

# QCD driven Supernova Explosions

BRAINSTORMING WORKSHOP

9-11 September 2026, PWr, Wrocław, Poland

Noshad Khosravi Largani

11 September 2026



Uniwersytet  
Wrocławski



SILESIA  
UNIVERSITY  
IN OPAVA

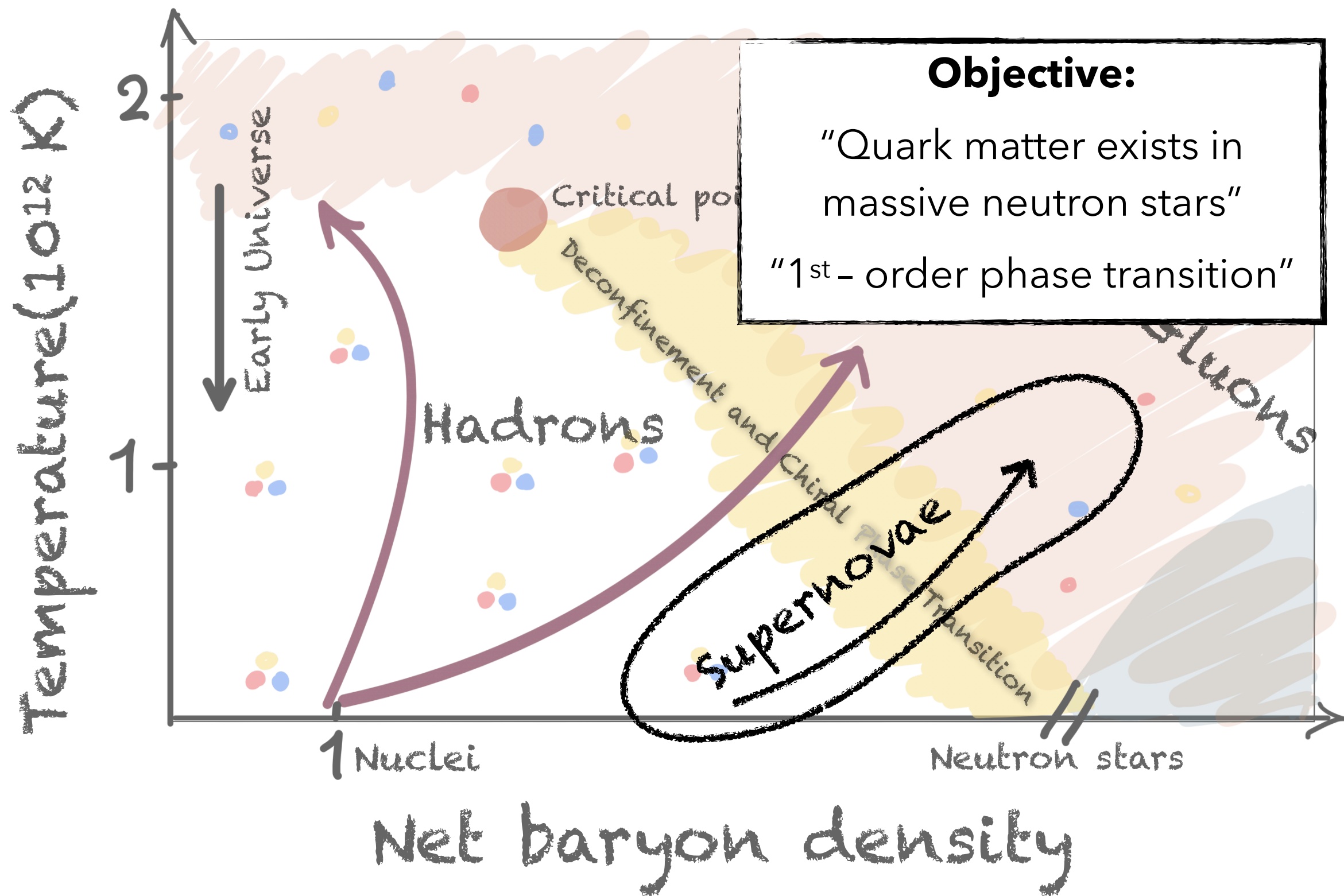


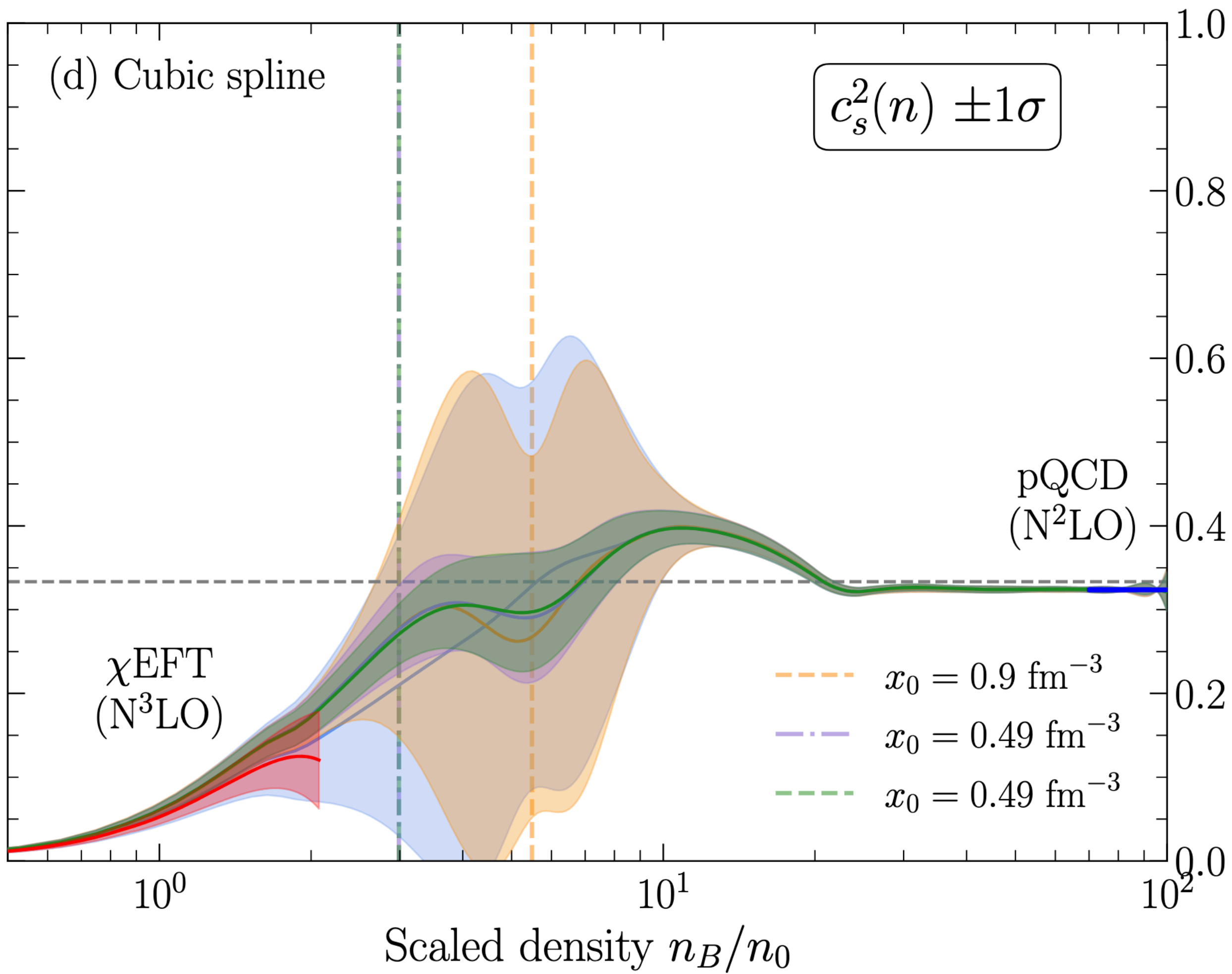
Wrocław  
University of  
Science and  
Technology

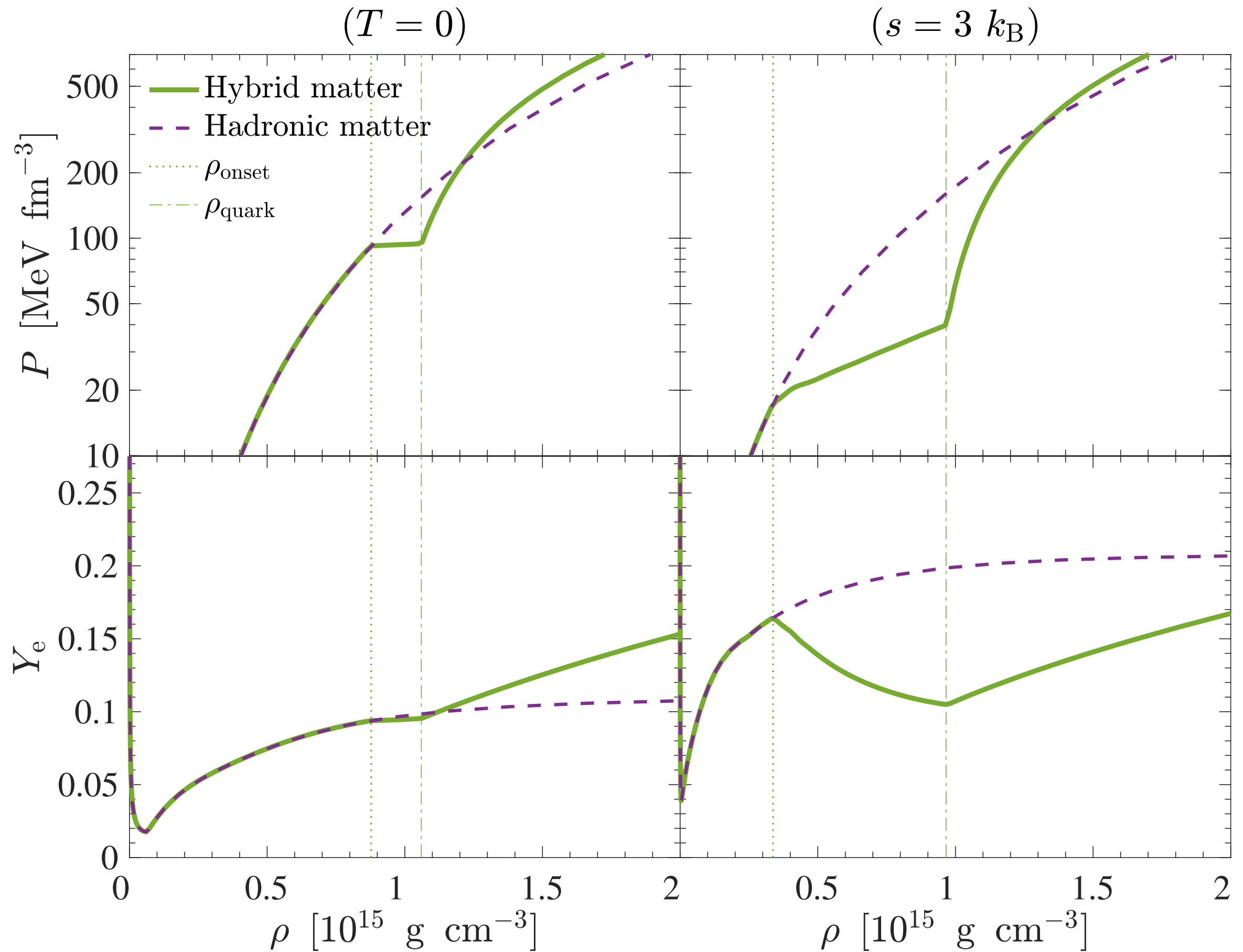


Narodowe  
Centrum  
Nauki

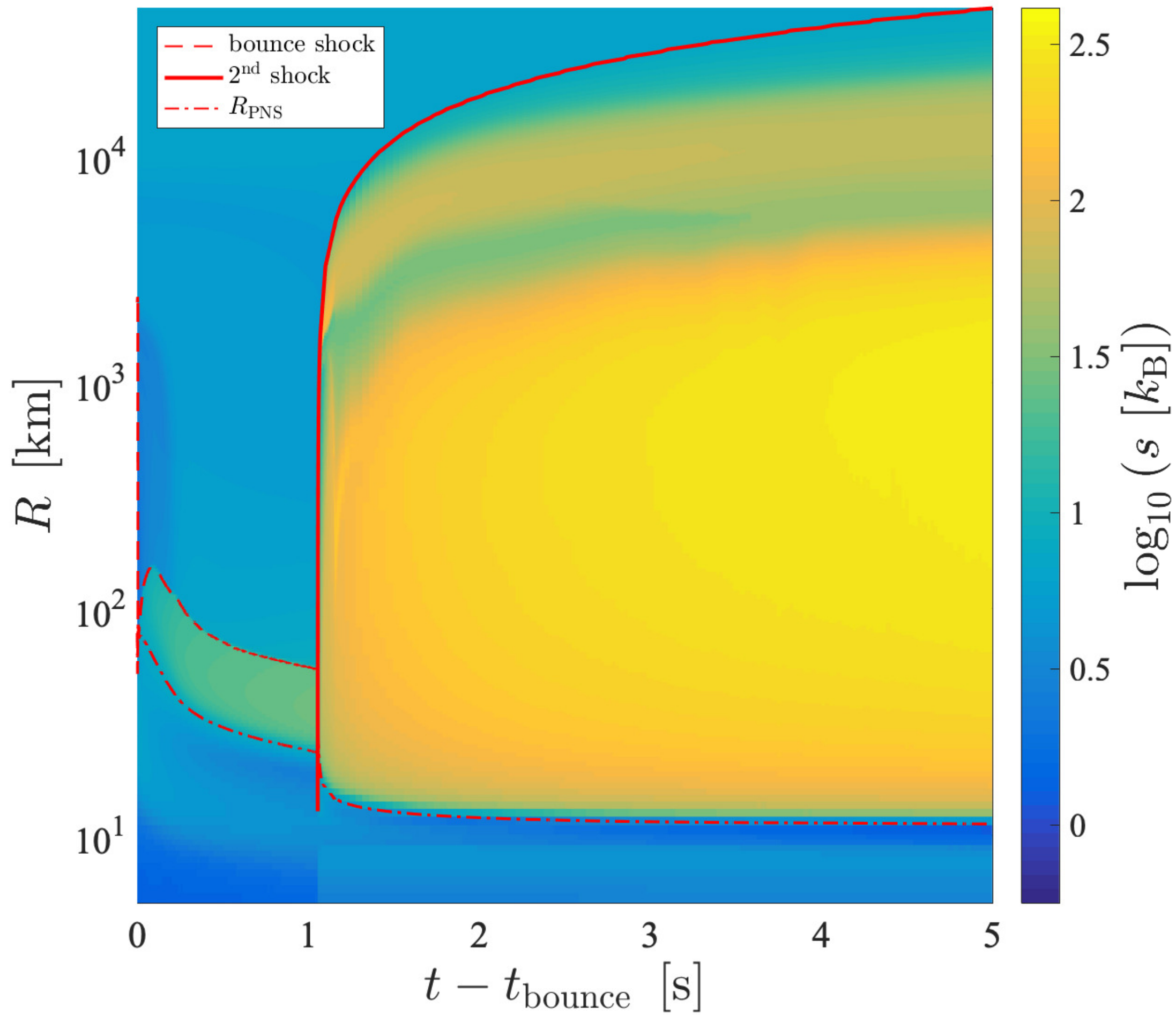


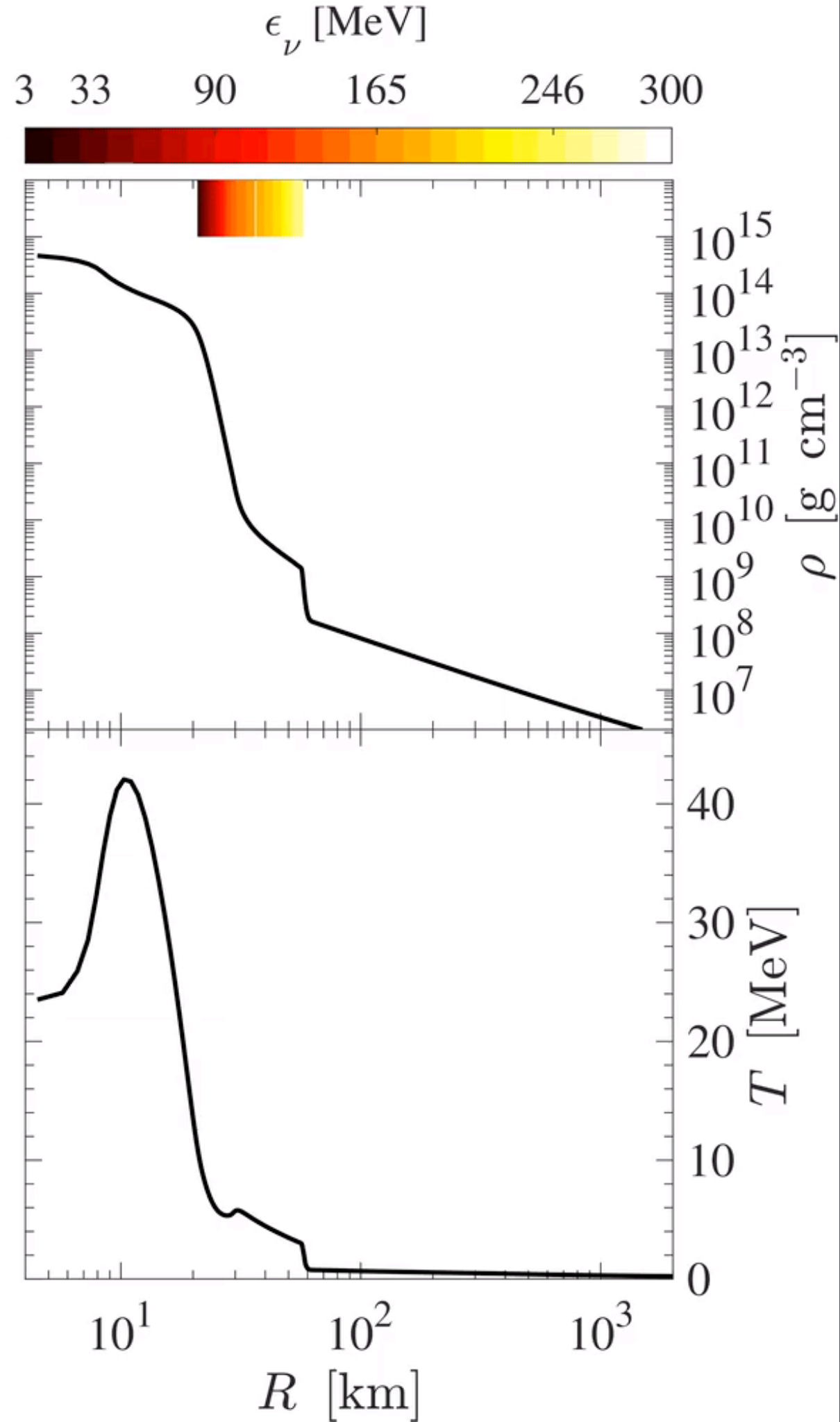
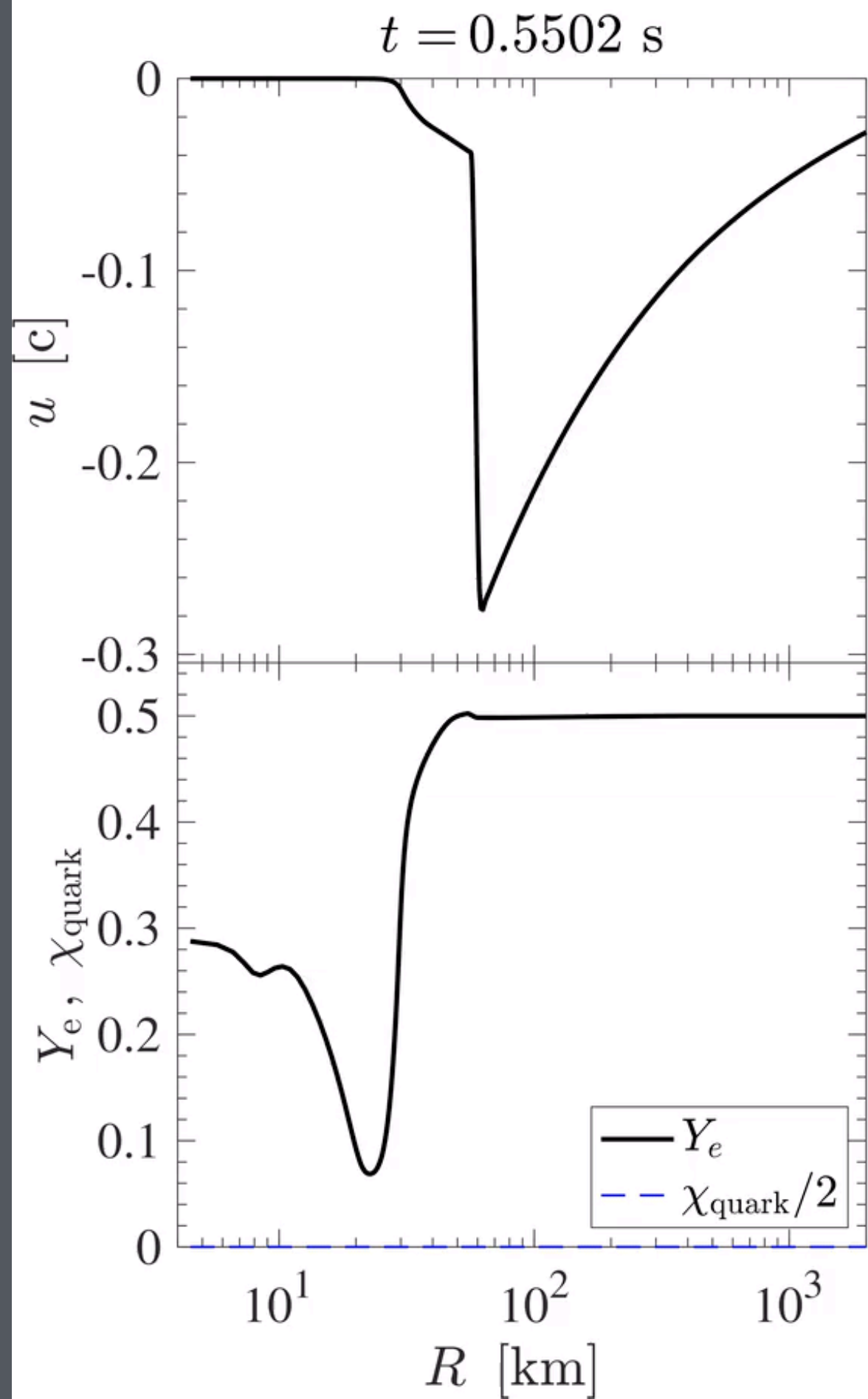


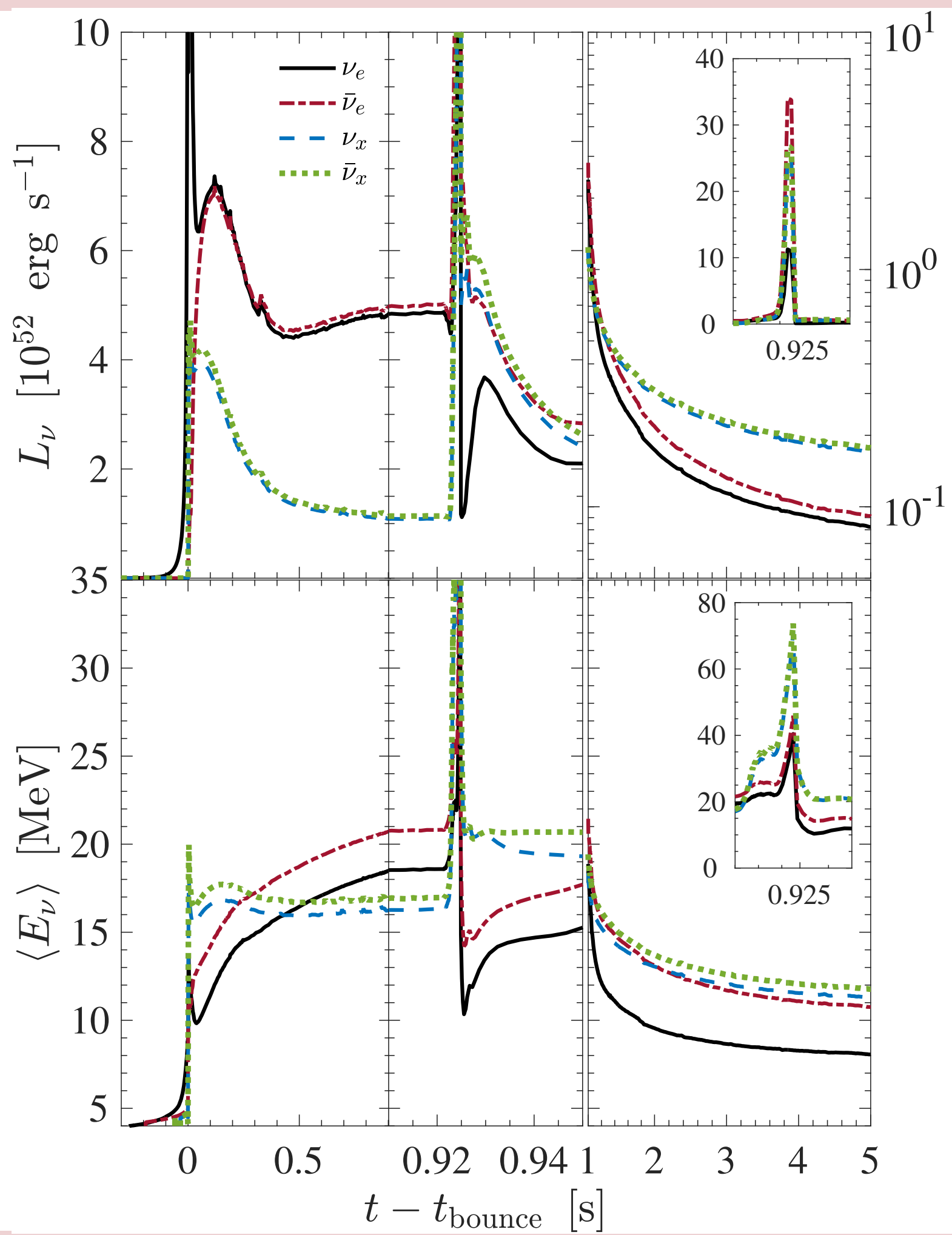




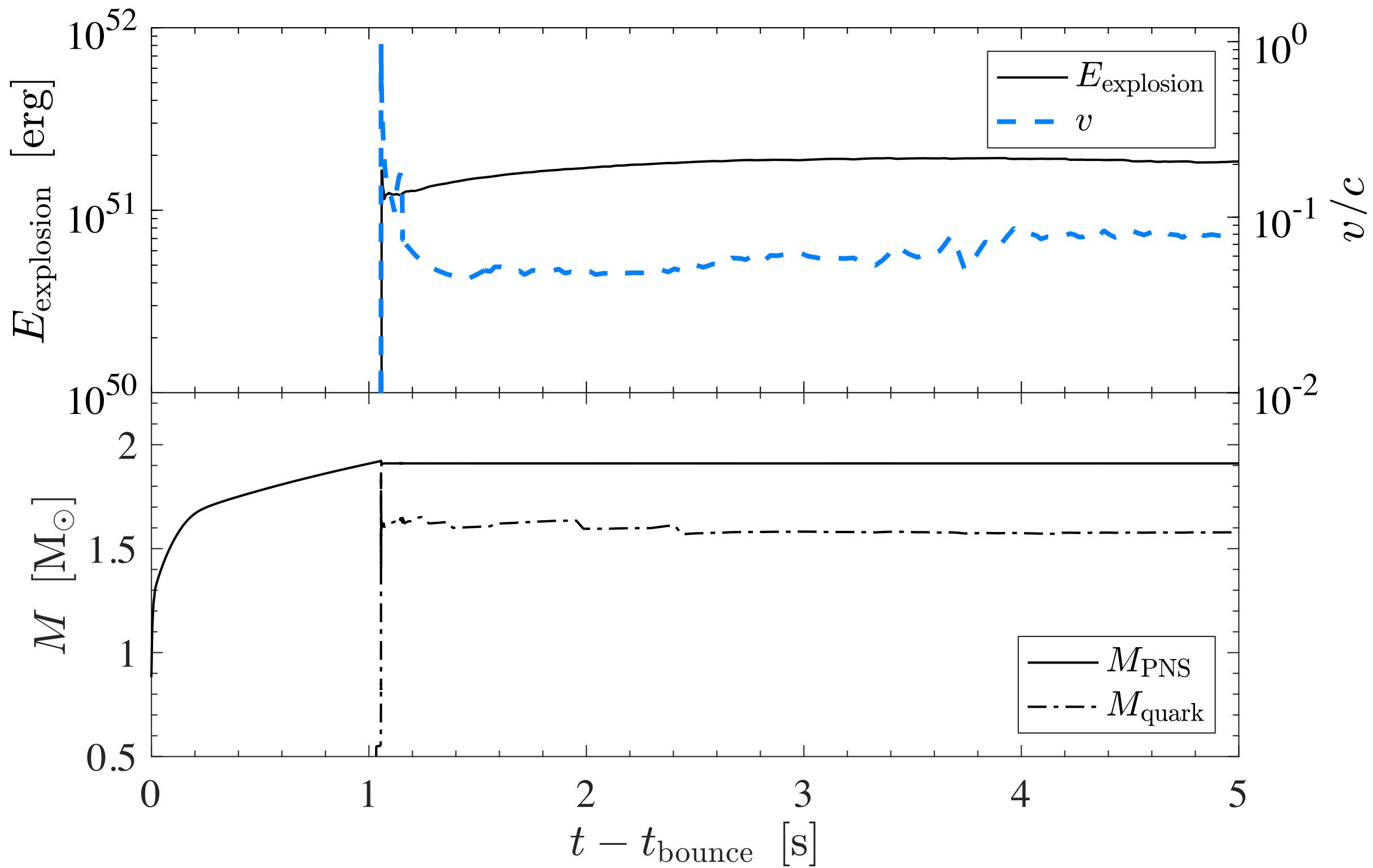








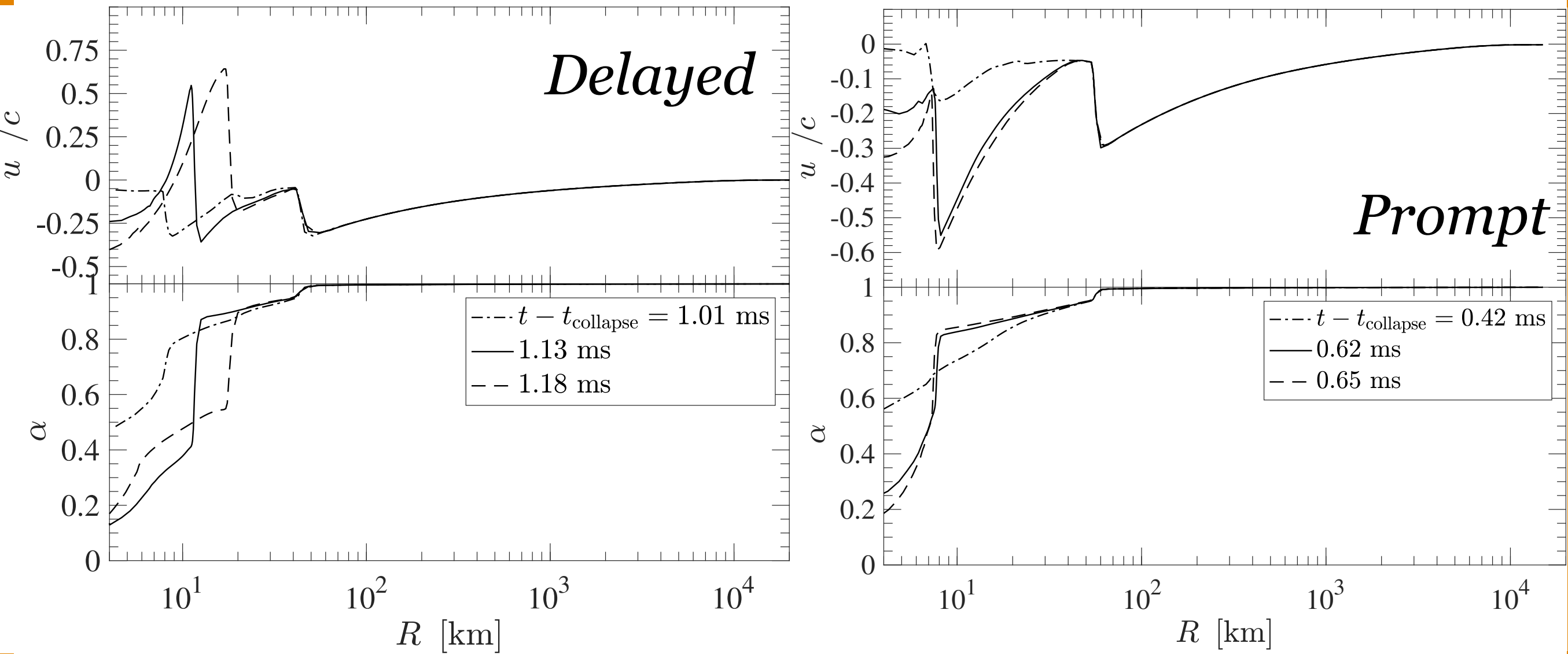




$$E_{\text{expl}} = 3 \times 10^{51} \text{ erg}$$

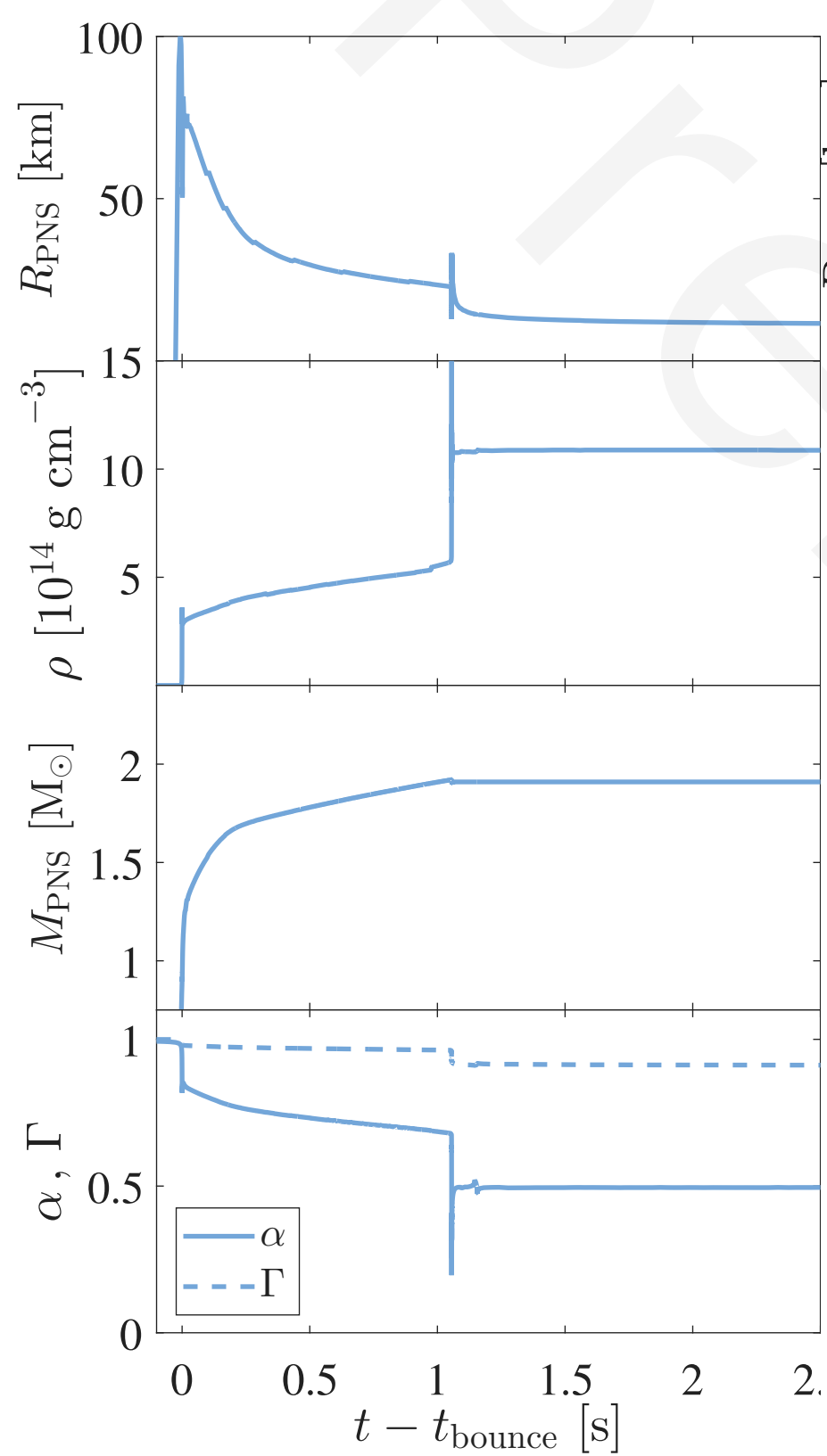
$$M_{\text{NS}} \simeq 2 M_{\odot}$$

# Black-hole formation: Two distinct scenarios

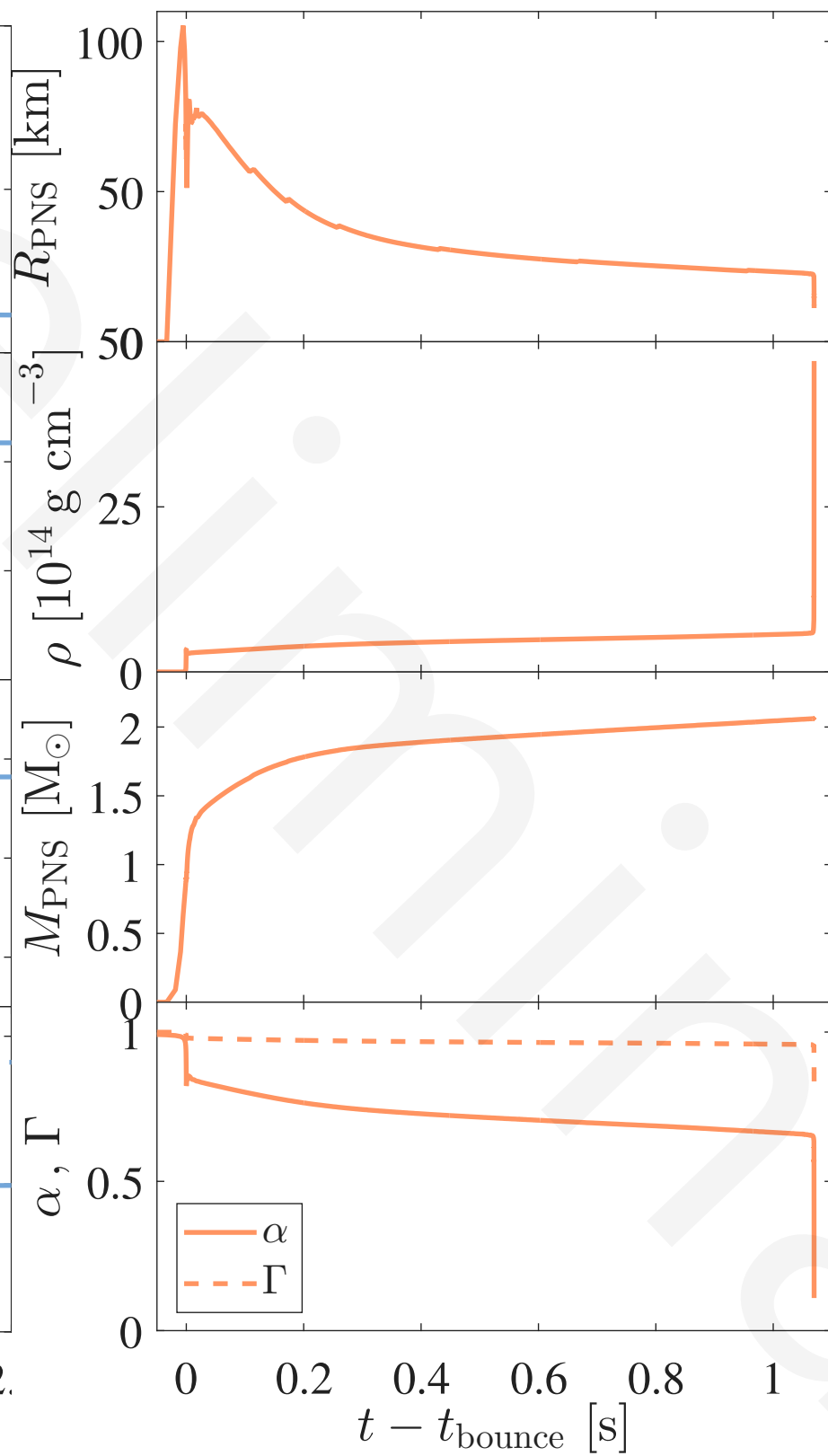


Jakobus et al., MNRAS, 516, 2554 (2022)

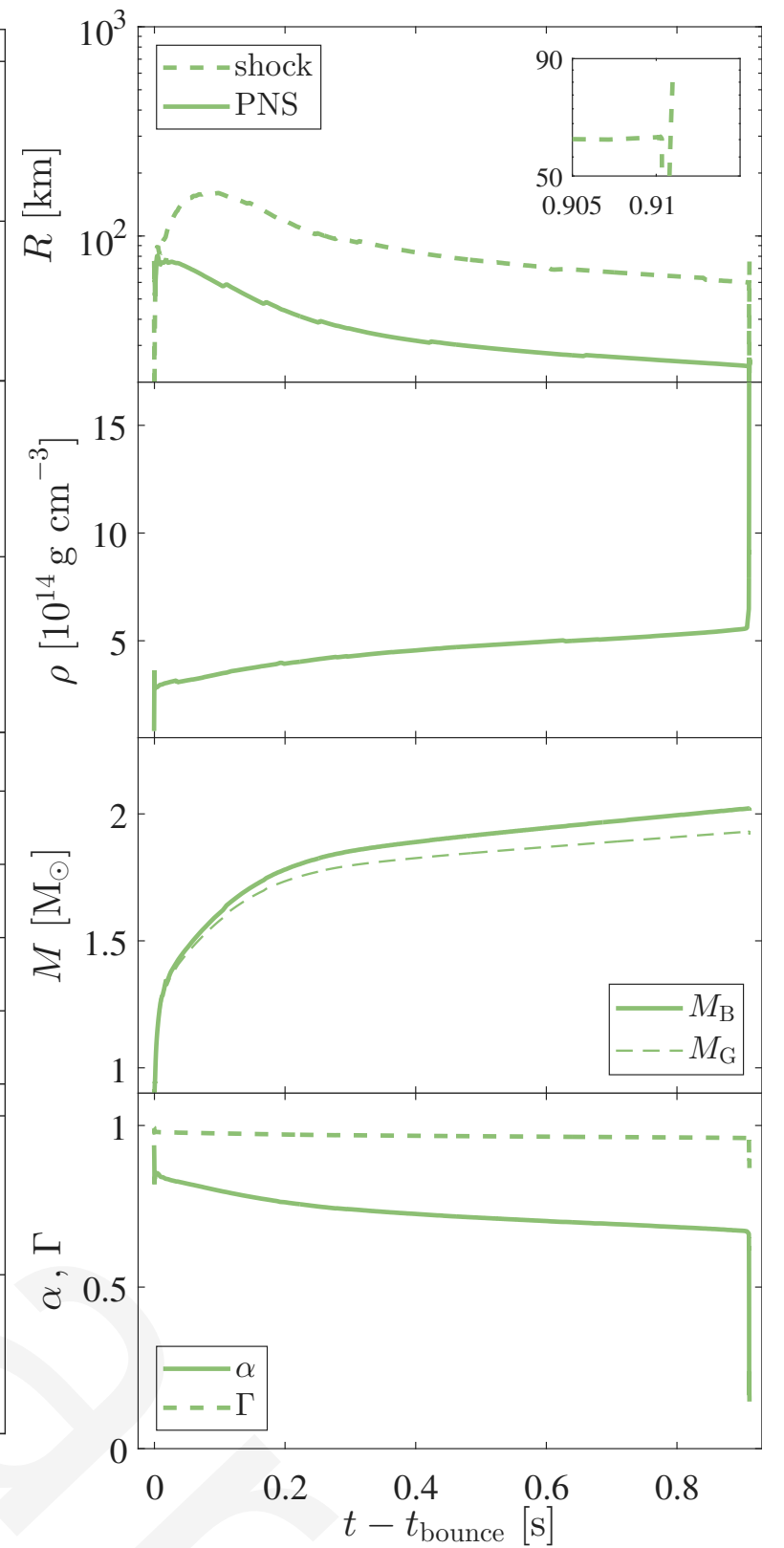
Khosravi Largani et al., ApJ 946, 143 (2024)



Explosion

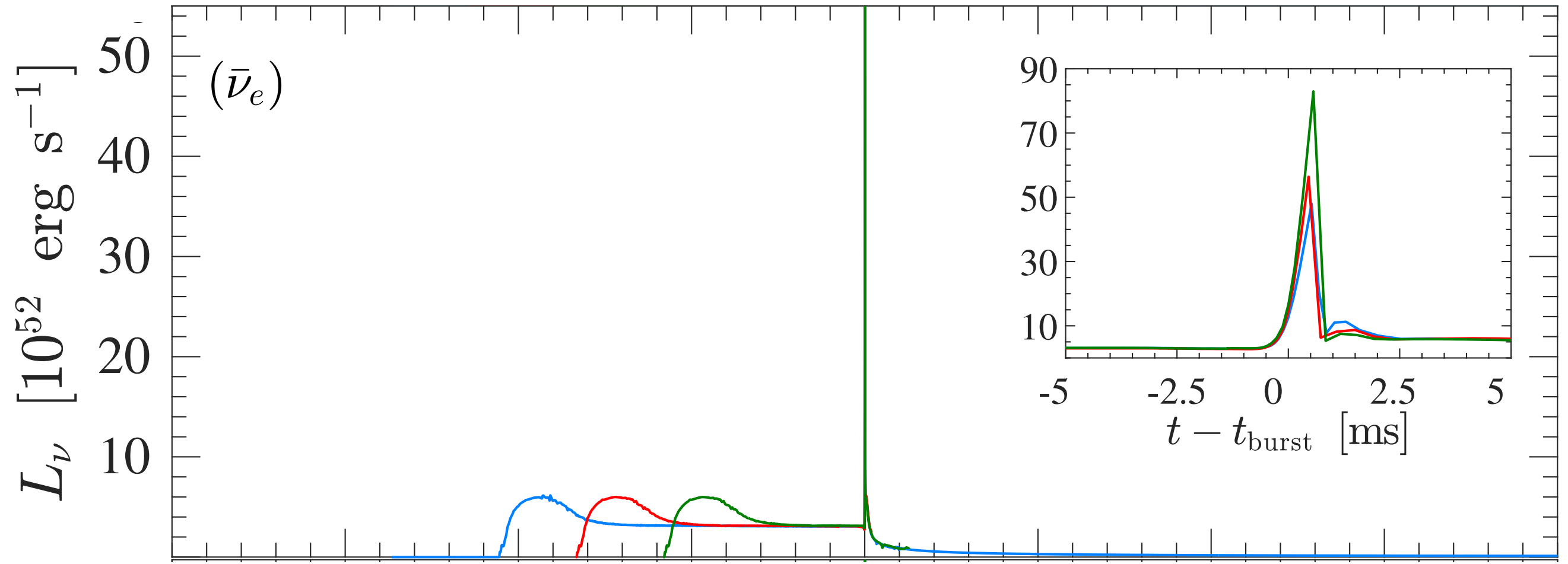


Prompted BH



Delayed BH

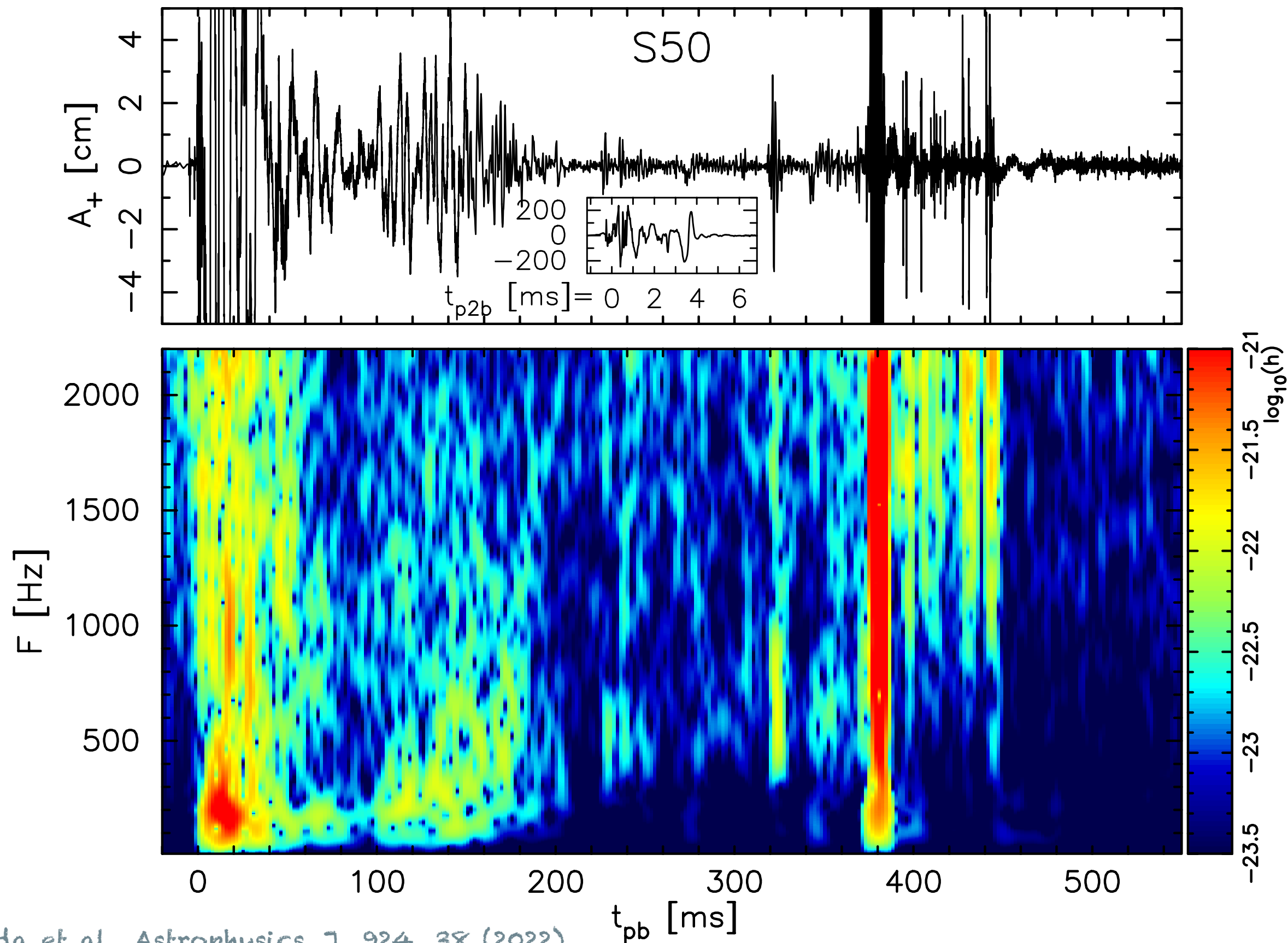




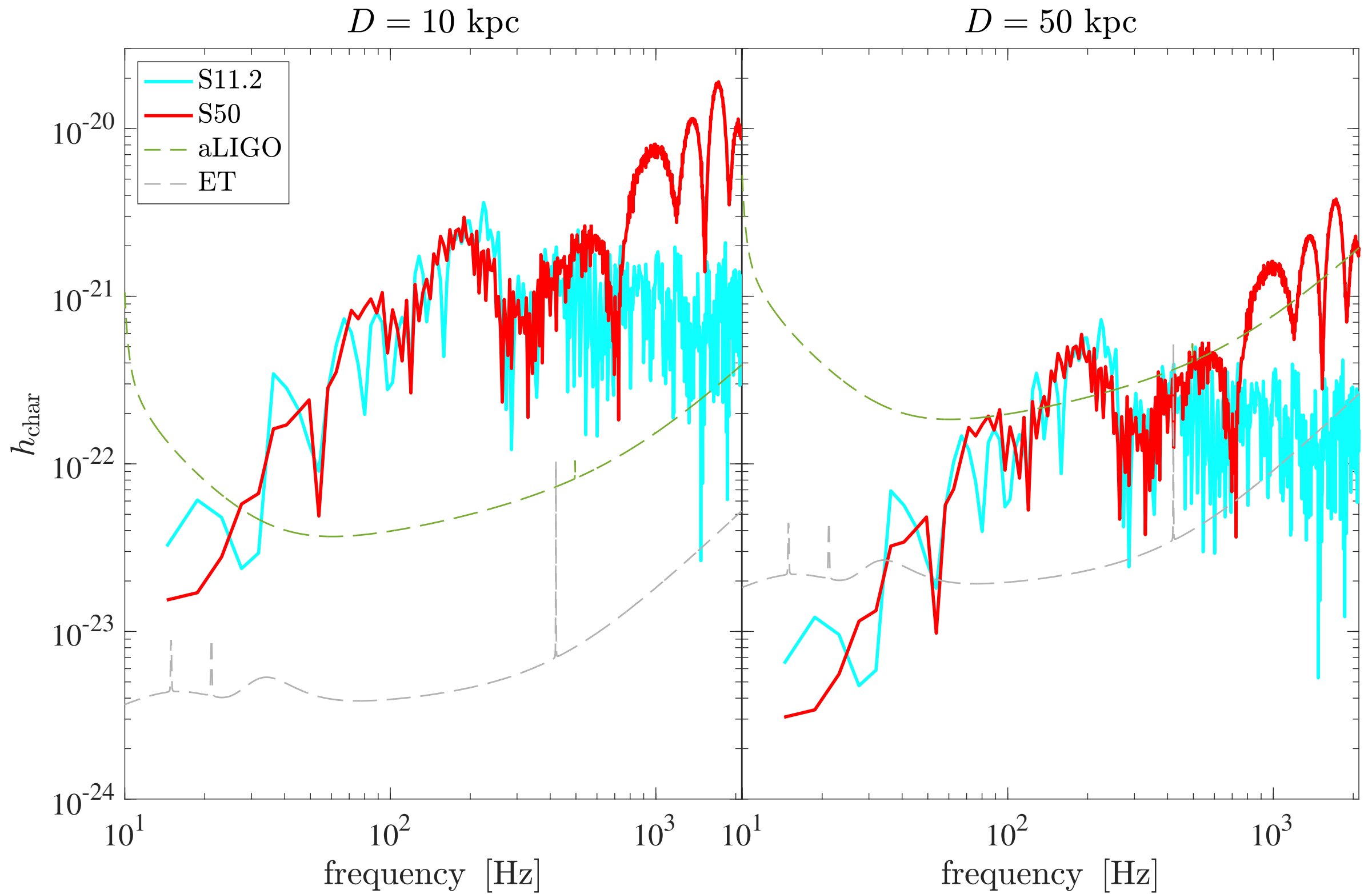
These systematic distinctions may put a constraint on the hybrid EoS

| Progenitor | EOS | $t_{\text{burst}}$ | $L_{\bar{\nu}_e, \text{peak}}$ | $\langle E_{\bar{\nu}_e} \rangle$ | $E_{\text{expl}}$       |
|------------|-----|--------------------|--------------------------------|-----------------------------------|-------------------------|
|            | RDF | [s]                | $[10^{53} \text{ erg s}^{-1}]$ | [MeV]                             | $[10^{51} \text{ erg}]$ |

# Gravitational waves



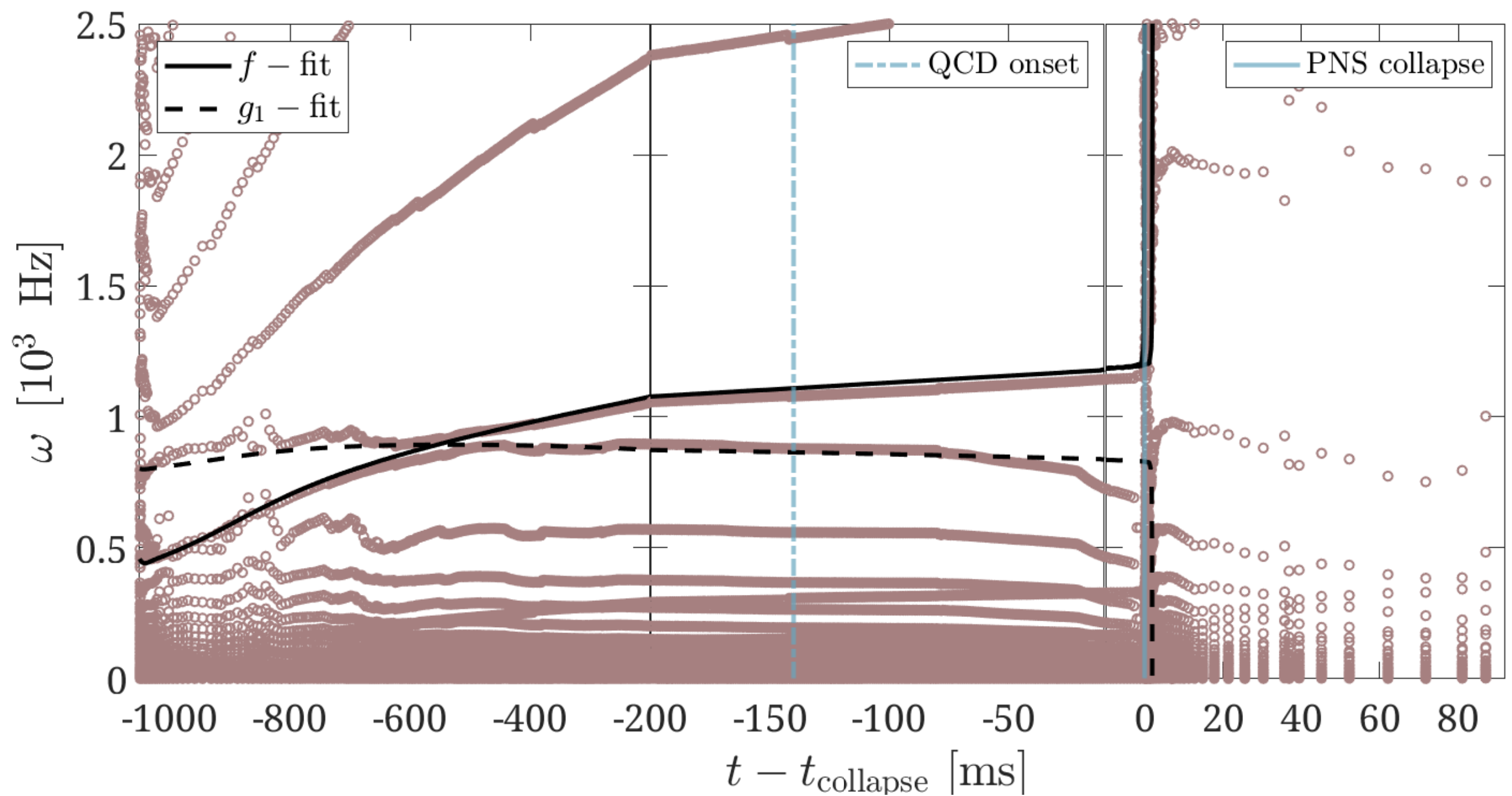
Kuroda et al., *Astrophysics J.*, 924, 38 (2022)  
 Zha et al., *Phys. Rev. L.*, 125, 051102 (2020)



$$f \quad x = \sqrt{M_{\text{PNS}}/R_{\text{PNS}}^3}$$

$$g_1 \quad x = M_{\text{PNS}}/R_{\text{PNS}}^2$$

$$\omega_{\text{fit}}(x) = a_0 + a_1 x + a_2 x^2 + a_3 x^3$$

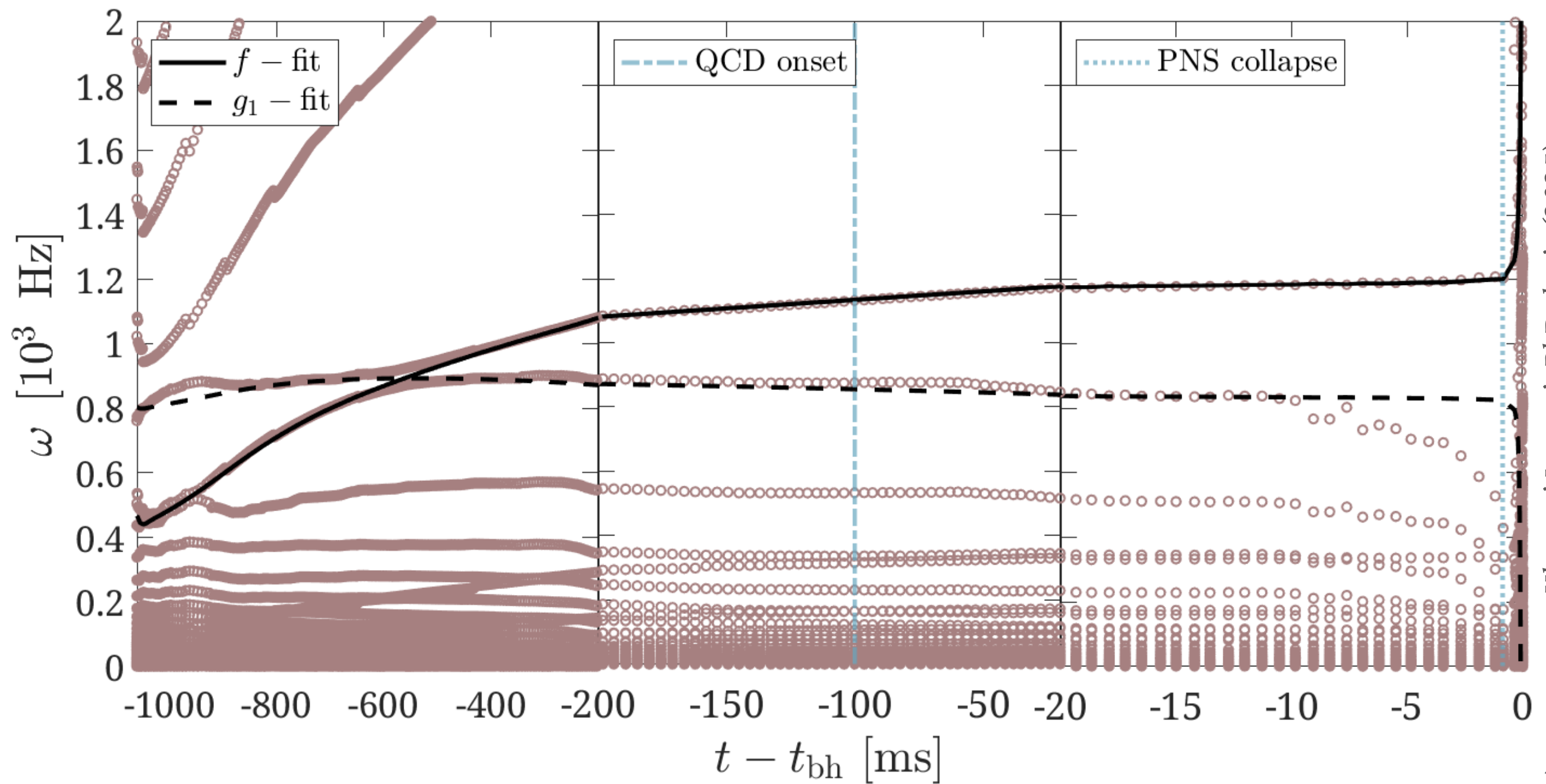




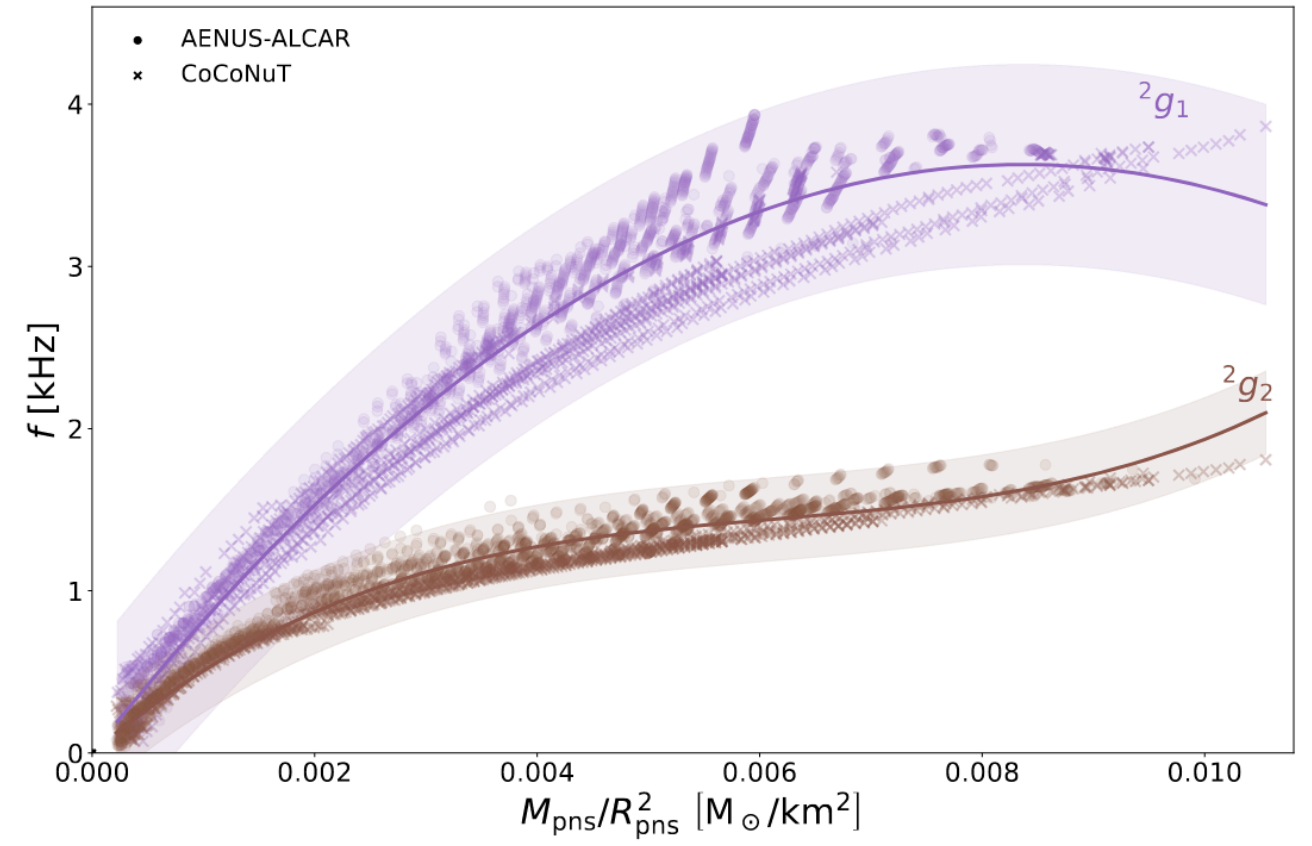
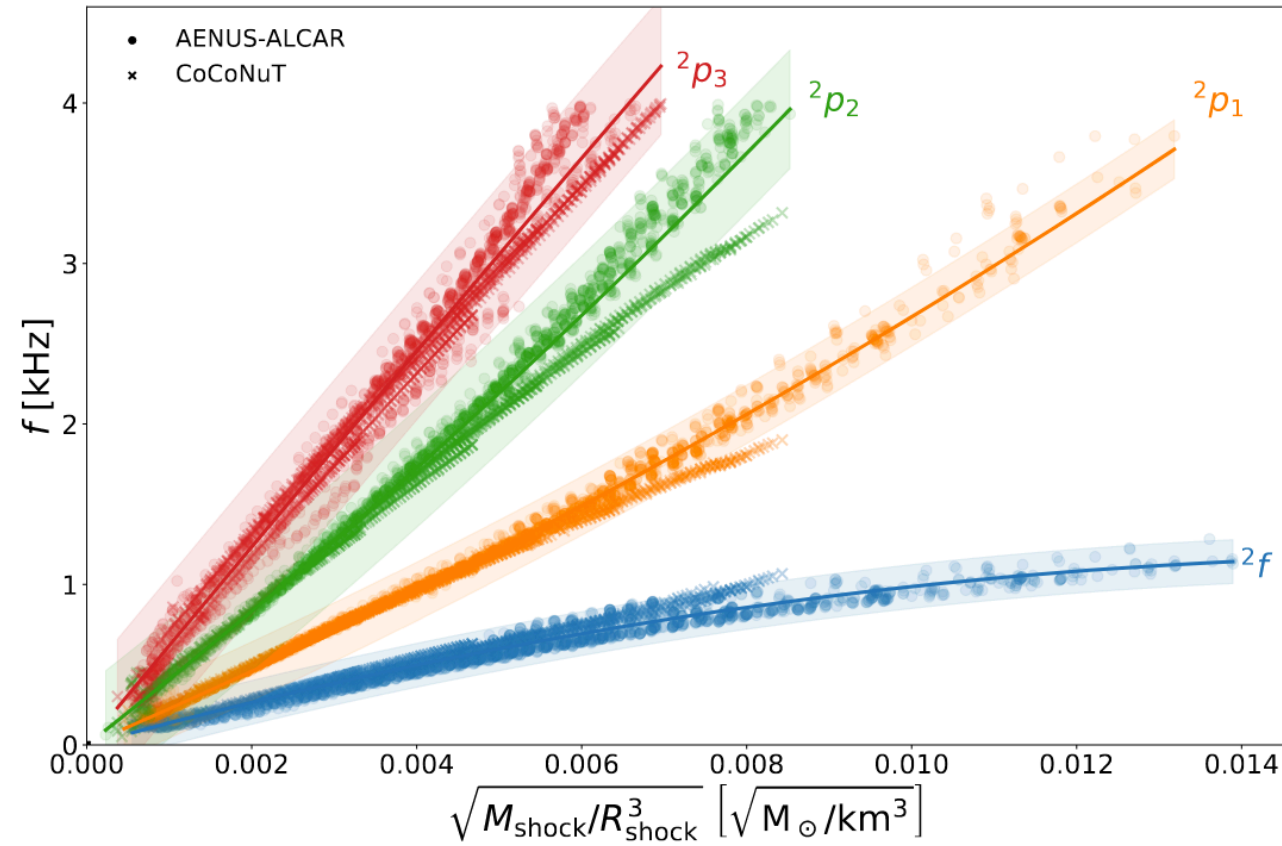
$$f \quad x = \sqrt{M_{\text{PNS}}/R_{\text{PNS}}^3}$$

$$g_1 \quad x = M_{\text{PNS}}/R_{\text{PNS}}^2$$

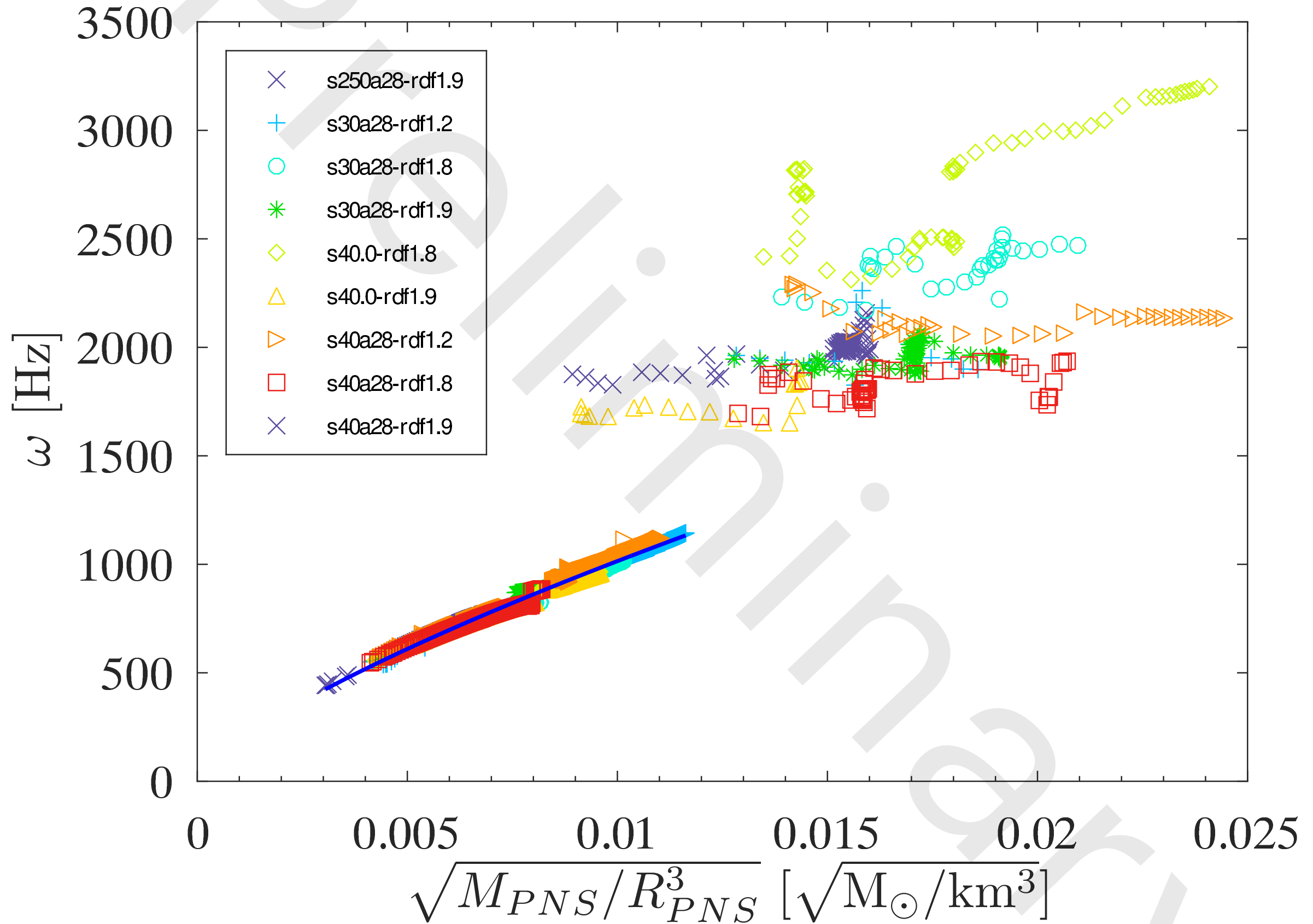
$$\omega_{\text{fit}}(x) = a_0 + a_1 x + a_2 x^2 + a_3 x^3$$



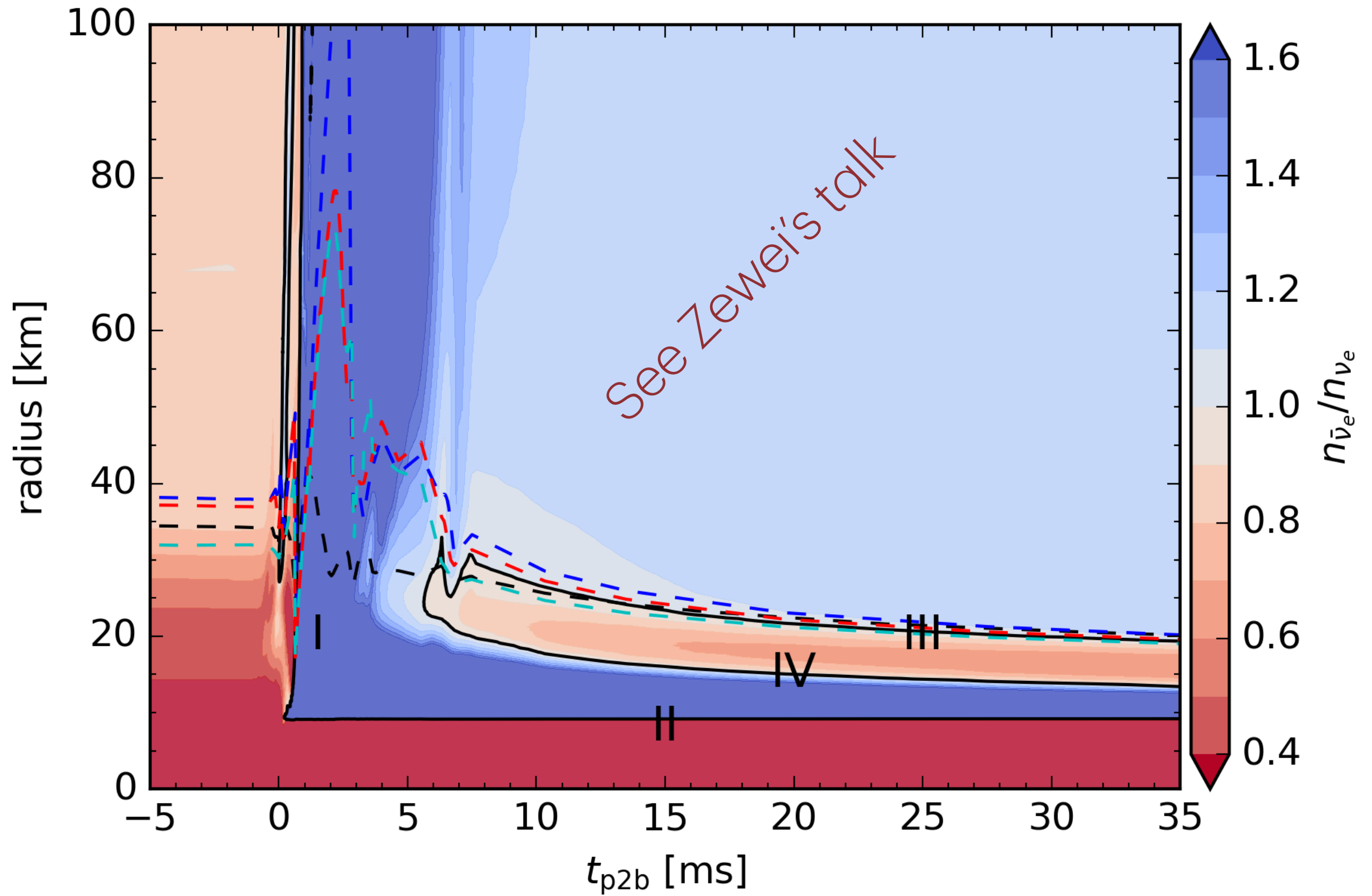
# Universal Relations



Torres Forne et al., Phys. Rev. Lett. 123, 051102 (2019)  
 Mori et al., Phys. Rev. D 110, 109901 (2023)  
 Sotani et al., Phys. Rev. D 109, 123021 (2024)



# Fast flavor conversions in QCD driven CCSN



Xiong et al., PRD 112, 063024 (2025)

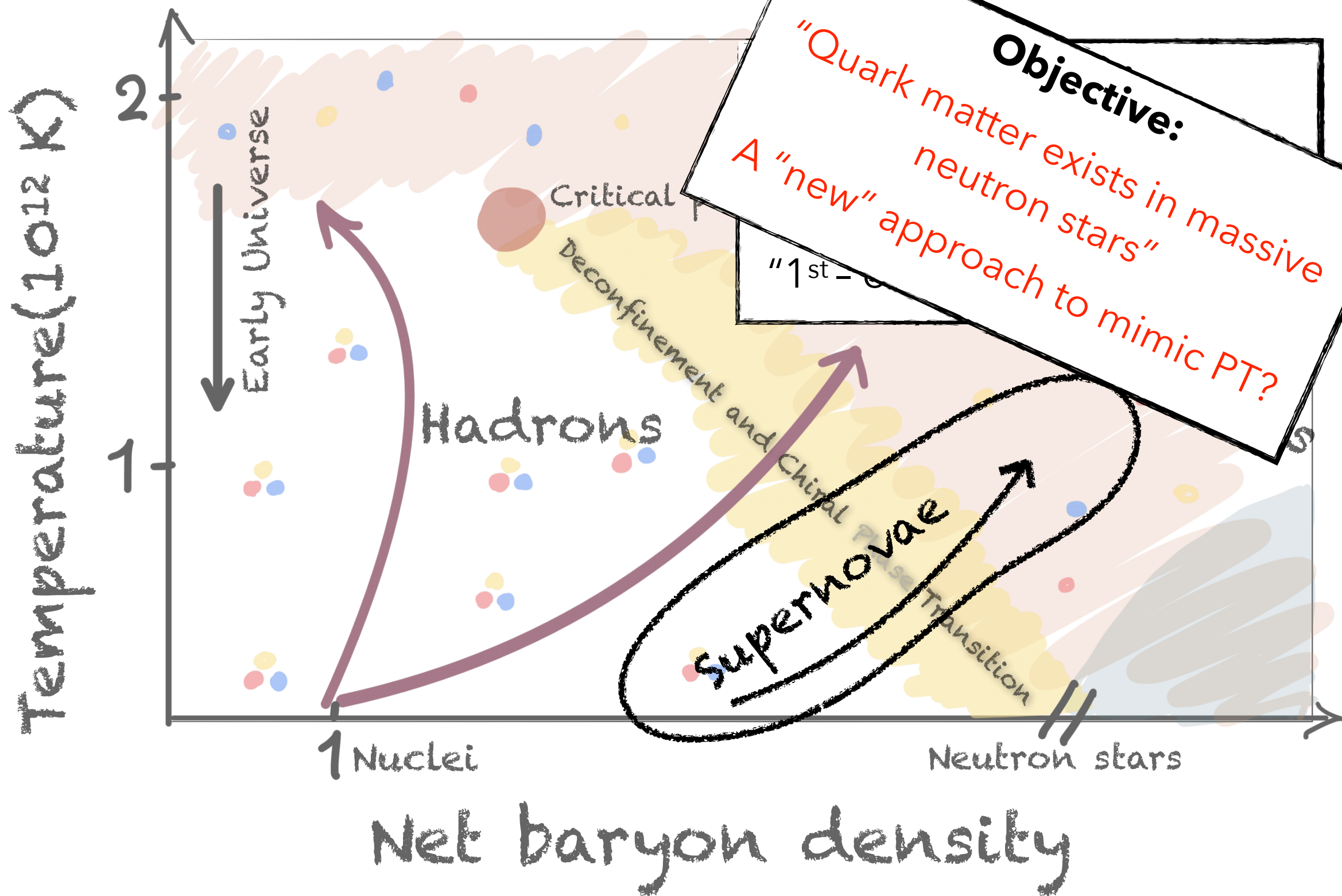




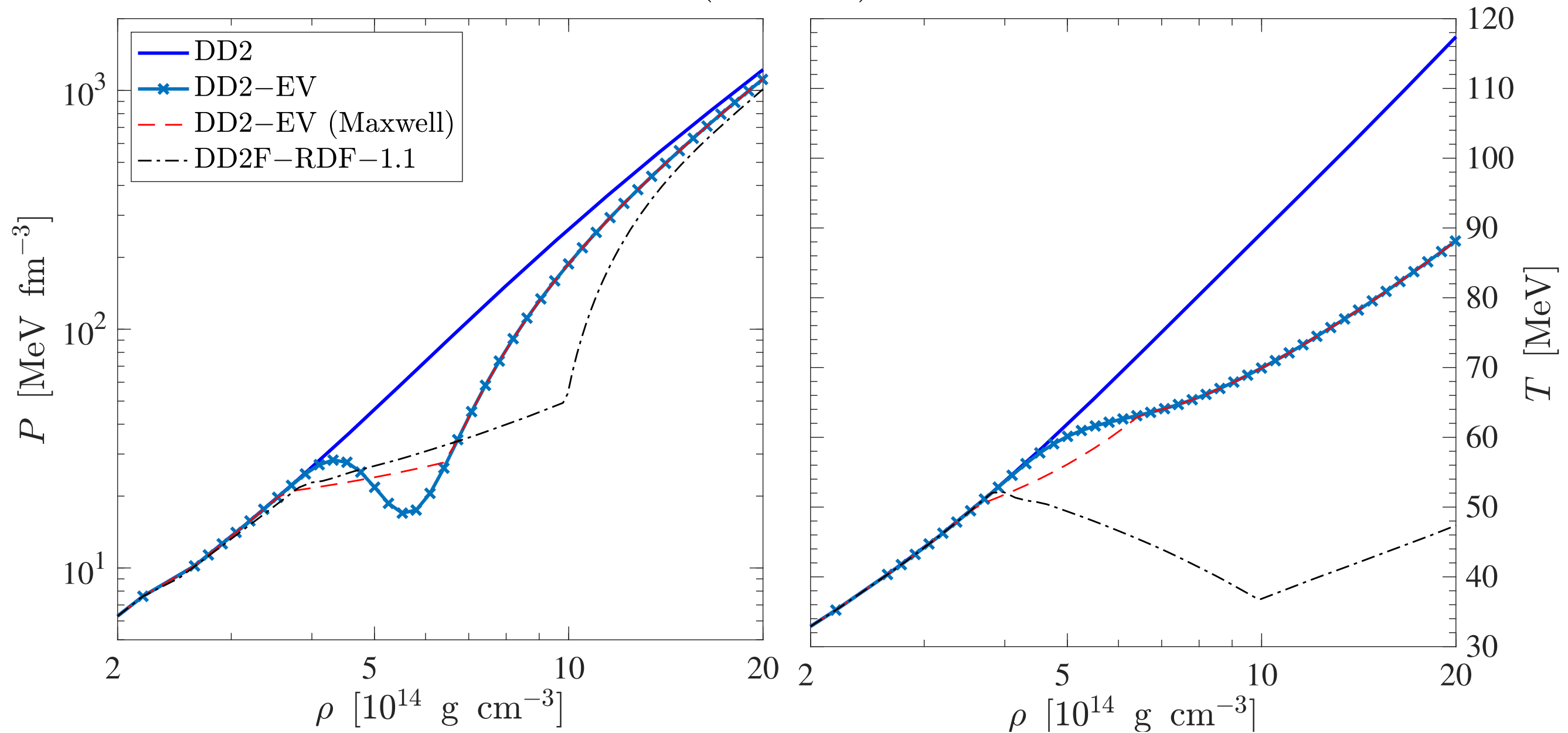
Table 1: Excluded volume parametrisation.

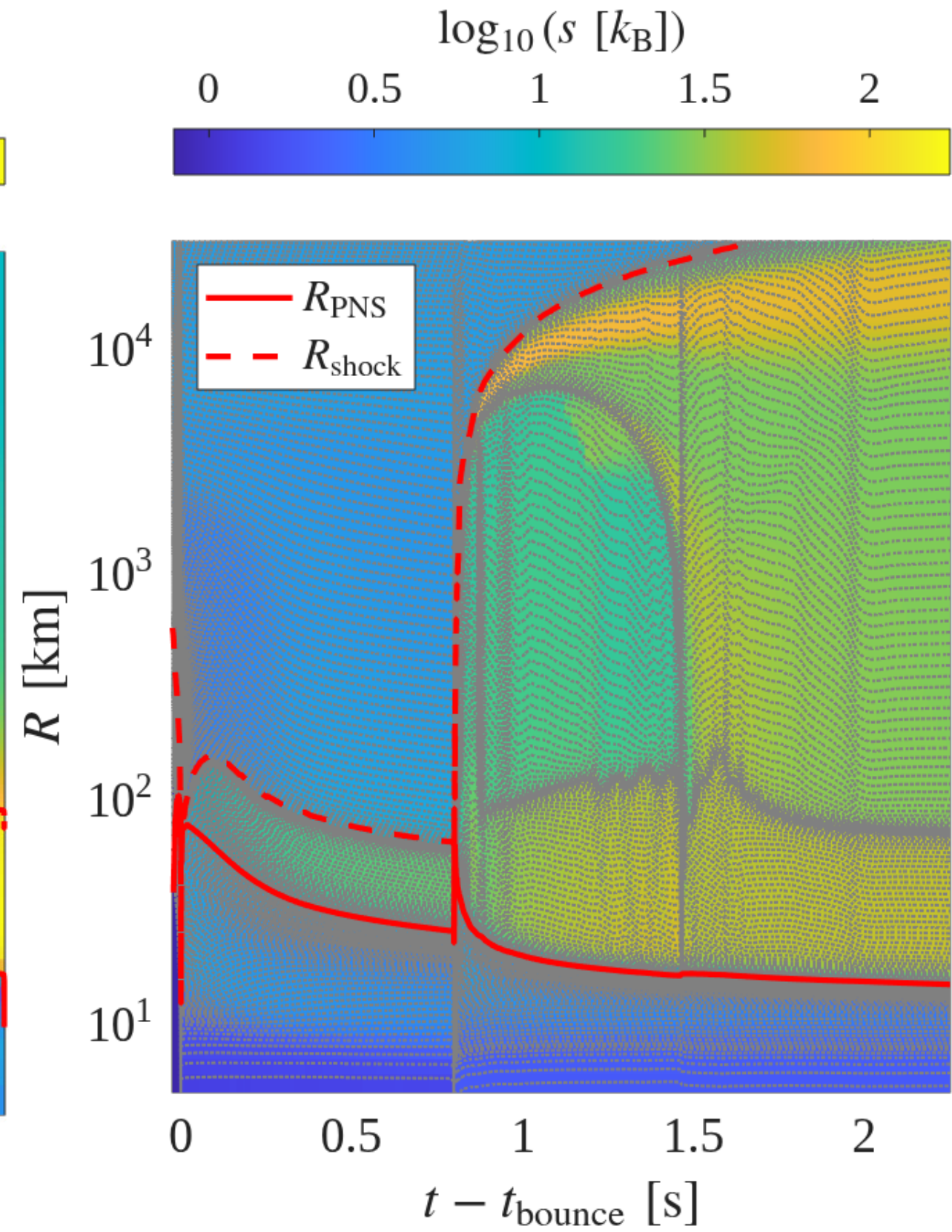
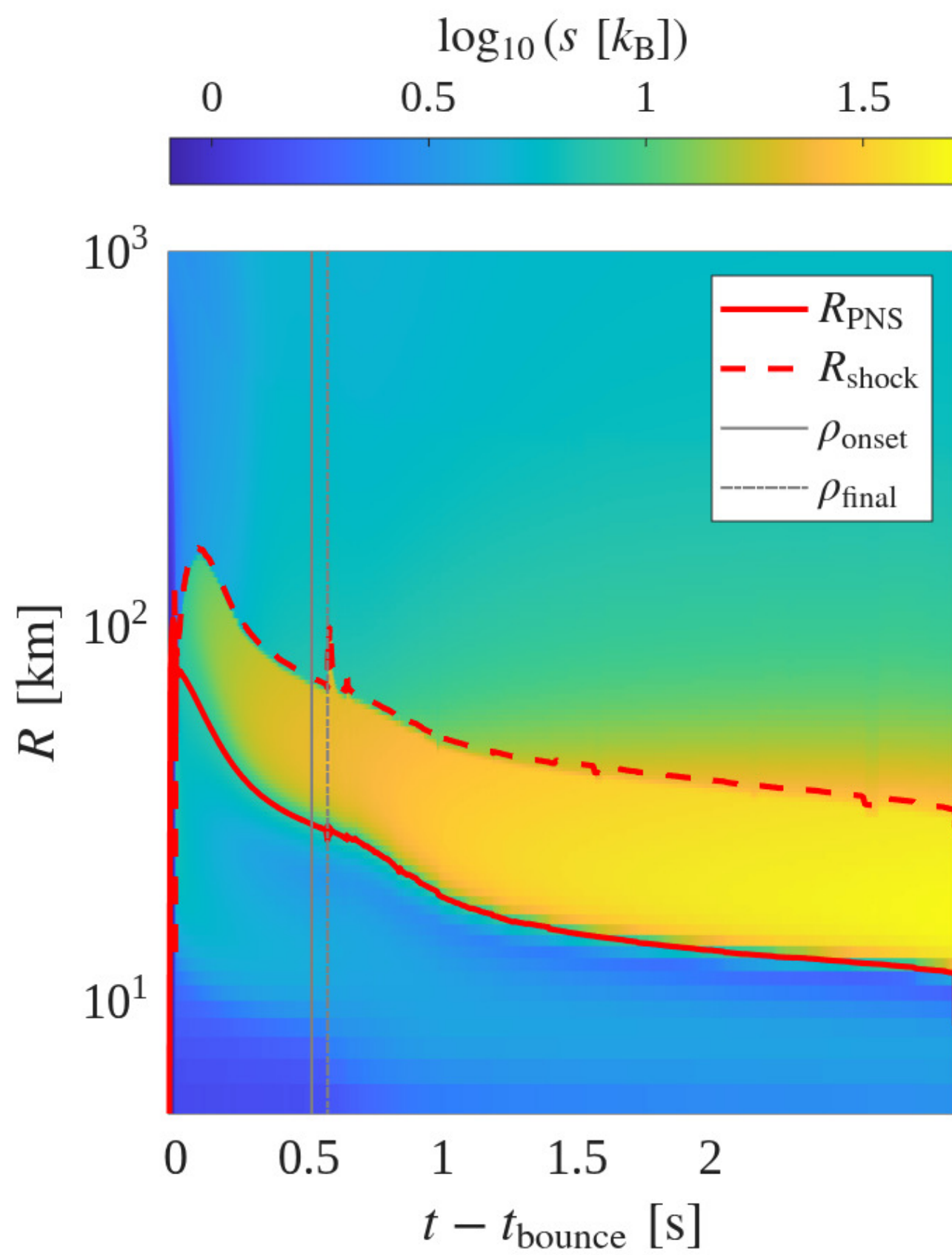
| $v$ (fm) | $n_{\text{cut}}$ (fm $^{-3}$ ) | $\rho_{\text{onset}}^a$ (fm $^{-3}$ ) | $\rho_{\text{end}}^b$ (fm $^{-3}$ ) |
|----------|--------------------------------|---------------------------------------|-------------------------------------|
| 2        | 0.149 <sup>d</sup>             | 0.268                                 | 0.412                               |

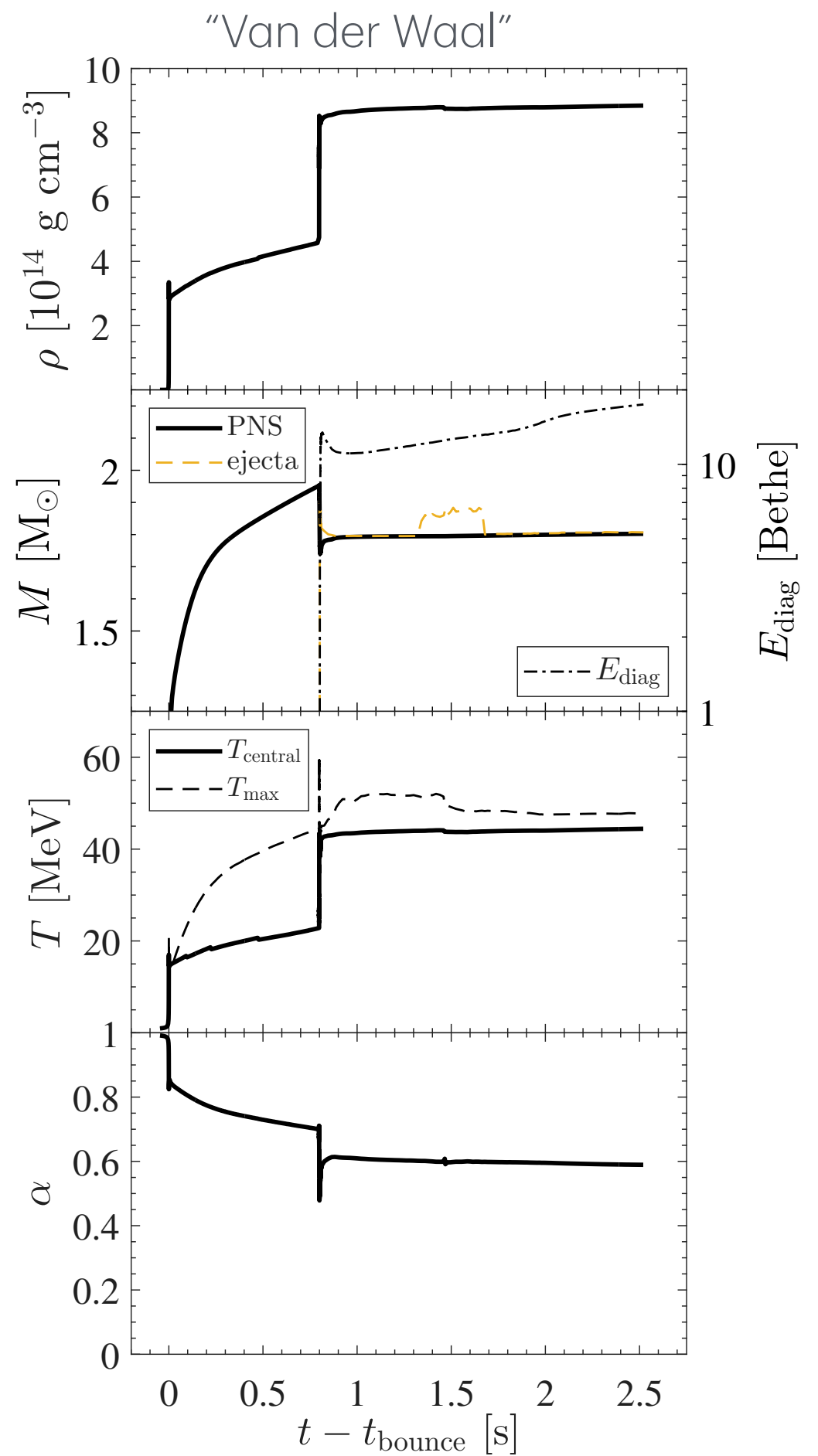
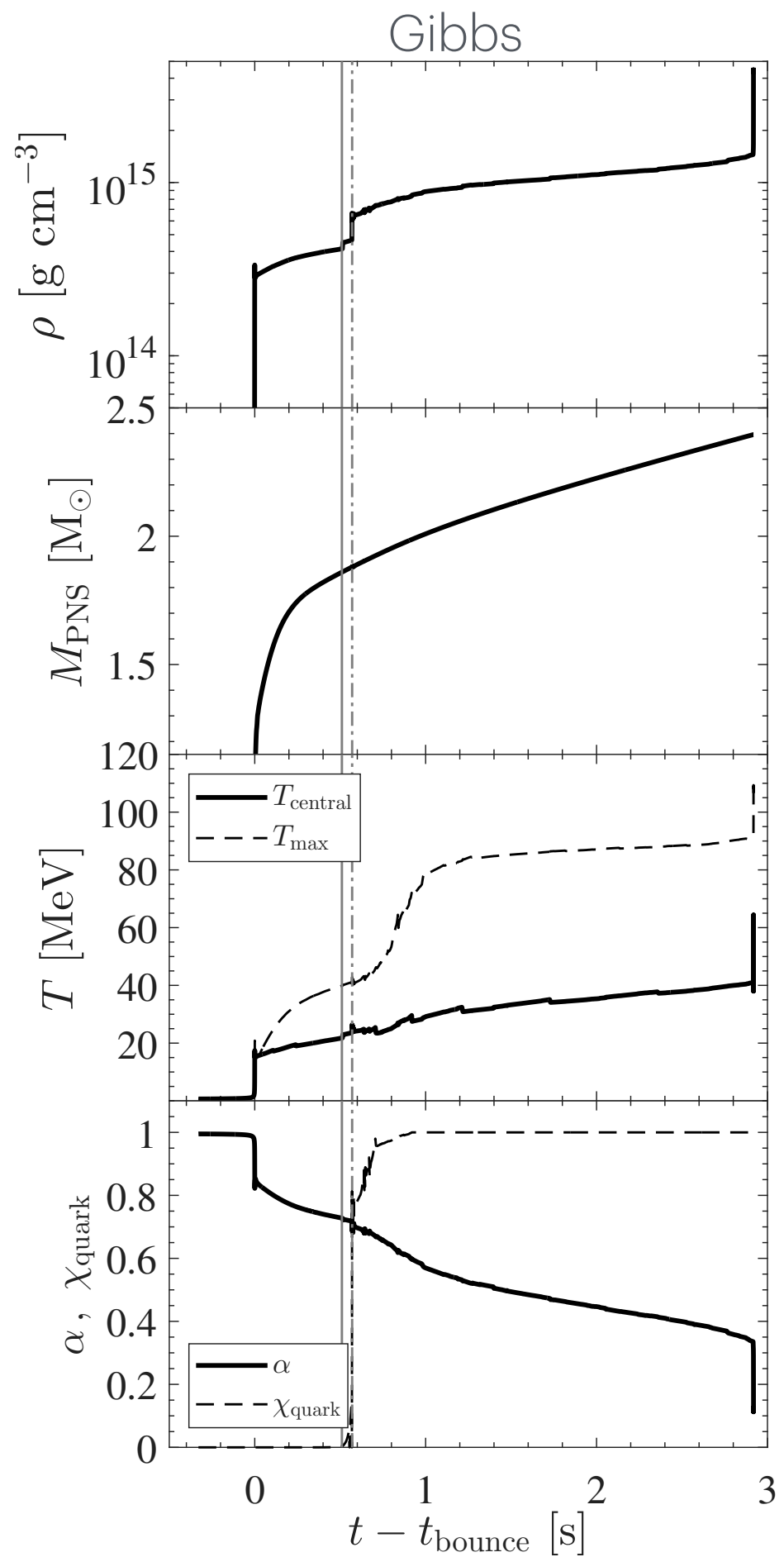
<sup>a</sup> onset density for the phase transition at  $T = 1$  MeV and  $Y_p = 0.3$

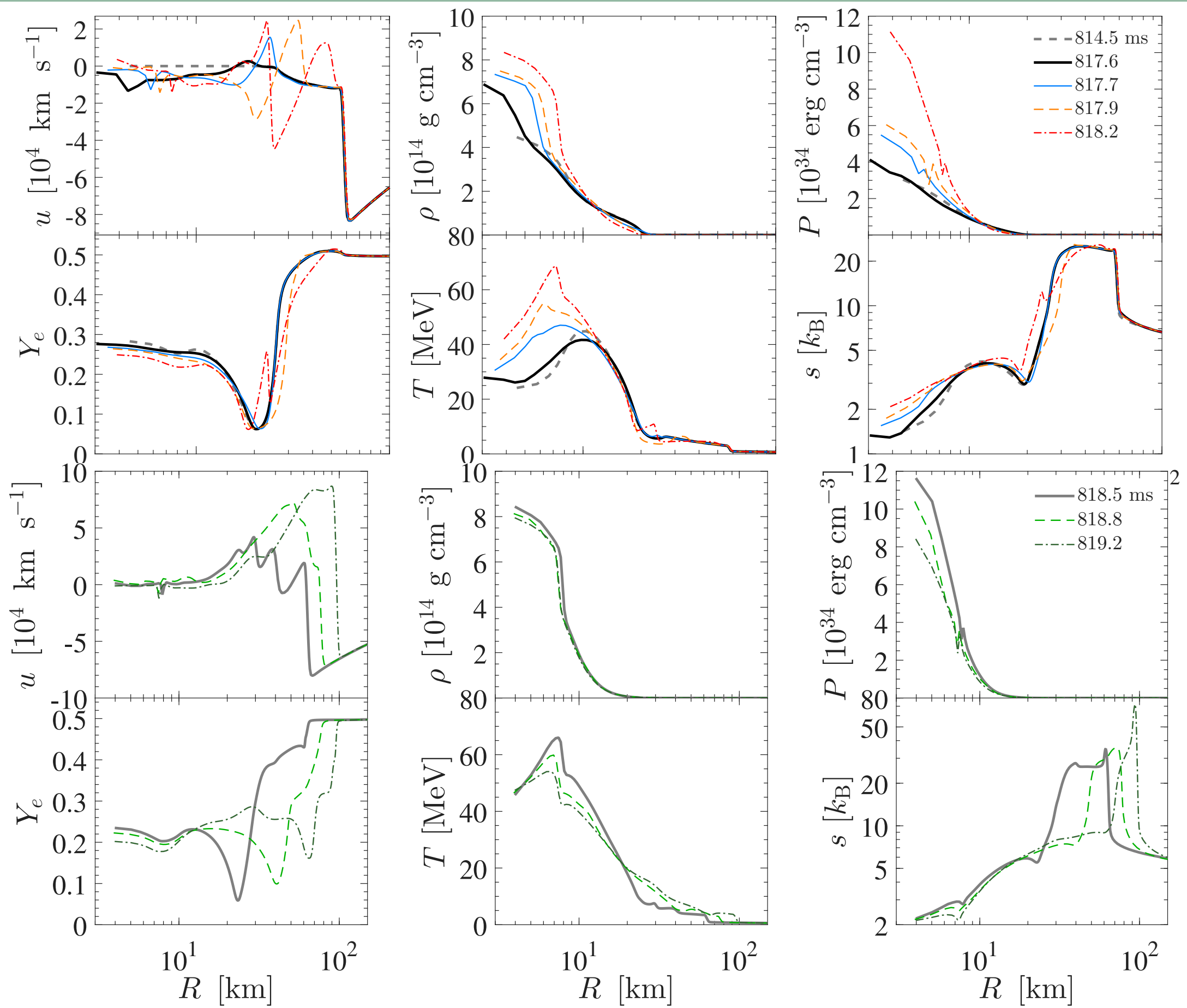
<sup>b</sup> end density for phase transition at  $T = 1$  MeV and  $Y_p = 0.3$

( $s = 3 k_B$ )

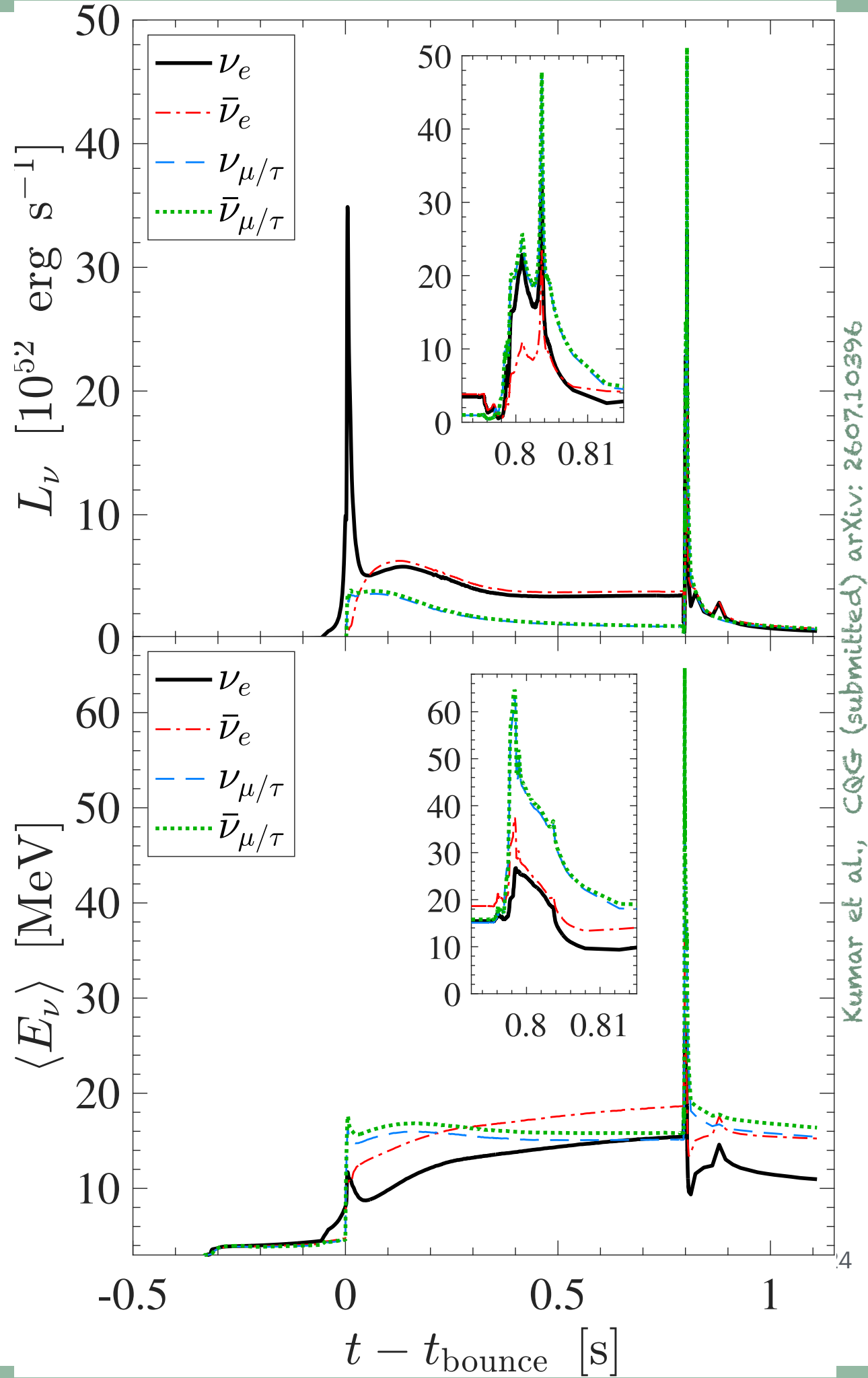
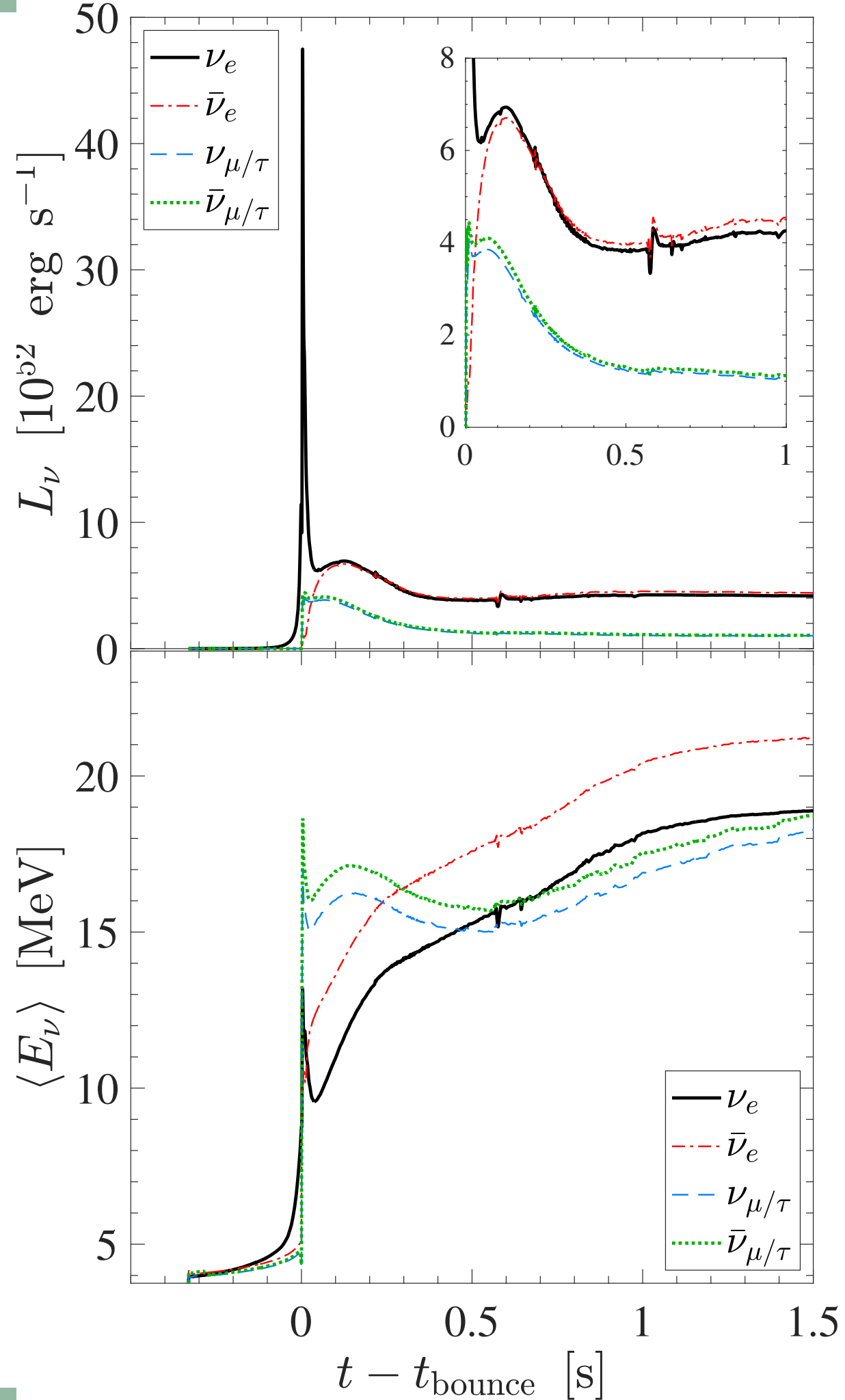




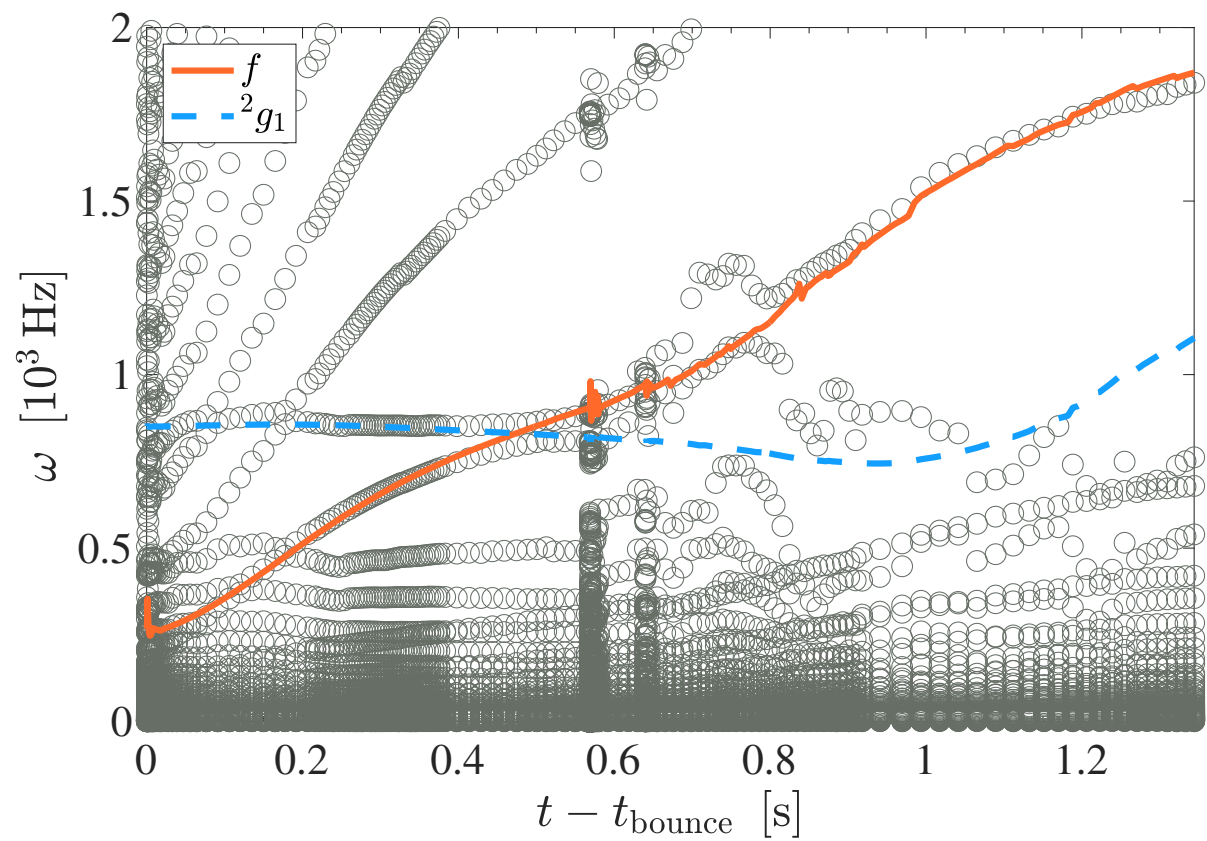
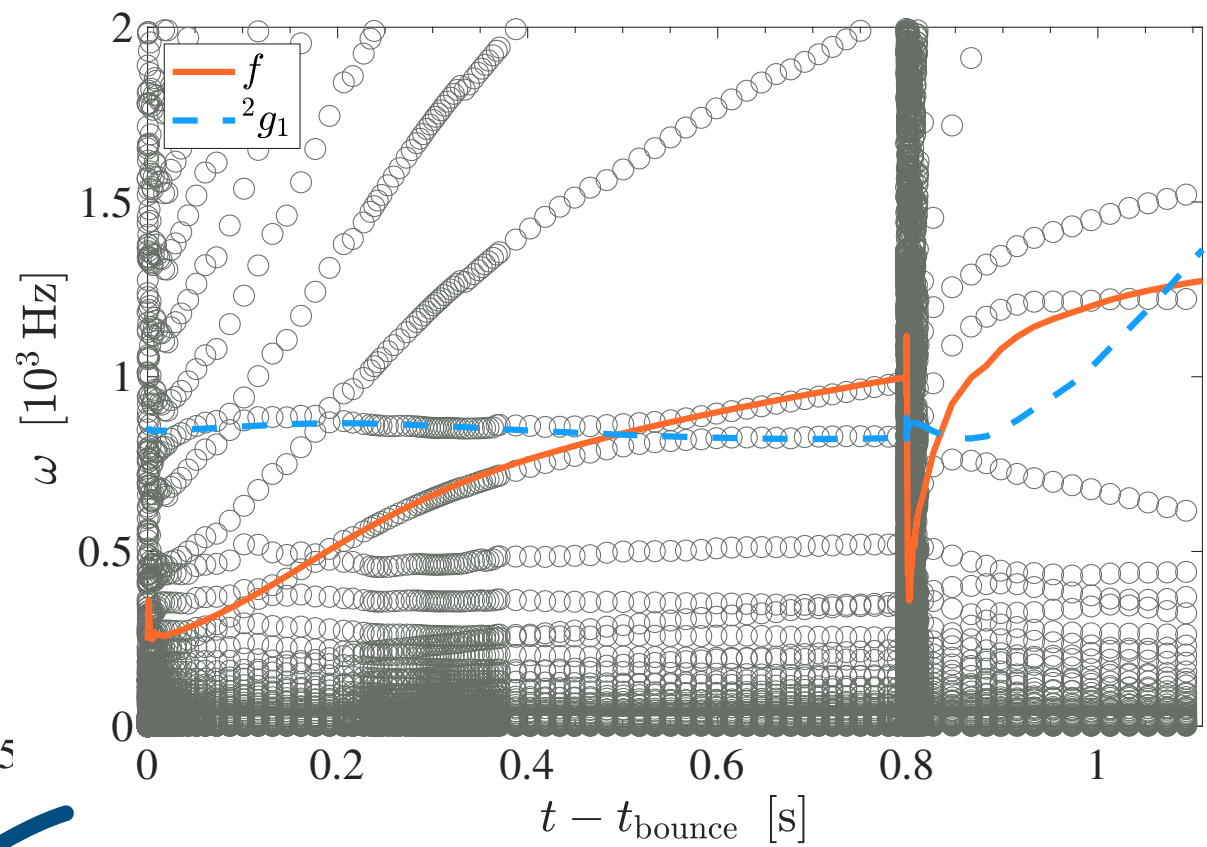
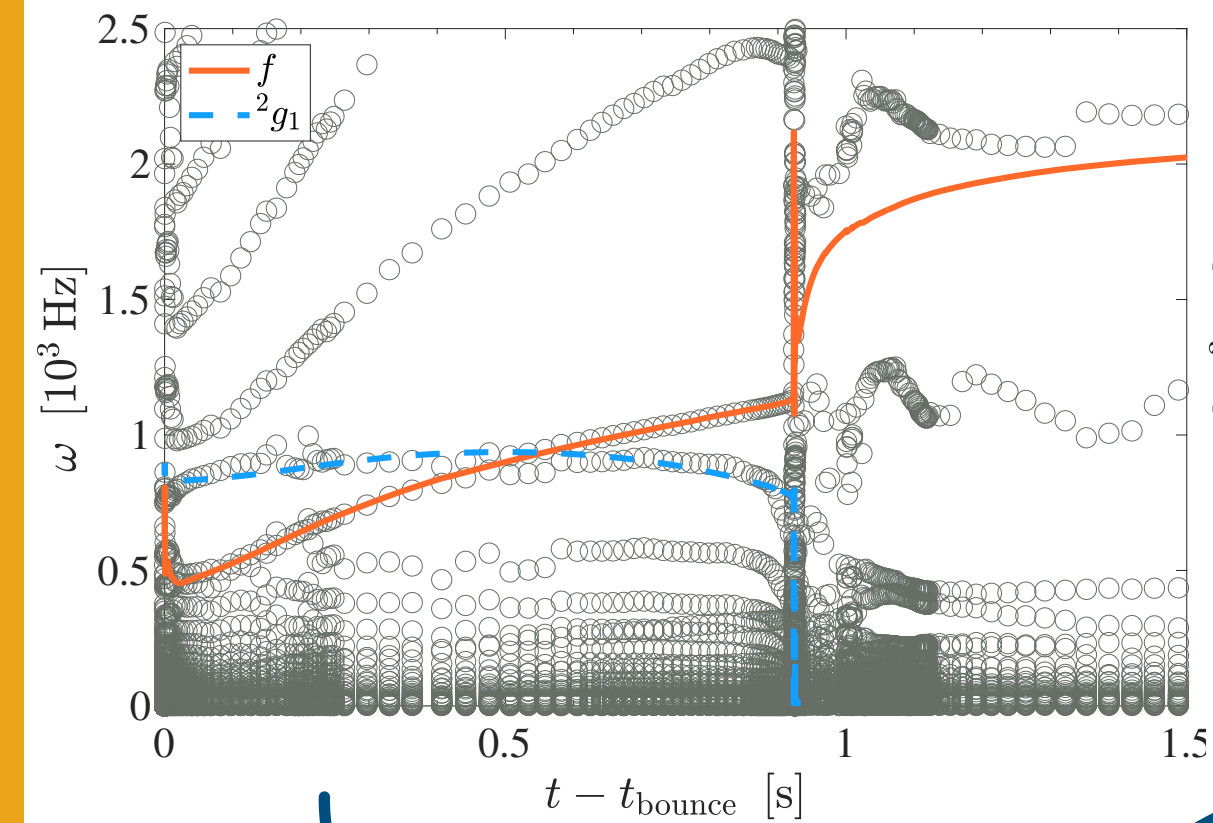










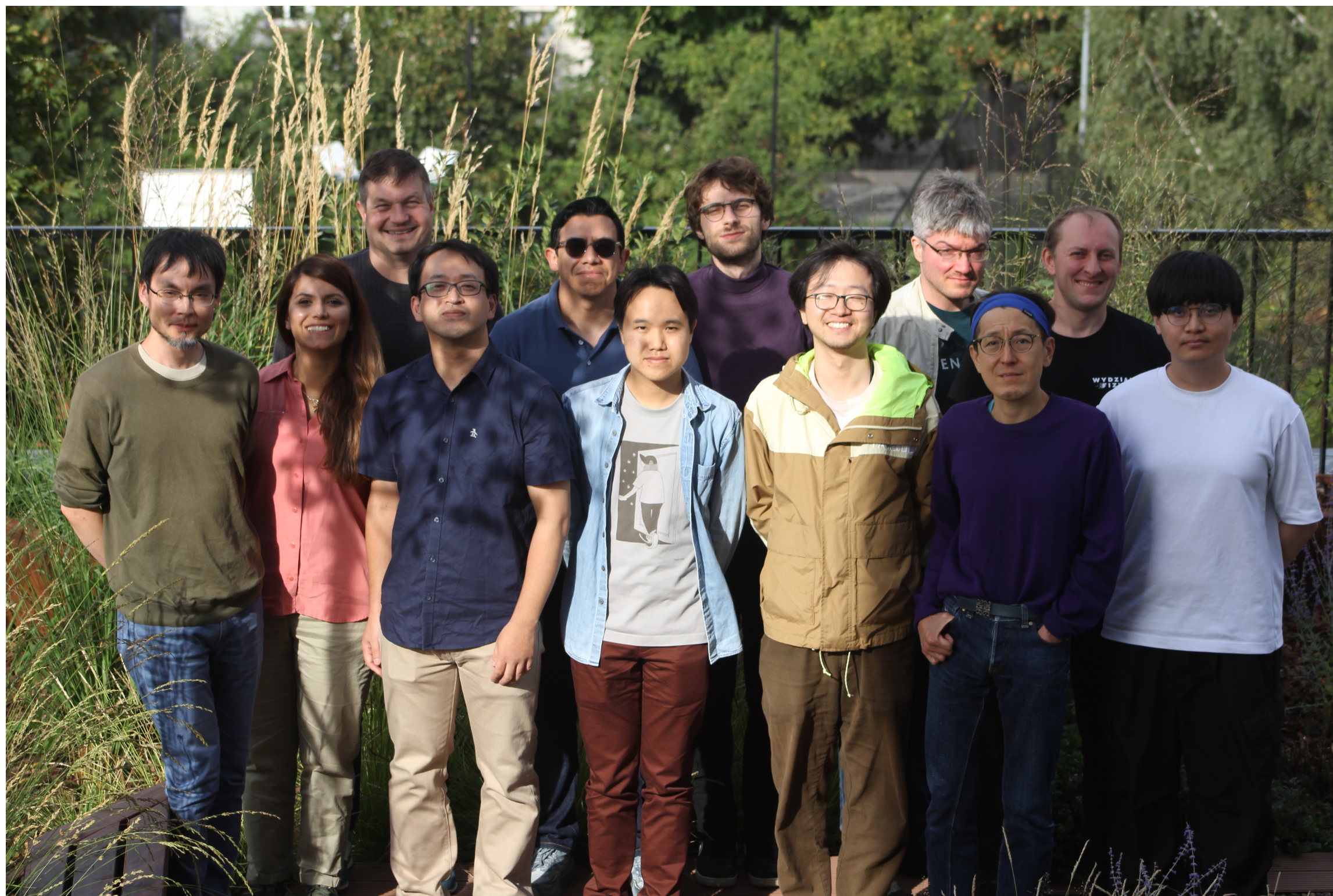


RDF 1.2

DD2-MEV

DD2-MEV(Gibbs)





Thank you!