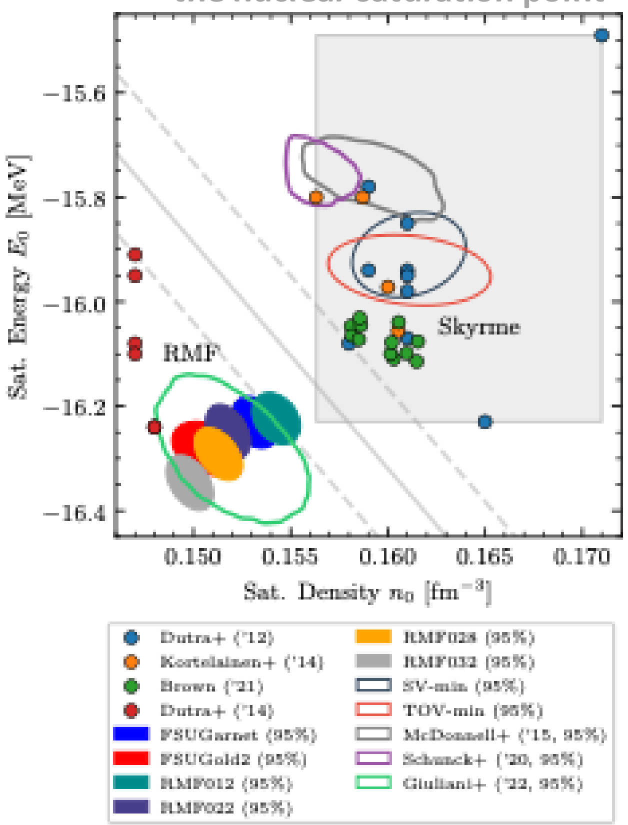
A Bayesian mixture model approach to quantifying the *empirical* nuclear saturation point

Goal: rigorous benchmarks of saturation properties of chiral NN+3N interactions (using Skyrme & RMF models)

DFT constraints on the nuclear saturation point



Nuclear saturation: **EOS of symmetric matter exhibits a minimum** at the density $n_0 \approx 0.16$ fm^{-3}, which is related to the typical central density of heavy nuclei, while the corresponding ground-state energy per particle $E(n_0)/A \equiv E_0 \approx -16$ MeV is closely related to the volume term of the semi-empirical mass formula.

The nuclear saturation point (n_0, E_0) is **ideal for benchmarking chiral effective field theory (EFT) interactions** in medium.

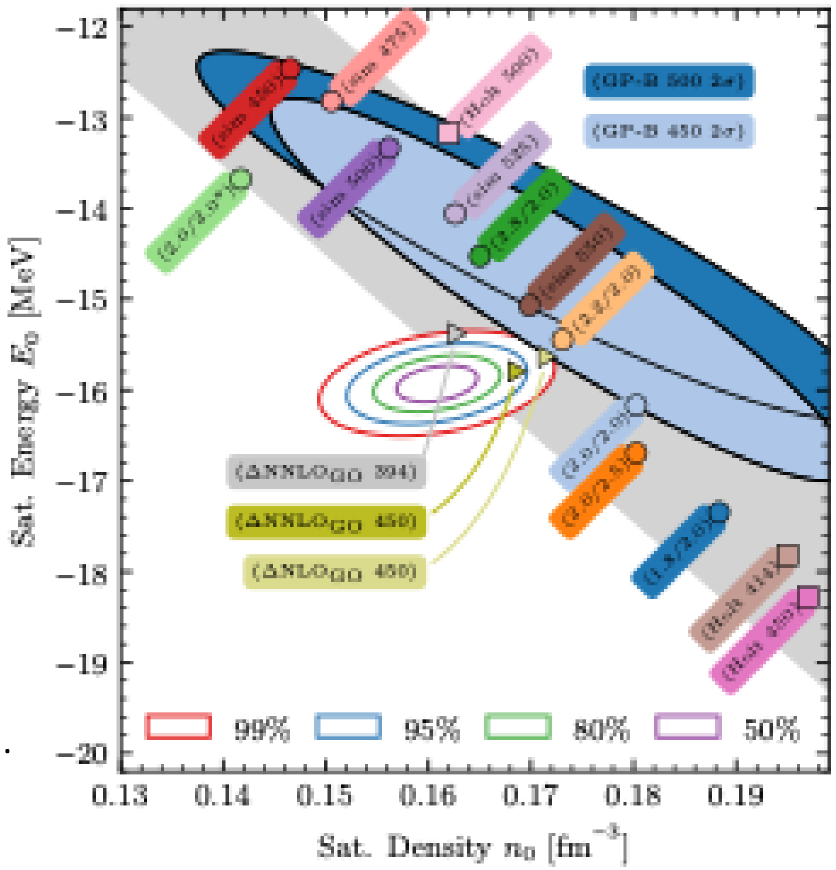
Density functional theory (DFT), informed by nuclear observables, provide important *empirical* constraints for (n_0, E_0)

Skyrme and relativistic mean field (RMF) models constrain (n_0, E_0) tightly, but when multiple DFT constraints are considered together, they are clearly inconsistent: **not all DFT predictions can be both precise and accurate simultaneously** (left figure).

We developed a **Bayesian hierarchical model that estimates the true empirical saturation point by mixing multiple DFT constraints**. This results in a posterior distribution for the empirical saturation point that enables statistically meaningful benchmarks of microscopic interactions in terms of nuclear saturation (right figure).

We also derived **tight constraints on the nuclear symmetry energy and its slope parameter at the saturation density** using microscopic calculations of the pure neutron matter EOS.

DFT vs EFT: nuclear saturation



STREAMLINE
SmarT Reduction and Emulation Applying Machine Learning In Nuclear Environments

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CD, Giuliani, Bezoui, Piekarewicz, and Viens, arXiv:2405.02748