

Profile Physics Programming Tutorial More

Introduction

This tutorial follows the one from Dr. Bazin for a summer school in 2003 at NSCL (<u>link</u>) and the one from Tom Ginter (<u>link</u>). The NIM paper can be found here (<u>pdf, black/white</u>), and the publication on sciencedirect is <u>here</u> (<u>pdf, with color</u>). The LISE++ demonstration here uses version 9.10.280. If you spot mistakes or have suggestions, please feel free to let me know, and I am very appreciative of your help. The goal of this tutorial is to help a beginner, such as me, to get familiar with LISE's GUI and the basic understanding of the procedures. (Date: Aug 31, 2016) (Date: Jan 15, 2018 -- update)

The brief story is that we want to produce 22 Al and study its β -decay. The requirement is 1000 pps (particle per second) for the beam intensity, 80% for the beam purity, and the momentum of 22 Al is small enough to stop in a 100- μ m Si detector. One can also directly jump to Part 8 for a quick guide.

structure

- 1. Select the primary beam and fragment
- 2. <u>Spectrometer setting</u>
- 3. Momentum acceptance setting
- 4. Δ <u>E-TOF identification plot</u>
- 5. Al Wedge setting
- 6. FP_Slits setting
- 7. Adding new block
- 8. Guide from Tom Ginter (Quick guide)
- 9. Barney priout

Part 1: Select the Primary beam and fragment

Before staring any calculation, we should use the latest configuration. menu bar --> File --> Configurations --> Load. Here we select MSU --> A1900_2015.lcn

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W	I2_wedge											
D	D3	Brho 3.2490 Tm										
Ð	D4	Brho 3.2490 Tm										
	1	A1										

Primary beam

Go to http://nscl.msu.edu/users/beams.html, to see what the primary beam options we have.

			•
Α	Element	Energy (MeV/nucleon)	Intensity (pnA)
16	0	150	175
18	0	120	150
20	Ne	170	80
22	Ne	120	80
22	Ne	150	100
24	Mg	170	60
36	Ar	150	75
40	Ar	140	75
40	Са	140	50
48	Са	90	15

PRIMARY BEAM LIST

If we would like to have ²²Al as our secondary beam, it has 13 protons and 9 protons.

Let's try to use ³⁶Ar as our primary beam, which has 18 protons and 18 neurons.

When ³⁶Ar hits ⁹Be, we can create the ²²Al fragment, along with many other nuclei as contaminations.

As listed above for the ³⁶Ar beam, we will have 150 MeV/u as beam energy and 75 pnA for beam intensity.

We input the 36 Ar beam information into LISE.

File	Options	Experiment :	Settings Physics Model	s Calculations Utilities	10-Plot	2D-Plot Data	bases	Help						
<u>e</u>	B 📓	📓 🏟 Set	-Up 🚳 😒 🕂 T	i <mark>Rekise</mark> in	200	1 <u>19</u> 7 1	Py			BIM 74	\$			
Pro	jectile	36Ar18-	PROJECT	ue 🍄 🥖 🎸						1	42Cr 43	Cr ⁴⁴ Cr	46Cr	46
Fra	gment	32 S16+	Beam			1		A second					3	×
To	Target	9E 470	A Element q+	Beameneurov		Emittance (#	1]							-1
Sr 😦	Stripper		🔯 🗛 18	Energy (* 150	MeV/u	? (sig	leam CARI ma, semi-a) 1D - shape ids, (Distribution	2D mode	2D - shape (Monte Carlo	Correlated with	mm 🔎	⊂ cm	
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-1	D2	Br	Table of	U ⊂ 2.9965e+5	KV	3.Y mm	1	Gaussian	-			dY 0	mm	
ST	12 sits	3.2490 sli	C Z D	Beam intensity		4. P mrad	8	Gaussian				dP 0	degrees	
-25	5 11 +25.5			C 1350	enA	6.D %	0.07	Gaussian				dP 0	degrees	
w¥	12_wedge		V Ok	• 75	pnA									-
D	D3	Br 3.2490	Y Cancel	0.405	KW	Energy L	oss in the	0.05327	BFfm	equency 20	MHz	Beam Sigma Vec	tor (#2) used fr	or
D	D4	Br) 3.2490				target	DOX [KW]		Bunc	hlength 1	ns	Optics Optimization	in ("Opt.Beam	ŋ
M	FP_PPACI	0 A1	ngion 2								8		8	

Then setup the fragment as ^{22}AI .

File	Options	Experiment Settings	Physics Models	Calculations	Utilities	1D-Plot	2D-Plot	Databases	Help
<u>e</u>	B	👮 🤲 Set-Up 🔗	🔀 🕂 T		30 🗴		o 😼	8 8 P8	
Pro 19	jectile 50 MeV/u - 7 gment	36 <mark>Ar18+</mark> 5 pnA 22 <mark>Al13+</mark>					μį	Ir.	
T 🔵	Target	⁹ Be 470 morm2	8			~		11	1
St 💿	Stripper		01						
D	D1	3.2490 Settin	n Fragment					×	ì
s II	11_slits	slits	gringman				ne states		
-10 D	D2	Brho 3.2490 Tr	A Element Z 22 Al 13	/ Tab	ole of iclides	13+	D1	Set	
S ∏ -29.	12_slits	slits	Beta+ decay		11		Ok 3	Cancel	
WŦ	I2_wedge		II.						

We have calculate the 9 Be optimal thickness for producing 22 Al when using 36 Ar as the primary beam. (how many 22 Al ions will be created and pass through the 9 Be)

At the menu bar --> "Calculations" --> "Optimum Target"



I use the default options "no keep value".



key in the $^{\rm 22}{\rm AI}$ information again.

Choose Fragment	? ×
A Element Z 22 Al 13 Beta+ decay Target optimization options	Charge states Set 13+ D1 calculate a charge state combination for the maximum rate
use the contribution of secondary reactions	Cross sections Fixed C Energy dependent
V Ok Cancel	

We will see a plot with x axis is the thickness any y axis is the rate The optimal thickness is 1070.5 mg/cm^2 , and we have 1.23×10^3 for the 22 Al ions. Next, we return the optimal thickness value to LISE, just click the icon on the left.



Part 2: Spectrometer setting

After setting up the primary beam, fragment, the ⁹Be thickness, then we should tune the spectrometer. Just click the following button, and we will use this button several times.



At the left hand side, there is a panel show the parameters of the spectrometer. By default configuration of A1900 spectrometer, the Aluminum wedge thickness is zero. It results in magnetic rigidity B_{ρ} for dipole magnet D1, D2, D3, and D4 is the same.

D1 D1	Brho 2.5364 Tm
S I I1_slits	slits
D2 D2	Brho 2.5364 Tm
S 12_slits	SIIIS
V I2_wedge	
D D3	Brho 2.5364 Tm
D4 D4	Brho 2.5364 Tm

Note: $B_{\rho} = = \frac{momentum}{charge}$, a quantity to describe how stiff when we want to turn the beam.

²² Si	²³ Si	²⁴ Si	²⁵ Si	²⁶ Si	²⁷ Si
1.25e-3 0.002%	1.67e+1 1.377%	1.45e+3 6.602%	6.74e+3 1.605%	1.93 c+4 0.226%	
	²² AI	²³ AI	²⁴ AI	²⁵ AI	²⁶ AI
	1.22e+3 5.118%	8.59e+3 2.011%	2.88e+4 0.359%	9.74 c+ 4 0.075%	
²⁰ Mg	²¹ Mg	²² Mg	²³ Mg	²⁴ Mg	²⁵ Mg

use the mouse to double right click the nuclei in the chart.

For observing the yield (total events) and the transmission efficiency in %,

part 3 : Momentum acceptance setting

The goal is to change Image2 (I2_slits) setting to adjust the dp/p such that 22 Al beam range of spreading in detector within 100 μ m. So we will image that the FP_PIN detector, which is a silicon detector, is thick enough to stop all the 22 Al ions, and the proper I2_slits setting can let the range of the 22 Al ions within FWHM $\approx 100 \mu m$. So let's use "Goodies" to calculate the 22 Al ion's range in a silicon detector after magnetic dipole D4.

```
menu bar --> "calculations" --> "Goodies".
```

File	Options	Experiment Settings	Physics Models	Calculations
	Goodies	6 ·····		
	Calibrations			
	Transmissio	n and rate		*
	Optimum T	arget		
	Optimum T	arget-Wedge and Wedg	ge-Wedge configur	ations
	Brho scanni	ng		
	Optimum cl	harge state combinatio	n	
	Monte Carlo	calculation of transmi	ssion	٠
	Calculators			

select the "D4" options

We get the thickness around 5767 μ m.

	AFTER	INTO
A Element Z	Energy 102.58 MeV/	u
22 AI 13	sig.(Energy) 0.495 MeV/	u Energy Loss MeV
Beta+ decay	Brho 2.5362 Tm	sig.(Energy Loss) MeV
- Table of	Energy Straggling 0 MeV/	u Energy Straggling MeV/u
Nuclides	Angular Straggling 0 mrad	Angular Straggling mrad
	Velocity 13.018 cm/ns	Loss due to reactions
	Beta 0.4342	in this material [%]
arge states	Rest after reactions 100 %	
	L atter D4	Time of Flight
<u></u>		Start of TOF Target
** • • 1	Range to Si	Stop of TOF FP_PIN
X Quit	1338.612 mg/c	m2
🗐 Print	3700.000 PM	
	Energy Loss to Si 100 micron	sig(ror) 0.734 ns
Y Help	22.588 MeV	Length J 35.643 m

Next, we set the thickness of PIN detector at the Focal Plane to 6000 μ m, allowing to fully stop 22 Al.

I2_wedge	Brbo	FP_PIN		
D3 D3	2.5364 Tm Brho 2.5364 Tm	Si Density 2.321	State Dimension	Angle
M FP_PPAC0	Al 2 mgrcm2 Al	in this material	Gas g/cm2 & micron	0 degrees
S FP_slits -25 7 +28 -25 7 +28	2 marca2 slits	Z Element Mass IF 14 Si PT 28.086 IF 14 Si PT 28.086	Thickness at U degrees Filter F	ective Thickness 6000 micron 1392.6 mg/cm2
M FP_PIN	Si 6000 m cron C9H10 100 mm		Set the spectrometer after this block using changes	Atoms / cm2 2.99e+22
config: A 1900_2015 option: A 1900_2015 version: 9.10.280	dpip 1% tatat	Compound dictionary	General setting of block	Calibration Resolution Thickness defect
		Cancel		17 _F 18 _F

Let's check the range distribution plot of ²²Al in the PIN detector. menu bar --> "1D Plot" --> "Range distribution".



By click the button on the left-hand side, we find the FWHM is around 267.2 μ m. This is the current value, and we will change the "I2_slits" to make it $\approx 100 \mu$ m.



Adjust the Image2 (I2_slits)

I2 slits are horizontal slits at the dispersive focal plane, it is to change the momentum acceptance $\frac{dp}{p}$. Its default horizontal slits are set to \pm 150mm (fully open), and let we change it to 7. And we can see the $\frac{dp}{p} = 0.24\%$ now. Redo menu bar --> "1D Plot" --> "Range distribution", we can see the FWHM \approx 100 μ m in the 1D range plot.

Projectile ³⁶ Ar ¹⁸⁺ 150 MeV/u 75 pnA	12_slits	
Fragment ²² AI ¹³⁺	ANGULAR ACCEPTANCE // //2_slits" block : Apertures (throughout), Slits (after)	
Toget ⁹ Be 1070:48 mg/cm2	Shape	? Help
St Stripper	C Rectangle (aperture) (aperture) (aperture) (150 mm) (150 mm)	
D1 Brho 2.5364 Tm		
S II I1_slits	APERTURES SLIS	Top limit
D D2 Brho 2.5364 To	Vertical ± 1000 mrad	(aperture) 150 mm
S 12_sits Sits	Solid angle 2888.37 msr C Rectangle Horizontal Slit	T slit: 13
W 12_wedge	Comjointly V Use in Calculations C separately Show in schematics	
D3 Brho 2,5364 Tm	dispersion Use in Calculations	: :
D4 Brho 2.5364 Tm	x'-momentum(%) 100 E Horizontal	민구미
M FP_PPACO AI 2 mg/cm2	(accept,/disp) / Use in Lalculations	:T:
M FP_PPAC1 AI 2 mg/cm2	Vertical plane	1 1
S FP_slits slifs	Horizontal plane Vertical plane Vertical plane Vertical plane Vertical plane Vertical plane	2121
-25 V +25	[mrad/%] uspersion (min/%) uspersion (min/%) uspersion (min/%)	B slit: -13
FP_PIN 51 6000 m cron	(accept/disp.) 100 settings. x-momentum[%] y-momentum[%]	Bottom limit (aperture)
M FP_SCI C9H10	uses only "Rectangle" total 2,71 total 100	-150 mm
config: A1900_2015 dp/p option: A1900_2015 2.71% version: 9.10.280 cm	V OK Cancel	- vertical -

Now we done with our momentum acceptance setting, we should reset the thickness of "FP_PIN" detector, so that it would not stop the 22 Al beam anymore. Let's use 300μ m.



Part 4 : ΔE -TOF identification plot

Before having the plot, we need to calculate the transmission and rates, and then we can have data to plot. menu bar --> calculations --> transmission and rate --> all nuclei.

Of course, we can manually "double right click" the elements in the chart to do the calculations. then menu bar --> 2D Plot --> Plot dE-TOF.

Options Experiment Settings Physics Models Calcu	lations l	Utilities 1D-Plot 2D-Plot Databases Help		Plot dE-TOF
Goodies	h		3	Plot TKE-TOF
Calibrations	M		<i></i>	Plot dE-TKE
			2	Plot dE-dE2
Transmission and rate		One nucleus	105	Plot dE-X
Optimum Target		Area of nuclei		Plot dE-Y
Optimum Target-Wedge and Wedge-Wedge configurations	•••••	All nuclei		Plot TKE-X
Riho scanning		Drevious calculated area		Plot TKE-Y
uno scanning		Frevious calculated area		Plot TOF-X
Optimum charge state combination		Transmission statistics dialog		Plot TOF-Y
Monte Carlo calculation of transmission		Statistics of Fragment Production in Material (Wedge)		Plot X-Y
				Plot X-X2
Calculators	•	Clear all rate calculations		Plot Z-A/Q
11_SALS		Clear rate calculations of selected nucleus		Plot Z vs A-20
00 H +100 E		Clear All AA FR FF CF AF, and Sec React calculations		Plot Z vs A-30
Brho		cical All Ary repairs and accilicate calculations		Plot Range-X

The result will look like the following figure.

Y axis is the energy loss in FP_PIN detector (300 μ m Si detector),

X axis is the TOF is the time of flight from target to FP_PIN in ns.



We can Run the Monte Carlo simulations, by press the upper right button. One of useful thing is to do the channel calibration.



The rest of our jobs is to get rid of these unwanted contaminations in the secondary beams.

Part 5: AI Wedge setting

To eliminate or reduce the contaminations in the the secondary beams, one good idea is to use an achromatic wedge at the dispersive plane of the fragment separator. Because each nucleus will loose a different amount of energy in that wedge (Aluminum). Before setting the thickness for the Al wedge, we need to have some reference to know how good or bad our setting is, so we will use B_{ρ} selection plot.



menu bar --> 1D Plot --> Brho selection plot.



The results are like the following graph, x axis is B_{rho} and y axis is yield (in log scale). The red line is for ²²Al.

According to Dr. Bazin, a good rule of thumb is to set the wedge thickness to roughly 20% of the total range of the desired fragment. So I think that is the 20% of the total range for a 22 Al in the Aluminum. Again, we can use Goodies to calculate its range. And I select after I2_slits. (This part I am not 100% sure). The calculations show the range around 5110 μ m, and 20% will be 1022 μ m.



So let's set the thickness of wedge. And then we need to press the button of "Set the spectrometer after this block using changes". Then check the box of wedge profile, then press the button of calculate angle.

S I 11_slits	slits	12_wedge		
-100 H +100 D2 S 1 12_slits -7 H +7	Brho 2.5364 Tm slits	Al Density 2.702 Calculate reactions [g/cm3]	State Dimension Thickness defect (!!) Image: Solid Image: Solid Image: Solid Image: Solid Image: Solid Image: Solid	Calculate the Wedge thickness from Previous & Next optical blocks for the setting fragment
V I2_wedge		Z Element Mass		this block using changes
1 12 03	Brho 2.5364 Tm	17 19 AL PT 26.982	Position thickness 1022 micron	+7 d/R = 0.2
D D4	Brho 2.5364 Tm		276.1444 mg/cm2 1026.21 thickness, micron	1017.79 Atoms/cm2 = 6.16e+21
M FP_PPACO	Al 2 mg/cm2	□ <u>14</u>		
M FP_PPAC1	AI 2 mg/cm2	L 14	C Wedge profile Angle (mrad) -0.6016	Galculate angle
S FP_slits	slifs	Compound dictionary	C Homogeneous	
-25 17 +25	C1	General setting of block	Curved profile = internal profile =	Gurved profile dialog
FP_PIN	300 m cron		C Custom shape no current profile!	Gustom shape dialog
FP_SCI	100 mm -			

In the popping out window, press the "Fix". (The GUI seems different)

Wedge degrader in dispersive focal plane

 × (horizontal) 	Block WEDGE					
C Y (vertical)	Degrader Profile Wedge degrader					
	Setting fragment 22Al13+					
Tode Choose the block: to calculate an angle for the setting mode after it	-7 < slits(mm)> +7 -130.65 <angle (mrad)=""> +130.65 min max</angle>					
D4 💌	For the central trajectory					
ada Miladaa ayada (ayad)	Thickness Al (1022 micron)					
Achromatic -0.66 Fix Monochromatic -2.75 Fix	Energy before the degrader 102.59 MeV/u Energy after the degrader 90.23 MeV/u					
C Fixed in the code 0.5519	Dimension of wedge angle distributions (default 16) 32					
I o plot a dependence from angle	Wedge angle calculations from formulae (mrad)					

We can see a new wedge icon appears, and then we press the button to re-calculate the spectrometer setting.





Re-plot the ΔE -TOF plot, we will see the difference.

Part 6 : FP_slits seting

As being mentioned in part 4 to tune the "I2_slits" for momentum acceptance, we can also tune the "FP_slits" to do wedge selection for only allow our interested fragments to come through. So let's see the wedge selection plot first. Make sure you have done "transmission and rate" calculation. menu bar -> 1D-plot -> Wedge selection plot.



The result is the following graph. The x axis is the fragment position and y axis is the yield.





Now I set the horizontal opening of the slits to 17mm .



Then we re-run the "transmission and rate", and then re-plot "wedge selection plot" to check our setting. Note: the graph is in the log scale.



Part 7 : adding new blocks

The next thing to improve our beam is to add a Wien filter and a compensating dipole (for re-focusing) before the "FP_PIN" detector, in order to separate the isotones.

menu bar icon-> set-up -> check "FP-PIN"

And then insert the "Wien velocity filter" and " compensating dipole".



After adding the new block, we set the Electric filed to the "Wien velocity filter"

The E field is in the y direction. Now the fragments will have some y-direction deflection after the Wien filter, and hence we can close our slits of compensating dipole to allow 22 Al to pass.

D1	Brho 2.5363 Tm		
S [] 1_slits	slits	Wien 1	-?- <mark>-</mark> -×
D2	Brho 2.5363 Tm	Wien Velocity Filter settings	Optical block properties and data
8 ∏ 2_slits	slits	C Dispersion (SECAR) 0.000 mm/%	Section-Element construction property S-block (Section) • • E-block (Element)
₩ ▼ I2_wedge	Al 1022 m cron	Electric field E = 3000 KV/m Gauss	Setting Charge state Calculate the Values using
D3	Brho 2.3711 Tm Brbo	/	Tor the Block (2-4) i the Setting fragment from
D4	2.3711 Tm	Filter settings correspond to a Bhro-value for the setting fragment	Optical matrix Next
FP_PPAC1	Al 2.rg/cm2	Separation velocity plane Bending direction	General setting of block
-17 H +17 -25 V +25	stits	Horizontal (VAMOS) O Vertical (LISE3) Counterclockwise	Calculate other optic blocks
Wien 1	0 KV/m В 0.01 G DL 0 mm/%	Filter constants Dispersion coefficient 4.8139e-4 Wien filter	6 Utilities
FP_PIN	Si 300 m cron	Electric & magnetic effective Block (total)	10 "Classical" solution for
FP_SCI	C9H10 100 mm	OK X Cancel 7 Help	
anfig: A1900_2015 ption: A1900_2015 ersion: 9.10.280	dbib 0.24%		

Let's see the fragments into the compensating dipole.

By 1-D plot, then select "Block selection distributions", and then "compDip1".



The results are following. Check the Y-space graph in the middle since our E field is in the y direction. Next thing is to close the slits to proper length. Its process is very similar to closing the I2_slits or FP_slits, and hence I skip this demonstration.



Quick guide

This demonstrate here follows from the guide written by Tom Ginter. The main point here is to set specific beam energy. The main difference is the order of "9Be target thickness optimization" and "AI wedge thickness". Here we set the thickness of the AI wedge first, then optimize the thickness of 9Be target.

For convenience, we keep discussing the same $^{22}\mbox{Al}.$

(1) set 36 Ar for the projectile and 22 Al for fragment.

(2) click I2_slits and set 800 mg/cm^2 for AI wedge.

Note: according the guide, for $1 < Z_{fagment} < 15$, use 800 mg/cm^2 for Al wedge.

🕶 L1	SE++ [Noname]						
File	Options	Experiment Setting	s Physics Mor	lels Calculations	Utilities 1	1D-Plot 2D-F	Plot Databases	Help
c	B	😰 🌐 Set-Up	sel 🔽 🕂	1 🖬 🗐	98 🕅		🥳 😼 🗗 Pe	
Pro 1 Fra	i <mark>jectile</mark> 50 MeV/u Igment	³⁶ Ar ¹⁸⁺ ^{75 pnA} ²² Al ¹³⁺		CTILE MENT			H IAR	
To	Target	*Be 470 mg/cm2		Contraction of the local distance			17 111	H IN
St 💿	Stripper			JIL.	.			
D	D1	Brho 3.2490 Tm						
S ∏ -1	11_slits	slits						
D	D2	Brho 3.2490 Tm						
s I	l2_slits	slits						
w y	I2_wedge	Al 800 mg/cm2	ster	02				
D	D3	8rno 3.2490 Tm						22 5;
D,	D4	Brho 3.2490 Tm						
M	FP_PPAC	0 Al 2 mg/cm2	2					
M	FP_PPAC	1 Al 2 mg/cm2	2					
s I	FP_slits	slits						
	25 H +25 25 V +25							²⁰ Mg
M	FP_PIN	Si 513 m cron						
M	FP_SCI	C9H10 100 mm	•					
config option	A1908_20 A1900_20	15 dp. 15 19	9 %					
versio	n: 9:10.280							17No 18No

Suppose we want 40 MeV/u for our beam, which is the energy after magnetic dipole D4.

(1) We call "physical calculator" to convert MeV/u to magnetic rigidity (momentum/charge) in the unit of Tm. And then (2) Copy this number to D4.

rite options experiment settings i	nysics models calculations officies 10-Piot 20-Piot Databases	neip
🖆 🔁 👿 🥵 Set-Up 🚳	<u> + T B</u> ZSIQB <u>N</u> 700 <u>856</u> 79)	
Projectile 36 Ar18+ 150 MeV/u 75 pnA Fragment 22 Al13+ To Target 8Be 470 movers2 470 movers2	PROJECTILE FRAGMENT	
Stre Stripper	A Element Z Q	after/into Si 513 micron
D1 Brho 3.2490 Tm S II 11_sits	22 Al 13 13 Image: state stat	Energy Remain C 27.9857 MeV/u Energy Loss 264.46 MeV
-100 # +100 E D2 Brho 3.2490 Tm	Energy • 40 MeV/u Energy • 40.0226 AMeV	Energy Strag.(sigma) 0.070814 MeV/u Angular Strag.(sigma) 6.5125 (plane)
S I2_sits slits -25.5 H +28.5 W I2_wadas AI	Edite C 132.853 MJ/C Velocity C 8.5139 cm/ns	Lateral spread (sigma) 0.36705 microns Brho (for Q=Z) 1.2993 Tm
D3 2.9570 Tm	p_tmspt 0.467167 GeV/c Gamma C 1.042942	Equilibrium values for material "Si" Charge State <q> 13 dQ (sigma) 0.04</q>
D4 Brho 1.5583 Tm M FP_PPAC0 AI	Energy Remain E-Loss Block Z \ Thickness MeV/u MeV (Q) Model CD DIN CE512 minute 27.000 CE0.02 264.40 10.00	Thickness 0.44252 mg/cm2
FP_PPAC1 Al 2 mg/cm2	FP_SCI C9H10100 mm 0 0 616.03 0.00	Range and Energy Loss to Si
S II FP_slits Slits -25 H +25 -28 V +25		Hange dHange (sigma)
M FP_PIN Si 513 m cran		Energy Remain. 0.000 MeV/u
100 irim + config: A1900_2015 dp.p option: A1900_2015 1%		Material thickness 259.18 mg/cm2 for energy rest 1116.6 micron
rension syldi280 form		Calculation method of Energy Losses 2 Energy straggling 1
	Print Y Help X Quit	Charge States 3 Angular straggling 1

ps. the D4 is good approximation, maybe in your beam line, you have some other stuffs (ex. object scintillator) which can reduce your beam energy. The NSCL beam physicists will tell you more. Your LISE++ calculation can provide a preliminary simulation.

Now, (1) run the target thickness optimization, and

(2) keep to D4. Copy the optimal thickness to the target. Then,

(3) run rigidity calculation (to tune rigidity).



YOu can further play around the horizontal FP_slits. ± 25 mm is is appropriate for experiments taking place at the A1900 focal plane, and ± 25 mm is appropriate for simulating rates. You can make the slit opening smaller, then you have smaller momentum spread (dp/p).



Just for checking. We should not have an appreciable correlation between position and total kinetic energy. To check it (1) 2D-plot -> Plot TKE-X (2) run Monte Carlo.

If the correlation appears, we need to adjust the wedge (its angle).



For example, let try to mess up the setting, for example set the angle to -5.

T 🕘 Target	⁹ Be 1343.9 mg/cm2		11 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
ST Stripper		12_wedge		
D1 S II I1_slits	Brho 2.3502 Tm slits	Al Density 2.702 Calculate reactions in this material	State Dimension Thickness defect (II) © Solid © mg/cm2 & micron © % 0.3	Calculate the Wedge thickness from Previous & Next optical blocks for the setting fragment
-100 H +100	Brho 2.3502 Tm	Z Element Mass	C Gas C g/cm2 & mm C micron 8.8823	Set the spectrometer after this block using changes
S [] 2_slits -25.5 H +25.5	AI	Image:	Thickness at 0 degrees C 2960.7698 micron 800 mc/cm2 839.85 thickness mc/cm2	+29.5 d / R = 0.746
D3 D3	Brho 1.5622 Tm Brho		Pegrader profile	
M FP_PPAC0	Al 2 ingion2	Compound dictionary	C Homogeneous	
FP_PPAC1 S I FP_slits -7 8 +7	Al 2 mg/cm2 slits	General setting of block	Curved profile = internal profile = Custom shape no current profile!	Curved profile dialog Custom shape dialog
-25 V +25				

Then we see the correlations between position and total kinematic energy.



note:

The parameters we frequently change are:

(I) AI wedge thickness (angles),

(II) I2_slits and FP_Slits setting,

(III) Be 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 limit of 5%) but scarifies the 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.

Barney printout

The NSCL Barney printouts are the beam setting data, and they are available at here.

The following is an example from the beam line to the S3 valut with the S800 spectrograph. We can see the rigidity setting for each beam line segment. These are real setting, not the simulated ones. The last one, Set 8, is the rigidity setting inside the S800 spectrograph. It is usually optimized for the recoils after the reaction of experimentalist's interest. The rigidity in Seg 7 should be the beam energy before the target.

Bear	n:	86 Kr 14+	9	.37 MeV/1	nuc	(K500)	34+	100 Me	//n	uc (K1200)	Ch	npr off	
<at< td=""><td>t</td><td>10k> ECR</td><td>, Ap</td><td>ertures:</td><td>SU</td><td>SI 150</td><td>0.0;</td><td>15.0; 15</td><td>. 0</td><td>mm SHVBI:</td><td>19.</td><td>8400 kV</td><td></td></at<>	t	10k> ECR	, Ap	ertures:	SU	SI 150	0.0;	15.0; 15	. 0	mm SHVBI:	19.	8400 kV	
K500) a	,b: 59	7 A,	499 /	A K	1200:	671	A, 63	2 A	RF: 20.2	379	90 MHz	
		A1900 Op	tics	: L1953I	Fo	cus60x30	.dat	a		•			
		Rigidity		Field		Radius		(live)	D	ifference	(Fj	ield*Radiu	ls)
Seg	0:	3.73427	Tm										
Seg	1:	2.40800	Tm	0.77889	Т	3.09161	m	3.09158	m	0.00084	%	(2.40802	Tm)
Seg	2:	2.40800	Tm	0.77844	Т	3.09327	m	3.09336	m	-0.00267	%	(2.40794	Tm)
Seg	3:	2.40800	Tm	0.77974	Т	3.08818	m	3.08821	m	-0.00100	%	(2.40798	Tm)
Seg	4:	2.40800	Tm	0.77970	Т	3.08819	m	3.08837	m	-0.00580	%	(2.40786	Tm)
Seg	5:	2.34690	Tm										
Seg	6:	2.34690	Tm										
Seg	7:	2.34690	Tm										
Seg	8:	2.30271	Tm										

The rigidity changes between seg 4 and 5, since there is a plastic scintillator there (called XFP) so that the beam energy changes. Meanwhile, there could be another plastic scintillator between Set 5 and 6 (call object scint.). We can put the rigidity at Seg 4 into the D4 value in the LISE++.

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