



University of
New Hampshire



CONSTRAINING THE DENSE MATTER EOS WITH NEW NICER MR MEASUREMENTS AND NEW CHIRAL EFT INPUTS

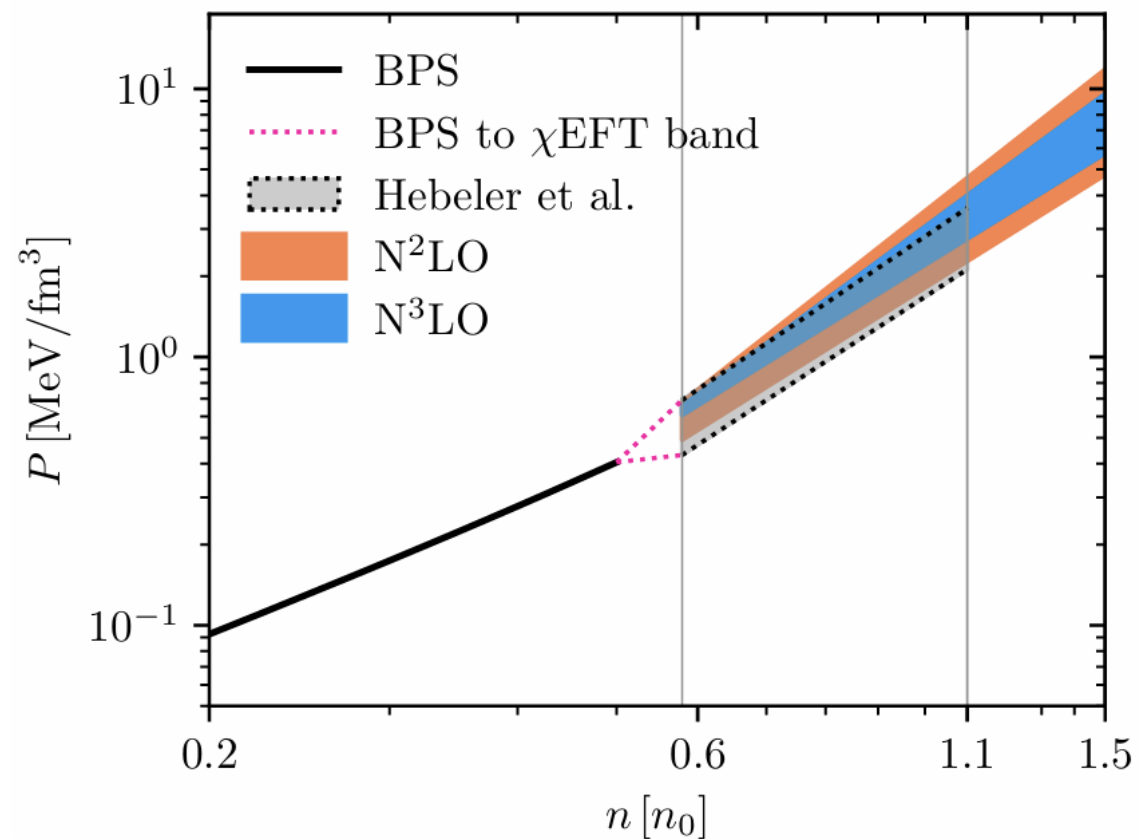
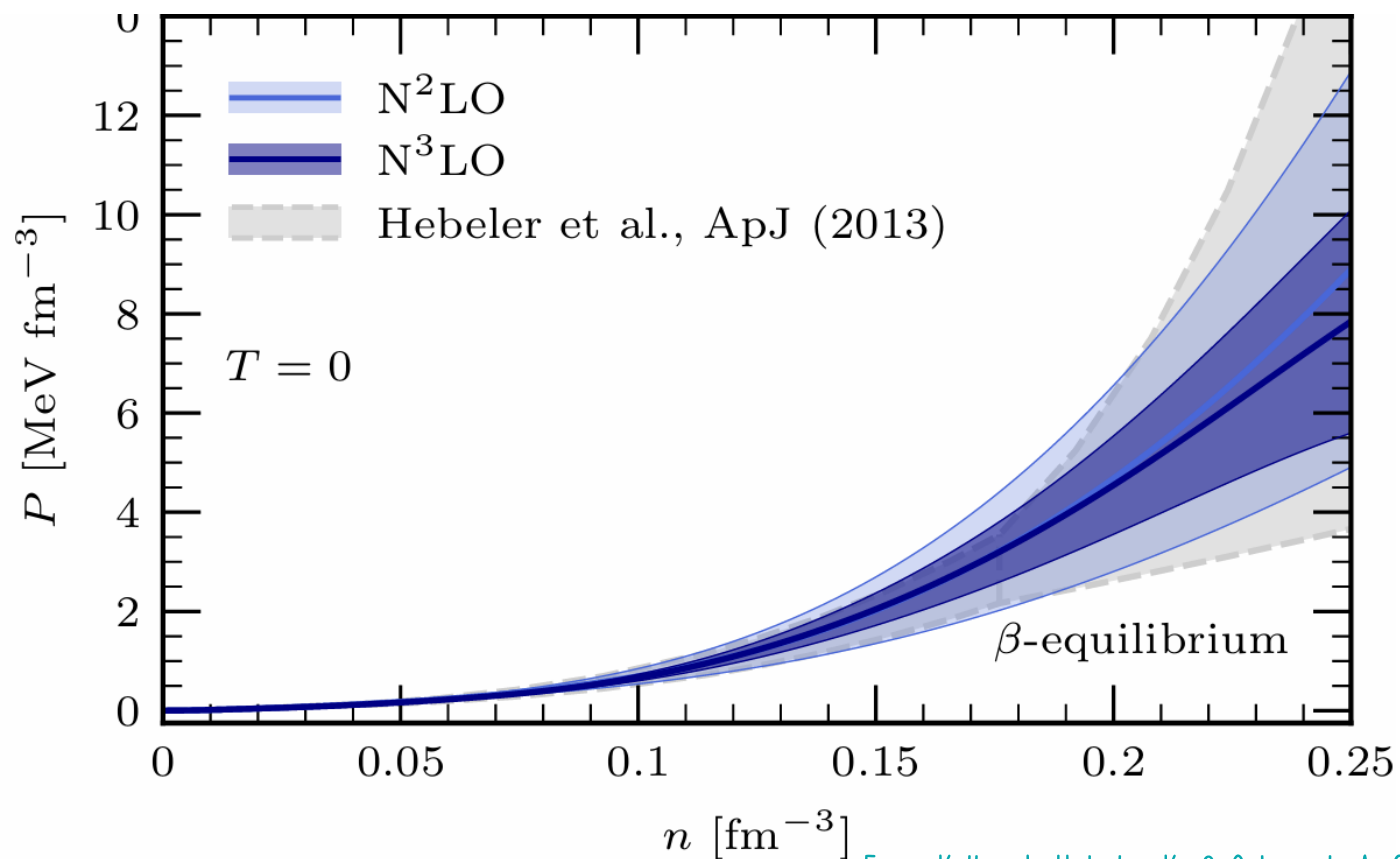
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Advisor: Chanda Prescod-Weinstein (unofficial co-advisor Anna Watts)

Based on Rutherford, N., Mendes, M., Svensson, I., Schwenk, A., Watts, A.L., et al. 2024, ApJL, 971, L19

UPDATED CHIRAL EFT INPUTS FROM KELLER ET AL 2023 (PRL)

➤ First many-body calculations in chiral EFT for arbitrary proton fraction and including n, p, μ, e^- contributions.



From Keller, J., Hebeler, K., & Schwenk, A. 2023, Phys. Rev. Lett., 130, 072701,

PIECEWISE POLYTROPE (PP)

- 3 varying polytropes with two varying transition densities, which are constrained by causality.

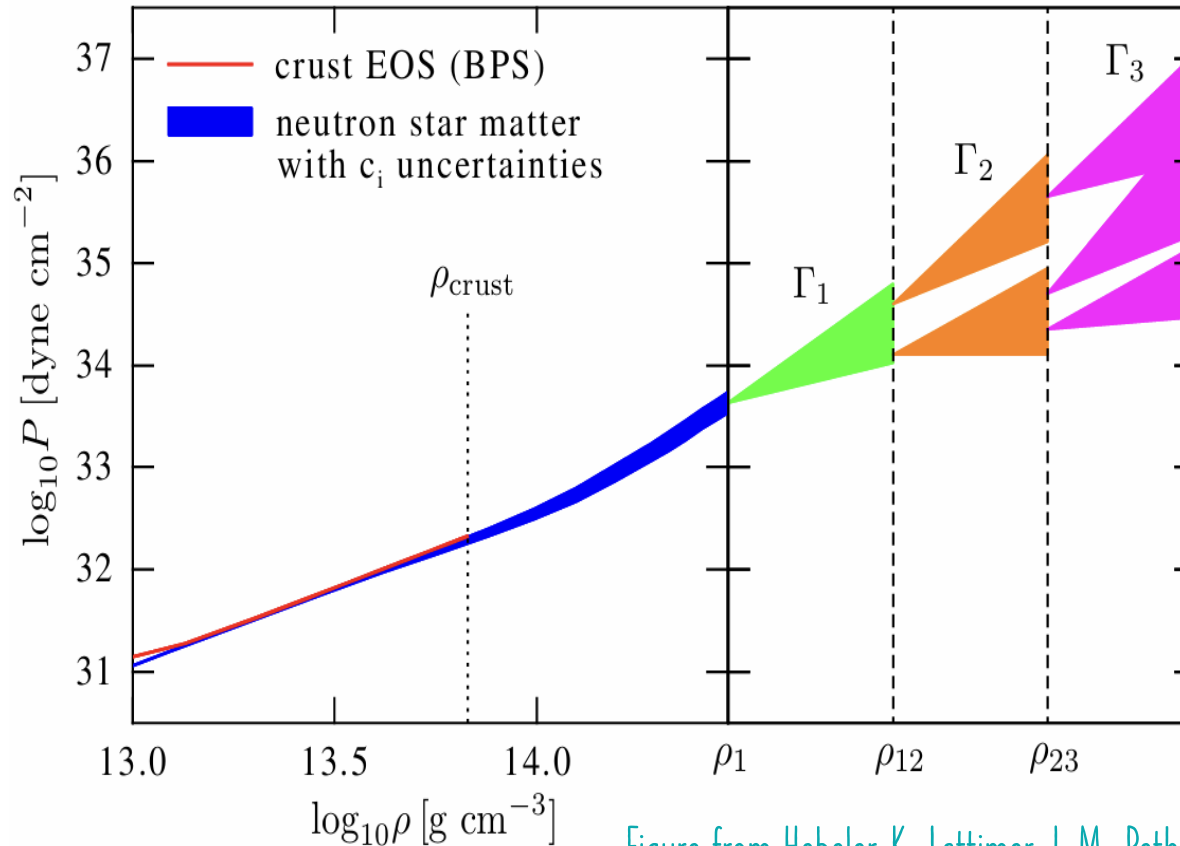


Figure from Hebeler, K., Lattimer, J. M., Pethick, C. J., & Schwenk, A. 2013, ApJ, 773

SPEED OF SOUND (c_s)

➤ Constrained by causality and PQCD

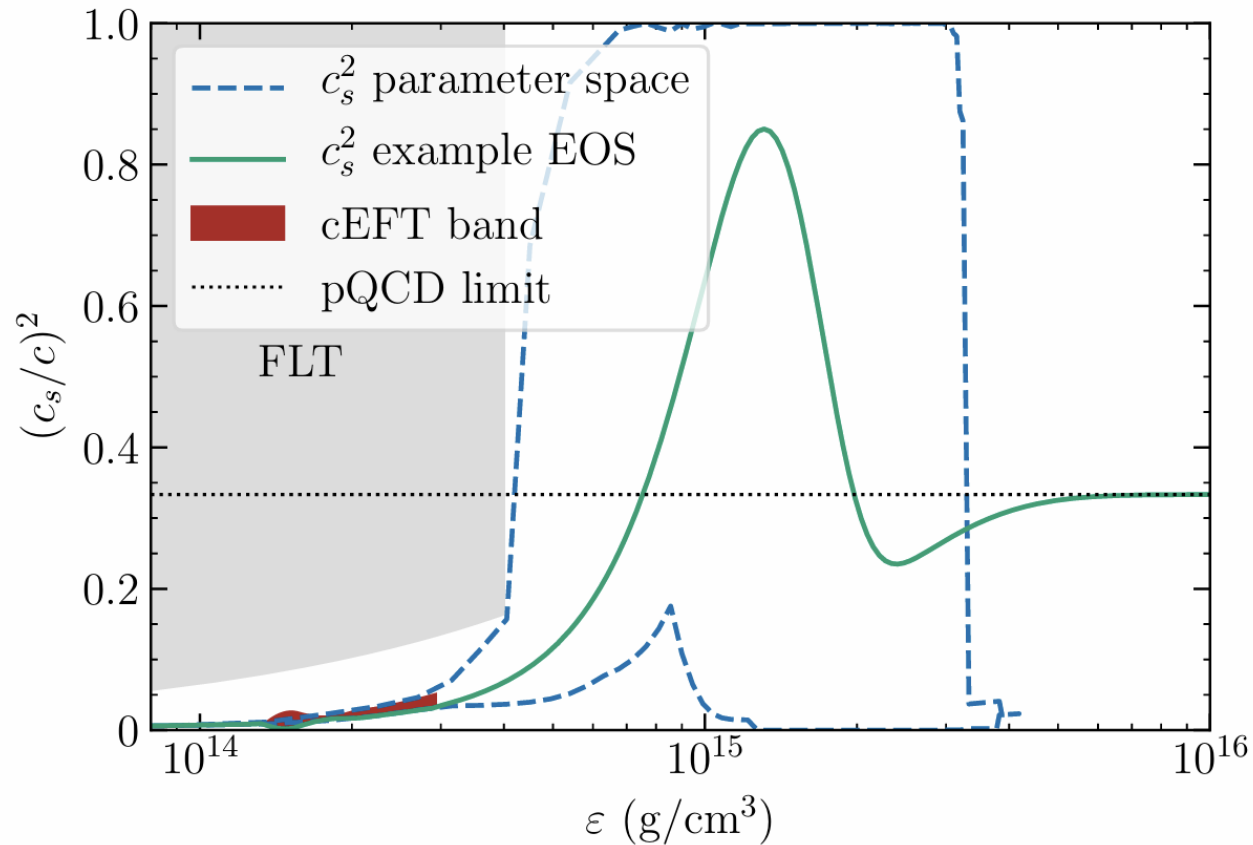
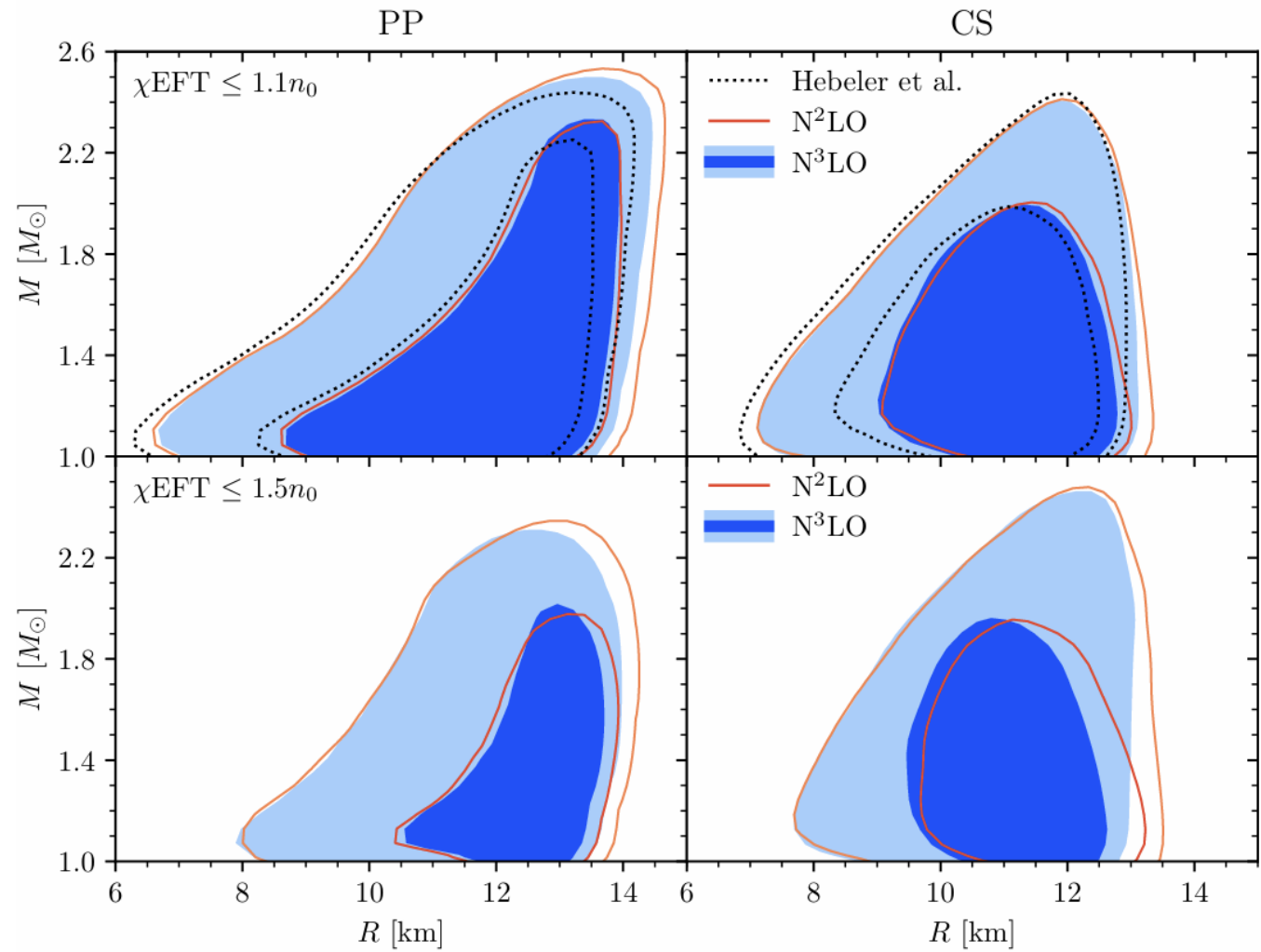


Figure from Greif, S. K., Raaijmakers, G., Hebeler, K., Schwenk, A., & Watts, A. L. 2019, MNRAS, 485, 5363

PRIORS IN THE M-R SPACE

- Overall the new bands are consistent with the old ones
- New bands favor slightly larger radii
- When chiral EFTs trusted to $1.5 n_0$, CS favors larger maximum masses *a priori*
- N^3 LO at $1.5 n_0$ is most constraining



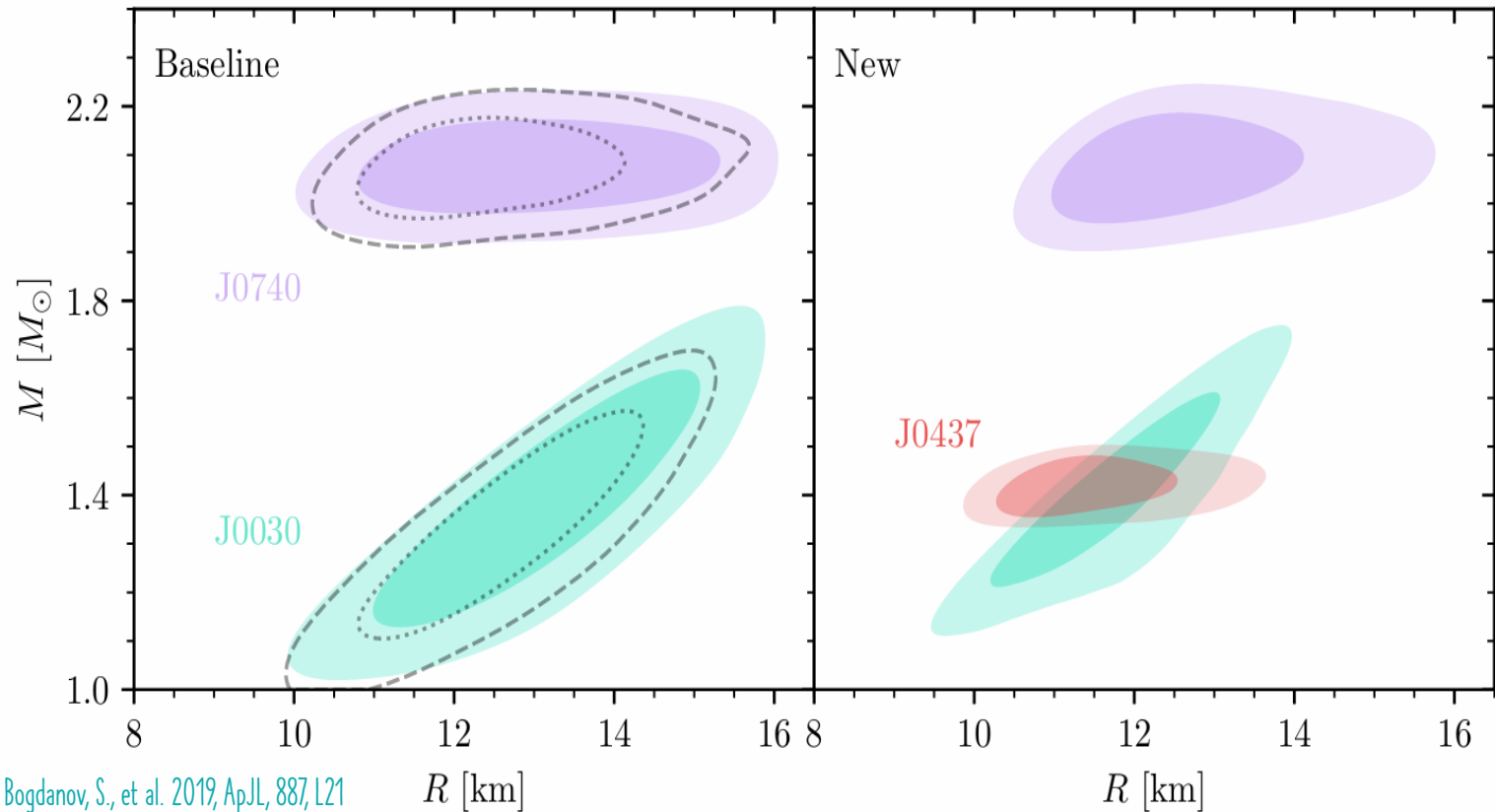
OLD AND NEW NICER MASS-RADIUS RESULTS

➤ Grey dashed contours are those of ¹Riley et al. (2019) & ²Riley et al. (2021)

➤ Baseline: ³J0740 NICER w/ background & ⁴J0030 NICER-only

➤ New: ⁵J0740 NICER-XMM, J0030 ST+PDT, and ⁶J0437 CST+PDT

➤ Mass-Tidal posteriors of GW170817 and GW190425 are also folded in



1. Riley, T. E., Watts, A. L., Bogdanov, S., et al. 2019, ApJL, 887, L21

2. Riley, T. E., Watts, A. L., Ray, P. S., et al. 2021, ApJL, 918, L27

3. Salmi, T., Vinciguerra, S., Choudhury, D., et al. 2022, ApJ, 941, 150

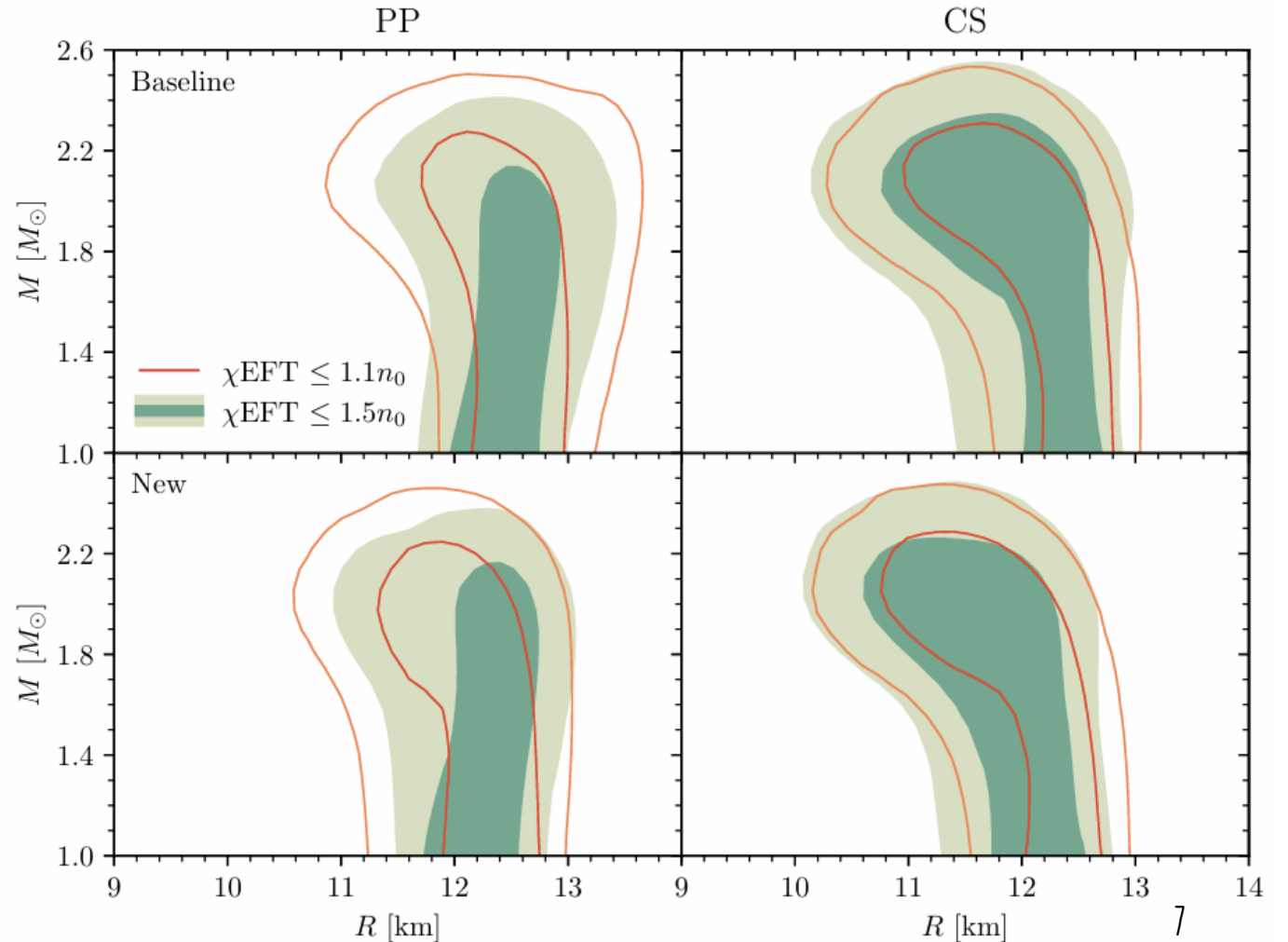
4. Vinciguerra, S., Salmi, T., Watts, A. L., et al. 2023, ApJ, 959, 55

5. Salmi, T., Choudhury, D., Kini, Y., et al. 2024, ApJ in press, arXiv:2406.14466

6. Choudhury, D., Salmi, T., Vinciguerra, S., et al. 2024a, ApJL, 971, L20

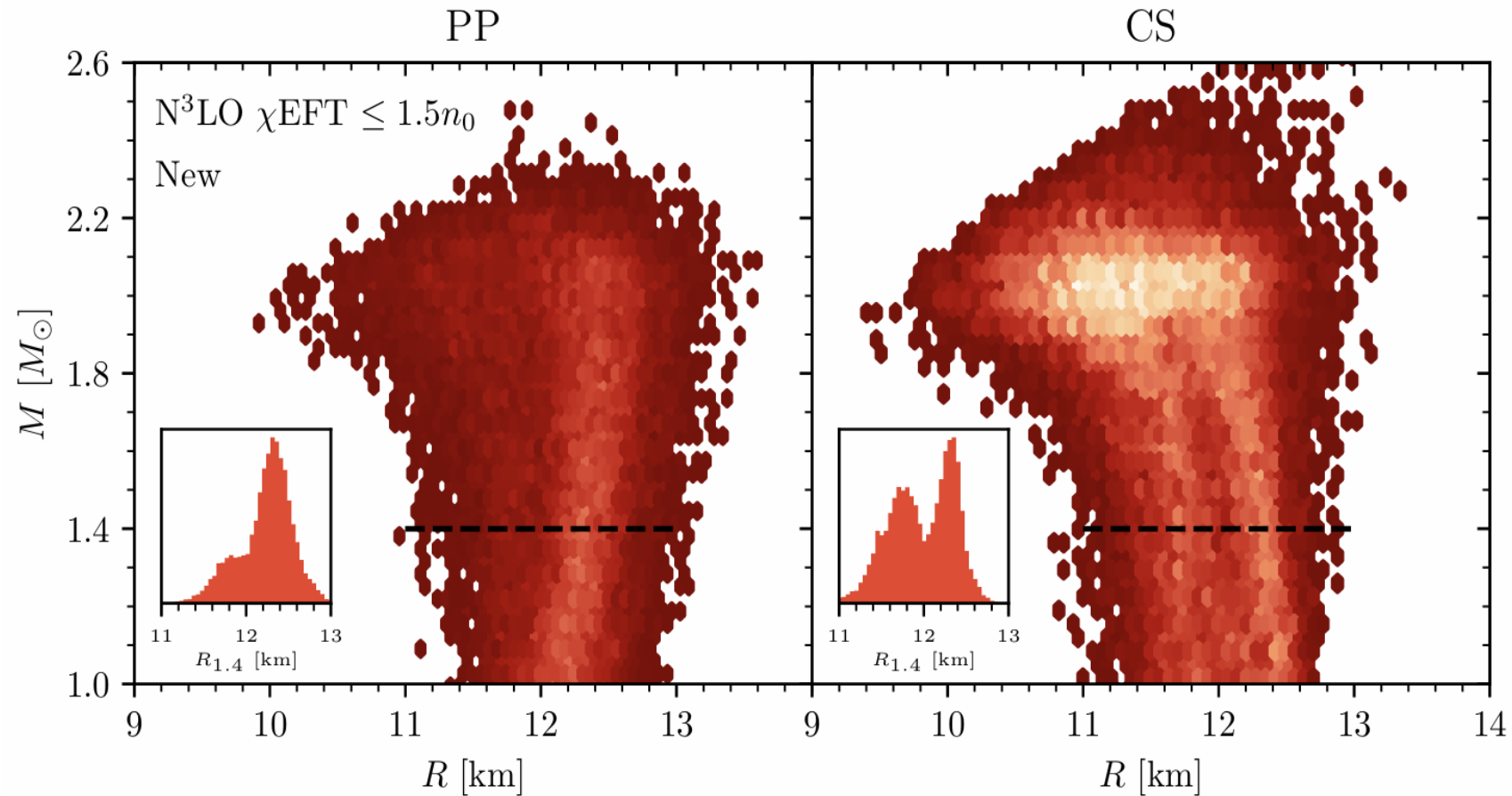
POSTERIORIORS IN THE M-R SPACE

- For PP: trusting the N³LO chiral EFT to 1.5 n_0 reduces the radius and maximum mass
- For CS: the chiral EFT results predict similar confidence regions with the 1.5 n_0 tending to lower radii
- For both PP & CS: "New" scenario posteriors shifted/narrowed to smaller radii compared to "Baseline"
- Shifting/narrowing due to the addition of J0437 and ST+PDT J0030 is consistent with J0437



AN INTERESTING FEATURE

- Both posteriors show hints of bimodal-like distribution in "New" scenario
- Not shown, but also appears at $1.1 n_0$
- Shows more strongly in the N^2 LO posteriors
- Suggests the EOS can be realized in different ways with a bimodal preference.



SUMMARY

➤ Posteriors are consistent, but N³LO at 1.5 n_0 is most constraining.

➤ New results are more reliable in terms of input physics priors and the degree to which they are data-driven.

➤ Bimodal-like structure → the inferred EOS could be equally well described by both softer or stiffer EOSs within our PDF space

