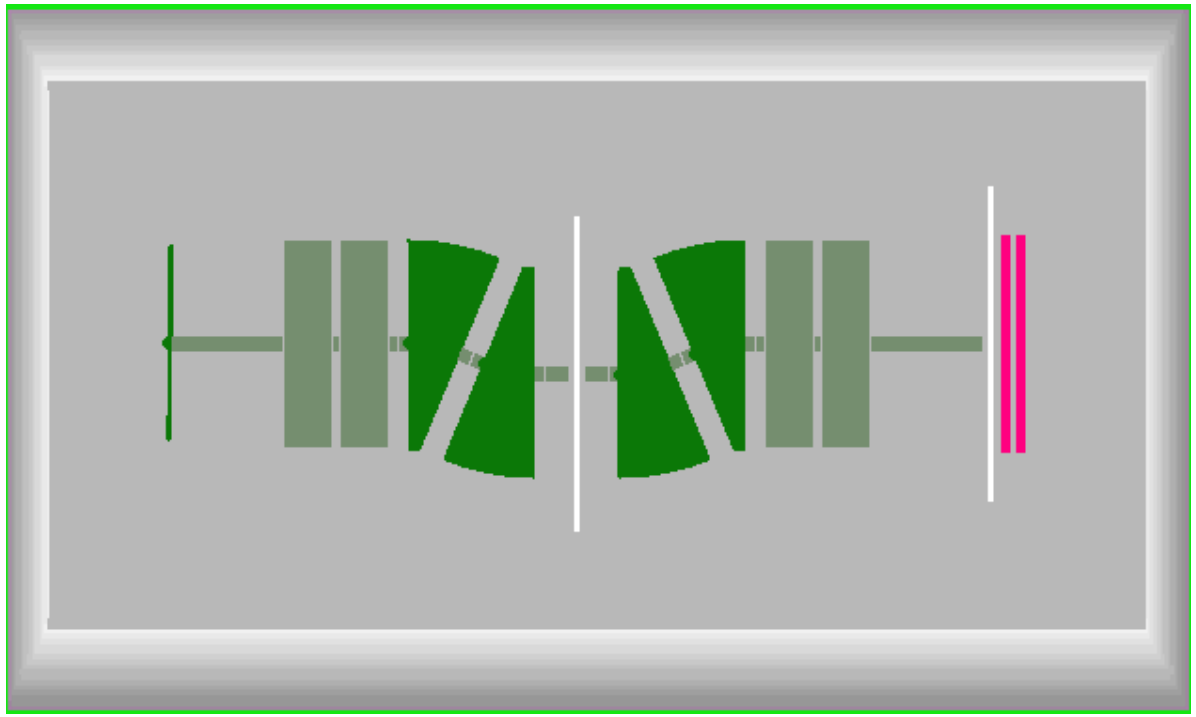
Argonne In-Flight Radioactive Ion Separator (AIRIS)

AIRIS: https://www.phy.anl.gov/airis/



Version 4:

Quad Pole-radii 4 cm instead 3.5 cm,
Dipole vertical half-gaps 4 cm instead 3.5 cm.

Now agreement between LISE^{++} and
COSY in quad-fields

RF kicker

F11

Topic	: configuration	URL address
Optics with beam	: extended	http://lise.nscl.msu.edu/10_1/AIRIS/**e_AIRIS_v4_beam**.lpp
Experiment	: extended	http://lise.nscl.msu.edu/10_1/AIRIS/**e_AIRIS_v4_experiment**.lpp
Experiment	: segmented	http://lise.nscl.msu.edu/10_1/AIRIS/**s_AIRIS_v4_experiment**.lpp
AIRIS2 Bis-version	: extended	http://lise.nscl.msu.edu/10_1/AIRIS/**e_AIRIS2_bis**.lpp

Optics optimization in LISE++

Block with parameters to vary

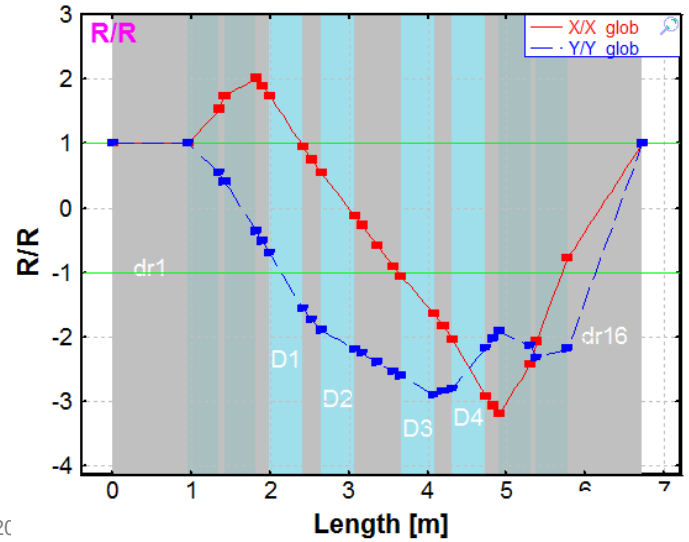
Constraints

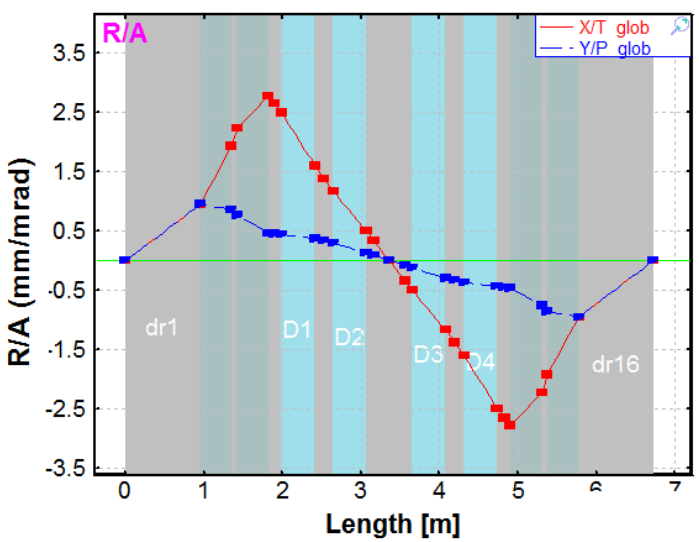
Final matrix

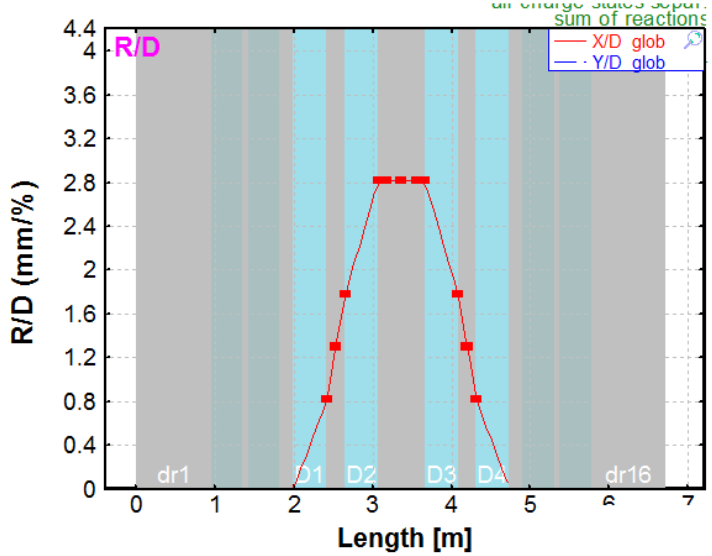
```
c:\program files (x86)\lise\results\AIRIS v4 beam.fit_init
chi2: Initial   0.0152462  LISE fit reduced values
chi1: Initial    0.506632  LISE fit reduced values

Parameters:          LeftBound       Initial      RightBound
#01-q: Q1          -1.0e+99  <  -4.644e+00  <  +1.0e+99
#02-q: Q2          -1.0e+99  <  +4.182e+00  <  +1.0e+99
#03-q: Q3          +3.0e+00  <  +4.182e+00  <  +4.5e+00
#04-q: Q4          -5.0e+00  <  -4.643e+00  <  -3.5e+00

Constraint values:    Initial        Y-value       Precision   (Init-Des)/P|     Desired
#01: FocX          -6.454e-06     -6.454e-06      1.0e-03    +6.454e-03 |   = 0
#02: FocY          -2.210e-06     -2.210e-06      1.0e-02    +2.210e-04 |   = 0
#03: FP FocX       +4.762e-04     +4.762e-04      1.0e-03    +4.762e-01 |   = 0
#04: FP FocY       -2.377e-04     -2.377e-04      1.0e-02    +2.377e-02 |   = 0
#05: FP dipX       +1.894e-16     +1.894e-16      1.0e-02     0         |   = 0

==> "FP dipX" : last fitting block global optical matrix and sigma vector

                                                    Format [mm-mrad]
=================== G L O B A L ====  matrix ==================  | Beam(sigma) |
   +1.000e+00  +4.762e-04   0           0          0    +1.894e-16  |    1.00e+00 |
   +1.871e+00  +1.000e+00   0           0          0    +1.772e-16  |    4.01e+01 |
    0           0          +9.994e-01  -2.377e-04  0     0          |    9.99e-01 |
    0           0          +3.349e+00  +9.998e-01  0     0          |    4.01e+01 |
   -1.110e-16  -1.110e-16   0           0          1.0   +1.724e+00  |    1.72e+00 |
    0           0          0           0          0     +1.000e+00  |    1.00e+00 |
```

First order matrix elements

^{14}O (14 MeV/u); Settings on $^{14}O^{8+..8+}$; Config: DSSSSSSDSSDSSFFSSSDSSDSSSS...







LISE^{++} and COSY calculation comparison

MICHIGAN STATE UNIVERSITY

	LISE^{++}		COSY
Calculated fields	Mass=A*amu Bρ = 0.94612 Tm Q1= -4.6349 kG Q2=+4.1821 kG	$^{14}O^{8+}$ E=196 MeV	Bρ = 0.94626 Tm Q1= -4.6483 kG Q2=+4.1899 kG
1st half	Global matrix		6 1
Both halves	Global matrix		6 1

Global matrix

-0.58611	-6.454e-7	0	0	0	0.28157	[cm]
-15.95854	-1.70619	0	0	0	0	[mrad]
0	0	-2.39548	-2.21e-7	0	0	[cm]
0	0	-6.99108	-0.41745	0	0	[mrad]
-0.44934	-0.04804	0	0	1	0.08619	[cm]
0	0	0	0	0	1	[%]
/[cm]	/[mrad]	/[cm]	/[mrad]	/[cm]	/[%]	

```
6 1
-0.58320E+00 -0.95784E-06  0.00000E+00  0.00000E+00  0.00000E+00  0.27835E+00
-0.16022E+02 -0.17147E+01  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
 0.00000E+00  0.00000E+00 -0.23918E+01 -0.14729E-06  0.00000E+00  0.00000E+00
 0.00000E+00  0.00000E+00 -0.70355E+01 -0.41810E+00  0.00000E+00  0.00000E+00
-0.44597E+00 -0.47729E-01  0.00000E+00  0.00000E+00  0.10000E+01  0.84958E-01
 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.10000E+01
```

Global matrix

1.00048	4.762e-5	0	0	0	0	[cm]
18.71078	1.00041	0	0	0	0	[mrad]
0	0	0.99941	-2.377e-5	0	0	[cm]
0	0	33.48892	0.9998	0	0	[mrad]
0	0	0	0	1	0.17238	[cm]
0	0	0	0	0	1	[%]
/[cm]	/[mrad]	/[cm]	/[mrad]	/[cm]	/[%]	

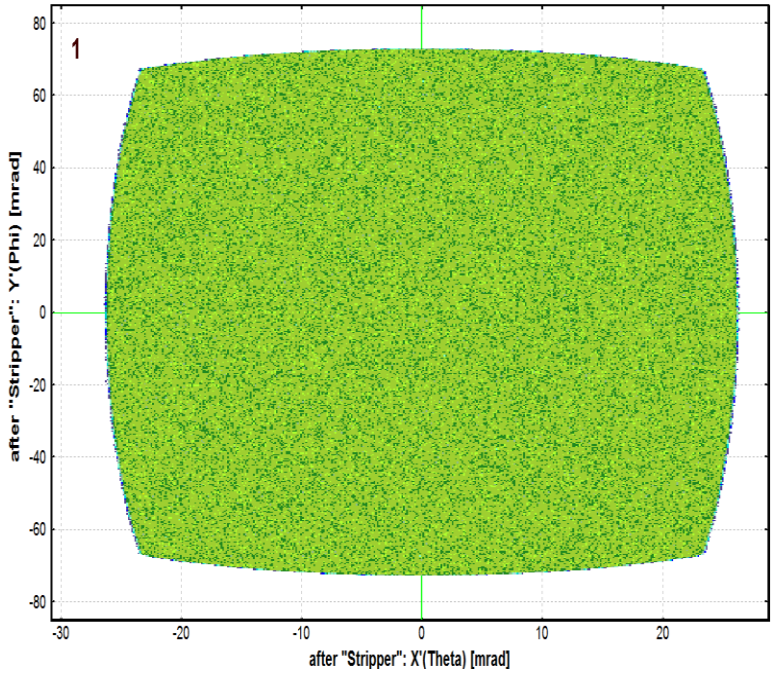
```
6 1
 0.10000E+01  0.32849E-05  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
 0.18688E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
 0.00000E+00  0.00000E+00  0.10000E+01  0.12316E-06  0.00000E+00  0.00000E+00
 0.00000E+00  0.00000E+00  0.33655E+02  0.10000E+01  0.00000E+00  0.00000E+00
 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.10000E+01  0.16992E+00
 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.10000E+01
```

Angular acceptances

1st half

rectangle
X’ = ± 26 mrad
Y’ = ± 72 mrad

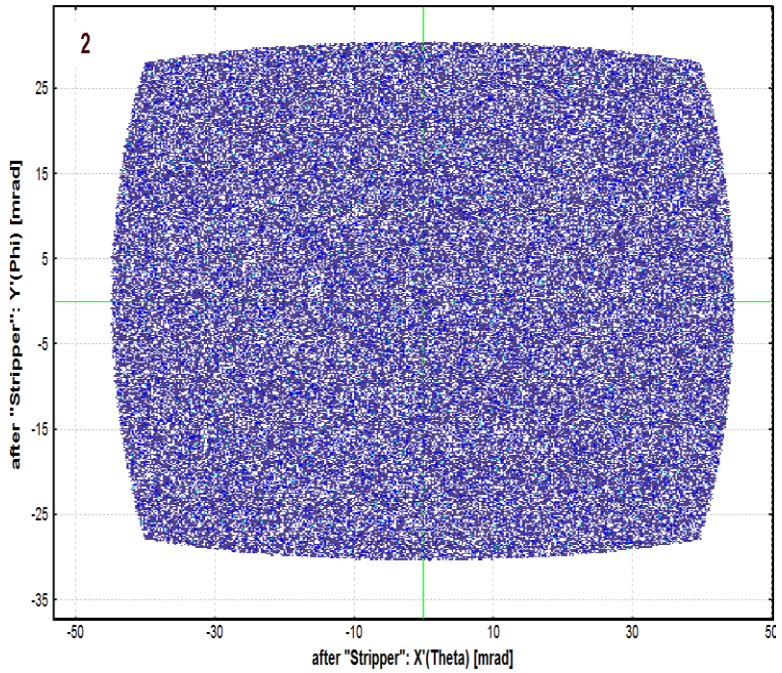
Solid angle 7.49 msr



2nd half

rectangle
X’ = ± 43 mrad
Y’ = ± 30 mrad

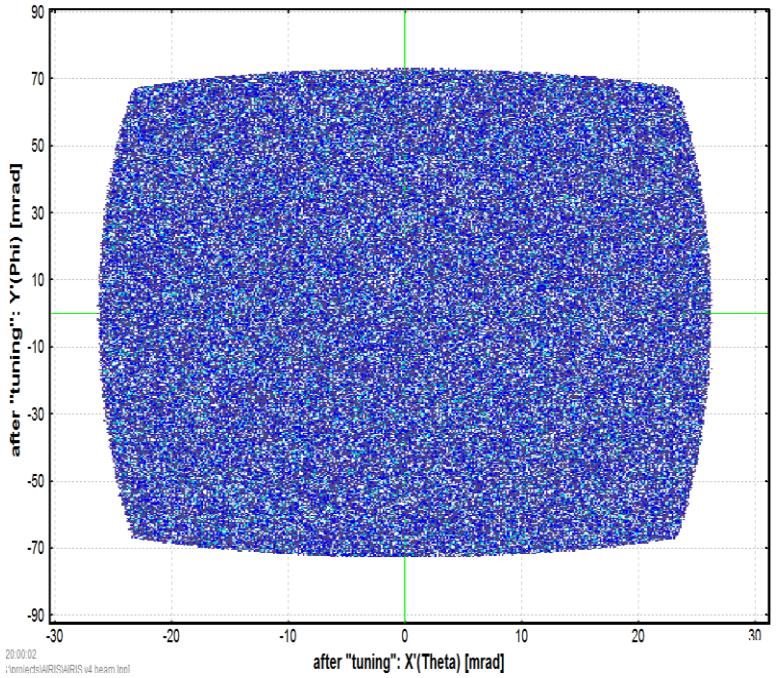
Solid angle 5.16 msr



Total

rectangle
X’ = ± 25 mrad
Y’ = ± 72 mrad

Solid angle 7.2 msr



Angular acceptance benchmark: Monte Carlo & Distribution methods

Monte Carlo

Angular Acceptance & Bounds

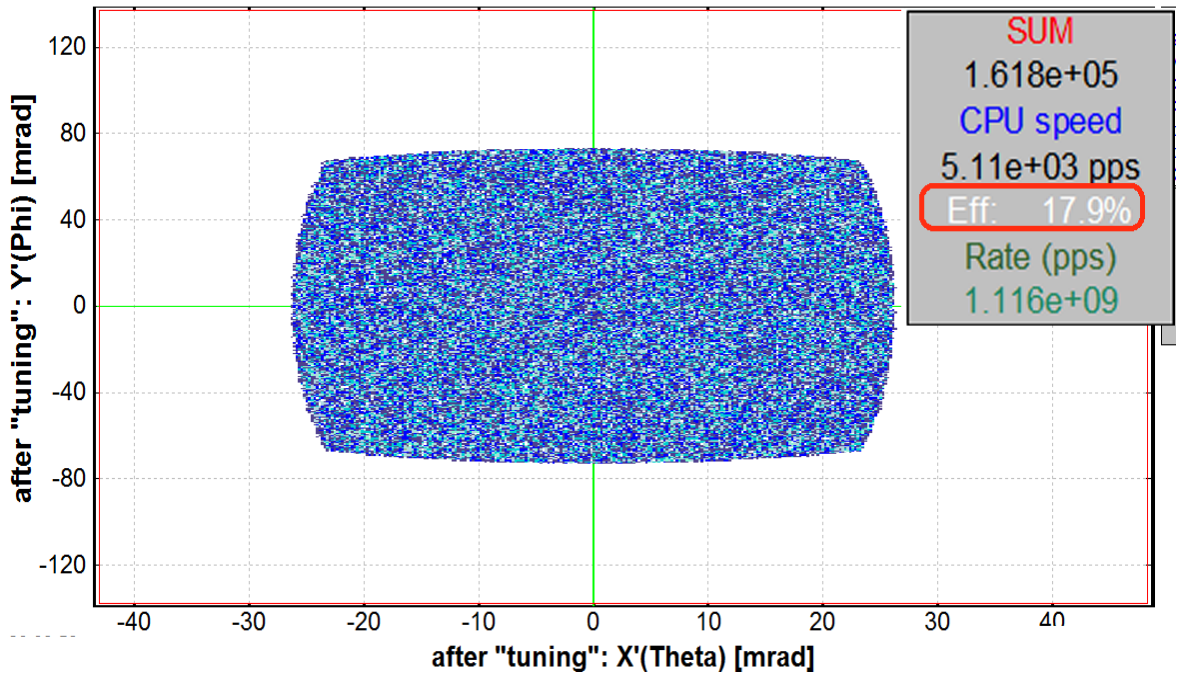
☐ Use fixed angular acceptances

☑ 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

Emittance [#1]

		Beam CARD (sigma, semi-axis, half-width...)	1D - shape (Distribution method)
1. X	mm	0.1	Gaussian
2. T	mrad	100	Rectangle uniform
3. Y	mm	0	Gaussian
4. P	mrad	100	Rectangle uniform
5. L	mm	0	Gaussian
6. D	%	0	Rectangle uniform



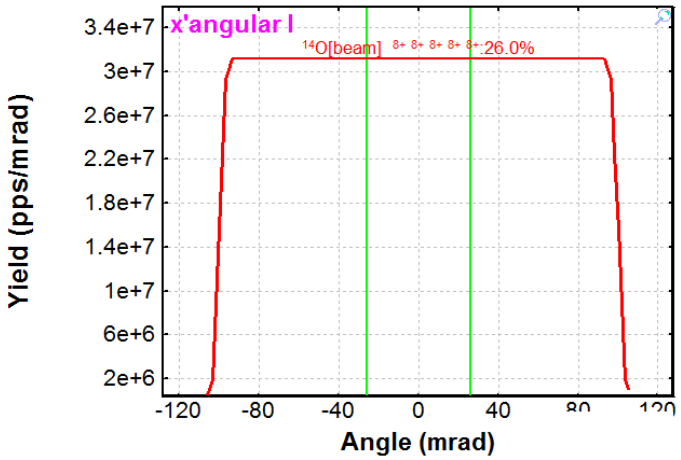
Distribution

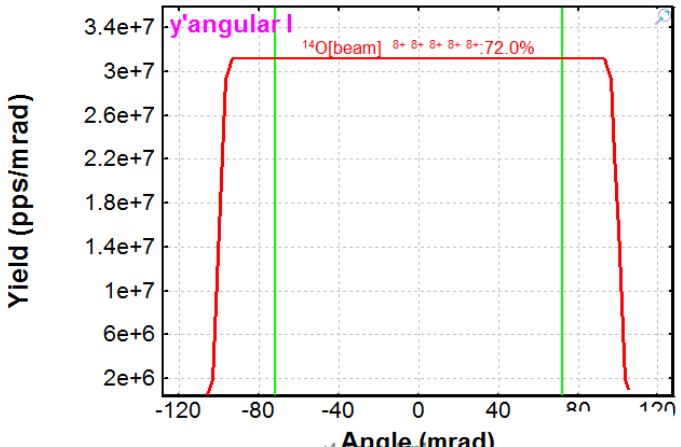
Using deduced angular acceptance values shown the previous page

statistics: 14O

14O Beta+ decay (Z=8, N=6)

Q1 (tuning)		8
Q2 (D1)		8
Q3 (D2)		8
Q4 (D3)		8
Q5 (D4)		8
Reaction		BEAM
Ion Production Rate	(pps)	1.12e+9
Total ion transmission	(%)	17.957
Total: this reaction	(pps)	1.12e+9
Total: All reactions	(pps)	1.12e+9
X-Section in target	(mb)	beam
Target	(%)	100
Q (Charge) ratio	(%)	100
tuning	(%)	18.71
X angular transmission	(%)	26
Y angular transmission	(%)	71.99
dr1	(%)	100
Q1	(%)	100
dr2	(%)	100
Q2	(%)	100
dr3	(%)	100
dr4	(%)	100
D1	(%)	100
dr5	(%)	100
dr6	(%)	100
D2	(%)	100
d7	(%)	100
d8	(%)	100
Slits	(%)	100
X space transmission	(%)	100
d9	(%)	95.96
X angular transmission	(%)	96.88
Y angular transmission	(%)	99.05

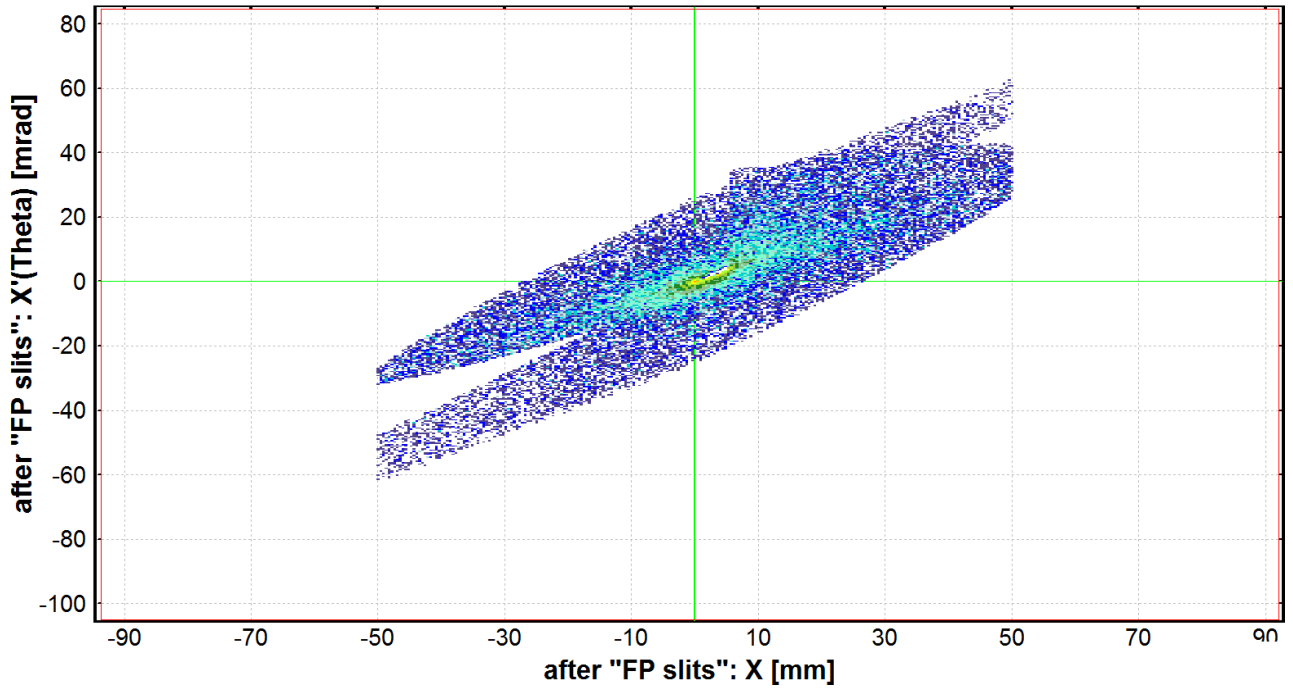




Second order aberrations

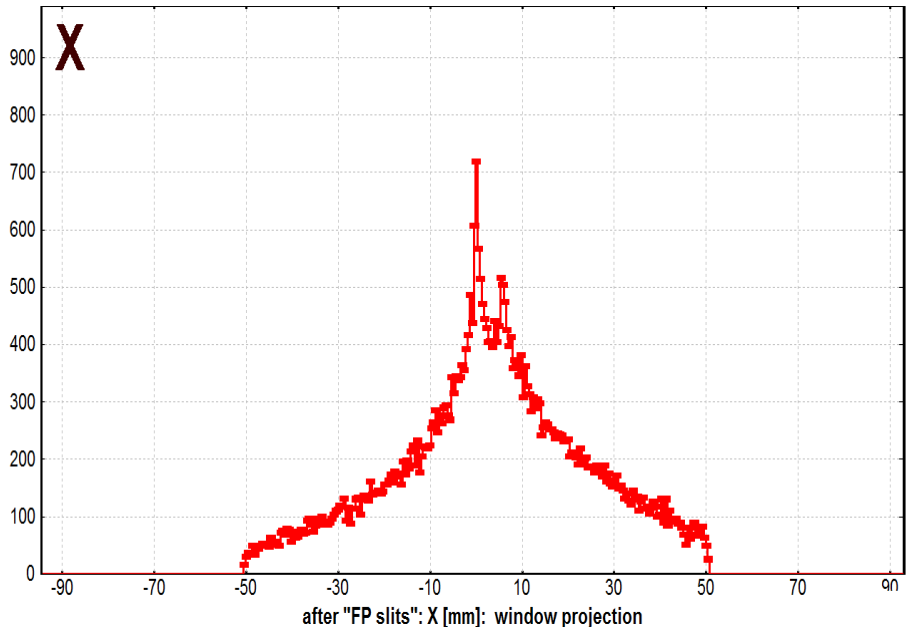
Emittance [#1]

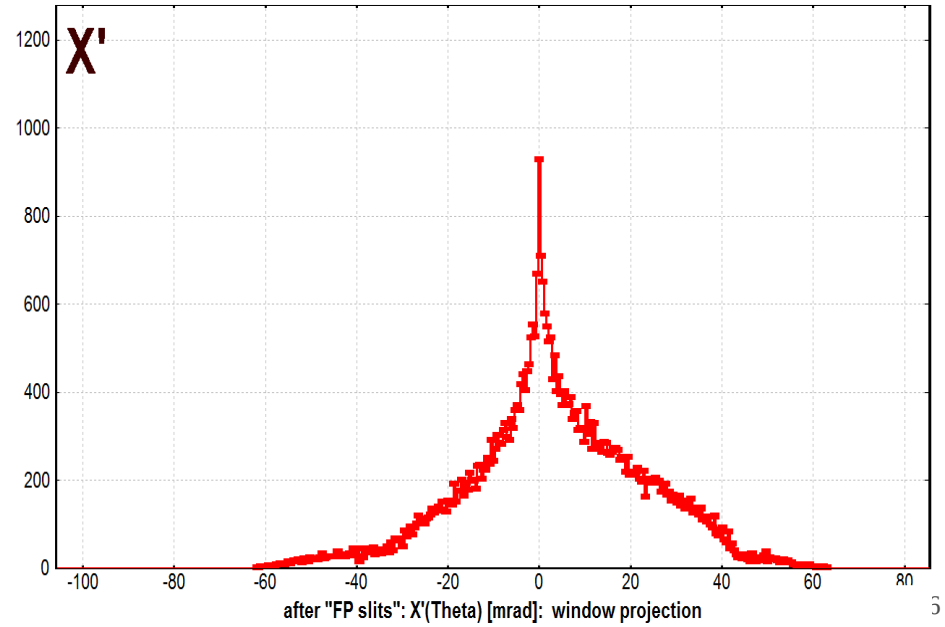
	Beam CARD (sigma, semi-axis, half-width...)		1D - shape (Distribution method)
1. X	mm	0	Gaussian
2. T	mrad	26	Rectangle uniform
3. Y	mm	0	Gaussian
4. P	mrad	72	Rectangle uniform
5. L	mm	0	Gaussian
6. D	%	50	Rectangle uniform



Transmission

1st order : 45.6%
2nd order: 30.0%

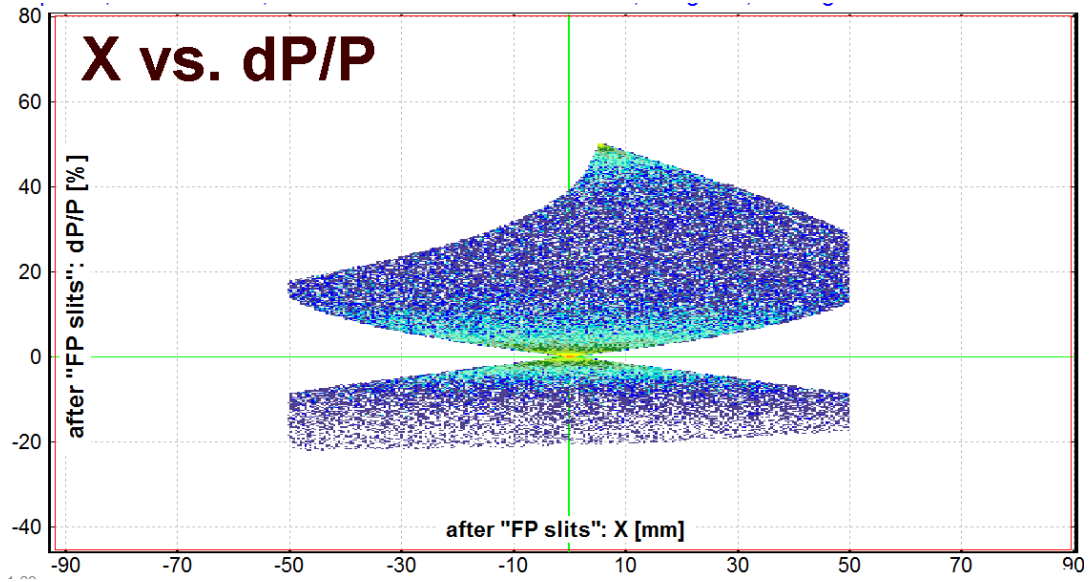


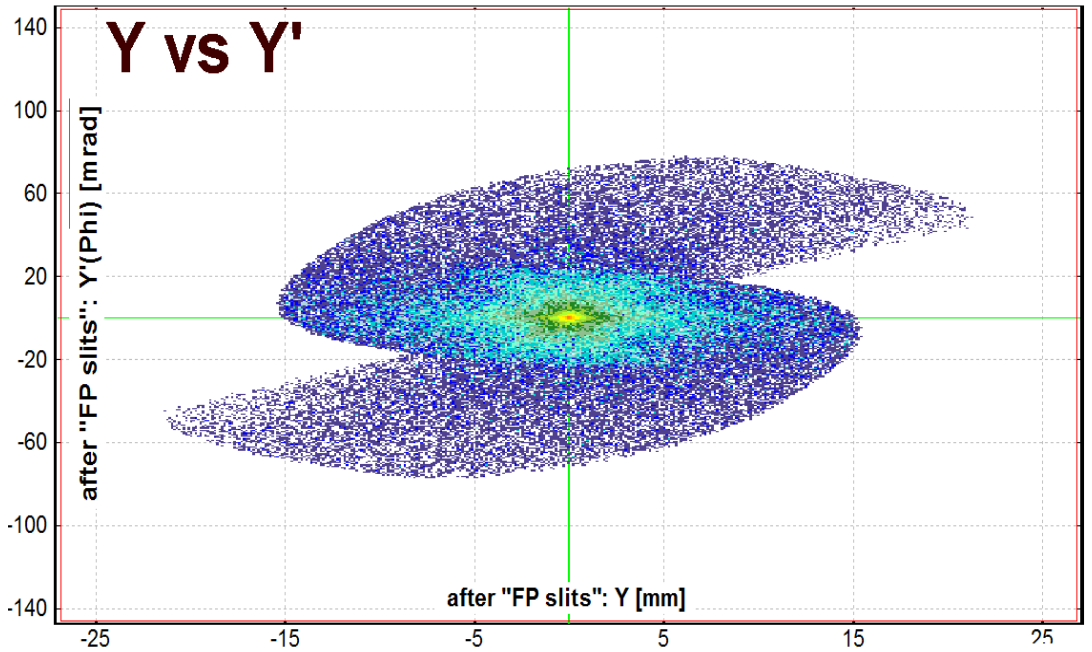


Second order aberrations

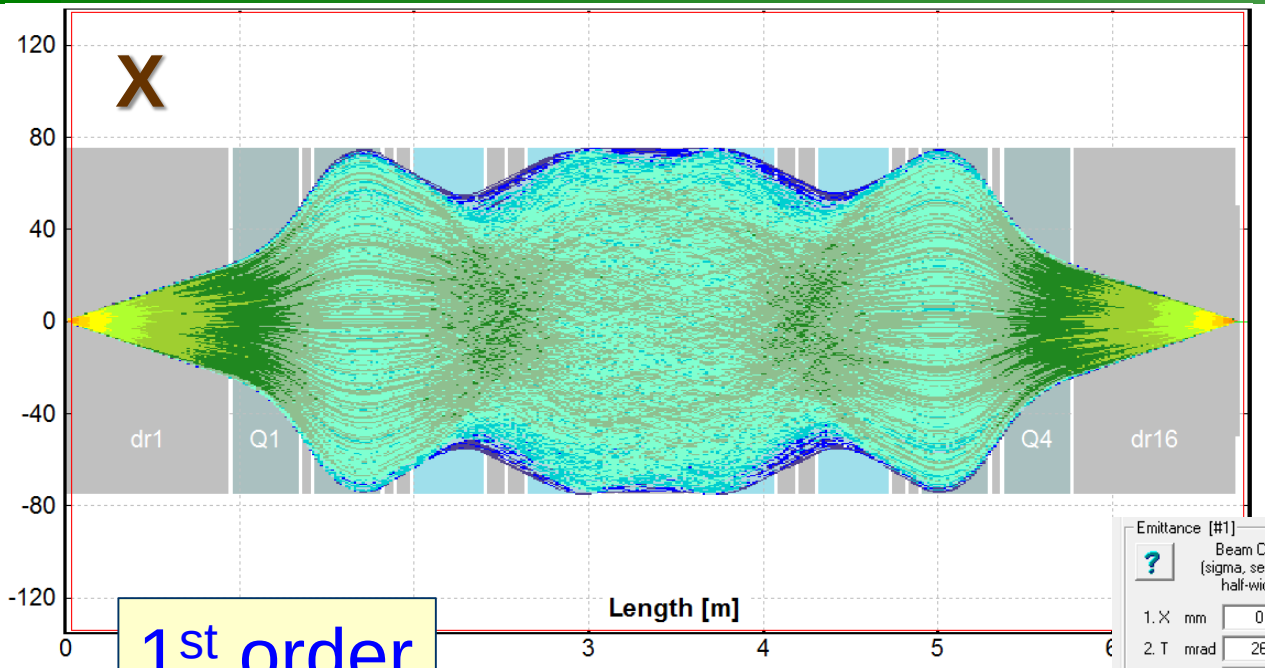
Emittance [#1]

		Beam CARD (sigma, semi-axis, half-width...)	1D - shape (Distribution method)
1. X	mm	0	Gaussian
2. T	mrad	26	Rectangle uniform
3. Y	mm	0	Gaussian
4. P	mrad	72	Rectangle uniform
5. L	mm	0	Gaussian
6. D	%	50	Rectangle uniform

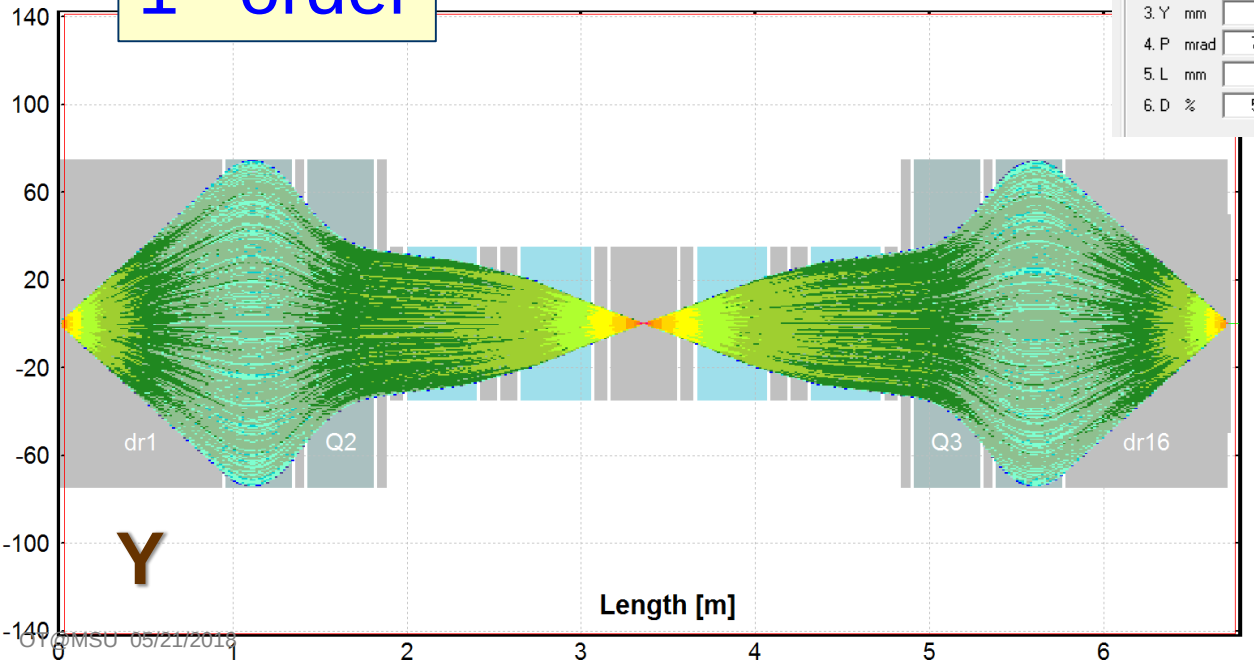


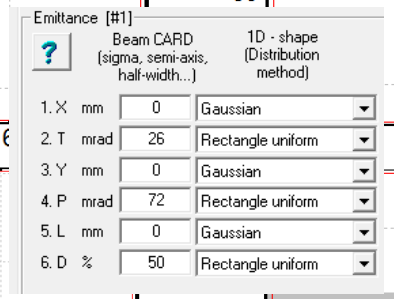


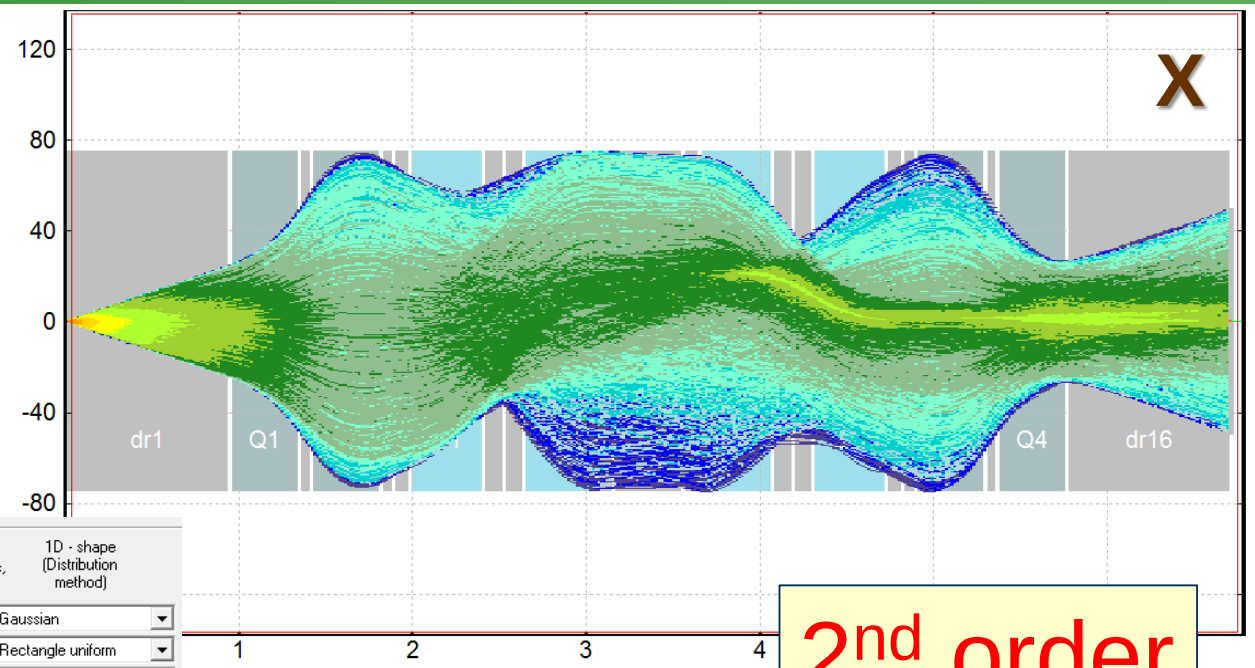
Second order aberrations



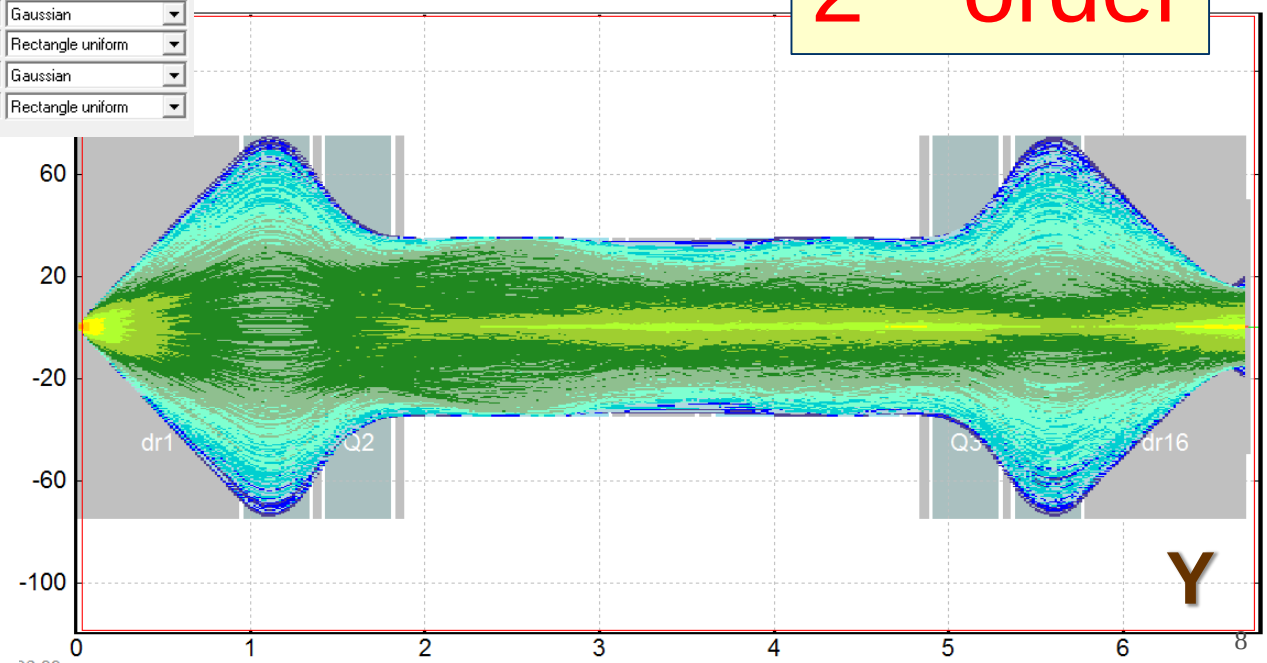
1st order







2nd order



Experiment (extended configuration) : transmission

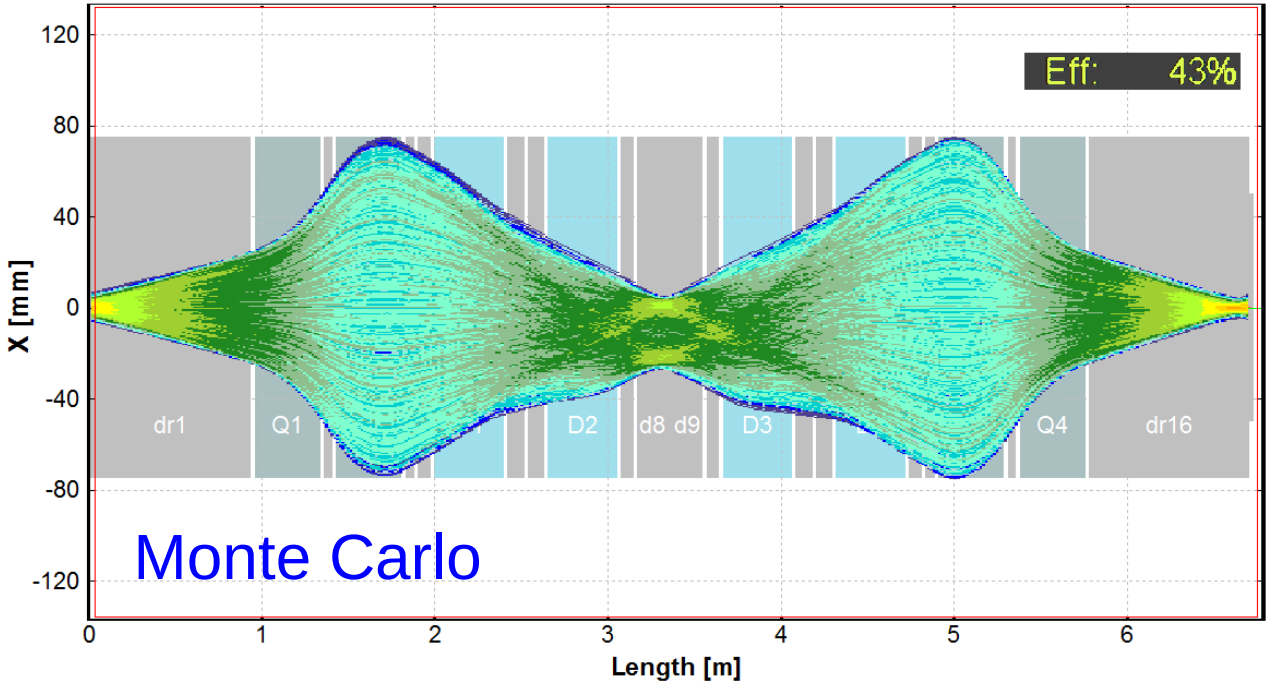
Two Body Reactions

Pay attention for cross sections!
By default is EPAX

statistics: 14O

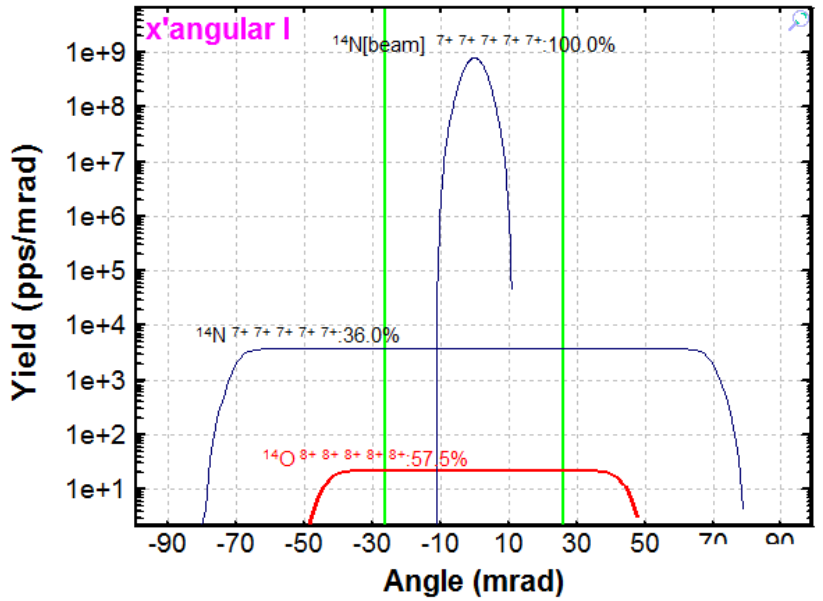
14O Beta+ decay (Z=8, N=6)

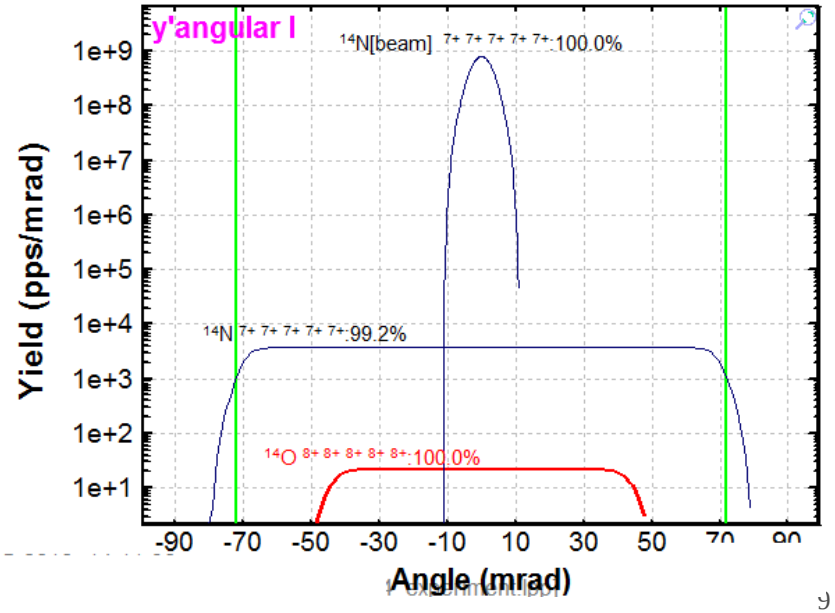
Q1 (tuning)		8
Q2 (D1)		8
Q3 (D2)		8
Q4 (D3)		8
Q5 (D4)		8
Reaction		TwoBody
Ion Production Rate	(pps)	1.05e+3
Total ion transmission	(%)	55.563
Total: this reaction	(pps)	1.05e+3
Total: All reactions	(pps)	1.05e+3
X-Section in target	(mb)	2.53e-1
Target	(%)	100
Unreacted in material	(%)	100
Q (Charge) ratio	(%)	100
Unstopped in material	(%)	100
tuning	(%)	57.53
X angular transmission	(%)	57.53
Y angular transmission	(%)	100



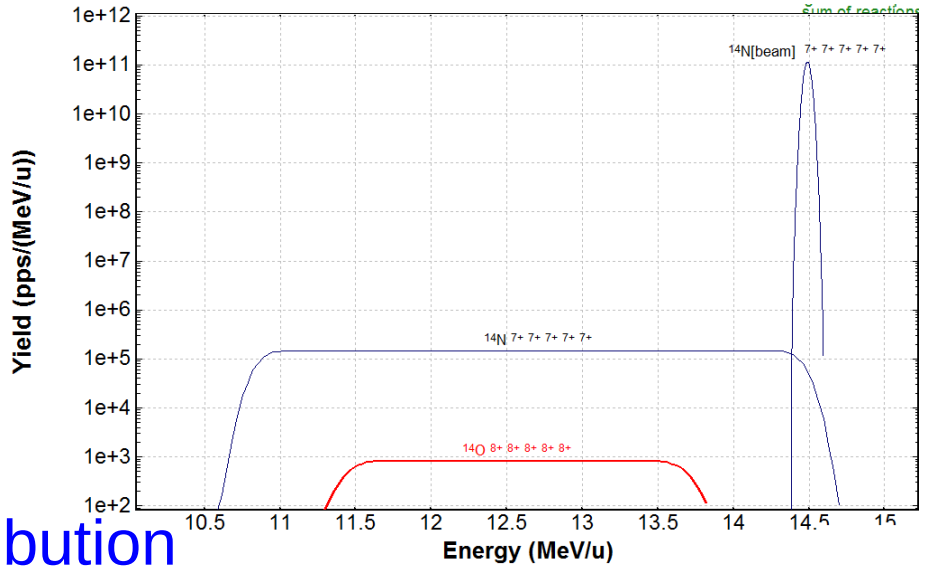
Distribution

tuning





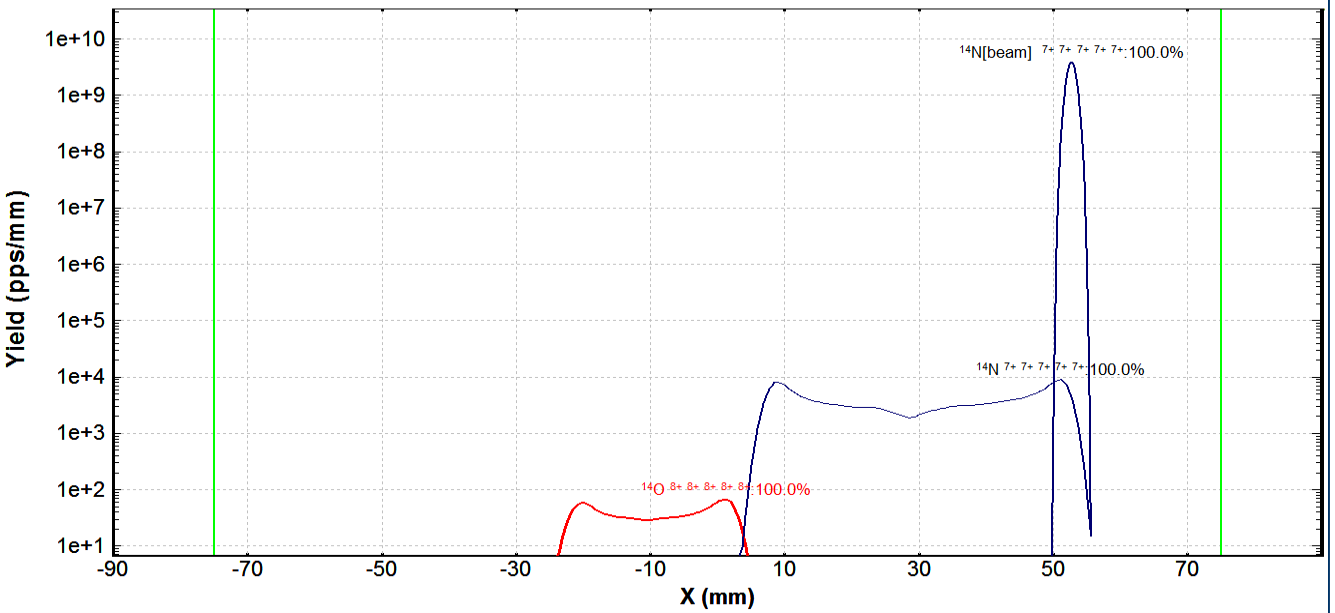
Experiment (extended configuration) : selection



Distribution

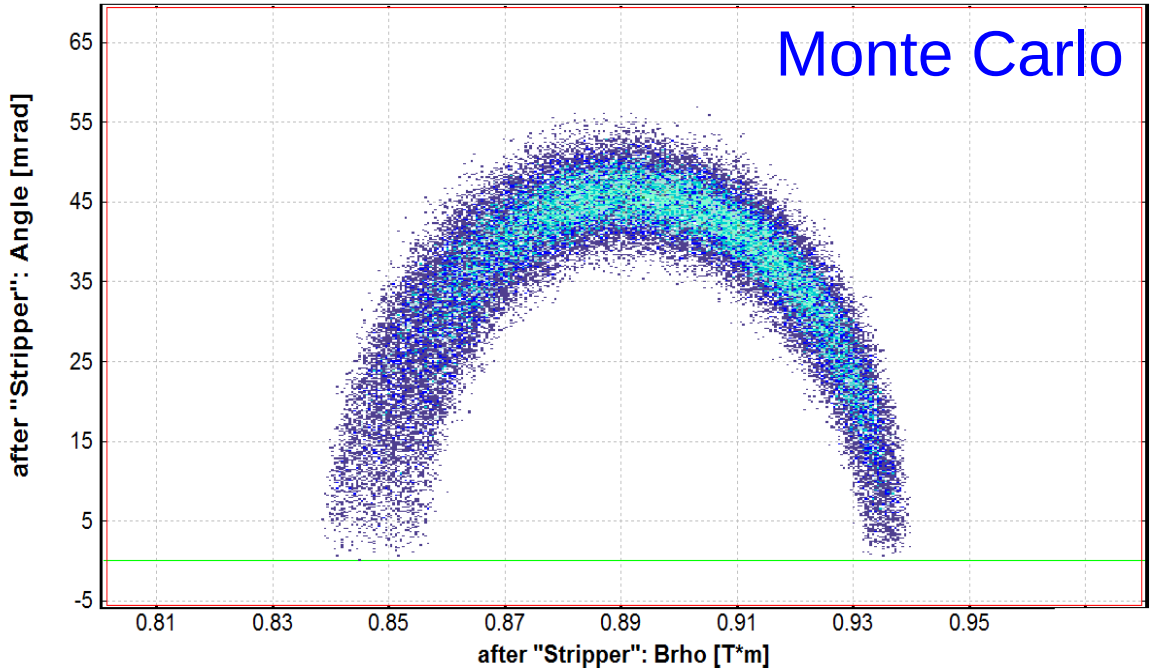
Slits => Xspace: output before slits

^{14}N (15 MeV/u) + H2 (2 mg/cm^2); Settings on ^{14}O$^{8+..8+}$; Config: DSSSSSSDSSDSSFFSSSDSSDSSSS...
dp/p=53.27% ; Brho(Tm): 0.9265, 0.9265, 0.9265, 0.9265, 0.9265



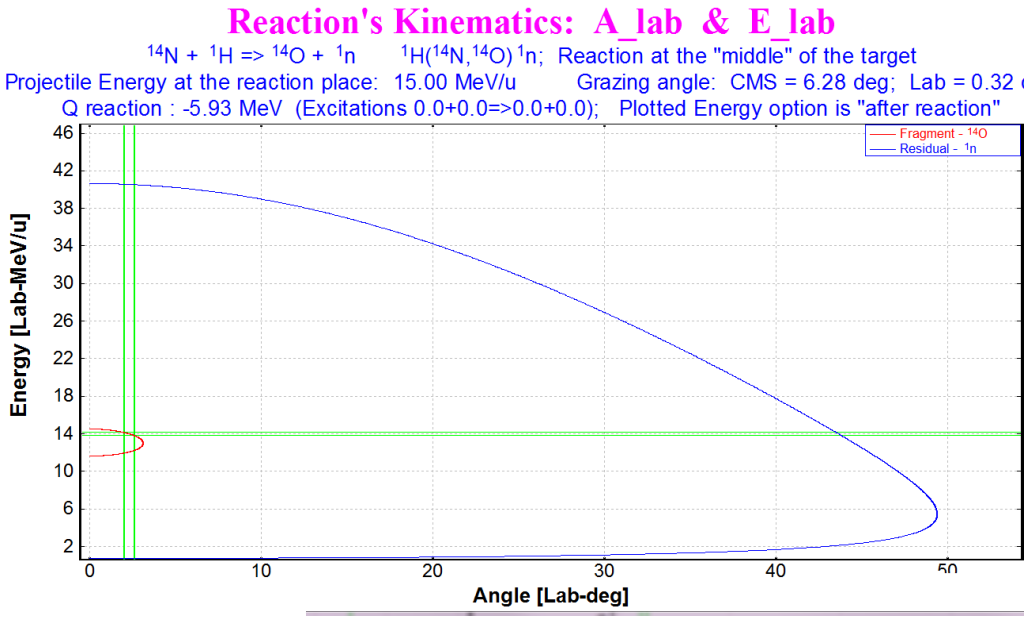
^{14}O : Monte Carlo Transmission Plot

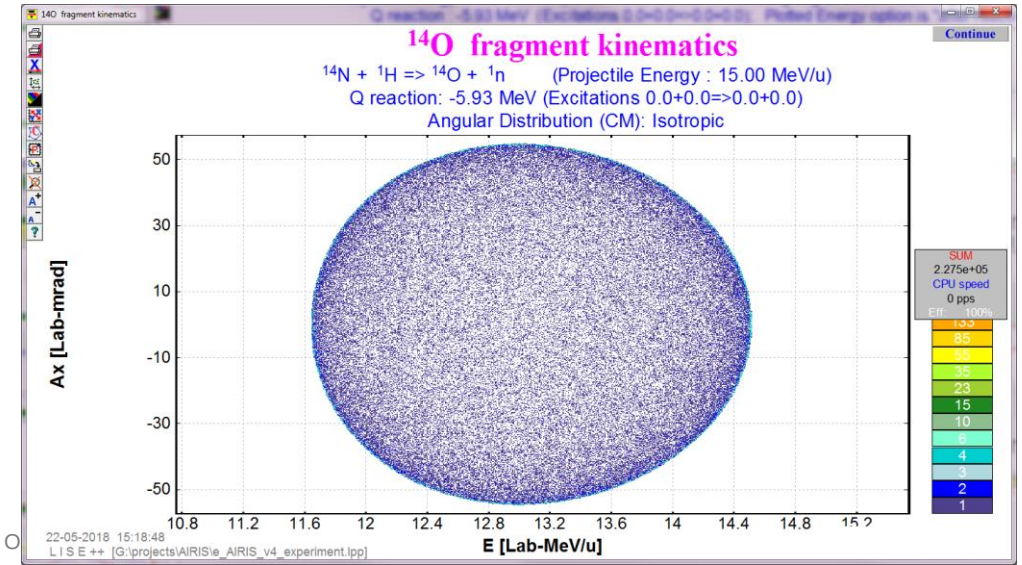
^{14}N (15 MeV/u) + H2 (2 mg/cm^2); Transmitted Fragment ^{14}O$^{8+..8+}$ (TwoBody); Optics Orde
dp/p=53.27% ; Brho(Tm): 0.9265, 0.9265, 0.9265, 0.9265, 0.9265
AngAccept: Off; Bounds: ON; "Stripper" - last block for MC calc; no gates; Config: DSSSSSSDSSDSSS



Experiment (extended configuration) : kinematics

Kinematic calculator

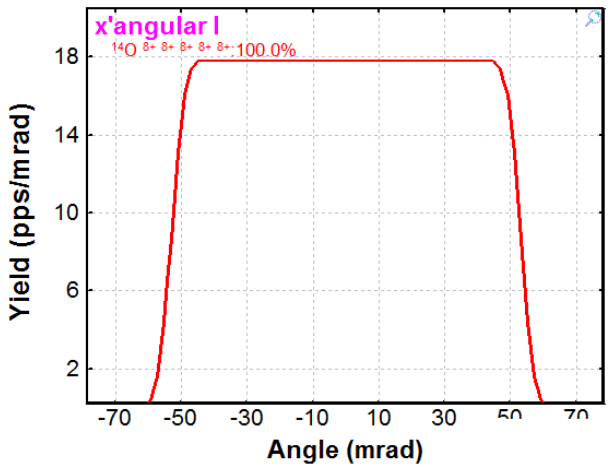


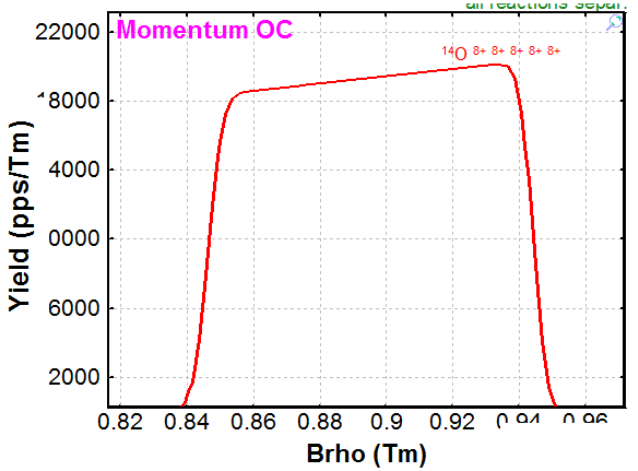


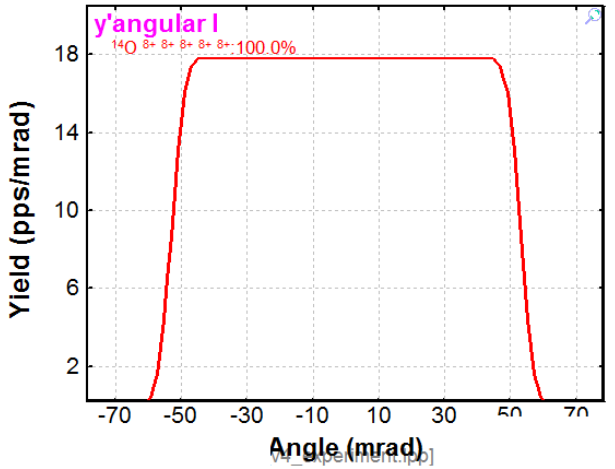
Distribution method

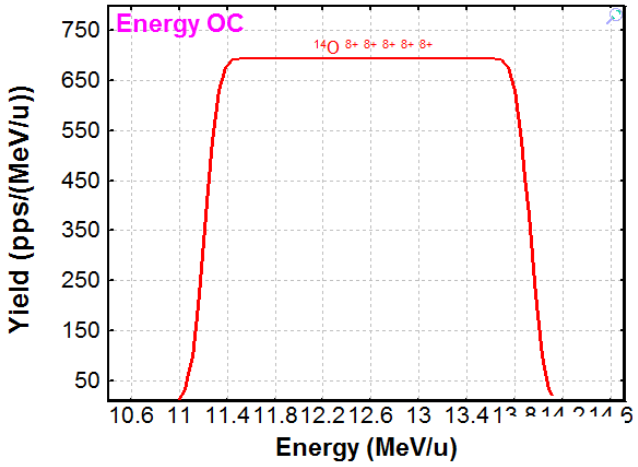
Stripper

^{14}N (15 MeV/u) + H2 (2 mg/cm^2); Settings on $^{14}O^{8+..8+}$; Config: DSSSSSSDSSDSSFFSW
dp/p=17.76% ; Wedges: 0; Brho(Tm): 0.8972, 0.8972, 0.8972, 0.8972, 0.897









Experiment (extended configuration) : Used Diff CS

Should be updated

Examples:

LISE++ files:

d + ^{18}O -> p + ^{19}O	http://lise.nscl.msu.edu/9_6/DifCS/d_18O.lpp
^{3}He + d -> p + a	http://lise.nscl.msu.edu/9_6/DifCS/d_3He.lpp

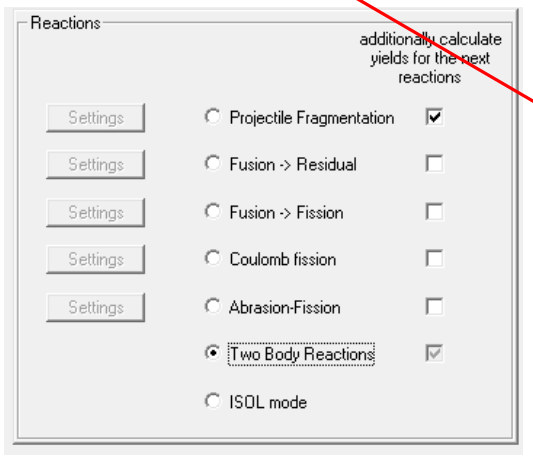
DiffCS Files:

Ground State :	http://lise.nscl.msu.edu/9_6/DifCS/19O_gs.txt
At 0.96 MeV :	http://lise.nscl.msu.edu/9_6/DifCS/19O_L0.96.txt
Isotropical distribution:	http://lise.nscl.msu.edu/9_6/DifCS/19O_isotropic.txt

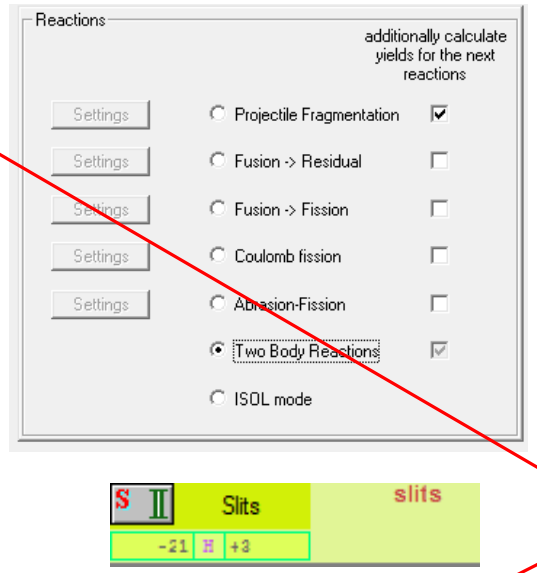
http://lise.nscl.msu.edu/9_6/DifCS/9_6_44_DifCS.pdf

Experiment (extended configuration) : Wedge

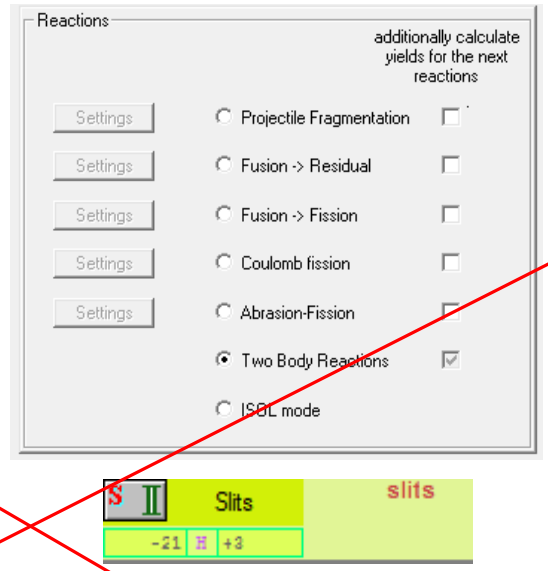
Should be updated



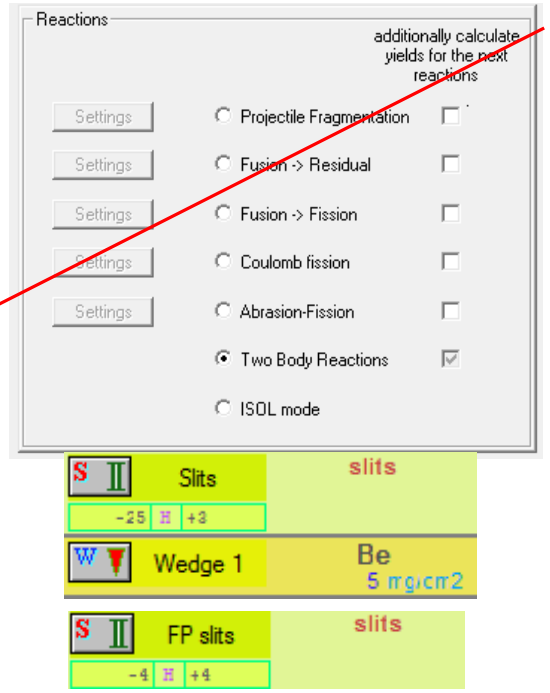
^{14}O : 1.7% (purity)



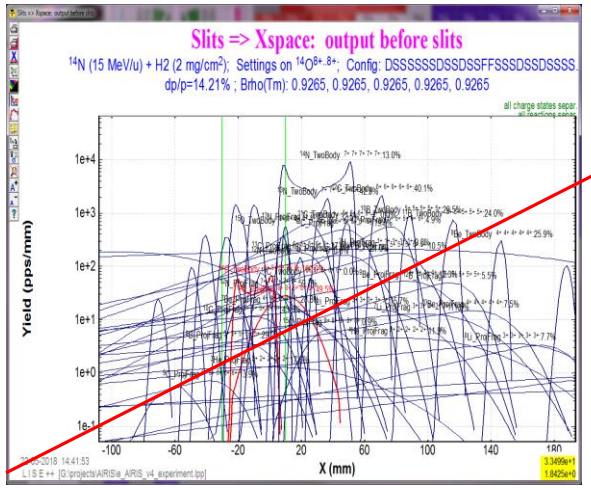
^{14}O : 3.0%

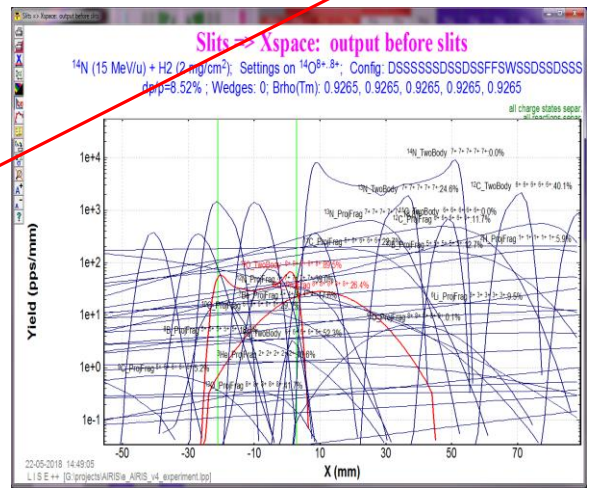


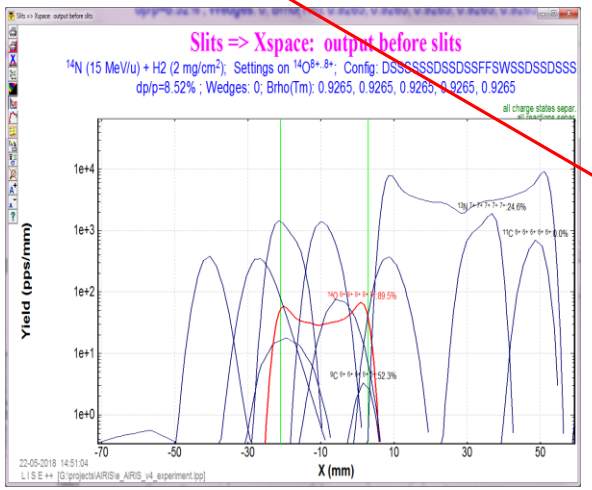
^{14}O : 5.8%

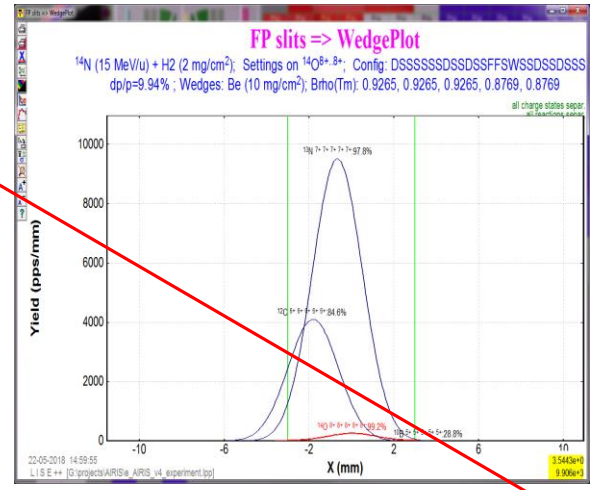


^{14}O : ---



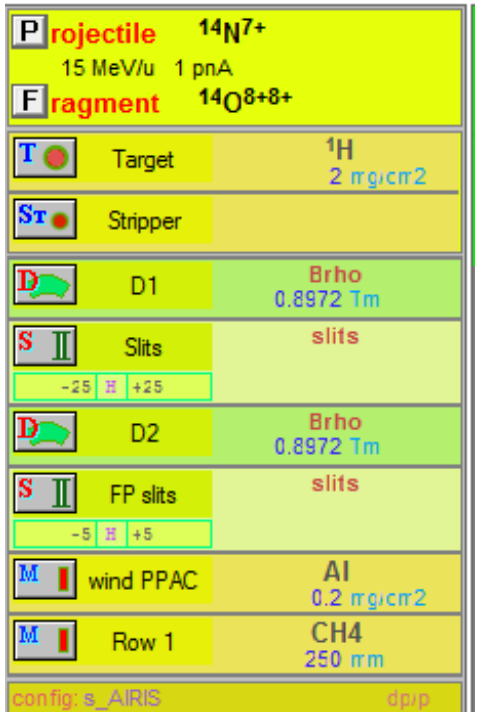


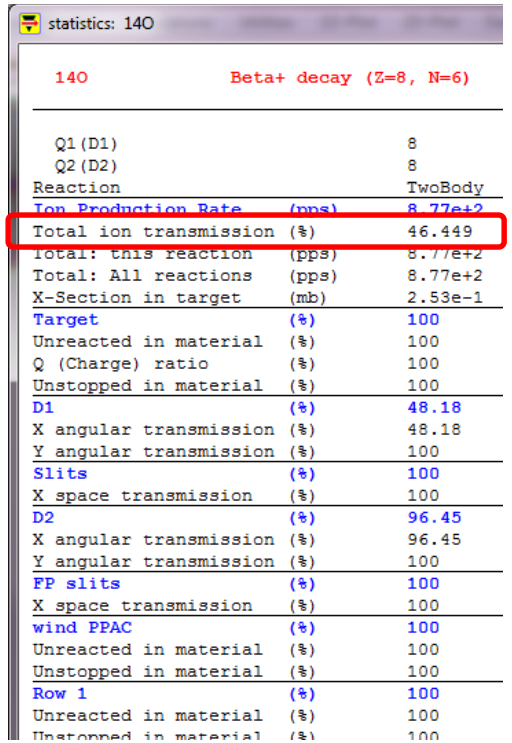


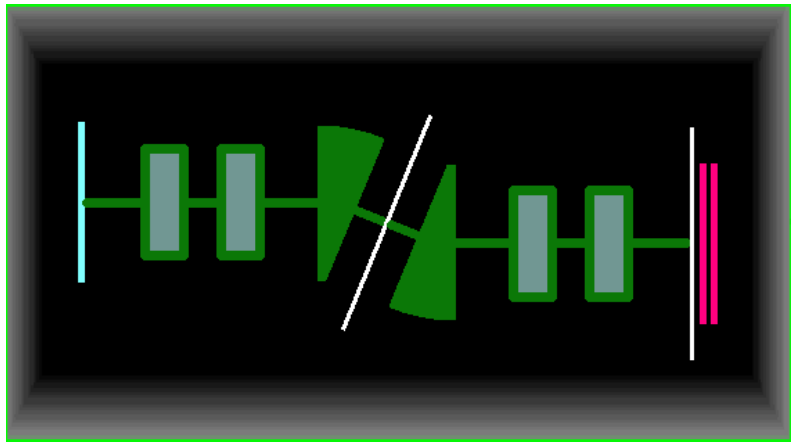


Experiment : segmented configuration

Simple configuration with two dispersive segments

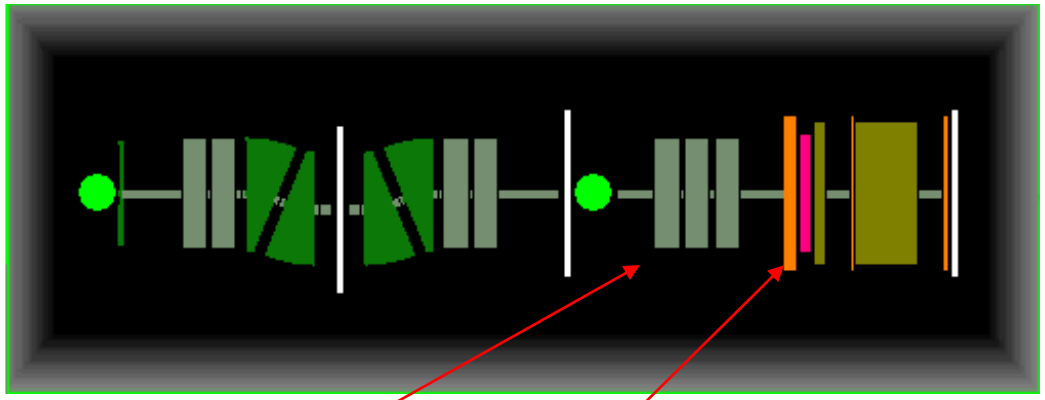






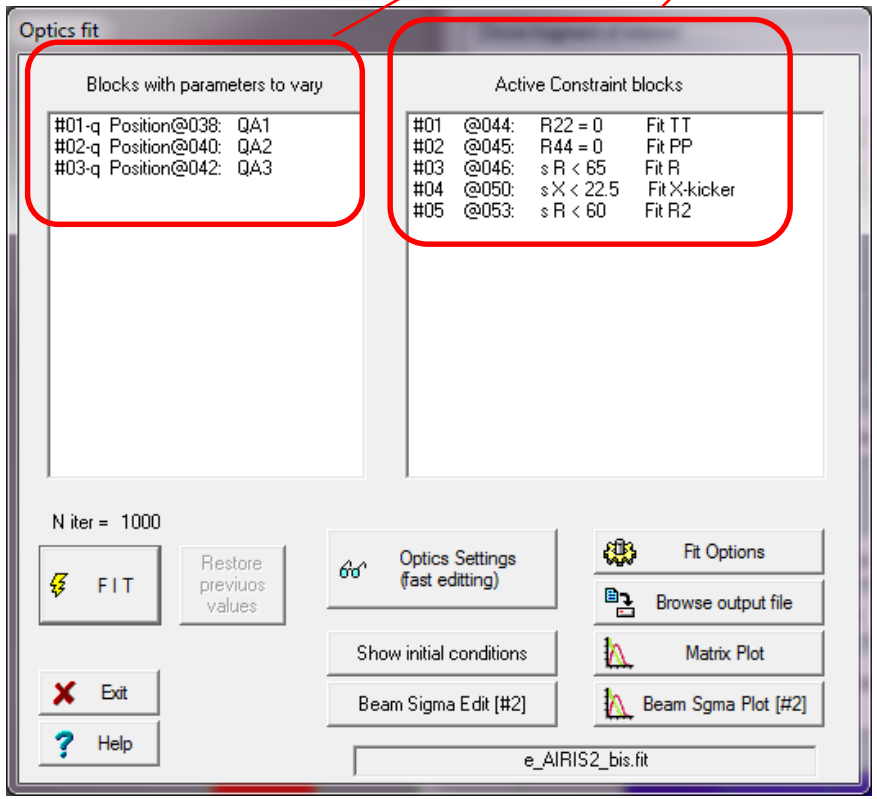
AIRIS2 (with RF-buncher & RF-kicker) : extended

Preliminary!

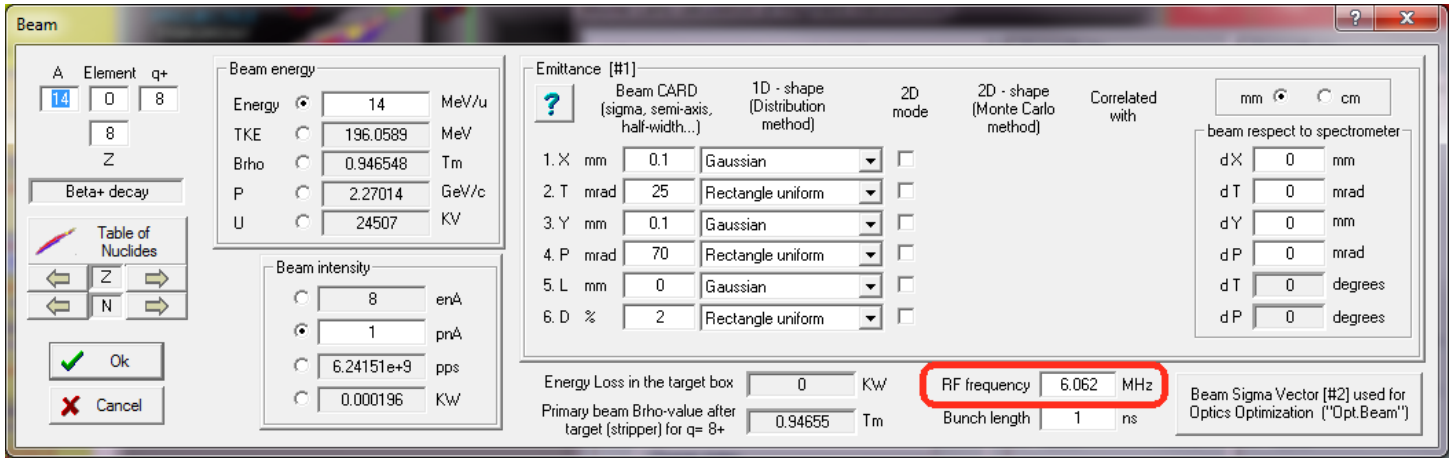


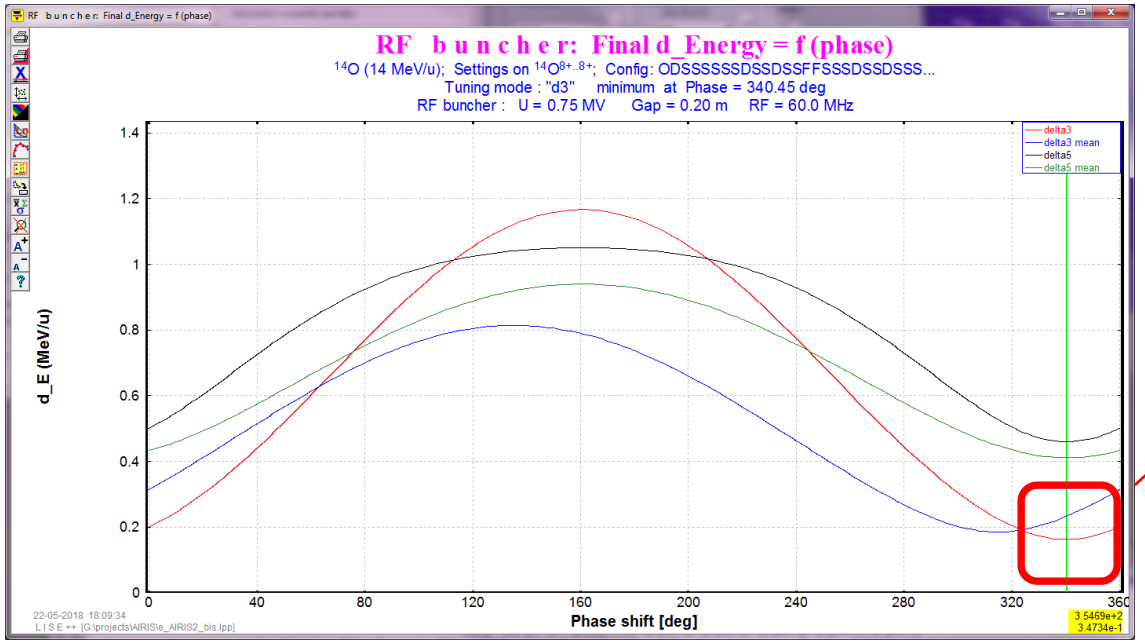
Second half

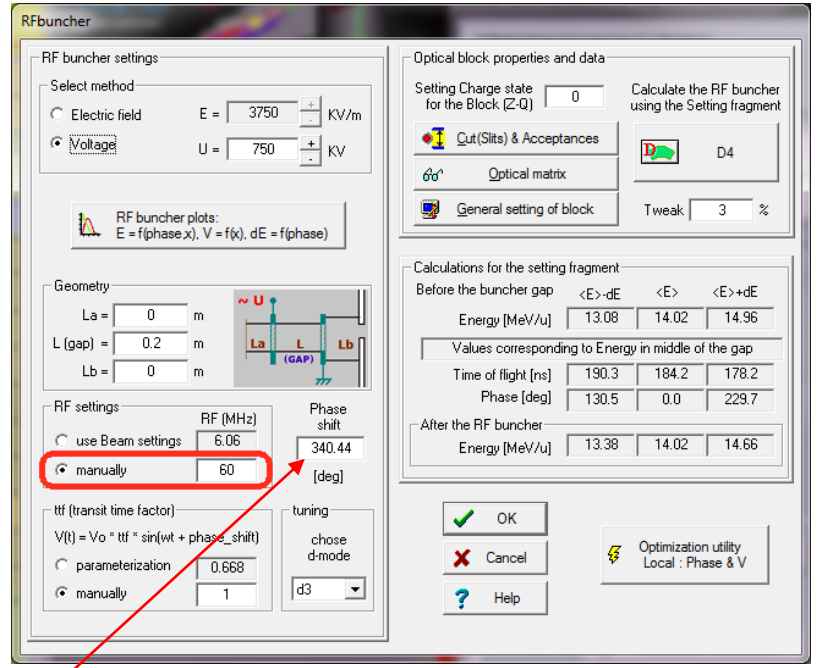
d	da1	standard 60 cm
Q	QA1	QUAD 4.5894 kG
d	da2	standard 7 cm
Q	QA2	QUAD -4.6453 kG
d	da3	standard 7 cm
Q	QA3	QUAD 1.9415 kG
d	da4	standard 70 cm
M	Material	Si 0.01 m cron
B	RFbuncher	U 750 kV Ph 340.4 deg
d	da5	standard 40 cm
K	RFsepar	U 70 kV Ph 257.2 deg
	-25 H +25	
	-100 V +100	
d	da6	standard 40 cm



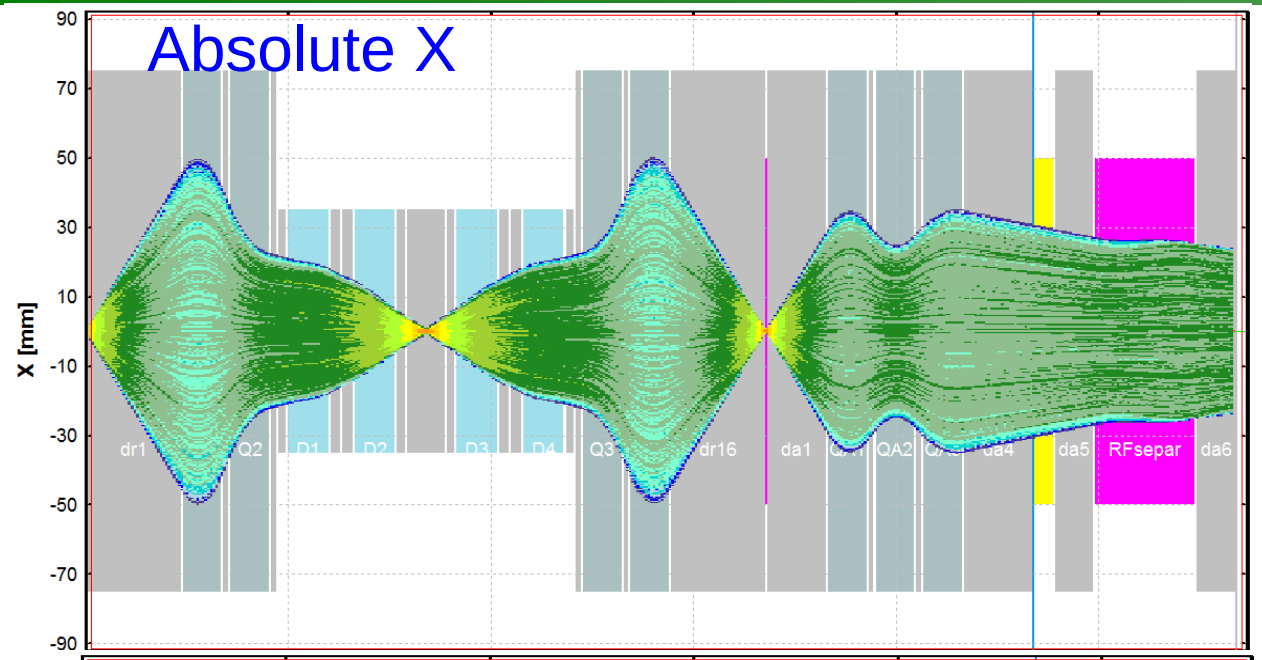
AIRIS2 : RF-buncher

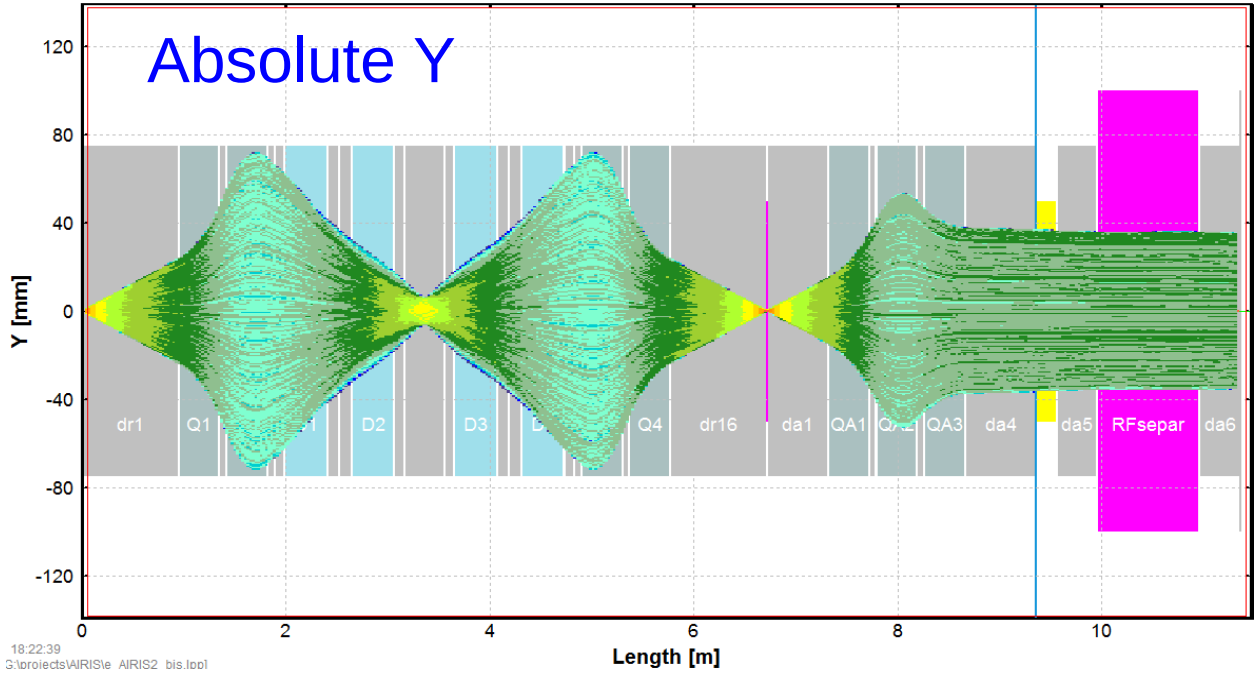






AIRIS2 (+RF-buncher & RF-kicker) : extended

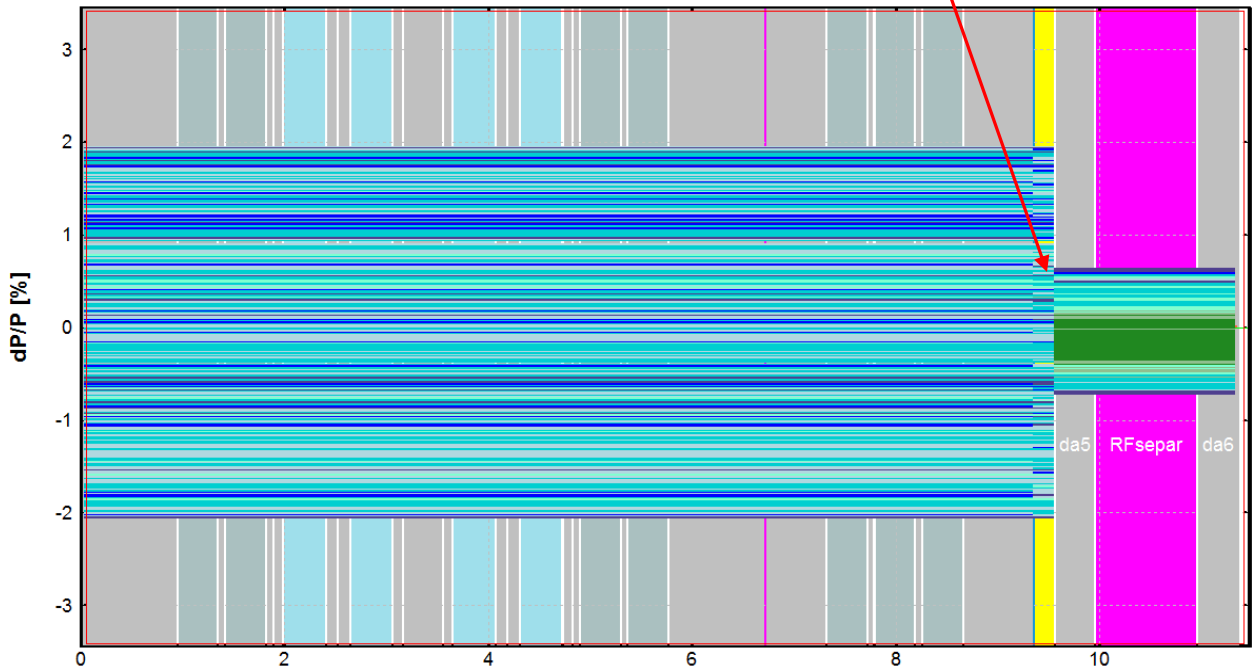




Emittance [#1]

		Beam CARD (sigma, semi-axis, half-width...)	1D - shape (Distribution method)
1. X	mm	0.1	Gaussian
2. T	mrad	25	Rectangle uniform
3. Y	mm	0.1	Gaussian
4. P	mrad	70	Rectangle uniform
5. L	mm	0	Gaussian
6. D	%	2	Rectangle uniform

Compression by RF-buncher



Before and After the RF-Buncher