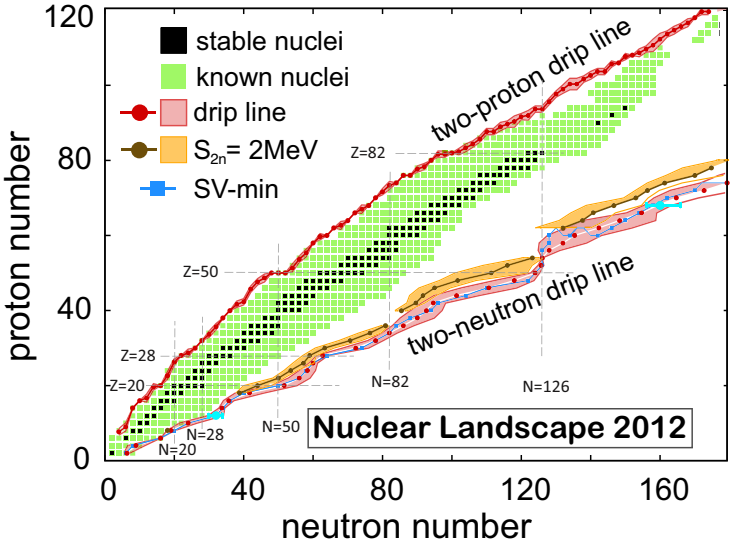
How Many Neutrons and Protons Can Get Along? Nuclear Density Functional Theory calculations on JAGUAR map the nuclear landscape

Objectives

- Use the state-of-the-art nuclear density functional theory, coupled with state-of-the-art computational tools, to estimate the borders of the nuclear landscape and elucidate its properties
- Quantify statistical and systematic uncertainties of theoretical predictions
- Estimate the number of nuclei that can exist in nature

Impact

- Enable rigorous data-driven predictive modeling in complex physical systems, supported by:
  - inference and calibration from experimental data
  - model selection and learning of model structure
  - validation and verification of model-based extrapolations
- Guidance for the radioactive beam facilities worldwide
- Provide benchmark for planned experiments and future model developments



Map of bound even-even nuclei as a function of the proton number Z and the neutron number N. There are 767 even-even isotopes known experimentally: both stable (black squares) and radioactive (green squares). Mean drip lines and their uncertainties (red) were obtained by averaging the results of different models. The two-neutron drip line of SV-min (blue) is shown together with the statistical uncertainties at Z=12 and 68 (blue error bars). The S_{2n}=2 MeV line is also shown (brown) together with its systematic uncertainty (orange).

Accomplishments

1. By using several models, theorists were able for the first time to quantify uncertainties of predicted borders of the nuclear existence.
2. Model extrapolations turned out to be unexpectedly consistent between the current effective interactions, leading the team to estimate that the number of bound nuclei with Z between 2 and 120 is around 7,000.

U.S. DEPARTMENT OF ENERGY | Office of Science

NUCLEI Nuclear Computational Low-Energy Initiative

Reference: J. Erler et al., Nature **486**, 509 (2012)

Contact: W. Nazarewicz, witek@utk.edu
M. Kortelainen, markus.kortelainen@jyu.fi