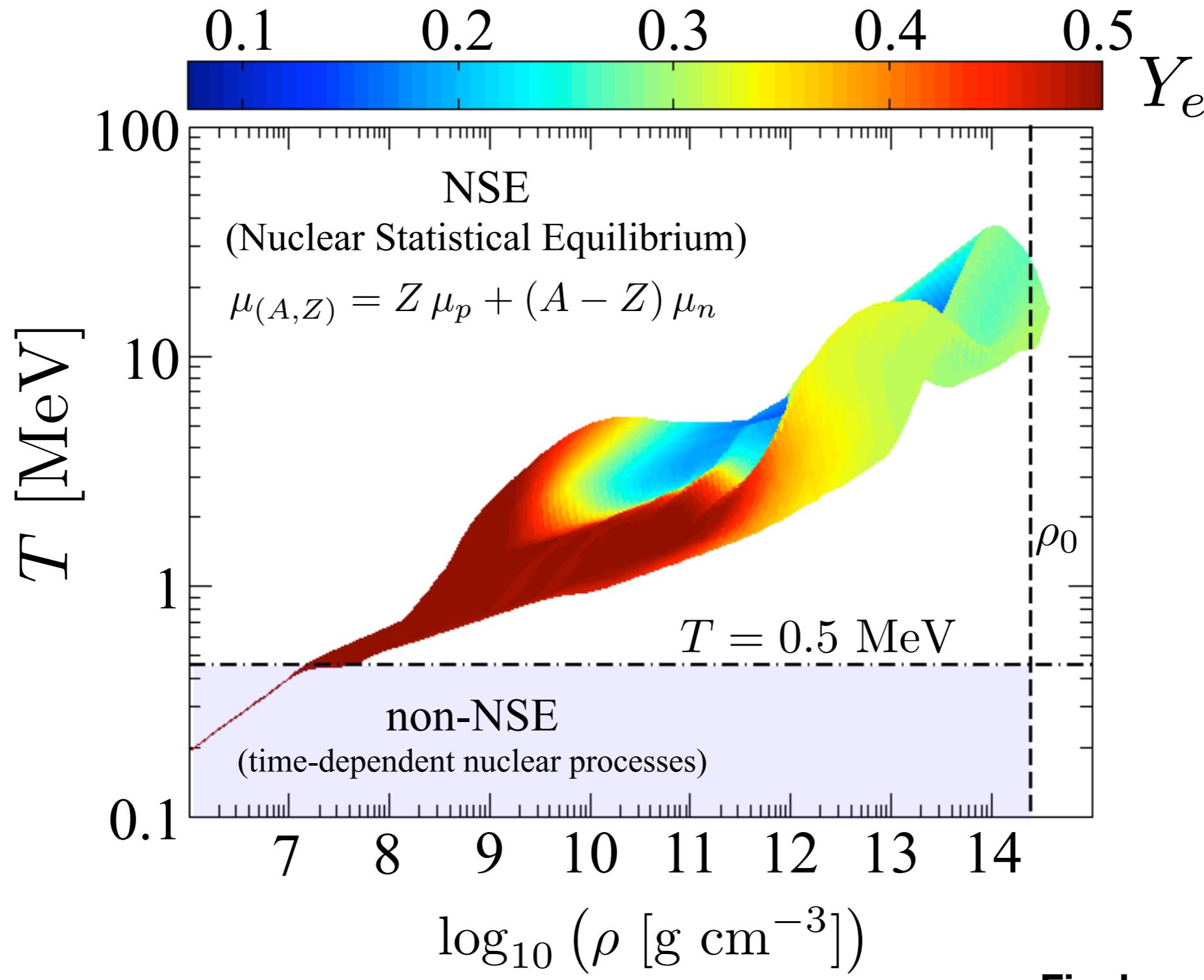


# **2nd Discussion Round Equation of State and Neutrinos**

**Jürgen Schaffner-Bielich**

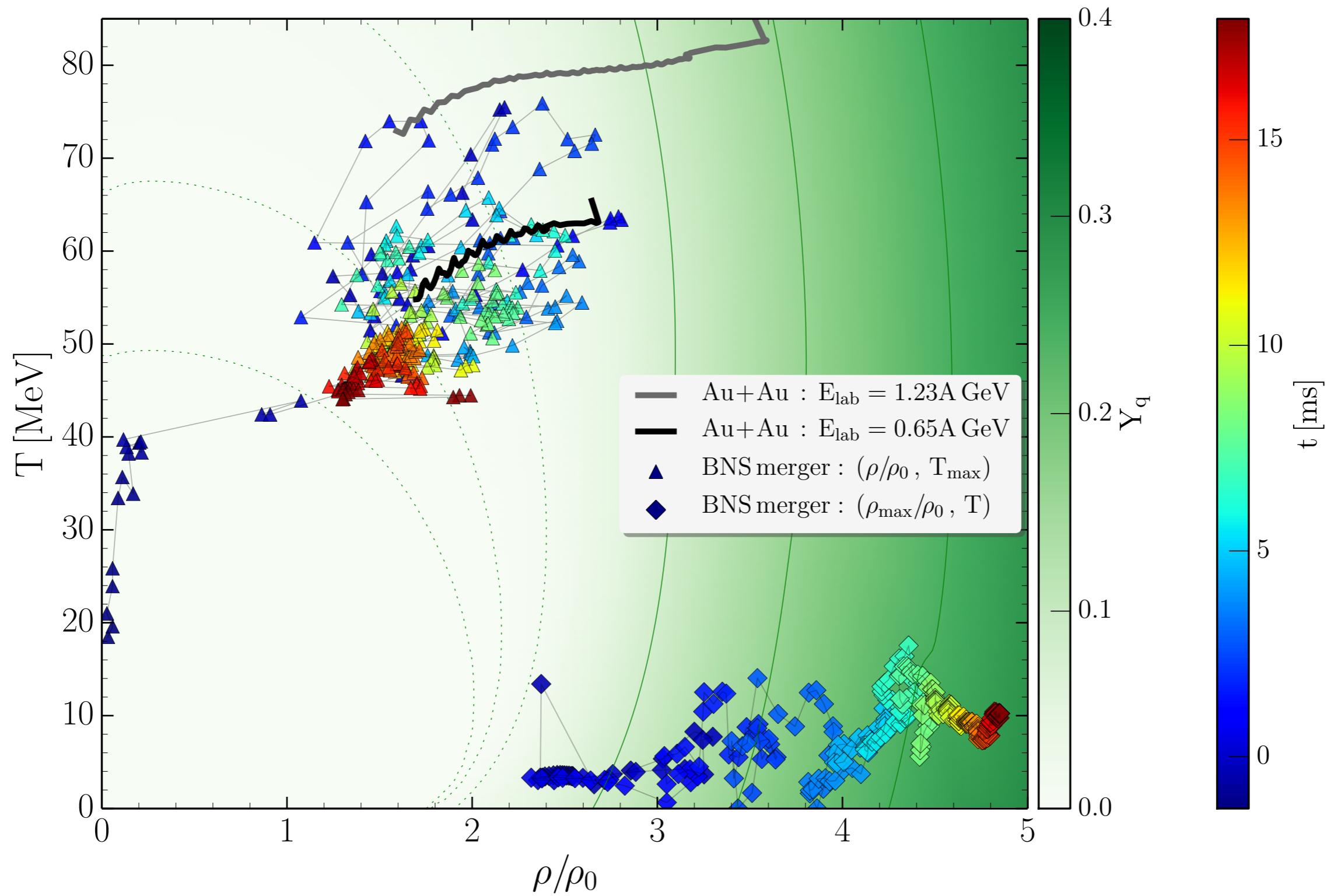
EMMI Rapid Reaction Task Force Meeting on  
The Physics of Neutron Star Mergers at GSI/FAIR  
GSI, Darmstadt, June November 4-15, 2018

# Phase diagram map for core-collapse supernovae



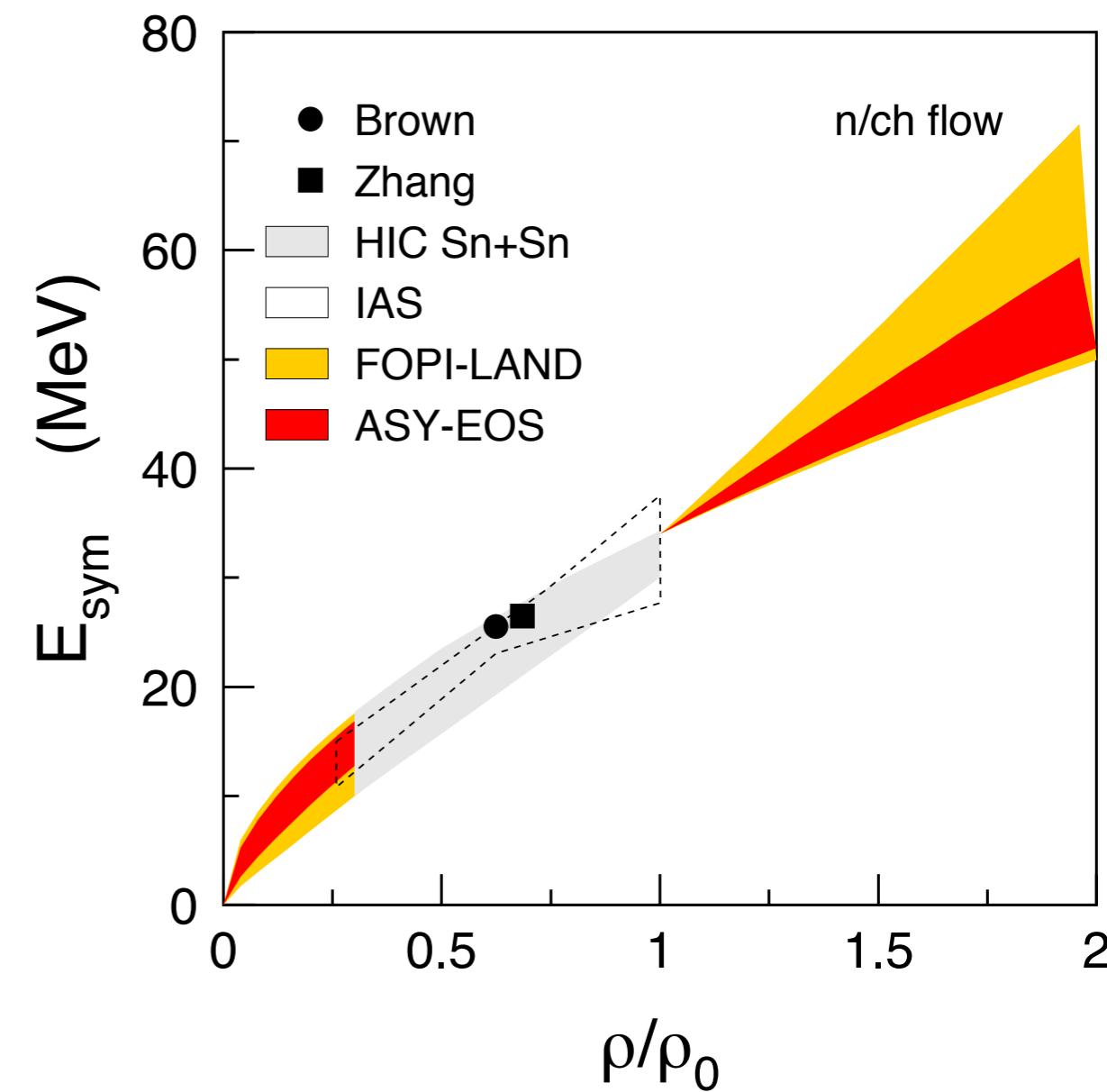
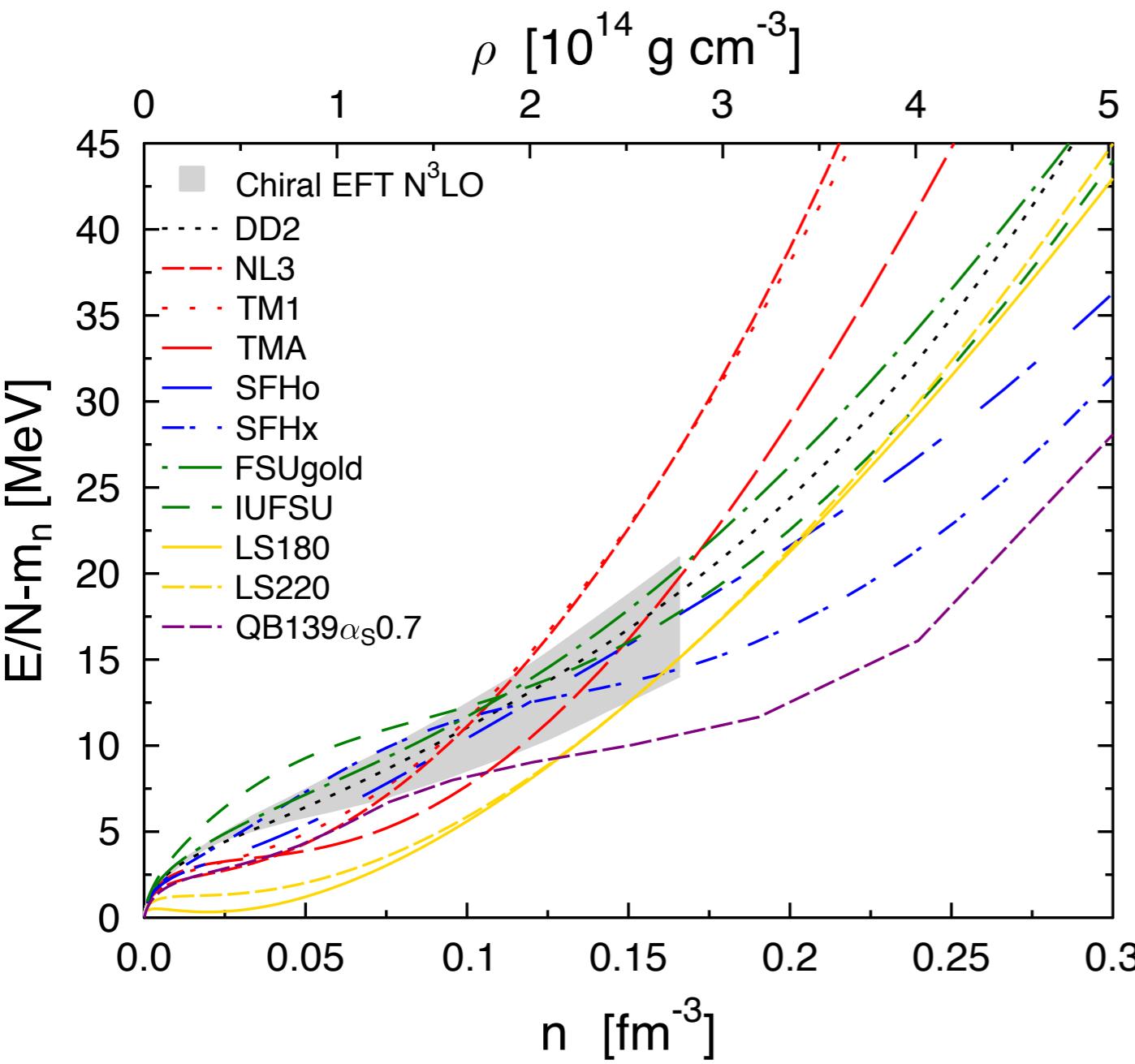
Fischer et al. 2017

# Phase diagram map for neutron star merger



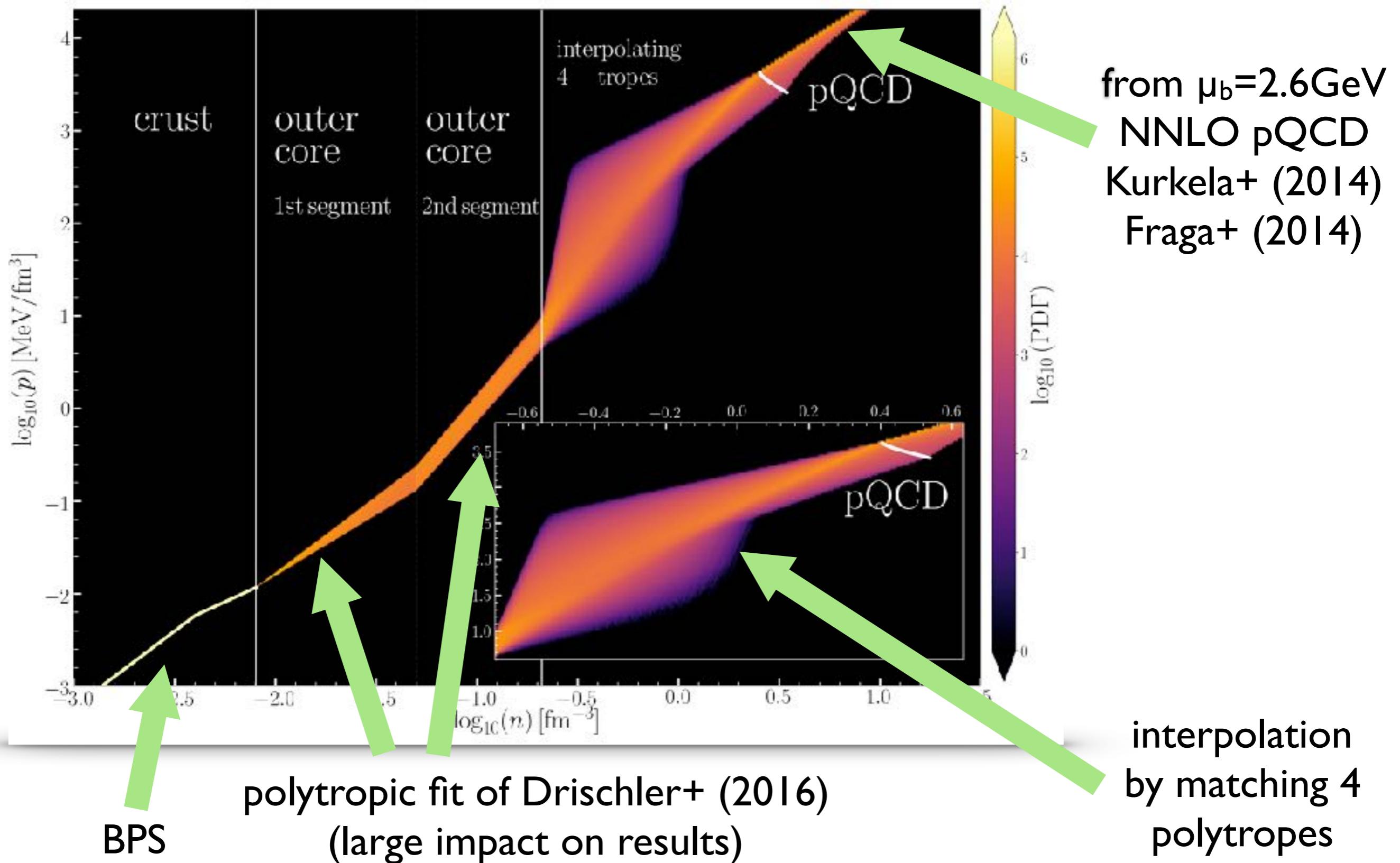
Hanauske et al., in prep.

# Supernova EoS and neutron matter EoS



# parametrising our ignorance

- Construct most generic family of NS-matter EOSs



# Constraining tidal deformability

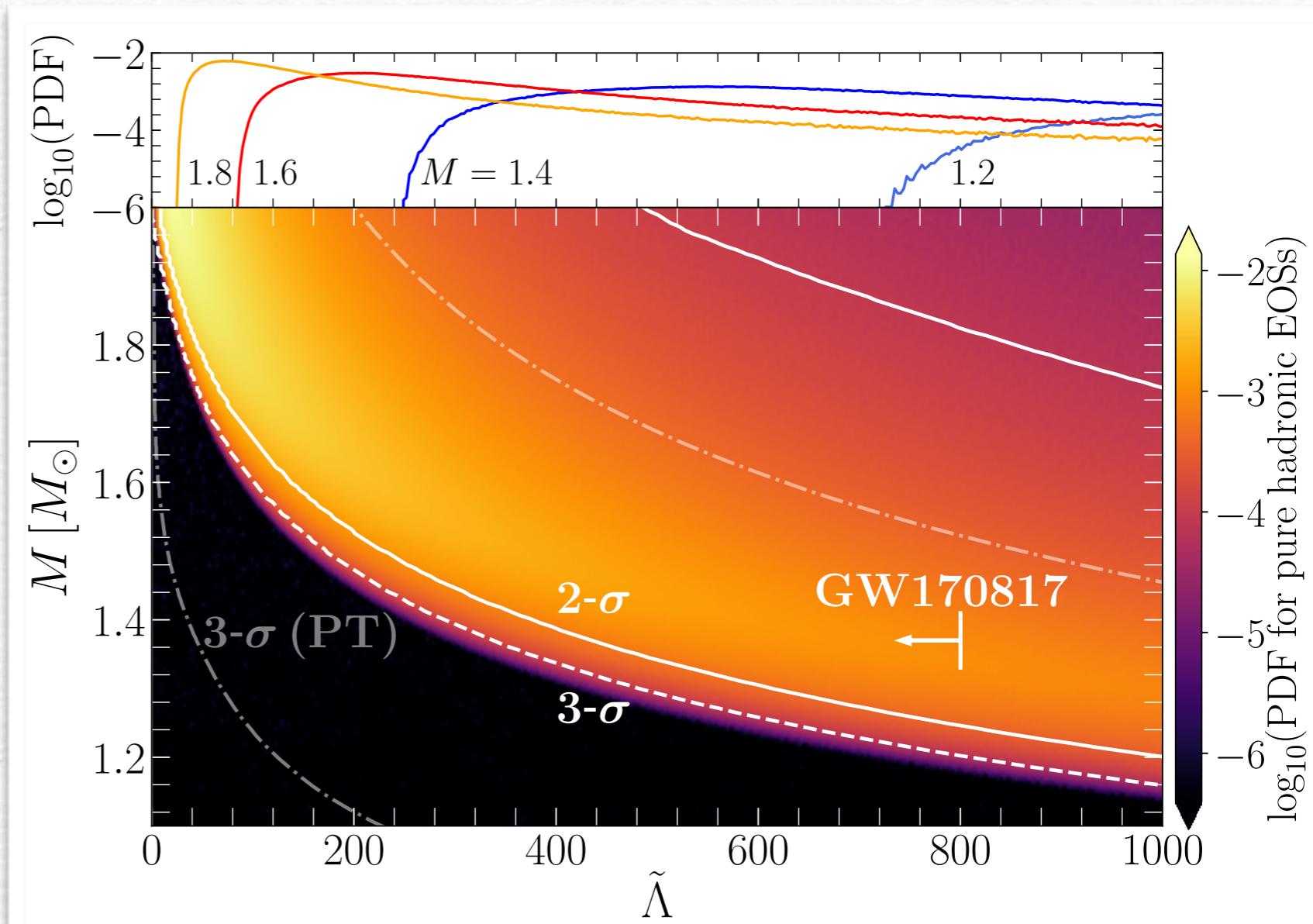
- Can explore statistics of all properties of our  $10^9$  models.
- In particular can study PDF of tidal deformability:  $\tilde{\Lambda}$

- LIGO has already set upper limit:

$$\tilde{\Lambda}_{1.4} \lesssim 800$$

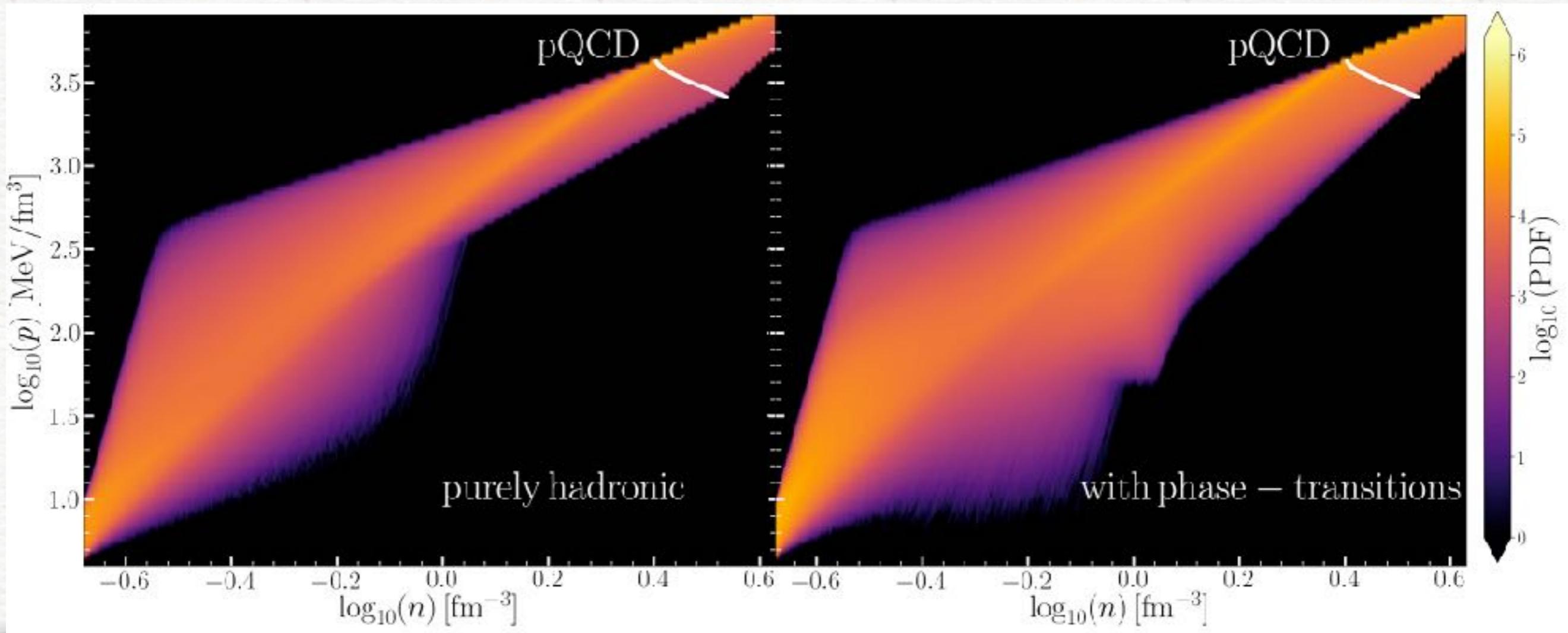
- Our sample naturally sets a lower limit:

$$\tilde{\Lambda}_{1.4} > 375$$



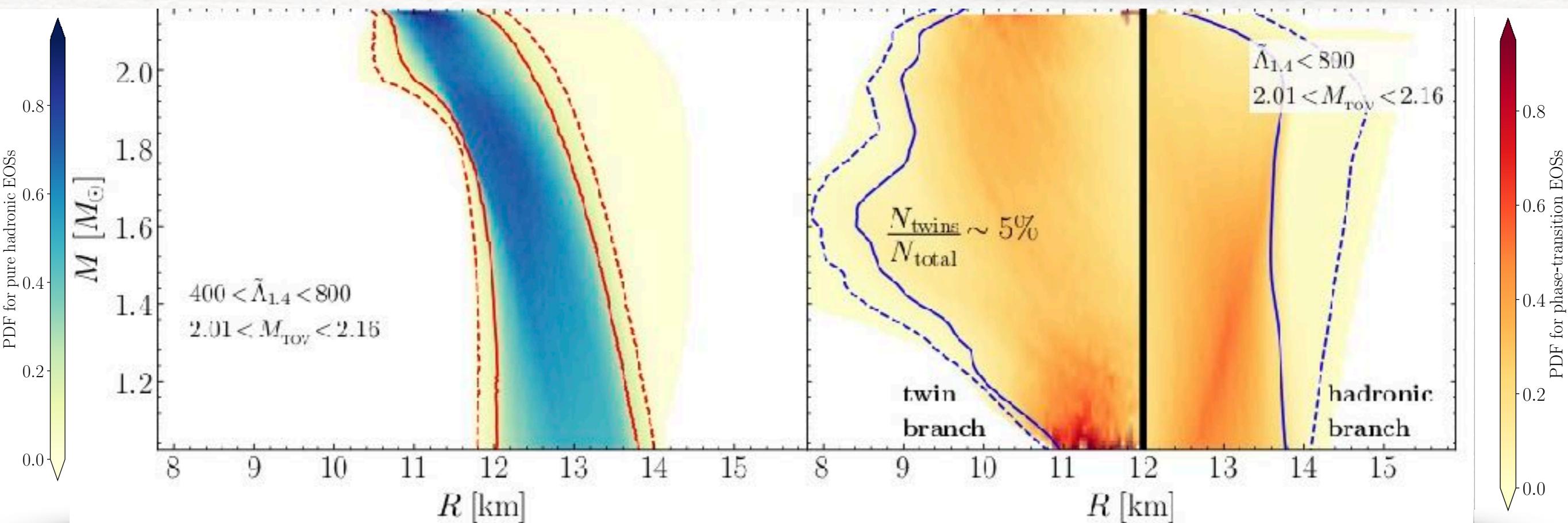
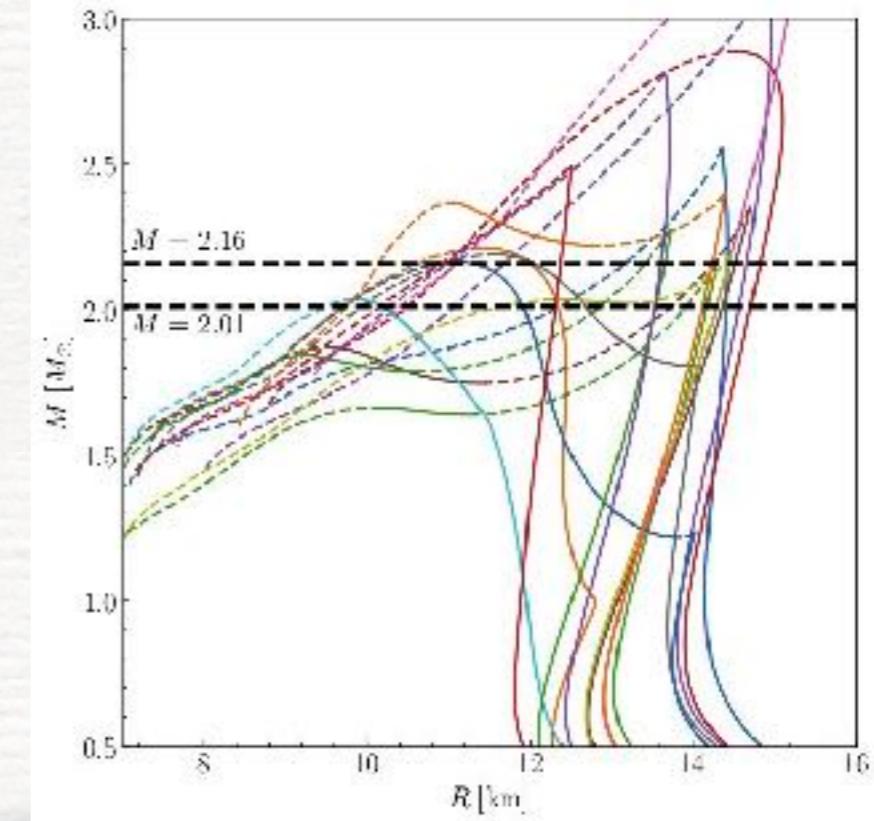
# What about phase transitions?

- All EOSs so far are purely hadronic; a conservative but probably **reasonable** assumption.
- What about the possibility of **phase transitions**?
- These are not trivial but not too difficult to model.

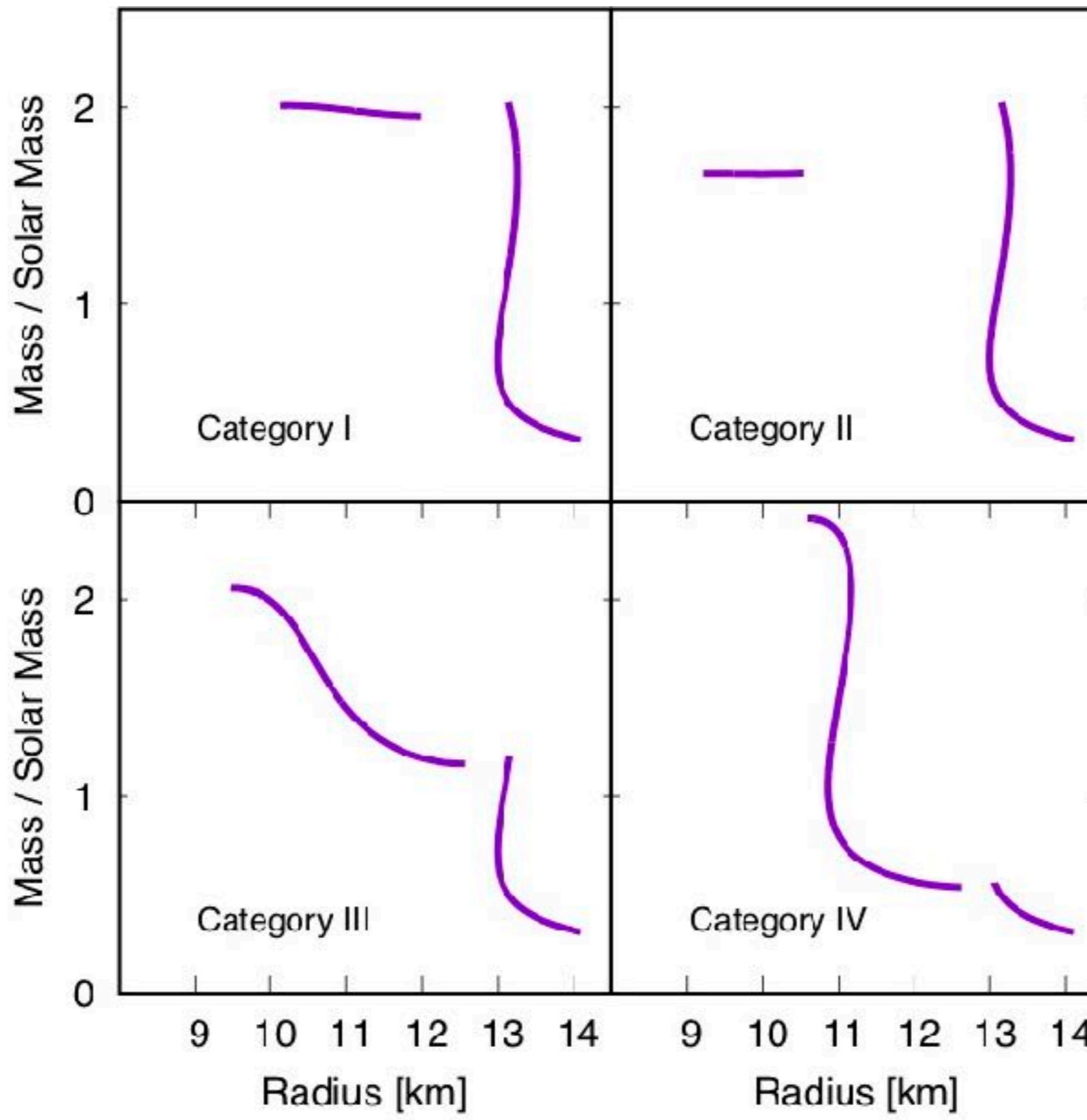


# Mass-radius relations

- Presence of a phase transition leads to second stable branch and “twin-star” models.



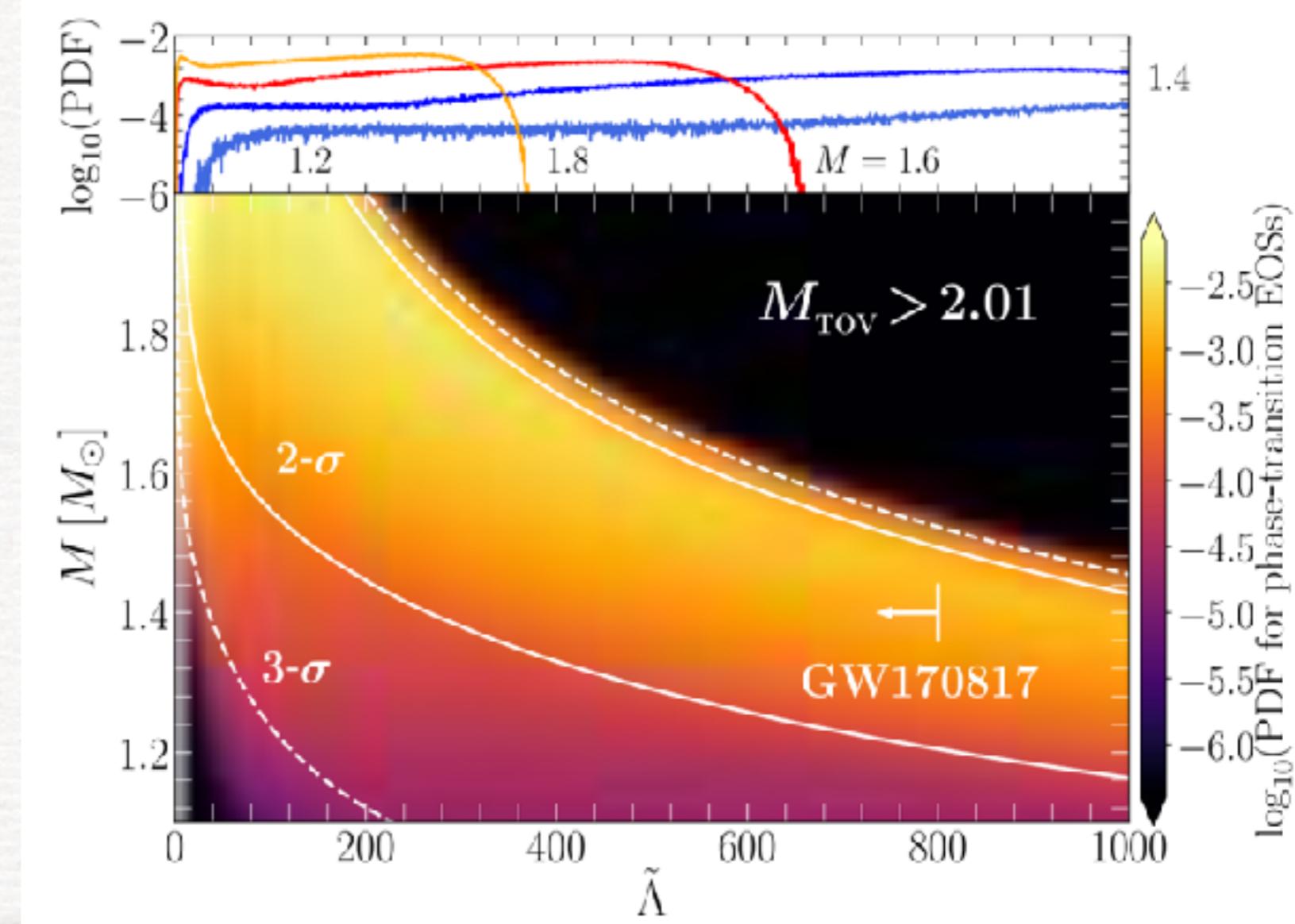
# Classification of neutron star twins



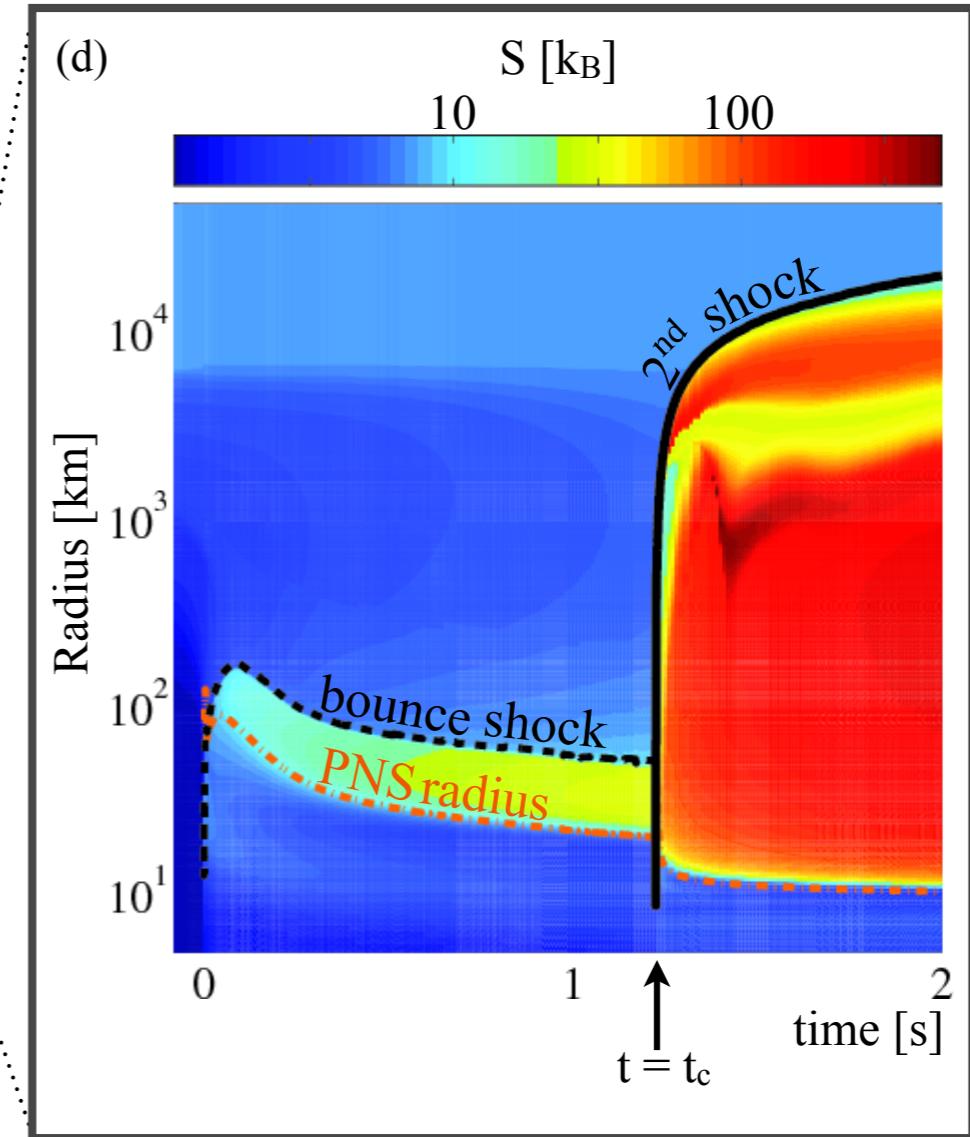
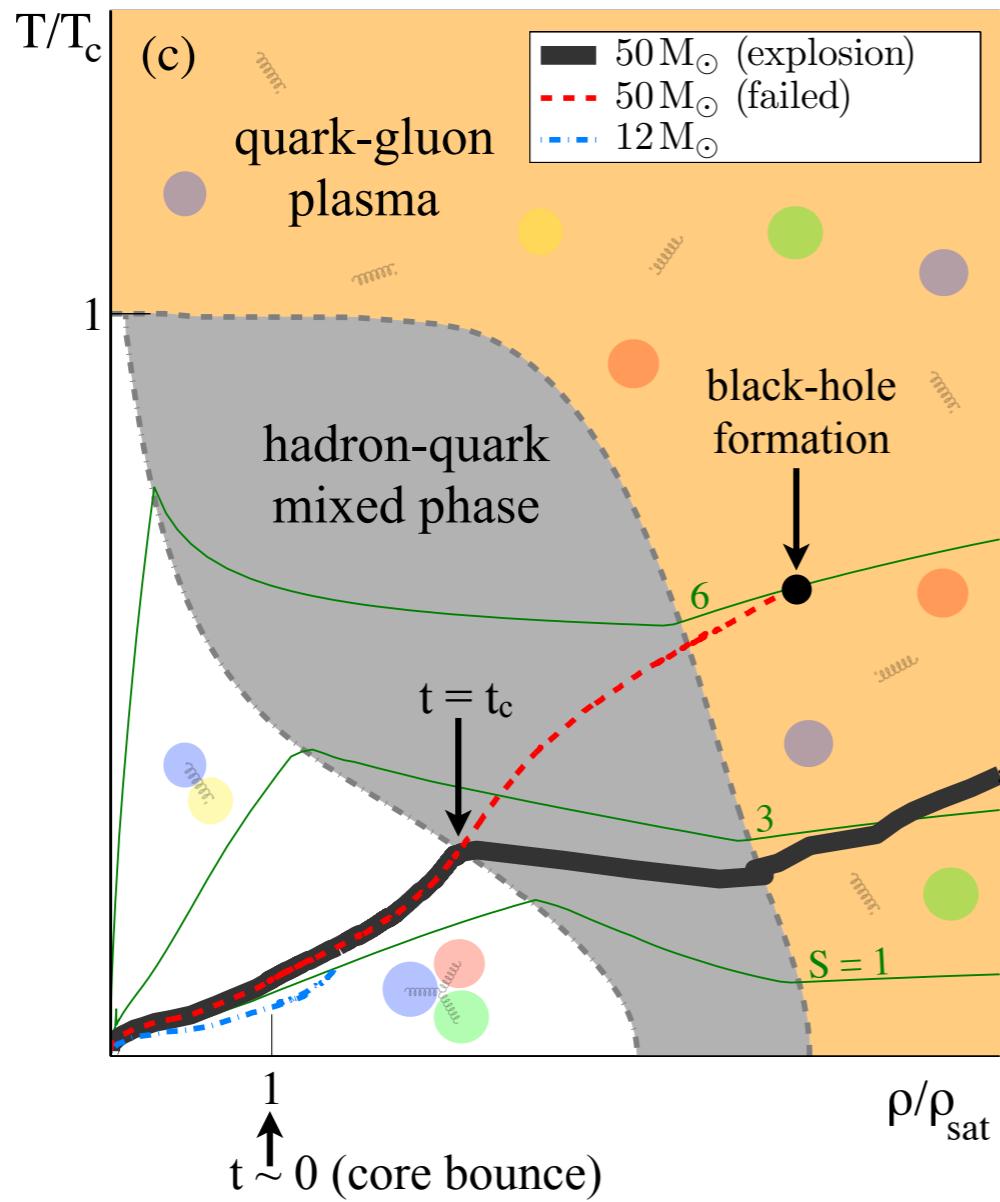
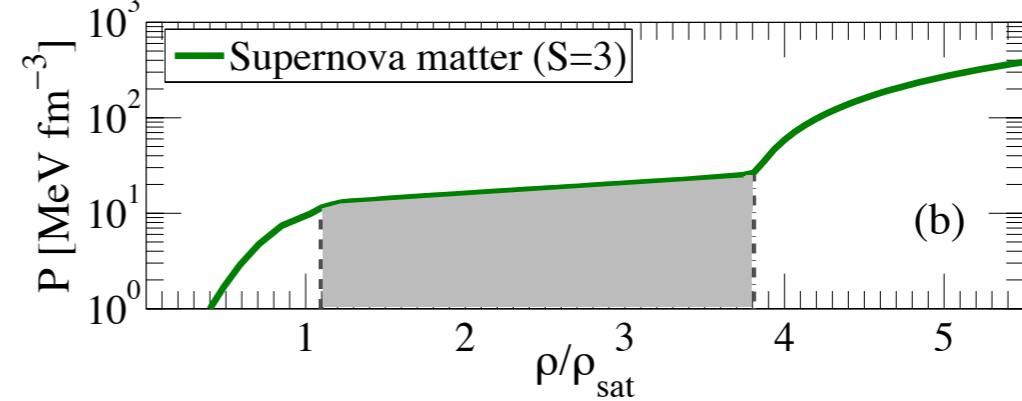
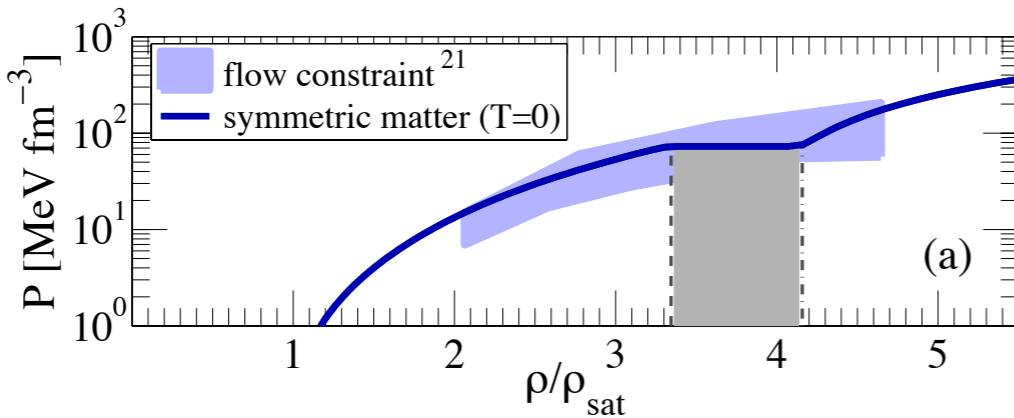
# Constraining tidal deformability: PTs

- Can repeat considerations with EOSs having PTs
- Lower limit much weaker:  $\tilde{\Lambda}_{1.4} \gtrsim 35$
- Large masses have sharp cut-off on upper limit:  
 $\tilde{\Lambda}_{1.7} \lesssim 460$

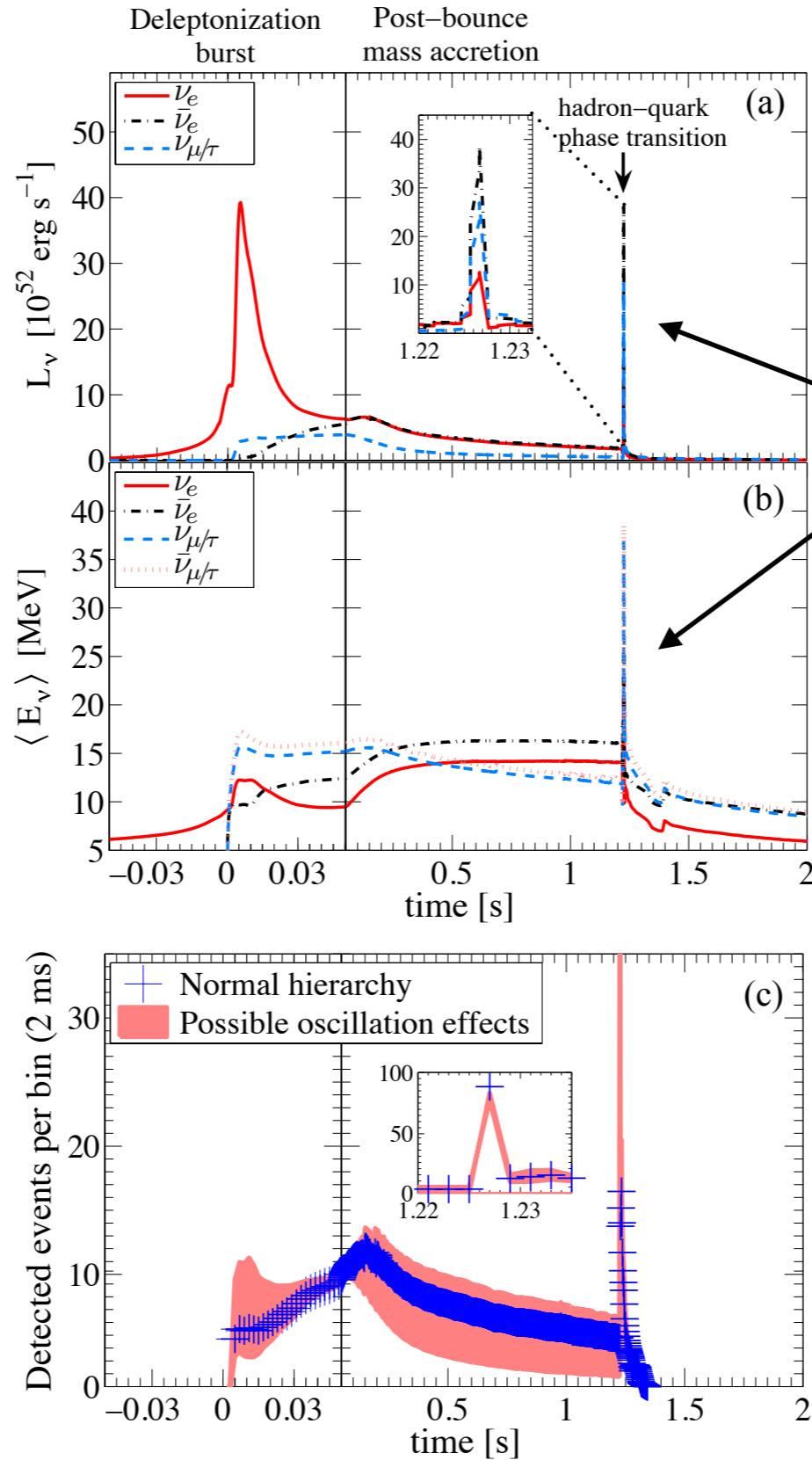
**GW detection  
with  $\tilde{\Lambda}_{1.7} \sim 700$   
would rule out  
twin stars!**



# Supernova EoS with a phase transition



# Supernova EoS with a phase transition



**second burst in antineutrinos  
due to phase transition**