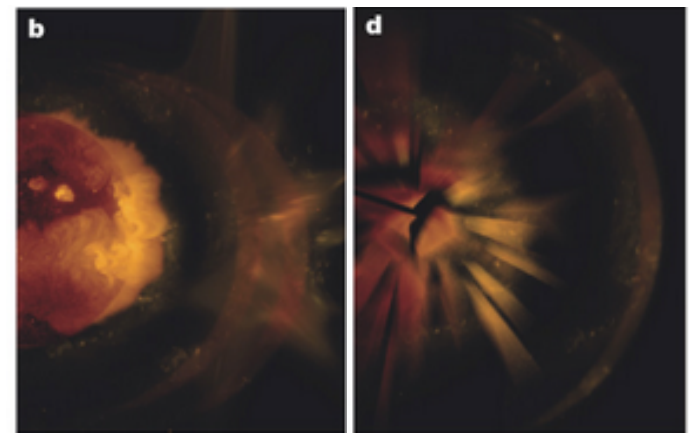
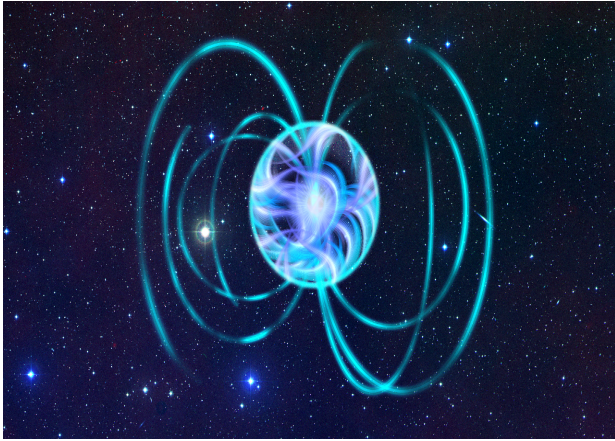
Inserra et al. 2015, ApJ

SLSNe: History Diversity Characteristic Energy Sources



Adapted from Inserra et al. 2013, ApJ 770, 128

SLSNe: History Diversity Characteristics Energy Sources



Magnetar spin down

Pair Instability

CSM-ej. interaction

- Wide range of light curves
- SLSNe I (slow and fast)

- $> 100M_{\odot}$
- ^{56}Ni rich
- Slow rise-time and line blanketing never observed

- SNe IIn
- Optical thick CSM at large radius ($2.5-6.0 \times 10^{15}\text{cm}$)

Woosley 2010,
Kasen & Bildstein 2010,
Inserra et al. 2013,
Nicholl et al. 2013

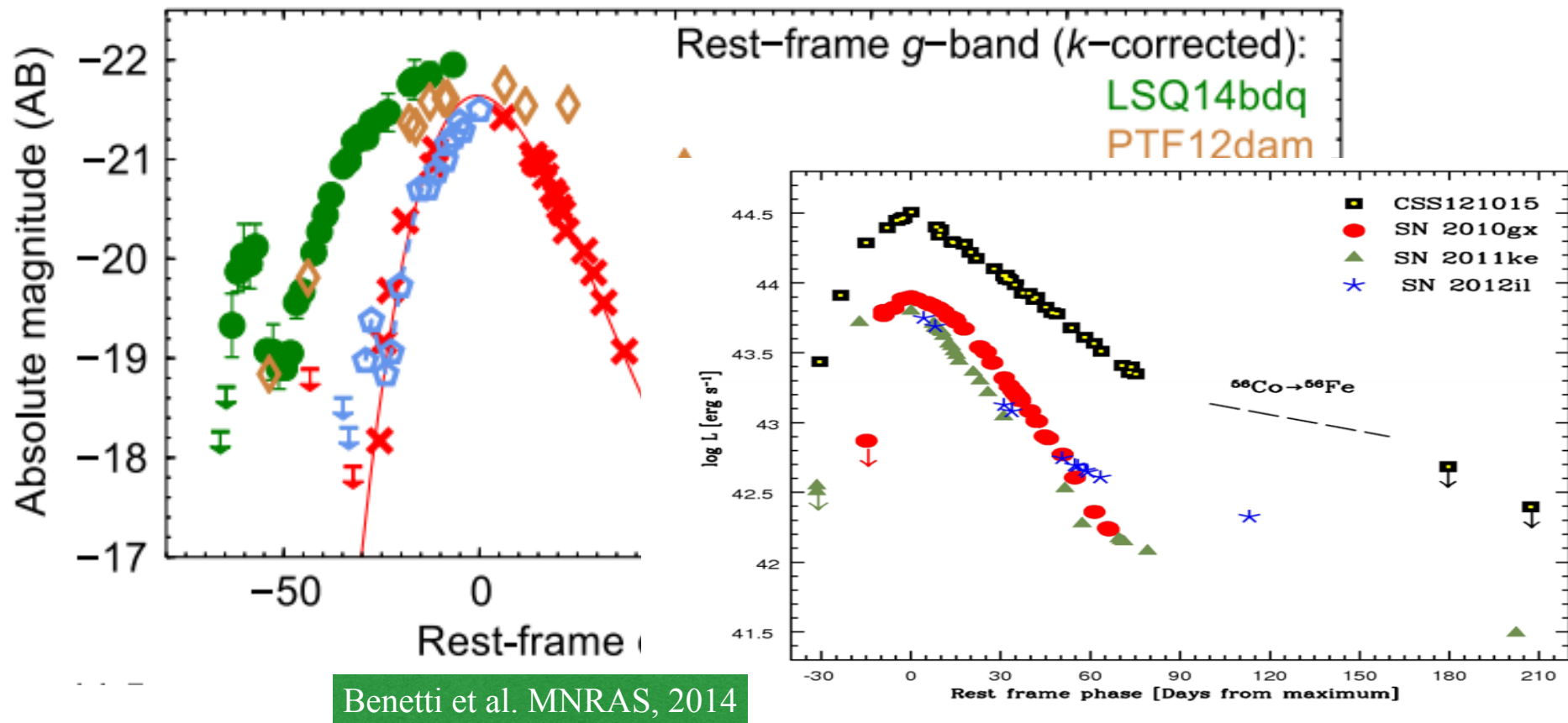
Heger & Woosley 2002,
Gal-Yam et al. 2009

Woosley 2007,
Chevalier & Irwin 2011,
Gizburg & Balberg 2012

SLSNe: What PESSTO has done!

- Doubled the sample of well observed objects at low redshift
- Allowed the first detailed studies about their properties
- Classified the first SLSN with a double peak

- Pro
- Pro
- Cl
obs



New cosmological probes



SLSNe at high redshift (DES+LSST)

Bump investigation:
probing the physical origin



Probing their geometry
and mapping their diversity



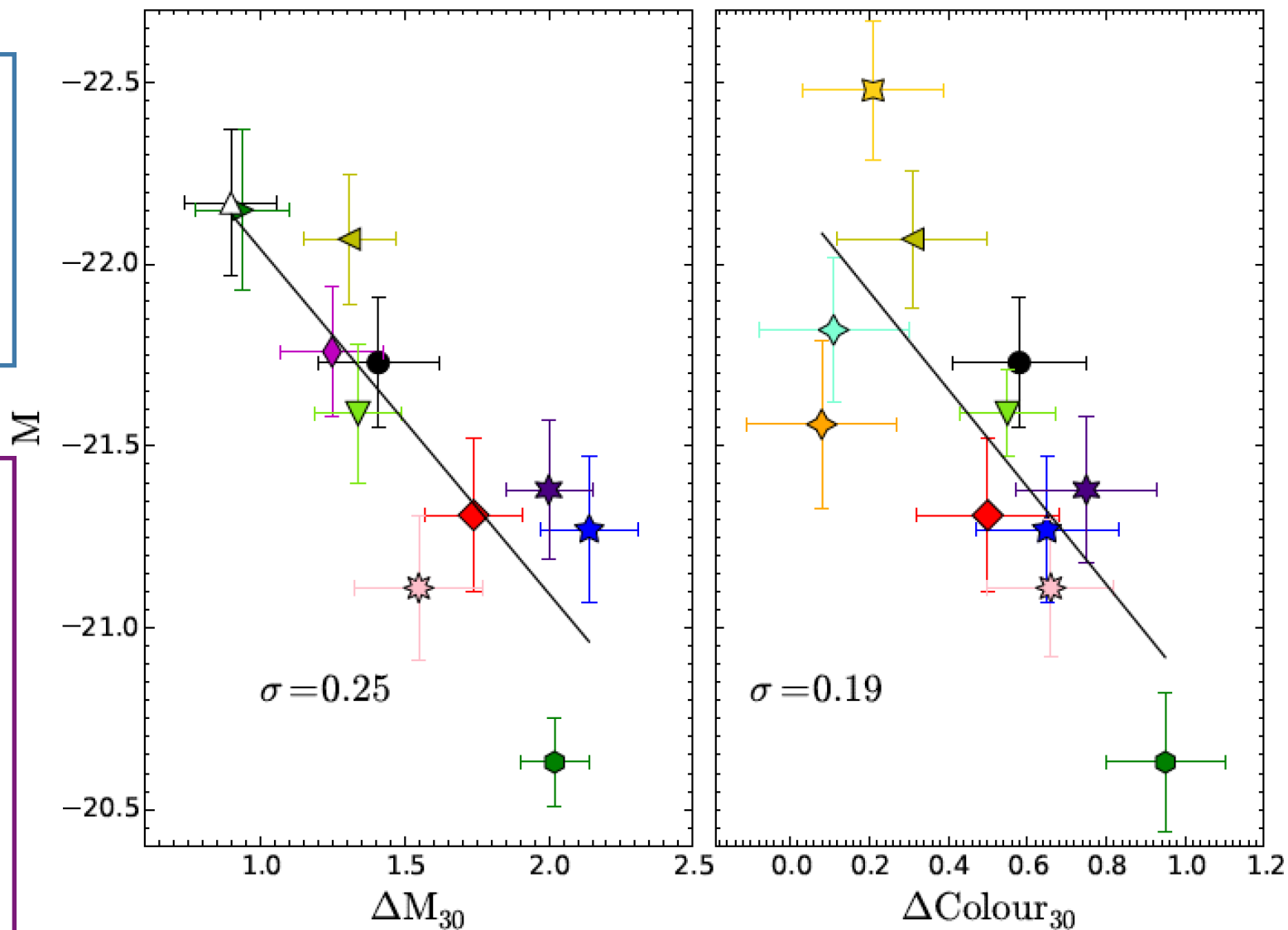
Exploring nebular spectroscopy
and early UV



New cosmological probes

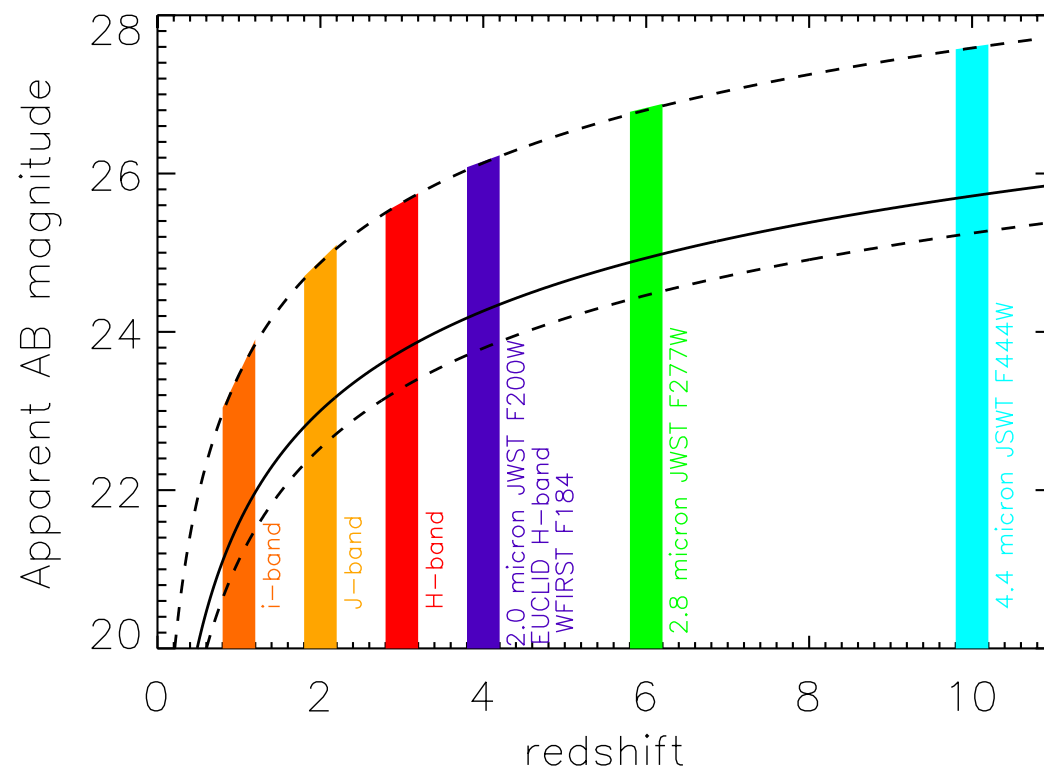
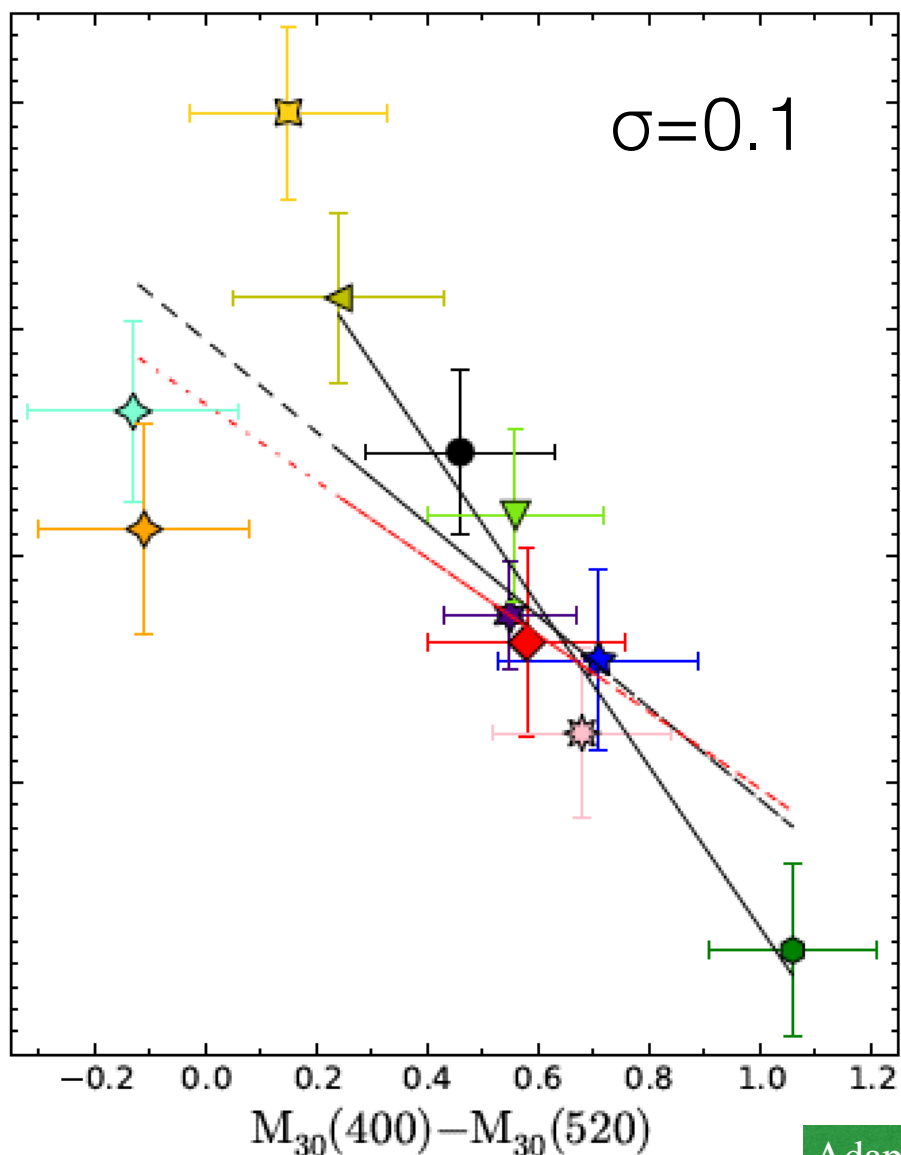
199^{+137}_{-86}
events
 $\text{Gpc}^{-3} \text{ yr}^{-1} h^3_{71}$
at $z < 0.2$

Recent
predictions
suggest
10000 SLSNe
to $z \sim 2.5$
discovered by
LSST



Adapted from Inserra & Smartt 2014, ApJ

New cosmological probes



Can be observed at $z > 2$
with current instrumentation

Up to $z = 10$ with future survey

Adapted from Inserra & Smartt 2014, ApJ

ESO can play a crucial role **NOW**
and in the next **TWO DECADES**

NOW with VLT for spectropolarimetry,
late spectroscopy, $z > 0.5$ objects from DES

TWO DECADES

ESO facilities can support DES and LSST discoveries

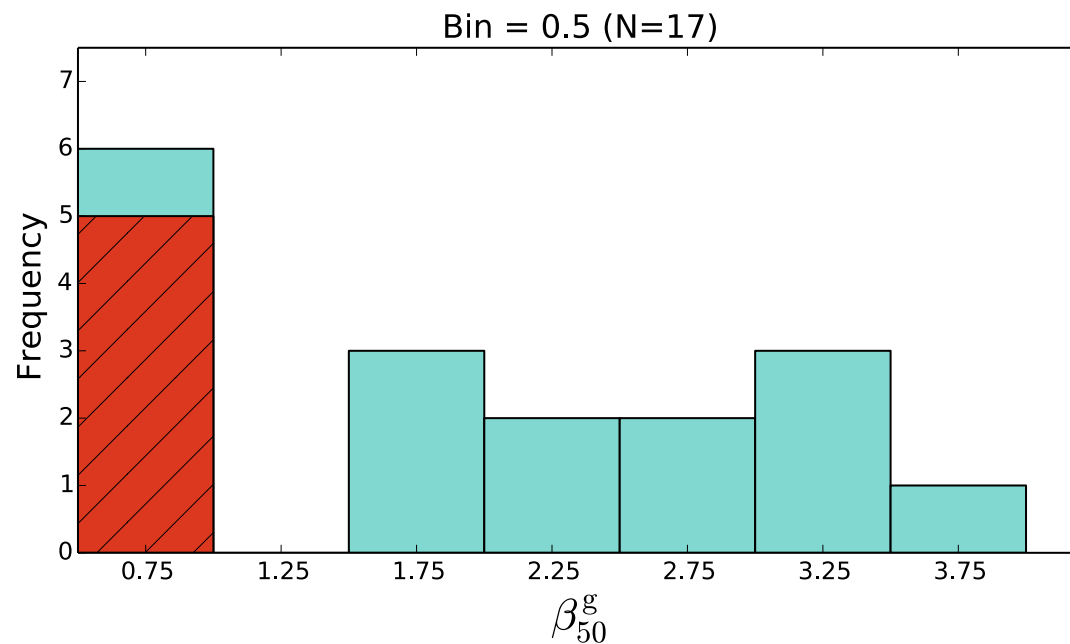
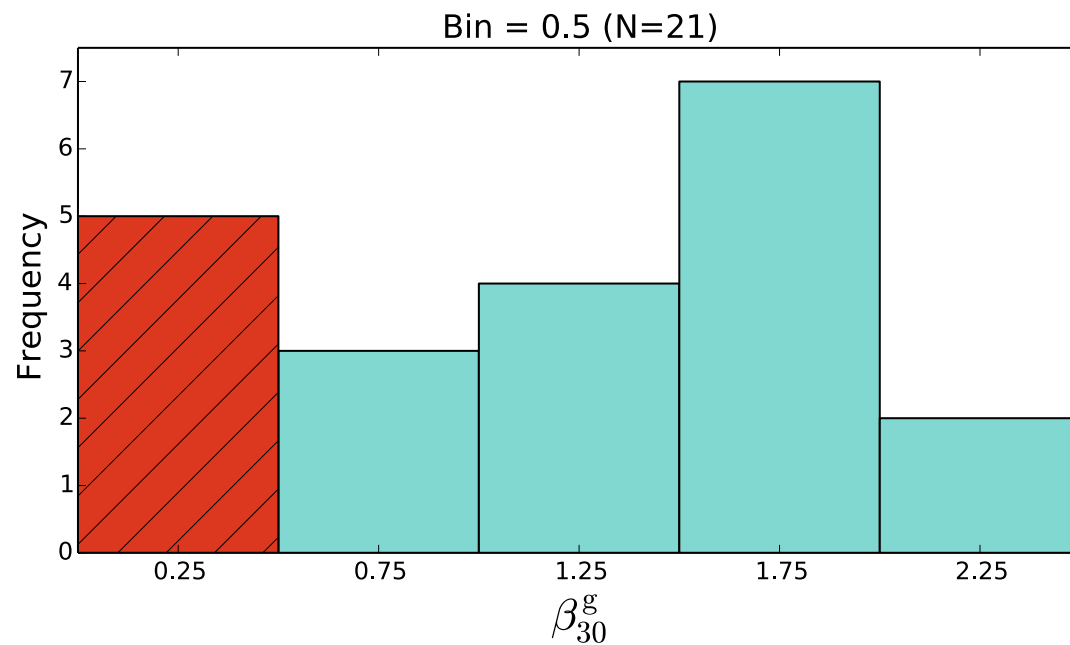
e.g. E-ELT+HARMONI

ZTF in the north
Incredible stream of SLSNe from the south

FILTER Survey: from PESSTO to SOXS

SLSNe: Backup slides

SLSNe: Backup slides

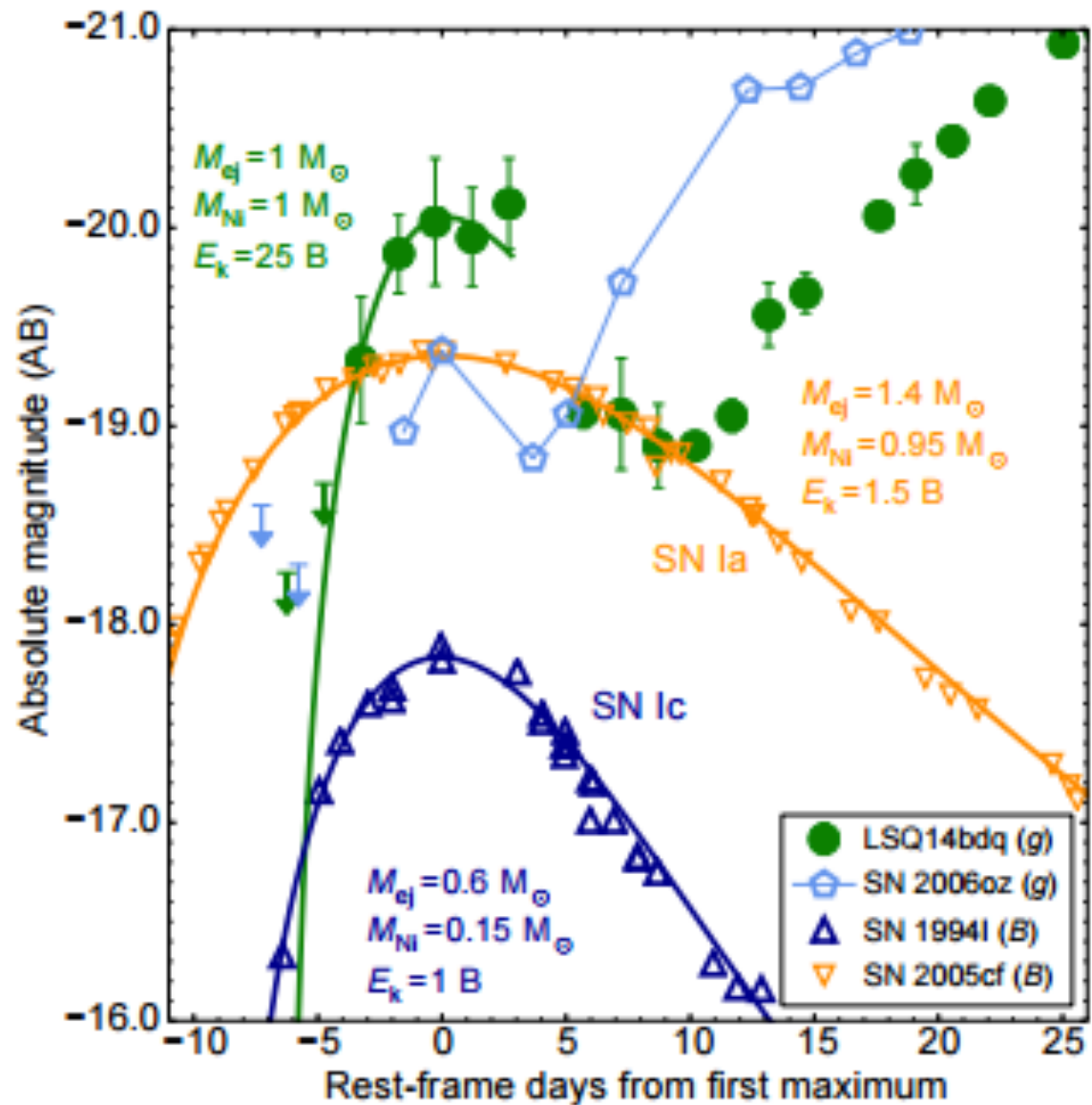


SLSNe: Backup slides

First, fainter peak
of 5-10 days
High energy and/or
large radius

Can reveal additional
information on the
explosion mechanism

Post-shock cooling



SLSNe: Backup slides

