The source of GW170817: neutron-star properties

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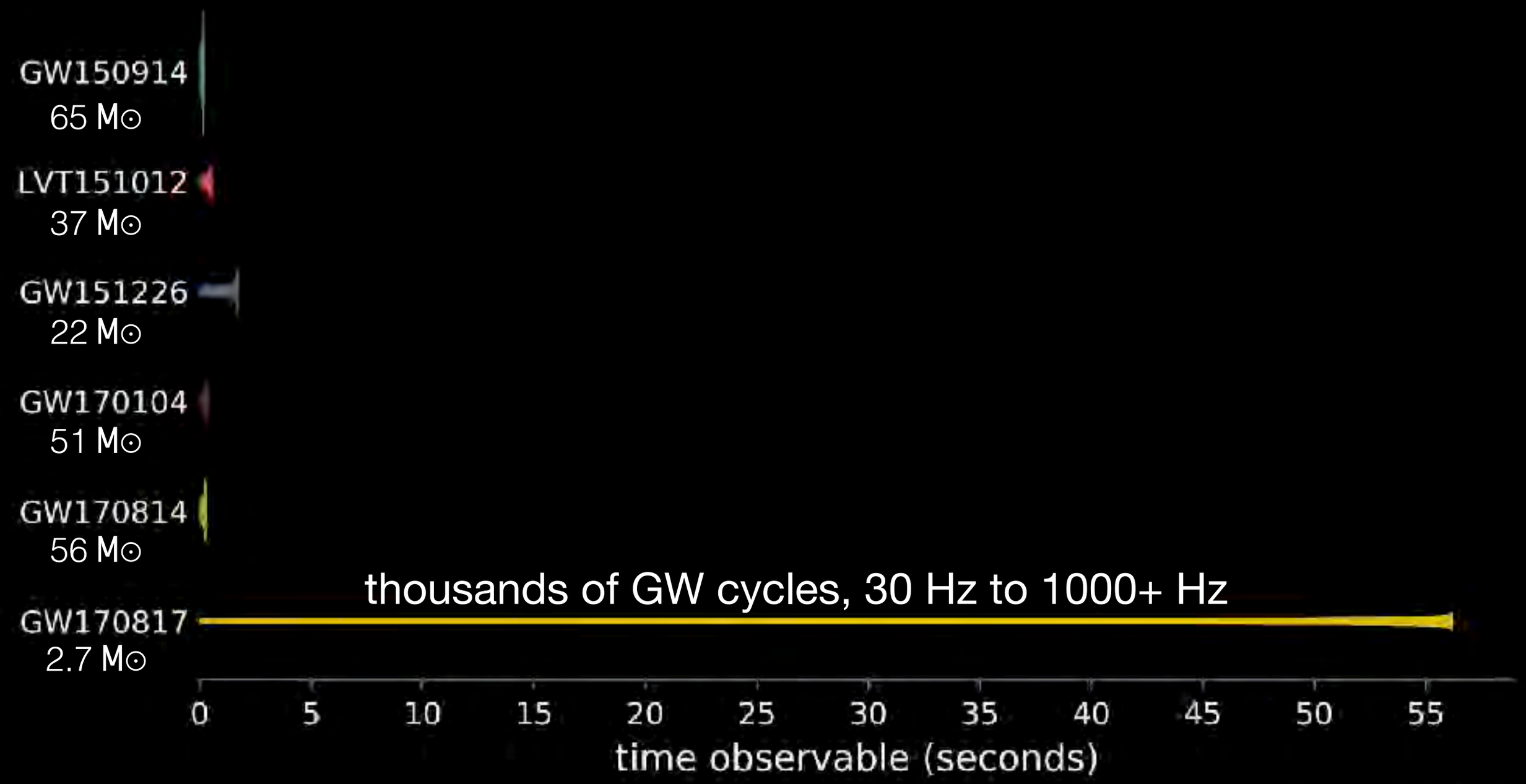
JINA-CEE Livestream
1 Dec 2017

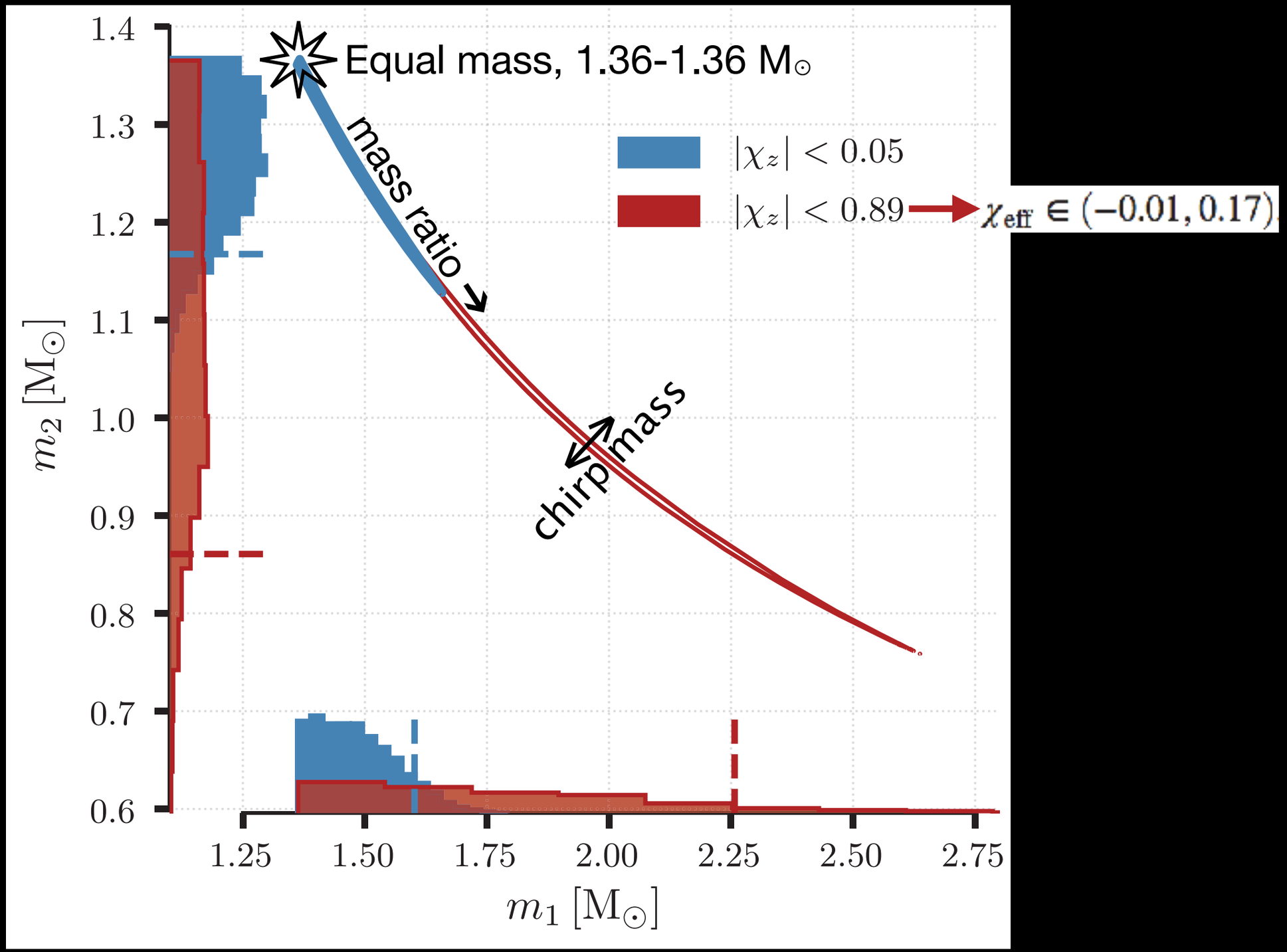
LIGO/Virgo data
simulation image: T. Dietrich(AEI/FSU)/BAM

Neutron-star merger

https://www.youtube.com/watch?v=vTeAFAGpfso



GW170817 Masses and Spin



LSC/Virgo PRL 119, 161101 (2017)

An astrophysical collider

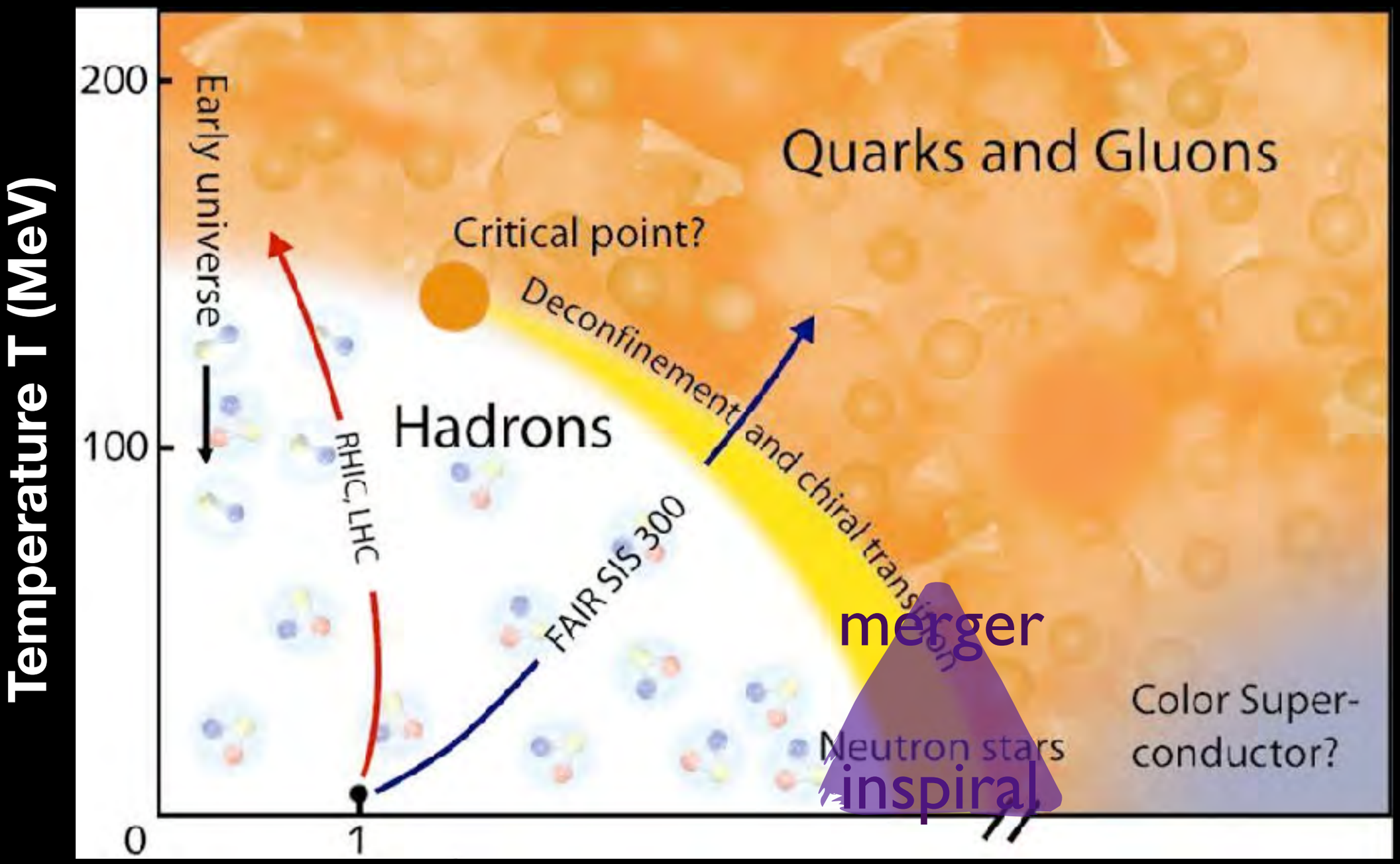


figure from FAIR CBM experiment

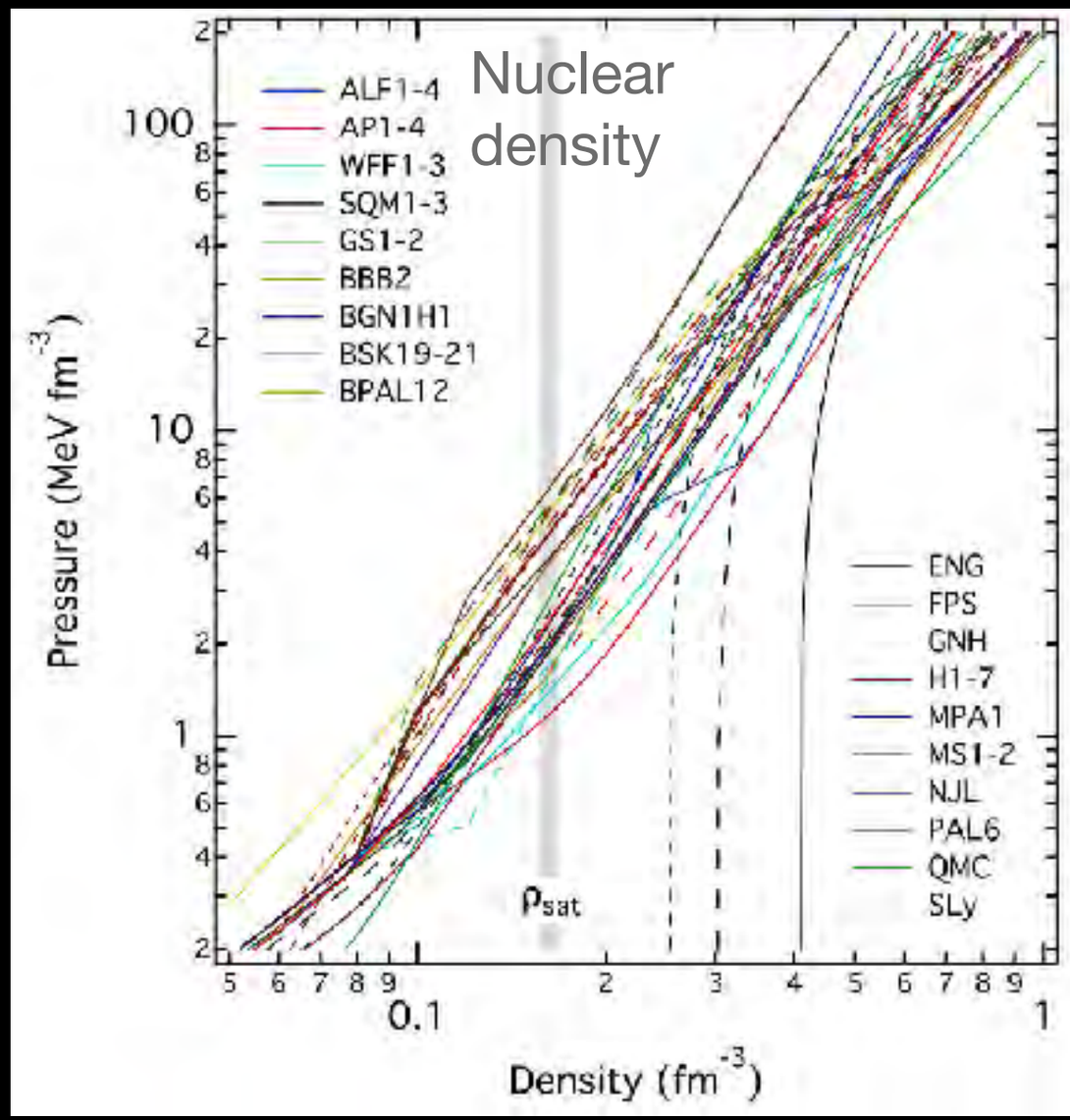
Properties of dense matter

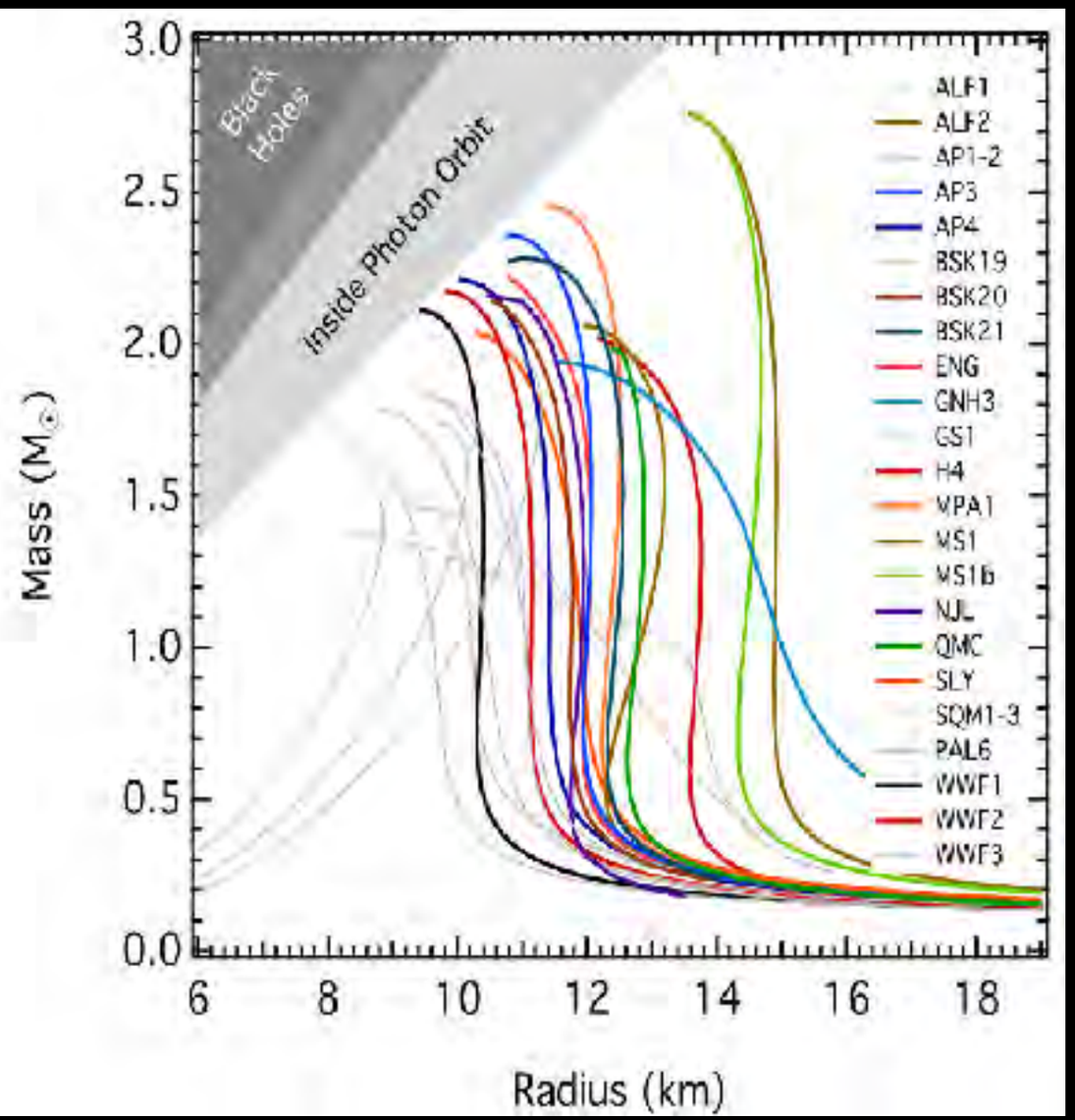
↔

Neutron star properties

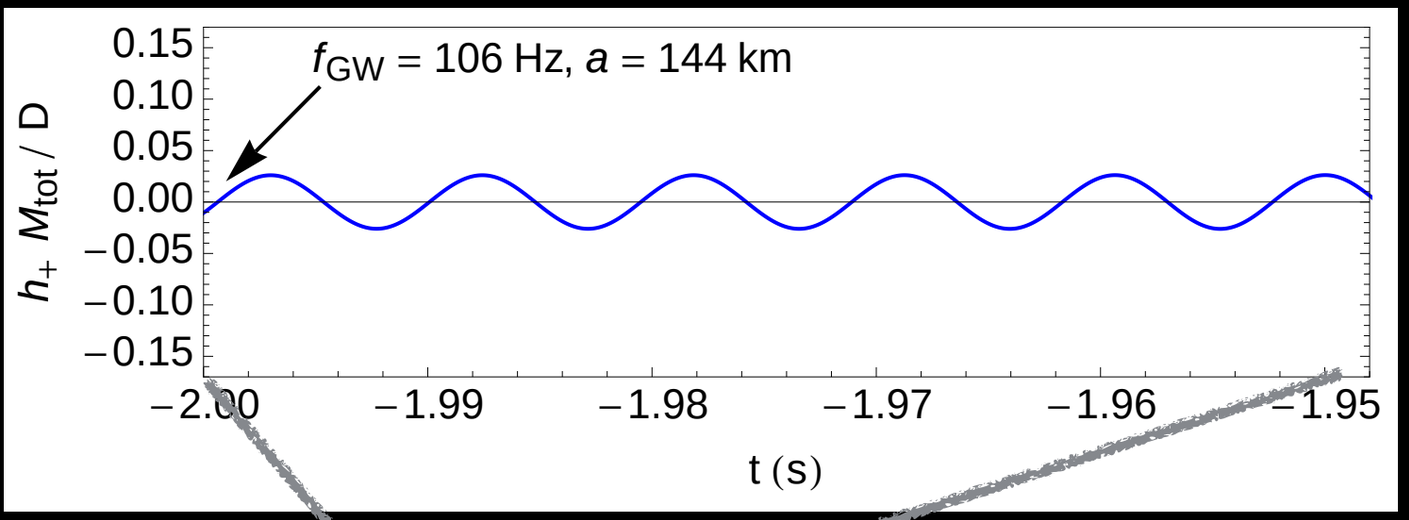
Equation of state in beta equilibrium

Mass-radius relation, max mass, deformability



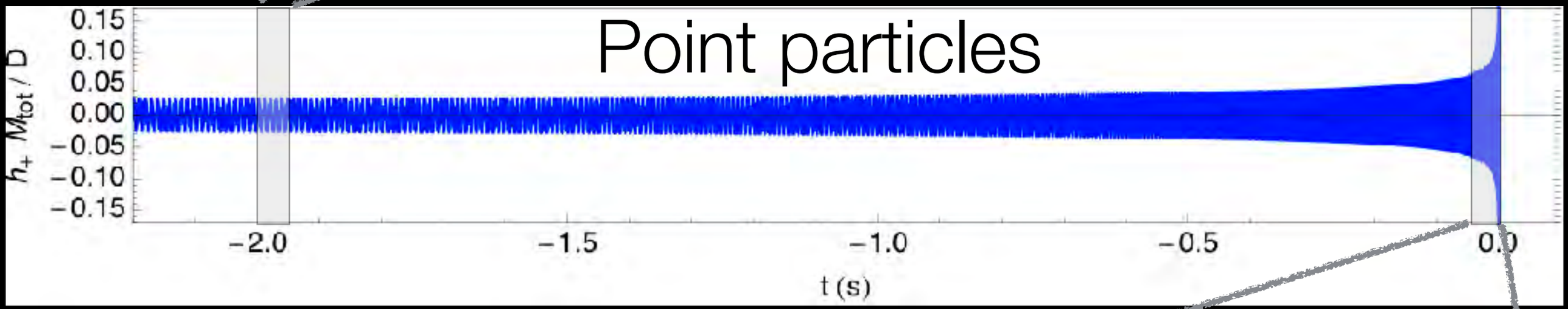


Ozel and Friere 2016

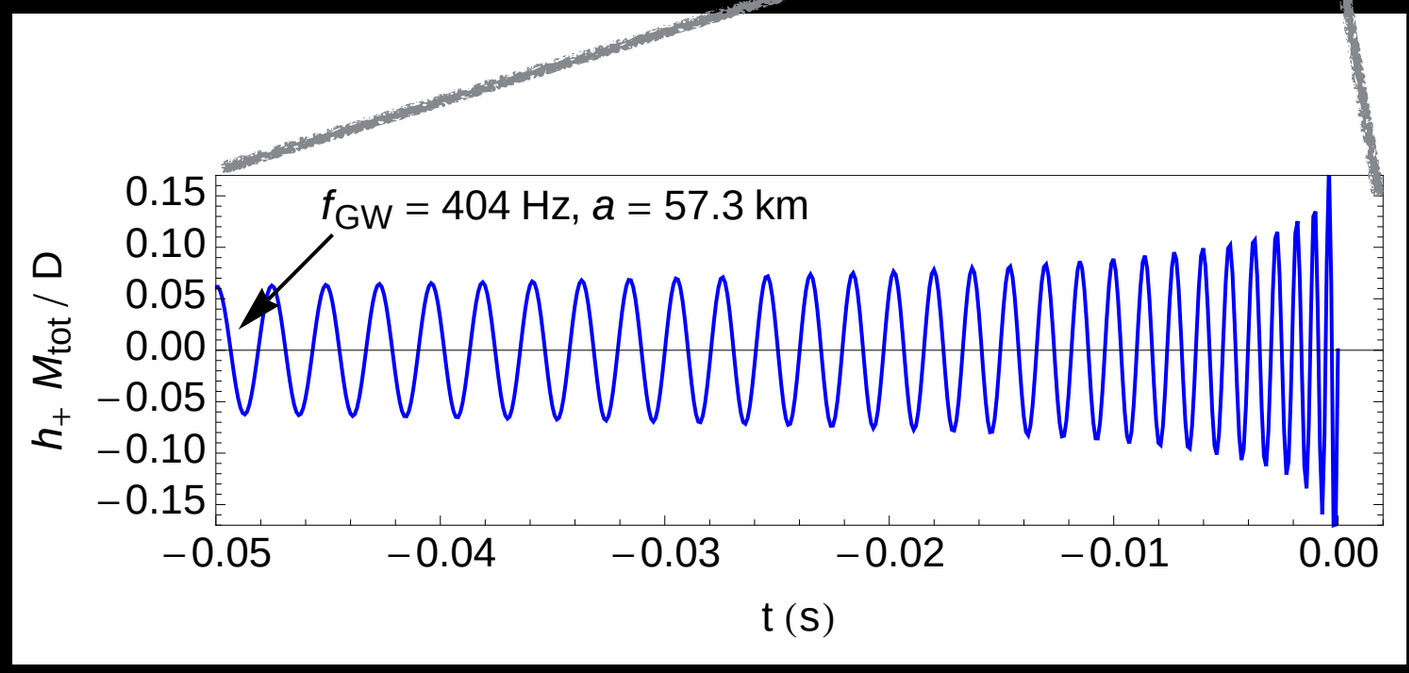


2 seconds before merger

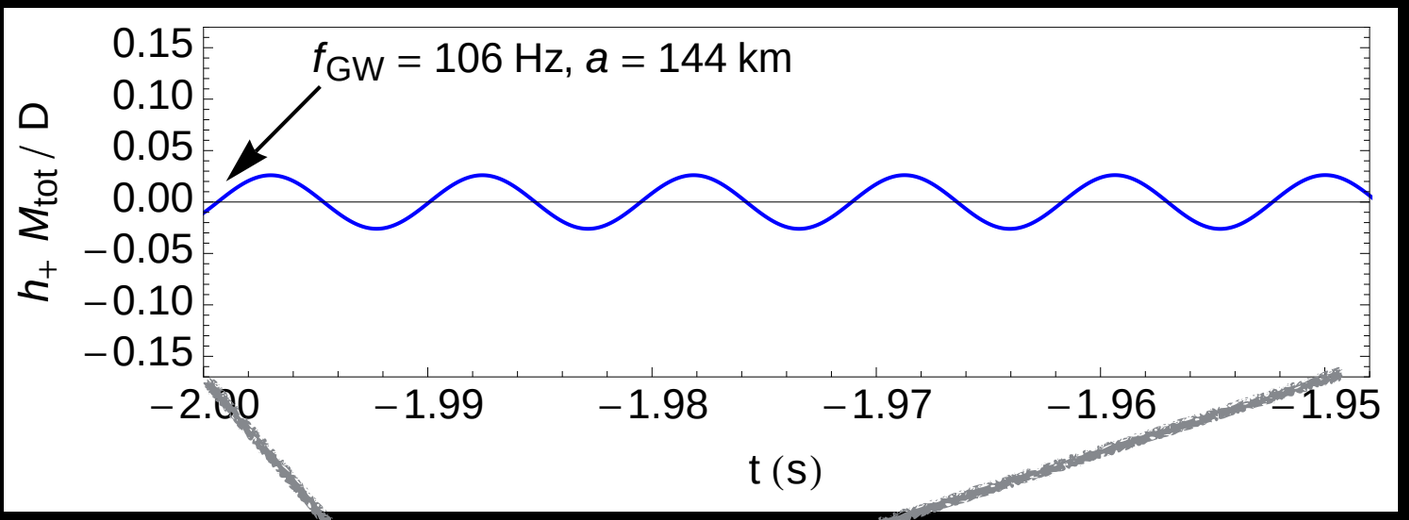
Point particles



Final ~0.05 seconds

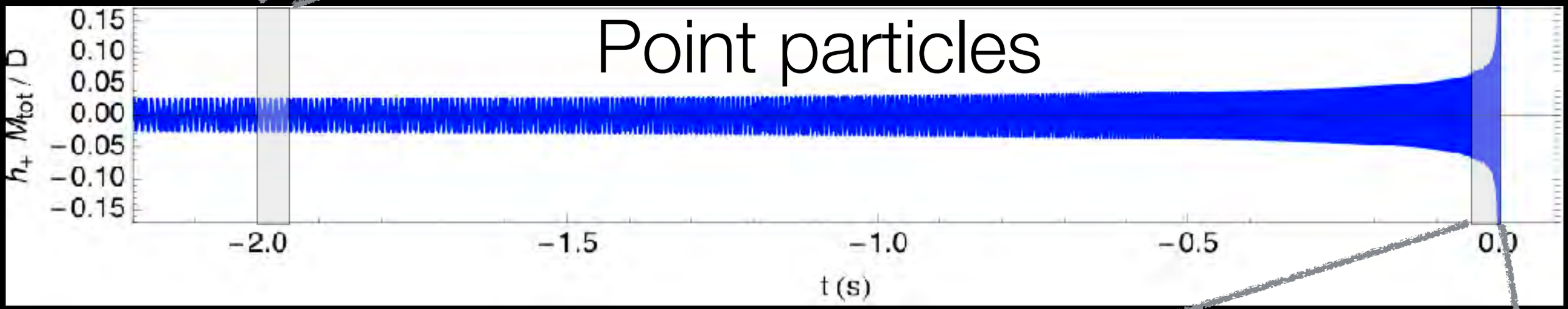


Read et al 1306.4065



Early inspiral dynamics determined by masses and spins (hard to modify!)

Point particles



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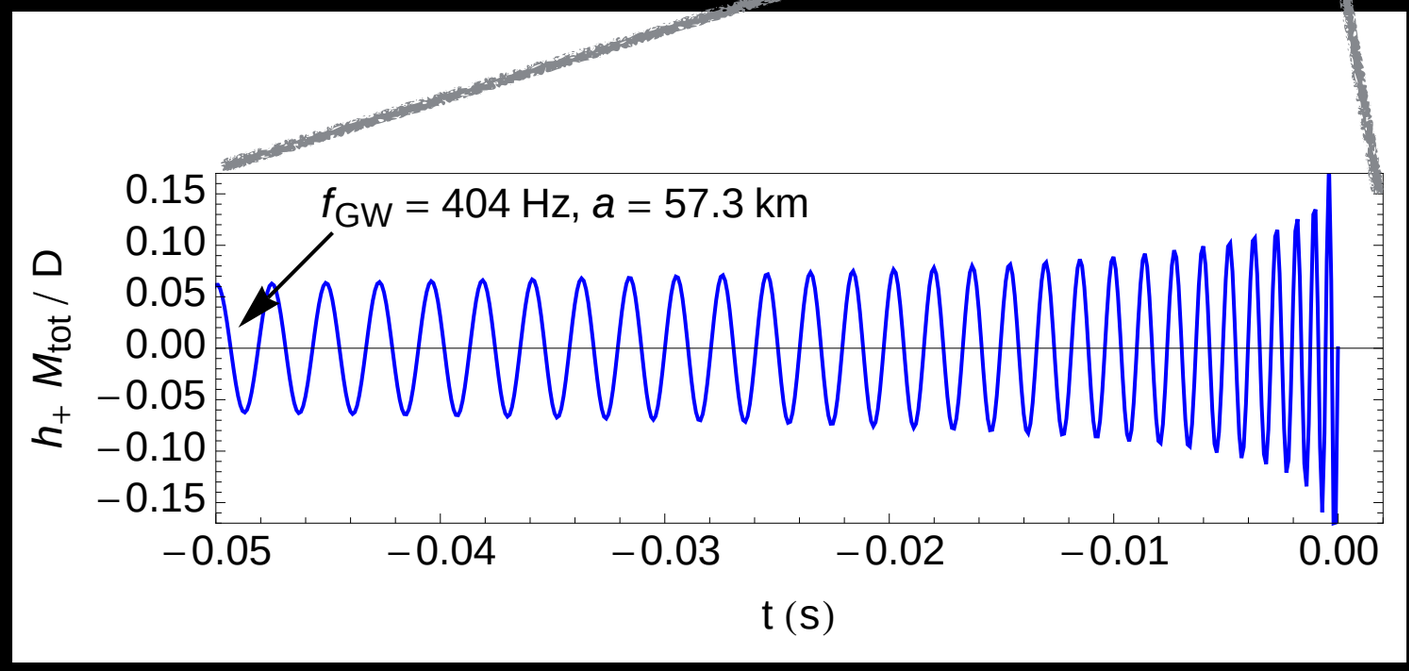
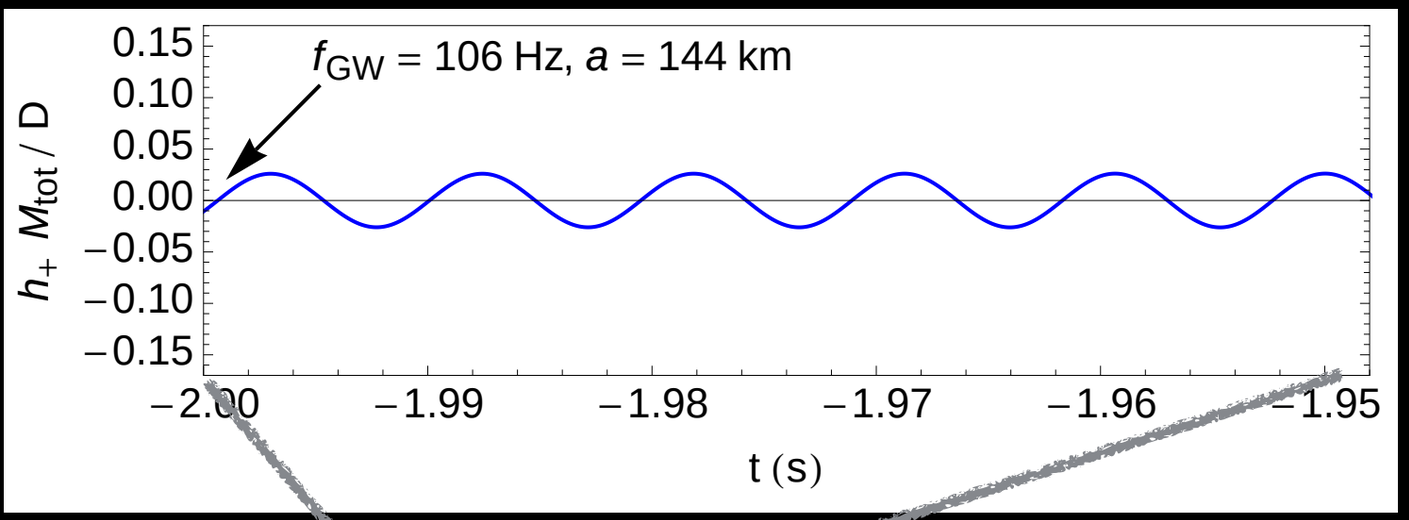
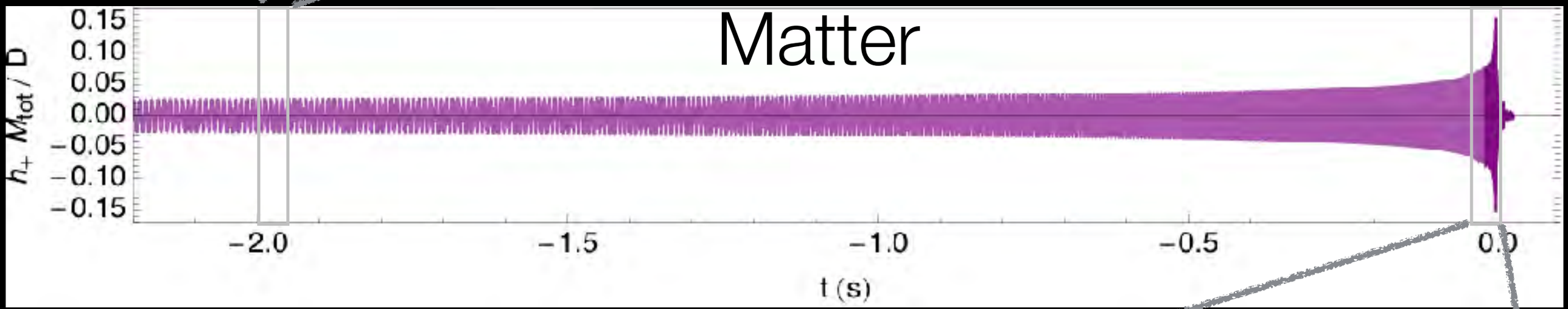


Read et al 1306.4065



Early inspiral dynamics determined by masses and spins (hard to modify!)

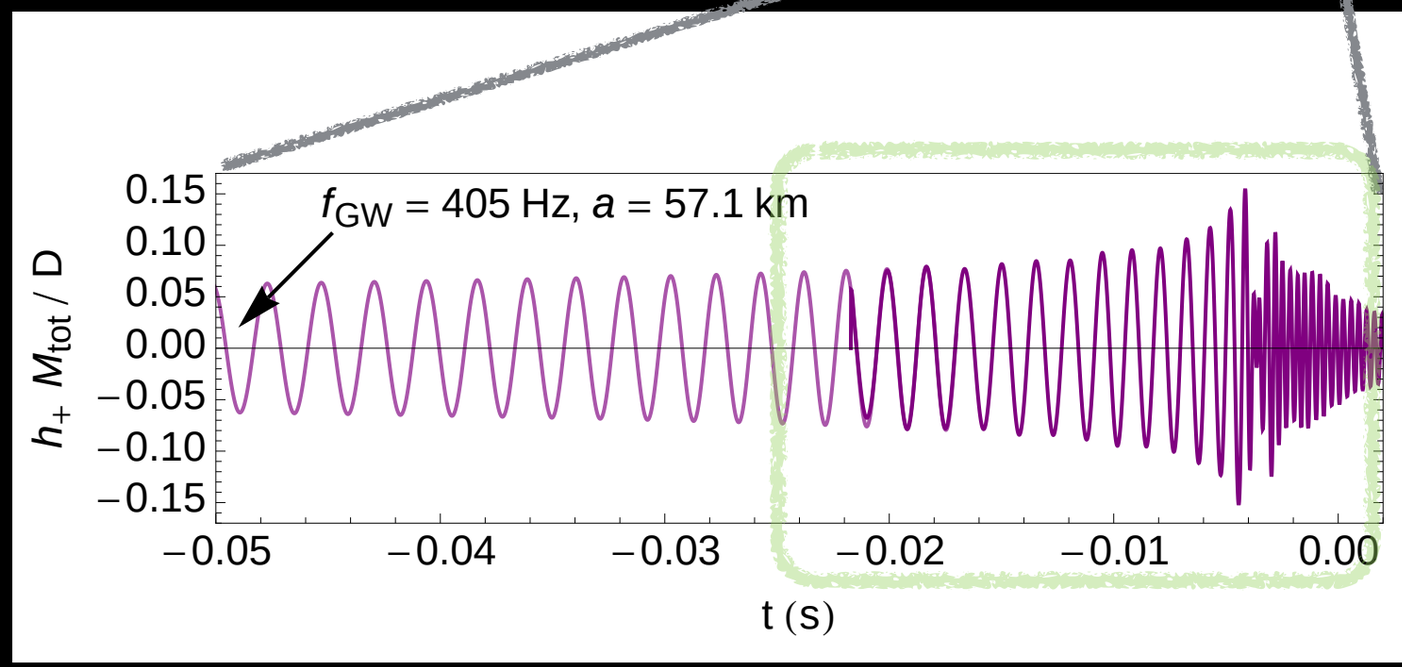
Matter

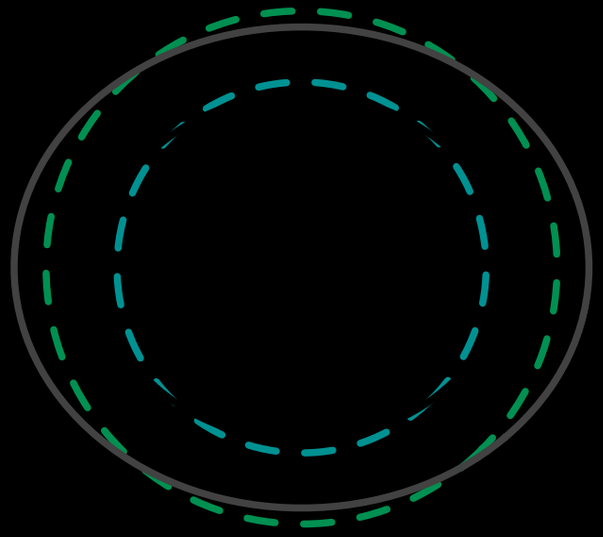


Tidal interactions lead to accumulated phase shift at higher frequencies.

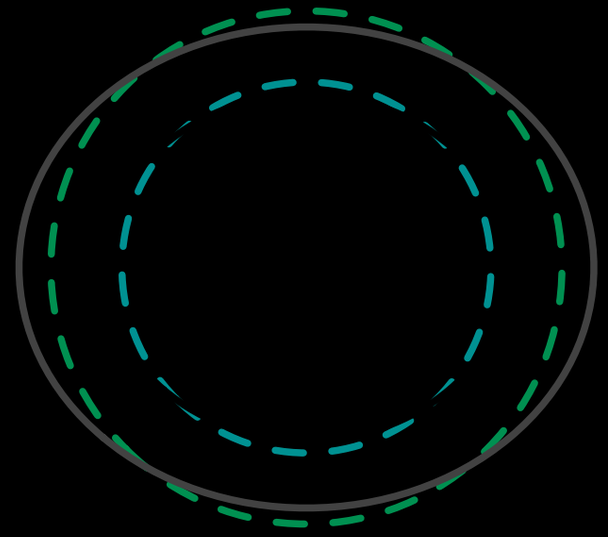
Numerical simulations for the final coalescence

Read et al 1306.4065



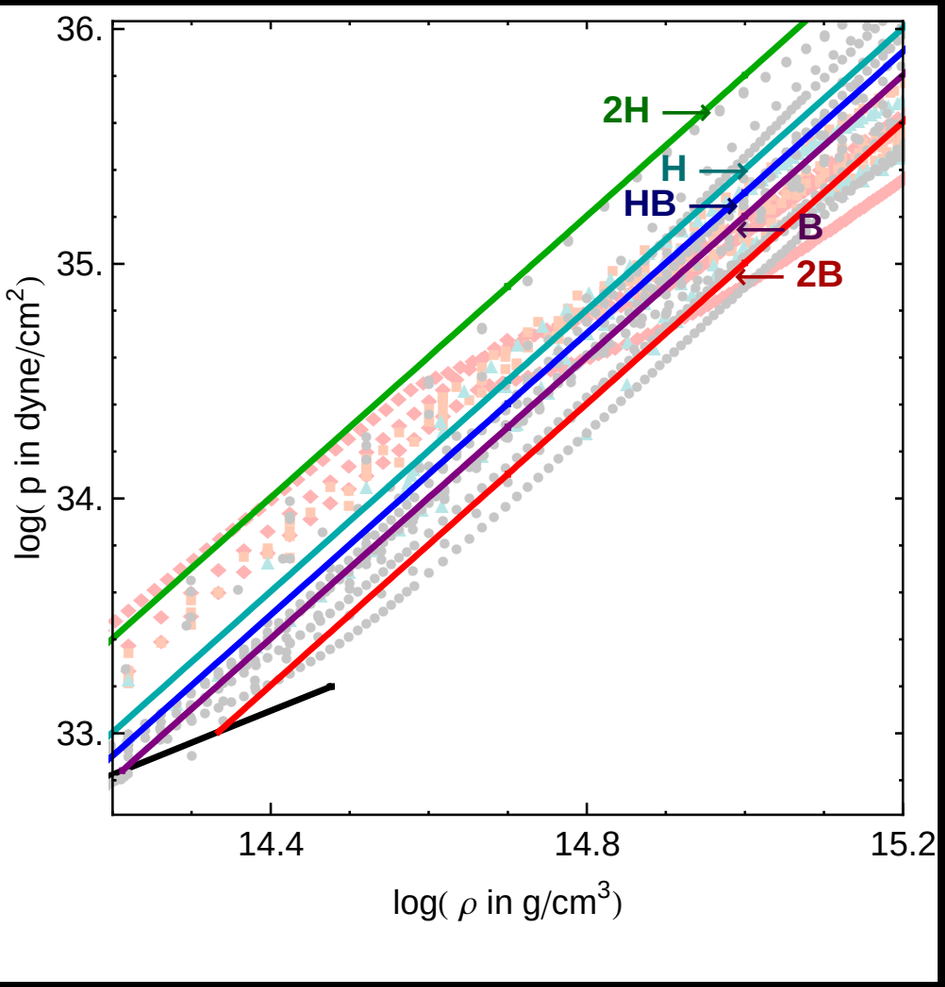


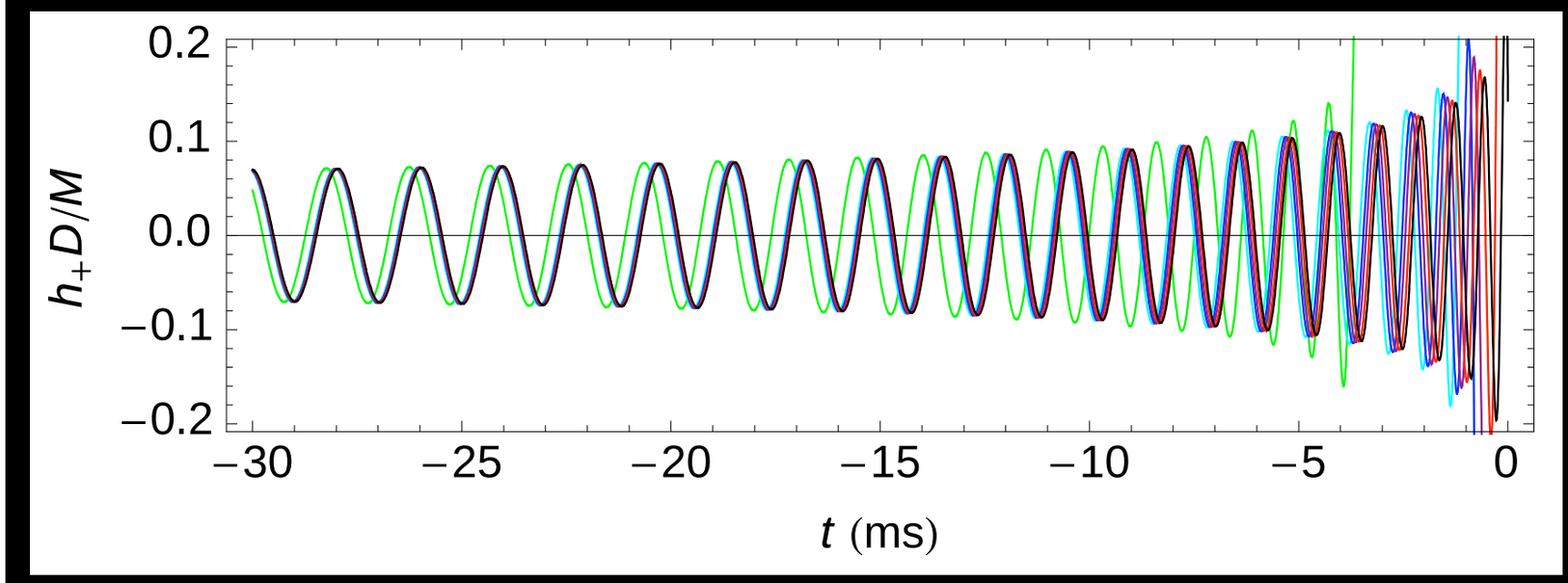
Matter effects on inspiral



- Deformation accelerates inspiral
- Size of effect on waveform determined by tidal deformability:

$$\Lambda = \frac{2}{3} k_2 \left(\frac{R}{M}\right)^5$$



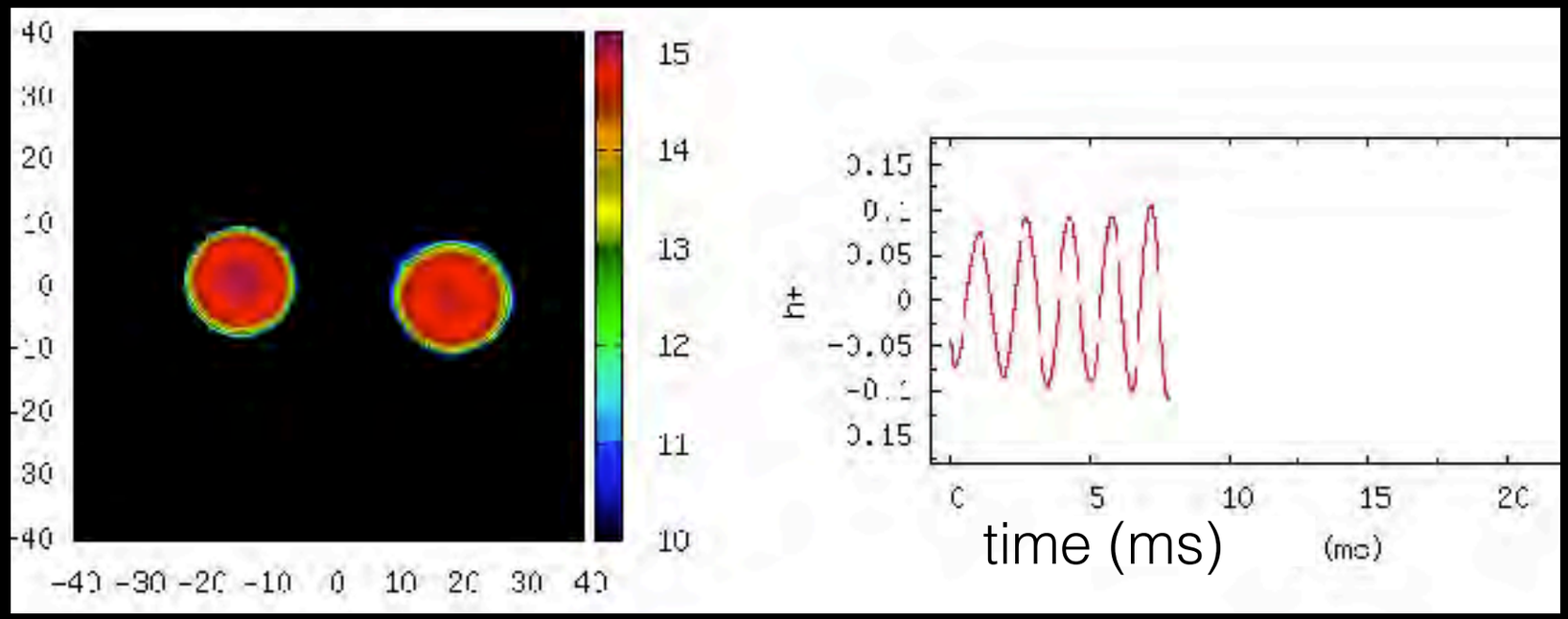


extreme radius like 2H disfavored by GW170817

Flanagan and Hinderer 2008

Merger

Compact stars: merge at higher frequency, more similar to BBH

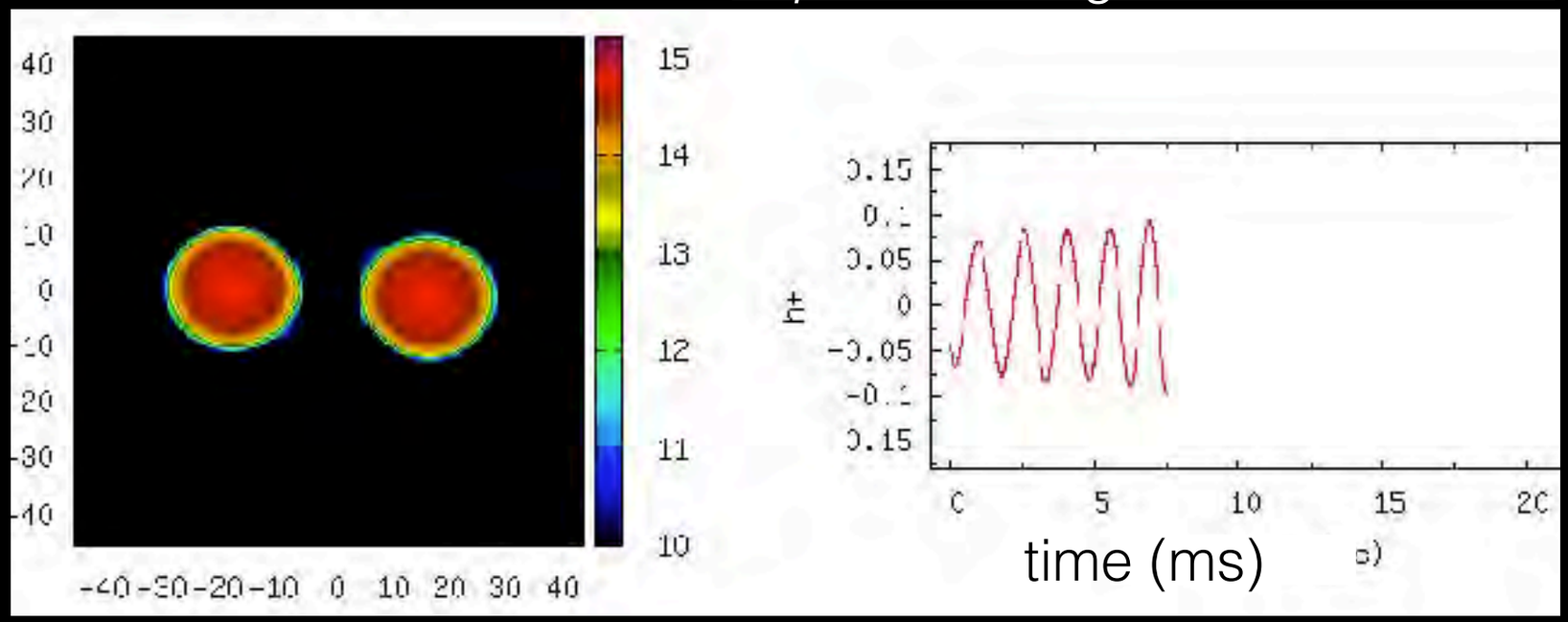


GW170817 post-merger

hidden by detector noise

https://arxiv.org/abs/1710.09320

Large-radius stars: collide earlier, merge at lower frequency



Numerical simulations: K. Hotokezaka, YITP

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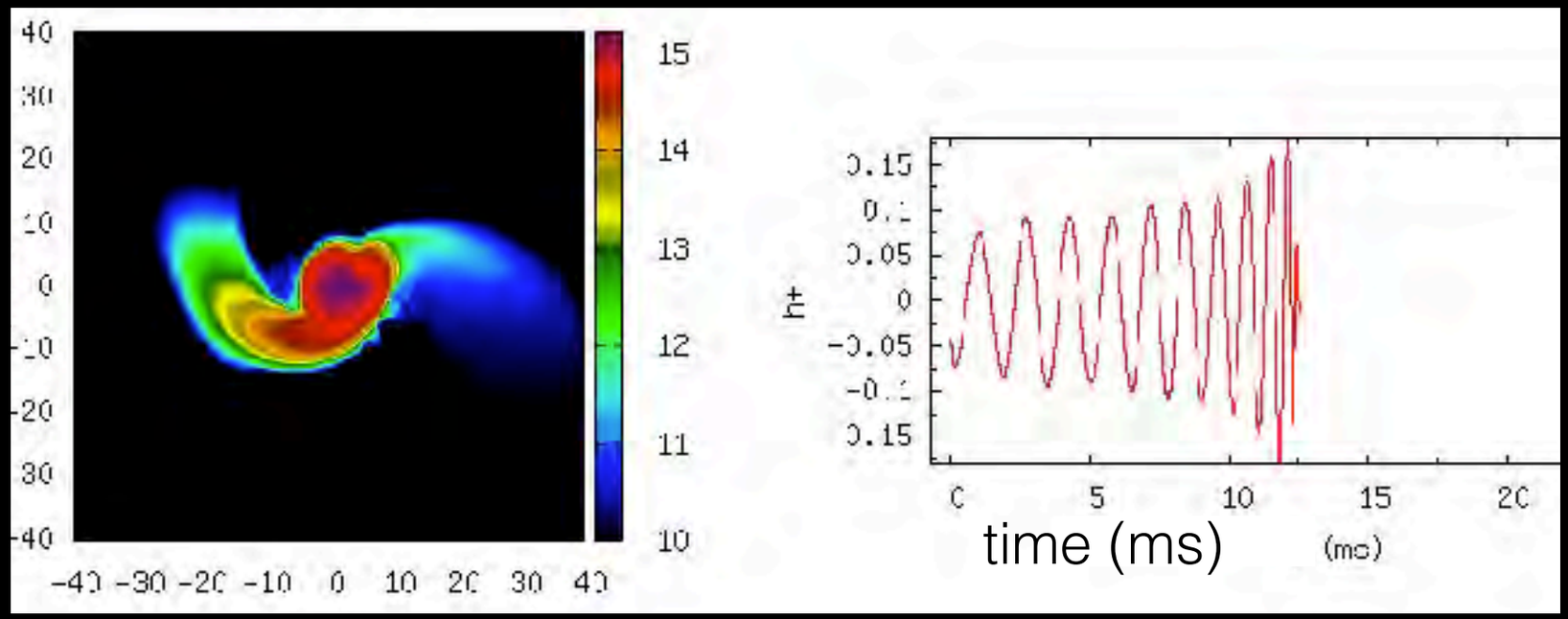

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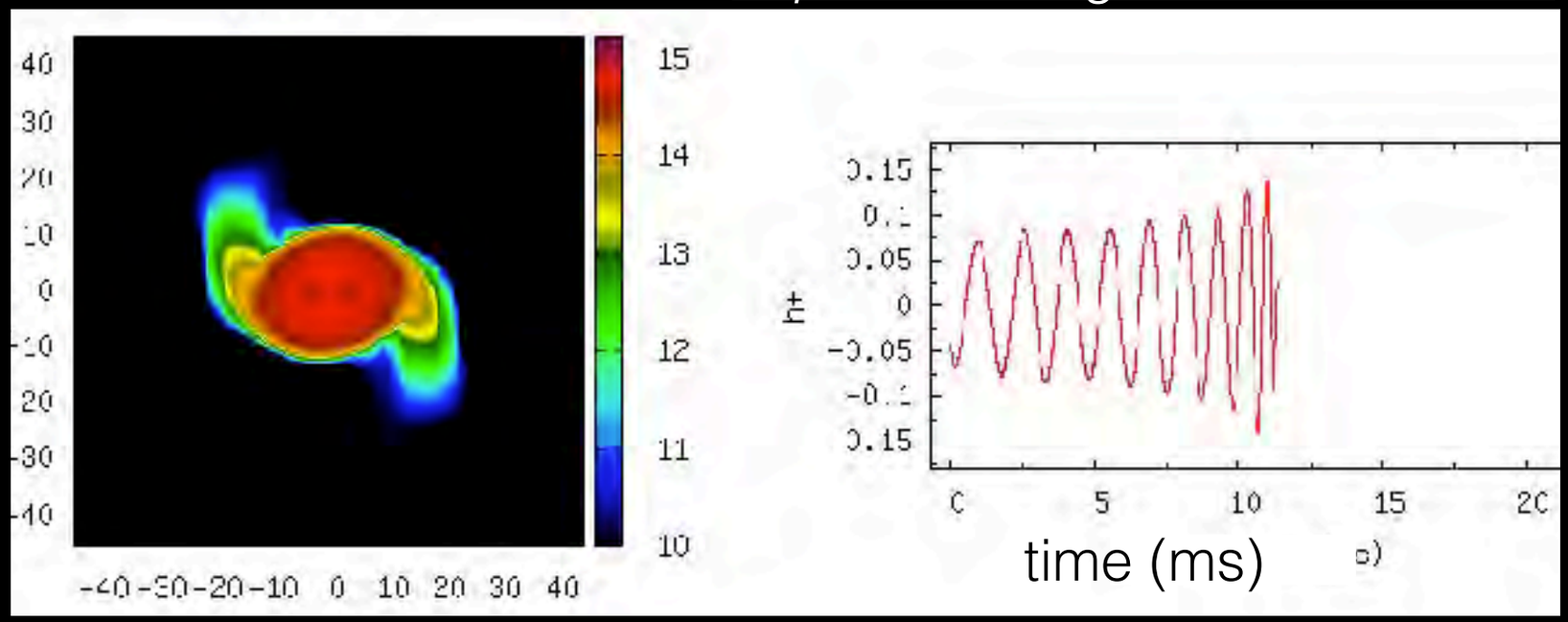

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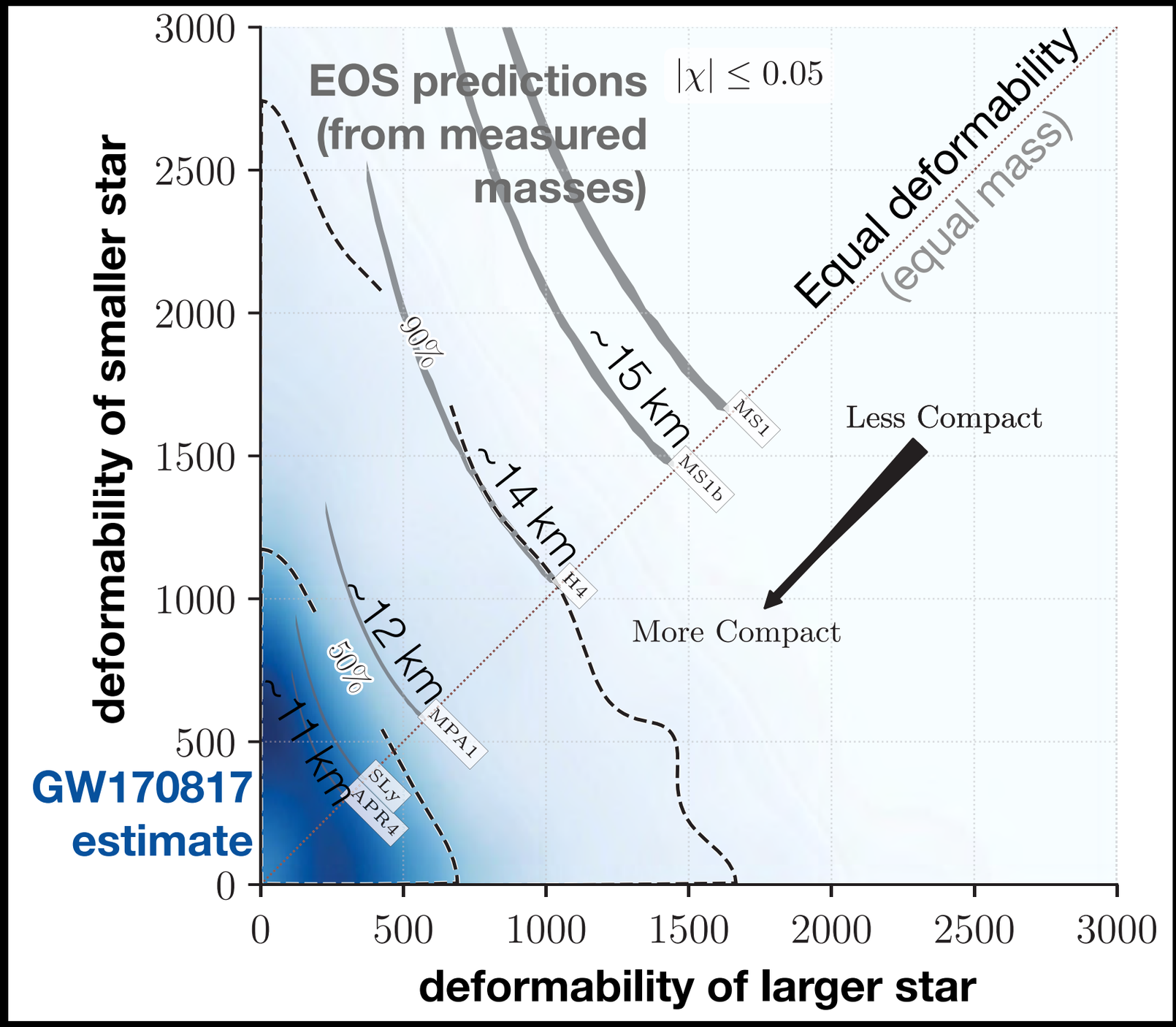
Dense matter in GW170817



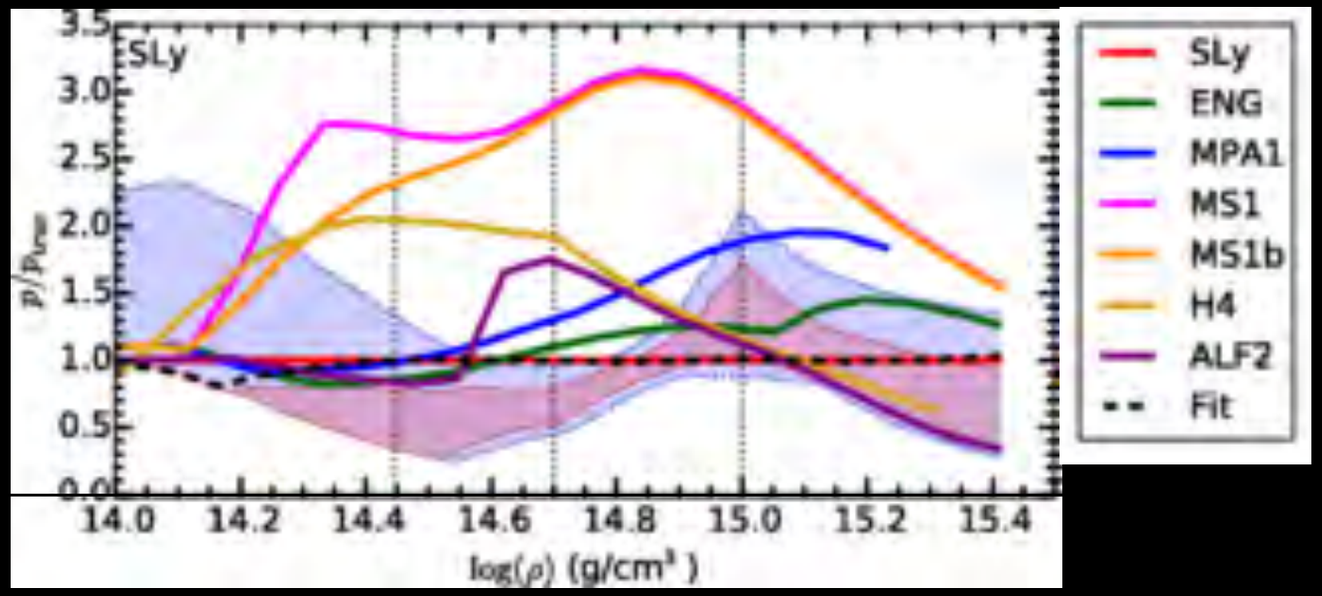
TaylorF2 model, low-spin prior

Independent deformabilities (no assumption that both are NS w/same EOS)

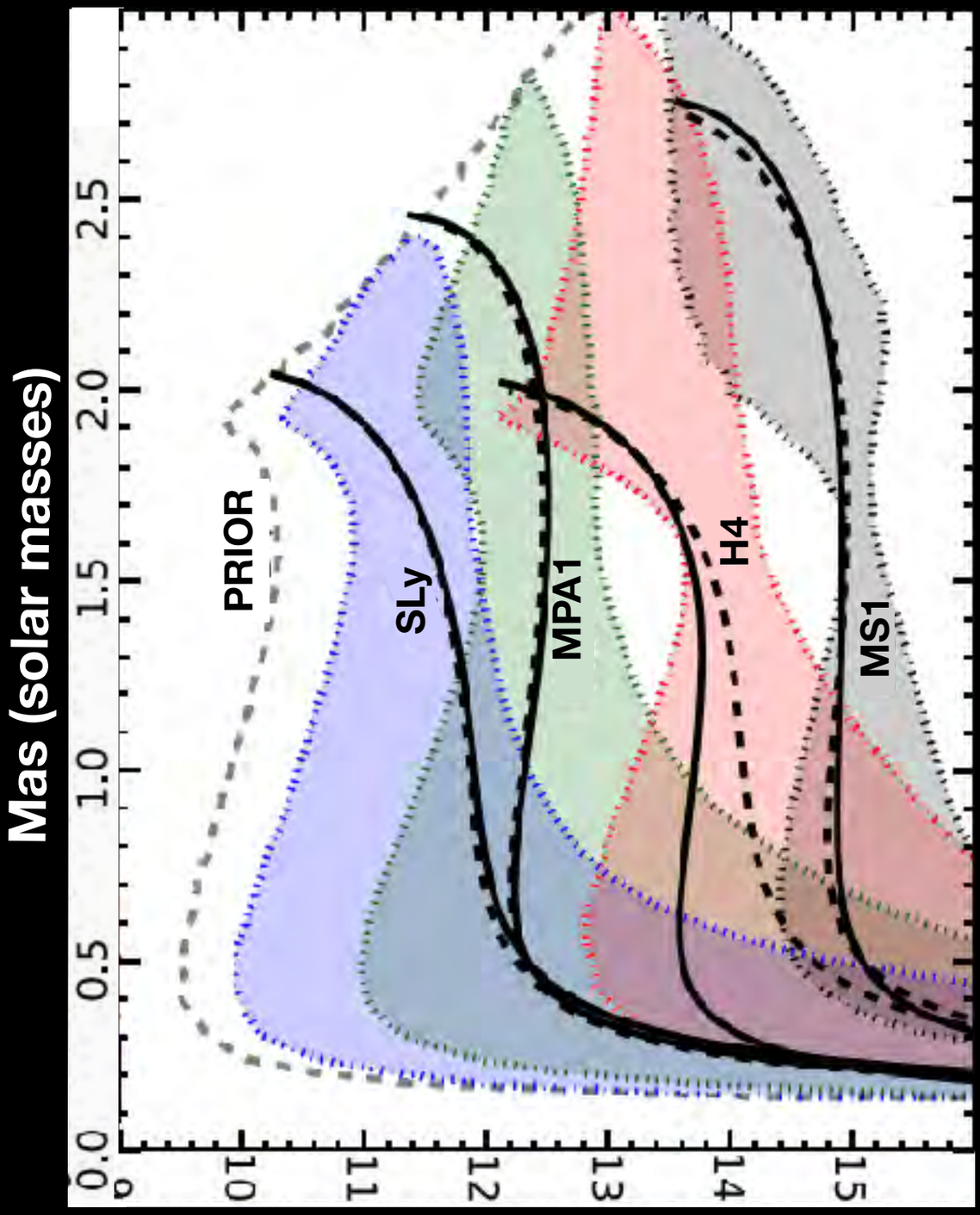
In progress: waveform systematics, direct EOS constraint

LSC/Virgo PRL 119, 161101 (2017)

Future possibilities for EOS/NS radius

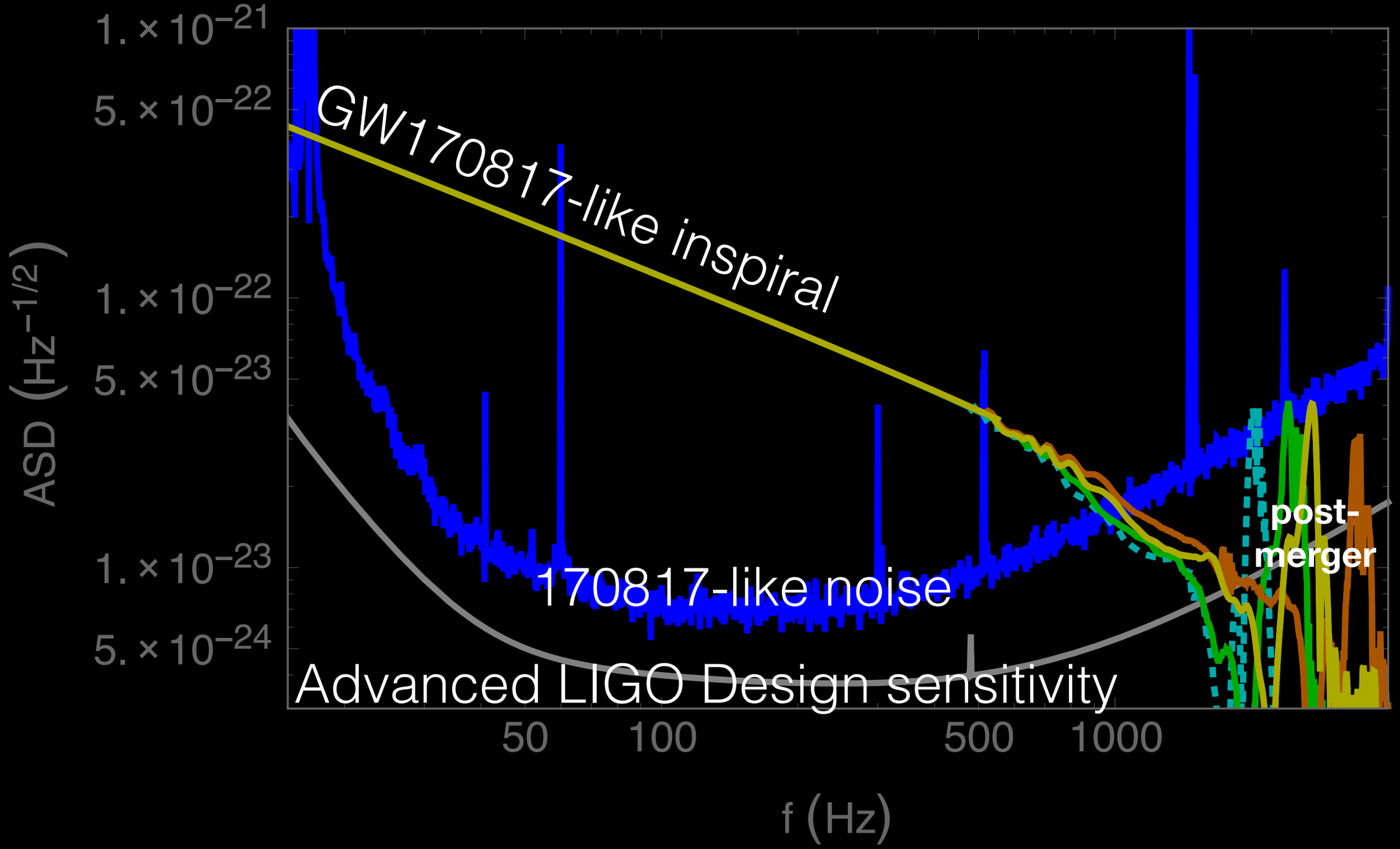


- 95% regions
- 40 events (~ 1 yr)
- Advanced LIGO design
- Direct EOS constraint;
- implications for radius



Lackey & Wade 2014 arxiv:1410.8866

Gravitational-wave spectrum



Above 500Hz: simulation data Tim Dietrich (AEI/FSU/BAM Collaboration)
Phys. Rev. D95(12):124006 and Phys. Rev. D95(2):024029.