Robert Quimby

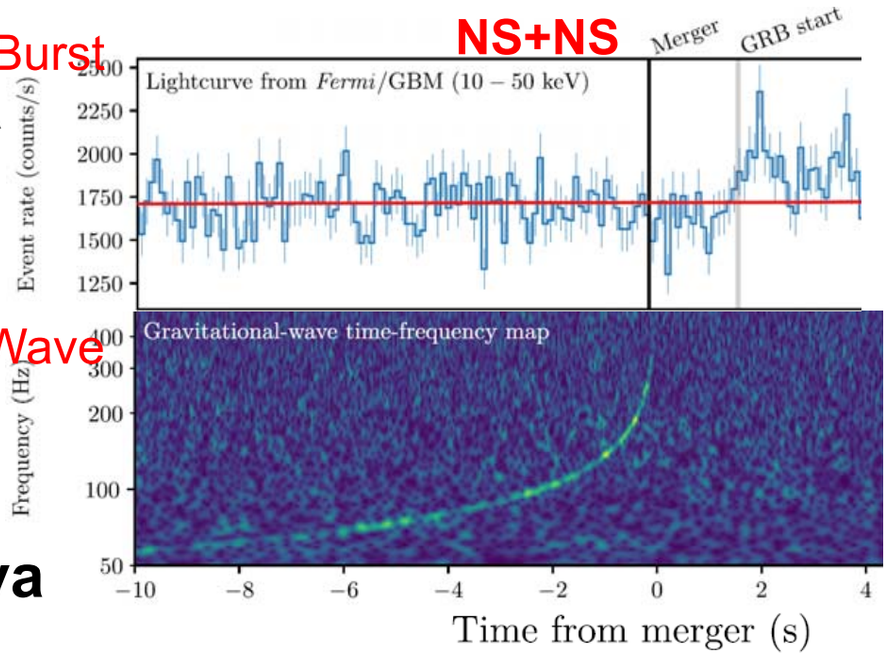
- 2006: PhD
  at U. Texas, Austin

Gamma-Ray Burst
GRB170817A

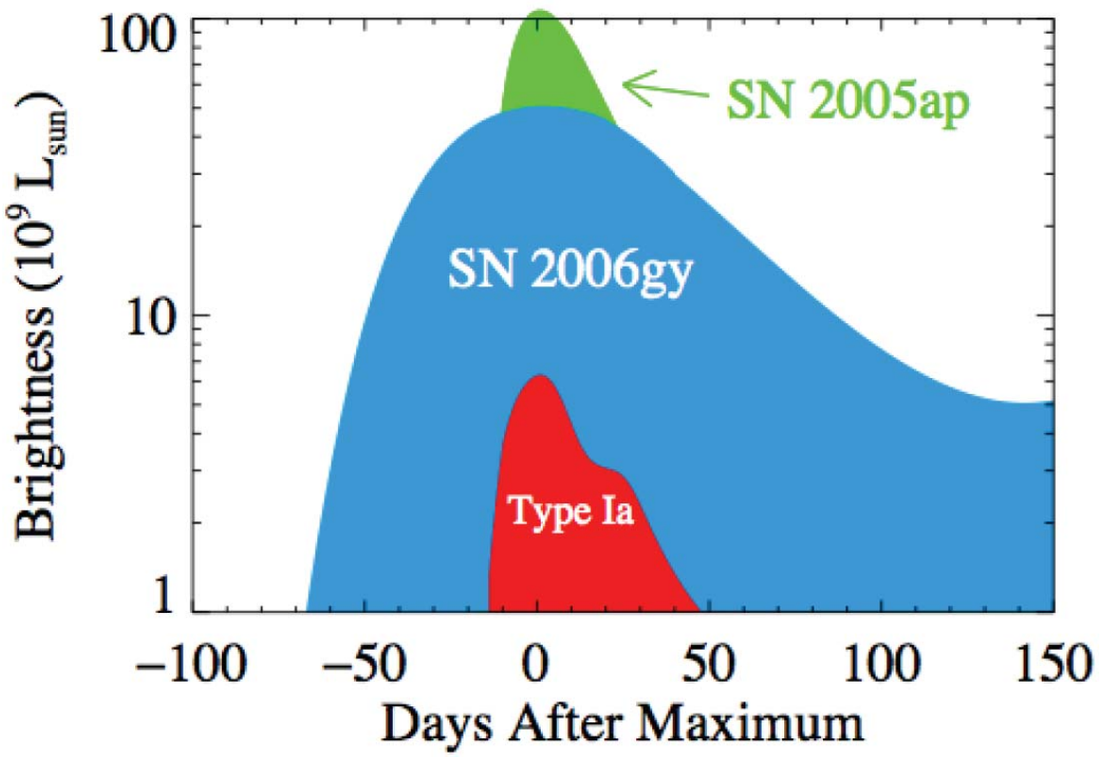
NS+NS

Gravitational Wave
GW170817

➔ **Kilo-nova**



- Discovery of
  Super-luminous Supernovae SN 2005ap, 2006gy
- 2007 - 2011: Postdoctoral Scholar
  at Caltech
- **2011 - 2014: Distinguished Postdoctoral Fellow at Kavli IPMU**
- 2014 - : Associate Professor,
  San Diego State University
- 2014 - : Director ,
  Mount Laguna Observatory



IPMU INSTITUTE FOR THE PHYSICS AND MATHEMATICS OF THE UNIVERSE

wpi World Premier International Research Center Initiative

東京大学 THE UNIVERSITY OF TOKYO

東京大学国際高等研究所 Todai Institutes for Advanced Study

Gravitational Lens & Supernova

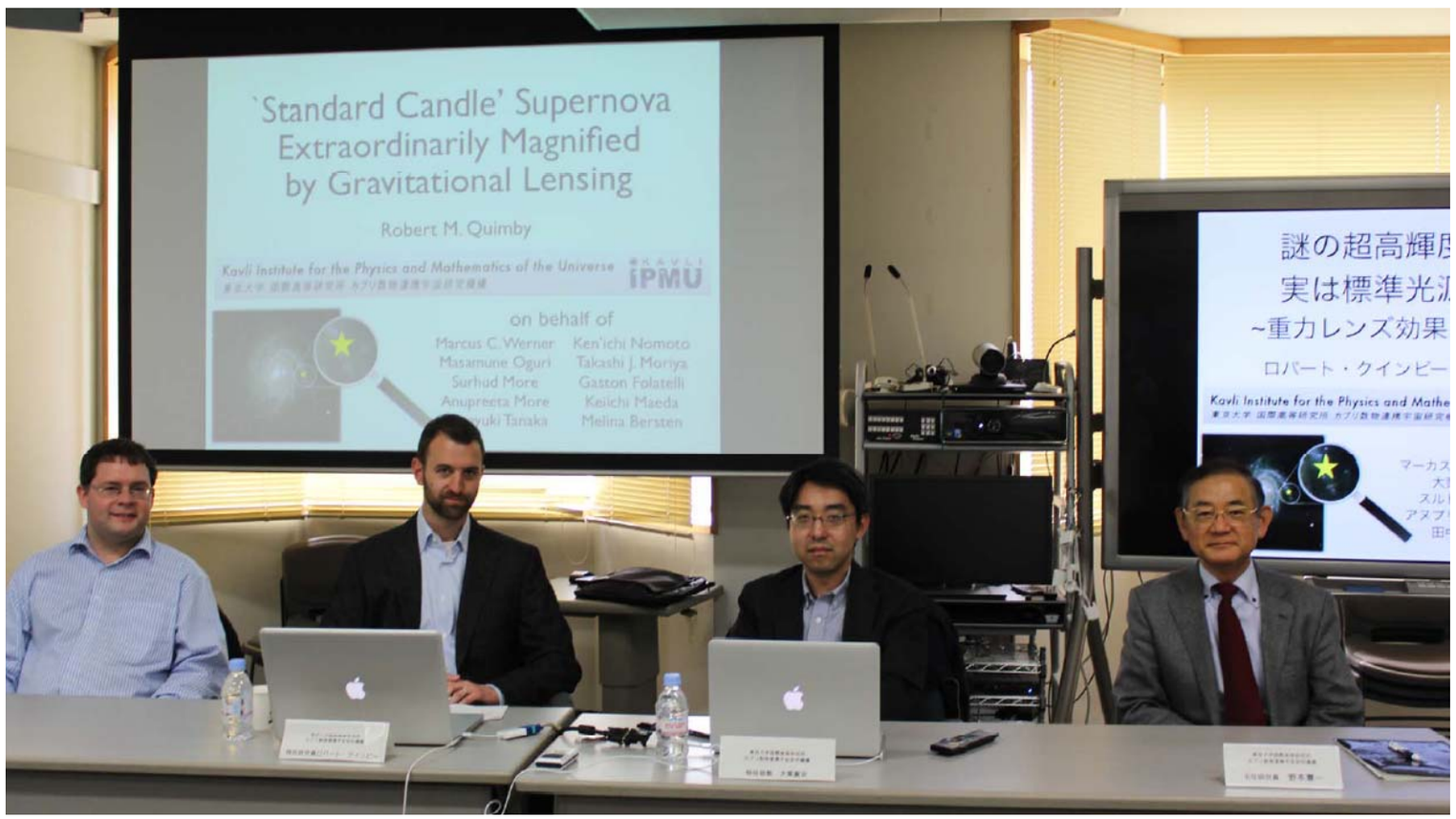
'STANDARD CANDLE' SUPERNOVA EXTRAORDINARILY MAGNIFIED BY GRAVITATIONAL LENSING

April 23, 2013
Kavli Institute for the Physics and Mathematics of the Universe

Kashiwa Japan - A team of researchers at the Kavli IPMU led by Robert Quimby has identified what may prove to be the first ever Type Ia supernova (SNIa) magnified by a strong gravitational lens. In this work, the 'standard candle' property of Type Ia supernovae is used to directly measure the magnification due to gravitational lensing. This provides the first glimpse of the science that will soon come out of dark matter and dark energy studies derived from deep, wide-field imaging surveys.

2 Press Conferences

1) 2013/04/23
2) 2014/04/25



2 papers:

1) Astrophys Journal (2013)
2) Science (2014)

Quimby, Werner, Oguri, S.More, A.More, Tanaka, Nomoto, Moriya, Folatelli, Maeda, Bersten
(all Kavli IPMU)

Mathematician + Astronomer + Physicist

Coffee time product

Extraordinary Supernovae

Robert Quimby

東京大学 国際高等研究所 カブリ数物連携宇宙研究機構

KAVLI INSTITUTE FOR THE PHYSICS AND MATHEMATICS OF THE UNIVERSE

SAN DIEGO STATE UNIVERSITY

Supernova Classification

Core-Collapse

Explosions of massive stars (initial masses greater than about $8M_\odot$)

Type II

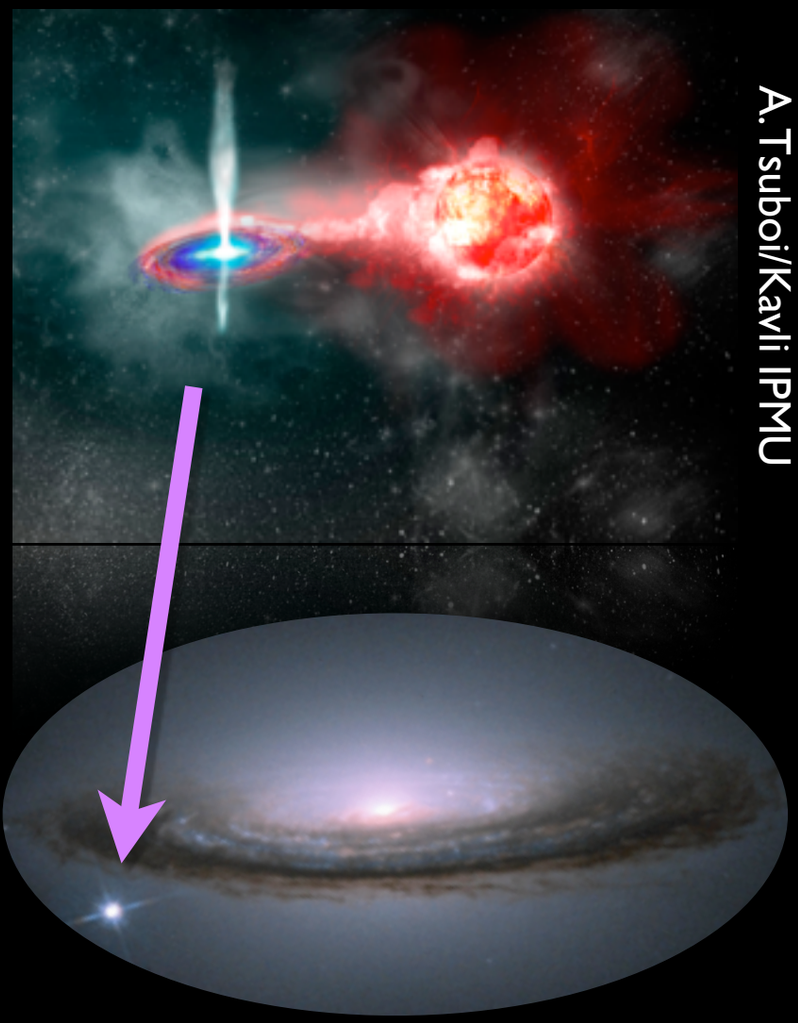
Hydrogen envelope intact

Type Ibc

stripped envelope (no Hydrogen)

Thermonuclear

Explosions of low-mass stars in binary systems



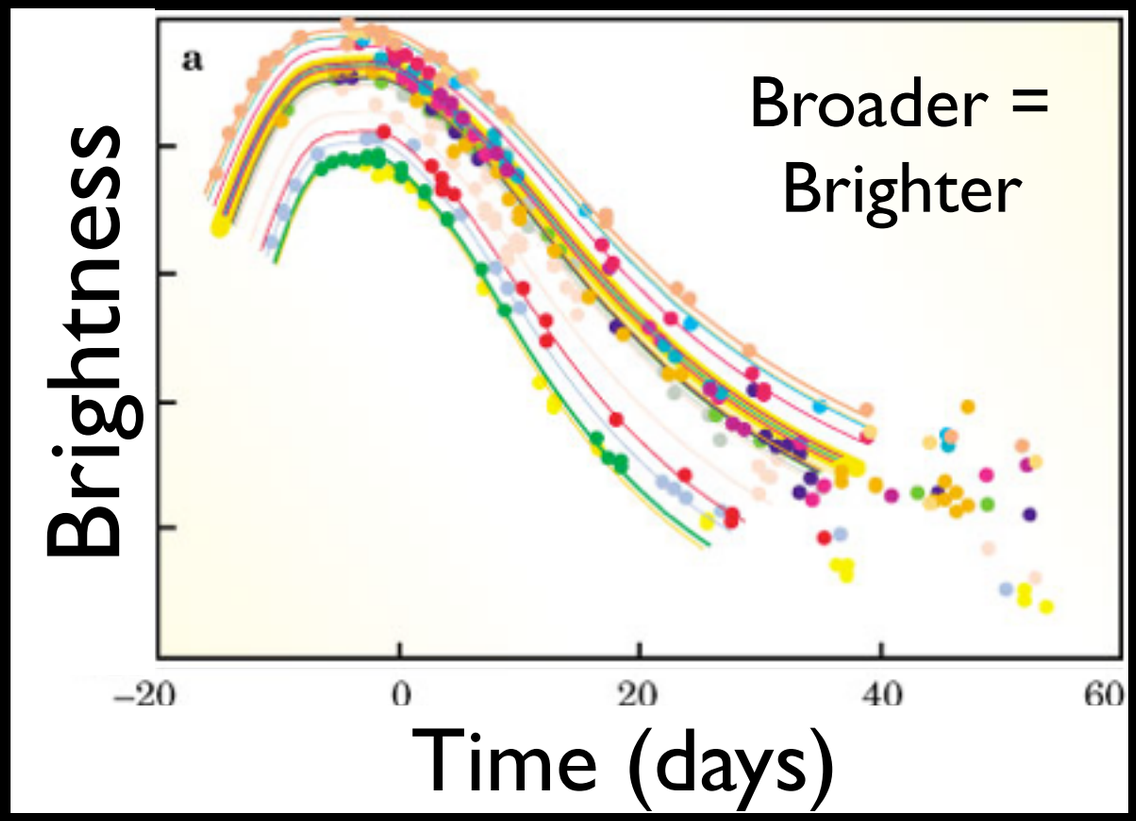
A. Tsuboi/Kavli IPMU

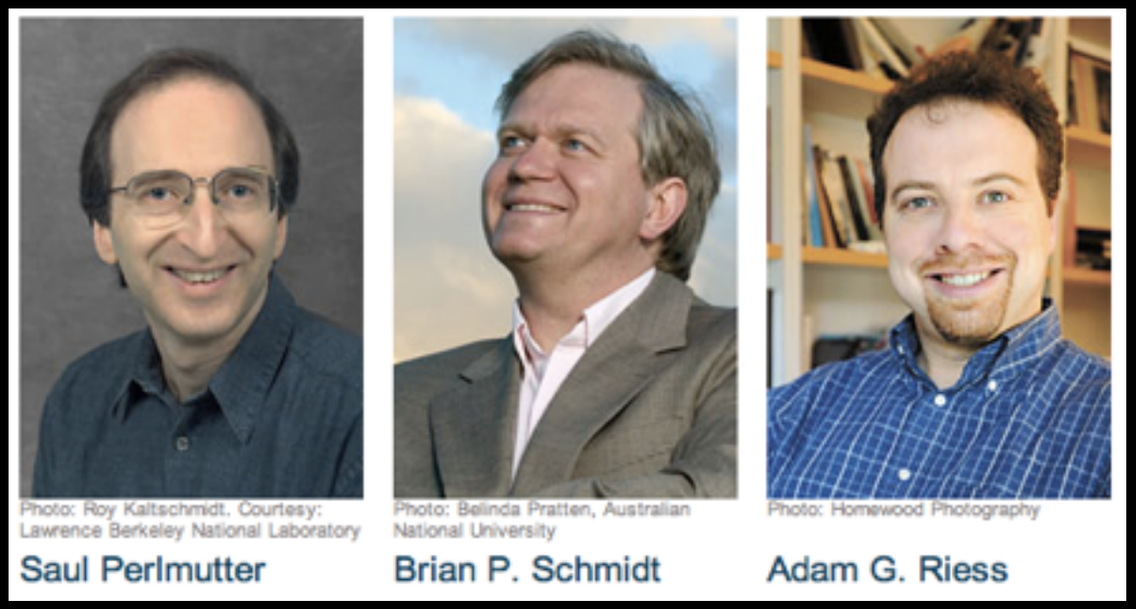
Type Ia

White dwarf star explodes

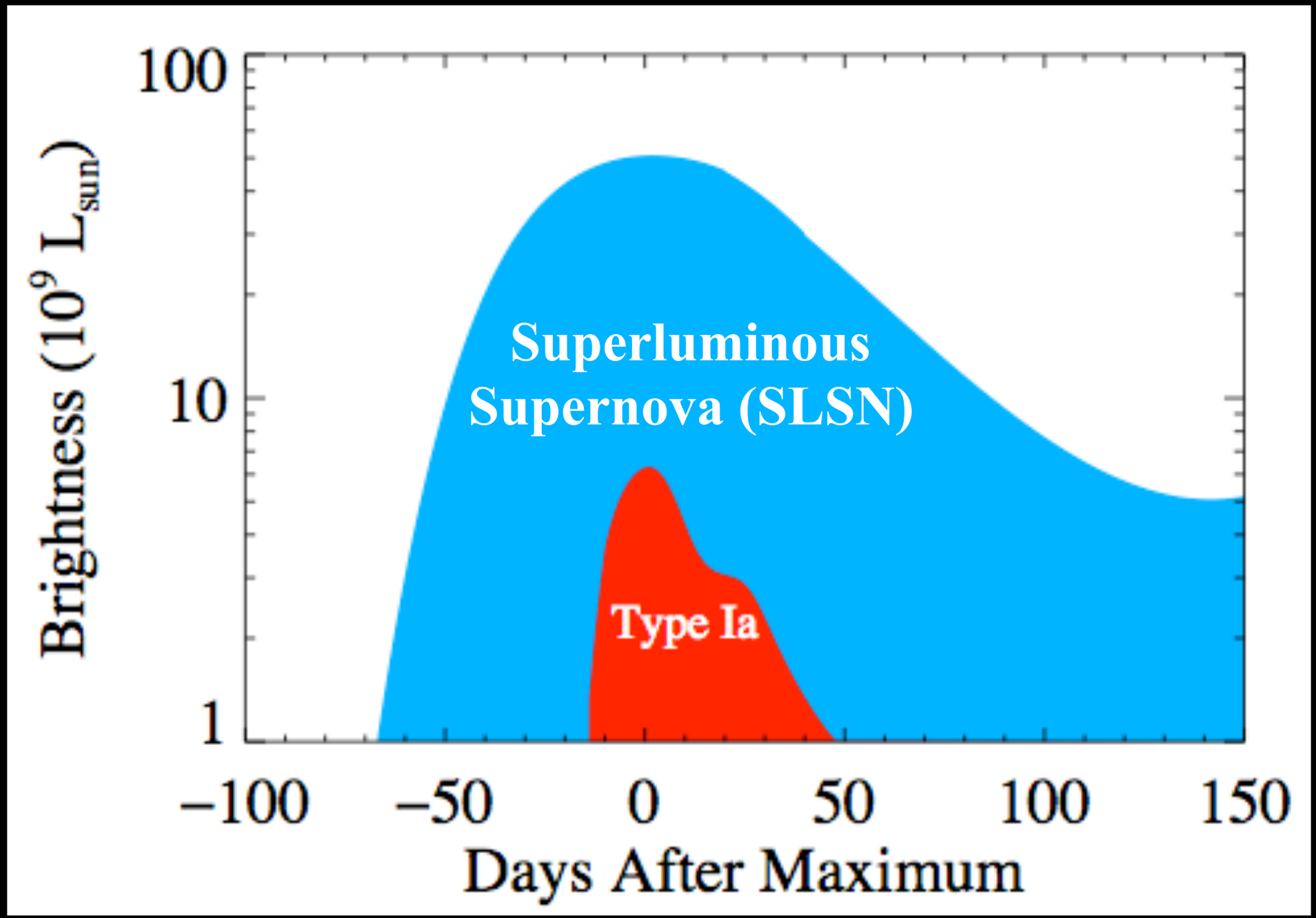
Type Ia Supernova

- Strikingly similar luminosities
- Used as a `Standard Candle' to chart the Universe's expansion
- 2011 Nobel Prize in Physics for the discovery of the accelerating Universe in 1997

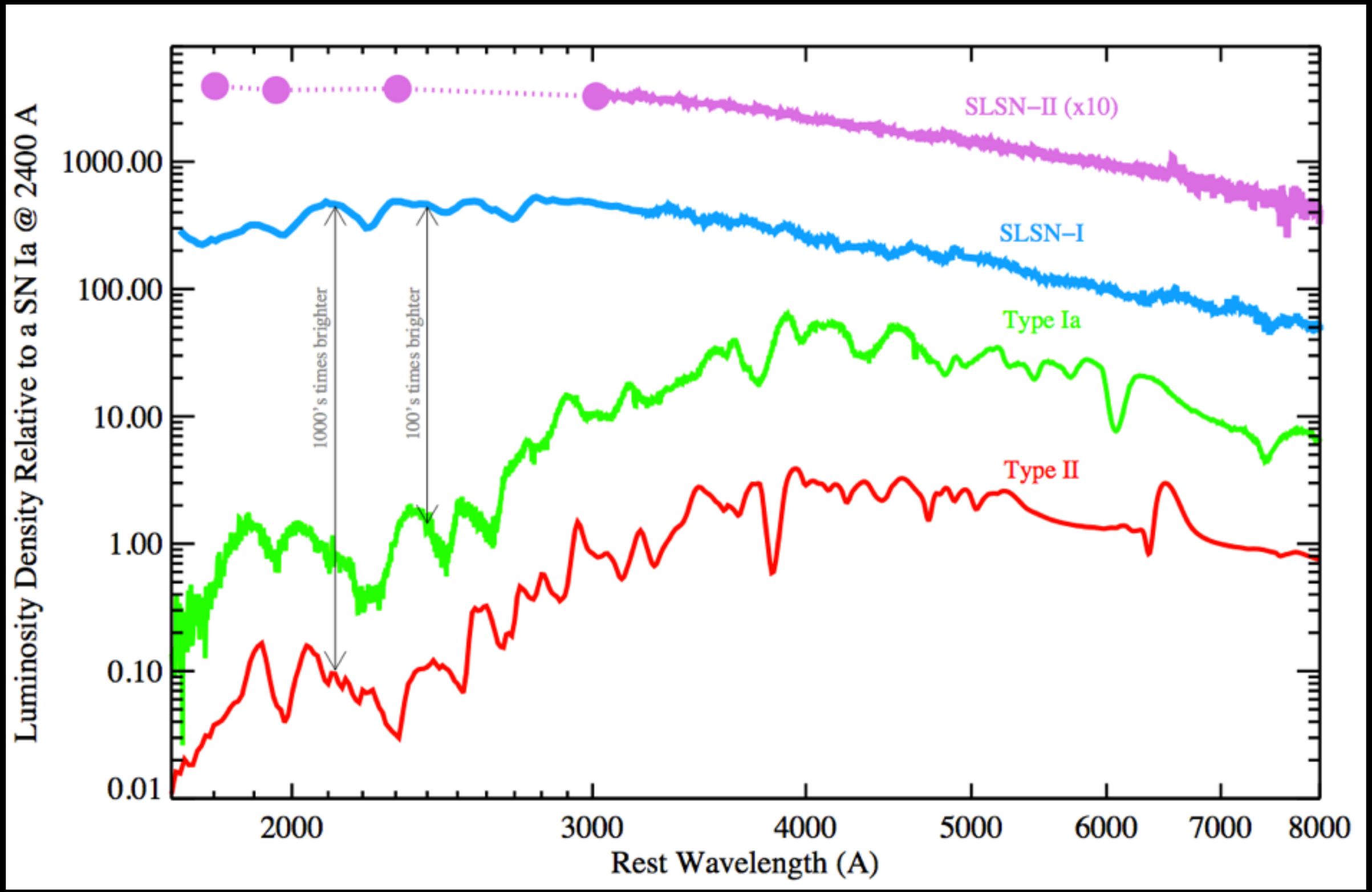




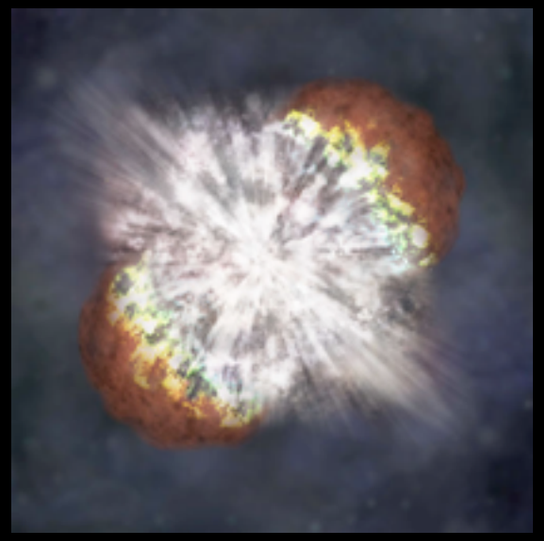
Supernova Light Curves



Supernova Spectra



SLSN Models

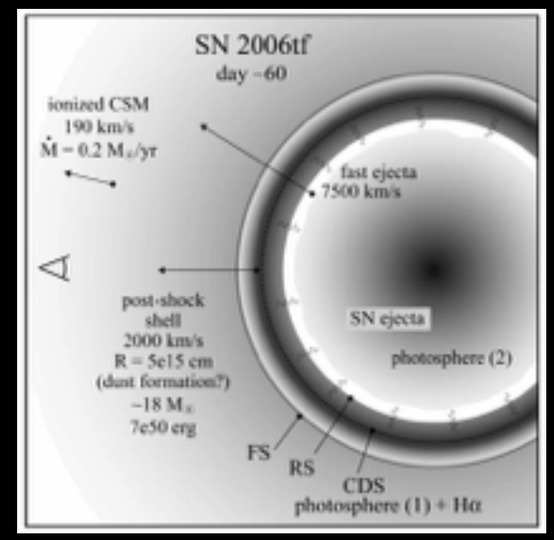


Pair-Instability

Complete obliteration of the core of a very massive star

e.g., **Rakavy & Shaviv (1967), Barkat et al. (1967)**

Circumstellar Interaction



Fast-moving supernova ejecta overtake a slow-moving wind

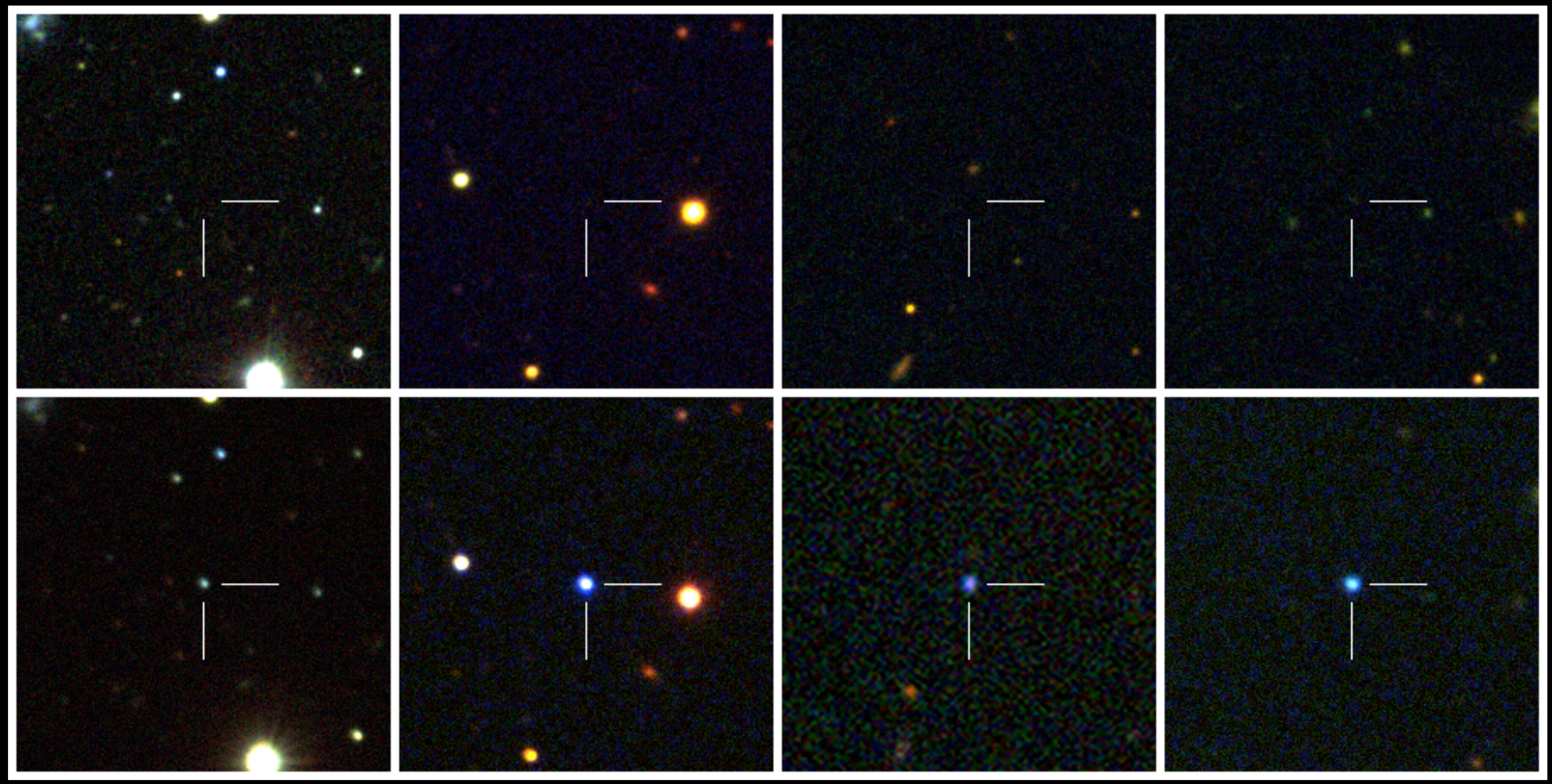
e.g., **Smith & McCray (2007), Chevalier & Irwin (2011)**

Magnetar

Spin-down energy from a nascent neutron star energizes the ejecta

e.g., **Kasen & Bildsten (2011), Woosley (2011)**

SLSN Sample in 2011



RQ et al. 2011

The Astrophysical Journal, 767:162 (16pp), 2013 April 20 doi:10.1088/0004-637X/767/2/162

PS1-10afx AT $z = 1.388$: PAN-STARRS1 DISCOVERY OF A NEW TYPE OF SUPERLUMINOUS SUPERNOVA

R. Chornock[1], E. Berger[1], A. Rest[2], D. Milisavljevic[1], R. Lunnan[1], R. J. Foley[1,14], A. M. Soderberg[1], S. J. Smartt[3], A. J. Burgasser[4], P. Challis[1], L. Chomiuk[5,15], I. Czekala[1], M. Drout[1], W. Fong[1], M. E. Huber[6], R. P. Kirshner[1], C. Leibler[7], B. McLeod[1], G. H. Marion[1], G. Narayan[1], A. G. Riess[2,8], K. C. Roth[9], N. E. Sanders[1], D. Scolnic[8], K. Smith[3], C. W. Stubbs[1,10], J. L. Tonry[6], S. Valenti[11,12], W. S. Burgett[6], K. C. Chambers[6], K. W. Hodapp[6], N. Kaiser[6], R.-P. Kudritzki[6], E. A. Magnier[6], and P. A. Price[13]

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[5] Department of Physics and Astronomy, Michigan State University, East Lansing, MI 48824, USA
[6] Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu, HI 96822, USA
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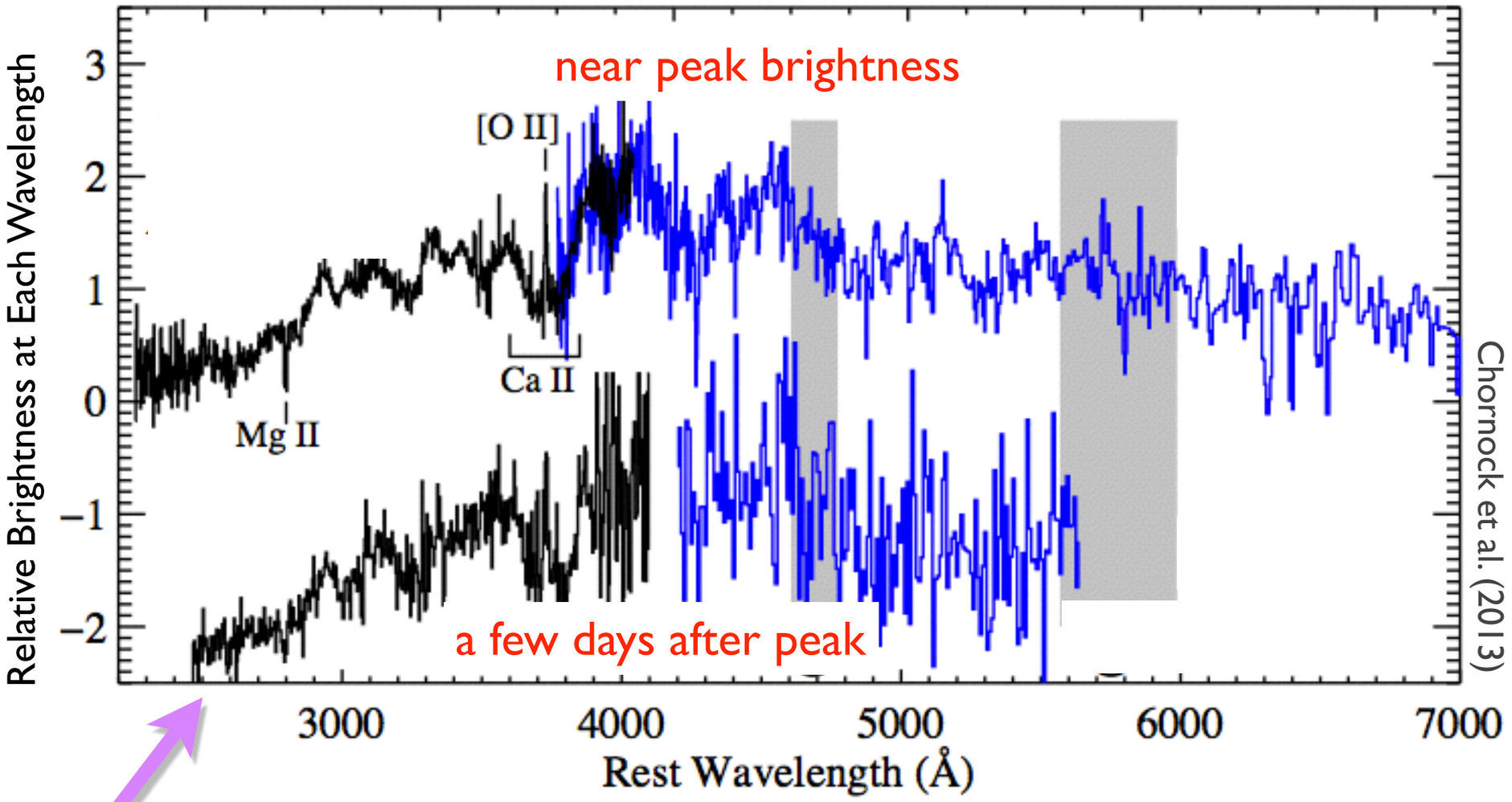
[9] Gemini Observatory, 670 North Aohoku Place, Hilo, HI 96720, USA
[10] Department of Physics, Harvard University, 17 Oxford Street, Cambridge, MA 02138, USA
[11] Las Cumbres Observatory Global Telescope Network, Inc., Santa Barbara, CA 93117, USA
[12] Department of Physics, University of California Santa Barbara, Santa Barbara, CA 93106-9530, USA
[13] Department of Astrophysical Sciences, Princeton University, Princeton, NJ 08544, USA
Received 2013 January 31; accepted 2013 March 11; published 2013 April 8

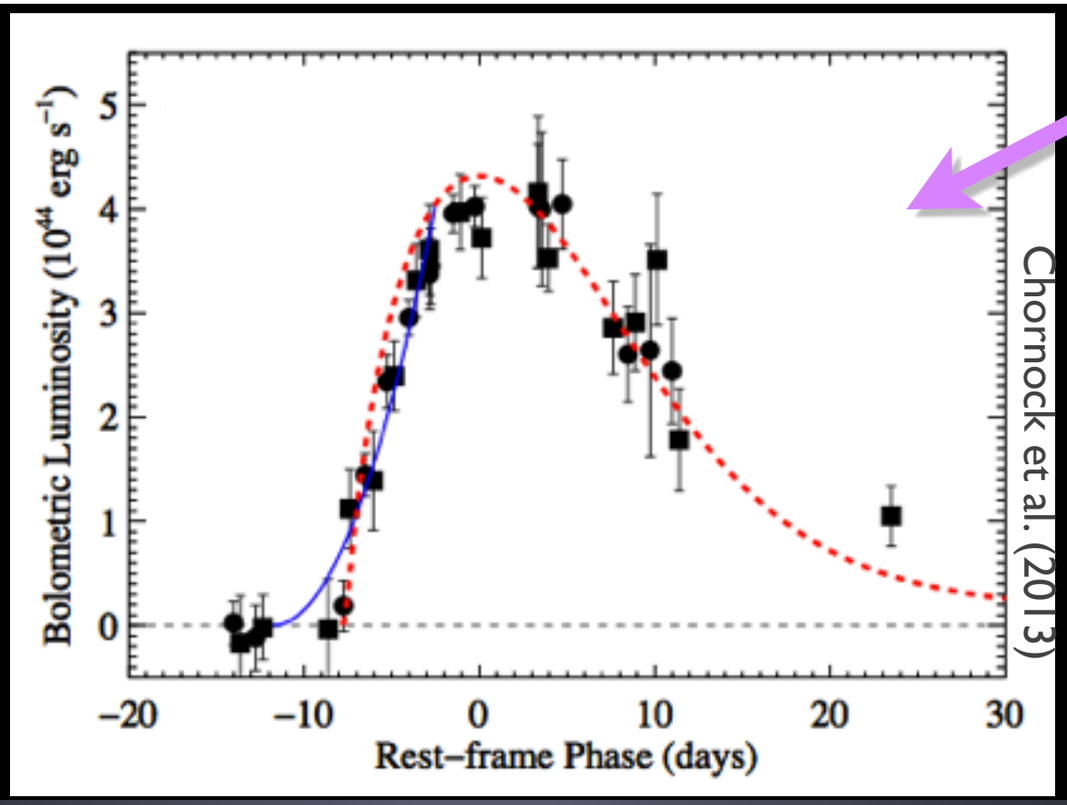
ABSTRACT

We present the Pan-STARRS1 discovery of PS1-10afx, a unique hydrogen-deficient superluminous supernova (SLSN) at redshift $z = 1.388$. The light curve peaked at $z_{P1} = 21.7$ mag, making PS1-10afx comparable to the most luminous known SNe, with $M_u = -22.3$ mag. Our extensive optical and near-infrared observations indicate that the bolometric light curve of PS1-10afx rose on the unusually fast timescale of ~12 days to the extraordinary peak luminosity of 4.1×10^{44} erg s^{-1} ($M_{bol} = -22.8$ mag) and subsequently faded rapidly. Equally important, the spectral energy distribution is unusually red for an SLSN, with a color temperature of ~6800 K near maximum light, in contrast to previous hydrogen-poor SLSNe, which are bright in the ultraviolet (UV). The spectra more closely resemble those of a normal SN Ic than any known SLSN, with a photospheric velocity of ~11,000 km s^{-1} and evidence for line blanketing in the rest-frame UV. Despite the fast rise, these parameters imply a very large emitting radius ($\gtrsim 5 \times 10^{15}$ cm). We demonstrate that no existing theoretical model can satisfactorily explain this combination of properties: (1) a nickel-powered light curve cannot match the combination of high peak luminosity with the fast timescale; (2) models powered by the spindown energy of a rapidly rotating magnetar predict significantly hotter and faster ejecta; and (3) models invoking shock breakout through a dense circumstellar medium cannot explain the observed spectra or color evolution. The host galaxy is well detected in pre-explosion imaging with a luminosity near L^*, a star formation rate of ~15 $M_\odot$ yr^{-1}, and is fairly massive (~2×10^{10} $M_\odot$), with a stellar population age of ~10^8 yr, also in contrast to the young dwarf hosts of known hydrogen-poor SLSNe. PS1-10afx is distinct from known examples of SLSNe in its spectra, colors, light-curve shape, and host galaxy properties, suggesting that it resulted from a different channel than other hydrogen-poor SLSNe.



Spectra

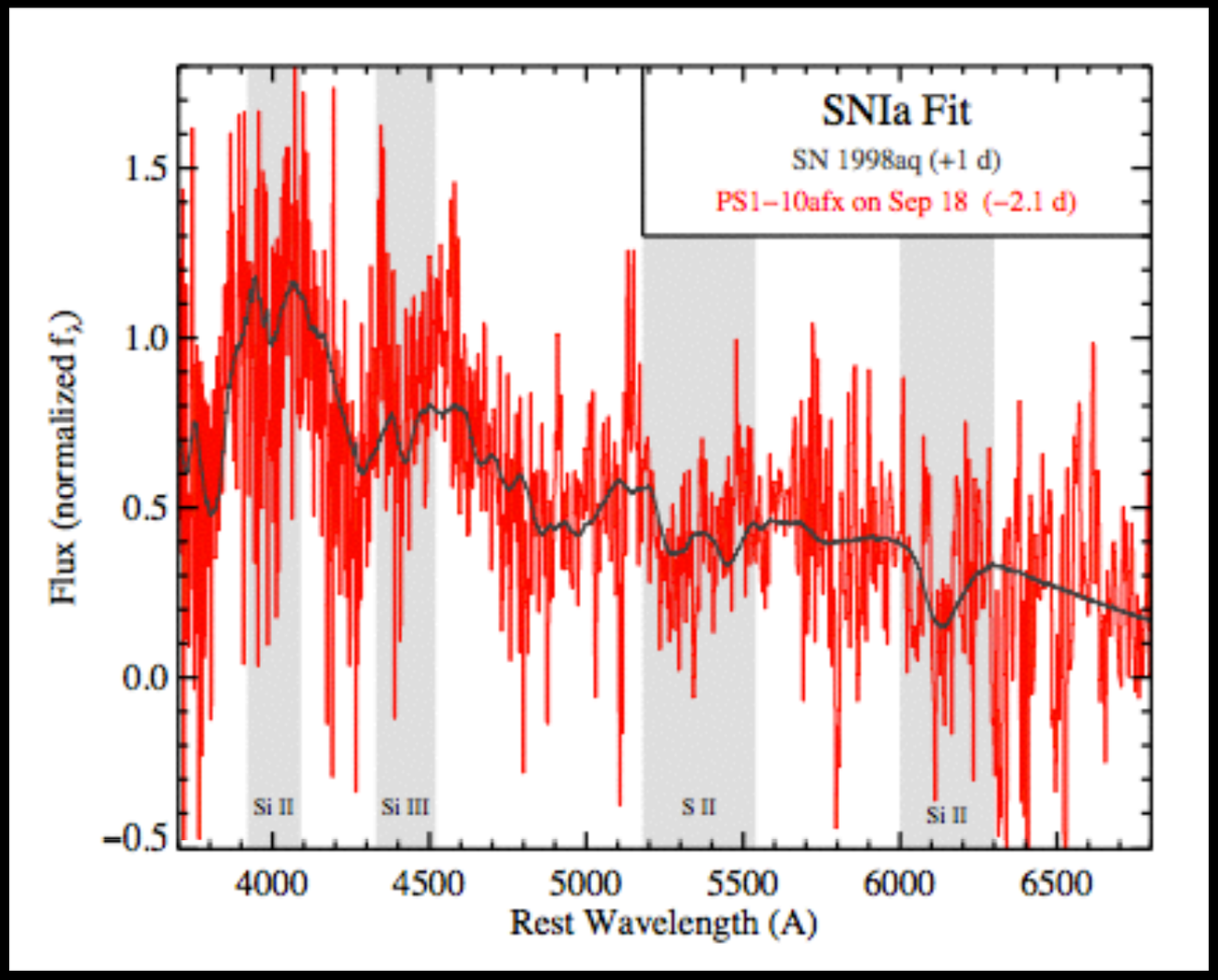
Shows what the supernova has a normal temperature and composition



Photometry

Shows the supernova brighten and faded on a timescale similar to normal supernovae

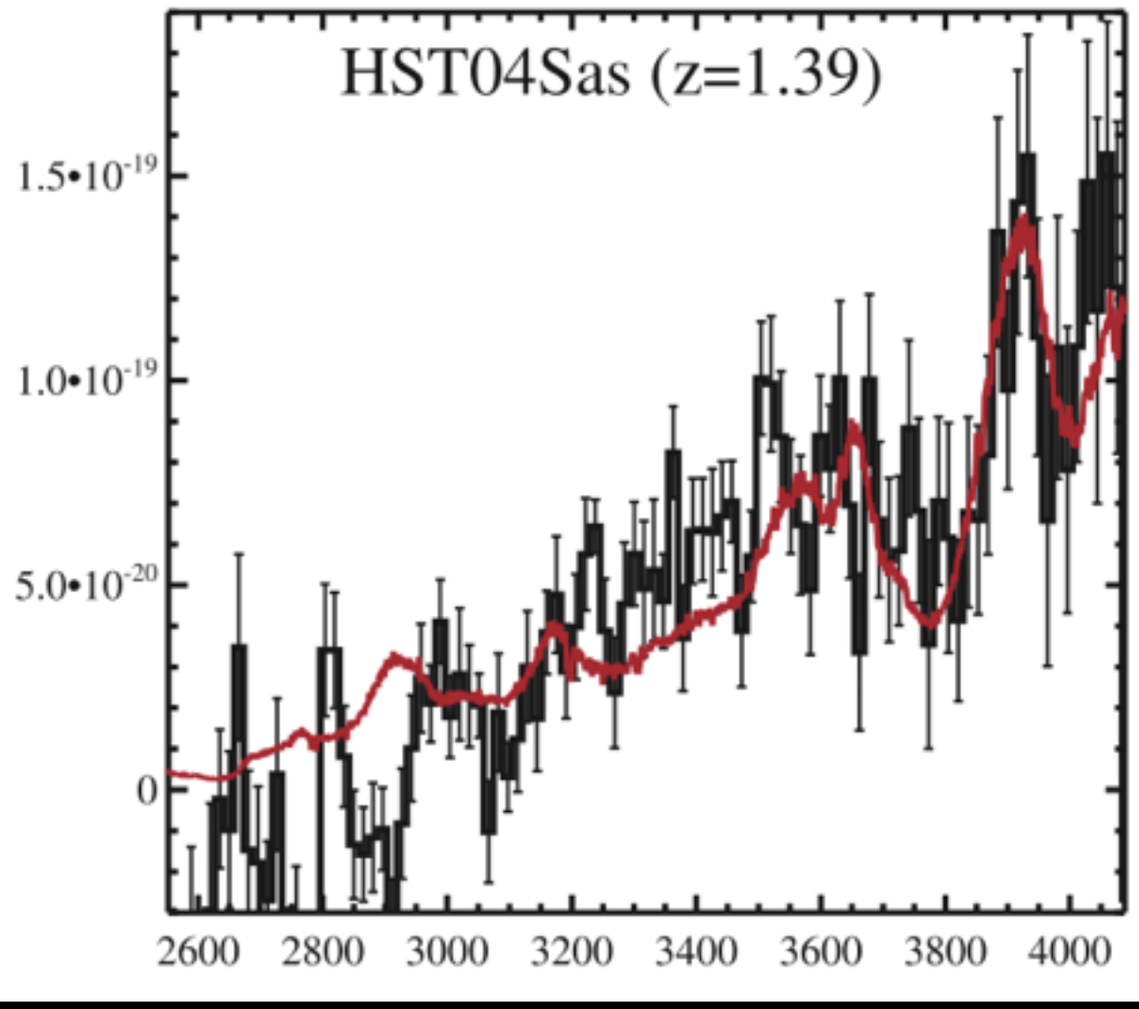
PS1-10afx Spectra Match to SNIa



RQ et al. 2013

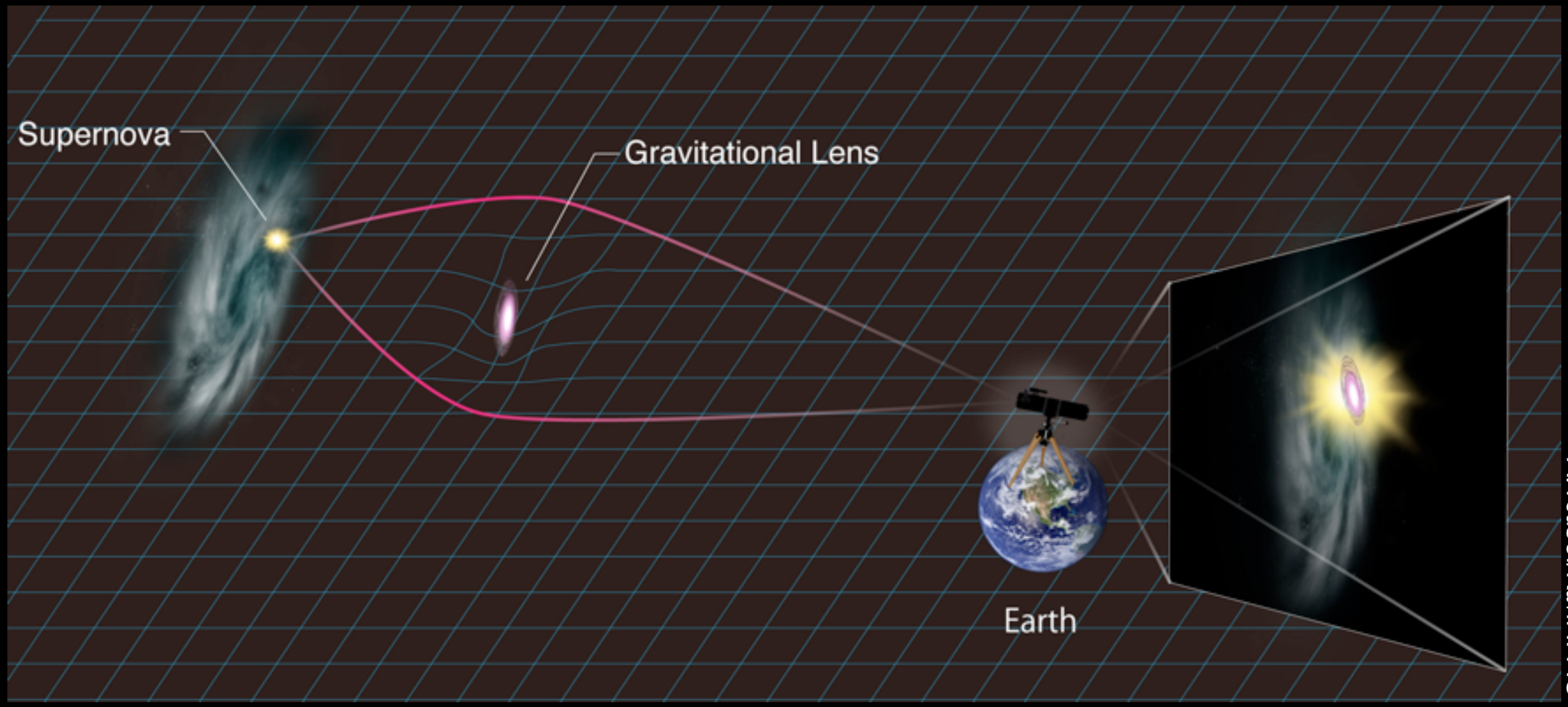
HST04Sas.....	53,156.2 (+1)	*HST* ACS	1.39[a,b]

[a] From cross-correlation with broad SN features.
[b] Classified as SN Ia with high confidence from spectrum.



Riess et al. (2007)

PS1-10afx is a Type Ia Supernova Magnified by a Gravitational Lens



First strongly lensed Type Ia supernova!

Kavli IPMU Does it All

The Astrophysical Journal Letters, 768:L20 (5pp), 2013 May 1 doi:10.1088/2041-8205/768/1/L20

EXTRAORDINARY MAGNIFICATION OF THE ORDINARY TYPE Ia SUPERNOVA PS1-10afx

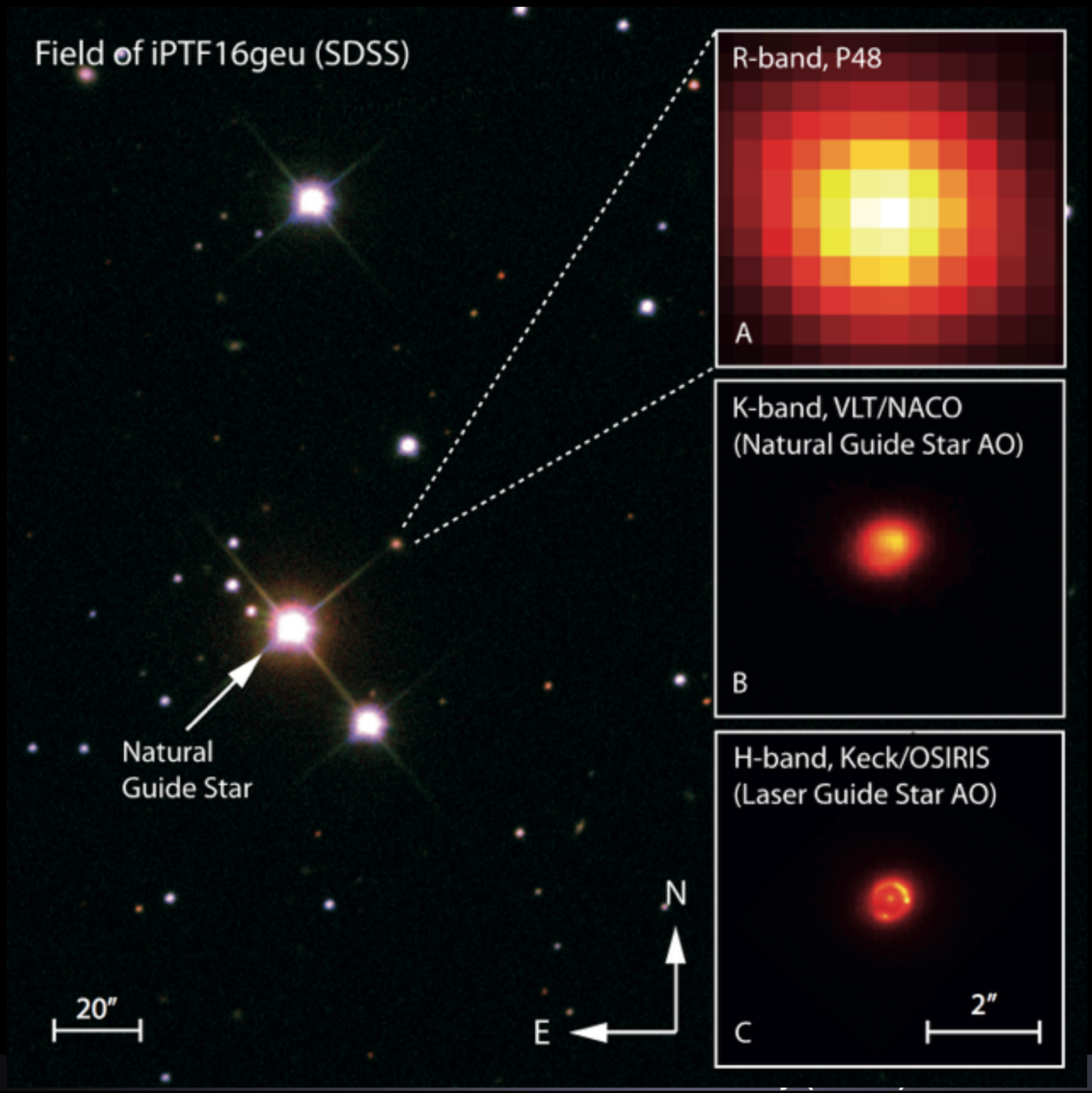
Robert M. Quimby, Marcus C. Werner, Masamune Oguri, Surhud More, Anupreeta More, Masayuki Tanaka, Ken'ichi Nomoto, Takashi J. Moriya, Gaston Folatelli, Keiichi Maeda, and Melina Bersten
Kavli Institute for the Physics and Mathematics of the Universe (Kavli IPMU), The University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa-shi, Chiba 277-8583, Japan; robert.quimby@ipmu.jp
Received 2013 February 12; accepted 2013 April 4; published 2013 April 18

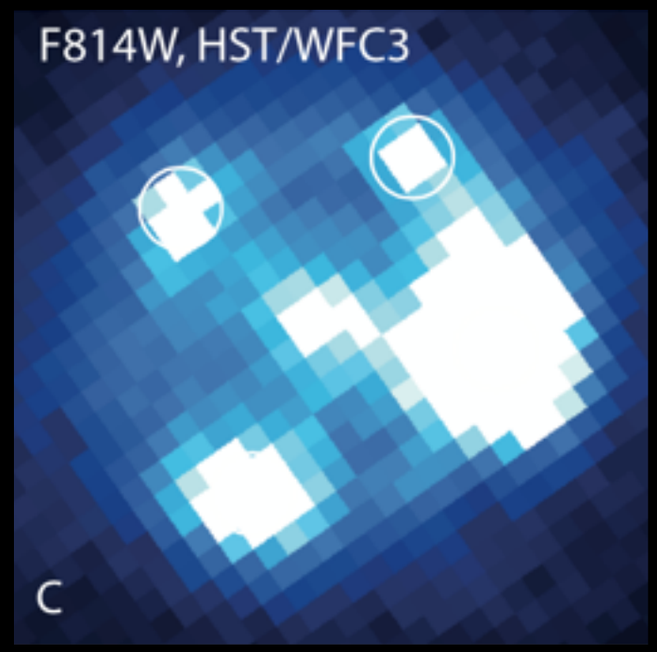
ABSTRACT

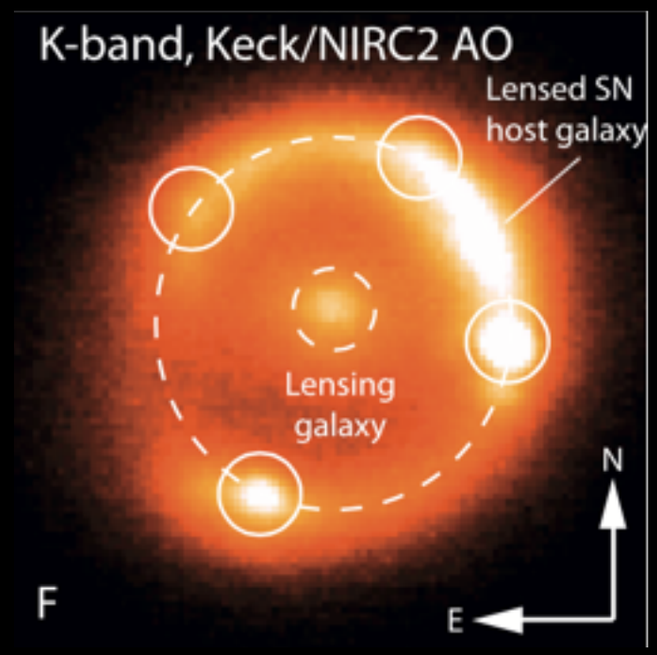
Recently, Chornock and co-workers announced the Pan-STARRS discovery of a transient source reaching an apparent peak luminosity of $\sim 4 \times 10^{44}$ erg s^{-1}. We show that the spectra of this transient source are well fit by normal Type Ia supernova (SNIa) templates. The multi-band colors and light-curve shapes are also consistent with normal SNeIa at the spectroscopically determined redshift of $z = 1.3883$; however, the observed flux is a constant factor of $\sim$30 times too bright in each band over time as compared to the templates. At minimum, this shows that the peak luminosities inferred from the light-curve widths of some SNeIa will deviate significantly from the established, empirical relation used by cosmologists. We argue on physical grounds that the observed fluxes do not reflect an intrinsically luminous SNIa, but rather PS1-10afx is a normal SNIa whose flux has been magnified by an external source. The only known astrophysical source capable of such magnification is a gravitational lens. Given the lack of obvious lens candidates, such as galaxy clusters, in the vicinity, we further argue that the lens is a supermassive black hole or a comparatively low-mass dark matter halo. In this case, the lens continues to magnify the underlying host galaxy light. If confirmed, this discovery could impact a broad range of topics including cosmology, gamma-ray bursts, and dark matter halos.

iPTF Finds Another

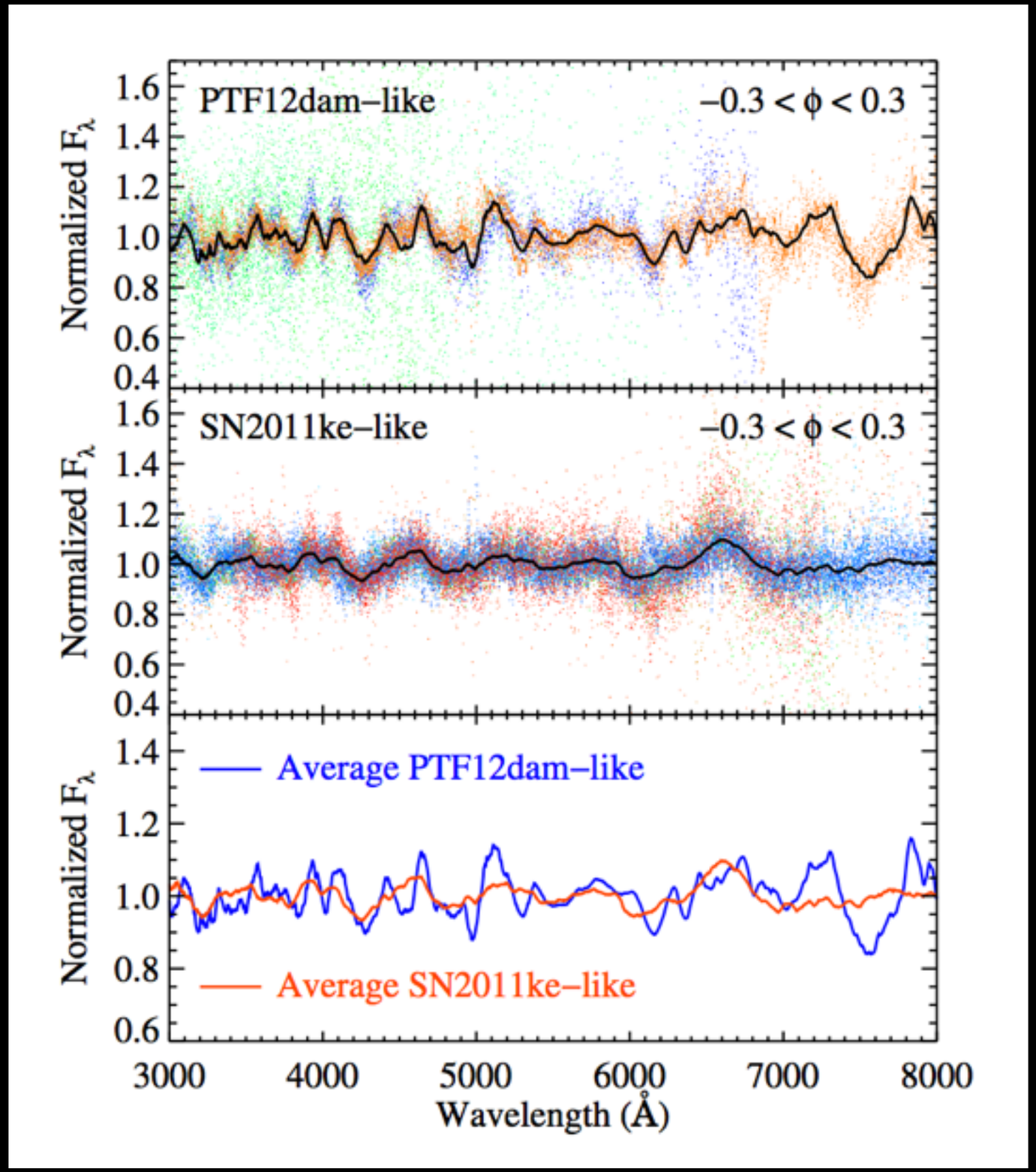
Goobar et al. 2017
(see also More et al. 2017)





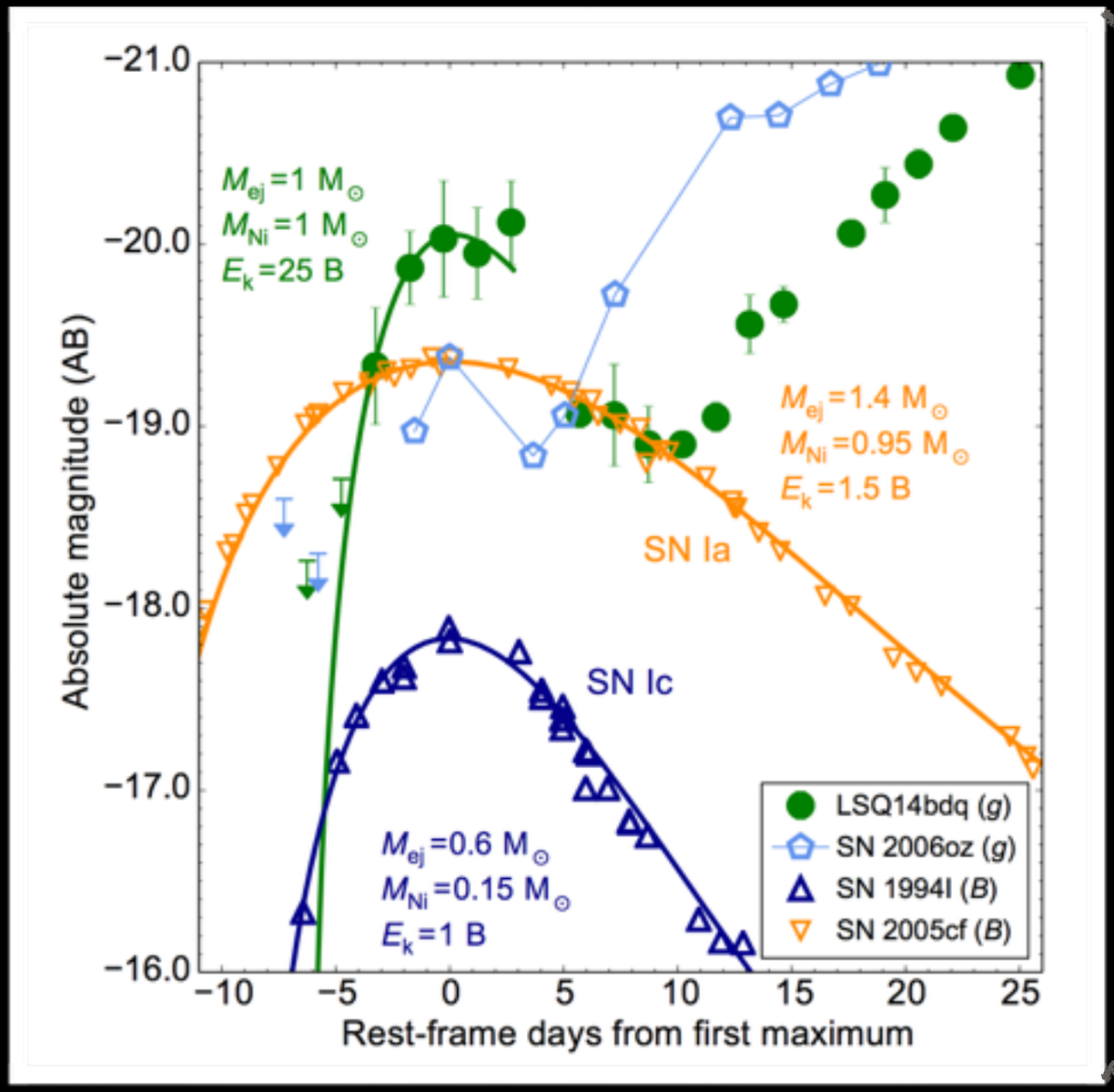


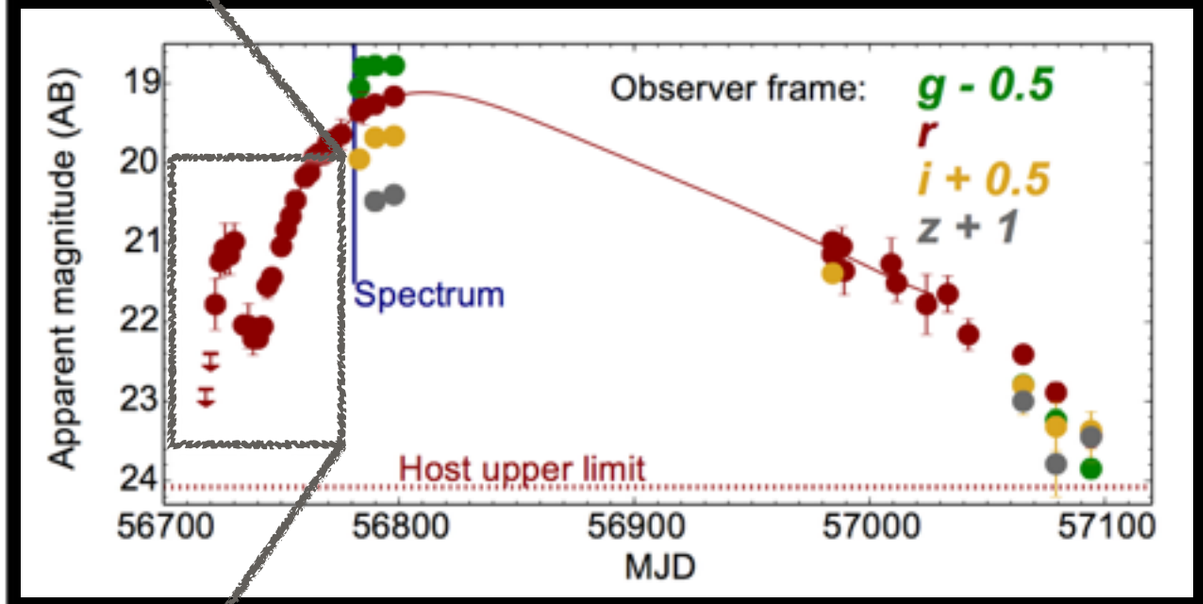
PTF SLSN-I



RQ et al. (submitted)

Early SLSN-I Bump



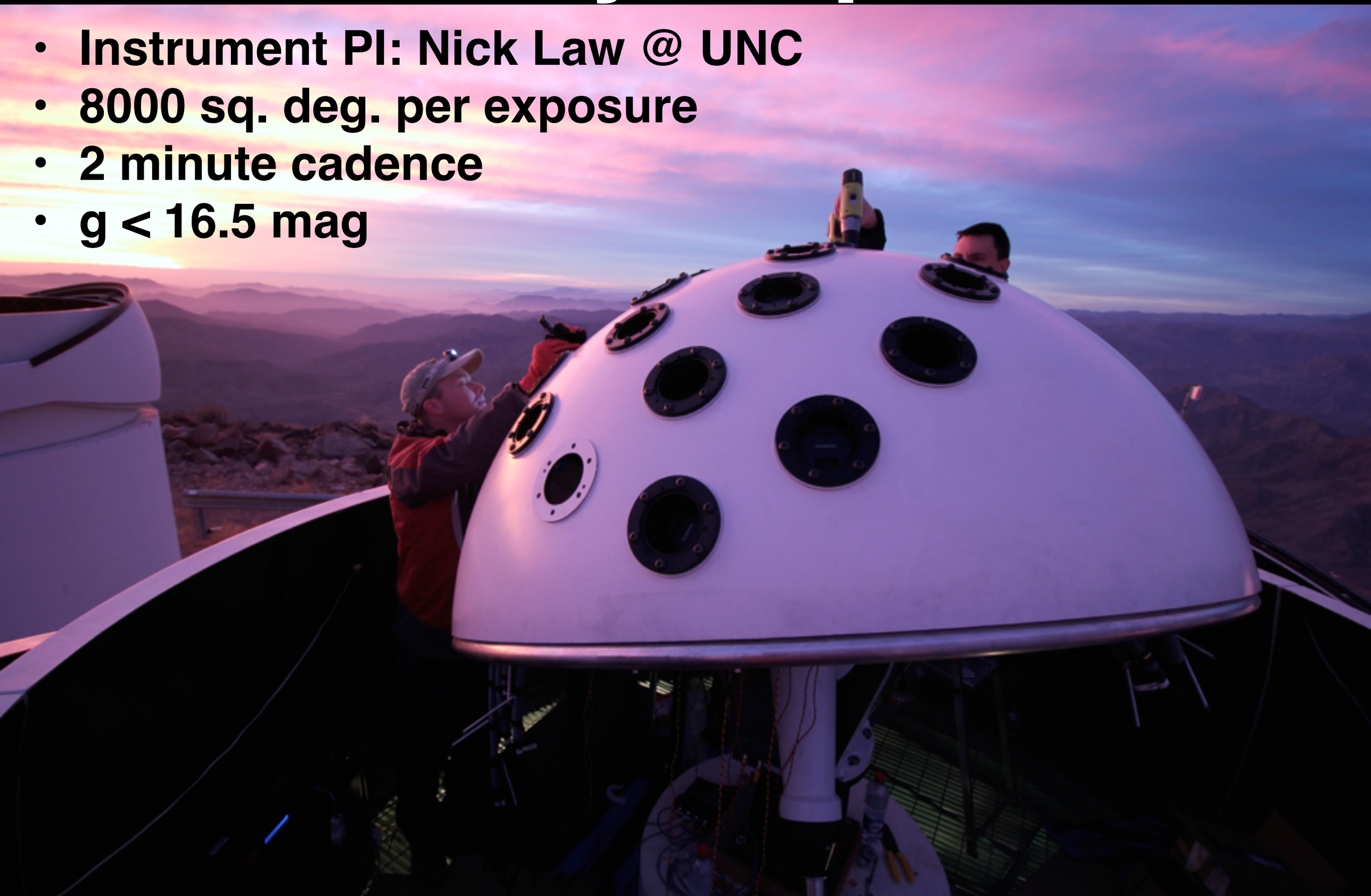


Nicholl et al. (2015)

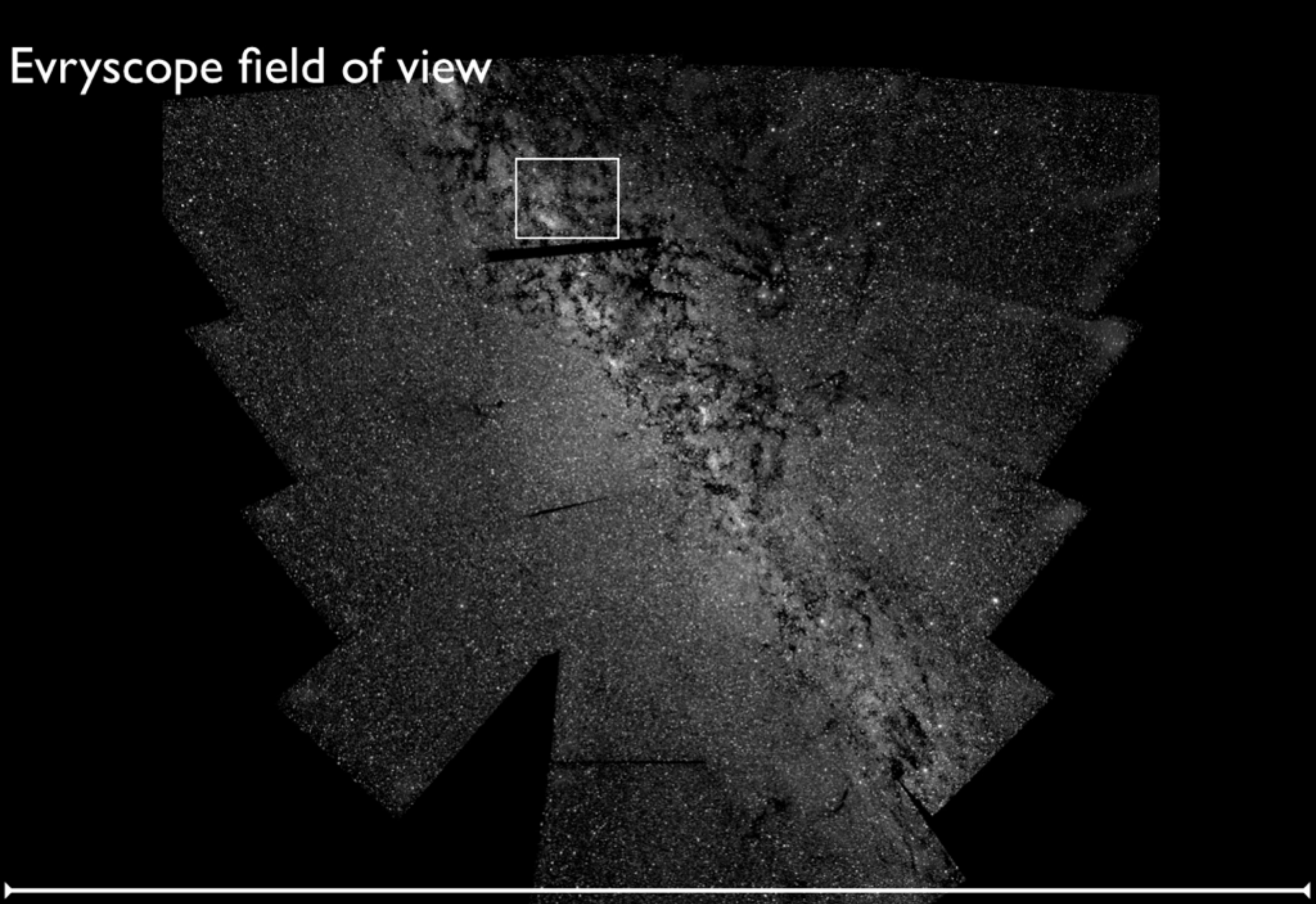
See also Leloudas et al. 2012
Nicholl & Smartt 2016
Kasen et al. 2016

Evryscope

- **Instrument PI: Nick Law @ UNC**
- **8000 sq. deg. per exposure**
- **2 minute cadence**
- **g < 16.5 mag**



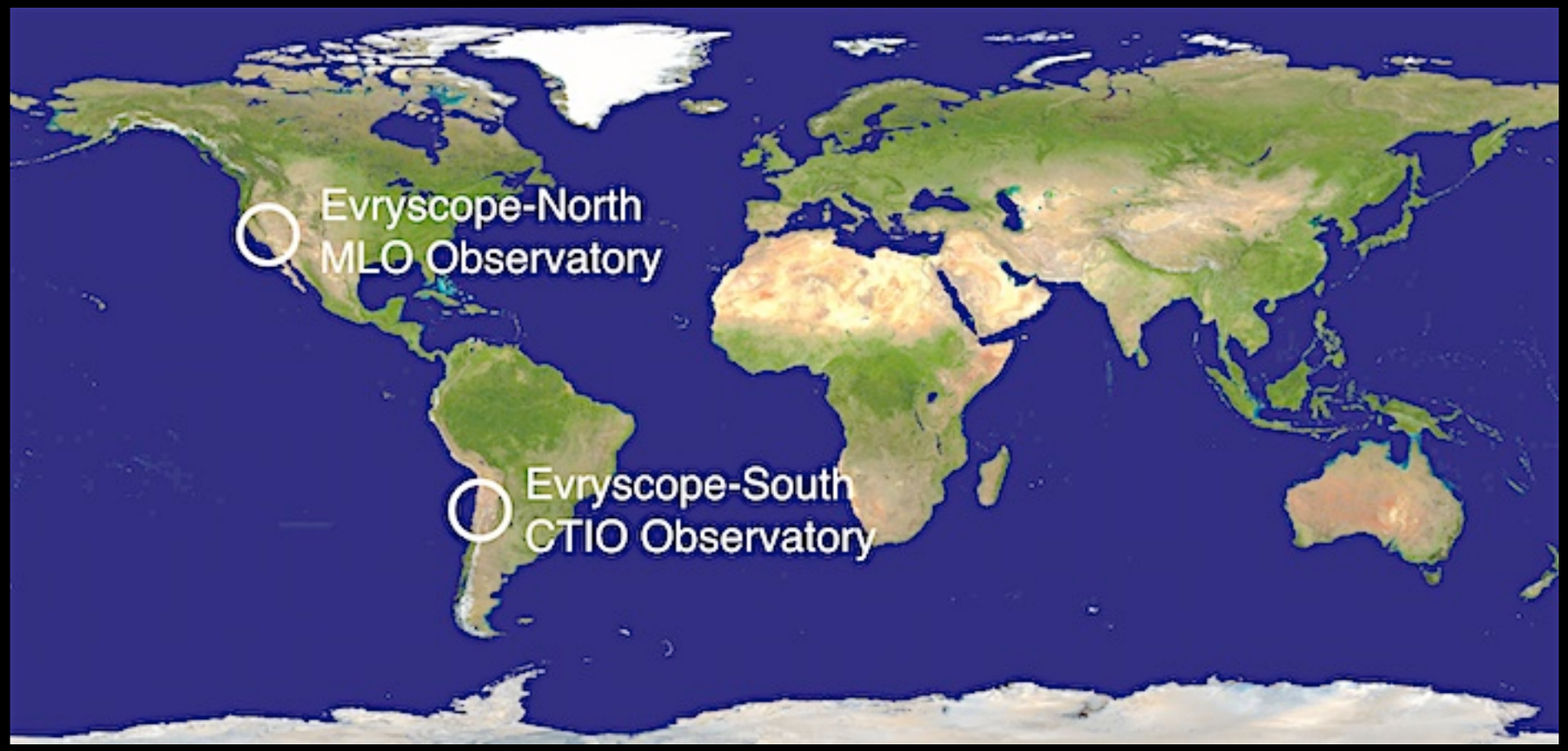
Evryscope field of view



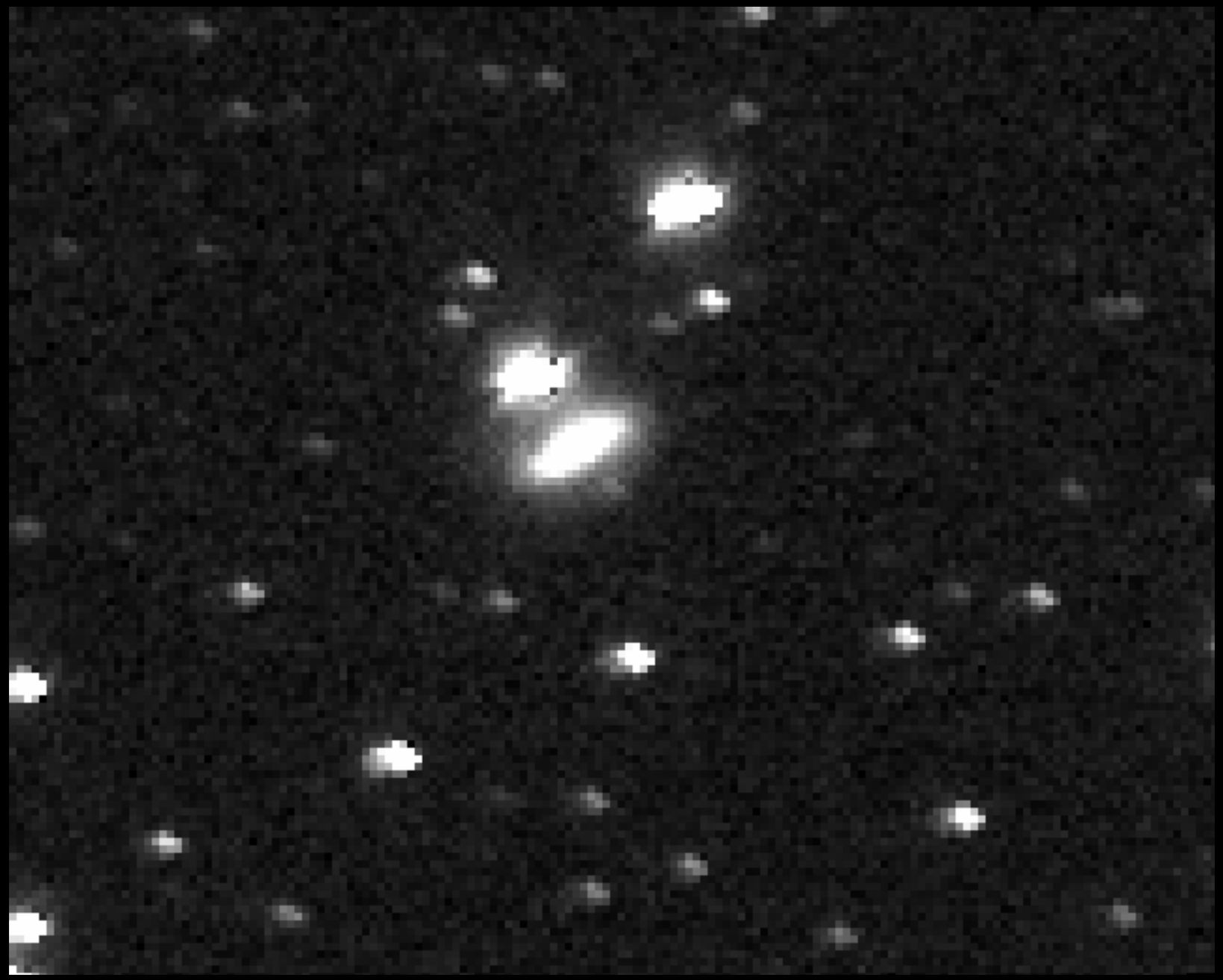
36,000 pixels; 100 degrees

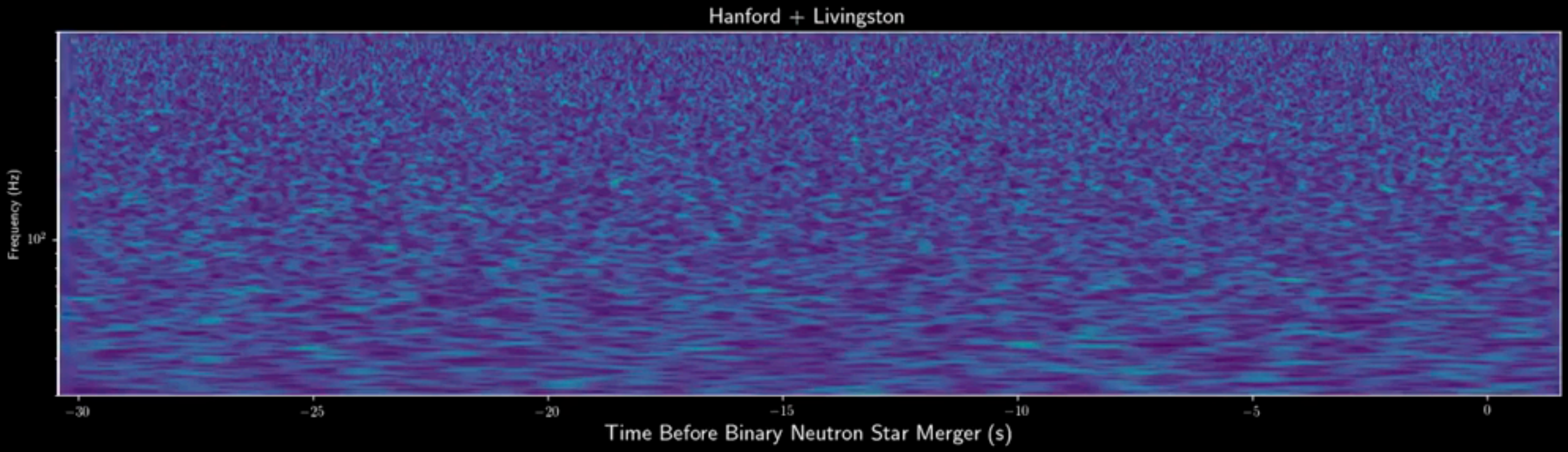

1% of Evryscope field of view

Evryscope North Coming Soon



Catching Fast Transients




Hanford + Livingston
Frequency (Hz)
10^2
−30
−25
−20
−15
−10
−5
0
Time Before Binary Neutron Star Merger (s)