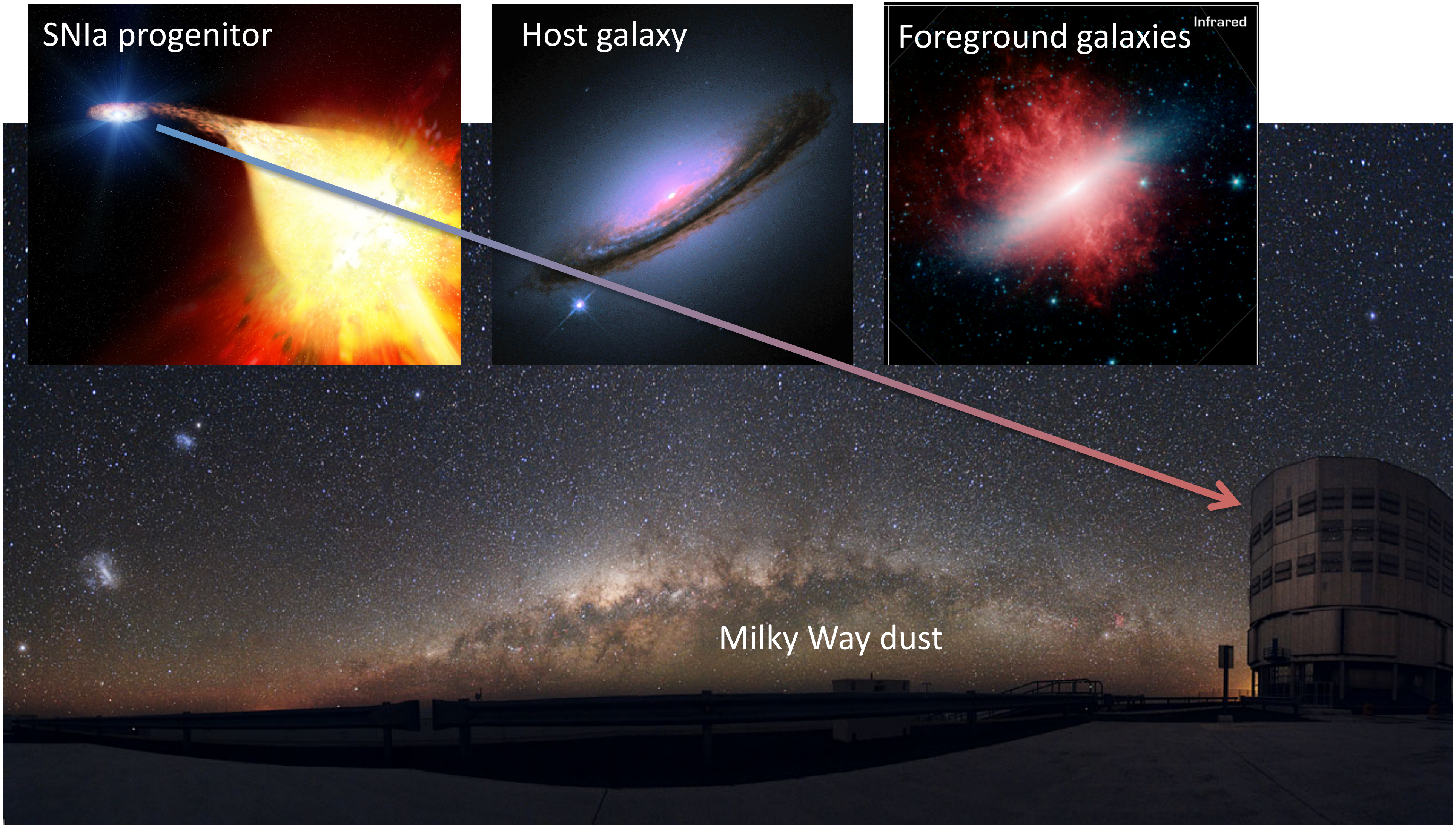
iPTF
Type Ia Supernovae in the infrared

(work in progress together with
Ori Fox, Ariel, Mansi, Yi and many more)

Stockholm University

Oskar Klein Centre for Cosmoparticle Physics


Stockholm
University


SNIa progenitor
Host galaxy
Foreground galaxies
Infrared
Milky Way dust

Why Infrared?

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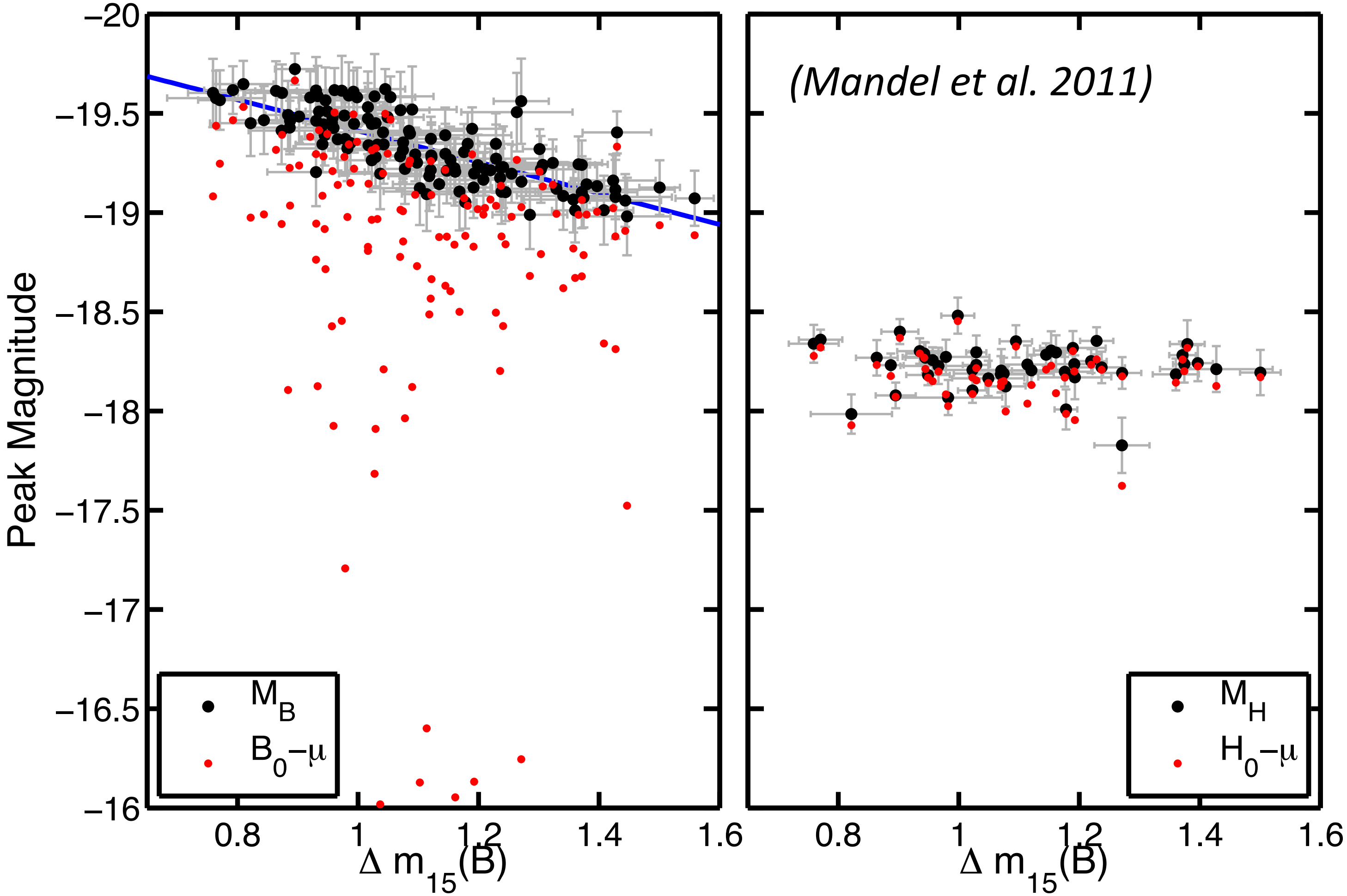
- SNe Ia are not standard candles!
  - ”Standardizable” = apply color and stretch corrections ($\sigma_B \approx 0.13$ mag)
  - already standard in the NIR! ($\sigma_{J,H} \approx 0.15$ mag)
  - Less dust absorption ($A_B / A_H \approx 6$)

- Thermal emission from heated circumstellar dust?

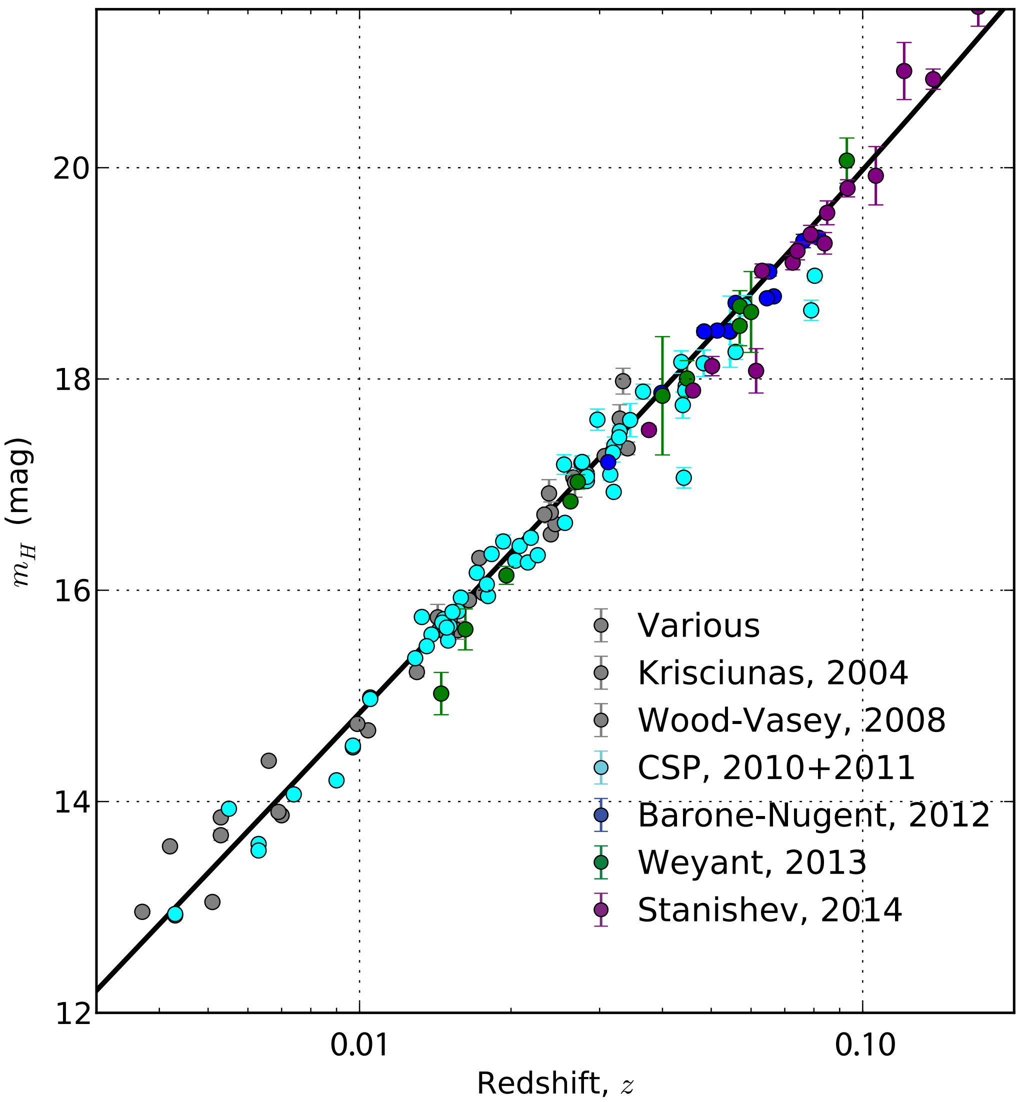
Minimizing dust extinction…



Dust extincted / corrected peak magnitudes in optical *B*-band

Dust extincted / corrected peak magnitudes in near-IR *H*-band

NIR Hubble diagram

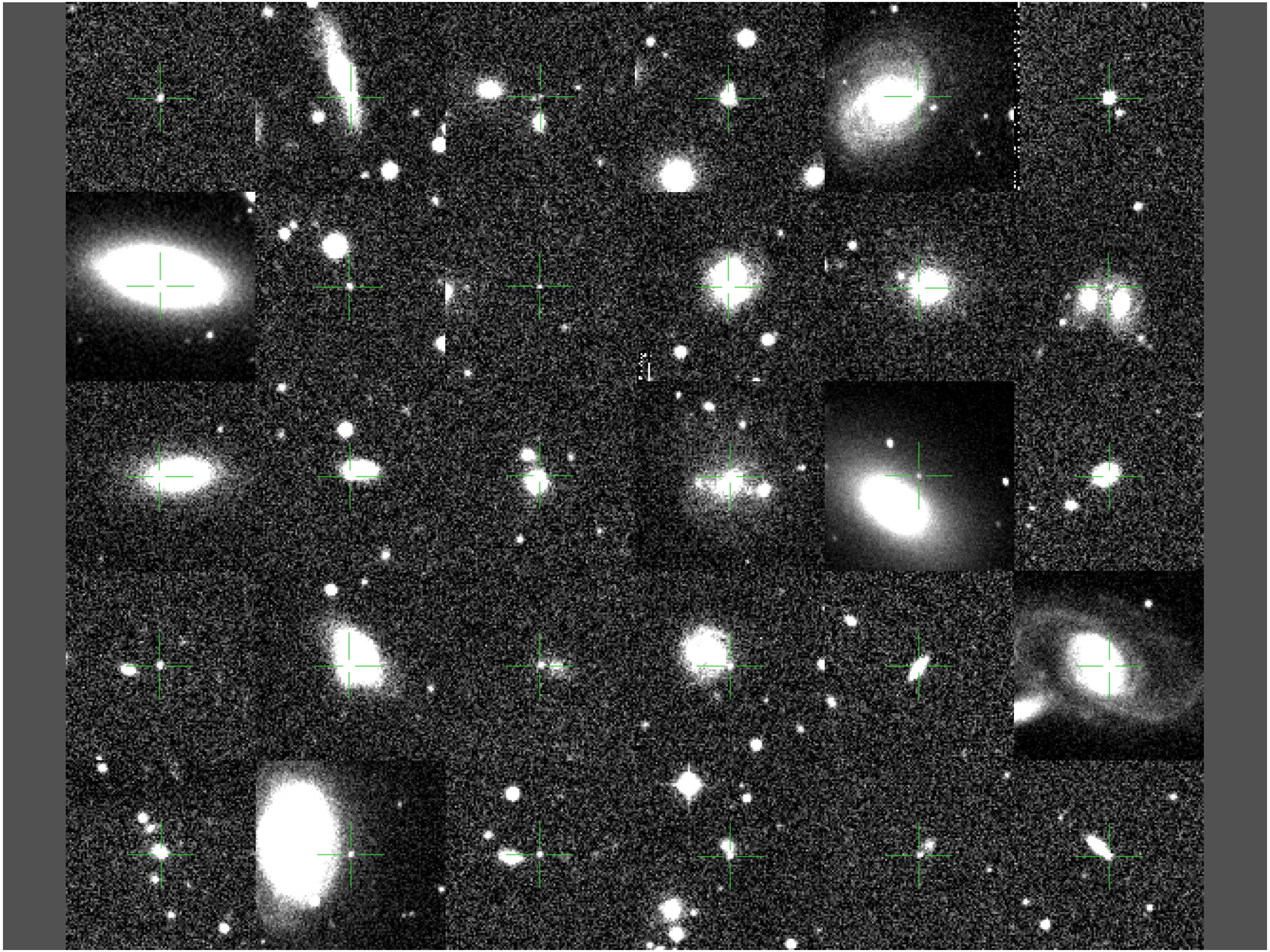


CSP: Contreras (2010) + Stritzinger et al. (2011)
69 Sne, <*z*> = 0.027, many epochs!
2.5m du Pont (+1m Swope, 6.5m Magellan)

Barone-Nugent et al. (2012)
12 (**PTF**) SNe, <*z*>=0.056
8.2m Gemini & VLT HAWK-I

Weyant et al. 2013
11 SNe (5 ***PTF****),* <*z*> = 0.041, 3-6 NIR epochs
3.5m WIYN

Stanishev et al. 2014 (*in prep.*)
16 SNe, <*z*>=0.091, 1-2 NIR epochs
2.5m NOT, 8.2m VLT



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Optical+NIR follow-up of iPTF SNIa

iPTF13s	0.060	RATIR
iPTF13ez	0.044	RATIR+CSP
iPTF13ft	0.039	RATIR
iPTF13abc	0.074	RATIR+NOT
iPTF13ahk	0.026	RATIR+NOT
iPTF13anh	0.062	RATIR+CSP+NOT
iPTF13aro	0.085	RATIR+NOT
iPTF13asv	0.035	RATIR+NOT
iPTF13ayw	0.054	RATIR+NOT
iPTF13azs	0.034	RATIR+NOT
iPTF13bkw	0.064	RATIR+NOT
iPTF13crp	0.062	RATIR+NOT
iPTF13daw	0.070	RATIR+NOT
iPTF13ddg	0.084	RATIR
iPTF13dge	0.016	RATIR+NOT
iPTF13dkj	0.036	RATIR+NOT
iPTF13dkx	0.030	RATIR+NOT
iPTF13duj	0.016	RATIR+CSP+NOT
iPTF13dwl	0.080	CSP
iPTF13dym	0.042	RATIR+CSP+NOT
iPTF13dyt	0.11	CSP

iPTF13dzm	0.016	RATIR+NOT
iPTF13ebh	0.013	RATIR+CSP
iPTF13efe	0.070	RATIR+CSP
iPTF14w	0.019	CSP
iPTF14uo	0.090	RATIR+CSP
iPTF14yw	0.017	RATIR+CSP
iPTF14yy	0.043	RATIR+CSP
iPTF14aaf	0.059	CSP
iPTF14aje	0.028	RATIR+CSP
iPTF14ale	0.093	RATIR
iPTF14ans		CSP
iPTF14apg	0.080	RATIR
iPTF14atg	0.021	RATIR
iPTF14bbr	0.065	RATIR+HAWKI
iPTF14bdn	0.016	RATIR

…

Summary:
+ 38 SNe Ia followed in BVugrizYJH
+ Redshift range: 0.01 – 0.1
+ Typically 4 NIR epochs (2 to 13)
= NICE SAMPLE!

Optical+NIR follow-up of iPTF SNIa

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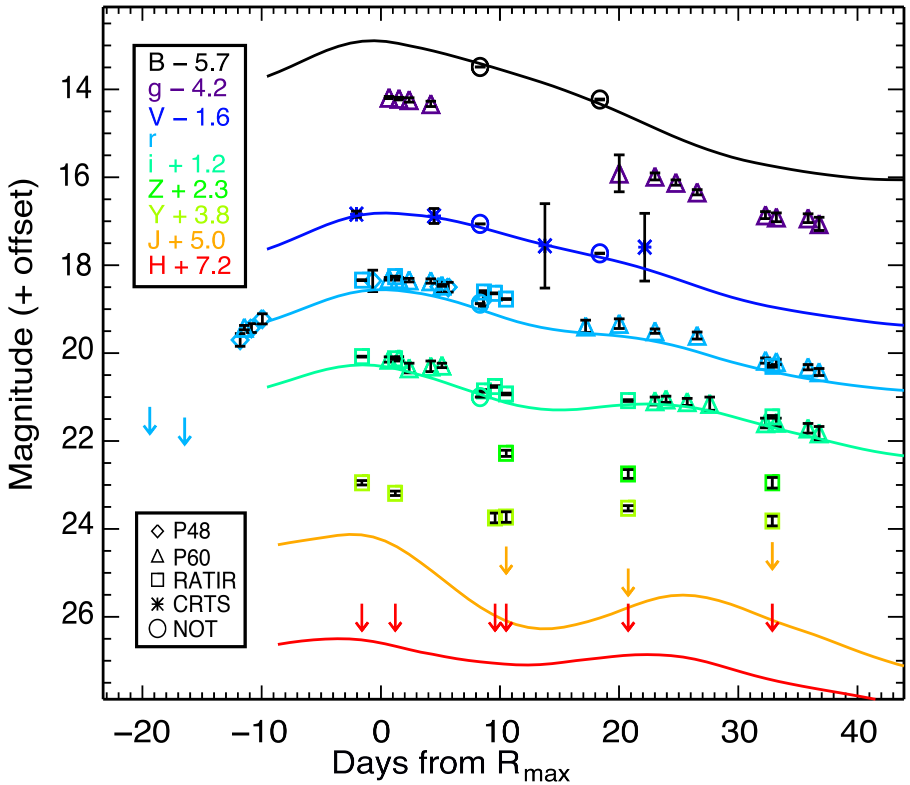
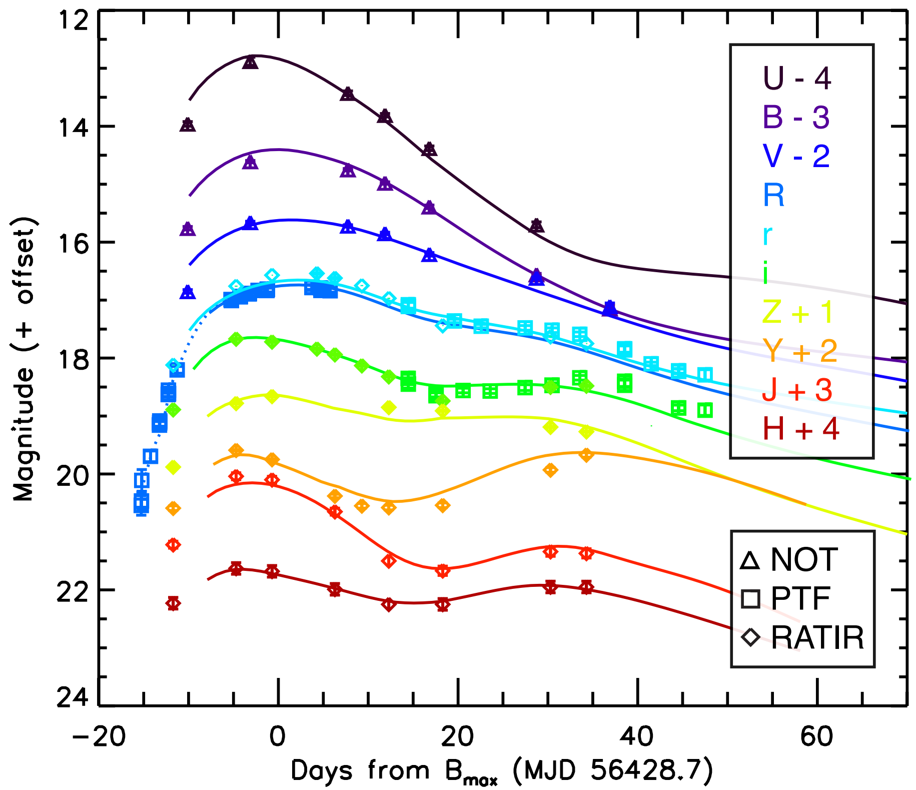
P48+P60 (Bgriz) + NOT/ALFOSC (*UBVRI*, 2.5m) and SPM/RATIR (*rizYJH*, 1.5m) + 4m/8m VISTA/VLT time to follow SNe at $z > 0.06$ during P93

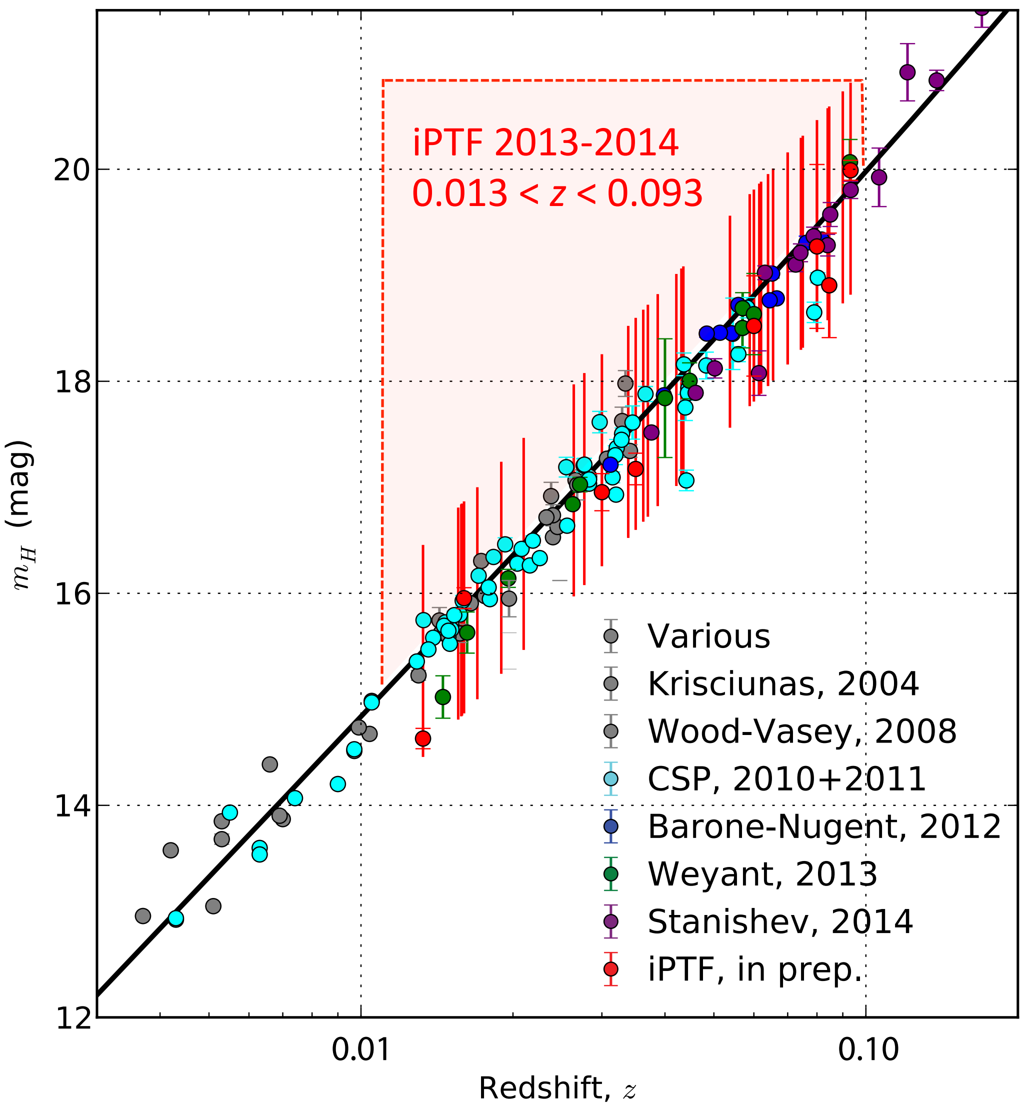
iPTF13abc (SN2013bh) at z=0.074
2000cx-like, Published in Silverman et al. 2013



iPTF13asv (SN 2013cv) at z=0.035
See Yi's talk!



NIR Hubble diagram



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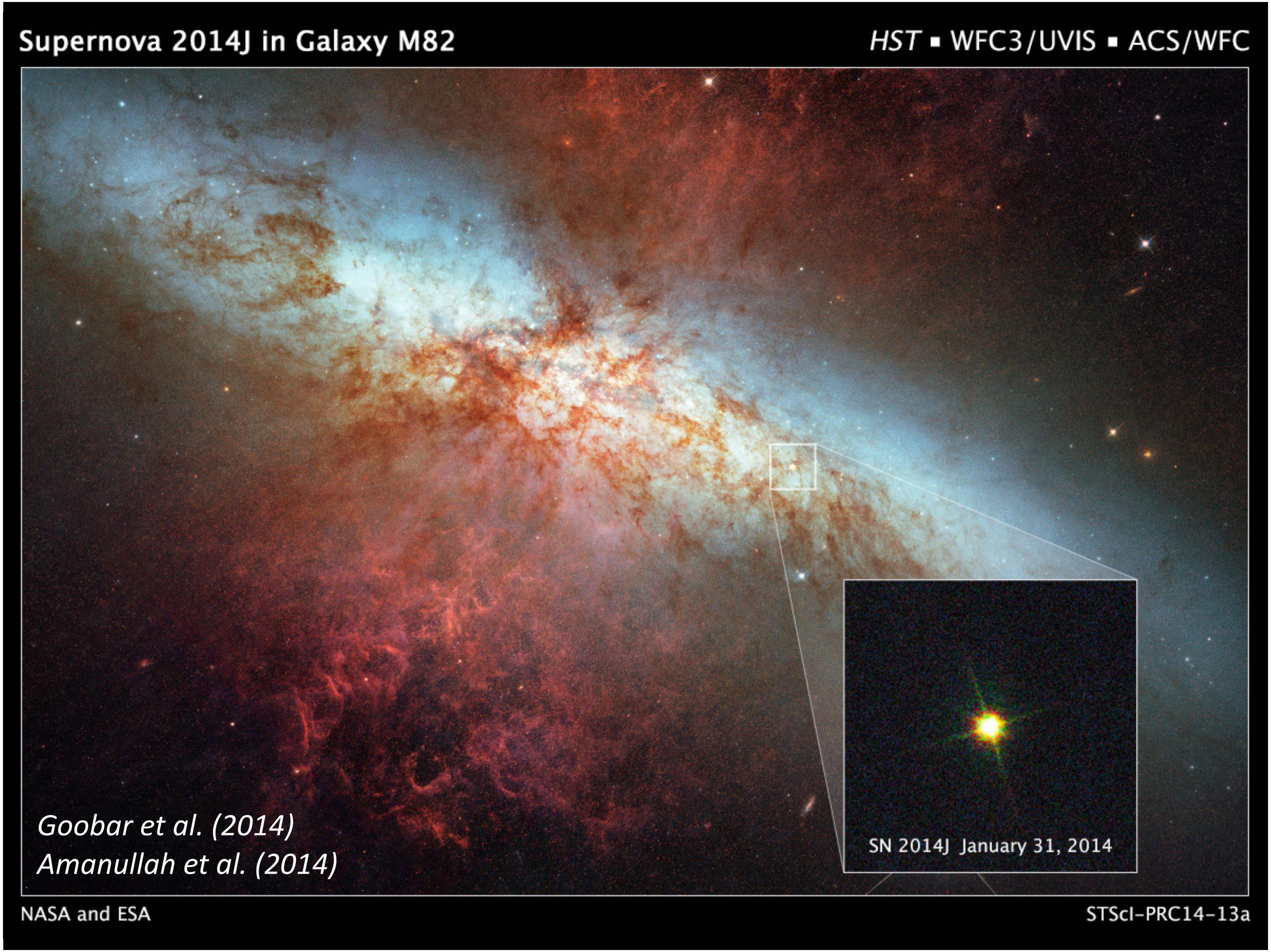
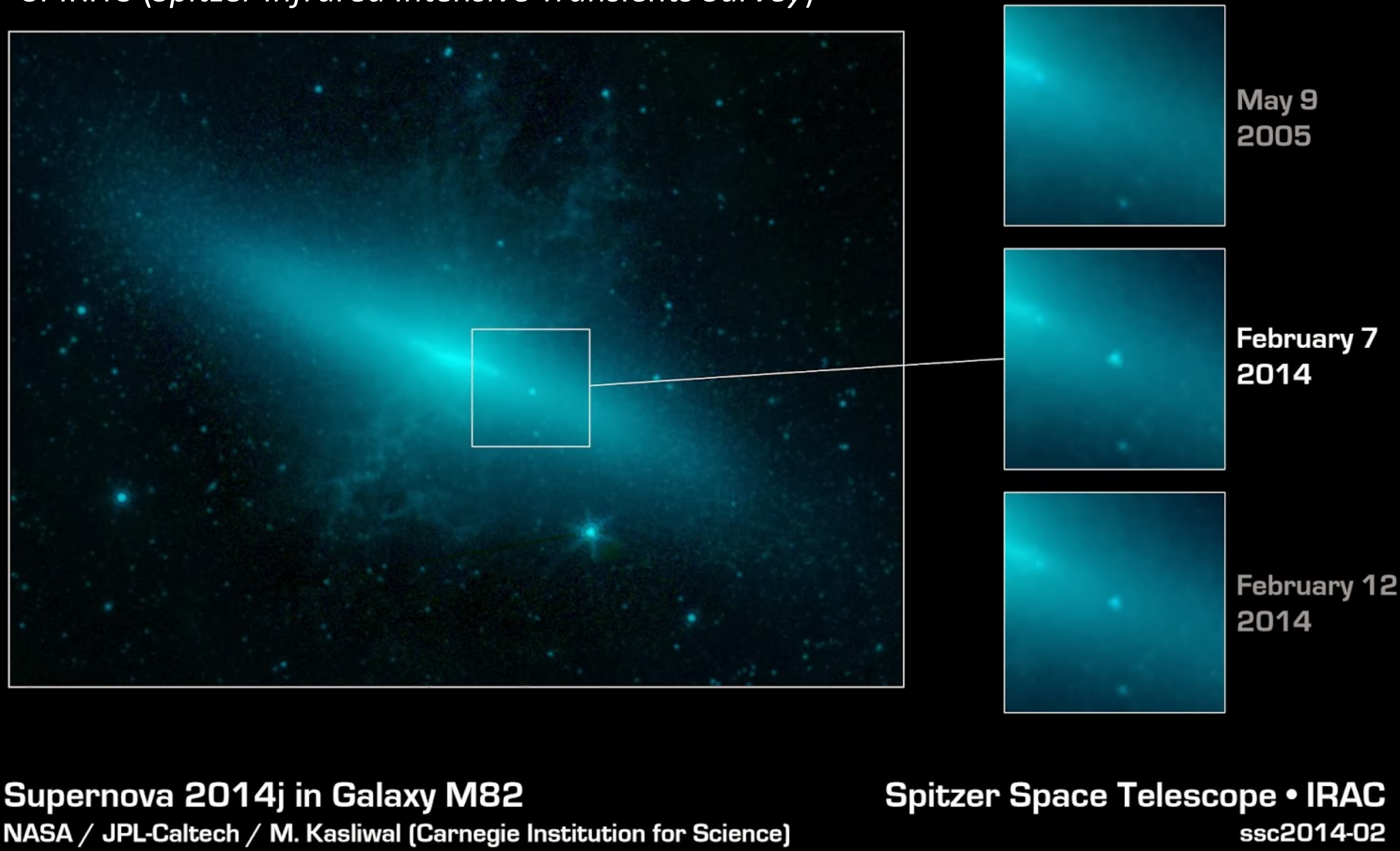
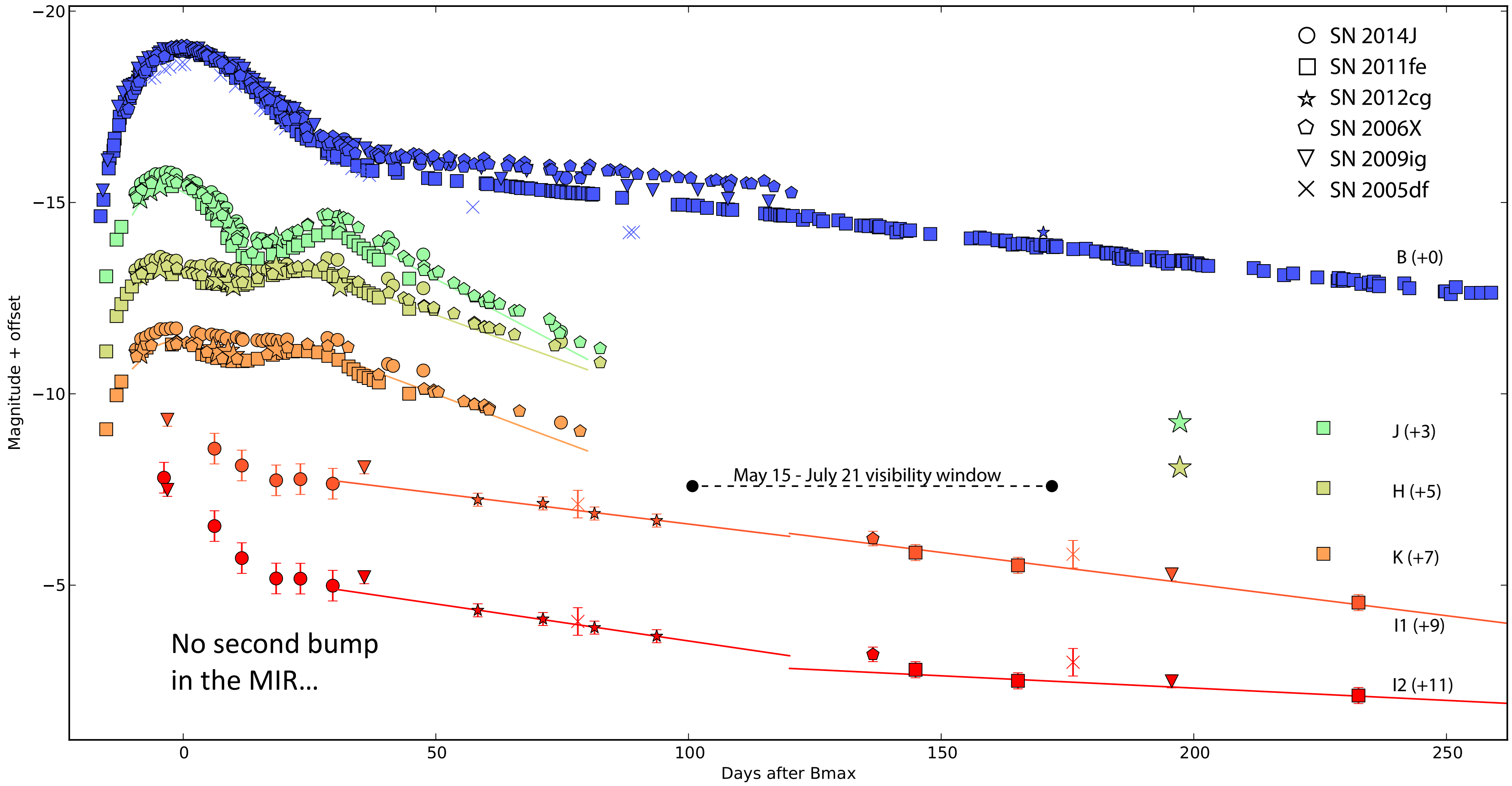
iPTF NIR sample:
- Preliminary photometry for 10 (of 38) iPTF SNe
- 10 with both RATIR and CSP follow-up
- Currently collecting reference images for 2013 data
- rizYJH 1.5m RATIR data (+ CSP and 4/8m VISTA/VLT)


Supernova 2014J in Galaxy M82
HST ▪ WFC3/UVIS ▪ ACS/WFC
SN 2014J January 31, 2014
Goobar et al. (2014)
Amanullah et al. (2014)
NASA and ESA
STScI-PRC14-13a

SPIRITS (*Spitzer Infrared Intensive Transients Survey*)



SN 2014J in the mid-Infrared



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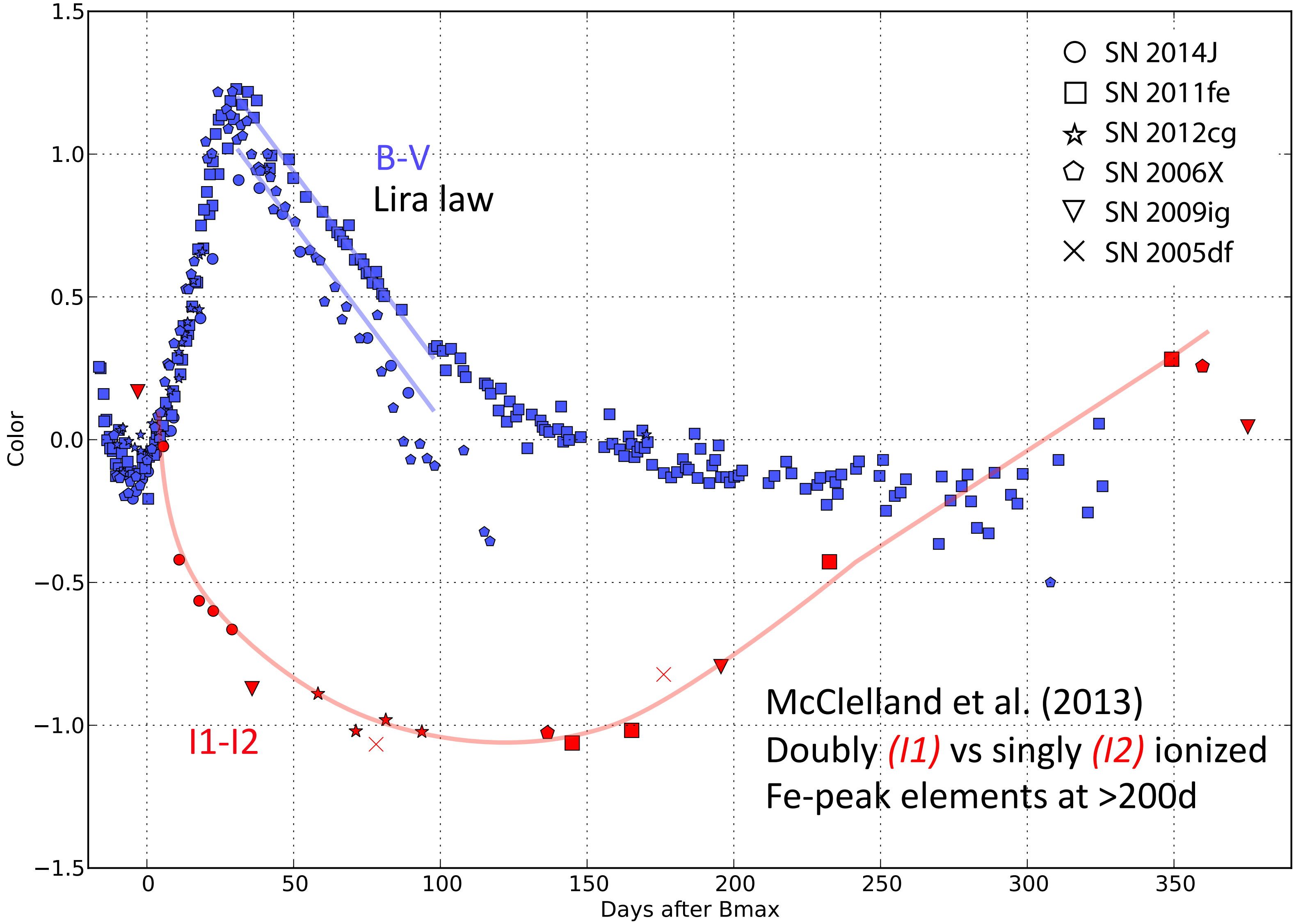

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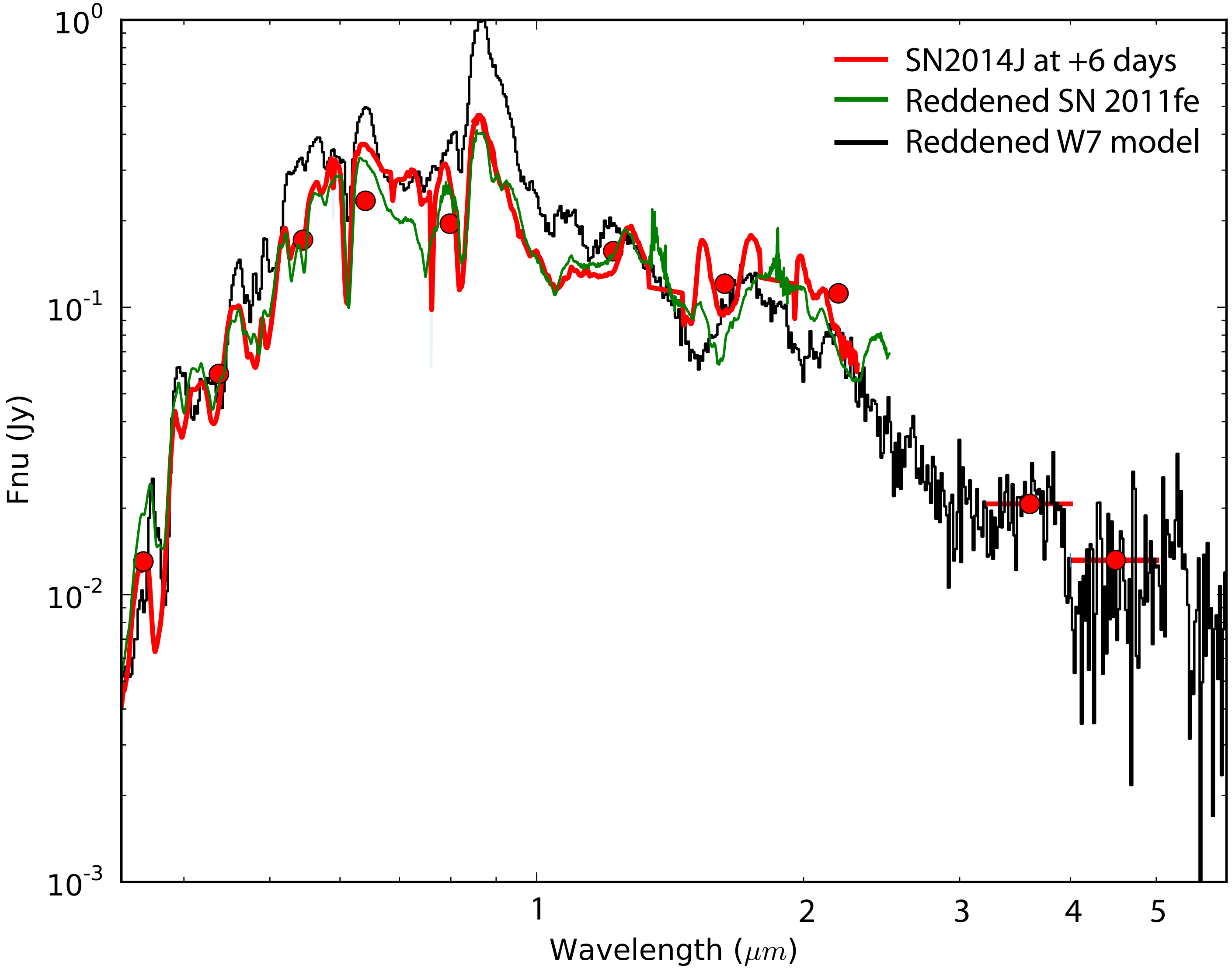

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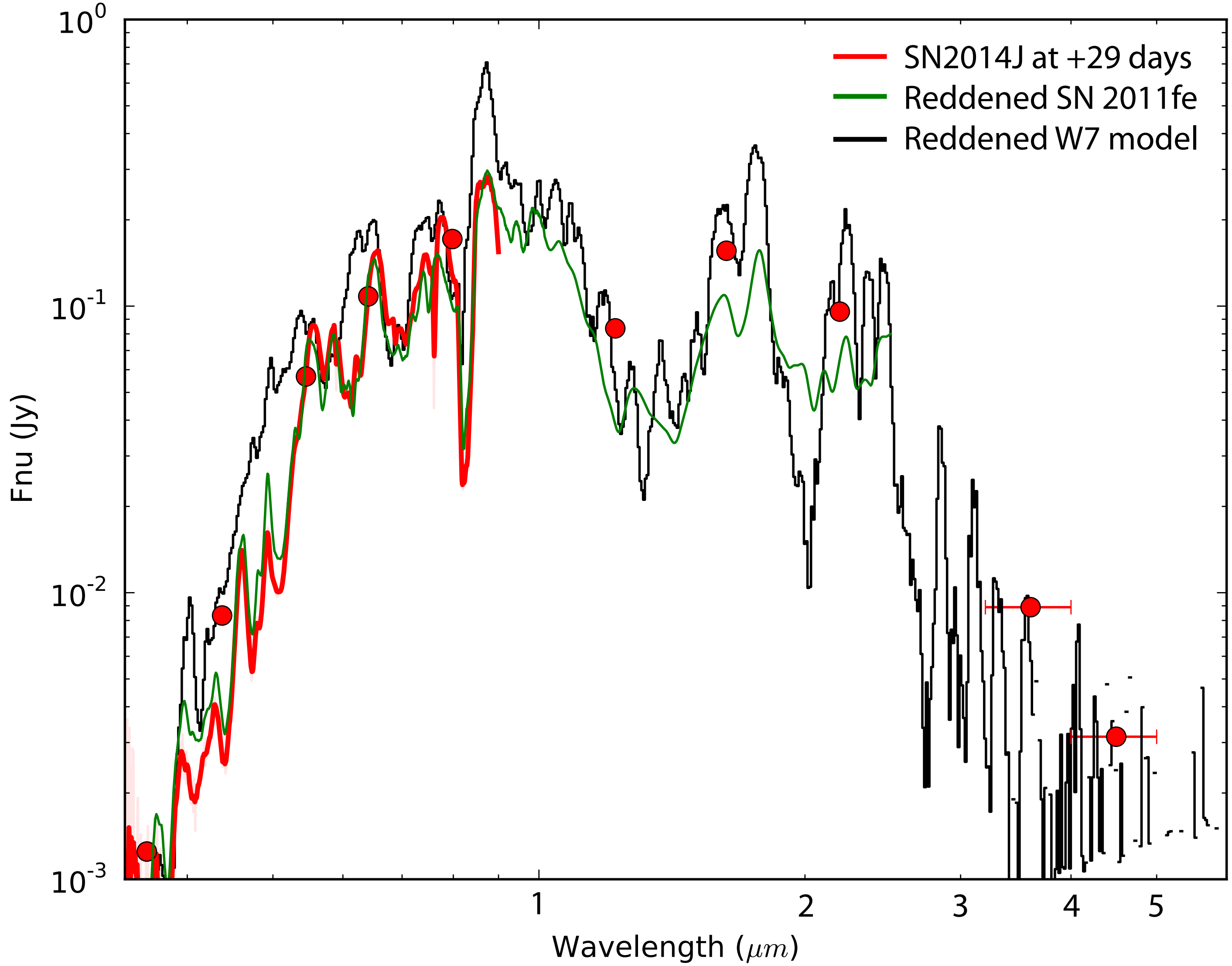

Ni II & Fe II (model from M. Kromer)

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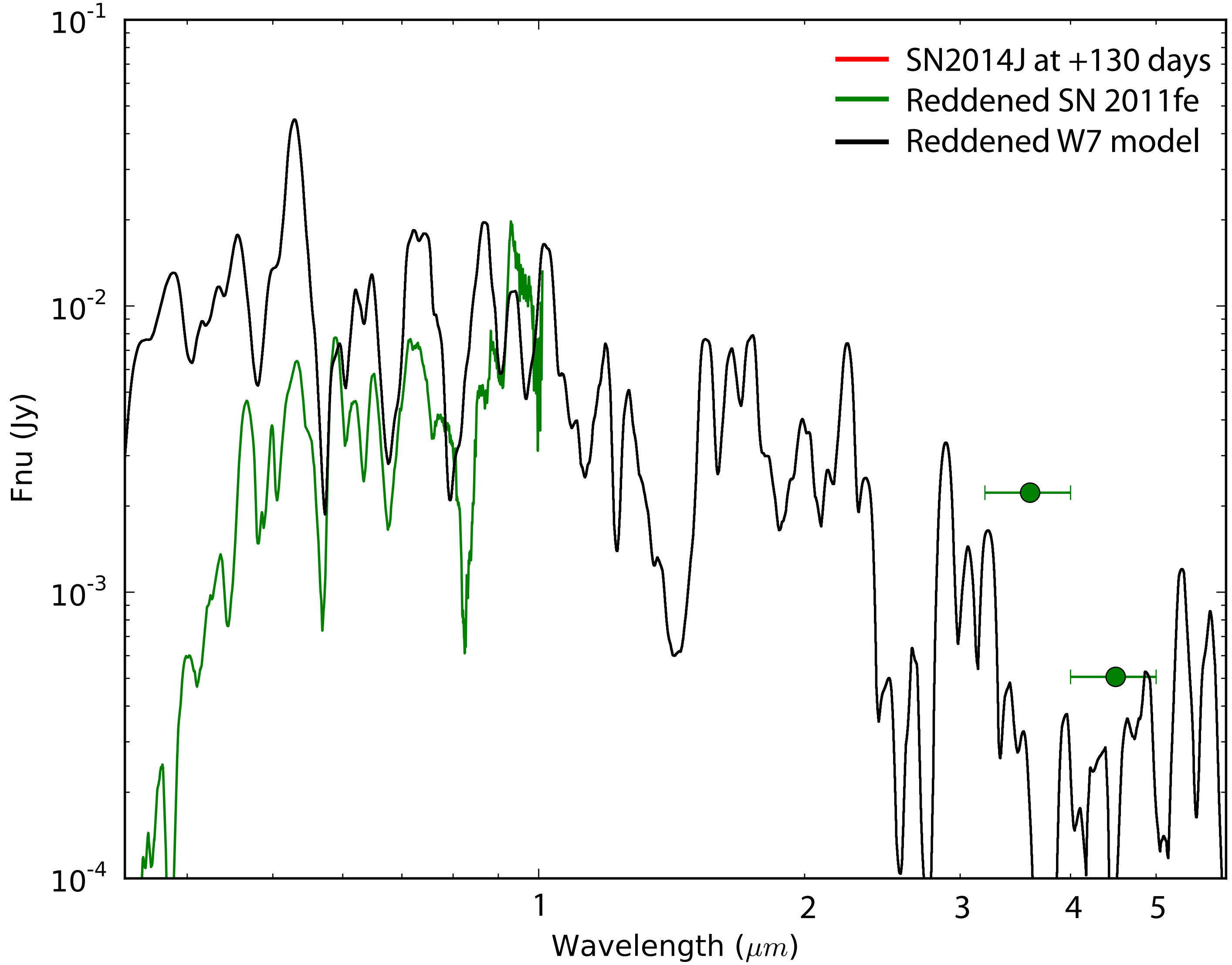
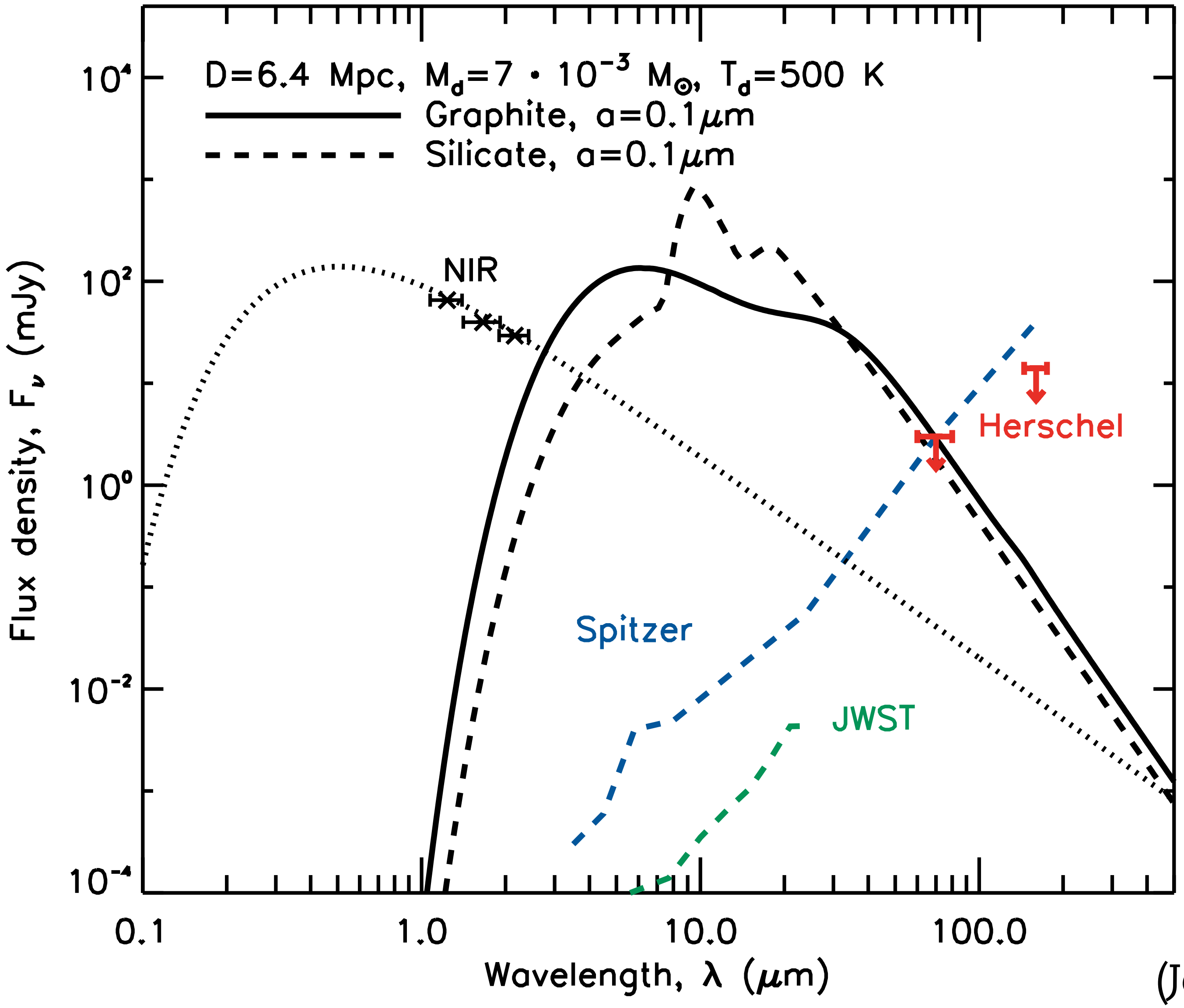


Ni II & Fe II (model from A. Jerkstrand)

CS dust limits from mid-IR



Dust shell at $r_d \sim 10^{17}$ cm

Heated to ~ 500 K (Fox, 2010)

Upper limit on CS dust mass For SN 2011fe, $M_d < 7 \times 10^{-3}\ M_\odot$

(Johansson et al, 2012)

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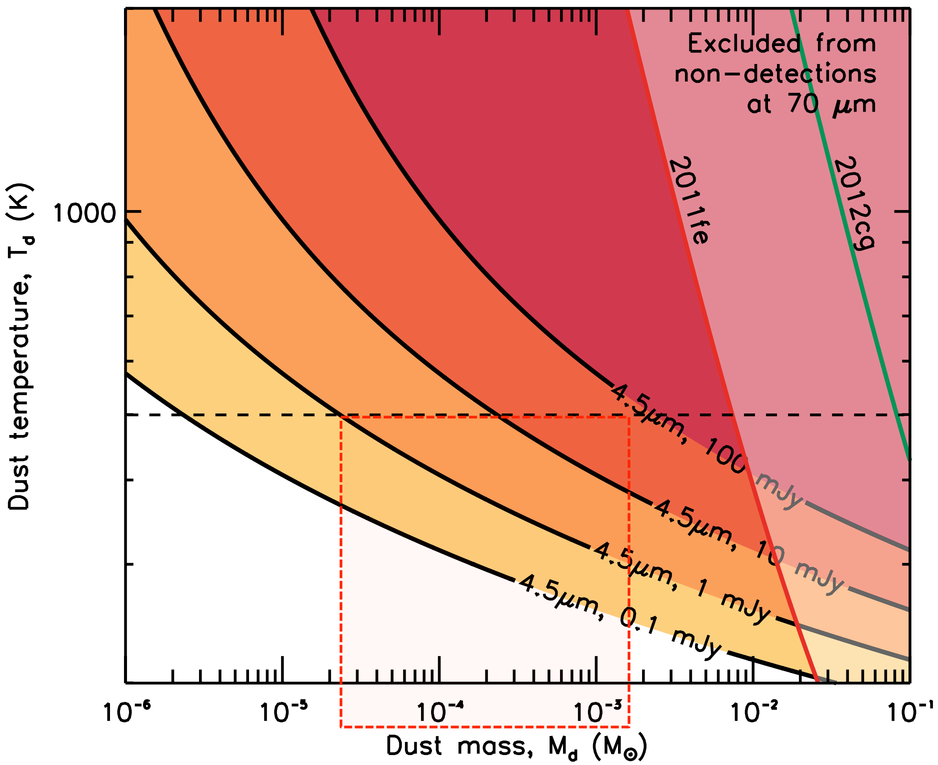
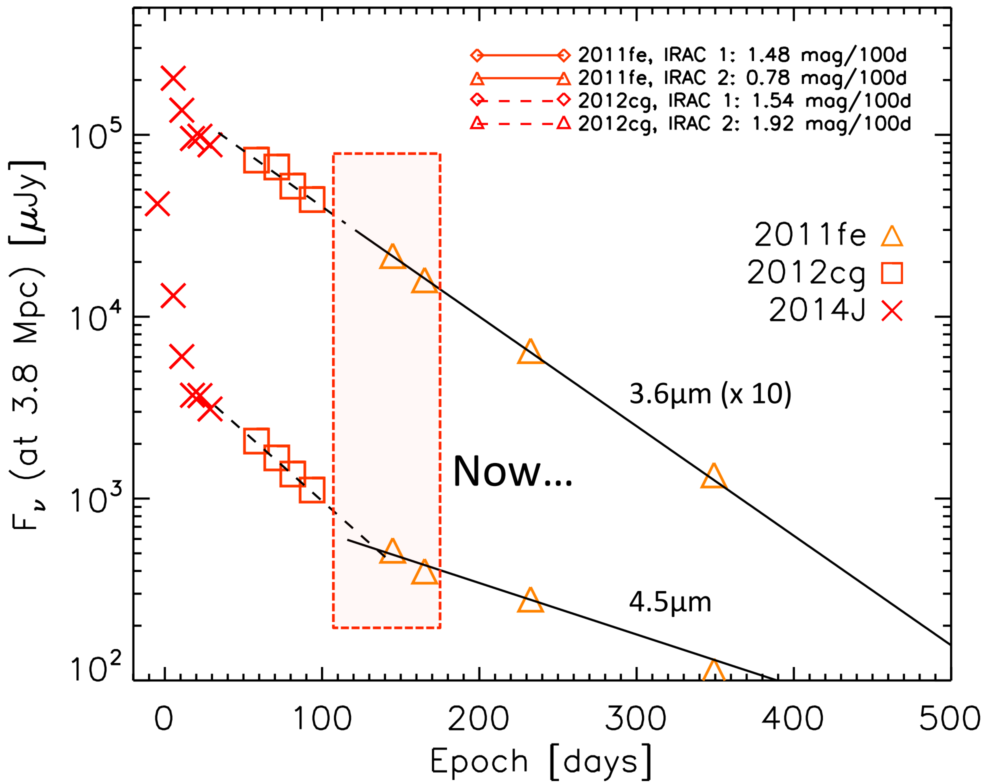
CS dust limits from mid-IR





- CS dust extinction law provides good fit to SN 2014J (*Amanullah et al. 2014*)
- No variable Sodium absorption in high-res spectra…
- Relevant dust masses for CS extinction ~10^{-4} $M_\odot$ (*Amanullah & Goobar, 2011*)