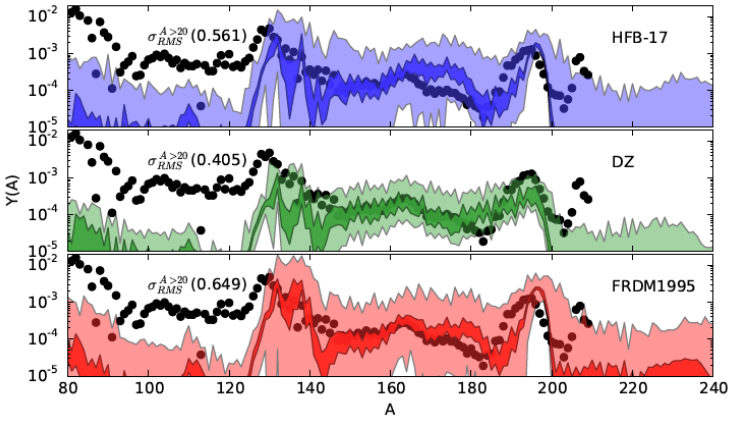
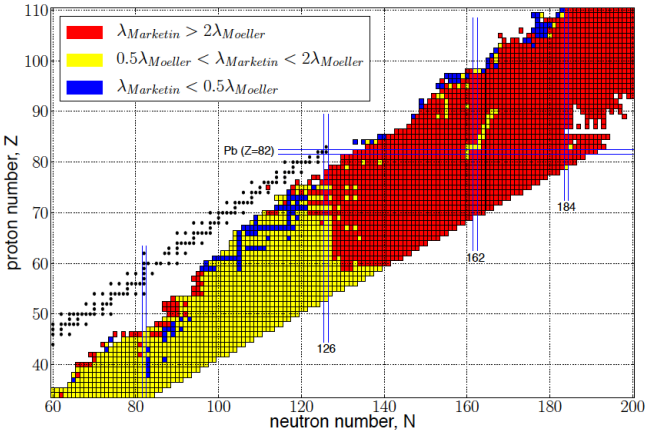
Nuclear Theory for Nuclear Astrophysics

Developing theory framework for tracking the evolution of an r-process:

- Identifying critical input from nuclear theory
- Quantifying the impact of nuclear input
- Propagation of uncertainties from nuclear structure models



M.R. Mumpower et al., PPNP 86, 86 (2016).



M. Eichler et al., ApJ 808, 1 (2015).

Providing all relevant nuclear quantities for multidimensional supernova simulations

- Due to lack of systematic nuclear input from microscopic theory, even today the old Bruenn weak interaction rates (1985) are sometimes used in supernova simulations.

Development of a unified theoretical framework to supply all astrophysically relevant nuclear input:

- Use of a unique effective interaction increases self-consistency and reliability of r-process and supernova simulations

- Consistent evaluation of nuclear properties (binding energies, decay properties, neutron capture rates, neutrino-nucleus reactions, spontaneous and induced fission, electron capture)
- Unified framework allows easier extensions of the model (e.g., deformations, second QRPA, etc.)
- Increased consistency between supernova simulations and heavy element nucleosynthesis modeling
- Easier evaluation of error propagation, allows us to estimate critical aspects of nuclear structure models to focus on
- Quantification of theoretical uncertainties in nuclear properties, error propagation in astrophysical simulations allows us to estimate critical aspects of nuclear structure models to focus on

Impact of astrophysical conditions on nuclear properties:

- Effects of finite temperature and density of the medium in which nuclei are found
- Exotic nuclear modes of excitation and their role in astrophysics, reactions to and from excited states

Perspectives of nuclear energy density functionals – potential to provide a unified description of relevant nuclear theory for nuclear astrophysics and neutron star properties

- Estimates of statistical (using covariance analysis) and systematic uncertainties of any calculated quantity, identification of relevant correlations
- Connecting nuclear observables with nuclear matter and neutron star properties

Perspectives of ab-initio approaches (e.g., based on NN and NNN interactions derived from the EFT) to nuclear theory for nuclear astrophysics