

- Reverse technique
 - Coordinate systems
 - Methods
 - Application

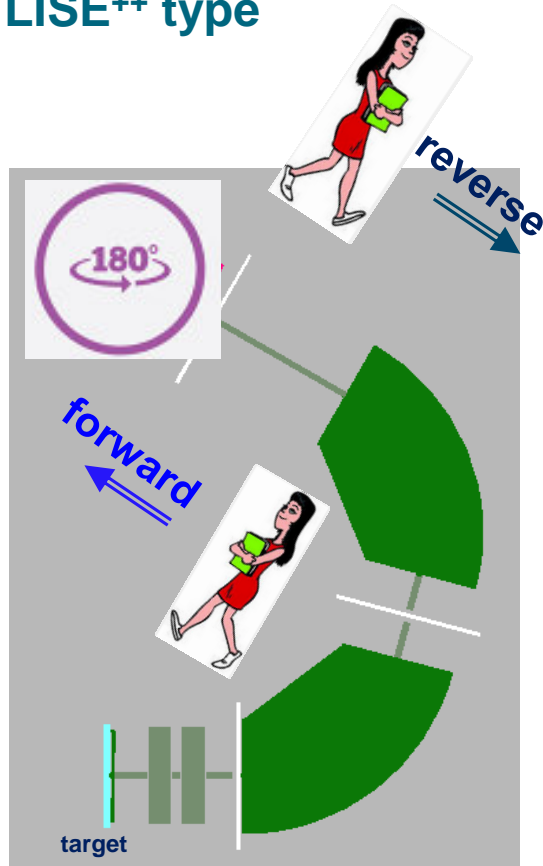
- Creation of reverse configurations
 - Rays file generation for reverse configurations
 - Block and configuration benchmarks
 - Operations with secondary maps in Excel

- Reverse technique and detector resolution
 - S800
 - A1900

- Fission mechanism study with reverse configurations

- The Reverse technique is widely used in Spectrographs, so, to get a momentum vector at the S800 target, the COSY procedure “RR” based on measured X, A,Y, B values and the “global” spectrograph map reconstructs a trajectory (initial A,Y, B) with energy computing.
- The LISE++ reverse technique approach is assumed to applied for extended (elemental) configurations, that makes it more useful for beam dynamics and benchmarking.
- Therefore, local maps are used in reverse configurations, which can be calculated by LISE++, or be entered by the user directly or linked to COSY maps (up to fifth order).
- There are two methods can be used in the LISE++ reverse technique:
 - ✓ LISE++ type → `turn around & go forward`
 - ✓ COSY type → `go backwards`

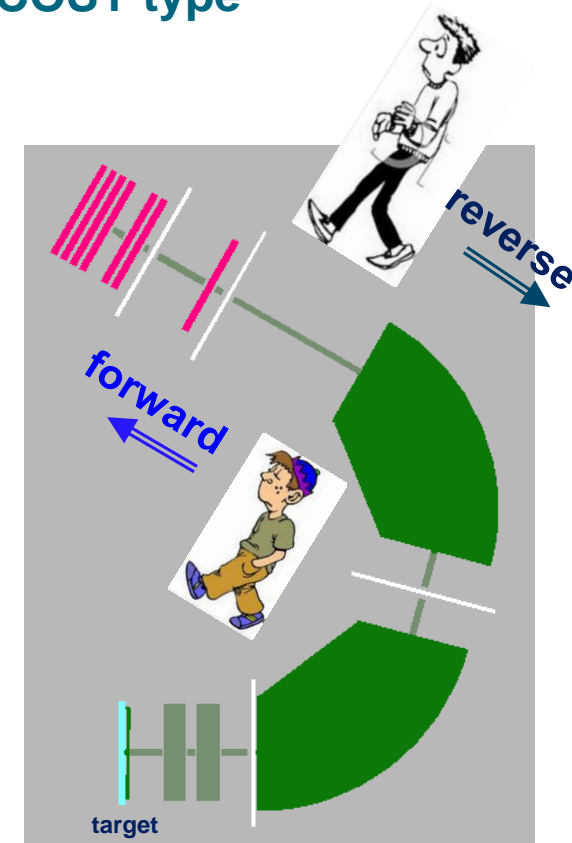
LISE⁺⁺ type



turn around & go forward

- The coordinate system is changed ($x_n = -x, y'_n = -y_n, L_n = -L$)
- Matrices are calculated by LISE⁺⁺

COSY type



go backwards

- The coordinate system is not changed
- COSY matrices are imported (linked)
- These maps are inverted from the “direct” maps by the COSY procedure “MI”
- Ideal case : invert matrices inside LISE

- **Momentum vector after reaction in target** (for example standard S800 technique)
 - Reaction mechanism study
 - Beam spot
 - Angular acceptance vs emittance

- **Beam emittance measurement (X,A,Y,B,E)**
 - Study of correlations between beam emittance components γ

- **Determination of location of new ions production**
 - BigRIPS case : production in the beam-dump

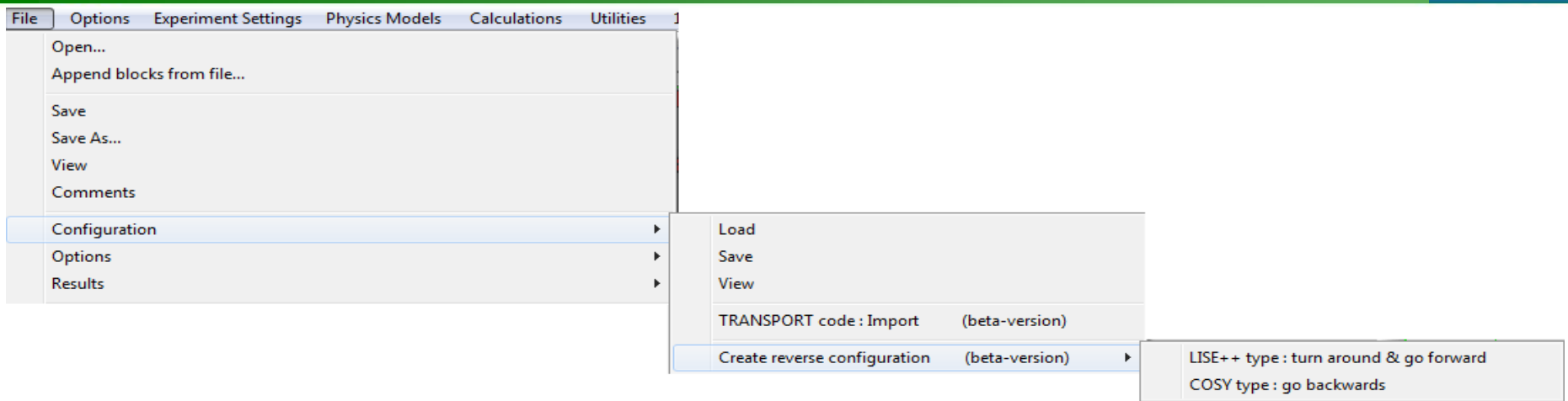
- **Benchmarks γ based on LISE++ MC apparatus and spectrograph segmentation**
 - Beam dynamics visualization
 - Beam optics calculation verification
 - Experimental analysis and calibrations test

- **Experiment set-up feedback γ with LISE++**
 - Obtaining experimental information by detecting devices in some (or one) locations
 - Retracing up-stream (or down-stream) from detection locations based
 - Analysis, minimization

γ will be demonstrated here

γ in future

Creation of reverse configurations



1. Blocks behind the stripper up to a last optic block (or Faraday cup) will be inversely located in a new file
2. The New Primary beam will be set to after the Setting Fragment in the direct configuration with energy corresponding to its energy in the last optical block of the direct configuration
3. New “tuning” dipole will be inserted behind the stripper with rigidity corresponding to the new primary beam energy
4. All materials will obtain corresponding negative thickness
5. Optical blocks with “element” properties:
 - * LISE⁺⁺ method : dispersive block bending & sextupole field signs will be changed, entrance and exit dipole faces will be swapped
 - * COSY method : all standard drift blocks will be set to drift with beam-line properties, and their dx/dt and dy/dp signs will be changed; old links to map files will be destroyed
6. The separator scheme will be rotated on 180 degrees
7. Matrices of Optical blocks with the “Element” property in the case of the LISE⁺⁺ method will be recalculated
8. The New file name will be based on old one with adding substring “_Lreverse” or “_Creverse” to the end

Courtesy
of
M.Portillo
&
D.Bazin

Example of COSY-file to create simultaneously
S800 direct and reverse 5th order maps to use in LISE++

http://lise.nsl.msu.edu/doc/e12006/Br1/invmap_Br1.fox

```

UM; "zeroing"
CB; rotation
FRINGED2 ;
DI RHOD2 ANGLED2 APERD2 EDGED2 0 0 0 ;           second dipole {D2}
CB; rotation                                     direct map
PM_LISE 'S800D2 COSY.TXT' ;

SM MAP1 ;      MI MAP1 MAPI 6 F_IER NO NV NM1 ;
UM; AM MAPI ;  PM_LISE 'I_S800D2_COSY.TXT' ;      inverse map
    
```

Important! Do not use "FR3.0" & "CB". Use "FR2.5" for this purpose

Experiment Settings | Physics Models | Calculations

- Projectile
- Target
- Stripper after Target
- Spectrometer Design
- Optics**
- Gamma registration
- Setting Fragment
- Tune spectrometer for the primary beam

Optics sub-menu:

- Tune spectrometer for setting fragment on beam axis
- Tune spectrometer for setting fragment at middle of slit
- OPTIMIZATION (optical element parameters fitting)
- Manual recalculation of e-blocks matrices (only for Experts!)
- Update matrices linked with COSY files**
- Envelope plot

All optical (except drift standard and rotation) should be linked or manually entered

Upload linked COSY matrices

L I S E ++ [G:\e12006\Br1\Bp1_COSY_beam.lpp]
10-03-2016 16:08:43

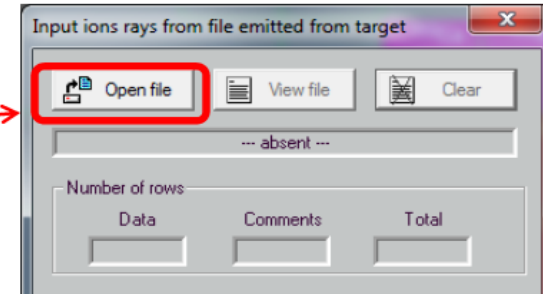
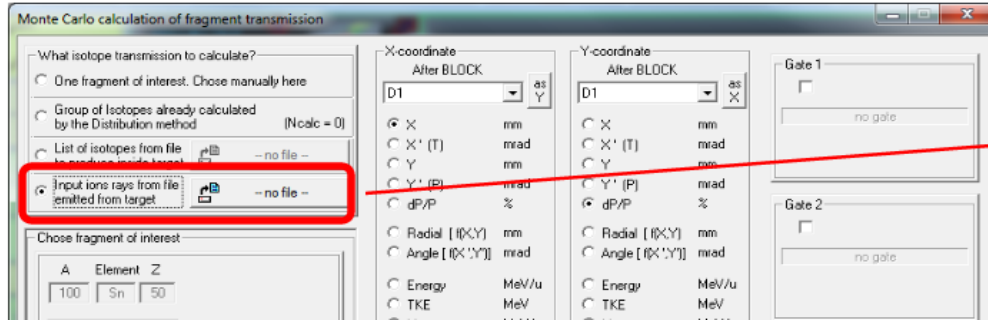
Block	Name	Number of Lines / Status	Filename
Drift	"Q1"	198	G:\e12006\Br1\S800Q1_COSY.TXT
Drift	"Q2"	194	G:\e12006\Br1\S800Q2_COSY.TXT
Dipole	"D1_S800"	252	G:\e12006\Br1\S800D1_COSY.TXT
Dipole	"D2_S800"	252	G:\e12006\Br1\S800D2_COSY.TXT

Number of links: 4 Number of good links: 4

http://lise.nsci.msu.edu/9_6/9_6_23.pdf#page=10

Input ions rays from file emitted from target in MC mode (1)

DJM's request



Data line structure

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
1	!	Z	N	q	X	d(X)	X'	d(X')	Y	d(Y)	Y'	d(Y')	E	d(E)	t	d(t)
3	!				mm	mm	mrad	mrad	mm	mm	mrad	mrad	MeV/u	MeV/u	ns	ns
4	18	20	18	-0.549	1	-0.409	4	-1.521	0.8	-4.046	5	95.20	1	-0.891	2	
5	18	23	18	-0.509	1	6.557	4	0.120	0.8	7.029	5	102.66	1	-0.463	2	
6	16	19	16	-1.603	1	-1.041	4	-1.435	0.8	8.051	5	97.17	1	0.869	2	
7	15	19	15	-2.177	1	4.244	4	1.317	0.8	-0.575	5	104.09	1	0.683	2	
8	15	19	15	0.209	1	-2.225	4	1.561	0.8	1.710	5	98.53	1	0.004	2	
9	14	15	14	2.412	1	-4.756	4	-1.051	0.8	0.530	5	102.42	1	-0.095	2	
10	14	17	14	2.288	1	0.295	4	0.992	0.8	4.415	5	95.77	1	-0.173	2	
11	14	15	14	1.495	1	1.112	4	0.580	0.8	-0.943	5	102.13	1	0.455	2	
12	17	20	17	1.533	1	4.954	4	0.863	0.8	6.794	5	98.28	1	-0.404	2	
13	16	17	16	2.462	1	-5.620	4	1.109	0.8	-1.494	5	104.95	1	0.424	2	
14	13	15	13	1.185	1	-4.911	4	1.873	0.8	-1.027	5	99.03	1	-0.504	2	
15	18	22	18	1.373	1	7.311	4	0.105	0.8	-9.834	5	98.95	1	0.191	2	
16	16	19	16	0.710	1	5.501	4	-0.534	0.8	-6.920	5	98.37	1	-0.057	2	

The Isotope list file is in ASCII format. Comment string begin with "!" or "!"

The Columns can be separated by a Space, a Comma or a Tabulation. User can put comments also at the end of data line

At least 13 columns should be in the specified order.

Three first columns: "Z", "N", "q", where Z is atomic number, N is number of neutrons, q is ionic charge

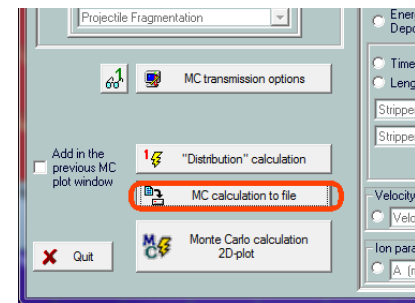
The next ten are X, dX, X', dX', Y, dY, Y', dY', E, dE. "d" means StDev. Set 0 if you do not want to use it. X,Y in mm, X',Y' in mrad, E in MeV/u

Two additional columns can be used for time (t,dt) in ns



Rays file generation in LISE++ for reverse configurations

Besides experimental data the LISE++ rays can be used for benchmark purpose



LISE++ approach

COSY approach

Fields

Number of fields = 15
1..15

N	Field
1	Z (atomic number)
2	N (neutron number)
3	q (ion charge)
4	X [mm]
5	0 (empty)
6	X(Theta) [mrad]
7	0 (empty)
8	Y [mm]
9	0 (empty)
10	Y(Phi) [mrad]
11	0 (empty)
12	Energy [MeV/u]
13	0 (empty)
14	Time from Target [ns]
15	0 (empty)

Number of Rays = 100
1.. 1 000 000

Output Mode

0: User mode

Compatible with LISE++ MC input format

1: no coordinate system modifications

2: X'n=-X' ; Y'n=-Y' (OT)

3: X'n=-X' ; Y'n=-Y' (MP)

Passed/Unpassed rays

Write only passed rays

Write all rays (including unpassed)

Unit of Spatial fields

mm cm

File format

Field separator = tab

Header (settings, field names)

Column for event number

Fields

Number of fields = 15
1..15

N	Field
1	Z (atomic number)
2	N (neutron number)
3	q (ion charge)
4	X [mm]
5	0 (empty)
6	X(Theta) [mrad]
7	0 (empty)
8	Y [mm]
9	0 (empty)
10	Y(Phi) [mrad]
11	0 (empty)
12	Energy [MeV/u]
13	0 (empty)
14	Time from Target [ns]
15	0 (empty)

Number of Rays = 100
1.. 1 000 000

Output Mode

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Write only passed rays

Write all rays (including unpassed)

Unit of Spatial fields

mm cm

File format

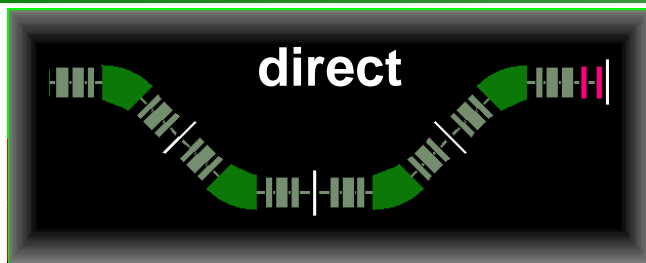
Field separator = tab

Header (settings, field names)

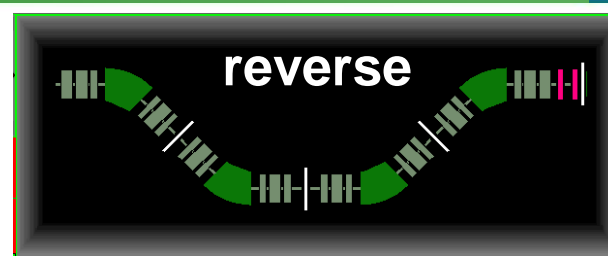
Column for event number

Block and configurations benchmarks

beam →



← beam



P rojectile	124 Sn ⁵⁰⁺
80 MeV/u	pnA
F ragment	124 Sn ⁵⁰⁺ =beam=
T arget	
Str ipper	
D tuning	Brho 3.2582 Tm
d z015	standard 3.2582 Tm
Q Q017-1TA	QUAD 11.4038 kG
d z018	standard 3.2582 Tm
Q Q019-1TB	QUAD -10.5976 kG
d z020	standard 3.2582 Tm
Q Q021-1TC	QUAD 7.6243 kG
d z022	standard 3.2582 Tm
D D1	Brho 3.2582 Tm

P rojectile	124 Sn ⁵⁰⁺
79.5 MeV/u	pnA
F ragment	124 Sn ⁵⁰⁺ =beam=
T arget	
Str ipper	
D tuning	Brho 3.2477 Tm
S Image4(105)	slits
	-150 X +150
	-150 Y +150
M FP_PPAC1	AI -2 mrg/cr2
d z104	standard 43.2 cm
M FP_PPAC0	AI -2 mrg/cr2
d z103	standard 37.5 cm
Q Q102-8TC	QUAD 6.0177 kG
d z101	standard 17.56 cm
Q Q100-8TB	QUAD -10.195 kG
d z099	standard 17.2 cm
Q Q098-8TA	QUAD 8.3052 kG
d z097	standard 52.6 cm
D D4	Brho 3.2582 Tm

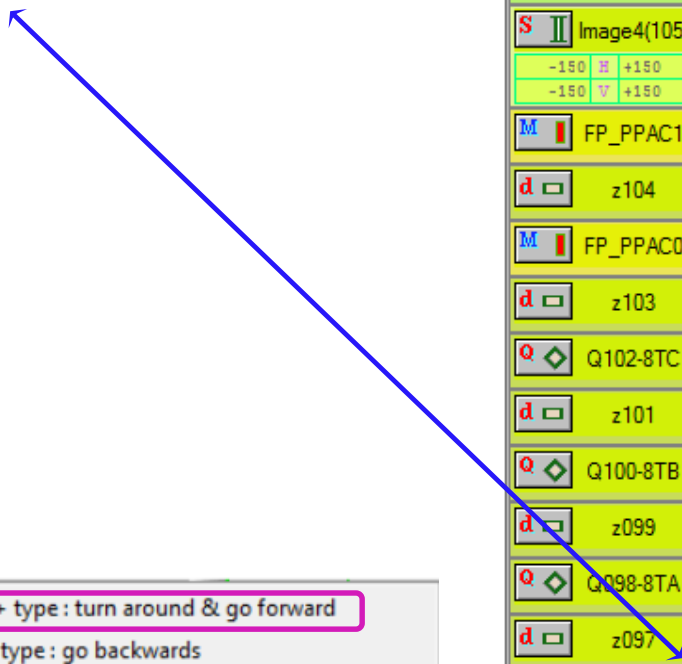
Load
Save
View

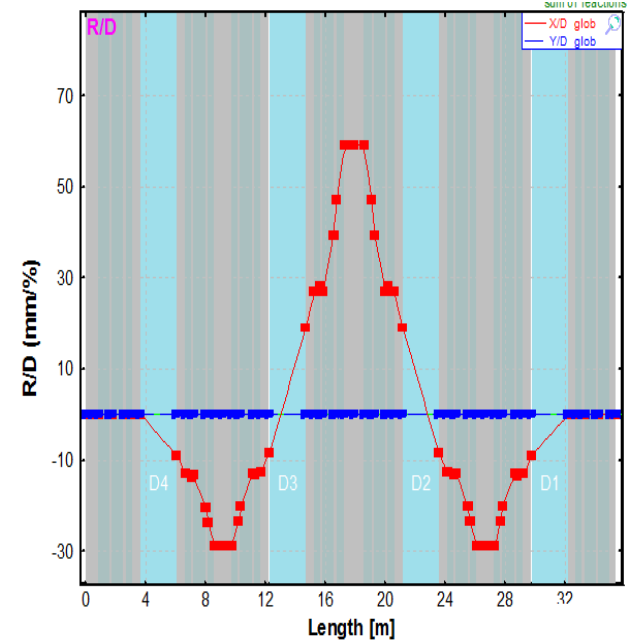
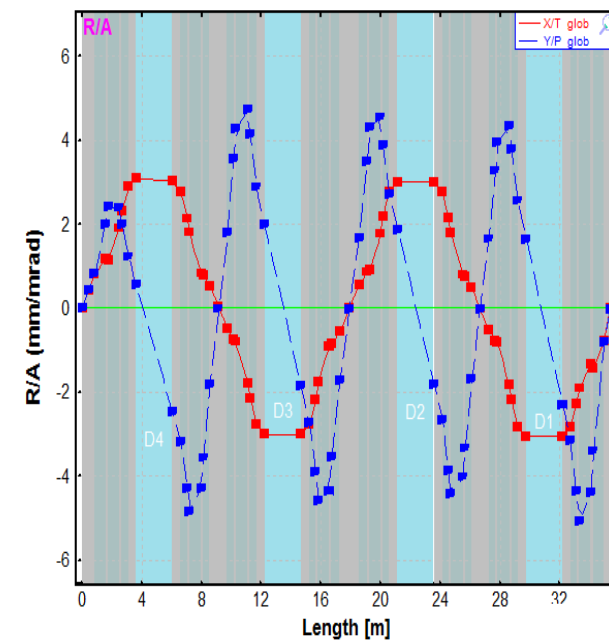
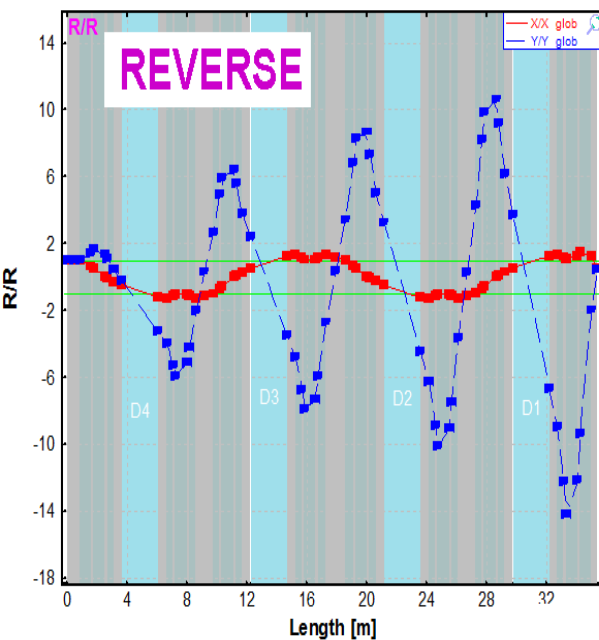
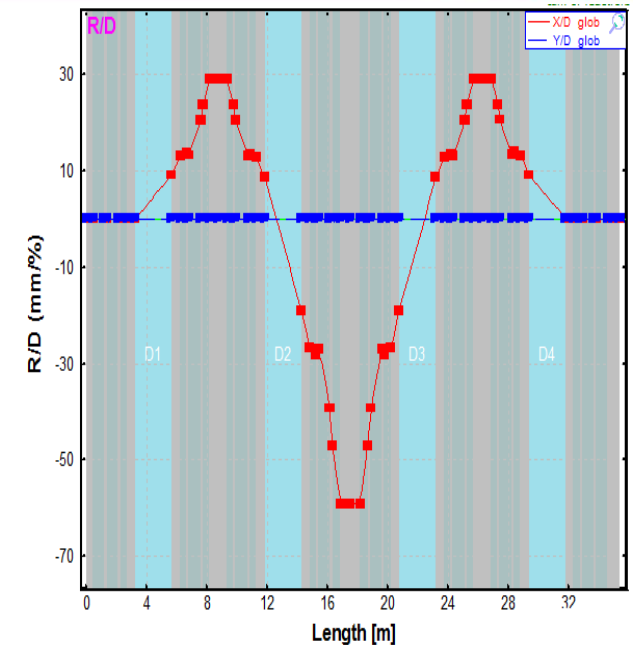
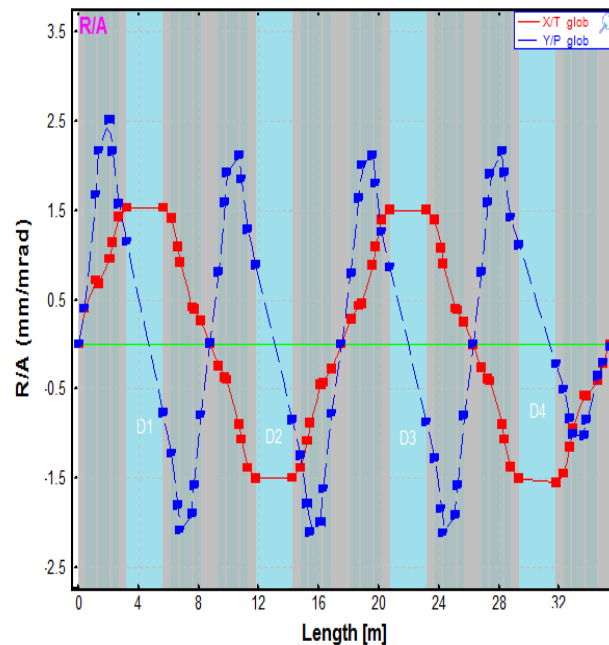
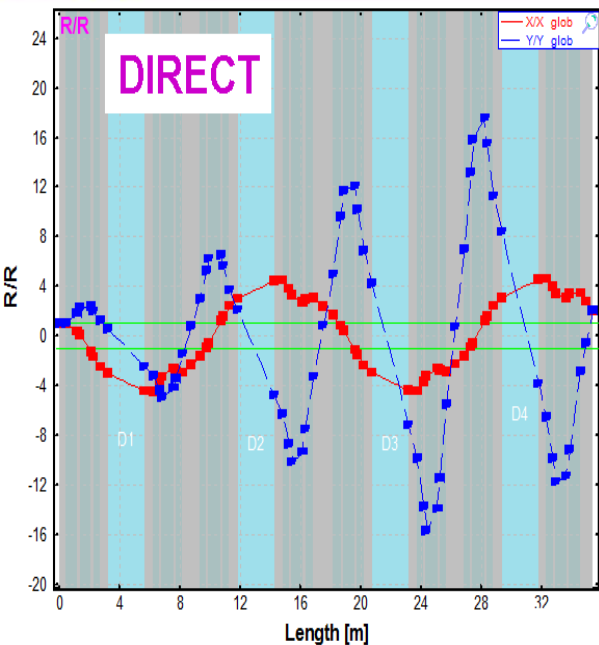
TRANSPORT code : Import (beta-version)

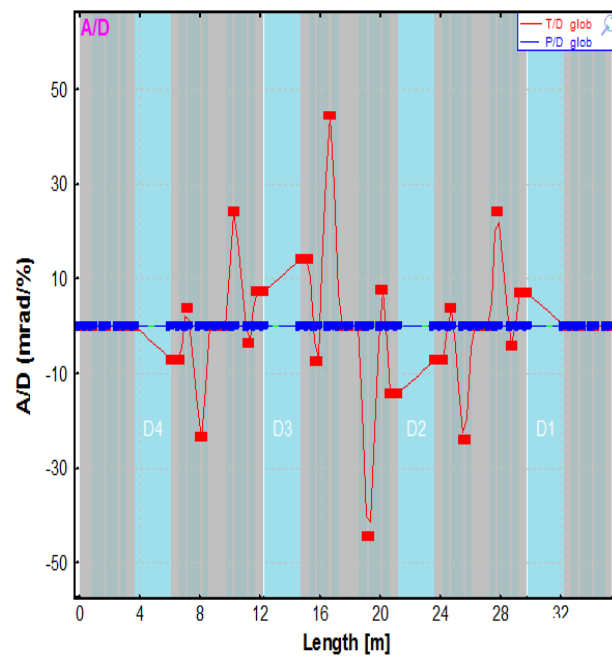
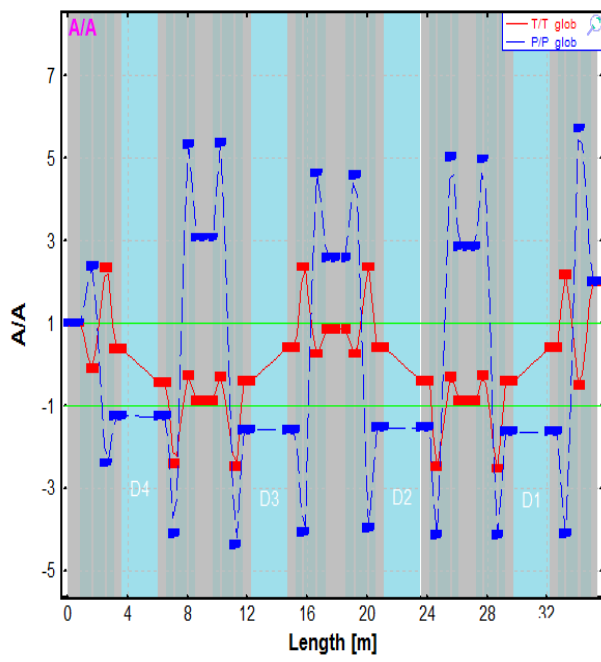
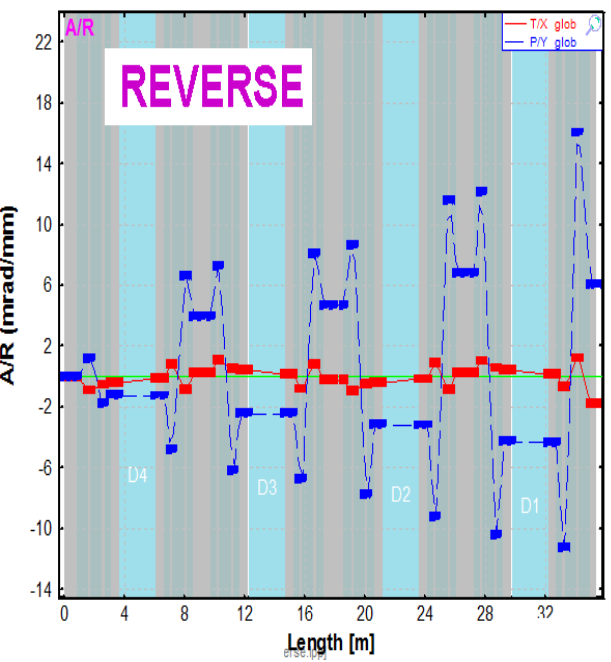
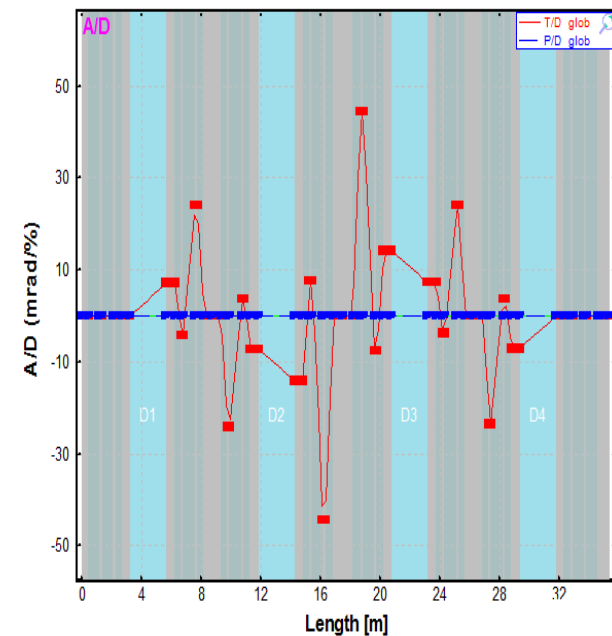
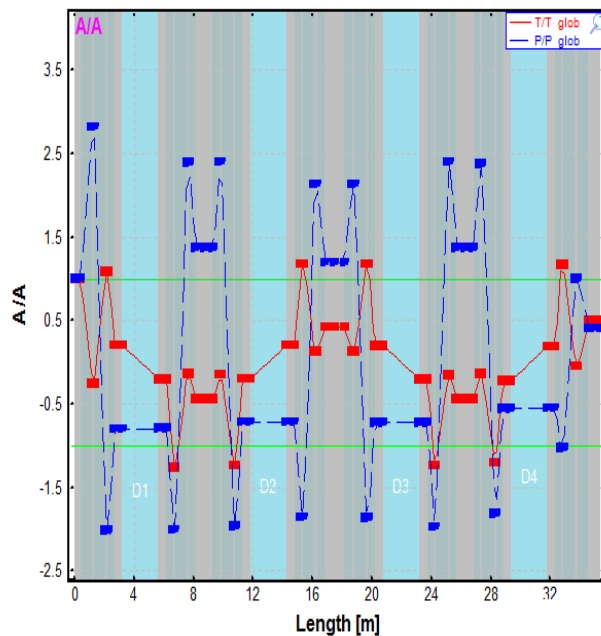
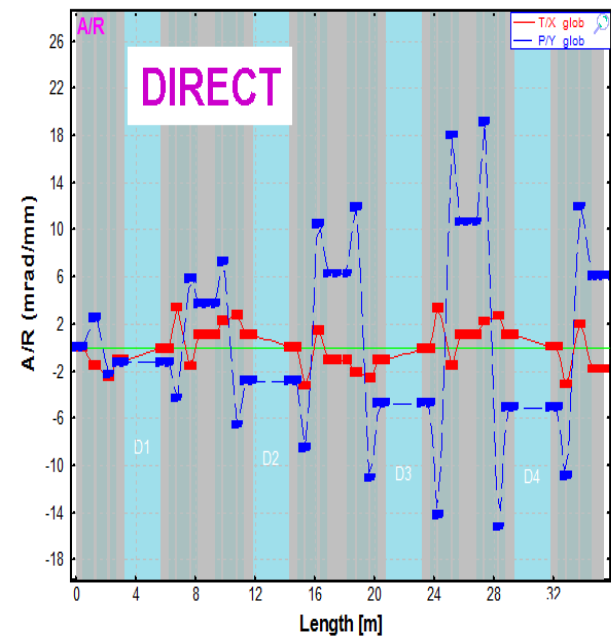
Create reverse configuration (beta-version) ▶

LISE++ type : turn around & go forward

COSY type : go backwards







Emittance [#1]		Beam CARD (sigma, semi-axis, half-width...)	1D - shape (Distribution method)	2D mode	2D - shape (Monte Carlo method)	Com w
1. X	mm	3	Rectangle uniform	<input type="checkbox"/>		
2. T	mrاد	50	Rectangle uniform	<input type="checkbox"/>		
3. Y	mm	3	Rectangle uniform	<input type="checkbox"/>		
4. P	mrاد	40	Rectangle uniform	<input type="checkbox"/>		
5. L	mm	0	Gaussian	<input type="checkbox"/>		
6. D	%	2.5	Rectangle uniform	<input type="checkbox"/>		

initial
Target

Gate 1

Settings

"NOT" [-0.7, -0.4]

< X [mm] > after Stripper

Gate 2

Settings

"NOT" [0.4, 0.7]

< Y [mm] > after Stripper

Gate 3

Settings

"NOT" [-20, -15]

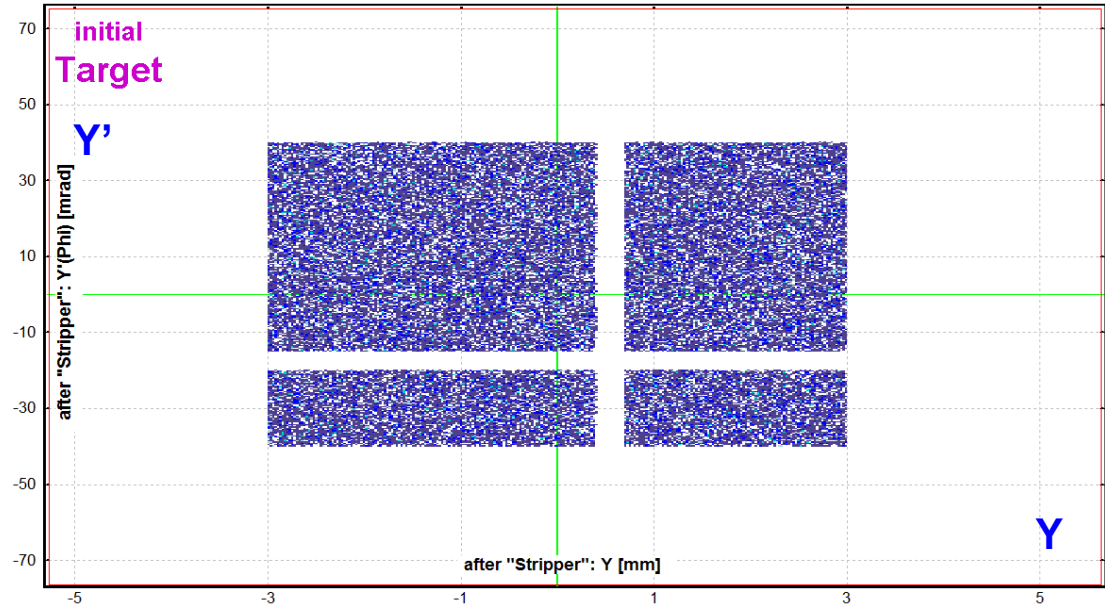
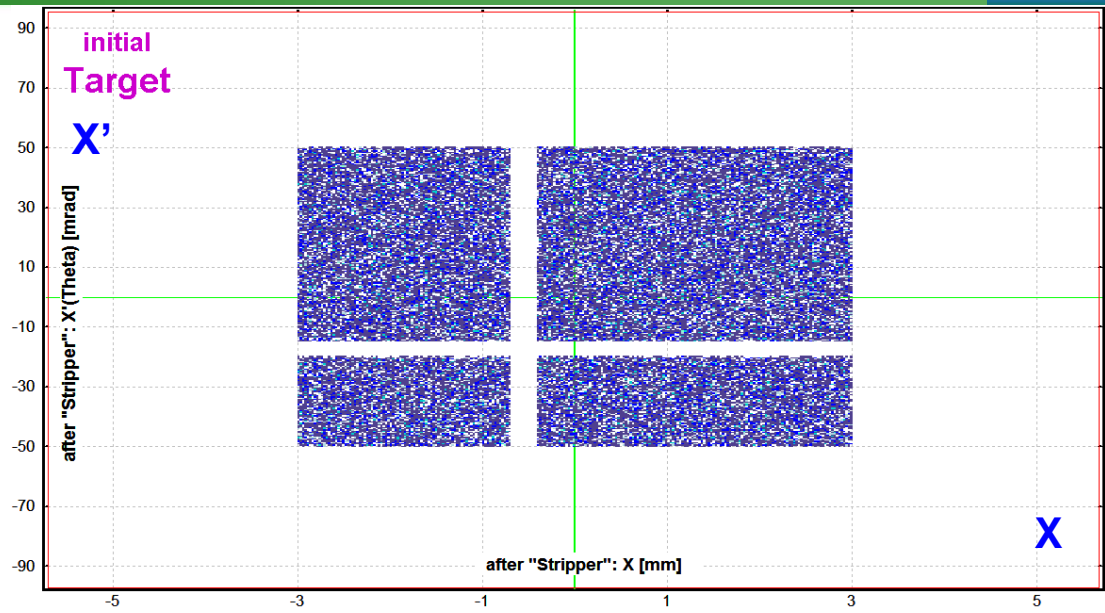
< X[Theta] [mrad] > after Stripper

Gate 4

Settings

"NOT" [-20, -15]

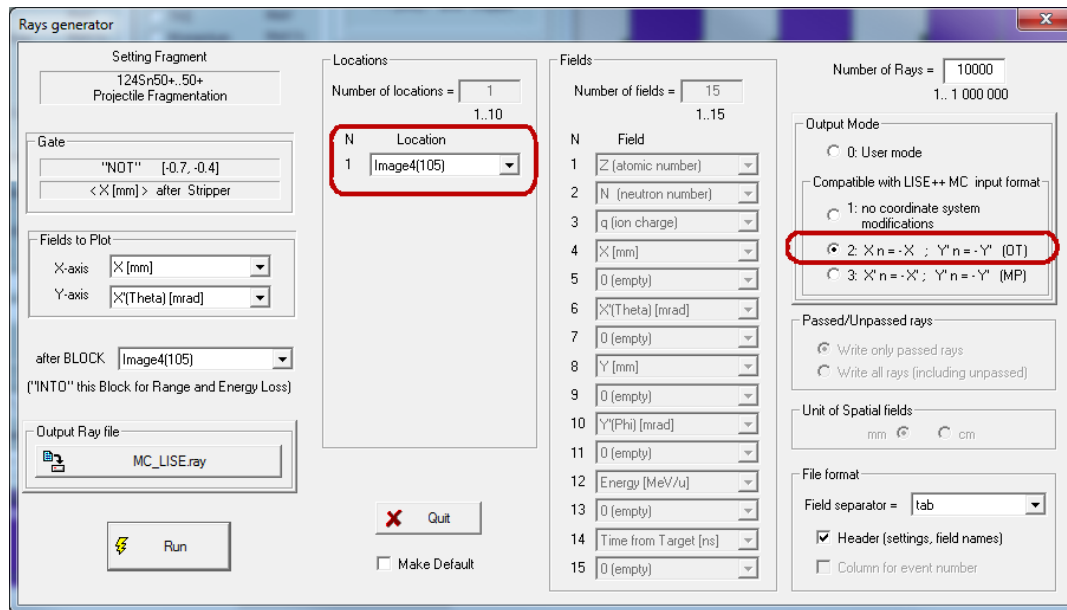
< Y[Phi] [mrad] > after Stripper



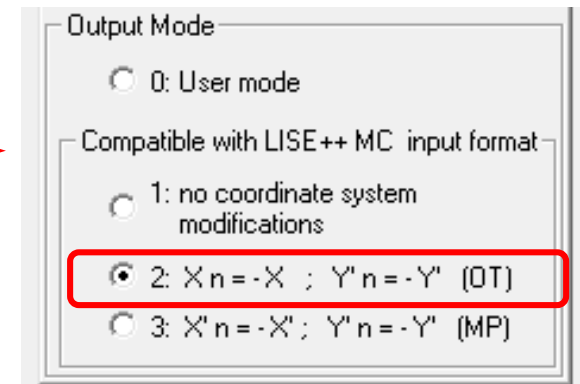
- Pay attention to the optics order

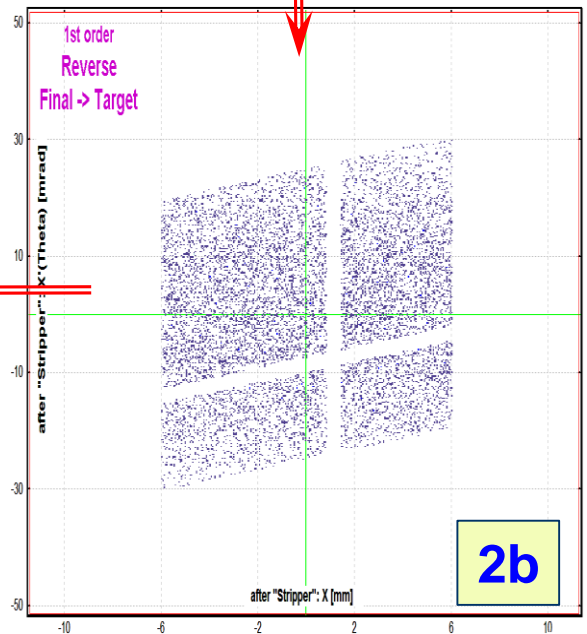
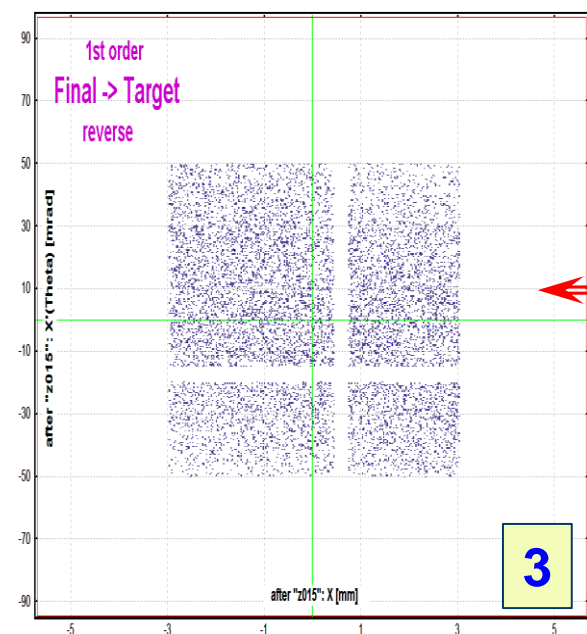
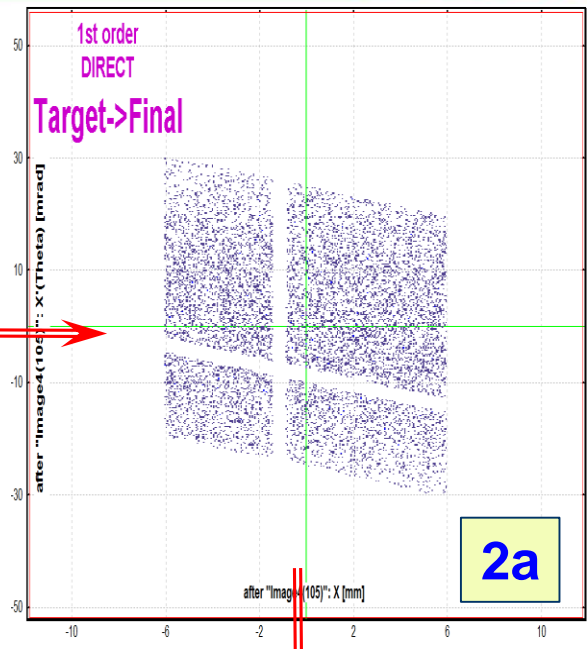
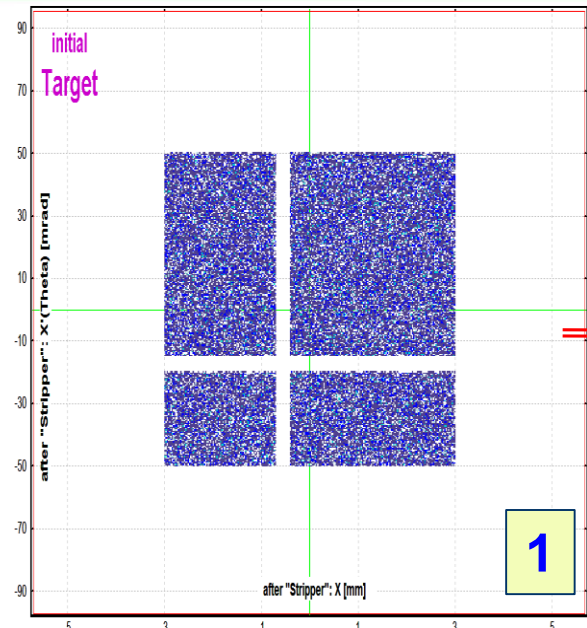
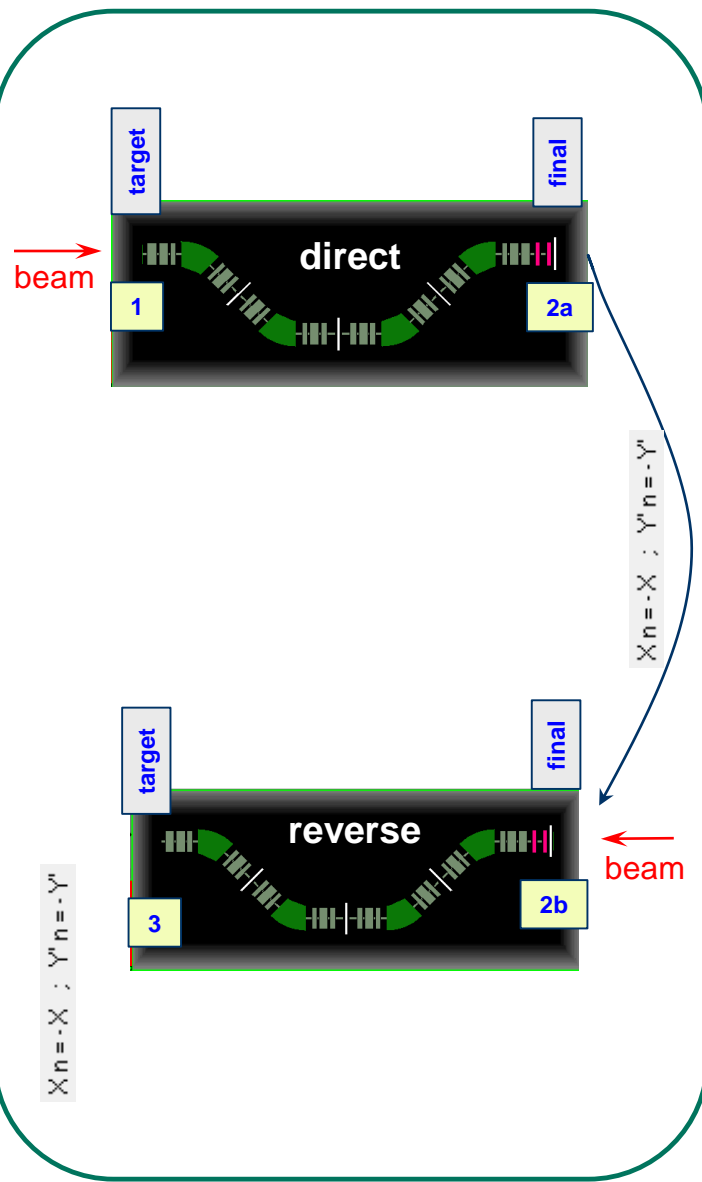
With reverse configurations it is possible to use

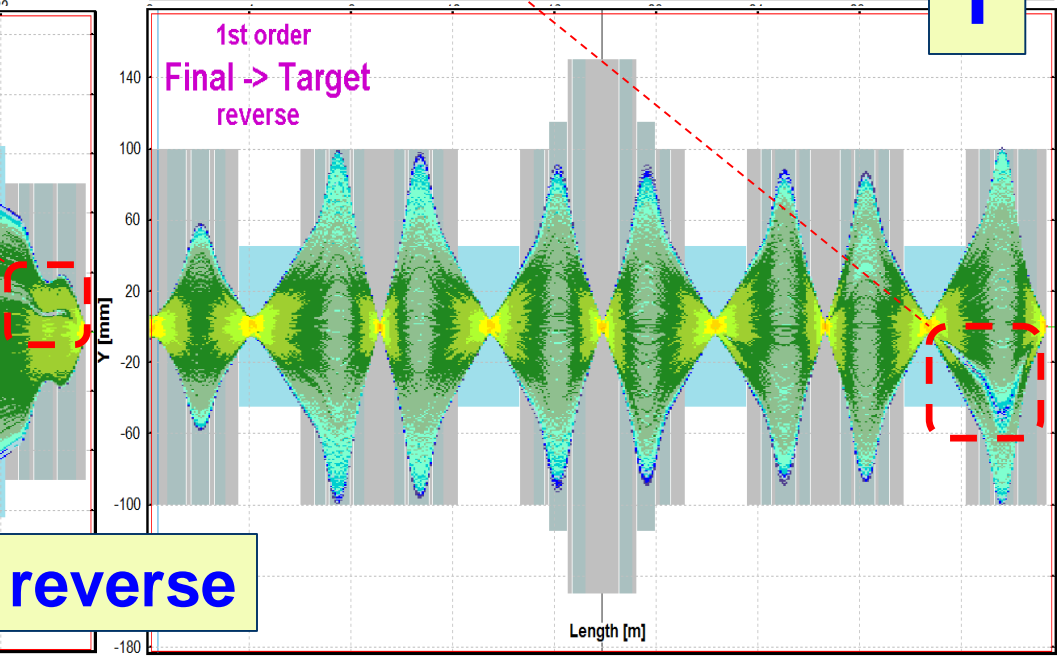
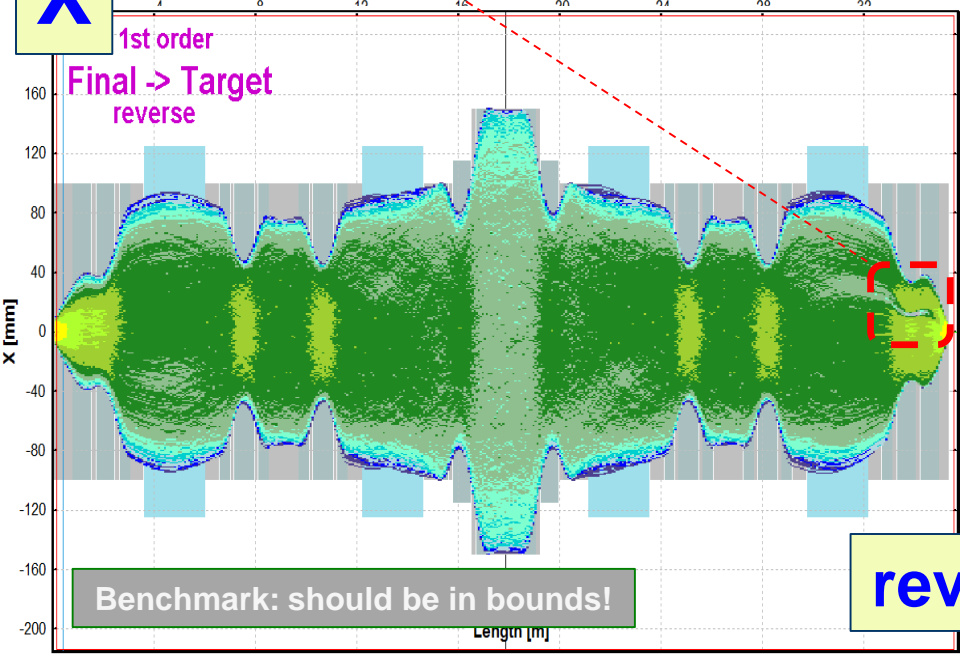
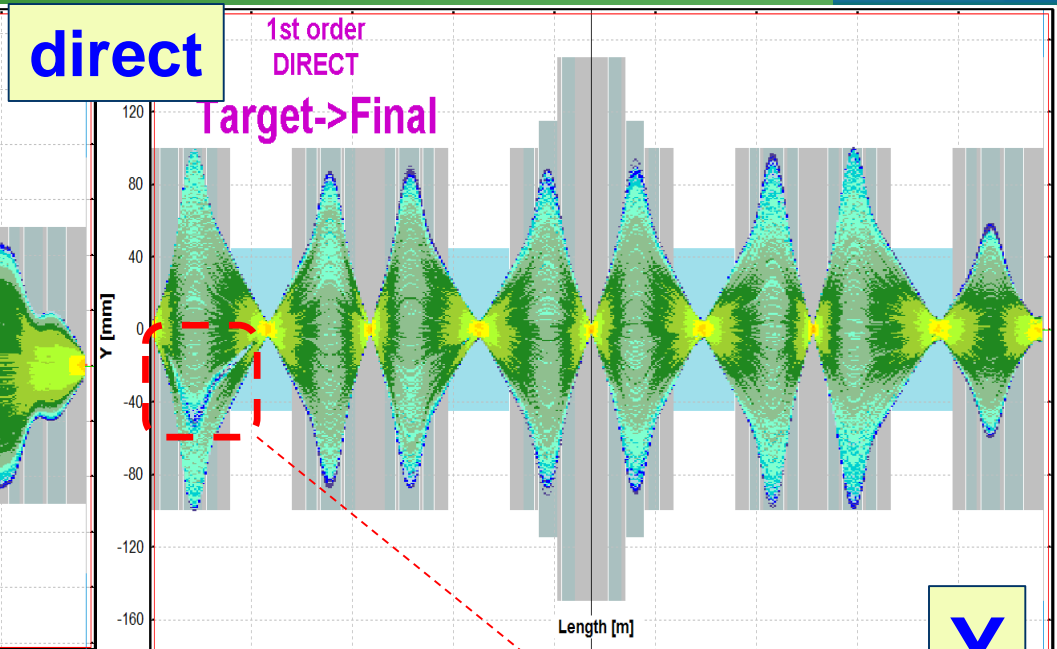
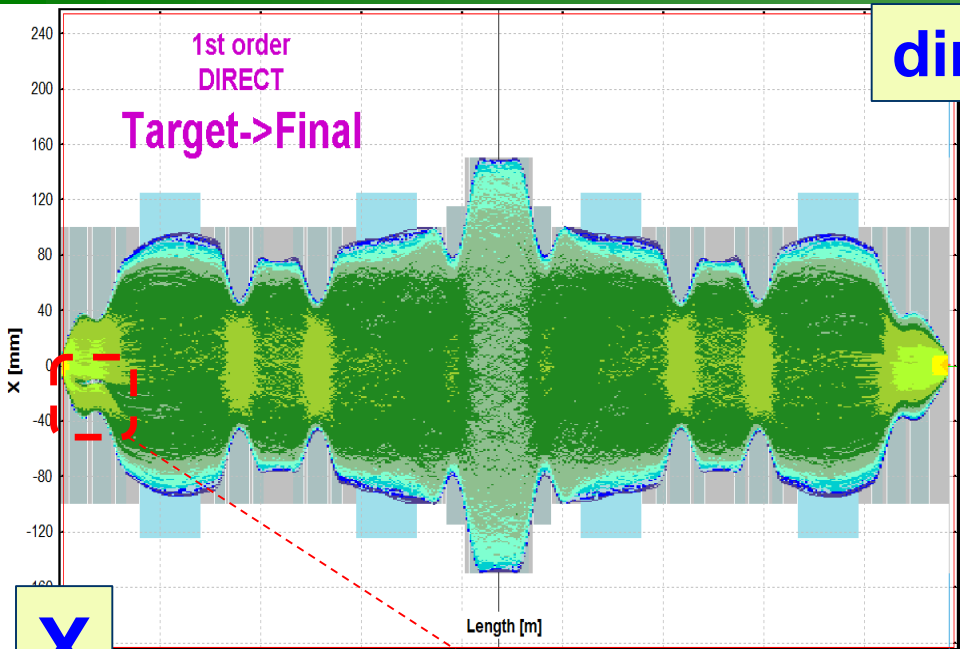
- experimental rays from the final point
- LISE++ rays generated for current reverse mode (LISE or COSY)



zoom →

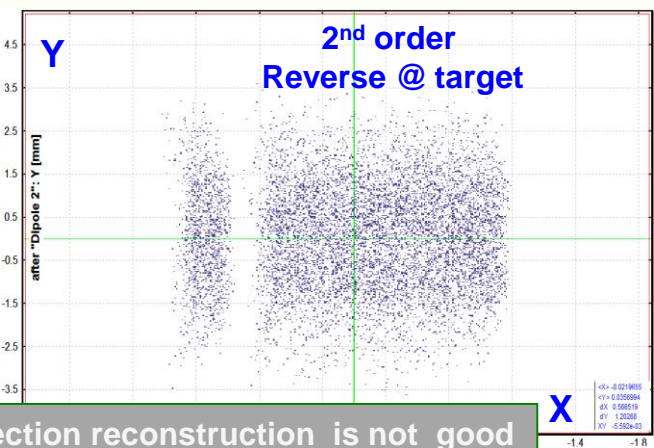
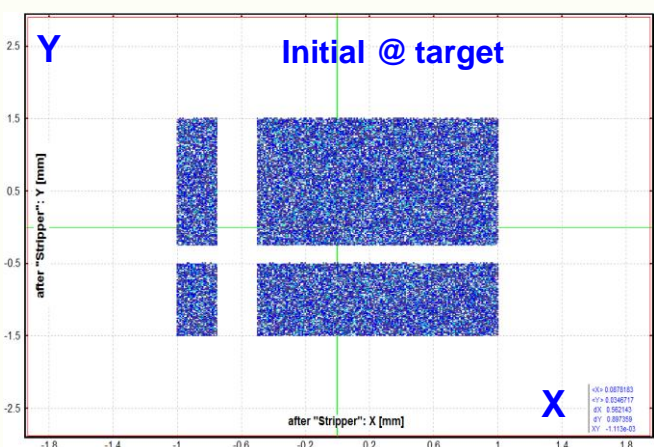




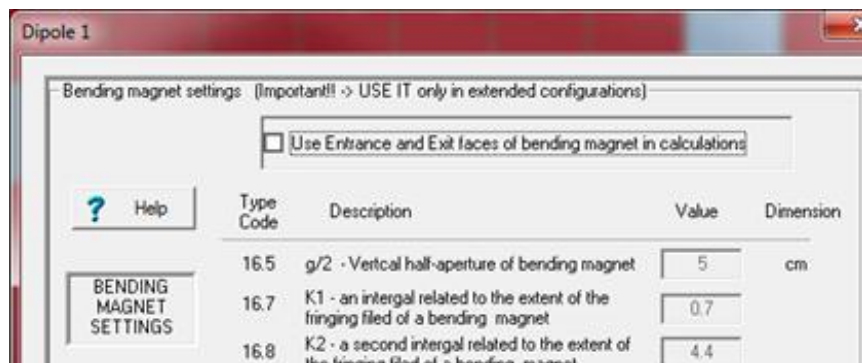


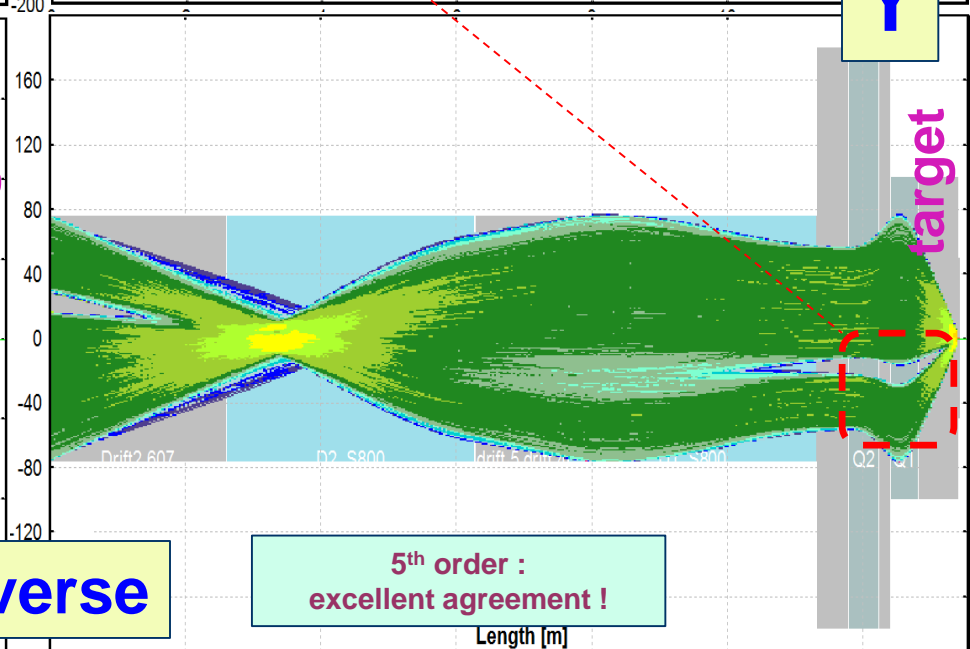
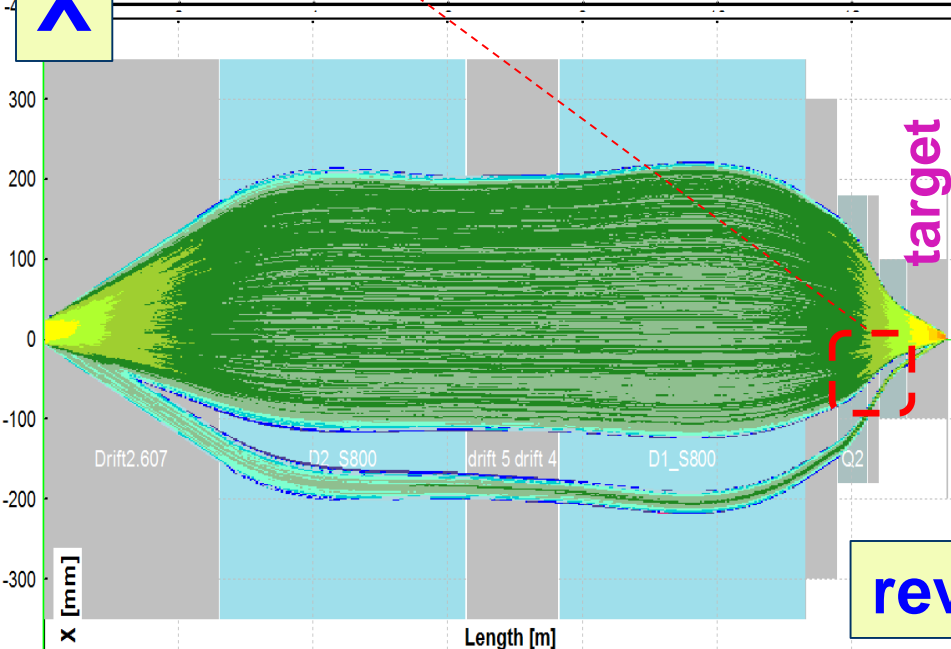
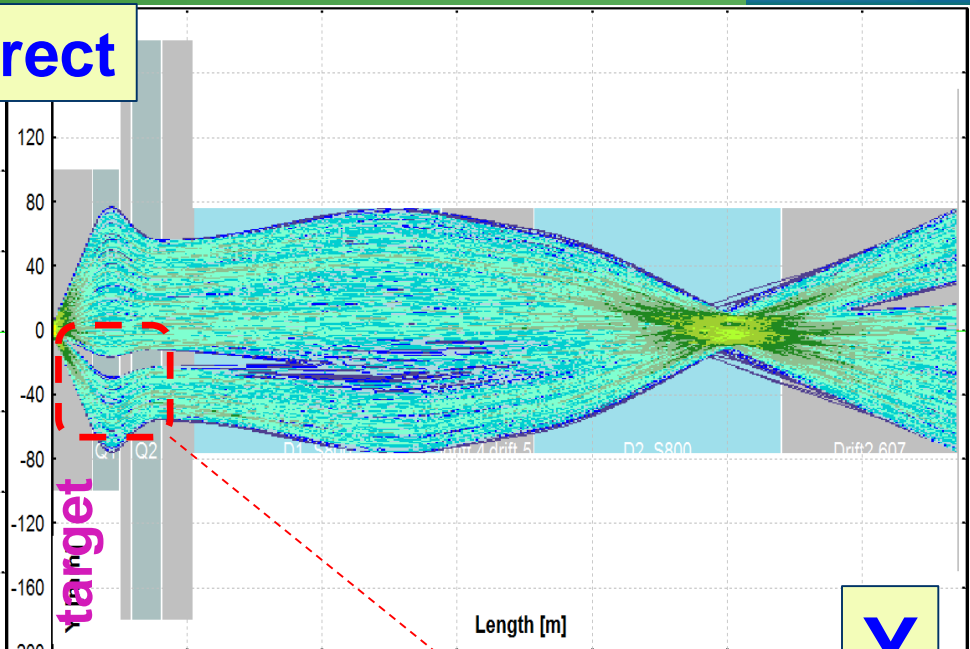
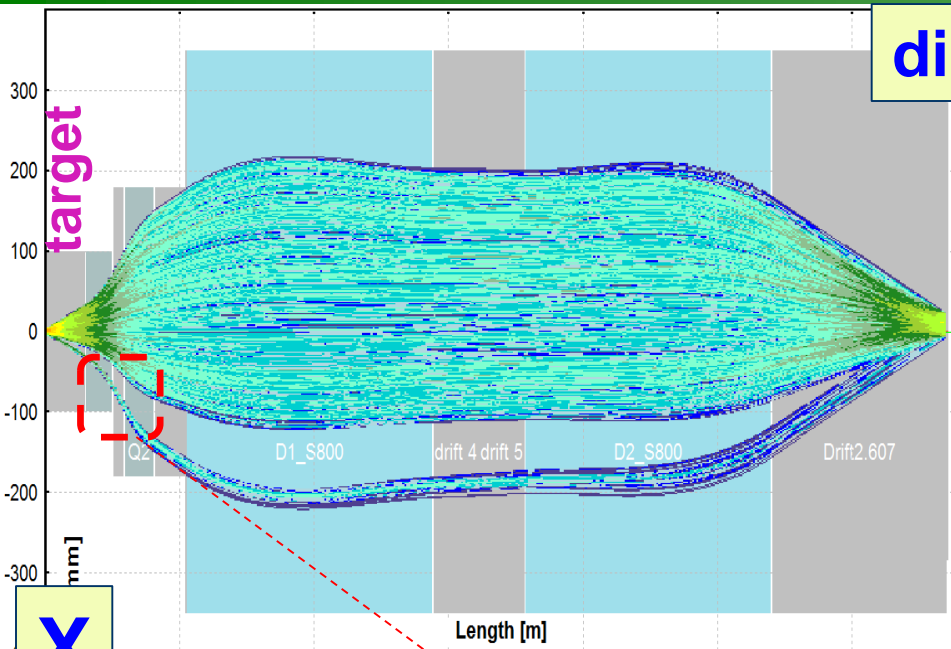
Block	1st order	2nd order
Drift	+	+
Quad (M)	+	+
Sextupole	+	+ with opposite field sign
Wien-fiter	+	
Dipole: no faces	+	+ very good, but not ideal
Dipole: empty faces	+	+ good
Dipole: S800	+	+/- fair

1. X mm	1	Rectangle uniform
2. T mrad	30	Rectangle uniform
3. Y mm	1.5	Rectangle uniform
4. P mrad	30	Rectangle uniform
5. L mm	0	Rectangle uniform
6. D %	1	Rectangle uniform



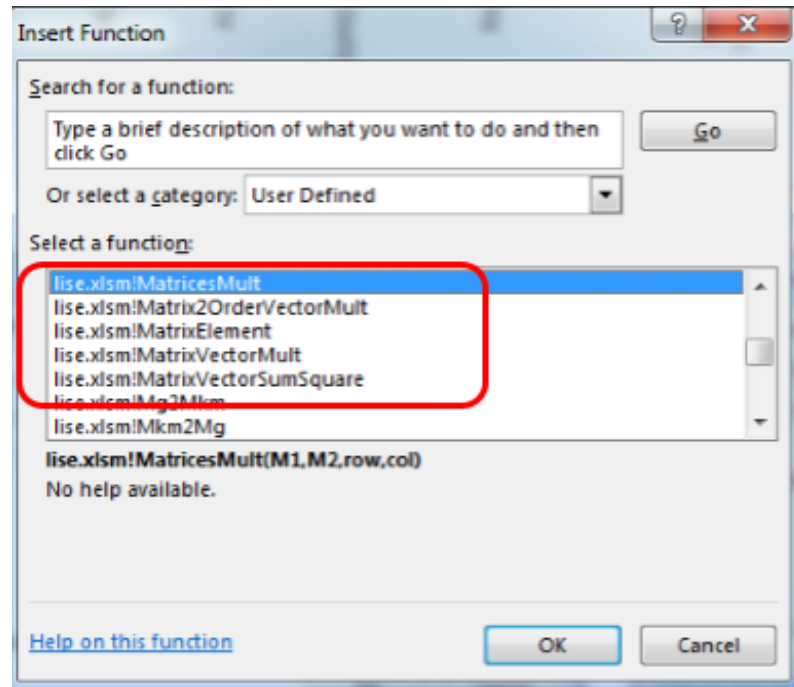
Y-direction reconstruction is not good





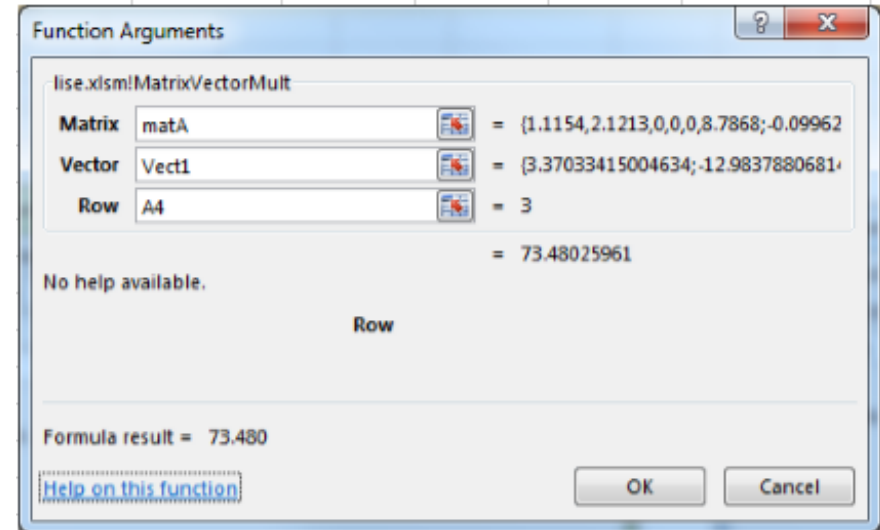
Operations with secondary maps in Excel

Lise.xlsm



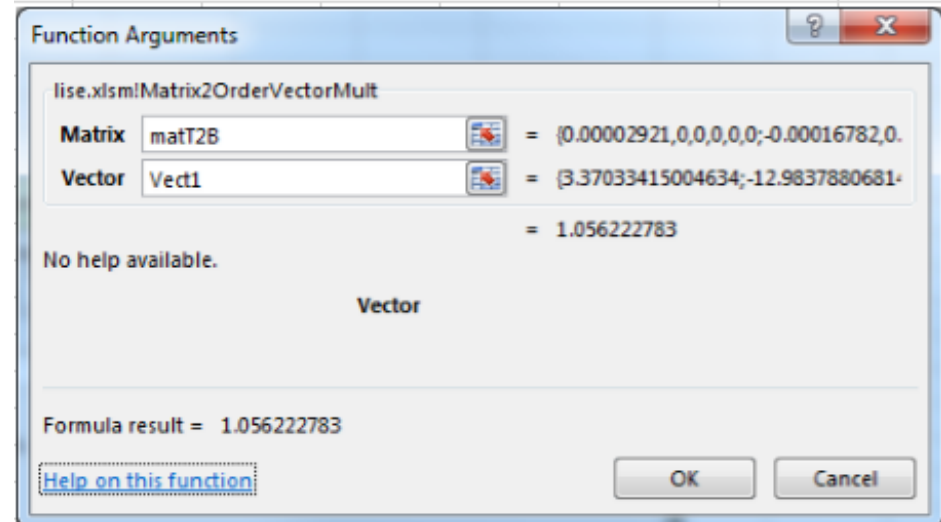
$$y_{\text{row}} = A_1 * V * \delta_{\text{row}}$$

MatrixVectMult (Matrix,Vector,Index)



$$y_{\text{row}} = T_{2,\text{row}} * V$$

Matrix2OrderVectorMult (Matrix,Vector)



http://lise.nsci.msu.edu/doc/e12006/Dipole_MatriceMultipl%20v3.xlsx

$$\mathbf{v}_2 = \mathbf{A}_{\text{direct}} * \mathbf{v}_1$$

$$\mathbf{v}_{2R} = \text{rotated}(\mathbf{v}_2)$$

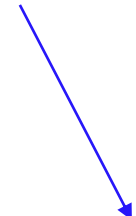
$$\mathbf{v}_{3R} = \mathbf{A}_{\text{reverse}} * \mathbf{v}_{2R}$$

$$\mathbf{v}_3 = \text{rotated}(\mathbf{v}_{3R})$$

$\mathbf{A}_{\text{reverse}}$ is correct if $\mathbf{v}_1 = \mathbf{v}_3$

Where \mathbf{A} is the set of 1st and 2nd order maps

Minimization of $|\mathbf{v}_1 - \mathbf{v}_3|$
varying $\mathbf{A}_{\text{reverse}}$



row	V1	D matr 2nd	V2 1st	V2 2nd	V2 Total	V2 Reverse	R matr 2nd	V3	V3 2nd	V3 Total	V3 Reverse	d
1	3.37	matT1	-42.981	-1.51E+00	-44.493	44.493	matT1B	-3.90	6.2E-01	-3.29	3.29	0.08
2	-12.98	matT2	-24.966	-7.56E-01	-25.722	-25.722	matT2B	-13.98	1.0E+00	-12.94	-12.94	0.05
3	-1.40	matT3	73.480	-4.65E-01	73.015	73.015	matT3B	-1.26	-1.1E-01	-1.37	-1.37	0.03
4	31.53	matT4	32.352	-2.60E-01	32.092	-32.092	matT4B	-31.30	6.4E-01	-30.66	30.66	0.88
5	-41.75	matT5	-28.161	-1.25E-02	-28.174	28.174	matT5B	42.17	-6.3E-01	41.54	-41.54	0.21
6	-2.18	matT6	-2.185	0.00E+00	-2.185	-2.185	matT6B	-2.18	0.0E+00	-2.18	-2.18	0.00
												1.24
	initial Vector	pointer to direct A2i matrix	A1*V1	A2i*V1	Sum(1st+2nd)	Reverse	pointer to reverse A2i matrix	A1R*V2R	A2iR*V2R	Sum(1st+2nd)	Reverse	V1-V3

http://lise.nslc.msu.edu/doc/e12006/Dipole_MatriceMultipl%20v3.xlsx

Direct 1st & 2nd order maps

A	D1_S800	Matrices: LOCAL				
1.1154	2.1213	0	0	0	0	8.7868
-0.09962	0.70711	0	0	0	0	7.0711
0	0	0.57914	2.3562	0	0	0
0	0	-0.17411	1.0183	0	0	0
-0.87621	-0.87868	0	0	1	0	-2.3487
0	0	0	0	0	1	0

transport format [mm-mrad]

Direct

T1	-1.49E-05	7.95E-04	3.11E-04	8.99E-05	-5.50E-04	-1.36E-03	2.11E-03	6.21E-03	-7.50E-02
T2	1.05E-05	-3.54E-04	-2.59E-05	-1.54E-05	-3.54E-04	9.96E-04	-7.07E-02		
T3	-4.54E-05	-1.20E-03	6.14E-04	8.79E-04	4.12E-03	2.35E-03			

Reversed 1st & 2nd order maps used in calculations, and varied in the minimization

Ab	REVERSE BENDING MATRIX						
0.70711	2.1213	0	0	0	0	0	-8.7868
-0.09962	1.1154	0	0	0	0	0	-8.7621
0	0	1.0183	2.3562	0	0	0	0
0	0	-0.17411	0.57914	0	0	0	0
0.70711	0.87868	0	0	0	1	0	-2.3487
0	0	0	0	0	0	1	0

Reverse (fitted)

T1B	1.11E-04	-4.17E-04	-6.07E-05	1.04E-04	5.20E-04	3.94E-04	4.65E-03	5.18E-03	7.93E-02
T2B	2.92E-05	-1.68E-04	7.90E-05	2.73E-05	8.93E-05	6.41E-04	2.58E-03	-1.02E-03	9.43E-02
T3B	-8.41E-05	1.03E-03	4.46E-05	2.42E-03	1.83E-05	2.35E-03			

9 random initial vectors compared with their reversed images

delta's	9 random beam vectors									sum
	v1	v2	v3	v4	v5	v6	v7	v8	v9	
1	0.08	0.02	0.04	0.12	0.01	0.03	0.03	0.00	0.22	0.54
2	0.05	0.16	0.18	0.02	0.14	0.03	0.03	0.23	0.16	0.98
3	0.03	0.23	0.00	0.21	0.18	0.03	0.05	0.11	0.02	0.85
4	0.88	0.21	0.25	0.23	0.43	0.03	0.07	0.00	0.03	2.13
5	0.21	0.33	0.85	0.25	0.13	0.00	0.04	1.06	0.93	3.81
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	1.24	0.95	1.32	0.82	0.88	0.12	0.23	1.40	1.36	8.32

minimized value

Opposite signs

Opposite signs

Reversed 2nd order maps calculated by LISE++

reverse initial from LISE									
T1ir	1.11E-04	-4.17E-04	-6.07E-05	-1.04E-04	-5.20E-04	-7.94E-04	4.65E-03	5.18E-03	7.93E-02
T2ir	2.92E-05	-1.68E-04	7.90E-05	-2.73E-05	8.93E-05	6.41E-04	2.58E-03	-1.02E-03	9.43E-02
T3ir	-8.41E-05	-1.03E-03	-8.92E-04	-1.43E-03	1.83E-05	2.35E-03			

**Reverse technique
and detector resolution:
S800**

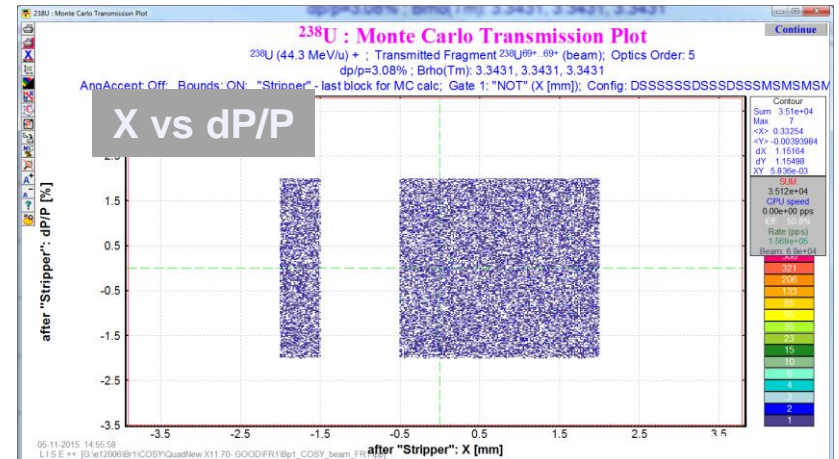
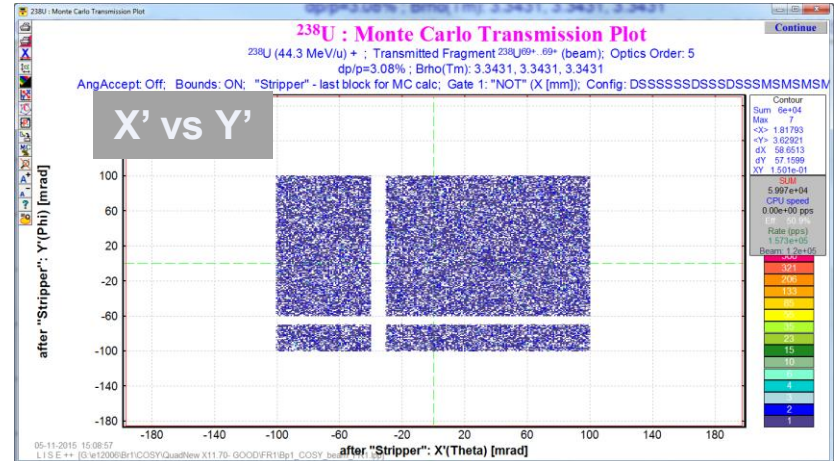
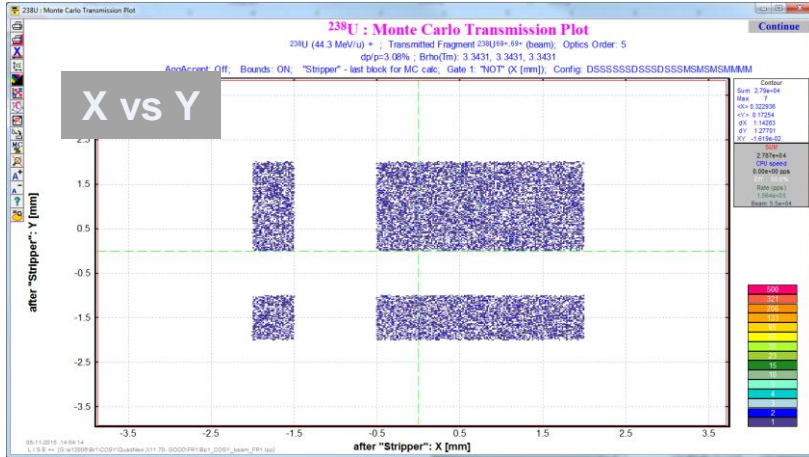
http://lise.nsci.msu.edu/doc/e12006/S800_reverse_resolution.pdf

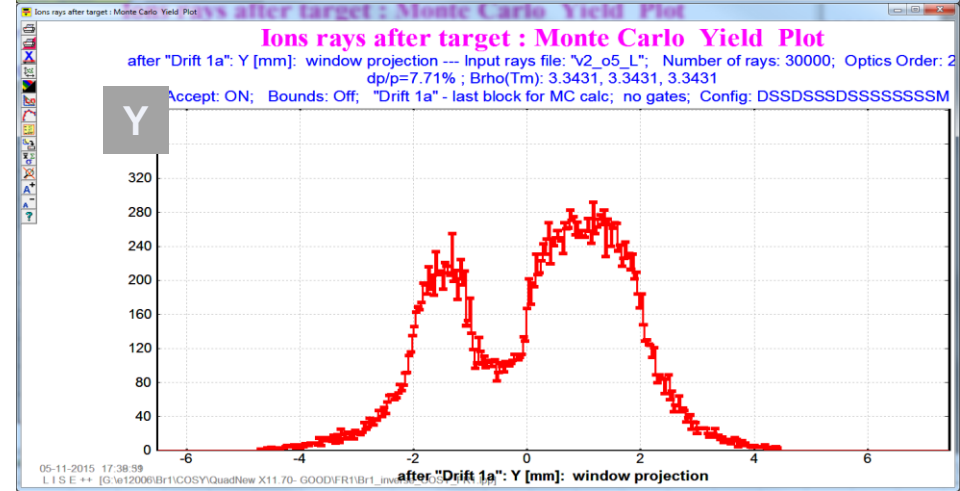
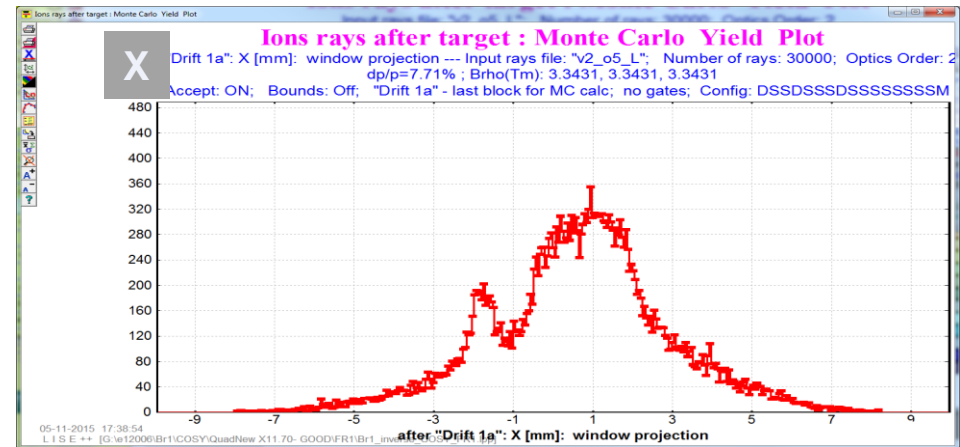
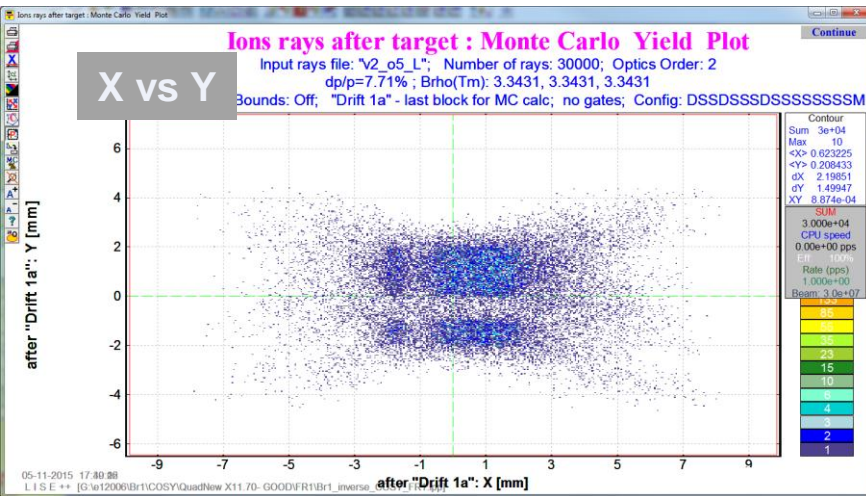
The screenshot displays the S800 simulation software interface, which is used for reverse simulation with detector resolution and optics. The main window is titled "Beam" and contains several configuration panels:

- Beam Parameters:** Includes fields for Element (U), q+ (69), Energy (44.26129 MeV/u), TKE (10534.766 MeV), Brho (3.34308 Tm), P (69.1539 GeV/c), and U (1.527e+5 KV).
- Beam Intensity:** Options for 0.003409 enA, 4.941e-5 pnA, 3.0883e+5 pps, and 5.205e-7 KW.
- Emitance:** A table for 1D and 2D shapes (Rectangle uniform, Gaussian) with parameters like X, Y, T, P, L, and D.
- Energy Loss:** A field for Energy Loss in the target box [KW], currently set to 0.

Overlaid on the main window are several other configuration windows:

- MC transmission options:** A window for setting High Order Optics Calculations, Detector resolution, Angular Acceptance & Bounds, and other simulation parameters.
- Monte Carlo calculation of fragment transmission:** A large window for selecting isotopes, fragment types, and detector parameters. It includes sections for "What isotope transmission to calculate?", "Chose fragment of interest", "Charge states", "Reaction mechanism", and "X-coordinate" and "Y-coordinate" settings.
- Gate Settings:** A vertical panel on the right showing settings for four gates (Gate 1 to Gate 4), including "NOT" ranges and "after Stripper" options.

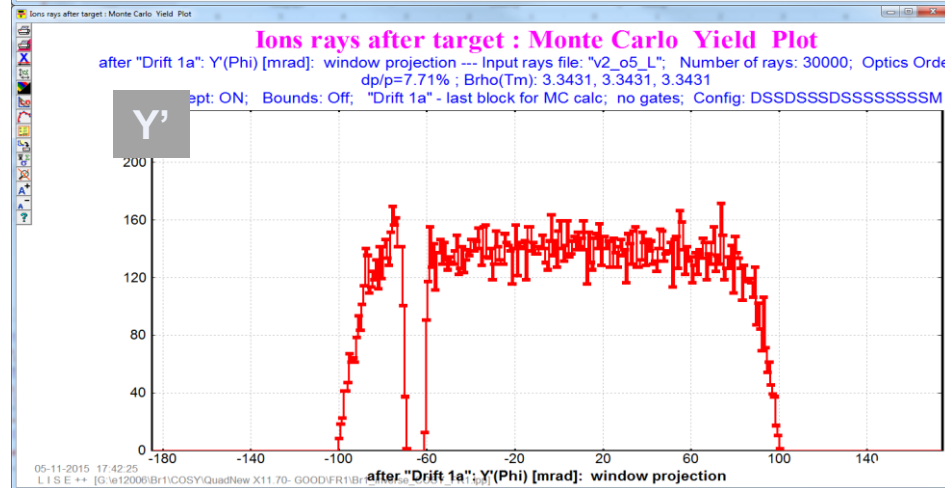
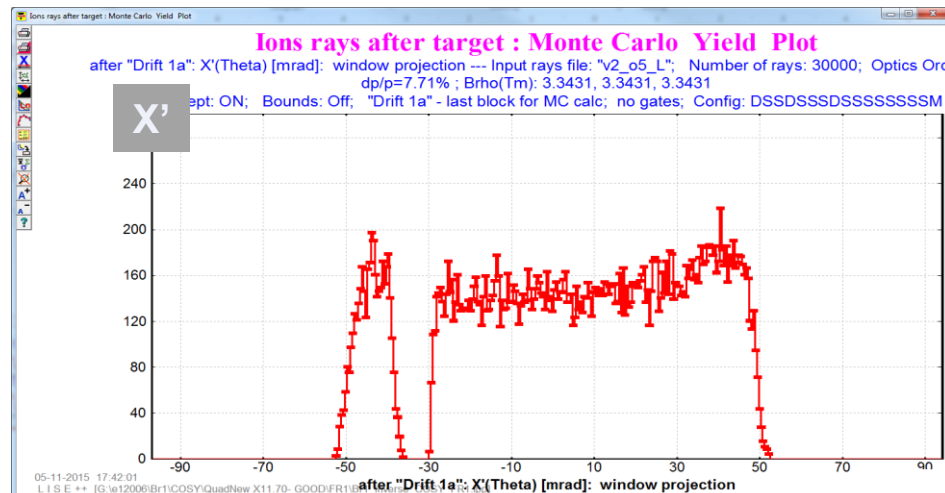
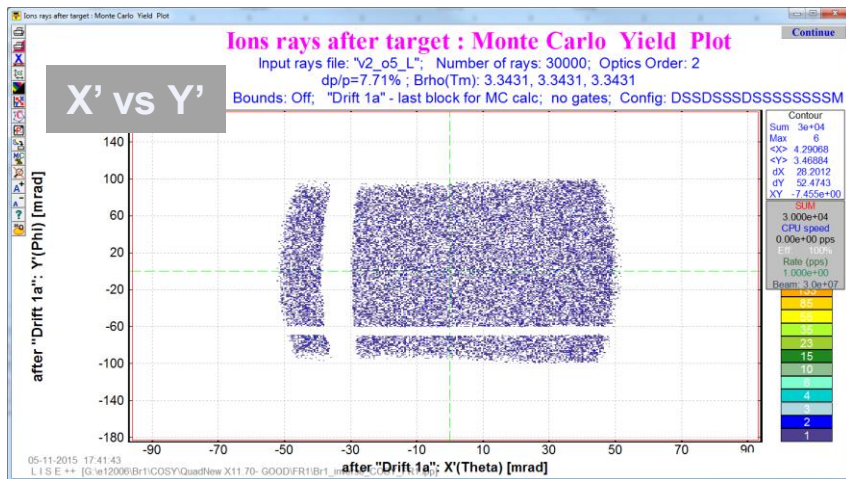




Case 2-2

Reverse @ Target
2nd order (5→2)
 With Ideal detector resolution

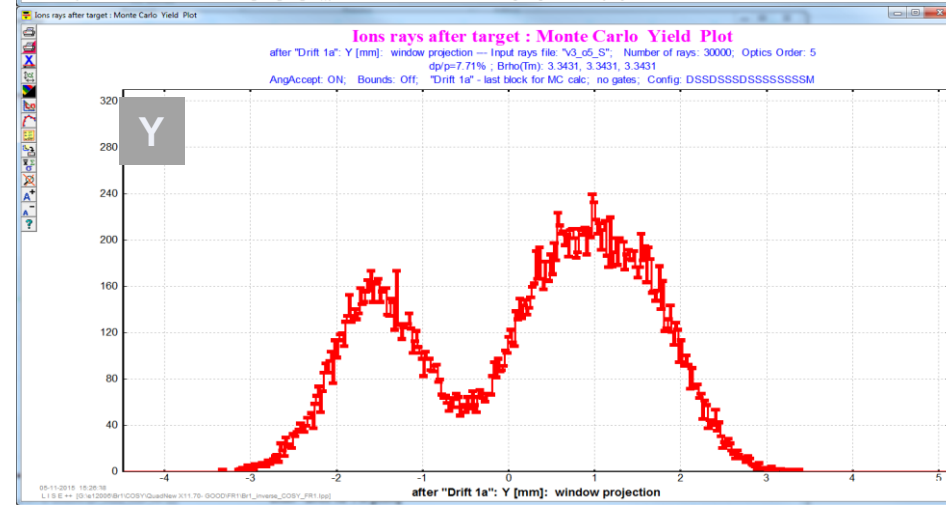
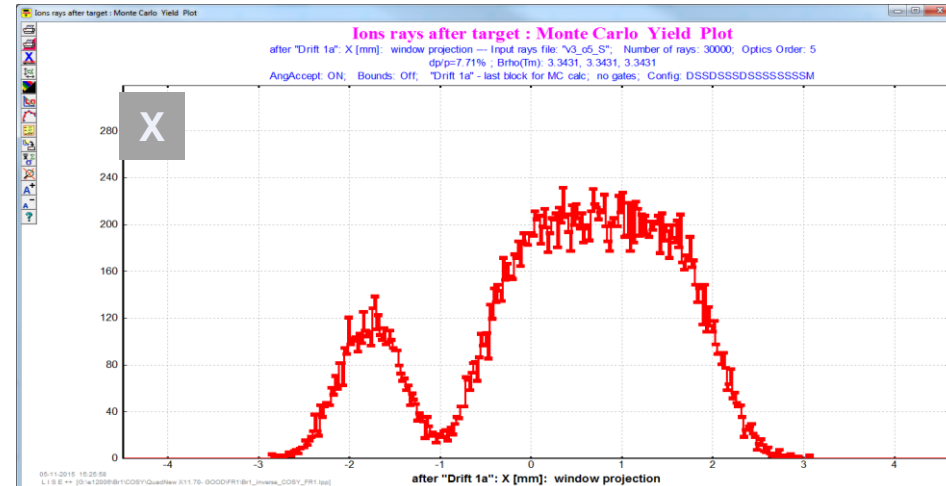
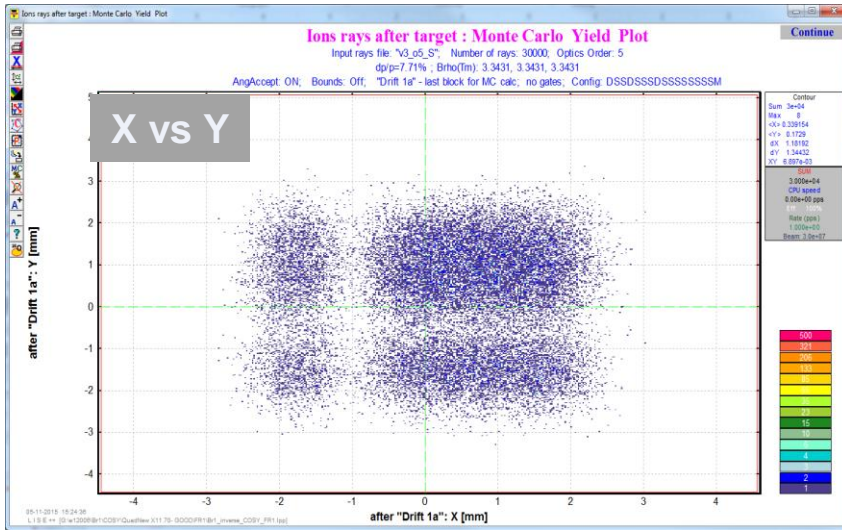
Fair..



Case 2-2

Reverse @ Target
2nd order (5→2)
Ideal resolution

Good!

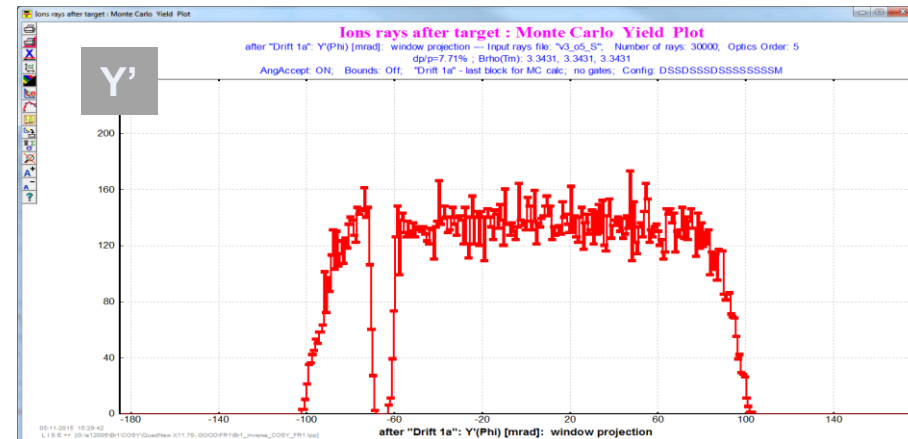
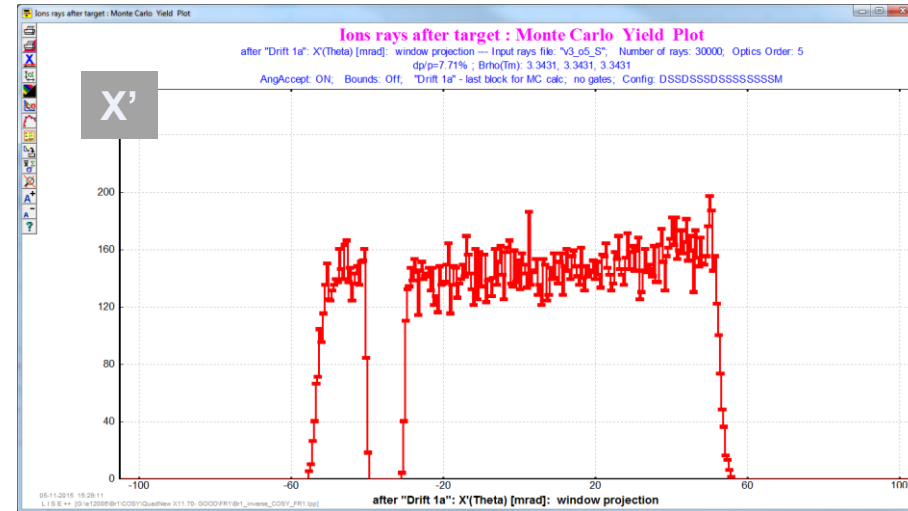
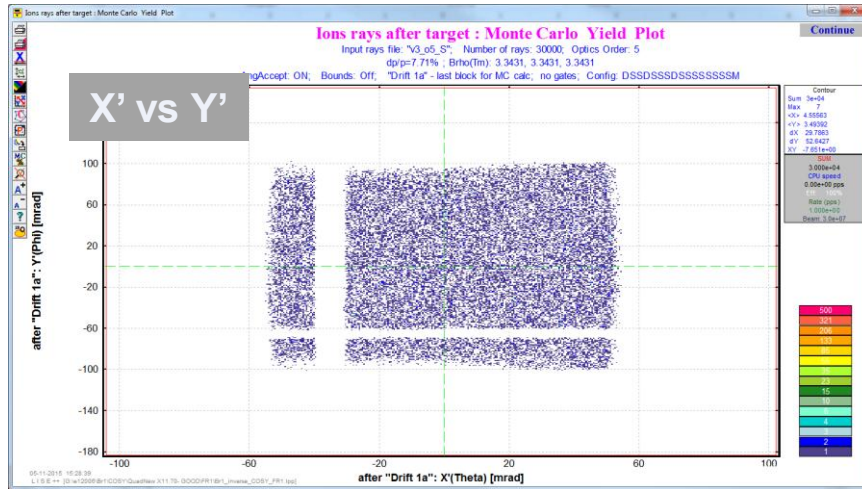


Case 3

Reverse @ Target
 5th order (5→5)

Resolution
dX = 0.25 mm
dX' = 0.25 mrad
dY = 0.50 mm
dY' = 0.50 mrad
 dE = 0%

V3_o5_S.ray



Case 3

Reverse @ Target
 5th order (5→5)

Resolution
dX = 0.25 mm
dX' = 0.25 mrad
dY = 0.50 mm
dY' = 0.50 mrad
 dE = 0%

V3_o5_S.ray

Reverse Case	Optics	Spatial resolution	dE	Quality of reconstruction				
				X	Y	X'	Y'	Global
2-1	5->1	ideal	0	2	7	3	7	3
2-2	5->2	ideal	0	5	8	8	9	7
2-3	5->5	ideal	0	10	10	10	10	10
3	5->5	good	0	8	8	10	9	9
4	5->5	good	0.2%	1	8	4	9	4
5	5->5	poor	0	4	4	8	7	6

Case 3 : current analysis for #12006 experiment (S800)
 Case 2-1 (inverse 1st order LISE++) & 4 (E from ToF) : non-acceptable

We need ^(MH) for this S800 particular case*

- (1) at least 2nd order,
- (2) good spatial resolution,
- (3) an energy measurement that is clearly better than a typical TOF measurement.

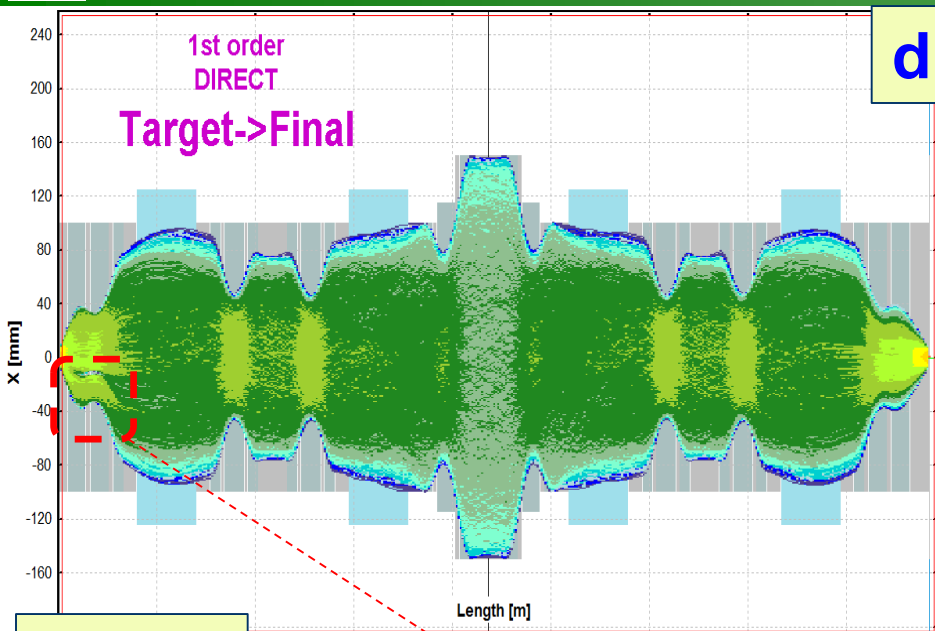
* for A1900 (achromatic case) the conclusions may be different

**Reverse technique
and detector resolution:
A1900**

http://lise.nsl.msu.edu/doc/e12006/A1900_reverse_resolution.pdf

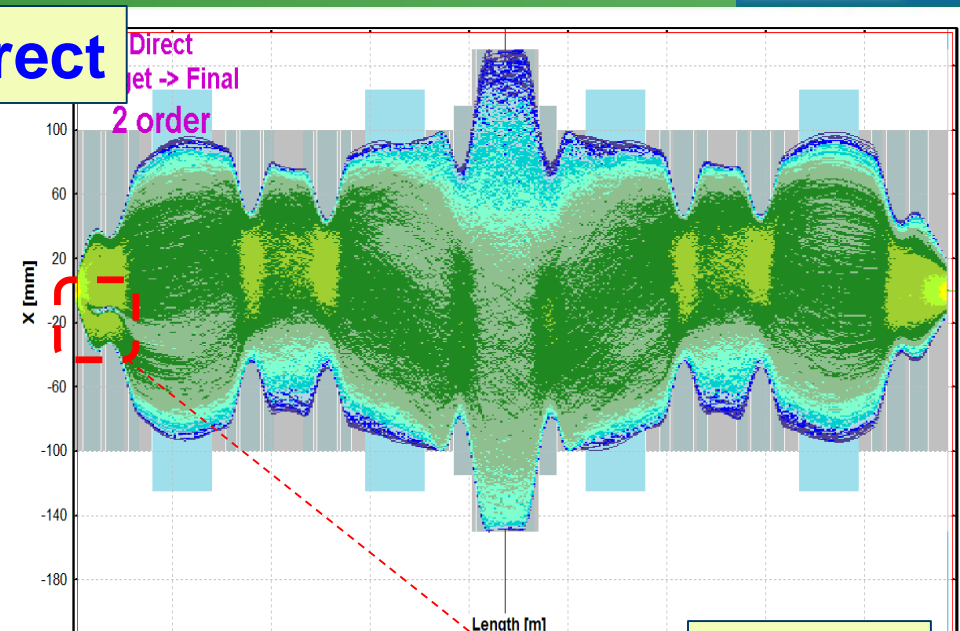
1. LISE-type reverse file creation
2. Optics (1→1)
3. Optics (2→1)
4. Detector resolution for optics (1→1)
5. Contribution of straggling in wedge
6. Some remarks: charge states
7. Summary

Direct file: http://lise.nsl.msu.edu/9_10/reverse/A1900_direct.lpp
Reverse file: http://lise.nsl.msu.edu/9_10/reverse/A1900_Lreverse.lpp

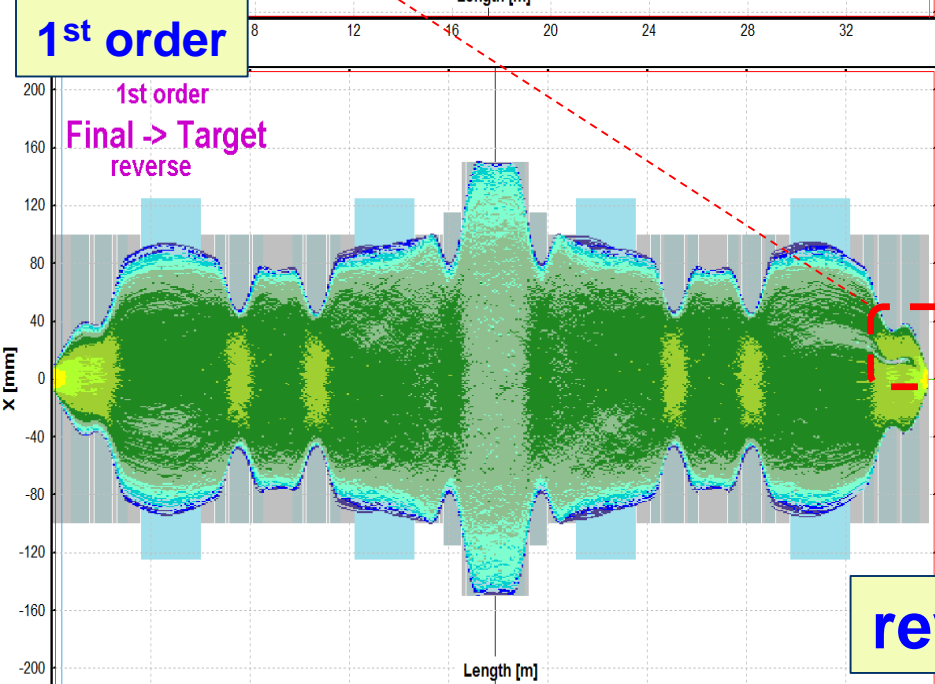


direct

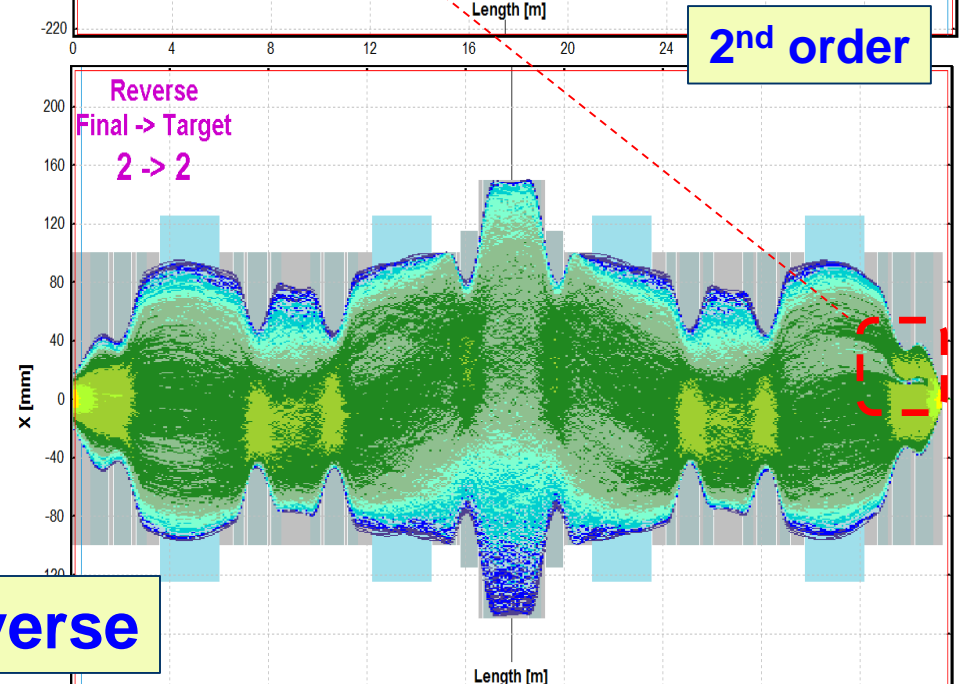
Direct
jet -> Final
2 order

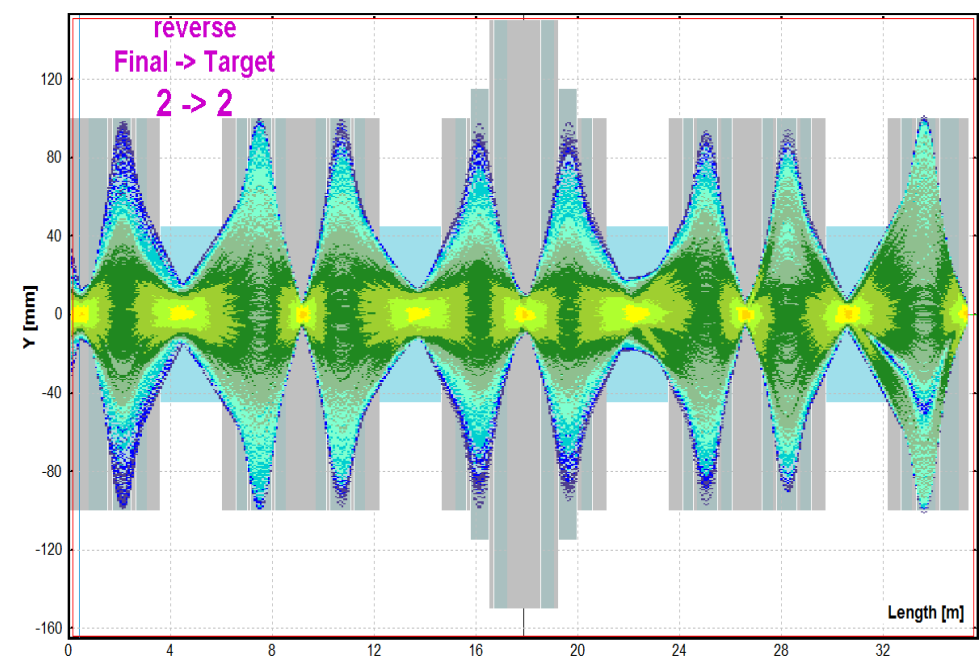
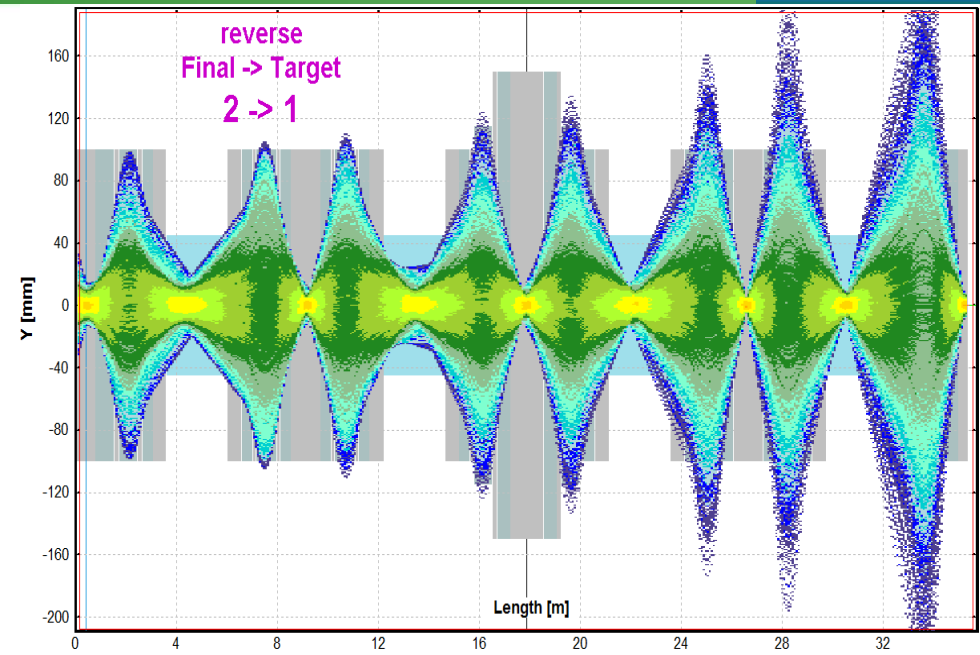
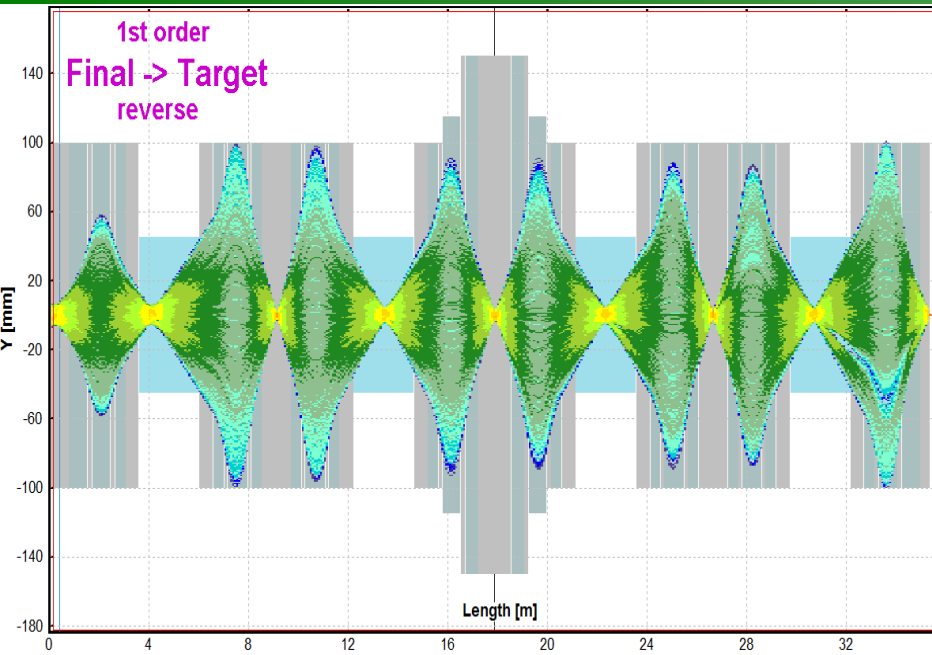


2nd order



reverse



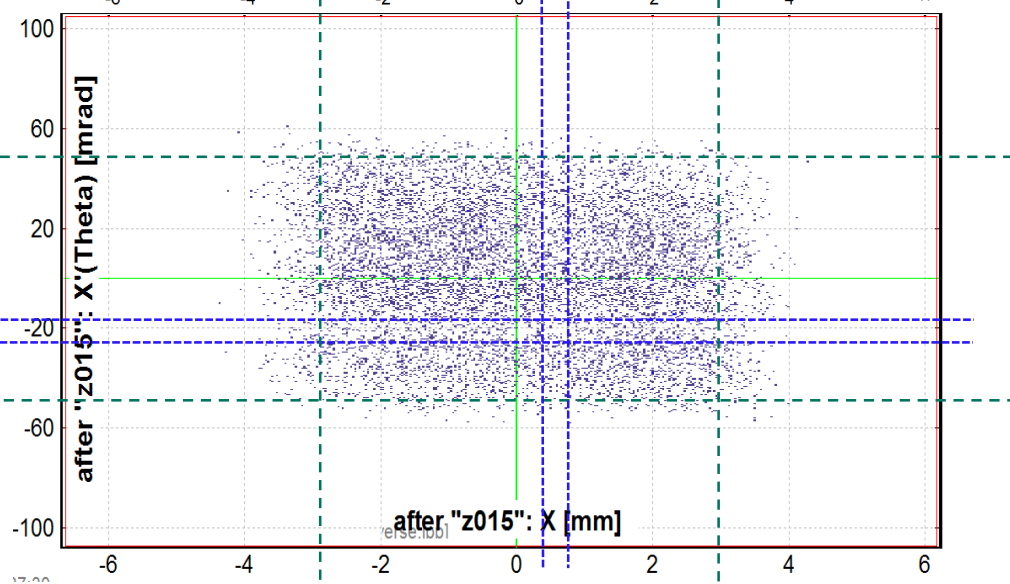
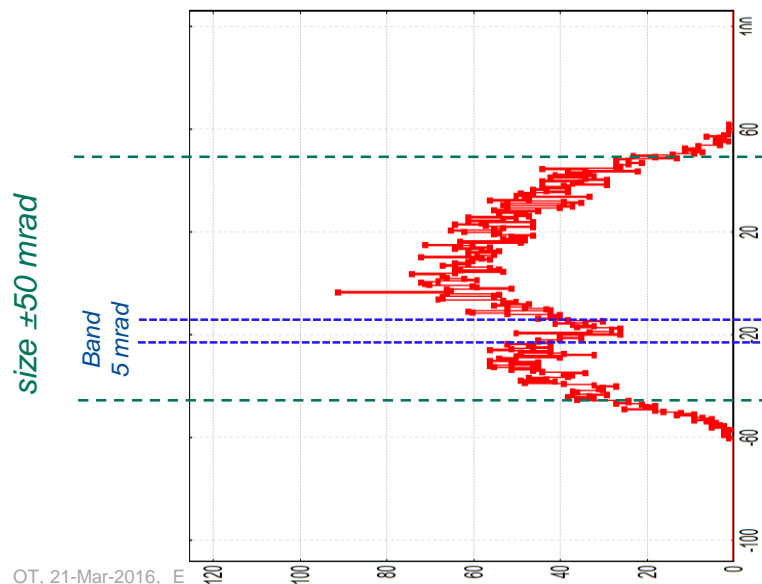
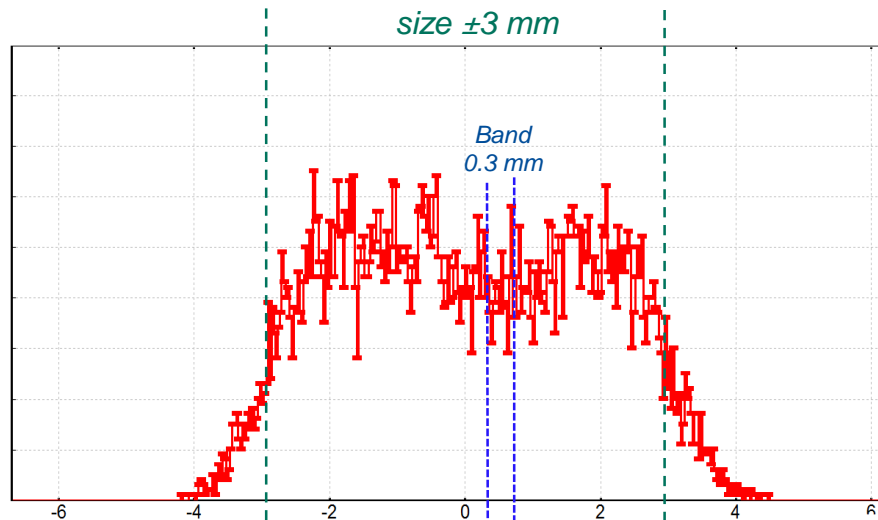
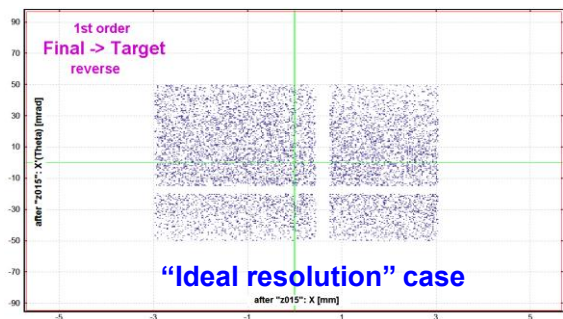


Using detector resolution (x,y) with 1st order optics : X vs X'

$d(X), d(Y) = 1 \text{ mm}$, $d(X'), d(Y') = 2 \text{ mrad}$, $d(E) = 0 \%$ manually been entered in the ray file

X vs X'
1st order

01-Z [atom]	01-N [neutro]	01-q [ion cha]	01-X [mm]	01-0 [empty]	01-X'(Theta) [m]	01-0 [empty]	01-Y [mm]	01-0 [empty]	01-Y'(Phi) [m]	01-0 [empty]	01-Energy [M]	01-0 [empty]	01-Time from
50	74	50	-0.57374	1	-20.595	2	-1.7892	1	9.0715	2	78.559	0	304.34
50	74	50	-2.3107	1	-15.824	2	1.3066	1	-17.313	2	82.128	0	298.7
50	74	50	-1.3571	1	5.0458	2	2.5585	1	9.3088	2	81.03	0	300.39

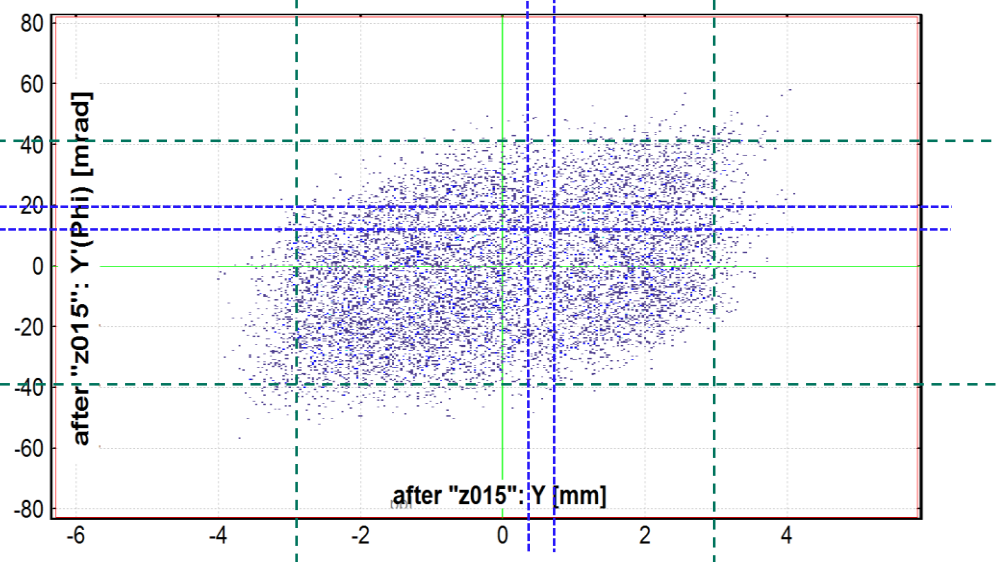
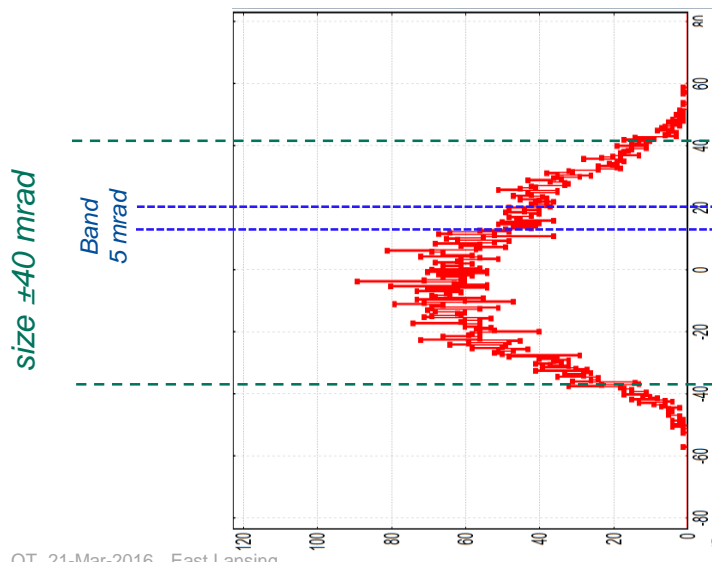
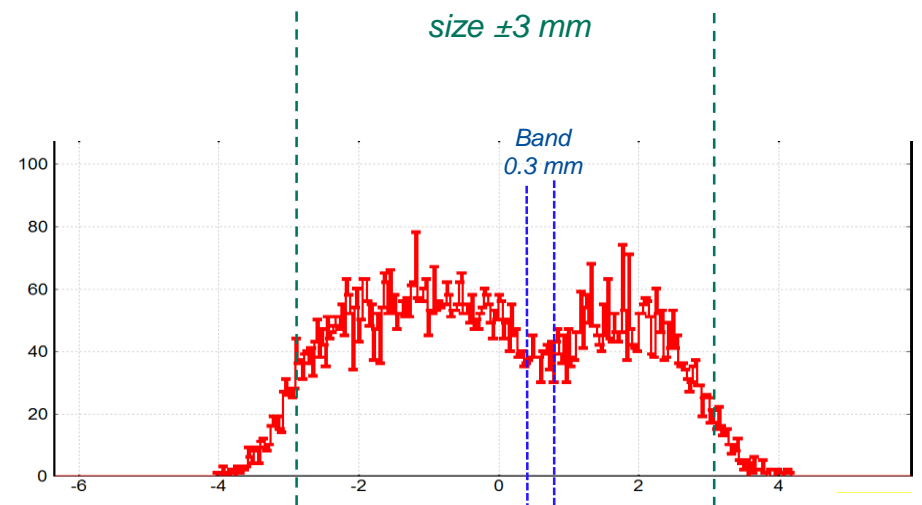
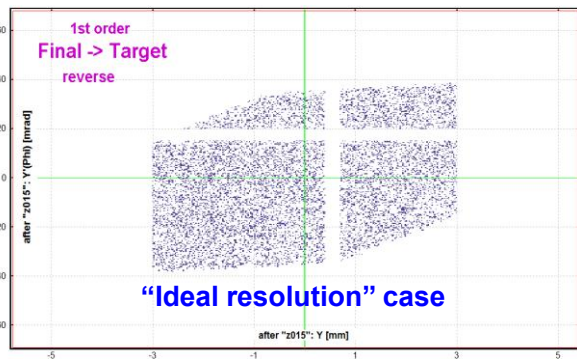


Using detector resolution (x,y) with 1st order optics : Y vs Y'

$d(X), d(Y) = 1 \text{ mm}$, $d(X'), d(Y') = 2 \text{ mrad}$, $d(E) = 0 \%$ manually been entered in the ray file

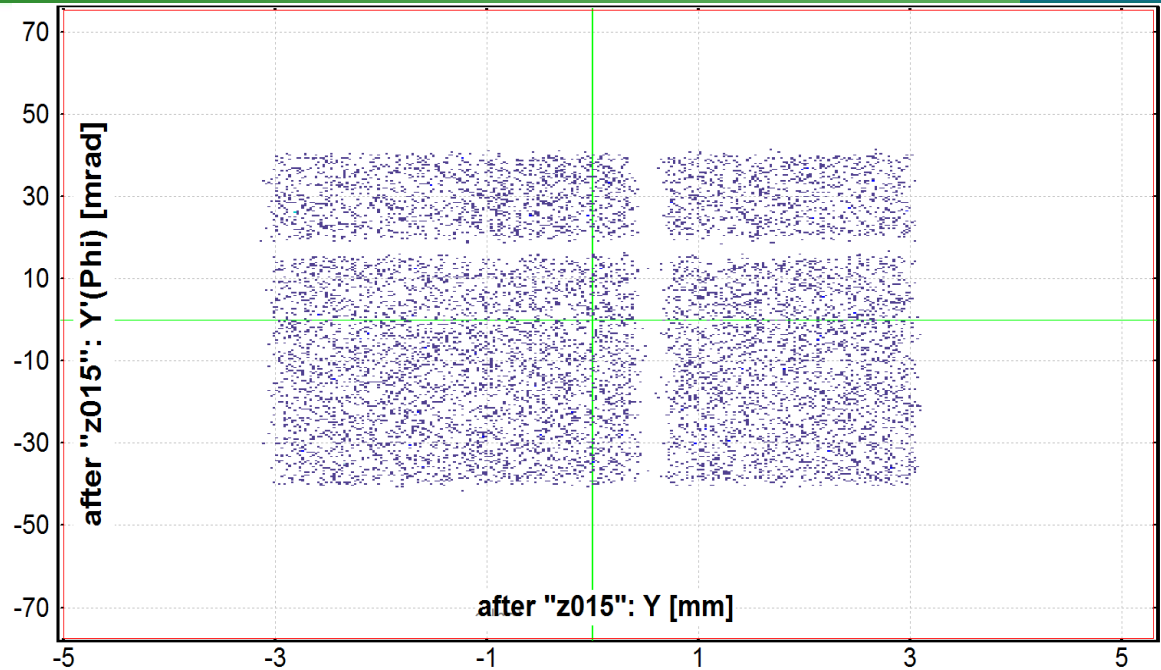
Y vs Y'
1st order

01-Z (atom)	01-N (neutr)	01-q (ion cha)	01-X [mm]	01-0 (empty)	01-X'(Theta)	01-0 (empty)	01-Y [mm]	01-0 (empty)	01-Y'(Phi) [m]	01-0 (empty)	01-Energy [M]	01-0 (empty)	01-Time from
50	74	50	-0.57374	1	-20.595	2	-1.7892	1	9.0715	2	78.559	0	304.34
50	74	50	-2.3107	1	-15.824	2	1.3066	1	-17.313	2	82.128	0	298.7
50	74	50	-1.3571	1	5.0458	2	2.5585	1	9.3088	2	81.03	0	300.39

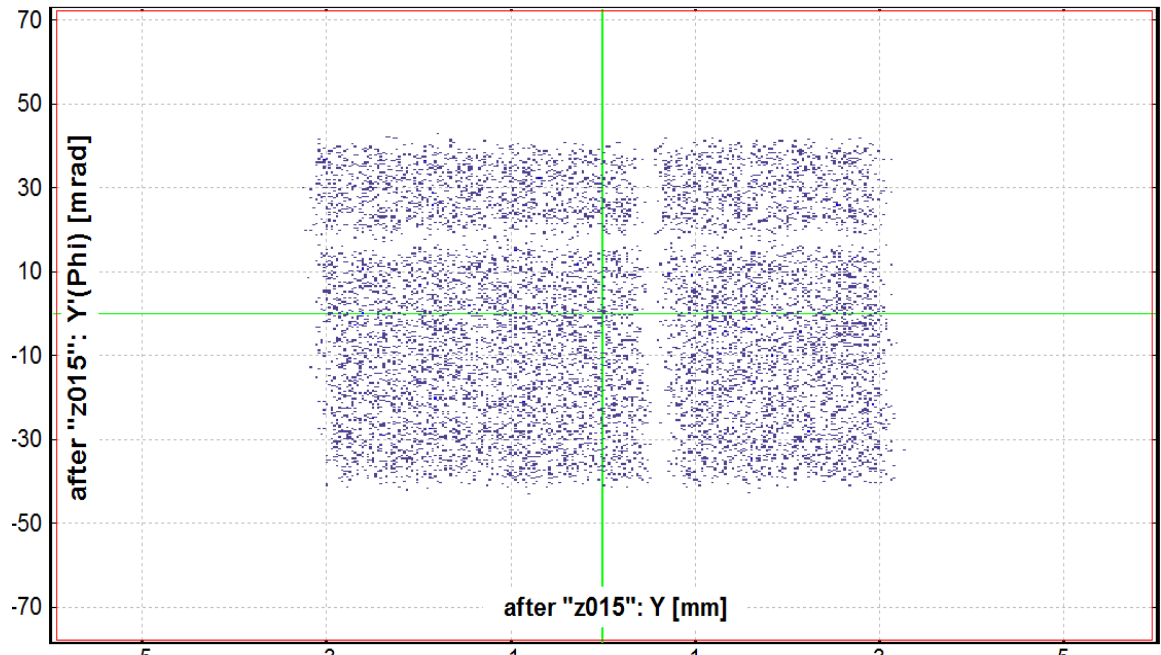


Y vs Y'
1st order

**Thin wedge:
10% of range**

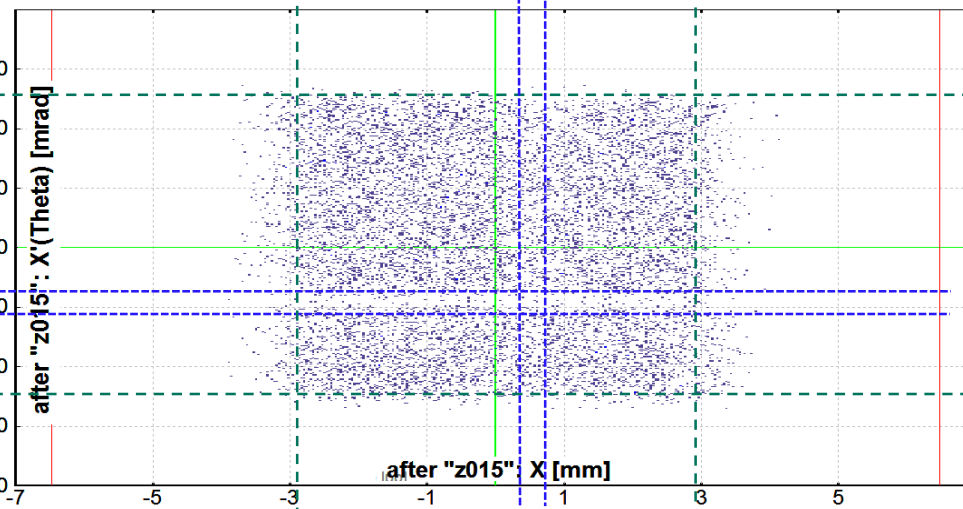
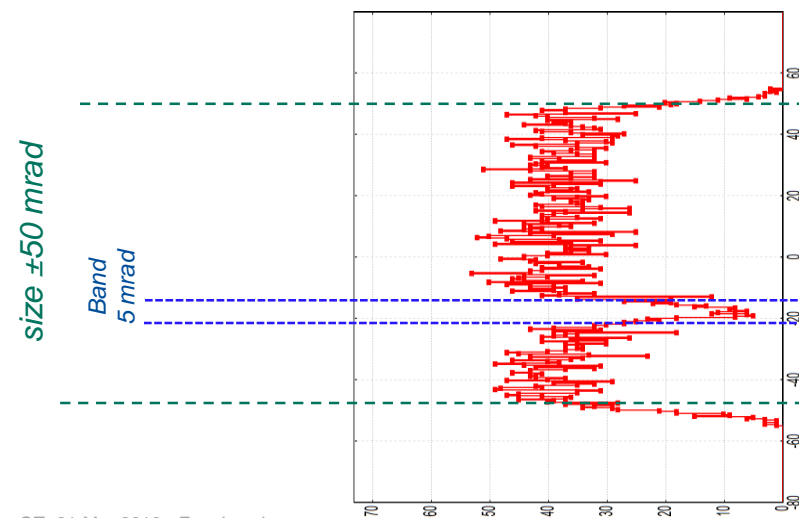
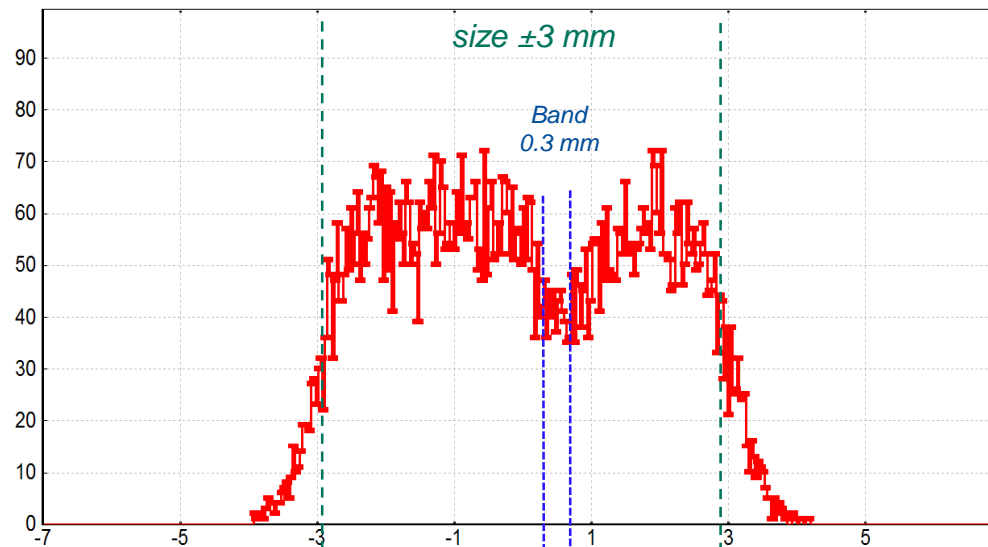
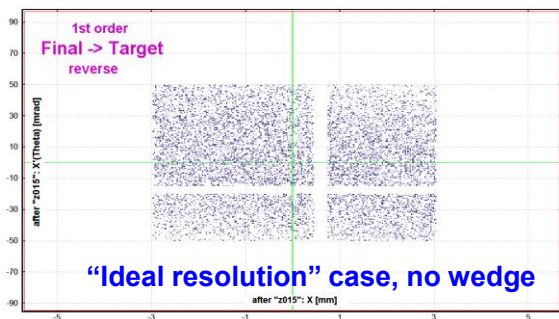


**Thick wedge:
40% of range**



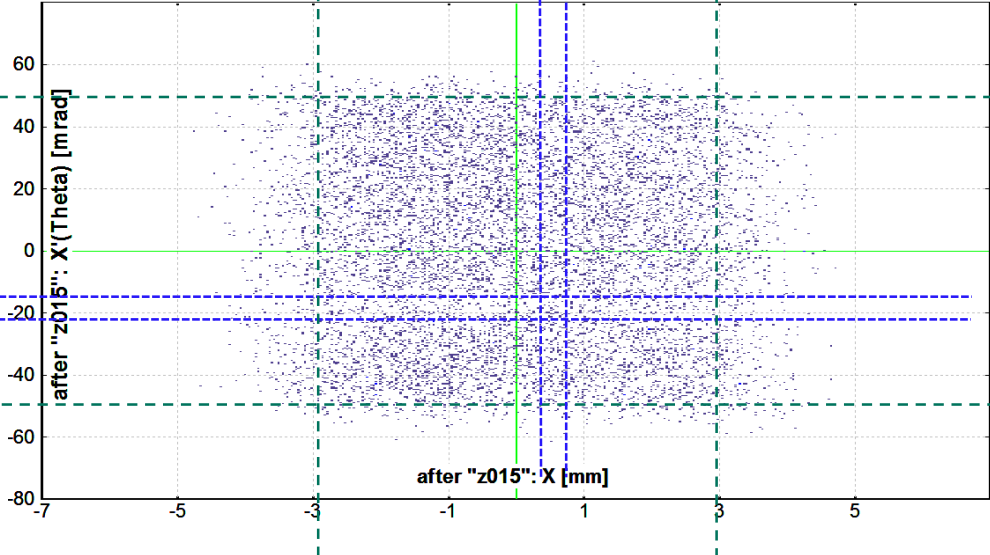
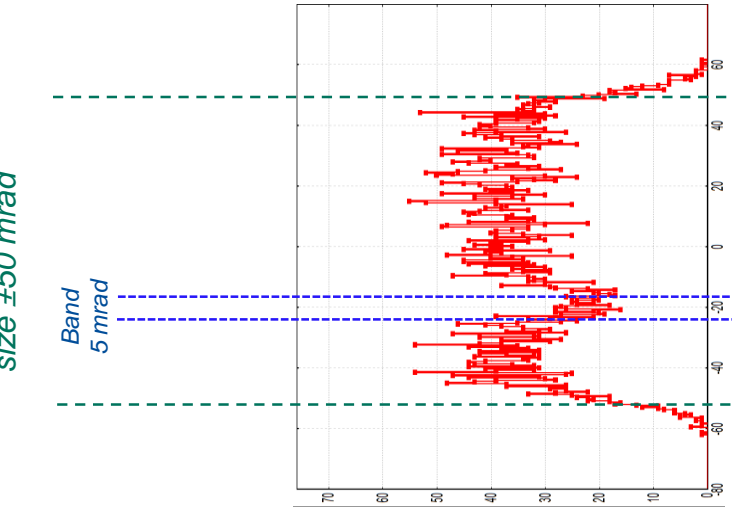
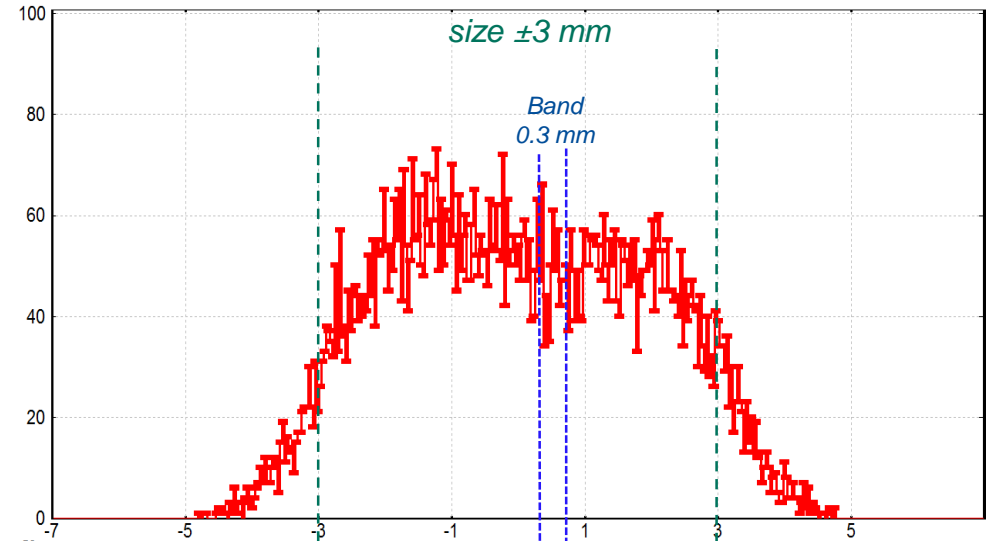
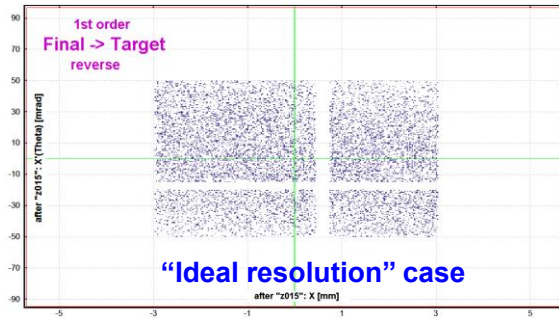
X vs X'
1st order

Thin wedge: 10% of range



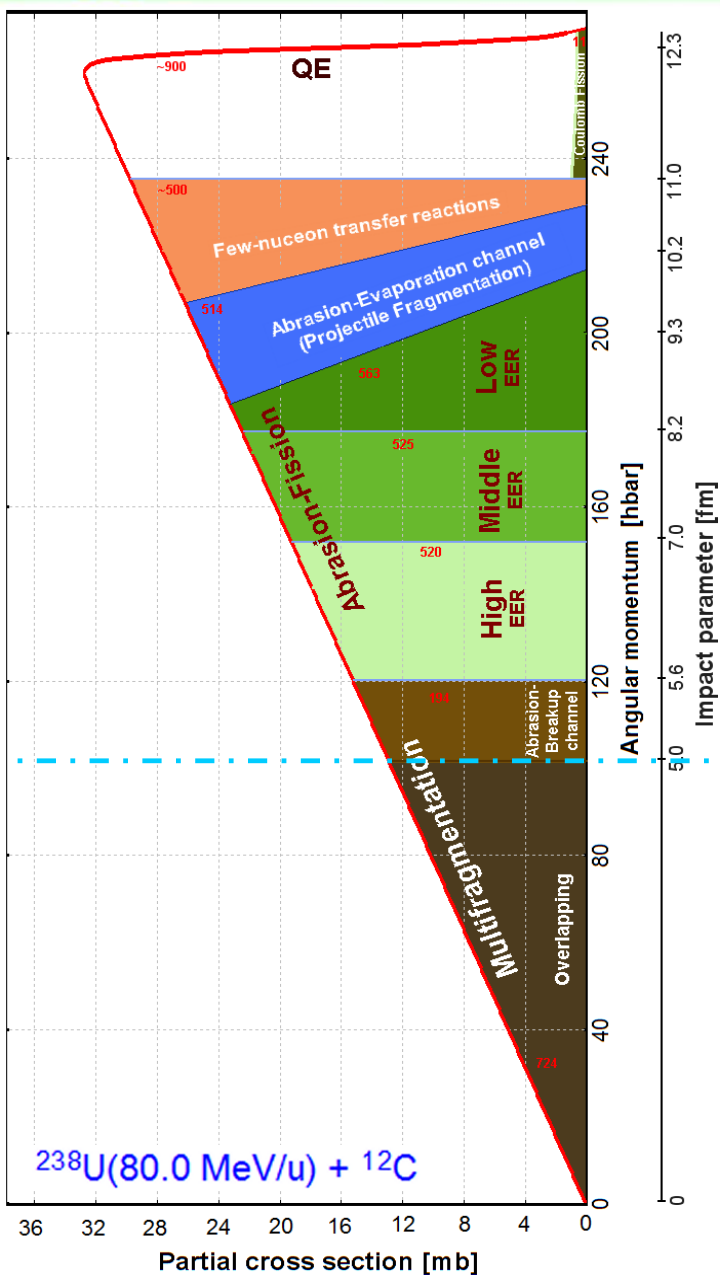
X vs X'
1st order

Thick wedge: 40% of range



1. The A1900 LISE-type reverse configuration has been **created**, its benchmarks have been done
2. **High order optics** is important in the reverse A1900 case. COSY-type reverse configuration should be tested.
3. **LISE-type second order** optics operates well in the reverse A1900 case
4. **Energy resolution** at the final focal plane detectors is not a key factor in the reverse A1900 case comparing to the S800 case
5. Use of **thick wedge** destroys reverse resolution quality in the horizontal spatial plane

Reaction mechanisms, Abrasion-Fission

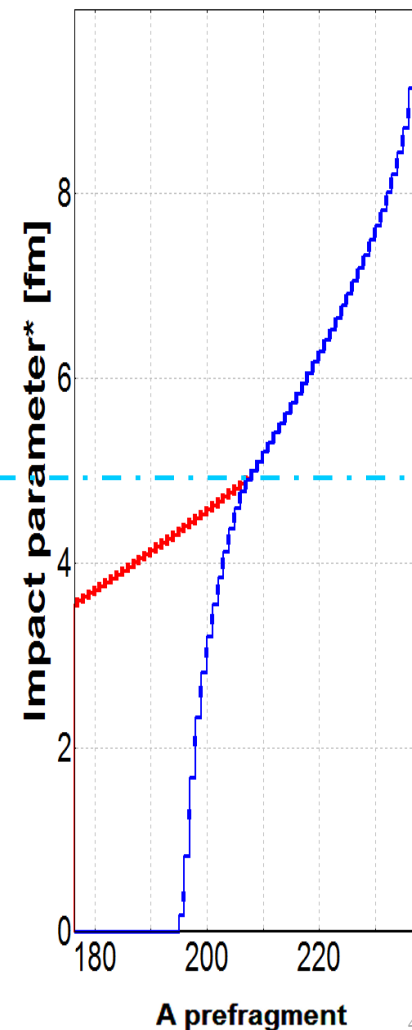
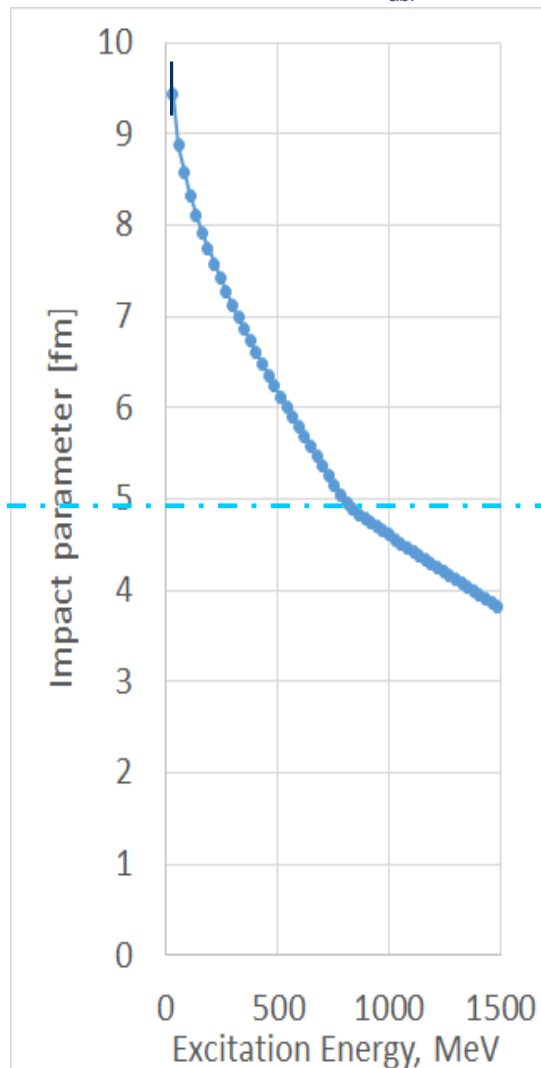


LISE++ calculations based on

J.-J.Gaimard, K.-H.Schmidt,
Nucl.Phys. A531 (1991) 709-745;

J.Gosset et al.,
Phys.Rev. C16 (1977) 629.

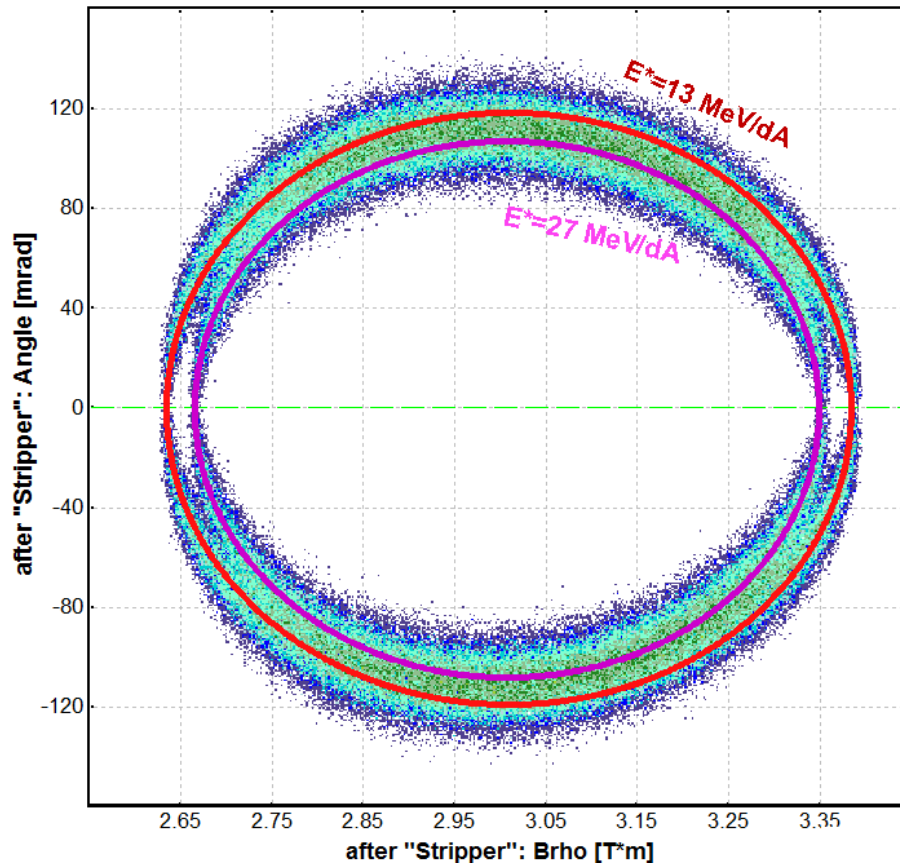
$$E^* = 27 * \Delta A_{\text{abr}}$$



Monte Carlo method

^{238}U (79.56 MeV/u) + C
Transmitted Fragment ^{83}Kr (AFmid)

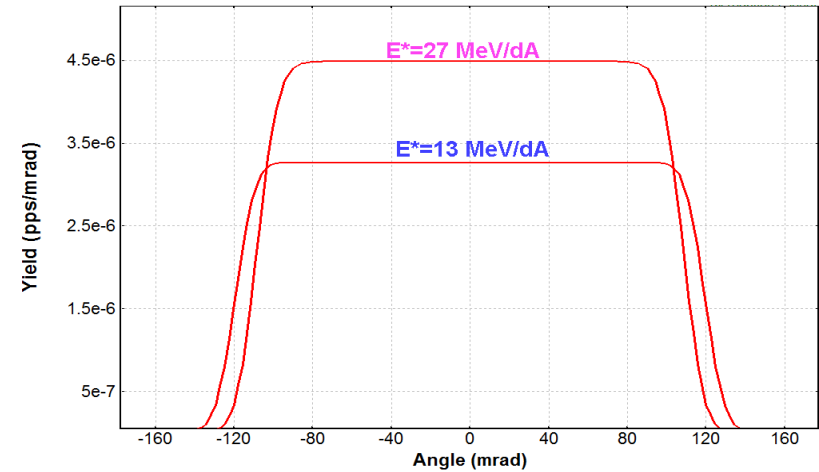
special case: $d(E^*)=0$ & thin target



Distribution method

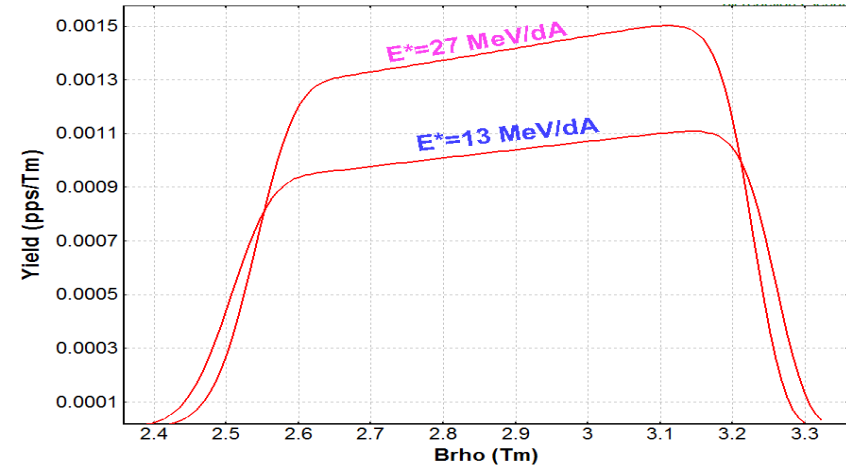
Stripper: x'angular

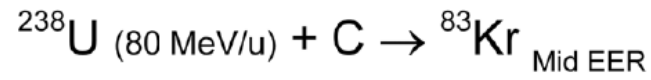
^{238}U (79.56 MeV/u) + C (33.5 mg/cm²)
Settings on ^{83}Kr



Stripper: Momentum

^{238}U (79.56 MeV/u) + C (33.5 mg/cm²)
Settings on ^{83}Kr



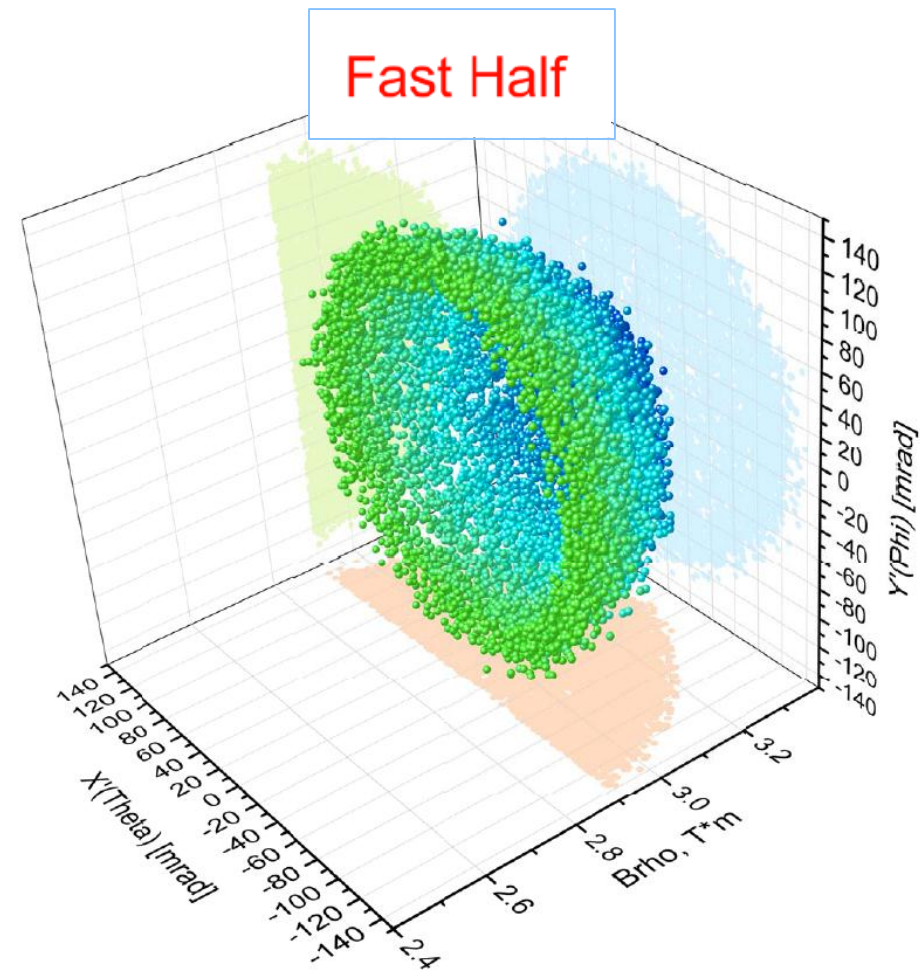
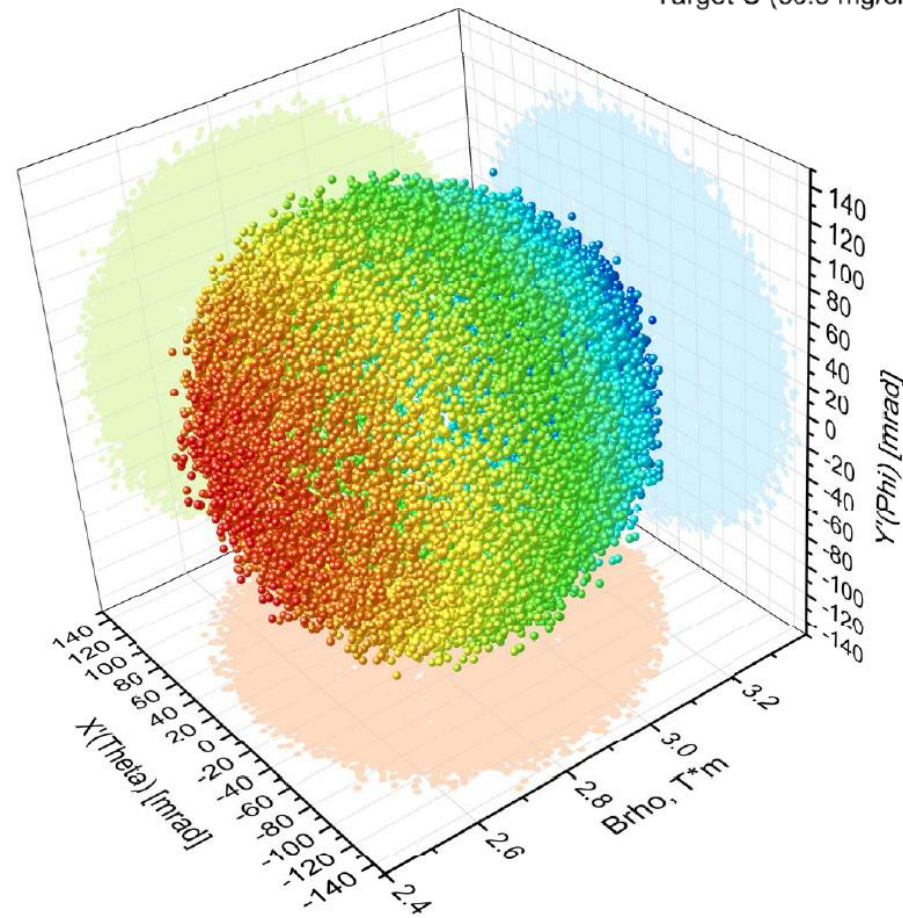


after target

LISE++

$B_p = 3.1743 \text{ Tm}$,

Target C (33.5 mg/cm^2)

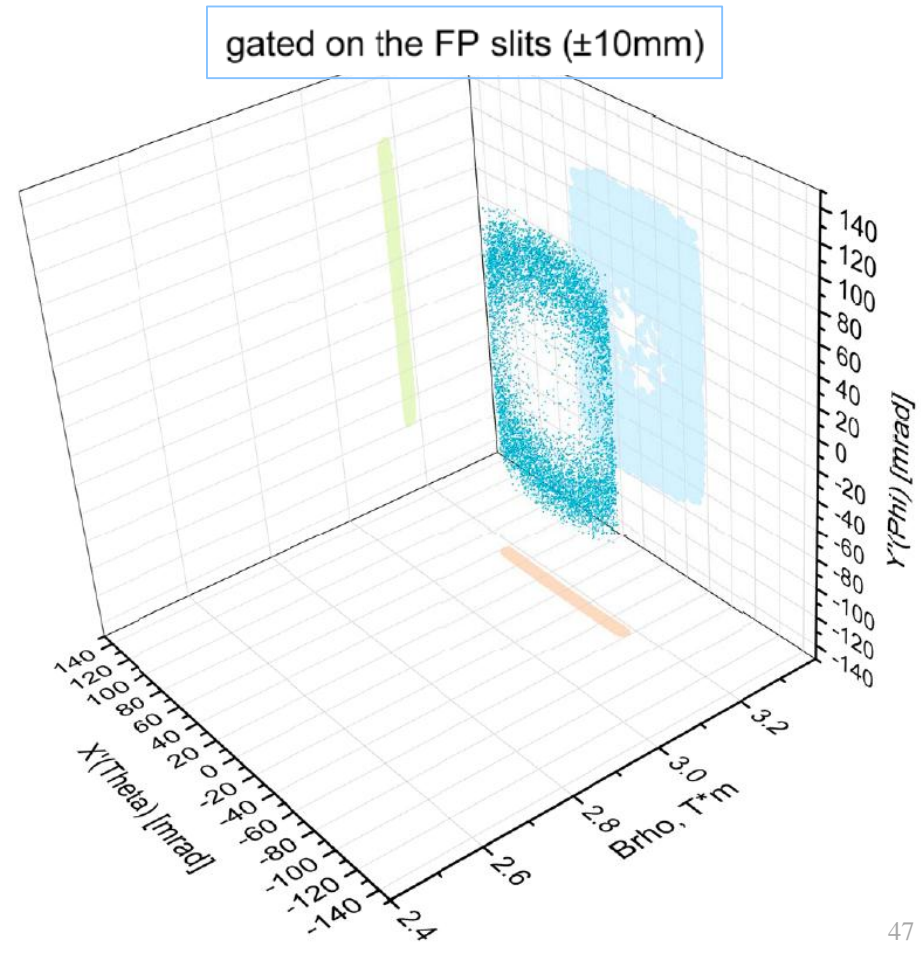
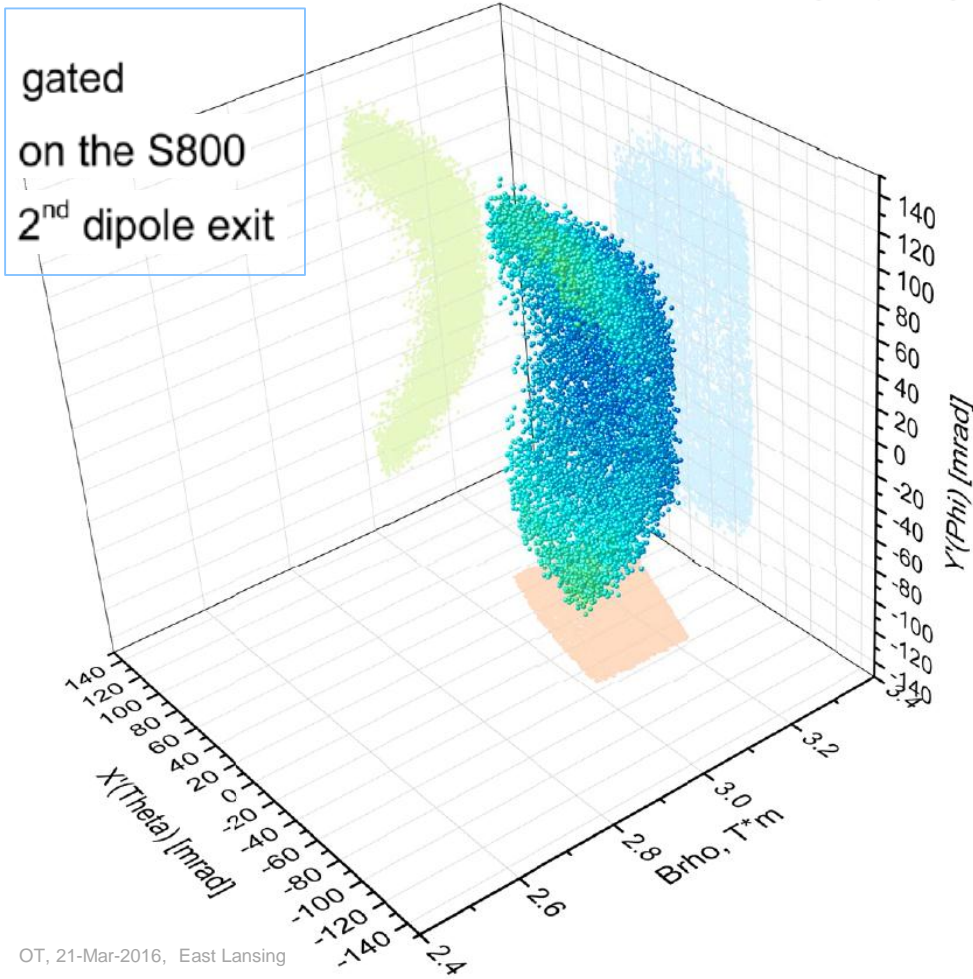


^{238}U (80 MeV/u) + C \rightarrow ^{83}Kr Mid EER
after target

LISE⁺⁺

B ρ =3.1743 Tm,

Target C (33.5 mg/cm²)



Monte Carlo options

MC transmission options

High Order Optics Calculations

Use in calculations:

- through 3rd order
- only 1-st order
- through 2nd order
- through 4th order
- through 5th order

Highest Order in this configuration: 5

for the Isotope group case only

- X-sections independent calculations (all cross sections equal)

Straggling in material

- Angular
- Energy
- Lateral

Detector resolution

- Use energy and time resolution of detectors for TOF, Energy loss, and TKE values
- Use spatial resolution of detectors for X and Y values

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)

only for the ENVELOPE mode

- Show trajectories of all fragments (including unselected by fragment-separator)

X-Y orientation

- "Absolute" -> Laboratory frame
- "Local" -> Follow Rotation blocks

Width to plot Integer Values (A,Z,q...)

X-sigma = 0.1 0.001 < Sigma < 0.5 default 0.1

Y-sigma = 0.1

Options for the "Input file of ion rays" mode

- Recycle input reading file
- Use standard deviations from the file
- "Radial" & "Angular" values sign
 - Always positive value
 - Use X-coordinate sign

OK Cancel Help

Monte Carlo calculation of fragment transmission

What isotope transmission to calculate?

- One fragment of interest. Choose manually here
- Group of isotopes already calculated by the Distribution method (Ncalc = 0)
- List of isotopes from file to produce inside target
- Input ions rays from file emitted from target: Bp1_raytable_v10_random_144895

Chose fragment of interest

A	Element	Z
238	U	92

Charge states: 63+ tuning Set

Reaction mechanism: Projectile Fragmentation

MC transmission options

Add in the previous MC plot window

"Distribution" calculation

MC calculation to file

Monte Carlo calculation 2D-plot

Out

X-coordinate After BLOCK: Target_image

Y-coordinate After BLOCK: Target_image

Radial [I(X,Y)] mrad

Angle [I(X,Y)] mrad

Energy MeV/u

TKE MeV

Momentum MeV/c

Brho T/m

Erho MJ/C

Energy Loss MeV

Range mm

Envelope m

Energy Deposition MeV/mm/particle

Time of flight ns

Length m

Stripper

Velocity: Velocity_Z [cm/ns]

Ion parameters (M,Z,q...)

A [mass number]

Z [atomic number]

Gate 1: 2

Gate 2: Settings, "<Z (atomic number) > after FP"

Gate 3: no gate

Gate 4: no gate

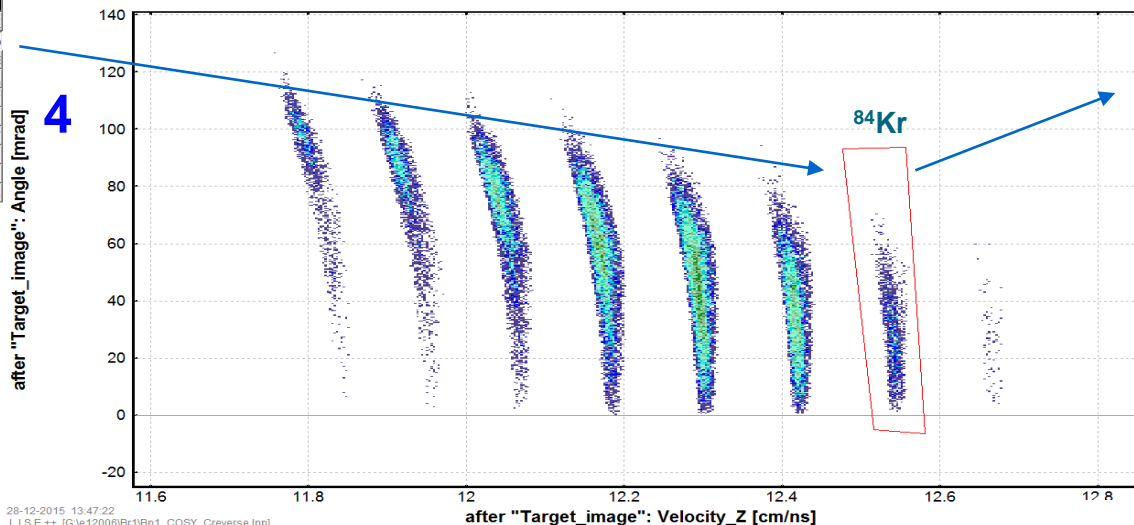
Gate for Kr isotopes

Ions rays after target : Monte Carlo Yield Plot

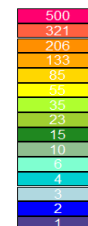
Input rays file: "Bp1_raytable_v10_random"; Number of rays: 144895; Optics Order: 5
dp/p=3.85% ; Brho(Tm): 3.3431, 3.3431, 3.3431

Continue

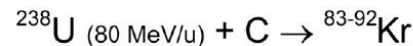
contour



Contour	Sum
1	1.87e+03
2	8
3	12.5405
4	28.8949
5	0.00746812
6	13.442
7	-5.151e-02
8	Sum
9	4.898e+04
10	CPU speed
11	0.00e+00 pps
12	Eff: 33.8%
13	Rate (pps)
14	3.390e-01



Bp1_COSY_Creverse.lpp

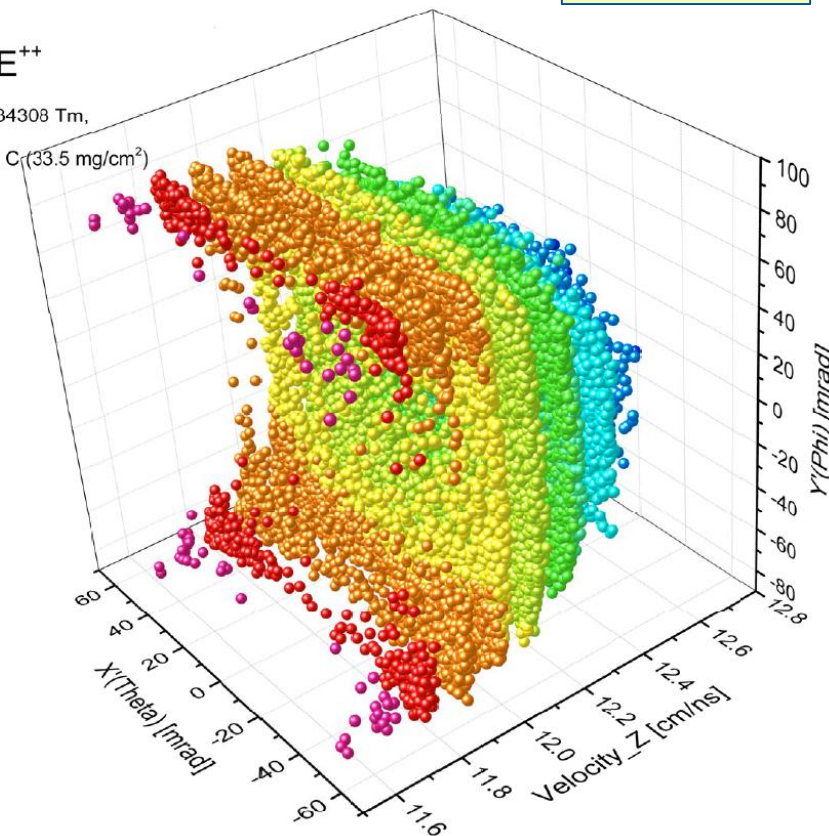


Bp1_COSY.lpp

LISE⁺⁺

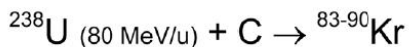
B_p=3.34308 Tm,

Target C_r(33.5 mg/cm²)



LISE⁺⁺ direct calculations are gated on the Scintillator position

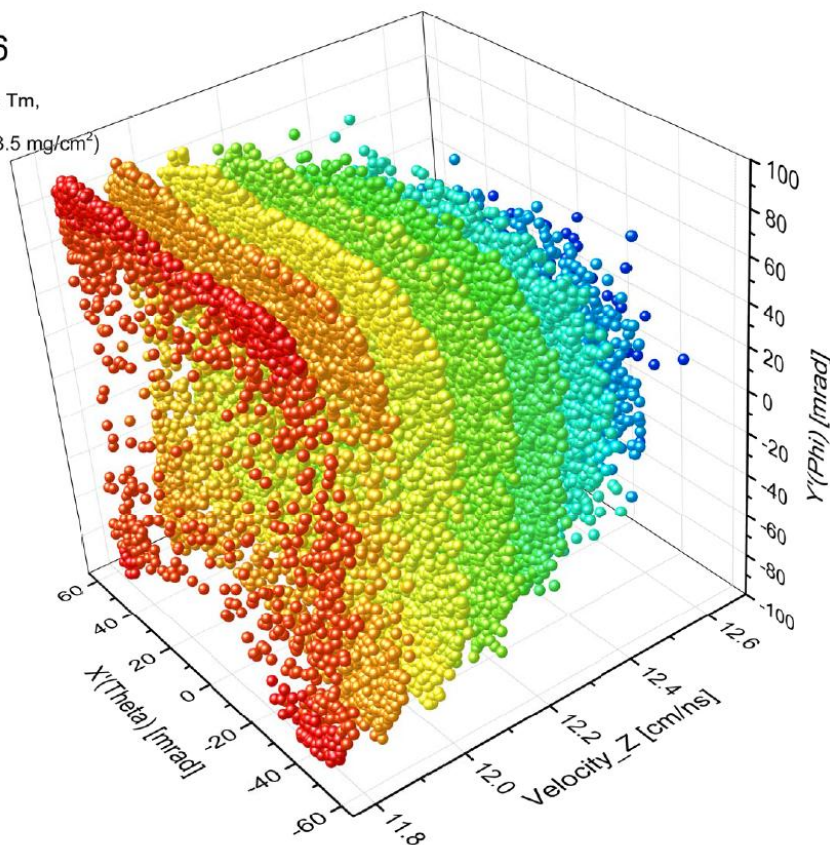
Pay attention that in LISE⁺⁺ calculations the isotope range is 83-92 instead experimental 83-90



e12006

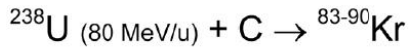
B_p=3.34308 Tm,

Target C (33.5 mg/cm²)



Bp1_COSY_Creverse.Ipp

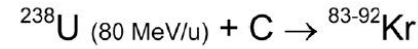
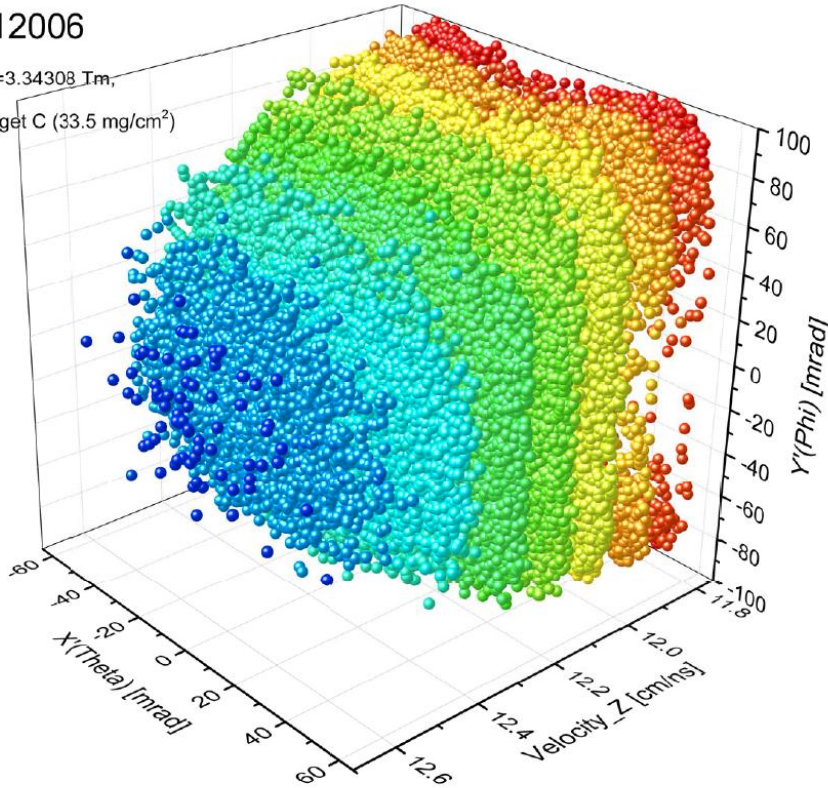
Bp1_COSY.Ipp



e12006

Bp=3.34308 Tm,

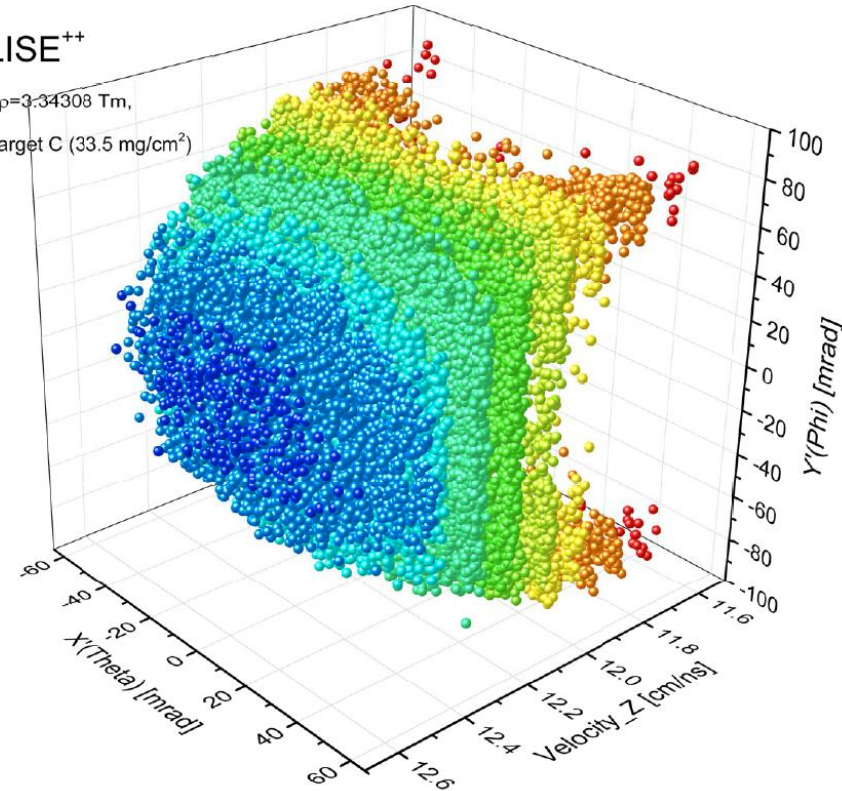
Target C (33.5 mg/cm²)



LISE++

Bp=3.34308 Tm,

Target C (33.5 mg/cm²)



LISE++ direct calculations are gated on the Scintillator position

Pay attention that in LISE++ calculations the isotope range is 83-92 instead experimental 83-90

- Thanks to a large group of MSU colleagues for discussions and help during this reverse technique development
- e12006 analysis with the reverse technique was done jointly with M.Bowry and A.Gade