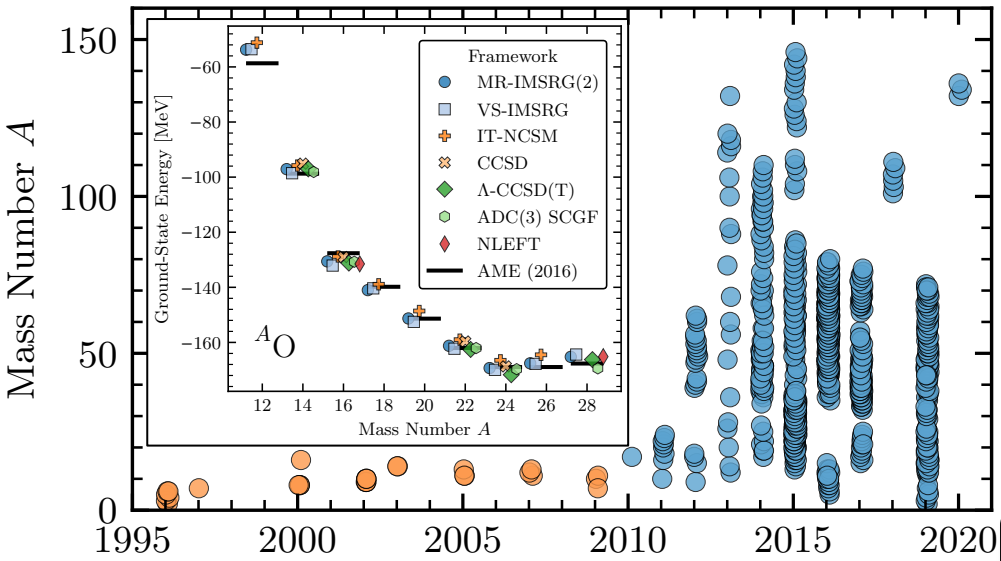
nuclear physics in the *precision* era:
limitations due to NN+3N forces

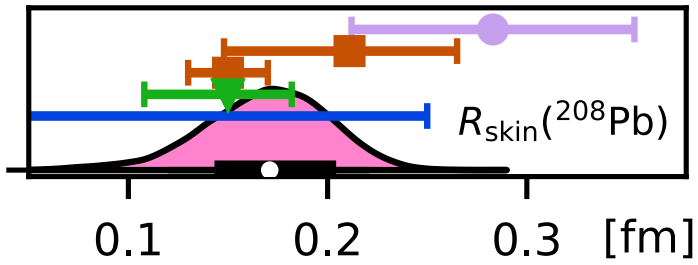


finite nuclei

Hergert, Front. in Phys. **8**, 379
CD & Bogner, Few Body Syst. **62**, 109

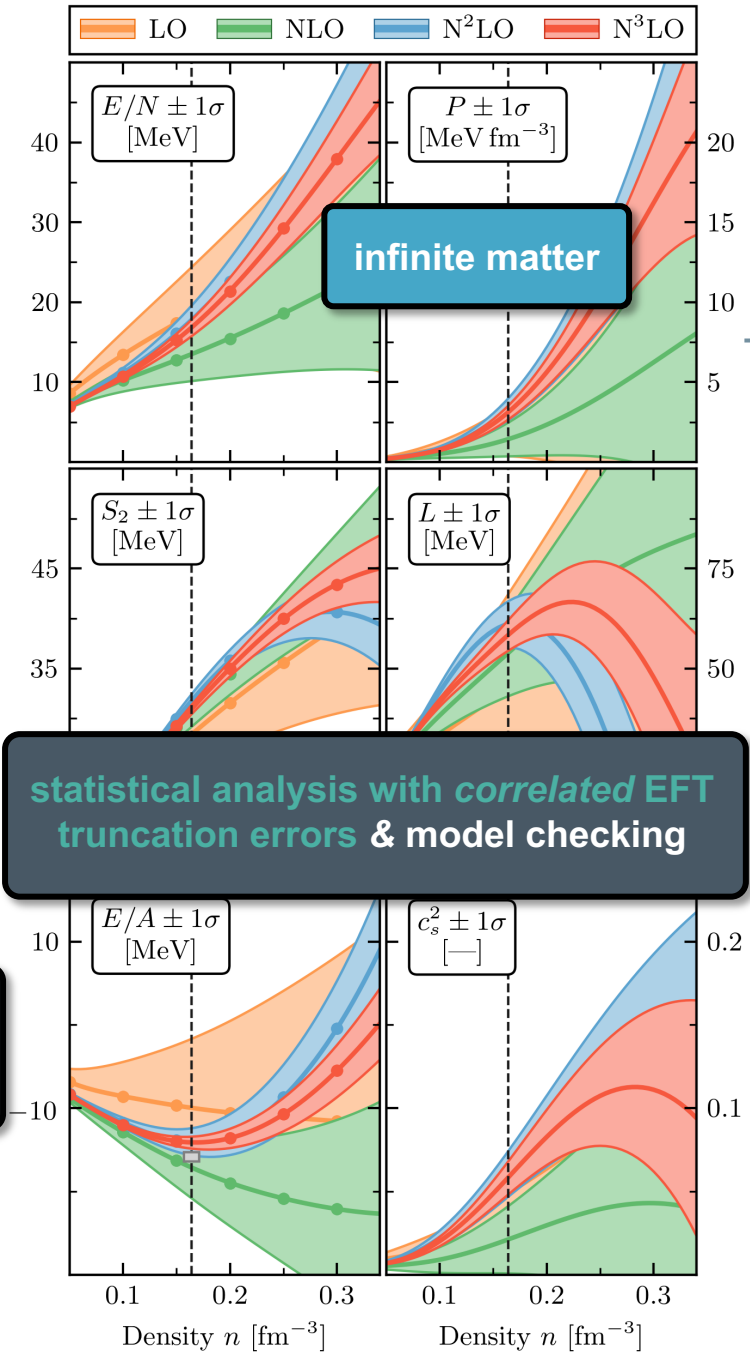
Hu, Jiang *et al.*, Nature Phys. **18**, 1196

first *ab initio* calculation of ^{208}Pb, incl. neutron skin prediction with UQ



Constraints from:

electroweak
hadronic
electromagnetic
gravitational waves



infinite matter

statistical analysis with *correlated* EFT truncation errors & model checking

CD, Furnstahl, Melendez, Phillips, PRL **125**, 202702
CD, Hebeler, Schwenk, PRL **122**, 042501

CD, Holt & Wellenhofer, Ann. Rev. NPS **71**, 403

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Tremendous progress
in CEFT, many-body theory, UQ & HPC

CEFT enables *ab initio* calculations of **finite nuclei** & **nuclear matter** at $T \geq 0$ and arbitrary proton fractions ($n \lesssim 2n_{\rm sat}$)

Computational & algorithmic advances in all many-body frameworks

Here: **many-body perturbation theory**

- fully automated | GPU-accelerated
- full N^{3}LO calculations with NN+3N contributions at high MBPT orders

Bayesian statistics allows for **rigorous UQ & propagation** in EFT-based calculations (use emulators!)

Correlated EFT truncation errors from **order-by-order calculations** and GP truncation error model (physics-informed)

At what density does CEFT break down and how ?

Need a more precise PREX-II measurement

Tension (at ≈ 1σ) between PREX-II-informed and other determinations of R_{skin} or L and α_D (RCNP)

Adhikari *et al.* (CREX), PRL **129**, 042501
Reinhard *et al.*, PRL **127**, 232501
Essick *et al.*, PRL **127**, 192701
Reed *et al.*, PRL **126**, 172503

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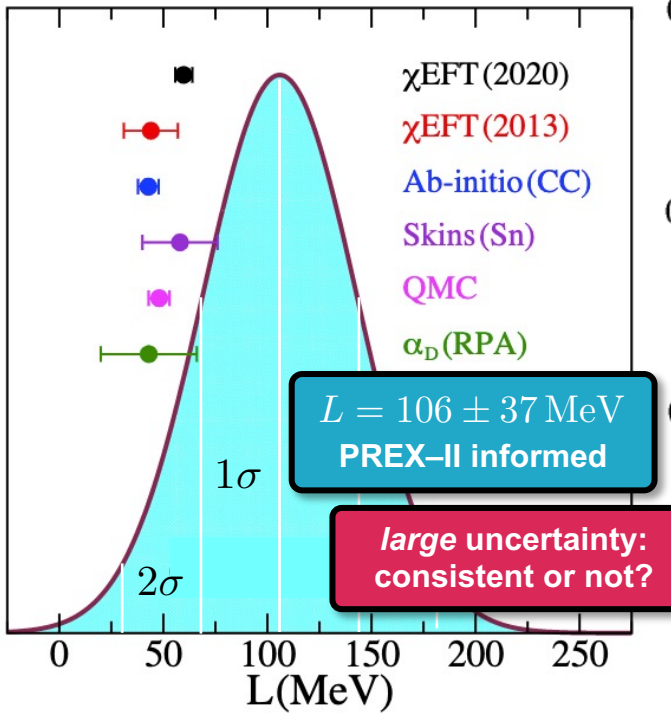
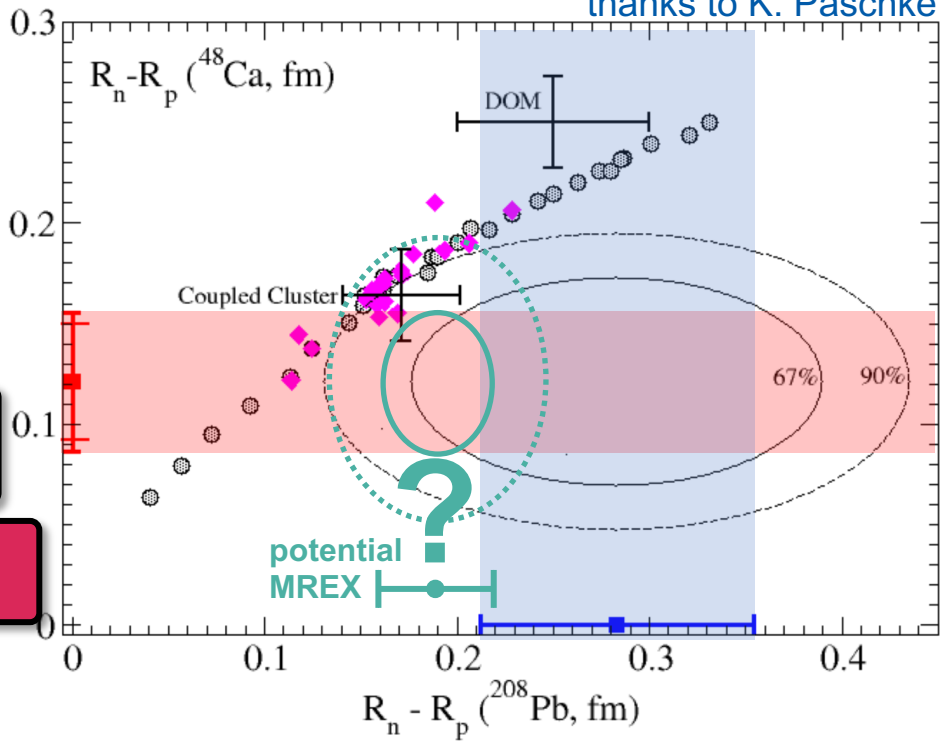
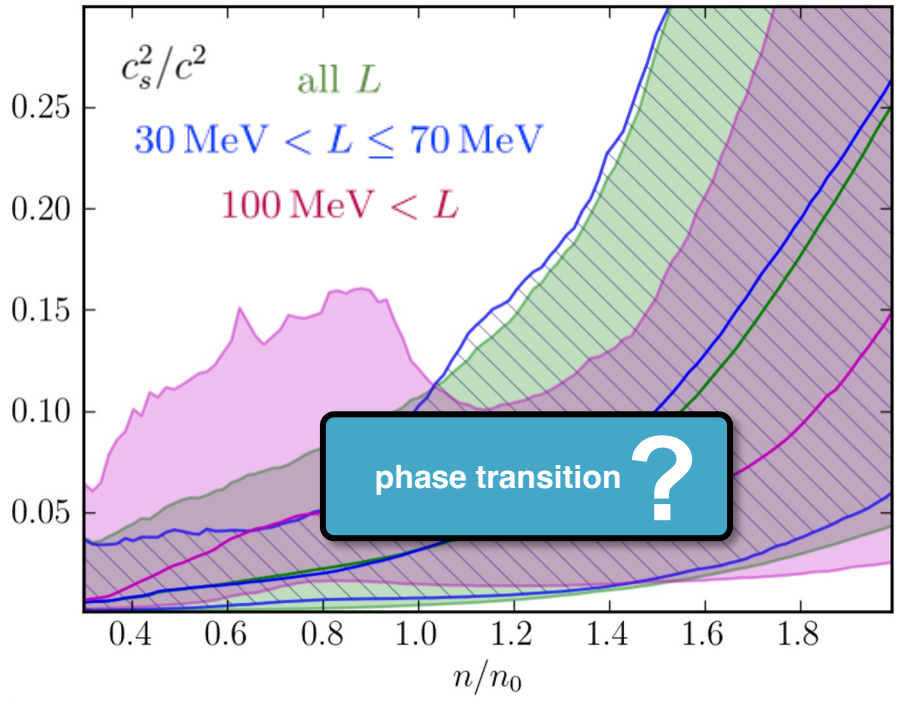
thanks to K. Paschke



large uncertainty: consistent or not?





MREX at the MESA facility (Mainz) will double the precision of PREX-II (≈2030): $R_{skin}(^{208}Pb)$ to ± 0.03 fm uncertainty

» stringent constraint on the neutron-rich matter EOS at n_{sat}

MREX will also provide invaluable data for **calibrating experiments with hadronic probes** at FRIB/FRIB400 and other (future) beam facilities

for MREX, see Thiel, Sfienti *et al.*, J. Phys. G: Nucl. Part. Phys. **46**, 093003

Golden era for neutron-rich matter studies, with *great potential* for discovery:

- neutron star observation (tidal deformabilities, masses, radii, …)
- nuclear experiment (skins, polarizabilities, …)
- nuclear theory (*ab initio* predictions, …)

Careful: **PREX/CREX measured A_{PV} and not the somewhat model-dependent R_{skin} or L**

needs joint efforts and funding