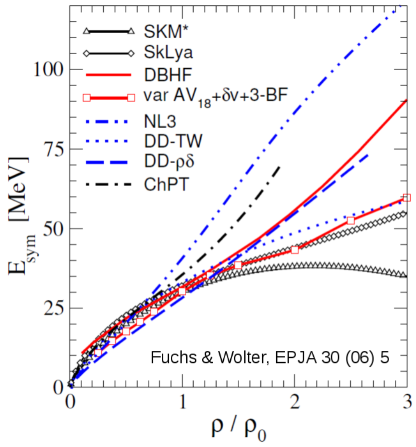
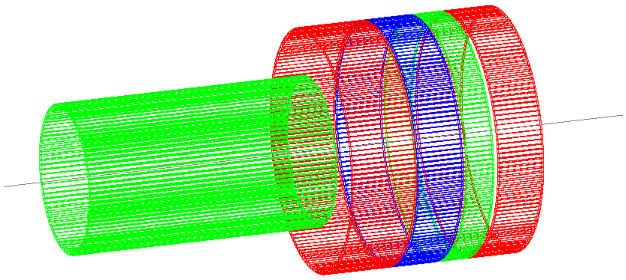


The strategic aim of the carried research is to *determine the nuclear symmetry energy at densities 2-3 times the normal nuclear matter density, ρ_0*. The *symmetry energy* accounts for a surplus of the nucleon binding in a pure neutron matter with respect to a symmetric one. It is a basic quantity entering the *Equation of State (EoS) of the asymmetric nuclear matter.* The EoS describes the dependence of the energy per nucleon in a nuclear matter on the temperature, density and isospin asymmetry. While the parameters of the EoS for symmetric matter are relatively well known, the density dependence of the symmetry energy is still uncertain, especially at high densities (see the curves in the figure on the left, representing different model predictions) and remains a subject of an intense experimental and theoretical research.

This strategic aim can be achieved through simultaneous measurement of excitation functions of neutron, proton, light cluster and pion observables within an experimental program proposed by the ASY-EOS II Collaboration. This will be the first measurement of this kind and quality, allowing to pin down the symmetry energy at 2-3ρ_0 with an unprecedented precision.

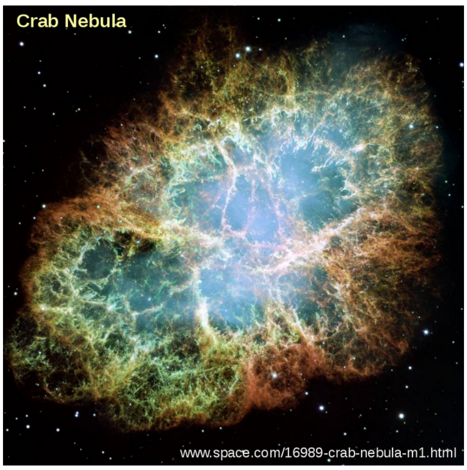
The main direct objective of the project is *construction of a compact and fast Kraków Barrel trigger detector, KRAB*. The detector will constitute an essential part of the future setup. Thanks to the high segmentation it will allow to precisely measure the azimuthal distributions necessary for the reaction plane estimates as well as the multiplicities indispensable for estimating the centrality of the relativistic heavy ion collisions. KRAB will consist of 5 rings and of 736 segments made of fast scintillating fiber (see fig. on the right). It is supposed to cover more than 90% of the total solid angle.



The only way to study the properties of the asymmetric nuclear matter at high densities in the laboratory conditions is to investigate the relativistic heavy ion collisions. The degree of compression and pressures achieved during the reaction depend on the susceptibility of the nuclear matter to compression, and hence on its EoS. In particular, the measured angular and energy distributions of the neutrons and protons, light isobars and positive and negative pions emitted form the interaction zone depend on the symmetry energy values and its gradients at the attained densities.

Realization of the strategic aim will consist in performing of the measurements of the emission angles, and of the energy, mass and charge of the reaction products including pions which will allow to construct the distributions of the specific quantities (observables) sensitive to the stiffness of the symmetry energy. The experimental distributions will be compared to the model ones obtained for different assumptions on the form of the symmetry energy and filtered through the software replica of the experimental setup.

Construction of the new detector will require performing of the realistic simulations allowing to come up with an optimal design of the device and of the necessary electronics. It also requires performing tests of the prototypes and of the final device using the radioactive sources or the accelerator beams if possible.



The knowledge of the density dependence of the symmetry energy is essential in the *nuclear structure physics* to determine the limits of the stability of the exotic nuclei, their masses, sizes, density distributions and description of collective excitations. In *heavy ion reaction physics*, it is essential to describe the isotopic composition and flow patterns of the measured reaction products and the multifragmentation mechanism. In *astrophysics*, the symmetry energy plays an important role in modeling of the supernova explosions, the process of nucleosynthesis, and in particular of the structure and properties of the neutron stars, like the one in the center of the Crab Nebula in the photo on the right. In the latter case, it is particularly important to know the symmetry energy at densities up to three times the normal density. Knowledge of the parameters of the symmetry energy will allow for realistic simulation of the nuclear processes and objects in the femto- and astro-scales.