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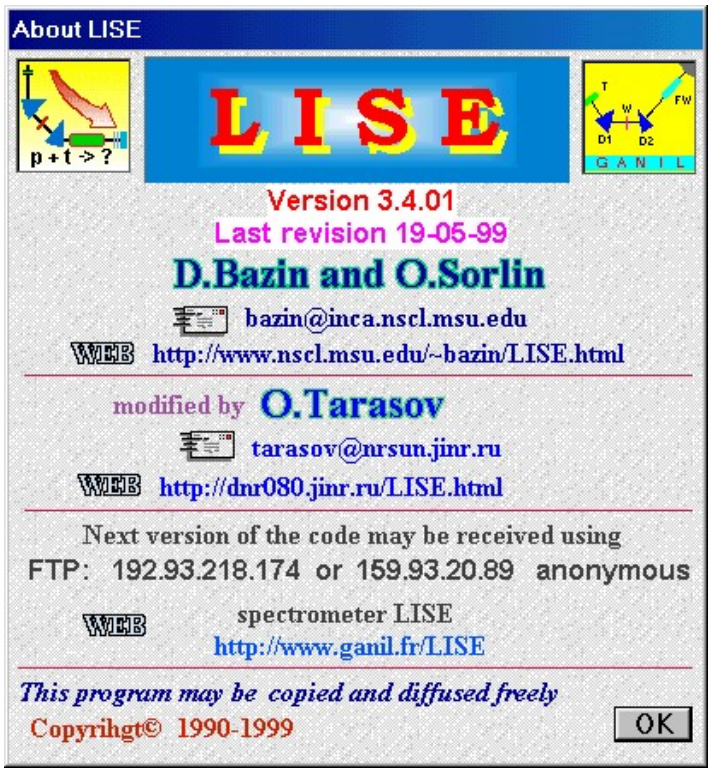

CONTENTS

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1. Introduction (brief description of previous series)

The program [1] called after the spectrometer “LISE” [2] has been developed in GANIL (Caen, France) to calculate the transmission and yields of fragments produced and collected in an achromatic spectrometer. This code allows one to simulate an experiment, beginning with the parameters of the reaction mechanism and ending with the registration of products selected by a spectrometer. The program allows one to quickly optimize the parameters of the spectrometer before or during the experiment. It also makes it possible to estimate and work in conditions of maximum output of the studied reaction products and their unambiguous identification.

Wedge and Wien filter selections are also included in the program. In-built Energy loss, Time-of-Flight, Position, Angular, Charge, Cross-Section distribution plots and dE-E, dE-TOF and Z-A/Q two-dimensional plots allow to visualize the results of the program calculations.

The application of transport integrals [3] lies at the basis of the program's fast calculations for estimating the temporal evolution of phase-space distributions.

Recently, within the framework of the Dubna-GANIL collaboration, the program has undergone a number of serious changes and has been adapted to the environment of "Windows":

- Being adapted to the 32-bit operating system “Windows,” the program has received an improved interface with which the user gets all the capabilities of the given operating system (work in several windows, printer drivers, etc.);
- The concept of a “dead” layer of a target has been incorporated (that is very important for work with thick targets producing light exotic nuclei);
- There is now an opportunity to choose the parameterization of fragmentation cross-sections [4,5] and model the charge distributions of ions [6];
- A number of the graphic subroutines have been changed, while some discrepancies have been corrected;
- A number of utilities for taking into account optimum values (target thickness, beam energy, magnetic rigidity) have been added for the given spectrometer parameters;
- In-built information support helps the user quickly become familiar with the program;
- In-built database of nuclides (Mass excess, Binding energy, β-decay energy, S_{2n} , S_{2p} , Q_{α} , S_n , S_p , $T_{1/2}$) [7,8] has been added. It is possible to see the transmission of a given isotope, its characteristics, and its energy after the second dipole by clicking on an isotope of interest in the table of nuclides with the right mouse button;
- The optical parameters of the spectrometer are entered as transport matrices [9] that are more convenient. Initial angular, spatial, and energy beam emittances are used;
- The new dipole after the Wien filter of velocities has been added (see §2. Dipole “D6).

A more detailed description of the program, as well as all information about changes and new versions of the program, can be found at the WWW reference: http://http:"//lise.nscl.msu.edu.html.

It is possible to obtain this program and the latest MS-DOS version using FTP at the address below (user: *anonymous*):

- 192.93.218.174 (at Caen);
- 159.93.20.89 (at Dubna).

You can send all your comments and remarks to the address indicated in the program.

2. Dipole "D6" after the Wien Filter

D6 The dipole "D6" is placed on the turning platform in a vertical plane behind the Wien Filter. The dipole radius is determined as $R \cong Lm / \theta$, where θ is the platform turning angle. The angle may be varied from 0 up to 23 degrees. This dipole (denoted as DSMW in Fig.1) serves as the fourth selection on the mass and charge of the nucleus (A/Q). Selection by this dipole, as with the Wien filter, is performed in the vertical plane.

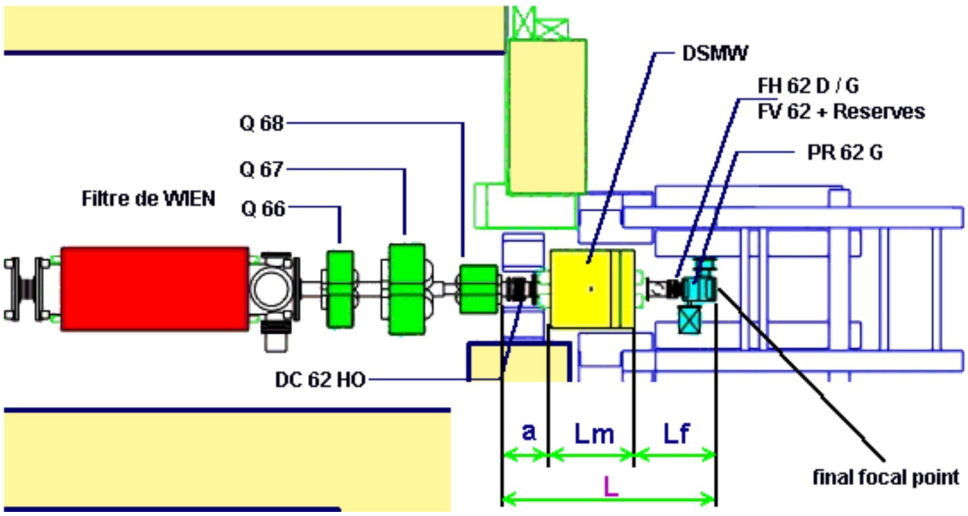

Fig.1

2.1. Angle of platform

The platform turning angle is calculated from the optical conditions and, as much as possible, compensates the filter velocity dispersion so as to obtain only A/Q dispersion at the focal point after the turning dipole. The Wien filter optical structure assumes that six focusing conditions must be fulfilled to achieve the best matching at the detection location. With the addition of the turning dipole D6, these conditions must be preserved. To find the turning angle, it is necessary to solve the following equation (given by R.Anne) arising from the optical conditions:

$$\cos(\theta)\cdot D_F + R\cdot\sin(\theta)\cdot DS_F - R\cdot(1-\cos(\theta)) - Lf\cdot D_F\frac{1}{R}\cdot\sin(\theta) + Lf\cdot\cos(\theta)\cdot DS_F - Lf\cdot\sin(\theta) = 0 \quad , [1]$$

where D_F is the dispersion [mm/%] from Wien-filter calculations, DS_F is the angular dispersion [mrad/%], R is the radius of the dipole, and Lf is the distance (see Fig.1) from the dipole to the final focal point ($L = a + Lm + Lf$ =2 meters (default), where Lm = 0.8m and Lf = 0.8m). The solution of the above equation, assuming a negligible contribution of DS_F, is

$$\theta = \frac{-Lm + \sqrt{Lm^2 + \frac{8\cdot D_F^2\cdot Lm}{Lm+Lf}}}{2\cdot D_F}\ [rad] \quad . [2]$$

2.2. Image shift

The image shift of nuclei in the final focal plane can be roughly determined in the following way:

$$shift_{FD} = shift_{filter} + shift_{D6}\,, \quad [3]$$

where

$$shift_{filter} = D_{filter} \cdot \frac{\nu - \nu_0}{\nu_0}\,, \quad [4]$$

$$shift_{D6} = D_{D6} \cdot \frac{\Delta B\rho}{B\rho}, \quad [5]$$

D_{filter} is the filter dispersion [mm/%] and $D_{D6}$is the dipole dispersion [mm/%].

Using equation

$$B\rho = c\ \frac{A}{Q}\ \frac{\beta}{\sqrt{1-\beta^2}}, \quad [6]$$

we find that

$$\frac{\Delta B\rho(A/Q,\beta)}{B\rho} = \frac{\frac{\partial B\rho}{\partial(A/Q)} \cdot \Delta(A/Q)}{B\rho} + \frac{\frac{\partial B\rho}{\partial\beta} \cdot \Delta\beta}{B\rho} \quad [7]$$

and then

$$\frac{\Delta B\rho(A/Q,\beta)}{B\rho} = \frac{\Delta(A/Q)}{A/Q} + \frac{\Delta\beta}{\beta \cdot (1-\beta^2)}. \quad [8]$$

Taking into account that the sum

$$\frac{\Delta\beta_{D6}}{\beta_{D6} \cdot (1-\beta_{D6}^2)} \cdot D_{D6} + \frac{\Delta\beta_{filter}}{\beta_{filter}} \cdot D_{filter} \quad [9]$$

is close to 0 (in the case of combined operation, $\beta_{D6} = \beta_{filter}$ must hold), one can estimate the image shift as

$$shift_{FD} \cong \frac{\Delta(A/Q)}{A/Q} \cdot D_{D6} \quad [10]$$

or, in other words, only the A/Q selection takes place.

Some possible combinations are considered in the program :

- $D_{D6} = 0$ (the dipole is absent)
- $D_{filter} = 0$ (the velocity filter is absent)
- $D_{D6} \neq 0$, $D_{filter} \neq 0$, $D_{filter} \neq D_{D6}$ (it means that the angle of platform turning is not correct)
- $B\rho_2 \neq B\rho_{D6}$

2.3. Image size

The image size (distribution) defined in the program LISE is the result of the convolution of two distributions P_Y and $P_{Y'}$:

$$P_Y^* = \overline{P}_Y \otimes \overline{P}_{\delta/Y}, \text{[11]}$$

where

1. P_Y - The image in the vertical focal plane before the Wien filter, multiplied by the vertical magnification (y/y) of the filter-dipole system.
2. $P_{\delta/Y}$ - the contribution of the momentum distribution due to dispersion in the final focal plane, which can be determined as

$$P_{\delta/Y} = \frac{PM - B\rho_2}{B\rho_2} \cdot D_{FD}, \text{[12]}$$

where PM is the momentum distribution of a nucleus before the Wien filter in $T \cdot m$, D_{FD} is the total dispersion of the filter-dipole system ("fd-system") [mm/%], $B\rho_2$ is the magnetic rigidity of the second dipole.

Repeating all the steps as in the previous section, it is possible to conclude that the use of the "fd-system" assumes that $P_{\delta/Y}$ vanishes because as it was mentioned before the sum (equation 9) is close to 0 and the value Δ (A/Q) for an isotope relative to itself is equal to 0. It means that the final Y-image will be narrower, thus providing a better resolution than in the simple case of the velocity filter only. Hence the second distribution is taken as the δ -function in order to obtain $P_Y^* = P_Y$ as a result of convolution.

After this consideration it is possible to compare the “fd-system” with an ordinary velocity filter (see Table 1) : application of the “fd-system” provides better results for smaller object size and wider momentum distribution.

Table 1.

Spectrometer	SISSI + degrader in LISE	SISSI + degrader in ALPHA	LISE	LISE2000
Y-object size, mm	0.2	0.2	1.5	1.5
magnification (Y/Y) 1	15.91	12.18	4.26	3.14
magnification (Y/Y) 2	0.43	3.44	0.43	0.60
magnification (Y/Y) Wien	1	1	1	1
Y-object size final, mm	1.37	8.37	2.76	2.83
Acceptance, %	0.5	0.5	2.5	5
Dispersion W, mm/%	3	3	3	3
Acc*DispW, mm	1.5	1.5	7.5	15
Y-image final, mm	2.0	8.5	8.0	15.3
Y-image / Y-object	**1.5**	**1.0**	**2.9**	**5.4**

2.4. Separation with the Dipole D6

The LISE standard configuration was chosen in order to compare different modes of selection. These experimental settings (beam, target, wedge, slits) are given below.

```
Projectile : 40Ar 18+ at 50 MeV/u - Intensity : 1000 enA
Target : Ta Thickness : 100 mg/cm2 (60.241 microns)
Wedge : Al Thickness : 100 mg/cm2 (370.37 microns)
Settings calculated on 36Ar 18+ 18+
Brho1=1.9467 Tm Brho2=1.7067 Tm (B1=0.7487 T B2=0.8521 T)
Wien filter : E=3500.0 kV/m B=417.9618 G Disp=3.725 mm/% Magn=1
D6 : B=0.6069 T Angle=15.87 deg Disp=3.725 mm/%
Acceptances :
Maximum momentum acceptance : +/- 2.50 %
Target : Theta : +/- 17.45 mrad Phi : +/- 17.45 mrad
Wedge : Theta : +/- 20.27 mrad Phi : +/- 6.00 mrad
Slits :
X,Y Slits before target (Collimator) mm +/- : 15 15
X,Y Slits intermediate (Momentum sel.) mm +/- : 45 20
% in Brho +/- : 2.50
```

```
X,Y Slits first focus(Wedge selection) mm +/- : 10 10
Second image slits (Wien selection) mm +/- : 7
```

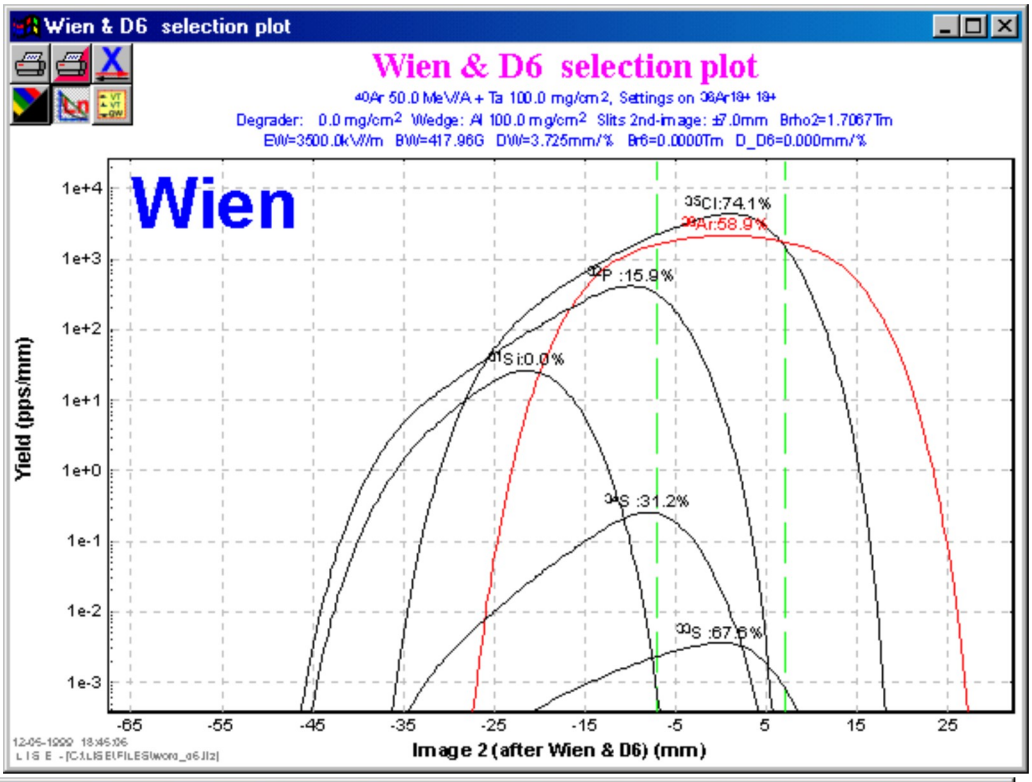

Fig.2.

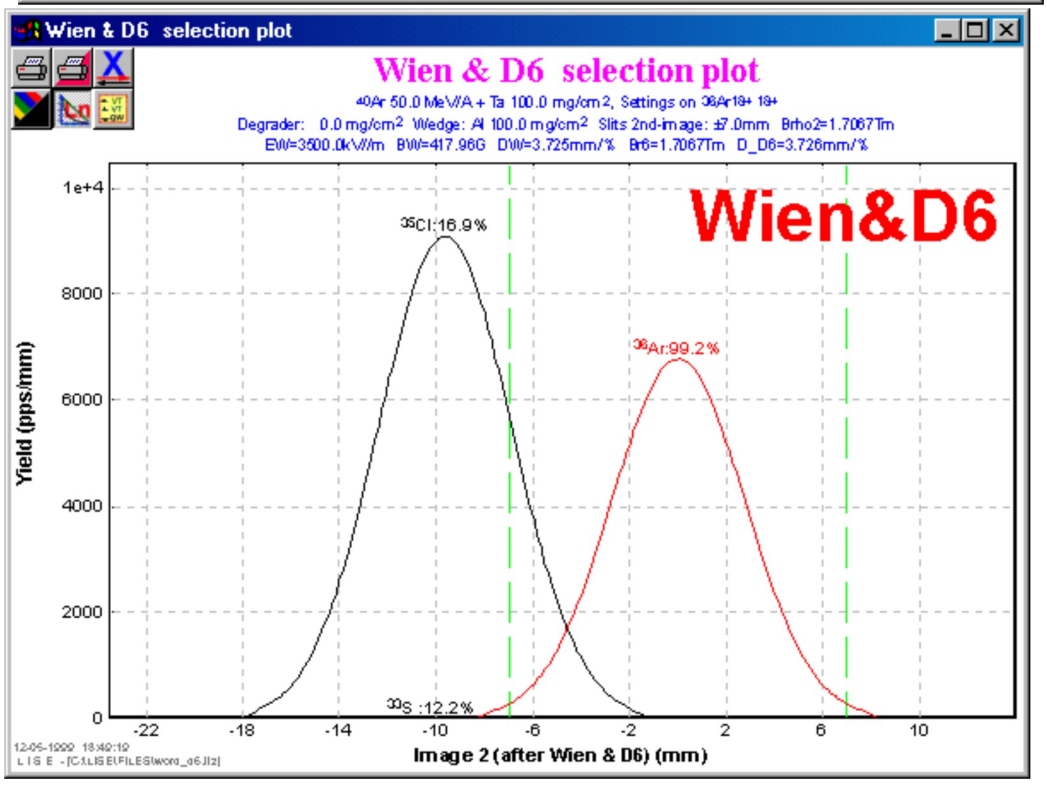

Fig.3.

Table 2.

	Mode	Selection	N° nuclei	Σ , pps	^{36}Ar rate	^{36}Ar rate / Σ
1	First dipole	v· A/Q	116	2.4e+6	7.0e+4	2.9%
2	1 + Wedge	$A^{2.5}/Z^{1.5}$	8	1.1e+5	4.6e+4	41.8%

3	2 + Wien Filter	v	6	7.5e+4	2.8e+4	37.3%
4	3 + D6-dipole	A/Q	3	5.7e+4	4.6e+4	80.7%

The advantage of using all 4 selections follows clearly from Table 2. In this case, the purification is 30 times better than after the first selection, but the ^{36}Ar rate is lower by only a factor of 1.5. Figures 2 and 3 show vertical spatial distributions in the final focal plane for selections by the velocity filter and the "fd-system". The contribution of momentum distribution into the vertical image due to the existence of non-zero velocity dispersion in the mode with the velocity filter only (Fig.2) makes the image wider as compared to the "fd-system" that was already discussed in "§2.3. Image size".

2.5. The program "LISE" for the new spectrometer VAMOS

VAMOS [10] is a collaboration to build a large acceptance spectrometer for identifying products of reactions induced by the Systeme de Production d'Ions Radioactifs et d'Acceleration en Ligne (SPIRAL) facility at the Grand Accelerateur National d'Ions Lourds (GANIL).

The QQFD-spectrometer VAMOS has the following main properties and characteristics:

- A very large geometrical acceptance, of the order of 100 msr, that is equivalent to an angular acceptance of ±160 mrad ;
- A nominal dispersion of about 2.5 cm/% at the focal plane ;
- A momentum acceptance of the order of ± 5% ;
- A velocity filter function.

The new version of " LISE " may be useful for estimating transmission and viewing different plots of spatial distributions. The spectrometer VAMOS is developed for the energy region from 4 to 20 MeV/A where for example the parameterization of reaction cross-sections does not work. Due to this fact, the program unfortunately cannot be used with all its possibilities. It is necessary to examine the procedures of reaction mechanisms more accurately. The configuration file allowing one to view spatial distributions in the focal plane of the spectrometer is given below.

```
Version 3.4
[general]
File = C:\LISE\config\VAMOS.lcf
Date = 12-05-1999
Time = 13:41:31
Title = VAMOS
[object]
X Slits before target = 10 (±)mm ; hor.slit width before target to collimate a beam
Y Slits before target = 10 (±)mm ; ver.slit width before target to collimate a beam
X Slits intermediate = 100 (±)mm ; hor.slit width at the dispersive focal plane
Y Slits intermediate = 10 (±)mm ; ver.slit width at the dispersive focal plane
X Slits first focus = 10 (±)mm ; hor.slit width at the first focal point /after wedge/
Y Slits first focus = 10 (±)mm ; ver.slit width at the first focal point /after wedge/
Slits second focus = 10 (±)mm ; ver.slit width at the second focal point /after Wien/
[acceptances]
Maximal momentum accept = 5 (±)% ; upper limit for the setting of the slits
Theta target acceptance = 160 (±)mrad ; angular target horiz.acceptance
Theta wedge acceptance = 200 (±)mrad ; angular wedge horiz.acceptance
Phi target acceptance = 160 (±)mrad ; angular target vert.acceptance
Phi wedge acceptance = 200 (±)mrad ; angular wedge vert.acceptance
[optics]
BX = 1.5 (±)mm ; one-half the horizontal beam extent (x)
BT = 3.3 (±)mrad ; one-half the horizontal beam divergence(x')
BY = 1.5 (±)mm ; one-half the vertical beam extent (y)
BF = 3.3 (±)mrad ; one-half the vertical beam divergence (y')
BD = 0.1 (±)% ; one-half of the momentum spread (dp/p)
Ra1 = 2.6 m ; Curvature radius of first dipole
Ra2 = 2.003 m ; Curvature radius of second dipole
L target-wedge = 0 m ; Object - DispFocPlane
L wedge-detector#1 = 0 m ; DispFocPlane-AchrFinalPlane
M1X = 1 ; X Magnification target -> wedge
D1X = 10 mm/% ; X dispersion target -> wedge
M1T = 1 ; theta magnific. target -> wedge
D1T = 0 mrad/% ; theta dispers. target -> wedge
ThX = 0.1 mrad/mm ; theta/x coef. target -> wedge
M1Y = 1 ; Y Magnification target -> wedge
PhY = 0.1 mrad/mm ; fi/y coef. target -> wedge
M1P = 1 ; fi magnificat. target -> wedge
M2X = 1 ; X Magnification wedge -> focal
D2X = -10 mm/% ; X dispersion wedge -> focal
M2T = 1 ; theta magnific. wedge -> focal
D2T = -1 mrad/% ; theta dispers. wedge -> focal
T2X = 0.1 mrad/mm ; theta/x coef. wedge -> focal
M2Y = 1 ; Y Magnification wedge -> focal
P2Y = 0.1 mrad/mm ; fi/y coef. wedge -> focal
M2P = 1 ; fi magnificat. wedge -> focal
Angle = 0 mrad ; beam respect to the spectrometer axis
[wien_filter]
```

```
Wien filter = Enabled ; Disabled & Enabled
E_F = 2000 kV/m ; electric field
B_F = 478.861416 G ; magnetic field
DiC = 1.3856e-3 mm/% ; dispersion coefficient
LenE = 1 m ; effective electric length
LenB = 1 m ; effective magnetic length
Red = 1 ; Real/Red field
Mag = 1 ; Magnification
```

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3. New features of the version 3.4

3.1. Physical calculator

Very often it is necessary for the User to perform a fast transformation from one physical value to another while working with the program. The dialog “GOODIES” allows one to obtain a calculated correlated value only for a given Bρ -value obtained for a setting fragment. However, what if the User needs to know (for example) a range in some material for an energy unconnected with the given settings? The new version of the code “LISE” allows one to solve this problem. The new dialog “Physical calculator” permits one to perform calculations of correlated values immediately and independently of calculations for a setting fragment. By clicking on any radio button, the User may choose the respective form to enter a physical value in order to obtain other correlated values. For example, User may input the Bρ -value for ^{36}Ar (see Fig.4) and get all correlated values including the range in the given material and the energy loss for the chosen thickness, or, by typing the residual energy of ^{22}Al after the material (Si 100 mg/cm^2 in Fig.4), one can recalculate initial energy of a nucleus before the material and other correlated values as shown in Fig.5.

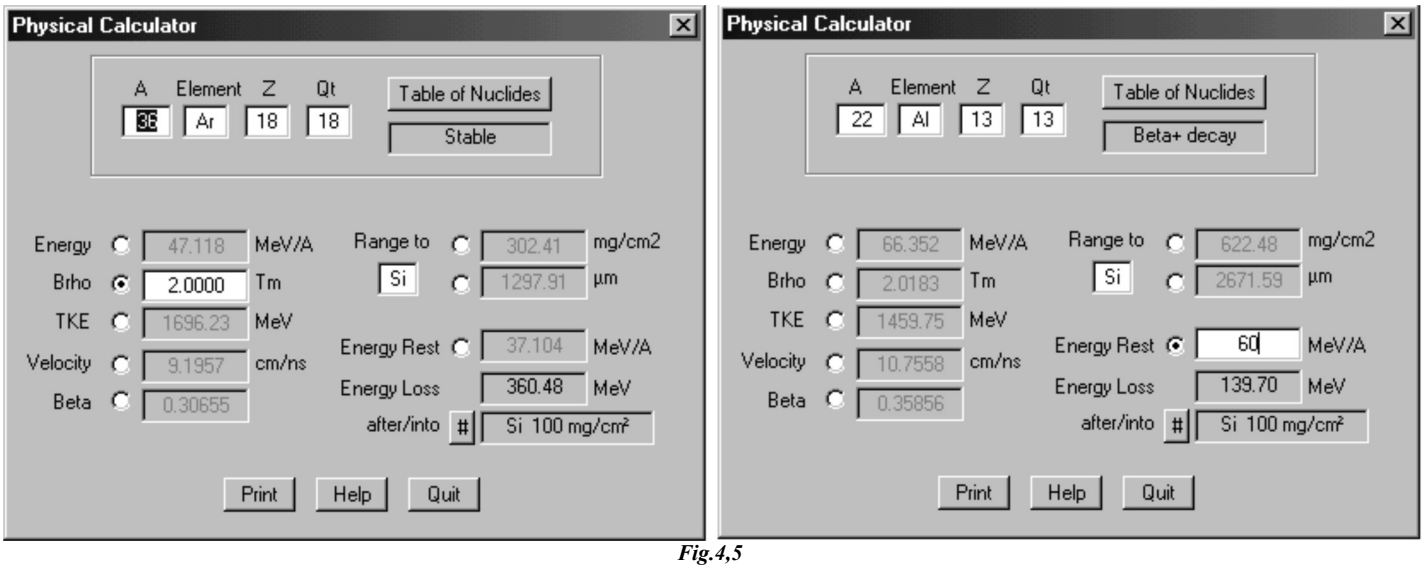


Fig.4,5

The eight correlated values of a nucleus (which is entered in the upper part of the dialog) are included in the “Physical calculator”:

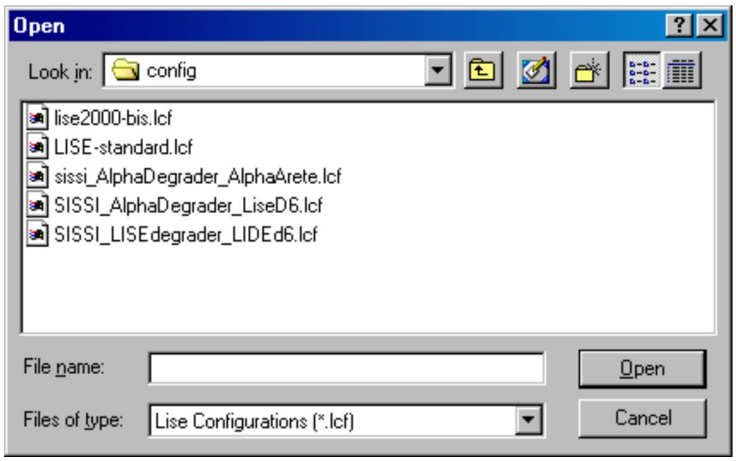
- Energy [MeV per nucleon] ;
- Bρ -value [Tm] (for calculations, Qt - the ionic charge - is used) ;
- TKE is the Total Kinetic Energy [MeV] ;
- Velocity [cm/ns] and beta ;
- Range in the specific material chosen by User. The range may be entered in mg/cm^2 as well as in microns.
- Residual energy of a nucleus [MeV per nucleon] after the material defined by the User. For convenience the energy loss [MeV] in the material is shown in the static window below.

Correlated values of time of flight and Wien magnetic field may possibly also be added to the Physical calculator. All this makes the Physical Calculator a powerful tool, allowing the User to quickly obtain a physical value of interest from other correlated values.

3.2. Configuration file

Two types of files were used in the previous version of the program: LISE files (extension LIZ) and Result files (extension RES). The settings data could be recovered only from LISE files. If the User wanted to repeat old settings for a new file, it was first necessary to find the corresponding LISE file with the same setup configuration and then save it with a new name. In the new version there is an additional possibility to save and extract settings to and from a new kind of file called the Configuration file. The User has access to these files via the menu “File -> Configuration”. These files contain only some sections from a standard LISE file :

- general (creation date, description);
- object (size of all slits);
- acceptances;
- optics;
- Wien-filter.



Configuration files (file extension “LCF”) are placed by default in the directory “CONFIG” which is a subdirectory of the LISE directory (see Fig.6). The listing of the configuration file “VAMOS.lcf” has already been included in the section "2.5. The program “LISE” for the new spectrometer VAMOS".

On the basis of the optical matrices and physical characteristics of setups given in Ref.[11,10], different setups for the LISE program were put into configuration files. User may find these configuration files in the distributed version “lise34.zip” :

- LISEstandard.lcf - *the standard spectrometer LISE configuration. A target is placed into the LISE target box ;*
- LISE2000-bis.lcf - *the new project of the spectrometer LISE with large angular and momentum acceptances, maximal magnetic rigidity of the second dipole is 4.3 Tm . A target is placed into the LISE target box ;*
- SISSI_AlphaDegrader_AlphaArete.lcf - *a target is placed into the device **SISSI**, an achromatic degrader in the dispersive focal plane of the spectrometer **Alpha**. The final focus plane is “**ARETE**” (the Alpha spectrometer outlet) ;*
- SISSI_AlphaDegrader_LISEd6.lcf - *a target is placed into the device **SISSI**, an achromatic degrader in the dispersive focal plane of the spectrometer **Alpha**. The final focus plane is the hall “**D6**” of the spectrometer **LISE** ;*
- SISSI_LISEdegrader_LISEd6.lcf - *a target is placed into the device **SISSI**, an achromatic degrader in the dispersive focal plane of the spectrometer **LISE**. The final focus plane is the hall “**D6**” of the spectrometer **LISE**;*
- VAMOS.lcf - *this configuration has been already discussed in “§2.5. The program “LISE” for the new spectrometer VAMOS”.*

Using this new feature, the User may call these configuration files to estimate which setup is more favorable for given experimental settings (beam, target, degrader, wedge, Bρ -values and setting fragments). The experiment parameters will not be changed, while the acceptances, optics, slits, and velocity-filter coefficients will be taken from a configuration file.

3.3. Angle for Thickness

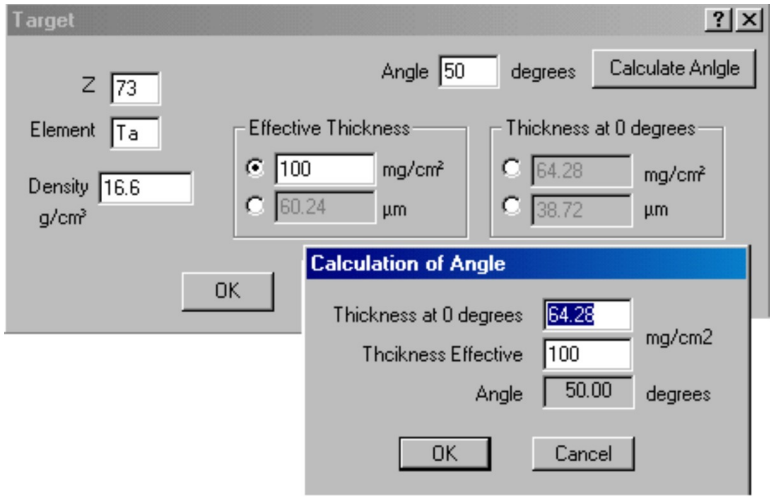
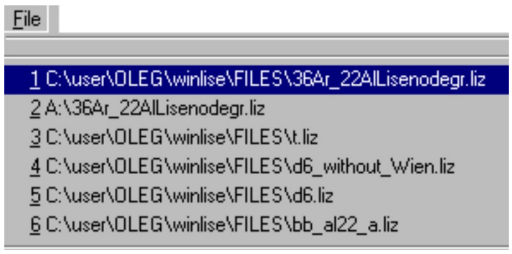


Fig.7.

F T D W M A physicist may vary the target thickness by changing the angle of the target placed in the target box of the SISSI device or the LISE spectrometer. Sometimes it is necessary to calculate and enter the value of the angle in the experiment. In the new version of the code, the User can change the angle of a target (wedge, degrader, materials). There is a possibility to calculate each of the three values from the other two known ones : Effective thickness, thickness at 0 degrees, or turning angle (see Fig.7). For example, if User knows the effective target thickness and the thickness at 0 degrees he can simply click on the button “Calculate Angle ” to get the angle value as shown in Fig.7. User may input the material thickness using two dimensions : mg/cm^2 or microns.

3.4. List of recently used files

To open a document recently used by the User, it is necessary to click its name at the bottom of the File menu, where the list of recently used documents is placed.



3.5. Calculation of Q-ground value for binary reaction

In the new version, the User may see the Q-value of a reaction at the bottom of the window “ Statistics ” (this window appears when the User clicks on an isotope of interest in the table of nuclides with the right button of the mouse). The Q-value is calculated from the assumption that the reaction has two nuclei as a result. The first nucleus is the nucleus chosen by User, the second one is calculated as the residual from “ Projectile + Target - Fragment of Interest ”. Therefore, the Q-value is estimated as:

$$Q = (ME_{projectile} + ME_{target}) - (ME_{fragment} + ME_{residual}) \text{ , [13]}$$

where *ME* is the mass excess from the database built into the program. The database uses the recommended values proposed by G.Audi and A.H.Wapstra [7].

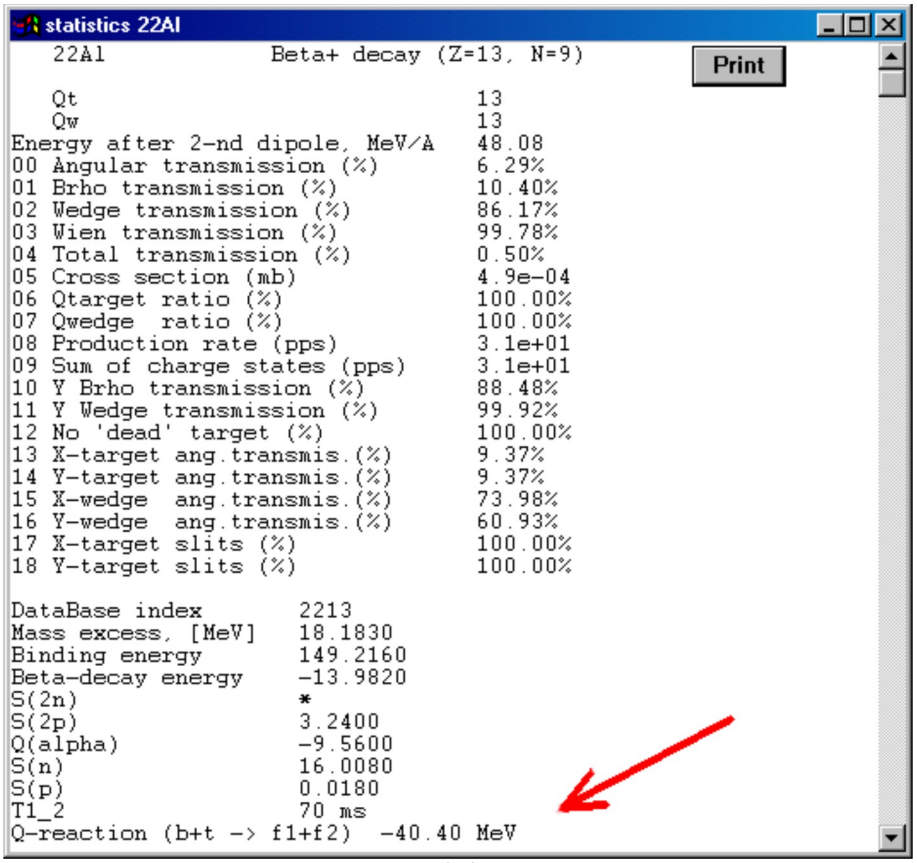


Fig.8 .

3.6. Chromatic mode (Dispersion ≠ 0)

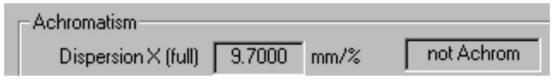
Since its first version, the program has been adapted to operate only in the achromatic mode. The focal plane of the second section being achromatic, there is no momentum dependence of the final horizontal position (as well as vertical). In the new version, the assumption that the full momentum dispersion is not equal to 0 has been included. The User may observe this assumption on the Wedge image (X) plot in the first focal plane. This assumption is fulfilled because the selection by the velocity filter and the dipole "D6" takes place in the Y-plane. Using this new mode, the User may visualize the images and obtain a transmission not only for the "ideal" case of an achromatic spectrometer.

The code calculates full momentum and angular dispersions on the basis of the two transport matrices input into the program for both parts of the spectrometer, as follows:

$$\left(\frac{x}{\delta}\right)_G = \left(\frac{x}{\delta}\right)_1\left(\frac{x}{x}\right)_2 + \left(\frac{x}{\delta}\right)_2 \quad [mm/\%], \ [14]$$

$$\left(\frac{\theta}{\delta}\right)_G = \left(\frac{x}{\delta}\right)_1\left(\frac{\theta}{x}\right)_2 + \left(\frac{\theta}{\delta}\right)_1\left(\frac{\theta}{\theta}\right)_2 + \left(\frac{\theta}{\delta}\right)_2 \quad [mrad/\%] \ . \ [15]$$

The code always accepts the angular achromatism at the second focal point, though User may observe in the dialog "Optics" a nonzero value of the full angular dispersion from Equation 15. User may see the calculated value of the full momentum dispersion in the dialog "Optics" as well as in the StatusBar at the bottom of the code screen.



Figures 9 and 10 demonstrate the new possibility. Three distributions on the Wedge selection plot are presented in Fig.9 for the achromatic case as it was in previous versions. The distributions of the same nuclei as in Fig.9 are shown in Fig.10, but for this case the global momentum dispersion is equal to 9.7 mm/%. It is clearly apparent that, in the chromatic case, the distributions are wider and the transmission is not equal to 100%. Peak shifts in the distributions of ^{35,37}Ar as well as shapes of these distributions are

explained by a non-optimal Bρ value for these nuclei, as demonstrated for the ^{36}Ar isotope (see the Brho Selection plot in Fig.11). The low energy part of the ^{37}Ar distribution and the high energy part of the ^{35}Ar distribution have been cut by the momentum slits. Their momentum distributions are more similar to a triangle, whereas the ^{36}Ar distribution presents itself as a symmetrically cut Gaussian. The convolution of these distributions with the object distributions gives the result shown in Fig.10.

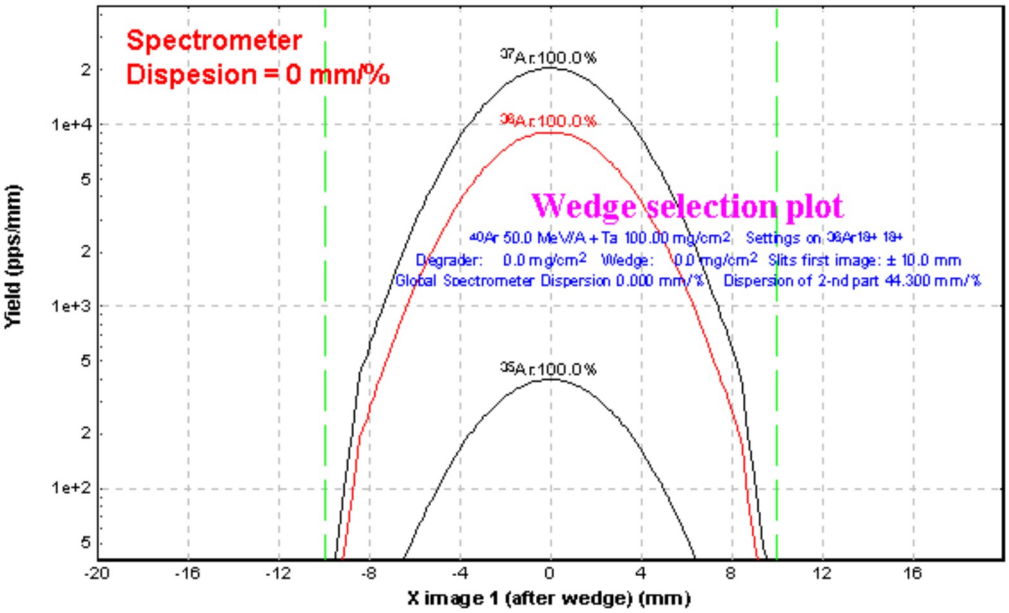


Fig.09.

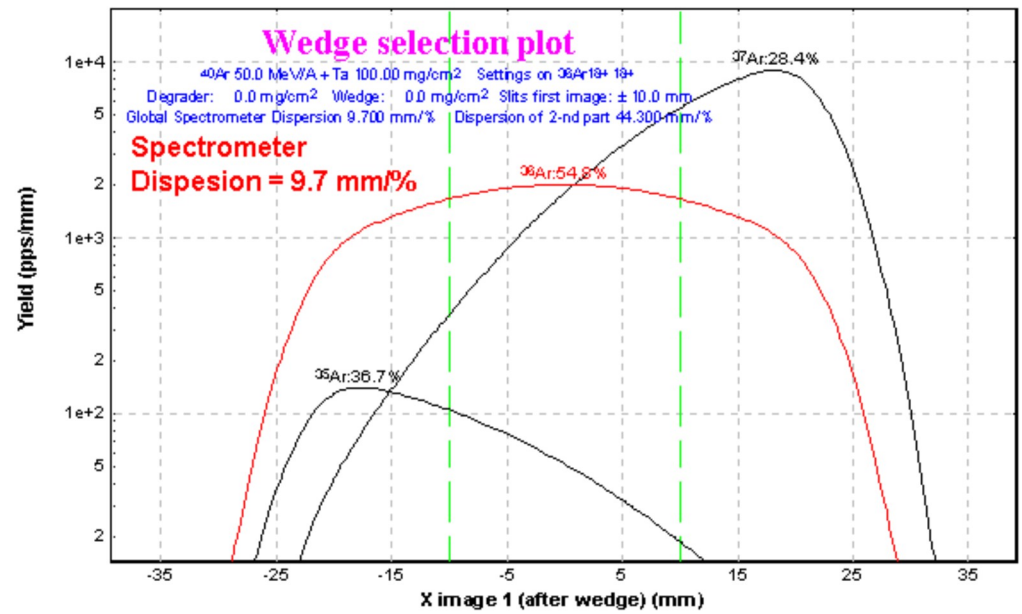
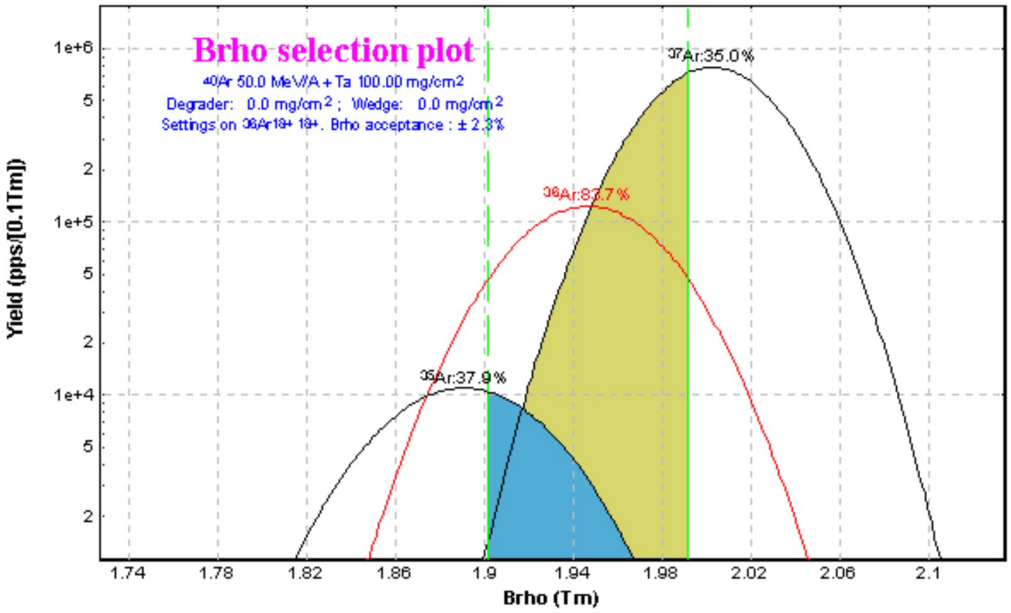


Fig.10.

Fig.11.



---

4. Development

4.1. Results file

The Results file has not been changed since its DOS version 2.5, and consequently, in versions 3.0-3.3.05, it does not reflect all parameters needed by the User ("D6"-dipole parameters, applied methods of the cross-section parameterization and the ionic charge state distributions, target angle). In the new version the Results file has taken on a more readable form, and all values needed for further work of User with this file have been included.

```
LISE CALCULATIONS Version 3.4
File : C:\user\OLEG\winlise\FILES\36Ar_22AlLisenodegr.liz
Date : 5/19/1999 Time : 9:13:01
Title : 22Al
Projectile : 36Ar 18+ at 94.4 MeV/u - Intensity : 1000 enA
Target : Be Thickness : 537.95 mg/cm2 (2907.84 microns)
Wedge : Be Thickness : 196.47 mg/cm2 (1062 microns)
Material(s) :
#1 : Si Thickness : 69.9 mg/cm2 (300 microns)
#2 : Si Thickness : 69.9 mg/cm2 (300 microns)
#4 : Si Thickness : 116.5 mg/cm2 (500 microns)
#5 : Si Thickness : 116.5 mg/cm2 (500 microns)
#6 : Si Thickness : 1398 mg/cm2 (6000 microns)
Settings calculated on 22Al 13+ 13+
Brho1=1.9530 Tm Brho2=1.7100 Tm (B1=0.7512 T B2=0.8537 T)
Wien filter : E=3500.0 kV/m B=331.8000 G Disp=3.184 mm/% Magn=1
D6 : B=0.5354 T Angle=13.97 deg Disp=3.185 mm/%
Mechanism: Vopt/Vbeam=1.000 Sigma0=90.0 MeV/c SigmaD=200.0 MeV/c
Methods: Cross Section=0 Charge states=0
Acceptances :
Maximum momentum acceptance : +/- 2.50 %
Target : Theta : +/- 17.45 mrad Phi : +/- 17.45 mrad
Wedge : Theta : +/- 20.26 mrad Phi : +/- 6.00 mrad
Slits :
X,Y Slits before target (Collimator) mm +/- : 15 15
X,Y Slits intermediate (Momentum sel.) mm +/- : 8.6 10
% in Brho +/- : 0.50
X,Y Slits first focus(Wedge selection) mm +/- : 7 10
Second image slits (Wien selection) mm +/- : 5
Beam emittance (+/-): 1.5 mm 3.3 mrad 1.5 mm 3.3 mrad 0.1 %
Beam angle on target : 0 mrad
OPTICS ([mm],[mrad]):
Target - DispFocalPlane(Wedge) DispFocalPlane(Wedge)-First image
-0.783 * * * 17.3 -2.5607 * * * 44.3
0.267 -1.284 * * 3.51 0.4 -0.389 * * -5.56
* * -4.26 * * * * -0.432 * *
* * -0.858 -0.273 * * * -0.32 -2.4 *

TRANSMISSION AND RATE CALCULATIONS
A Z |Qt |Qw | Ang. | Brho |Wedge |WienD6|Y&C&DT| Total | Cross | Rate | Qt | Qw
| | |Trans.|Trans.|Trans.|Trans.|Trans.| Trans.|Section| | |
| | | (%) | (%) | (%) | (%) | (%) | (%) | (mb) | (pps) | (%) | (%)
-----|---|---|------|------|------|------|------|-------|-------|-------|------|-----
23Si| | | 6.534| 4.692| 85.05| 2.641| 88.41| 0.0061|3.3e-06| 0.0025| |
22Al| | | 6.291| 10.40| 86.17| 99.78| 88.41| 0.4972|0.00049| 31| |
21Mg| | | 6.018| 4.905| 84.89| 0.921| 88.41| 0.0020| 0.029| 7.5| |
================================================================================
```

```
ALMOST : 38 pps
```

4.2. New parameterization

The code used three in-built parameterizations of cross-sections based on EPAX [4]. The new parameterization EPAX 2.13 has been kindly presented by B.Blank and K.Summerer for the new LISE-version. This new approximation shows very good agreement in cross-section estimation for proton-rich fragments, while for the super-neutron-rich isotopes located far from the beam [12] the discrepancy appears (see Fig.12), as in the previous parameterization, but on the other side.

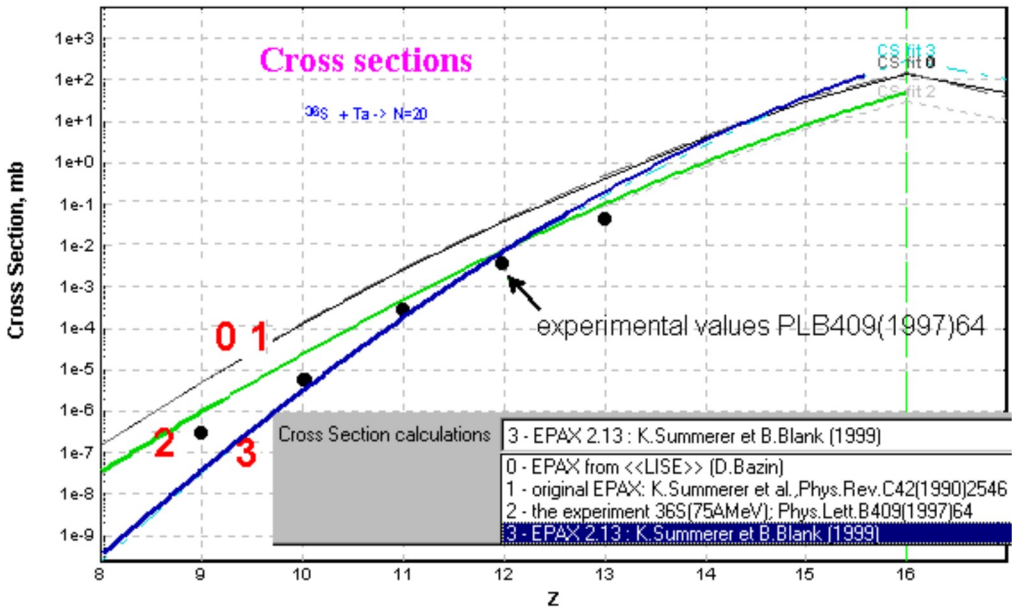
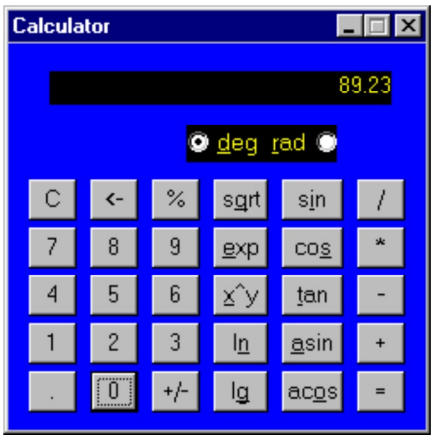


Fig.12.

The User may choose the new parameterization to perform calculations via the menu "Options->Production Mechanism".

4.3. Trigonometric function of the in-built calculator

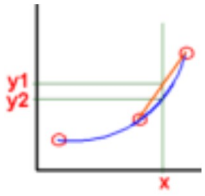
Fig.13.



The trigonometric functions (sin, cos, tan, arcsin, arccos) have been added in the in-built calculator. The User has also got an opportunity to choose units (degrees or radians) for trigonometric calculations (see Fig.13).

4.4. Three points interpolation for the energy loss and range subroutines

Fig.14.



In the previous version the energy loss and range subroutines used the linear interpolation to get a result from the tabulated values. The new code version describes the tabulated values by a second order polynomial using three points (see Fig.14). This allows one to smooth some distributions (for example the Range distribution in materials).

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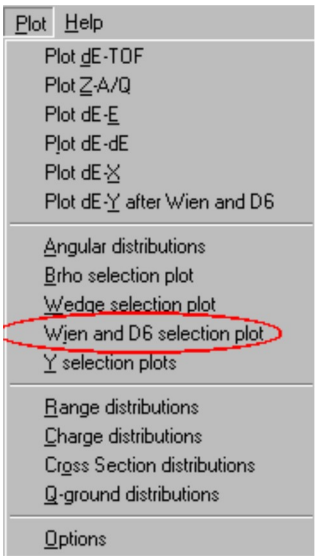
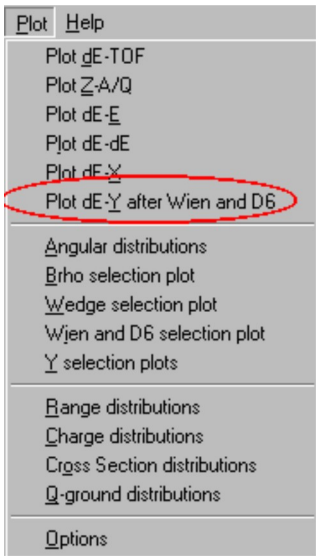
5. Plots

5.1. image after Wedge & D6 (one-dimensional plot) and dE - Y image (after wedge & D6)



Two kinds of plots have been created to visualize the Y-image distribution in the final focus plane after the velocity filter and the dipole "D6". The one-dimensional plot (left menu) has been already presented in Fig.2 and 3.

The two-dimensional plot (right menu) dE-Y (Energy Loss versus Y-image) is presented in Fig.15.



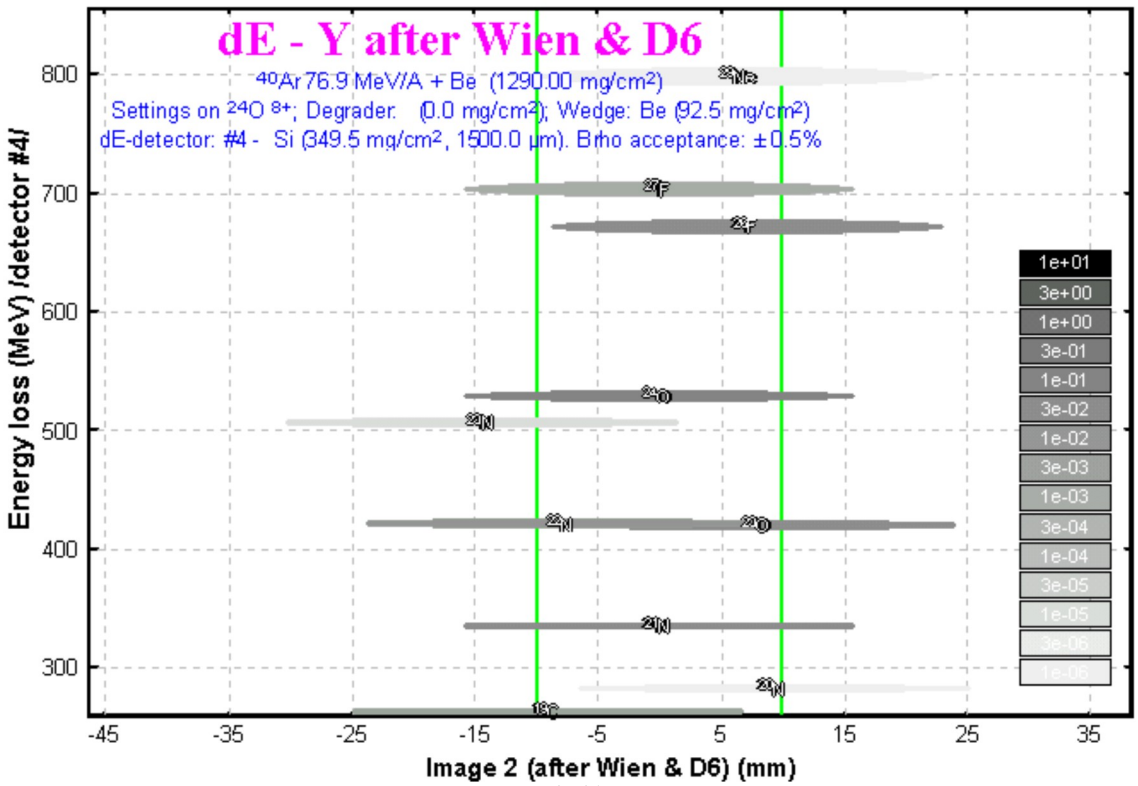


Fig.16.

5.2. dE-dE plot

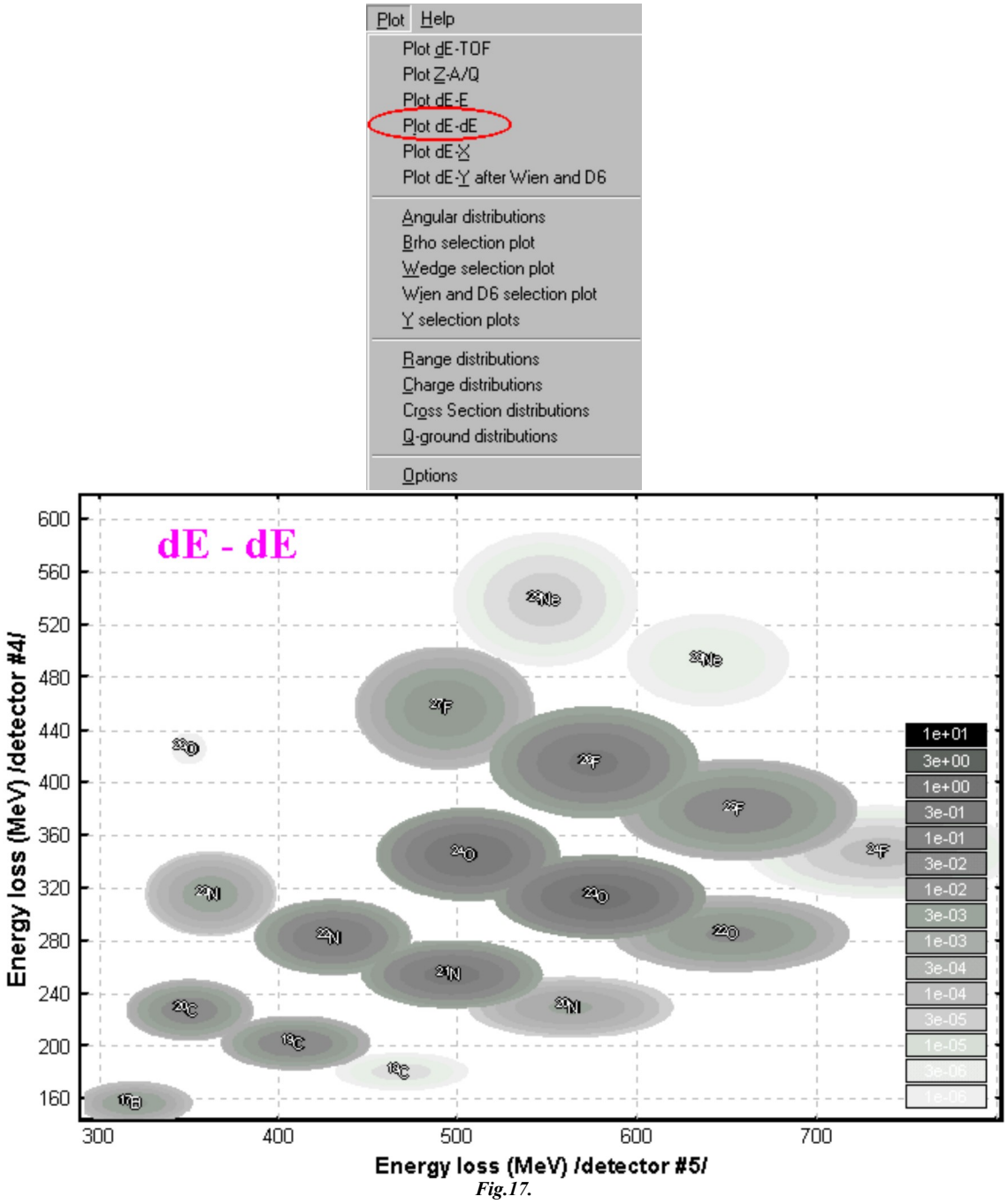


Fig.17.

5.3. dE-X plot

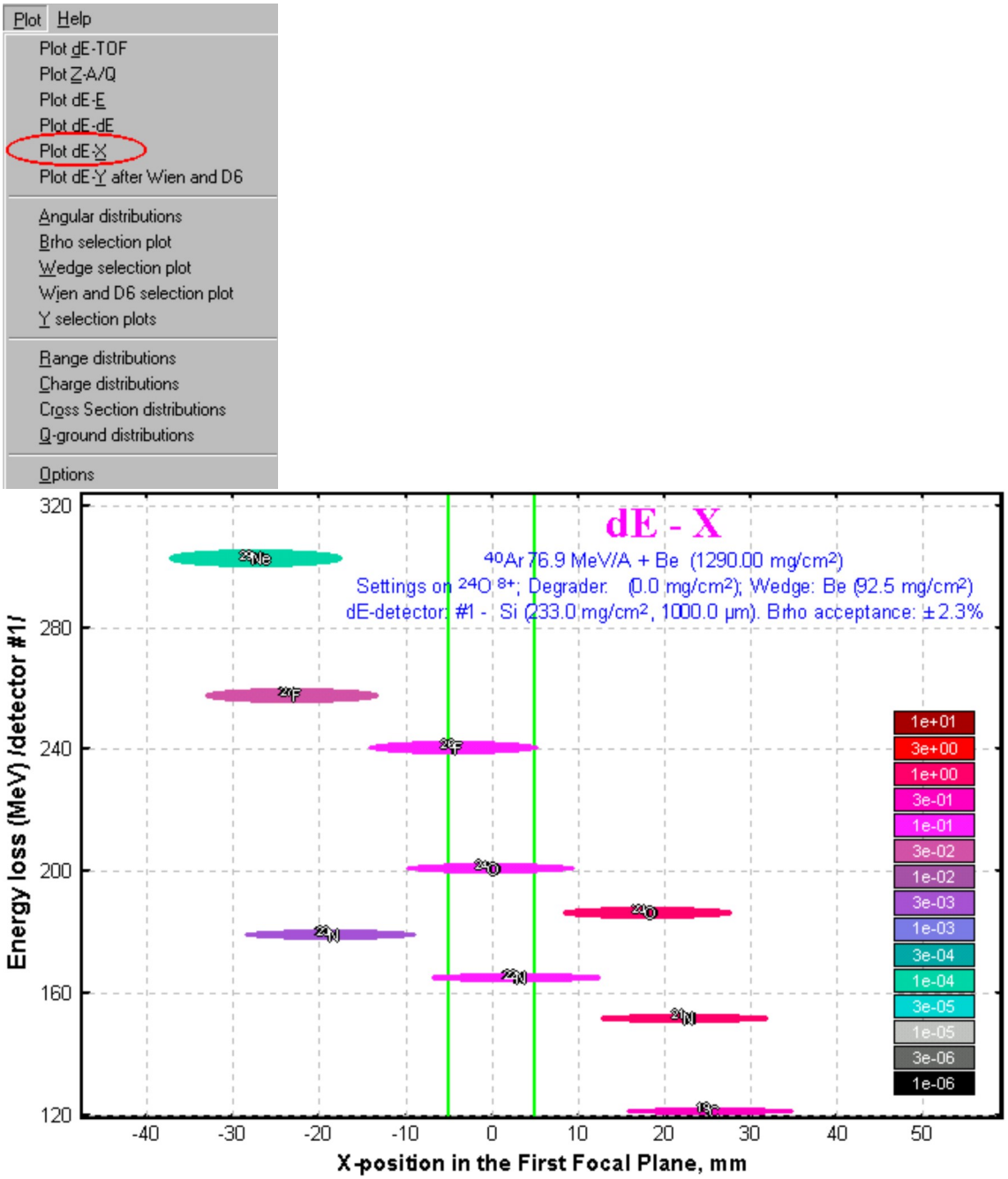


Fig.18.

5.4. Plot of Q-ground values

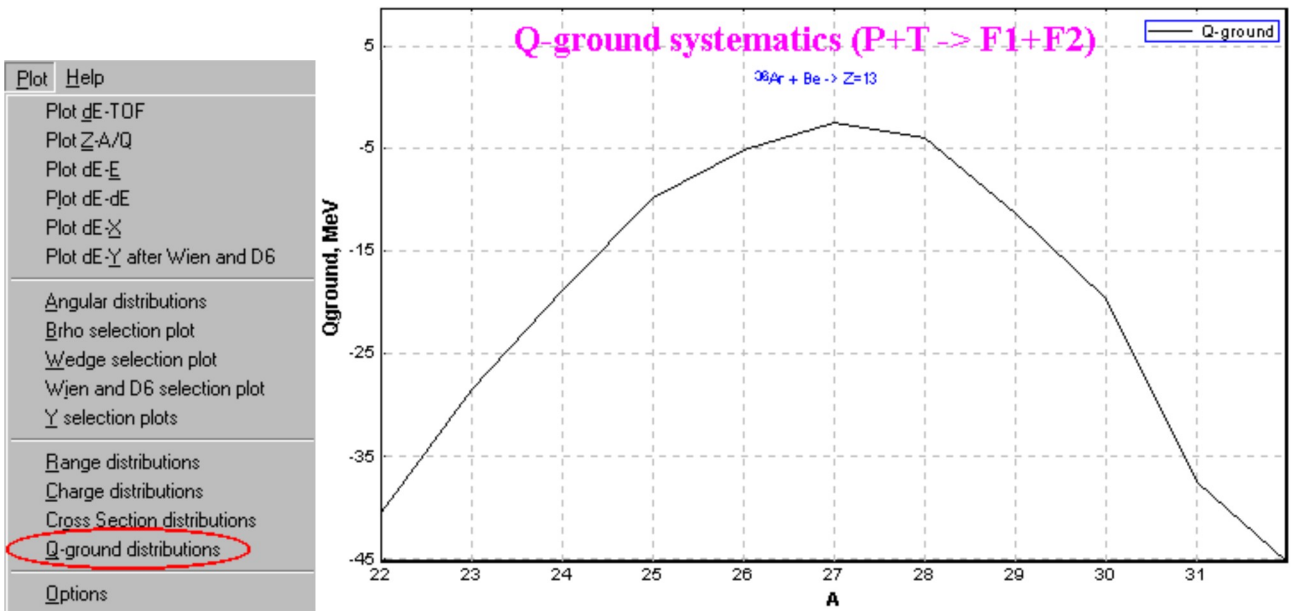


Fig.19.

5.5. Realistic image of peaks

Two-dimensional plots in standard mode are drawn only by one color corresponding to their intensity. The width of the peak is equal to its distribution FWHM. “Realistic” mode for peak drawing uses some colors depending on the distance between the peak center and a given point inside the peak (width $\pm$ 2σ). Example of the plot drawn in the “realistic” mode is presented in Fig.17.

5.6. Gray and Color Palettes for two-dimensional plots

The User does not always have the possibility of printing two-dimensional plots on color printers. Therefore, a button has been added to switch the plot palettes in order to reproduce the peak intensity for printing.

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6. Bugs

6.1. The thickness dialog - density

Previously, it was impossible to enter a float value into the density window of the thickness dialog. This has been corrected.

6.2. The dialog “Calibrations”

After inputting a new nucleus in the calibrations dialog, the range was not recalculated. This has been corrected.

6.3. Adaptation the code to the PC emulator on Mac

Cross-section calculations were performed incorrectly on Mac under the PC emulator due to some discrepancy in the C function “pow(x,y)” between these system platforms (?). The function pow(x,y) has been changed in the code by redefinition #define pow(x,y) exp((y) log(x))

6.4. Negative dispersion

The negative momentum dispersion caused the program to crash. This has been corrected, and the User may use negative momentum dispersion.

6.5. After reading of a LISE-file the program did not calculate magnetic field

The conjugate values (Bρ and B) are immediately recalculated when User changes the Bρ-values or the B(magnetic field)-values using the dipoles dialog or when the program calculates these values. When the User read a LISE file, the Bρ values were

entered into the code without recalculation of the magnetic field. This has been corrected.

6.6. Distributions

Some bugs provoking crashes of the program have been corrected.

References

1) D.Bazin et al., to be published; Web site -http://www.nscl.msu.edu/~bazin/LISE.html.

2) R.Anne et al., **NIM A257(**1987) p.215-232; Web-site of the LISE spectrometer: http://www.ganil.fr/LISE.

3) D.Bazin and B.Sherrill, **Phys.Rev. E50**(1994) 4017-4021.

4) K.Sümmerer et al., **Phys.Rev. C42**(1990)2546-2561.

5) O.Tarasov et al., **Nucl.Phys. A629**(1998)605.

6) A.Leon et al., Atom.Data and Nucl.Data Tables, v.69, 1998.

7) THE 1995 ATOMIC MASS EVALUATION, G.Audi and A.H.Wapstra, Atom.Data and Nucl.Data Tables (1995).

8) The code “NUCLEUS” - I.Duflo, G.Audi et al, CSNSM, Orsay

9) “Transport: a computer program for designing charged particle beam transport system”, K.L.Brown, D.C.Carey, Ch.Iselin, F.Rothacker. CERN 80-04.

10) VAMOS: WEB-reference http://www.ganil.fr/vamos/index.html.

11) Guide de l’utilisateur de SISSI, M-H.Moscatello et le groupe SISSI, GANIL R96 05 ;. WEB-reference http://www.ganil.fr/equipements/equip_detect.htmlx.

12) O.Tarasov et al., **Phys.Lett. B409**(1997)64.