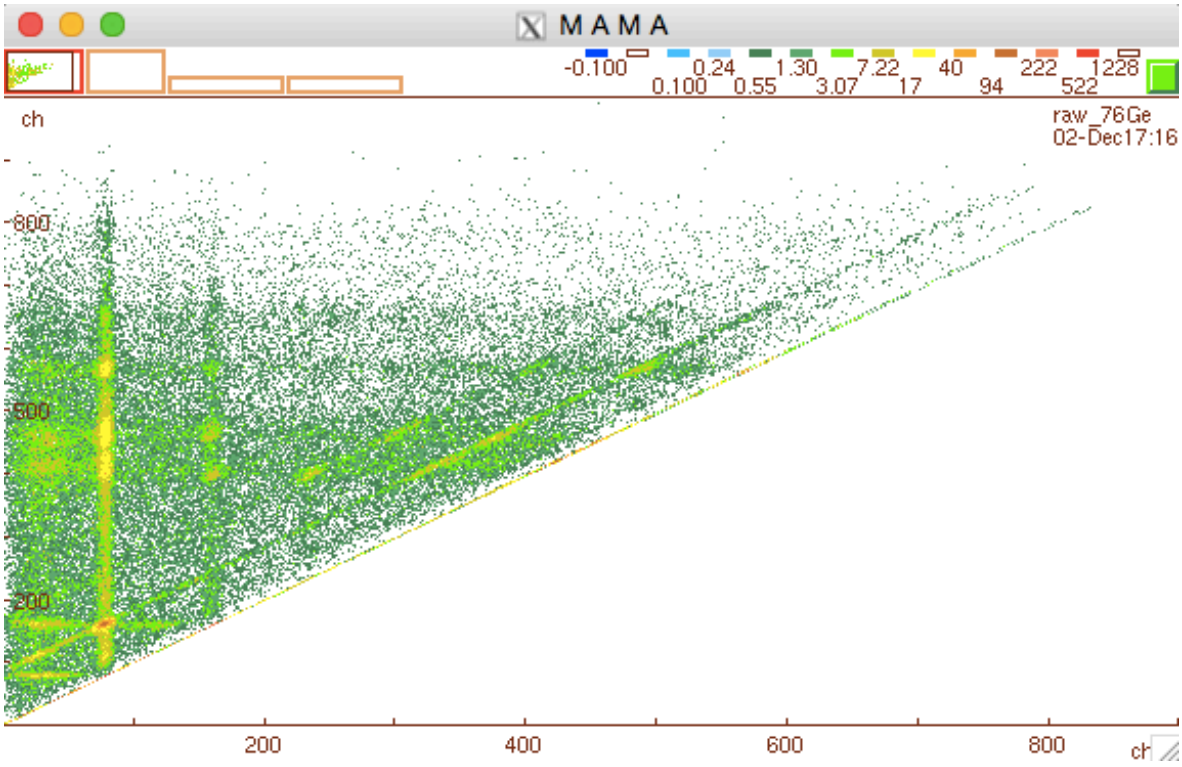
Analysis 76Ge – Dec 3, 2015
NSCL/MSU workshop Dec 1-4, 2015
Cecilie

1. Unfolding

The silicon detector was not placed exactly in the center of SuN. Therefore, segment 2 and 3 will have somewhat different response functions. The two “raw data” matrices, **raw_76Ge_seg2** and **raw_76Ge_seg3,** need to be unfolded separately and then added together before extracting the distribution of primary gamma rays.

We start with **raw_76Ge_seg2:**

```
anncecil@Ann-Cecilies-MacBook-Air-2:76Ge_EB09> mama

 _____________________________________________________
|                                                     |
|              Welcome to M A M A  7.4.1              |
|                                                     |
|   MAtrix MAnipulation, Oslo Cyclotron Laboratory    |
|           Magne Guttormsen, November 2002           |
|                                                     |
|   MAMA handles 2 matrices of dimension 4096x2048    |
|       and 2 singles spectra of length 8192          |
|                                                     |
| Imortant commands:                                  |
|  HE - help            ST - stop MAMA                |
|  RE - read file       WR - write file               |
|  DS - display spec.   CR - curser, activate spec.   |
|  HE NW - news                                       |
|_____________________________________________________|
mama>re
Destination spectrum <1>:
Filename          <TEST>:raw_76Ge_seg2
 FILE=Disk
 KIND=Matrix
 LABORATORY=Oslo Cyclotron Laboratory (OCL)
 EXPERIMENT=siri2root
 COMMENT=none
 TIME=2014-07-09 10:21:54
 CALIBRATION EkeV=6, 1.000000E+00, 7.000000E+00, 0.000000E+00, 1.000000E
+00, 7.000000E+00, 0.000000E+00
 PRECISION=16
 DIMENSION=2,0: 999,0: 999
 CHANNEL=(0: 999,0: 999)
.....................
mama>ds2
```



Make response matrix for this segment:

```
mama>rm
Dimension of response-matrix <1000>:

Cal. coeff. a0 (keV)     <     1.0>:
Cal. coeff. a1 (keV/ch)  <     7.0>:

 List of response functions. The ones marked old, are not recommended
 (1) NaI_old,    CACTUS 5x5 inch before 2012
 (2) LaBr_2012,  Campaign 4x8 inch LaBr from Milano in CACTUS frame
 (3) NaI_2012,   CACTUS 5x5 inch after 2012
 (4) Seg2,       SuN at MSU 2014, with target inside  (2 cm?), GEANT4
 (5) Seg3,       SuN at MSU 2014, with target outside (2 cm?), GEANT4
 (6) Clover_old, Notre Dame 2015, GEANT4
 (7) Clover,     Notre Dame 2015, GEANT4
 (8) Seg23,      SuN at MSU 2015 with target in center, GEANT4
 (9) Gaussian

Choose your response function <3>:4

 If you are unfolding/folding a gamma-ray matrix or spectrum,
 you should create response functions with 10 times less FWHM
 than experimentally known. Then FWHM(response) = FWHM(real)/10,
 which is optimal for the unfolding (UN) and folding (FO) procedures.
 If you just want to view the response matrix with command GR,
 then use a factor = 1. Then FWHM(response) = FWHM(real).

Respons functions for unfolding/folding (10.) or viewing (1.) <10.0>:
Real experimental relative FWHM value at Egam=1.33 MeV (%)<  5.9>:

(In the calculation the response function is obtained
with a FWHM value of (1/10.0)*(the real experimental FWHM)
due to technical reasons in the unfolding procedure)
.................................
 Parameters for response function written to resp.dat
```

```
mama>
```

Choose limits for unfolding:

```
mama>cr
Type X or click on green button to exit
x=  159, energy =   1114.000 keV
y=  146, energy =   1023.000 keV
Number of counts=  0.000000E+00
x=  622, energy =   4355.000 keV
y=  596, energy =   4173.000 keV
Number of counts=  0.000000E+00
```

Unfold:

```
mama>un
Destination spectrum <2>:
Source spectrum      <1>:

New (0) or old (1) unfolding procedure <0>:

Dimension along x-axis <1000>:
Dimension along y-axis <1000>:
 Give upper limits for the unfolding. The boarder is
 given by interpolation between (x1,y1) and (x2,y2)

     (x2,y2) second point
 xxxxxxx
 xxxxxxxxx
 xxxxxxxxxxx
 xx matrix xxx
 xxxxxxxxxxxxxx
              (x1,y1) first point


First point x1  <  999>:159
First point y1  <    0>:146
Second point x2 <  999>:622
Second point y2 <  999>:596
  Give limits for the chisquare-test:
  Opt. 1: Recommended for LaBr- and NaI-spectra. For full-
          energy gammas above 2 MeV, we set lower limit at 500 keV.
           Below, the limit is 1/4 of the full-energy. Remember,
          full-energy is taken from the upper unfolding limit
  Opt. 2: A fixed lower limit for the chi-test is applied
  Opt. 3: Return and set proper upper limits for unfolding


Option (1/2/3)                 <1>:

Include total detector efficiency (y/n) <y>:

 The efficiency at low energy (< 1000 keV) have to be given.
 It depends on various experimental conditions as thresholds
 on ADCs, gamma-absorber (2 mm Cu), timing etc. The program
 always assumes Eff = 0.0 at Egam < 30 keV and Eff = 1.00 at
 Egam > 1000 keV. However, in between these energies you can
 define a new shape of the discrimination.

   |                                                 ************
   |                                  ***************
0.8|                                ***
   |                               *
0.6|                            ***
   |                         ***
```

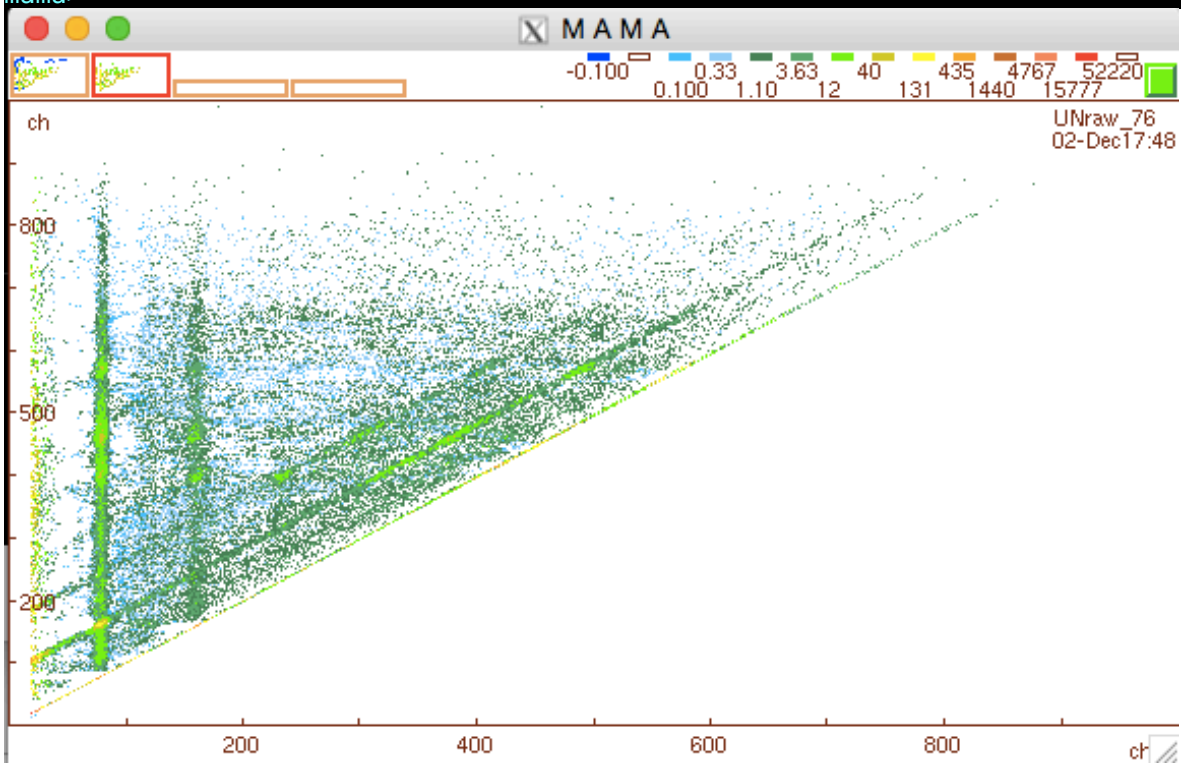
```
0.4|                     **
   |                    *
0.2|                   *
   |                 ***
0.0|---------.---------.---------.---------.---------.---------.
   0        100       200       300       400       500   E(keV)

Do you want to change the discriminator threshold <n>:

Number of iterations ( <200 )  <33>:

 The iteration is terminated when the folding of
 the unfolded spectrum equals the raw spectrum. It
 is however recommended to stop before the Chi2 is
 at minimum. Thus, you can put a certain weight on
 the importance not to have too strong fluctuations
 in the final spectrum. We recommend a weight-factor
 of 0.2 (valid range is 0.0 - 0.5)

Weight on fluctuations <0.2>:
 Row:   0  Mode: n  Area:        0(        0)  Chi:   0.00  Fluct:  1.00
 Row:   1  Mode: n  Area:        0(        0)  Chi:   0.00  Fluct:  1.00
 Row:   2  Mode: n  Area:        0(        0)  Chi:   0.00  Fluct:  1.00
```

Fill and delete negative counts with the commands >fn and >rn, and save matrix:

```
mama>fn
Destination spectrum <1>:
Source spectrum      <2>:

Dimension along x-axis <1000>:
Dimension along y-axis <1000>:

Lowest and highest counts are (min,max) = (-0.15E+04 0.47E+05)
You may now delete the most negative numbers before filling
Do you want to delete these negative counts     <n>:

Write FWHMx (ch) around ch x=  100 <   6.1>:
Write FWHMx (ch) around ch x=  900 <  33.6>:

Write FWHMy (ch) around ch y=  100 <   1.0>:
Write FWHMy (ch) around ch y=  900 <   1.0>:
 FWHM have been expressed by A + B * SQRT(ch):
Ax= -7.5844  Bx=  1.3713     Ay=  1.0000 By= -0.0000
Probability-matrix around (x,y)=( 100, 100):

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0010.0030.0050.0100.0150.0200.0250.0260.0250.0200.0150.0100.0050.0030.00
1

0.0040.0090.0190.0330.0510.0700.0840.0900.0840.0700.0510.0330.0190.0090.00
4

0.0010.0030.0050.0100.0150.0200.0250.0260.0250.0200.0150.0100.0050.0030.00
1

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
```

```
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

 Probability-matrix around (x,y)=( 900, 900):

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0050.0050.0050.0050.0050.0050.0050.0050.0050.0050.0050.0050.0050.00
5

0.0160.0160.0160.0170.0170.0170.0170.0170.0170.0170.0170.0160.0160.01
6

0.0050.0050.0050.0050.0050.0050.0050.0050.0050.0050.0050.0050.0050.00
5

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

Probability-matrix OK? (y/n) <y>:
.....................................................................
.........................
Before number of neg. ch. was: 274777, with total counts:   -472878
After  number of neg. ch. is:   44316, with total counts:   -216574
mama>rn
Destination spectrum <2>:
Source spectrum      <1>:

 With this command you may replace the counts in the
 spectrum/matrix with a given value. The options are:
 Replace counts if they are below a certain value, or,
 if the counts are in-between two values, or if the
 counts exceed a certain value. The defaults are:
 Choose (1), replace-value = 0 and Max = 0 which will
 delete all negative numbers.
 You may also change floating point values -> integers.
 ---------------------------------------------------
       Counts < Max is replaced..... choose: (1)
 Min < Counts < Max is replaced..... choose: (2)
 Min < Counts       is replaced..... choose: (3)
 Replace floating counts by integers..... choose: (4)
 Return to MAMA..... choose: (5)
 ---------------------------------------------------
 Choose your option                          <1>:

Give new value for the counts to be replaced <  0.00>:
```

```
Delete counts with value lower than          <  0.00>:

Number of channels replaced:         44316
Number of counts before:           818055.7
Number of counts after:           1034512.9
Increase of counts:                216457.2
mama>wr

Spectrum to write            <2>:
Singles spectrum                1
Set of spectra NA-0, NA-1,...   2
2-dimensional spectrum (matrix) 3
Please, choose your type     <3>:

Cal. coeff. a0 (keV) on x-axis     <        1.0>:
Cal. coeff. a1 (keV/ch) on x-axis  <      7.000>:
Cal. coeff. a2 (keV/ch2) on x-axis < 0.0000E+00>:

Cal. coeff. a0 (keV) on y-axis     <        1.0>:
Cal. coeff. a1 (keV/ch) on y-axis  <      7.000>:
Cal. coeff. a2 (keV/ch2) on y-axis < 0.0000E+00>:

Dimension on x-axis (max=4096) <1000>:
Dimension on y-axis (max=2048)  <1000>:
Filename                      <TEST>:unf_seg2_76Ge
mama>
```



Now, let's do the same with **raw_76Ge_seg3:**
Read matrix in MAMA:

```
mama>re
Destination spectrum <1>:
Filename          <TEST>:raw_76Ge_seg3
 FILE=Disk
 KIND=Matrix
 LABORATORY=Oslo Cyclotron Laboratory (OCL)
 EXPERIMENT=siri2root
 COMMENT=none
```

```
 TIME=2014-07-09 10:10:58
 CALIBRATION EkeV=6, 1.000000E+00, 7.000000E+00, 0.000000E+00, 1.000000E
+00, 7.000000E+00, 0.000000E+00
 PRECISION=16
 DIMENSION=2,0: 999,0: 999
 CHANNEL=(0: 999,0: 999)
.....................
mama>
```

Create response matrix for SuN segment 3:

```
mama>rm
Dimension of response-matrix <1000>:

Cal. coeff. a0 (keV)     <     1.0>:
Cal. coeff. a1 (keV/ch)  <     7.0>:

 List of response functions. The ones marked old, are not recommended
 (1) NaI_old,    CACTUS 5x5 inch before 2012
 (2) LaBr_2012,  Campaign 4x8 inch LaBr from Milano in CACTUS frame
 (3) NaI_2012,   CACTUS 5x5 inch after 2012
 (4) Seg2,       SuN at MSU 2014, with target inside  (2 cm?), GEANT4
 (5) Seg3,       SuN at MSU 2014, with target outside (2 cm?), GEANT4
 (6) Clover_old, Notre Dame 2015, GEANT4
 (7) Clover,     Notre Dame 2015, GEANT4
 (8) Seg23,      SuN at MSU 2015 with target in center, GEANT4
 (9) Gaussian

Choose your response function <3>:5

 If you are unfolding/folding a gamma-ray matrix or spectrum,
 you should create response functions with 10 times less FWHM
 than experimentally known. Then FWHM(response) = FWHM(real)/10,
 which is optimal for the unfolding (UN) and folding (FO) procedures.
 If you just want to view the response matrix with command GR,
 then use a factor = 1. Then FWHM(response) = FWHM(real).

Respons functions for unfolding/folding (10.) or viewing (1.) <10.0>:
Real experimental relative FWHM value at Egam=1.33 MeV (%)<  6.0>:

(In the calculation the response function is obtained
with a FWHM value of (1/10.0)*(the real experimental FWHM)
due to technical reasons in the unfolding procedure)
.................................
 Parameters for response function written to resp.dat

mama>
```

Choose limits for unfolding again (same as for segment 2, doesn't matter):

```
mama>cr
Type X or click on green button to exit
x=  159, energy =   1114.000 keV
y=  146, energy =   1023.000 keV
Number of counts=  0.000000E+00
x=  622, energy =   4355.000 keV
y=  596, energy =   4173.000 keV
Number of counts=  0.000000E+00
```

Unfold again:

```
mama>un
Destination spectrum <2>:
Source spectrum      <1>:

New (0) or old (1) unfolding procedure <0>:
```

```
Dimension along x-axis <1000>:
Dimension along y-axis <1000>:
 Give upper limits for the unfolding. The boarder is
 given by interpolation between (x1,y1) and (x2,y2)

     (x2,y2) second point
 xxxxxxx
 xxxxxxxxx
 xxxxxxxxxxx
 xx matrix xxx
 xxxxxxxxxxxxxx
              (x1,y1) first point


First point x1  <  999>:159
First point y1  <    0>:146
Second point x2 <  999>:622
Second point y2 <  999>:596
  Give limits for the chisquare-test:
  Opt. 1: Recommended for LaBr- and NaI-spectra. For full-
          energy gammas above 2 MeV, we set lower limit at 500 keV.
           Below, the limit is 1/4 of the full-energy. Remember,
          full-energy is taken from the upper unfolding limit
  Opt. 2: A fixed lower limit for the chi-test is applied
  Opt. 3: Return and set proper upper limits for unfolding


Option (1/2/3)                  <1>:

Include total detector efficiency (y/n) <y>:

 The efficiency at low energy (< 1000 keV) have to be given.
 It depends on various experimental conditions as thresholds
 on ADCs, gamma-absorber (2 mm Cu), timing etc. The program
 always assumes Eff = 0.0 at Egam < 30 keV and Eff = 1.00 at
 Egam > 1000 keV. However, in between these energies you can
 define a new shape of the discrimination.

   |                                                  ************
   |                                  ***************
0.8|                                ***
   |                               *
0.6|                           ***
   |                        ***
0.4|                      **
   |                     *
0.2|                    *
   |                 ***
0.0|---------.---------.---------.---------.---------.---------.
   0        100       200       300       400       500   E(keV)

Do you want to change the discriminator threshold <n>:

Number of iterations ( <200 )  <33>:

 The iteration is terminated when the folding of
 the unfolded spectrum equals the raw spectrum. It
 is however recommended to stop before the Chi2 is
 at minimum. Thus, you can put a certain weight on
 the importance not to have too strong fluctuations
 in the final spectrum. We recommend a weight-factor
 of 0.2 (valid range is 0.0 - 0.5)
```

```
Weight on fluctuations <0.2>:
 Row:   0  Mode: n  Area:        0(        0)  Chi:   0.00  Fluct:  1.00
 Row:   1  Mode: n  Area:        0(        0)  Chi:   0.00  Fluct:  1.00
 Row:   2  Mode: n  Area:        0(        0)  Chi:   0.00  Fluct:  1.00
 Row:   3  Mode: n  Area:        0(       14)  Chi:   1.75  Fluct:  1.00
 Row:   4  Mode: r  Area:        8(       20)  Chi:   0.88  Fluct:  1.17
```

Again, fill and delete negative counts with the commands >fn and >rn, and save matrix:

```
mama>fn
Destination spectrum <1>:
Source spectrum      <2>:

Dimension along x-axis <1000>:
Dimension along y-axis <1000>:

Lowest and highest counts are (min,max) = (-0.14E+05 0.21E+06)
You may now delete the most negative numbers before filling
Do you want to delete these negative counts     <n>:

Write FWHMx (ch) around ch x=  100 <   6.1>:
Write FWHMx (ch) around ch x=  900 <  33.6>:

Write FWHMy (ch) around ch y=  100 <   1.0>:
Write FWHMy (ch) around ch y=  900 <   1.0>:
 FWHM have been expressed by A + B * SQRT(ch):
Ax= -7.5844  Bx=  1.3713     Ay=  1.0000 By= -0.0000
Probability-matrix around (x,y)=( 100, 100):

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0010.0030.0050.0100.0150.0200.0250.0260.0250.0200.0150.0100.0050.0030.00
1

0.0040.0090.0190.0330.0510.0700.0840.0900.0840.0700.0510.0330.0190.0090.00
4

0.0010.0030.0050.0100.0150.0200.0250.0260.0250.0200.0150.0100.0050.0030.00
1

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

 Probability-matrix around (x,y)=( 900, 900):

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0
```

```
0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0050.0050.0050.0050.0050.0050.0050.0050.0050.0050.0050.0050.0050.0050.00
5

0.0160.0160.0160.0170.0170.0170.0170.0170.0170.0170.0170.0170.0160.0160.01
6

0.0050.0050.0050.0050.0050.0050.0050.0050.0050.0050.0050.0050.0050.0050.00
5

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

Probability-matrix OK? (y/n) <y>:
.....................................................................
.....................
Before number of neg. ch. was: 294395, with total counts:  -2473656
After  number of neg. ch. is:   43839, with total counts:  -1296269
mama>
mama>rn
Destination spectrum <2>:
Source spectrum      <1>:

 With this command you may replace the counts in the
 spectrum/matrix with a given value. The options are:
 Replace counts if they are below a certain value, or,
 if the counts are in-between two values, or if the
 counts exceed a certain value. The defaults are:
 Choose (1), replace-value = 0 and Max = 0 which will
 delete all negative numbers.
 You may also change floating point values -> integers.
 ---------------------------------------------------
       Counts < Max is replaced..... choose: (1)
 Min < Counts < Max is replaced..... choose: (2)
 Min < Counts       is replaced..... choose: (3)
 Replace floating counts by integers..... choose: (4)
 Return to MAMA..... choose: (5)
 ---------------------------------------------------
 Choose your option                          <1>:

Give new value for the counts to be replaced <  0.00>:
Delete counts with value lower than          <  0.00>:

Number of channels replaced:         43839
Number of counts before:         1713730.8
Number of counts after:          3009991.8
Increase of counts:              1296261.0
mama>wr

Spectrum to write           <2>:
Singles spectrum               1
Set of spectra NA-0, NA-1,...  2
2-dimensional spectrum (matrix) 3
Please, choose your type    <3>:

Cal. coeff. a0 (keV) on x-axis     <        1.0>:
```

```
Cal. coeff. a1 (keV/ch) on x-axis  <      7.000>:
Cal. coeff. a2 (keV/ch2) on x-axis < 0.0000E+00>:

Cal. coeff. a0 (keV) on y-axis     <        1.0>:
Cal. coeff. a1 (keV/ch) on y-axis  <      7.000>:
Cal. coeff. a2 (keV/ch2) on y-axis < 0.0000E+00>:

Dimension on x-axis (max=4096) <1000>:
Dimension on y-axis (max=2048)  <1000>:
Filename                      <TEST>:unf_seg3_76Ge
mama>
```

Now, these two matrices should be added together before getting the first-generation gammas:

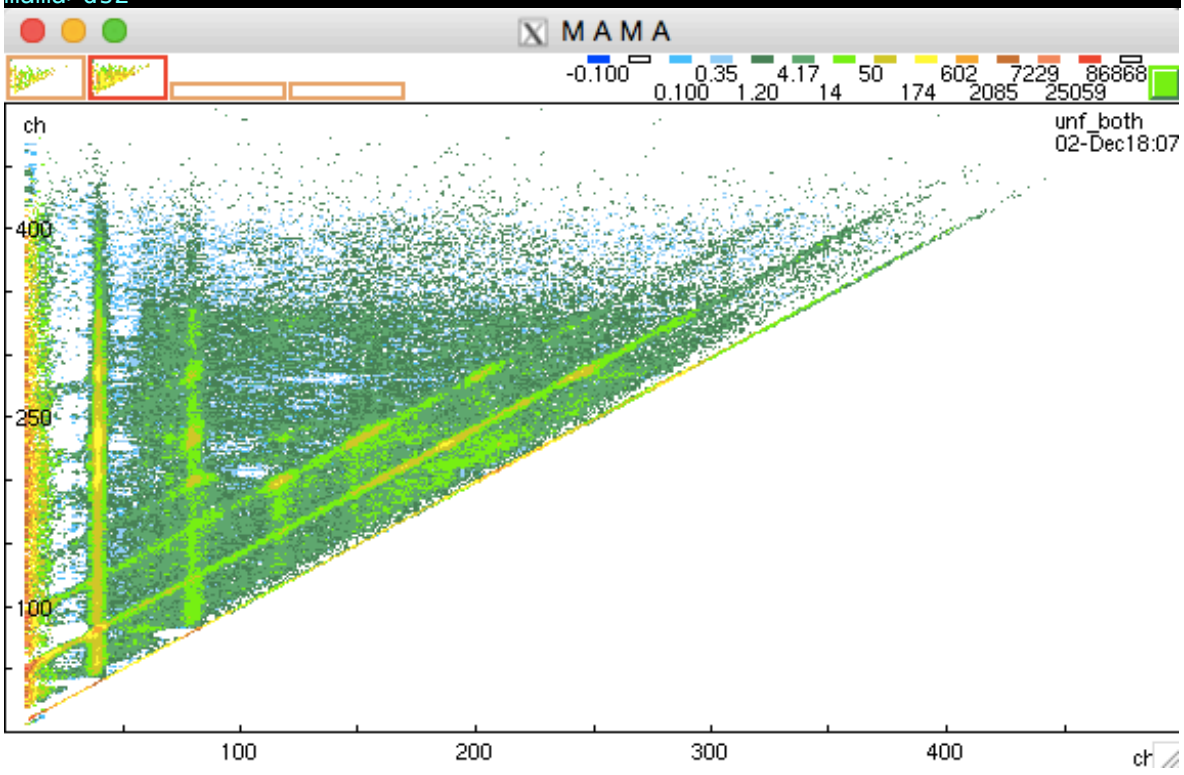
```
mama>re
Destination spectrum <1>:
Filename          <TEST>:unf_seg2_76Ge
 FILE=Disk
 KIND=Spectrum
 LABORATORY=Oslo Cyclotron Laboratory (OCL)
 EXPERIMENT=mama
 COMMENT=none|RE:raw_76GeUN:FN:RN:
 TIME=DATE:02-Dec-15 17:47:46W
 CALIBRATION EkeV=6, 0.100000E+01, 0.700000E+01, 0.000000E+00, 0.100000E
+01, 0.700000E+01, 0.000000E+00
 PRECISION=16
 DIMENSION=2,0: 999,0: 999
 CHANNEL=(0: 999,0: 999)
.....................
mama>re
Destination spectrum <1>:2
Filename          <TEST>:unf_seg3_76Ge
 FILE=Disk
 KIND=Spectrum
 LABORATORY=Oslo Cyclotron Laboratory (OCL)
 EXPERIMENT=mama
 COMMENT=none|RE:raw_76GeUN:FN:RN:
 TIME=DATE:02-Dec-15 18:00:45W
 CALIBRATION EkeV=6, 0.100000E+01, 0.700000E+01, 0.000000E+00, 0.100000E
+01, 0.700000E+01, 0.000000E+00
 PRECISION=16
 DIMENSION=2,0: 999,0: 999
 CHANNEL=(0: 999,0: 999)
.....................
mama>ar

Write your expression:
adding spectra               1=1+2
adding constant              2=1+120.0
subtracting spectra          2=1-2
subtract constant            2=1-120.0
multiply spectra             2=1*2
multiply by constant         1=2*1.17
divide spectra               2=1/2
divide by constant           2=2/1.17
multiply spectrum*matrix     1=1x1
natural logarithm            2=2log
derivate                     2=2der
NOTE: Integer means spectra and real means constant
Type your expression:1=1+2
mama>ds2

mama>wr
```

```
Spectrum to write            <1>:
Singles spectrum               1
Set of spectra NA-0, NA-1,...  2
2-dimensional spectrum (matrix) 3
Please, choose your type     <3>:

Cal. coeff. a0 (keV) on x-axis     <        1.0>:
Cal. coeff. a1 (keV/ch) on x-axis  <      7.000>:
Cal. coeff. a2 (keV/ch2) on x-axis < 0.0000E+00>:

Cal. coeff. a0 (keV) on y-axis     <        1.0>:
Cal. coeff. a1 (keV/ch) on y-axis  <      7.000>:
Cal. coeff. a2 (keV/ch2) on y-axis < 0.0000E+00>:

Dimension on x-axis (max=4096) <1000>:
Dimension on y-axis (max=2048)  <1000>:
Filename                      <TEST>:unf_bothseg_76Ge
mama>
```

2. First-generation gammas

First, let's compress a factor of 2:

```
mama>co
Destination spectrum <2>:
Source spectrum      <1>:
 Compression factors must be integer. With a factor
 of e.g. 3, channels 0,1,2,3 goes to 0,0,0,1

Compression along x-axis <  1>:2
Compression along y-axis <  1>:2
.....................................................................
New dimension (0: 499,0: 499)

mama>ds2
```



Use the >fg command in MAMA:

```
mama>fg
 The original gamma-matrix should be stored in
 the source matrix and the extracted 1.gen. matrix
 will appear in the destination spectrum. The last
 weighting functions used can be accessed from the
 response matrix using the command GR

Destination spectrum <1>:
Source spectrum      <2>:

Calibration for gamma-energies:
Cal. coeff. a0 (keV) on x-axis   <     4.5>:
Cal. coeff. a1 (keV/ch) on x-axis<    14.0>:

Calibration for excitation energies:
Cal. coeff. a0 (keV) on y-axis   <     4.5>:
Cal. coeff. a1 (keV/ch) on y-axis<    14.0>:

Excitation energy of highest gate (keV)  <  6990.5>:

Normalization: singles(1) or multiplicity(2)    <2>:
Multiplicity:  statistical(1) or total(2)       <2>:
Area correction for 1. gen. spectra (y/n)       <y>:
Experimental lower gamma thresholds (keV)  <  200.>:
Upper threshold for nonstat. gammas (keV)  <  200.>:
Average entry point in ground band (keV)   <    0.>:

It is recommended to use a sliding upper threshold when the
excitation energy is lower than 1 - 2 MeV. This is performed
by defining a ratio R, giving Thres=Ex*R with a lower and
higher limit of 200. and 200. keV. Use R = 0.2 - 0.3.

Give ratio R           (no sliding = 100.) <  0.30>:

First geneneration spectra extracted for
excitation energies between  6990.-    4. keV
corresponding to y-channels   499 -    0

You may read weighting functions from disk
Weighting by exp. 1. gen. spectra (y/n)         <n>:

Assumes Fermi gas distribution
Level density parameter a (1/MeV)           < 9.00>:
Exponent n for Eg**n                        < 4.20>:

 Multiplicity in each gate:
 -----------------------------------
 Y-ch= 499 Ex=  6990.5 keV < 1.967>:
 Y-ch= 498 Ex=  6976.5 keV < 1.995>:
 Y-ch= 497 Ex=  6962.5 keV < 9.505>:
 Y-ch= 496 Ex=  6948.5 keV < 0.000>:
 Y-ch= 495 Ex=  6934.5 keV < 0.000>:
```

...

```
Y-ch=  17  Ex=    242.  Area=      4671.1  Alpha=   1.00  dA/A(%)=
0.00
Y-ch=  16  Ex=    228.  Area=      6135.9  Alpha=   1.00  dA/A(%)=
0.00
Y-ch=  15  Ex=    214.  Area=      7907.8  Alpha=   1.00  dA/A(%)=
0.00
Y-ch=  14  Ex=    200.  Area=     12501.6  Alpha=   1.00  dA/A(%)=
0.00
Y-ch=  13  Ex=    186.  Area=      3911.4  Alpha=   1.00  dA/A(%)=
0.00
```

```
Y-ch=  12  Ex=    172.  Area=         0.6  Alpha=   1.00  dA/A(%)=
0.00
Y-ch=  11  Ex=    158.  Area=         1.7  Alpha=   1.00  dA/A(%)=
0.00
Y-ch=  10  Ex=    144.  Area=         1.9  Alpha=   1.00  dA/A(%)=
0.00
Y-ch=   9  Ex=    130.  Area=         0.2  Alpha=   1.00  dA/A(%)=
0.00
Y-ch=   8  Ex=    116.  Area=         0.0  Alpha=   1.00  dA/A(%)=
9999.99
Y-ch=   7  Ex=    102.  Area=         0.0  Alpha=   1.00  dA/A(%)=
9999.99
Y-ch=   6  Ex=     88.  Area=         0.0  Alpha=   1.00  dA/A(%)=
9999.99
Y-ch=   5  Ex=     74.  Area=         0.0  Alpha=   1.00  dA/A(%)=
9999.99
Y-ch=   4  Ex=     60.  Area=         0.0  Alpha=   1.00  dA/A(%)=
9999.99
Y-ch=   3  Ex=     46.  Area=         0.0  Alpha=   1.00  dA/A(%)=
9999.99
Y-ch=   2  Ex=     32.  Area=         0.0  Alpha=   1.00  dA/A(%)=
9999.99
Y-ch=   1  Ex=     18.  Area=         0.0  Alpha=   1.00  dA/A(%)=
9999.99
Y-ch=   0  Ex=      4.  Area=         0.0  Alpha=   1.00  dA/A(%)=
9999.99
-----------------------------------------------

Iteration loop =  2, stop(0), activate/modify direct decay(1) or
continue(2)  <2>:
```

...

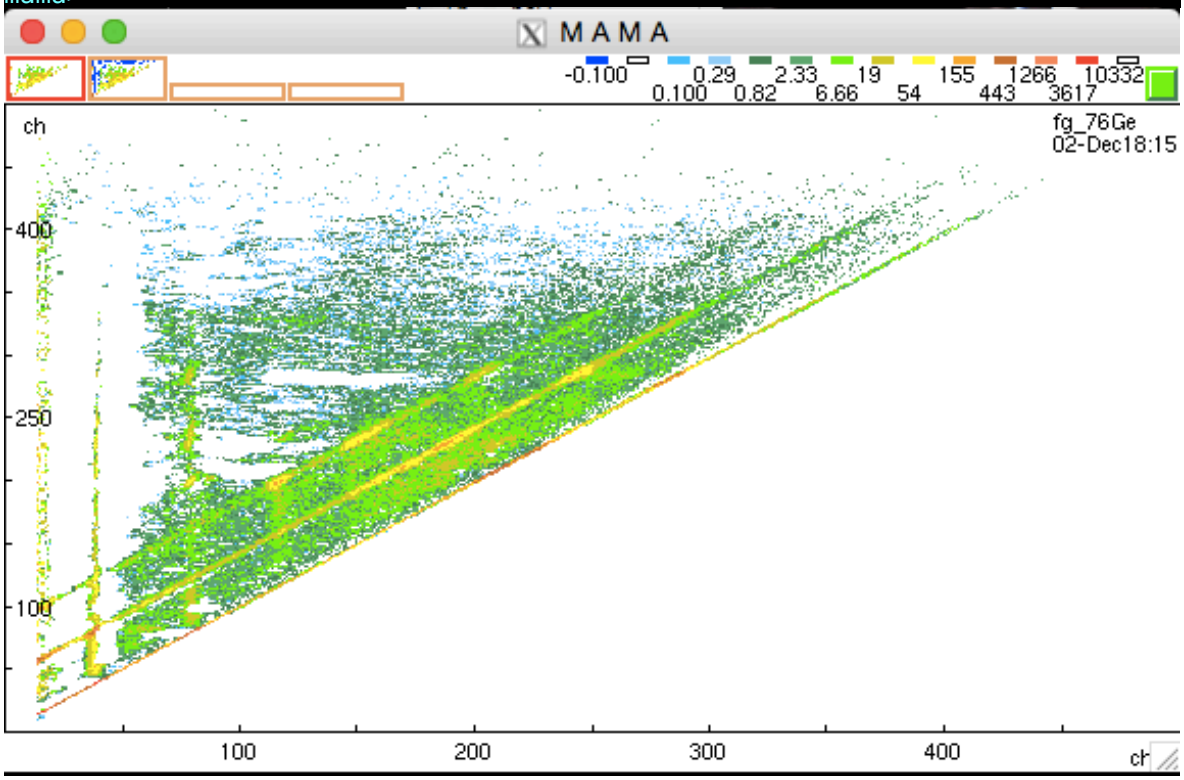
```
Y-ch=  12  Ex=    172.  Area=         0.6  Alpha=   1.00  dA/A(%)=
0.00
Y-ch=  11  Ex=    158.  Area=         1.7  Alpha=   1.00  dA/A(%)=
0.00
Y-ch=  10  Ex=    144.  Area=         1.9  Alpha=   1.00  dA/A(%)=
0.00
Y-ch=   9  Ex=    130.  Area=         0.2  Alpha=   1.00  dA/A(%)=
0.00
Y-ch=   8  Ex=    116.  Area=         0.0  Alpha=   1.00  dA/A(%)=
9999.99
Y-ch=   7  Ex=    102.  Area=         0.0  Alpha=   1.00  dA/A(%)=
9999.99
Y-ch=   6  Ex=     88.  Area=         0.0  Alpha=   1.00  dA/A(%)=
9999.99
Y-ch=   5  Ex=     74.  Area=         0.0  Alpha=   1.00  dA/A(%)=
9999.99
Y-ch=   4  Ex=     60.  Area=         0.0  Alpha=   1.00  dA/A(%)=
9999.99
Y-ch=   3  Ex=     46.  Area=         0.0  Alpha=   1.00  dA/A(%)=
9999.99
Y-ch=   2  Ex=     32.  Area=         0.0  Alpha=   1.00  dA/A(%)=
9999.99
Y-ch=   1  Ex=     18.  Area=         0.0  Alpha=   1.00  dA/A(%)=
9999.99
Y-ch=   0  Ex=      4.  Area=         0.0  Alpha=   1.00  dA/A(%)=
9999.99
-----------------------------------------------

Iteration loop = 20, stop(0), activate/modify direct decay(1) or
continue(2)  <2>:0
Last iteration 20 stored in matrix 1
Additional results written to figegaout.dat
mama>
```

Fill & remove negative counts & save matrix:

```
mama>fn
Destination spectrum <2>:
Source spectrum      <1>:

Dimension along x-axis < 500>:
Dimension along y-axis < 500>:

Lowest and highest counts are (min,max) = (-0.98E+03 0.94E+04)
You may now delete the most negative numbers before filling
Do you want to delete these negative counts     <y>:
Counts < Limit will be deleted, Limit = <-0.94E+03>:

Write FWHMx (ch) around ch x=   50 <   3.1>:
Write FWHMx (ch) around ch x=  450 <  16.8>:

Write FWHMy (ch) around ch y=   50 <   1.0>:
Write FWHMy (ch) around ch y=  450 <   1.0>:
 FWHM have been expressed by A + B * SQRT(ch):
Ax= -3.7900  Bx=  0.9692     Ay=  1.0000 By= -0.0000
Probability-matrix around (x,y)=(  50,  50):

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0070.0210.0390.0490.0390.0210.0070.0000.0000.00
0

0.0000.0000.0000.0050.0240.0700.1350.1670.1350.0700.0240.0050.0000.00
0

0.0000.0000.0000.0000.0070.0210.0390.0490.0390.0210.0070.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

 Probability-matrix around (x,y)=( 450, 450):

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0060.0070.0080.0090.0090.0100.0100.0100.0100.0100.0090.0090.0080.0070.00
6
```

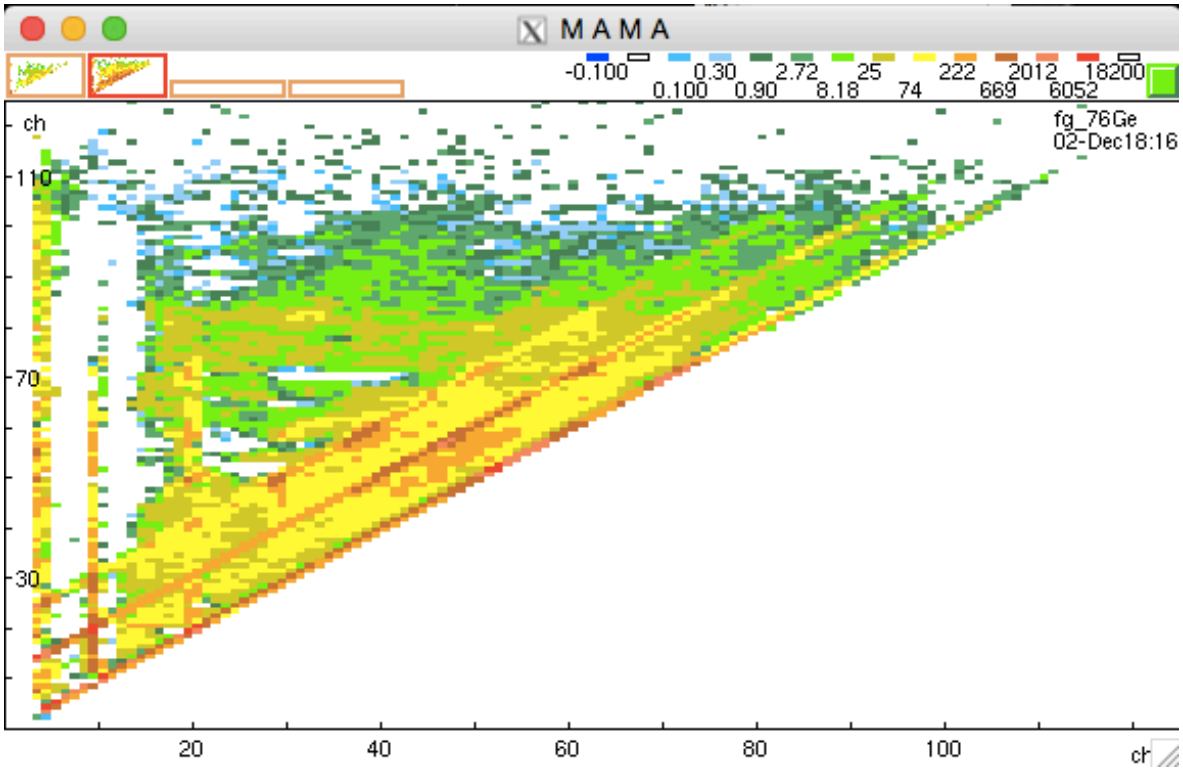
```
0.0220.0250.0270.0300.0320.0330.0340.0340.0340.0330.0320.0300.0270.0250.02
2

0.0060.0070.0080.0090.0090.0100.0100.0100.0100.0100.0090.0090.0080.0070.00
6

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.00
0

Probability-matrix OK? (y/n) <y>:
.....................................................
Before number of neg. ch. was:  53289, with total counts:   -150257
After  number of neg. ch. is:   17792, with total counts:    -83120
mama>rn
Destination spectrum <1>:
Source spectrum      <2>:

 With this command you may replace the counts in the
 spectrum/matrix with a given value. The options are:
 Replace counts if they are below a certain value, or,
 if the counts are in-between two values, or if the
 counts exceed a certain value. The defaults are:
 Choose (1), replace-value = 0 and Max = 0 which will
 delete all negative numbers.
 You may also change floating point values -> integers.
 ------------------------------------------------------
       Counts < Max is replaced..... choose: (1)
 Min < Counts < Max is replaced..... choose: (2)
 Min < Counts       is replaced..... choose: (3)
 Replace floating counts by integers..... choose: (4)
 Return to MAMA.......................... choose: (5)
 ------------------------------------------------------
 Choose your option                              <1>:

Give new value for the counts to be replaced <  0.00>:
Delete counts with value lower than          <  0.00>:

Number of channels replaced:         17792
Number of counts before:          622553.4
Number of counts after:           705629.0
Increase of counts:                83075.6
mama>wr

Spectrum to write            <1>:
Singles spectrum               1
Set of spectra NA-0, NA-1,...  2
2-dimensional spectrum (matrix) 3
Please, choose your type     <3>:

Cal. coeff. a0 (keV) on x-axis     <        4.5>:
Cal. coeff. a1 (keV/ch) on x-axis  <     14.000>:
Cal. coeff. a2 (keV/ch2) on x-axis < 0.0000E+00>:

Cal. coeff. a0 (keV) on y-axis     <        4.5>:
Cal. coeff. a1 (keV/ch) on y-axis  <     14.000>:
Cal. coeff. a2 (keV/ch2) on y-axis < 0.0000E+00>:
```

```
Dimension on x-axis (max=4096) < 500>:
Dimension on y-axis (max=2048)  < 500>:
Filename                       <TEST>:fg_76Ge
mama>
```



Compress a factor of 4 and save:

```
mama>co
Destination spectrum <2>:
Source spectrum      <1>:
 Compression factors must be integer. With a factor
 of e.g. 3, channels 0,1,2,3 goes to 0,0,0,1

Compression along x-axis <  1>:4
Compression along y-axis <  1>:4
.....................................................................
New dimension (0: 124,0: 124)

mama>wr

Spectrum to write            <2>:
Singles spectrum                1
Set of spectra NA-0, NA-1,...   2
2-dimensional spectrum (matrix) 3
Please, choose your type     <3>:

Cal. coeff. a0 (keV) on x-axis     <       25.5>:
Cal. coeff. a1 (keV/ch) on x-axis  <     56.000>:
Cal. coeff. a2 (keV/ch2) on x-axis < 0.0000E+00>:

Cal. coeff. a0 (keV) on y-axis     <       25.5>:
Cal. coeff. a1 (keV/ch) on y-axis  <     56.000>:
Cal. coeff. a2 (keV/ch2) on y-axis < 0.0000E+00>:

Dimension on x-axis (max=4096) < 125>:
Dimension on y-axis (max=2048)  < 125>:
Filename                       <TEST>:fg_comp_76Ge
mama>
```



3. Rhosigchi

```
anncecil@Ann-Cecilies-MacBook-Air-2:76Ge_EB09> rhosigchi

 ------------------------------------------
|                                          |
|          R H O S I G C H I  1.5.1        |
|                                          |
|   Program to calculate level density     |
|  Rho, and gamma strength function Sig    |
|  from first-generation spectra, using    |
|    FgNorm(Ex,Eg)=Rho(Ex-Eg)*Sig(Eg)      |
|                                          |
|       Oslo Cyclotron Laboratory          |
|                                          |
|         Created: 13/08 - 1999            |
|            Andreas Schiller              |
|   Lisbeth Bergholt, Magne Guttormsen     |
|                                          |
|         Improved: 01/05 - 2003           |
|            Alexander Voinov              |
|   Magne Guttormsen, Andreas Schiller     |
|         Dubna, Oslo, Livermore           |
|   Modified 28 Mar 2014: Ex < 0 MeV       |
|   Modified 13 Feb 2015: One ch shift,    |
|   ch ig < 0, cut igmax                   |
|   Modified 31 Aug 2015: No normalization |
|__________________________________________|
 Please, answer 1 and the name of your input first-
 generation matrix in the two next questions...
Destination spectrum <1>:
Filename          <TEST>:fg_comp_76Ge
 FILE=Disk
 KIND=Spectrum
 LABORATORY=Oslo Cyclotron Laboratory (OCL)
 EXPERIMENT=mama
 COMMENT=unf_seg2AR:1=1+2|RE:unf_bothCO:2-2FG:FN:RN:|RE:fg_76GeCO:4-4
 TIME=DATE:02-Dec-15 18:16:19]
```

```
 CALIBRATION EkeV=6, 0.255000E+02, 0.560000E+02, 0.000000E+00, 0.255000E
+02, 0.560000E+02, 0.000000E+00
 PRECISION=16
 DIMENSION=2,0: 124,0: 124
 CHANNEL=(0: 124,0: 124)
..
Lower limit of gamma energy (keV)      < 1257.5>:
Lower limit of excitation energy (keV) < 4057.5>:
Upper limit of excitation energy (keV) < 5961.5>:
 Number of data points         639
 DOF, data points - rho - sig         576
Common calibration is a0=-758.50keV and a1= 112.00keV/ch
Dimension is  66 x  61
excitation energy region is  4058.keV to   5962.keV
rho extracted from  -758.keV to   4730.keV
sig extracted from  1258.keV to   6522.keV
 ------------------------------------------------------------
       Convergence test using various indicators
Indicator Iteration = 0    10    20    30    40    50
Rho/Rho0 at  U= 922.  1.00  0.75  0.76  0.73  0.75  0.75
Rho/Rho0 at  U=2602.  1.00  0.98  0.89  0.83  0.85  0.85
Rho/Rho0 at  U=4282.  1.00  0.25  0.14  0.11  0.10  0.09
Sig/Sig0 at Eg=2602.  1.00  0.79  0.90  0.88  0.89  0.89
Sig/Sig0 at Eg=4282.  1.00  1.25  1.15  1.18  1.16  1.16
Chi^2 for 1.gen.sp.   2.52  0.28  0.16  0.15  0.14  0.14
 ------------------------------------------------------------

 ch    Ex(keV)     Rho(1/MeV)  dRho(1/MeV) (UNNORMALIZED)
    0  -758.5     0.000E+00   0.000E+00
    1  -646.5     0.000E+00   0.000E+00
    2  -534.5     0.000E+00   0.000E+00
    3  -422.5     0.000E+00   0.000E+00
    4  -310.5     0.000E+00   0.000E+00
    5  -198.5     0.872E-01   0.195E-01
    6   -86.5     0.124E+01   0.109E+00
    7    25.5     0.214E+01   0.109E+00
    8   137.5     0.489E+00   0.661E-01
    9   249.5     0.560E+00   0.773E-01
   10   361.5     0.682E+00   0.115E+00
   11   473.5     0.125E+01   0.221E+00
   12   585.5     0.295E+01   0.525E+00
   13   697.5     0.126E+01   0.272E+00
   14   809.5     0.572E+00   0.139E+00
   15   921.5     0.747E+00   0.198E+00
   16  1033.5     0.990E+00   0.287E+00
   17  1145.5     0.171E+01   0.494E+00
   18  1257.5     0.120E+01   0.364E+00
   19  1369.5     0.665E+00   0.194E+00
   20  1481.5     0.788E+00   0.243E+00
   21  1593.5     0.930E+00   0.290E+00
   22  1705.5     0.743E+00   0.232E+00
   23  1817.5     0.501E+00   0.157E+00
   24  1929.5     0.427E+00   0.188E+00
   25  2041.5     0.498E+00   0.181E+00
   26  2153.5     0.653E+00   0.220E+00
   27  2265.5     0.584E+00   0.217E+00
   28  2377.5     0.674E+00   0.241E+00
   29  2489.5     0.744E+00   0.260E+00
   30  2601.5     0.846E+00   0.299E+00
   31  2713.5     0.138E+01   0.454E+00
   32  2825.5     0.206E+01   0.672E+00
   33  2937.5     0.248E+01   0.923E+00
   34  3049.5     0.229E+01   0.906E+00
   35  3161.5     0.239E+01   0.904E+00
```

```
  36  3273.5     0.209E+01   0.654E+00
  37  3385.5     0.119E+01   0.723E+00
  38  3497.5     0.305E+00   0.996E+00
  39  3609.5     0.116E+00   0.118E+01
  40  3721.5     0.872E-01   0.127E+01
  41  3833.5     0.872E-01   0.134E+01
  42  3945.5     0.872E-01   0.156E+01
  43  4057.5     0.872E-01   0.153E+01
  44  4169.5     0.872E-01   0.206E+01
  45  4281.5     0.872E-01   0.259E+01
  46  4393.5     0.872E-01   0.333E+01
  47  4505.5     0.872E-01   0.486E+01
  48  4617.5     0.100E+00   0.576E+01
  49  4729.5     0.184E+00   0.637E+01

 ch   Eg(keV)         Sig        dSig (UNNORMALIZED)
  18  1257.5     0.116E+00   0.106E+00
  19  1369.5     0.201E+00   0.991E-01
  20  1481.5     0.299E+00   0.995E-01
  21  1593.5     0.313E+00   0.114E+00
  22  1705.5     0.390E+00   0.111E+00
  23  1817.5     0.448E+00   0.130E+00
  24  1929.5     0.375E+00   0.125E+00
  25  2041.5     0.348E+00   0.105E+00
  26  2153.5     0.475E+00   0.143E+00
  27  2265.5     0.407E+00   0.128E+00
  28  2377.5     0.299E+00   0.164E+00
  29  2489.5     0.303E+00   0.202E+00
  30  2601.5     0.296E+00   0.180E+00
  31  2713.5     0.413E+00   0.169E+00
  32  2825.5     0.694E+00   0.142E+00
  33  2937.5     0.518E+00   0.138E+00
  34  3049.5     0.542E+00   0.138E+00
  35  3161.5     0.661E+00   0.119E+00
  36  3273.5     0.864E+00   0.138E+00
  37  3385.5     0.116E+01   0.141E+00
  38  3497.5     0.111E+01   0.998E-01
  39  3609.5     0.931E+00   0.988E-01
  40  3721.5     0.902E+00   0.965E-01
  41  3833.5     0.869E+00   0.124E+00
  42  3945.5     0.111E+01   0.163E+00
  43  4057.5     0.126E+01   0.222E+00
  44  4169.5     0.919E+00   0.187E+00
  45  4281.5     0.774E+00   0.183E+00
  46  4393.5     0.831E+00   0.227E+00
  47  4505.5     0.861E+00   0.248E+00
  48  4617.5     0.895E+00   0.268E+00
  49  4729.5     0.121E+01   0.446E+00
  50  4841.5     0.136E+01   0.547E+00
  51  4953.5     0.134E+01   0.562E+00
  52  5065.5     0.148E+01   0.674E+00
  53  5177.5     0.140E+01   0.661E+00
  54  5289.5     0.166E+01   0.838E+00
  55  5401.5     0.135E+01   0.729E+00
  56  5513.5     0.140E+01   0.781E+00
  57  5625.5     0.147E+01   0.820E+00
  58  5737.5     0.158E+01   0.999E+00
  59  5849.5     0.158E+01   0.113E+01
  60  5961.5     0.103E+01   0.807E+00
  61  6073.5     0.000E+00   0.000E+00
  62  6185.5     0.000E+00   0.000E+00
Observed first generation matrix written to file:     fg.rsg
Estimated first gen. err. matrix written to file:  fgerr.rsg
Theoret. first generation matrix written to file:  fgteo.rsg
```

```
Unnormalized Rho and dRho written to array file:  rhopaw.rsg
Unnormalized T and dT     written to array file:  sigpaw.rsg
Unnormalized Rho and dRho written to mama file:    rhosp.rsg
Unnormalized T and dT     written to mama file:    sigsp.rsg
Note: The following floating-point exceptions are signalling:
IEEE_UNDERFLOW_FLAG IEEE_DENORMAL
anncecil@Ann-Cecilies-MacBook-Air-2:76Ge_EB09>
```

4. Normalization of level density, using spin-cutoff estimates from phenomenological models (von Egidy & Bucurescu, PRC (2009)) and systematics of neutron-resonance parameters from RIPL-3

```
anncecil@Ann-Cecilies-MacBook-Air-2:76Ge_EB09> counting

 _____________________________________________________________
|                                                             |
|                    C O U N T I N G   1.7.1                  |
|                                                             |
|Program to normalize experimental nuclear level density (NLD)|
|  to NLD from known low energy levels and NLD extracted from |
|     resonances spacing data at Bn. Thus, the A and alpha    |
|     parameters are determined for NLD. The slope of the     |
|   transmision coefficient T(Eg) is normalized according to  |
|                    the alpha parameter.                     |
|                                                             |
|  Input files:  counting.dat    Output files: rhopaw.cnt     |
|                rhosp.rsg                     rhotmopaw.cnt  |
|                sigsp.rsg                     sigpaw.cnt     |
|               (input.cnt)                    input.cnt      |
|                                              spincut.cnt    |
|                                              fermigas.cnt   |
|                                              efit.f         |
|                                              counting.kumac |
|                                              spincut.kumac  |
|                                              sigext.kumac   |
|                                              counting.cpp   |
|                                              spincut.cpp    |
|                                              sigext.cpp     |
|                                                             |
|  Fermi gas or constant temperatur parameteres are calculated|
|      from Egidy and Bucurescu: PRC 80, 054310 (2009)        |
| E-mail  : magne.guttormsen@fys.uio.no                       |
| Created : 11 Aug 2006                                       |
| Modified: 17 Jun 2009                                       |
| Modified: 16 Nov 2014 Ex < 0 MeV, CT output, CT with sig_FG |
| Modified: 10 Feb 2015 dimRhox, dimSigx                      |
| Modified: 01 Jun 2015 allow modifying ExL and ExH of sigext |
|_____________________________________________________________|

Reading calibration and dimensions from: rhosp.rsg
rhosp.rsg has dimension (0 : 60, 0 : 1) and calibration (a0, a1) =
(-758.500000, 112.000000)
Reading calibration and dimensions from: sigsp.rsg
sigsp.rsg has dimension (0 : 65, 0 : 1) and calibration (a0, a1) =
(-758.500000, 112.000000)

Reading data and errors of experimental nuclear level density: rhopaw.rsg
 No   Ex(keV)      Rho(1/MeV)     dRho(1/MeV)
  0   -758.50       0.000e+00       0.000e+00
  1   -646.50       0.000e+00       0.000e+00
  2   -534.50       0.000e+00       0.000e+00
  3   -422.50       0.000e+00       0.000e+00
```

```
  4   -310.50        0.000e+00        0.000e+00
  5   -198.50        8.724e-02        1.947e-02
  6    -86.50        1.237e+00        1.093e-01
  7     25.50        2.144e+00        1.089e-01
  8    137.50        4.892e-01        6.613e-02
  9    249.50        5.599e-01        7.730e-02
 10    361.50        6.821e-01        1.149e-01
 11    473.50        1.253e+00        2.206e-01
 12    585.50        2.947e+00        5.254e-01
 13    697.50        1.259e+00        2.725e-01
 14    809.50        5.723e-01        1.391e-01
 15    921.50        7.474e-01        1.977e-01
 16   1033.50        9.903e-01        2.868e-01
 17   1145.50        1.706e+00        4.944e-01
 18   1257.50        1.199e+00        3.642e-01
 19   1369.50        6.649e-01        1.938e-01
 20   1481.50        7.875e-01        2.431e-01
 21   1593.50        9.295e-01        2.898e-01
 22   1705.50        7.434e-01        2.324e-01
 23   1817.50        5.005e-01        1.566e-01
 24   1929.50        4.272e-01        1.882e-01
 25   2041.50        4.981e-01        1.815e-01
 26   2153.50        6.525e-01        2.201e-01
 27   2265.50        5.836e-01        2.169e-01
 28   2377.50        6.742e-01        2.406e-01
 29   2489.50        7.438e-01        2.602e-01
 30   2601.50        8.459e-01        2.987e-01
 31   2713.50        1.378e+00        4.540e-01
 32   2825.50        2.058e+00        6.717e-01
 33   2937.50        2.485e+00        9.228e-01
 34   3049.50        2.288e+00        9.058e-01
 35   3161.50        2.389e+00        9.040e-01
 36   3273.50        2.092e+00        6.541e-01
 37   3385.50        1.194e+00        7.232e-01
 38   3497.50        3.046e-01        9.956e-01
 39   3609.50        1.164e-01        1.184e+00
 40   3721.50        8.724e-02        1.267e+00
 41   3833.50        8.724e-02        1.339e+00
 42   3945.50        8.724e-02        1.565e+00
 43   4057.50        8.724e-02        1.526e+00
 44   4169.50        8.724e-02        2.061e+00
 45   4281.50        8.724e-02        2.591e+00
 46   4393.50        8.724e-02        3.335e+00
 47   4505.50        8.724e-02        4.865e+00
 48   4617.50        1.003e-01        5.764e+00
 49   4729.50        1.835e-01        6.368e+00
 50   4841.50        0.000e+00        0.000e+00
 51   4953.50        0.000e+00        0.000e+00
 52   5065.50        0.000e+00        0.000e+00
 53   5177.50        0.000e+00        0.000e+00
 54   5289.50        0.000e+00        0.000e+00
 55   5401.50        0.000e+00        0.000e+00
 56   5513.50        0.000e+00        0.000e+00
 57   5625.50        0.000e+00        0.000e+00
 58   5737.50        0.000e+00        0.000e+00
 59   5849.50        0.000e+00        0.000e+00
 60   5961.50        0.000e+00        0.000e+00

Reading data and errors of experimental transmision coefficient:
sigpaw.rsg
 No   Eg(keV)          Trans           dTrans
  0   -758.50        0.000e+00        0.000e+00
  1   -646.50        0.000e+00        0.000e+00
  2   -534.50        0.000e+00        0.000e+00
```

```
 3   -422.50        0.000e+00        0.000e+00
 4   -310.50        0.000e+00        0.000e+00
 5   -198.50        0.000e+00        0.000e+00
 6    -86.50        0.000e+00        0.000e+00
 7     25.50        0.000e+00        0.000e+00
 8    137.50        0.000e+00        0.000e+00
 9    249.50        0.000e+00        0.000e+00
10    361.50        0.000e+00        0.000e+00
11    473.50        0.000e+00        0.000e+00
12    585.50        0.000e+00        0.000e+00
13    697.50        0.000e+00        0.000e+00
14    809.50        0.000e+00        0.000e+00
15    921.50        0.000e+00        0.000e+00
16   1033.50        0.000e+00        0.000e+00
17   1145.50        0.000e+00        0.000e+00
18   1257.50        1.162e-01        1.060e-01
19   1369.50        2.014e-01        9.912e-02
20   1481.50        2.985e-01        9.948e-02
21   1593.50        3.127e-01        1.138e-01
22   1705.50        3.901e-01        1.113e-01
23   1817.50        4.482e-01        1.303e-01
24   1929.50        3.748e-01        1.252e-01
25   2041.50        3.477e-01        1.045e-01
26   2153.50        4.746e-01        1.428e-01
27   2265.50        4.068e-01        1.285e-01
28   2377.50        2.994e-01        1.640e-01
29   2489.50        3.034e-01        2.022e-01
30   2601.50        2.960e-01        1.800e-01
31   2713.50        4.133e-01        1.686e-01
32   2825.50        6.937e-01        1.416e-01
33   2937.50        5.181e-01        1.380e-01
34   3049.50        5.422e-01        1.380e-01
35   3161.50        6.614e-01        1.193e-01
36   3273.50        8.645e-01        1.381e-01
37   3385.50        1.161e+00        1.413e-01
38   3497.50        1.111e+00        9.981e-02
39   3609.50        9.312e-01        9.877e-02
40   3721.50        9.015e-01        9.653e-02
41   3833.50        8.688e-01        1.239e-01
42   3945.50        1.114e+00        1.635e-01
43   4057.50        1.262e+00        2.223e-01
44   4169.50        9.194e-01        1.874e-01
45   4281.50        7.741e-01        1.831e-01
46   4393.50        8.313e-01        2.270e-01
47   4505.50        8.607e-01        2.479e-01
48   4617.50        8.951e-01        2.679e-01
49   4729.50        1.206e+00        4.462e-01
50   4841.50        1.361e+00        5.467e-01
51   4953.50        1.342e+00        5.617e-01
52   5065.50        1.480e+00        6.743e-01
53   5177.50        1.396e+00        6.608e-01
54   5289.50        1.659e+00        8.375e-01
55   5401.50        1.346e+00        7.293e-01
56   5513.50        1.400e+00        7.808e-01
57   5625.50        1.466e+00        8.201e-01
58   5737.50        1.582e+00        9.988e-01
59   5849.50        1.578e+00        1.129e+00
60   5961.50        1.026e+00        8.073e-01
61   6073.50        0.000e+00        0.000e+00
62   6185.50        0.000e+00        0.000e+00
63   6297.50        0.000e+00        0.000e+00
64   6409.50        0.000e+00        0.000e+00
65   6521.50        0.000e+00        0.000e+00
```

```
Reading excitation energies of known levels: counting.dat
Binning 111 known levels:
 No    Ex(keV)   NoLev   RhoLeV(1/MeV)
  0   -758.50       0       0.000e+00
  1   -646.50       0       0.000e+00
  2   -534.50       0       0.000e+00
  3   -422.50       0       0.000e+00
  4   -310.50       0       0.000e+00
  5   -198.50       0       0.000e+00
  6    -86.50       0       0.000e+00
  7     25.50       1       8.929e+00
  8    137.50       0       0.000e+00
  9    249.50       0       0.000e+00
 10    361.50       0       0.000e+00
 11    473.50       0       0.000e+00
 12    585.50       1       8.929e+00
 13    697.50       0       0.000e+00
 14    809.50       0       0.000e+00
 15    921.50       0       0.000e+00
 16   1033.50       0       0.000e+00
 17   1145.50       1       8.929e+00
 18   1257.50       0       0.000e+00
 19   1369.50       1       8.929e+00
 20   1481.50       0       0.000e+00
 21   1593.50       1       8.929e+00
 22   1705.50       0       0.000e+00
 23   1817.50       0       0.000e+00
 24   1929.50       1       8.929e+00
 25   2041.50       1       8.929e+00
 26   2153.50       1       8.929e+00
 27   2265.50       1       8.929e+00
 28   2377.50       0       0.000e+00
 29   2489.50       3       2.679e+01
 30   2601.50       4       3.571e+01
 31   2713.50       4       3.571e+01
 32   2825.50       1       8.929e+00
 33   2937.50       4       3.571e+01
 34   3049.50       6       5.357e+01
 35   3161.50       5       4.464e+01
 36   3273.50       6       5.357e+01
 37   3385.50       6       5.357e+01
 38   3497.50       6       5.357e+01
 39   3609.50       5       4.464e+01
 40   3721.50       3       2.679e+01
 41   3833.50       7       6.250e+01
 42   3945.50       3       2.679e+01
 43   4057.50       4       3.571e+01
 44   4169.50       4       3.571e+01
 45   4281.50       4       3.571e+01
 46   4393.50       4       3.571e+01
 47   4505.50       3       2.679e+01
 48   4617.50       3       2.679e+01
 49   4729.50       5       4.464e+01
 50   4841.50       4       3.571e+01
 51   4953.50       1       8.929e+00
 52   5065.50       0       0.000e+00
 53   5177.50       1       8.929e+00
 54   5289.50       1       8.929e+00
 55   5401.50       0       0.000e+00
 56   5513.50       1       8.929e+00
 57   5625.50       1       8.929e+00
 58   5737.50       1       8.929e+00
 59   5849.50       1       8.929e+00
 60   5961.50       0       0.000e+00
```

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 61   6073.50       1       8.929e+00
Mass number A             < 76>:
Neutron or proton binding energy (Bn or Bp) (MeV)  < 9.428>:


Choose constant temperature CT (1) or Fermi gas FG (2) formula <1>:


You should take care to use formulas from the same reference.
Example: If you use rigid moment of inertia from (E&B2006),
you should also use temperature T from (E&B2006), as well.
We recommend to use (E&B2006) (or maybe the old (G&C)) for nuclei heavier
than A > 150,
and (E&B2009) for lighter nuclei with A < 150.

If you have chosen the CT formula, we recommend to use FG spin cut-off
formula since
the CT spin cut-off formula is a constant, which is rather unphysical. In
the following,
option (1) might be the most appropriate for the CT-model (instead of
(3)).

You may choose between 4 spin cut-off formulas:
1 The rigid moment of inertia formula (RMI) (E&B2006)
2 The Gilbert and Cameron formula (G&C) Can. J. Phys 43(1965) 1446
3 The constant temperature (CT) formula (E&B2009) and NPA 481 (1988) 189
4 The Fermi gas formula with appropriate cut-off parameter (E&B2009)
Type 1 for RMI: sig**2=0.0146*(A**(5/3))*T for FG+CT (E&B2006)
Type 2 for G&C: sig**2=0.0888*(A**(2/3))*a*T for FG+CT
Type 3 for E&B: sig**2=(0.98*(A**(0.29)))**2 for CT
Type 4 for E&B: sig**2=0.391*A**0.675*(E-0.5*Pa_prime)**0.312 for FG+CT


Choose RMI(FG+CT) (1), G&C(FG+CT) (2), E&B(CT) (3) or E&B(FG+CT) (4) <4>:

Be sure to use the correct Rho(Bn or Bp) according
to type 1, 2, 3 or 4. Run the d2rho program to find Rho
or use the systematic value found by running Robin
Level density at Bn or Bp (1/MeV)               <   47032>:
Uncertainty of level density at Bn or Bp (1/MeV) <    5686>:

You need to run the program Robin to get the Fermi-gas parameters a and
E1:
Level density parameters a (1/MeV) <  9.570>:
Fermi-gas shift parameter E1 (MeV) <  1.009>:

You need to run the program Robin to get the constant temperature
parameters T:
Temperature parameter T (MeV) <  0.920>:

The level density goes through Rho(Bn), thus determining the
const. temp. shift parameter to be E0 =  -0.393 MeV

 No   Ex(keV)   RhoLeV(1/MeV)
  0   -758.50       0.000e+00
  1   -646.50       0.000e+00
  2   -534.50       0.000e+00
  3   -422.50       0.000e+00
  4   -310.50       0.000e+00
  5   -198.50       0.000e+00
  6    -86.50       0.000e+00
  7     25.50       8.929e+00
----------------------------
  8    137.50       0.000e+00
```

```
 9    249.50       0.000e+00
10    361.50       0.000e+00
11    473.50       0.000e+00
12    585.50       8.929e+00
13    697.50       0.000e+00
14    809.50       0.000e+00
15    921.50       0.000e+00
16   1033.50       0.000e+00
17   1145.50       8.929e+00
18   1257.50       0.000e+00
19   1369.50       8.929e+00
20   1481.50       0.000e+00
21   1593.50       8.929e+00
22   1705.50       0.000e+00
23   1817.50       0.000e+00
24   1929.50       8.929e+00
-----------------------------
25   2041.50       8.929e+00
26   2153.50       8.929e+00
27   2265.50       8.929e+00
28   2377.50       0.000e+00
29   2489.50       2.679e+01
30   2601.50       3.571e+01
31   2713.50       3.571e+01
32   2825.50       8.929e+00
33   2937.50       3.571e+01
Lower fit limit L1 for known levels  <  8>:
Higher fit limit L2 for known levels < 24>:

 No   Ex(keV)      Rho(1/MeV)     dRho(1/MeV)
 24   1929.50       4.272e-01       1.882e-01
 25   2041.50       4.981e-01       1.815e-01
 26   2153.50       6.525e-01       2.201e-01
 27   2265.50       5.836e-01       2.169e-01
 28   2377.50       6.742e-01       2.406e-01
 29   2489.50       7.438e-01       2.602e-01
 30   2601.50       8.459e-01       2.987e-01
 31   2713.50       1.378e+00       4.540e-01
 32   2825.50       2.058e+00       6.717e-01
-------------------------------------------
 33   2937.50       2.485e+00       9.228e-01
 34   3049.50       2.288e+00       9.058e-01
 35   3161.50       2.389e+00       9.040e-01
 36   3273.50       2.092e+00       6.541e-01
-------------------------------------------
 37   3385.50       1.194e+00       7.232e-01
 38   3497.50       3.046e-01       9.956e-01
 39   3609.50       1.164e-01       1.184e+00
 40   3721.50       8.724e-02       1.267e+00
 41   3833.50       8.724e-02       1.339e+00
 42   3945.50       8.724e-02       1.565e+00
 43   4057.50       8.724e-02       1.526e+00
 44   4169.50       8.724e-02       2.061e+00
 45   4281.50       8.724e-02       2.591e+00
Lower fit limit H1 for Rho around Bn or Bp  < 33>:
Higher fit limit H2 for Rho around Bn or Bp < 36>:

 No   Eg(keV)        Trans          dTrans
  0   -758.50       0.000e+00       0.000e+00
  1   -646.50       0.000e+00       0.000e+00
  2   -534.50       0.000e+00       0.000e+00
  3   -422.50       0.000e+00       0.000e+00
  4   -310.50       0.000e+00       0.000e+00
  5   -198.50       0.000e+00       0.000e+00
```

```
  6    -86.50       0.000e+00       0.000e+00
  7     25.50       0.000e+00       0.000e+00
  8    137.50       0.000e+00       0.000e+00
  9    249.50       0.000e+00       0.000e+00
 10    361.50       0.000e+00       0.000e+00
 11    473.50       0.000e+00       0.000e+00
 12    585.50       0.000e+00       0.000e+00
 13    697.50       0.000e+00       0.000e+00
 14    809.50       0.000e+00       0.000e+00
 15    921.50       0.000e+00       0.000e+00
 16   1033.50       0.000e+00       0.000e+00
 17   1145.50       0.000e+00       0.000e+00
-----------------------------------------------
 18   1257.50       1.162e-01       1.060e-01
 19   1369.50       2.014e-01       9.912e-02
 20   1481.50       2.985e-01       9.948e-02
 21   1593.50       3.127e-01       1.138e-01
 22   1705.50       3.901e-01       1.113e-01
 23   1817.50       4.482e-01       1.303e-01
 24   1929.50       3.748e-01       1.252e-01
 25   2041.50       3.477e-01       1.045e-01
 26   2153.50       4.746e-01       1.428e-01
 27   2265.50       4.068e-01       1.285e-01
 28   2377.50       2.994e-01       1.640e-01
-----------------------------------------------
 29   2489.50       3.034e-01       2.022e-01
 30   2601.50       2.960e-01       1.800e-01
 31   2713.50       4.133e-01       1.686e-01
 32   2825.50       6.937e-01       1.416e-01
 33   2937.50       5.181e-01       1.380e-01
 34   3049.50       5.422e-01       1.380e-01
 35   3161.50       6.614e-01       1.193e-01
 36   3273.50       8.645e-01       1.381e-01
 37   3385.50       1.161e+00       1.413e-01
Lower fit limit L1 for low energy region of T(Eg)  < 18>:
Higher fit limit L2 for low energy region of T(Eg) < 28>:

 No   Eg(keV)         Trans           dTrans
 45   4281.50       7.741e-01       1.831e-01
 46   4393.50       8.313e-01       2.270e-01
 47   4505.50       8.607e-01       2.479e-01
 48   4617.50       8.951e-01       2.679e-01
 49   4729.50       1.206e+00       4.462e-01
 50   4841.50       1.361e+00       5.467e-01
 51   4953.50       1.342e+00       5.617e-01
 52   5065.50       1.480e+00       6.743e-01
 53   5177.50       1.396e+00       6.608e-01
-----------------------------------------------
 54   5289.50       1.659e+00       8.375e-01
 55   5401.50       1.346e+00       7.293e-01
 56   5513.50       1.400e+00       7.808e-01
 57   5625.50       1.466e+00       8.201e-01
 58   5737.50       1.582e+00       9.988e-01
-----------------------------------------------
 59   5849.50       1.578e+00       1.129e+00
 60   5961.50       1.026e+00       8.073e-01
 61   6073.50       0.000e+00       0.000e+00
Lower fit limit H1 for high energy region of T(Eg)  < 54>:
Higher fit limit H2 for high energy region of T(Eg) < 58>:

Fermi-gas level density has been multiplied with eta =  1.000
in order to match Rho(Bn or Bp) =  47031.6 (1/MeV)

Spin cut-off parameter used at Bn or Bp =  3.733
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```
First estimate of normalization parameters: A =  0.9290 and alpha = 0.9933
Improved Chi2 for lower part:  11.69 ->  6.63 with count correction =
1.677
Improved Chi2 for higher part:  1.82 ->  0.07 with count correction =
1.061
Final estimate of normalization parameters: A =  1.9700 and alpha = 0.7662

File fermigas.cnt (0:61) written to disk, (a0,a1)=( -758.50, 112.000)
File rhotmopaw.cnt (0:892) written to disk, (a0,a1)=( -758.50, 112.000)
File rhopaw.cnt (0:123) written to disk, (a0,a1)=( -758.50, 112.000)
File sigpaw.cnt (0:123) written to disk, (a0,a1)=( -758.50, 112.000)

 Transmission function sigext = exp(a*Eg + b) is fitted to the
 lower data points with result: Chi2 = 0.335889 a = 1.259624 b = -1.259887
 Change a and b parameters? (0 = no, 1 = yes) <0>:

 Transmission function sigext = exp(a*Eg + b) is fitted to the
 upper data points with result: Chi2 = 0.025163 a = 0.694532 b = 1.468999
 Change a and b parameters? (0 = no, 1 = yes) <0>:

File sigpawext.cnt (0:95) written to disk, (a0,a1)=( -758.50, 112.000)
File extendLH.cnt (0:95) (0:95) written to disk, (a0,a1)=( -758.50,
112.000)
File rholev.cnt (0:61) written to disk, (a0,a1)=( -758.50, 112.000)
File spincut.cnt (0:183) written to disk, (a0,a1)=( -758.50, 112.000)
File counting.kumac written to disk. Run paw to plot normalized NLD.
File spincut.kumac written to disk. Run paw to plot the spincut.
File sigext.kumac written to disk. Run paw to plot the sigextpaw.cnt.
File counting.cpp written to disk. Run root to plot normalized NLD.
File spincut.cpp written to disk. Run root to plot the spincut.
File sigext.cpp written to disk. Run root to plot sigextpaw.cnt.
anncecil@Ann-Cecilies-MacBook-Air-2:76Ge_EB09>
```

View the level density with ‘counting.cpp’, the spin cutoff with ‘spincut.cpp’, and the transmission coefficient with ‘sigext.cpp’ in ROOT.

5. Normalization of gamma strength function, using systematics of <Gg> from RIPL-3

```
anncecil@Ann-Cecilies-MacBook-Air-2:76Ge_EB09> normalization

 ------------------------------------------------------------
|                                                            |
|               N O R M A L I Z A T I O N  1.5               |
|                                                            |
|  Program to normalize the gamma-ray strength function f(Eg)|
|         to the total average radiation width Gamma         |
|                     measured at Bn or Bp                   |
|        (based on normalization.f by Andreas Schiller)      |
|                                                            |
|  Input files: rhotmopaw.cnt    Output files: input.nrm     |
|               sigextpaw.cnt                  strength.nrm  |
|               spincut.cnt                    trans.nrm     |
|               sigpaw.cnt                     transext.nrm  |
|               (input.nrm)                    strength.kumac|
|                                              strength.cpp  |
| E-mail  : magne.guttormsen@fys.uio.no                      |
| Created : 14 Nov 2006                                      |
| Modified: 26 Mar 2014                                      |
|____________________________________________________________|
```

```
Reading calibration and dimensions from: rhosp.rsg
Dimension (0 : 60, 0 : 1) and calibration (a0, a1) = ( -758.50, 112.000)
s- (l=0) or p- (l=1) wave neutron/proton capture                <0>:
Neutron or proton binding energy (Bn or Bp) (MeV)         < 9.428>:
Target spin in (n,g) or (p,g) reaction (for the A-1 nucleus). Use
values 0.0, 1.0,... for even and 0.5, 1.5,... for odd spins < 0.5>:
Neutron resonance spacing parameter D (eV)                < 315.0>:
Average total radiative resonance width G (meV)           < 192.0>:

Reading data of experimental nuclear level density: rhotmopaw.cnt
Reading data of experimental transmision coefficient: sigextpaw.cnt
Reading data and errors of experimental transmision coefficient:
sigpaw.cnt
Reading spincutoff parameters: spincut.cnt

 No Ex(keV) Rho(1/MeV)  2*Spincut**2  Eg(keV)    Sigext      Sigpaw
dSigpaw
  0  -758.5  0.000e+00     3.46       -758.5    1.091e-01    0.000e+00
( 0.000e+00)
  1  -646.5  0.000e+00     3.46       -646.5    1.257e-01    0.000e+00
( 0.000e+00)
  2  -534.5  0.000e+00     3.46       -534.5    1.447e-01    0.000e+00
( 0.000e+00)
  3  -422.5  0.000e+00     3.46       -422.5    1.666e-01    0.000e+00
( 0.000e+00)
  4  -310.5  0.000e+00     3.46       -310.5    1.919e-01    0.000e+00
( 0.000e+00)
  5  -198.5  1.476e-01     3.46       -198.5    2.209e-01    0.000e+00
( 0.000e+00)
  6   -86.5  2.281e+00     3.46        -86.5    2.544e-01    0.000e+00
( 0.000e+00)
  7    25.5  4.308e+00     3.46         25.5    2.929e-01    0.000e+00
( 0.000e+00)
  8   137.5  1.071e+00     3.46        137.5    3.373e-01    0.000e+00
( 0.000e+00)
  9   249.5  1.335e+00     3.46        249.5    3.884e-01    0.000e+00
( 0.000e+00)
 10   361.5  1.772e+00     3.46        361.5    4.473e-01    0.000e+00
( 0.000e+00)
 11   473.5  3.548e+00     3.46        473.5    5.151e-01    0.000e+00
( 0.000e+00)
 12   585.5  9.093e+00     3.46        585.5    5.931e-01    0.000e+00
( 0.000e+00)
 13   697.5  4.233e+00     3.46        697.5    6.830e-01    0.000e+00
( 0.000e+00)
 14   809.5  2.096e+00     3.46        809.5    7.865e-01    0.000e+00
( 0.000e+00)
 15   921.5  2.983e+00     3.46        921.5    9.056e-01    0.000e+00
( 0.000e+00)
 16  1033.5  4.307e+00     3.46       1033.5    1.043e+00    0.000e+00
( 0.000e+00)
 17  1145.5  8.081e+00     3.46       1145.5    1.201e+00    0.000e+00
( 0.000e+00)
 18  1257.5  6.188e+00     3.46       1257.5    1.383e+00    6.002e-01
( 5.471e-01)
 19  1369.5  3.740e+00     3.46       1369.5    1.133e+00    1.133e+00
( 5.576e-01)
 20  1481.5  4.827e+00     6.90       1481.5    1.830e+00    1.830e+00
( 6.098e-01)
 21  1593.5  6.208e+00     8.85       1593.5    2.088e+00    2.088e+00
( 7.601e-01)
 22  1705.5  5.410e+00    10.15       1705.5    2.839e+00    2.839e+00
( 8.097e-01)
```

```
 23  1817.5  3.969e+00    11.16        1817.5    3.553e+00    3.553e+00
( 1.033e+00)
 24  1929.5  3.691e+00    12.00        1929.5    3.238e+00    3.238e+00
( 1.082e+00)
 25  2041.5  4.689e+00    12.73        2041.5    3.273e+00    3.273e+00
( 9.839e-01)
 26  2153.5  6.693e+00    13.37        2153.5    4.868e+00    4.868e+00
( 1.464e+00)
 27  2265.5  6.522e+00    13.96        2265.5    4.546e+00    4.546e+00
( 1.436e+00)
 28  2377.5  8.211e+00    14.49        2377.5    3.646e+00    3.646e+00
( 1.997e+00)
 29  2489.5  9.869e+00    14.98        2489.5    4.026e+00    4.026e+00
( 2.683e+00)
 30  2601.5  1.223e+01    15.44        2601.5    4.279e+00    4.279e+00
( 2.603e+00)
 31  2713.5  2.171e+01    15.88        2713.5    6.511e+00    6.511e+00
( 2.656e+00)
 32  2825.5  3.533e+01    16.28        2825.5    1.191e+01    1.191e+01
( 2.430e+00)
 33  2937.5  4.647e+01    16.67        2937.5    9.690e+00    9.690e+00
( 2.581e+00)
 34  3049.5  4.662e+01    17.04        3049.5    1.105e+01    1.105e+01
( 2.811e+00)
 35  3161.5  5.305e+01    17.39        3161.5    1.469e+01    1.469e+01
( 2.650e+00)
 36  3273.5  5.061e+01    17.72        3273.5    2.092e+01    2.092e+01
( 3.342e+00)
 37  3385.5  6.607e+01    18.05        3385.5    3.060e+01    3.060e+01
( 3.724e+00)
 38  3497.5  7.462e+01    18.36        3497.5    3.190e+01    3.190e+01
( 2.867e+00)
 39  3609.5  8.428e+01    18.65        3609.5    2.914e+01    2.914e+01
( 3.091e+00)
 40  3721.5  9.519e+01    18.94        3721.5    3.074e+01    3.074e+01
( 3.292e+00)
 41  3833.5  1.075e+02    19.22        3833.5    3.228e+01    3.228e+01
( 4.605e+00)
 42  3945.5  1.214e+02    19.49        3945.5    4.509e+01    4.509e+01
( 6.619e+00)
 43  4057.5  1.371e+02    19.76        4057.5    5.567e+01    5.567e+01
( 9.807e+00)
 44  4169.5  1.549e+02    20.01        4169.5    4.419e+01    4.419e+01
( 9.010e+00)
 45  4281.5  1.750e+02    20.26        4281.5    4.054e+01    4.054e+01
( 9.589e+00)
 46  4393.5  1.976e+02    20.50        4393.5    4.744e+01    4.744e+01
( 1.295e+01)
 47  4505.5  2.232e+02    20.74        4505.5    5.352e+01    5.352e+01
( 1.541e+01)
 48  4617.5  2.521e+02    20.97        4617.5    6.064e+01    6.064e+01
( 1.815e+01)
 49  4729.5  2.847e+02    21.19        4729.5    8.901e+01    8.901e+01
( 3.294e+01)
 50  4841.5  3.216e+02    21.41        4841.5    1.095e+02    1.095e+02
( 4.398e+01)
 51  4953.5  3.632e+02    21.62        4953.5    1.177e+02    1.177e+02
( 4.923e+01)
 52  5065.5  4.102e+02    21.83        5065.5    1.413e+02    1.413e+02
( 6.440e+01)
 53  5177.5  4.633e+02    22.04        5177.5    1.453e+02    1.453e+02
( 6.876e+01)
 54  5289.5  5.233e+02    22.24        5289.5    1.881e+02    1.881e+02
( 9.496e+01)
```

```
 55  5401.5  5.911e+02    22.44        5401.5    1.663e+02    1.663e+02
( 9.010e+01)
 56  5513.5  6.676e+02    22.63        5513.5    1.885e+02    1.885e+02
( 1.051e+02)
 57  5625.5  7.540e+02    22.82        5625.5    2.150e+02    2.150e+02
( 1.203e+02)
 58  5737.5  8.516e+02    23.01        5737.5    2.337e+02    2.529e+02
( 1.596e+02)
 59  5849.5  9.619e+02    23.19        5849.5    2.526e+02    2.747e+02
( 1.966e+02)
 60  5961.5  1.086e+03    23.37        5961.5    2.730e+02    1.947e+02
( 1.532e+02)
 61  6073.5  1.227e+03    23.55        6073.5    2.951e+02    0.000e+00
( 0.000e+00)
 62  6185.5  1.386e+03    23.72        6185.5    3.189e+02    0.000e+00
( 0.000e+00)
 63  6297.5  1.565e+03    23.89        6297.5    3.447e+02    0.000e+00
( 0.000e+00)
 64  6409.5  1.768e+03    24.06        6409.5    3.726e+02    0.000e+00
( 0.000e+00)
 65  6521.5  1.997e+03    24.23        6521.5    4.028e+02    0.000e+00
( 0.000e+00)
 66  6633.5  2.255e+03    24.39        6633.5    4.354e+02    0.000e+00
( 0.000e+00)
 67  6745.5  2.547e+03    24.56        6745.5    4.706e+02    0.000e+00
( 0.000e+00)
 68  6857.5  2.877e+03    24.71        6857.5    5.086e+02    0.000e+00
( 0.000e+00)
 69  6969.5  3.250e+03    24.87        6969.5    5.498e+02    0.000e+00
( 0.000e+00)
 70  7081.5  3.670e+03    25.03        7081.5    5.943e+02    0.000e+00
( 0.000e+00)
 71  7193.5  4.145e+03    25.18        7193.5    6.423e+02    0.000e+00
( 0.000e+00)
 72  7305.5  4.682e+03    25.33        7305.5    6.943e+02    0.000e+00
( 0.000e+00)
 73  7417.5  5.288e+03    25.48        7417.5    7.505e+02    0.000e+00
( 0.000e+00)
 74  7529.5  5.973e+03    25.62        7529.5    8.112e+02    0.000e+00
( 0.000e+00)
 75  7641.5  6.746e+03    25.77        7641.5    8.768e+02    0.000e+00
( 0.000e+00)
 76  7753.5  7.619e+03    25.91        7753.5    9.477e+02    0.000e+00
( 0.000e+00)
 77  7865.5  8.606e+03    26.05        7865.5    1.024e+03    0.000e+00
( 0.000e+00)
 78  7977.5  9.720e+03    26.19        7977.5    1.107e+03    0.000e+00
( 0.000e+00)
 79  8089.5  1.098e+04    26.33        8089.5    1.197e+03    0.000e+00
( 0.000e+00)
 80  8201.5  1.240e+04    26.47        8201.5    1.294e+03    5.471e-01
( 0.000e+00)
 81  8313.5  1.400e+04    26.60        8313.5    1.398e+03    5.576e-01
( 0.000e+00)
 82  8425.5  1.582e+04    26.74        8425.5    1.511e+03    6.098e-01
( 0.000e+00)
 83  8537.5  1.787e+04    26.87        8537.5    1.634e+03    7.601e-01
( 0.000e+00)
 84  8649.5  2.018e+04    27.00        8649.5    1.766e+03    8.097e-01
( 0.000e+00)
 85  8761.5  2.279e+04    27.13        8761.5    1.909e+03    1.033e+00
( 0.000e+00)
 86  8873.5  2.574e+04    27.26        8873.5    2.063e+03    1.082e+00
( 0.000e+00)
```

```
 87  8985.5  2.907e+04    27.38       8985.5    2.230e+03    9.839e-01
( 0.000e+00)
 88  9097.5  3.284e+04    27.51       9097.5    2.410e+03    1.464e+00
( 0.000e+00)
 89  9209.5  3.709e+04    27.63       9209.5    2.605e+03    1.436e+00
( 0.000e+00)
 90  9321.5  4.189e+04    27.76       9321.5    2.816e+03    1.997e+00
( 0.000e+00)
 91  9433.5  4.731e+04    27.88       9433.5    3.044e+03    2.683e+00
( 0.000e+00)

Normalization integral =  4.1155256e+07
Normalization factor =    6.7520344e+07
File strength.nrm (0:123) written to disk, (a0,a1)=( -758.50, 112.000)
File trans.nrm (0:123) written to disk, (a0,a1)=( -758.50, 112.000)
File transext.nrm (0:91) written to disk, (a0,a1)=( -758.50, 112.000)
File strength.kumac written to disk. Run paw to plot strength.nrm
File strength.cpp written to disk. Run root to plot strength.nrm
anncecil@Ann-Cecilies-MacBook-Air-2:76Ge_EB09>
```

View the gamma strength function with ‘strength.cpp’ in ROOT.