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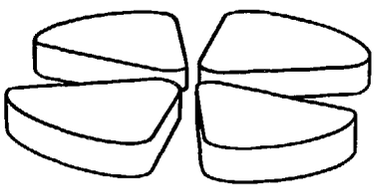

Program AUTO

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Abstract

The program AUTO was developed to be used in the analysis of dE vs E type spectra. This program is written in FORTRAN and calculates dE vs E lines in MeV. The provision is also made in the program to convert these lines from MeV to ADC channel numbers to facilitate the comparison with the raw data from the experiments. Currently the output of this program can be plotted with the display program, called VISU, but it can also be used independent of the program VISU, with little or no modification in the actual fortran code. The program AUTO has many useful applications. In this article the program AUTO is described along with its applications.

1 Introduction

This program was written to be used eventually with the detector INDRA, [1] to help in analyzing dE vs E type spectra. The detectors are assumed to be silicon detectors only, although you can also use the program for the cases where an E detector is a CsI detector. This program can calculate dE vs E lines in MeV for a given detector system. These lines are then converted into ADC channels, provided one gives the calibration (in units $\frac{channels}{MeV}$) and the pedestal value (in units of ADC channels) of the corresponding ADC to the program. Currently the output of this program can be displayed with Mr. P. Bertrand's VISU [2] program. These output files are written in ASCII format. In the section 2.3, we discuss where changes could be made

in order to make the program compatible with other display or analysis programs.

2 The program

The program AUTO is capable of predicting dE vs E lines in MeV or in ADC channel numbers for incident particles with z in the range 1 to 92 in the given experimental environment. To have these lines in the units of ADC channel numbers one must give the calibrations in $\frac{ADCchannels}{MeV}$ along with the pedestal of the ADC in channel numbers used in measuring dE or E. This program will help you estimate the first guess at the calibration. One can also obtain χ^2 (chisquare) to check the agreement between the data and the calculated lines in this program. To go about calculating these things one will have to answer a few questions. The following subsection will explore these questions in detail.

2.1 Questions and Answers

The main program automain asks the questions which are in the bold type below. Depending on the answers to these questions it also decides the initial course of action. The flow chart of these questions is shown in figure 1. These questions and their possible answers are discussed below. To illustrate the questions and answers imagine an experiment A in which you have two silicon detectors, one after the other as in a typical dE-E telescope. The thickness of the first detector dE was $11mg/cm^2$, and of the second detector E was $70mg/cm^2$. Assume that the reaction was Kr on Au with 40 MeV/u as the maximum energy an outgoing nucleus could have. In this experiment let us assume that calibration is already determined for both the dE and E ADCs. The dE ADC had a calibration of $0.35\frac{MeV}{channel}$ and its pedestal was at channel number 4.60. The E ADC has calibration value of $1.274\frac{MeV}{channel}$ with the pedestal in channel 0.471. Assume that in this experiment one sees z lines starting at $z = 2$.
The questions this program will ask you are

1. **"give minimum and maximum z you want"**
   In the experiment A minimum value of z would be 2 and max-

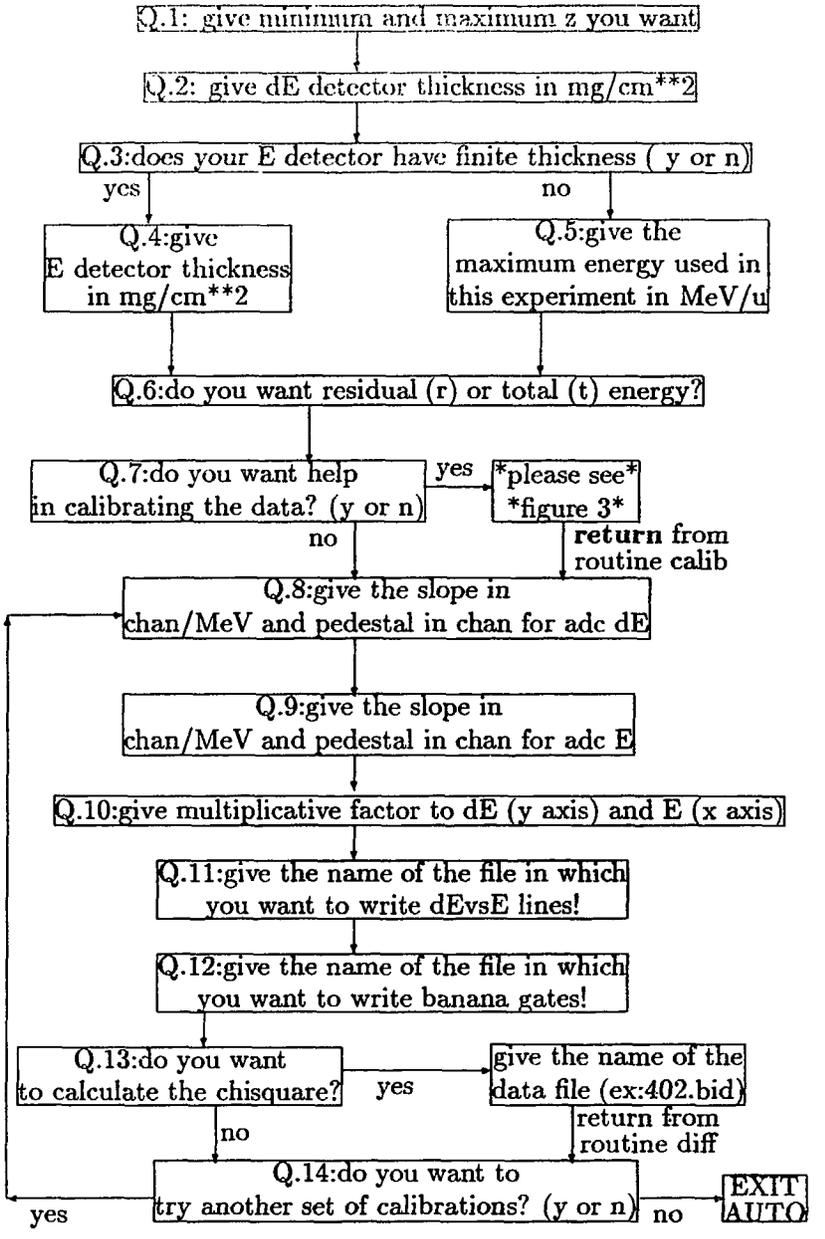


Figure 1: The flow chart of the questions asked by the main program automain.

imum would be 36 to compare values calculated using this program with the data from experiment A. The minimum value of z is stored in the common as izmin and the maximum value of z is stored as izmax.

2. **"give dE detector thickness in mg/cm**2"**
   The valid answer for experiment A would be **11. Note that in this program the energy loss in the dE detector is always plotted on the y axis.**

3. **"does your E detector have finite thickness?(y or n)"**
   The choices for the answer are **y** for yes and **n** for no. The choice of answer n (no) will assume that all the residual energy is observed since here the observation of the residual energy is not limited by the finite thickness of E detector. The same answer would be used if you had CsI as your E detector. This is because in the current state the program can not be used for particles which pass through CsI detectors. In the case of the experiment A, mentioned above answer would be **y** (yes). If you answer yes here, then you will be prompted for the next question, otherwise the next question will be bypassed.

4. **"give E detector thickness in mg/cm**2"**
   For experiment A the answer would be **70. Note: You won't be asked this question if your answer to question 3 above was n (no).**

5. **"give the maximum energy used in this experiment in MeV/u"**
   The answer for experiment A here is **40. Note: You won't be asked this question if your answer was y (yes) to question 3.**

6. **"do you want residual (r) or total (t) energy?"**
   The answer to this question strictly depends on what type of data spectrum one is trying to compare. If experimenters A are trying to compare dE vs E+dE data then their answer would be **t**. If they were trying to compare dE vs E data then their answer should be **r**. **Note: In this program depending on your answer to this question either the energy loss in**

the E detector or the sum of the energy loss in E and dE detectors will get plotted on the x axis.

7. **"do you want help in calibrating the data?(y or n)"** Possible answers here are **y** (yes) or **n** (no). If you already have calibrations then answer would be **n** (no). The calibration procedure here is very simple-minded and demands the knowledge of the pedestal of ADC and assignment of the z to each of the z lines in the ADC spectrum. If the answer to this question is yes then the call to routine calib is made. This routine will then ask you whether it is the dE ADC (d) or E ADC (e) you want to calibrate. Then it will ask you for the z for which you would like to calibrate the ADC. (For silicon detectors ideally calibrations for different z lines should be equal.) Then it would ask you to give the maximum ADC channel number $ADCMAX$ for this particular z (see figure 2). After this the program will ask for the pedestal value of that ADC. The eloss2 subroutine in the program is capable of calculating maximum energy lost, $emax$, by an incident particle z in the given silicon thickness. The value of the parameter $calibration_{\frac{MeV}{chan}}$ is then $\frac{emax}{ADCMAX-pedestal}$.

   We have found this method of calibration to give at least a very good first guess at the calibration. The calculated values of both the parameters $calibration_{\frac{MeV}{chan}}$ and slope in $\frac{chan}{MeV}$, where slope is the inverse of the $calibration_{\frac{MeV}{chan}}$, are printed on the screen. After this it will ask you if you would like to calibrate the other ADC. If you say yes then it will ask you similar questions as for the first ADC otherwise you will be brought back to the main program. For the flow chart of the questions asked in routine calib, see figure 3. For the case where 'infinite' thickness for the E detectors is assumed, the program **will not** help you calibrate the ADC, though later on you will be able to give the parameter slope and the pedestal for the E ADC and have the E axis plotted in terms of the ADC. **Though here the program calculates the calibrations it does not automatically set the values of the calibrations within the program. Therefore one must enter these values as the answers to the next two questions.**

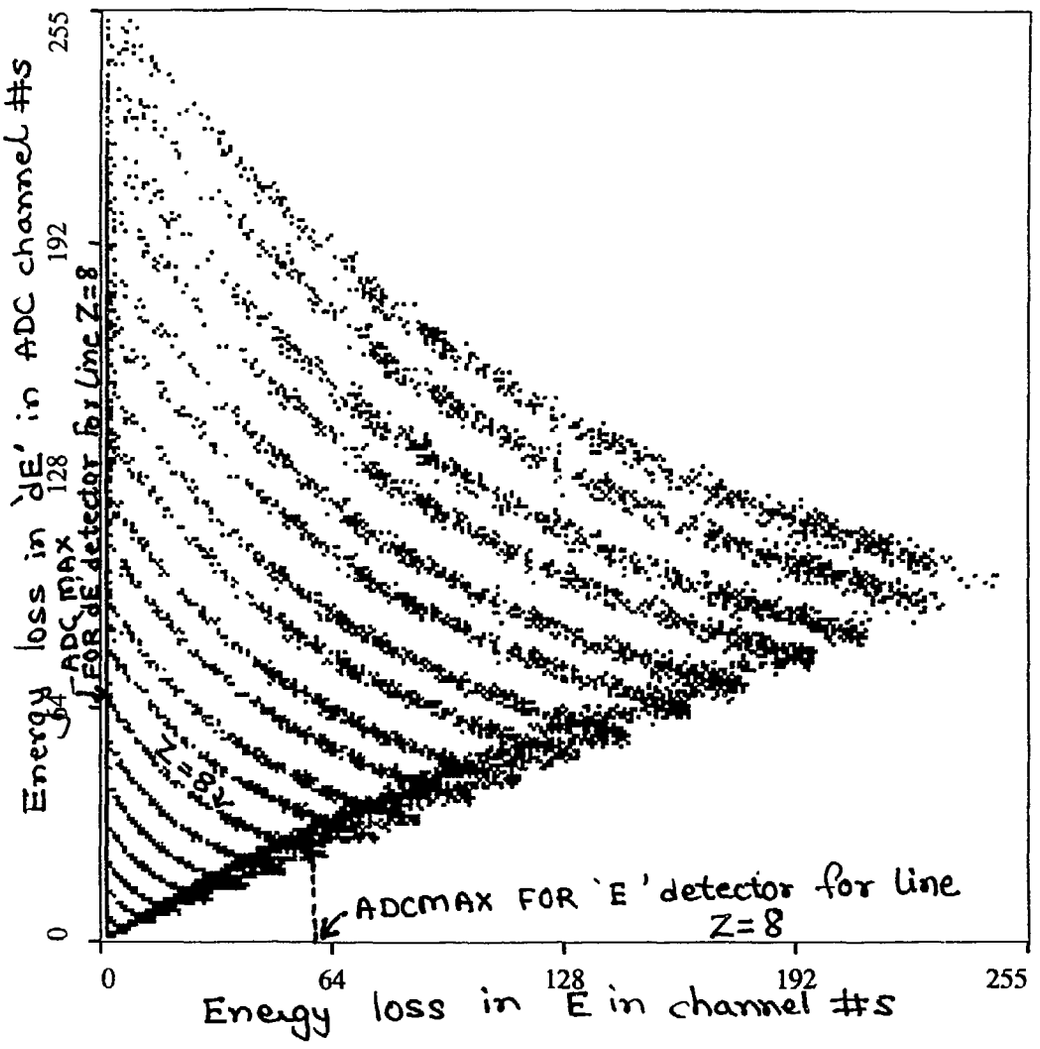
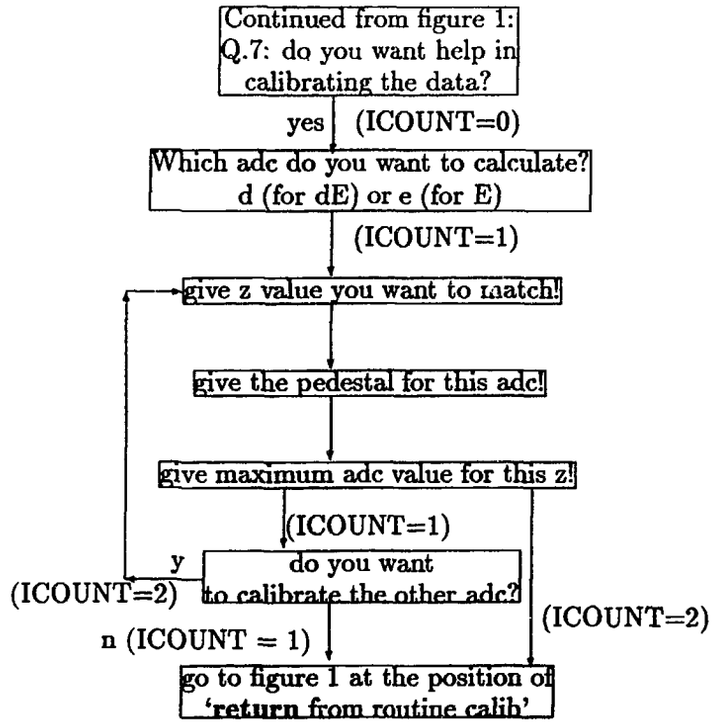


Figure 2: The *ADCMAX* for the detectors dE and E

Note there are only two loops through this routine,
since the maximum number for the detectors involved is 2.
ICOUNT is the counter for the number of detectors calibrated.



If you choose to calibrate the "infinite"
E detector then you will see the following message.

****

It is not possible in this version to calibrate
the "infinite" E detectors though you may be able to
give a guess for the calibration later on. Sorry!

****

After this depending on the value of the
parameter ICOUNT it will ask you
do you want to calibrate the other adc? (ICOUNT=1)
or take you out of the routine calib (ICOUNT=2).

Figure 3: The flow chart of the questions asked in routine calib.

8. **"give the slope in chan/MeV and pedestal in chan for adc dE"**
   If in the data spectrum (the one that you want to compare to the calculations) the dE axis is in MeV then the slope would be 1 and pedestal would be 0. If the data spectrum being used in experiment A has the dE axis in units of ADC channel numbers then the answer to above question can be estimated using the parameter $calibration_{\frac{MeV}{chan}}$ in the following equations.

$$dE_{MeV} = calibration_{\frac{MeV}{chan}} * (dE_{adc} - pedestal)$$

   Thus,

$$dE_{adc} = dE_{MeV}/calibration_{\frac{MeV}{chan}} + pedestal.$$

   Therefore the parameter slope mentioned in question is

$$slope = 1/calibration_{\frac{MeV}{chan}}.$$

   Using these equations and substituting proper values, for experiment A the answer to this question would be **2.86,4.60**.

9. **"give the slope in chan/MeV and pedestal in chan for adc E"**
   The same explanation for the dE ADC above, applies for E ADC also. Using the same method as for dE, the answers for experiment A will be **.78,.47** if they wish to have E ADC plotted in terms of the channel #s. For the CsI E detectors one can take a guess at the calibrations or enter known calibration in the proper units. Since the Si detector calibrations do not depend on z values, no z dependence is taken into account while converting the calculated energy from MeV to ADC channels. This might cause a problem for the CsI E detectors, which have stronger z dependence for higher z lines.

10. **"give multiplicative factor to dE (y axis) and E (x axis)"**
    As pointed out here this program expects dE to be plotted on y axis and E to be plotted on x axis. We have found many times that the data spectra have an overall multiplicative factor applied to the axes. We will assume that the experimenters A do not do that, so their answer would be **1,1**.

11. **"give the name of the file in which you want to write dEvsE lines!"**
    Here you must give the name of the file in which you want to write dE vs E lines calculated by the program. The answer could be for example **auto.gri**. Let us assume that this is the answer for experimenters of the experiment A.

12. **"give the name of the file in which you want to write banana gates!"**
    Here you must give the name of the file where you want to write the 'banana' gates calculated by the program. The answer could be for example **banan.gri**. Let us assume that this is the answer for experimenters of the experiment A.

13. **"do you want to calculate the chisquare?"**
    Note: This part is tested only on the SUN workstations at GANIL, where it works fine. *Choices are once again* **y** (yes) or **n** (no). If you say yes, you will be prompted to give the name of the file which has the experimental spectra on it. This part is done in subroutine diff. **Currently these files are read in only from files which are written in the format ready to be displayed by Mr. Bertrand's VISU program on the SUN.** If the data spectra are in any format other than Mr. Bertrand's, then one will have to make changes related to reading in of the spectra in the subroutine diff. The data are read here one by one as x and y points. For a given data point, the value of z is assigned by determining which calculated point is closest to this data point. Asume that the closest calculated point to data (x,y) is (xc,yc). Then the shortest distance between data point and the calculated z line containing the point (xc,yc) is estimated. The sum of the square of such distances (sumsq) for all the data points (n) is then obtained, which in turn is used to calculate chisquare (chisq) using the formula

$$chisq = (sumsq/n)/resol^2.$$

    Here *resol* should be the average width of the z lines. Right now *resol* is set at 10 ADC channels. The people who wish to change this value could do so in subroutine diff. The value of

chisquare calculated in this program will give one some indication of the quality of the calibration but certainly it is not a 100% full proof measure. Calculation of chisquare is fairly time consuming and should not be used every time you make change in calibration. (Of course, this being a free country, you are allowed to do whatever you want!)

14. **do you want to try another set of calibrations? (y or n)** The choice of the answer y (yes) will take you back to the question 8. After that questions 9 to 14 will get repeated. The answer **n** (no) here will get you out of the program.

2.2 Energy loss calculation within the program

For each z within the minimum and maximum z limits (inclusive) you have specified, this program will calculate energy loss for 20 incident energies. The lowest of these incident energies is always the quantity *emax*, (which is the maximum energy deposited by a nuclei z in the thickness of the detector) for the dE detector. At this incident energy, energy loss in the dE detector is same as the incident energy thus no energy is left to go through the E detector. After that, incident energy is incremented in a certain MeV step size. The highest of the incident energies will be the quantity *emax* for the E detector, if your E detector has finite thickness. Otherwise you will be prompted to give maximum energy used (in $\frac{MeV}{u}$) in the experiment (see question 5 in the section 2.1.). Using this energy the corresponding velocity is calculated which in turn is used to get the information about the maximum energy a nucleus of given z could have. The step size is determined using this lowest and highest incident energies.

The calculation of energy loss in MeV/mg/cm^2 is performed using the parameters from the Naval Ecole [3]. These equations are in file perte.for on the VAX and perte.f on the SUN. The parameters are stored in the subroutine lecdata. In the subroutine eloss2, for a given incident z and the detector or absorber z along with its thickness are used to calculate the range vs energy/nucleon table. Then a spline fit is made to this data twice. Once to obtain range as a function of incident energy/nucleon and once to obtain energy/nucleon as a function of range. Both the fit parameters are then stored. The energy loss for a given incident energy is determined

using these fits.

2.3 Outputs of the program

The dE vs E values and 'banana' gates are written in the files specified by the users. For experimenters A, the name of this file will be auto.gri, since they gave this name as the answer to question 11 in the section 2.1 **Ideally,** these lines will pass through the data lines. The half-way spaced lines, or the bananas, are put in the file banan.gri for experimenters A since they gave this name as the answer to question 12 in the section 2.1. **Ideally,** these lines will pass between the data lines and can be used to form the 'banana' gates. The output files are currently compatible with Mr. P. Bertrand's VISU program and can be accessed using the **read grill** facility which plots either auto.gri or banan.gri (**at your specification**) on top of your data spectrum on the screen. (You need to plot your data spectrum on the screen first to plot auto.gri or banan.gri.) The output files are written in ASCII format. If you do not like the way they are written or created then you should make the necessary changes in the fortran files. Both the data files are opened in the program automain. How the x and y values are written in the data files is controlled by subroutine autoout. **If you do not give different names for these files every time you use different calibrations or restart the program, both the data files will get overwritten.**

3 Getting started with the program

In this section we discuss how to get the program installed in your directories on the VAX or the SUN. The different files needed to compile and run the program are also listed below. The last subsection describes different subroutines along with their input and output. **If you are at GANIL then copying of these files will not be necessary if you know how to use the program VISU. This is because you can access the program AUTO from within the program VISU.**

3.1 VAX version

Currently this program resides in the disk$user:[ranool.auto] directory on GANAC4. The main program is in the file auto.for. The other files required are eloss2.for, deloss.for, diff.for, steps.for, calib.for, perte.for, spdedx.for, datdedx.for, and autoout.for. The file auto.for contains the main program automain along with the subroutine meloss. The file eloss2.for contains a subroutine eloss2 and file deloss.for contains function deloss. Files diff.for, steps.for and calib.for contain routines diff, steps and calib, respectively. The file perte.for consists of routines perte and helium. The routines derivxy, derivyx, rangesp and enersp are in the file spdedx.for. The routine lecdat is in the file datdedx.for. The routine autoout, which deals with writting out the results, is in the file autoout.for. The file autocmp.com can compile and link the program. The executable file created with command '@autocmp' is named auto.exe.

3.2 SUN versions

There are two SUN versions available. One version can be run independently. This version is described in the subsection 3.2.1. The other version can be accessed from within the program VISU. This latter version is probably more useful for the GANIL users. This version is briefly described in the subsection 3.2.2. Both versions follow the same logic in calculating the dE vs E type lines.

3.2.1 The 'independent' version

The SUN version of the auto program has exactly the same FORTRAN code as the VAX version, except files are named according to SUN convention and the open statement for creating the output files is a bit different. The SUN version resides in the directory usr3:[users.rawool] on the SUN work-station GANSU1. The main program automain and the subroutine meloss are in the file auto.f. The other files required are eloss2.f, deloss.f, diff.f, steps.f, calib.f, perte.f, spdedx.f, datdedx.f and autoout.f. The file eloss2.f and deloss.f contain subroutine eloss2 and the function deloss, respectively. The files diff.f, steps.f and calib.f contain subroutines diff,steps and calib, respectively. The file perte.f consists of subroutines perte and

helium. The subroutines derivxy, derivyx, rangesp and enersp are in the file spdedx.f. The routine lecdat is in the file datdedx.f. The subroutine autoout is in the file autoout.f. The commands to compile these files on SUN are as follows:
(Attention: For commands 'farauto', 'autol' and 'autocmp' to run from other directories besides the one mentioned above, one must have the files farauto, autol and autocmp in the directory from which you are executing these commands. These files are in the same directory as the fortran files for the SUN.)

farauto eloss2
farauto diff
farauto steps
farauto perte
farauto spdedx
farauto datdedx
farauto autoout
farauto calib
farauto deloss

The command 'farauto' will compile files and put them in library libauto.a. **Do not compile file auto.f.** It will get compiled at the time you are linking the program. The command for linking is:

autol -o auto.exe auto.f.

This will create the file auto.exe. All of the above commands for SUN are combined in the file autocmp, thus typing command 'autocmp' would execute all the necessary commands provided that one has all the required fortran files along with files farauto, autol and autocmp in the same directory from which command is issued. To run the program simply type 'auto.exe'. **While typing commands on the SUN, please keep in mind that on the SUN, the commands are upper and lower case sensitive. The names of the fortran files and command files are all in lower case.**

3.2.2 The SUN version for GANIL users

The AUTO program can be accessed from within the VISU program by clicking the mouse on the option **grilles auto. This work was carried out in association with Mr. P. Bertrand and he should be contacted if there are any problems with this version.** Once you get inside the **grille auto** utility you are prompted for six options to begin with. One option is the 'help' option which should give you a brief introduction on using the utility AUTO. The second option is 'nom grille' which would ask you to give the name of the two output files. (The answers to questions 11 and 12 in the section 2.1 above). The third option is 'calculs' which will lead you through questions 1 to 10 (see section 2.1) and calculate the lines and write output files. You can go to the 'calculs' option without executing 'nom grille' option. In that case your dE vs E lines will be written in the file auto.gri and the 'banana' gates will be written in the file 'banan.gri'. The fourth option is 'zoom'. Which has nothing to do with the program AUTO but it is a part of the VISU program. The fifth option is 'menu depart' which will take you back to the main menu of the VISU program. The sixth option is 'sortie', which will take you out of the VISU program.

After you have executed 'calculs' once, you will have two more options available. The 'chisquare' option which calculates the χ^2 and 'load grille' which will plot the specified output file on your data. In the 'chisquare' option you will not be asked for the name of the data spectrum file in this version since the VISU program will have that file stored in the memory. While installing this utility the main routine auto was modified considerably by Mr. P. Bertrand to make it compatible with his VISU program. Also in future Mr. Bertrand is likely to make further cosmetic changes in the fortran code.

3.3 Different codes and their purpose

All of the programs are commented. For more complete information than the following, users are requested to look at the actual fortran codes.

1. **automain:** As the name suggests, this is the main part of the program. This is where the questions described in the section 2.1

(in bold type) are asked and the answers are received. Depending on these answers proper action is taken by calling various subroutines. **This program is in the file auto.for on the VAX and auto.f on the SUN.**

2. **meloss:** This routine receives answers from the main program through common blocks. The parameter step is calculated here and also depending on the experimental conditions, various calls to subroutine eloss2 are made. The conversion of the energy from MeV to the ADC channel #s is also done here. The spacings between the calculated z lines are also estimated here. The inputs here are:
   - ans1 = answer to question 3 in section 2.1.
   - izmin = minimum z limit you give as an answer to question 1 in section 2.1.
   - izmax = maximum z limit given by the user as an answer to question 1 in section 2.1.
   - zt1 = z of the dE detector
   - z = z of the incident nucleus (incident on the detector)
   - mmz = mass of the incident nucleus (incident on the detector)
   - beta = beta corresponding to the maximum energy available in the experiment
   - zt2 = z of the E detector
   - thik1 = thickness of dE detector
   - thik2 = thickness of E detector
   - rort = answer to question 6 in section 2.1 .
   - rde1 = value of the calibration for dE ADC in chan/MeV
   - ped1 = value of the dE ADC pedestal in channel #
   - ped2 = value of the E pedestal in channel #
   - rde2 = value of the calibration for E ADC in chan/MeV

   The outputs here are:
   - em1(z) = Array of *emax* for dE detector.

- em2(z) = Array of *emax* for E detector, or in the case of the infinite detectors it is the maximum possible energy an outcoming nucleus could have.
- ev1(z,20) = Array of energy loss in dE detector, in MeV or in ADC channel
- ev2(z,20) = Array of energy loss in detector, could be residual or total energy. The total energy will have to be in MeV to make sense. The residual energy could be in MeV or in ADC channel #
- dmax(z,20) = array of the differences between $z+1$ and z lines at 20 different points along x axis.

This program is in the file auto.for on the VAX and auto.f on the SUN.

3. **eloss2:** This subroutine calculates the energy loss of an incident nucleus (z,m) with incident energy E in the given absorber (zt) of thickness thik. The inputs to these subroutine are:
   - z = z of the incident nuclei.
   - m = mass of the above nuclei in atomic mass units (amu)
   - E = incident energy in MeV.
   - zt = z of the detector
   - thik = thickness of the detector

   The outputs here are:
   - rang = range of the incident nucleus in the given material at energy E.
   - EMAX = maximum energy that can be deposited by the incident particle in the detector material of thickness thik.
   - dedxx = electronic stopping power for these conditions
   - el = energy loss
   - iter = eloss is calculated by an iterative procedure which should converge rapidly. A maximum of 11 iterations are allowed.

   This routine is in the file eloss2.for on the VAX and eloss2.f on the SUN.

4. **dedx:** This is a function routine. The energy loss which is calculated by routine perte is returned from here as dedx. The inputs here are:
   - z = z of the incident nucleus
   - m = mass of the incident nucleus
   - eh = incident energy in MeV
   - zt = z of the detector

   The output is dedx=energy loss in MeV/Mg/cm^2. **This function is in the file deloss.for on the VAX and deloss.f on the SUN.**

5. **perte:** This is the routine which calculates energy loss in MeV per mg/cm^2. The input parameter zt has the same meaning as in function dedx. The other input parameters are
   - E= The incident energy in MeV/nucleon
   - icle = 2 for ecole naval version and 1 for Hubert 1980 version. In this program icle = 2.
   - zz1 = z of the incident nucleus

   The output is s, which is energy loss in MeV/mg/cm^2. **This subroutine is in the file perte.f on the SUN and perte.for on the VAX.**

6. **helium:** This routine calculates the energy loss for a helium ion, whose incident energy is E (in MeV/nucleon), in the material with z=zt. The output here is s, which is the energy loss of the helium ion in Mev/mg/cm^2. **This subroutine is in the file perte.f on the SUN and perte.for on the VAX.**

7. **steps:** This subroutine is one part of the χ^2 calculations. This program defines the boundaries around all the calculated points so that each data point can be associated with the single calculated point. The inputs here are the output arrays ev1, ev2 and dmax mentioned in the description of the routine meloss earlier. The inputs and outputs are passed through the commons. The outputs here are
   - parx1(i,j) = The lowest x limit on the calculated x point ev2(i,j)

- parx2(i,j) = The highest x limit on the calculated x point ev2(i,j)
- pary1(i,j) = The lowest y limit on the calculated y point ev1(i,j)
- pary2(i,j) = The highest y limit on the calculated y point ev1(i,j)

This program is in the file steps.for on the VAX and steps.f on the SUN.

8. **diff:** This routine reads in the data file and using all the output parameters from the routine steps and the ev1 and ev2 arrays calculated in the routine meloss, calculates the χ^2 (chisq) and prints it out on the screen. **This routine is in the file diff.for on the VAX and diff.f on the SUN.**

9. **autoout:** This subroutine writes the output files. The inputs for this routine comes through the commons from the routine meloss. The arrays ev1, ev2 and dmax are the inputs. The outputs are:
   - xout(i,j) = x point for dE vs E lines
   - yout(i,j) = corresponding y point for dE vs E lines
   - by(i,j) = the banana gate y point
   - bx(i,j) = the banana gate x point

   This routine is in the file autoout.for on the VAX and in the file autoout.f on the SUN.

10. **calib:** This is the routine which calculates the calibrations. The inputs here are:
    - ans1 = answer to question 3 in the section 2.1
    - ans6 = answer to the question "which adc do you want to calibrate"
    - zmat = the z of the line (calculated and data) to be matched
    - ped = the pedestal value in channel #
    - z = zmat
    - mmz = mass of the nucleus z

The output is calde, the calibration in MeV/channel. The value of calde and its inverse are printed out on the screen. **This program is in the file calib.for on the VAX and calib.f on the SUN.**

11. **lecdata:** All the parameters required to calculate the energy loss are stored in this file. **This routine is in file datdedx.for on VAX and in the file datdedx.f on the SUN.**
12. **derivxy:** The spline fit is made here for the curve energy per nucleon vs range. **This routine is in the file spdedx.for on the VAX and spdedx.f on the SUN.**
13. **derivyx:** The spline fit is made here for the curve range vs energy per nucleon. **This routine is in the file spdedx.for on VAX and in the file spdedx.f on the SUN.**
14. **rangesp:** This function routine calculates the range of a nucleus at the given energy (xx) using routine derivyx. **This routine is stored in the file spdedx.f on the SUN and spdedx.for on the VAX.**
15. **enersp:** This function routine calculates the maximum energy deposited by a nucleus in the target of given thickness (xx) using function derivxy. **This routine is stored in the file spdedx.for on the VAX and spdedx.f on The SUN.**

4 Results

Some of the data plots superimposed with the calculated values are shown in figures 4, 5 and 6. The solid lines are the calculated values using the program AUTO. The figure 4 has the energy loss in the detector with thickness of 70 mg/cm^2, in the units of ADC channel number plotted on the y axis against the incident energy in MeV. The calibration value we used here was .797 channels/MeV and the pedestal value was .471 channel. The agreement between the data and the calculated value is fairly good for all z lines here. The minimum z line here is for z=2 and the maximum z line is for z=36. The 32 MeV/u Kr on Au reaction was used for this data spectrum. The banana gates calculated using the same calibration for the sama data are plotted in figure 6.

Figure 5 has the energy loss in the thin detector (10.65 mg/cm^2), in the units of ADC channel number plotted on the y axis against the incident energy in MeV. The calibration value we used here was 3.00 channels/MeV and the pedestal value was 4.58 channel. The minimum z line here is for z=2 and the maximum z line is for z=36. The 32 MeV/u Kr on Au reaction was used for this data spectrum. The agreement is not so good here specially at the lower incident energies for all z lines. The bending of these lines at lower energies for the thin detector is similar to that found in the Northcliff and Schilling tables [4], although this bending is not seen in the data spectrum which we have used here.

In conclusion we believe that program AUTO can predict z lines for the heavy-ion reactions and help one analyze and calibrate the data. The calculated lines are in fair agreement with the data except for thin detectors where at lower incident energies it is not clear how well our calculation match the data. To obtain the copy of this program please contact one of the authors. **Bon courage!**

We would like to thank W. Mittig, K. Fifield, P. Bertrand and J. Sullivan for useful suggetions and discussions regarding this program. We would also like to thank E. Crema for letting us use his data spectra.

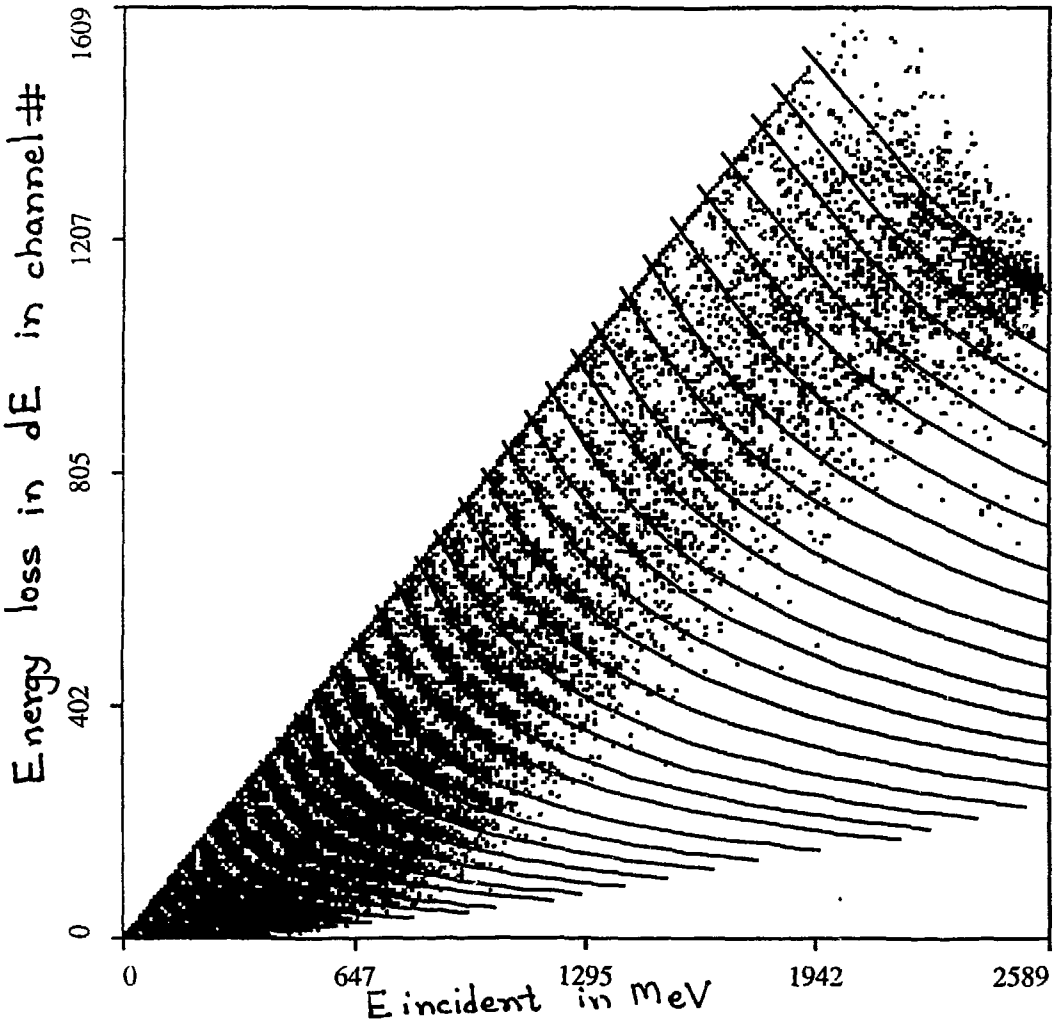


Figure 4: dE vs $E_{incident}$ spectra. The detector thickness was 70mg/cm^2. The solid lines on the data are the calculated dE vs E lines using the program AUTO.

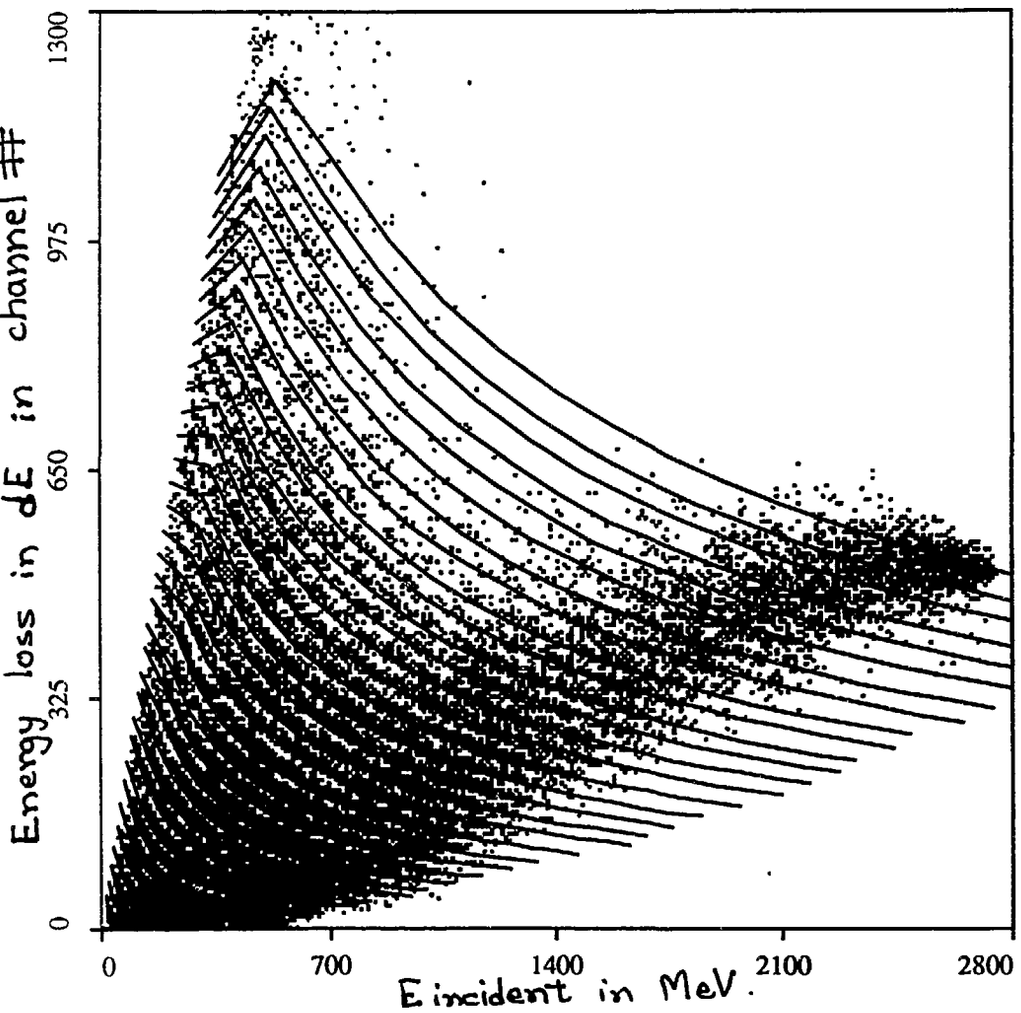


Figure 5: dE vs $E_{incident}$ spectra. The detector thickness was 10.65mg/cm^2. The solid lines on the data are the calculated dE vs E lines using the program AUTO. The bending of these lines at lower energies, and higher z values is similar to that found in Northcliff and Schilling tables [4].

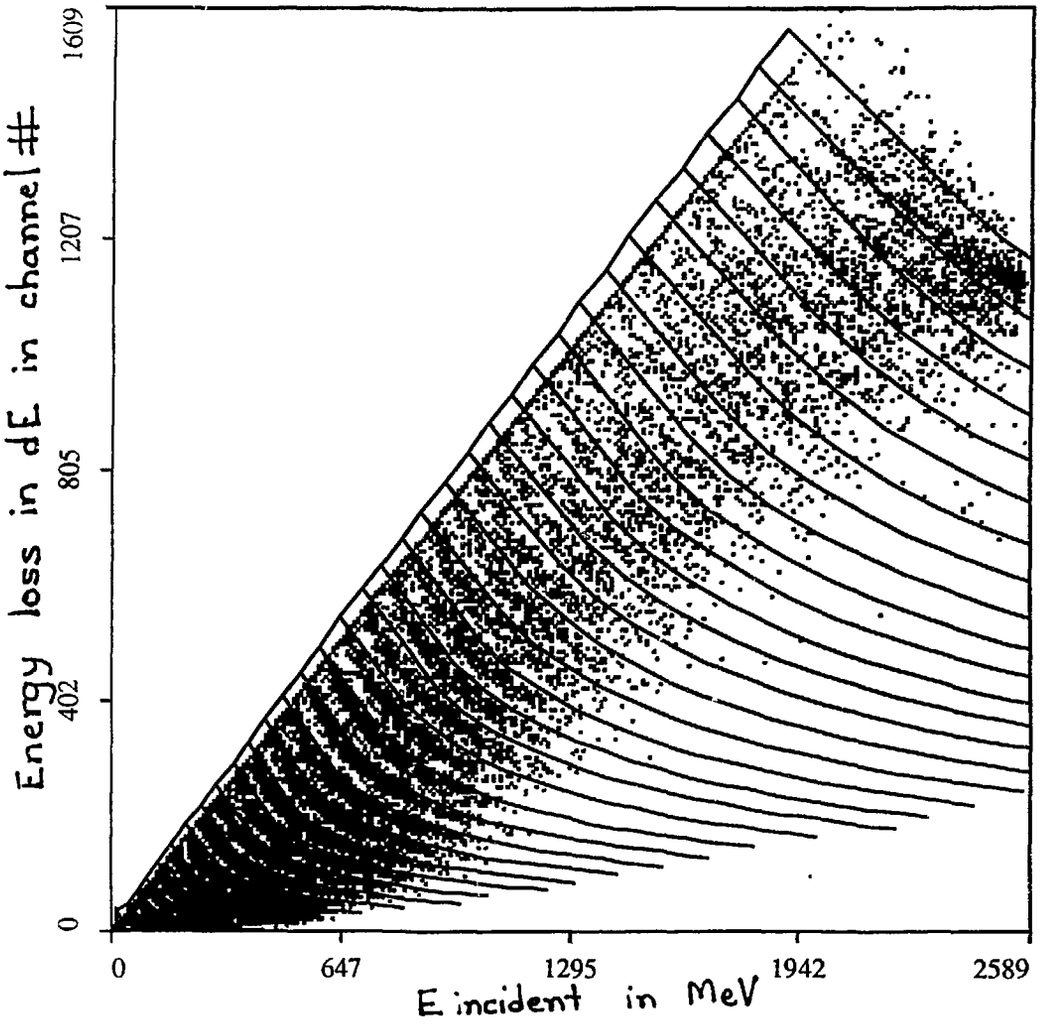


Figure 6: dE vs $E_{incident}$ spectra. The detector thickness was 70mg/cm^2. The solid lines on the data are the calculated banana gates using the program AUTO.

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