Wien filter revision

version 8.5.43

Contents:

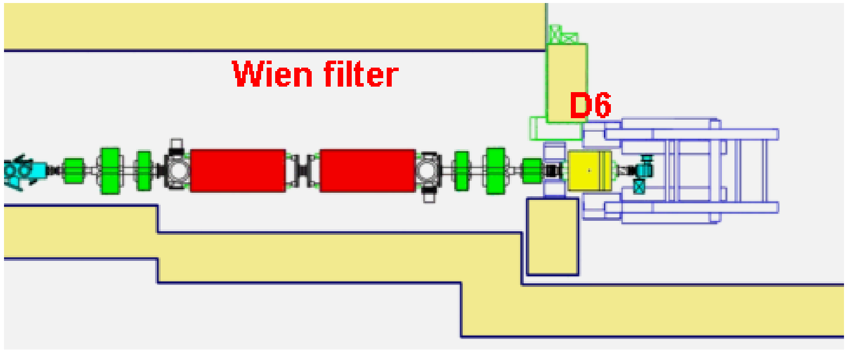
- *Setting Wien filter in LISE++*
- *"Transport" solution of Wien-filter optics*
- *"Classical" solution for the dispersion coefficient*
- *Dispersion as a function of fields, energies, lengths*
- *Revision of the Wien filter dispersion*
- *Examples of Wien filter selection*

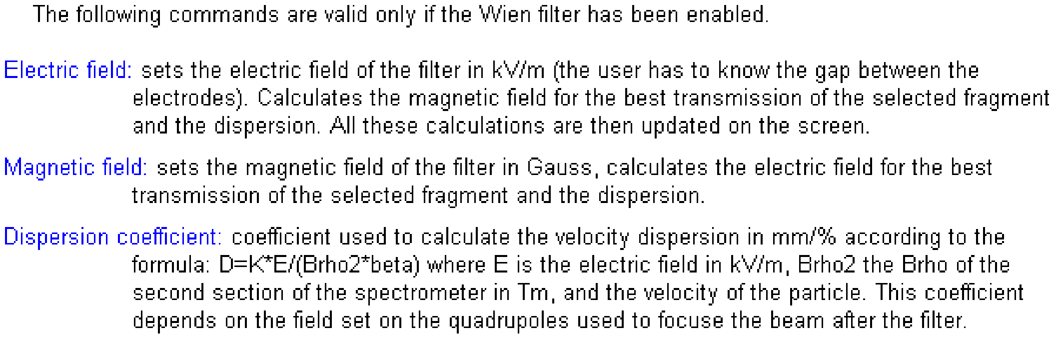
Requests from

François de Oliveira,

Christelle Stodel,

and Pedja (GANIL)




The following commands are valid only if the Wien filter has been enabled.

Electric field: sets the electric field of the filter in kV/m (the user has to know the gap between the electrodes). Calculates the magnetic field for the best transmission of the selected fragment and the dispersion. All these calculations are then updated on the screen.

Magnetic field: sets the magnetic field of the filter in Gauss, calculates the electric field for the best transmission of the selected fragment and the dispersion.

Dispersion coefficient: coefficient used to calculate the velocity dispersion in mm/% according to the formula: D=K*E/(Brho2*beta) where E is the electric field in kV/m, Brho2 the Brho of the second section of the spectrometer in Tm, and the velocity of the particle. This coefficient depends on the field set on the quadrupoles used to focuse the beam after the filter.

See more for Wien-filter

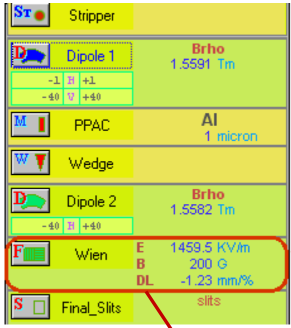
LISE 3: a magnetic spectrometer—Wien filter combination for secondary radioactive beam production by Remy Anne, Alex C. Mueller

Nuclear Instruments and Methods in Physics Research Section B
Volume 70, Issues 1-4, 1 August 1992, Pages 276-285
http://dx.doi.org/10.1016/0168-583X(92)95943-L

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.nscl.msu/edu/lise

Setting Wien filter in LISE++: Lengths

http://groups.nscl.msu.edu/lise/8_5/wien/wien_test.lpp



Stripper

Dipole 1 — Brho 1.5591 Tm — -1 H +1 — -40 V +40

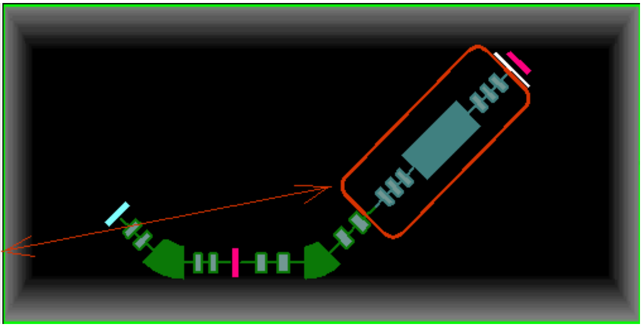
PPAC — Al 1 micron

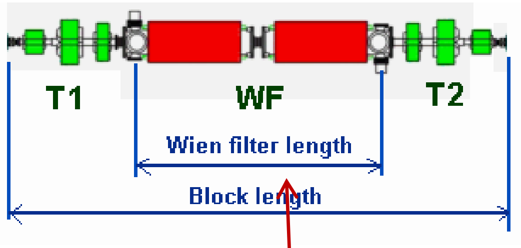
Wedge

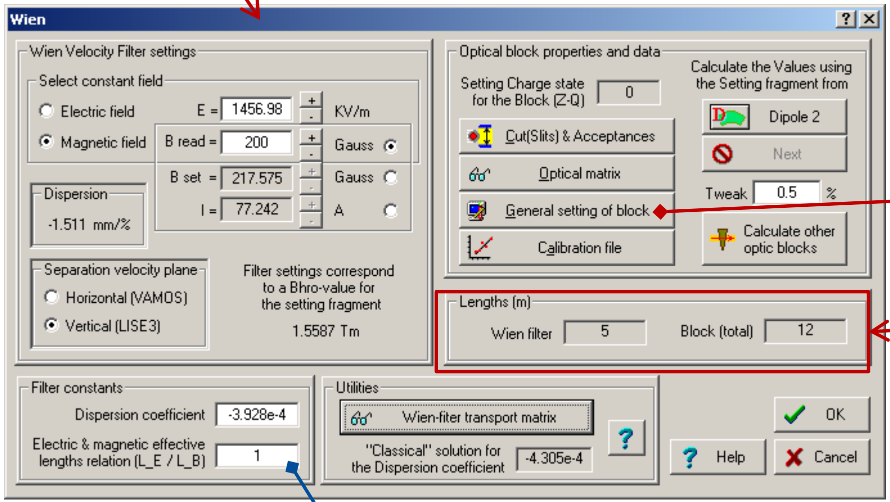
Dipole 2 — Brho 1.5582 Tm — -40 H +40

Wien — E 1459.5 KV/m — B 200 G — DL -1.23 mm/%

Final_Slits — slits







Wien Velocity Filter settings

Select constant field

○ Electric field E = 1456.98 KV/m

● Magnetic field B read = 200 Gauss ●

B set = 217.575 Gauss ○

I = 77.242 A ○

Dispersion -1.511 mm/%

Separation velocity plane

○ Horizontal (VAMOS)

● Vertical (LISE3)

Filter settings correspond to a Bhro-value for the setting fragment 1.5587 Tm

Optical block properties and data

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

Calculate the Values using the Setting fragment from: Dipole 2

Tweak 0.5 %

Lengths (m)

Wien filter 5 Block (total) 12

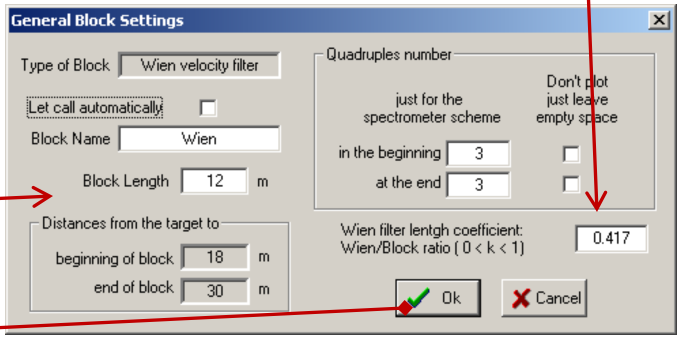
Filter constants

Dispersion coefficient -3.928e-4

Electric & magnetic effective lengths relation (L_E / L_B) 1

Utilities

"Classical" solution for the Dispersion coefficient -4.305e-4



Type of Block: Wien velocity filter

Let call automatically ☐

Block Name: Wien

Block Length 12 m

Distances from the target to

beginning of block 18 m

end of block 30 m

Quadruples number

	just for the spectrometer scheme	Don't plot just leave empty space
in the beginning	3	☐
at the end	3	☐

Wien filter lentgh coefficient: Wien/Block ratio (0 < k < 1) 0.417

Electric length

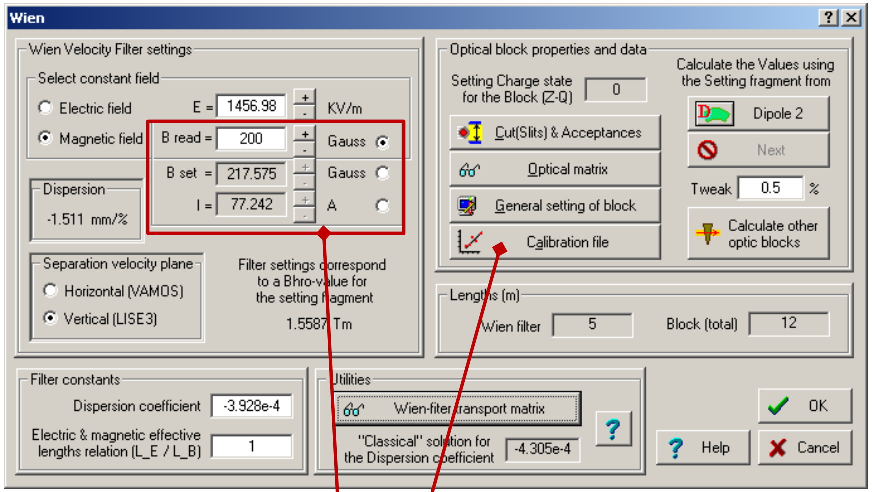
Magnetic length

Electric length: effective electric length of the filter taking into account the fringe fields.

Wien filter length *in LISE++* = **Magnetic length**

(effective magnetic length of the filter taking into account the fringe fields)

Setting Wien filter in LISE++: Magnetic field entry



Wien Velocity Filter settings

Select constant field

○ Electric field E = 1456.98 KV/m

● Magnetic field B read = 200 Gauss ●

B set = 217.575 Gauss ○

I = 77.242 A ○

Dispersion -1.511 mm/%

Separation velocity plane
○ Horizontal (VAMOS)
● Vertical (LISE3)

Filter settings correspond to a Bhro-value for the setting fragment 1.5587 Tm

Optical block properties and data

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

Calculate the Values using the Setting fragment from: Dipole 2

Tweak 0.5 %

Lengths (m): Wien filter 5; Block (total) 12

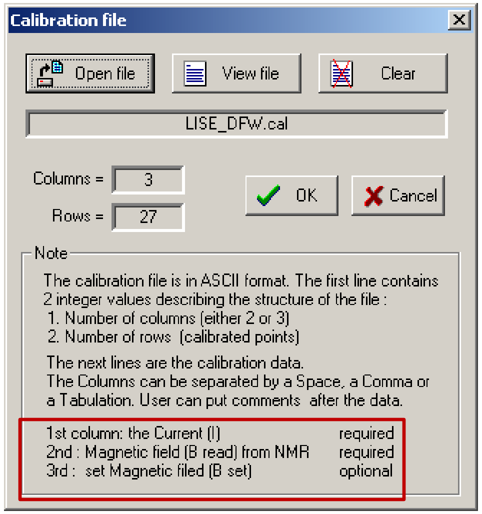
Filter constants

Dispersion coefficient -3.928e-4

Electric & magnetic effective lengths relation (L_E / L_B) 1

Utilities

"Classical" solution for the Dispersion coefficient -4.305e-4



LISE_DFW.cal

Columns = 3

Rows = 27

Note

The calibration file is in ASCII format. The first line contains 2 integer values describing the structure of the file :
1. Number of columns (either 2 or 3)
2. Number of rows (calibrated points)

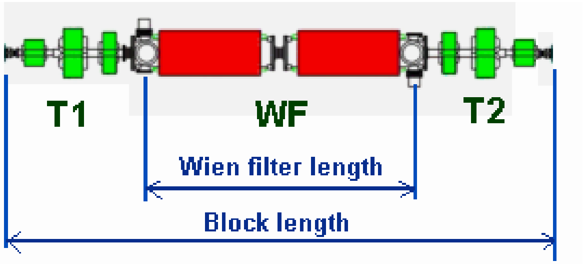
The next lines are the calibration data.
The Columns can be separated by a Space, a Comma or a Tabulation. User can put comments after the data.

1st column: the Current (I)	required
2nd : Magnetic field (B read) from NMR	required
3rd : set Magnetic filed (B set)	optional

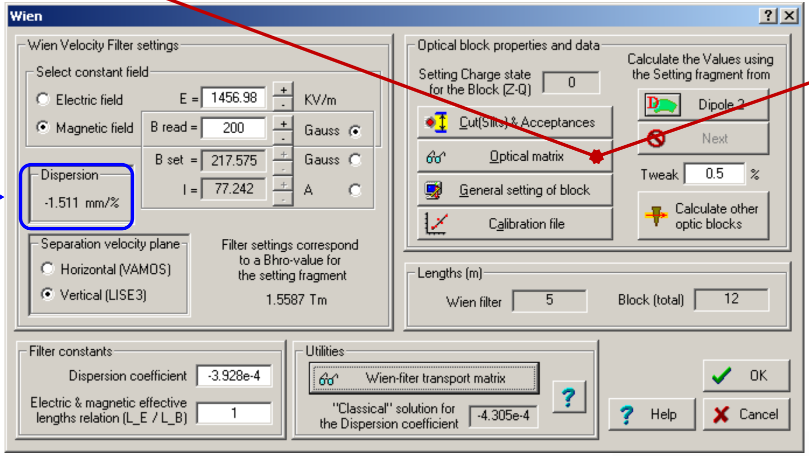
$$E = \beta \cdot v_c \cdot B \ / \ R_{L_E/L_B}$$

E	*electric field [in KV/m]*
β	*setting fragment velocity*
v_c	*speed of light [as 29.979 cm/ns]*
B	*magnetic filed [in Gauss]*
R_{L_E/L_B}	*effective electric & magnetic lengths ratio*

Optics : matrix of Wien filter block



optical matrix BLOCK = T2 * WF * T1


Wien

Wien Velocity Filter settings

Select constant field

- ○ Electric field E = 1456.98 KV/m
- ● Magnetic field

B read = 200 Gauss ●

B set = 217.575 Gauss ○

I = 77.242 A ○

Dispersion: -1.511 mm/%

Separation velocity plane

- ○ Horizontal (VAMOS)
- ● Vertical (LISE3)

Filter settings correspond to a Bhro-value for the setting fragment 1.5587 Tm

Optical block properties and data

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

Calculate the Values using the Setting fragment from: Dipole 2

Tweak 0.5 %

Lengths (m): Wien filter 5; Block (total) 12

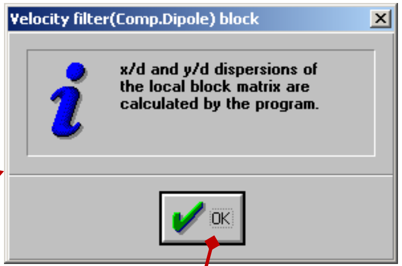
Filter constants

Dispersion coefficient: -3.928e-4

Electric & magnetic effective lengths relation (L_E / L_B): 1

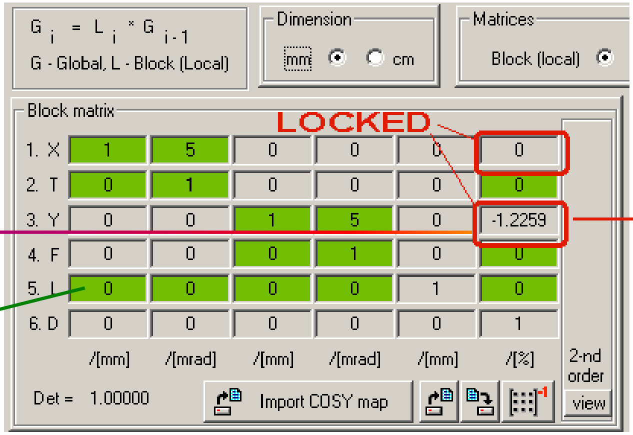
Utilities

"Classical" solution for the Dispersion coefficient: -4.305e-4


Velocity filter(Comp.Dipole) block

x/d and y/d dispersions of the local block matrix are calculated by the program.

LISE++ calculates automatically the dispersion for each ion based on filter E & B fields, ion velocity and dispersion coefficient


$G_i = L_i * G_{i-1}$

G - Global, L - Block (Local)

Dimension: mm ● cm ○

Matrices: Block (local) ●

Block matrix

LOCKED

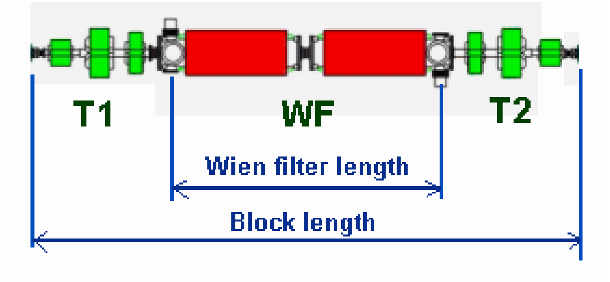
1. X	1	5	0	0	0	0
2. T	0	1	0	0	0	0
3. Y	0	0	1	5	0	-1.2259
4. F	0	0	0	1	0	0
5. L	0	0	0	0	1	0
6. D	0	0	0	0	0	1
	/[mm]	/[mrad]	/[mm]	/[mrad]	/[mm]	/[%]

Det = 1.00000

Y-selection in this example

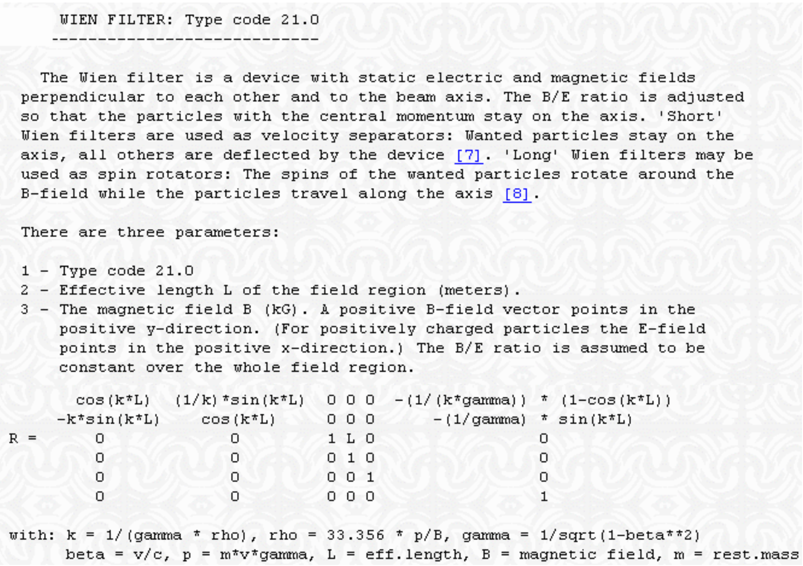
should be edited

Optics : Wien filter ("Transport" solution)



<u>optical matrix</u> BLOCK = T2 * WF * T1

http://people.web.psi.ch/rohrer_u/trancomp.htm



WIEN FILTER: Type code 21.0

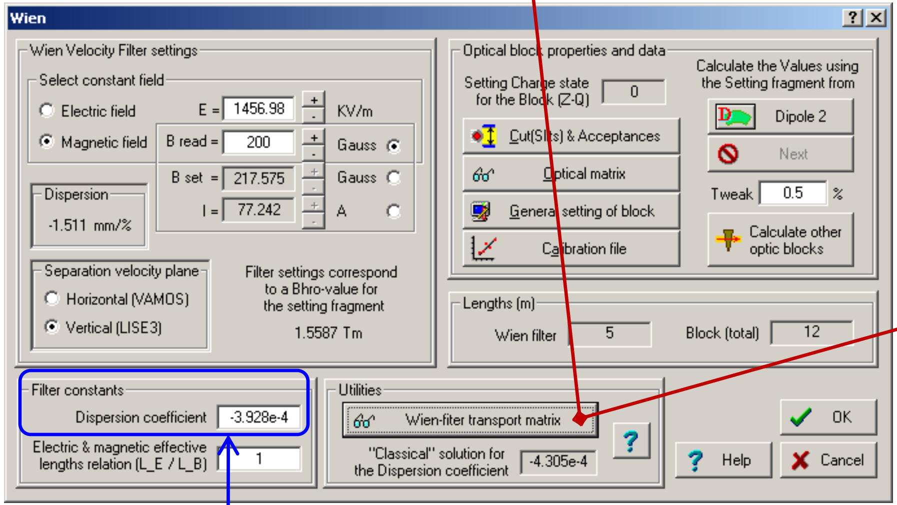
The Wien filter is a device with static electric and magnetic fields perpendicular to each other and to the beam axis. The B/E ratio is adjusted so that the particles with the central momentum stay on the axis. 'Short' Wien filters are used as velocity separators: Wanted particles stay on the axis, all others are deflected by the device [7]. 'Long' Wien filters may be used as spin rotators: The spins of the wanted particles rotate around the B-field while the particles travel along the axis [8].

There are three parameters:

1 - Type code 21.0
2 - Effective length L of the field region (meters).
3 - The magnetic field B (kG). A positive B-field vector points in the positive y-direction. (For positively charged particles the E-field points in the positive x-direction.) The B/E ratio is assumed to be constant over the whole field region.

```
      cos(k*L)   (1/k)*sin(k*L)   0 0 0  -(1/(k*gamma)) * (1-cos(k*L))
   -k*sin(k*L)      cos(k*L)      0 0 0      -(1/gamma) * sin(k*L)
R =     0              0          1 L 0                0
        0              0          0 1 0                0
        0              0          0 0 1                0
        0              0          0 0 0                1
```

with: k = 1/(gamma * rho), rho = 33.356 * p/B, gamma = 1/sqrt(1-beta**2)
beta = v/c, p = m*v*gamma, L = eff.length, B = magnetic field, m = rest.mass



Wien

Wien Velocity Filter settings

Select constant field
○ Electric field E = 1456.98 KV/m
● Magnetic field B read = 200 Gauss ●
B set = 217.575 Gauss ○
I = 77.242 A ○

Dispersion
-1.511 mm/%

Separation velocity plane
○ Horizontal (VAMOS)
● Vertical (LISE3)

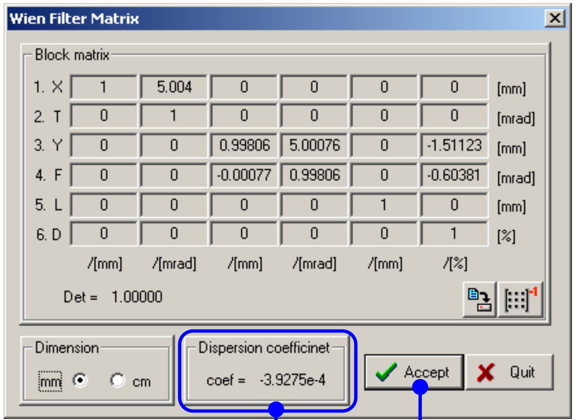
Filter settings correspond to a Bhro-value for the setting fragment
1.5587 Tm

Optical block properties and data
Setting Charge state for the Block (Z-Q) 0
Calculate the Values using the Setting fragment from
Tweak 0.5 %

Lengths (m)
Wien filter 5
Block (total) 12

Filter constants
Dispersion coefficient -3.928e-4
Electric & magnetic effective lengths relation (L_E / L_B) 1

Utilities
"Classical" solution for the Dispersion coefficient -4.305e-4



Wien Filter Matrix

Block matrix

1. X	1	5.004	0	0	0	0	[mm]
2. T	0	1	0	0	0	0	[mrad]
3. Y	0	0	0.99806	5.00076	0	-1.51123	[mm]
4. F	0	0	-0.00077	0.99806	0	-0.60381	[mrad]
5. L	0	0	0	0	1	0	[mm]
6. D	0	0	0	0	0	1	[%]
	/[mm]	/[mrad]	/[mm]	/[mrad]	/[mm]	/[%]	

Det = 1.00000

Dimension: mm ● ○ cm

Dispersion coefficinet
coef = -3.9275e-4

Recommendation to use experimental values or optical calculations for whole block to deduce the dispersion coefficient

Optics : Dispersion (“classical” approach)

“Classical” approach (L>>dx)

$t = L / \upsilon$

$F = q\,(\upsilon \cdot B - E)$

$dx = a \cdot t^2 / 2$

$a = F / M$

$dx = q\,(\upsilon \cdot B - E) \cdot [L / \upsilon]^2 / (2 \cdot M)$

$\upsilon = \upsilon_0 + \delta\upsilon$, where $\upsilon_0 = E / B$, then

$dx = q\,(E \cdot \delta\upsilon / \upsilon) \cdot [L / \upsilon]^2 / (2 \cdot M)$

$Disp = L^2 \cdot q \cdot E \cdot / (2 \cdot M\,\upsilon^2)$

$Disp = coef \cdot E \cdot / (\beta \cdot B\rho)$

Example

^{10}B (25 MeV/A)

B = 200 G

L = 5 m

“Classical” solution

Disp = -1.77 mm/%
Coef = -4.28e-4

“Transport” solution

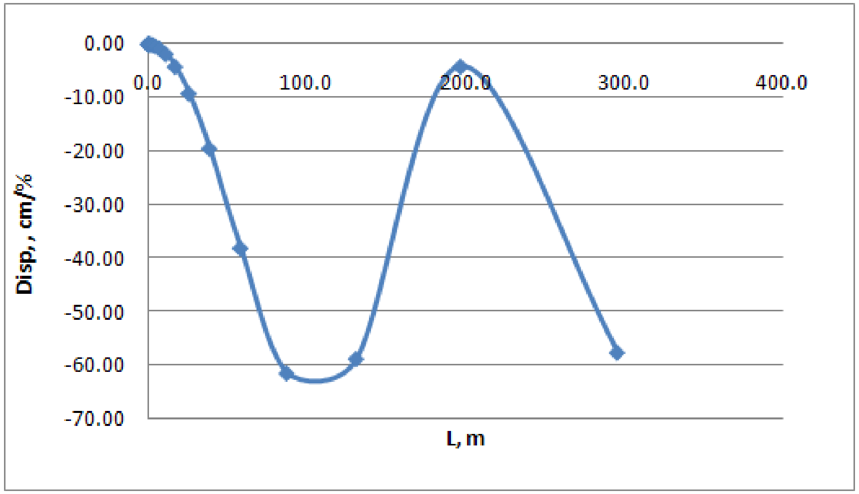
Disp = -1.64 mm/%
Coef = -3.96e-4

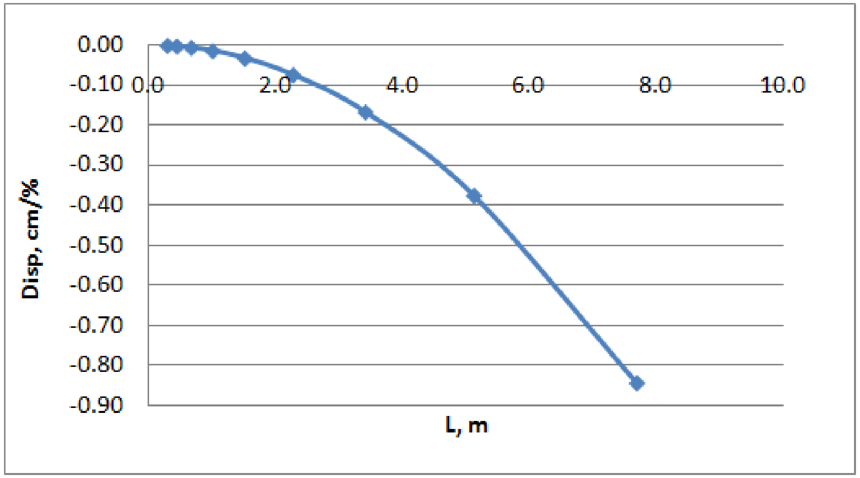
Optics : Dispersion

$$D_{(A,Q)} = coef \cdot E \;/\; [\, B\rho_{\,(A,Q)} \cdot \beta_{\,(A,Q)} \,]$$

$D_{(A,Q)}$	*fragment (A,Q) dispersion [in mm/%]*
coef	*dispersion coefficient (~ L^2)*
E	*electric field [in KV/m]*
$B\rho$	*magnetic rigidity corresponding to this part of the spectrometer [in Tm]*
$\beta_{(A,Q)}$	*fragment (A,Q) velocity*

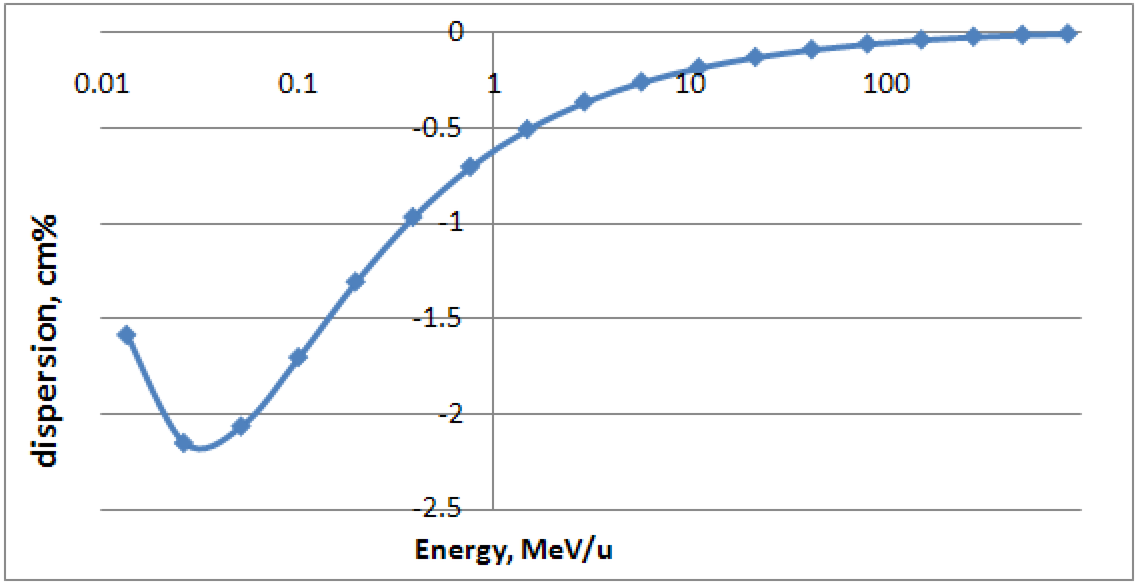
“Transport” solution





^{10}B (21.2 MeV/u) , B = 400 G (E=25.2 KV/cm)

Optics : Dispersion (B=const, L=const)

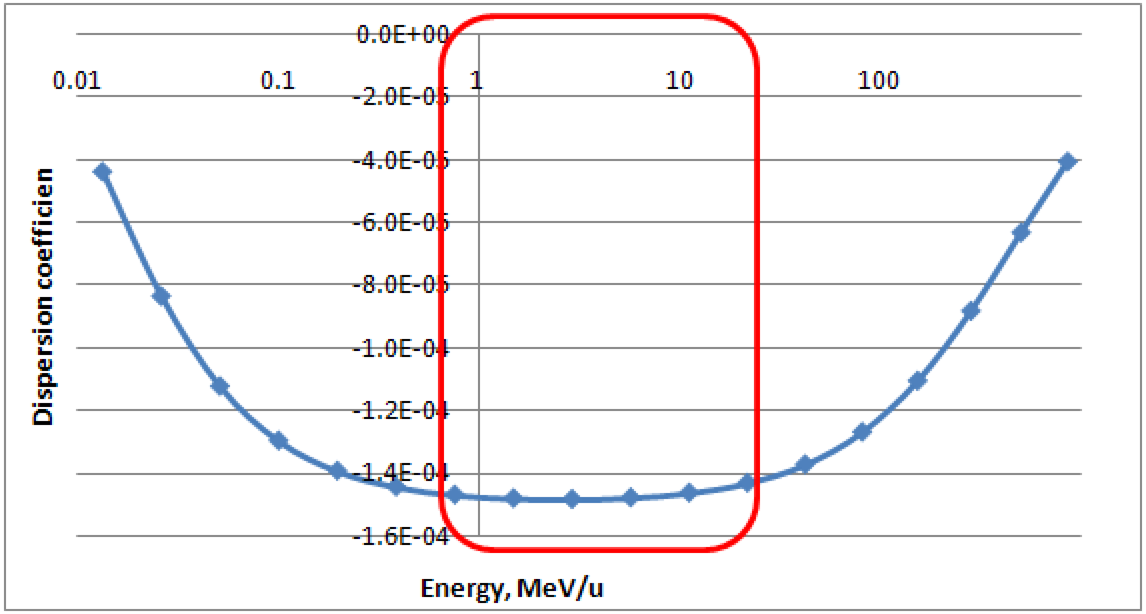


“Transport” solution

^{10}B (**** MeV/u)

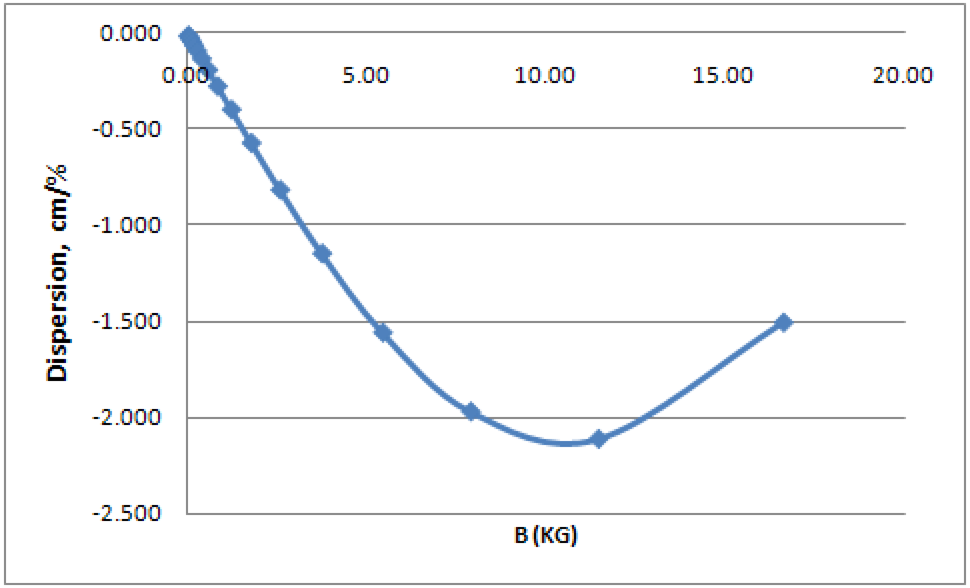
B = 400 G

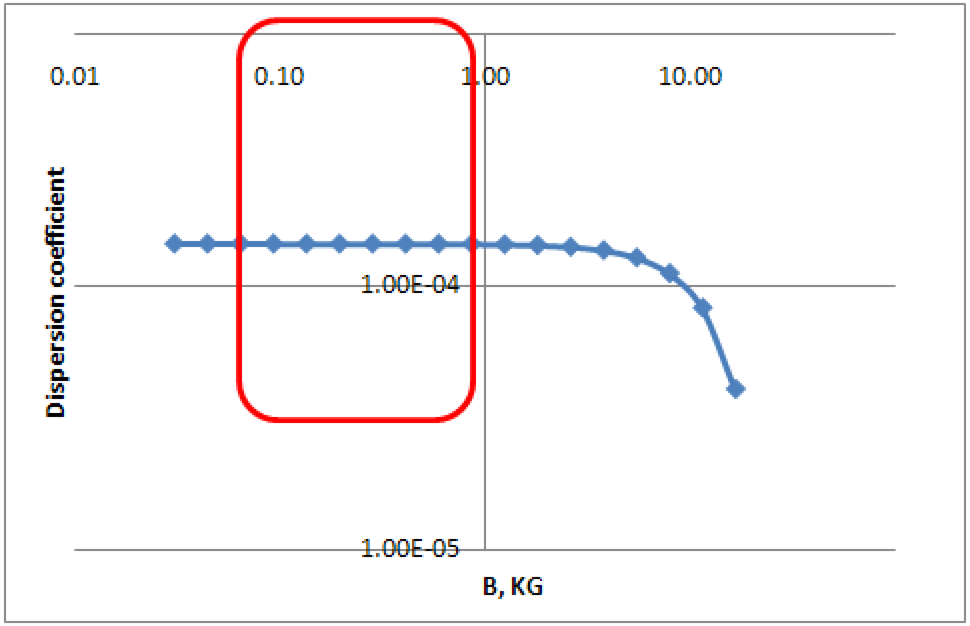
L = 3 m



The dispersion coefficient is almost constant in the energy region of interest

Optics : Dispersion (Energy=const, L=const)





"Transport" solution

^{10}B (21.2 MeV/u)

B = *** G

L = 3 m

The dispersion coefficient is constant with magnetic field change

Revision of the Wien filter dispersion

LISE++ (version 8.5.24 and older) was using the setting fragment dispersion to calculate transmission of other ions.

Now, LISE++ (version 8.5.43) calculates a dispersion for each ion, so called “floating” optical matrix. It has been realized for the Distribution and Monte Carlo methods, Corrections have been done as well for the Ellipse and Pseudo Monte Carlo plots.

Therefore LISE fragment-separator configuration files should be revised too to have correct lengths and dispersion coefficients.

See example http://groups.nscl.msu.edu/lise/8_5/wien/wien_test.lpp

For simulations shown in the next slides following files have been used

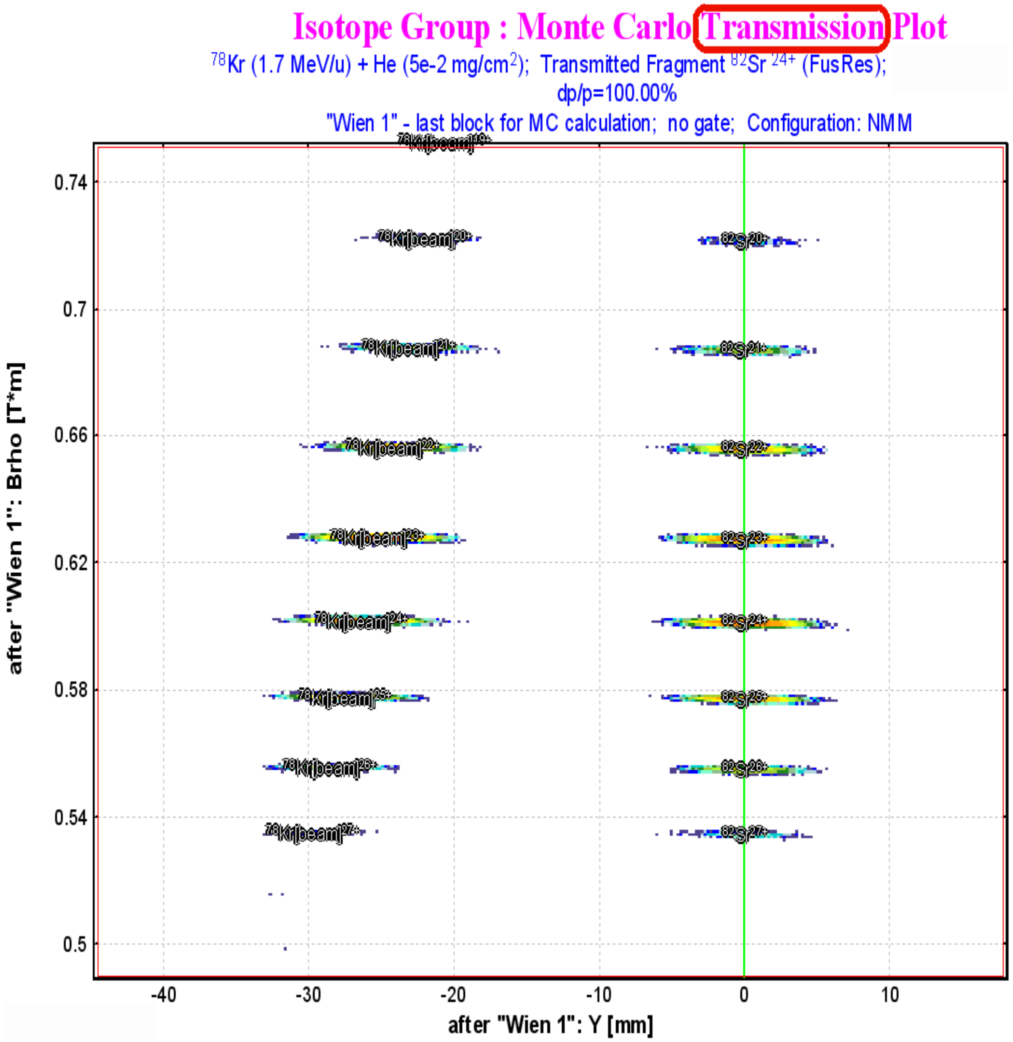
http://groups.nscl.msu.edu/lise/8_5/wien/78Kr.lpp (from Pedja)

http://groups.nscl.msu.edu/lise/8_5/wien/78Kr2.lpp (thin target, small initial emittance)

Read the new LISE++ option, which has been used to simulate several isotopes in the MC mode

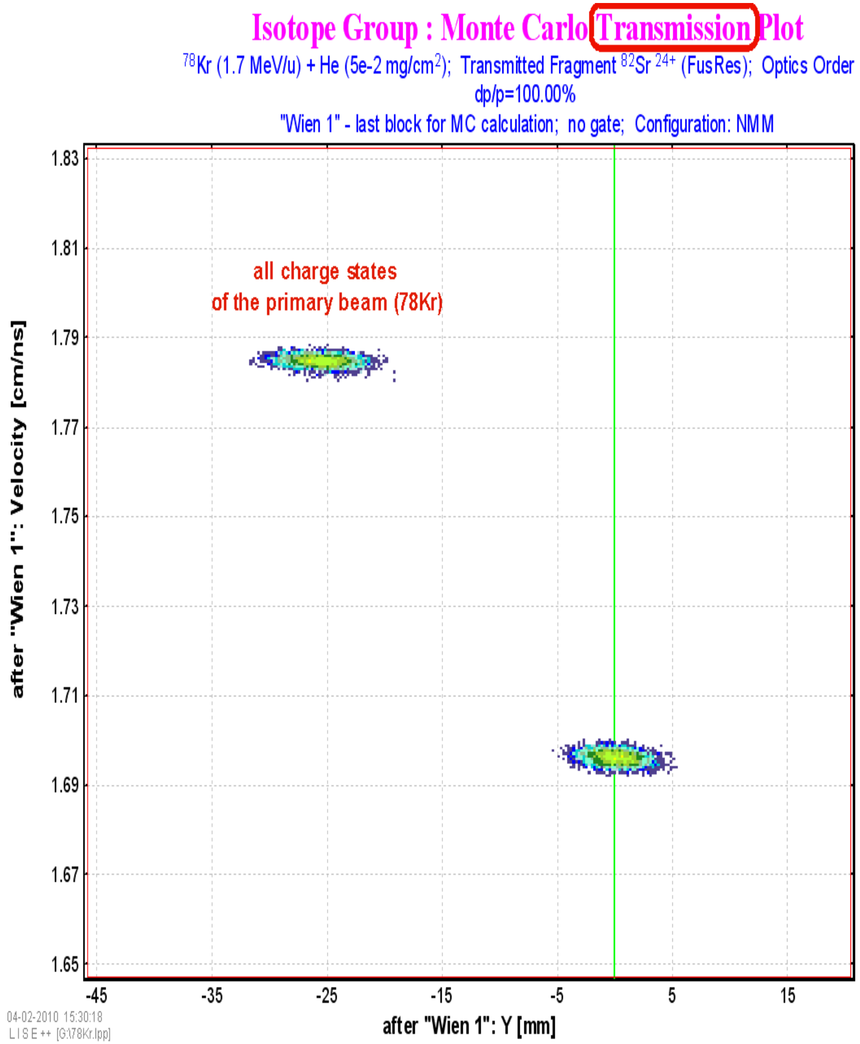
http://groups.nscl.msu.edu/lise/8_5/8_5_034__MC_isotope_group.pdf

Wien-filter selection : Monte Carlo method



Isotope Group : Monte Carlo Transmission Plot

^{78}Kr (1.7 MeV/u) + He (5e-2 mg/cm^2); Transmitted Fragment ^{82}Sr $^{24+}$ (FusRes);
dp/p=100.00%
"Wien 1" - last block for MC calculation; no gate; Configuration: NMM



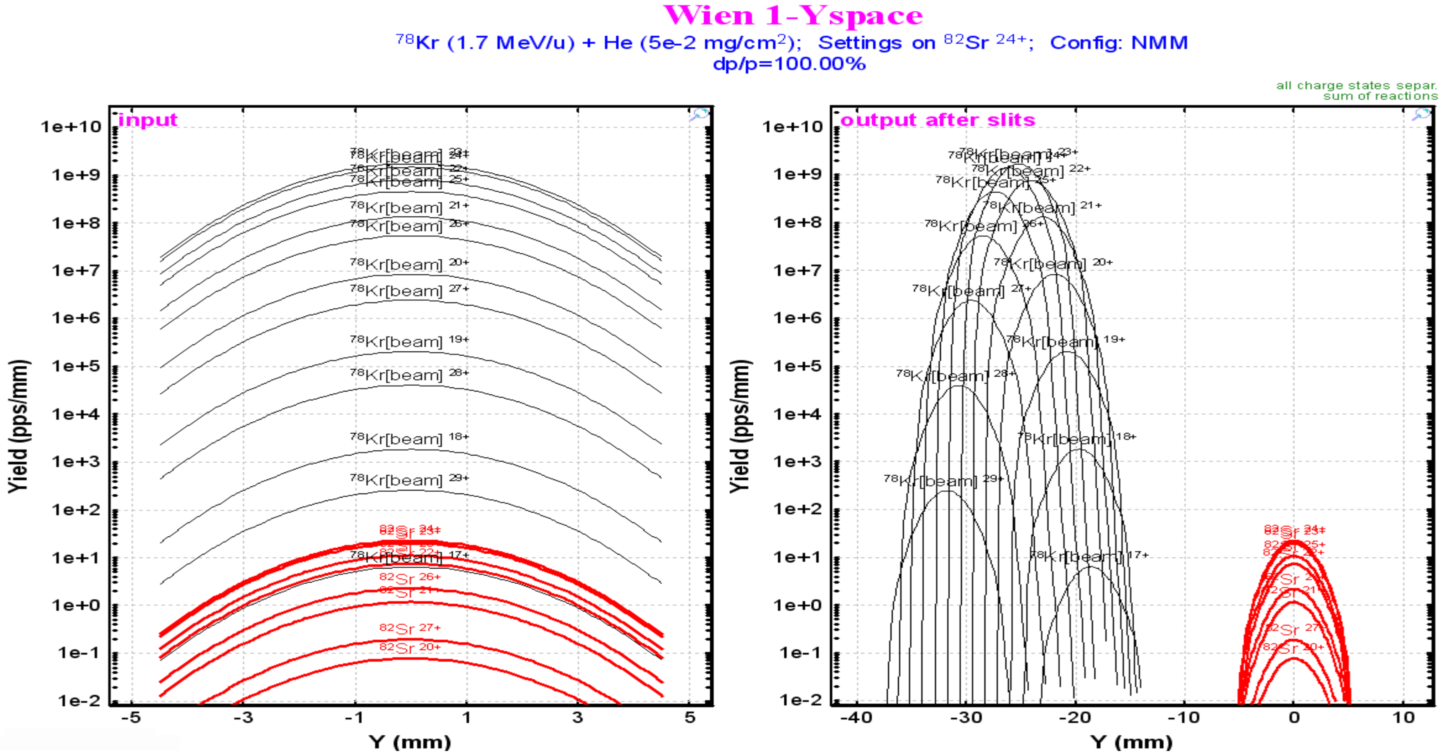
Isotope Group : Monte Carlo Transmission Plot

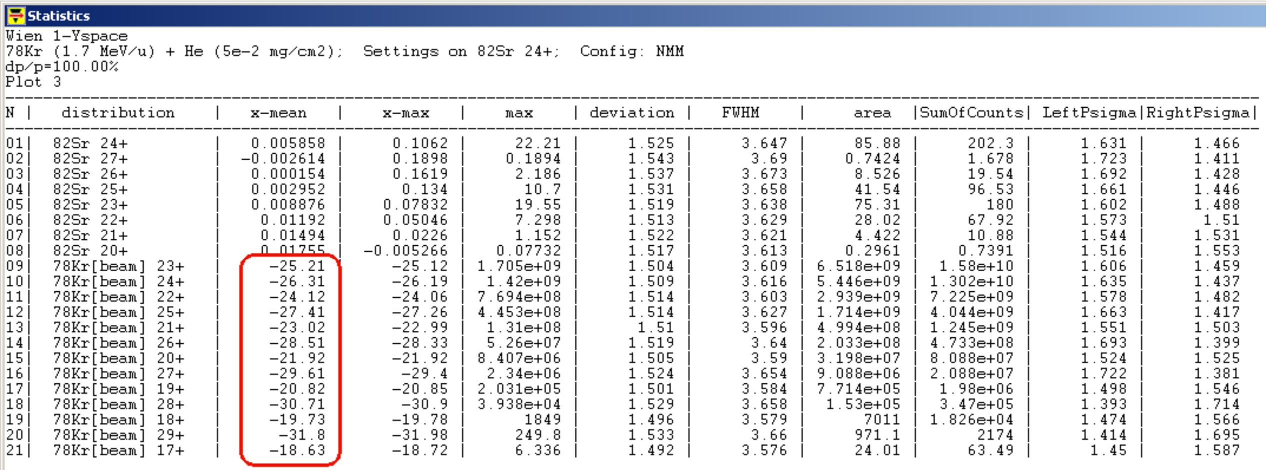
^{78}Kr (1.7 MeV/u) + He (5e-2 mg/cm^2); Transmitted Fragment ^{82}Sr $^{24+}$ (FusRes); Optics Order
dp/p=100.00%
"Wien 1" - last block for MC calculation; no gate; Configuration: NMM

all charge states
of the primary beam (78Kr)

04-02-2010 15:30:18
LISE++ [G:\78Kr.lpp]

Wien-filter selection : Distribution method





```
Wien 1-Yspace
78Kr (1.7 MeV/u) + He (5e-2 mg/cm2);  Settings on 82Sr 24+;  Config: NMM
dp/p=100.00%
Plot 3
------------------------------------------------------------------------------------------------------------------------------------
N |   distribution          |   x-mean    |    x-max    |     max     | deviation |   FWHM      |      area   |SumOfCounts| LeftPsigma|RightPsigma|
------------------------------------------------------------------------------------------------------------------------------------
01|   82Sr 24+              |   0.005858  |     0.1062  |      22.21  |    1.525  |     3.647   |      85.88  |     202.3 |     1.631 |     1.466
02|   82Sr 27+              |  -0.002614  |     0.1898  |     0.1894  |    1.543  |      3.69   |     0.7424  |     1.678 |     1.723 |     1.411
03|   82Sr 26+              |   0.000154  |     0.1619  |      2.186  |    1.537  |     3.673   |      8.526  |     19.54 |     1.692 |     1.428
04|   82Sr 25+              |   0.002952  |      0.134  |       10.7  |    1.531  |     3.658   |      41.54  |     96.53 |     1.661 |     1.446
05|   82Sr 23+              |   0.008876  |    0.07832  |      19.55  |    1.519  |     3.638   |      75.31  |       180 |     1.602 |     1.488
06|   82Sr 22+              |    0.01192  |    0.05046  |      7.298  |    1.513  |     3.629   |      28.02  |     67.92 |     1.573 |      1.51
07|   82Sr 21+              |    0.01494  |     0.0226  |      1.152  |    1.522  |     3.621   |      4.422  |     10.88 |     1.544 |     1.531
08|   82Sr 20+              |    0.01755  |  -0.005266  |    0.07732  |    1.517  |     3.613   |     0.2961  |    0.7391 |     1.516 |     1.553
09|   78Kr[beam] 23+        |     -25.21  |     -25.12  |  1.705e+09  |    1.504  |     3.609   |  6.518e+09  |  1.58e+10 |     1.606 |     1.459
10|   78Kr[beam] 24+        |     -26.31  |     -26.19  |   1.42e+09  |    1.509  |     3.616   |  5.446e+09  | 1.302e+10 |     1.635 |     1.437
11|   78Kr[beam] 22+        |     -24.12  |     -24.06  |  7.694e+08  |    1.514  |     3.603   |  2.939e+09  | 7.225e+09 |     1.578 |     1.482
12|   78Kr[beam] 25+        |     -27.41  |     -27.26  |  4.453e+08  |    1.514  |     3.627   |  1.714e+09  | 4.044e+09 |     1.663 |     1.417
13|   78Kr[beam] 21+        |     -23.02  |     -22.99  |   1.31e+08  |     1.51  |     3.596   |  4.994e+08  | 1.245e+09 |     1.551 |     1.503
14|   78Kr[beam] 26+        |     -28.51  |     -28.33  |   5.26e+07  |    1.519  |      3.64   |  2.033e+08  | 4.733e+08 |     1.693 |     1.399
15|   78Kr[beam] 20+        |     -21.92  |     -21.92  |  8.407e+06  |    1.505  |      3.59   |  3.198e+07  | 8.088e+07 |     1.524 |     1.525
16|   78Kr[beam] 27+        |     -29.61  |      -29.4  |   2.34e+06  |    1.524  |     3.654   |  9.088e+06  | 2.088e+07 |     1.722 |     1.381
17|   78Kr[beam] 19+        |     -20.82  |     -20.85  |  2.031e+05  |    1.501  |     3.584   |  7.714e+05  |  1.98e+06 |     1.498 |     1.546
18|   78Kr[beam] 28+        |     -30.71  |      -30.9  |  3.938e+04  |    1.529  |     3.658   |   1.53e+05  |  3.47e+05 |     1.393 |     1.714
19|   78Kr[beam] 18+        |     -19.73  |     -19.78  |       1849  |    1.496  |     3.579   |       7011  | 1.826e+04 |     1.474 |     1.566
20|   78Kr[beam] 29+        |      -31.8  |     -31.98  |      249.8  |    1.533  |      3.66   |      971.1  |      2174 |     1.414 |     1.695
21|   78Kr[beam] 17+        |     -18.63  |     -18.72  |      6.336  |    1.492  |     3.576   |      24.01  |     63.49 |      1.45 |     1.587
```

Wien-filter selection : Ellipse and Pseudo MC plots