An Antiproton Ion Collider (AIC) for Measuring Neutron and Proton Distributions of Stable and Radioactive Nuclei

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Abstract

An antiproton-ion collider is proposed to independently determine rms radii for protons and neutrons in stable and short lived nuclei by means of antiproton absorption at medium energies.
The experiment makes use of the electron ion collider complex (ELISE) of the GSI FAIR project with appropriate modifications of the electron ring to store, cool and collide antiprotons of 30 MeV energy with 740A MeV ions in the NESR. Antiprotons are collected, in the RESR and will be cooled and slowed to 30 MeV by an additional electron cooler. Hereafter the 30 MeV antiprotons are transferred to the electron storage ring using a new transfer line.
Radioactive nuclei are produced by projectile fragmentation and projectile fission of 1.5A GeV primary beams and separated in the Super FRS. The separated beams are transferred to the collector ring (CR) and cooled at 740A MeV and transported via the RESR to NESR, in which especially short lived nuclei are accumulated continuously to increase the luminosity.
The total absorption cross-section for antiprotons on the stored ions with mass A will be measured by detecting the loss of stored ions by means of the Schottky method. Cross sections for the absorption on protons and neutrons, respectively, will be measured by the detection of residual nuclei with A-1 either by the Schottky method or by detecting them in recoil detectors after the first dipole stage of the NESR following the interaction zone. With a measurement of the A-1 fragment momentum distribution, one can test the momentum wave functions of the annihilated neutrons and protons, respectively. Furthermore by changing the incident ion energy the tails of neutron and proton distribution can be measured.
Theoretical calculations show that the absorption cross sections are in leading order directly proportional to the mean square radii. Predicted cross sections and luminosities show that the method is applicable to nuclei with production rates down to about $10^5 s^{-1}$ or lower depending on the lifetime of the ions in the NESR and half-lives of about down to 1 second.