Recoil separator "SECAR" configurations in the LISE^{++} package

by Oleg Tarasov

According to the LISE^{++} site

LISE^{++} : calculation of the transmission and yields of fragments produced and collected in a separator. This code allows to simulate an experiment, beginning from the parameters of the reaction mechanism and finishing with the registration of products selected by a separator.

- predict the separator settings necessary to obtain a specific RIB;
- predict the intensity and purity of the chosen RIB;
- simulate identification plots for on-line comparison;
- provide a highly user-friendly graphical environment;
- allow configuration for different fragment separators.

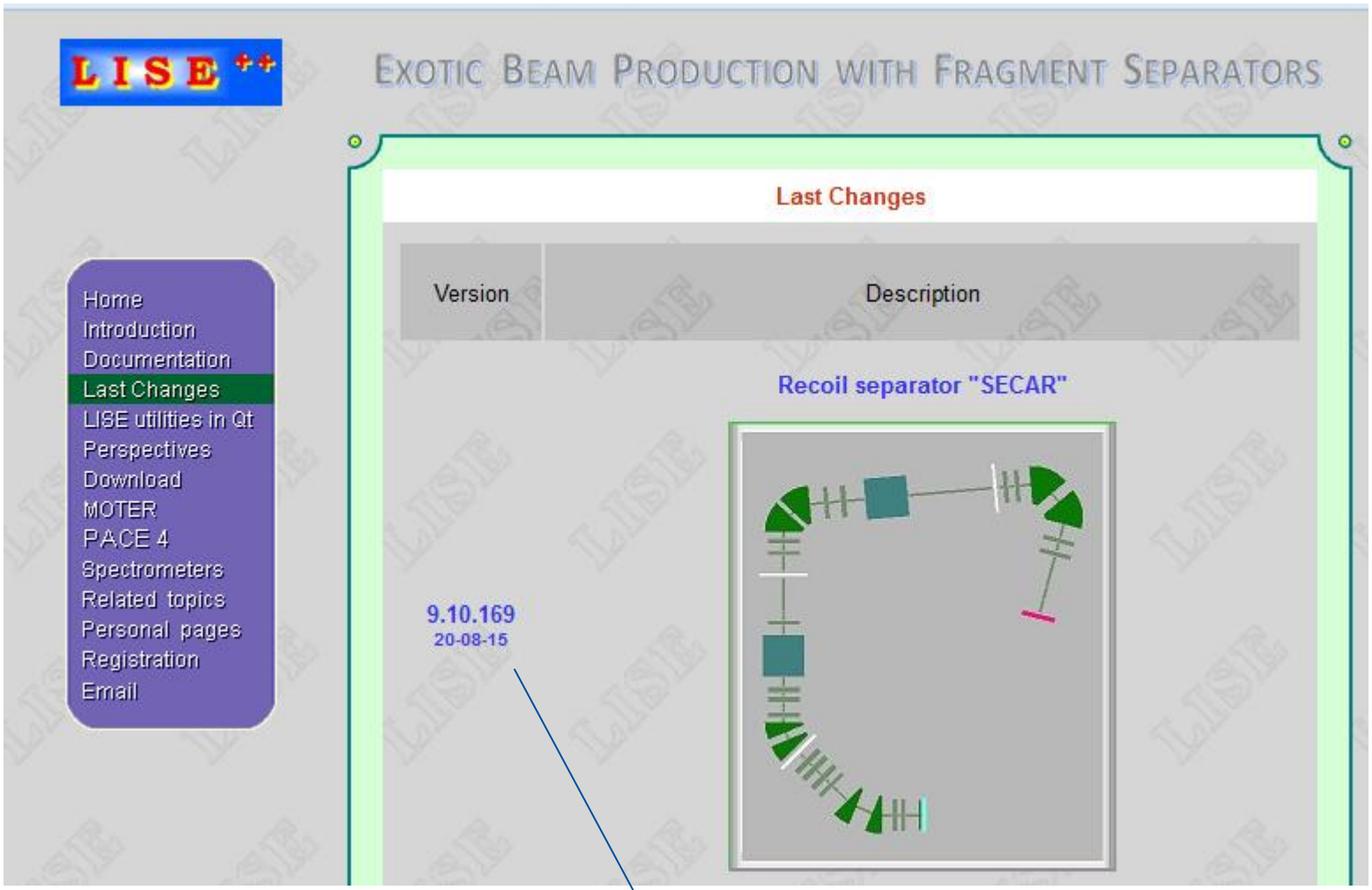
The LISE^{++} code may be applied at medium-energy and high-energy facilities (fragment- and recoil-separators with electrostatic and/or magnetic selections).

2015: Go to the low energy domain!

- SHE -- Update of Fusion reaction mechanism , "SHELLS"
- S3 (GANIL), MSP144 (Dubna), PRISMA (LNL)
- Region of light nuclei – "DRAGON",… and now "SECAR"

SECAR configurations & corresponding documentation

http://lise.nscl.msu.edu/changes.html



SECAR.pdf (49 pages)

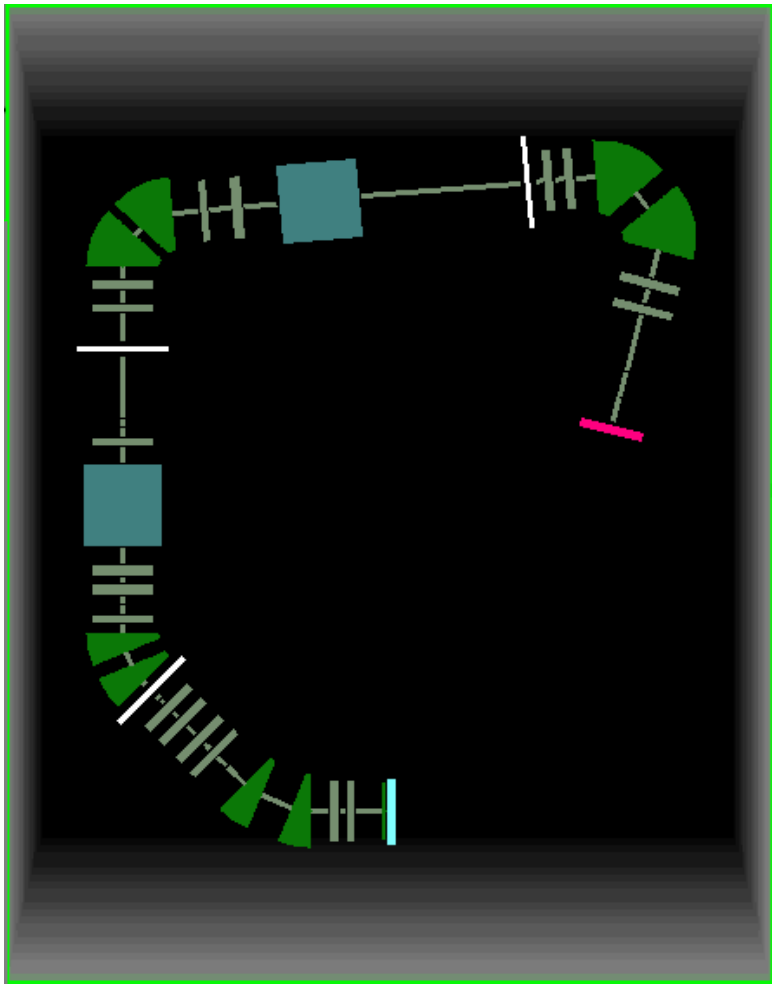
Recoil separator "SECAR" @ MSU

High Order Extended Configurations

Version 9.10.169
from 08/20/2015

Link: Separator "SECAR"

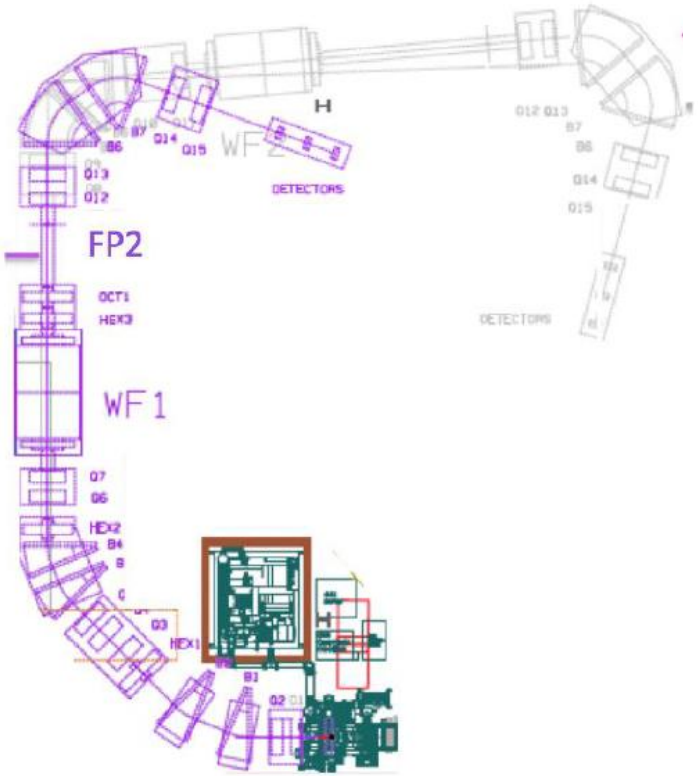
- SECAR extended configurations
  - SECAR documentation
  - SECAR phase1
  - LISE^{++} modifications for SECAR
  - SECAR files location
  - SECAR phase 1 with COSY maps
  - Optimization with LISE^{++}
- SECAR phase1: Angular Acceptance
- SECAR phase1: Momentum Acceptance
- SECAR phase1: Charge states selection
- Experiment $^{15}O(\alpha,\gamma)^{19}Ne$
  - Fusion
  - Selection
- Segmented configuration
- Open questions



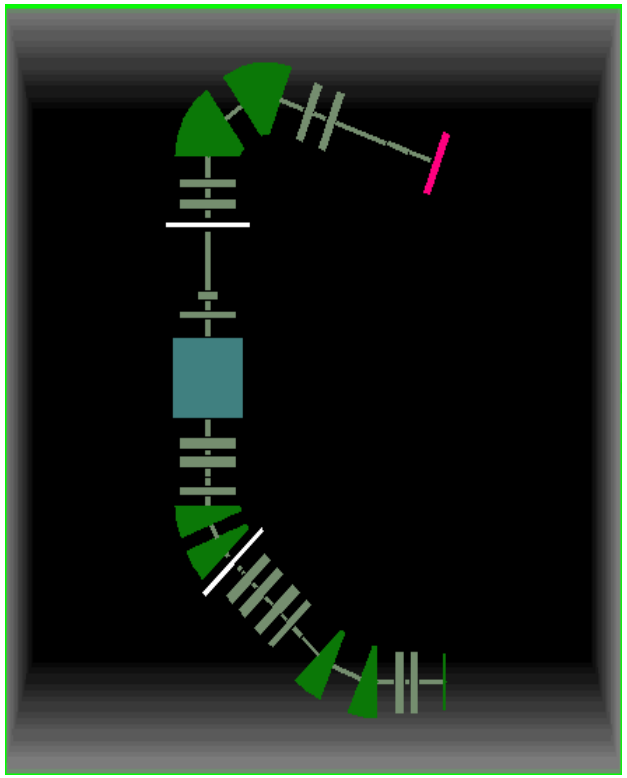
Configuration “SECAR phase1”

Table 3.13. SECAR Optimized Setup for a 1 VF system

Quadrupole	Radius (m)	Pole tip field (T)	Gradient T/m
Q1	0.05	-0.36534	-7.3068000
Q2	0.068	0.21788	3.2041176
Q3	0.11	0.242644	2.2058545
Q4	0.08	-0.24501	-3.0626250
Q5	0.06	0.11128	1.8546667
Q6	0.14	0.181721	1.2980071
Q7	0.13	-0.0301475	-0.2319038
Q8			
Q9			
Q10			
Q11			
Q12	0.07	-0.22000	-3.1428571
Q13	0.05	0.20160	4.0320000
Q14	0.05	0.13147	2.6294000
Q15	0.05	-0.1450	-2.9000000
HEX(Q1)	0.05	-0.0006	
HEX1	0.11	0.008620	
HEX2	0.12	0.01449	
HEX3	0.11	-0.0435	
OCT1	0.07	0.006225	

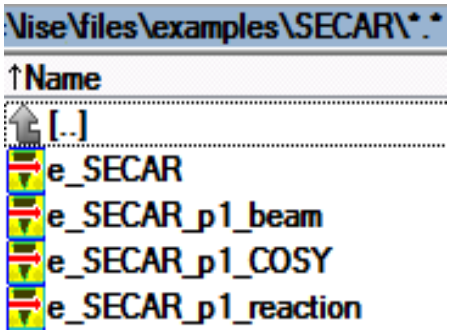


@ LISE++



SECAR files location @ LISE^{++} package

LISE^{++} files



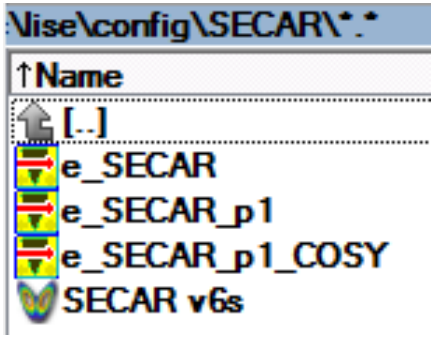
→ *SECAR extended for primary beam (not optimized yet)*

→ *SECAR phase1 extended for primary beam*

→ *SECAR phase1 extended with COSY 5th order maps*

→ *SECAR phase1 extended : $^{15}O(\alpha, \gamma)^{19}Ne$*

LISE^{++} configurations



→ *SECAR extended configurations*

→ *COSY file to generate SECAR maps for LISE^{++}*

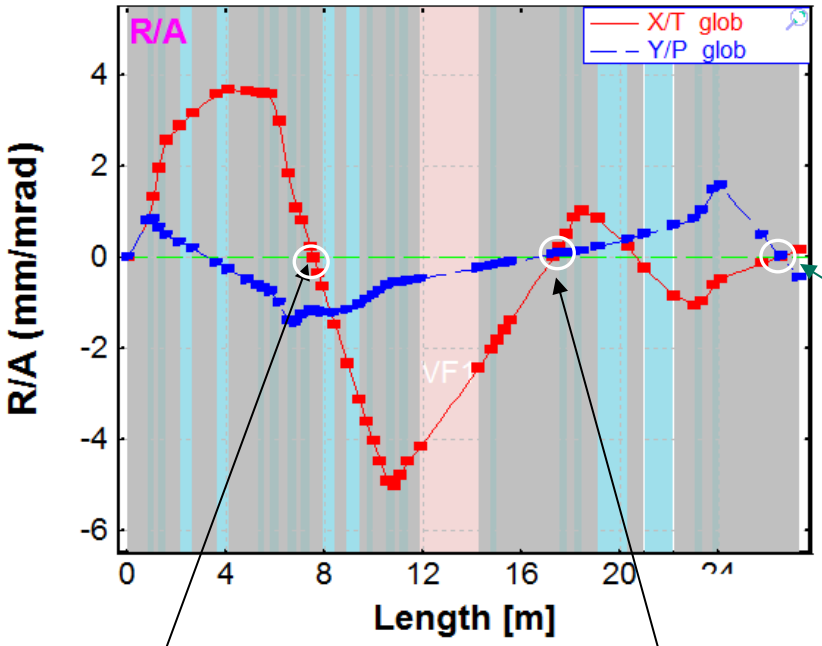
SECAR segmented configurations will be done soon

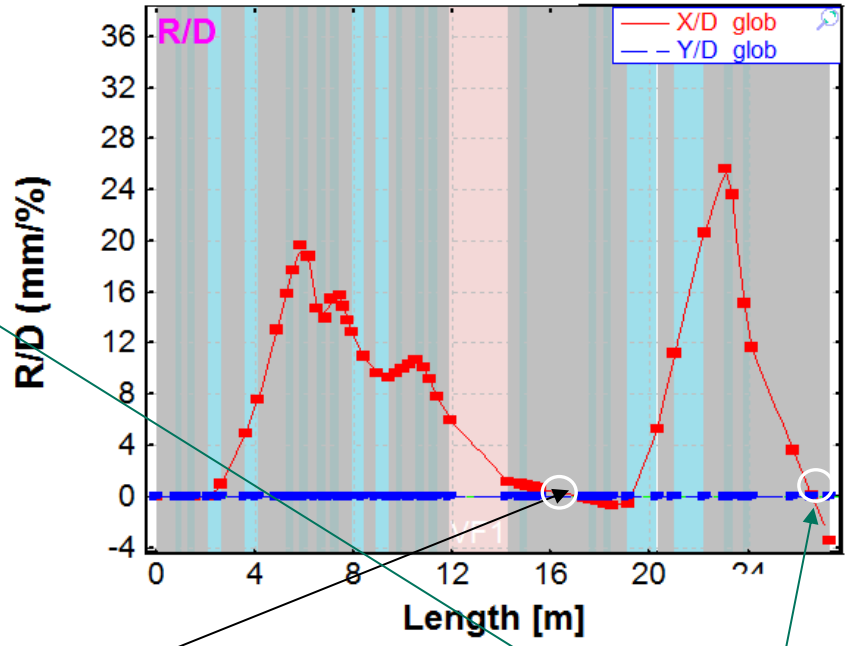
File: e_SECAR_phase1_COSY_o5.lpp

First order matrix elements

^{66}Se (3.1 MeV/u); Settings on $^{66}Se^{21+..21+}$; Config: DSSSSSDSDSSSSSSSSSS

dp/p=14.49% ; Brho(Tm): 0.8000, 0.8000, 0.8000, 0.8000, 0.8000....



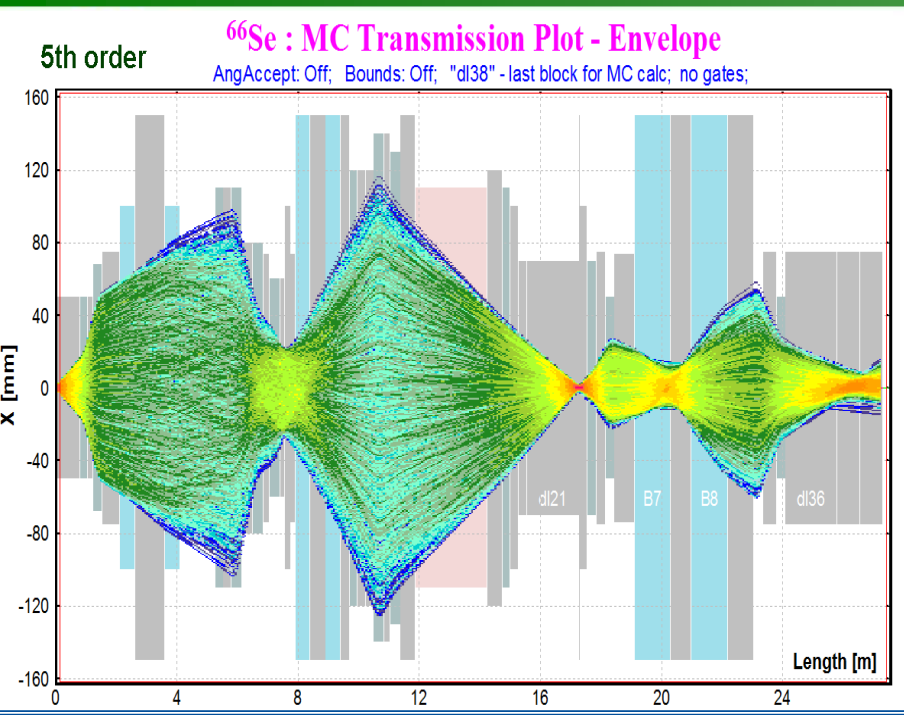


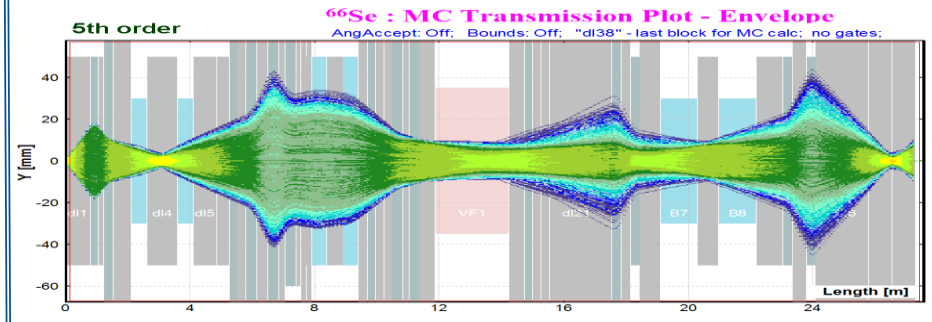
FP1– horizontal focus, charge selection

FP2 – double focus, double achromat

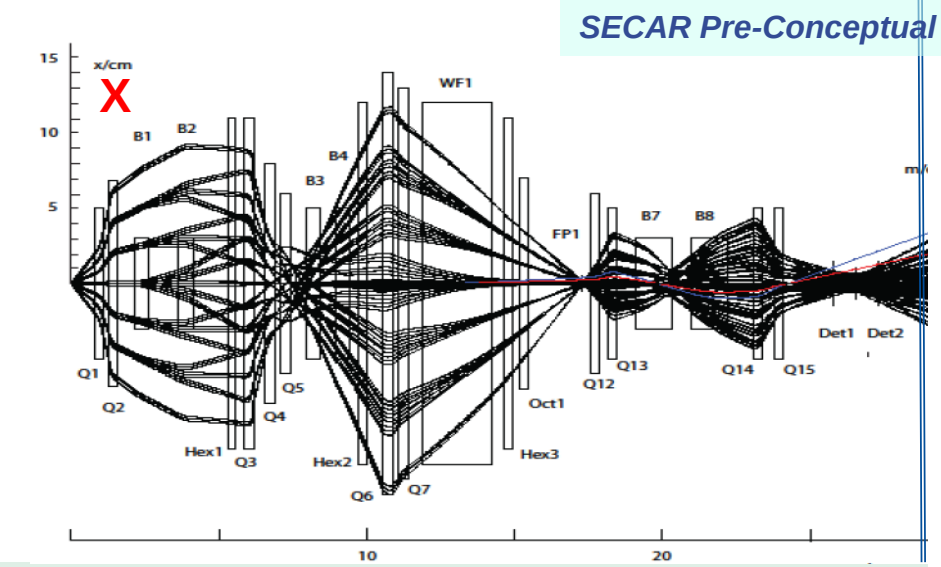
DL37 – double focus, achromat

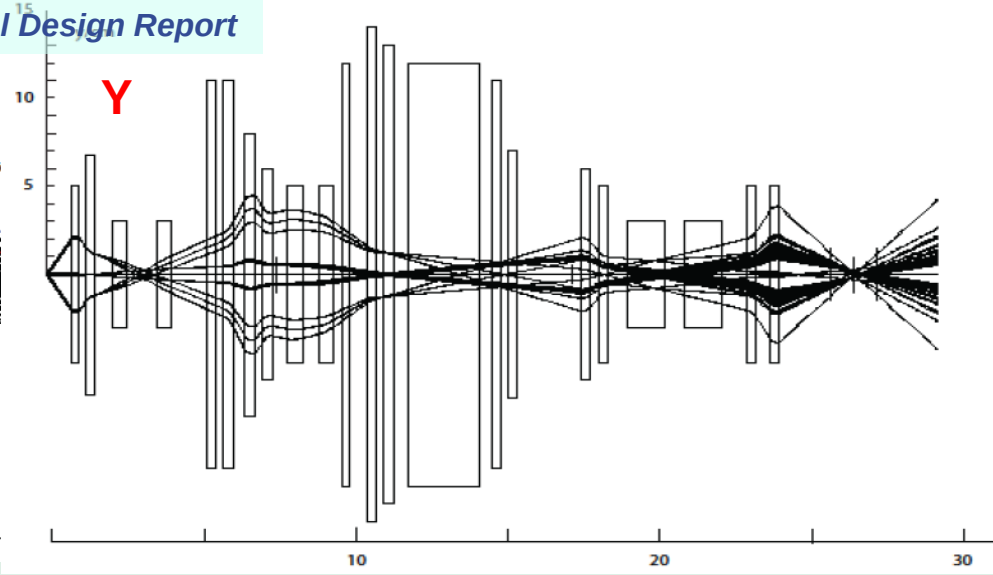
SECAR phase 1 with COSY maps : LISE^{++} MC envelopes





SECAR Pre-Conceptual Design Report





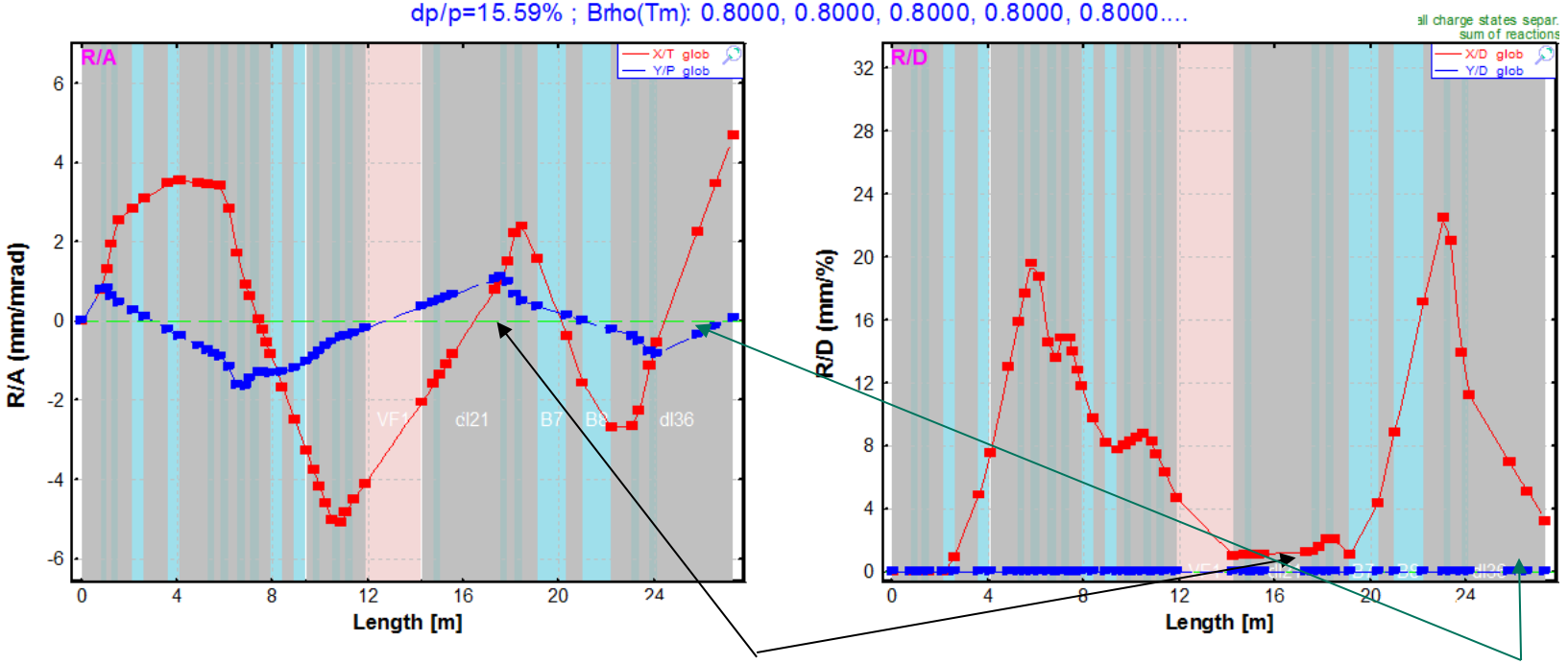
SECAR phase 1 calculated by LISE++

File: **e_SECAR_phase1.**lpp

Using <u>fields</u> from the SECAR Pre-Conceptual Design Report

First order matrix elements

^{66}Se (3.1 MeV/u) + Be (1e-3 mg/cm^2); Settings on ^{66}Se$^{21+..21+}$; Config: DSSFSSFSFDSDFSSSFSSFSSFSSF...
dp/p=15.59% ; Brho(Tm): 0.8000, 0.8000, 0.8000, 0.8000, 0.8000....



FP2 – no double focus, small dispersion

Global matrix

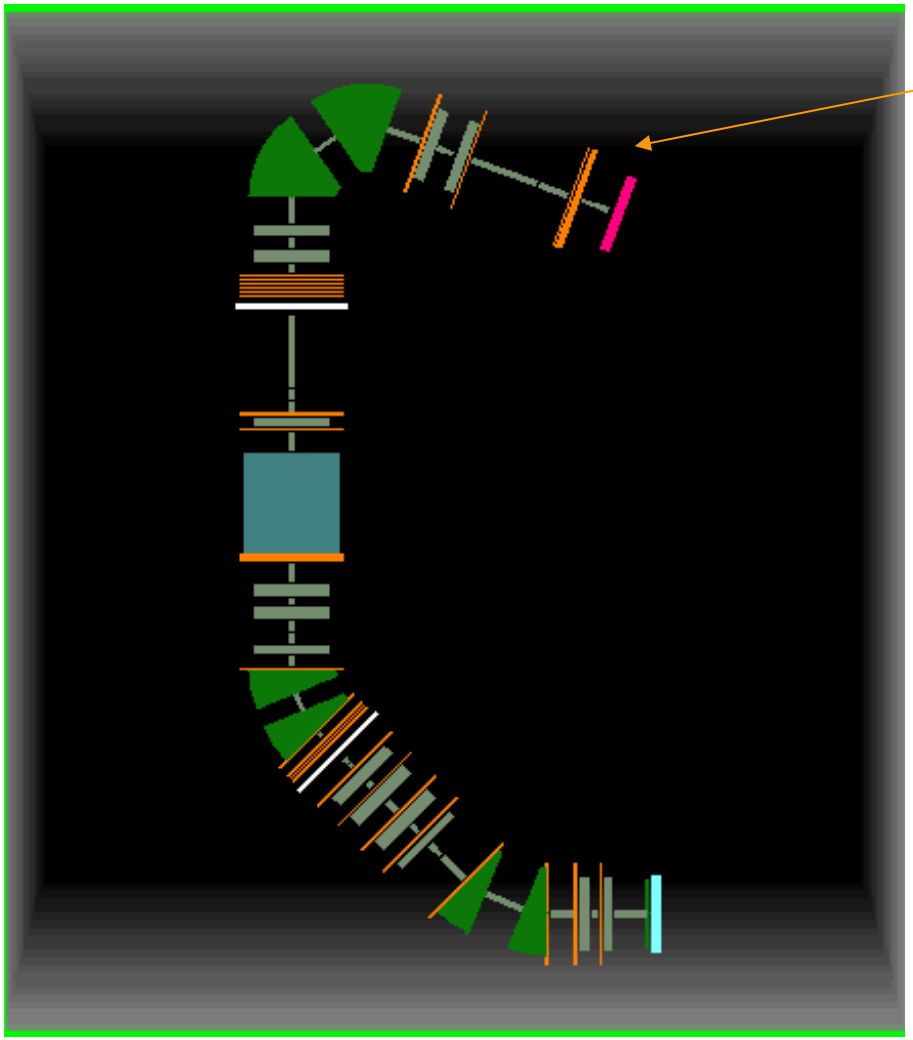
1.71399	0.7896	0	0	0	1.27182	[mm]
0.75758	0.93241	0	0	0	0.08012	[mrad]
0	0	15.94788	1.06042	0	0	[mm]
0	0	2.52905	0.23087	0	0	[mrad]
-0.4117	-0.9308	0	0	1	-9.86959	[mm]
0	0	0	0	0	1	[%]
/[mm]	/[mrad]	/[mm]	/[mrad]	/[mm]	/[%]	

DL37 – no X-focus, small dispersion

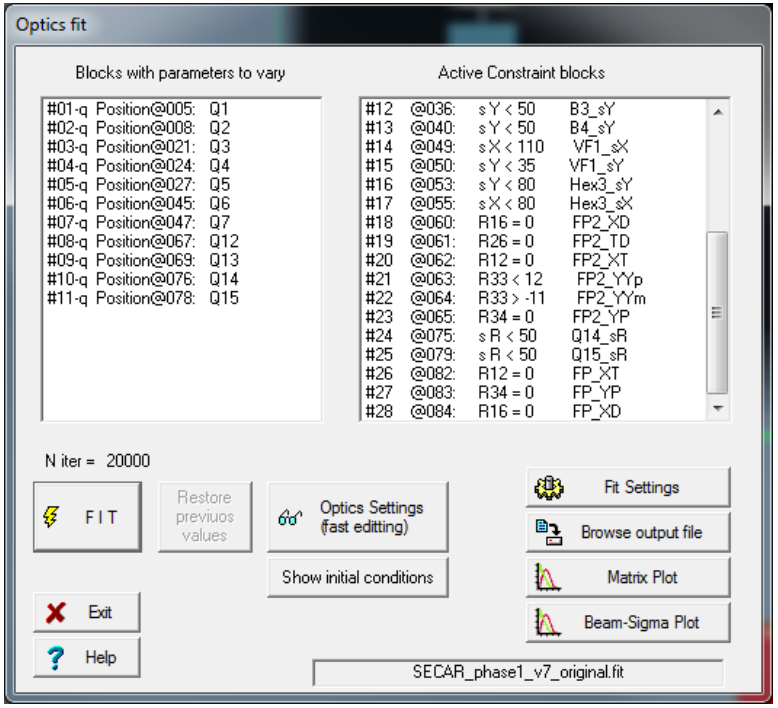
Global matrix

7.39269	3.46894	0	0	0	5.11233	[mm]
3.19314	1.6336	0	0	0	-2.49489	[mrad]
0	0	-1.96752	-0.13856	0	0	[mm]
0	0	11.19827	0.28033	0	0	[mrad]
2.98263	0.65761	0	0	1	-24.18632	[mm]
0	0	0	0	0	1	[%]
/[mm]	/[mrad]	/[mm]	/[mrad]	/[mm]	/[%]	

SECAR phase1 optimization in LISE++

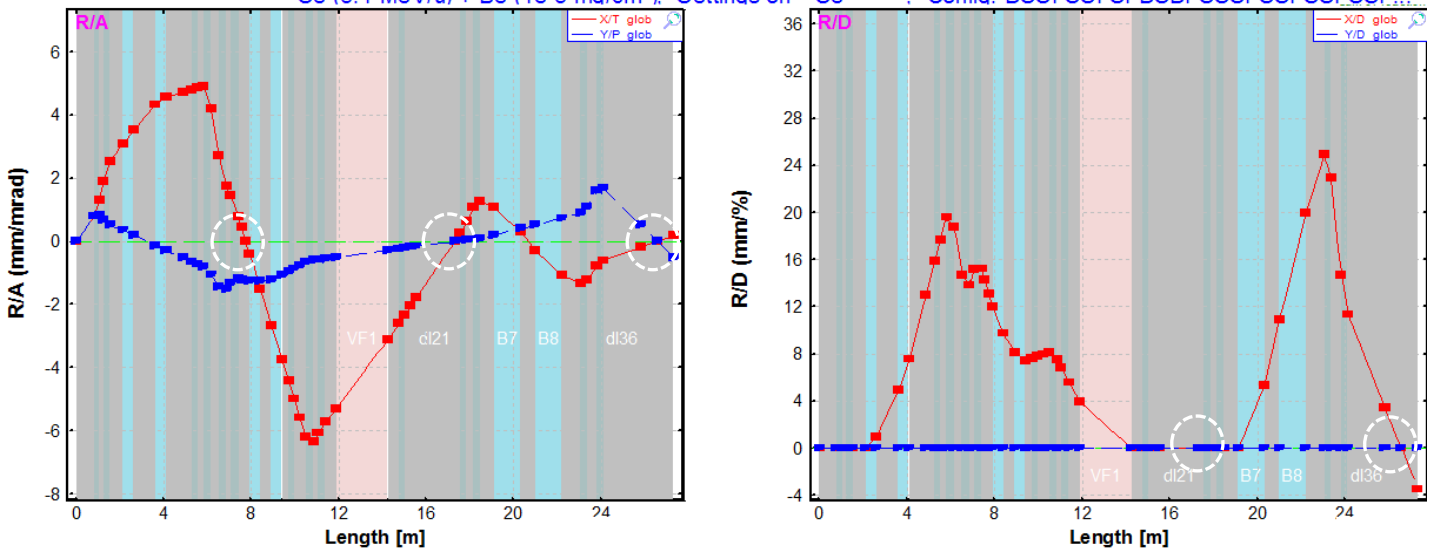


28 constraints,
11 variable fields

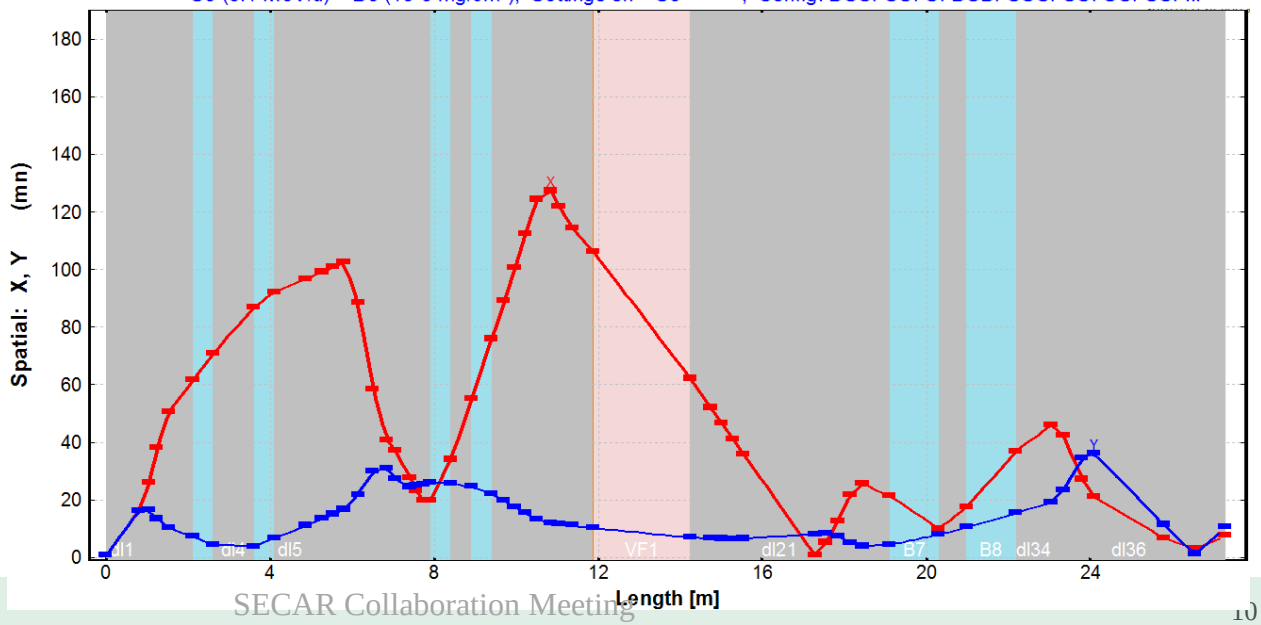


SECAR phase1 optimization in LISE^{++} : results

First order matrix elements



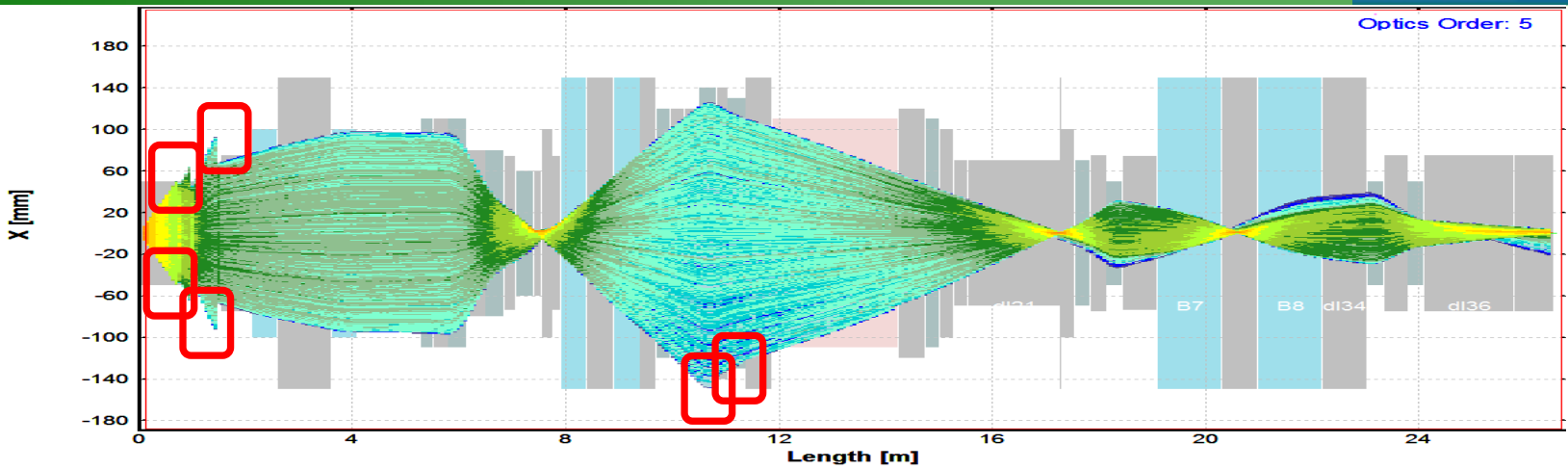
Beam Sigmas: spatial



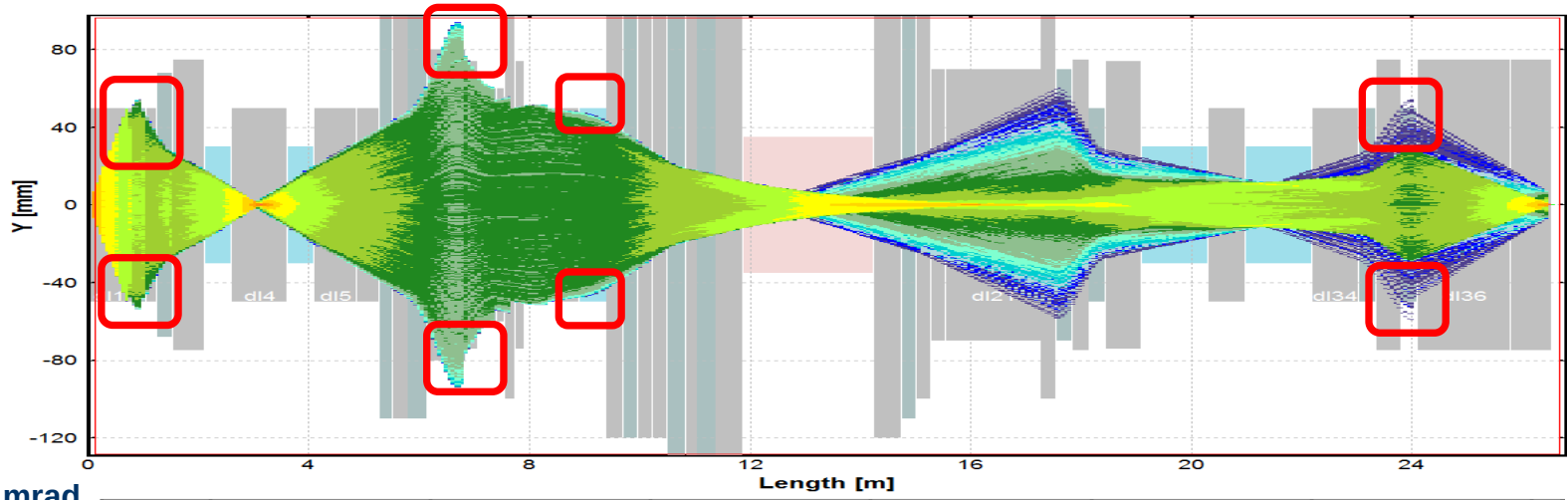
element	Initial	LISE^{++} result	delta
Q1	-3.6534	-3.4260	0.2274
Q2	2.1788	1.7540	-0.4248
Q3	2.4264	2.3870	-0.0394
Q4	-2.4501	-2.4240	0.0261
Q5	1.1128	1.1480	0.0352
Q6	1.8172	1.8350	0.0178
Q7	-0.3015	-0.2694	0.0321
Q12	-2.2000	-2.2020	-0.0020
Q13	2.0160	1.9960	-0.0200
Q14	1.3147	1.3100	-0.0047
Q15	-1.4500	-1.4450	0.0050

Angular Emittance Loss (5th order optics)

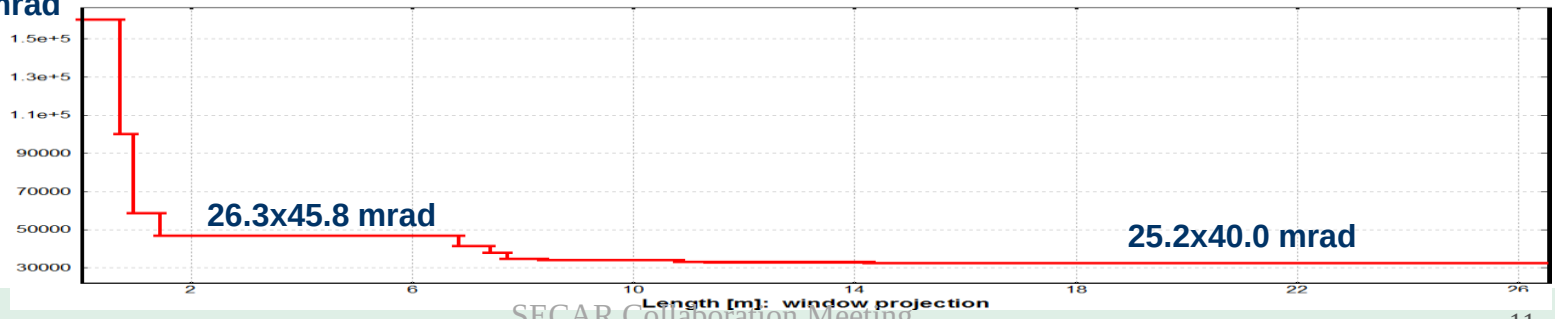
X'



Y'



70x70 mrad



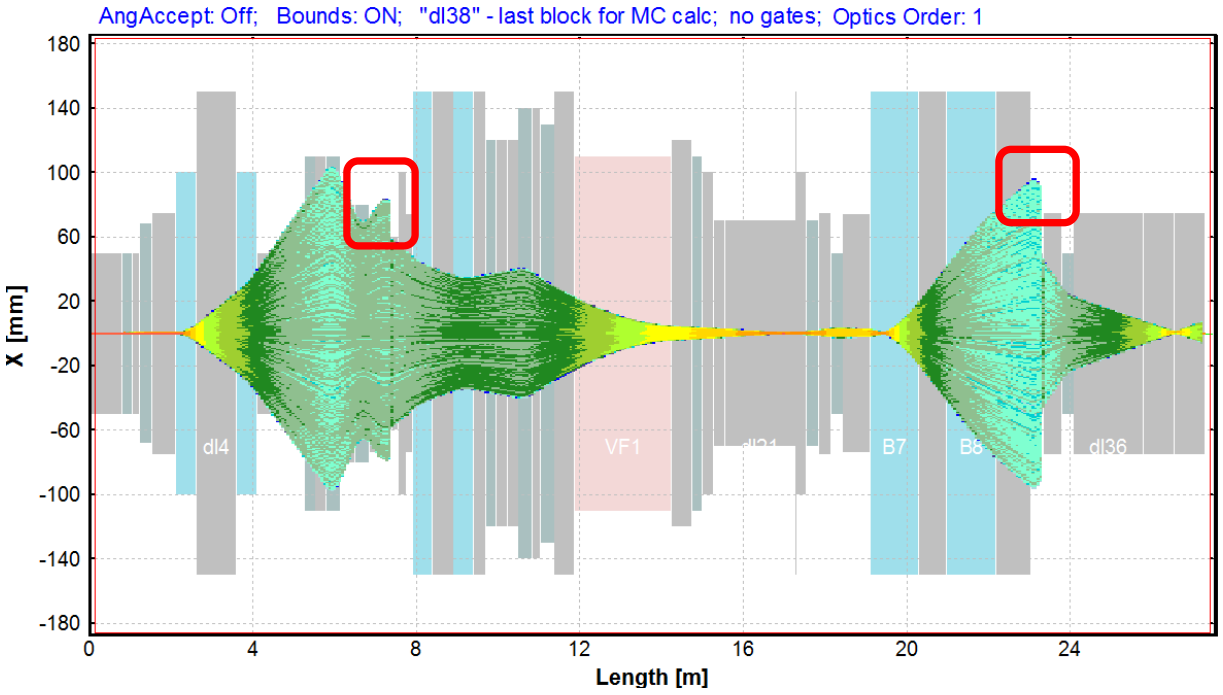
Intensity lost

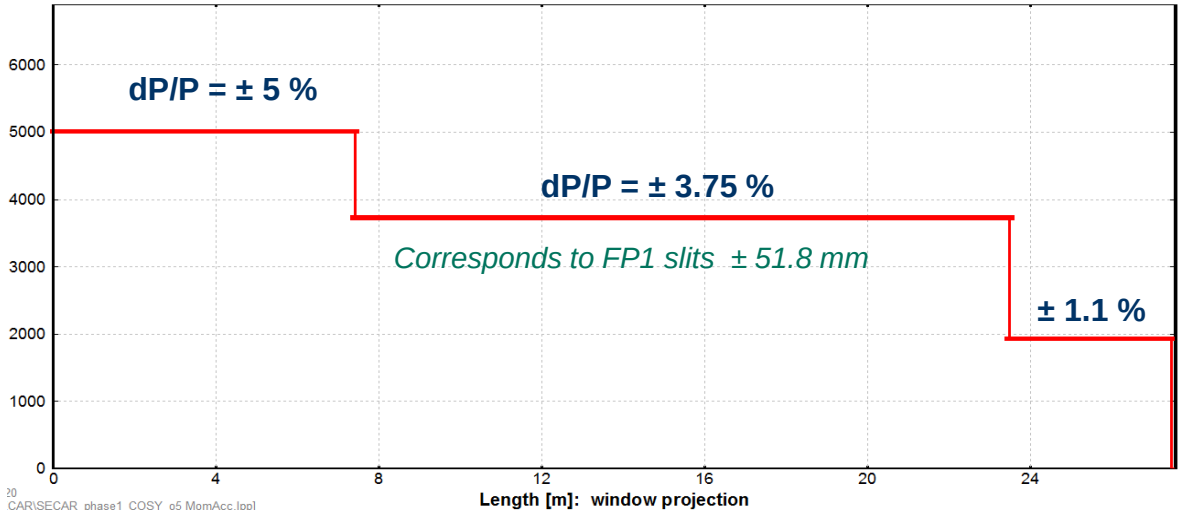
Momentum Acceptance

1st order

Emittance

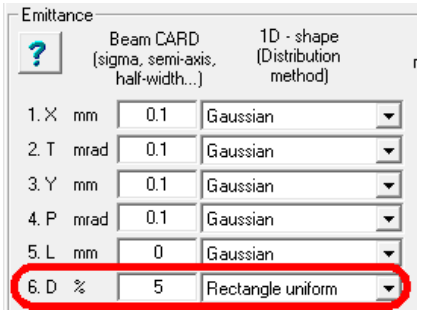
		Beam CARD (sigma, semi-axis, half-width...)	1D - shape (Distribution method)
1. X	mm	0.1	Gaussian
2. T	mrad	0.1	Gaussian
3. Y	mm	0.1	Gaussian
4. P	mrad	0.1	Gaussian
5. L	mm	0	Gaussian
6. D	%	5	Rectangle uniform

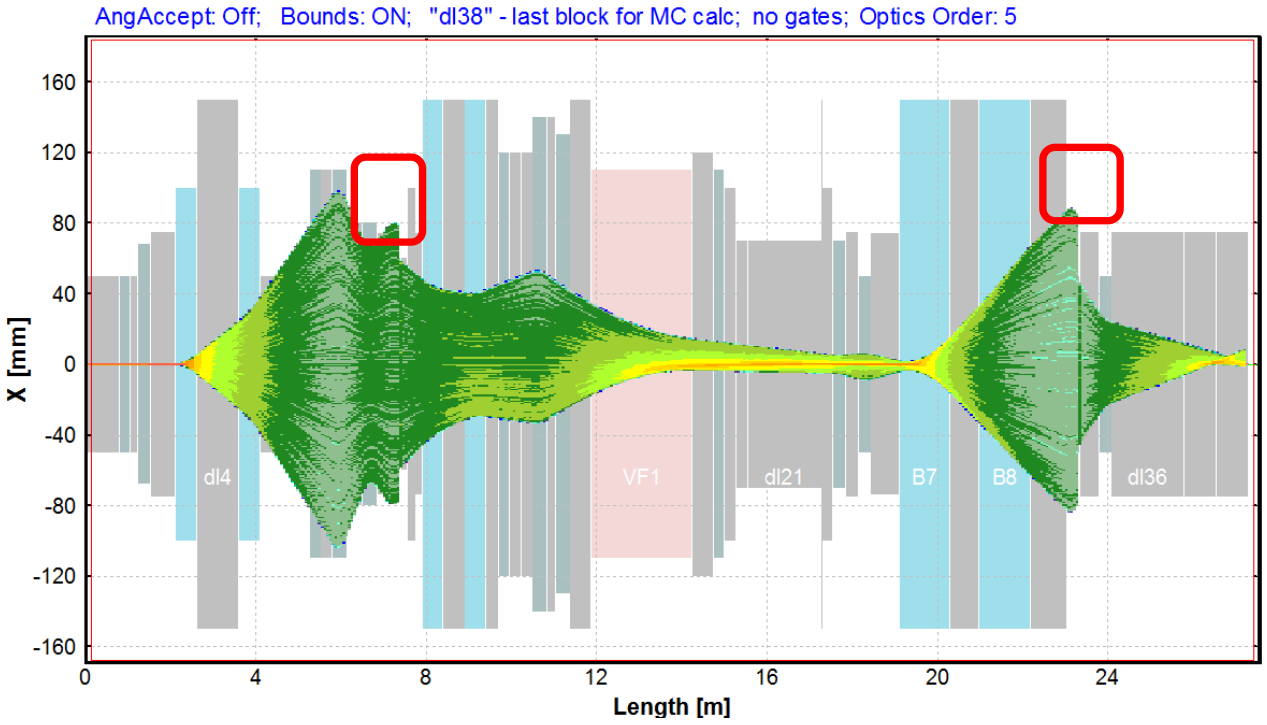


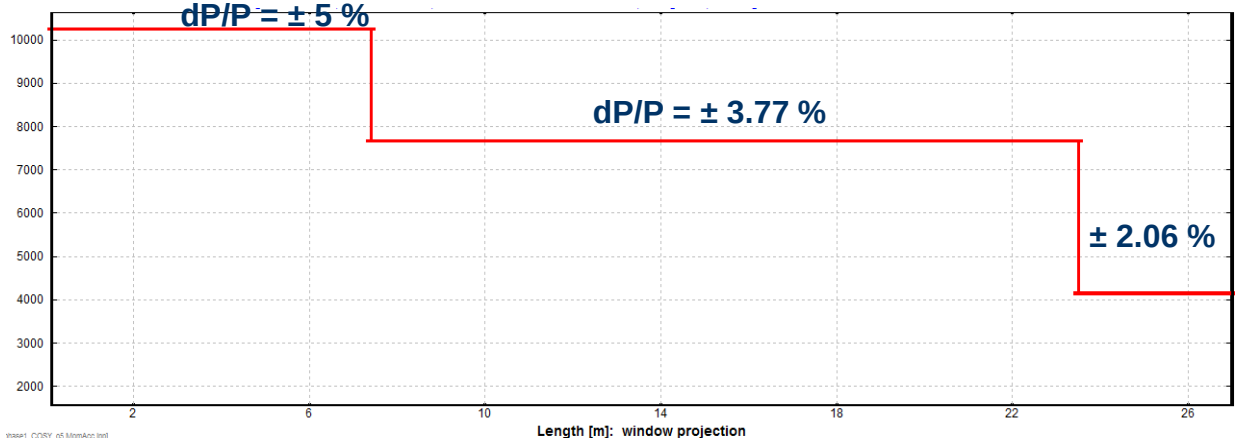


Momentum Acceptance

5th order



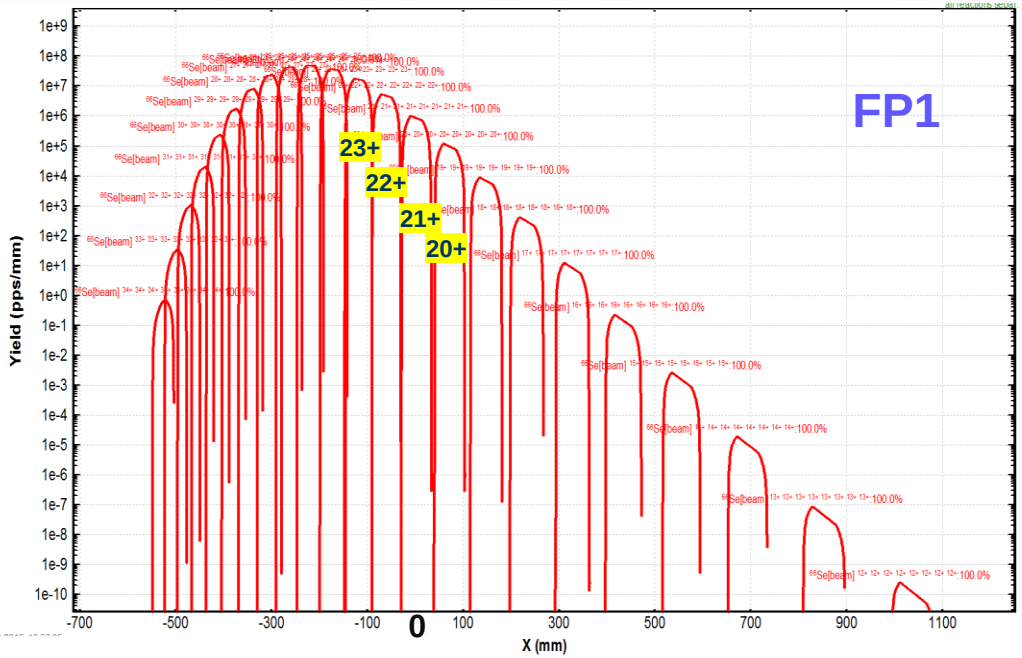




Charge States Selection: "Distribution" method

File: e_SECAR_p1_COSY.lpp

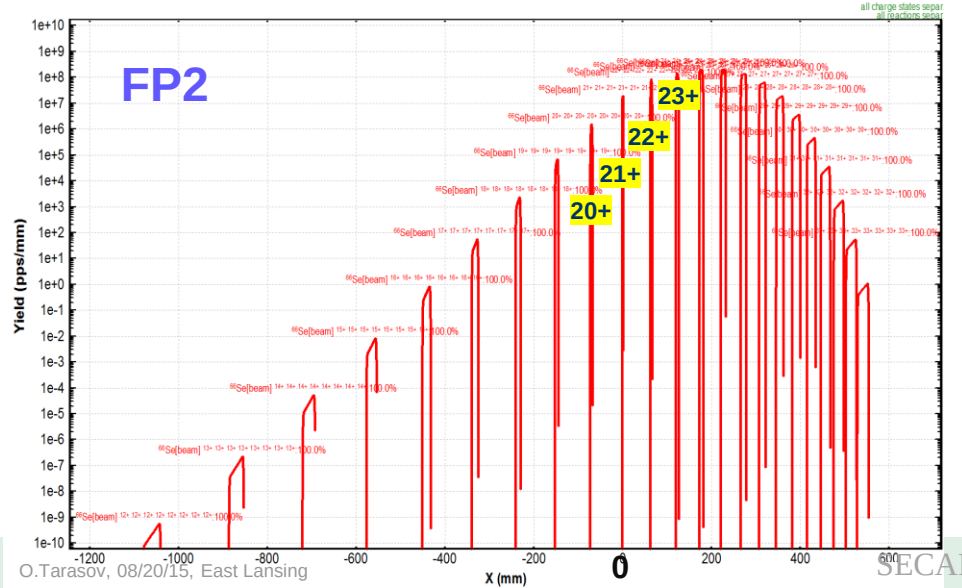
No slits, no apertures



slits FP2 : Beam & SetFragment Charge States

^{66}Se (3.1 MeV/u) + Be (1e-4 mg/cm^2); Settings on ^{66}Se^{21+}..$^{21+}$; Config: DSSSSSDSDSSSSSSSSSSSSSDSDS...

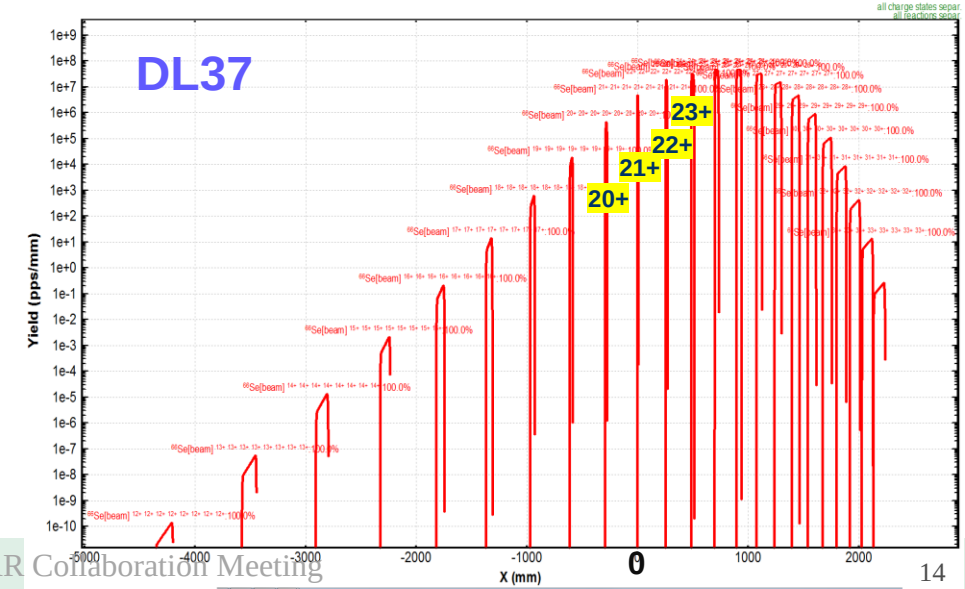
dp/p=100.00% ; Brho(Tm): 0.7988, 0.7988, 0.7988, 0.7988, 0.7988



dl37 : Beam & SetFragment Charge States

^{66}Se (3.1 MeV/u) + Be (1e-4 mg/cm^2); Settings on ^{66}Se^{21+}..$^{21+}$; Config: DSSSSSDSDSSSSSSSSSSSSSDSDS...

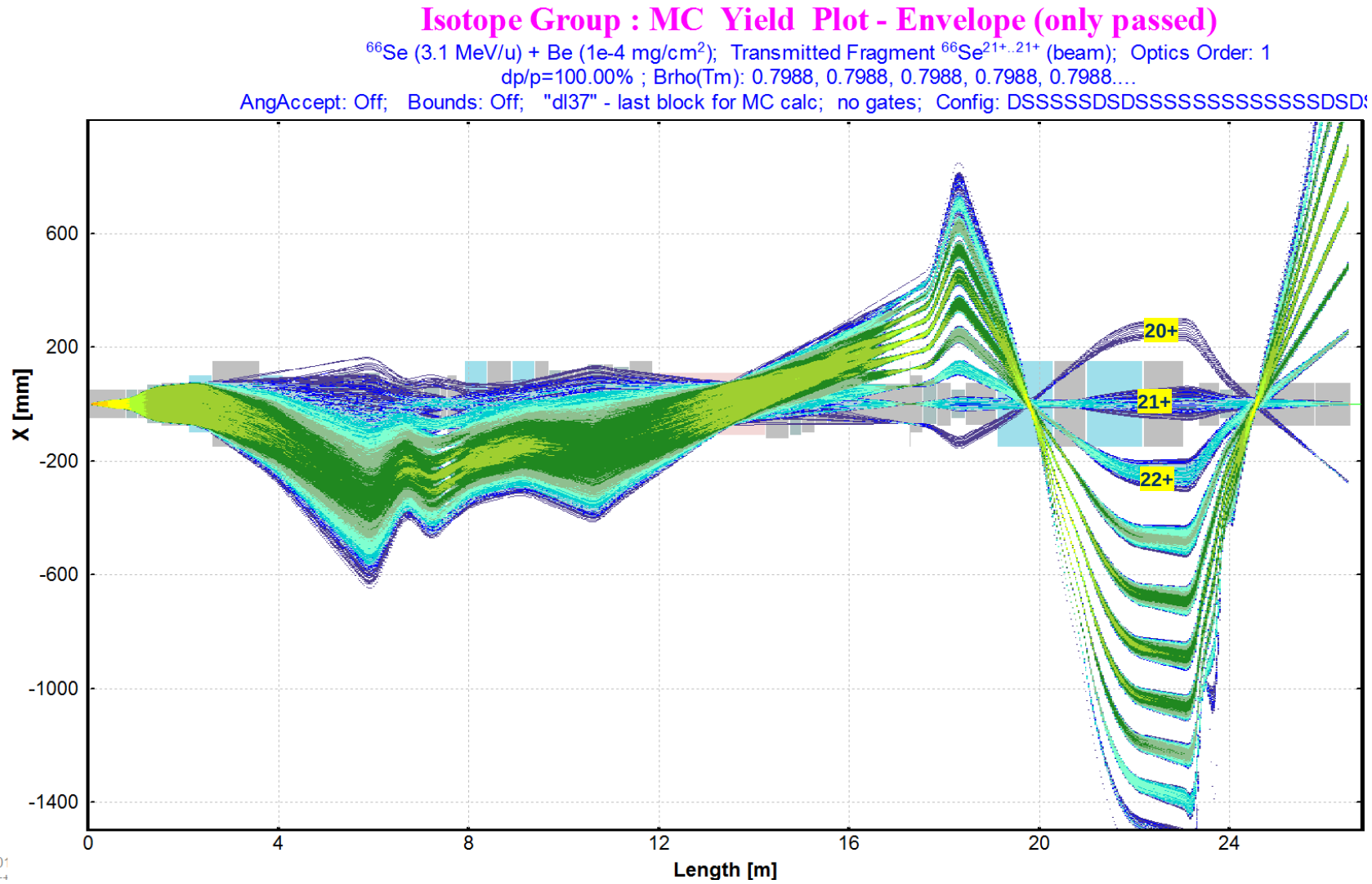
dp/p=100.00% ; Brho(Tm): 0.7988, 0.7988, 0.7988, 0.7988, 0.7988....



Charge States Selection: Monte Carlo solution

No slits, no apertures

1st order



Experiment $^{15}O(\alpha, \gamma)^{19}Ne$

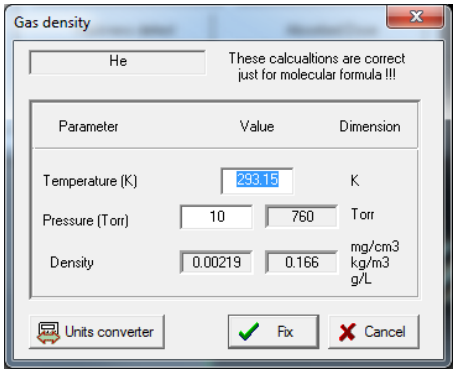
Table 3.14. Transmission results for a set of crucial reactions from the target to the final focus in the single VF system.

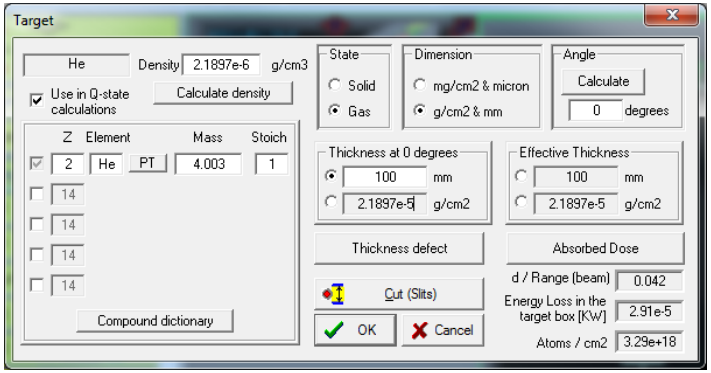
Reaction	Energy (MeV/u)	Transmission
$^{15}O(\alpha,\gamma)^{19}Ne$	0.3	95

LISE^{++} settings

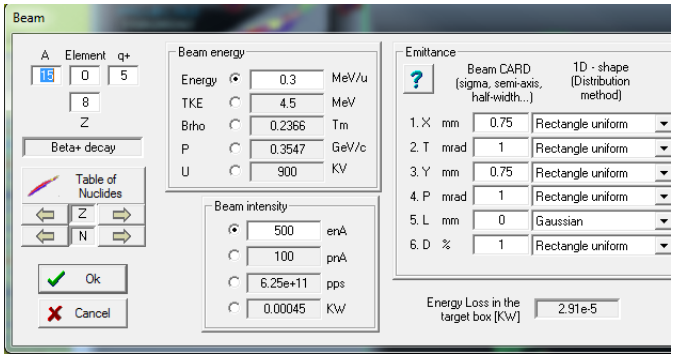
File: e_SECAR_phase1_reaction.lpp

Target

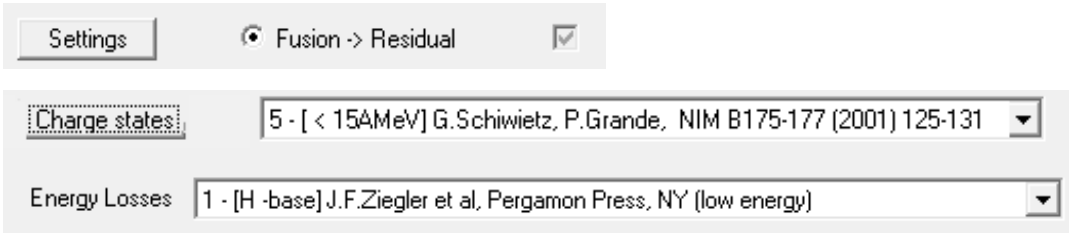




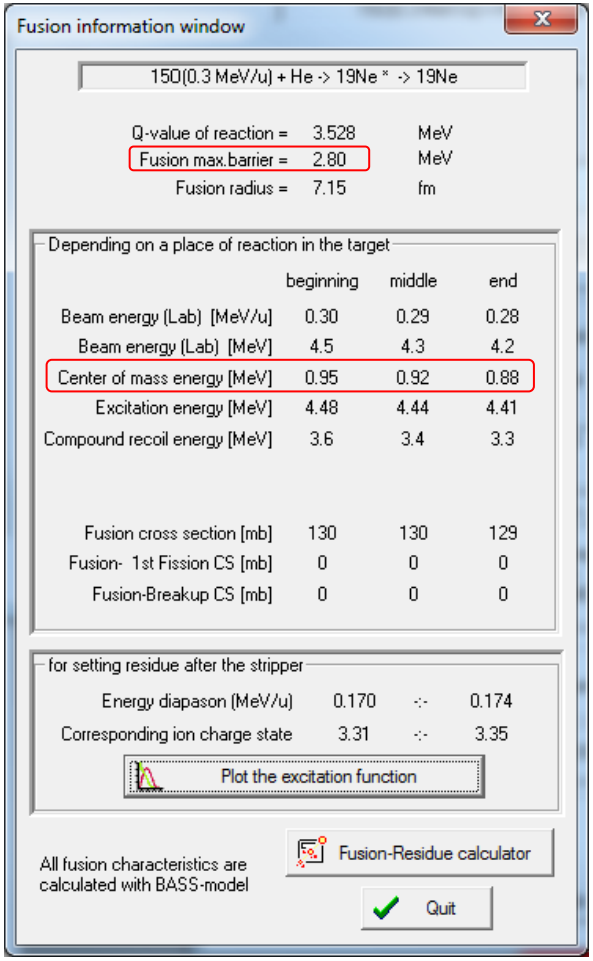
Beam

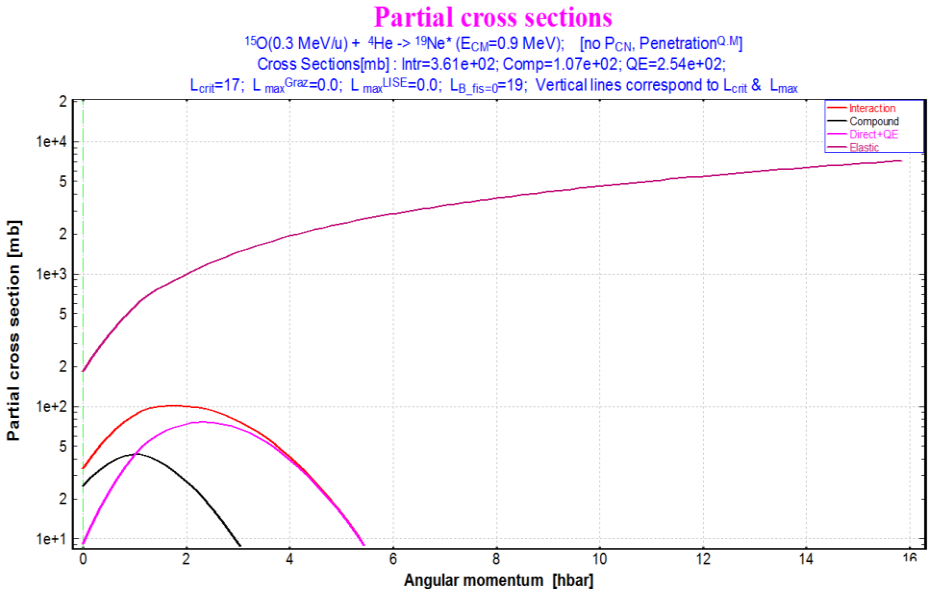


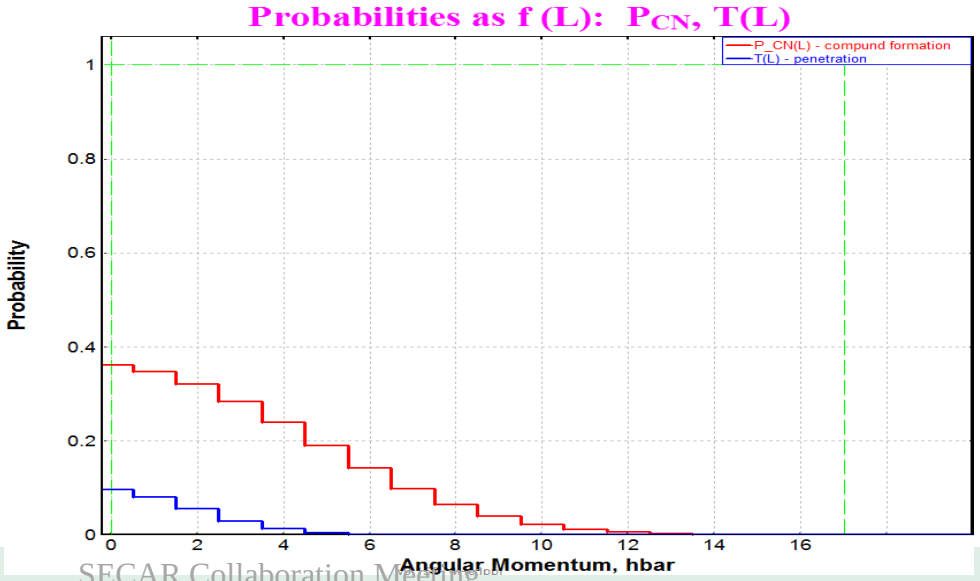
Production mechanism



Experiment $^{15}O(\alpha, \gamma)^{19}Ne$: sub-barrier fusion



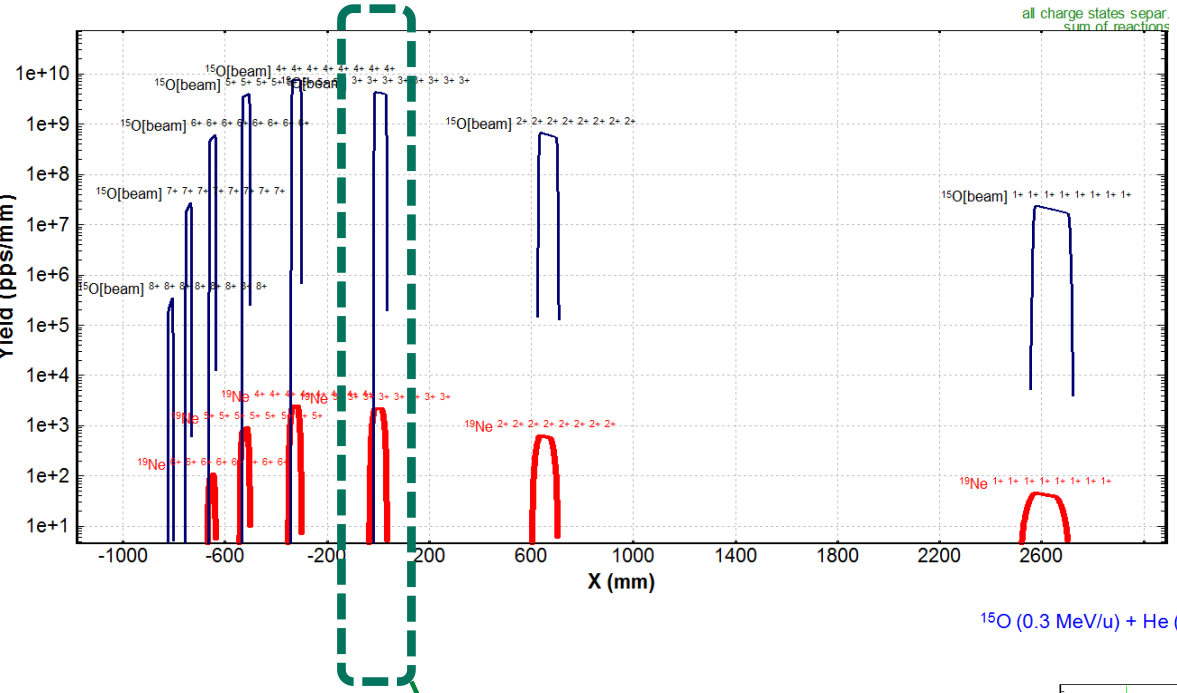




Experiment $^{15}O(\alpha, \gamma)^{19}Ne$: selection

slits FP1-Xspace: output after slits

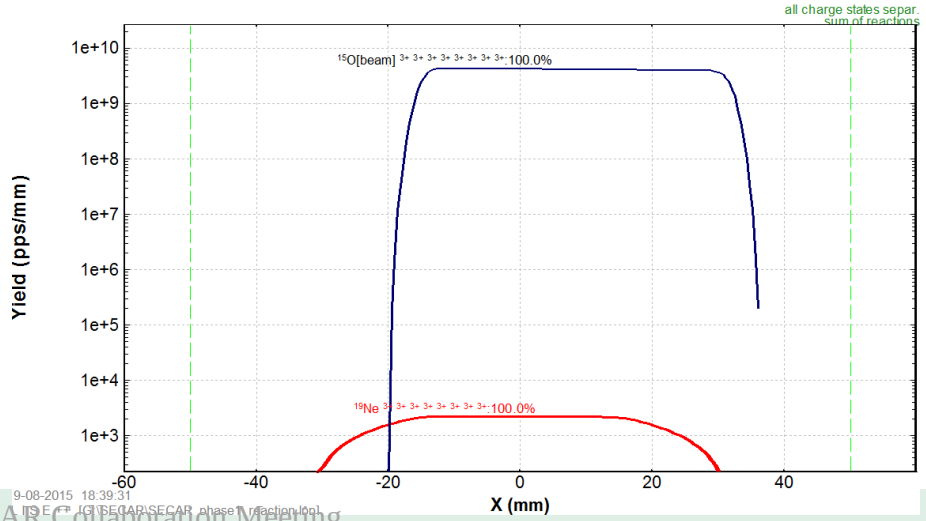
^{15}O (0.3 MeV/u) + He (100 mm); Settings on $^{19}Ne^{3+..3+}$; Config: DSSFSSFSFDSDFSSSFSSFSSFSSF...
dp/p=100.00% ; Brho(Tm): 0.3783, 0.3783, 0.3783



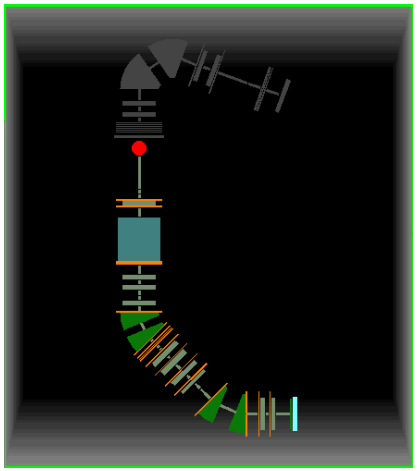
@ FP1 slits →

slits FP1-Xspace: output before slits

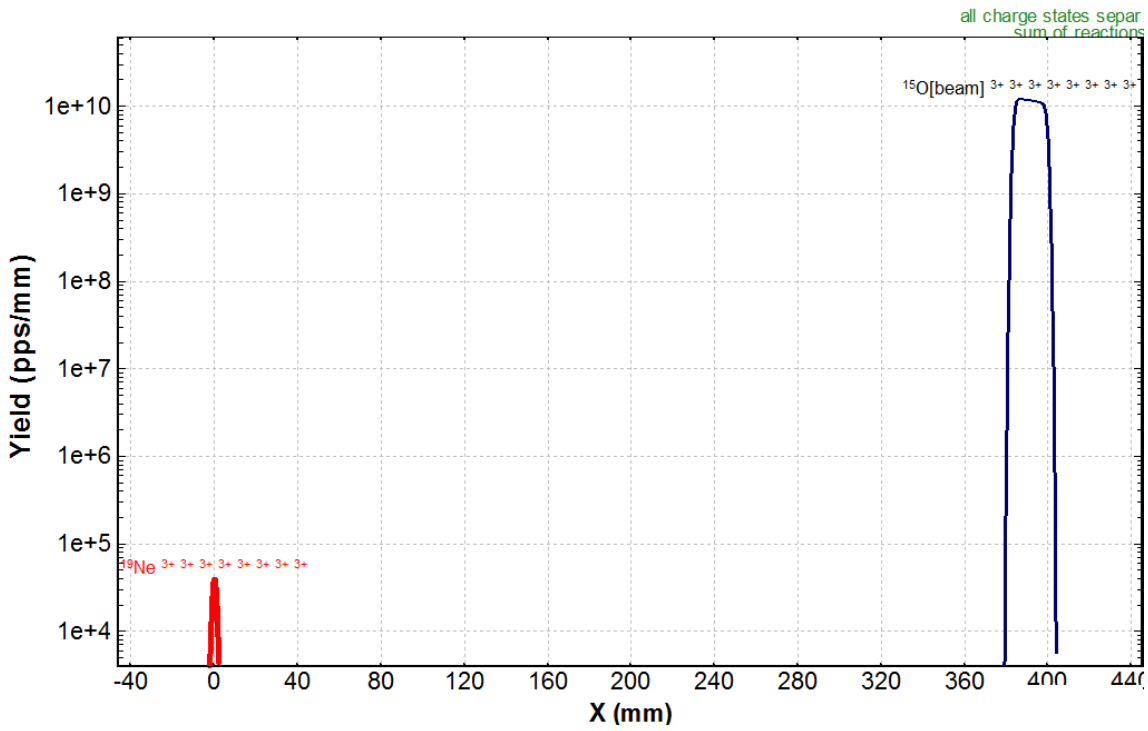
^{15}O (0.3 MeV/u) + He (100 mm); Settings on $^{19}Ne^{3+..3+}$; Config: DSSFSSFSFDSDFSSSFSSFSSF
dp/p=7.65% ; Brho(Tm): 0.3783, 0.3783, 0.3783



Experiment $^{15}O(\alpha, \gamma)^{19}Ne$: selection @ FP2



In front of the Mass Slits (FP2) with the Charge slits and Angular acceptances



Pay attention for The Wien filter parameters!!!
The purpose of E(or B) choice is to compensate dispersion after dipoles!

Experiment $^{15}O(\alpha, \gamma)^{19}Ne$: selection

$^{19}Ne^{3+}$ after the DL37

Only $^{19}Ne^{3+}$ passing through the separator !

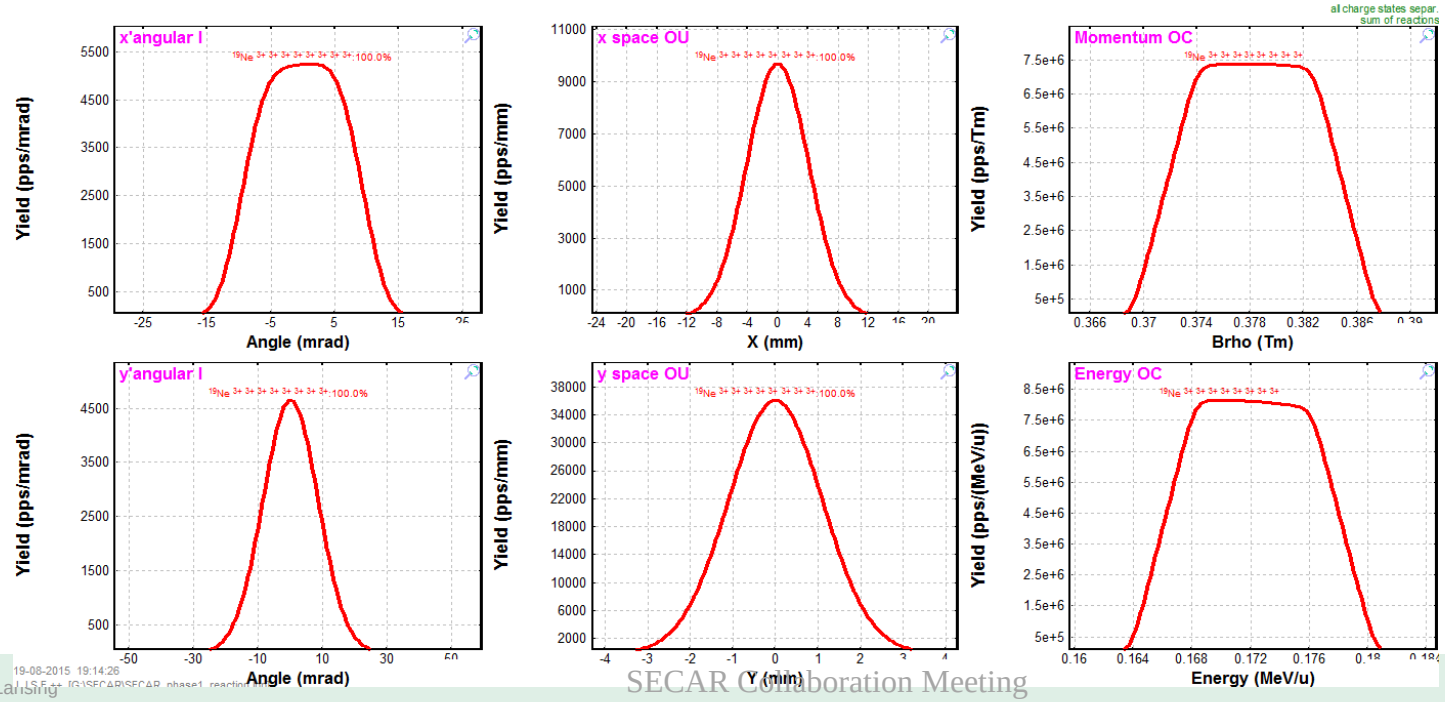
19Ne	Beta+ decay (Z=10, N=9)	
Q1 (tuning)		3
Reaction		FusRes
Ion Production Rate	(pps)	9.9e+4
Total ion transmission	(%)	37.077
Total: this reaction	(pps)	9.9e+4
Total: All reactions	(pps)	9.9e+4
X-Section in target	(mb)	1.3e+2
Target	(%)	39.09
Unreacted in material	(%)	100
Q (Charge) ratio	(%)	39.09
Unstopped in material	(%)	100
tuning	(%)	99.32
X angular transmission	(%)	99.32
Y angular transmission	(%)	100
dl12	(%)	95.59

$^{19}Ne^{3+}$ transmission 94.8%

Main cut by the 2-nd horizontal angular acceptance

dl37

^{15}O (0.3 MeV/u) + He (100 mm); Settings on $^{19}Ne^{3+..3+}$; Config: DSSFSSFSFDSDFSSSFSSFSSFSSF...
dp/p=7.65% ; Brho(Tm): 0.3783, 0.3783, 0.3783, 0.3783, 0.3783....



Summary

Open Questions:

1. Modify the two-body kinematics mechanism for the HI & γ case
2. Primary beam scattering (large angles)
3. Create the Wien characteristics utility to compensate a dipole dispersion

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