Unique Experiments at the Frontiers of Nuclear Physics: the Experimental Program for the Super-FRS

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The superconducting fragment separator (Super-FRS) is the magnetic high-resolution spectrometer, which is coupled to the heavy-ion synchrotron complex at FAIR. It is the central device of the NuSTAR collaboration and will provide relativistic beams of exotic nuclei ranging from hydrogen to uranium. With intense primary beams in the range of 1000 A MeV, universal isotope production mechanisms (fragmentation, fission, spallation) and in-flight separation at a maximum magnetic rigidity of 20 Tm, high momentum resolution capability up to p/Δp~20.000 in the dispersion-matched mode, strong background suppression (due to a multiple-stage separation scheme) and specialized detector systems, the Super-FRS [1] will allow for a variety of unprecedented nuclear physics experiments, which are not possible elsewhere in the world. In year 2012, the Super-FRS collaboration has identified its main goals:

- experiments along the lines described here
- construction of the Super-FRS, including R&D and commissioning, based on the FAIR partners by in-kind and additional contributions from collaboration partners
- operation for and together with all other NuSTAR sub-collaborations.

The experimental program will take advantage of the specific strengths mentioned above and will be complementary to other NuSTAR experiments. Key examples are for instance the production and study of exotic hypernuclei (i.e.: nuclei far-off stability containing hyperons) [2], the production and study of mesic atoms (i.e.: atoms containing bound mesons, like pions or eta mesons) [3], direct measurements of in-medium mass shifts [4], the discovery of new neutron-rich isotopes [5], the search for new phenomena in weakly bound or dilute nuclear systems, and the search for neutron radioactivity [6], an elementary radioactive decay mode which was not discovered so far. These experimental goals are intimately connected with the development of dedicated separation schemes and novel detection concepts, and it is the challenging goal of the Super-FRS collaboration to prepare and carry out these unique experiments. The existing FRS is the platform for developments and tests and will be used for pilot experiments in the coming years.

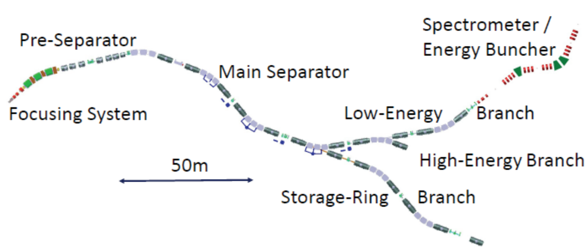

Figure 1. Schematic view of the Super-FRS and its branches. When the spectrometer/energy buncher at the Low-Energy Branch is operated in a dispersion-matched mode, secondary-reaction and charge-exchange experiments become possible with a momentum resolution down to $\delta p/p \sim 5 \cdot 10^{-5}$. An experimental program, specific for high energies and complementary to other existing or planned high-resolution spectrometers is presently under development.

References

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