Project for the JINA ion optics for Recoil Separator School

September 2018

Group:

Group members:

Member 1: ___________________________________

Member 2: ___________________________________

Member 3: ___________________________________

Preparation:

1. Introduce yourself to each other
2. Write down your names into the spaces above. Figure out who is member 1, member2, and member 3.
3. Find a name for the group

Project:

This is not a race, nor a competition, it is better if you understand the first few steps than to rush it to finish. You can also decide if you want to stop investigate a specific point and move ahead.

1. Based on today's instructions identify the person in your group responsible for documentation. Each group should use the wiki to document the steps they took to carry out their activities. The goal is to create step by step instructions that will enable others to use the wiki to self-learn – the more useful the documentation is for this purpose the better.
    a. The member responsible for documentation should create a sub page for the group to get ready for documenting.

2. Prepare the measurement of a radiative capture reaction of your choice with either St. George or SECAR. Note that St. George is designed to study (α,γ) reactions (for example: ^{12}C+α, ^{20}Ne+p, ^{15}O+α, …). As a group, choose a reaction and if you are going to work with SECAR or St. George. Stick to that choice.

3.
    a. Write a COSY script made of a drift, a 45-degree dipole magnet with a 1 meter bending radius and a drift.
    b. Extract the first order matrix elements in the horizontal plane of this system. Describe the meaning of each of the values associated with the position in the horizontal plane.

c. Plot the trajectory of a ray with a small momentum difference (How would you express the momentum difference in the eight COSY variables system? Ignore the complications associated with variable 2 and 4, just implement something that changes variable 6). Calculate with the first order matrix elements the position where you expect the ray to end up. If needed an example is given on the wiki under Lectures/ Link to tutorial files/dispersion.zip (unzip it to get the cosy script)

4. Calculate the reaction kinematics, discuss the properties of the beam and recoil after the target picking your favorite energy.
If you do not have a favorite kinematics code you can use:
http://skisickness.com/2010/04/relativistic-kinematics-calculator/
The information you obtain will be used to specify some of the parameters describing the recoils in the COSY calculation of the separator you choose.
    a. What is the opening angle of your recoils? Does it fit the angular acceptance of the separator you choose (For St. George $\theta_{max} = 40\ mrad$ and for SECAR $\theta_{\max} = 25\ mrad$)? If it does not, how would you change the energy of the beam to make it match?
    b. What is the energy spread of your recoils? Does it fit the energy acceptance of the separator you choose (For St. George $\frac{\Delta E}{E} = \pm 7.4\%$ and for SECAR $\frac{\Delta E}{E} = \pm 3.1\%$)? If it does not, how would you change the energy of the beam to make it match?

5. Research some bibliographical information on the reaction you propose to study
To make bibliography search you can use
http://scholar.google.com
http://adsabs.harvard.edu

6. Application of the Quadrupole/viewer emittance measurement method:
Use slide 13, of G. Berg Lecture 1 to explain the principle of the emittance (epsilon) measurement by Quadrupole Variation. A minimum of 3 measurements for different quadrupole settings is needed to determine epsilon.
On p. 13 of the file provided on the wiki under: Lectures/Student Projects/Emittance Procedure a procedure describing how to determine a more precise epsilon using more than 3 measurements is provided.
    a. Lacking real measurements, use the cosy script provided on the wiki under "Lectures/Student Projects/COSY fox file to create Quad tuning data" to create a set of profile widths (Half Image size) at focal plane FP2 (line 125) of SECAR by varying the quadrupole strength of Q7 (line117).
    b. Extract the distance L from the center of quad Q7 to the focal plane FP2 from the fox file.
    c. Determine the fit parameters a, b, and c and calculate the emittance epsilon per procedure.
    d. Compare the determined emittance epsilon with the beam emittance.

7. If the effective length of one quadrupole in either St. George or SECAR is changed, the ion optics solution for the whole system would most probably not deliver the best mass resolution and possibly change the acceptance (angular and/or energy).
   Such a change would most probably come from a real magnet vs the designed magnets. The way installation would proceed would be the make sure that the magnet center does not move relative to the design because this would affect the whole footprint of the installation.
   Change the effective field length of the either Q2, Q3, Q4 in St. George or SECAR by 3%. Correct the surrounding drift length to make sure the position of the center of your quadrupole does change. Estimate the impact In terms of mass resolution only.
   What would you have to change to attempt to recover the best mass resolution?
   Add a fitting routine in your COSY script to attempt to recover the best mass resolution. The fit should not change more than 2-3 parameters and definitely not the position of any magnet.

8. The concepts of resolving power and mass separation are used to evaluate the quality of the separator. When a parameter is changed, the resolving power and mass separation will change. There is also a risk of changing the acceptance (angle and energy) of the system. What is the tolerance such that the mass resolution does not decrease by more than 5% in terms of (SECAR or St. George)
   a. Beam position, beam size
   b. Magnet alignment (in any directions). Pick two elements of your choice prior to the first Wien filter and evaluate the impact of longitudinal, transversal and pitch, roll and yaw changes and provided the maximum changes that will not affect the mass resolution more than 5%.

9.
   a. Using results of question 4, generate rays characteristic of your reaction and plot them on your selected separator to demonstrate that they actually fit within the beam pipe.
   b. Plot the trajectory of beam with +/-1 the charge for which the separator is tuned
   c. Suggests ways to study acceptance (angular and/or energy) (SECAR or St. George). Plot various rays to show that your propose method achieves the goal using your COSY script.

10. Propose a method to study charge state fractions with SECAR or St. George.

11. Change radius of WF either up or down (for SECAR 6m or 8m, for St. George either 5m or 3.7m) depending on acceptance and rejection.
    Modify your separator cosy script to write a fitting routine changing the quadrupole fields to find a solution that maximizes the mass resolution with the new radii while maintaining the acceptance of the recoil you plan to study.