Nuclear Structure & Reaction Theory

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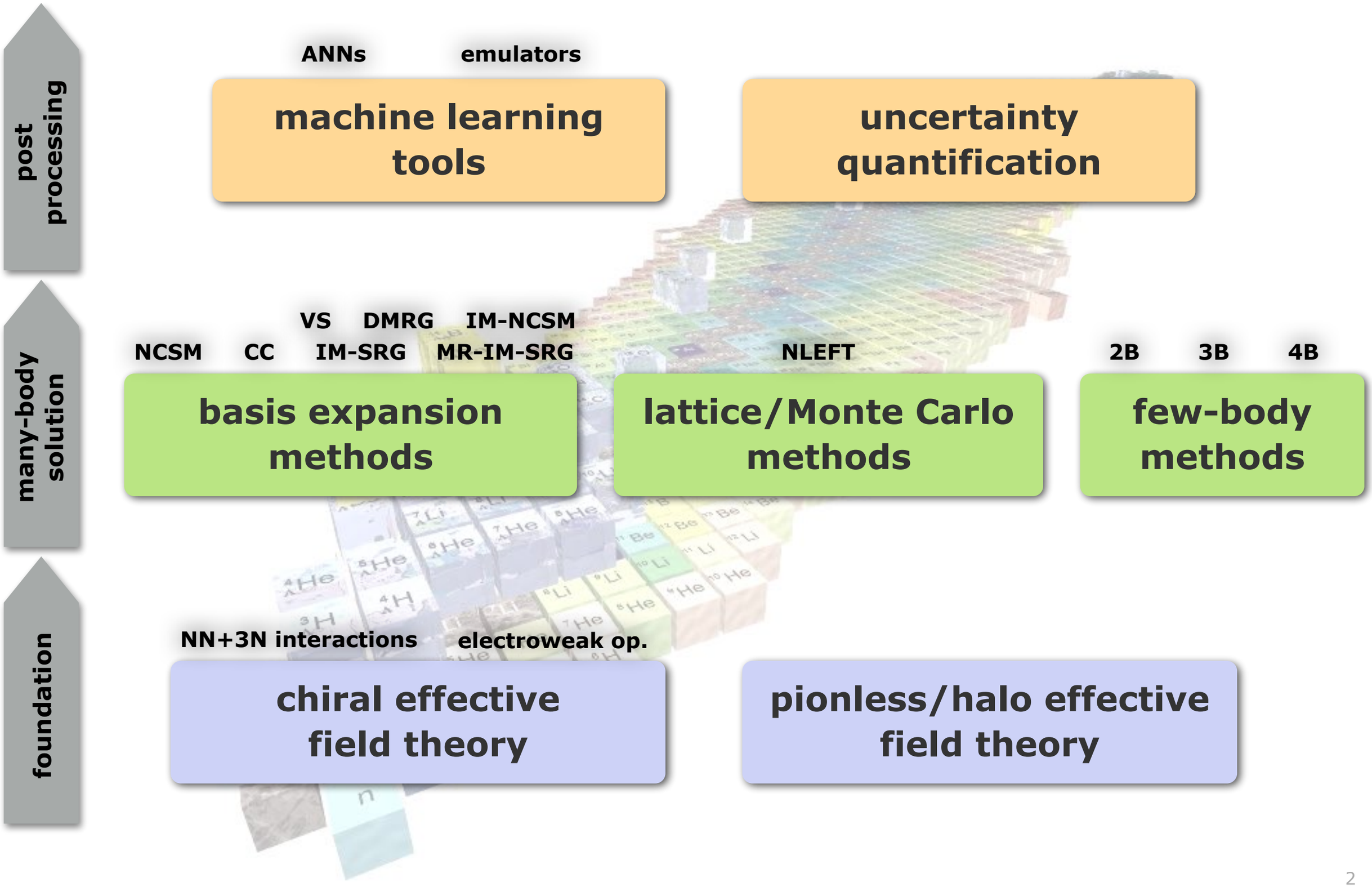


Chiral EFT: Foundations

Bochum

- rigorous proof that finite-cutoff chiral EFT approach to NN scattering is renormalizable in the EFT sense (at least to NLO)

  Gasparyan, Epelbaum, PRC 105 (2022); PRC 107 (2023)

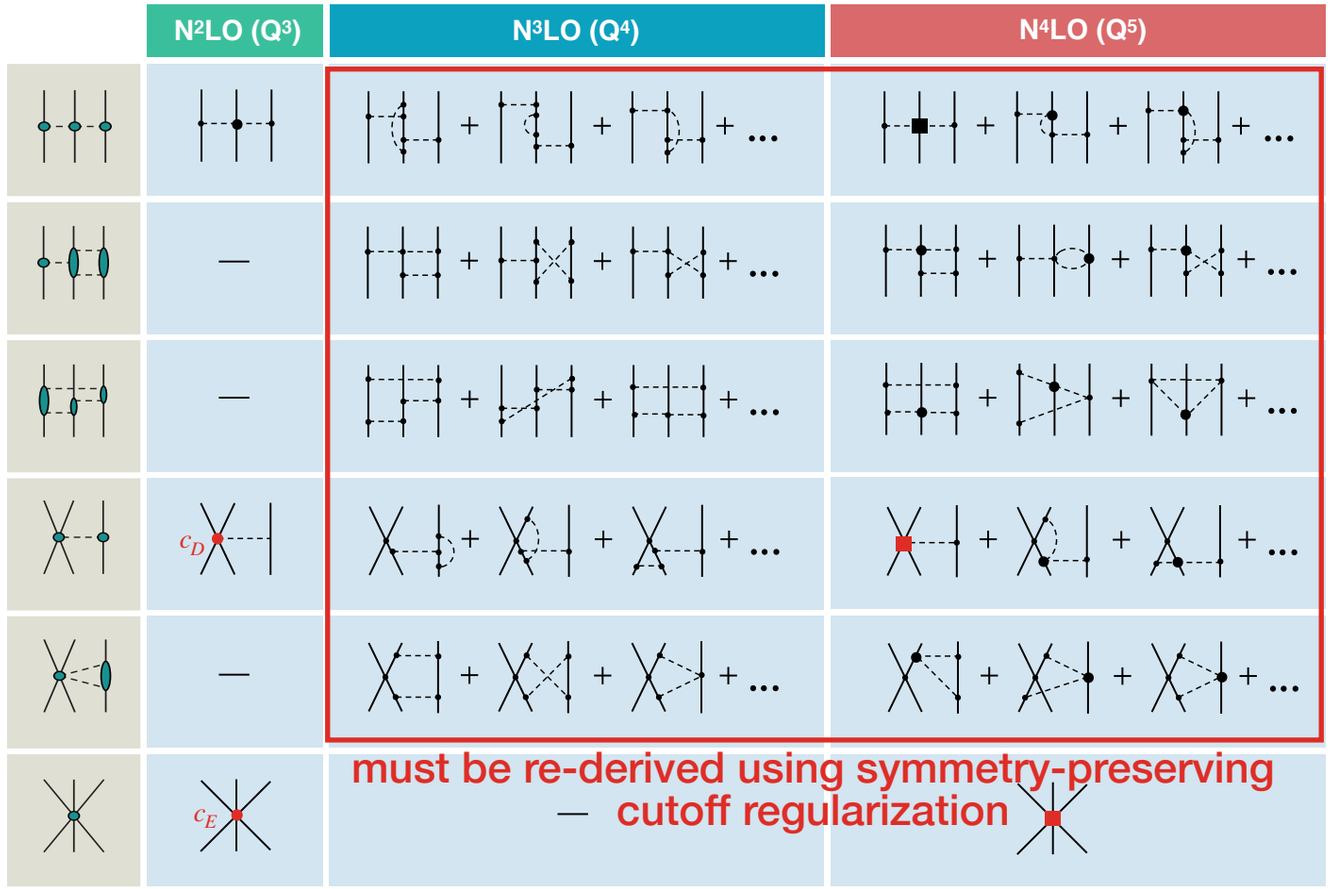
- mixing dimensional (to derive 3N) and cutoff regularization (in the Schrödinger equation) violates chiral symmetry

  ➡ 3N interactions & currents beyond N2LO need to be re-derived

  Epelbaum, Krebs, Reinert arXiv:2206.07072 (2022)

- novel path-integral approach using the gradient flow method

  Epelbaum, Krebs, arXiv:2311.10893 (2023)

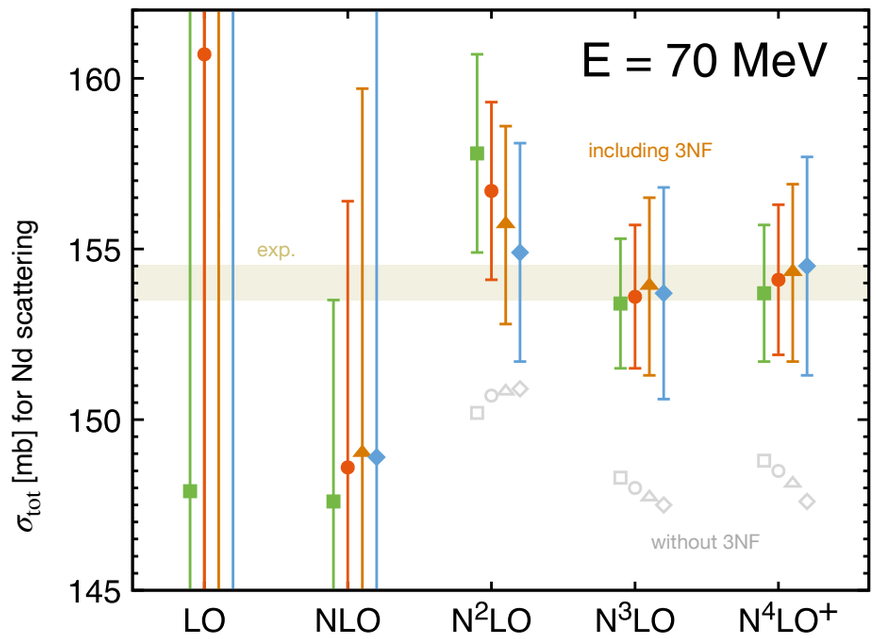


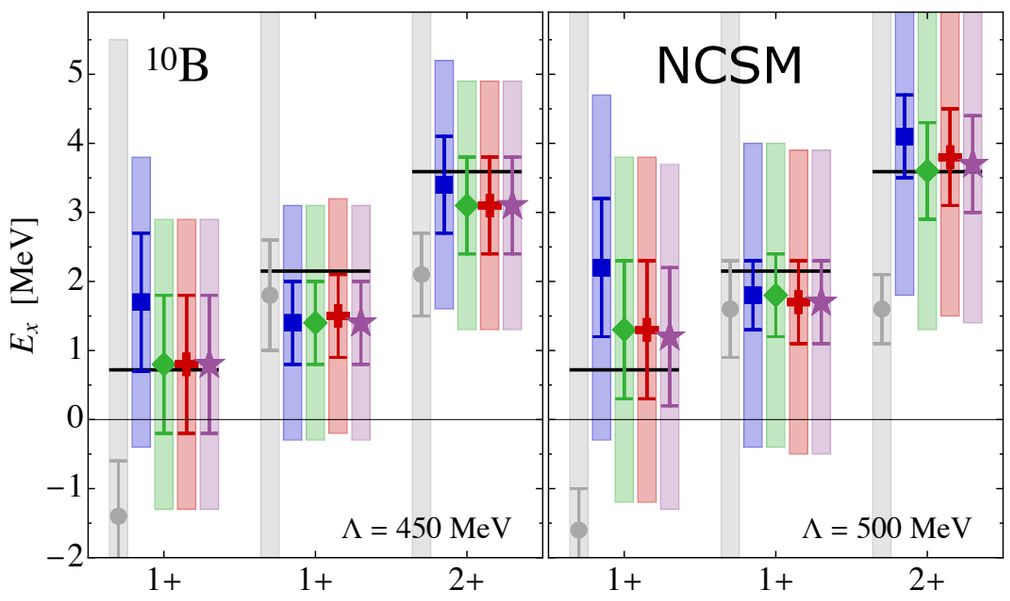
Chiral EFT: Applications

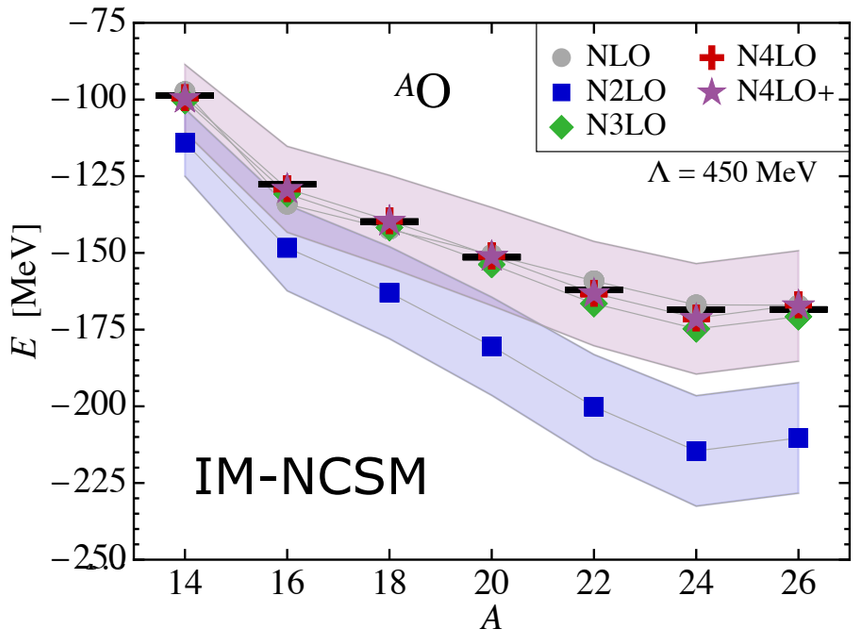
Bochum
Bonn/Jülich
Darmstadt

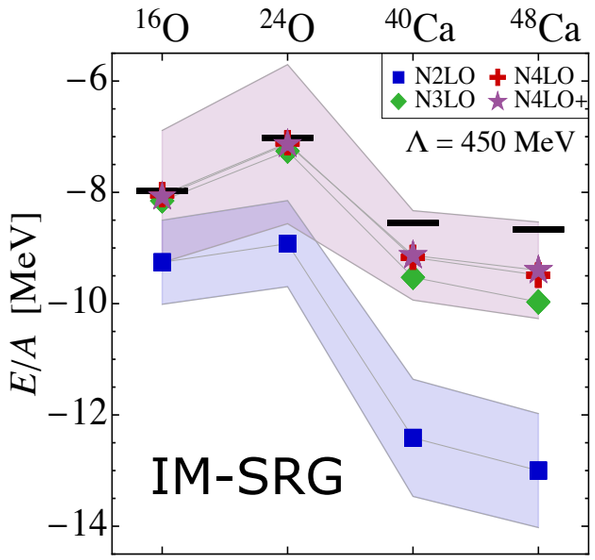
- Low-Energy Nuclear Physics International Collaboration (LENPIC): bringing together chiral EFT developers and many-body practitioners
- semilocal momentum-space regularized chiral interactions: NN up to N4LO+, 3N at N2LO
- application in range of many-body methods: few-body, NCSM, IM-NCSM, and IM-SRG
- correlated Bayesian uncertainty quantification

Maris, Roth, Epelbaum, et al.; PRC 106, 064002 (2022)
Maris, Epelbaum, Furnstahl et al.; PRC 103, 054001 (2021)







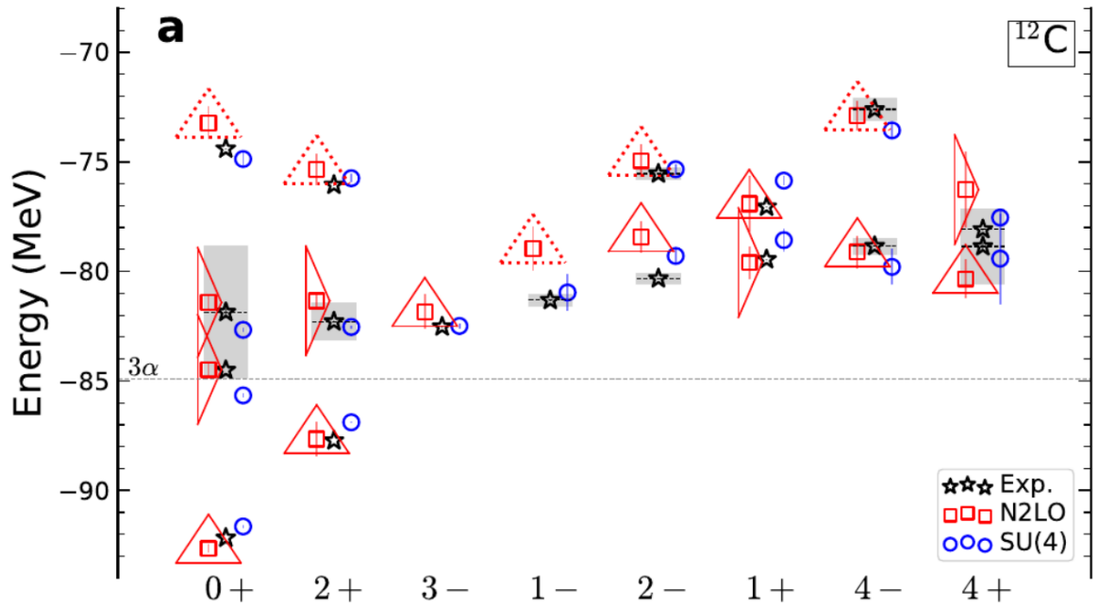


Nuclear Lattice EFT: Applications

Bonn/Jülich Bochum

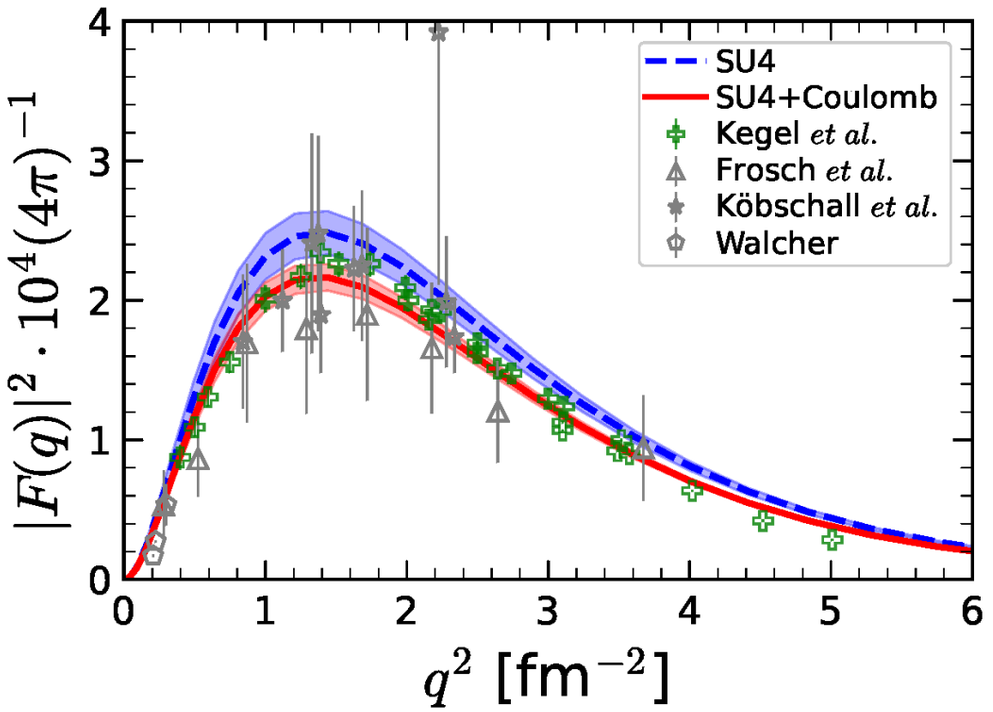
- combining chiral EFT with lattice methods: complementary ab initio avenue
- excitation spectrum of ^{12}C and emergent geometry and duality
- insight into the intrinsic structure of individual state (shell-model/cluster)

Shen et al., Nature Comm. 14, 2777 (2023)



- transition form factor from excited 0^+ to ground state 0^+ in ^{4}He
- 'minimal' nuclear interaction provides correct excitation energy
- excellent description of MAMI data

Meißner et al., arXiv:2309.01558 (2023)

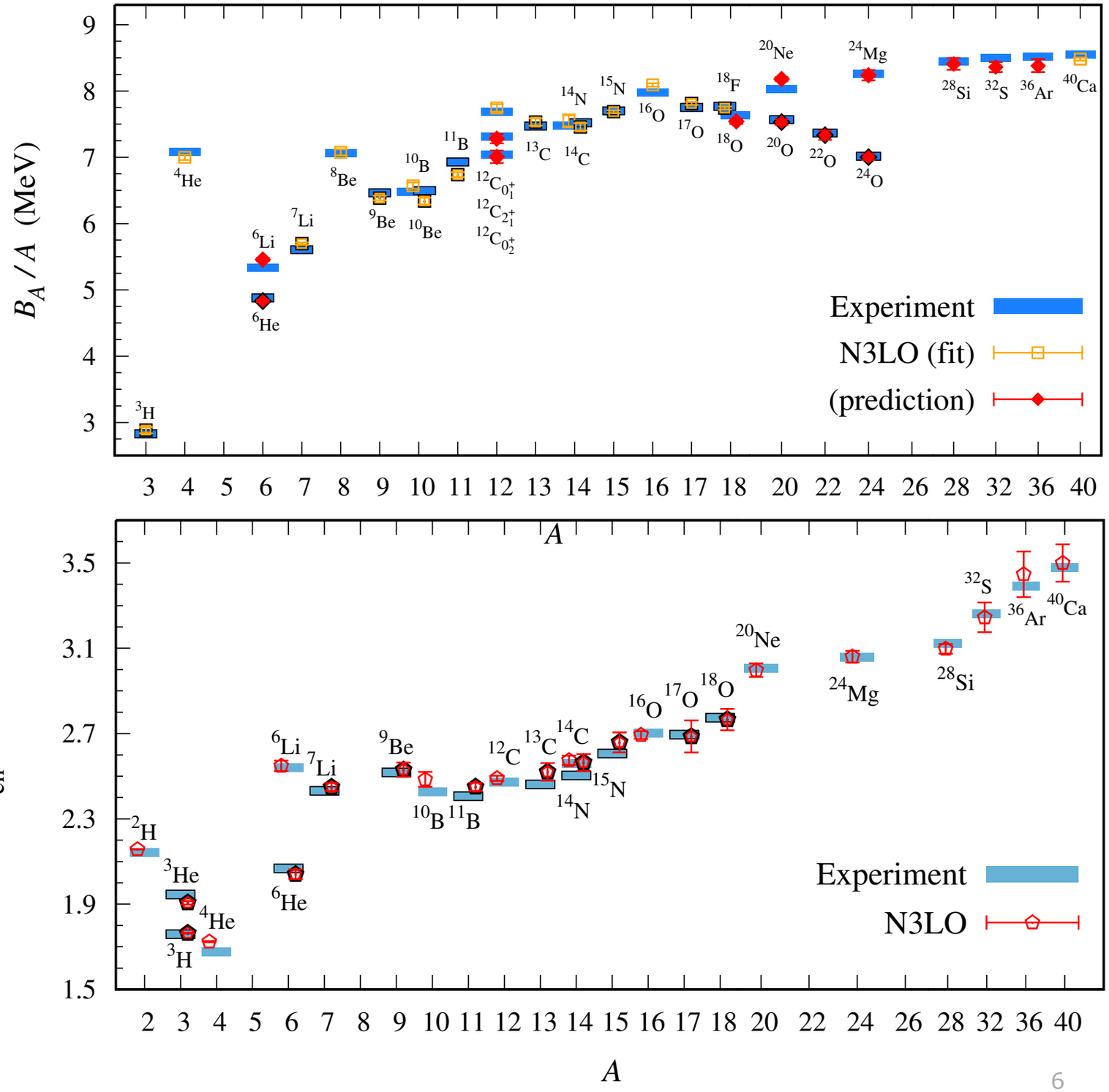


Nuclear Lattice EFT: Extensions

Bonn/Jülich Bochum

- extension to larger nuclei: sign problem gets severe
- wave function matching: map short-range wave function to that of easily computable problem → tame sign problem
- fit 3N interaction to set of energies from A=3 to 40
- ground-state energies and charge radii very well reproduced

Elhatisari et al., arXiv:2210.17488 (2022)



Valence-Space In-Medium SRG

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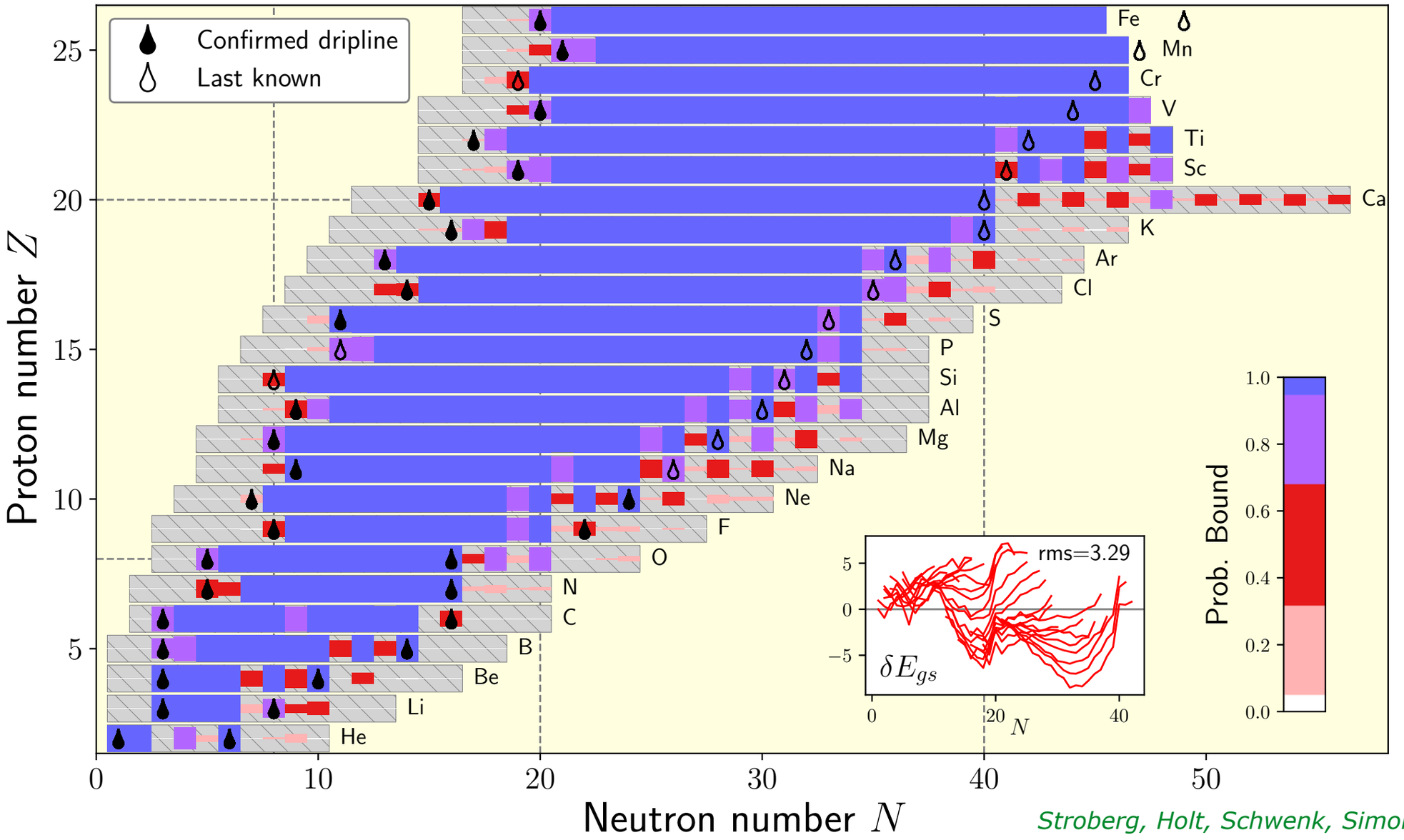
- in-medium SRG as a tool to derive Hamiltonians for valence-space shell model in ab initio spirit using the same chiral EFT inputs
- ab initio is advancing to global theories, limited by input NN+3N interactions



Stroberg, Holt, Schwenk, Simonis, PRL (2021)

Electroweak Observables

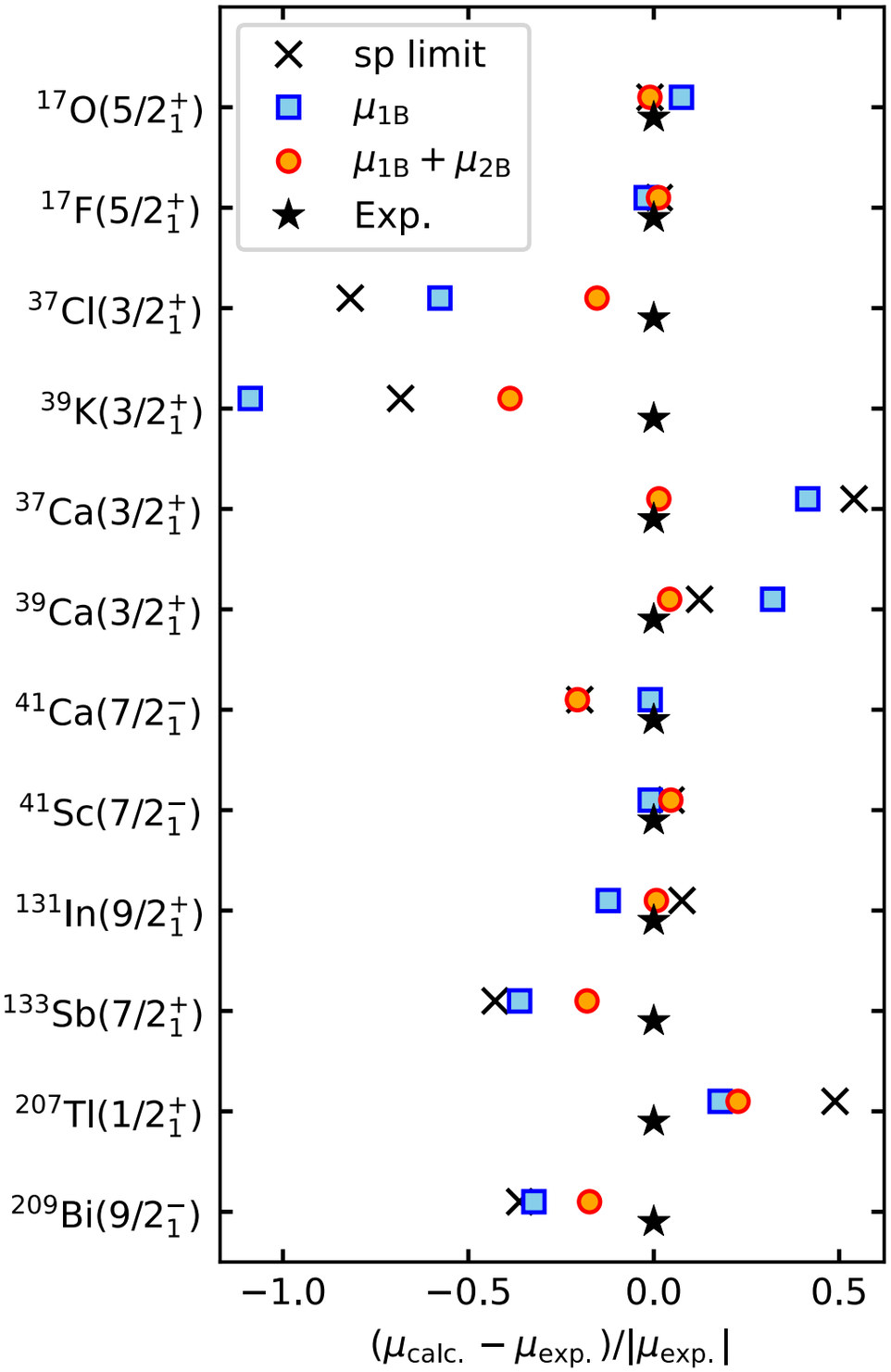
Darmstadt Mainz

- electroweak operators from chiral EFT with two-body current contributions
- successful applications to quenching of Gamow-Teller matrix element in ^{100}Sn

  Gysbers et al., Nature Phys. (2019)
- magnetic dipole moments of selected odd-A nuclei in valence-space IM-SRG
- inclusion of two-body currents always improves agreement with experiment

  Miyagi et al.; arXiv:2311.14383 (2023)
- similarly: precision NCSM study of M1 observables for ^{6}Li

  Friman-Gayer et al.; PRL 126, 102501 (2021)



Valence-Space DMRG

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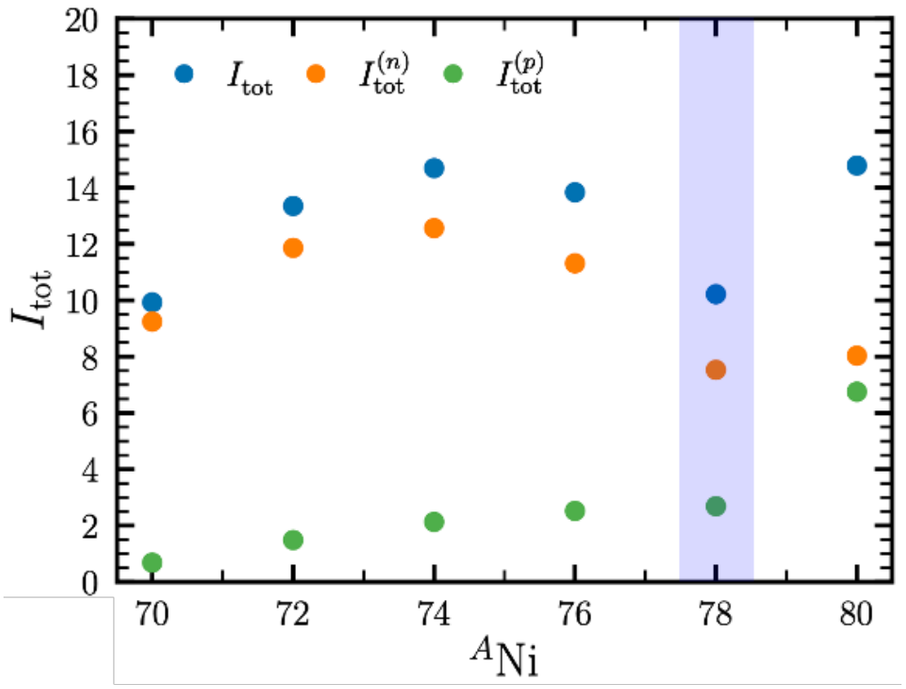
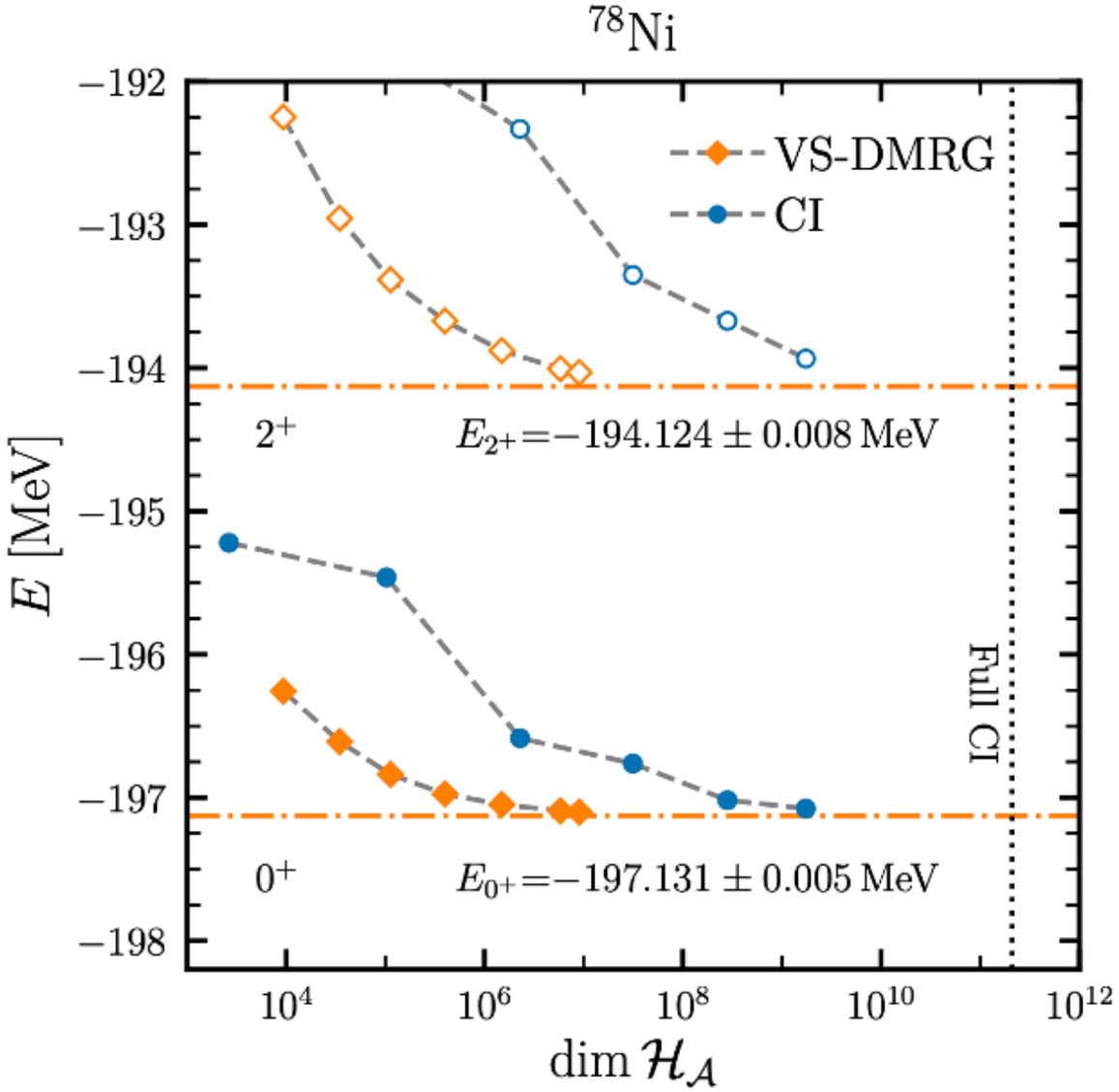
- replace diagonalization in a valence-space shell model setting with density matrix renormalization group

- efficiently sample correlations and reduce model space dimension by factor ~100

Tichai et al., PLB 845, 138139 (2023)





- information entropy as useful diagnostic for shell structure

Coupled Cluster

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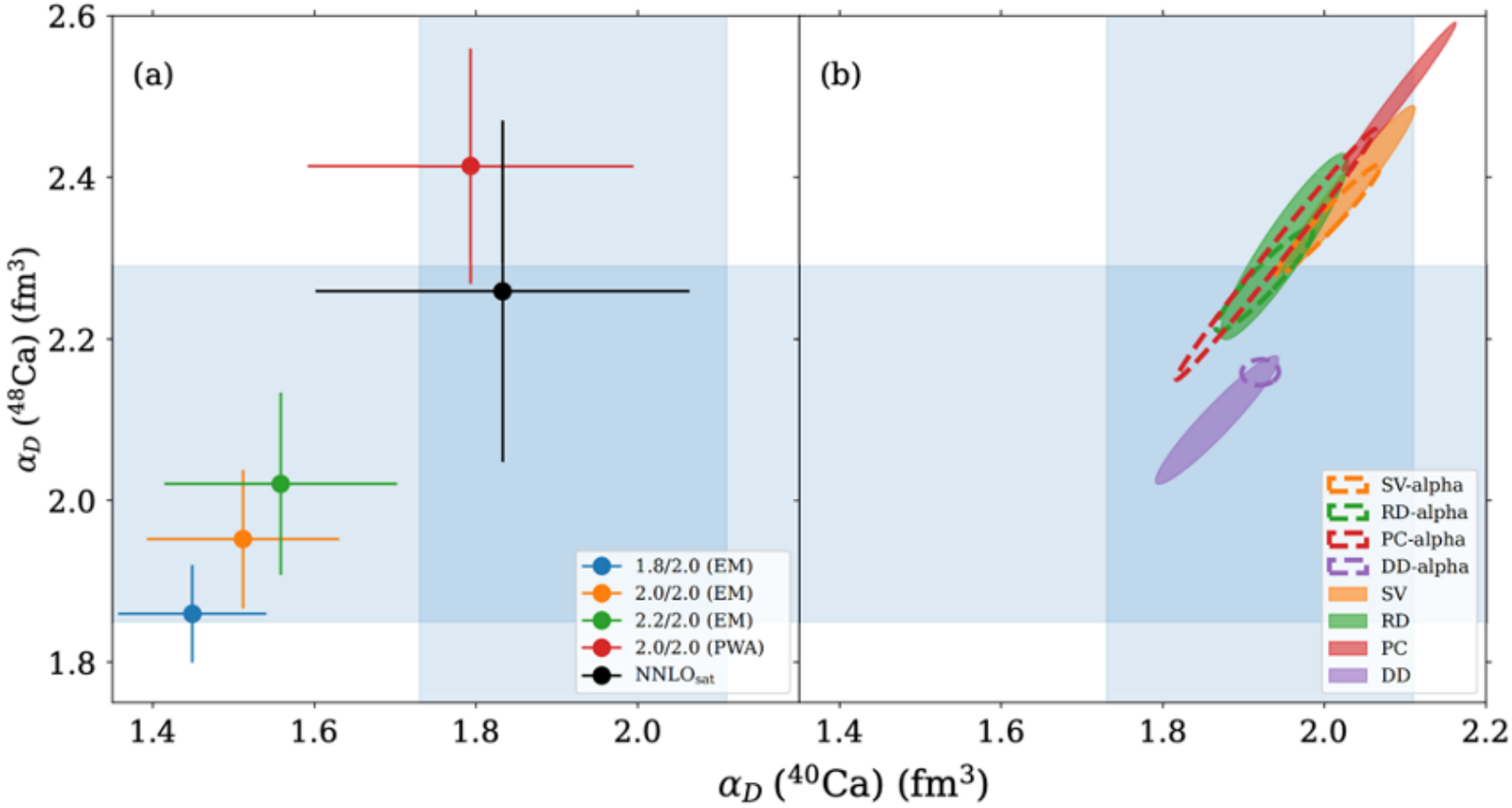
- coupled cluster theory combined with Lorentz integral transform method to address collective response in nuclei
- ab initio calculation of dipole polarizability in Ca isotopes for constraining EOS

Fearick et al.; Phys. Rev. Research 5, L022044 (2023)

- new development: spectral function from coupled cluster theory for describing electron- and neutrino-nucleus scattering cross sections

Sobczyk, Bacca; arXiv:2309.00355 (2023)



In-Medium No-Core Shell Model

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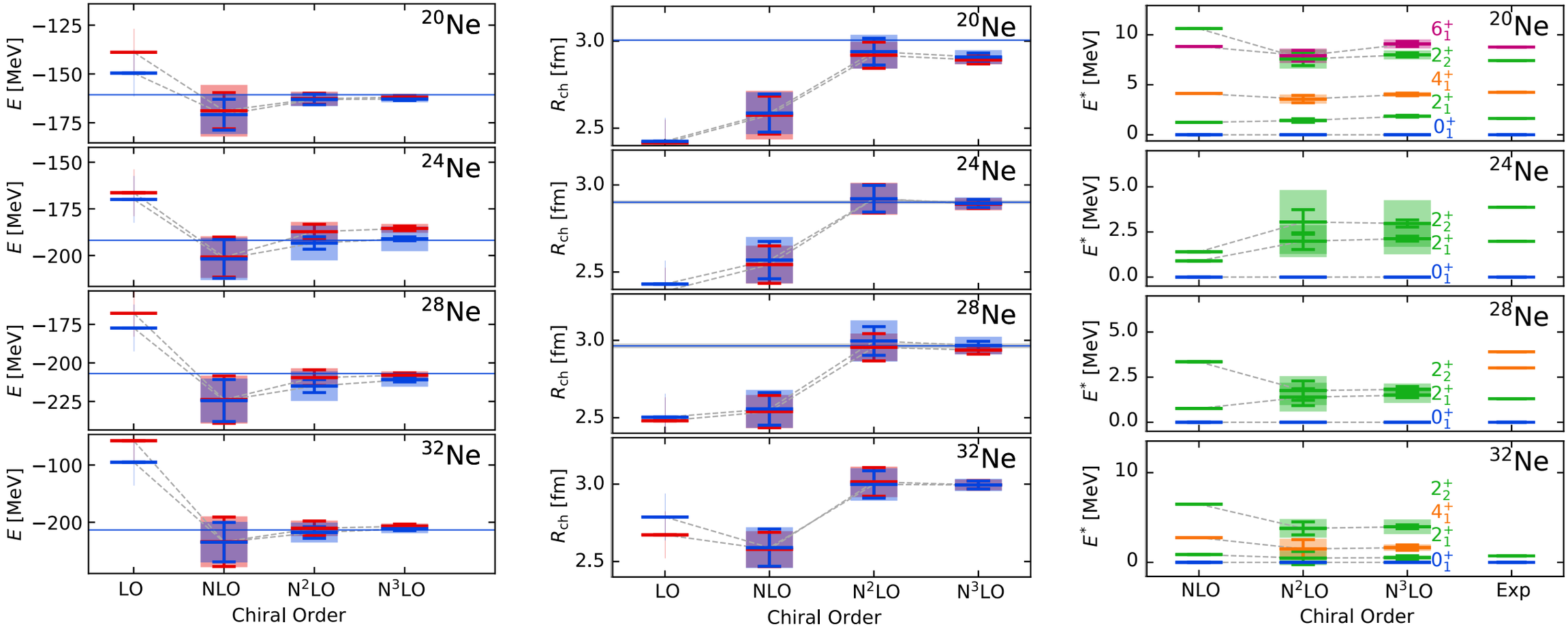
- multi-reference in-medium SRG as a tool accelerate NCSM convergence
- decoupling of NCSM model space high-lying states, development of more general active-space scheme in progress
- study of Ne isotopes with nonlocal chiral NN+3N interaction up to N3LO

Frosini et al.; EPJA 58, 63 (2022); EPJA 58, 64 (2022)



Hypernuclear No-Core Shell Model

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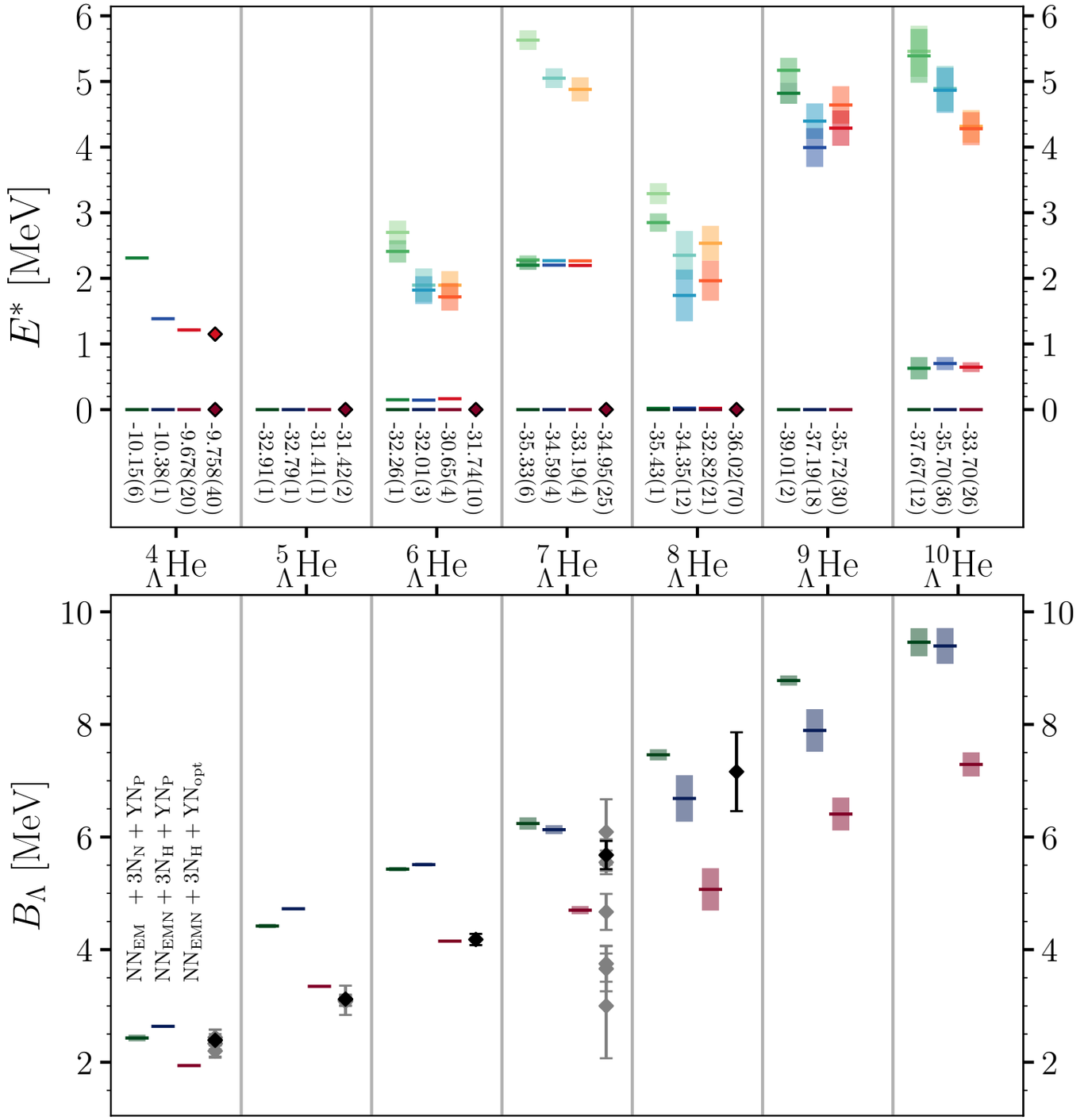
- structure of light hypernuclei in NCSM with full inclusion of Λ and Σ degrees of freedom in model space and Hamiltonian
- Λ-Σ conversion plays critical role
- optimization of the chiral YN interaction using selected p-shell energy levels
- prediction of binding energies and spectra towards neutron-rich hypernuclei

  Knöll, Roth; PLB 846, 138258 (2023)
- artificial neural networks for prediction of converged energies and many-body uncertainties



NCSM plus Neural Networks

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- train neural network to predict the converged values of an observable (energy, radius,...) based on sets of non-converged NCSM sequences

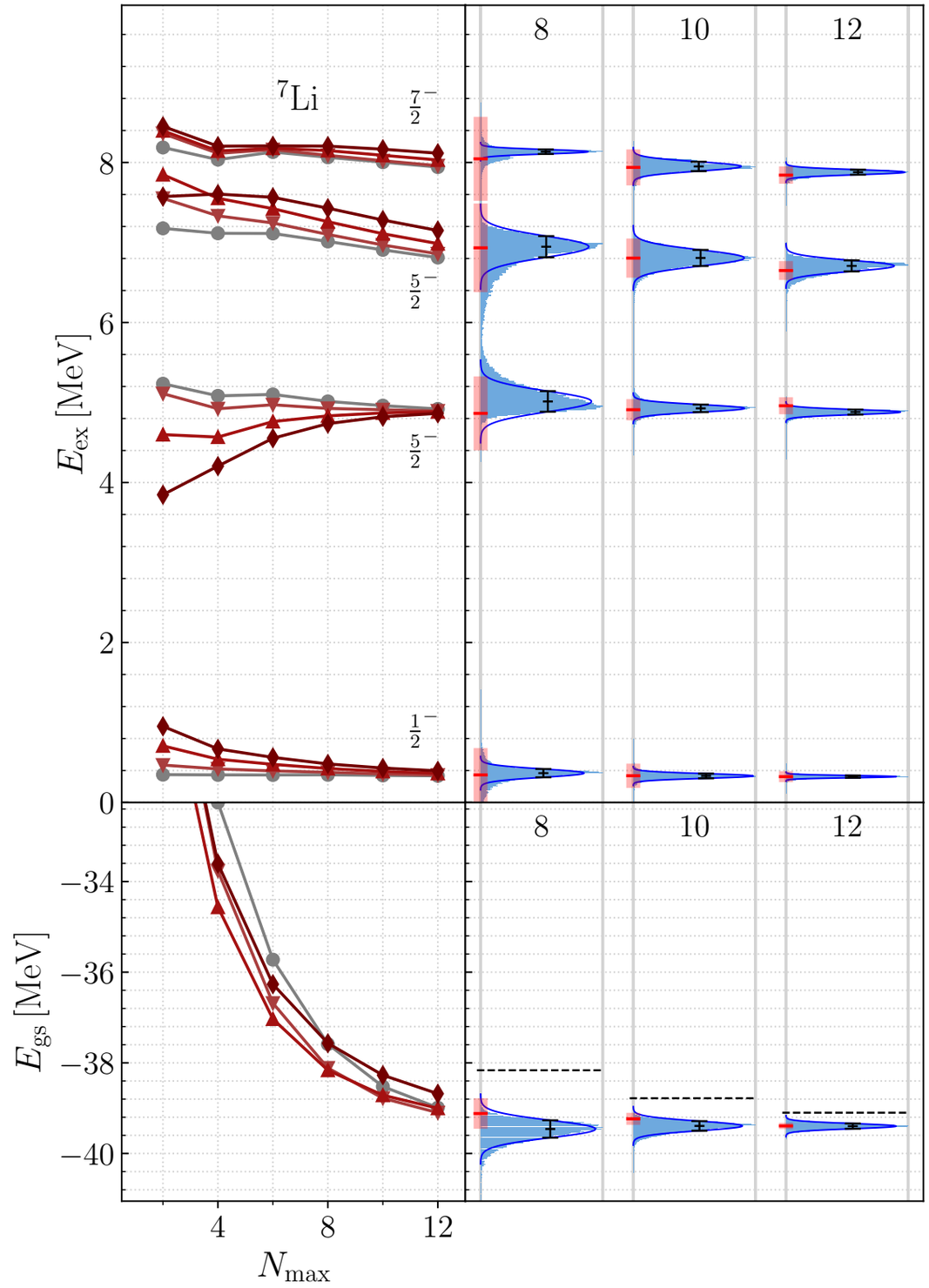
  Knöll, et al; PLB 839, 137781 (2023)

- large set of training data from NCSM calculations with NN+3N interactions of A<=4 nuclei, where converged values are accessible

- train many network realizations to enable statistical evaluation: predictions with uncertainties

- successfully applied to ground-state and excitation energies and radii

  Wolfgruber, Knöll, Roth; arXiv:2310.05256 (2023)



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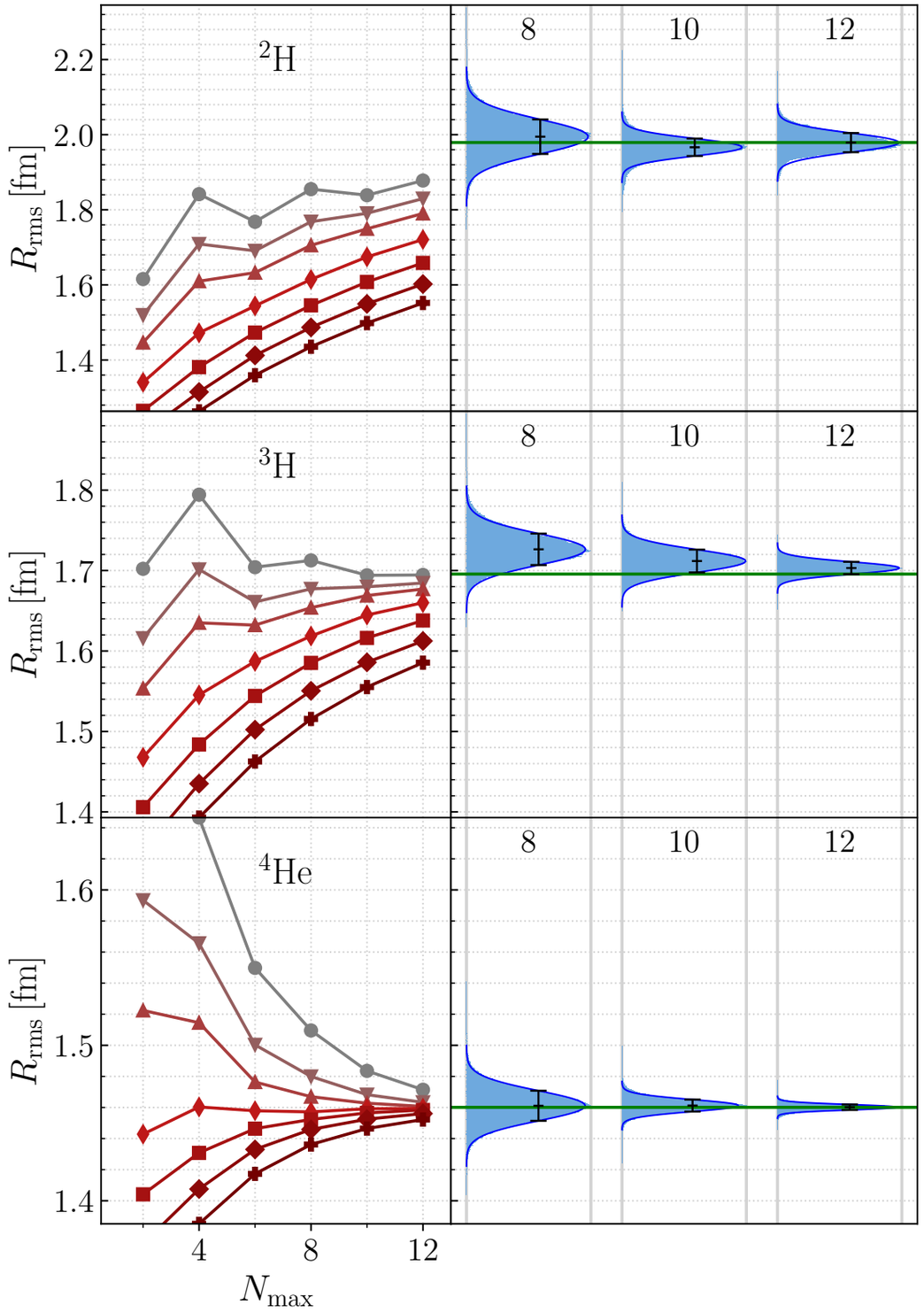


Weak Decays in Halo/Pionless EFT

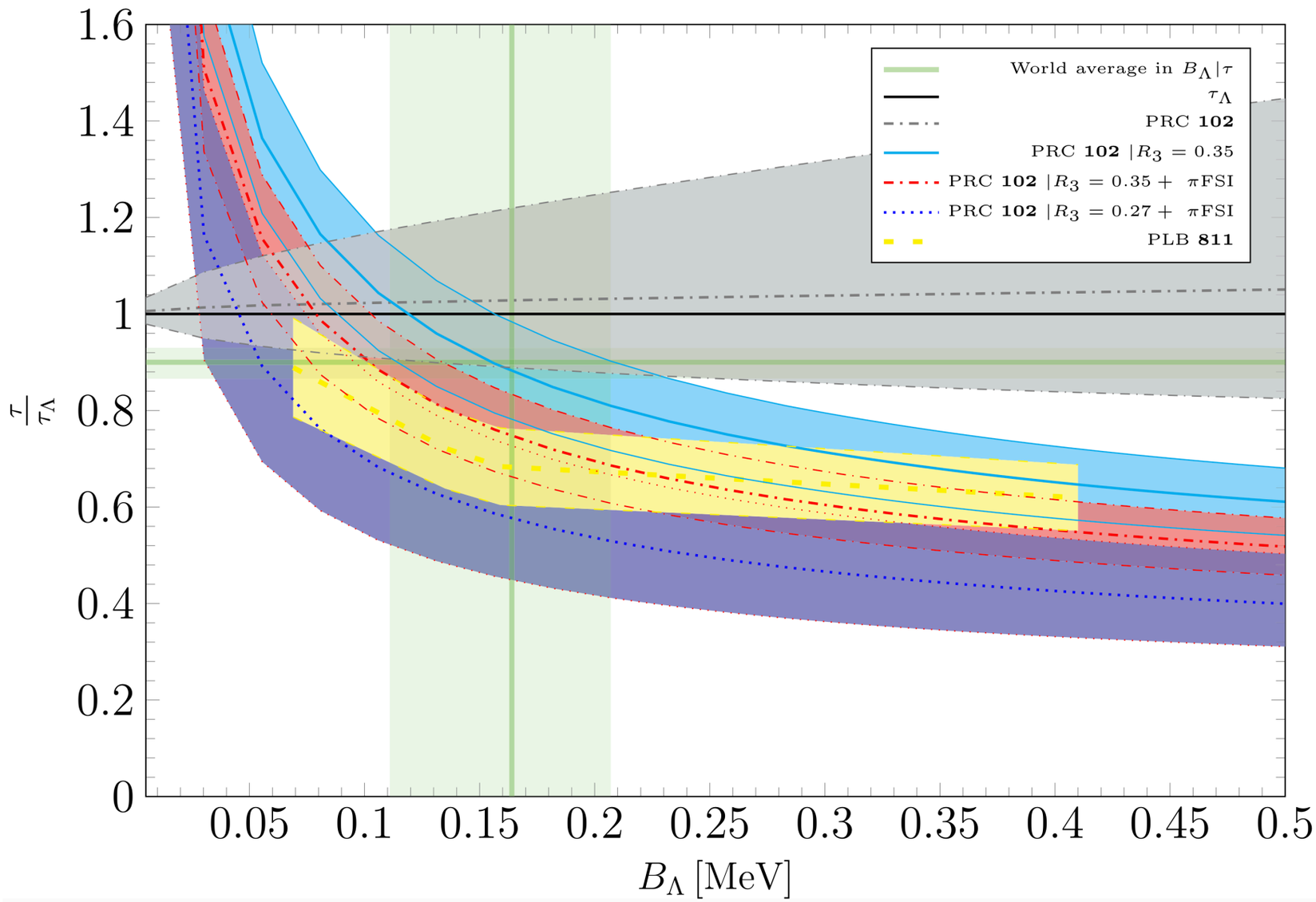
Darmstadt

- weak decay of one-neutron halo nuclei, particularly ^{11}Be, using Halo EFT

  Elkamhawy et al., PRC 108, 015501 (2023)

- prediction of hypertriton lifetime including pionic final state interactions in pionless EFT

  Hildenbrand, Hammer, EPJA 59, 280 (2023)



Next Generation

- TALENT School on Few-Body Physics in Mainz (2022)
- student project: re-analysis of Coulomb breakup data of ^{19}C using halo EFT and simple reaction model

Eur. Phys. J. A (2023) 59:273
https://doi.org/10.1140/epja/s10050-023-01181-7

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Regular Article - Theoretical Physics

Effective field theory analysis of the Coulomb breakup of the one-neutron halo nucleus ^{19}C

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