

version 8.3.59

Requests of
D.J.Morrissey (NSCL),
G.Chubarian & © (TAMU)

Spectrometer designing

Block	Given Name	Z-Q	Length,m	Enable
S	Drift		0	+
S	Drift		5	+
M	Material			+
D	Dipole	0	12	+
W	Wedge			+
L	Solenoid		1.95	+
S	Drift		0	NO
M	Material			NO
G	GasFS	0	0	NO
S	Drift		0	NO
M	Material			NO
M	Material			+
M	Material			+

Selected block:
 Enable Dispersive (Dipole)
 Let call automatically Block Length [m] 8.719
 Block name = D1 Length after this block [m] 8.719
 Charge State (Z-Q) = 0 Total Length [m] 54.434

Insert Mode:
 before
 after

Move element:

Insert block:

Buttons:

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://www.nslc.msu.edu/lise>

version 7.6.56 (03-MAR-2006)

http://groups.nslc.msu.edu/lise/paper/2006_june_utilities.pdf

TwinSol

TwinSol settings

- Use the second solenoid
 - TwinSol operation mode: Antiparallel Parallel
- Use the absorber
- Use the dispersive block
- Use the "soft-edge" corrections for solenoid matrix calculations

1-st solenoid block

1-st solenoid block settings

Optical Matrix for setting fragment

Block Length = 5.703 m
B = 4.2 T

2-nd solenoid block

2-nd solenoid block settings

Optical Matrix for setting fragment

Block Length = 2.977 m
B = 2.4599 T

Absorber

Absorber settings

Distance from target to absorber = 2.1 m
Charge state after absorber (Z_A) = 0

Utility

current file: twinsol_init

Save file as

Load file

Save for multidisplay

Delete scratch file

Plot options. Show:

- Transport: Beam Sigmas
- Transport: Ray Values
- Ray Trace
- Scratch file data

Selected plot: 1.X

Calculate

Plot

Save & Exit

Quit

Initial Beam

Projectile

	Beam emittance	Initial ray values	
1.X	1	5	mm
2.T	20	20	mrاد
3.Y	1	-5	mm
4.F	20	25	mrاد
1&3.R	1.41	7.07	mm
2&4.A	28.28	32.02	mrاد

40Ar18+ (40.00 MeV/u)
P tnsprt 0.6125 GeV/c

Beam tracking

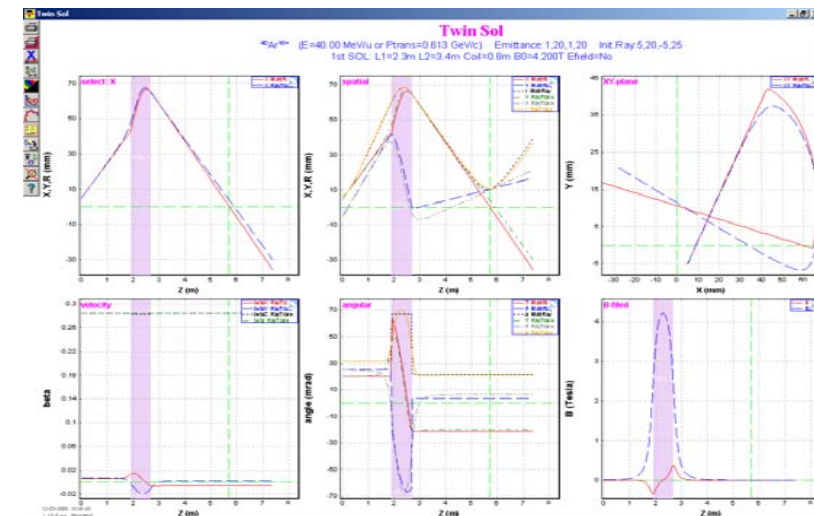
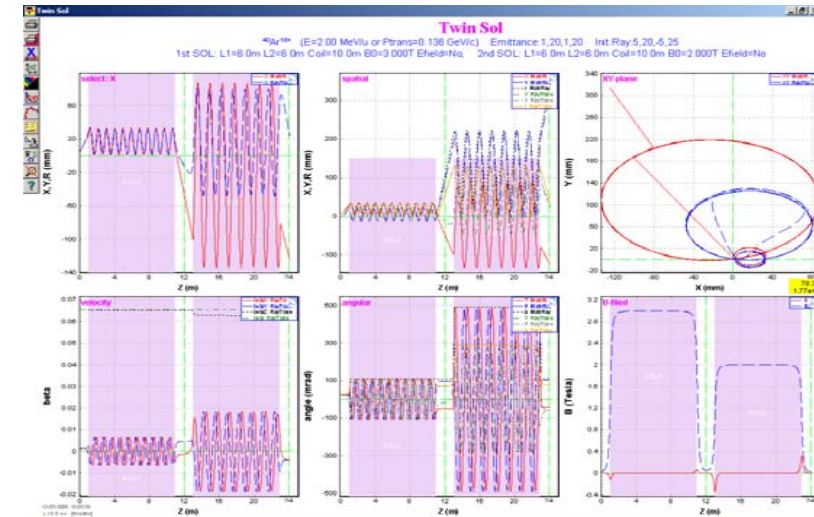
Distance to plot rays = 7.4 m

"Transport" (matrix solution)

	Beam sigmas	Ray Values	Ray TRACE
1.X	23.23	-35.91	-30.06
2.T	13.56	-21.39	-19.88
3.Y	23.23	16.9	21.5
4.F	13.56	3.8	6.74
1&3.R	32.85	39.68	36.96
2&4.A	19.18	21.72	20.99

Energy (MeV/u) = 40
Time of flight (ns) = 87.36

Under construction (2nd stage)



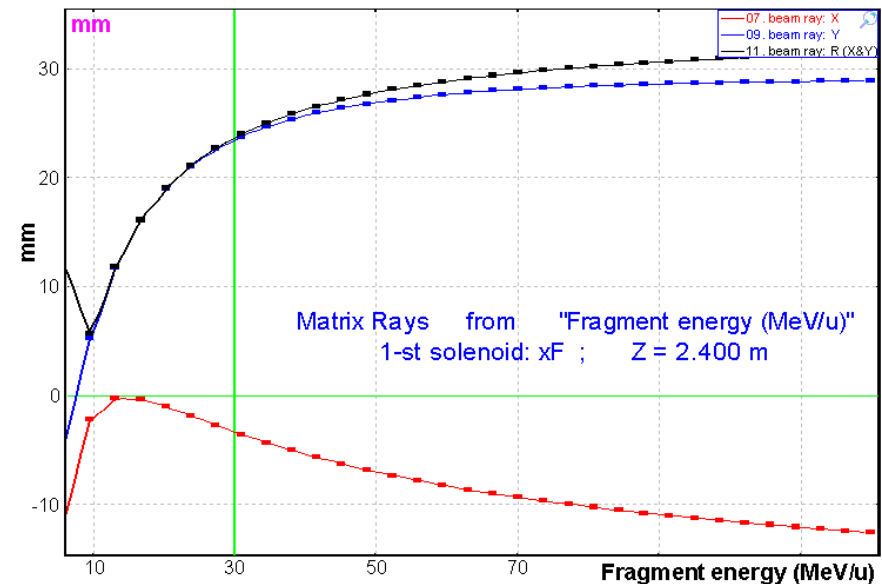
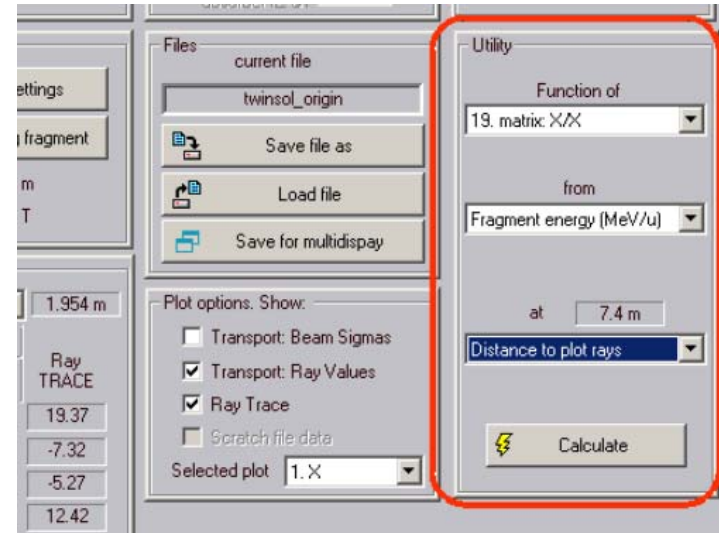
05/30/08 version 8.3.45

http://groups.nslc.msu.edu/lise/8_3/TwinsolUtility_v8_3_45.pdf

- Function of
- 19. matrix: X/X
 - 01. beam sigma: X
 - 02. beam sigma: T (X')
 - 03. beam sigma: Y
 - 04. beam sigma: P (Y')
 - 05. beam sigma: R (X&Y)
 - 06. beam sigma: A (P&T)
 - 07. beam ray: X
 - 08. beam ray: T (X')
 - 09. beam ray: Y
 - 10. beam ray: P (Y')
 - 11. beam ray: R (X&Y)
 - 12. beam ray: A (P&T)
 - 13. ray trace: X
 - 14. ray trace: T (X')
 - 15. ray trace: Y
 - 16. ray trace: P (Y')
 - 17. ray trace: R (X&Y)
 - 18. ray trace: A (P&T)
 - 19. matrix: X/X
 - 20. matrix: X/T
 - 21. matrix: X/Y
 - 22. matrix: X/P
 - 23. matrix: T/X
 - 24. matrix: T/T
 - 25. matrix: T/Y
 - 26. matrix: T/P
 - 27. matrix: Y/X
 - 28. matrix: Y/T
 - 29. matrix: Y/Y
 - 30. matrix: Y/P
 - 31. matrix: P/X
 - 32. matrix: P/T
 - 33. matrix: P/Y
 - 34. matrix: P/P
 - 35. Field: BH
 - 36. Field: BZ

- from
- 1-st solenoid: B_field Max
 - 1-st solenoid: B_field Max
 - 1-st solenoid: I (Current)
 - 1-st solenoid: Coil Length
 - 1-st solenoid: Effective Radius
 - 1-st solenoid: 1-st half
 - 1-st solenoid: 2-nd half
 - 2-nd solenoid: B_field Max
 - 2-nd solenoid: I (Current)
 - 2-nd solenoid: Coil Length
 - 2-nd solenoid: Effective Radius
 - 2-nd solenoid: 1-st half
 - 2-nd solenoid: 2-nd half
 - 3-nd solenoid: B_field Max
 - 3-nd solenoid: I (Current)
 - 3-nd solenoid: Coil Length
 - 3-nd solenoid: Effective Radius
 - 3-nd solenoid: 1-st half
 - 3-nd solenoid: 2-nd half
 - Fragment energy (MeV/u)

- at 1.877 m
- 2-nd solenoid: x0
 - 1-st solenoid: xU
 - 1-st solenoid: x1L
 - 1-st solenoid: x1R
 - 1-st solenoid: xC
 - 1-st solenoid: x2L
 - 1-st solenoid: x2R
 - 1-st solenoid: xF
 - 2-nd solenoid: x0
 - 2-nd solenoid: x1L
 - 2-nd solenoid: x1R
 - 2-nd solenoid: xC
 - 2-nd solenoid: x2L
 - 2-nd solenoid: x2R
 - 2-nd solenoid: xF
 - 3-nd solenoid: xU
 - 3-nd solenoid: x1L
 - 3-nd solenoid: x1R
 - 3-nd solenoid: xC
 - 3-nd solenoid: x2L
 - 3-nd solenoid: x2R
 - 3-nd solenoid: xF
 - Distance to plot rays



http://people.web.psi.ch/rohrer_u/trantext.htm#Solen

Urs C. Rohrer, PSI (SIN), CH-5232 Villigen-PSI, Switzerland

SOLENOID: Type code 19.0

Inside the solenoid, particles possessing a transverse velocity will describe an orbit which is helical in space. In order to study these movements, the beam centroid may be shifted and traced through the solenoid.

For $B * L > Brho$, the solenoid has to be divided into a sufficient amount of smaller elements in order to get an accurate image of the particle rays. But the R-matrix used in transport includes the fringe field effects at the entrance and exit of the solenoid.

First-order matrices for the solenoid:

1) Entrance face :

$$Ri = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & K & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ -K & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

$$2 * K = B / Brho$$

2) Exit face :

$$Ro = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & -K & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ K & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

3) Homogeneous field:

$$Rh = \begin{pmatrix} 1 & S*C/K & 0 & S*S/K & 0 & 0 \\ 0 & 2*C*C-1 & 0 & 2*S*C & 0 & 0 \\ 0 & -S*S/K & 1 & S*C/K & 0 & 0 \\ 0 & -2*S*C & 0 & 2*C*C-1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

$$C = \cos(K*L)$$

$$S = \sin(K*L)$$

'soft-edge' solenoid – edge effect

Alex Bogacz, Workshop on Muon Collider Simulations,
Miami Beach, FL December 15, 2004

$$M_{\text{soft sol}} = M_{\text{edge}} M_{\text{sol}} M_{\text{edge}}$$

$$M_{\text{edge}} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ -\Phi_{\text{edge}} & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & -\Phi_{\text{edge}} & 1 \end{bmatrix}$$

$$\Phi_{\text{edge}} = \frac{1}{2} \left(\int_{-\infty}^{\infty} B_z^2(s) ds - B_0^2 L \right) = -\frac{k^2 a}{8}$$

$$k = eB_0/pc$$

Solenoid settings

B, max field T

I, current A

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

V (L * B / PI) = Tm

V / Brho =

Field Direction

"+" positive

"-" negative

Solenoid Block Scheme

TwinSol Utility

Optical block properties and data

Setting Charge state for the Block (Z-Q)

Cut(Slits) & Acceptances

Optical matrix

General setting of block

Tweak %

Block Tuning

Tune Solenoid using the Setting fragment

Take into account the GLOBAL matrix of the previous block

Tuning is minimisation of

Plot v=f(B)

Geometry

1-st half = m

2-nd half = m

Coil length = m

Effective radius = m

Block Length = m

optional (estimation of Ang.Accept.)

Solenoid length = m

Bore = m

Ang.Accept. ± mrad

MA = MAconst * I

MAconst = T/A MA = T

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

Setting fragment parameters

	Mean	StDev	Method
1. X	0.00	29.00	"Distribution"
2. T	0.00	41.42	
3. Y	0.00	29.00	
4. F	0.00	41.42	
5. E	1.4	0.1	

Setting fragment distribution parameters before Solenoid

OK Cancel Help

LISE++ attention!!

Memo: The Solenoid block is effective for the Monte Carlo transmission mode

OK

Calculation of setting fragment parameters in front of the solenoid and solenoid tuning are done by the "Distribution" method.

Phase space distributions and transmission with the Solenoid block are recommended with the Monte Carlo transmission method.

Setting fragment parameters in front of Solenoid

Emittance **Beam**

Beam CARD (sigma)

1. X	1	mm	d X	0	mm
2. T	20	mrاد	d T	20	mrاد
3. Y	1	mm	d Y	0	mm
4. P	20	mrاد	d P	20	mrاد
5. L	0	mm	d T	1.15	degrees
6. D	0.07	%	d P	1.15	degrees

beam respect to spectrometer

Setting fragment parameters

	Mean	StDev
1. X	14.00	29.00
2. T	20.00	41.42
3. Y	14.00	29.00
4. F	20.00	41.42
5. E	1.4	0.1

Method

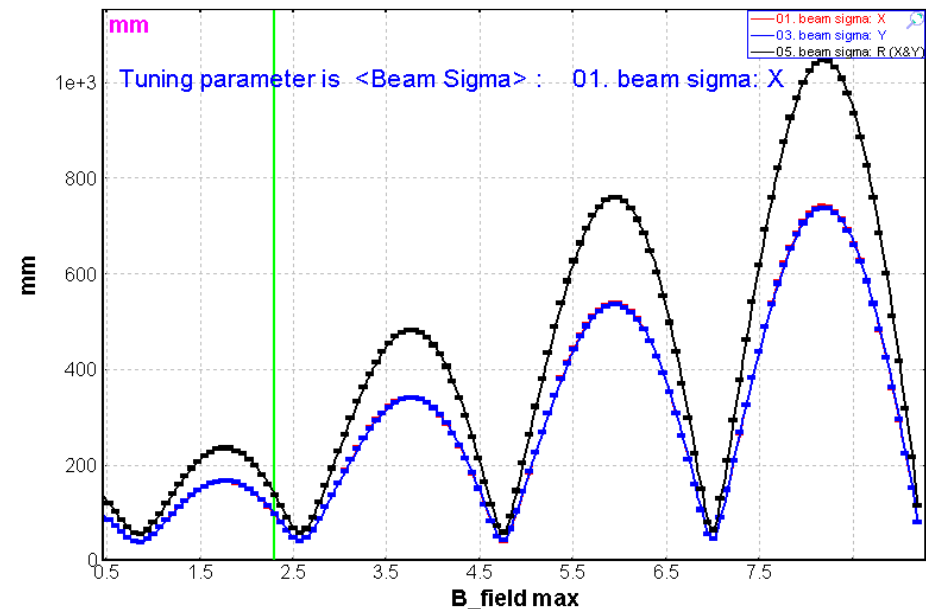
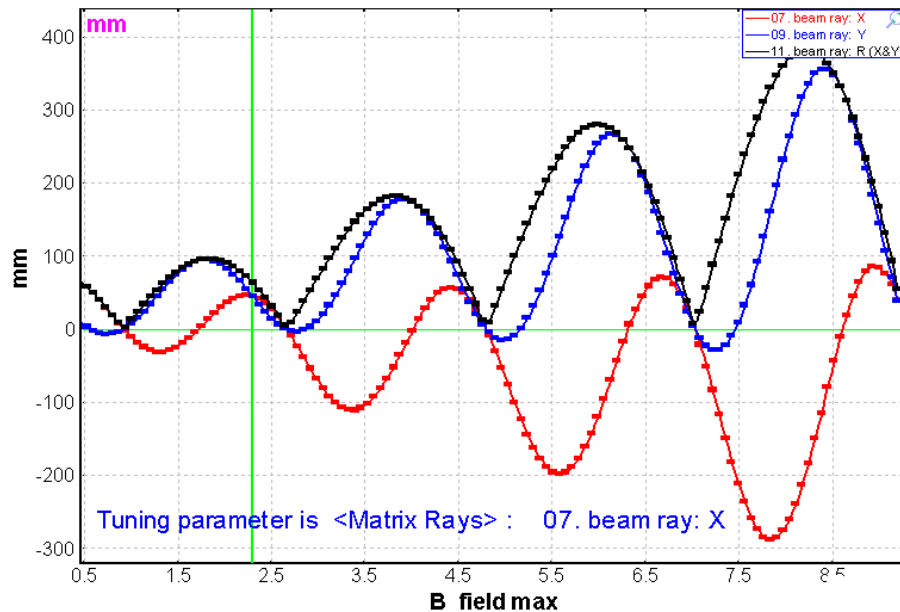
"Distribution"

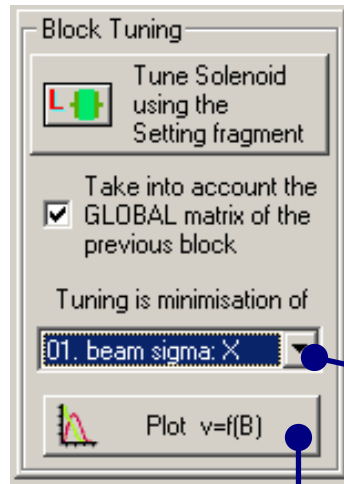
Setting fragment distribution parameters before Solenoid

- "Distribution" method is used if setting fragment transmission up to the solenoid block is more than 0%
- Otherwise "Gaussian" method (based on 5 points determining a distribution shape. Used in "Ellipse" 2D-plot, The "Goodies" dialog)

it is used for "beam ray" tuning

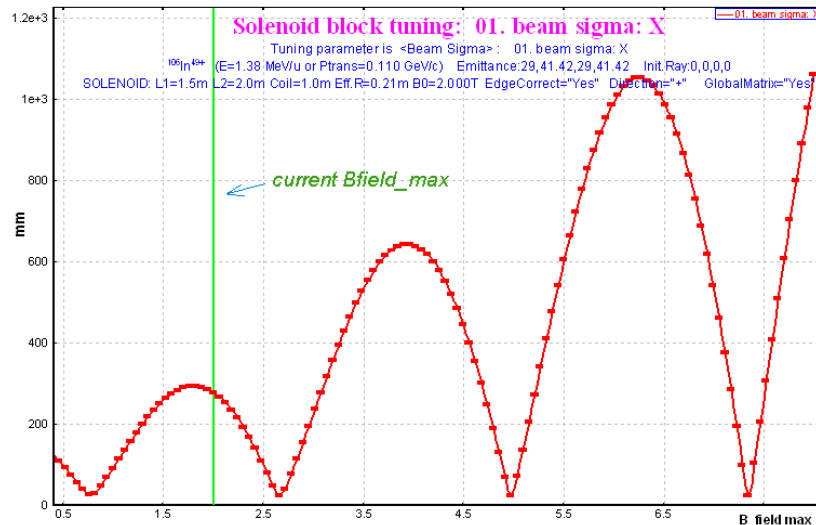
it is used for "beam sigma" tuning

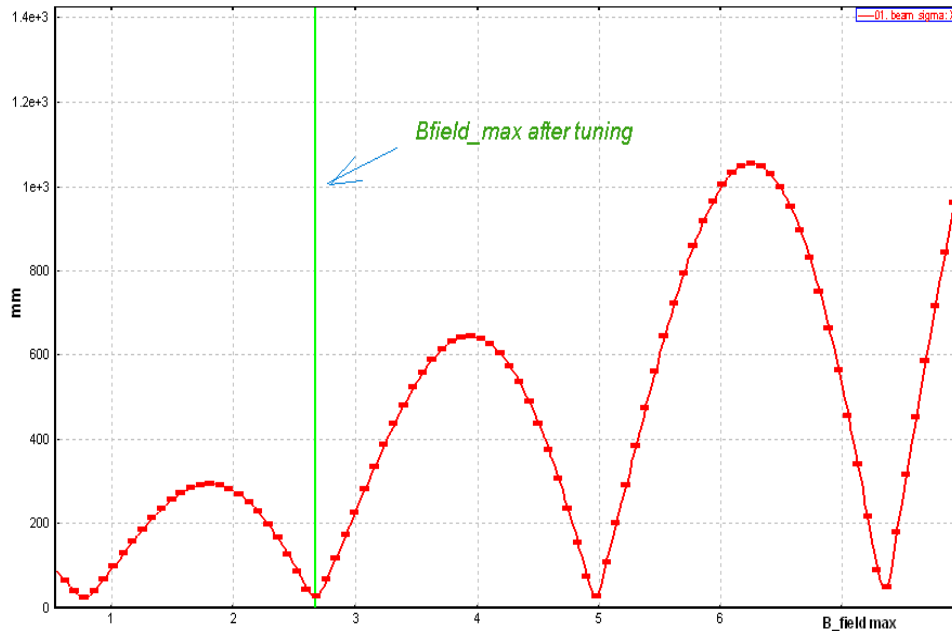
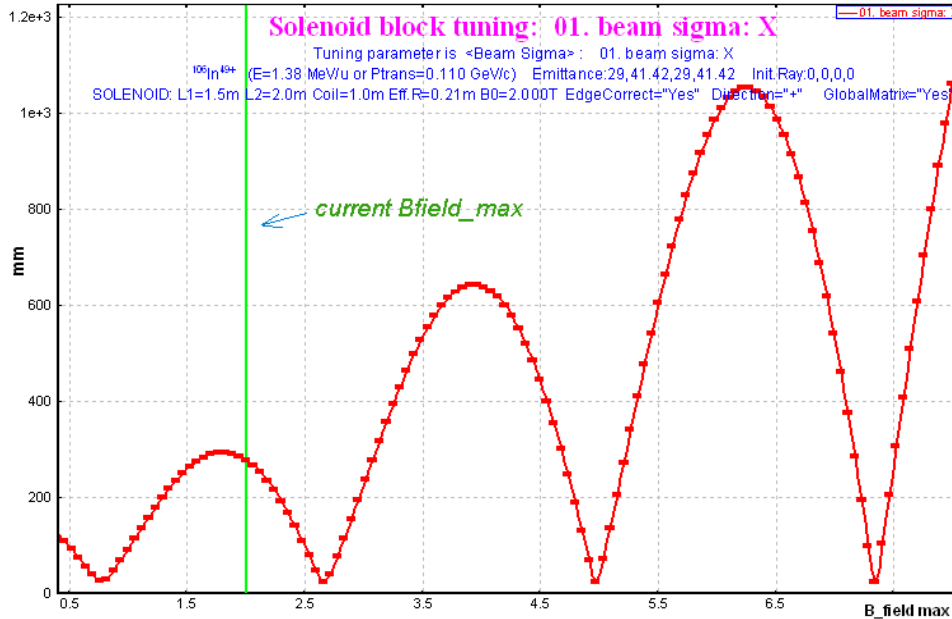




Tuning is minimisation of

- 01. beam sigma: X
- 02. beam sigma: T (X')
- 03. beam sigma: Y
- 04. beam sigma: P (Y')
- 05. beam sigma: R (X&Y)
- 06. beam sigma: A (P&T)
- 07. beam ray: X
- 08. beam ray: T (X')
- 09. beam ray: Y
- 10. beam ray: P (Y')
- 11. beam ray: R (X&Y)
- 12. beam ray: A (P&T)
- 13. matrix: X/X
- 14. matrix: X/T
- 15. matrix: X/Y
- 16. matrix: X/P
- 17. matrix: T/X
- 18. matrix: T/T
- 19. matrix: T/Y
- 20. matrix: T/P
- 21. matrix: Y/X
- 22. matrix: Y/T
- 23. matrix: Y/Y
- 24. matrix: Y/P
- 25. matrix: P/X
- 26. matrix: P/T
- 27. matrix: P/Y
- 28. matrix: P/P





$$B_{curr} = \max (B_{curr}, 0.1)$$

$$X_{min} = B_{curr} * 0.05$$

$$X_{max} = B_{curr} * 20$$

$$coef = \exp(\ln(X_{max}/X_{min}) / NP_Tune_Plot)$$

$$X_i = X_{min} * coef^i$$

at B_{curr}

$$i_{start} = NP_Tune_Plot / 2$$

Go to both directions
(left & right) from i_{start}

Search for 1-st minimum

```
#define NP_Tune_Plot 512
#define NP_Tune_fit 16
```


P rojectile	$^{58}\text{Ni}^{28+}$
6.04 MeV/u	1 pnA
C ompound	^{117}Ba
R esidual	$^{106}\text{In}^{49+}$
T arget	Ni 0.5 micron
St ripper	
S 1st Drift	standard 0.3654 Tm
L Solenoid	B 1.1527 T

Solenoid
 Solenoid settings
 B, max field T
 I, current A
 Use the "soft-edge" corrections for solenoid matrix calculations
 $V (L * B / \text{PI}) = 0.3669$ Tm
 $V / \text{Brho} = 1.0043$

Use Local matrix
No "soft-edge" corrections

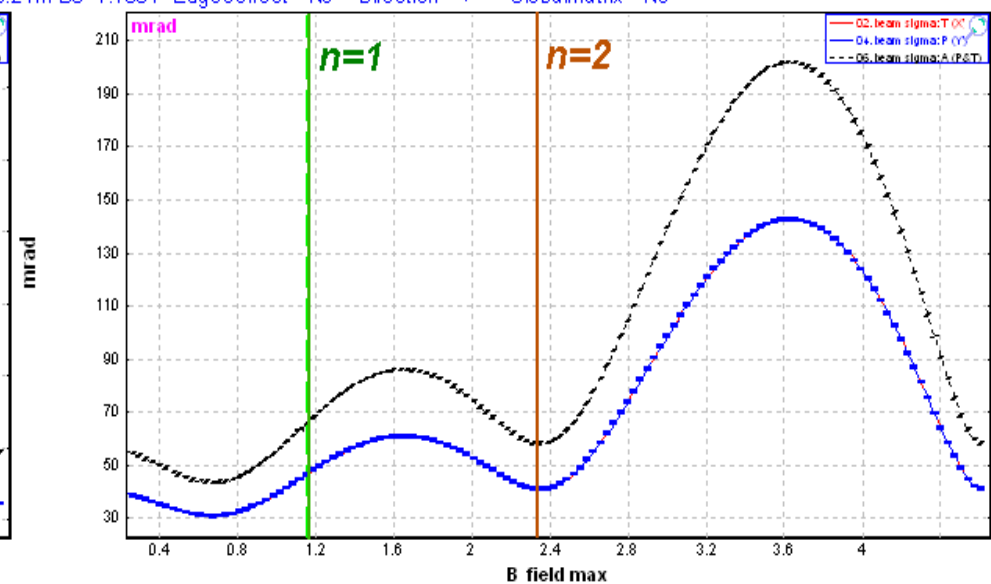
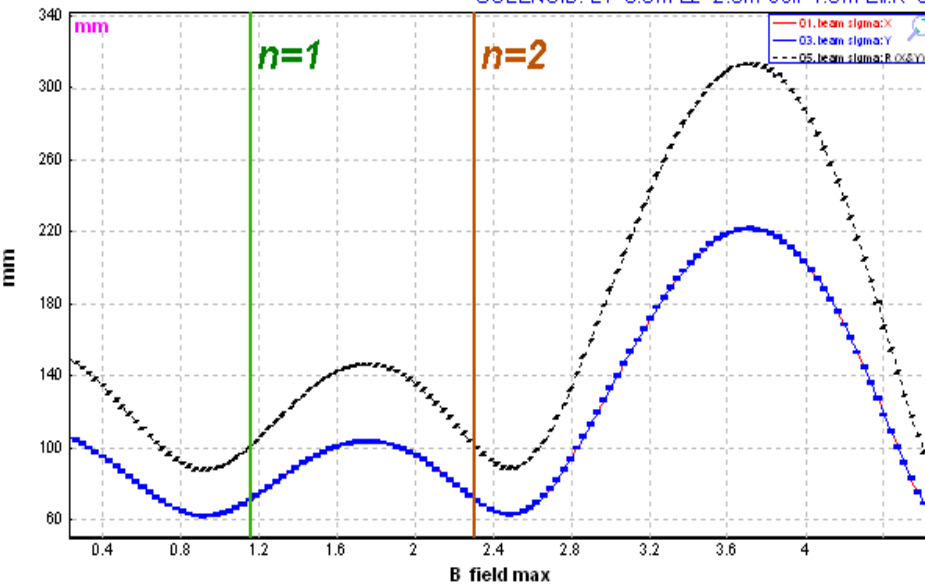
http://groups.nsl.msu.edu/lise/8_3/solenoid_test.lpp

Solenoid block tuning

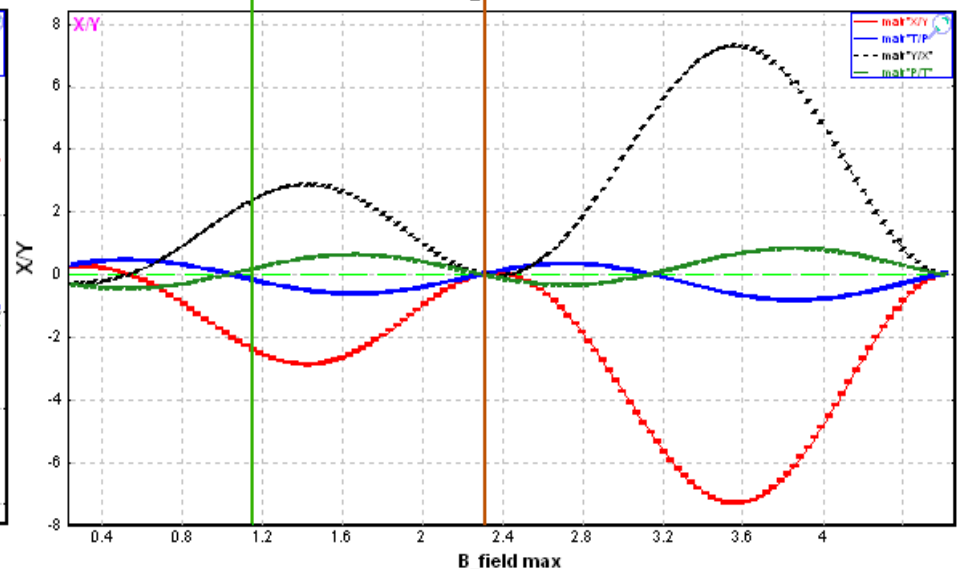
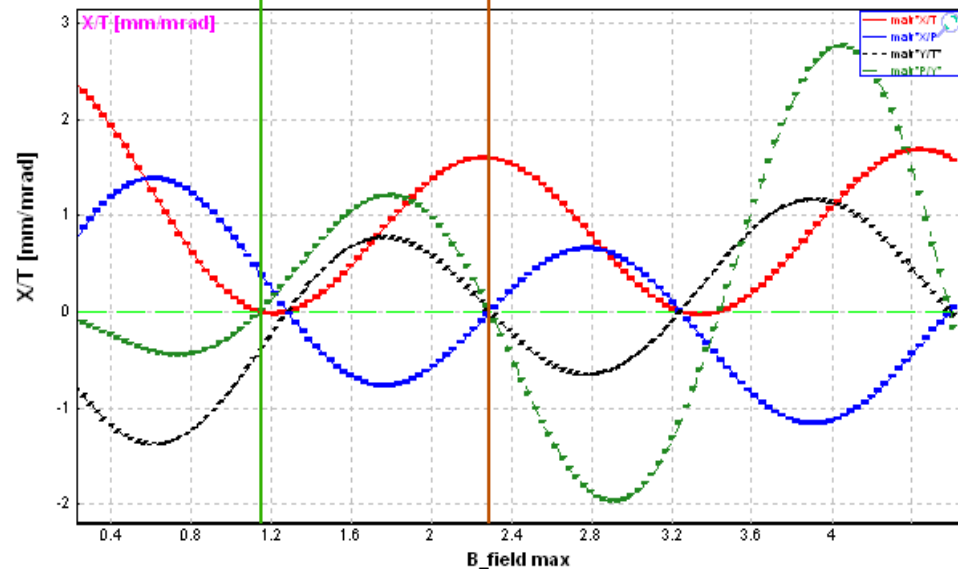
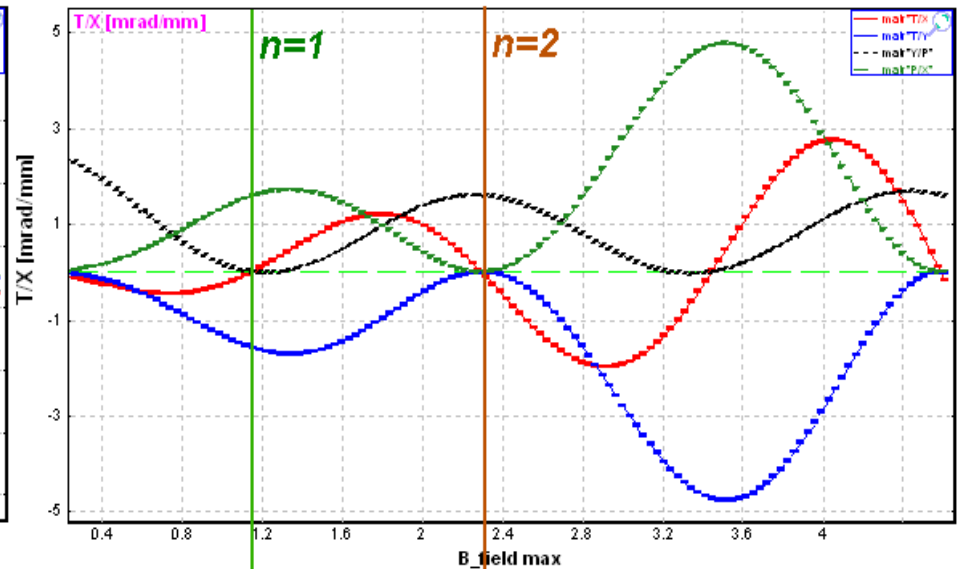
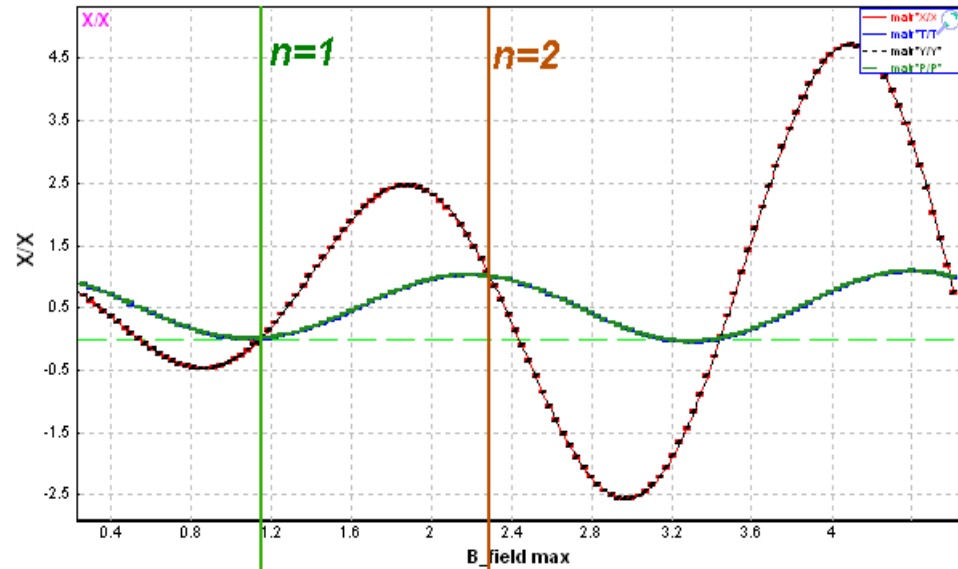
Tuning parameter is <Beam Sigma>: 01. beam sigma: X

$^{106}\text{In}^{49+}$ (E=1.38 MeV/u or Ptrans=0.110 GeV/c) Emittance:29,41,42,29,41,42 Init.Ray:0,0,0

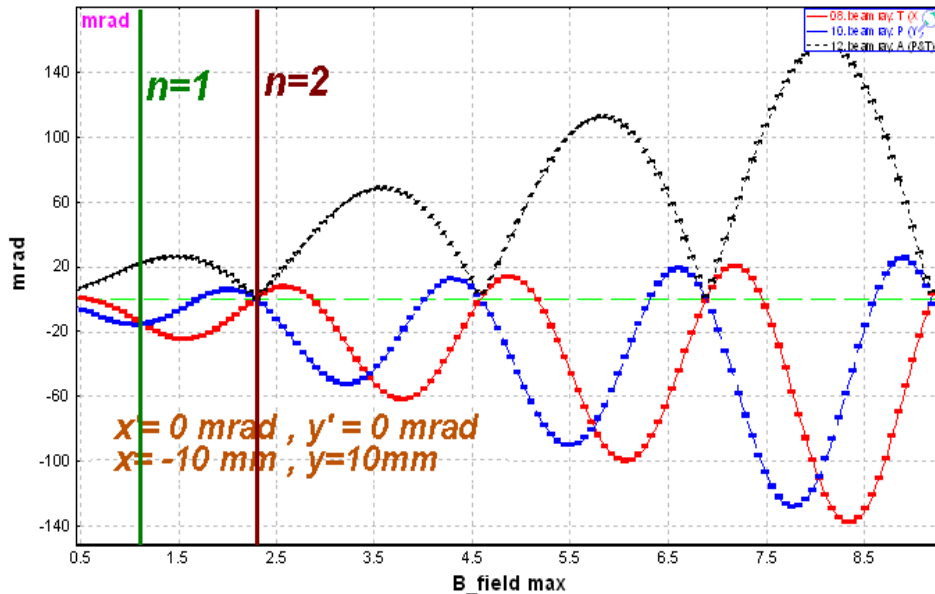
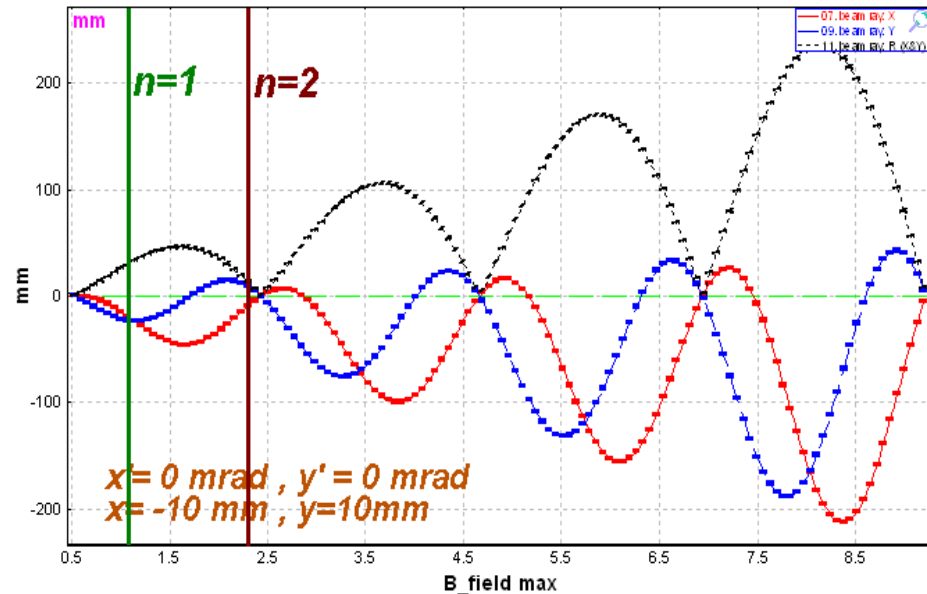
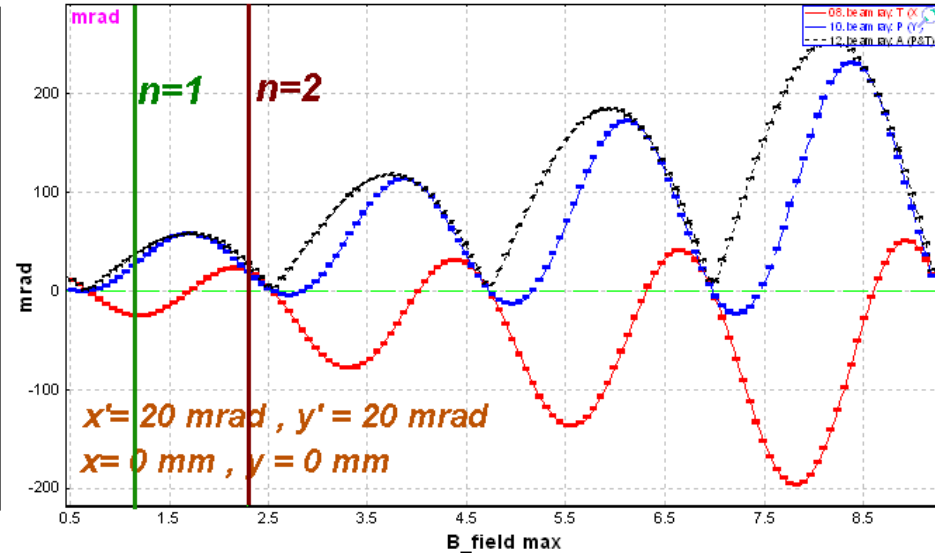
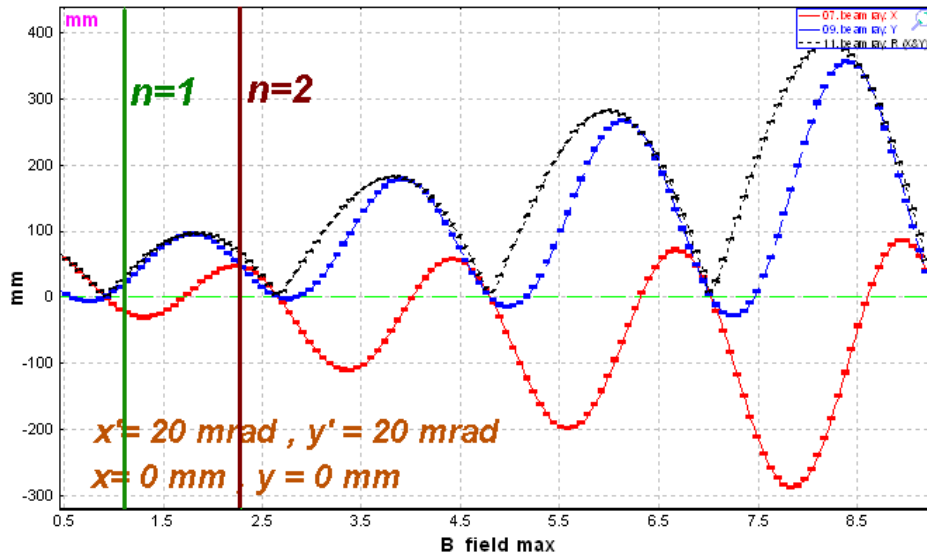
SOLENOID: L1=0.6m L2=2.0m Coil=1.0m Eff.R=0.21m B0=1.153T EdgeCorrect="No" Direction="+" GlobalMatrix="No"

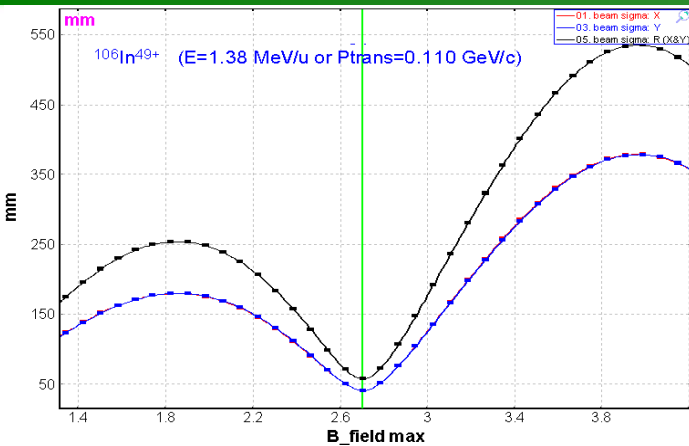


Local matrix. No "soft-edge" corrections



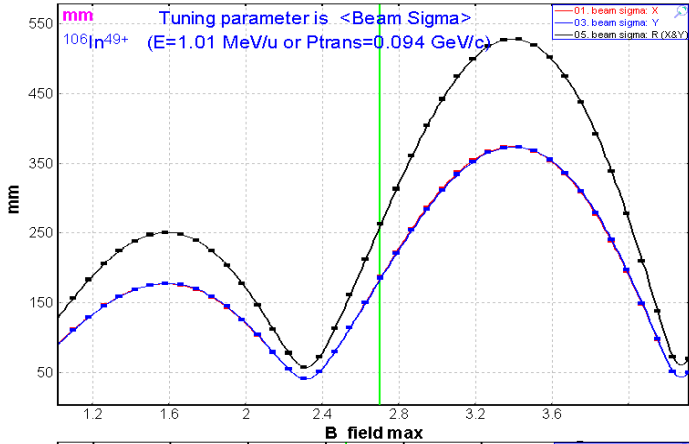
No "soft-edge" corrections





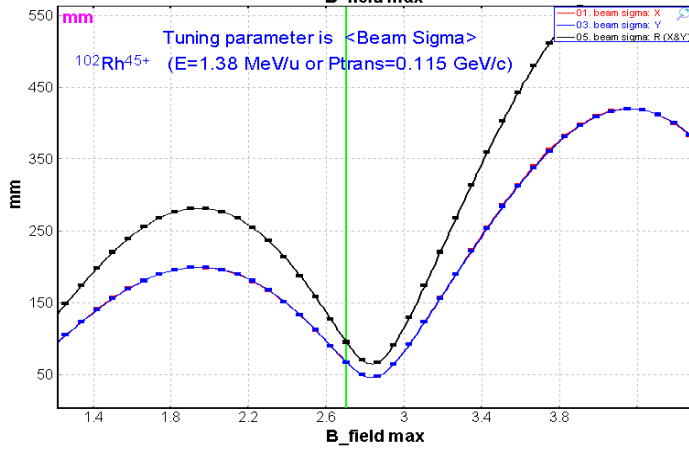
^{106}In at 1.4 MeV/u

Block matrix							Global matrix						Beam	
1. X	-0.9105	1.1786	-0.5655	0.7319	0	0	-0.9105	0.5413	-0.5655	0.3361	0	0	[mm]	12.654
2. T	-1.1175	0.6539	-0.694	0.4061	0	0	-1.1175	-0.1283	-0.694	-0.0797	0	0	[mrad]	3.292
3. Y	0.5655	-0.7319	-0.9105	1.1786	0	0	0.5655	-0.3361	-0.9105	0.5413	0	0	[mm]	12.927
4. F	0.694	-0.4061	-1.1175	0.6539	0	0	0.694	0.0797	-1.1175	-0.1283	0	0	[mrad]	3.306
5. L	0	0	0	0	1	0	0	0	0	0	1	0	[mm]	0
6. D	0	0	0	0	0	1	0	0	0	0	0	1	[%]	0.07
	/[mm]	/[mrad]	/[mm]	/[mrad]	/[mm]	/[%]	/[mm]	/[mrad]	/[mm]	/[mrad]	/[mm]	/[%]		



^{106}In at 1.0 MeV/u

Block matrix							Global matrix						Beam	
1. X	-1.8574	0.1773	-4.4777	0.4273	0	0	-1.8574	-1.1229	-4.4777	-2.7071	0	0	[mm]	59.83
2. T	-1.3632	0.0511	-3.2863	0.1231	0	0	-1.3632	-0.9031	-3.2863	-2.1773	0	0	[mrad]	48.098
3. Y	4.4777	-0.4273	-1.8574	0.1773	0	0	4.4777	2.7071	-1.8574	-1.1229	0	0	[mm]	57.823
4. F	3.2863	-0.1231	-1.3632	0.0511	0	0	3.2863	2.1773	-1.3632	-0.9031	0	0	[mrad]	46.476
5. L	0	0	0	0	1	0	0	0	0	0	1	0	[mm]	0
6. D	0	0	0	0	0	1	0	0	0	0	0	1	[%]	0.07
	/[mm]	/[mrad]	/[mm]	/[mrad]	/[mm]	/[%]	/[mm]	/[mrad]	/[mm]	/[mrad]	/[mm]	/[%]		



^{102}Rh at 1.4 MeV/u

Block matrix							Global matrix						Beam	
1. X	-0.0842	1.4274	-0.0341	0.5788	0	0	-0.0842	1.3685	-0.0341	0.5549	0	0	[mm]	29.009
2. T	-0.6504	0.8264	-0.2637	0.3351	0	0	-0.6504	0.3711	-0.2637	0.1505	0	0	[mrad]	7.903
3. Y	0.0341	-0.5788	-0.0842	1.4274	0	0	0.0341	-0.5549	-0.0842	1.3685	0	0	[mm]	30.068
4. F	0.2637	-0.3351	-0.6504	0.8264	0	0	0.2637	-0.1505	-0.6504	0.3711	0	0	[mrad]	8.181
5. L	0	0	0	0	1	0	0	0	0	0	1	0	[mm]	0
6. D	0	0	0	0	0	1	0	0	0	0	0	1	[%]	0.07
	/[mm]	/[mrad]	/[mm]	/[mrad]	/[mm]	/[%]	/[mm]	/[mrad]	/[mm]	/[mrad]	/[mm]	/[%]		

Tuning

Calculation of setting fragment parameters in front of the solenoid and solenoid tuning are done by the “Distribution” method.

Distribution method:

Local solenoid matrix, and following recalculation of Global matrices for average energy of each ion.
 Non-zero X/T, T/X, X/Y, Y/X, X/P, P/X, T/Y, Y/T, X/P, P/X, Y/P, P/Y matrix coefficients wash out all structures.

Transmission

Monte Carlo method uses only local matrices. Solenoid local matrix is recalculated for EACH ray (for each fragment energy).

Phase space distributions and transmission calculations with the Solenoid block are recommended with the Monte Carlo transmission method.

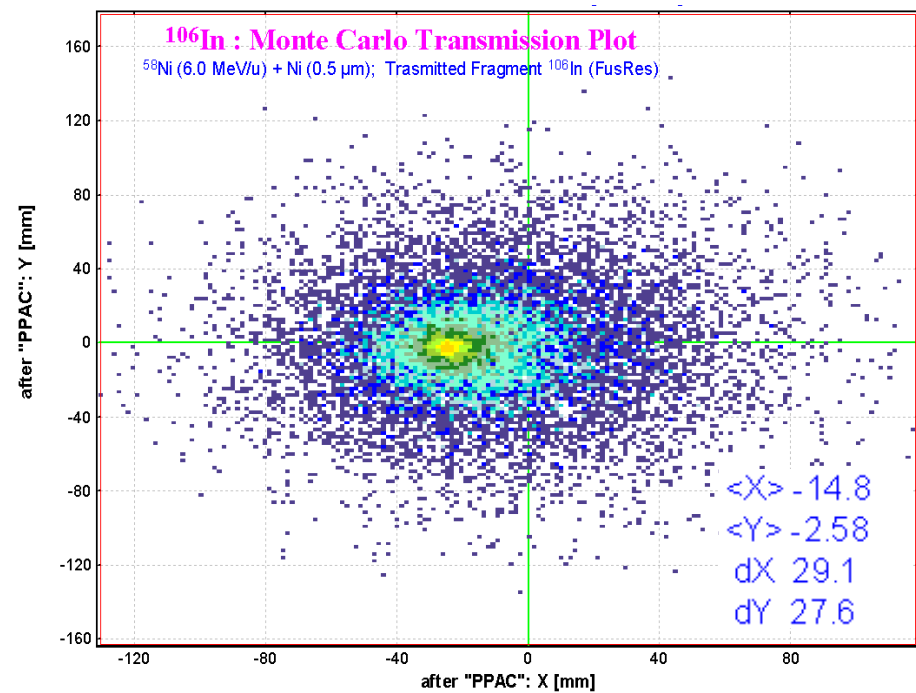
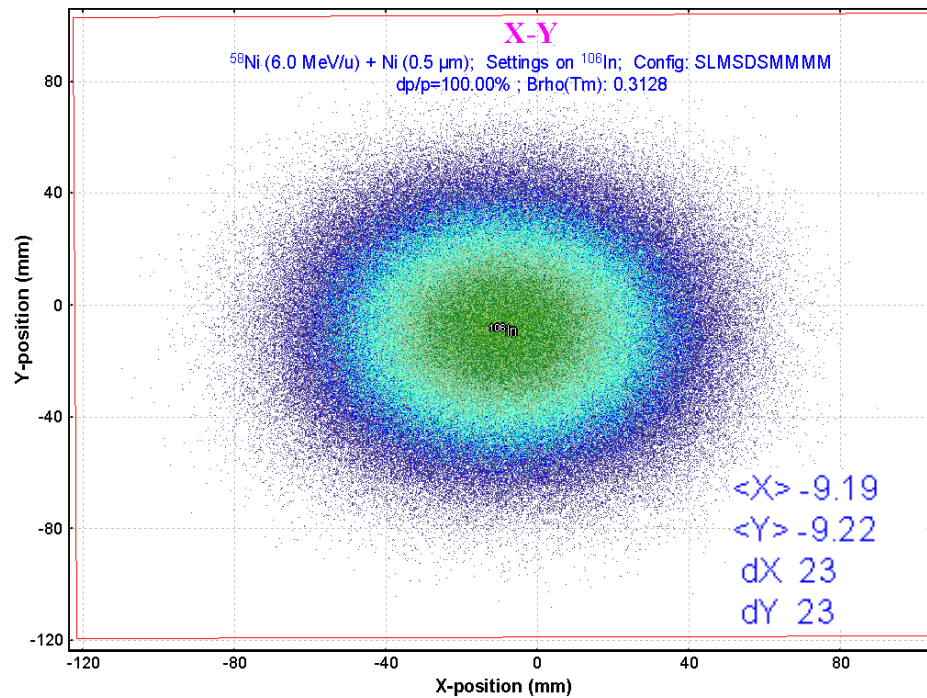
Block matrix							Global matrix							Beam
1. X	-0.0842	1.4274	-0.0341	0.5788	0	0	-0.0842	1.3685	-0.0341	0.5549	0	0	[mm]	29.009
2. T	-0.6504	0.8264	-0.2637	0.3351	0	0	-0.6504	0.3711	-0.2637	0.1505	0	0	[mrad]	7.903
3. Y	0.0341	-0.5788	-0.0842	1.4274	0	0	0.0341	-0.5549	-0.0842	1.3685	0	0	[mm]	30.068
4. F	0.2637	-0.3351	-0.6504	0.8264	0	0	0.2637	-0.1505	-0.6504	0.3711	0	0	[mrad]	8.181
5. L	0	0	0	0	1	0	0	0	0	0	1	0	[mm]	0
6. D	0	0	0	0	0	1	0	0	0	0	0	1	[%]	0.07
	/[mm]	/[mrad]	/[mm]	/[mrad]	/[mm]	/[%]	/[mm]	/[mrad]	/[mm]	/[mrad]	/[mm]	/[%]		

Emittance			
Beam CARD (sigma)			
1. X	1.1	mm	
2. T	19.5	mrاد	
3. Y	0.9	mm	
4. P	20.5	mrاد	
5. L	0	mm	
6. D	0.07	%	

beam respect to spectrometer			
dX	10	mm	
dT	0	mrاد	
dY	10	mm	
dP	0	mrاد	
dT	0	degrees	
dP	0	degrees	

Distribution method

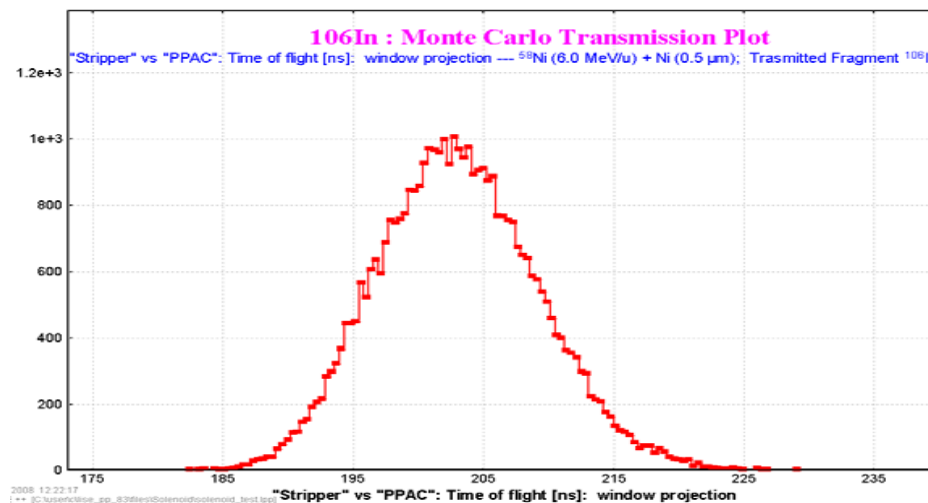
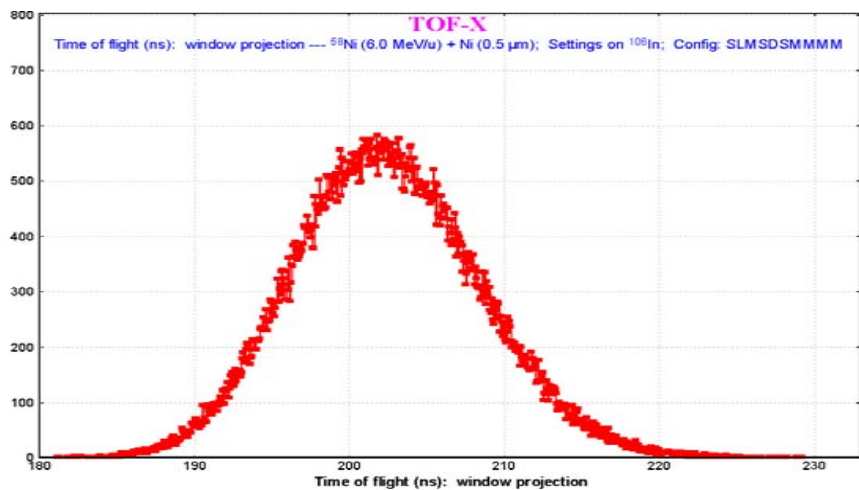
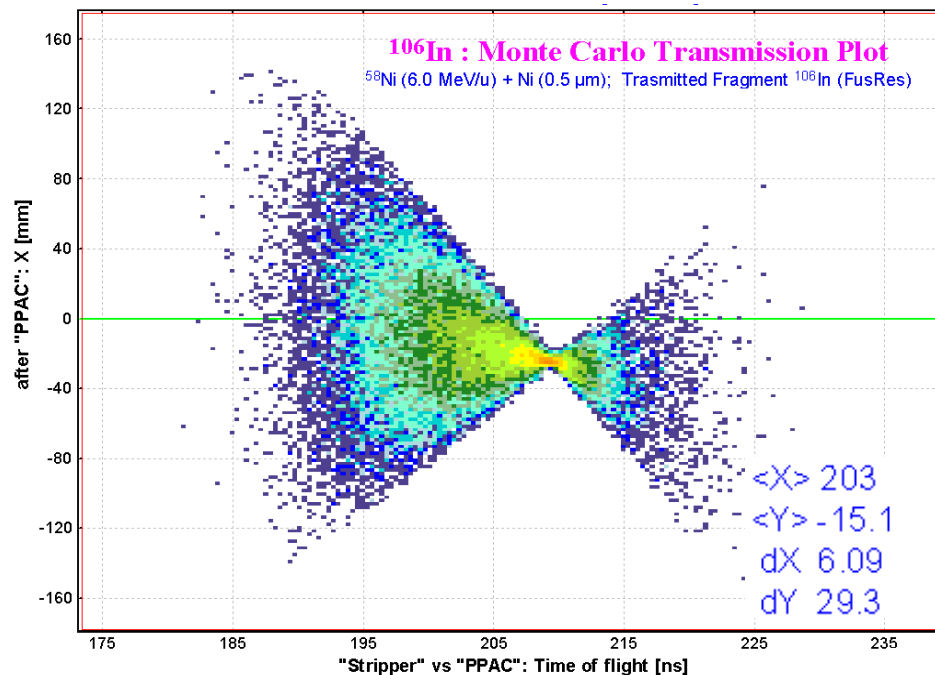
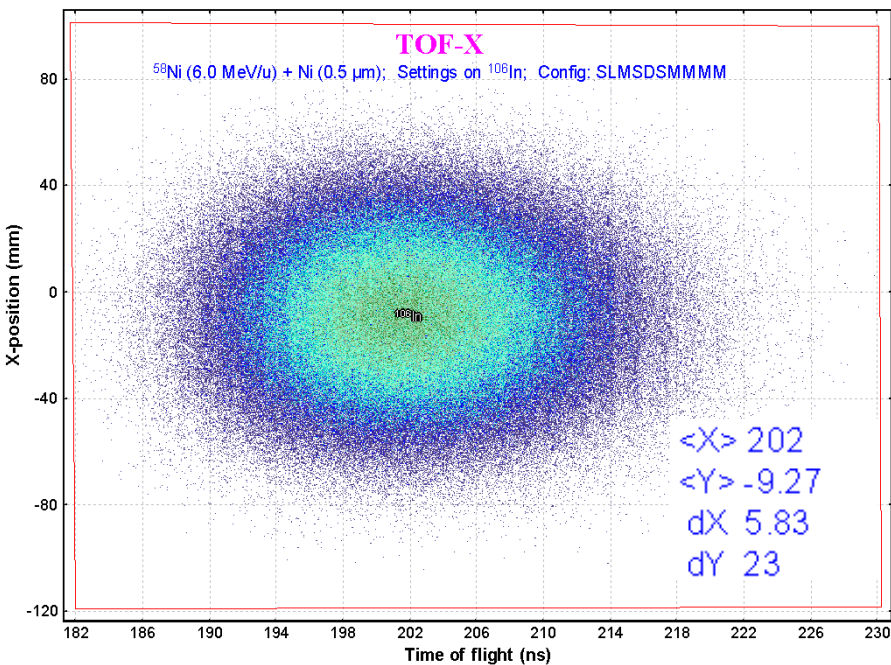
Monte Carlo method



Distribution method

After solenoid

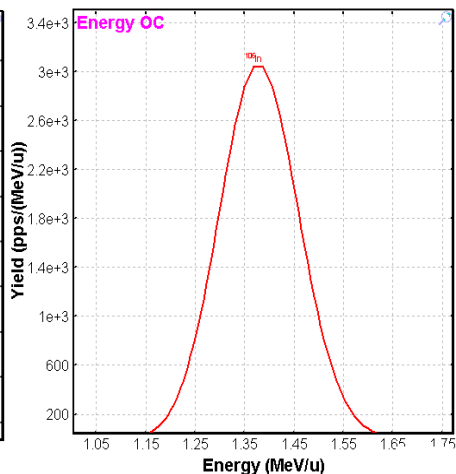
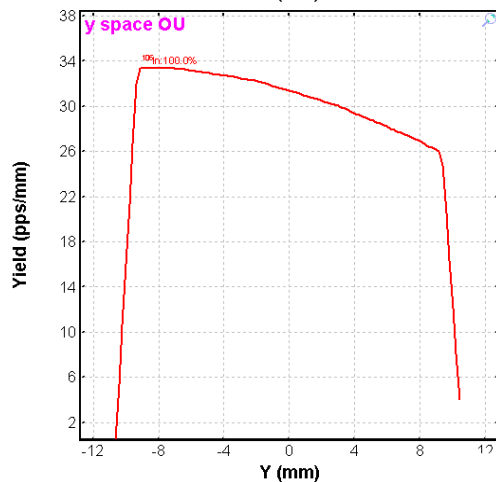
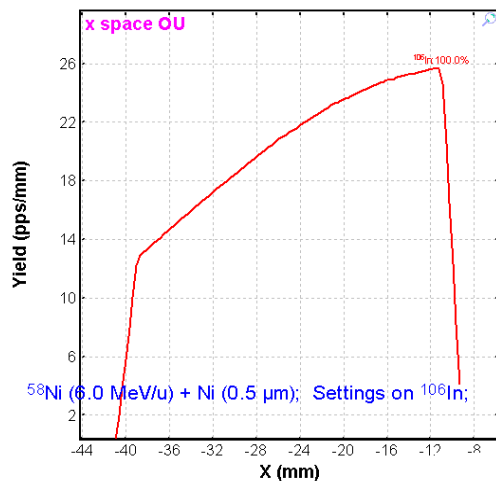
Monte Carlo method



Distribution method

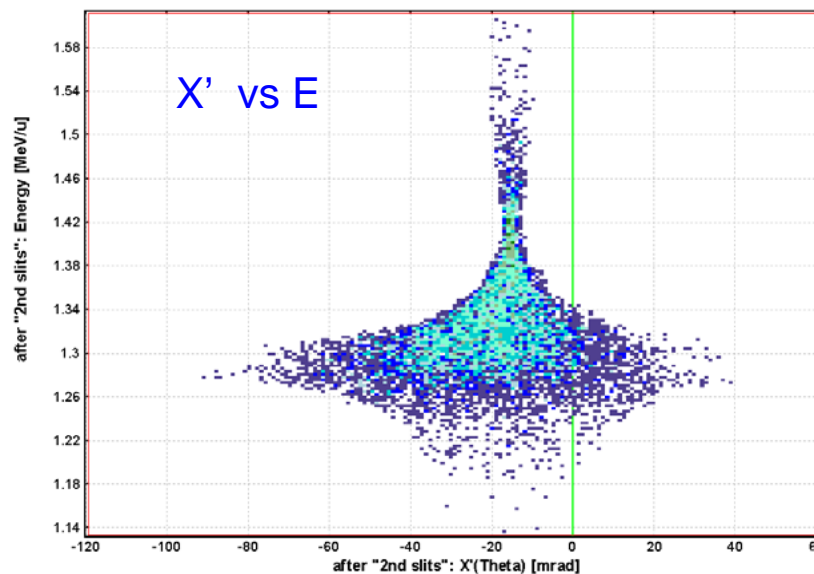
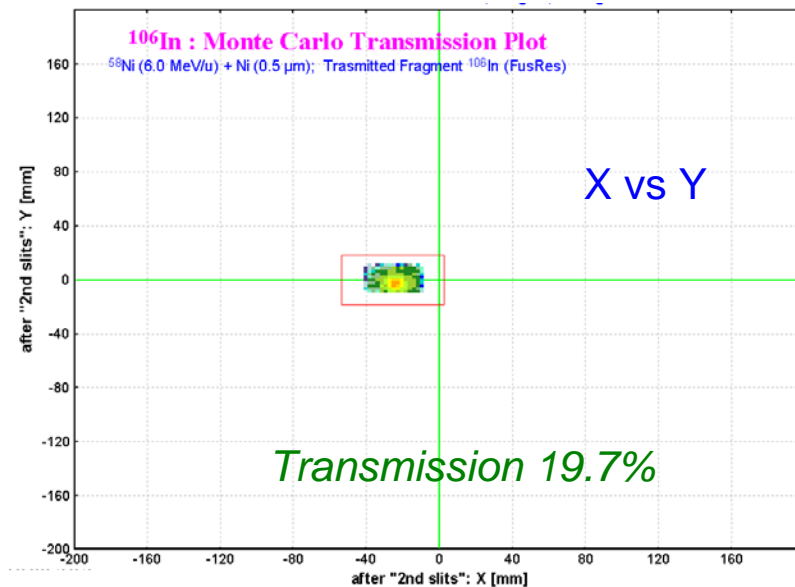
T	Target	Ni
		0.5 micron
St	Stripper	
S	1st Drift	standard
		0.3654 Tm
L	Solenoid	B
		2.7020 T
M	PPAC	Al
		1 micron
S	2nd slits	slits

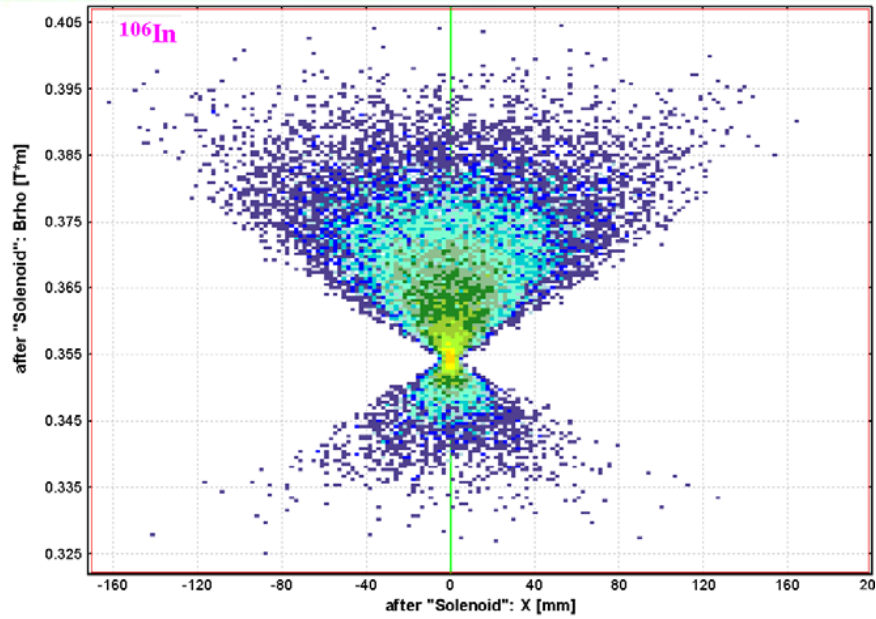
After 2nd slits



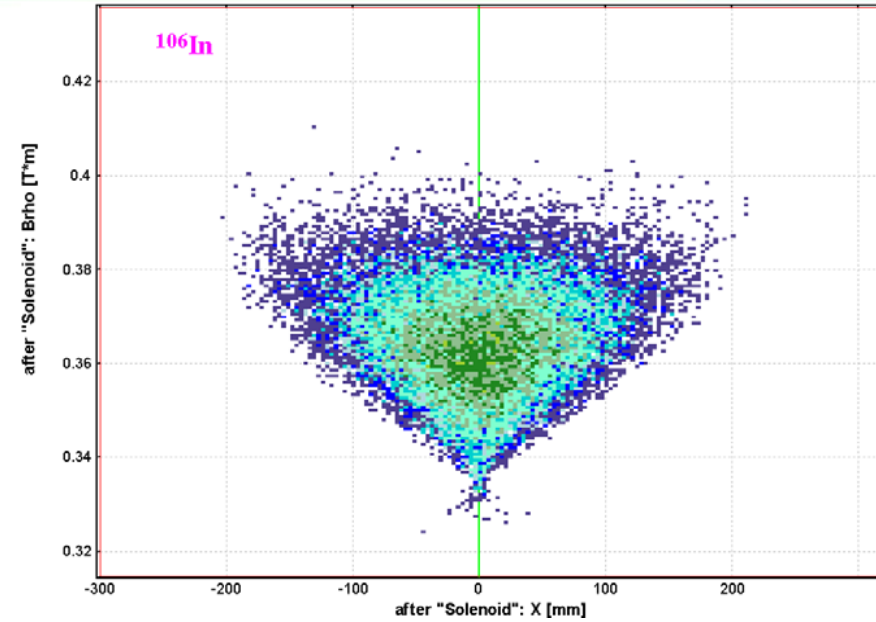
Transmission 10.5%

Monte Carlo method

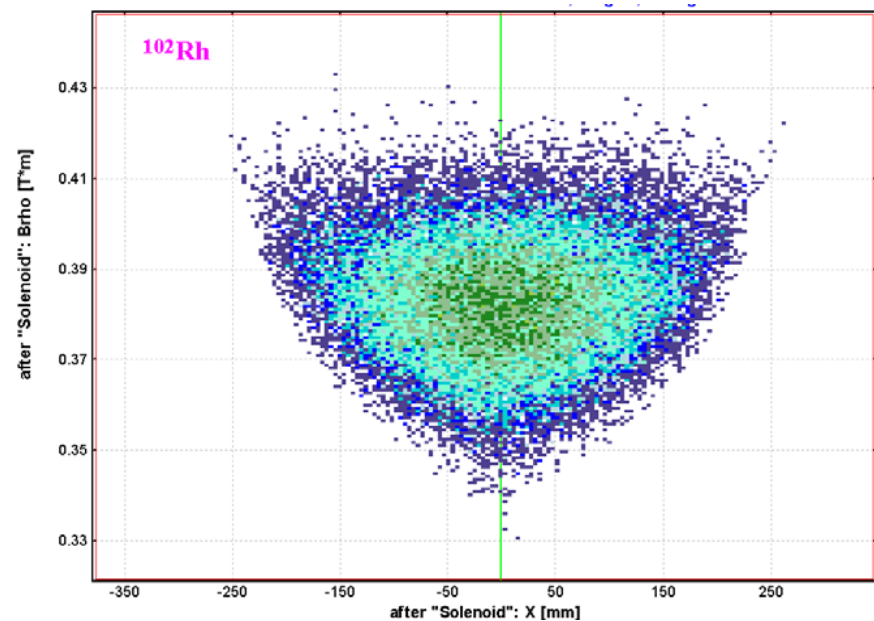
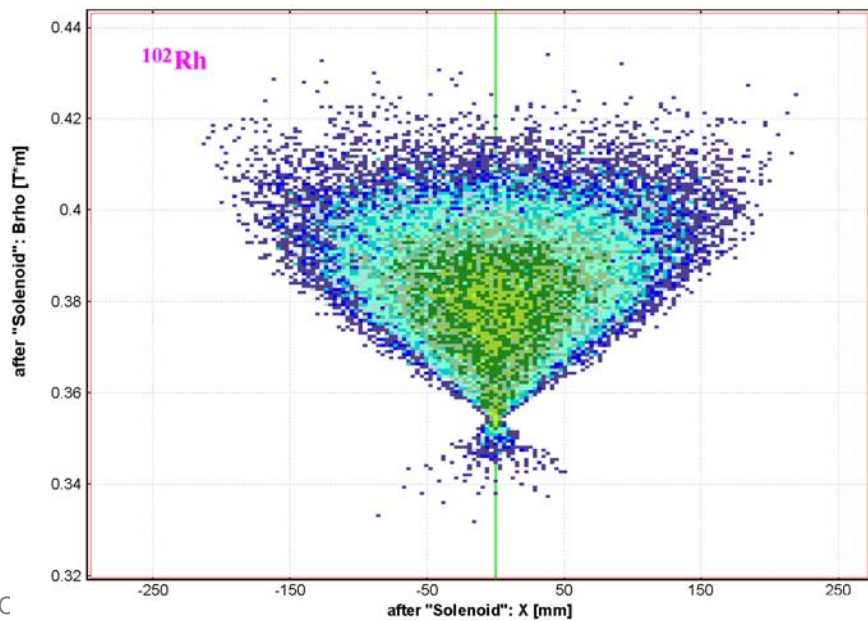


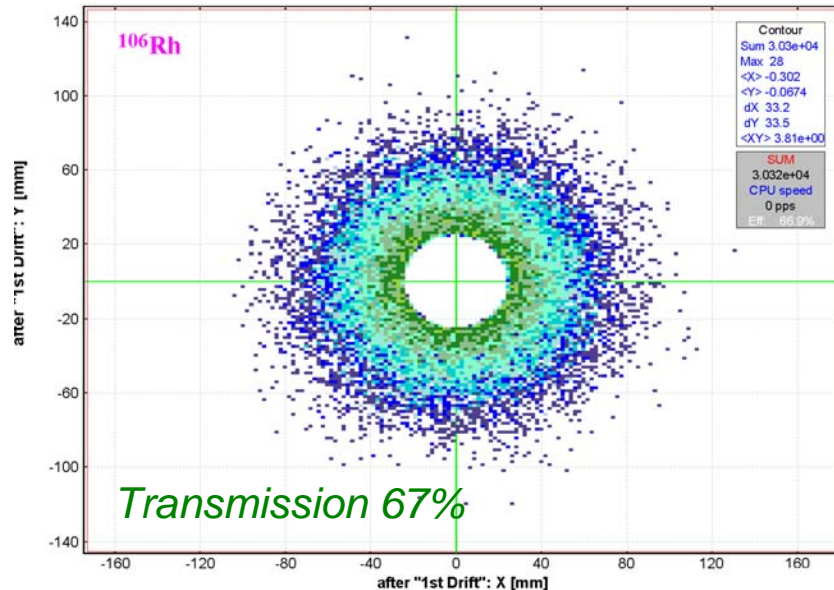
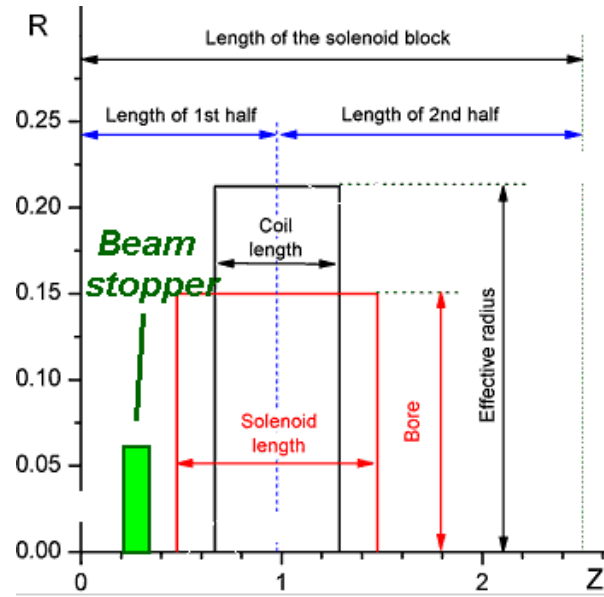
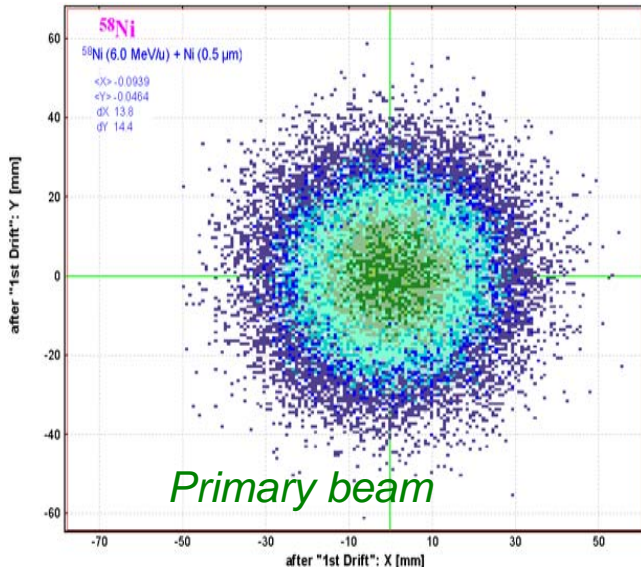


$B_{\text{solenoid}} = 2.7 \text{ T}$



$B_{\text{solenoid}} = 2.55 \text{ T}$





Gate for Monte Carlo calculation transmission

Coordinate
After BLOCK
1st Drift

- X mm
- X' (T) mrad
- Y mm
- Y' (P) mrad
- dP/P %
- R [R(X;Y)] mm
- A [A(X;Y)] mrad
- Energy MeV/u
- TKE MeV
- Momentum MeV/c
- Btho T^m
- Velocity cm/ns
- Energy Loss MeV
- Range mm
- Energy Deposition MeV/mm /particle
- Time of flight ns
- Length m

Status (Condition)

- absent
- " AND "
- " NOT "

Gate

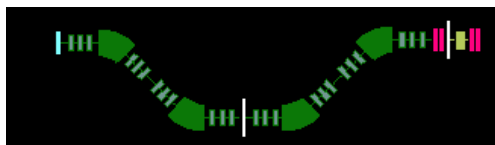
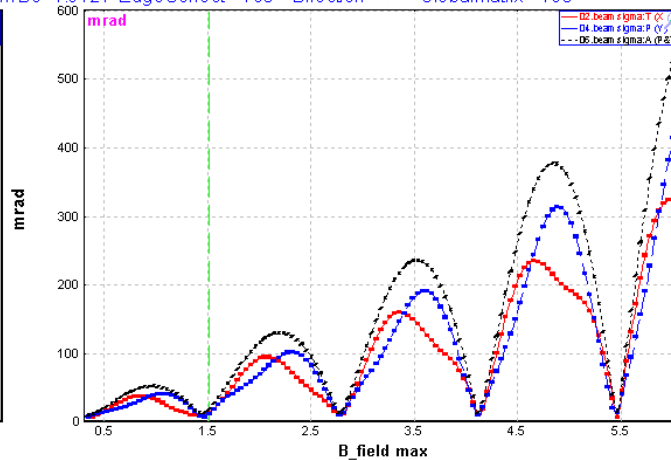
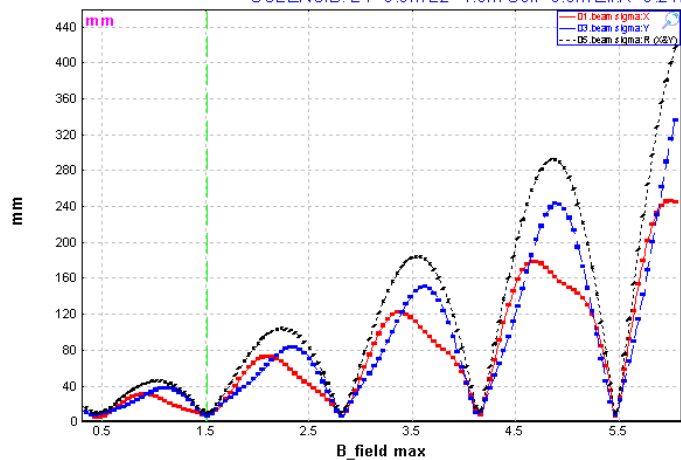
v1 = -25
v2 = 25

OK Cancel

Start Stripper
Stop Stripper

Solenoid block tuning

Tuning parameter is <Beam Sigma> : 01. beam sigma: X
 $^{106}\text{In}^{49+}$ (E=0.10 MeV/u or Ptrans=0.030 GeV/c) Emittance:2.48,20.78,2.24,20.36 InitRay:0.03,-0.08,0.08,0.96
 SOLENOID: L1=0.5m L2=1.0m Coil=0.5m Eff R=0.21m B0=1.512T EdgeCorrect="Yes" Direction="+" GlobalMatrix="Yes"



106In transmission 15%
 102Rh transmission 3%
 For 2% momentum acceptance

