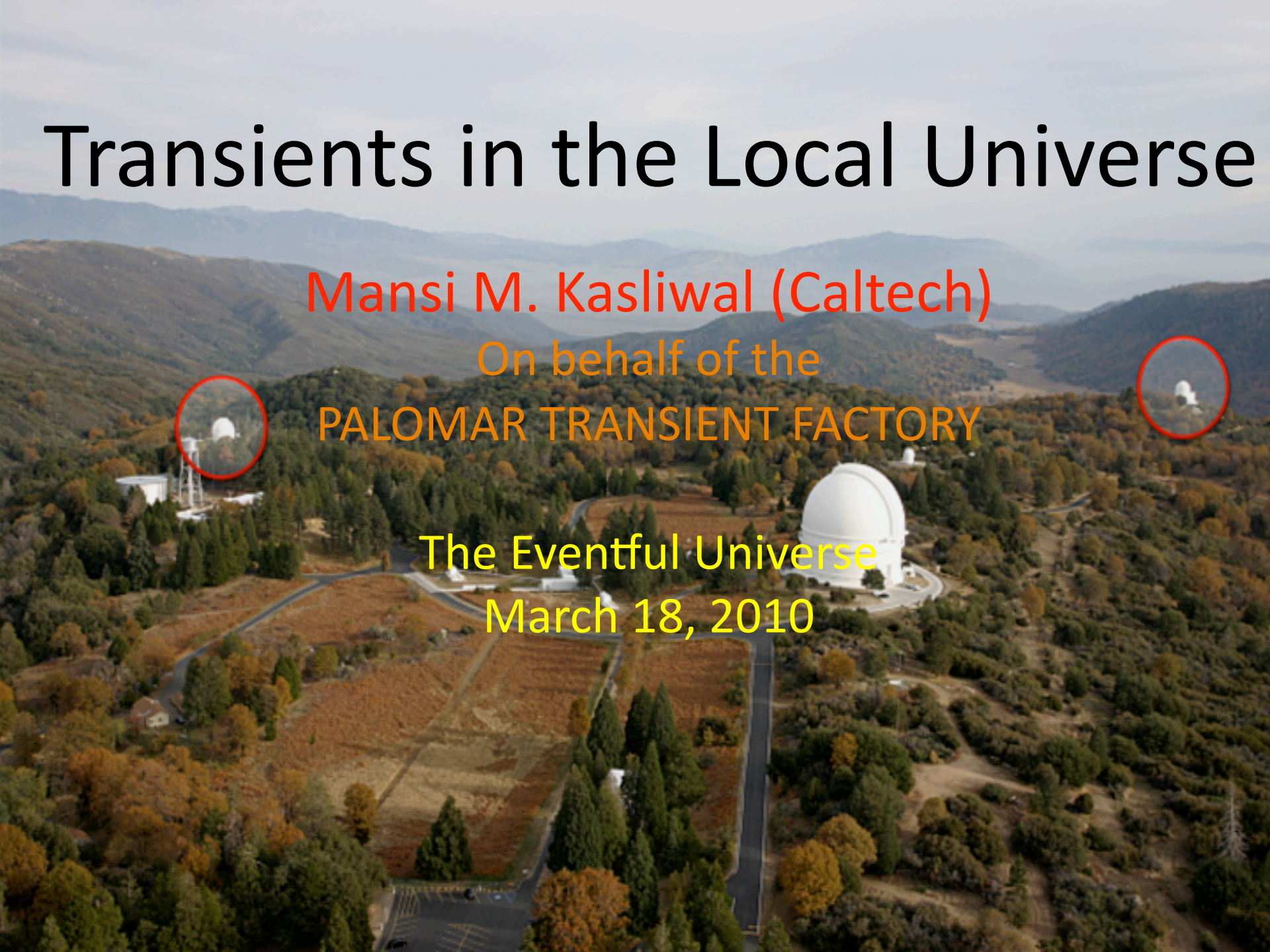
Transients in the Local Universe



Mansi M. Kasliwal (Caltech)
On behalf of the
PALOMAR TRANSIENT FACTORY

The Eventful Universe
March 18, 2010

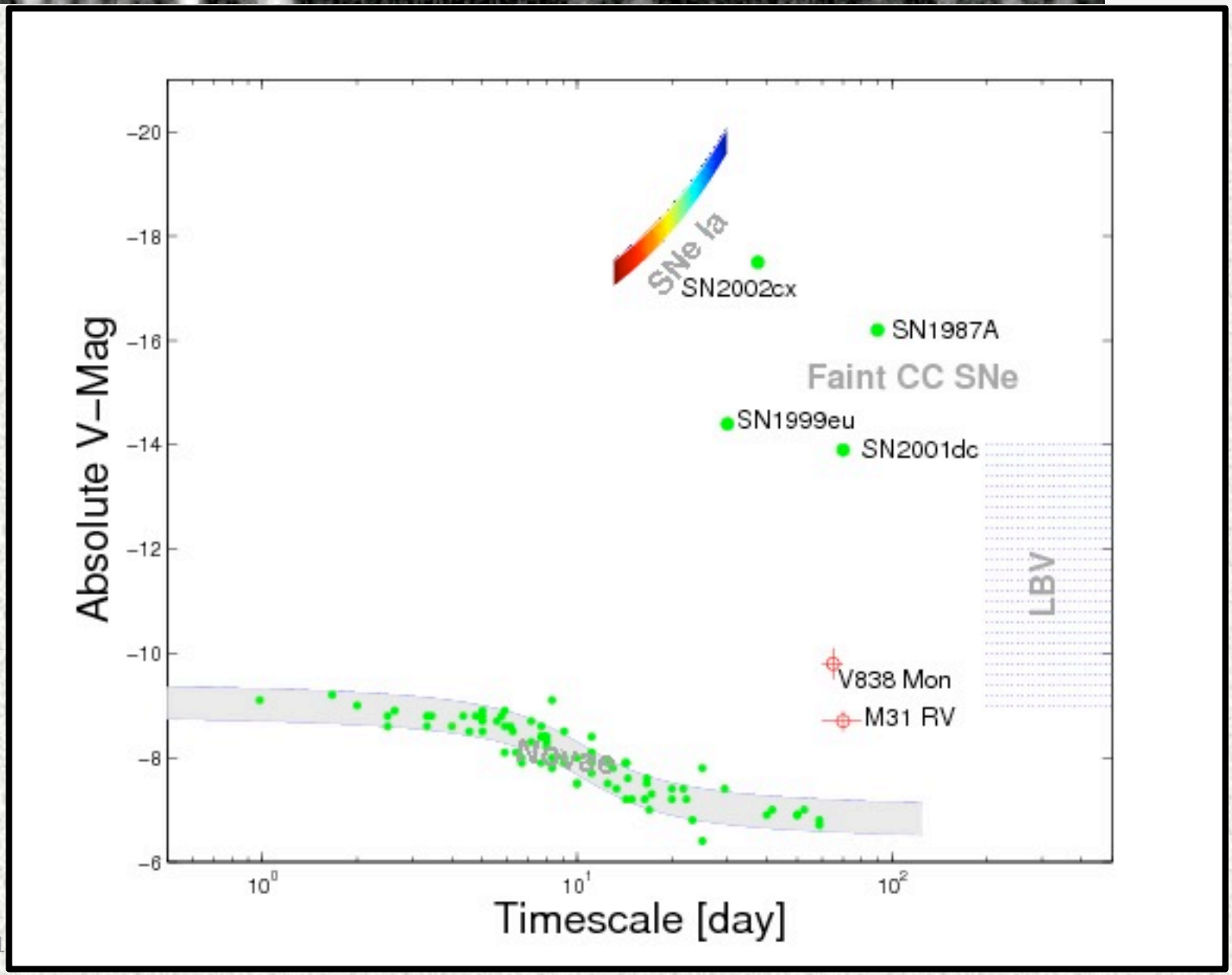
Why “Local” Universe?

PALOMAR TRANSIENT FACTORY

Which “Transients”?

Which “Transients”?

PALOMAR TRANSIENT FACTORY



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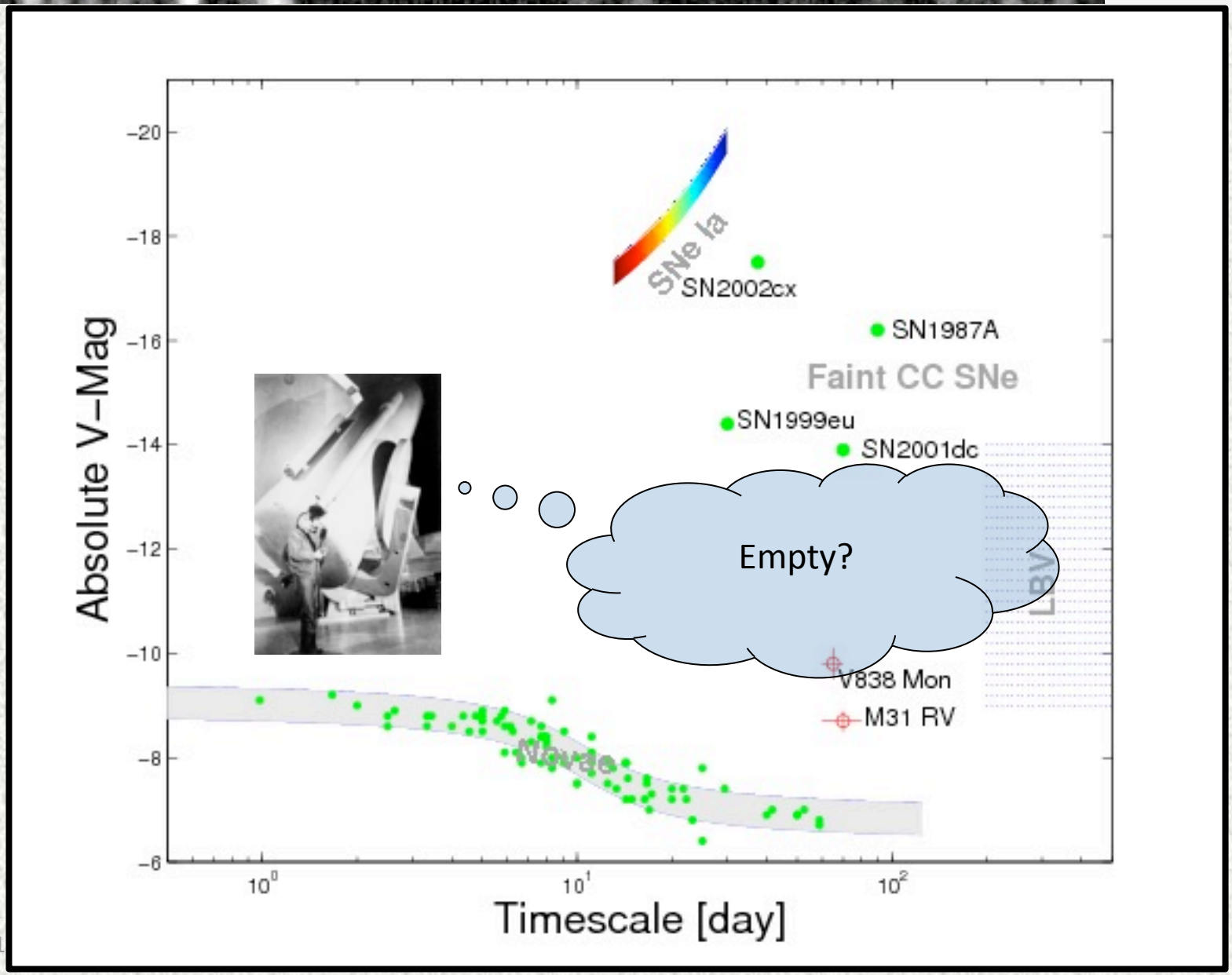

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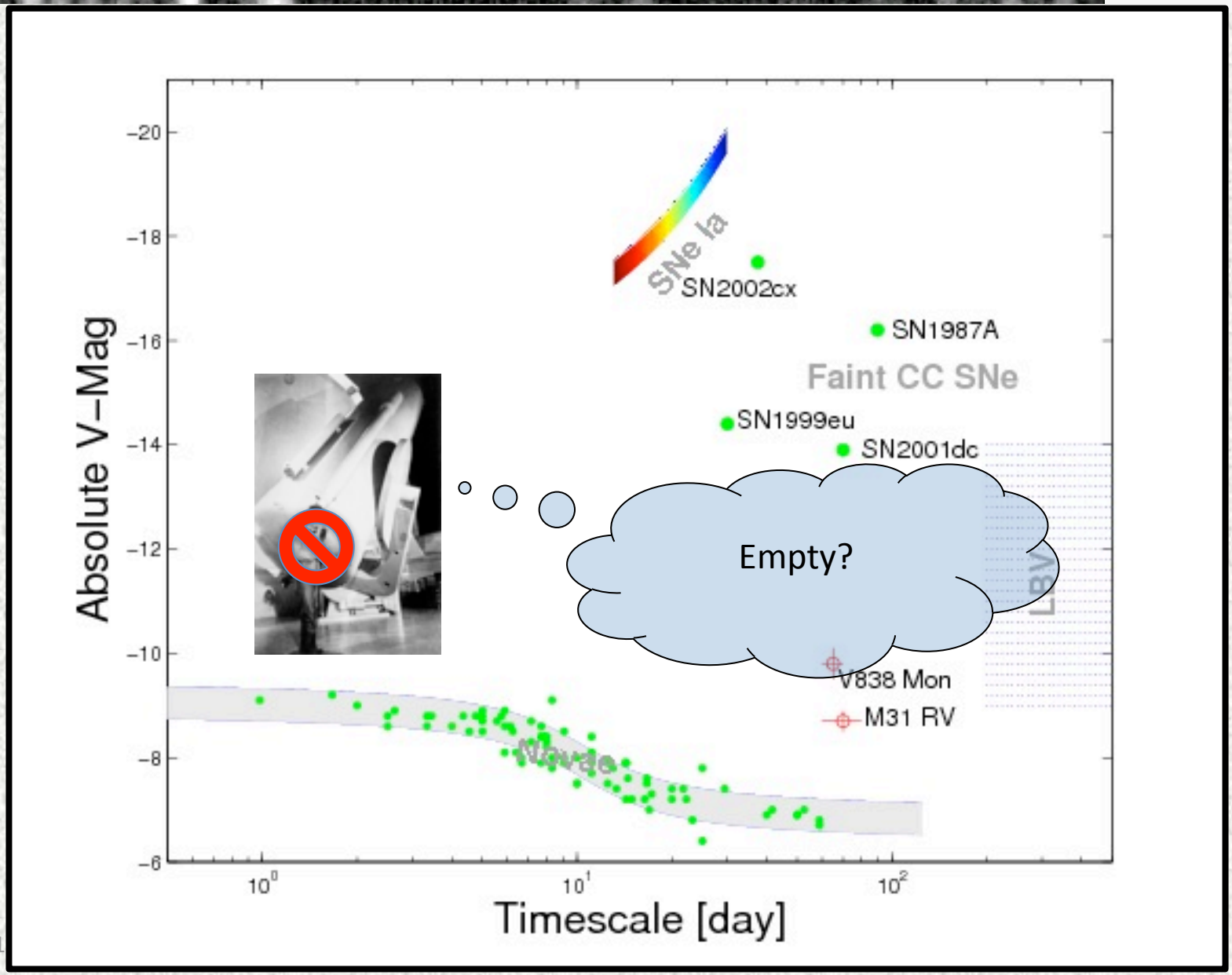

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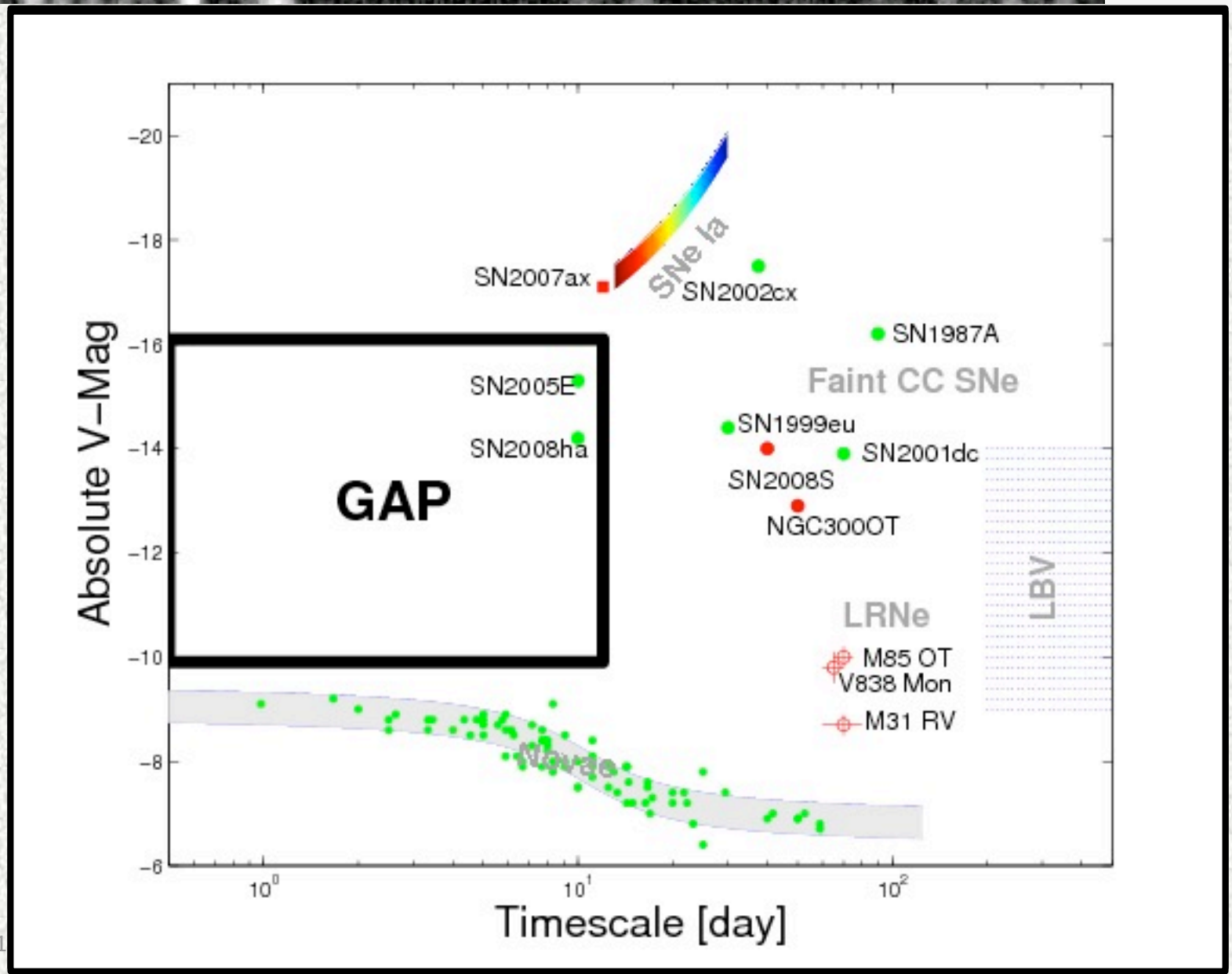

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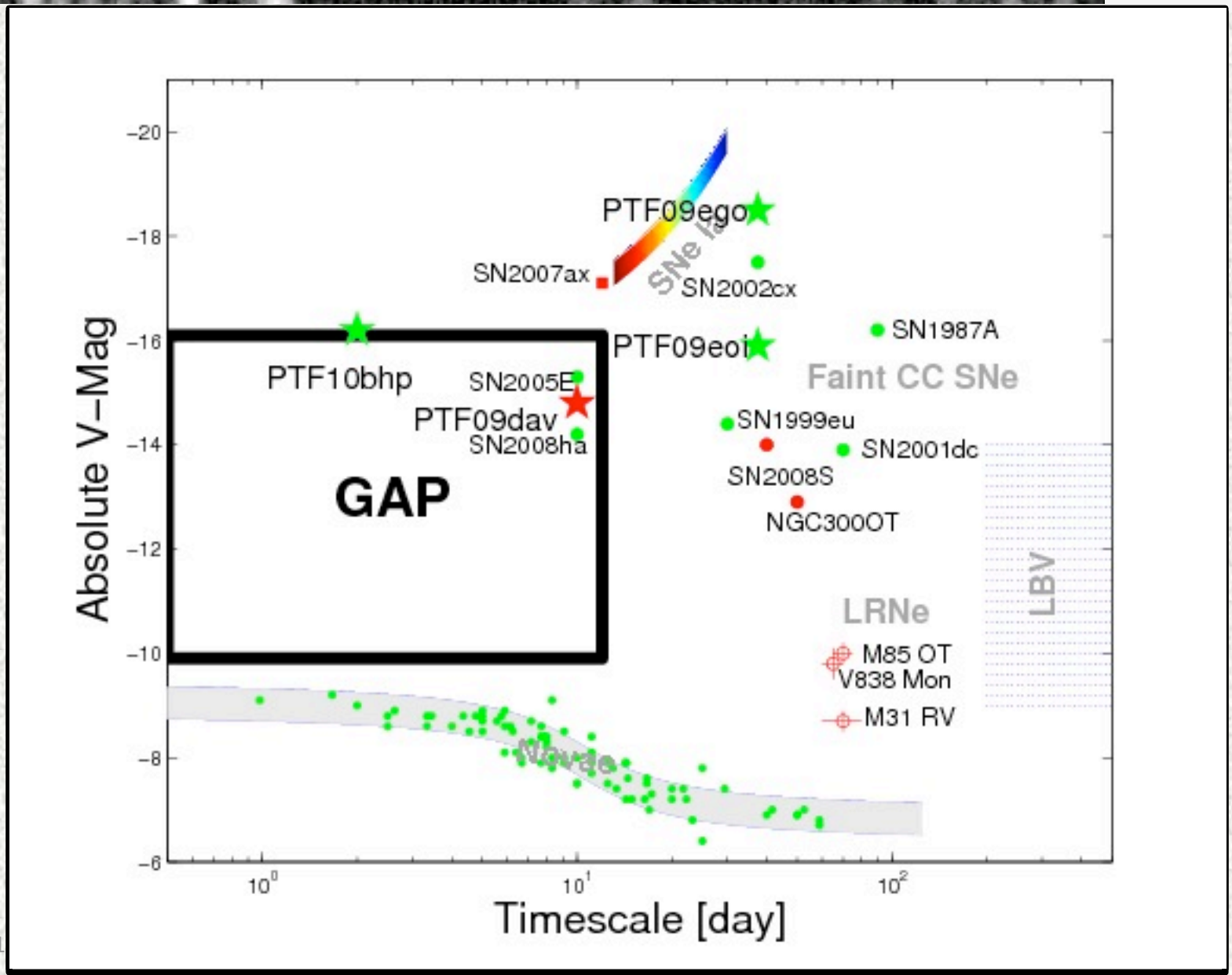


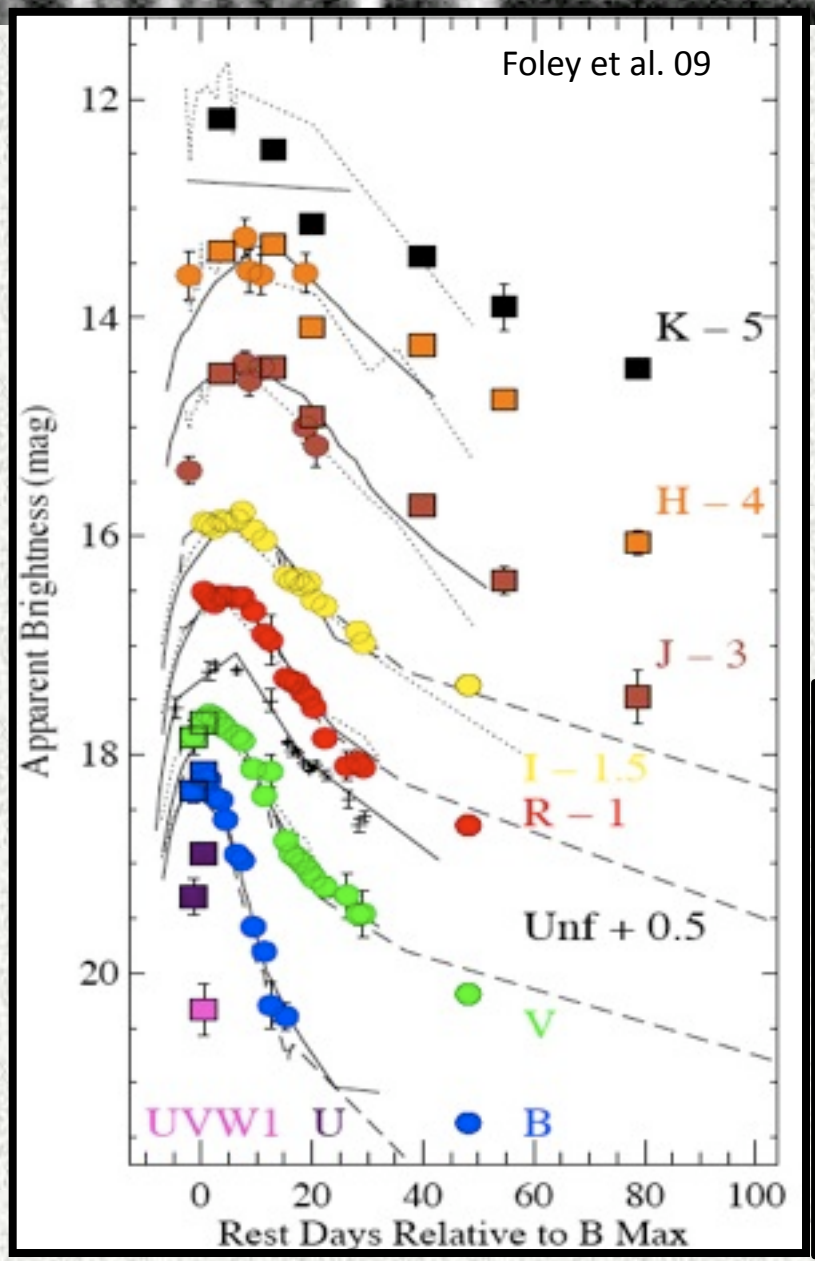
The Experiment

PALOMAR TRANSIENT FACTORY

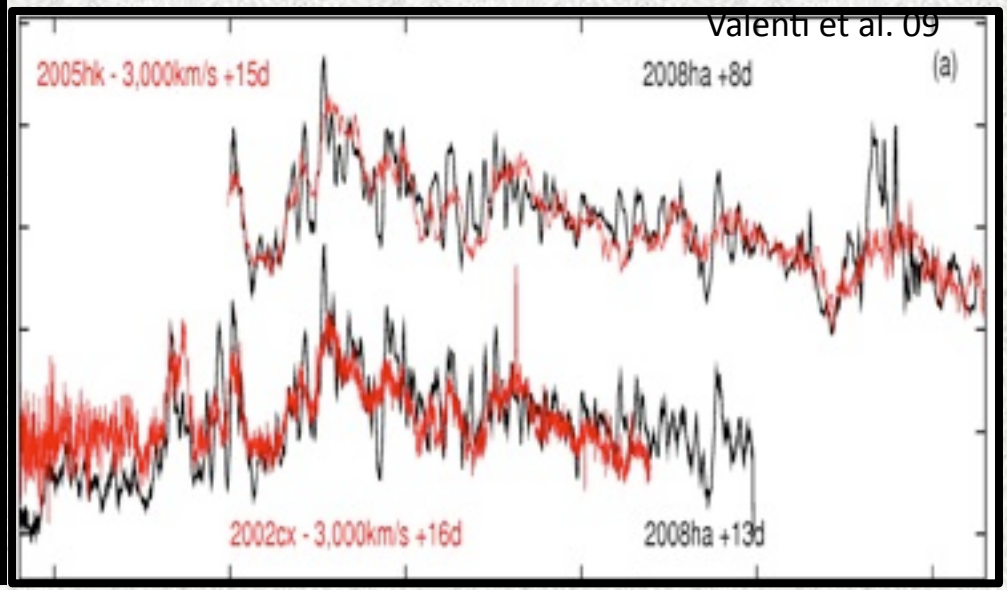
- ★ ~20,000 galaxies with d < 200 Mpc (RARE)
- ★ 1-day cadence (FAST)
- ★ m < 21 depth (FAINT)
- ★ Real-time discovery pipeline
- ★ Built-in photometric follow-up
- ★ Spectroscopic classification of ALL candidates

To find transients in the gap,
PTF is the most sensitive survey thus far….

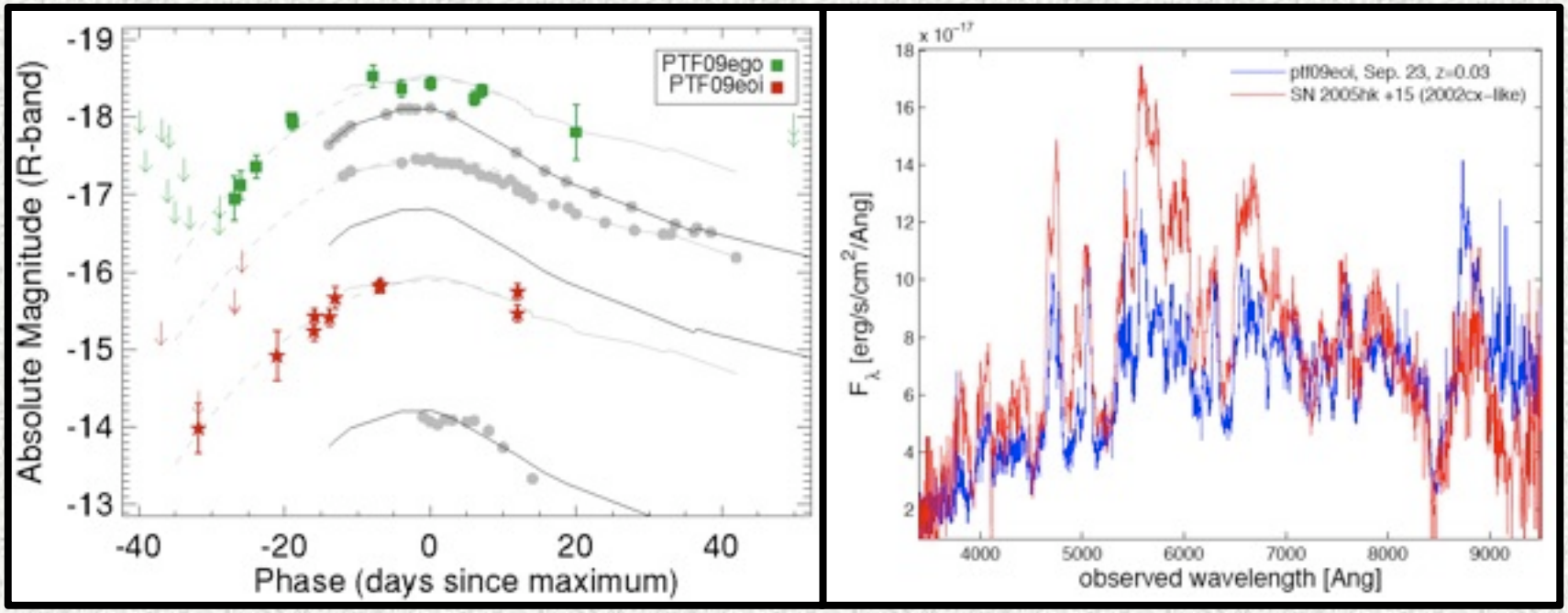
2008ha in 2002cx-family?



- ★ 2002cx-family: "peculiar" Ia as standard candle deviants
- ★ 2008ha:
  - ✦ >10x fainter
  - ✦ >30 days shorter lived
  - ✦ >3000 km/s slower ejecta
- ★ White Dwarf OR Massive Star?



Result I: Origin of 2002cx-family



★ PTF09eoi bridges the gap between 2008ha and 2002cx

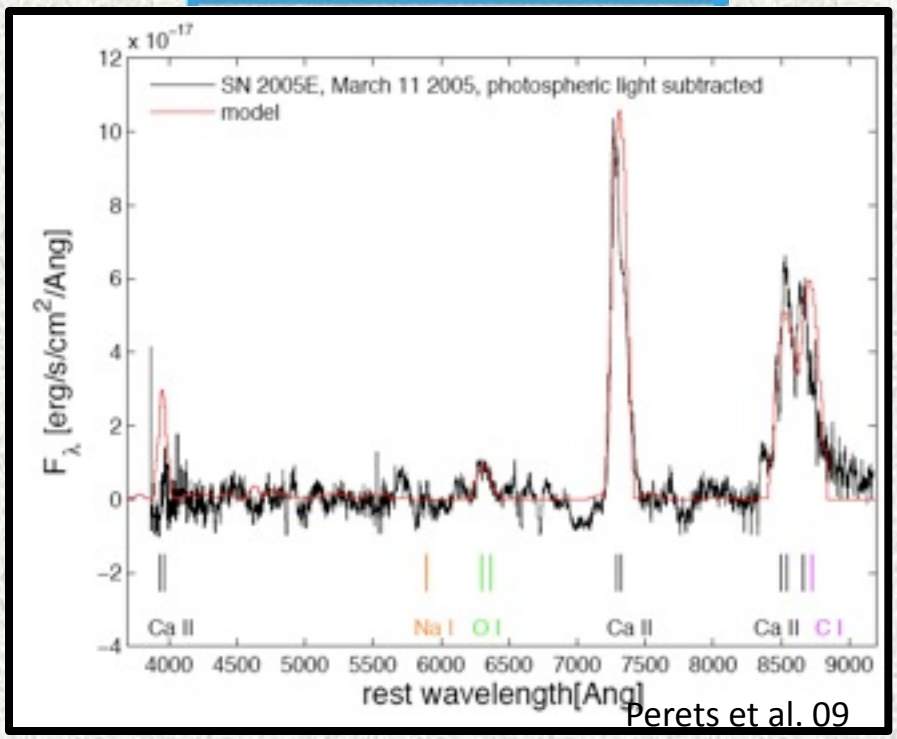
★ PTF09ego is the brightest member of this class

✦ If Ia, $M_{ej} > 4.5\ M_{\odot}$! NOT a white dwarf

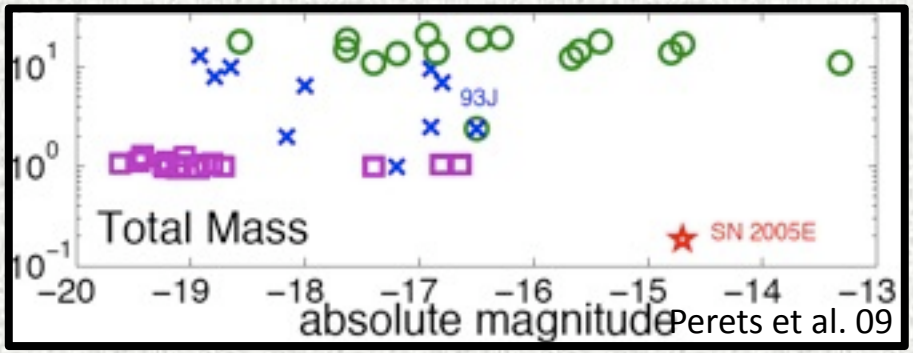
★ Are these massive stars, perhaps collapsing into a black hole?

Background: 2005E

- ★Halo Location:
  - ✦ Not a Massive Star
- ★Fast Photometric Evolution
- ★Faint Luminosity
- ★Lowest Known Ejecta
- ★AIC or SN .Ia?

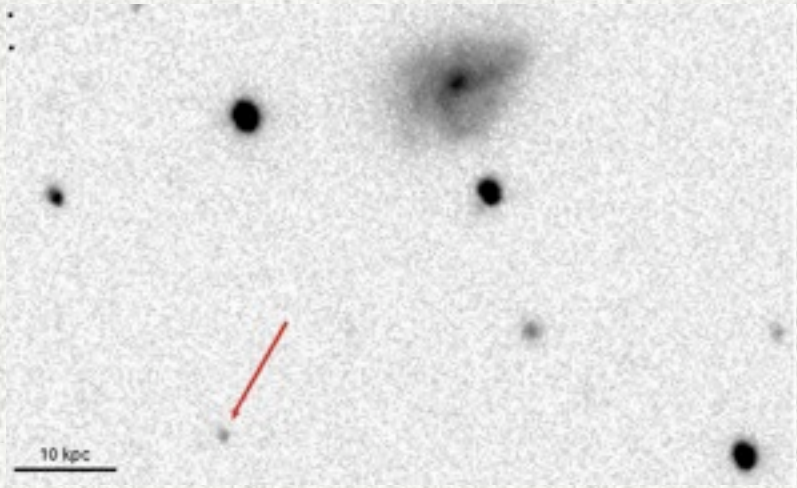


Perets et al. 09



Perets et al. 09

Result II: Mysterious PTF09dav



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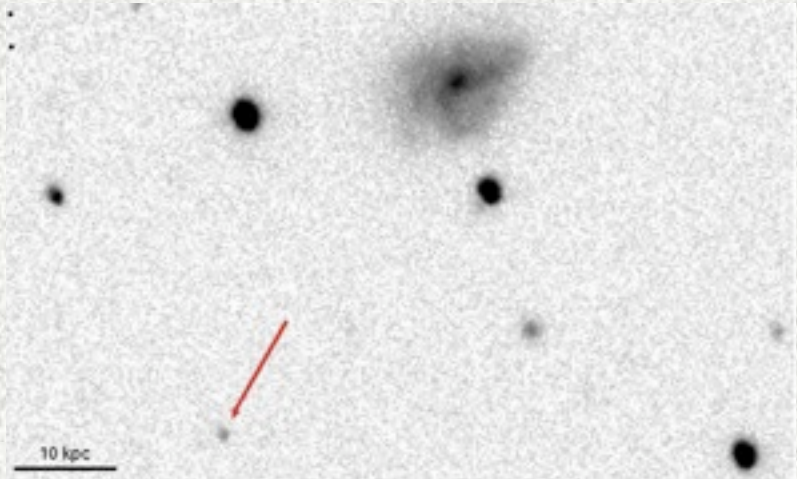

- ★Location:
  - ✦ 40kpc from putative spiral host
- ★Photometric Evolution:
  - ✦ In the GAP, Mg = -14.8
  - ✦ Very fast, 1 mag in 10 days
  - ✦ Very red, g-r = 1.2
- ★Spectrum:
  - ✦ Similar to SN1991bg but with He
  - ✦ Hydrogen in nebular phase

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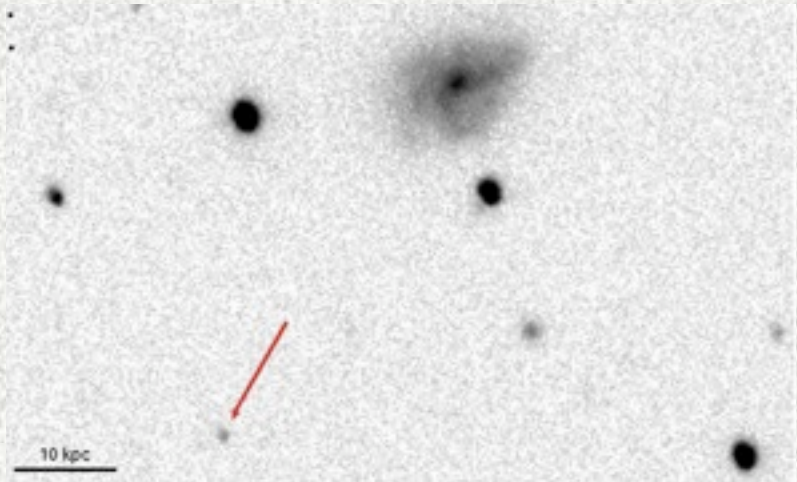

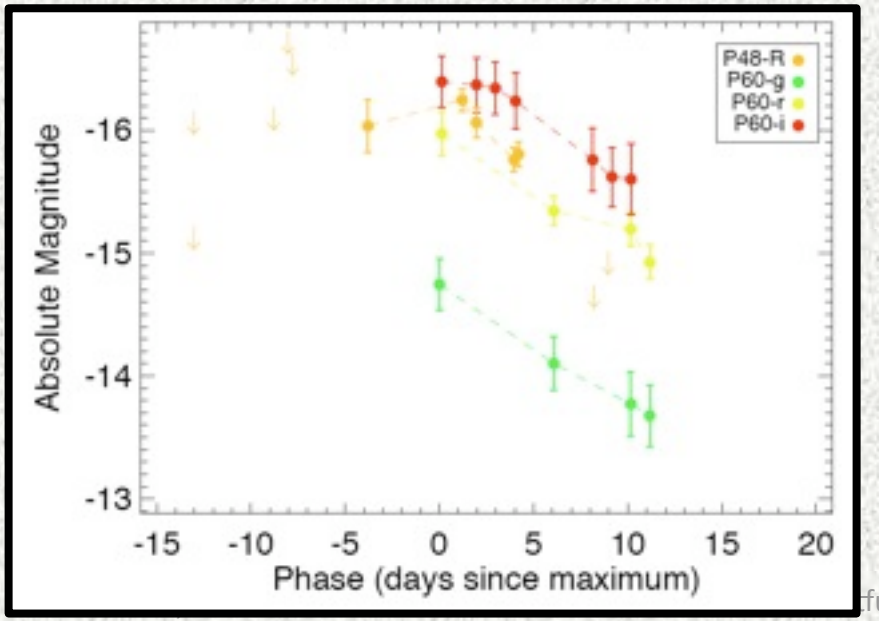

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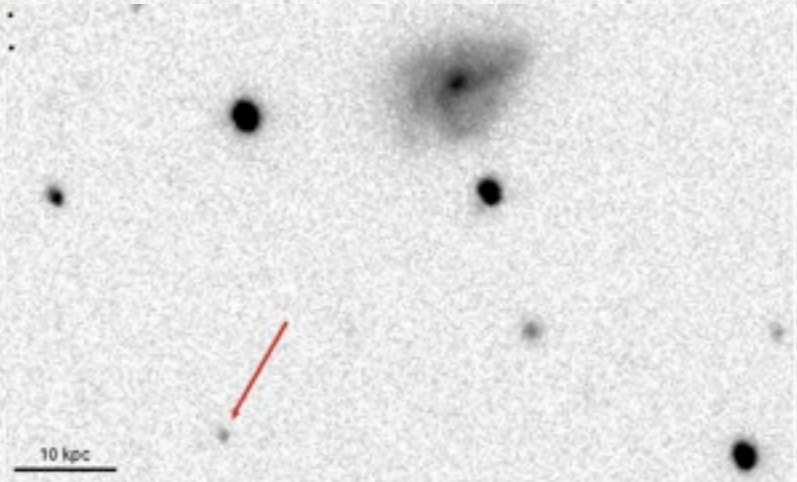
PALOMAR TRANSIENT FACTORY



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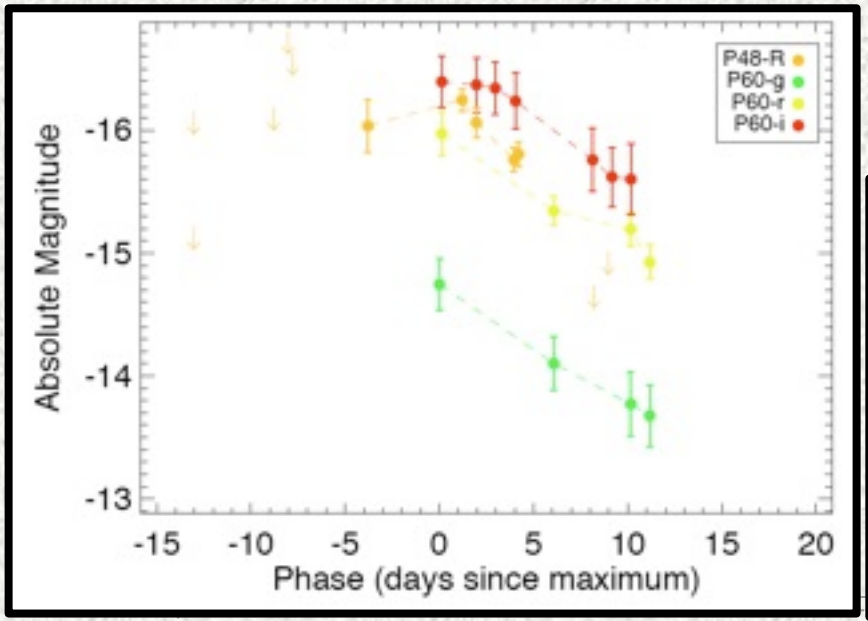
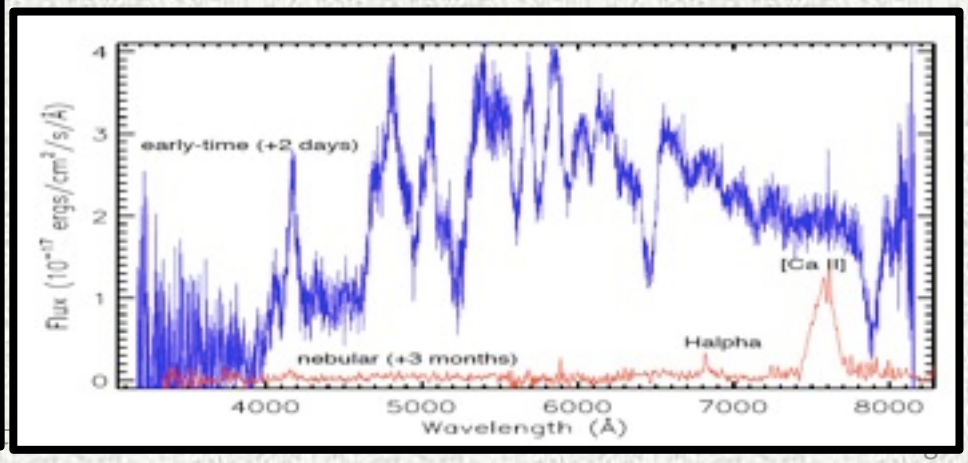
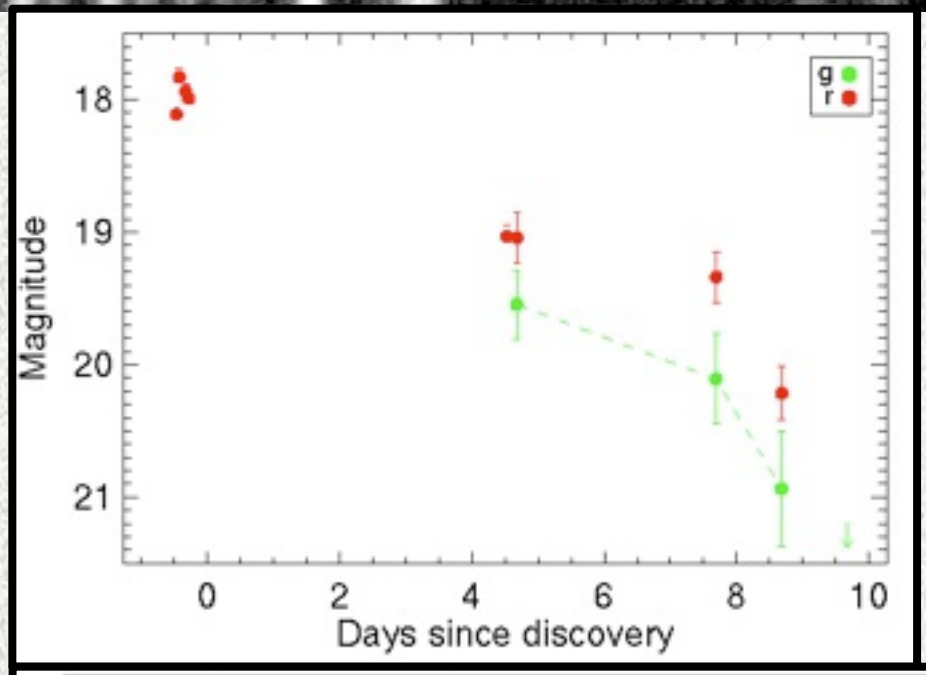




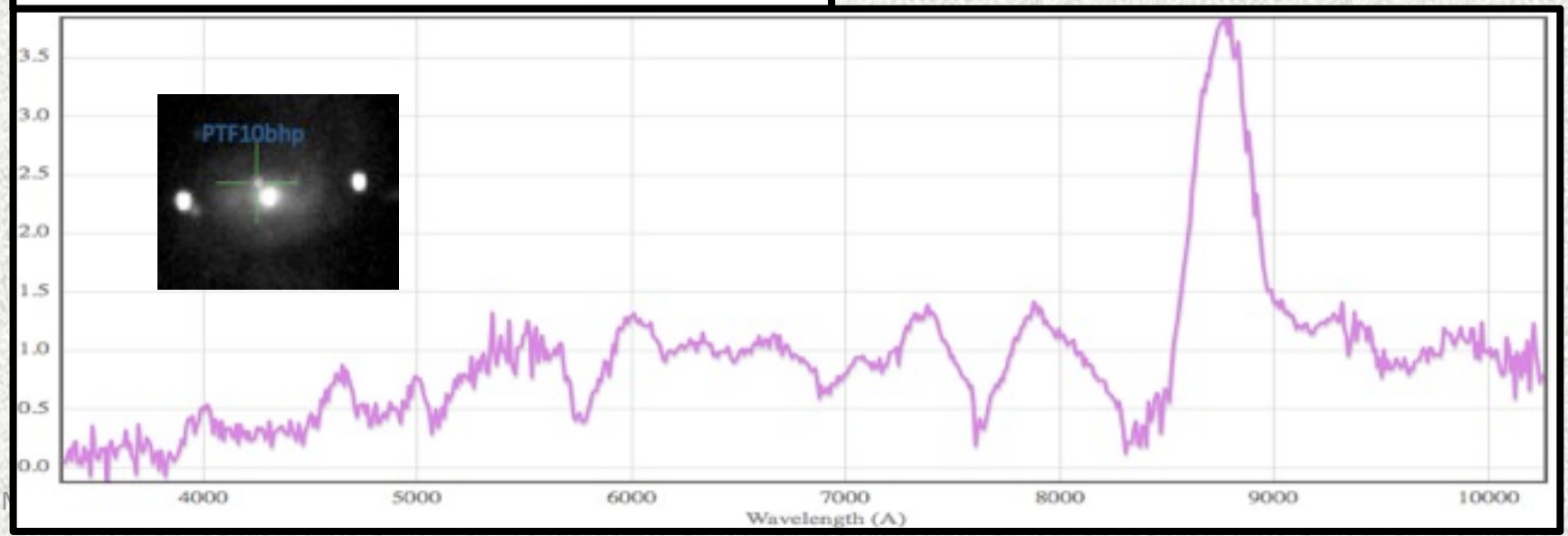
Result III: Ephemeral PTF10bhp



★ Very short-lived?
- ✦t1 = 5 days

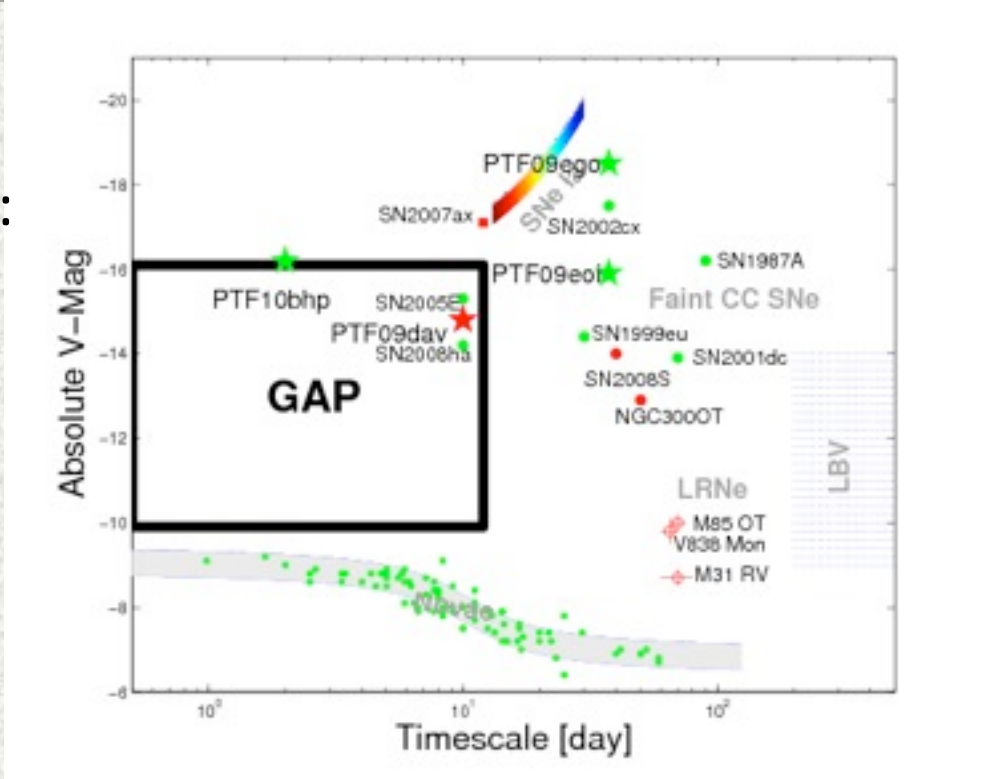
★ Subluminous
- ✦ Mr = -16

★Spectroscopically, Type Ic



Summary:

1. New members of the 02cx-family: Evidence for a massive star origin
2. The mysterious, faint, fast PTF09dav
3. The short-lived PTF10bhp



PALOMAR TRANSIENT FACTORY

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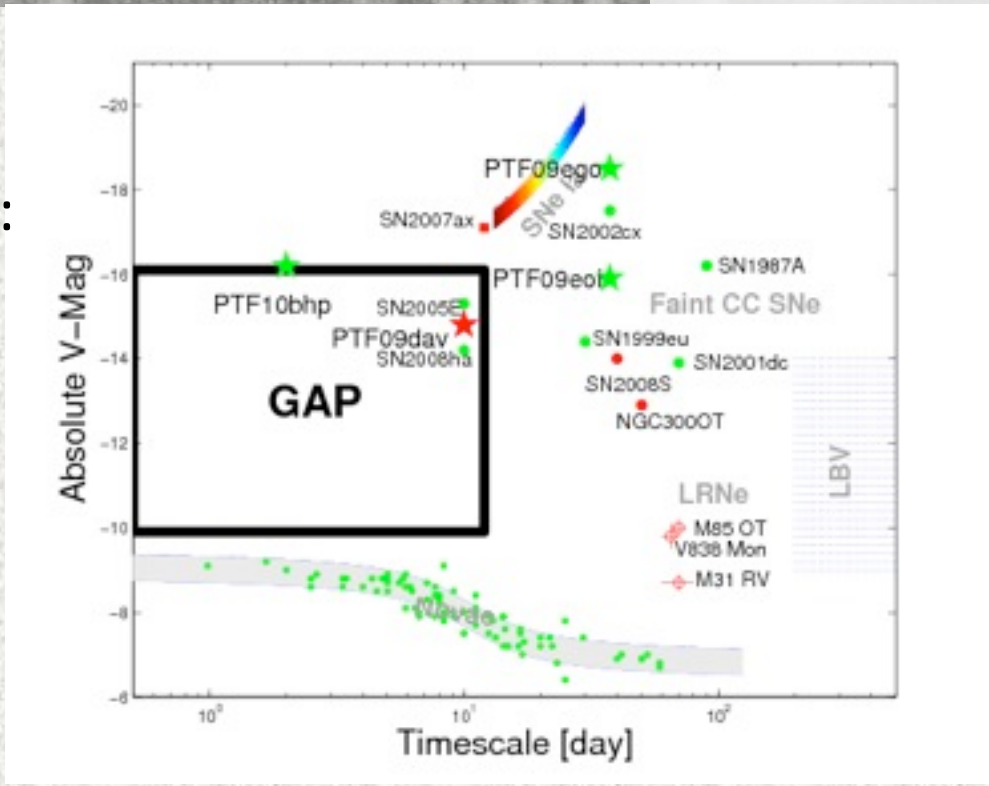


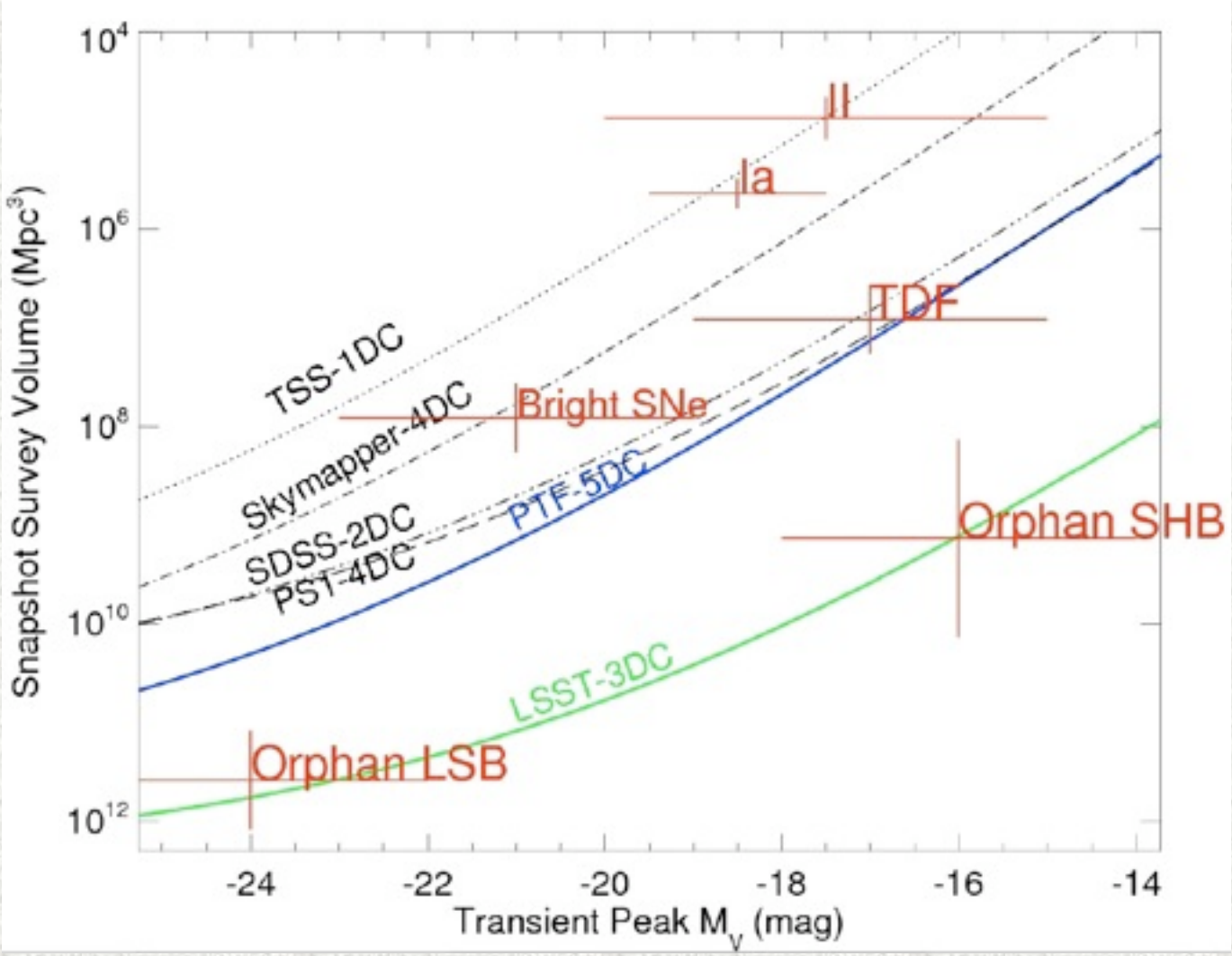
Stay tuned…

The fun has only just begun!

PALOMAR TRANSIENT FACTORY

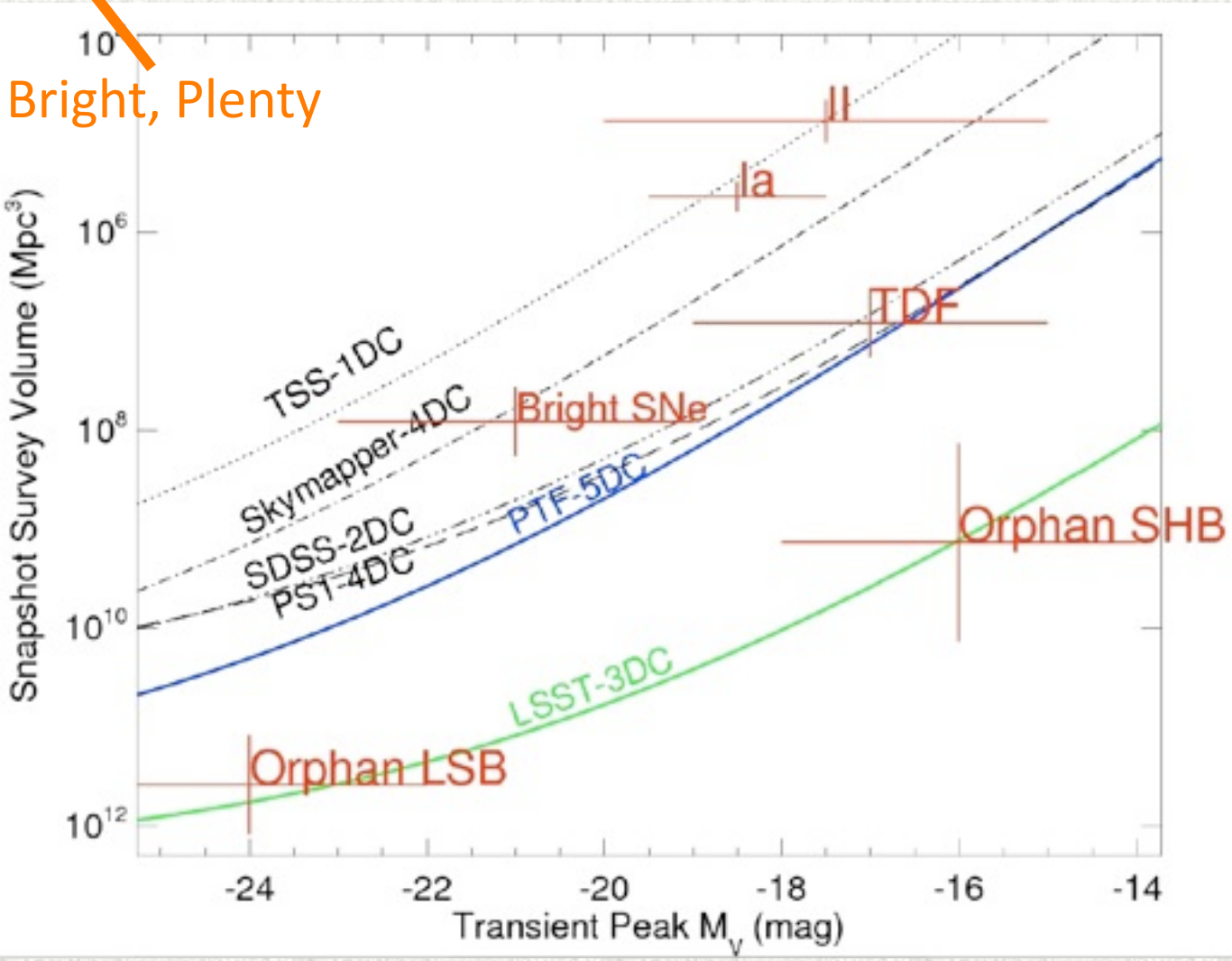
Extra slides…

PALOMAR TRANSIENT FACTORY



PALOMAR TRANSIENT FACTORY

Bright, Plenty



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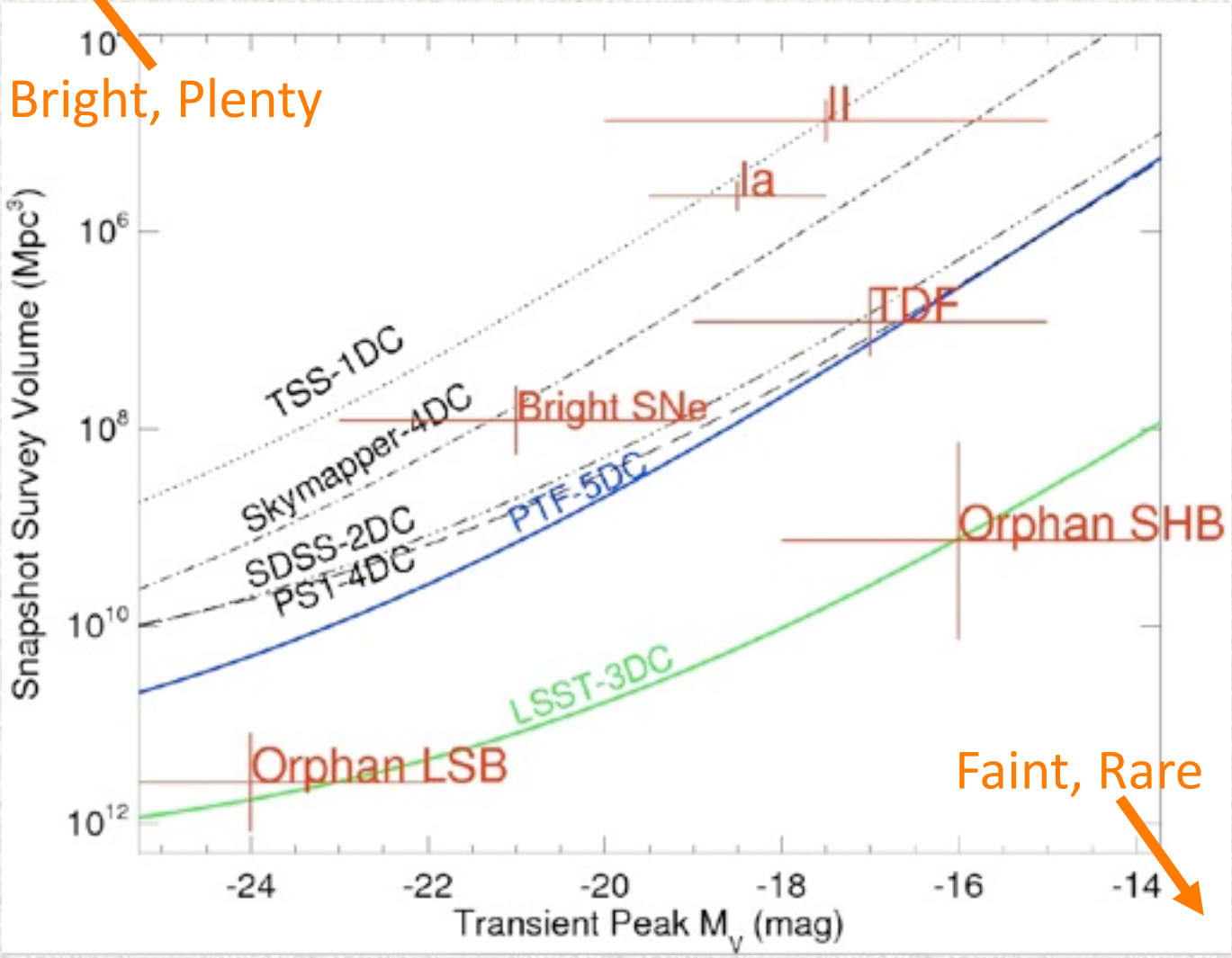
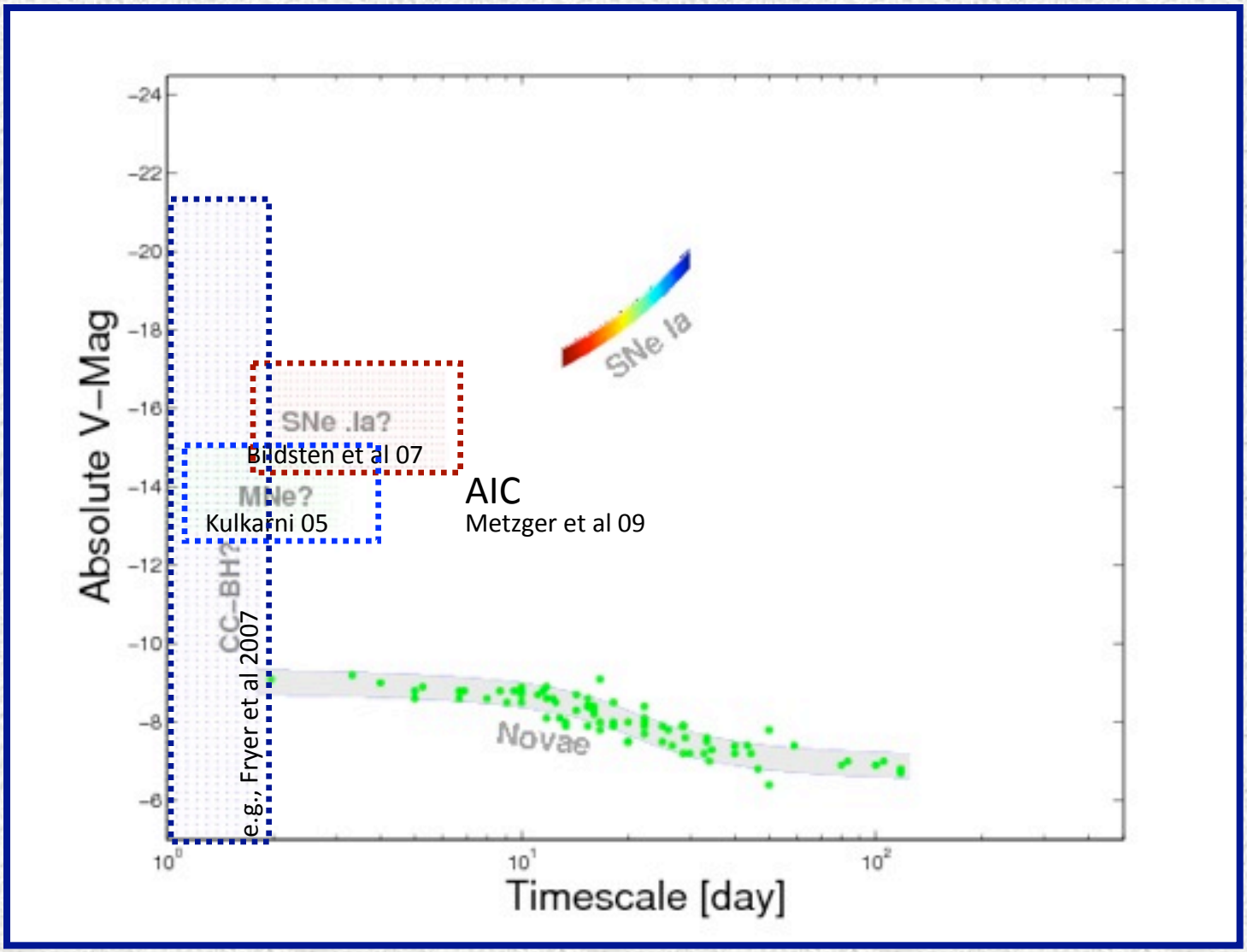
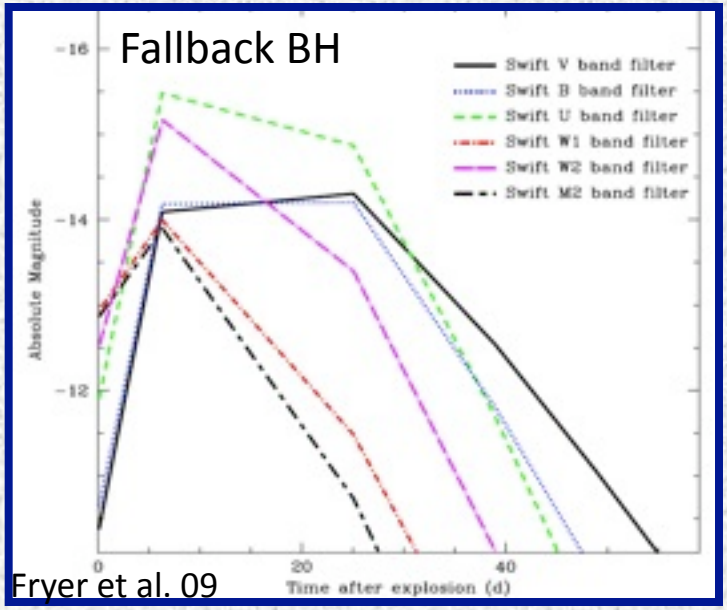


Theoretical Impetus



Predicted Light Curves



Fryer et al. 09

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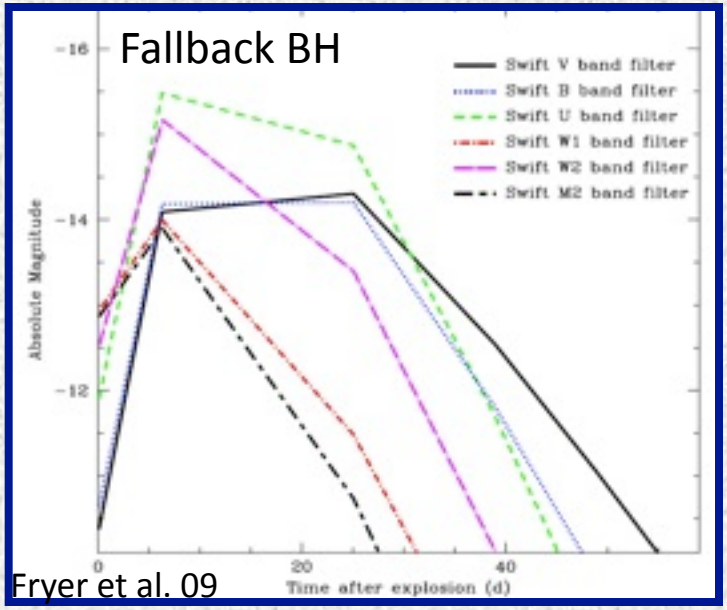

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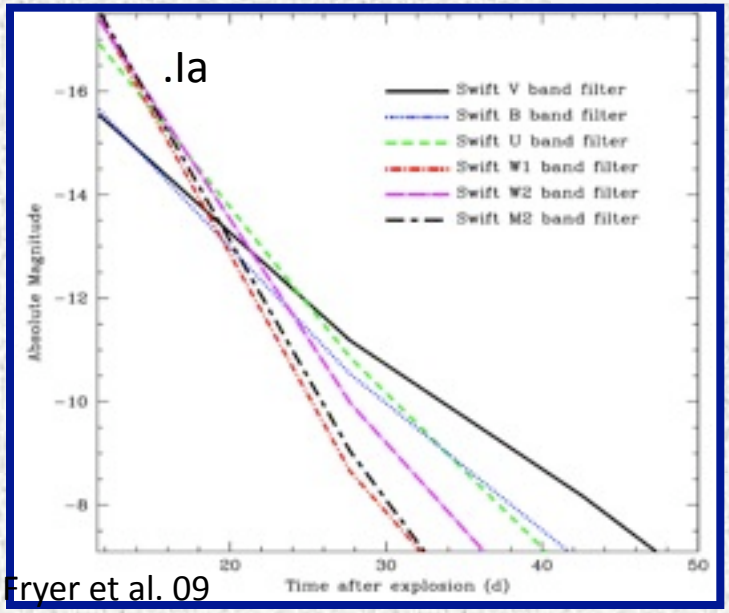

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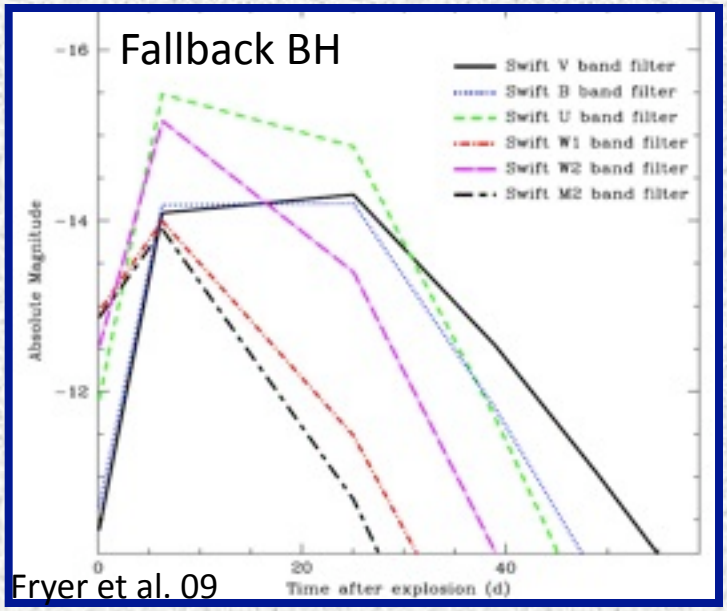

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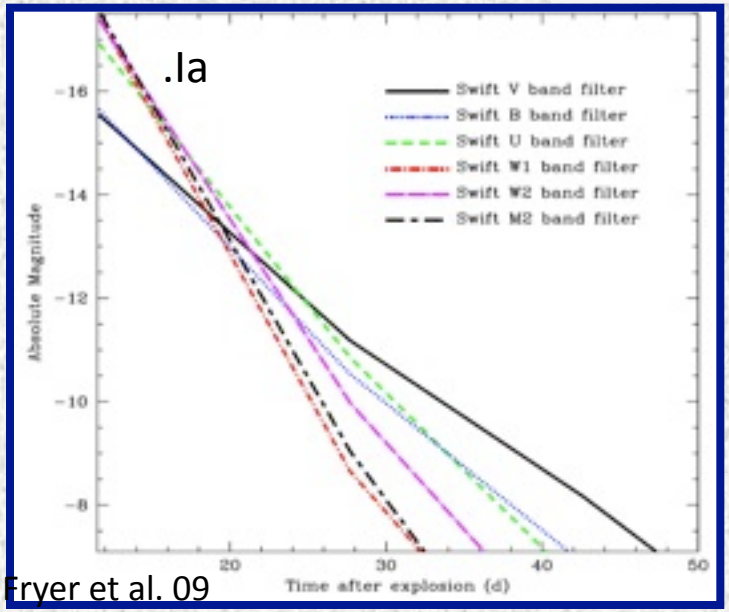

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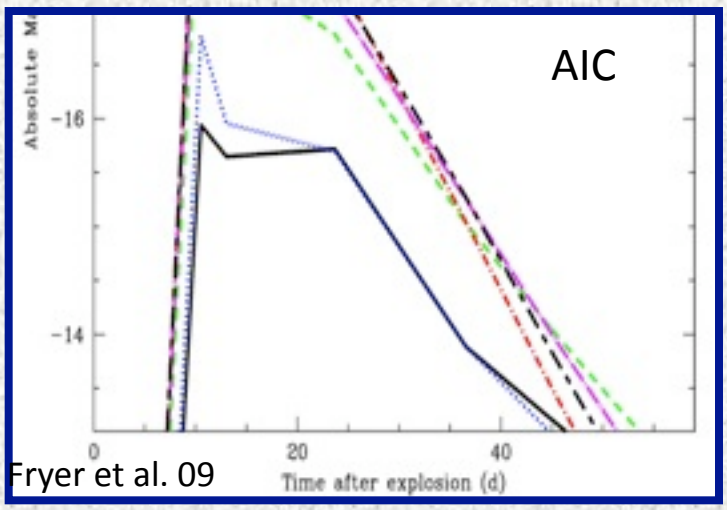
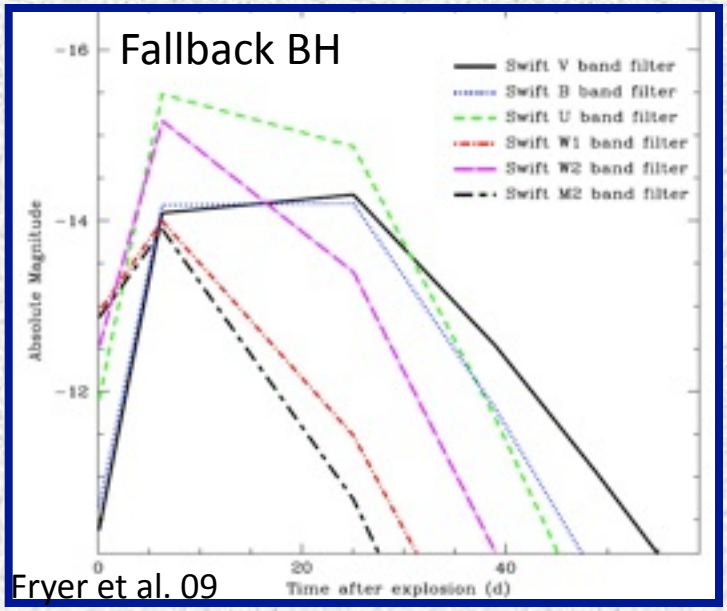


Fryer et al. 09

Predicted Light Curves

PALOMAR TRANSIENT FACTORY



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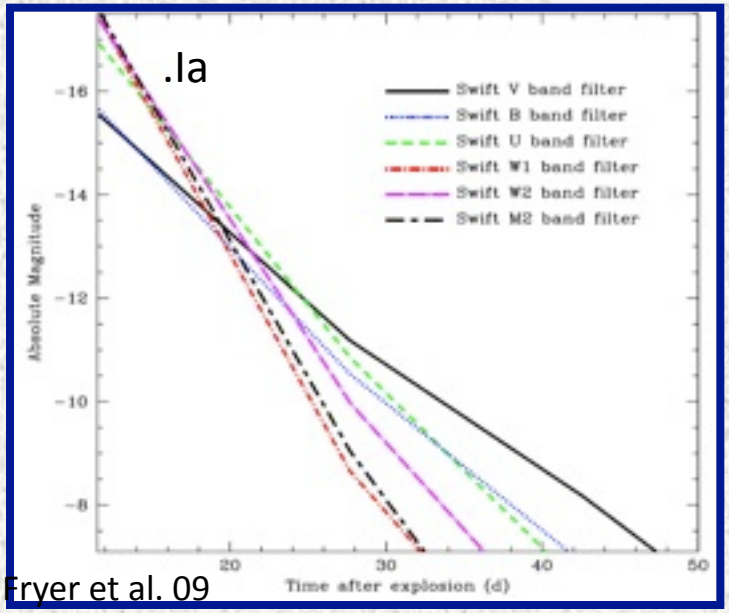

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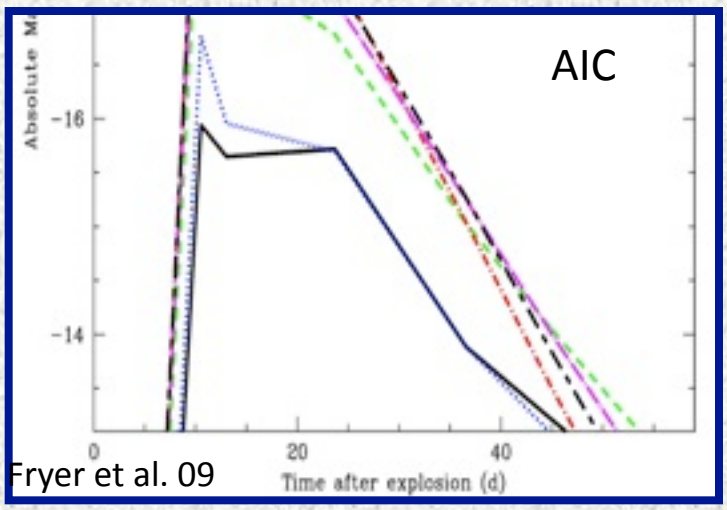

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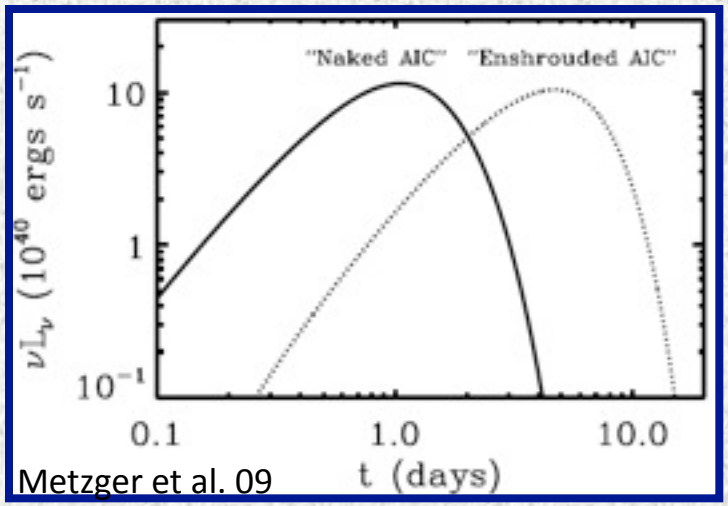
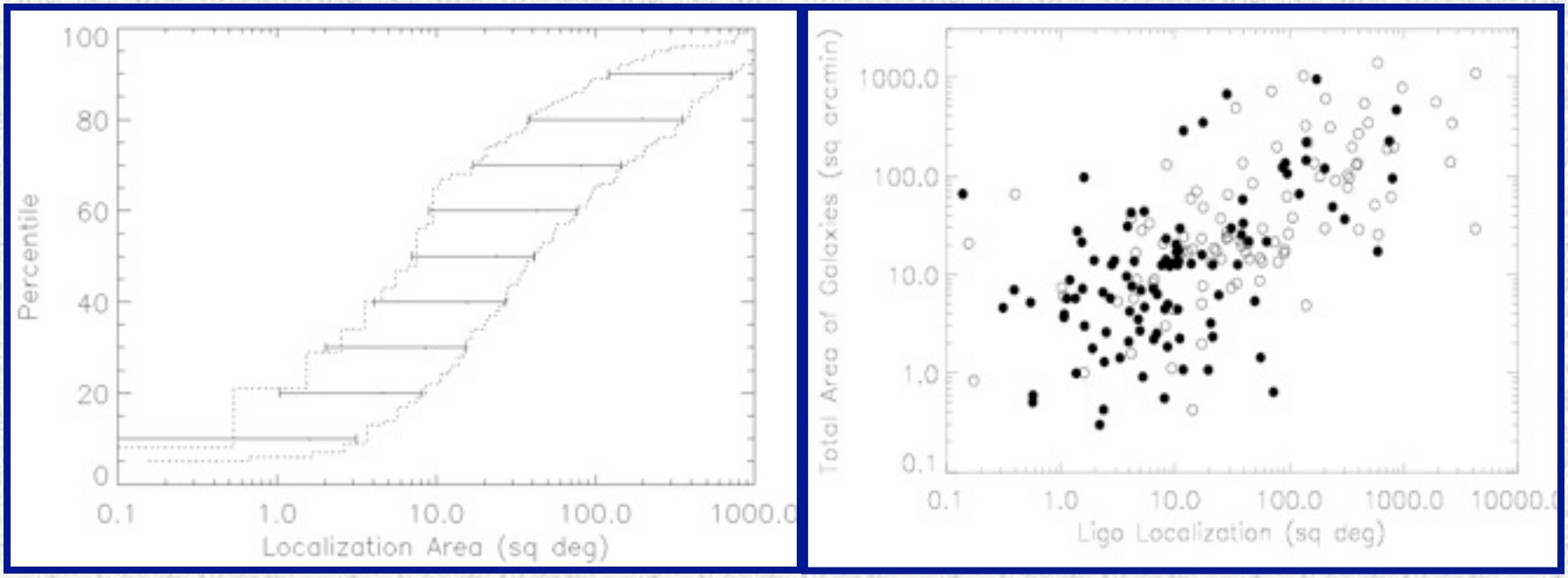


Metzger et al. 09

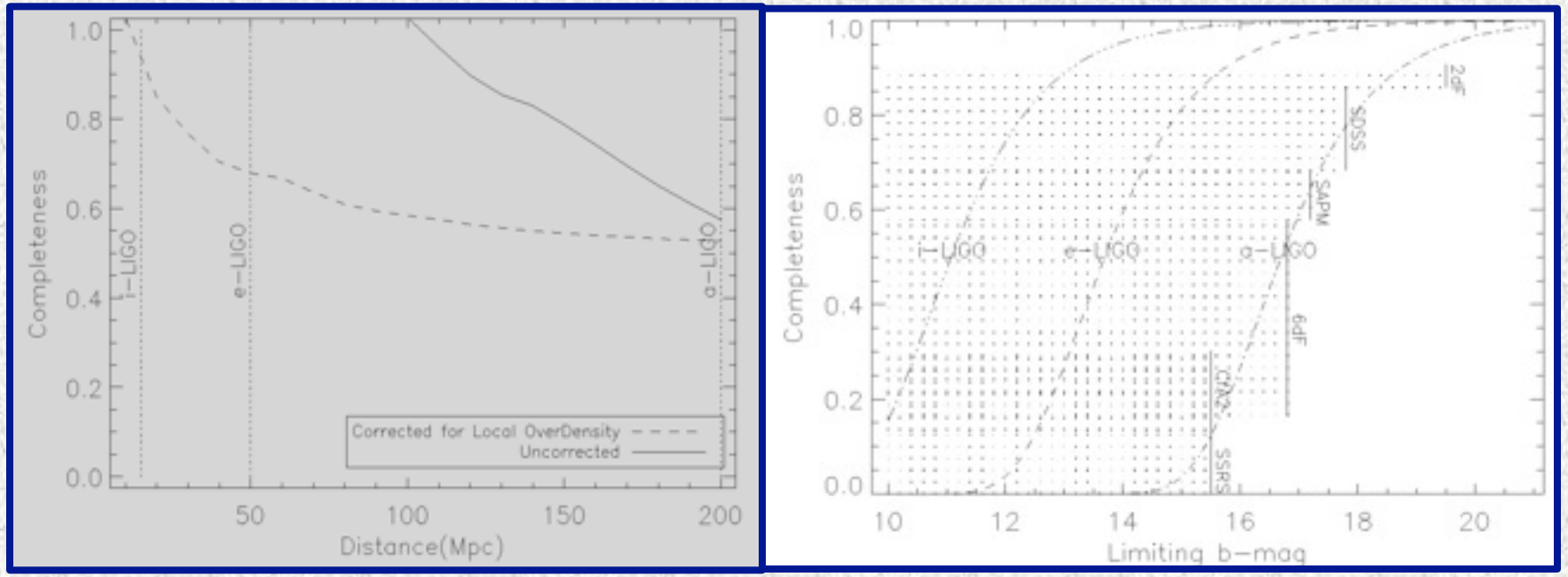
eLIGO -> PTF



Kasliwal et al, in prep

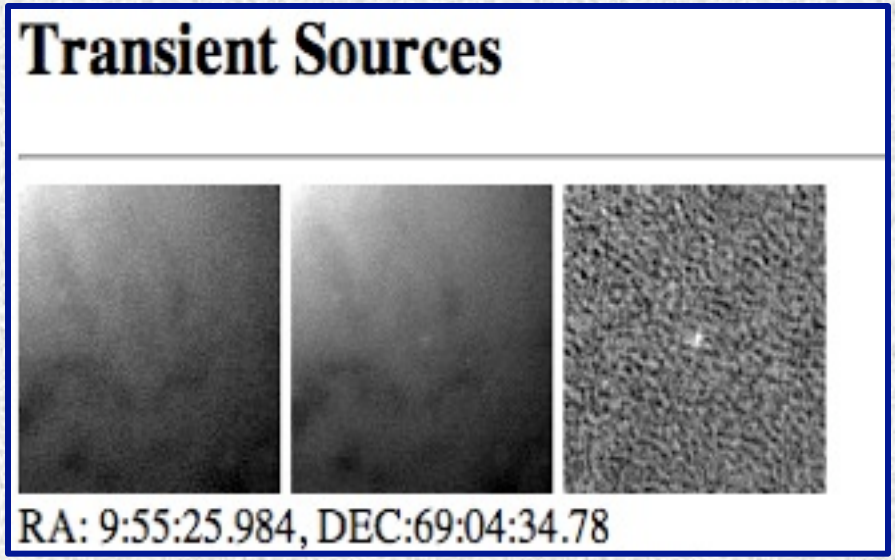
- LIGO localizations are very poor
  - 50%ile : 7..40 sq deg
  - 90%ile : 120..700 sq deg
- If follow-up is concentrated on known galaxies within 50 Mpc, foreground/ background false positives are reduced to tens to hundreds of arcmin!

A 200Mpc Catalog



- Left : Completeness of compiled galaxy catalog given expected total light (Schechter function) vs. distance
- Right : Completeness as a function of depth of survey. Major surveys contributing to nearby galaxy measurements are denoted by vertical lines with length proportional to fraction of

P60-M81OT-071213 : Faint, Fast Nova?



Kasliwal et al, in prep

- Discovery by P60-FasTING on UT 2007 Dec 13, Mg = -7.3
- Too fast declining (1 mag day^{-1}) for its faintness
- Width of Balmer emission lines, 3100 km s^{-1}, 2400 km s^{-1}
- $H\alpha/H\beta$ = 3.8 => Av = 0.85
- No X-ray emission a week after peak : Not a NS/BH

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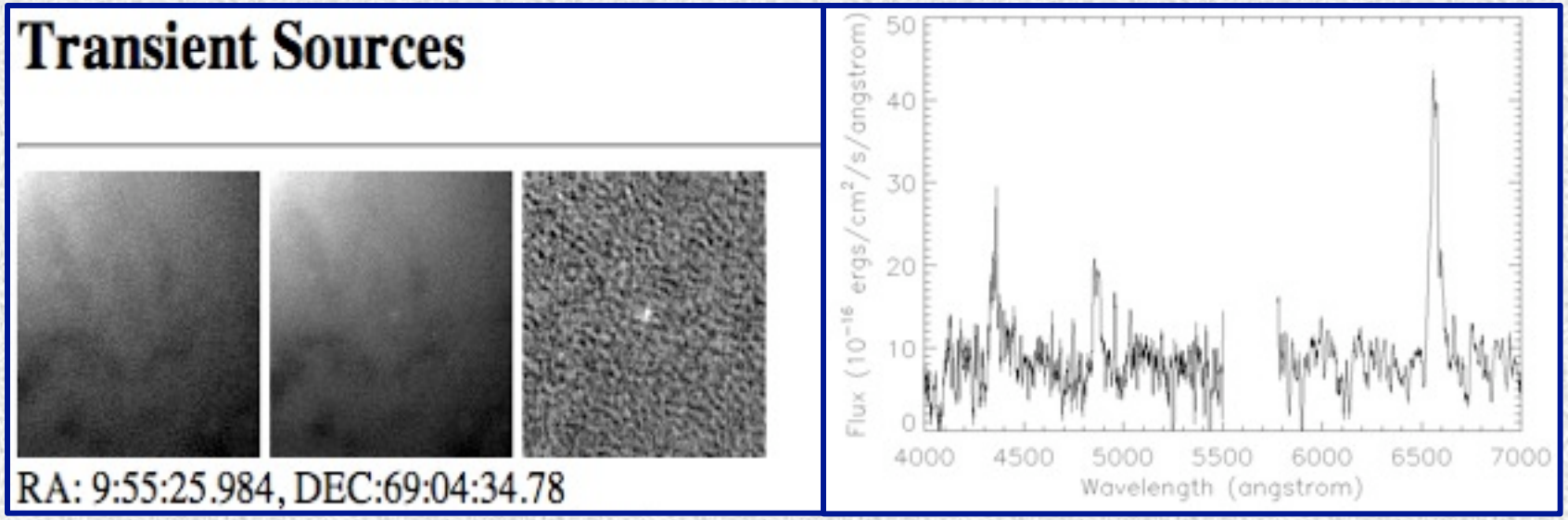

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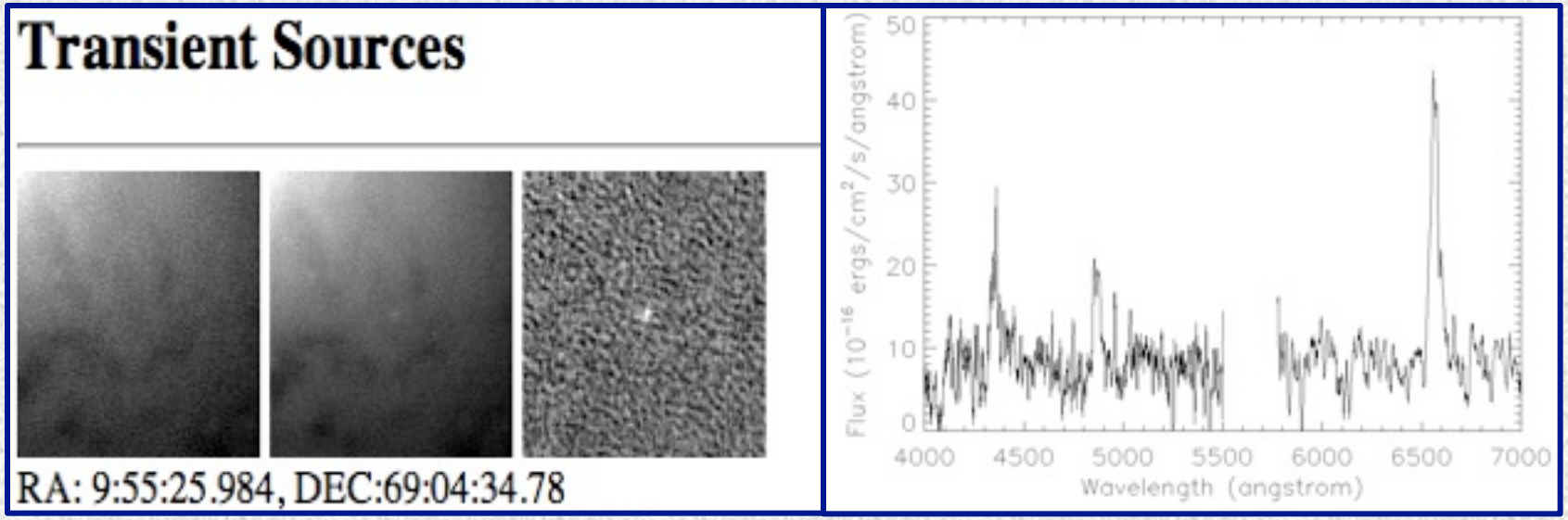

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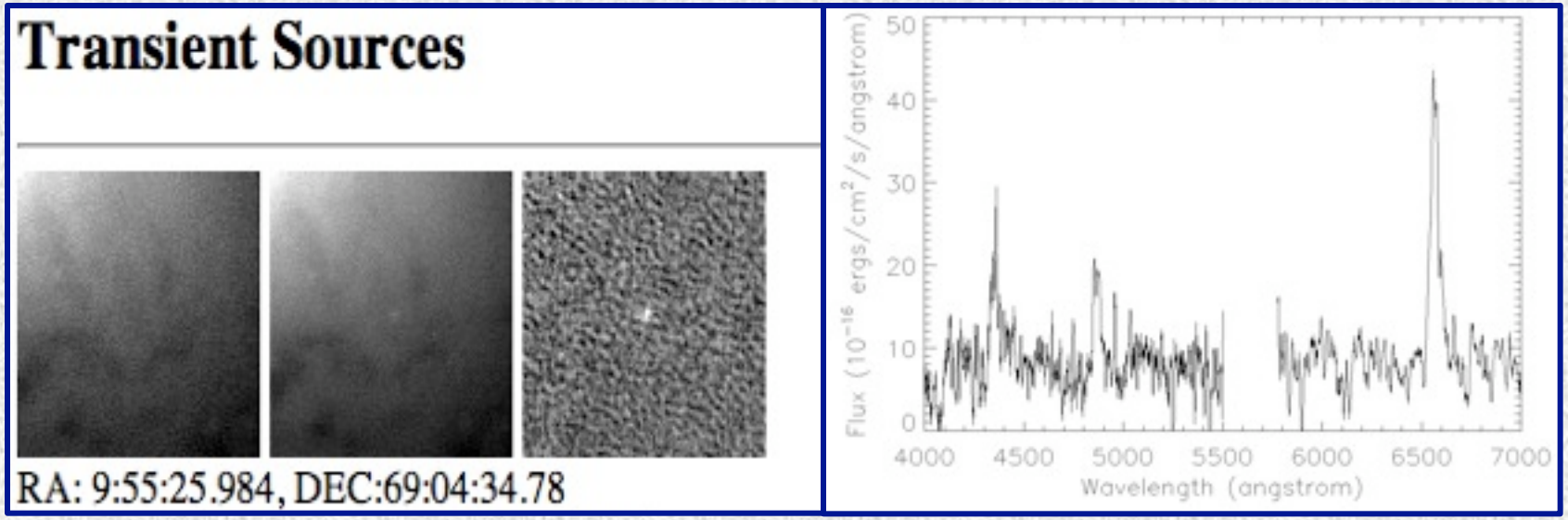

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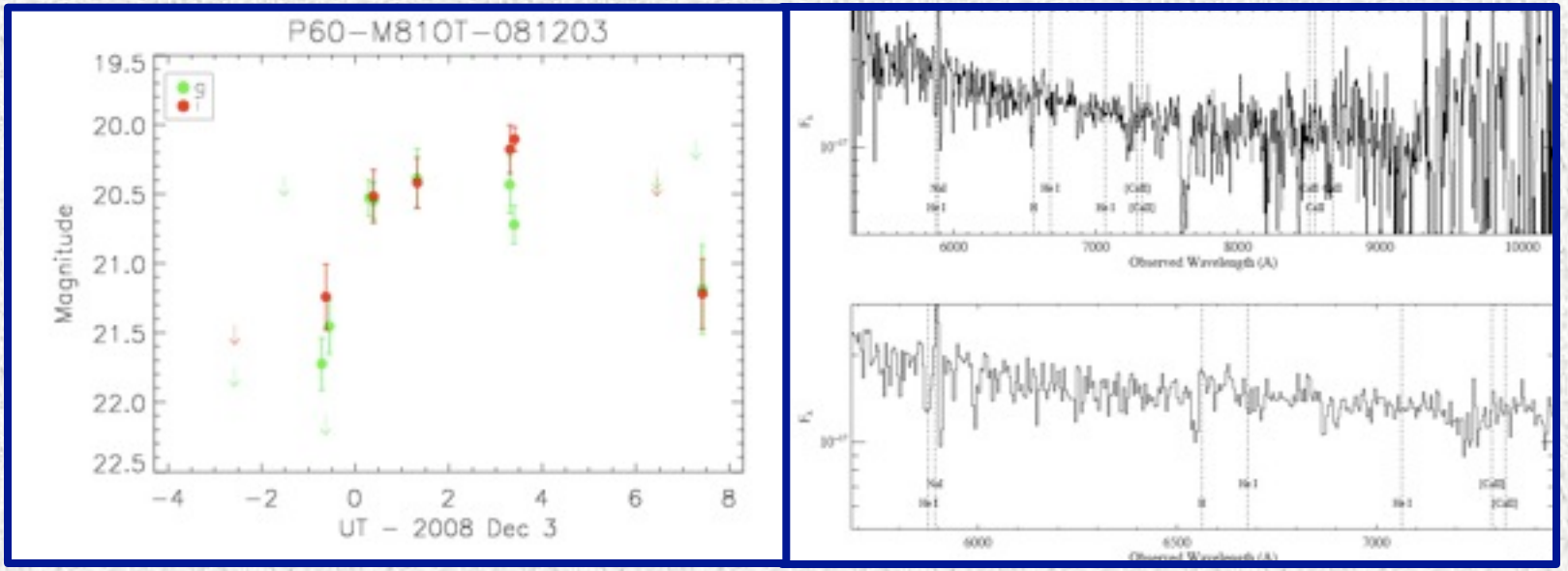
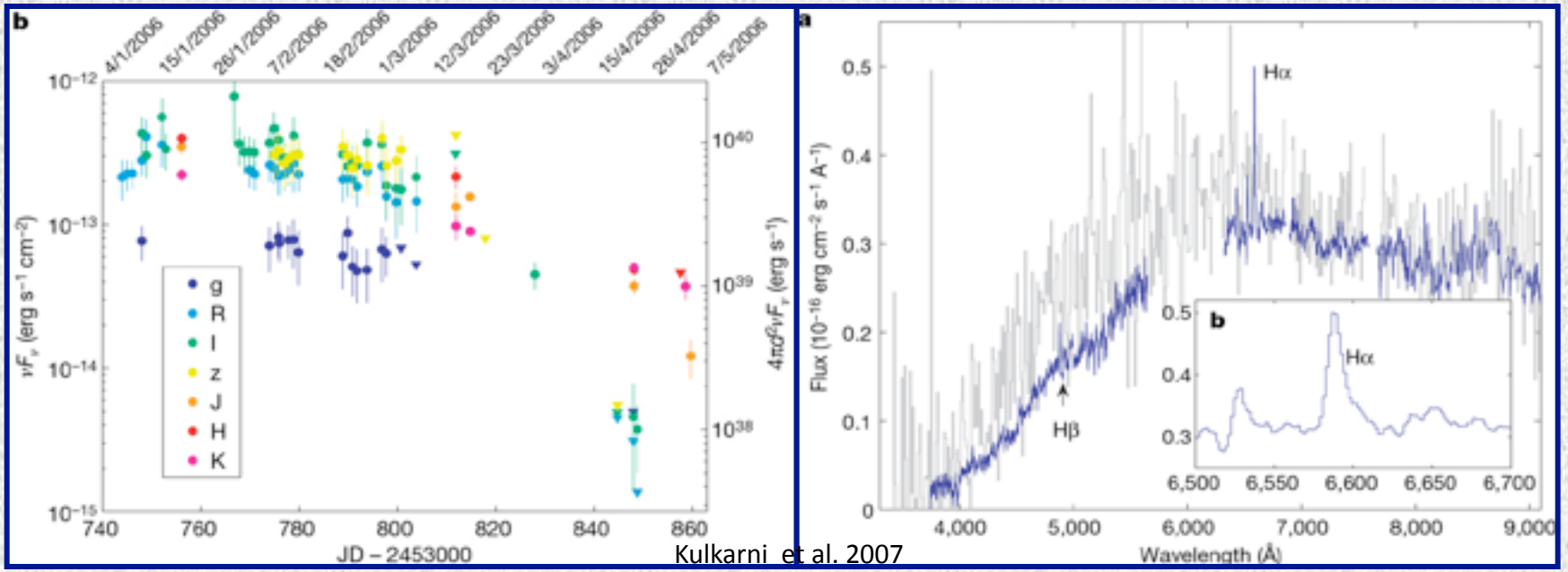
P60-M81OT-081203 - Featureless?



Kasliwal et al, in prep

- Photometrically like a nova, -7.6
- Spectroscopically featureless!
- Foreground? Background?
- Novel? Synchrotron?

M85OT : A Luminous Red Nova



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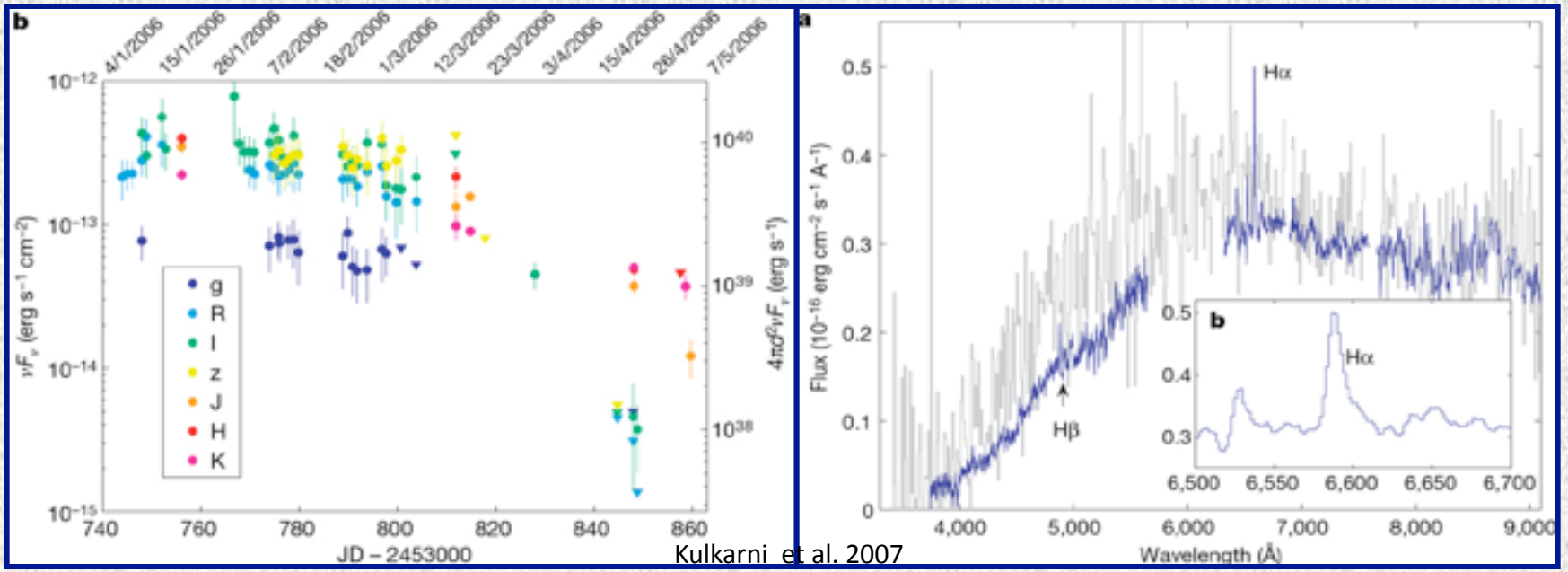

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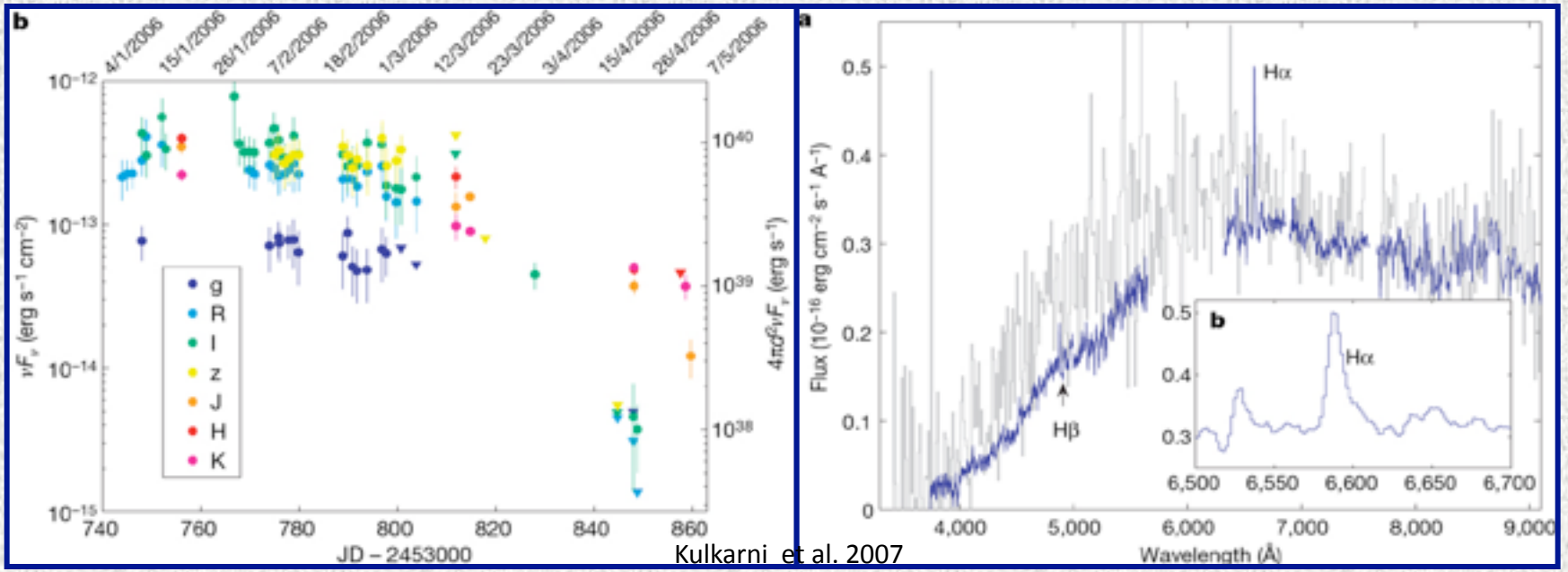

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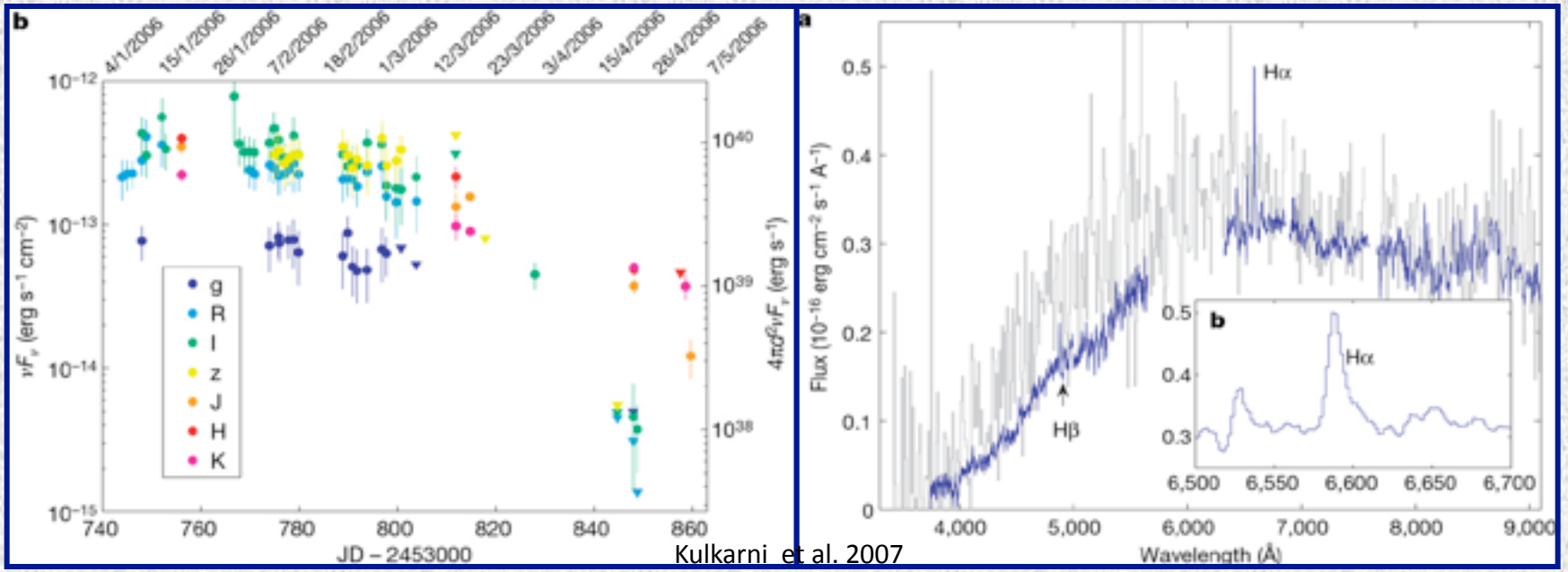

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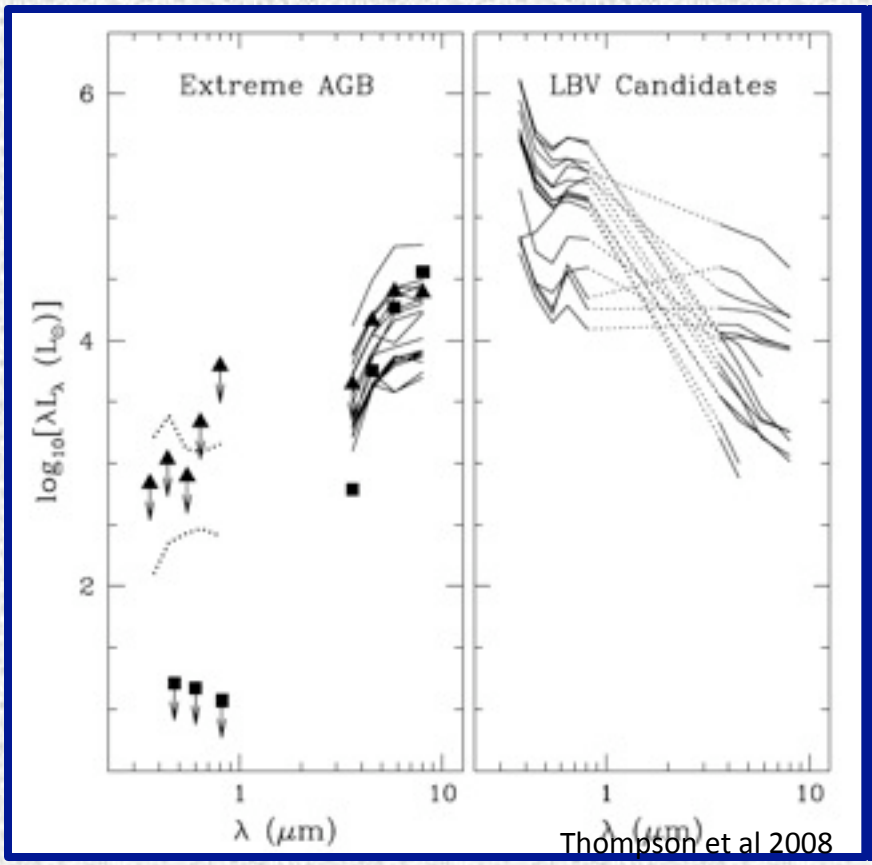
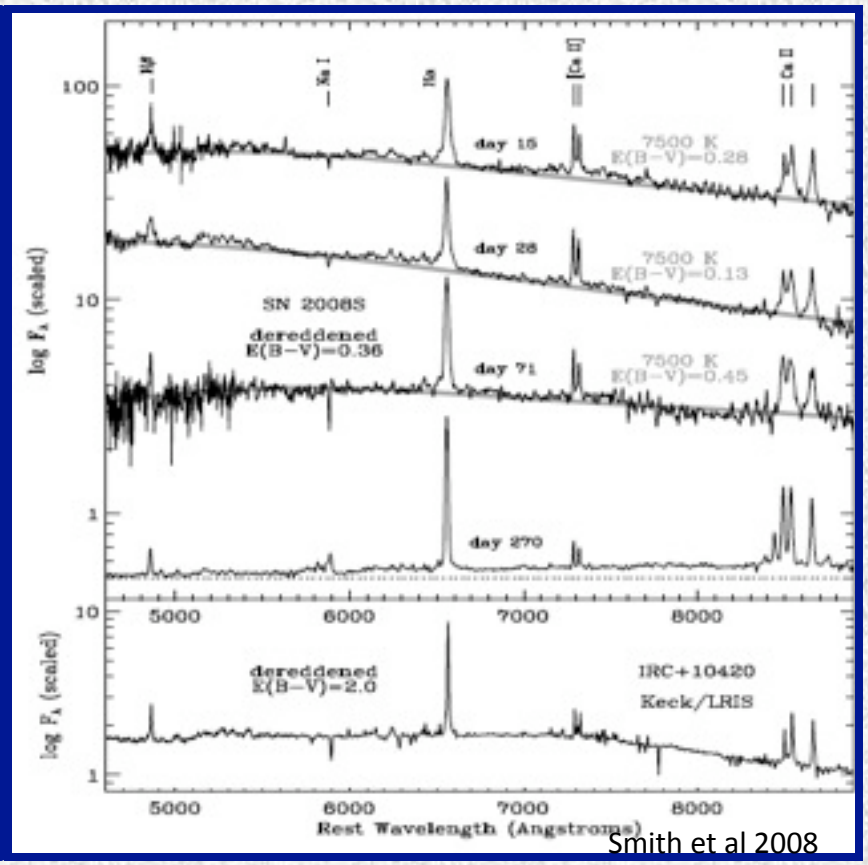
- Rate : >0.015 / yr / 10^{11} Lsun

“eAGB” stars



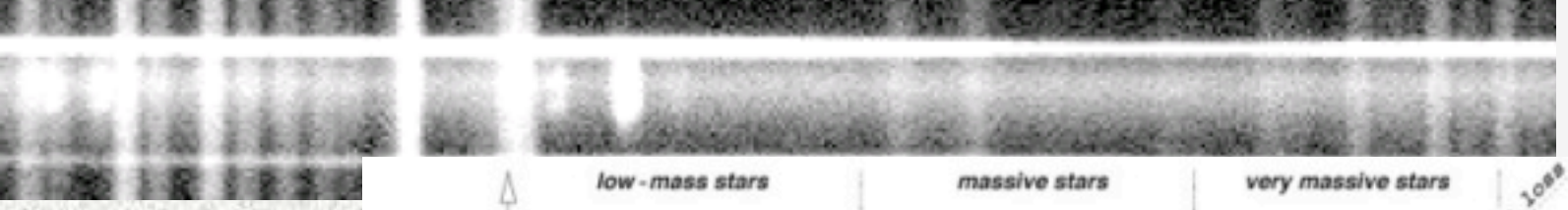
Thompson et al 2008

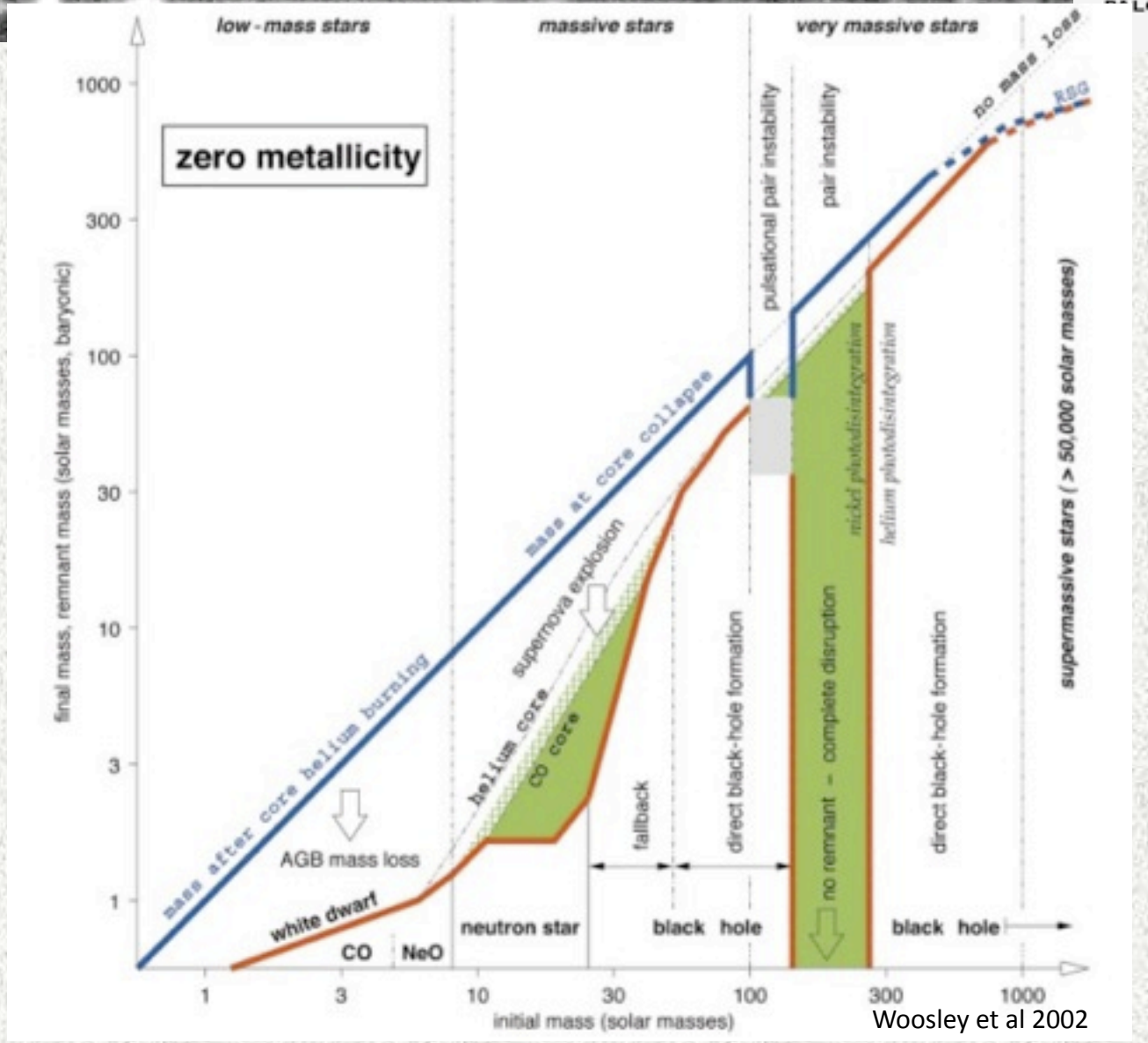


Smith et al 2008

- SN2008S (in NGC6946) and NGC300-OT had extremely red progenitors - dust enshrouded SNe? e-capture SNe?
- Spectroscopic and Photometric explosion signature - LBV?

PALOMAR TRANSIENT FACTORY

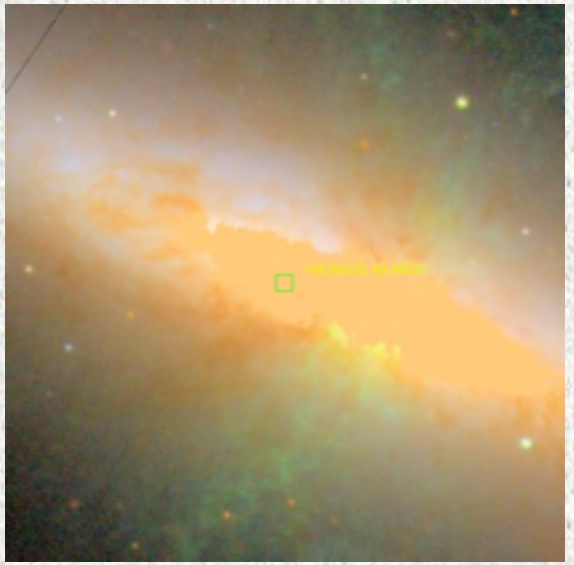




Woosley et al 2002

PALOMAR TRANSIENT FACTORY

I. P60-FasTING



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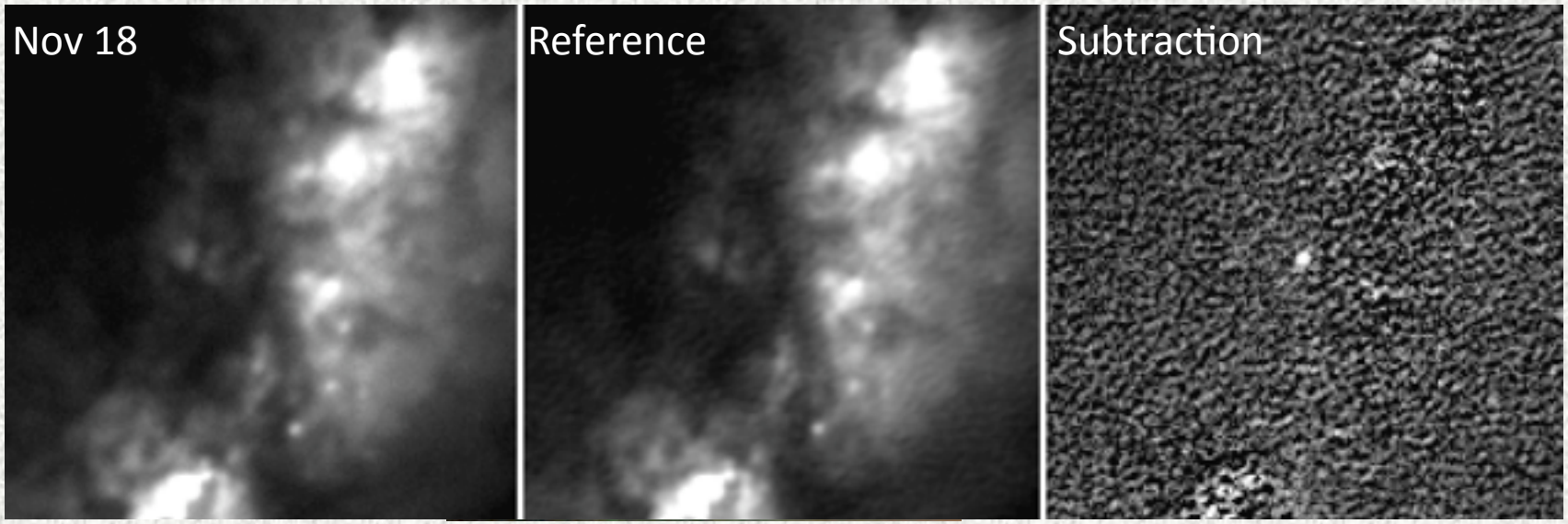

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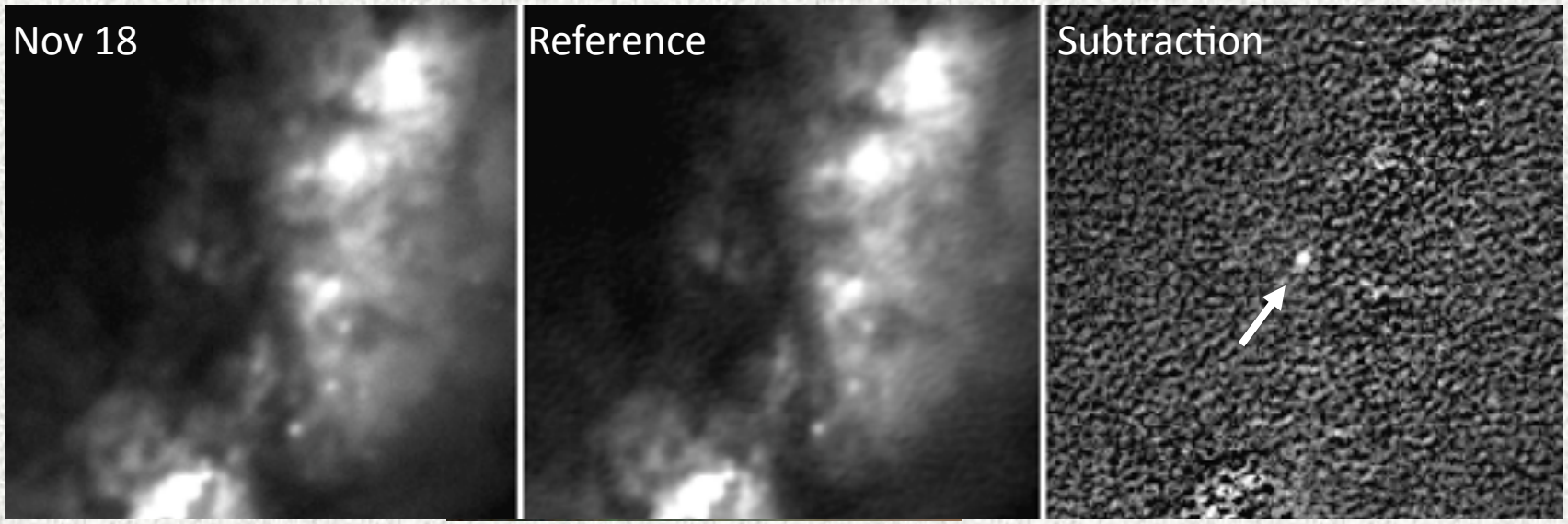

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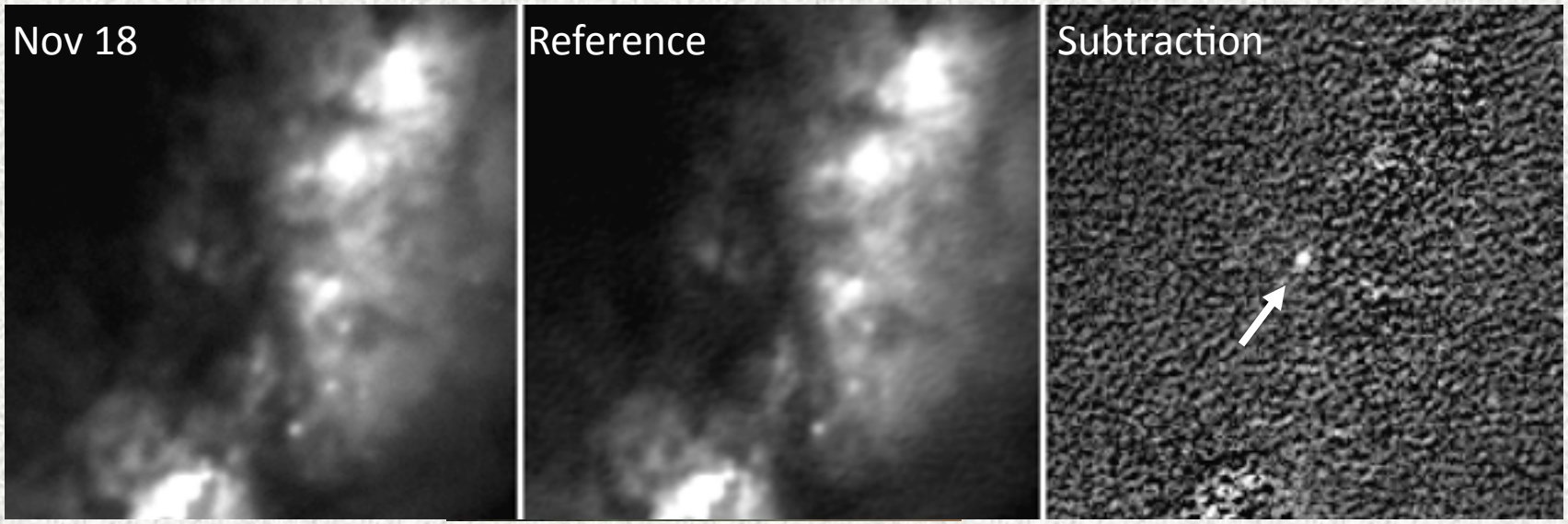

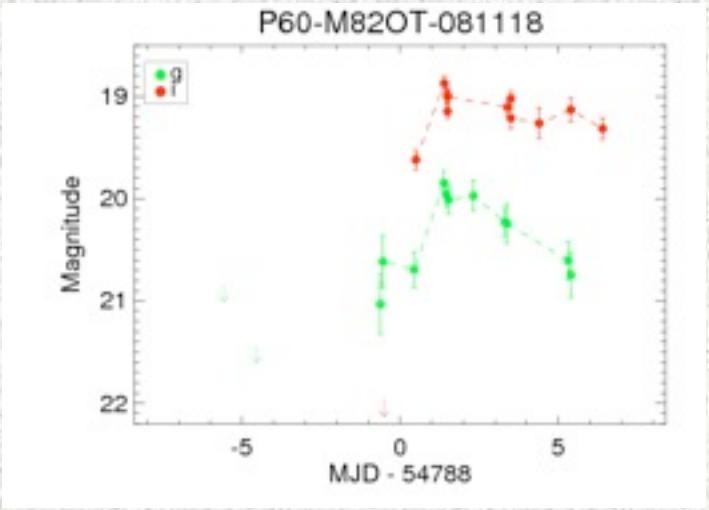

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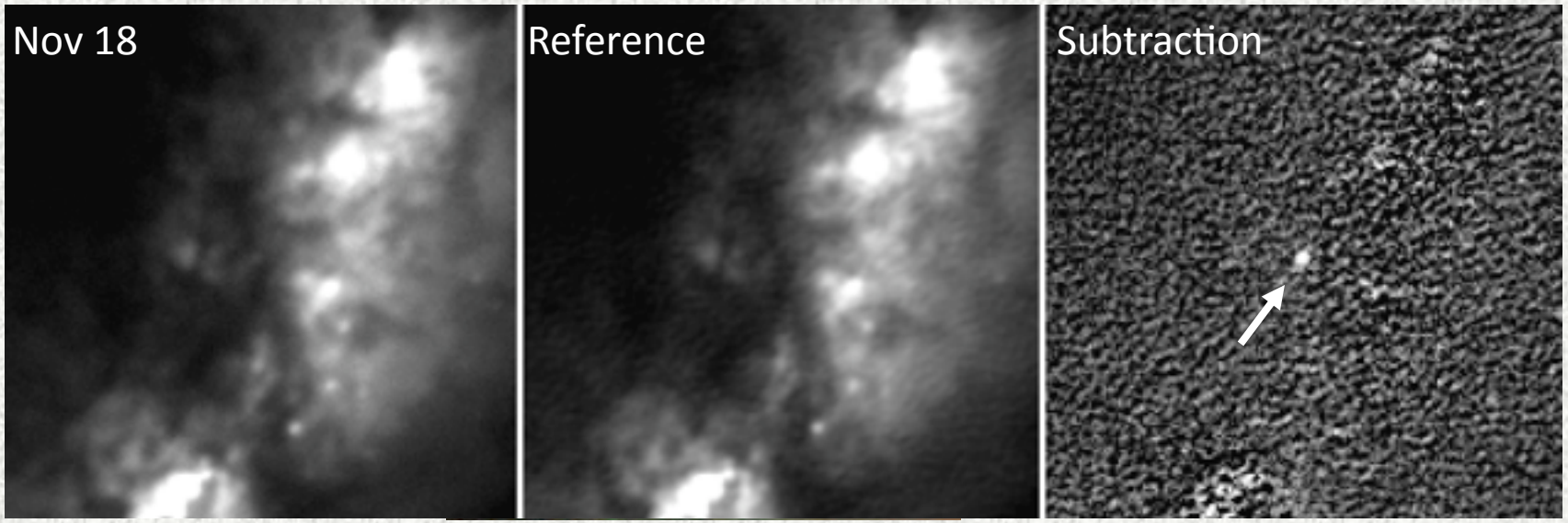
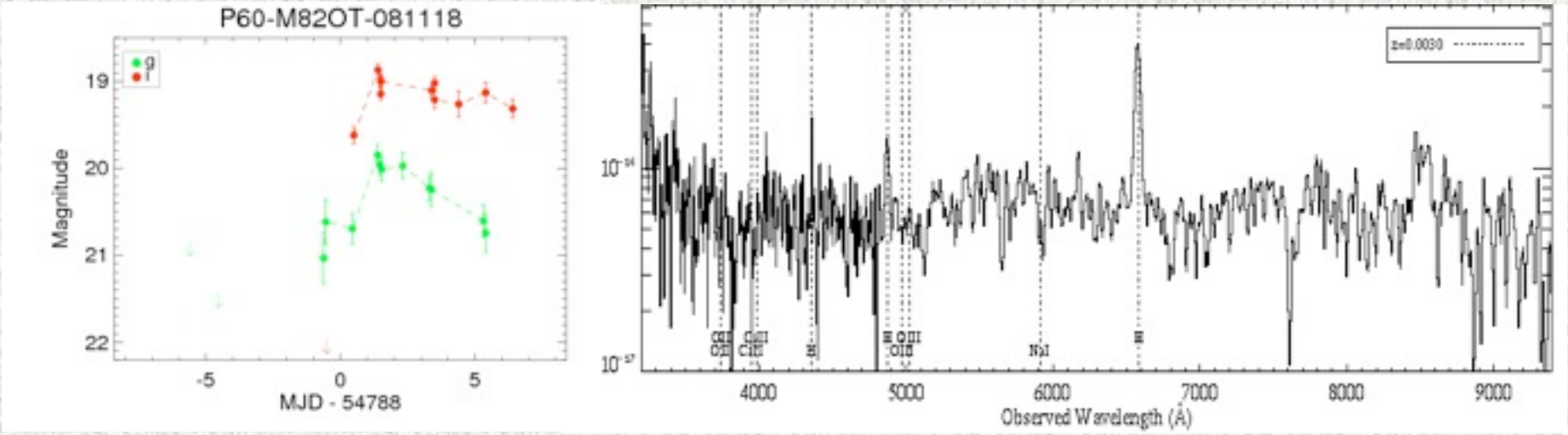
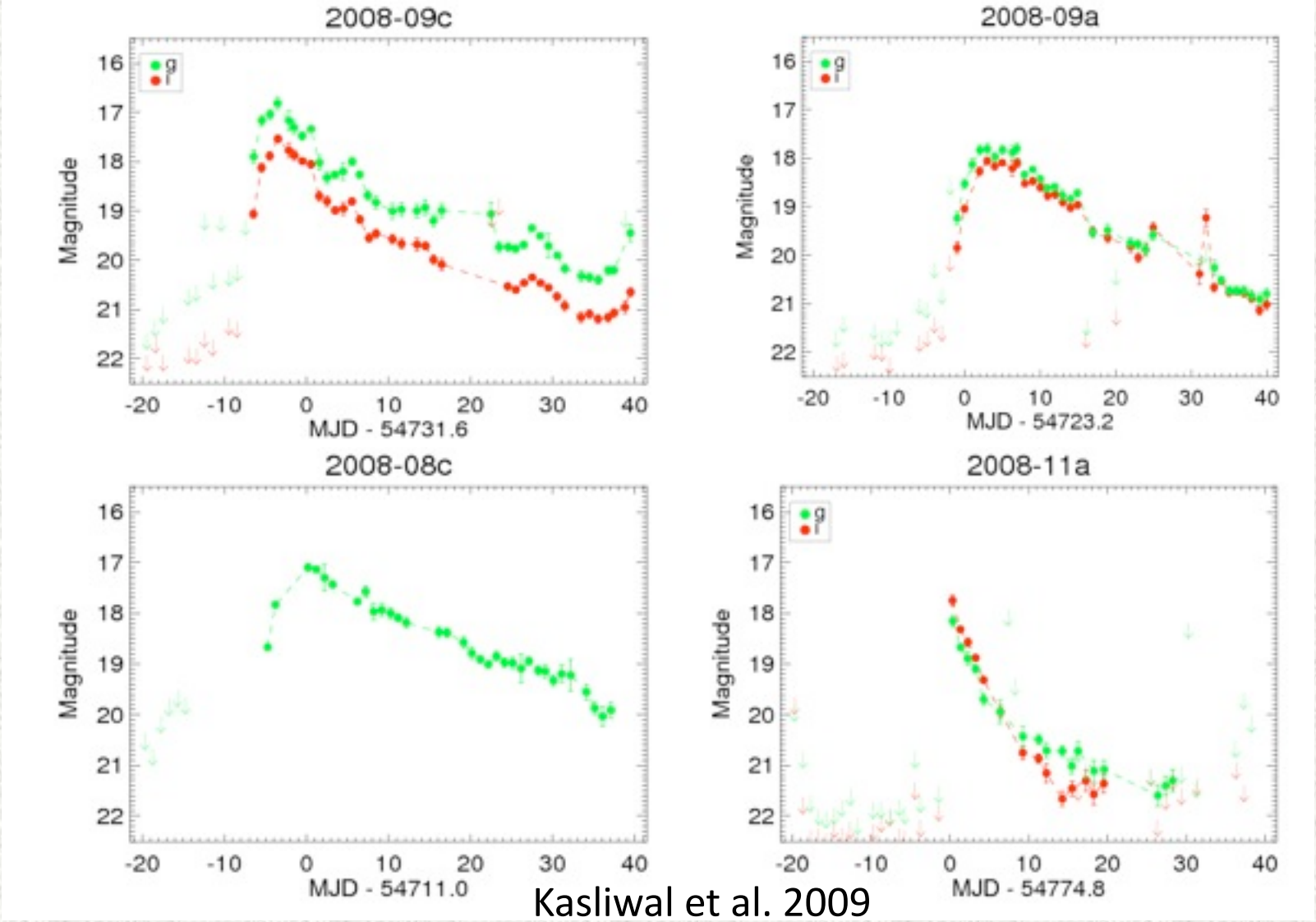




Faint and Fast Novae

PALOMAR TRANSIENT FACTORY



Kasliwal et al. 2009

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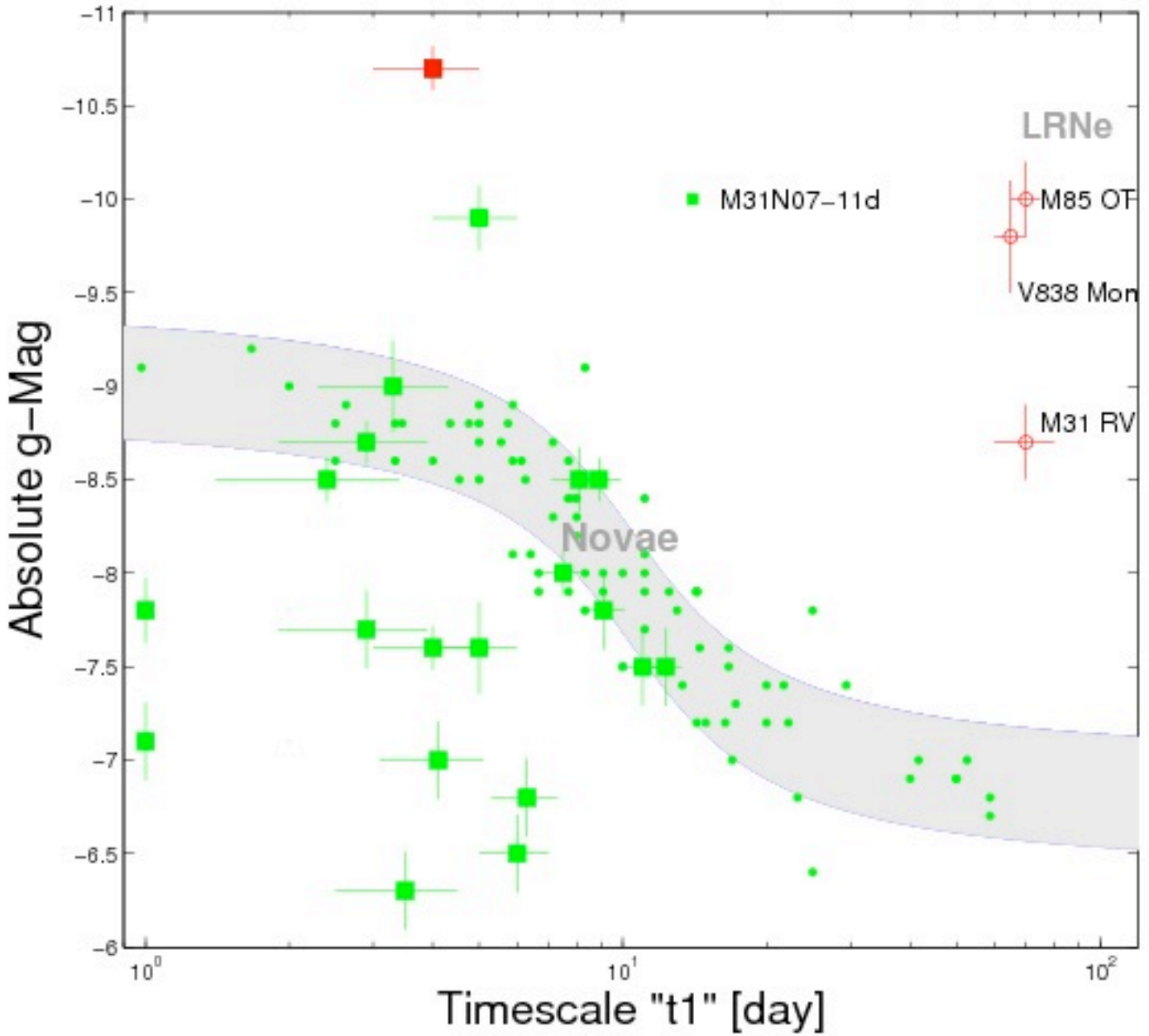

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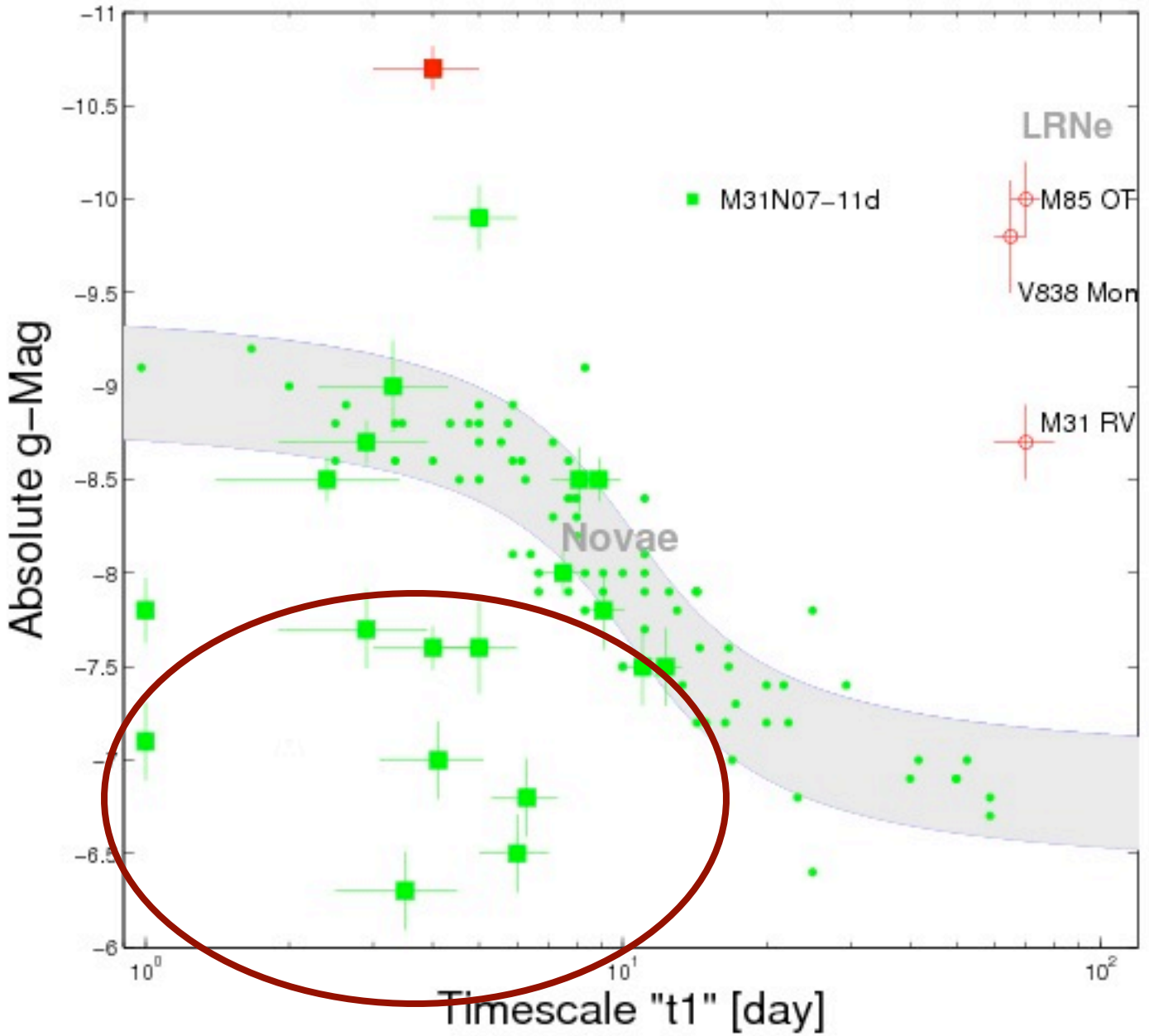

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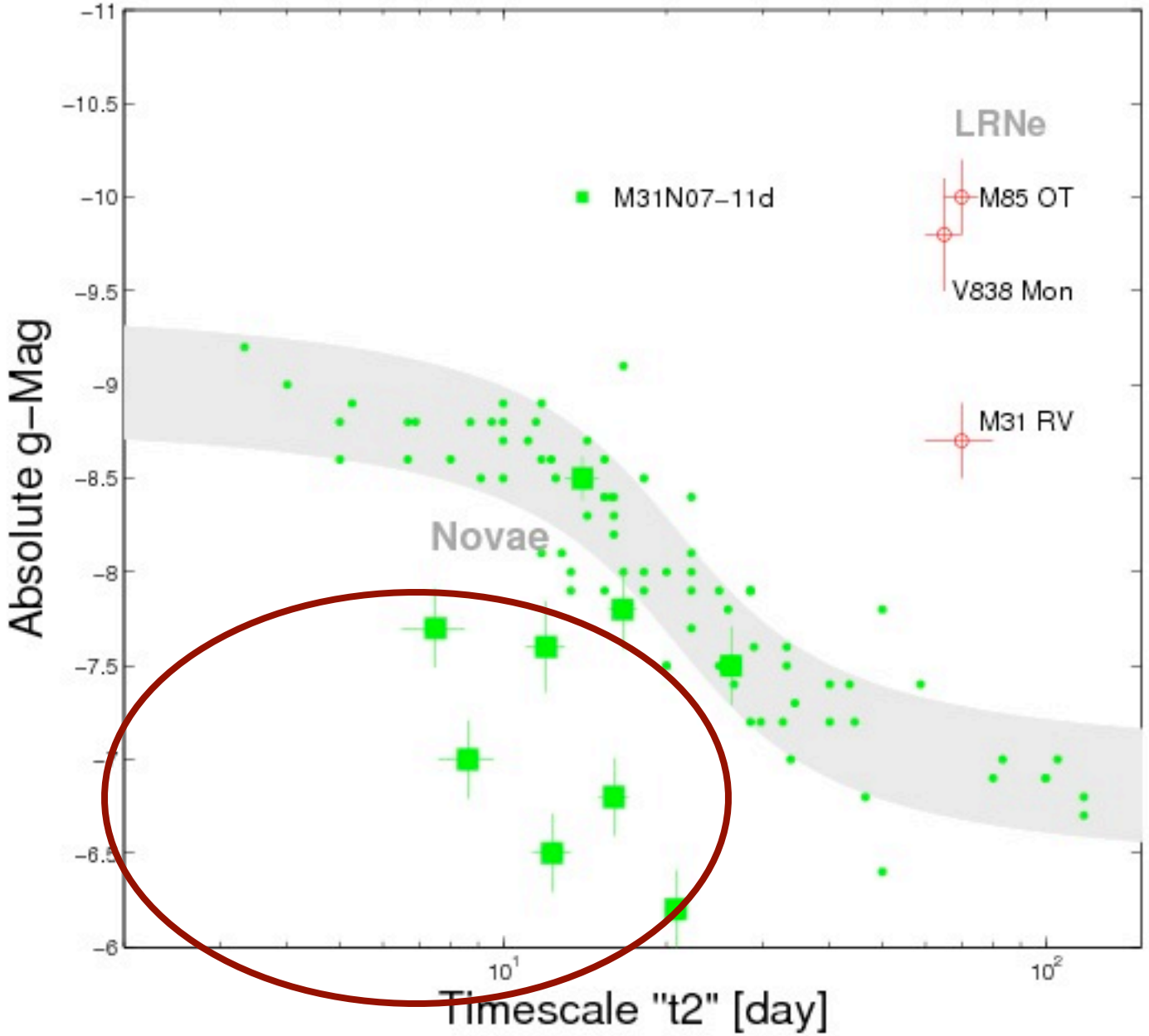

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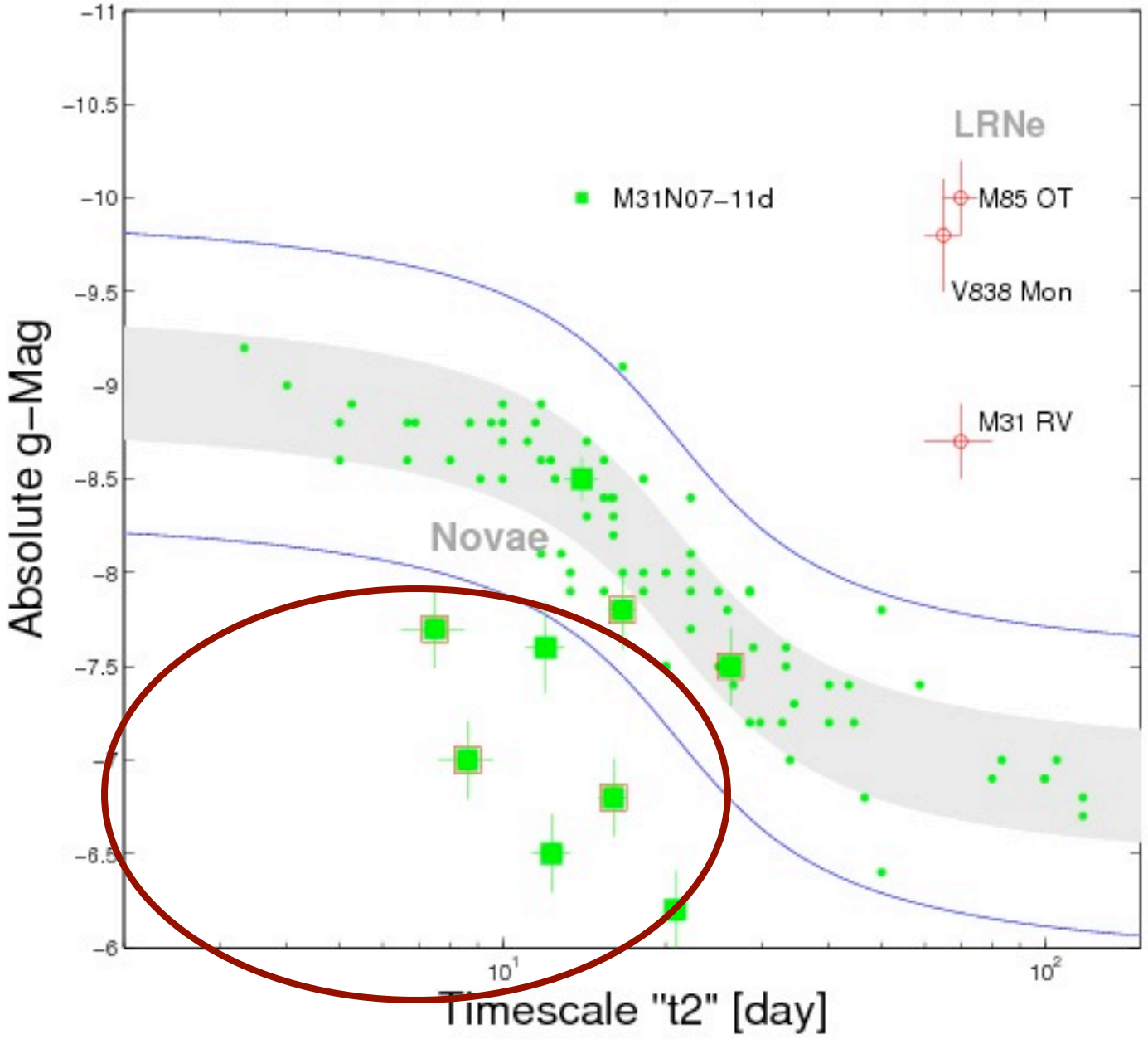

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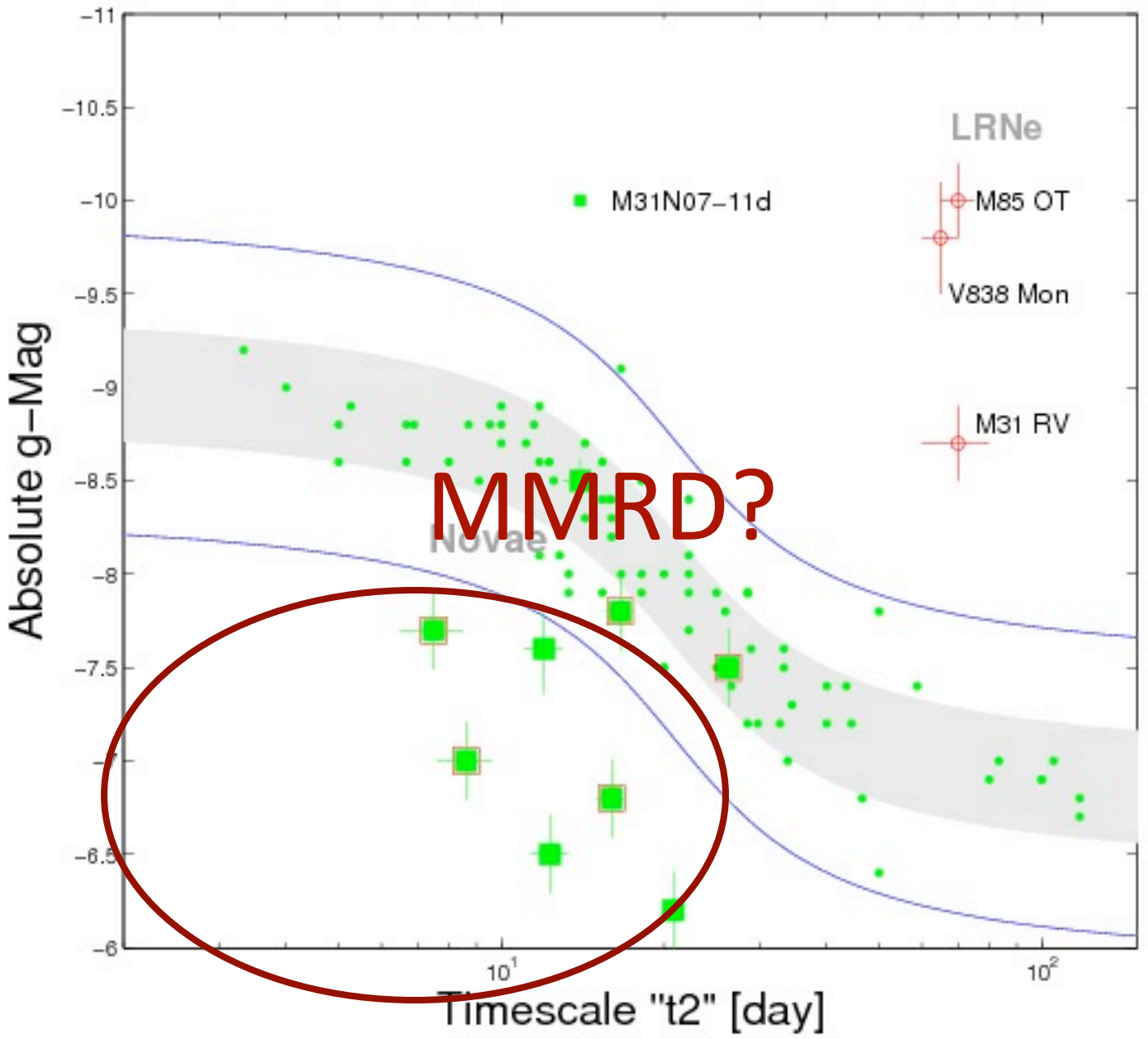

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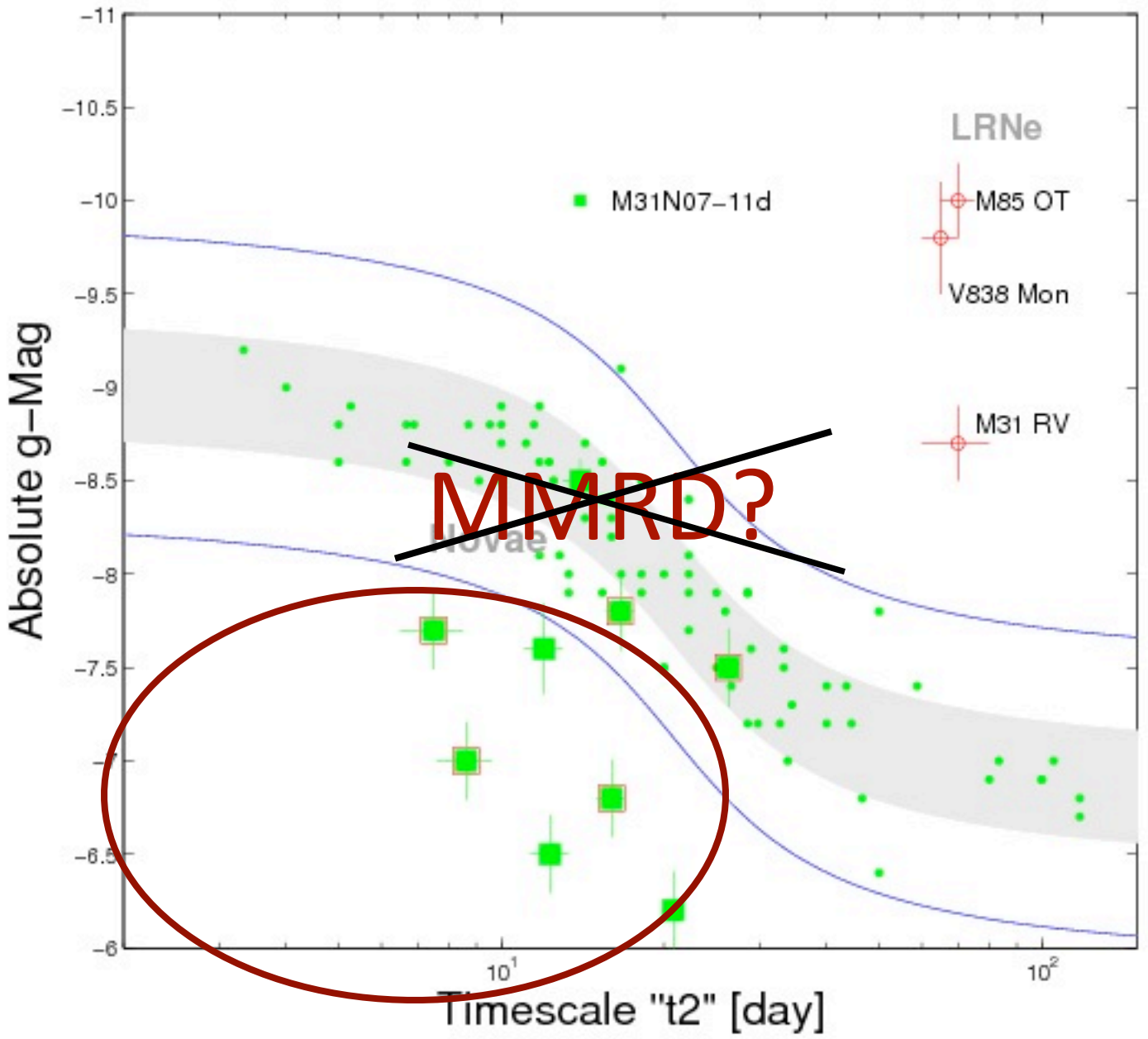
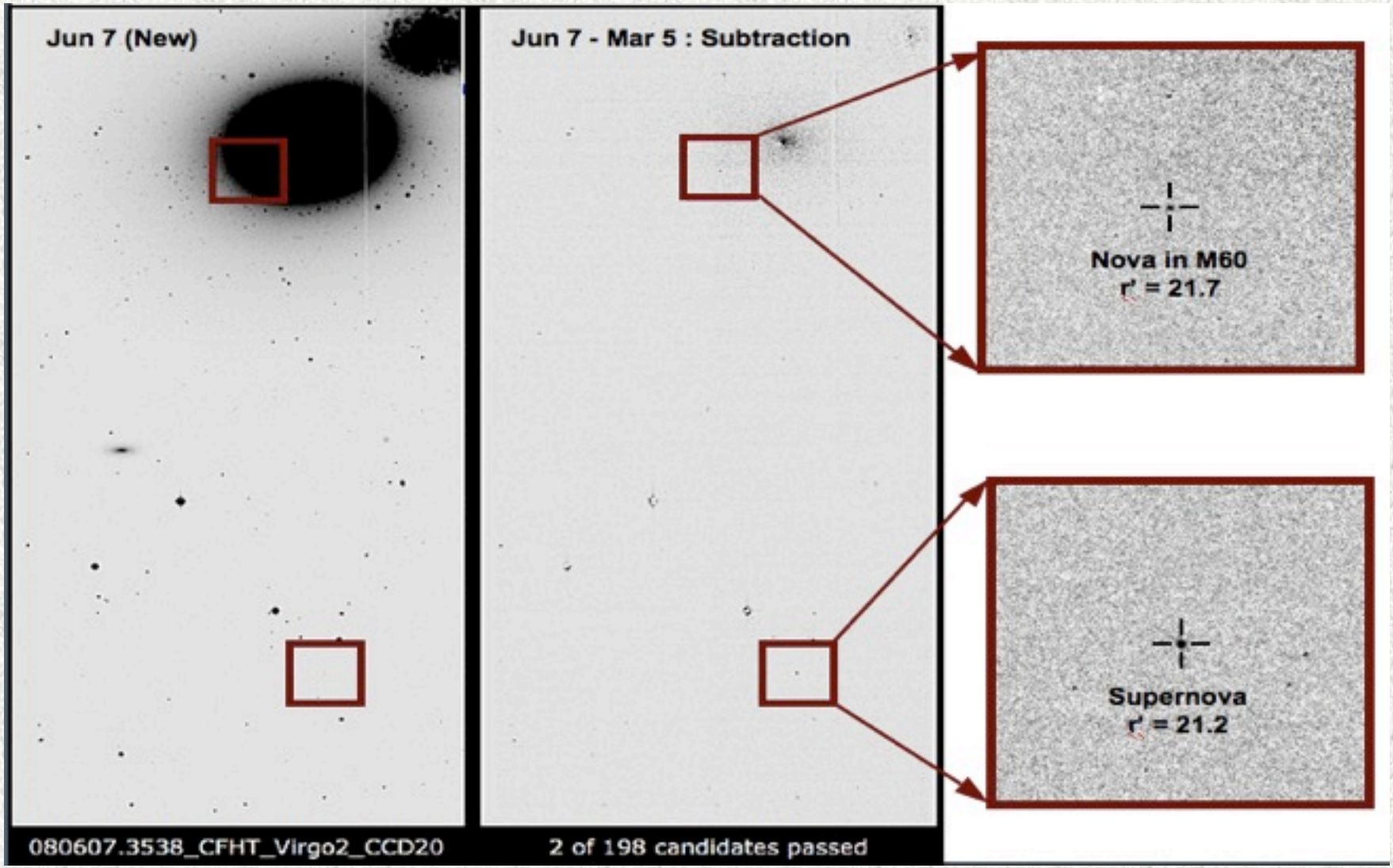


Kasliwal et al. 2009

II. CFHT-COVET



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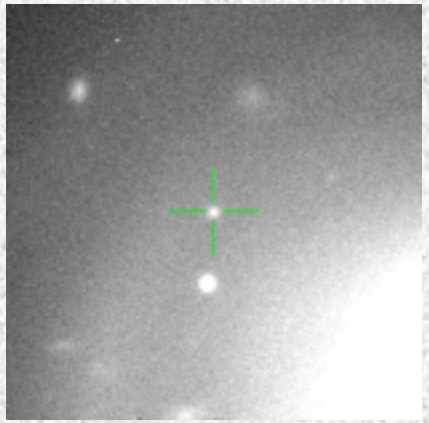
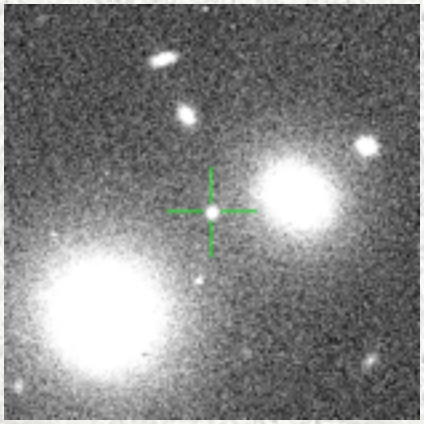
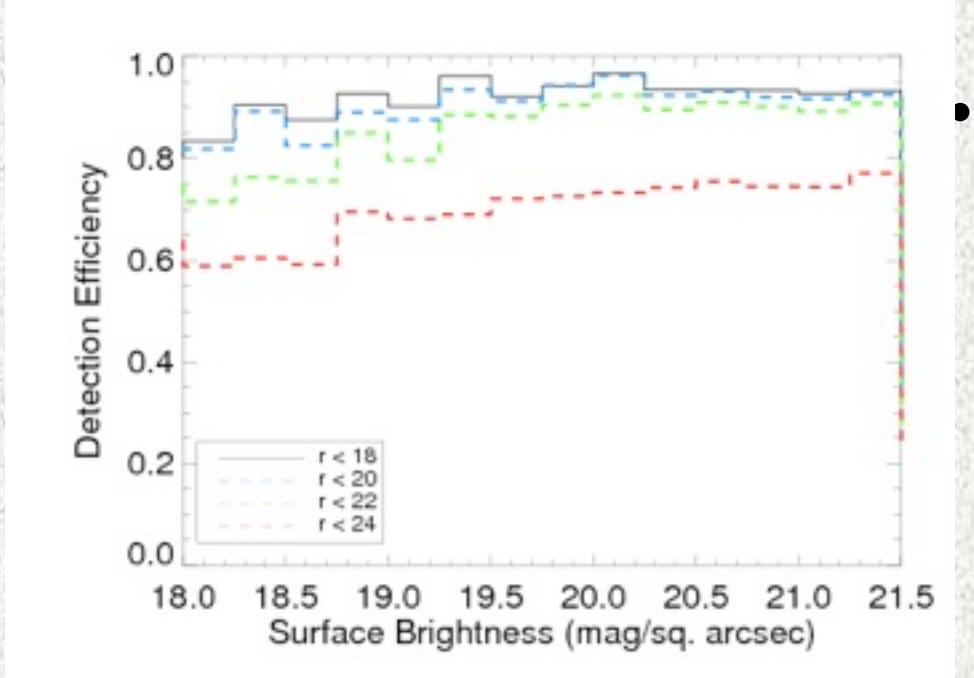




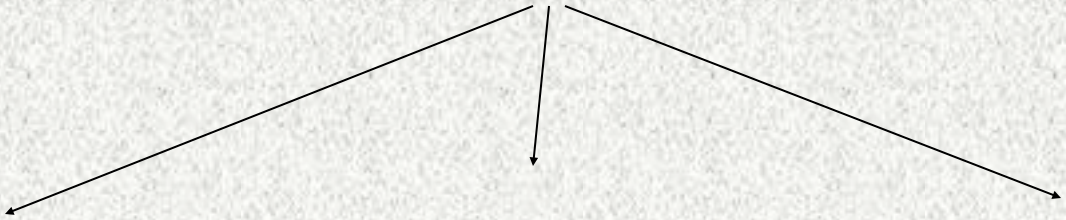


- 7 sq deg Virgo + 3 sq deg Coma, daily, 56 days
- 160 Transients :
  - 140 Background SN/AGN
  - 20 Virgo Novae
- Upper limit :
  - @ Mv < -9, Rate < 9.5 x 10^{10} Lsun-yr
  - @ Mv < -13, Rate < 4.4 x 10^{11} Lsun-yr

Mystery III. 2008S/NGC300-OT

PALOMAR TRANSIENT FACTORY

What type of star exploded !?



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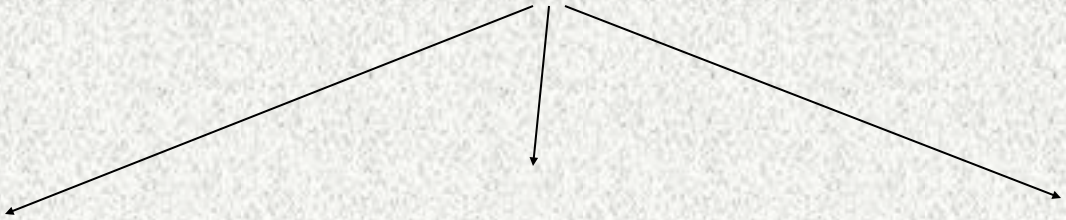
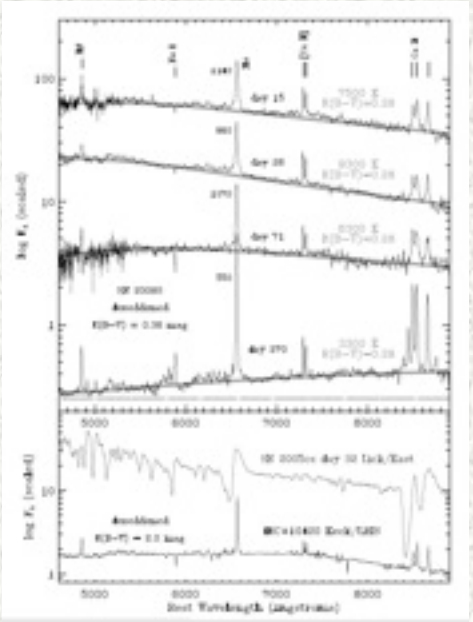


>20 $M_{\odot}$ LBV



Smith et al. 2009

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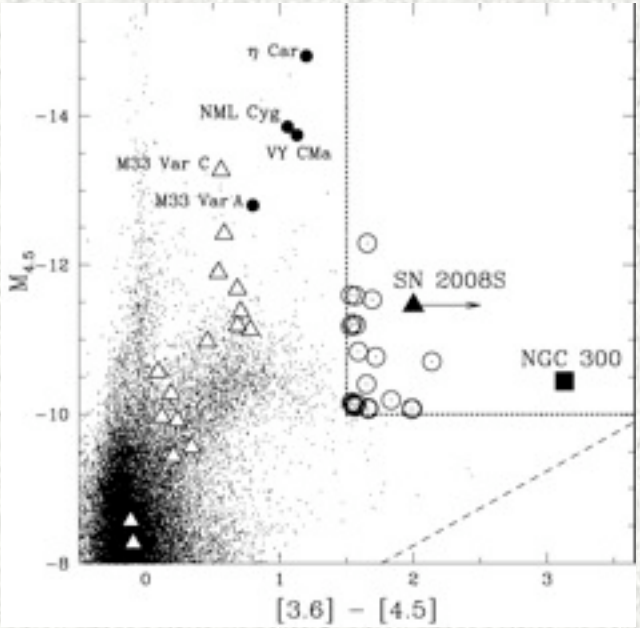
8-11 $M_\odot$ e- capture?



Thompson et al. 2008, Prieto et al. 2008

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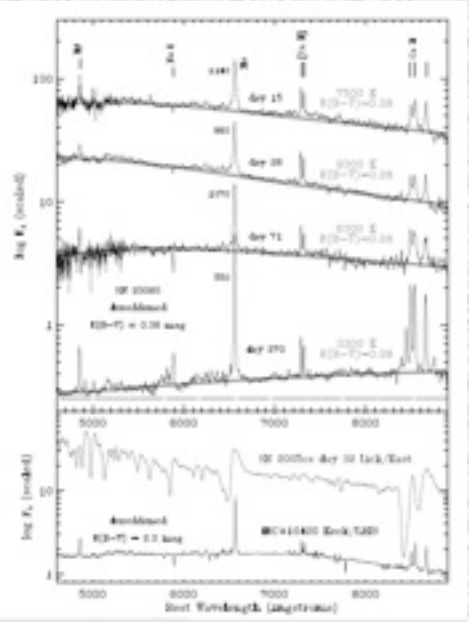

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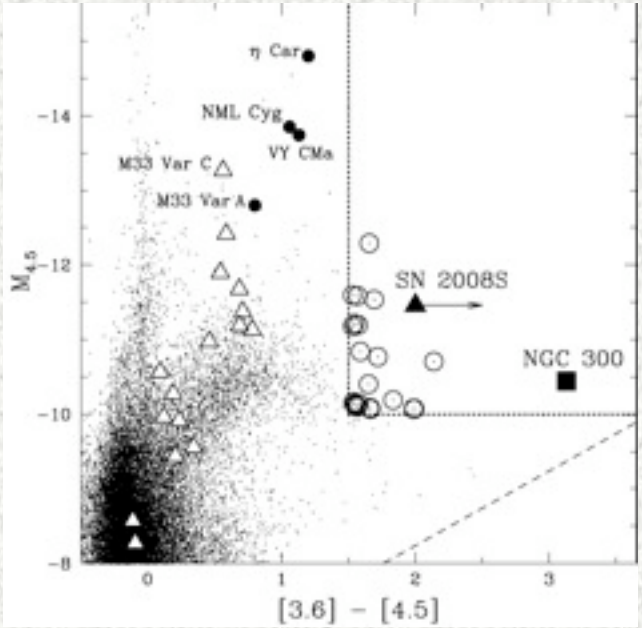

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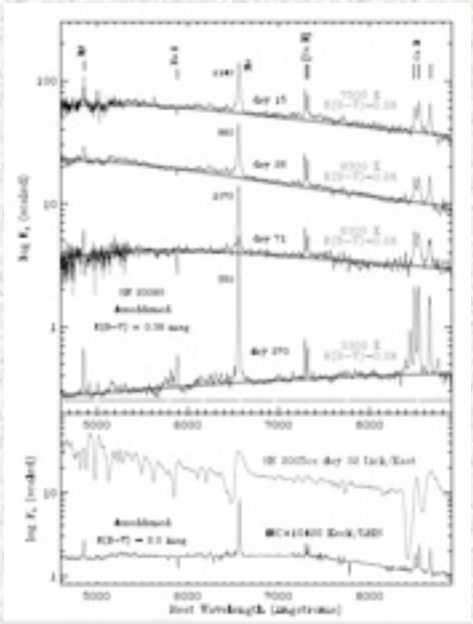
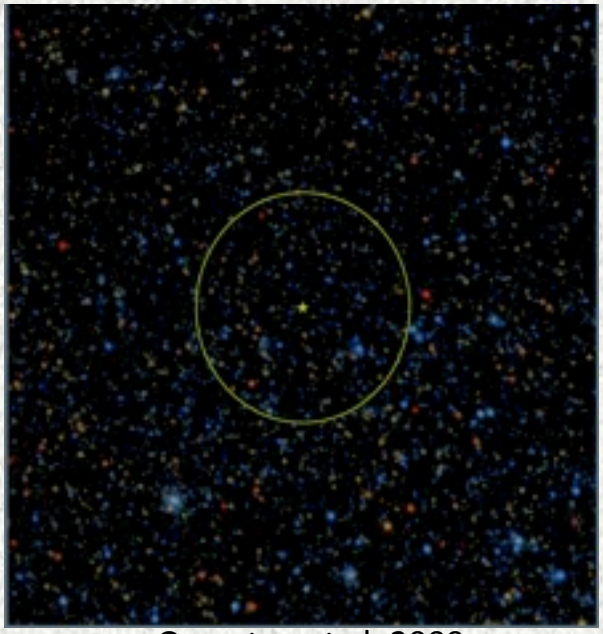


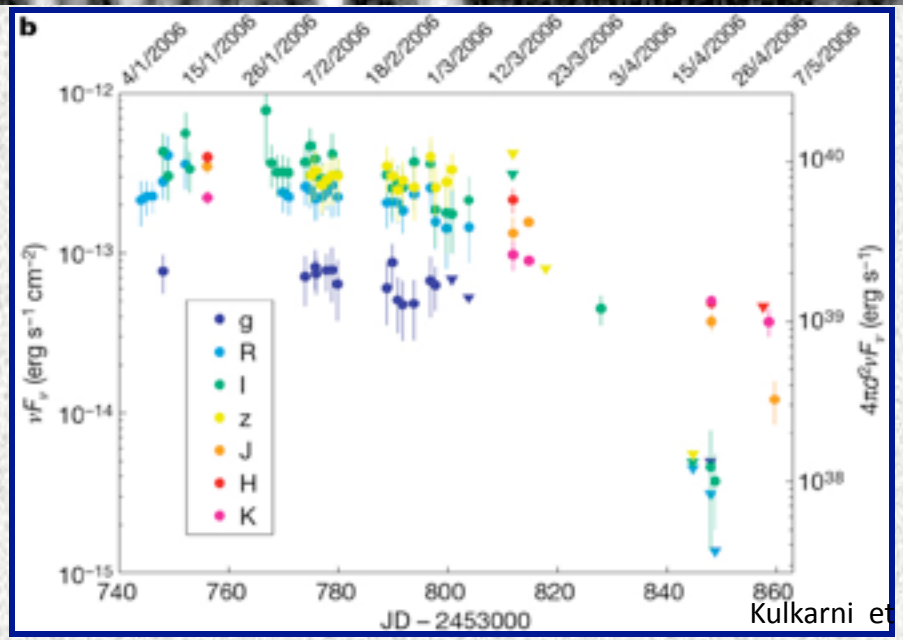
Smith et al. 2009

12-25 $M_\odot$ SN?



Gogarten et al. 2009

Mystery IV. M85OT/M31RV/V838Mon



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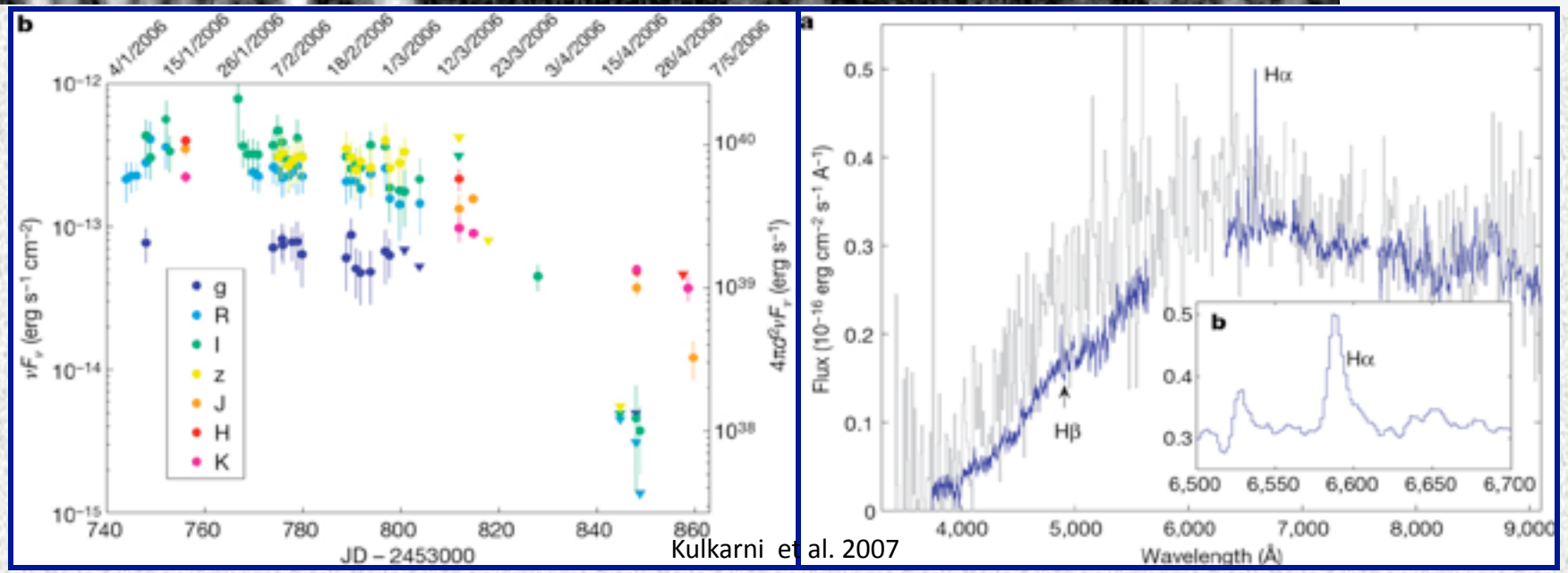

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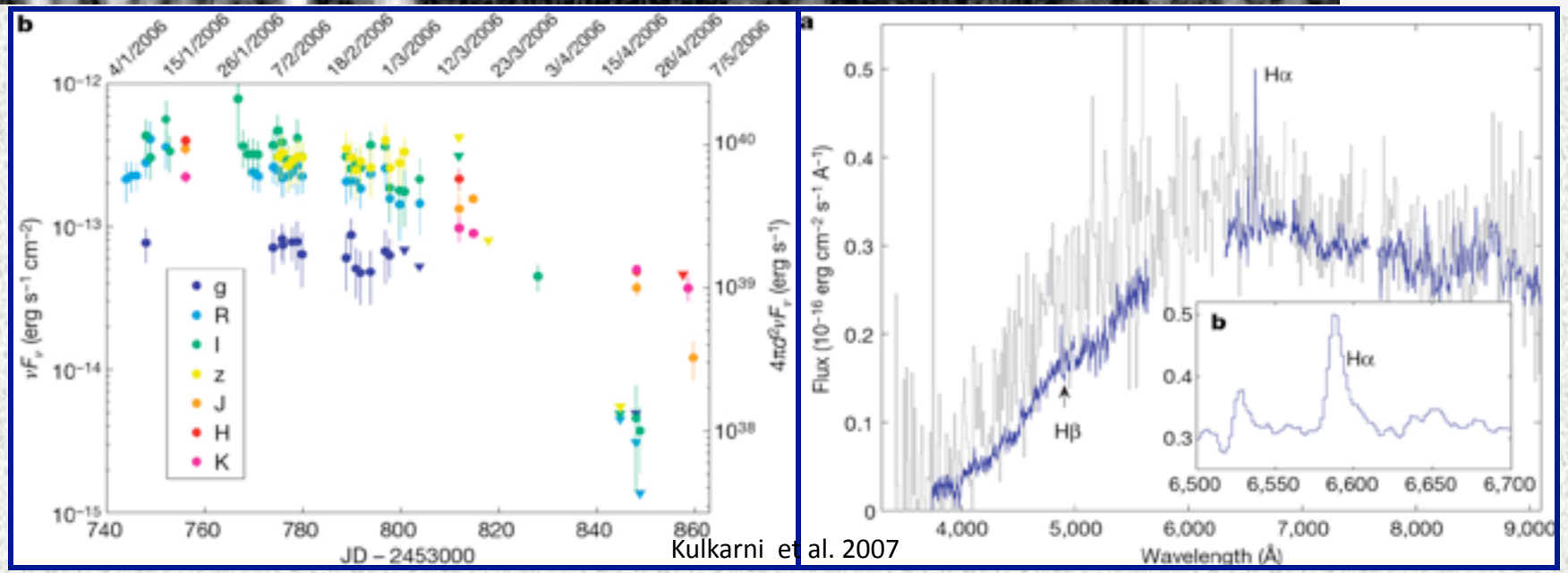

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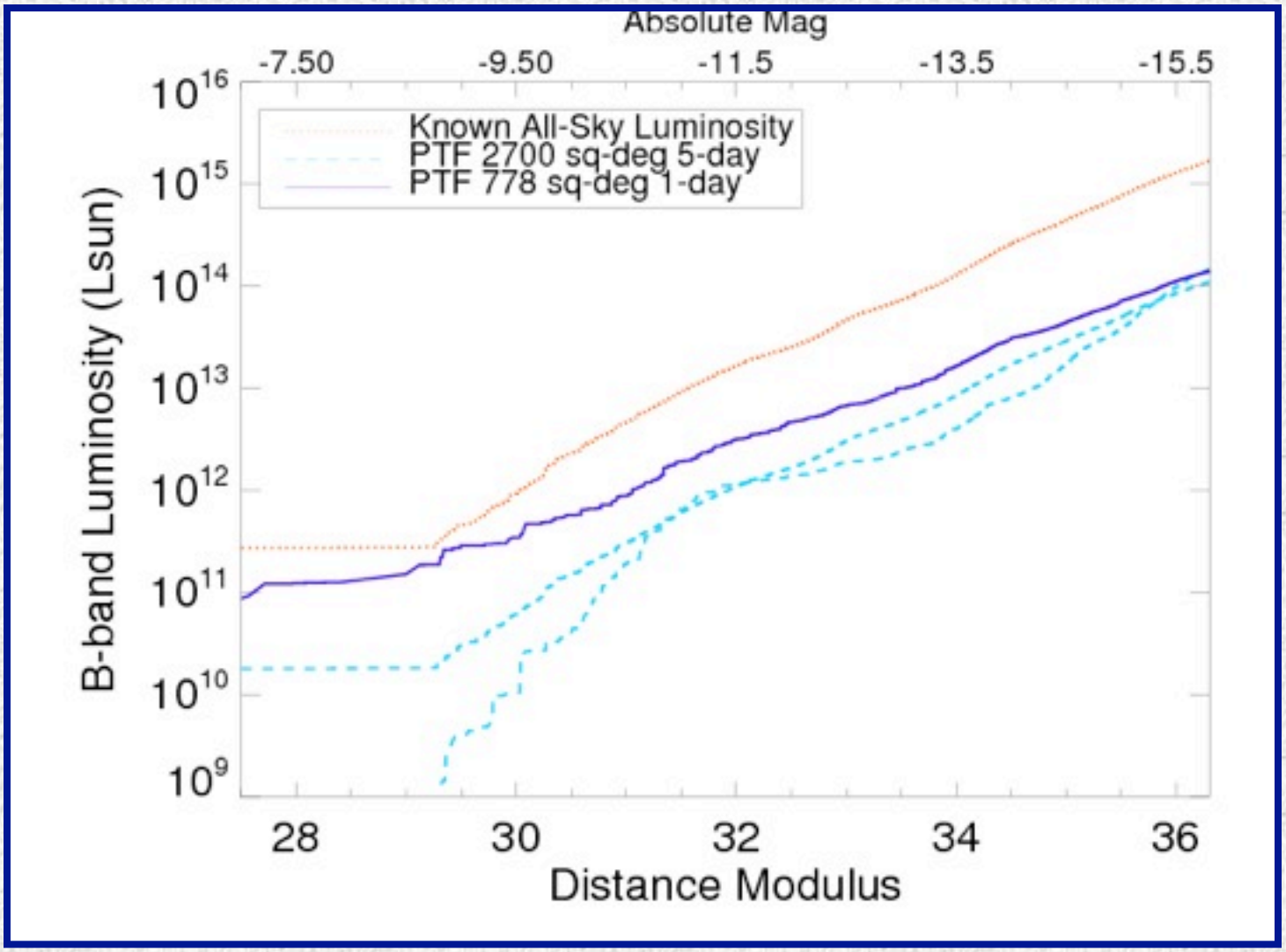
Local Overdensity