# Nuclei in a relativistic framework: at and beyond density functional theory

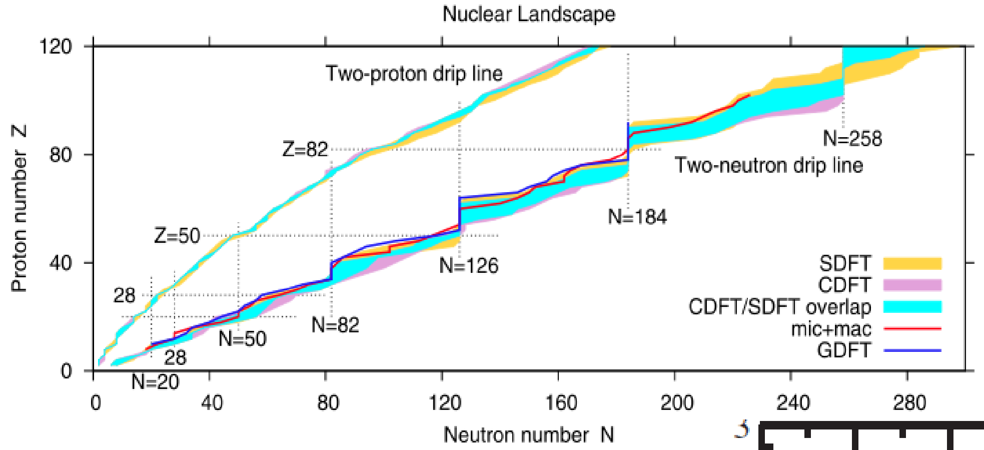
- There is strong need for microscopically based density functional framework which provides accurate description of existing experimental data related to nuclear structure and nuclear astrophysics and possesses high predictive power across unknown part of nuclear chart.

- Covariant density functional theory (CDFT) is one of such DFT candidates which possesses important advantages over non-relativistic DFT such as
  - spin-orbit interaction is naturally defined
  - time-odd mean fields are defined through the Lorentz invariance, and thus they do not require additional coupling constants

- The development of CDFT and the methods beyond mean field based on CDFT as well as their applications are required for a microscopic understanding of
  - fission
  - rotation
  - single-particle properties of nuclei
  - properties of the crust of neutron stars
  - r-process

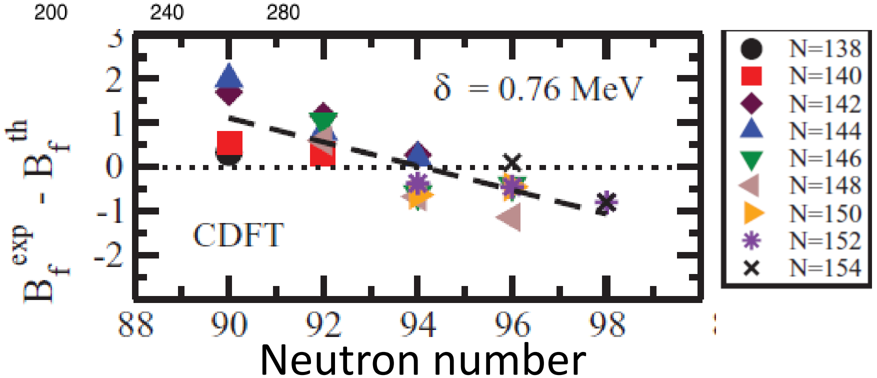
# Present status

1. Global assessment of the accuracy and theoretical uncertainties in the description of bulk properties (radii, masses, deformations etc) of nuclei




*Theoretical uncertainties in the definition of two-proton and two-neutron drip lines*

2. Systematic investigation of fission barriers in actinides and superheavy nuclei




*Accuracy of the description of inner fission barriers in actinides*

3. Systematic study of pycnonuclear reactions in the crust of neutron stars
4. Systematic exploration of the single-particle degrees of freedom in spherical nuclei (with inclusion of particle-vibration coupling) and in deformed nuclei (at the mean field level)
5. Rotational excitations of actinides and superheavy nuclei (systematic study); behavior of nuclei at ultra-high spins

# Future prospects and needs

1. Development of new class of covariant energy density functionals with spectroscopic quality at the DFT and DFT+particle-vibration coupling levels. The single-particle information on spherical/deformed nuclei will provide an extra constraint for the form of the functionals and missing physics.

2. Further development of microscopic theory of fission based on covariant density functional theory. Its application to the study of fission process in known nuclei, superheavy nuclei and nuclei of astrophysical interest.

3. Using QRPA formalism based on CDFT to study

- **β-decay rates** in spherical and deformed nuclei and building their table for nuclear astrophysics applications
- **collective excitations** in deformed (non-rotating and rotating) nuclei
- **wobbling excitations** and **octupole phonon condensation** in rotating nuclei

4. To study the composition and thermal properties of the crust of neutron stars as a function of depth [density] and initial conditions using self-consistent network calculations.

**Requirements**: Faculty + students + postdoc, large scale computing