Simulations for the in-ring spectrometer of EXL

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The forward spectrometer of the EXL setup is meant to detect heavy projectile fragments emerging from the gas-jet target [1]. It consists of a cascade of magnetic lenses, which are part of NESR storage ring, and three position sensitive detectors. The first detector is placed at 2 meters away from the target, while the second and third ones are located before and after the third dipole, respectively; for more information see [1].

The simulations of the forward spectrometer are being performed using GEANT4 toolkit [2]. As the first step in the simulations, the geometry of the lenses was created. The interaction of the magnetic fields with charged fragments is described using transfer matrices. Simple implementation and saving CPU time were the main motivations to use transfer matrices instead of direct implementation of magnetic fields. One should note that obtaining the trajectory of projectiles by means of transfer matrices is fair if the life-time of the projectile is much longer than its time of flight inside the lenses.

Since this setup is designed to study exotic nuclei, which are not stable, the decay process was also needed to be included in the `PhysicsList` as well. The decay tables for ions needed for the description of the decay process were obtained from the decay data provided by GEANT4. Fortunately, these decay tables are written in an easy to understand format and can, consequently, be simply edited, if necessary.

Event generation is done by a FORTRAN-based code, called GENBOD [3]. It generates a multi-particle weighted event according to Lorentz-invariant Fermi phase space. The total center of mass energy as well as the number and masses of the outgoing particles are specified by the user. GENBOD then generates momentum vectors of the outgoing particles in the center of mass and gives the weight which must be associated with each event. The momenta of the particles in the exit channel were put in a ROOT tree [4]. In order to feed the events generated by the GENBOD to the simulations, a method capable of opening a ROOT-file and reading in events off a tree was added to the `PrimaryGeneratorAction`.

The data analysis part of the simulation was done by developing and adding a ROOT-based class to save the desired information, for instance the coordinates of fragments at the moment of impact on position-sensitive detectors, in a ROOT tree. The off-line analysis of these data can be done using ROOT software [4], interactively.

In order to compare the response of the spectrometer to light and heavy nuclei, elastically scattered ^{24}F (^{132}Sn) nuclei off a proton target with the incident beam energy of 783 MeV/u (796 MeV/u) were generated by GENBOD and tracked in the simulations. As the simulations reveal, the outgoing ^{24}F reaches the first position-sensitive detector but hardly makes it to the second and third detectors. However, almost 20% of ^{132}Sn^{50+} can be detected by the third detector. This has simply to do with the fact that the recoil that ^{24}F receives in the scattering process is big enough to push the outgoing ^{24}F out of the ring before arriving at the second detector. This test implies that, contrary to heavy nuclei, light nuclei with different charge states cannot be distinguished using position sensitive detectors together with the magnetic elements. Moreover, for kinematic reconstruction of events for light nuclei one has to rely merely on information delivered by recoil detectors and there would be no information from the second and third detectors. A typical charge state separation for ^{132}Sn^{50+} and ^{132}Sn^{49+} ions is shown in figure 1. This work is partially supported by EURONS/EXL project.

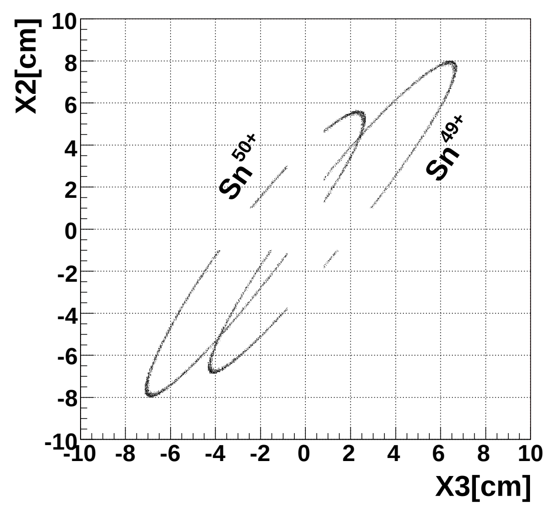

Figure 1: Separation of ^{132}Sn^{49+} and ^{132}Sn^{50+} obtained with the second and third tracking detectors. The openings in the elliptical-shape rings indicate the space that has to be free of matter for the circulating beam. The vertical (horizontal) axis is the x-coordinate of ion, in the reference plane, detected by the second (third) position sensitive detector.

References

[1] EXL technical proposal; http://www-linux.gsi.de/ wwwnusta/tech_report/05-exl.pdf

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