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LISE++ : design your own spectrometer

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The program LISE is designed to predict intensities and purities for the planning of future experiments with in-flight separators, as well as for beam tuning during experiments where its results can be quickly compared to on-line data.

LISE++ is the new generation of the LISE code, which allows the creation of a spectrometer through the use of different sections (dispersive section, velocity filter, electrostatic separator and gas-filled separator ...) called "blocks". The code has an improved interface, new utilities, and a spectrometer schematics which allows a quick editing of blocks. The code can be freely downloaded from the following sites: http://www.nscl.msu.edu/lise or http://dnr080.jinr.ru/lise.

1. INTRODUCTION

The program LISE [1] simulates the operation of fragment separators used to produce radioactive beams via fragmentation (or fusion-evaporation [2]). There are various aspects of the physical phenomena involved in the production of such radioactive beams. They include fragmentation (fusion-evaporation) cross-sections, momentum and angular distributions of fragments, energy losses in materials, ionic charge state distributions, as well as ion optics calculations and acceptance effects. The original LISE was restricted to a configuration consisting of two dipoles, a wedge, and a velocity filter. LISE++ is the new generation of the LISE code which eliminates this restriction by constructing the spectrometer from different available sections. The number of sections used to create a spectrometer in LISE++ is only limited by the operating memory of the computer and the users imagination.

The LISE++ distribution includes configurations for most of the existing fragment and recoil separators such as the A1900 and the S800 at NSCL, LISE3 at GANIL, FRS at GSI, COMBAS and ACCULINA at Dubna, and RIPS at RIKEN. The code has a user-friendly interface that helps to quickly construct any spectrometer from the different sections developed in LISE++ (see Figure 1).

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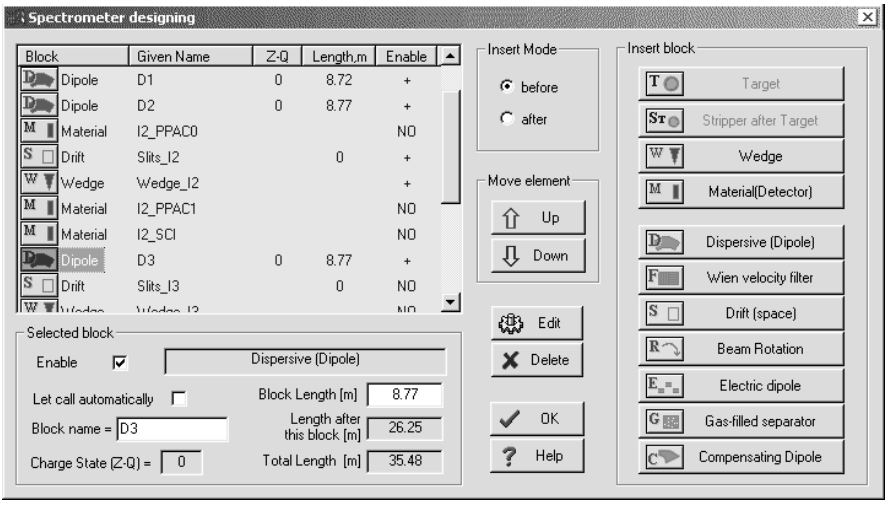

Figure 1. The dialog "Spectrometer design" is the first step designing fragment separator.

2. DESCRIPTION OF THE BLOCKS

LISE++ has been written in spirit of inheritance of object-oriented programming. The fundamental "Block" class is inherited by classes "Material" and "Optical". The hierarchy of optical blocks is shown in Figure 2.

It is also planned to develop a "Secondary target" block to calculate a *tertiary* radioactive beams, as well as to take into account reactions in the wedge. The dialog "Spectrometer design" allows the user to begin construction of a fragment separator using the available blocks (see Figure 1).

The spectrometer schematics is a convenient innovation provided in the new version (see Figure 3). LISE++ draws the spectrometer on the basis of the blocks, entered by the user. It is possible to select a block of the spectrometer by clicking on it and bringing up the dialog of block settings.

3. LISE++ PACKAGE

The LISE++ package consists of utilities developed within the framework of the LISE++ program and existing programs ported from FORTRAN to C++. New utilities were developed and incorporated in LISE++ in addition to the already existing tools such as the physical parameters calculator, database of nuclear properties, and relativistic two-body kinematics calculations:

- The "Range optimizer" calculates the thickness (or inclination angle) of a degrader used to slow down beam particles in order to alter their stopping distance into a gas-cell.

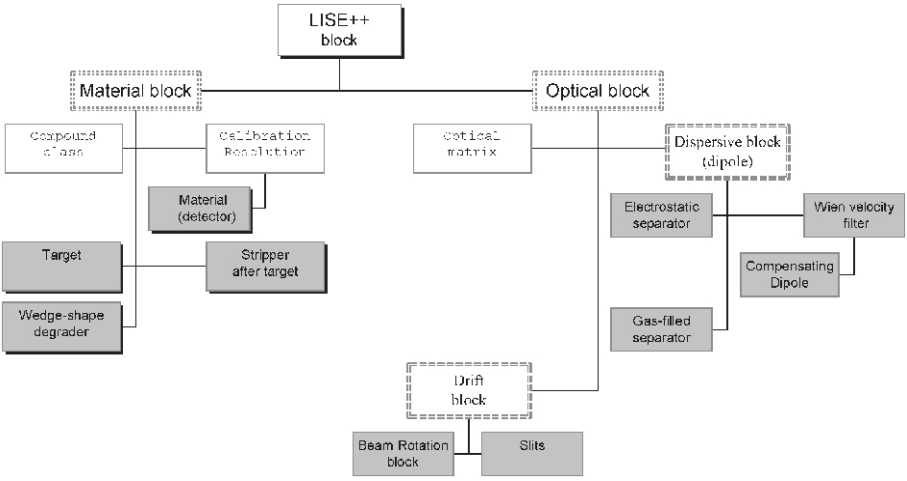

Figure 2. The LISE++ block hierarchy.

- The "Brho/Erho analyzer" calculates and plots trajectories of ions in the magnetic/electrical dipoles depending on the energy and emittance of the beam and the settings of the dipole. This utility can help calculate the position of a primary beam trap in the dipole chamber to avoid scattering of a primary beam on the walls.

- "Evaporation calculator": this new tool allows the user to visualize the dynamics of the deexcitation process in the case of projectile fragmentation reactions using the fast analytical Abrasion-Ablation model or fusion-residue reactions with the LisFus model [2].

The programs "Charge" and "Global" [3] have been recently ported to the LISE++ package. These programs are intended to calculate atomic charge-changing cross sections, charge-state evolution, and equilibrium-charge-state distributions of heavy ions penetrating through matter. The energy range in the case of the code Global can vary between 30 MeV/u and 2000 MeV/u. It has also been modified to work more effectively with thick targets, as well as to perform calculations for projectiles with a nuclear charge of less than 29. PACE4 [2,4] and Global calculation results can be used directly in LISE++ calculations to predict rates of secondary beams.

Besides the possibility to design the spectrometer from different sections among new development in the program it is necessary to note the following:

- Development of the improved mass formula with shell crossing corrections to extrapolate the masses of unknown isotopes.

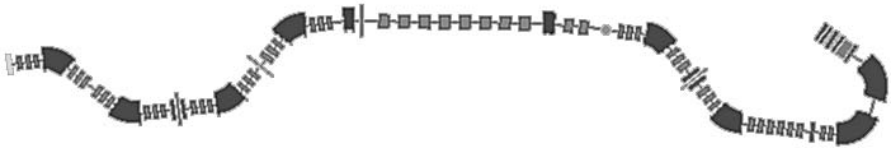

Figure 3. The A1900+S800 spectrometer (NSCL) scheme.

- Implementation of the fission channel in the LisFus model to calculate evaporation-residues cross section.
- Possibility to calculate a fusion cross section below the Coulomb barrier in the PACE4 code and the LisFus model of LISE++ using the quantum-mechanical approach developed by C.Wong [5].
- Development of the envelope calculation package to visualize the changes in distributions along the spectrometer. The code provides envelope plots for horizontal and vertical angular distributions, horizontal and vertical spatial distributions, and energy and momentum distributions.

4. SUMMARY

The LISE++ program is an important resource that will be a key to developing the fragment separators for RIA[6]. It is has also become an important tool for the planning of experiments at different laboratories around the world. Fission yields, secondary reactions in the wedge, as well as use of the secondary target to produce tertiary radioactive beams are near-term priorities of the LISE++ development.

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