Estimation of Magnetic Rigidities for Experiments Involving the S800 Spectrograph

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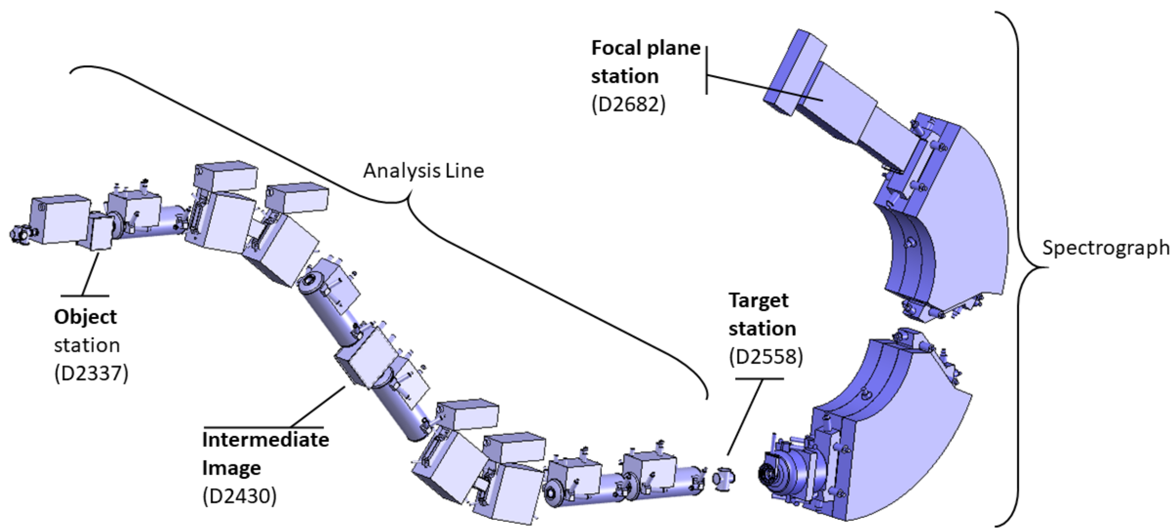
1. Introduction

The S800 Spectrograph has two parts: The analysis line (running from the Object position to the Target Station) and the spectrograph itself (See Fig. 1). The maximum magnetic rigidity (Bρ) of these two sections is defined by the maximum fields and bending radius of the dipole magnets, and by the maximum currents (fields) of that the different quadrupoles can withstand. In the case of the spectrograph, the typical maximum value is 4 Tm. As for the analysis line, the limit depends slightly on the optics mode used (focus or dispersion matched). Typical maximum values for these two modes are **~5 Tm** (dispersion matched), and **~4.2 Tm** (focus mode).



2. Evaluation of Magnetic Rigidities in S800 Experiments

During the preparation of a FRIB proposal, it is important to estimate the rigidities of the nuclear beams involved in order to make sure that they do not exceed the maximum rigidities of the S800. These rigidities depend on the mass-over-charge ratio and velocity of the nucleus:

$$B\rho\ (in\ Tm) = \frac{A}{Q} \cdot \beta\gamma \cdot \frac{uc}{e} = 3.1071 \cdot \frac{A}{Q} \cdot \beta\gamma$$

where e is the electron charge, u is the amu in MeV/u, c is the speed of light, and

$$\gamma = \frac{1}{\sqrt{1-\beta^2}} \quad .$$

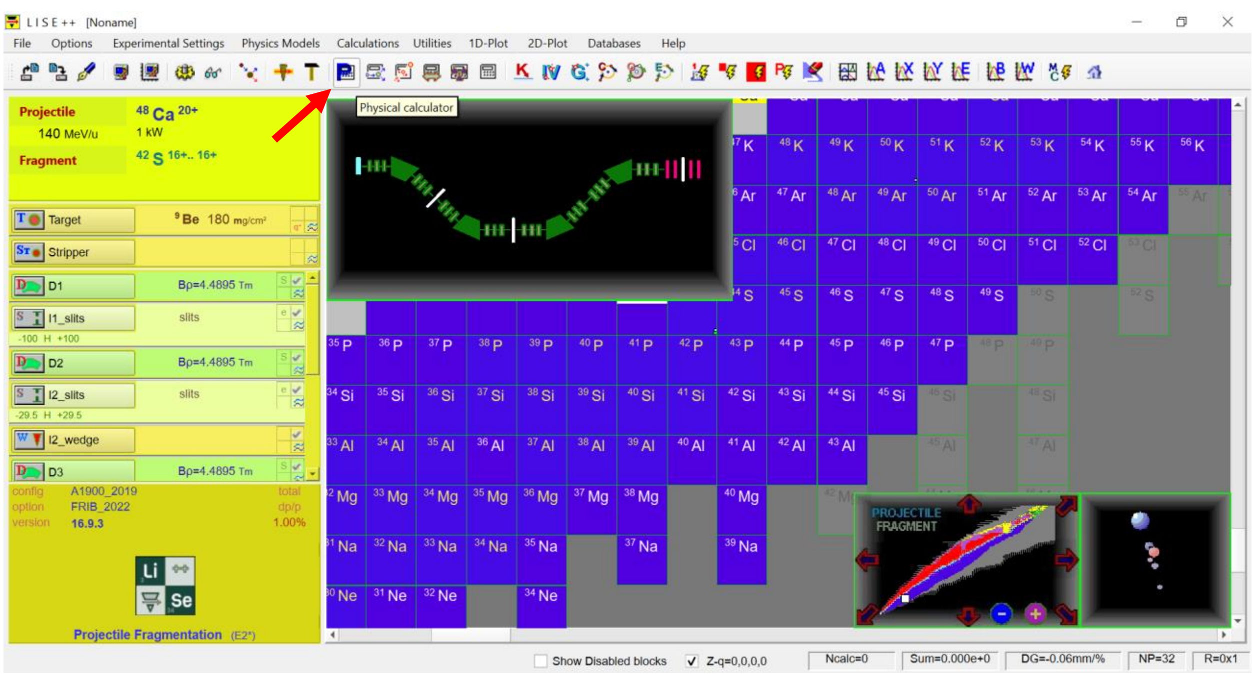
The following guideline describes how to evaluate the magnetic rigidity of a nuclear beam using the Physical Calculator of LISE++:

Step 1

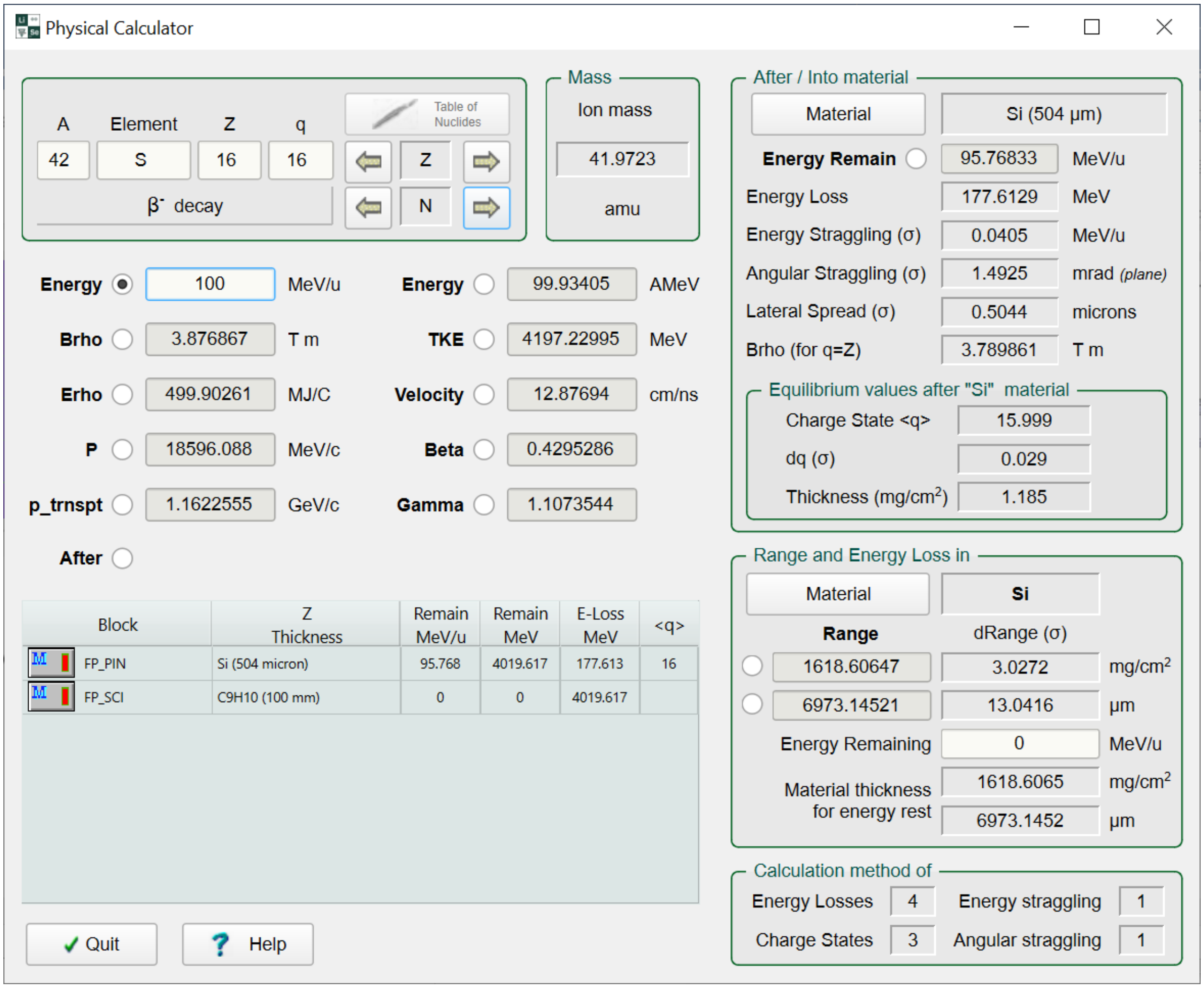
The information required is the energy of the beam provided by ARIS **(ARIS beam)** and the energy of the reaction product after the S800 target **(S800 recoil)** , as well as their mass and proton numbers (**A and Z**), and their charge state **Q**.

Step 2

Open LISE++ and click on the Physical Calculator icon shown in the figure below (see red arrow)

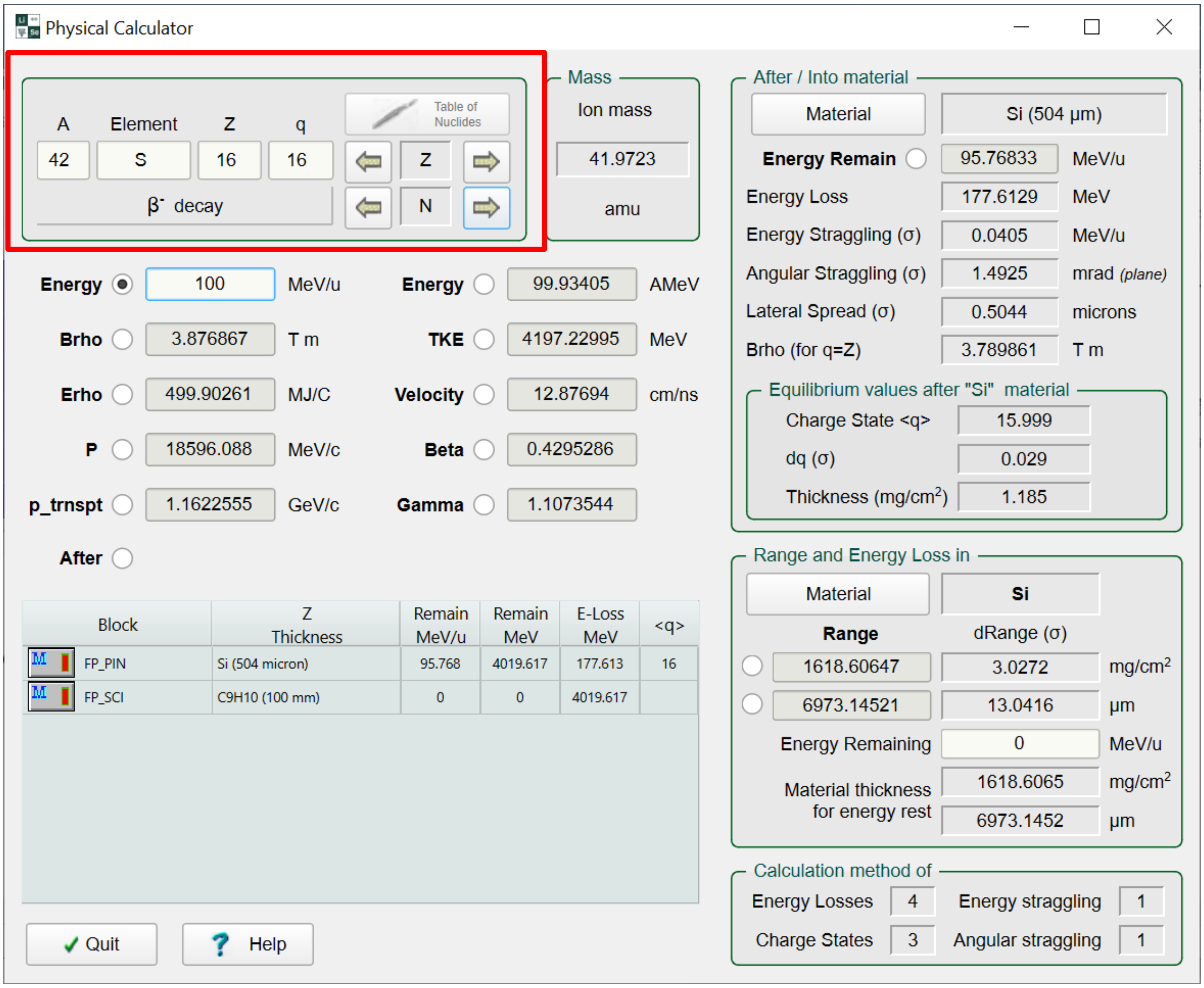


The Physical Calculator window will pop out (see Figure below).



Step 3

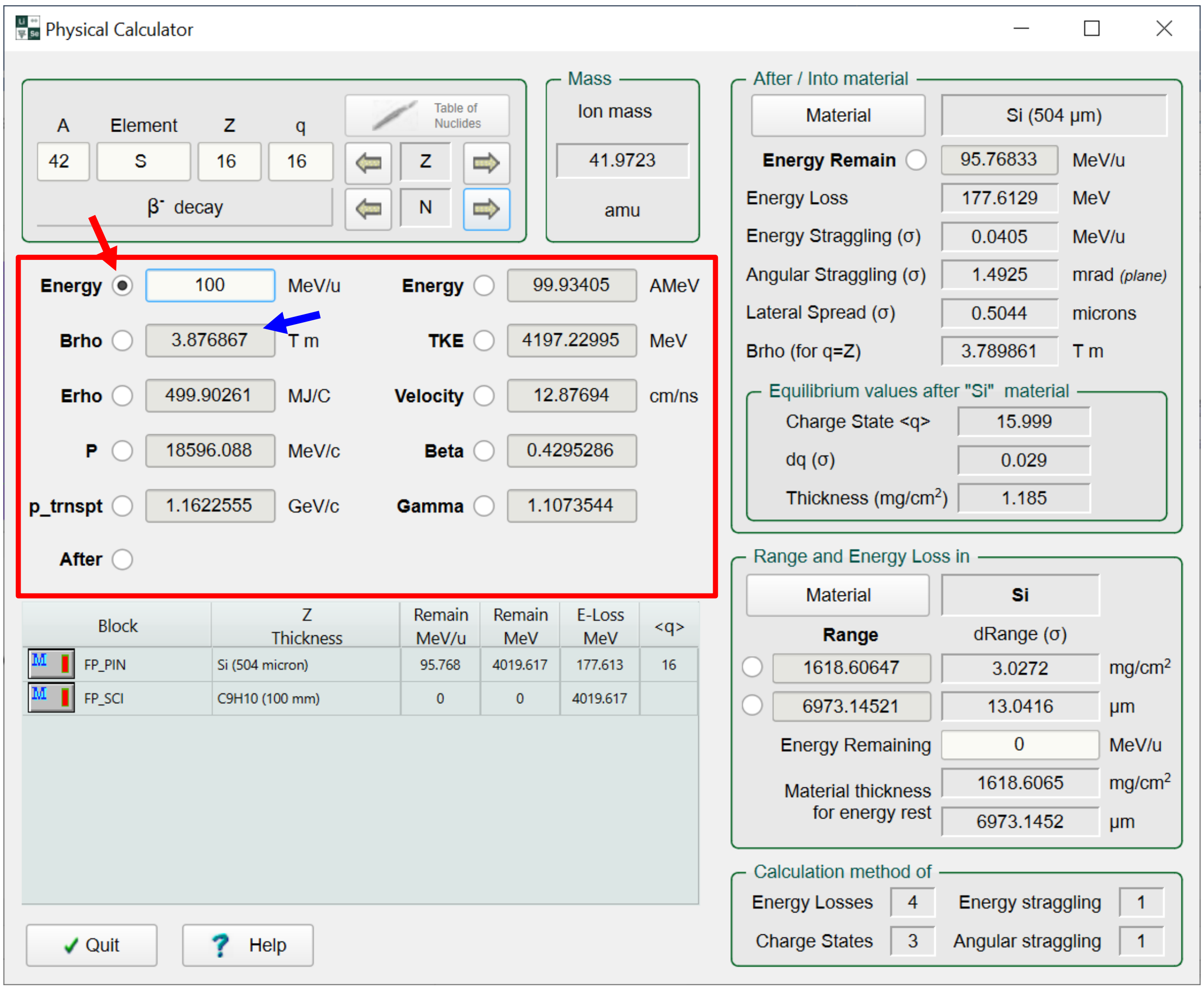
Use the left top region of the window (indicated in the figure below by a red box) and enter the A and Z numbers, and charge state Q (In the example, the nuclear beam is ^{42}S fully stripped (Q=Z=16)).


Physical Calculator
A
Element
Z
q
Table of Nuclides
42
S
16
16
Z
β- decay
N
Mass
Ion mass
41.9723
amu
After / Into material
Material
Si (504 μm)
Energy Remain
95.76833
MeV/u
Energy Loss
177.6129
MeV
Energy Straggling (σ)
0.0405
MeV/u
Angular Straggling (σ)
1.4925
mrad (plane)
Lateral Spread (σ)
0.5044
microns
Brho (for q=Z)
3.789861
T m
Equilibrium values after "Si" material
Charge State <q>
15.999
dq (σ)
0.029
Thickness (mg/cm2)
1.185
Energy
100
MeV/u
Energy
99.93405
AMeV
Brho
3.876867
T m
TKE
4197.22995
MeV
Erho
499.90261
MJ/C
Velocity
12.87694
cm/ns
P
18596.088
MeV/c
Beta
0.4295286
p_trnspt
1.1622555
GeV/c
Gamma
1.1073544
After
Block
Z Thickness
Remain MeV/u
Remain MeV
E-Loss MeV
<q>
FP_PIN
Si (504 micron)
95.768
4019.617
177.613
16
FP_SCI
C9H10 (100 mm)
0
0
4019.617
Range and Energy Loss in
Material
Si
Range
dRange (σ)
1618.60647
3.0272
mg/cm2
6973.14521
13.0416
μm
Energy Remaining
0
MeV/u
Material thickness for energy rest
1618.6065
mg/cm2
6973.1452
μm
Calculation method of
Energy Losses
4
Energy straggling
1
Charge States
3
Angular straggling
1
Quit
Help

Step 4

Use the left middle region of the window (indicated in the figure below by a red box) and select **Energy** by clicking on the checking circle on the (see red arrow). Enter the energy value in MeV/u (in this example 100 MeV/u).

The Physics Calculator will automatically calculate the Magnetic Rigidity "Brho" (see blue arrow) (in this example 3.8769 Tm)



Step 5

Repeat this sequence to calculate all the rigidities of ARIS beams, and select the maximum and minimum values. For contingency purposes, apply a factor +/- 2% to the maximum and minimum rigidities. This range will define the maximum and minimum rigidities needed in the analysis line.

Do the same for all the S800 recoils.