Recoil separator "DRAGON" @ TRIUMF

High Order extended configuration

Version 9.10.142
from 07/22/2015

Link: Spectrometer "DRAGON" (TRIUMF)

- DRAGON2000 extended configuration
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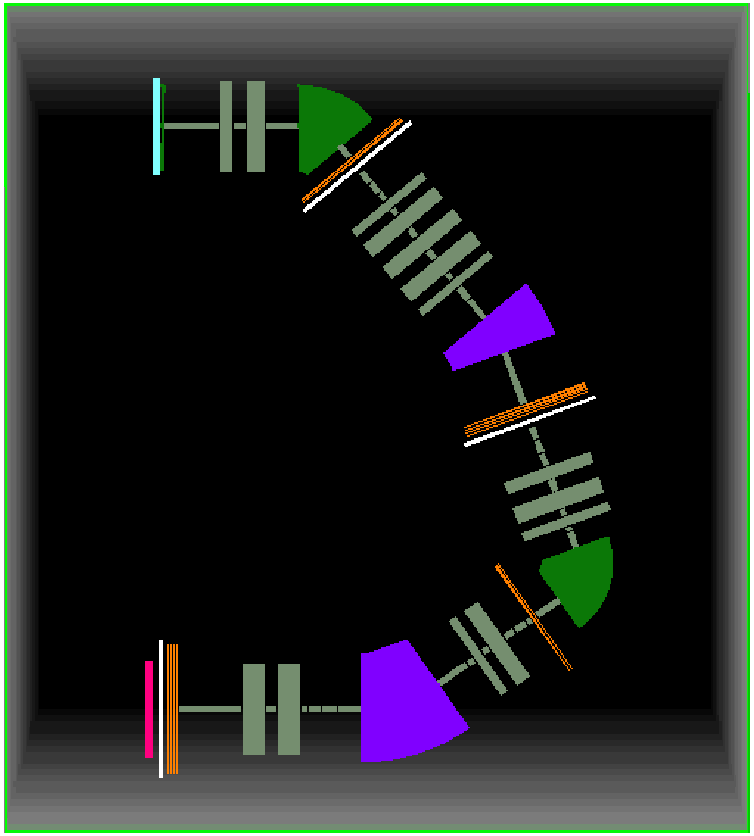


DRAGON documentation sources

1. THE DRAGON Recoil Separator Optics by The Recoil Group from January 3, 2001
2. D.A. Hutcheon et al. / Nuclear Instruments and Methods in Physics Research A 498 (2003) 190–210
3. Fax by D.A. Hutcheon from 09/01/2003 with GIOSP input
4. Commissioning the DRAGON facility at ISAC by S.Engel et al. from 06/23/2005
5. On-line DRAGON tools http://dragon.triumf.ca/DragonTools.php#md1
6. Unrike's comments

Finally, the DRAGON's extended configuration has been created mainly based on the first very detail document *(THE DRAGON Recoil Separator Optics by The Recoil Group from January 3, 2001)*, so let's call this configuration as DRAGON2000, because there are some differences were found with other sources which will be discussed.

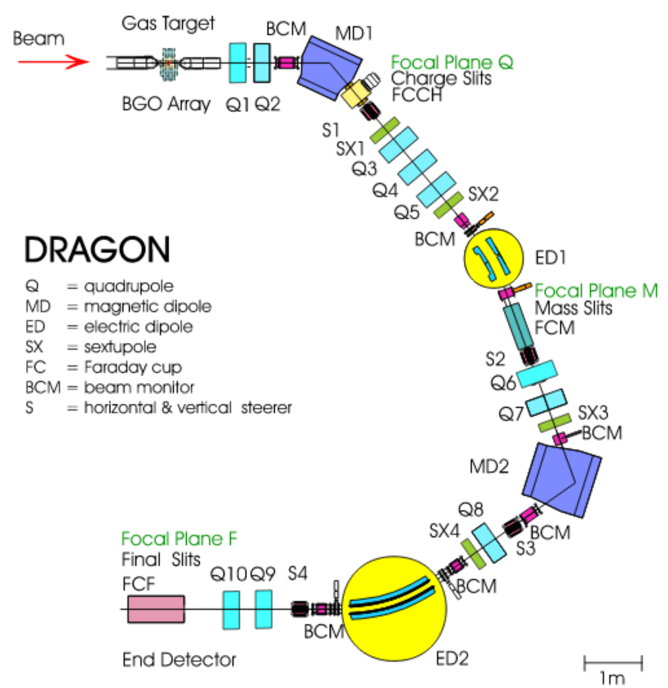


Fig. 1. Schematic view of the DRAGON facility.

DRAGON2000 parameters (p.1)

Table 1.1: Important parameters of DRAGON dipoles.

dipole	ρ(cm)	ϕ(deg)	α(deg)	gap(cm)	L_{eff}(cm)
MD_1	100	50	5.8	10	87.27
ED_1	200	20	-	10	69.81
MD_2	81.3	75	29	12	106.42
ED_2	250	35	-	10	152.72

Table 1.2: Important parameters and status of DRAGON quads(Q), sextupoles(S) an steering magnets(SM).

device	L_{eff}(cm)	L_{tot}(cm)	aperture(inch)	status
$Q_{1,6}$	25.23	31.5	4.25	mapped/placed
Q_2	33.385	45(?)	6.25	mapped/placed
$Q_{9,10}$	46.7	58.2	5.91	SMIT-ELMA quads mapped
$Q_{3..5,7,8}$	33.38	45(?)	6.25	mapped/placed
$S_{1,2}$	18.75	21.6	6.26	mapped
$S_{3,4}$	19.9	23.5	6.26(4.49) X(Y)	mapped asymmetric design
$SM_{3,4}$	25.9(?)	16.3	6.25	mapped(?)
$SM_{1,2}$	25.6	16.5	4.25	Chalk River mapped(rough)

Table 2.1: First-order optics properties of magnetic and electrostatic dipoles (file reso2000.dat 28 Sept 00).

Element	Radius (m)	Bend (deg)	Direction	Gap (m)	Entry pole angle (deg)	Exit pole angle (deg)
MD1	1.00	50	Right	0.10	5.8	5.8
ED1	2.00	20	Right	0.10	0.0	0.0
MD2	0.813	75	Right	0.12	29.0	29.0
ED2	2.50	35	Right	0.10	0.0	0.0

Table 2.2: Separator backbone segment lengths (GIOS output file reso2000.dat 28 Sept 00).

Segment	Begins	Ends	Length (m)
1	Target	MD1	3.0163
2	MD1	ED1	4.7819
3	ED1	MD2	4.4815
4	MD2	ED2	4.1351
5	ED2	Final focus	4.2975
All	Target	Final focus	10.2461 (90.346°)

error?

DRAGON2000 parameters (p.2)

Table 2.3: E.M.S. element spacings in the first stage (file reso2000.dat 28 Sept 00). Distances are between effective field boundaries. The positioning of beam position monitors (MON) and steering magnets (SM) could be modified slightly (i.e. a few cm either way) without serious effect.

DRAGON2000a

Segment 1			Segment 2			Segment 3		
Begin	End	Len (m)	Begin	End	Len (m)	Begin	End	Len (m)
Target	Q1 in	1.06885	Seg. beg.	MD1 out	0.4663	Seg. beg.	ED1 out	0.3527
Q1 in	Q1 out	0.2523	MD1 out	Ch. slit	0.3079	ED1 out	Mass slit	1.05
Q1 out	Q2 in	0.256925	Ch. slit	SM1 in	0.272			
Q2 in	Q2 out	0.33385	SM1 in	SM1 out	0.256			
Q2 out	MD1 in	0.638075	SM1 out	S1 in	0.1862			
MD1 in	Seg. end	0.4663	S1 in	S1 out	0.1875			
			S1 out	Q3 in	0.1614			
			Q3 in	Q3 out	0.3338			
			Q3 out	Q4 in	0.2162			
			Q4 in	Q4 out	0.3338			
			Q4 out	Q5 in	0.2162			
			Q5 in	Q5 out	0.3338			
			Q5 out	S2 in	0.1614			
			S2 in	S2 out	0.1875			
			S2 out	MON1	0.3092			
			MON1	ED1 in	0.50			
			ED1 in	Seg. end	0.3527			
Total		3.0163	Total		4.7819	(next table)		

Table 2.4: E.M.S. element spacings in the second stage (file reso2000.dat 28 Sept 00). Distances are between effective field boundaries.The positioning of beam position monitors (MON) and steering magnets (SM) could be modified slightly (i.e. a few cm either way) without serious effect. The quoted effective lengths of the steering magnets are not critical and could be reduced.

Segment 3			Segment 4			Segment 5		
Begin	End	Len (m)	Begin	End	Len (m)	Begin	End	Len (m)
Mass slit	SM2 in	0.277	Seg. beg.	MD2 out	0.6238	Seg. beg.	ED2 out	0.7883
SM2 in	SM2 out	0.256	MD2 out	MON3	0.56076	ED2 out	MON5 in	0.425
SM2 out	Q6 in	0.27085	MON3	SM3 in	0.1205	MON5 out	SM4 in	0.3155
Q6 in	Q6 out	0.2523	SM3 in	SM3 out	0.259	SM4 in	SM4 out	0.259
Q6 out	Q7 in	0.25695	SM3 out	Q8 in	0.24084	SM4 out	Q9 in	0.12
Q7 in	Q7 out	0.3338	Q8 in	Q8 out	0.3338	Q9 in	Q9 out	0.467
Q7 out	S3 in	0.1581	Q8 out	S4 in	0.1581	Q9 out	Q10 in	0.199
S3 in	S3 out	0.199	S4 in	S4 out	0.199	Q10 in	Q10 out	0.467
S3 out	MON2	0.098	S4 out	MON4	0.15	Q10 out	Final	1.176693
MON2	MD2 in	0.353	MON4	ED2 in	0.701			
MD2 in	Seg. end	0.6238	ED2 in	Seg. end	0.7883			
Total		4.4815	Total		4.1351	Total		4.2975

Oleg's check: 3.0163 | 4.7819 | 4.4815 | 4.1301 | 4.2175

Corrections for Dipoles lengths:

dipole	ρ(cm)	ϕ(deg)	α(deg)	gap(cm)	L_{eff}(cm)
MD_1	100	50	5.8	10	87.27
ED_1	200	20	-	10	69.81
MD_2	81.3	75	29	12	106.42
ED_2	250	35	-	10	152.72

DRAGON2000

seg1	seg2	seg3	seg4	seg5
1.06885	0.43635	0.34905	0.5321	0.7636
0.2523	0.3079	1.05	0.56076	0.425
0.256925	0.272	0.277	0.1205	0.3155
0.33385	0.256	0.256	0.259	0.259
0.638075	0.1862	0.27085	0.24084	0.12
0.43635	0.1875	0.2523	0.3338	0.467
	0.1614	0.25695	0.1581	0.199
	0.3338	0.3338	0.199	0.467
	0.2162	0.1581	0.15	1.176693
	0.3338	0.199	0.701	
	0.2162	0.098	0.7636	
	0.3338	0.353		
	0.1614	0.5321		
	0.1875			
	0.3092			
	0.5			
	0.34905			
2.9864	4.7483	4.3862	4.0187	4.1928

lengths

	configurations		
	DRAGON2000A		DRAGON2000
	Document	Check	With Corrected dipoles lengths
seg1	3.016	3.016	2.986
seg2	4.782	4.782	4.748
seg3	4.482	4.482	4.386
seg4	4.135	4.130	4.019
seg5	4.298	4.217	4.193
Total	20.712	20.627	20.332

The configuration "DRAGON2000" is used for optimization and benchmarks.
Lengths of drifts should be corrected for the new DRAGON2015 configuration!!!

DRAGON2000 parameters (p.3)

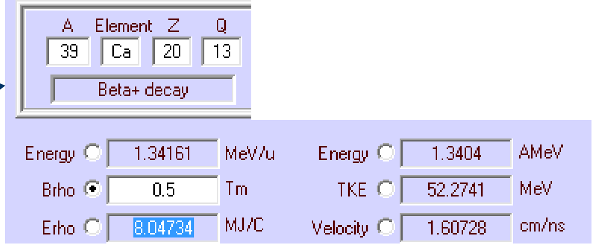
Table 3.1: Limiting apertures and slit widths used for ^{19}Ne acceptance calculations.

components	apertures(cm)
$Q_{1,6}$	10
$Q_{2..5}, Q_{7,8}$	15
$S_{1..4}$	15
$Q_{9,10}$	15
$Q_{9,10}$	15
MD_1	8(y)
MD_2	9(y)
ED_1	10(x)
ED_2	10(x)
gas target collimators	diameter in cm
entrance	0.8
exit	3.6
slit location	full width x(y) in cm
Q	2.32(2.2)
M	0.48(2.4)
F	0.92(1.2)

Table 2.5: Field strengths for rigidities 0.5 T·m and 8 MV scaled from the GIOS input file reso2000.dat Tunes must be obtained by scaling to the rigidities of a given reaction.Note that the sextupole strengths have been scaled to the new L_{eff} values listed in table 1.2.

Element	Gap or Diam.	Effective length	Field
Q1	10.8 cm	25.23 cm	-2.187 kG
Q2	15.9 cm	33.385 cm	+2.003 kG
S0	15.9 cm	33.385 cm	+0.106 kG
MD1	10 cm		+4.991 kG
S1	15.9 cm	18.75 cm	+0.425 kG
Q3	15.9 cm	33.38 cm	+1.826 kG
Q4	15.9 cm	33.38 cm	-2.412 kG
Q5	15.9 cm	33.38 cm	+1.329 kG
S2	15.9 cm	18.75 cm	+0.089 kG
ED1	10 cm		±200. kV
Q6	10.8 cm	25.23 cm	-1.181 kG
Q7	15.9 cm	33.38 cm	+1.696 kG
S3	16 cm	19.9 cm	+0.047 kG
MD2	12 cm		6.139 kG
Q8	15.9 cm	33.38 cm	+1.257 kG
S4	16 cm	19.9 cm	+0.360 kG
ED2	10 cm		±160. kV
Q9	15 cm	46.7 cm	-0.972 kG
Q10	15 cm	46.7 cm	+1.087 kG

In order to use these EM devices settings in LISE^{++} an ion ^{39}Ca^{13+} has been selected with energy 1.34161 MeV/u what corresponds to Br=0.5 Tm and Er=8.047 MV



DRAGON settings in LISE^{++}

1 N	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 *	+1.667	0.5000*	3.00*	0.00*	–		--	rectn					ellps				
2.	t-q1	Drift	0.000	1.069	standard							--	rectn					ellps	-50	+50	-50	+50
3.	Q1	Drift	1.069	0.252	multipole	-2.158	0.5000	5.40	0.25	yes	1	--	rectn					ellps	-50	+50	-50	+50
4.	q1-q2	Drift	1.321	0.257	standard							--	rectn					rectn				
5.	Q2	Drift	1.578	0.334	multipole	+1.965	0.5000	7.94	0.33	yes	1	--	rectn					ellps	-75	+75	-75	+75
6.	d3-md1	Drift	1.912	0.638	standard							--	rectn					ellps	-75	+75	-75	+75
7.	MD1	Dipole	2.550	0.873	+50.0 *	+1.667	0.5000*	1.00*	0.87*	yes		--	rectn					rectn			-40	+40
8.	md1-slits	Drift	3.423	0.308	standard							--	rectn					rectn				
9.	Fit XT	Fit	3.731	0.000								--	rectn					ellps				
10.	Fit XX	Fit	3.731	0.000								--	rectn					ellps				
11.	Fit YP	Fit	3.731	0.000								--	rectn					ellps				
12.	CHARGE slits	Drift	3.731	0.000	SLITS							--	rectn					rectn				
13.	slts-sm1	Drift	3.731	0.272	standard							--	rectn					ellps	-50	+50	-50	+50
14.	SM1	Drift	4.003	0.256	standard							--	rectn					ellps	-50	+50	-50	+50
15.	sm1-s1	Drift	4.259	0.186	standard							--	rectn					ellps	-50	+50	-50	+50
16.	S1	Drift	4.445	0.188	multipole	+0.000	0.5000	7.94	0.19	yes	1	--	rectn					ellps	-75	+75	-75	+75
17.	s1-q3	Drift	4.632	0.161	standard							--	rectn					ellps	-74	+74	-74	+74
18.	Q3	Drift	4.794	0.334	multipole	+1.775	0.5000	7.94	0.33	yes	1	--	rectn					ellps	-75	+75	-75	+75
19.	q3-q4	Drift	5.127	0.216	standard							--	rectn					ellps	-74	+74	-74	+74
20.	Q4	Drift	5.344	0.334	multipole	-2.299	0.5000	7.94	0.33	yes	1	--	rectn					ellps	-75	+75	-75	+75
21.	q4-q5	Drift	5.677	0.216	standard							--	rectn					ellps	-74	+74	-74	+74
22.	Q5	Drift	5.894	0.334	multipole	+1.263	0.5000	7.94	0.33	yes	1	--	rectn					ellps	-75	+75	-75	+75
23.	q5-s2	Drift	6.227	0.161	standard							--	rectn					ellps	-74	+74	-74	+74
24.	S2	Drift	6.389	0.188	multipole	+0.000	0.5000	7.94	0.19	yes	1	--	rectn					ellps	-75	+75	-75	+75
25.	s2-mon1	Drift	6.576	0.309	standard							--	rectn					rectn				
26.	mon1-ed1	Drift	6.886	0.500	standard							--	rectn					rectn				
27.	ED1	ElecDip	7.386	0.698	+20.0 *	0.0kV	0.5000*	2.00*	0.70*	–		--	rectn					rectn	-50	+50		
28.	ed1-slts	Drift	8.084	1.050	standard							--	rectn					rectn	-50	+50		
29.	Mass_XA	Fit	9.134	0.000								--	rectn					ellps				
30.	Mass_XD	Fit	9.134	0.000								--	rectn					ellps				
31.	Mass_PP	Fit	9.134	0.000								--	rectn					ellps				
32.	Mass TD	Fit	9.134	0.000								--	rectn					ellps				
33.	Mass YY	Fit	9.134	0.000								--	rectn					ellps				
34.	MASS Slits	Drift	9.134	0.000	SLITS							--	rectn					rectn				
35.	slts-sm2	Drift	9.134	0.277	standard							--	rectn					ellps	-50	+50	-50	+50
36.	SM2	Drift	9.411	0.256	standard							--	rectn					ellps	-50	+50	-50	+50
37.	sm2-q6	Drift	9.667	0.271	standard							--	rectn					ellps	-50	+50	-50	+50
38.	Q6	Drift	9.938	0.252	multipole	-1.459	0.5000	5.40	0.25	yes	1	--	rectn					ellps	-50	+50	-50	+50
39.	q6-q7	Drift	10.190	0.257	standard							--	rectn					ellps	-50	+50	-50	+50
40.	Q7	Drift	10.447	0.334	multipole	+1.752	0.5000	7.94	0.33	yes	1	--	rectn					ellps	-75	+75	-75	+75
41.	q7-s3	Drift	10.781	0.158	standard							--	rectn					ellps	-74	+74	-74	+74
42.	S3	Drift	10.939	0.199	multipole	+0.000	0.5000	7.95	0.20	yes	1	--	rectn					ellps	-75	+75	-75	+75
43.	s3-mon2	Drift	11.138	0.098	standard							--	rectn					ellps	-74	+74	-74	+74
44.	mon2-md2	Drift	11.236	0.353	standard							--	rectn					ellps	-75	+75	-50	+50
45.	MD2	Dipole	11.589	1.064	+75.0 *	+1.667	0.5000*	0.81*	1.06*	yes		--	rectn					rectn			-45	+45
46.	md2-mon3	Drift	12.653	0.561	standard							--	rectn					ellps	-100	+100	-50	+50
47.	Charge2 XT	Fit	13.214	0.000								--	rectn					ellps				
48.	Charge2 PP	Fit	13.214	0.000								--	rectn					ellps				
49.	Fit XX	Fit	13.214	0.000								--	rectn					ellps				
50.	mon3-sm3	Drift	13.214	0.120	standard							--	rectn					ellps	-75	+75	-75	+75
51.	SM3	Drift	13.334	0.259	standard							--	rectn					ellps	-75	+75	-75	+75
52.	sm3-q8	Drift	13.593	0.241	standard							--	rectn					ellps	-74	+74	-74	+74
53.	Q8	Drift	13.834	0.334	multipole	+1.238	0.5000	7.94	0.33	yes	1	--	rectn					ellps	-75	+75	-75	+75
54.	q8-s4	Drift	14.168	0.158	standard							--	rectn					ellps	-74	+74	-74	+74
55.	S4	Drift	14.326	0.199	multipole	+0.000	0.5000	7.95	0.20	yes	1	--	rectn					ellps	-75	+75	-75	+75
56.	s4-mon4	Drift	14.525	0.150	standard							--	rectn					ellps	-75	+75	-75	+75
57.	mon4-ed2	Drift	14.675	0.701	standard							--	rectn					rectn				
58.	ElecDip 2	ElecDip	15.376	1.527	+35.0 *	0.0kV	0.5000*	2.50*	1.53*	–		--	rectn					rectn	-50	+50		
59.	ed2-mon5	Drift	16.903	0.425	standard							--	rectn					rectn				
60.	mon5-sm4	Drift	17.328	0.316	standard							--	rectn					ellps	-74	+74	-74	+74
61.	SM4	Drift	17.644	0.259	standard							--	rectn					ellps	-74	+74	-74	+74
62.	sm4-q9	Drift	17.903	0.120	standard							--	rectn					ellps	-74	+74	-74	+74
63.	Q9	Drift	18.023	0.467	multipole	-0.956	0.5000	7.51	0.47	yes	1	--	rectn					ellps	-75	+75	-75	+75
64.	q9-q10	Drift	18.490	0.199	standard							--	rectn					ellps	-75	+75	-75	+75
65.	Q10	Drift	18.689	0.467	multipole	+1.066	0.5000	7.51	0.47	yes	1	--	rectn					ellps	-75	+75	-75	+75
66.	q10-final	Drift	19.156	1.177	standard							--	rectn					ellps	-75	+75	-75	+75
67.	Fin XT	Fit	20.332	0.000								--	rectn					ellps				
68.	Fin XD	Fit	20.332	0.000								--	rectn					ellps				
69.	Fin YP	Fit	20.332	0.000								--	rectn					ellps				
70.	Fit XX	Fit	20.332	0.000								--	rectn					ellps				
71.	Fin TD	Fit	20.332	0.000								--	rectn					ellps				
72.	Final Slits	Drift	20.332	0.000	SLITS							--	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.

DRAGON files location @ LISE^{++} site

lise.nscl.msu.edu/9_10/DRAGON/

Index of /9_10/DRAGON

Name	Last modified	Size	Description
Parent Directory		-	
Acceptances/	2015-07-22 14:33	-	
ChargeStates/	2015-07-22 14:33	-	
DRAGON.pdf	2015-07-22 14:21	11M	
Fit/	2015-07-22 14:33	-	
LISE_package/	2015-07-22 14:33	-	

http://lise.nscl.msu.edu/9_10/DRAGON/

- [9_10]
  - [DRAGON]
    - DRAGON → *This document*
    - [Acceptances]
      - AngAcc_fromChargeS_MassS lpp → *Angular Acceptance analysis from the Charge Slits*
      - AngAcc_fromMassS_FinalS lpp → *Angular Acceptance analysis from the Mass Slits*
      - AngAcc_fromTarget lpp → *Angular Acceptance analysis from the Target position*
      - MomentumAcc lpp → *Momentum Acceptance analysis*
    - [ChargeStates]
      - e_DRAGON2000_39Ca_beam_charge.. lpp → *Beam charge states after thin target*
    - [Fit]
      - e_DRAGON_fit_part1 lpp → *DRAGON optics optimization : 1st sector*
      - e_DRAGON_fit_part2 lpp → *DRAGON optics optimization : 2nd sector*
      - e_DRAGON_fit_part3 lpp → *DRAGON optics optimization : 3rd sector*
      - e_DRAGON_fit_part4 lpp → *DRAGON optics optimization : 4th sector*
      - e_DRAGON_fit_part1-4 lpp → *DRAGON optics optimization : ALL sector*
    - [LISE_package] → *DRAGON files in the LISE^{++} installation package*
      - [config]
        - e_DRAGON2000 lcn → *DRAGON extended configuration*
        - s_DRAGON2000 lcn → *DRAGON segmented configuration*
      - [files]
        - e_DRAGON2000_reaction lpp → *DRAGON extended* : $^{15}O(\alpha, \gamma)^{19}Ne$
        - e_DRAGON2000_39Ca_beam lpp → *DRAGON extended* : primary beam $^{39}Ca^{5+}$
        - e_DRAGON2000a_39Ca_beam lpp → *DRAGON extended alternative configuration*
        - s_DRAGON2000_reaction lpp → *DRAGON segmented* : $^{15}O(\alpha, \gamma)^{19}Ne$

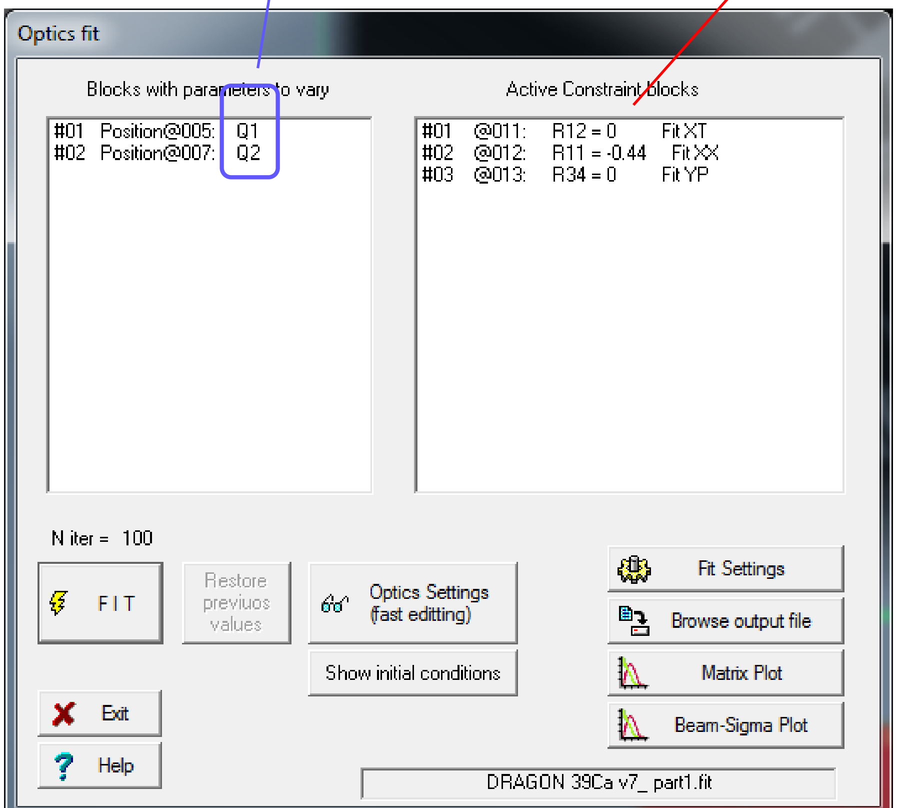
DRAGON optimization in LISE^{++} : 1st step

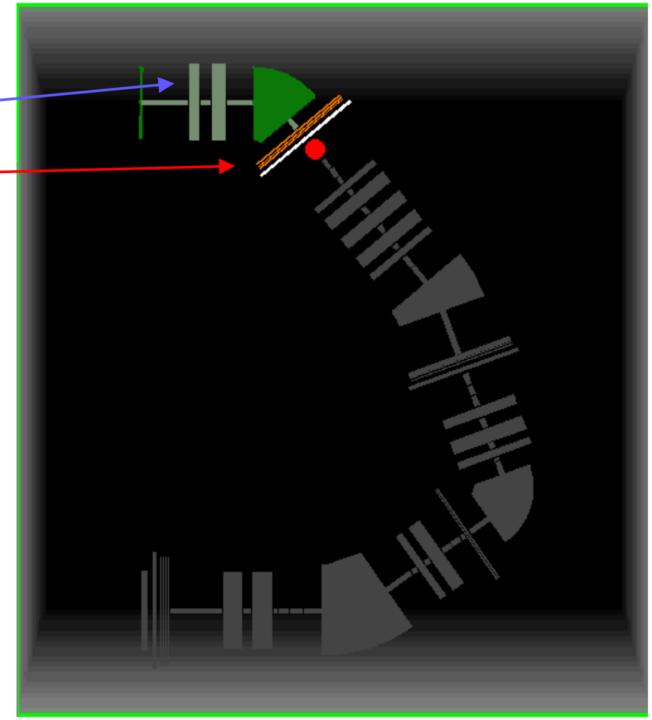
Settings

e_DRAGON_fit_part1 lpp

Quads 1 & 2

Fitting constraints





DRAGON optimization in LISE^{++} : 1st step

Results

THE DRAGON Recoil Separator Optics by The Recoil Group from January 3, 2001

Table 2.6: GIOS First-order transfer matrix elements at the four horizontal image points (file reso2000.dat 28 Sept 00): x is horizontal position (m); a is horizontal angle (rad); y is vertical position (m); b is vertical angle (rad); d is fractional energy difference; g is fractional mass difference; t is fractional difference in time-of-flight.

	Charge	Mass	Charge'	Final
(x|x)	-0.440	0.689	-0.580	0.980
(x|a)	0.000	0.000	0.000	0.000
(x|g)	0.302	-0.472	-0.472	-1.828
(x|d)	0.302	0.000	0.684	0.000
(a|x)	-1.648	1.147	-2.122	0.052
(a|a)	-2.273	1.451	-1.725	1.020
(a|g)	0.401	-0.321	1.589	1.303
(a|d)	0.401	0.015	0.669	-0.022
(t|x)	0.172	0.002	0.161	-0.002
(t|a)	0.368	0.000	0.179	0.000
(t|g)	0.515	0.504	0.462	0.515
(t|d)	-0.485	-0.492	-0.482	-0.477
(y|y)	-3.554	0.980	3.487	-1.767
(y|b)	0.018	-0.430	0.227	0.000
(b|y)	-1.563	2.307	-3.336	1.657
(b|b)	-0.273	0.008	0.070	-0.566

LISE^{++}

Global matrix — CHARGE slits

-0.44468	0	0	0	0	0.60425	[cm]
-16.27856	-2.24881	0	0	0	8.02329	[mrad]
0	0	-3.63955	-0.00001	0	0	[cm]
0	0	-17.27569	-0.27482	0	0	[mrad]
-0.62685	-0.13588	0	0	1	-0.10662	[cm]
0	0	0	0	0	1	[%]
/[cm]	/[mrad]	/[cm]	/[mrad]	/[cm]	/[%]	

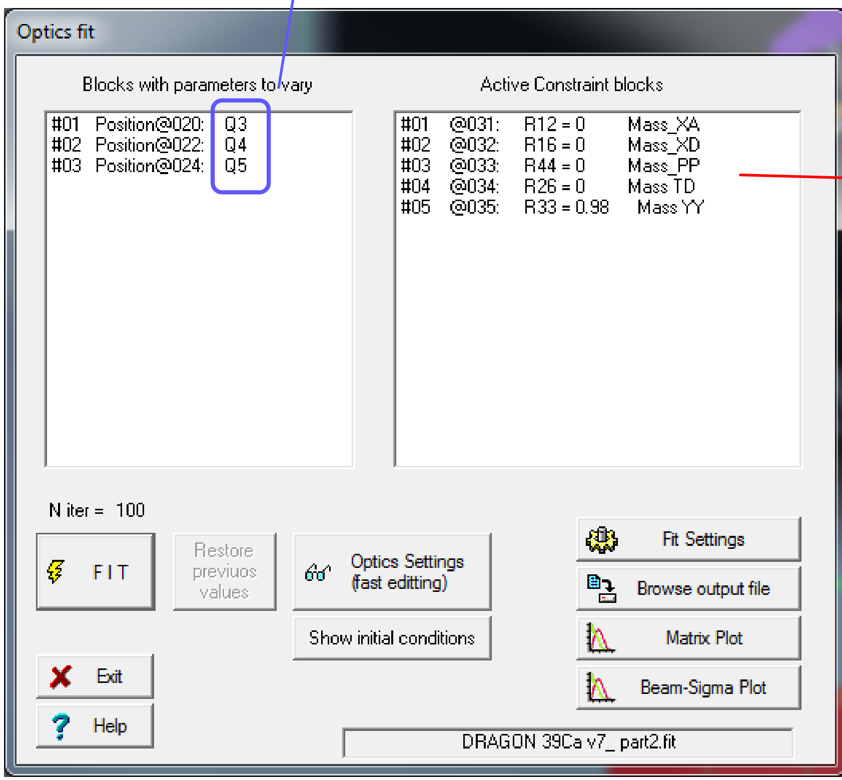
Factor 2. it's correct

DRAGON optimization in LISE++ : 2nd step

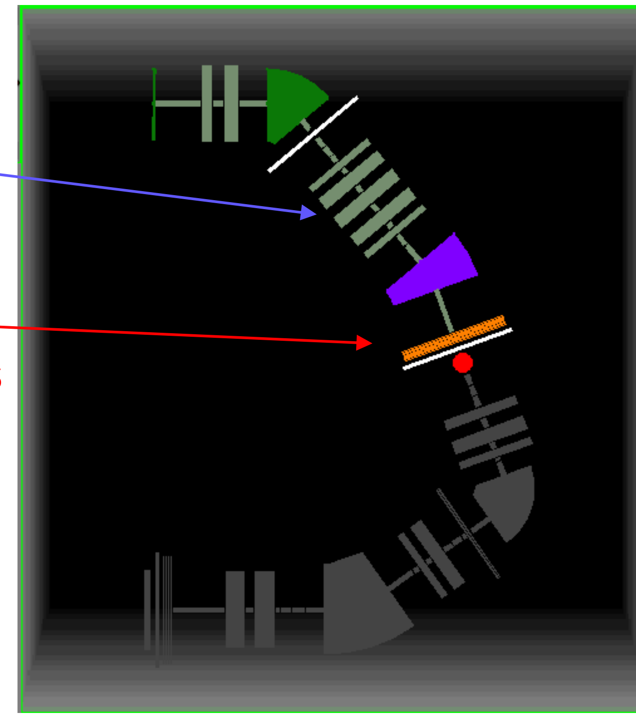
Settings

e_DRAGON_fit_ part2 lpp

Quads 3,4,5



Fitting constraints



DRAGON optimization in LISE^{++} : 2nd step

Results

THE DRAGON Recoil Separator Optics by The Recoil Group from January 3, 2001

Table 2.6: GIOS First-order transfer matrix elements at the four horizontal image points (file reso2000.dat 28 Sept 00): x is horizontal position (m); a is horizontal angle (rad); y is vertical position (m); b is vertical angle (rad); d is fractional energy difference; g is fractional mass difference; t is fractional difference in time-of-flight.

	Charge	Mass	Charge′	Final
(x|x)	-0.440	0.689	-0.580	0.980
(x|a)	0.000	0.000	0.000	0.000
(x|g)	0.302	-0.472	-0.472	-1.828
(x|d)	0.302	0.000	0.684	0.000
(a|x)	-1.648	1.147	-2.122	0.052
(a|a)	-2.273	1.451	-1.725	1.020
(a|g)	0.401	-0.321	1.589	1.303
(a|d)	0.401	0.015	0.669	-0.022
(t|x)	0.172	0.002	0.161	-0.002
(t|a)	0.368	0.000	0.179	0.000
(t|g)	0.515	0.504	0.462	0.515
(t|d)	-0.485	-0.492	-0.482	-0.477
(y|y)	-3.554	0.980	3.487	-1.767
(y|b)	0.018	-0.430	0.227	0.000
(b|y)	-1.563	2.307	-3.336	1.657
(b|b)	-0.273	0.008	0.070	-0.566

LISE^{++}

Global matrix — MASS Slits

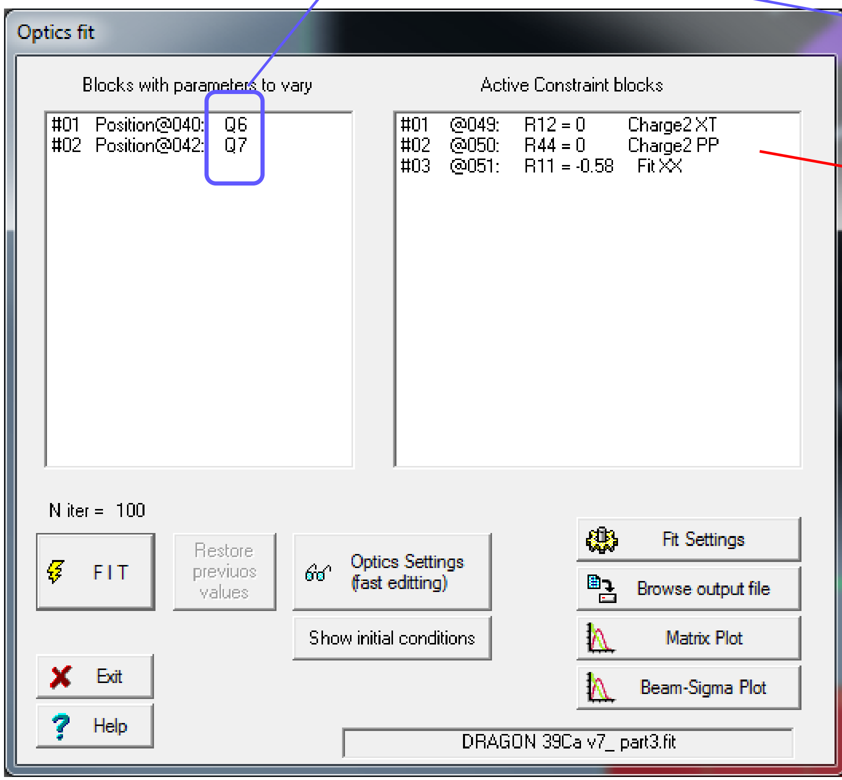
0.69257	0	0	0	0	0	[cm]
11.33552	1.44388	0	0	0	0.33979	[mrad]
0	0	0.97923	-0.04018	0	0	[cm]
0	0	24.28975	0.02465	0	0	[mrad]
-0.02353	0	0	0	1	-0.13051	[cm]
0	0	0	0	0	1	[%]
/[cm]	/[mrad]	/[cm]	/[mrad]	/[cm]	/[%]	

DRAGON optimization in LISE++ : 3rd step

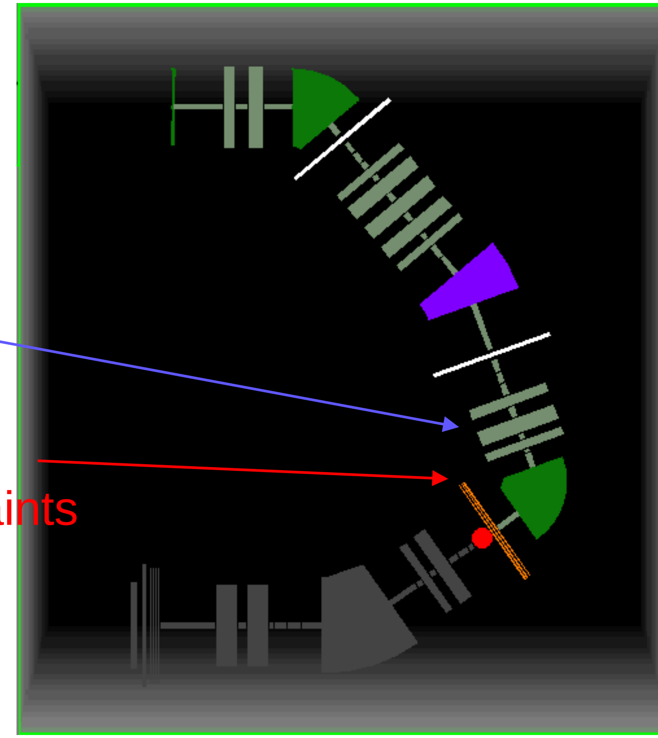
Settings

e_DRAGON_fit_part3 lpp

Quads 6,7



Fitting constraints



Results

THE DRAGON Recoil Separator Optics by The Recoil Group from January 3, 2001

Table 2.6: GIOS First-order transfer matrix elements at the four horizontal image points (file reso2000.dat 28 Sept 00): x is horizontal position (m); a is horizontal angle (rad); y is vertical position (m); b is vertical angle (rad); d is fractional energy difference; g is fractional mass difference; t is fractional difference in time-of-flight.

	Charge	Mass	Charge′	Final
(x|x)	-0.440	0.689	-0.580	0.980
(x|a)	0.000	0.000	0.000	0.000
(x|g)	0.302	-0.472	-0.472	-1.828
(x|d)	0.302	0.000	0.684	0.000
(a|x)	-1.648	1.147	-2.122	0.052
(a|a)	-2.273	1.451	-1.725	1.020
(a|g)	0.401	-0.321	1.589	1.303
(a|d)	0.401	0.015	0.669	-0.022
(t|x)	0.172	0.002	0.161	-0.002
(t|a)	0.368	0.000	0.179	0.000
(t|g)	0.515	0.504	0.462	0.515
(t|d)	-0.485	-0.492	-0.482	-0.477
(y|y)	-3.554	0.980	3.487	-1.767
(y|b)	0.018	-0.430	0.227	0.000
(b|y)	-1.563	2.307	-3.336	1.657
(b|b)	-0.273	0.008	0.070	-0.566

LISE++

Global matrix — md2-mon3

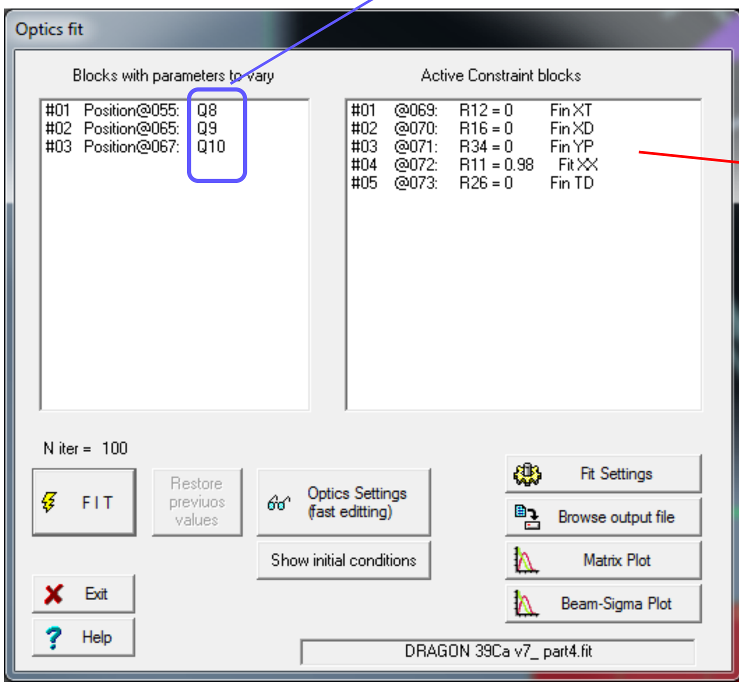
-0.5614	0.0000	0	0	0	1.37453	[c
-21.90339	-1.78101	0	0	0	13.34855	[m
0	0	3.32725	0.03882	0	0	[c
0	0	-24.99532	0.0089	0	0	[m
-2.26132	-0.24481	0	0	1	-0.46704	[c
0	0	0	0	0	1	[%
/[cm]	/[mrad]	/[cm]	/[mrad]	/[cm]	/[%]	

Factor 2. it's correct

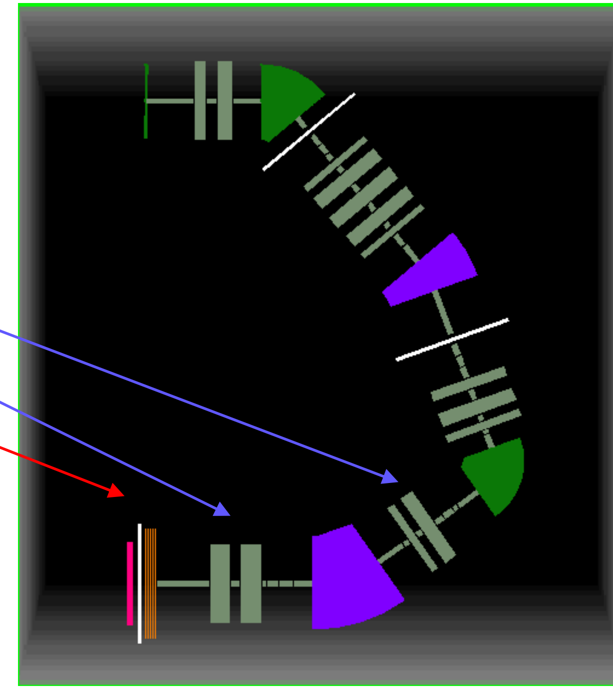
Settings

e_DRAGON_fit_part4 lpp

Quads 8,9,10



Fitting constraints



DRAGON optimization in LISE^{++} : 4th step

Results

THE DRAGON Recoil Separator Optics by The Recoil Group from January 3, 2001

Table 2.6: GIOS First-order transfer matrix elements at the four horizontal image points (file reso2000.dat 28 Sept 00): x is horizontal position (m); a is horizontal angle (rad); y is vertical position (m); b is vertical angle (rad); d is fractional energy difference; g is fractional mass difference; t is fractional difference in time-of-flight.

	Charge	Mass	Charge	Final
(x|x)	-0.440	0.689	-0.580	0.980
(x|a)	0.000	0.000	0.000	0.000
(x|g)	0.302	-0.472	-0.472	-1.828
(x|d)	0.302	0.000	0.684	0.000
(a|x)	-1.648	1.147	-2.122	0.052
(a|a)	-2.273	1.451	-1.725	1.020
(a|g)	0.401	-0.321	1.589	1.303
(a|d)	0.401	0.015	0.669	-0.022
(t|x)	0.172	0.002	0.161	-0.002
(t|a)	0.368	0.000	0.179	0.000
(t|g)	0.515	0.504	0.462	0.515
(t|d)	-0.485	-0.492	-0.482	-0.477
(y|y)	-3.554	0.980	3.487	-1.767
(y|b)	0.018	-0.430	0.227	0.000
(b|y)	-1.563	2.307	-3.336	1.657
(b|b)	-0.273	0.008	0.070	-0.566

LISE^{++}

Global matrix — Final Slits

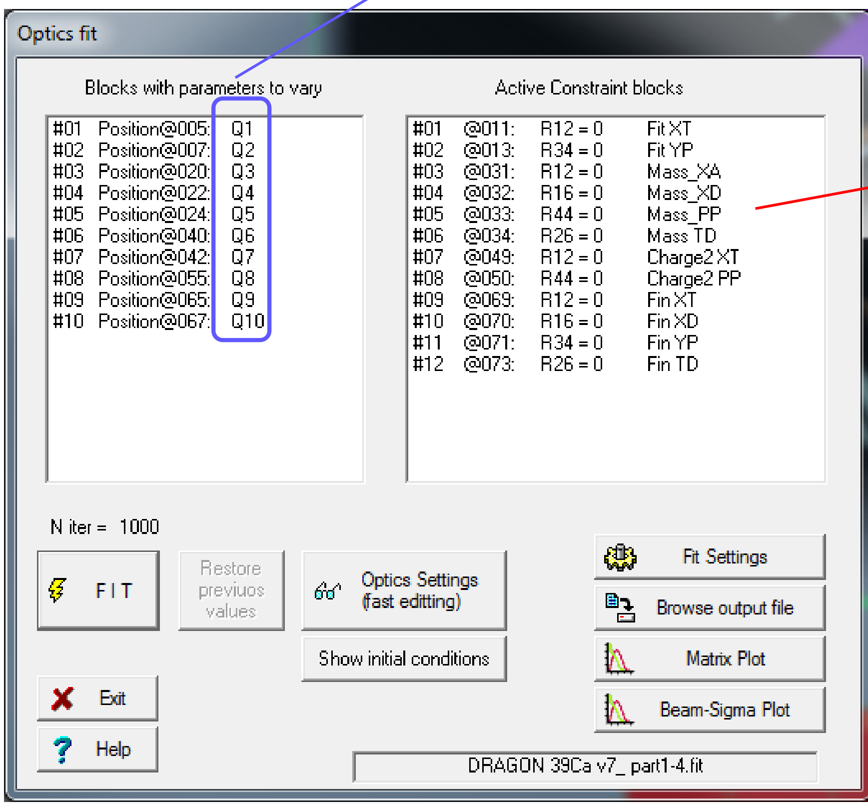
0.9359	0	0	0	0	0
2.16241	1.06841	0	0	0	-0.56728
0	0	-1.49957	0	0	0
0	0	-0.36975	-0.66686	0	0
0.05309	0	0	0	1	-0.96196
0	0	0	0	0	1
/[cm]	/[mrad]	/[cm]	/[mrad]	/[cm]	/[%]

DRAGON optimization in LISE++ : final step

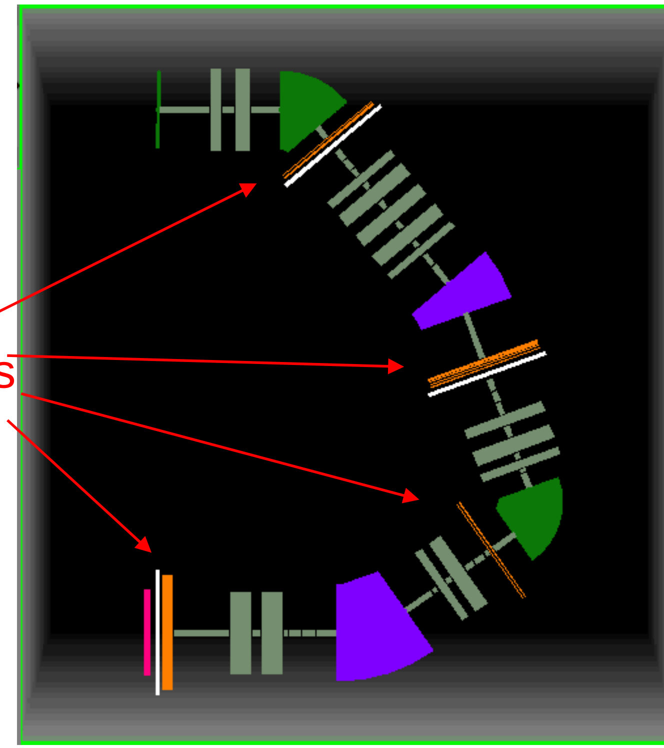
Settings

e_DRAGON_fit_ part 1-4 lpp

Quads 1-10



Fitting constraints



DRAGON optimization in LISE++ : final step

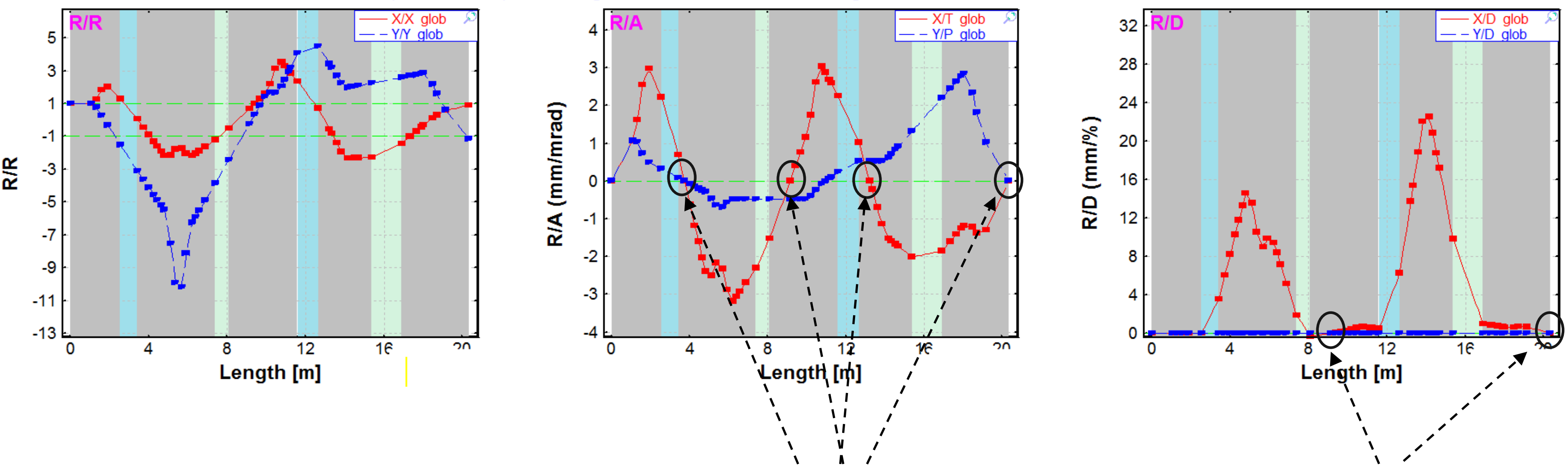
Results

Fitting values:	Initial	Final	Precision	|Init-Des)/P|	Desired
#01: Fit XT	-1.106e-05		1.0e-03	+1.106e-02 |	= 0
#02: Fit YP	+6.658e-04		1.0e-01	+6.658e-03 |	= 0
#03: Mass_XA	-8.393e-06		1.0e-03	+8.393e-03 |	= 0
#04: Mass_XD	+1.295e-04		1.0e-03	+1.295e-01 |	= 0
#05: Mass_PP	+3.036e-04		1.0e-01	+3.036e-03 |	= 0
#06: Mass TD	+3.174e-01		1.0e+00	+3.174e-01 |	= 0
#07: Charge2 XT	+2.370e-05		1.0e-03	+2.370e-02 |	= 0
#08: Charge2 PP	-1.065e-03		1.0e-01	+1.065e-02 |	= 0
#09: Fin XT	-2.912e-05		1.0e-03	+2.912e-02 |	= 0
#10: Fin XD	+1.384e-04		1.0e-03	+1.384e-01 |	= 0
#11: Fin YP	-1.670e-05		1.0e-03	+1.670e-02 |	= 0
#12: Fin TD	-5.771e-01		1.0e+00	+5.771e-01 |	= 0

All constraints are good!

First order matrix elements

^{39}Ca (1.3 MeV/u); Settings on $^{39}Ca^{13+..13+}$; Config: DSSSSDSFFFSSSSSSSSSSSSSS...



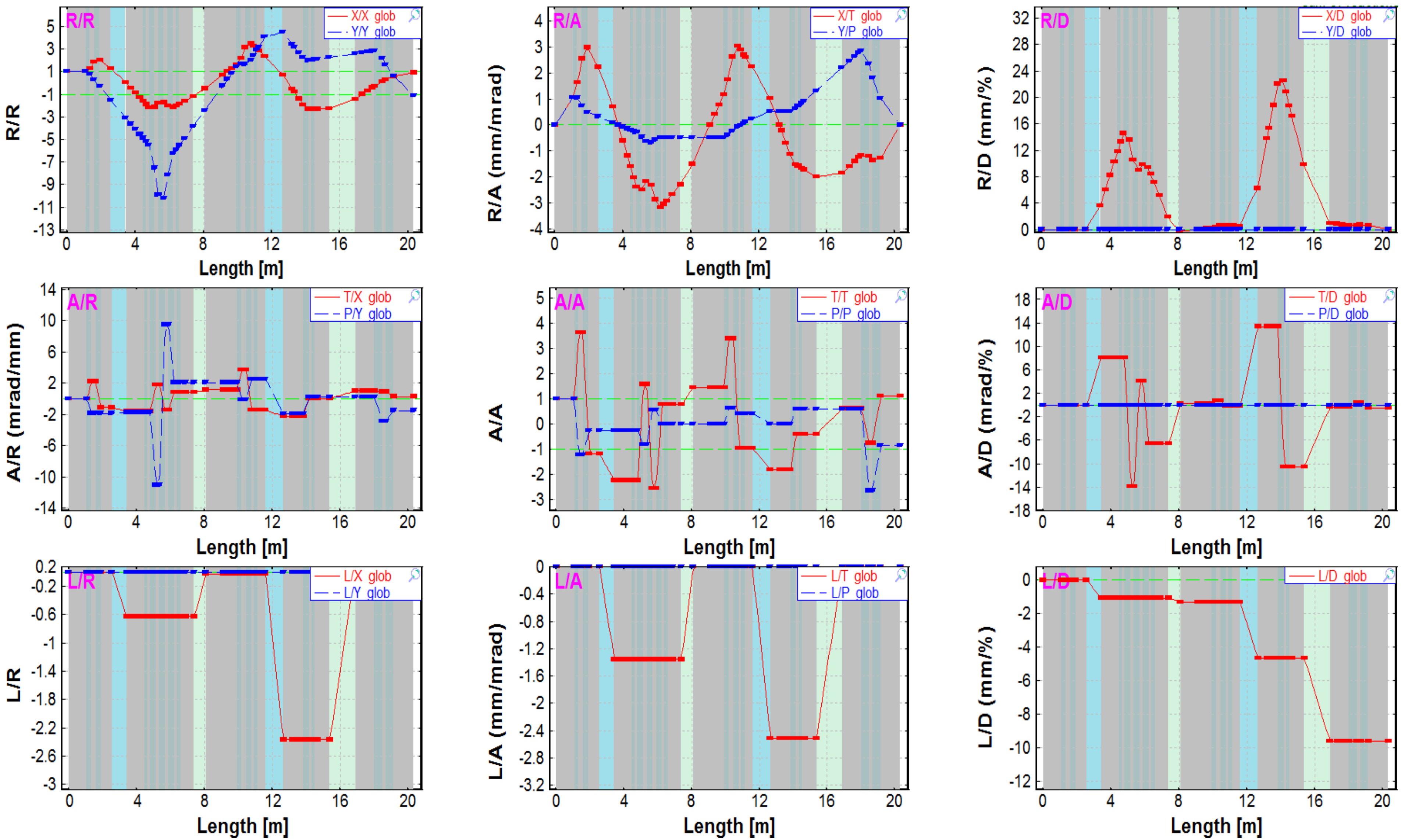
Four X-images

"Mass" selection

Results

First order matrix elements

^{39}Ca (1.3 MeV/u); Settings on $^{39}Ca^{13+..13+}$; Config: DSSSSSDSFFFSSSSSSSSSSSSSS...



DRAGON E-M devices settings

e_DRAGON2000_39Ca_beam lpp

e_DRAGON2000 lcn

THE DRAGON Recoil Separator Optics by The Recoil Group from January 3, 2001

Table 2.5: Field strengths for rigidities 0.5 T·m and 8 MV scaled from the GIOS input file reso2000.dat Tunes must be obtained by scaling to the rigidities of a given reaction.Note that the sextupole strengths have been scaled to the new L_{eff} values listed in table 1.2.

Element	Gap or Diam.	Effective length	Field
Q1	10.8 cm	25.23 cm	-2.187 kG
Q2	15.9 cm	33.385 cm	+2.003 kG
S0	15.9 cm	33.385 cm	+0.106 kG
MD1	10 cm		+4.991 kG
S1	15.9 cm	18.75 cm	+0.425 kG
Q3	15.9 cm	33.38 cm	+1.826 kG
Q4	15.9 cm	33.38 cm	-2.412 kG
Q5	15.9 cm	33.38 cm	+1.329 kG
S2	15.9 cm	18.75 cm	+0.089 kG
ED1	10 cm		±200. kV
Q6	10.8 cm	25.23 cm	-1.181 kG
Q7	15.9 cm	33.38 cm	+1.696 kG
S3	16 cm	19.9 cm	+0.047 kG
MD2	12 cm		6.139 kG
Q8	15.9 cm	33.38 cm	+1.257 kG
S4	16 cm	19.9 cm	+0.360 kG
ED2	10 cm		±160. kV
Q9	15 cm	46.7 cm	-0.972 kG
Q10	15 cm	46.7 cm	+1.087 kG

DRAGON2000 in LISE++

#01: Q1	-2.158	kG	
#02: Q2	1.965	kG	
S0	0.106	kG	not modified
MD1	5.000	kG	
S1	0.425	kG	not modified
#03: Q3	1.775	kG	
#04: Q4	-2.299	kG	
#05: Q5	1.263	kG	
S2	0.089	kG	not modified
ED1	402.4	kV	correspond to 39Ca13+
#06: Q6	-1.459	kG	
#07: Q7	1.752	kG	
S3	0.047	kG	not modified
MD2	6.105	kG	
#08: Q8	1.238	kG	
S4	0.360	kG	not modified
ED2	321.900	kG	correspond to 39Ca13+
#09: Q9	-0.956	kG	
#10: Q10	1.066	kG	

See page 4

e_DRAGON2000a_39Ca_beam lpp

DRAGON2000a — configuration with additional drift blocks around dispersive elements corresponding to lengths in *THE DRAGON Recoil Separator Optics by The Recoil Group from January 3, 2001*

Parameters:		Final
#01:	Q1	-2.127e+00
#02:	Q2	+1.932e+00
#03:	Q3	+1.822e+00
#04:	Q4	-2.568e+00
#05:	Q5	+1.352e+00
#06:	Q6	-1.633e+00
#07:	Q7	+1.745e+00
#08:	Q8	+1.153e+00
#09:	Q9	-8.220e-01
#10:	Q10	+1.017e+00

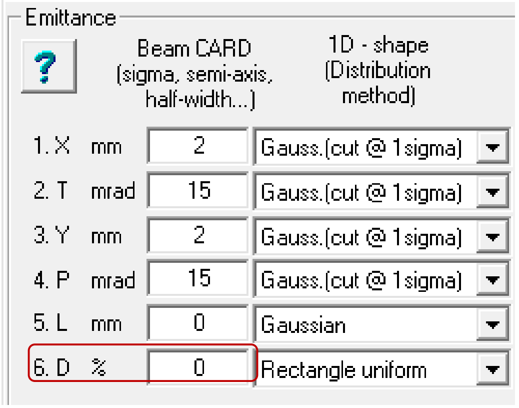
Fitting values:		Final	Precision	(Fin -Des)/P	Desired
#01:	Fit XT	-7.494e-05	1.0e-03	+7.494e-02	= 0
#02:	Fit YP	+7.661e-02	1.0e-01	+7.661e-01	= 0
#03:	Mass_XA	-3.167e-05	1.0e-03	+3.167e-02	= 0
#04:	Mass_XD	-9.100e-05	1.0e-03	+9.100e-02	= 0
#05:	Mass_PP	+8.482e-02	1.0e-01	+8.482e-01	= 0
#06:	Mass TD	+2.044e-01	1.0e+00	+2.044e-01	= 0
#07:	Charge2 XT	-3.320e-04	1.0e-03	+3.320e-01	= 0
#08:	Charge2 PP	-8.067e-02	1.0e-01	+8.067e-01	= 0
#09:	Fin XT	-1.135e-04	1.0e-03	+1.135e-01	= 0
#10:	Fin XD	-1.669e-04	1.0e-03	+1.669e-01	= 0
#11:	Fin YP	-5.317e-05	1.0e-03	+5.317e-02	= 0
#12:	Fin TD	-1.608e+00	1.0e+00	+1.608e+00	= 0

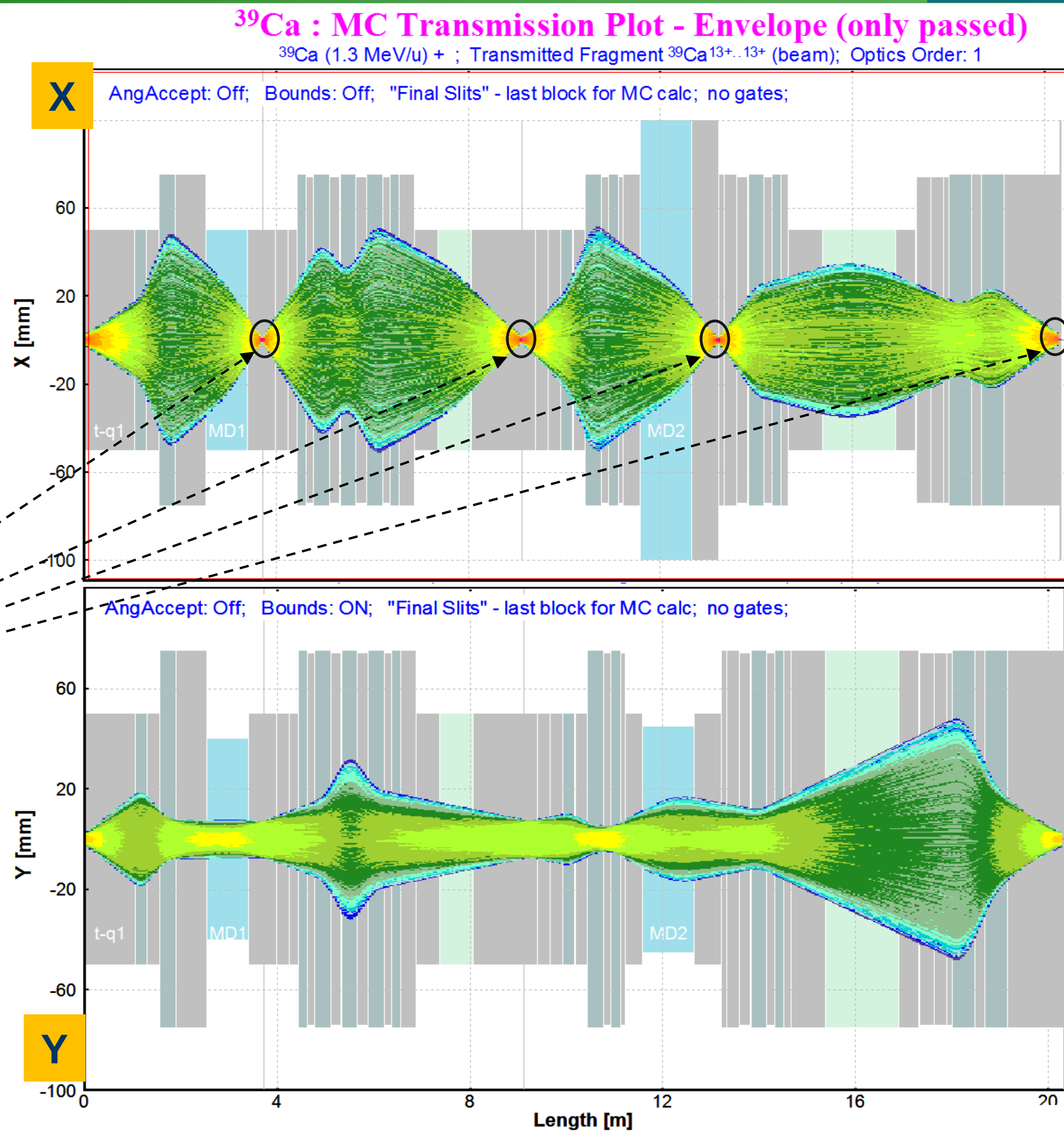
==> "Fin TD" : last fitting block global optical matrix and sigma vector

Format [mm-mrad]

GLOBAL matrix						Beam(sigma)
+7.928e-01	-1.135e-04	0	0	0	-1.669e-04	1.59e+00
+5.936e-01	+1.261e+00	0	0	0	-1.608e+00	1.91e+01
0	0	-2.782e+01	-5.317e-05	0	0	4.17e+01
0	0	+3.035e+00	-3.594e-02	0	0	4.57e+00
+1.274e-01	-4.561e-05	0	0	1.0	-1.181e+01	1.77e+01
0	0	0	0	0	+1.000e+00	1.50e+00

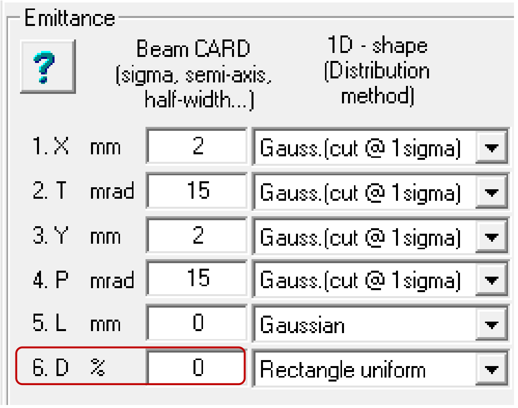
DRAGON2000 X & Y envelopes : dp/p = 0%





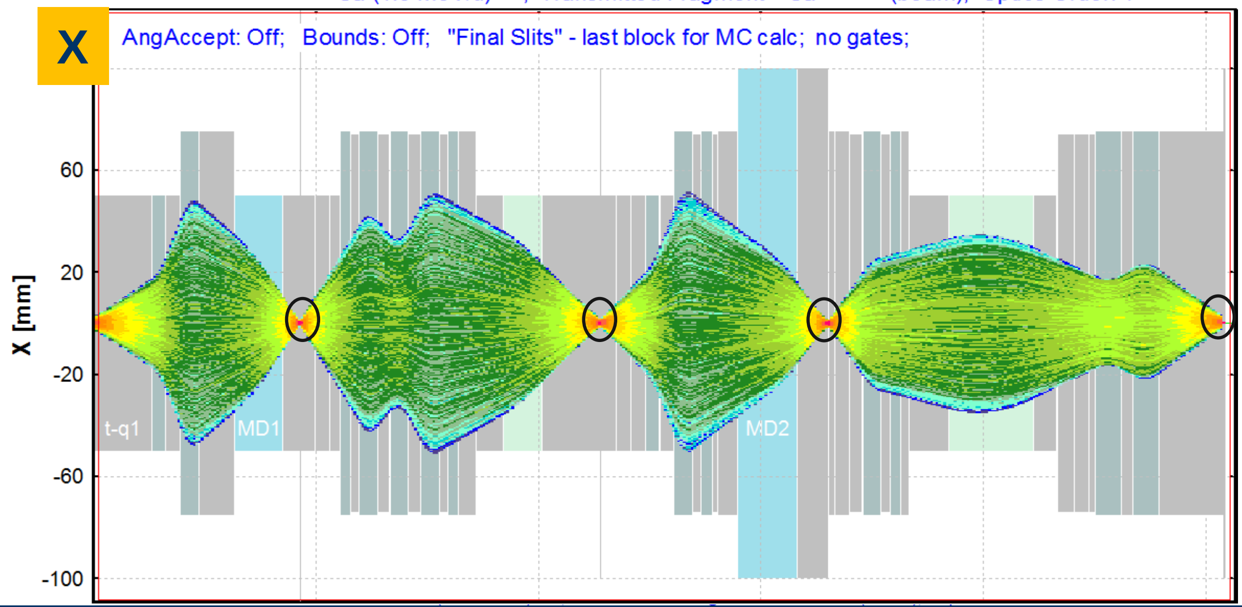
Four images

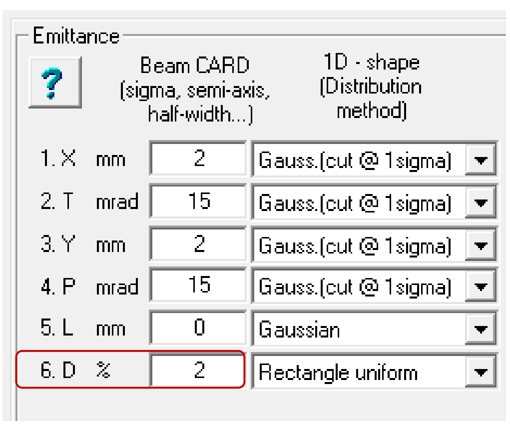
DRAGON2000 X envelopes : dp/p = 0 & 2 %

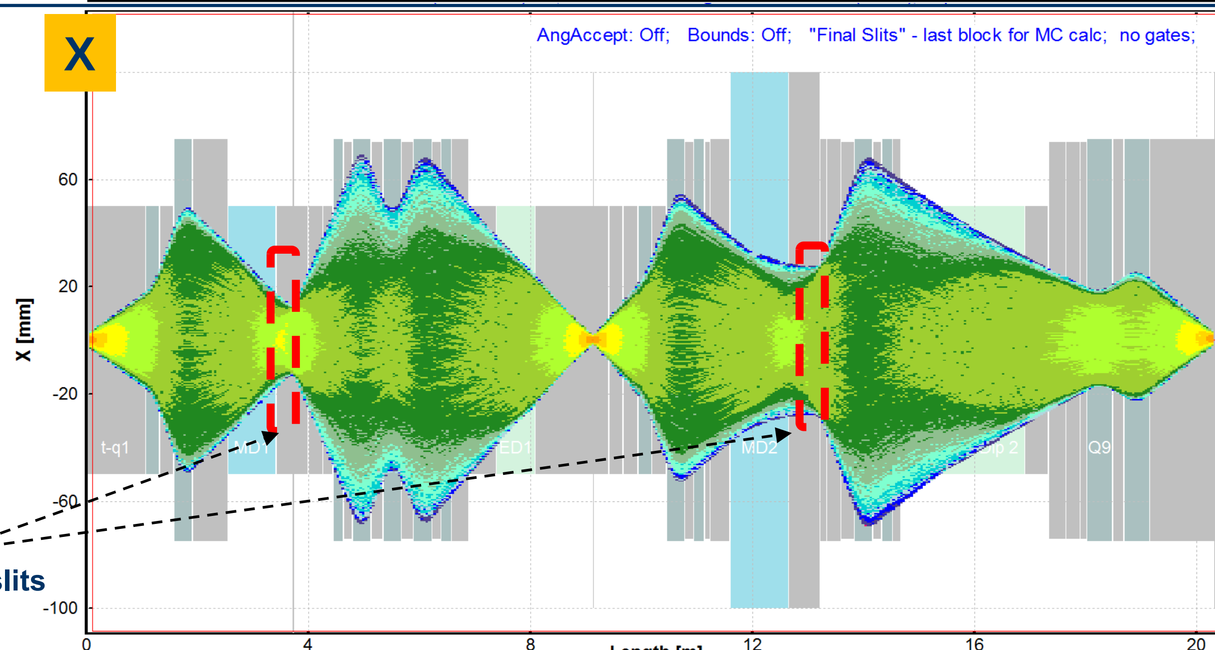


^{39}Ca : MC Transmission Plot - Envelope (only passed)

^{39}Ca (1.3 MeV/u) + ; Transmitted Fragment ^{39}Ca$^{13+..13+}$ (beam); Optics Order: 1

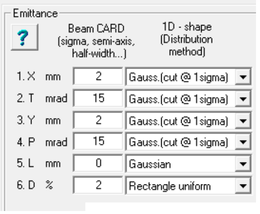




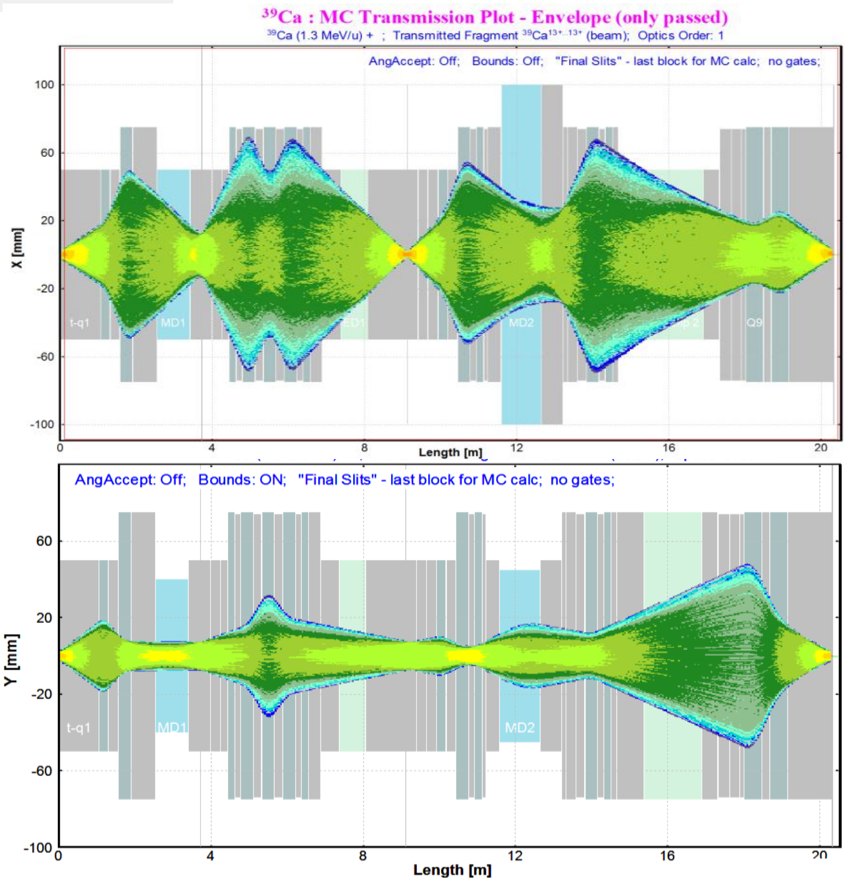


"charge" (momentum) slits

DRAGON2000 envelopes comparison



LISE++



THE DRAGON Recoil Separator Optics by The Recoil Group from January 3, 2001

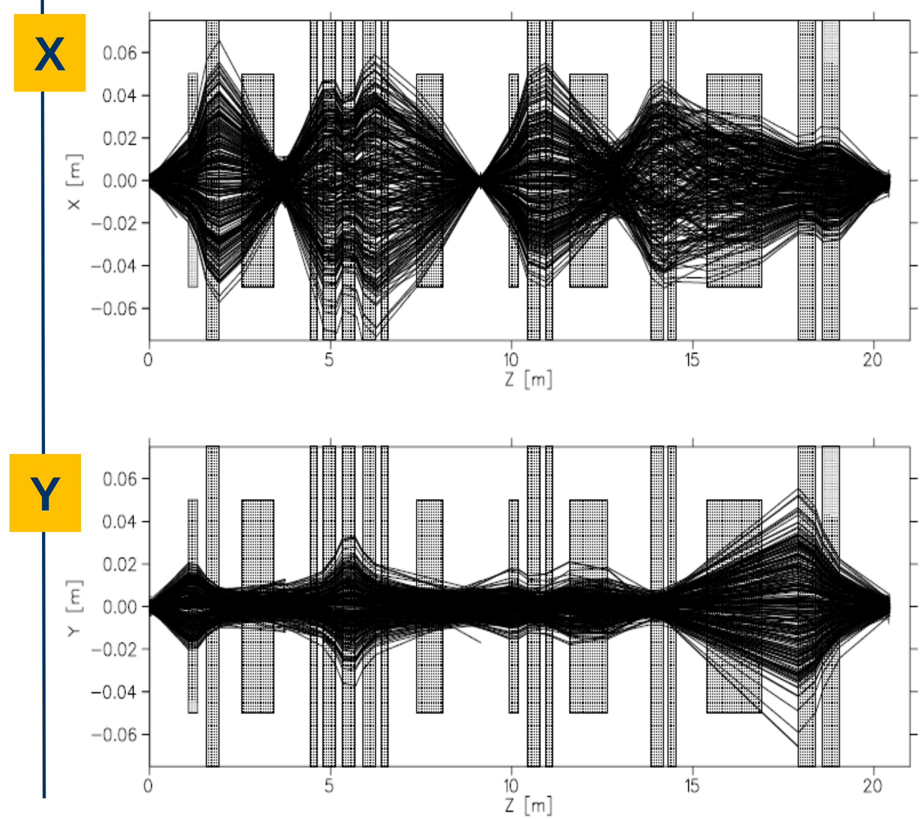


Figure 3.6: X and Y projections of 250 ^{19}Ne trajectories from the full GEANT simu-

initial distributions after target

THE DRAGON Recoil Separator
Optics by The Recoil Group from
January 3, 2001

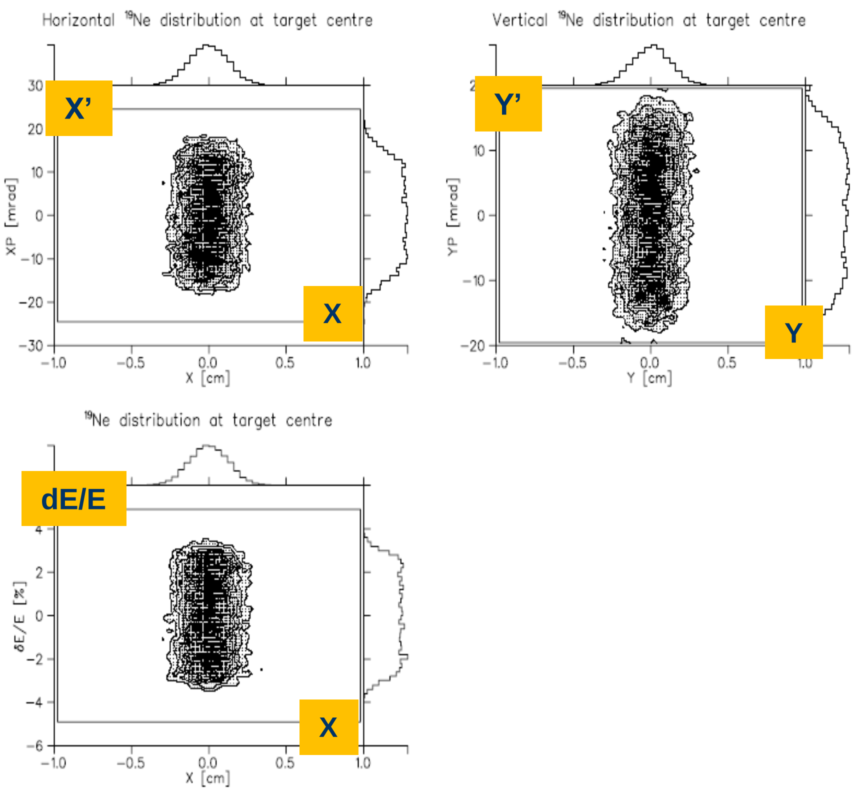
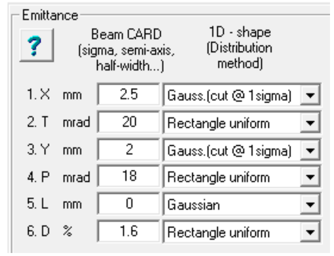
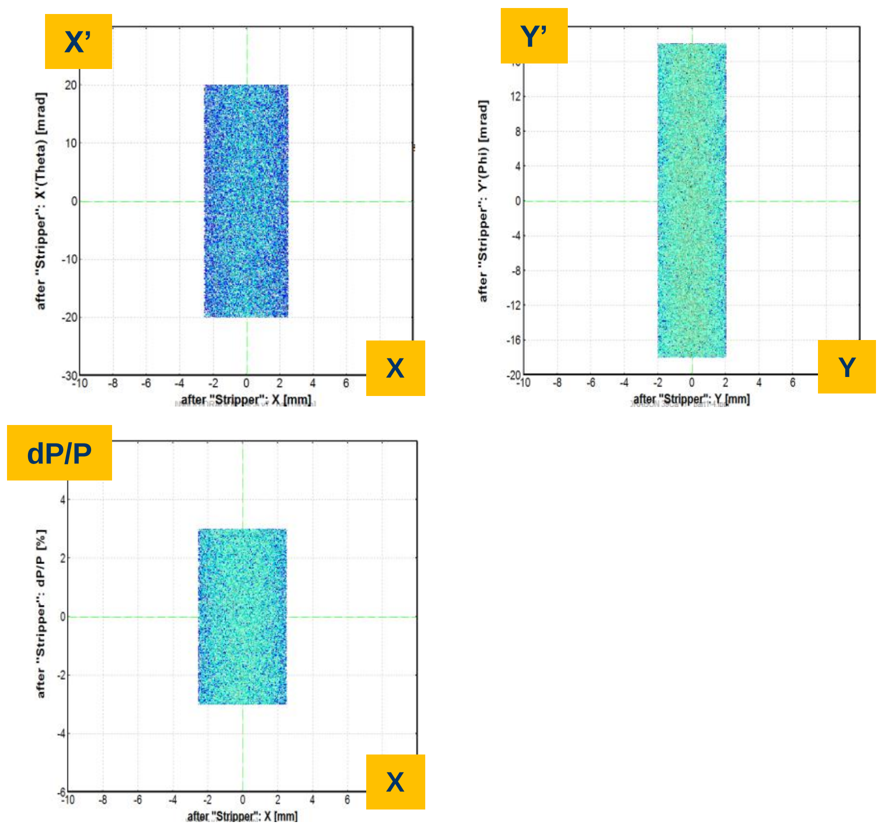


Figure 3.1: X and Y phase space plots and a plot of relative energy versus horizontal position at the gas target centre for 10000 simulated ^{19}Ne ion trajectories.

LISE^{++}





distributions @ Charge slits

THE DRAGON Recoil Separator Optics by The Recoil Group from January 3, 2001

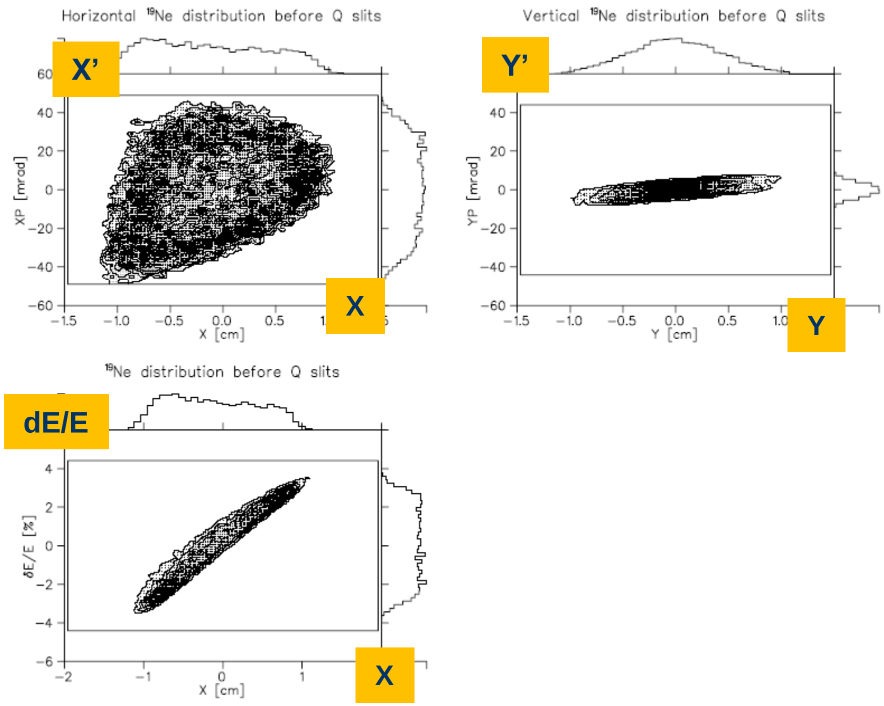
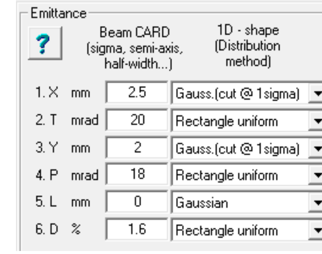
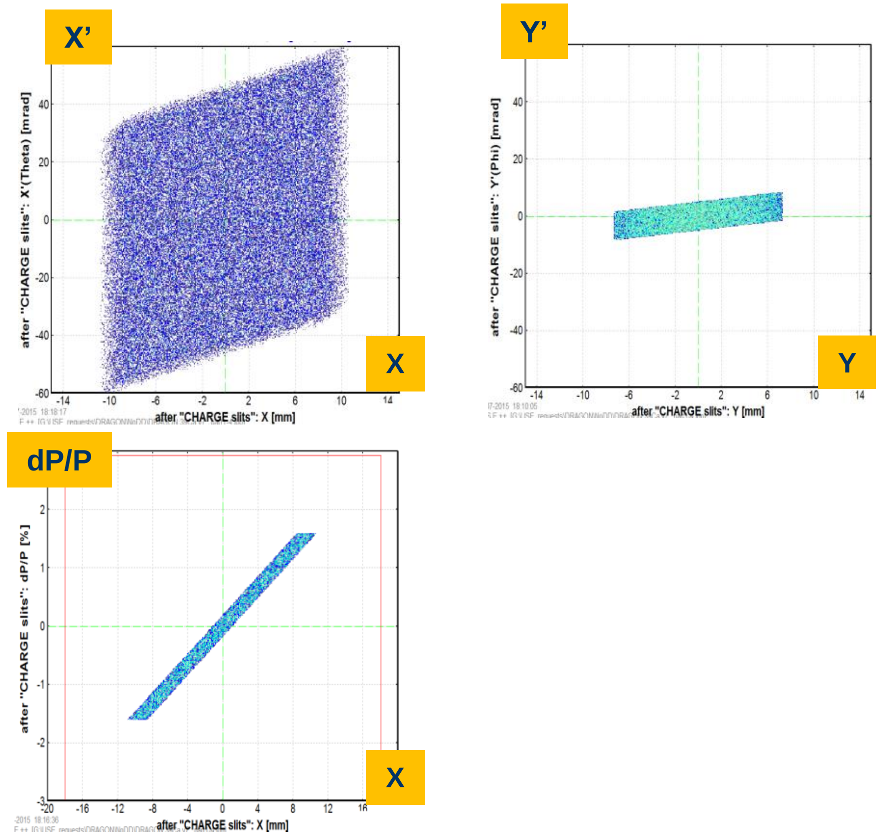


Figure 3.2: X and Y phase space plots and a plot of relative energy versus horizon position at the charge slits for 10000 simulated ^{19}Ne ion trajectories.

LISE++



1st order



distributions @ Charge slits

THE DRAGON Recoil Separator
Optics by The Recoil Group from
January 3, 2001

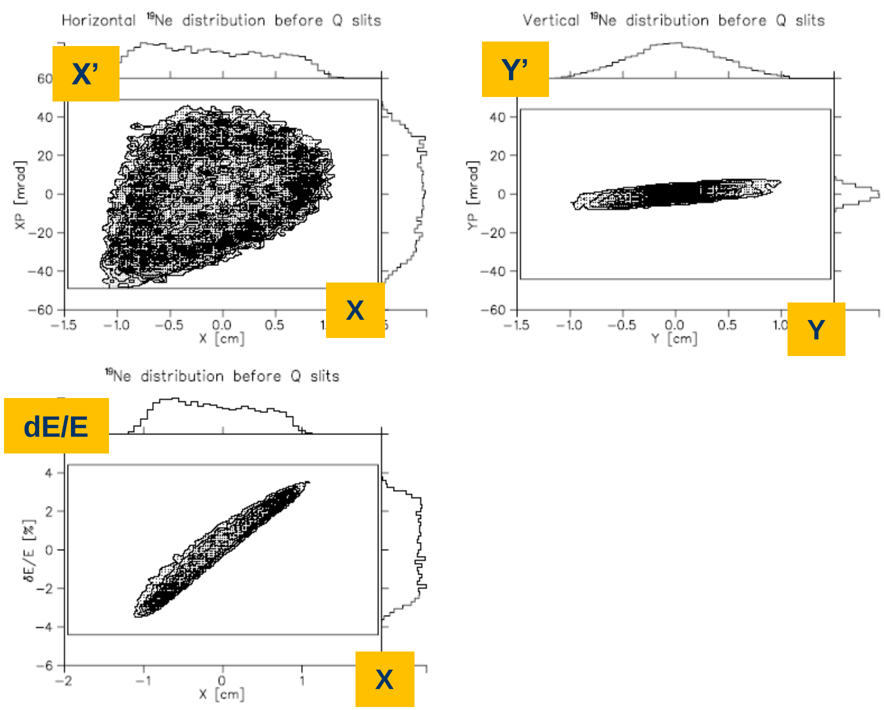
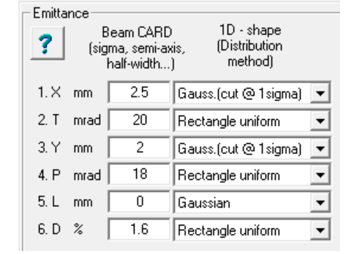
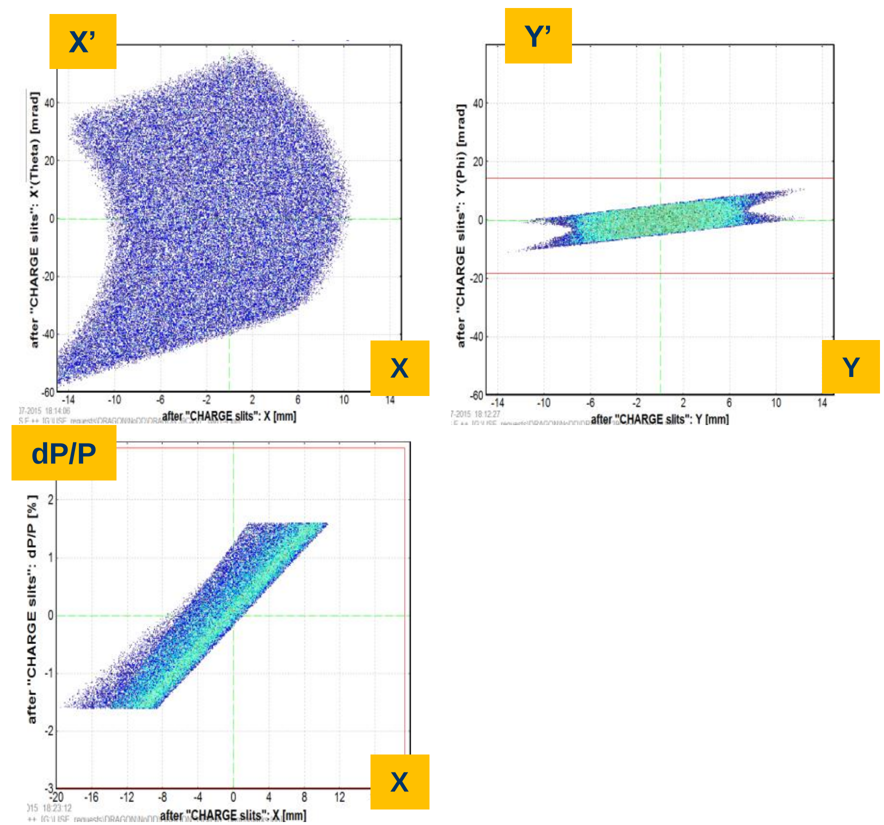


Figure 3.2: X and Y phase space plots and a plot of relative energy versus horizon position at the charge slits for 10000 simulated ^{19}Ne ion trajectories.

LISE^{++}

2nd order





DRAGON2000 calculation comparison : Mass slits

distributions @ Mass slits

THE DRAGON Recoil Separator
Optics by The Recoil Group from
January 3, 2001

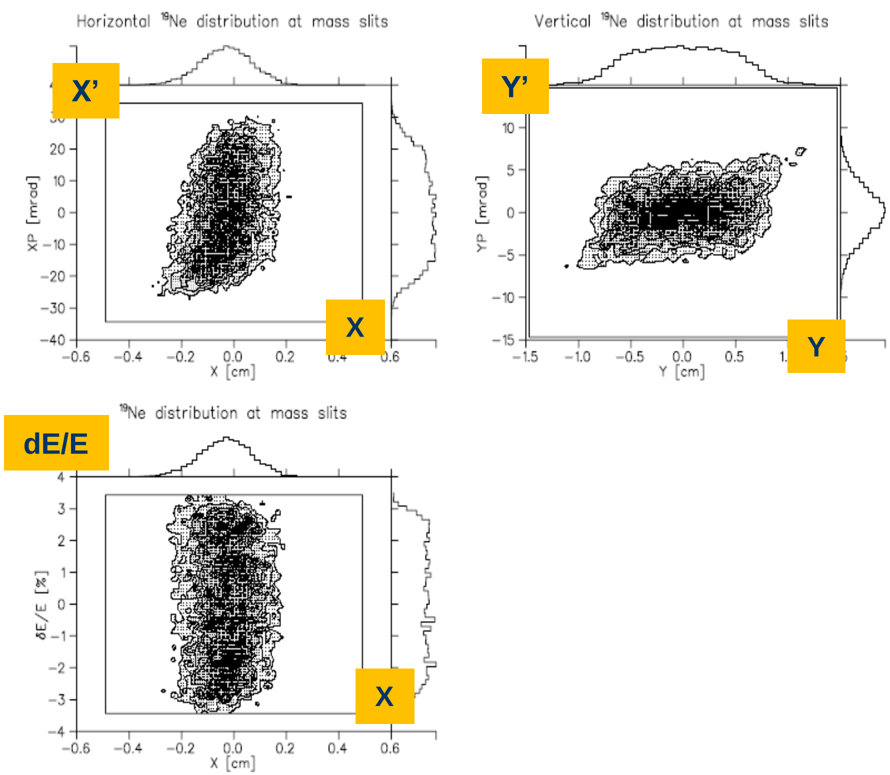
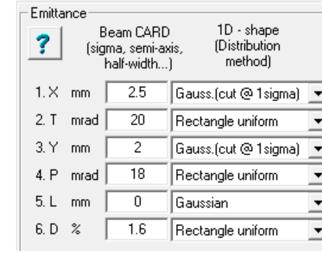
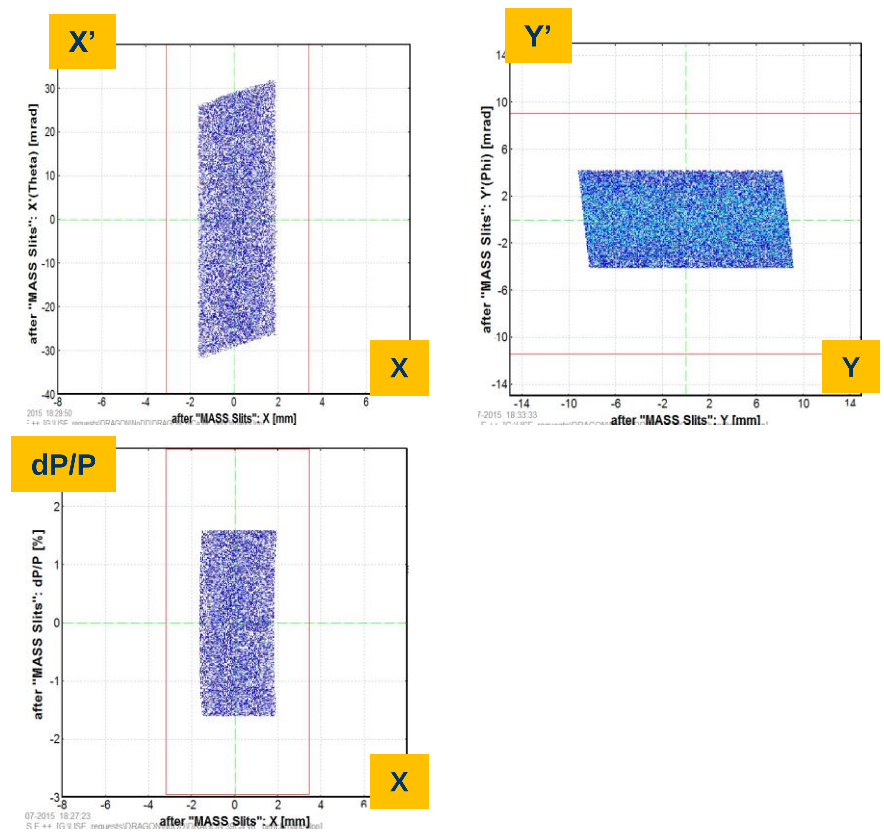


Figure 3.3: X and Y phase space plots and a plot of relative energy versus horizon position at the mass slits for 10000 simulated ^{19}Ne ion trajectories.

LISE++

1st order





distributions @ Mass slits

THE DRAGON Recoil Separator Optics by The Recoil Group from January 3, 2001

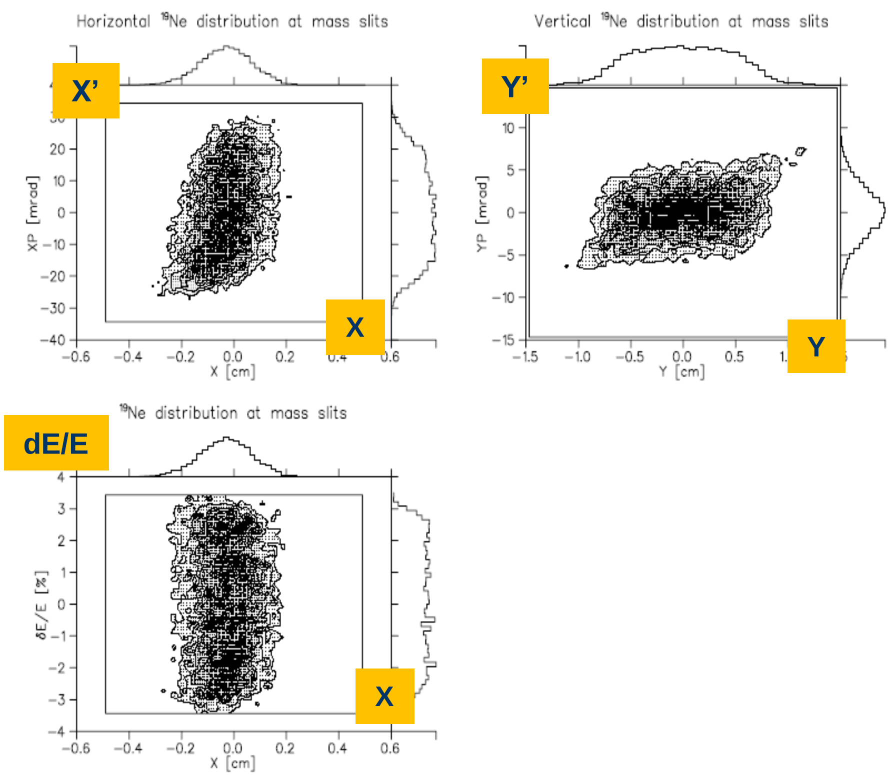
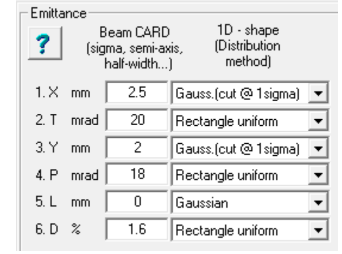
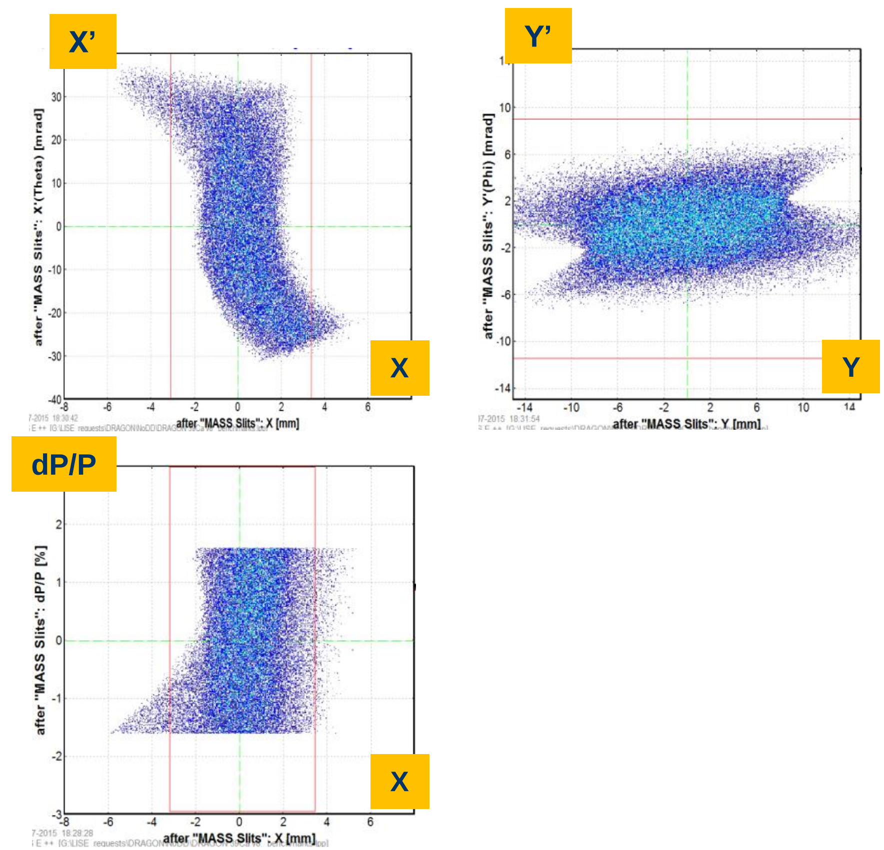


Figure 3.3: X and Y phase space plots and a plot of relative energy versus horizon position at the mass slits for 10000 simulated ^{19}Ne ion trajectories.

LISE++

2nd order





distributions @ Final slits

THE DRAGON Recoil Separator
Optics by The Recoil Group from
January 3, 2001

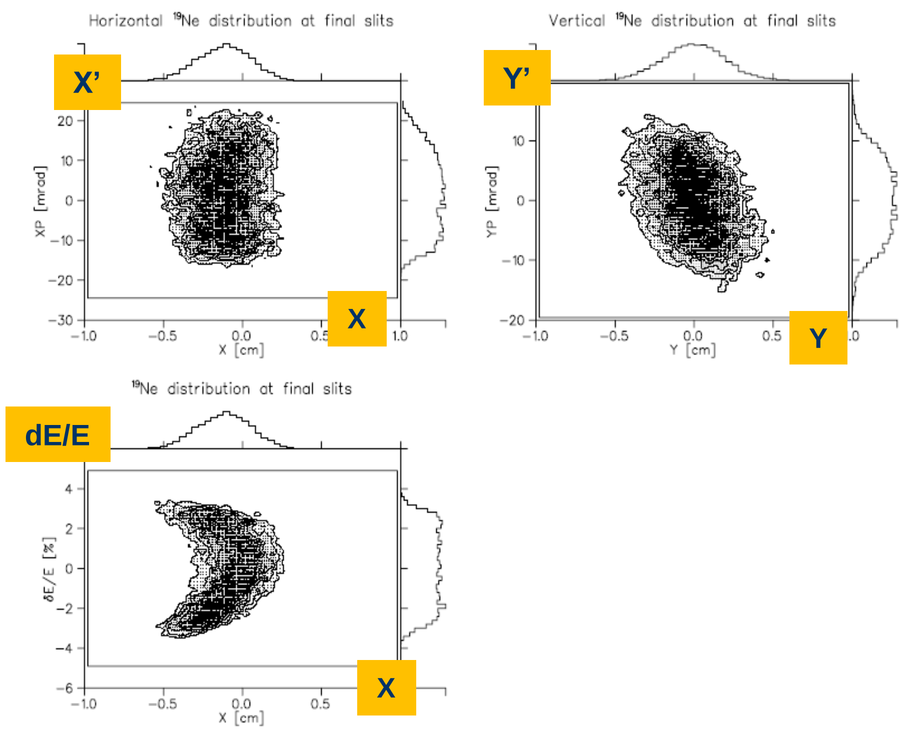


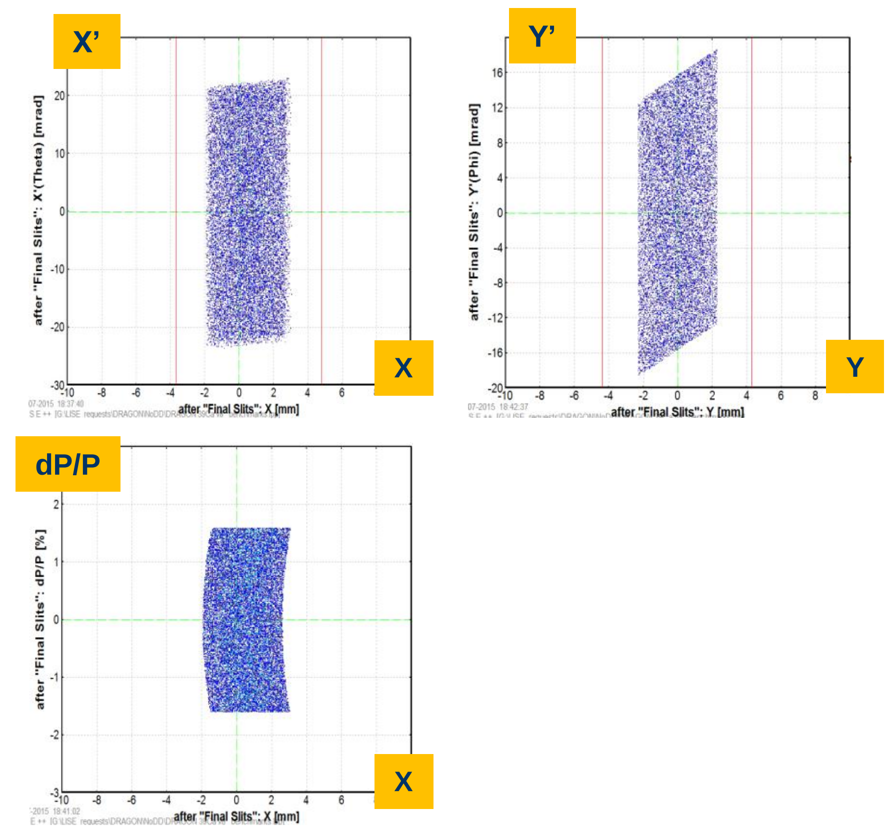
Figure 3.5: X and Y phase space plots and a plot of relative energy versus horizontal position at the final slits for 10000 simulated ^{19}Ne ion trajectories.

LISE++

Emittance

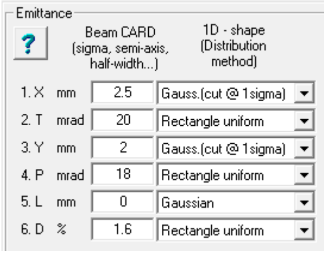
		Beam CARD (sigma, semi-axis, half-width...)	1D - shape (Distribution method)
1. X	mm	2.5	Gauss.(cut @ 1sigma)
2. T	mrad	20	Rectangle uniform
3. Y	mm	2	Gauss.(cut @ 1sigma)
4. P	mrad	18	Rectangle uniform
5. L	mm	0	Gaussian
6. D	%	1.6	Rectangle uniform

1st order



DRAGON2000 calculation comparison : Final slits

distributions @ Final slits



THE DRAGON Recoil Separator Optics by The Recoil Group from January 3, 2001

LISE++

2nd order

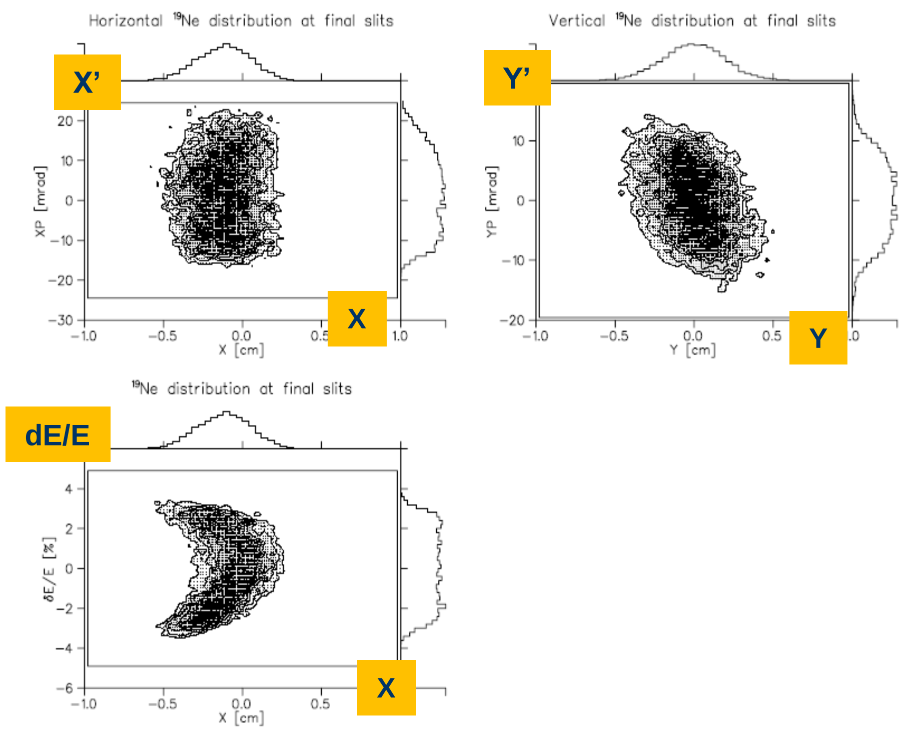
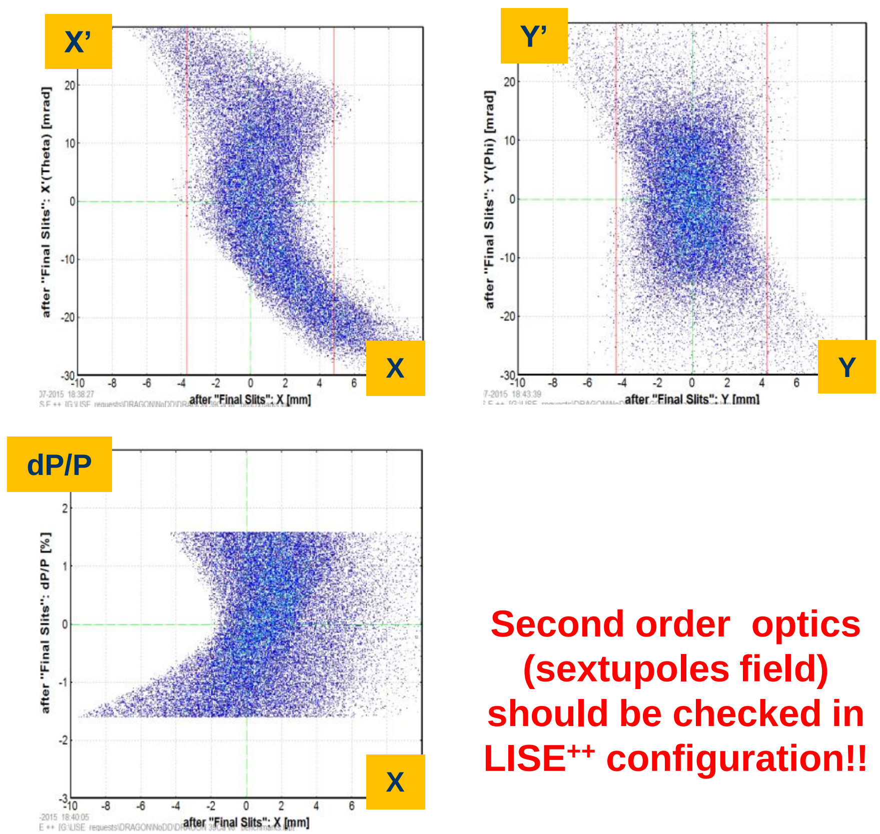


Figure 3.5: X and Y phase space plots and a plot of relative energy versus horizontal position at the final slits for 10000 simulated ^{19}Ne ion trajectories.



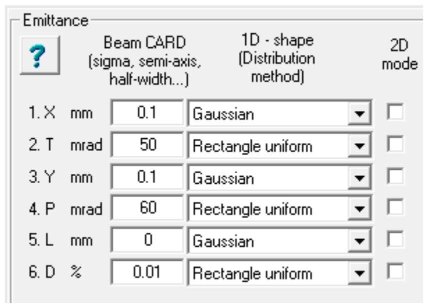
Second order optics (sextupoles field) should be checked in LISE++ configuration!!

Angular Acceptance

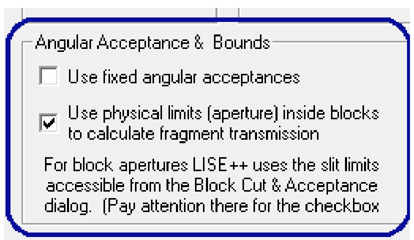
See details for angular acceptance with the next link http://lise.nscl.msu.edu/9_8/SE_blocks.pdf#page=5

Settings

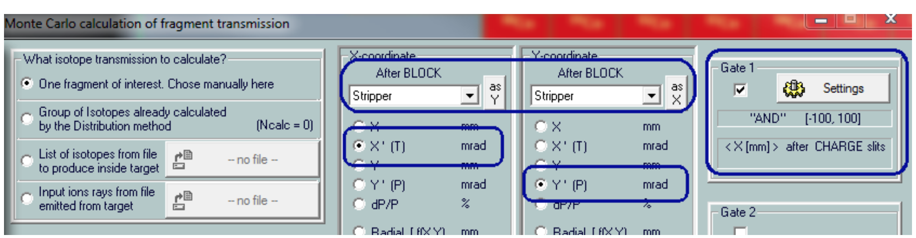
Beam dialog



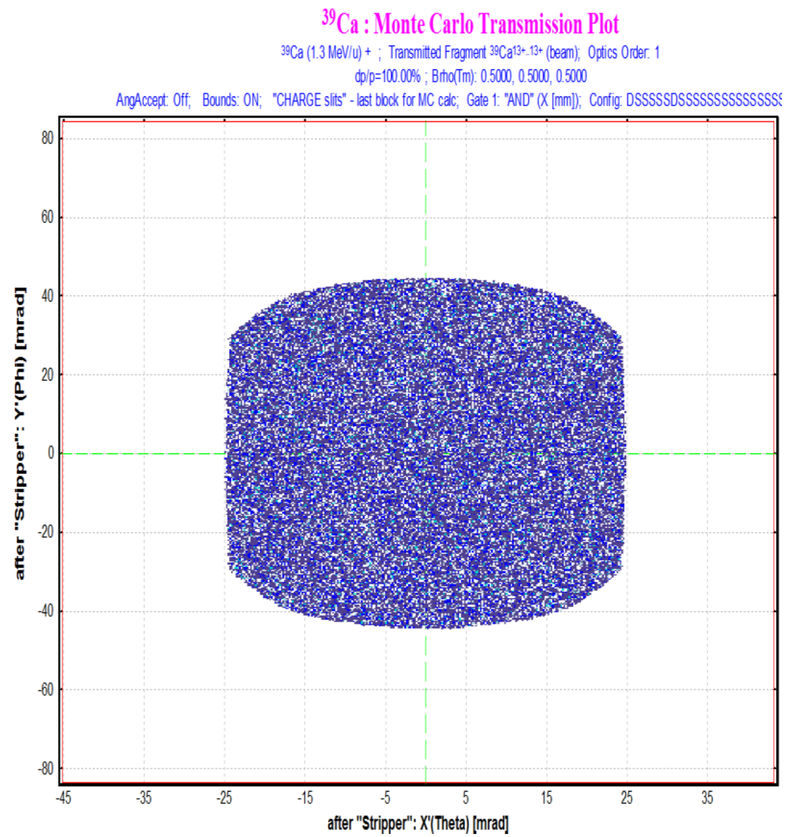
Monte Carlo options



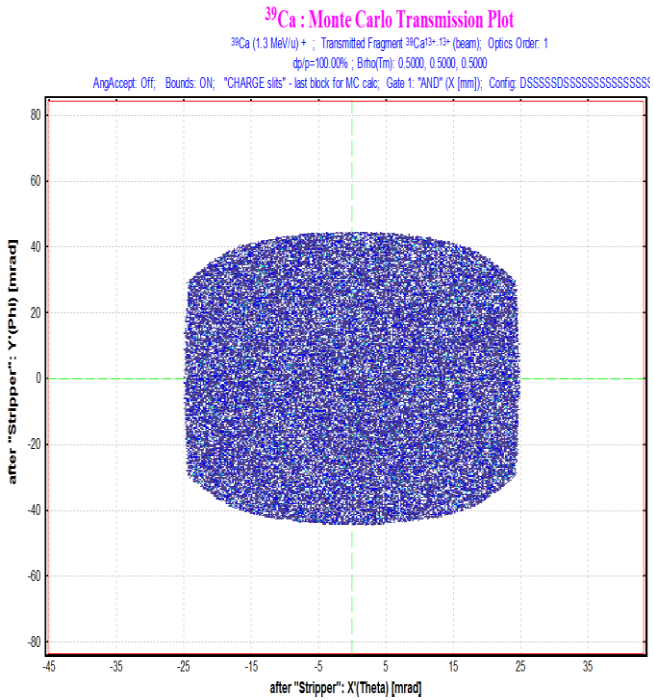
Monte Carlo Transmission settings



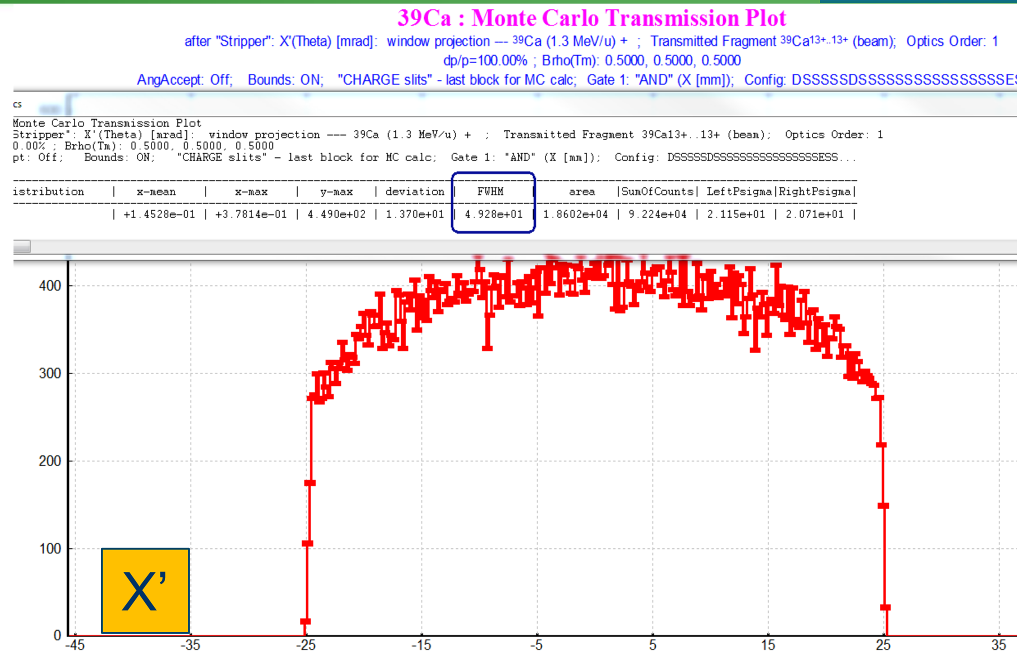
Coming to the Charge slits

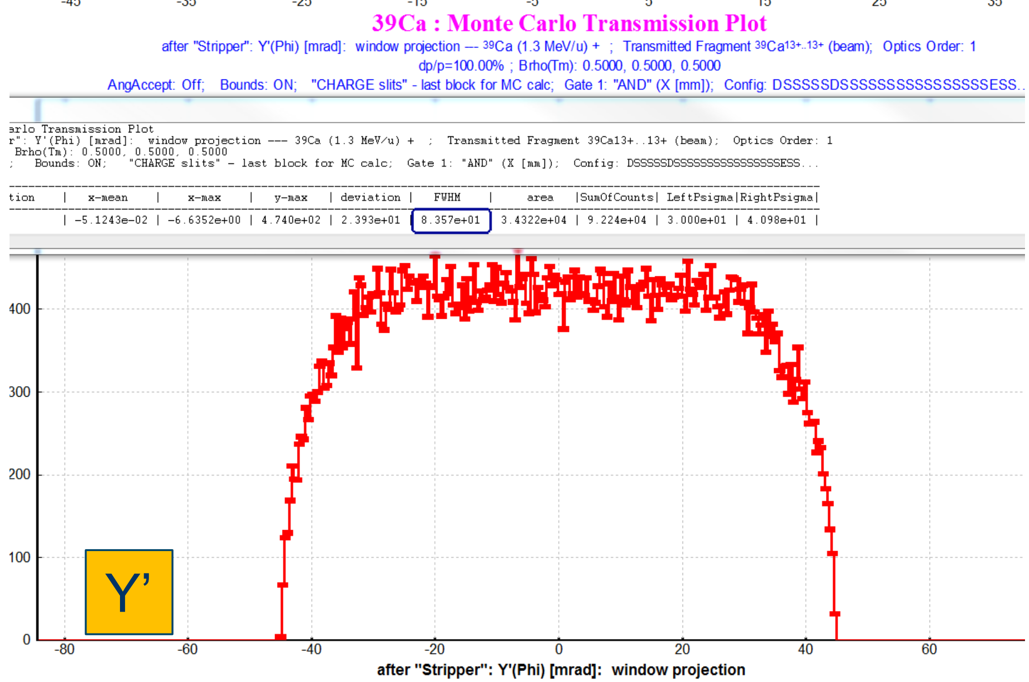


Angular Acceptance : Target-Charge slits



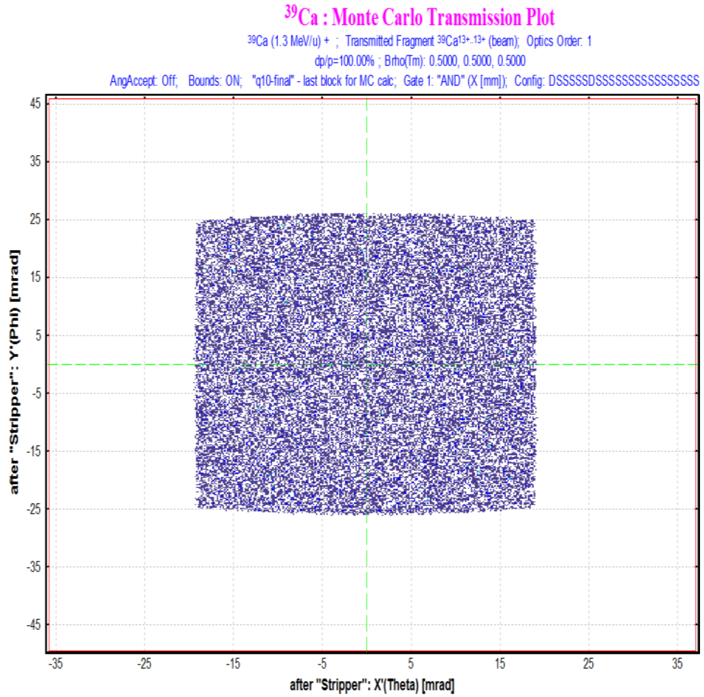
AngAcc_fromTarget lpp

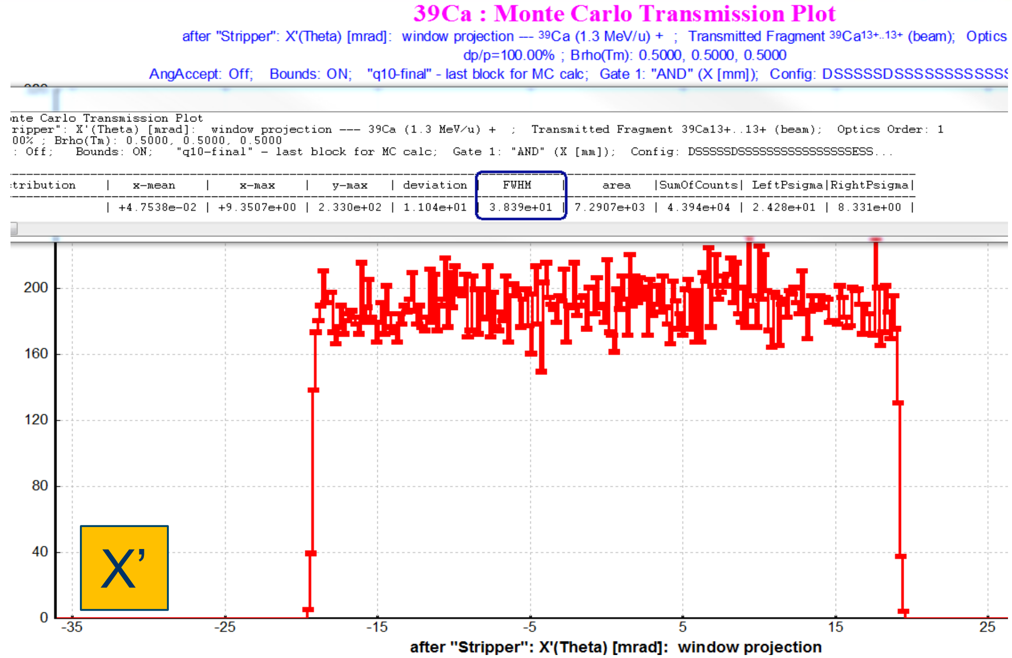


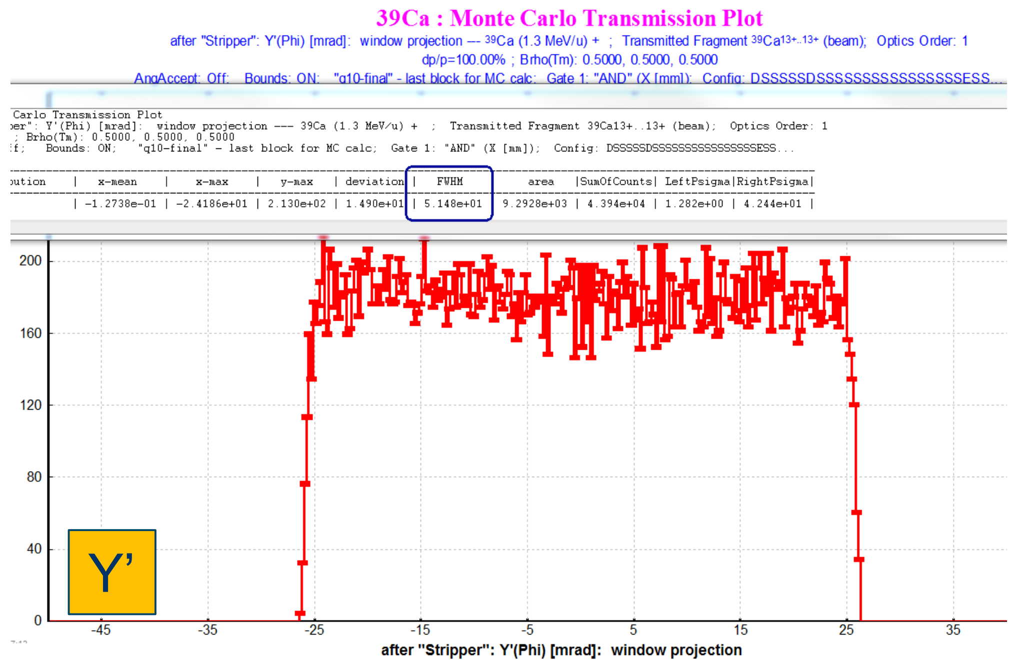


Angualr acceptance "Target - Charge slits"		
	1st order	
X'	24.6	mrad
Y'	41.8	mrad

Angular Acceptance: Target - Final slits



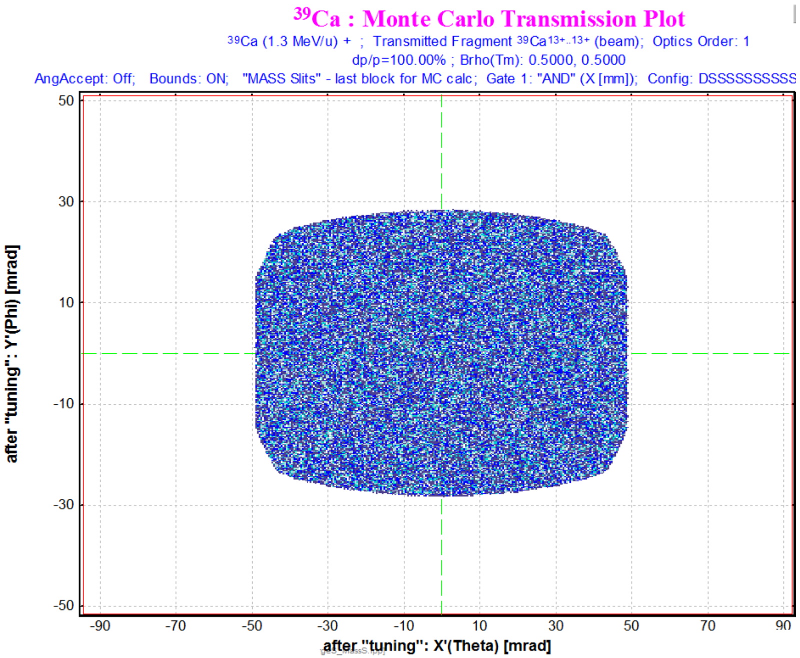




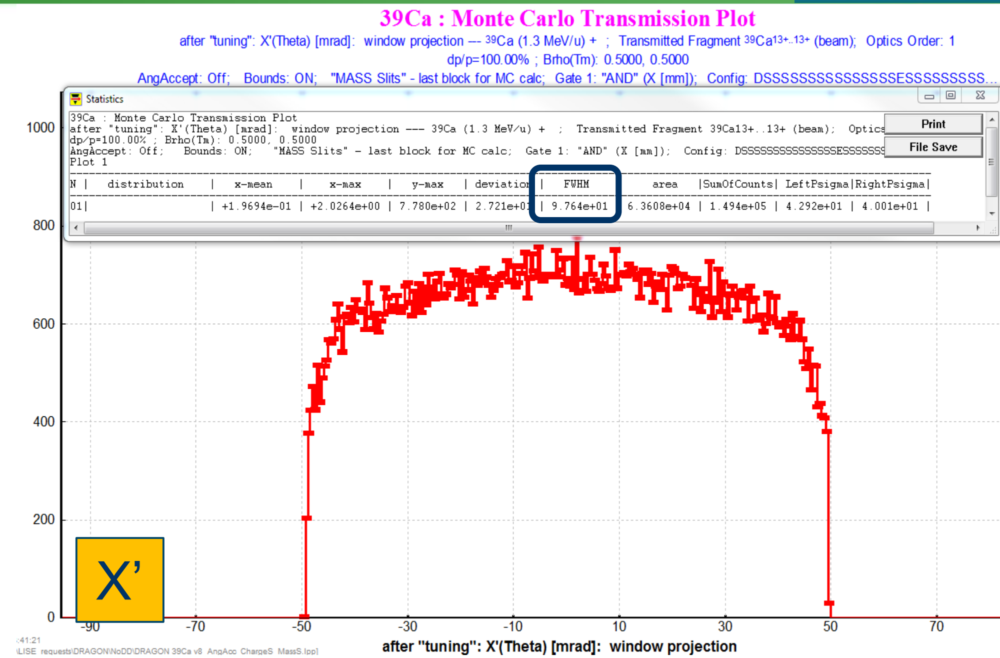
Angular acceptance "Target - Final slits"		
	1st order	
X'	19.2	mrad
Y'	25.7	mrad

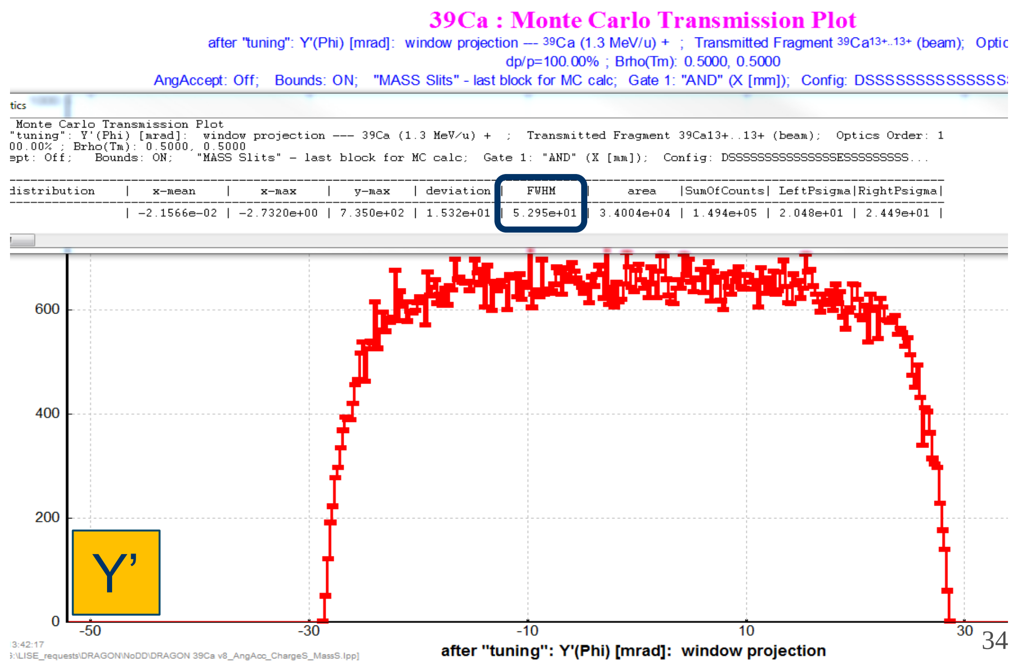
These values are recommended to use in calculations by the Distribution method in the case of use of one angular acceptance.

Angular Acceptance: Charge Slits - Mass slits



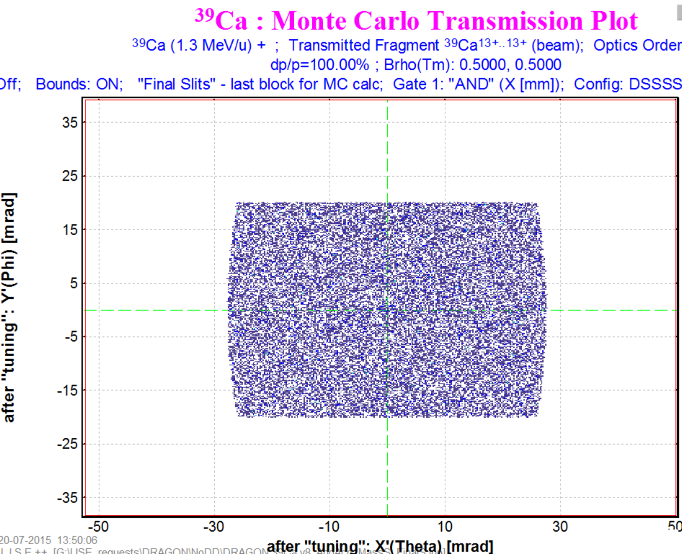
AngAcc_fromChargeS_MassS lpp

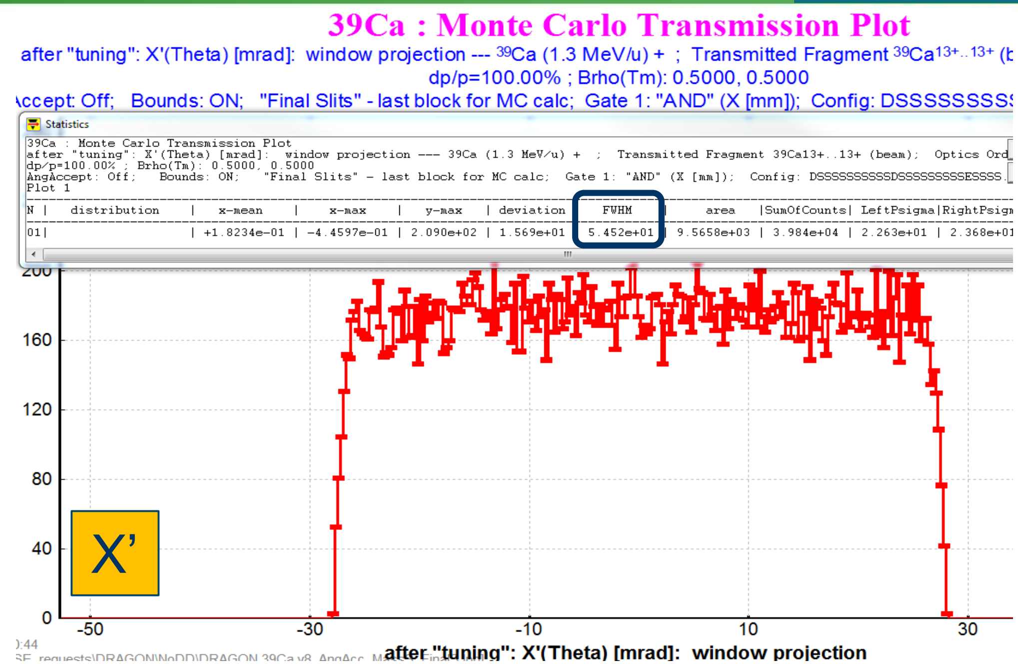




Angular acceptance "Charge Slits - Mass slits"		
	1st order	
X'	48.8	mrad
Y'	26.5	mrad

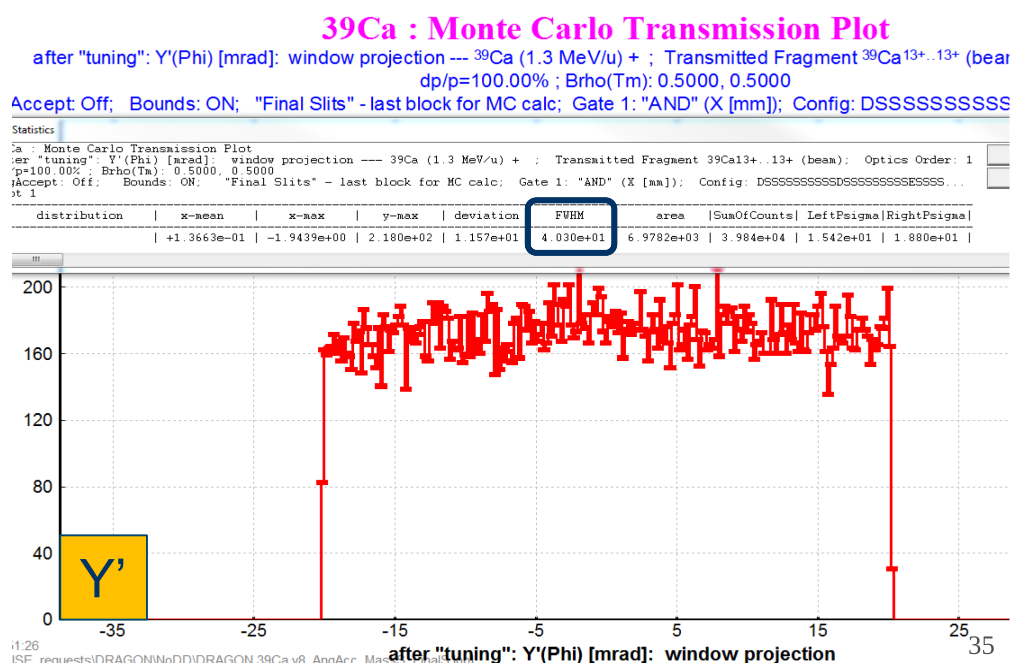
Angular Acceptance: Mass Slits - Final slits





AngAcc_fromMassS_FinalS lpp

Angular acceptance "Mass Slits - Final slits"		
	1st order	
X'	27.3	mrad
~~Y'~~	~~20.2~~	~~mrad~~



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

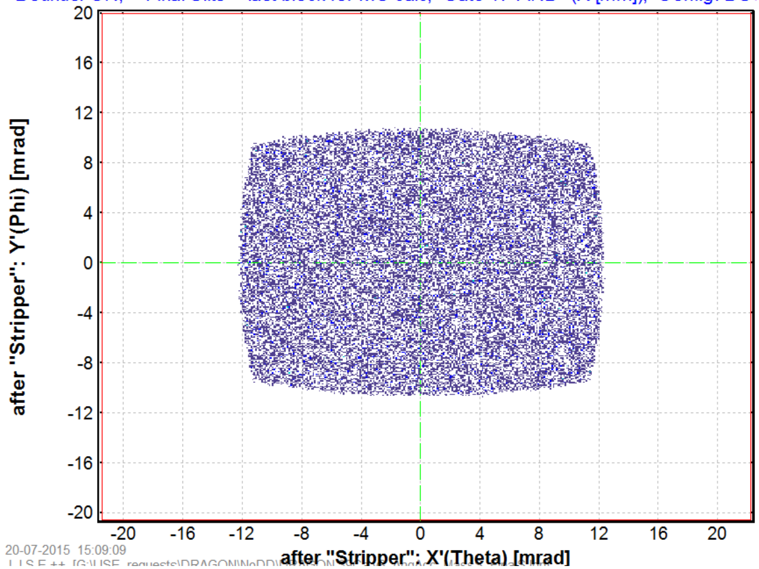
Angular Acceptance: S3 - Final slits

^{39}Ca : Monte Carlo Transmission Plot

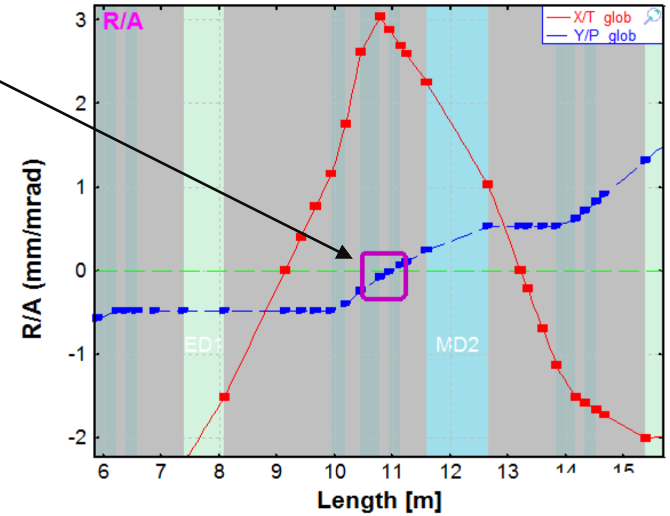
^{39}Ca (1.3 MeV/u) + ; Transmitted Fragment ^{39}Ca$^{13+..13+}$ (beam); Optics Or

dp/p=100.00% ; Brho(Tm): 0.5000, 0.5000

Bounds: ON; "Final Slits" - last block for MC calc; Gate 1: "AND" (X [mm]); Config: DS



There is vertical focus before S3



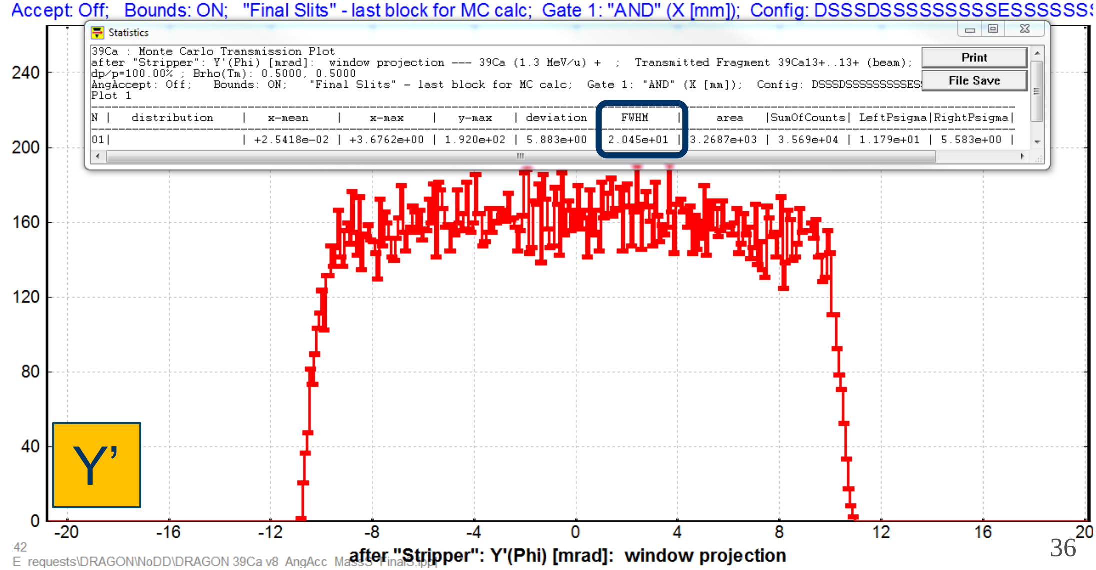
Angular acceptance "S3 - Final slits"		
	1st order	
X'		mrad
Y'	10.2	mrad

39Ca : Monte Carlo Transmission Plot

after "Stripper": Y'(Phi) [mrad]: window projection --- ^{39}Ca (1.3 MeV/u) + ; Transmitted Fragment ^{39}Ca$^{13+..13+}$ (beam); Optics Order:

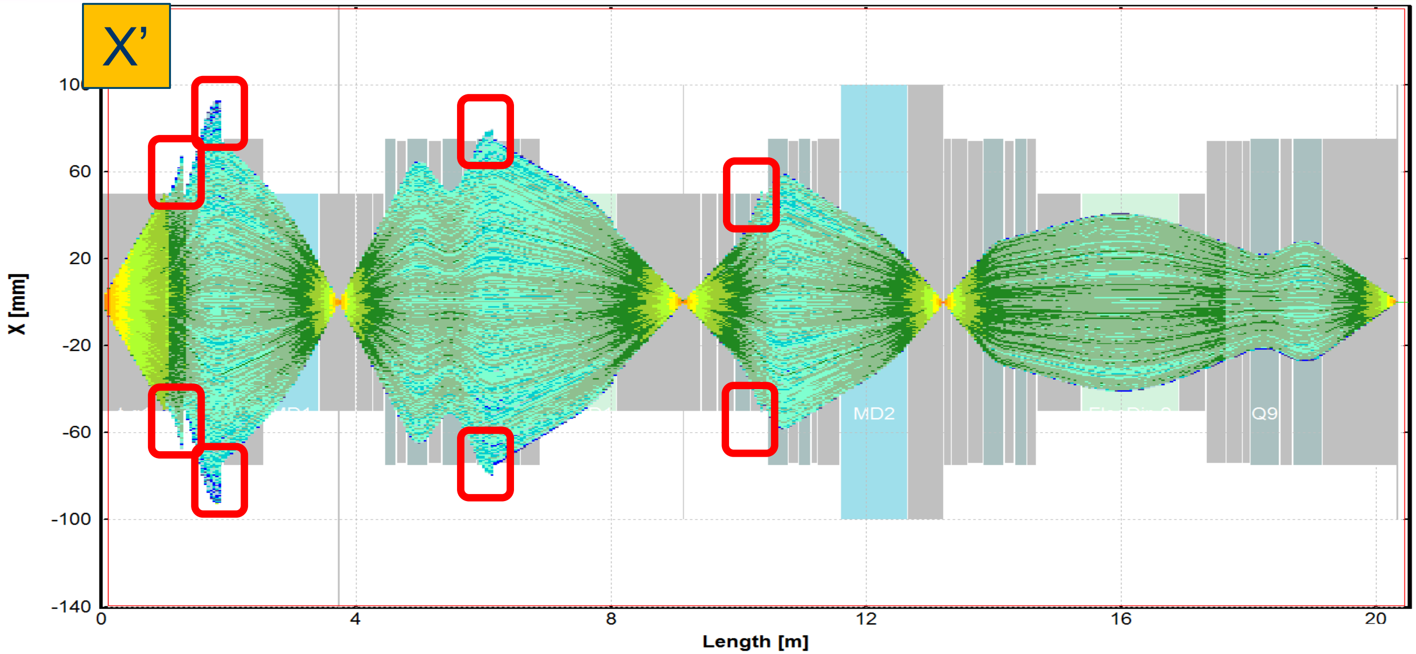
dp/p=100.00% ; Brho(Tm): 0.5000, 0.5000

Accept: Off; Bounds: ON; "Final Slits" - last block for MC calc; Gate 1: "AND" (X [mm]); Config: DSSSDSSSSSSSSSSESSSSSS

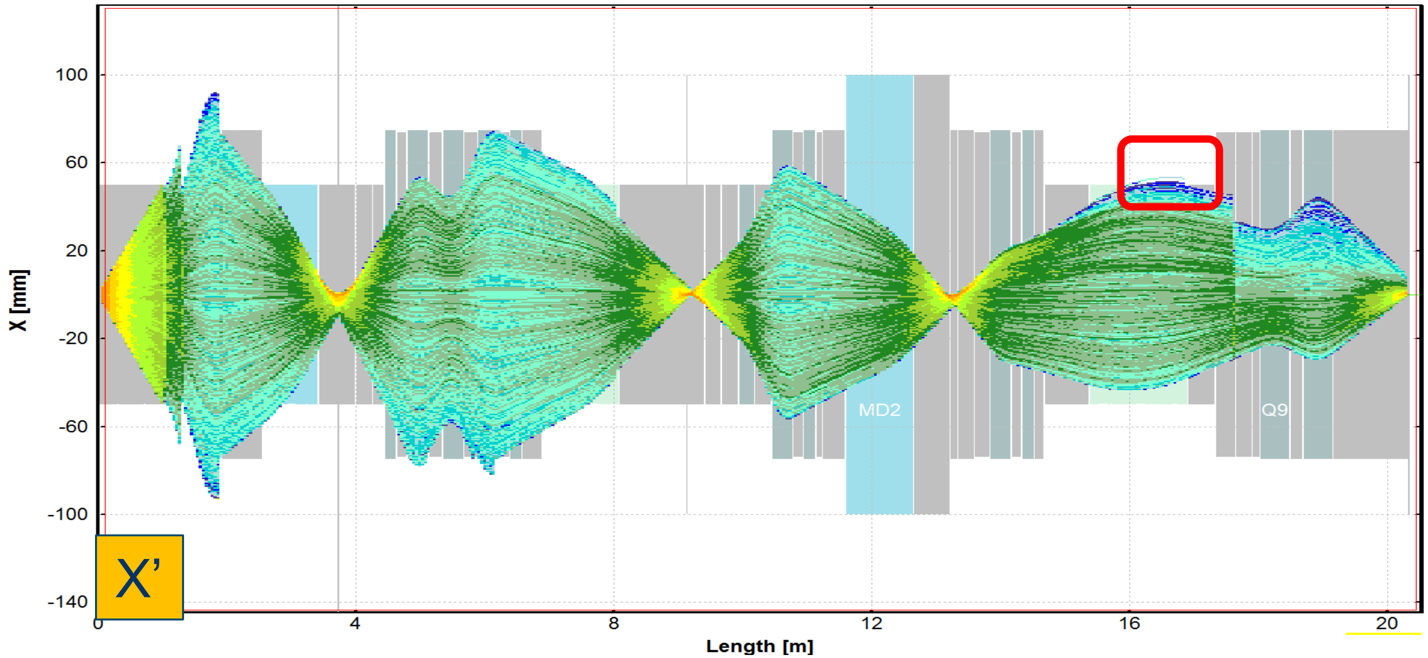


Horizontal Angular Emittance Loss

1st order

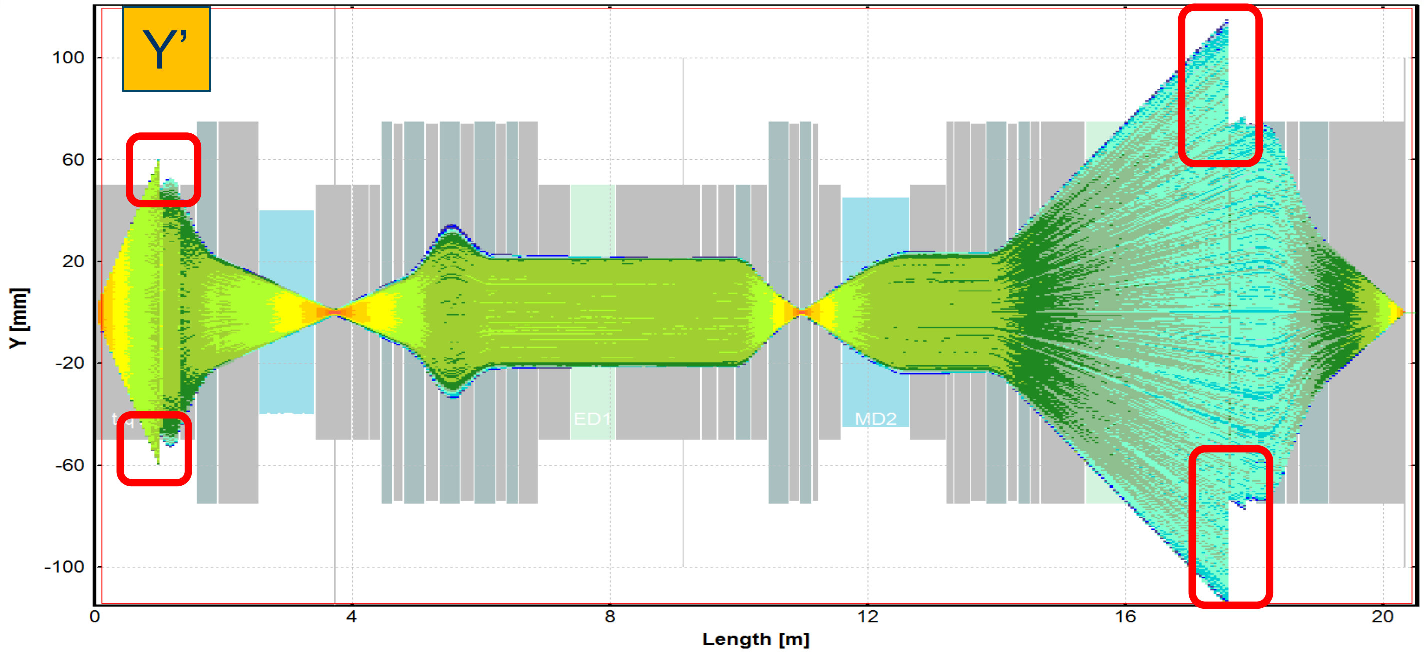


2nd order

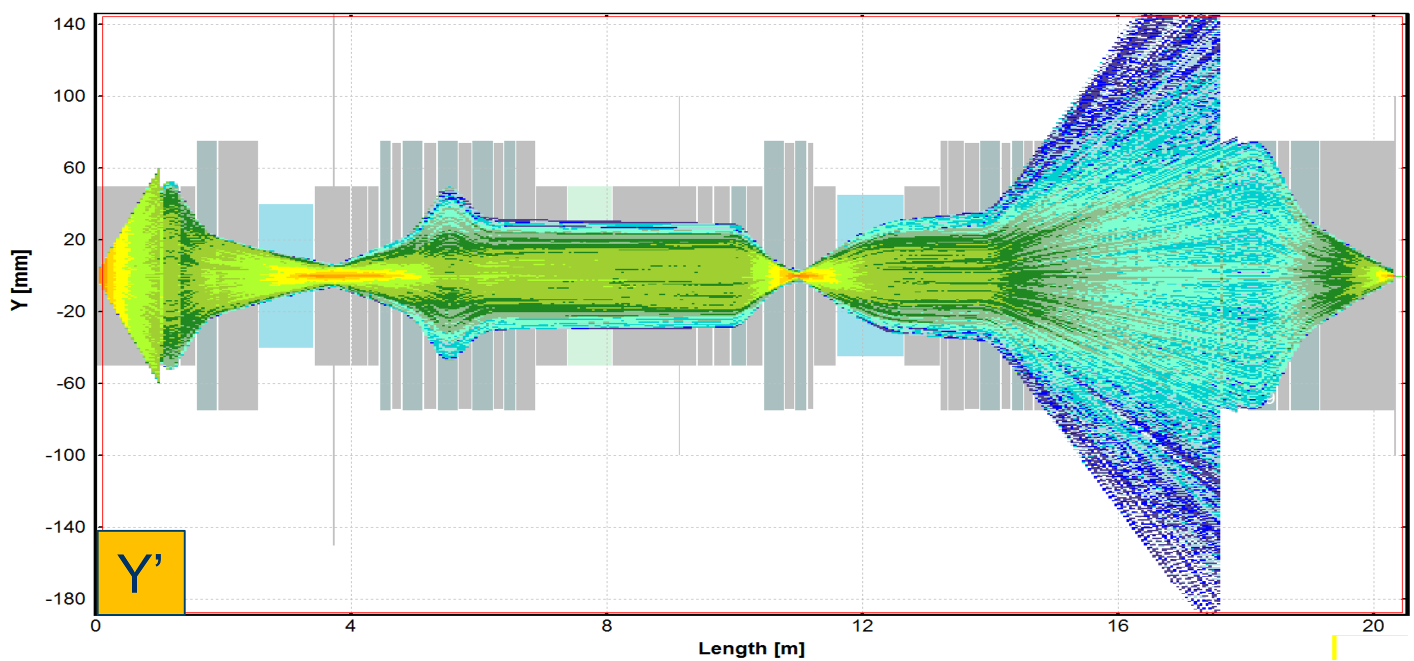


Vertical Angular Emittance Loss

1st order



2nd order



Angular Acceptances in the Configuration file

Angular acceptances are used in the DRAGON2000 configuration					
	Target-ChargeSlits	ChargeSlit-MassSlits	MassSlits-FinalSlits	S3-FinalSlits	
X'	24.6	48.8	27.3		mrad
Y'	41.8	26.5		10.2	mrad

or		Block	(m)	(m)	Angle(°)*		Br-dip*	R(m)*	Len(m)*	order	Mode	mode	shape	slit
1.	tuning	Dipole	0.000	0.000	+0.0 *	+1.667	0.5000*	3.00*	0.00*	-		HV	rectn	
2.	t-q1	Drift	0.000	1.069	standard							--	rectn	
3.	Q1	Drift	1.069	0.252	multipole	-2.158	0.5000	5.40	0.25	yes	1	--	rectn	
4.	q1-q2	Drift	1.321	0.257	standard							--	rectn	
5.	Q2	Drift	1.578	0.334	multipole	+1.965	0.5000	7.94	0.33	yes	1	--	rectn	
6.	d3-md1	Drift	1.912	0.638	standard							--	rectn	
7.	MD1	Dipole	2.550	0.873	+50.0 *	+5.000	0.5000*	1.00*	0.87*	yes		--	rectn	
8.	md1-slits	Drift	3.423	0.308	standard							--	rectn	
9.	Fit XT	Fit	3.731	0.000								--	rectn	
10.	Fit XX	Fit	3.731	0.000								--	rectn	
11.	Fit YP	Fit	3.731	0.000								--	rectn	
12.	CHARGE slits	Drift	3.731	0.000	SLITS							--	rectn	
13.	slts-sm1	Drift	3.731	0.272	standard							HV	rectn	
14.	SM1	Drift	4.003	0.256	standard							--	rectn	
15.	sm1-s1	Drift	4.259	0.186	standard							--	rectn	
16.	S1	Drift	4.445	0.188	multipole	+0.000	0.5000	7.94	0.19	yes	1	--	rectn	
17.	s1-q3	Drift	4.632	0.161	standard							--	rectn	
18.	Q3	Drift	4.794	0.334	multipole	+1.775	0.5000	7.94	0.33	yes	1	--	rectn	
19.	q3-q4	Drift	5.127	0.216	standard							--	rectn	
20.	Q4	Drift	5.344	0.334	multipole	-2.299	0.5000	7.94	0.33	yes	1	--	rectn	
21.	q4-q5	Drift	5.677	0.216	standard							--	rectn	
22.	Q5	Drift	5.894	0.334	multipole	+1.263	0.5000	7.94	0.33	yes	1	--	rectn	
23.	q5-s2	Drift	6.227	0.161	standard							--	rectn	
24.	S2	Drift	6.389	0.188	multipole	+0.000	0.5000	7.94	0.19	yes	1	--	rectn	
25.	s2-mon1	Drift	6.576	0.309	standard							--	rectn	
26.	mon1-ed1	Drift	6.886	0.500	standard							--	rectn	
27.	ED1	ElecDip	7.386	0.698	+20.0 *	402.4kV	0.5000*	2.00*	0.70*	-		--	rectn	
28.	ed1-slts	Drift	8.084	1.050	standard							--	rectn	
29.	Mass_XA	Fit	9.134	0.000								--	rectn	
30.	Mass_XD	Fit	9.134	0.000								--	rectn	
31.	Mass_PP	Fit	9.134	0.000								--	rectn	
32.	Mass TD	Fit	9.134	0.000								--	rectn	
33.	Mass YY	Fit	9.134	0.000								--	rectn	
34.	MASS Slits	Drift	9.134	0.000	SLITS							--	rectn	
35.	slts-sm2	Drift	9.134	0.277	standard							H-	rectn	
36.	SM2	Drift	9.411	0.256	standard							--	rectn	
37.	sm2-q6	Drift	9.667	0.271	standard							--	rectn	
38.	Q6	Drift	9.938	0.252	multipole	-1.459	0.5000	5.40	0.25	yes	1	--	rectn	
39.	q6-q7	Drift	10.190	0.257	standard							--	rectn	
40.	Q7	Drift	10.447	0.334	multipole	+1.752	0.5000	7.94	0.33	yes	1	--	rectn	
41.	q7-s3	Drift	10.781	0.158	standard							--	rectn	
42.	S3	Drift	10.939	0.199	multipole	+0.000	0.5000	7.95	0.20	yes	1	-V	rectn	
43.	s3-mon2	Drift	11.138	0.098	standard							--	rectn	
44.	mon2-md2	Drift	11.236	0.353	standard							--	rectn	
45.	MD2	Dipole	11.589	1.064	+75.0 *	+1.667	0.5000*	0.81*	1.06*	yes			rectn	

"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

39Ca Beta+ decay (Z=20, N=19)

Q1 (tuning)		13
Q2 (MD1)		13
Q3 (ED1)		13
Q4 (MD2)		13
Q5 (ElecDip 2)		13
Reaction		BEAM
Ion Production Rate	(pps)	1.02e+9
Total ion transmission	(%)	16.382
Total: this reaction	(pps)	1.02e+9
Total: All reactions	(pps)	1.02e+9
X-Section in target	(mb)	beam
Target	(%)	100
Q (Charge) ratio	(%)	100
tuning	(%)	34.33
X angular transmission	(%)	49.24
Y angular transmission	(%)	69.72
slts-sm1	(%)	88.3
X angular transmission	(%)	88.3
Y angular transmission	(%)	100
slts-sm2	(%)	87.22
X angular transmission	(%)	87.22
S3	(%)	61.95
Y angular transmission	(%)	61.95

"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

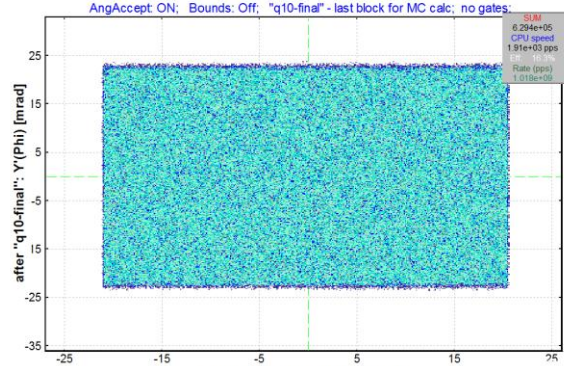
For block apertures LISE++ uses the slit limits accessible from the Block Cut & Acceptance dialog. (Pay attention there for the checkbox

39Ca (1.3 MeV/u) + ; Transmitted Fragment 39Ca13+
dp/p=12.16% ; Brho(Tm): 0.5000, 0.5000, 0.5000
AngAccept: ON; Bounds: Off; "q10-final" - last b

#	Ion	N of Passed	N of Initial	Transmission
All		629448	3864960	16.29%
0	39Ca	629448	3864960	16.29% +/-0.02%

Target	100.0%
tuning	34.26%
Angular acceptance	34.26%
slts-sm1	88.20%
Angular acceptance	88.20%
slts-sm2	87.08%
Angular acceptance	87.08%
S3	61.89%
Angular acceptance	61.89%

AngAccept: ON; Bounds: Off; "q10-final" - last block for MC calc; no gates;



"Monte Carlo" method
No Angular Acceptances
WITH bounds

Angular Acceptance & Bounds

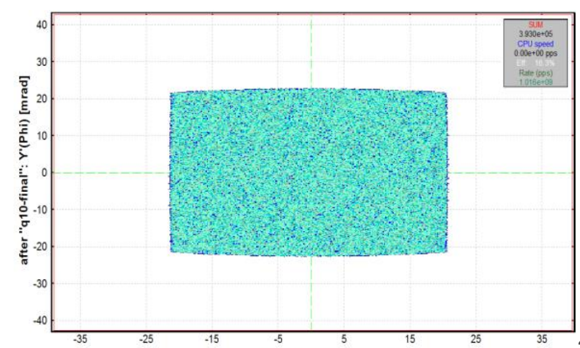
- [ ] Use fixed angular acceptances
- [x] Use physical limits (aperture) inside blocks to calculate fragment transmission

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

39Ca (1.3 MeV/u) + ; Transmitted Fragment 39Ca13+.
dp/p=12.16% ; Brho(Tm): 0.5000, 0.5000, 0.5000
AngAccept: Off; Bounds: ON; "q10-final" - last b

#	Ion	N of Passed	N of Initial	Transmission
All		393042	2416640	16.26%
0	39Ca	393042	2416640	16.26% +/-0.03%

Target	100.0%
tuning	100.0%
t-q1	57.28%
Inside of bounds	57.28%
Q1	65.15%
Inside of bounds	65.15%
q1-q2	100.0%
Q2	89.36%
Inside of bounds	89.36%
d3-md1	100.0%



Angular Acceptances transmission benchmarks

"Distribution" method
With set Angular Acceptances

"Monte Carlo " method
With set Angular Acceptances
No bounds

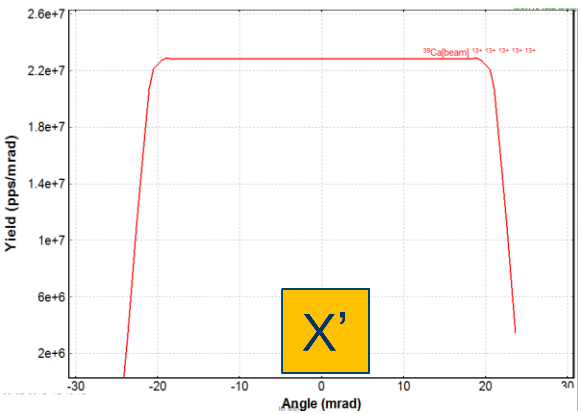
"Monte Carlo " method
No Angular Acceptances
WITH bounds

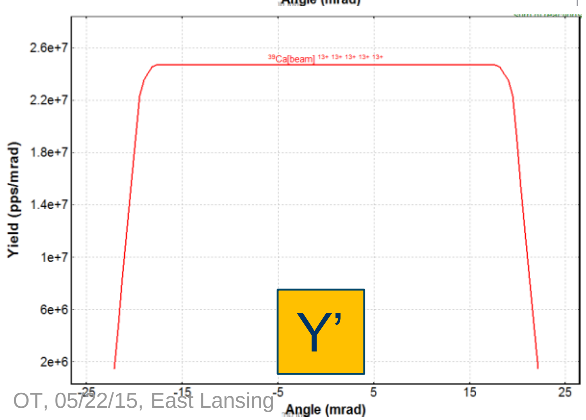
@ Final Slits

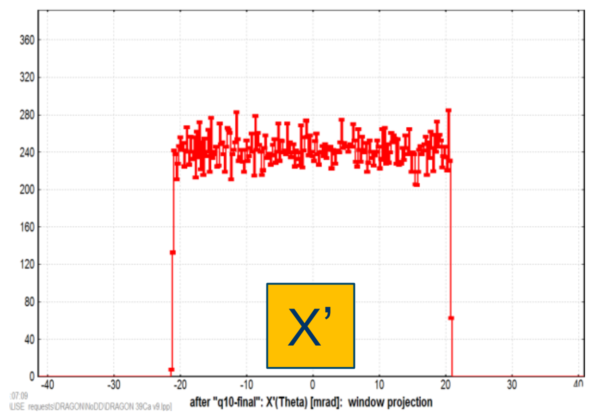
X' : FWHM (mrad)	41.50
Y' : FWHM (mrad)	45.13
transmission	16.38%

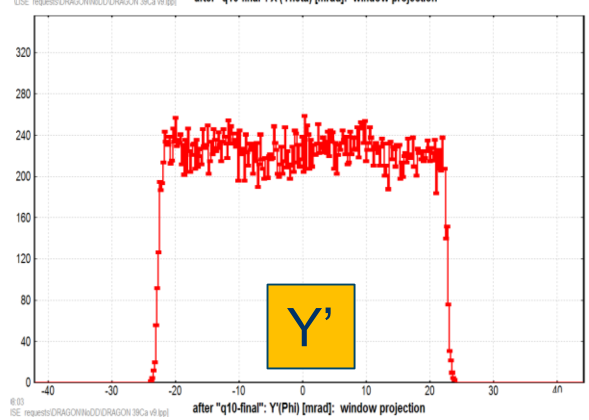
X' : FWHM (mrad)	41.82
Y' : FWHM (mrad)	45.41
transmission	16.29%

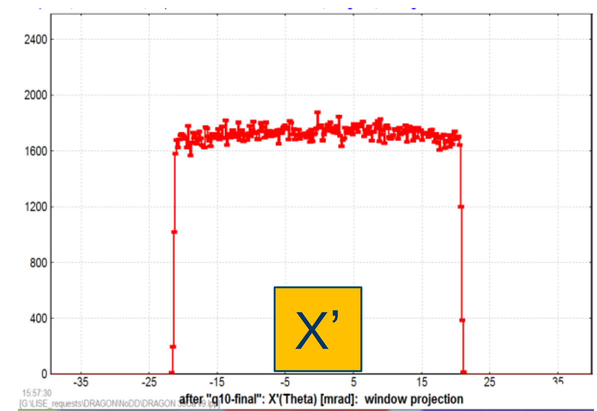
X' : FWHM (mrad)	42.16
Y' : FWHM (mrad)	45.50
transmission	16.26%

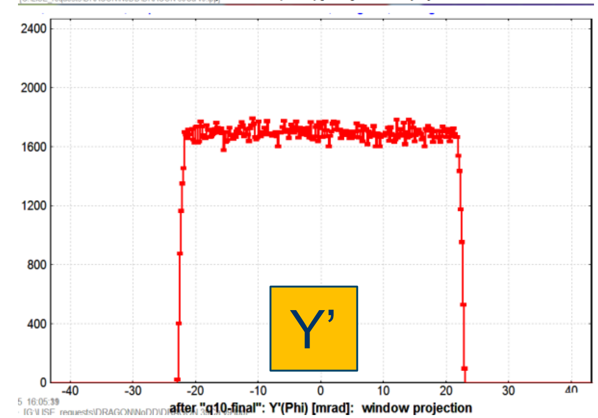












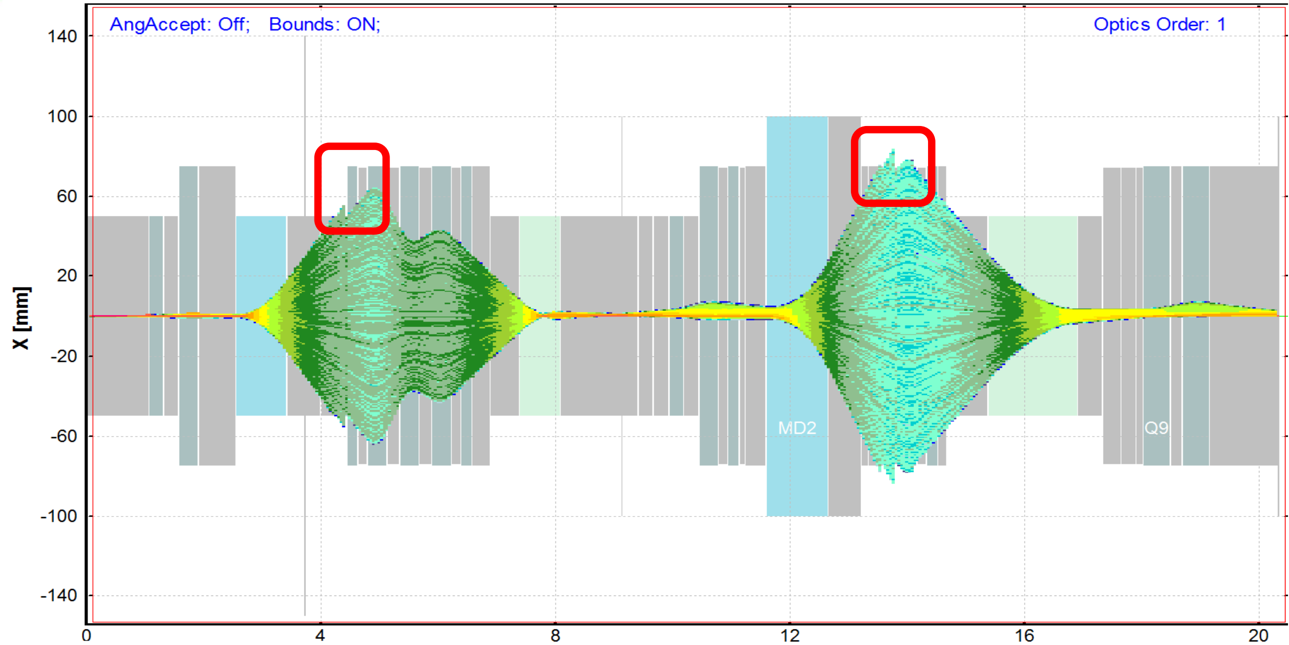
Momentum Acceptance

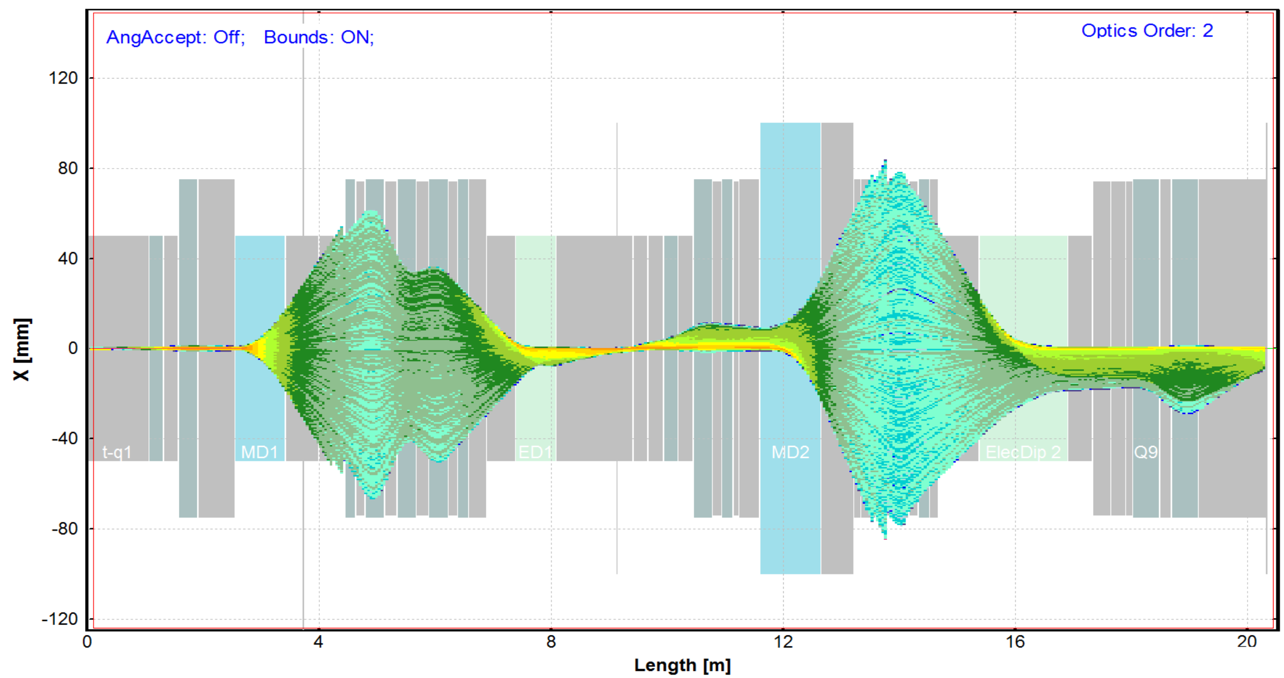
MomemtumAcc lpp

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



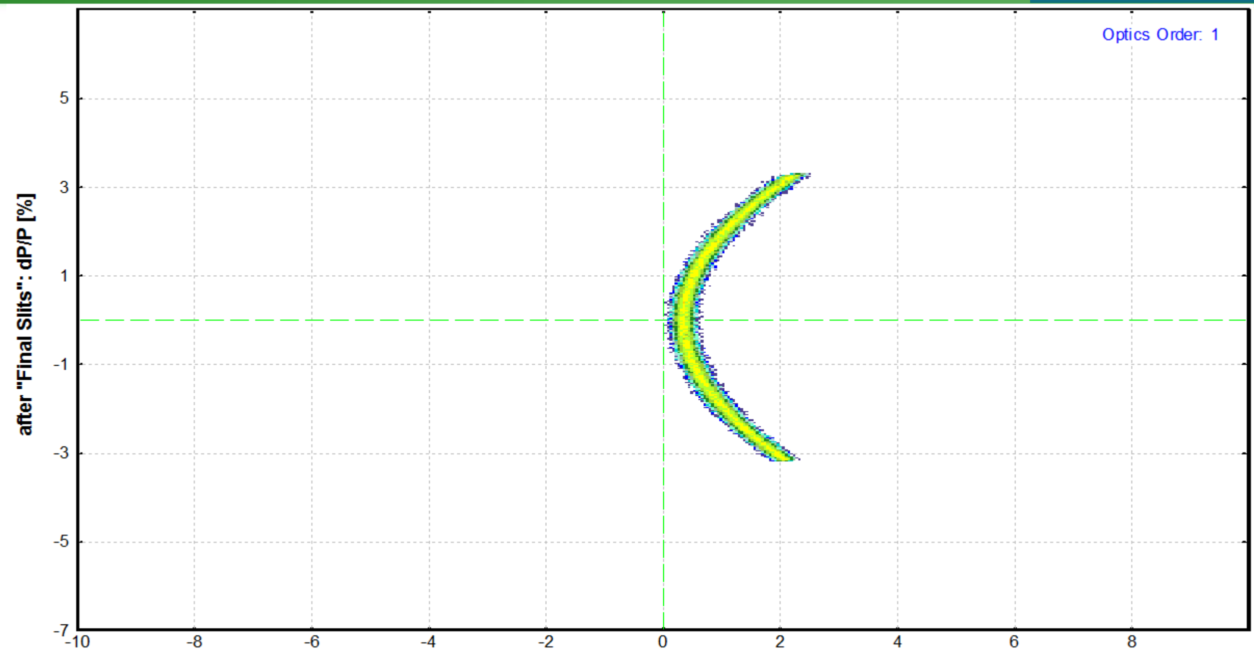


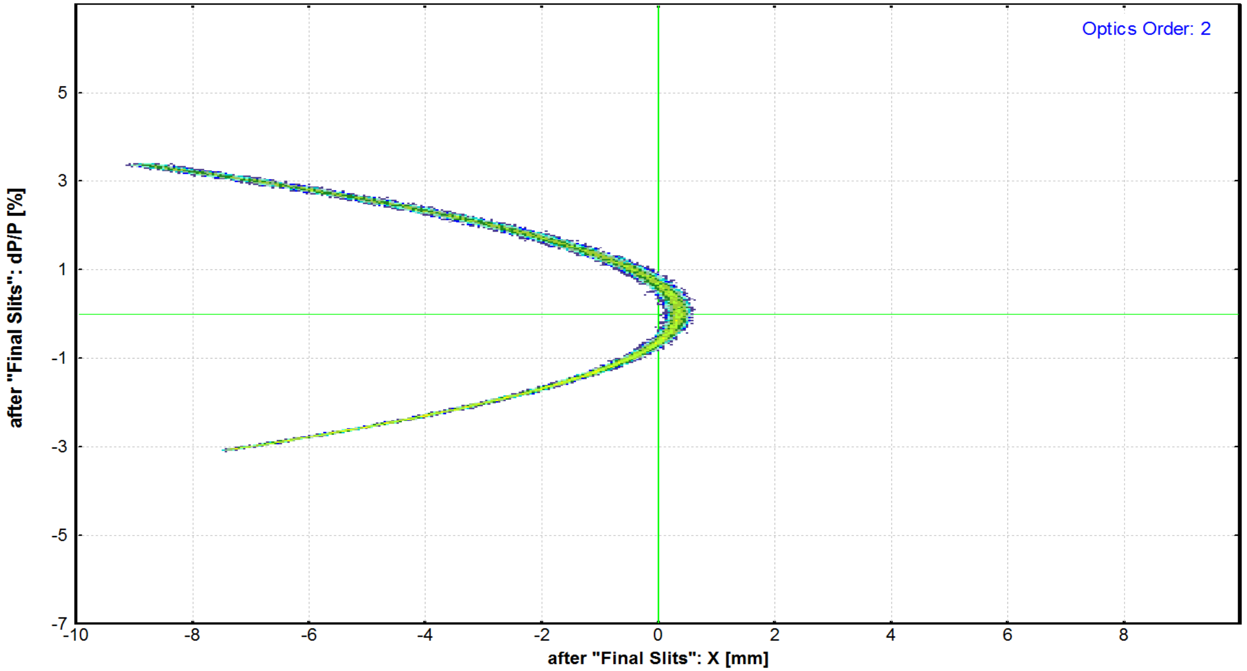
2nd order

Momentum Acceptance

1st order

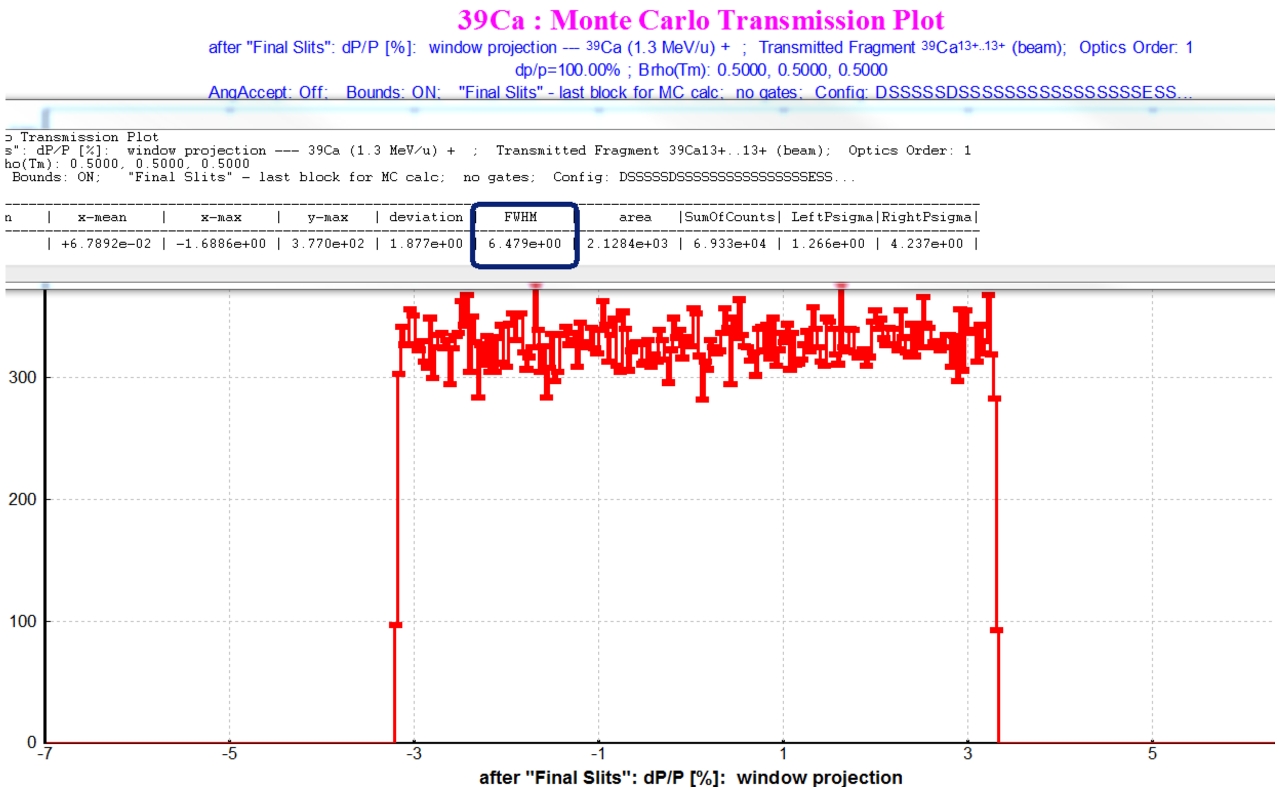
dp/p vs. Final X





2nd order

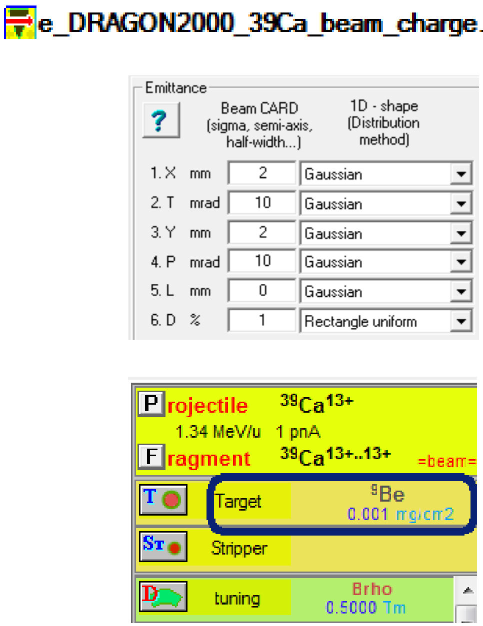
Momentum Acceptance

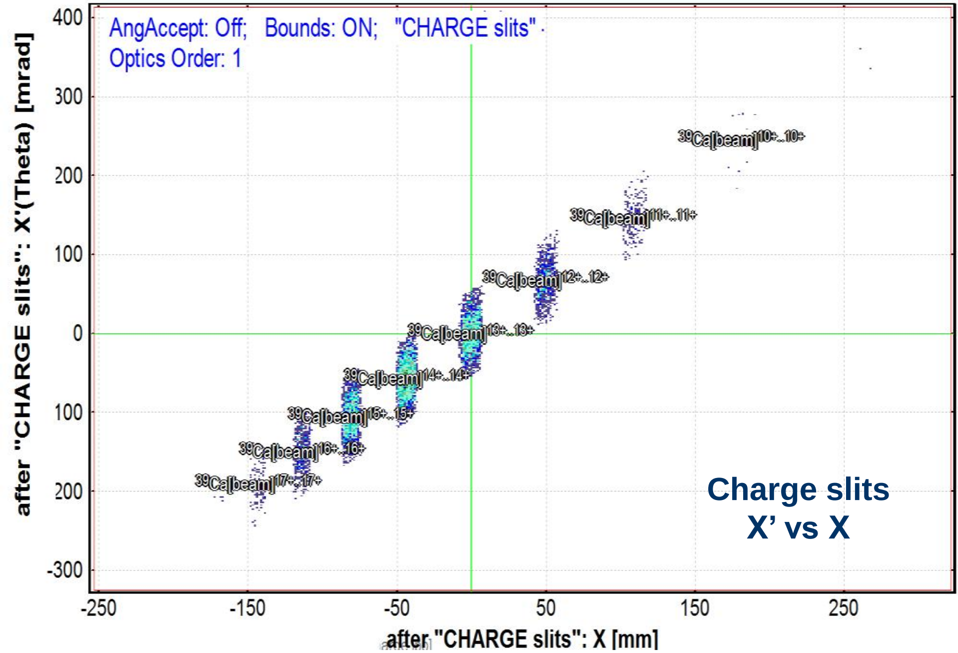


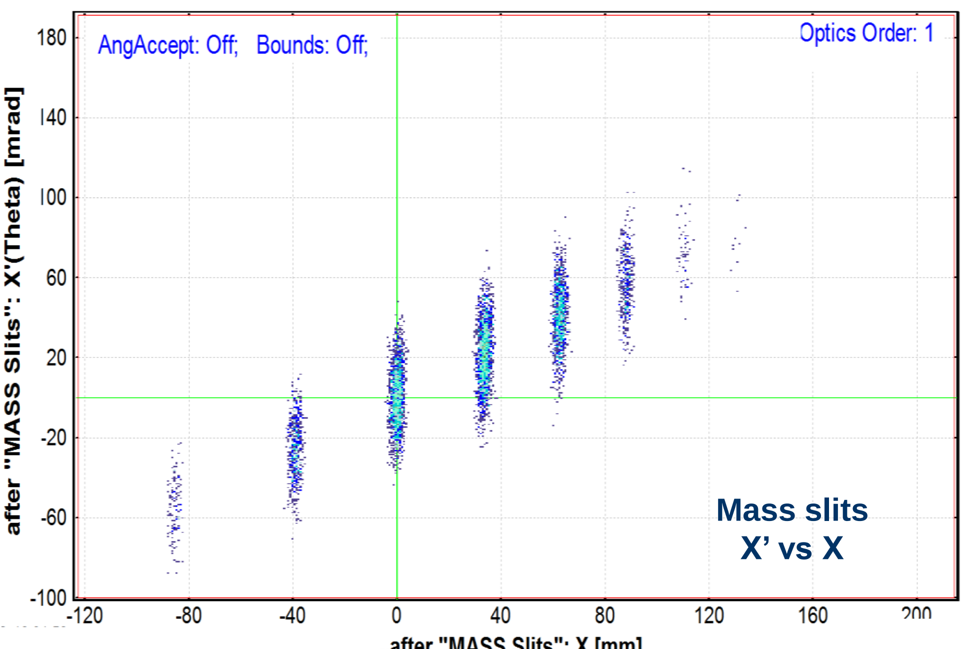
Momentum acceptance of the 1st half separator (Target - Mass Slits) is equal to ± 4.27%, that corresponds to the Charge slits size of ± 26.0 mm.

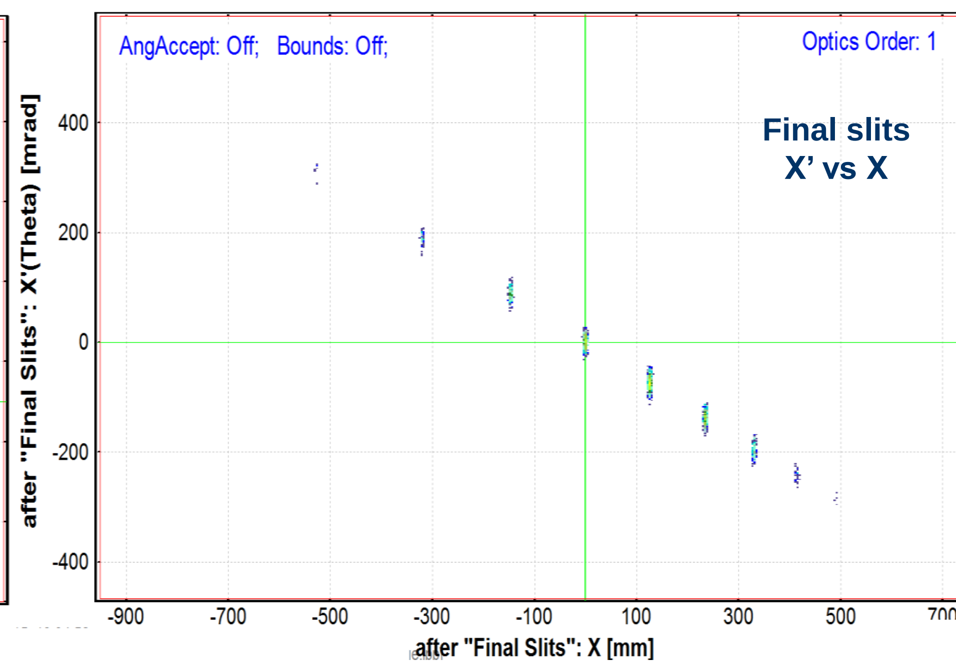
Total momentum acceptance of the separator is equal to ± 3.24 %, that corresponds to the Charge slits size of ± 19.7 mm.

Charge States Selection: Monte Carlo solution



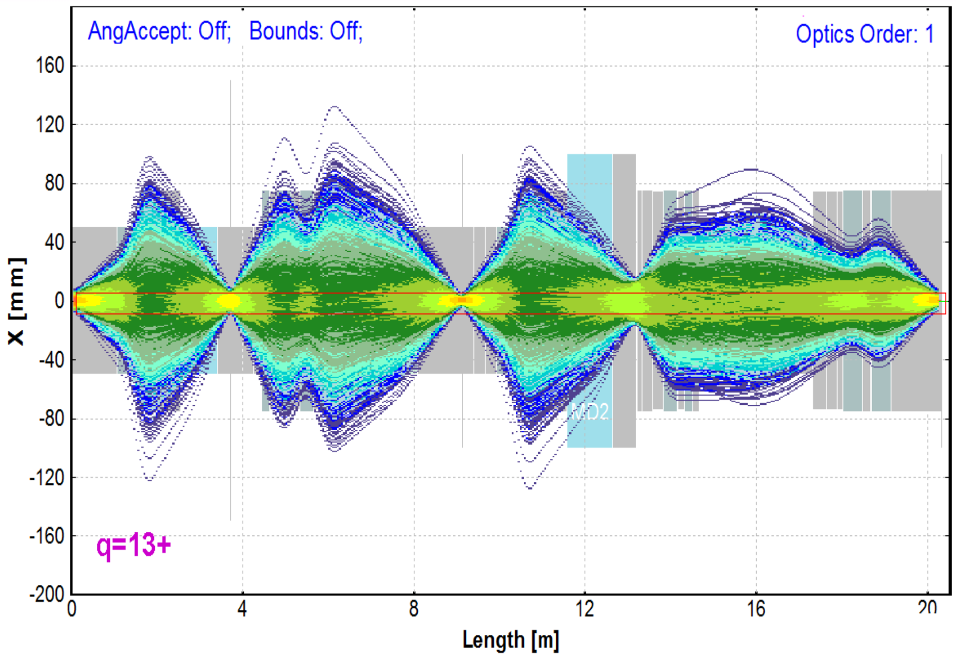


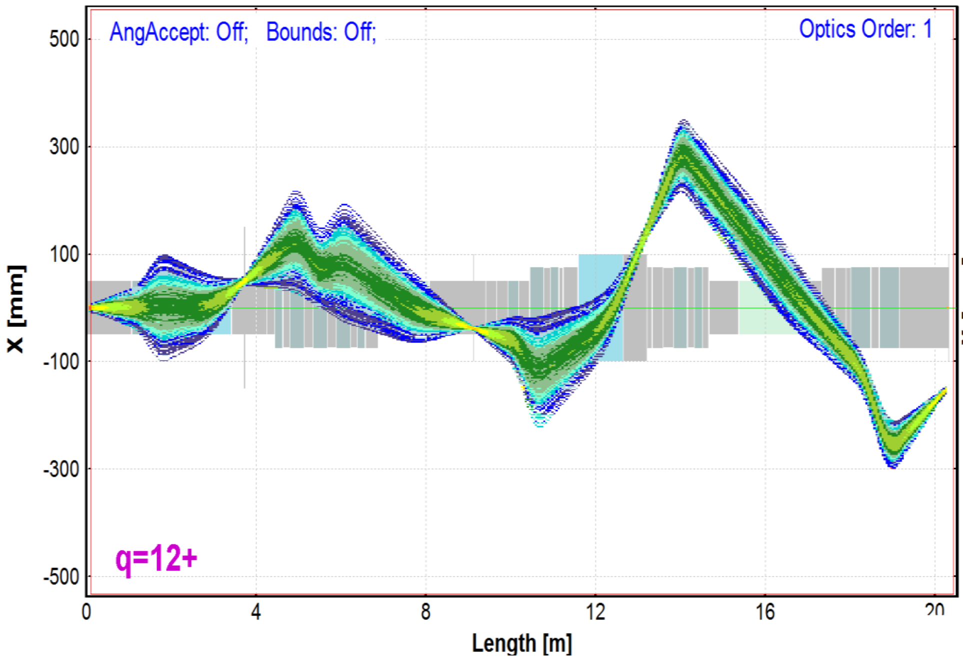


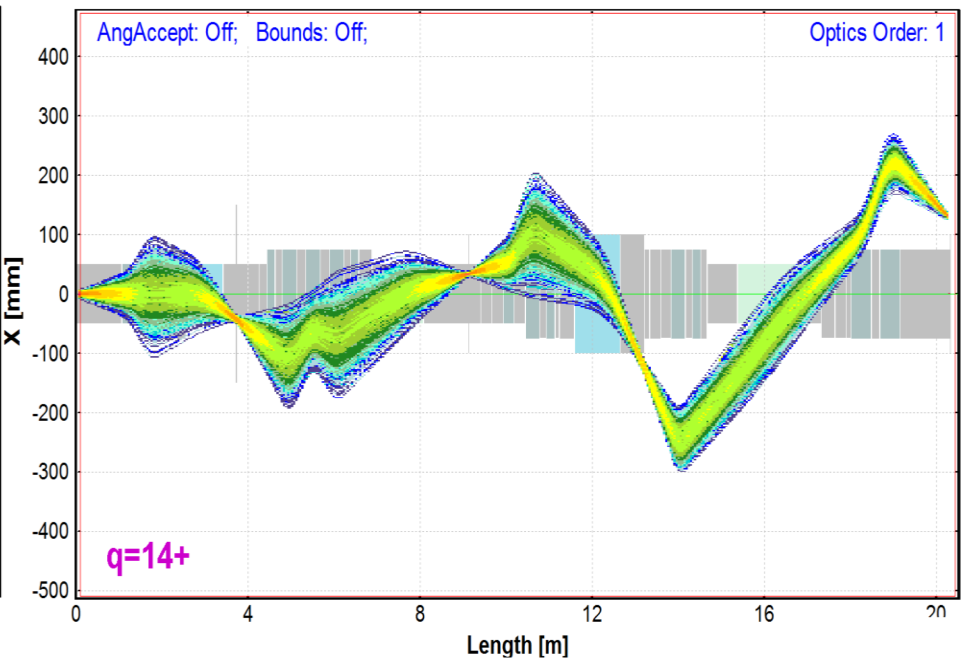


Charge States Selection: Monte Carlo solution

1st order

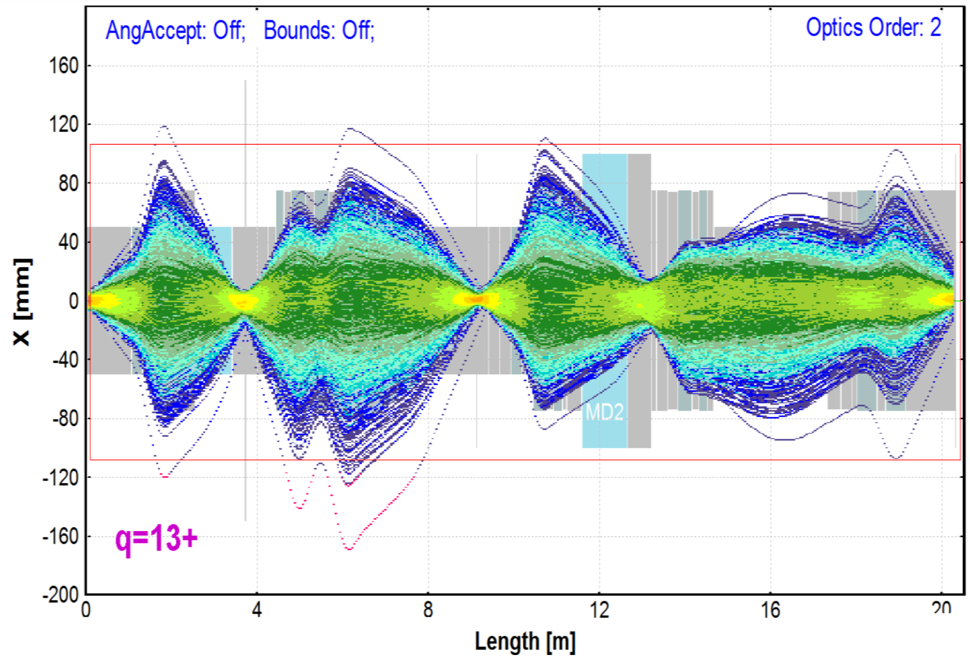


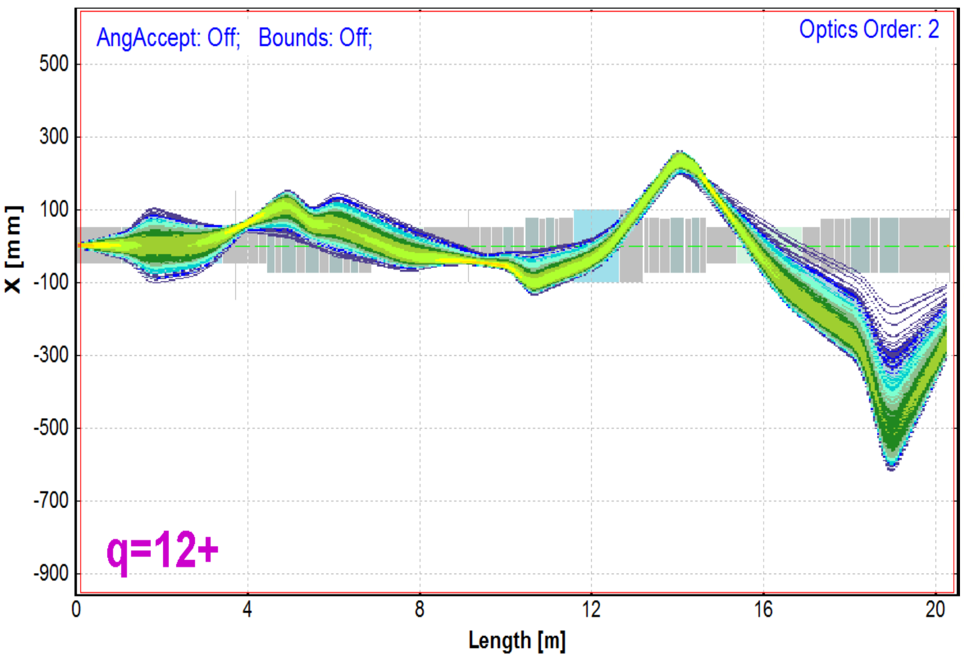


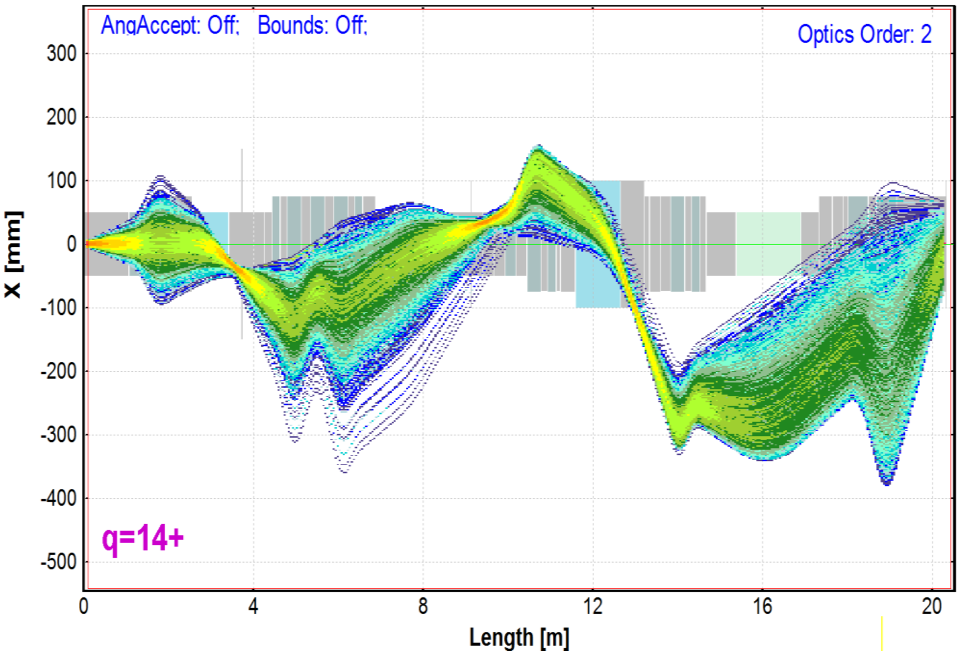


Charge States Selection: Monte Carlo solution

2^{nd} order

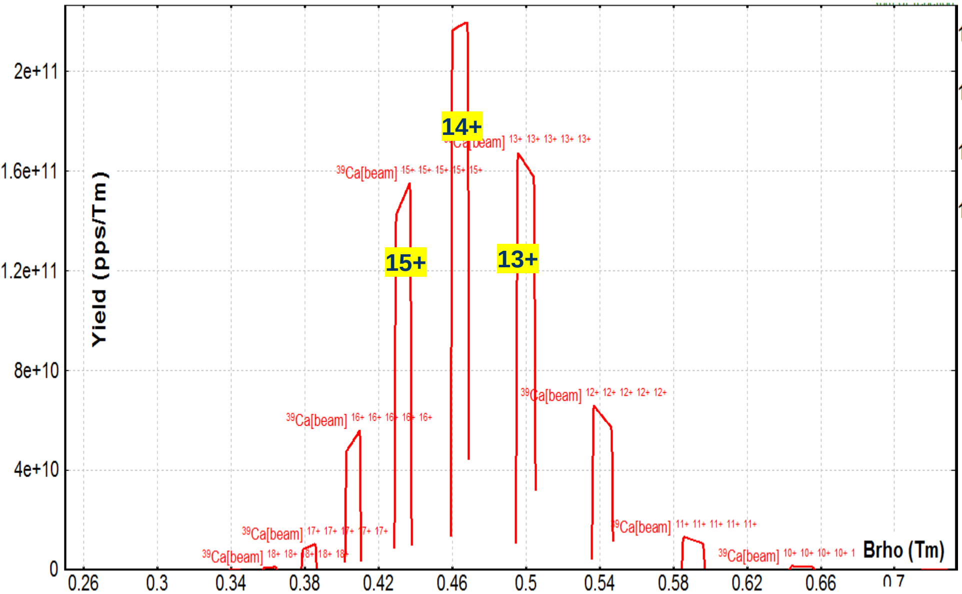




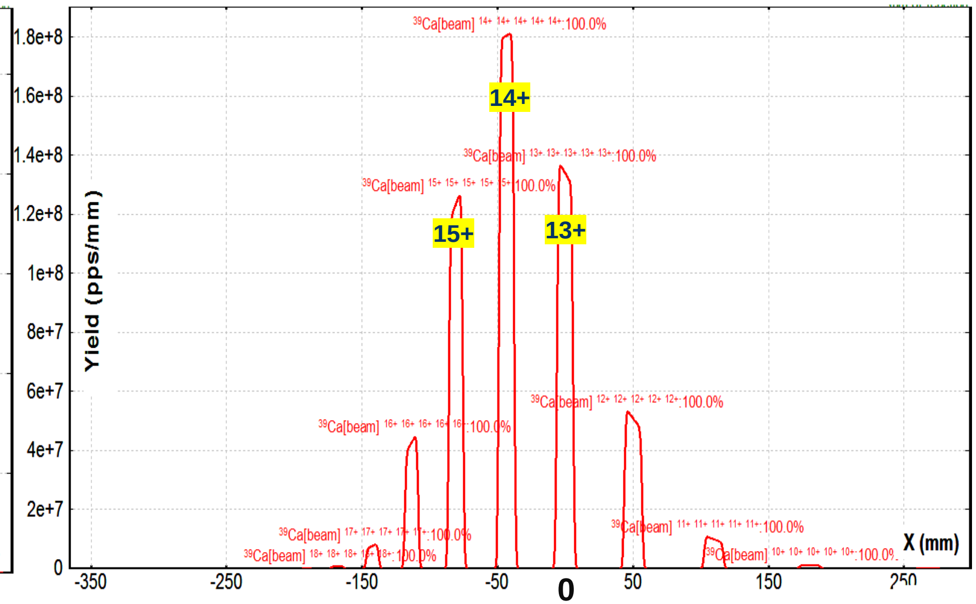


Charge States Selection: “Distribution” method

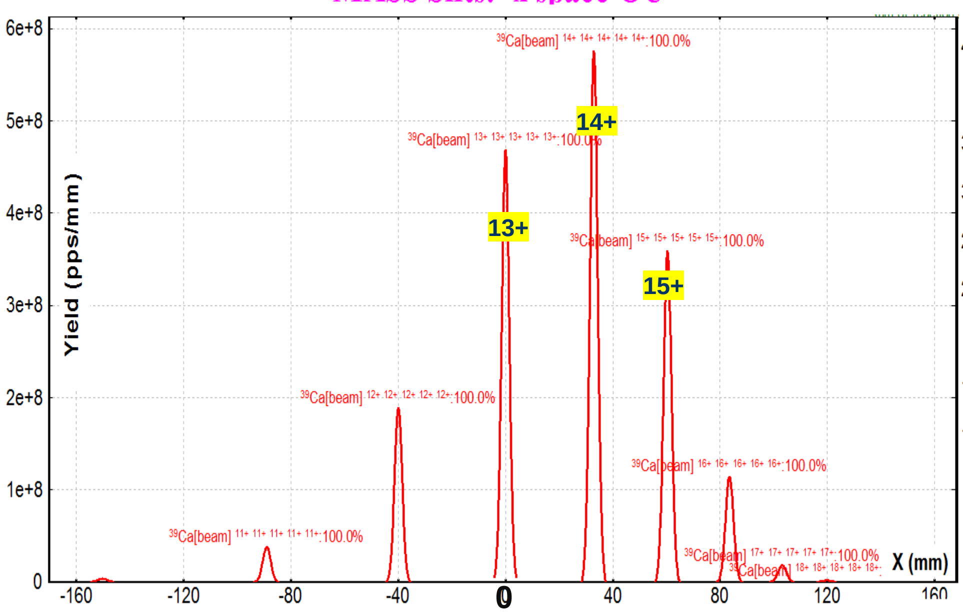
CHARGE slits: Momentum OC



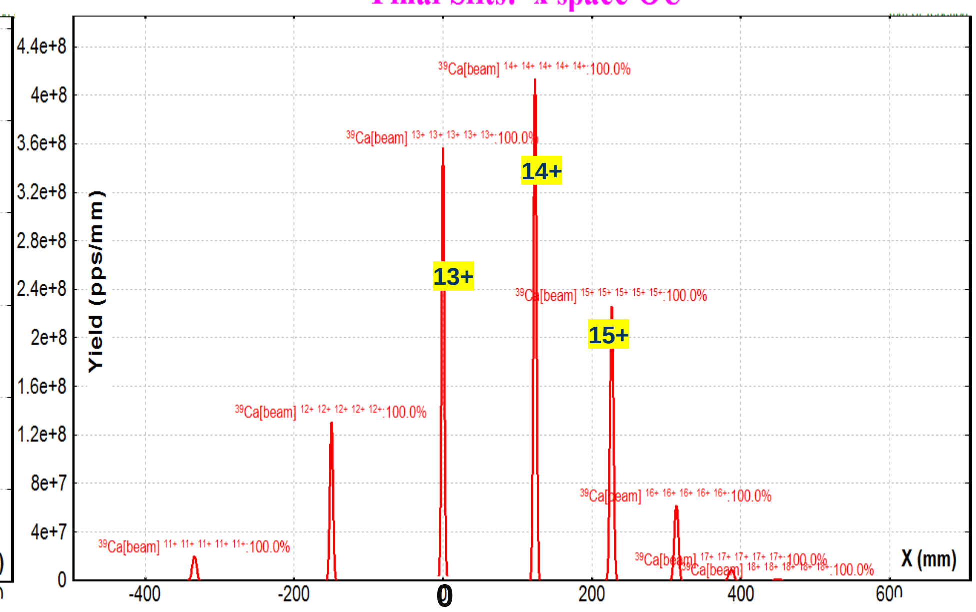
CHARGE slits: x space OU



MASS Slits: x space OU



Final Slits: x space OU



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

D.A. Hutcheon et al. / Nuclear Instruments and Methods in Physics Research A 498 (2003) 190–210 193

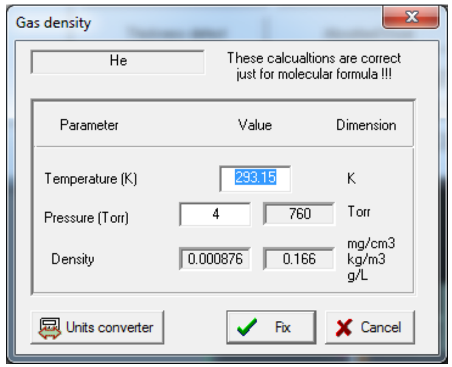
Table 1
Parameters of radiative reactions in the DRAGON program

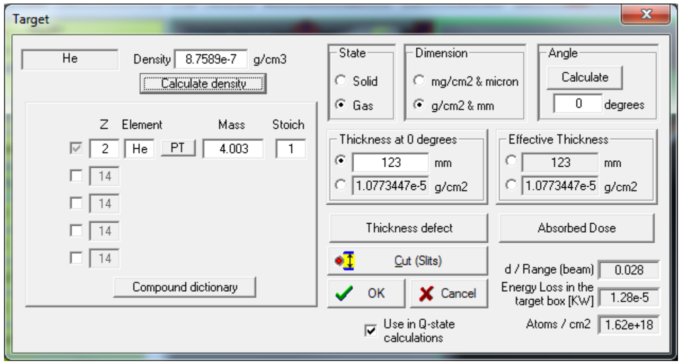
Reaction	E_x (MeV)	E_{beam} (MeV/u)	E_{recoil} (MeV/u)	E_{γ} (MeV)	Recoil cone (mrad)	Required suppression
$^{15}O(\alpha,\gamma)^{19}Ne$	4.033	0.16	0.10	4.03	15.6	10^{-15}

LISE^{++} settings

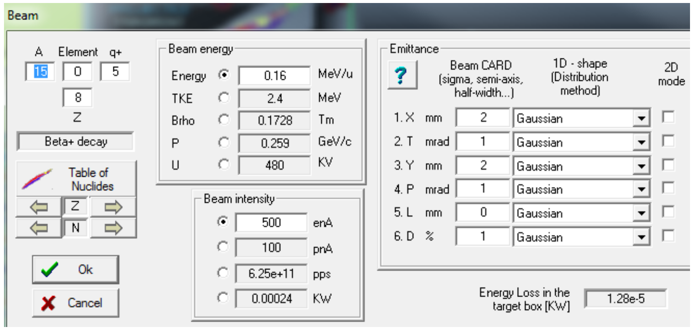
e_DRAGON2000_reaction lpp

Target

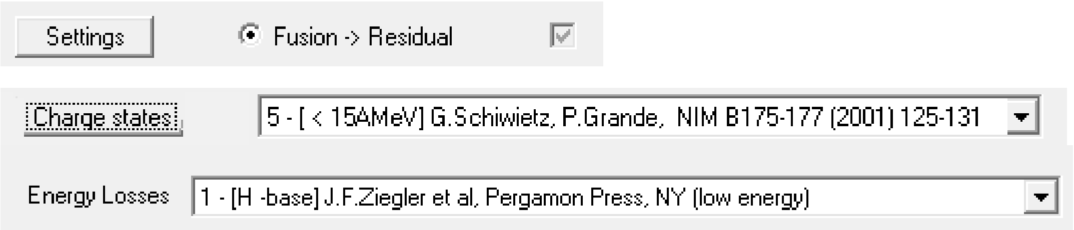




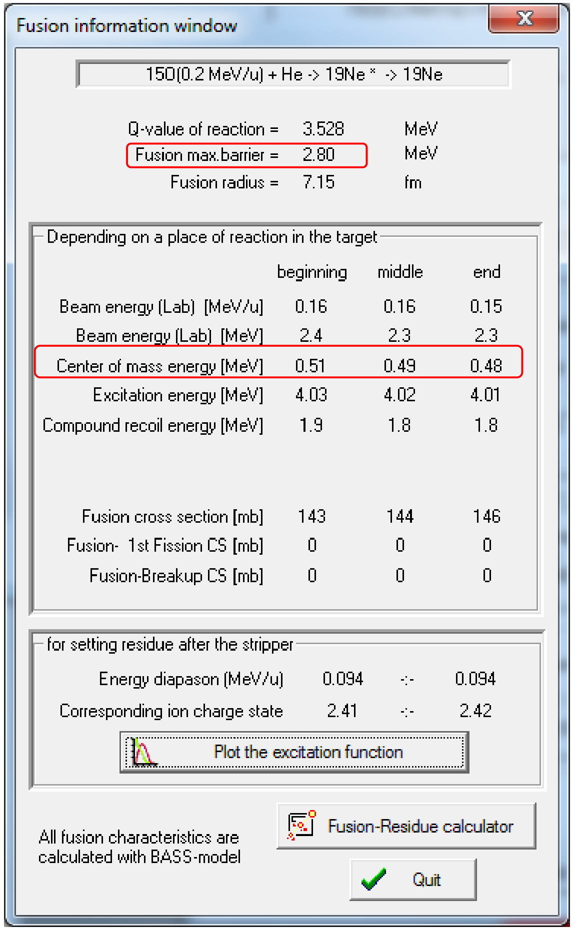
Beam

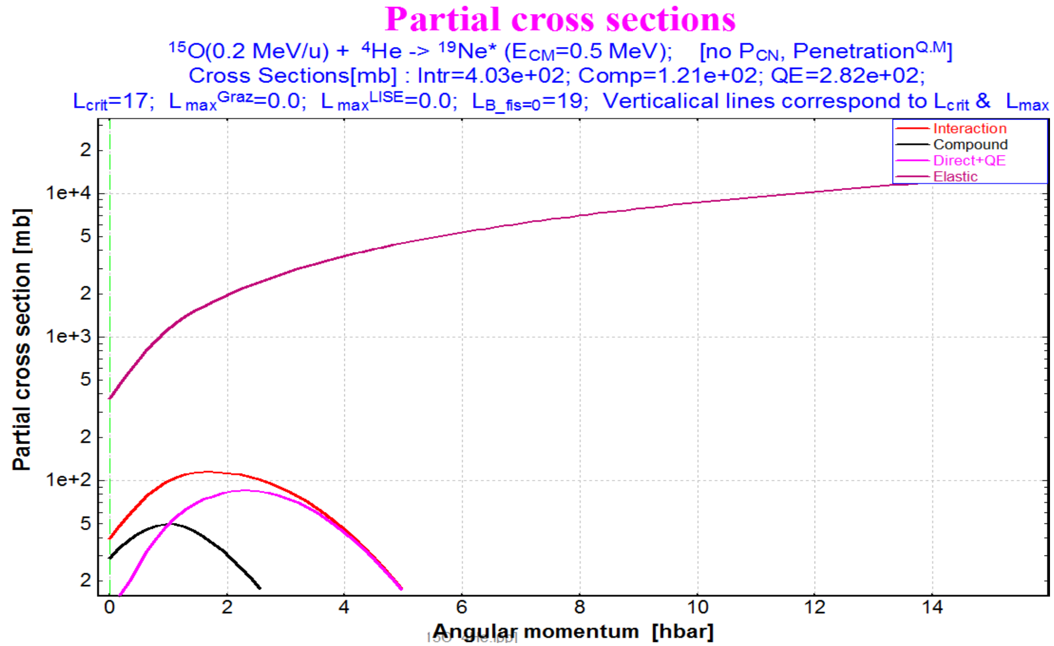


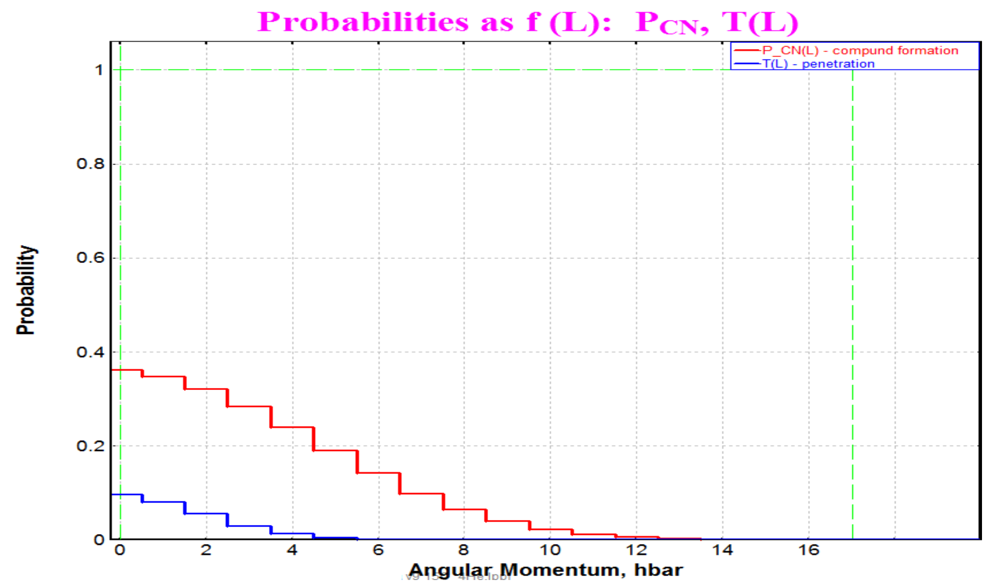
Production mechanism



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





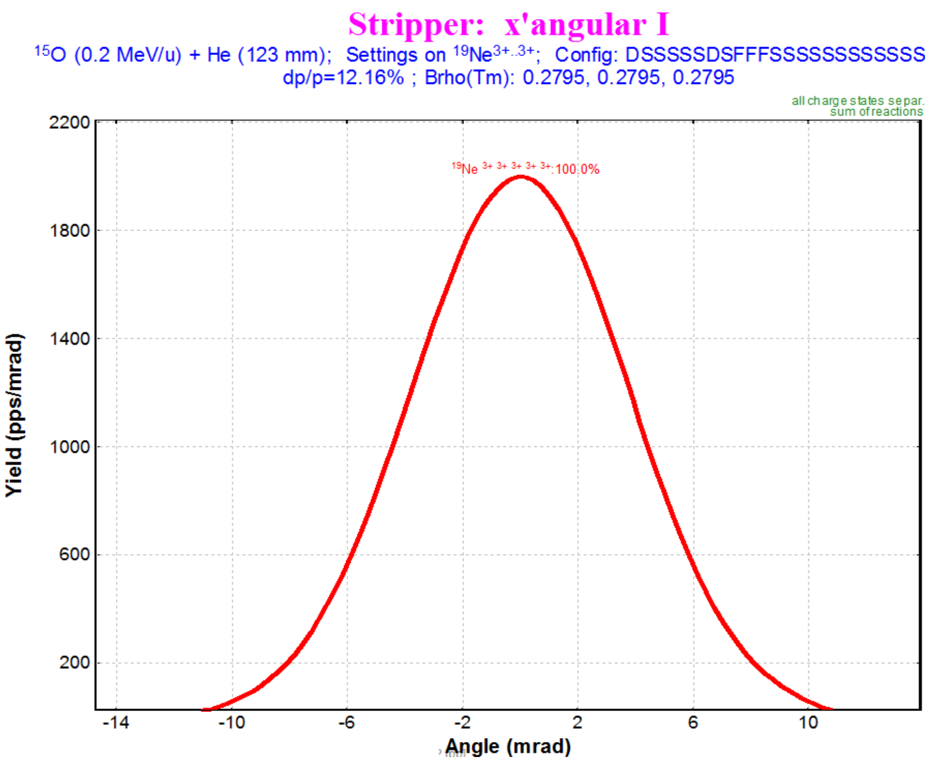


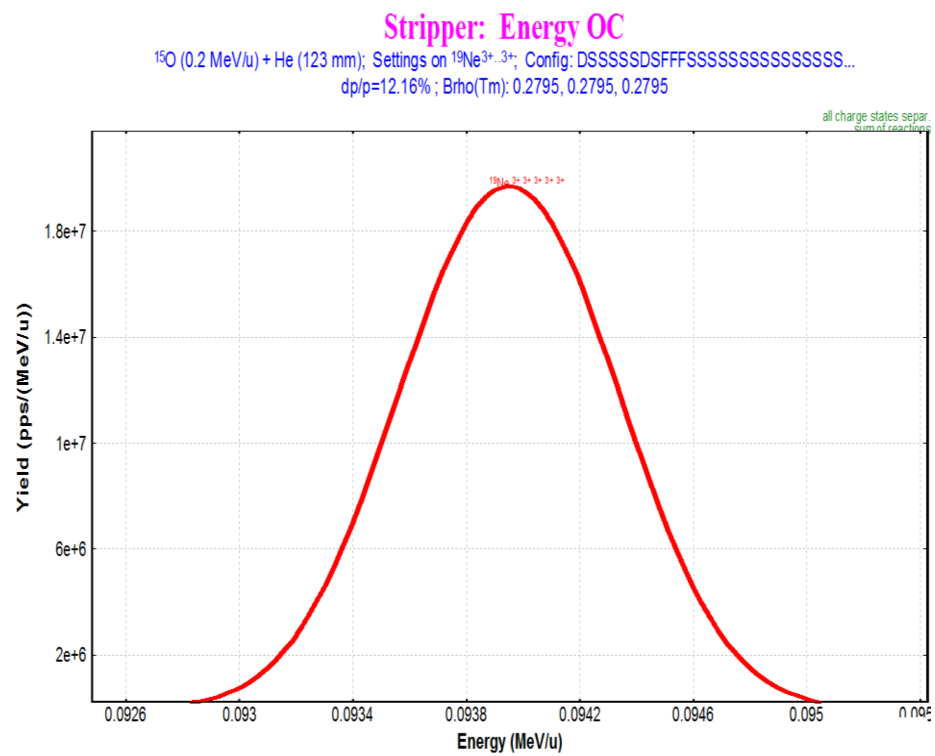
Experiment $^{15}O(\alpha, \gamma)^{19}Ne$: kinematics

At so low energy the compound de-excitation should be considered as two-body kinematics.

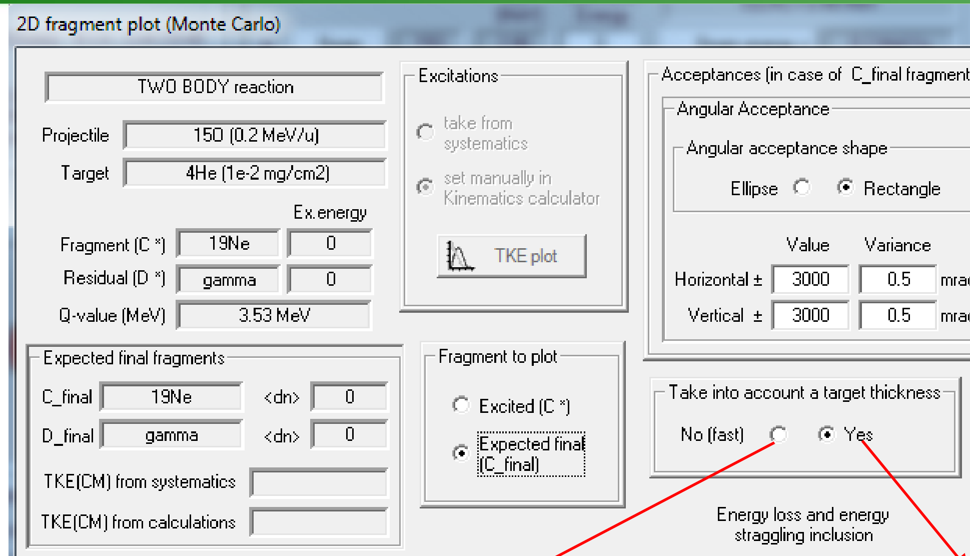
But in LISE^{++} two-body kinematics is used only for two nuclei. No yet option for HI & gamma

^{19}Ne compound distribution from fusion kinematics without gamma-emission taking into account are narrow, Gaussian-shape!!



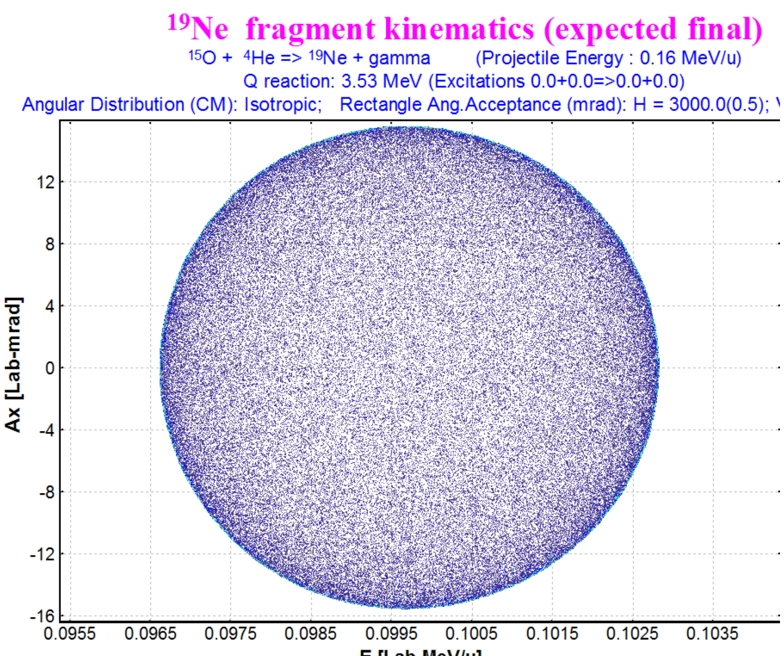


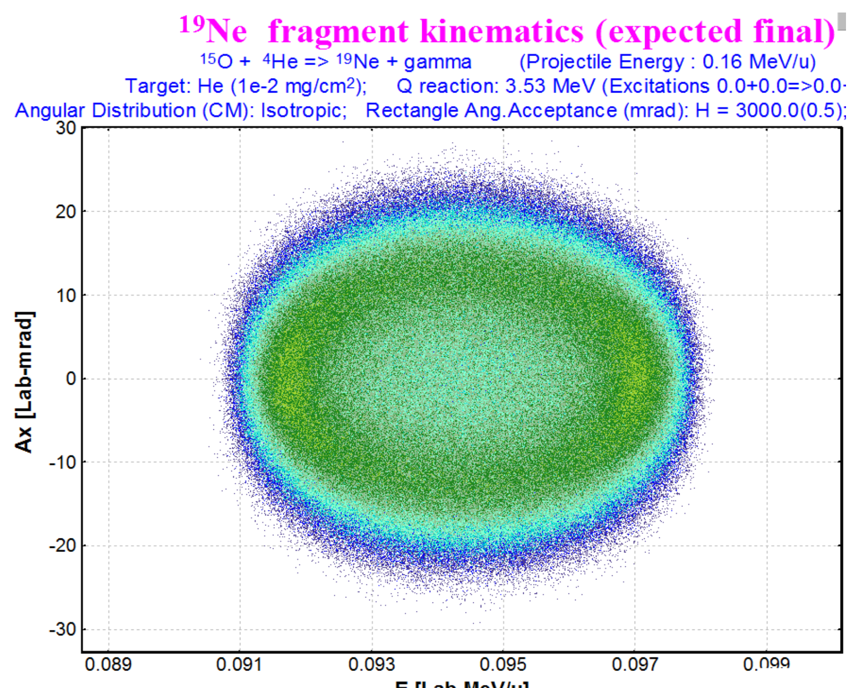
Experiment $^{15}O(\alpha, \gamma)^{19}Ne$: two-body kinematics



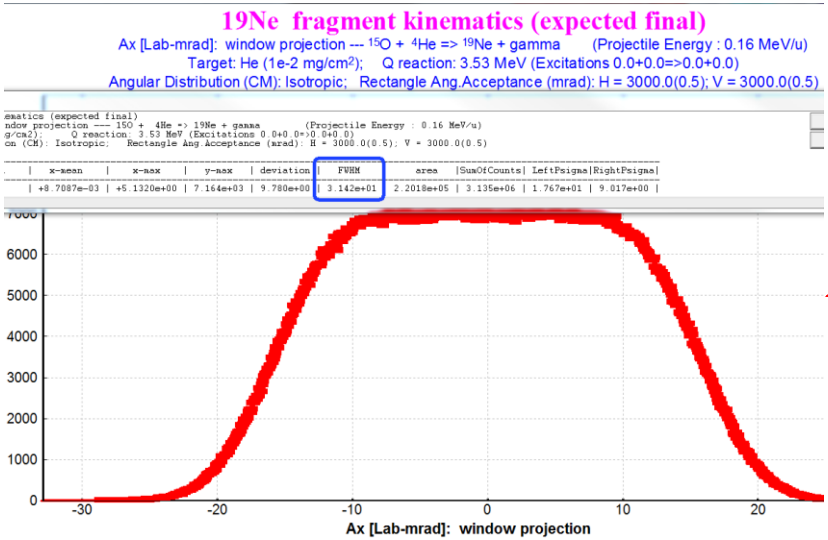
Ax	FWHM
	3.133e+01

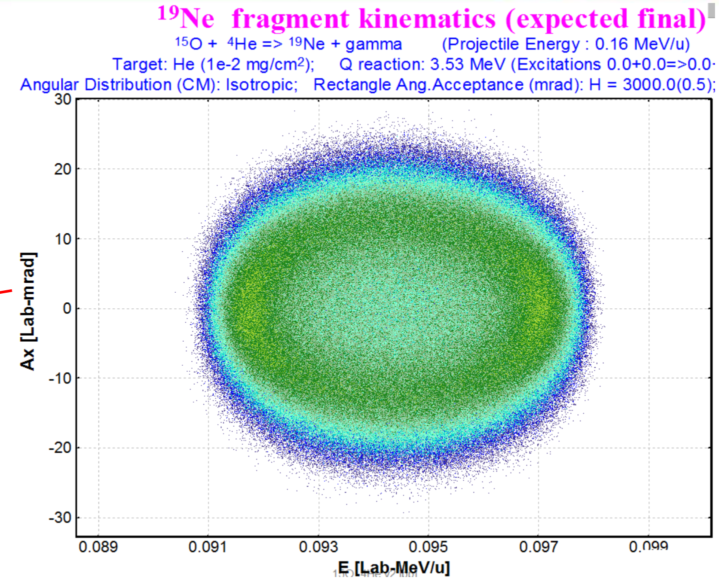
or the cone is equal to 15.6 mrad

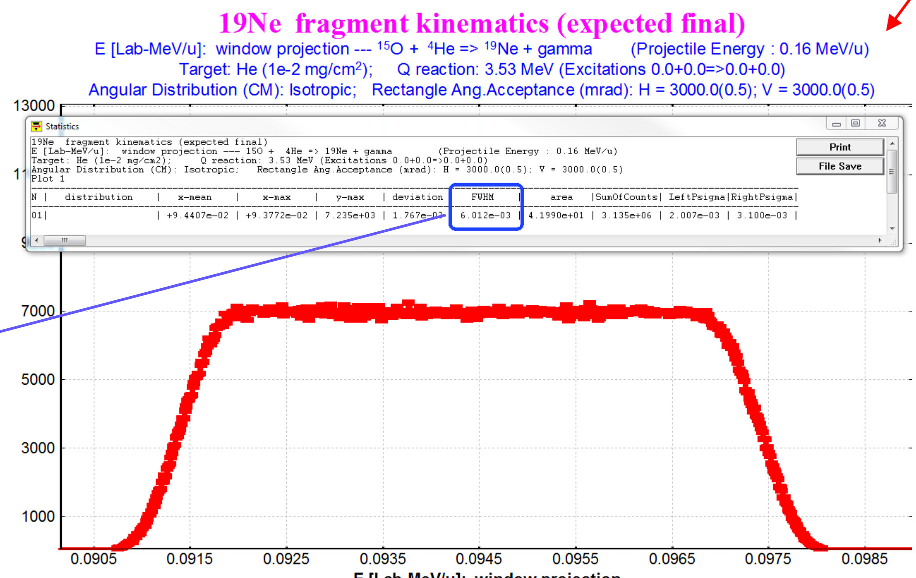




Experiment $^{15}O(\alpha, \gamma)^{19}Ne$: two-body kinematics







It's corresponds to initial rectangle emittance dp/p = +/- 1.5%

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

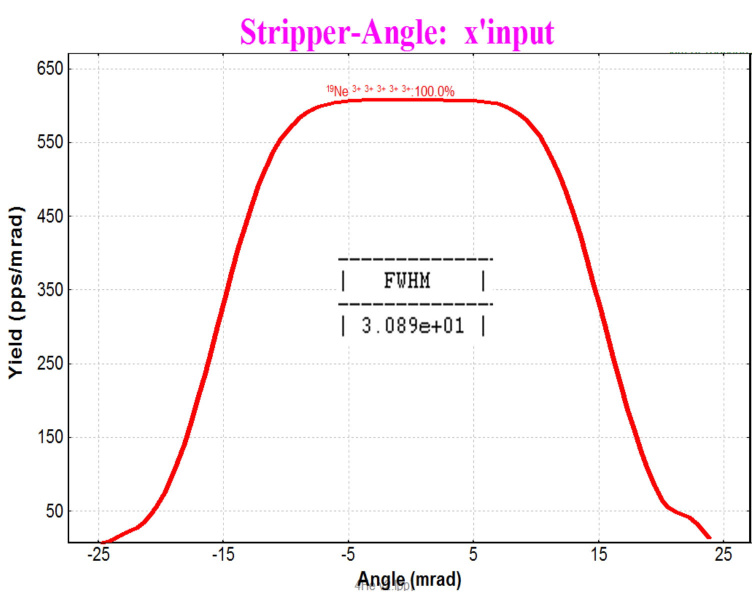
Emittance (initial)

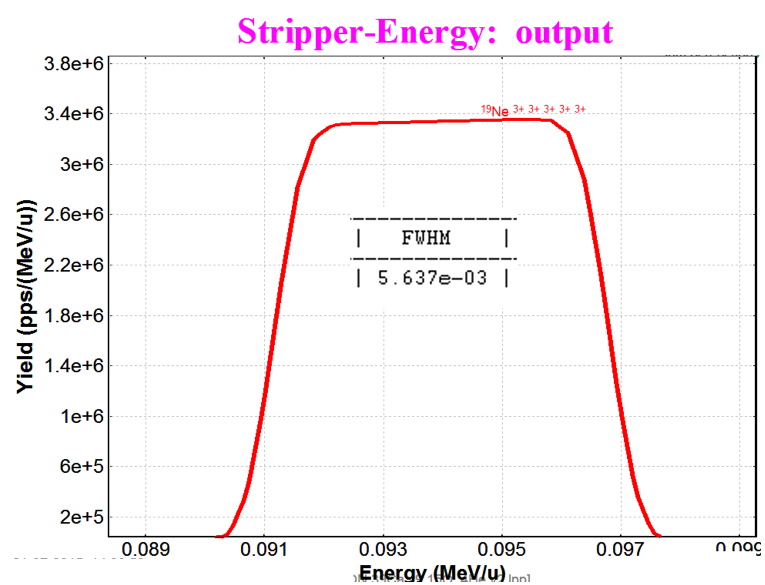
		Beam CARD (sigma, semi-axis, half-width...)	1D - shape (Distribution method)
1. X	mm	2	Gaussian
2. T	mrad	1	Gaussian
3. Y	mm	2	Gaussian
4. P	mrad	1	Gaussian
5. L	mm	0	Gaussian
6. D	%	1	Gaussian

Emittance (changed)

		Beam CARD (sigma, semi-axis, half-width...)	1D - shape (Distribution method)
1. X	mm	2	Gaussian
2. T	mrad	15.5	Rectangle uniform
3. Y	mm	2	Gaussian
4. P	mrad	15.5	Rectangle uniform
5. L	mm	0	Gaussian
6. D	%	1.5	Rectangle uniform

e_DRAGON2000_reaction lpp

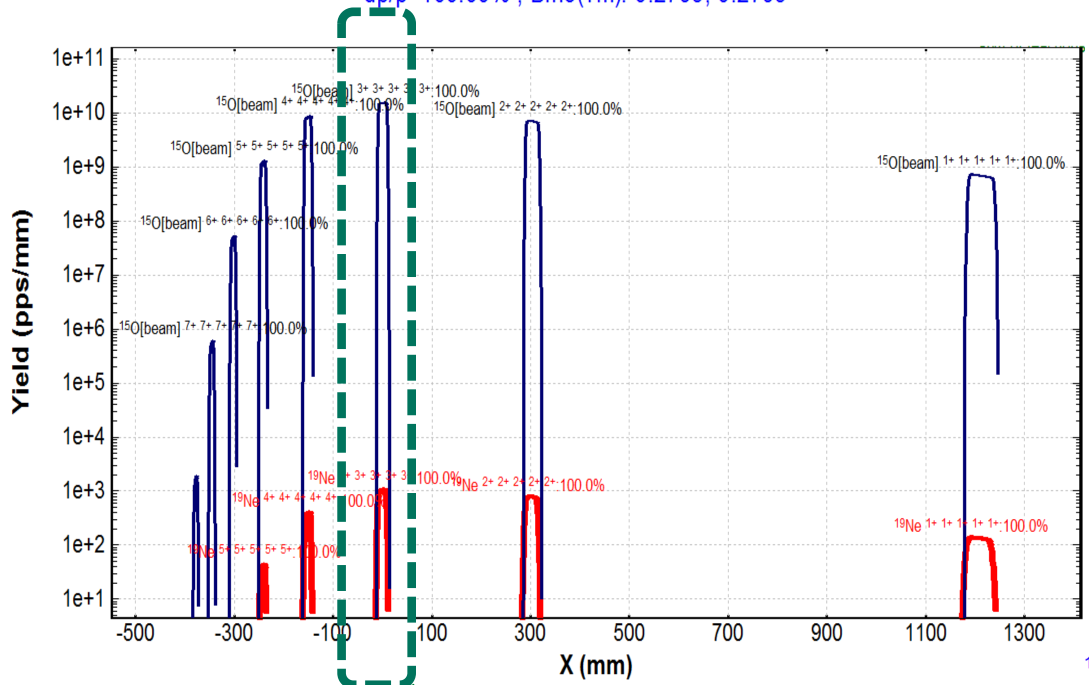




Experiment $^{15}O(\alpha, \gamma)^{19}Ne$: selection

md1-slits : Beam & SetFragment Charge States

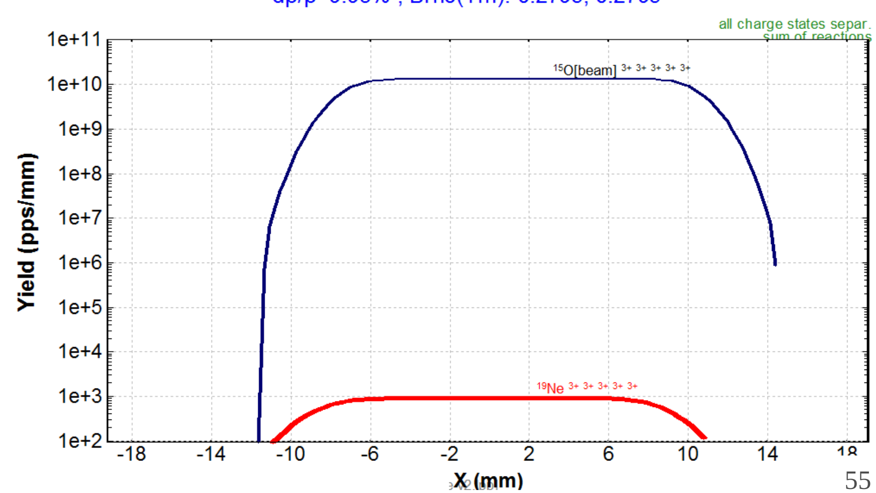
^{15}O (0.2 MeV/u) + He (123 mm); Settings on $^{19}Ne^{3+..3+}$; Config: DSSSSSDSA
dp/p=100.00% ; Brho(Tm): 0.2795, 0.2795



@ Charge Slits

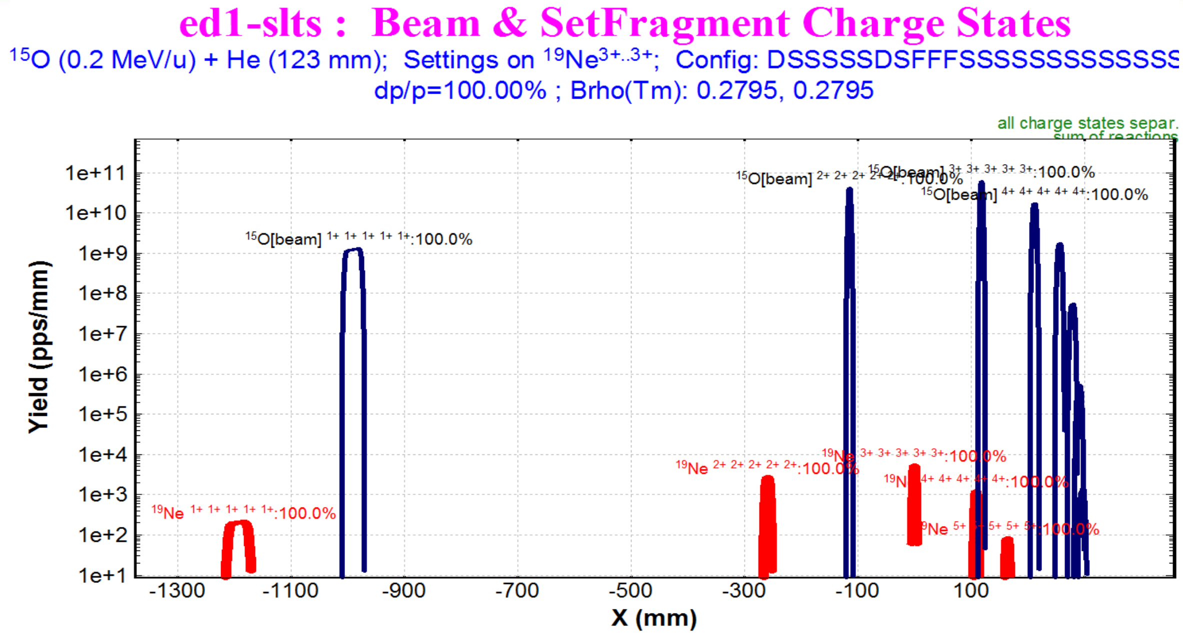
CHARGE slits-Xspace: output after slits

^{15}O (0.2 MeV/u) + He (123 mm); Settings on $^{19}Ne^{3+..3+}$; Config: DSSSSSDSFFFSA
dp/p=9.93% ; Brho(Tm): 0.2795, 0.2795

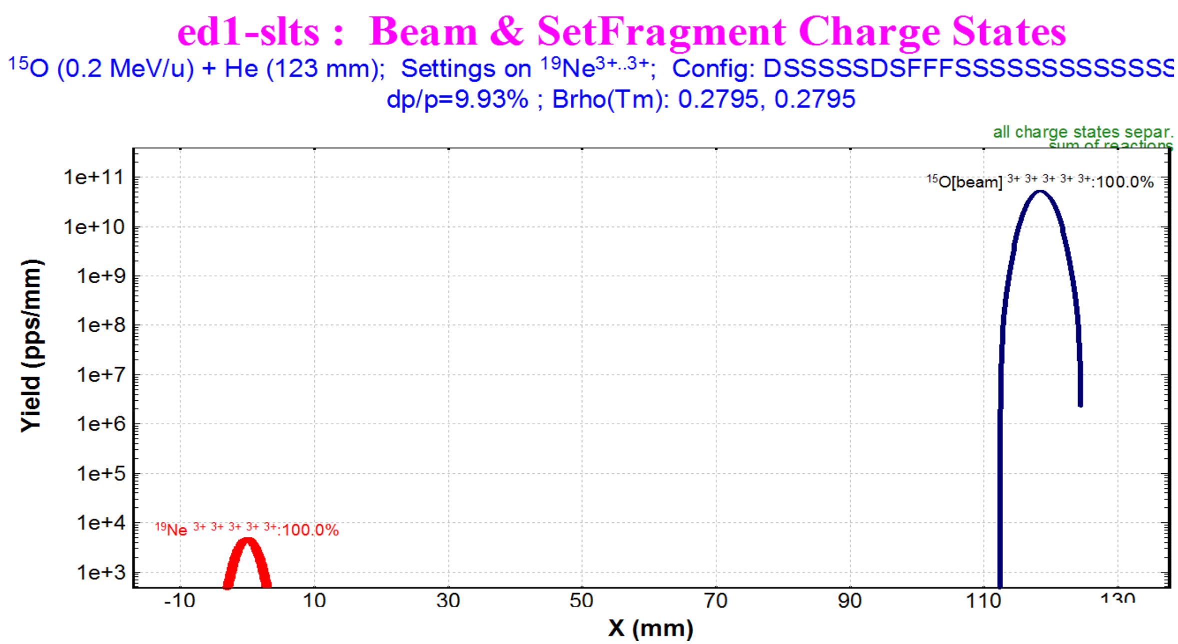


Experiment $^{15}O(\alpha, \gamma)^{19}Ne$: selection

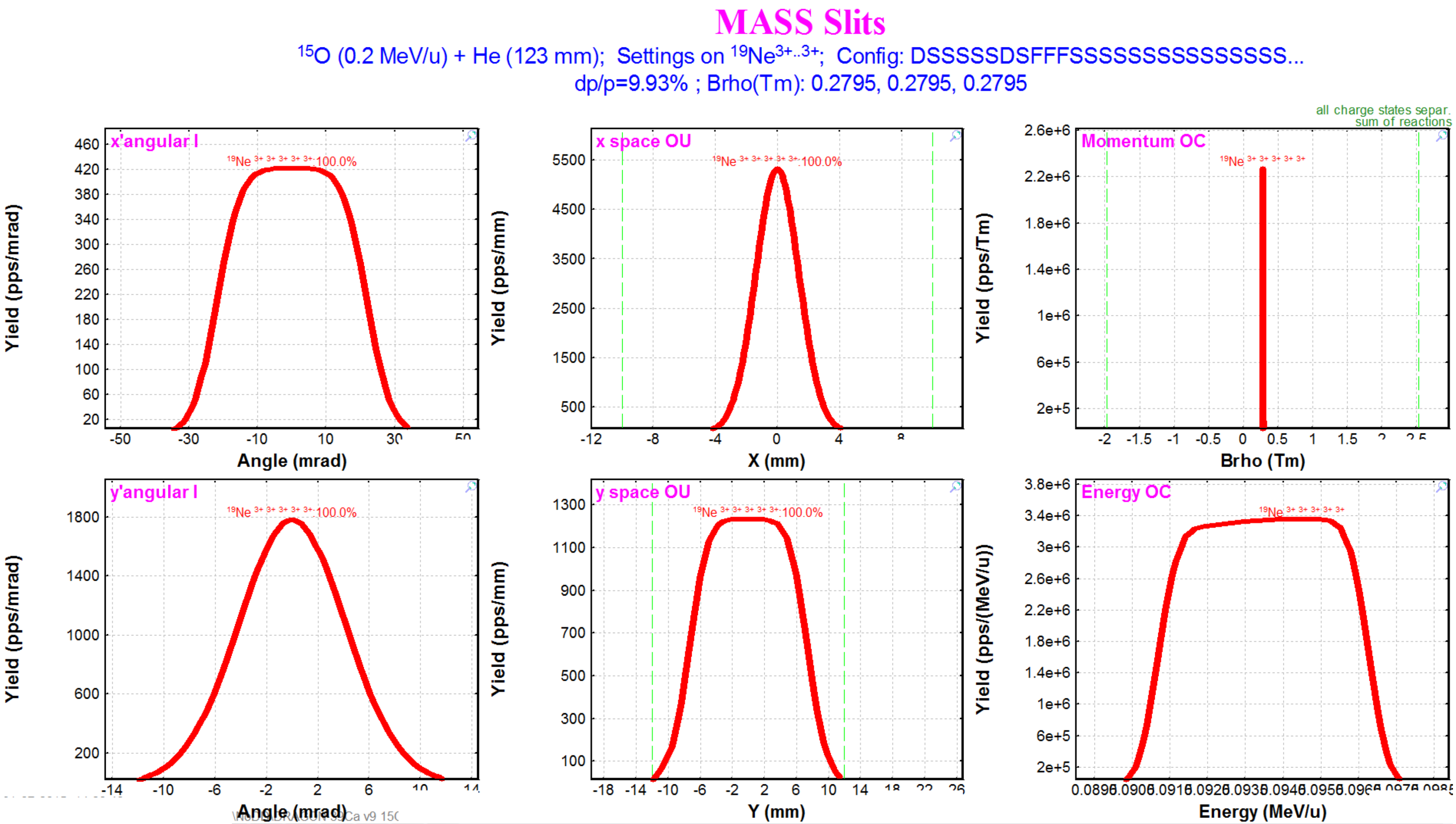
In front of the Mass Slits assuming there are not the Charge slits and Angular acceptances



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



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



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

$^{19}Ne^{3+}$ after the Final Slits

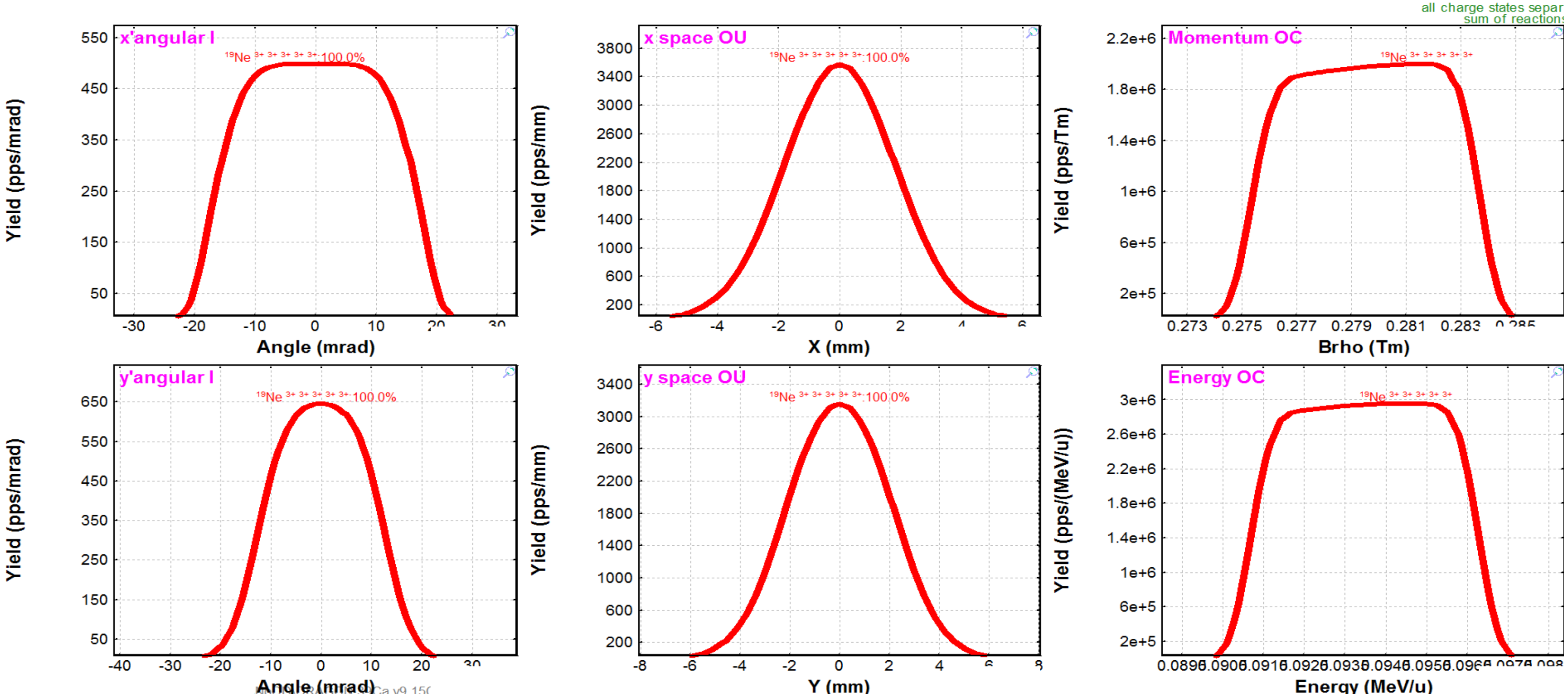
Only $^{19}Ne^{3+}$ passing through the separator !

19Ne	Beta+ decay (Z=10, N=9)	
Q1 (tuning)		3
Q2 (MD1)		3
Q3 (ED1)		3
Q4 (MD2)		3
Q5 (ElecDip 2)		3
Reaction		FusRes
Ion Production Rate	(pps)	1.62e+4
Total ion transmission	(%)	30.863
Total: this reaction	(pps)	1.62e+4
Total: All reactions	(pps)	1.62e+4
X-Section in target	(mb)	5.19e+1
Target	(%)	35.79
Unreacted in material	(%)	100
Q (Charge) ratio	(%)	35.79
Unstopped in material	(%)	100

$^{19}Ne^{3+}$ transmission 86.2%
Main cut by the vertical angular acceptance @ S3

Final Slits

^{15}O (0.2 MeV/u) + He (123 mm); Settings on $^{19}Ne^{3+..3+}$; Config: DSSSSSDSFFFSSSSSSSSSSSSSS...
dp/p=9.93% ; Brho(Tm): 0.2795, 0.2795, 0.2795



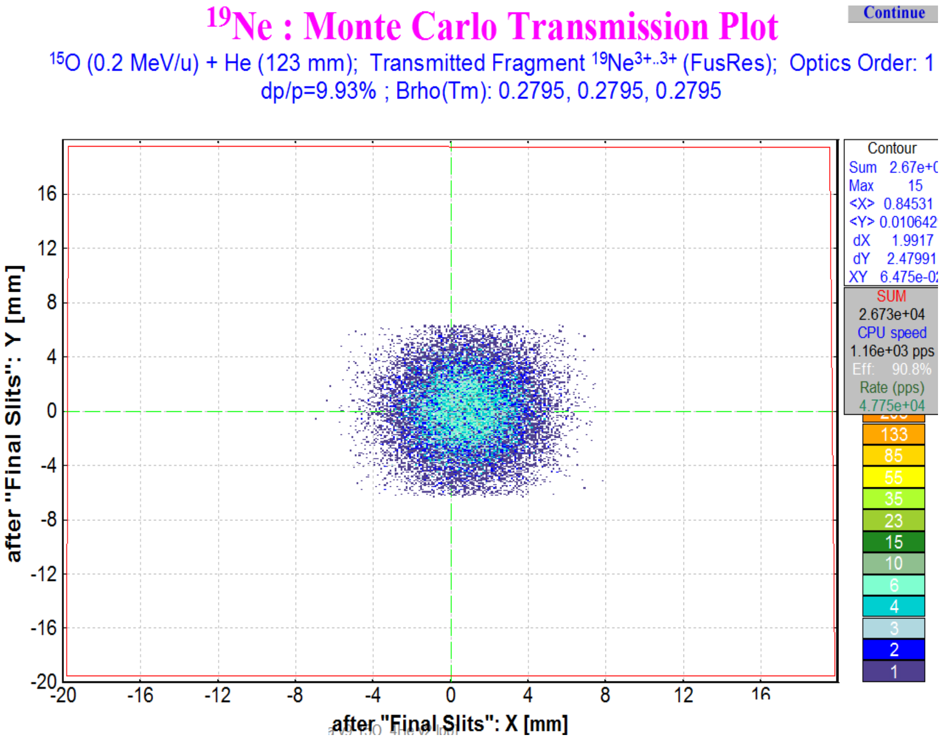
Experiment $^{15}O(\alpha, \gamma)^{19}Ne$: selection

$^{19}Ne^{3+}$ after the Final Slits

Monte Carlo solution :
With bounds, no Angular Acceptances

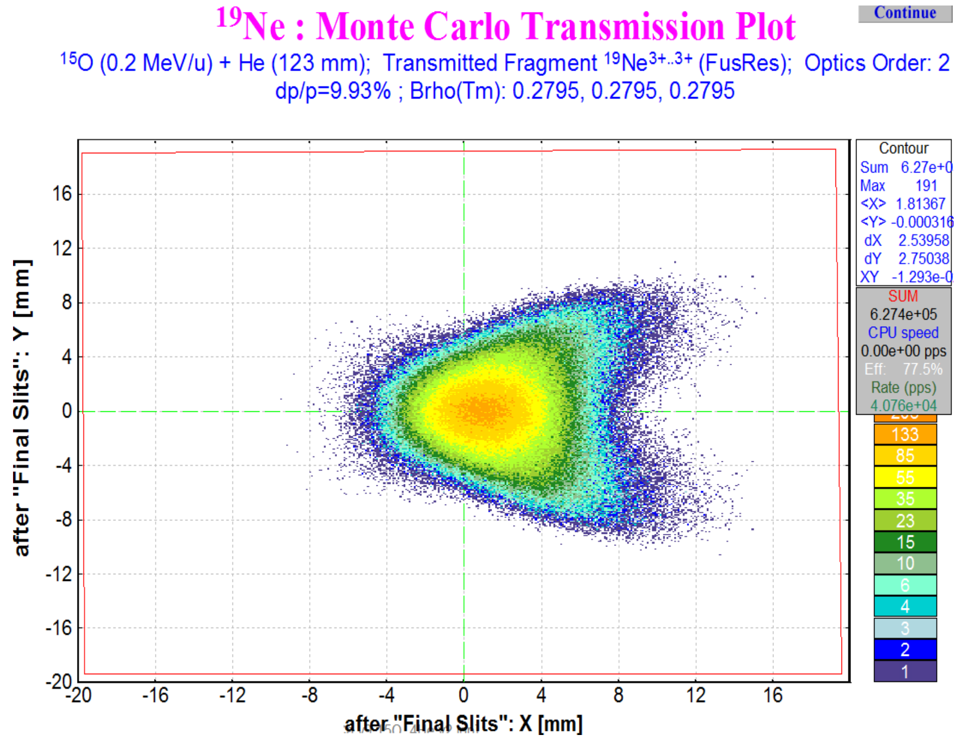
1st order

$^{19}Ne^{3+}$ transmission 90.8%



2nd order

$^{19}Ne^{3+}$ transmission 77.5%

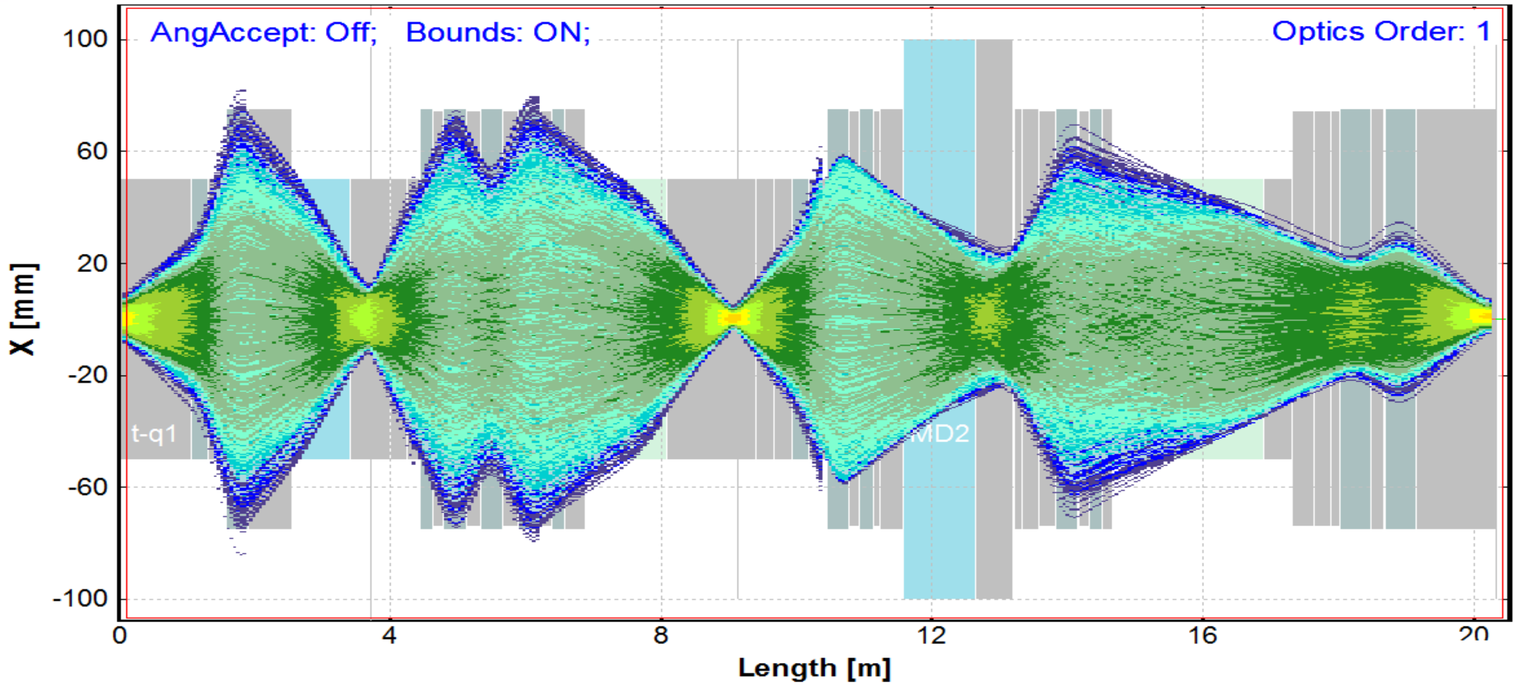


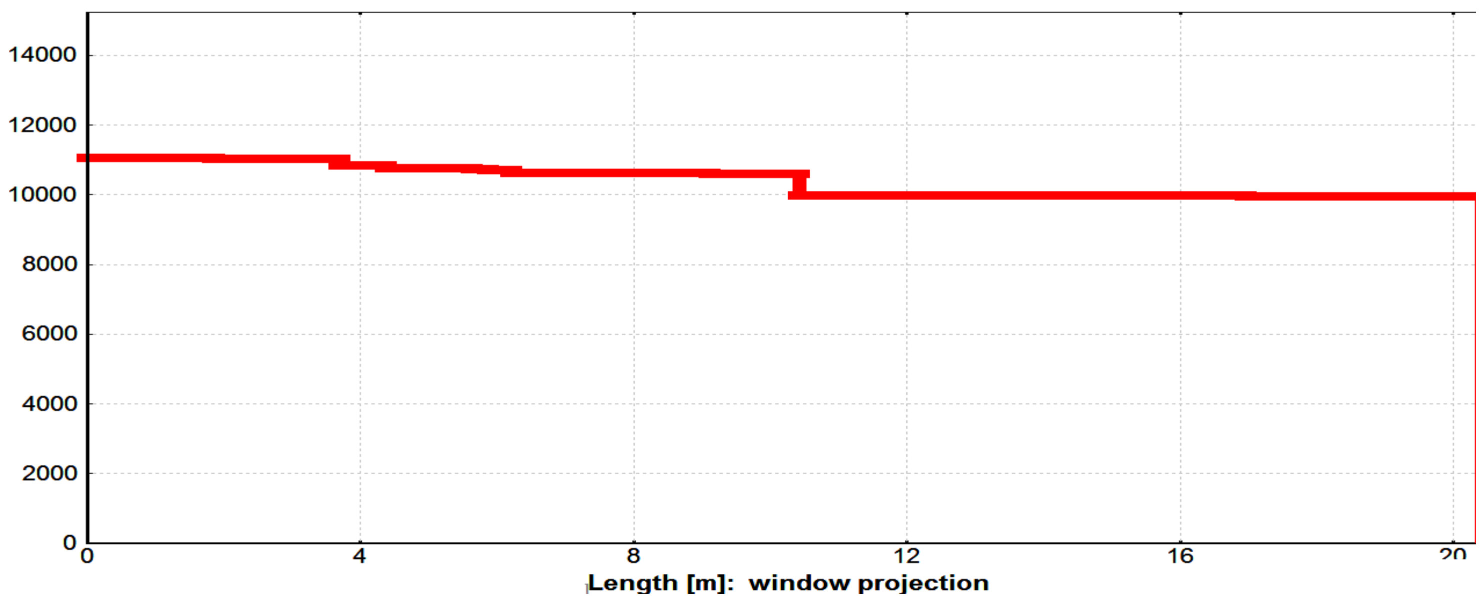
Experiment $^{15}O(\alpha, \gamma)^{19}Ne$: transmission loss

MICHIGAN STATE UNIVERSITY

LISE++

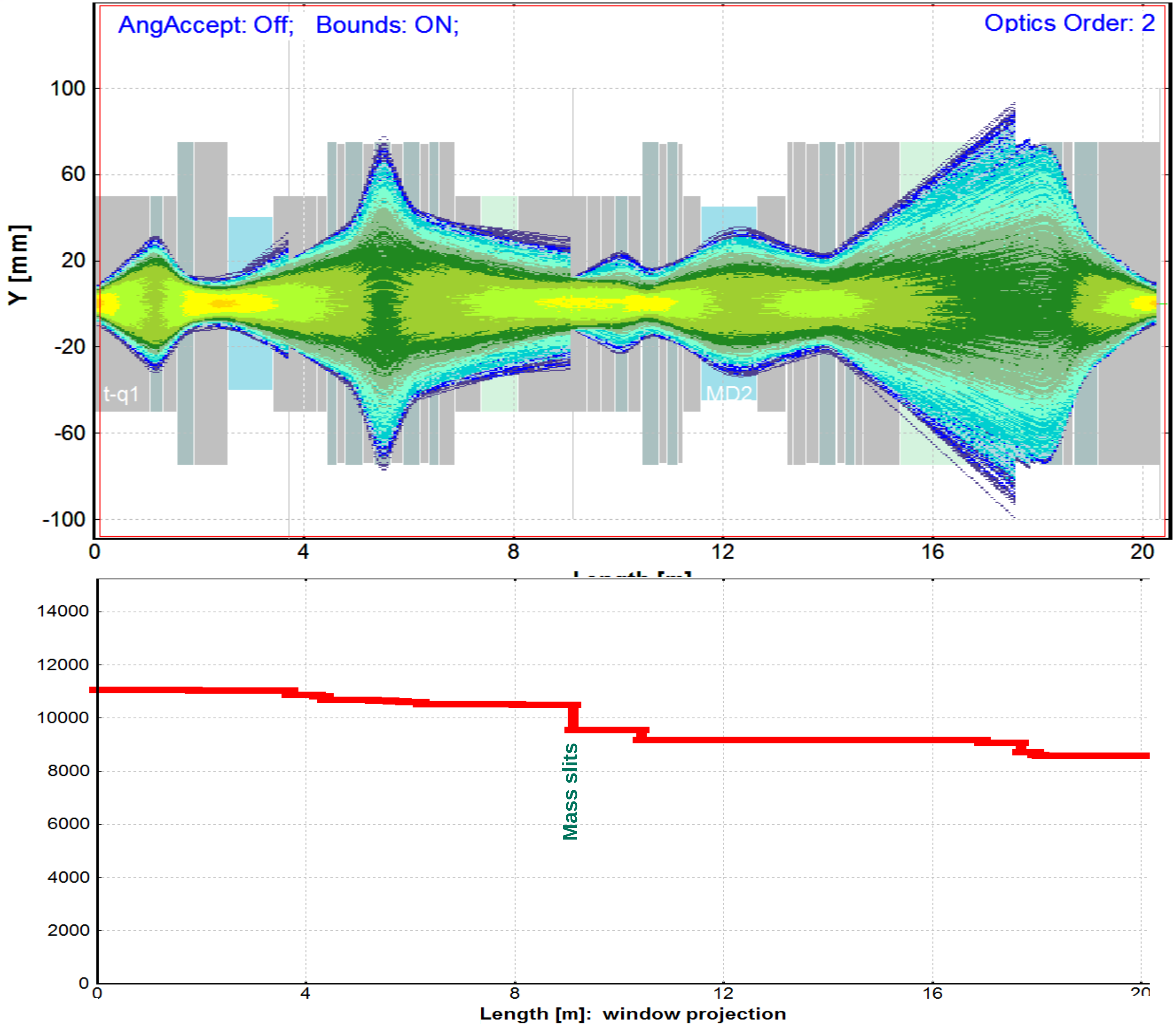
1^{st} order





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

2nd order

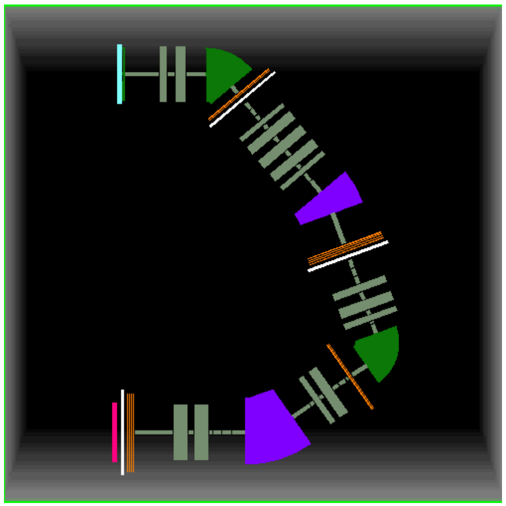


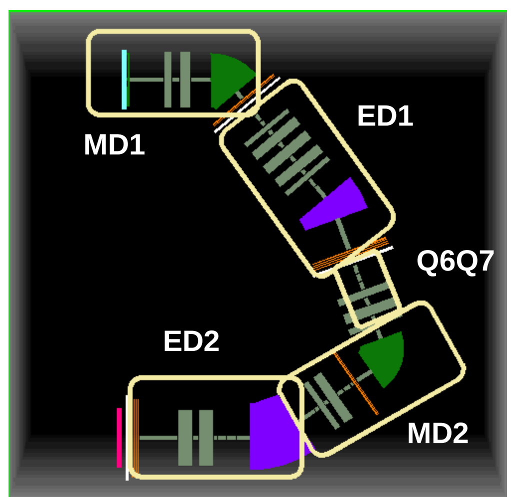
Segmented configuration

Extended

Detail configuration for experts

90 blocks

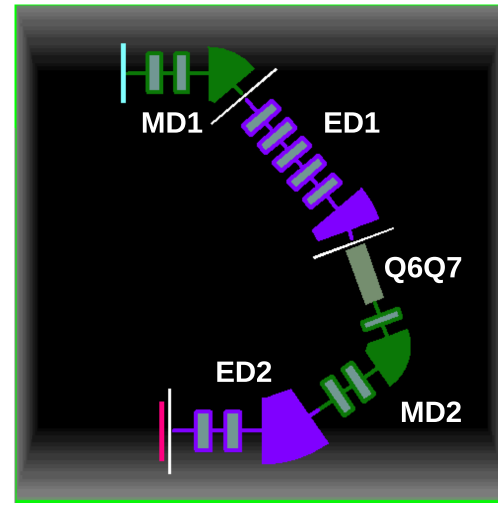




Segmented

"Easy" configuration for regular users

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



s_DRAGON2000 lcn

Segmented configuration

Optics settings (fast editing)

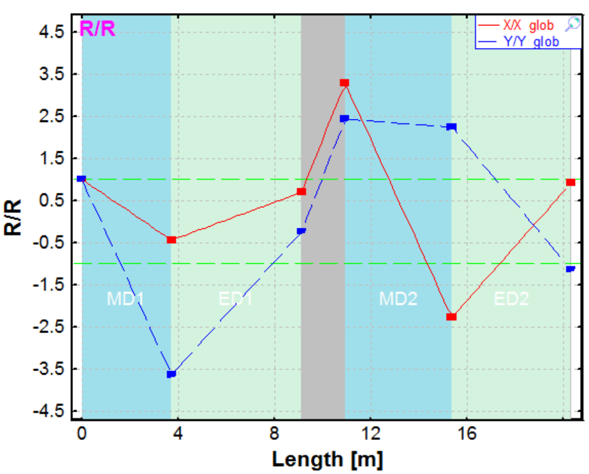
Block	Given Name	Start(m)	Length(m)	B0(kG)/*U	Br(Tm)cor/*real	DriftM/*Angle	Rapp(cm)/*R(...	Leff(m)/*Ldip(m)	2 nd order	CalcMatr/*Z-Q	AngAcc,Apps,Slits	COSY | Fi	SE
= Dipole	MD1	0.000	3.7310	+2.7948	* 0.2795	* +50.0	* 1.0000	* 0.8727	-	* 7	HV -- --	-	S
slits	CHARGE slits	3.731	0.0000			SLITS					-- -- HV	-	e
=ElecDip	ED1	3.731	5.4030	*59.6kV	0.2795	* +20.0	* 2.0000	* 0.6981	-	* 7	HV -- --	-	S
slits	MASS Slits	9.134	0.0000			SLITS					-- -- HV	-	e
beamline	Q6Q7	9.134	1.8050			beam-line					H- -- --	-	s
= Dipole	MD2	10.939	4.4370	+3.4376	* 0.2795	* +75.0	* 0.8130	* 1.0642	-	* 7	-V -- --	-	S
=ElecDip	ED2	15.376	4.9560	*47.7kV	0.2795	* +35.0	* 2.5000	* 1.5272	-	* 7	-- -- --	-	S
slits	Final Slits	20.332	0.0000			SLITS					-- -- HV	-	e

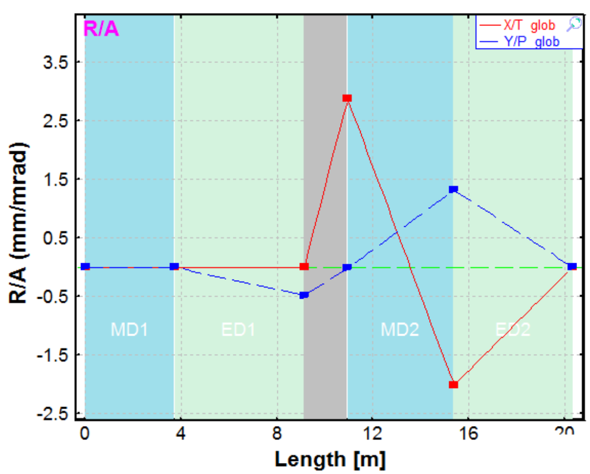
Pay attention for cut settings:
4 angular acceptances, 3 slits

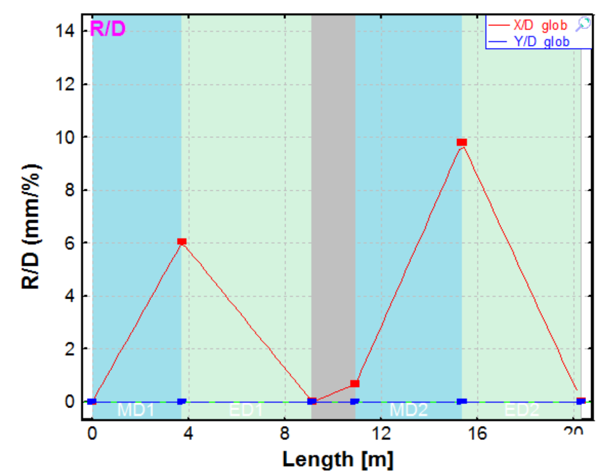
5 sectors
(segments)

First order matrix elements

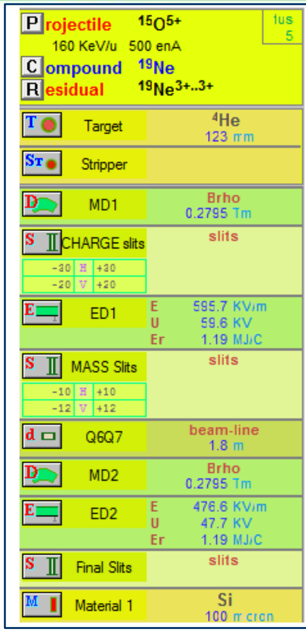
Config: DSESSDESM







Segmented configuration : $^{15}O(\alpha, \gamma)^{19}Ne$ case

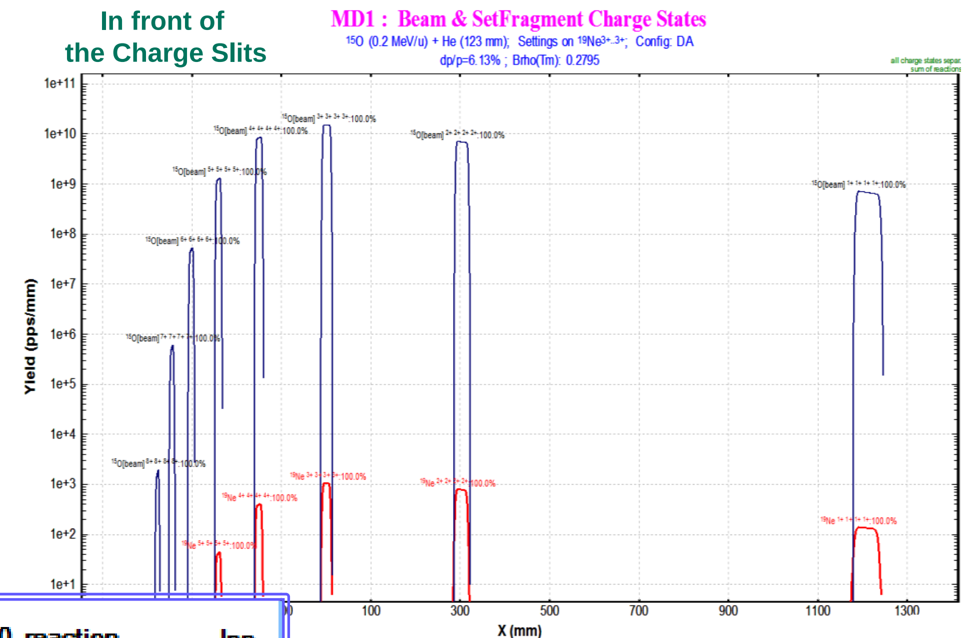


- 19Ne Beta+ decay (Z=10, N=9) —

The same transmission as for the extended configuration (see page 58)

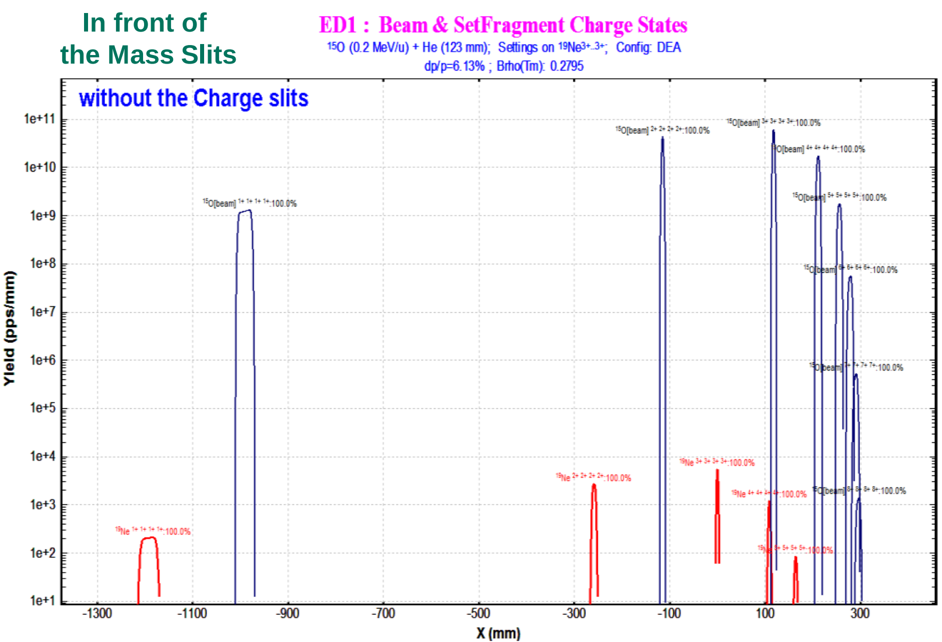
Reaction		FusRes
Ion Production Rate	(pps)	1.62e+4
Total ion transmission	(%)	30.868
Total: this reaction	(pps)	1.62e+4
Total: All reactions	(pps)	1.62e+4
X-Section in target	(mb)	5.19e+1
Target	(%)	35.79
Unreacted in material	(%)	100
Q (Charge) ratio	(%)	35.79
Unstopped in material	(%)	100
MD1	(%)	100
X angular transmission	(%)	100
Y angular transmission	(%)	100
CHARGE slits	(%)	99.67
X space transmission	(%)	100
Y space transmission	(%)	99.67
ED1	(%)	98.27
X angular transmission	(%)	98.27
Y angular transmission	(%)	100
MASS Slits	(%)	100
X space transmission	(%)	100
Y space transmission	(%)	100
Q6Q7	(%)	97.97
X angular transmission	(%)	97.97
MD2	(%)	89.88
Y angular transmission	(%)	89.88
ED2	(%)	

In front of the Charge Slits

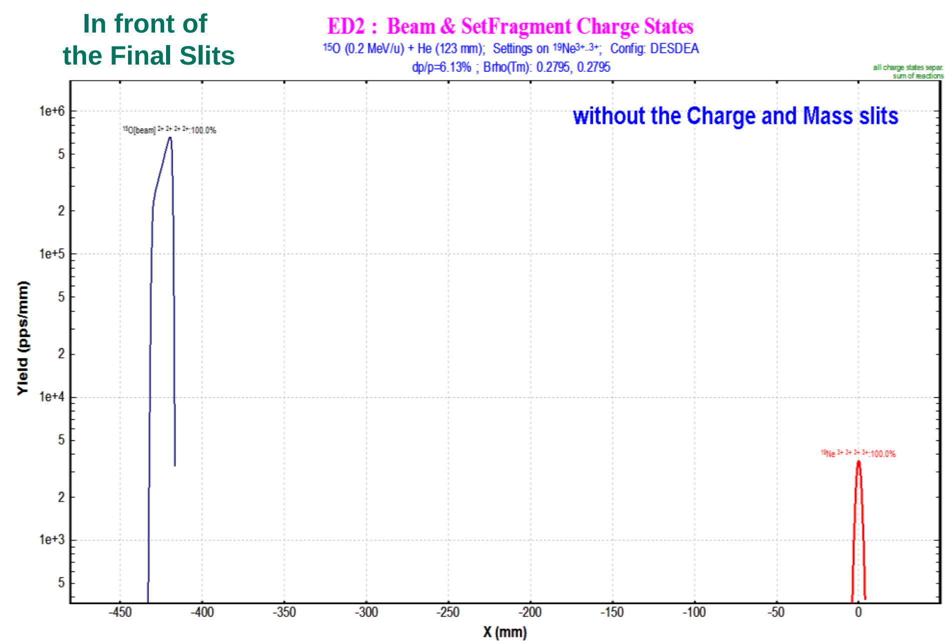


s_DRAGON2000_reaction lpp

In front of the Mass Slits



In front of the Final Slits



Open Questions

1. Differences between DRAGON 2000 and DRAGON 2015, Drifts? Create extended DRAGON2015 configuration
2. Define sextupole field values for LISE++ configuration
3. Develop the two-body kinematics mechanism in the case HI & γ
4. Difference in Quad fields between DRAGON 2000 and DRAGON 2015 :

Table 2.5: Field strengths for rigidities 0.5 T·m and 8 MV scaled from the GIOS input file reso2000.dat Tunes must be obtained by scaling to the rigidities of a given reaction.Note that the sextupole strengths have been scaled to the new L_{eff} values listed in table 1.2.

DRAGON 2000

Element	Gap or Diam.	Effective length	Field
Q1	10.8 cm	25.23 cm	-2.187 kG
Q2	15.9 cm	33.385 cm	+2.003 kG
S0	15.9 cm	33.385 cm	+0.106 kG
MD1	10 cm		+4.991 kG
S1	15.9 cm	18.75 cm	+0.425 kG
Q3	15.9 cm	33.38 cm	+1.826 kG
Q4	15.9 cm	33.38 cm	-2.412 kG
Q5	15.9 cm	33.38 cm	+1.329 kG
S2	15.9 cm	18.75 cm	+0.089 kG
ED1	10 cm		±200. kV
Q6	10.8 cm	25.23 cm	-1.181 kG
Q7	15.9 cm	33.38 cm	+1.696 kG
S3	16 cm	19.9 cm	+0.047 kG
MD2	12 cm		6.139 kG
Q8	15.9 cm	33.38 cm	+1.257 kG
S4	16 cm	19.9 cm	+0.360 kG
ED2	10 cm		±160. kV
Q9	15 cm	46.7 cm	-0.972 kG
Q10	15 cm	46.7 cm	+1.087 kG

?

http://dragon.triumf.ca/DragonTools.php#md1

MD1 field [G]: 5000 MD1 setpoint [A]: 1
Mass number: 39 Charge state: 13
ED1 setpoint voltage [kV]:
calculate

E = 1339.72 keV/u = 52.249 MeV
ED1 = 205.67 kV, ED2 = 164.54 kV

Please insert B and ED1 to calculate the mass-to-charge ratio (and q for mass).

Magnet	Field
Q1	3545
Q2	3385
MD1	5000
Q3	2765
Q4	3675
Q5	1905
Q6	1830
Q7	2560
MD2	6150
Q8	1935
Q9	1190
Q10	1330

Magnet	Setpoint
SX1	0.0528
SX2	0.0112
MD1	1
SX3	0.01
SX4	0.0974