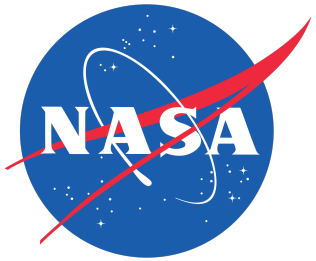
Constraining cold dense matter with observations of merging NSs

multi-wavelength, multi-messenger

Ben Margalit,
Einstein Fellow @ UC Berkeley



Berkeley
UNIVERSITY OF CALIFORNIA

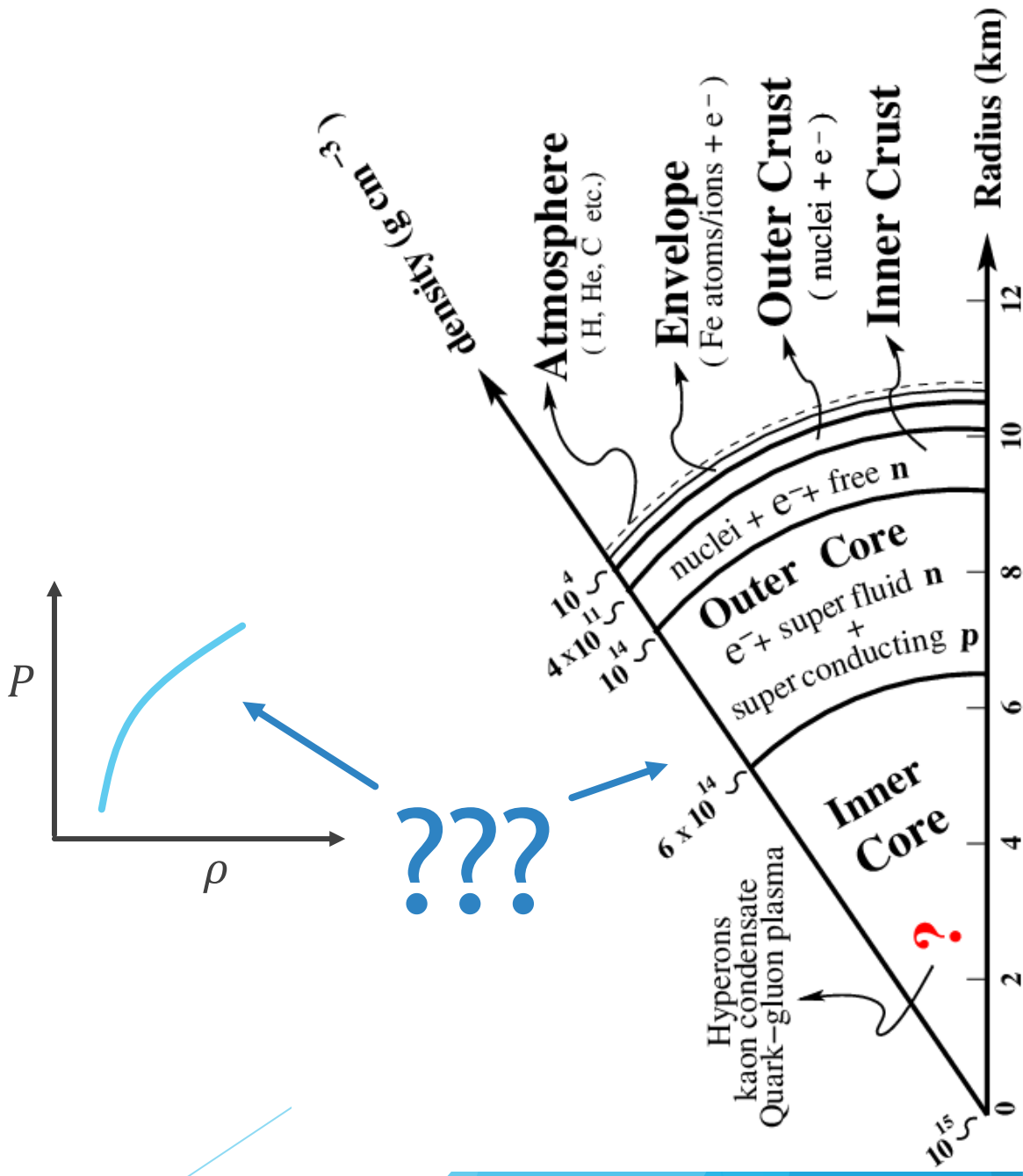
N3AS Zoom Seminar,

August 25th 2020

Constraining the nuclear EOS using NS Mergers

NS EOS and NS mergers:

- equation-of-state (EOS) of cold dense (asymmetric) nuclear matter unknown



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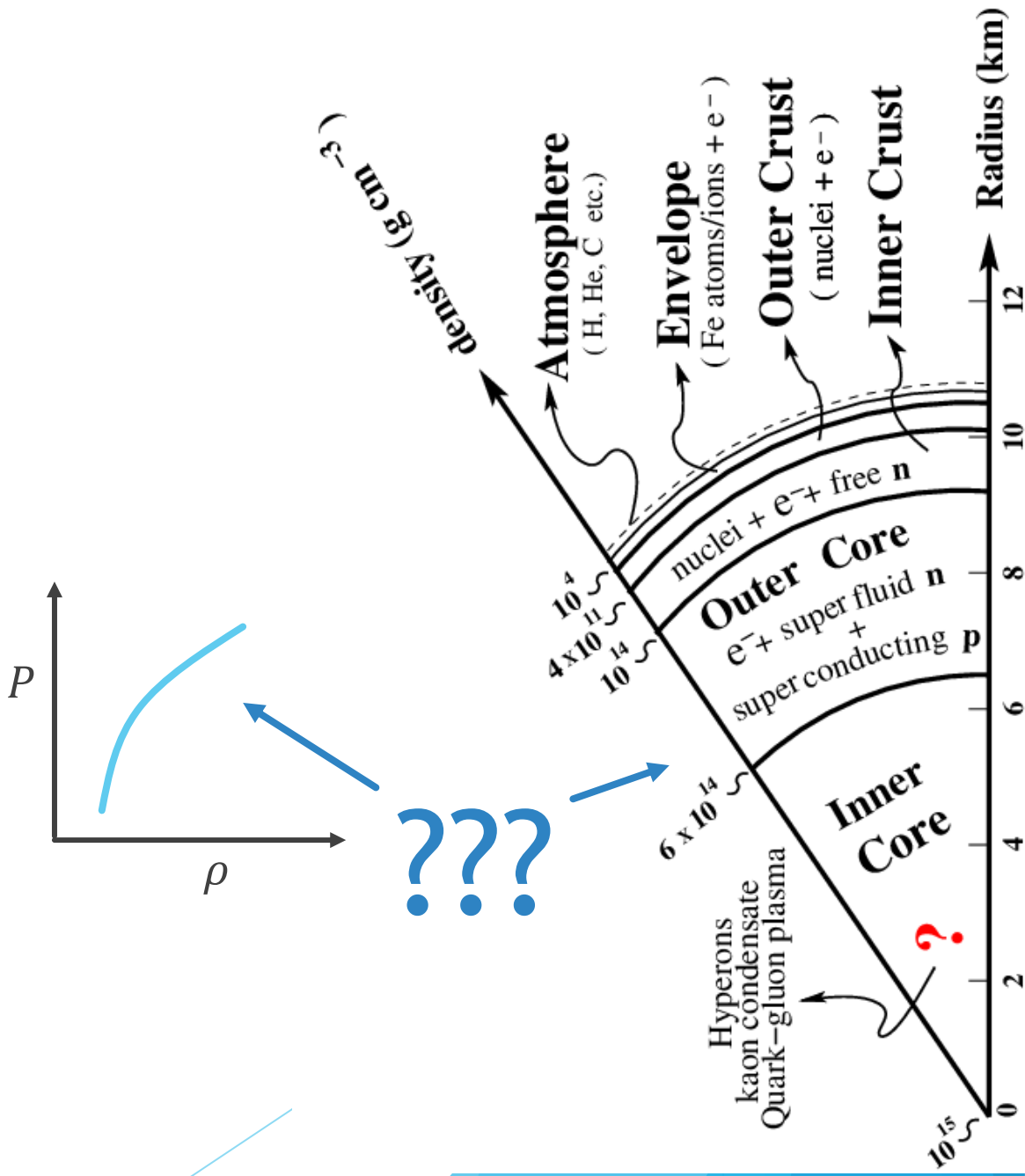

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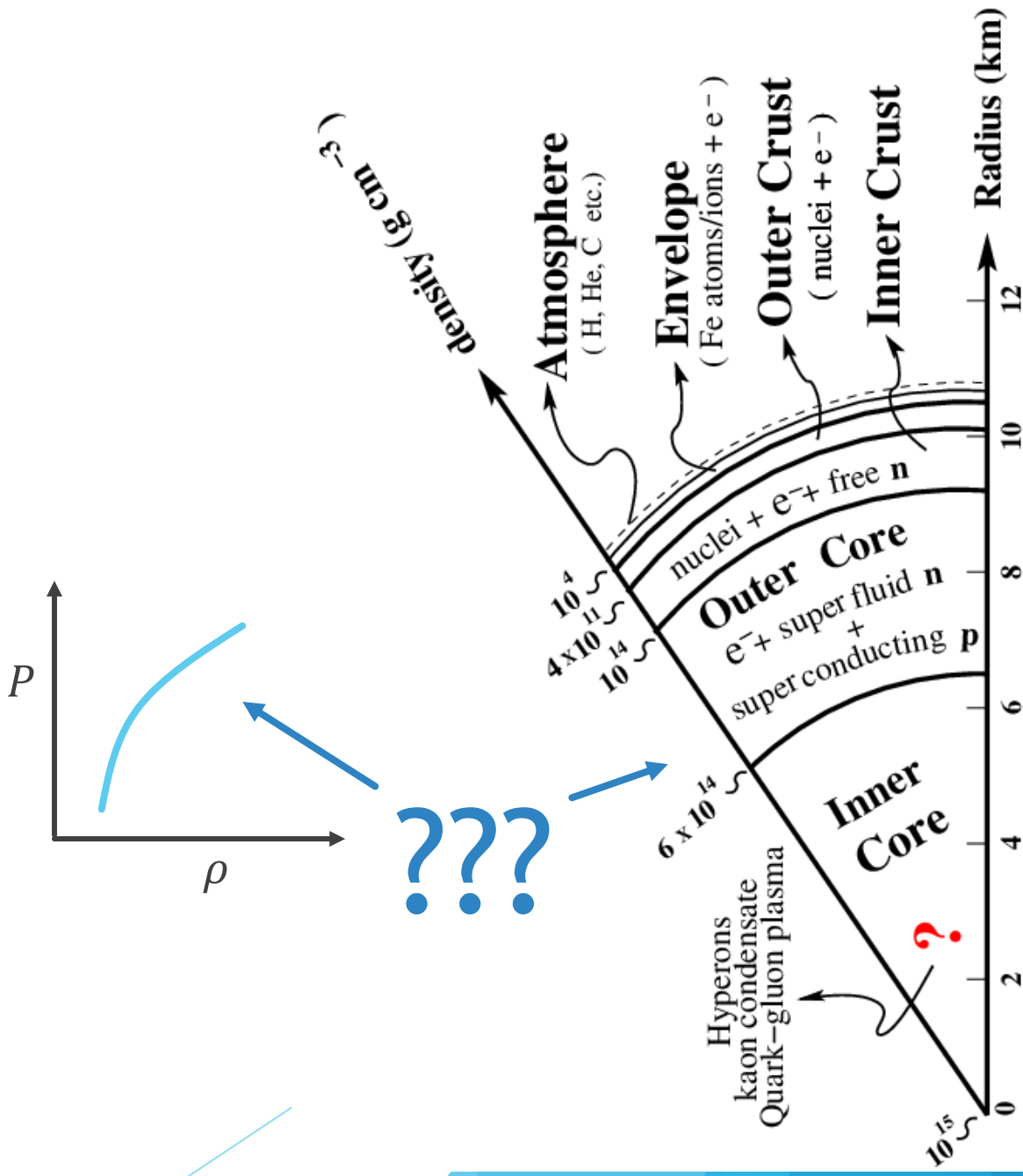

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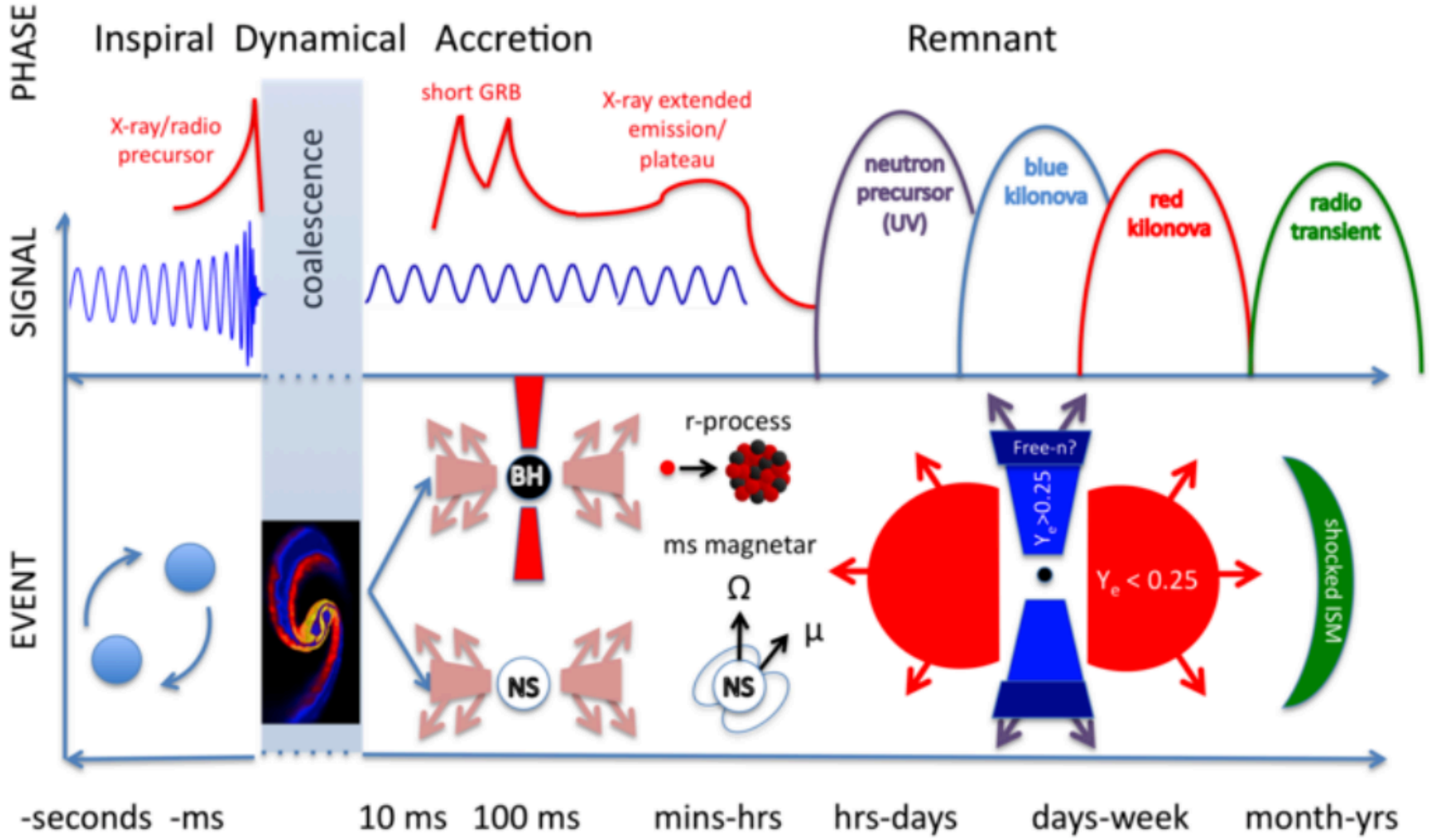
NS EOS and NS mergers:

- neutron star mergers can produce many observable signatures!

Fernandez & Metzger (2016)



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(LVC+17; Fattoyev+18; Annala+18; Raithel+18; De+18; LVC+18; Landry&Essick19; Coughlin+19; Capano+20)

[and many many more…]

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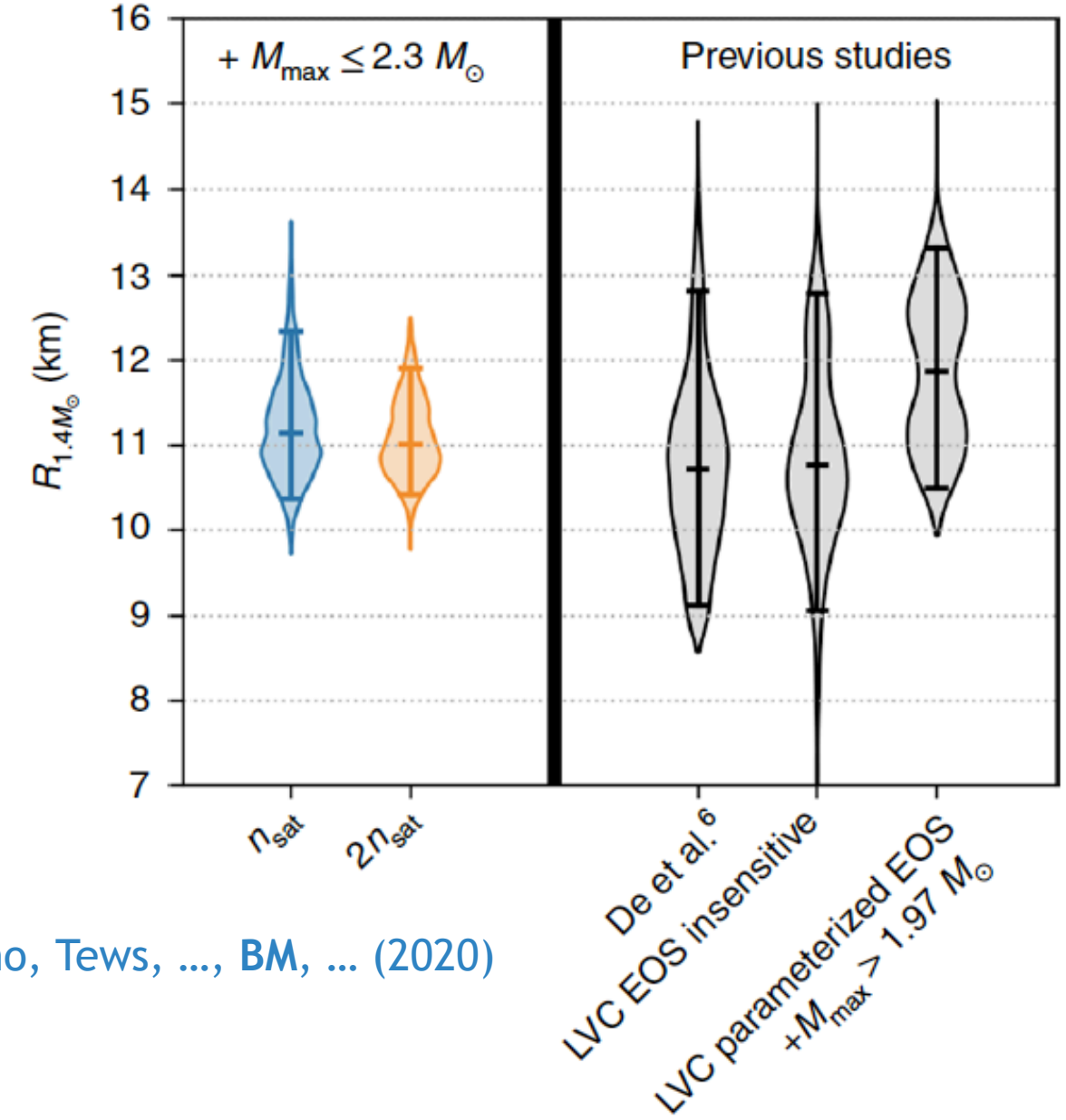


Capano, Tews, …, **BM**, … (2020)

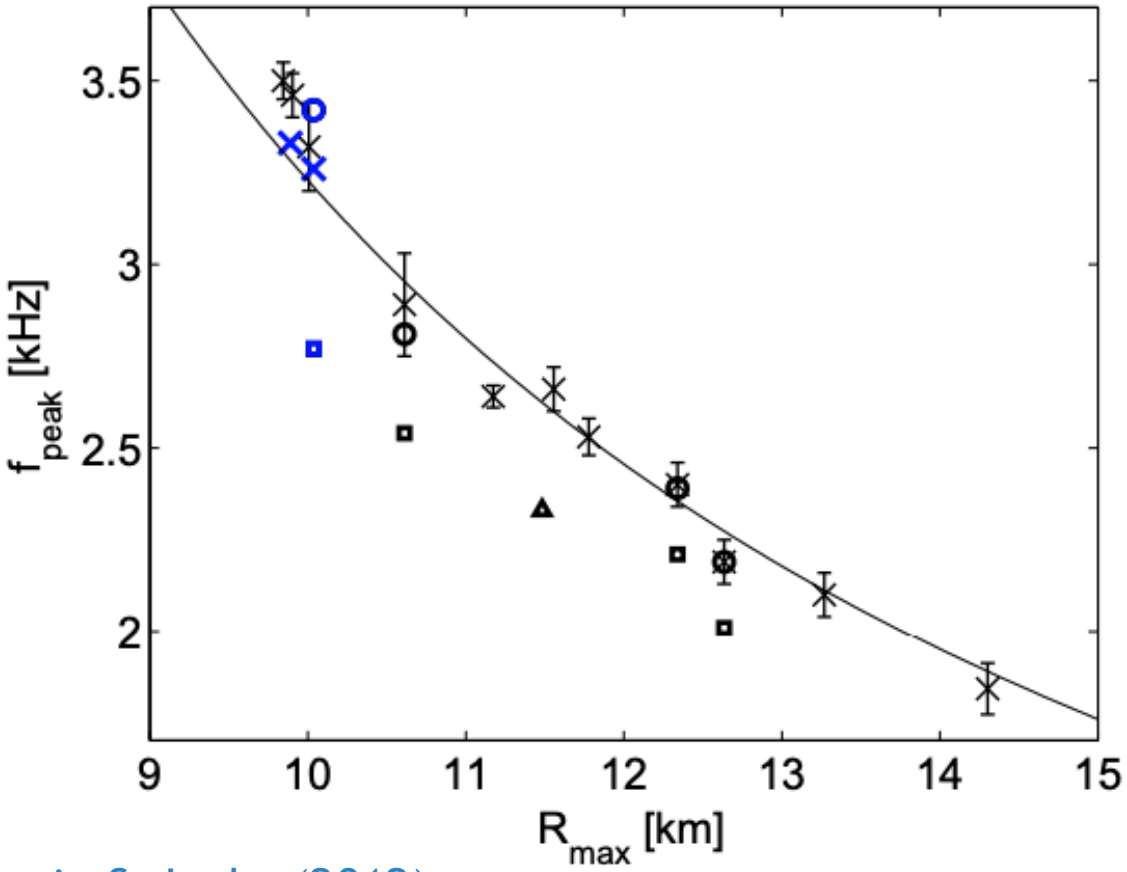
Constraining the nuclear EOS using NS Mergers

(2) Post-merger GWs:

- $f_{\rm peak}$ of post-merger GW emission (remnant oscillation) correlates with NS size

(Bauswein&Janka12; Bauswein+12; Chatziioannou+17; …)

- but hard to detect!



Bauswein & Janka (2012)

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[+ nuclear & atomic physics of *r*-process nuclei,
viewing angle, neutrino transport?, magnetic fields?]

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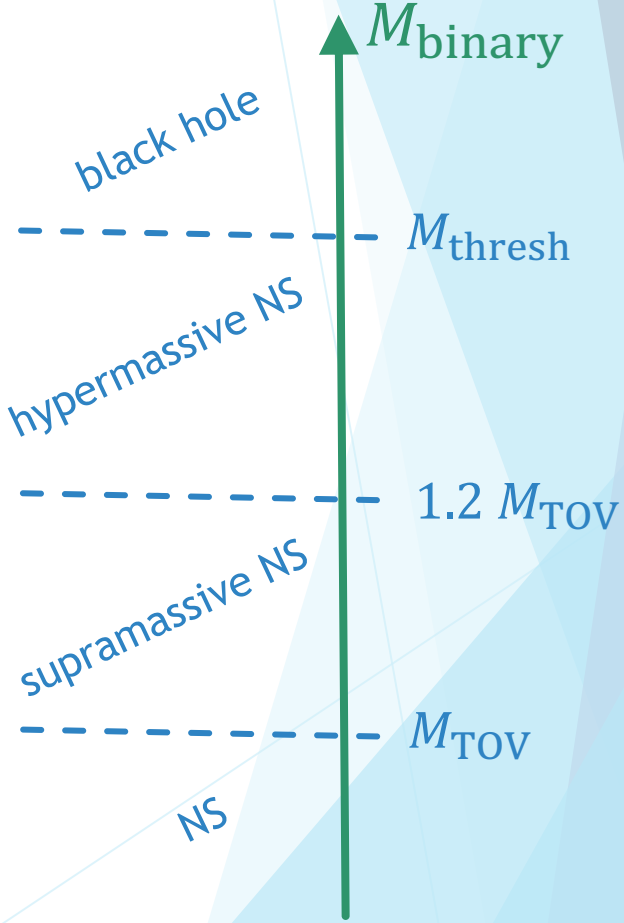

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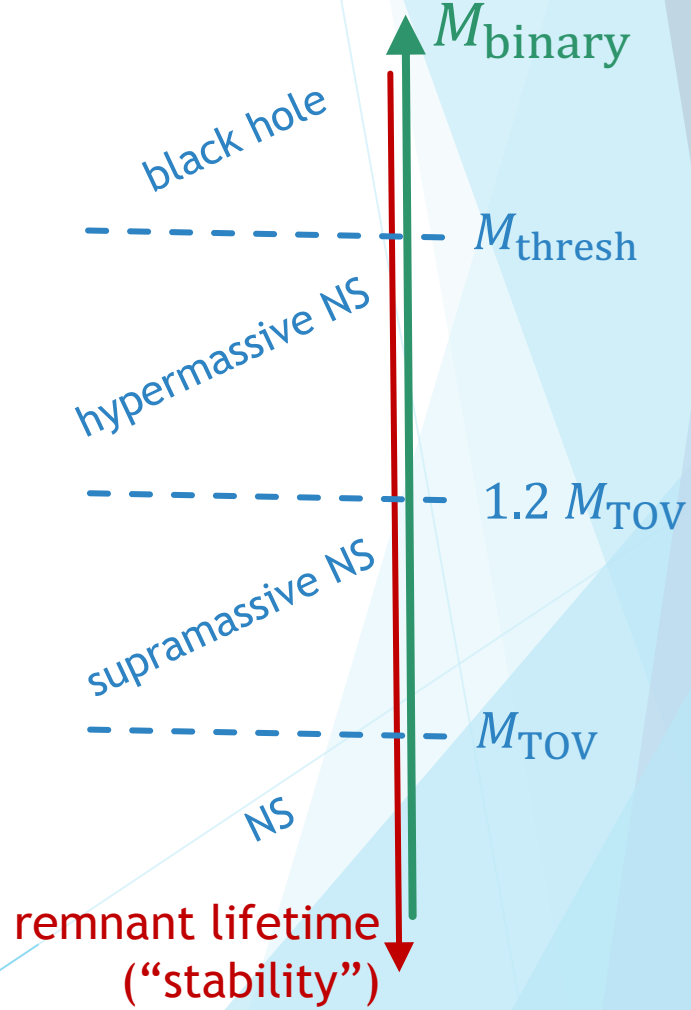

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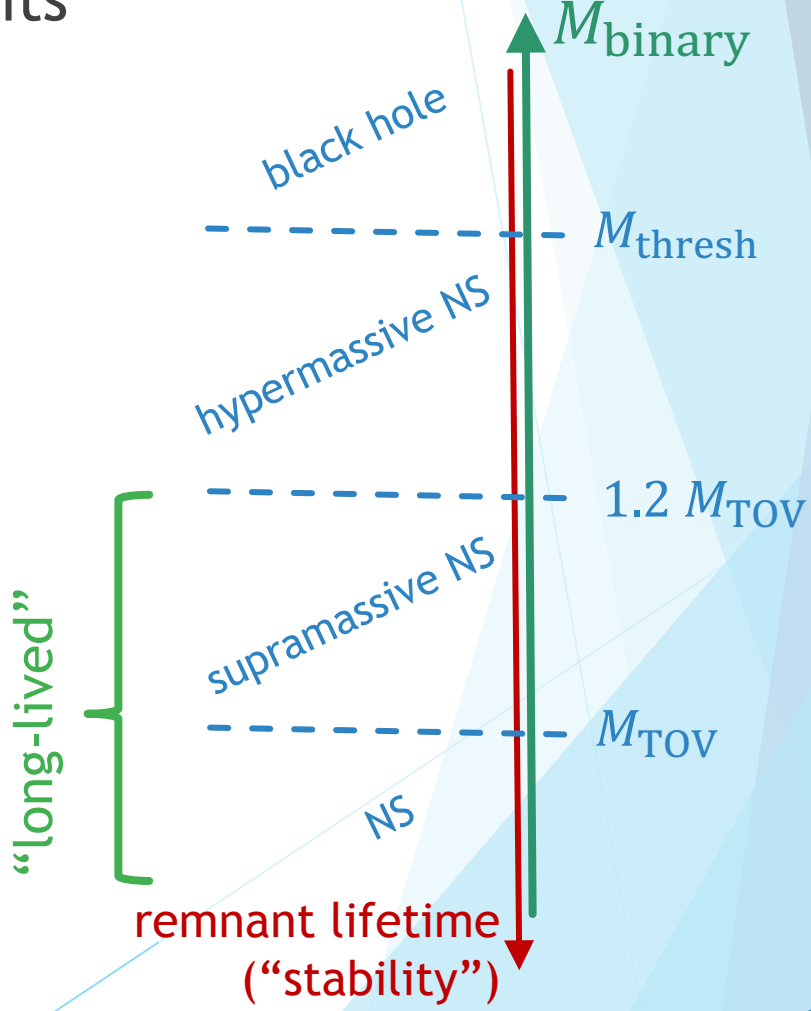

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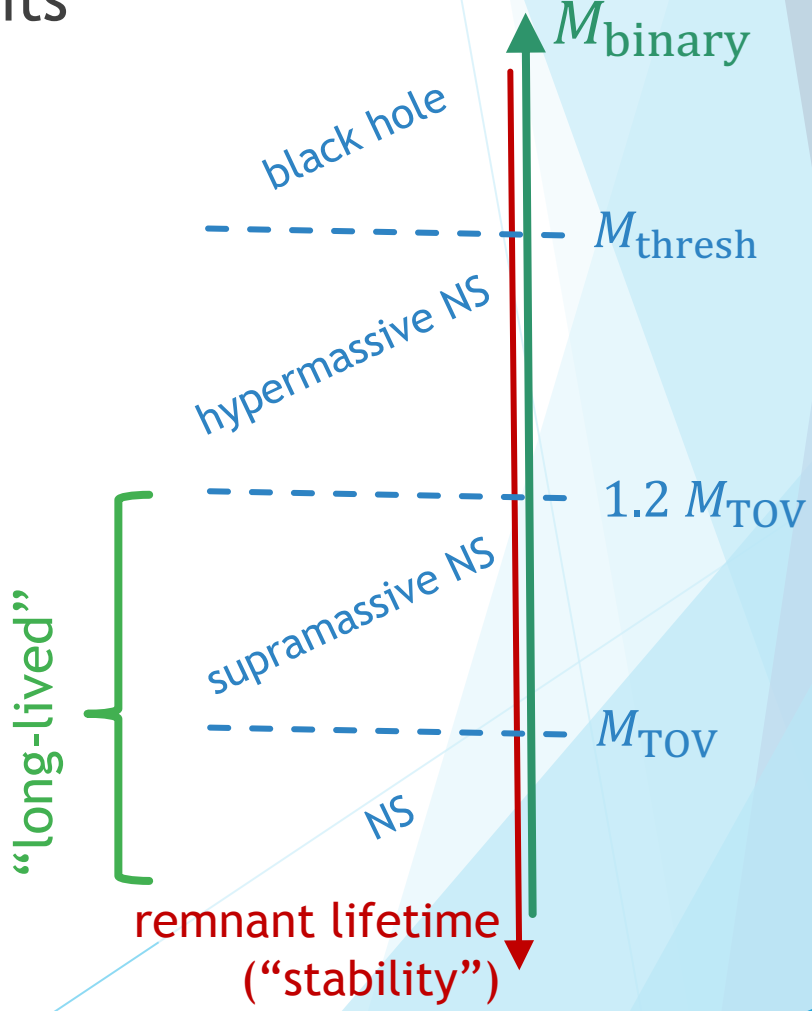
$\Rightarrow M_{\rm TOV} \lesssim 2.2 M_\odot$

(BM&Metzger17; …; Shibata+19)



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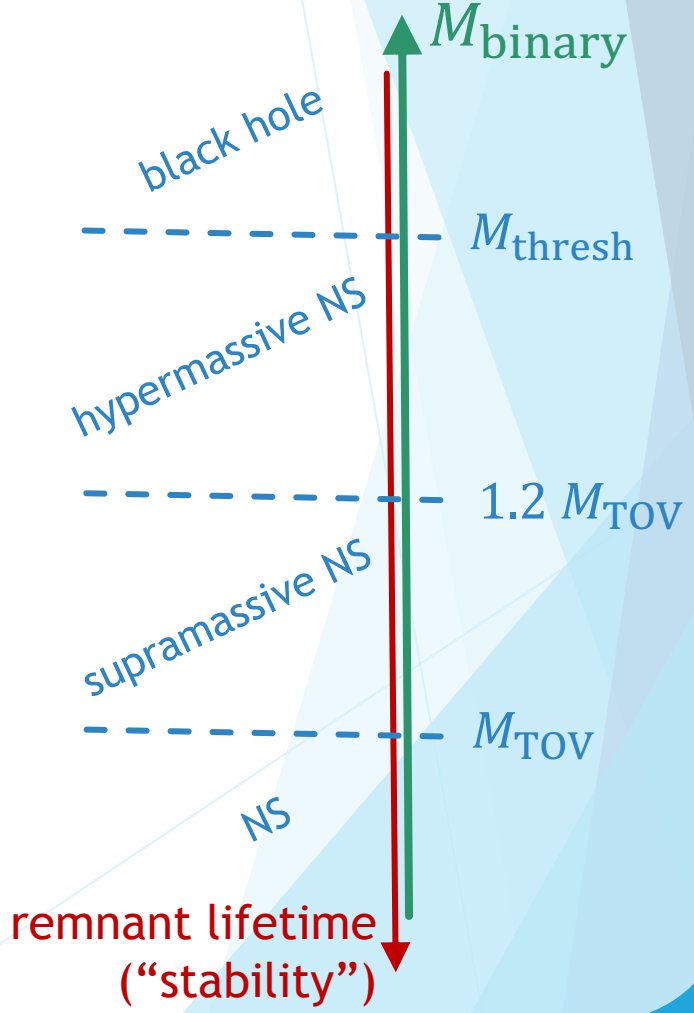

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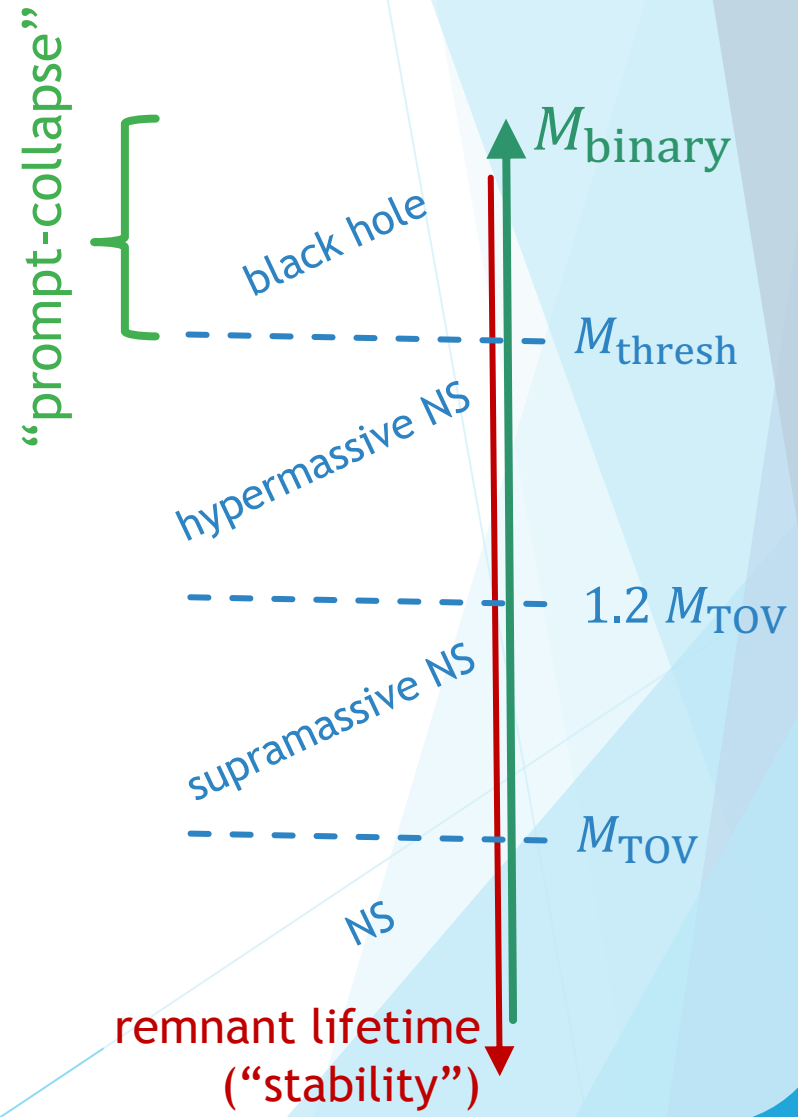

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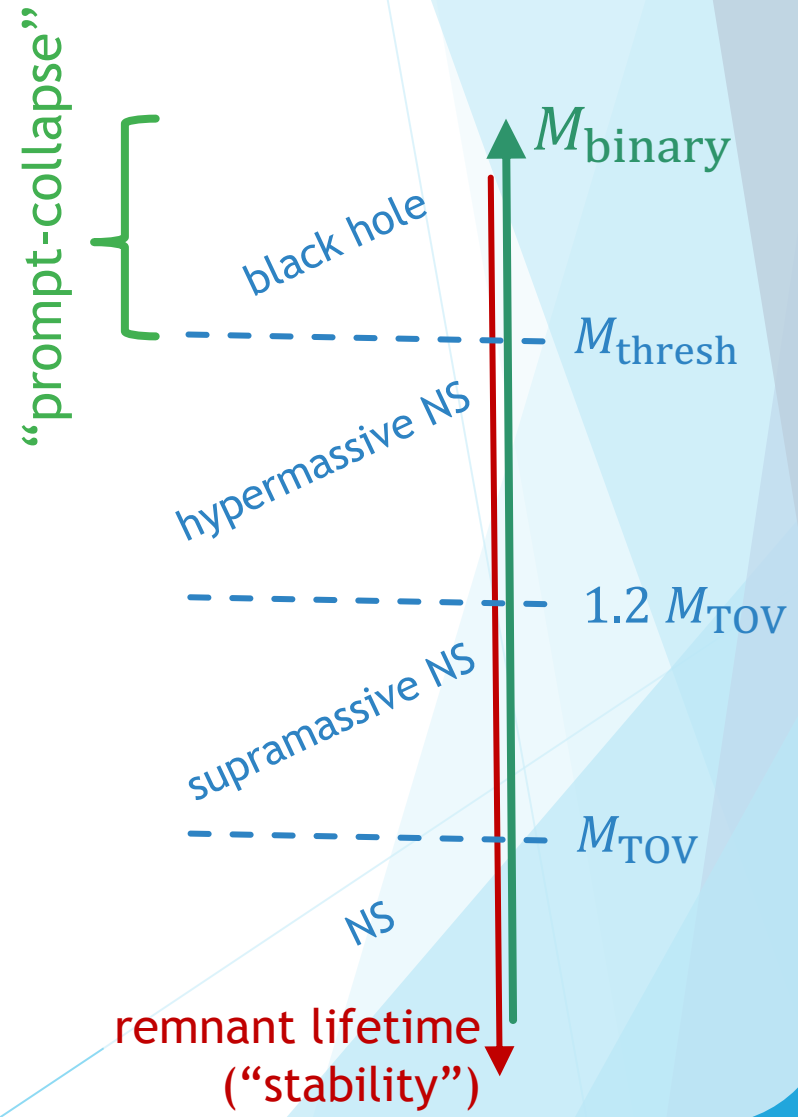
$$\Rightarrow M_{170817} < M_{\rm thresh}(M_{\rm TOV}, R_{1.6})$$

$$\Rightarrow R_{1.6} > 10.3\ \rm km$$

(Bauswein+17; Radice+18; though see Kiuchi+19)



(5) Detailed Kilonova Modeling:

- can use numerical relativity simulations + radiative transfer to quantitatively map binary parameters + EOS properties to kilonova light-curve

(Coughlin+18; Radice&Dai19; Coughlin,Dietrich,**BM**+19)

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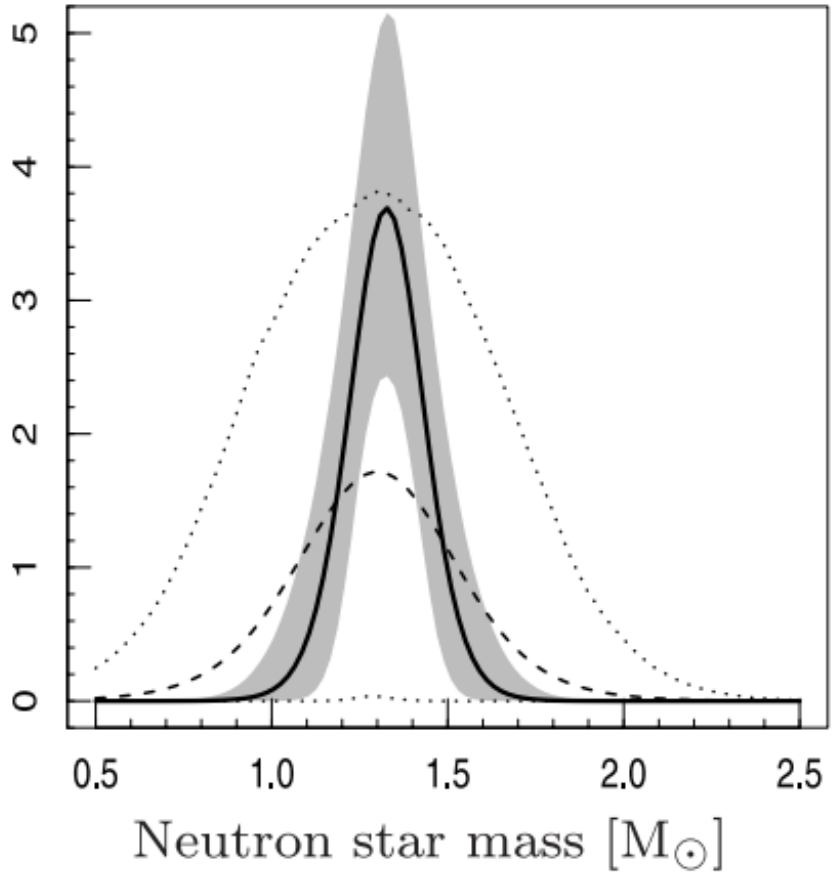
Kiziltan et al. (2013)



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  - $\Rightarrow$ produce bright radio emission at late times

(Nakar&Piran11; **BM**&Piran15; Hotokezaka&Piran15; …; **BM**&Piran20)

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(Metzger&Bower14; Horesh+16; Fong+16; Klose+19; Liu+20; Schroeder+20)

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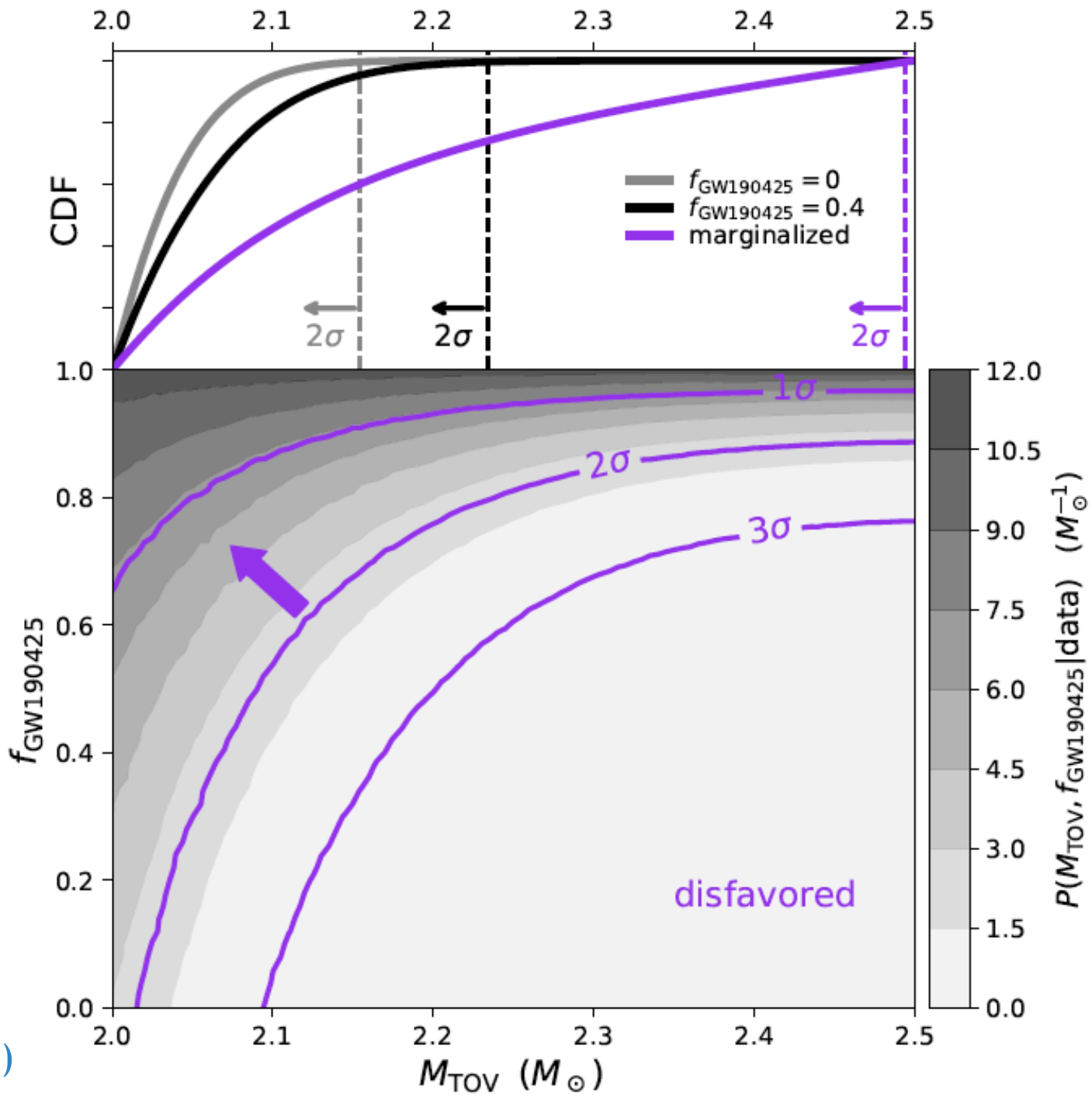

Schroeder, **BM**, … (2020)

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- within this model: can constrain magnetar and EOS parameters from X-ray light-curves

  (Fan+13; Lasky+14; Gao+16; …; Sarin+20)

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