

LISE⁺⁺ version 9.4.90 *From 30.01.2013*

block "RF buncher" – [link to v.9.4.24](#)

Note: RF-buncher block is effective in MC mode

- Initial RESOLUT scheme
- Angular acceptance of the Solenoid block
- Calculated RESOLUT values for ²⁵Al (5 MeV/u) beam
- 1-st Solenoid tuning
- Three gaps RF-buncher in COSY
- Three RF-bunchers in LISE⁺⁺
- 2-nd Solenoid tuning
- Three RF-bunchers in LISE⁺⁺ vs. Reaction (separation, transmission)
- RESOLUT : 1 gap RF-buncher solution
- RESOLUT (1 gap RF-buncher) : optimization
- Summary, Outlook

+ update

LISE⁺⁺ version 9.4.103 *From 28.02.2013*

The code operates under MS Windows environment and provides a highly user-friendly interface. It can be freely downloaded from the following internet addresses:

<http://lise.nsci.msu.edu>

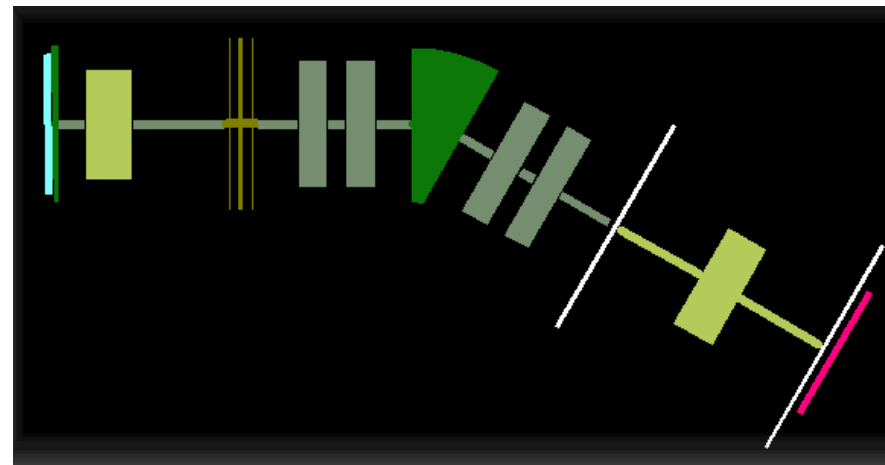
D	Tuning Dipole	Brho	0.6197 Tm
S	Drift 1	standard	0.35 m
L	Solenoid 1	B	2.6844 T
S	Drift 2	standard	1.21 m
B	RFbuncher 1	U Ph	119 kV 35 deg
B	RFbuncher 2	U Ph	238 kV 215 deg
B	RFbuncher 3	U Ph	119 kV 35 deg
S	Drift 3	standard	0.54 m
Q	MQ1	quadrupole	0.38 m
S	Drift 4	standard	0.22 m
Q	MQ2	quadrupole	0.41 m
S	Drift 5	standard	0.47 m
D	Dipole	Brho	0.6197 Tm
S	Drift 6	standard	0.48 m
Q	MQ3	quadrupole	0.41 m
S	Drift 7	standard	0.22 m
Q	MQ4	quadrupole	0.38 m
S	Drift 8	standard	0.74 m
S	slits1	s-ls	
		-200	+200
		-50	+50
L	Solenoid 2	B	2.2688 T
S	slits2	s-ls	
		-200	+200

← Tuning dipole to define magnetic rigidity of the separator,
Unitary matrix, no slits, zero length

← Initial drift+solenoid+drift
configuration to define angular acceptance

← 3 gap Rf-buncher was realized as 3 RF bunchers

← QQDQQ spectrometer



Solenoid 1

solenoid

Solenoid settings

Field Direction
 "+" positive
 "-" negative

Optical block properties and data
 Setting Charge state for the Block (Z-Q) 0
 Cut(Slits) & Apertances
 Optical matrix
 General setting of block

Geometry
 1-st half = 0.3 m
 2-nd half = 0.3 m
 Coil length = 0.6 m
 Effective radius = 0.05 m
 Block length = 0.6 m
 optional (estimation of Ang.Accept.)
 Solenoid length = 0.6 m
 Bore = 0.045 m
 Ang.Accept. ± 74.9 mrad

Setting fragment parameters

	Mean	StDev
1. X	0.00	20.26
2. T	0.00	57.90
3. Y	0.00	20.26
4. F	0.00	57.90
5. E	5.0	0.0

MA = MAconst * I
 MAconst = 0.03933 T/A MA = 1.3607 T
 $B(0) = MA * CoilLength / \sqrt{(EffRadius^2 + CoilLength^2 / 4)}$

OK Cancel

Solenoid 1

ANGULAR ACCEPTANCE

Shape
 Rectangle
 Ellipse

Horizontal ± 47 mrad
 Vertical ± 47 mrad
 Solid angle 6.94 msr

Horizontal plane
 Use in Calculations
 dispersion [mrad/%] 0
 x'-momentum[%] (accept./disp.) 100

Vertical plane
 Use in Calculations
 dispersion [mrad/%] 0
 y'-momentum[%] (accept./disp.) 100

"Solenoid 1" block : Apertures (throughout), Slits (after)

Left limit (aperture) -45 mm
 Right limit (aperture) 45 mm
 L slit -30
 R slit 30

APERTURES
 Shape (see *)
 Rectangle
 Ellipse
 Use in Calculations

SLITS
 Slits shape (see *)
 Rectangle
 Ellipse
 Horizontal Slit
 Set
 conjointly Use in Calculations
 separately Show in schematics
 Vertical Slit
 Set
 conjointly Use in Calculations
 separately Show in schematics

Horizontal plane dispersion (mm/%) 0
 x-momentum[%] (slit/dispersion) total 100

Vertical plane dispersion (mm/%) 0
 y-momentum[%] (slit/dispersion) total 100

Top limit (aperture) 45 mm
 Bottom limit (aperture) -45 mm
 B slit -30
 vertical

OK Cancel

+ Drift1 & Drift 2 (before and after the solenoid : ellipse apertures +/- 50 mm)

Beam

A Element q+
 13 Al 13
 13
 Z

Beta+ decay

Table of Nuclides
 Z N
 Ok Cancel

Beam energy
 Energy 5 MeV/u
 TKE 124.95 MeV
 Brho 0.6197 Tm
 P 2.415 GeV/c
 U 9.61e+3 KV

Beam intensity
 13 enA
 1 pA
 6.25e+9 pps
 0.000125 KW

Emitance
 Beam CARD (sigma, semi-axis, half-width...)
 1D - shape (Distribution method)

1. X mm	0.01	Gaussian
2. T mrad	100	Rectangle uniform
3. Y mm	0.01	Gaussian
4. P mrad	100	Rectangle uniform
5. L mm	0	Gaussian
6. D %	0.001	Rectangle uniform

Energy Loss in the target box [KW] 1.72e-10

Monte Carlo calculation of fragment transmission

What isotope transmission to calculate?

- One fragment of interest. Chose manually here
- Group of Isotopes already calculated by the Distribution method (Ncalc = 0)
- List of Isotopes from file

Chose fragment of interest

A: 25, Element: Al, Z: 13

Charge states: 13+ Tuning Dipole

Reaction mechanism: Projectile Fragmentation

MC transmission options

MC calculation to file

Monte Carlo calculation 2D-plot

Quit

X-coordinate After BLOCK

Stripper

- X (T) mm
- Y (T) mm
- X' (P) mrad
- Y' (P) mrad

Y-coordinate After BLOCK

Stripper

- X (T) mm
- Y (T) mm
- X' (P) mrad
- Y' (P) mrad

Gate 1

Settings

"AND" [-100, 100]

<X [mm]> after Drift 3

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: 1

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 TDF, Energy loss, and TKE values
- Use spatial resolution of detectors for X and Y values

^ No resolution will be taken into account if the selected block is optical or wedge

^ Only energy resolution of first detector after the selected block will be taken into account for TKE value

Bounds

- Use physical limits (aperture) inside blocks to calculate fragment transmission
- Take into account thickness defect of materials
- Take into account losses due to reactions in materials
- Include charge state calculations in the total transmission ***

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

Assume the reaction takes place at the middle of target

- for Angular distributions
- for Momentum distributions

* these two distributions are correlated for fusion and fission reactions

only for ENVELOPE mode

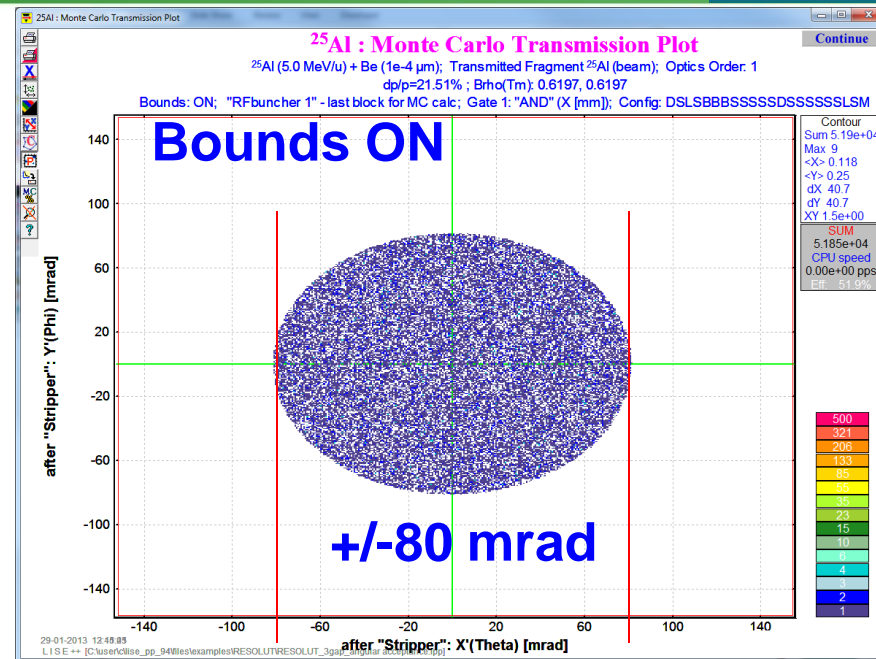
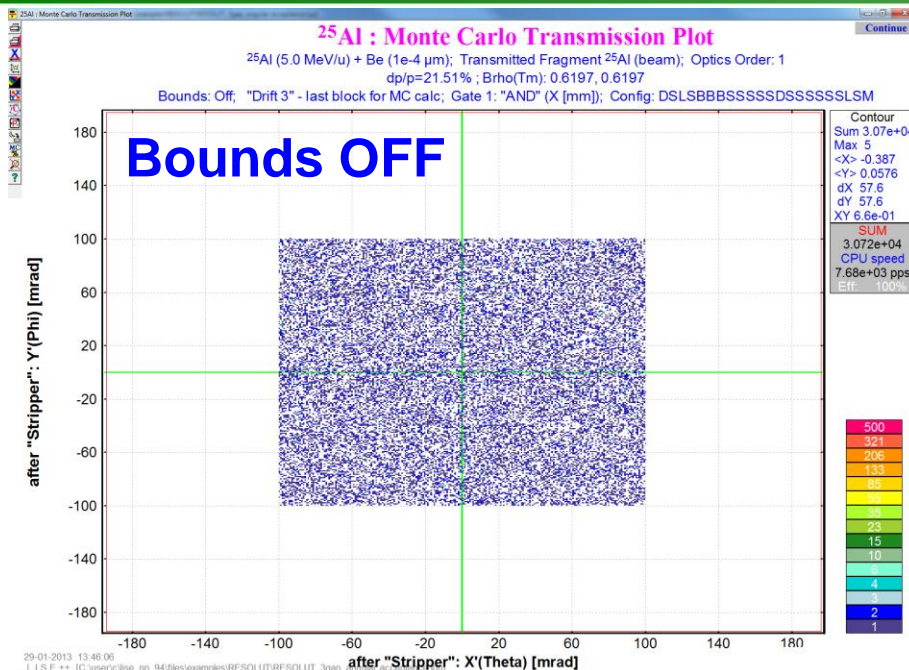
- Show trajectories of all fragments (including unselected by fragment-separator)

*** time consumed options

Make default

OK Cancel Help

Angular acceptance of the Solenoid block #3



For analytical solution or MC method without bounds it is necessary to set this value (or 47 mrad from geometry without fields) to the Solenoid block acceptance

Geometry		optional (estimation of Ang.Accept.)	
1-st half =	0.65 m	Solenoid length =	0.6 m
2-nd half =	1.51 m	Bore =	0.045 m
Coil length =	0.6 m	Ang.Accept. ±	47.3 mrad
Effective radius =	0.05 m		
Block Length =	2.16 m		

Solenoid 1

ANGULAR ACCEPTANCE

Shape: Rectangle Ellipse

Horizontal ±: 47 mrad
 Vertical ±: 47 mrad
 Solid angle: 6.94 msr

Horizontal plane: Use in Calculations
 dispersion [mrad/%]: 0
 x'-momentum[%] (accept./disp.): 100

Vertical plane: Use in Calculations
 dispersion [mrad/%]: 0
 y'-momentum[%] (accept./disp.): 100

"Solenoid 1" block : Apertures (throughout), Slits (after)

Left limit (aperture): -45 mm
 Right limit (aperture): 45 mm
 L slit: -30
 R slit: 30

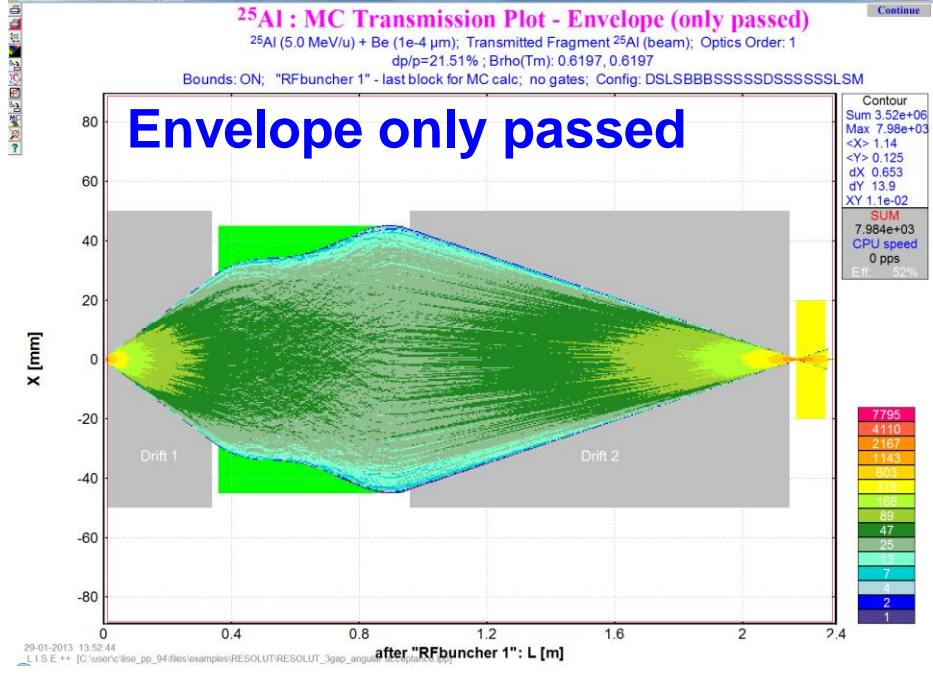
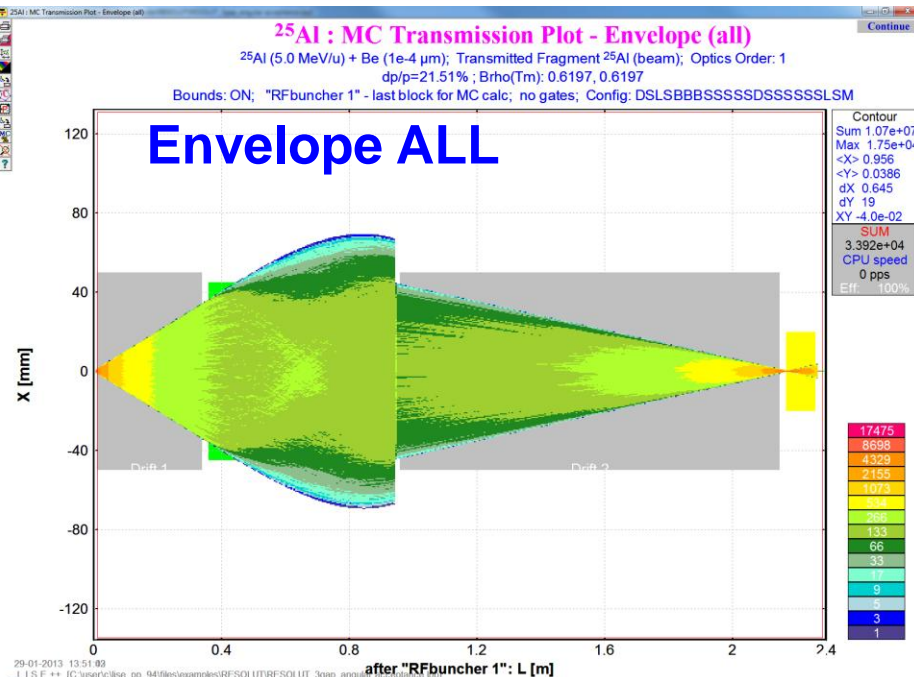
APERTURES

Shape (see ?): Rectangle Ellipse

Use in Calculations: Horizontal Vertical

Only the Monte Carlo mode uses "Ellipse" Shapes and Aperture settings.
 The Distribution method uses only "Rectangle" shape slits.

OK Cancel



Link to this file

http://lise.nsci.msu.edu/9_4/buncher/RESOLUT_3gap_angular%20acceptance.lpp

MC transmission options

High Order Optics Calculations
 Use in calculations : through 3rd order Highest Order in this configuration X-sections independent calculations (all cross sections equal)
 only 1-st order through 4th order 1
 through 2nd order through 5th order

Straggling in material Angular Energy Lateral **

Detector resolution
 Use energy and time resolution of detectors for TOF, Energy loss, and TKE values ^ No resolution will be taken into account if the selected block is optical or wedge
 Use spatial resolution of detectors for X and Y values ^ Only energy resolution of first detector after the selected block will be taken into account for TKE value

Bounds
 Use physical limits (aperture) inside blocks to calculate fragment transmission Take into account thickness defect of materials Take into account losses due to reactions in materials
 For block apertures LISE++ uses the slit limits accessible from the Block Cut & Acceptance dialog. (Pay attention there for the checkbox) Include charge state calculations in the total transmission **

Assume the reaction takes place at the middle of target
 for Angular distributions * these two distributions are correlated for fusion and fission reactions
 for Momentum distributions

only for ENVELOPE mode
 Show trajectories of all fragments (including unselected by fragment separator)

** time consumed options Make default

OK Cancel Help

Abeam= 25		c_speed= 3.00E+08	m/sec
Mbeam= 24.990428		beta= 1.03E-01	
Zbeam= 13		tof= 7.62E-08	sec
Ebeam= 5	MeV/u	dedt= 3.28E+09	
		turns= 7	
LISE++ Brho= 0.619938	Tm		
	Hz	RFF= 119.623	kV
Freq= 9.70E+07	1/sec	Voltage_in_LISE++= 0.478	MV
omega= 6.09E+08		4 x V for one gap	
length= 2.36	m		
		MaXGain (V*Q)= 6.22	MeV
TKE= 124.95	MeV	MaxGain/TKE= 5.0%	
Brho (FCU COSY source) = 0.6204303	Tm	phase= 217.9	degrees

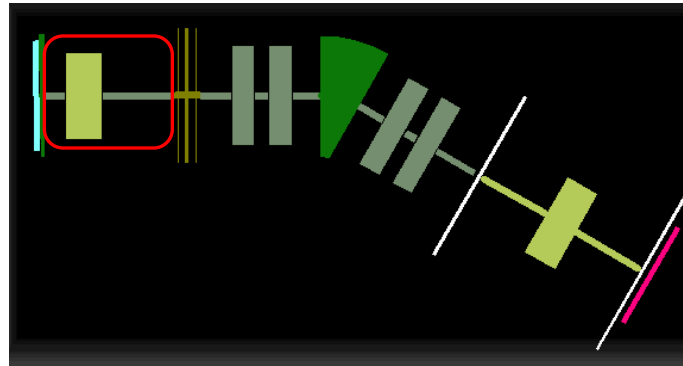
they use TKE in source

		COSY	LISE++ calc	
	coef	value,T	value,T	
S1	4.364	2.7054	2.68	make a small spot at the RF-buncher
S2	3.933	2.4382	2.29	make a small spot at the detector
Q1	-0.48933	-0.3034		
Q2	0.21589	0.1338		
Q3	0.21192	0.1314		
Q4	-0.48933	-0.3034		
S1			2.2	make parralel after the solenoid

D	Tuning Dipole	Brho 0.6197 Tm
S	Drift 1	standard 0.35 m
L	Solenoid 1	B 2.6844 T
S	Drift 2	standard 1.21 m
B	RFbuncher 1	U 119 kV Ph 35 deg
B	RFbuncher 2	U 238 kV Ph 215 deg
B	RFbuncher 3	U 119 kV Ph 35 deg
S	Drift 3	standard 0.54 m
Q	MQ1	quadrupole 0.38 m
S	Drift 4	standard 0.22 m
Q	MQ2	quadrupole 0.41 m
S	Drift 5	standard 0.47 m
D	Dipole	Brho 0.6197 Tm
S	Drift 6	standard 0.48 m
Q	MQ3	quadrupole 0.41 m
S	Drift 7	standard 0.22 m
Q	MQ4	quadrupole 0.38 m
S	Drift 8	standard 0.74 m
S	slits1	s :ls
		-200 H +200 -50 V +50
L	Solenoid 2	B 2.2688 T
S	slits2	s :ls
		-200 H +200



Initial drift+solenoid+drift configuration to define angular acceptance



10st solenoid values from the previous slide:

FSU COSY : 2.71 T

LISE++ small object at the RF buncher : 2.68 T

LISE++ makes parallel after solenoid : 1.83 T

1-st Solenoid tuning : parallel after solenoid

Solenoid 1

Solenoid settings

B, max field: 1.83066 T

I, current: 23.5941 A

Use the "soft-edge" corrections for solenoid matrix calculations

$V(L * B / PI) = 0.3496 \text{ Tm}$

$V / Brho = 0.5642$

Field Direction

"+" positive

"-" negative

Solenoid Block Scheme

TwinSol Utility

Optical block properties and data

Setting Charge state for the Block (Z-Q): 0

Block Tuning

Take into account the GLOBAL matrix of the previous block

Tuning is minimisation of: 06. beam sigma: A (P%)

Plot v=f(B)

Setting fragment parameters

	Mean	StDev
1. X	0.00	2.25
2. T	0.00	5.79
3. Y	0.00	2.25
4. F	0.00	5.79
5. E	5.0	0.0

Method: "Distribution"

Setting fragment distribution parameters before Solenoid

Length of the solenoid block

Length of 1st half: 0.3 m

Length of 2nd half: 0.3 m

Coil length: 0.6 m

Bore: 0.045 m

Effective radius: 0.05 m

Block Length: 0.6 m

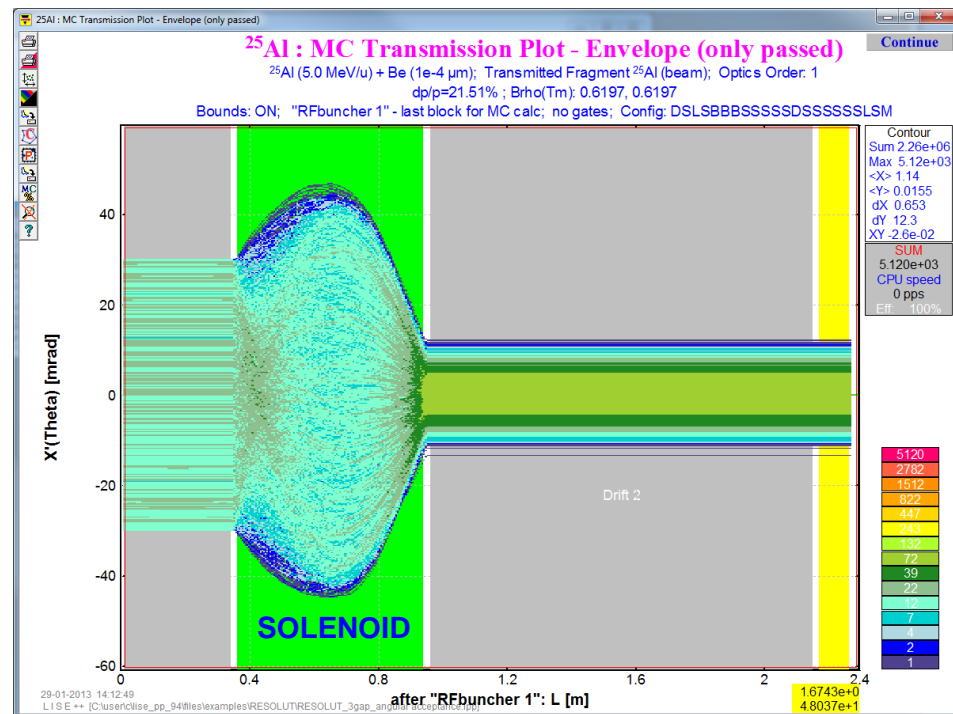
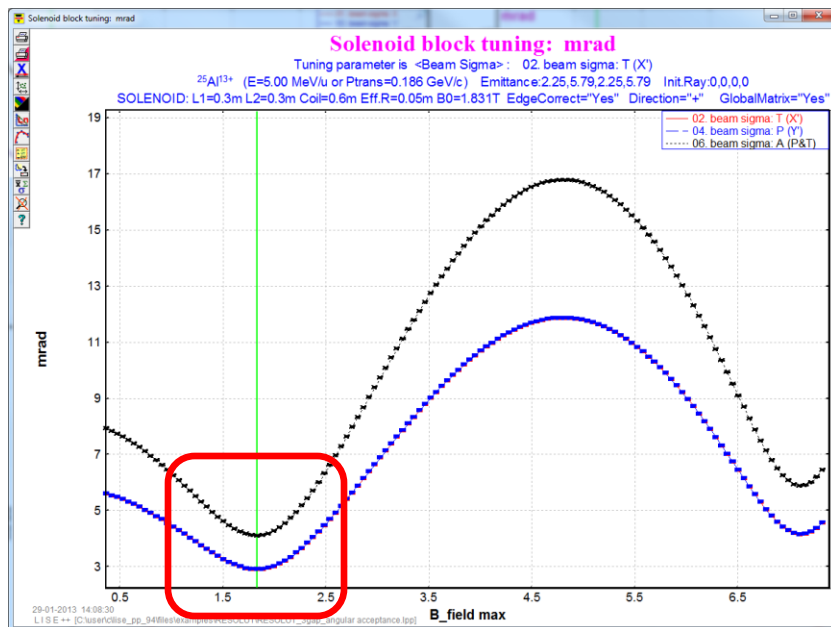
Ang. Accept. ±: 74.9 mrad

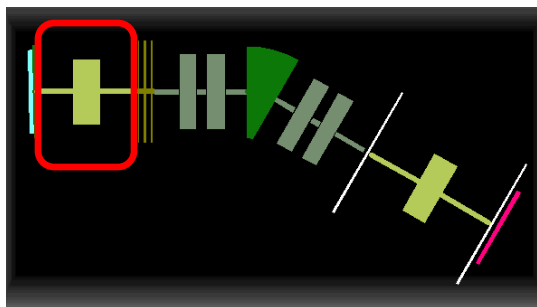
MA = MAconst * I

MAconst = 0.03933 T/A MA = 0.92796 T

$B(0) = MA * CoilLength / \sqrt{EffRadius^2 + CoilLength^2 / 4}$

OK Cancel Help





Drifts have been implemented to the Solenoid block

Solenoid 1

Solenoid settings:

B, max field = 2.68 T

I, current = 34.5406 A

Use the "soft-edge" corrections for solenoid matrix calculations

$V(L * B / \pi) = 0.5118$ Tm

$V / B\rho_0 = 0.8260$

Field Direction:

"+" positive

"-" negative

Solenoid Block Scheme

TwinSol Utility

Geometry:

1-st half = 0.65 m

2-nd half = 1.5 m

Coil length = 0.6 m

Effective radius = 0.05 m

Block Length = 2.15 m

optional (estimation of Ang.Accept.)

Solenoid length = 0.6 m

Bore = 0.045 m

Ang.Accept. ± = 47.3 mrad

MA = MAconst * I

MAconst = 0.03933 T/A MA = 1.35848 T

$B(0) = MA * CoilLength / \sqrt{(EffRadius^2 + CoilLength^2 / 4)}$

Optical block properties and data

Setting Charge state for the Block (Z-Q) = 0

Optical matrix

General setting of block

Tweak = 0.1 %

Block Tuning

Tune Solenoid using the Setting fragment

Take into account the GLOBAL matrix of the previous block

Tuning is minimisation of 05. beam sigma: R (X&Y)

Plot v=f(B)

Setting fragment parameters

	Mean	StDev
1. X	0.00	0.99
2. T	0.00	17.37
3. Y	0.00	0.99
4. F	0.00	17.37
5. E	5.0	0.0

Method: "Distribution"

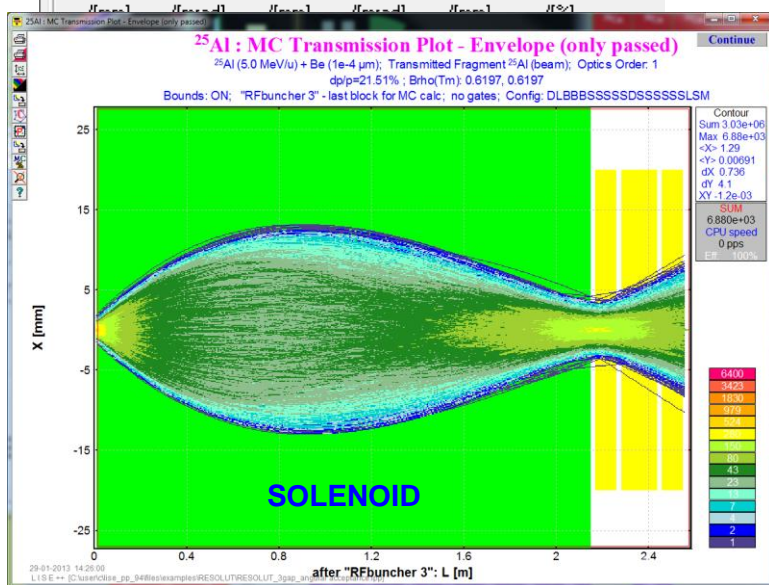
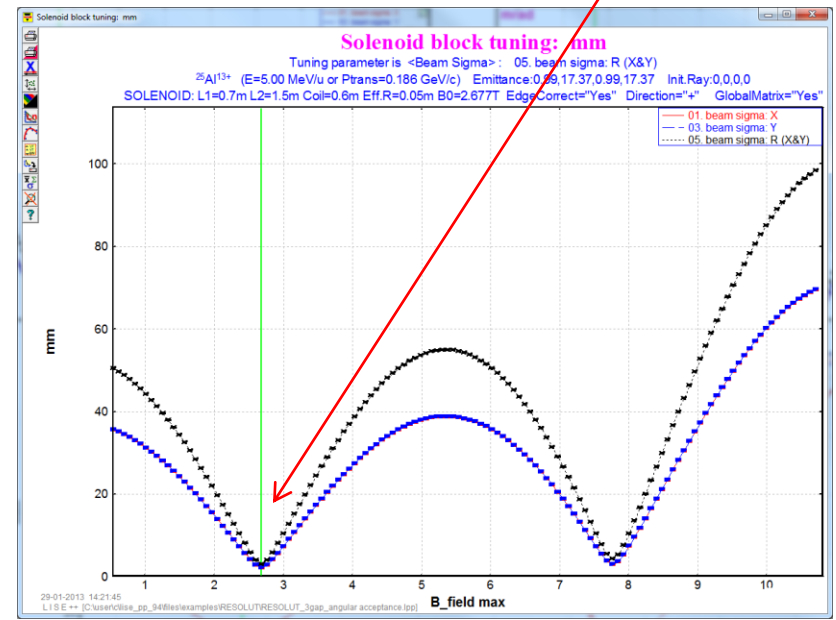
Setting fragment distribution parameters before Solenoid

OK Cancel Help

After the solenoid block (B=2.68 T)

Global matrix

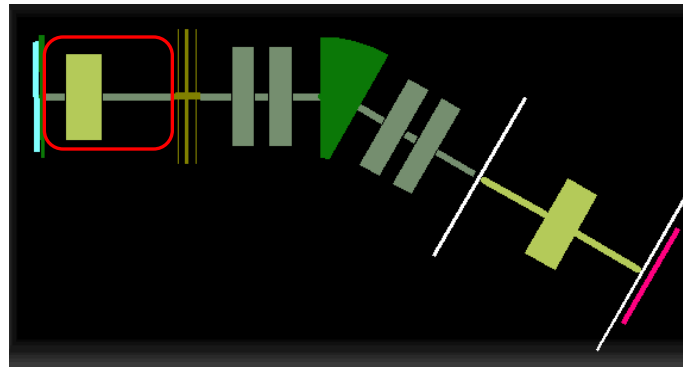
-0.60027	0.00433	-2.12804	-0.01536	0	0	[mm]
-0.55992	-0.11874	-1.98499	-0.42095	0	0	[mrad]
2.12804	-0.01536	-0.60027	0.00433	0	0	[mm]
1.98499	0.42095	-0.55992	-0.11874	0	0	[mrad]
0	0	0	0	1	0	[mm]
0	0	0	0	0	1	[%]



D	Tuning Dipole	Brho 0.6197 Tm
S	Drift 1	standard 0.35 m
L	Solenoid 1	B 2.6844 T
S	Drift 2	standard 1.21 m
B	RFbuncher 1	U 119 kV Ph 35 deg
B	RFbuncher 2	U 238 kV Ph 215 deg
B	RFbuncher 3	U 119 kV Ph 35 deg
S	Drift 3	standard 0.54 m
Q	MQ1	quadrupole 0.38 m
S	Drift 4	standard 0.22 m
Q	MQ2	quadrupole 0.41 m
S	Drift 5	standard 0.47 m
D	Dipole	Brho 0.6197 Tm
S	Drift 6	standard 0.48 m
Q	MQ3	quadrupole 0.41 m
S	Drift 7	standard 0.22 m
Q	MQ4	quadrupole 0.38 m
S	Drift 8	standard 0.74 m
S	slits1	s :ls
		-200 H +200 -50 V +50
L	Solenoid 2	B 2.2688 T
S	slits2	s :ls
		-200 H +200



Initial drift+solenoid+drift configuration to define angular acceptance

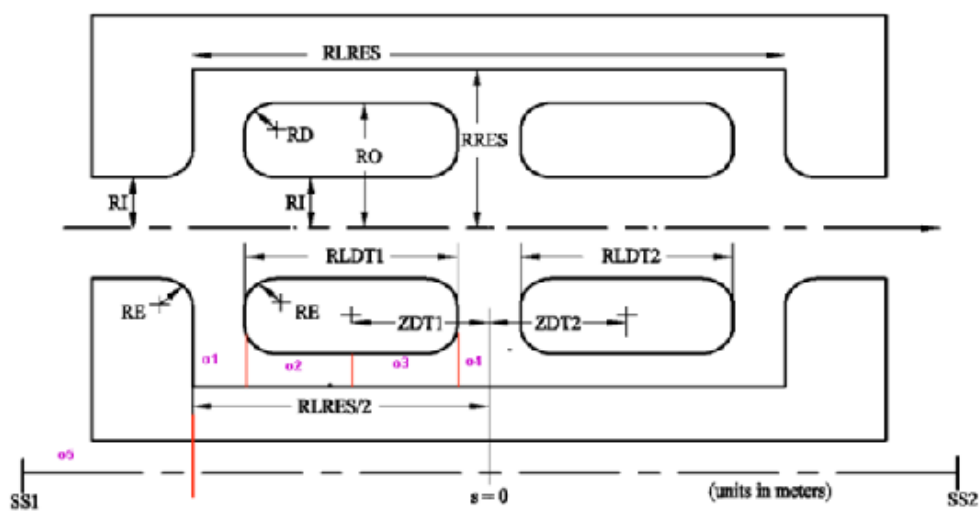


1-st solenoid values from the previous slide:

FSU COSY : 2.71 T

LISE++ small object at the RF buncher : 2.68 T

LISE++ makes parallel after solenoid : 2.2 T



GAPIH1 RI RO RE RD RLRES RRES RLDT1 RLDT2 ZDT1 ZDT2 PAR ; (generates structure file)
 THREEGAP SS1 SS2 SCL W PHI RREST; (calculates map)

Cavity voltage, $V = SCL \cdot \cos(W \cdot t + \text{PHI})$

SCL = max voltage (kV)
 W = angular frequency (rad/s)
 PHI = relative cavity phase (rad)
 RREST = RI (set the same or smaller)
 ZDT1 = center position of tube 1 relative to $s = 0$.
 ZDT2 = center position of tube 2 relative to $s = 0$.
 PAR = +1 for even, -1 for odd voltage symmetry between tubes

Figure B3. Diagram illustrating the parameters of subroutine THREEGAP.

reduced one gap geometry

od2a	0.162	ss1 - gap2/2
ogap2	0.076	gap2
od2b	0.162	od2b

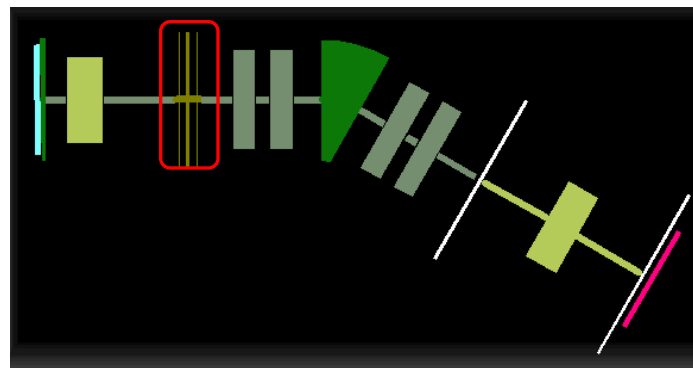
```
GAPIH1 0.019 0.05 0.01 0.01 0.35 0.198 0.1 0.1 -0.088 0.088 -1.;
THREEGAP -0.2 0.2 RFF 9.7E7*2.*PI*PHI*DEGRAD 0.019;
```

- RI= 0.019
- RO= 0.05
- RE= 0.01
- RD= 0.01
- RLRES= 0.35
- RRES= 0.198
- RLDT1= 0.1
- RLDT2= 0.1
- ZDT1= -0.088
- ZDT2= 0.088
- PAR= -1 odd

- SS1= 0.2
- SS2= 0.2
- o1 0.037 RLRES/2 - RLDT1 - o4
- o2 0.05 RLDT1 / 2
- o3 0.05 RLDT1 / 2
- o4 0.038 ZDT1 - o3
- o5 0.025 SS1 - RLRES/2

d1a	0.025	o5	L
gap1	0.037	o1	0.025
d1b	0.05	o2	0.062
			0.112
			0.112
d2a	0.05	o3	0.162
gap2	0.076	2*o4	0.238
d2b	0.05	o3	0.288
			0.288
d3a	0.05	d1b	0.338
gap3	0.037	gap1	0.375
d3b	0.025	d1a	0.400

RESOLUT_3gap.Ipp



First buncher

RFbuncher 1

RF buncher settings

Select method:

- Electric field $E = 3216.22$ KV/m
- Voltage $U = 119$ KV

RF buncher plots:
 $E = f(\text{phase } x), V = f(x), dE = f(\text{phase})$

Geometry

$L_a = 0.025$ m
 $L(\text{gap}) = 0.037$ m
 $L_b = 0.05$ m

RF settings

use Beam settings RF [MHz] 97 Phase shift 32 [deg]
 manually 93

tff (transit time factor)

$V(t) = V_0 * tff * \sin(\omega t + \text{phase_shift})$
 parameterization 0.999 chose d-mode
 manually 1 d5

Optical block properties and data

Setting Charge state for the Block (Z-Q) 0 Calculate the RF buncher using the Setting fragment

Out(Slits) & Acceptances Solenoid 1

Optical matrix Tweak 0.1 %

General setting of block

Calculations for the setting fragment

Before the buncher gap	<E> dE	<E>	<E>+dE
Energy [MeV/u]	4.88	5.00	5.12

Values corresponding to Energy in middle of the gap

Time of flight [ns]	72.1	71.2	70.4
Phase [deg]	29.8	359.5	329.3

Alter the RF buncher

Energy [MeV/u]	4.91	5.00	5.09
----------------	------	------	------

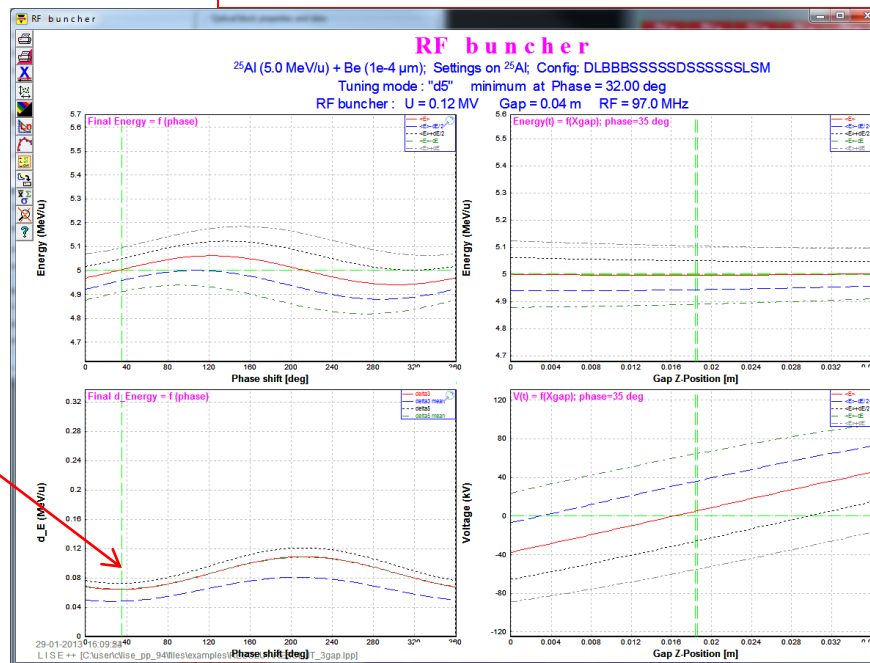
OK Cancel Optimization utility Local : Phase & V Help

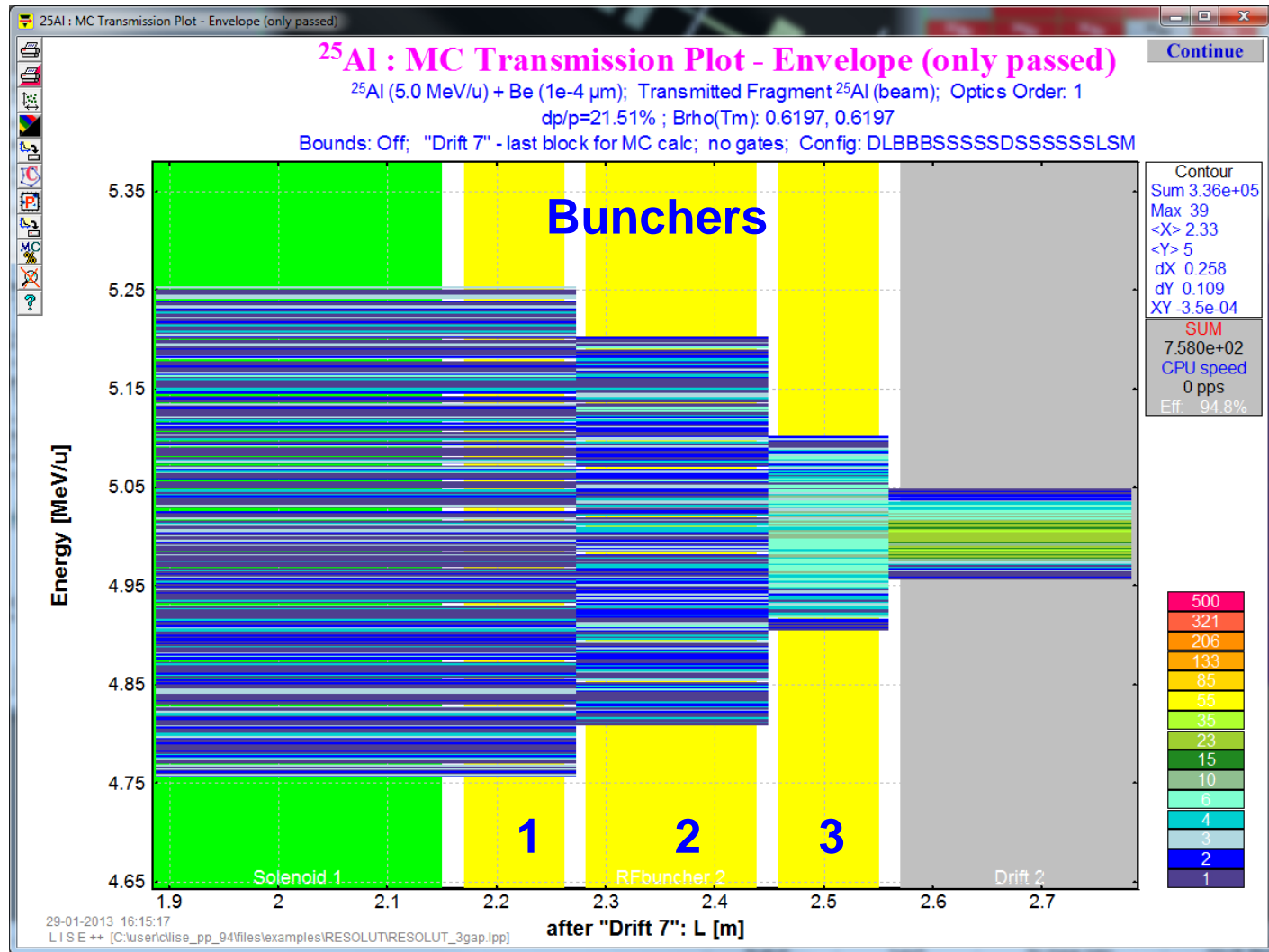
COSY 3 gaps :

Gap	Gap Size	Bias
1	D	+V
2	2D	-2V
3	D	+V

LISE++ 3 bunchers:

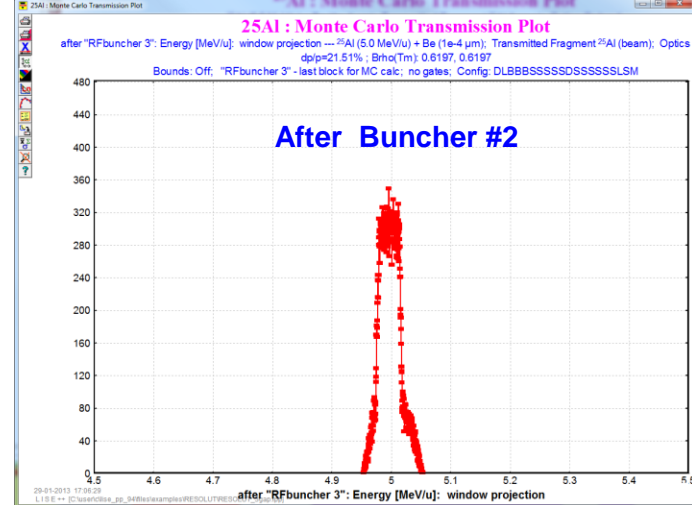
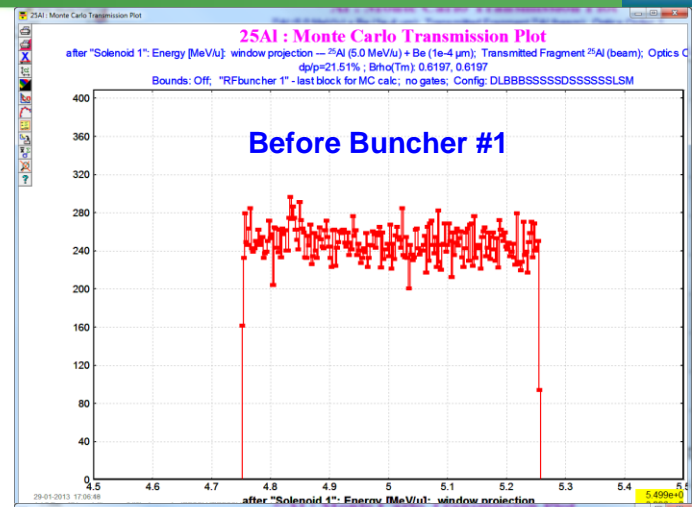
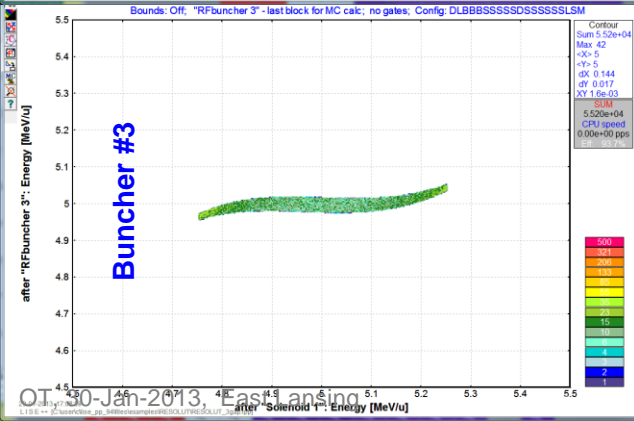
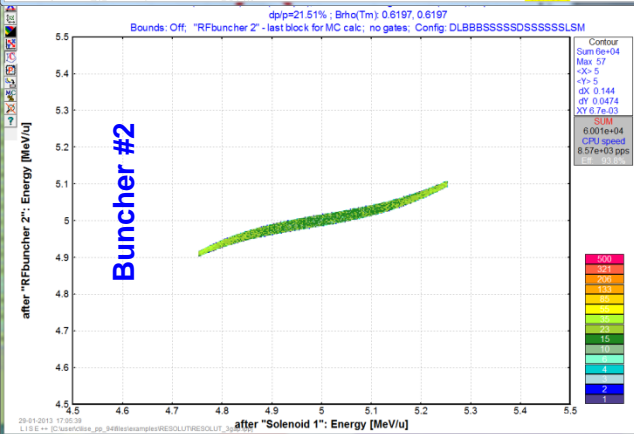
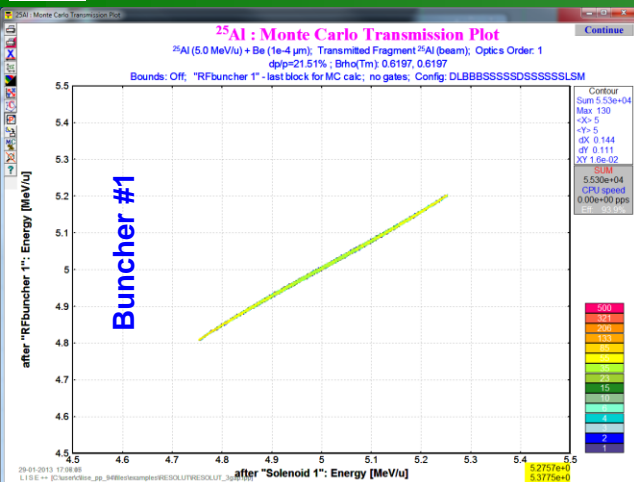
Buncher	Gap Size	Bias	Phase
1	D	V	a
2	2D	2V	a+180
3	D	V	a



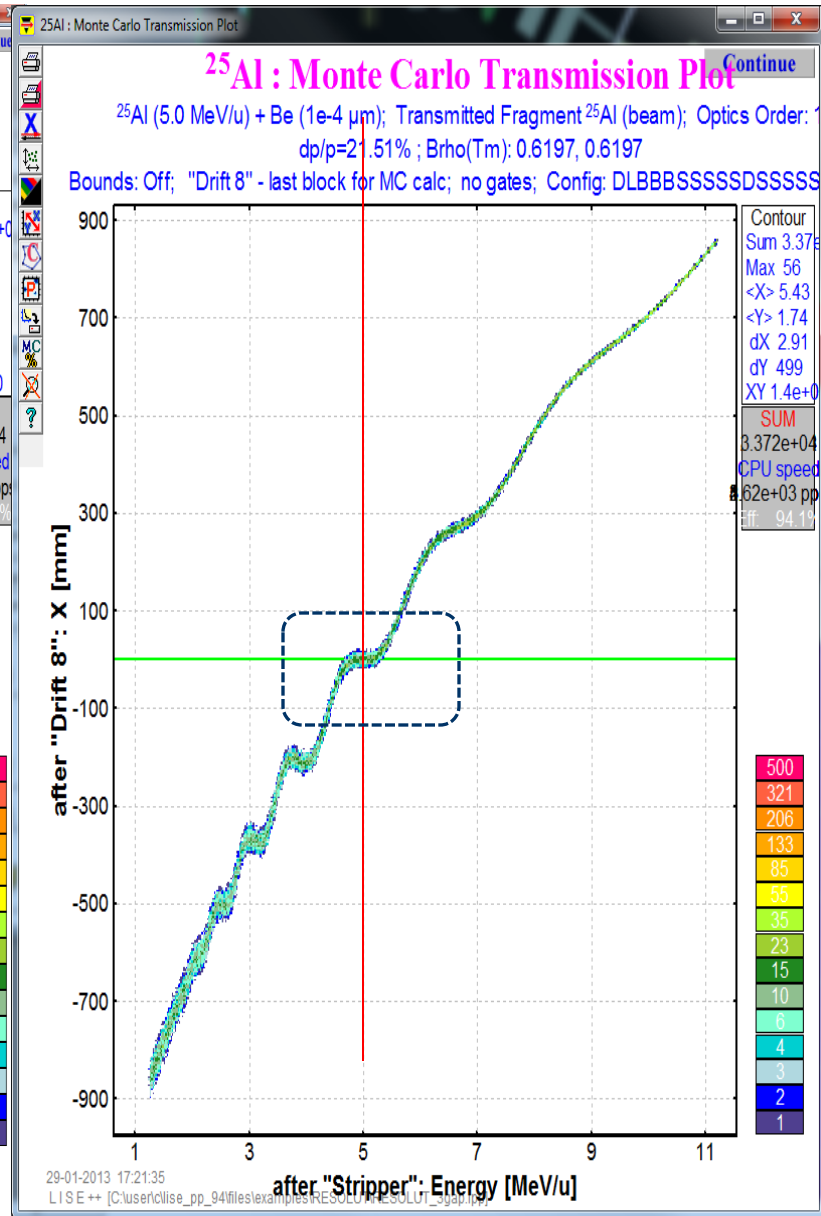
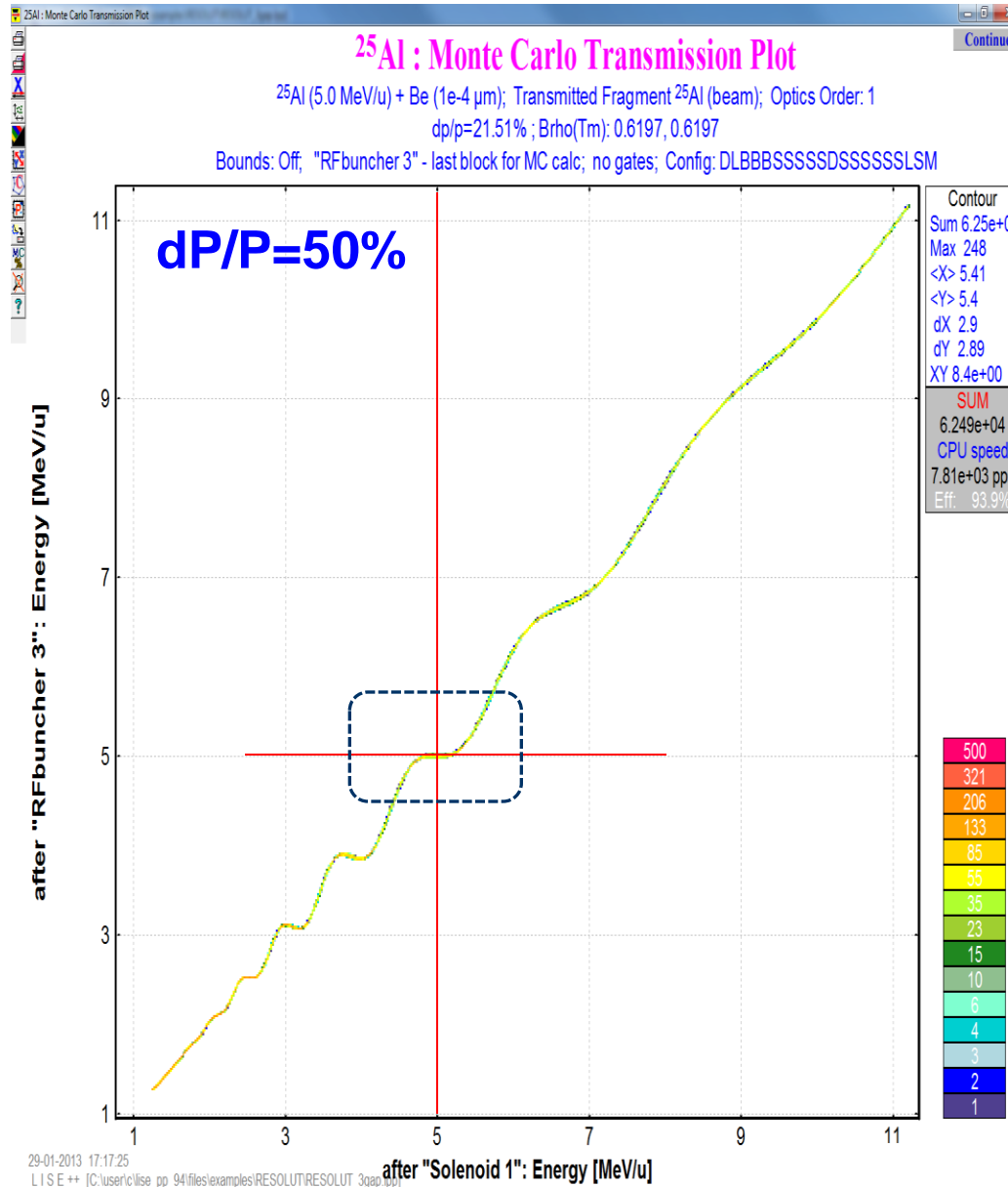


File: RESOLUT_3gap.lpp

Three gaps RF-buncher in COSY → Three RF-bunchers in LISE++



	StDev
Before Buncher #1	0.144
After Buncher #1	0.111
After Buncher #2	0.0474
After Buncher #3	0.017



Three RF-bunchers in LISE++

Advantages:

- It Can be use for all velocities
- Realistic simulation

Disadvantages:

- Difficult to find a phase
- It is necessary manually to set this phase for all bunchers
- It is impossible to make simultaneously optimization for all three bunchers.

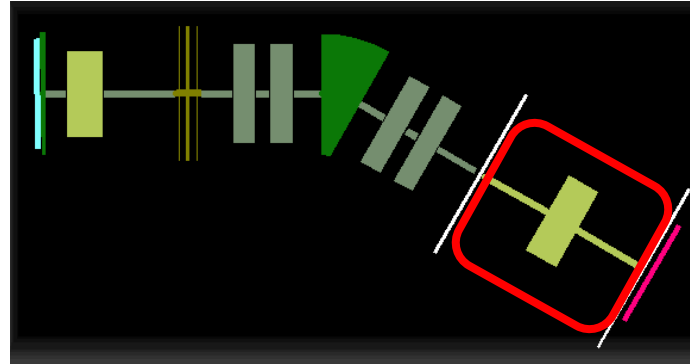
Solutions:

- Creation the ThreeGap block
- Creation configurations with one RF-buncher* which can be reproduced main properties current configurations and used for optimization

* it has been realized. See RESOLUT_1gap.lpp slides

D	Tuning Dipole	Brho 0.6197 Tm
S	Drift 1	standard 0.35 m
L	Solenoid 1	B 2.6844 T
S	Drift 2	standard 1.21 m
B	RFbuncher 1	U 119 kV Ph 35 deg
B	RFbuncher 2	U 238 kV Ph 215 deg
B	RFbuncher 3	U 119 kV Ph 35 deg
S	Drift 3	standard 0.54 m
Q	MQ1	quadrupole 0.38 m
S	Drift 4	standard 0.22 m
Q	MQ2	quadrupole 0.41 m
S	Drift 5	standard 0.47 m
D	Dipole	Brho 0.6197 Tm
S	Drift 6	standard 0.48 m
Q	MQ3	quadrupole 0.41 m
S	Drift 7	standard 0.22 m
Q	MQ4	quadrupole 0.38 m
S	Drift 8	standard 0.74 m
S	slits1	s :ls
		-200 H +200 -50 V +50
L	Solenoid 2	B 2.2688 T
S	slits2	s :ls
		-200 H +200

← 2nd - solenoid



2nd solenoid values from the previous slide:

FSU COSY : 2.44 T

LISE++ small object at the solenoid : 2.29 T

Solenoid 2

Solenoid settings

B, max field: 2.29 T

I, current: 31.925 A

Use the "soft-edge" corrections for solenoid matrix calculations

$V(L \cdot B / \pi) = 0.4374 \text{ Tm}$

$V / Brho = 0.6981$

Field Direction

"+" positive

"-" negative

Solenoid Block Scheme

TwinSol Utility

Optical block properties and data

Setting Charge state for the Block (Z-Q): 0

Block Tuning

Tune Solenoid using the Setting fragment

Take into account the GLOBAL matrix of the previous block

Tuning is minimisation of: 05. beam sigma: R (X&Y)

Tweak: 0.1 %

Geometry

1-st half = 1.06 m

2-nd half = 1.89 m

Coil length = 0.6 m

Effective radius = 0.05 m

Block Length = 2.95 m

optional (estimation of Ang.Accept.)

Solenoid length = 0.6 m

Bore = 0.05 m

Ang.Accept. ± = 36.7 mrad

Setting fragment parameters

	Mean	StDev
1. X	0.00	115.79
2. T	5.89	99.77
3. Y	0.00	4.21
4. F	0.00	20.15
5. E	5.1	0.9

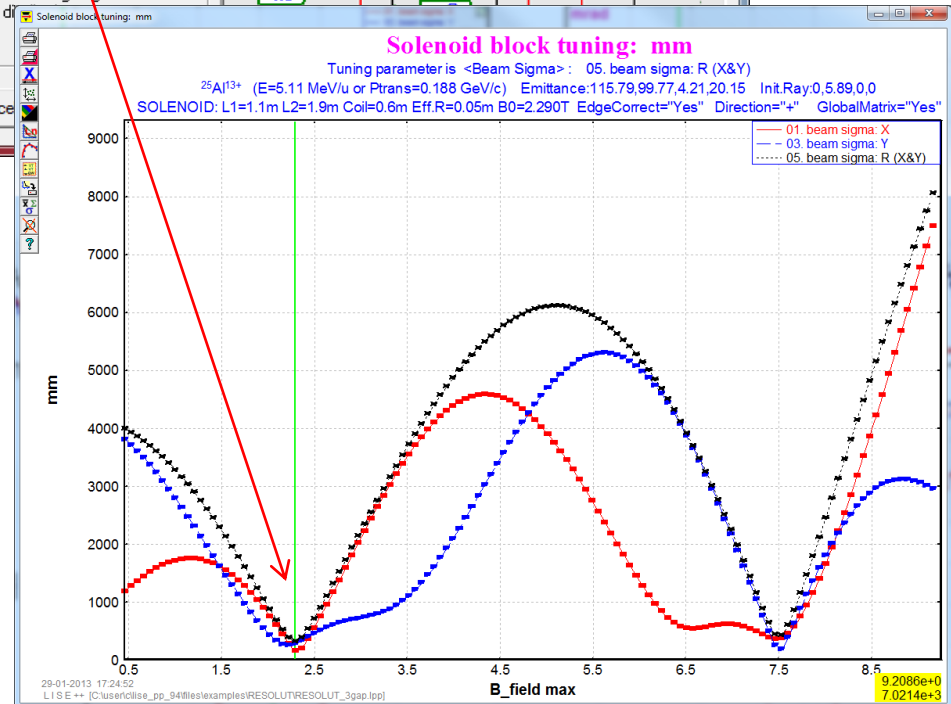
Method: "Distribution"

MA = MAconst * I

MAconst = 0.03636 T/A

MA = 1.16079 T

$B(0) = MA \cdot CoilLength / \sqrt{(EffRadius^2 + CoilLength^2 / 4)}$



File: RESOLUT_3gap_reaction.lpp

Beam

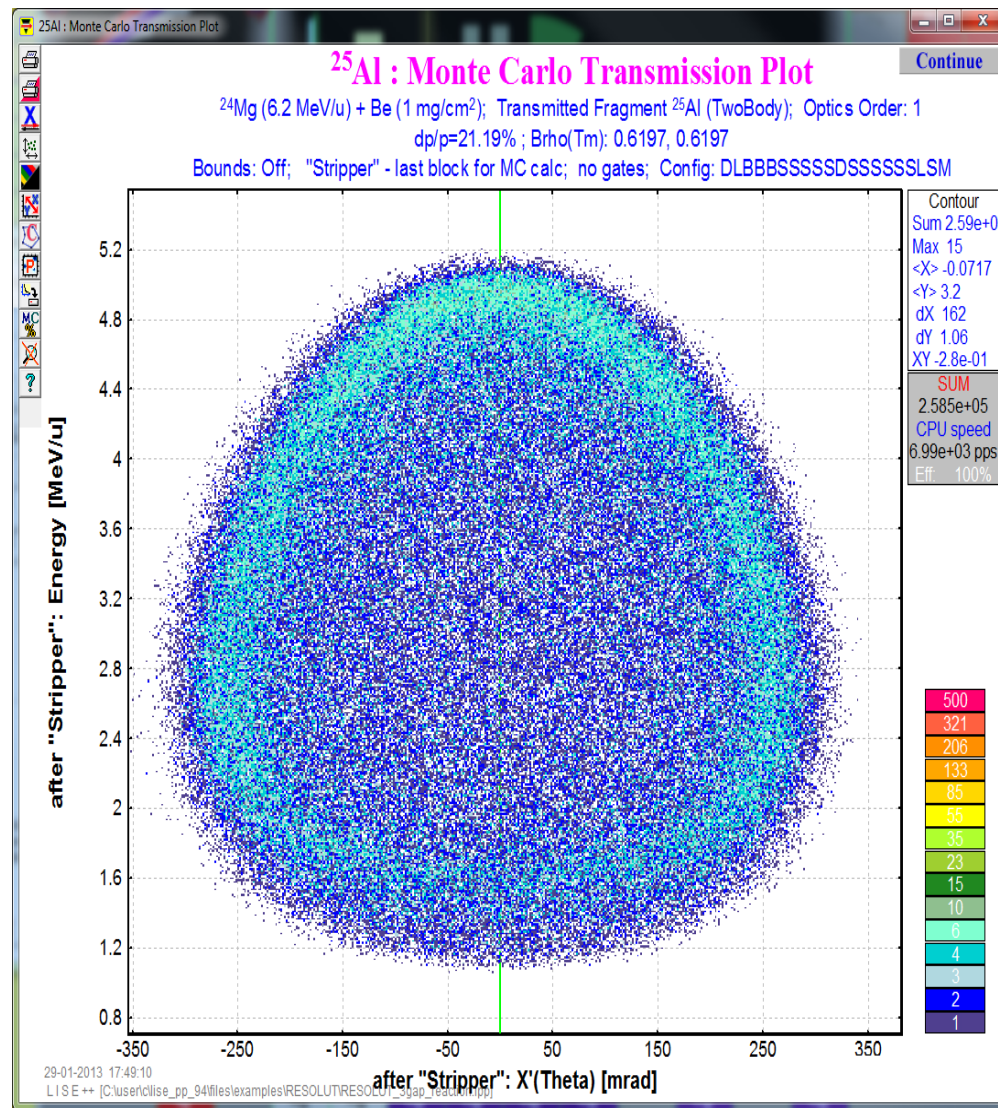
A	Element	q+	Beam energy		Emittance	
24	Mg	12	Energy	6.2 MeV/u	Beam CARD	1D - shape
12			TKE	148.71 MeV	(sigma, semi-axis, half-width...)	(Distribution method)
Z			Brho	0.7177 Tm	1. X mm	1.5 Gaussian
Stable			P	2.582 GeV/c	2. T mrad	20 Gaussian
Table of Nuclides			U	1.24e+4 KV	3. Y mm	1.5 Gaussian
Z			Beam intensity		4. P mrad	20 Gaussian
N			12 enA		5. L mm	0 Gaussian
Ok			1 pA		6. D %	0.5 Gaussian

P Projectile	$^{24}\text{Mg}^{12+}$
	6.2 MeV/u 1 pA
F Fragment	$^{25}\text{Al}^{13+}$
T Target	Be
	1 mg/cm ²
Two body reaction	
D Tuning Dipole	Brho
	0.6197 Tm

Primary beam is taken into account, but
Think about other reactions.

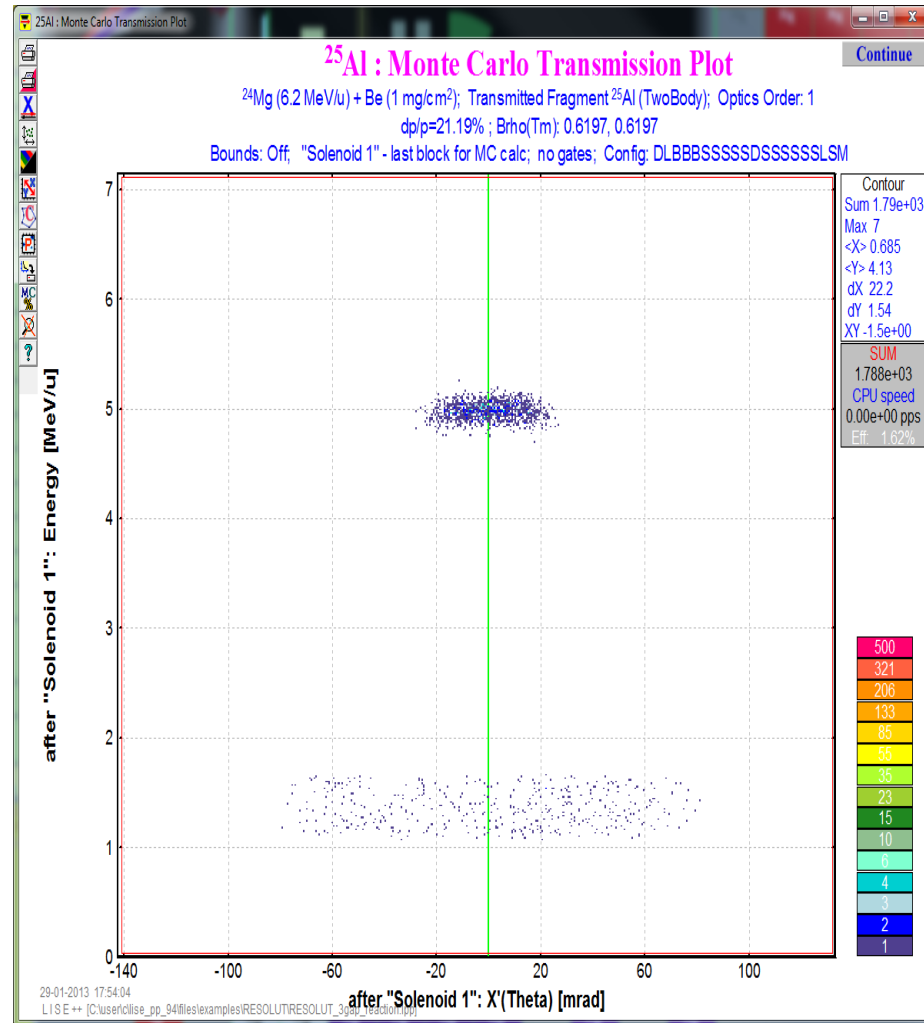
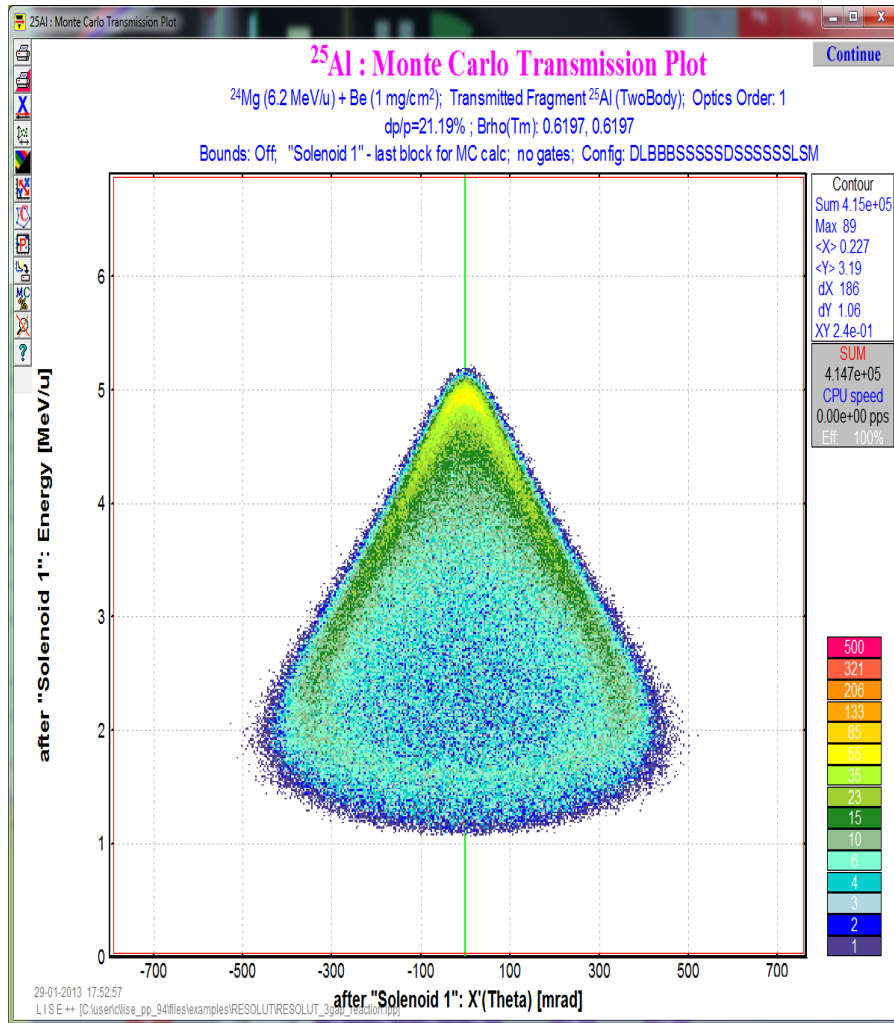
EPAX cross section have been used
for Two-body reactions

After target

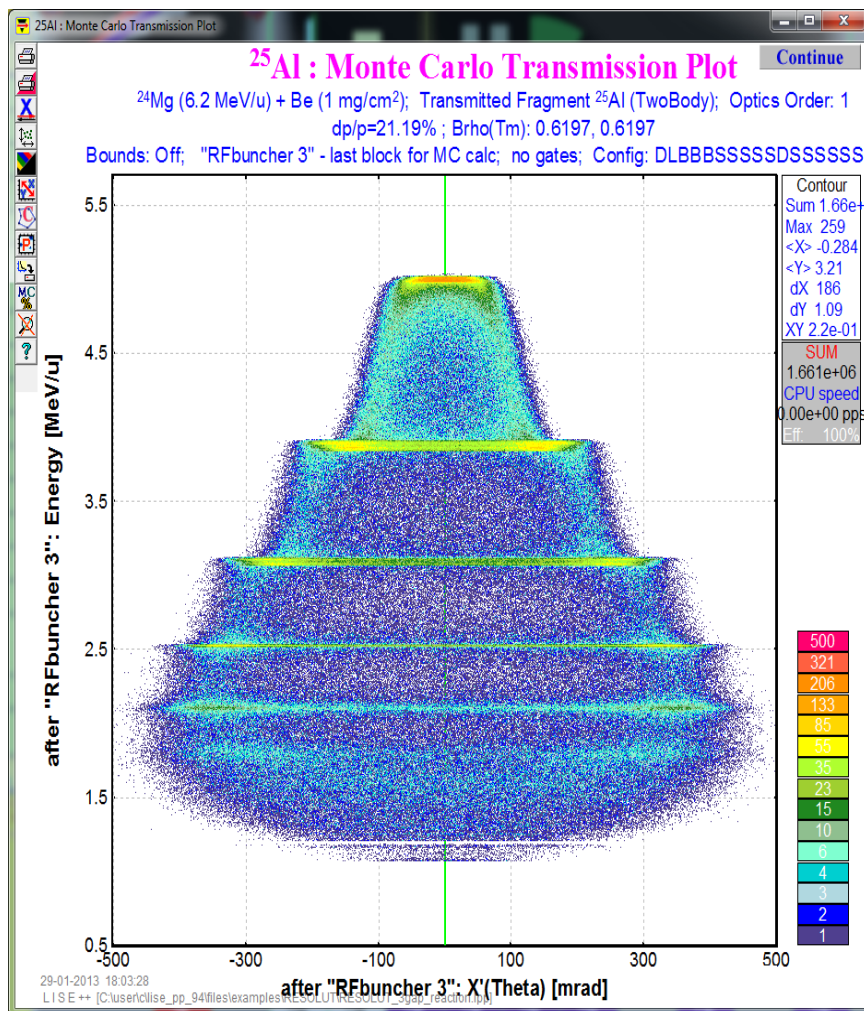


After the 1st solenoid **without** angular acceptance

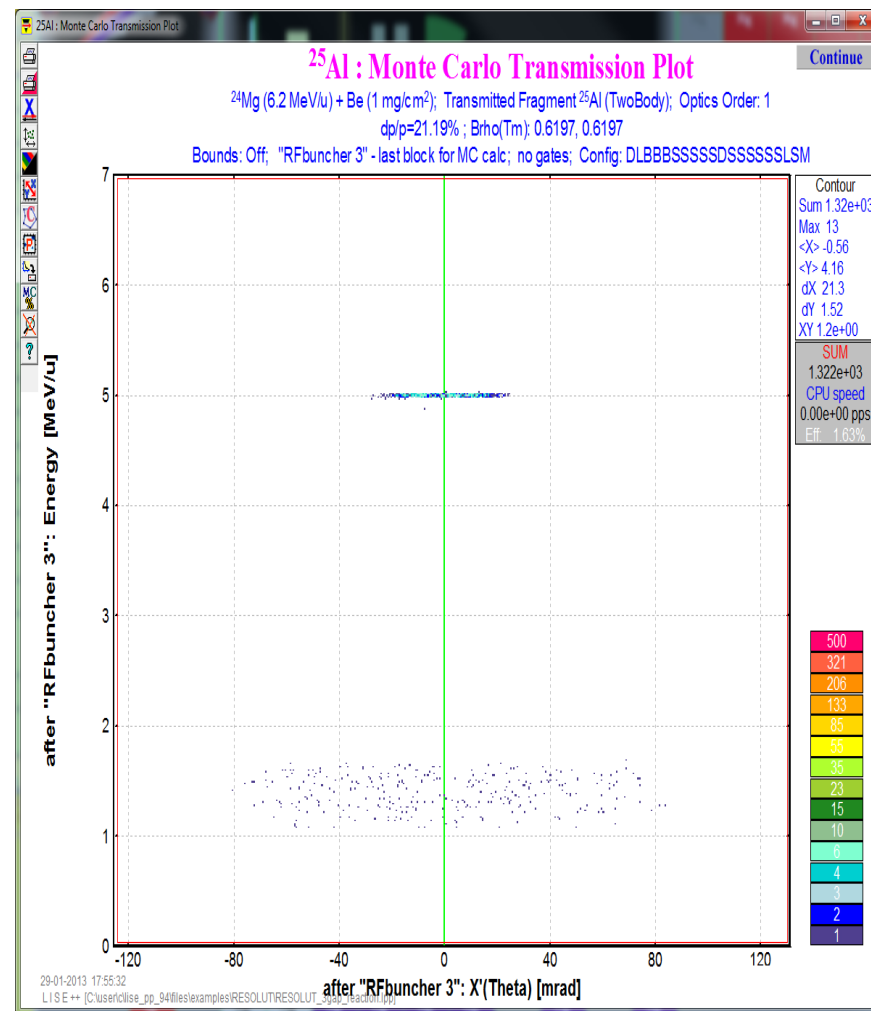
After the 1st solenoid **with** angular acceptance



After the 3 gap buncher **without** angular acceptance

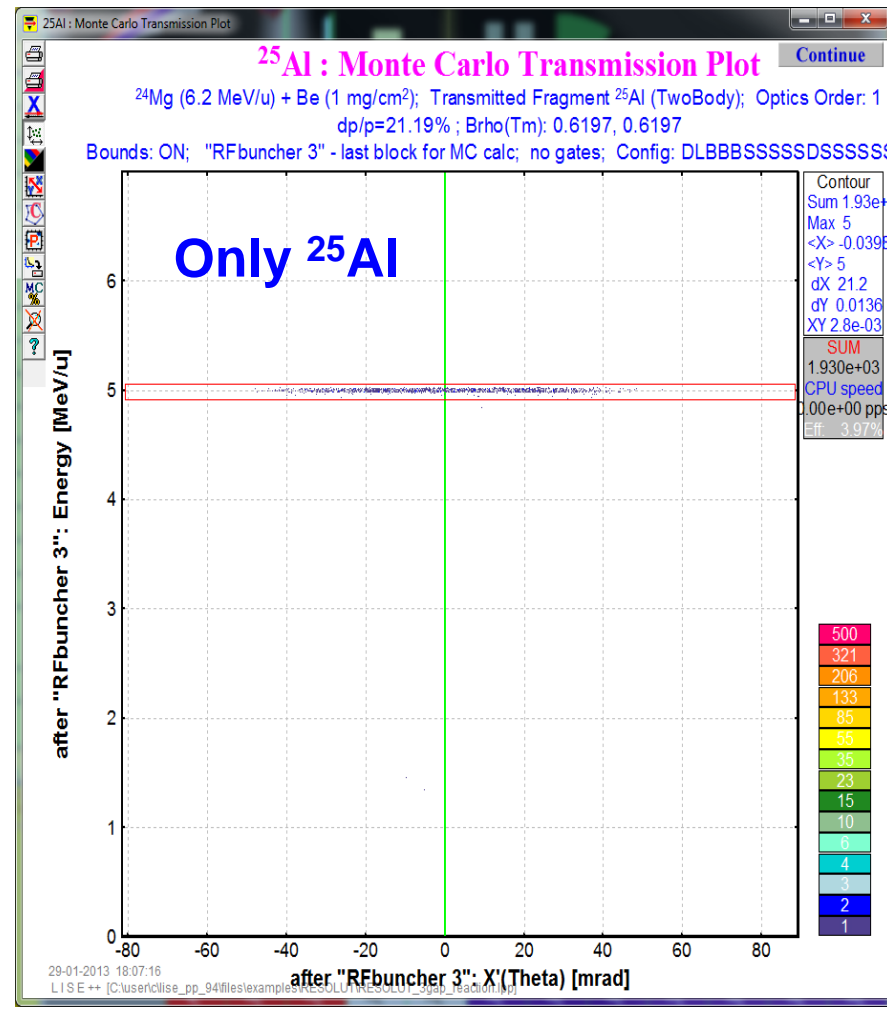
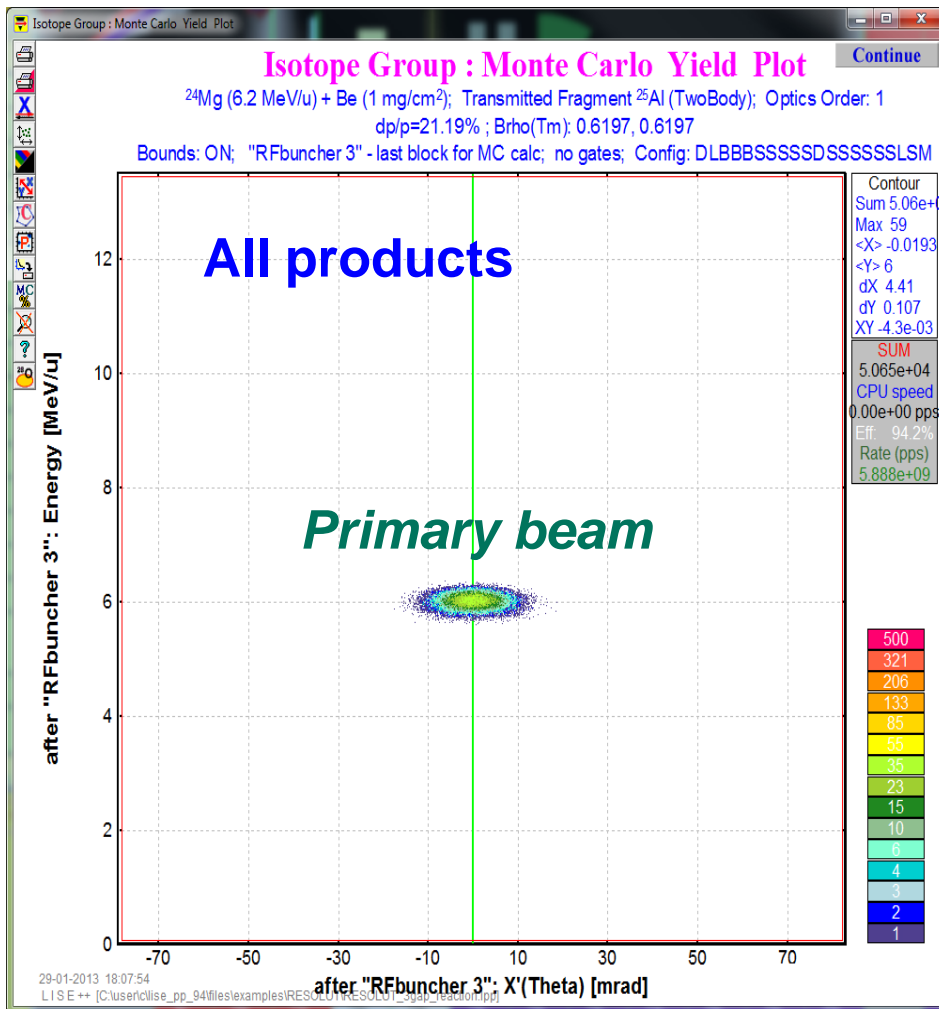


After the 3 gap buncher **with** angular acceptance



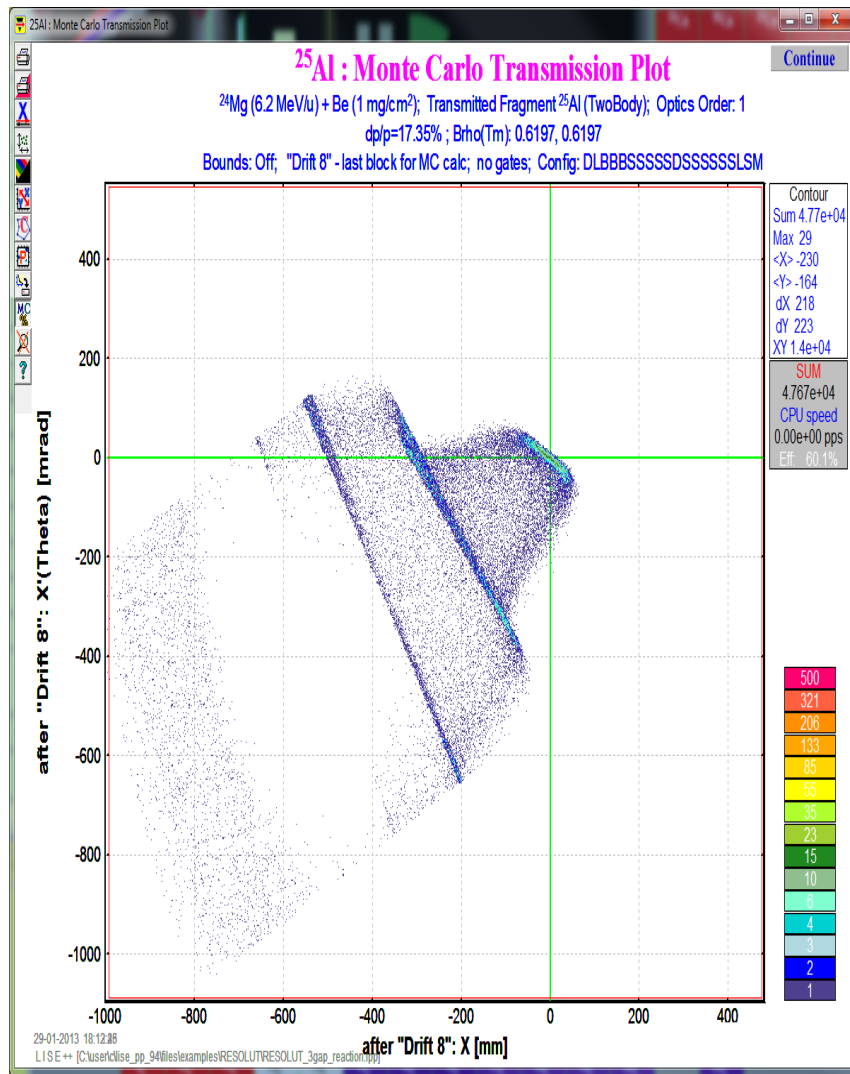
**+/- 47 mrad acceptance,
 Transmission 1.6%**

After the 3 gap buncher **without**
angular acceptance,
But taken **bounds** into account

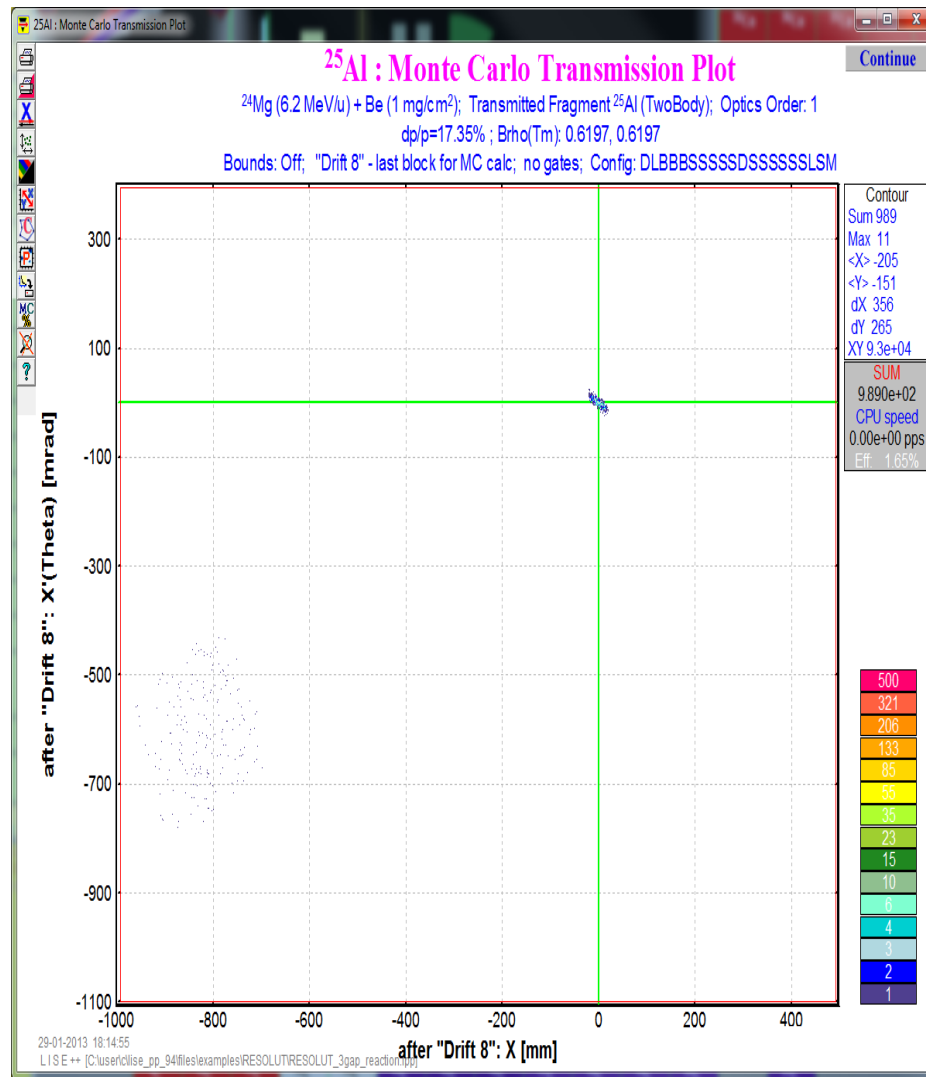


Transmission 4.0%

After the MQ4 **without**
angular acceptance,

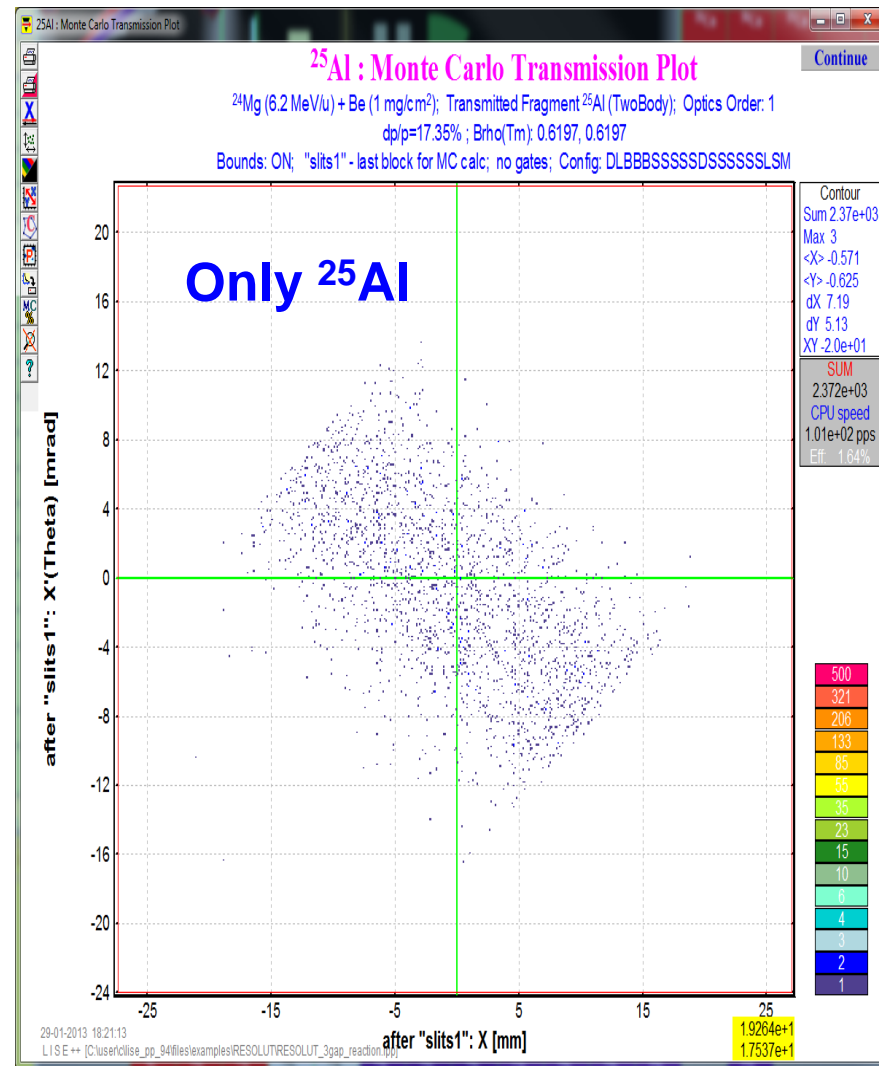
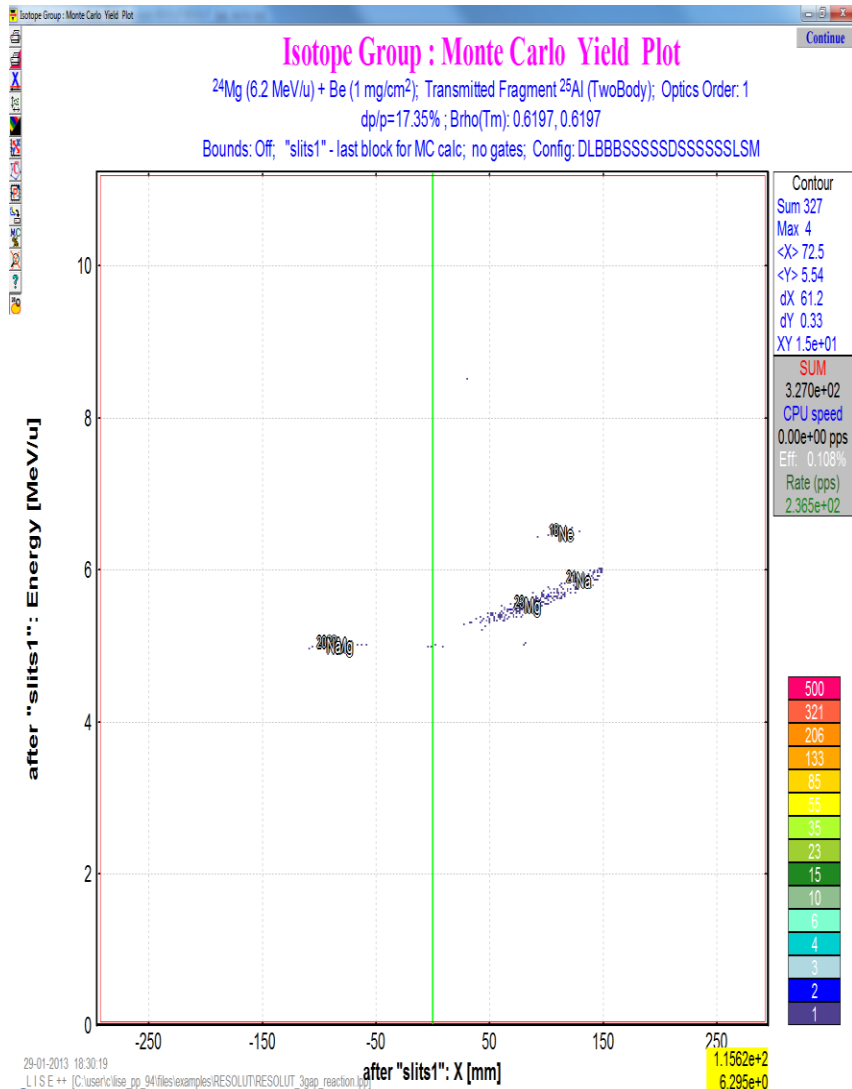


After the MQ4 **without**
angular acceptance,



**+/- 47 mrad acceptance,
Transmission 1.6%**

After the slits1 **without**
angular acceptance,
But taken **bounds** into account

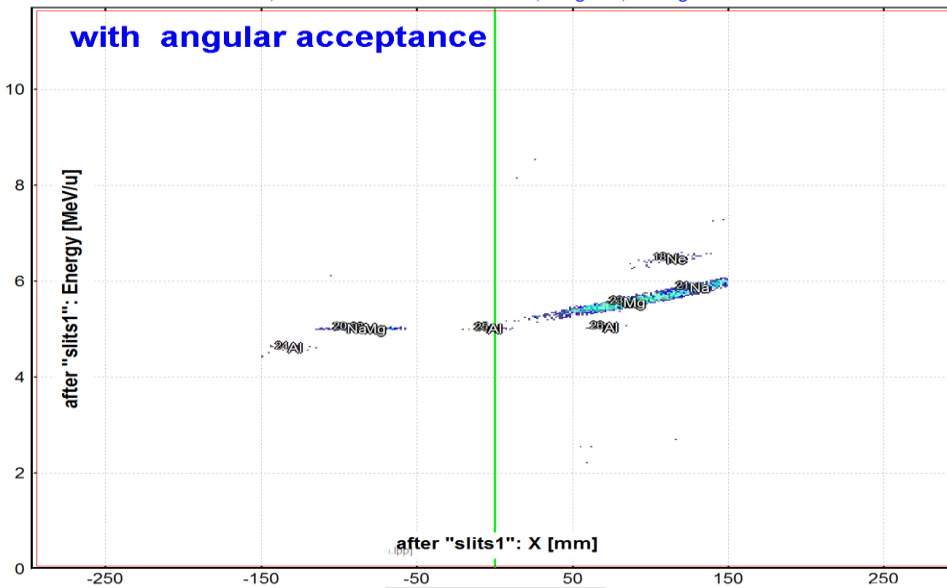


Transmission 1.6%

Isotope Group : Monte Carlo Yield Plot

^{24}Mg (6.2 MeV/u) + Be (1 mg/cm²); Transmitted Fragment ^{25}Al (TwoBody); Optics Order: 1
 dp/p=17.35% ; Brho(TM): 0.6197, 0.6197
 Bounds: Off; "slits1" - last block for MC calc; no gates; Config: DLBBBSSSSSDSSSSSSLSM

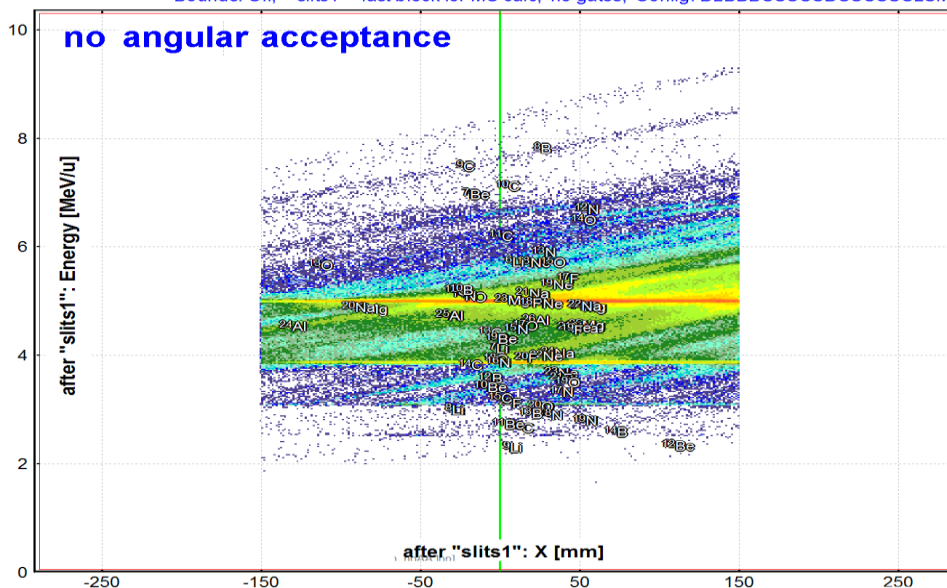
with angular acceptance



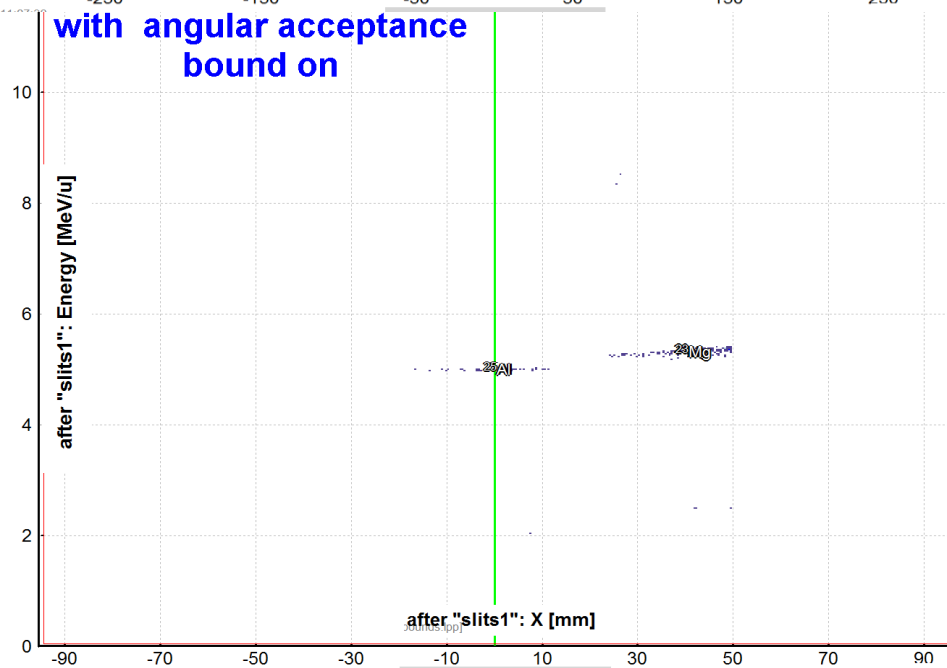
Isotope Group : Monte Carlo Yield Plot

^{24}Mg (6.2 MeV/u) + Be (1 mg/cm²); Transmitted Fragment ^{25}Al (TwoBody); Optics Order: 1
 dp/p=17.35% ; Brho(TM): 0.6197, 0.6197
 Bounds: Off; "slits1" - last block for MC calc; no gates; Config: DLBBBSSSSSDSSSSSSLSM

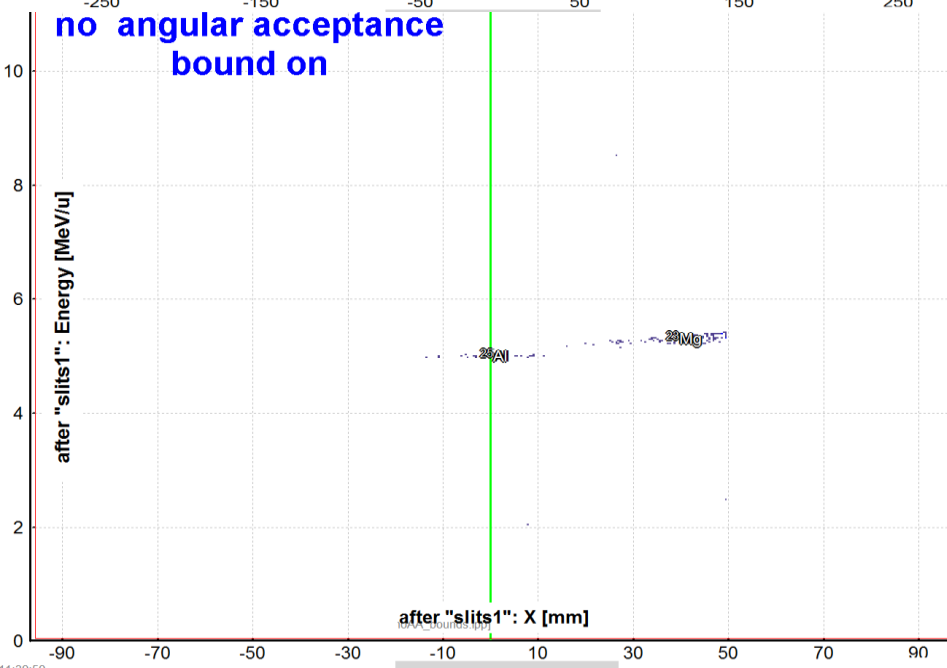
no angular acceptance

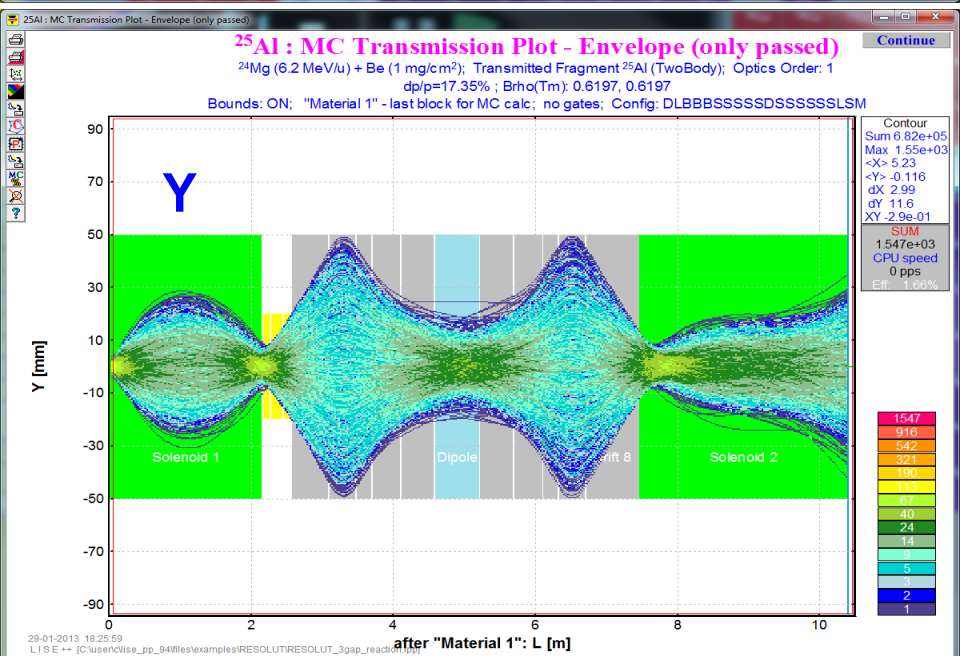
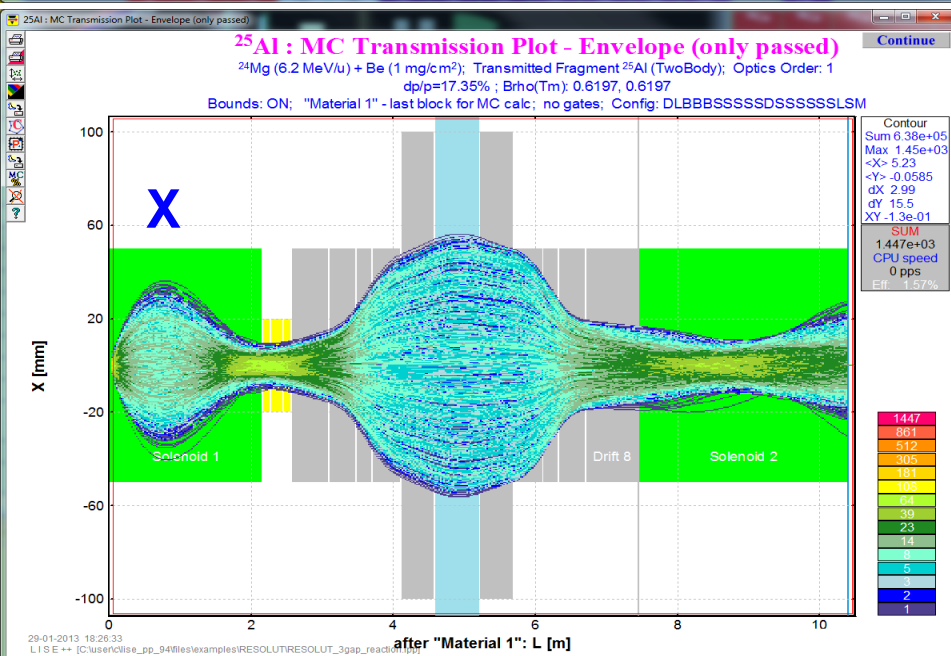
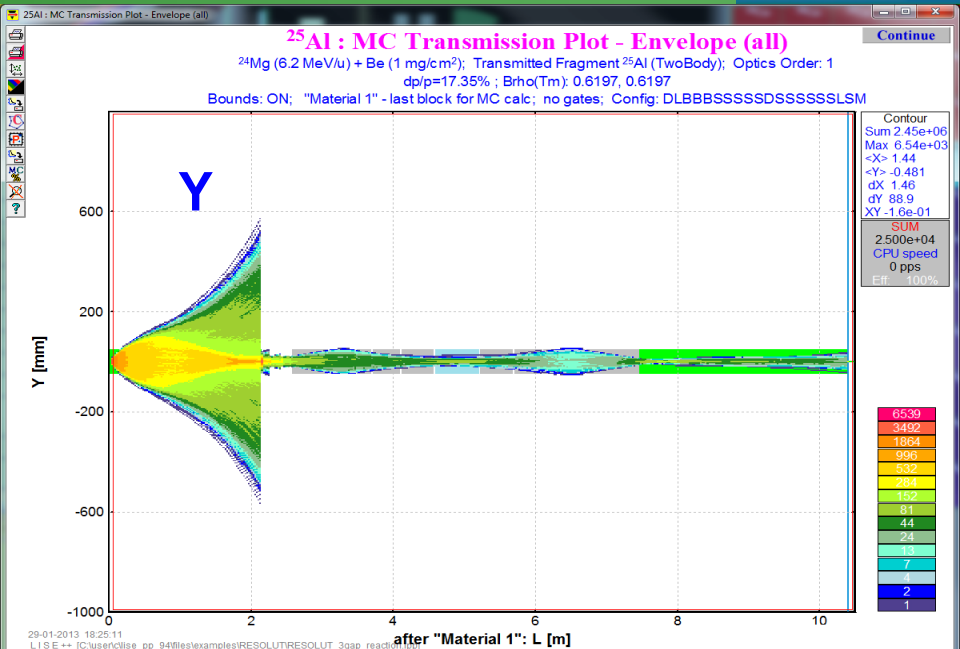
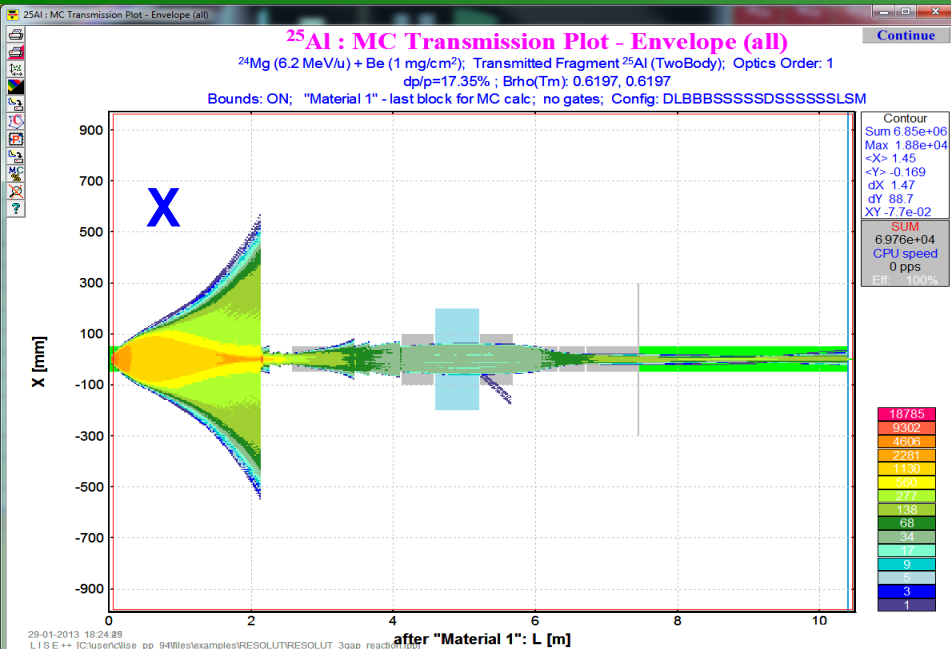


with angular acceptance bound on



no angular acceptance bound on



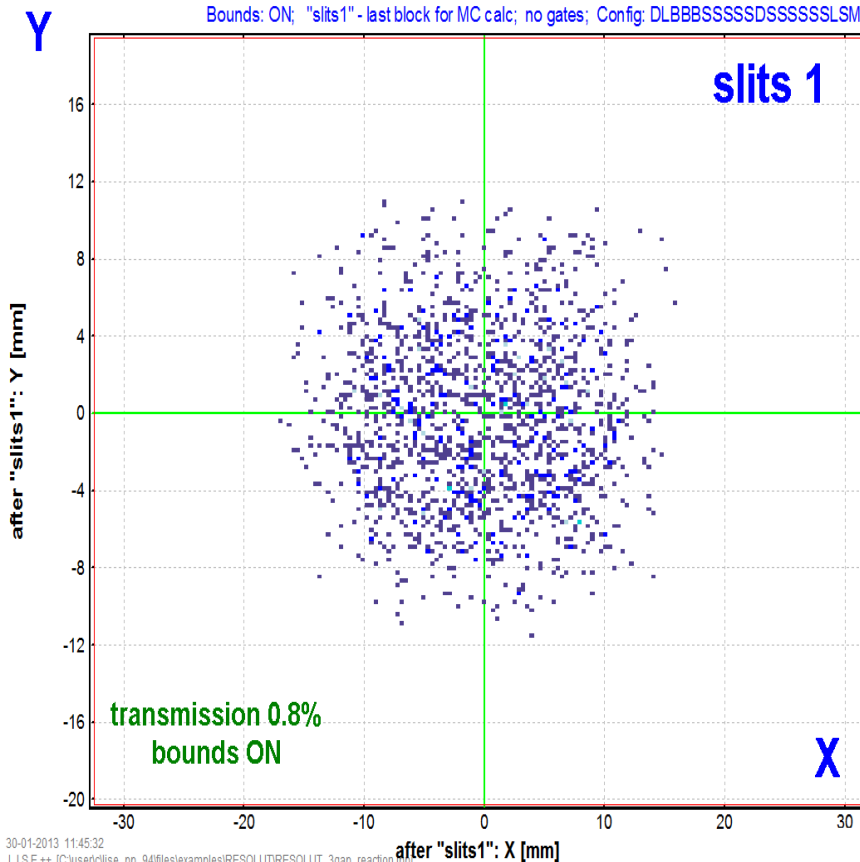


^{25}Al : Monte Carlo Transmission Plot

^{24}Mg (6.2 MeV/u) + Be (1 mg/cm²); Transmitted Fragment ^{25}Al (TwoBody); Optics Order: 1

dp/p=17.35% ; Brho(Tm): 0.6197, 0.6197

Bounds: ON; "slits1" - last block for MC calc; no gates; Config: DLBBBSSSSDSSSSSSLSM

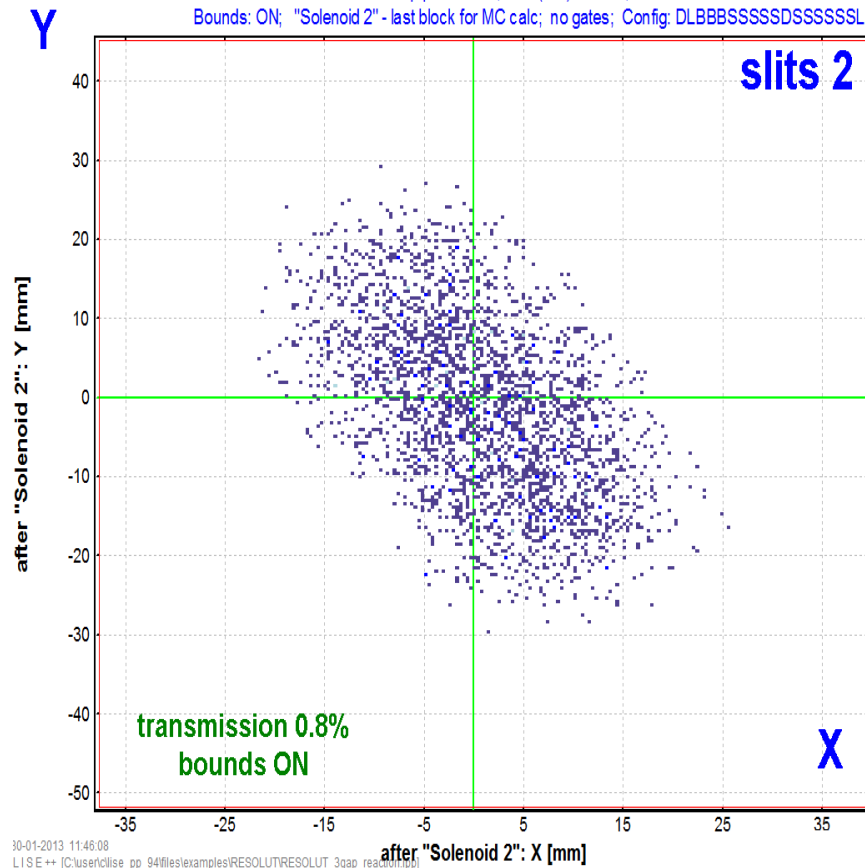


^{25}Al : Monte Carlo Transmission Plot

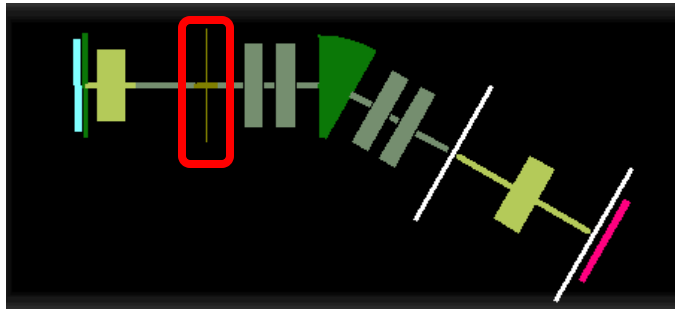
^{24}Mg (6.2 MeV/u) + Be (1 mg/cm²); Transmitted Fragment ^{25}Al (TwoBody); Optics Order: 1

dp/p=17.35% ; Brho(Tm): 0.6197, 0.6197

Bounds: ON; "Solenoid 2" - last block for MC calc; no gates; Config: DLBBBSSSSDSSSSSSLSI



RESOLUT_1gap.Ipp



Should be used factor 4 relatively nominal voltage

Click this button to set the phase corresponded to smallest d-value

	Tuning Dipole	Brho	0.6197 Tm
	Solenoid 1	B	2.1165 T
	Drift 1	standard	1.21 m
	RFbuncher	U Ph	488 kV 216 deg
	Drift 2	standard	0.54 m
	MQ1	quadrupole	0.38 m

Main advantage of this configuration is possibility to use the LISE++ built-in optimization procedures

RFbuncher

RF buncher settings

Select method

Electric field E = 6421.05 KV/m

Voltage U = 488 KV

RF buncher plots:
E = f(phase x), V = f(x), dE = f(phase)

Geometry

La = 0.162 m

L (gap) = 0.076 m

Lb = 0.162 m

RF settings

use Beam settings RF (MHz) 97 Phase shift 216 [deg]

manually RF (MHz) 93 [deg]

tff (transit time factor)

$V(t) = V_0 * tff * \sin(\omega t + \text{phase_shift})$

parameterization 0.999

manually 0.999

tuning chose d-mode d5

Optical block properties and data

Setting Charge state for the Block (Z-Q) 0

Calculate the RF buncher using the Setting fragment

Solenoid 1

Tweak 0.1 %

Calculations for the setting fragment

Before the buncher gap	<E>-dE	<E>	<E>+dE
Energy [MeV/u]	4.88	5.00	5.12

Values corresponding to Energy in middle of the gap

	77.2	76.3	75.4
Time of flight [ns]	77.2	76.3	75.4
Phase [deg]	32.6	0.2	327.8

After the RF buncher

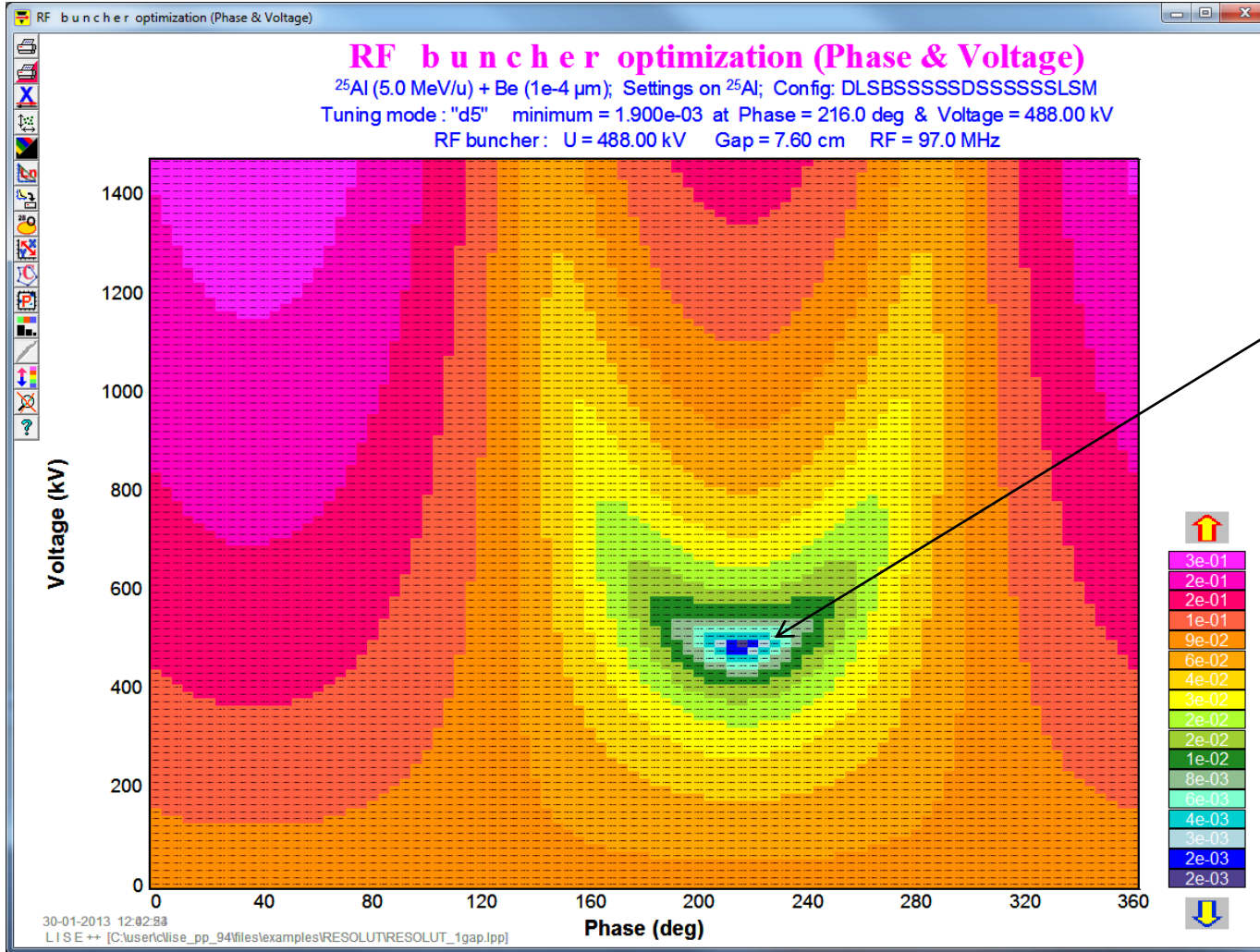
Energy [MeV/u]	5.00	5.00	5.00
Energy [MeV/u]	5.00	5.00	5.00

OK Cancel Help

Optimization utility Local : Phase & V

Pay attention for the factor in this configuration

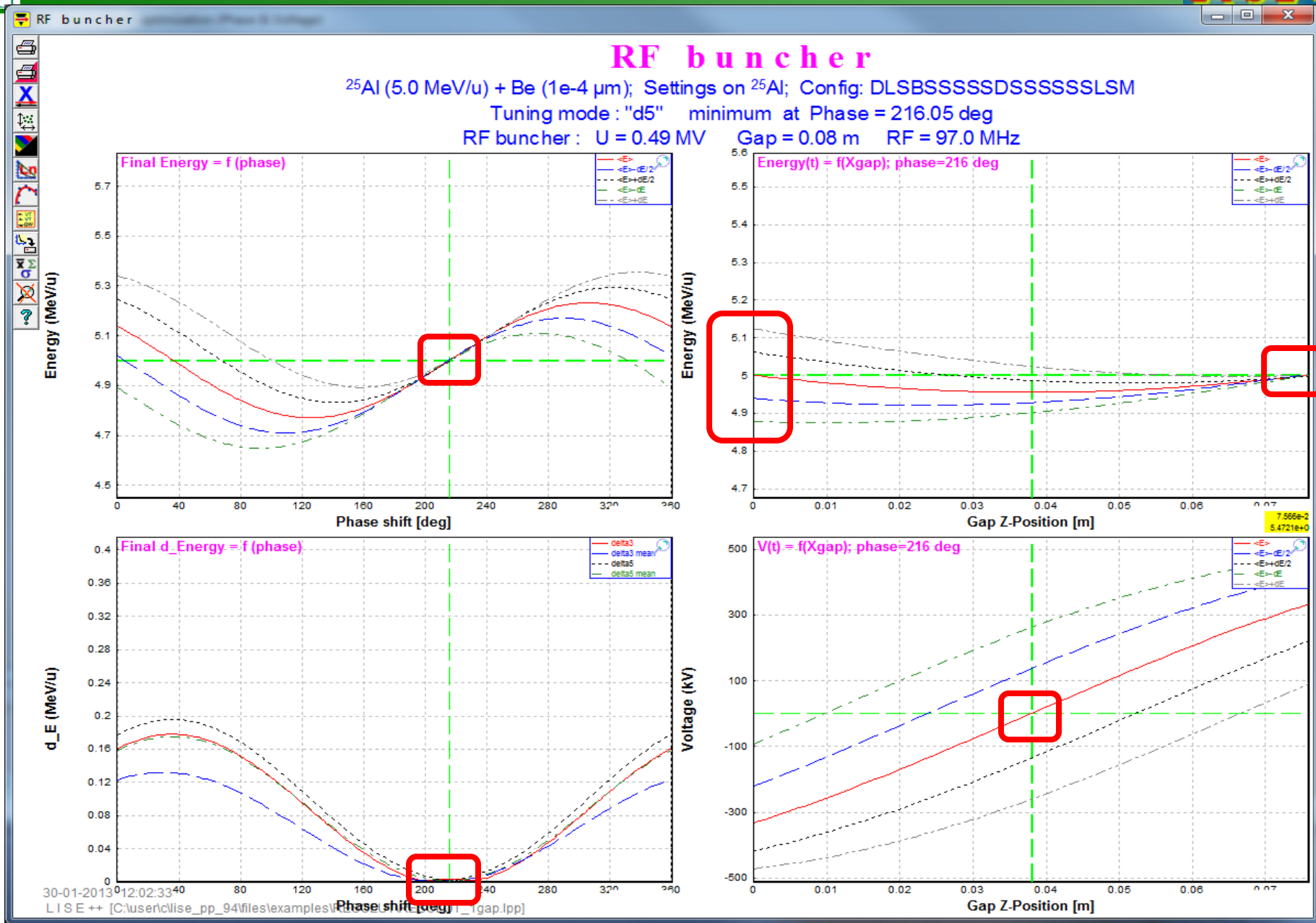
See the next slide



488 kV
216 degrees

488 kV in this mode
corresponds to
122 kV nominal value.

From FSU COSY file
V= 119.6 kV
(see page 7)



Beam

A	Element	q+
25	Al	13
Z		
Beta+ decay		
Table of Nuclides		
Z		
N		

Beam energy

Energy	5	MeV/u
TKE	124.95	MeV
Brho	0.6197	Tm
P	2.415	GeV/c
U	9.61e+3	KV

Beam intensity

	13	enA
	1	pnA

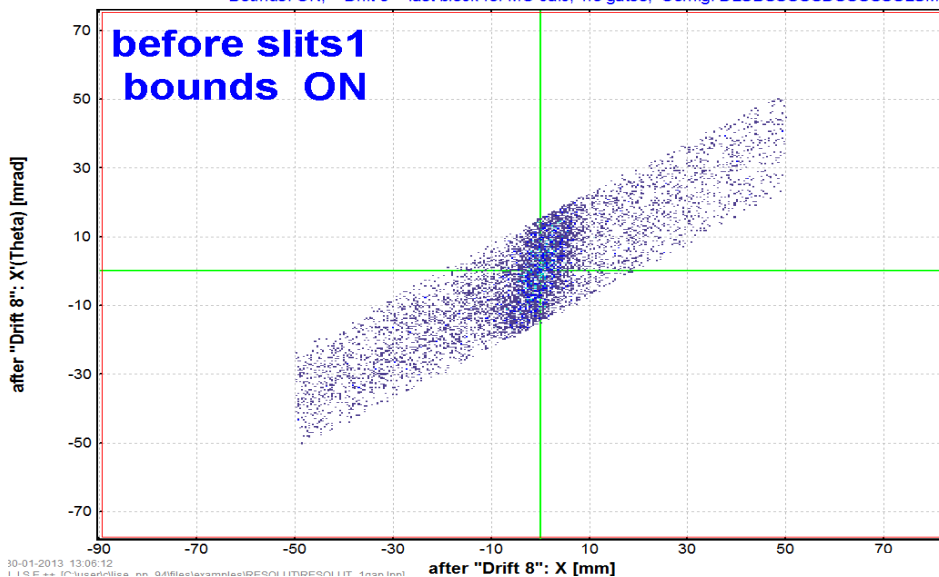
Emitance

Beam CARD (sigma, semi-axis, half-width...)	1D - shape (Distribution method)	2D mode
1. X mm	1.5 Gaussian	<input type="checkbox"/>
2. T mrad	20 Gaussian	<input type="checkbox"/>
3. Y mm	1.5 Gaussian	<input type="checkbox"/>
4. P mrad	20 Gaussian	<input type="checkbox"/>
5. L mm	0 Gaussian	<input type="checkbox"/>
6. D %	50 Rectangle uniform	<input type="checkbox"/>

²⁵Al : Monte Carlo Transmission Plot

²⁵Al (5.0 MeV/u) + Be (1e-4 μm); Transmitted Fragment ²⁵Al (beam); Optics Order: 1
dp/p=17.35%; Brho(Tm): 0.6197, 0.6197

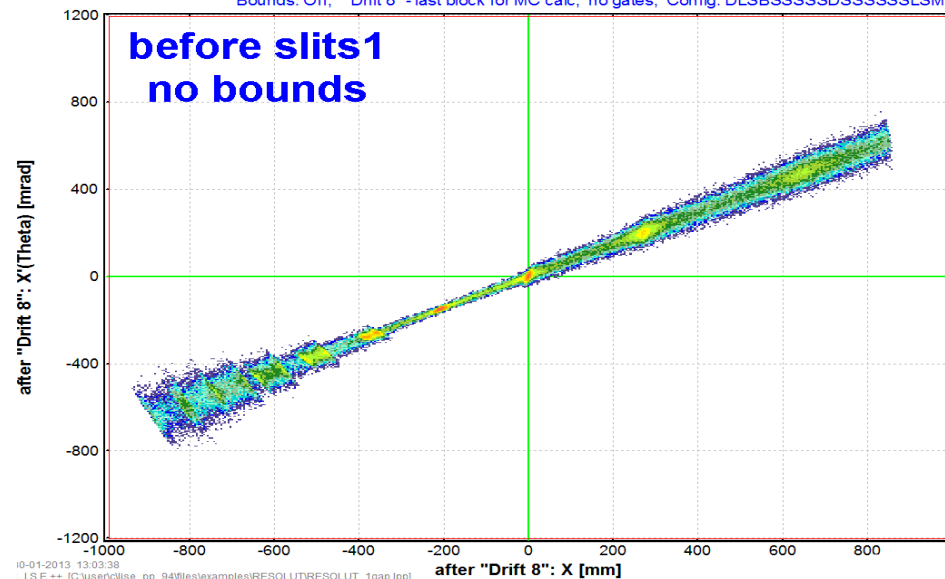
Bounds: ON; "Drift 8" - last block for MC calc; no gates; Config: DLSBSSSSSDSSSSSLSM



²⁵Al : Monte Carlo Transmission Plot

²⁵Al (5.0 MeV/u) + Be (1e-4 μm); Transmitted Fragment ²⁵Al (beam); Optics Order: 2
dp/p=17.35%; Brho(Tm): 0.6197, 0.6197

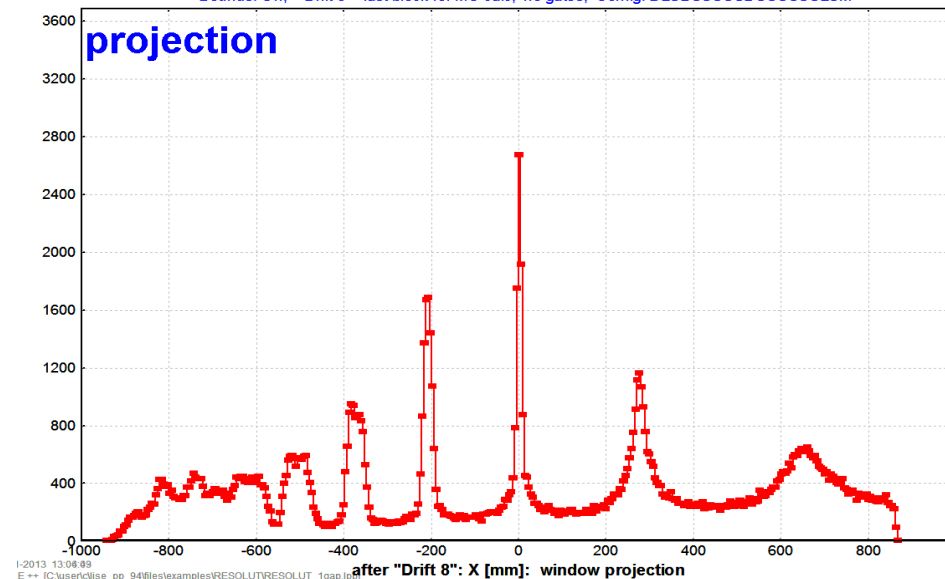
Bounds: Off; "Drift 8" - last block for MC calc; no gates; Config: DLSBSSSSSDSSSSSLSM



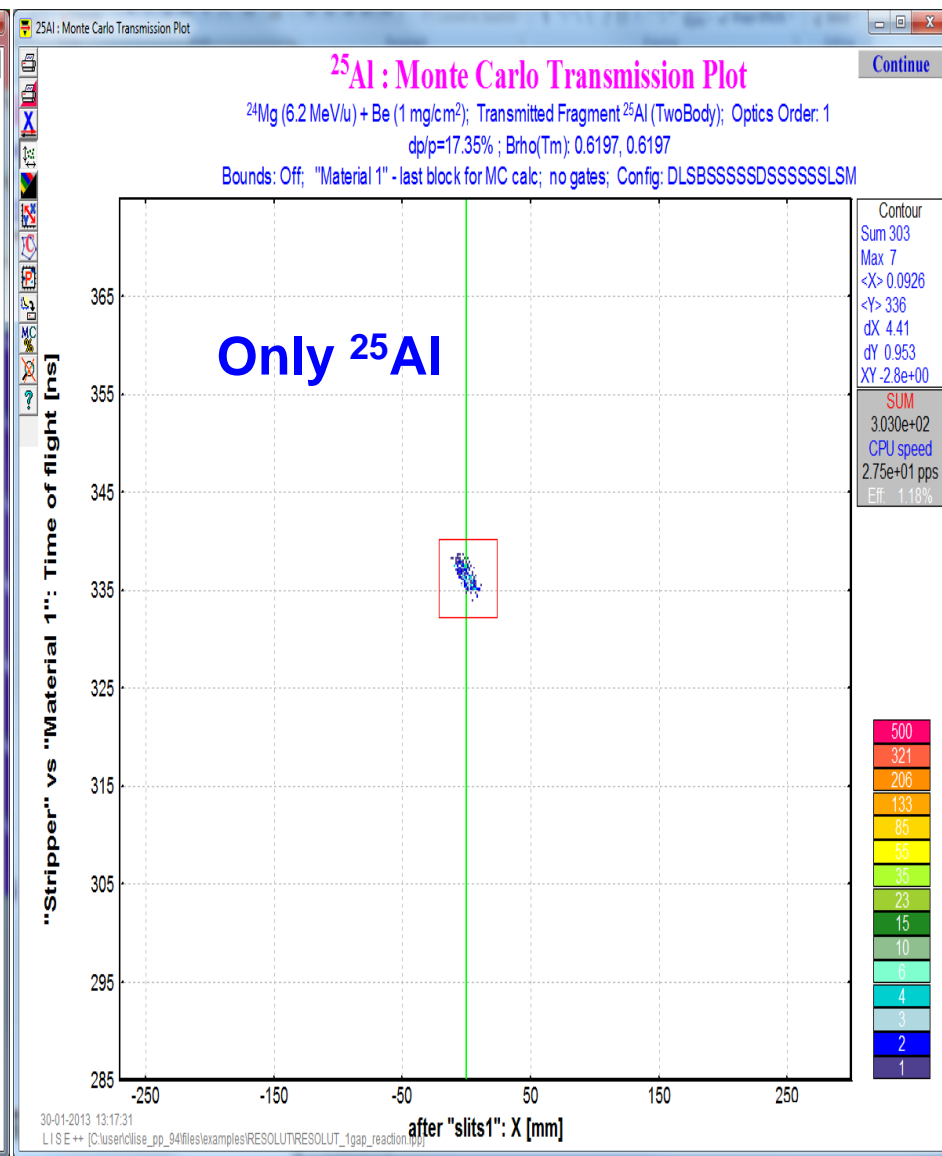
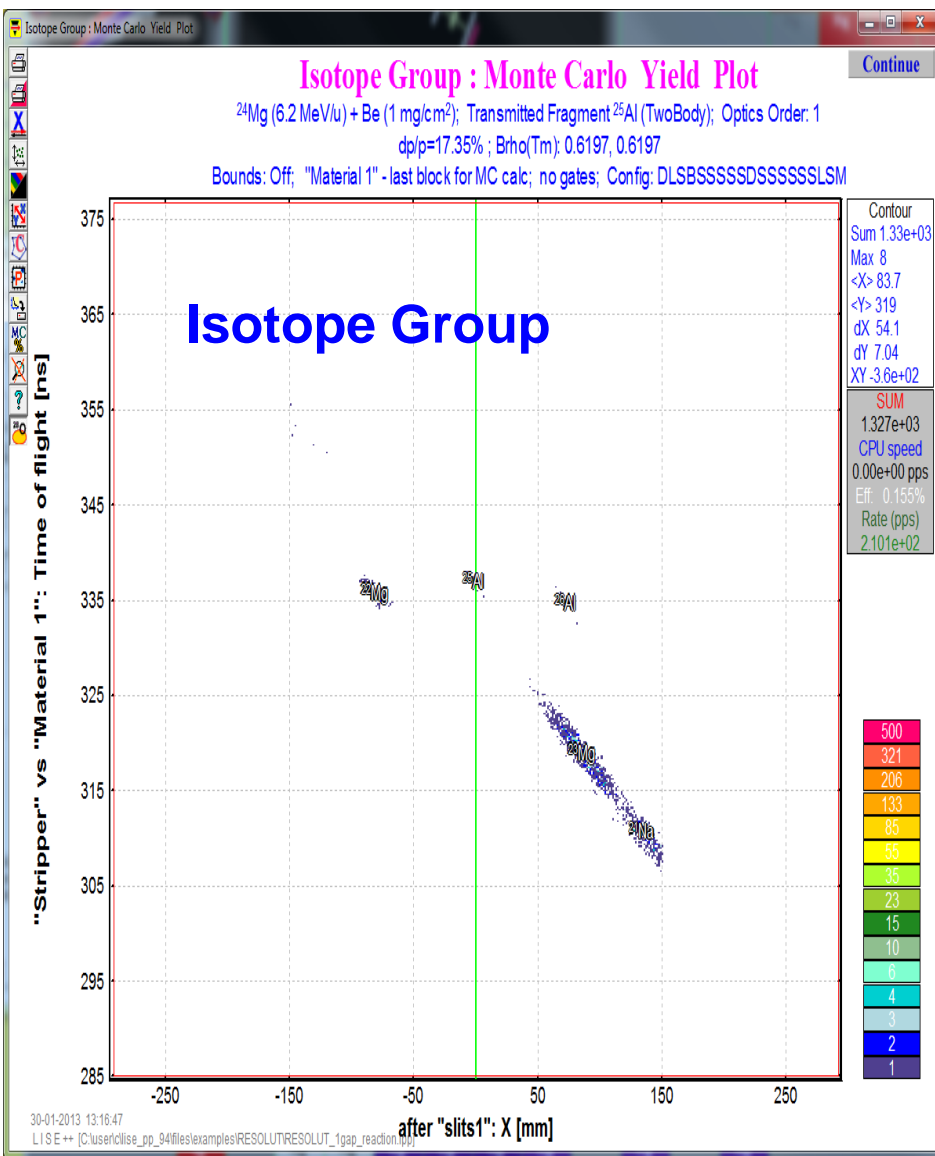
²⁵Al : Monte Carlo Transmission Plot

after "Drift 8": X [mm]; window projection — ²⁵Al (5.0 MeV/u) + Be (1e-4 μm); Transmitted Fragment ²⁵Al (beam); Optics Order: 2
dp/p=17.35%; Brho(Tm): 0.6197, 0.6197

Bounds: Off; "Drift 8" - last block for MC calc; no gates; Config: DLSBSSSSSDSSSSSLSM



After the Slits1 with angular acceptance, Bounds OFF



Transmission values are identical in RESOLUT_1gap & RESOLUT 3_gap

- ❑ The RESOLUT separator configurations can be used in Monte Carlo mode to simulate experiments, fragment transmission and separation
- ❑ Analytical solutions for optimization of RF-buncher in RESOLUT separator configuration (1 gap solution) can be used to tune Three-gap RF buncher (Bias, Phase)
- ❑ It is recommended in the case of fragment velocity $\beta \sim 0.1$ to use the Separator configuration with 1-gap solution in order to have optimization tools working properly
- ❑ 1 gap RF-buncher “Distribution” solution will be done soon (now it is acting as a drift block for transmission calculations)
- ❑ MC solution for the RF-buncher should be checked for large angles
- ❑ ? Consider creation of blocks “2gap RF-buncher” and “3gap RF-buncher” by analogy with COSY
- ❑ ? Consider implementation of $V = V_0 \cdot f(R, Z)$ in MC calculations
- ❑ Apertures, acceptances should be checked

FSU's request (Prof.I.Wiedenhoever)

Information from Prof.I.Wiedenhoever and discussions with Dr.M.Portillo and Prof.G.Rogachev are very appreciated.

configurations:

config/other/RESOLUT_1gap.lcn
config/other/RESOLUT_3gap.lcn

example files:

examples/RESOLUT/RESOLUT_1gap.lpp
examples/RESOLUT/RESOLUT_1gap_reaction.lpp
examples/RESOLUT/RESOLUT_3gap.lpp
examples/RESOLUT/RESOLUT_3gap_reaction.lpp

This file http://lise.nsci.msu.edu/9_4/buncher/9_4_87_buncher.pdf

- configurations revision

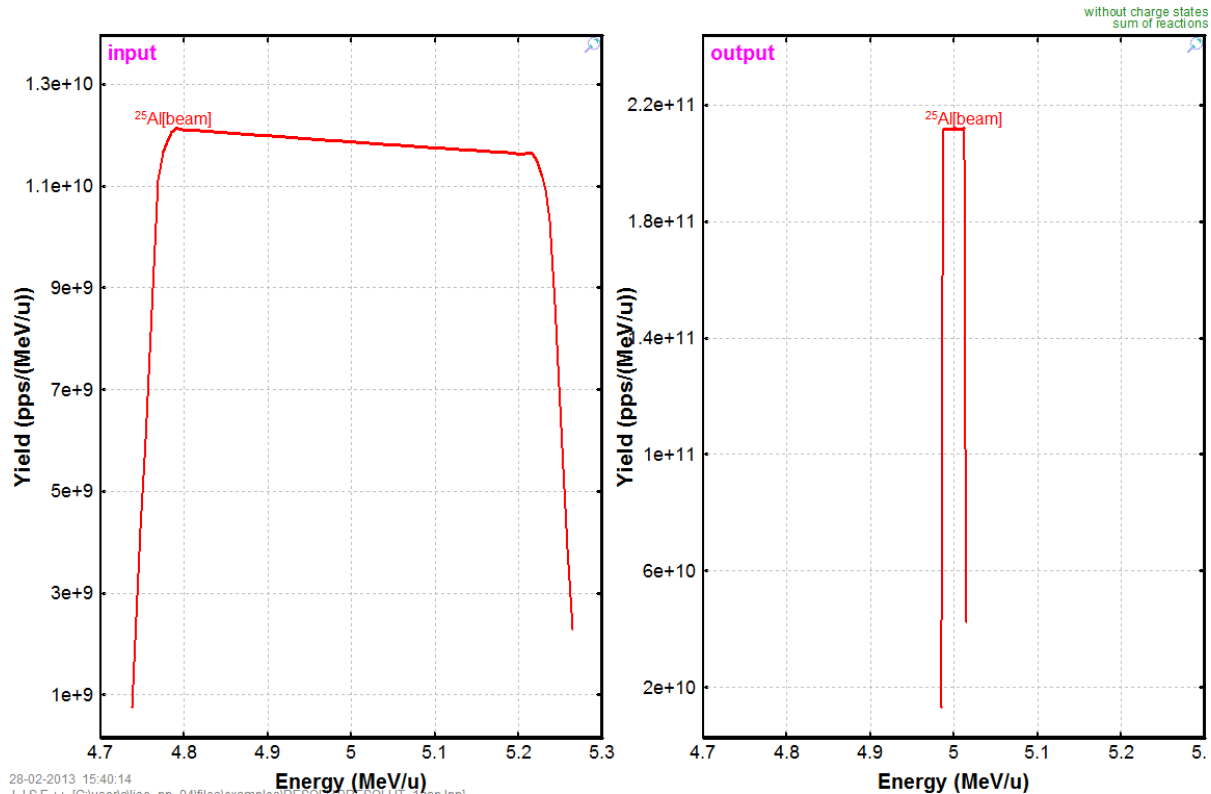
Do not use angular acceptance for a Solenoid block!

Angular acceptances +/-47 mrad moved to the “tuning dipole” block

- RF-buncher transmission analytical calculations

RFbuncher-Energy

²⁵Al (5.0 MeV/u) + Be (1e-4 μm); Settings on ²⁵Al; Config: DLBSSSSSSSSSSLSM
dp/p=7.33% ; Brho(Tm): 0.6329, 0.6329



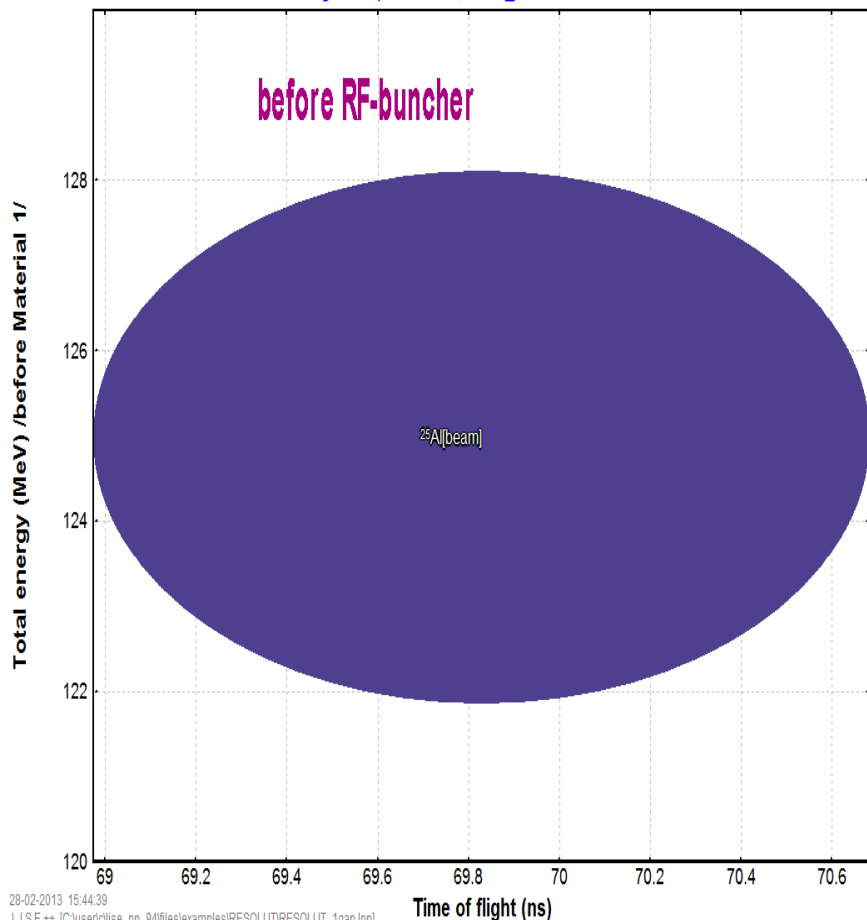
28-02-2013 15:40:14

• Graph_goodies (ellipse plot)

TKE-TOF

²⁵Al (5.0 MeV/u) + Be (1e-4 μm); Settings on ²⁵Al; Config: DLBMSSSSSDSSSSSSLSM
 dp/p=7.33% ; Brho(TM): 0.6329, 0.6329
 Start: Target; Stop: Material 1; ACQ_start: Detector ** 1st TKE detector: Material 1

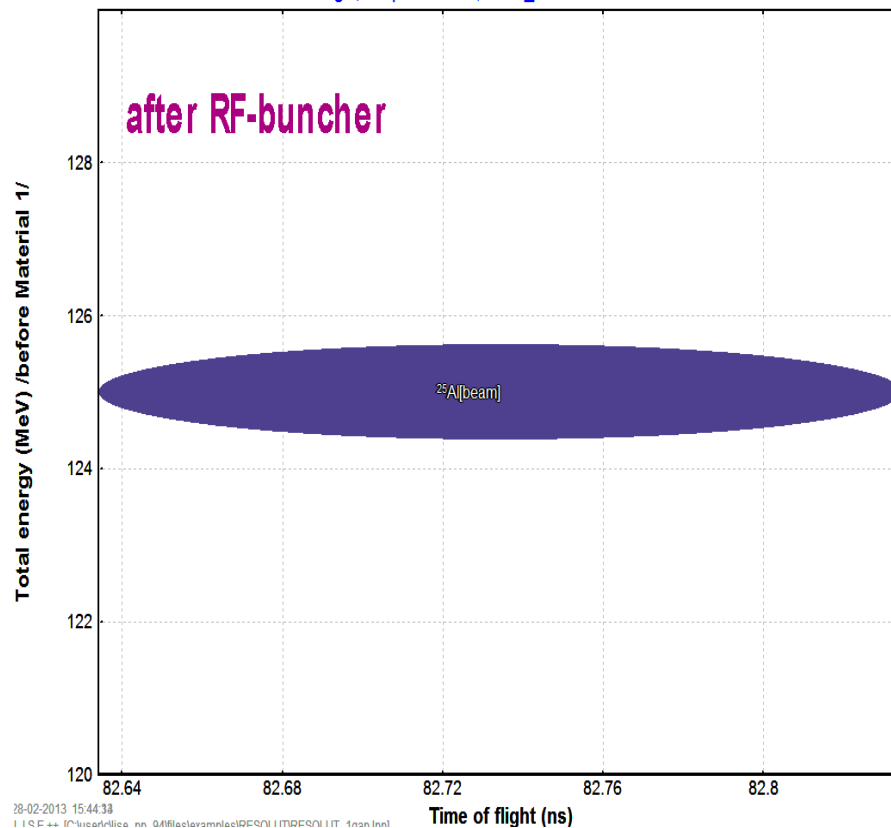
before RF-buncher



TKE-TOF

²⁵Al (5.0 MeV/u) + Be (1e-4 μm); Settings on ²⁵Al; Config: DLBMSSSSSDSSSSSSLSM
 dp/p=7.33% ; Brho(TM): 0.6329, 0.6329
 Start: Target; Stop: Material 1; ACQ_start: Detector ** 1st TKE detector: Material 1

after RF-buncher



Pseudo Monte Carlo plot is under construction

- **develop the Timing component for the Distribution4 class**