Developments of the analysis of AGATA and ancillary data for AGATA@LNL

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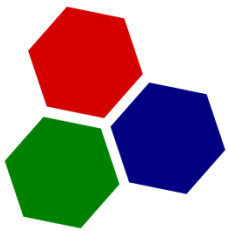
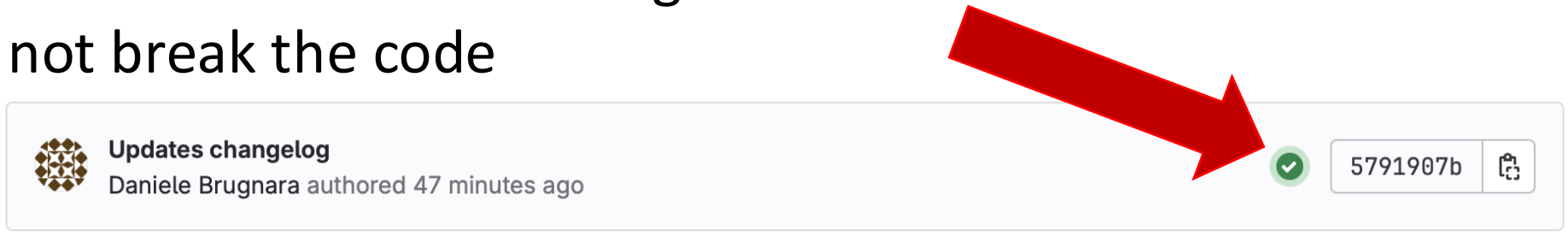
and the local LNL group

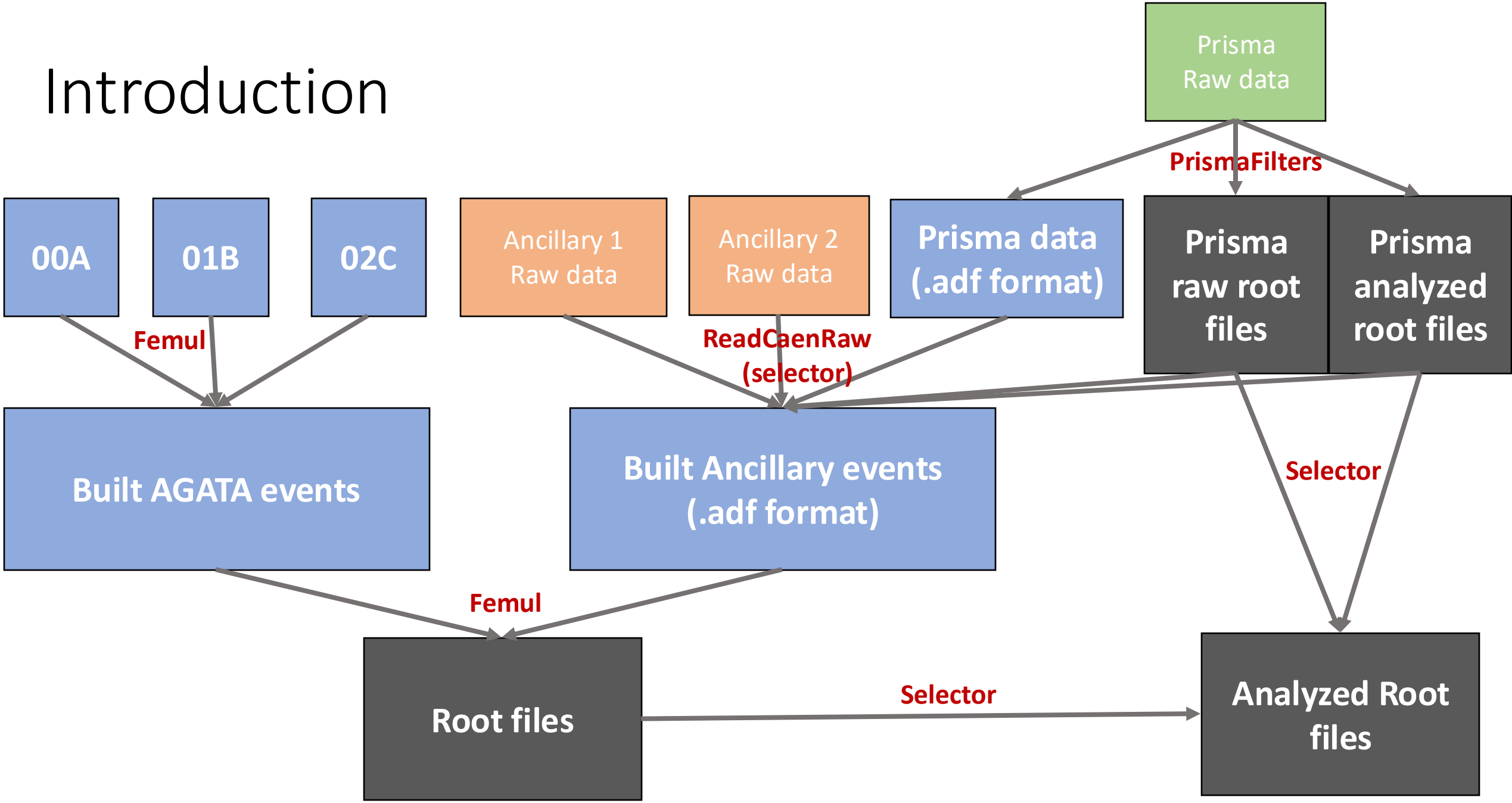


The starting point

- Femul produces a root file containing MANY leaves
- The analysis procedure is common to all experiments and there is little benefit of repeating the same steps over and over
- The code was created for a quick near-line analysis and has since evolved with more refinements with full analysis capabilities
- This also means that the code changes often, so we implemented automatic testing to make sure that a commit does not break the code



Introduction

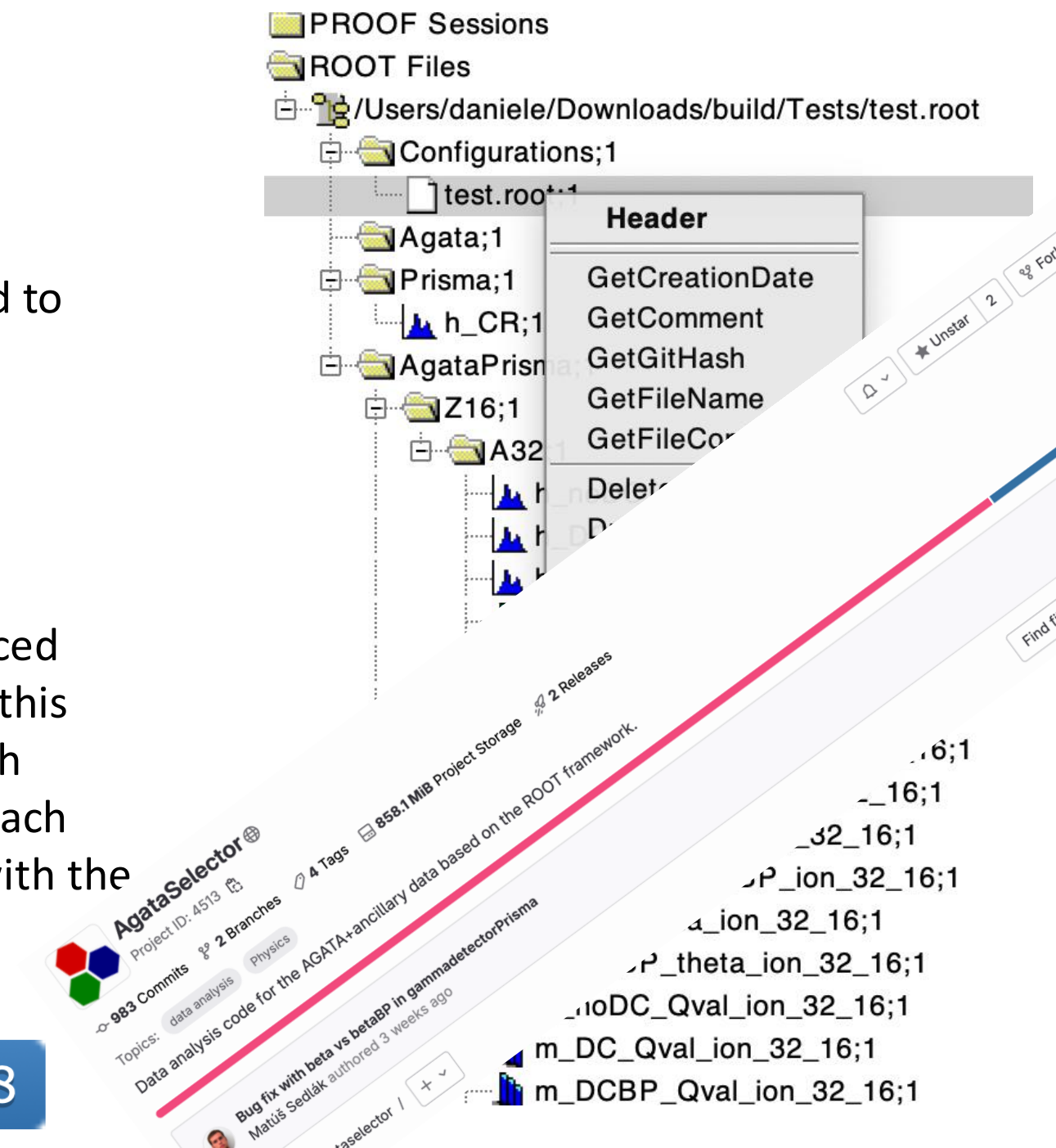


The output

- The selector produces ROOT files containing:
  - Histograms (each analysis is contained within a folder):
    - Single detector analysis
    - Coincidence analysis
  - TTrees of:
    - High level data of a single detector. For instance, Spider provides things such as excitation energy or angles
    - Doppler correction based on the analysis of the agata+ancillary coincidence
- The analysis code handles kinematic reconstruction, energy loss, event selection, time and energy gates, optimization procedures
- It can be distributed on multiple machines if compiled with MPI

Reproducibility

- The output files contain the parameters used to generate it:
  - The entire selector.conf
  - The lookup tables
  - The git hash
  - The date of creation
- This means that the analysis can be reproduced simply by printing the selector.conf used for this specific file and checking out the correct hash
- The nearline analysis and configurations of each experiment can be recalled by compiling it with the right flags
- It is also citable with a DOI:



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Features and detectors

- Several detectors have been added since the last AGATA week
- Current supported detectors:
  - AGATA
  - PRISMA
  - SPIDER
  - EUCLIDES
  - DANTE
  - $LABR_3$
  - SAURON (S1)
  - OSCAR
  - EXOTIC's MCPS

Configuration of the analysis

- Based on a configuration file and Lookup tables
- These files can be modified multiple times since analyzing an entire experiment often does not require more than 2 hours (depending on computing capabilities)

Board | channel | map | thr low | thr high| various par | …| time offset | ncal | cal par 1 | …

LUT_LABR.dat 1.16 KiB — Edit

```
#LaBr Co+Cs
#board (V1730)  channel map     name    thr_lo  thr_hi  theta   phi     TimeOffset      npar_gl p0_gl   p1_q2   npar_qs p0_qs   p1_qs
1       0       0       D0      0       16000   90.422684  124.92098   0       2       -8.590549465 0.5683940043  2     -16.614035 0.584031
1       1       1       D1      0       16000   84.308418  97.489398   0       2       4.994643769  0.441859949    2  10.570262 0.443247
1       2       2       D2      0       16000   90.572804  73.768608   0       2       -4.882700373 0.4567364497   2  -9.782321 0.473778
1       3       3       D3      0       16000   99.968116  51.748253   0       2       -2.68135951  0.4616749283   2  -9.040133 0.473527
1       4       4       D4      0       16000   93.353077  26.901224   0       2       -3.368474921 0.4774816369   2  0.609657 0.481297
1       9       9       D5      0       16000   94.007297  1.3778600   0       2       0            1              2  0        1
1       5       5       D6      0       16000   99.883486  -28.723198  0       2       10.52197059  0.4435828877   2  18.918459 0.444711
1       6       6       D7      0       16000   86.180070  -45.908423  0       2       12.53667474  0.4240481389   2  28.411274 0.421525
1       7       7       D8      0       16000   91.699165  -66.505287  0       2       16.78408614  0.3897415818   2  35.049303 0.387539
1       8       8       D9      0       16000   85.591641  -95.344627  0       2       -12.39452343 0.4289130669  2  -38.673472 0.452371
##########
1       15      15      monitor 0       16000   0                      0       0       2       0         1        2  0         1
```

KEYWORD | value(s) | unit of measure | comment

```
#Configuration file for the selector
#Format: | KEYWORD | value(s) | Unit of measure | Comment |
#Comments are ignored unit of measure # means none
#------------------------------------------------------------

#------------------------------------------------------------
DETECTORS_PRESENT
MCP                     NO      #               EXOTIC Mcps are present YES/NO
SAURONFW                NO      #               Sauron Forward is present YES/NO
EUCLIDES                NO      #               Euclides is present YES/NO
LABR                    NO      #               Labr is present YES/NO
OSCARUP                 NO      #               Oscar Up is present YES/NO
SPIDER                  NO      #               Spider is present YES/NO
OSCARDOWN               NO      #               Oscar Down is present YES/NO
AGATA                   NO      #               Agata is present YES/NO
SAURONBW                NO      #               Sauron Backward is present YES/NO
DANTE                   NO      #               Dante is present YES/NO
EXSSIDE                 NO      #               EXSSIDE Forward is present YES/NO
PRISMA                  NO      #               Prisma is present YES/NO
#------------------------------------------------------------

#------------------------------------------------------------
REPLAY_CONF
ENABLED_HISTOS                  enabled_histos.conf     #               File name with list of enabled histograms
SUM_ALL_PATTERN                 runs                    #               Sum of all hadded files pattern
TREE_NAME                       TreeMaster              #               Input tree name
SUM_FILE_PATTERN                sum                     #               Hadded file pattern
OUT_FILE_PATTERN                run_                    #               Output file pattern
IN_FILE_PATTERN                 Tree_                   #               Input file pattern
REPLAY_DIR_PATTERN              run_                    #               Replay directory pattern
IN_SUB_PATH                     /Out/Analysis           #               Input sub path
CONF_PATH                       ./Conf                  #               Replay conf folder path
OUT_PATH                        ./Out                   #               Output path
IN_PATH                         ./Data                  #               Input path
#------------------------------------------------------------

#------------------------------------------------------------
REACTION_CONF
REACTION_POSITION       0.5     #                       Position of the reaction in the taget 0->front 0.5->middle
ENERGY                  0       MeV                     Beam energy
TARGET                  1 1     #                       Target ion A Z
BEAM                    1 1     #                       Beam ion A Z
ION                     1 1     #                       Fragment of interest for binary reaction calculation: A Z
#------------------------------------------------------------

#------------------------------------------------------------
TARGET_CONF
ELOSS_TABLE_TYPE                0       #                       Type of eloss table 0 -> SRIM, 1-> Geant4, 2 ->Lis
DEG_DISTANCE                    0       um                      Degrader distance in um
DEG_THICKNESS                   0       mg/cm2                  Degrader thickness in mg
ROTATIONZ                       0       deg                     Target rotation on the Z axis in degrees
ROTATIONX                       0       deg                     Target rotation on the X axis in degrees
TILT                            0       deg                     Target tilt in degrees; Negative values for clockw
THICKNESS                       0       mg/cm2                  Target thickness-density in mg/cm2 or units alike
DEG_PRESENT                     NO      #                       Degrader present YES/NO
DEG_MATERIAL                    none    #                       Degrader material
MATERIAL                        none    #                       Target material
DEG_POS                         AFTER                           Degrader position BEFORE/AFTER
#------------------------------------------------------------

#------------------------------------------------------------
AGATA_CONF
BIN_WIDTH                               1       #               Bin width in gamma histograms
COINC_W_RIGHT_RIGHT_BKG                 0       #               Right Background time window on the right
COINC_W_LEFT_LEFT_BKG                   0       #               Left Background time window on the left si
```

The UserSelector

- In many cases some things are experiment-specific and can be handled be added in a specific section of the code
- This will create an additional part of the analysis with histograms
- One can recall the configuration and specific code of the nearline analysis as by compiling the selector with an experiment-specific cmake option

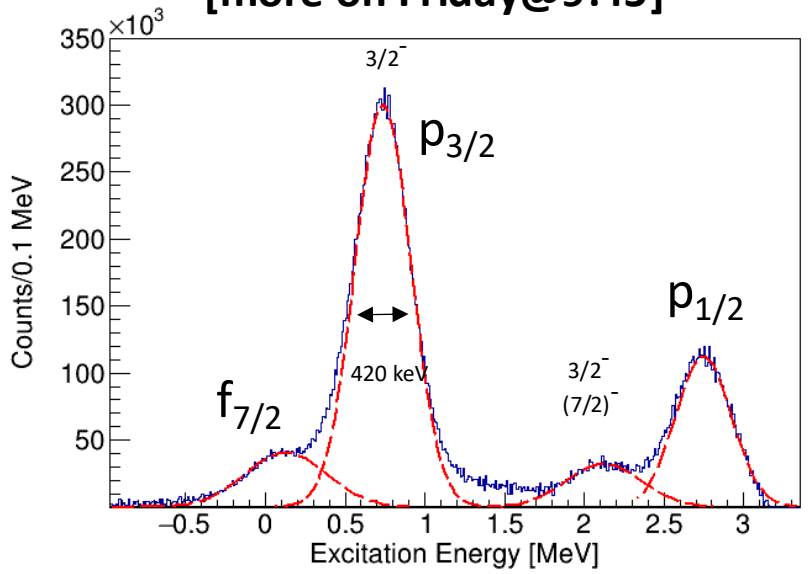
h UserSelector.h 592 B

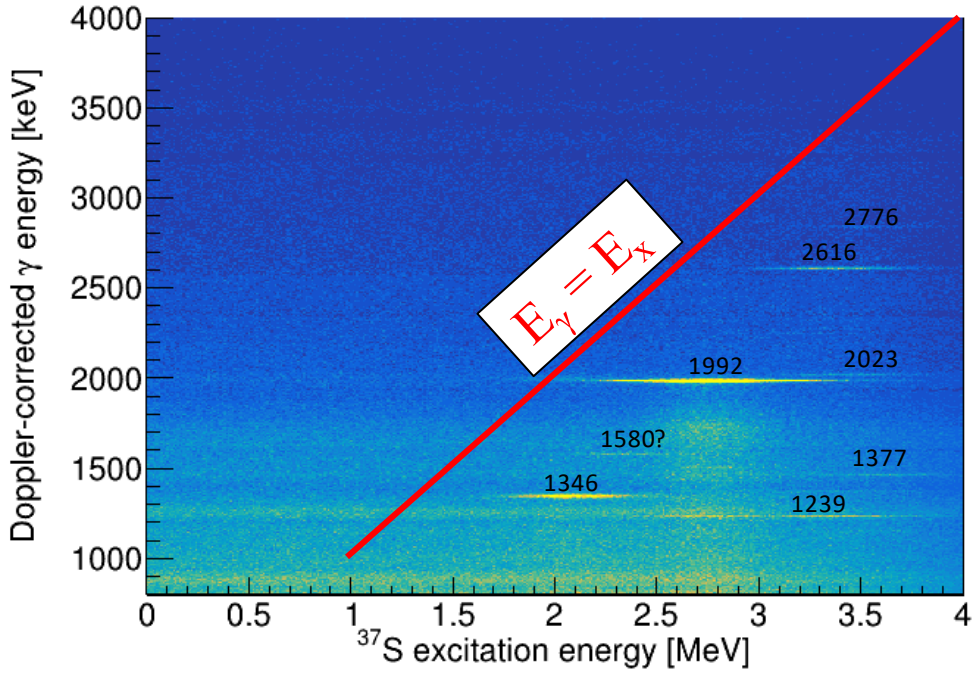
```
1  #pragma once
2  #include "AgataSelector.h"
3
4  class UserSelector : public AgataSelector {
5    public:
6      explicit UserSelector(const std::string& options)
7          : AgataSelector(options){};
8      Bool_t Process(Long64_t entry) override;
9      void   SlaveBegin(TTree* tree) override;
10     void   SlaveTerminate() override;
11
12   private:
13     // USER variable and histogram definition section
14
15     // unsigned long long timeRef = 0;
16
17     struct UserHistograms {
18         std::vector<TObject*> ptrs;
19         TDirectory*           dir{nullptr};
20         // TH1D *h_agataCR = nullptr;
21
22     } userHistograms;
23 };
24
```

Spider

- $^{36}S(d,p)^{37}S$ to study intruder states along the N=20 shell closure
- Example of kinematic reconstruction
- In many cases, the excitation energy can be very helpful
- The EX_VALUES keyword allows to generate histograms gated on the right value

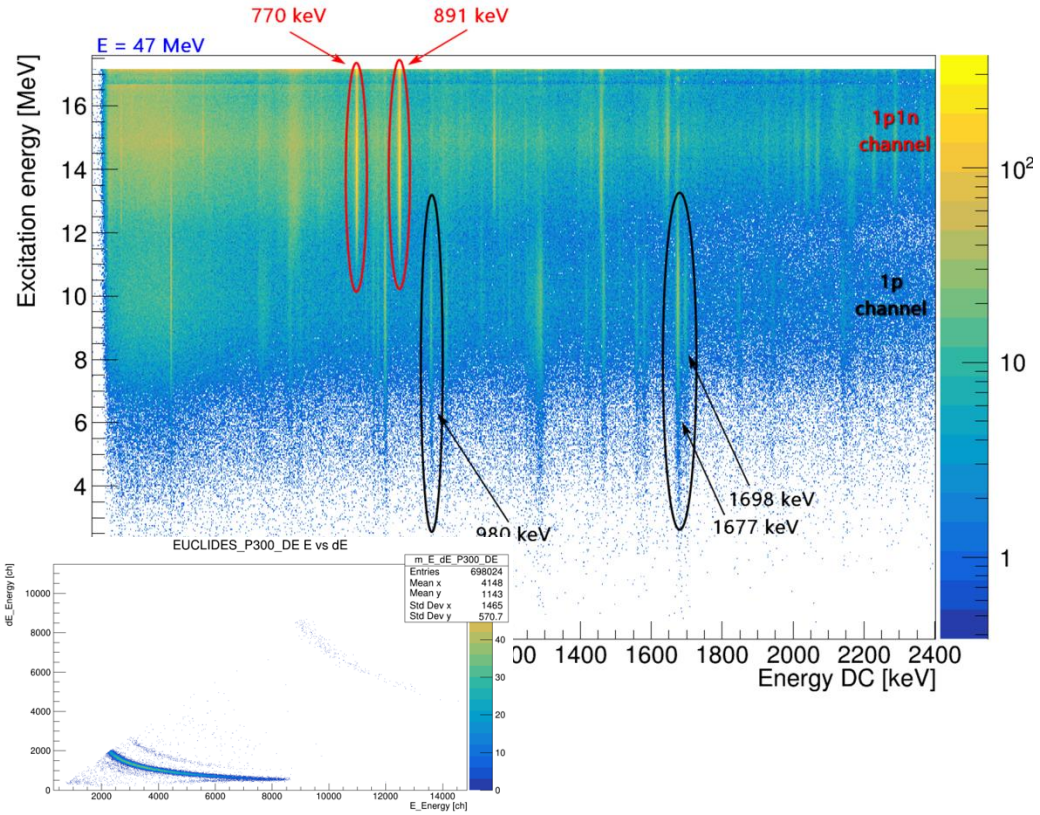
L. Zago PhD Thesis
[more on Friday@9:45]

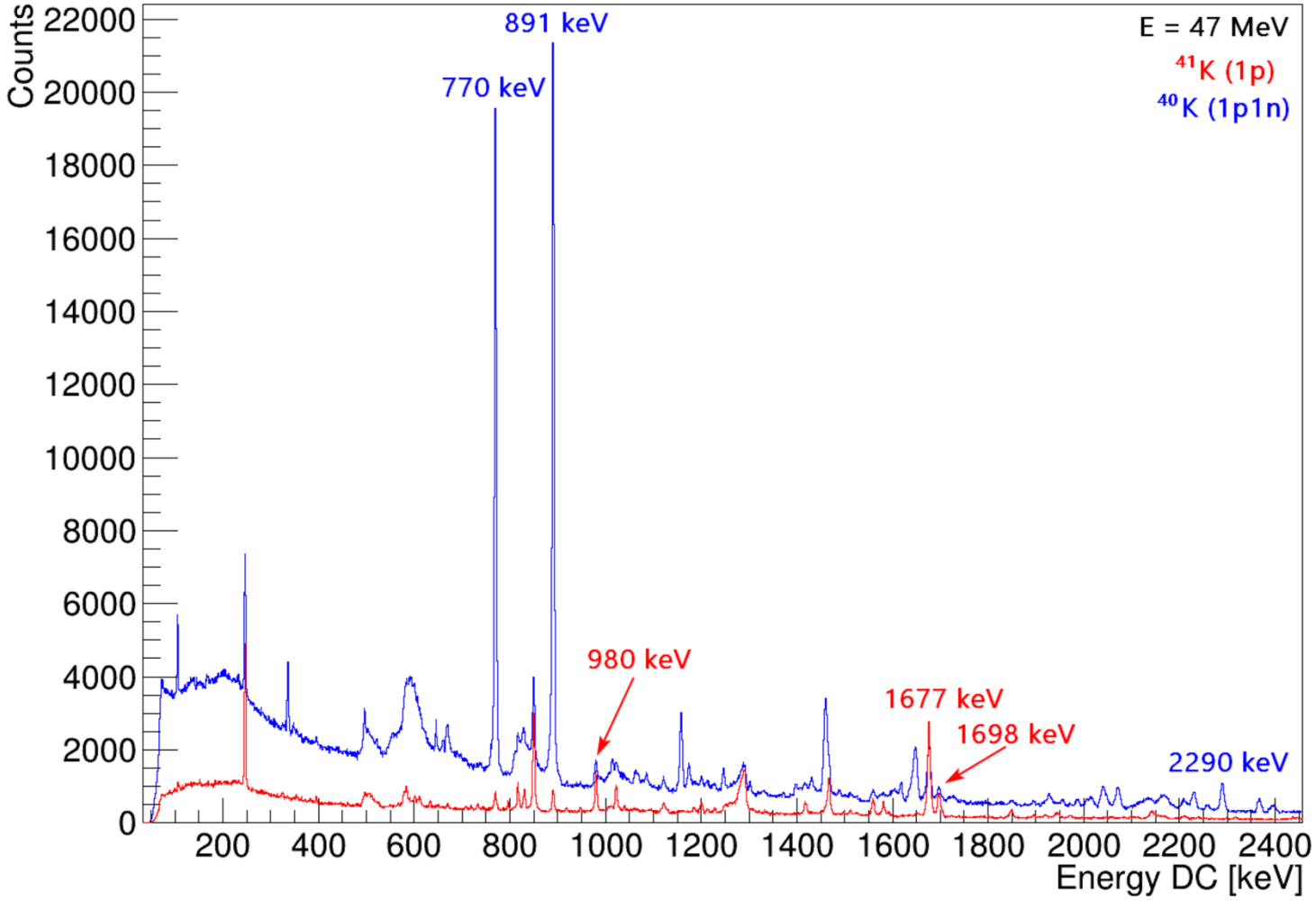




Mirco Del Fabbro, PhD Thesis

Euclides



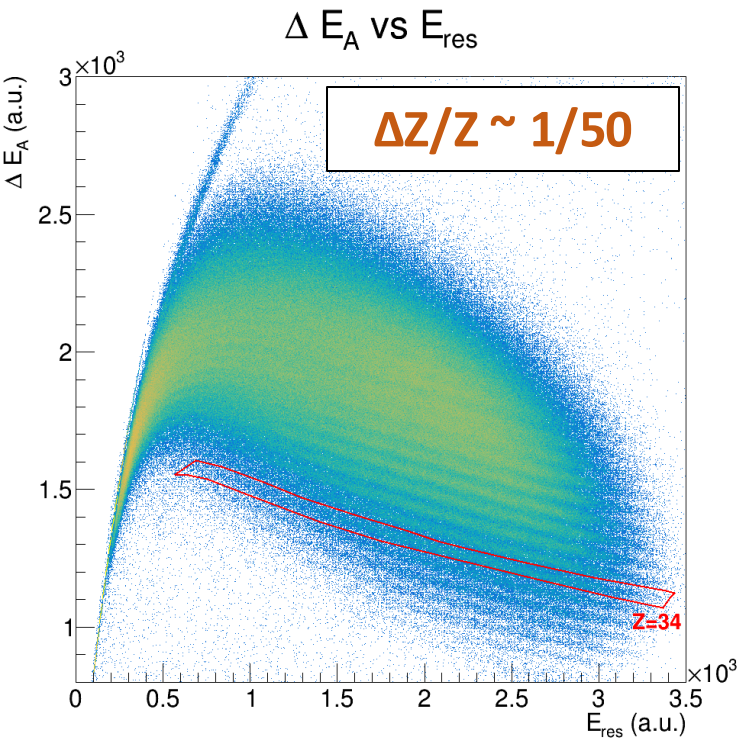


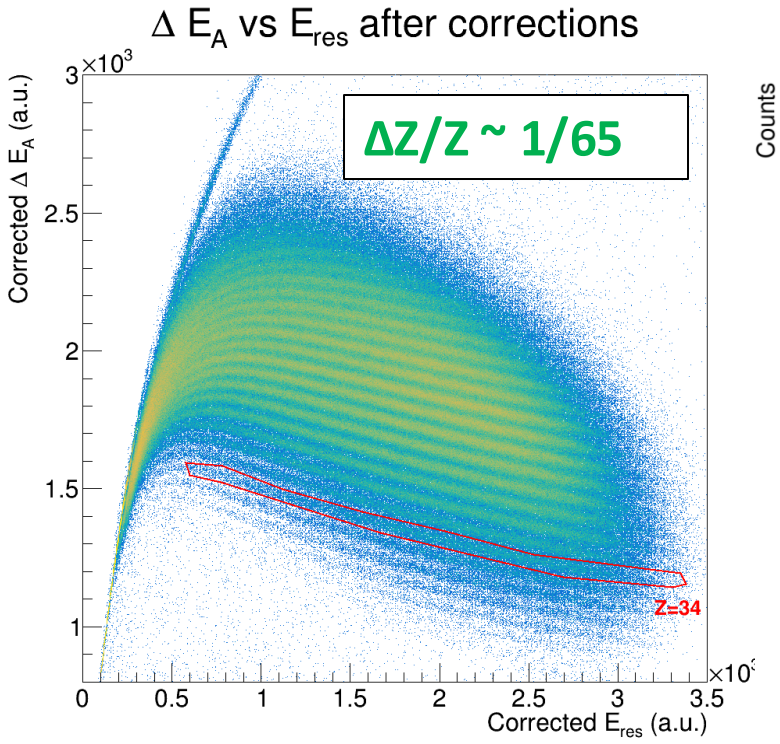
- Constructing a “rough” compound system excitation energy it is possible to discriminate not only protons, deutrons and alphas but also the 1p1n channel from the 1p channel (reaction dependent outcome)

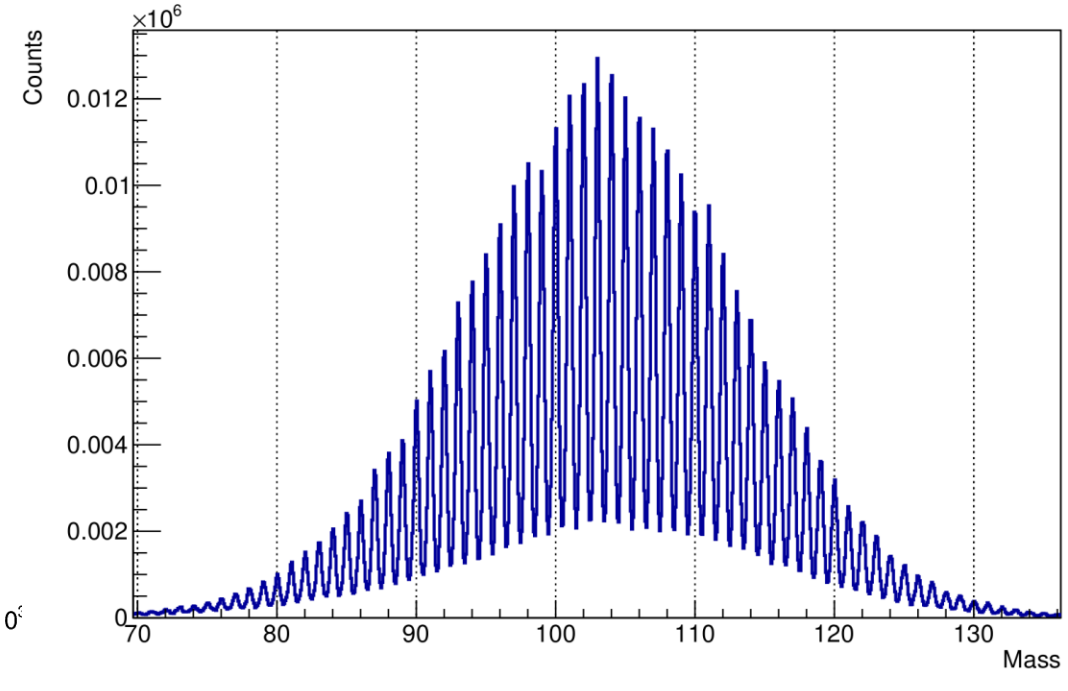
F. Angelini, E. Pilotto

Prisma

- The analysis of the spectrometer has been included in the selector
- This allows to exploit the optimization procedure of the selector even on the optical parameters of the spectrometer
- Some improvements have also been done on the ionization chamber selection

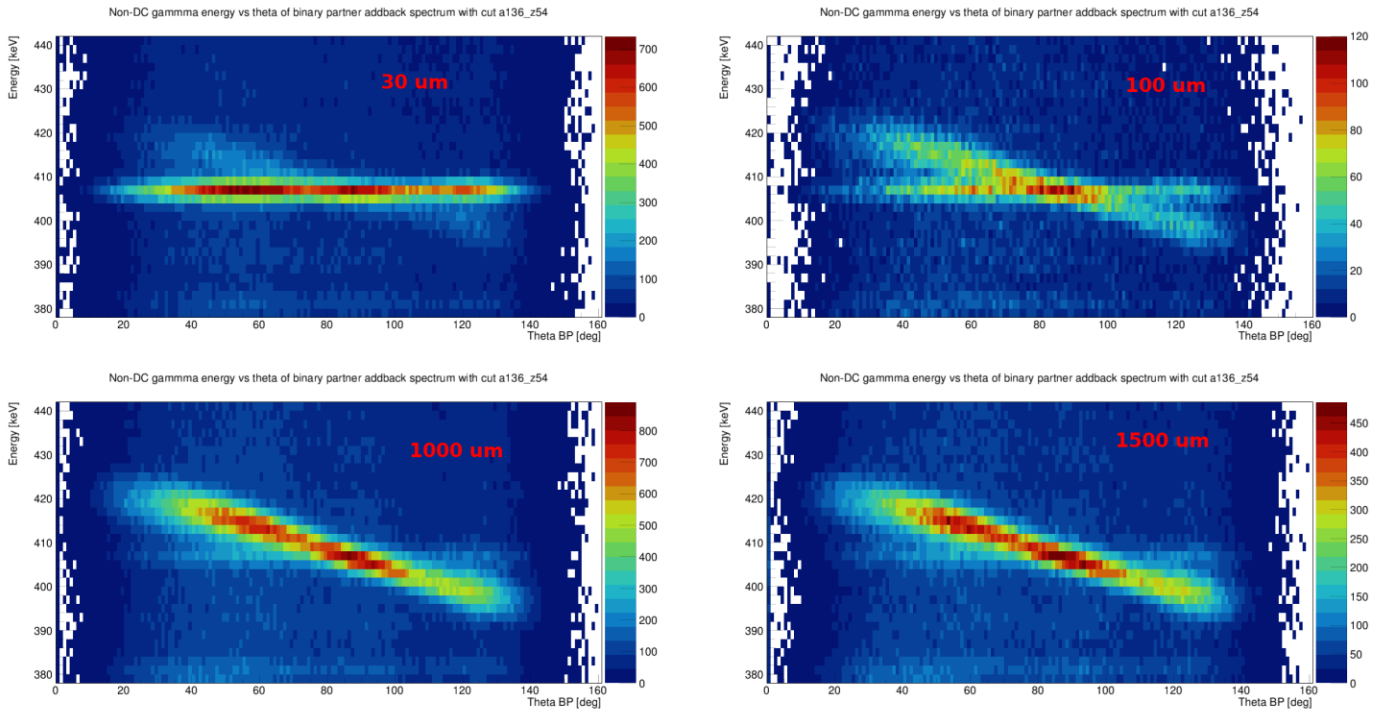






Prisma

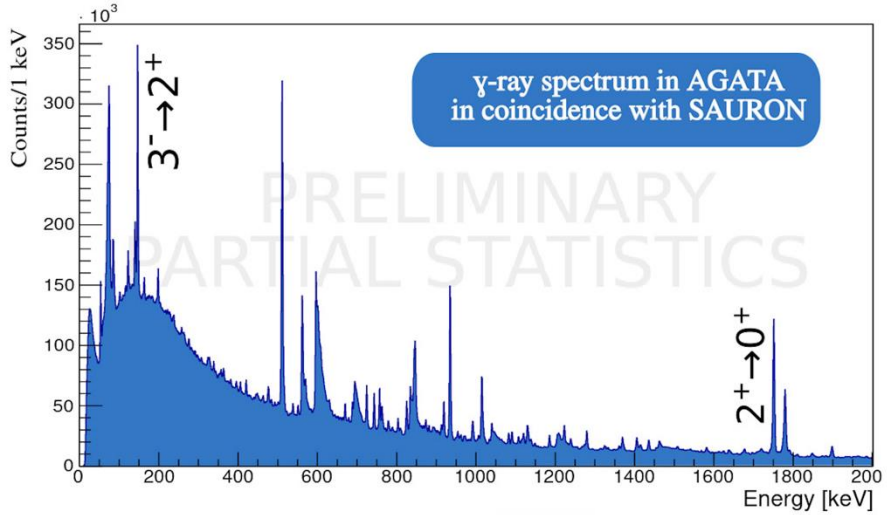
- The kinematic reconstruction and the high position sensitivity of AGATA shows exciting results

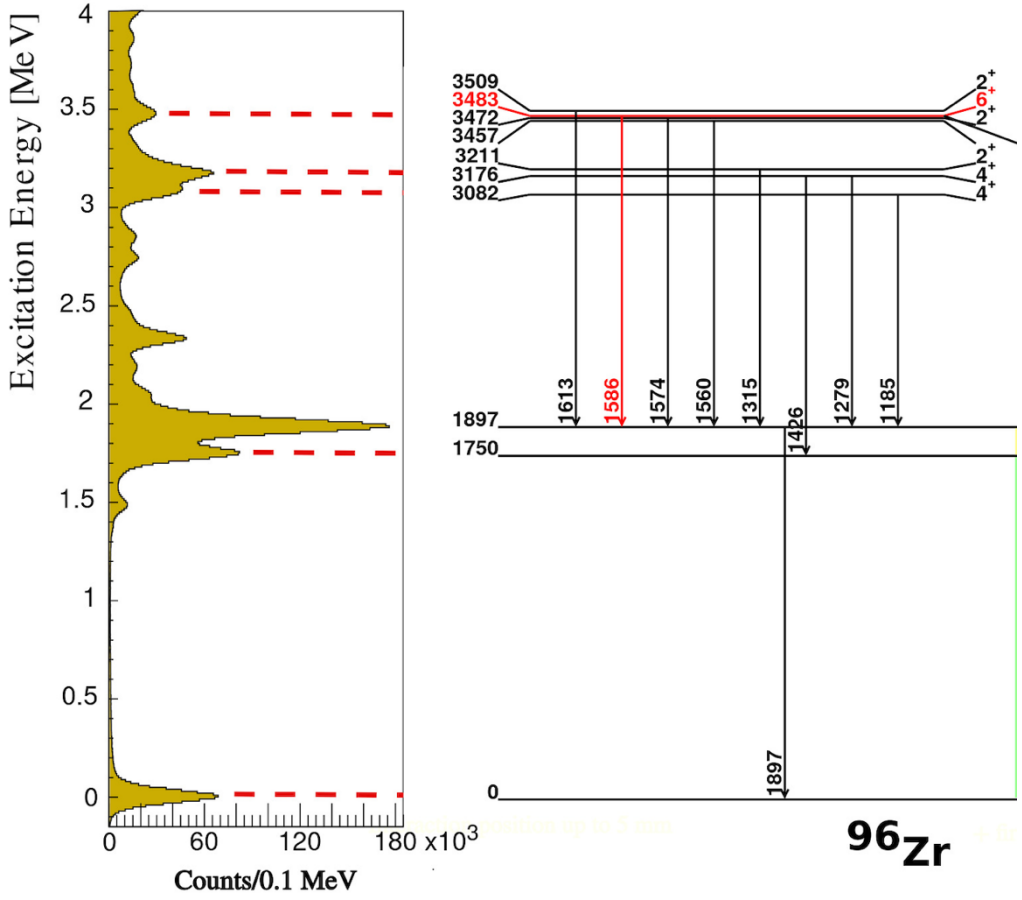


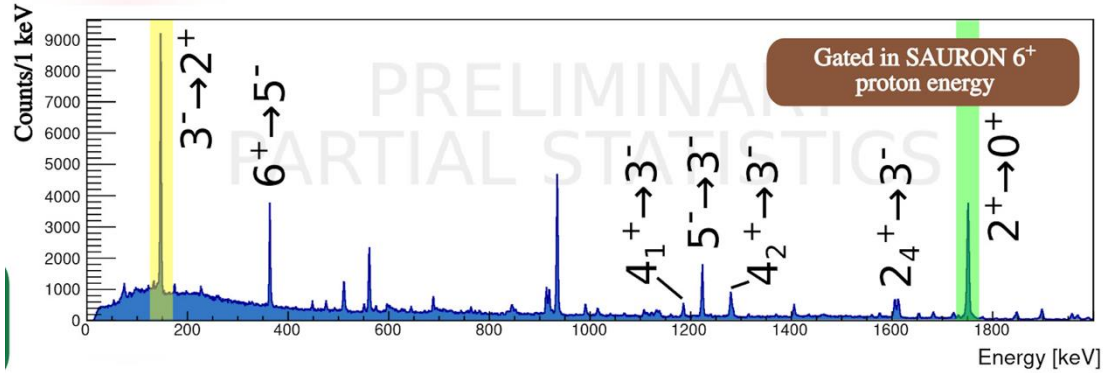
Sauron

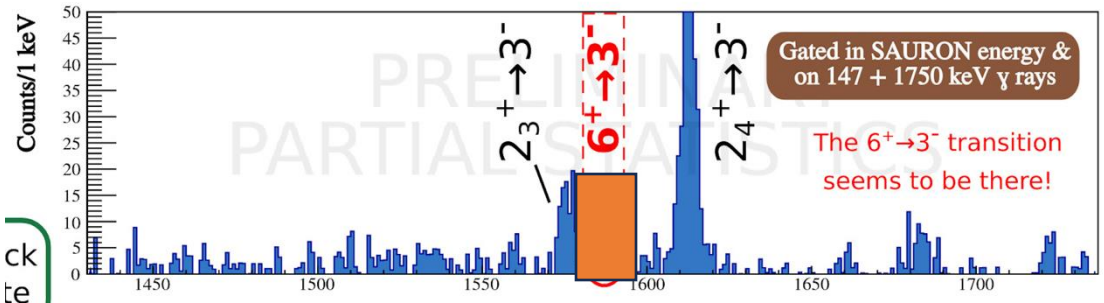
D. Stramaccioni
[more on Friday at 10:30]

- Particle identification trough pulse shape analysis
- Event-by-event kinematic reconstruction and Doppler correction
- $^{96}Zr(p,p')^{96}Zr$ to investigate the two phonon octupole excitation
- Excitation energy gate selects precisely the direct population of the 6^+ state of interest





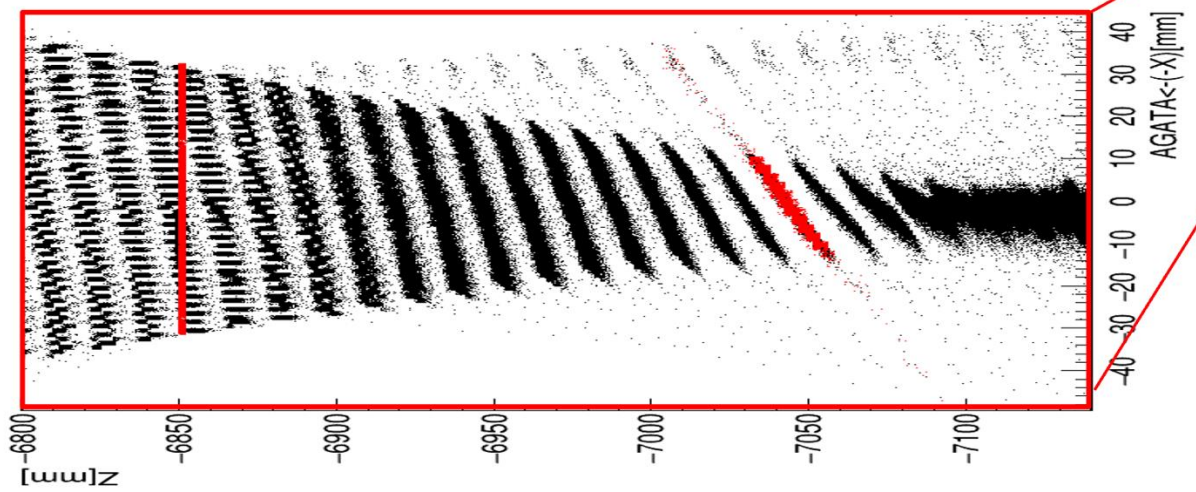


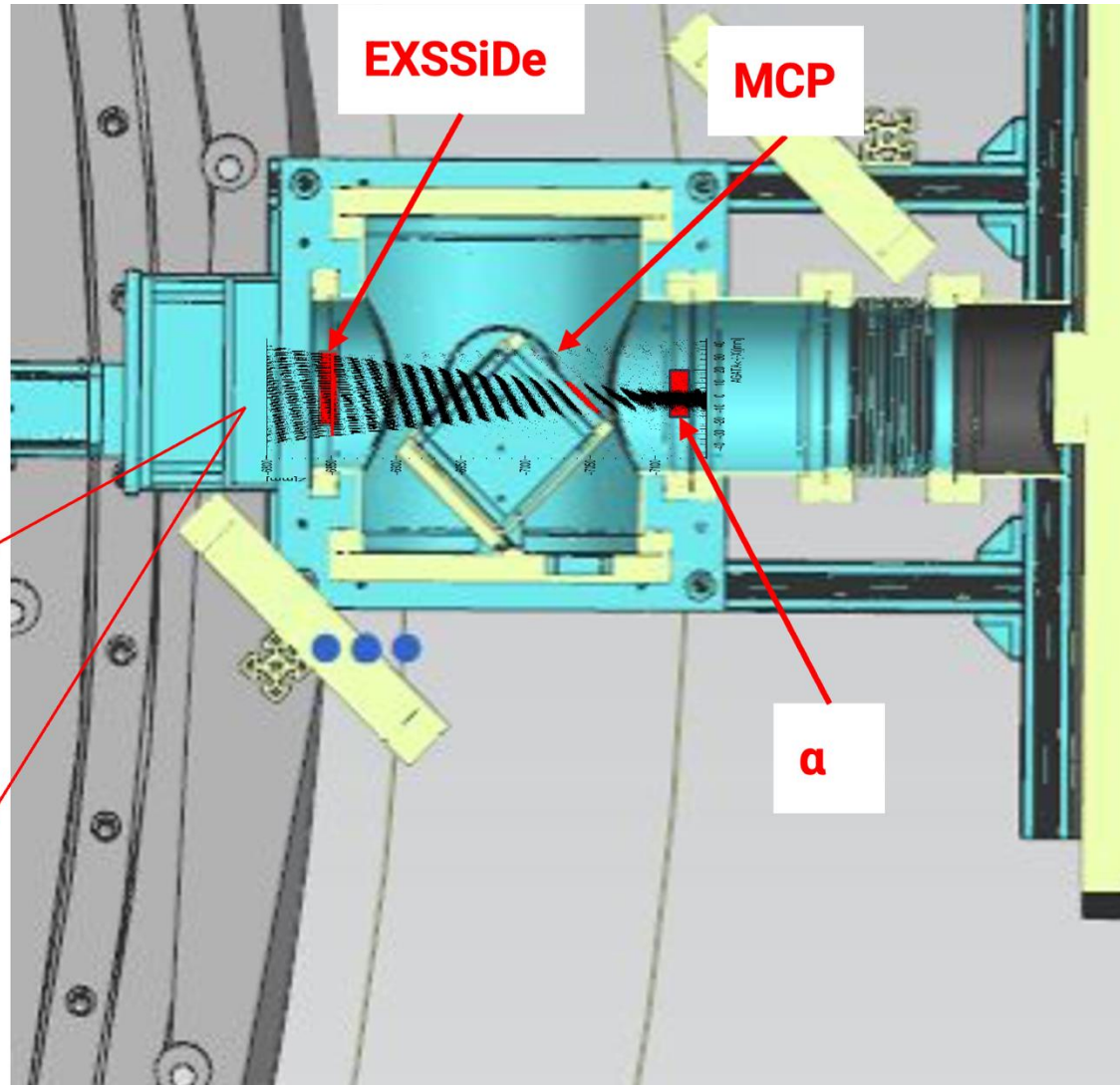


Exotic

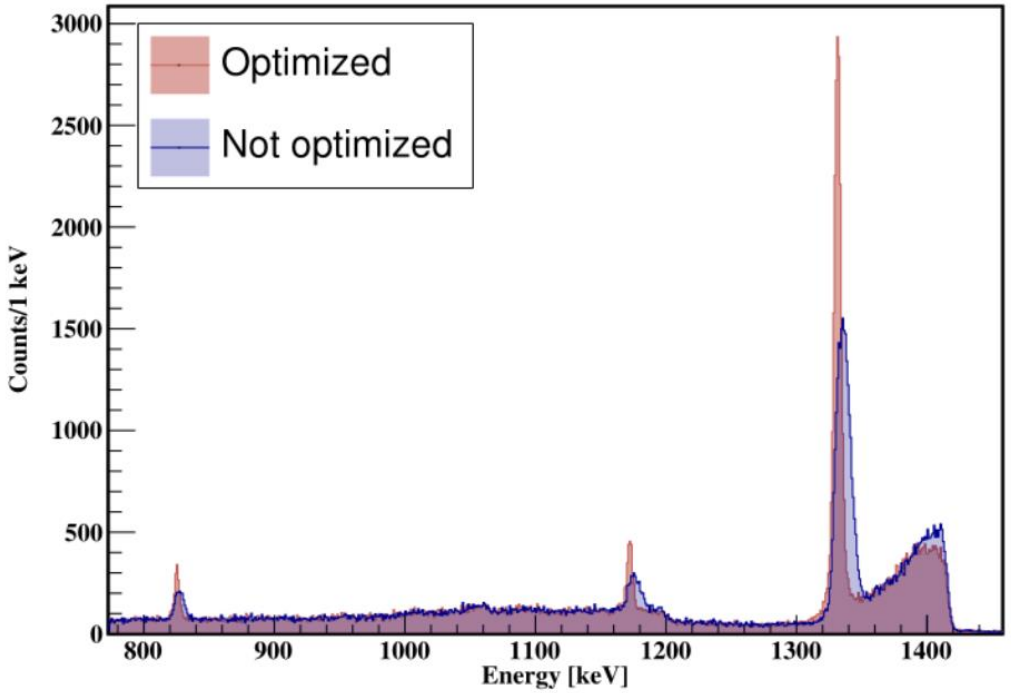
S. Pigliapoco

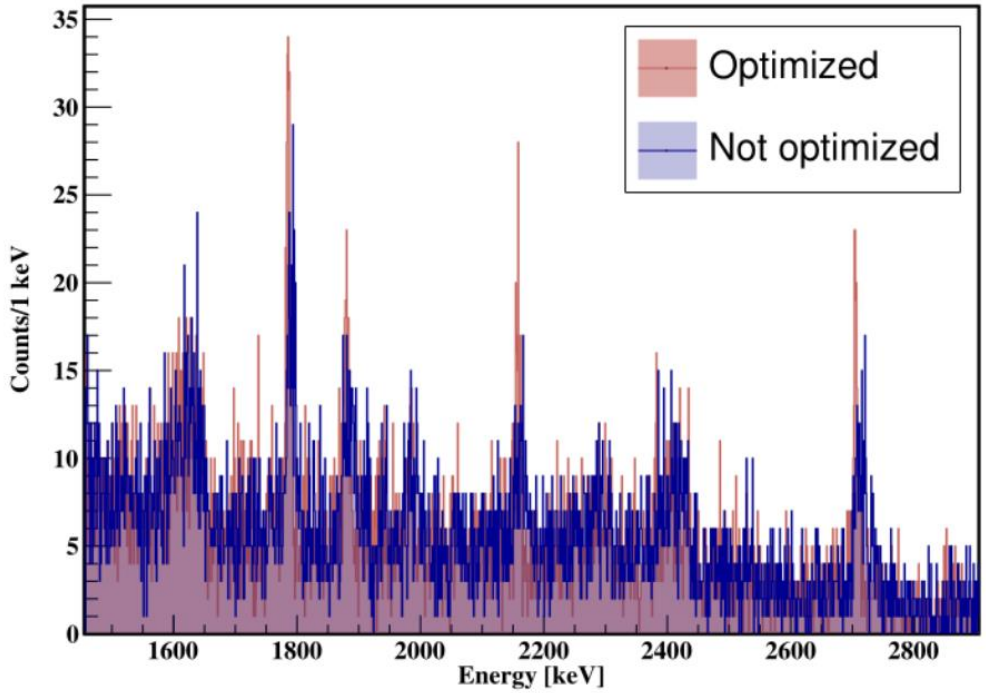
- Radioactive beam tracking based on two MCPs similar to the one of PRISMA
- The tests are being performed and the code is under development





The optimization procedure





- Remarkable improvements are possible with the optimization but are experiment dependent.
- The selector contains a procedure to find the optimal parameters by running

  RunSelector - -optimize 2

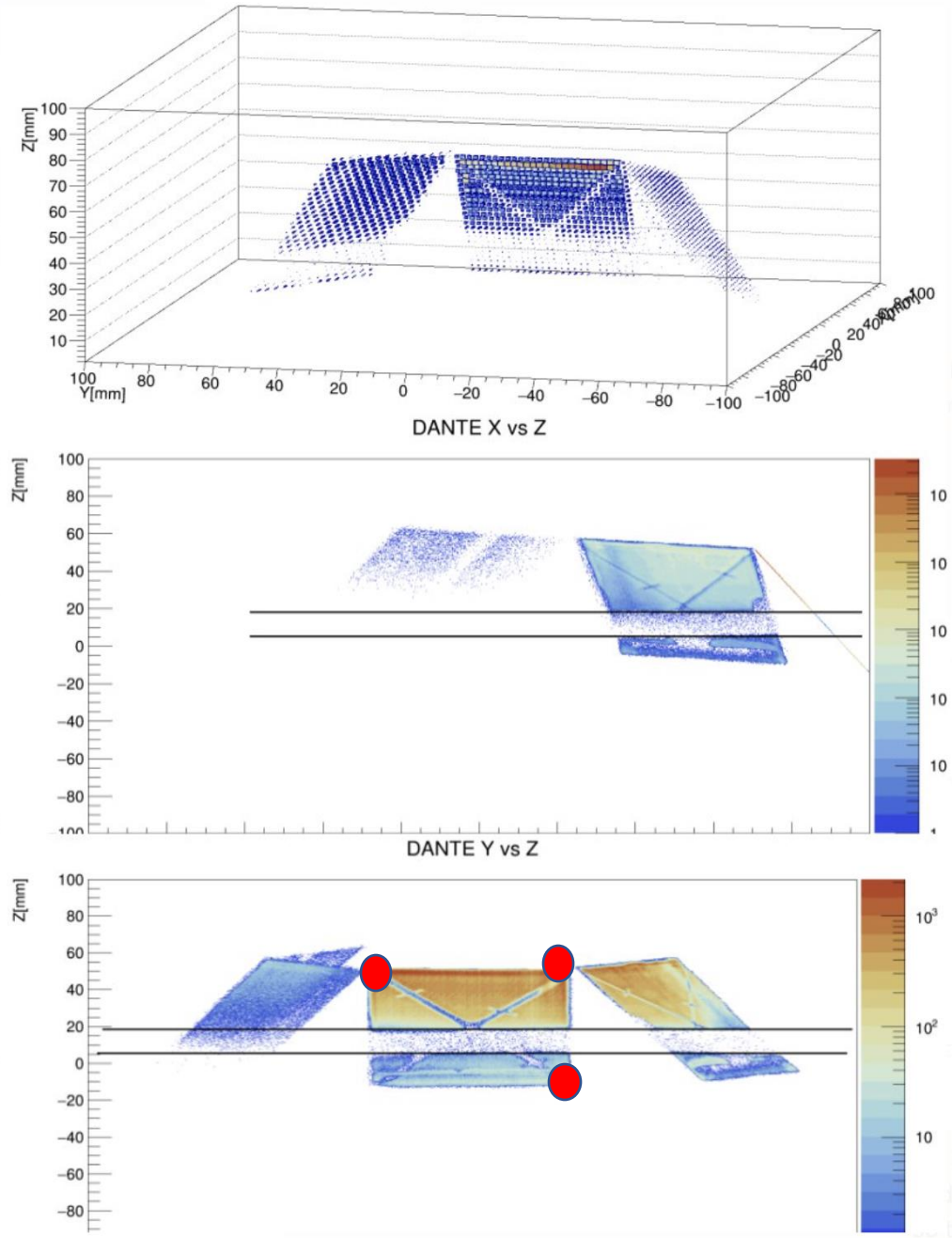
Distributed analysis

- MPI based parallelization on multiple machines (boost-mpi)
- Needs to be compiled with “cmake -DCMAKE_CXX_COMPILER=mpic++ -DUSE_MPI=On .”
- Very simple server/worker structure
- Usually limited by read disk speed

The end.

Dante

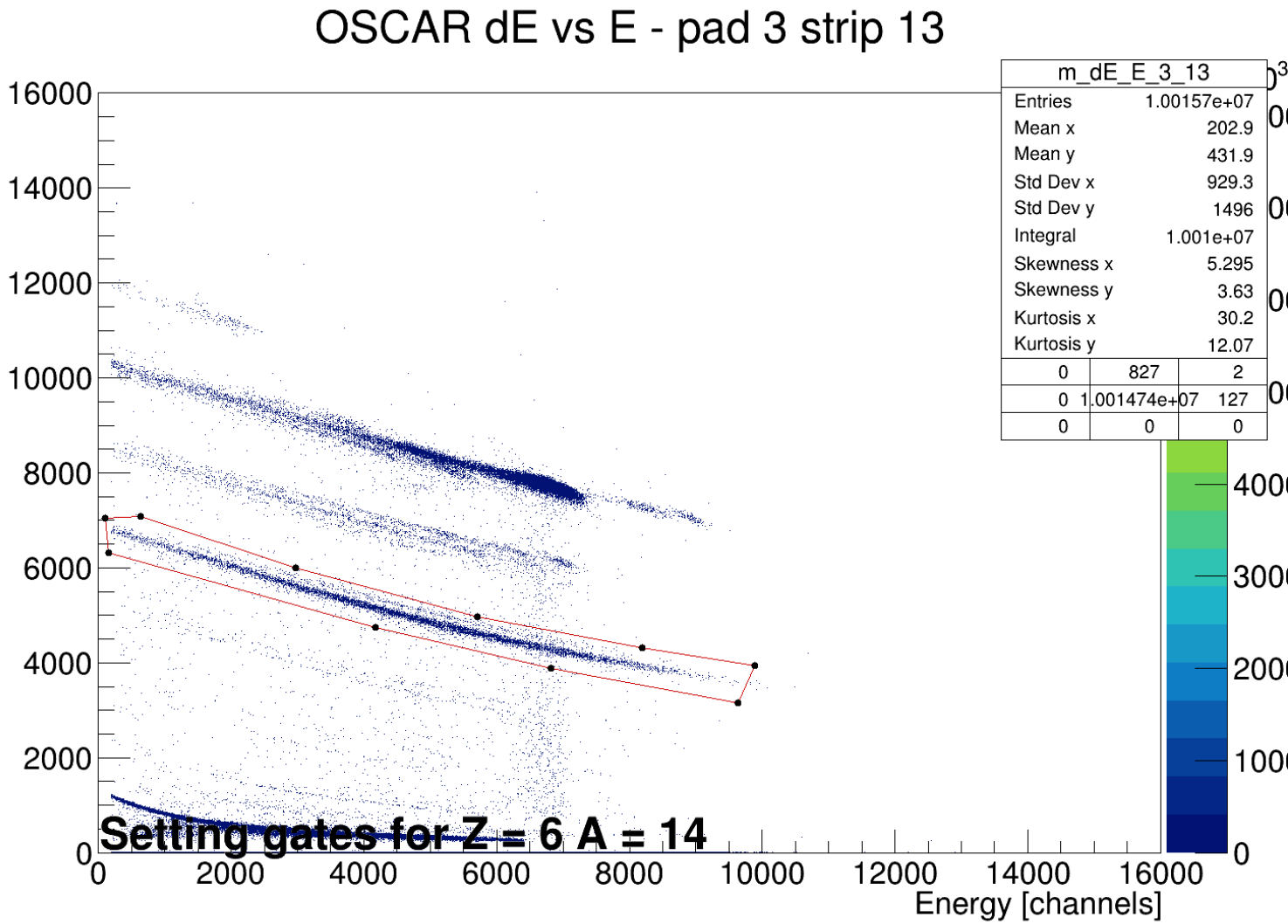
- The position is used to refine the Doppler correction
- In this case of the triple coincidence AGATA-PRISMA-DANTE it is possible to operate a fine selection exploiting the TOF between Prisma and Dante



Agata & LaBr

- LaBr and Agata share the same base class, GammaDetector
- As a consequence, the analysis of coincidences with Agata is exactly the same and one can obtain a refined analysis also for the LaBr

Oscar


OSCAR dE vs E - pad 3 strip 13
m_dE_E_3_13
Entries 1.00157e+07
Mean x 202.9
Mean y 431.9
Std Dev x 929.3
Std Dev y 1496
Integral 1.001e+07
Skewness x 5.295
Skewness y 3.63
Kurtosis x 30.2
Kurtosis y 12.07
0 827 2
0 1.001474e+07 127
0 0 0
Setting gates for Z = 6 A = 14
Energy [channels]