Type Ia supernova remnant tomography

Ivo Seitenzahl

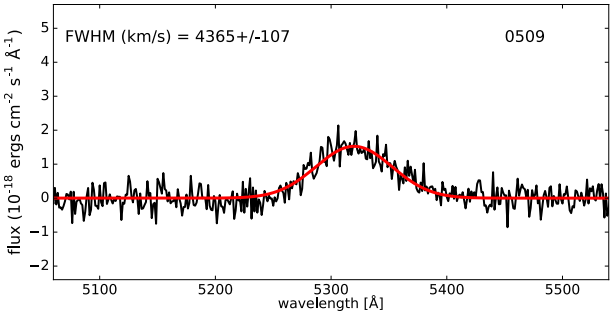
UNSW Canberra

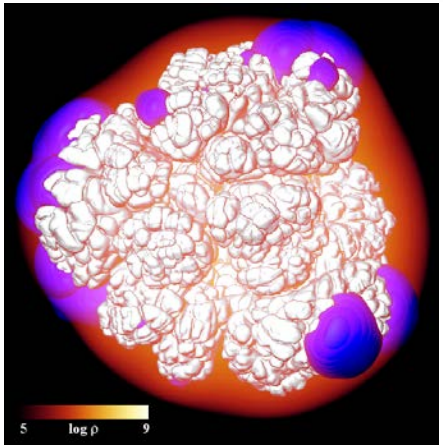
main collaborators for this work:

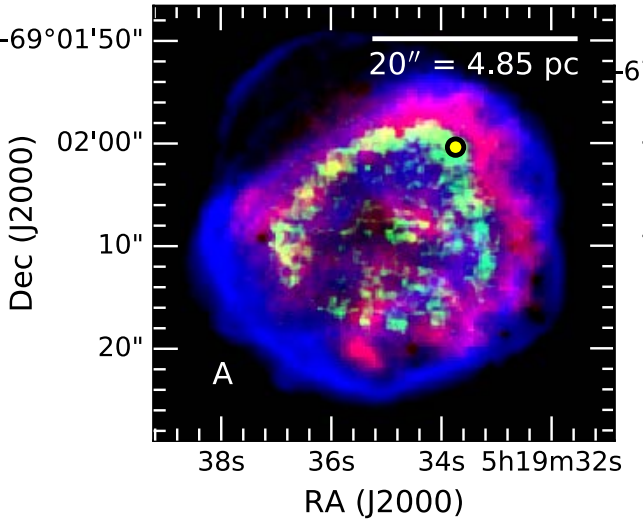
P Ghavamian

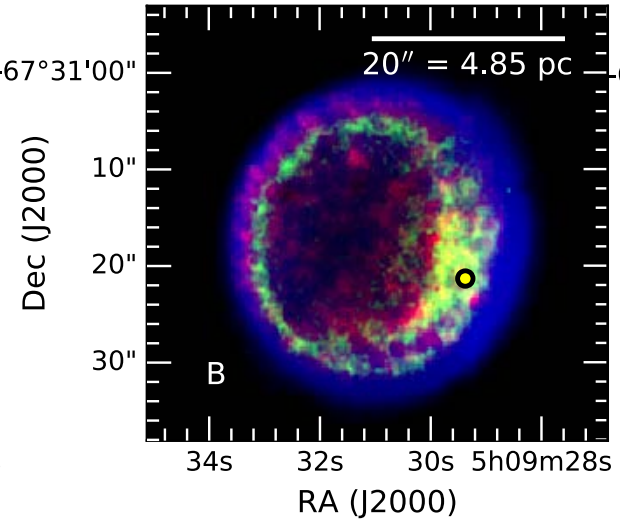
JM Laming

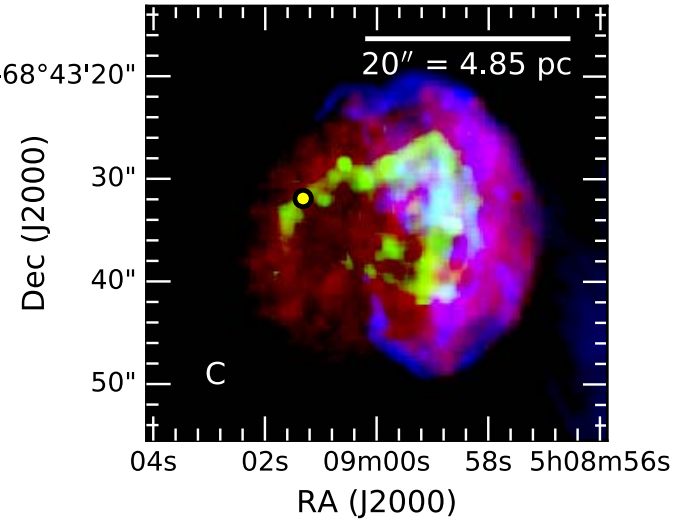
FPA Vogt











Chania, Greece

5 June 2019

University of New South Wales Canberra at the Australian Defence Force Academy

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Fiona Panther's latest paper SN1991bg-like SNe Ia

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PASA, accepted for publication 4 June 2019

SN1991bg-like supernovae are associated with old stellar populations

Fiona H. Panther[1,2,3]*, Ivo R. Seitenzahl[1,2], Ashley J. Ruiter[1,2,3], Roland M. Crocker[2], Chris Lidman[2,3], Ella Xi Wang[2], Brad E. Tucker[2,4,5] and Brent Groves[2,4].

[1]School of Science, UNSW Canberra, Australian Defence Force Academy, Canberra 2612, Australia

[2]The Research School of Astronomy and Astrophysics, Mount Stromlo Observatory, Australian National University, Canberra, ACT 2611, Australia.

[3]ARC Centre of Excellence for All-Sky Astrophysics (CAASTRO)

[4]The ARC Centre of Excellence for All-Sky Astrophysics in 3 Dimensions (ASTRO 3D), Australia

[5]National Centre for the Public Awareness of Science, Australian National University, Canberra, ACT 2611, Australia.

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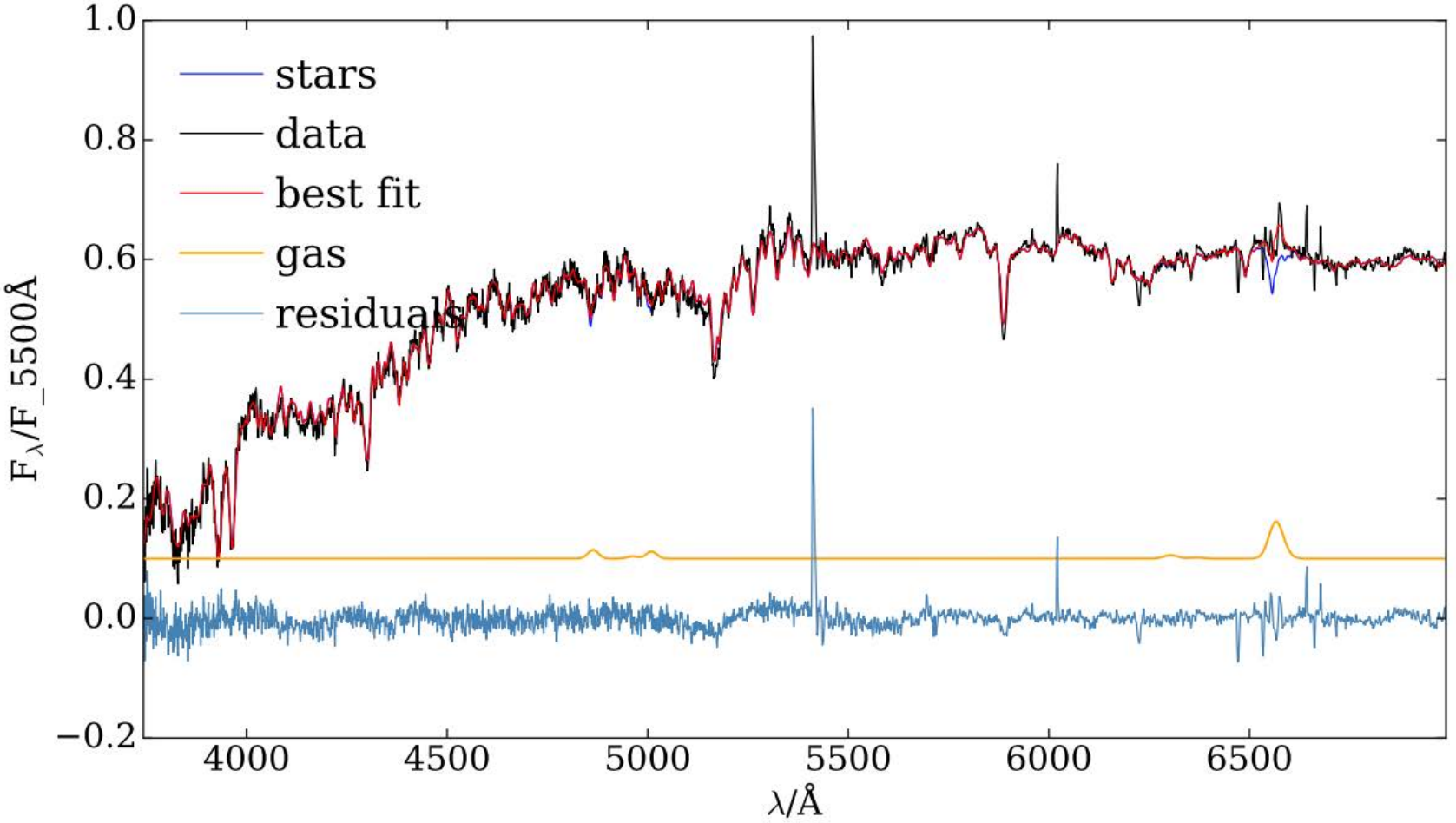

(a) Fitted spectrum of SN2000ej host

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Fiona Panther's latest paper SN1991bg-like SNe Ia

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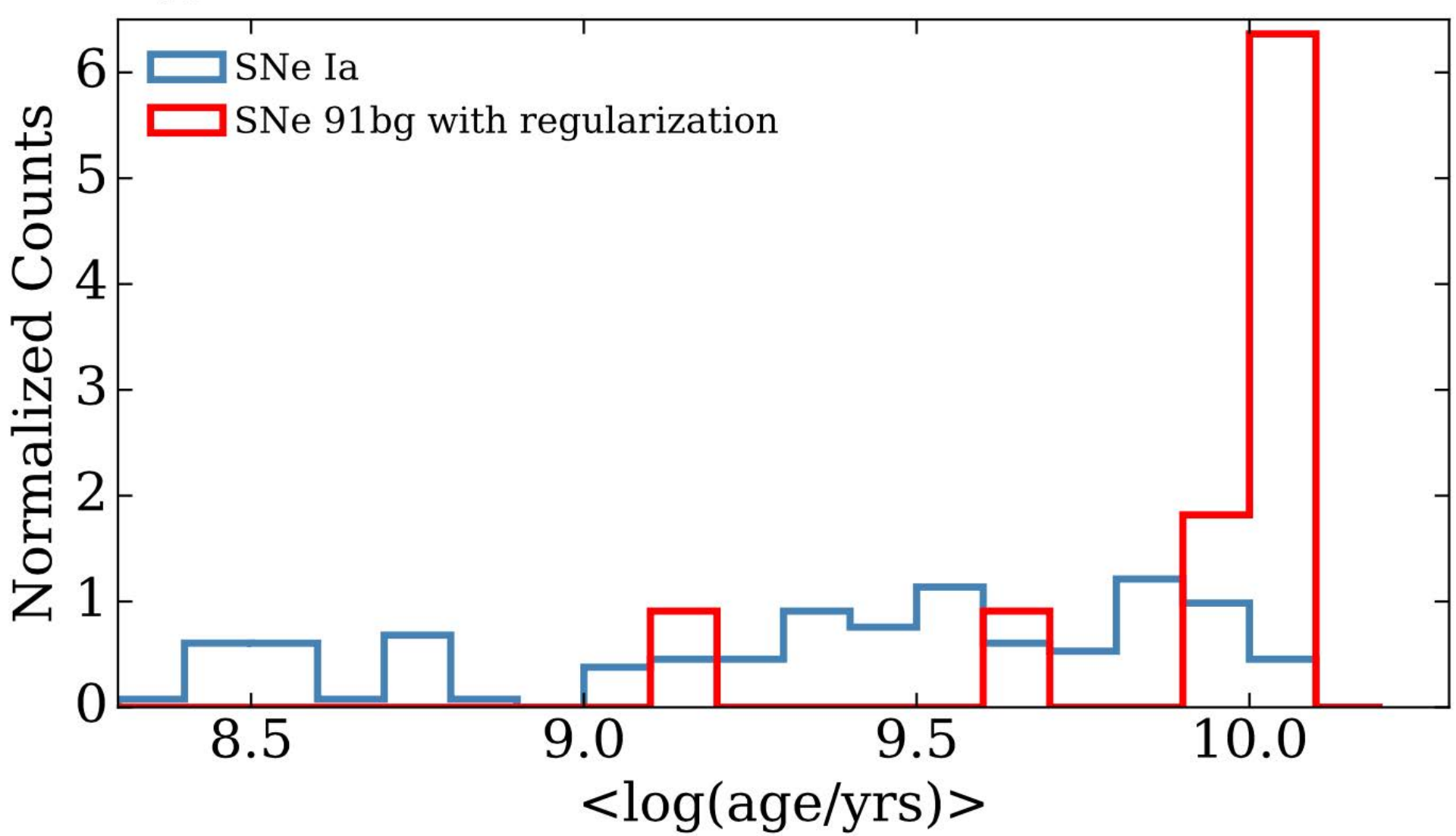
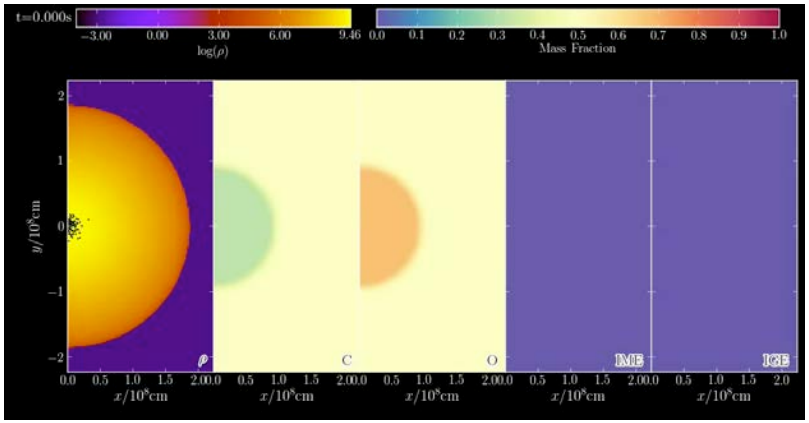


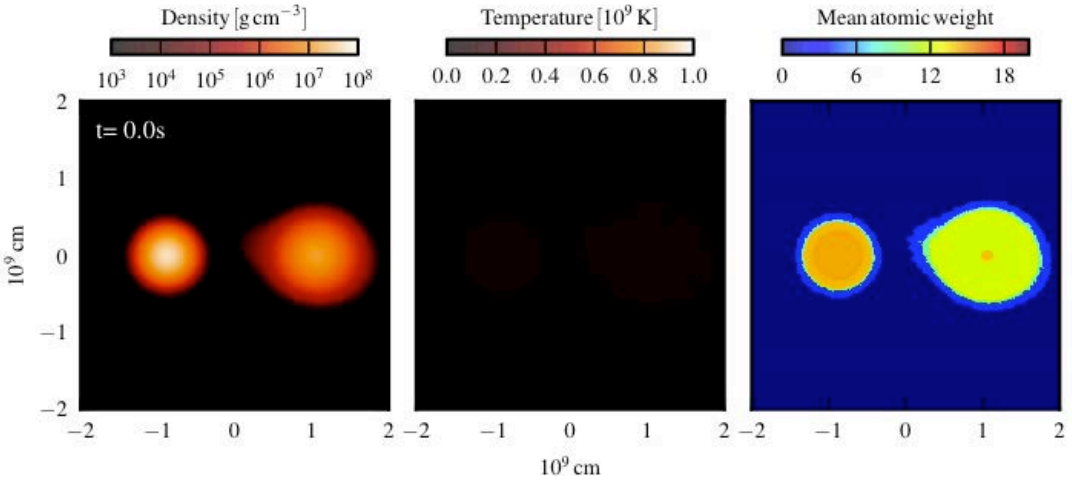
context

2 major categories near-M_{Ch} vs sub-M_{Ch}

e.g., delayed detonations
pure turbulent deflagrations



e.g., violent mergers
He double-detonations



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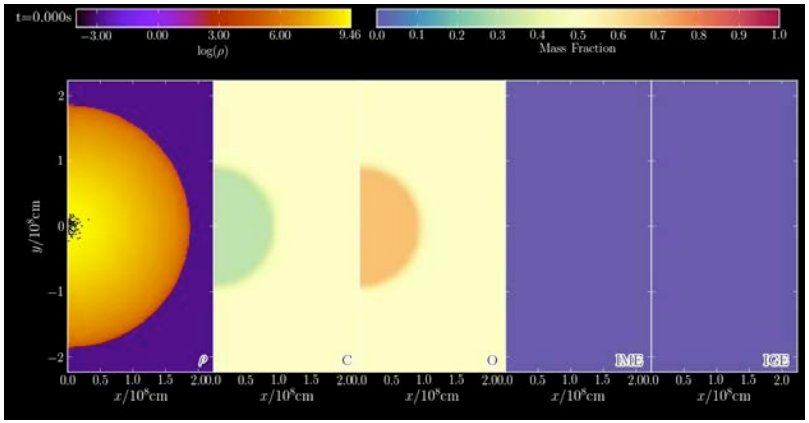

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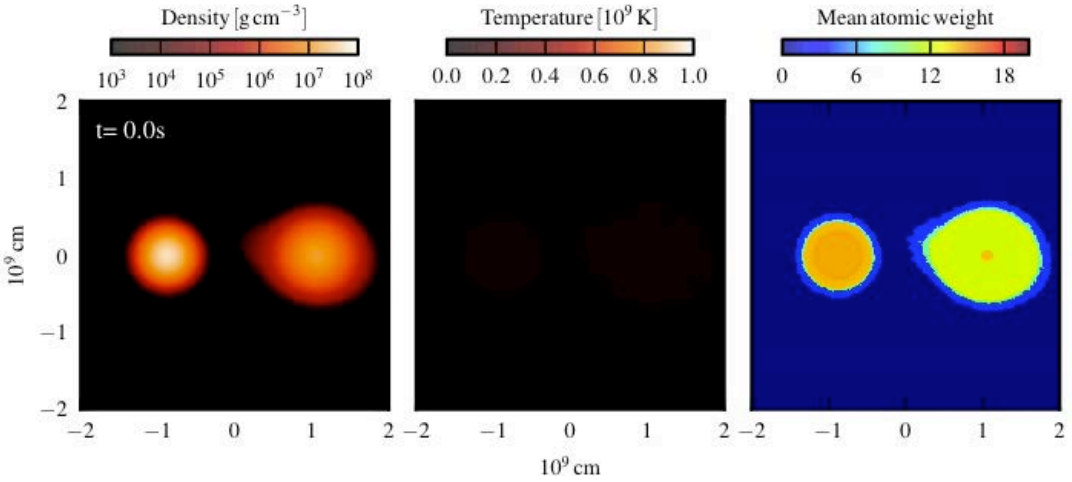

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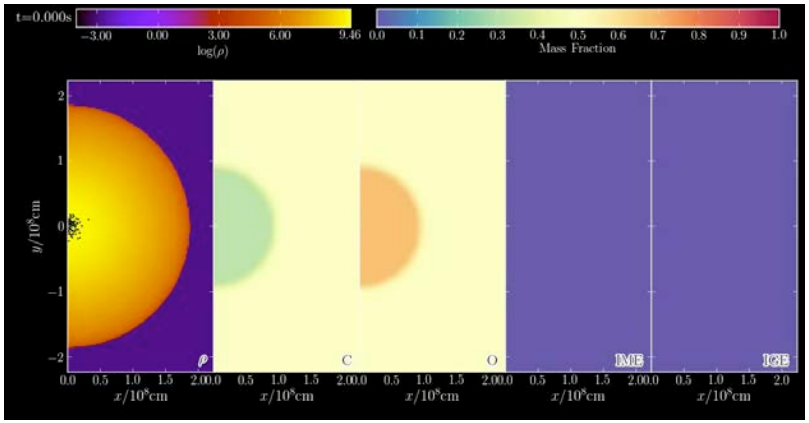

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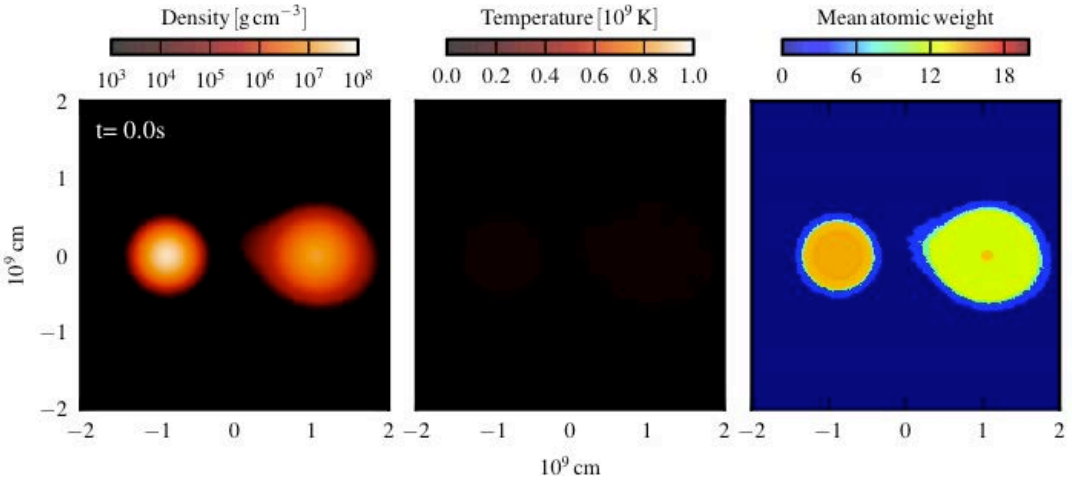

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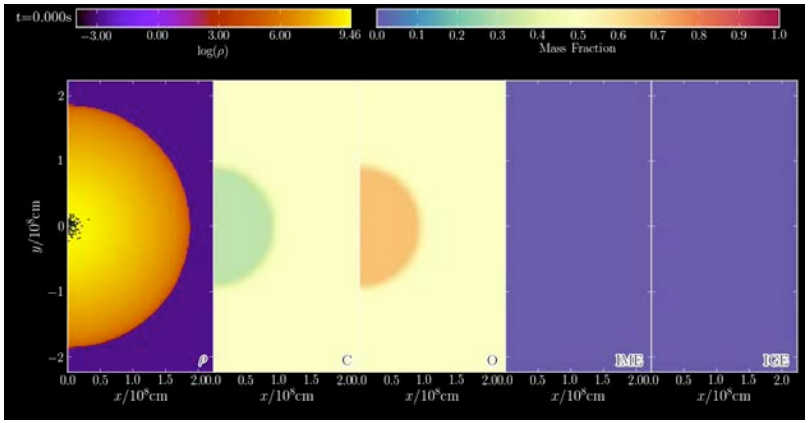

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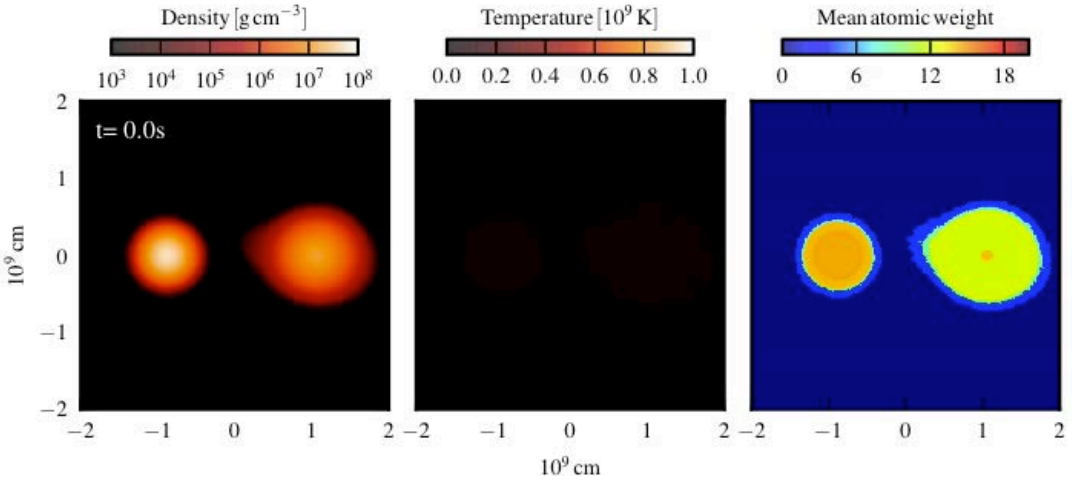

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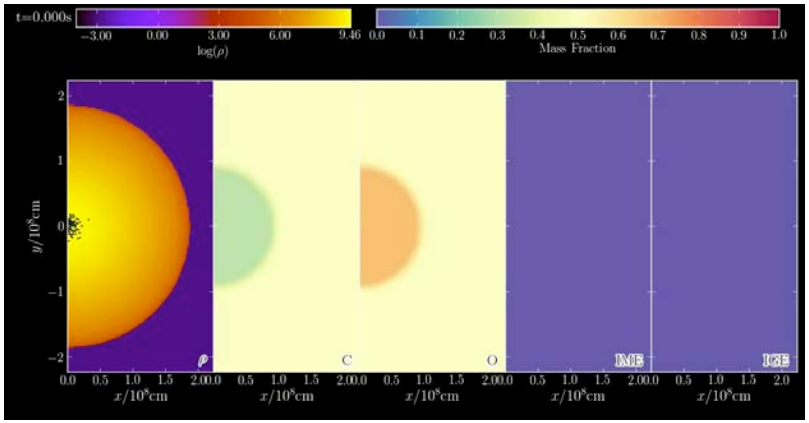

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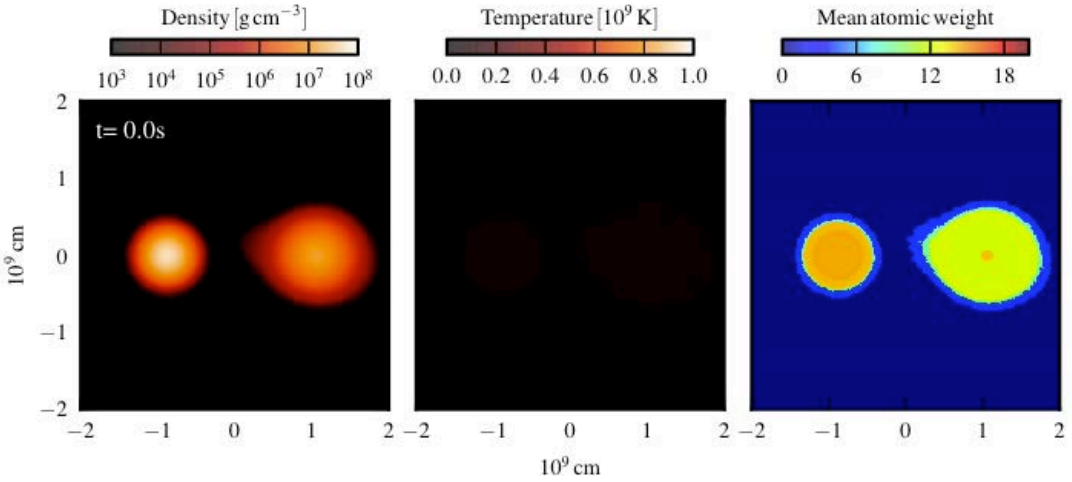

➡ $M_{primary} \approx 1.4$ solar masses

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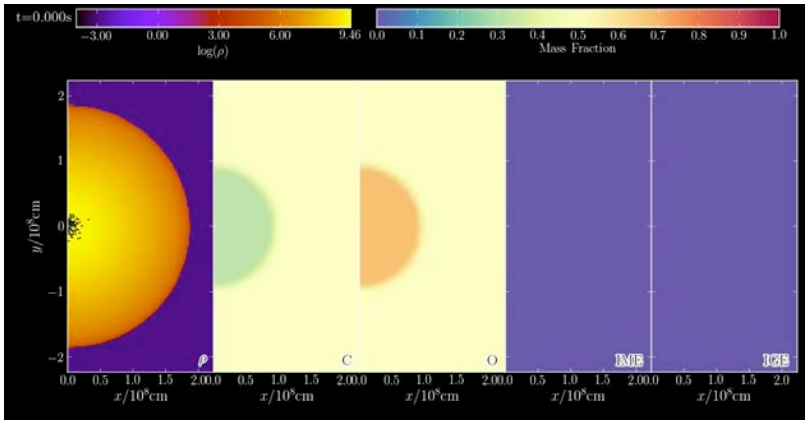

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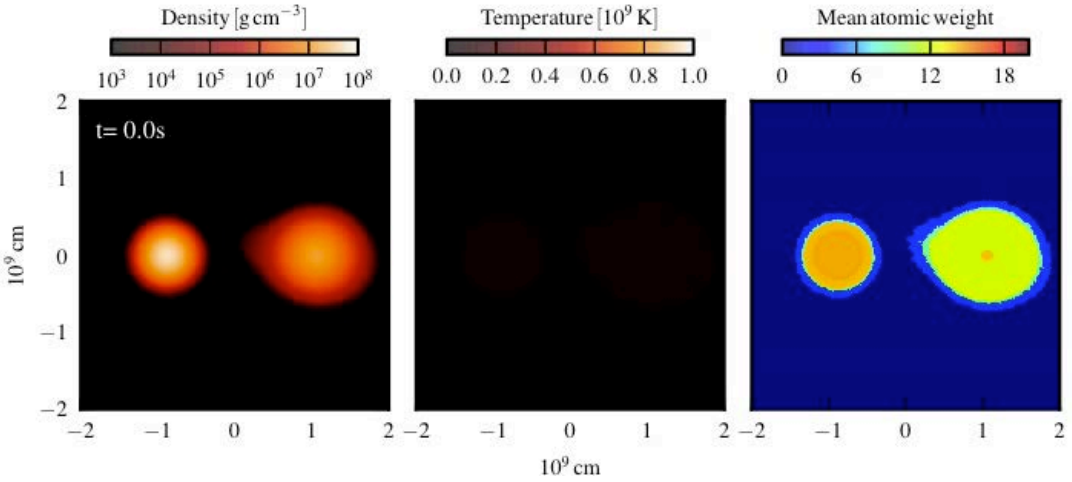

- $M_{primary} \approx 1.4$ solar masses
- ignition of deflagration by pycno-nuclear fusion of ^{12}C at high dens.

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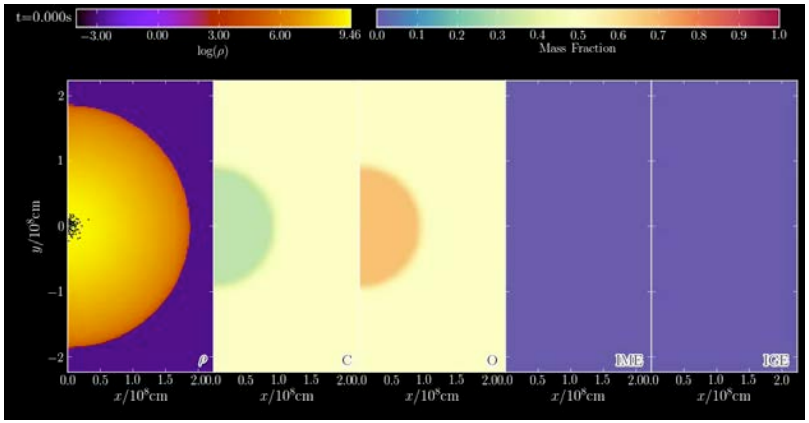

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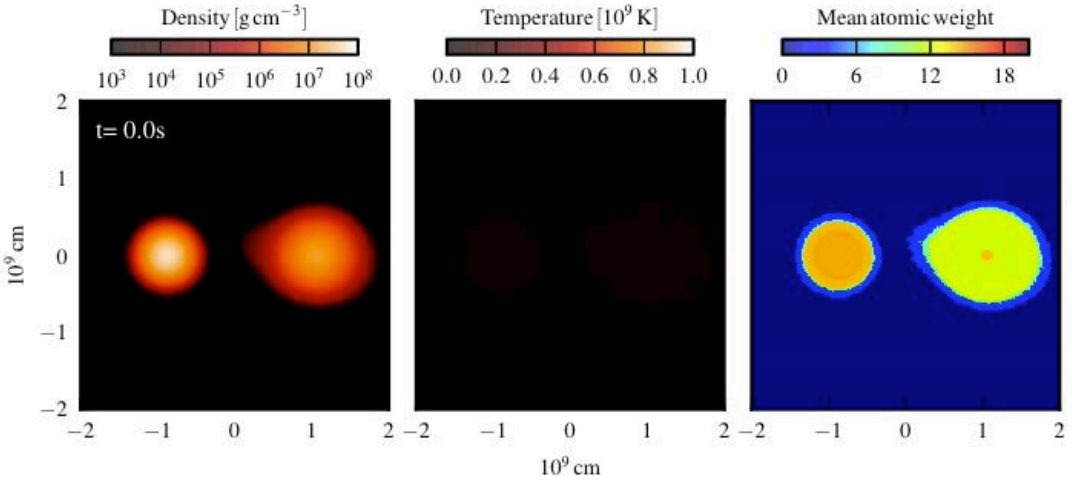

- $M_{primary} \approx 0.8$ —1.1 solar masses

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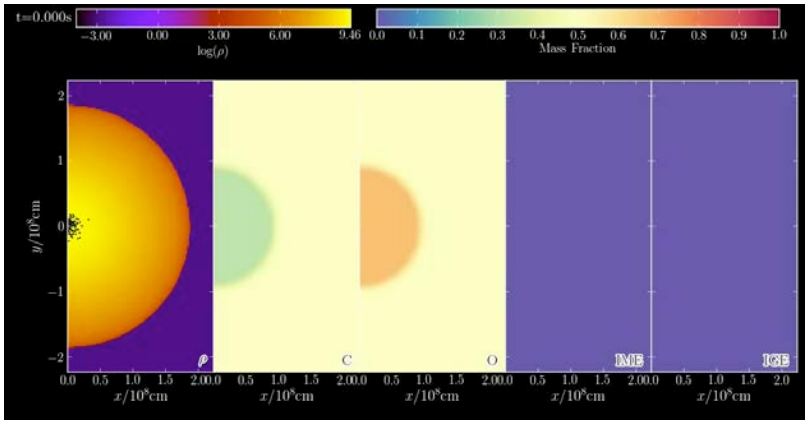

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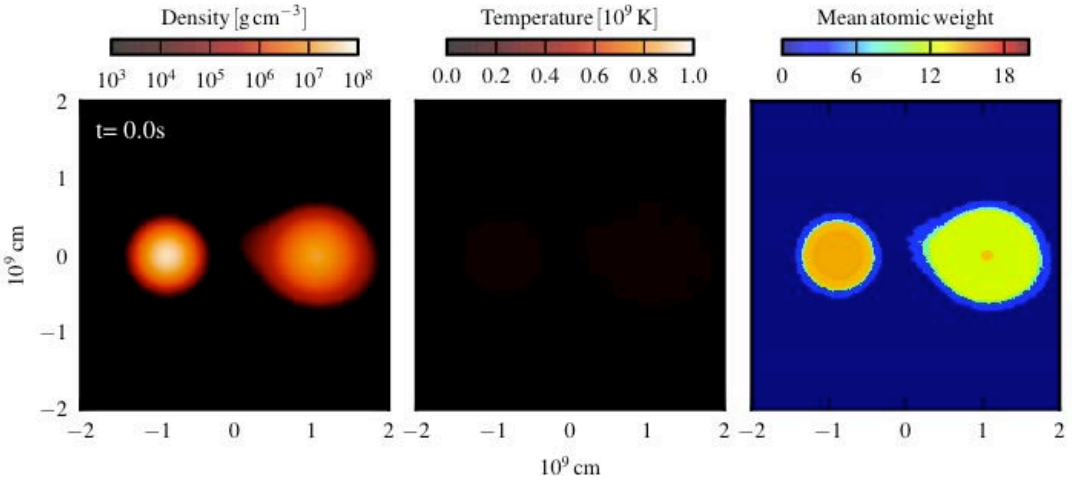

- $M_{primary} \approx 0.8$ —1.1 solar masses
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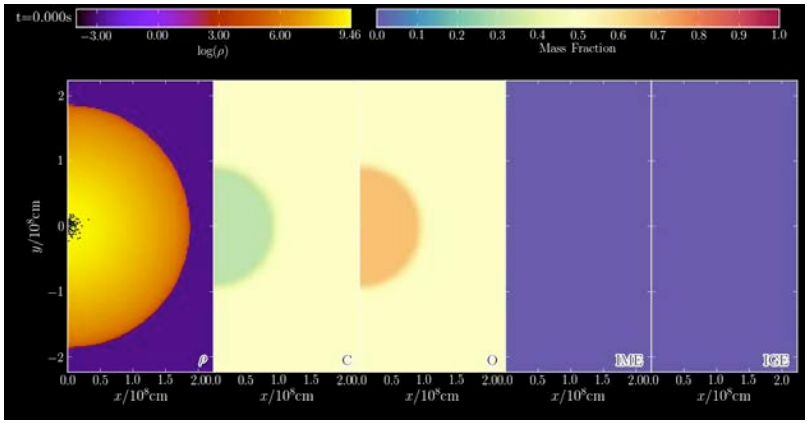

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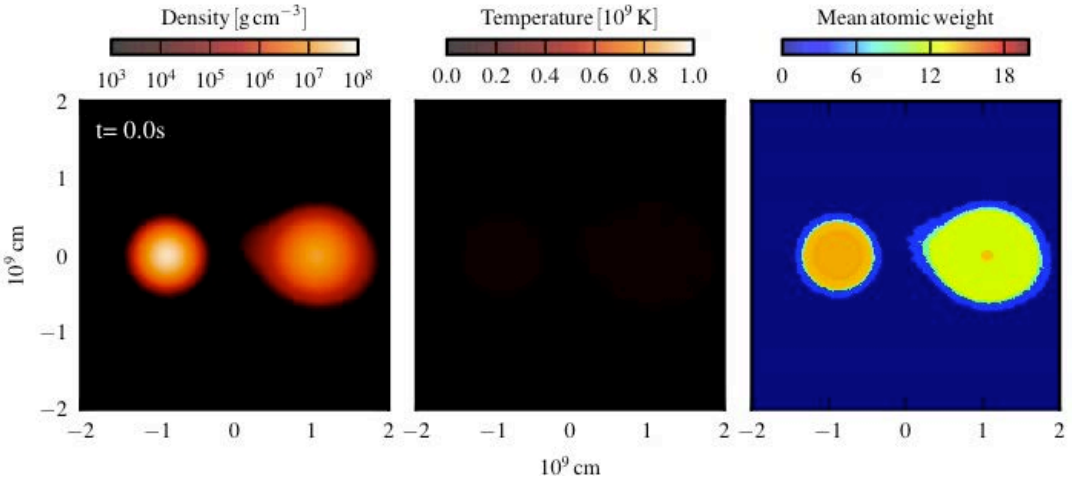

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  - ★ violent accretion stream triggers detonation

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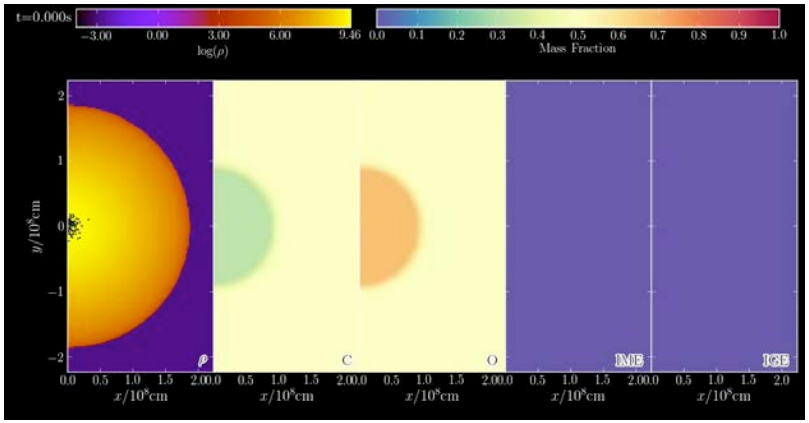

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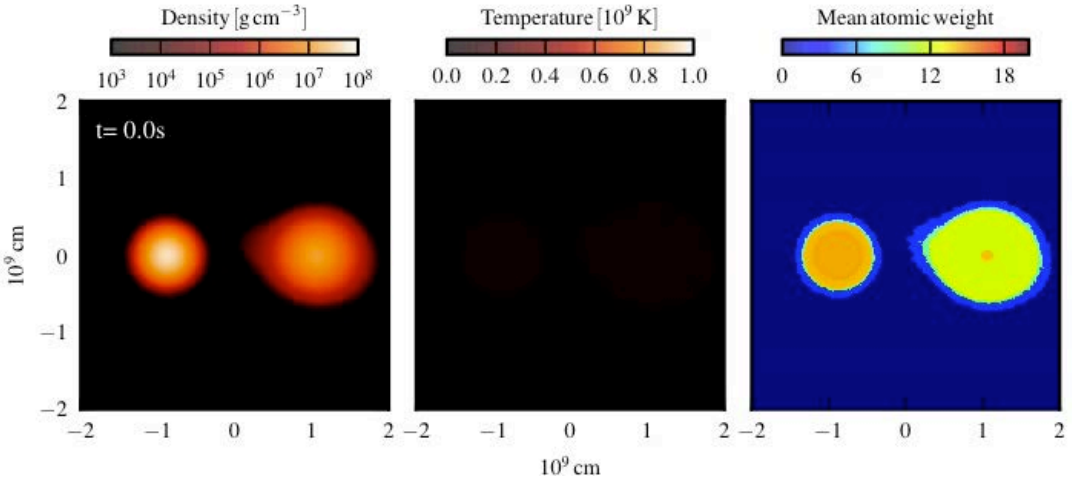
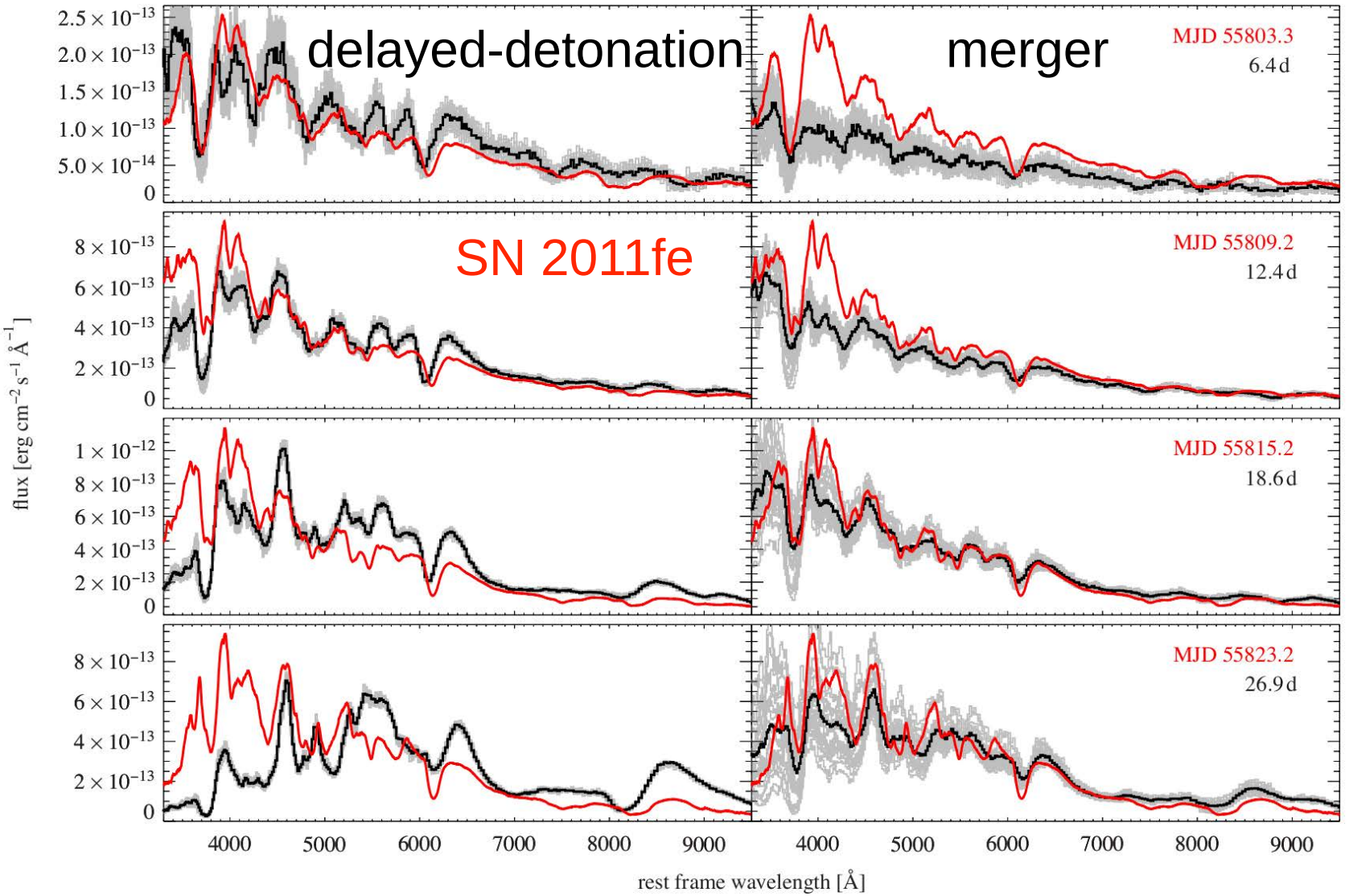


- $M_{primary} \approx 0.8$ —1.1 solar masses
- ignition occurs as
  - ★ violent accretion stream triggers detonation
  - ★ He-layer detonates

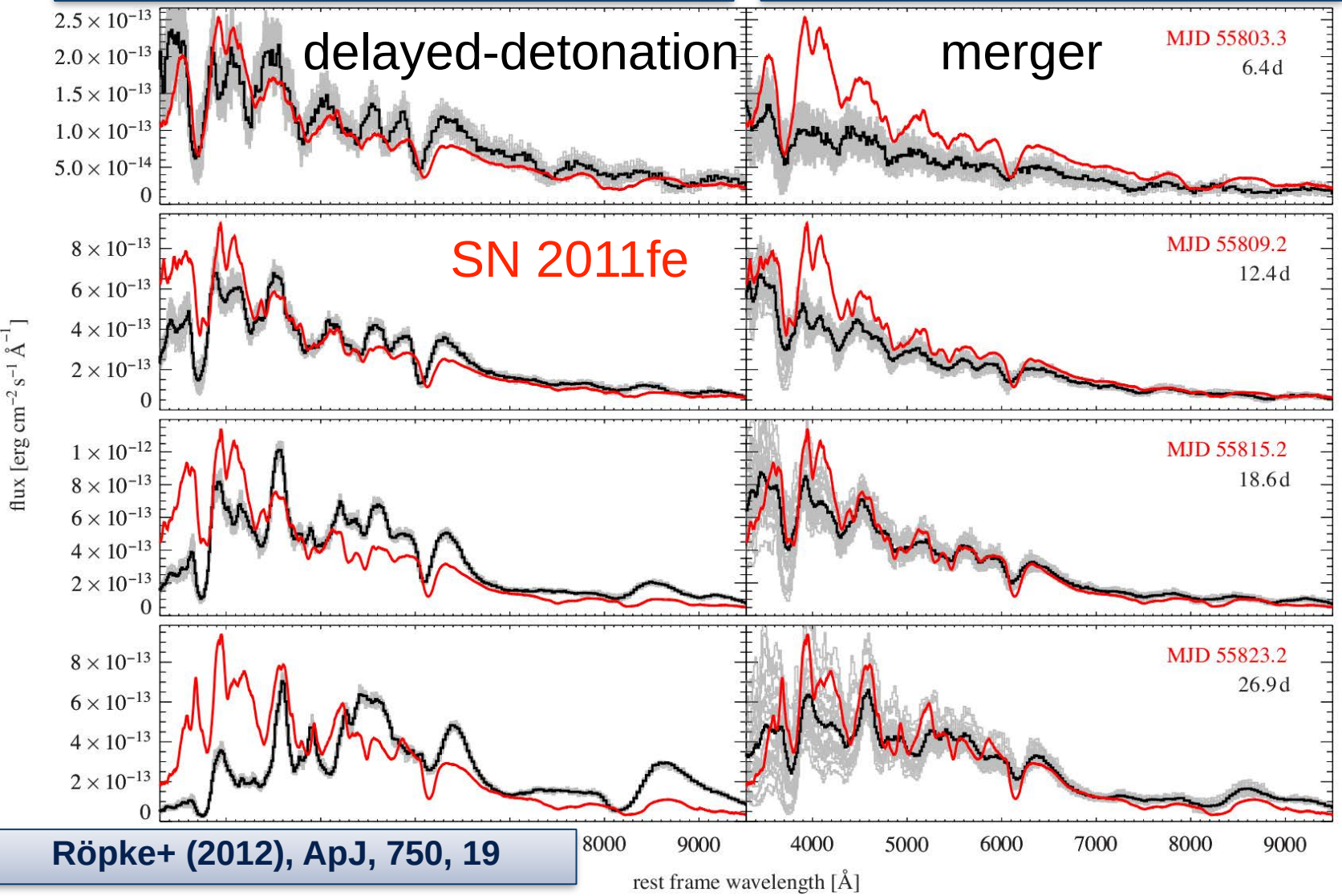
Spectral comparison inconclusive



Spectral comparison inconclusive

Seitenzahl+ (2013), MNRAS, 429, 1156

Pakmor+ (2013), ApJ, 747, 10



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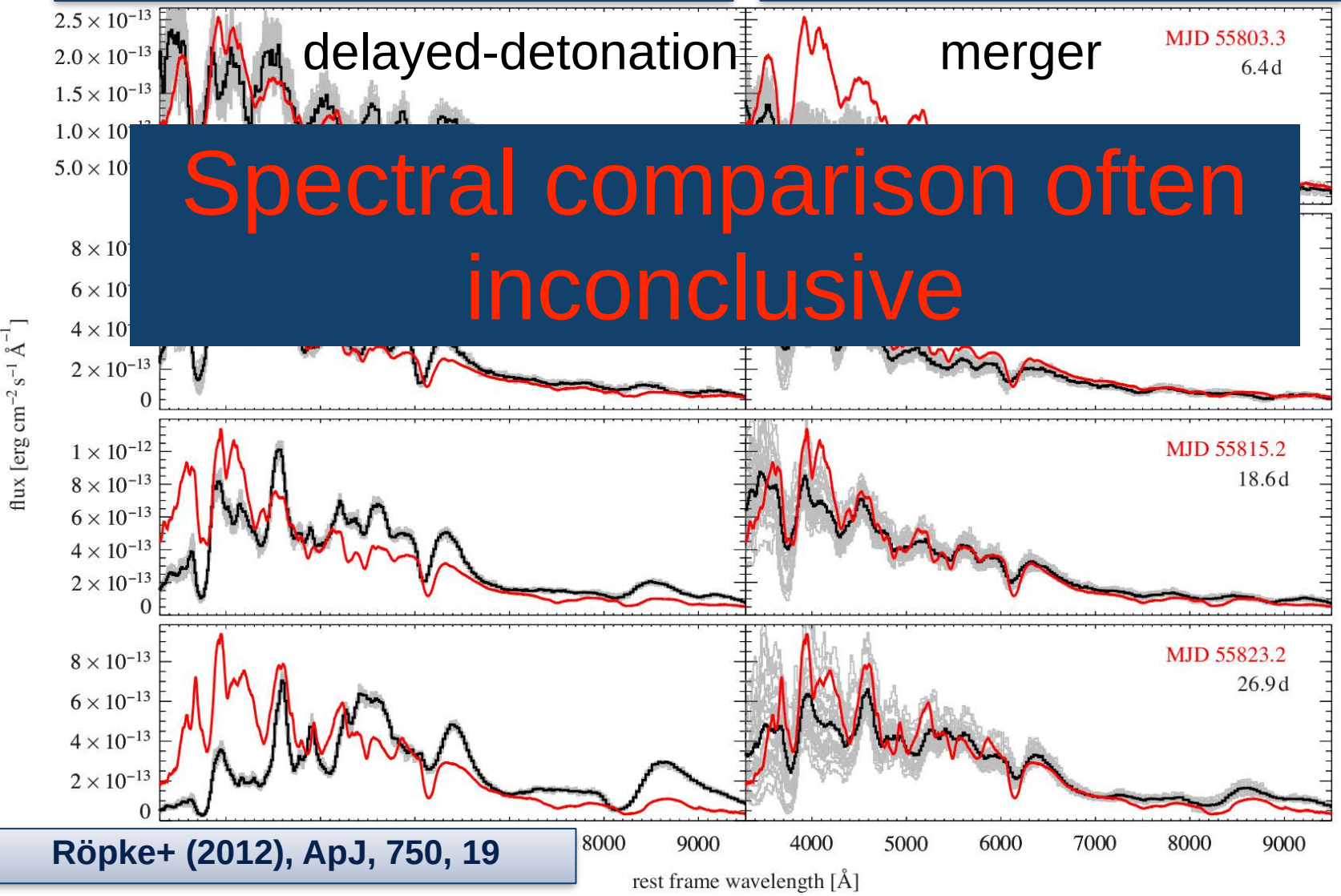

Spectral comparison often inconclusive

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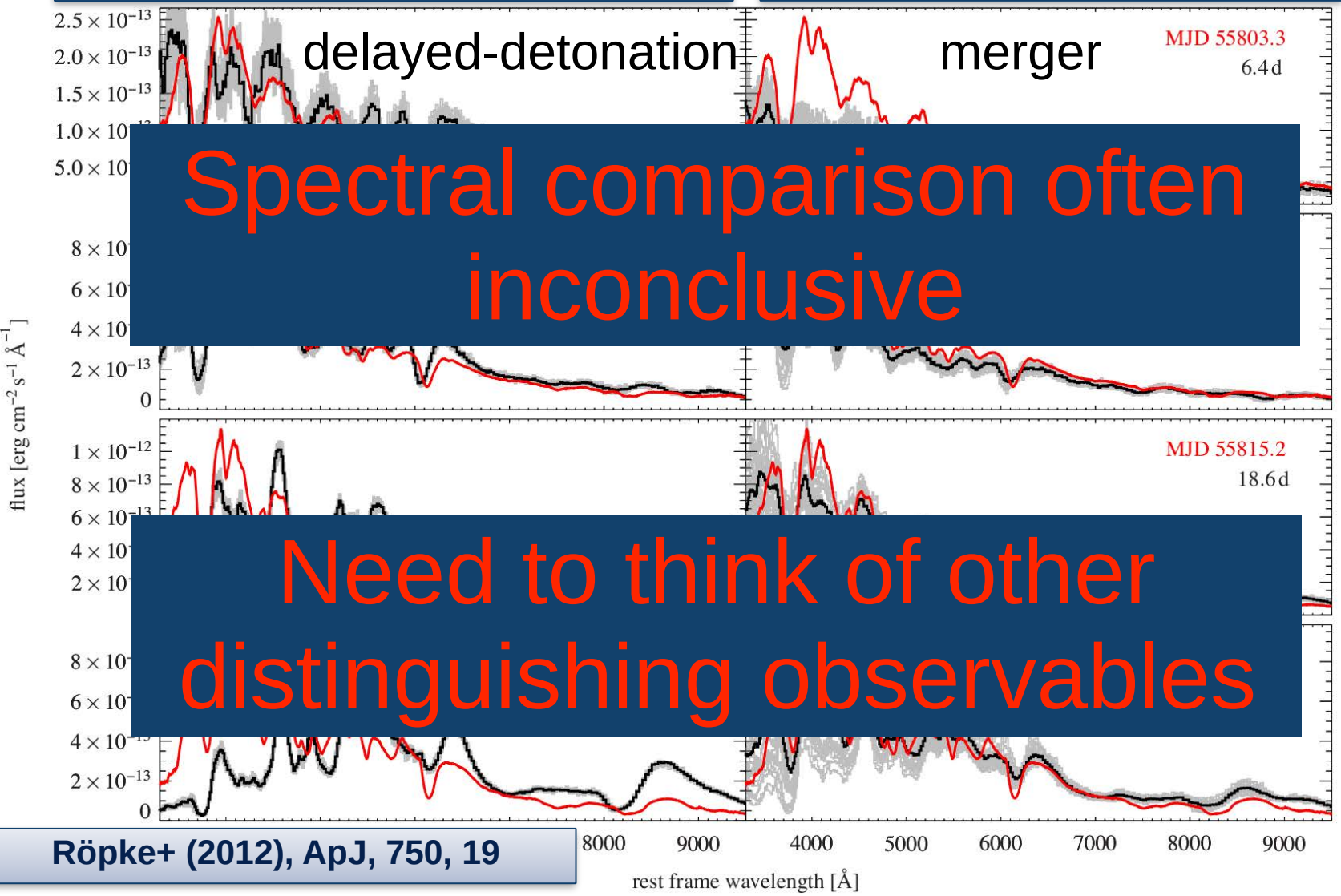


Spectral comparison often inconclusive

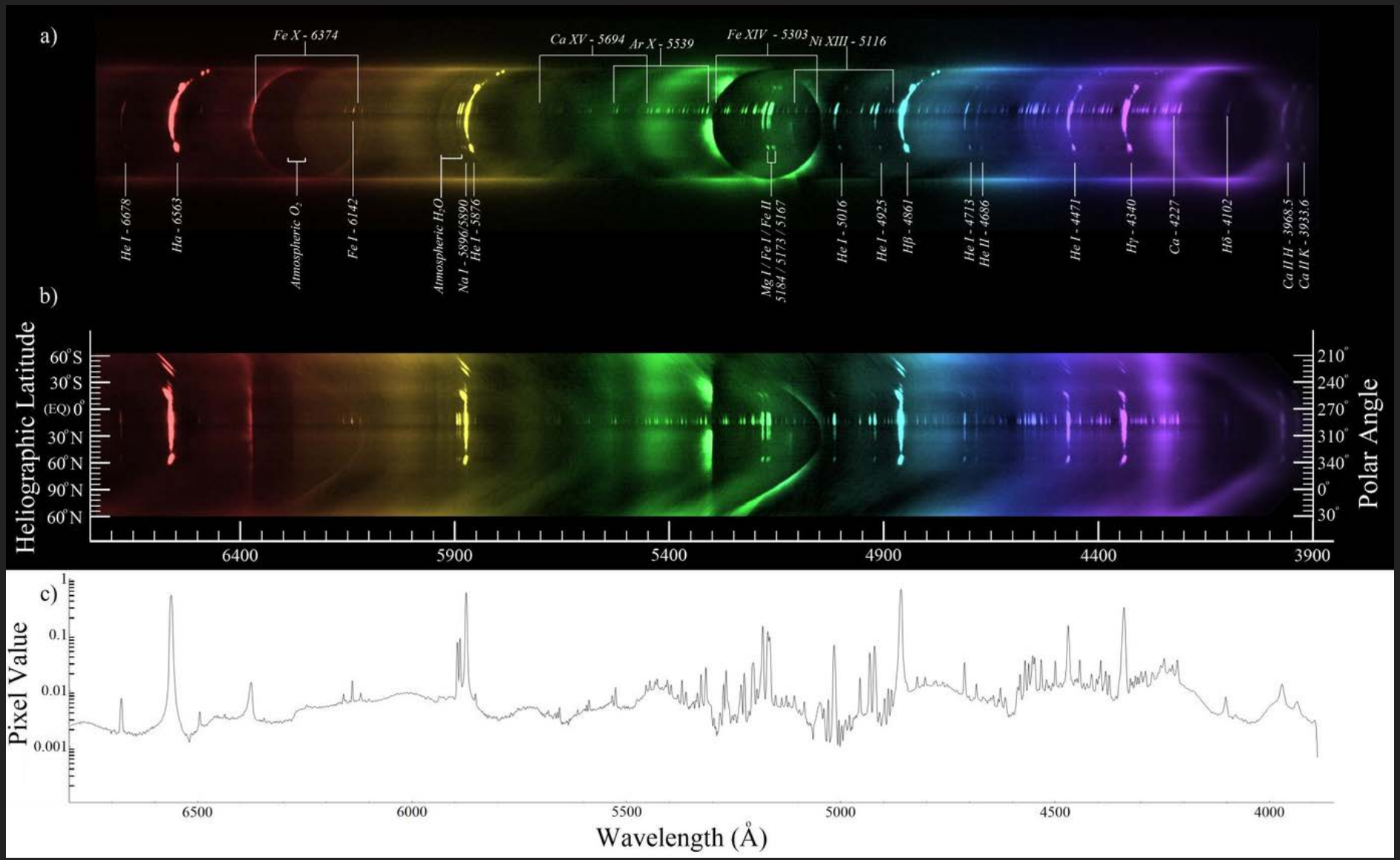
Need to think of other distinguishing observables

Röpke+ (2012), ApJ, 750, 19

supernova remnant tomography
with
coronal lines in the shocked ejecta

Coronal lines

Voulgaris et al. 2012, Solar Physics, 278, 187



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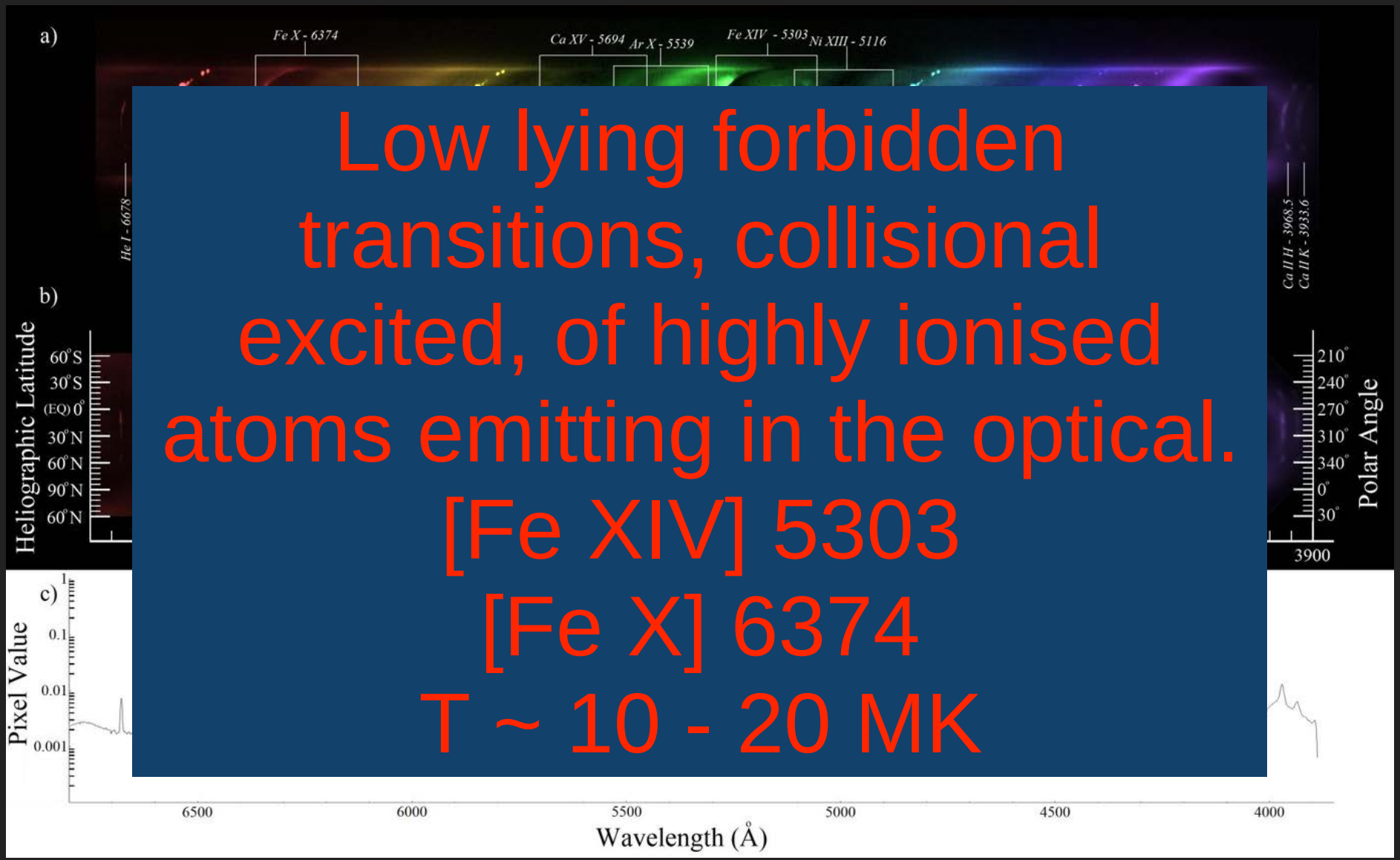

Low lying forbidden transitions, collisional excited, of highly ionised atoms emitting in the optical.

[Fe XIV] 5303

[Fe X] 6374

T ~ 10 - 20 MK


http://www.cielaustral.com/galerie/photo95.htm


http://www.cielaustral.com/galerie/photo95.htm

MUSE on UT4 “Yepun” Archival data from PI Morlino and PI Leibundgut

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SNR 0519-69.0

R: X-ray, G: Fe XIV, B:Ha

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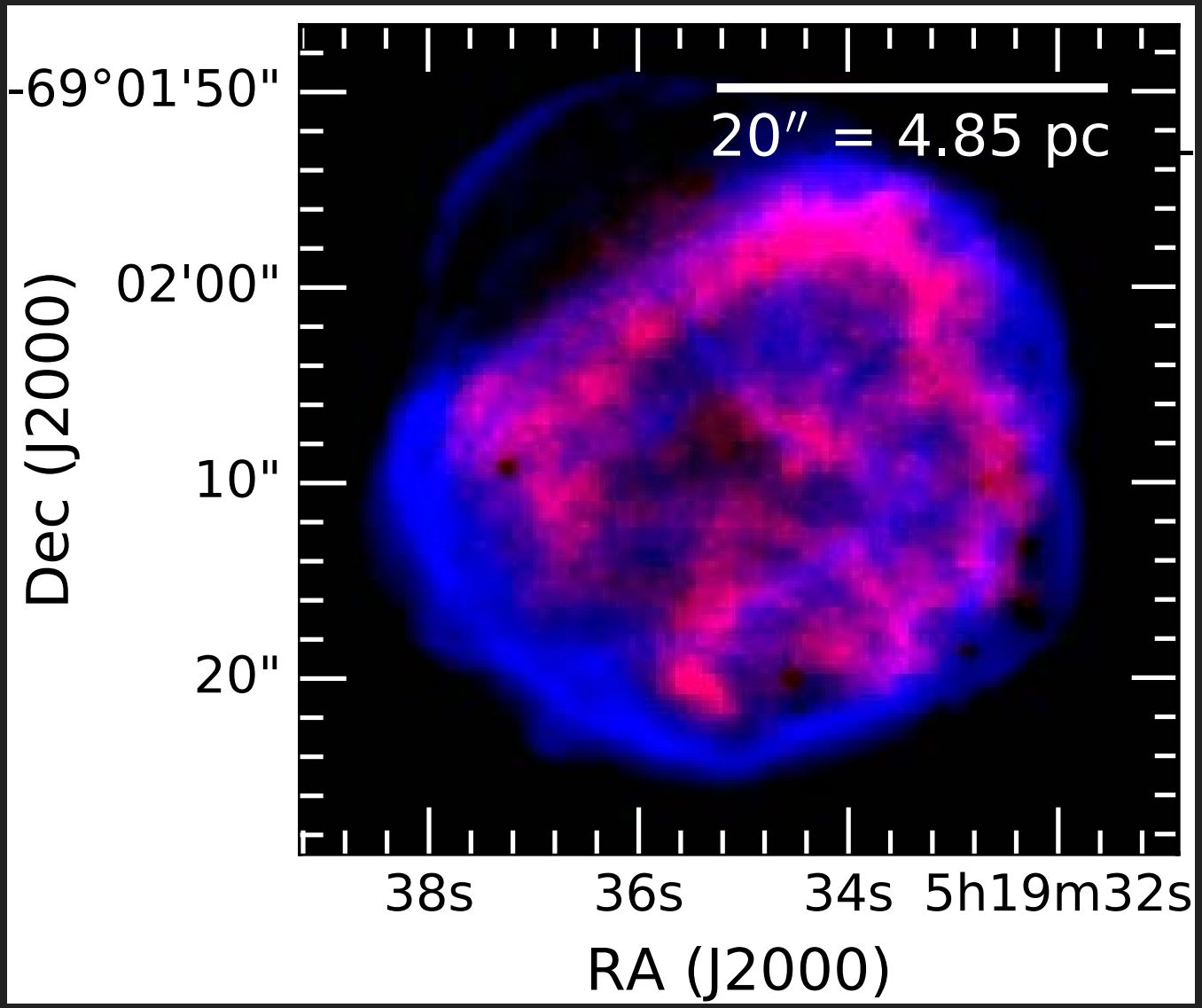

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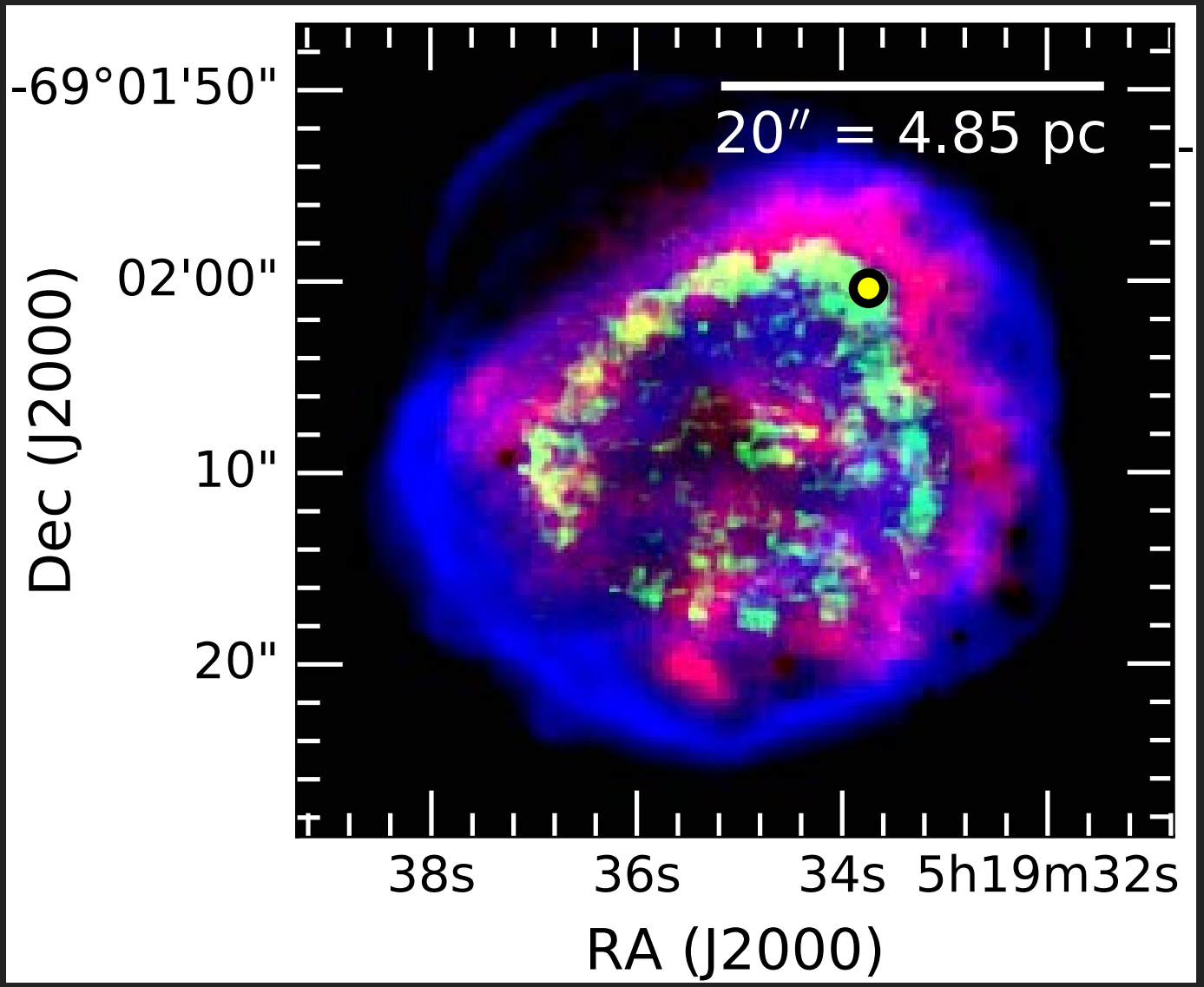

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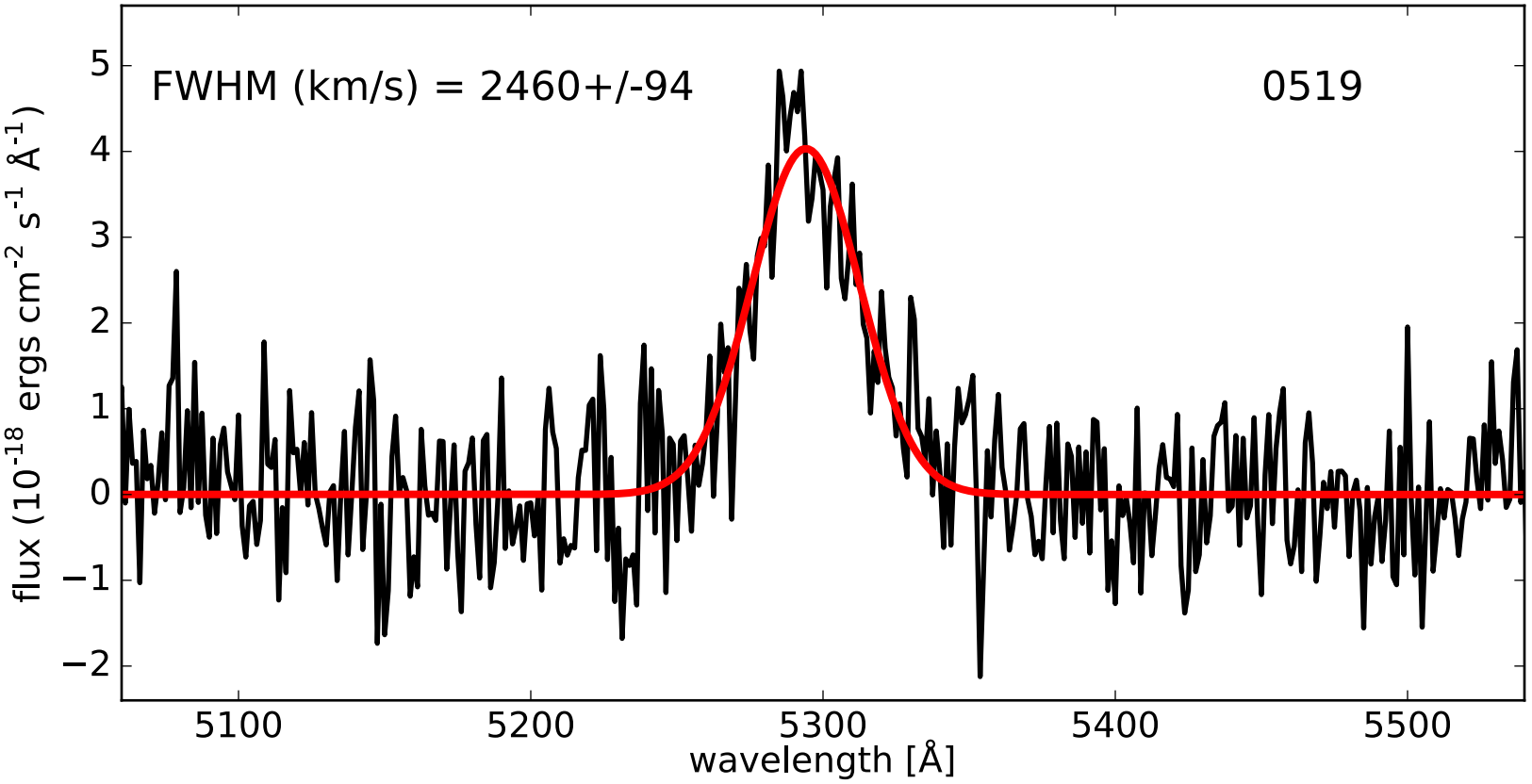

RA (J2000)

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SNR 0509-67.5

R: X-ray, G: Fe XIV, B:Ha

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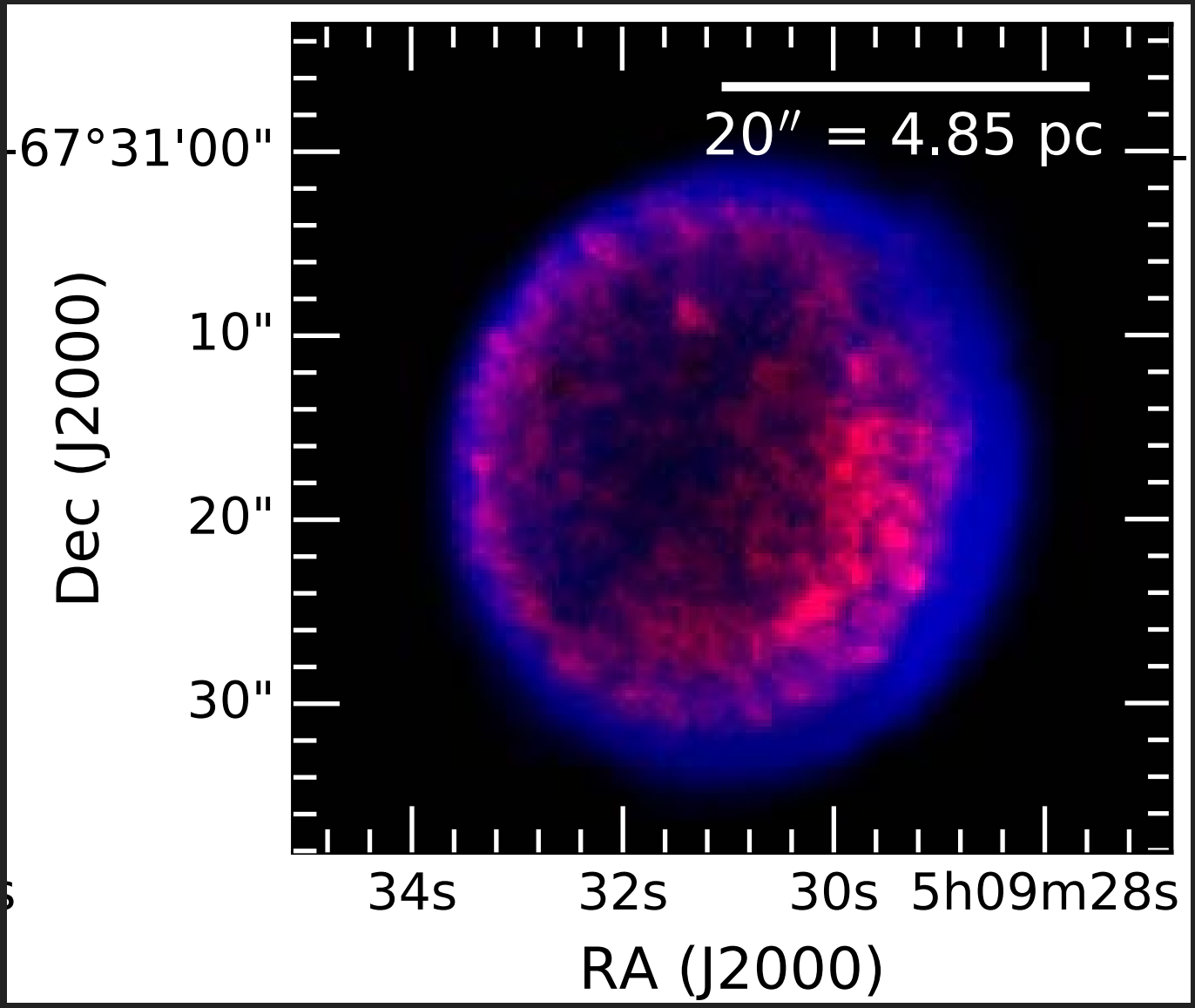

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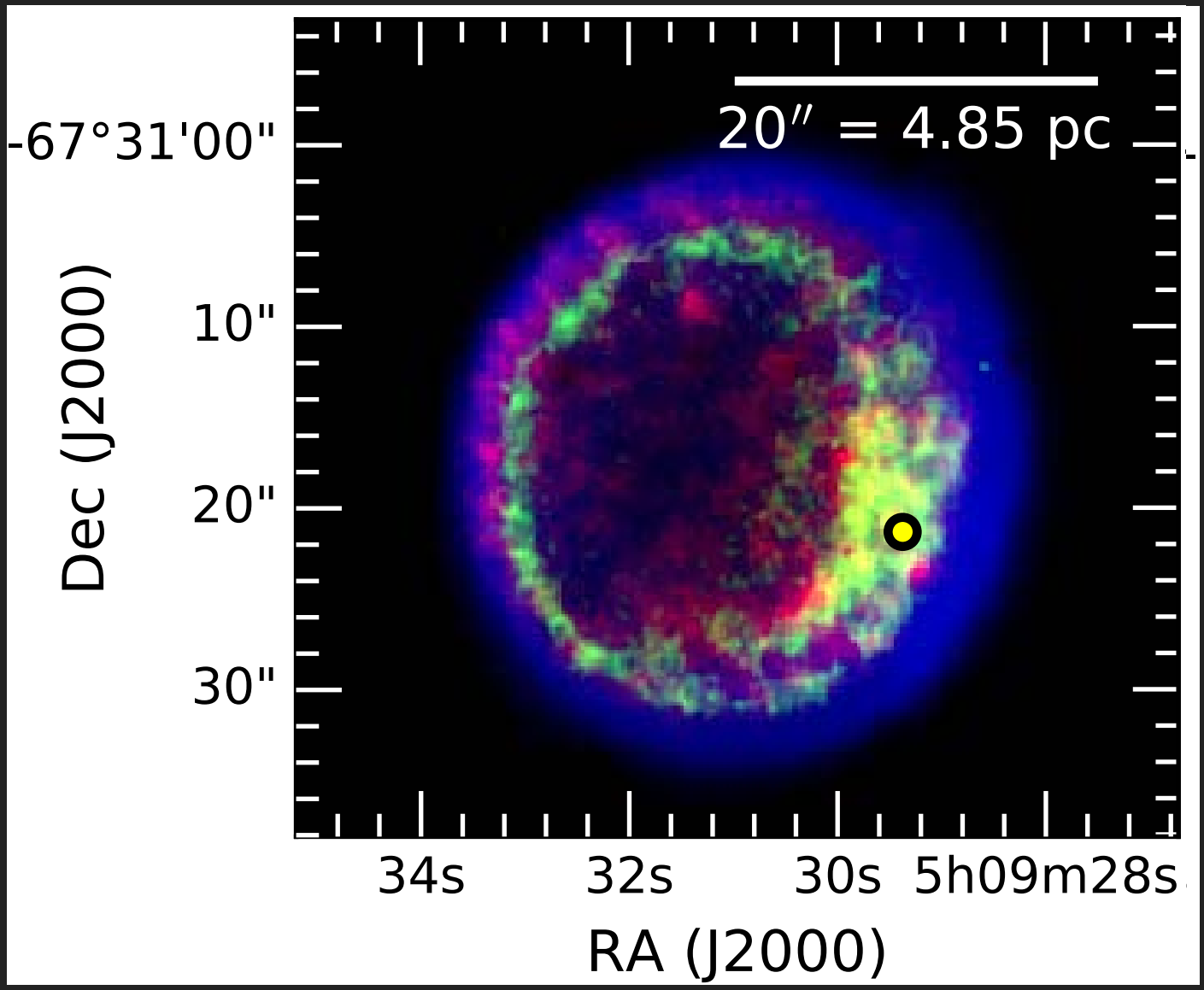

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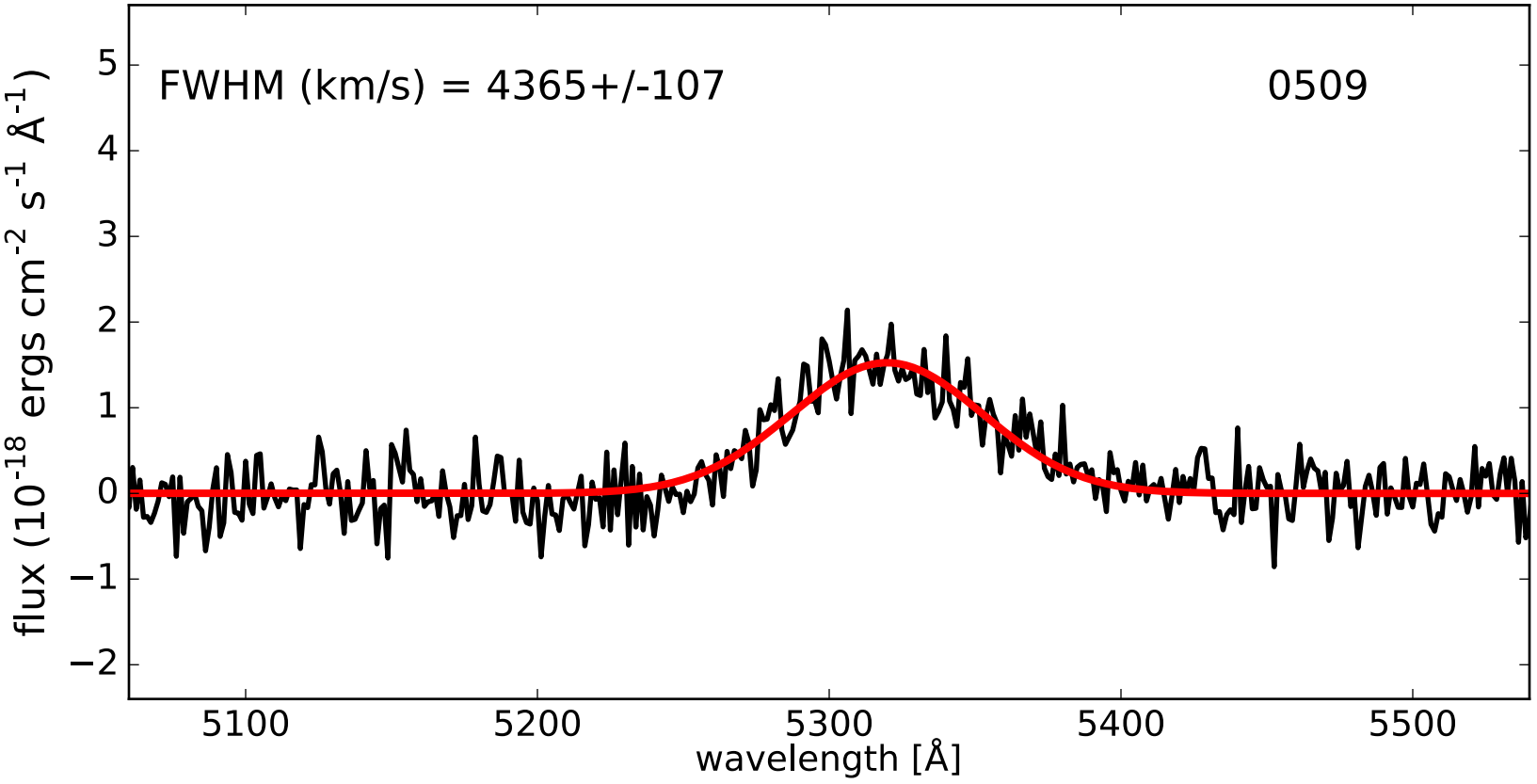


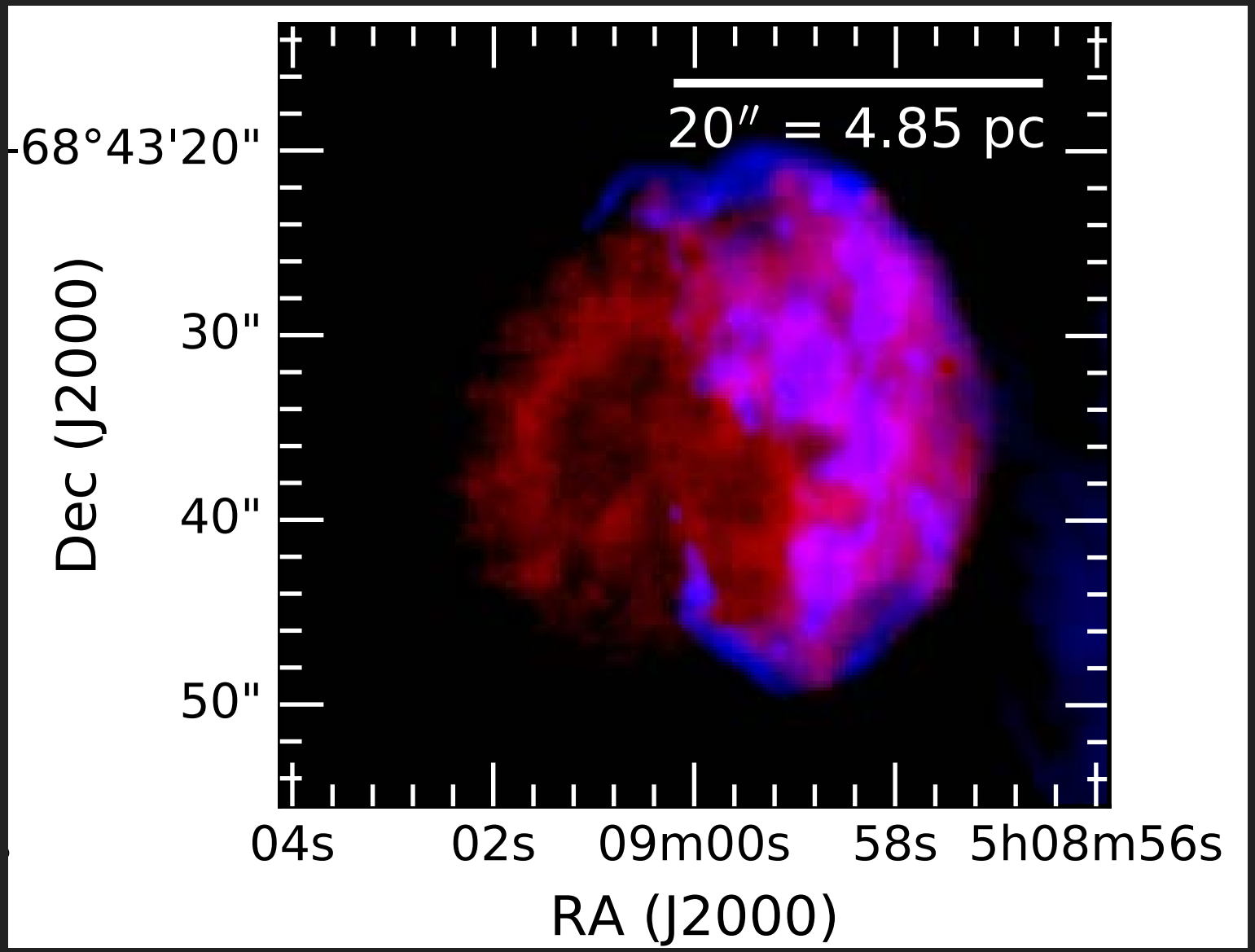
RA (J2000)

UNSW CANBERRA

N103B

R: X-ray, G: Fe XIV, B:Ha

ADFA AUSTRALIAN DEFENCE FORCE ACADEMY



UNSW CANBERRA

N103B

R: X-ray, G: Fe XIV, B:Ha

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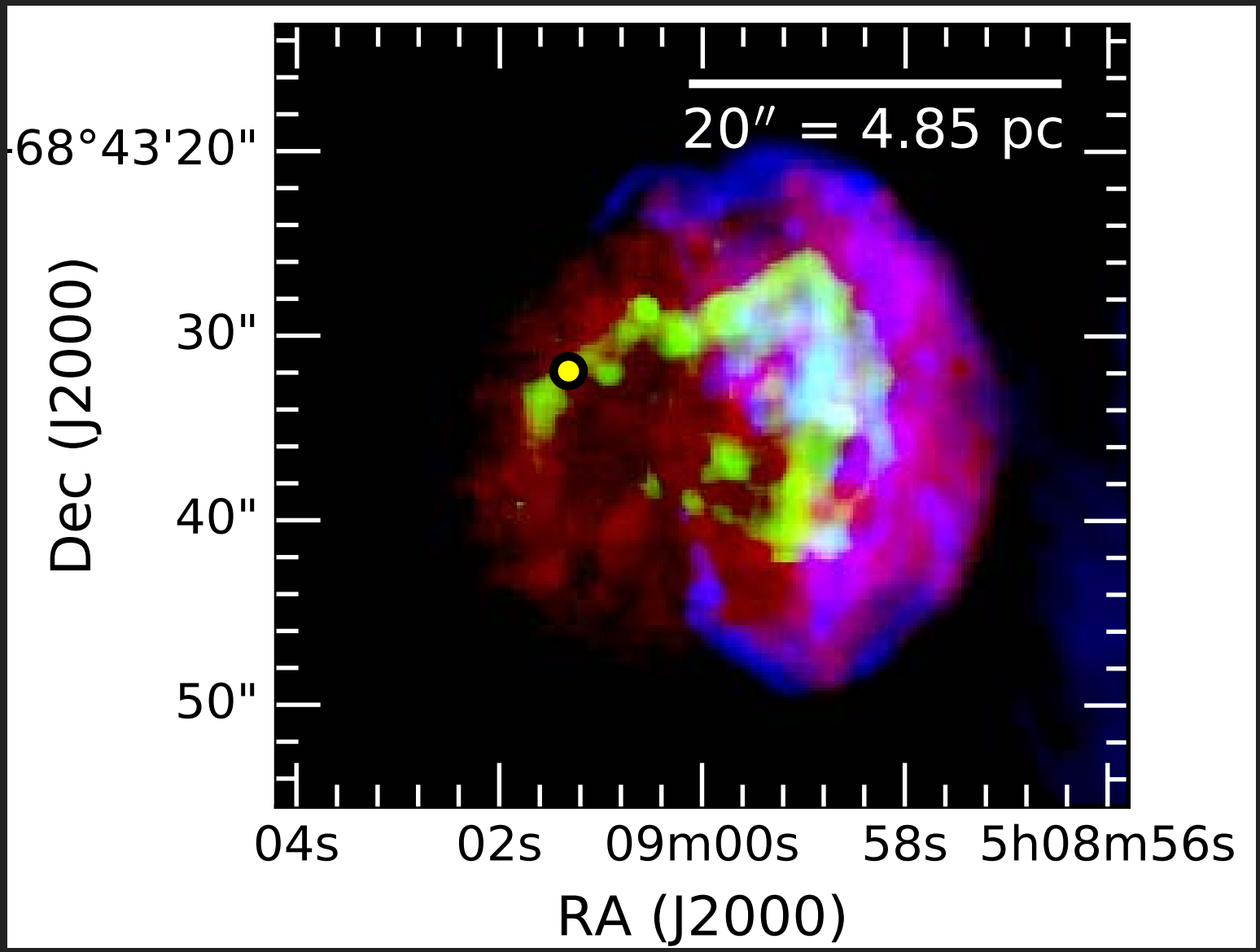

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N103B

R: X-ray, G: Fe XIV, B:Ha

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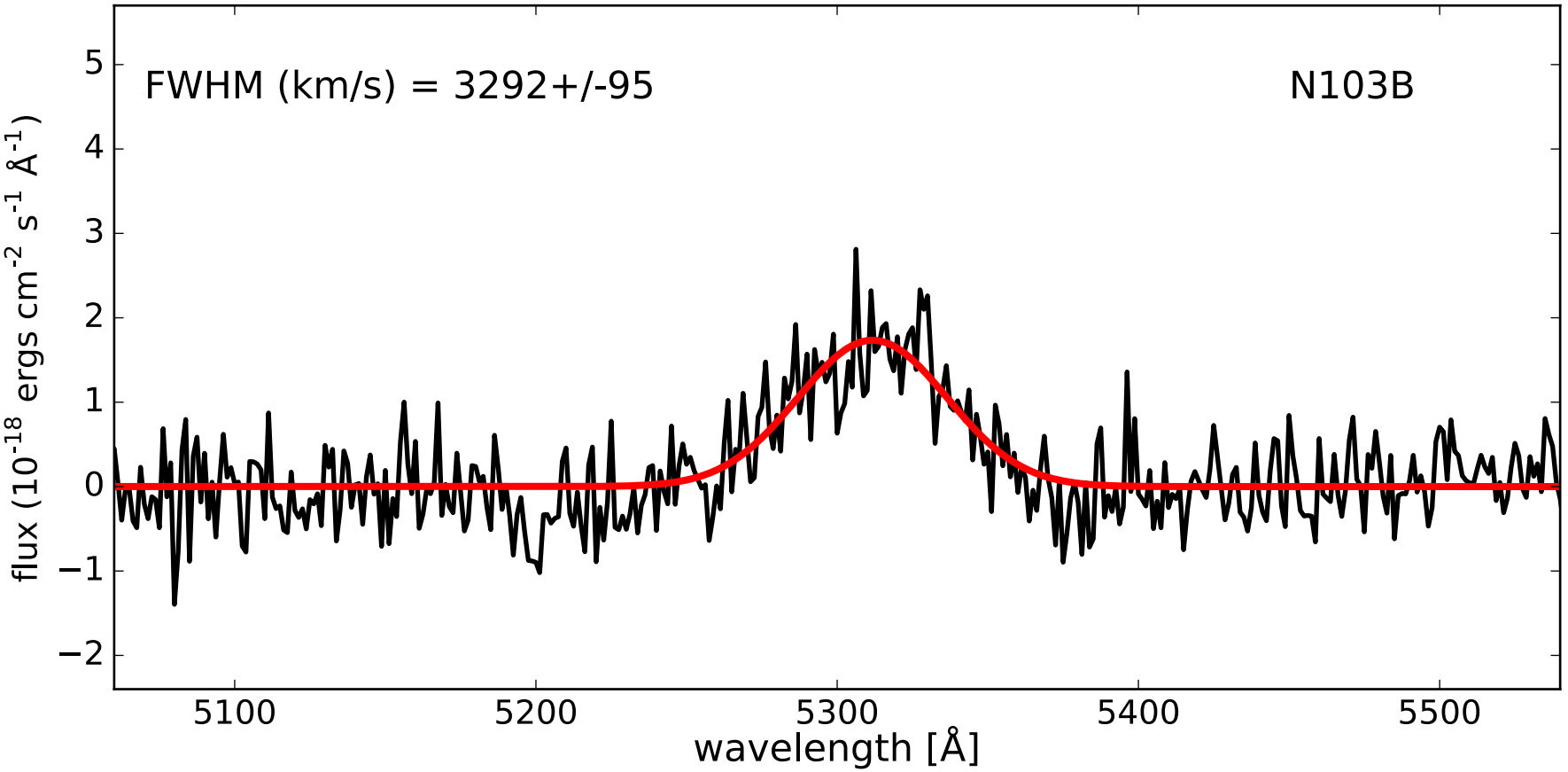

RA (J2000)

Constraining the models with SNR evolution

Leahy & Williams, ascl:1703.006

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SNR Modelling Program

Input parameters:

Age (yr):	310
Energy (x 10^{51} erg):	1.7
ISM Temperature (K):	100
Ejected mass (Msun):	1.4
Ejecta power-law index, n:	7
Ambient media power-law index, s:	0
ISM number density (cm^{-3}):	0.4
Electron to ion temperature ratio T_e/T_i:	0.072
Cooling adjustment factor:	1.0
ISM turbulence/random speed (km/s):	7.0

Change ISM Abundances

Change Ejecta Abundances

Model type:

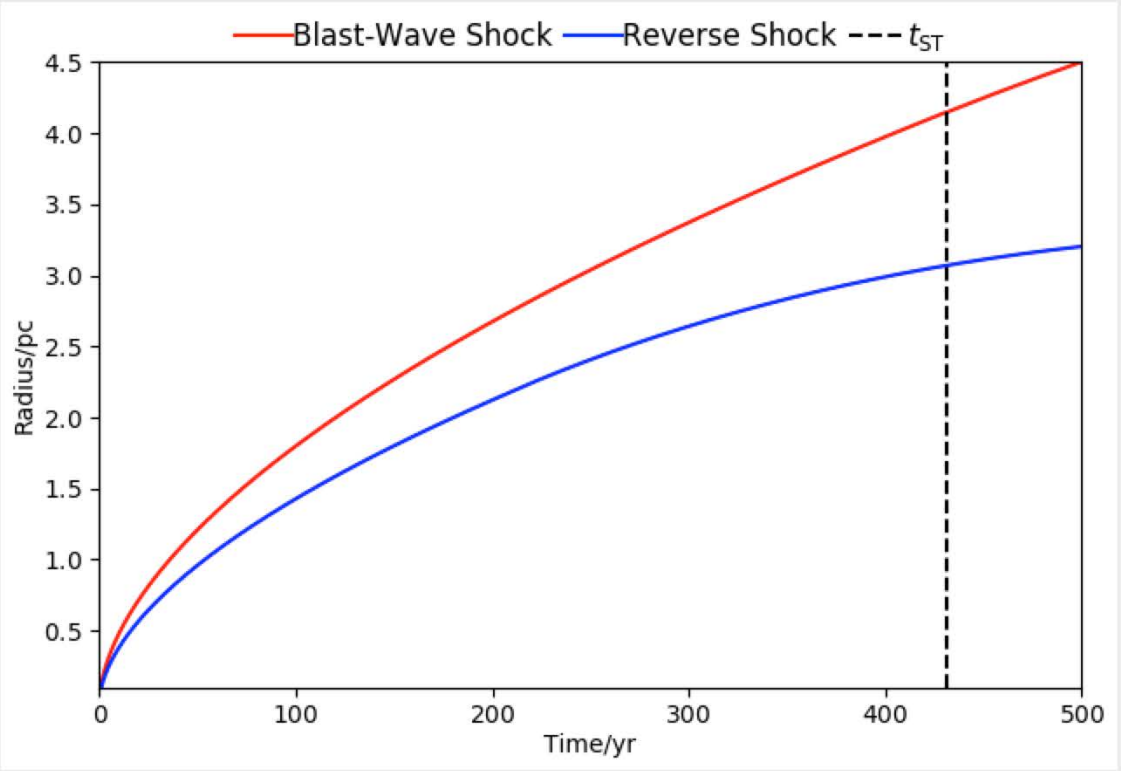
(•) Standard ( ) Fractional energy loss

( ) Hot low-density media ( ) Cloudy ISM

Emissivity

Output:

Plot Type: (•) Radius ( ) Velocity Log scale: [ ] x-axis [ ] y-axis



Plotted Time: Custom Min: 0 Max: 500

Values at specified time:

Blast-wave shock electron temperature: 7.266e+07 K

Reverse shock electron temperature: 5.061e+08 K

Blast-wave shock radius: 3.436 pc

Reverse shock radius: 2.684 pc

Blast-wave shock velocity: 6193 km/s

Reverse shock velocity: 4469 km/s

Phase transition times:

ED to ST: 431.2 yr

ST to PDS: 2.516e+04 yr

PDS to merger: 2.055e+06 yr

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Also [Fe XV] 7062.1

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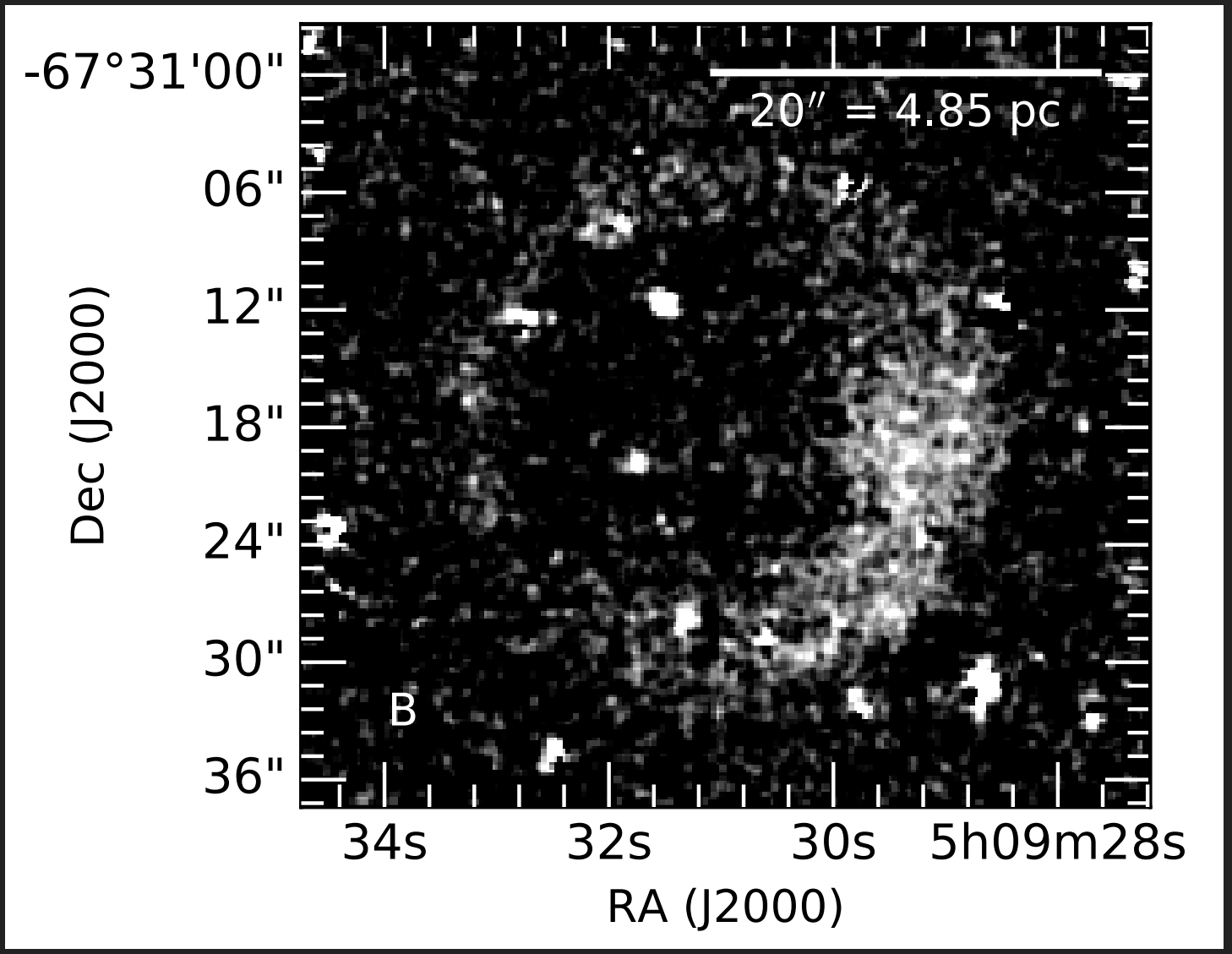

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[S XII] 7613.1 (red)
[Fe IX] 8236.8 (blue)

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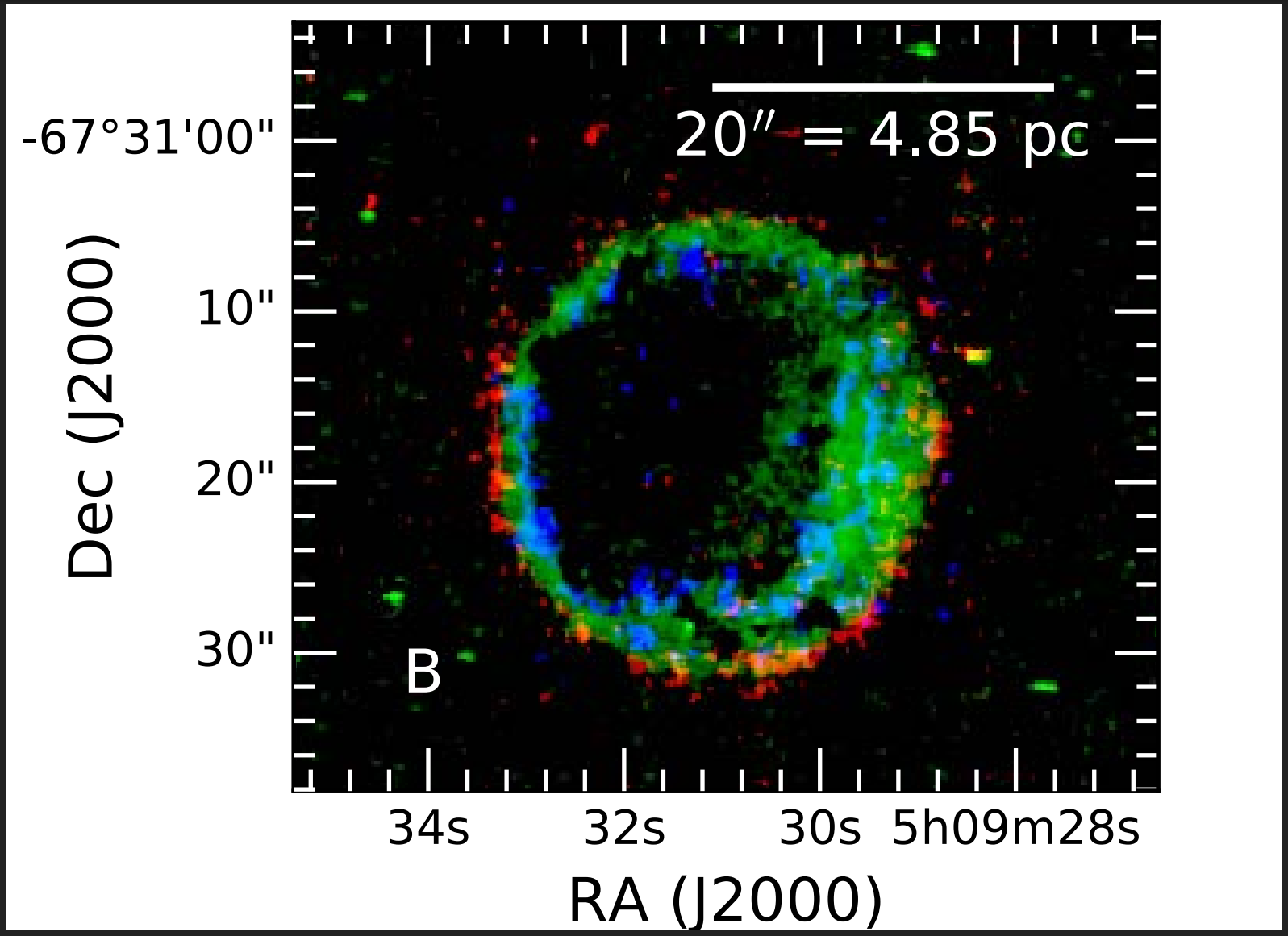
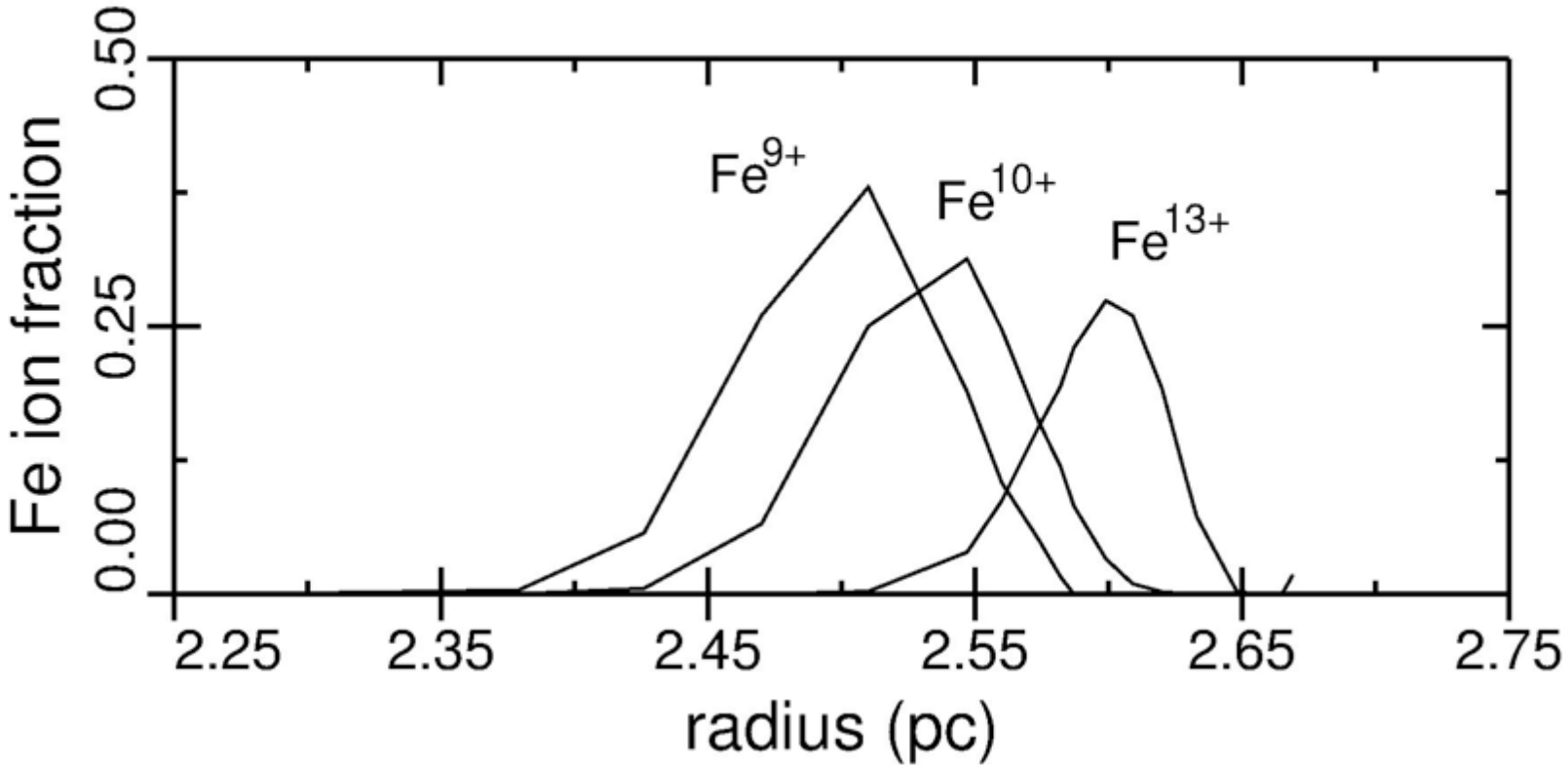


BLASPHEMER models

BLASt Propagation in Highly EMitting EnviRonment

by Martin Laming



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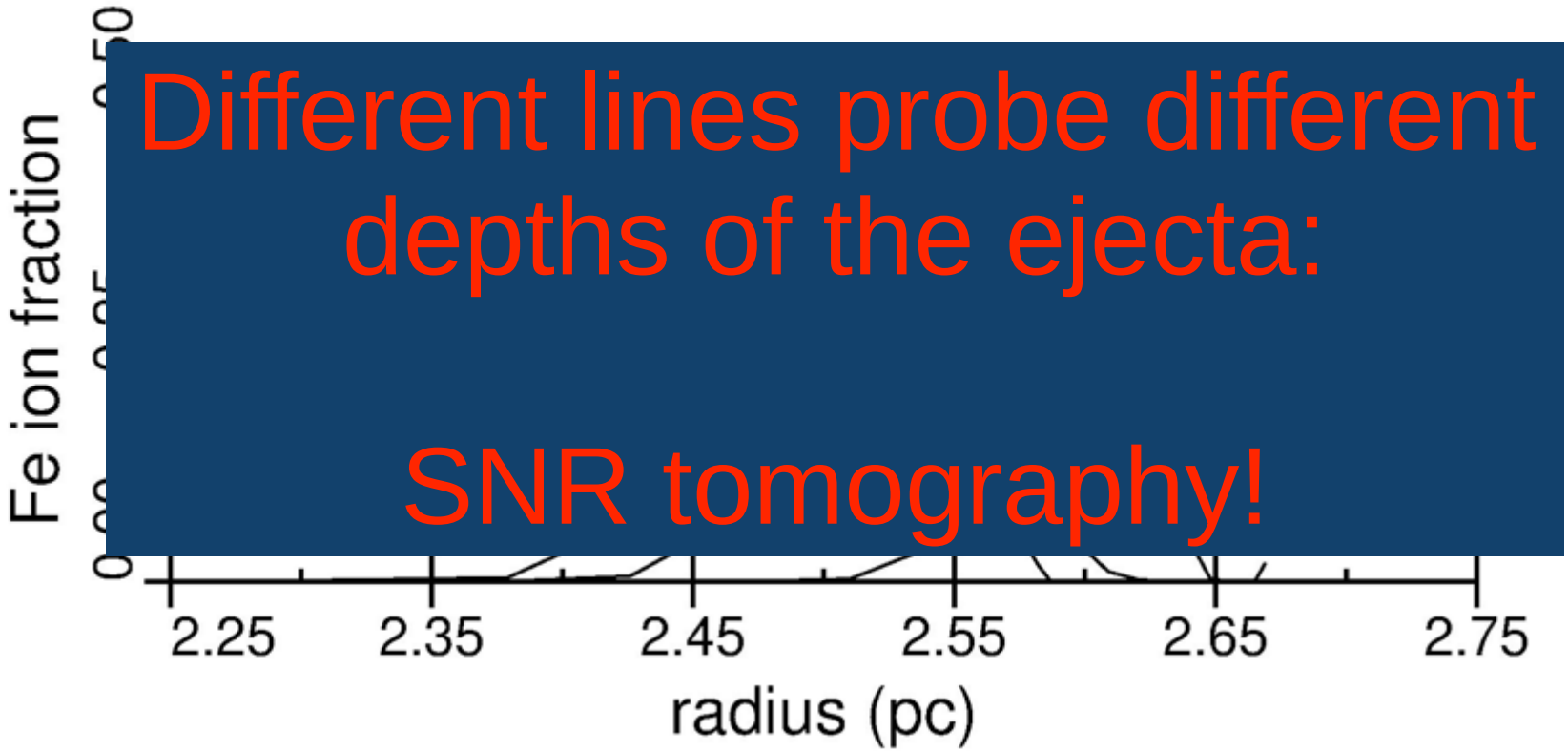

Different lines probe different depths of the ejecta:

SNR tomography!

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Shock velocities time-dependent

Leahy & Williams, ascl:1703.006

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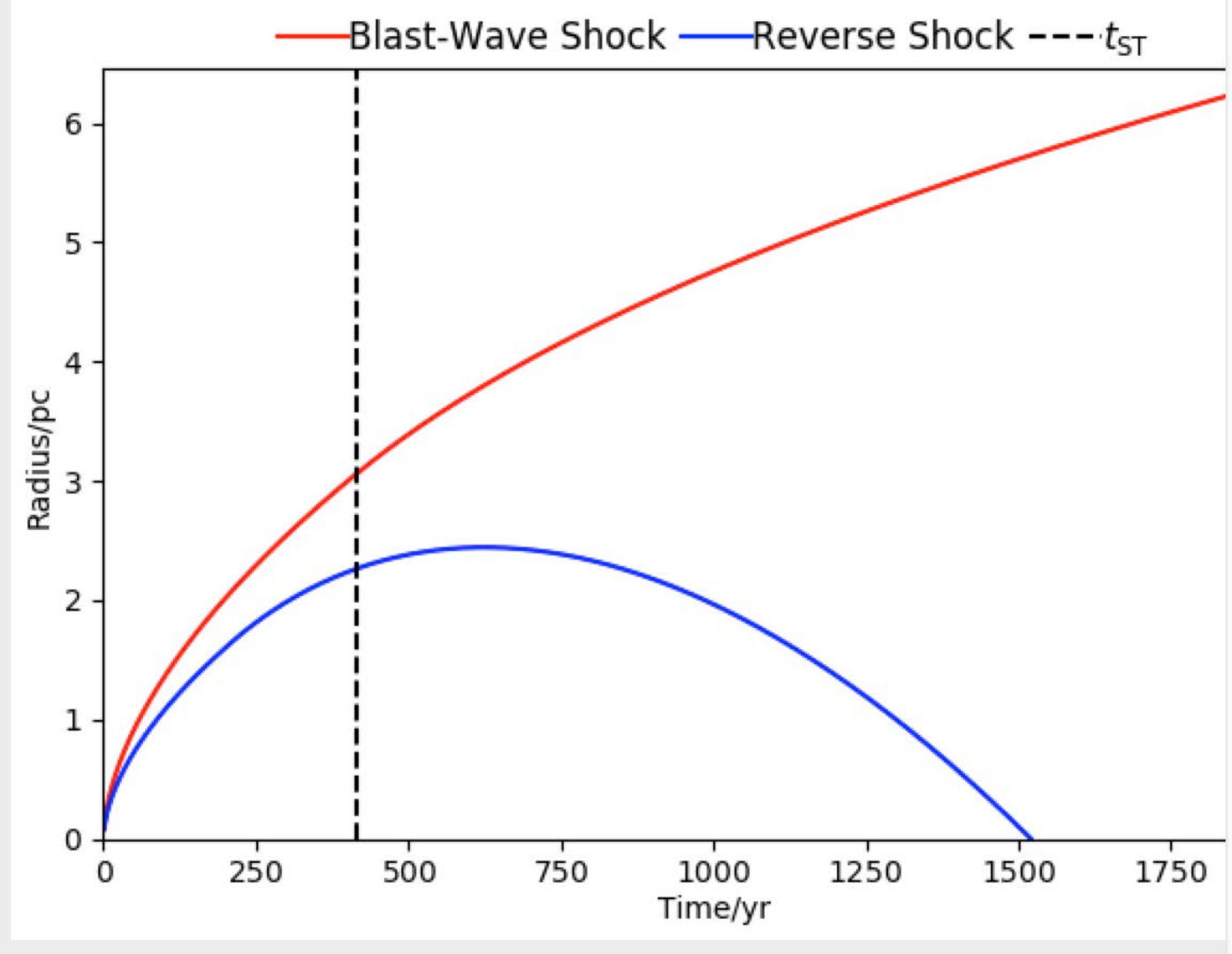

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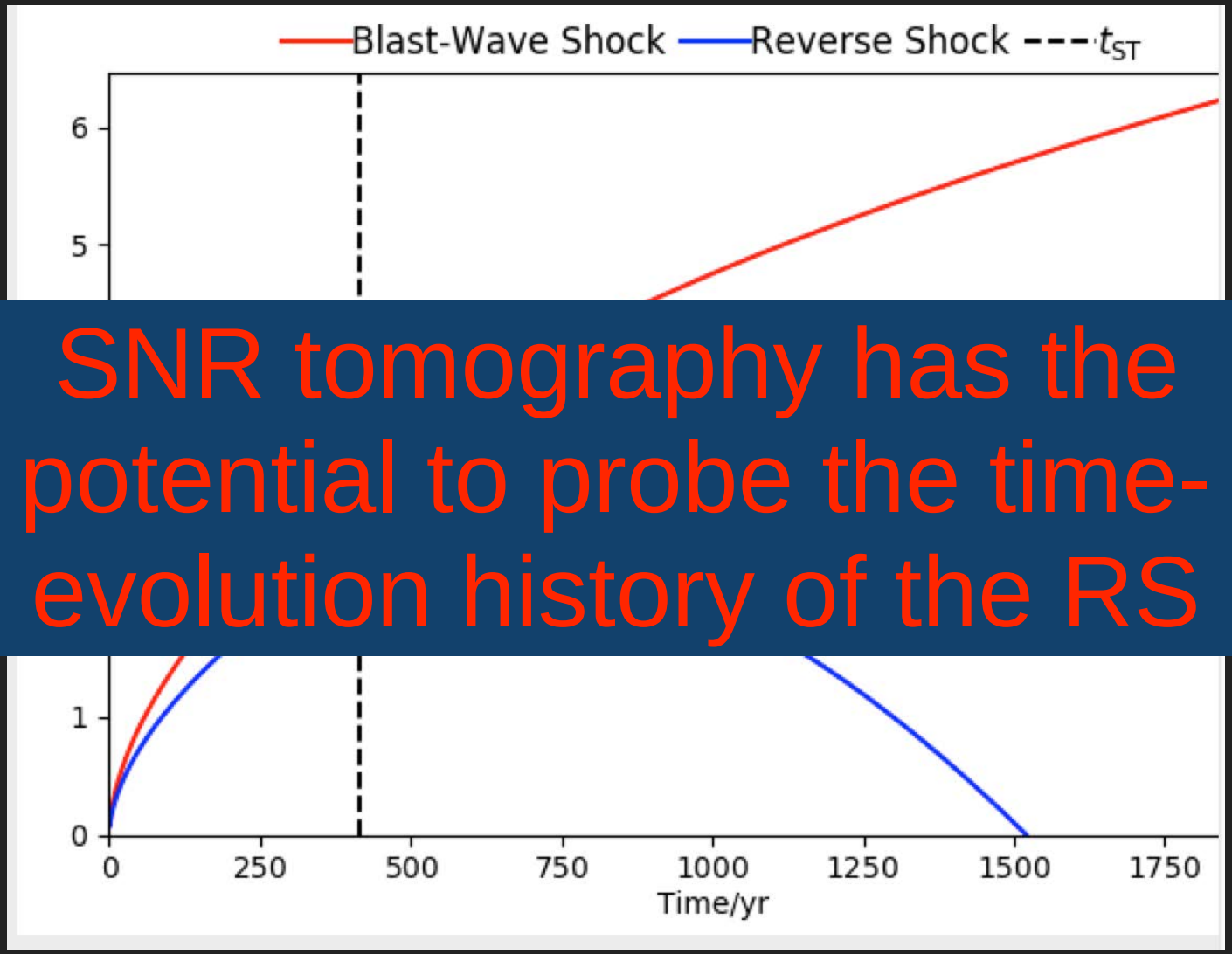

SNR tomography has the potential to probe the time-evolution history of the RS

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Final thoughts

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- ISSI proposal “SNR tomography with JWST”, only 12 pax :-(