Guide for Using LISE++ to Simulate Rare-Isotope Settings in the A1900

LISE++ is the most common tool for planning rare-isotope settings for experiments at the National Superconducting Cyclotron Laboratory (NSCL). This guide outlines steps for using LISE++ to obtain reasonably fast and accurate simulations over the range of rare isotope beams most commonly produced with the NSCL's A1900 fragment separator. The approach presented here, together with the appropriate LISE configuration and option files (available online at http://groups.nscl.msu.edu/a1900/software/lise++/), incorporates the A1900 group's experience with both LISE++ and the A1900. A more detailed LISE++ tutorial is available in PDF format at http://groups.nscl.msu.edu/lise/doc/tutorial.pdf.

Specify Primary Beam

Click the 

icon for beam entry and in the dialogue box enter A, Element, and Energy (MeV/u). If you leave the beam current set to 1 pnA, the fragment rates calculated by LISE will be per particle nano-Ampere of primary beam current, a useful quantity to keep in mind for experiment planning.

Specify Fragment

Click the 

icon for fragment entry and in the dialogue box enter A and Element.

Specify Wedge

Click the 

icon for wedge entry and in the dialogue box enter the material (usually Aluminum) and the thickness. Typical starting values are 800 mg/cm^2 for $1 \leq Z_{Fragment} \leq 15$, 300 mg/cm^2 for $15 \leq Z_{Fragment}$ $Z \leq 30$, etc. (Another rule-of-thumb for selecting a starting wedge thickness is that the wedge thickness be 20% of the range of the desired fragment.) A curved profile is pre-loaded into the NSCL distribution of LISE that matches the standard wedge profile used in the A1900. This profile is chosen to be achromatic for the range of rare-isotope settings most commonly run in the A1900.

Specify I2 Slit Setting

Click the 

icon for the I2 slits and in the dialogue box click the "Cut (Slits) & Acceptances" button. In the next dialogue box click the "R: 29.5" button to enter the opening half-width in mm. The default value of ±29.5 mm (corresponding to a total momentum acceptance of 1% or, equivalently, ±0.5%) is a good starting point.

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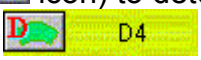
Specify Fragment Energy

Skip this step if you do not require your fragment to have a particular energy.

Use the "Physical Calculator" (obtained by clicking the  icon) to determine the rigidity (Brho) corresponding to the energy you need. Click the 

icon for the fourth A1900 dipole, and in the dialogue box enter the rigidity value corresponding to your desired energy in the field labeled "Brho". Note that fragments will not be transmitted well to an experimental device downstream from the A1900 if they have energy values below about 30 MeV/u.

Calculate Optimum Target Thickness

From the "Calculations" Menu select "Optimum Target". If you specified the fragment energy by entering a rigidity value for D4, select "D4" using the "Keep value" option; otherwise, LISE will optimize for production by varying the final energy as well as the target thickness.

In the next dialogue box specify the fragment by entering A and Element. If you want the optimum target thickness for some material other than Be, you should enter the target material (see "Specify Target" below) and repeat the steps for calculating the optimum target thickness.

Specify Target

Click the 

icon for the Target and in the dialogue box enter the target thickness obtained from the optimum target calculation. (This dialogue box is also where you can specify a target material other than the default selection of Be.)

Specify A1900 Rigidity Settings

Click the  icon for rigidity calculation to obtain the A1900 rigidity settings as matched to the fragment yield curve for the target you have specified. The rigidities will automatically be entered for each segment of the A1900.

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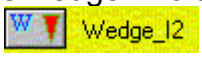
Specify FP Slit Setting

Click the 

icon for the FP slits and in the dialogue box click the "Cut (Slits) & Acceptances" button. In the next dialogue box enter the horizontal opening width (mm). The default setting of ±25 mm (which is the size of the FP PIN detector) is appropriate for experiments taking place at the A1900 focal plane. A horizontal setting of ± 7 mm approximates the cut in the fragment distribution made by beamlines downstream from the A1900; this setting is appropriate for simulating rates and fragment cocktails for experiments downstream from the A1900. It is important to set this slit appropriately to obtain a meaningful simulation of fragment rate and purity. Keep in mind, however, that the A1900 does not actually have a slit system at the focal plane.

Confirm Achromaticity of Wedge

From the "2D-Plot" Menu select "Plot TKE-X". In the plot window that opens, click the "Monte Carlo" button to start a Monte Carlo simulation of the dependence of the total kinetic energy of the fragment on the position at the A1900 focal plane. Stop the calculation by clicking the "STOP" button. There should not be an appreciable correlation between position and total kinetic energy.

If a significant correlation between position and total kinetic energy does appear, the properties of the wedge can be adjusted to improve its achromaticity. Note the width of the fragment distribution from the Monte Carlo simulation as a point of reference before adjusting the wedge. To adjust the wedge, open the wedge properties dialogue box by clicking the 

icon. Note the angle corresponding to the curved profile located in the box labeled "Angle [mrad]" found next to the "Wedge profile" option. Select the "Wedge profile" option and vary the angle around the curved profile's value. For each angle repeat the Monte Carlo simulation of the TKE vs. X distribution to look for a more achromatic wedge. Be sure to open a new "Plot TKE-X" window for each wedge angle you enter.

Calculate Rates

Click the  icon to calculate the rates for all transmitted fragments based on the settings you have specified. The rates will appear in the chart of nuclides.

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Evaluate Results

Decide if the setting meets the experiment's needs based on considerations such as fragment rates, purity, cocktail composition, energy, position distributions, momentum spread, etc. Make use of the plots available in the menus "1D-Plot" and 2D-Plot".

Optimize Setup

Repeat the steps above as necessary to optimize the fragment settings to meet the needs of the experiment. Obvious quantities to vary are wedge thickness, I2 slit setting, and target thickness. Thinner wedges lead to smaller spot sizes for individual isotopes; thicker wedges lead to a wider position separation between different isotopes. Larger I2 slit settings give higher rates (up to the A1900 acceptance limit of 5%) at the expense of isotopic resolution on the basis of ΔE vs. TOF measurements; settings of 1% or less are usually necessary to maintain particle identification resolution without resorting to particle-by-particle momentum correction techniques.

Simulate Fragment Charge States for Primary Beams with Z=28 and Higher

Click the  icon for preferences and in the dialogue box select "Yes" under charge states. Recalculate rates and reevaluate your results to look for any problems arising from the presence of fragment charge states (i.e., from the presence of fragments that are not fully stripped of electrons) or from charge states of the primary beam.

Physical Calculator

Note that the "Physical Calculator" (obtained by clicking the  icon) is a useful tool to make quick calculations of the corresponding energy, rigidity, and momentum values for a given isotope. It also provides an easy way to calculate the isotope's range and energy loss in a material you specify.

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