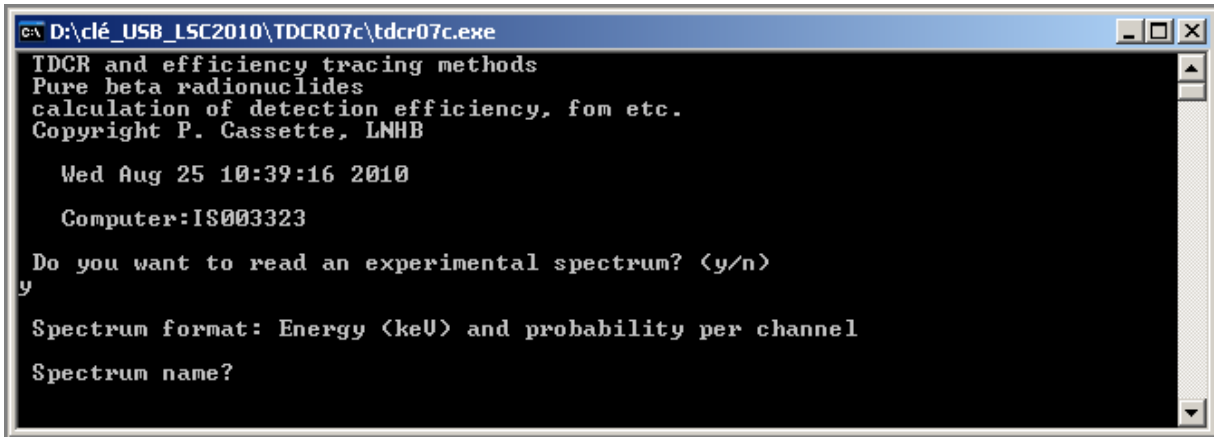
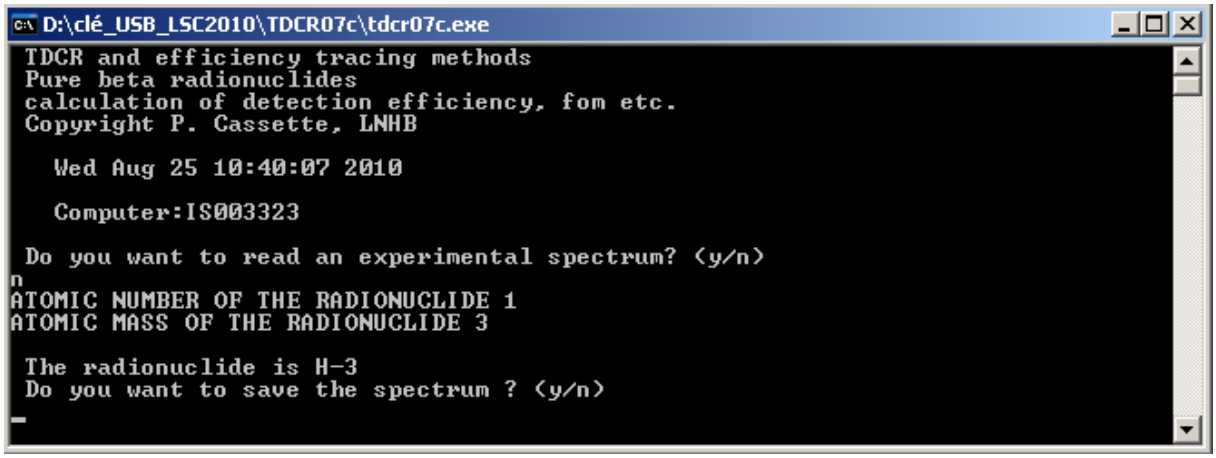
Tutorial TDCR07c

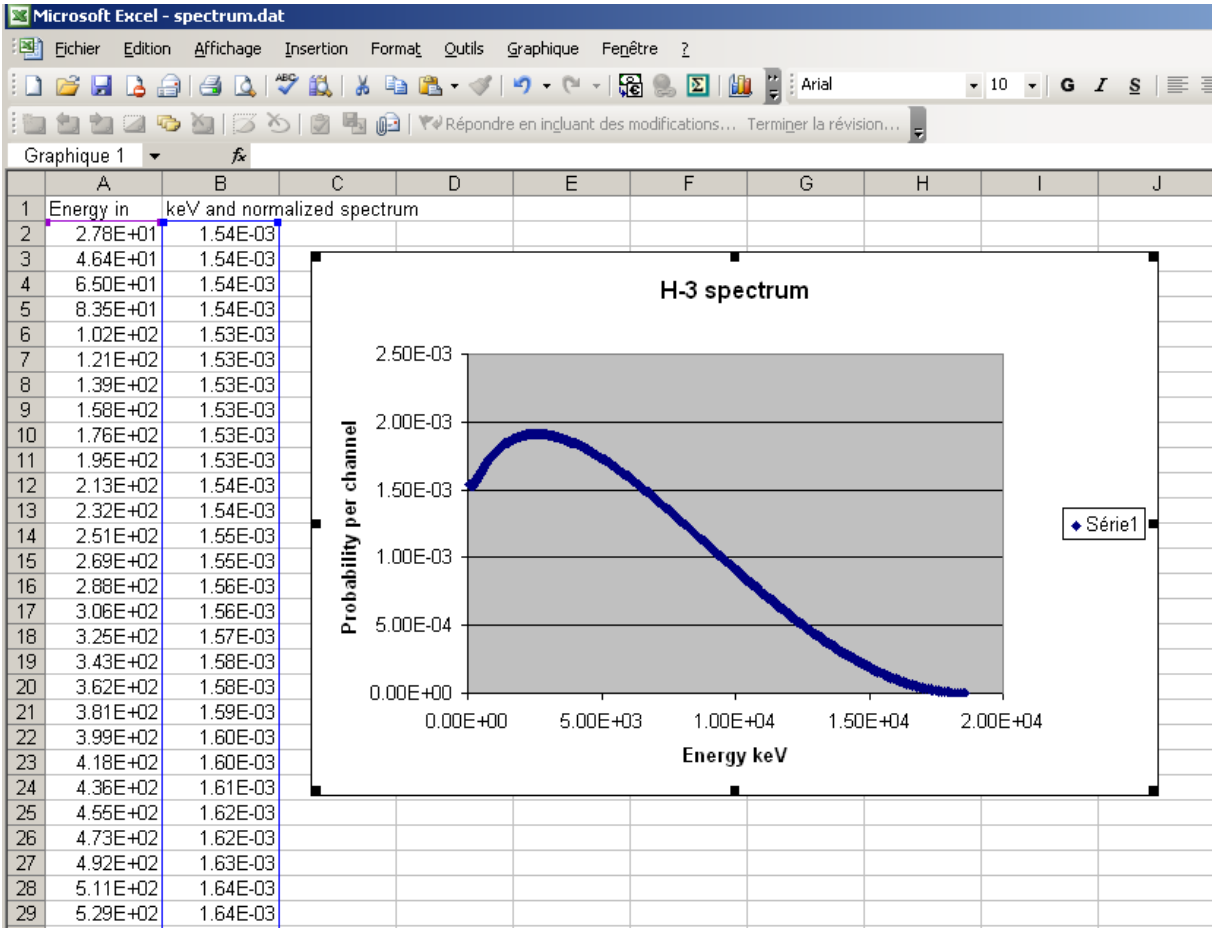
Start TDCR07c.exe program.
The date, hour and computer name is displayed for QA purposes. You can use an external spectrum file for the calculation, as for example an experimental spectrum or a spectrum calculated by a Monte Carlo simulation program. In this case, the spectrum format is an ASCII file with energy in keV and probability per channel, separated by a blank. The spectrum does not need to be normalized, as this normalization is done, if necessary, by the program.



If you do not provide an experimental spectrum file, the spectrum is calculated by the program. You are invited to enter the atomic number and atomic mass of the radionuclide. The program has a small default library of input data for usual radionuclides like ^{3}H, ^{14}C, ^{63}Ni, etc. If the radionuclide is not in the library, you are invited to enter the maximum beta energy, the nature of the transition and the spectrum shape factor. In the following example (Z=1 and A=3), the radionuclide is tritium and is recognized by the program.

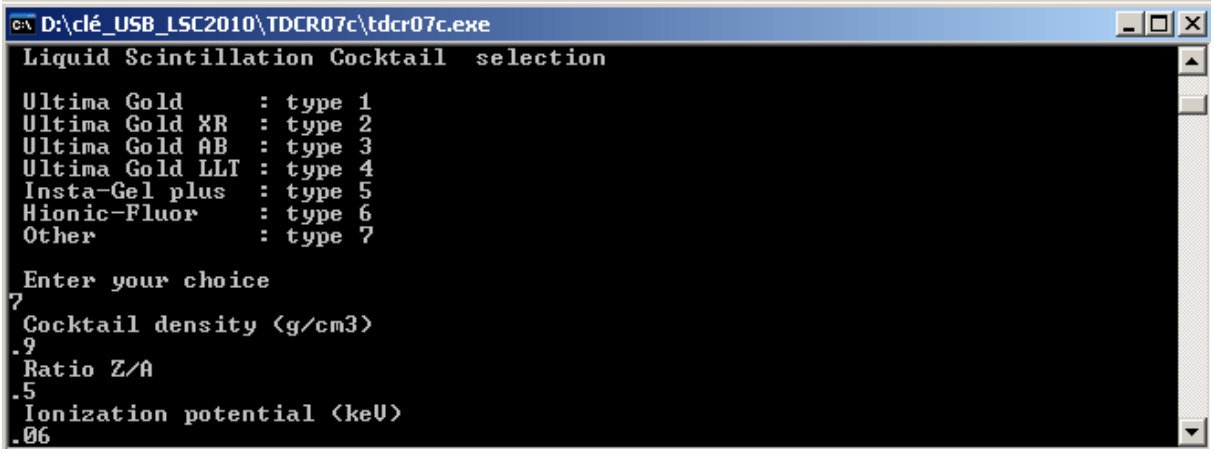


After calculation, the spectrum can be saved in the current directory under the name “spectrum.dat”. This file can be for example opened by Excel for spectrum visualization as shown in the following example:



	A	B
1	Energy in	keV and normalized spectrum
2	2.78E+01	1.54E-03
3	4.64E+01	1.54E-03
4	6.50E+01	1.54E-03
5	8.35E+01	1.54E-03
6	1.02E+02	1.53E-03
7	1.21E+02	1.53E-03
8	1.39E+02	1.53E-03
9	1.58E+02	1.53E-03
10	1.76E+02	1.53E-03
11	1.95E+02	1.53E-03
12	2.13E+02	1.54E-03
13	2.32E+02	1.54E-03
14	2.51E+02	1.55E-03
15	2.69E+02	1.55E-03
16	2.88E+02	1.56E-03
17	3.06E+02	1.56E-03
18	3.25E+02	1.57E-03
19	3.43E+02	1.58E-03
20	3.62E+02	1.58E-03
21	3.81E+02	1.59E-03
22	3.99E+02	1.60E-03
23	4.18E+02	1.60E-03
24	4.36E+02	1.61E-03
25	4.55E+02	1.62E-03
26	4.73E+02	1.62E-03
27	4.92E+02	1.63E-03
28	5.11E+02	1.64E-03
29	5.29E+02	1.64E-03

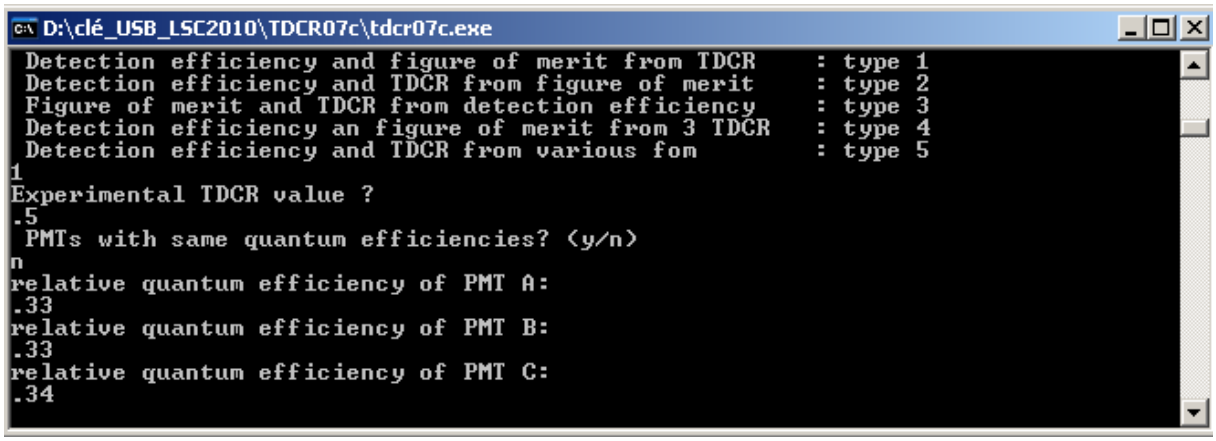
Then you are asked to enter the nature of the LS cocktail. There is a small library for popular Perkin Elmer cocktail but, if necessary, another cocktail can be selected by entering the density, the Z/A ratio and the ionization potential in keV. This supposes of course the knowledge of the chemical composition of the main components of the scintillator (i.e. solvent and surfactant). The ionization potential (more exactly the mean excitation energy) can be found in the ICRU n°37 report or can be calculated using the “material” subroutine of the PENELOPE Monte Carlo simulation package.



After the cocktail selection you enter the main calculation menu with 5 different options depending on your needs:

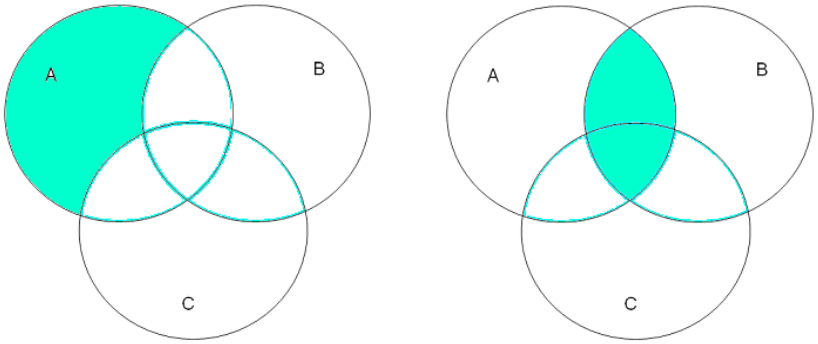
Option 1

Calculation of the detection efficiency in double and triple coincidences and the figure of merit (number of photoelectrons created per keV absorbed in the scintillator). In case of differences in the quantum efficiency of each photomultiplier tube, this can be taken into account by entering the relative efficiency of each tube. The sum of these relative efficiencies must be equal to 1.

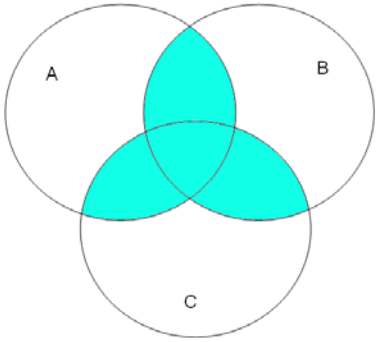


Then the program gives, for kB values in a range of 0.007 to 0.015 cm/MeV with a step of 0.001 cm/MeV, the figure of merit, the detection efficiency of the logical sum of double coincidences, the detection efficiency of triple coincidence and the average detection efficiency for double coincidences. The best estimate of the source activity is the ratio of the count rate in double coincidences to the detection efficiency in double coincidence, which must also be equal to the ratio of the counting rate in triple coincidence to the detection efficiency in triple coincidence. It must be pointed out that the logical sum of double coincidences includes the triple coincidences as shown in the following diagram relative to a counter with 3 PMT's: A, B and C.

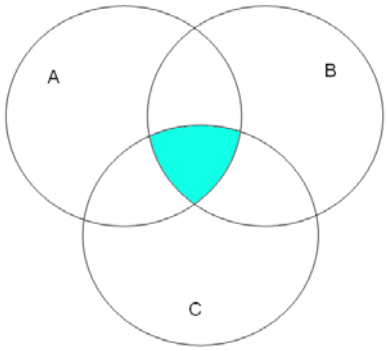
Non coincident (PMT A) Double coincidences AB



Logical sum of double coincidences



Triple coincidences



D:\clé_USB_LSC2010\TDCR07c\tdcr07c.exe

```
kB= .007cm/MeV
figure of merit                                    = .7550 e-/keV
TDCR                                               =  .5000
Logical sum of double coincidence detection efficiency =  .5643
Triple coincidence detection efficiency            =  .2821
Double coincidence detection efficiency            =  .3730

kB= .008cm/MeV
figure of merit                                    = .7770 e-/keV
TDCR                                               =  .5000
Logical sum of double coincidence detection efficiency =  .5602
Triple coincidence detection efficiency            =  .2801
Double coincidence detection efficiency            =  .3703

kB= .009cm/MeV
figure of merit                                    = .7987 e-/keV
TDCR                                               =  .5000
Logical sum of double coincidence detection efficiency =  .5564
Triple coincidence detection efficiency            =  .2782
Double coincidence detection efficiency            =  .3678

kB= .010cm/MeV
figure of merit                                    = .8201 e-/keV
TDCR                                               =  .5000
Logical sum of double coincidence detection efficiency =  .5530
Triple coincidence detection efficiency            =  .2765
Double coincidence detection efficiency            =  .3655

kB= .011cm/MeV
figure of merit                                    = .8413 e-/keV
TDCR                                               =  .5000
Logical sum of double coincidence detection efficiency =  .5498
Triple coincidence detection efficiency            =  .2749
Double coincidence detection efficiency            =  .3634

kB= .012cm/MeV
figure of merit                                    = .8622 e-/keV
TDCR                                               =  .5000
Logical sum of double coincidence detection efficiency =  .5468
Triple coincidence detection efficiency            =  .2734
Double coincidence detection efficiency            =  .3614

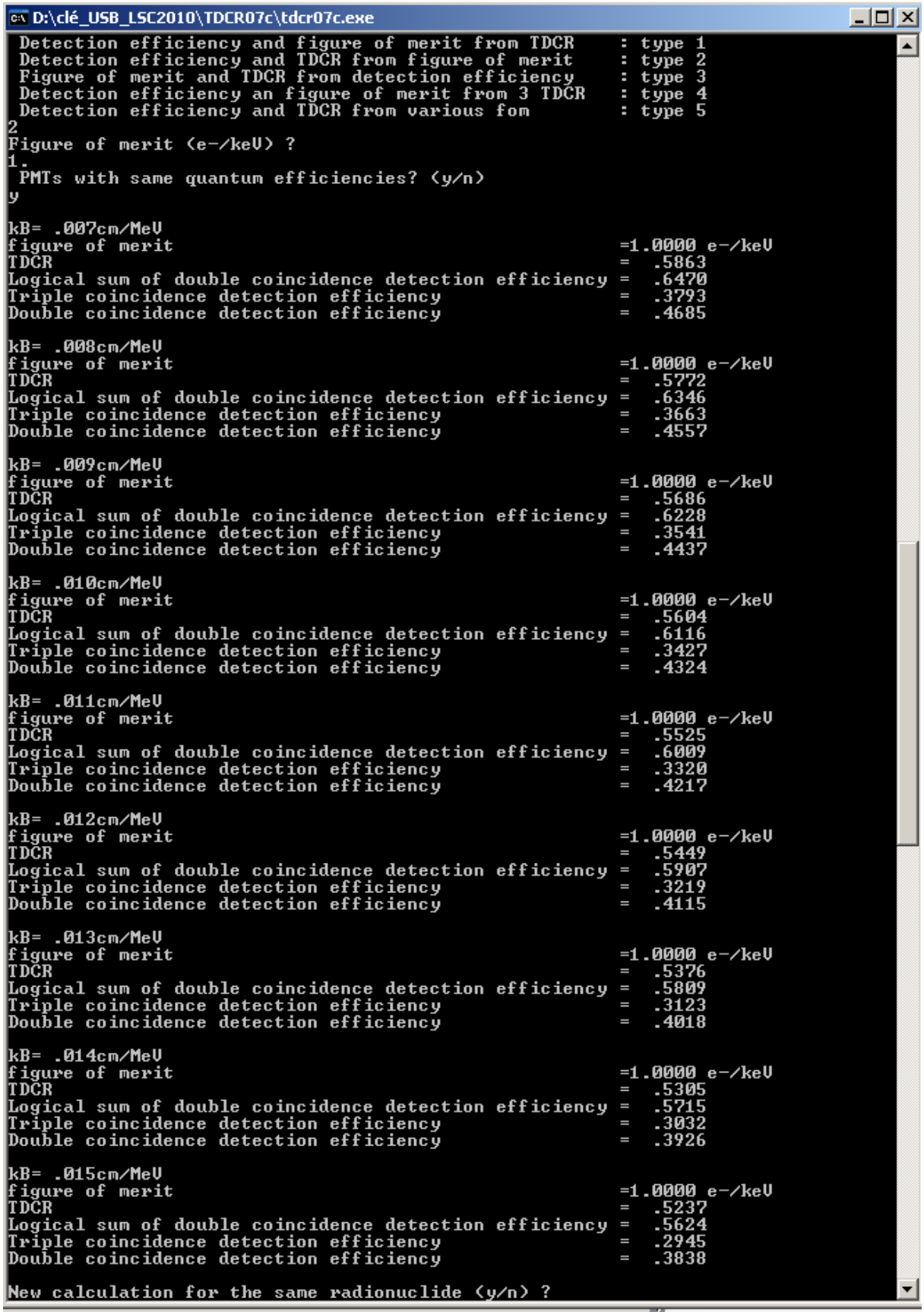
kB= .013cm/MeV
figure of merit                                    = .8830 e-/keV
TDCR                                               =  .5000
Logical sum of double coincidence detection efficiency =  .5440
Triple coincidence detection efficiency            =  .2720
Double coincidence detection efficiency            =  .3596

kB= .014cm/MeV
figure of merit                                    = .9037 e-/keV
TDCR                                               =  .5000
Logical sum of double coincidence detection efficiency =  .5414
Triple coincidence detection efficiency            =  .2707
Double coincidence detection efficiency            =  .3579

kB= .015cm/MeV
figure of merit                                    = .9242 e-/keV
TDCR                                               =  .5000
Logical sum of double coincidence detection efficiency =  .5389
Triple coincidence detection efficiency            =  .2695
Double coincidence detection efficiency            =  .3563
```

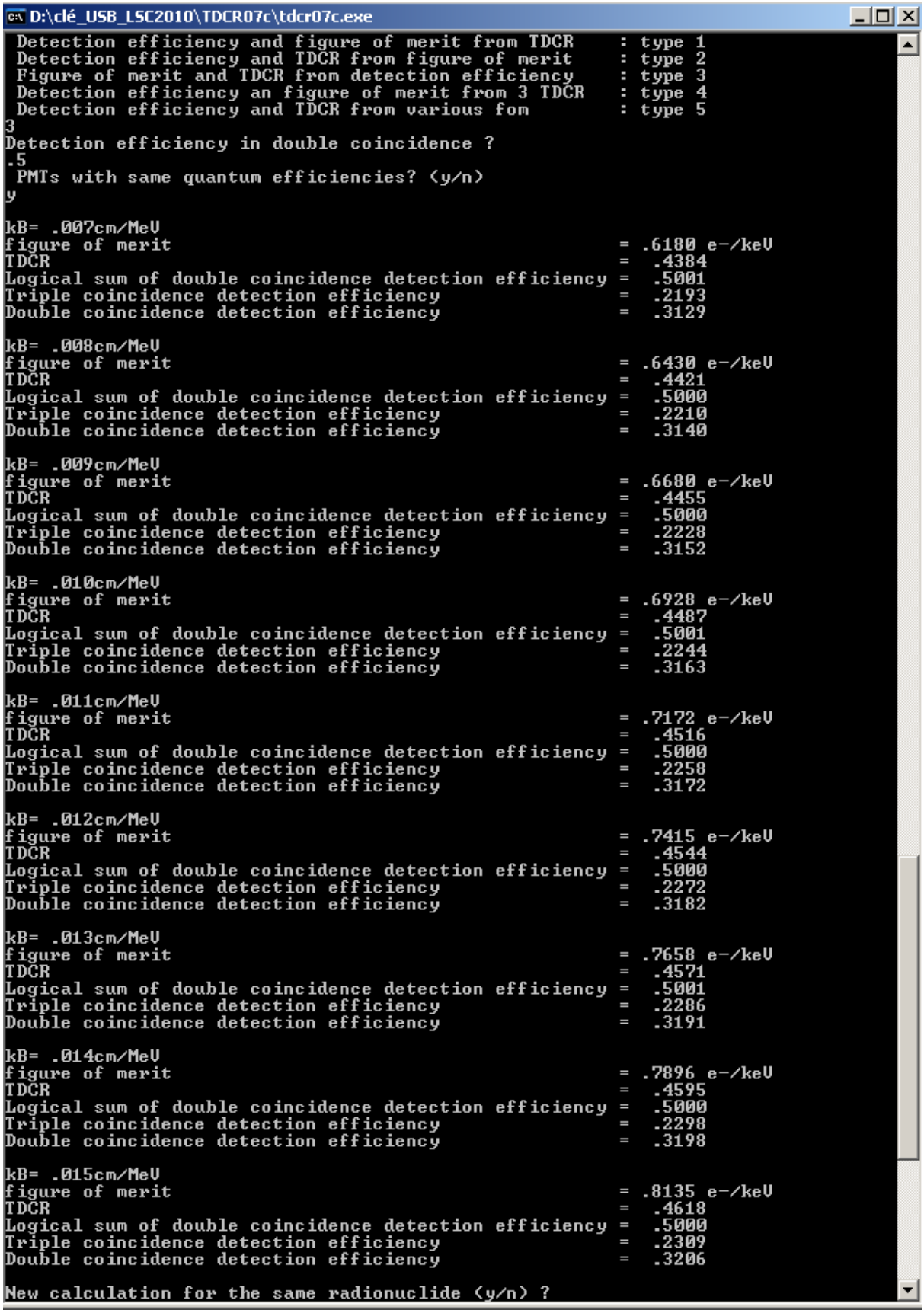
Option 2

An alternative calculation can be made using the figure of merit, for example obtained from the previous measurement of a radionuclide standard for the same scintillator and the same chemical composition of the source. This is done by selecting option 2 in the menu:



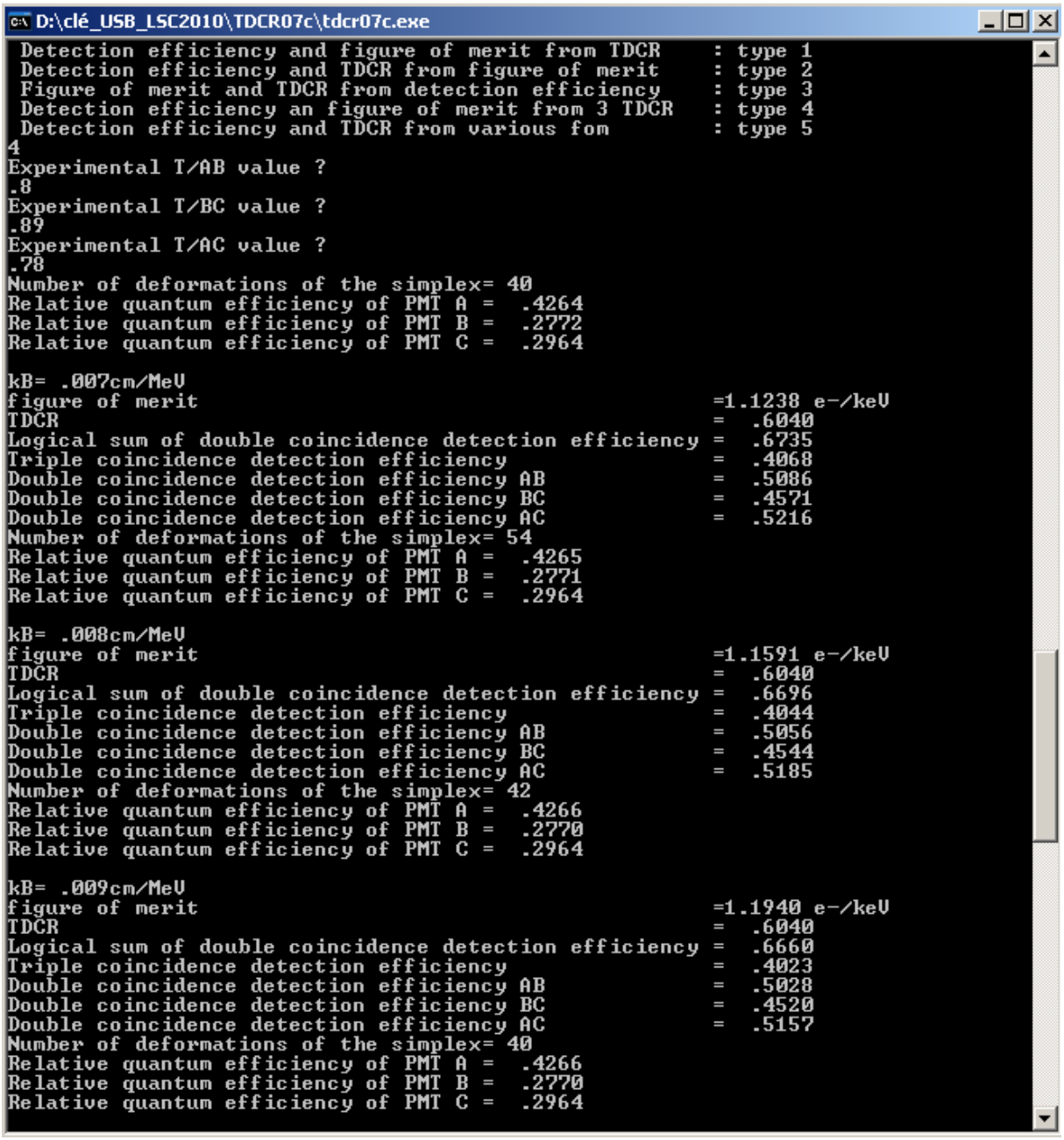
Option 3

This option allows the determination of the figure of merit from the detection efficiency. This option is used for the implementation of the tracer method, when measuring a radioactive standard and before using option 2.



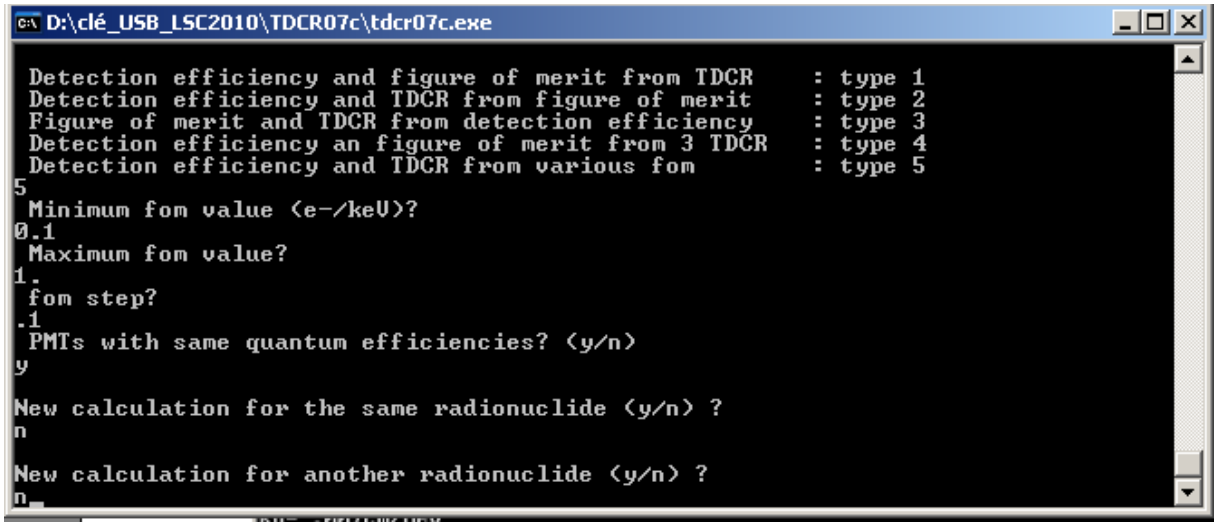
Option 4

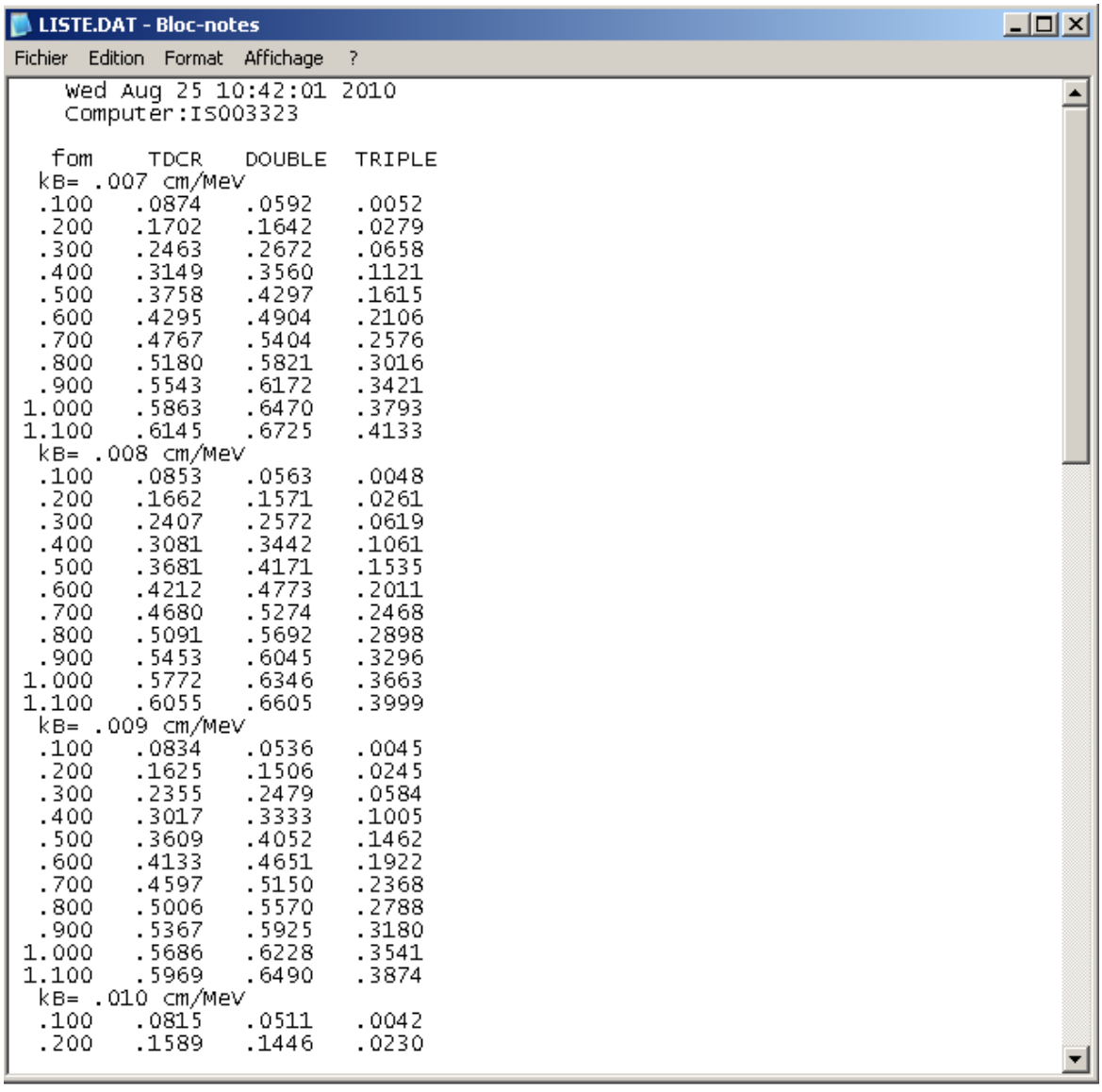
This option is used to calculate the detection efficiencies from the 3 values of individual double coincidences, when the asymmetry of the 3 PMT is not negligible. The program calculates the detection efficiency for each 3 double coincidences and also gives the relative quantum efficiencies of each PMT:



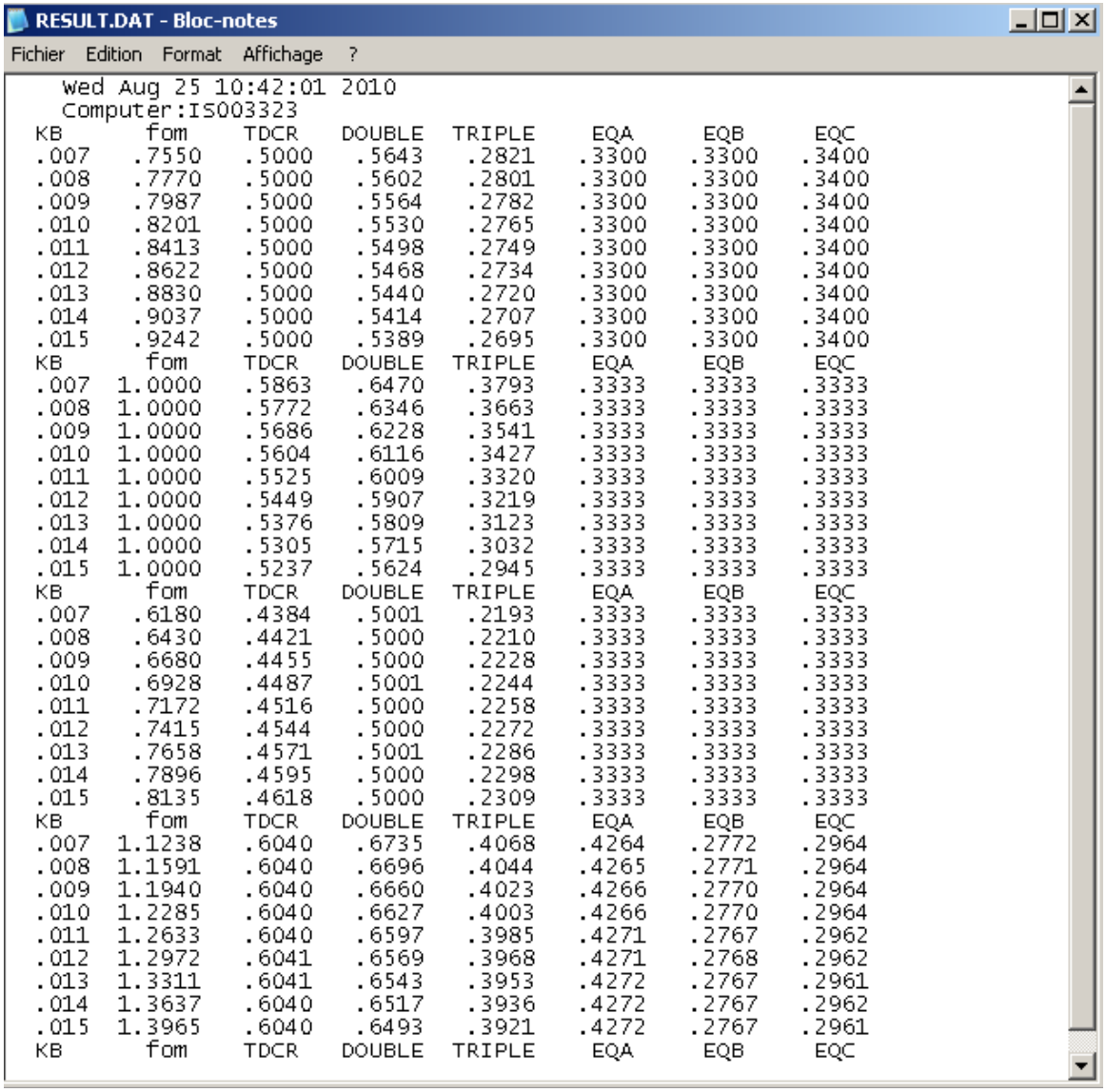
Option 5

This last option is to calculate detection efficiencies and TDCR in a given range of figures of merit. This could be useful when using non-monotonic spectra, when the solution algorithm used in option 1 and 5 does not work, or more generally, in the case where a value of TDCR corresponds to multiples values of detection efficiency. This option generates the file “liste.dat”.





At the end of the calculation, the main results are resumed in the file “result.dat” as shown in the next example corresponding to the sequence of calculations previously described. The program then asks for a new calculation of the same radionuclide or of another radionuclide. When multiple calculations are done, the results are written in the same “result.dat” file.



RESULT.DAT - Bloc-notes

Fichier Edition Format Affichage ?

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   Wed Aug 25 10:42:01 2010
   Computer:IS003323
KB      fom     TDCR    DOUBLE  TRIPLE     EQA      EQB      EQC
.007   .7550   .5000    .5643   .2821    .3300    .3300    .3400
.008   .7770   .5000    .5602   .2801    .3300    .3300    .3400
.009   .7987   .5000    .5564   .2782    .3300    .3300    .3400
.010   .8201   .5000    .5530   .2765    .3300    .3300    .3400
.011   .8413   .5000    .5498   .2749    .3300    .3300    .3400
.012   .8622   .5000    .5468   .2734    .3300    .3300    .3400
.013   .8830   .5000    .5440   .2720    .3300    .3300    .3400
.014   .9037   .5000    .5414   .2707    .3300    .3300    .3400
.015   .9242   .5000    .5389   .2695    .3300    .3300    .3400
KB      fom     TDCR    DOUBLE  TRIPLE     EQA      EQB      EQC
.007  1.0000   .5863    .6470   .3793    .3333    .3333    .3333
.008  1.0000   .5772    .6346   .3663    .3333    .3333    .3333
.009  1.0000   .5686    .6228   .3541    .3333    .3333    .3333
.010  1.0000   .5604    .6116   .3427    .3333    .3333    .3333
.011  1.0000   .5525    .6009   .3320    .3333    .3333    .3333
.012  1.0000   .5449    .5907   .3219    .3333    .3333    .3333
.013  1.0000   .5376    .5809   .3123    .3333    .3333    .3333
.014  1.0000   .5305    .5715   .3032    .3333    .3333    .3333
.015  1.0000   .5237    .5624   .2945    .3333    .3333    .3333
KB      fom     TDCR    DOUBLE  TRIPLE     EQA      EQB      EQC
.007   .6180   .4384    .5001   .2193    .3333    .3333    .3333
.008   .6430   .4421    .5000   .2210    .3333    .3333    .3333
.009   .6680   .4455    .5000   .2228    .3333    .3333    .3333
.010   .6928   .4487    .5001   .2244    .3333    .3333    .3333
.011   .7172   .4516    .5000   .2258    .3333    .3333    .3333
.012   .7415   .4544    .5000   .2272    .3333    .3333    .3333
.013   .7658   .4571    .5001   .2286    .3333    .3333    .3333
.014   .7896   .4595    .5000   .2298    .3333    .3333    .3333
.015   .8135   .4618    .5000   .2309    .3333    .3333    .3333
KB      fom     TDCR    DOUBLE  TRIPLE     EQA      EQB      EQC
.007  1.1238   .6040    .6735   .4068    .4264    .2772    .2964
.008  1.1591   .6040    .6696   .4044    .4265    .2771    .2964
.009  1.1940   .6040    .6660   .4023    .4266    .2770    .2964
.010  1.2285   .6040    .6627   .4003    .4266    .2770    .2964
.011  1.2633   .6040    .6597   .3985    .4271    .2767    .2962
.012  1.2972   .6041    .6569   .3968    .4271    .2768    .2962
.013  1.3311   .6041    .6543   .3953    .4272    .2767    .2961
.014  1.3637   .6040    .6517   .3936    .4272    .2767    .2962
.015  1.3965   .6040    .6493   .3921    .4272    .2767    .2961
KB      fom     TDCR    DOUBLE  TRIPLE     EQA      EQB      EQC
```

All the files ”result.dat”, “spectrum.dat” and “liste.dat” are overwritten for each program execution and thus, it is a good idea to rename these files if necessary. Another consequence is that the program crashes if one of these file is already opened in another application.
For option 4, the input data must be realistic and consistent and entering random data could also lead to an execution error.