Improving Skyrme energy density functionals with chiral effective field theory
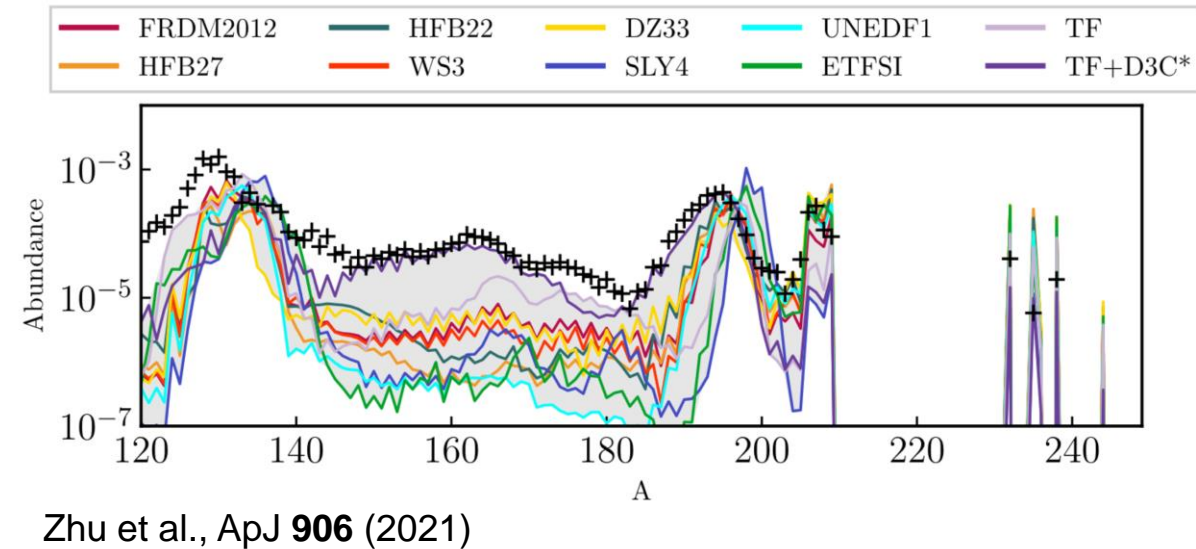
Lars Zurek

March 2, 2023

Bundesministerium
für Bildung
und Forschung

Energy density functionals

- Successful reproduction of experimental results

  - Even-even binding energy rms deviation for UNEDF2: 1.95 MeV

- Favorable computational scaling

- Phenomenological construction

  - Extrapolation outside fitting region uncontrolled

Zhu et al., ApJ **906** (2021)

Energy density functionals

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- Have standard EDFs reached their accuracy limit?   McDonnell et al., PRL **114** (2015)

Ab initio calculations with chiral EFT

- Systematically improvable

  - Uncertainty estimates "built-in"

- Computationally more expensive

→ (How) can EDFs profit from the ab initio approach?

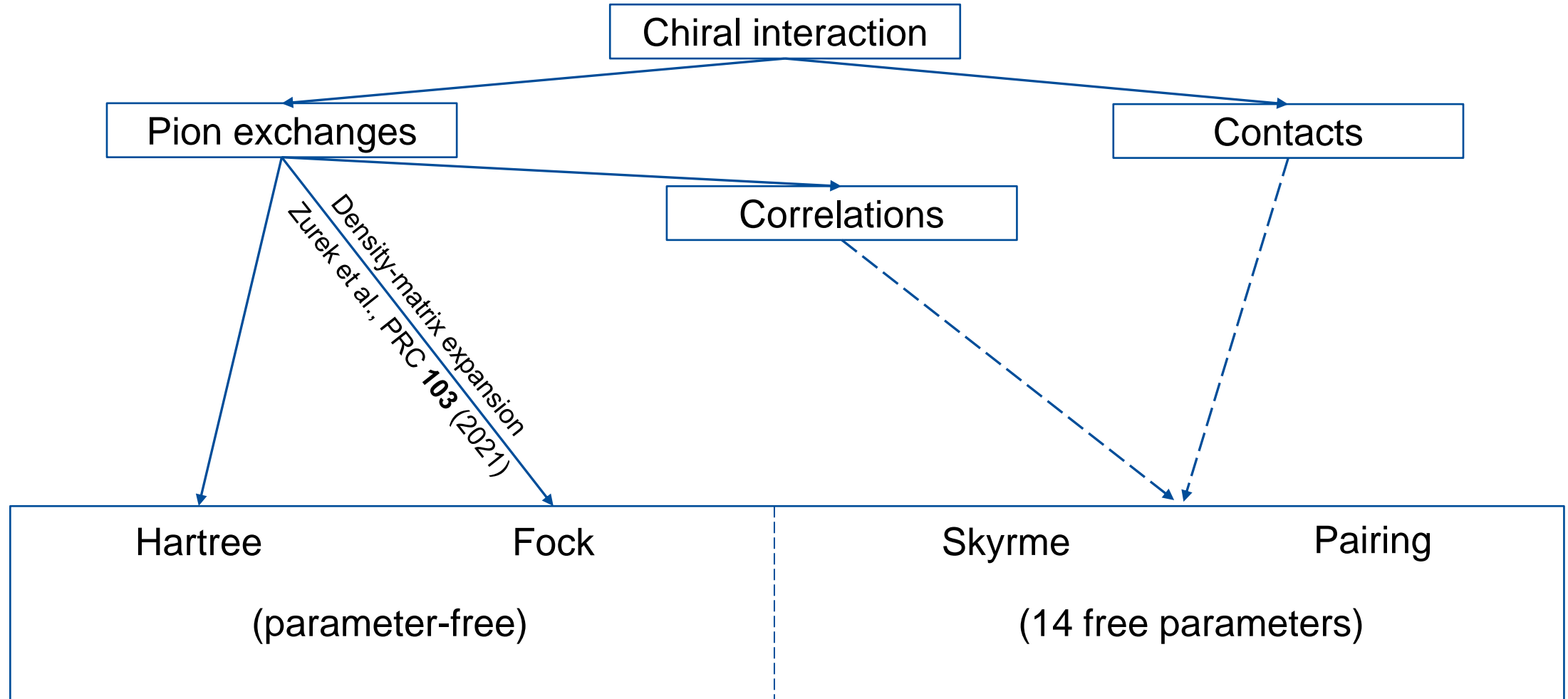Salvioni et al., JPG **47** (2020)
Furnstahl, EPJA **56** (2020)
Marino et al., PRC **104** (2021)
Duguet et al., EPJA **59** (2023)

Semi-phenomenological hybrid EDFs

Stoitsov et al., PRC **82** (2010); Navarro Pérez et al., PRC **97** (2018)
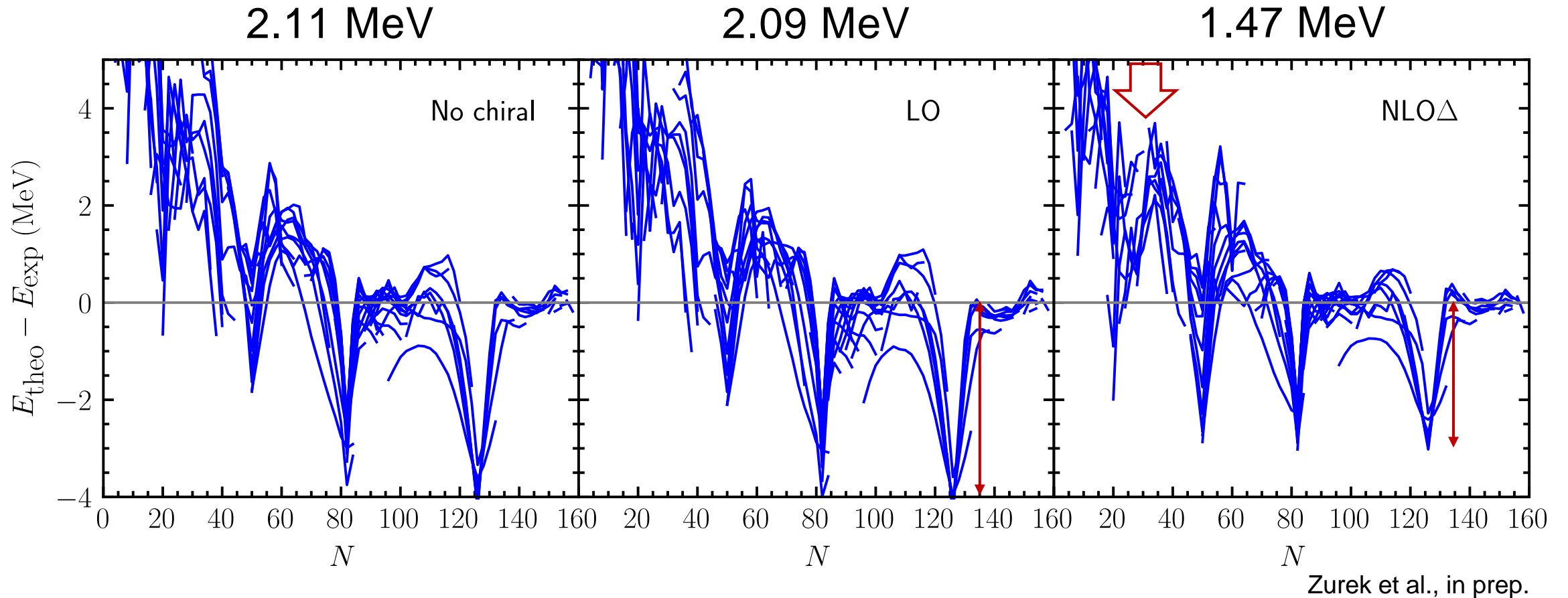
Semi-phenomenological hybrid EDFs

- Skyrme + HF long-range pions

  - At different chiral orders up to N²LO, with and without Δs and 3N forces

  → Fit Skyrme parameters to 81 nuclei

  - Constrain nuclear matter properties to physically plausible region

Results: global comparison to experiment

- Root-mean square deviations to experiment for even-even nuclei with Z>7:

Zurek et al., in prep.

Poster

- EDF parameter optimization

- More results

- Which terms are driving improvements?

- …

Thanks for your attention

and to my collaborators
Scott Bogner, Dick Furnstahl, Rodrigo Navarro Pérez,
Nicolas Schunck, and Achim Schwenk