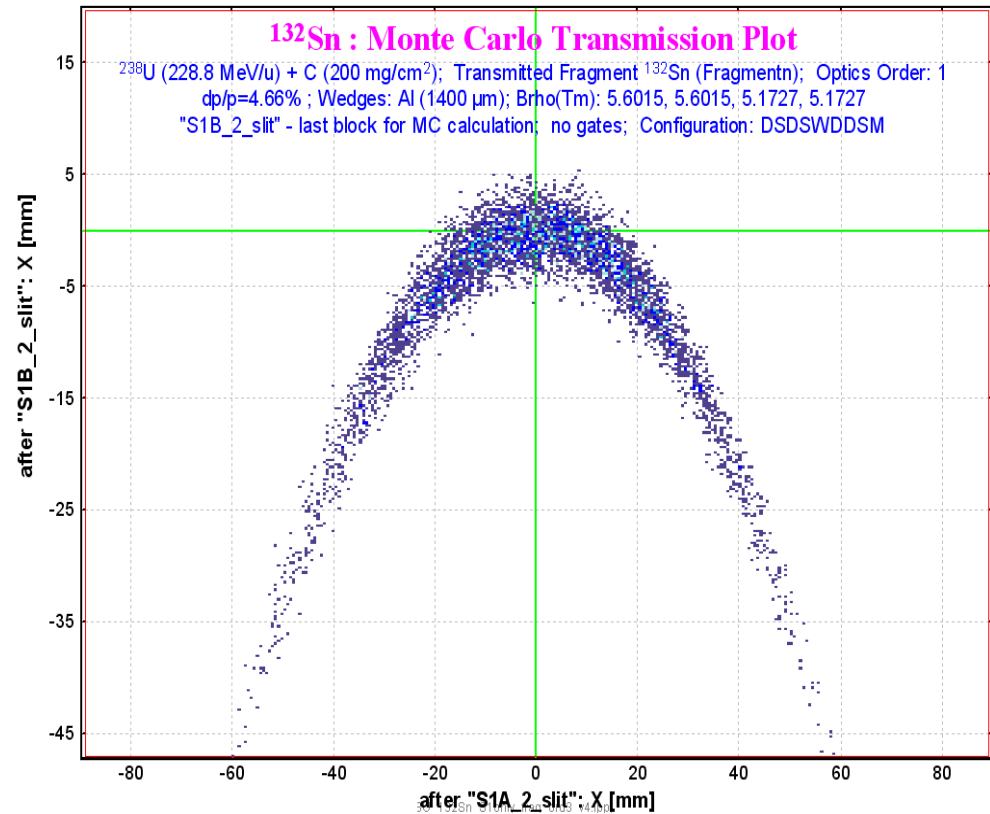


version 9.0.23

Contents:

- "DistributionX" classes
- Transformation of distributions
- Monochromatic Wedge case in previous versions
- Wedge "Curiosity" solution @ v.9.0
- Modifications of transmission calculations
 - Material
 - Optical block



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.nsl.msu.edu/lise>

Each integral is now independent and corresponds to a convolution product

$$P_i'(q_i') = \frac{1}{\prod_{k=1}^n R_{ik}} \int_2 \cdots \int_{n-1} \bar{P}_1(q_i' - t_2) \bar{P}_2(t_2 - t_3) \cdots \times [\bar{P}_{n-1} \otimes \bar{P}_n](t_{n-1}) \times dt_2 \cdots dt_{n-1}.$$

Finally, the result is given by the convolution product of all \bar{P}_j functions

$$P_i'(q_i') = \frac{1}{\prod_{k=1}^n R_{ik}} [\bar{P}_1 \otimes \bar{P}_2 \otimes \cdots \otimes \bar{P}_n](q_i'). \quad (10)$$

Where P_k is $I_k(x)$ (intensity distribution),
where $x_i = x_0 + i \cdot h$,
h is the step,
 $0 \leq i \leq N$ (distribution dimension)

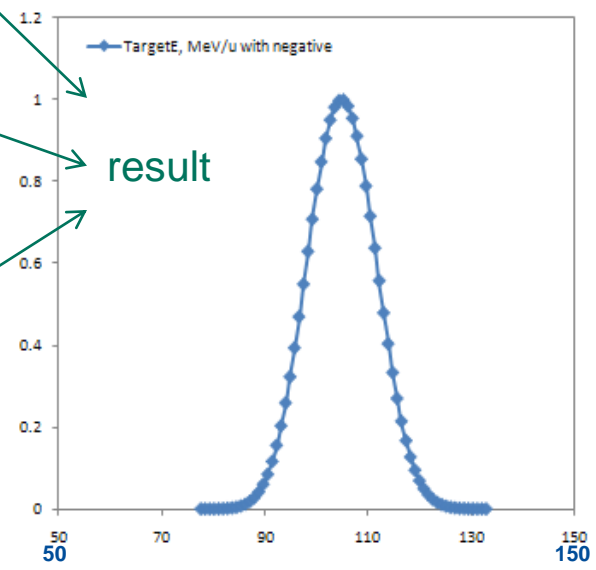
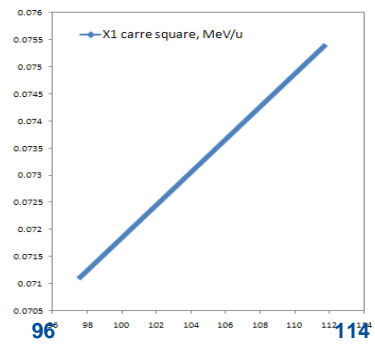
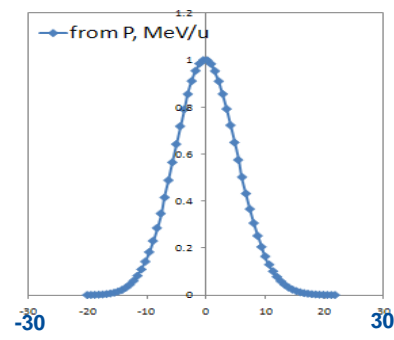
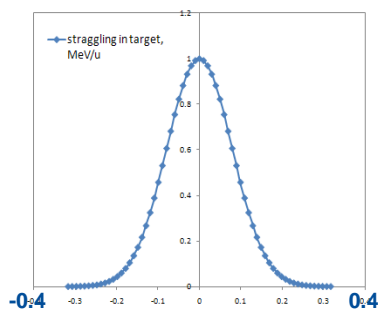
Transport integral: A method to calculate the time evolution of phase-space distributions

D. Bazin* and B. M. Sherrill
 National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, Michigan 48824
 (Received 7 February 1994; revised manuscript received 22 August 1994)

For example the energy distribution after the target:

Input:

1. Beam emittance,
2. Energy straggling in target
3. Momentum distribution after reaction
4. Energy distribution due to energy loss difference in target between beam and fragment



result

2.1. Transformation of distributions

http://groups.nsci.msu.edu/lise/4_5/lise_4_5.htm

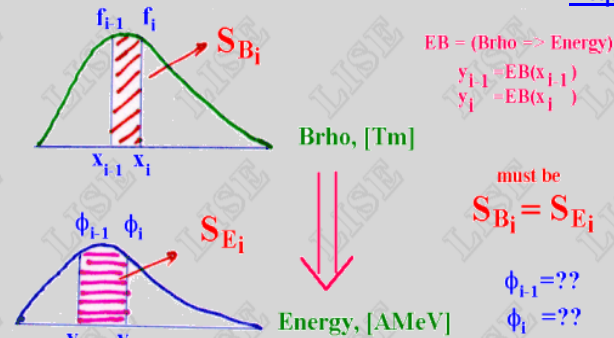


Fig. 4. The scheme of conversion of one distribution in another

In a basis of conversion of one distribution in another (the scheme represented in Fig.4) lays saving of squares between every each $i-1$ and i points. In the last versions the given task was solved rather simple way that had an effect for quality of conversions at such small dimension of distributions (NP=128).

The edge effects were especially appeared in distributions of energy, ranges in matter as they may not be negative. We shall assume that the nucleus with the certain distribution passes through substance and the i -point of distribution stops in matter, and following passes. Then function appropriate between $i-1$ and i points for preservation of the area should aspire to infinity. Rather complex mechanism of smoothing was applied. But all the same it is ideal to solve this problem it was not possible!

In the last versions the area between points was determined by the next primitive expression:

$$S_i = \frac{(f_{i-1} + f_i)}{2} \cdot |x_i - x_{i-1}|$$

We may use now correct calculation of area is next:

$$S_i = \int_{x_{i-1}}^{x_i} f(x) dx$$

because we have infinite function $f(x)$ due to introduction of procedure cubic spline.

The condition of equality of the areas in both distributions between in an interval can be presented in the following kind:

$$S_{E_i} = S_{B_i} \Rightarrow \int_{x_{i-1}}^{x_i} f(x) dx = \int_{y_{i-1}}^{y_i} \phi(y) dy$$

Doing substitution $y=EB(x)$ it possible to get simple and good solution with application of the first derivative of the function $f(x)$:

$$\phi[y(x)] = f(x) \cdot \left(\frac{dEB}{dx} \right)^{-1}$$

This derivative can be taken with the help of cubic spline procedure having constructed distribution x from y . Using further cubic spline procedure for $f(y)$ distribution can be proceeded from complicated distribution with a variable step between points to more simple with a constant step accordingly.

Version 4.

If the "distribution" class has just one array double I[N],

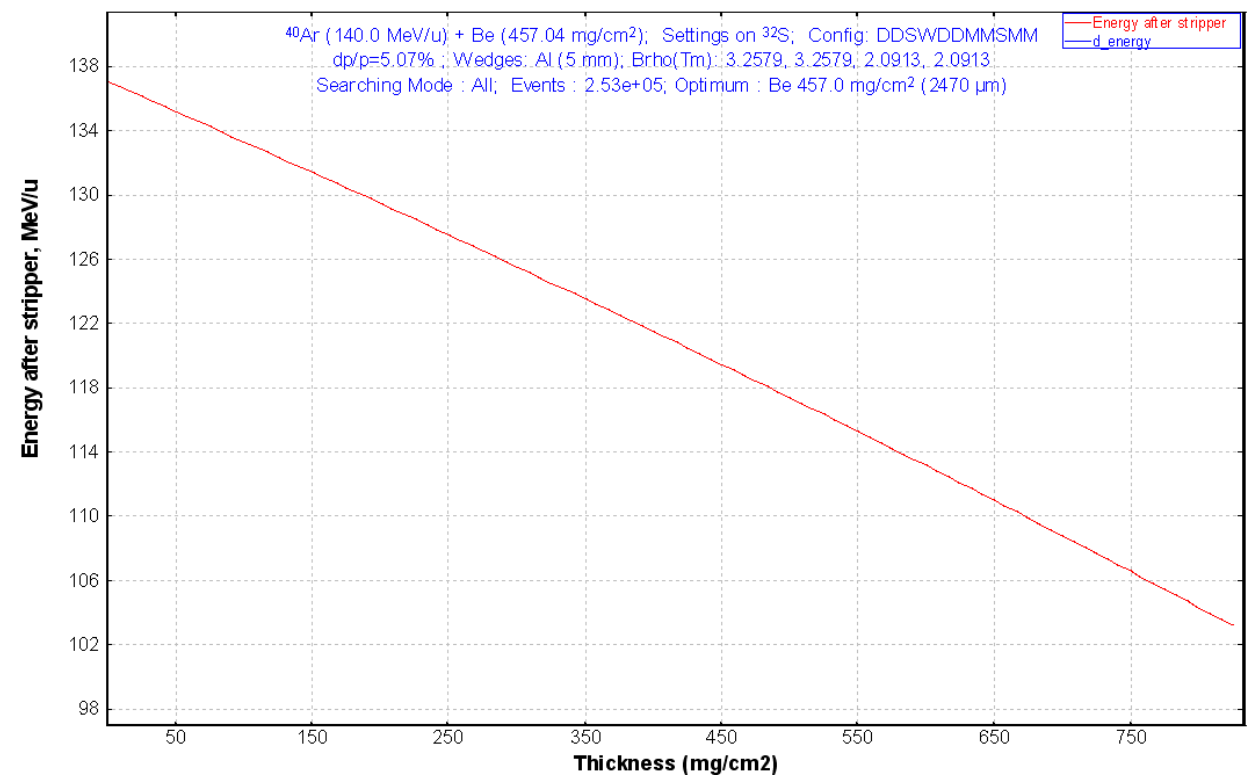
whereas the "distribution2" class

double y[N]
double x[N],

What allows easily create $x=f^{-1}(y)$ from $y=f(x)$

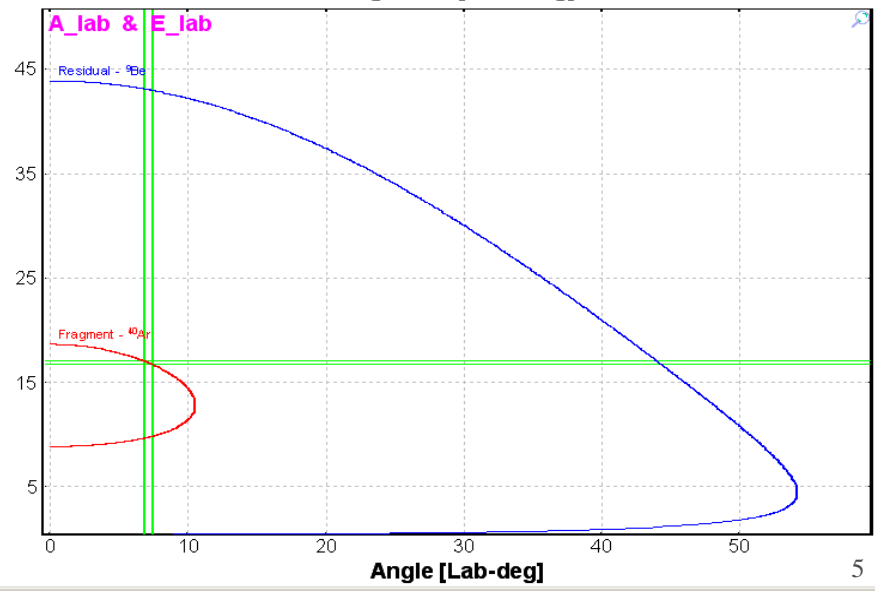
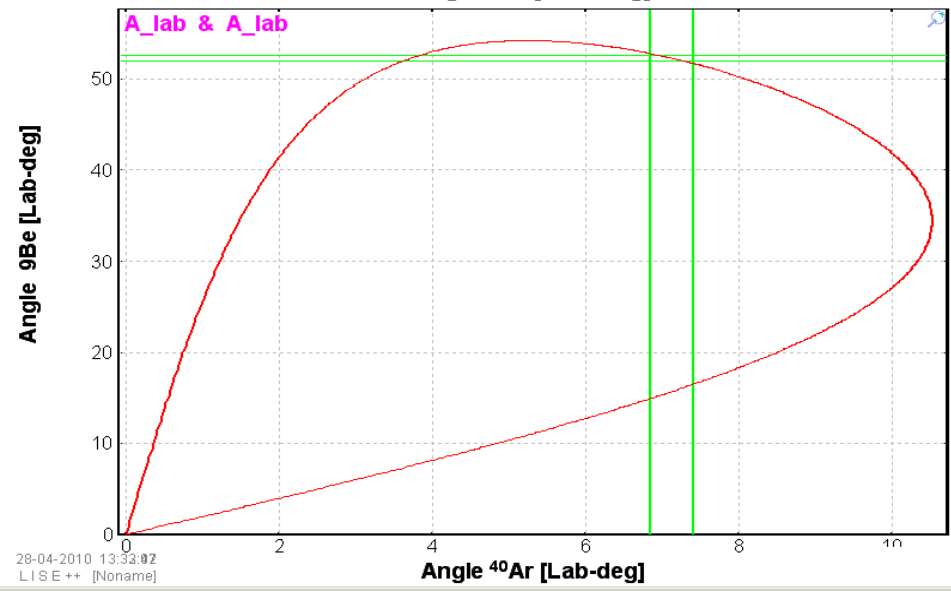
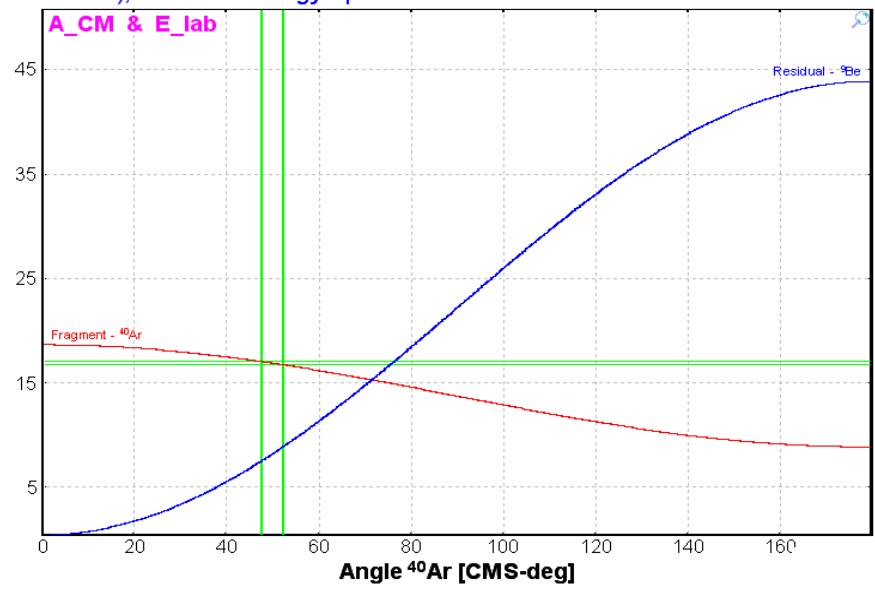
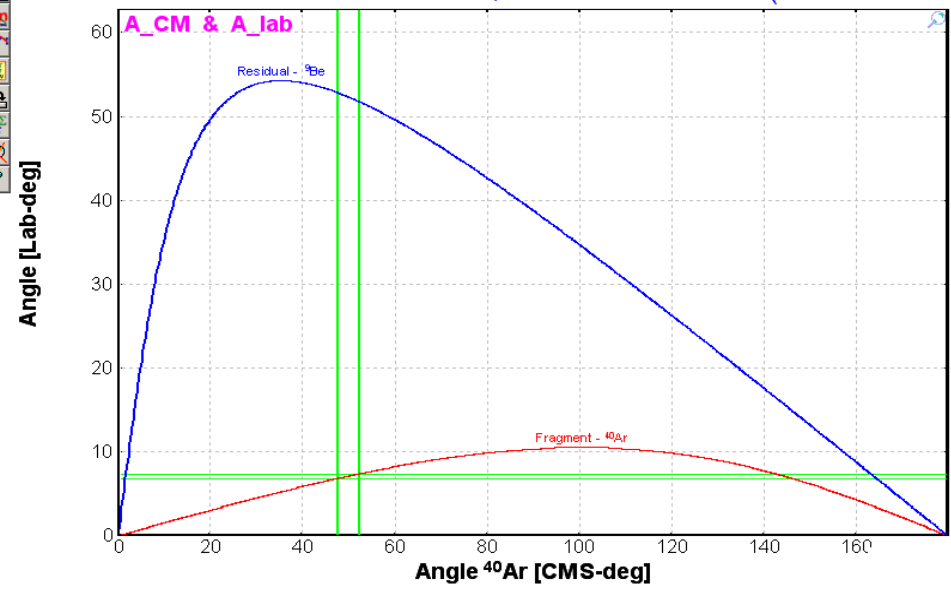
```
//=====
class distribution2 : public distribution {
public:
distribution2(double a, double b, int n ,char
*un, char *dim);
distribution2(distribution&);
distribution2(distribution2&);
~distribution2();

void operator = (distribution&);
void operator = (distribution2&);
.....
}
```



Reaction's Kinematics

$^{40}\text{Ar} + ^9\text{Be} \Rightarrow ^{40}\text{Ar} + ^9\text{Be}$ $^9\text{Be}(^{40}\text{Ar},^{40}\text{Ar})^9\text{Be}$; Reaction at the "middle" of the target
 Projectile Energy at the reaction place: 20.00 MeV/u Grazing angle in CMS [$^{40}\text{Ar} + ^9\text{Be}$] = 4.63 deg
 Q reaction : -50.00 MeV (Excitations 0.0+0.0=>50.0+0.0); Plotted Energy option is "after reaction"



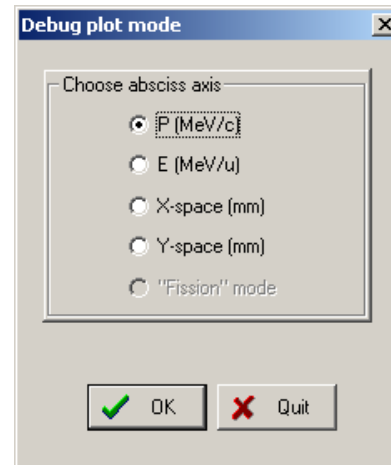
Version 6.

```
class distrFour{
public:
  distrFour(int Ninit=Ndistr4_XY, int mode_init=em_XY);
  distrFour(distrFour&);
  ~distrFour();

  distribution2 **d4;

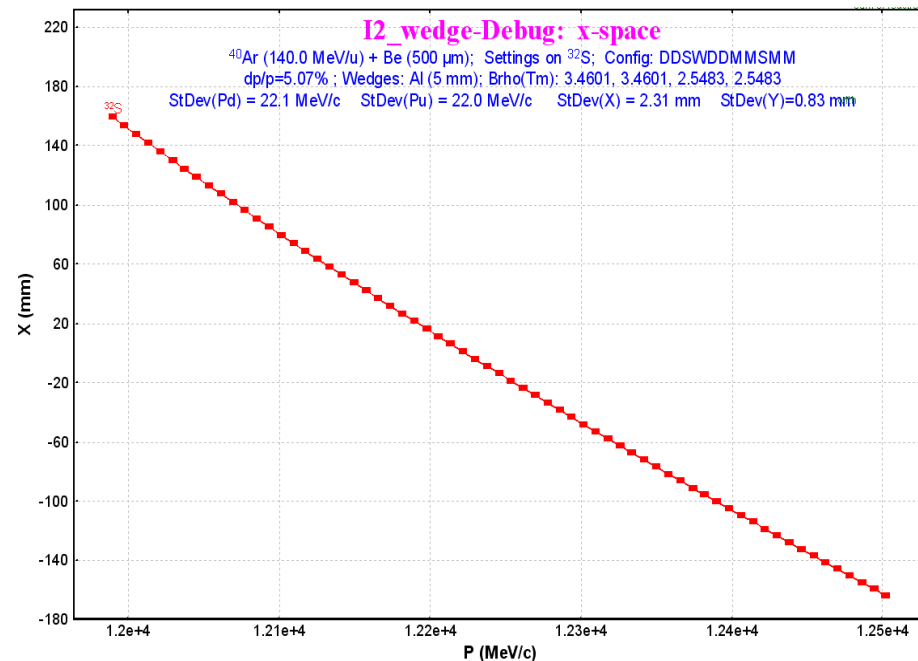
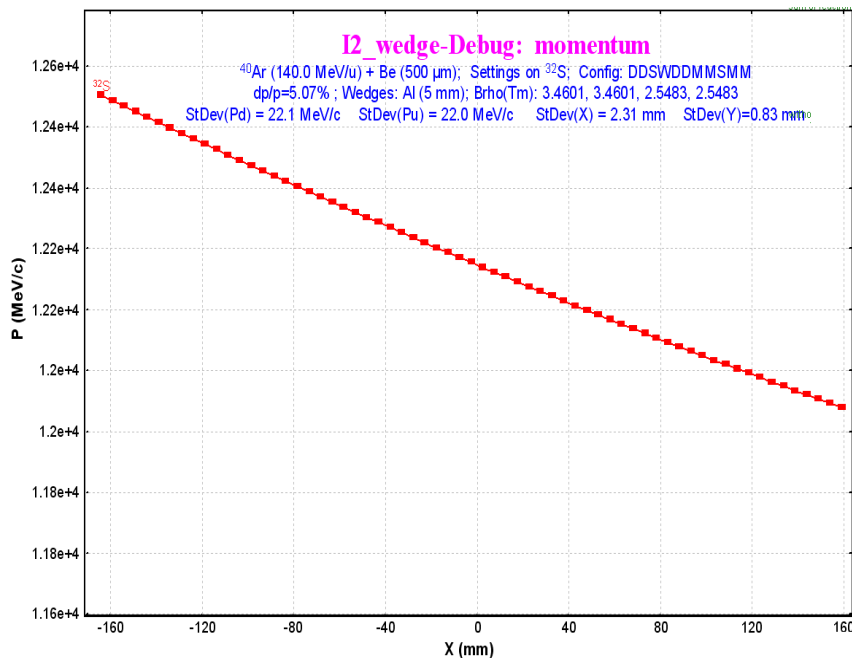
  void ChangeBase(int BaseNew, bool MakeUniformOpt=false);
  .....

```



Can be "Base" {

```
enum edistrFour {
  e4I,
  e4P,
  e4E,
  e4X,
  e4Y,
  e4Pd,
  e4Pu,
  e4Ed,
  e4Eu
};
```



Probably X' and Y' should be included in DistrFour and be used as "Base" to solve MH effect

Two solutions for one variable

Kinematics calculator (relativistic)

Reactions: TWO BODY reaction B(A,C)D
 SCATTERING B(A,C+A)D=B
 BREAKUP (FISSION) x(A,C,D)x (gamma-emission)

Participants:

	ME [MeV]	Excitation Energy	E(CM) = 1018.16 MeV
A	Beam 40Ar -35.04	0	Beam energy = 140.0 MeV/u
B	Target 9Be 11.35	0	Intensity = 1 pA
C*	Fragment 40Ar -35.04	0	Target thickness = 1e-1 micron
D*	Residual 9Be 11.35	0	Q-value = 0.00 MeV

Reaction takes place at the: ENTRANCE of the target MIDDLE of the target EXIT of the target

Setup:

Search an angle in CM	fragment (C)	residual (D)
<input checked="" type="radio"/> from 0 degrees and up	R = 100 cm	100
<input type="radio"/> from 180 degrees and down	w = 1 cm	1
	h = 2 cm	2

Angle (deg) = 8.439 62.885 50 130
 fragment (C) residual (D) fragment (C) residual (D)

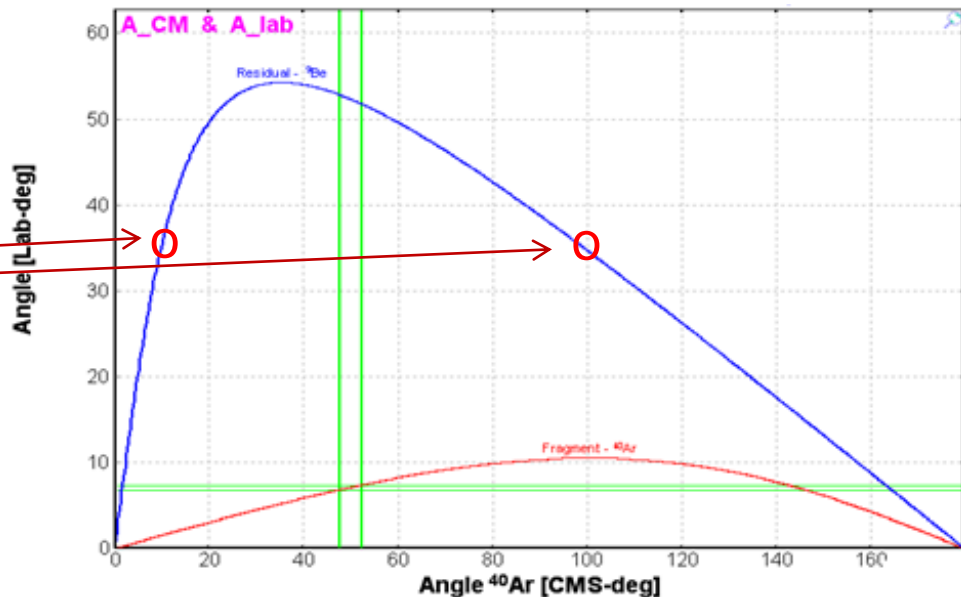
Calculations:

Counting in monitor = 1.13e-2	5.1e-4	pps
Differential Cross Section = 7.29	0.33	0.203 0.203 mb/sr
Energy after reaction = 124.55	68.51	4.864 91.41 MeV/u**
Energy at the entrance of detectors = 124.55	68.51	MeV/u (** for gamma [MeV])
Maximum Angle = 13.03	90.00	deg
Solid Angle = 0.2	0.2	7.17 0.325 msr
delta Theta = 0.57	0.57	3.9 1.1 deg

For Kinematics Plots use energy values: after reaction at entrance of detectors

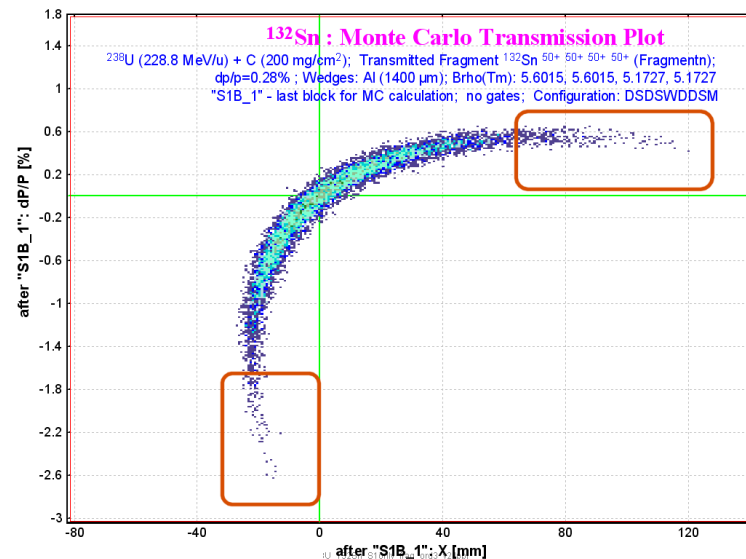
Kinematics plots
 Rutherford plot
 2D fragment plot (Monte Carlo)

Quit Help



For transmission calculation (material and optical block passing) “distribution2”s are transformed to simple intensity “distribution”s for convolution.

Two solutions for one variable are not acceptable in this case. This situation was used to happen in the case of monochromatic wedge, so called “wedge curiosity.”



Wedge degrader in dispersive focal plane

Dispersion Plane
 X (horizontal)
 Y (vertical)

Mode
 Choose the block: to calculate an angle for the setting mode after it
 D4

mode Wedge angle (mrad)
 Achromatic -2.97 Fix
 Monochromatic -4.65 Fix
 Fixed in the code -2.9737

To plot a dependence from angle

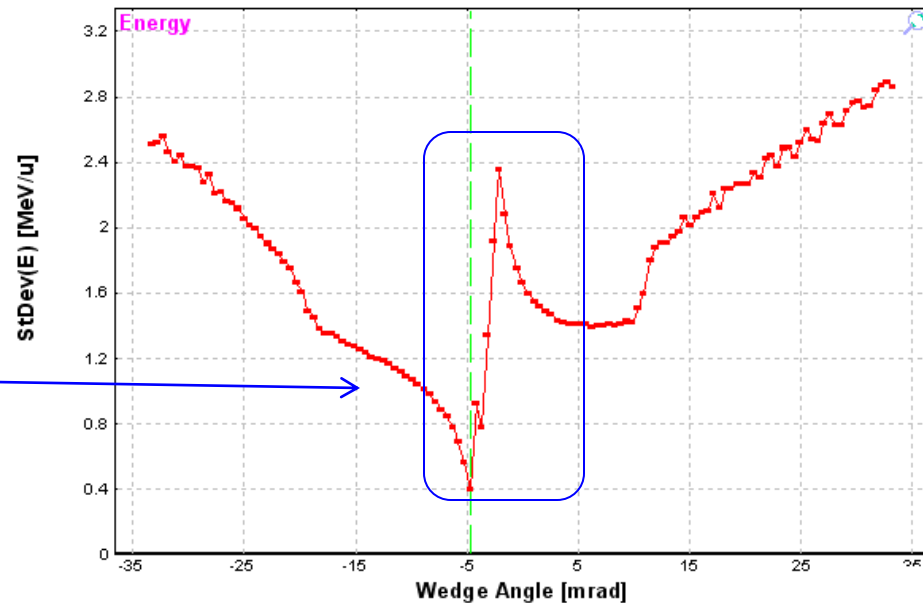
Block: WEDGE
 Degrader Profile: Wedge degrader
 Setting fragment: 32S16+

-150 <- slits(mm) -> +150
 -33.3 <-angle (mrad) -> +33.3
 min max

For the central trajectory
 Thickness: Al (5551.44 micron)
 Energy before the degrader: 134.88 MeV/u
 Energy after the degrader: 66.71 MeV/u

Dimension of wedge angle distributions (default 16): 128

Wedge angle calculations from formulae (mrad)
 Achromatic: -2.97 Fix Monochromatic: -4.3 Fix



Wedge degrader in dispersive focal plane

Dispersion Plane
 X (horizontal)
 Y (vertical)

Mode
 Choose the block: to calculate an angle for the setting mode after it
 51B_2

mode Wedge angle (mrad)
 Achromatic -11.38 Fix
 Monochromatic -13.85 Fix
 Fixed in the code -15.3554

To plot a dependence from angle

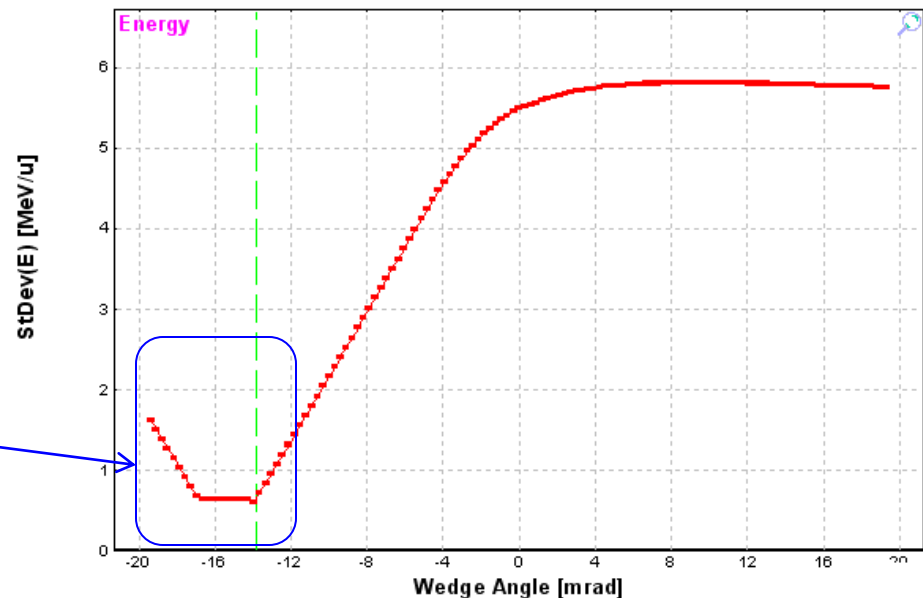
Block: WEDGE
 Degrader Profile: Wedge degrader
 Setting fragment: 132Sn50+

-65 <- slits(mm) -> +65
 -19.38 <-angle (mrad) -> +19.38
 min max

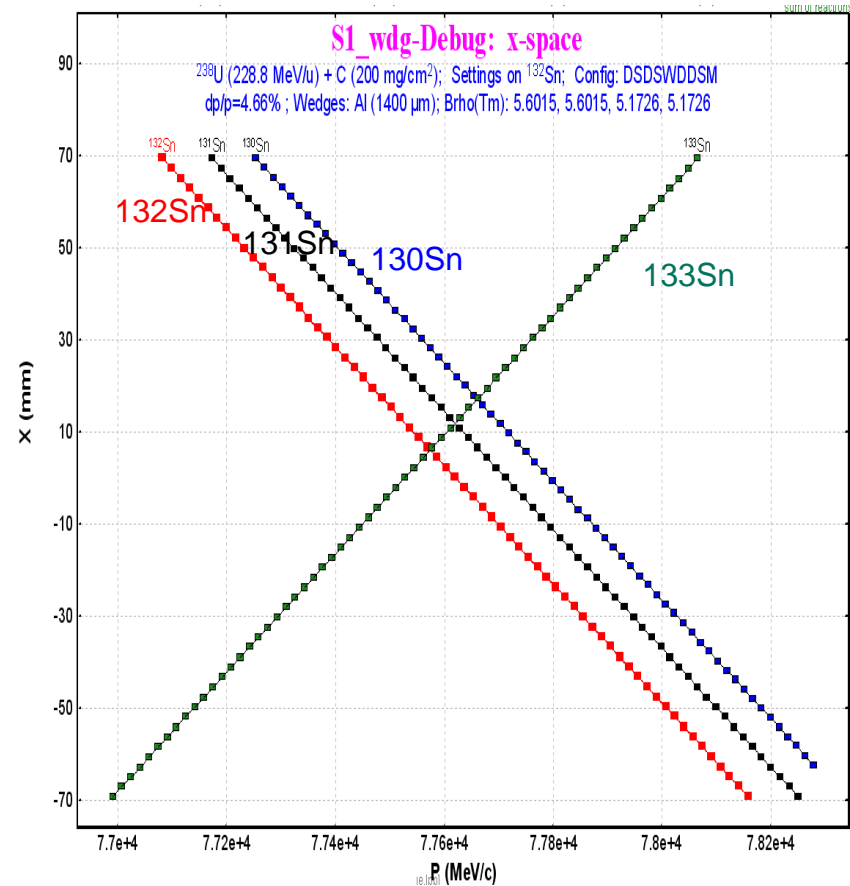
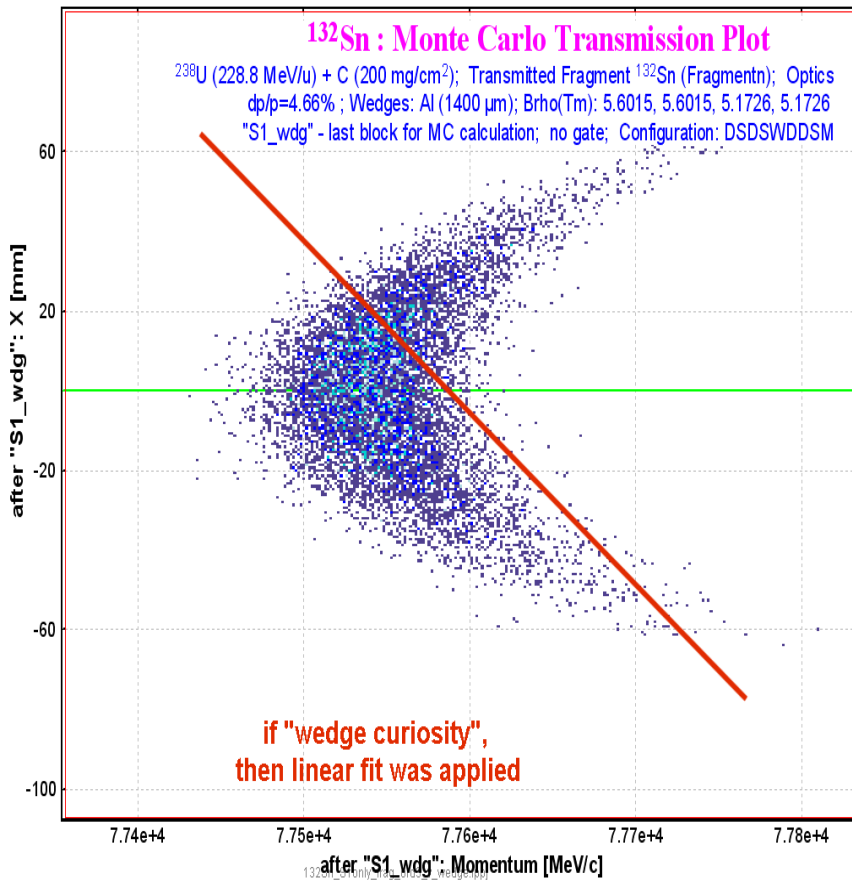
For the central trajectory
 Thickness: Al (1400 micron)
 Energy before the degrader: 196.69 MeV/u
 Energy after the degrader: 169.93 MeV/u

Dimension of wedge angle distributions (default 16): 128

Wedge angle calculations from formulae (mrad)
 Achromatic: -11.66 Fix Monochromatic: -15.36 Fix



The worse case is zero transmission for the setting fragment ☹️



In DistFour distributions the “base” has been changed

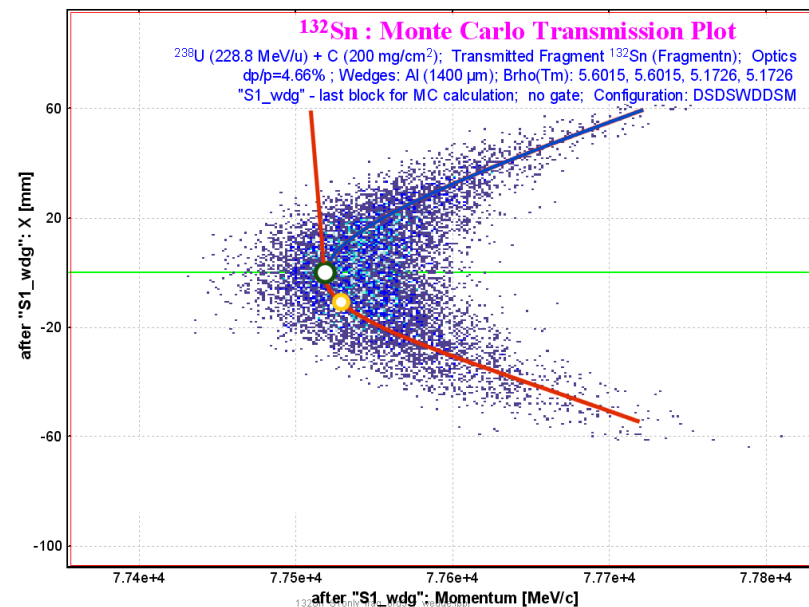
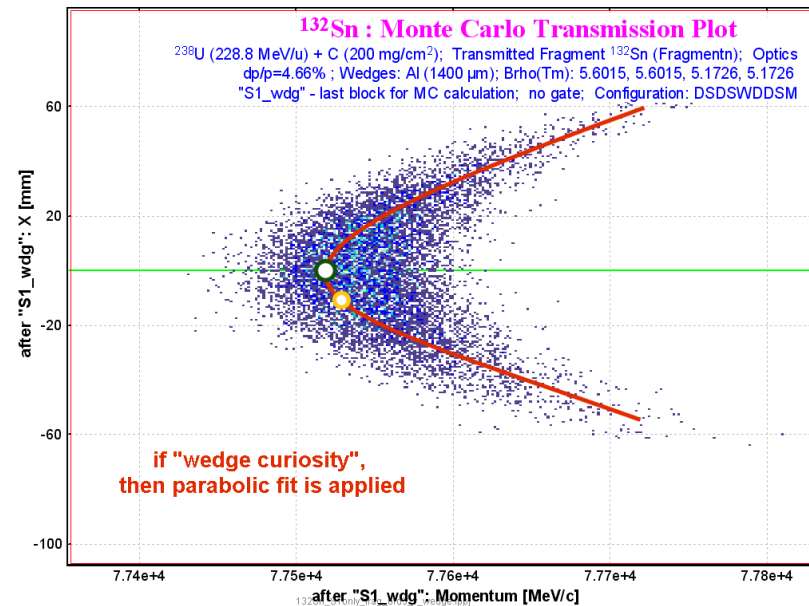
Passing Materials from P to X(Y)

Passing Optical blocks from X(Y) to P

Steps

1. Parabolic fit
2. Search a turning point
3. Search more intense point
4. Combining this parabola with line.

More Intense point should have the same X and P values after these operations



Wedge degrader in dispersive focal plane

Dispersion Plane
 X (horizontal)
 Y (vertical)

Mode
 Choose the block: to calculate an angle for the setting mode after it
 S1B_2

mode Wedge angle (mrad)
 Achromatic -11.69 **Fix**
 Monochromatic **-15.35** **Fix**
 Fixed in the code -15.3522

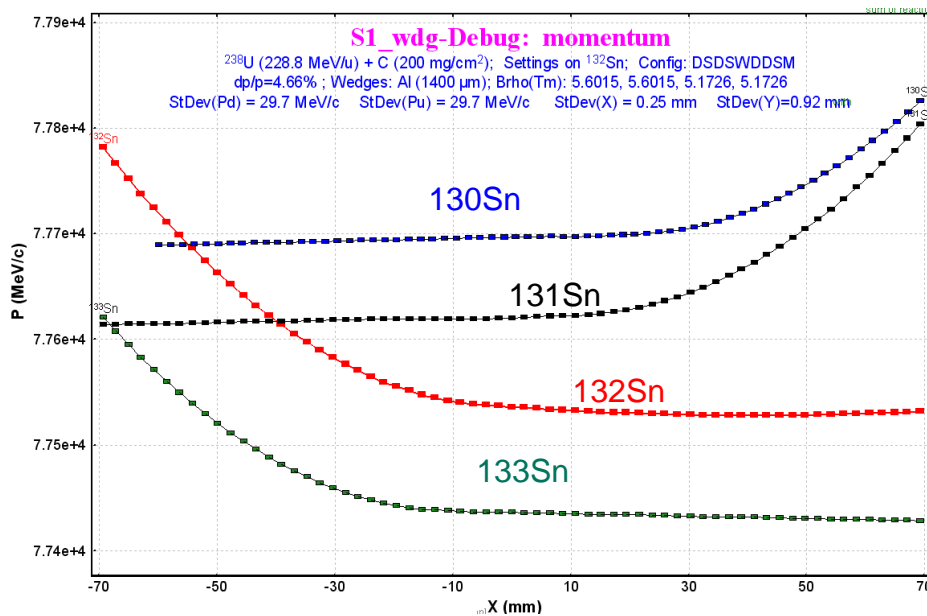
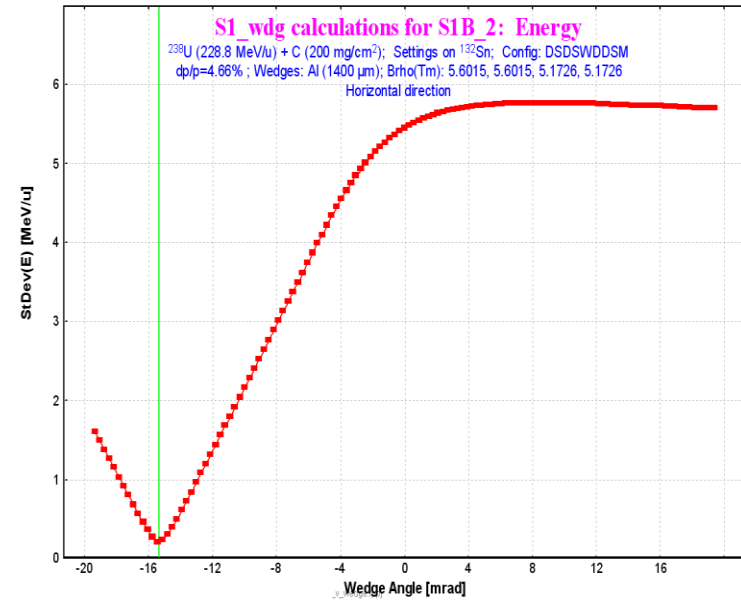
To plot a dependence from angle

Block: WEDGE
 Degradar Profile: Wedge degrader
 Setting fragment: 132Sn50+
 -65 <- slits(mm) -> +65
 -19.38 <-angle (mrad)-> +19.38
 min max

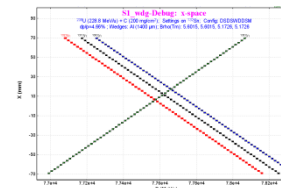
For the central trajectory
 Thickness: Al (1400 micron)
 Energy before the degrader: 196.69 MeV/u
 Energy after the degrader: 169.93 MeV/u

Dimension of wedge angle distributions (default 16): 128

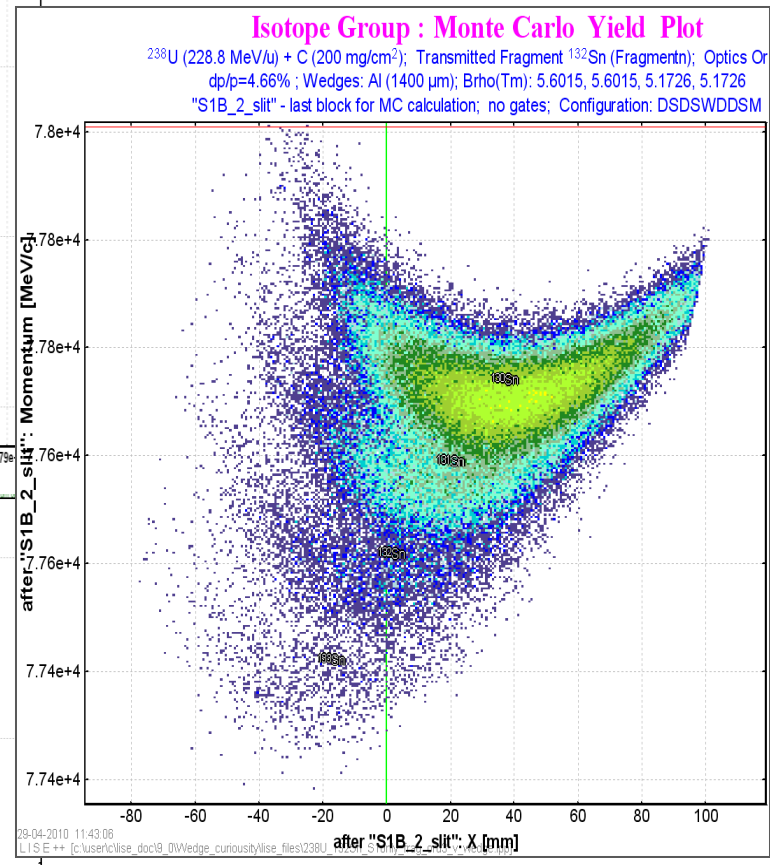
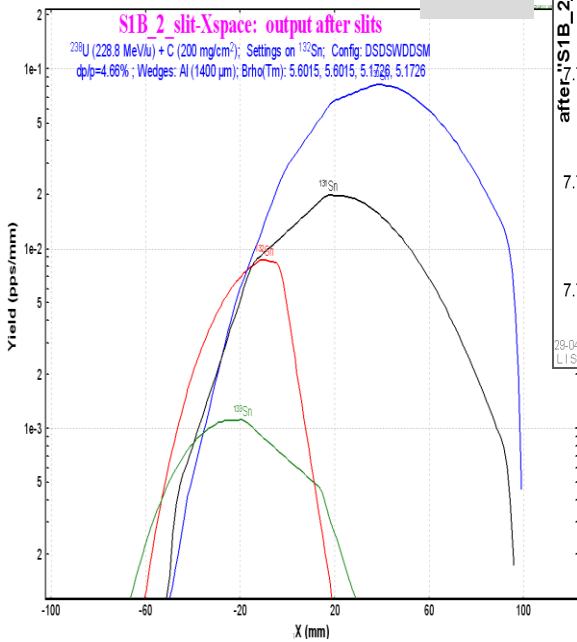
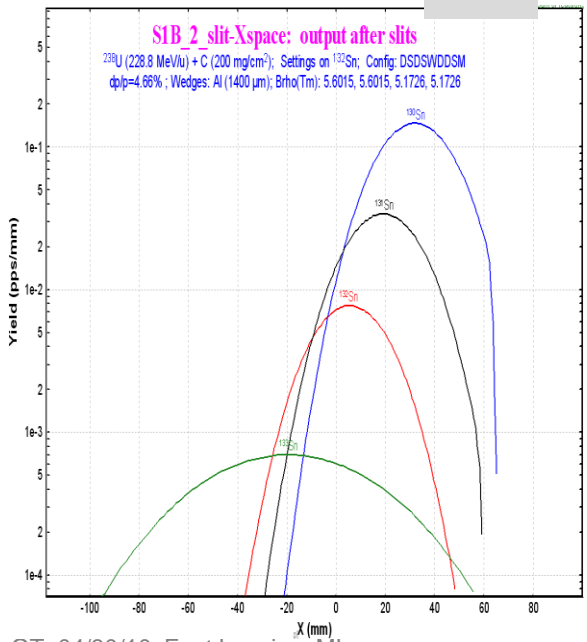
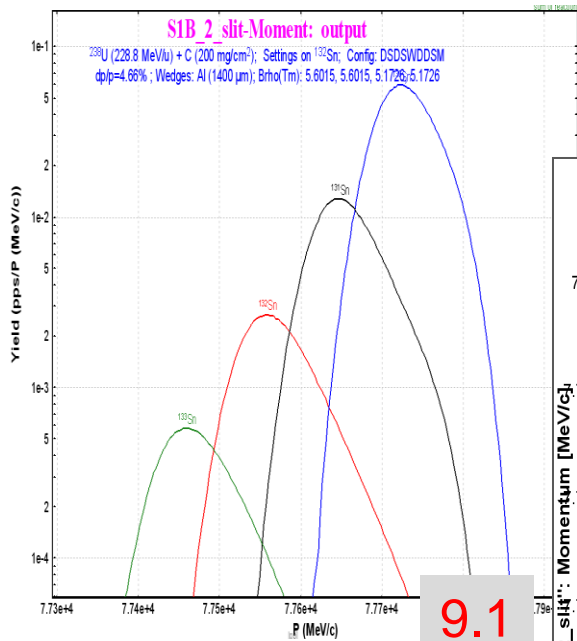
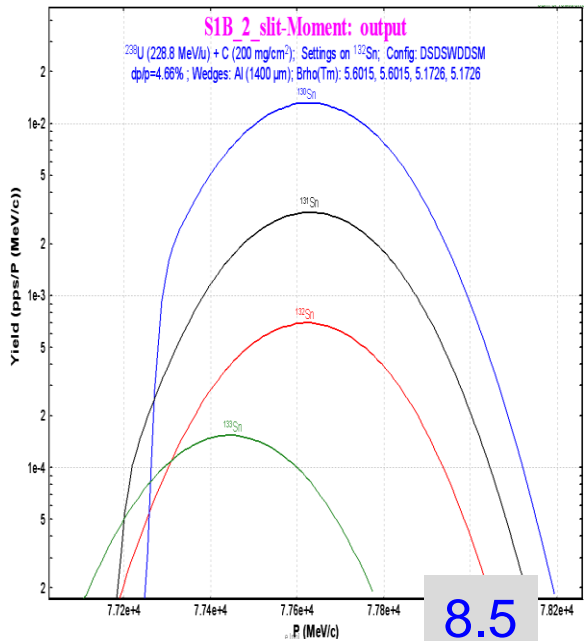
Wedge angle calculations from formulae (mrad)
 Achromatic: -11.66 **Fix** **Monochromatic** -15.36 **Fix**



8.5

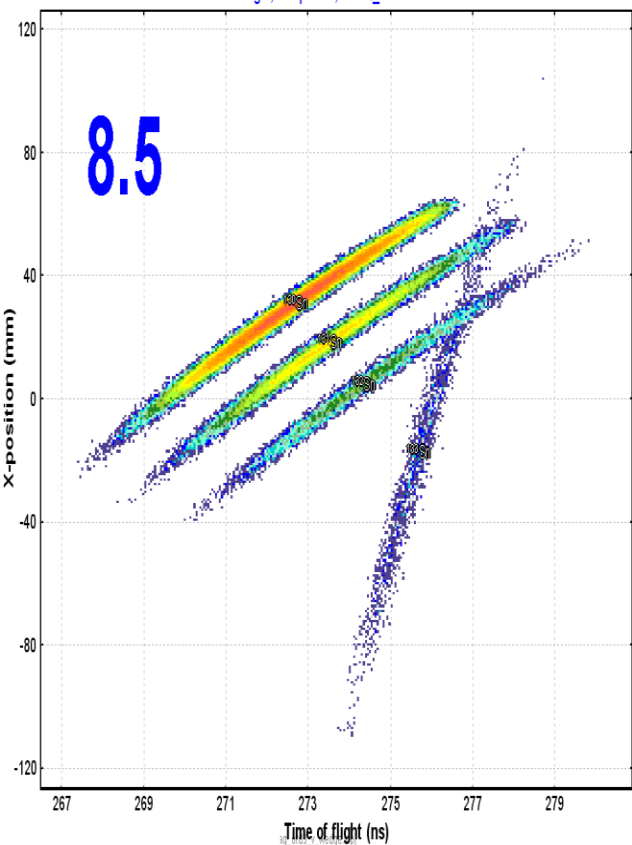


Comparison (X & P)



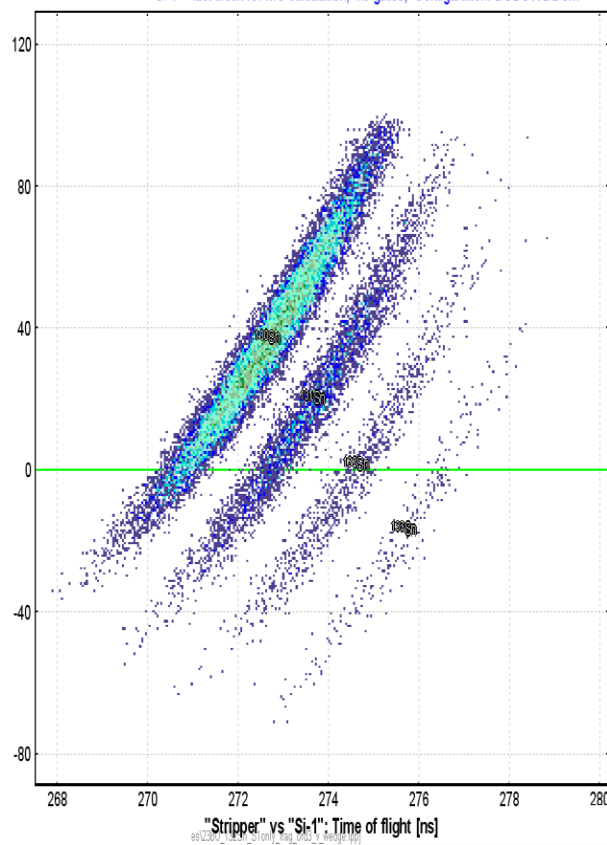
TOF-X

^{238}U (228.8 MeV/u) + C (200 mg/cm²); Settings on ^{132}Sn ; Config: DSDSWDDSM
 dplp=4.66%; Wedges: Al (1400 μm); Brho(Tm): 5.6015, 5.6015, 5.1726, 5.1726
 Start: Target; Stop: Si-1; ACQ_start: Detector ** X-detector: Si-1



Isotope Group : Monte Carlo Yield Plot

^{238}U (228.8 MeV/u) + C (200 mg/cm²); Transmitted Fragment ^{132}Sn (Fragmentn); Optics Ord
 dplp=4.66%; Wedges: Al (1400 μm); Brho(Tm): 5.6015, 5.6015, 5.1726, 5.1726
 Si-1 - last block for MC calculation; no gates; Configuration: DSDSWDDSM



TOF-X

^{238}U (228.8 MeV/u) + C (200 mg/cm²); Settings on ^{132}Sn ; Config: DSDSWDDSM
 dplp=4.66%; Wedges: Al (1400 μm); Brho(Tm): 5.6015, 5.6015, 5.1726, 5.1726
 Start: Target; Stop: Si-1; ACQ_start: Detector ** X-detector: Si-1

