Machine learning & low-energy nuclear theory: Why?

ML tools can help us to speed up the scientific method cycle and hence facilitate discoveries

- Enabling fast emulation for big simulations
- Revealing the information content of measured observables
- Identifying crucial experimental data for better constraining theory
- Providing meaningful input to applications and planned measurements

ML tools can help us to reveal the structure of our models

- Parameter estimation with heterogeneous/multi-scale datasets
- Model reduction

ML tools can help us to provide predictive capability

- No predictive capability without uncertainty quantification
- Theoretical results often involve ultraviolet and infrared extrapolations due to Hilbert-space truncations
- Theoretical models are often applied to entirely new nuclear systems and conditions that are not accessible to experiment

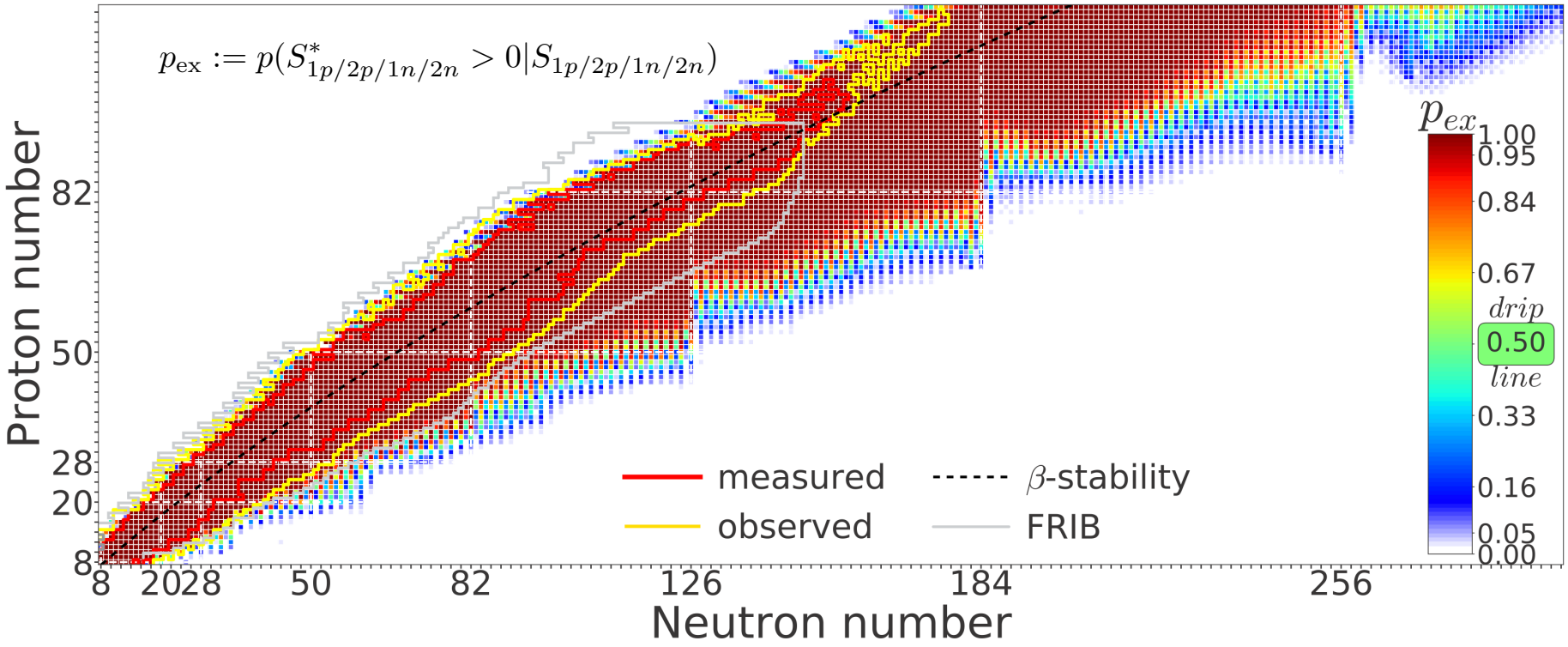
Experimental design: the future!

- Bayesian ML provides a framework to maximize the success of on experiment based on the best information available on existing data, experimental conditions, and theoretical models

Example 1: Quantified limits of the nuclear landscape

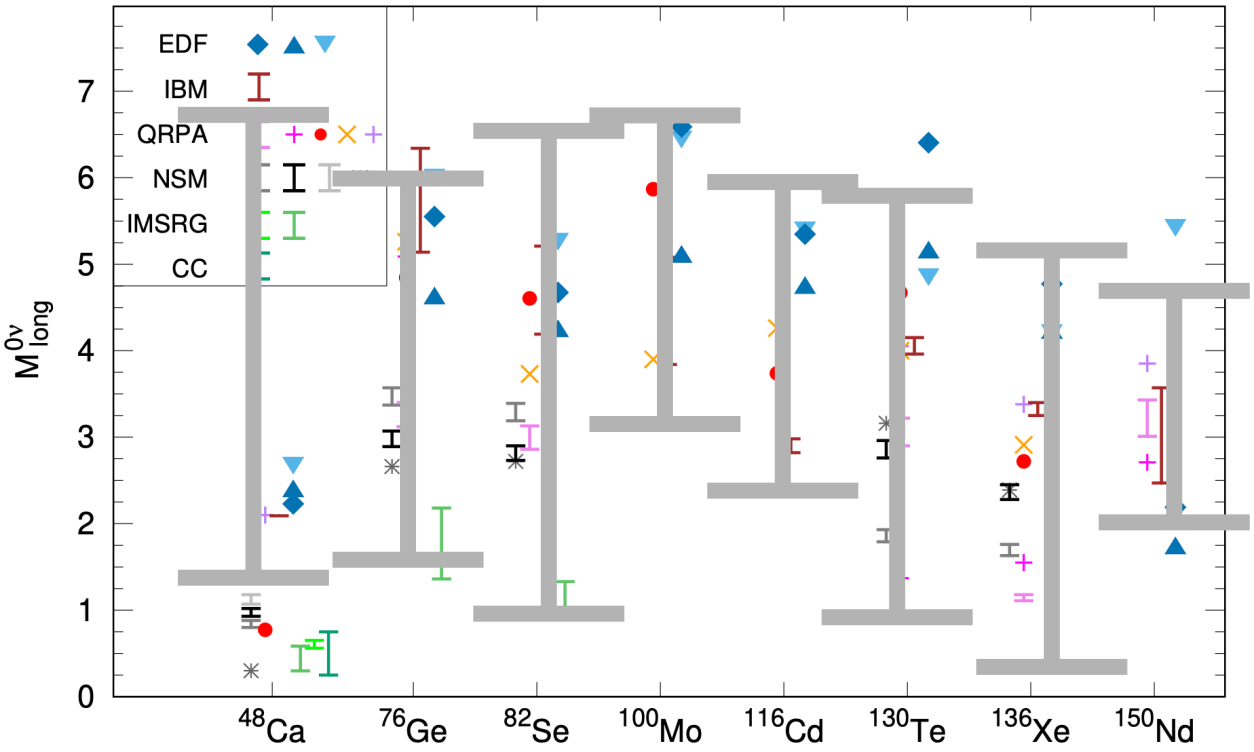
Neufcourt et al., Phys. Rev. C 101, 044307 (2020)

- Predictions (made with 11 global mass model and Bayesian Model Averaging)
- Inform future existence experiments



Eliminating “a … contest in which the main concern of the parties involved is the conspicuous demonstration of superiority”

Example 2: 0νββ predictions



"There is generally significant variation among different calculations of the nuclear matrix elements for a given isotope. For consideration of future experiments and their projected sensitivity it would be very desirable to reduce the uncertainty in these nuclear matrix elements." (Neutrinoless Double Beta Decay NSAC Report 2014)

Cirigliano et al. arXiv:2207.01085, J. Phys. G, in press

- Low-resolution and high-resolution models
- Fitted to vastly different observables
- Explore the collective wisdom of different models

BAND
Bayesian Analysis of Nuclear Dynamics