Time Domain Surveys

Peter Nugent(LBNL/UCB)

The Surveys

The Hunters:

- Palomar Transient Factory → iPTF
- La Silla Supernova Search
- Pan-STARRS
- SkyMAPPER

Single-band vs. multi-colour (cadence vs. calibration)

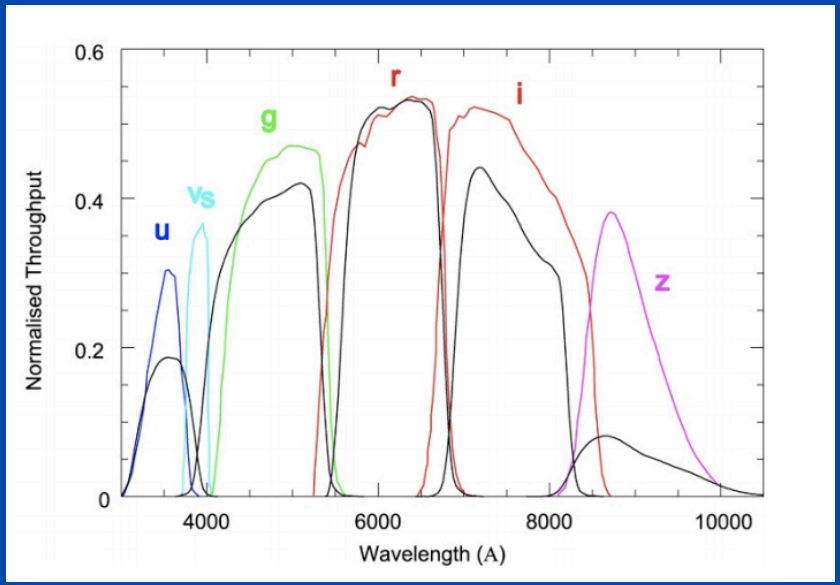
The Gatherers:

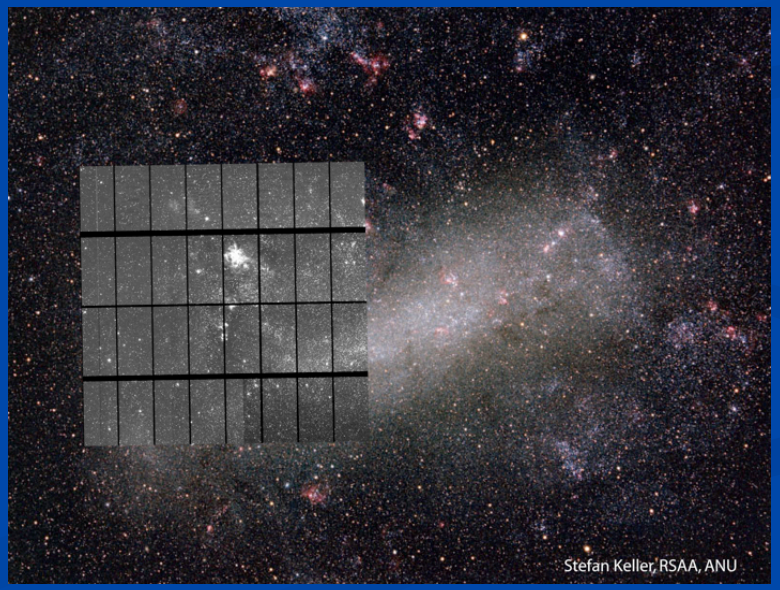
- PESSTO (fed by LSSN, PS-1, SkyMAPPER)
- SNfactory (fed by PTF & LSSN)

SkyMAPPER

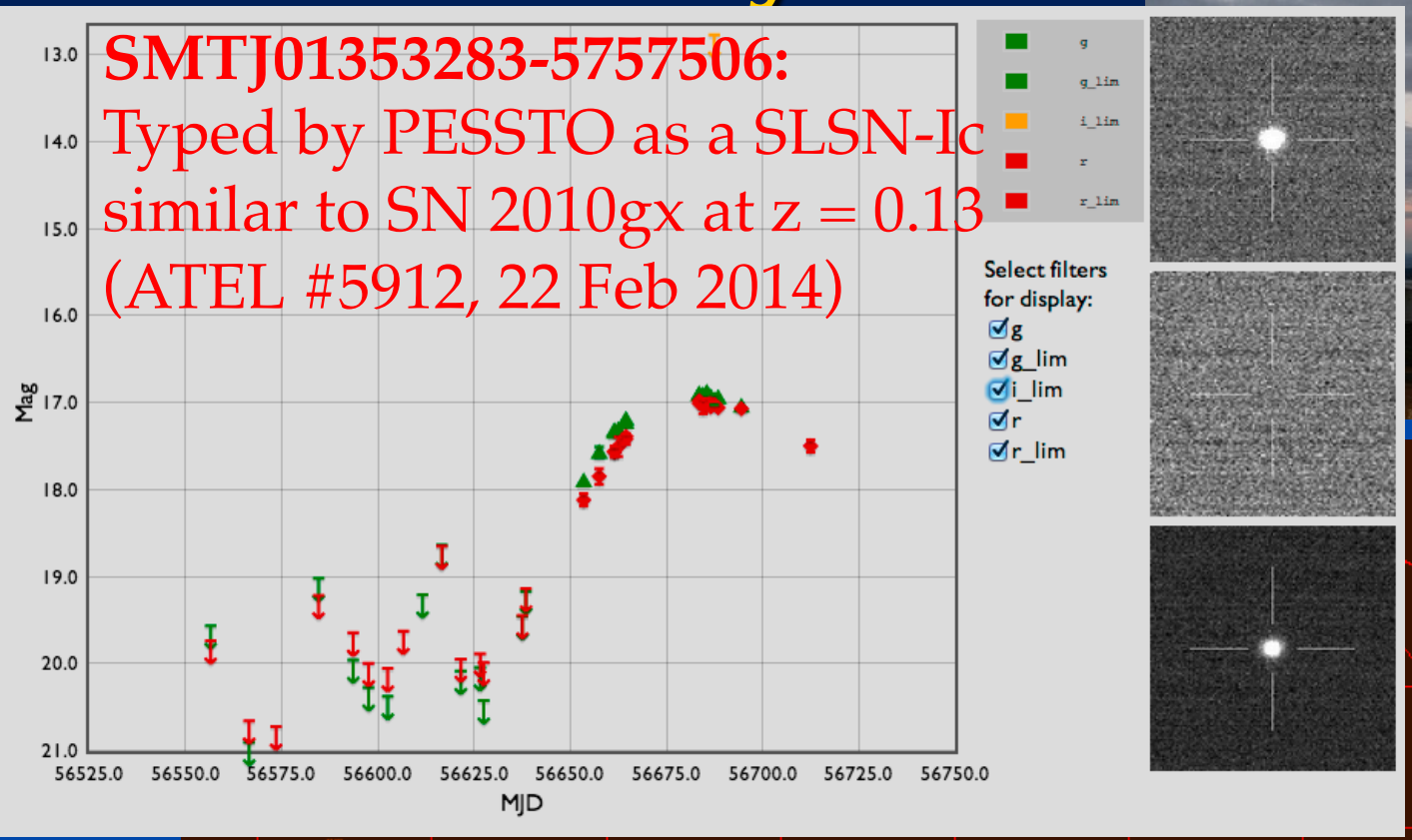
1.3-m telescope, 6 deg^2 FOV, 268 Mpix camera.
Scheduling and observing completely robotic.

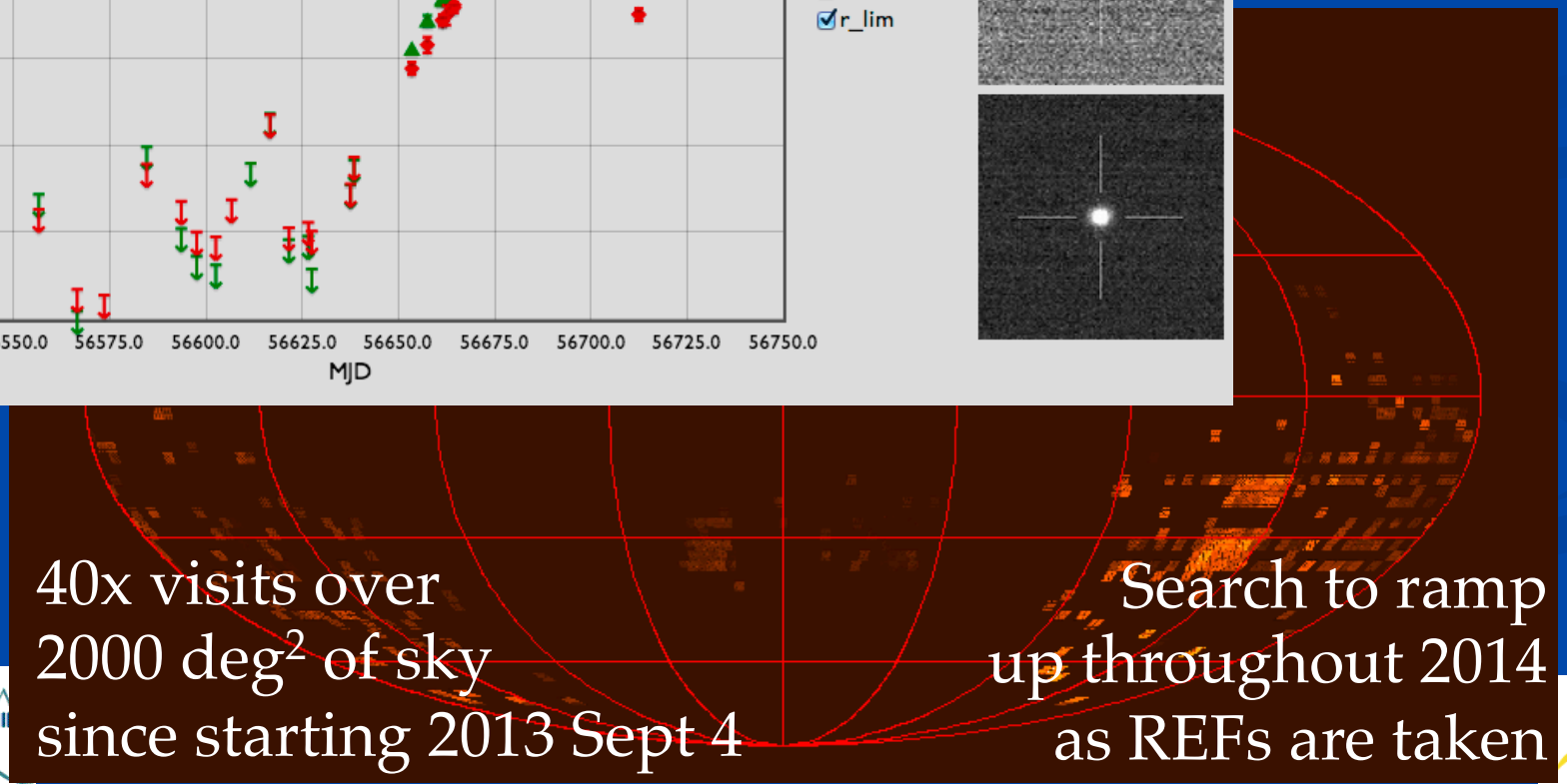
Main Survey: SDSS-like survey of the southern sky.
SDSS *ugriz* + Stromgren-like *v* filter (for stars)
x 6 visits (quasi-logarithmic "universal" cadence).





SkyMAPPER

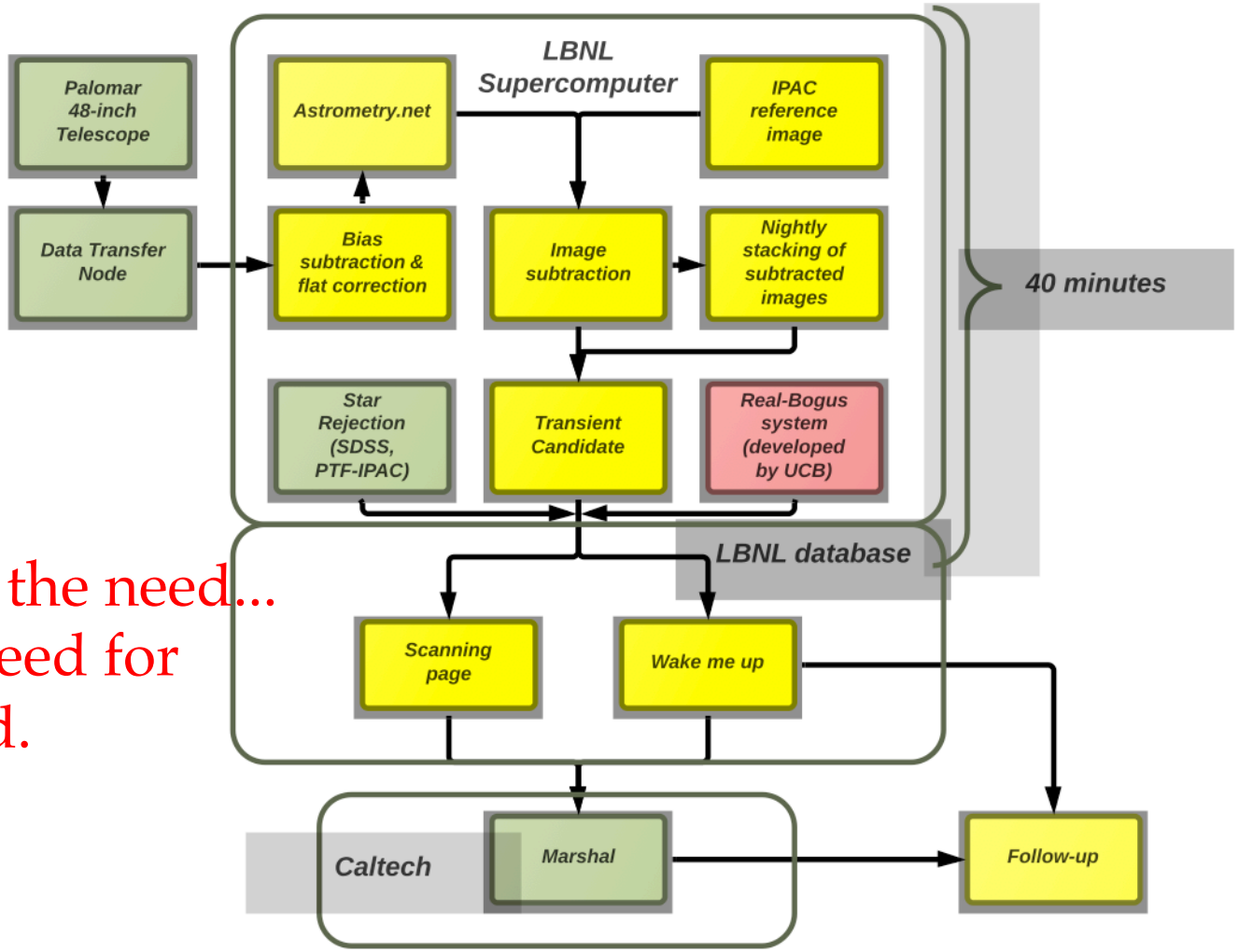




40x visits over
2000 deg^2 of sky
since starting 2013 Sept 4

Search to ramp
up throughout 2014
as REFs are taken

iPTF Pipeline

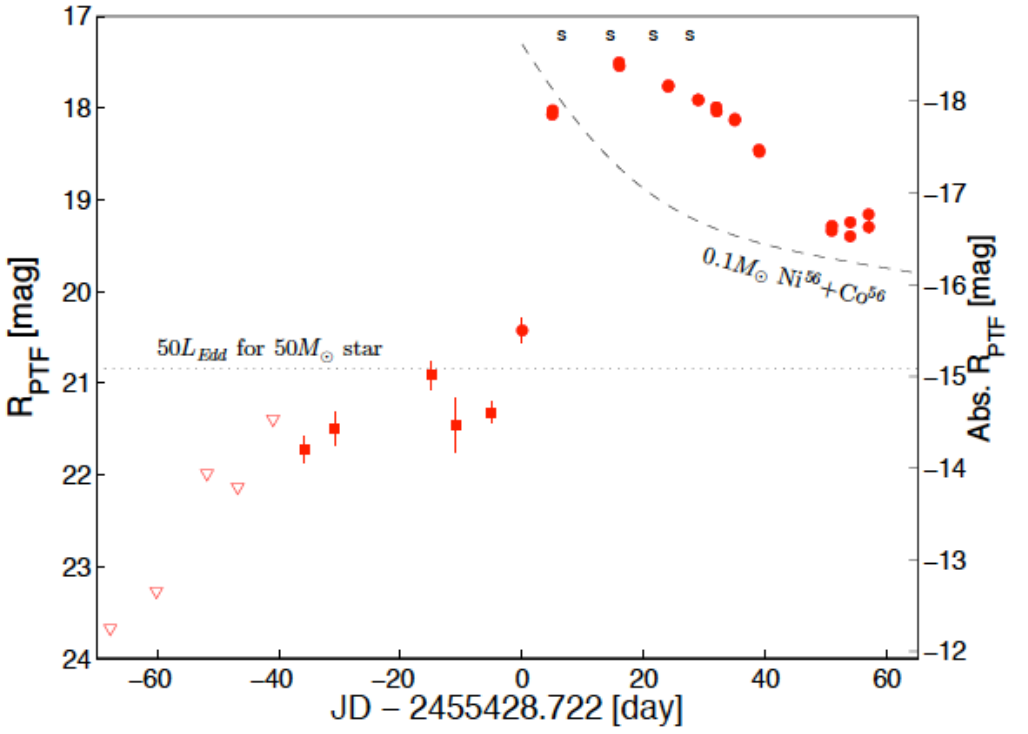


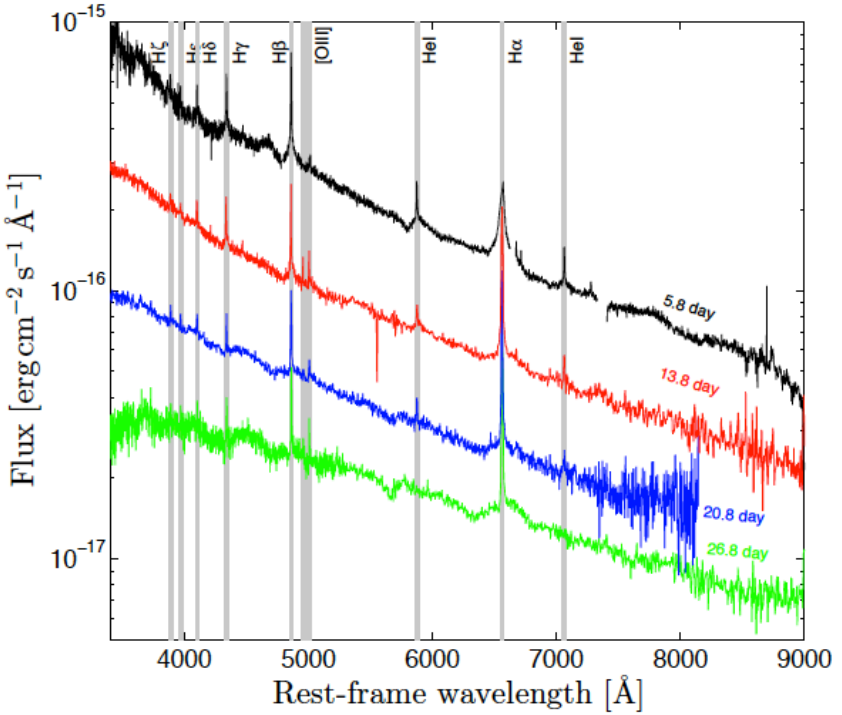
I feel the need... the need for speed.

Science

- Pre-Outburst Supernova Detections
- Poorly localized GRB follow-up
- Orphan Afterglow
- “Flash” Spectroscopy
- Sub-Chandrasekhar Mass SNe Ia
- Statistically Meaningful (Impressive) Samples

Pre-Outbursts

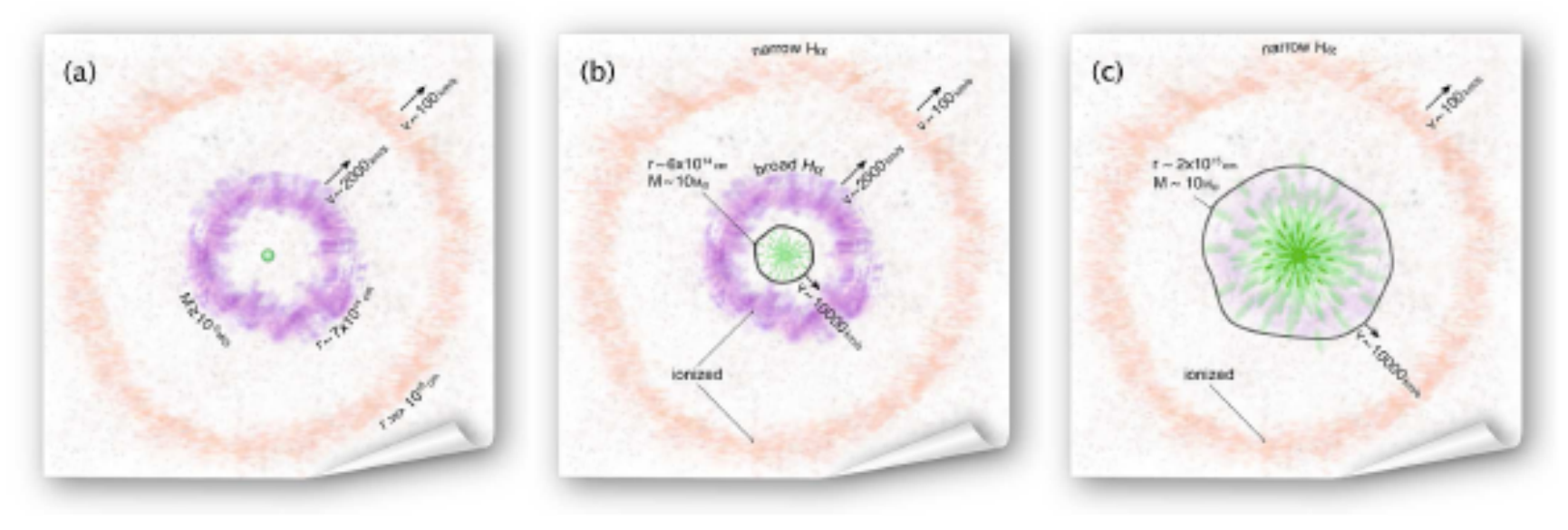




SN 2010mc - Ofek et al. (2013) *Nature* & SN 2011ht – Fraser et al. (2013) *ApJ*

Possible Explanation: Super-Eddington fusion luminosities, shortly prior to core collapse, drive convective motions that in turn excite gravity waves that propagate toward the stellar surface and eject substantial mass.

Pre-Outbursts

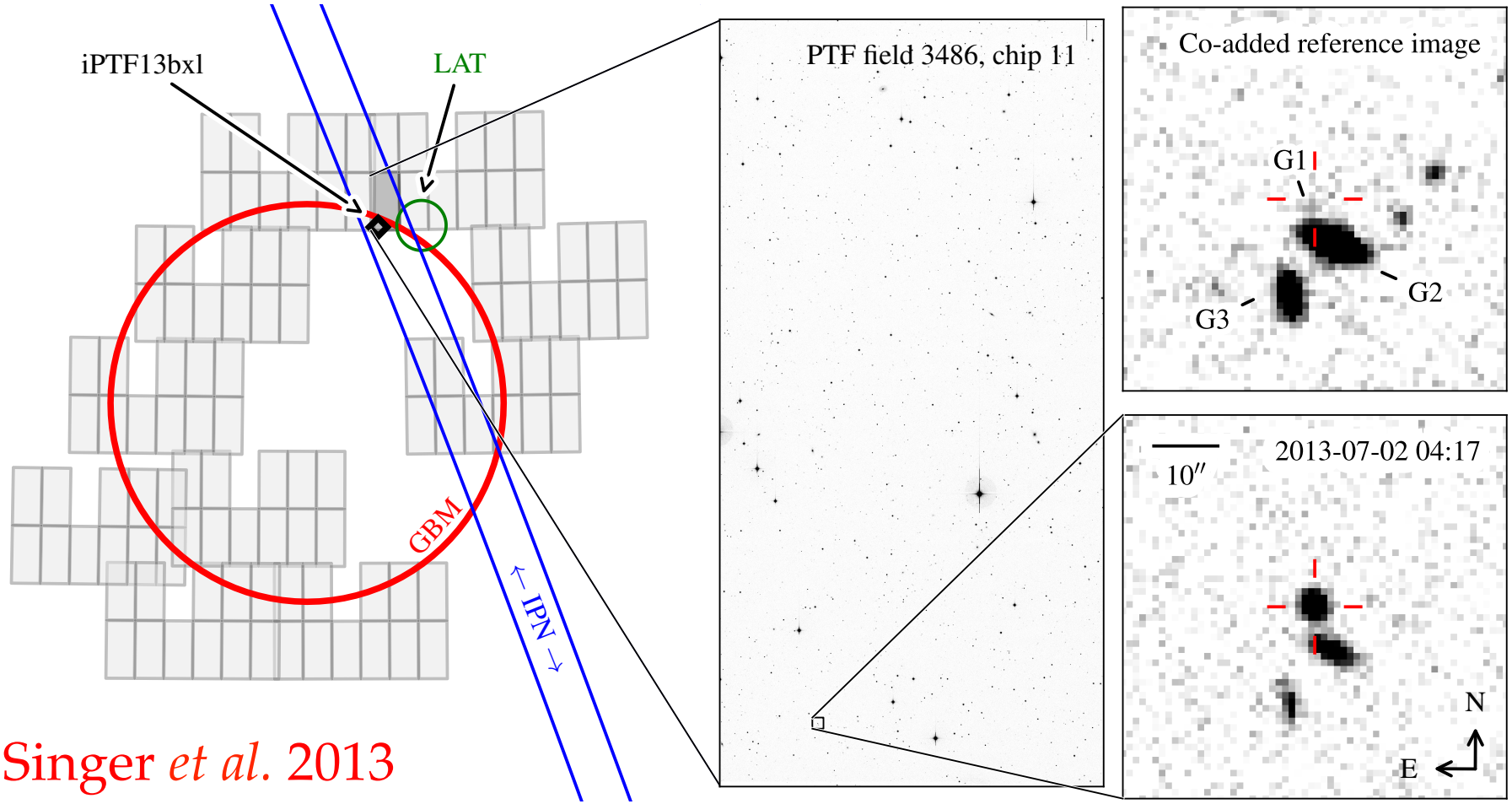


(a) $10^{-2}\,M_{\odot}$ ejected one month earlier during pre-outburst ~2000 km/s

(b) At day ~ 5, the SN shock front (grey line at 10^4 km/s) is ionising the inner and outer shells which produce the broad and narrow H emission seen in the early-time spectra.

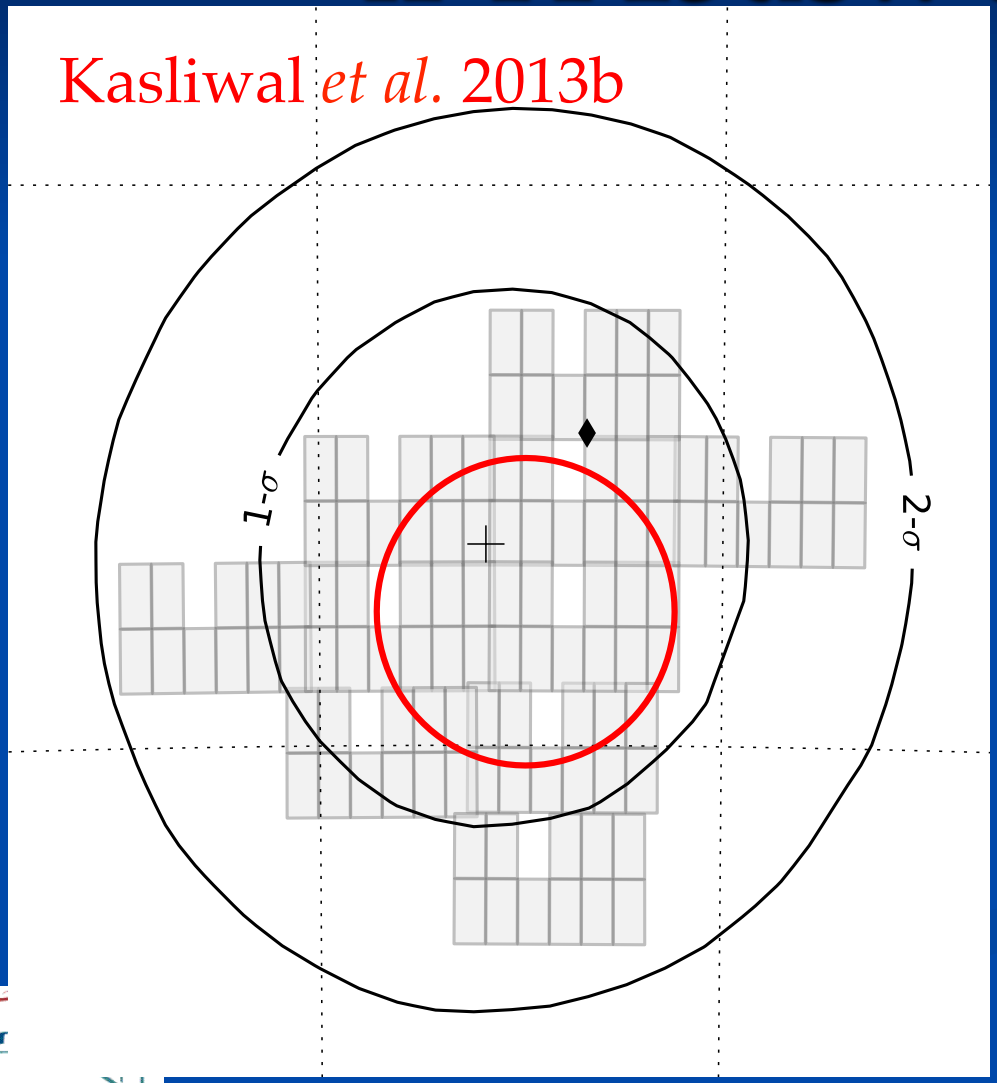
(c) At day ~ 20, the SN shock engulfs the inner shell, and the intermediate width Hα vanishes and narrower features appear: pre-pre-outbursts.

Overcoming wide & fast: iPTF13bxl in 71 deg²!



Singer *et al.* 2013

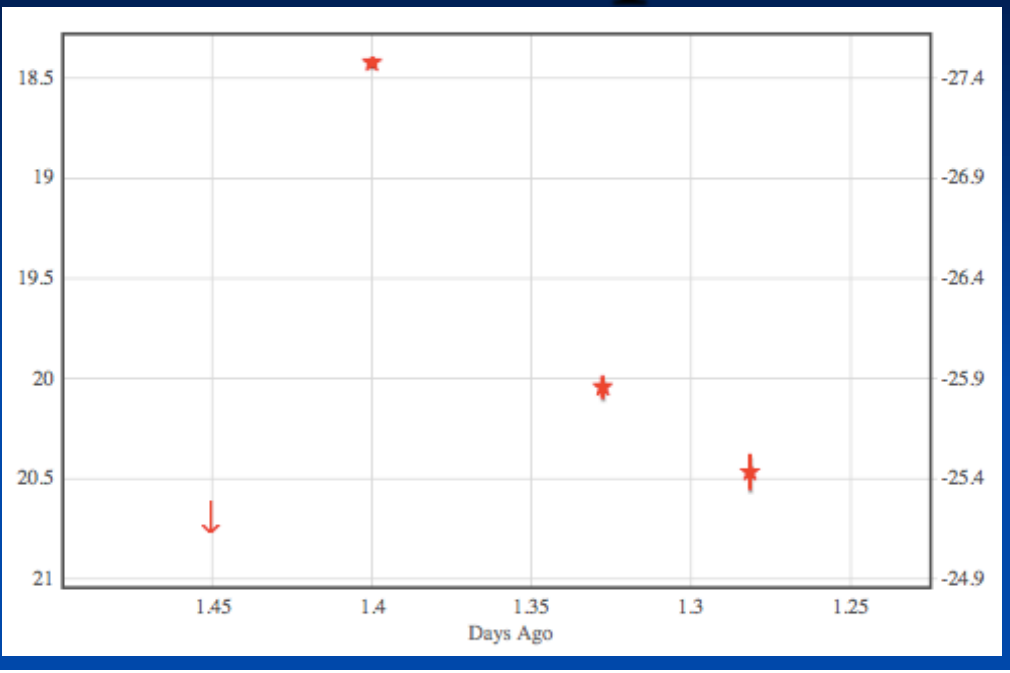
The second Fermi afterglow: iPTF13dsw at z=1.87!

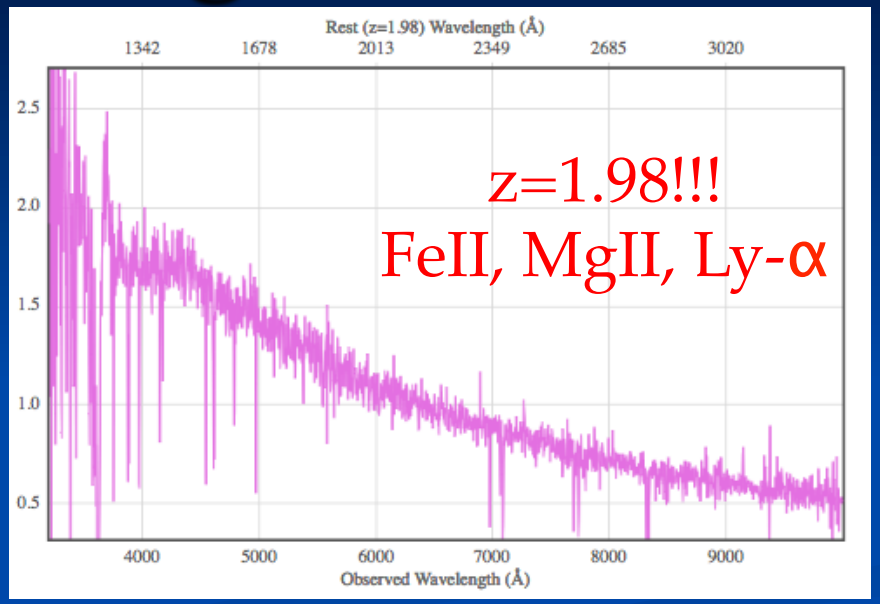


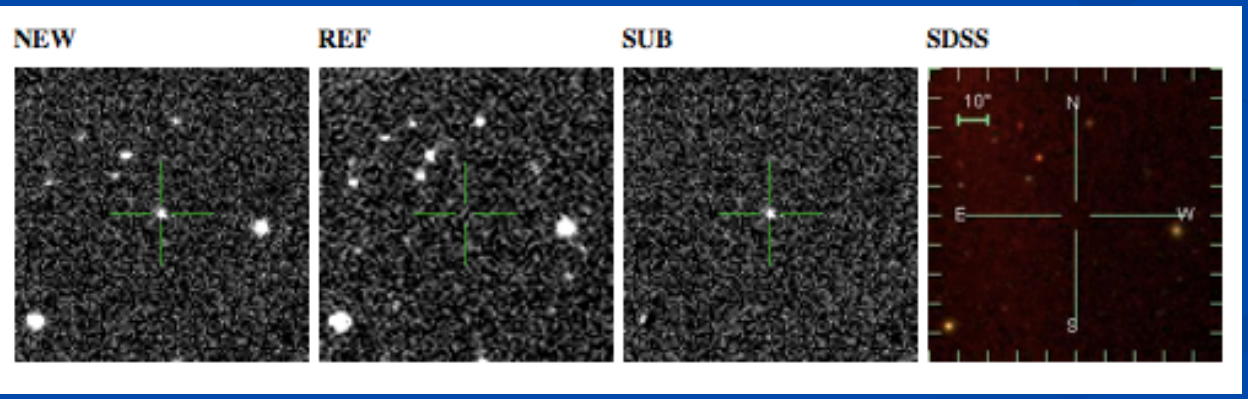
Overcoming
Wide, Fast & Faint

Pinpointing the afterglow amidst 30,000 candidates

Orphan Afterglow



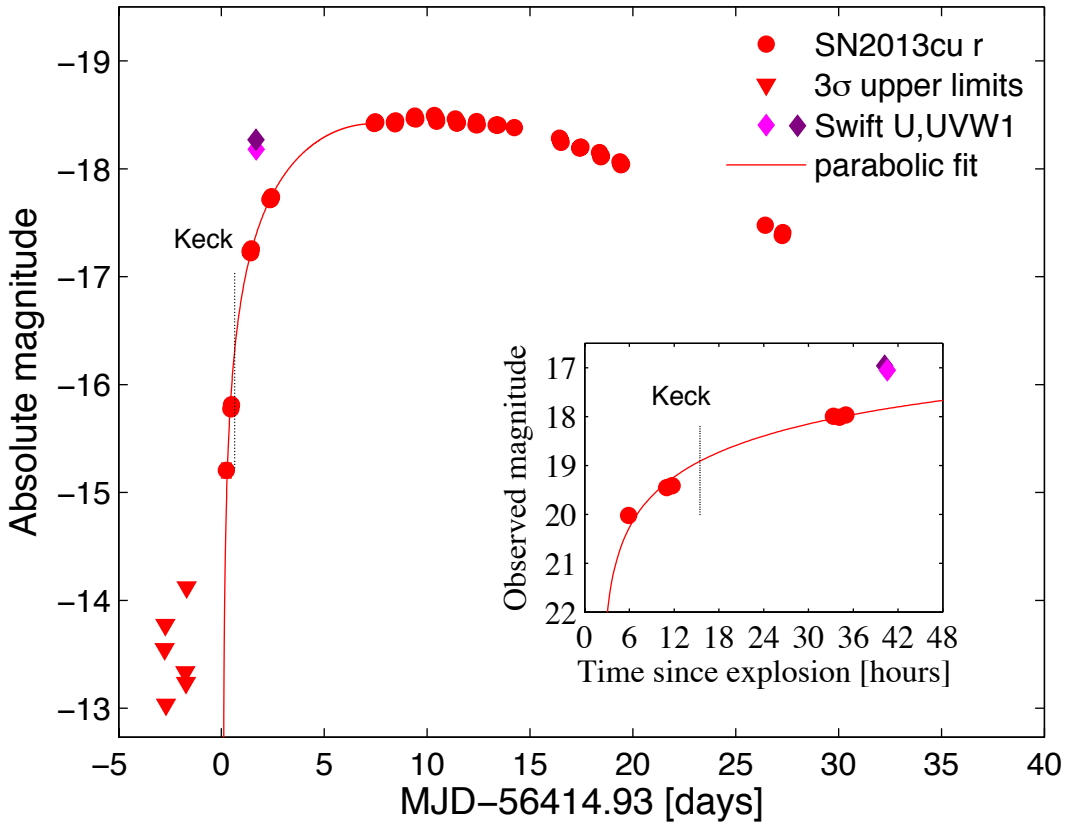




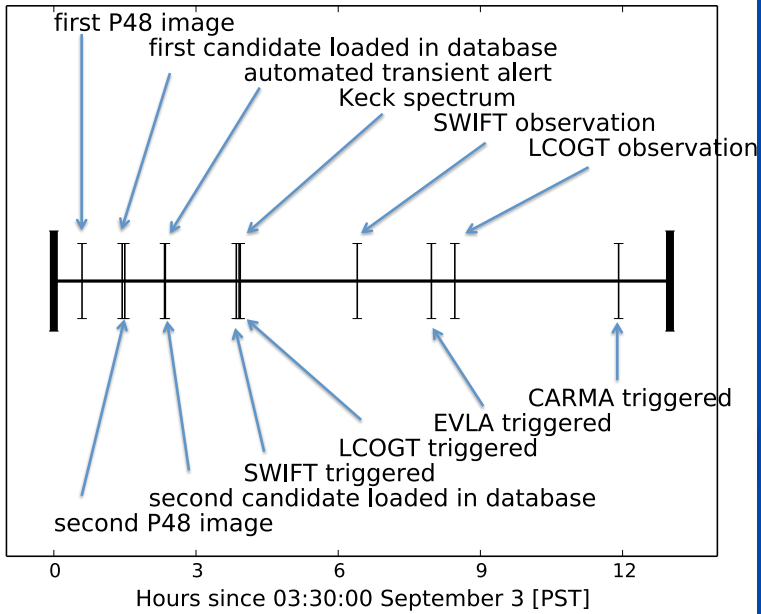
iPTF14yb
Cenko et al. 2014

IPN found a GRB (localization ~200-300 sq. deg.)
~15 min before first detection.....

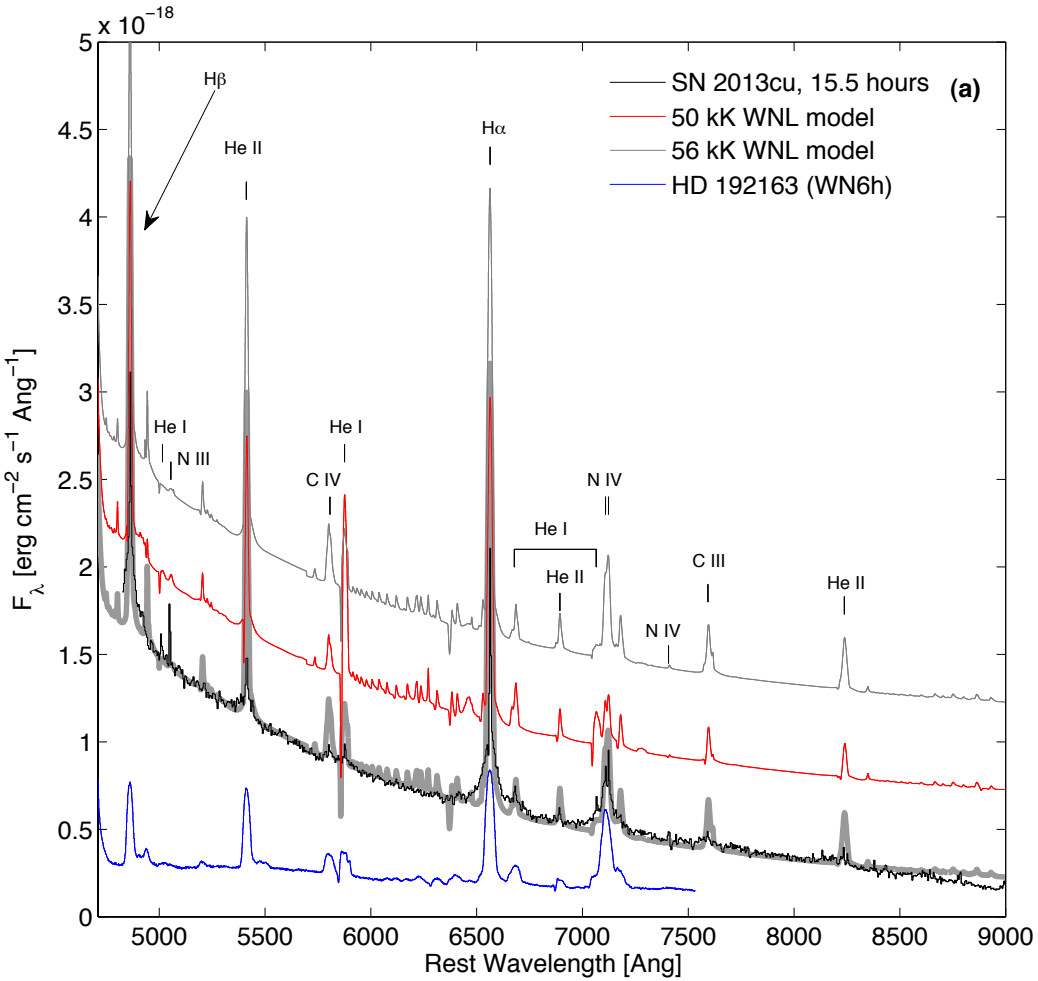
Flash Spectroscopy



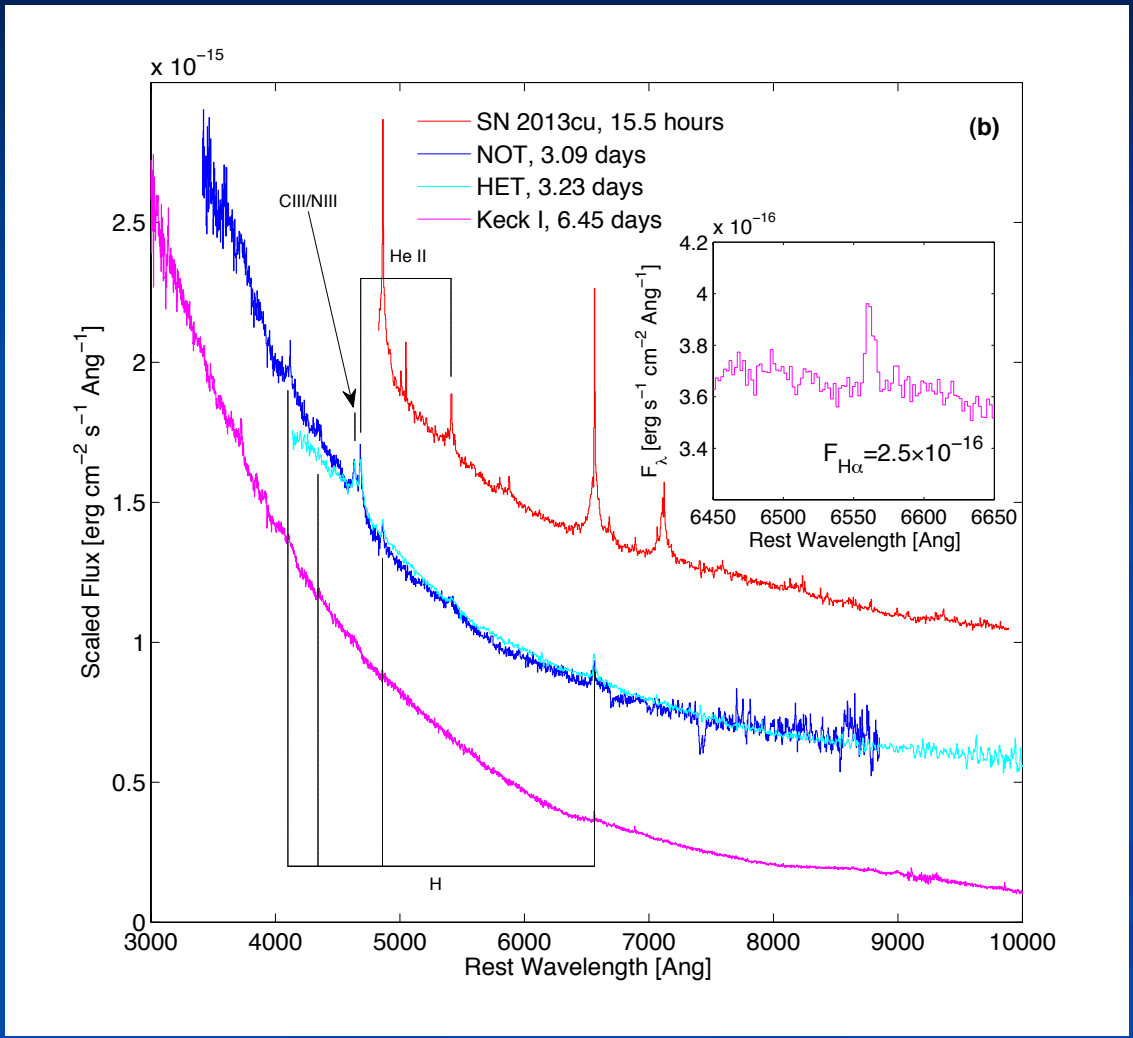
SN2013cu (iPTF13ast)
Gal-Yam et al. (2014) *Nature*



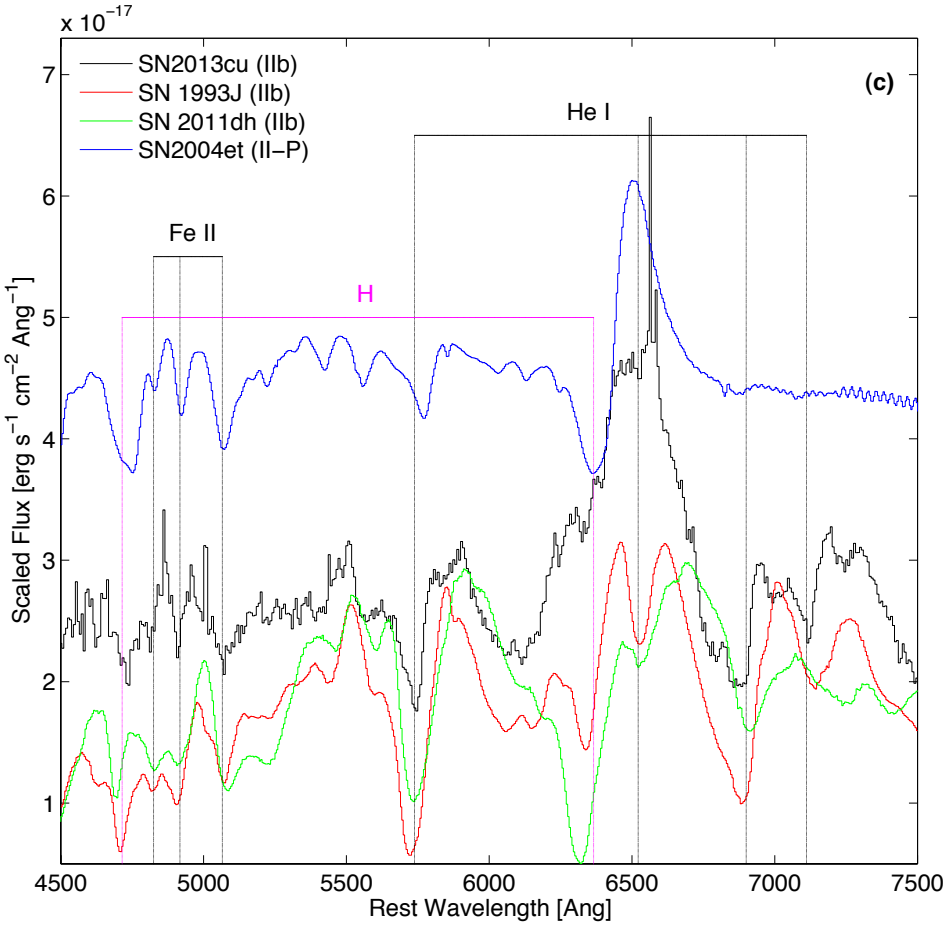
Flash Spectroscopy



Flash Spectroscopy

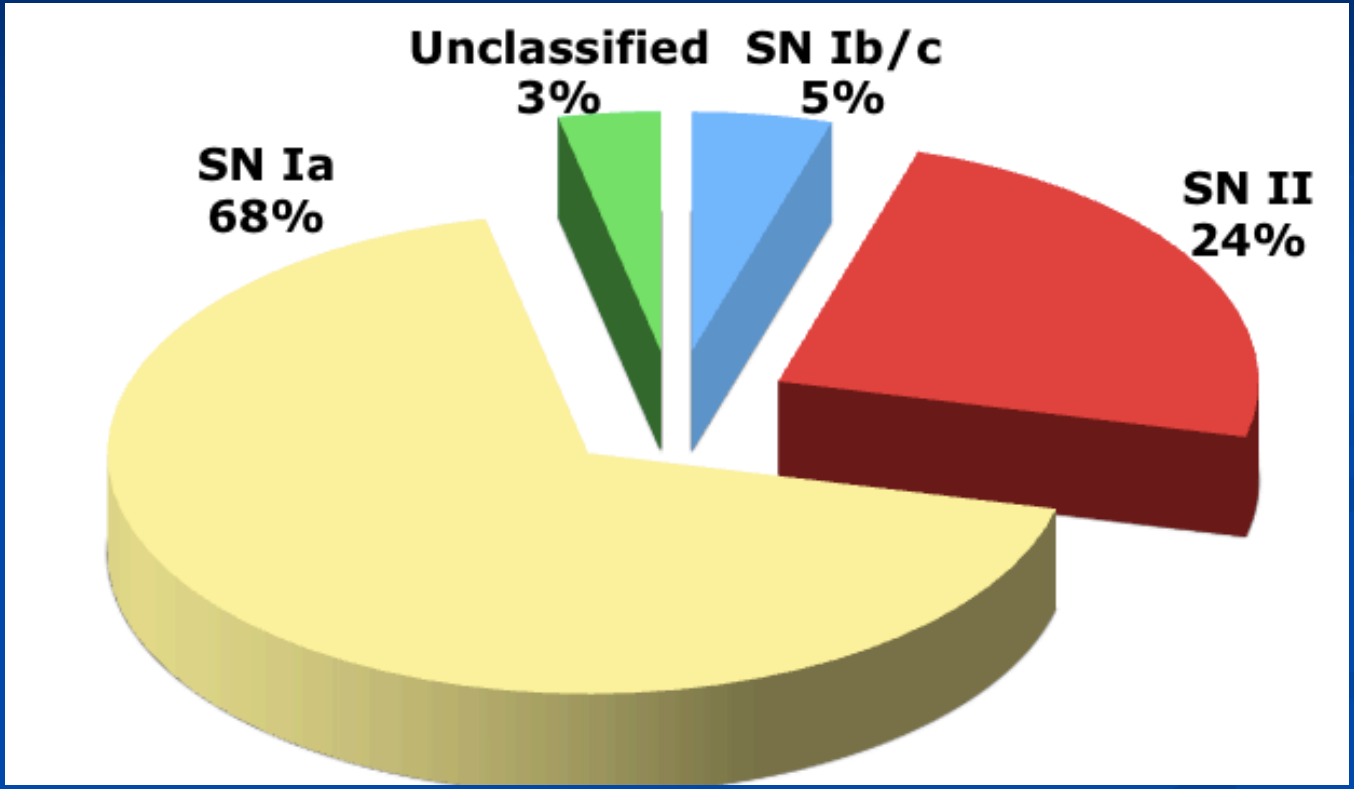


Flash Spectroscopy



SN2013cu became a SN IIb

Stats



PTF/iPTF: 2153+ Spectroscopically Classified Transients
82+ Refereed Papers
(all but a handful on single SNe)

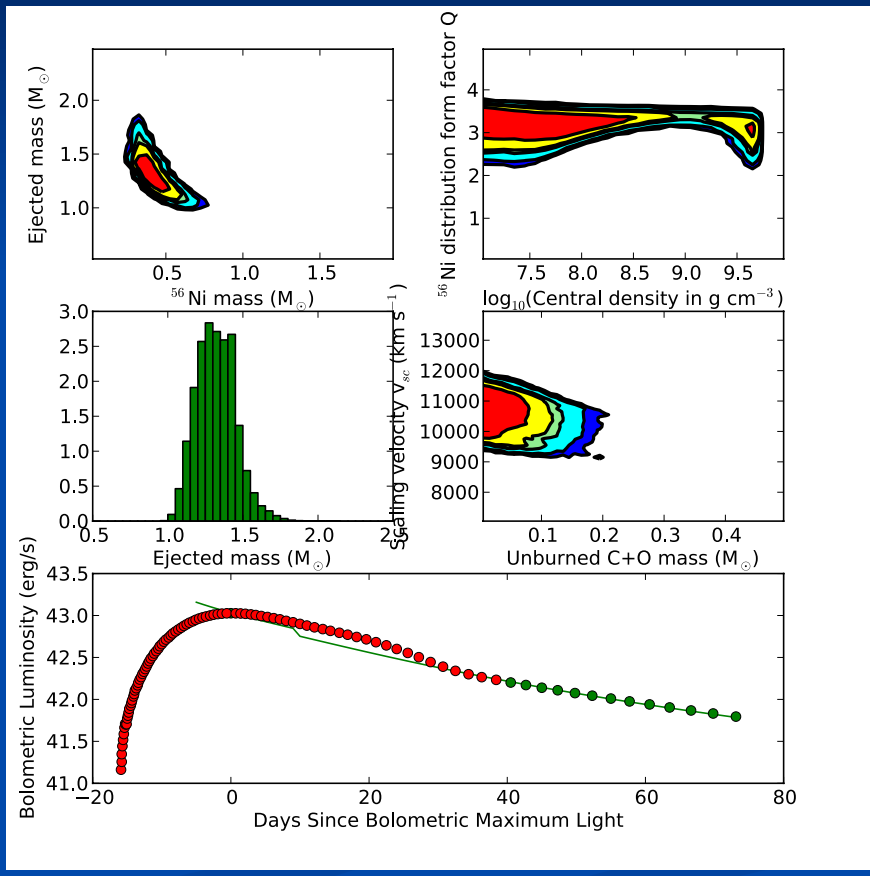
SNe Ia

Semi-analytic model
(RS + SNfactory 2010, 2012):

Spherically symmetric, user-defined $\rho(v)$
Parameters: central density,
final ejecta composition,
^{56}Ni mass + mixing scale

Likelihood: Arnett+ 1982 light curve model
Priors: neutronization,
energy conservation,
gamma-ray trapping
(see Jeffery+ 1999)

MCMC sampling: emcee
(Foreman-Mackey+ 2013)
Systematics treated naturally, output full joint posterior PDF of all variables.



SNe Ia – Sub M_{Ch}

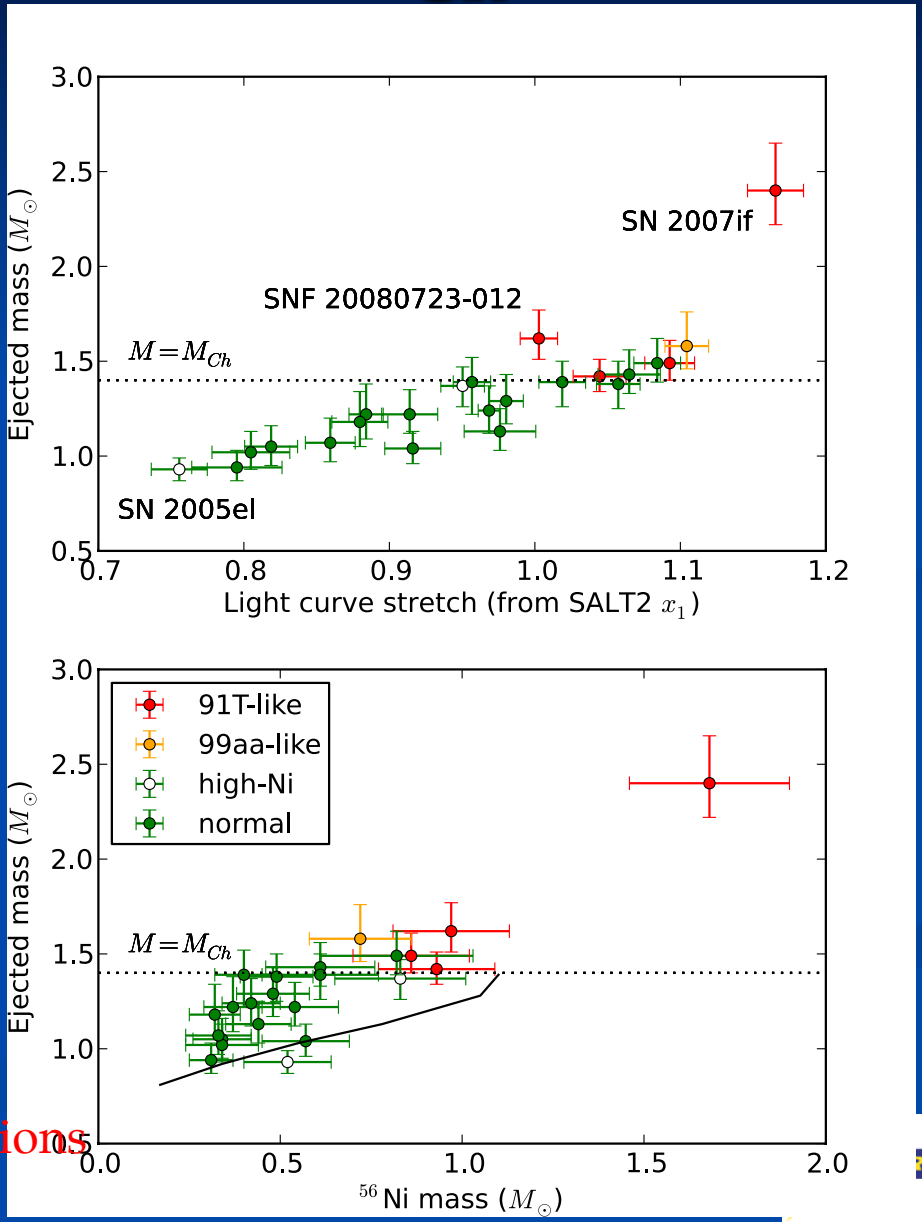
Applied to 19 normal SNe Ia observed by SNfactory:

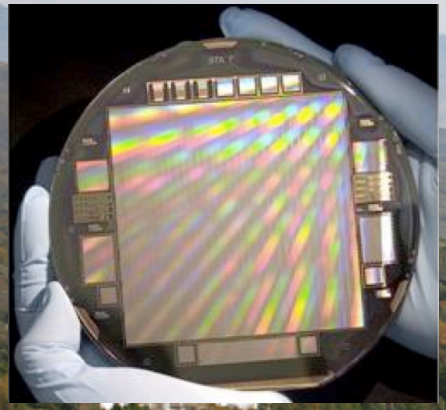
Mass correlates w/light curve width near max.

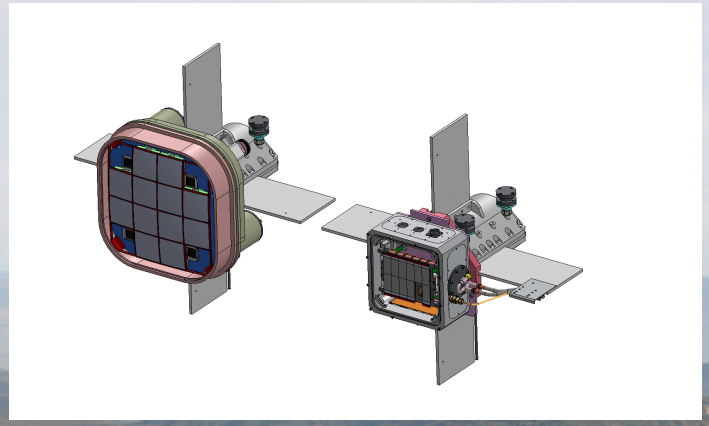
Evidence for sub-Chandra SNe at fast decline rates.

Absolute mass scale uncertain to ~0.15 $M_\odot$, depends on $\rho(v)$. But we get the same slope for a variety of input priors.

solid: Fink+ 2010 helium detonations
dashed: Kushnir+ 2013 WD+WD collisions







P48

Discovery:

47 sq deg!

PI: S. Kulkarni

(2016)

P200:

Spectroscopy

P60:

Follow-Up

The SED Machine

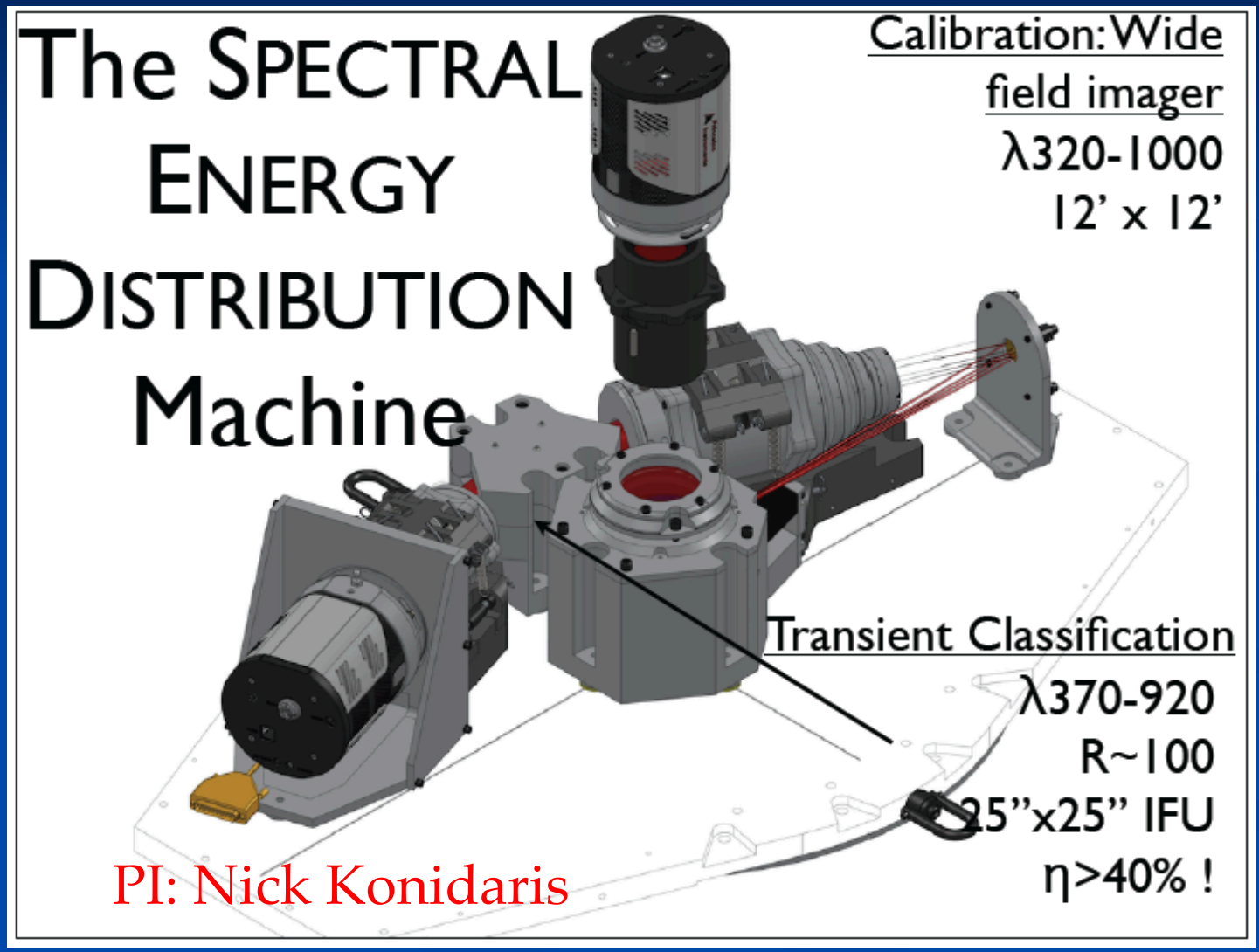
PI: N. Konidaris

(2014)

Survey Speed of 3800 sq deg per hour i.e. 10x PTF!

The Zwicky Transient Facility

SED Machine


The SPECTRAL ENERGY DISTRIBUTION Machine
Calibration: Wide field imager
λ320-1000
12' x 12'
Transient Classification
λ370-920
R~100
25"x25" IFU
η>40% !
PI: Nick Konidaris

Conclusions - Future

LSST - 15TB data/night
Only one 30-m telescope