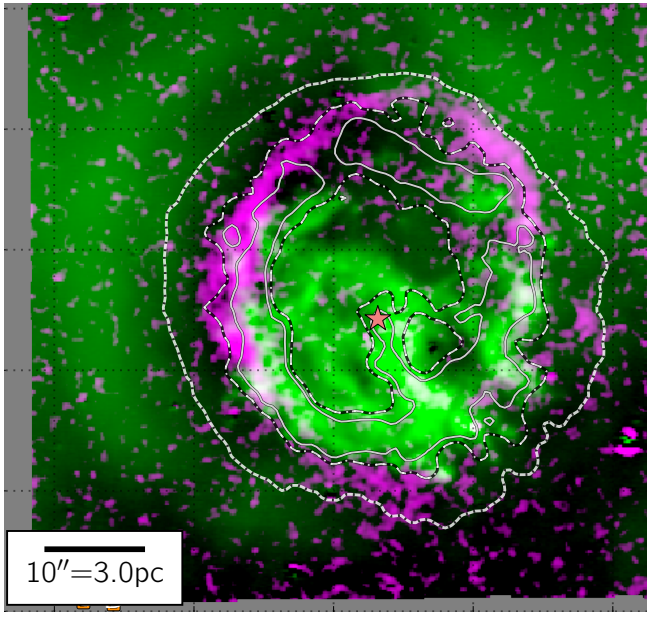
PWNe in young oxygen-rich supernova remnants as TeV sources for CTA

Ivo Seitenzahl
ANU / CAASTRO

CTA OZ-meeting, 10 April 2017



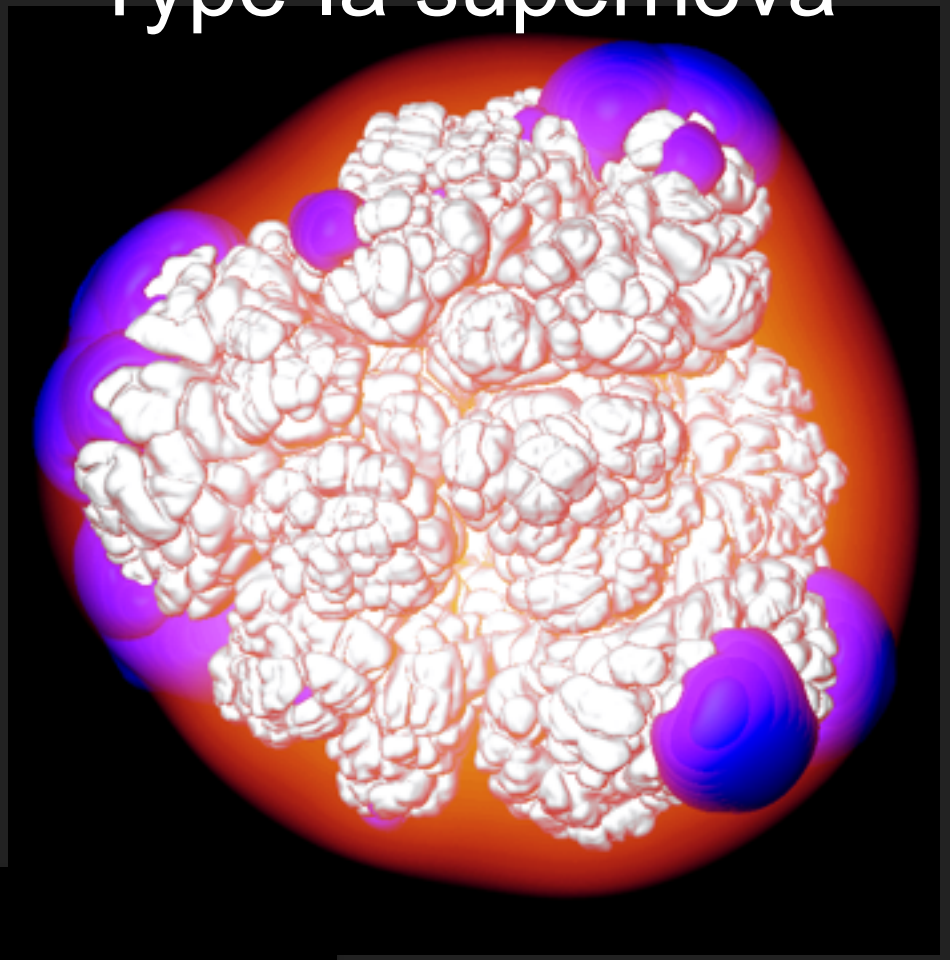
Main Collaborators for this work:
Fréderíc Vogt (ESO, Santiago)
Jason Terry (UGA)
Michael Dopita (ANU)
Ashley Ruiter (ANU)
Julie Banfield (ANU)
Parviz Ghavamian (Towson U)
Tuguldur Sukhbold (OSU)

Australian Government
Australian Research Council

My Background

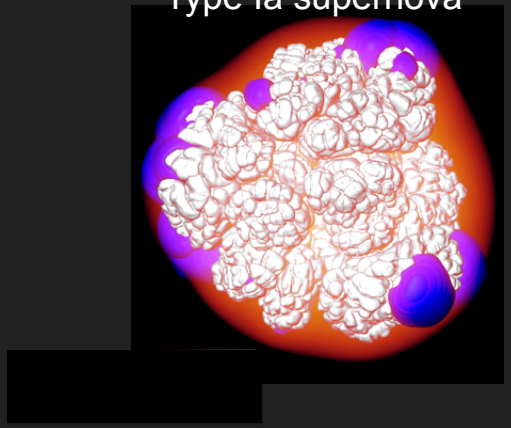
SNe besides Cosmology

Type Ia supernova



SNe besides Cosmology

Type Ia supernova



Interstellar medium

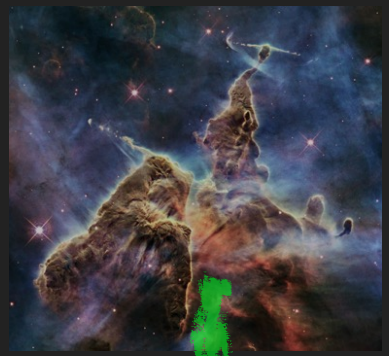
SNe besides Cosmology

Interstellar medium

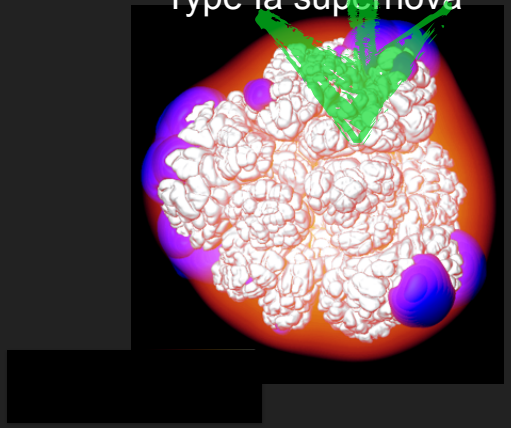
Type Ia supernova

SNe besides Cosmology

Interstellar medium

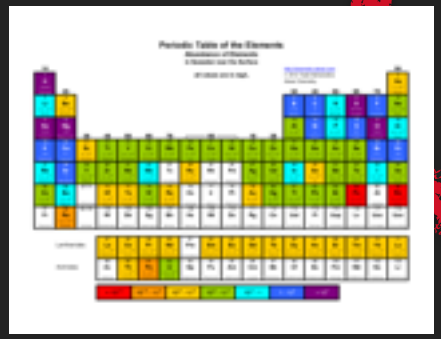


Type Ia supernova

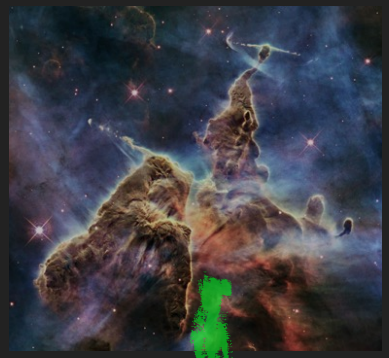


SNe besides Cosmology

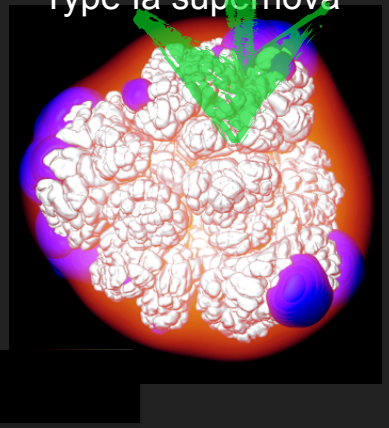
Heavy element enrichment



Interstellar medium



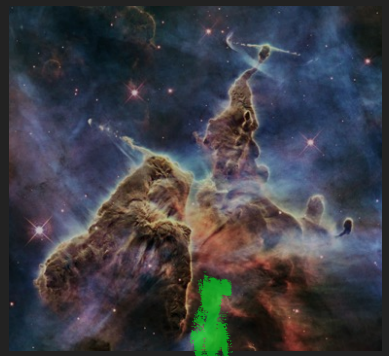
Type Ia supernova



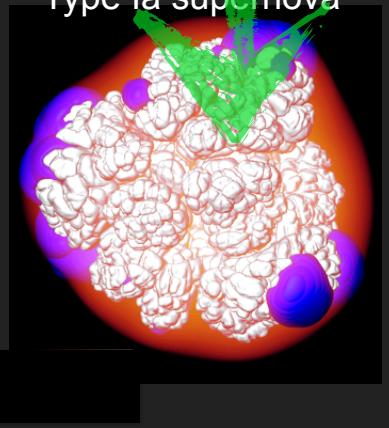
SNe besides Cosmology

Heavy element enrichment

Interstellar medium



Type Ia supernova



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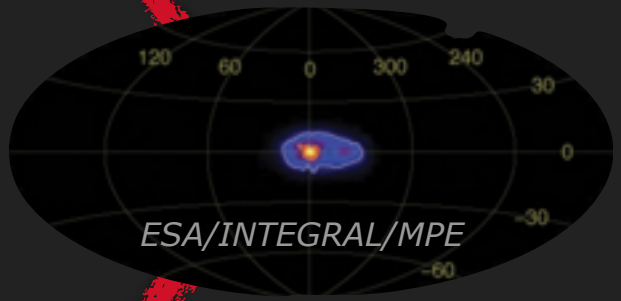
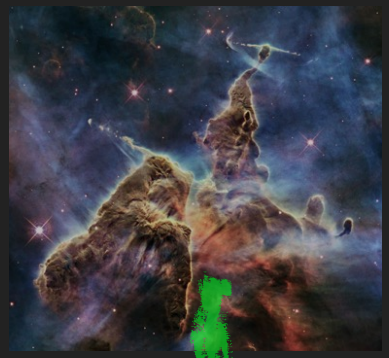
Positron production



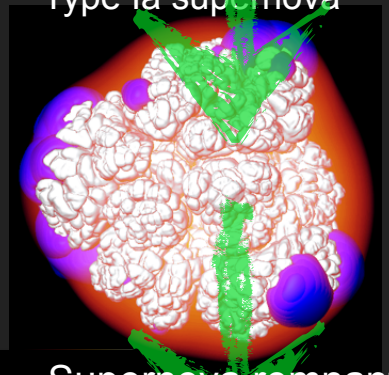
SNe besides Cosmology

Heavy element enrichment

Interstellar medium



Type Ia supernova



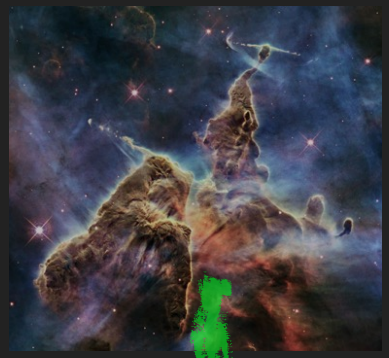
Supernova remnant

Positron production

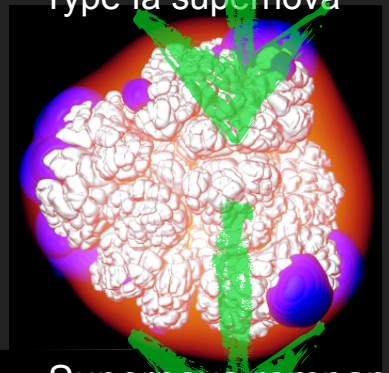
SNe besides Cosmology

Heavy element enrichment

Interstellar medium

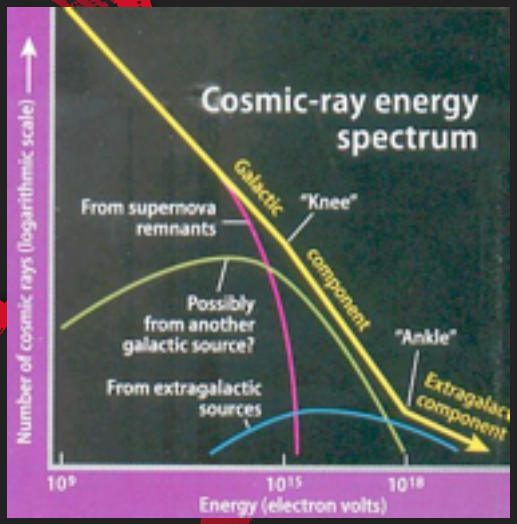


Type Ia supernova



Supernova remnant

Positron production



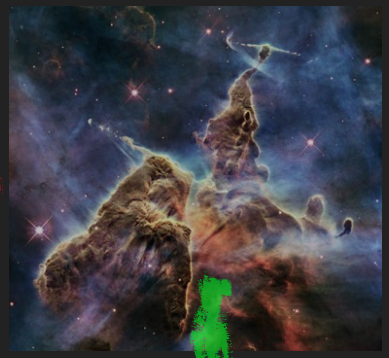
Cosmic rays / high energy photons

CAASTRO
ARC CENTRE OF EXCELLENCE FOR ALL-SKY ASTROPHYSICS

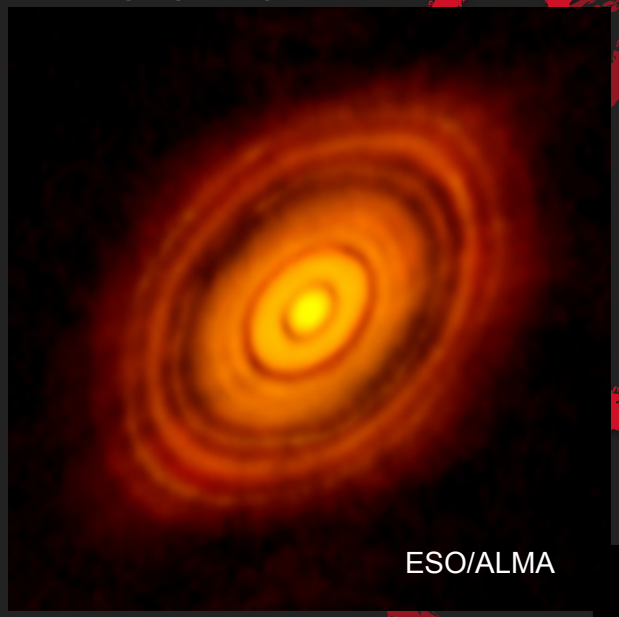
SNe besides Cosmology

Australian National University

Interstellar medium

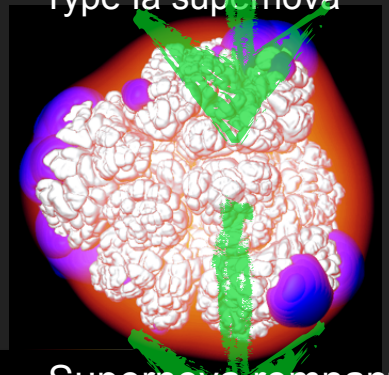


Heavy element



ESO/ALMA

Type Ia supernova



Supernova remnant

Positron production

Cosmic rays / high energy photons

Dissipation of kinetic energy / galaxy feedback / star formation

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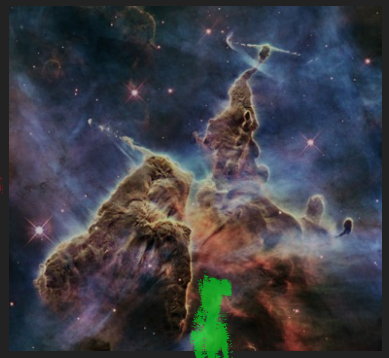
SNe besides Cosmology

Australian National University

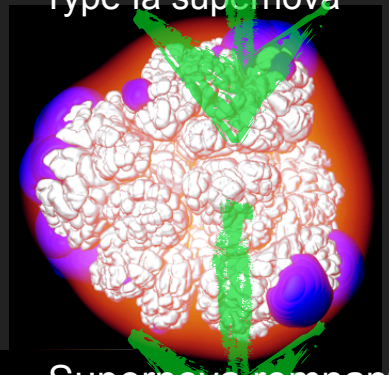
Interstellar medium



Heavy element enrichment

Positron production

Type Ia supernova



Supernova remnant

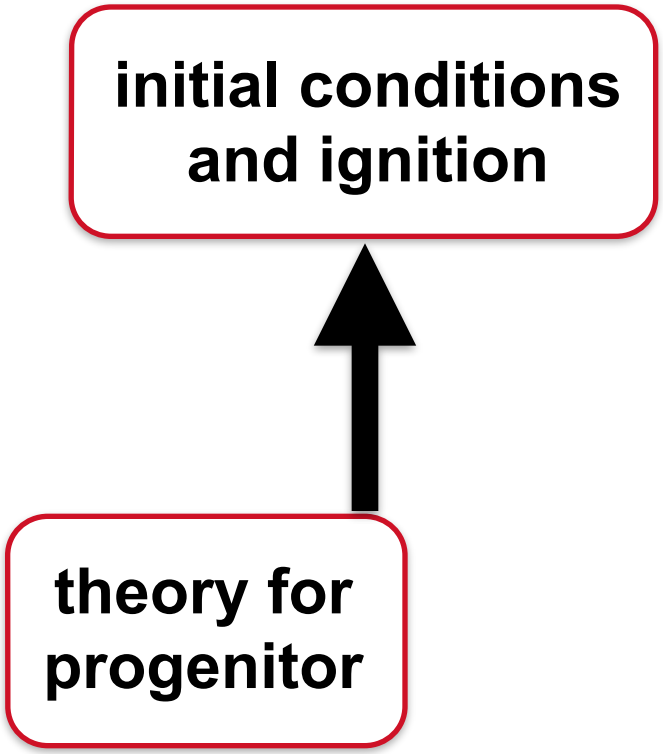
Dissipation of kinetic energy / galaxy feedback / star formation

Cosmic rays / high energy photons

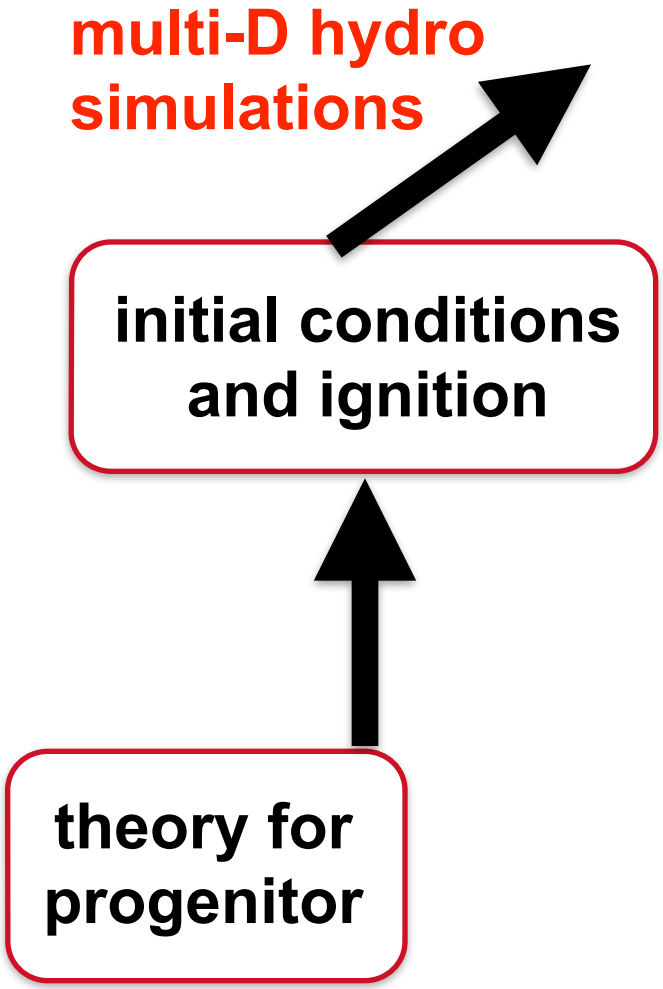
modelling pipeline

theory for progenitor

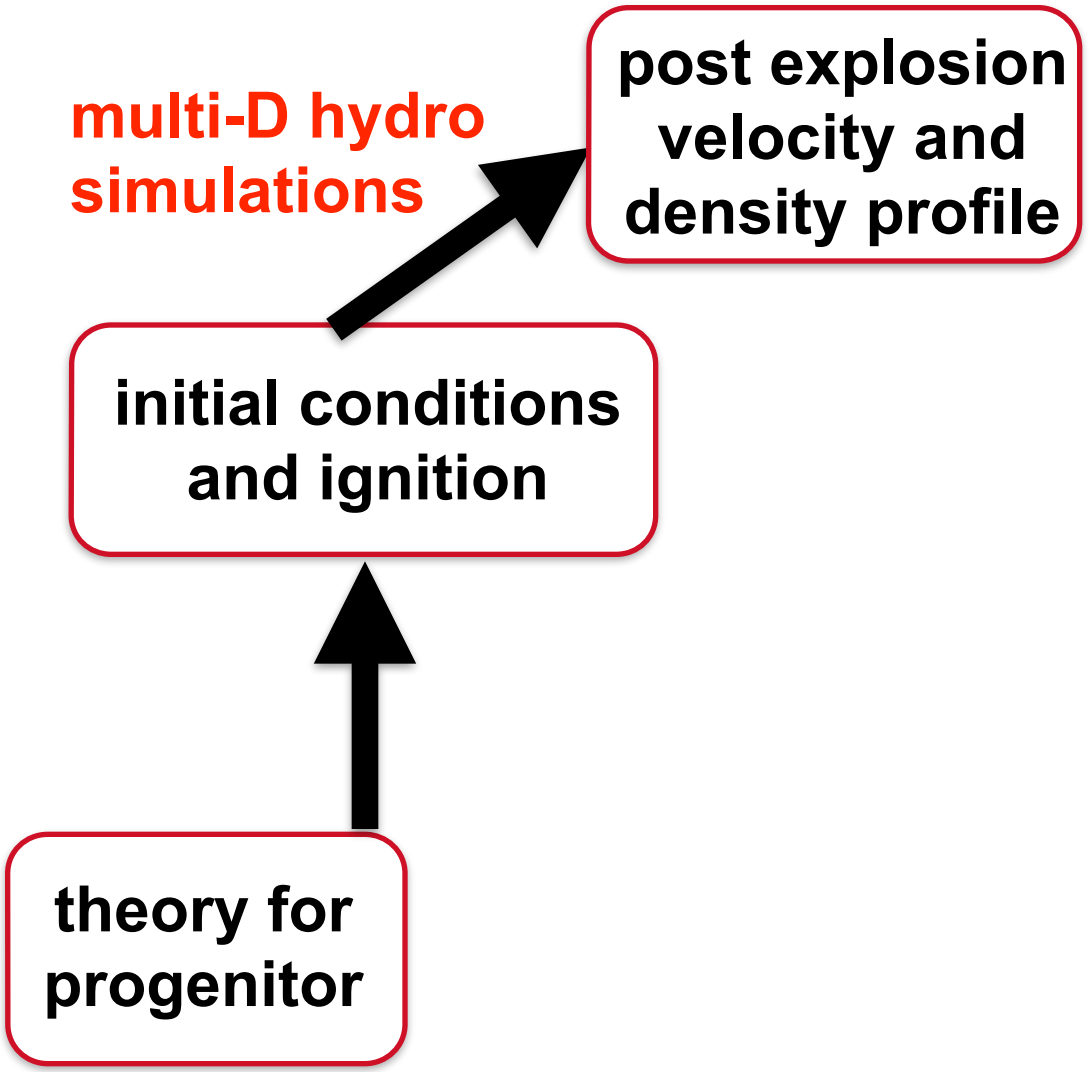
modelling pipeline



modelling pipeline



modelling pipeline



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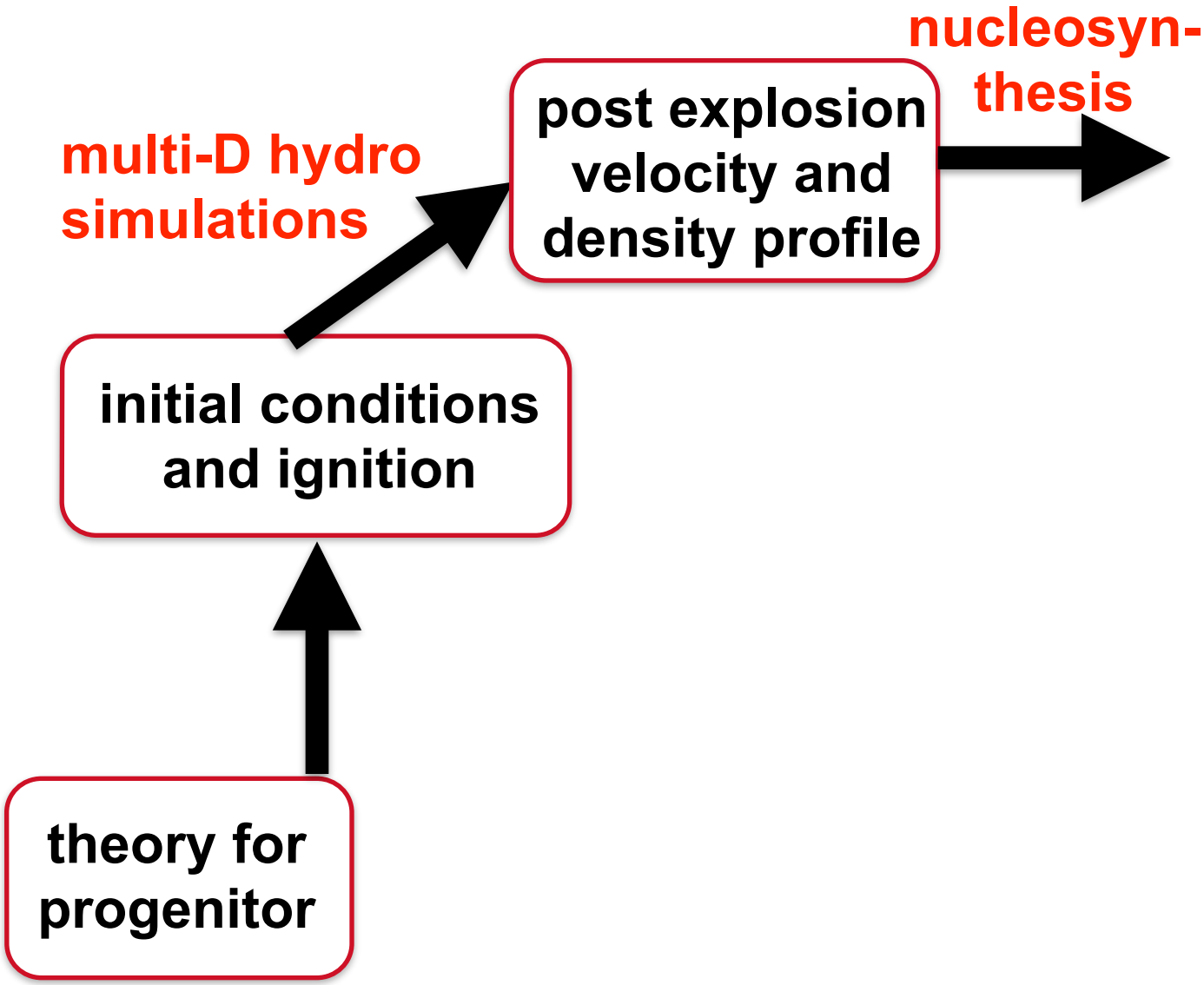
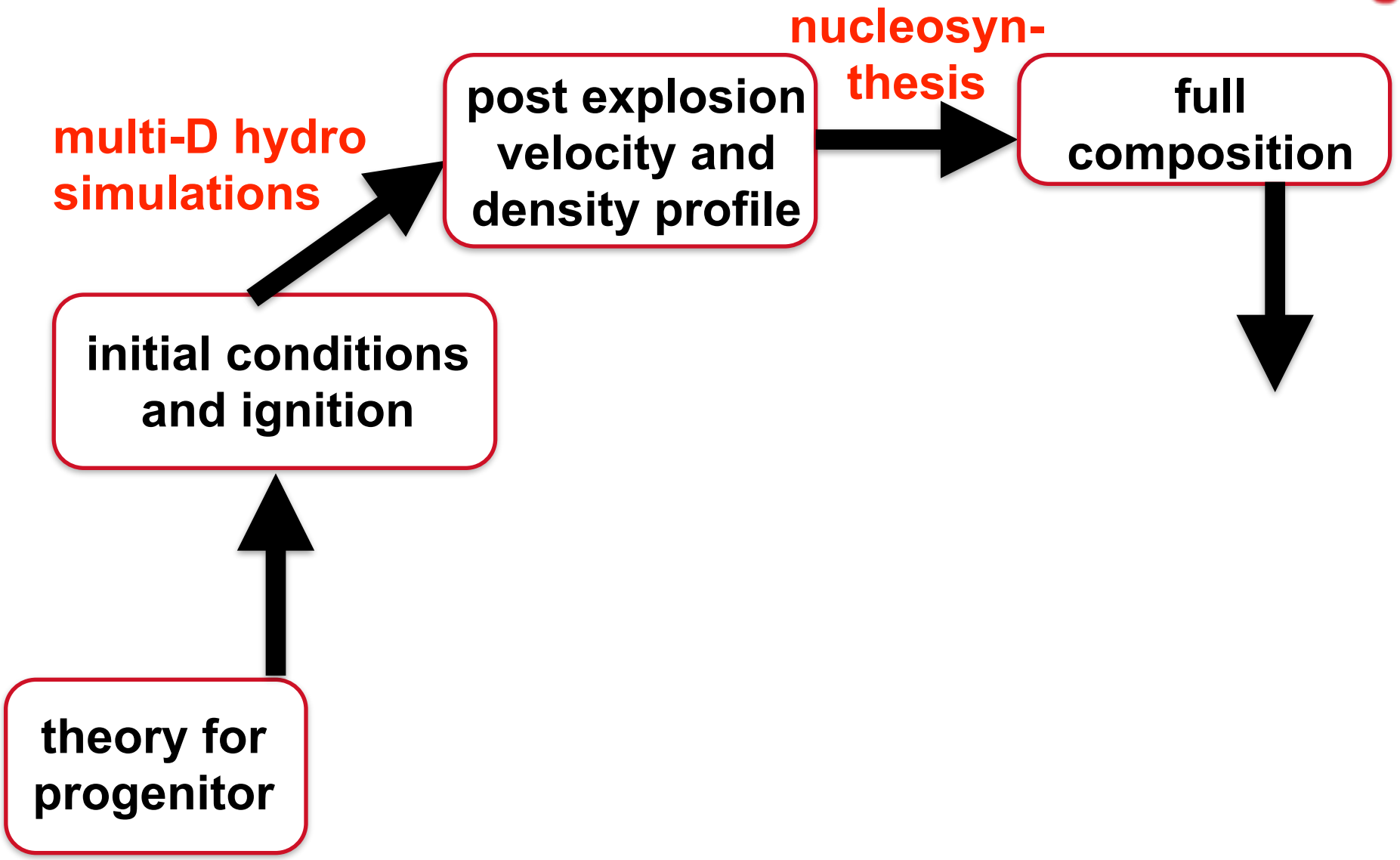


modelling pipeline



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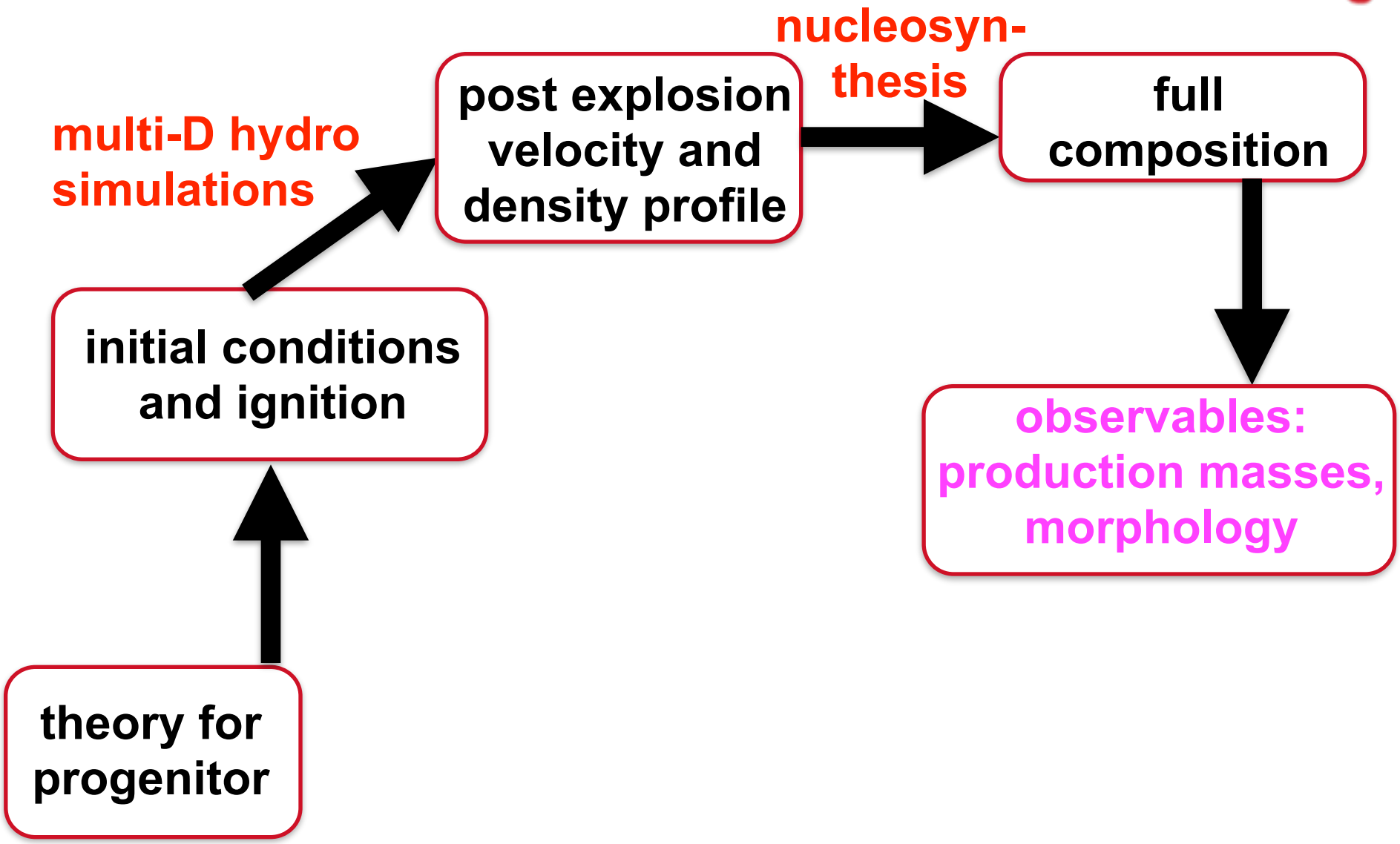

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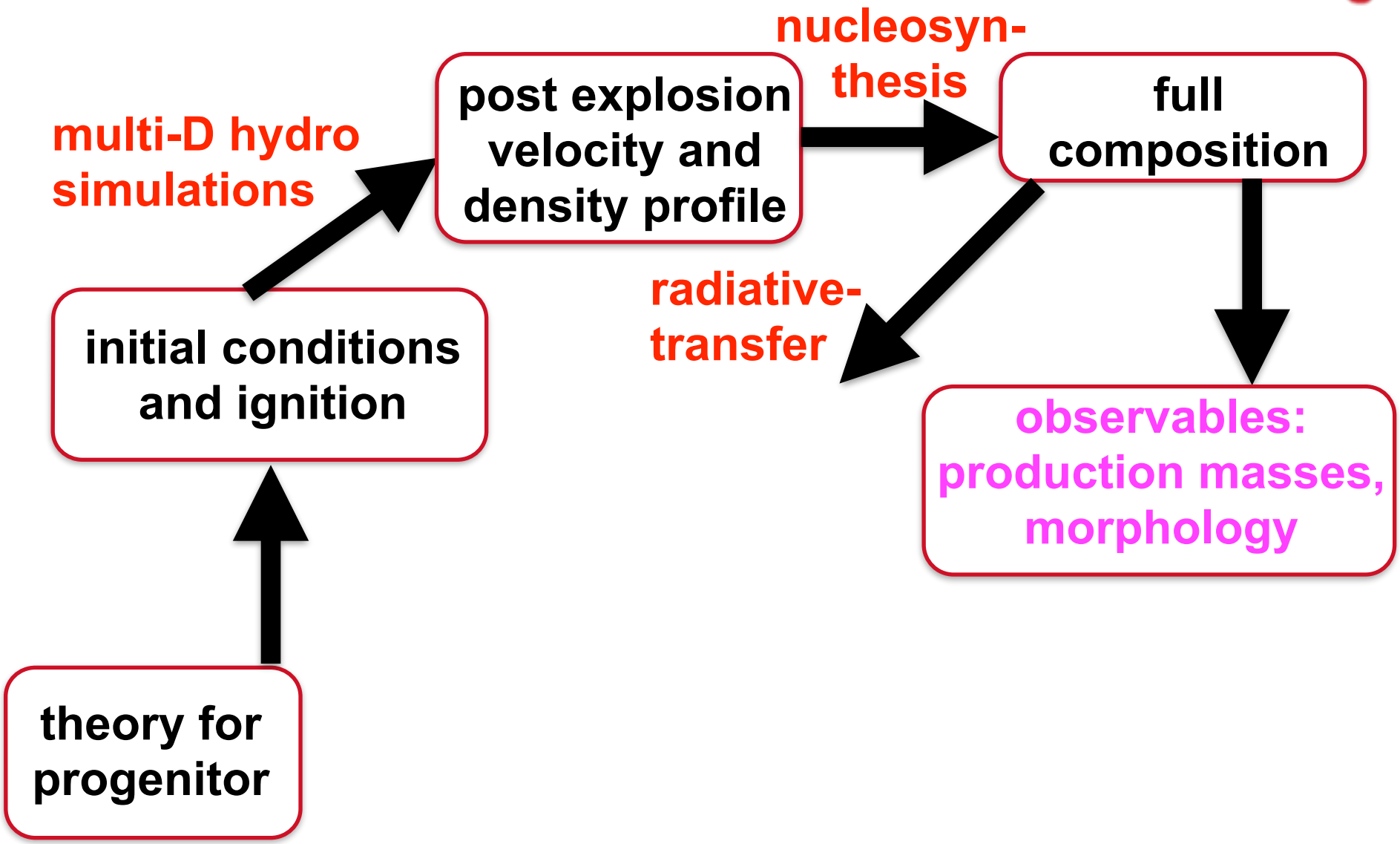

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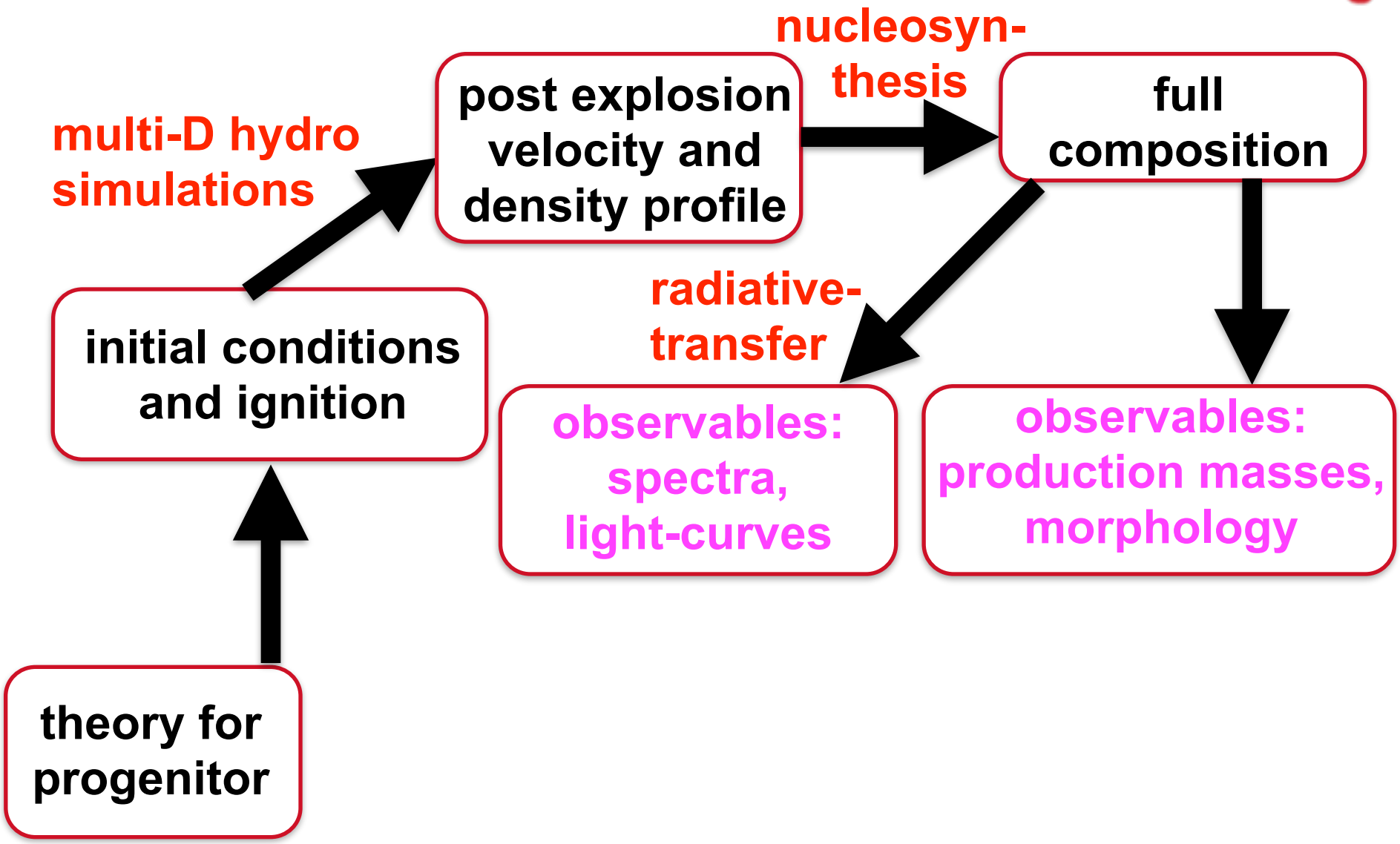

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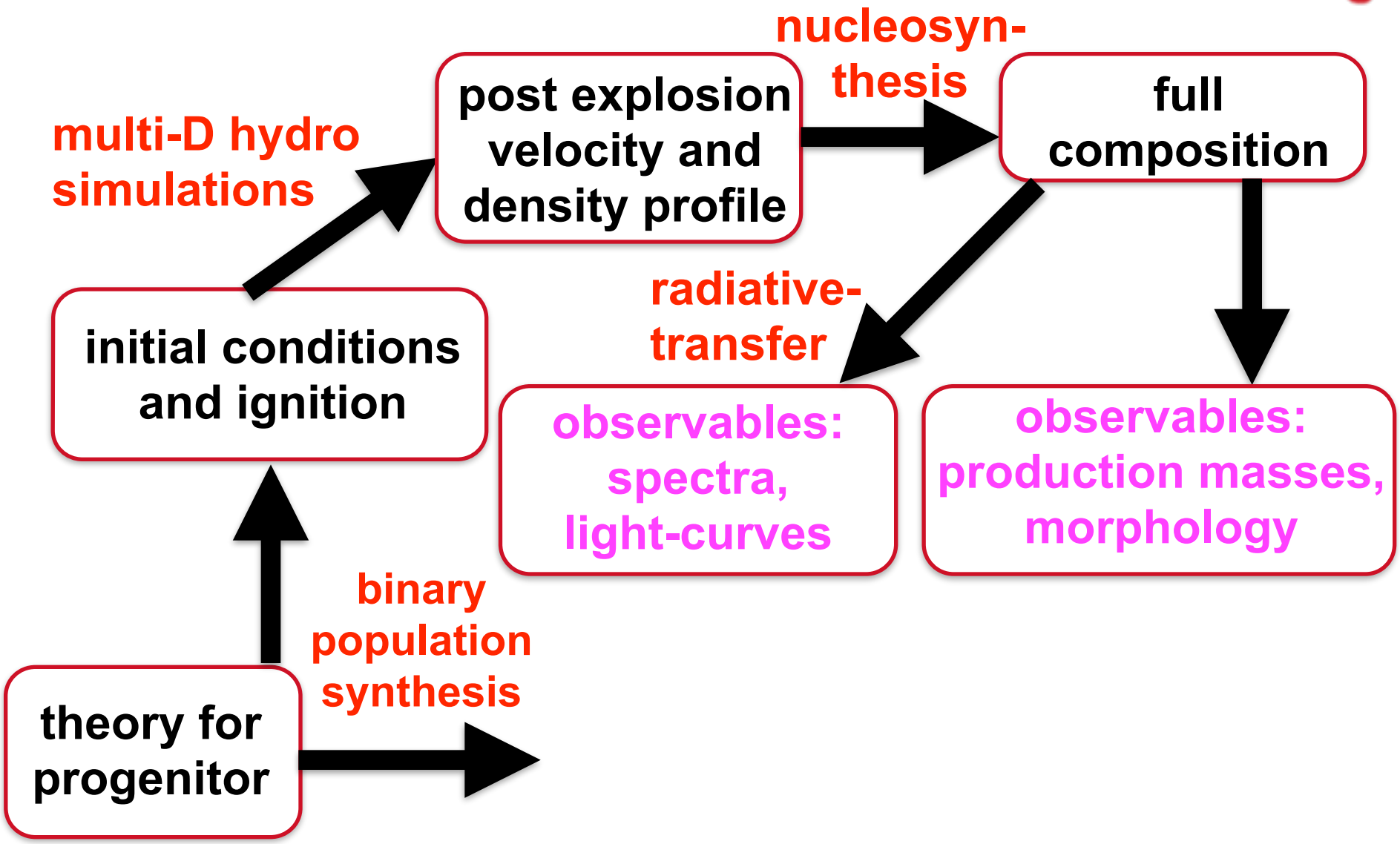

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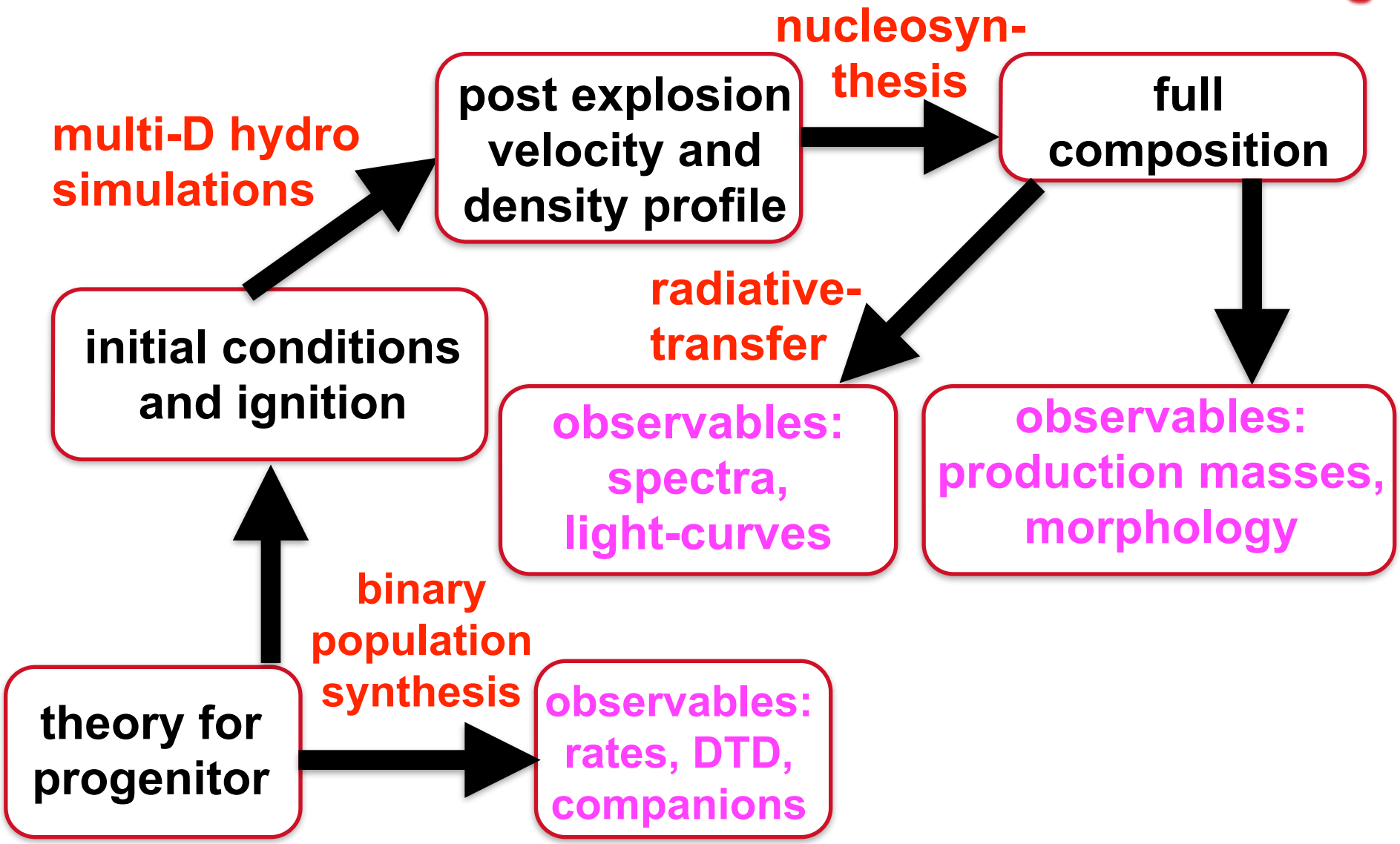

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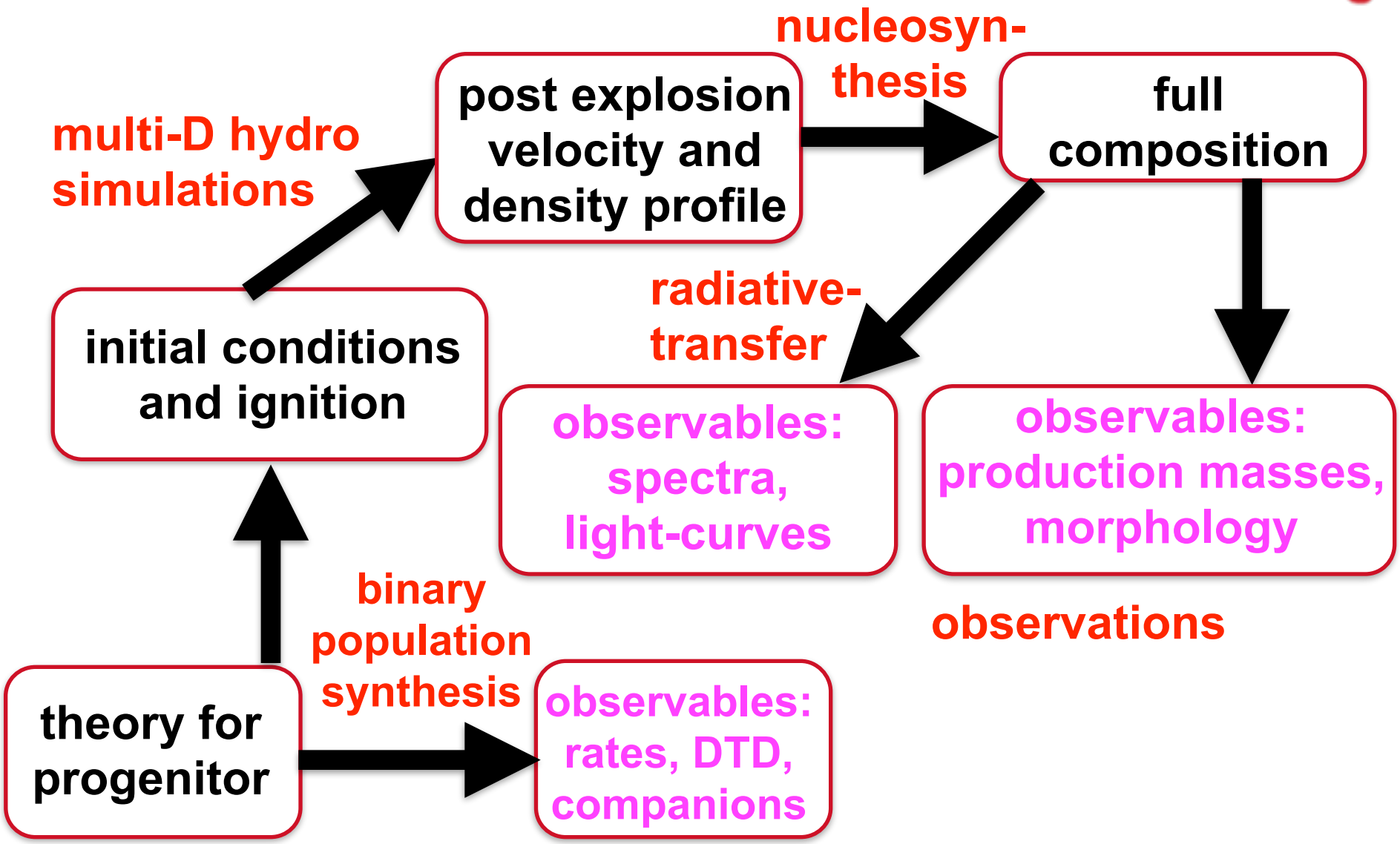

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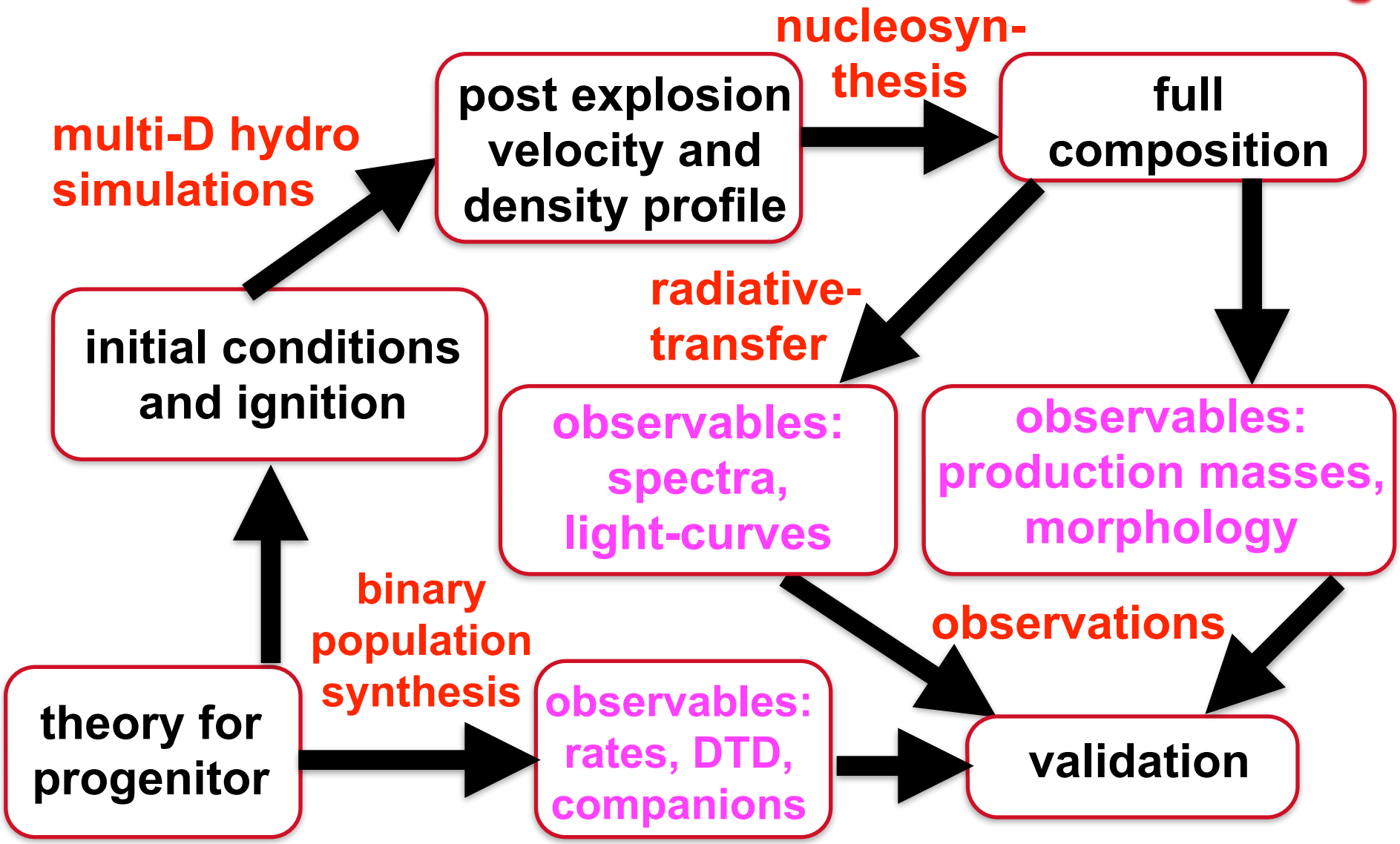

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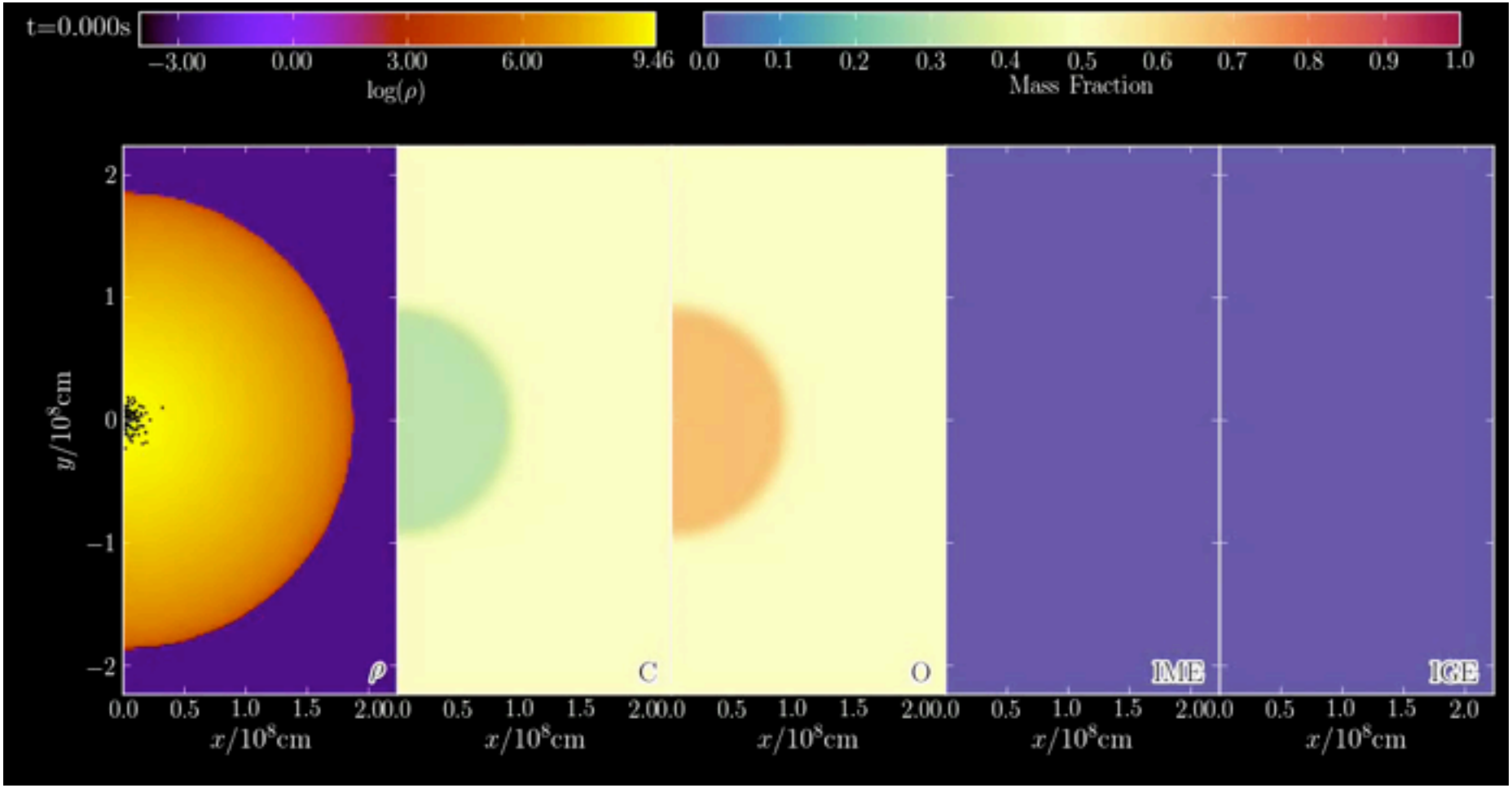
N100 delayed-detonation

Australian National University



Seitenzahl+ (2013), MNRAS, 429, 1156

Ohlmann+ (2014), A&A, 572, 57

Movie by S. Ohlmann, Univ. Würzburg

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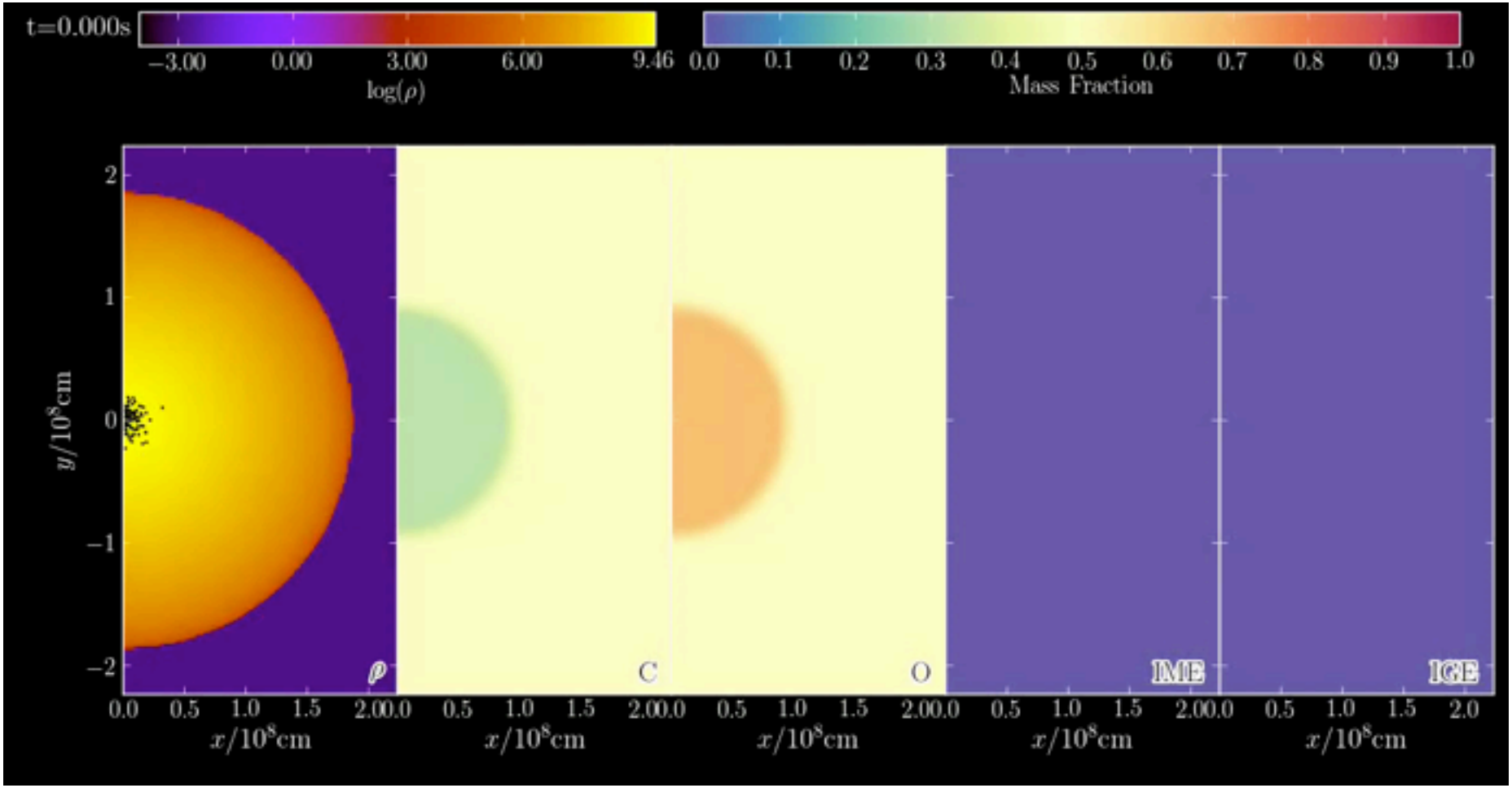

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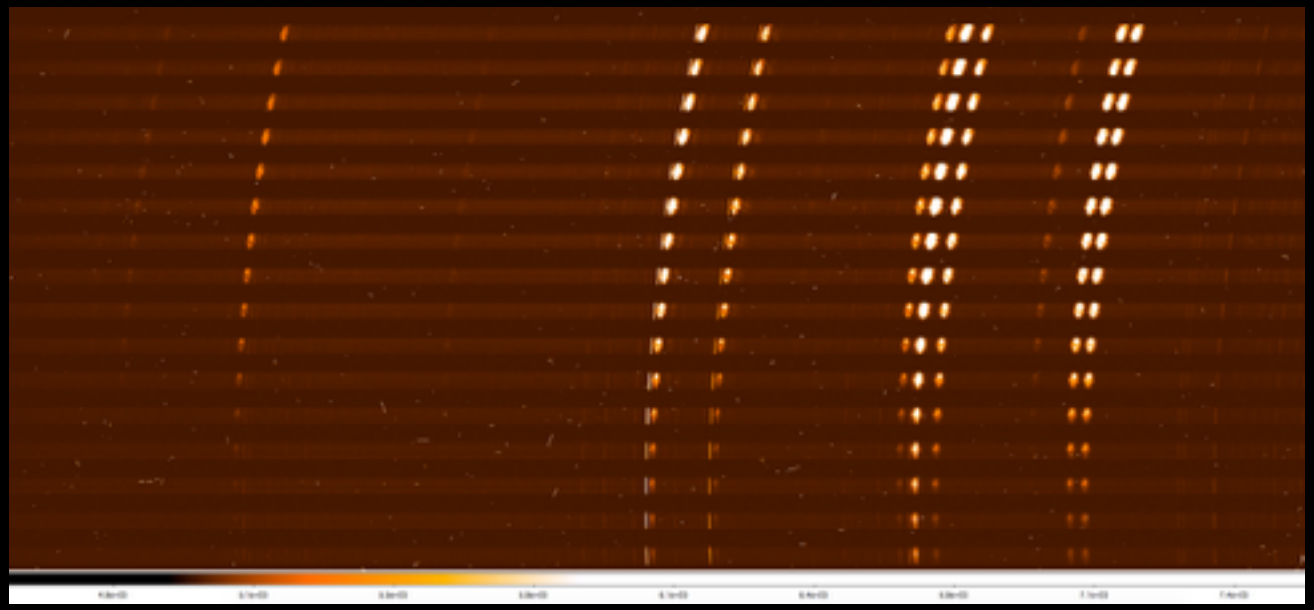
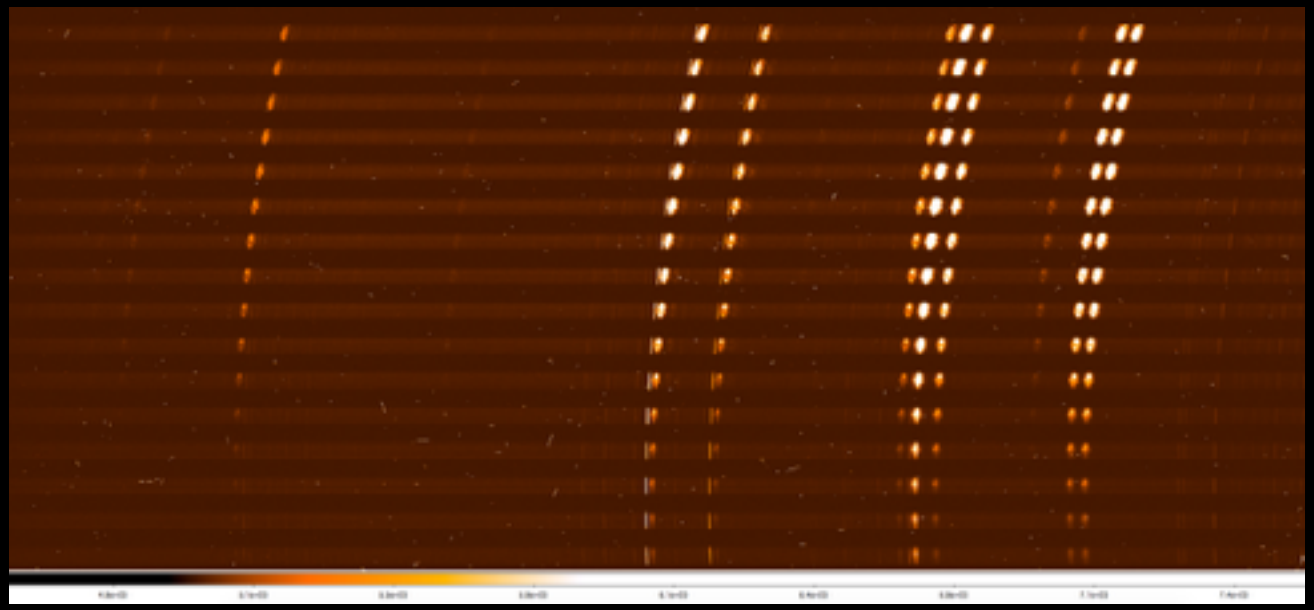
Integral field spectroscopy of SNRs



Integral field spectroscopy of SNRs



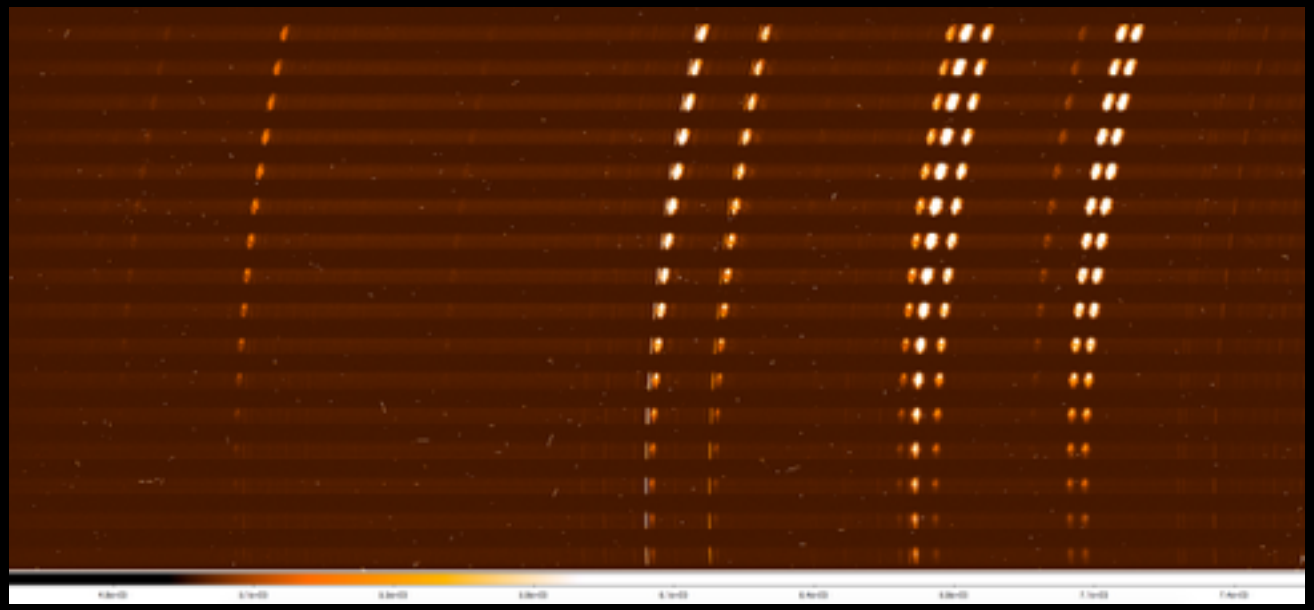
Wide-Field Spectrograph

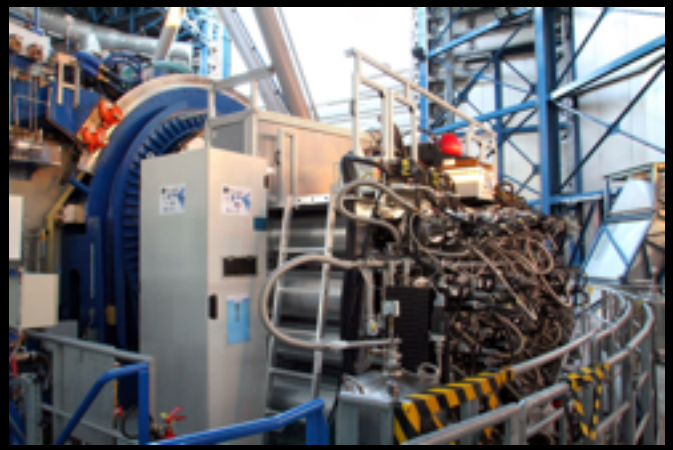
(WiFeS)

ANU 2.3m Telescope

(Siding Spring Observatory)

Integral field spectroscopy of SNRs





Multi Unit Spectroscopic Explorer

(MUSE)

ESO Very Large Telescope (VLT)

(UT 4)

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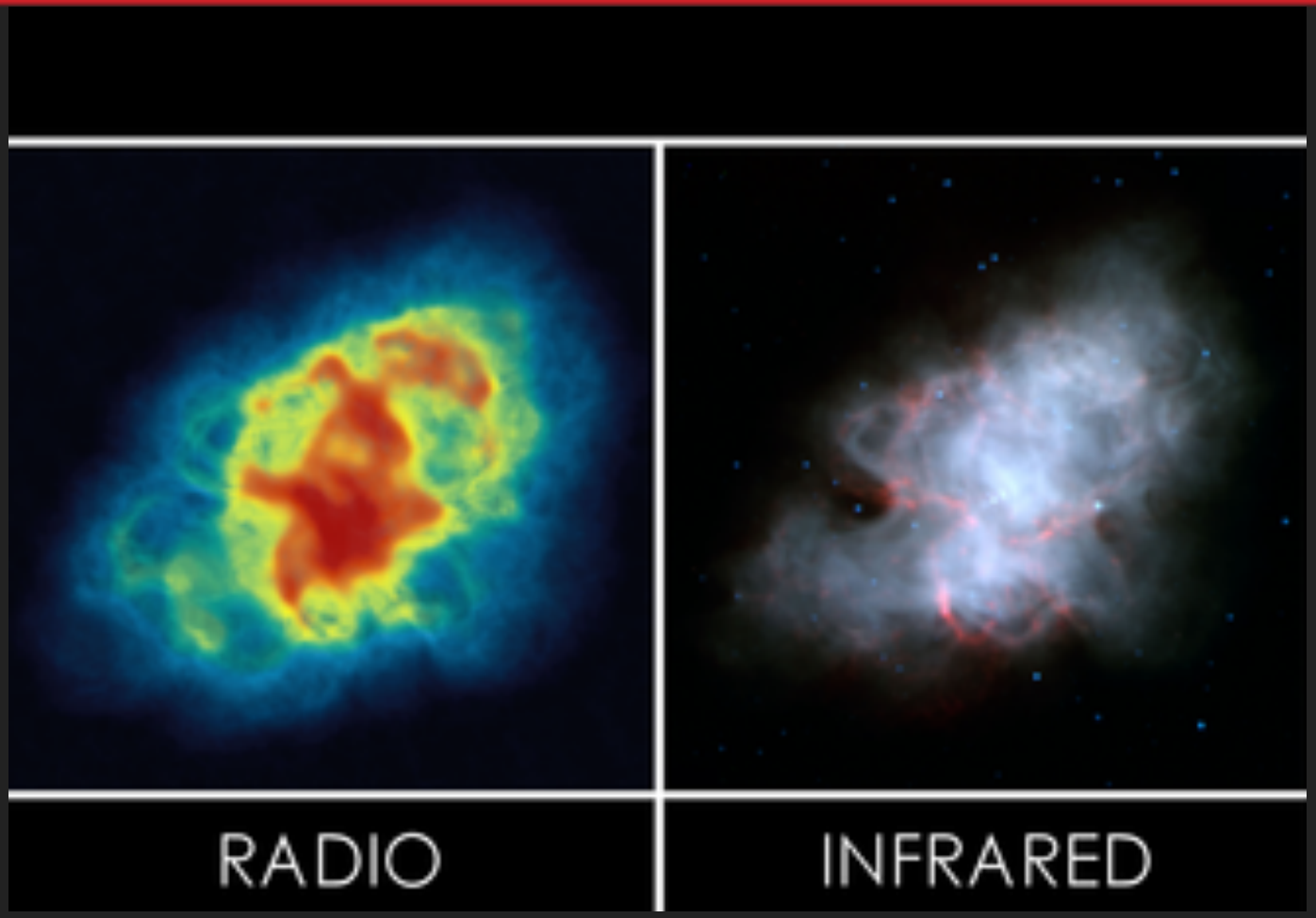
MUSE on UT4 “Yepun”

Australian National University

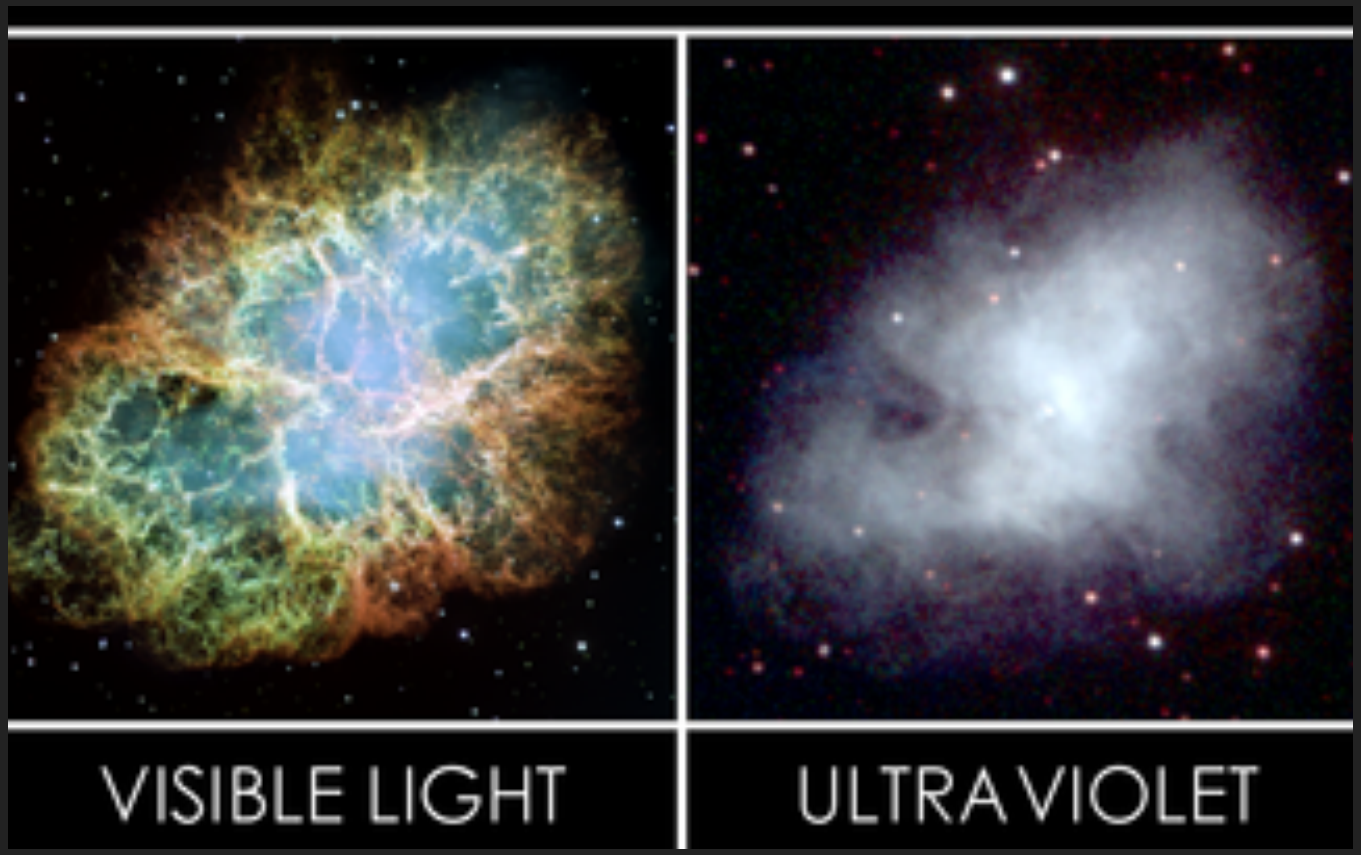
The Crab Nebula

Crab Nebula
(not O-rich, but ejecta in optical)



source: wikipedia

Crab Nebula
(not O-rich, but ejecta in optical)



source: wikipedia

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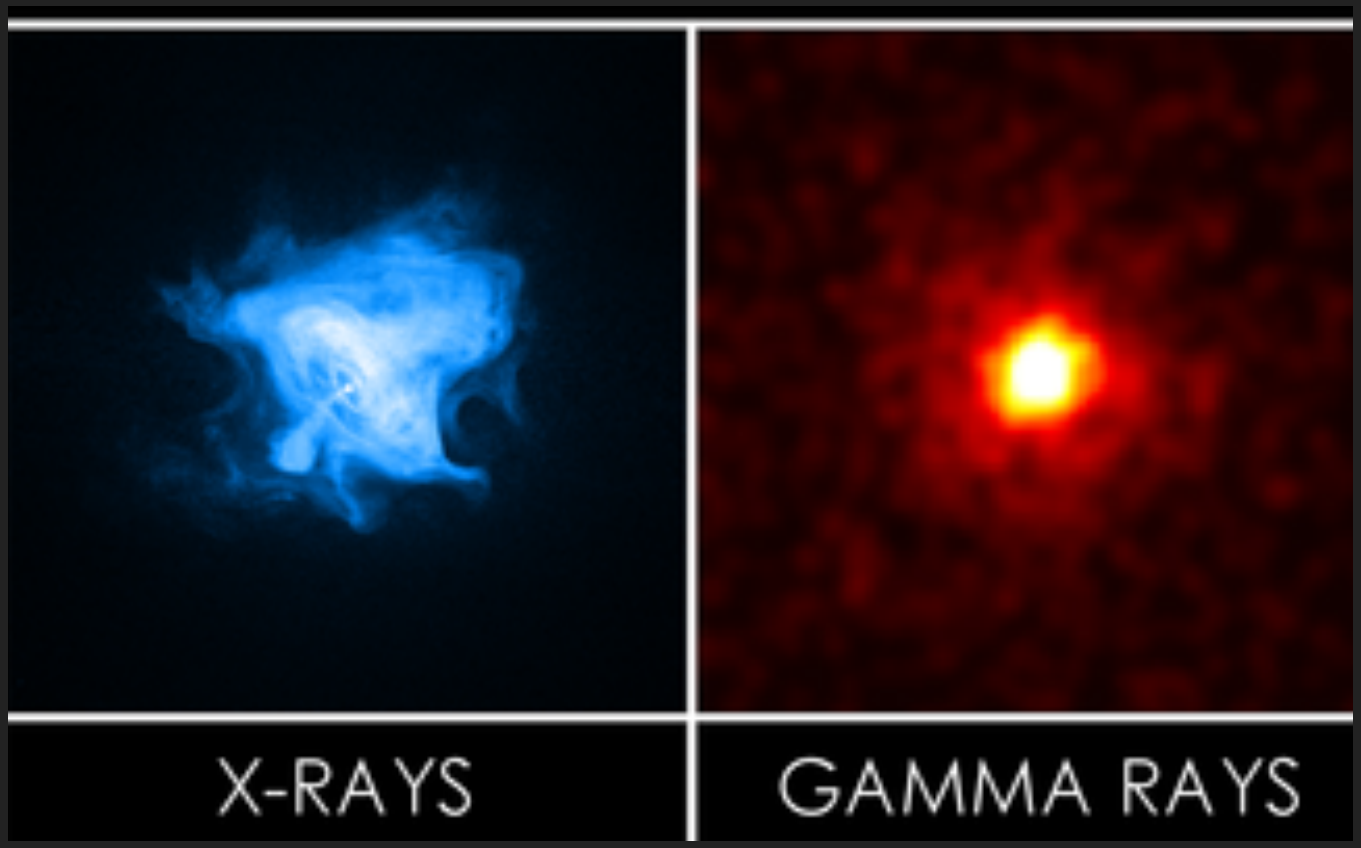
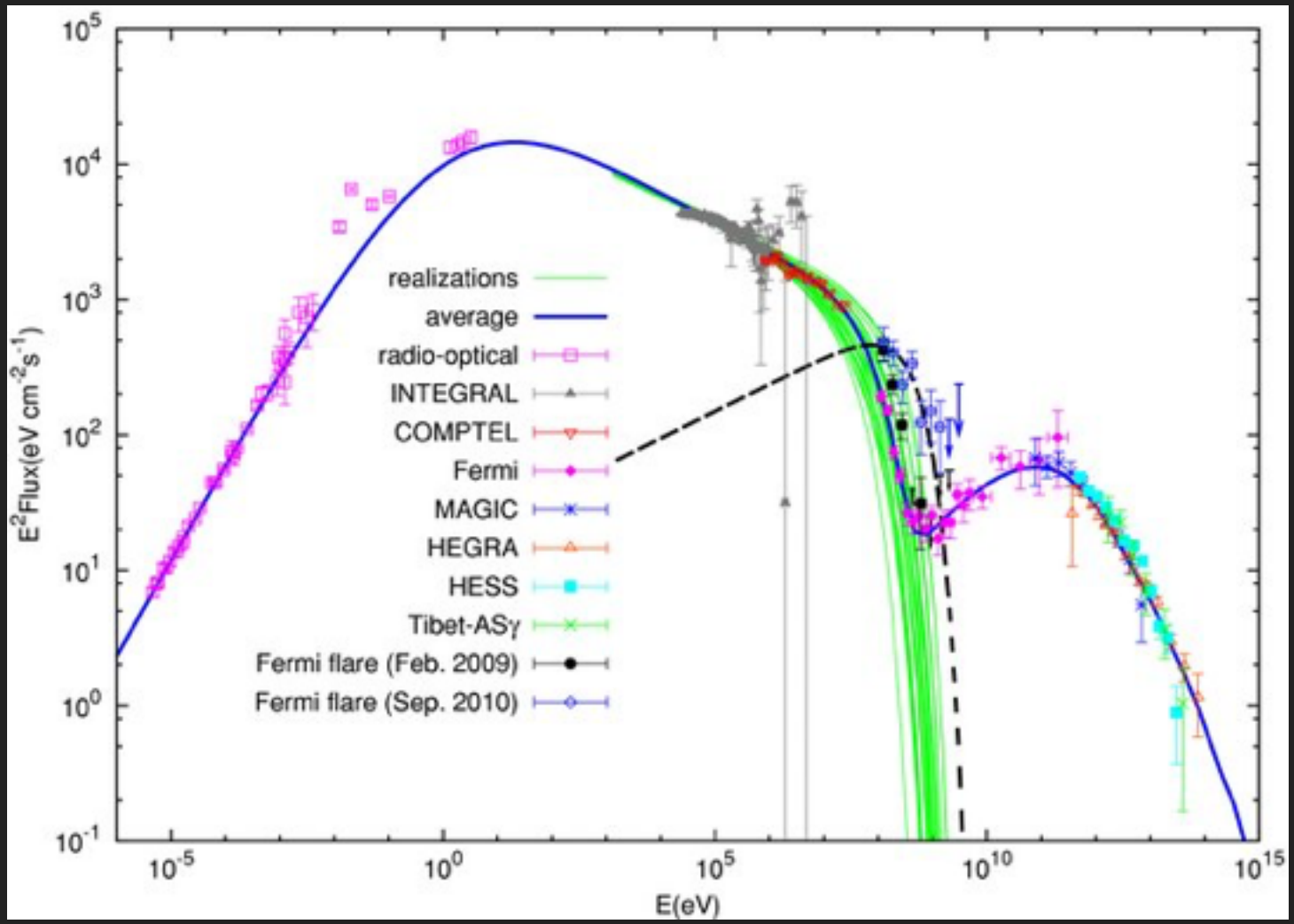
Crab Nebula
(not O-rich, but ejecta in optical)

Australian National University



source: wikipedia

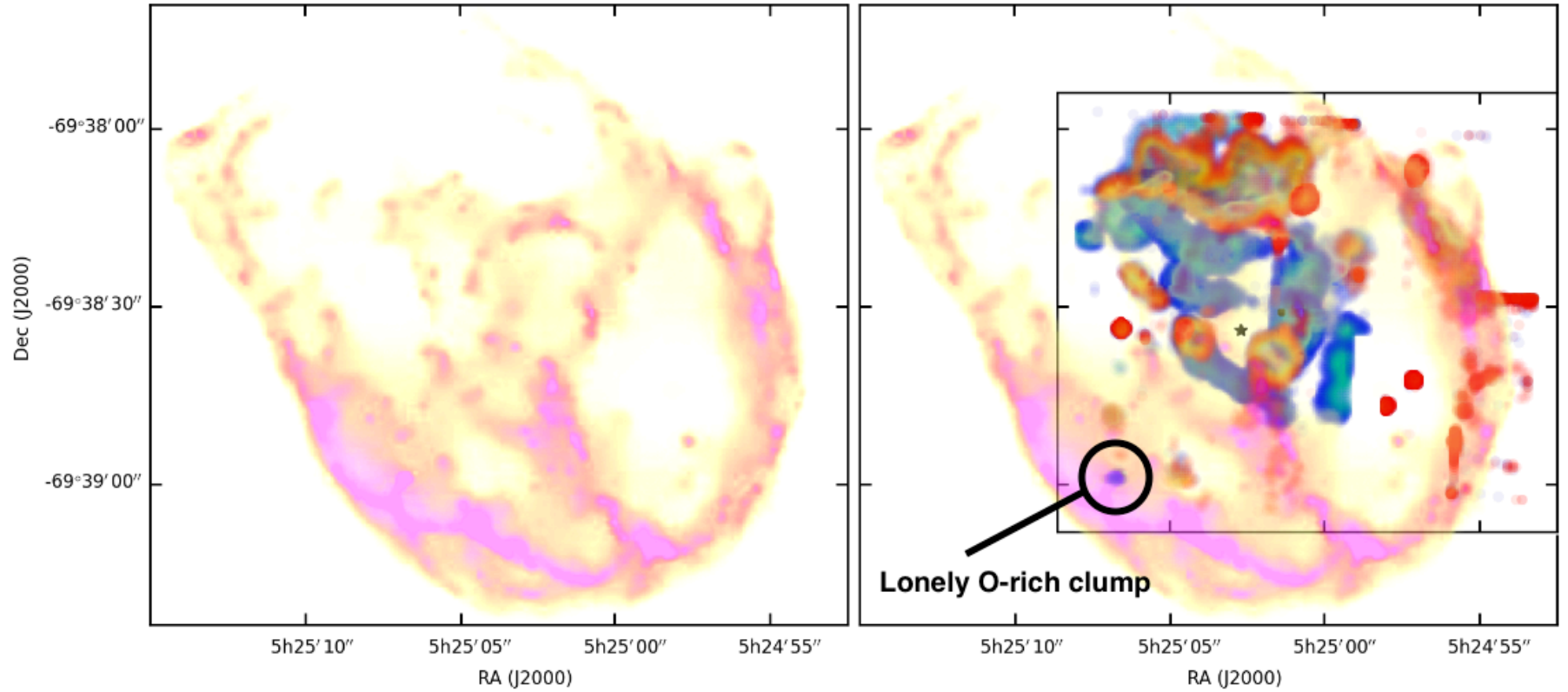
Crab Nebula
SED



Yuan+ 2011, ApJL, 730, 32

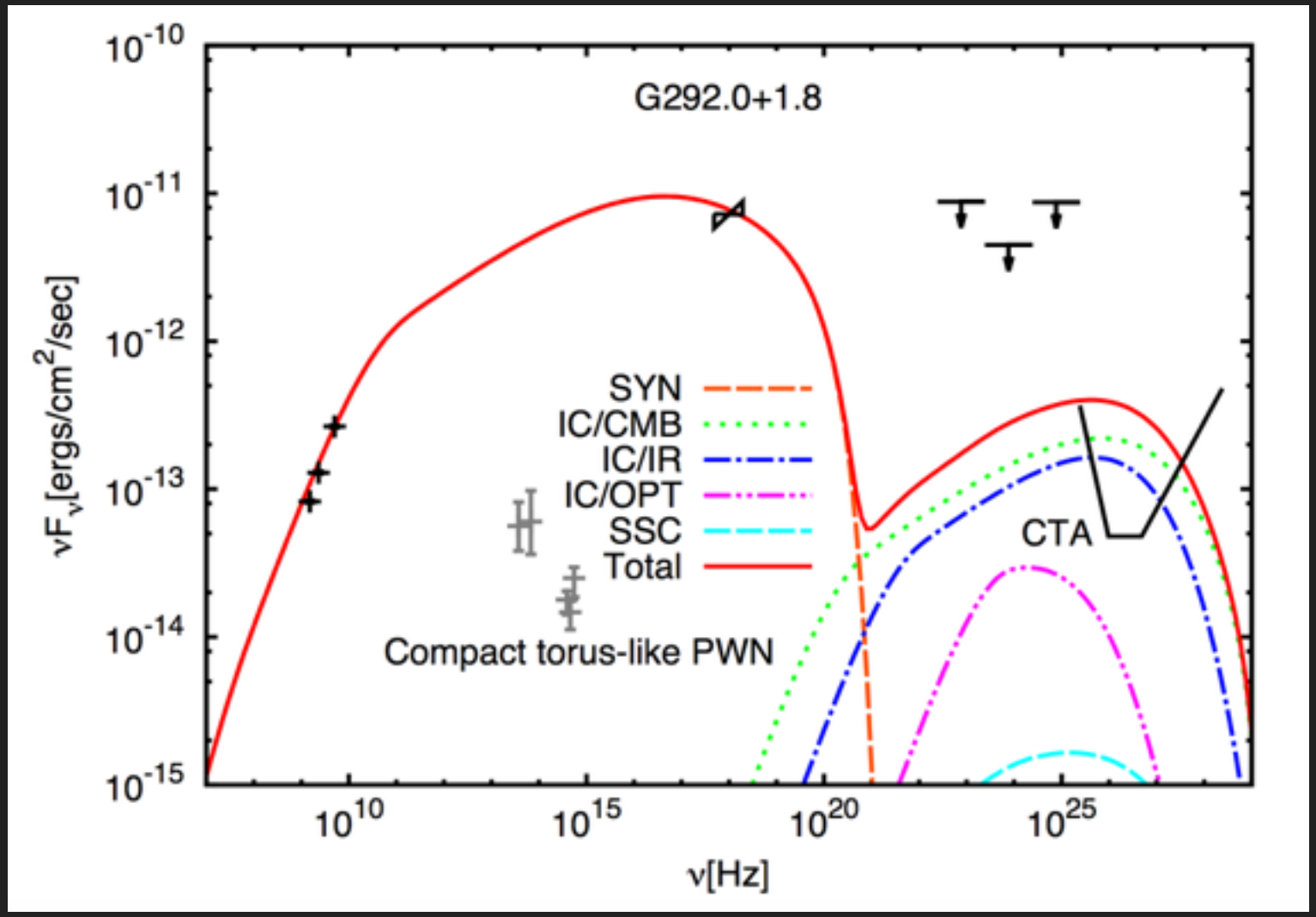
Other SNRs

N132D



12.6h awarded in cycle 99A.
Rank B, RA/DEC crowded.
Convinced TAC to switch targets.

G292.0+1.8



Tanaka & Takahara (2013) MNRAS, 429, 2945

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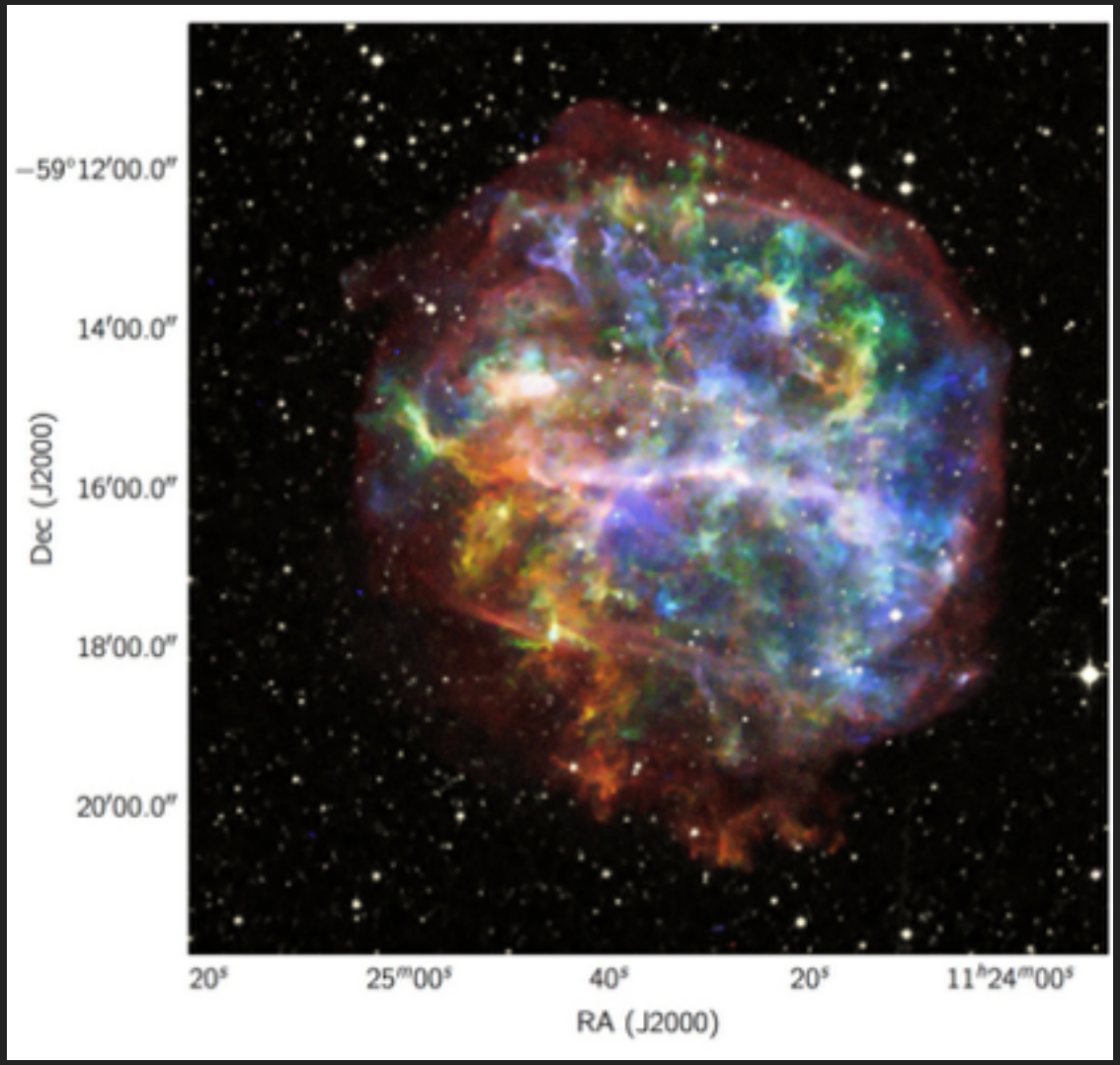
G292.0+1.8

Australian National University

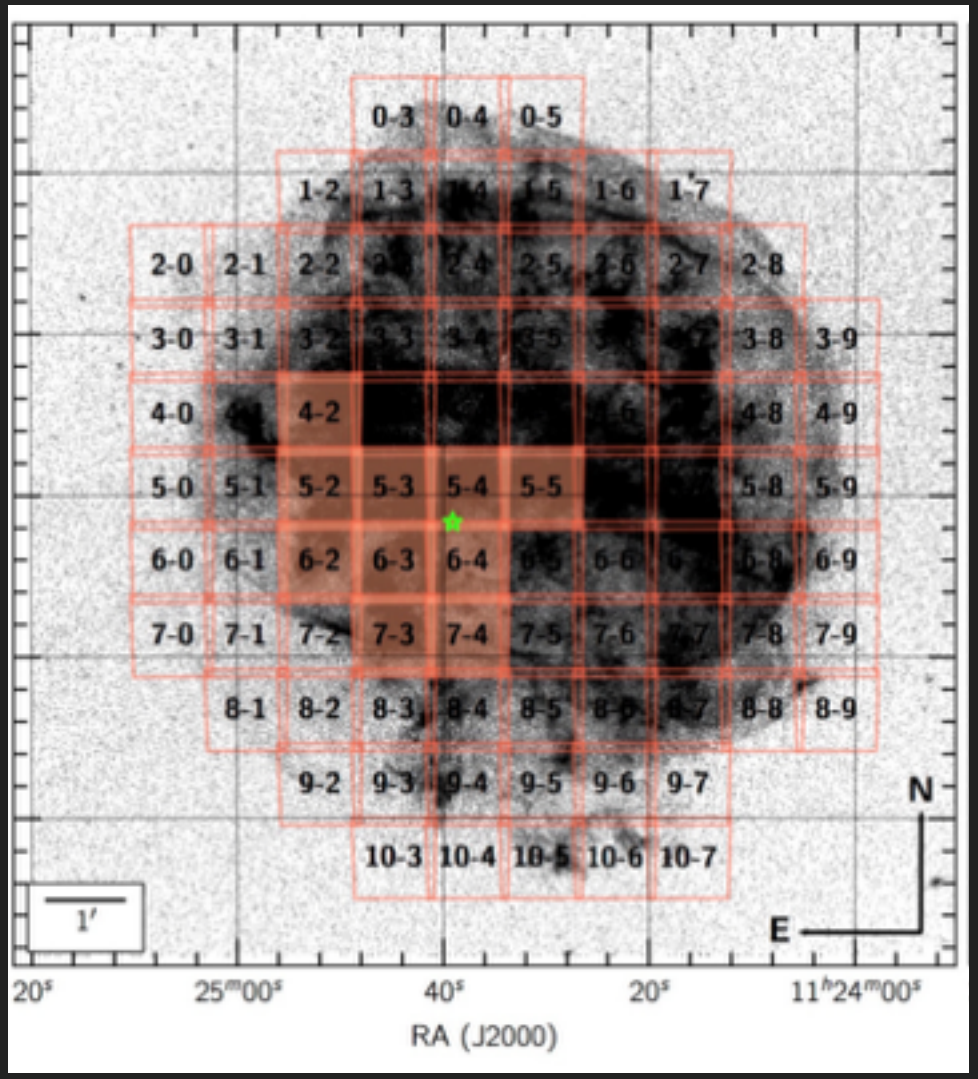


Chandra view of G292, Park+, 2007

CAASTRO
ARC CENTRE OF EXCELLENCE FOR ALL-SKY ASTROPHYSICS

G292.0+1.8

Australian National University

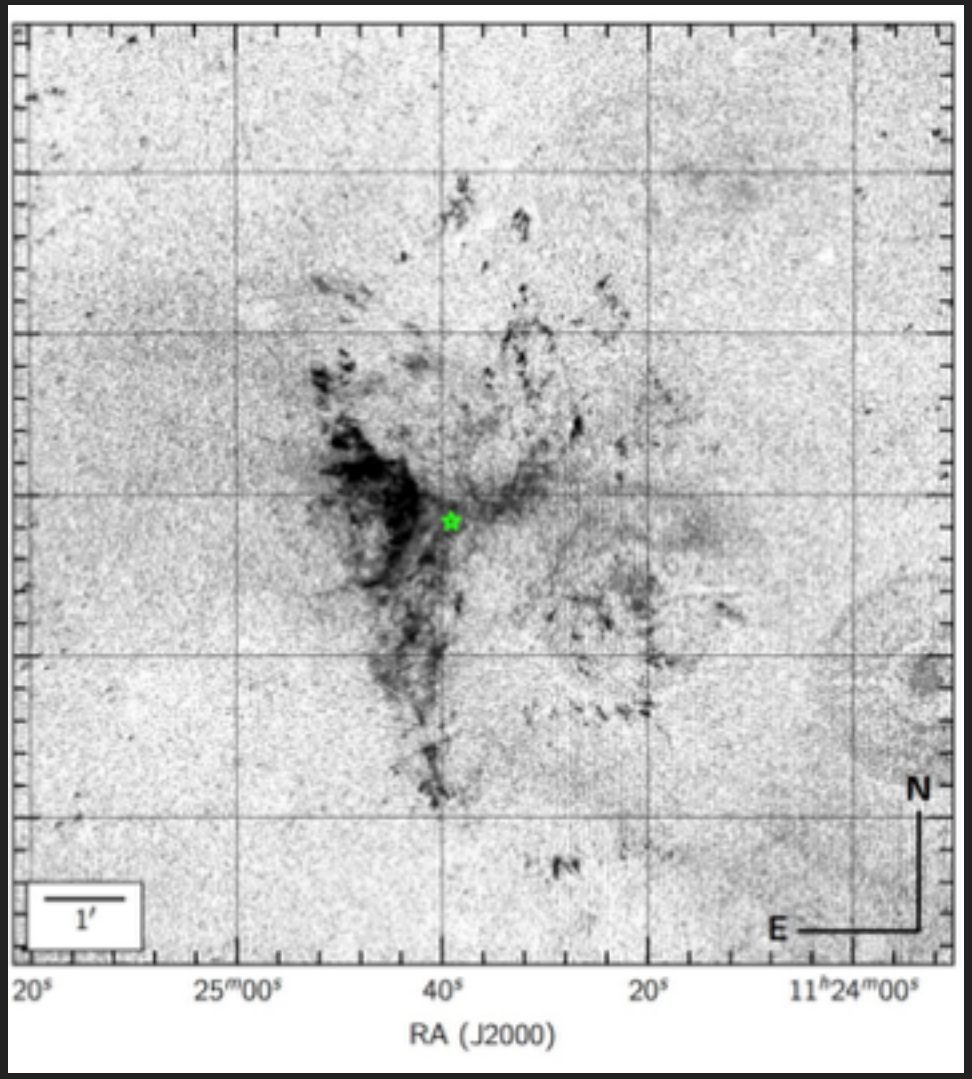


Our proposed MUSE mosaic of G292

CAASTRO
ARC CENTRE OF EXCELLENCE FOR ALL-SKY ASTROPHYSICS

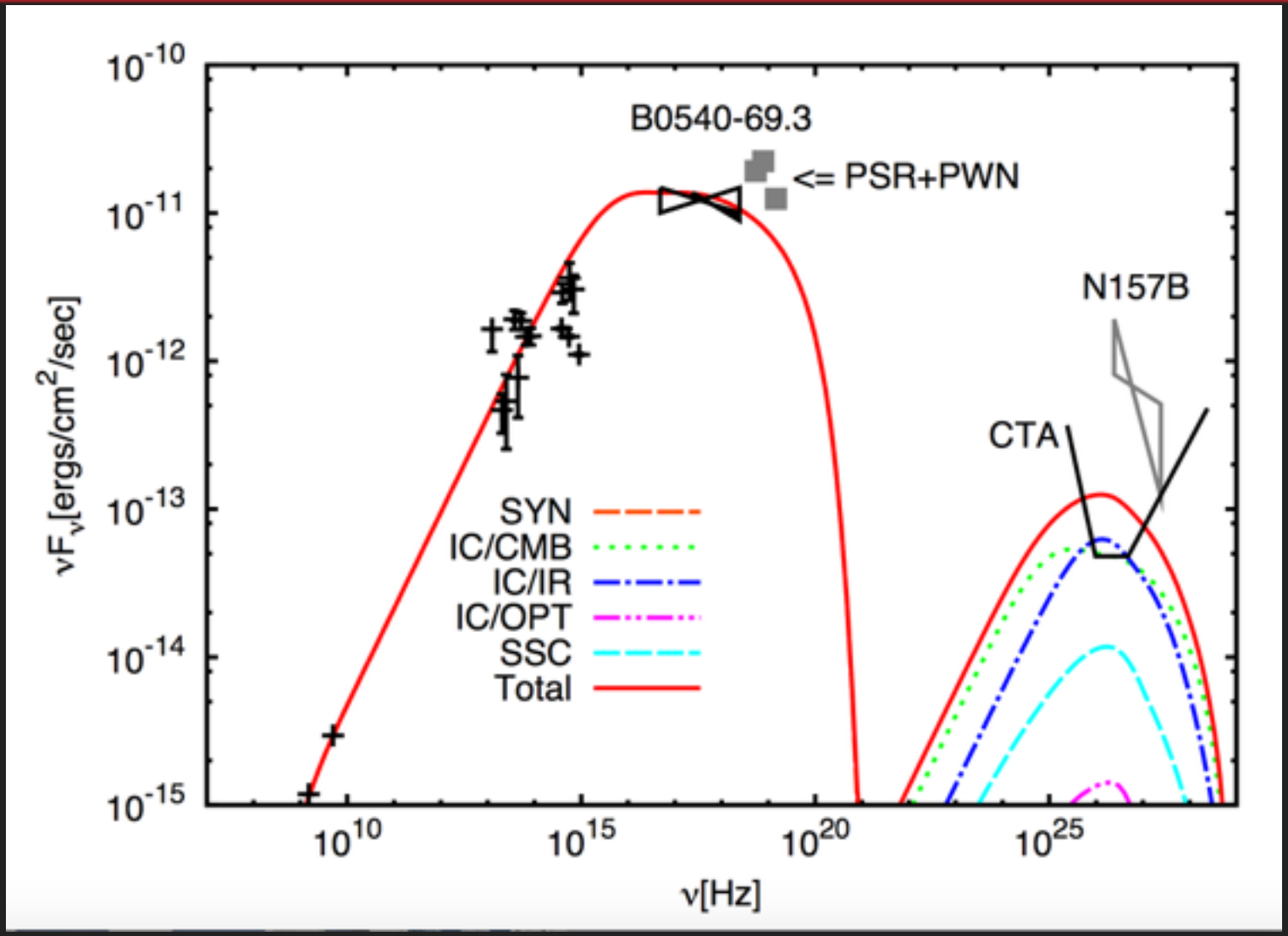
G292.0+1.8

Australian National University



Our proposed MUSE mosaic of G292

B0540–69.3



Tanaka & Takahara (2013) MNRAS, 429, 2945

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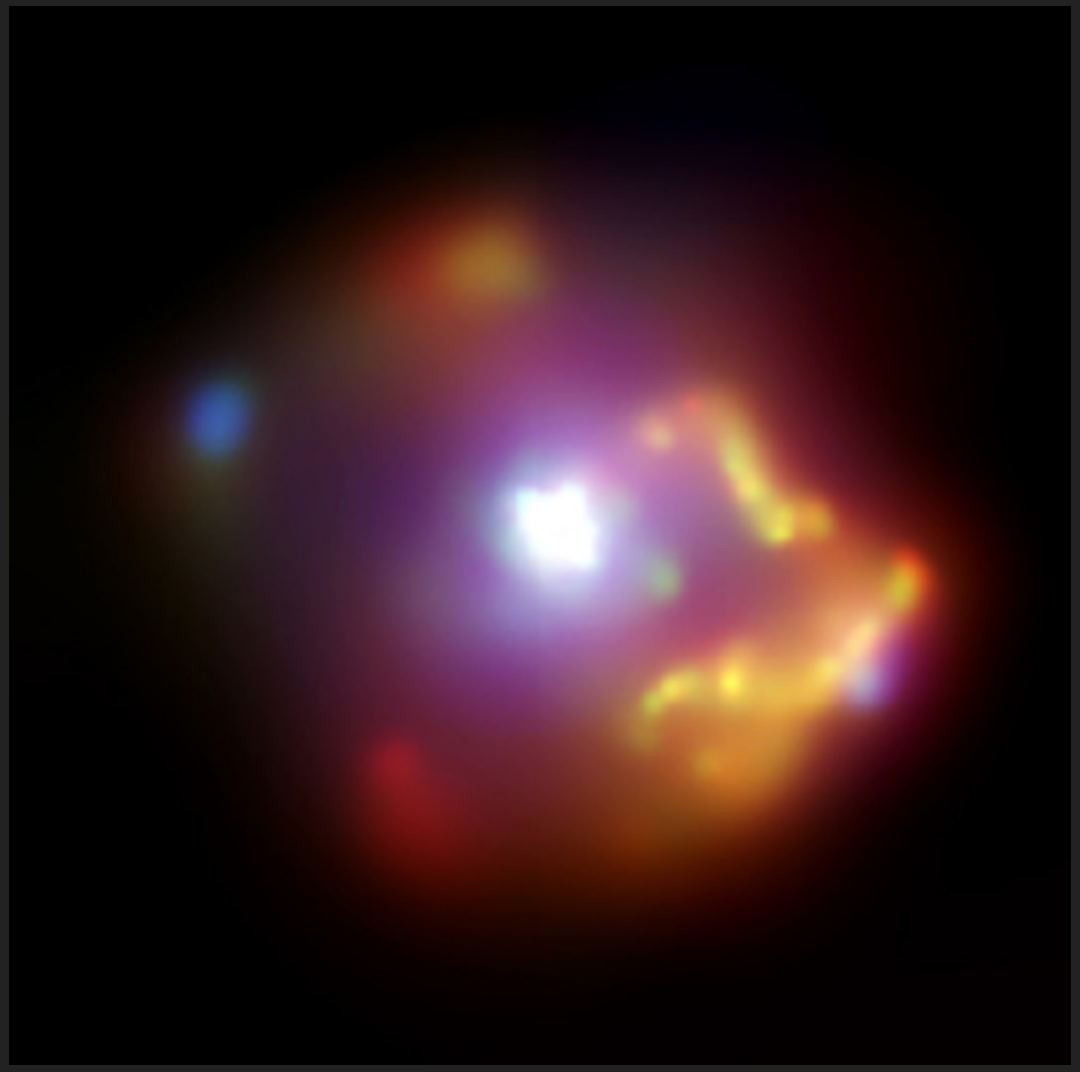
ARC CENTRE OF EXCELLENCE
FOR ALL-SKY ASTROPHYSICS

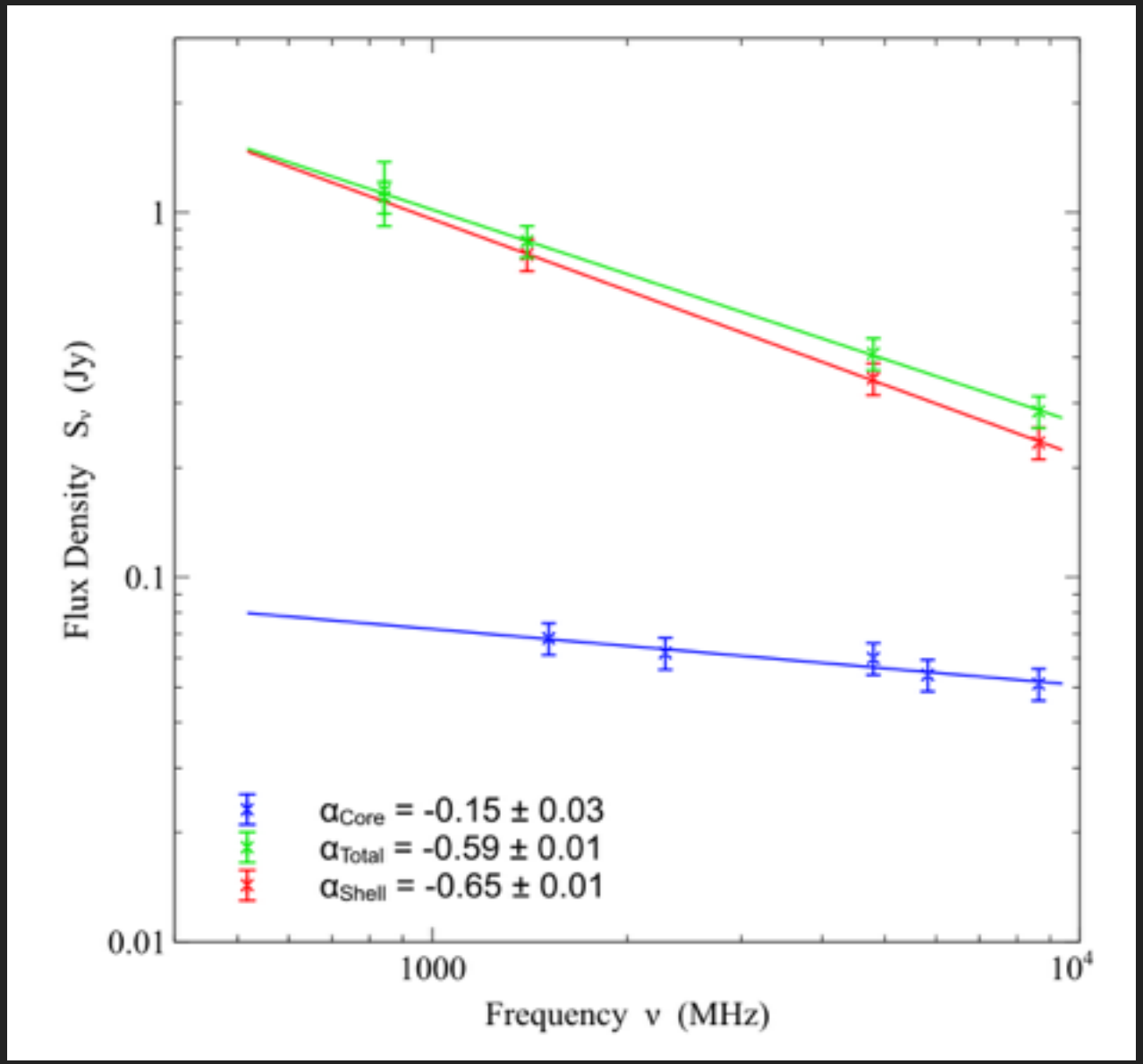
B0540–69.3

Australian
National
University



Chandra ACIS RGB Credit: NASA/CXC/SAO

B0540–69.3



Brantseg+ (2014), ApJ, 780, 50

CAASTRO
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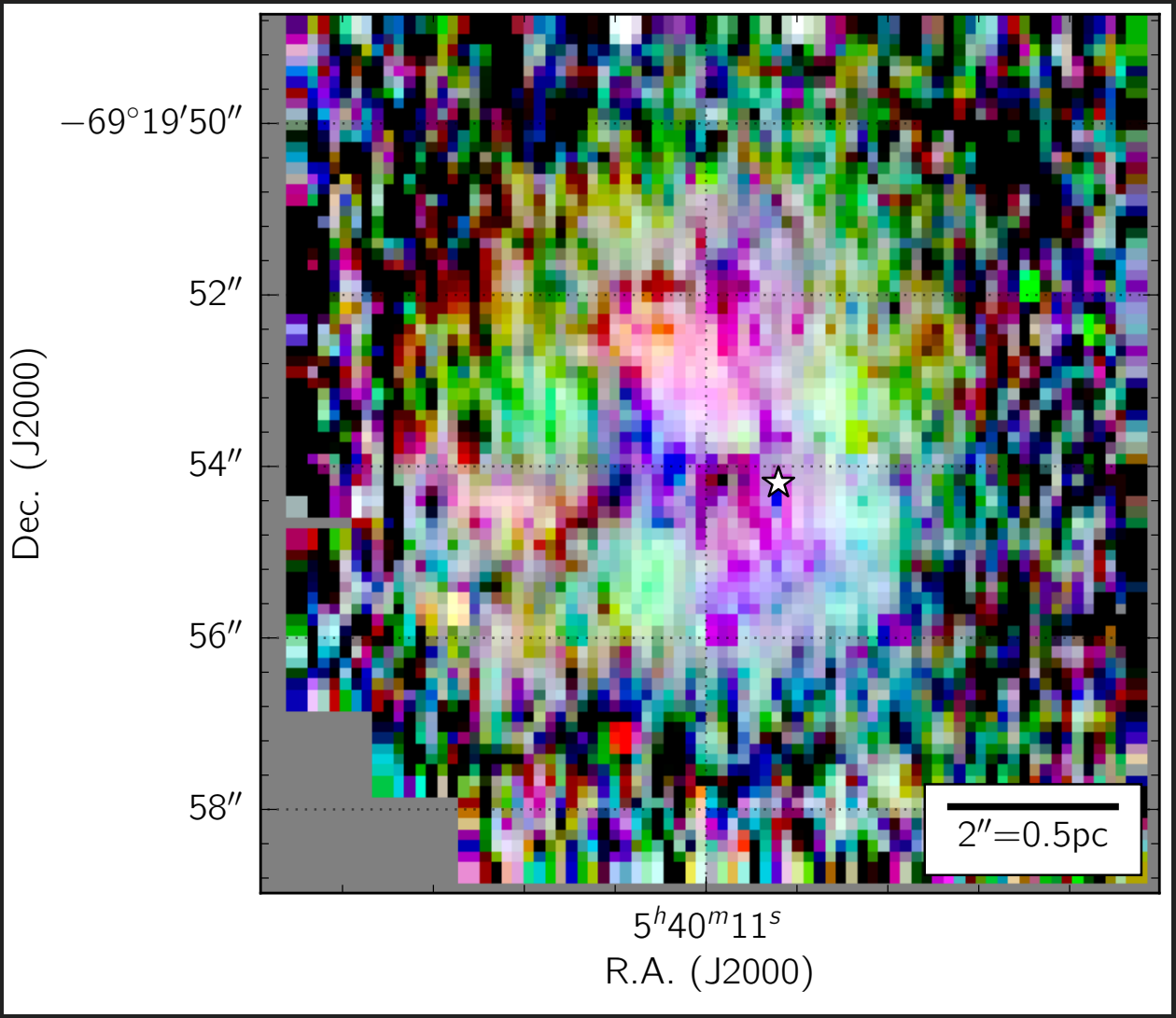
B0540–69.3

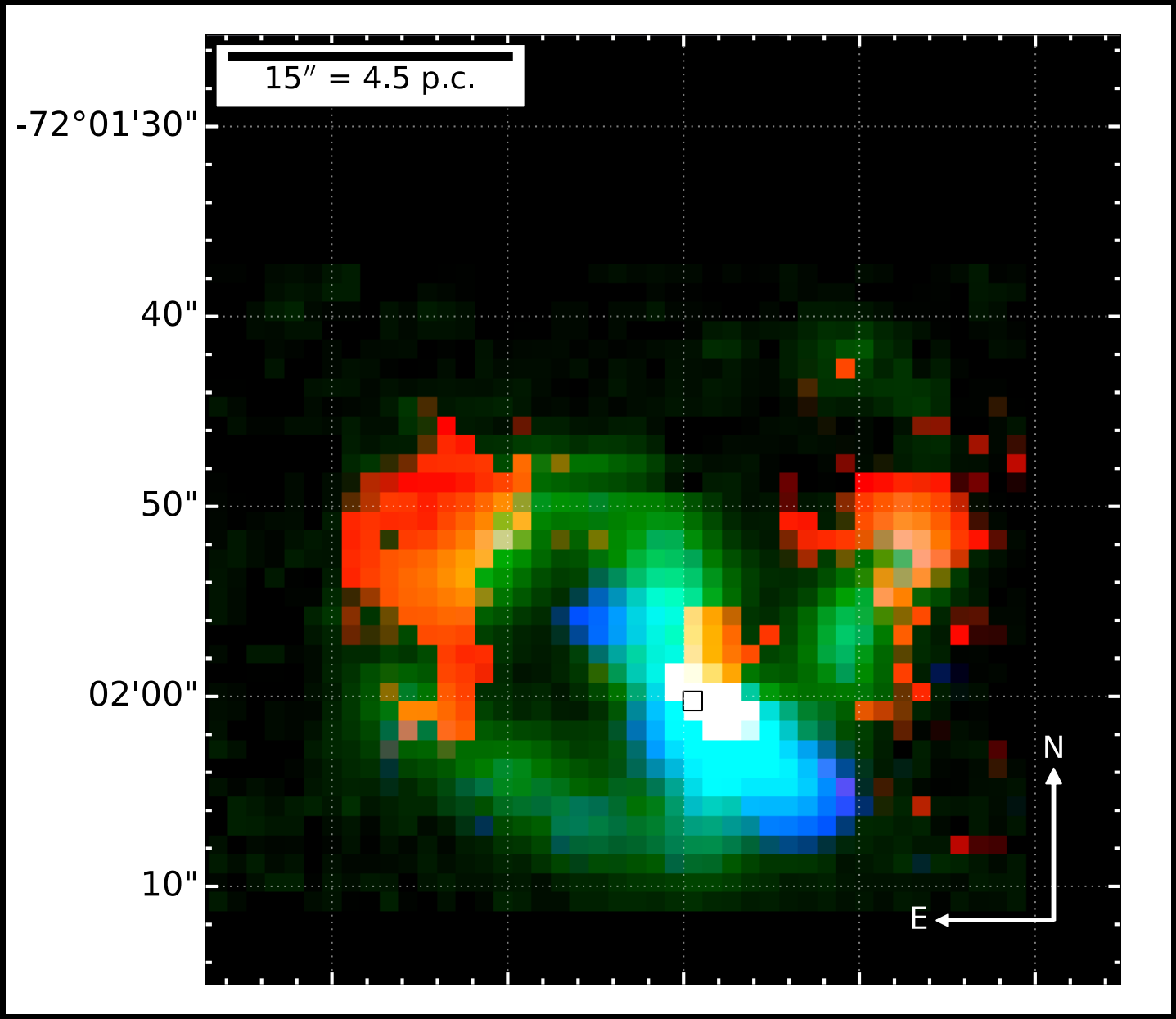
Australian National University



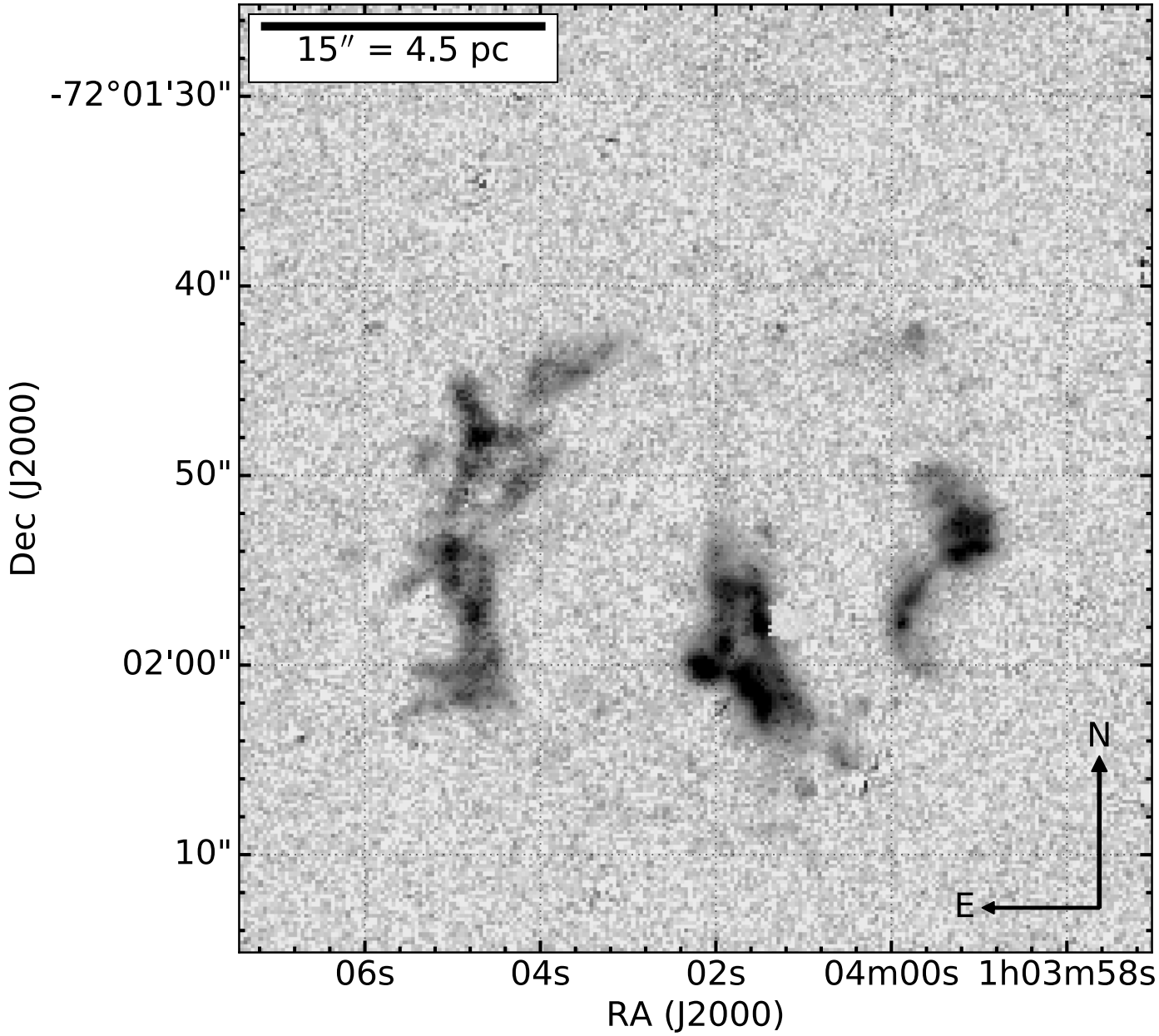
UT4 VLT Sinfoni [Fe II], Vogt, Seitenzahl et al., unpublished

Discovery of the products of O-burning in the ejecta of 1E0102

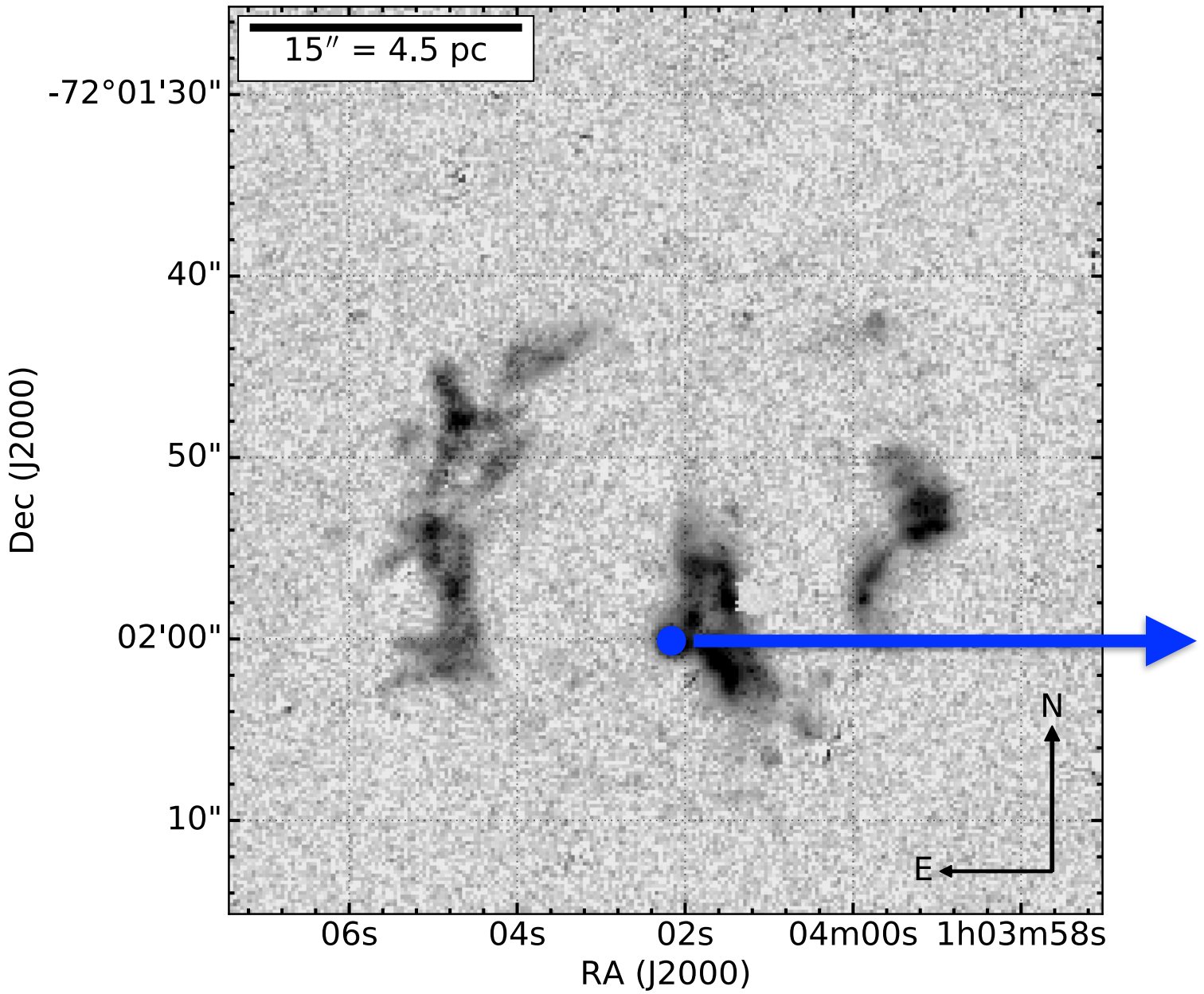
Discovery of [S II] with WiFeS



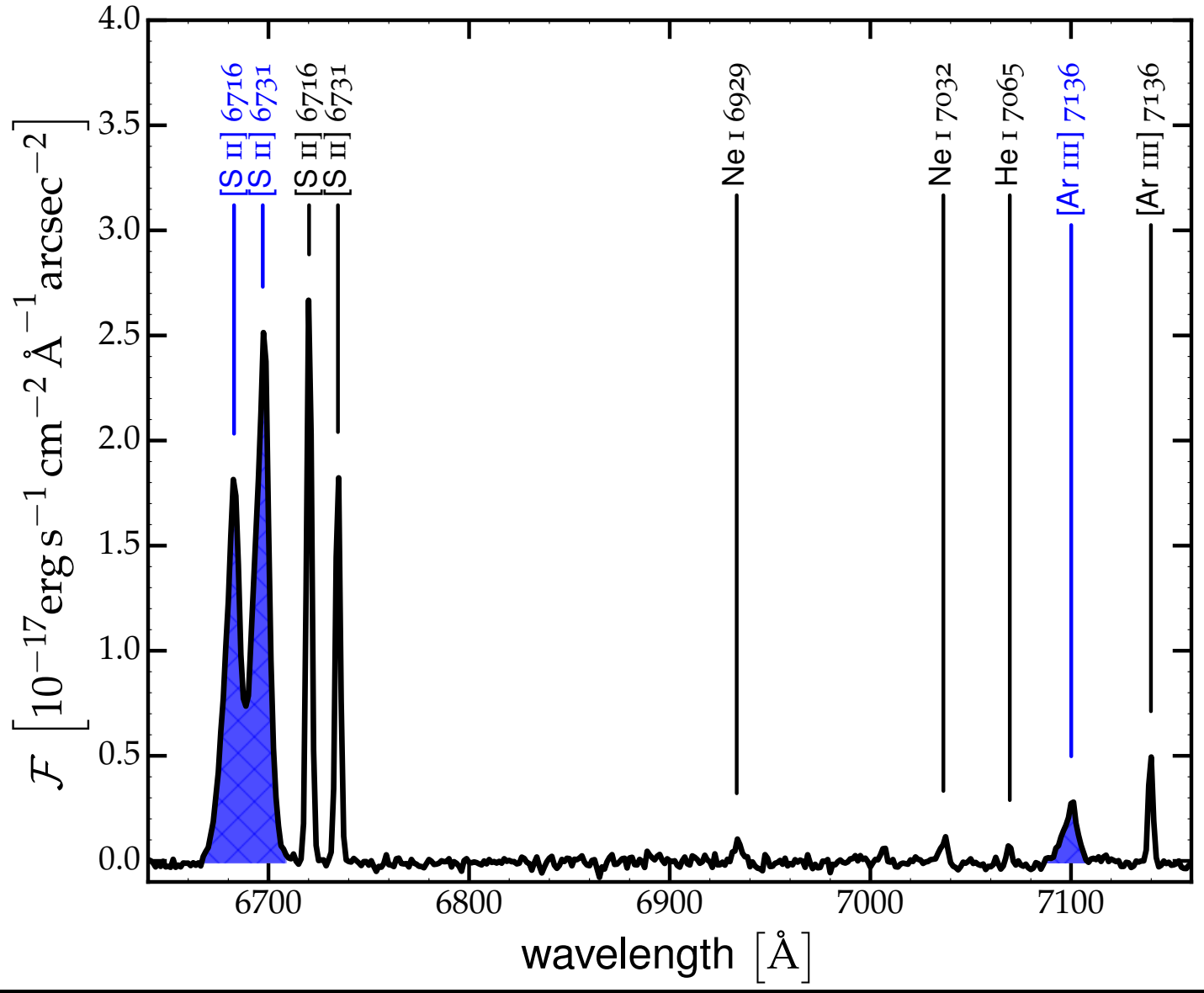
MUSE: fitted red- and blue-shifted [S II]



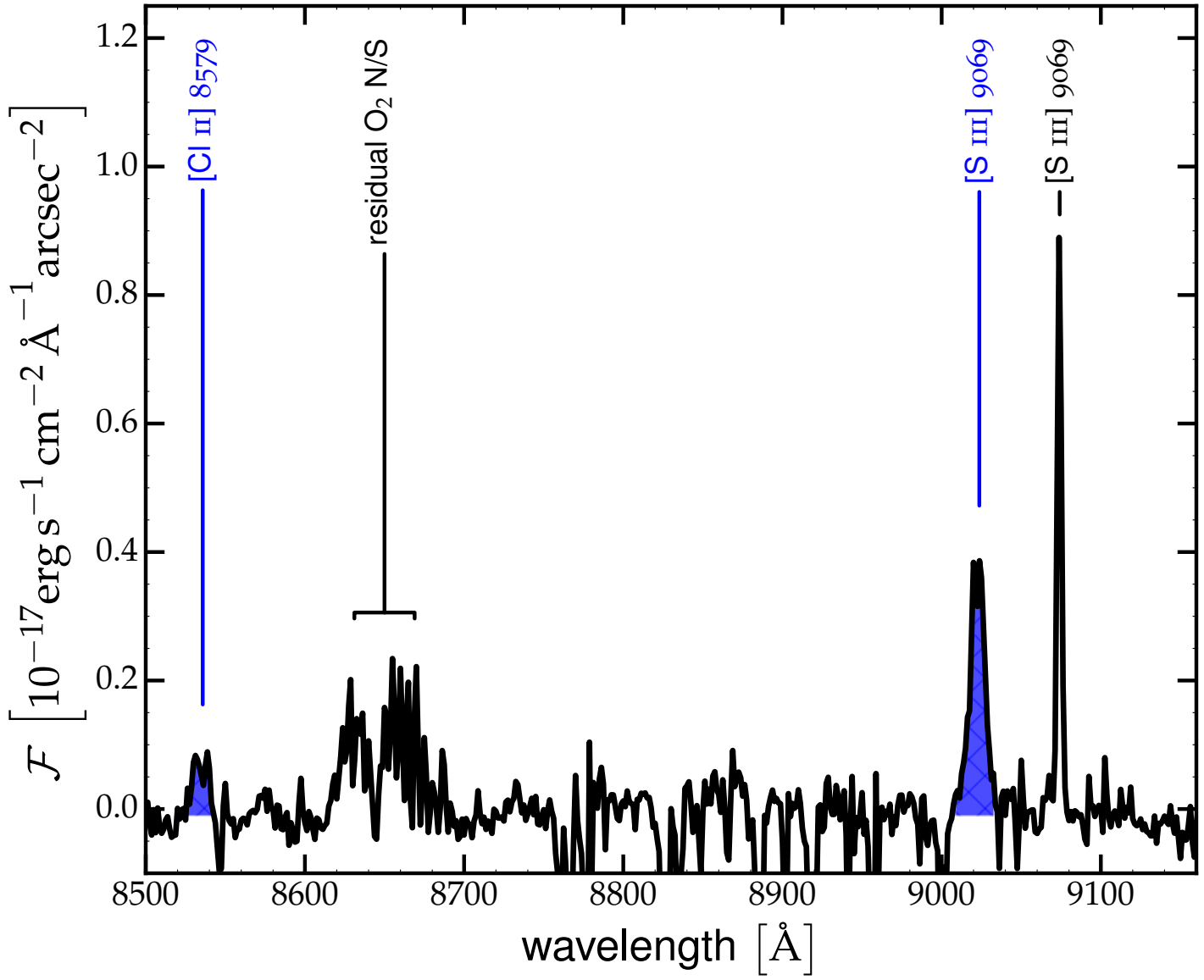
MUSE: fitted red- and blue-shifted [S II]

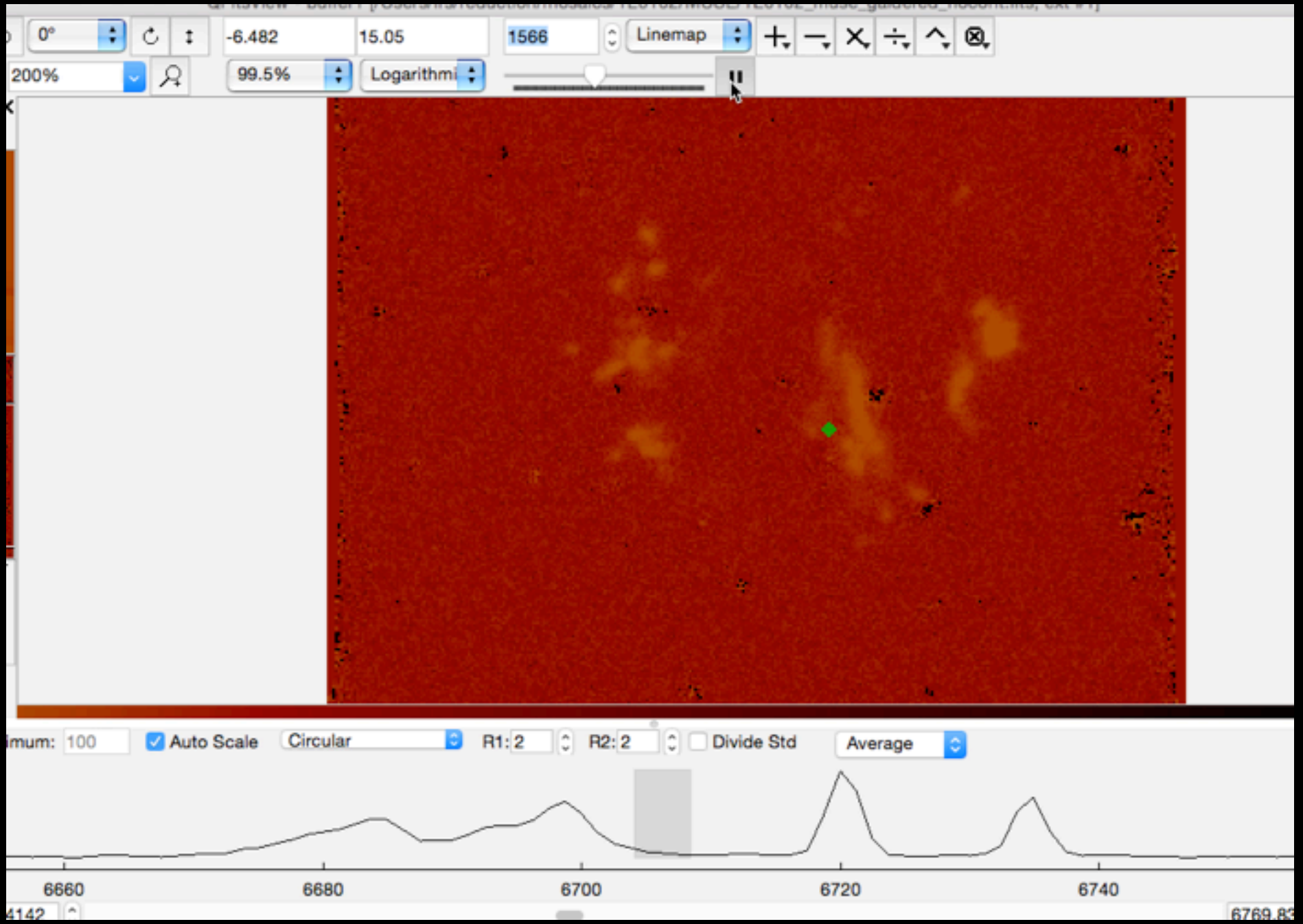


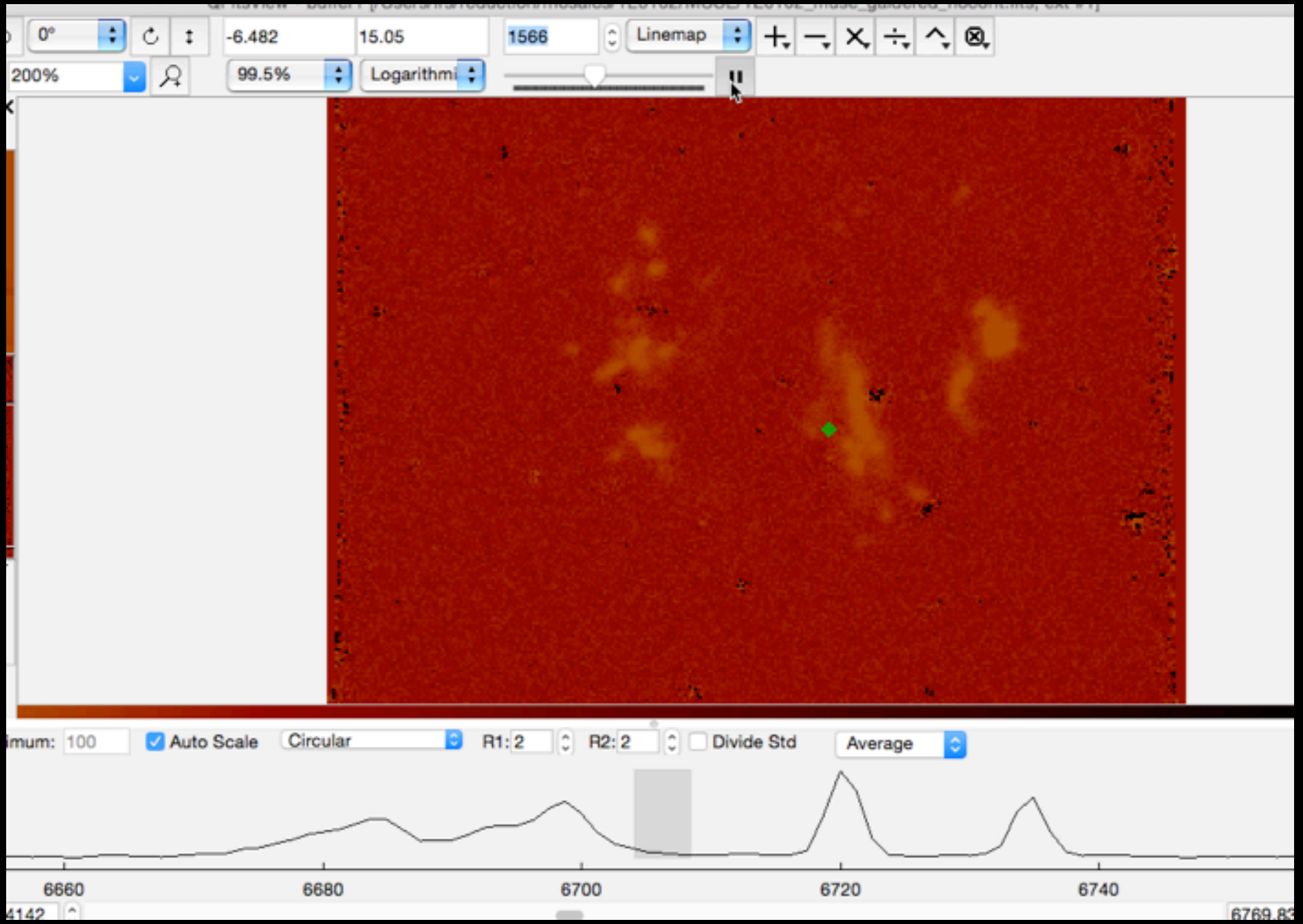
~1650 km/s blue shifted ejecta component



~1650 km/s blue shifted ejecta component

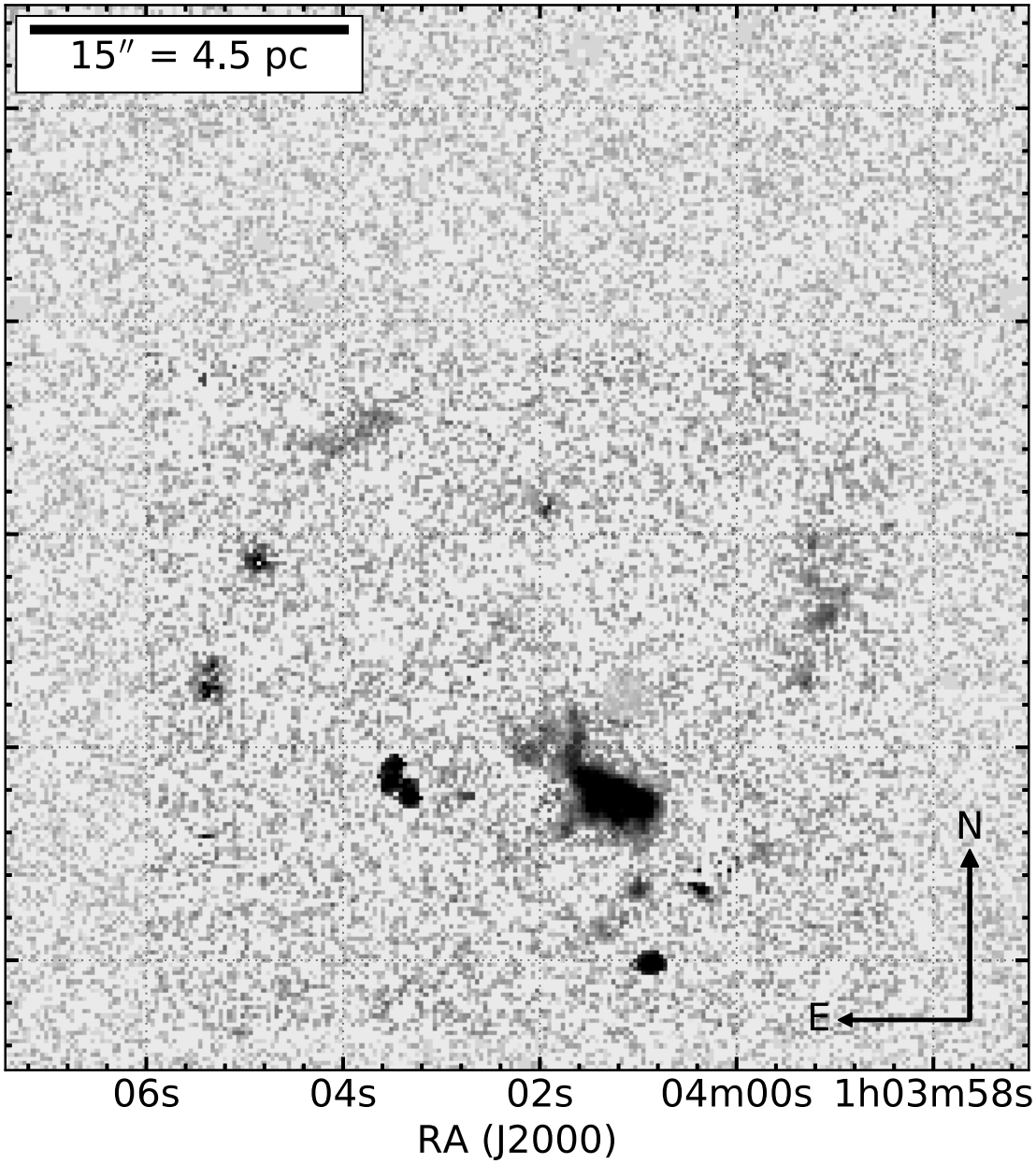



0°
-6.482
15.05
1566
Linemap
200%
99.5%
Logarithmi
Auto Scale
Circular
R1: 2
R2: 2
Divide Std
Average
6660
6680
6700
6720
6740

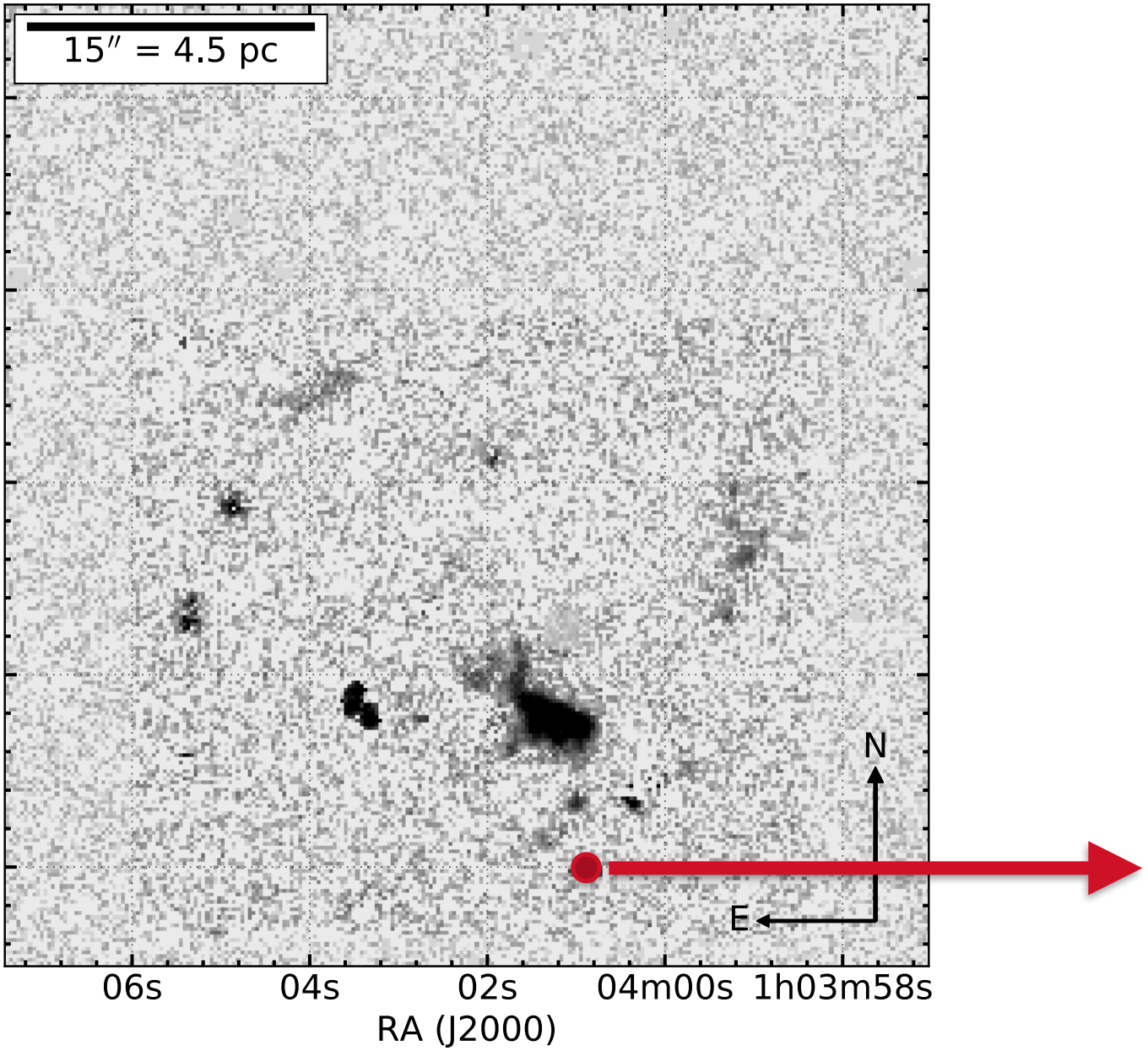

0°
-6.482
15.05
1566
Linemap
200%
99.5%
Logarithmi
Auto Scale
Circular
R1: 2
R2: 2
Divide Std
Average
6660
6680
6700
6720
6740

Hydrogen

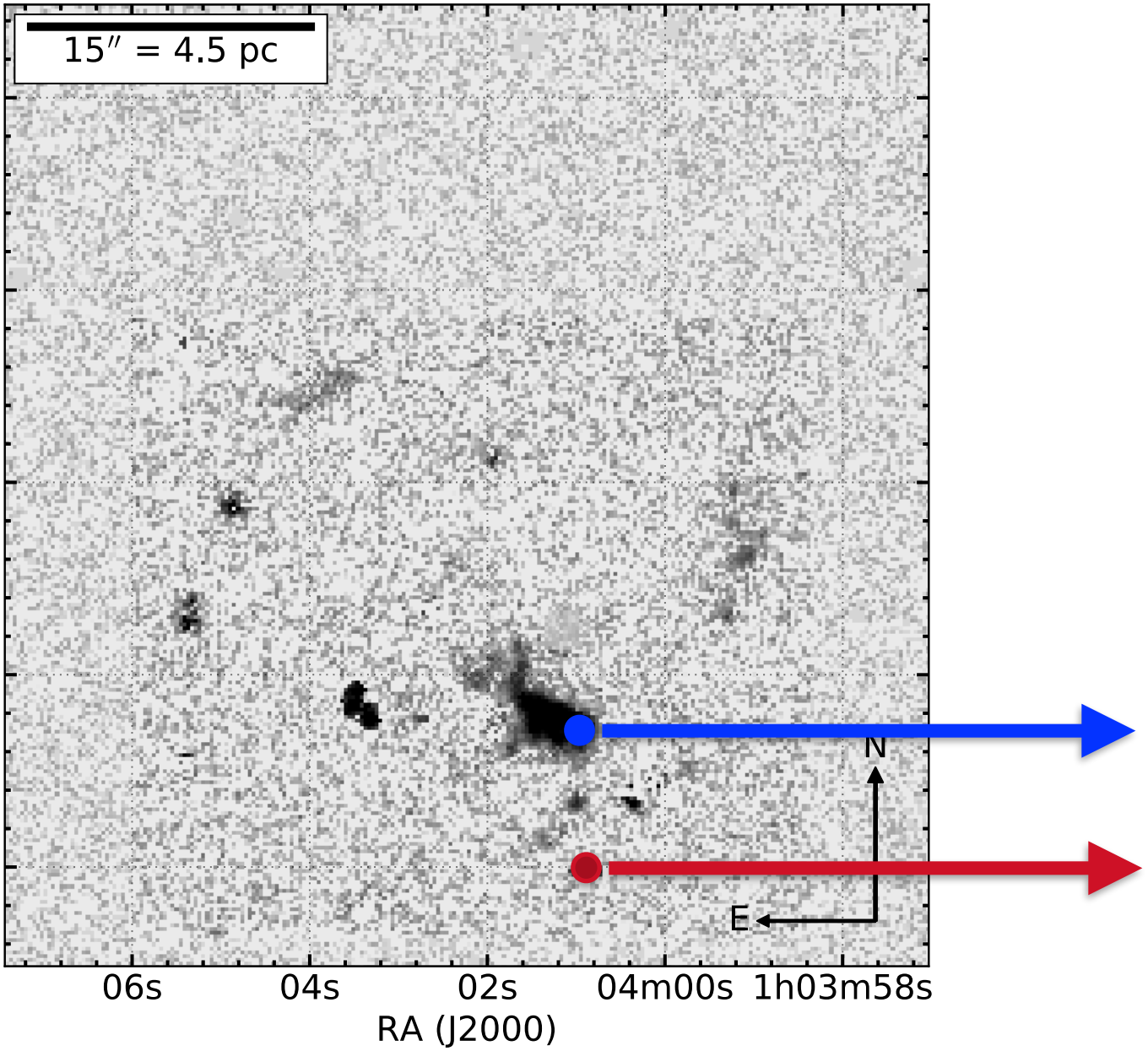
Fitted red- and blue-shifted H-alpha

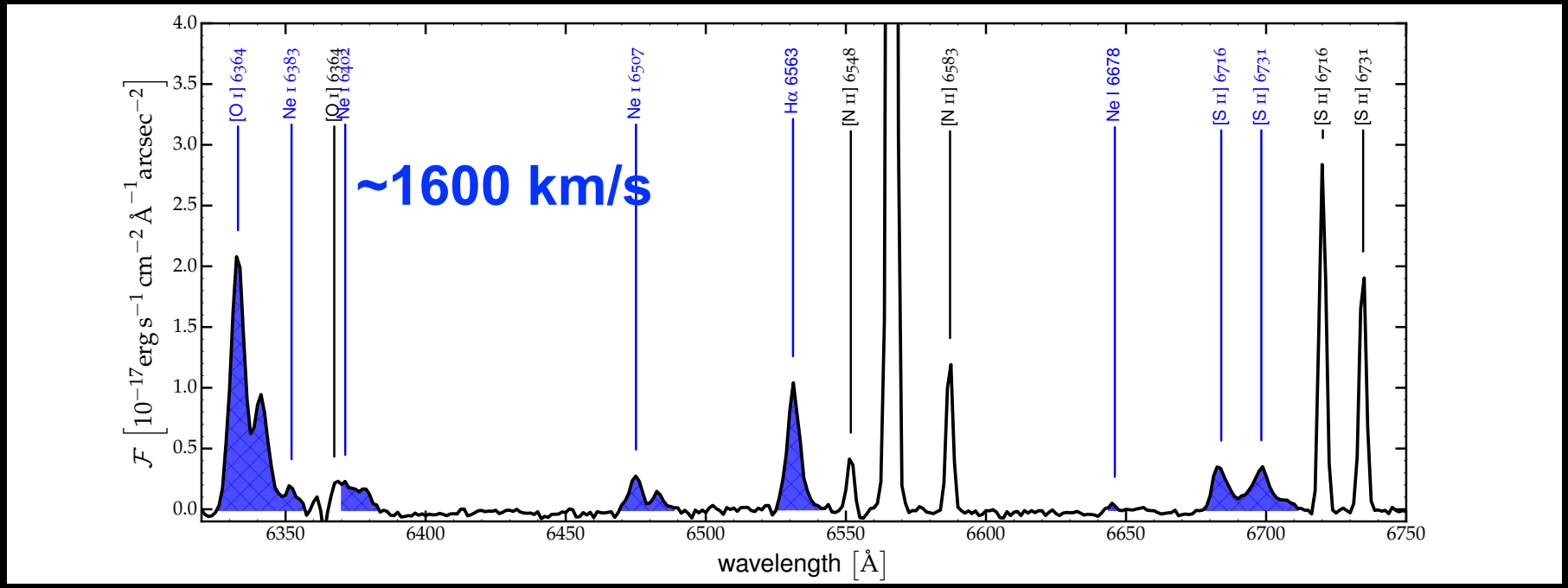


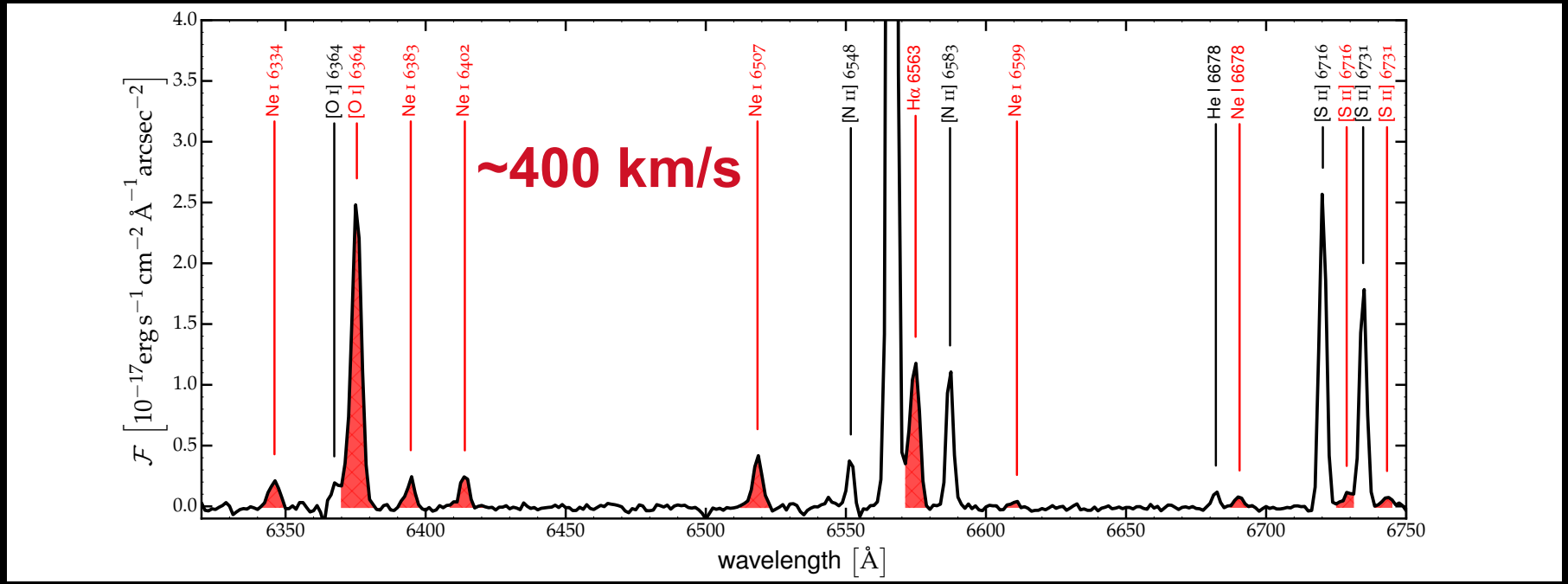
Fitted red- and blue-shifted H-alpha



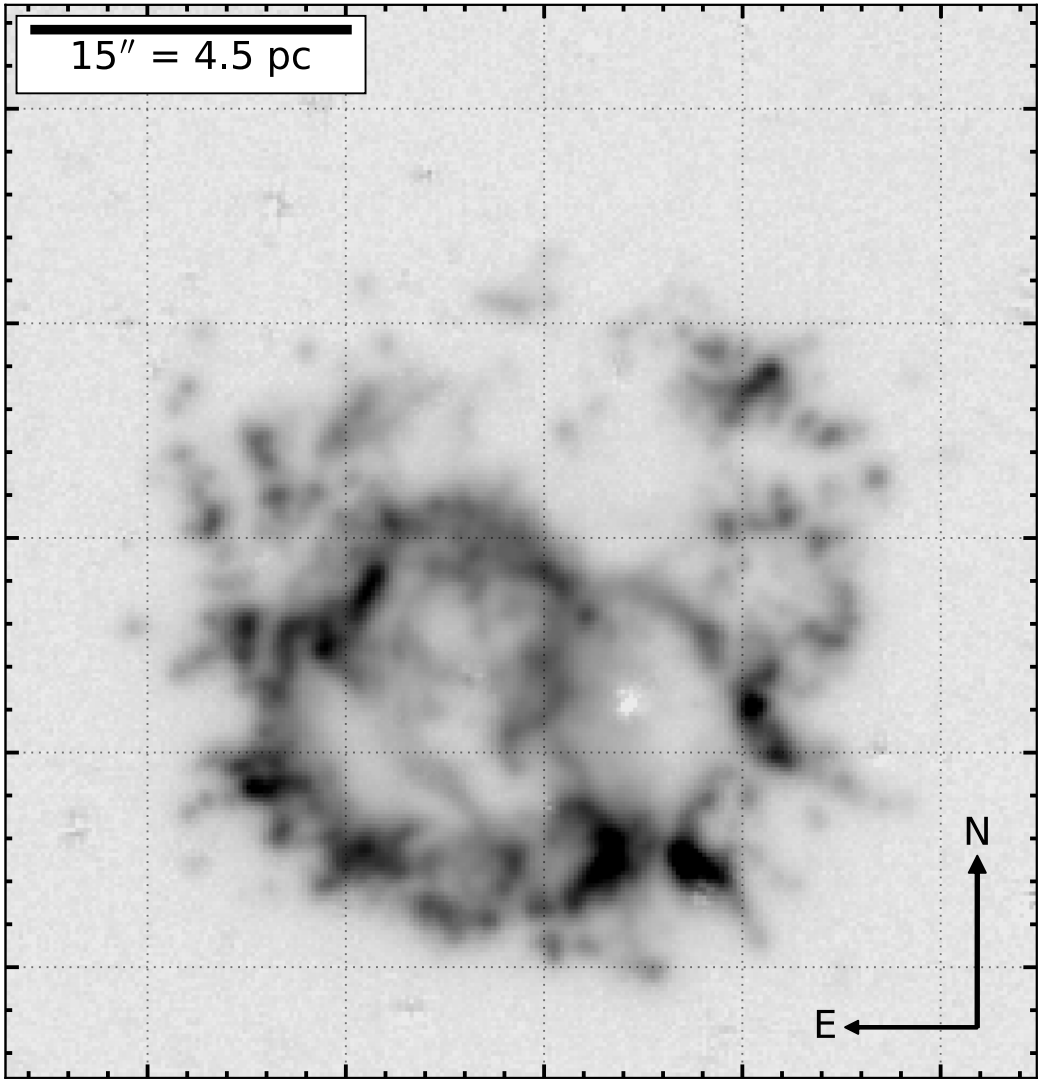
Fitted red- and blue-shifted H-alpha

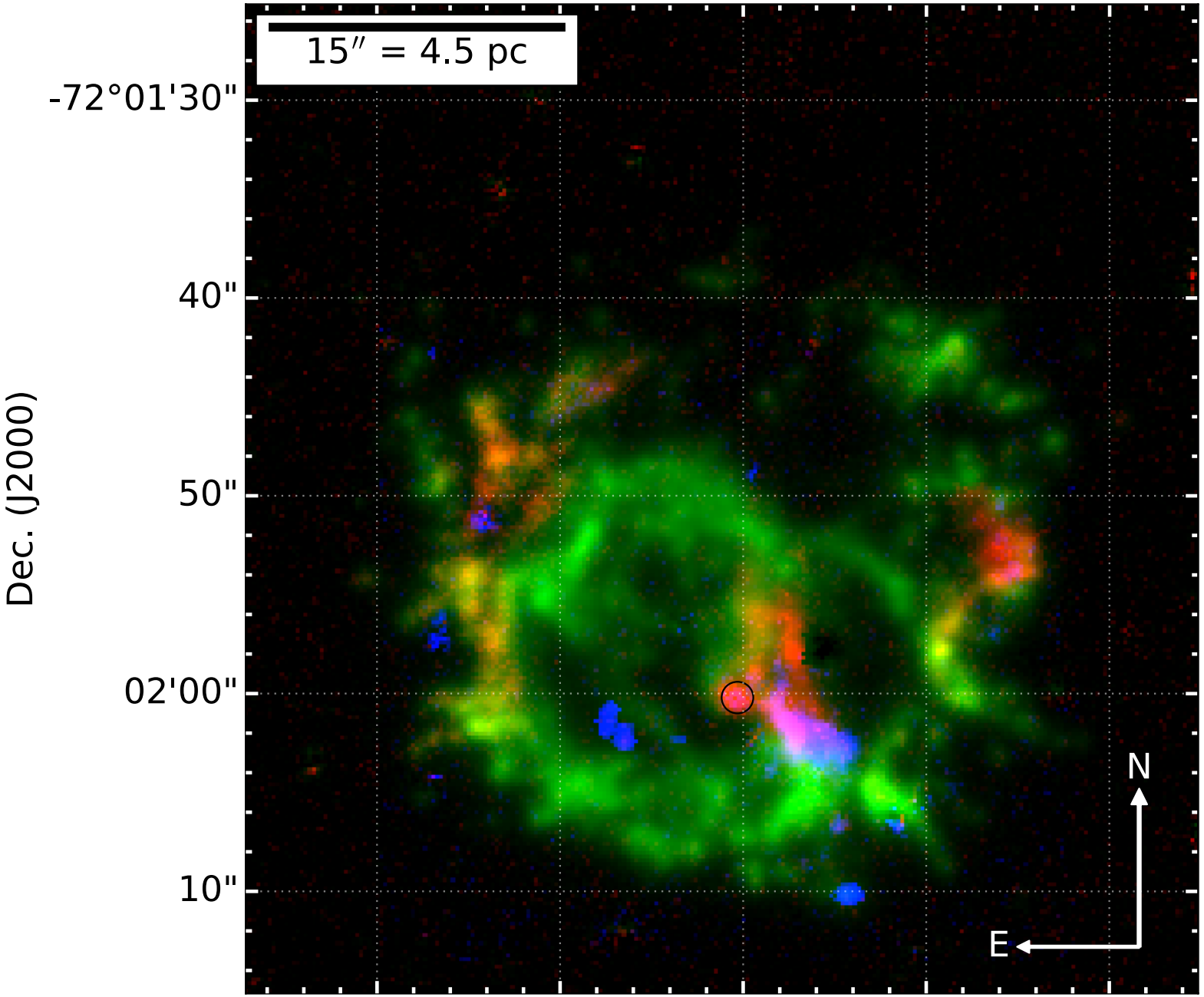



~1600 km/s
[O I] 6364
Ne I 6383
[O I] 6364
Ne I 6402
Ne I 6507
Hα 6563
[N II] 6548
[N II] 6583
Ne I 6678
[S II] 6716
[S II] 6731
[S II] 6716
[S II] 6731
wavelength [Å]

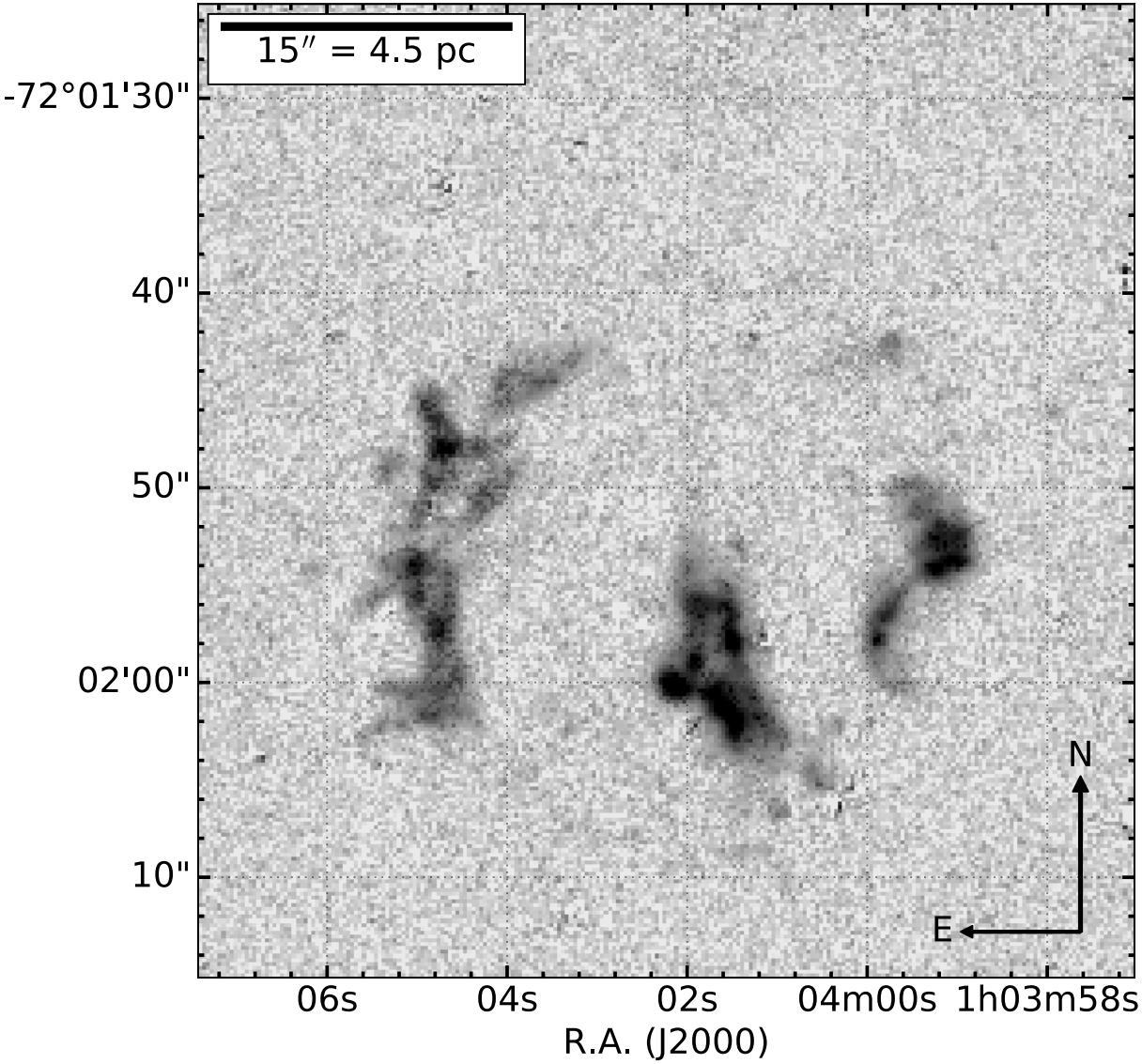

~400 km/s
Ne I 6334
[O I] 6364
[O I] 6364
Ne I 6383
Ne I 6402
Ne I 6507
[N II] 6548
Hα 6563
[N II] 6583
Ne I 6599
He I 6678
Ne I 6678
[S II] 6716
[S II] 6716
[S II] 6731
[S II] 6731
wavelength [Å]

[O III] 5007

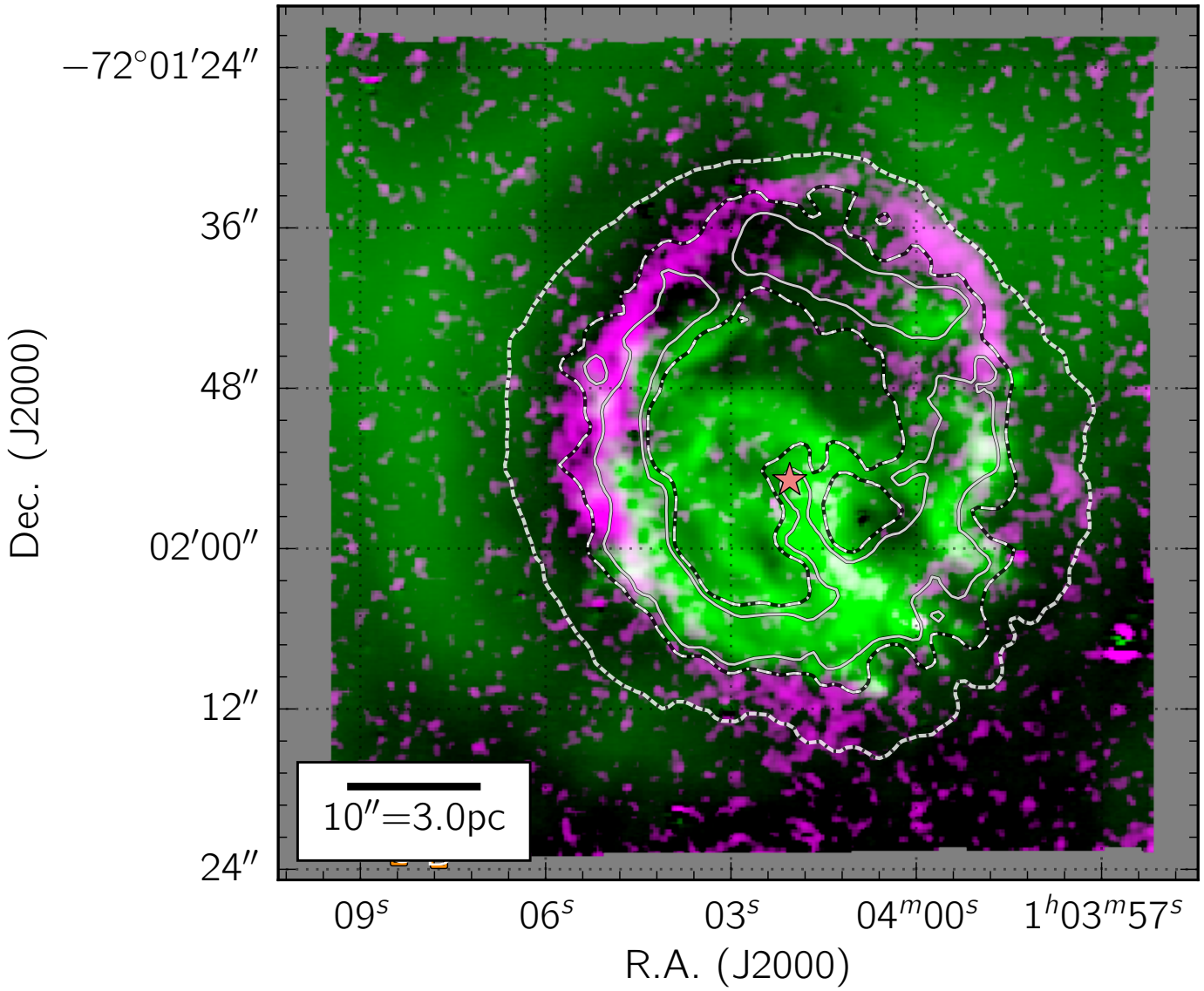



15″ = 4.5 pc
-72°01'30"
40"
50"
02'00"
10"
Dec. (J2000)
N
E

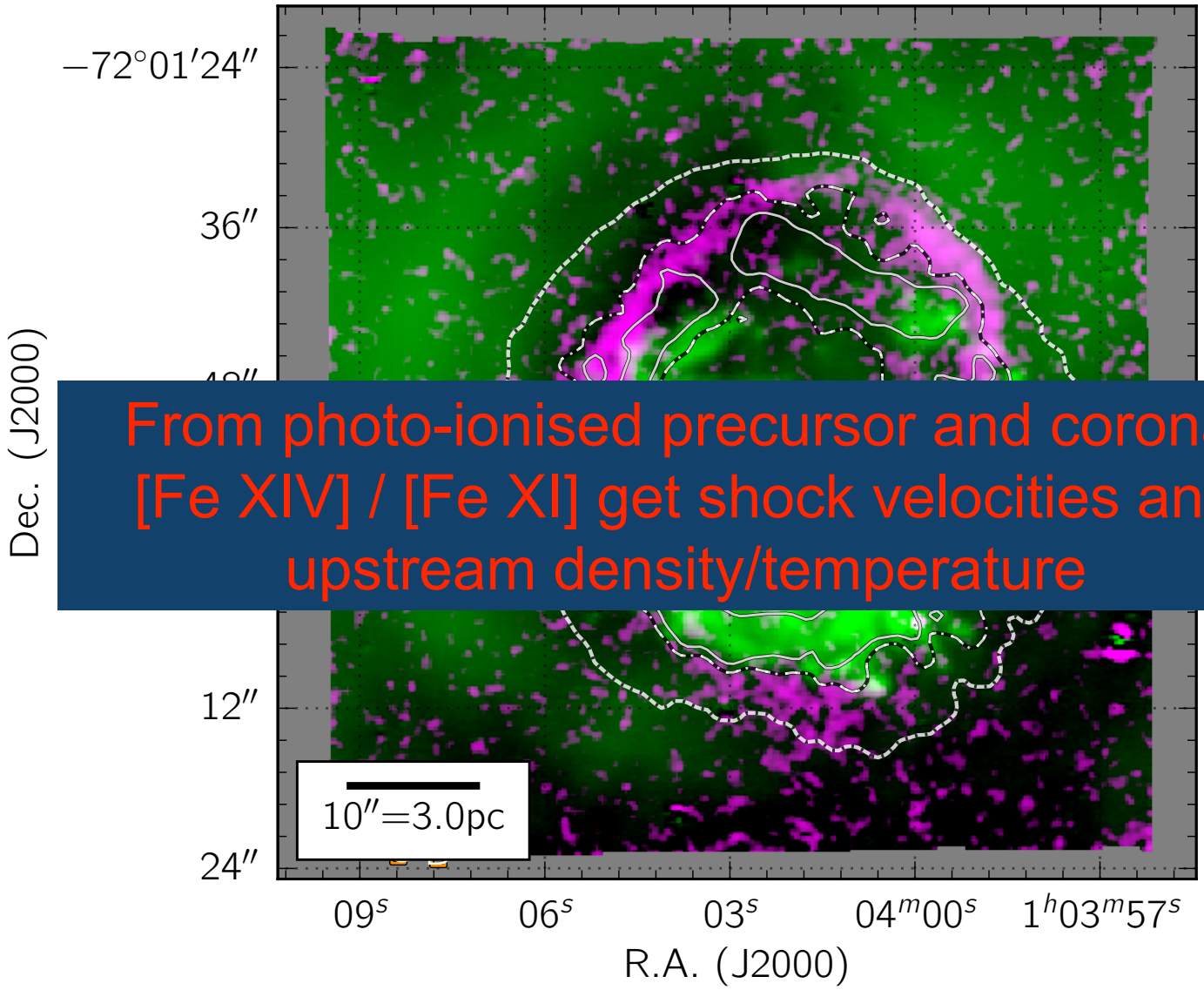
1E0102.2-7219 with MUSE



1E0102.2-7219 with MUSE

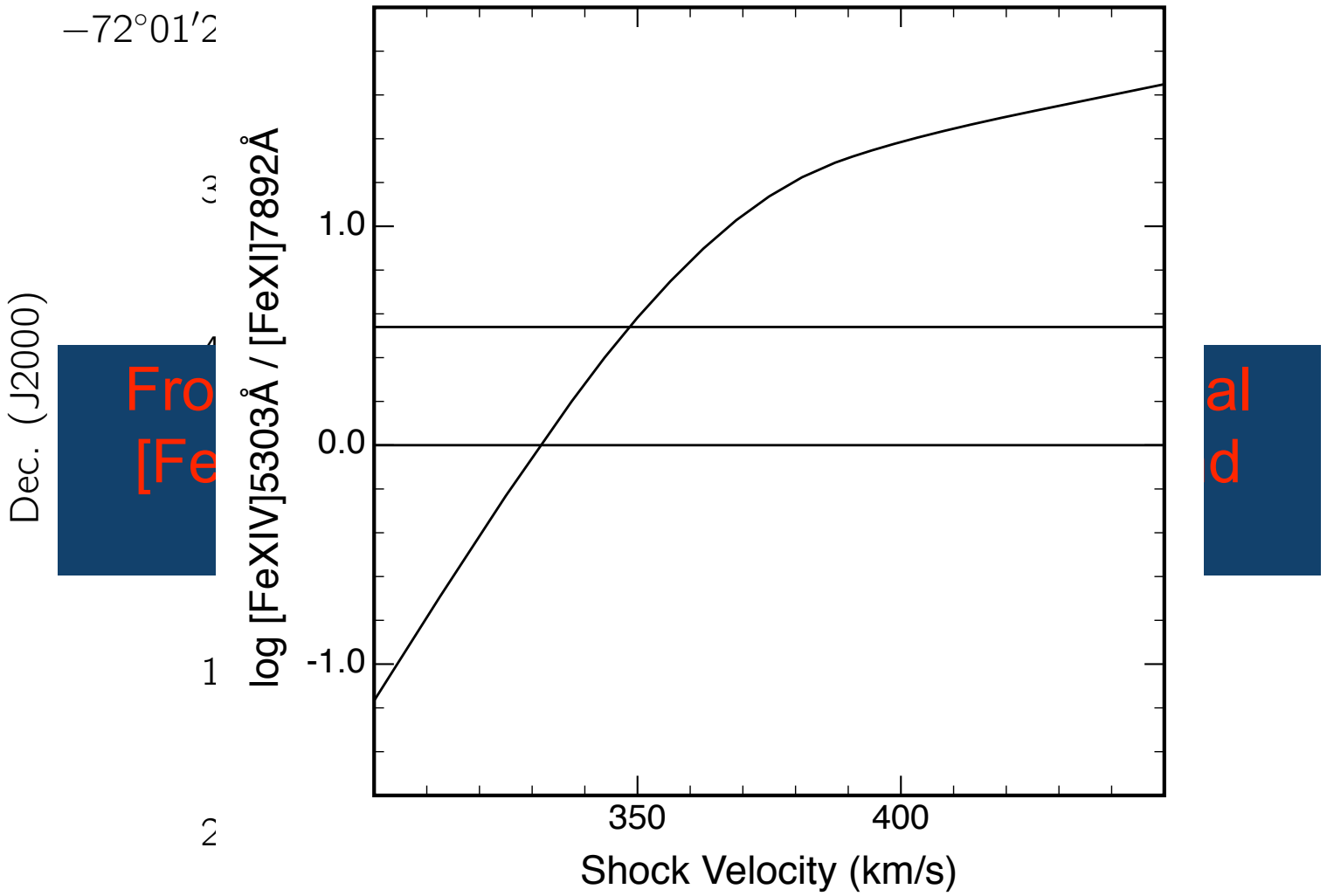


1E0102.2-7219 with MUSE

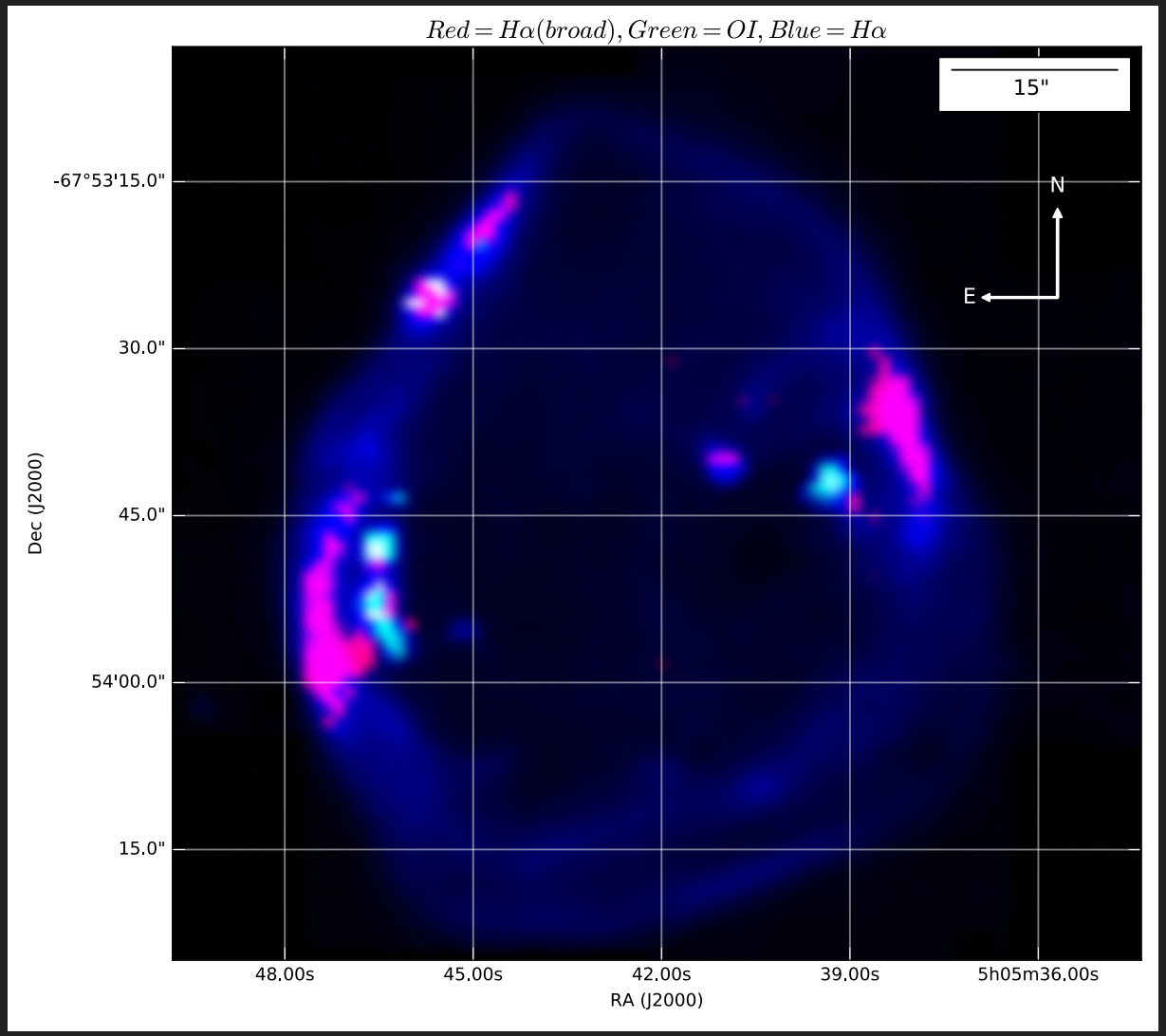


From photo-ionised precursor and coronal [Fe XIV] / [Fe XI] get shock velocities and upstream density/temperature

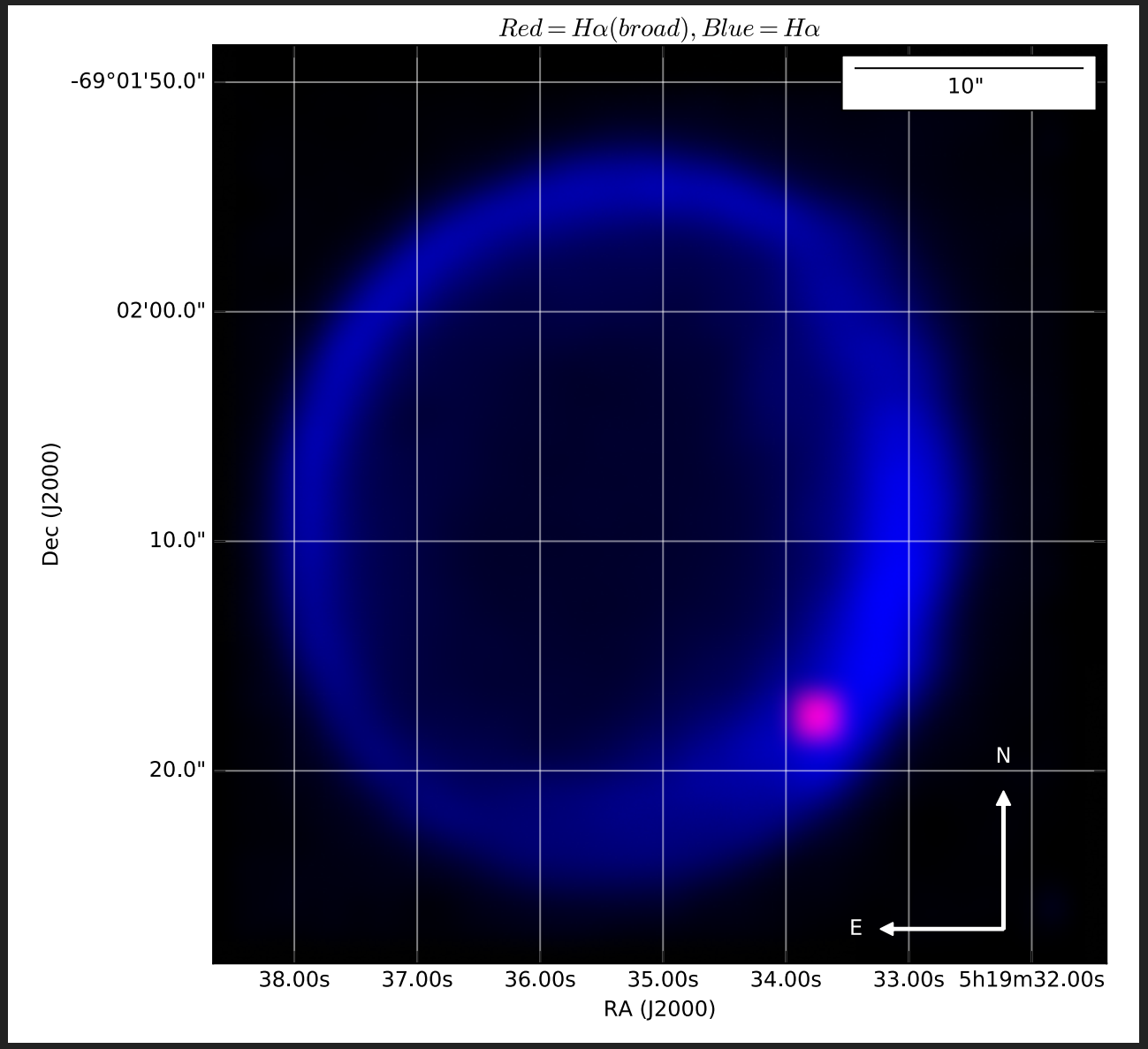
1E0102.2-7219 with MUSE



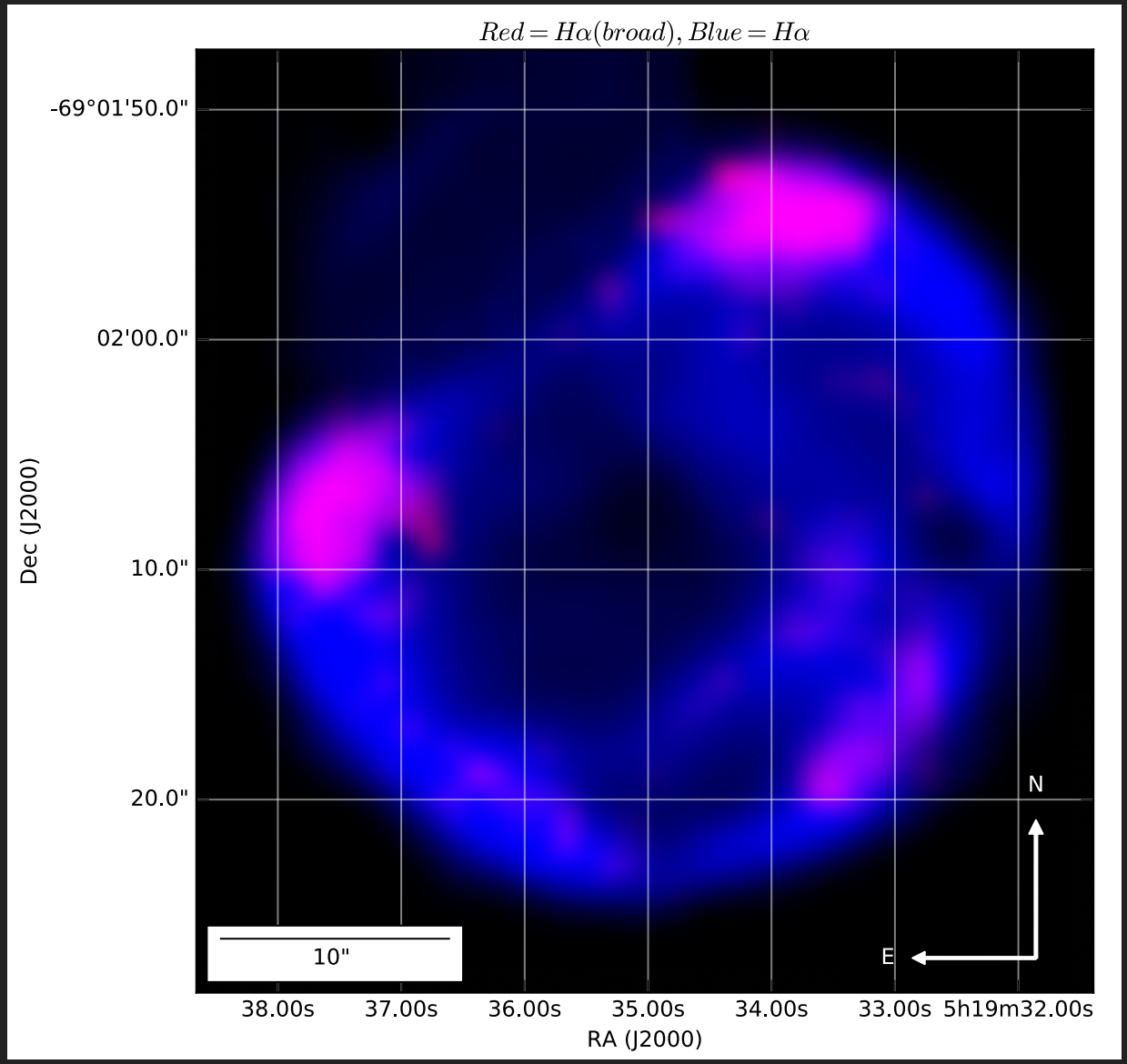
DEM L71


$Red = H\alpha(broad), Green = OI, Blue = H\alpha$
15"
N
E
-67°53'15.0"
30.0"
45.0"
54'00.0"
15.0"
Dec (J2000)
48.00s
45.00s
42.00s
39.00s
5h05m36.00s
RA (J2000)

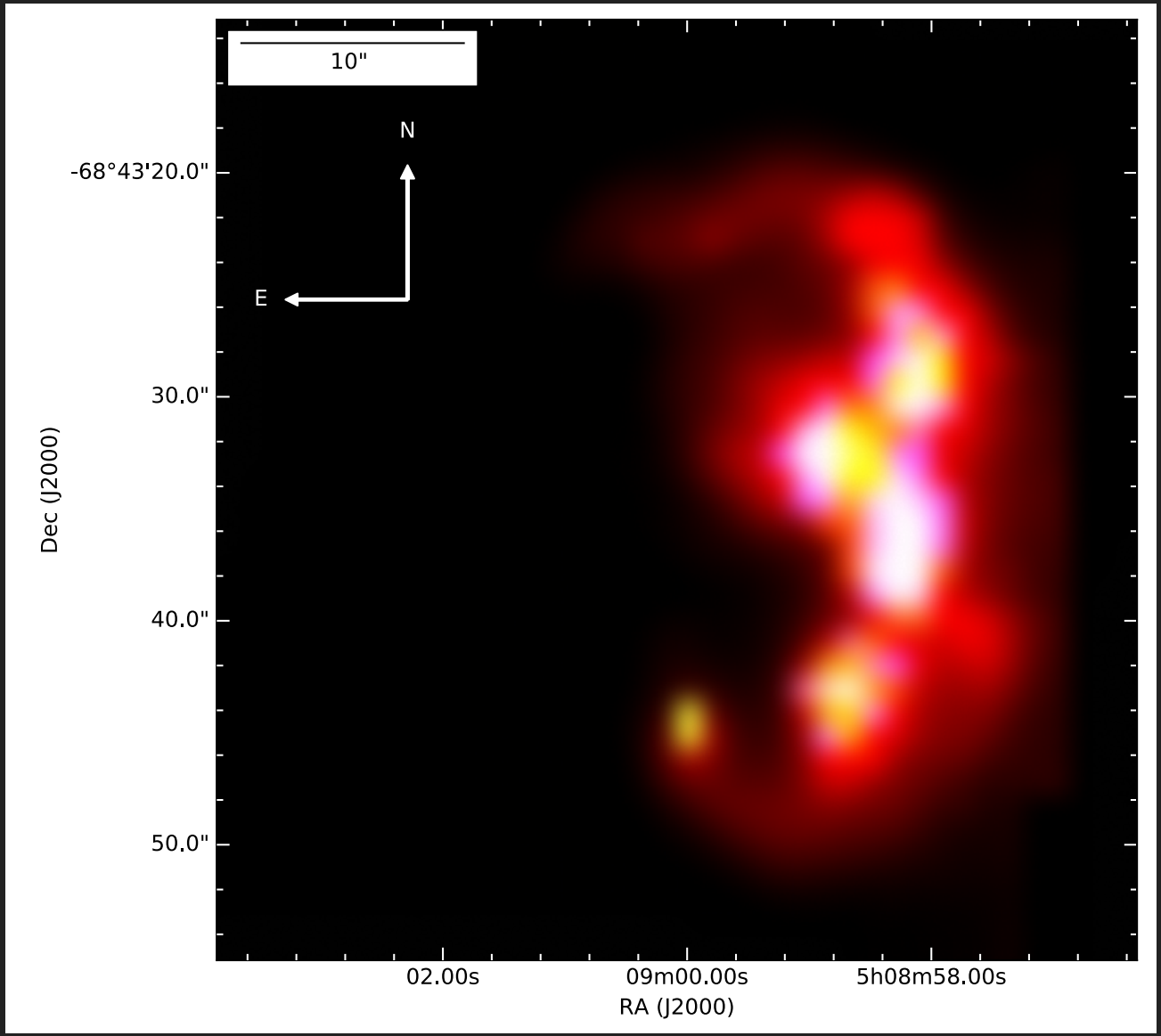
0509-67.5


$Red = H\alpha(broad), Blue = H\alpha$
-69°01'50.0"
02'00.0"
10.0"
20.0"
Dec (J2000)
10"
N
E
38.00s
37.00s
36.00s
35.00s
34.00s
33.00s
5h19m32.00s
RA (J2000)

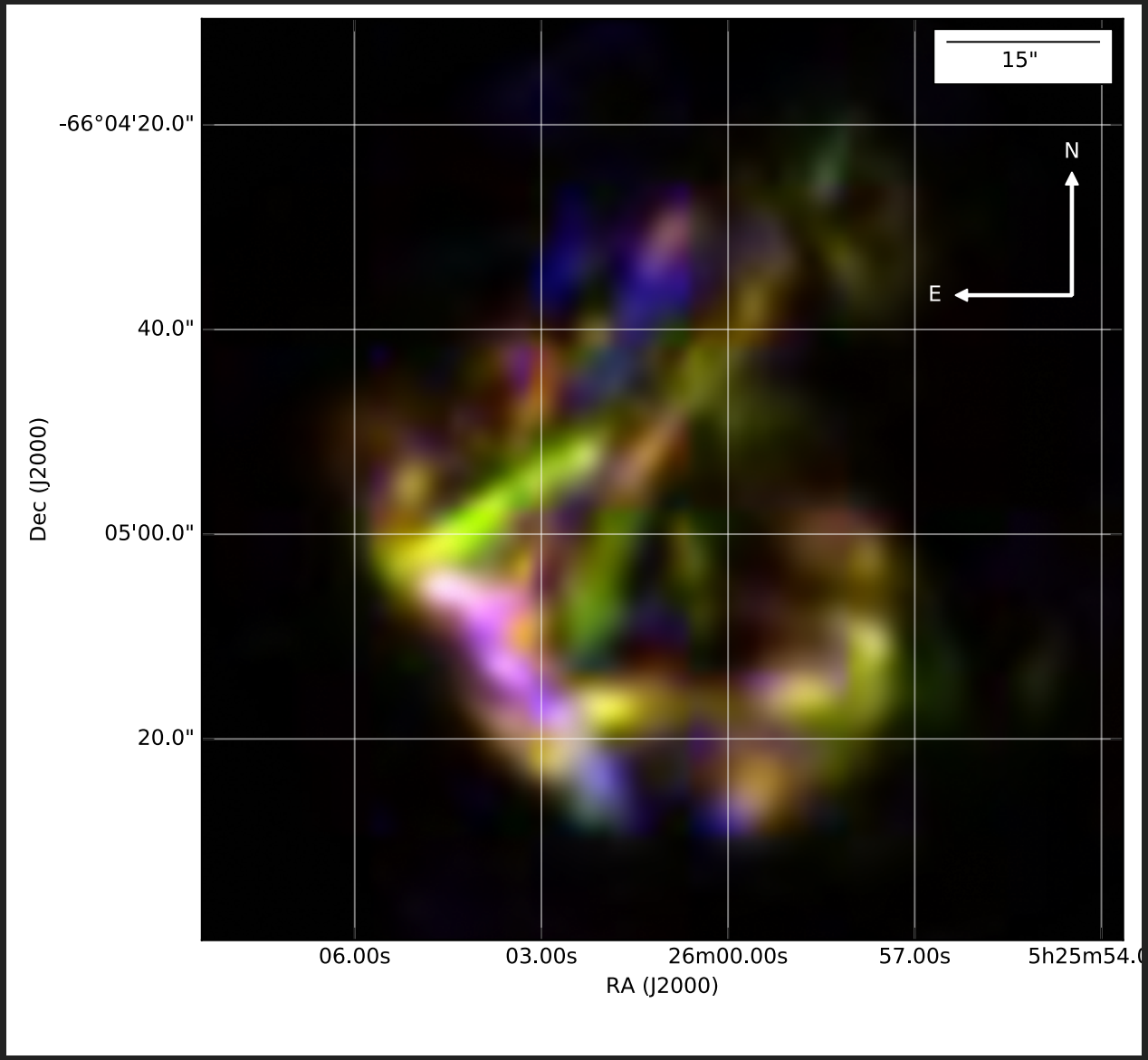
0519-69.0


$Red = H\alpha(broad), Blue = H\alpha$
-69°01'50.0"
02'00.0"
10.0"
20.0"
Dec (J2000)
10"
N
E
38.00s
37.00s
36.00s
35.00s
34.00s
33.00s
5h19m32.00s
RA (J2000)

N103B


10"
N
E
-68°43'20.0"
30.0"
40.0"
50.0"
Dec (J2000)
02.00s
09m00.00s
5h08m58.00s
RA (J2000)

N49


15"
N
E
-66°04'20.0"
40.0"
05'00.0"
20.0"
Dec (J2000)
06.00s
03.00s
26m00.00s
57.00s
RA (J2000)