Recoil separator "SECAR" @ MSU

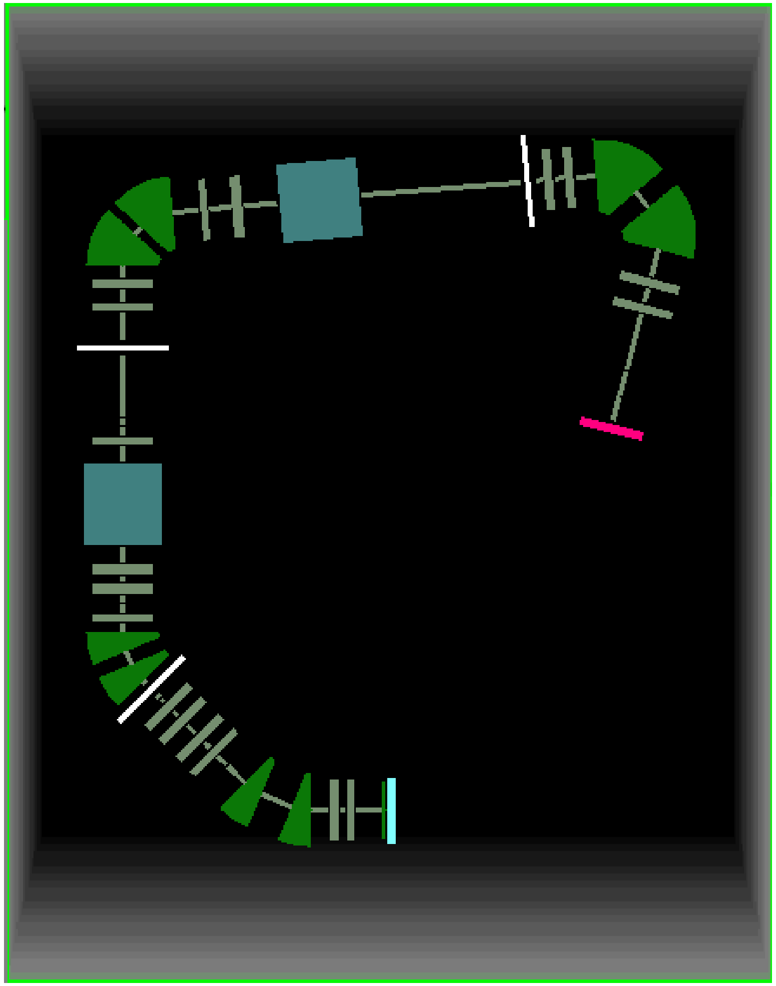
(update)

High Order Extended Configurations

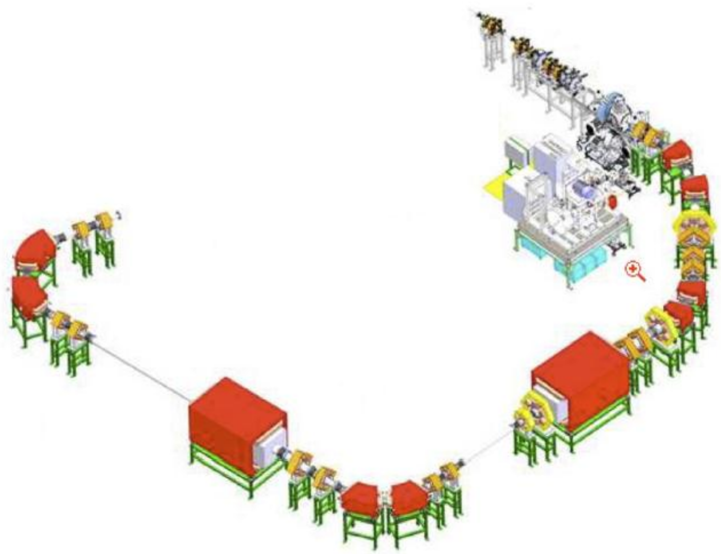
Version 9.10.169 from 08/20/2015
Version 9.10.171 from 08/27/2015
(for the update check pages: 11,12, 45, 50-54)

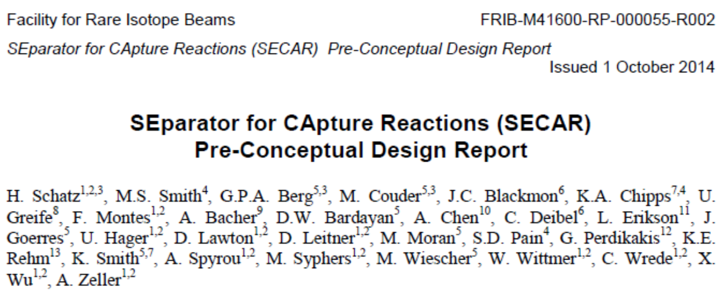
Link: Separator "SECAR"

- 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
  - De-excitation by gamma at low energies vs. kinematics
- Segmented configuration
- Open questions



1. SEparator for CApture Reactions (SECAR) Pre-Conceptual Design Report





Facility for Rare Isotope Beams FRIB-M41600-RP-000055-R002

SEparator for CApture Reactions (SECAR) Pre-Conceptual Design Report

Issued 1 October 2014

SEparator for CApture Reactions (SECAR)
Pre-Conceptual Design Report

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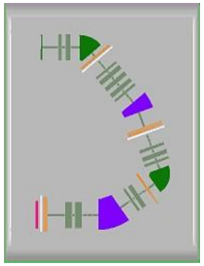
2. COSY file "inputCOSY-MC-4.fox" by G.Berg & M.Couder (Notre Dame)

Helpful information for the recent recoil separator development in LISE^{++}:
Documentation for extended configurations of the recoil separator "DRAGON" @ TRIUMF
http://lise.nscl.msu.edu/9_10/DRAGON/DRAGON.pdf



SECAR parameters (p.1)

Table 3.3. The optimized longitudinal locations and lengths of the various SECAR ele

Element		Element properties	
Technical Name	Description	"Effective" Length(m)/ angle(deg) 1VF/2VF	Radius/half gap (m)
DL1	Drift	0.8	
Q1	Quad+Hex	0.25	0.05
DL2	Drift	0.19	
Q2	Quad	0.30	0.068
DL3	Drift	0.58	
B1	Dipole	22.5 deg	1.25/0.03
DL4	Drift	1.00	
B2	Dipole	22.5 deg	1.25/0.03
DL5	Drift	0.77	
DL6	Drift	0.40	
HEX1	Hexapole	0.26	0.11
DL7	Drift	0.27	
Q3	Quad	0.35	0.11
DL8	Drift	0.35	
Q4	Quad	0.35	0.08
DL9	Drift	0.21	
Q5	Quad	0.35	0.06
DL10	Drift	0.145	
DL11	Drift	0.185	
DL12	Drift	0.17	
B3	Dipole	22.5 deg	1.25/0.05
DL13	Drift	0.51	
B4	Dipole	22.5 deg	1.25/0.05
DL14	Drift	0.30	
HEX2	Hexapole	0.26	0.12
DL15	Drift	0.27	
DL16	Drift	0.27	
Q6	Quad	0.34	0.14
DL17	Drift	0.20	
Q7	Quad	0.34	0.13
DL18	Drift	0.50	
VF1	Velocity filter	2.365	0.11
DL19	Drift	0.50	
HEX3	Hexapole	0.26	0.11
DL20	Drift	0.28	
OCT1	Octupole	0.26	0.07
DL21	Drift	1.75	
DL22	Drift	0.872	
Q8	Quad	0.25	0.05
DL23	Drift	0.395	
Q9	Quad	0.30	0.06
DL24	Drift	0.36	
B5	Dipole	42.5 deg	1.25/ 0.03
DL25	Drift	0.35	
B6	Dipole	42.5 deg	1.25/0.03
DL26	Drift	0.83	
Q10	Quad	0.26	0.09
DL27	Drift	0.65	
Q11	Quad	0.34	0.12
DL28	Drift	1.00	
VF2	Velocity filter	2.365	0.11
DL29	Drift	4.60	
DL30	Drift	0.25	
Q12	Quad	0.30	0.07
DL31	Drift	0.30/0.35	
Q13	Quad	0.30	0.05
DL32	Drift	0.66	
B7	Dipole	55.0 deg	1.25/0.03
DL33	Drift	0.68	
B8	Dipole	55.0 deg	1.25/ 0.03
DL34	Drift	0.86	
Q14	Quad	0.30	0.05
DL35	Drift	0.45	
Q15	Quad	0.30	0.05
DL36	Drift	1.70/1.21	
DL37	Drift	0.75/1.10	
DL38	Drift	0.75/0.40	

SECAR parameters (p.2)

Dipoles

		Parameter							
	Units	B1	B2	B3	B4	B5	B6	B7	B8
Bending radius	mm	1250	1250	1250	1250	1250	1250	1250	1250
Maximum rigidity	Tm	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Max. magnetic field B	T	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
Bending angle, to right	deg	22.5	22.5	22.5	22.5	42.5	42.5	55.0	55.0
Central ray, arc length	mm	490.9	490.9	490.9	490.9	927.2	927.2	1199.9	1199.9
Vertical gap, full size	mm	60	60	100	100	60	60	60	60
GFR, dB/B <+/-0.02%	mm	200	200	100	200	100	100	100	100
Pole width	mm	380	380	400	500	300	300	280	280
Entrance s_{11}		0.1900	0.1150	0.1900	0.1900	0.1890	0.1970	0	0
Entrance s_{12}	1/m	0.0025	0.0125	1.07	-0.339	0.696	-1.66	0	0
Entrance s_{13}	1/m²	0.154	0.198	-9.10	-5.51	-0.953	-50..	0	0
Entrance s_{14}	1/m³	0.78	-40.77	0.	-0.84	-53.	0.	0	0
Exit s_{21}		0.1500	0.1150	0.1150	0.1900	-0.172	0.200	0	0
Exit s_{22}	1/m	-0.019	-0.2448	0.0410	-0.030	-5.928	-4.00	0	0
Exit s_{23}	1/m²	0.147	1.411	32.7	-0.364	-26.5	69.	0	0
Exit s_{24}	1/m³	0.10	37.47	-57.	-0.15	-940..	0.	0	0

Table 3.10. Specifications of SECAR Velocity Filters

Good-field Region (GFR)	Horizontal	mm	± 110
	Vertical	mm	± 35
Dipole Magnet	Max. B field in GFR	T	0.12
	Effective field length	mm	2365
	Pole gap, vertical	mm	900
	Pole width, approx..	mm	1020
	B field, homogeneity		± 0.0002 in GFR
	Estimated power	kW	50
	Iron weight	kg	12800
	2 Coils Weight	kg	2300
Electrostatic system	Max. E field in GFR	kV/mm	2.7
	Max. Voltages on electrodes	kV	+/- 300
	Effective field length	mm	2365
	Electrode gap, horizontal	mm	220
	Electrode height, vertical	mm	538

SECAR parameters (p.3)

Table 3.4. Quadrupole and multipole field settings for the SECAR C charge state 21, energy 206 MeV).

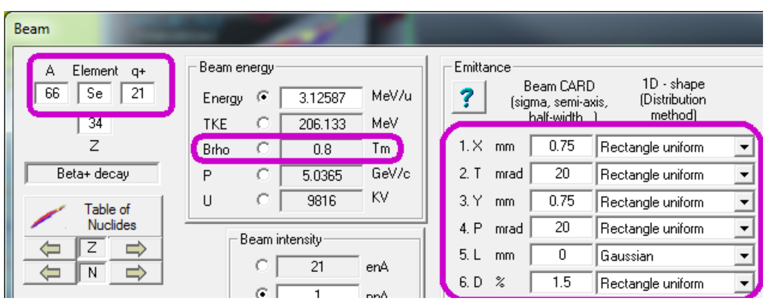
Quadrupole	Radius (m)	Pole tip field (T)	Gradient T/m
Q1	0.05	-0.3654	-7.3080000
Q2	0.068	0.217880	3.2041176
Q3	0.11	0.242643	2.2058455
Q4	0.08	-0.24501	-3.0626250
Q5	0.06	0.1112810	1.8546833
Q6	0.14	0.181721	1.2980071
Q7	0.13	-0.0301435	-0.2318731
Q8	0.05	-0. 15032	-3.0064000
Q9	0.06	0.23438	3.3482857
Q10	0.09	-0.03250	-0.3611111
Q11	0.12	0.1616	1.3466667
Q12	0.07	-0.1820	-2.6000000
Q13	0.05	0.1910	3.8200000
Q14	0.05	0.1290	2.5800000
Q15	0.05	-0.138	-2.7600000
HEX(Q1)	0.05	-0.00289	
HEX1	0.11	0.0103064	
HEX2	0.12	0.011057	
HEX3	0.11	-0.01251	

The optimized ion optics setup was calculated for the transmission of "reference" ions with mass 66, charge 21, and a laboratory energy of 206 MeV corresponding to 3.12 MeV center of mass energy. These ions correspond to the recoiling ^{66}Se ions from the ^{65}As(p,γ)^{66}Se reaction, and have the maximum magnetic rigidity of $B\rho$ = 0.800 Tm. The field settings for recoils from any particular reaction are then determined by appropriately scaling the optimized settings by the ratio of magnetic rigidities. The lowest design rigidity for our system is 0.14 Tm. In the optimized setup, the maximum magnetic design rigidity of 0.8 Tm and a dipole magnet with bending radius of 1.25 m require dipole fields of 0.64 T. The pole tip fields and pole tip radii of the quadrupoles, hexapoles, octupole, and multipole strengths are listed in Table 3.4. The optimum field settings of the velocity filter are 0.1143 T magnetic field and +/- 308.3 kV for the HV on the electrodes, corresponding to an electric field of 2.80kV/mm. Component specifications for the velocity filters are given in Table 3.9 in §3.7.3. The bending radii for the magnetic and electric fields in the velocity filters correspond to 7 m for both the electric and the magnetic fields.

For SECAR phase1

element	REPORT from October 2014	COSY file, table v4
	T	T
Q1	-0.3654	-0.3653
Q2	0.2179	0.2179
Q3	0.2426	0.2426
Q4	-0.2450	-0.2450
Q5	0.1113	0.1113
Q6	0.1817	0.1817
Q7	-0.0301	-0.0301
Q8	-0.1503	
Q9	0.2344	
Q10	-0.0325	
Q11	0.1616	
Q12	-0.1820	-0.2200
Q13	0.1910	0.2016
Q14	0.1290	0.1315
Q15	-0.1380	-0.1450
HEX(Q1)	-0.0029	-0.0006
HEX1	0.0103	0.0086
HEX2	0.0111	0.0145
HEX3	-0.0125	-0.0434

Beam in LISE^{++}



SECAR settings in LISE^{++} : target – FP2

1 N or	2 Block name	3 Kind of Block	4 Start (m)	5 Length (m)	6 DriftMode Angle(°)*	7 B0(kG)	8 Br-corrsp Br-dip*	9 Rapp(cm) R(m)*	10 L_eff(m) Len(m)*	11 2nd order	12 Calc Mode	13 AngAcc mode	14 Slits shape	15 Xmin slit	16 Xmax slit	17 Ymin slit	18 Ymax slit	19 Appert shape	20 Xmin limit	21 Xmax limit	22 Ymin limit	23 Ymax limit
1.	tuning	Dipole	0.000	0.000	+0.0 *	+2.667	0.8000*	3.00*	0.00*	-		--	rectn					ellps	-50	+50	-50	+50
2.	dl1	Drift	0.000	0.800	standard							--	rectn					ellps	-50	+50	-50	+50
3.	Q1	Drift	0.800	0.250	multipole	-3.653	0.8000	5.00	0.25	yes	1	--	rectn					ellps	-50	+50	-50	+50
4.	dl2	Drift	1.050	0.190	standard							--	rectn					ellps				
5.	Q2	Drift	1.240	0.300	multipole	+2.179	0.8000	6.80	0.30	yes	1	--	rectn					ellps	-68	+68	-68	+68
6.	dl3	Drift	1.540	0.580	standard							--	rectn					ellps				
7.	B1	Dipole	2.120	0.491	+22.5 *	+2.667	0.8000*	1.25*	0.49*	yes		--	rectn					rectn			-30	+30
8.	dl4	Drift	2.611	1.000	standard							--	rectn					rectn				
9.	B2	Dipole	3.611	0.491	+22.5 *	+2.667	0.8000*	1.25*	0.49*	yes		--	rectn					rectn			-30	+30
10.	dl5	Drift	4.102	0.770	standard							--	rectn					rectn				
11.	dl6	Drift	4.872	0.400	standard							--	rectn					rectn				
12.	Hex1	Drift	5.272	0.260	multipole	+0.000	0.8000	11.00	0.26	yes	1	--	rectn					ellps	-110	+110	-110	+110
13.	dl7	Drift	5.532	0.270	standard							--	rectn					rectn				
14.	Q3	Drift	5.802	0.350	multipole	+2.426	0.8000	11.00	0.35	yes	1	--	rectn					ellps	-110	+110	-110	+110
15.	dl8	Drift	6.152	0.350	standard							--	rectn					rectn				
16.	Q4	Drift	6.502	0.350	multipole	-2.450	0.8000	8.00	0.35	yes	1	--	rectn					ellps	-80	+80	-80	+80
17.	dl9	Drift	6.852	0.210	standard							--	rectn					rectn				
18.	Q5	Drift	7.062	0.350	multipole	+1.113	0.8000	6.00	0.35	yes	1	--	rectn					ellps	-60	+60	-60	+60
19.	dl10	Drift	7.412	0.145	standard							--	rectn					rectn				
20.	dl11	Drift	7.557	0.185	standard							--	rectn					rectn				
21.	slits FP1	Drift	7.742	0.000	SLITS							--	rectn	-100	+100	-50	+50	rectn				
22.	dl12	Drift	7.742	0.170	standard							--	rectn					rectn				
23.	B3	Dipole	7.912	0.491	+22.5 *	+2.667	0.8000*	1.25*	0.49*	yes		--	rectn					rectn			-50	+50
24.	dl13	Drift	8.403	0.510	standard							--	rectn					rectn			-50	+50
25.	B4	Dipole	8.913	0.491	+22.5 *	+2.667	0.8000*	1.25*	0.49*	yes		--	rectn					rectn			-50	+50
26.	dl14	Drift	9.403	0.300	standard							--	rectn					rectn				
27.	Hex2	Drift	9.703	0.260	multipole	+0.000	0.8000	12.00	0.26	yes	1	--	rectn					ellps	-120	+120	-120	+120
28.	dl15	Drift	9.963	0.270	standard							--	rectn					rectn				
29.	dl16	Drift	10.233	0.270	standard							--	rectn					rectn				
30.	Q6	Drift	10.503	0.340	multipole	+1.817	0.8000	14.00	0.34	yes	1	--	rectn					ellps	-140	+140	-140	+140
31.	dl17	Drift	10.843	0.200	standard							--	rectn					rectn				
32.	Q7	Drift	11.043	0.340	multipole	-0.301	0.8000	13.00	0.34	yes	1	--	rectn					ellps	-130	+130	-130	+130
33.	dl18	Drift	11.383	0.500	standard							--	rectn					ellps				
34.	VF1	Wien	11.883	2.365								--	rectn					rectn	-110	+110	-35	+35
35.	dl19	Drift	14.248	0.500	standard							--	rectn					rectn				
36.	Hex3	Drift	14.748	0.260	multipole	+0.000	0.7999	11.00	0.26	yes	1	--	rectn					ellps	-110	+110	-110	+110
37.	dl20	Drift	15.008	0.280	standard							--	rectn					rectn				
38.	Oct1	Drift	15.288	0.260	standard							--	rectn					ellps	-70	+70	-70	+70
39.	dl21	Drift	15.548	1.750	standard							--	rectn					rectn				
40.	slits FP2	Drift	17.298	0.000	SLITS							--	rectn	-150	+150	-100	+100	rectn				

This settings list can be produced in LISE^{++} using menu "Experimental Settings -> Optics -> Optics settings: View and Print"

These aperture parameters are used to obtain angular and momentum acceptances of the separator.

SECAR settings in LISE++ : FP2 – DL38

1 N or	2 Block name	3 Kind of Block	4 Start (m)	5 Length (m)	6 DriftMode Angle(°)*	7 B0(kG)	8 Br-corrsp Br-dip*	9 Rapp(cm) R(m)*	10 L_eff(m) Len(m)*	11 2nd order	12 Calc Mode	13 AngAcc mode	14 Slits shape	15 Xmin slit	16 Xmax slit	17 Ymin slit	18 Ymax slit	19 Appert shape	20 Xmin limit	21 Xmax limit	22 Ymin limit	23 Ymax limit
41.	dl22	Drift	17.298	0.872	standard							--	rectn					rectn				
42.	Q8	Drift	18.170	0.250	multipole	-1.503	0.7999	5.00	0.25	yes	1	--	rectn					ellps	-50	+50	-50	+50
43.	dl23	Drift	18.420	0.395	standard							--	rectn					rectn				
44.	Q9	Drift	18.815	0.300	multipole	+2.343	0.7999	6.00	0.30	yes	1	--	rectn					ellps	-60	+60	-60	+60
45.	dl24	Drift	19.115	0.360	standard							--	rectn					rectn				
46.	B5	Dipole	19.475	0.927	+42.5 *	+2.667	0.8000*	1.25*	0.93*	yes		--	rectn					rectn			-30	+30
47.	dl25	Drift	20.403	0.350	standard							--	rectn					rectn				
48.	B6	Dipole	20.753	0.927	+42.5 *	+2.667	0.8000*	1.25*	0.93*	yes		--	rectn					rectn			-30	+30
49.	dl26	Drift	21.680	0.830	standard							--	rectn					rectn				
50.	Q10	Drift	22.510	0.260	multipole	-0.325	0.8000	9.00	0.26	yes	1	--	rectn					ellps	-90	+90	-90	+90
51.	dl27	Drift	22.770	0.650	standard							--	rectn					rectn				
52.	Q11	Drift	23.420	0.340	multipole	+1.616	0.8000	12.00	0.34	yes	1	--	rectn					ellps	-120	+120	-120	+120
53.	dl28	Drift	23.760	1.000	standard							--	rectn					rectn				
54.	VF2	Wien	24.760	2.365								--	rectn					rectn	-110	+110	-35	+35
55.	dl29	Drift	27.125	4.600	standard							--	rectn					rectn				
56.	slits FP3	Drift	31.725	0.000	SLITS							--	rectn	-150	+150	-100	+100	rectn				
57.	dl30	Drift	31.725	0.250	standard							--	rectn					rectn				
58.	Q12	Drift	31.975	0.300	multipole	-1.820	0.7999	7.00	0.30	yes	1	--	rectn					ellps	-70	+70	-70	+70
59.	dl31	Drift	32.275	0.300	standard							--	rectn					rectn				
60.	Q13	Drift	32.575	0.300	multipole	+1.910	0.7999	5.00	0.30	yes	1	--	rectn					ellps	-50	+50	-50	+50
61.	dl32	Drift	32.875	0.660	standard							--	rectn					rectn				
62.	B7	Dipole	33.535	1.200	+55.0 *	+2.667	0.8000*	1.25*	1.20*	yes		--	rectn					rectn			-30	+30
63.	dl33	Drift	34.735	0.680	standard							--	rectn					rectn				
64.	B8	Dipole	35.415	1.200	+55.0 *	+2.667	0.8000*	1.25*	1.20*	yes		--	rectn					rectn			-30	+30
65.	dl34	Drift	36.615	0.860	standard							--	rectn					rectn				
66.	Q14	Drift	37.475	0.300	multipole	+1.290	0.8000	5.00	0.30	yes	1	--	rectn					ellps	-50	+50	-50	+50
67.	dl35	Drift	37.775	0.450	standard							--	rectn					rectn				
68.	Q15	Drift	38.225	0.300	multipole	-1.380	0.8000	5.00	0.30	yes	1	--	rectn					ellps	-50	+50	-50	+50
69.	dl36	Drift	38.525	1.700	standard							--	rectn					rectn				
70.	dl37	Drift	40.225	0.750	standard							--	rectn					rectn				
71.	dl38	Drift	40.975	0.750	standard							--	rectn					rectn				

This settings list can be produced in LISE++ using menu "Experimental Settings -> Optics -> Optics settings: View and Print"

These aperture parameters are used to obtain angular and momentum acceptances of the separator.

Configuration "SECAR phase1"

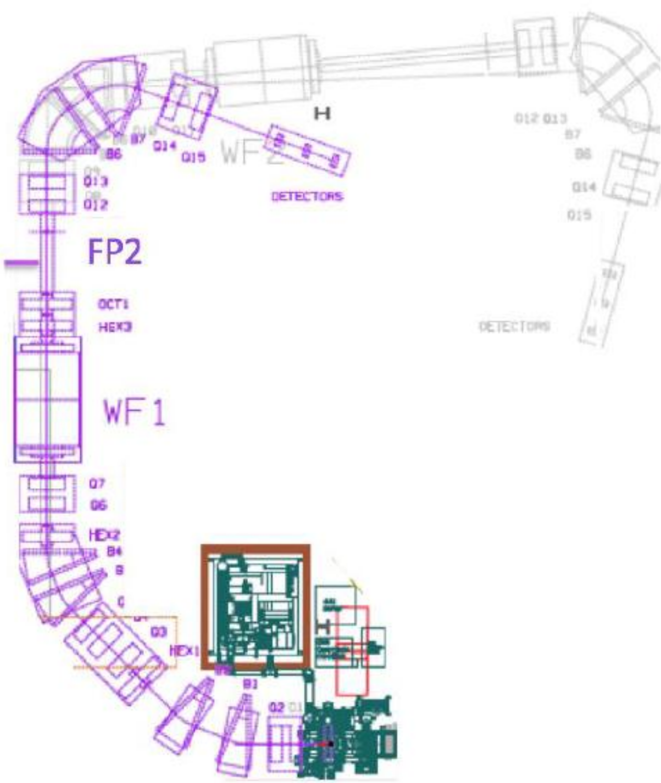
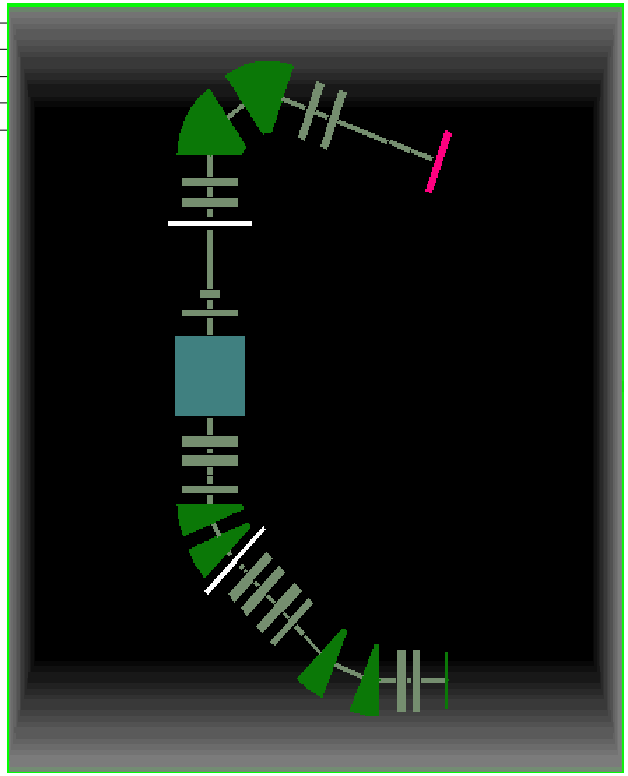


Table 3.13. SECAR Optimized Setup for a 1 VF system

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	

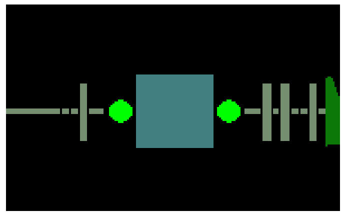
@ LISE^{++}



SECAR Wien filter in LISE^{++}

Up to v.9.10.164 only clockwise bending direction

R	Rotate 1	Angle 180 deg
V	VF1	E 2800 KV/m B 1142.93 G DL -3.93 mm/%
R	Rotate 2	Angle 180 deg



SECAR Wien filter in COSY

```
CB;
WF 7.0  7.0 2.365 0.11 ;                      {WF1}
CB;
```

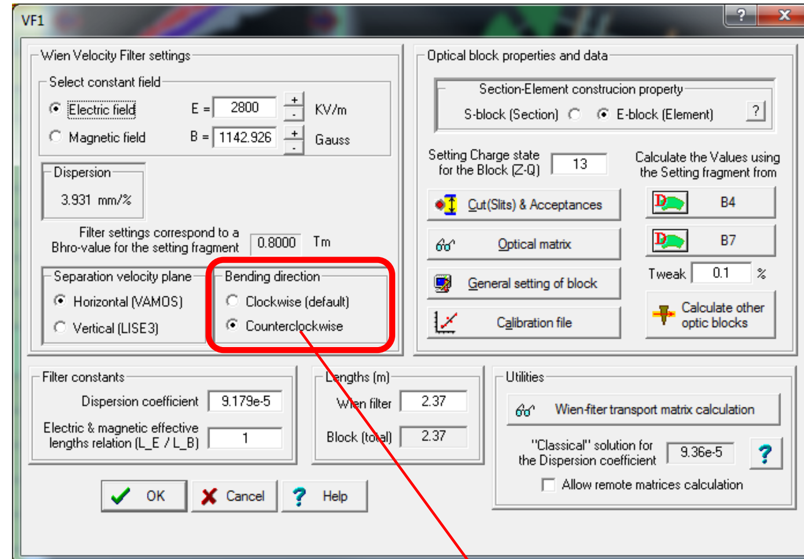
Block matrix

1. X	0.94766	2.32124	0	0	0	3.93094
2. T	-0.04391	0.94766	0	0	0	3.2983
3. Y	0	0	1	2.365	0	0
4. P	0	0	0	1	0	0
5. L	-0.32983	-0.39309	0	0	1	-0.45165
6. D	0	0	0	0	0	1
	/[mm]	/[mrad]	/[mm]	/[mrad]	/[mm]	/[%]

Det = 0.99999 Import/link COSY map

Wien velocity filter
Link to COSY map
☑ WF1.TXT

v.9.10.165



V	VF1	E 2800 KV/m B 1142.93 G DL 3.93 mm/%

We do not need more rotation blocks

Block matrix

1. X	0.94383	2.32055	0	0	0	3.93137
2. T	-0.04705	0.94383	0	0	0	3.29318
3. Y	0	0	1	2.365	0	0
4. P	0	0	0	1	0	0
5. L	0	0	0	0	1	0
6. D	0	0	0	0	0	1
	/[mm]	/[mrad]	/[mm]	/[mrad]	/[mm]	/[%]

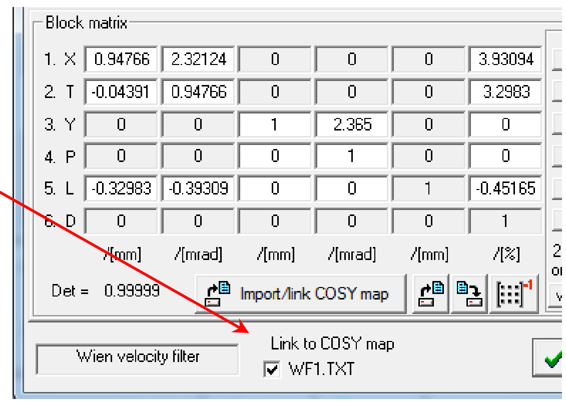
Det = 1.00000 Import/link COSY map

v.9.10.168

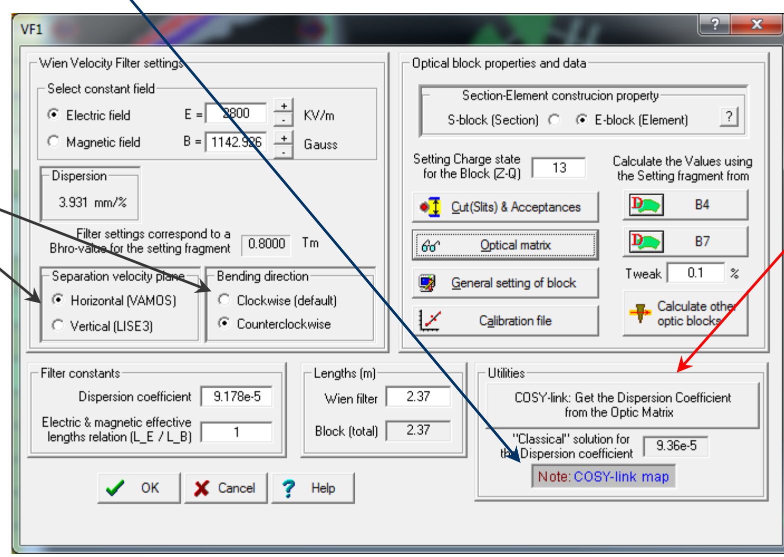
- Wien filter dispersion is "floating" for each ion in LISE++, and is calculated based on the Dispersion coefficient.
- A new option has been developed for consistency in the case of COSY linked map

- Link a COSY map to LISE++ block

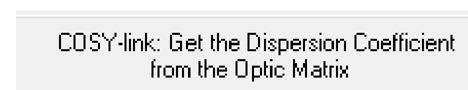
  you will get the message later in the Wien filter dialog



- Set correct Selection and Bending directions



- Click the button



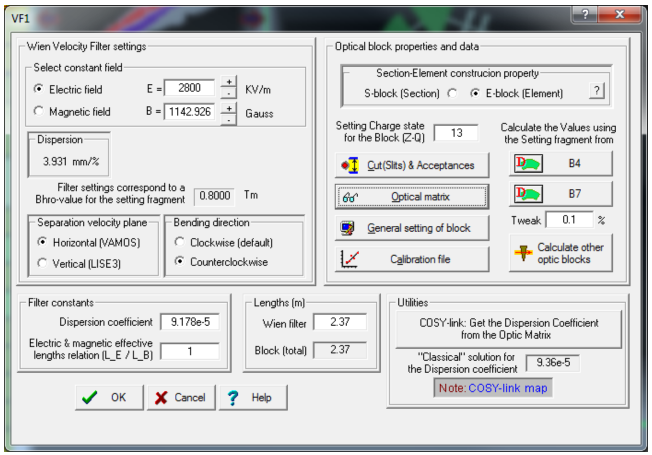
to calculate the dispersion coefficient corresponding to the COSY map.

This coefficient will be valid for all fragments at different energies

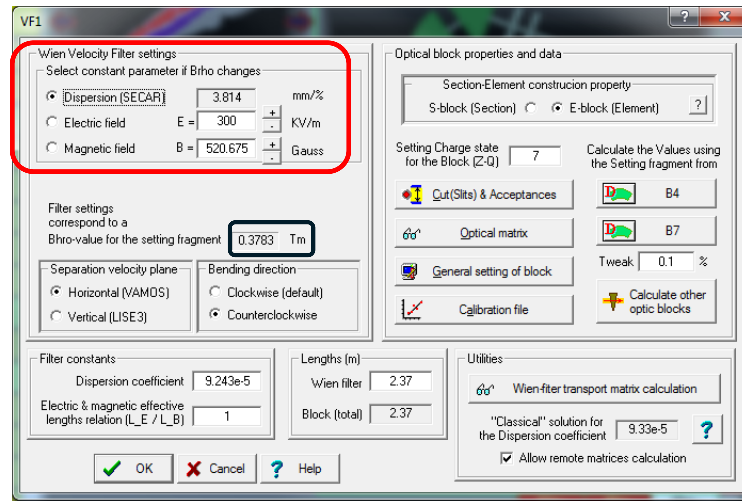
LISE^{++} modifications for SECAR : new Wien Filter constant parameter

Keep "Dispersion" constant if Brho changes is a new option of the Wien filter block

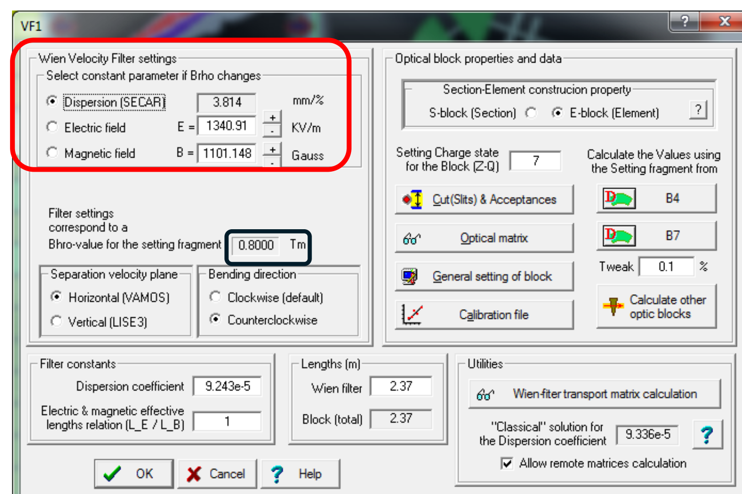
v.9.10.169



v.9.10.170



See example
@ Br = 0.37833 Tm



See example
@ Br = 0.8 Tm

SECAR files location @ LISE^{++} package

Important!! All these files have been update in *version 9.10.171* for the new Fien filter feature "keep dispersion constant"

LISE^{++} files

\lise\files\examples\SECAR*.*

↑Name	
[..]	
e_SECAR	→ *SECAR extended for primary beam (not optimized yet)*
e_SECAR_p1_beam	→ *SECAR phase1 extended for primary beam*
e_SECAR_p1_COSY	→ *SECAR phase1 extended with COSY 5th order maps*
e_SECAR_p1_reaction	→ *SECAR phase1 extended :* ^{15}O(α, γ)^{19}Ne

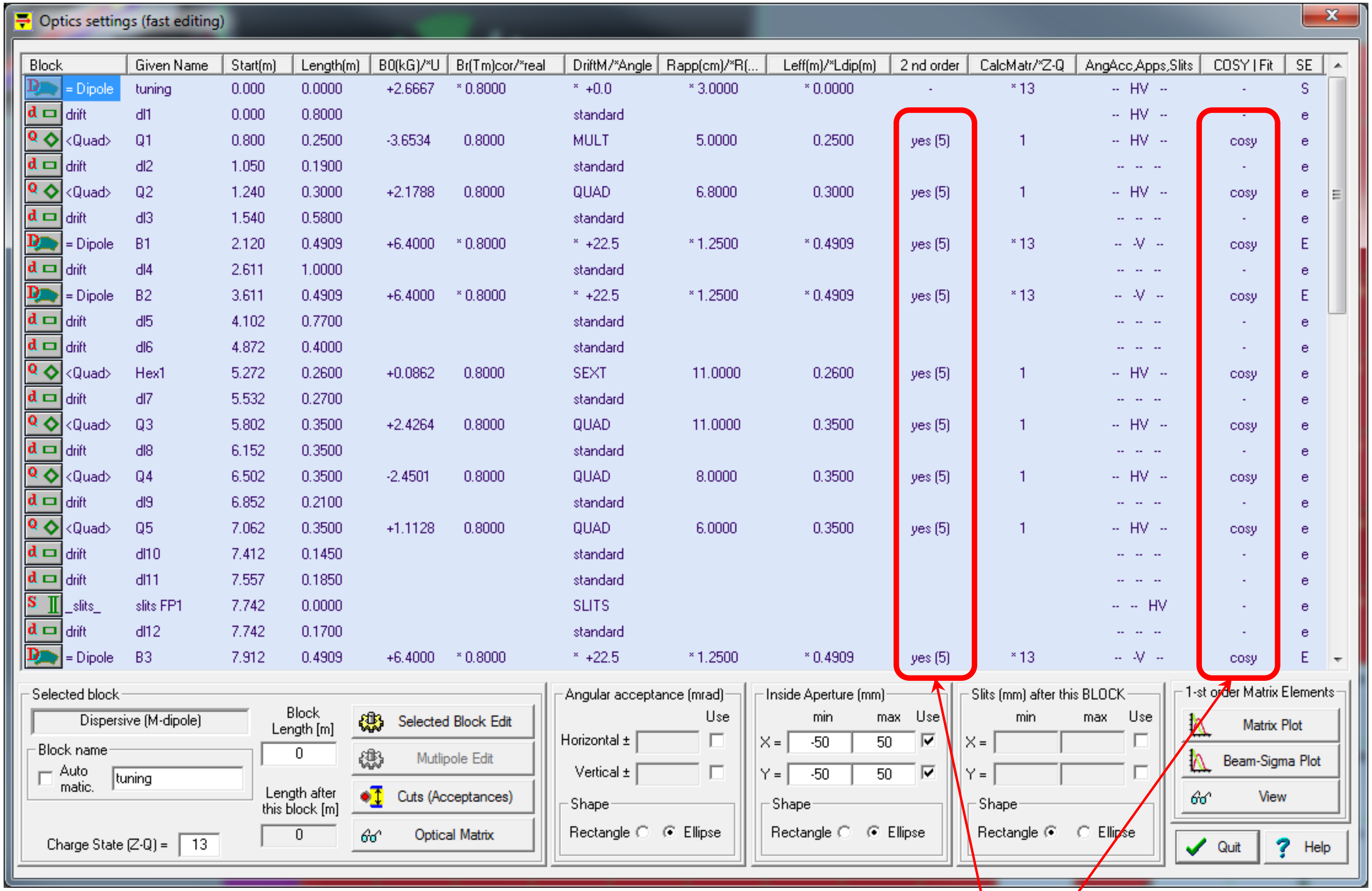
LISE^{++} configurations

\lise\config\SECAR*.*

↑Name	
[..]	
e_SECAR	
e_SECAR_p1	→ *SECAR extended configurations*
e_SECAR_p1_COSY	
SECAR v6s	→ *COSY file to generate SECAR maps for LISE^{++}*

SECAR segmented configurations will be done soon

File: e_SECAR_p1_COSY.lpp



Block	Given Name	Start(m)	Length(m)	B0(kG)/*U	Br(Tm)cor/*real	DriftM/*Angle	Rapp(cm)/*R(...	Leff(m)/*Ldip(m)	2 nd order	CalcMatr/*Z-Q	AngAcc,Apps,Slits	COSY | Fit	SE
= Dipole	tuning	0.000	0.0000	+2.6667	* 0.8000	* +0.0	* 3.0000	* 0.0000	-	* 13	-- HV --	-	S
drift	dl1	0.000	0.8000			standard					-- HV --	-	e
<Quad>	Q1	0.800	0.2500	-3.6534	0.8000	MULT	5.0000	0.2500	yes (5)	1	-- HV --	cosy	e
drift	dl2	1.050	0.1900			standard					-- -- --	-	e
<Quad>	Q2	1.240	0.3000	+2.1788	0.8000	QUAD	6.8000	0.3000	yes (5)	1	-- HV --	cosy	e
drift	dl3	1.540	0.5800			standard					-- -- --	-	e
= Dipole	B1	2.120	0.4909	+6.4000	* 0.8000	* +22.5	* 1.2500	* 0.4909	yes (5)	* 13	-- -V --	cosy	E
drift	dl4	2.611	1.0000			standard					-- -- --	-	e
= Dipole	B2	3.611	0.4909	+6.4000	* 0.8000	* +22.5	* 1.2500	* 0.4909	yes (5)	* 13	-- -V --	cosy	E
drift	dl5	4.102	0.7700			standard					-- -- --	-	e
drift	dl6	4.872	0.4000			standard					-- -- --	-	e
<Quad>	Hex1	5.272	0.2600	+0.0862	0.8000	SEXT	11.0000	0.2600	yes (5)	1	-- HV --	cosy	e
drift	dl7	5.532	0.2700			standard					-- -- --	-	e
<Quad>	Q3	5.802	0.3500	+2.4264	0.8000	QUAD	11.0000	0.3500	yes (5)	1	-- HV --	cosy	e
drift	dl8	6.152	0.3500			standard					-- -- --	-	e
<Quad>	Q4	6.502	0.3500	-2.4501	0.8000	QUAD	8.0000	0.3500	yes (5)	1	-- HV --	cosy	e
drift	dl9	6.852	0.2100			standard					-- -- --	-	e
<Quad>	Q5	7.062	0.3500	+1.1128	0.8000	QUAD	6.0000	0.3500	yes (5)	1	-- HV --	cosy	e
drift	dl10	7.412	0.1450			standard					-- -- --	-	e
drift	dl11	7.557	0.1850			standard					-- -- --	-	e
slits	slits FP1	7.742	0.0000			SLITS					-- -- HV	-	e
drift	dl12	7.742	0.1700			standard					-- -- --	-	e
= Dipole	B3	7.912	0.4909	+6.4000	* 0.8000	* +22.5	* 1.2500	* 0.4909	yes (5)	* 13	-- -V --	cosy	E

Blocks are linked with 5th order COSY maps

SECAR phase 1 with COSY maps : links

File: e_SECAR_p1_COSY.lpp

List of blocks with 5th order COSY maps

Upload linked COSY matrices

```
L I S E ++  [G:\SECAR\SECAR_phase1_COSY_o5.lpp]
18-08-2015  11:31:59

---------------------------------------------------------------------------------
Block       Name        Number of Lines / Status        Filename
---------------------------------------------------------------------------------
Drift       "Q1"             242                        G:\SECAR\Q01.TXT
Drift       "Q2"             193                        G:\SECAR\Q02.TXT
Dipole      "B1"             252                        G:\SECAR\B01.TXT
Dipole      "B2"             252                        G:\SECAR\B02.TXT
Drift       "Hex1"           208                        G:\SECAR\H01.TXT
Drift       "Q3"             194                        G:\SECAR\Q03.TXT
Drift       "Q4"             194                        G:\SECAR\Q04.TXT
Drift       "Q5"             193                        G:\SECAR\Q05.TXT
Dipole      "B3"             252                        G:\SECAR\B03.TXT
Dipole      "B4"             252                        G:\SECAR\B04.TXT
Drift       "Hex2"           211                        G:\SECAR\H02.TXT
Drift       "Q6"             192                        G:\SECAR\Q06.TXT
Drift       "Q7"             186                        G:\SECAR\Q07.TXT
Wien        "VF1"            247                        G:\SECAR\WF1.TXT
Drift       "Hex3"           220                        G:\SECAR\H03.TXT
Drift       "Oct1"           148                        G:\SECAR\OCT1.TXT
Drift       "Q12"            193                        G:\SECAR\Q12.TXT
Drift       "Q13"            194                        G:\SECAR\Q13.TXT
Dipole      "B7"             252                        G:\SECAR\B07.TXT
Dipole      "B8"             252                        G:\SECAR\B08.TXT
Drift       "Q14"            193                        G:\SECAR\Q14.TXT
Drift       "Q15"            193                        G:\SECAR\Q15.TXT
---------------------------------------------------------------------------------

Number of links: 22      Number of good links: 22
```

Print

File Save

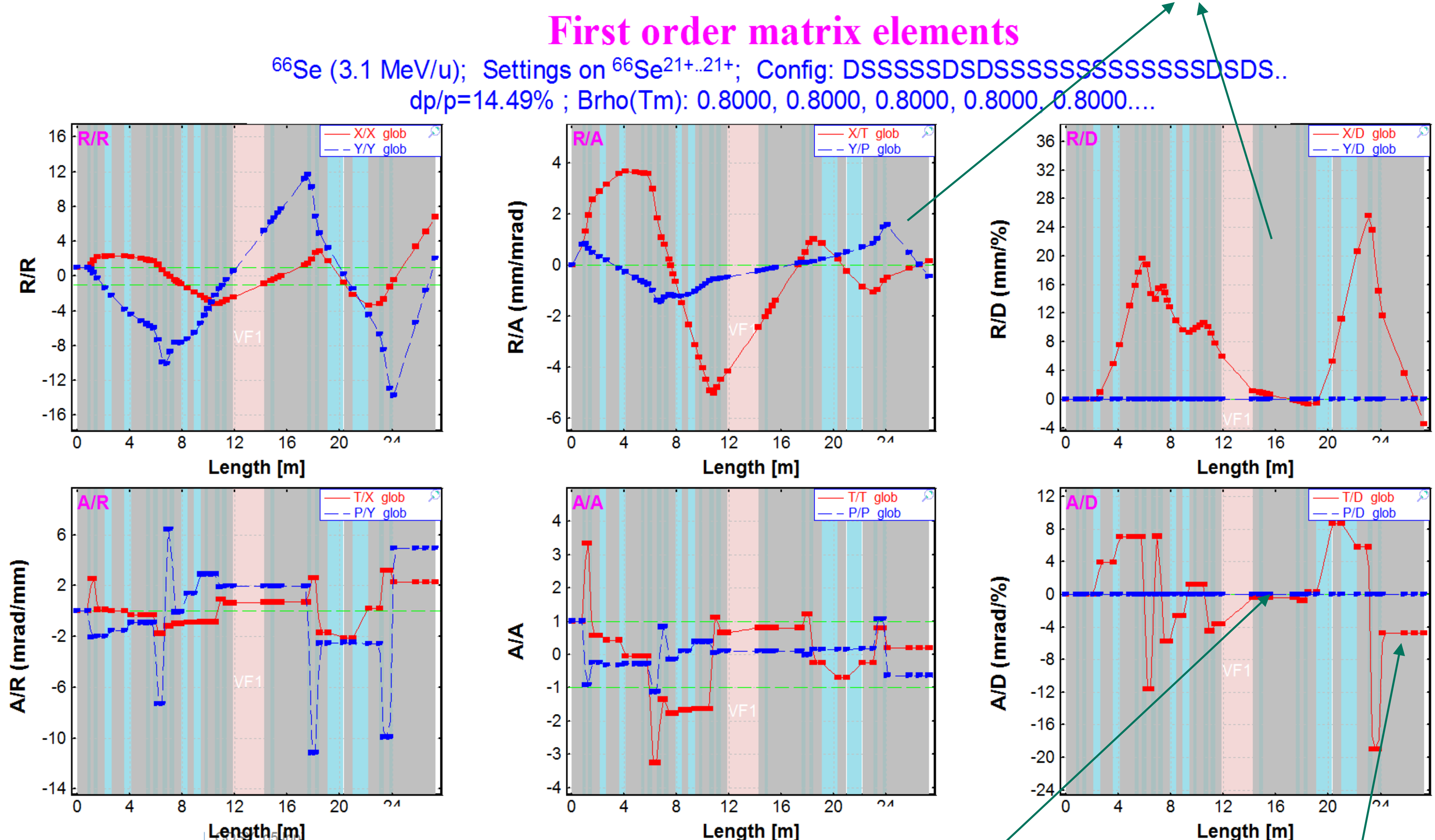
"SECAR v6s.fox" can be used to generate these "local "maps

```
UM;
MC RADIUS 22.5 0.030 B1N B1S1 B1S2 7;                   {B1}
PM_LISE 'B01.TXT' ;

DL 1.0000 ;                                              {DL4}

UM;
MC RADIUS 22.5 0.030 B1N B2S1 B2S2 7;                   {B2}
PM_LISE 'B02.TXT' ;

DL 0.7700 ;                                              {DL5}
DL 0.4000 ;                                              {DL6}

UM;
MH 0.2600 0.008620 0.11;                                 {HEX1}
PM_LISE 'H01.TXT' ;
```

SECAR phase 1 with COSY maps : 1st order matrix elements

File: e_SECAR_p1_COSY.lpp

Will be zoomed on the next page



Almost zero angular dispersion

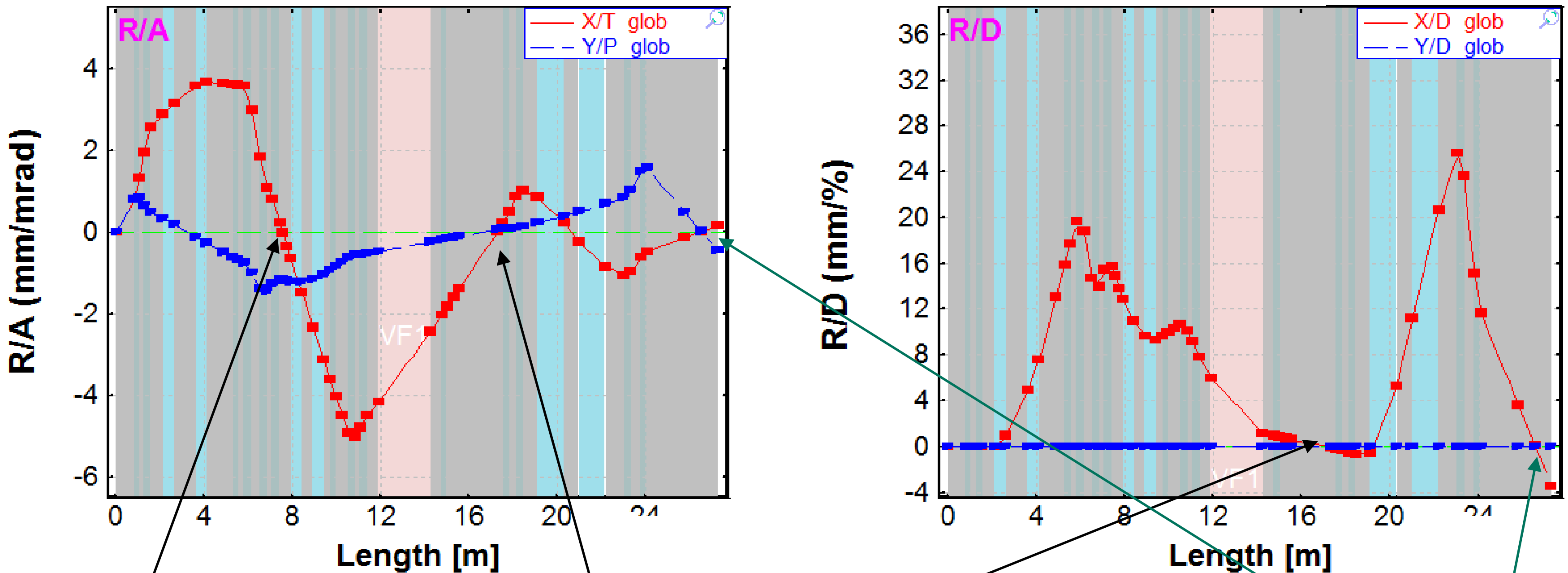
Non-zero angular dispersion

File: e_SECAR_p1_COSY.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....



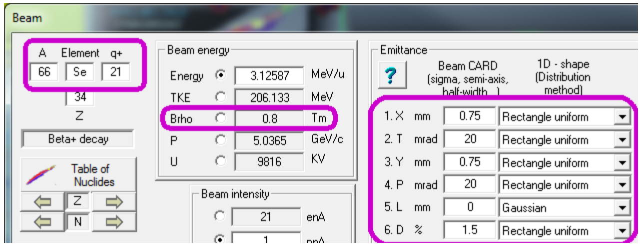
FP1– horizontal focus, charge selection

FP2 – double focus, double achromat

DL37 – double focus, achromat

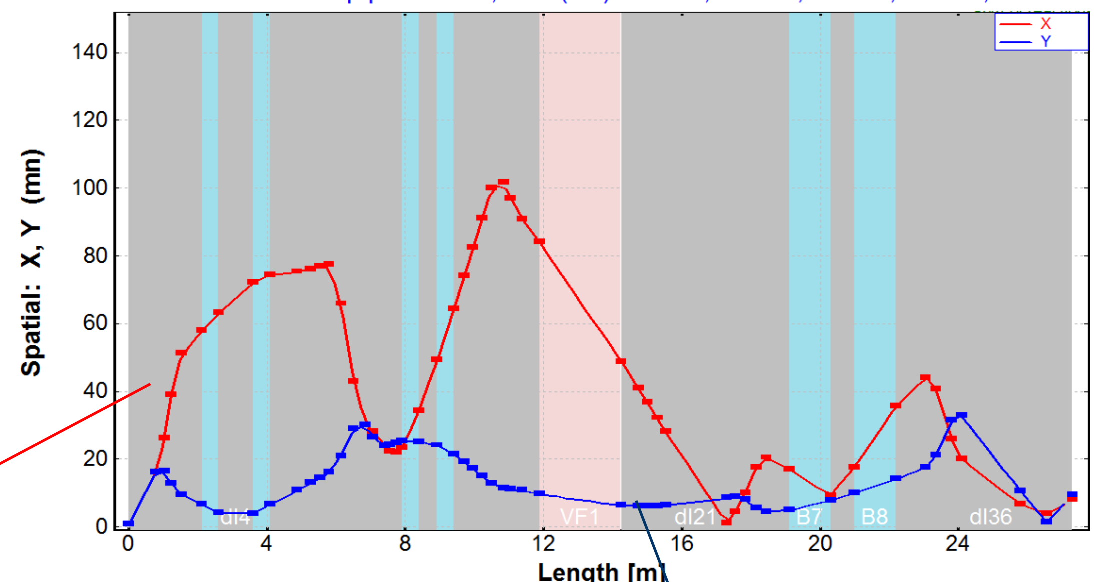
SECAR phase 1 with COSY maps : beam sigmas

File: e_SECAR_p1_COSY.lpp

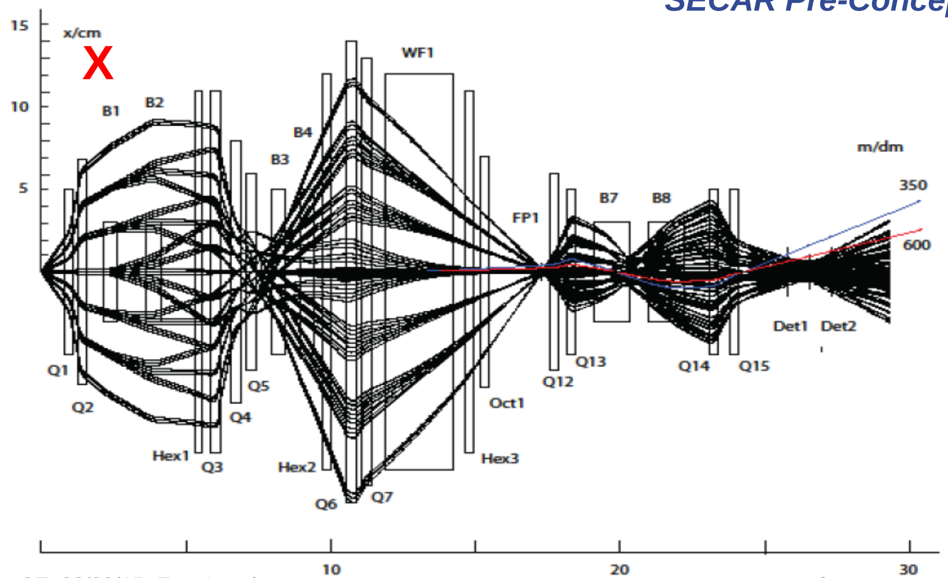


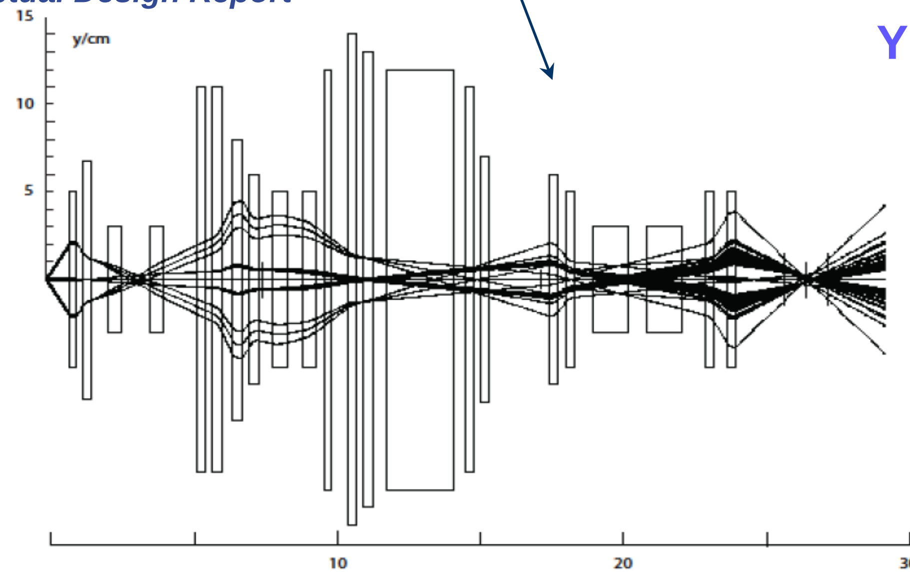
Beam Sigmas: spatial

^{66}Se (3.1 MeV/u); Settings on ^{66}Se$^{21+..21+}$; Config: DSSSSSDSDSSSSSSSSS
dp/p=14.49% ; Brho(Tm): 0.8000, 0.8000, 0.8000, 0.8000, 0.8000..



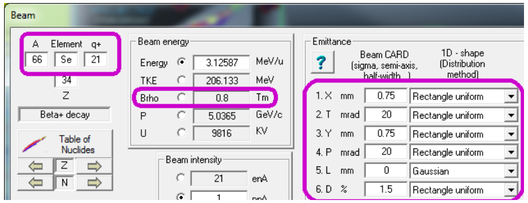
SECAR Pre-Conceptual Design Report

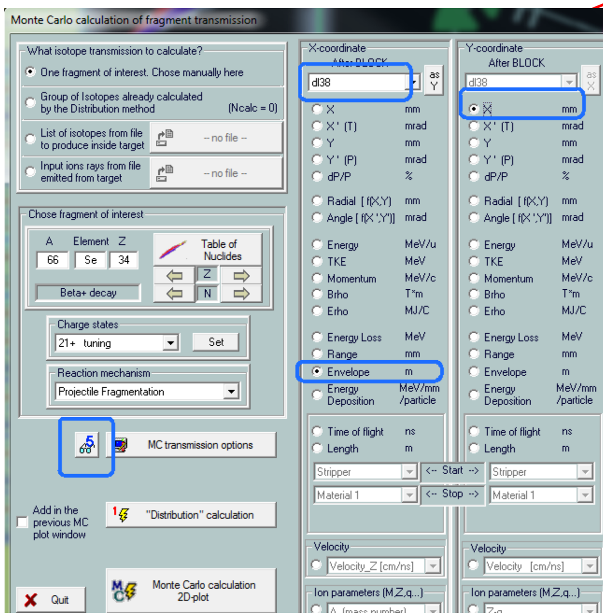


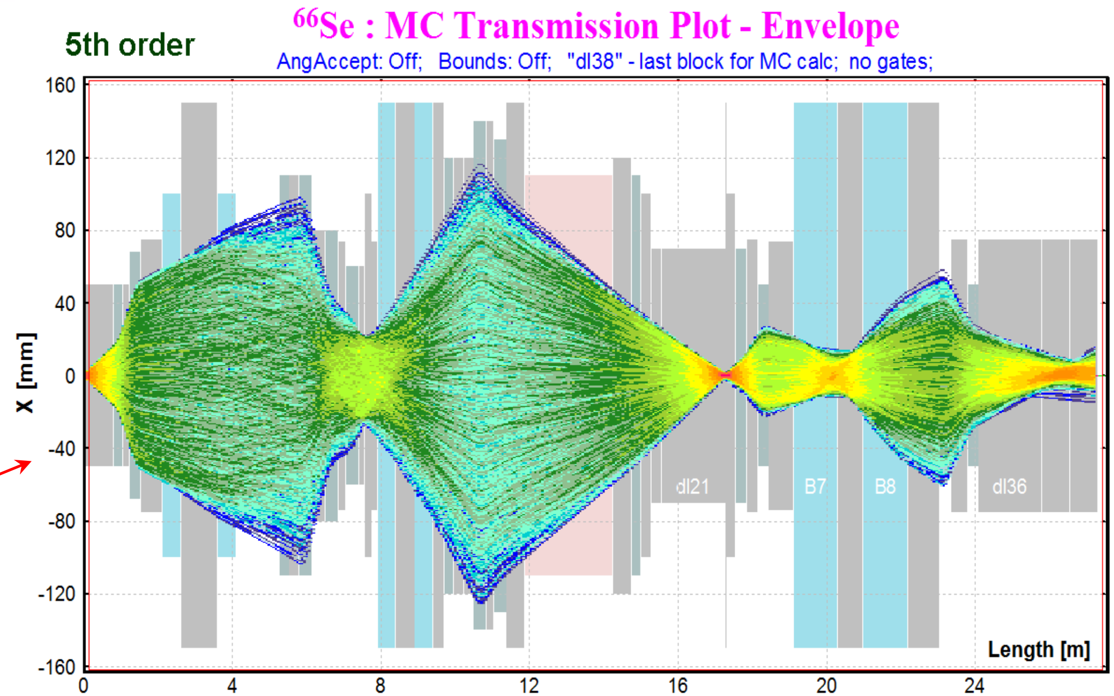


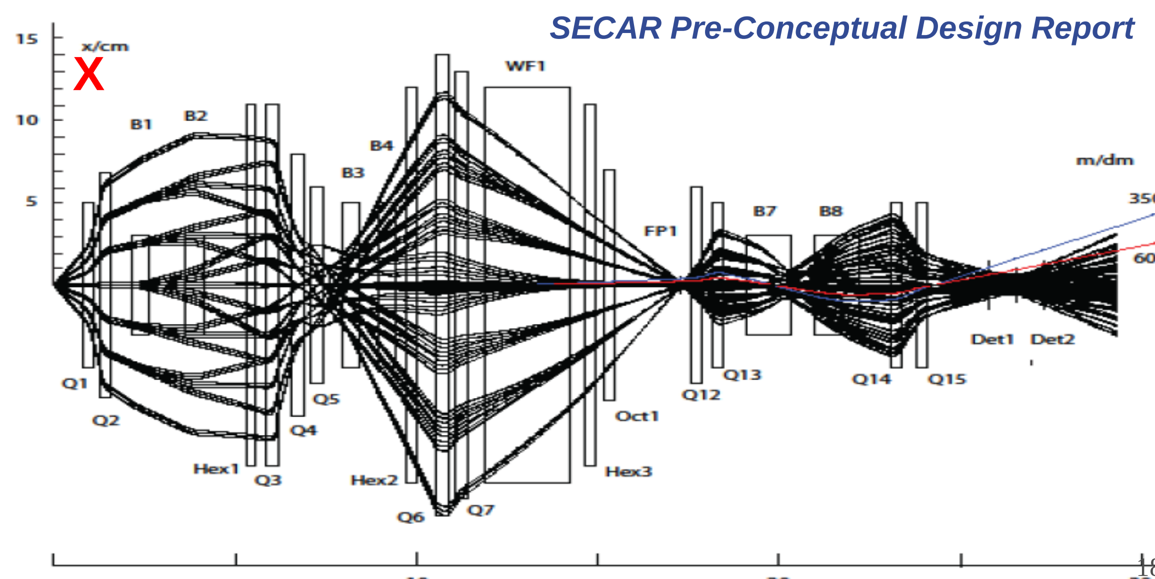
SECAR phase 1 with COSY maps : LISE++ MC X-envelope

File: e_SECAR_p1_COSY.lpp



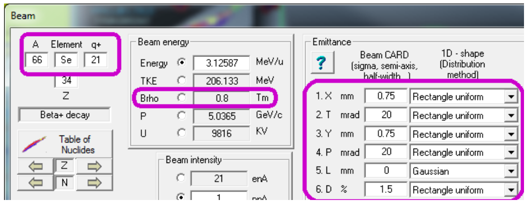


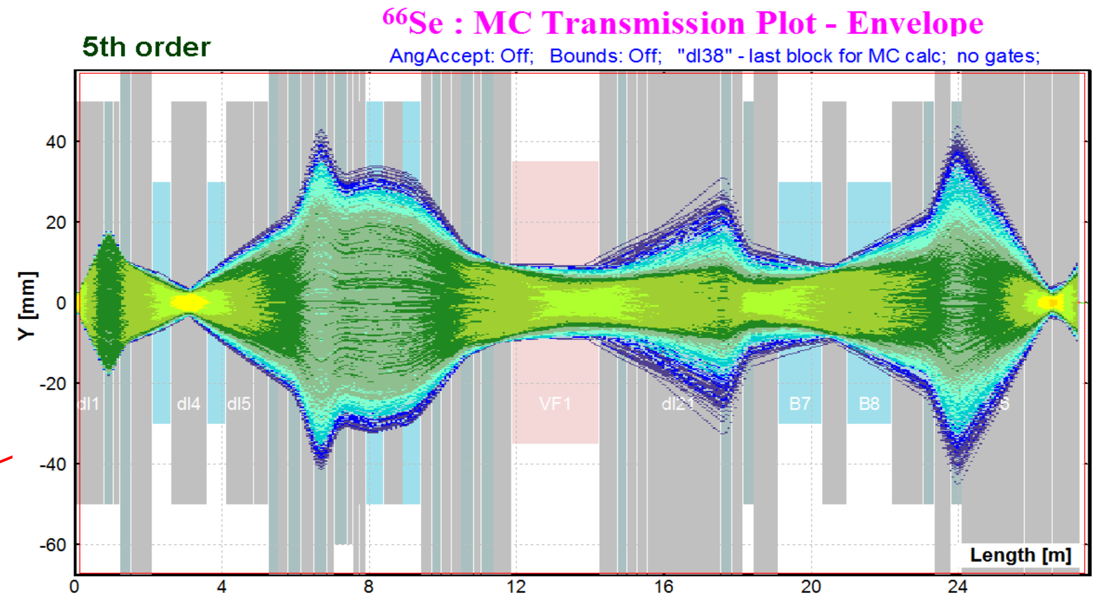


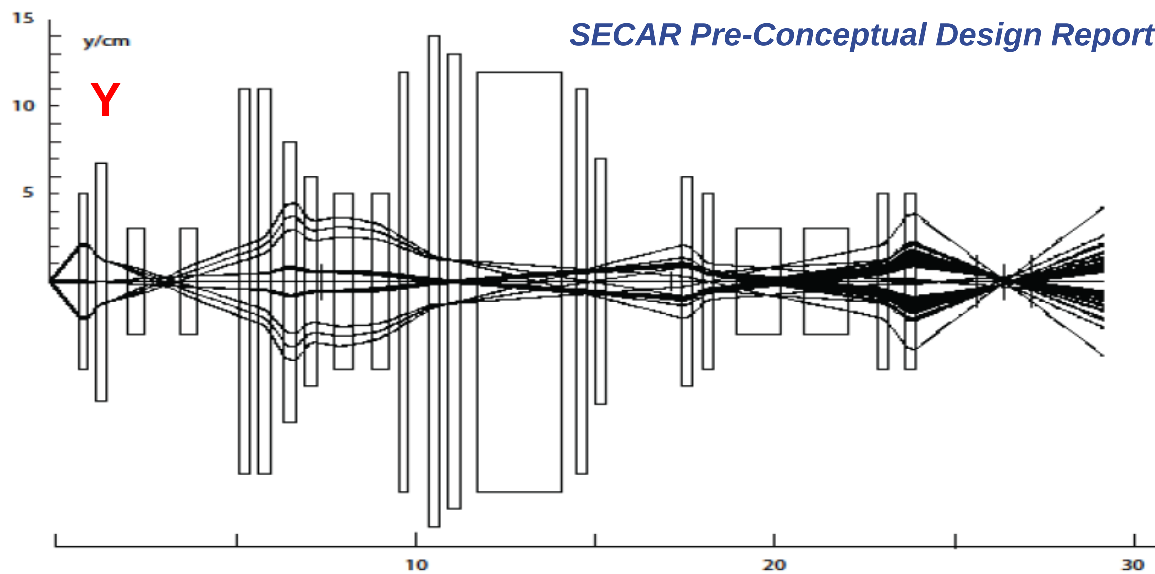


SECAR phase 1 with COSY maps : LISE++ MC Y-envelope

File: e_SECAR_p1_COSY.lpp







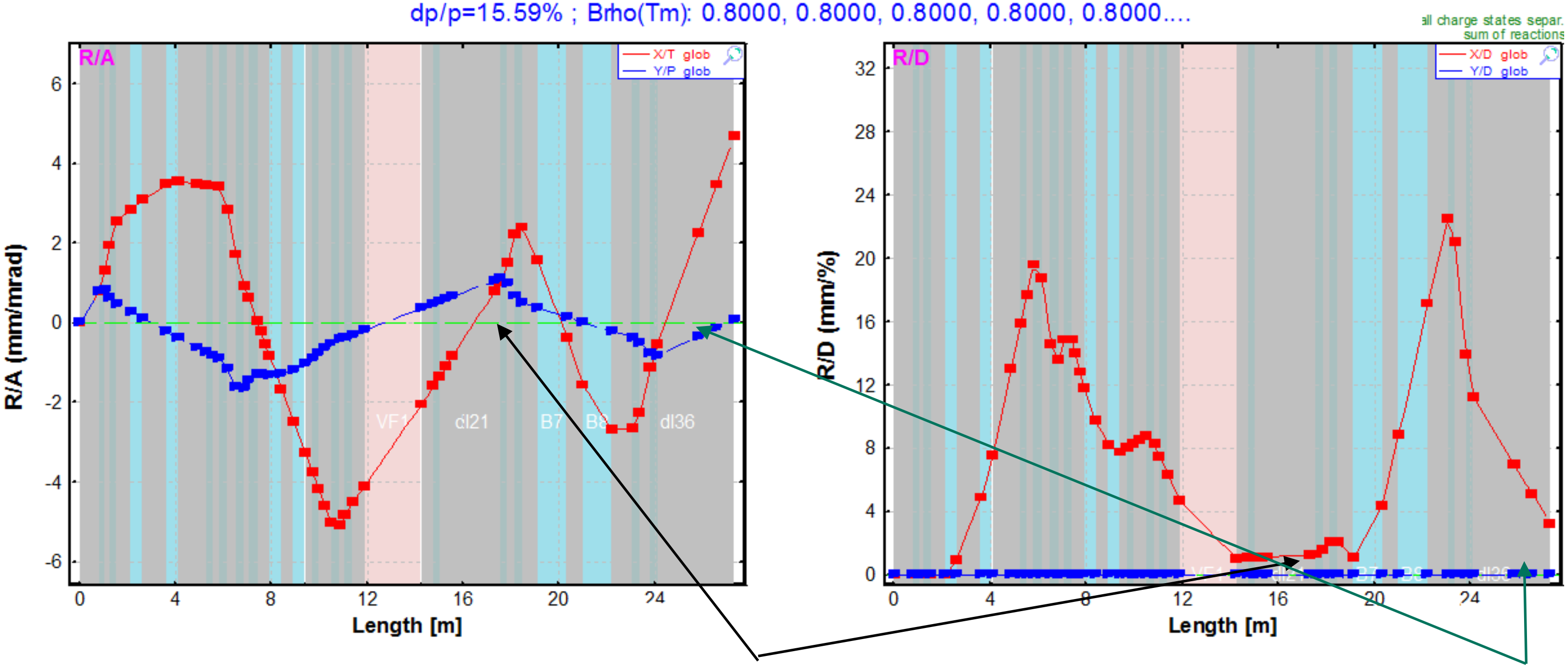
SECAR phase 1 calculated by LISE++

File: **e_SECAR_phase1**.lpp

Using __fields__ 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

DL37 – no X-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]	/[%]	

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]	/[%]	

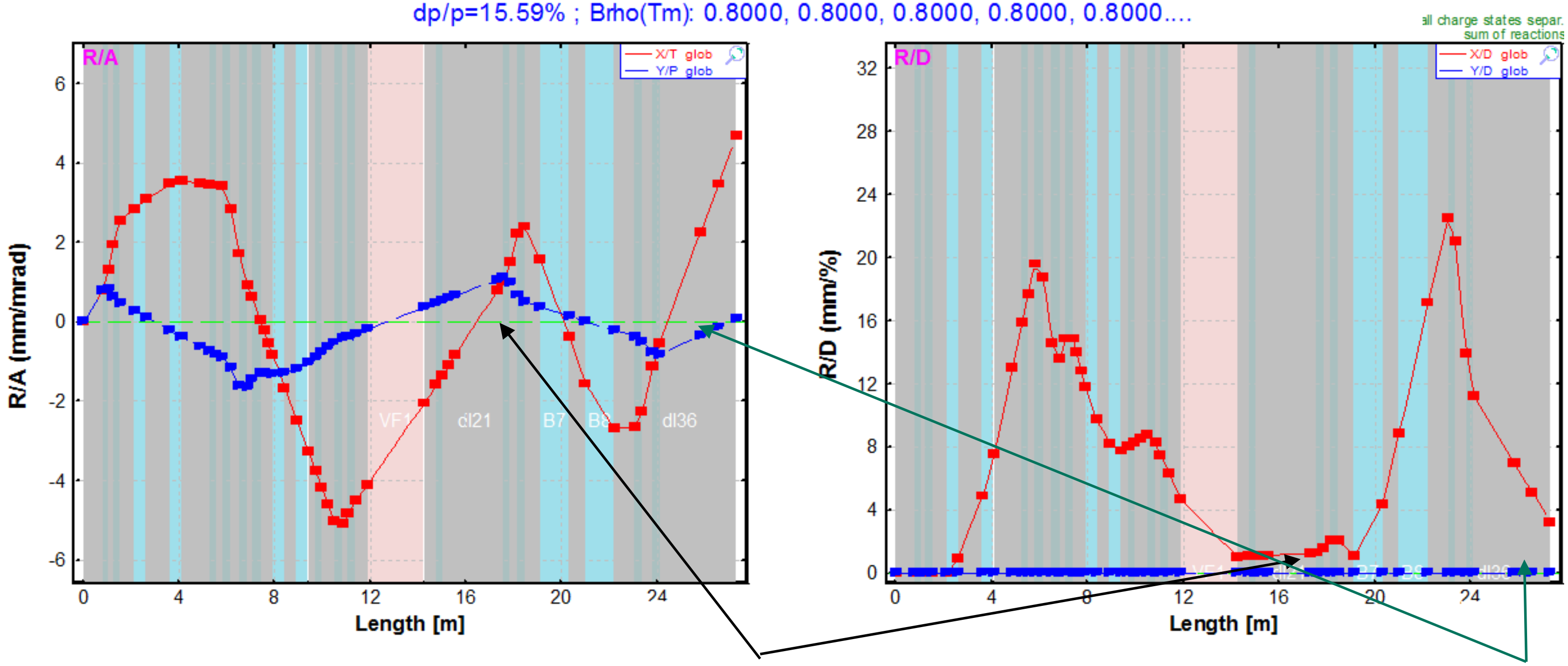
SECAR phase 1 calculated by LISE++

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

DL37 – no X-focus, small dispersion

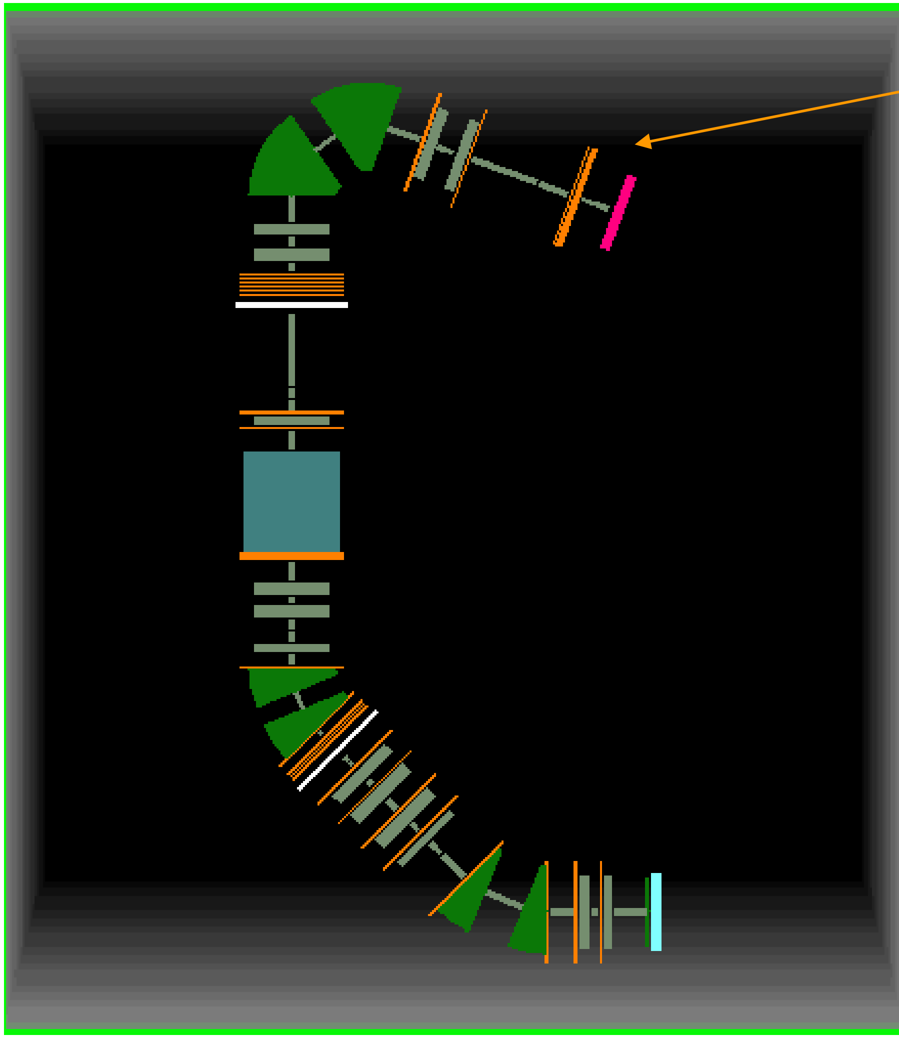
Global matrix (FP2)

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]	/[%]	

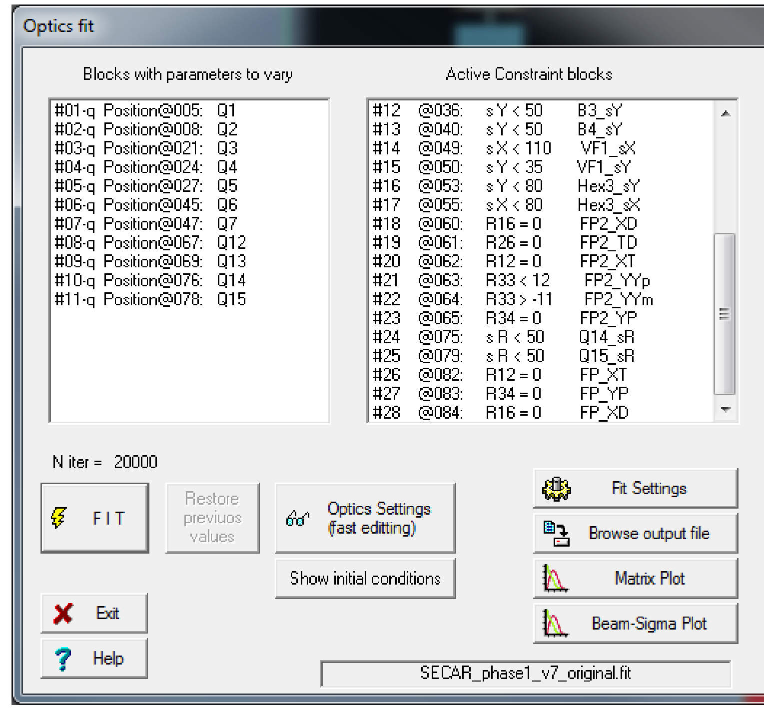
Global matrix (DL37)

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 pahse1 optimization in LISE^{++}



28 constraints,
11 variable fields



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

Initial +87.6086 and Final +0.0023725 LISE fit reduced values

Parameters:	LeftBound		Initial		RightBound		Final
#01-q: Q1	-5.0e+00	<	-3.653e+00	<	+0.0e+00	|	-3.426e+00
#02-q: Q2	+0.0e+00	<	+2.179e+00	<	+5.0e+00	|	+1.754e+00
#03-q: Q3	-5.0e+00	<	+2.426e+00	<	+5.0e+00	|	+2.387e+00
#04-q: Q4	-5.0e+00	<	-2.450e+00	<	+0.0e+00	|	-2.424e+00
#05-q: Q5	+0.0e+00	<	+1.113e+00	<	+5.0e+00	|	+1.148e+00
#06-q: Q6	+0.0e+00	<	+1.817e+00	<	+5.0e+00	|	+1.835e+00
#07-q: Q7	-5.0e+00	<	-3.015e-01	<	+5.0e+00	|	-2.694e-01
#08-q: Q12	-5.0e+00	<	-2.200e+00	<	+0.0e+00	|	-2.202e+00
#09-q: Q13	+0.0e+00	<	+2.016e+00	<	+5.0e+00	|	+1.996e+00
#10-q: Q14	+0.0e+00	<	+1.315e+00	<	+5.0e+00	|	+1.310e+00
#11-q: Q15	-5.0e+00	<	-1.450e+00	<	+0.0e+00	|	-1.445e+00

Constraint values:	Initial	Final	Precision	(Fin-Des)/P		Desired	(Init-Des)/P
#01: Q1_sX	+2.892e+01	+2.595e+01	1.0e-01	0	|	< 50	0
#02: Q2_sX	+5.580e+01	+5.056e+01	1.0e+00	0	|	< 68	0
#03: B1_sY	+6.303e+00	+7.172e+00	1.0e-01	0	|	< 30	0
#04: B2_sY	+9.241e+00	+6.603e+00	1.0e-03	0	|	< 30	0
#05: Hex1_sR	+8.225e+01	+1.019e+02	1.0e-01	+2.962e-06	|	< 110	0
#06: Q3_sX	+6.824e+01	+8.835e+01	1.0e+00	0	|	< 100	0
#07: Q4_sX	+2.884e+01	+4.068e+01	1.0e+00	0	|	< 80	0
#08: Q5_sX	+2.233e+01	+2.764e+01	1.0e+00	0	|	< 60	0
#09: FP1_12	-5.378e-01	+2.724e-09	1.0e-03	+2.724e-06	|	= 0	+5.378e+02
#10: FP1_sX	+2.260e+01	+1.961e+01	1.0e-01	+3.069e-07	|	< 30	+6.108e-06
#11: FP1_YY	-7.488e+00	-7.062e+00	1.0e-01	+5.299e-04	|	> -10	+8.113e-04
#12: B3_sY	+2.959e+01	+2.585e+01	1.0e+00	0	|	< 50	0
#13: B4_sY	+2.283e+01	+2.198e+01	1.0e+00	0	|	< 50	0
#14: VF1_sX	+9.055e+01	+1.061e+02	1.0e-02	+1.975e-03	|	< 110	0
#15: VF1_sY	+4.503e+00	+1.018e+01	1.0e+00	0	|	< 35	0
#16: Hex3_sY	+1.259e+01	+6.543e+00	1.0e+00	0	|	< 80	0
#17: Hex3_sX	+2.965e+01	+4.664e+01	1.0e+00	0	|	< 80	0
#18: FP2_XD	+1.272e+00	+3.472e-09	1.0e-03	+3.472e-06	|	= 0	+1.272e+03
#19: FP2_TD	+8.022e-02	+4.284e-07	1.0e-01	+4.284e-06	|	= 0	+8.022e-01
#20: FP2_XT	+7.895e-01	+5.695e-10	1.0e-03	+5.695e-07	|	= 0	+7.895e+02
#21: FP2_YYp	+1.595e+01	+1.066e+01	1.0e+00	+2.607e-04	|	< 12	+3.950e+00
#22: FP2_YYm	+1.595e+01	+1.066e+01	1.0e+00	0	|	> -11	0
#23: FP2_YP	+1.061e+00	+2.490e-06	1.0e-01	+2.490e-05	|	= 0	+1.061e+01
#24: Q14_sR	+6.911e+01	+4.977e+01	1.0e-01	+7.938e-03	|	< 50	+1.911e+02
#25: Q15_sR	+3.518e+01	+4.173e+01	1.0e-01	+2.568e-06	|	< 50	0
#26: FP_XT	+3.469e+00	-5.178e-09	1.0e-02	+5.178e-07	|	= 0	+3.469e+02
#27: FP_YP	-1.386e-01	-3.576e-07	1.0e-01	+3.576e-06	|	= 0	+1.386e+00
#28: FP_XD	+5.115e+00	+1.264e-08	1.0e-01	+1.264e-07	|	= 0	+5.115e+01

initial "bad" values

finally all constraints were positively done!!!

RESULTS

FP1

Global matrix

-0.42355	0	0	0	0	13.07058	[mm]
-1.4315	-2.36101	0	0	0	-6.50724	[mrad]
0	0	-7.06243	-1.24098	0	0	[mm]
0	0	-0.00062	-0.1417	0	0	[mrad]
-2.14666	-3.08598	0	0	1	-2.54049	[mm]
0	0	0	0	0	1	[%]
/[mm]	/[mrad]	/[mm]	/[mrad]	/[mm]	/[%]	

FP2

Global matrix

0.98207	0	0	0	0	0	[mm]
0.81236	1.01825	0	0	0	0	[mrad]
0	0	10.65564	0	0	0	[mm]
0	0	1.84593	0.09385	0	0	[mrad]
-0.81191	-1.42307	0	0	1	-9.82722	[mm]
0	0	0	0	0	1	[%]
/[mm]	/[mrad]	/[mm]	/[mrad]	/[mm]	/[%]	

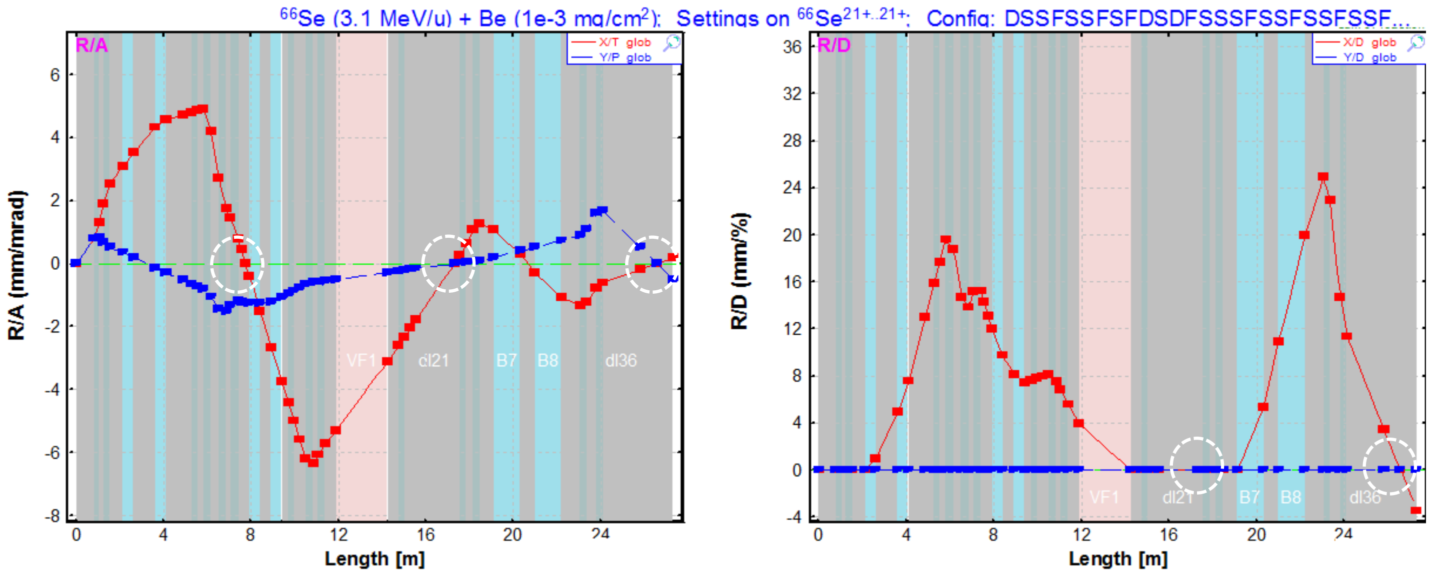
DL37

Global matrix

4.03844	0	0	0	0	0.00001	[mm]
1.85669	0.24762	0	0	0	-4.63011	[mrad]
0	0	-1.46124	0	0	0	[mm]
0	0	6.71082	-0.68434	0	0	[mrad]
1.05793	-1.42307	0	0	1	-26.6422	[mm]
0	0	0	0	0	1	[%]
/[mm]	/[mrad]	/[mm]	/[mrad]	/[mm]	/[%]	

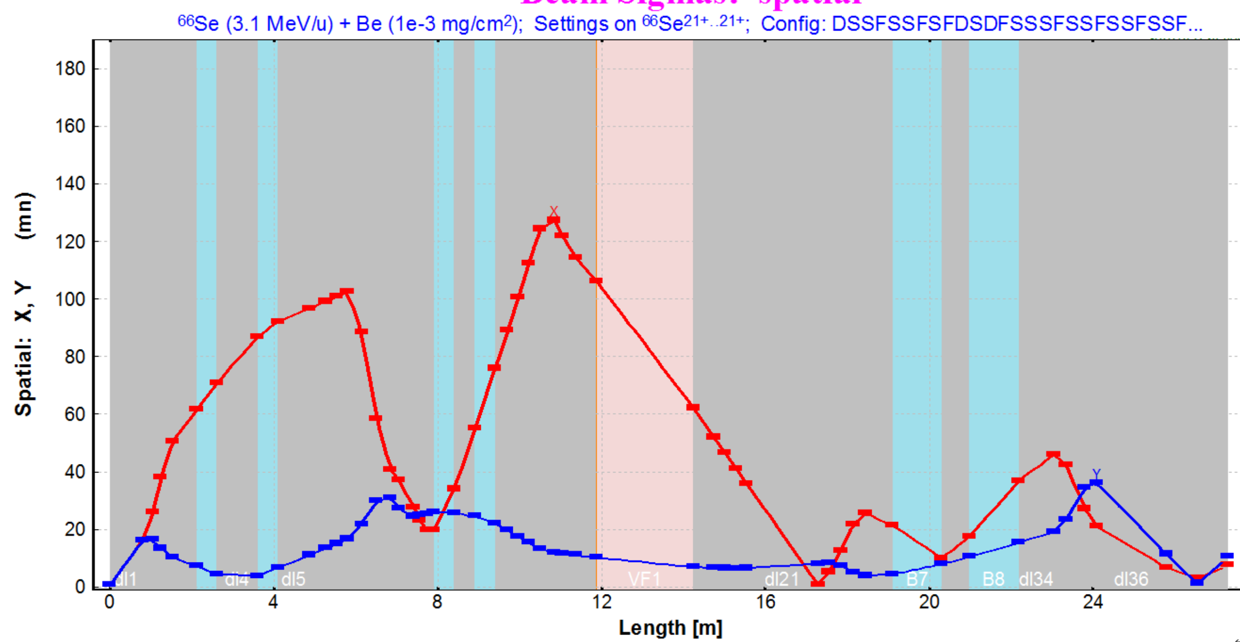
SECAR phase1 optimization in LISE^{++} : results

First order matrix elements



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

Beam Sigmas: spatial

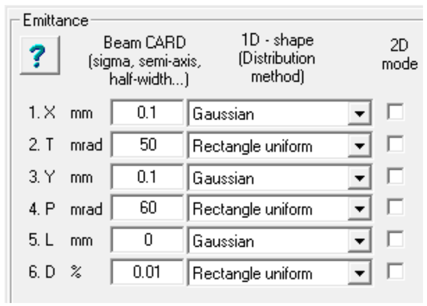


Angular Acceptance

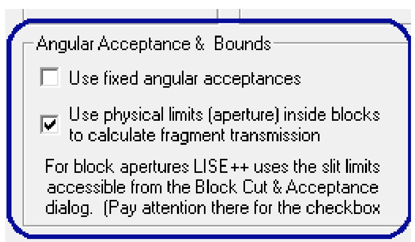
See details for angular acceptance with the next link http://lise.nscl.msu.edu/9_8/SE_blocks.pdf#page=5

Settings

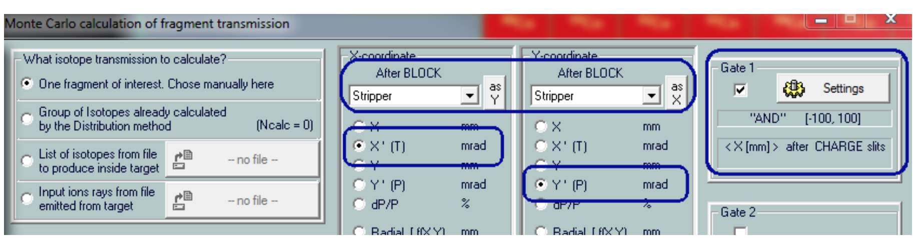
Beam dialog



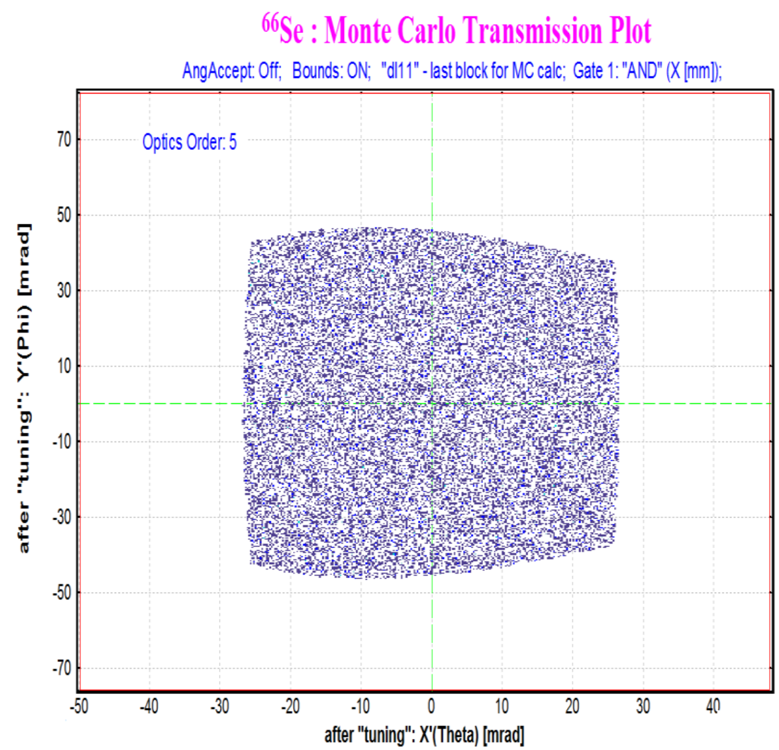
Monte Carlo options



Monte Carlo Transmission settings

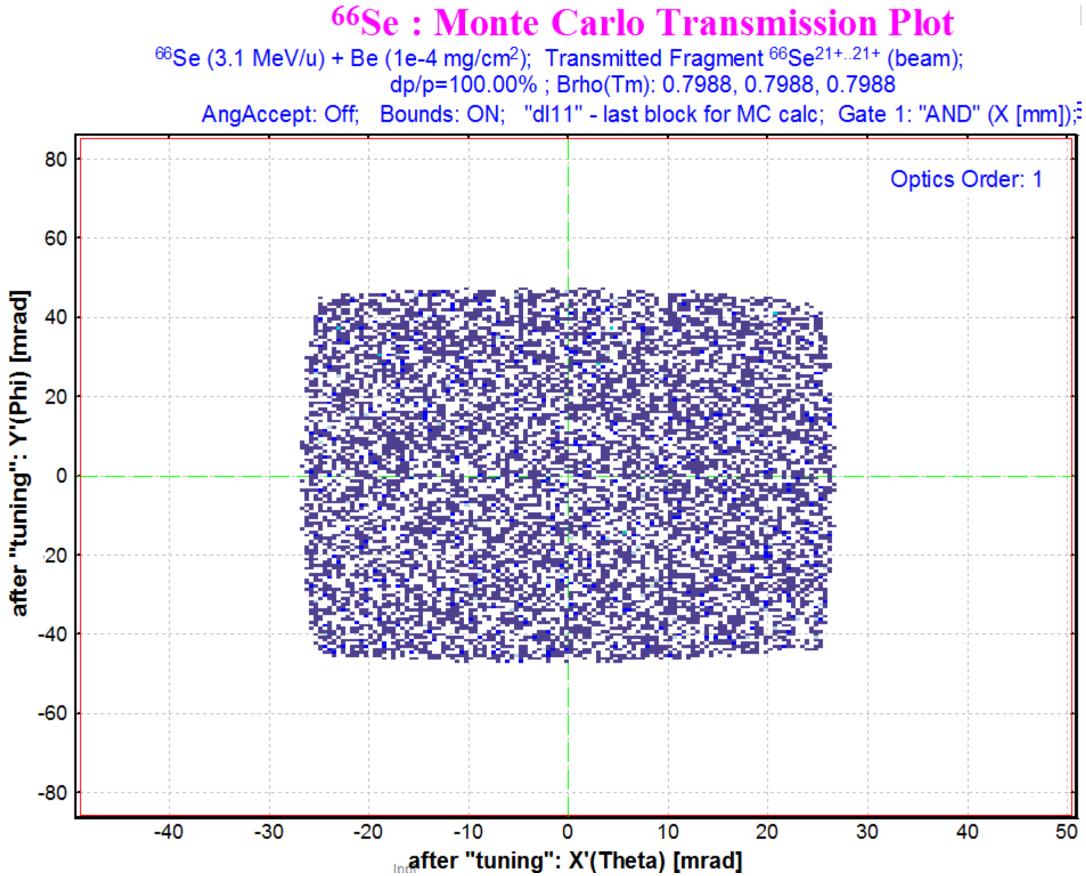


Coming to the FP1



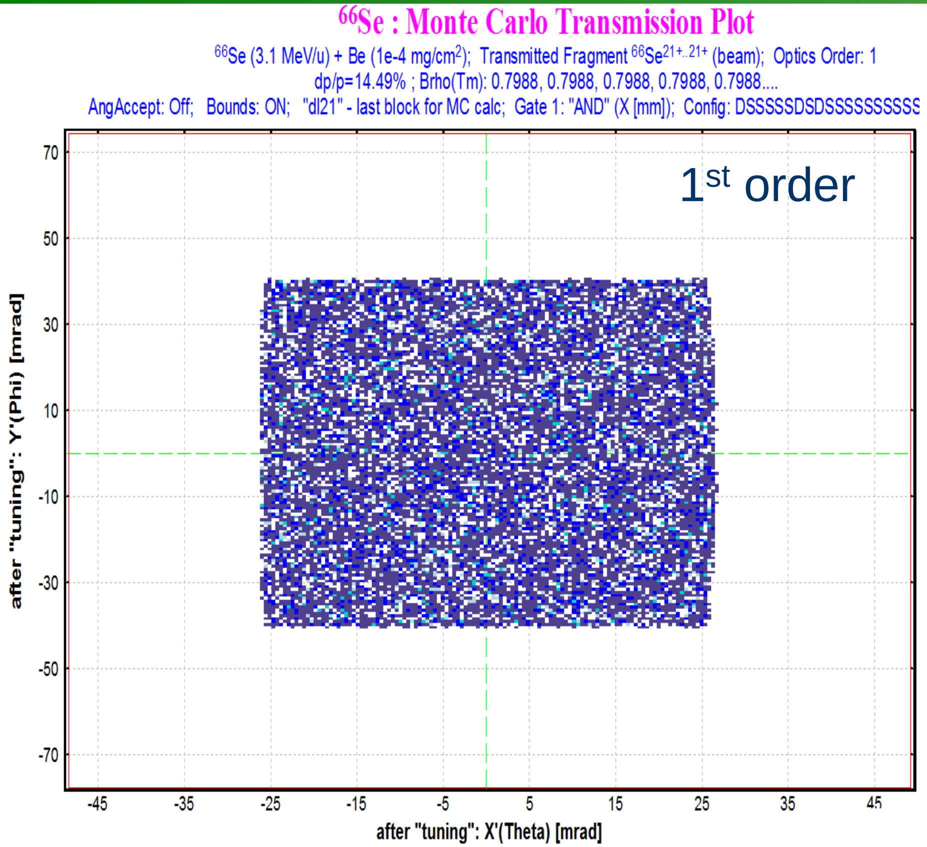
Angualr acceptance "Target - FP1"		
	5th order	
X'	26.4	mrad
Y'	43.4	mrad

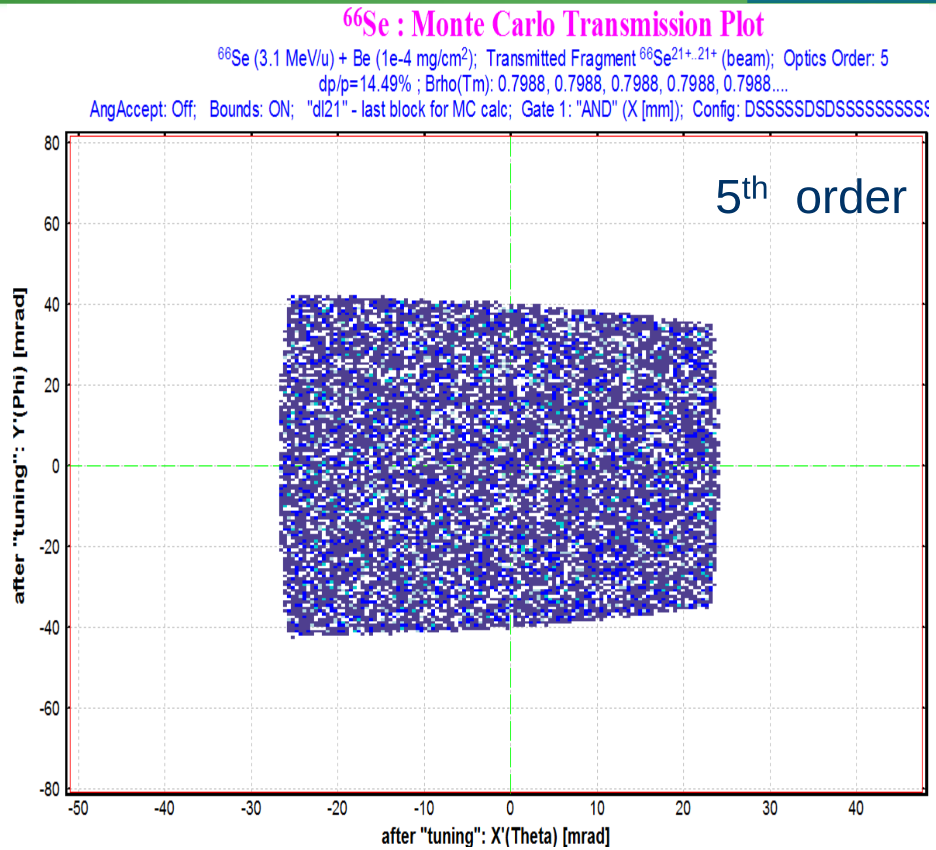
Angular Acceptance : Target – FP1



Angular acceptance "Target - FP1"		
	1st order	
X'	26.3	mrad
Y'	45.8	mrad

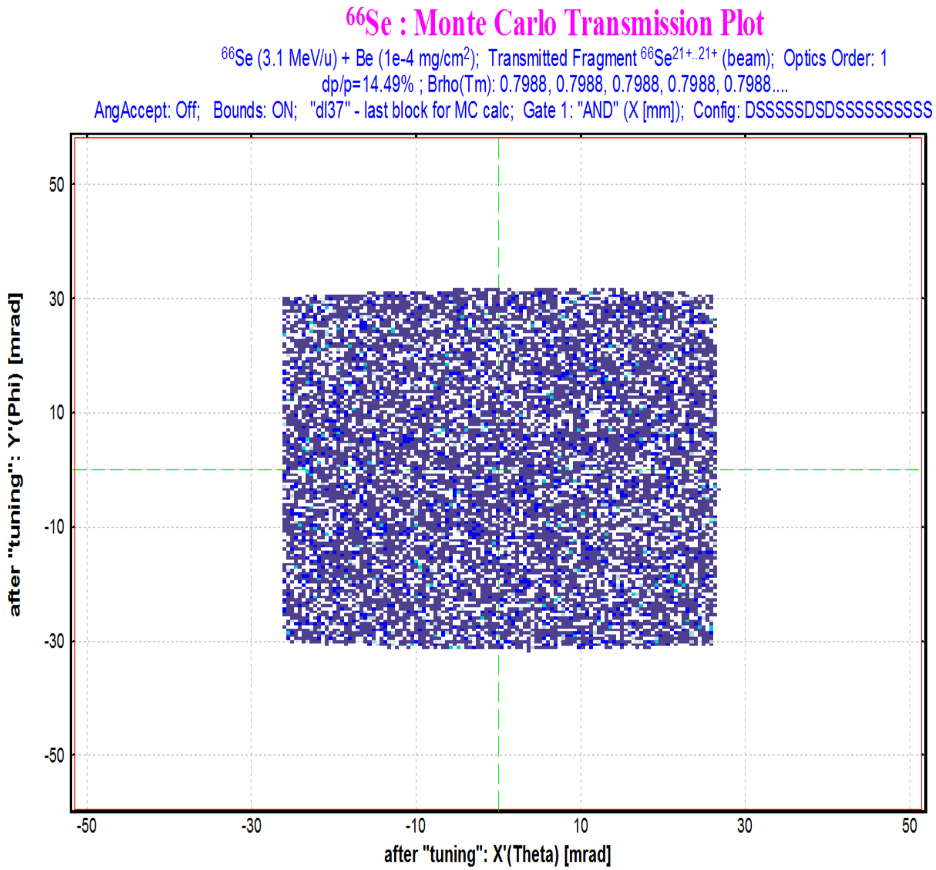
Angular Acceptance: Target - FP2

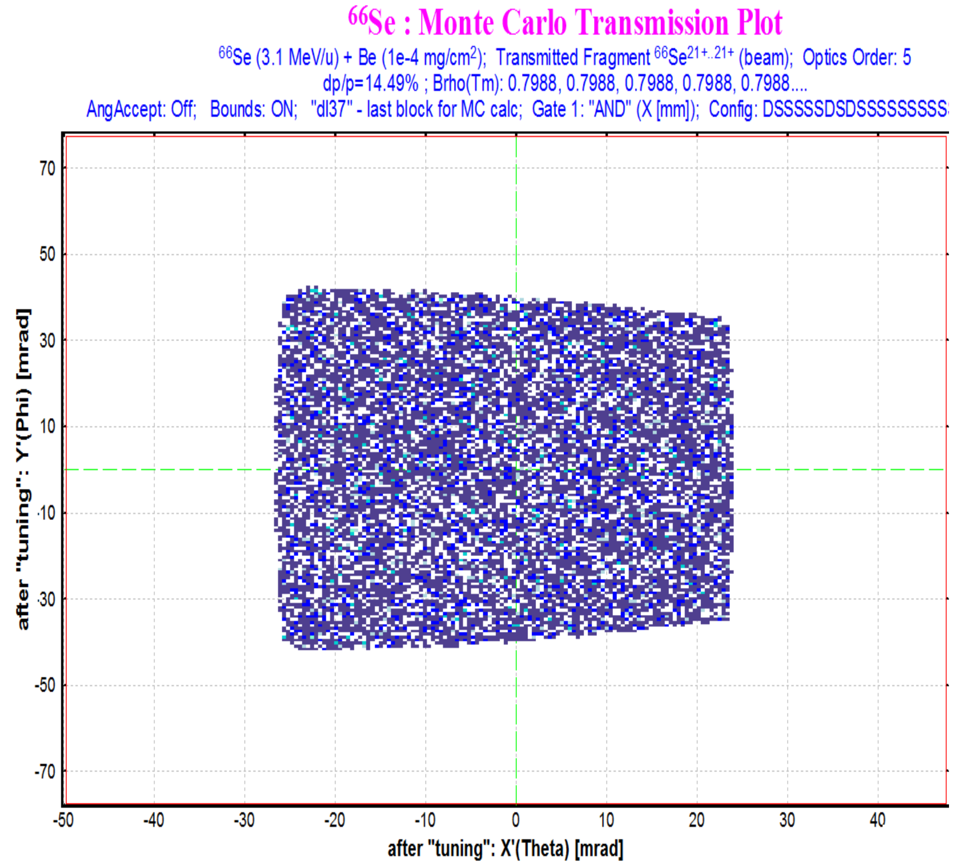




Angular acceptance "Target - FP2"		
	1st order	
X'	26.4	mrad
Y'	40.6	mrad

Angular acceptance "Target - FP2"		
	5th order	
X'	25.2	mrad
Y'	39.8	mrad



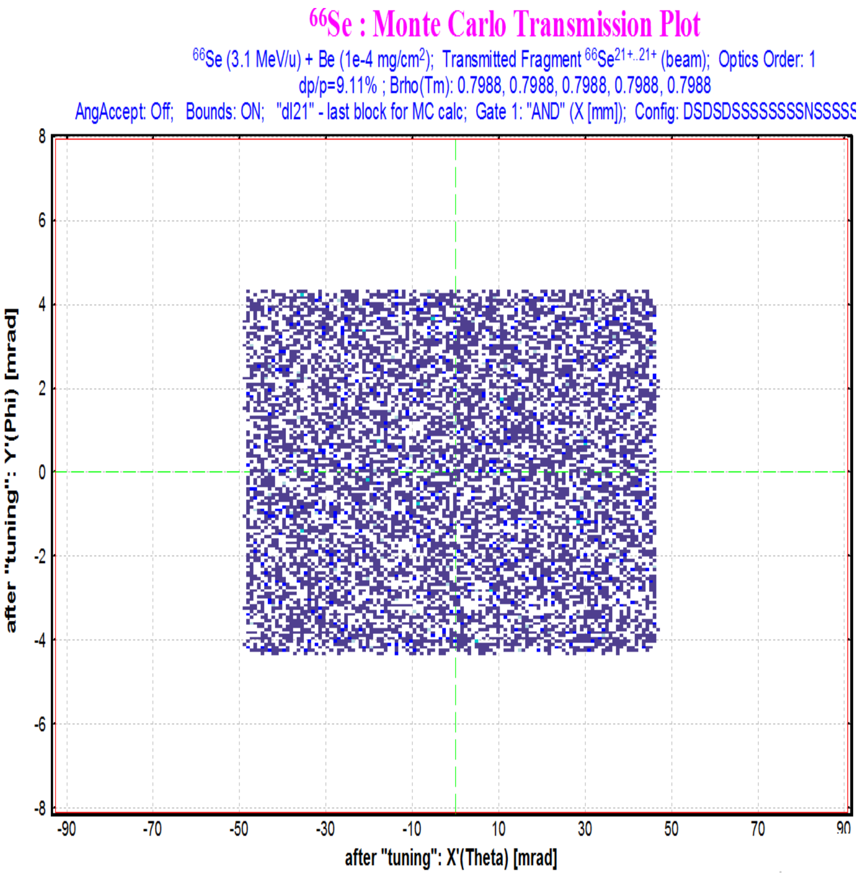


Angular acceptance "Target - DL37"		
	1st order	
X'	26.5	mrad
Y'	31.4	mrad

Angular acceptance "Target - DL37"		
	5th order	
X'	25.2	mrad
Y'	40.0	mrad

SECAP phase1 Angular Acceptance: sectors

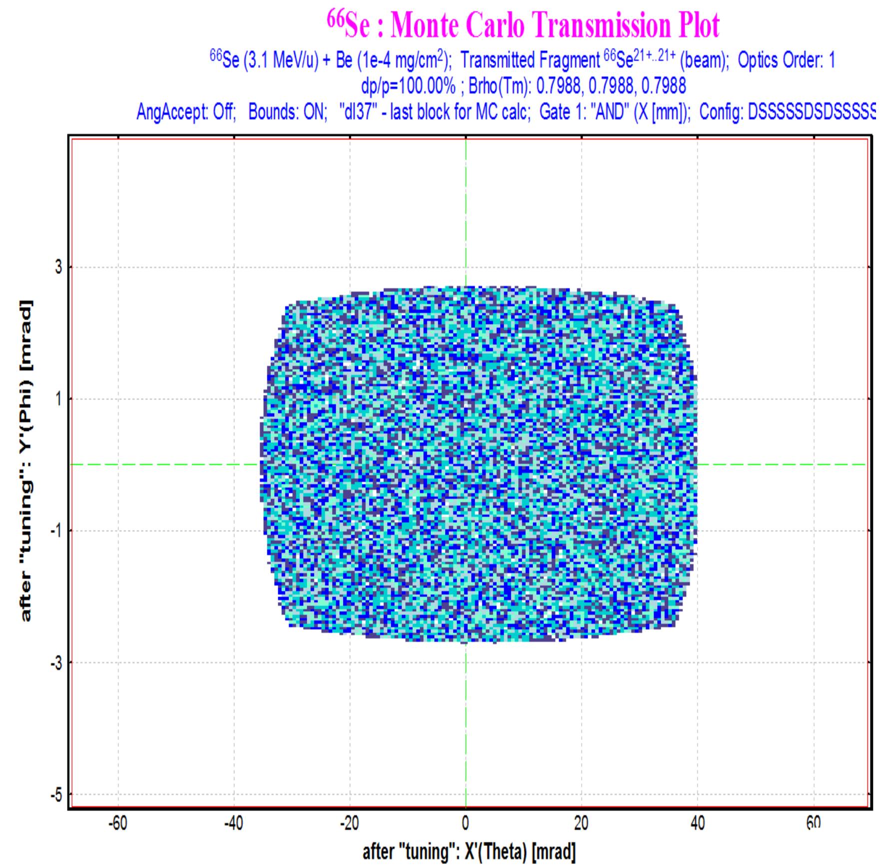
FP1 - FP2



	1st order	
X'	47.9	mrad
~~Y'~~		~~mrad~~

There is not vertical focus at FP1!
It is impossible to use vertical angular acceptance here

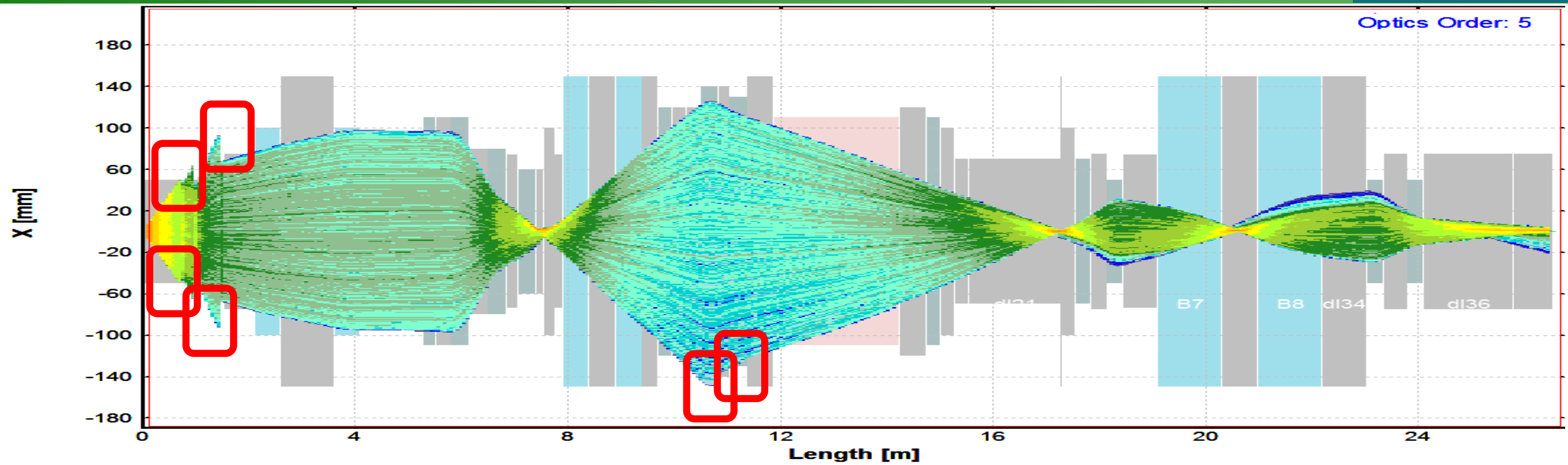
FP2 - DL37



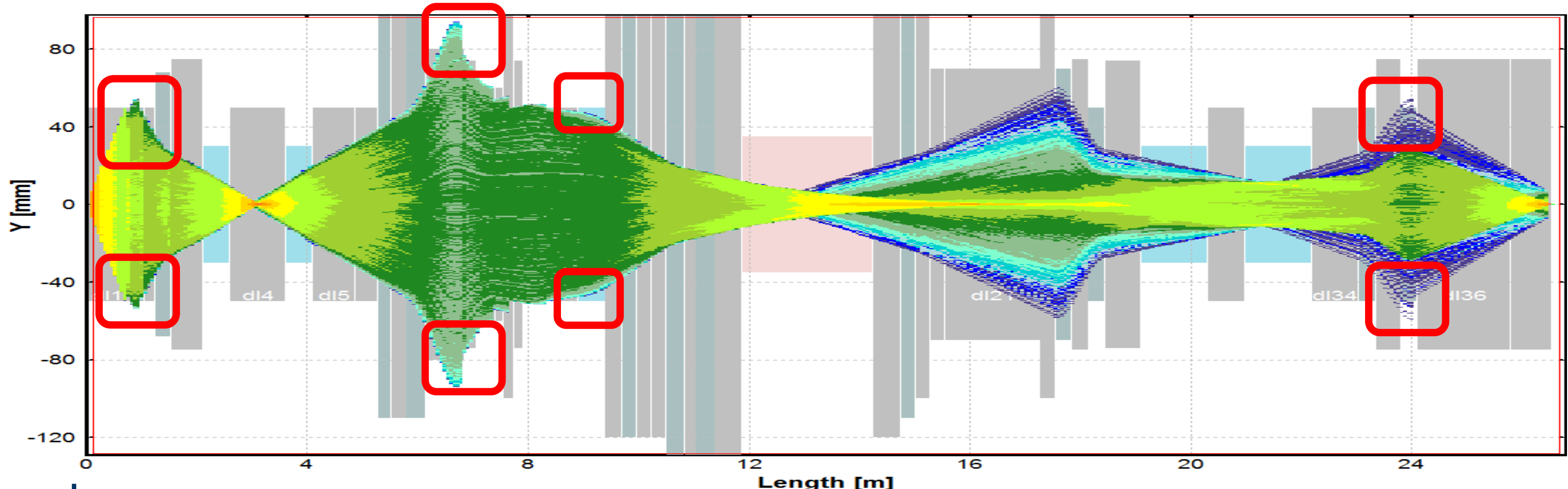
Angular acceptance "FP2 - DL37"		
	1st order	
X'	36.8	mrad
Y'	**5.24**	mrad

Angular Emittance Loss (5th order optics)

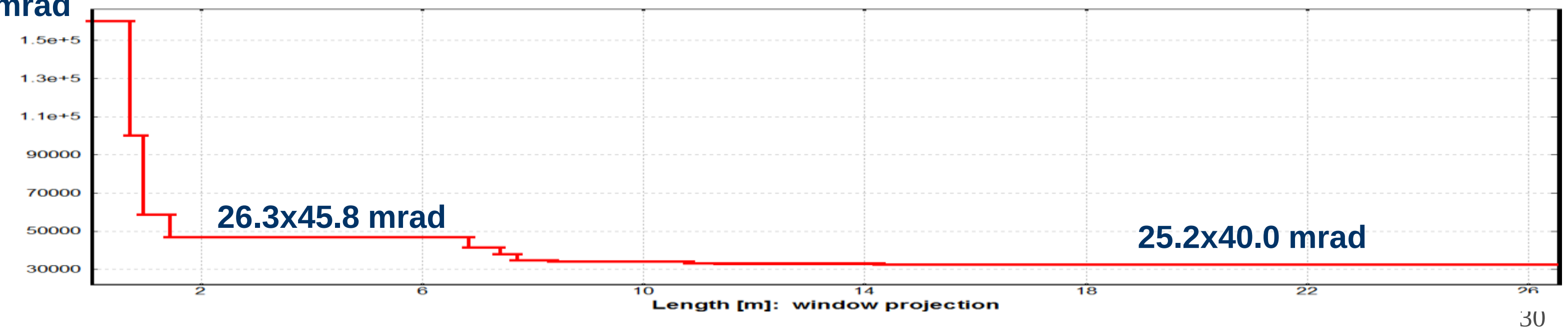
X’



Y’



Intensity lost



Angular Acceptances in the SECAR phase1 file

MICHIGAN STATE UNIVERSITY

LISE++

NSCL

Angular acceptances used in the SECAR phase1 configurations				
	Target-FP1	FP1 - FP2	FP2 - DL37	
X'	26.3	47.9	36.8	mrad
Y'	45.8		5.24	mrad

! FILE: G:\SECAR\SECAR_phase1_COSY_05 with_AA.lpp

1 N or	2 Block name	3 Kind of Block	4 Start (m)	5 Length (m)	6 DriftMode Angle(°)*	7 B0(kG)	8 Br-corrsp Br-dip*	9 Rapp(cm) R(m)*	10 L_eff(m) Len(m)*	11 2nd order	12 Calc Mode	13 AngAcc mode	14 Slits shape
1.	tuning	Dipole	0.000	0.000	+0.0 *	+2.663	0.7988*	3.00*	0.00*	-		HV	rectn
2.	dl1	Drift	0.000	0.800	standard							--	rectn
3.	Q1	Drift	0.800	0.250	multipole	-3.653	0.8000	5.00	0.25	yes	1	--	rectn
4.	dl2	Drift	1.050	0.190	standard							--	rectn
5.	Q2	Drift	1.240	0.300	multipole	+2.179	0.8000	6.80	0.30	yes	1	--	rectn
6.	dl3	Drift	1.540	0.580	standard							--	rectn
7.	B1	Dipole	2.120	0.491	+22.5 *	+6.390	0.7988*	1.25*	0.49*	yes		--	rectn
8.	dl4	Drift	2.611	1.000	standard							--	rectn
9.	B2	Dipole	3.611	0.491	+22.5 *	+6.390	0.7988*	1.25*	0.49*	yes		--	rectn
10.	dl5	Drift	4.102	0.770	standard							--	rectn
11.	dl6	Drift	4.872	0.400	standard							--	rectn
12.	Hex1	Drift	5.272	0.260	multipole	+0.000	0.8000	11.00	0.26	yes	1	--	rectn
13.	dl7	Drift	5.532	0.270	standard							--	rectn
14.	Q3	Drift	5.802	0.350	multipole	+2.426	0.8000	11.00	0.35	yes	1	--	rectn
15.	dl8	Drift	6.152	0.350	standard							--	rectn
16.	Q4	Drift	6.502	0.350	multipole	-2.450	0.8000	8.00	0.35	yes	1	--	rectn
17.	dl9	Drift	6.852	0.210	standard							--	rectn
18.	Q5	Drift	7.062	0.350	multipole	+1.113	0.8000	6.00	0.35	yes	1	--	rectn
19.	dl10	Drift	7.412	0.145	standard							--	rectn
20.	dl11	Drift	7.557	0.185	standard							--	rectn
21.	slits FP1	Drift	7.742	0.000	SLITS							--	rectn
22.	dl12	Drift	7.742	0.170	standard							H-	rectn
23.	B3	Dipole	7.912	0.491	+22.5 *	+6.390	0.7988*	1.25*	0.49*	yes		--	rectn
24.	dl13	Drift	8.403	0.510	standard							--	rectn
25.	B4	Dipole	8.913	0.491	+22.5 *	+6.390	0.7988*	1.25*	0.49*	yes		--	rectn
26.	dl14	Drift	9.403	0.300	standard							--	rectn
27.	Hex2	Drift	9.703	0.260	multipole	+0.000	0.8000	12.00	0.26	yes	1	--	rectn
28.	dl15	Drift	9.963	0.270	standard							--	rectn
29.	dl16	Drift	10.233	0.270	standard							--	rectn
30.	Q6	Drift	10.503	0.340	multipole	+1.817	0.8000	14.00	0.34	yes	1	--	rectn
31.	dl17	Drift	10.843	0.200	standard							--	rectn
32.	Q7	Drift	11.043	0.340	multipole	-0.301	0.8000	13.00	0.34	yes	1	--	rectn
33.	dl18	Drift	11.383	0.500	standard							--	rectn
34.	VF1	Wien	11.883	2.365								--	rectn
35.	dl19	Drift	14.248	0.500	standard							--	rectn
36.	Hex3	Drift	14.748	0.260	multipole	+0.000	0.7999	11.00	0.26	yes	1	--	rectn
37.	dl20	Drift	15.008	0.280	standard							--	rectn
38.	Oct1	Drift	15.288	0.260	beam-line							--	rectn
39.	dl21	Drift	15.548	1.750	standard							--	rectn
40.	slits FP2	Drift	17.298	0.000	SLITS							--	rectn
41.	dl30	Drift	17.298	0.250	standard							HV	rectn
42.	Q12	Drift	17.548	0.300	multipole	-2.200	0.7999	7.00	0.30	yes	1	--	rectn
43.	dl31	Drift	17.848	0.300	standard							--	rectn
44.	Q13	Drift	18.148	0.300	multipole	+2.016	0.7999	5.00	0.30	yes	1	--	rectn

Angular Acceptances transmission benchmarks

MICHIGAN STATE UNIVERSITY LISE++

"Distribution" method
With set Angular Acceptances

Emittance

		Beam CARD (sigma, semi-axis, half-width...)	1D - shape (Distribution method)
1. X	mm	0.1	Gaussian
2. T	mrad	60	Rectangle uniform
3. Y	mm	0.1	Gaussian
4. P	mrad	60	Rectangle uniform
5. L	mm	0	Gaussian
6. D	%	0.01	Rectangle uniform

statistics: 66Se

66Se Beta+ decay (Z=34, N=32)

Q1 (tuning)		21
Q2 (B1)		21
Q3 (B2)		21
Q4 (B3)		21
Q5 (B4)		21
Q6 (VF1)		21
Q7 (B7)		21
Q8 (B8)		21
Reaction		BEAM
Ion Production Rate	(pps)	1.89e+9
Total ion transmission	(%)	30.239
Total: this reaction	(pps)	1.89e+9
Total: All reactions	(pps)	1.89e+9
X-Section in target	(mb)	beam
Target	(%)	100
Q (Charge) ratio	(%)	100
tuning	(%)	33.45
X angular transmission	(%)	43.83
Y angular transmission	(%)	76.32
slits FP1	(%)	90.6
X space transmission	(%)	100
Y space transmission	(%)	90.6
dl12	(%)	99.78
X angular transmission	(%)	99.78
dl30	(%)	100
X angular transmission	(%)	100
Y angular transmission	(%)	100

"Monte Carlo " method
With set Angular Acceptances
No bounds

Angular Acceptance & Bounds

- [x] Use fixed angular acceptances
- [ ] Use physical limits (aperture) inside blocks to calculate fragment transmission

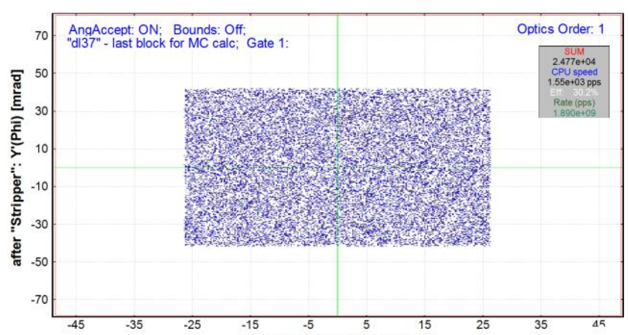
For block apertures LISE++ uses the slit limits accessible from the Block Cut & Acceptance dialog. (Pay attention there for the checkbox

66Se : Monte Carlo Transmission Plot

66Se (3.1 MeV/u) + ; Transmitted Fragment 66Se21+..
dp/p=14.49% ; Brho(Tm): 0.7988, 0.7988, 0.7988, 0.798
AngAccept: ON; Bounds: Off; "dl37" - last block f

#	Ion	N of Passed	N of Initial	Transmission
All		24821	82070	30.24%
0	66Se	24772	81920	30.24% (+/-0.19%)

Target	100.0%
tuning	33.43%
Angular acceptance	33.43%
slits FP1	90.46%
Slits	90.46%



"Monte Carlo " method
No Angular Acceptances
WITH bounds

Angular Acceptance & Bounds

- [ ] Use fixed angular acceptances
- [x] Use physical limits (aperture) inside blocks to calculate fragment transmission

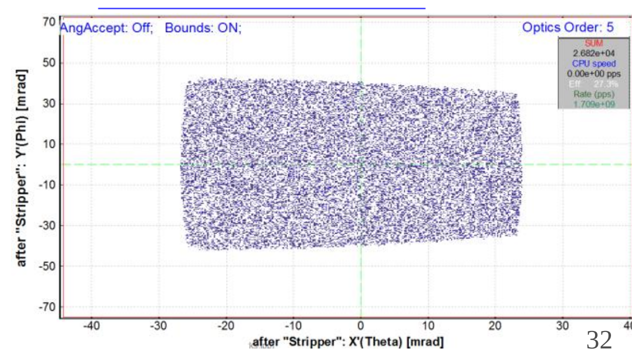
For block apertures LISE++ uses the slit limits accessible from the Block Cut & Acceptance dialog. (Pay attention there for the checkbox

66Se : Monte Carlo Transmission Plot

66Se (3.1 MeV/u) + ; Transmitted Fragment 66Se21+..
dp/p=14.49% ; Brho(Tm): 0.7988, 0.7988, 0.7988, 0.798
AngAccept: Off; Bounds: ON; "dl37" - last block f

#	Ion	N of Passed	N of Initial	Transmission
All		26874	98253	27.35%
0	66Se	26824	98080	27.35% (+/-0.17%)

Target	100.0%
tuning	100.0%
dl1	83.65%
Inside of bounds	83.65%
Q1	59.38%
Inside of bounds	59.38%
Q2	79.60%
Inside of bounds	79.60%
Q4	88.46%
Inside of bounds	88.46%

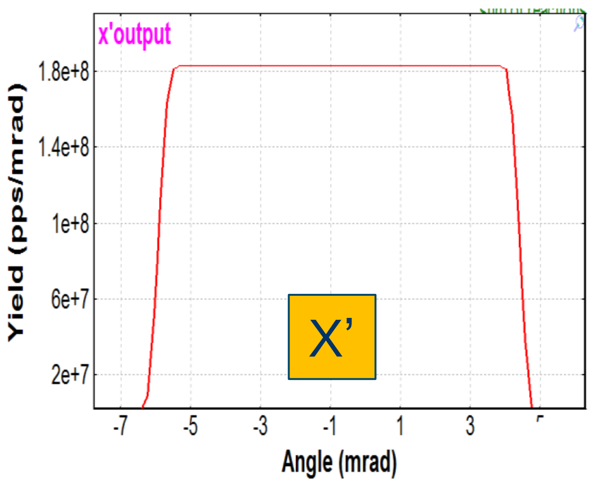


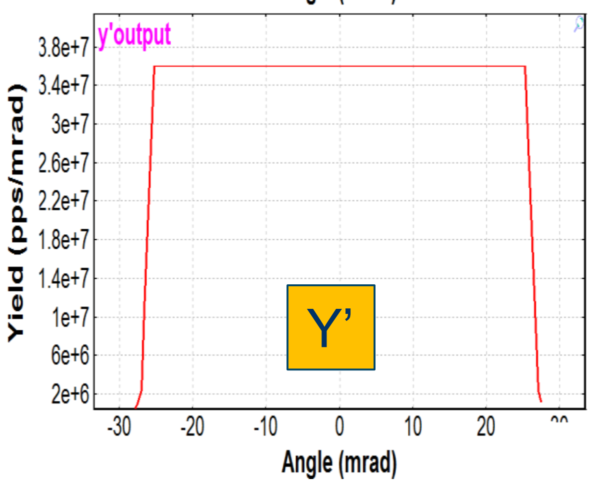
“Distribution” method
With set Angular Acceptances

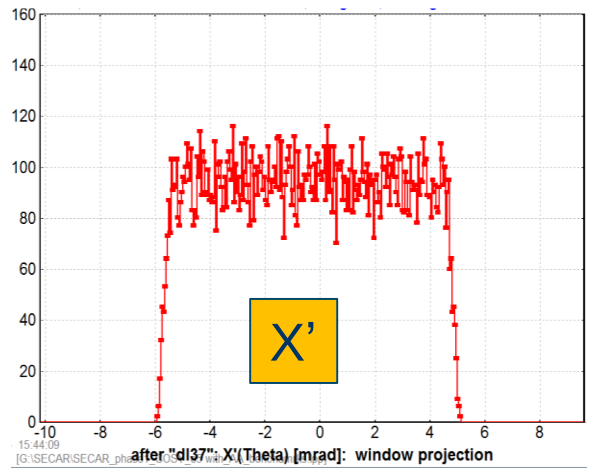
“Monte Carlo ” method
With set Angular Acceptances
No bounds

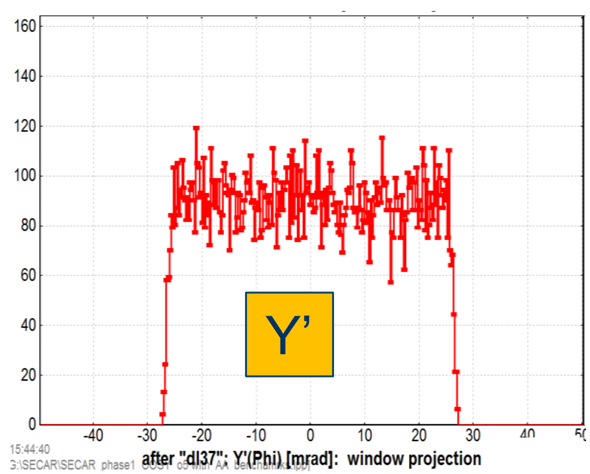
“Monte Carlo ” method
No Angular Acceptances
WITH bounds

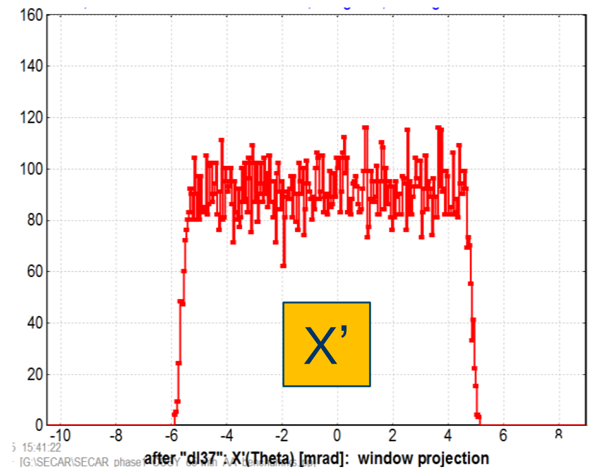
@ DL38

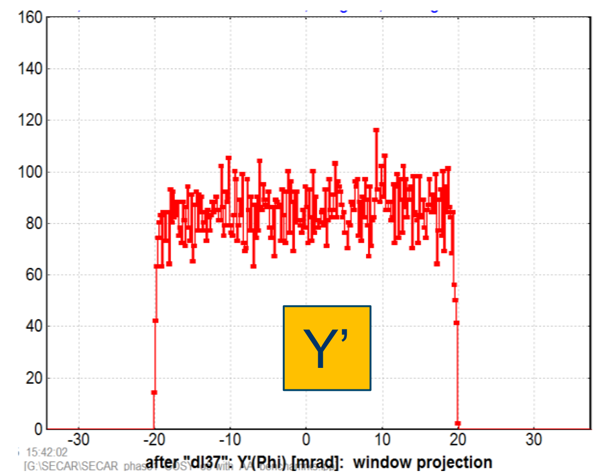






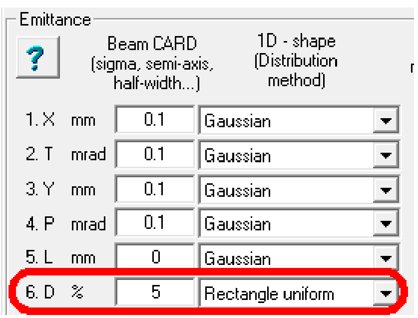






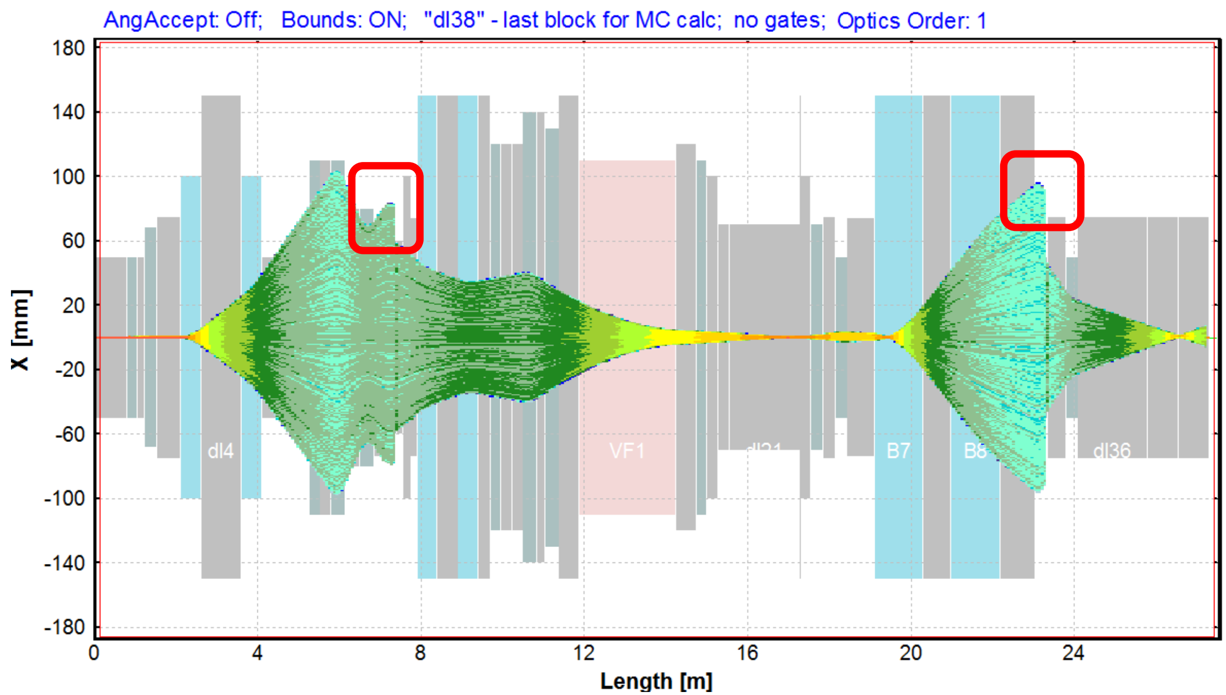
Momentum Acceptance

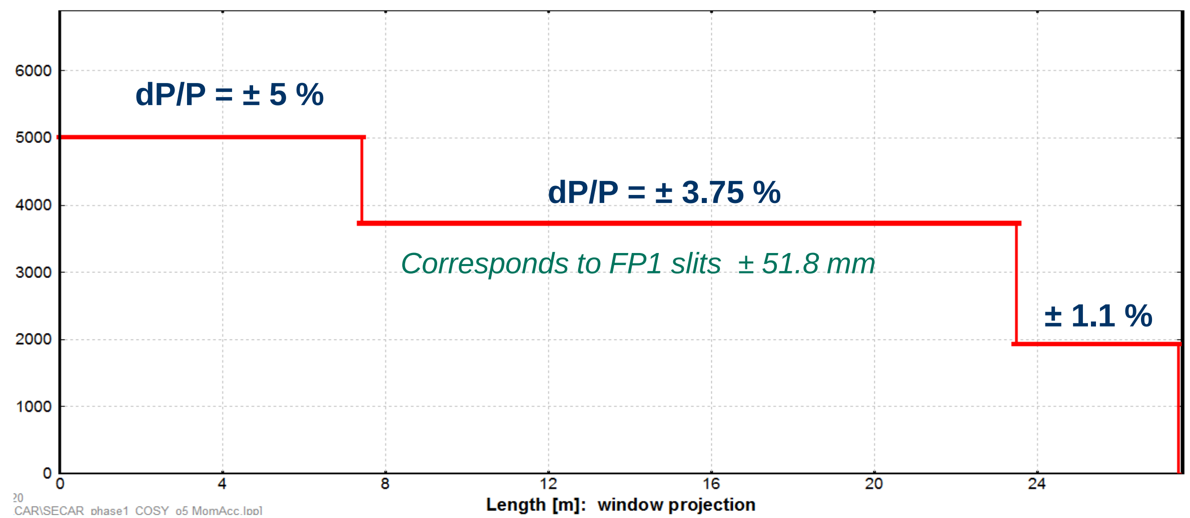
1st order



Emittance

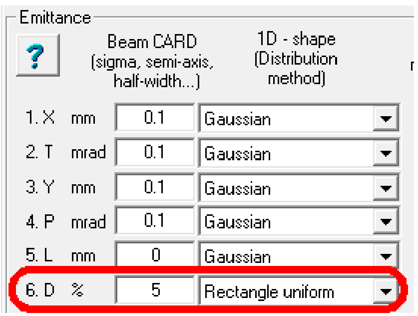
		Beam CARD (sigma, semi-axis, half-width...)	1D - shape (Distribution method)
1. X	mm	0.1	Gaussian
2. T	mrad	0.1	Gaussian
3. Y	mm	0.1	Gaussian
4. P	mrad	0.1	Gaussian
5. L	mm	0	Gaussian
6. D	%	5	Rectangle uniform

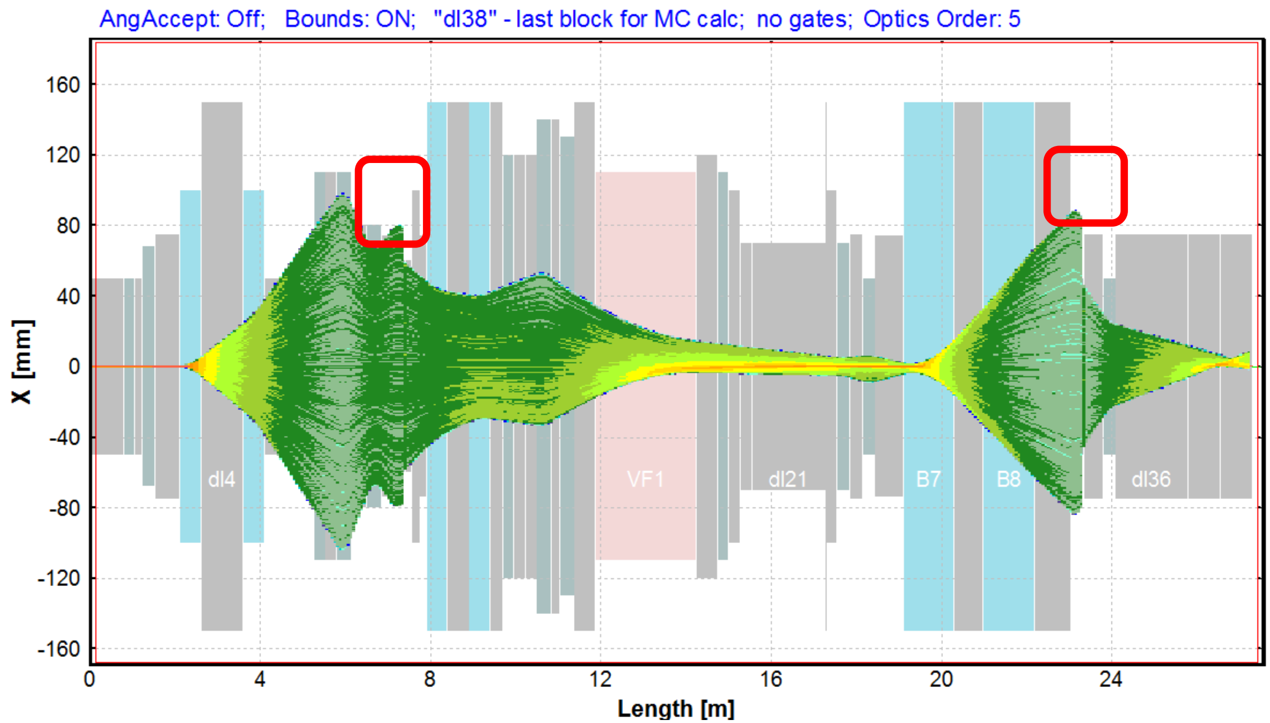


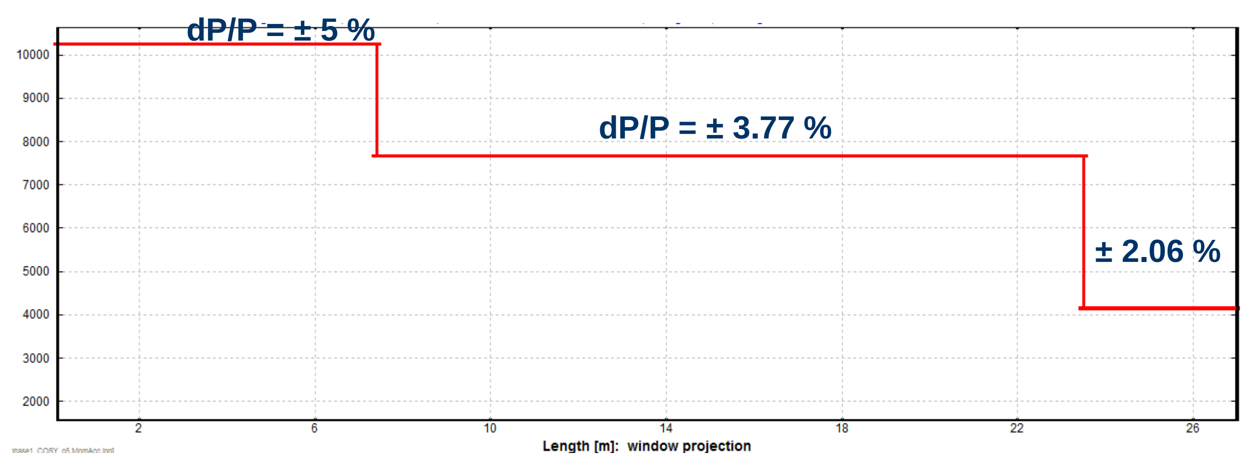


Momentum Acceptance

5^{th} order



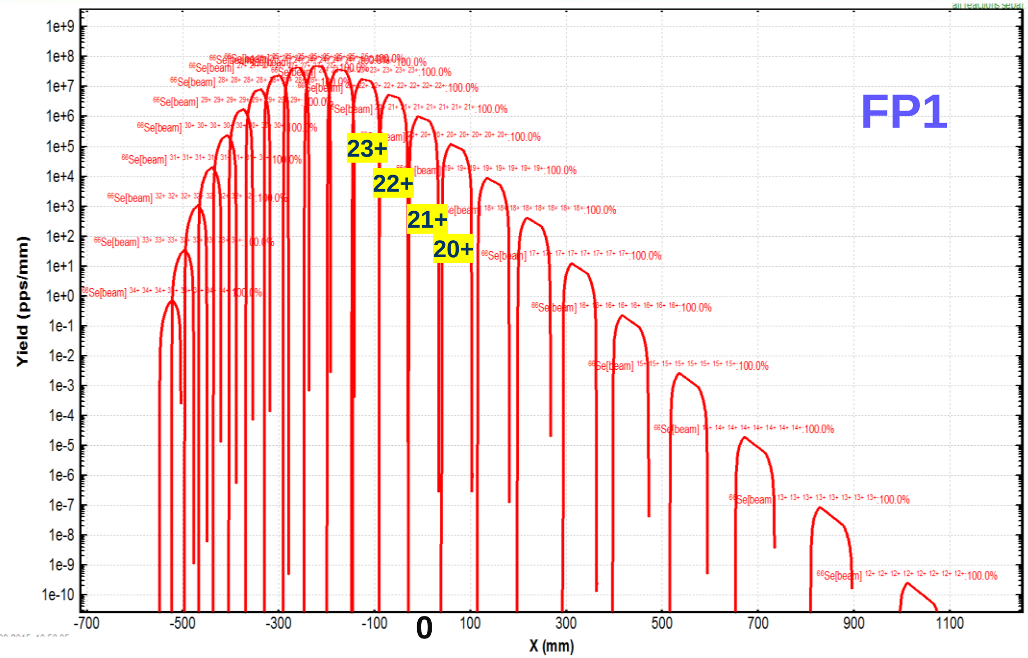


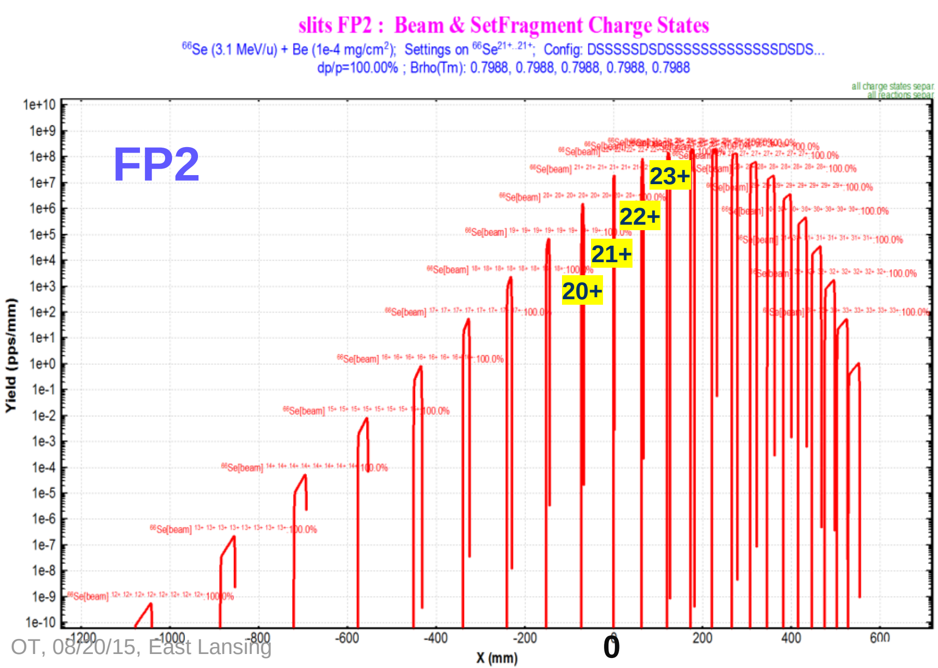


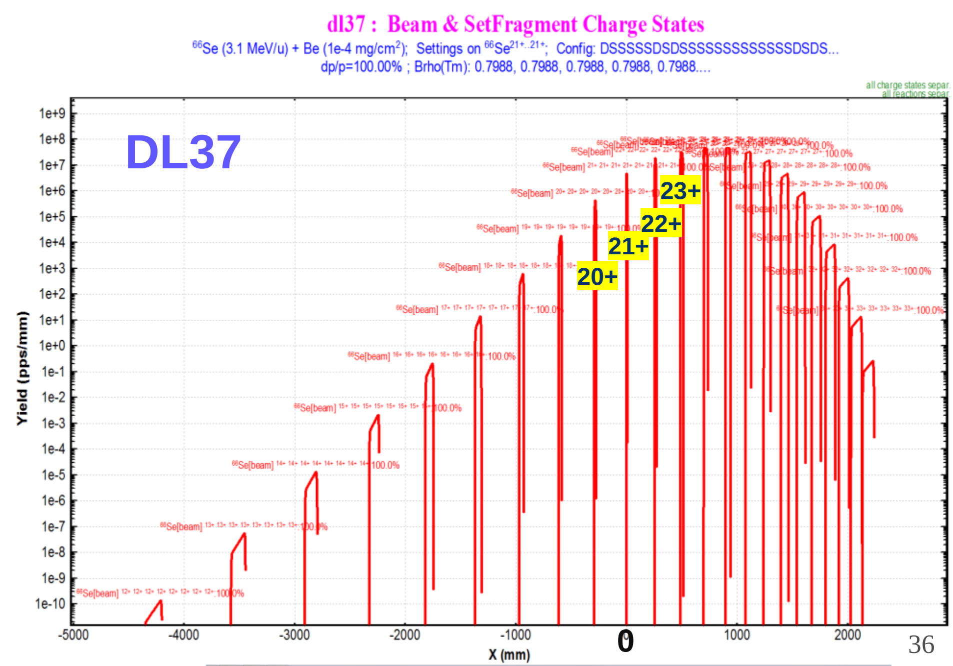
Charge States Selection: "Distribution" method

File: e_SECAR_p1_COSY.lpp

No slits, no apertures



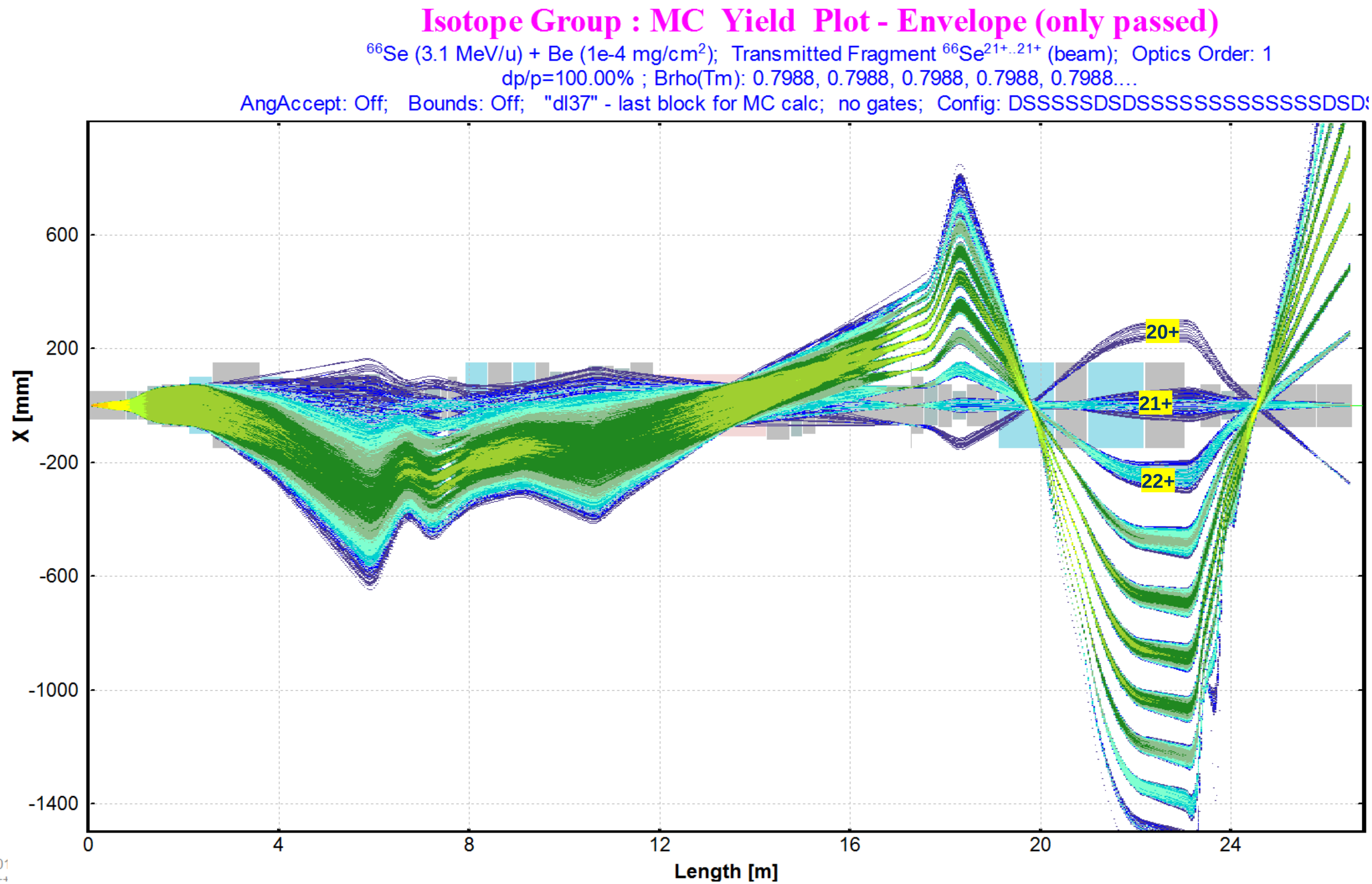




Charge States Selection: Monte Carlo solution

No slits, no apertures

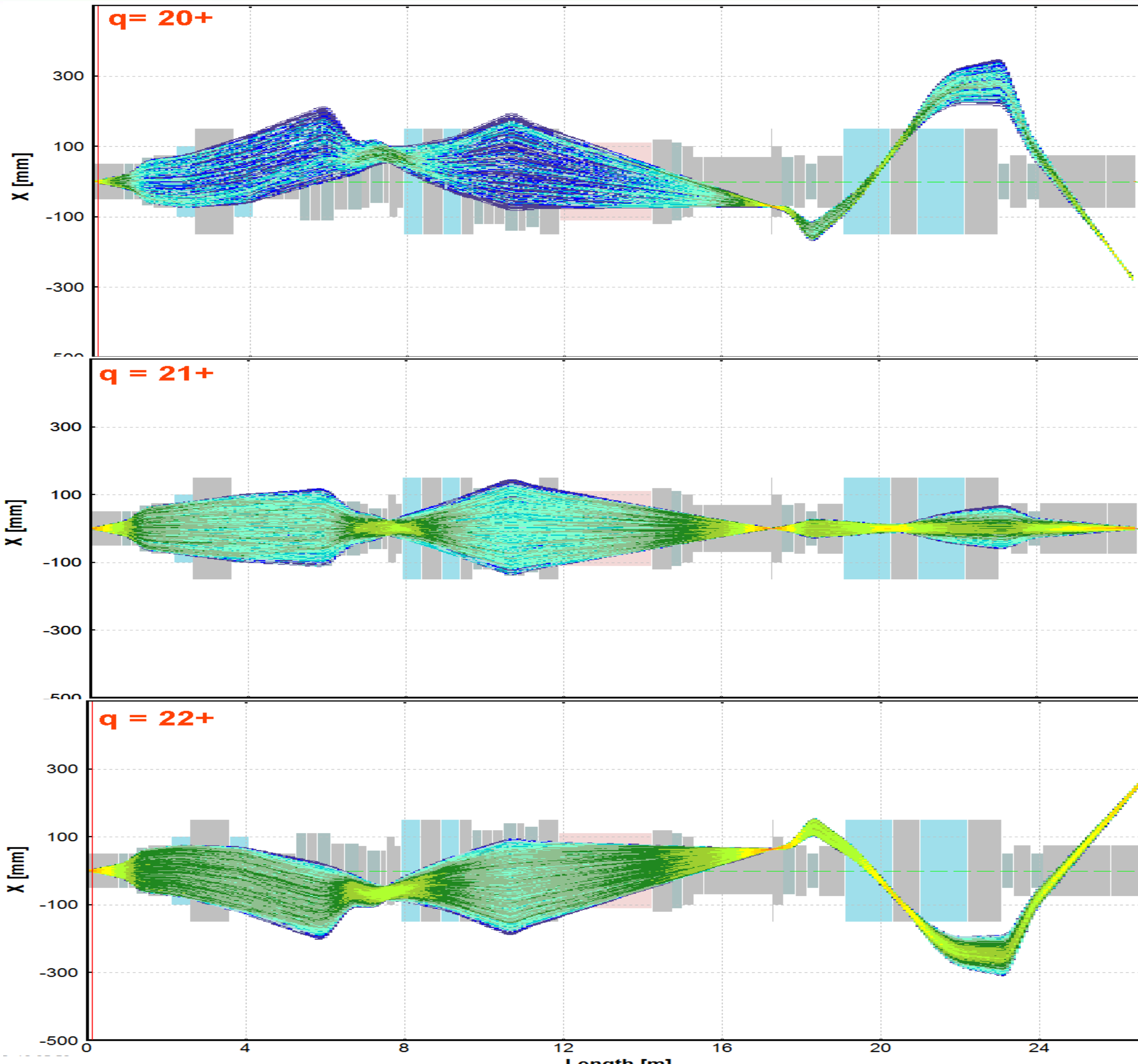
1^{st} order



Charge States Selection: Monte Carlo solution

1. X	mm	0.75	Rectangle uniform
2. T	mrad	25	Rectangle uniform
3. Y	mm	0.75	Rectangle uniform
4. P	mrad	25	Rectangle uniform
5. L	mm	0	Gaussian
6. D	%	1.5	Rectangle uniform

1st order



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

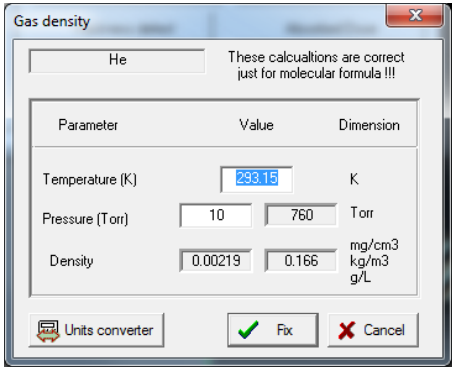
Table 3.14. Transmission results for a set of crucial reactions from the target to the final focus in the single VF system.

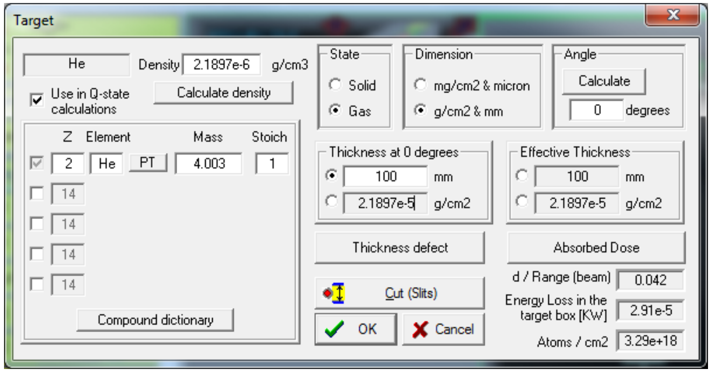
Reaction	Energy (MeV/u)	Transmission
$^{15}O(\alpha,\gamma)^{19}Ne$	0.3	95

LISE^{++} settings

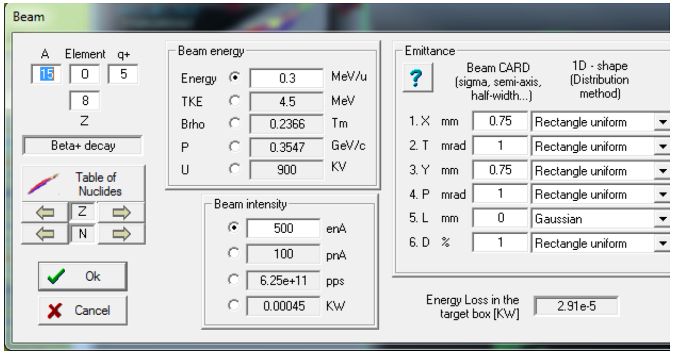
File: e_SECAR_phase1_reaction.lpp

Target

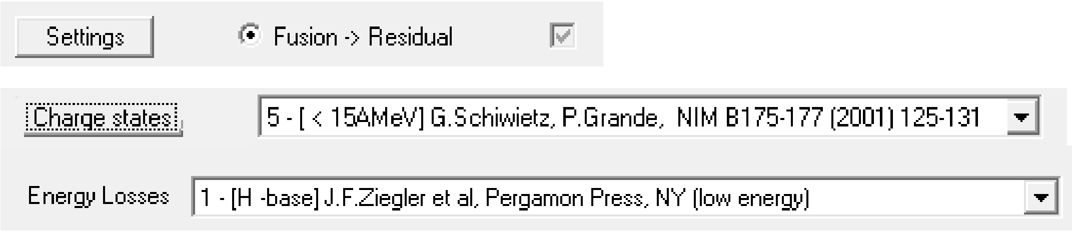




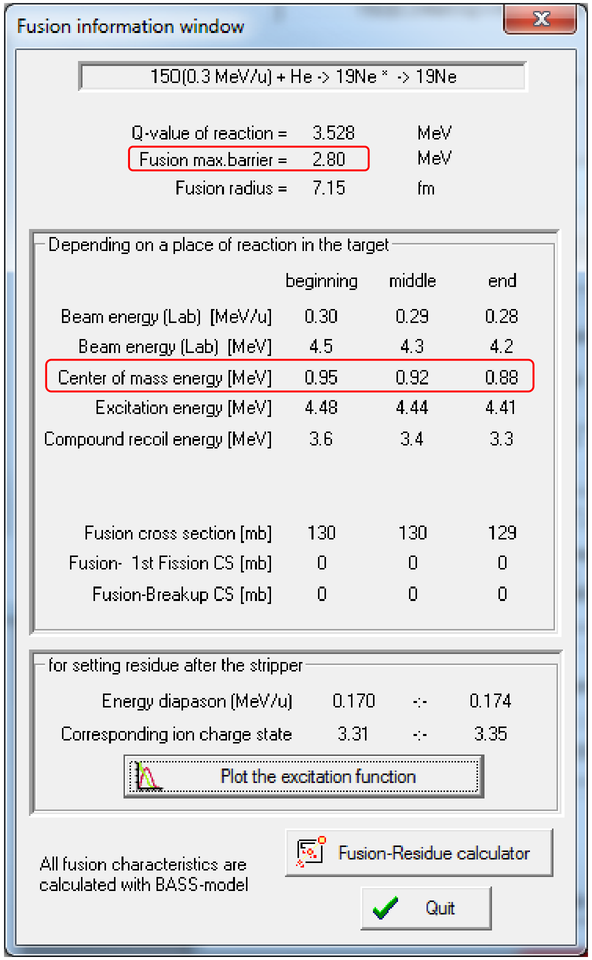
Beam

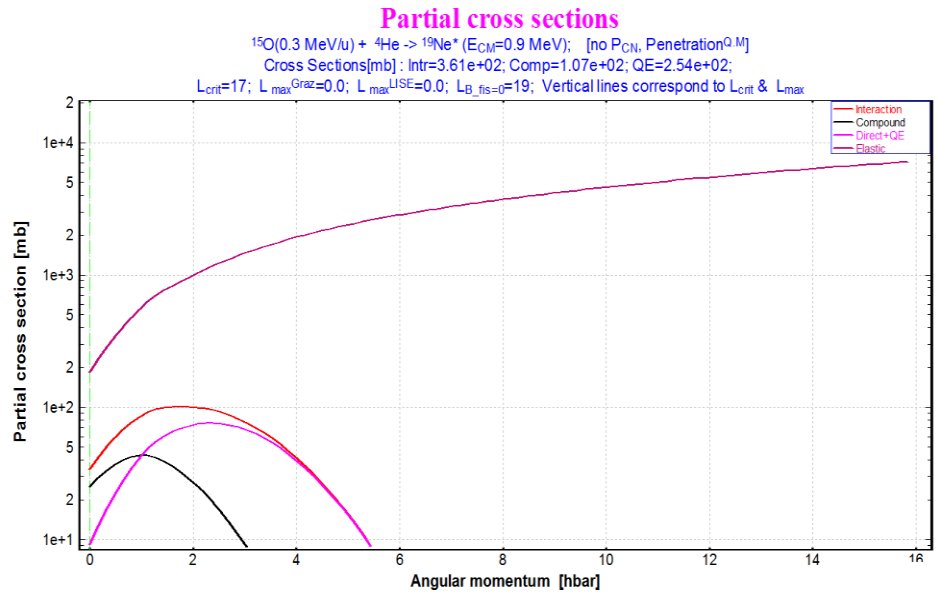


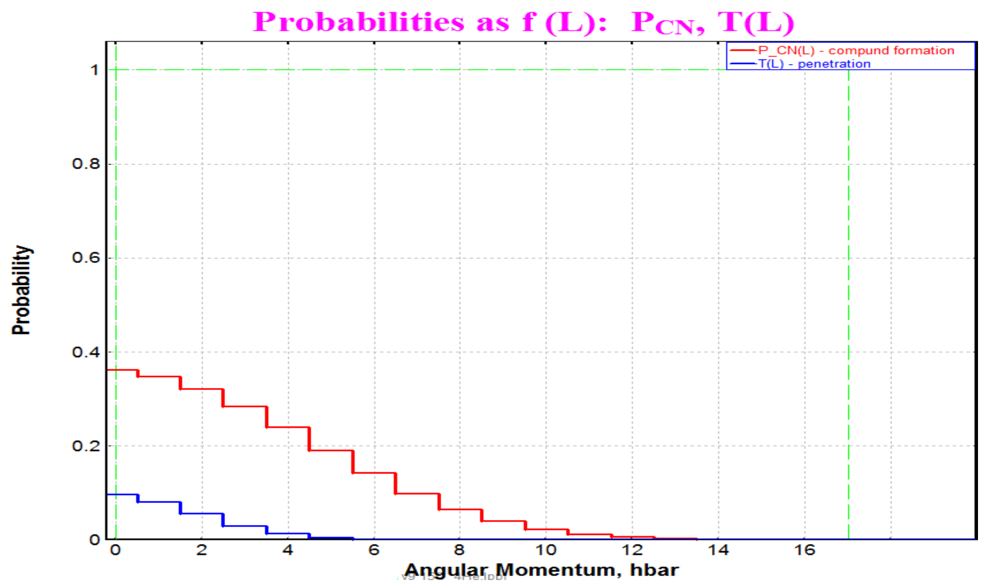
Production mechanism



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



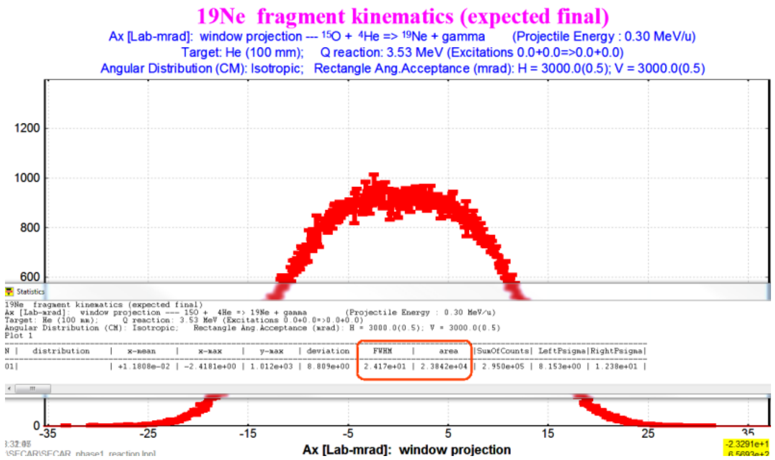


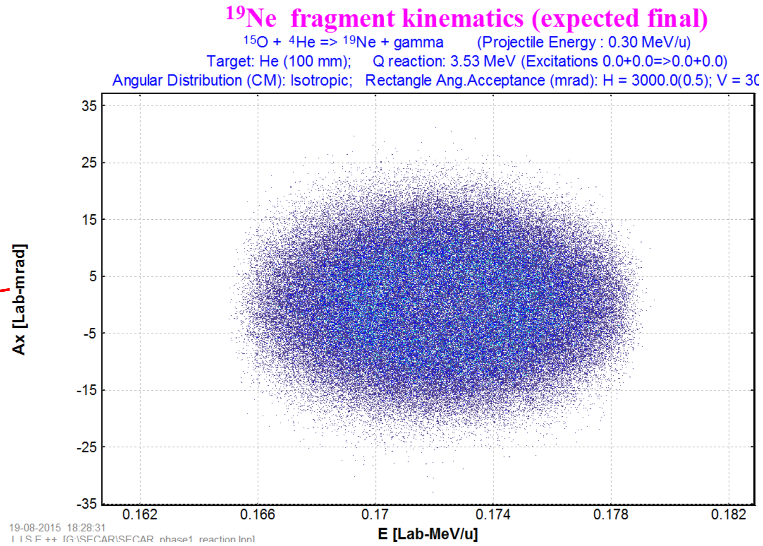


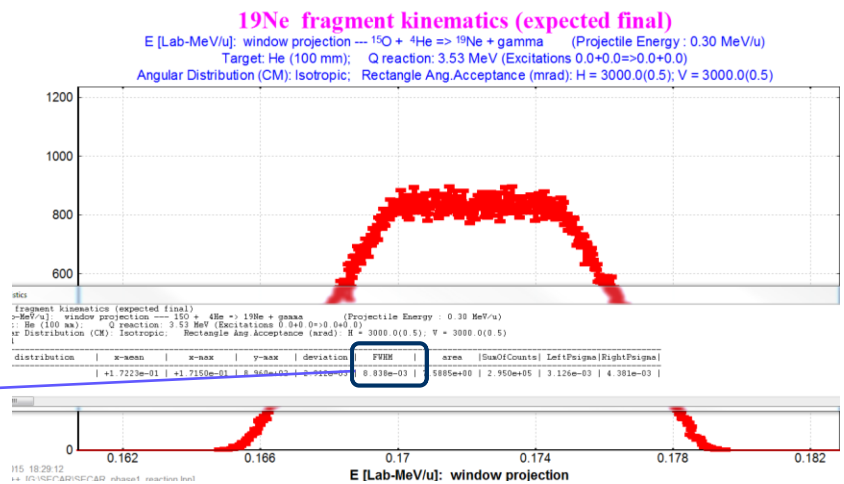
Experiment $^{15}O(\alpha, \gamma)^{19}Ne$: kinematics

Please check the kinematics discussion for the DRAGON separator
http://lise.nscl.msu.edu/9_10/DRAGON/DRAGON.pdf#page=51

Experiment $^{15}O(\alpha, \gamma)^{19}Ne$: two-body kinematics



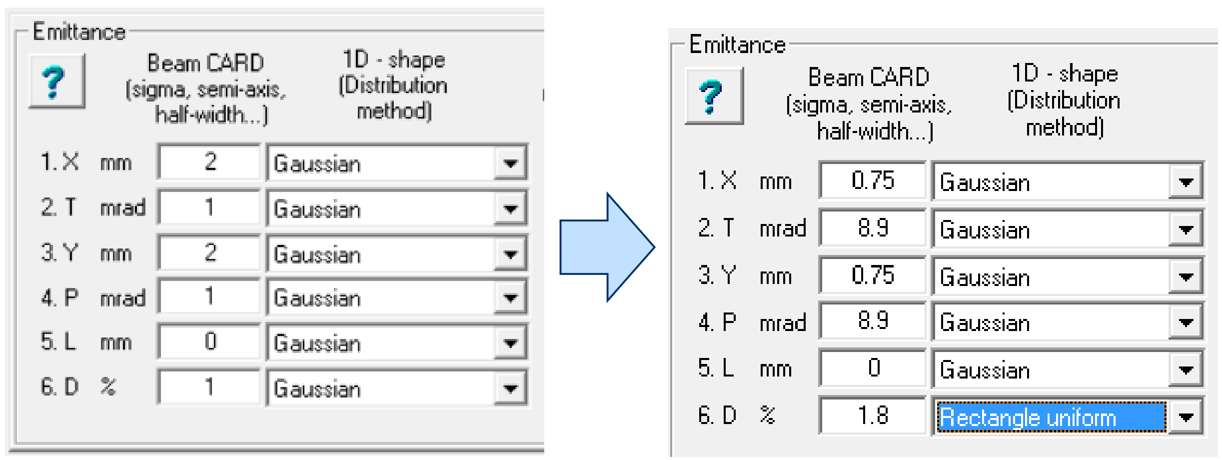




It's corresponds to initial rectangle emittance dp/p = +/- 1.8%

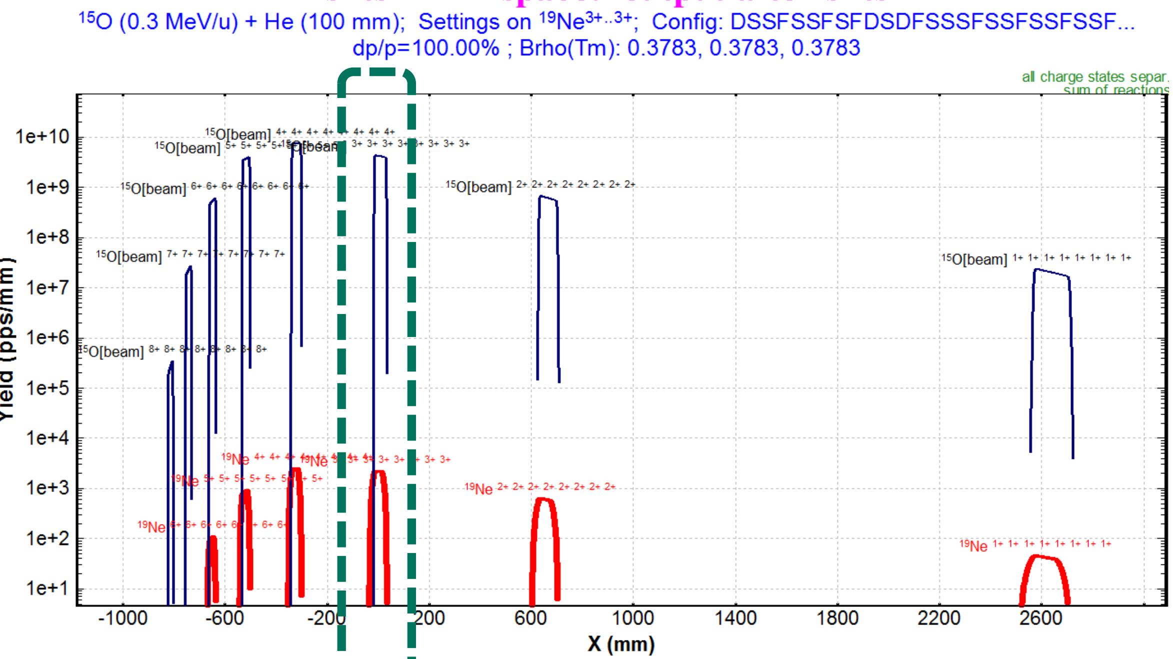
Experiment $^{15}O(\alpha, \gamma)^{19}Ne$: kinematics

In order to obtain distributions corresponding to two-boy kinematics HI+gamma
it is possible to change the initial beam emittance as



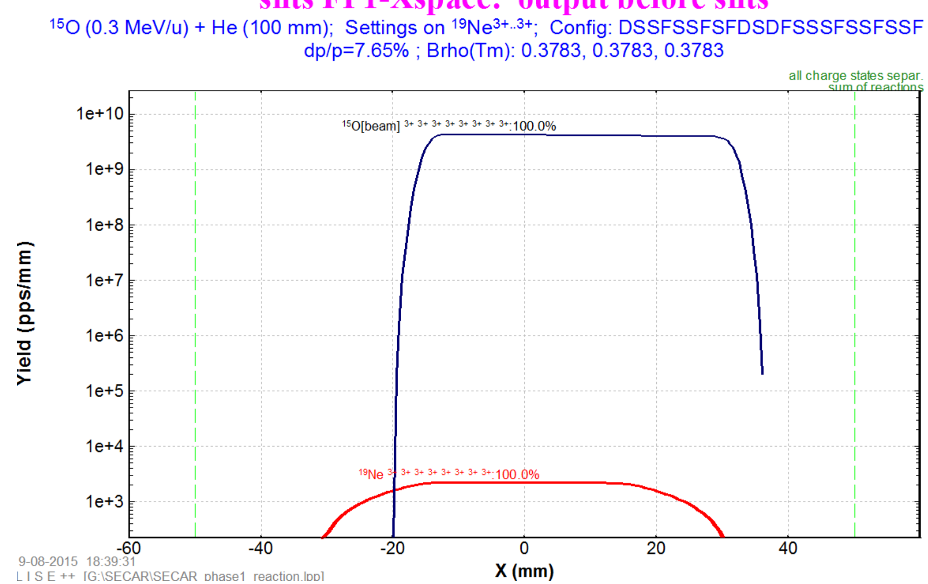
Experiment $^{15}O(\alpha, \gamma)^{19}Ne$: selection

slits FP1-Xspace: output after slits

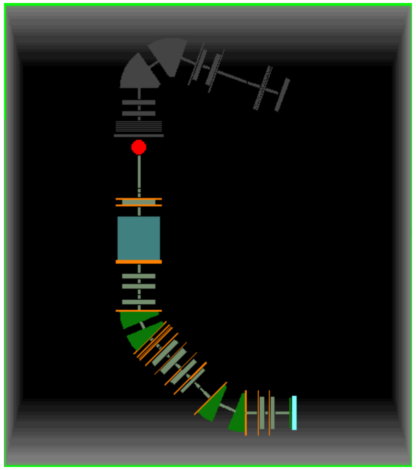


@ FP1 slits

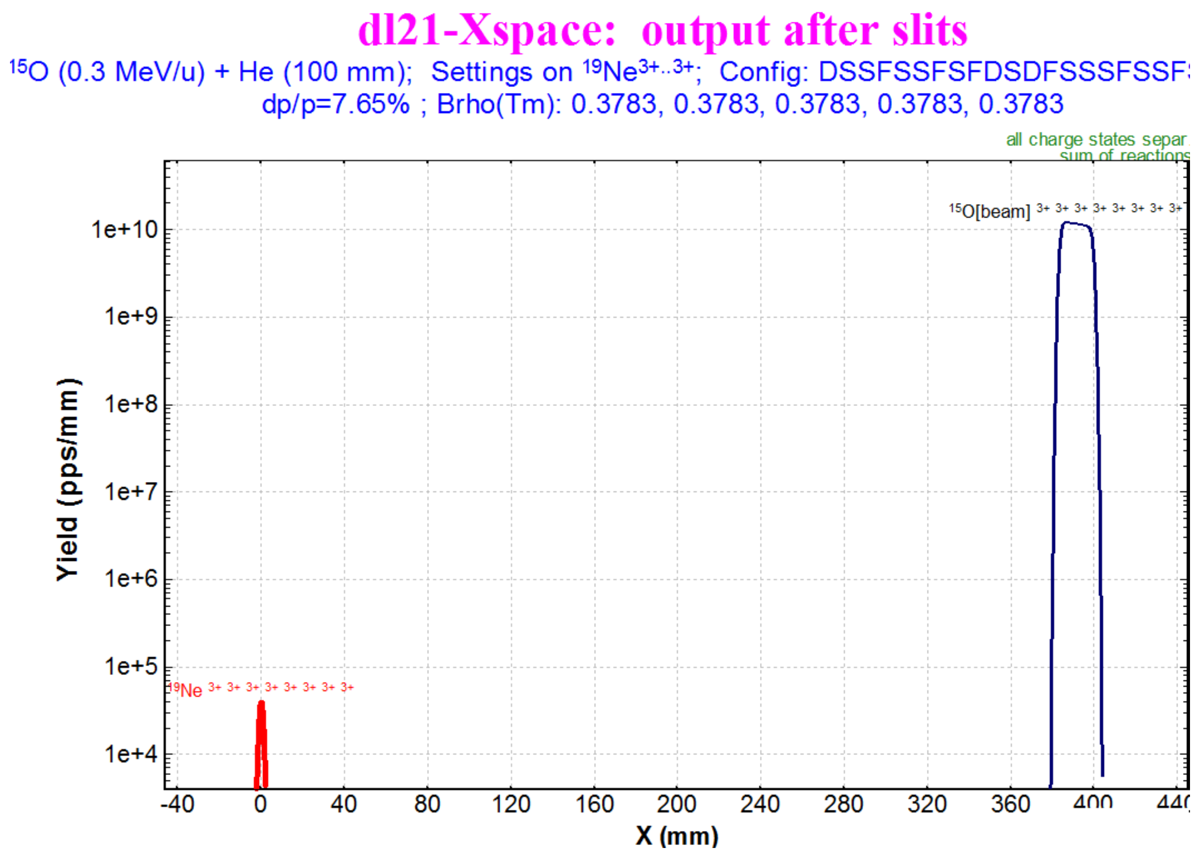
slits FP1-Xspace: output before slits



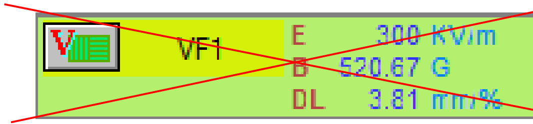
Experiment $^{15}O(\alpha, \gamma)^{19}Ne$: selection @ FP2



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



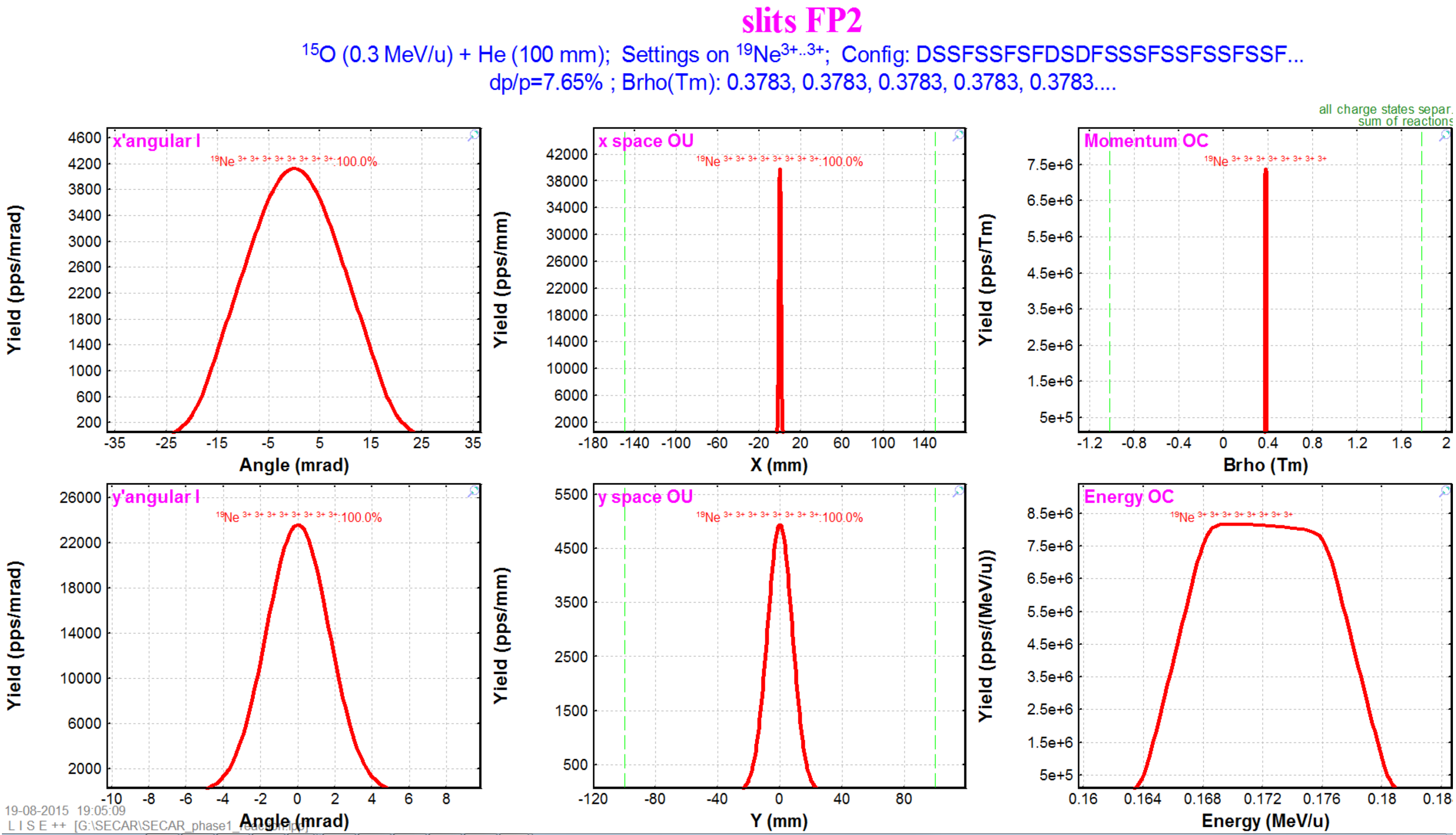
~~Pay attention for The Wien filter parameters!!! The purpose of E(or B) choice is to compensate dispersion after dipoles!~~



It has been solved in the version 9.10.171 with the new option "keep dispersion constant"

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

$^{19}Ne^{3+}$ after the Mass Slits (FP2)



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)

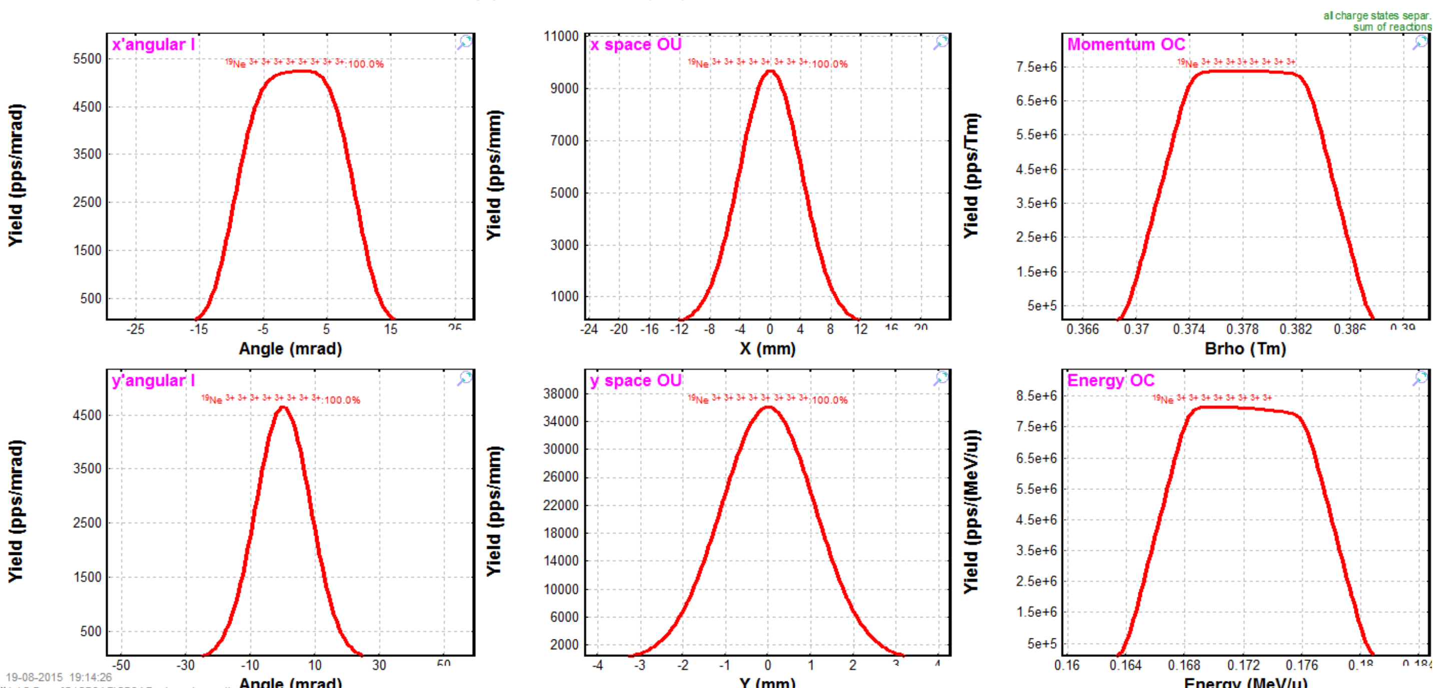
Q1 (tuning)		3
Reaction		FusRes
Ion Production Rate	(pps)	9.9e+4
Total ion transmission	(%)	37.077
Total: this reaction	(pps)	9.9e+4
Total: All reactions	(pps)	9.9e+4
X-Section in target	(mb)	1.3e+2
Target	(%)	39.09
Unreacted in material	(%)	100
Q (Charge) ratio	(%)	39.09
Unstopped in material	(%)	100
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....



Segmented configuration -- should be done soon

Extended

Detail configuration for experts

90 blocks

Segmented

“Easy” configuration for regular users

11 blocks (5 sectors, 3 material blocks and 3 slits)

Will be done soon!

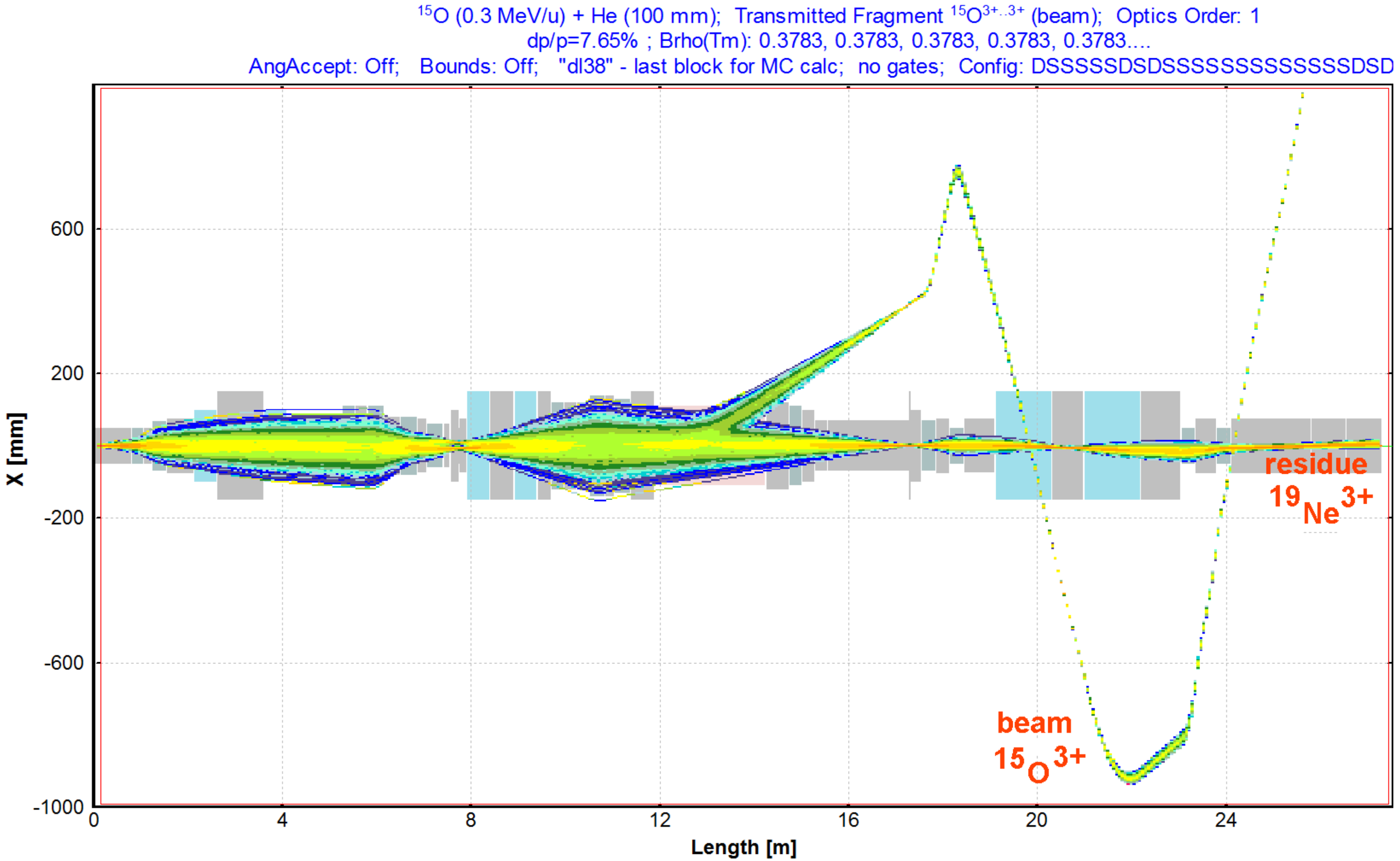
Segmented configuration

Pay attention for cut settings:
4 angular acceptances, 3 slits

5 sectors
(segments)

Will be done soon!

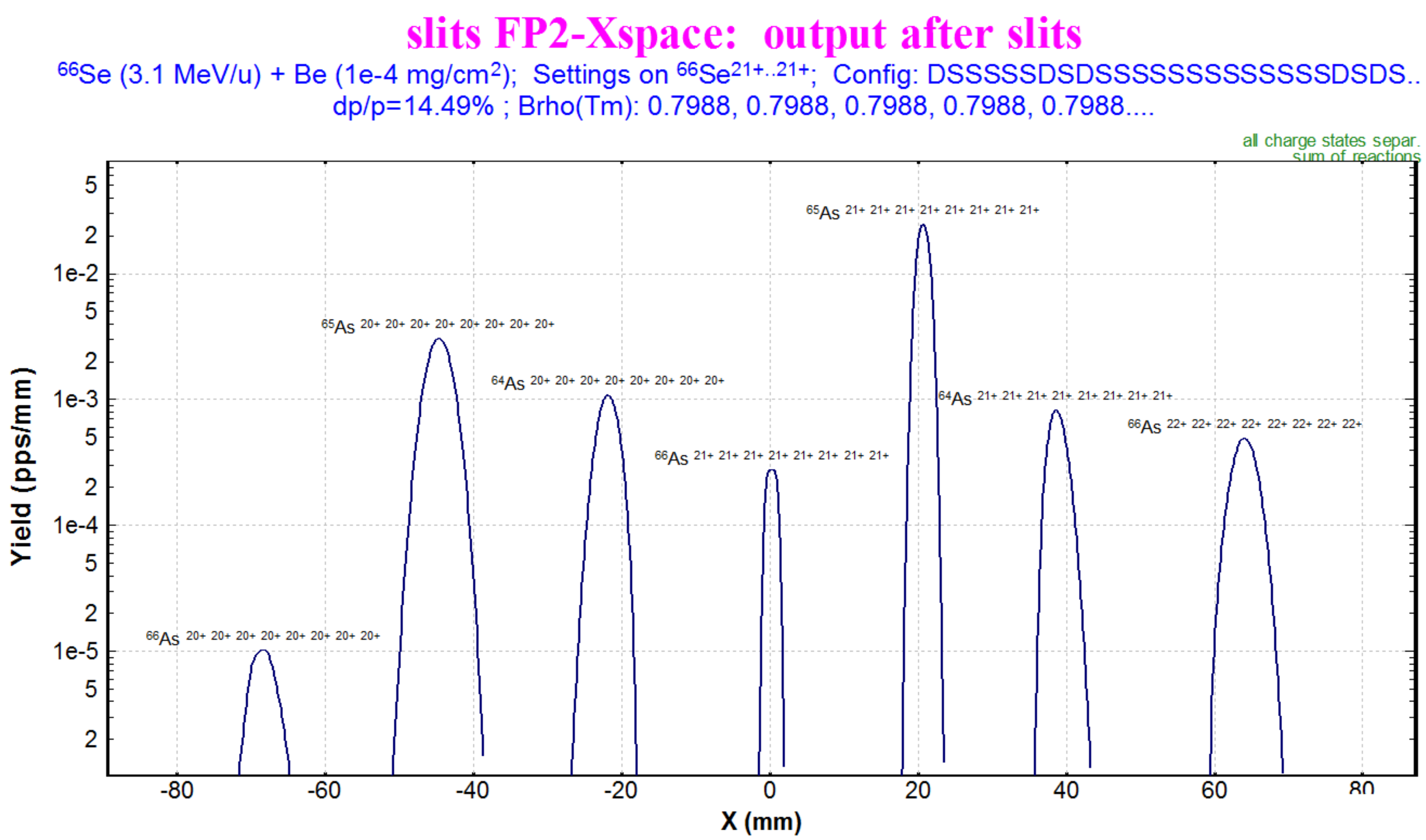
Request : Beam and Fragment in one plot



Request : Mass selection

"Fake" reaction (fragmentation of ^{66}Se) was used to obtain bunch of isotopes with different masses with wide energy distributions

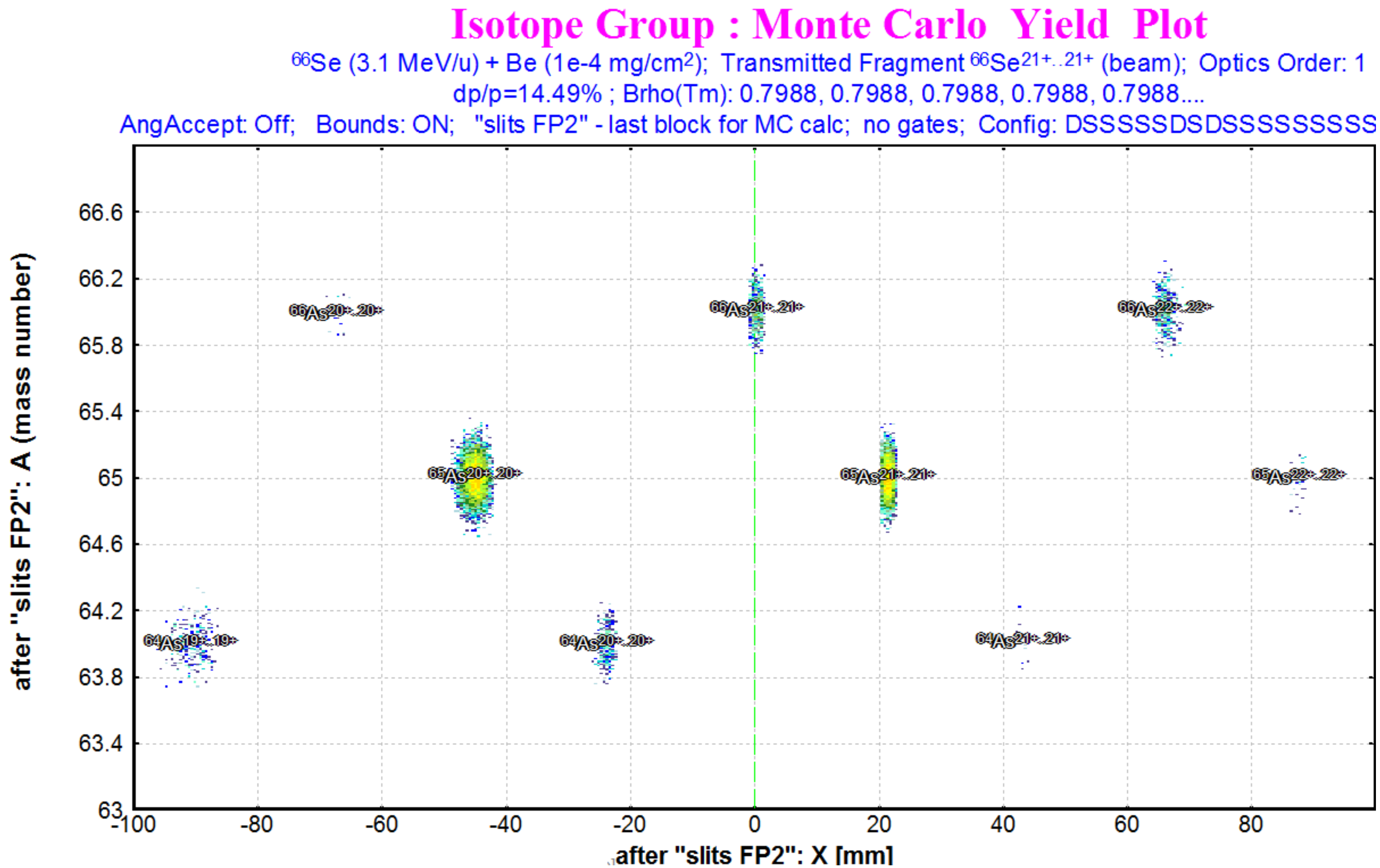
Analytical solution
1^{st} order



Request : Mass selection

"Fake" reaction (fragmentation of ^{66}Se) was used to obtain bunch of isotopes with different masses with wide energy distributions

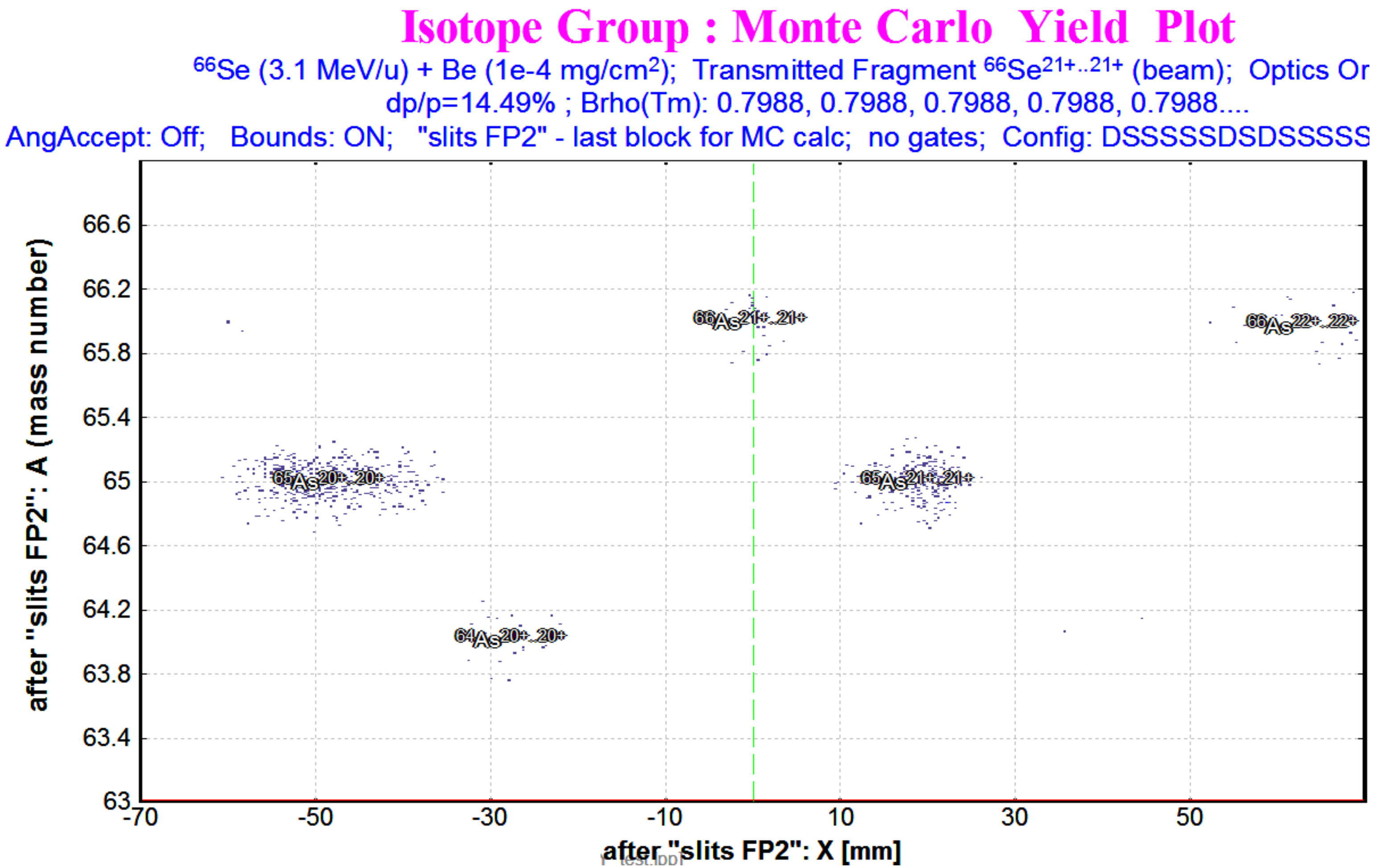
Monte Carlo solution
1st order



Request : Mass selection

“Fake” reaction (fragmentation of ^{66}Se) was used to obtain bunch of isotopes with different masses with wide energy distributions

Monte Carlo solution
5th order



Summary

Open Questions:

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

It has been solved in the version 9.10.171 with the new option “keep dispersion constant”

Acknowledgement:

to Hendrik Schatz and Fernando Motes for documents and files providing,
to Mauricio Portillo with COSY actions