Práctica de Laboratorio nº 5:
Breve introducción a la utilización de LISE++

El objetivo de esta práctica es iniciar al alumno a las reacciones de fragmentación para la producción de haces radioactivos y a cálculos de transmisión y pureza de los isótopos deseados, usando el código LISE++ como ejemplo. LISE++, desarrollado por O. Tarasov y D. Bazin a MSU, es un código que permite de calcular los parámetros necesarios para experimentos con separadores de fragmentos. Se considera en particular el caso de reacciones de fragmentación.

Bibliografía

1.- O.B.Tarasov, D.Bazin "*LISE++: Radioactive beam production with in-flight separators*" Nucl. Instrum. Methods B 266 (2008) 4657-4664

2.- O.B.Tarasov, D.Bazin "*LISE++ : design your own spectrometer" Nucl. Phys. A746 (2004) 411-414*

3.- Additional documentation can be found online at http://groups.nscl.msu.edu/lise/lise.html

Materiales

El alumno dispone del siguiente material:

1. Ordenador con entorno de trabajo Windows o Linux (WINE)
2. Directorio de trabajo
3. Hoja anexa, donde se especificarán los detalles de la reacción que se intenta simular, las restricciones experimentales, etc.

Realización

Beginning

1. Familiarize yourself with the working environment, start up the program LISE++, load the FRS configuration and options. Create your own directory (with your student name) inside the ~/LISE/files directory to save your files.
2. Set the spectrometer and calculate the transmission and rates of all nuclei. A smaller region can be chosen to reduce the calculation time.
3. Using the attached sheet of LISE++ options and preferences, the student will check and set the preferences used in the following calculations.

(Remember to **save your work** periodically, using meaningful filenames which will permit to go back to the work at a later stage.)

Search best fragment-target combination for the production of ^{98}In;

4. Check rates and transmission for ^{124}Xe (@750MeV/u) [beam intensity: 1pnA] on a 4g/cm^2 natural Pb target.
5. Find optimum target thickness using the "Optimum target" tool in the Calculation menu;
6. Find new rates and transmission and note them down;
7. Q. How does the transmission changes if you change the beam energy, keeping the same target thickness? Take a few points for ^{98}In to later plot a curve.
8. Now, keeping the initial beam energy (750MeV) and beam intensity (1pnA), find better combinations of beam and target to increase the production rates of ^{98}In (hint: low Z targets (Be, C) give largest yields, available targets: Pb,Be,C). Use the list of available beams provided (for this practice, we keep the beam intensity to 1pnA for all beams, even though in reality not all isotopes are available to the same intensity. Examples can be seen in the appendix "List of main primary beams available at GSI").

Obtain a pure ^{98}In beam at S4 (i.e. the other contaminants are at least 2 orders of magnitude smaller)

9. Once the best combination of beam and target has been found, inspect rates after each dipole magnet and write them down.
10. To measure rates, introduce Faraday cups using the "Set-up" button. The fraction of the spectrometer after the Faraday Cup should turn gray. Do calculation for 'All nuclei' and read value of Total sum at the very bottom of the window ("Sum=...")
11. What are the main contaminants before and after slits at S4? Plot horizontal (X) space distributions in 1D-plot menu and save them.

12. Try to cut the contaminants down to a minimum playing with slits. What are the main contaminants now at S4?
13. Plot DE-TOF. Can you clearly distinguish the different isotopes?
14. You may need to add the S2 wedge degrader to improve separation. As a first guess for the thickness, it is good to use 60% of the range (for the desired fragment) just before the wedge. To measure the range, use Calculations → Goodies, after sci21, and check the range in Al which is the material of the wedge
15. Introduce homogeneous wedge with thickness ~ 60% of the range, with no angle, and check again contaminants at S4.
16. Change wedge angle, using Calculate Angle program in the window which opens by clicking on Wedge in the menu. Choose achromatic value. The block in the dispersion plane is S4_Slits (where you want maximum separation of the beam components). Increase the Dimensions of wedge angle distributions to obtain a more precise determination of the minimum. Click on "Fix" next to Achromatic on the left-hand side of the window. Re-tune spectrometer and check again contaminants at S4 slits. To improve it further, try changing the wedge thickness. NOTE: If the search of the angle does not work, after changing the thickness click on "Set the spectrometer after this block using changes"; you can also reduce the slits at S4 and increase the number of points for the wedge calculation to 512 or 1024 (it takes longer, so better check with 64 and 128 first).
17. Plot DE-TOF. Can you clearly distinguish the remaining isotopes? What are the main other contaminants now? With what rate are they produced?
18. You can also try to put a homogenous 1g/cm^2 wedge at S1. Does that improve the situation? (remember that you need to recalculate the thickness and the angle of the wedge at S2 after adding the wedge at S1)
19. If typical experimental constraints applied, the TOTAL rates on sci21 would need to be <1E6, and rates at S4<1E4. Are your rates within these boundaries? If not, how could you reduce them?

Obtain monoenergetic ^{98}In at S4

20. Once you and the tutor are satisfied with the achieved beam purity, can try to obtain monoenergetic ^{98}In using the separator in the monochromatic mode. In the Calculate Angle program choose the monochromatic value. Plot horizontal (X) space distributions at S4 and also 1D Energy distribution. Do you see what you expect?
21. Add plexiglass stopper after sci41. What is the range of the ions in the stopper? (1D-pots → Range distributions)
22. Before leaving, remember to copy your files and your saved graphs on a usb stick or send them to yourself by email.

MINISTERIO
DE ECONOMÍA
Y COMPETITIVIDAD

CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS
INSTITUTO DE ERUCTURA
DE LA MATERIA (IEM)

LISE++ OPTIONS TO IMPLEMENT in LISE++ Practice

In Menu:	**Choose**
File → Configuration → Load	File:FRS-TA2B-S4 std (2006)Simplified.lcn In directory ~/Lise/config/GSI
File → Options → Load	File: madrid_master.lopt In directory ~/Lise/options
Preferences	Start Configuration and option file as before Display 1: sum of all reactions Display 2: Total Transmission Cross Section: Fit Angular Acceptance Method: Jacobian Settings using *mean* value of mom dist. Charge States: No (for now) 3D-Balls: Off Navigation map ON Spectrometer Scheme ON All others in this row: off Calc. Threshold: 1E-10 Dimension of distribution (n. of points) Without 32 (or 64) With 32 Wedge 32 Target Optimization Options: No of points for target plot: 50 [d] : [b] + secondary reactions Savitzky-Golay filter Plot Options: X space detector scint21 X2 sace detector scint41 dE-detector mu1glass(or other at S4) Acq start of ToF: Detector TOF Start: Scint21 TOF Stop: Scint41 No of 1-d distributions: 200
Options → Production Mechanisms → Reactions	Fragmentation
→ Settings → Fragment Velocity	Morrissey (E) No velocity shift for (p,n) and (n,p) reactions
→ Settings → Mom. Distr.	Goldhaber. σ_0 = 90MeV/c σ_D = 0 MeV/c
→ Settings → Cross sections..	2. EPAX 2.15
→ Settings → Cross Sec → → Exc. energy for abra.abla model	C. Parametrized Gaussian

Options → Production Mechanisms → E- Loss, Straggling	Energy Loss: ATIMA 1.2, LS Theory Energy Straggling: ATIMA 1.2 (LS) Gaussian Shape Distribution Interpolation from table Angular Straggling: Molière, ATIMA 1.2
Options → Production Mechanisms → Charge States	Method of Chrg State calculation: 3–Global Charge state value for all (Auto, if E<30 MeV/u) Always assume equilibrium distributions Method Eqm thickness: 1 – GLOBAL Charge-state suppression values Fragment: 1E-3, 1E-6 Primary: 1E-10, 1E-10
Options → Production Mechanisms → Databases	0- AME 2003

LIST OF MAIN PRIMARY BEAMS AVAILABLE AT THE FRS

^{238}U: 2 10^{9} pps
^{144}Sm: 2 10^{9} pps (no standard beam, used once)
^{136}Xe: 10^{10} pps
^{124}Xe: 10^{10} pps (x abundance of enriched material)
^{112}Sn: ~10^{8} pps (x abundance of enriched material)
^{107}Ag: 4$10^{9}$ pps
^{106}Cd: not available at GSI (poisonous)
^{86}Kr: 10^{10} pps
^{78}Kr: 10^{10} pps (x abundance of enriched material)
^{76}Ge: 3 10^{8} pps (no standard beam, needs to be developed)
^{64}Ni: 5 10^{9} pps (x abundance of enriched material)
^{58}Ni: 5 10^{9} pps
^{48}Ca: 3 10^{7} pps (low intensity from the source that is used for pulsed beams for SIS experiments; using an ECR source would improve the situation on the expense of much more material needed.)

Informe de Prácticas

Para la evaluación de la realización-comprensión de la práctica el alumno deberá presentar un informe de la misma antes del día 07 de Abril de 2015, que enviará por correo electrónico a las direcciones:
master.nuclear@iem.cfmac.csic.es

En la misma se debe *explicar la metodología seguida durante la práctica* y se presentará:

a) **Ejemplos** simulados de la variaciones de la transmisión en función de la energía del haz primario, explicando cualitativamente la origen de la variación.

b) Después haber explicado la diferencia entre modo acromático y mono-energético (o monocromático), **espectros** 1-D de distribución en X y en Energía relativos a los cuatro sectores del separador (S1, S2, S3 y S4) con los parámetros finales elegidos en el caso de haz achromatico.

c) Intensidad total de haz en pps en S2 y S4 en los dos casos.

d) **Espectros** 2-D de identificación de isotopos (Z vs AoQ o dE vs TOF, etc).

e) El alumno además contestará a las siguientes **cuestiones**:

   a. Que tipo de experimento pudiera requerir un haz monoenergetico, como en el caso simulado? Que tipo de experimento en vez podría necesitar de un haz puro?

   b. Que espesor de plexiglass se necesita para parar los iones de ^{98}In en el plano focal?