The new FRIBs solutions

Preliminary study and simulations

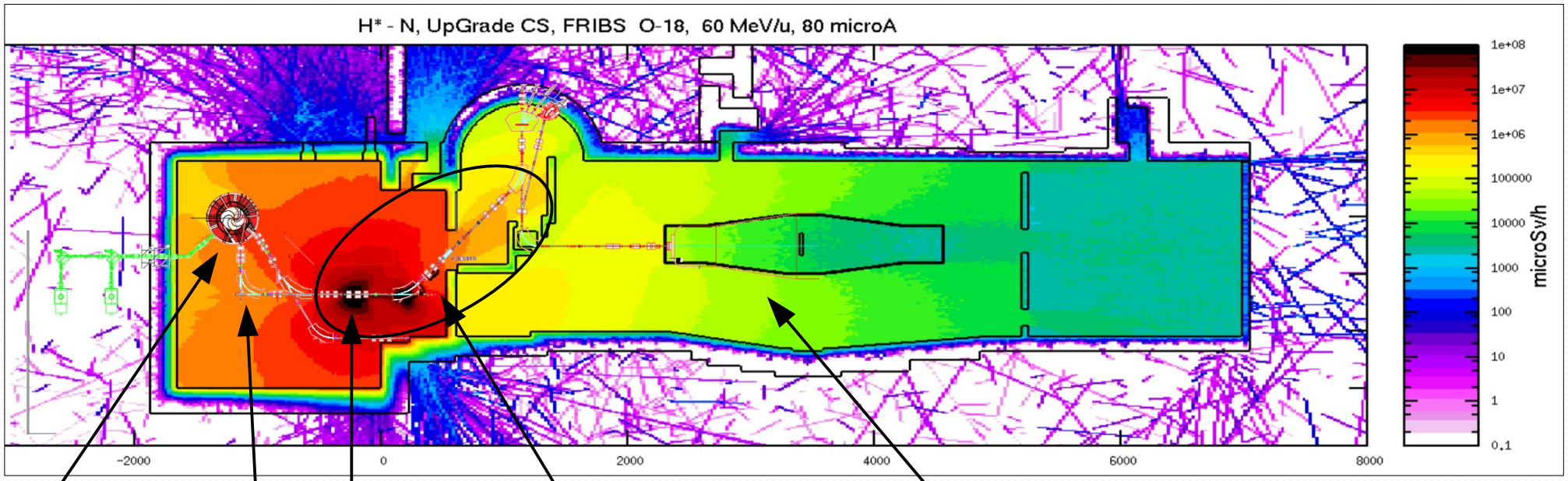
The first one-day workshop on “High Intensity cyclotron Beam” @ INFN-LNS

Catania, 14-15 December

Russo Antonio Domenico

Overview

In the perspective of superconducting cyclotron upgrade that will increase the beam ion power, a radioactive protection problem about the existing set-up of FRIBs facility arises at INFN-LNS of Catania. For this reason it is necessary to move the FRIBs equipment to another laboratory area.

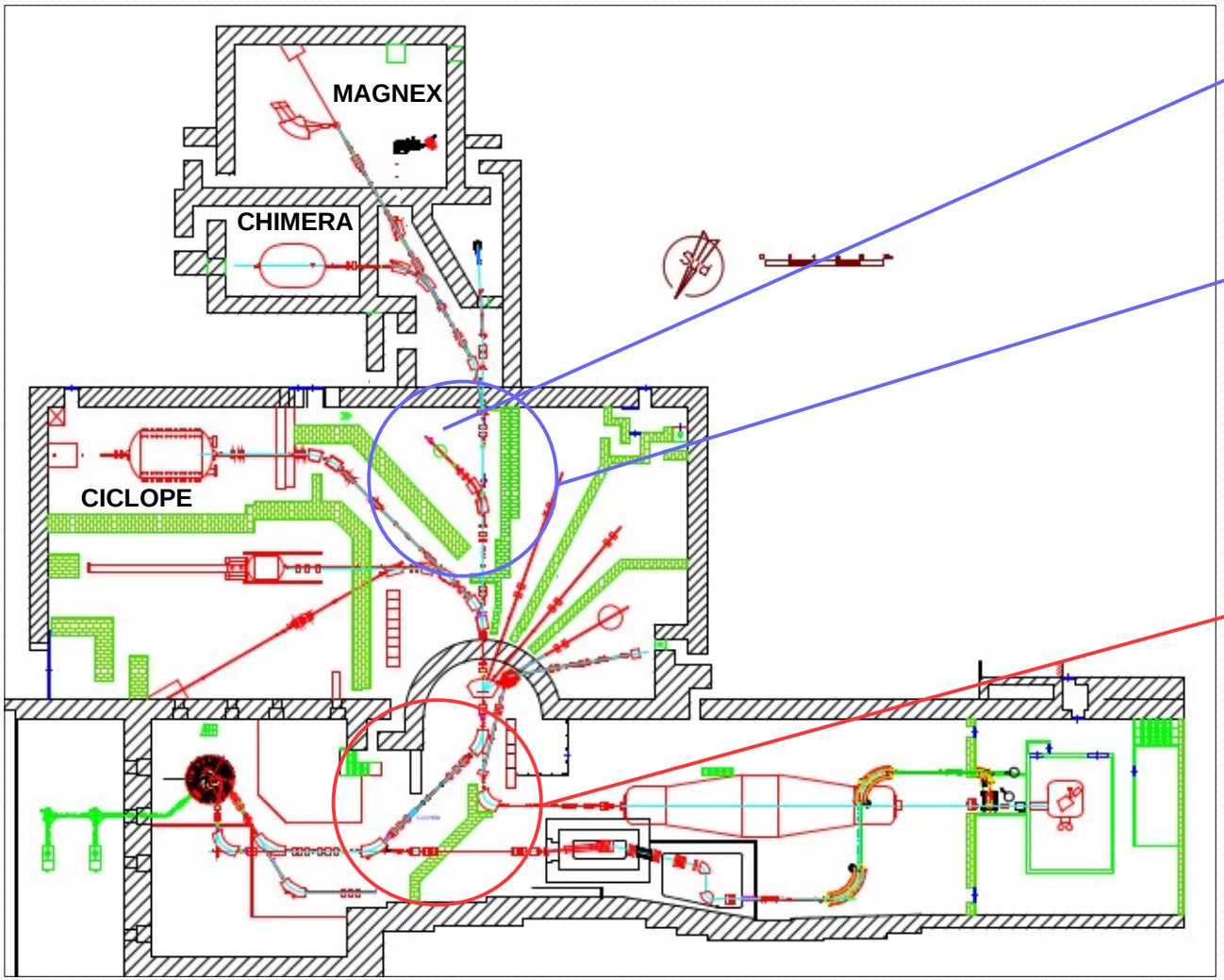


Courtesy of S. Russo

Summary

- Analysis of the available spaces at LNS;
- Beam line performance evaluation;
- Radioactive beams study;
- Conclusions.

LNS Layout



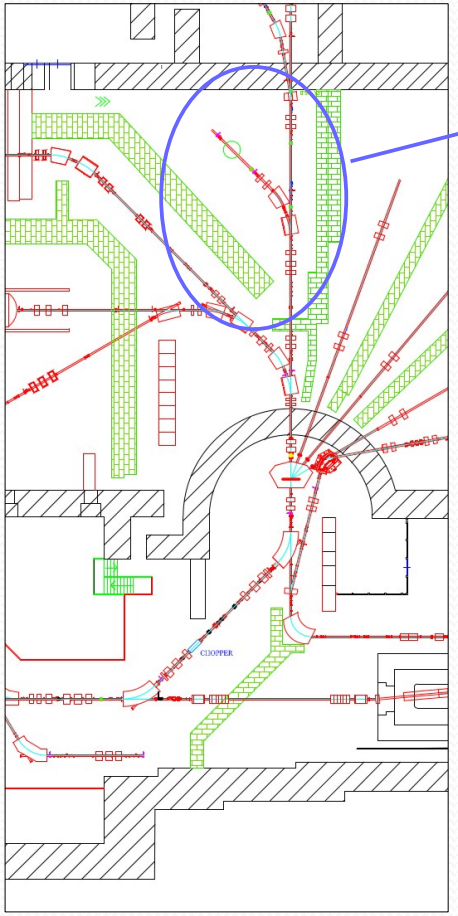
Zero degrees hall

New FRIBs area:
It is far to accelerators;
It is easier
to protect this area.

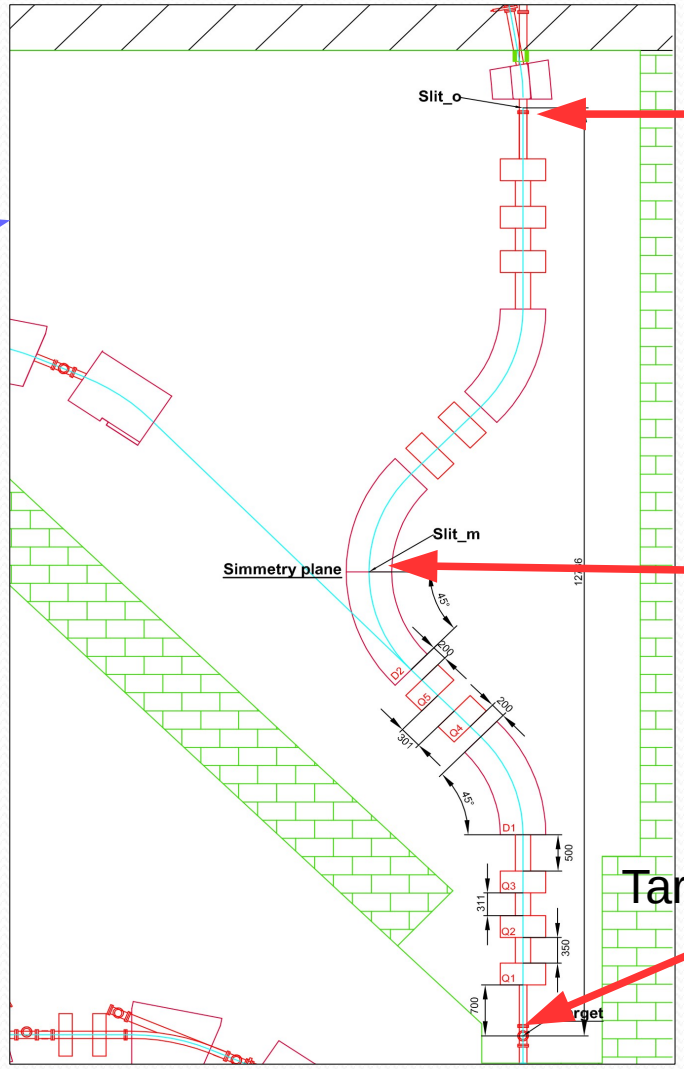
Existing FRIBs area
Increasing the beam
powera radio-protection
problem arises in this area

Transport line

New possible location for FRIBs



New FRIBs LINE



Output Slit

The new FRIBs solution consists in:

- 2 - triplets
- 2 - doublets
- 2 - 45° dipoles
- 1 - 90° dipole

Degrader inside the 90° dipole

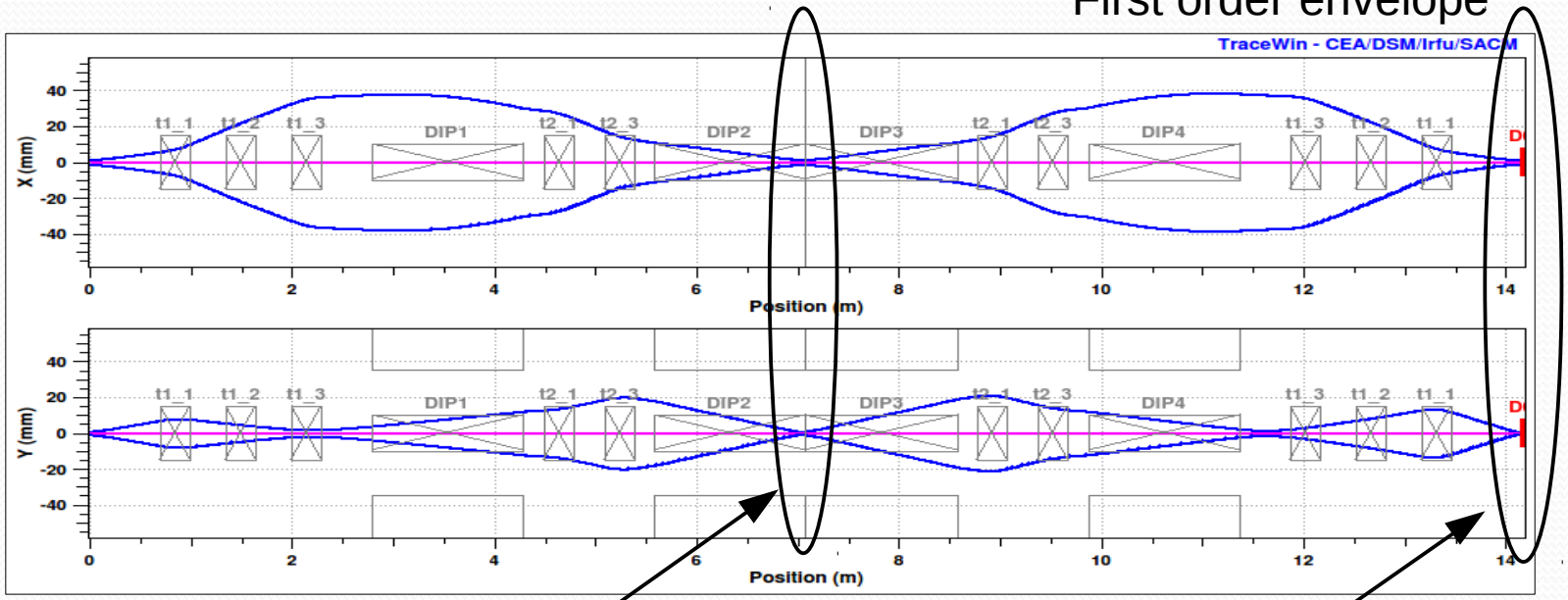
Target where fragmentation occurs

Study at the first order

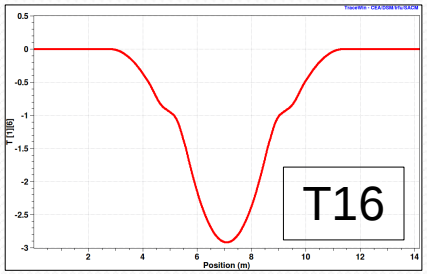
Reference beam

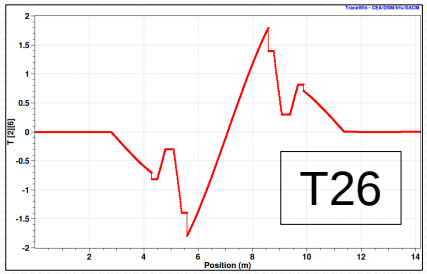
$^{20}_{10}Ne^{+10}$ @40AMeV

First order envelope



Matrix element trend





Symmetry plane-degrader

x [m]	-1	0	0	0	0	-2.9172
a [rad]	-1	-1	0	0	0	0
y [m]	0	0	1	0	0	0
b [rad]	0	0	7.34	1	0	0
z [m]	2.89	2.9172	0	0	1	8.2838
Δp/p [%]	0	0	0	0	0	1

Exit slit

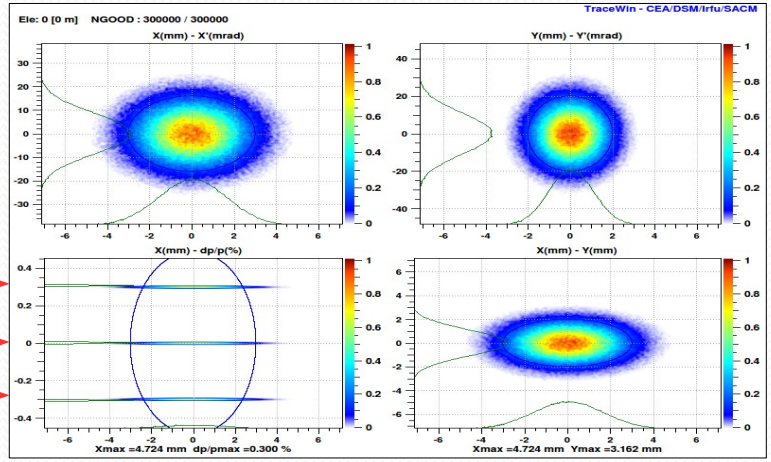
x [m]	1	0	0	0	0	0
a [rad]	2	1	0	0	0	0
y [m]	0	0	1	0	0	0
b [rad]	0	0	14	1	0	0
z [m]	0	0	0	0	1	16.56
Δp/p [%]	0	0	0	0	0	1

Mass Resolving power

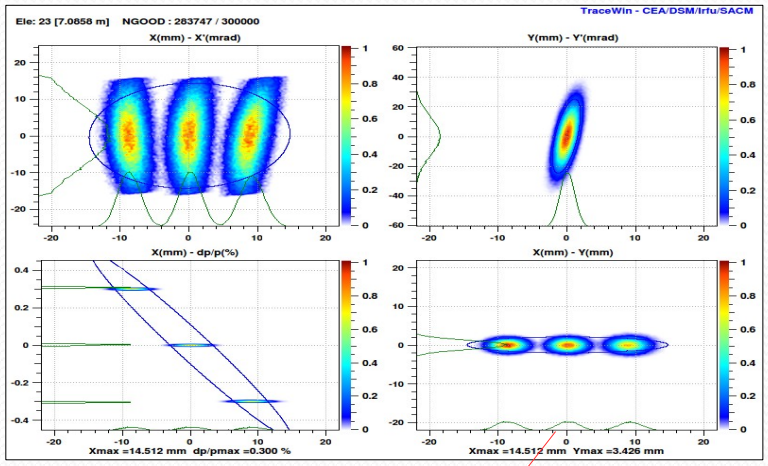
	X plane [pi*mm*mrad]	Y Plane [pi*mm*mrad]
Geometric Emittance	3*16	2*20
Norm - RMS Emittance	3.5542	2.9618

Gaussian distribution

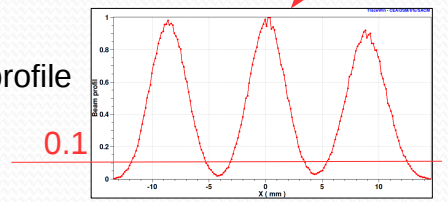
3 Beam at the entrance



Beam on symmetry plane



x plane profile



Pulse resolving power

Theoretic value at FWHM

$$RP = \left| \frac{T_{16}}{2 x_0 T_{11}} \right| = \frac{2.91}{2 \cdot 0.0015 \cdot 1} = 970 \qquad \Rightarrow Resolution \approx 0.1\%$$

Value at FWtM

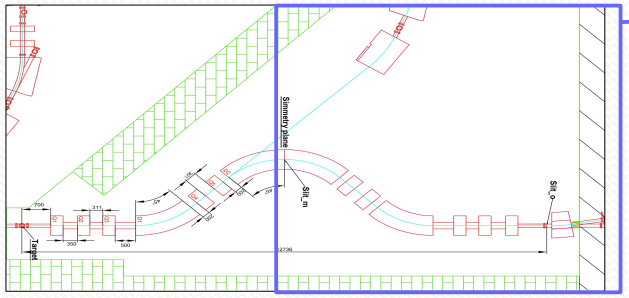
$$Resolution \approx 0.3\%$$

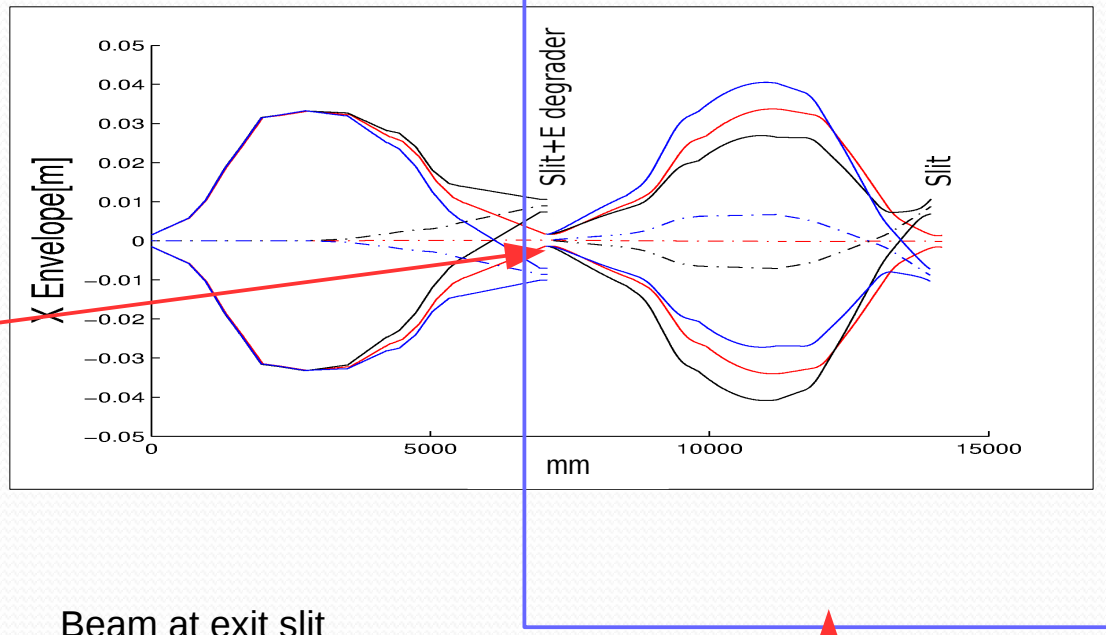
Mass resolving power

$$\frac{\Delta m}{m} = 2 \frac{\Delta p}{p} \Rightarrow Resolution \approx 0.6\%$$

Antonio Domenico Russo

Mass Resolving power

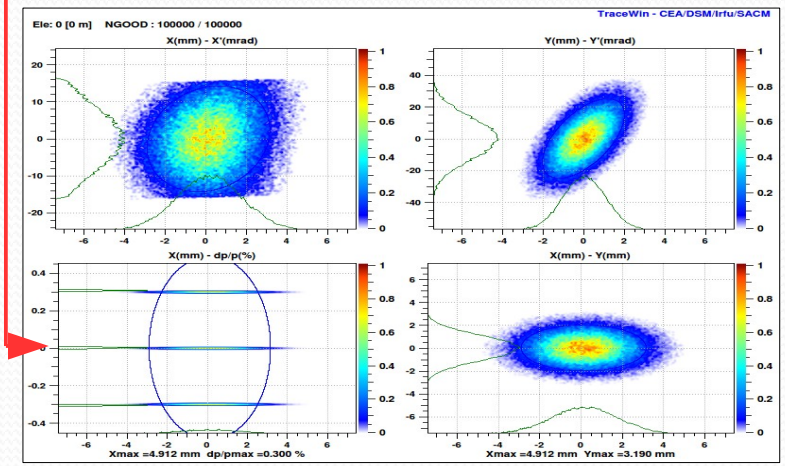




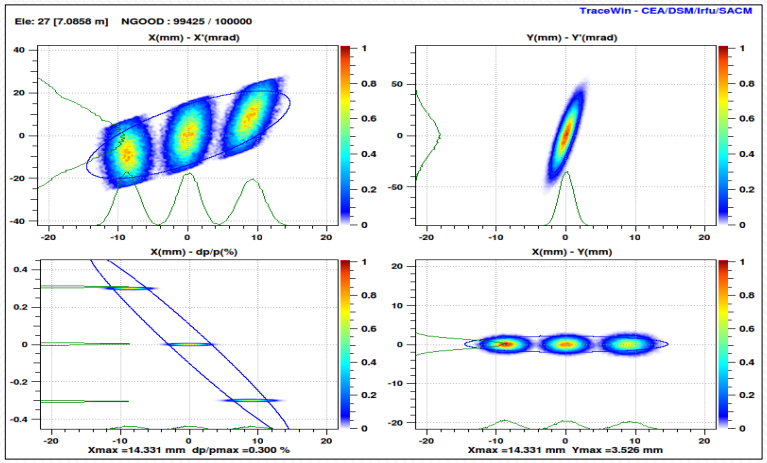
A slit and a degrader have been introduced

Introduced spread after the degrader
ΔP/P=±0.3%

Beam at symmetry system point



Beam at exit slit

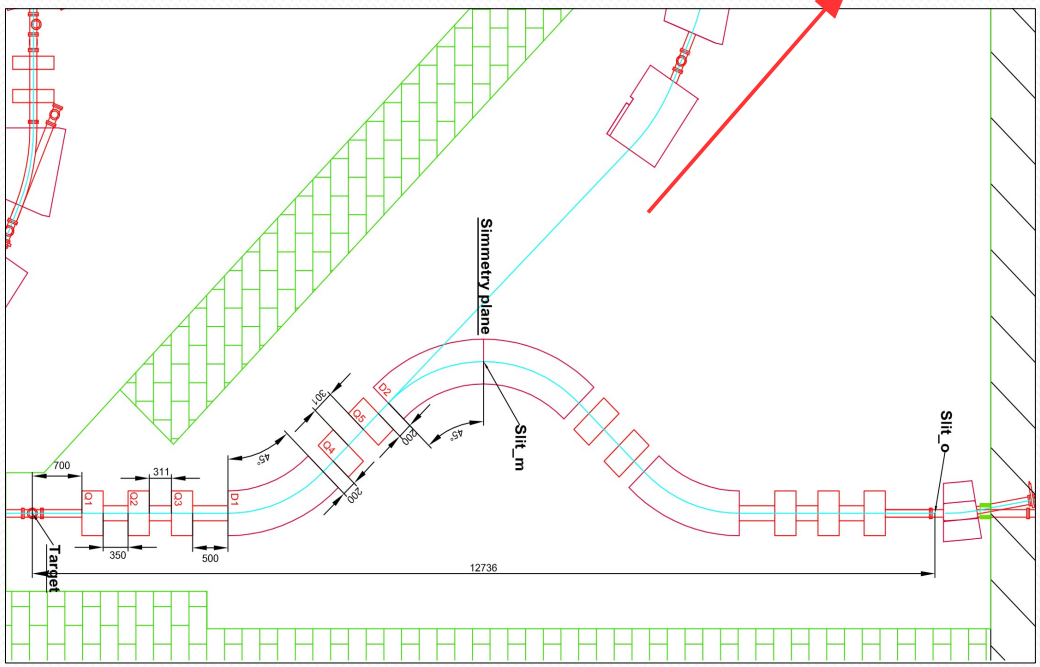


The dispersion property of the second part of line has been maintained

New system features

To Ciclope

In this case the system performance must be studied



<u>The new system guarantees very good optic performances.</u>

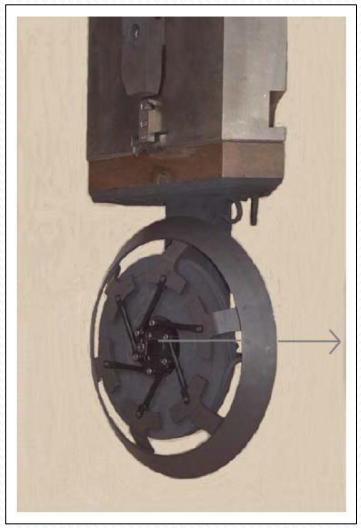
<u>The beam can be easily delivered to different experimental rooms.</u>

To Chimera, Magnex

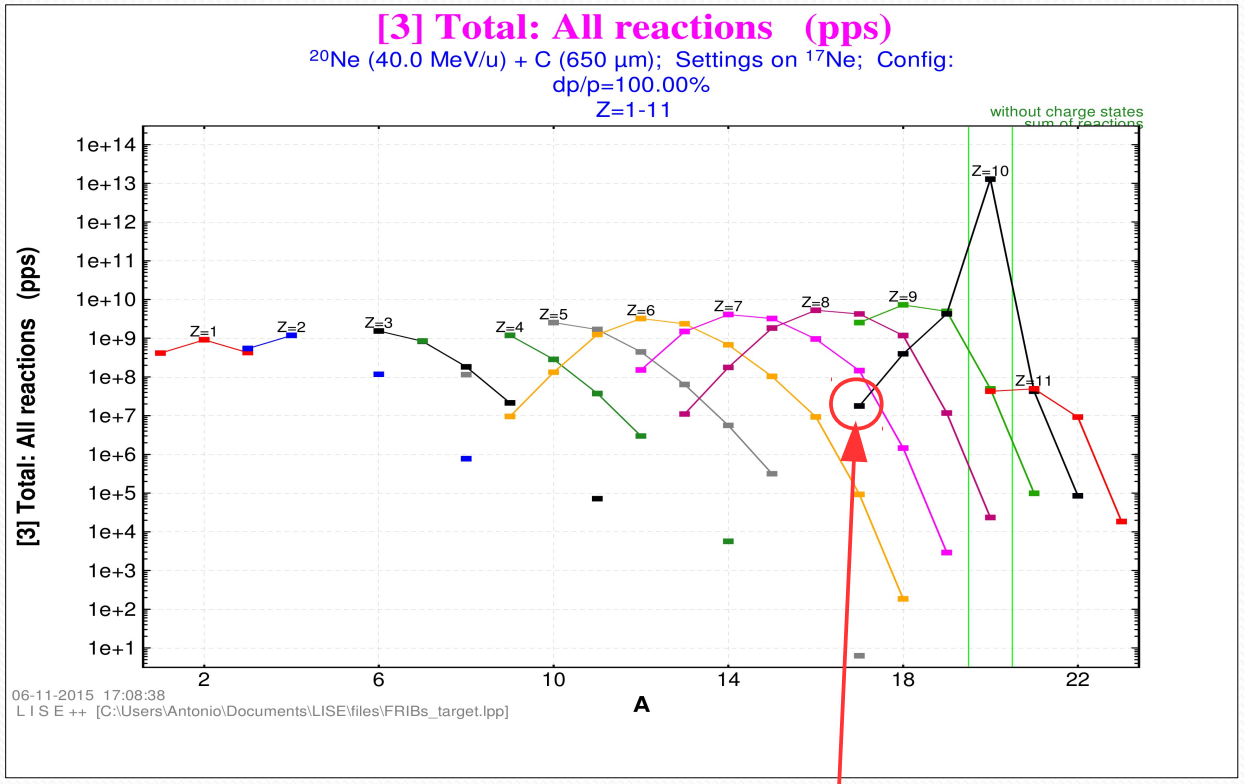
<u>Magnex could use it as energy spread selector</u>

	x-x' Acceptance [mm.mrad]	y-y' Acceptance [mm.mrad]	Momentum Acceptance $\Delta P/P$	Mass resolution at FWtM
New Fribs Line	3x16=48π	2x20=40π	±2.2%	0.6%

Study of the fragments



LISE + + Simulation



Target: $^{12}_{6}C$ thickness = 650 microm

Projectile beam: $^{20}_{10}Ne^{+10}$ @40 AMev P_{beam}= 2kW

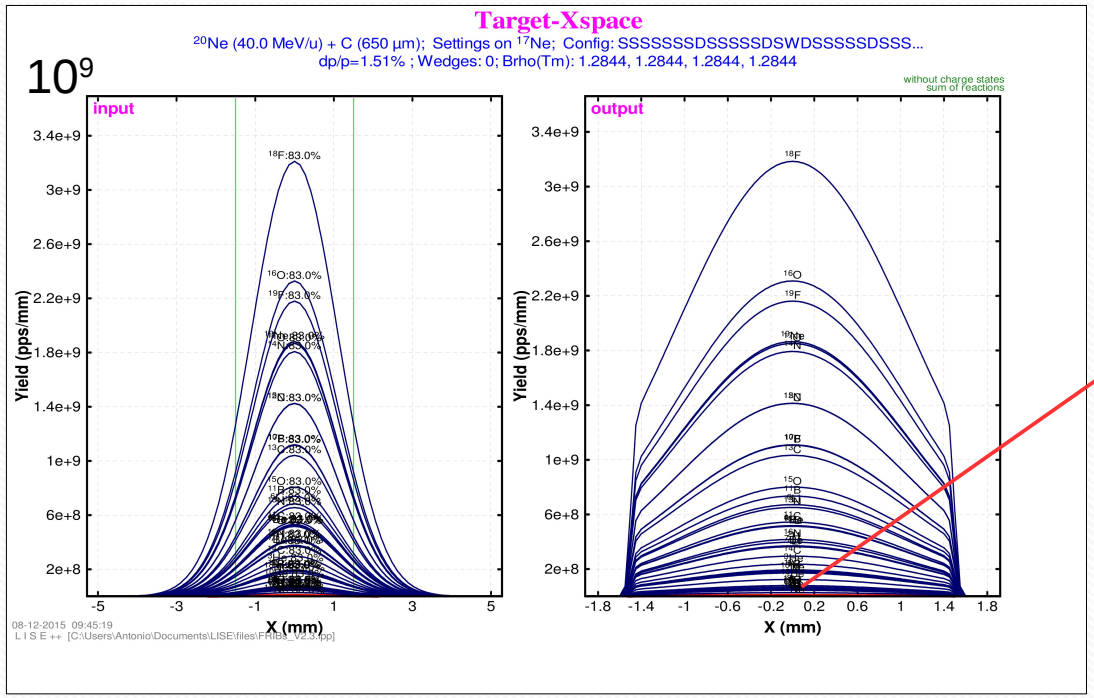
	X Plane [pi*mm*mrad]	Y Plane [pi*mm*mrad]
Geom Emittance	3*16	2*20

The beam features are the same used in the previous beam study

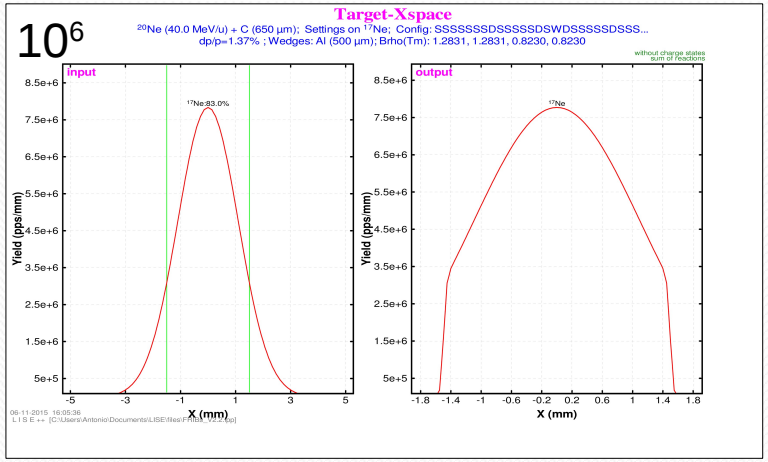
Fragment required $^{17}_{10}Ne^{+10}$

Study of the fragments

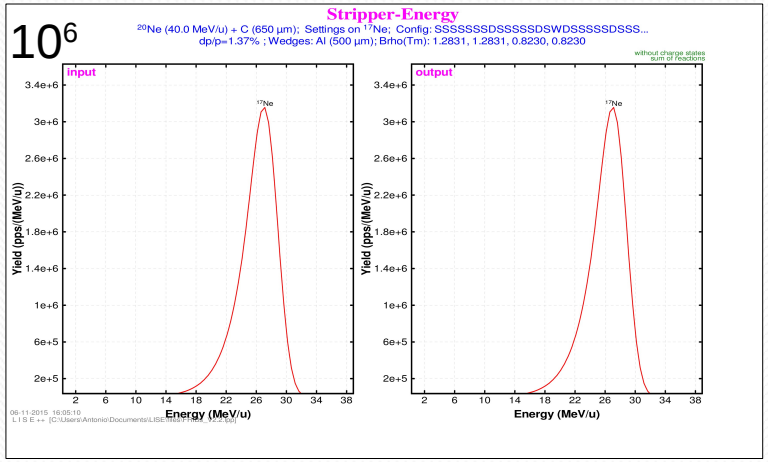
Whole X-distribution before and after entry slit of the target



X-Distribution



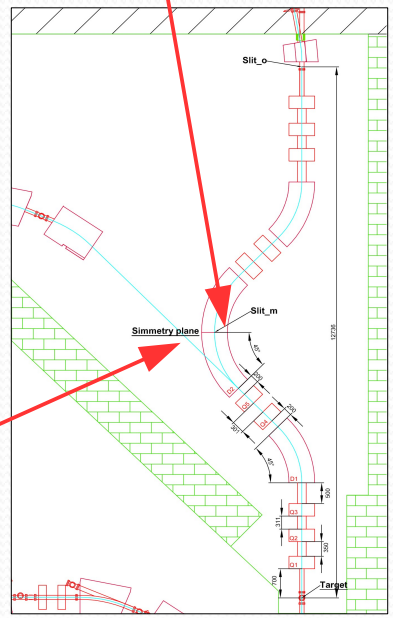
E-Distribution



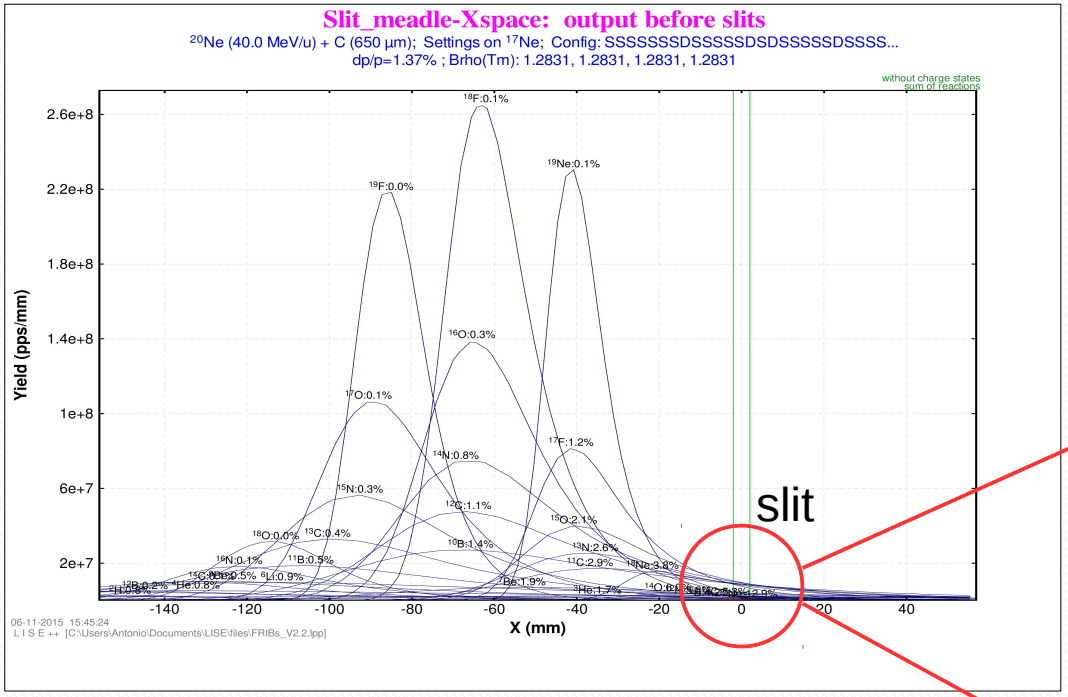
The intensity distribution of fragment of interest is very small compared to the numerous neighbours produced elements.

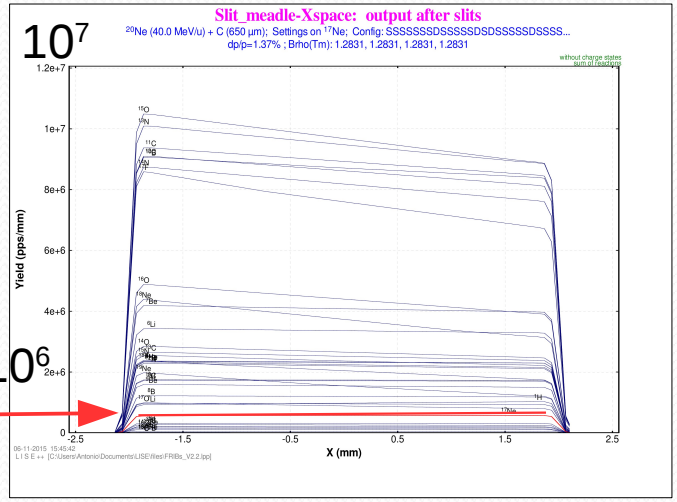
Study of the fragments

Element distribution
at slit before degrader



X plane





10^7

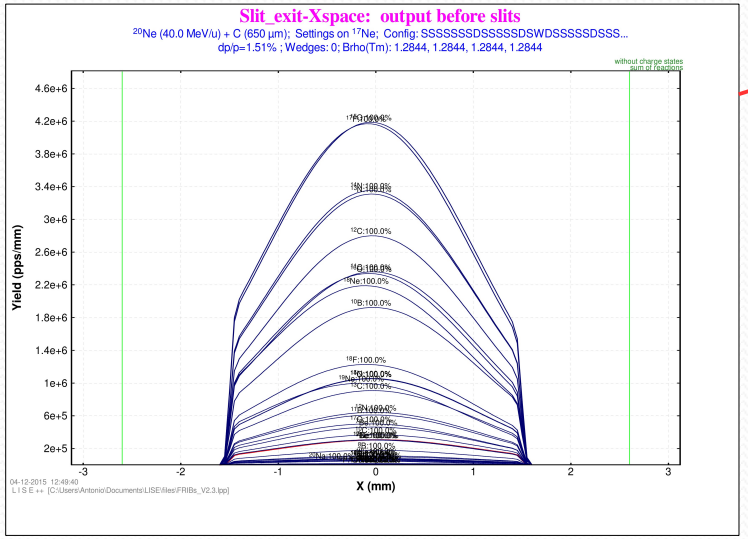
10^6

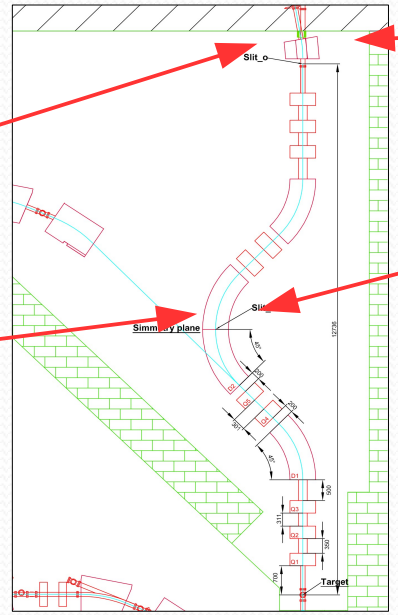
$^{17}_{10}Ne^{+10}$

At the system symmetry plane, where the slit is placed, the reference element is overhung by the neighbours contaminants queues.

Study of the fragments

Ions at the exit slit without degrader at the symmetry plane





Output slit

Degrader
is Aluminium made

Median slit

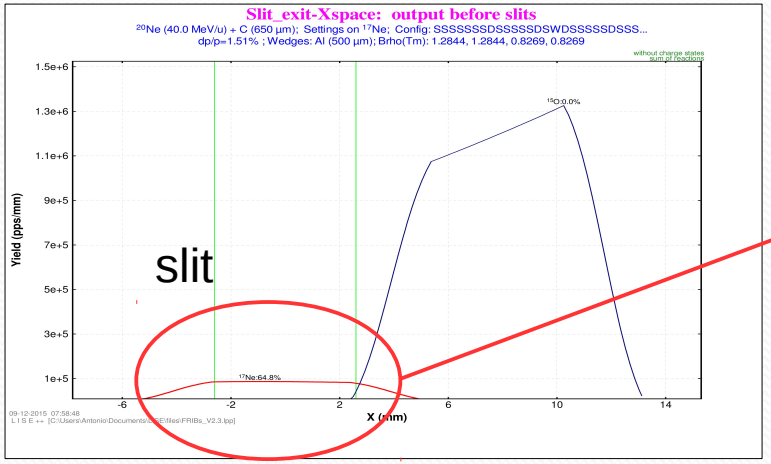
Putting a degrader on the symmetry plane:

- The Energy lost through a degrader depends on Z^2. We can use this effect to select the particle of interest in the output slit;
- The thickness of the degrader can be chosen to reduce the number of particles reaching the end of the beam line. In this way the count rate on the microchannel plate does not exceed the maximum acceptable rate. (1 MHz)

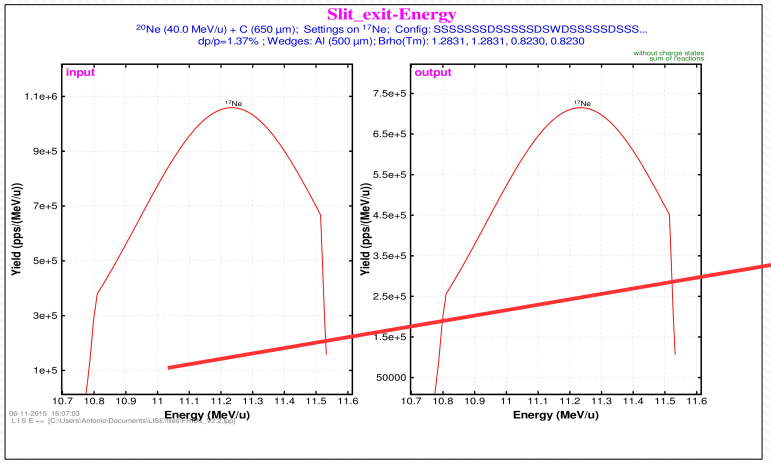
Study of the fragments

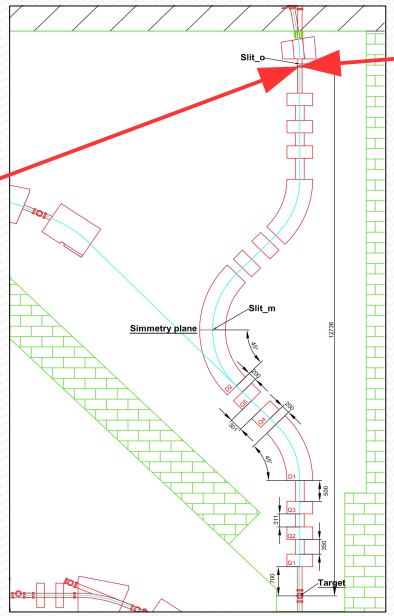
Separation at the exit slit

X plane



Energy





Output slit

Slit aperture ±2.2 mm

Degrader Thickness
500 microm

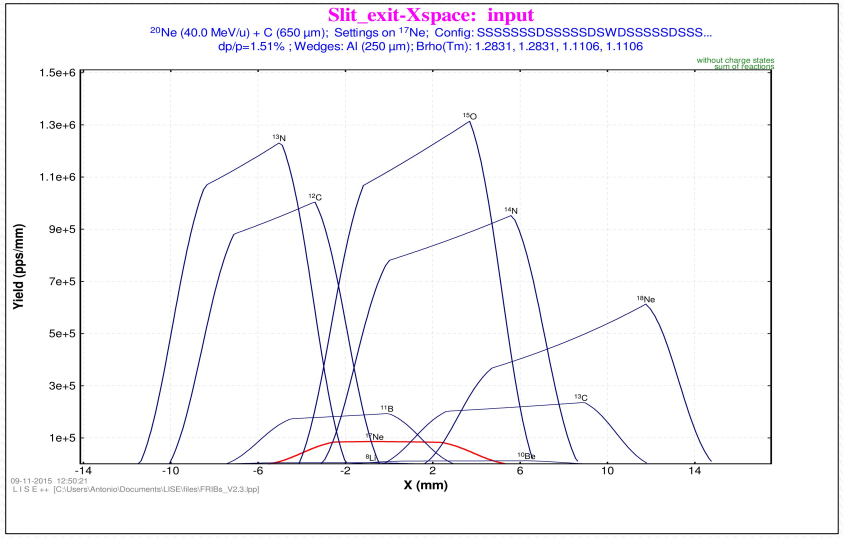
<u>Energy distribution</u>
Mean value is 11.25 AMeV

The number of particles of interest is equal to $4.4*10^{+5}$

Study of the fragments

Separation at the slit exit

Reducing the thickness of the degrader, the beam energy of the reference ion increases. Even if some contaminants still survive at the end of the system.

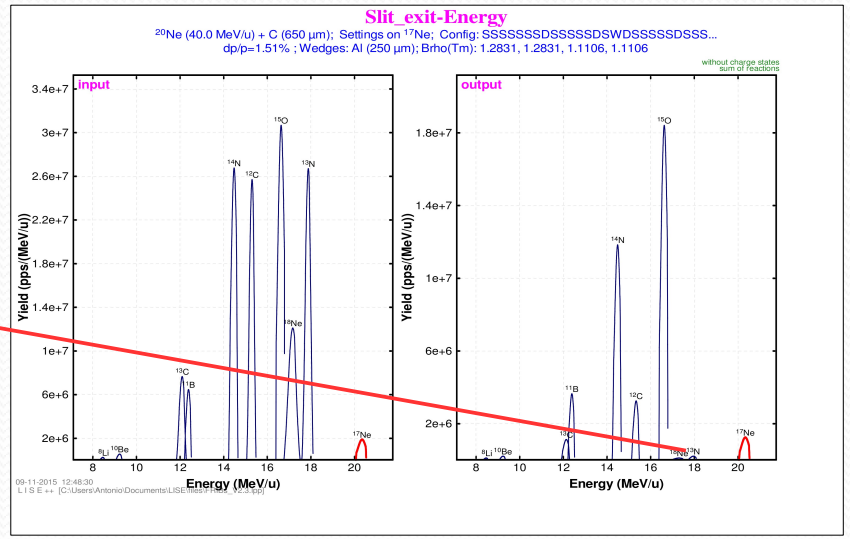


Degrader is Aluminium made

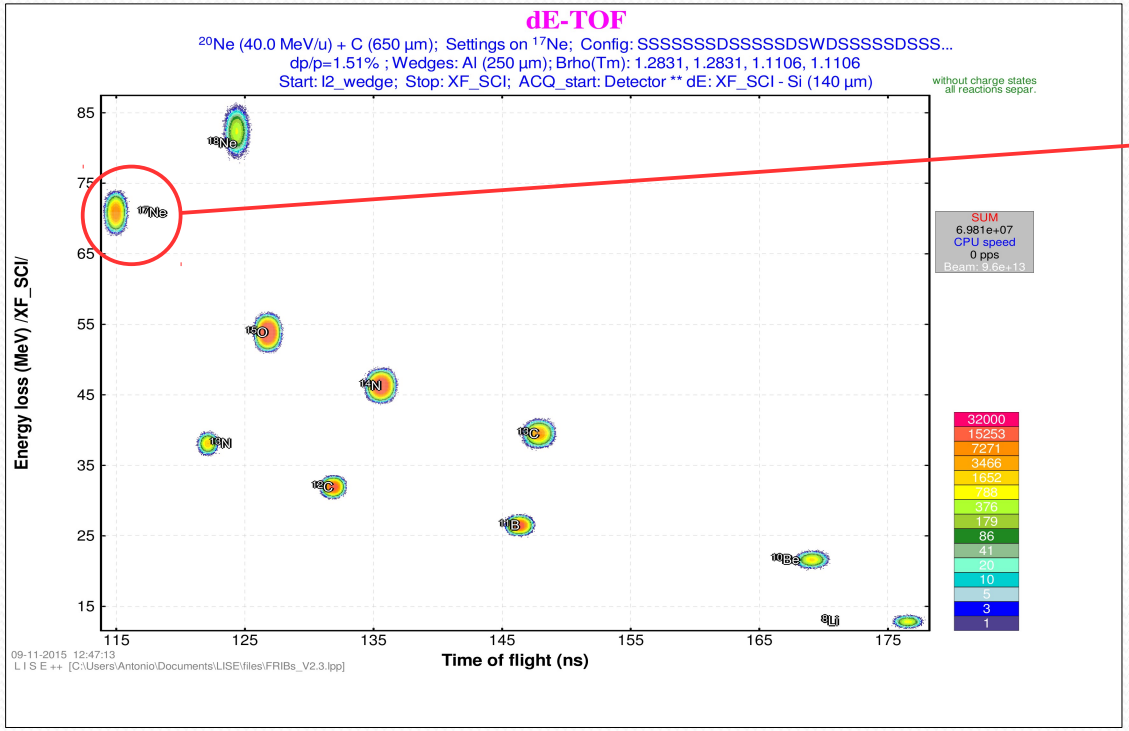
Thickness =250 um

The energy beam mean value is 20.5 AMeV

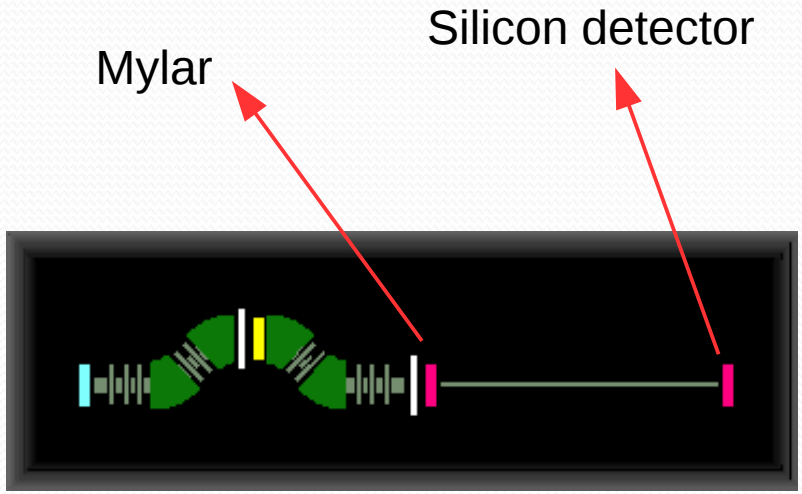
The number of particles of interest is equal to $4.5*10^{+5}$



Study of the fragments



Fragment required $^{17}_{10}Ne^{+10}$



It is possible to clean the beam evaluating the different Time Of Flight

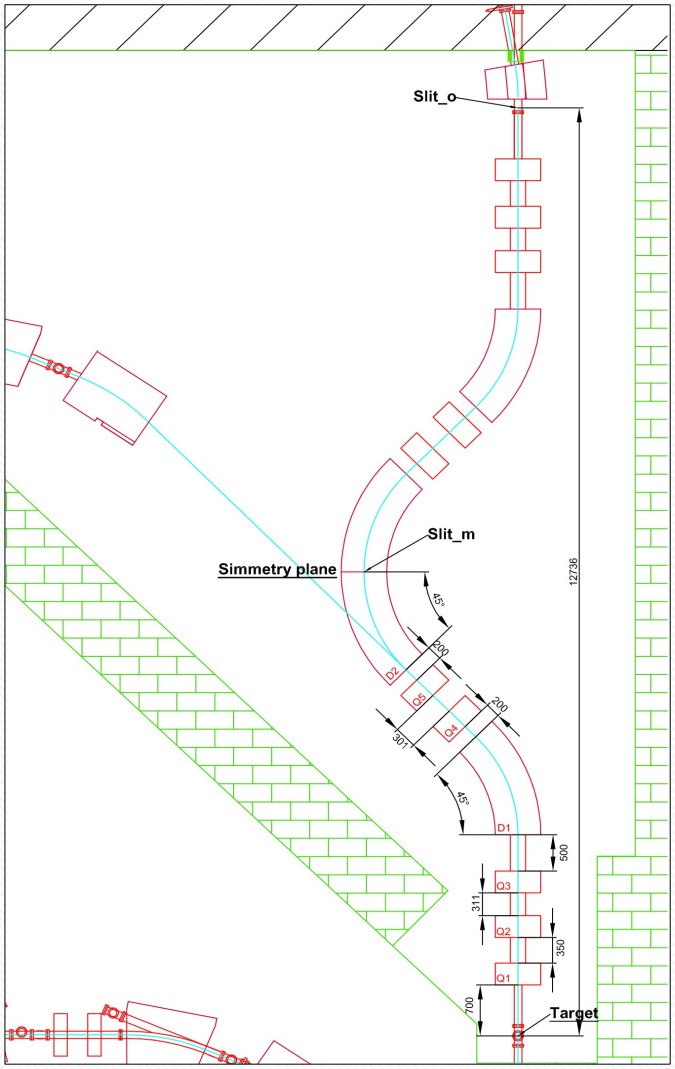
Conclusions

- A new location for FRIBs has been presented;
- The optics study gave good dispersion properties of the system;
- A reference case of Neon has been presented. The selection can be achieved in two ways according to the researcher purpose.
- The improvement of FRIBs performances is guaranteed. With the present beam power, 100W, the system will be better by a factor 5;

Next study

- to define fine details will be done according to the radio-protection division suggestions;

- A wider study of new species produced when the projectile beam power is increased (CS Upgrade).



Thank you for your attention