

Binary white dwarf merger simulations

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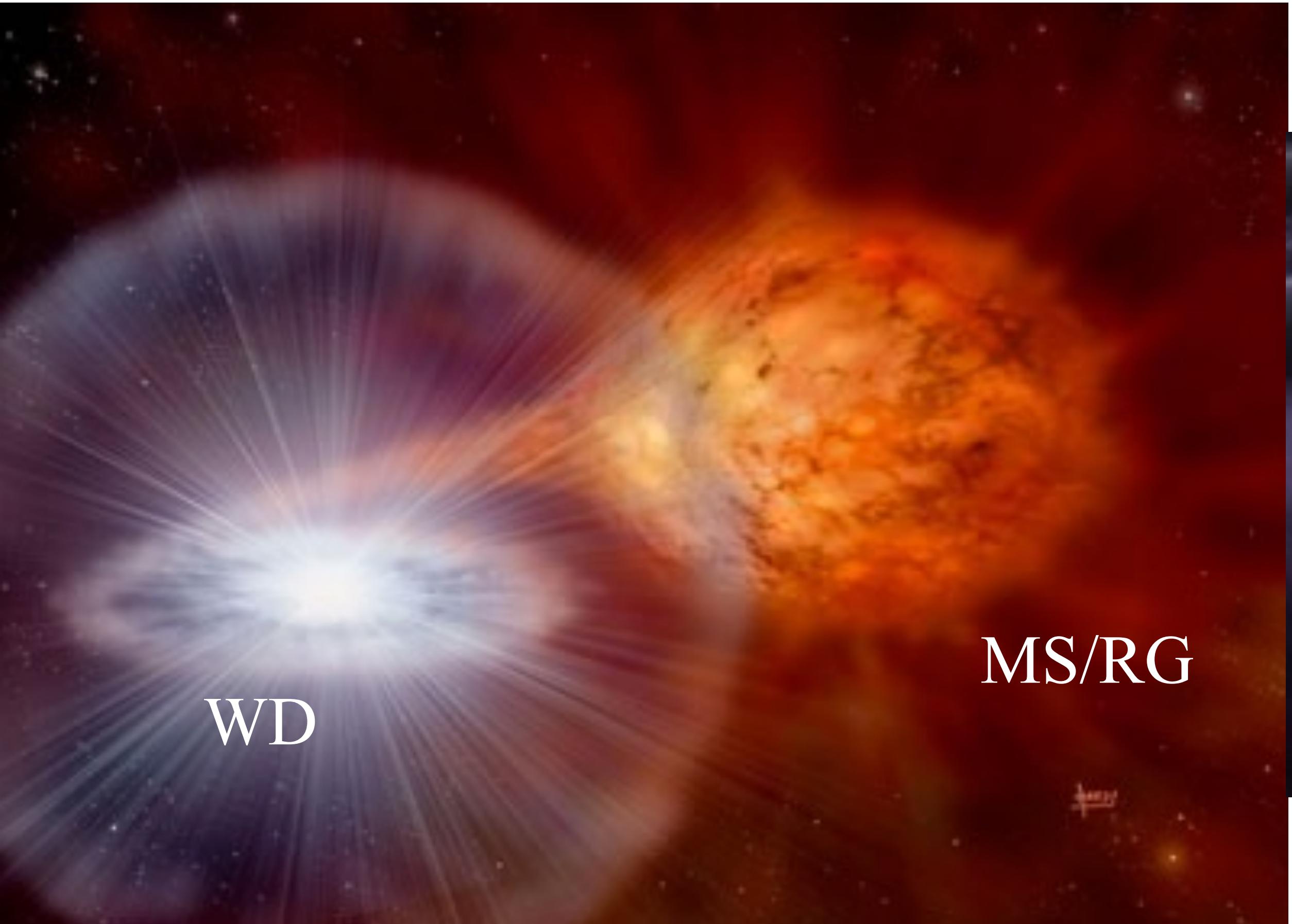
Exploring the Transient Universe

Hongo, Tokyo, Japan

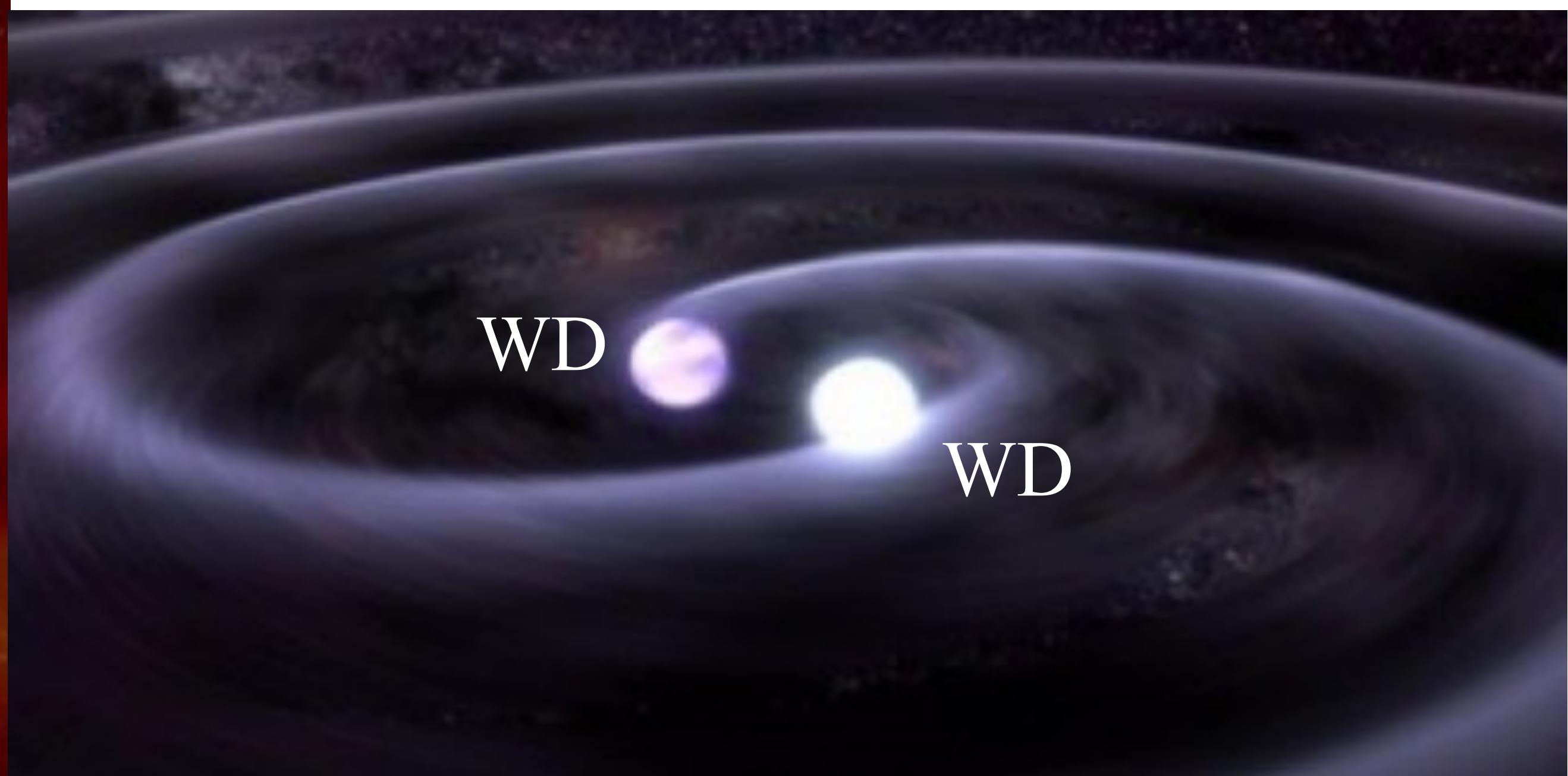
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Single degenerate

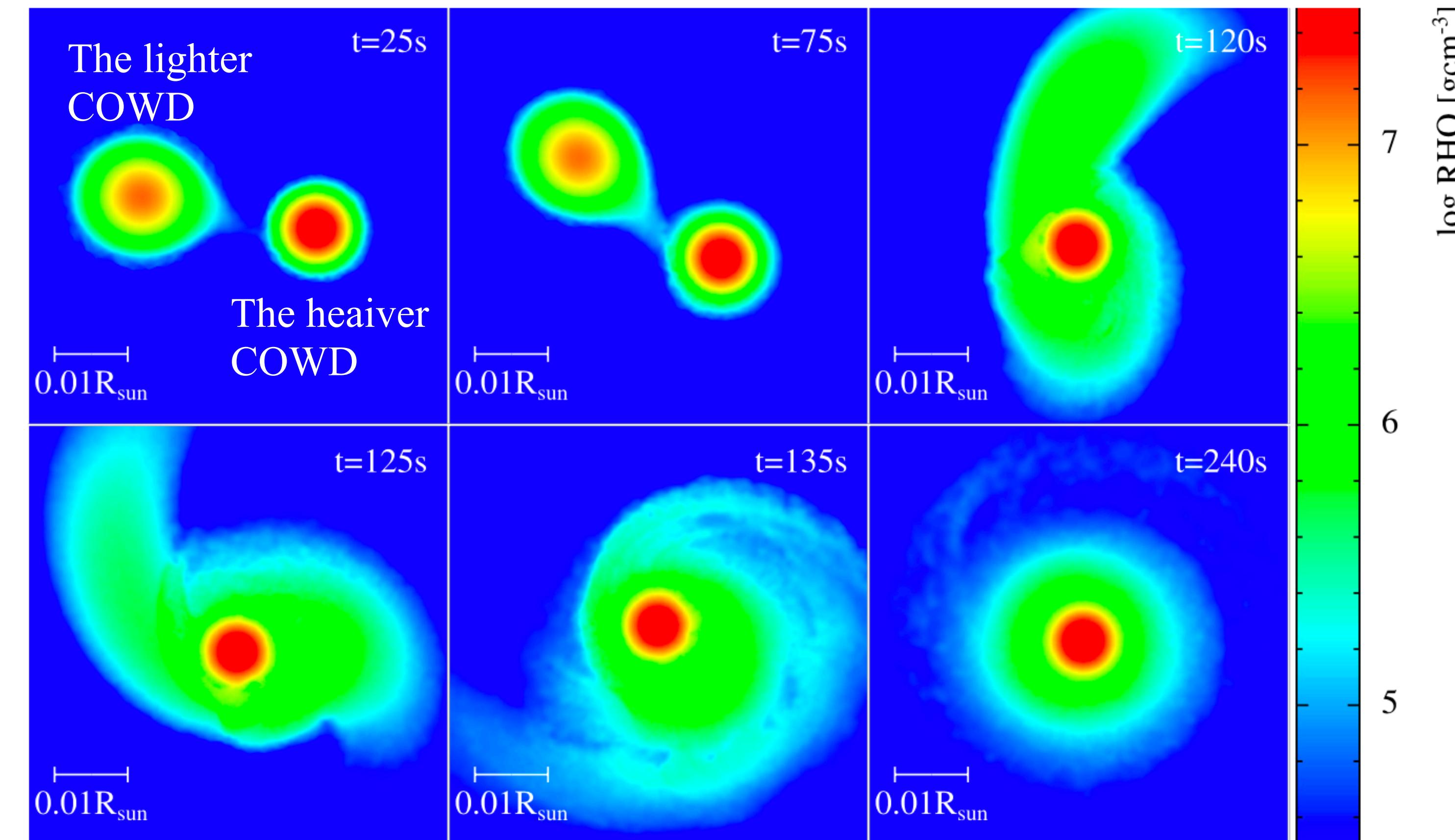


Double degenerate

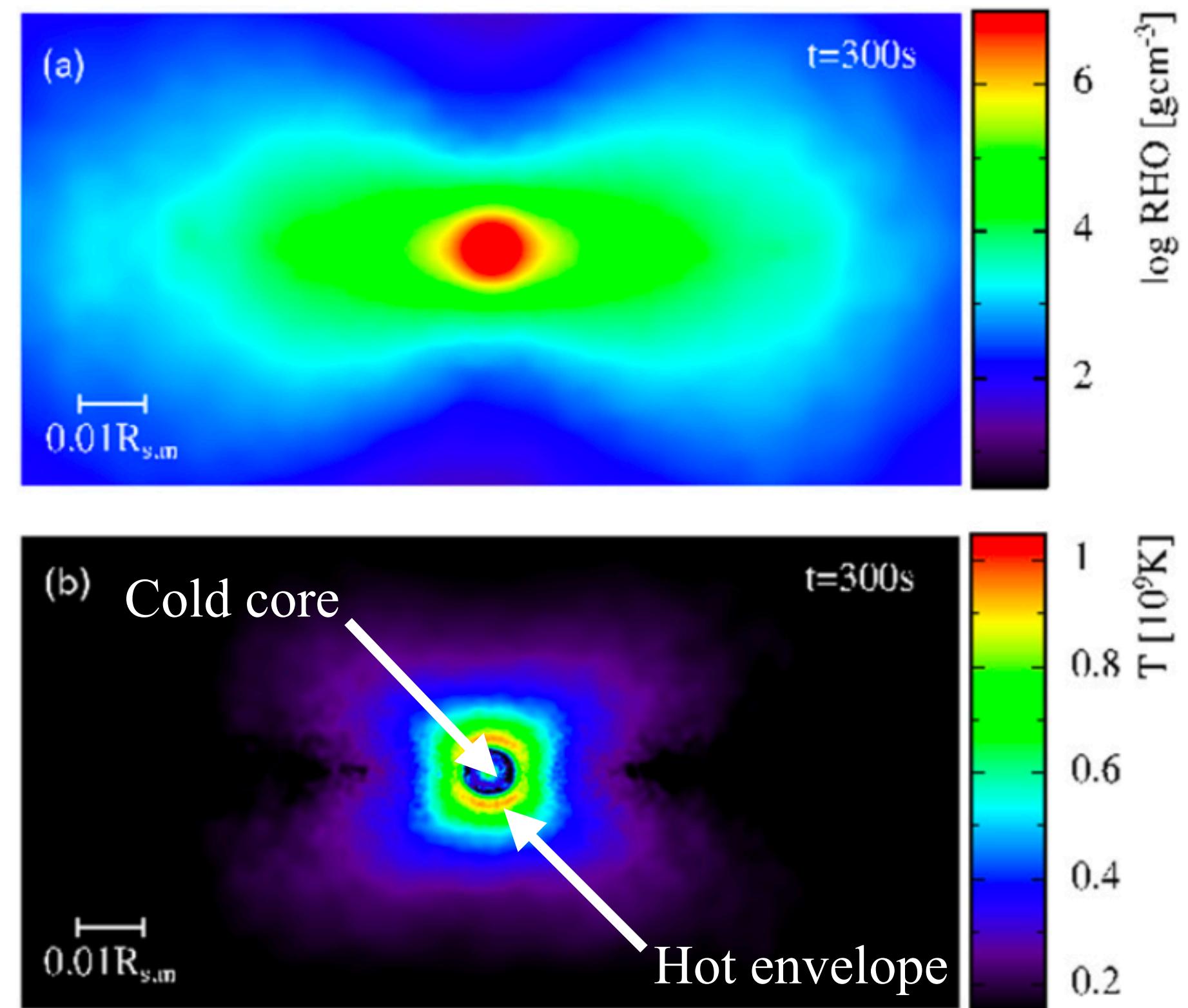


Near Chandrasekhar-mass explosion?

Time sequence from the face-on view

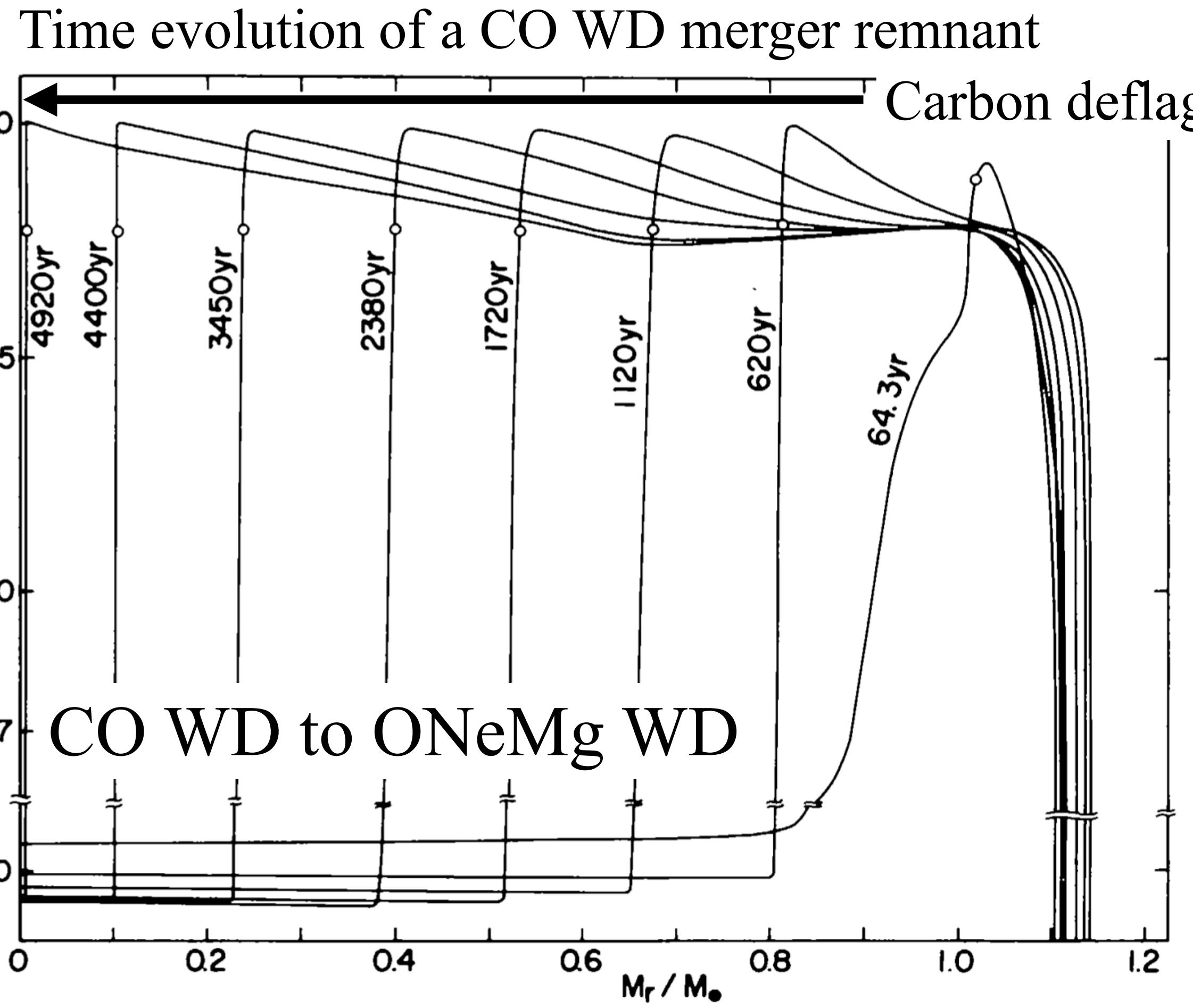


Final state from the edge-on view

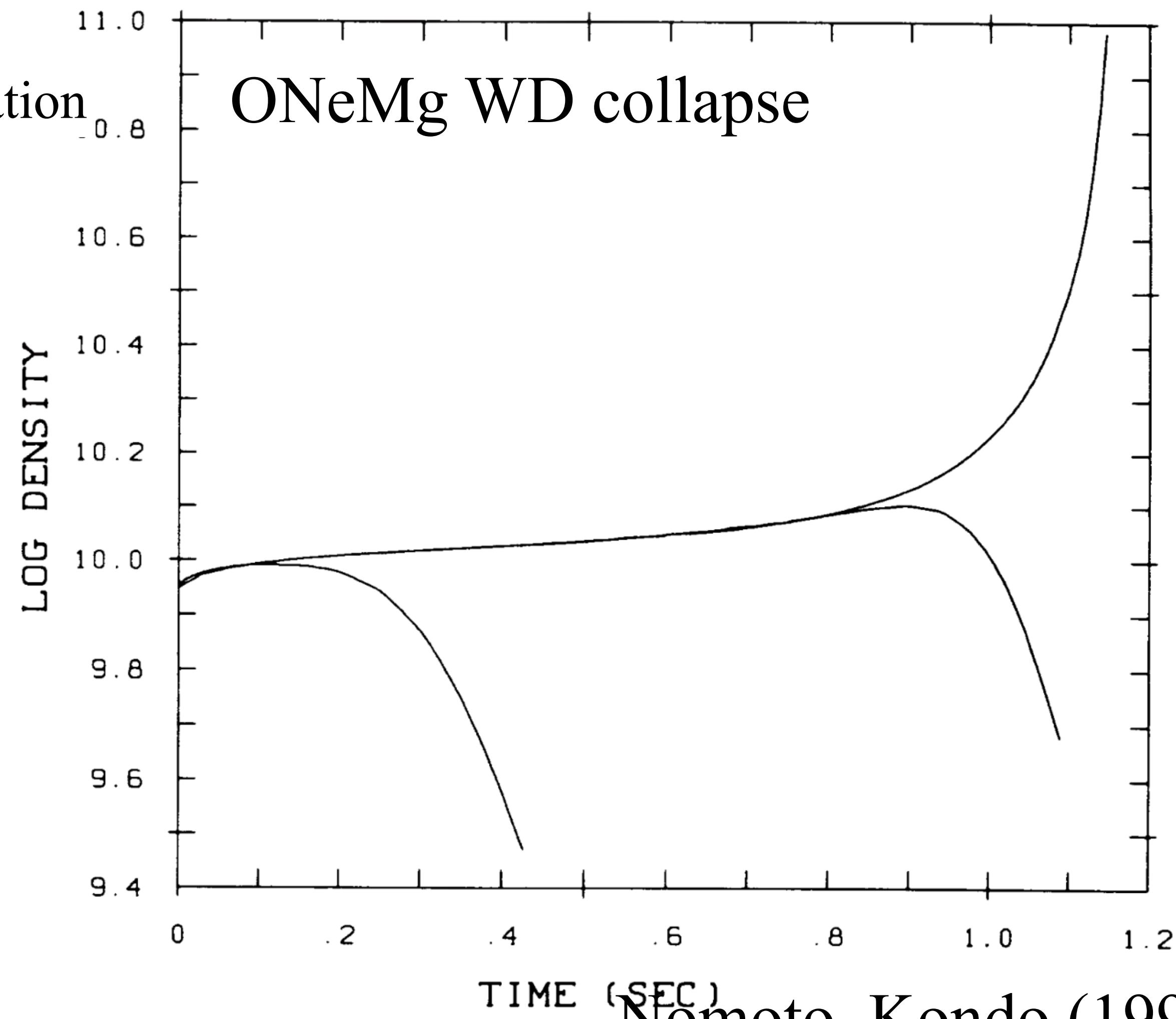


e.g. Sato+AT+ (2015, ApJ, 807, 105)

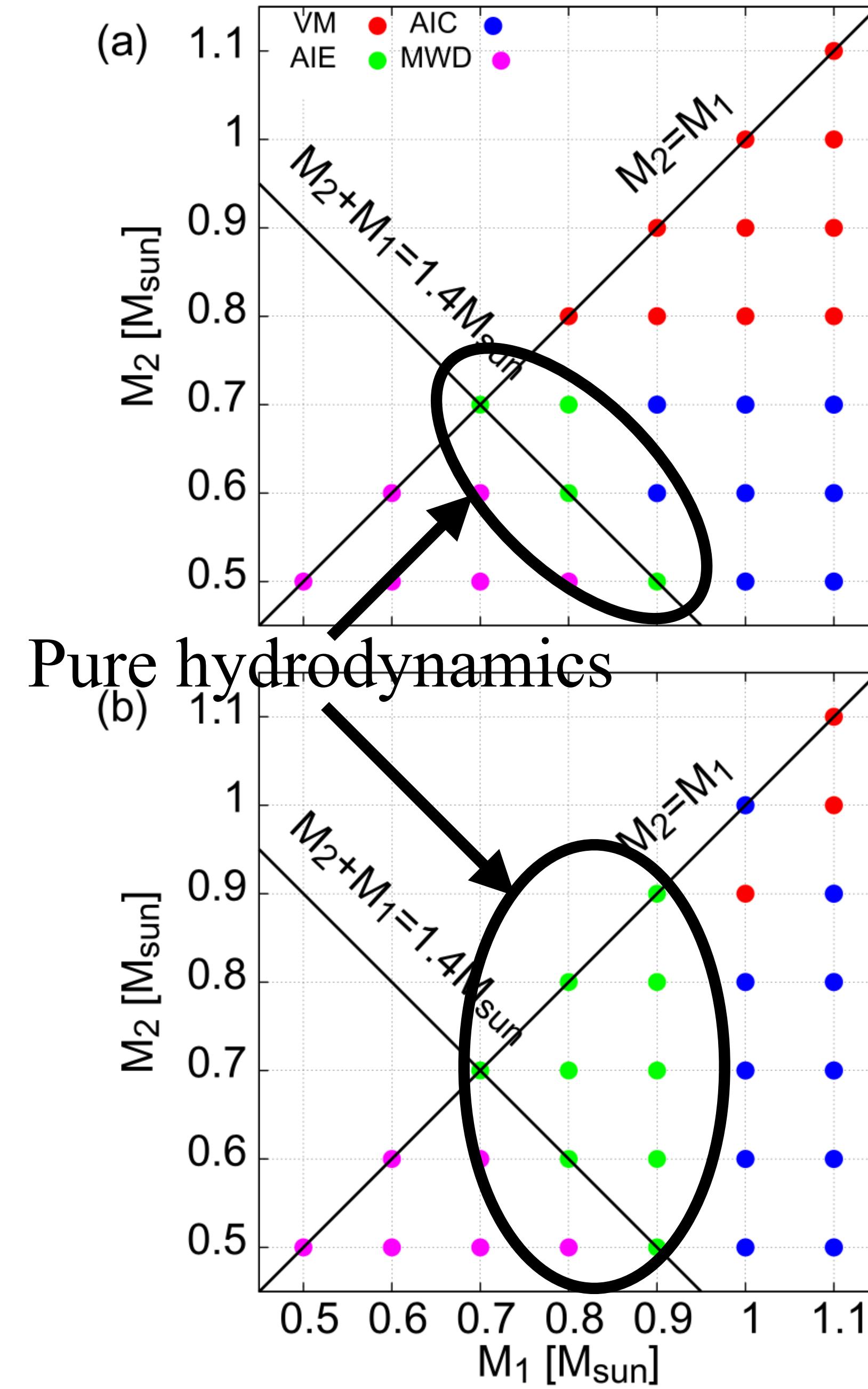
Near Chandrasekhar-mass explosion?



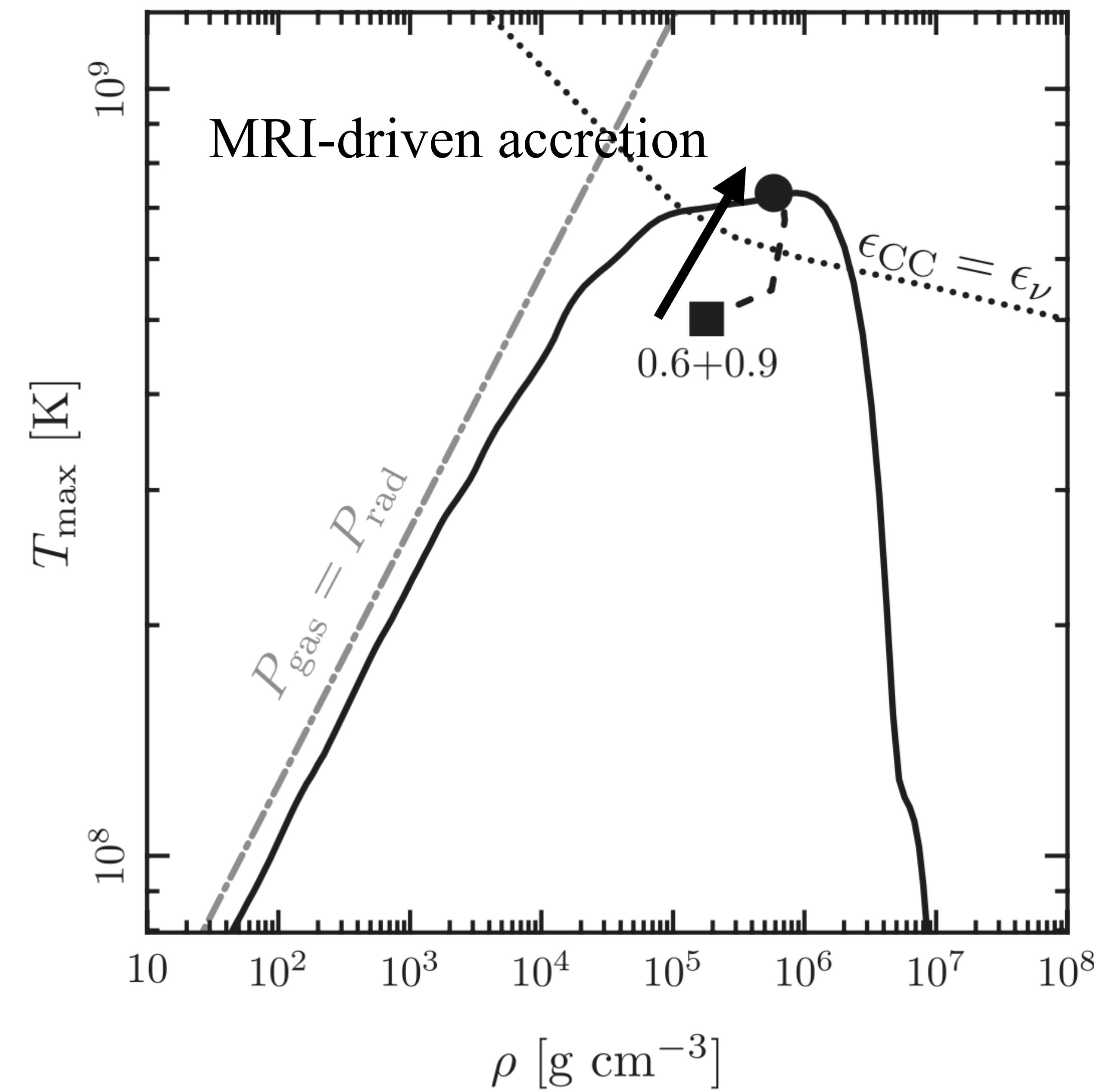
Saio, Nomoto (1985)



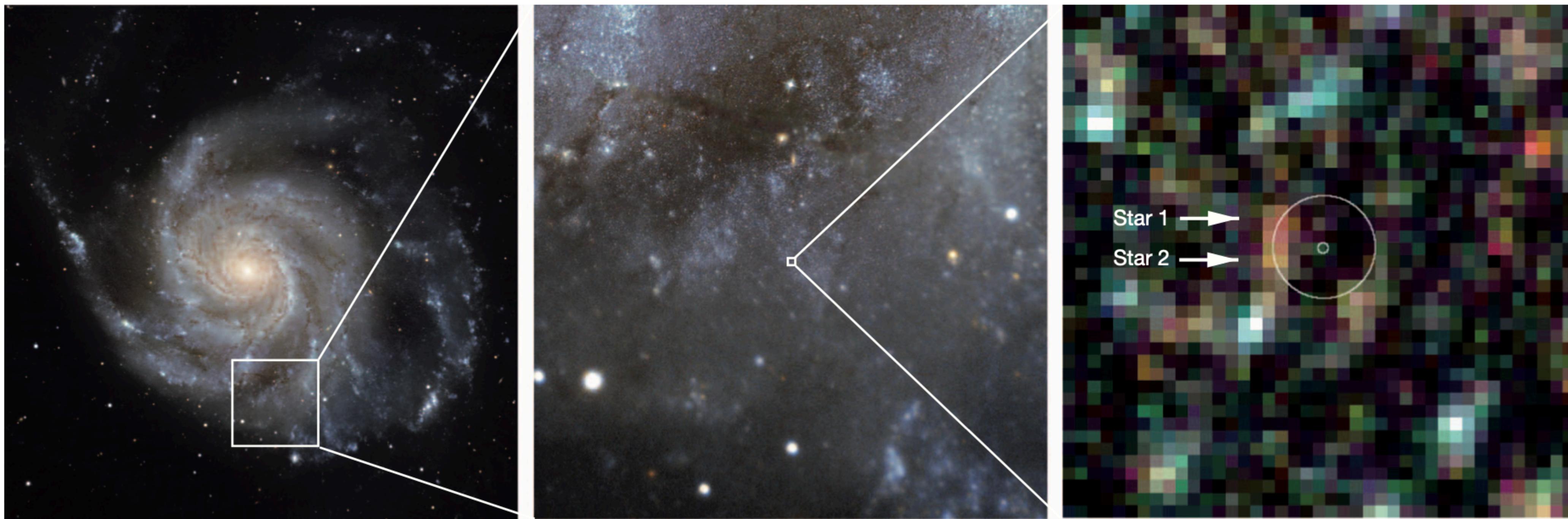
Nomoto, Kondo (1991)



e.g. Sato+AT+ (2015, ApJ, 807, 105)

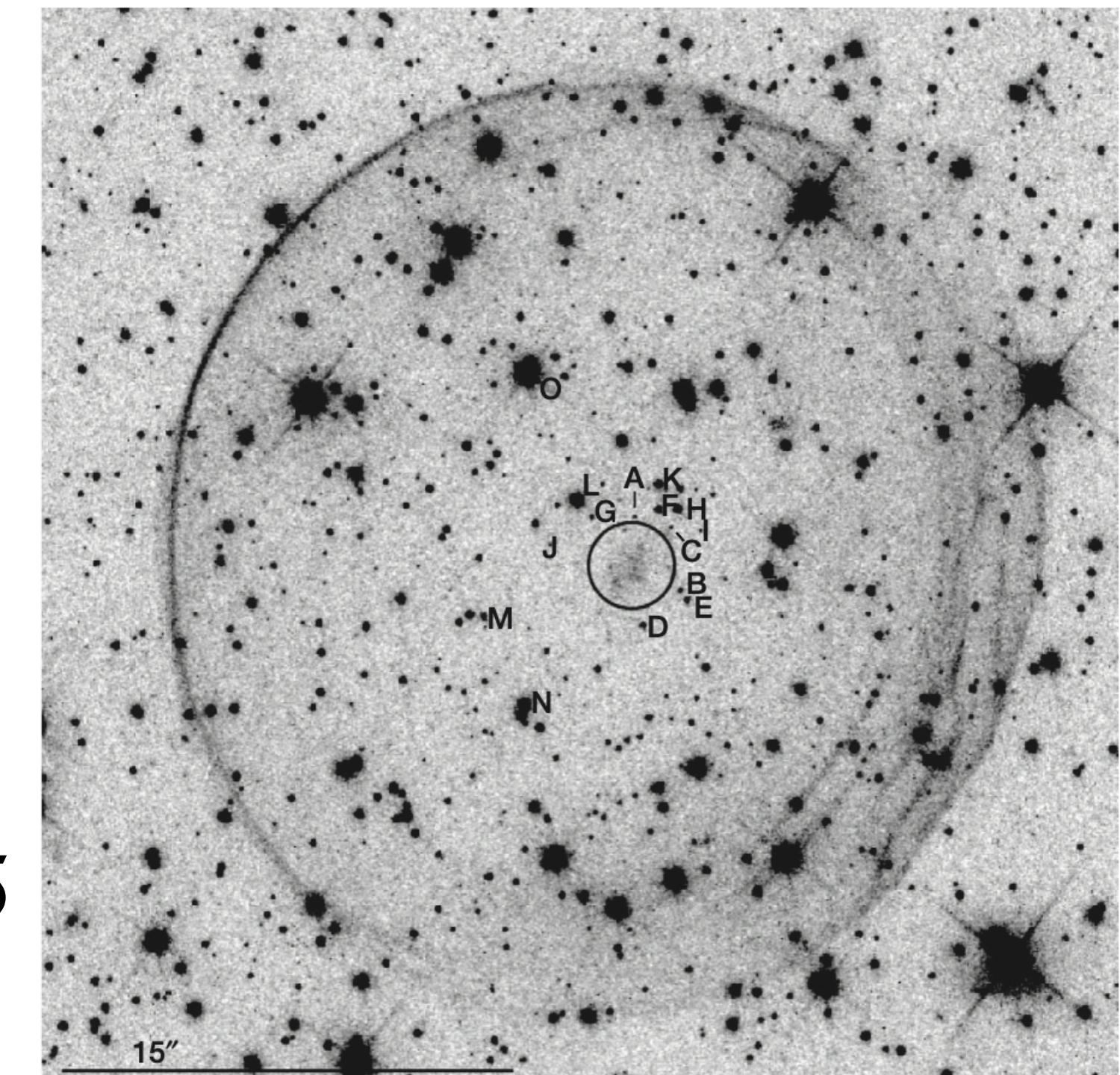


Schwab et al. (2012)



No RG in the pre-explosion image of SN2011fe
(Li et al. 2011)

No MS in SNR 0509-67.5
(Schaefer, Pagnotta 2012)

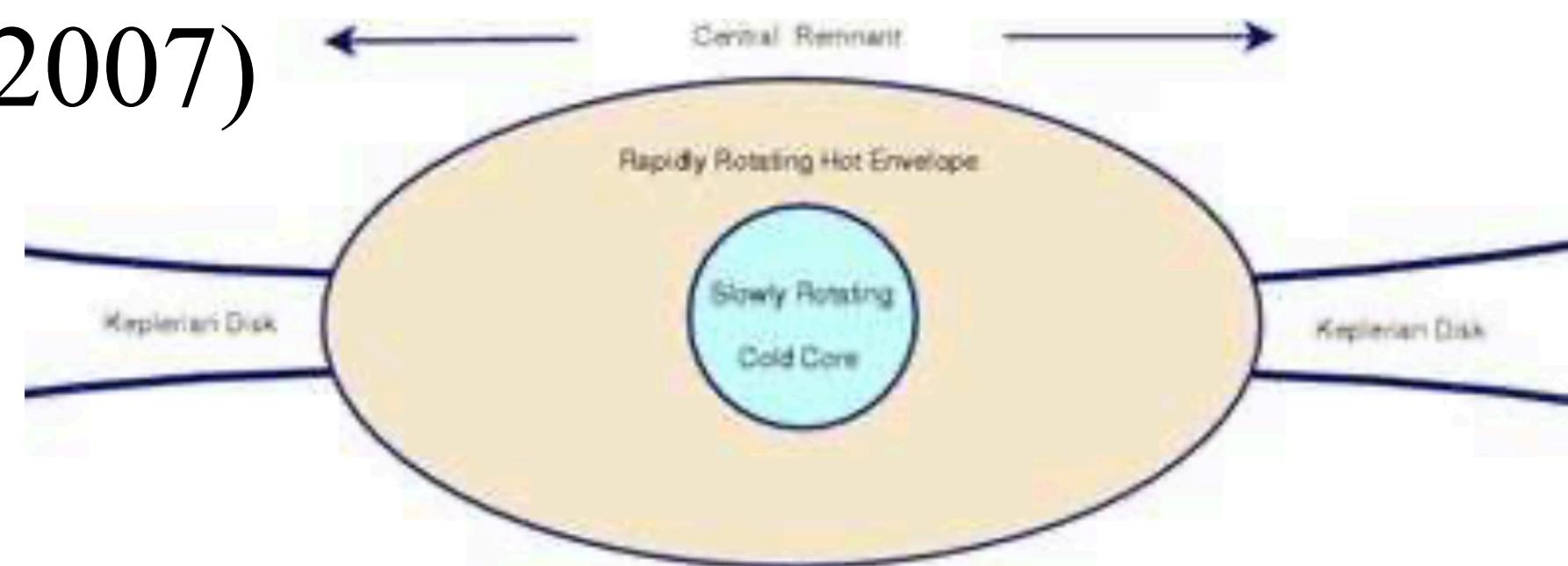


Two cases of WD explosions

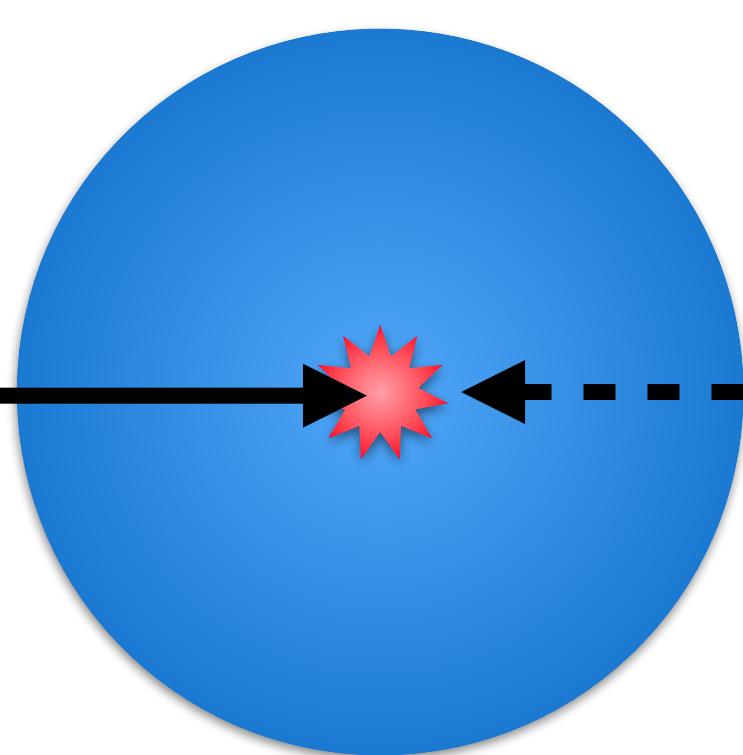
Near-Chandrasekhar-mass explosion

Sub-Chandrasekhar-mass explosion

Yoon et al. (2007)

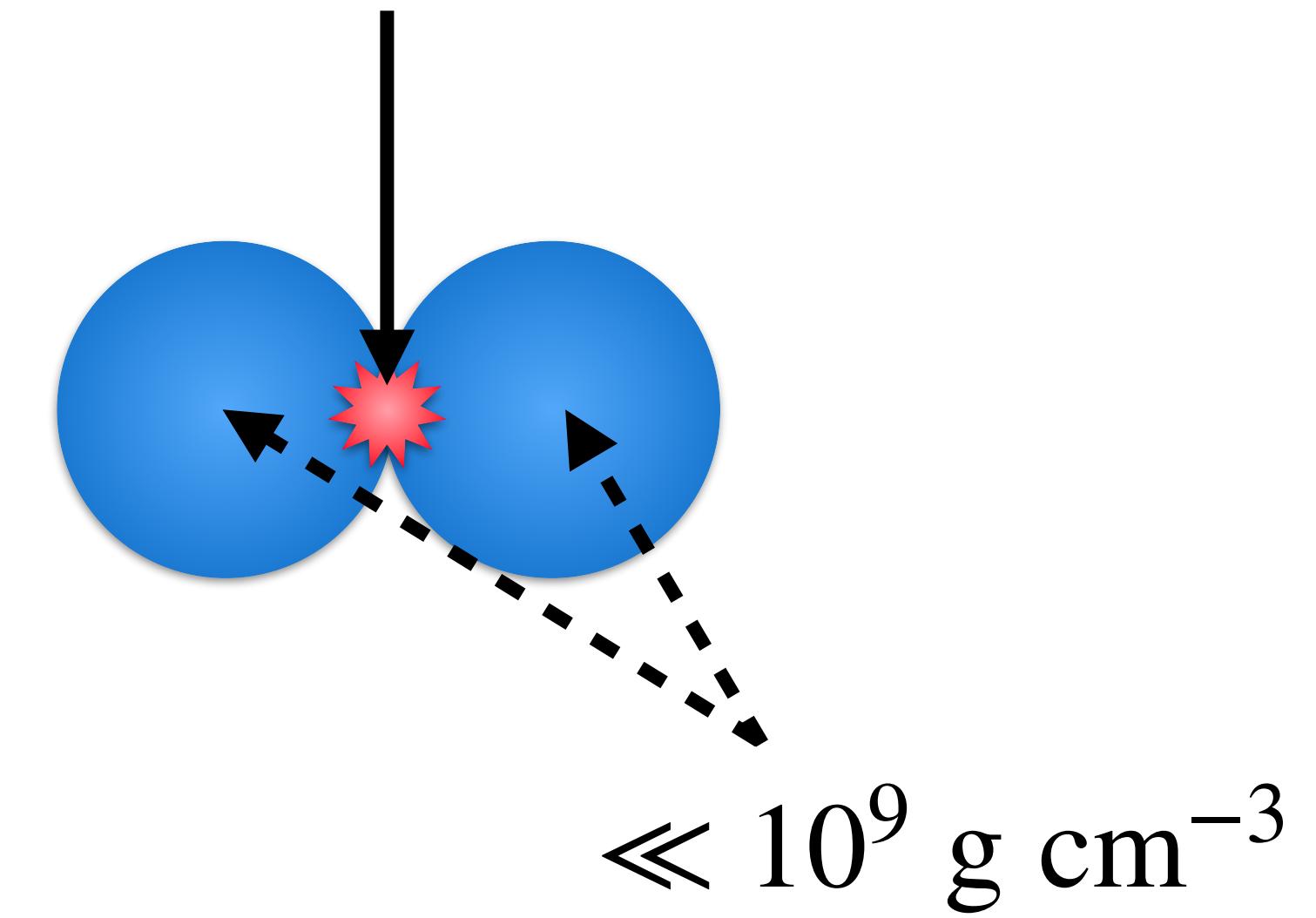


Evolve in hydrostatic way



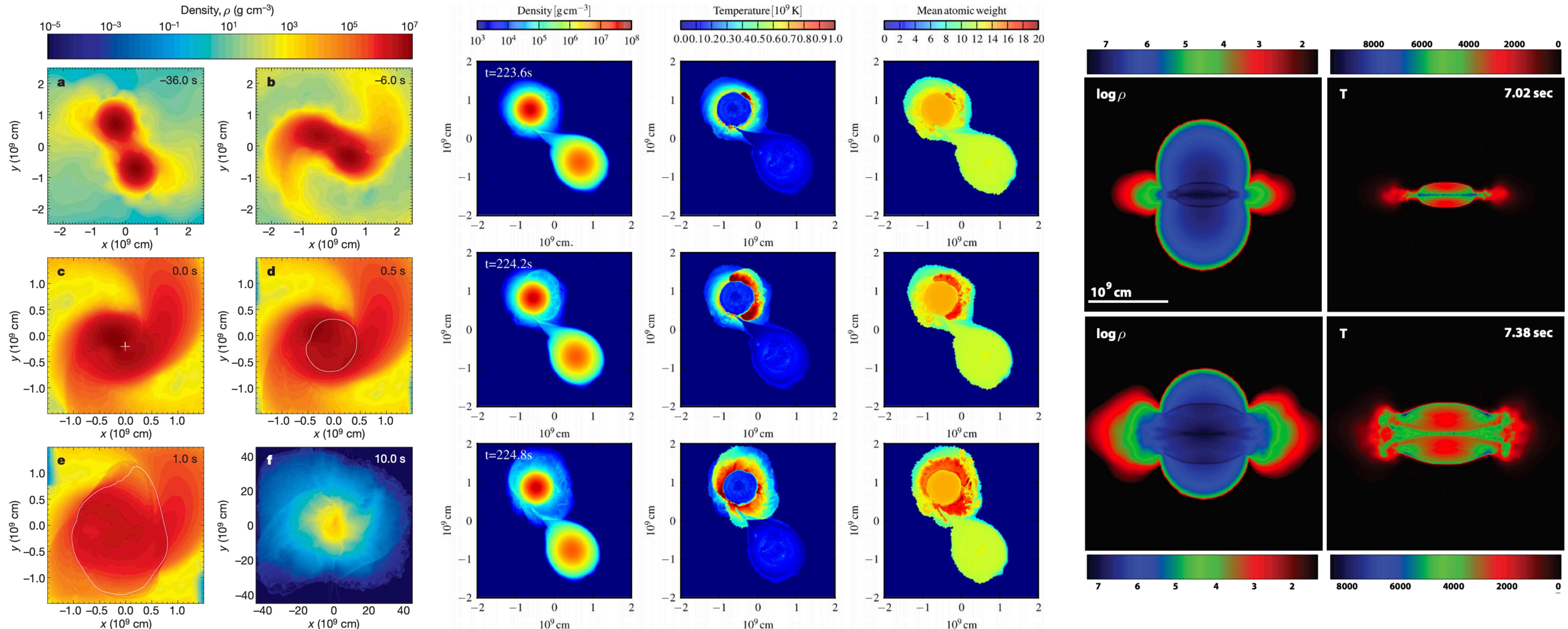
Ignite
in hydrostatic way

Ignite in hydrodynamical way



$\gtrsim 10^9 \text{ g cm}^{-3}$

Many sub-Chandrasekhar-mass explosion models



Violent merger (Pakmor et al. 2010)

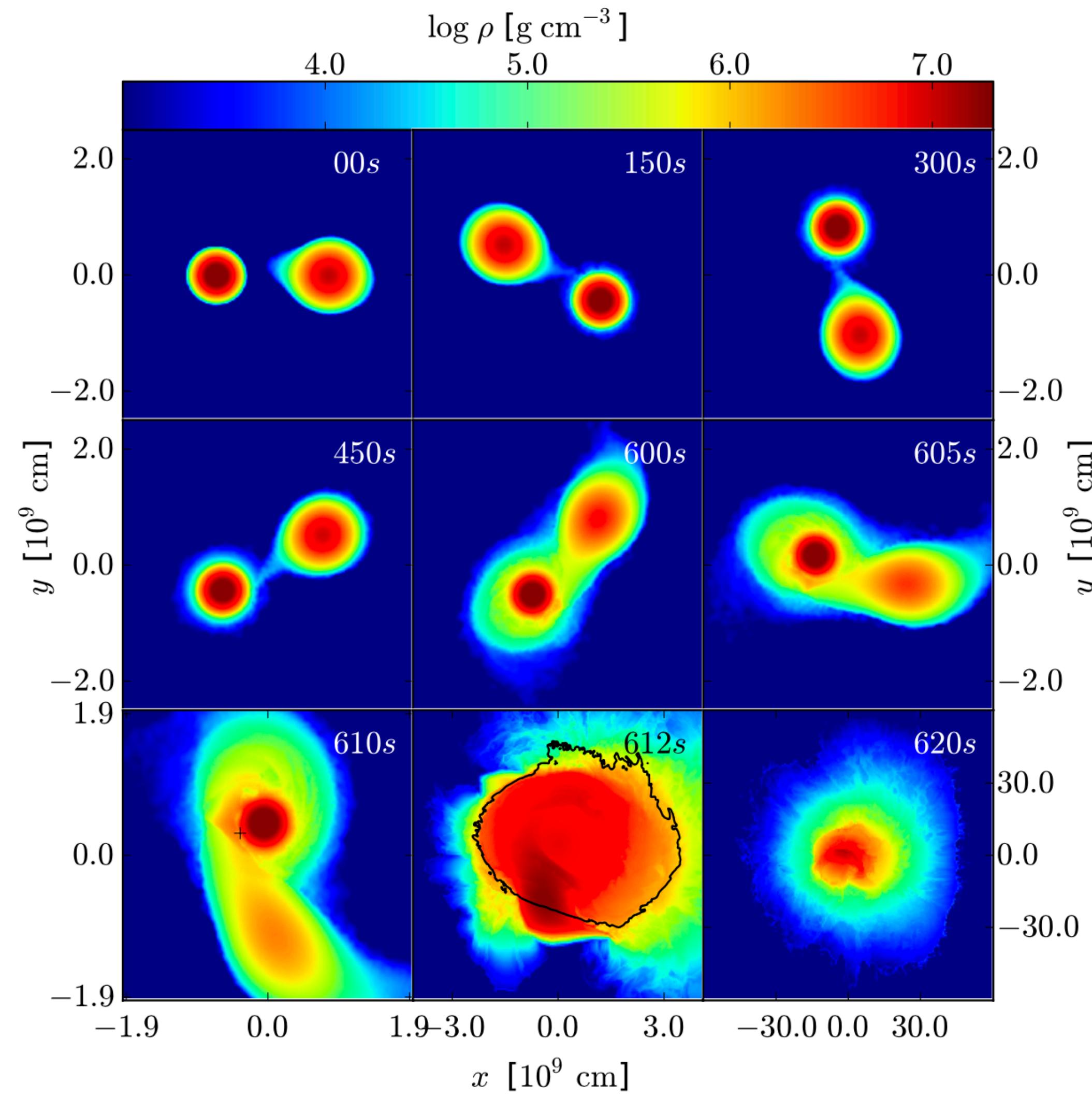
Hélium-ignited violent merger (Pakmor et al. 2013),
a.k.a. D⁶ (Shen et al. 2018)

WD collision (Rosswog et al. 2009)

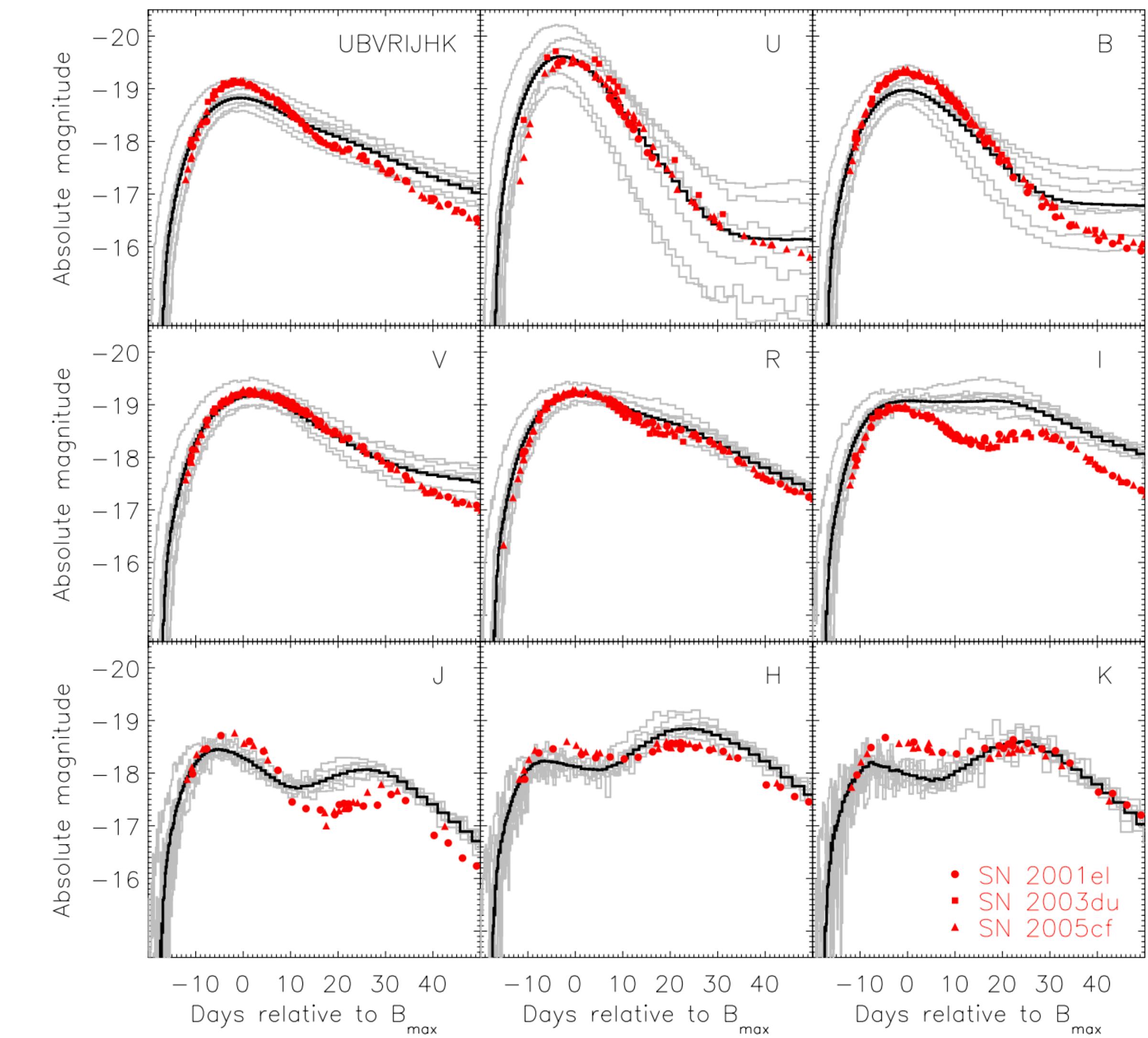
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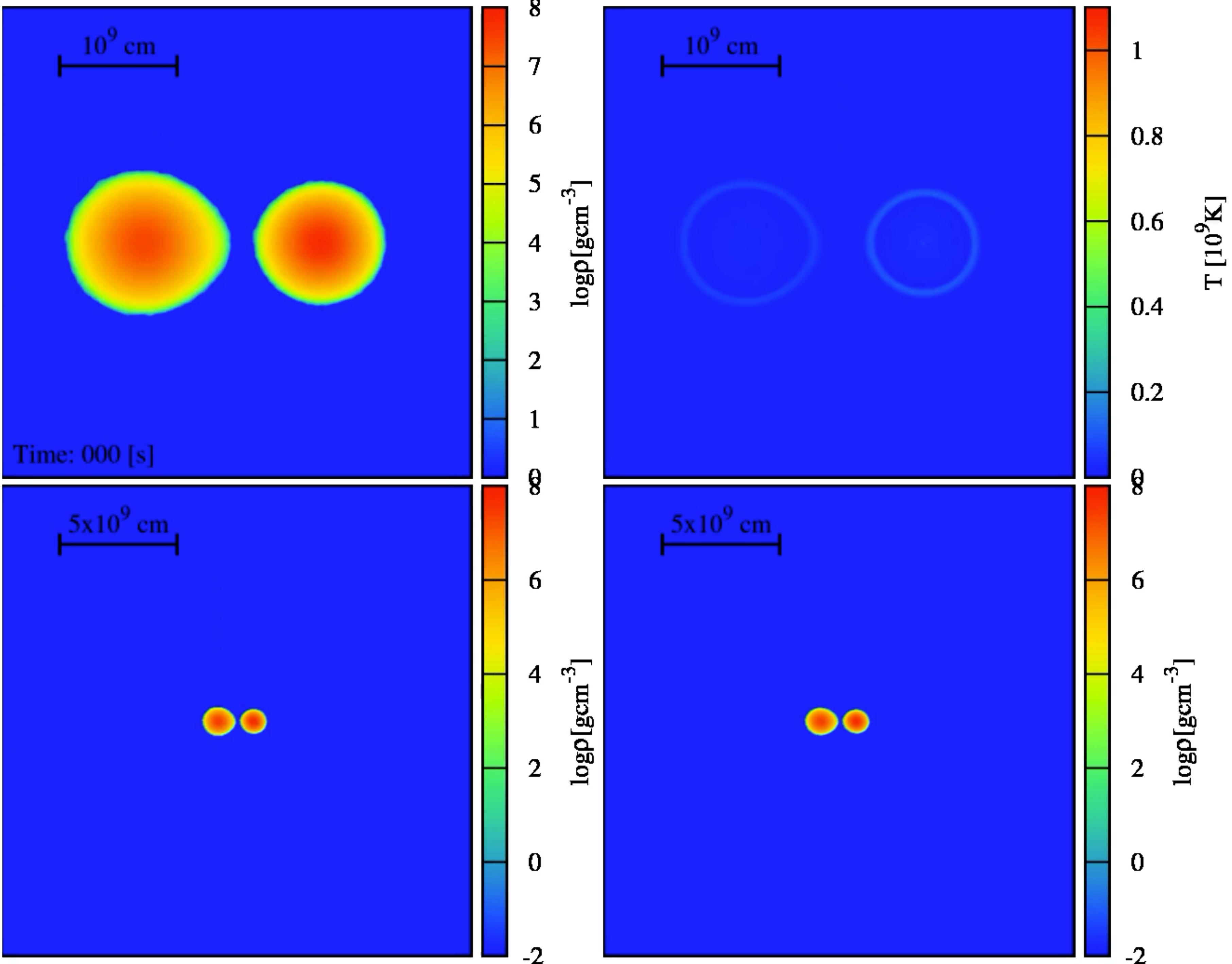
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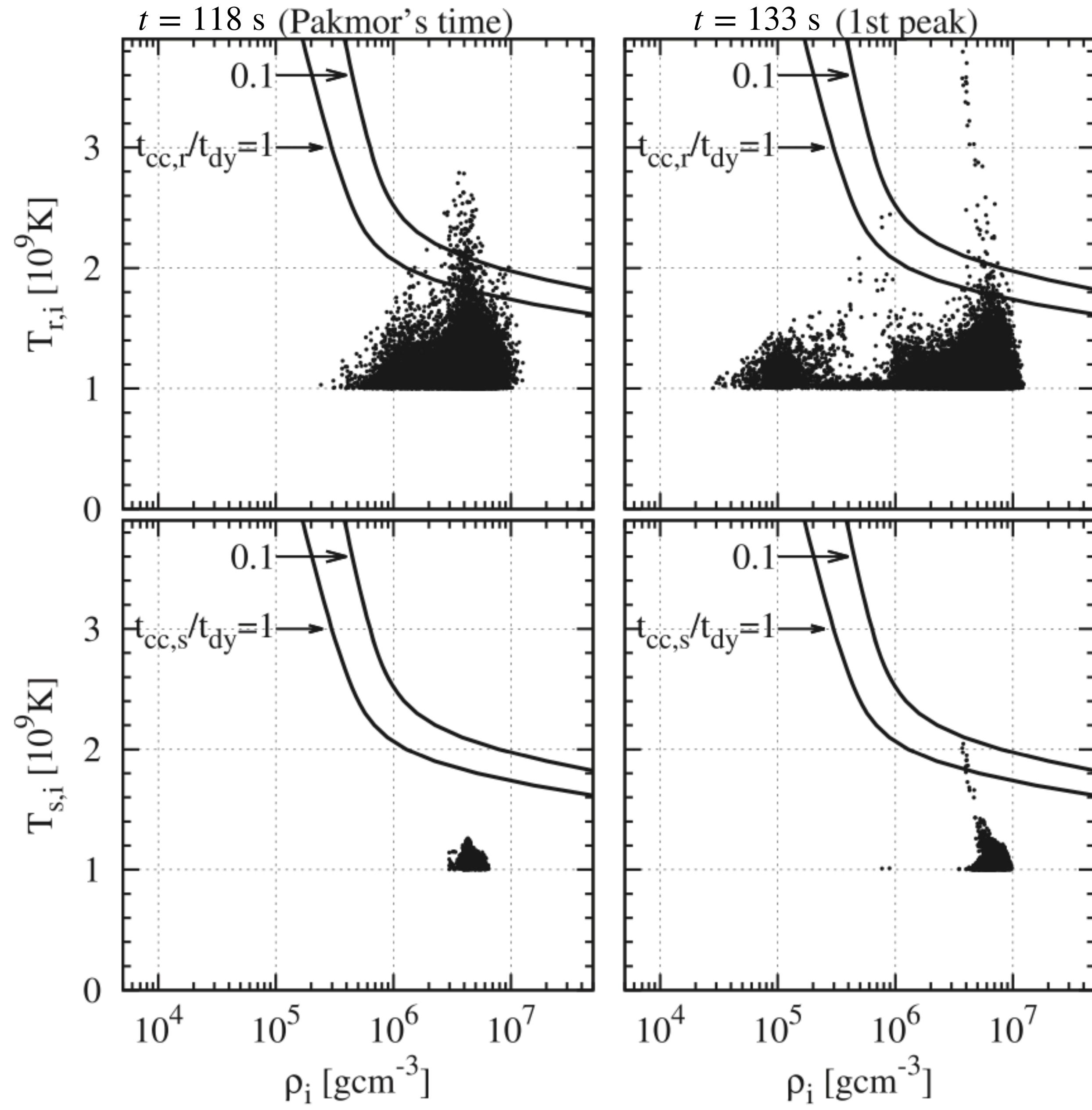
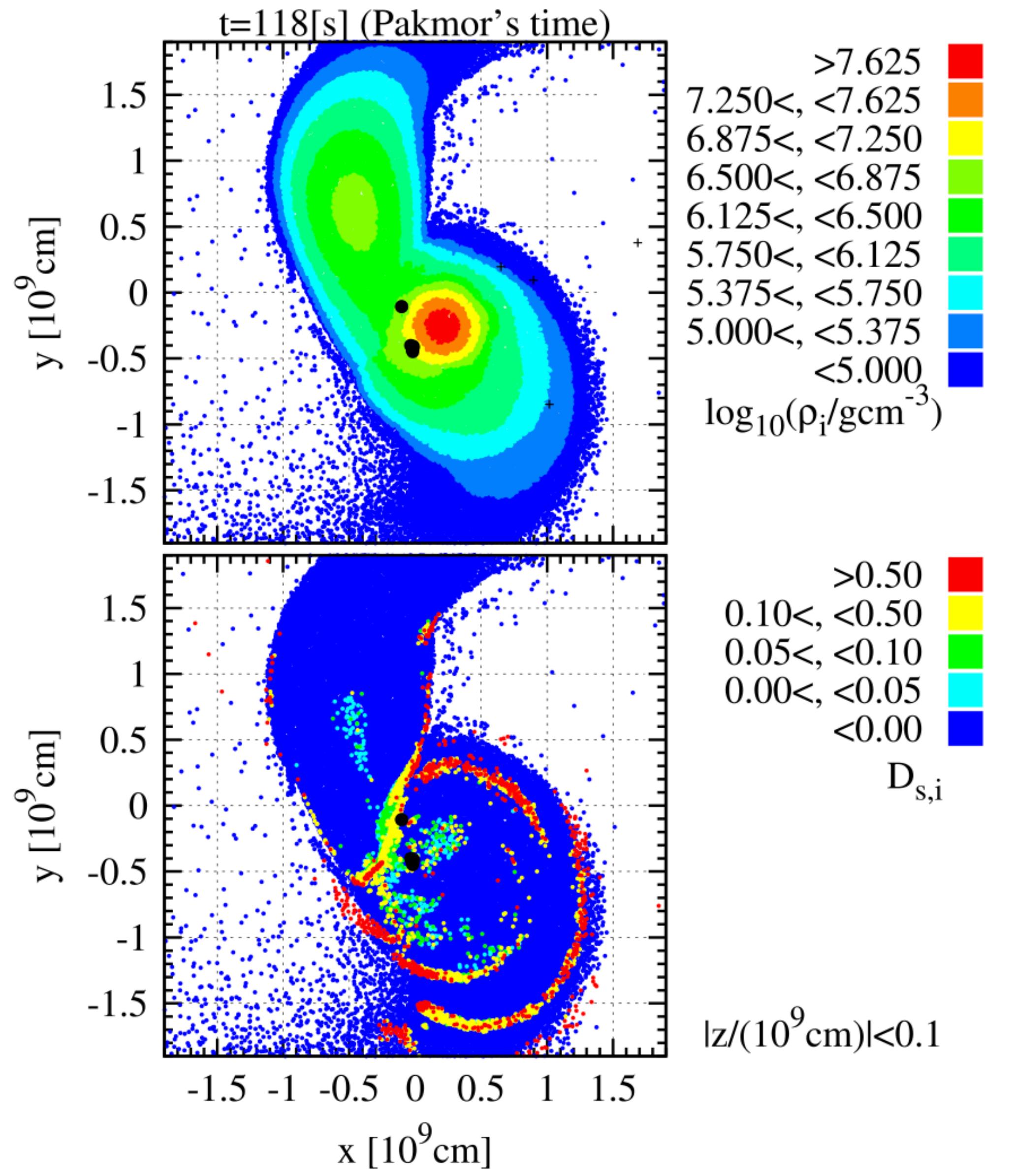
Violent merger



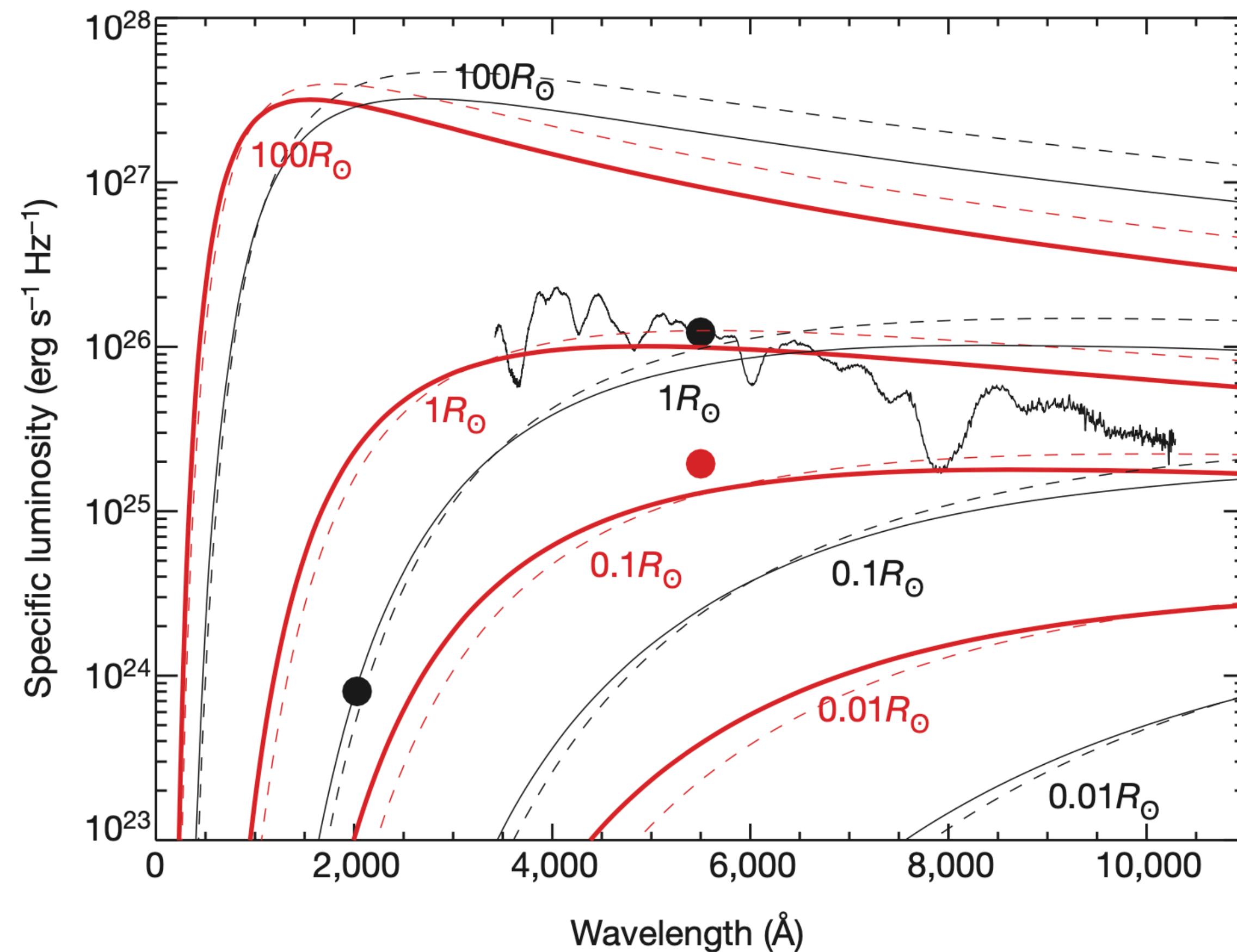
Pakmor et al. (2010; 2011; 2012)



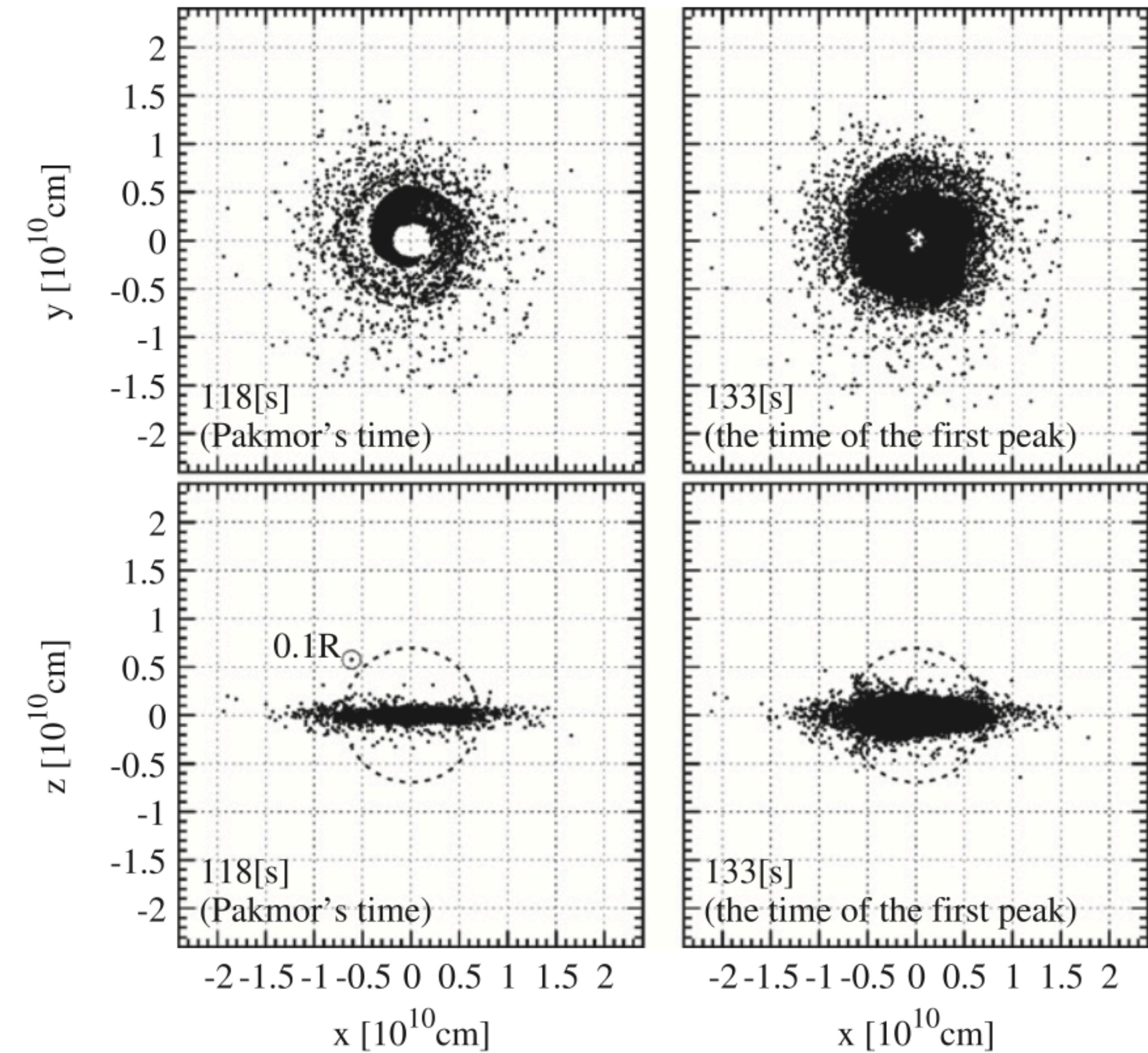




Early light curve of SN2011fe



Nugent et al. (2011)



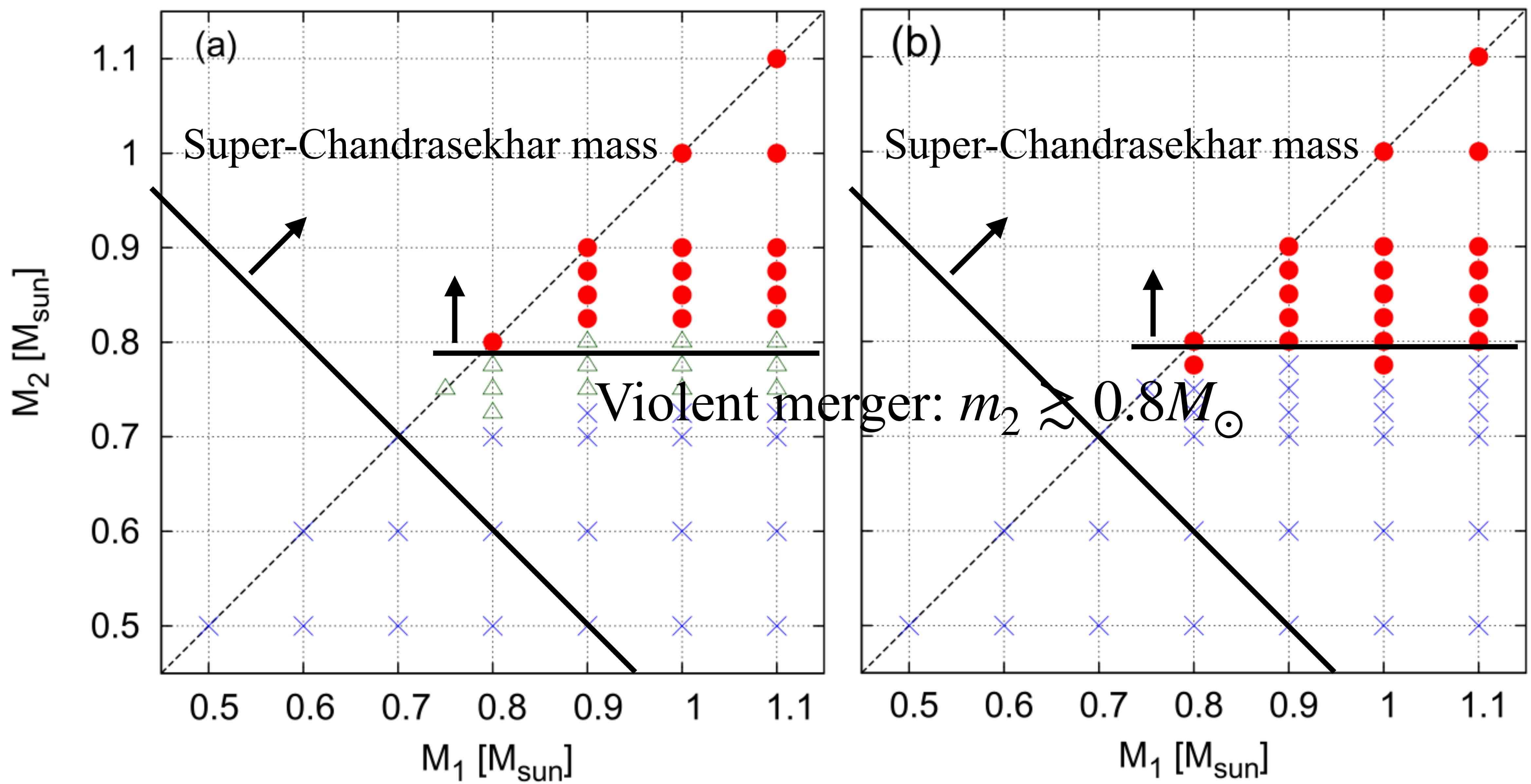
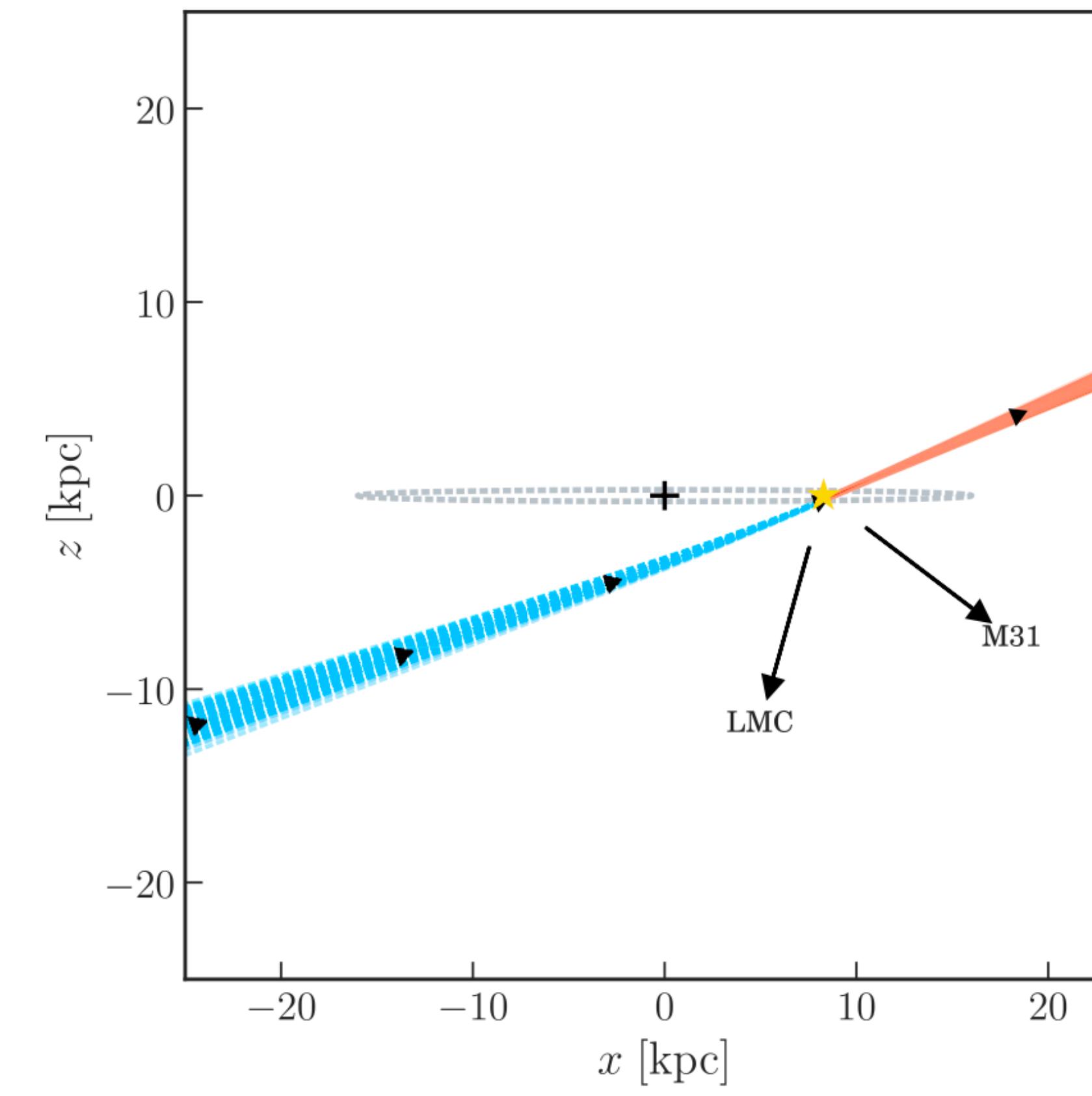
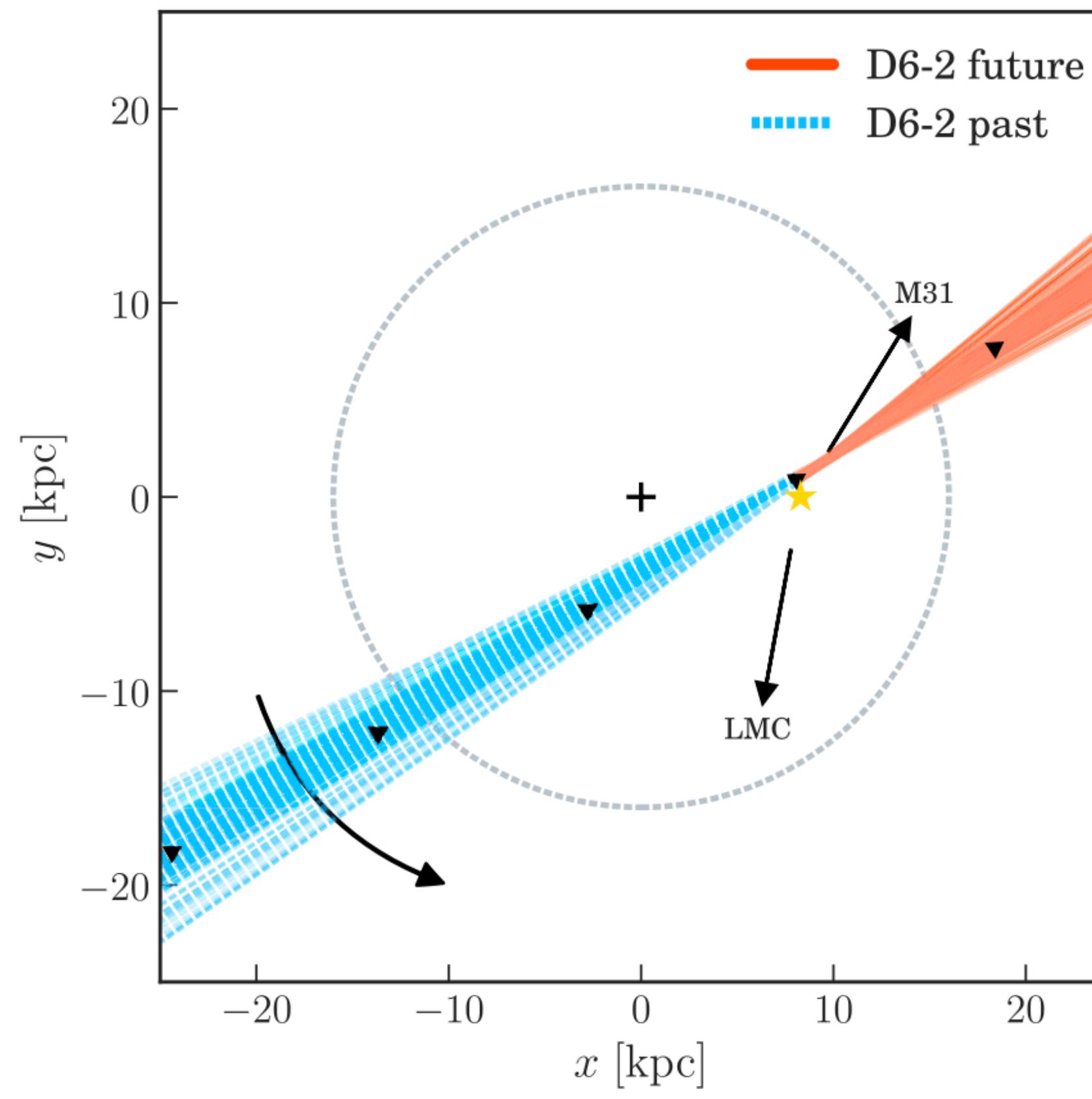


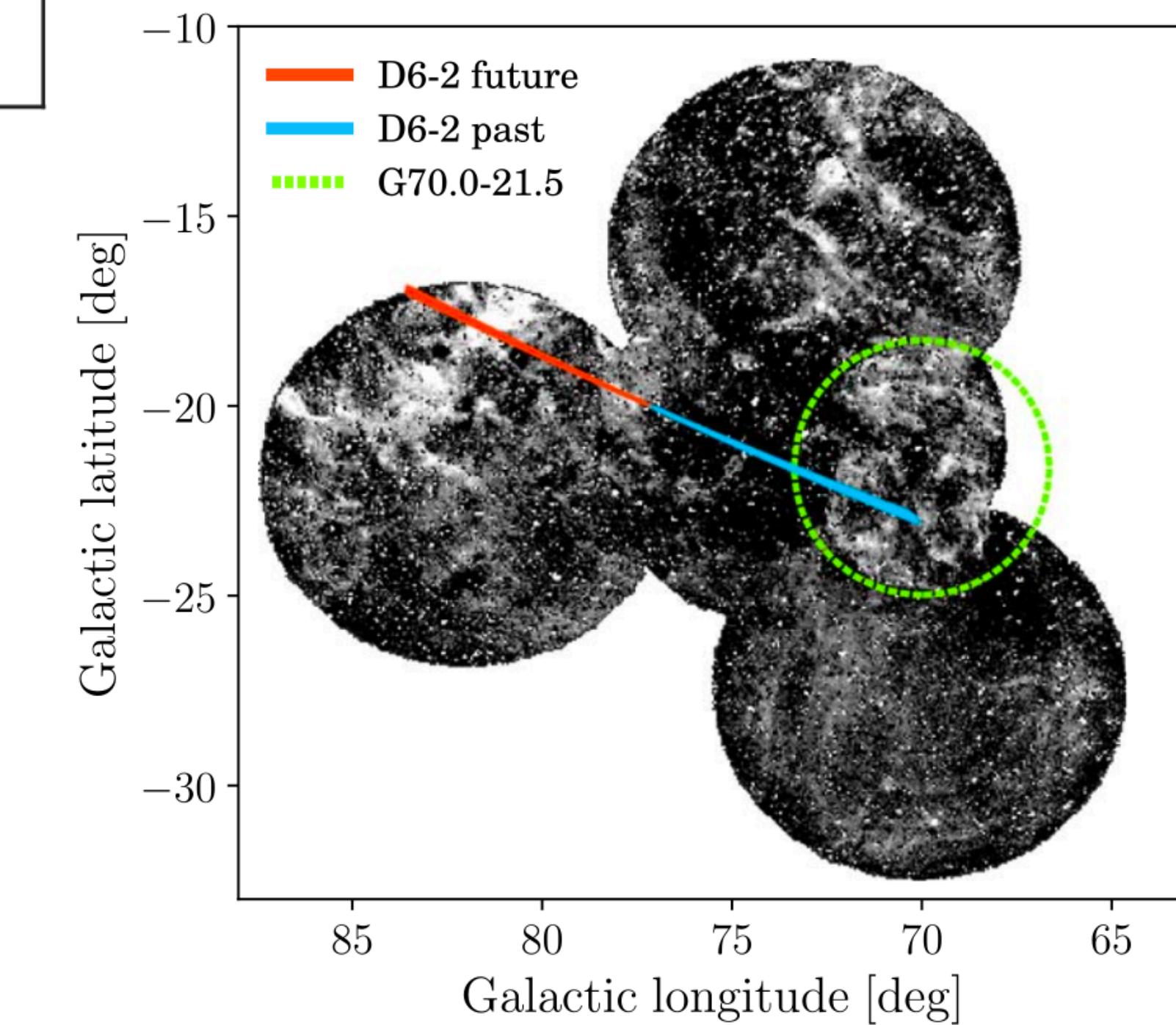
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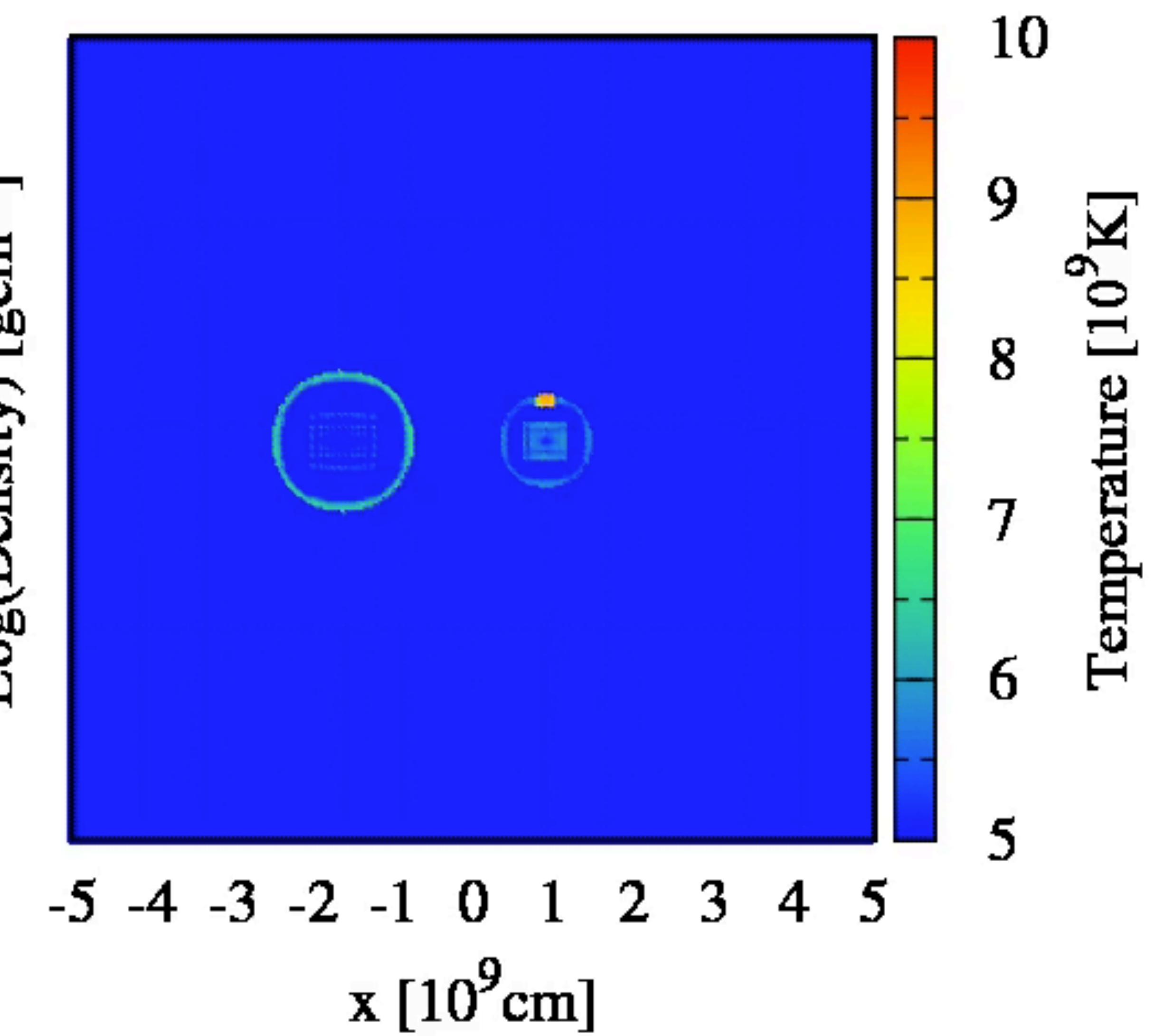
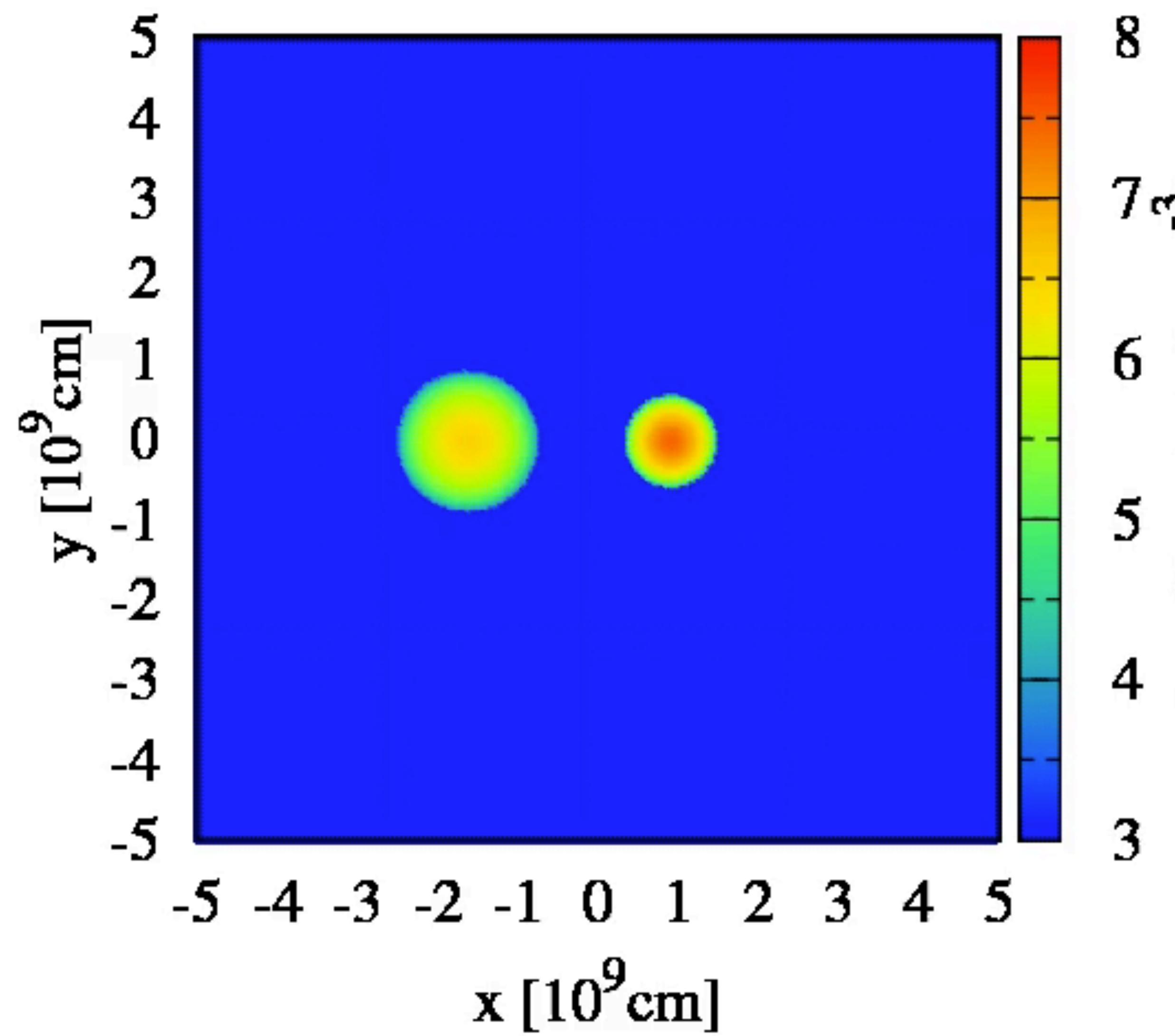
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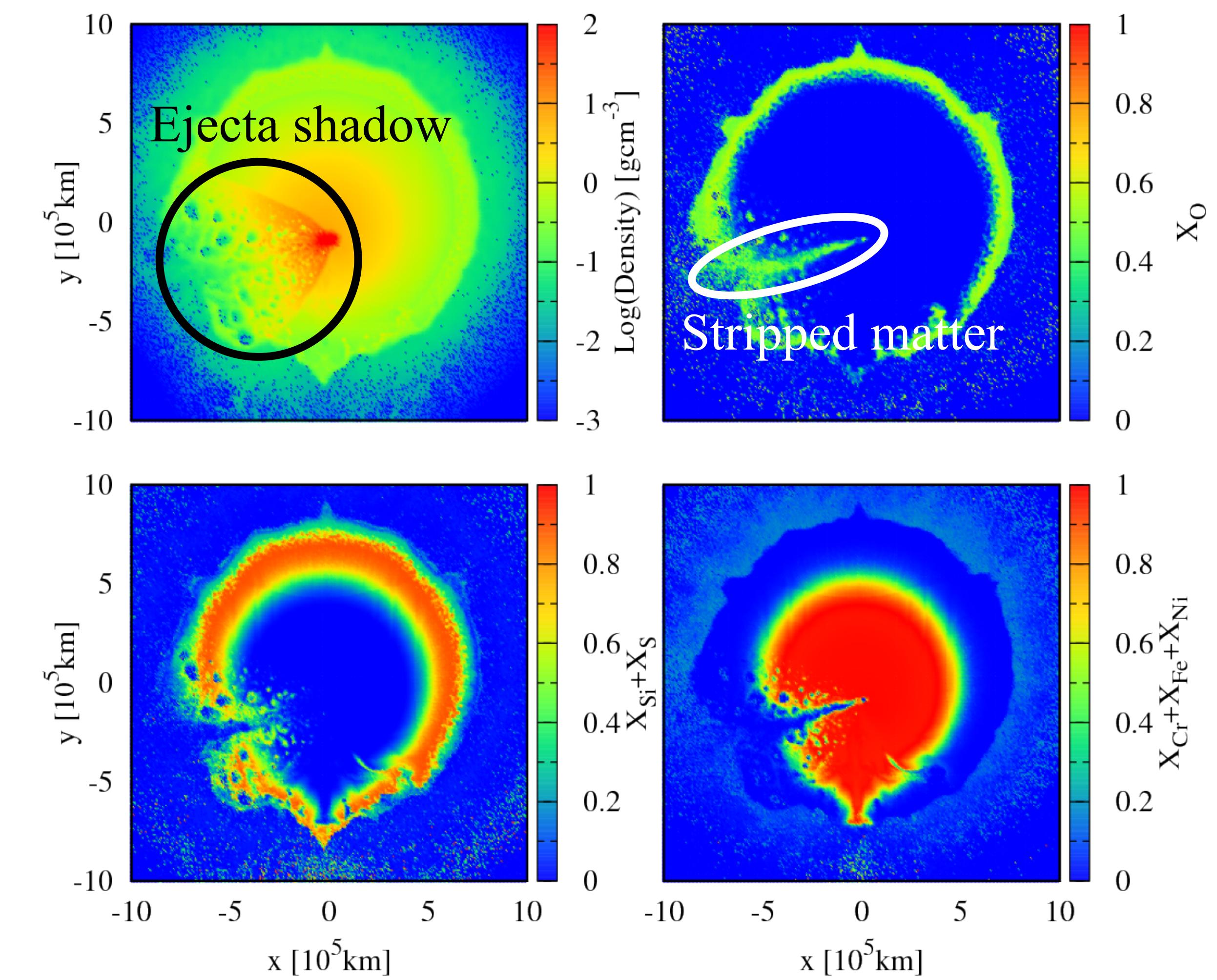
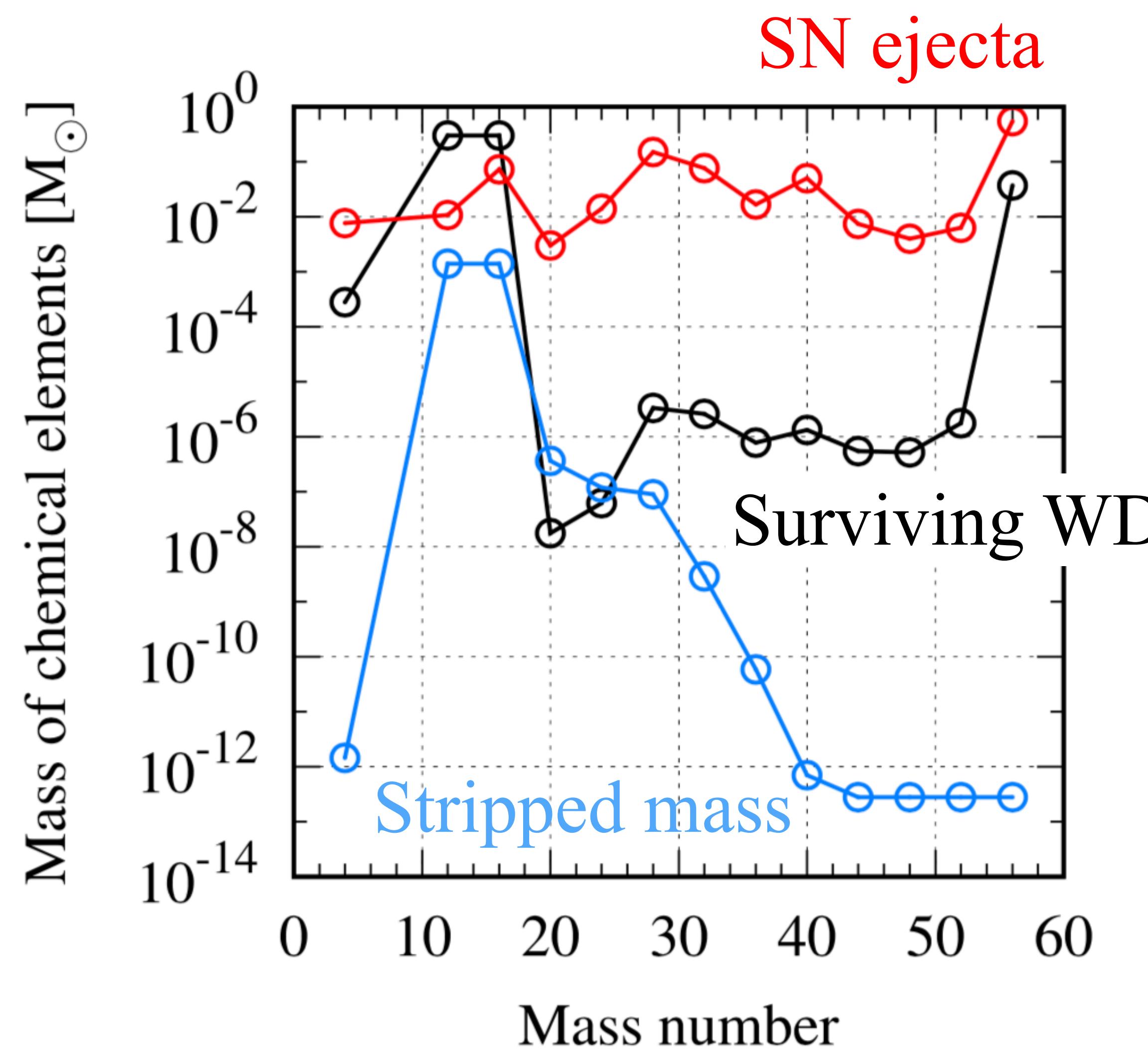
Nickname	$\text{RV}_{\text{helio}}^{\text{a}}$ (km s $^{-1}$)	$v_{\text{proper,helio}}^{\text{b}}$ (km s $^{-1}$)	$v_{\text{Galacto}}^{\text{c}}$ (km s $^{-1}$)
D6-1	1200 ± 40	2200 [1400–6800]	2300 [1600–6600]
D6-2	20 ± 60	1200 [700–1500]	1300 [1000–1900]
D6-3	-20 ± 80	2400 [1700–11100]	2400 [1400–9000]

Shen et al. (2018)





Tanikawa et al. (2018, ApJ, 868, 90; 2019, ApJ, 885, 103)

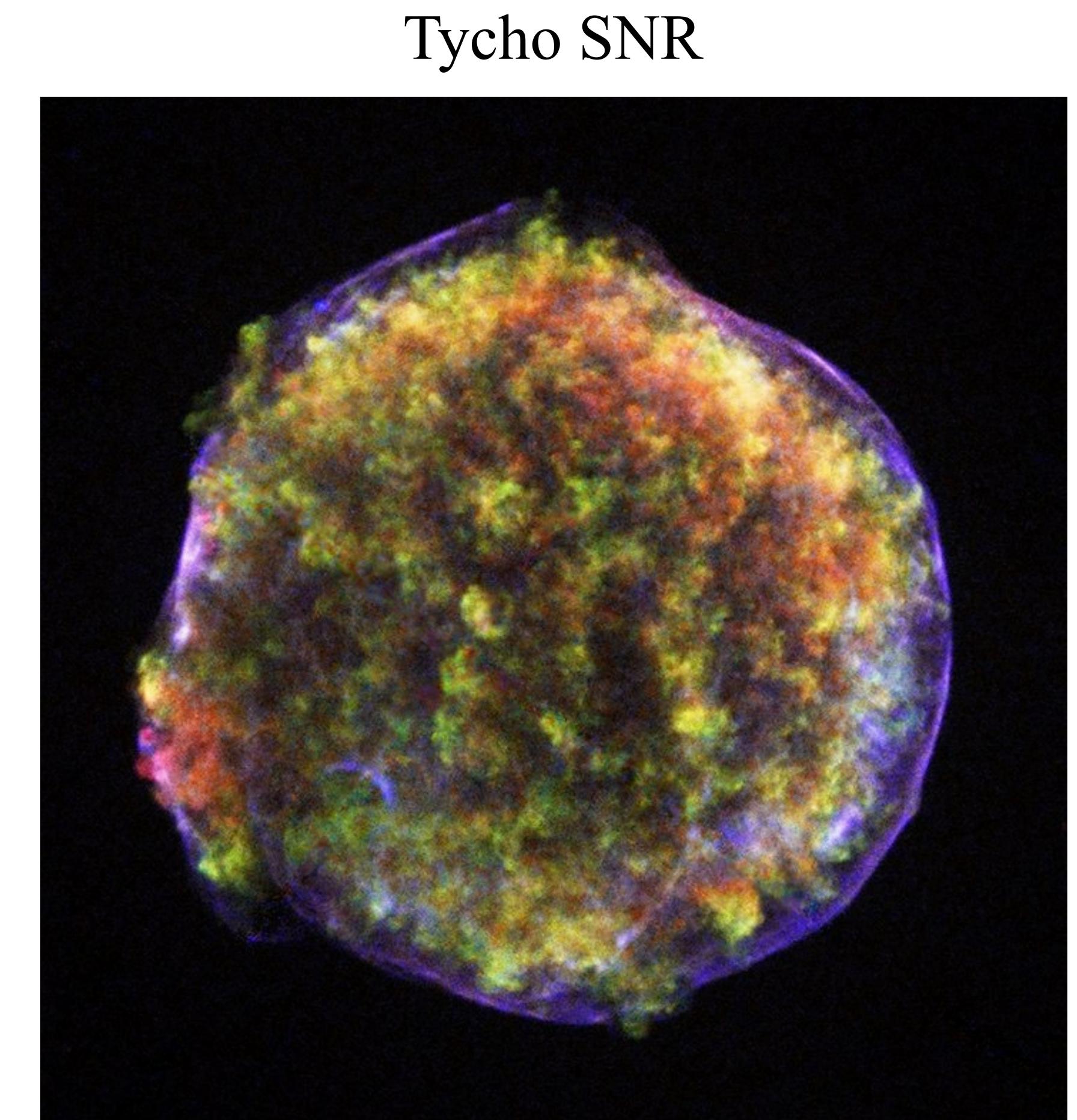
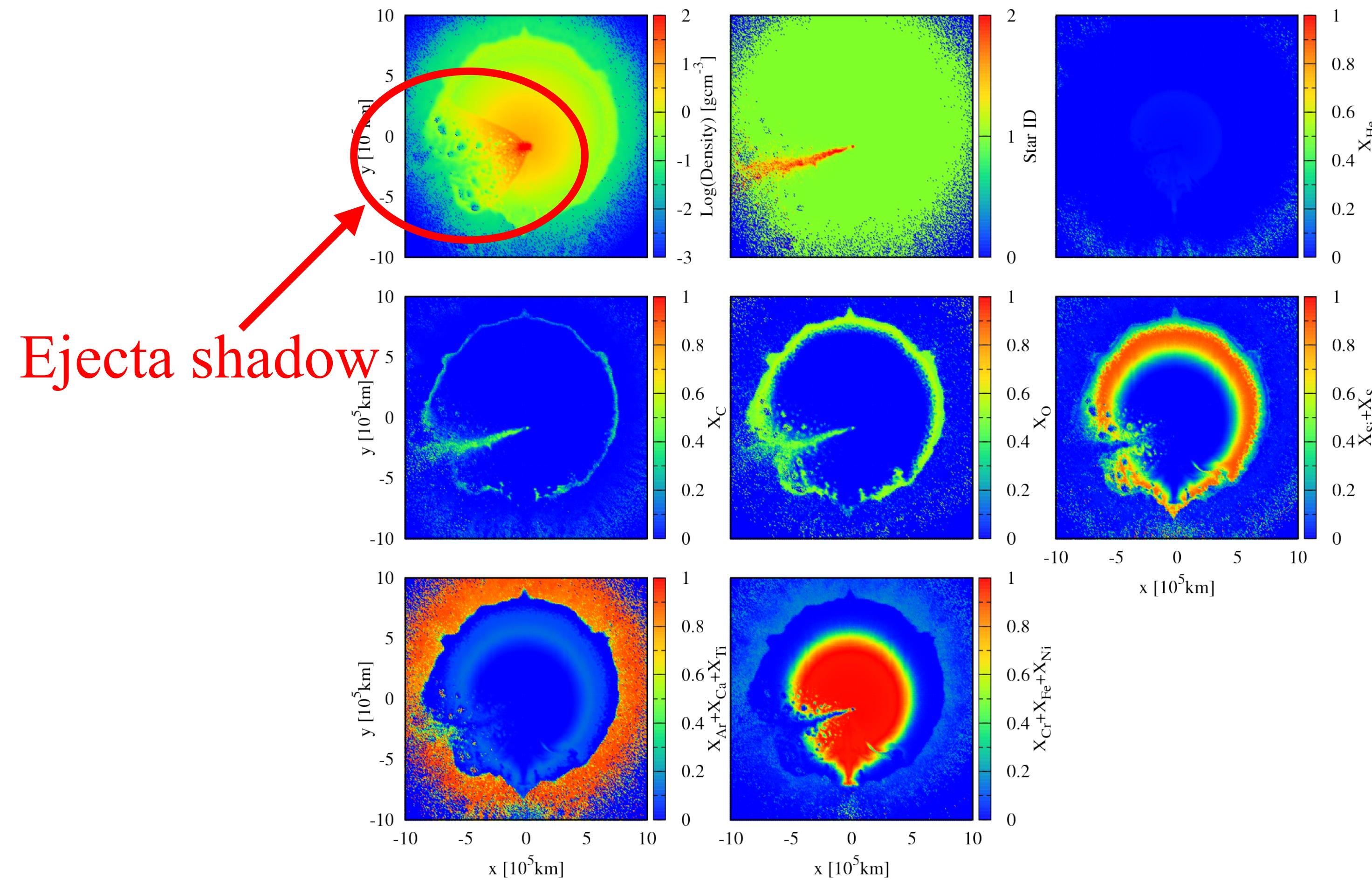


Tanikawa et al. (2018, ApJ, 868, 90; 2019, ApJ, 885, 103)

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D^6 supernova ejecta

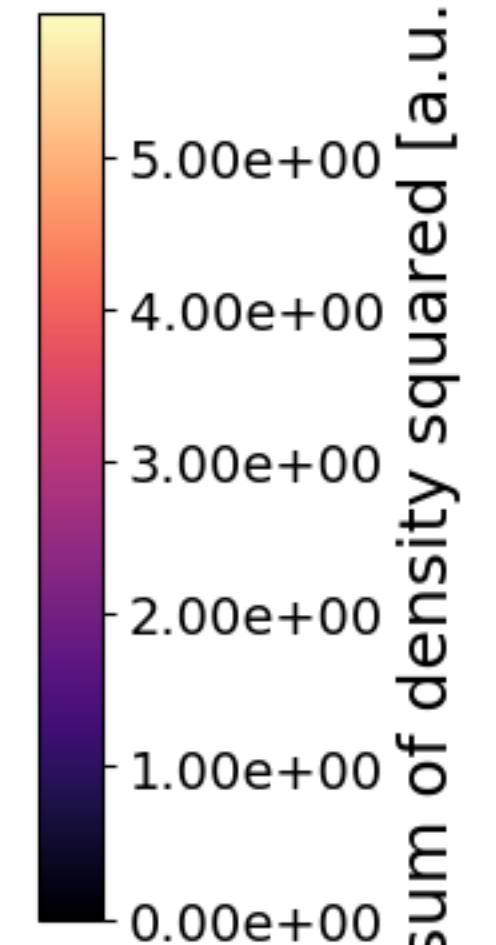


Tanikawa et al. (2018, ApJ, 868, 90; 2019, ApJ, 885, 103)

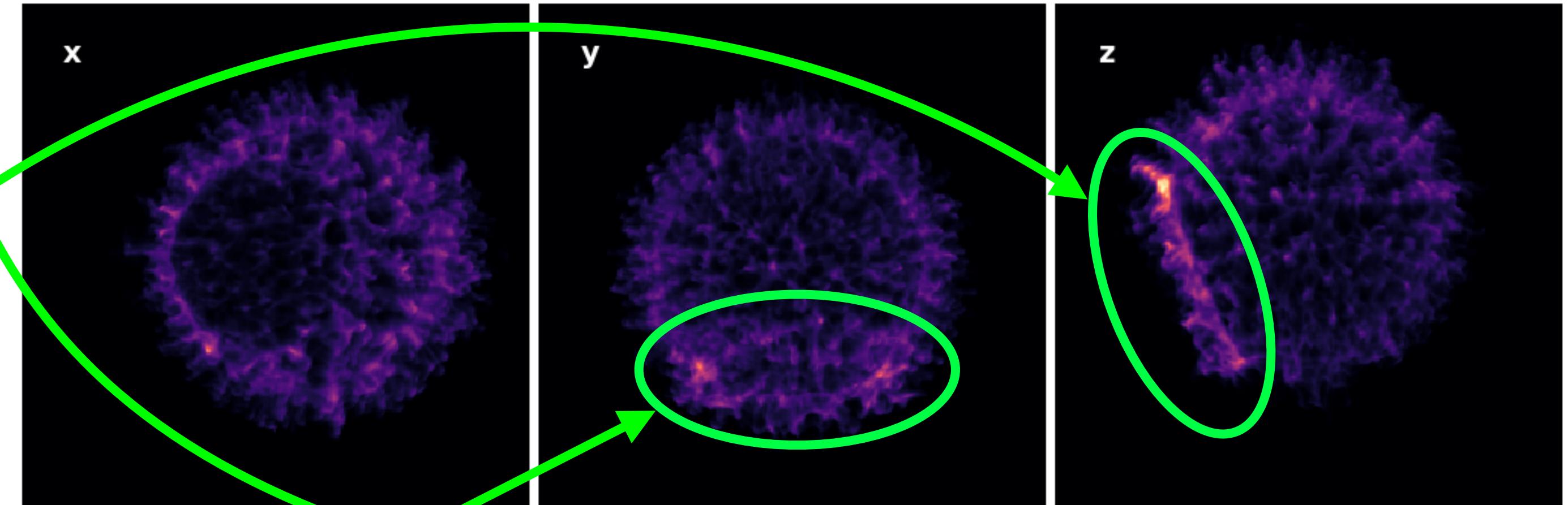
SNR simulation results



Gilles Ferrand

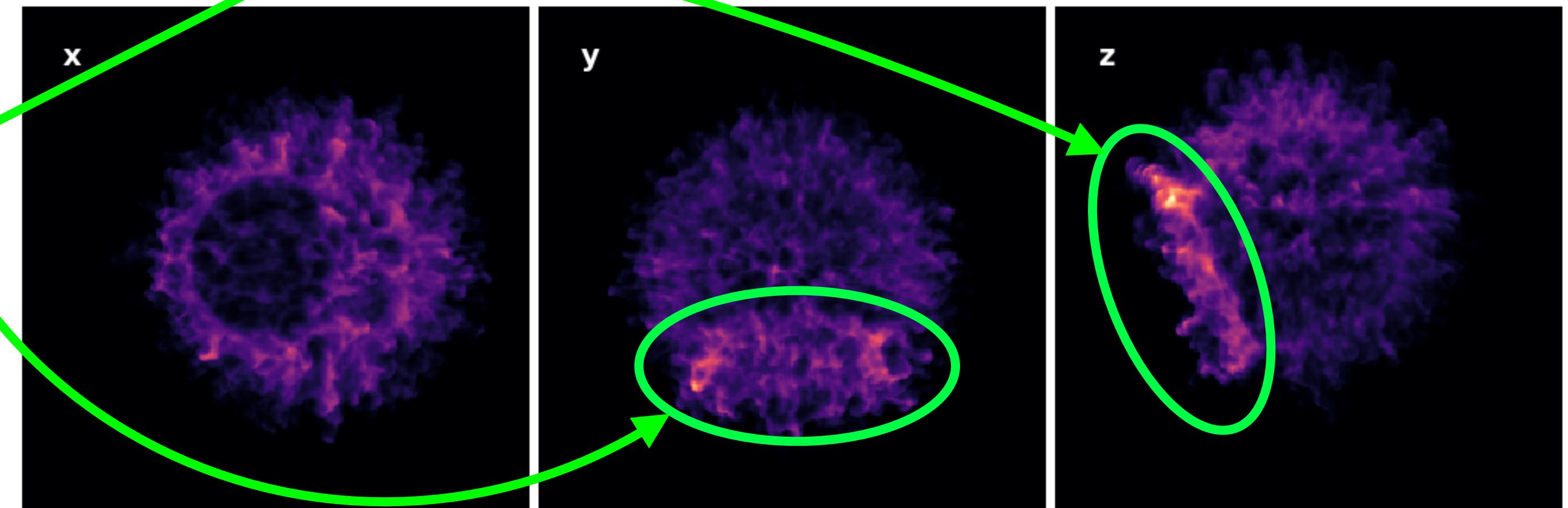


D6 at t = 500 yr



Faster reverse shock because
of the lower-density shadow

D6 at t = 1000 yr



Long-lived dark-patch and
bright-ring structure

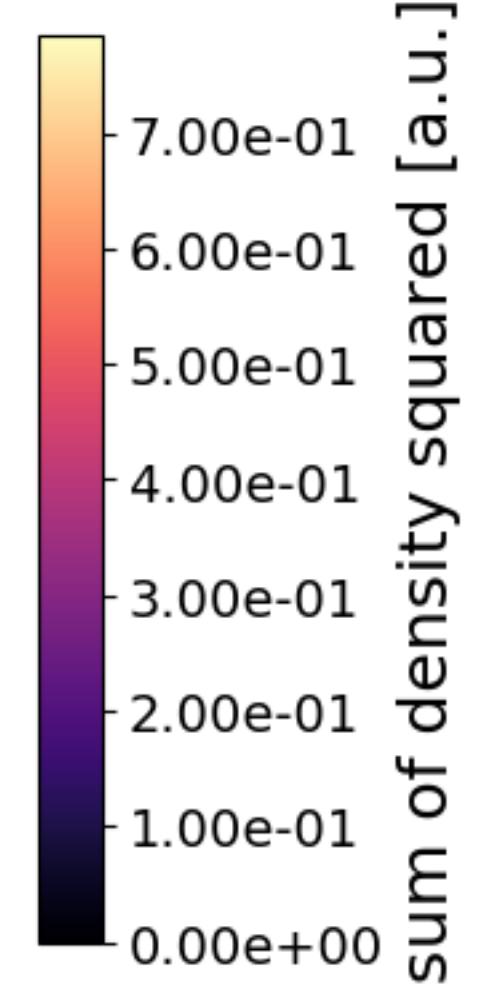


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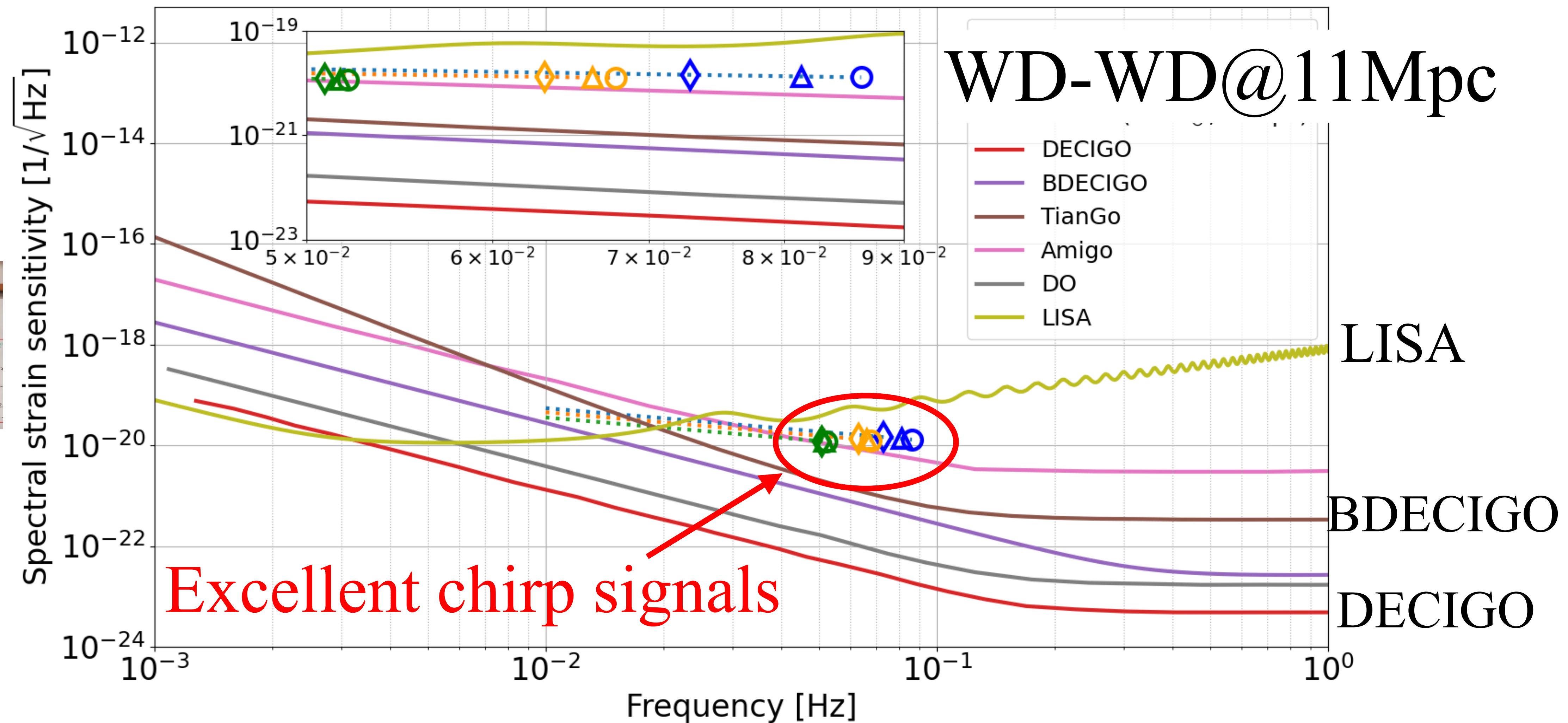
GW observation by DECIGO



Tomoya Kinugawa

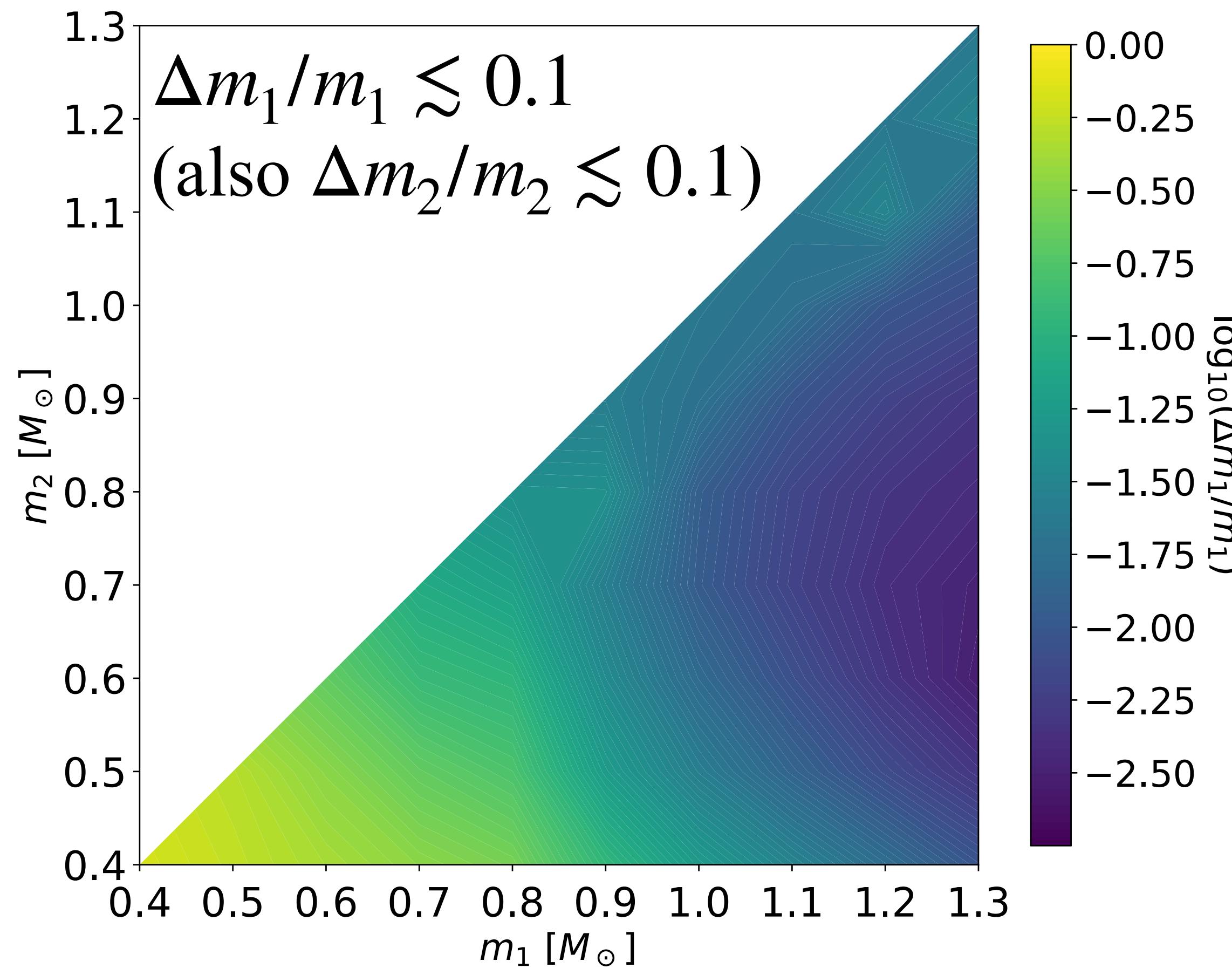


Hiroki Takeda

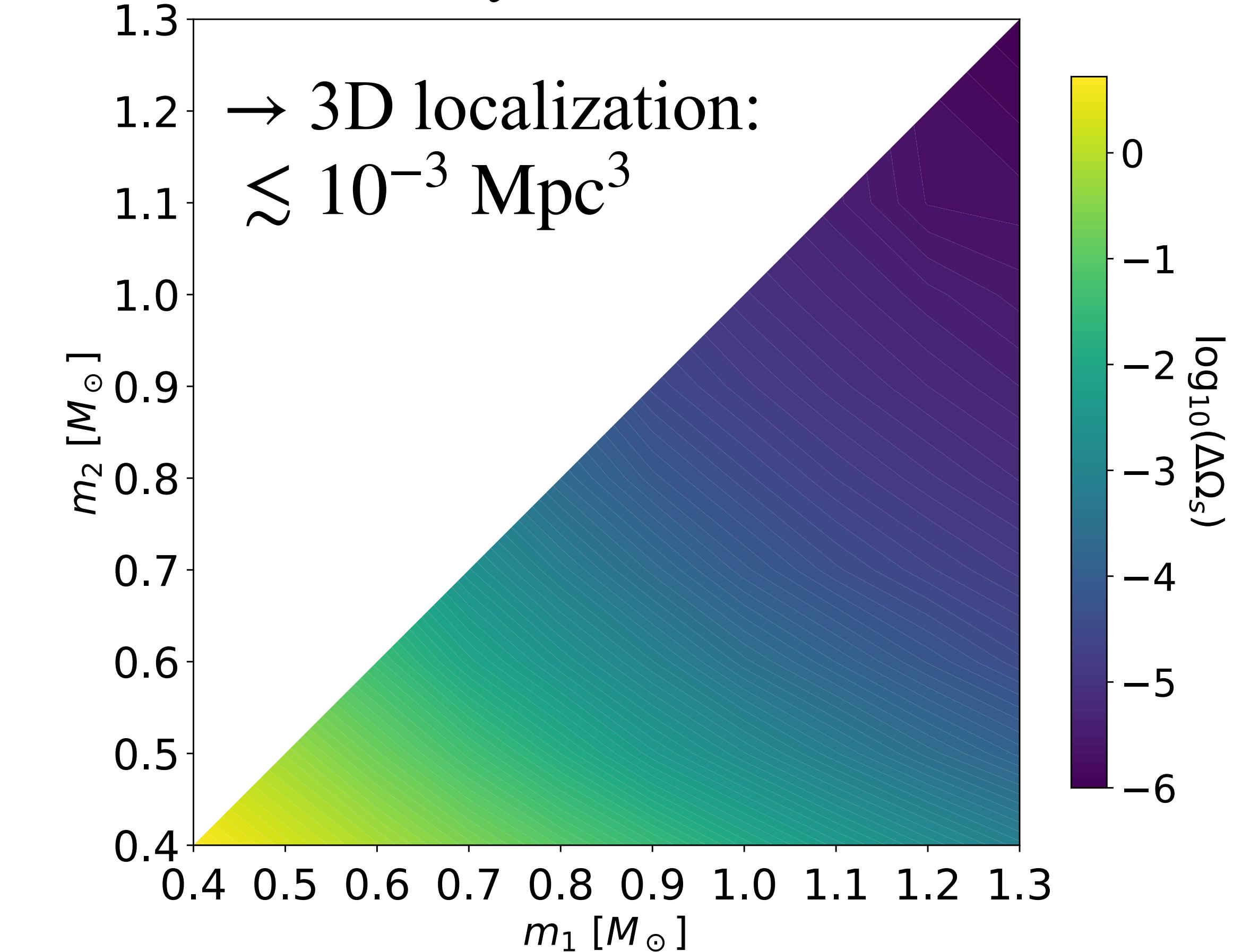


Well-measured mass and localization

The heavier WD

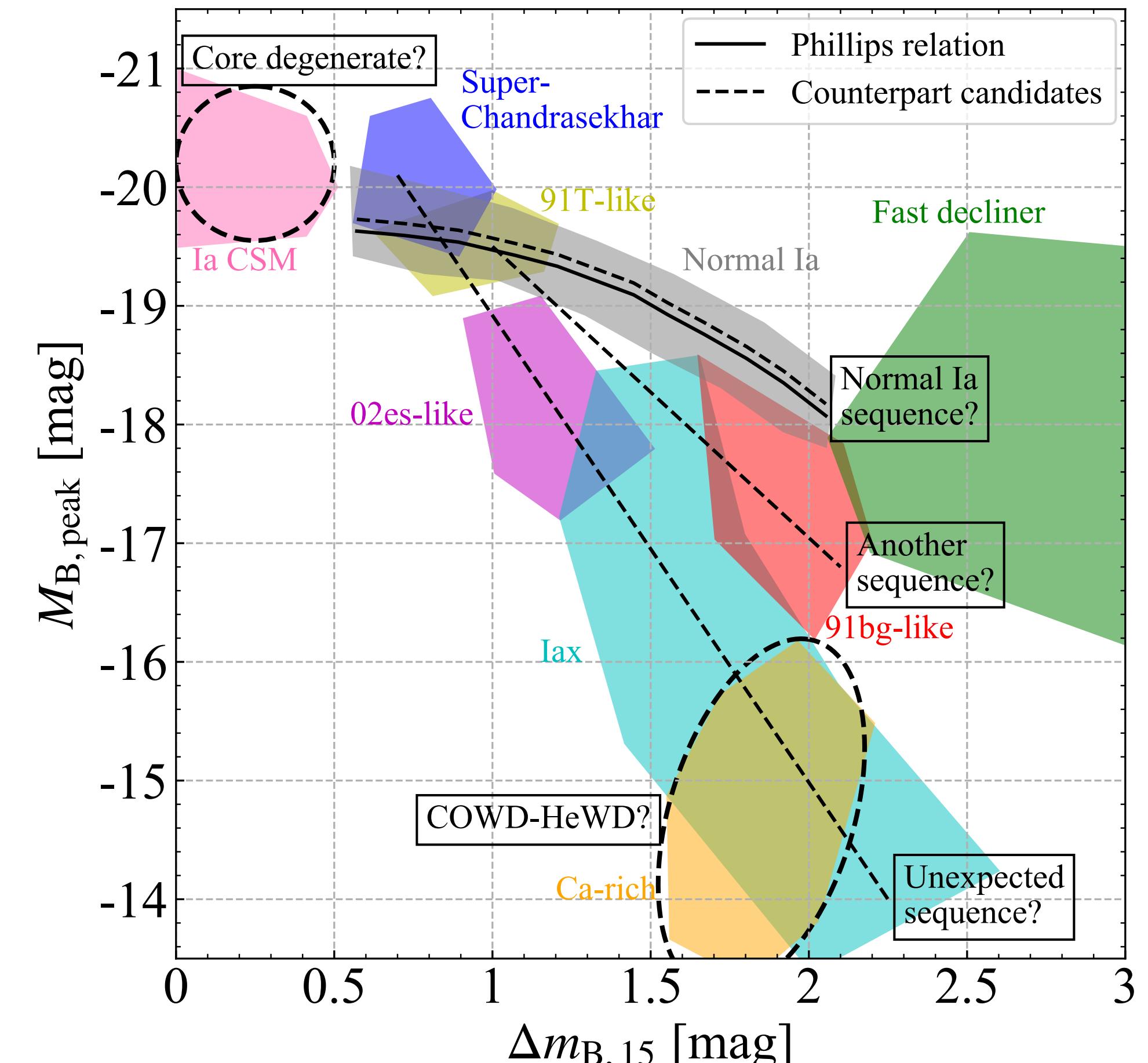


Sky localization



Multi-messenger astronomy

- GW disappearance → Any transient
 - Transient features (EM observations)
 - WD masses (GW observations)
- Connecting between sub-Ch models and SNIa
 - Helium-ignited violent merger, or D⁶
 - Carbon-ignited Violent merger
 - Spiral instability
- GW disappearance → No transient
 - No prompt explosion (possibly the slow merger)



Taubenberger (2017) reproduced by
Kinugawa, Takeda, Tanikawa, Yamaguchi (2022, ApJ, 938, 52)

Summary

- Violent merger is feasible, but
 - Progenitor size is large (Tanikawa et al. 2015, ApJ, 807, 40)
 - The event rate is small (Sato et al. 2016, ApJ, 821, 67)
- D⁶ model is similar to SN Ia, but
 - The central oxygen may be inconsistent (Tanikawa et al. 2018, 868, 90)
 - SNR shape is not spherical (Ferrand et al. ApJ, 930, 92)
- Deci-hertz GW will be helpful to link DD mergers to any transients (Kinugawa et al. 2022, ApJ, 938, 52)