Time Domain Science with WFIRST-AFTA

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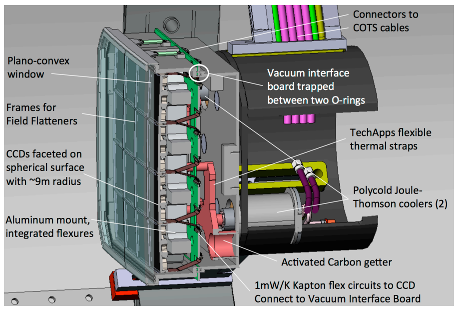
(On behalf of Brad Cenko's Working Group Team)

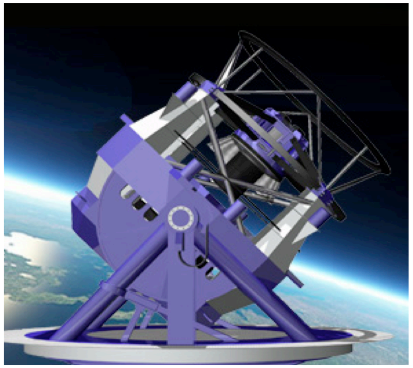
A Resurgence in TDA Discovery Engines

Optical:

Evryscope, ASASSN, HATPI



ZTF, CSS-II, PS, BG, ATLAS



DECAM, HSC, LSST

Radio:

LOFAR, MWA and LWA: meter and decameter-mapping

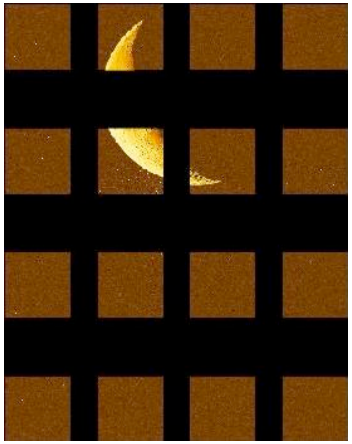
Apertif, Meerkat and Askap: decimetric mapping

Infrared: SPIRITS, Palomar Gattini-IR, Polar Gattini-IR

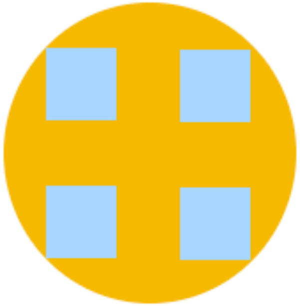
Ultra-Violet: CUTIE & ULTRASAT

X-rays and Gamma-rays: Swift, Fermi, MIRAX, Lobster-ISS

BUT Infrared Lags Behind

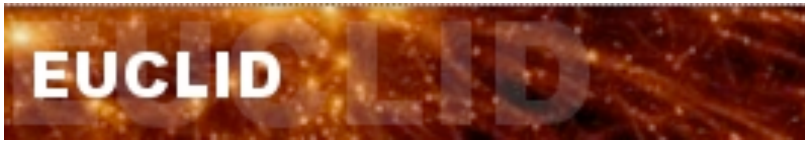


VIRCAM on VISTA
0.6 deg^2 on 4.1m



WFCAM on UKIRT
0.16 deg^2 on 3.8m

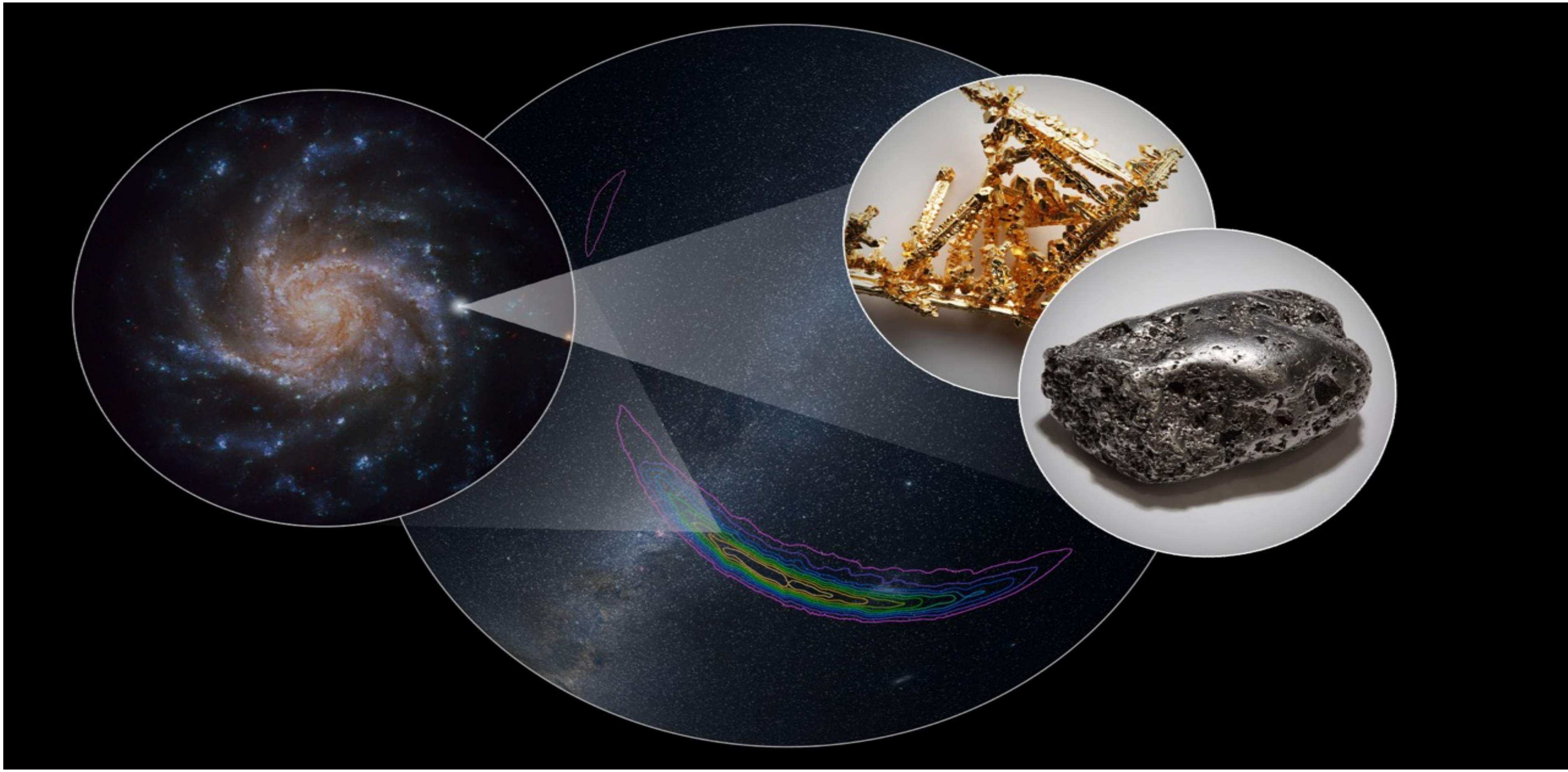
Space



ETA (proposed)

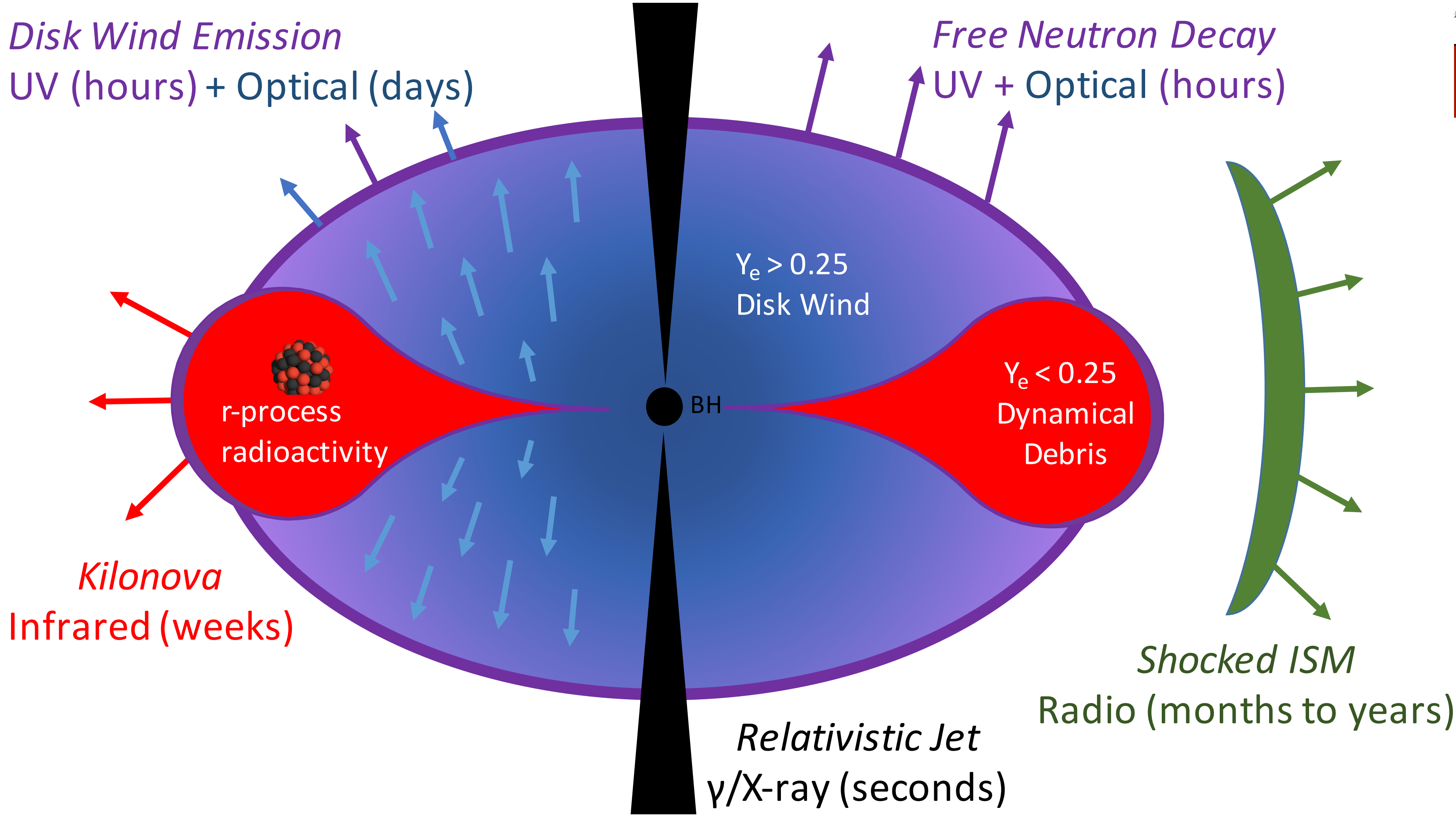
1. Opacity
e.g. Electromagnetic Counterparts to Gravitational Waves

Sites of r-process nucleosynthesis?

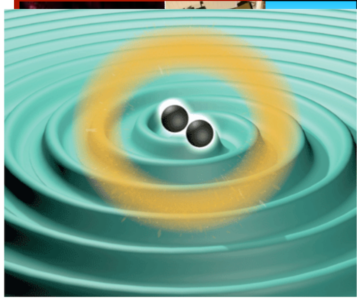


e.g. Li & Paczynski 1998, Kulkarni 2005, Roberts et al. 2011, Nakar & Pir
Barnes et al. 2013, Grossman et al. 2013, Metzger et al. 2014, Kasen et a

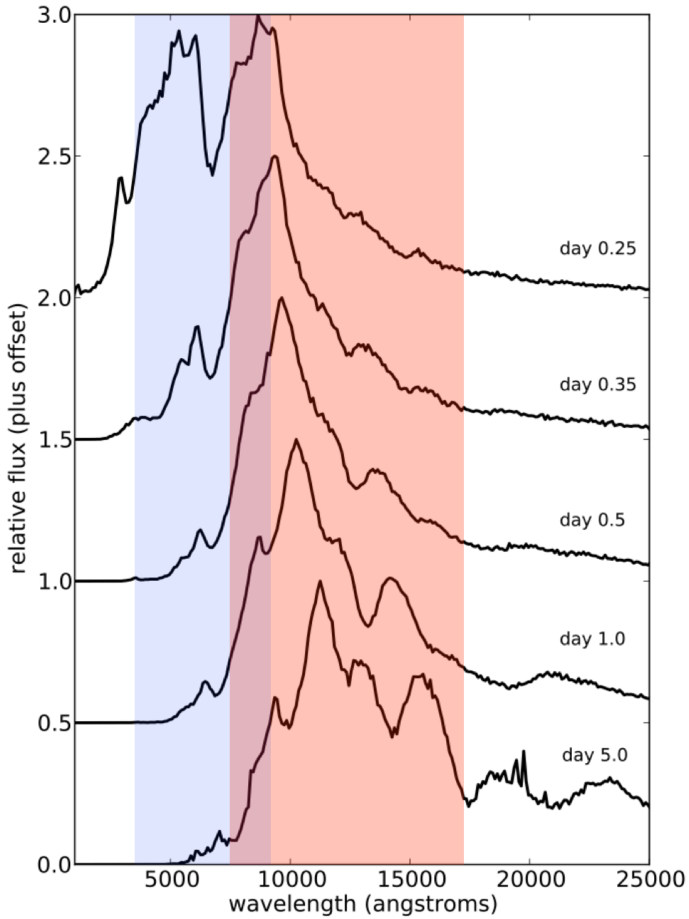
Models



Disk Wind Emission
UV (hours) + Optical (days)
Free Neutron Decay
UV + Optical (hours)
$Y_e > 0.25$
Disk Wind
$Y_e < 0.25$
Dynamical Debris
BH
r-process radioactivity
Kilonova
Infrared (weeks)
Shocked ISM
Radio (months to years)
Relativistic Jet
γ/X-ray (seconds)



WFIRST-AFTA ToO:
Kilonovae from Neutron Star Mergers



Barnes & Kasen 2013, Kasen et al. 2013

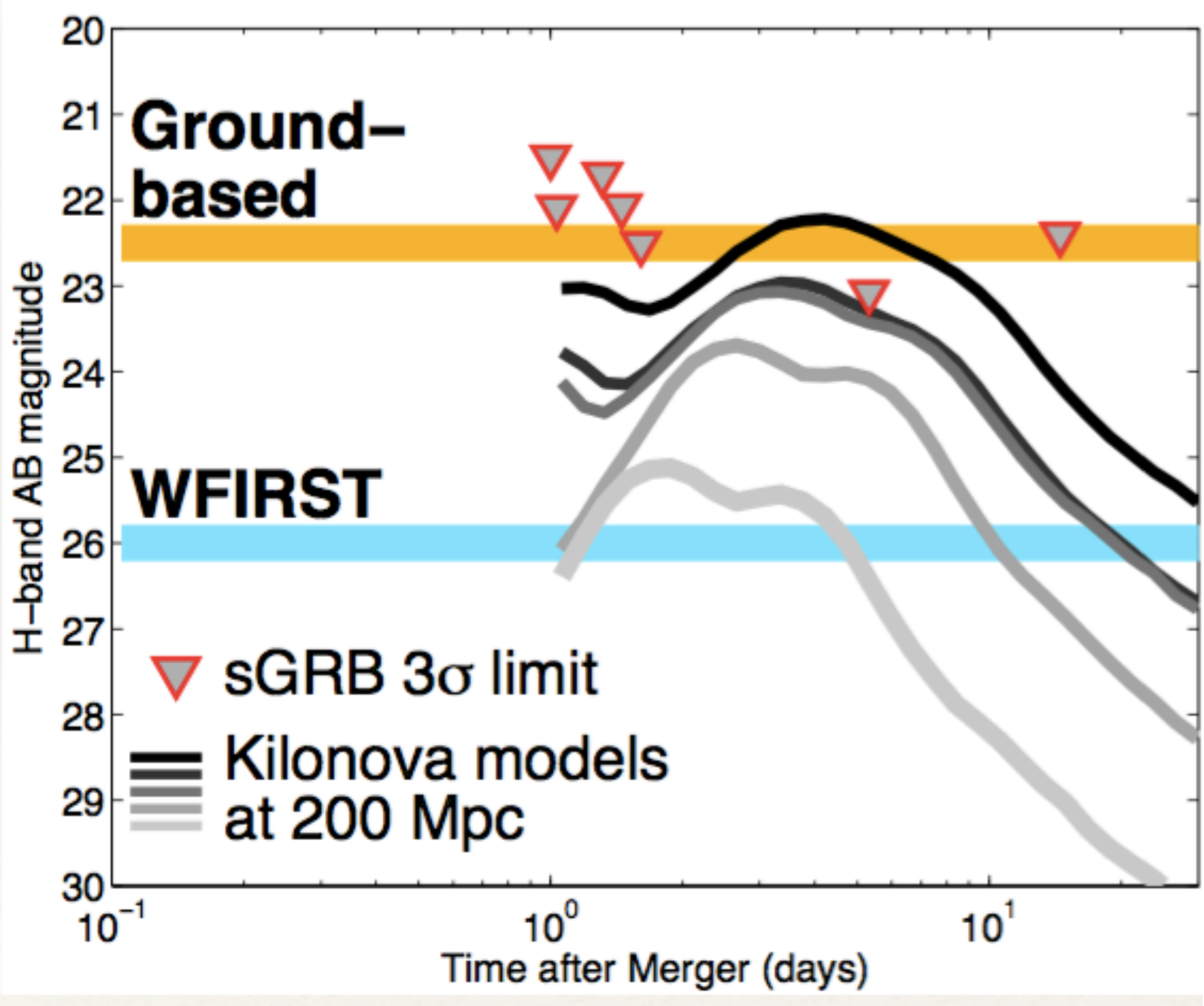
A WFIRST-AFTA ToO Trigger:

Era of 3-5 advanced gravitational wave Interferometers at full sensitivity

~30 mergers localized to <6 sq deg in 5 yr

A 27 hour WFIRST-AFTA ToO:
- J+H imaging x 5 epochs (24-25 mag)
- Grism spectroscopy x 1 epoch (22 mag
- IFU spectrum x 1 candidate (25 mag)

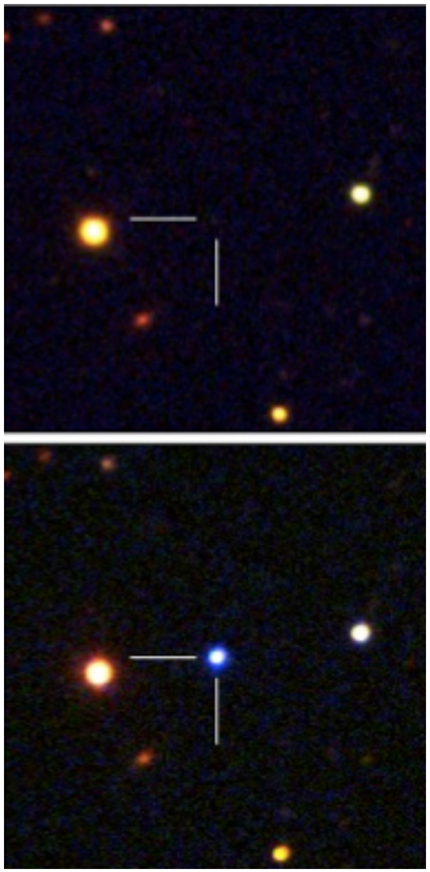
See Hirata, Kasliwal & Nissanke, white paper for WFIRST-AFTA

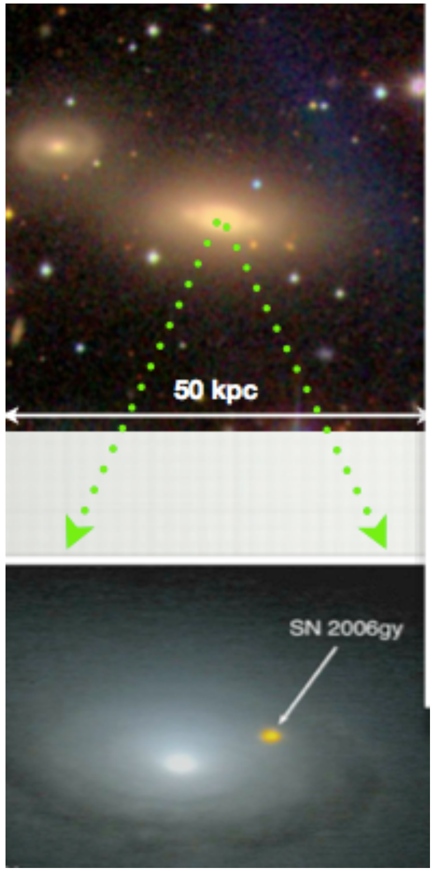


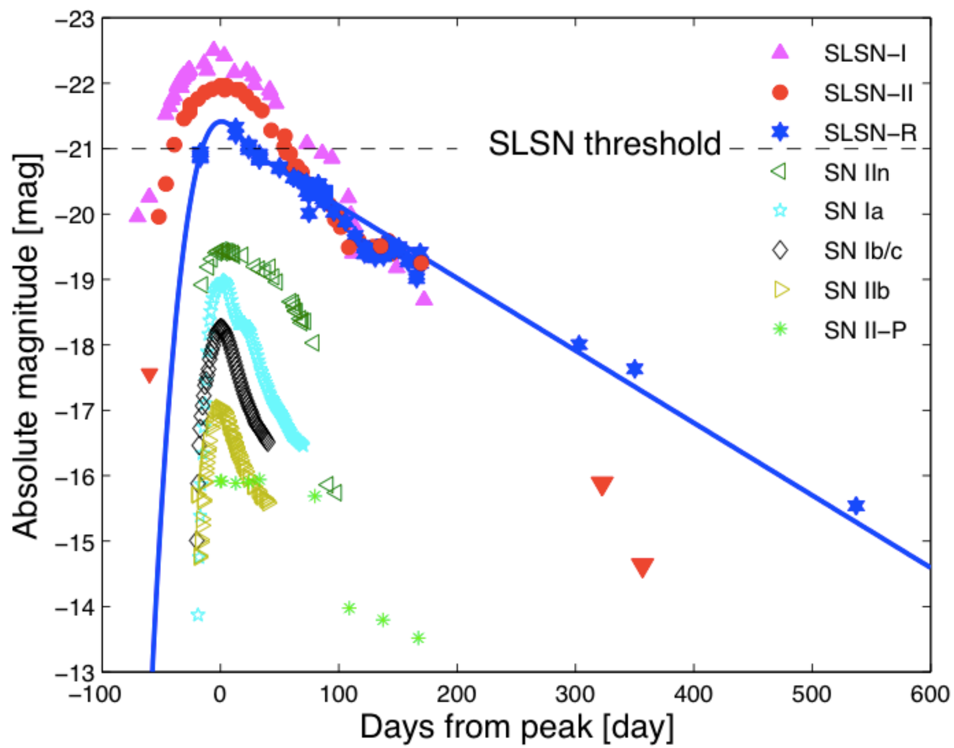
Depth for WFIRST is unique!

II. High Redshift
e.g. Superluminous Supernovae

Super Luminous Supernovae: Pushing to higher redshift





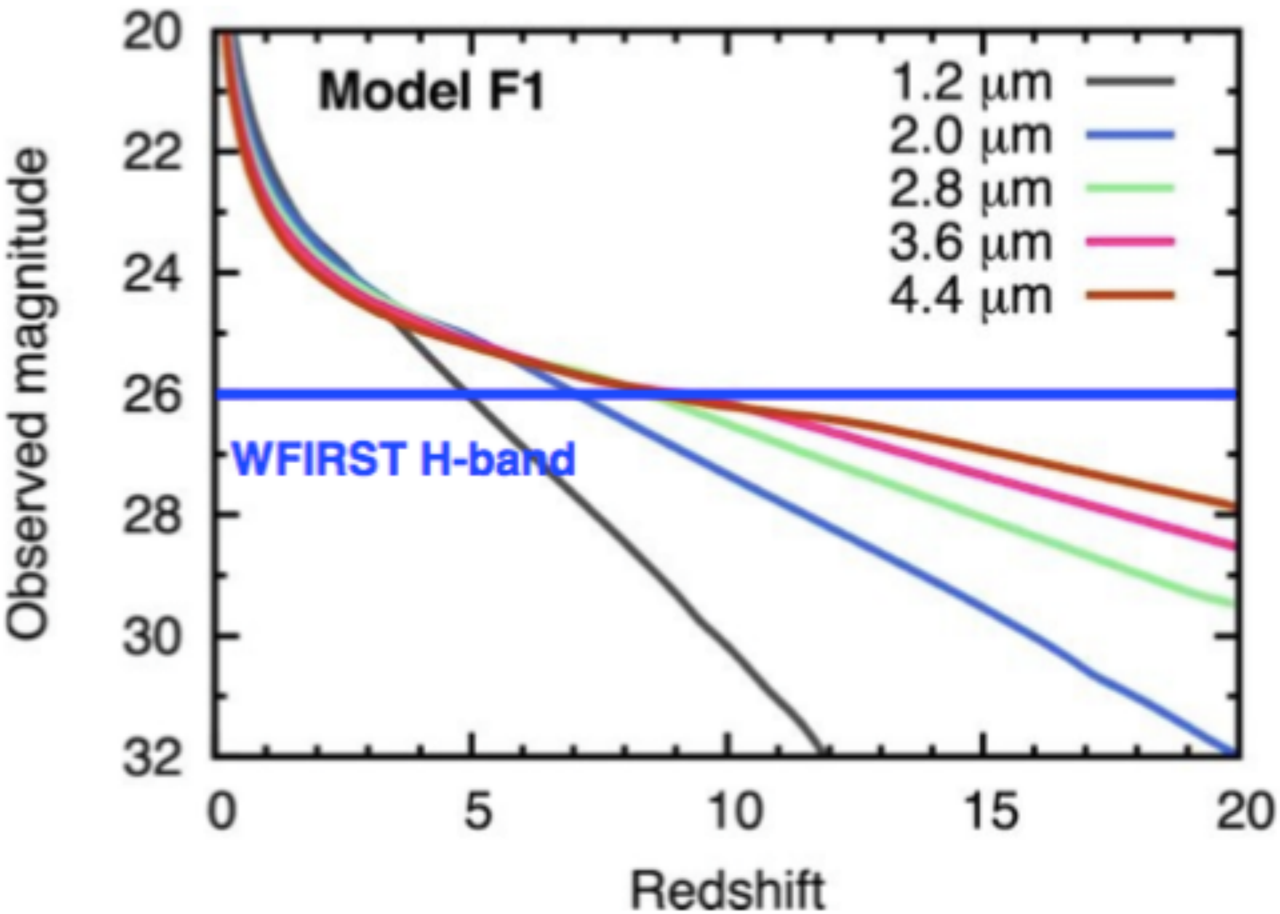


SLSN-I
Magnetars? PPI?
e.g. Quimby et al. 2011

SLSN-II
CSM Interaction
e.g. Ofek et al. 2008

SLSN-R
Pair Instability
e.g. Gal-Yam et al. 2009

SLSNe at epoch of reionization



Tanaka et al. 2013

Powerful probe of star formation across cosmic history

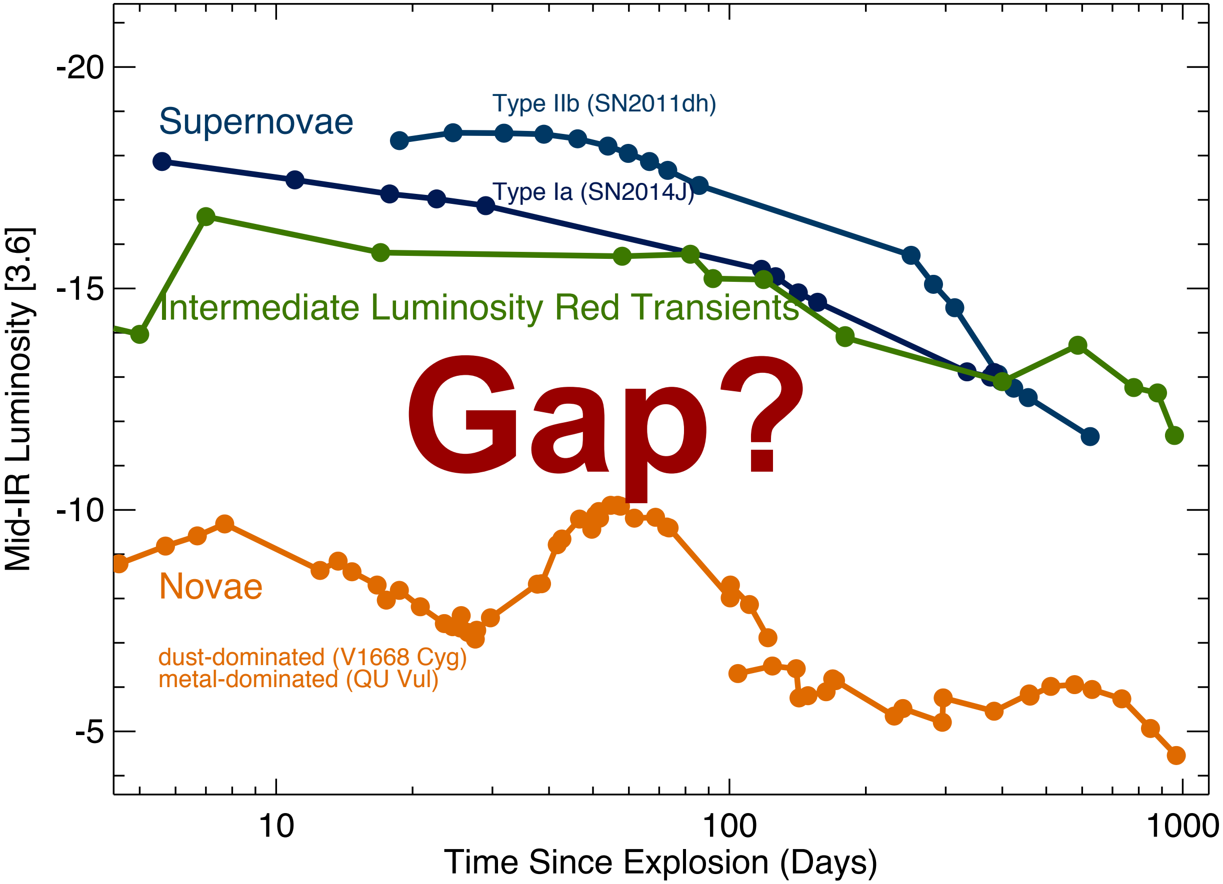
With HLS survey, z~7

BUT identiifying them Requires intelligent cadence design

III. Enshrouding

e.g. Stellar Mergers, Birth of Massive Star Binaries, stellar-mass Black Holes, e-capture supernovae etc.

SPIRITS:
SPitzer InfraRed Intensive Transients Survey

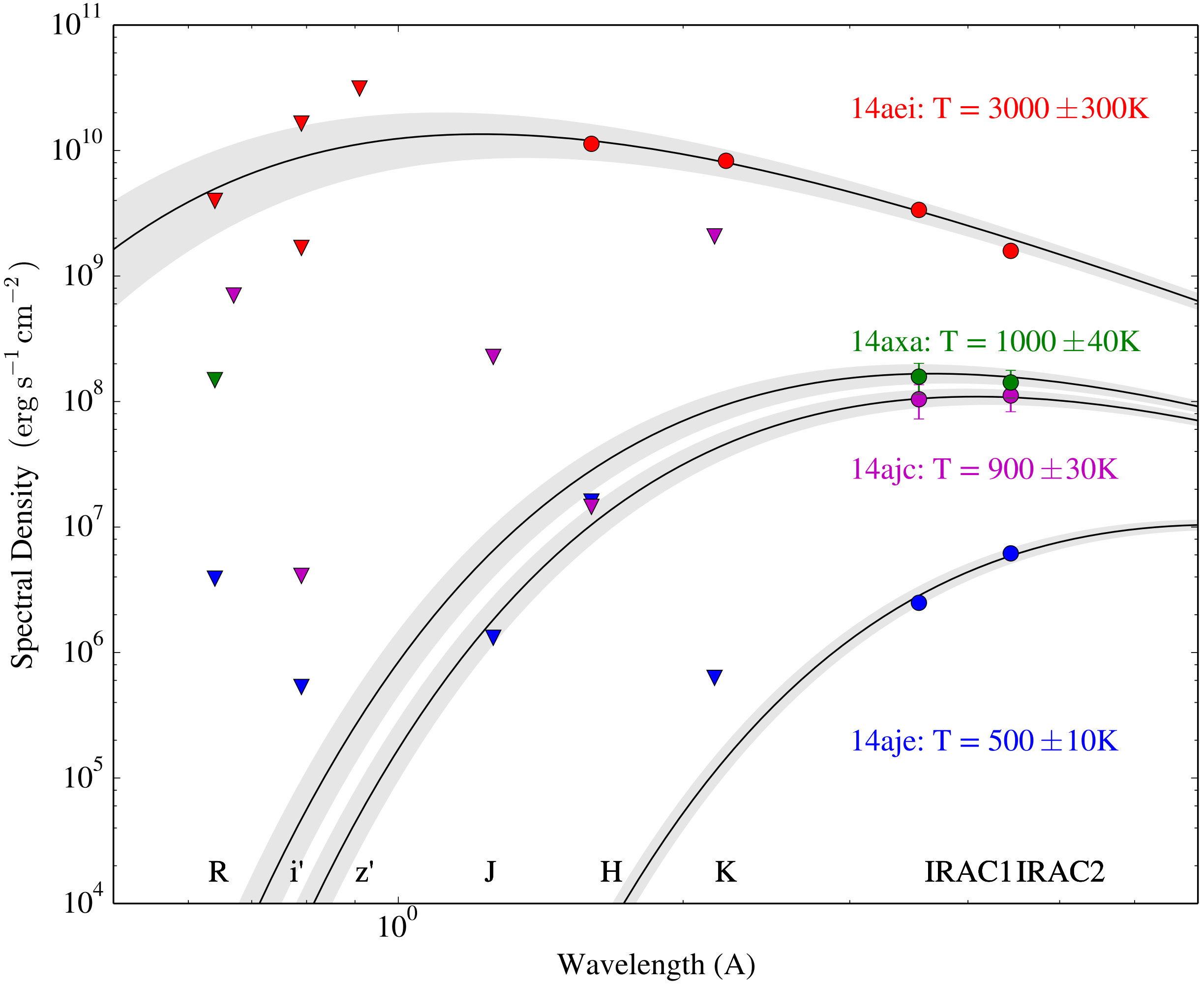


Cycles 10-14 (5 years):
194 Galaxies x 12 epochs
1410 hours of Spitzer mid-IR

Every Year:
110 nights of near-IR imaging
66 nights of optical imaging
33 nights of spectroscopy

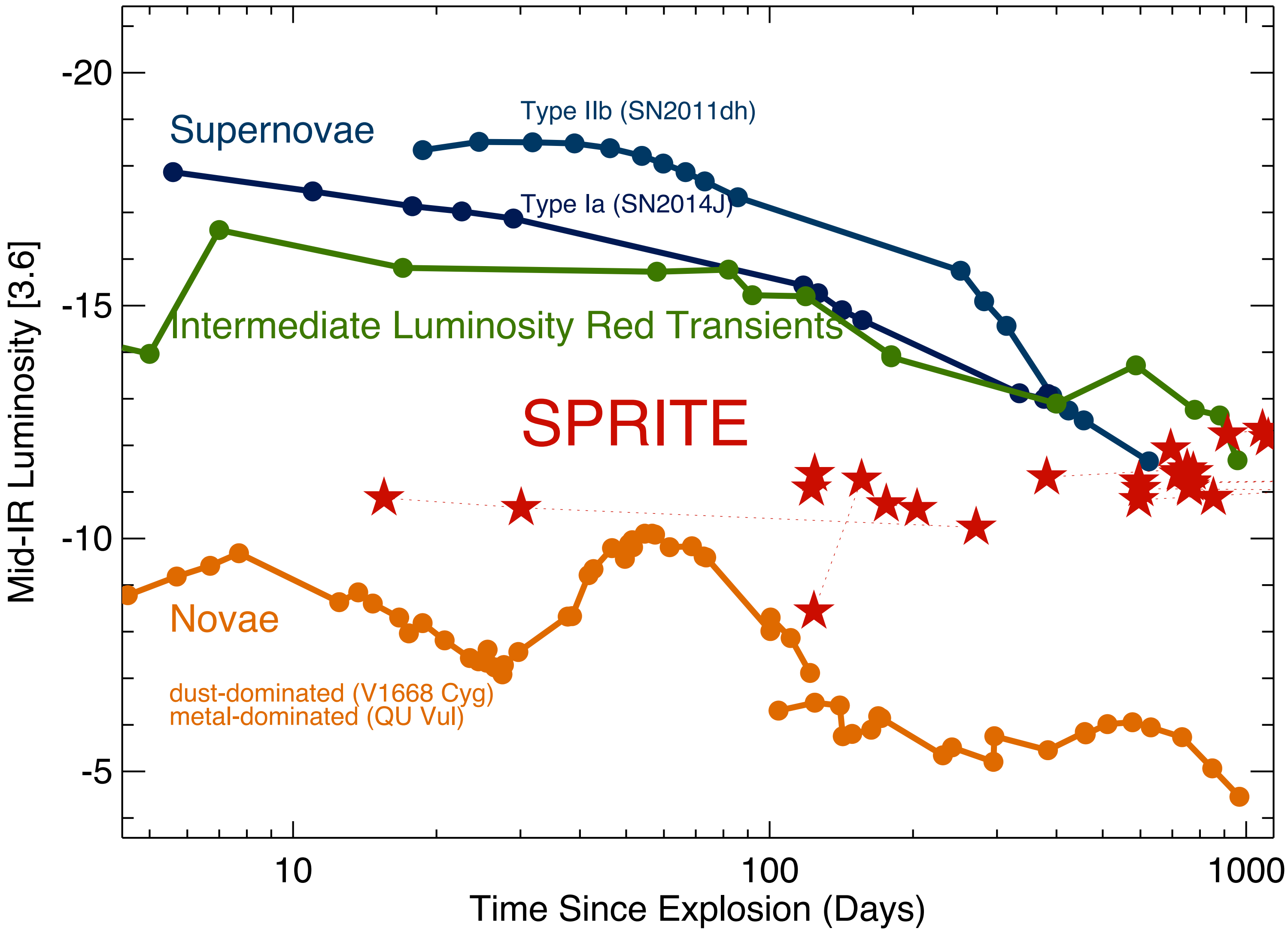
40+ transients/year
1200+ variables/year

Cold: Nothing in Optical

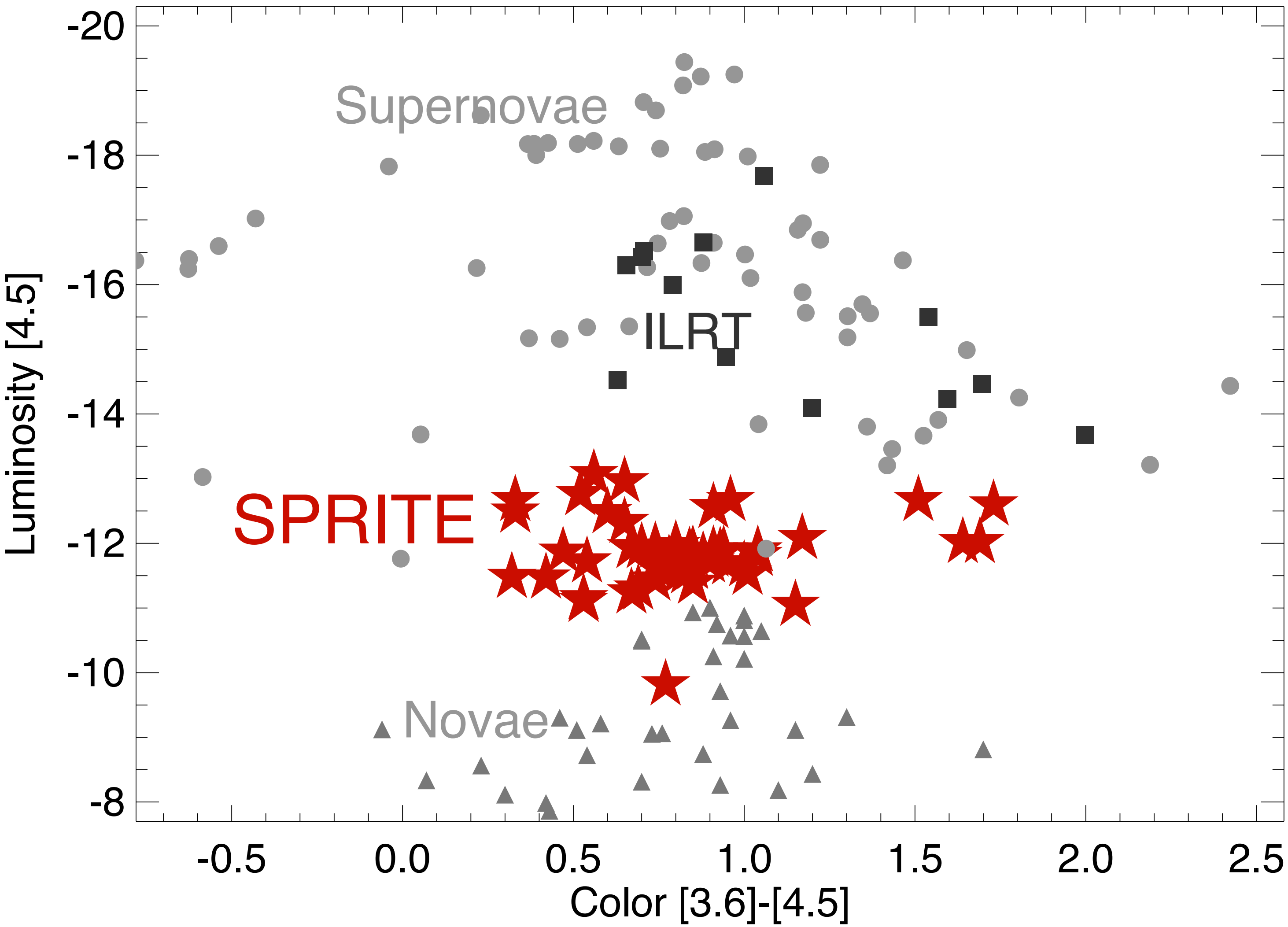


Kasliwal et al. 2017

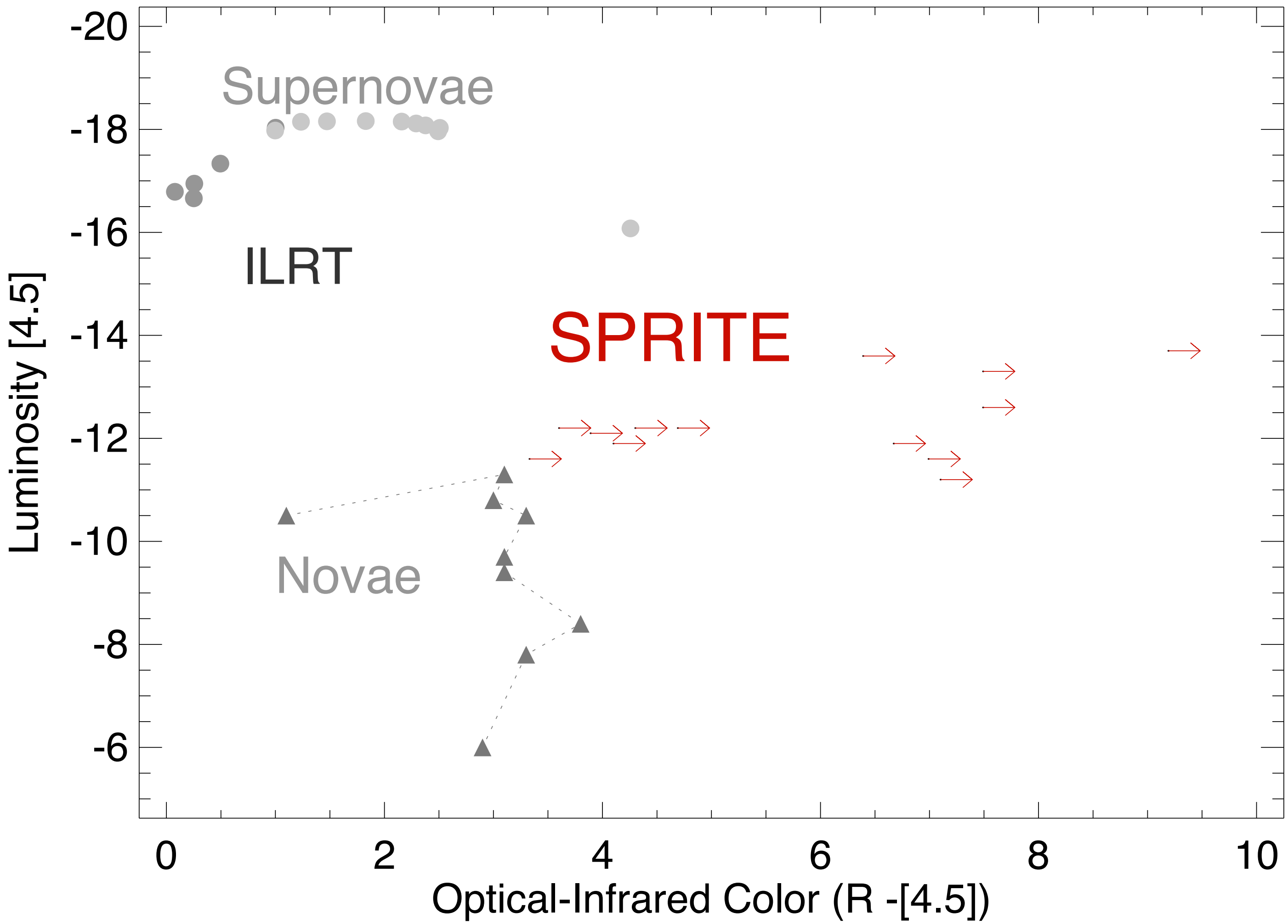
Optical Upper limits from Keck & Hubble



Kasliwal et al. 2017



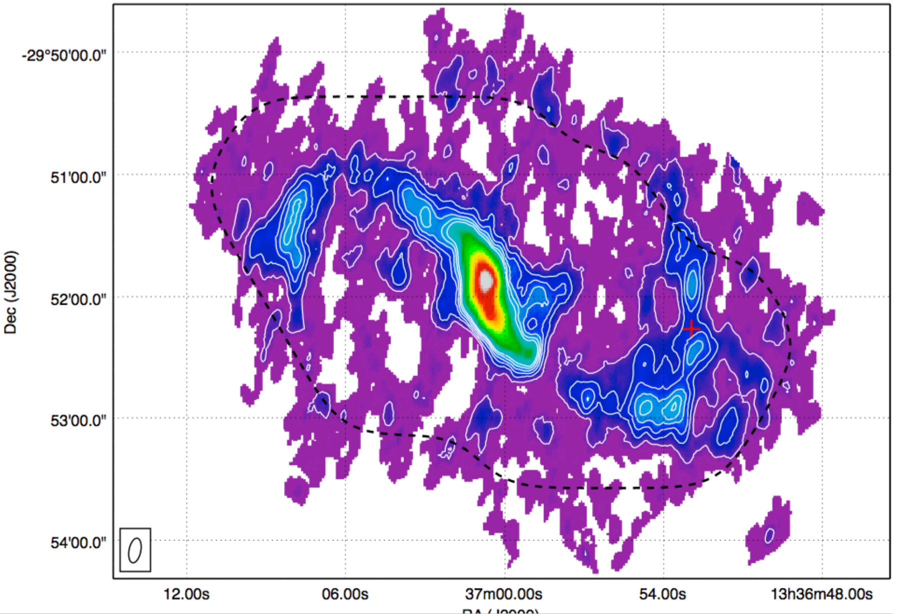
Kasliwal et al. 2017

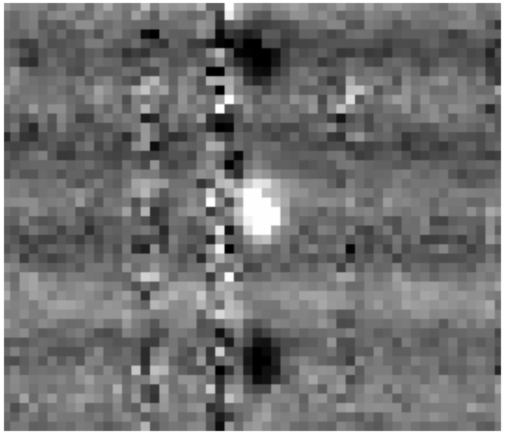

Supernovae
ILRT
SPRITE
Novae
Luminosity [4.5]
Optical-Infrared Color (R -[4.5])
-20
-18
-16
-14
-12
-10
-8
-6
0
2
4
6
8
10

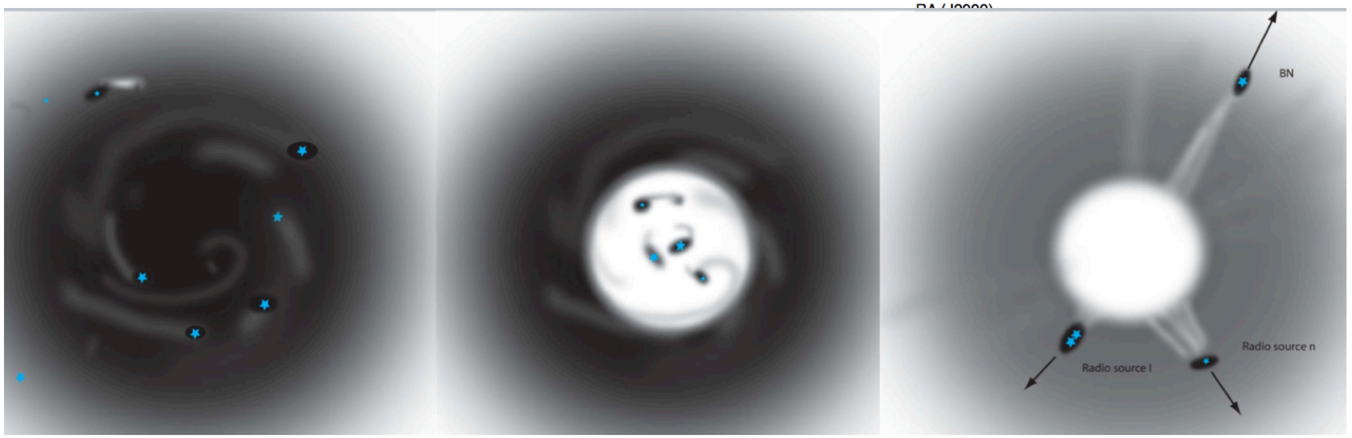
What are SPRITEs?

1. Formation of a Massive Star binary
2. Stellar Mergers
3. Extinguished Supernovae
4. Birth of Stellar-mass Black Holes
5. e-capture Supernovae in extreme AGB stars

I. A slow SPRITE: SPIRITS14ajc in M83







Shock-Excited Molecular Hydrogen Emission!!

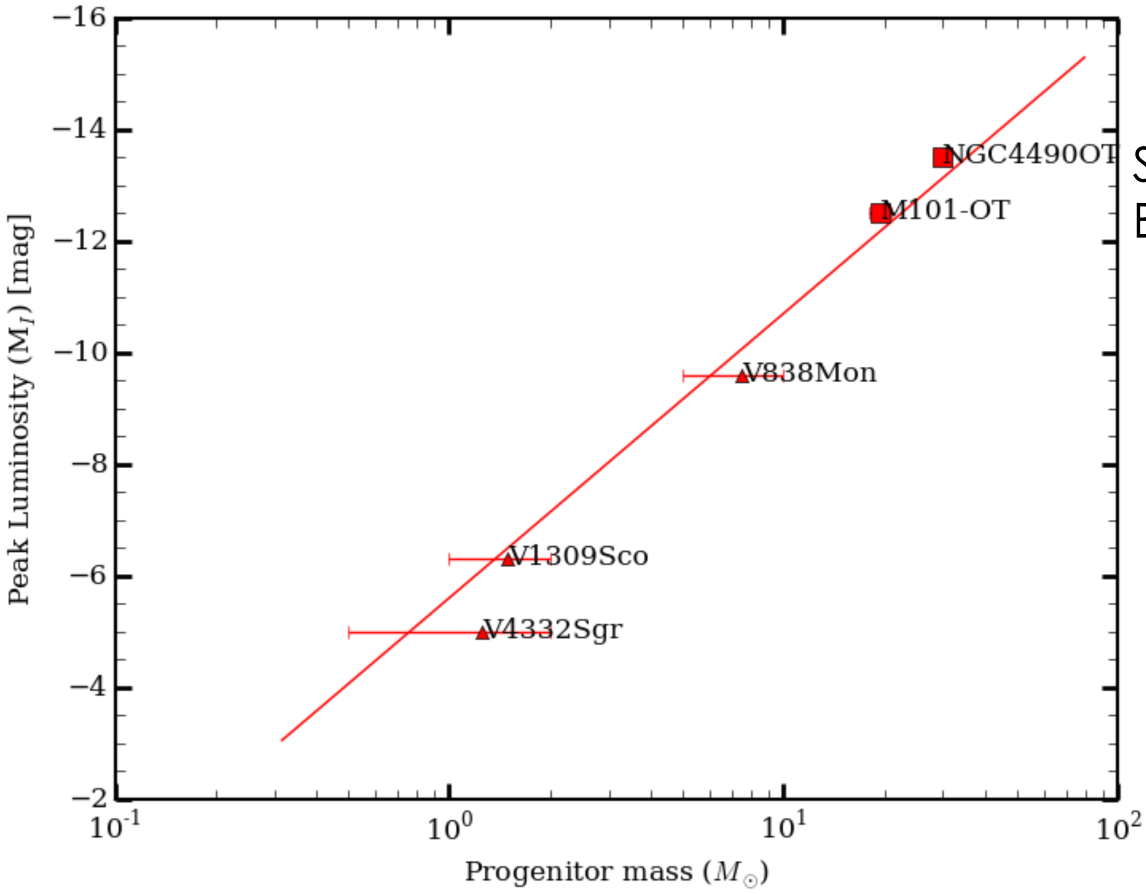
Kasliwal et al. 2017

Birth of a massive star binary??

~~Supernova behind molecular cloud??~~

II. Stellar Mergers:
Luminosity-Mass Correlation

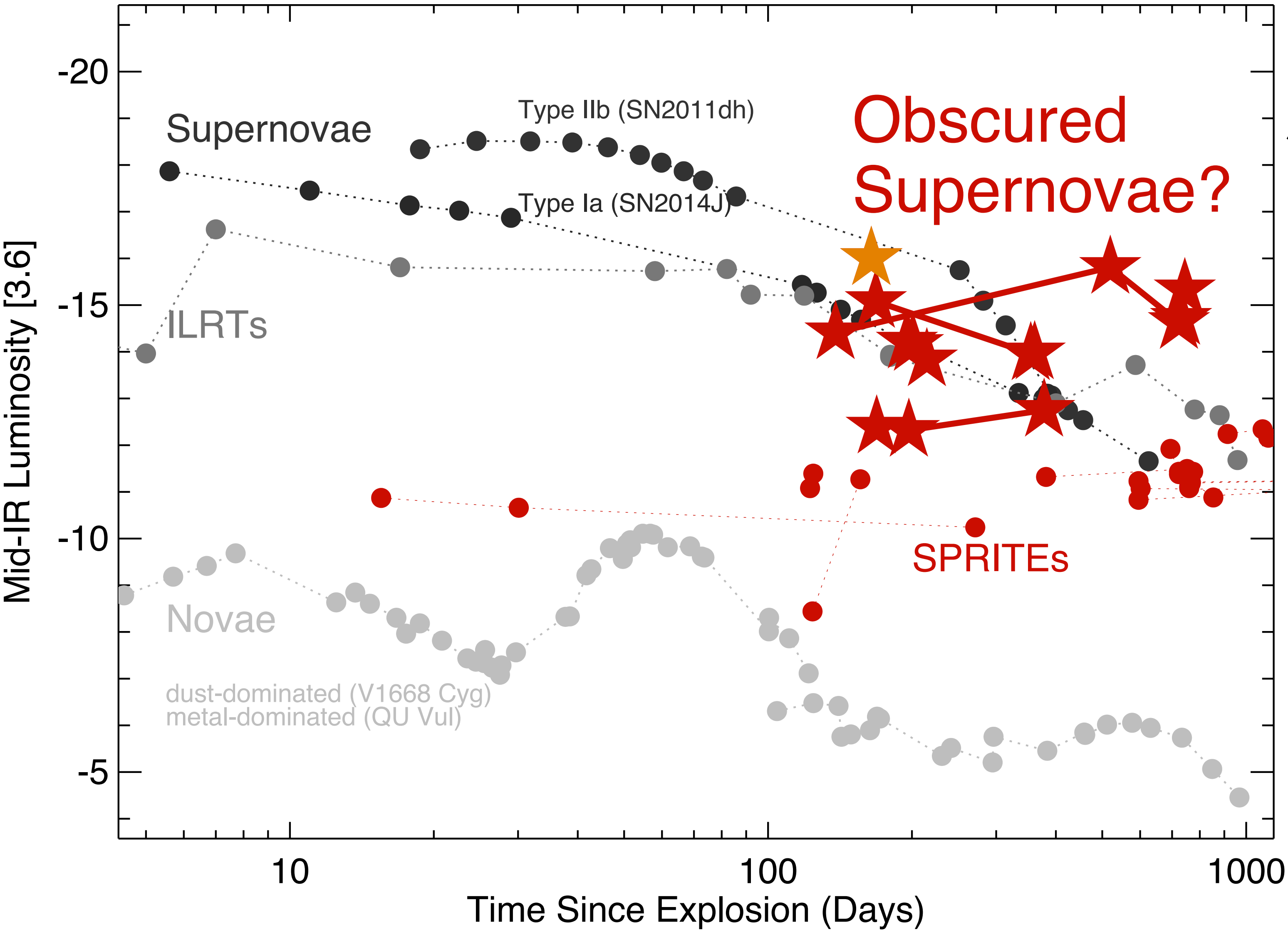
Nadia Blagorodnova
215.06 Talk



Smith et al. 2016
Blagorodnova et al. 2016

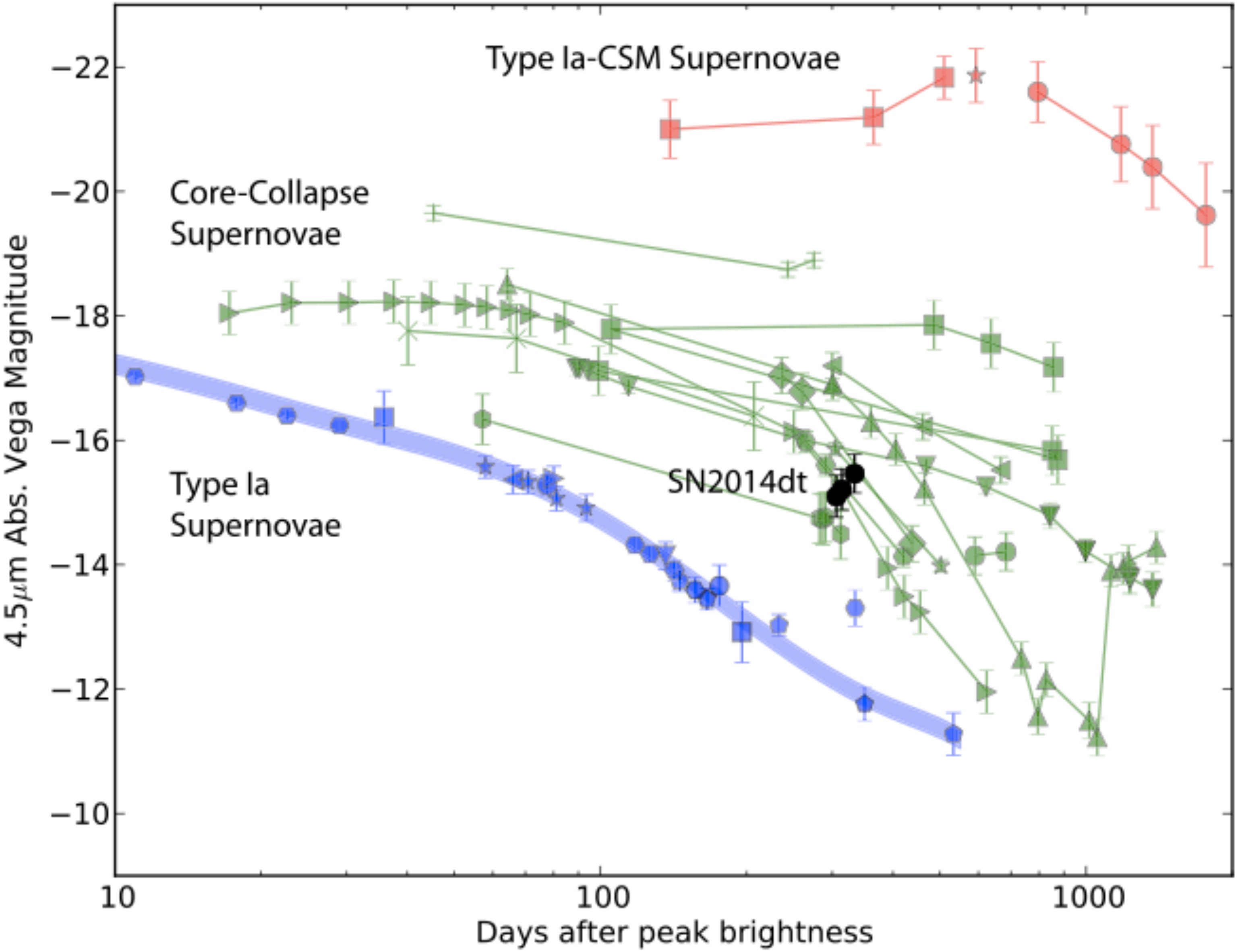
Correlation from
Kochanek et al. 2014

III. Extinguished Supernovae



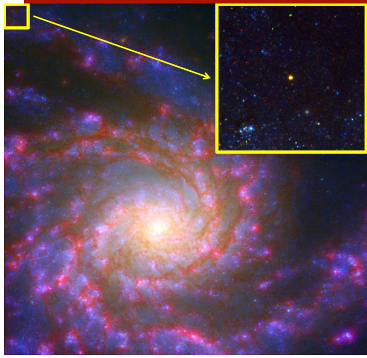
Jacob Jencson (Grad, PhDT)

Jencson et al. 2016, 2017

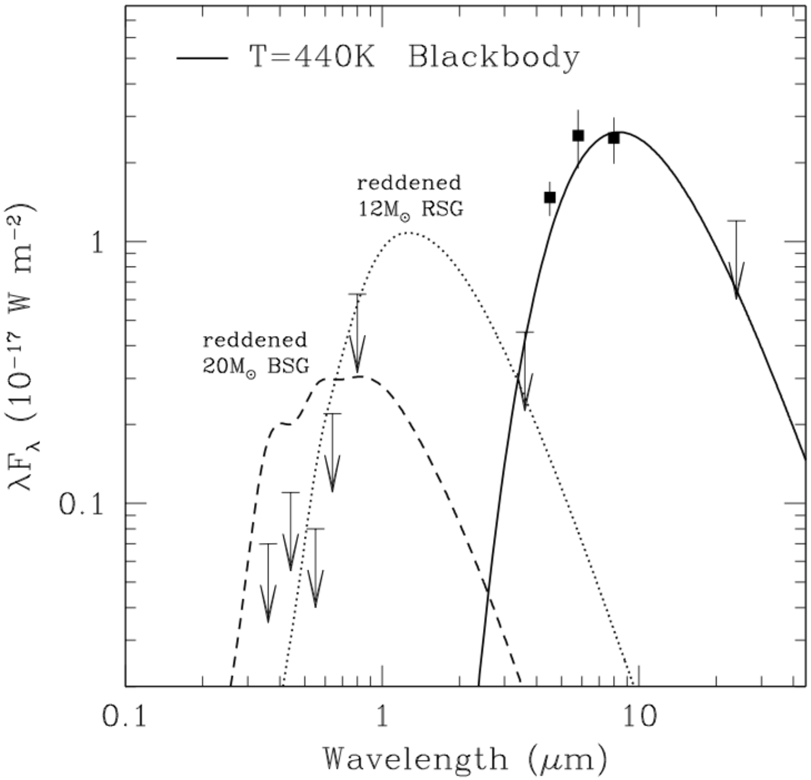


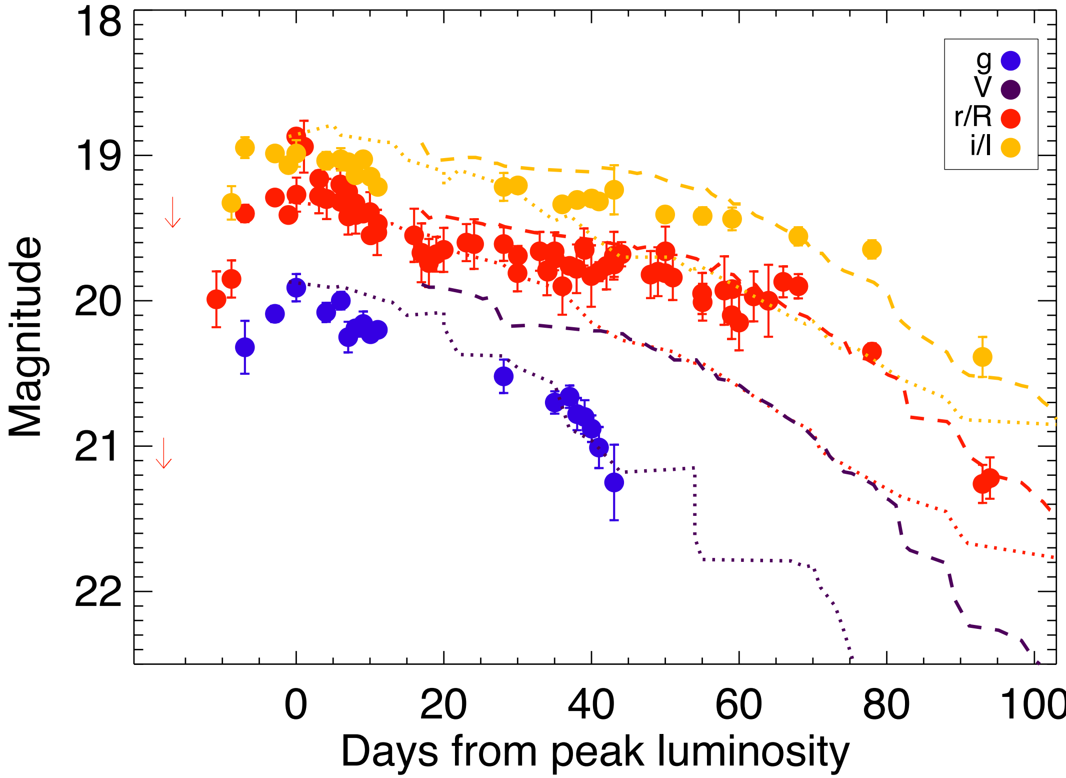
Samaporn
Tinyanont
341.15
Friday Poste

Tinyanont et al. 2016, Fox et al. 2016
Johansson et al. 2016



IV. e-capture supernovae

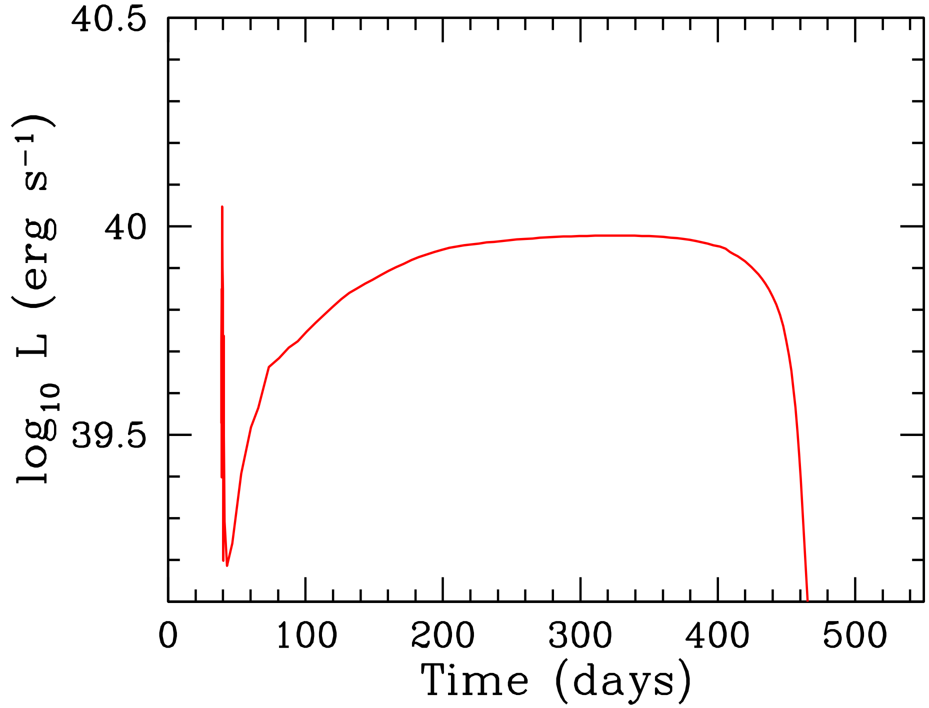




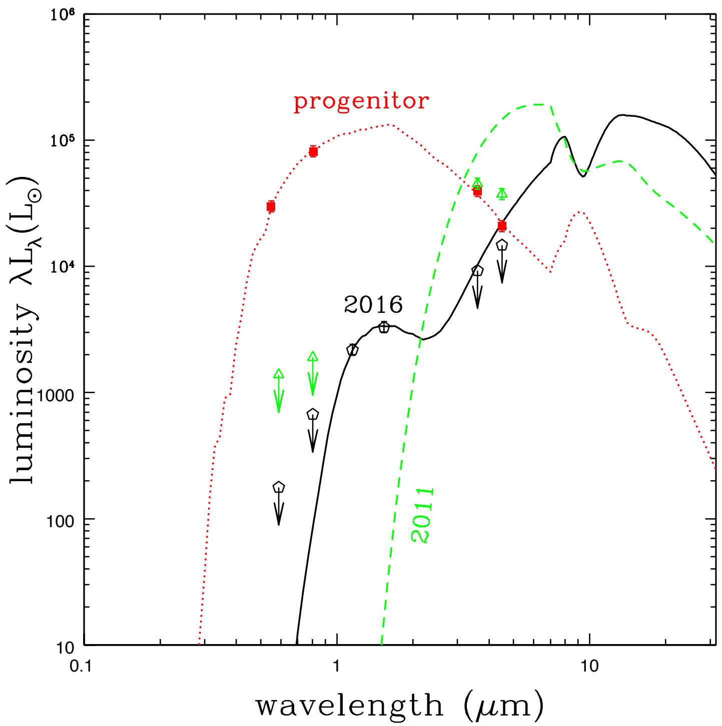
e.g. Prieto et al. 2008, Thompson et al. 2008, Kochanek 2011, Kasliwal et al. 2011b, Bond et al. 2009, Botticella et al. 2009

V. Birth of Black Holes?

Scott Adams



Lovegrove & Wooseley 2013,
Piro et al. 2013, Pejcha et al. 2015



Adams et al. 2016

The Dynamic Infrared Sky Is Ripe for Exploration!

Will WFIRST-AFTA be an infrared TDA discovery machine?

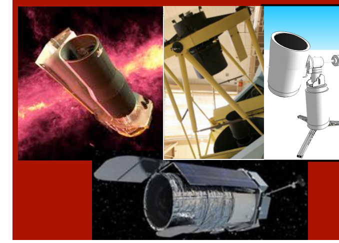
- Fast wide-field mapping
  - Cadence choice is critical

  e.g. trade depth for more epochs
- Real-time Transient Alerts
  - Prompt Data Downlink
  - Software Pipelines with Image Differencing
- Target of Opportunity Mode

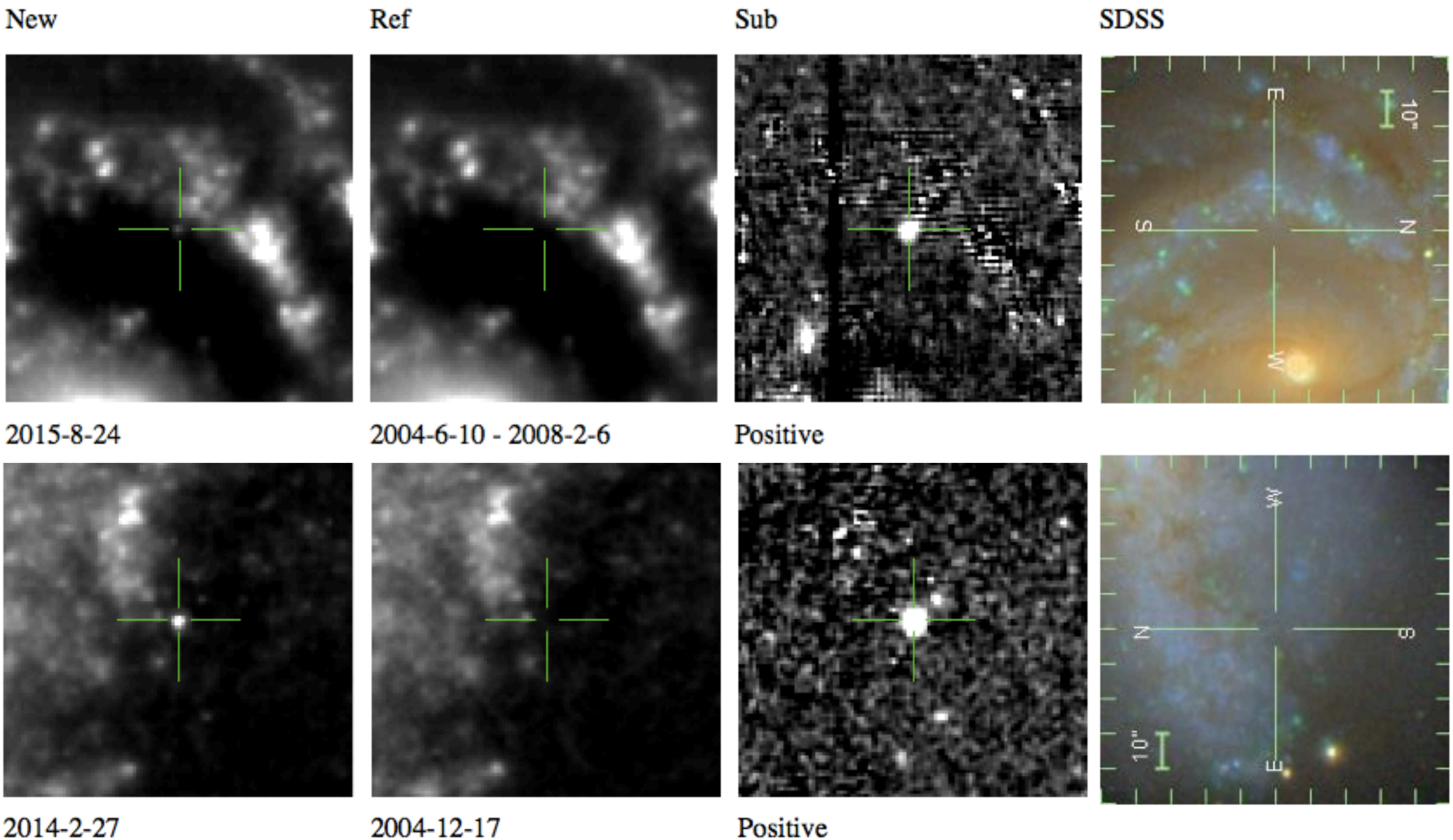
On-board spectroscopy is fantastic:

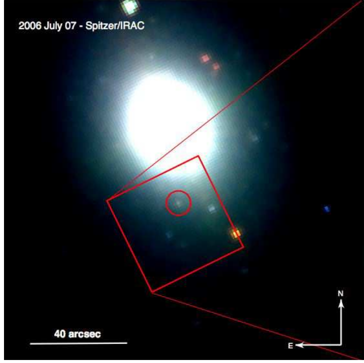
- Combining the power of discovery and follow-up

Thank You

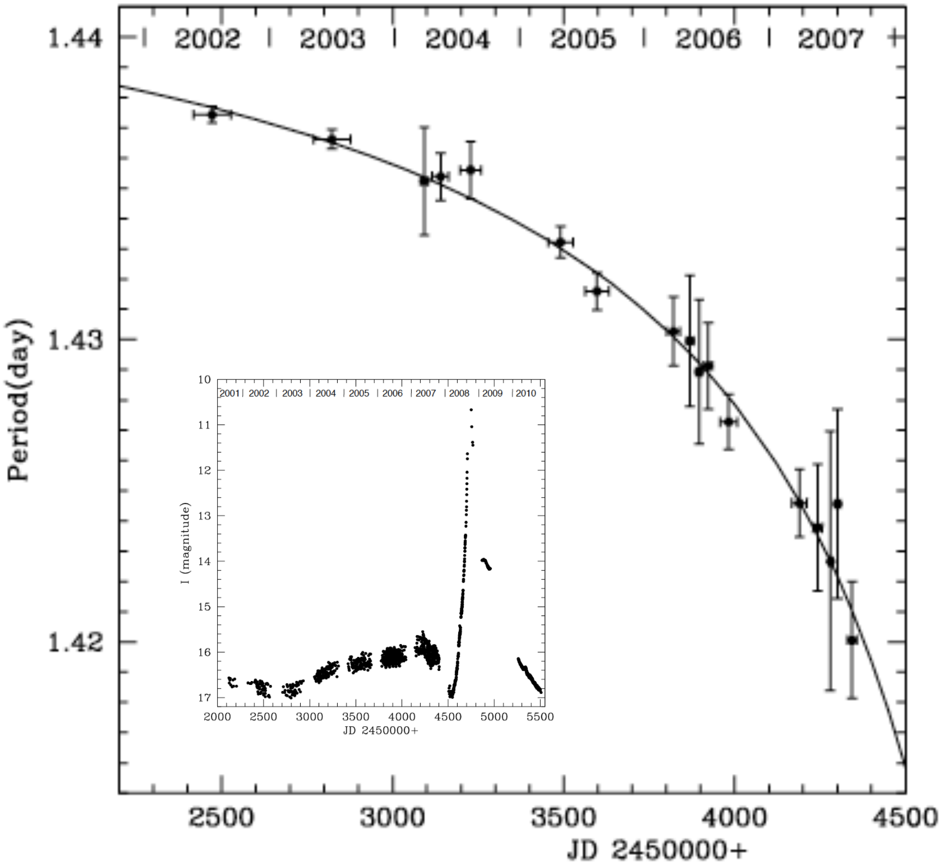


40+ infrared transients annually
(21 supernovae, 4 novae, 15 mysteries)

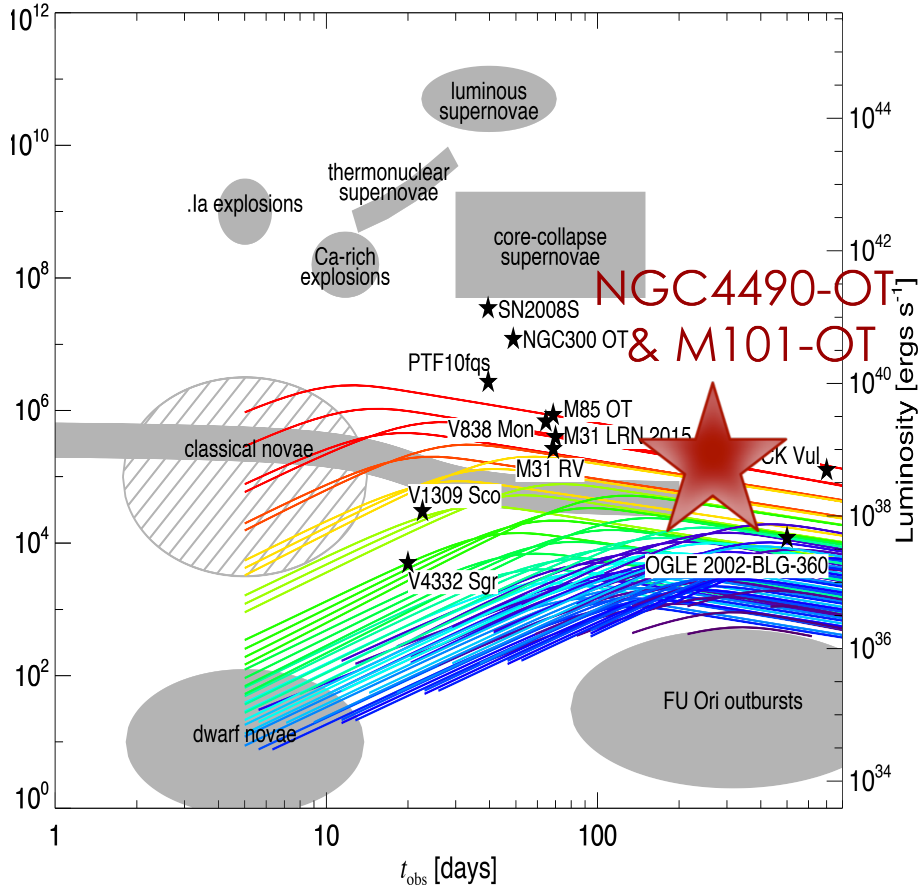




II. Stellar mergers

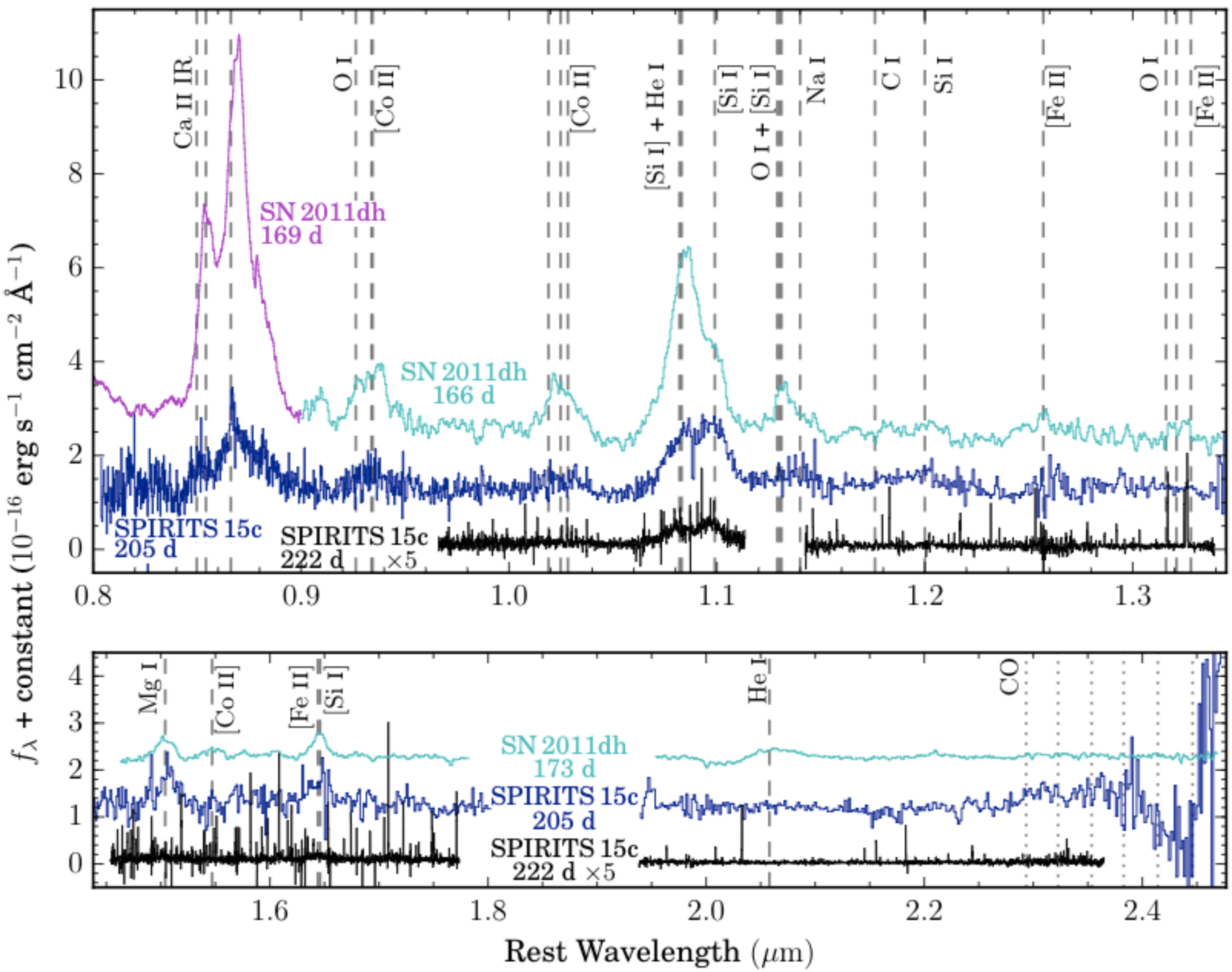


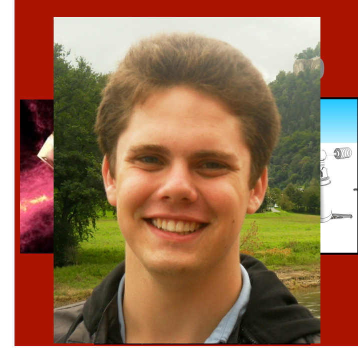
Tylenda et al. 2011



Ivanova et al. 2013, Pejcha et al. 2015

SPIRITS15c Spectra reminiscient of a Type IIb supernova

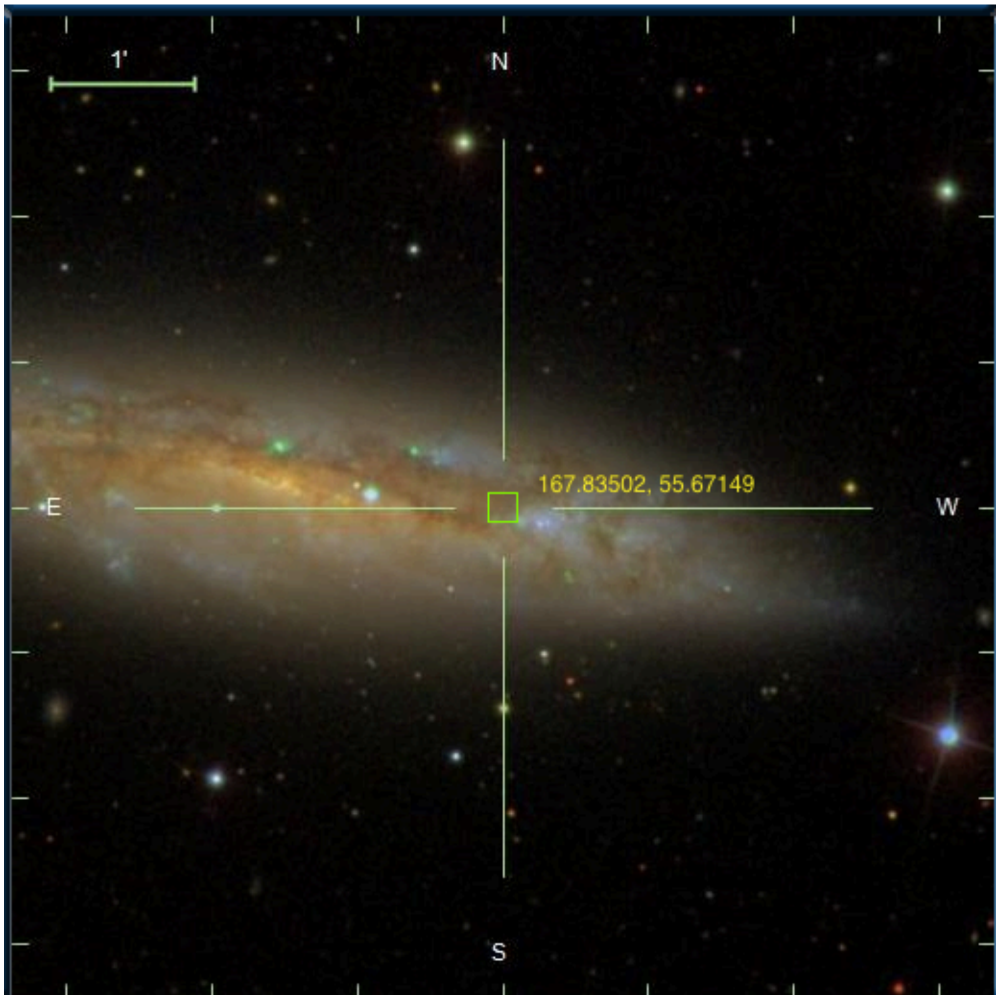


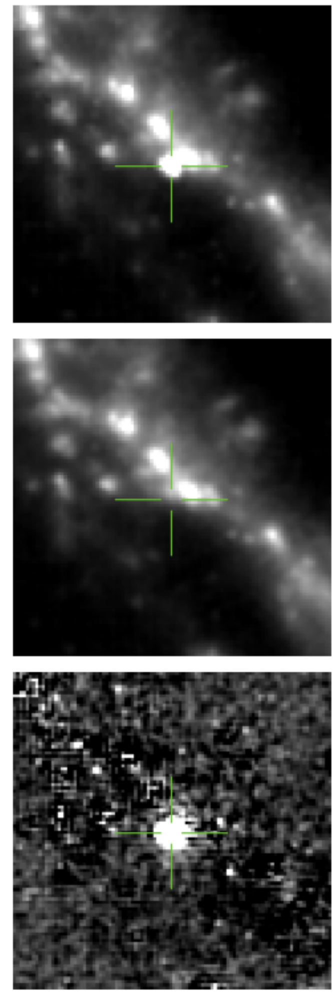


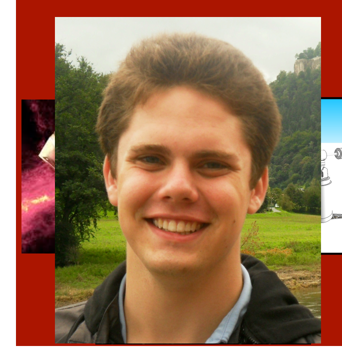
Jacob Jencson
(Grad, PhDT)

Jencson et al. 2016

New reddened supernova candidate in Messier 108?







Jacob Jencson

@ 8.8 Mpc

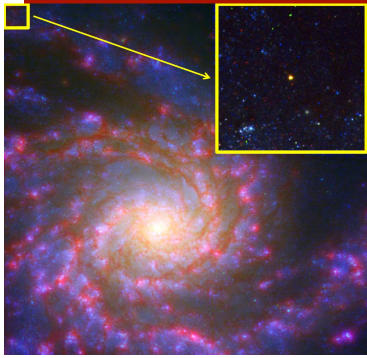
[4.5] = -16.7 mag

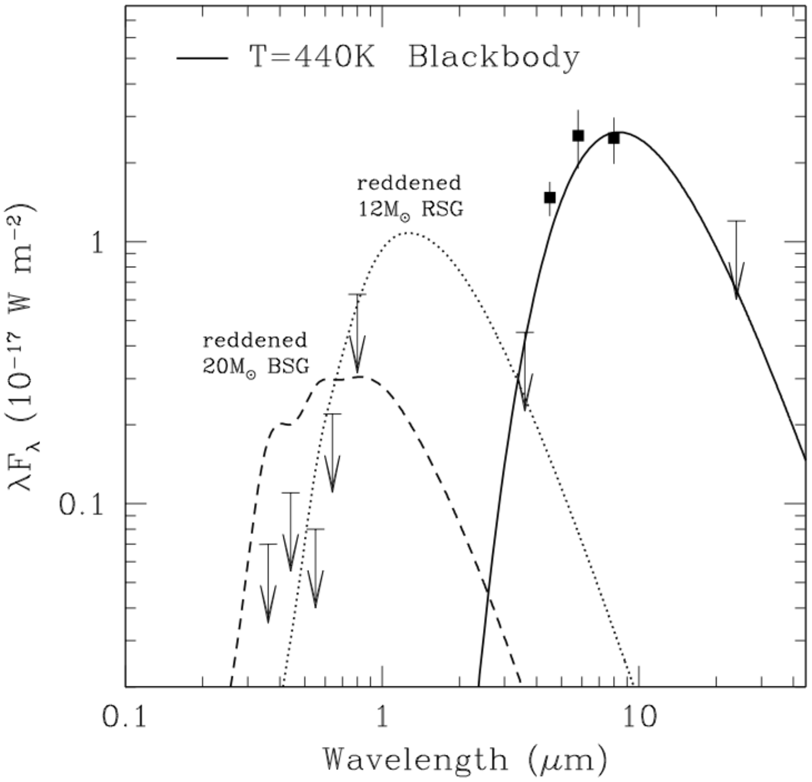
[3.6]-[4.5] = 0.7

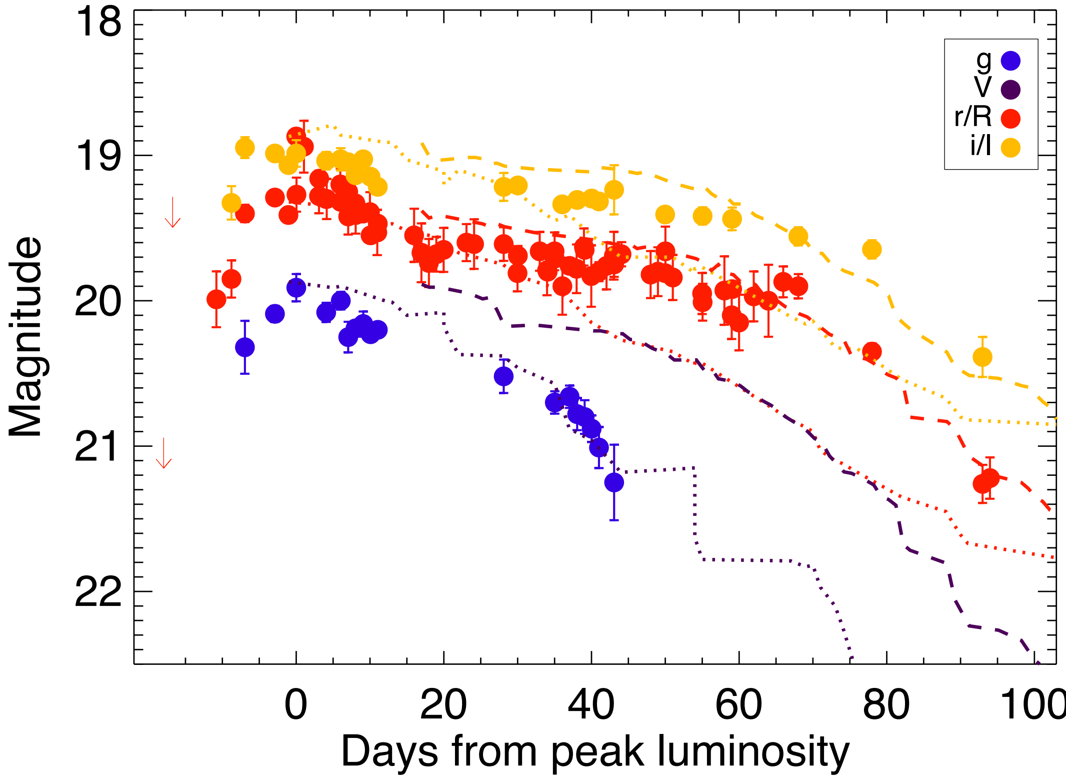
I – [4.5] = 8.8!

No radio source to 10uJy!

VI. e-capture supernovae







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