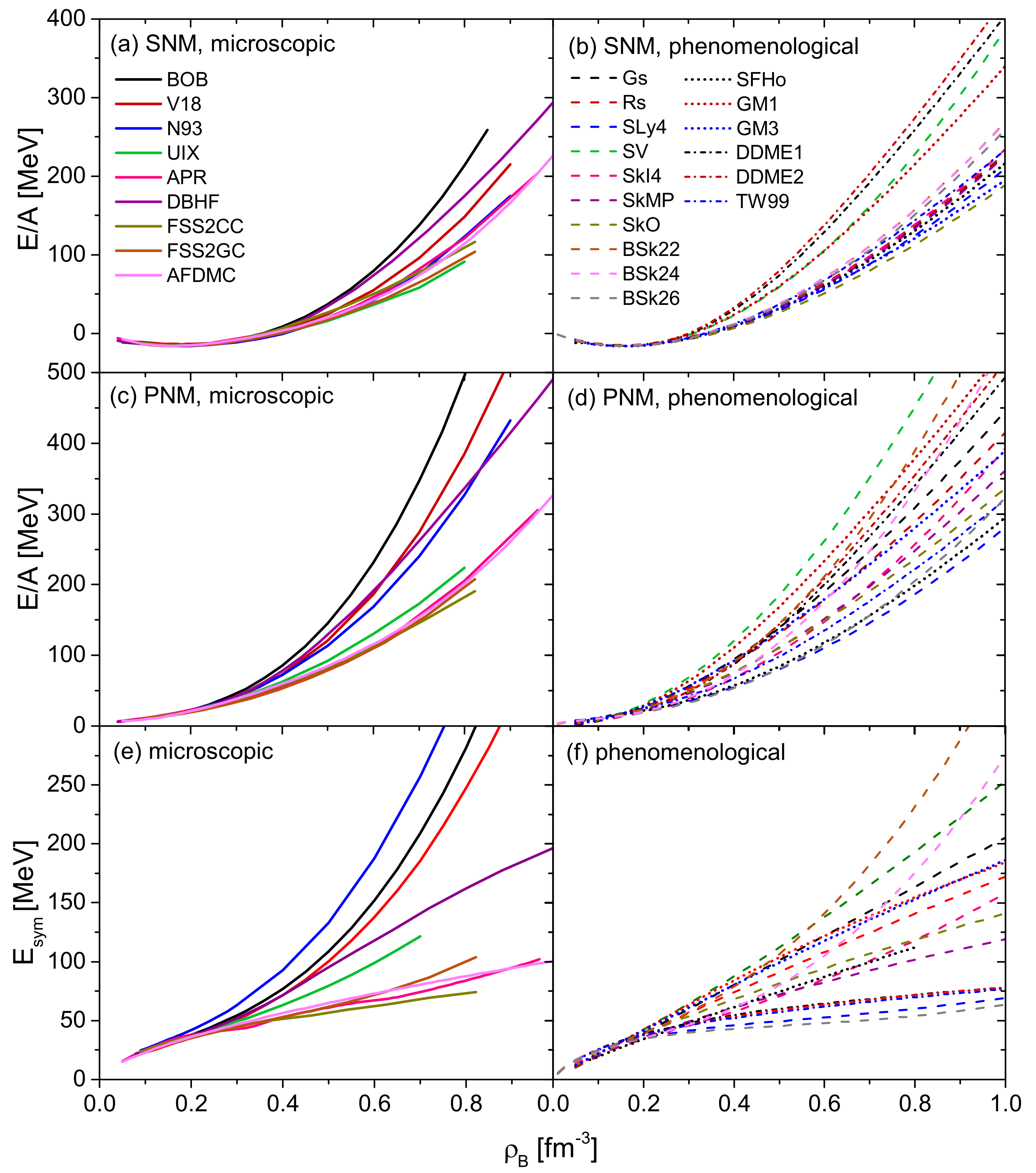
Microscopic approaches : where do we stand ?

Round table @NuSYM 24

- Symmetry energy uncertainties from the underlying EoS for SNM and PNM.



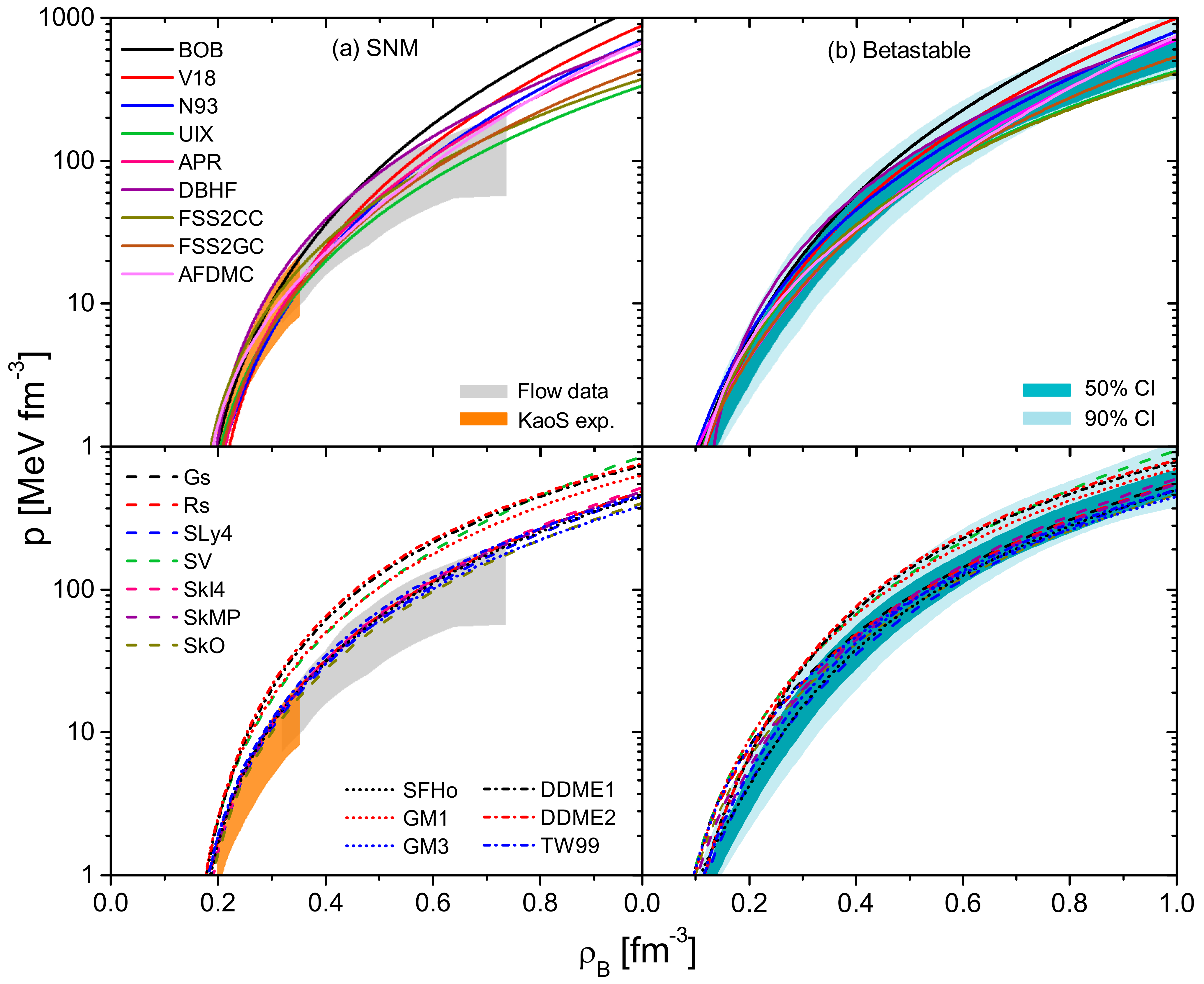
Microscopic EoS

- BHF with Argonne V18, Bonn B, Nijmegen 93 2NF and microscopic 3NF (BOB,V18, N93)
- BHF with Argonne V18 2NF + Urbana 3NF (UIX).
- BHF with FSS2 2NF
- APR, variational with Argonne V18 and Urbana 3NF
- Relativistic DBHF (Bonn A)
- AFDMC with modified V18

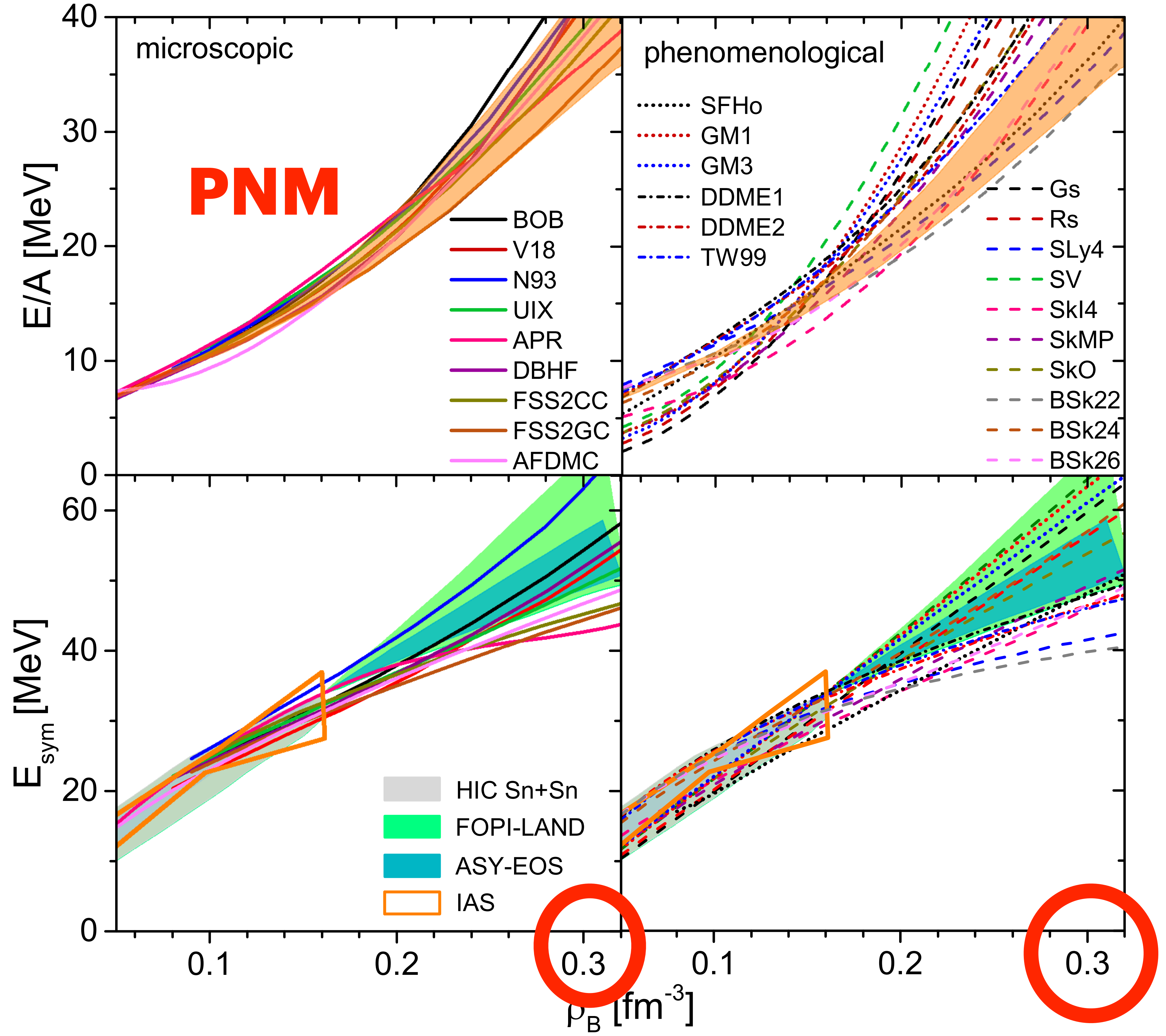
Phenomenological EoS

- Skyrme forces (Gs,Rs,SLy4,SV etc…)
- Brussels-Montreal group BSk22,24,26
- NLWM (SFHo, GM1,3), RMF models with different parameterizations.
- DDM, RMF model with density dependent coupling constants.

Burgio, Vidaña, Schulze and Wei, Progress in Particle and Nuclear Physics 120 (2021) 103879



Orange band : χEFT up to N3LO order
C. Drischler et al., PRL 125, (2020) 202702

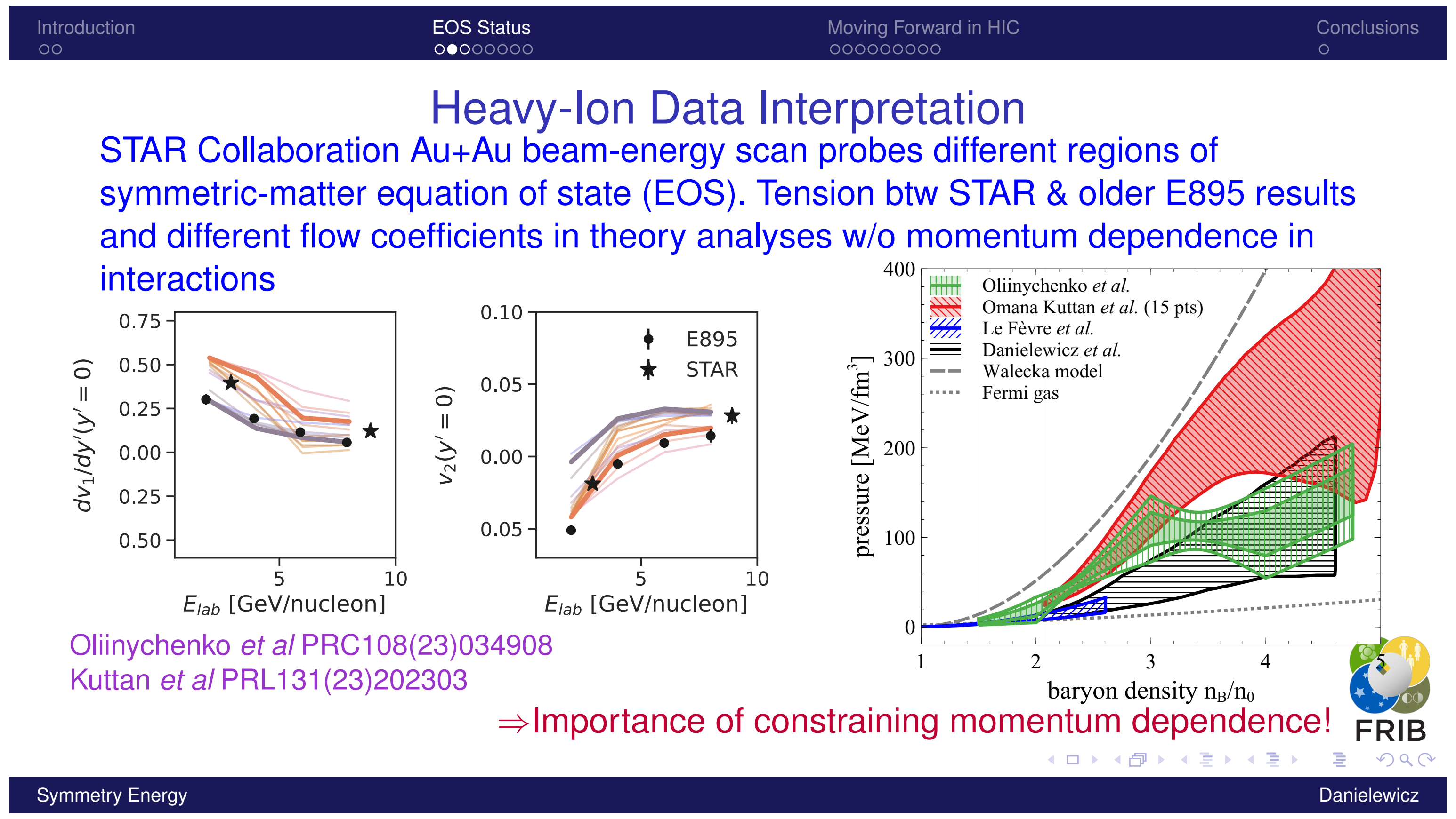


KaoS D. Miśśkowiec, et al., Phys. Rev. Lett. 72 (1994) 3650–3653.
Flow P. Danielewicz, R. Lacey, W.G. Lynch, Science 298 (2002) 1592.
GW170817 B.P. Abbot, et al., Phys. Rev. Lett. 119 (2017) 161101.

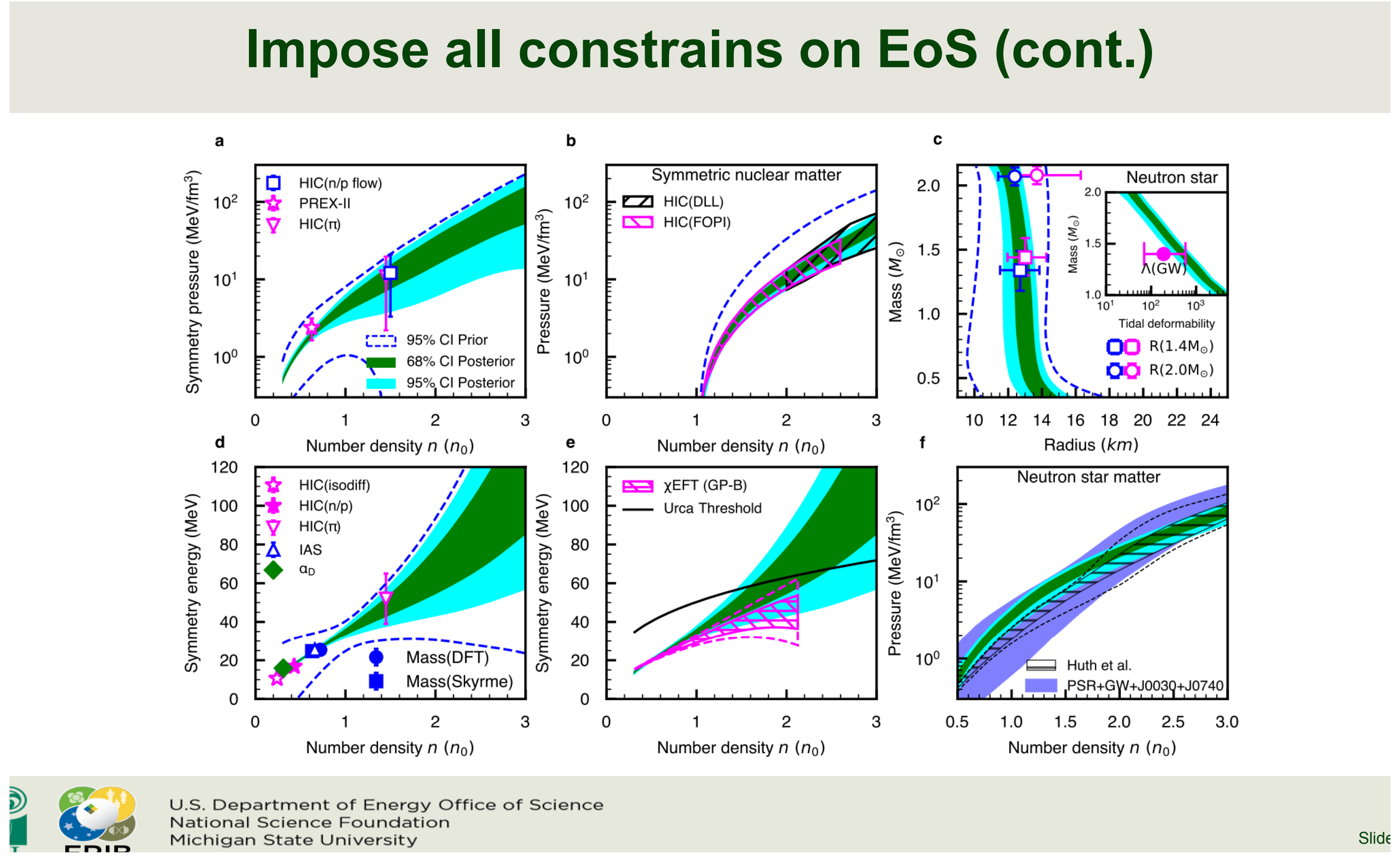
FOPI-LAND J.L. Ritman, et al., Z. Phys. A Hadrons Nuclei 352 (1995) 355–357.
ASY-EOS P. Russotto, et al., Phys. Rev. C 94 (3) (2016) 034608.
IAS P. Danielewicz, J. Lee, Nuclear Phys. A 922 (2014) 1.

Update from NuSYM 2024

cfr. Talk by P. Danielewicz

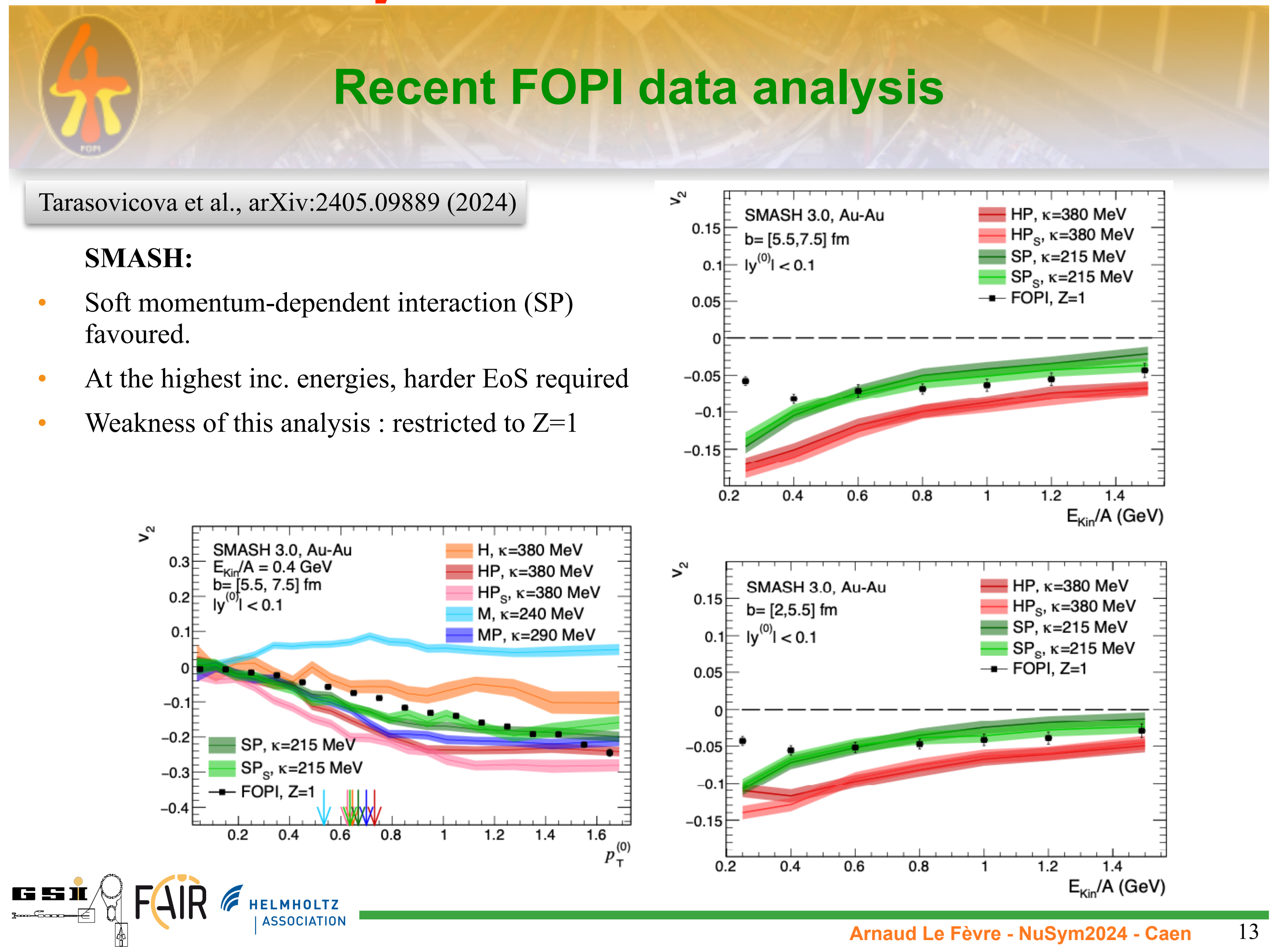


cfr. Talk by C. Y. Tsang

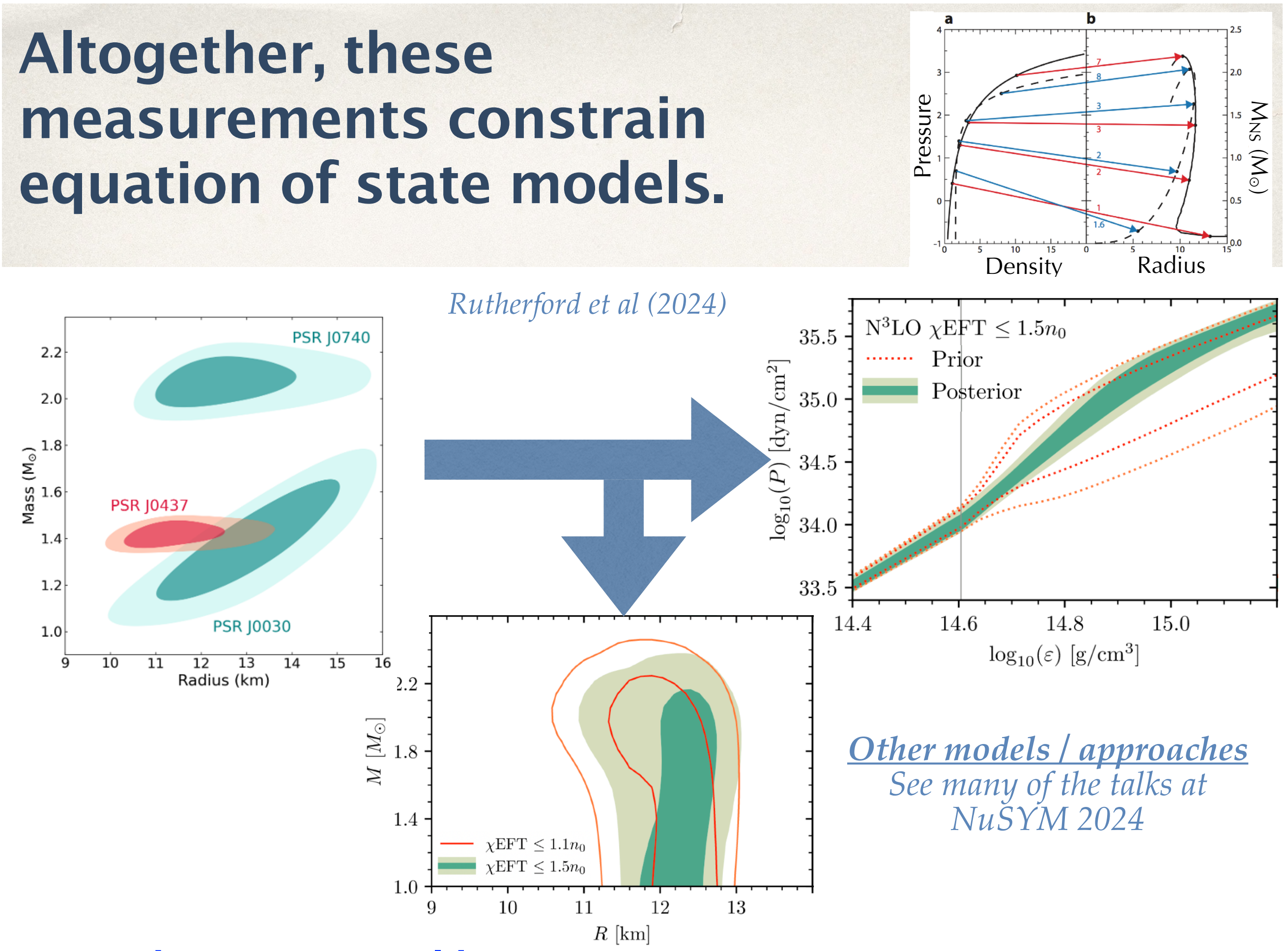


Nature 8(24)328

cfr. Talk by A. LeFevre



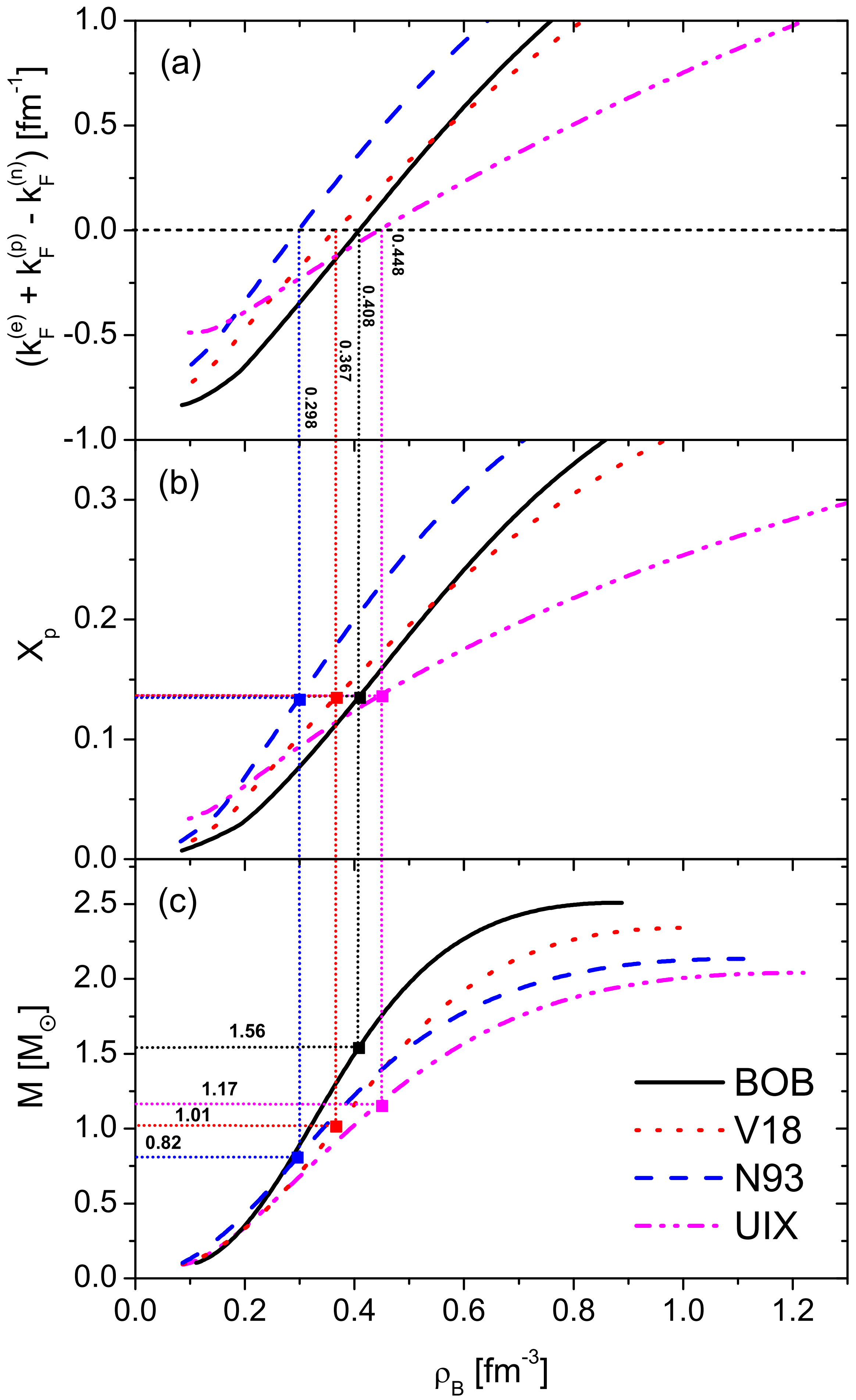
cfr. Talk by S. Guillot

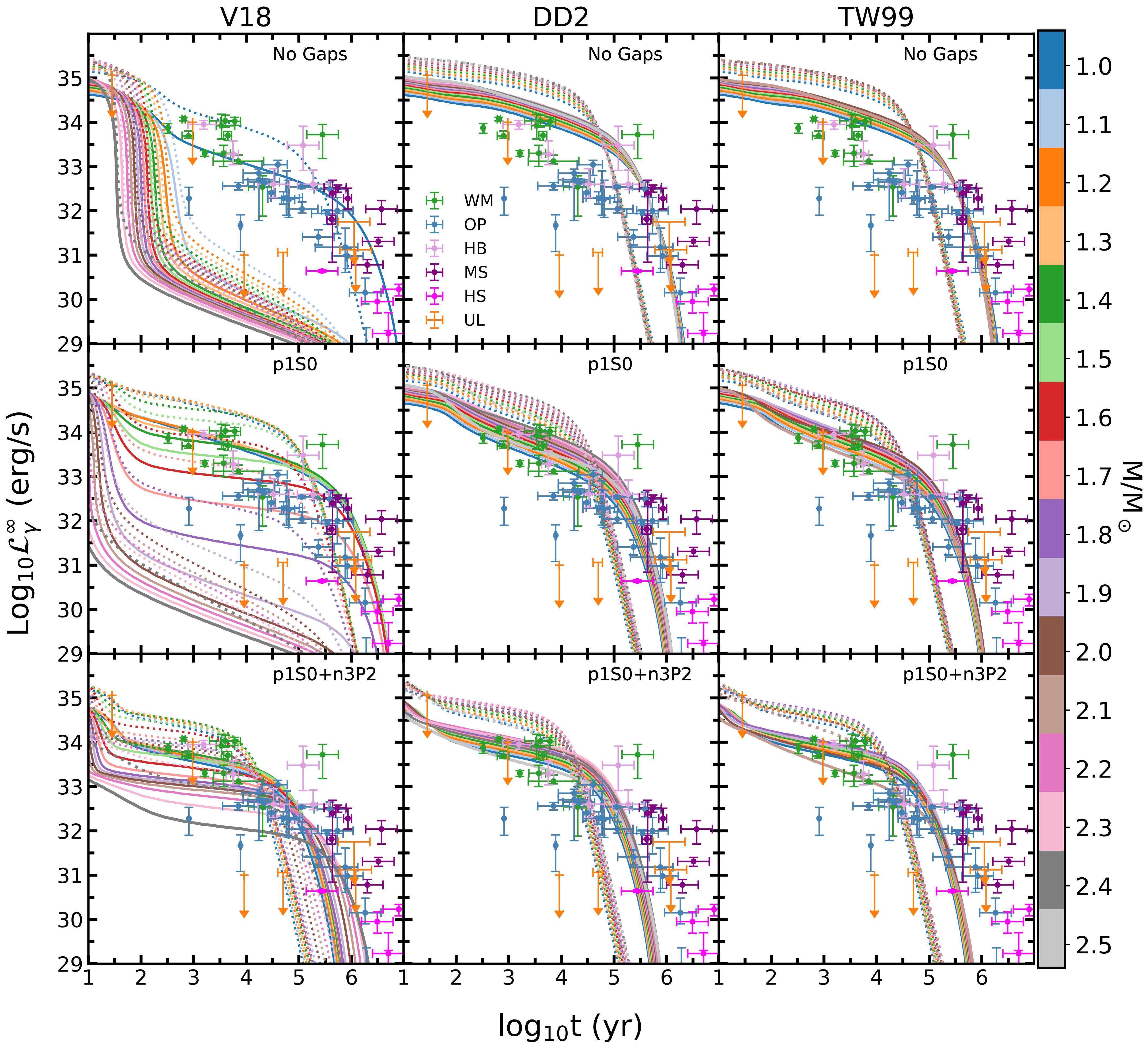


..... and many other talks @ NuSYM 2024

NS Cooling process

The proton fraction regulates the direct URCA process $(n \rightarrow p + e + \bar{\nu}_l, \dots)$





Cooling rate highly impacted by direct URCA process and pairing gaps in the p1S0 and n3P2 channels.

DD2 & TW99 : too slow cooling for middle-aged objects and too fast for old objects.

V18 : strong DU (no gaps). Even low mass stars cool rapidly. With p1S0 BCS gap. Strong quenching of the DU. Adding n3p2 difficult to accommodate.

Open problems in microscopic approaches

- Fitting the SNM saturation point. It seems obvious but is not trivial.
- 3NF are reduced to a density dependent 2NF by averaging over the generalized coordinates of the third particle.
- 3NF at large density ?

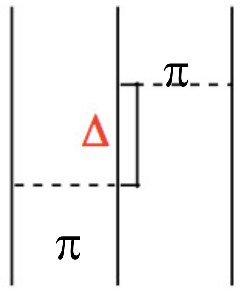
Necessary to:

- ✧ Reproduce the spectra of light nuclei
- ✧ Obtain proper saturation properties of symmetric nuclear matter in non-relativistic many-body calculations

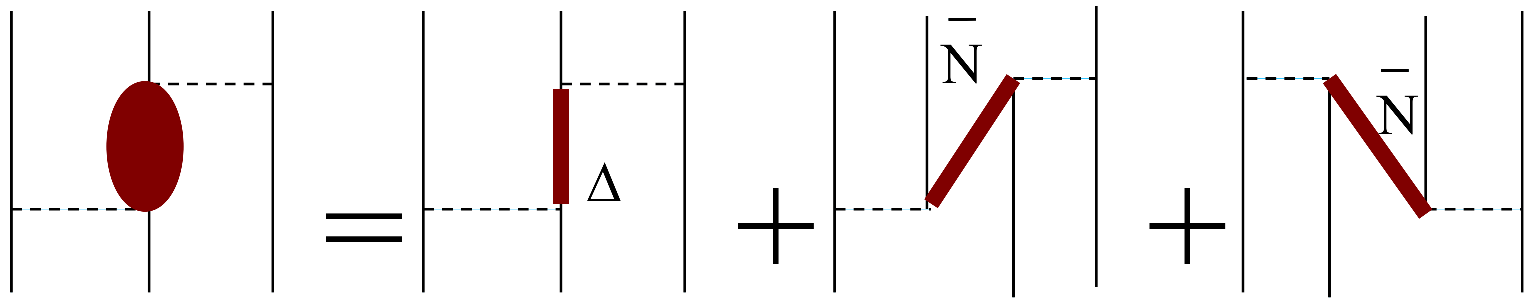
✧ **Urbana-type** $V_{ijk}^{UIX} = V_{ijk}^{2\pi} + V_{ijk}^{R}$

$V_{ijk}^{2\pi}$: Attractive Fujita-Miyazawa force

V_{ijk}^{R} : Repulsive & Phenomenological

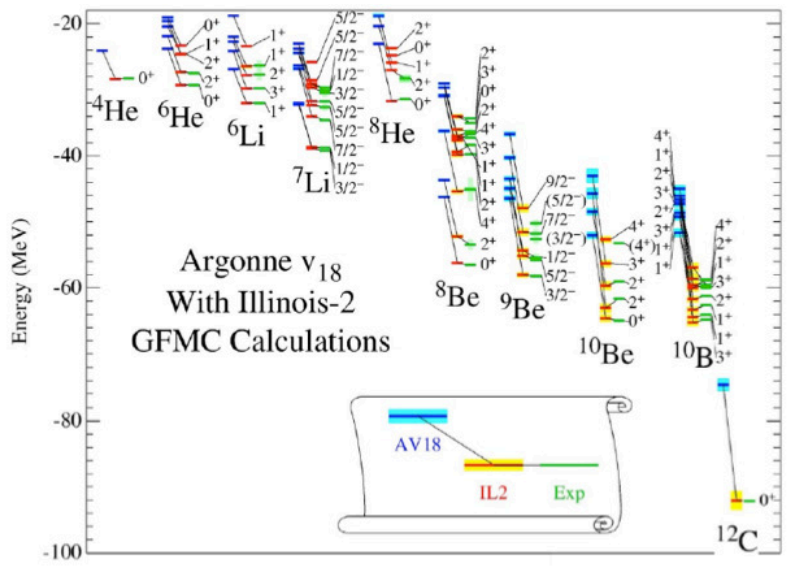


✧ **Microscopic-type**

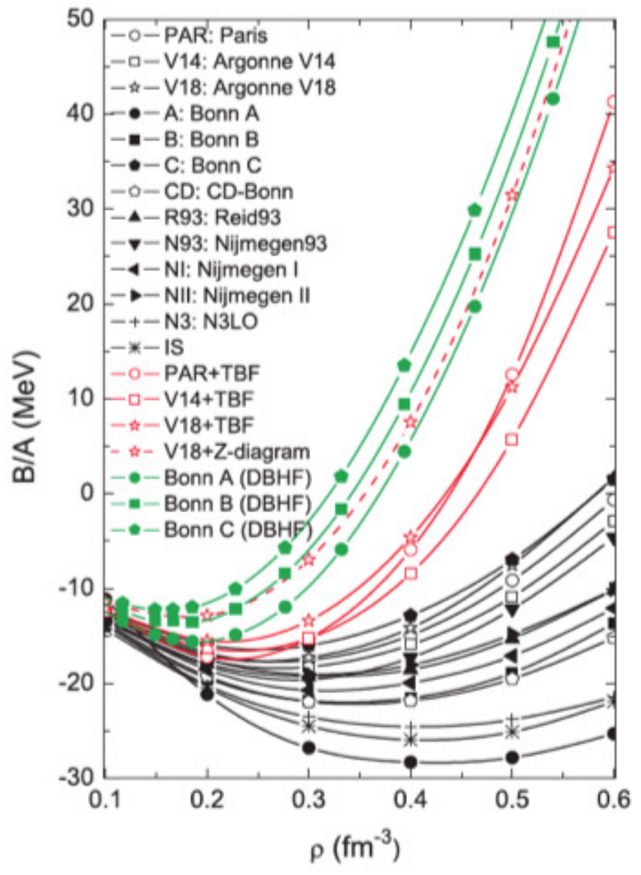


Problem: NNN is not independent of NN

Courtesy by I. Vidaña

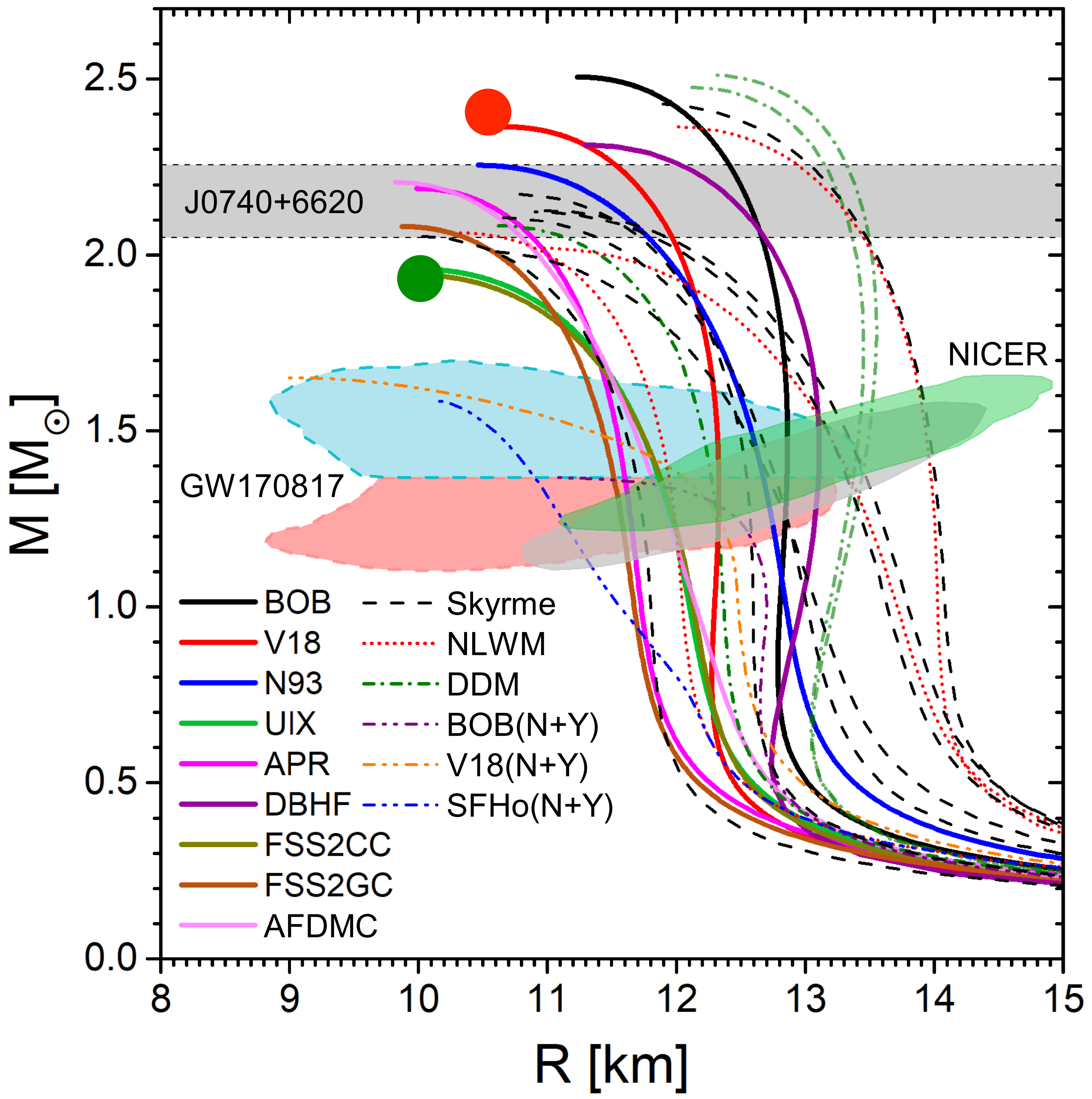


Pieper & Wiringa, ARNPS 51, 53 (2001)

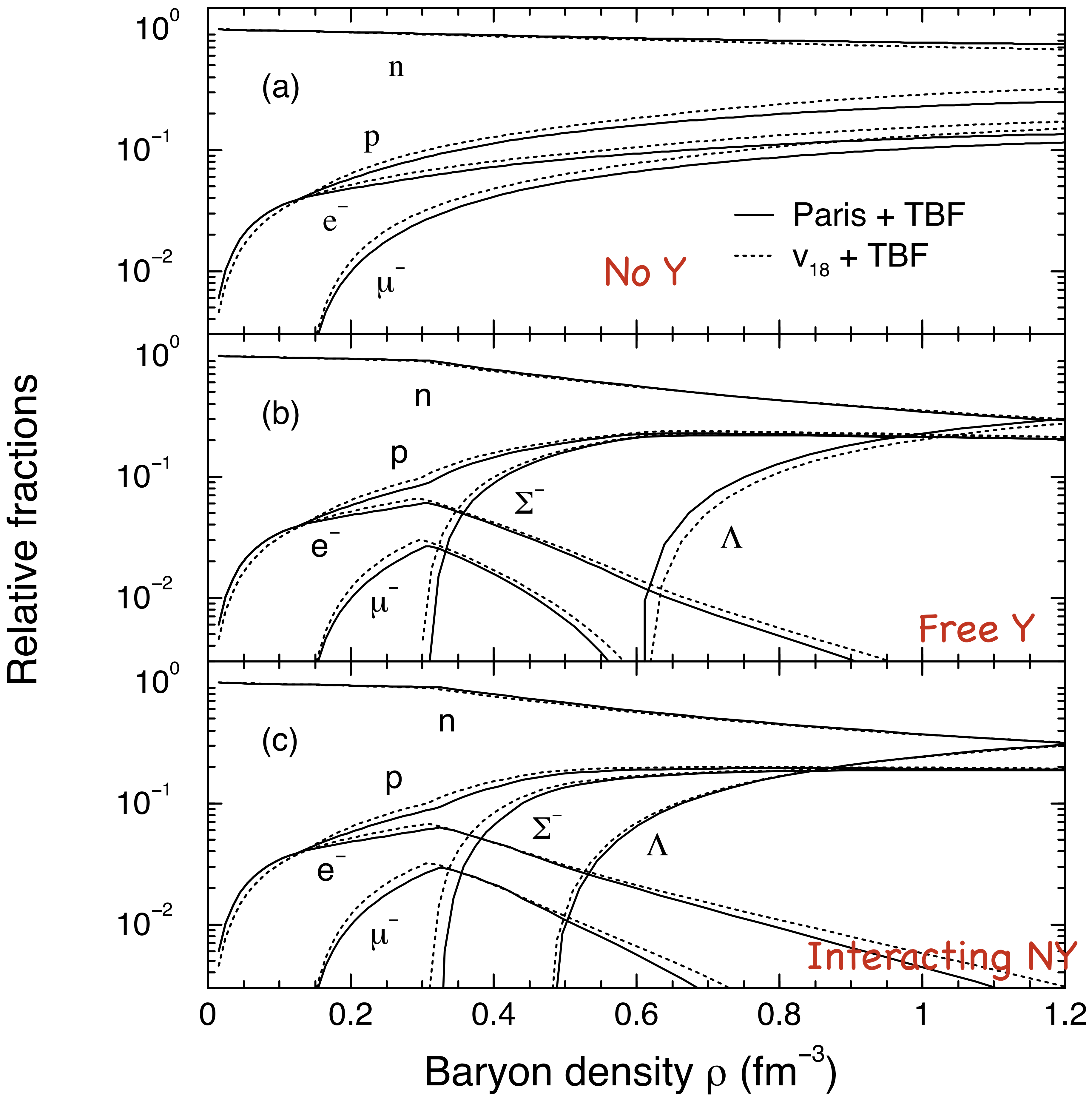


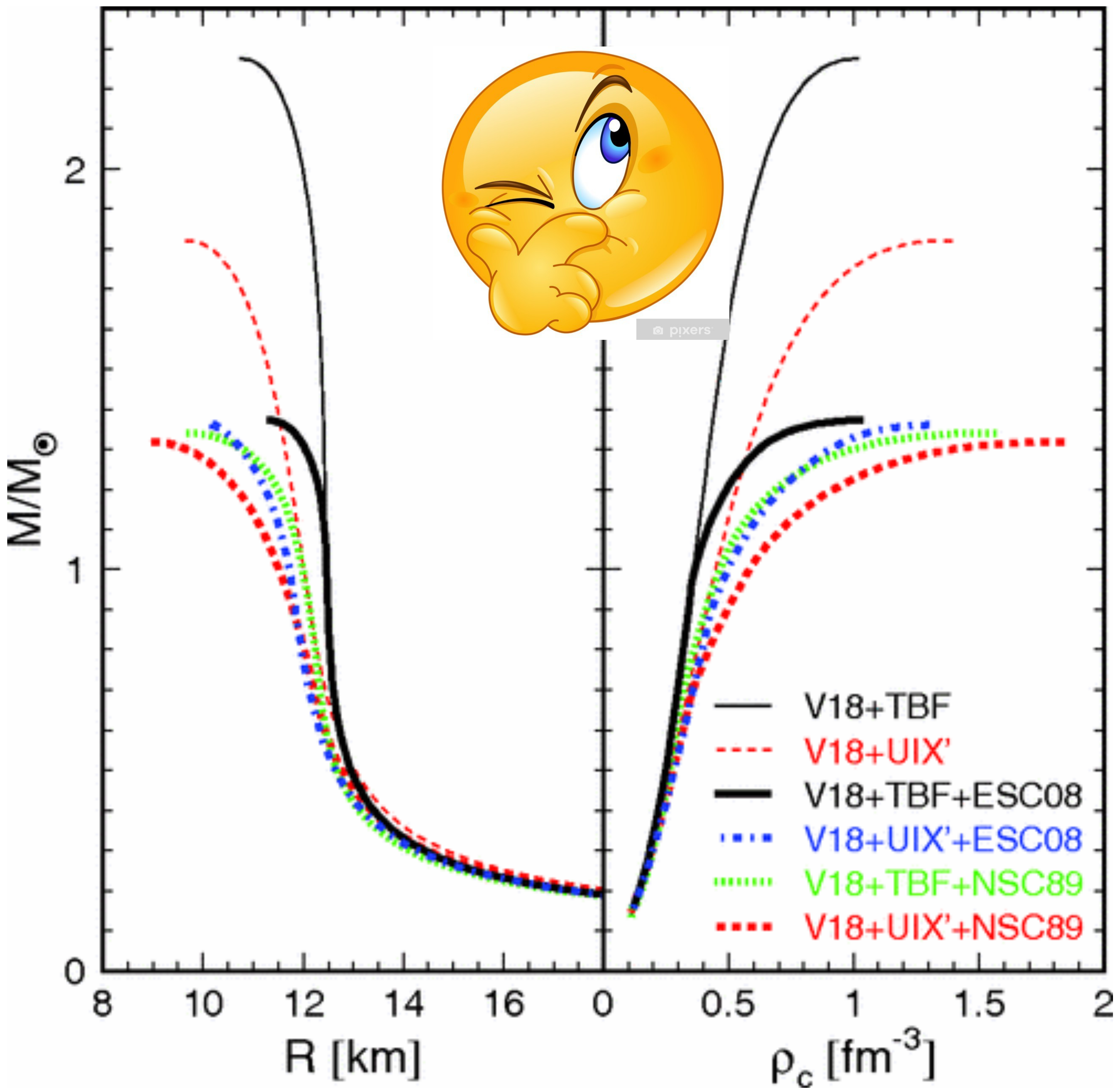
Li et al., PRC 74, 047304 (2006)

G.F. Burgio, H.-J. Schulze, I. Vidaña, J.-B. Wei , Progress in Particle and Nuclear Physics 120 (2021) 103879.



Open problem : The Hyperon Puzzle





- Hyperon onset @ $\rho \sim (2-3)\,\rho_0$
- Strong softening and low M_{max} below obs. data

Something available to the HIC community from microscopic calculations

- Binding energy per particle $\frac{E}{A}(\rho, x_p, T), \rho < 0.8 fm^{-3}, T < 70 MeV$ in a parameterised form as polynomial fit, with and without beta-stability.
- Effective masses $m^*_{n,p}(\rho, x_p, T)$
- Binding energy per particle $\frac{E}{A}(\rho, x_p, x_{\Sigma^-}, x_\Lambda, T), \rho < 0.8 fm^{-3}, T < 70 MeV$ as a polynomial fit.