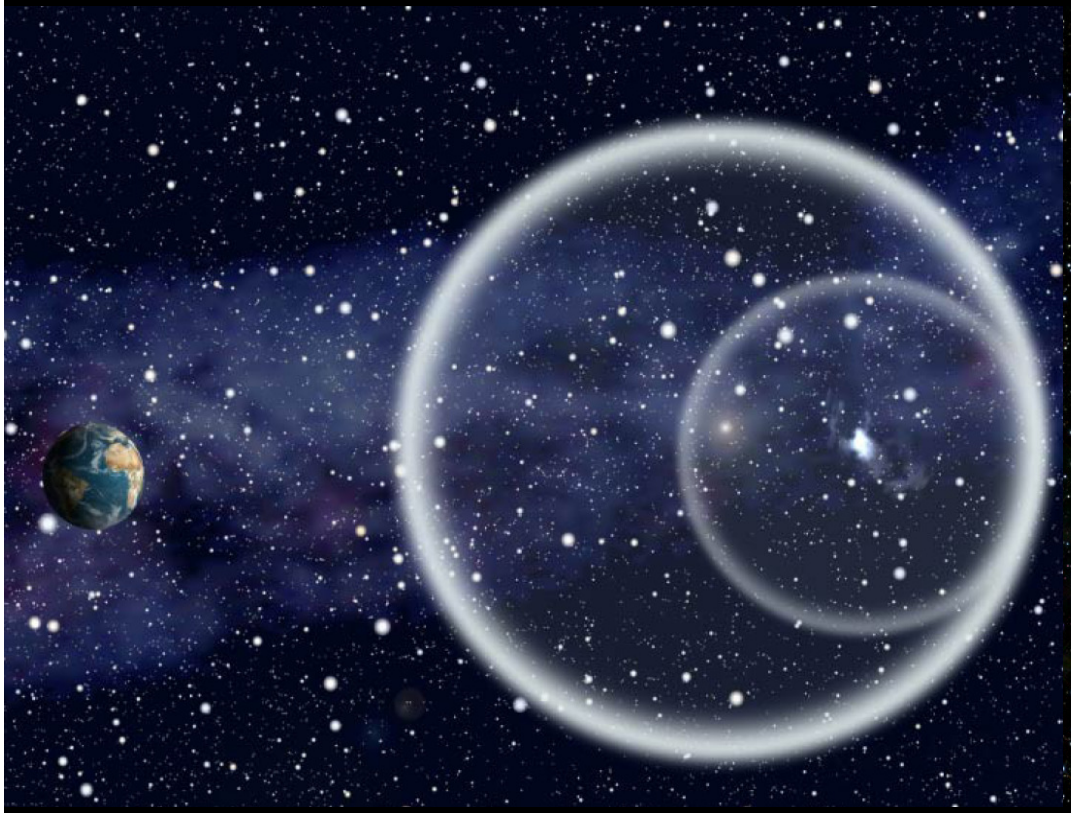
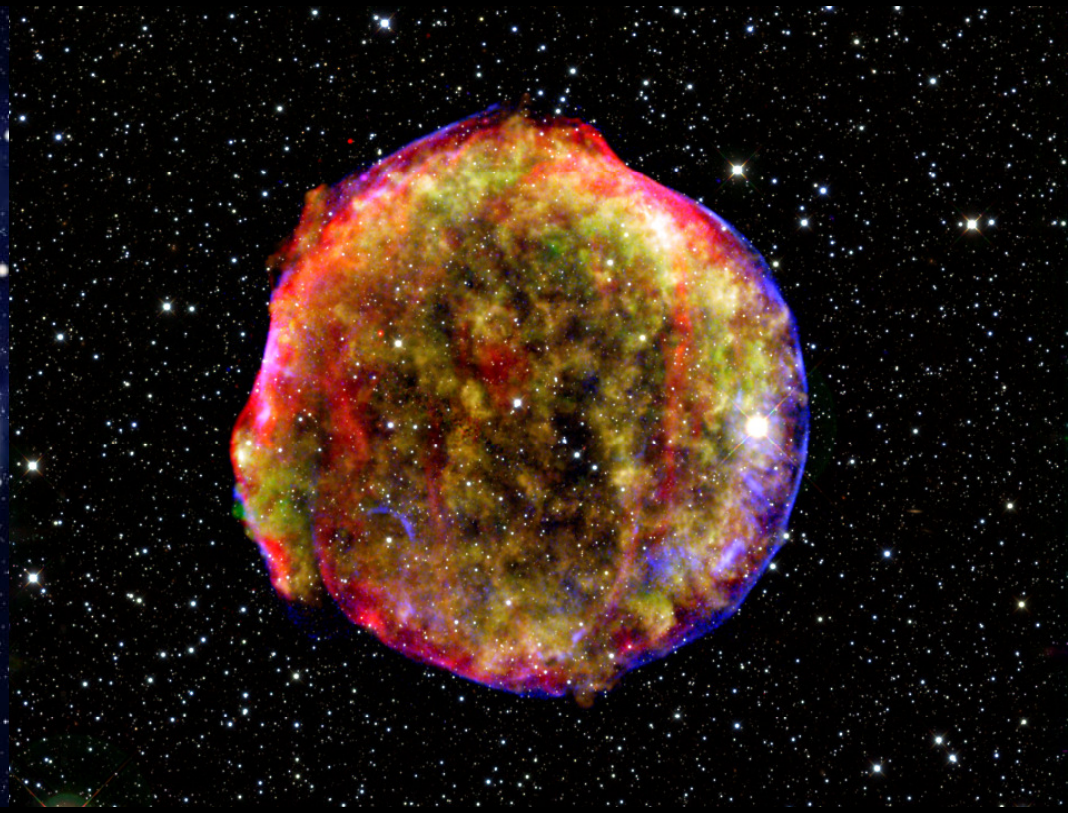
Subaru light-echo spectroscopy of historic galactic SNe:
Revealing the nature of Tycho´s SN1572 and Cas A





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- Tomonori Usuda, Takashi Hattori (Subaru)
- George Rieke, Karl Misselt (U. Arizona)
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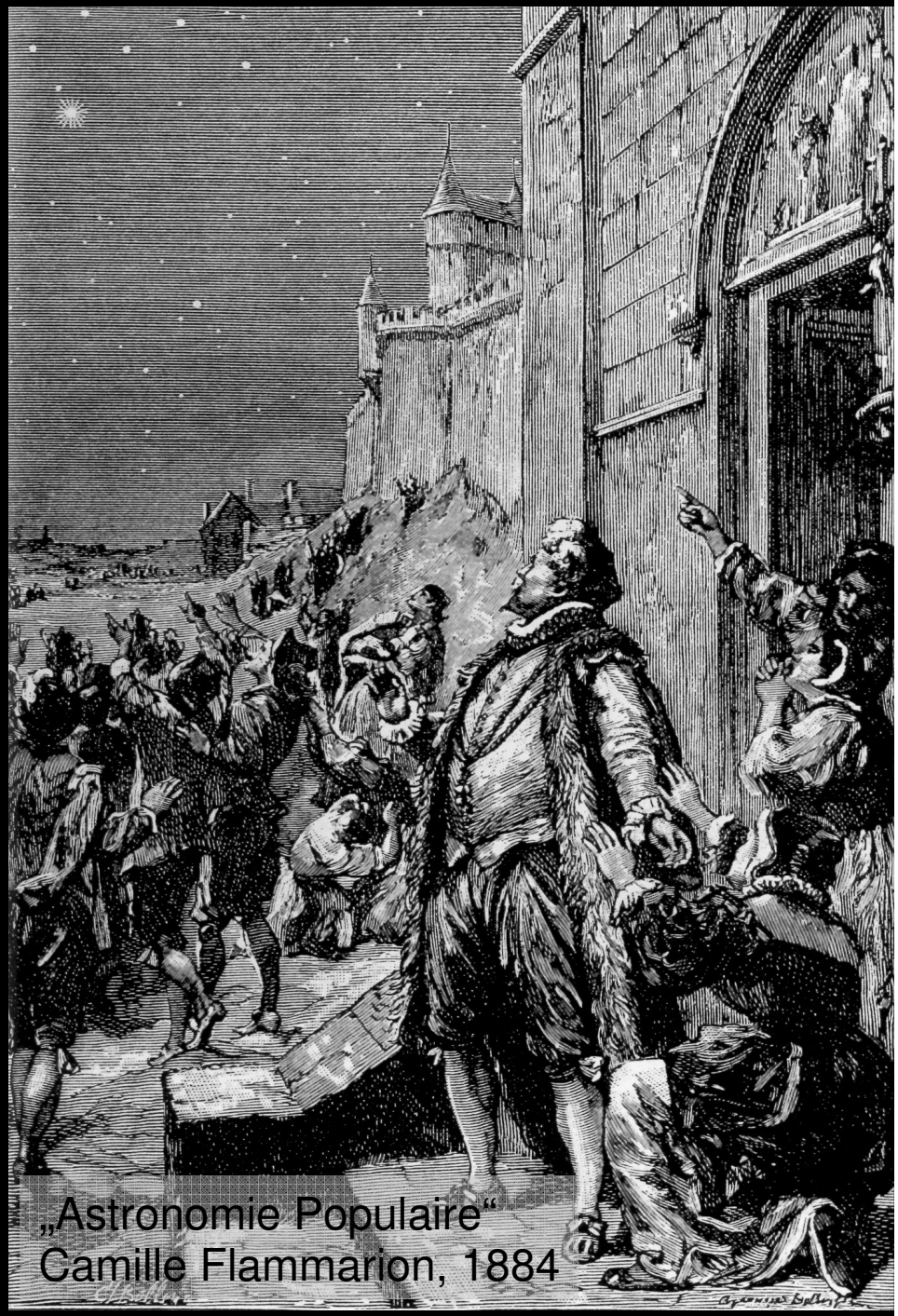
Supernova of the year 1572

No parallax ⟶ More distant than the moon

Contradiction to Aristotle
(Heavens not immutable and eternal)

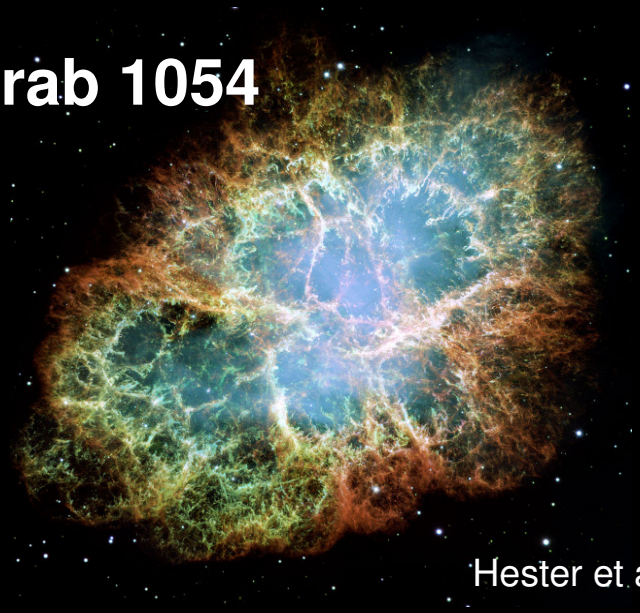
Milestone for a new view of the cosmos –
together with Galileo and Kepler in 1609

Today, SNe are still key objects to our understanding of the universe



Historic Galactic Supernovae

Crab 1054



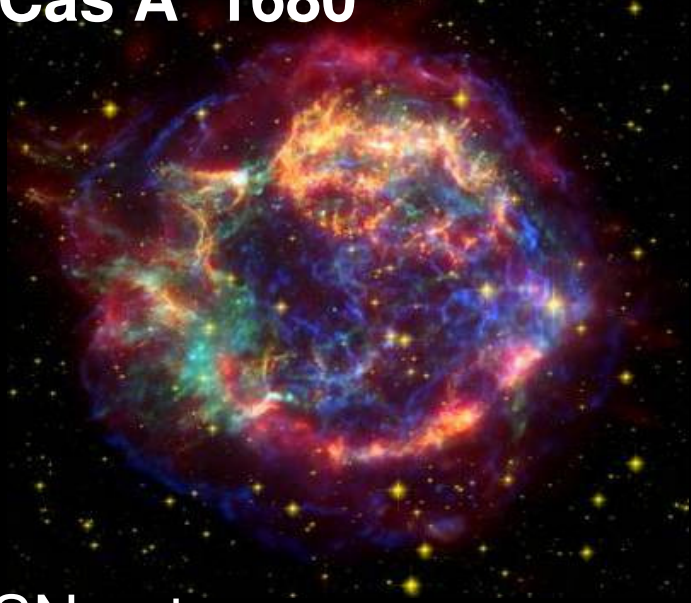
Hester et al.

Tycho 1572

Kepler 1604

Blair et al.

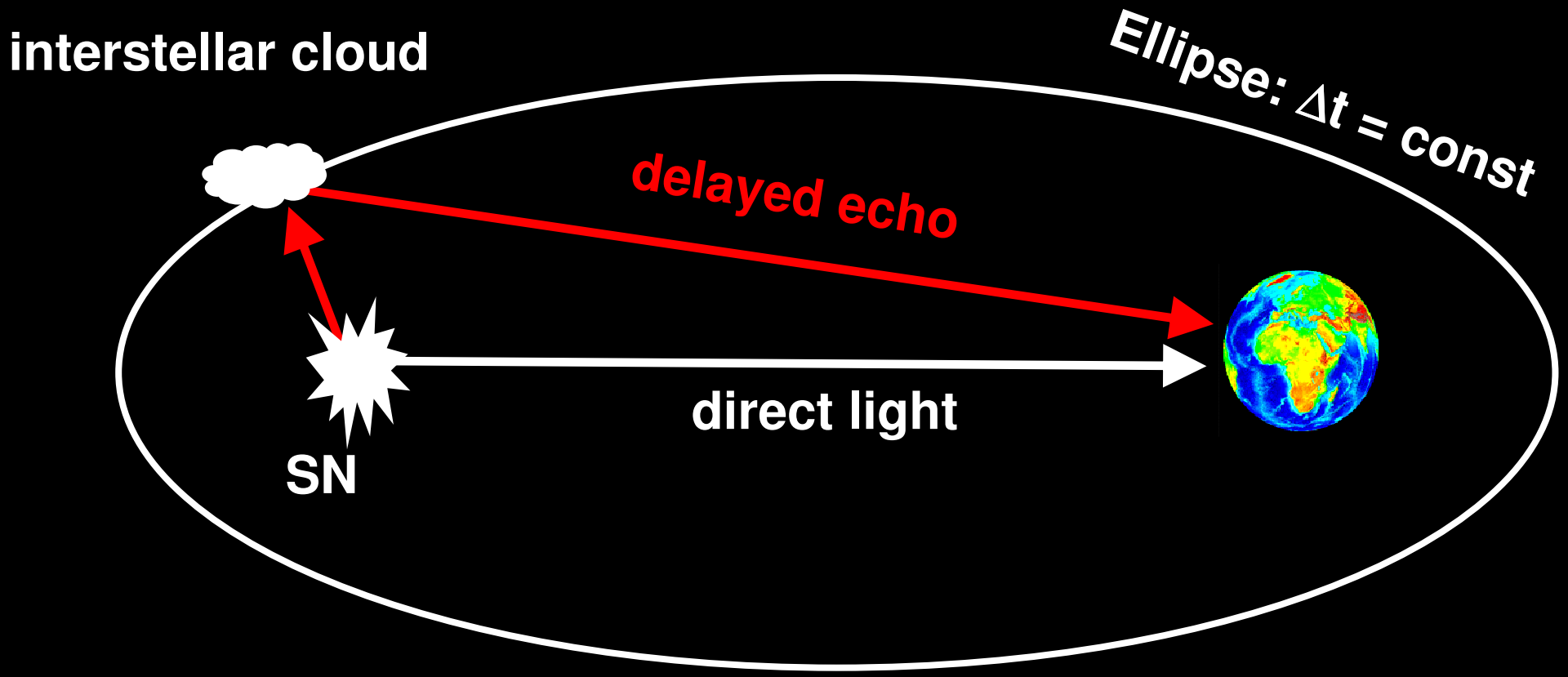
Cas A 1680



Due to proximity most detailed view of SN outcome

But: Precise classification required to relate to diverse SN population

Light echos - Window to the past



Zwicky, Oort 1940

Light echo principle

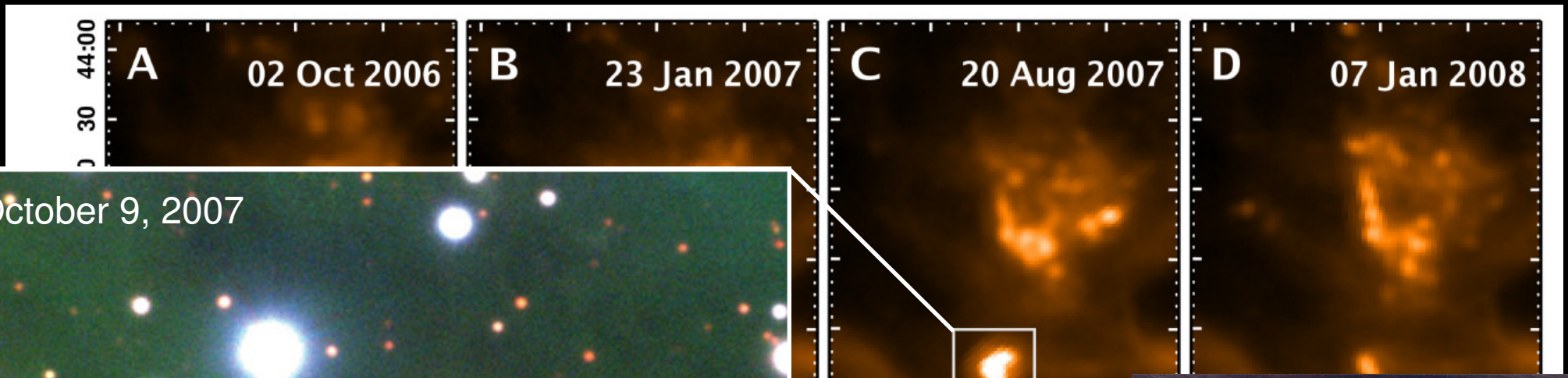
Infrared echoes near Cas A

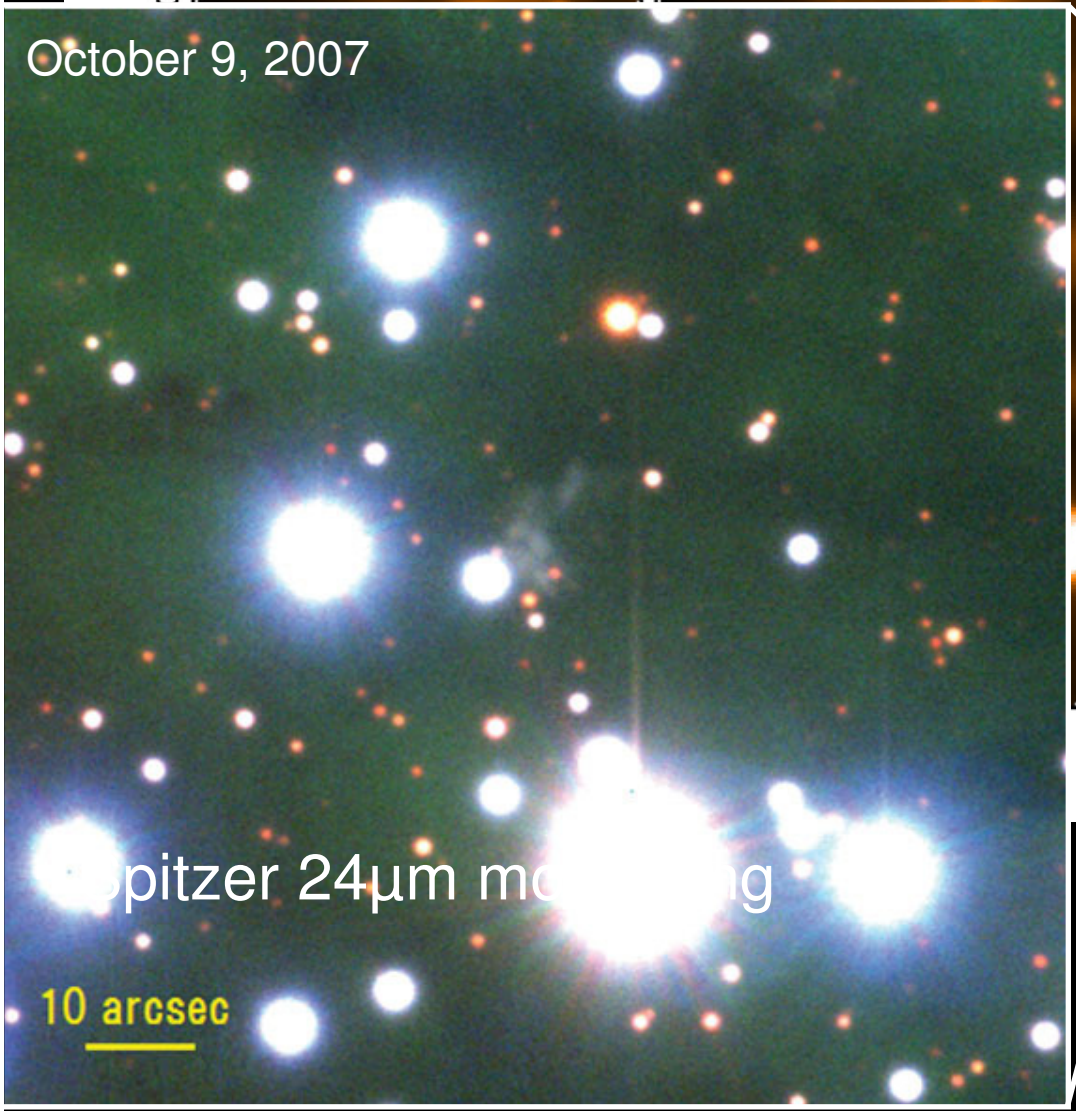
24μm time series (2003-2008)

15 arcmin = 15 pc

Krause et al. 2005,
Science 308, 1604

Subaru discovery of optical echo

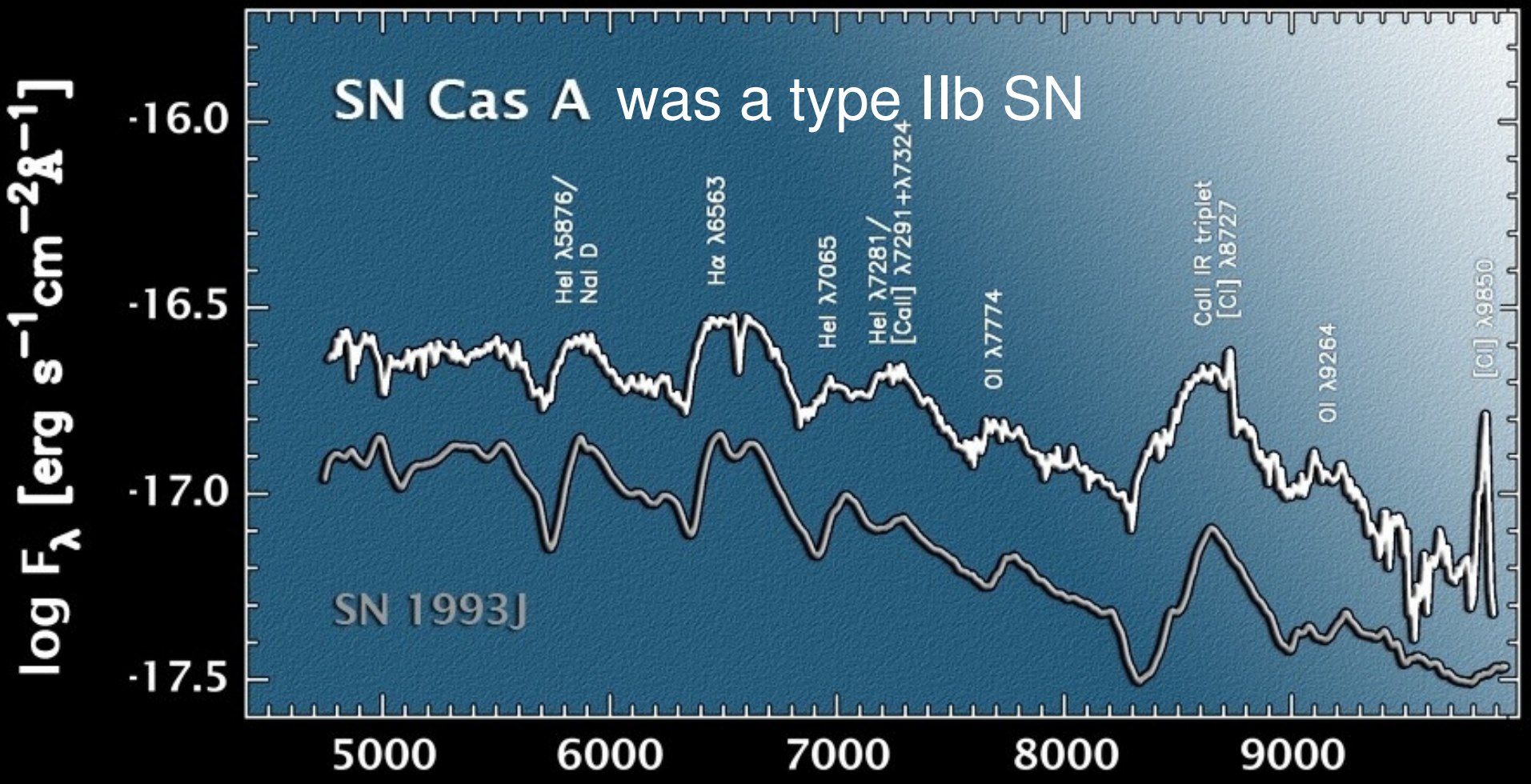




FOCAS

Echo surface brightness R = 23.4 mag / arcsec^2

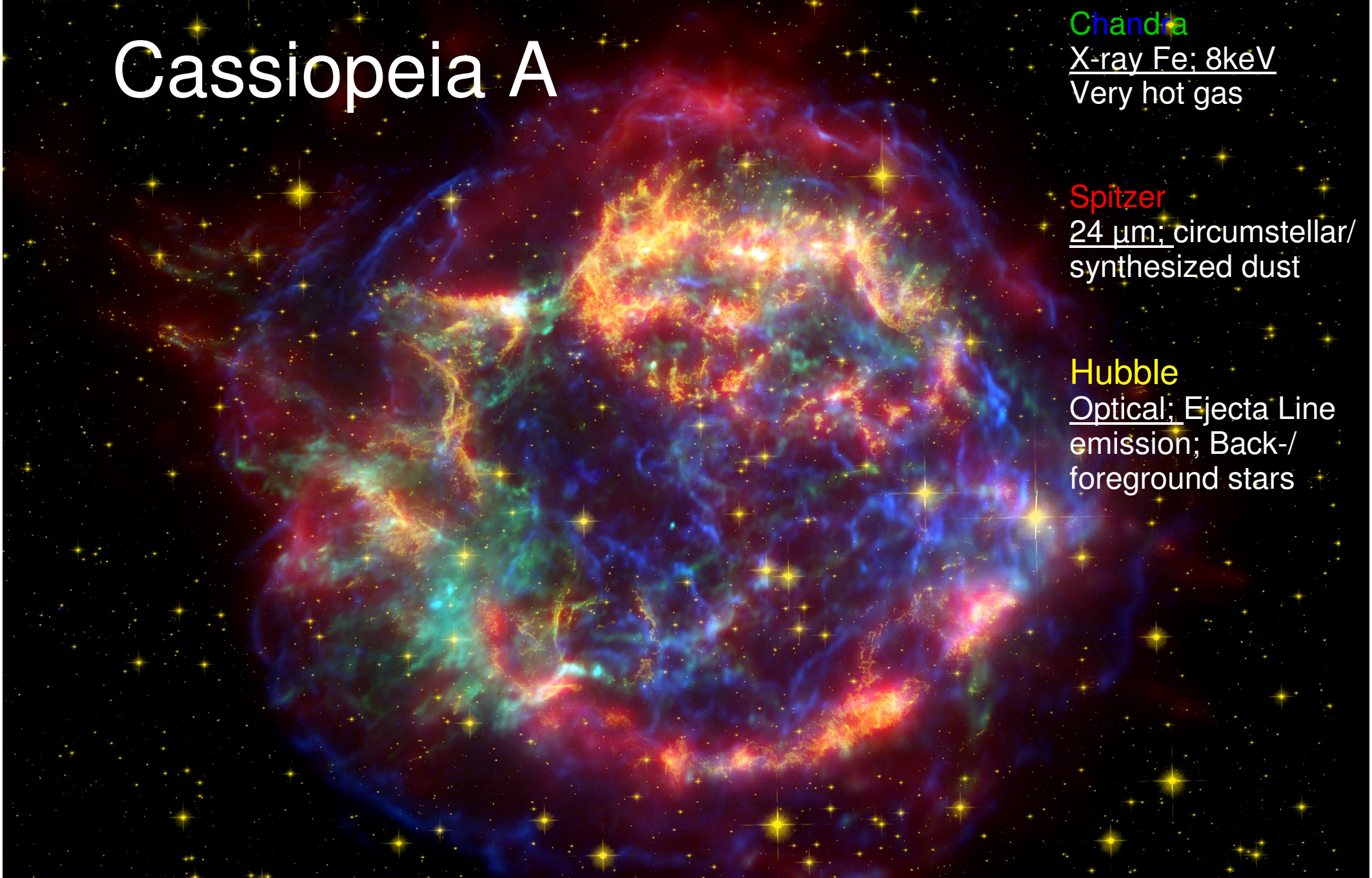
Cas A: First spectrum of a Galactic SN



SUBARU/FOCAS -
5.5 h integration time

Krause et al. 2008, Science 320, 1195

Cassiopeia A



Chandra
X-ray Fe; 8keV
Very hot gas

Spitzer
24 μm; circumstellar/ synthesized dust

Hubble
Optical; Ejecta Line emission; Back-/ foreground stars

- Prototypical shell-type core–collapse SNR
- Previously most quoted scenario: SN Ibc of WR Star Fesen ApJ 133, 161 (2001)
- Type IIb scenario consistent with a red supergiant progenitor in binary system

Tycho SNR

Chandra
X-ray Fe;Si;8keV
Hot gas

Spitzer
24 µm; circumstellar/
synthesized dust

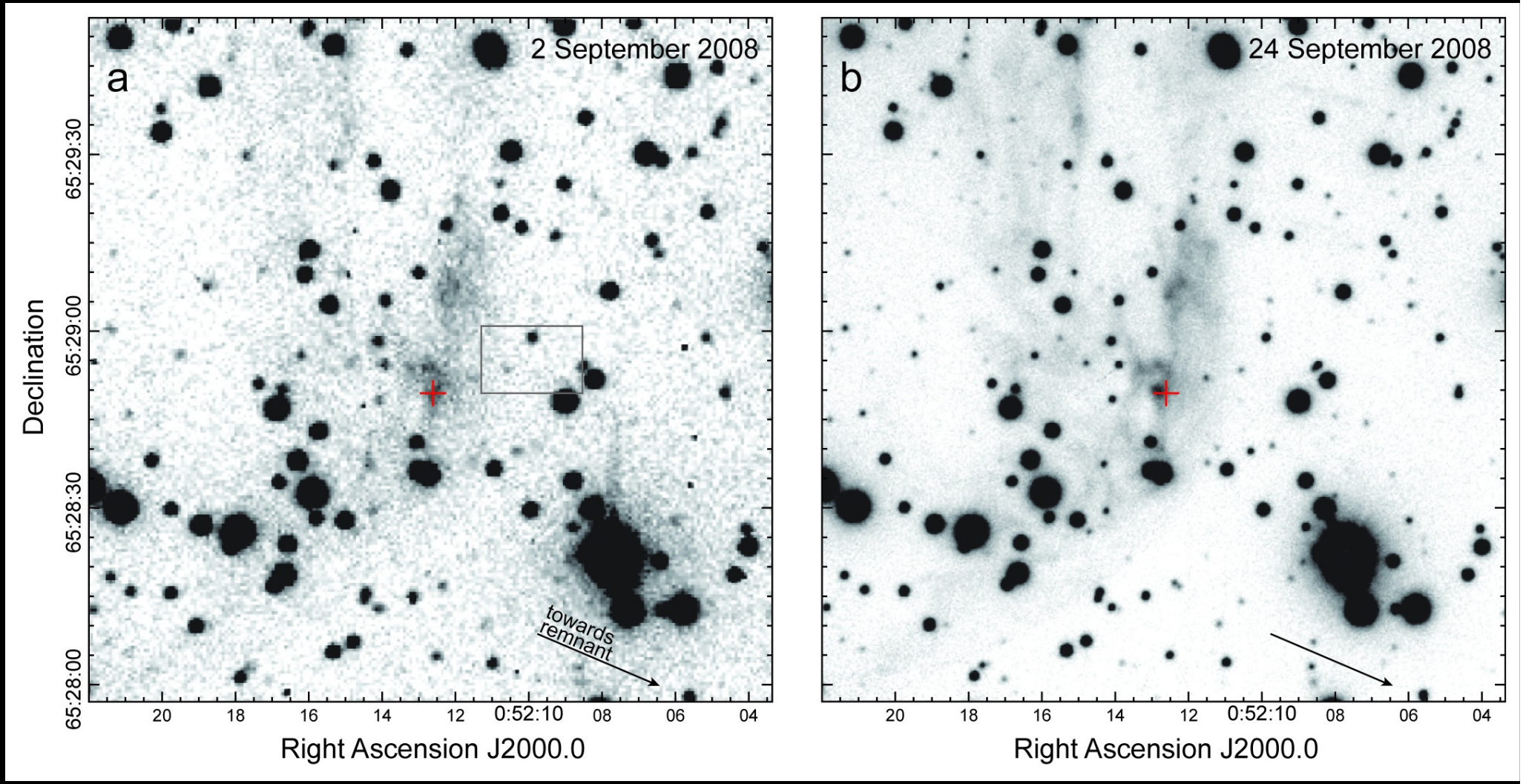
CaHa
JHK_s
fore-/background stars

- Balmer dominated optical spectra
- Historic light curve → type Ia
- Ejecta morphology and composition
- Binary companion Ruiz-Lapuente et al. 2004 Nature 431, 1069
- Subclass uncertain (subluminous – slightly overluminous)

SN 1572 light echo

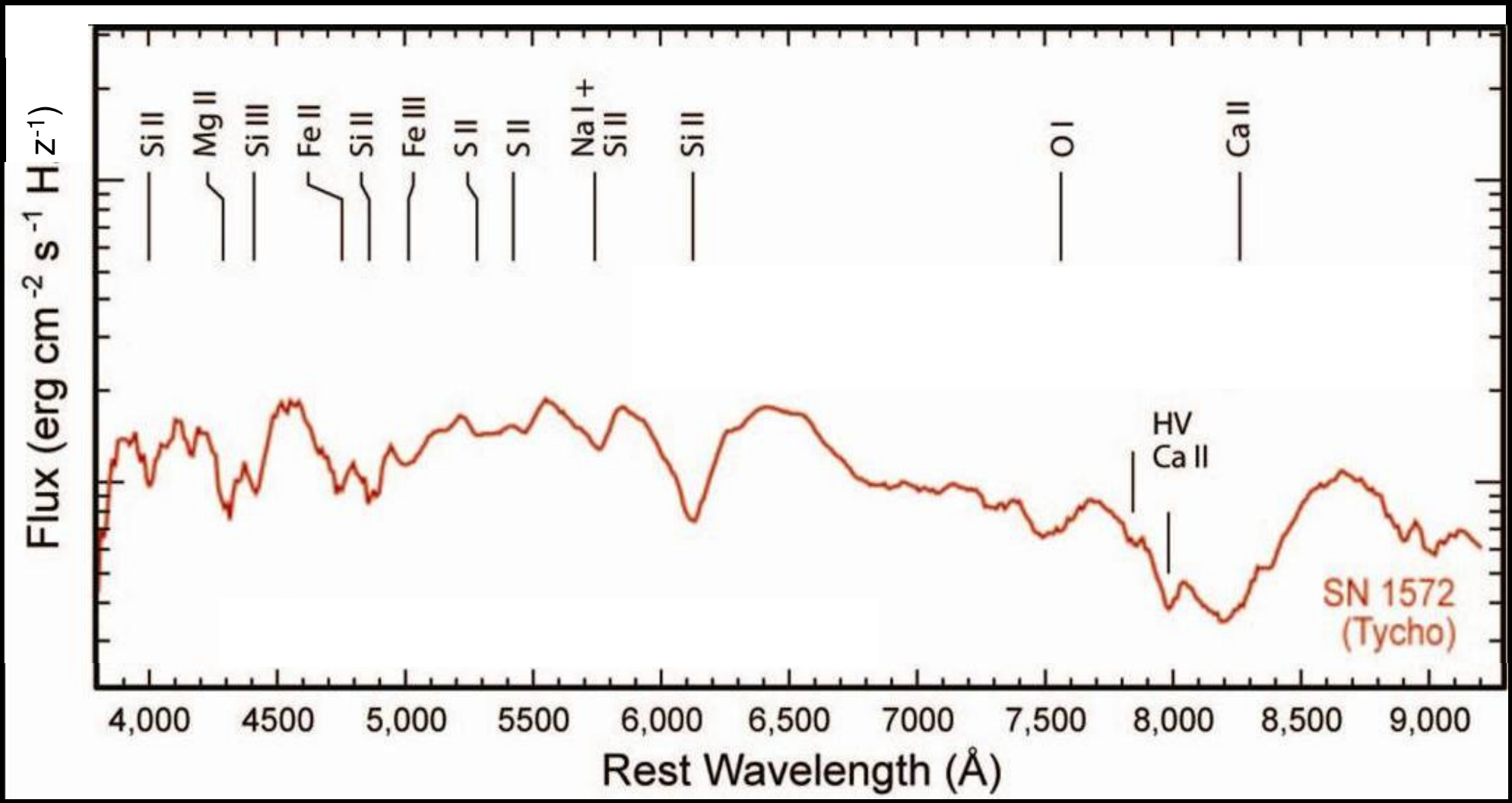
Calar Alto 2.2m

Subaru/FOCAS



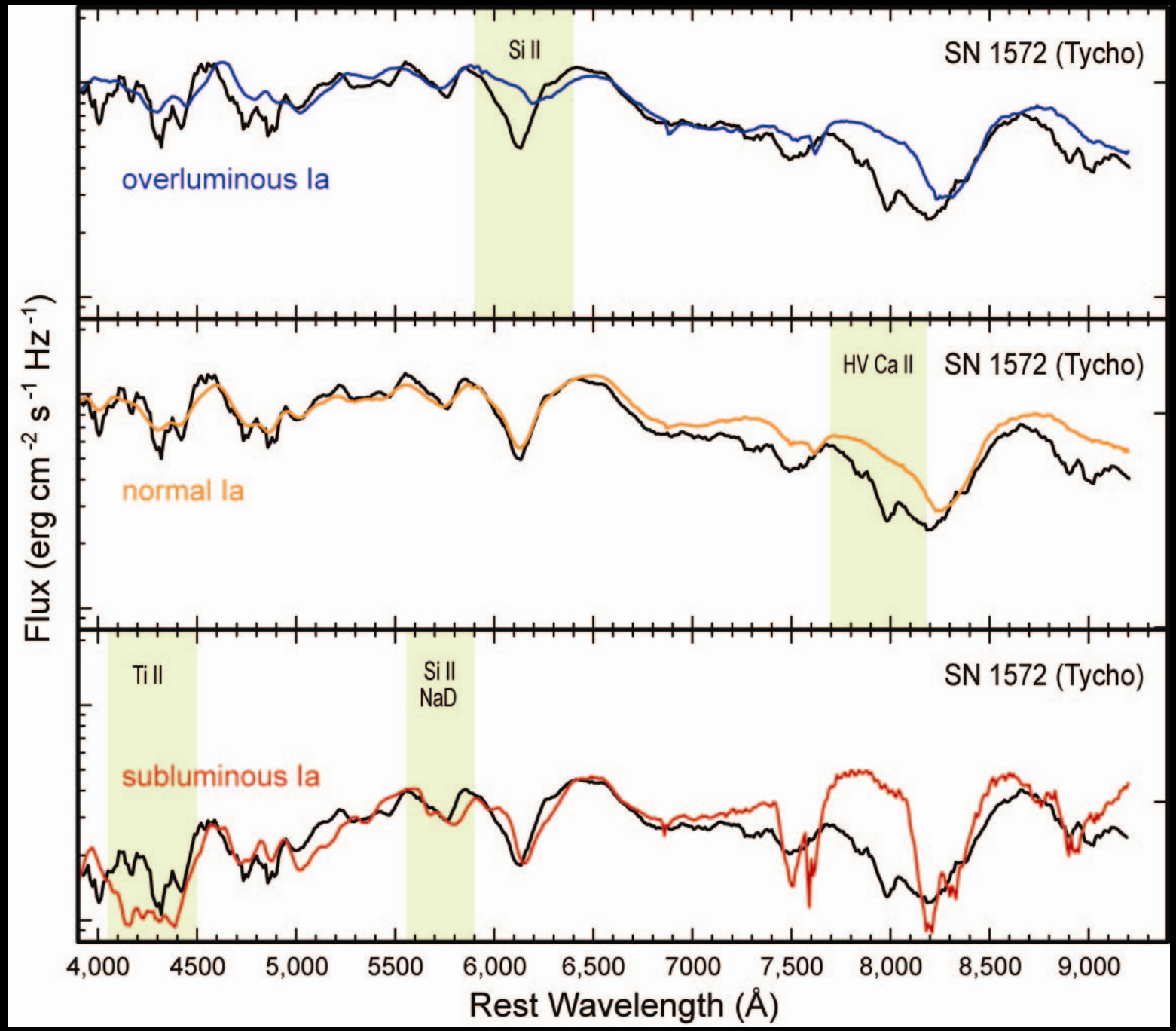
Field #4430 by Rest et al. 2008, ApJ 681, 81

Subaru spectrum of SN1572



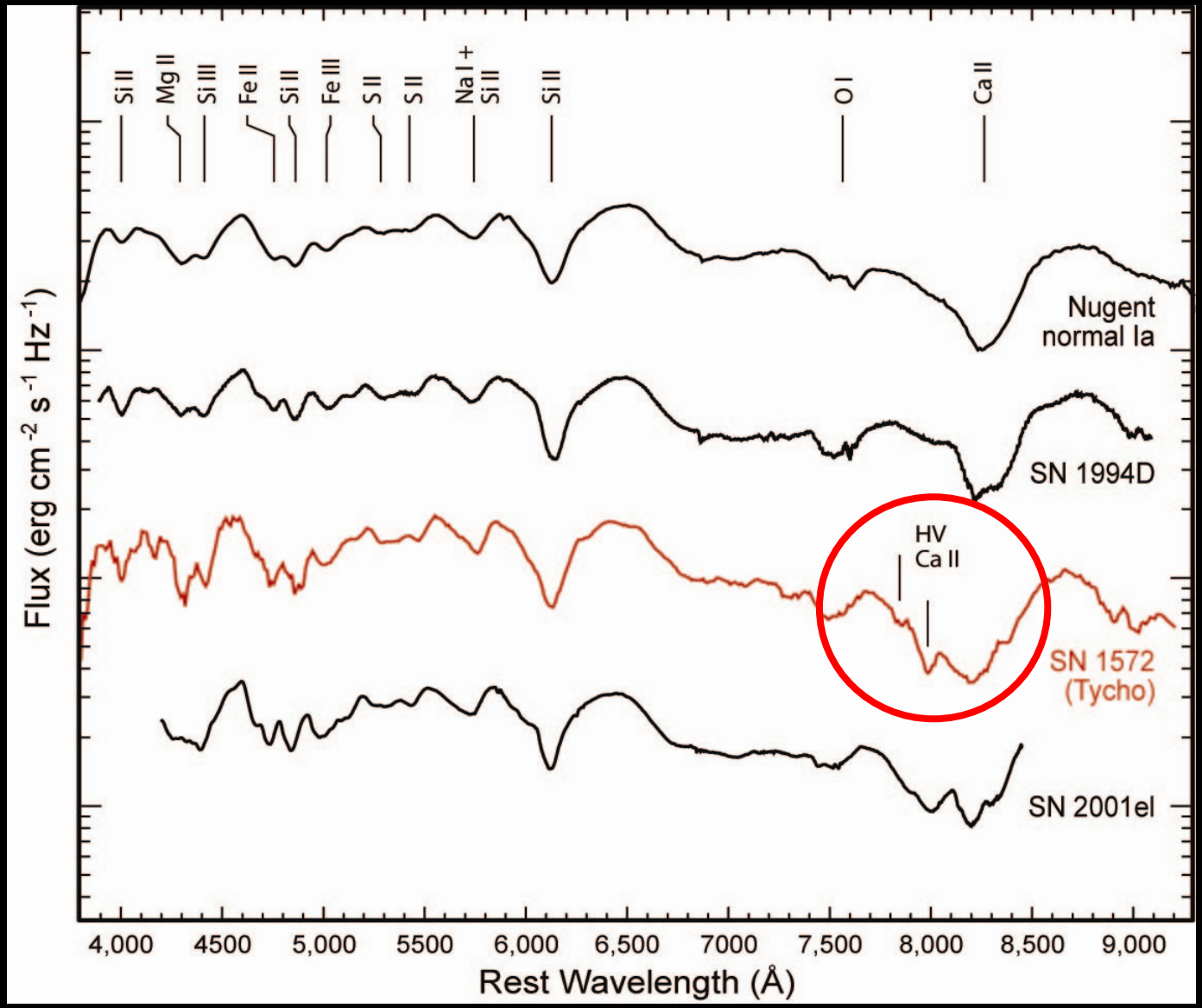
Krause et al. 2008, Nature 456, 617

SN1572 – A core normal type Ia



Krause et al. 2008, Nature 456, 617

High-velocity Ca II absorption in SN 1572



Photospheric Si II
12,000 km/s

HV Ca II
22,000 - 30,000 km/s

- Strength similar to SN 2001el
- Spectropolarimetry suggests asphericity in the case of SN 2001el

Wang et al. 2003, ApJ 591, 1110; Kasen et al. 2003, ApJ 593, 788

Conclusion and outlook

Subaru has obtained high-quality spectroscopy and precise classification of SNe1572 and Cas A hundreds of years after outburst –
providing a direct view of the explosions and connecting them with the wealth of knowledge about their remnants

- 3-dimensional echo spectroscopy

  Light echoes at different lines of sight relative to the remnant provide a true 3-dimensional spectroscopic view of the explosion

- Kepler

  Nitrogen-rich (CSM?) material and morphology indicates different Ia scenario –
  Spectral classification urgently required