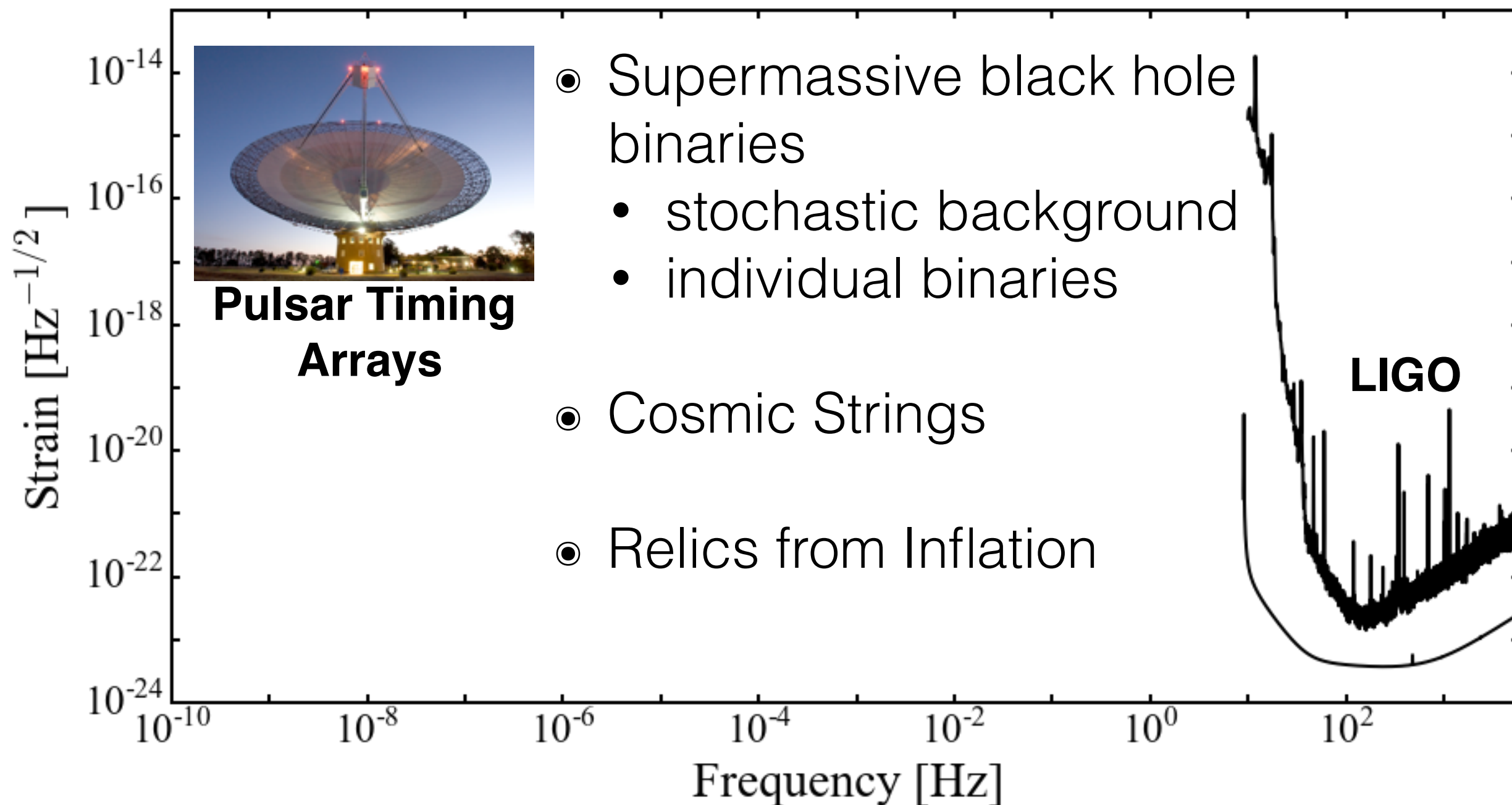
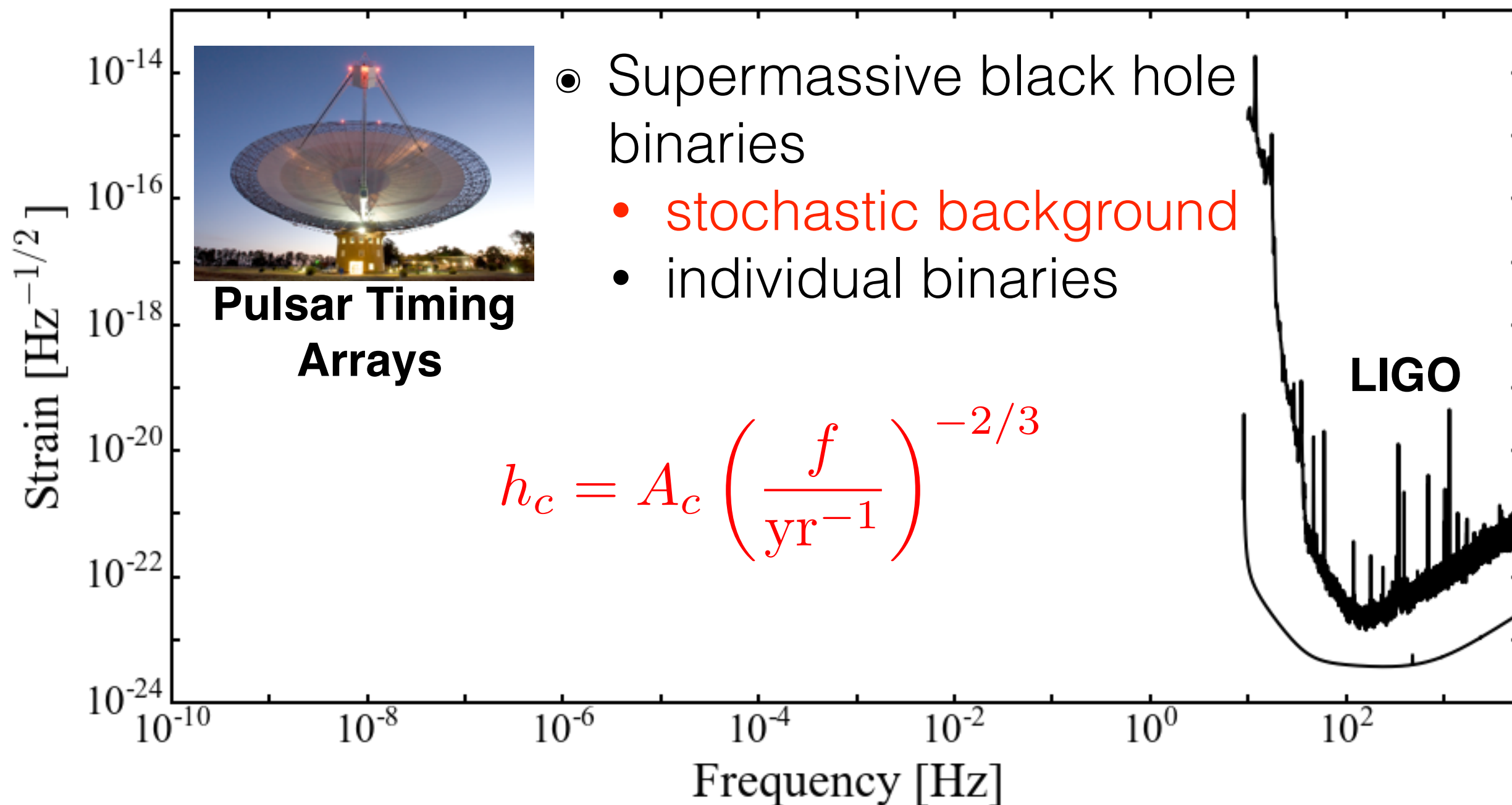


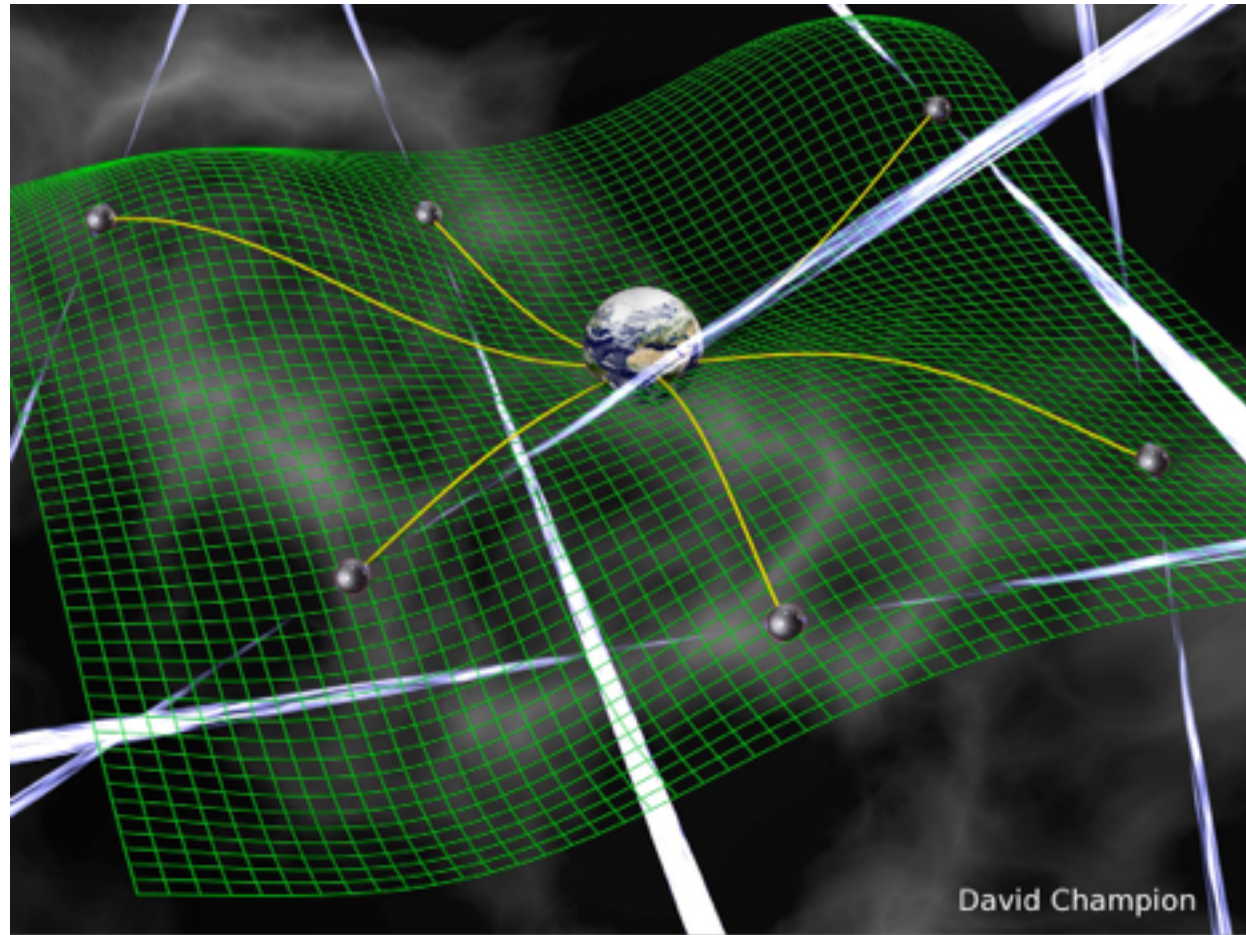
Gravitational waves from binary supermassive black holes missing in pulsar observations

Paul Lasky, on behalf of the  **PPTA**

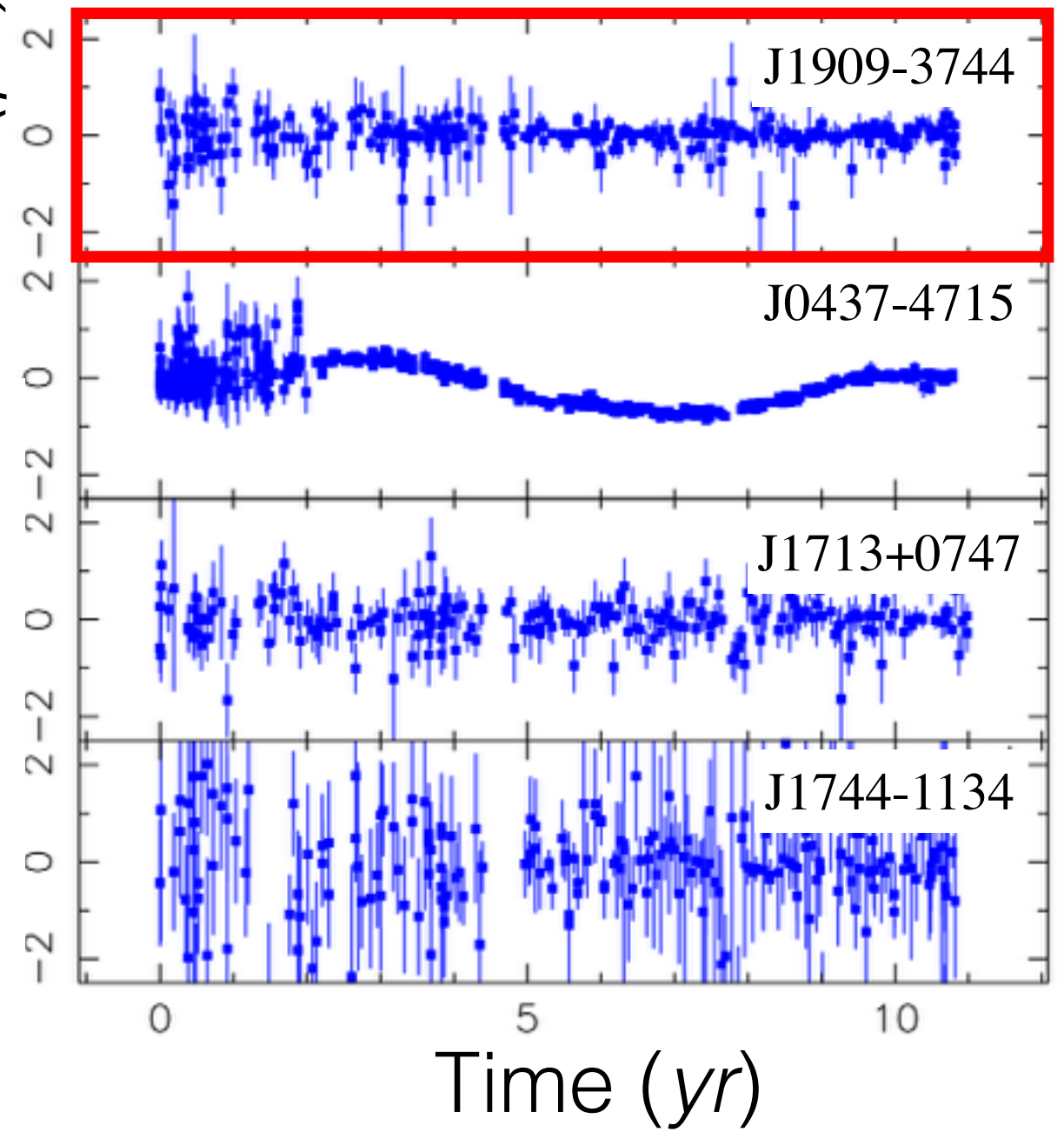
Shannon et al., 2015 (Science; accepted)





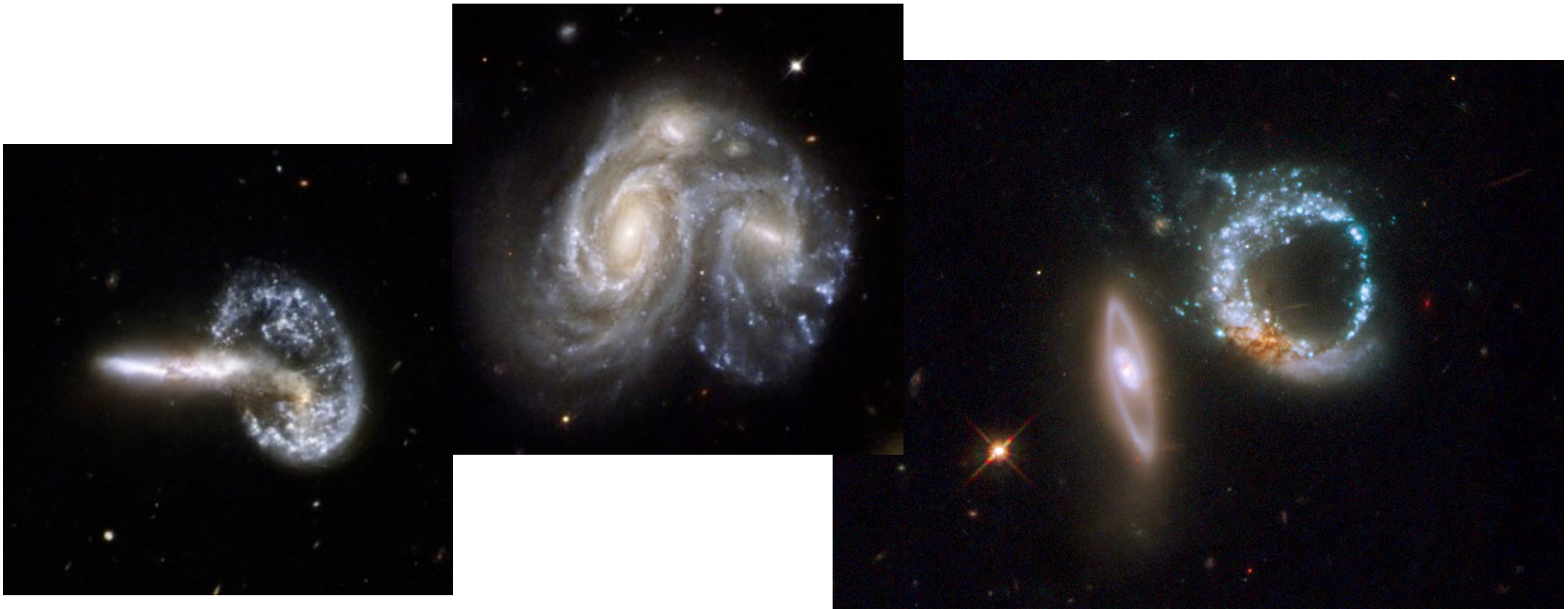


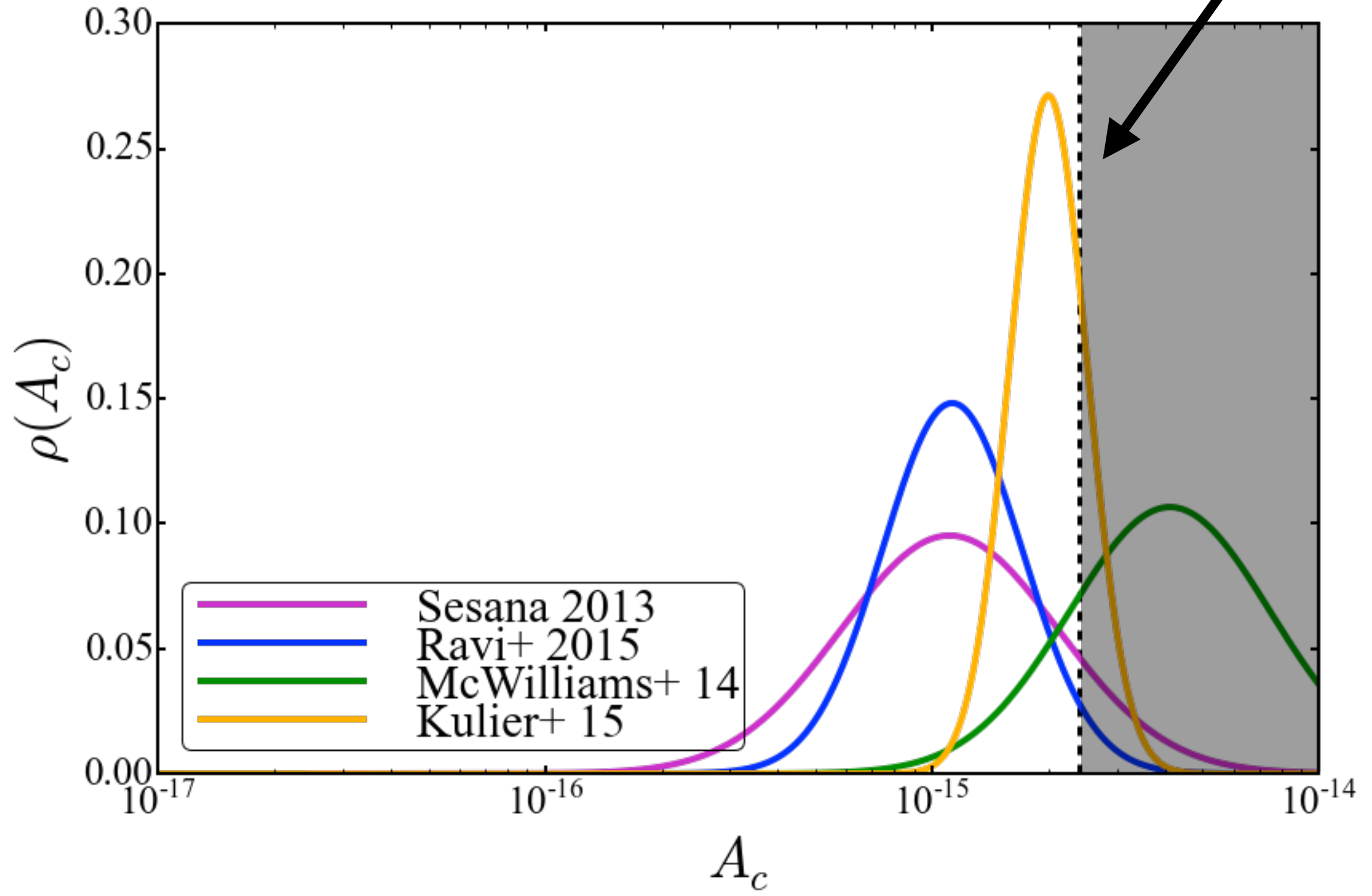
Time-of-arrival residual (μs)

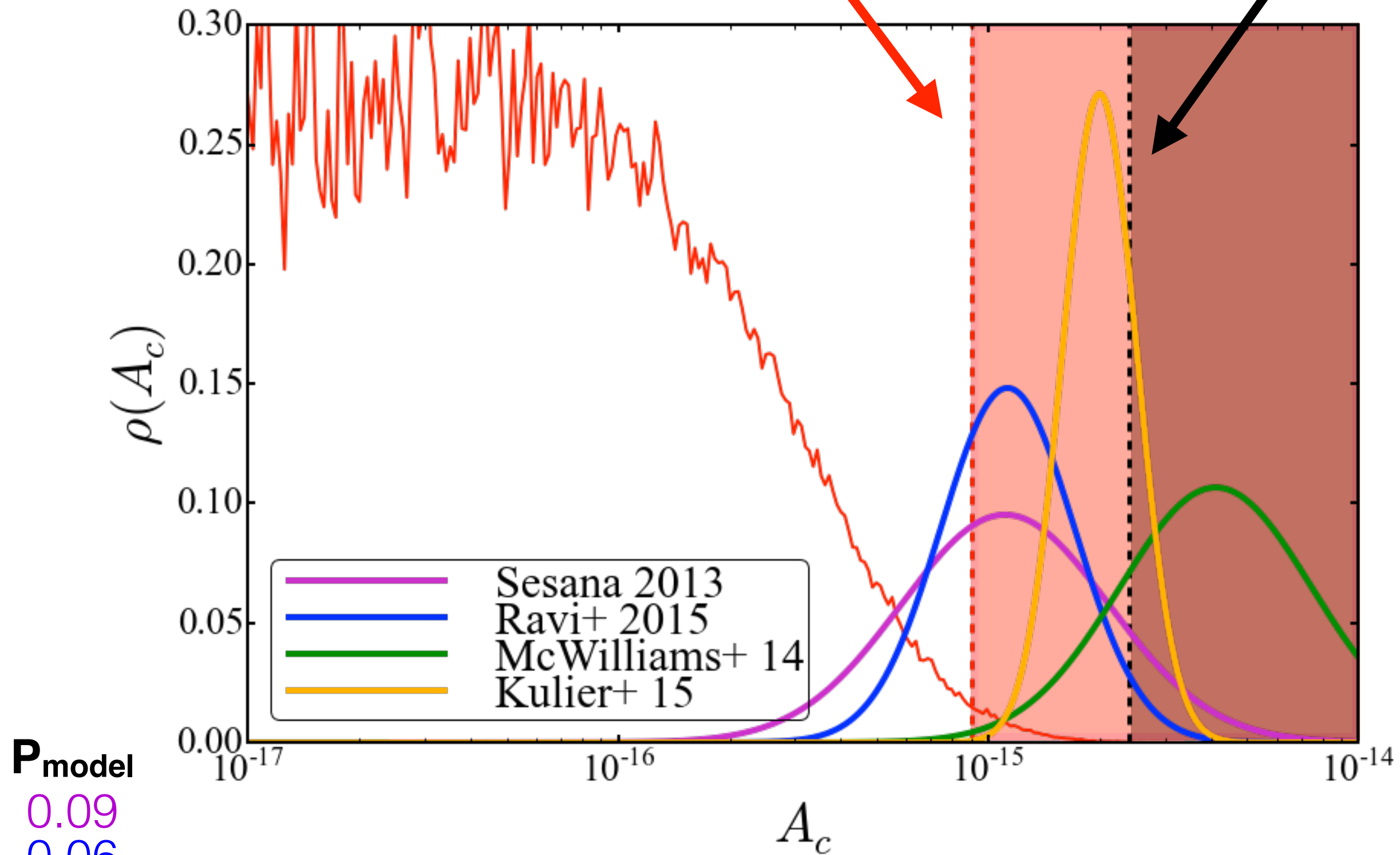


Supermassive black hole mergers

- ◉ Assume all galaxies host a SMBH
- ◉ Use observed BH-Galaxy mass relations
- ◉ Assume BH merger rate traces galaxy merger rate
- ◉ Assume GW dominated mergers (circular, ...)
- ◉ ...
- ◉ Sum up contribution from all SMBHs mergers in Universe







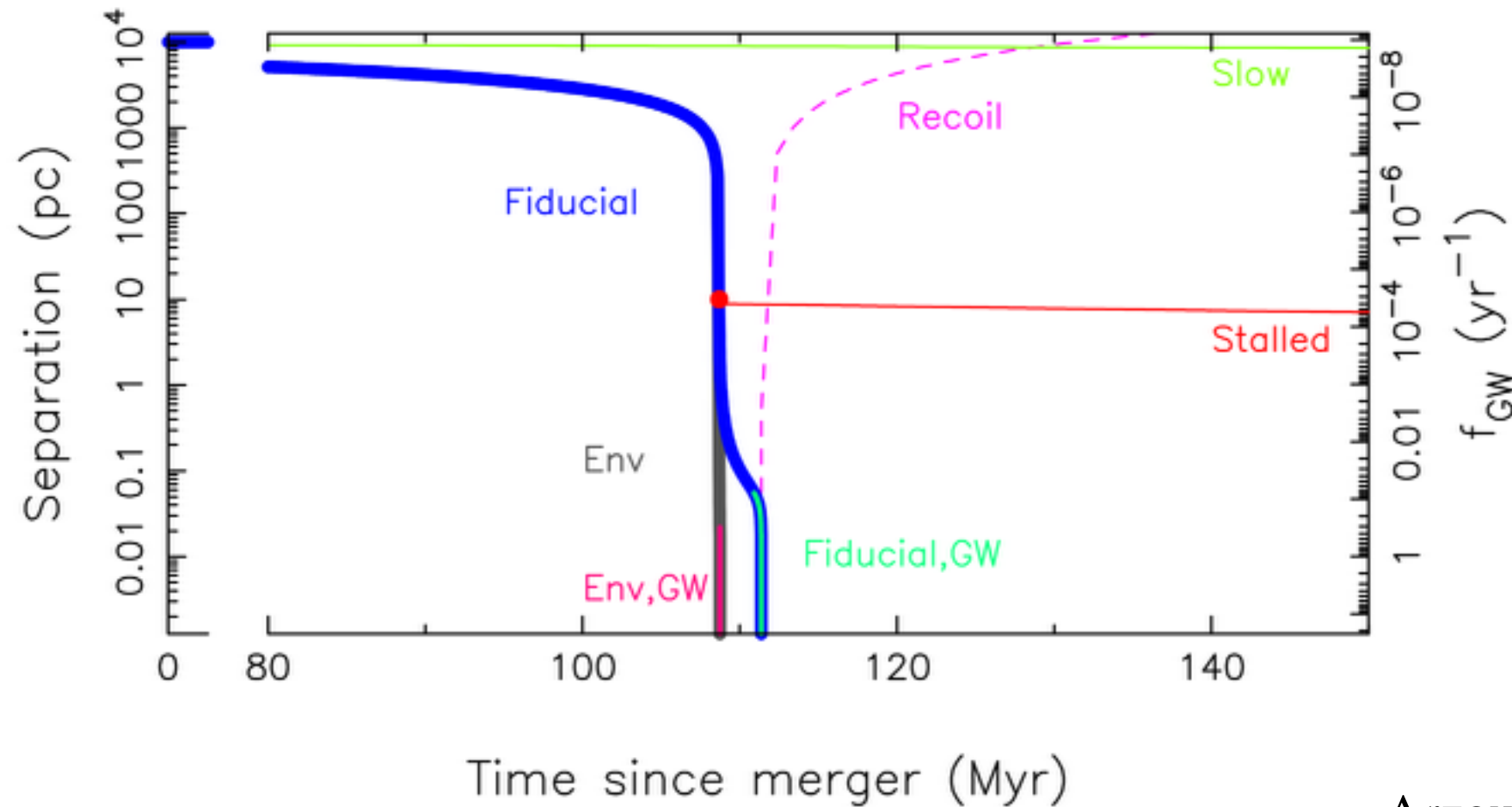
P_{model}

0.09

0.06

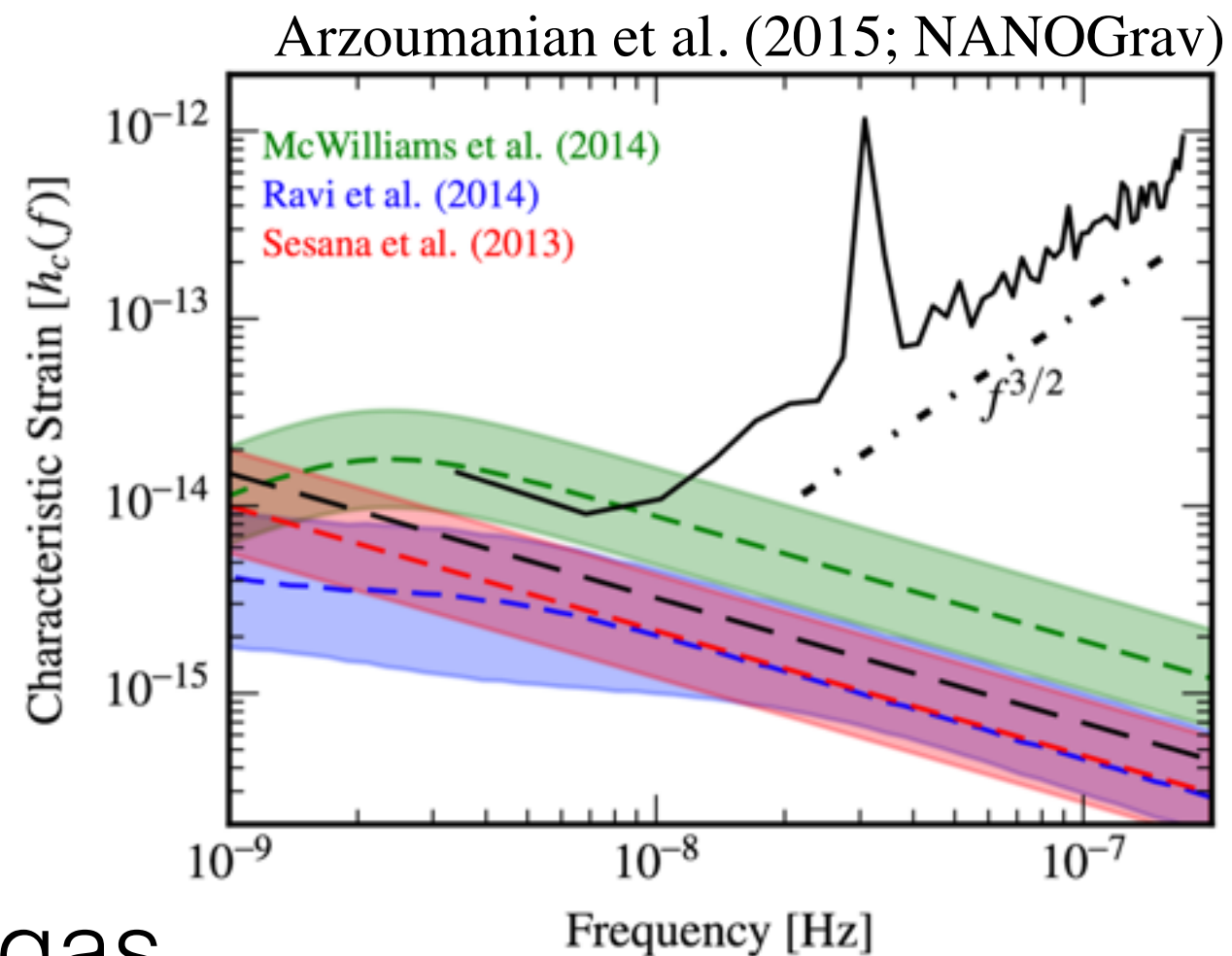
0.002

0.005



Astrophysical Inference

- Black hole mass function at $z \sim 2$?
- Galaxy merger rate?
- Environmental factors: stars, gas, ...



Gravitational-wave cosmology over 29 decades in frequency

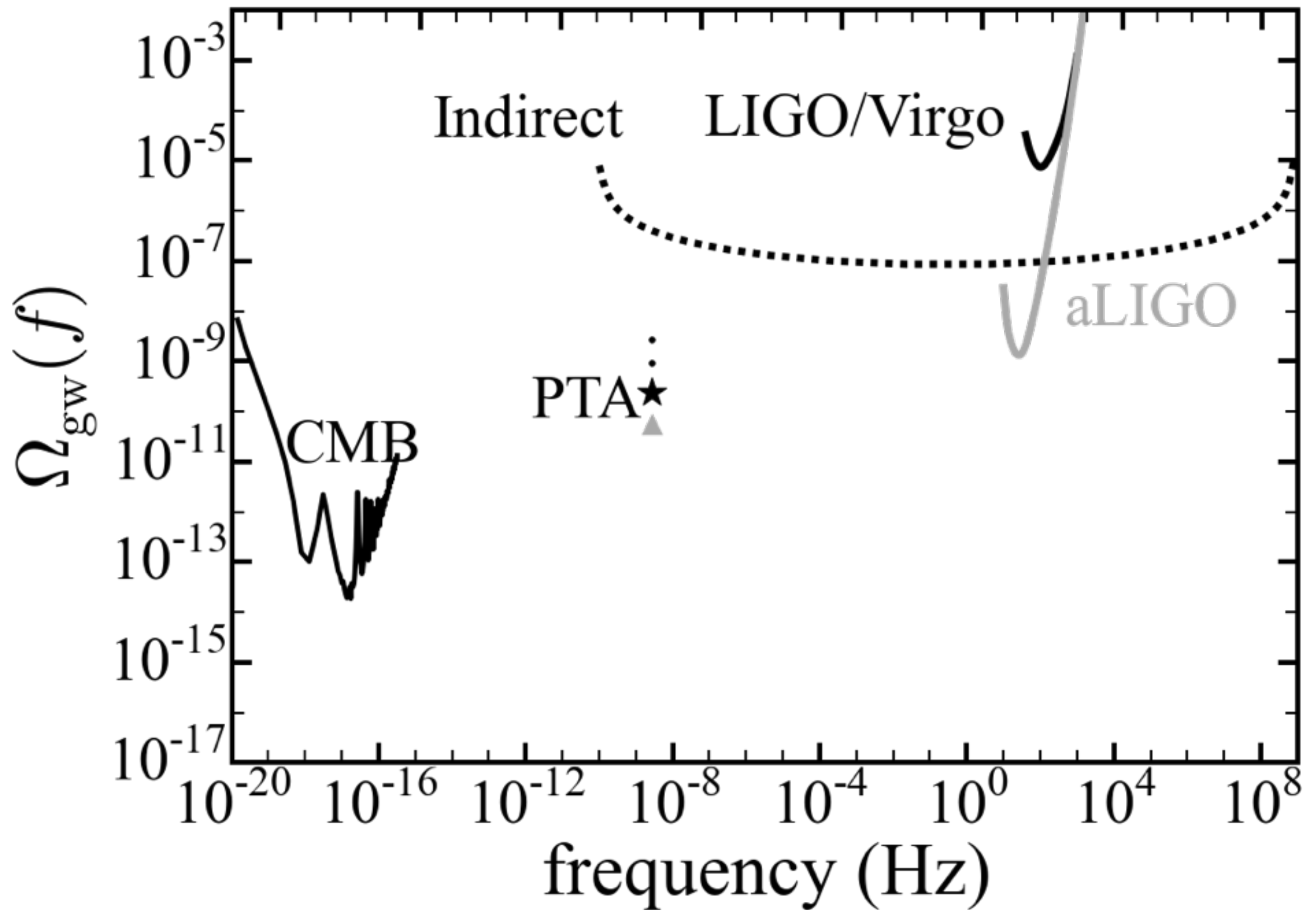


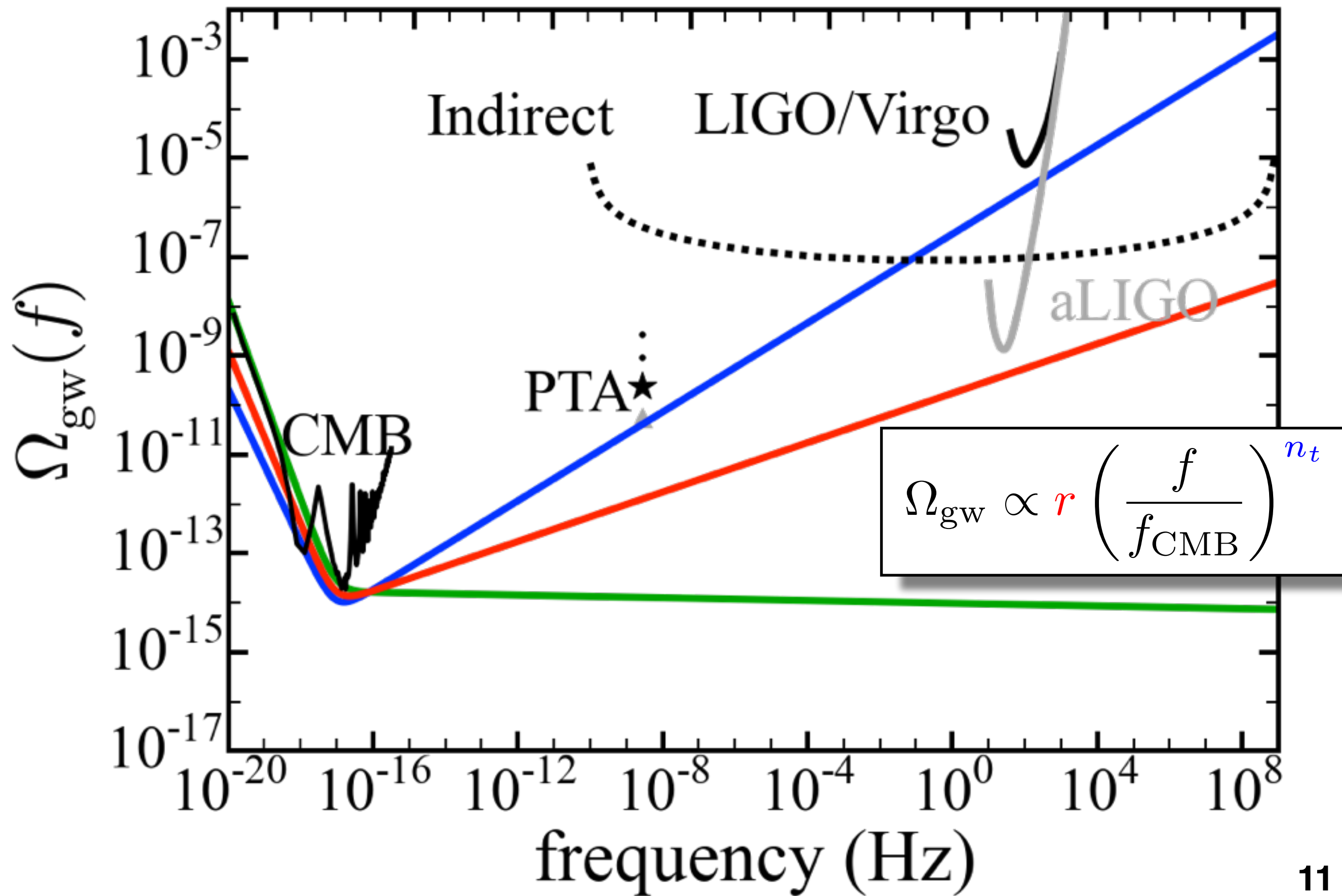
Paul Lasky

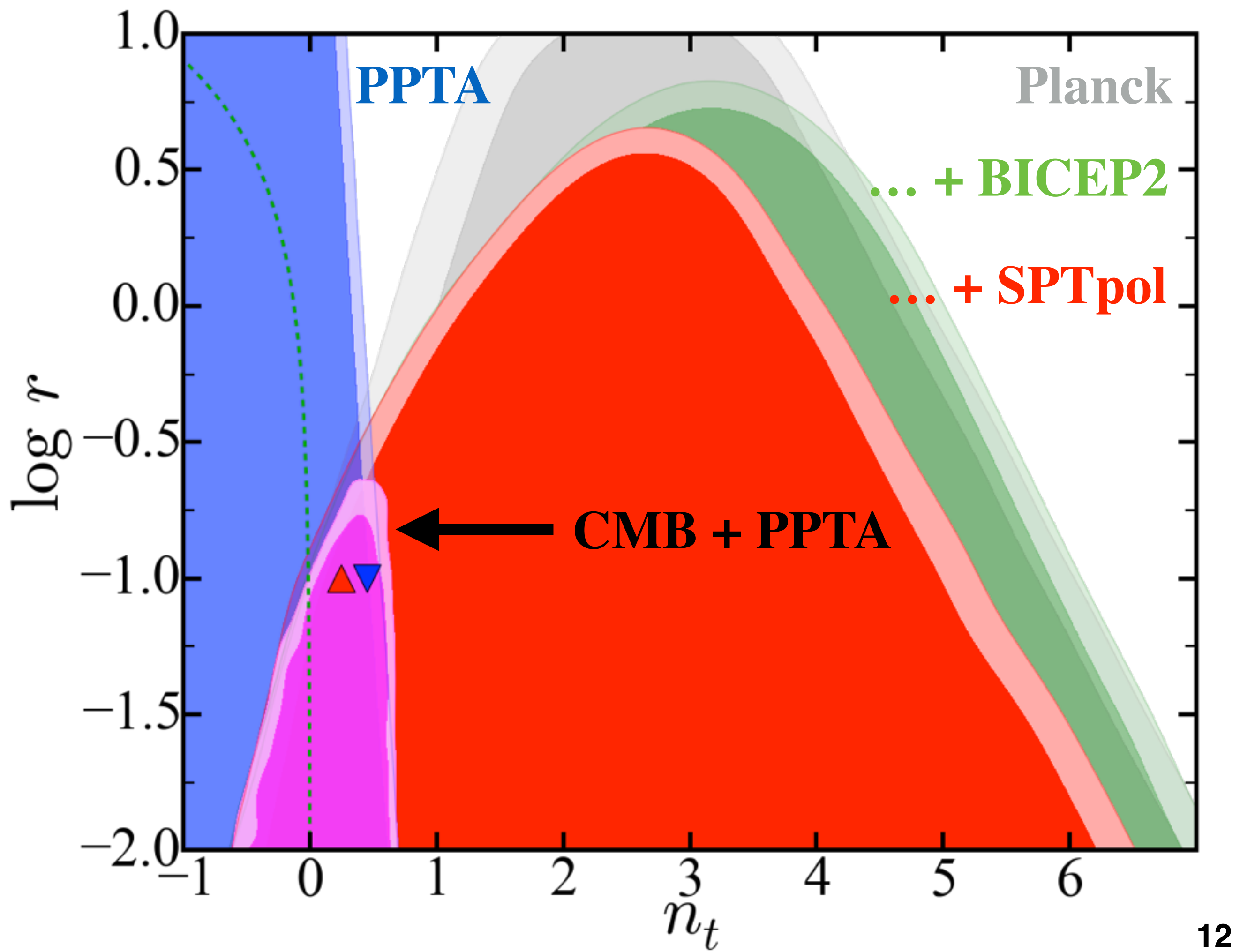


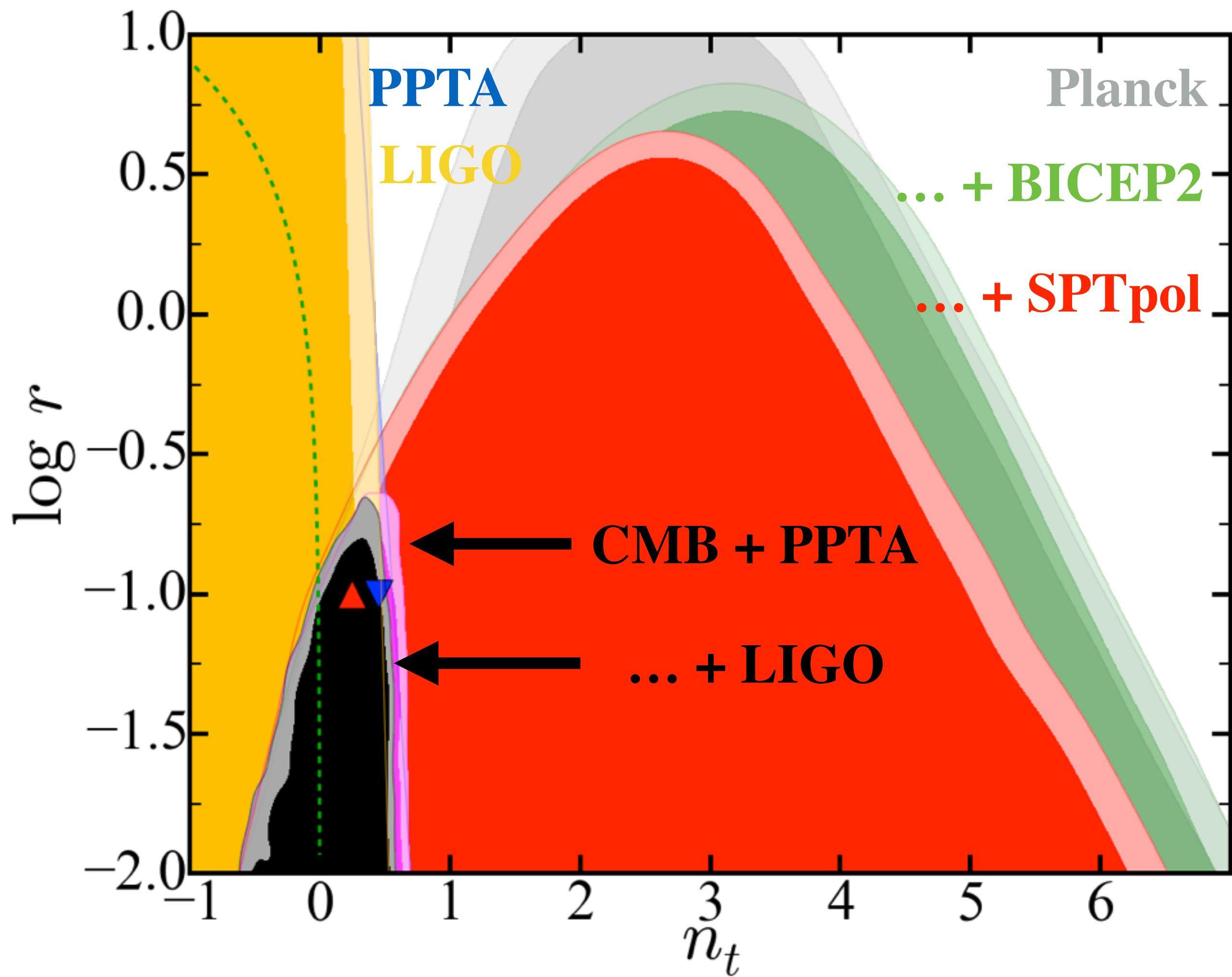
**Chiara Mingarelli, Tristan Smith,
Tom Giblin, Eric Thrane,
Daniel Reardon, and the PPTA**

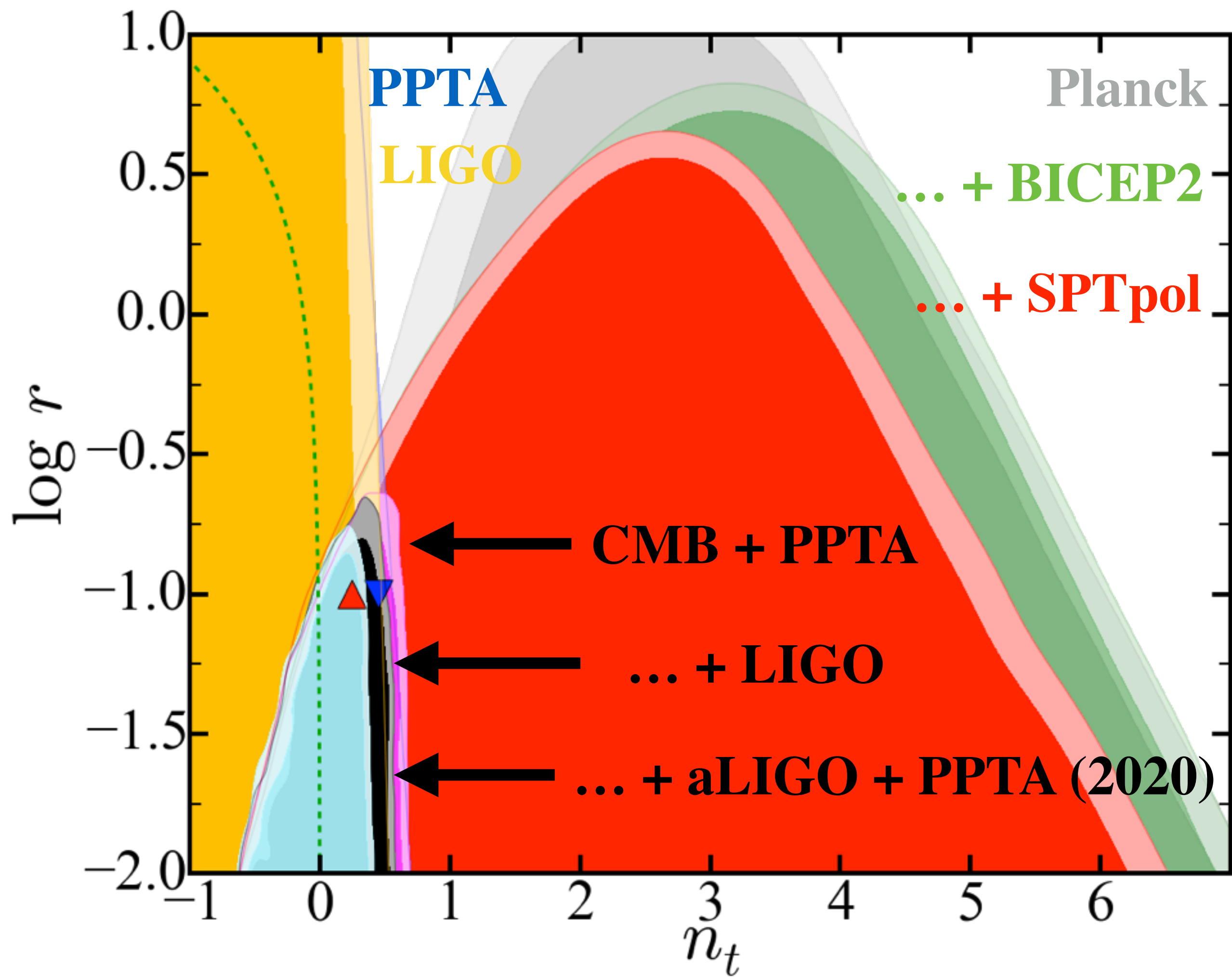












Conclusions

◎ **PPTA currently doing cosmology with non-detections!**

- Our understanding of galaxy/black hole evolution needs updating
- Bad news for stochastic GW backgrounds with PTAs
 - what about single sources?

◎ **Combined GW measurements constrain inflation**

- Watch this space...