Neutron damage corrections

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- PSA treatment
- Objectives of the presentation
- Neutron damage correction

Replay folder

Typical `Replay` folder:

```
[analysis:run_0015_local_ndamage] $ ls
Conf  Data  Out  Trapping_template.cal  gen_conf.py
```

Conf folder

Several files for detector 00A:

```
[analysis:Conf] $ ls -1 00A
BasicAFC.conf
BasicAFP.conf
CrystalProducer.conf
CrystalProducerATCA.conf
PSAFilter.conf
PostPSAFilter.conf
PreprocessingFilter.conf
PreprocessingFilterPSA.conf
Trapping_00A.cal
xdir_1325-1340.cal
xinv_1325-1340.cal
```

Conf folder

List of task that were done before doing the "neutron damage correction":

- Segment lookup table `CrystalProducerATCA.conf`
- Energy calibration → `PreProcessingPSA.conf`
- Cross-talk → `xdir / xinv` files
- Time alignment of segments →`PreProcessingPSA.conf`

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Parameter files

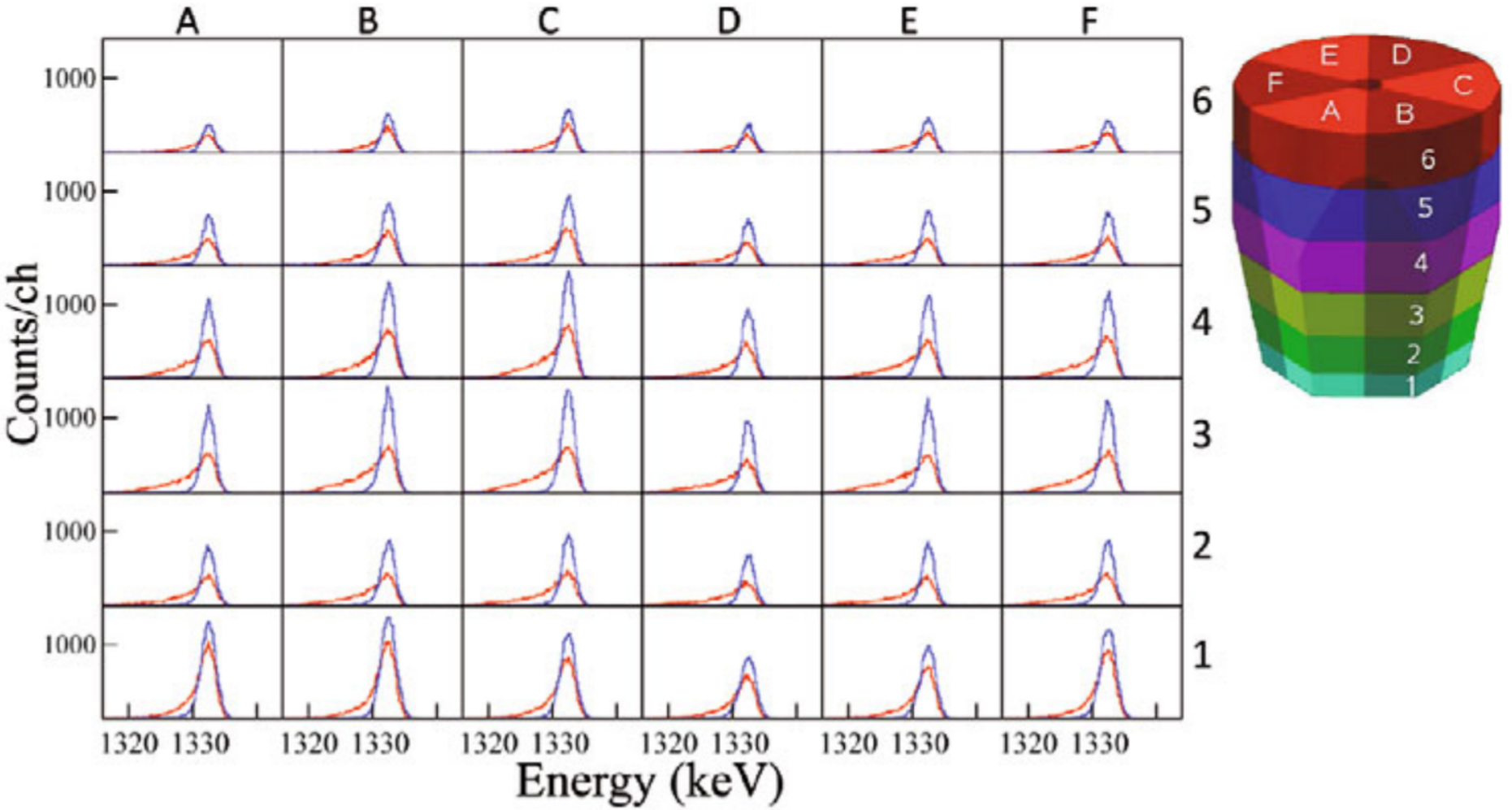
Explain how to get the parameters for:

- Neutron damage correction → `Trapping_00A.cal`
- Configuration of the actor → `PostPSAFilter.conf`
- Global time alignment → `gen_conf.py`

What could be achieved

B. Bruyneel et al. Eur. Phys. J. A. 49 (2013) 61

Reference work on neutron damage:



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Tools and data set

What is needed:

- `RecalEnergy`
- `SortPsaHits`
- `TkT, femul, (Mat)`

- A long ^{60}Co run (the traces are generally needed...)
- PSA hits files produced by the PSA actor:
  $\rightarrow$ `Psa__0-16-F__Hits.fdat`

femul key for this:

```
WritePsaHits      bool      write file of hits for calibrations of n-damage
```

Trapping file template

The `Trapping_XXX.cal` file has 36 lines, one per segment:

```
#SG gainSG_orig gainCC_orig lambdaE lambdaH gainSG_corr gainCC_corr
 0            1.          1.    1.6     6.6          1.          1.
 1            1.          1.    1.6     6.6          1.          1.
 2            1.          1.    1.6     6.6          1.          1.
 3            1.          1.    1.6     6.6          1.          1.
 4            1.          1.    1.6     6.6          1.          1.
```

lambdaE and lambdaH

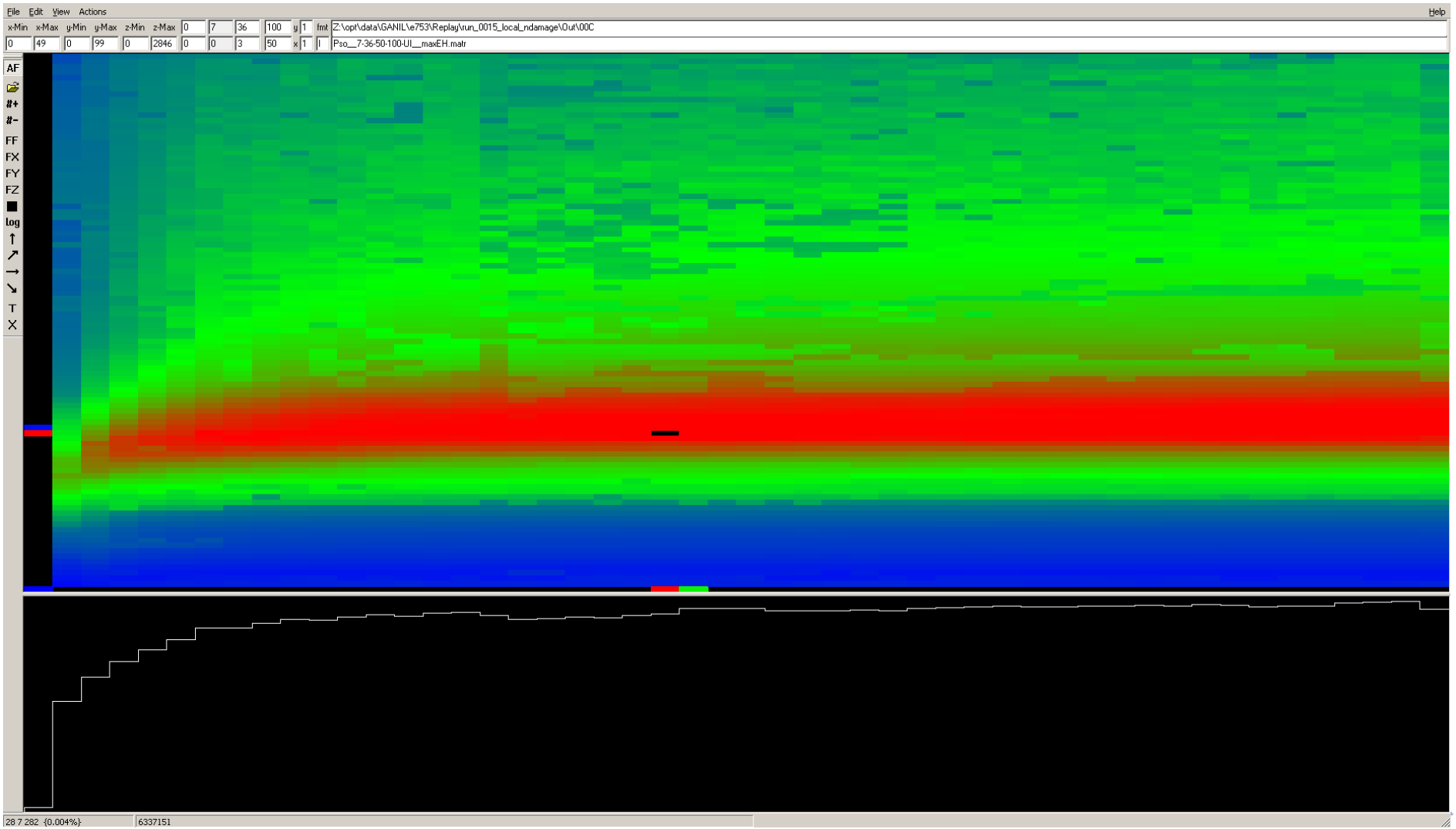
Get the parameter with `SortPsaHits` (this generate the `Pso__7-36-50-100-UI__maxEH.matr` to verify the procedure)

```
SortPsaHits   -f 00C/Psa__0-16-F__Hits.fdat -best 1300 1350 -bpar 1 10000 0
# seg       area     maxSG  lambdaE  lambdaH     maxCC  lambdaE  lambdaH  maxSG+CC  lambdaE  lambdaH
    0       1697       404 999999.9     48.5       346 999999.9     25.3       354 999999.9     48.5
    1       1113       294 999999.9     51.2       226   8228.2     27.8       243   8228.2     45.8
    2       1299       381   8228.2     65.4       268   2098.6     32.8       313 999999.9     65.4
    3       1400       418   1482.1     74.4       278 999999.9     56.8       338 999999.9     74.4
    4        924       302    985.8     90.2       195   2611.6     68.3       236   1305.8     90.2
```

lambdaE and lambdaH

7 spectra for 36 segments:

`Pso__7-36-50-100-UI__maxEH.matr [Ampl_seg Ampl_core Ampl_seg+core TL_SG TR_SG TL_CC TR_CC]`



lambdaE and lambdaH

Update the `Trapping_00C.cal` file

```
#SG gainSG_orig gainCC_orig lambdaE lambdaH gainSG_corr gainCC_corr
 0            1.          1. 999999.9     48.5           1.          1.
 1            1.          1. 999999.9     51.2           1.          1.
 2            1.          1.   8228.2     65.4           1.          1.
 3            1.          1.   1482.1     74.4           1.          1.
 4            1.          1.    985.8     90.2           1.          1.
```

Segment recalibration before trapping

Generation of the file `Pso__2-4-40-2048-UI__Ener.spec` for the recalibration of the segment before neutron correction

This file contains :

$$0 - SG, 1CC$$

$$0 - orig, 1 - orig + recal, 2 - corr, 3 - cor + recal$$

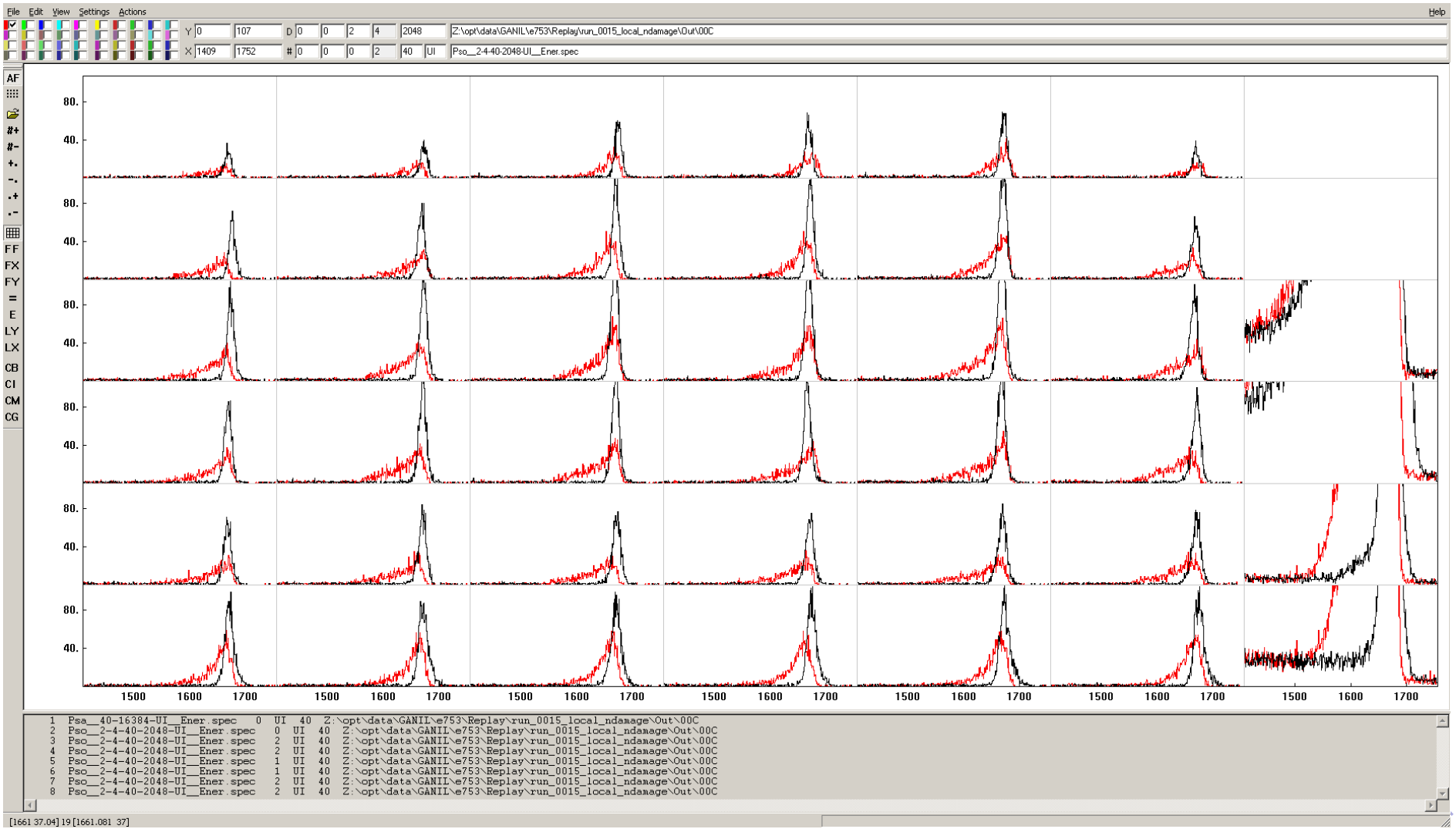
$$36seg, global$$

Command to generate it:

```
SortPsaHits -f Psa__0-16-F__Hits.fdat  -gain 5 -offs 5000 -fcal Trapping_00C.cal
```

Segment recalibration before trapping

Example: library 0 and 2 : before (red) and after (black) trapping correction



Segment recalibration before trapping

Segment recalibration parameters:

```
 RecalEnergy -spe Pso__2-4-40-2048-UI__Ener.spec -num 36 -sub 0 -gain 5 -offs -5000 -noTR -dwa 35 2
/../#spec #pks #ok rEnergy   FW05     FW01 Area Position  Width Ampli    WTML  WTMR  slope*gain rChi2%
/../    0    3   2 1332.34  5.374   14.628 1608  6664.10   17.8    46   6.383 1.823    0.999637   7.20
/../    1    2   2 1332.60  6.927   21.174 1038  6670.15   11.4    22  16.794 1.823    0.998929   1.77
/../    2    3   2 1332.59  6.604   19.349 1244  6666.80   15.4    28  10.738 1.823    0.999426   1.52
/../    3    2   2 1332.48  7.164   21.274 1405  6663.96   15.2    29  12.152 1.823    0.999767   0.23
/../    4    2   2 1332.88  6.412   19.393  850  6662.56   11.7    19  14.756 1.823    1.000272  30.05
```

Segment recalibration before trapping

Core recalibration parameters:

```
 RecalEnergy -spe Pso__2-4-40-2048-UI__Ener.spec -num 36 -sub 160 -gain 5 -offs -5000 -noTR -dwa 35 2
/../#spec #pks #ok rEnergy  FW05    FW01  Area  Position  Width Ampli   WTML  WTMR  slope*gain rChi2%
/../  160    2   2 1332.56 6.224  11.344  1707   6663.12   31.1    52  1.823 1.823    0.999948   0.41
/../  161    2   2 1332.67 4.983   9.083   806   6666.78   24.9    30  1.823 1.823    0.999487   5.83
/../  162    2   2 1332.52 5.737  10.456  1085   6663.81   28.7    36  1.823 1.823    0.999819   0.01
/../  163    2   2 1332.56 6.308  11.498  1264   6667.69   31.6    38  1.823 1.823    0.999268   0.57
/../  164    2   2 1332.69 5.415  11.985   830   6671.88   26.2    26  2.763 1.823    0.998737   7.21
```

Segment recalibration before trapping

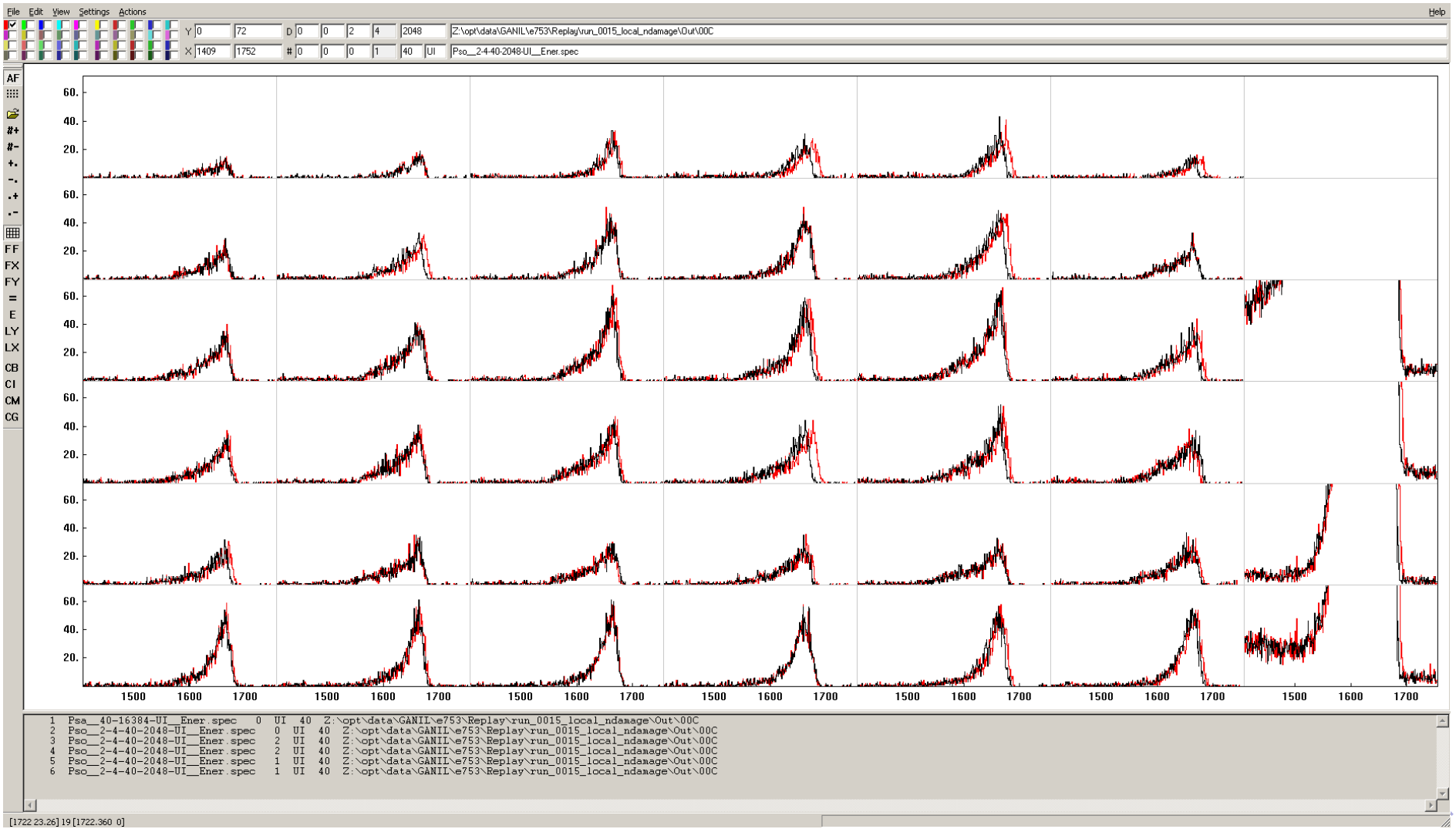
Update the `Trapping_00C.cal` file

```
#SG gainSG_orig gainCC_orig lambdaE lambdaH gainSG_corr gainCC_corr
 0      0.999637   0.999948 999999.9     48.5           1.          1.
 1      0.998929   0.999487 999999.9     51.2           1.          1.
 2      0.999426   0.999819   8228.2     65.4           1.          1.
 3      0.999767   0.999268   1482.1     74.4           1.          1.
 4      1.000272   0.998737    985.8     90.2           1.          1.
```

Post trapping recalibration

```
SortPsaHits -f Psa__0-16-F__Hits.fdat -gain 5 -offs 5000 -fcal Trapping_00C.cal
```

Before recalibration (lib 0, red) and after (lib 1, black):



Post trapping recalibration

Segment recalibration parameters:

```
RecalEnergy -spe Pso__2-4-40-2048-UI__Ener.spec -num 36 -sub 80 -gain 5 -offs -5000 -noTR -dwa 20 2
/../#spec #pks #ok rEnergy   FW05   FW01  Area  Position  Width Ampli    WTML    WTMR  slope*gain rChi2%
/../   80    3   2 1332.50  3.872  7.058  1622   6669.68   19.4    78   1.823   1.823    0.998924   0.03
/../   81    2   2 1332.55  3.366  6.135  1066   6666.79   16.8    59   1.823   1.823    0.999393   0.29
/../   82    2   2 1332.55  2.873  5.330  1254   6667.26   14.4    81   1.887   1.823    0.999320   0.25
/../   83    3   2 1332.49  3.061  5.578  1322   6671.90   15.3    81   1.823   1.823    0.998580   0.18
/../   84    2   2 1332.44  2.890  5.267   833   6674.64   14.5    54   1.823   1.823    0.998137   1.17
```

Post trapping recalibration

Core recalibration parameters:

```
RecalEnergy -spe Pso__2-4-40-2048-UI__Ener.spec -num 36 -sub 240 -gain 5 -offs -5000 -noTR -dwa 20 2
/../#spec #pks #ok rEnergy   FW05   FW01  Area  Position  Width Ampli    WTML    WTMR  slope*gain rChi2%
/../  240    3   2 1332.53  4.985  9.086  1710   6664.29   24.9    64   1.823   1.823    0.999752   0.05
/../  241    3   2 1332.48  5.063  9.235  1056   6662.07   25.3    39   1.826   1.823    1.000049   0.25
/../  242    2   2 1332.57  4.802  8.813  1289   6663.80   24.0    50   1.848   1.823    0.999856   0.72
/../  243    2   2 1332.54  5.030  9.168  1423   6669.06   25.2    53   1.823   1.823    0.999050   0.23
/../  244    2   2 1332.62  4.751  8.729   874   6671.95   23.8    34   1.852   1.823    0.998675   2.69
```

Post trapping recalibration

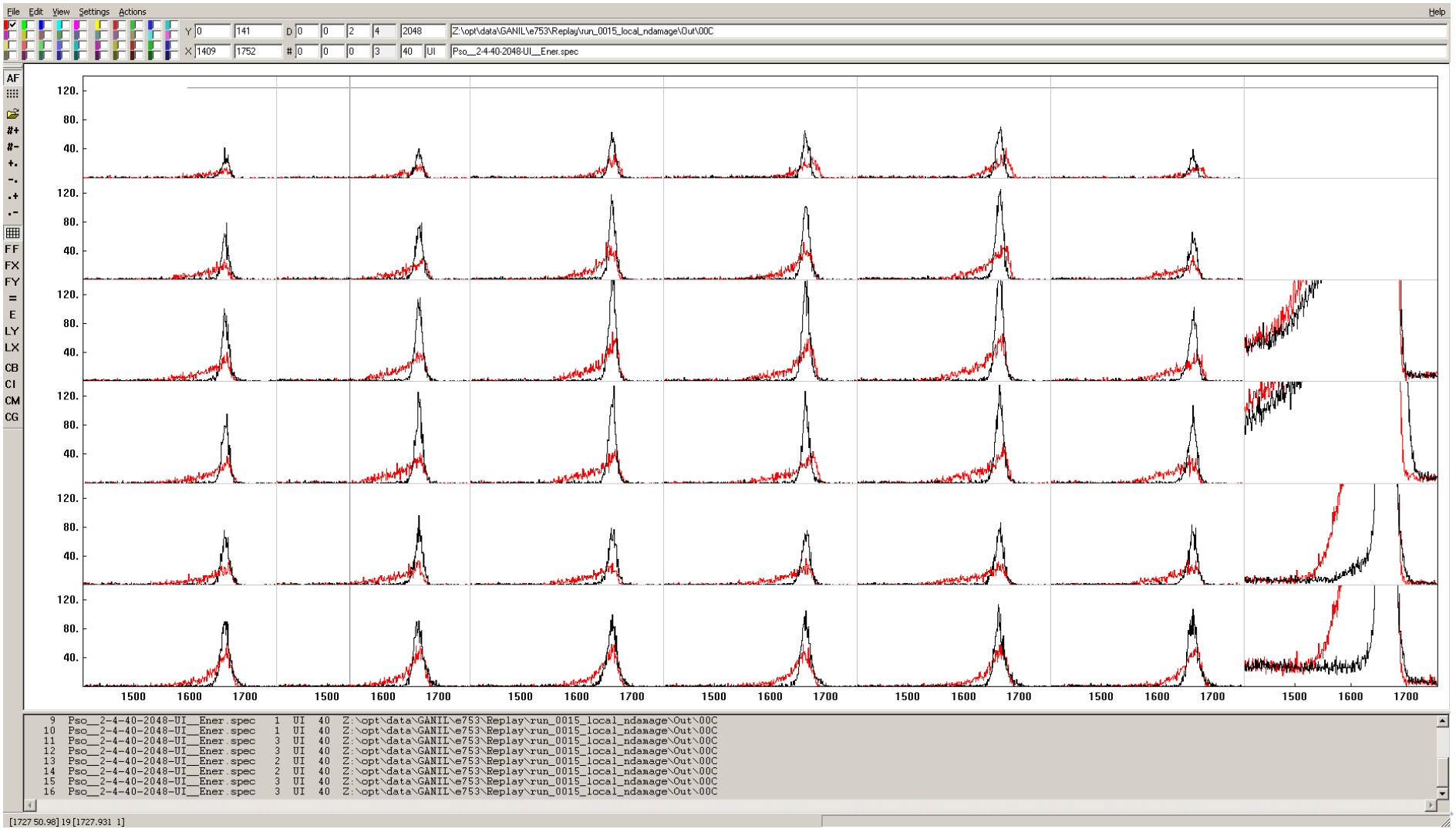
Update the `Trapping_00C.cal` file

```
#SG gainSG_orig gainCC_orig lambdaE lambdaH gainSG_corr gainCC_corr
 0      0.999637   0.999948 999999.9     48.5   0.998924  0.999752
 1      0.998929   0.999487 999999.9     51.2   0.999393  1.000049
 2      0.999426   0.999819   8228.2     65.4   0.999320  0.999856
 3      0.999767   0.999268   1482.1     74.4   0.998580  0.999050
 4      1.000272   0.998737    985.8     90.2   0.998137  0.998675
```

Final verifications of the spectra

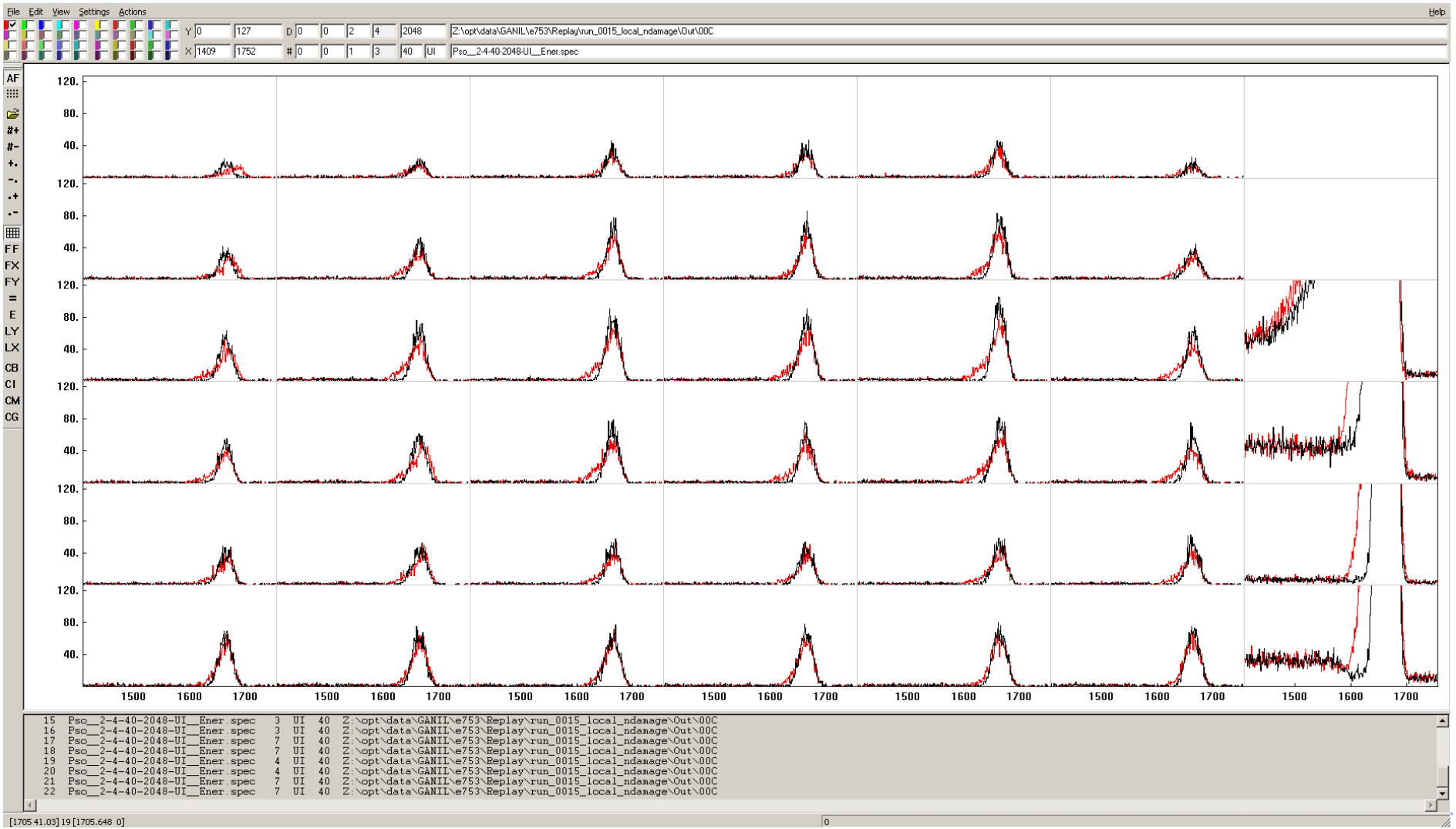
```
SortPsaHits -f Psa__0-16-F__Hits.fdat -gain 5 -offs 5000 -fcal Trapping_00C.cal
```

Segments before (lib 0, red) and after trapping and recal (lib 3, black):



Final verifications of the spectra

Core before (lib 0, red) and after trapping and recal (lib 3, black):



Is it over?

- Determination of the neutron damage parameters is a three steps process
- Once the `Trapping_00C.cal` file is ready : need to be verified with the femul replay
- The file that you will get is `Post__5-40-16384-UI__Ener.spec`
- 0 - SG_orig; 1-SG_cor; 2-CC_orig; 3-SG_cor; 4-SG_final

- The PostPSA actor is actually doing many more things...
- Some of them are redundant... and should not be done twice!

Possible key for femul

```
KEYWORDS ACCEPTED BY PostPSAFilter
ActualClass           str            name of daughter class
SaveDataDir           str            where to write data and spectra
TstampFile            str ui32 i32   File_with_timestams_to_selct  Width_of_selection  ID of crystal
                                     (-1 if not present in file)
TstampMask            str            bit mask for the timestamps, given as a hexadecimal string(e.g. FFFF)
CoreEnergyGate        f32 f32        acceptance window on core energy (keV)
SegmentFoldGate       ui32 ui32      selection of events based of number of fired segments
NumberOfHitsGate      ui32 ui32      selection of events based of number of hits
LambdaE               f32            global parameter to correct trapping of electrons
LambdaH               f32            global parameter to correct trapping of holes
TrappingFile          str            file containing detailed trapping and re-calibration parameters
RecalEnergy1          str            file containing the coefficients for the
                                     initial energy re-calibration
RecalEnergy2          str            file containing the coefficients for the
                                     final energy re-calibration
SegCenter             str            place hits at the center of their segment, as specified in the given f
DetCenter             f32 f32 f32    merge hits into a single one placed at the given x y z position
PackHits              f32            packing hits closer than this (0 &=&  nopack)
SmearPos              f32            xyz uniform smearing of hits (usually the size of the PSA fine-grid
RecalCC               f32 f32        offset and gain adjustment for core
RecalSG               f32 f32        offset and gain adjustment for all segments
TimeShiftCC           f32            time shift of core (ns)
ForceSegmentsToCore   bool           renormalize energy of segments so that their sum equals
                                     energy of core
NewCrystalID          i32            change ID of crystal
EnergyGain            f32            scaling factor for binary energy spectra
WriteTstampDiff       bool           List-mode of time stamp differences between successive events
WriteTstamp           ui64           List-mode of time stamp values for events later than the given limit
RateProfile           ui64 ui64 i32  TstampOffset, TstampStep, Length of rate-profile spectrum
NoMultiHist           bool           exclude flat binary spectra
Verbose               bool           verbosity of printouts
```

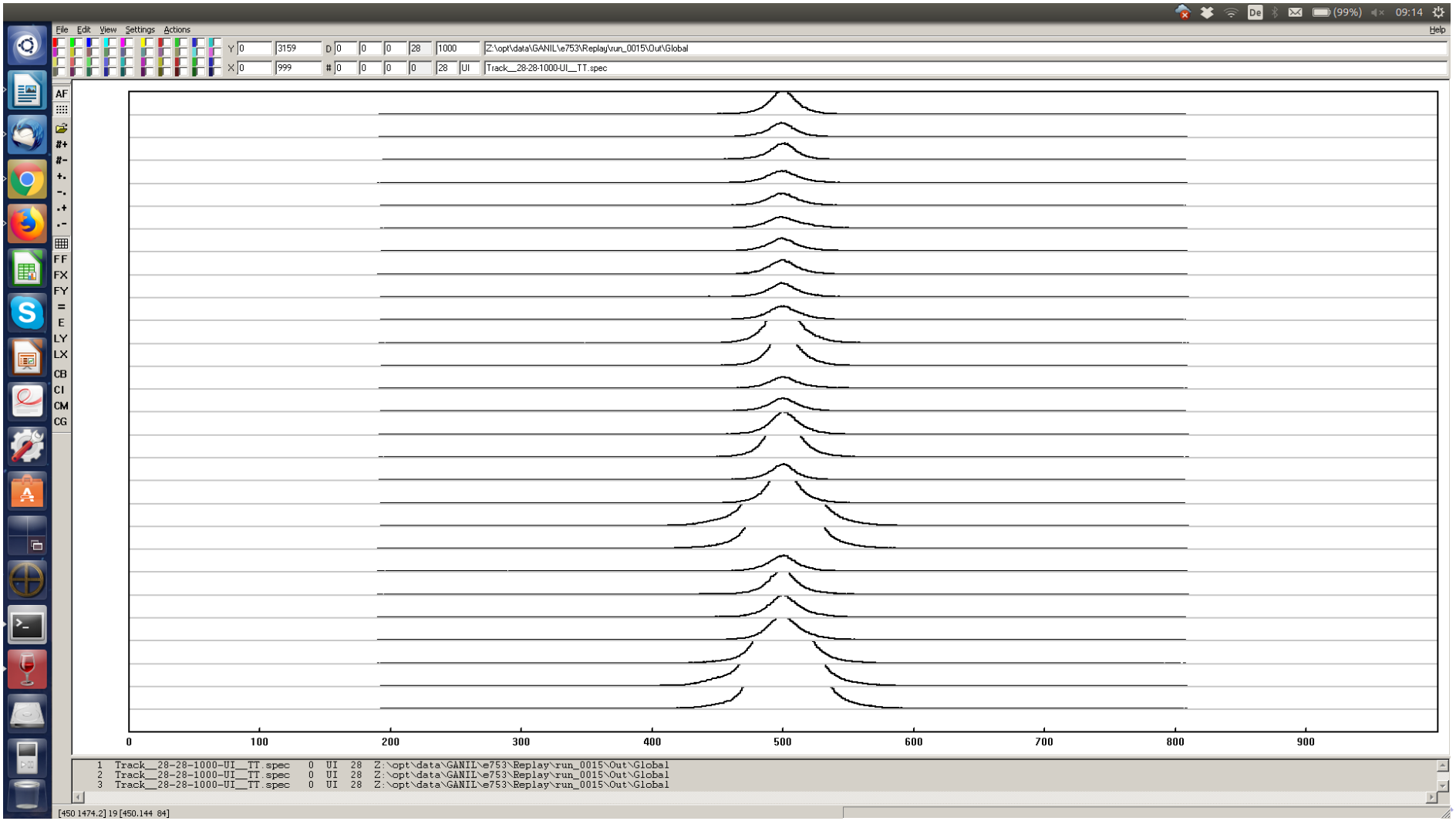
Possible key for femul

```
KEYWORDS ACCEPTED BY PostPSAFilter (REDUCED)

LambdaE                f32          global parameter to correct trapping of electrons
LambdaH                f32          global parameter to correct trapping of holes
TrappingFile           str          file containing detailed trapping and re-calibration parameters

RecalEnergy1           str          file containing the coefficients for the
                                    initial energy re-calibration
RecalEnergy2           str          file containing the coefficients for the
                                    final energy re-calibration


RecalCC                f32 f32      offset and gain adjustment for core
RecalSG                f32 f32      offset and gain adjustment for all segments
TimeShiftCC            f32          time shift of core (ns)
ForceSegmentsToCore    bool         renormalize energy of segments so that their sum equals
                                    energy of core


SegCenter              str          place hits at the center of their segment, as specified
                                    in the given file
SmearPos               f32          xyz uniform smearing of hits (usually the size of the PSA fine-grid
```

ATTENTION:

The following corrections have to be done in this order.
No need to do the energy recalibration twice (or more)

`Track__28-28-1000-UI__TT.spec` spectra generated by `TrackingFilter`



RecalEnergy for the 28*28 time spectra.

```
RecalEnergy -spe Track__28-28-1000-UI__TT.spec -T 500 -num 784 |tee recalT.dat
#
# indx  #spec #pks #ok rEnergy     FW05    FW01      Area Position  Width  Ampli   WTML  WTMR shift*gain
#
     0      0    0   0    0.00    0.000   0.000         0     0.00    0.0      0  0.000 0.000      0.000
     1      1    1   1  500.85   23.649  55.600   1480831   500.85   23.0  51178  2.171 2.653     -0.851
     2      2    1   1  500.47   20.929  48.502   1615273   500.47   20.7  63431  2.343 2.335     -0.473
     3      3    1   1  499.84   25.223  58.799    510810   499.84   24.9  16595  2.289 2.430      0.164
     4      4    1   1  499.65   25.046  60.172    105932   499.65   24.3   3416  2.247 2.715      0.350
```

SolveTT

Get the 28 time coefficient (`TimeShiftCC` of the gen_conf.py)

```
solveTT.py -f recalT_nohead.dat -n 28 -c 13 -p 500

Shifts that minimize Chi2
   0.001
  -0.181
   0.004
  -0.087
   0.040
  -0.239
   0.194
  -0.008
   0.068
  -0.048
   0.238
\..\
\..\
  -0.183

Inital:    Average of 756 nonzero values is -499.98149    Chi2 = 5.16749
Corrected: Average of 756 nonzero values is -499.98149    Chi2 = 3.02089
```

Post-PSA actor procedure

From October 2017 agapro libraries

```
-1) Change ID of detector

0) Recalibration of Segment and core from file RecalEnergy1
1) Recalibration of Segment from the Trapping file.
2) Recalibration of core    from the Trapping file.
3) Apply the trapping correction, and do the recalibration after (Trapping file)

3.5) Packing of hits
4) Smearing of hits
5 Time-Stamp mask and calculation of consecutive event time difference
6) Filling of histogram 0 to 3.

7?) Matrix of PSA hits  (XYZ + RZE)

10) Recalibration of energy (segment and core) from file RecalEnergy2

10) Core recalibration from RecalCC
11) Segment recalibration from RecalSg (one gain and offset for all segments)

12) Timing shift

13) Force segment to core

14) segment center
15) merge hit or fixed positions


16-1) Filled histogram 4. This is final event.
16-2) matrix of hits again
```

To remember

- Follow the order given here.
- Be careful of the possible redundant calibration done by the PostPSA filter actor.
- The PostPSA is the last chance to have properly calibrated segments.
- The calibration offset can only be set at this level of the analysis.
- ForceSegToCore $\rightarrow$ final correction, only when the core resolution is good.