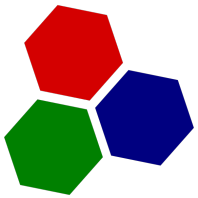
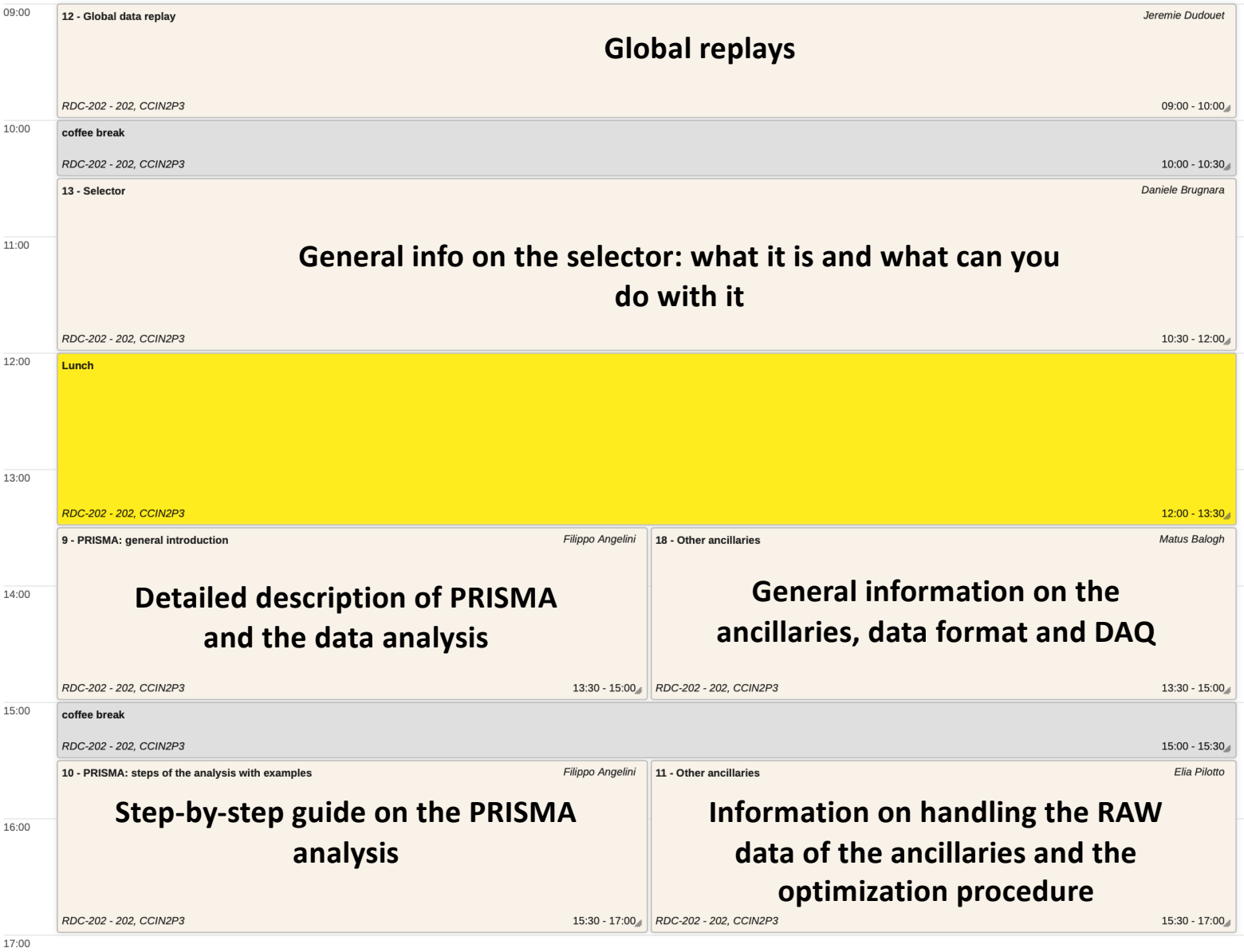
Selector analysis: AGATA+${ancillary} analysis

D. Brugnara

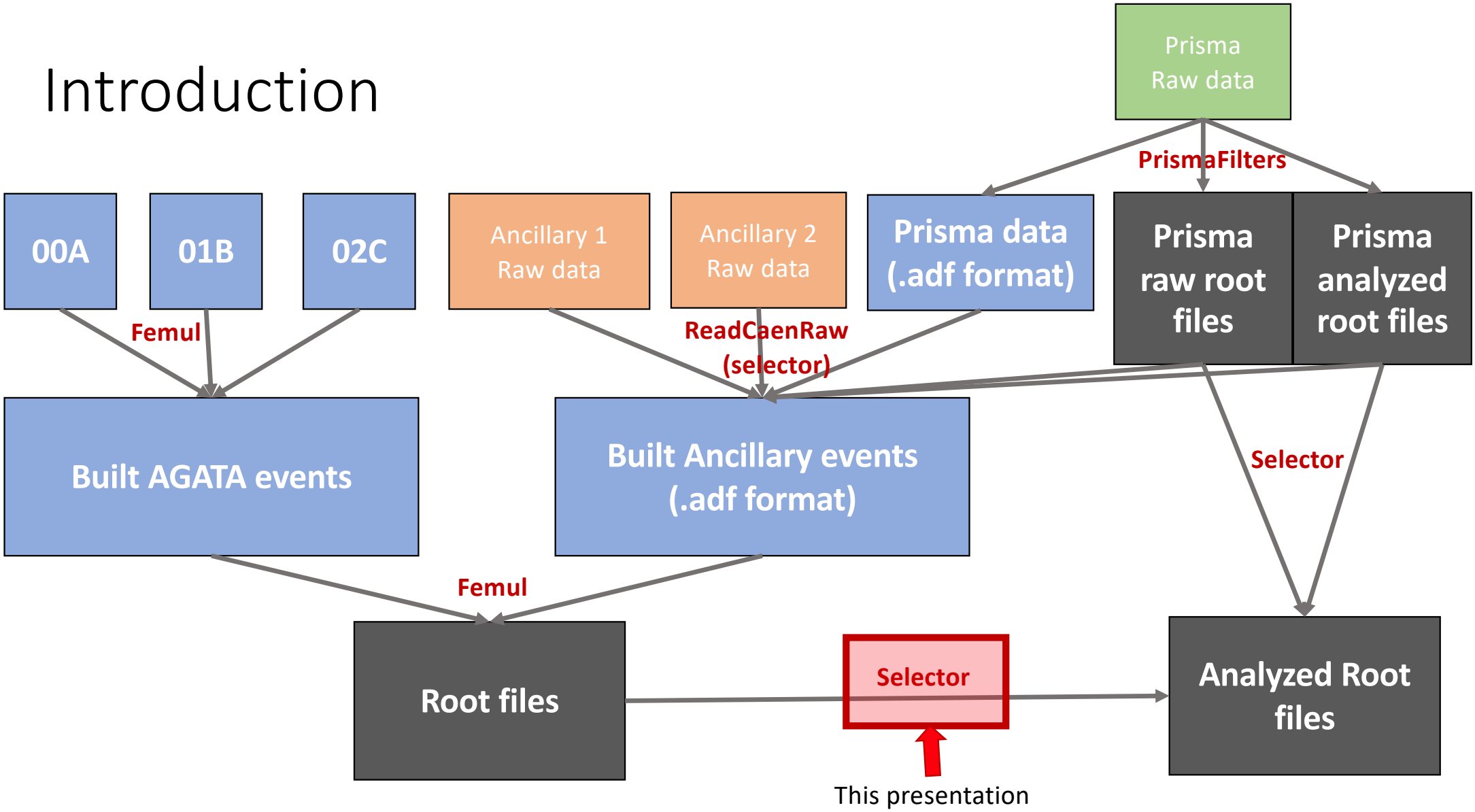


Outline

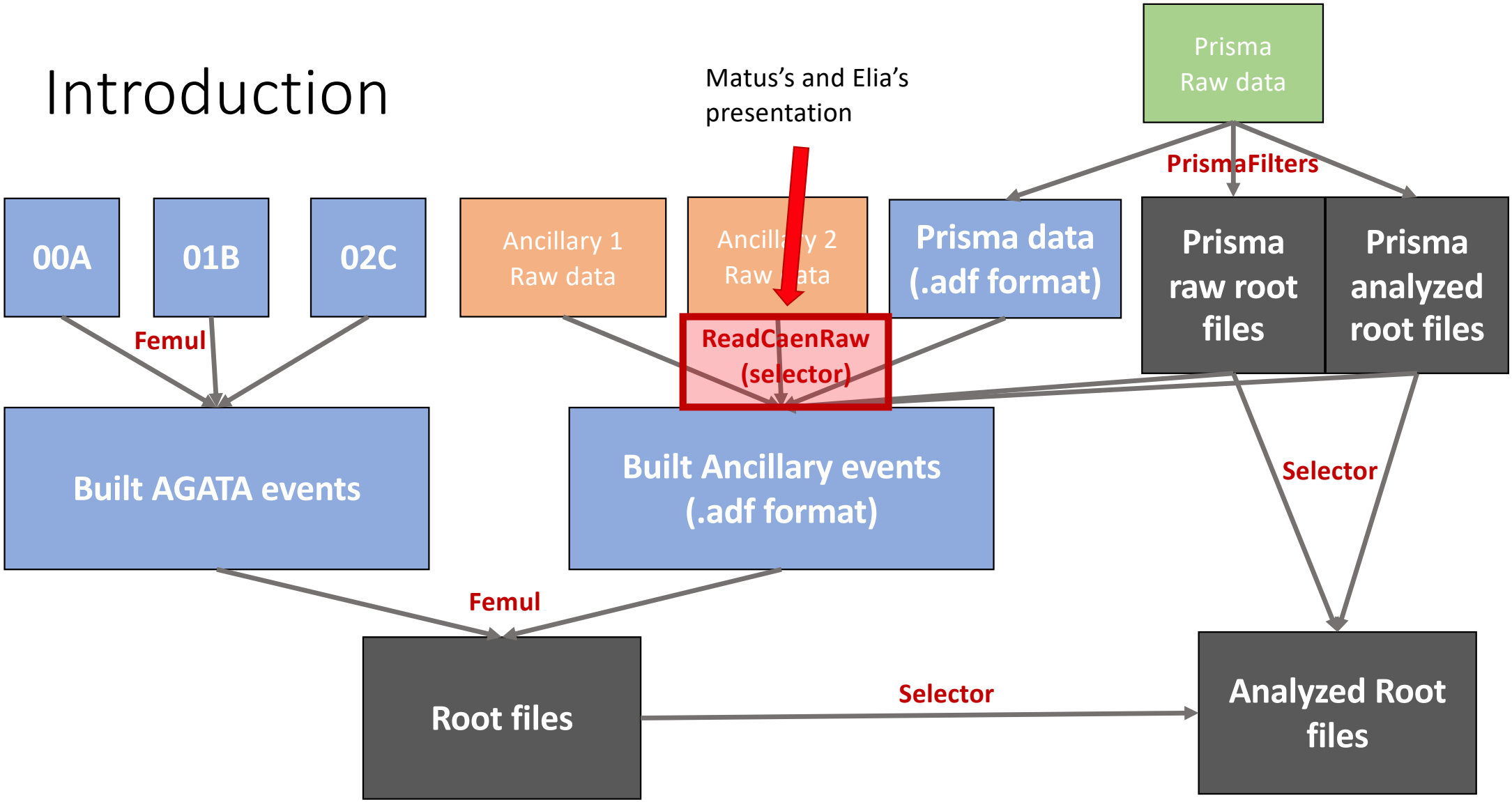

09:00
12 - Global data replay
Jeremie Dudouet
Global replays
RDC-202 - 202, CCIN2P3
09:00 - 10:00
10:00
coffee break
RDC-202 - 202, CCIN2P3
10:00 - 10:30
13 - Selector
Daniele Brugnara
11:00
General info on the selector: what it is and what can you do with it
RDC-202 - 202, CCIN2P3
10:30 - 12:00
12:00
Lunch
13:00
RDC-202 - 202, CCIN2P3
12:00 - 13:30
9 - PRISMA: general introduction
Filippo Angelini
Detailed description of PRISMA and the data analysis
RDC-202 - 202, CCIN2P3
13:30 - 15:00
18 - Other ancillaries
Matus Balogh
General information on the ancillaries, data format and DAQ
RDC-202 - 202, CCIN2P3
13:30 - 15:00
14:00
15:00
coffee break
RDC-202 - 202, CCIN2P3
15:00 - 15:30
10 - PRISMA: steps of the analysis with examples
Filippo Angelini
Step-by-step guide on the PRISMA analysis
RDC-202 - 202, CCIN2P3
15:30 - 17:00
11 - Other ancillaries
Elia Pilotto
Information on handling the RAW data of the ancillaries and the optimization procedure
RDC-202 - 202, CCIN2P3
15:30 - 17:00
16:00
17:00

Installation and introduction

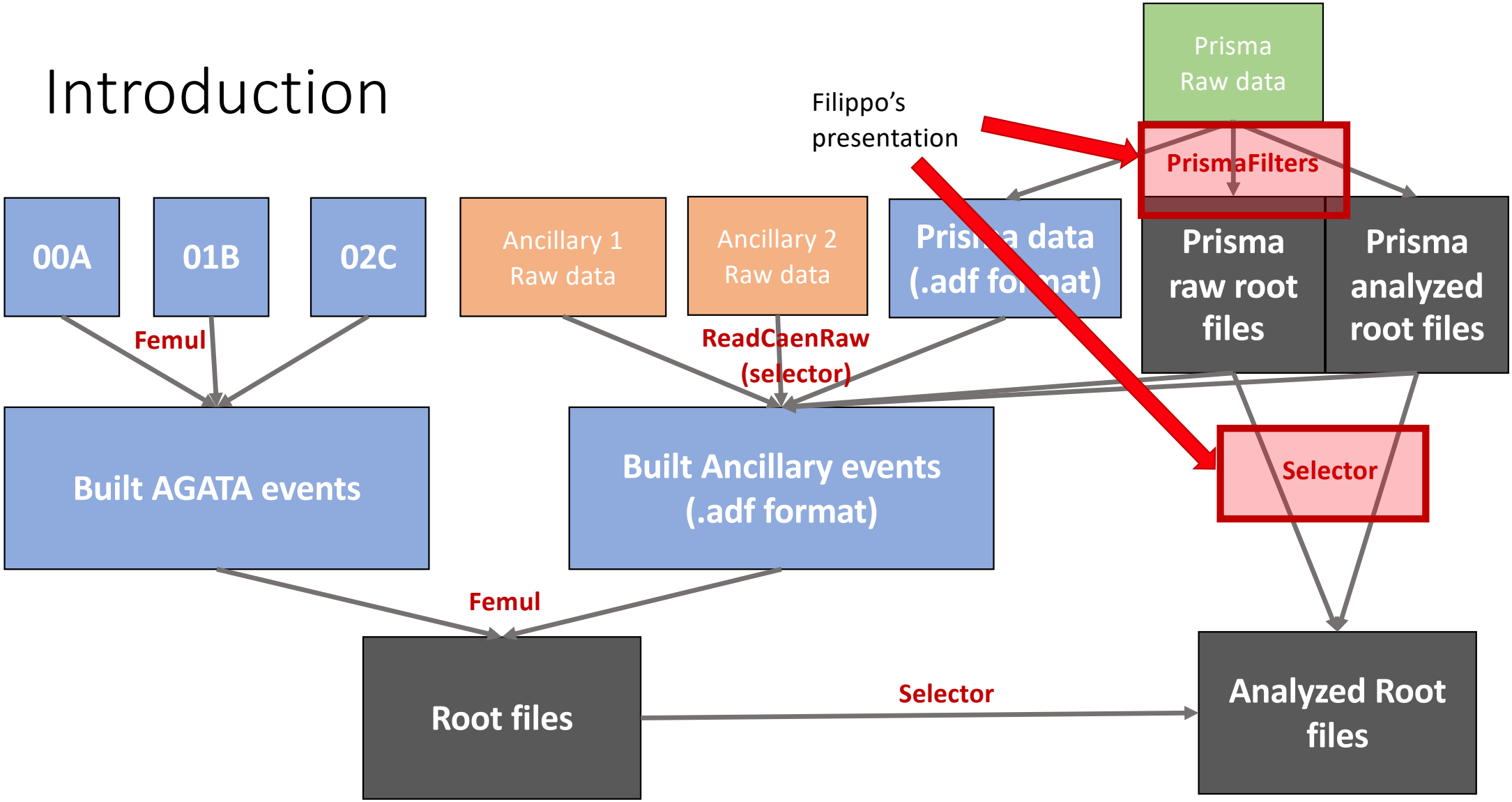
Introduction

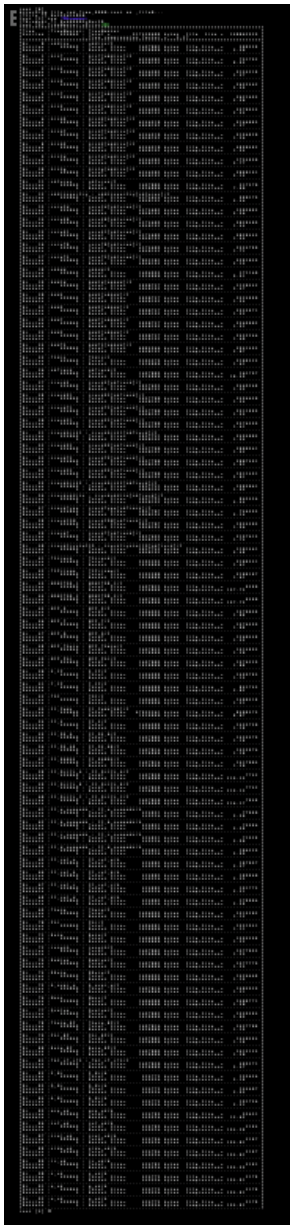


Introduction



Introduction





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 sometimes some changes/improvements are made and could break backward compatibility (for instance for the configuration file). Since the program is more stable now it does not happen often
- We try to log on the CHANGELOG.md significant changes in different versions
- Other README.md files are located in the Conf folder, explaining the meaning of the files.
- **You are meant to modify the code**

Agata leaves

- In general, the leaves contain the following information for:
  - Single hit (within a segment)
  - Single core
  - Addback (nearest cores)
  - Tracking

Leaf name	Data type	Content
nb	int	Number of gammas/interactions
id	int[nb]	Id of the core/segment
Energy	float[nb]	Energy of the gamma/hit
TS	unsigned long /[nb]	Lowest timestamp/array of all triggered channels
(G)X/(G)Y/(G)Z	float[nb]	Position of the hit/first interaction
T	float[nb]	Cfd time, needs to be added to TS

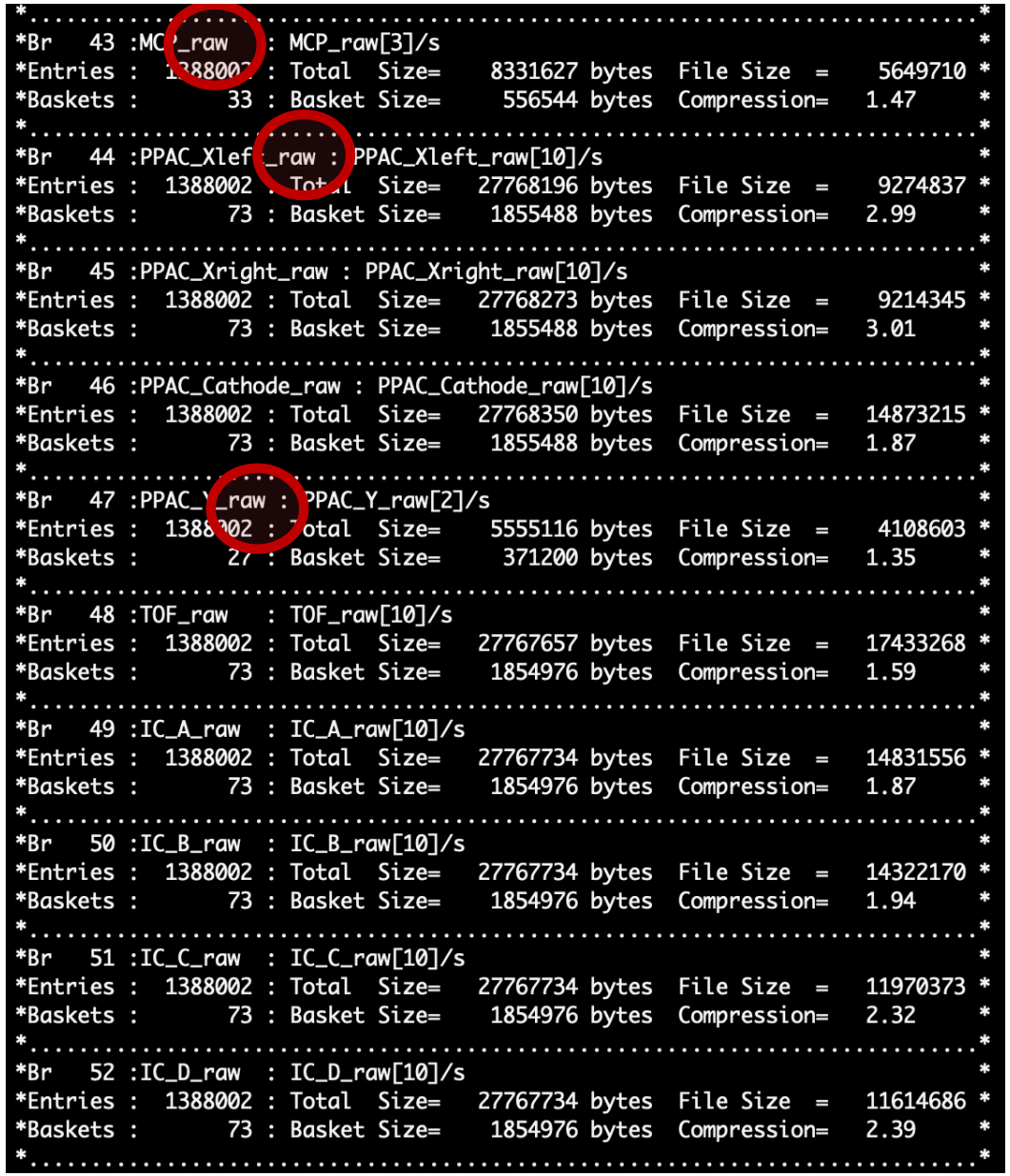
Agata leaves

- Some leaves are more specific

Leaf name	Data type	Content
trackX2/trackY2/trackZ2	float[nb]	Position of the second interaction of the gamma (for polarization analysis puroposes)
hitX/hitY/hitZ	float[nb]	Position of a hit in the crystal frame of reference
trackFOM	float[nb]	Figure of merit of tracking
trackType	float[nb]	Compton/photoelectric/pair production

Prisma

- Prisma has several leaves, but the data format is divided in raw and analyzed leaves.
- If you perform the analysis with the PrismaFilters+Prisma Library, the selector need the the analyzed variables
- If you need to create the histograms for the PRISMA analysis or to do all analysis with the selector, you only need the raw variables



Prisma: gen_conf.py

```
TB_PRISMA=(
"ConfPath       $CONFDIR/prisma",              #Path to Prisma configuration files
"LUTFile        lutPRISMA.txt",                #LUT file name (default is : lutPRISMA.txt)
"ManagerFile    manager.conf",                 #Manager file name (default is : manager.conf)
"WriteRawTree",                                #Store the raw data in the output Tree (default 1)
"WriteAnaTree",                                #Store the analyzed data in the output Tree (default 1)
#"DoPrismaAnalysis",                           #Ignore the input analyzed data (if present) and process the prisma lib on the raw data (default 0)
#"Verbose",                                    # Print warnings in the processing
)
```

- You can choose what to write in the root file based on your analysis strategy
- If you are feeding raw PRISMA data to femul (f10201a0), you can also perform the analysis during the replay with the “DoPrismaAnalysis” keyword
- Otherwise, it is recommended to only write the data that you need not to double the space on disk

Other ancillaries (aka CAEN digitizers)

- Data from CAEN digitizers has the same format and requires a lookup table (LUT)

Leaf name	Data type	Content
nb	int	Number of channels in an event
Channel	int[nb]	Channel that has triggered
Board	int[nb]	Board that has triggered
TS	unsigned long	Lowest timestamp of all triggered channels
TSHit	unsigned long[nb]	Timestamp of the single hit
Time	float[nb]	Interpolated time, needs to be added to TSHit
Energy	float[nb]	Energy of trapezoid (PHA) of Qlong (PSD)
QShort	float[nb]	Short integration (PSD only)

The output

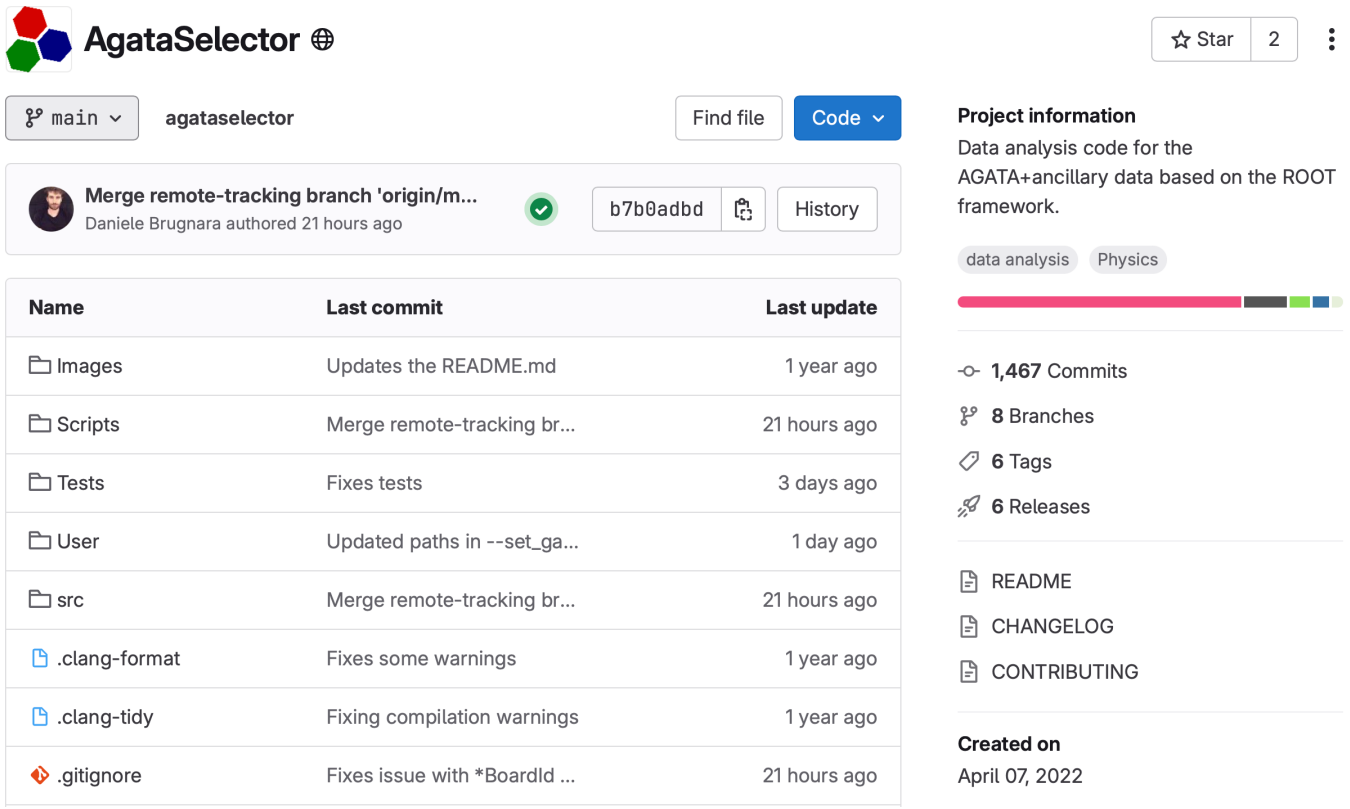
- The selector produces ROOT files containing:
  - Histograms (each analysis is contained within a folder):
    - Single detector analysis
    - Coincidence analysis
  - TTrees of:
    - High level data of a single detector. For instance, Spider provides things such as excitation energy or angles
    - Doppler correction based on the analysis of the agata+ancillary coincidence
- Generally, TTrees take up a considerable amount of disk space and are not very useful since histograms provide the high-level analysis already

The output

- For each input file an output file is produced in the output folder. The files of each run are added in a single file called sum_xxx-yyy.root, where xxx is the run number and yyy is the number of input files.
- Different runs can be also added with - -sum_all
- The partial files can be discarded with the option - -rm_partial
- Additionally to the “regular” output it is possible to personalize the analysis with the UserSelector which will in turn produce additional output in the User folder.

Installation procedure

- The repository can be found here: https://baltig.infn.it/gamma/agataselector



Installation procedure

- [x] Clone the repository
- [x] Create a build folder
- [x] Configure with cmake
- [x] Compile

Note: root needs to be installed and compiled with a c++ version > 14

```
git clone https://baltig.infn.it/gamma/agataselector.git
cd agataselector
mkdir build; cd build
cmake ..
make -j4
```

If you want to perform a personalized analysis for your experiment, before compiling with make, specify the proper experiment name. For instance for EXP_001 you would specify:

```
cmake -DEXP_NAME=EXP_001 .
```

```
source Scripts/selector.sh
```

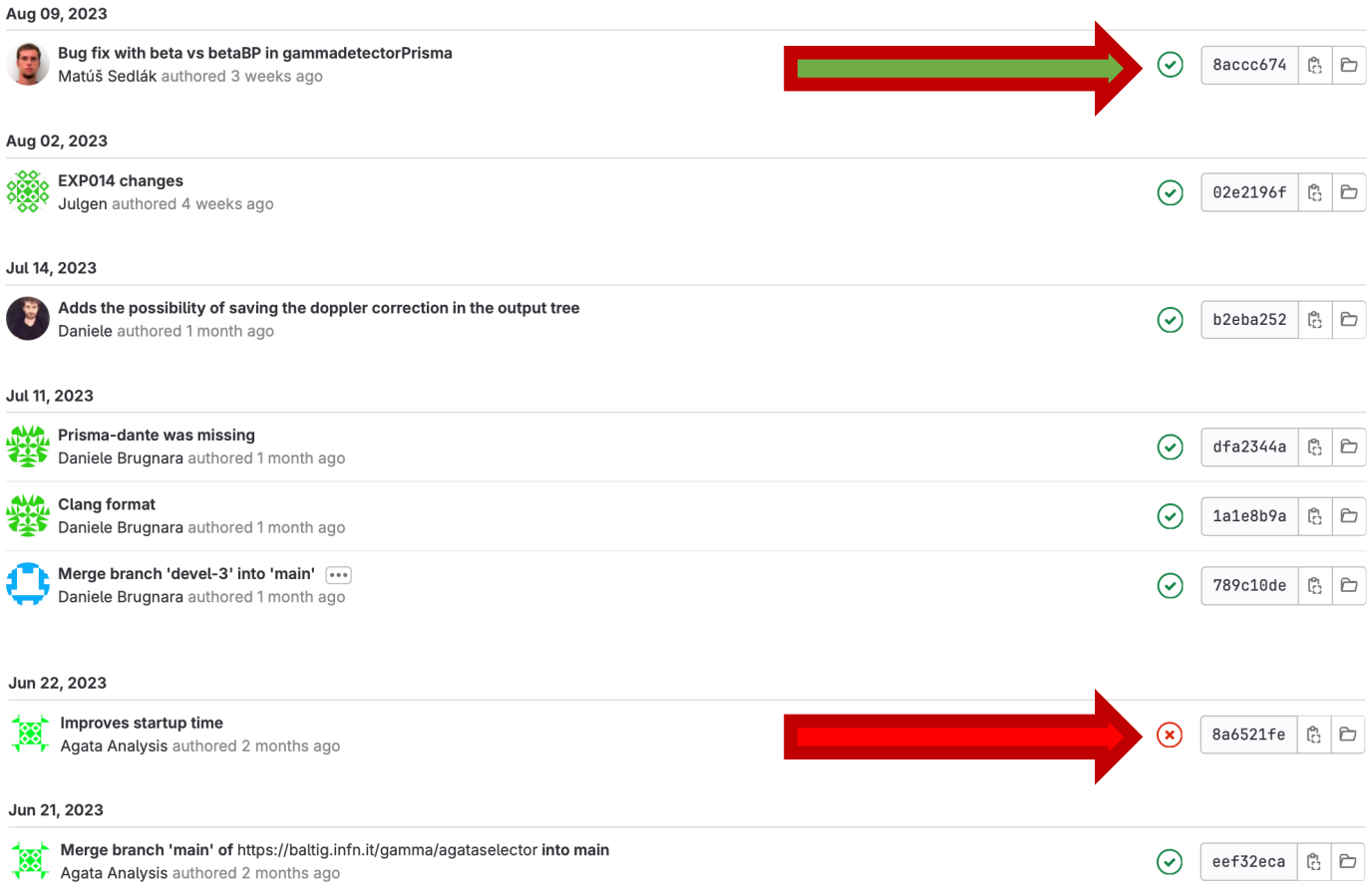
(Optional) Adds the build directory to $PATH and adds tab-completition

Known troubles and how to solve them

- Make sure to compile root with at least c++14:
    - DCMAKE_CXX_STANDARD=17 (or 14 if you prefer)
- In some cases, the selector remain stuck when reading one of the ancillary branches called *ChannelId or *BoardId. This is due to a ROOT problem with the TTReader because there is a name mismatch when writing the TTrees. The newest version of femul is writing the TTrees with no mismatch, in case you experience this problem, make sure to update femul and the selector.

Tests

- At each commit the code is tested.
- The test include:
  - Does the code build properly?
  - Additionally does the prisma-agata analysis work?
  - At last, two spectra (DC, DCBP) are fitted for fully identified isotopes
  - The test passes if integral, mean and sigma of the peaks of interest is within the parameters
- This helps us in controlling that nothing was broken in the process
- An X marked commit means that the test was not passed



Documentation

- Several README.md files are present in the root folder and serve as a reference
- Not everything is contained in these README files

README.md

AgataSelector

DOI 10.5281/zenodo.8329198

This analysis code is meant for the data of AGATA+$Ancillary, producing var performing kinematic calculations and other operations useful for Doppler c analysis tasks. The starting point of the selector are the ROOT files produce a work in progress and is meant to be updated and modified by both users a log the bug fixes, improvements and broken compatibility issues in the `CHAN` based on ROOT and requires an installed version where ROOT has been com 14. Our intent is to make the analysis procedure straightforward and reprodu will contain a configuration folder that contains the configuration file of the s the calculations, the lookup tables, the date and the git hash. This means tha outcome of the analysis is reproducible.

Contents

Installation procedure

- Clone the repository
- Create a build folder
- Configure with cmake
- Compile

```
git clone https://baltig.infn.it/gamma/agataselector.git
cd agataselector
mkdir build; cd build
cmake ..
make -j4
```

If you want to perform a personalized analysis for your experiment, before c specify the proper experiment name. For instance for EXP_001 you would sp

```
cmake -DEXP_NAME=EXP_001 .
```

In this case the code will look for a folder called `EXP_001` under `User/EXP`, will expect a new selector with your additions. You should copy the template folder. Add histograms to the struct defined in the `.h` file. If the experiment with the required name will be created.

In the root files you can write the TTree for a given detector. On top of that, configuration used to analyze it. However, ROOT needs the dictionaries to su functionalities of the classes serialized in the file. To support this feature you code to the `~/.bashrc`. You need to call it from the build directory:

```
source Scripts/selector.sh
```

This also adds the bash completition and the possibility to use some things li interactively.

If you want to be extra careful and check if your installation is done correctly test. To do so, compile with the correct flag and run the following commands

```
cmake -B build -DENABLE_TESTING=ON -S .
cmake --build build -j6
cd build/Tests
ctest --output-on-failure -j6
```

Prisma

The selector can now run the full analysis of prisma. This allows to run the o parameters of the spectrometer. Please refer to this PRISMA_README.md fo documentation is still preliminary and is not complete.

Selector options

This is a list with a brief description of the various command-line options:

Option	expected input	Description
--help	-	Prints a help menu
--nrevts	[#]	Specify number of events to analyz
--nrthr	[#]	Specify maximum number of thread that if the selector is killed by the O there is not enough memory and yo reduce the number of threads of dis produced histograms if possible.
--conf	[file]	Specify a conf file, default is in `../`
--iofile	[infile, outfile]	Specify an input and an output file, conf.
--iolistfile	[file]	Specify a file where to read a list of line by line.
--verb	[#]	Verbosity: 0 (prints progress Sel), 1 info).
--no_user_sel	-	Runs standard selector without the `User/UserSelector.cxx`.
--print_conf	[out_file]	Prints the default conf file with defa parameters. Note that some of the o present, an example is `EX_VALUES` AGATASPIDER_CONF.
--rm_partial	-	Removes partial output files that cor in the input folder.
--optimize	-	Runs optimizer on the given peak by multiple times.
--only_enabled_histos	-	Creates and fills only the histograms `${CONF_FOLDER}/enabled_histo`
--debug_canvas	-	Shows a canvas at each fit (at the m in the optimization procedure)
--reduction_cond	[reduction condition]	Creates a new reduced data TTree b reduction condition. Bash special ch escaped with the backslash charact a condition on Z in PRISMA and the gammas to reduce the input file, one `./RunSelector --reduction_co nbTrack\>0\&\&Z_Nr\>0 262`. In folder of run 262 one would find ne with the prefix `red_` the condition `"nbTrack>0&&Z_Nr>0"`.
--set_gates	[selector file]	Starts the automatic procedure to se gates are then read automatically. C a TCutG and close it with a double-c then ask you to input the id of the cu
--no_hadd	-	Does not hadd to sum up the statisti
--update_runs	-	Run the selector only for trees not p folder procedure)
--update_prisma	-	Updates the prisma part of the analy
--sum_all	-	Runs hadd of all runs processed in t the file will be called runs-#-#-#.roo
--subtract_bkg	-	Subtracts the background based on windows set up in the configuration
--window_size	-	Size of the progress window. If not calculated automatically

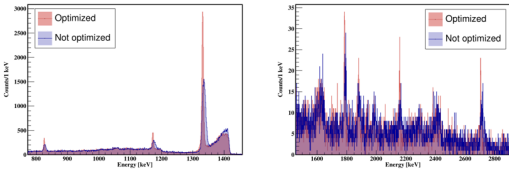
If you create a file:

`touch StopFile`

Optimizers

There are several ways to optimize the outcome of the data with the selector. Here we report a description of each.

Selector's builtin optimization



The `--optimize` option runs the selector multiple times trying to minimize a figure of merit wh is a combination of the centroid min and the sigma of the peak. The bias on the two conditions be set in the selector configuration file with `SIGMA_WEIGHT`. The fitter class can fit at the same multiple peaks and combine them in the figure of merit. The parameters to be optimized are tho included in the configuration file such as `Z_SHIFT`, `PHI`, ... In practice, any parameter that is a floating point number can be optimized. Different minimizer algorithms can be tried by choosing them in the configuration file. The outcome is a matter of trial and error. It is advised to run the optimization procedure on data which has been reduced with the `--reduction_cond option` speed up the procedure. For instance, if one wants to optimize the coincidence spectrum betwe agata and prisma, it will be faster to select only good coincidence events between prisma and agata. This can be done by setting the condition on `nbTrack>0` and `A_Nr==32` (for instance) so on.

Use `--debug_canvas` to check the quality of the fit at the first steps.

Check the progress of the minimizer during each step in the file `./Conf/Optimizer/log.txt` whatever specified in the selector configuration file.

The parameters of the fit, if the default ones are not ok can be set in the file called `./Conf/Optimizer/parameters.dat` or the name indicated with the keyword `FIT_PAR_FIL` This file will be created with the default parameters if nothing is found in the right folder. Be car if the file is there the parameters will be read from it. This means that when the fit does not mak sense it is probably because the parameters are not ok, so you can just delete the file so that it generated automatically.

The optimization procedure is not limited to the impovement of the Doppler correction but can be applied for the improvement of Q-value or excitation energy distributions.

Parameters part of the user configuration are also accessible. Generally, one should try to optim multiple transition at once to obtain the most stable results.

The range of variation of the parameters should be gradually reduced as one converges to a solution. To do so, it is often useful to plot the gradient of a parameter. This is done with the `SC` parameter in the configuration file. This will vary the specified parameter with the selected step ultimately produce a root file (specified as `ROOT_FILE`) with as many `TGraph`s as the number scanned parameters. The `SCAN` option will also add a `TH2D` histgram with the parameter on th axis (in internal units) and the spectrum on the y-axis. This allows to inspect the effect of the parameter on the whole spectrum. It is also possible to create a contour plot (with the keyword `CONTOUR`) to check the correlation of different minimized parameters. This, however, requires a of iterations and does not often converge to something that makes sense.

Scan of the LUT parameters

The previous selector can only optimize parameters in the `selector.conf` file. However, othe important parameters are contained on some detector's lookup tables. If this is the case there a two options, the grid search optimizer (see next section Grid-search optimizer) or the `LUT_OPTIMIZER`. The latter is a workaround that uses a special type of user selector to perfor scan of the LUT parameters. In this case one can scan parameters independently, but the algor is very general and can be used on many detectors. Please find a step-by-step guide in the User/EXP/LUT_OPTIMIZER.

Grid-search optimizator for silicon detectors

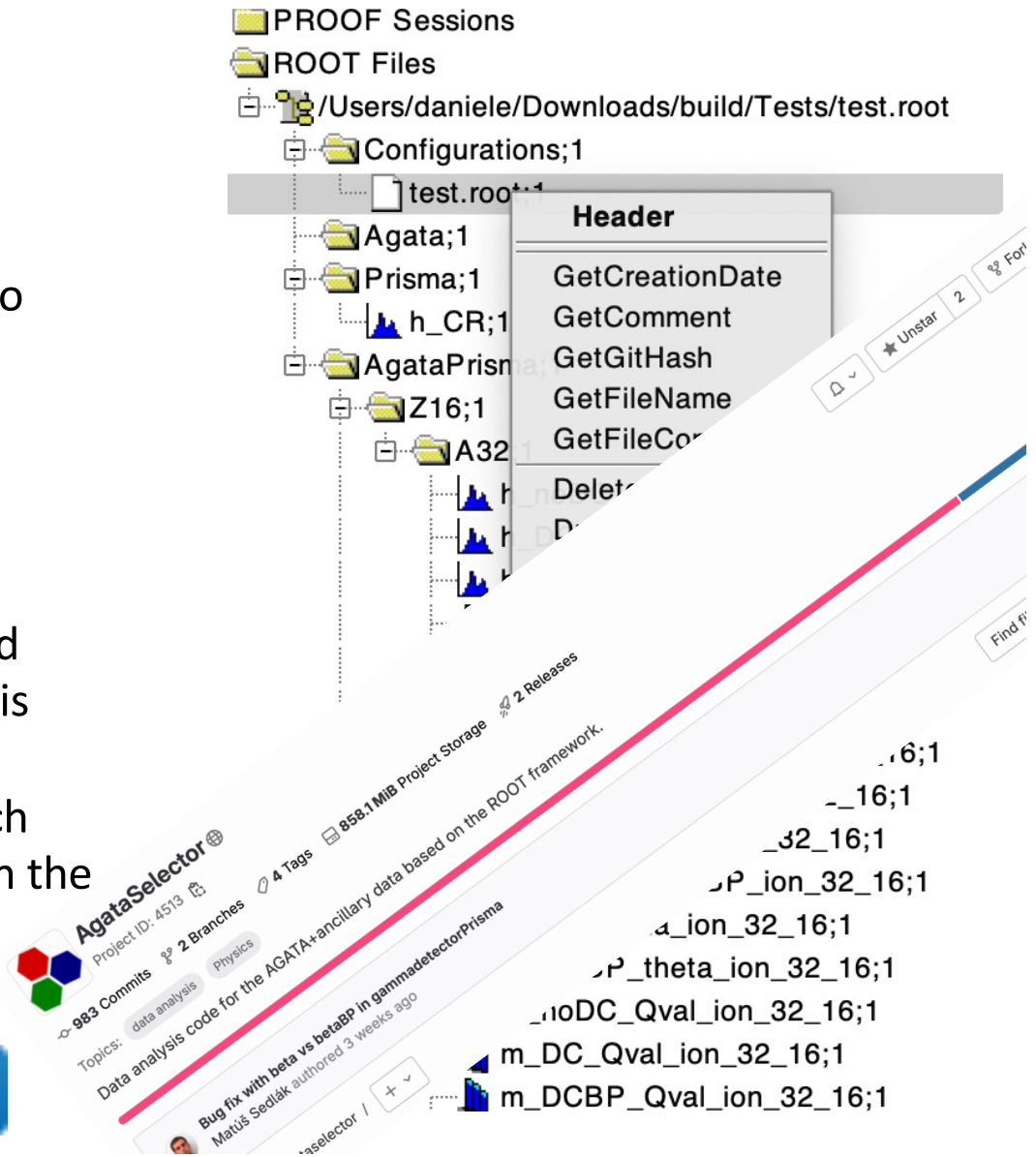
This program will perform a grid search of the optimal parameters in the lookup table of the detectors allowing for the fine-tuning.

Requirements

This application requires a compiler that supports `C++17` or newer, with ROOT compiled agains

Reproducibility

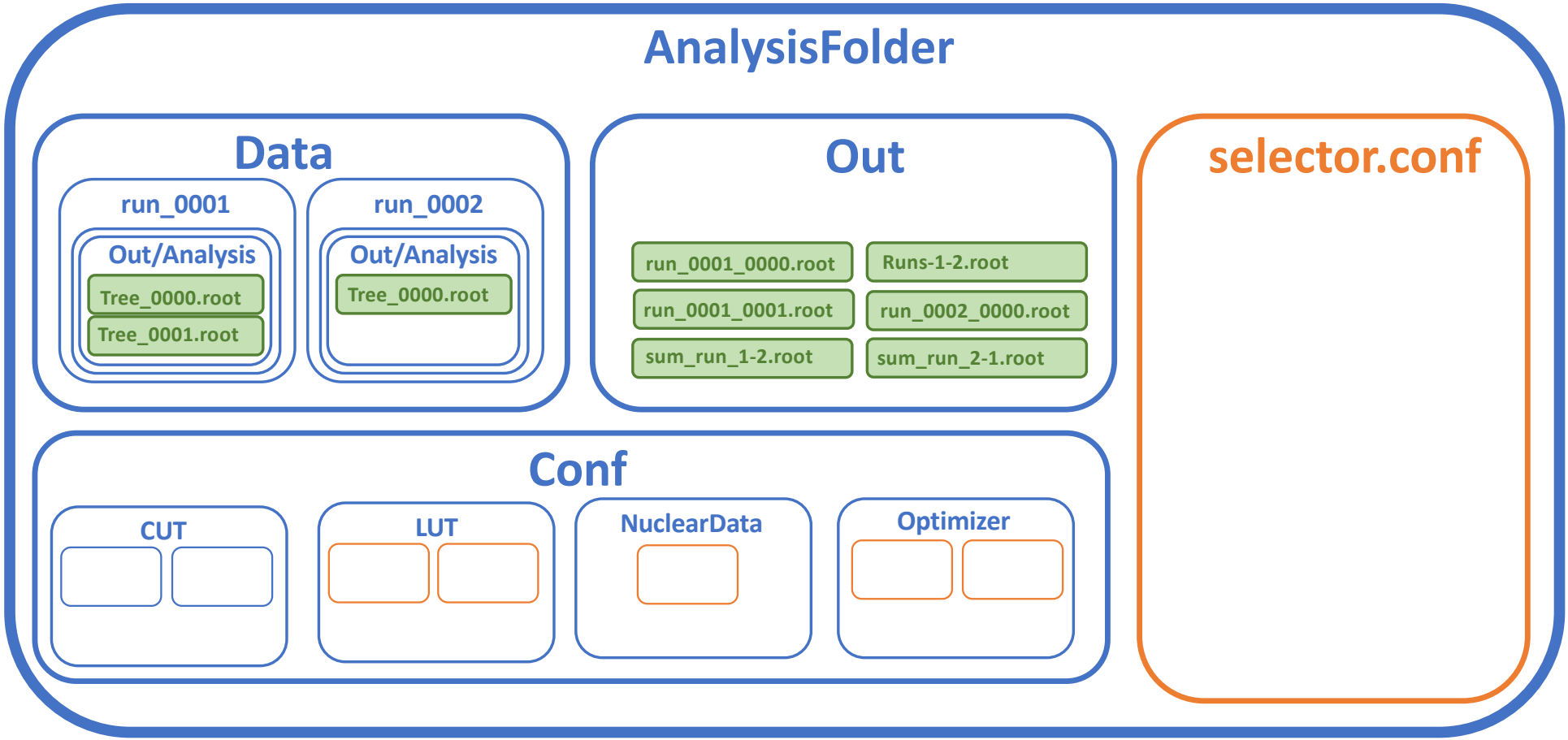
- The output files contain the parameters used to generate it:
  - The entire selector.conf
  - The lookup tables
  - The git hash
  - The date of creation
- This means that the analysis can be reproduced simply by printing the selector.conf used for this specific file and checking out the correct hash
- 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:



DOI 10.5281/zenodo.8329198

Setup of the analysis

Setup of the analysis folder



Generate/retrieve the default selector.conf

- The default selector.conf can be generated typing:
  - RunSelector - - print_conf selector.conf
- In all experiments, a nearline analysis was performed, it is a good starting point for the offline analysis.
- To “recall” the analysis you should have compiled the selector with che cmake option “-DEXP_NAME=EXP_###”. This will compile the UserSelector that you can find in agataselector/User/EXP/EXP_###
- The configuration folder adapted for your experiment is agataselector/User/EXP/EXP_###/Conf
- The selector.conf is in agataselector/User/EXP/EXP_###/selector.conf (you might have multiple versions if the setup was changed during the experiment)

In general, the selector is being constantly updated with bug fixes and improvements. This could mean that some features could have been added and some changes need to be applied to the selector.conf if you have pulled from origin. In order to get access to all options you can print the default configuration file with the option RunSelector - -print_conf my_selector.conf. Each conf parameter will contain a comment with some infos on the effect of the parameter

Options

How to run the code:
```
./RunSelector [options, ...] \
[#run, ...]
```

Option	expected input	Description
--help	-	Prints a help menu
--nrevts	[#]	Specify number of events to analyze, default is all.
--nrthr	[#]	Specify maximum number of threads, default is 6. Note that if the selector is killed by the OS, it might mean that there is not enough memory and you might have to reduce the number of threads of disable some of the produced histograms if possible.
--conf	[file]	Specify a conf file, default is in `../Conf/`.
--iofile	[infile, outfile]	Specify an input and an output file, this will disregard the conf.
--iolistfile	[file]	Specify a file where to read a list of inputFile outputFile line by line.
--verb	[#]	Verbosity: 0 (prints progress Sel), 1 (prints debugging info).
--no_user_sel	-	Runs standard selector without the analysis contained in `User/UserSelector.cxx`.
--print_conf	[out_file]	Prints the default conf file with default values for each parameters. Note that some of the options might not be present, an example is `EX_VALUES` of AGATASPIDER_CONF.
--rm_partial	-	Removes partial output files that correspond to each file in the input folder.
--optimize	-	Runs optimizer on the given peak by running the selector multiple times.
--only_enabled_histos	-	Creates and fills only the histograms present in the file `${CONF_FOLDER}/enabled_histos.conf`
--debug_canvas	-	Shows a canvas at each fit (at the moment it is used only in the optimization procedure)
--reduction_cond	[reduction condition]	Creates a new reduced data TTree based on the given reduction condition. Bash special characters should be escaped with the backslash character. For instance to set a condition on Z in PRISMA and the number of tracked gammas to reduce the input file, one would add `./RunSelector --reduction_cond nbTrack\>0\&\&Z_Nr\>0 262`. In this case in the data folder of run 262 one would find new reduced ROOT files with the prefix `red_` the condition `"nbTrack>0&&Z_Nr>0"`.
--no_hadd	-	Does not hadd to sum up the statistics
--update_runs	-	Run the selector only for trees not present in the output folder procedure)
--update_prisma	-	Updates the prisma part of the analysis
--sum_all	-	Runs hadd of all runs processed in the current session, the file will be called runs-#-#-#.root
--window_size	-	Size of the progress window. If not present it is calculated automatically

Structure of the selector.conf

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

Detectors considered in the analysis

Configuration of the folders, the file patterns, and the TTree names

Configuration of the reaction, multiple ions of interest can be added

Target thickness and rotations, used for energy loss calculaitons. The presence of a degrader before or after the target is also possible.

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

#------------------------------------------------------------
DETECTORS_PRESENT
EUCLIDES                        NO      #               Euclides is present YES/NO
PRISMA                  NO      #               Prisma is present YES/NO
DANTE                   NO      #               Dante is present YES/NO
LABR                    NO      #               Labr is present YES/NO
SPIDER                  NO      #               Spider is present YES/NO
AGATA                   NO      #               Agata is present YES/NO
#------------------------------------------------------------

#------------------------------------------------------------
REPLAY_CONF
ENABLED_HISTOS                  enabled_histos.conf     #               File name with list of enabled histograms
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, 1->back
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 (those detected)
#------------------------------------------------------------

#------------------------------------------------------------
TARGET_CONF
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 clockwise rotations
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
#------------------------------------------------------------
```

Example of Detector Conf: Agata

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

- Enable/disable histograms or TTrees
- Speficy LUT (if necessary)
- Set some global angles and psitions
- Sets parameters of the histograms such as bin width
- Sets other detector-dependent parameters

```
#------------------------------------------------------
AGATA_CONF
BIN_WIDTH                   1       #                   Bin width in gamma histograms
COINC_W_RIGHT               10      #                   Time window right with with the same type of det
COINC_W_LEFT                0       #                   Time window left with the same type of det
TRACKING_FOM_THR                    0       #                   Threshold for the figure of merit of the tracking (0-1.02)
GAMMA_E_MAX                 4000    keV                 Maximum gamma energy in histograms
BETA_AVG_PHI                180     deg                 Average beta phi Doppler correction for detector
BETA_AVG_MAG                0.1     #                   Average beta magnitude Doppler correction for detector
ANGLE               0       deg                 Detector angle. For AGATA should be 180-prisma_angle
BETA_AVG_THETA              20      deg                 Average beta theta Doppler correction for detector
PHI                 0       deg                 Detector phi rotation for optimization purposes
THETA_Y             0       deg                 Detector rotation on the vertical plane for optimization purposes
CFD_UNIT                    10      ns                  Cfd units
THETA_X             0       deg                 Detector rotation on the horizontal plane for optimization purposes
Z_SHIFT             0       mm                  Detector z shift for optimization purposes
TIME_UNIT                   10      ns                  Timestamp unit, should 10*ns
Y_SHIFT             0       mm                  Detector y shift for optimization purposes
X_SHIFT             0       mm                  Detector x shift for optimization purposes
EXCLUDE_ANCILLARY                   NO      #               Only analyze event in anticoincidence with ancillaries
ENABLE_TREE                 NO      #               Ebable or disable detector TTree to save memory (strongly encouraged)
ENABLE_HISTS                YES     #               Ebable or disable detector histos to save memory
EXCLUDE_TS                  0 0     ms                  Exclude events in this  timestamp region, beginning of run is TS=0
LUT                         #               Lookup table path
SPECTRA_TYPE                TRACKED                             Spectra type: SEGMENT, CORE, CORE1, ADDBACK, TRACKED, CALORIMETER
#------------------------------------------------------
```

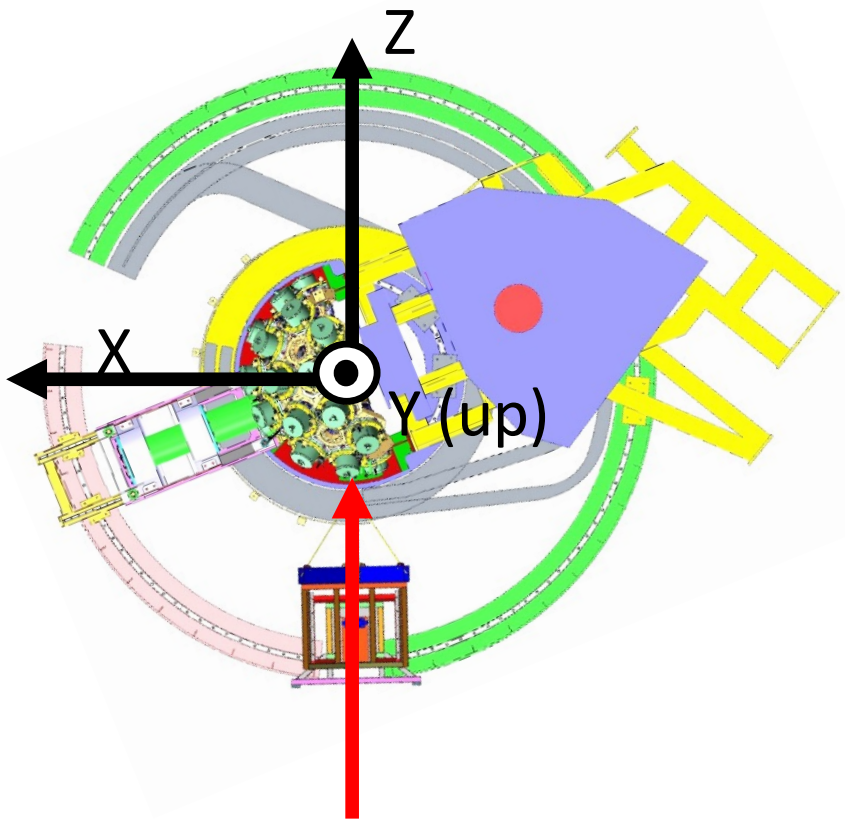
Example of Coincidence Conf: Agata+Spider

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

- Set the coincidence window based on the peak position
- Enable histograms and trees
- Set Doppler correction position
- Other detector-dependent parameters

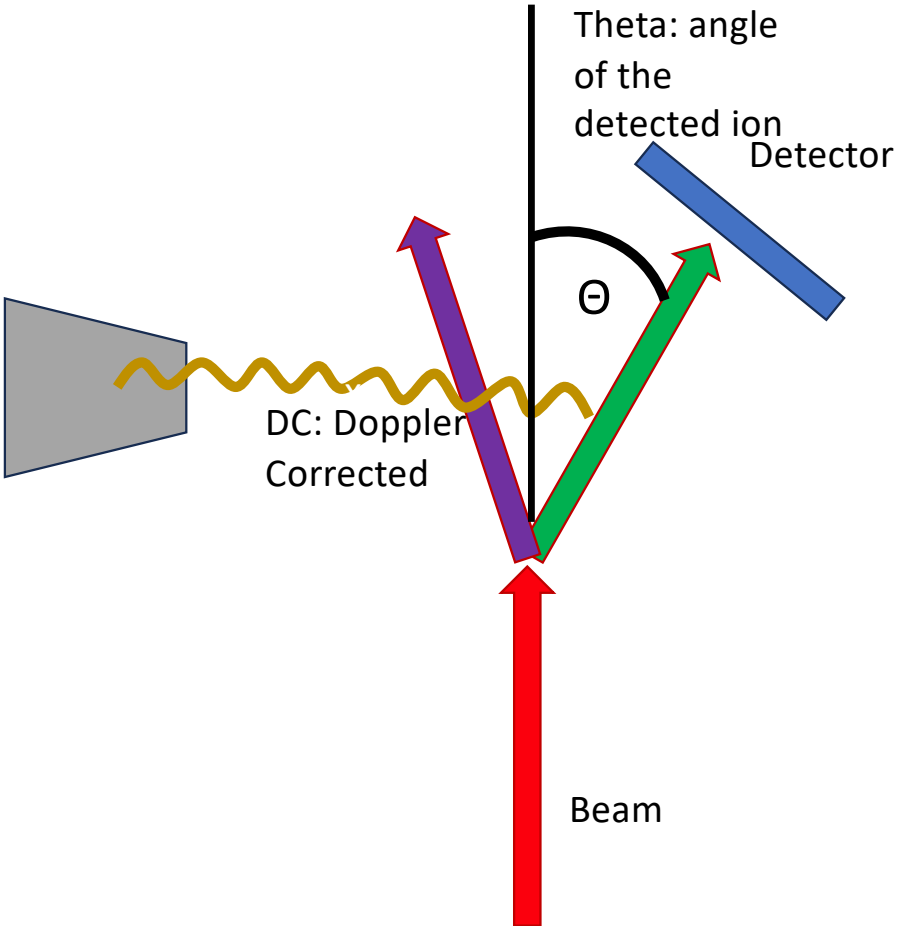
```
#------------------------------------------------------------
AGATASPIDER_CONF
COINC_W_RIGHT                0      #                    Time window right
COINC_W_LEFT                 0      #                    Time window left
ENABLE_TREE                  NO     #             Ebable or disable coincidence TTree branch to save memory (strongly encouraged)
ENABLE_HISTS                 YES    #             Enable histograms of coincidence
EX_VALUES                    0 1    MeV                  Excitation energy gates, first value is the min, second value is the max
EX_VALUES_FILE               NONE   #                    File name in the folder LUT containing the channel by channel gate in excitation energy
BP_FRAGMENT_POSITION                MID_TARGET                                Doppler correction position for binary partner
FRAGMENT_POSITION                   MID_TARGET                                Doppler correction position for detected ion
EX_VALUES_FILE               NONE   #                    File name in the folder LUT containing the channel by channel gate in excitation energy
#------------------------------------------------------------
```

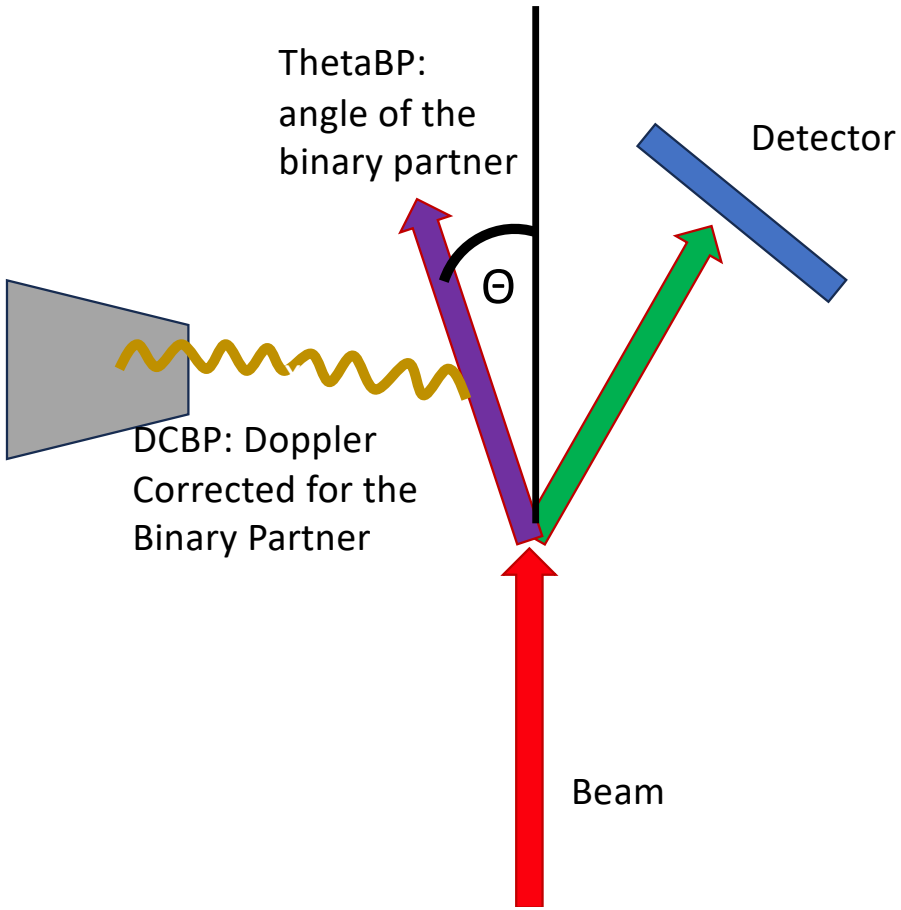
Frame of reference



- The frame of reference with respect to the beam is necessary for reaction calculations
- It is common to all detectors.
- Z points in the direction of the beam and Y points upwards

Naming Conventions





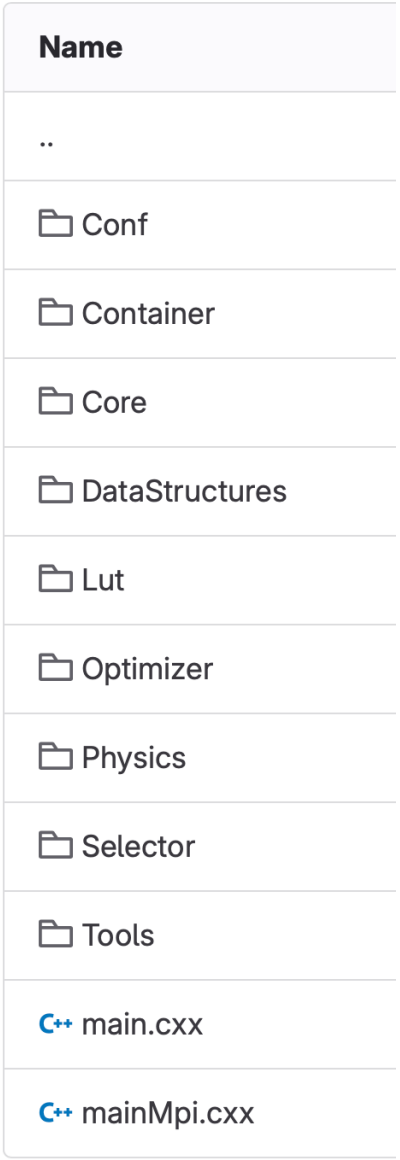
Energy loss corrections

- The energy loss corrections for the target are calculated for the kinematics reconstruction and the doppler correction. The kinematics reconstruction is done in at the reaction point specified in the REACTION_CONF ([0-1]).
- They are calculated **only if the eloss table is present** under Conf/EnergyLoss with the naming scheme given by the keyword MATERIAL/DEGRADER_MATERIAL under TARGET_CONF (check with - -verb 2).
- They need to be calculated with SRIM, and can be generated with the Script under Scripts/Srim

How to add histograms and personalize the analysis

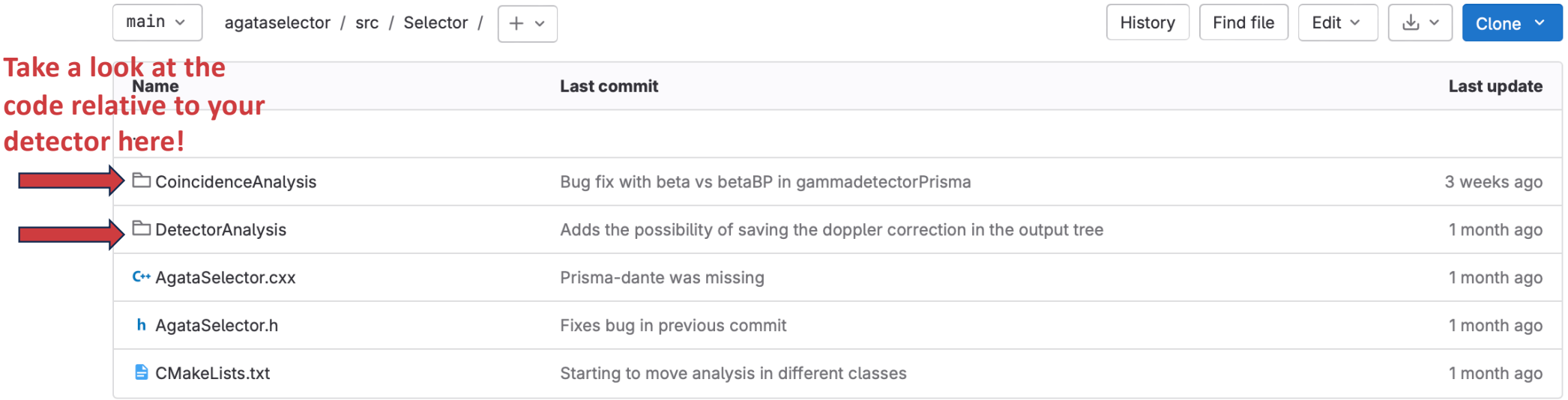
The source code

- Conf: parameters that can be read from the selector.conf
- Container: classes that represent the analyzed detector
- Core: things unrelated to the analysis
- Lut: classes that read the lookup tables of various detectors
- Optimizer: fitter class and minimizer for optimization
- Physics: nuclear data class, energy loss and reaction calculator
- Selector: analysis code



The source code

- The analysis is contained in src/Selector
- In the newest version, the detector analysis is separated from the coincidence analysis



The analyzed data

- The ”Analyzed” data is saved in classes that can be accessed in later steps of the analysis.
- These classes are the ones that can be saved in TTrees
- The Doppler correction is also saved for each detector that can provide it
- These classes are the ones that can be saved also in root files
- They are kept in the directory: src/Container/

```
// Container classes
Agata                   agataOutput;
Labr                    labrOutput;
Prisma                  prismaOutput;
Spider                  spiderOutput;
Dante                   danteOutput;
Euclides                euclidesOutput;

GammaDC                 gammaAgataPrisma;
GammaDC                 gammaAgataPrismaDante;
std::vector<GammaDC>    gammaAgataSpider;
std::vector<GammaDC>    gammaAgataDante;
GammaDC                 gammaAgataEuclides;
GammaDC                 gammaLabrPrisma;
GammaDC                 gammaLabrPrismaDante;
std::vector<GammaDC>    gammaLabrSpider;
std::vector<GammaDC>    gammaLabrDante;
GammaDC                 gammaLabrEuclides;
```

Basic steps of the analysis procedure

- Each analysis is associated to a different folder and all have some steps:
  - At the start
    - Istantiate->Associates to a detector the correct input
    - AllocateHistos->Allocates memory for the histograms if they are enabled
  - Every event
    - Clear -> Clears the containers of each detector
    - Analyze ->Fills the container based on the analysis
    - FillHistos -> Fills the histograms with the data in the containers
  - At the end
    - Finalize -> Performs operations on the final histogram

```
public:
  virtual void Istantiate();
  virtual bool AllocateHistos();
  virtual void Clear();
  virtual void Analyze();
  virtual bool FillHistos();
  virtual void Finalize();
```

How to add a histogram

- If you want to add an histogram you have to declare it in the correct analysis class's header
- The histogram are placed in a struct that correspond to the analysis folder
- Sub structs and subfolders are also present

main agataselector / src / Selector / DetectorAnalysis / AgataAnalysis.h

AgataAnalysis.h 5.15 KiB

```
1  #pragma once
2
3  #include "Agata.h"
4  #include "DetectorAnalysis.h"
5
6  class AgataAnalysis : public DetectorAnalysis {
7    public:
8      explicit AgataAnalysis(Inputs, Agata&);
9      void Istantiate() override;
10     bool AllocateHistos() override;
11     void Analyze() override;
12     bool FillHistos() override;
13     void Finalize() override;
14
15   protected:
16     // Container data
17     Agata& agata;
18
19     // Histograms
20     struct AgataHistograms : public DetectorHistograms {
21         TH1D* h_trackE{nullptr};
```

How to add a histogram

- Use the specific functions that ensure functionalities such as the detection of not enabled histograms:
  - **Allocate the memory with Initialize<TH*D>(…)**
  - **Fill with the Fill(…) function**

```
11
12  bool AgataAnalysis::AllocateHistos() {
13      AgataHistograms& h = agataHistograms;
14      h.dir = input.outFile.mkdir("Agata", "Agata standalone histograms");
15      h.dir->cd();
16
17      if(!DetectorAnalysis::AllocateHistos()) return false;
18
19      // 1-D histrograms
20      Initialize<TH1D>(
21          h.h_trackE,
22          new TH1D("h_trackE",
23                   Form("gamma tracked;Energy [keV];Counts/%d keV",
24                        conf.agata.binWidth),
25                   static_cast<int>(conf.agata.gammaEmax / UNITS::keV
26                                    / conf.agata.binWidth),
27                   0, conf.agata.gammaEmax / UNITS::keV),
```

```
736 bool AgataAnalysis::FillHistos() {
737     if(!DetectorAnalysis::FillHistos()) return false;
738
        }
756     for(int i{0}; i < **agataReader.nbTrack; ++i) {
757         Fill(h.h_trackE, agataReader.trackE->At(i));
758         if(i != lowesttrackIdx)
```

The Conf folder

- Contains the parameters used by the selector
- In case the selector performs the prisma analys, additional folders are present

README.md

Contents

Folder	Content description
CUT	Cuts (TGraphs) needed for the analysis. Each detector has its own folder.
EnergyLoss	Energy loss tables generated in SRIM
LUT	Lookup table configuration files for various experiments
NuclearData	Nuclear masses files
Optimizer	Files to perform the optimization

About configuration files

The default configuration file can be generated with

```
./RunSelector --print_conf my_conf.conf
```

Please note that old configuration files are no longer compatible with the updated version of the selector.

The UserSelector

- If a part of the analysis is of general interest, it should be added to the regular part of the code under src/Selector
- However, in many cases some things are experiment-specific and can be handled by the UserSelector
- Histograms can be added to the struct in the header

```
class UserSelector : public AgataSelector {
  public:
    explicit UserSelector(const std::string& options)
        : AgataSelector(options){};
    Bool_t Process(Long64_t entry) override;
    void   SlaveBegin(TTree* tree) override;
    void   SlaveTerminate() override;

  private:
    // USER variable and histogram definition section

    // unsigned long long timeRef = 0;

    TH1D *h_agataCR = nullptr;
};
```

The UserSelector

- Memory is allocated in the SlaveBegin
- Histograms are filled in the Process function
- You will find the result in the user folder!

```
void UserSelector::SlaveBegin(TTree* treeToRead) {
    AgataSelector::SlaveBegin(treeToRead);

    // User selector intitialisation - done just once per file

    // std::cout << "Example value retrieved from conf file: "<<
    // conf.user.example/UNITS::mm << " mm" << std::endl;

    outFile.mkdir("User","User's custom analysis");
    outFile.cd("User");

    UserHistograms& hu = userHistograms;
    hu.h_agataCR = new TH1D("h_agataCR","Count Rate per minute of"
    "AGATA;Time[min];Counts per min",10080,0,10080);
}
```

```
Bool_t UserSelector::Process(Long64_t entry) {
    AgataSelector::Process(entry);

     UserHistograms& hu = userHistograms;

     if(!agataOutput.E.empty())
        hu.h_agataCR->Fill(agataOutput.TS);

    return kTRUE;
}
```

The UserConf

UserConf.cxx 229 B

```cpp
#include "UserConf.h"

UserConf::UserConf() : Conf("USER_CONF") {
    parD.emplace("EXAMPLE",
                 Conf::Property<double&>{example, "mm",
                                         "Example of configuration value"});
}

```

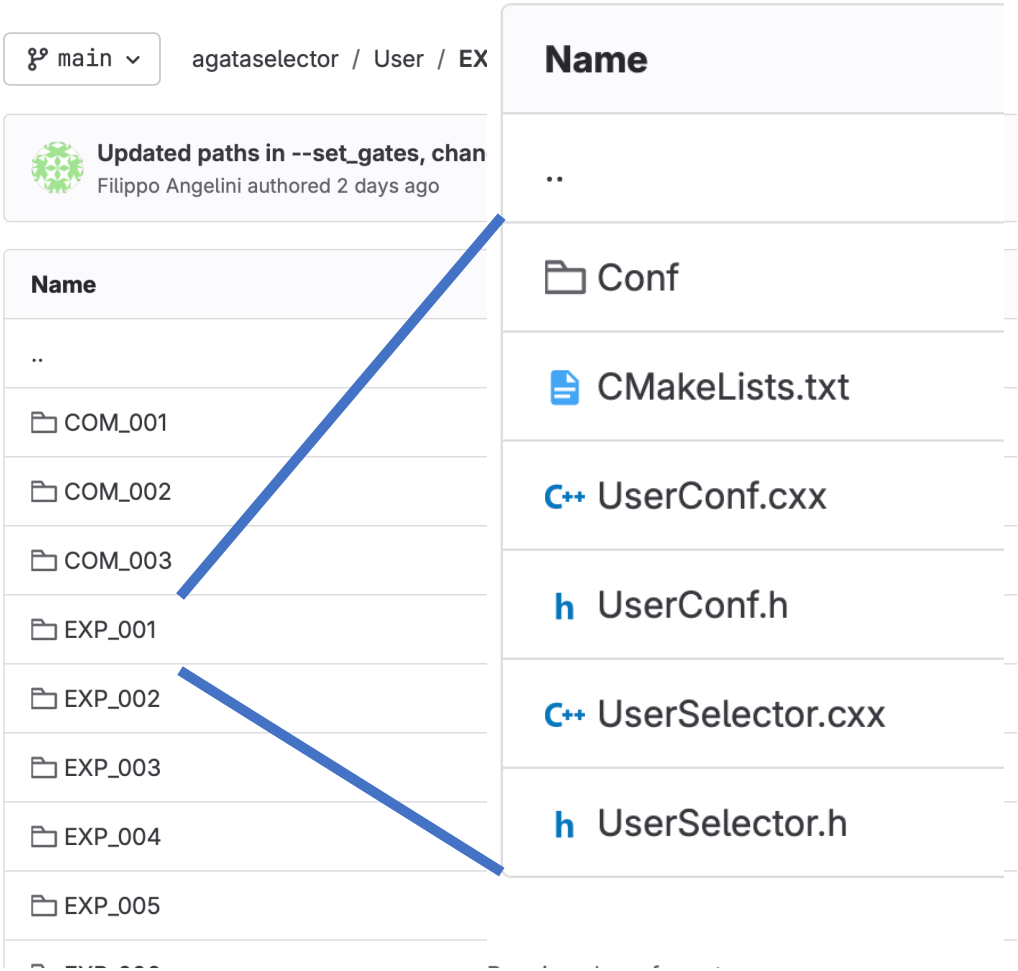
- It adds the possibility of reading custom parameters from the selector.conf
- You can declare a parameter in the .h and read it in the .cxx
- In this case the parameter to read is a double (parD), other types are also present such as strings (parS)
- Checkout src/Conf/Conf.h for other types

UserConf.h 126 B

```cpp
#pragma once

#include "Conf.h"

class UserConf : public Conf {
  public:
    UserConf();

  public:
    double example{0};
};
```

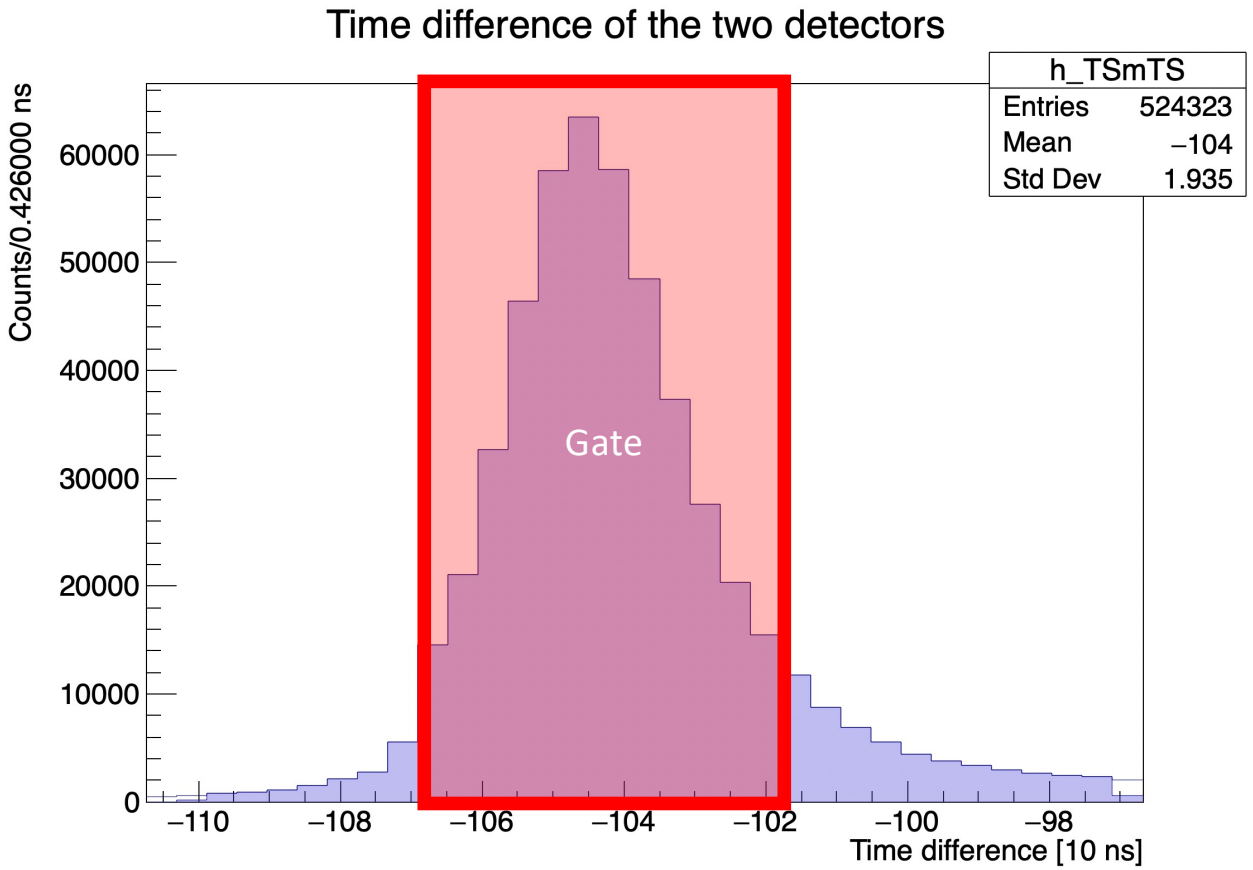
Your Experiment's configuration

- You will find your experiment's configuration under agataselector/User/EXP/EXP_***
- Link this directory in your analysis
- Recall the experiment specific code with:
  cmake –DEXP_NAME=EXP_*** .



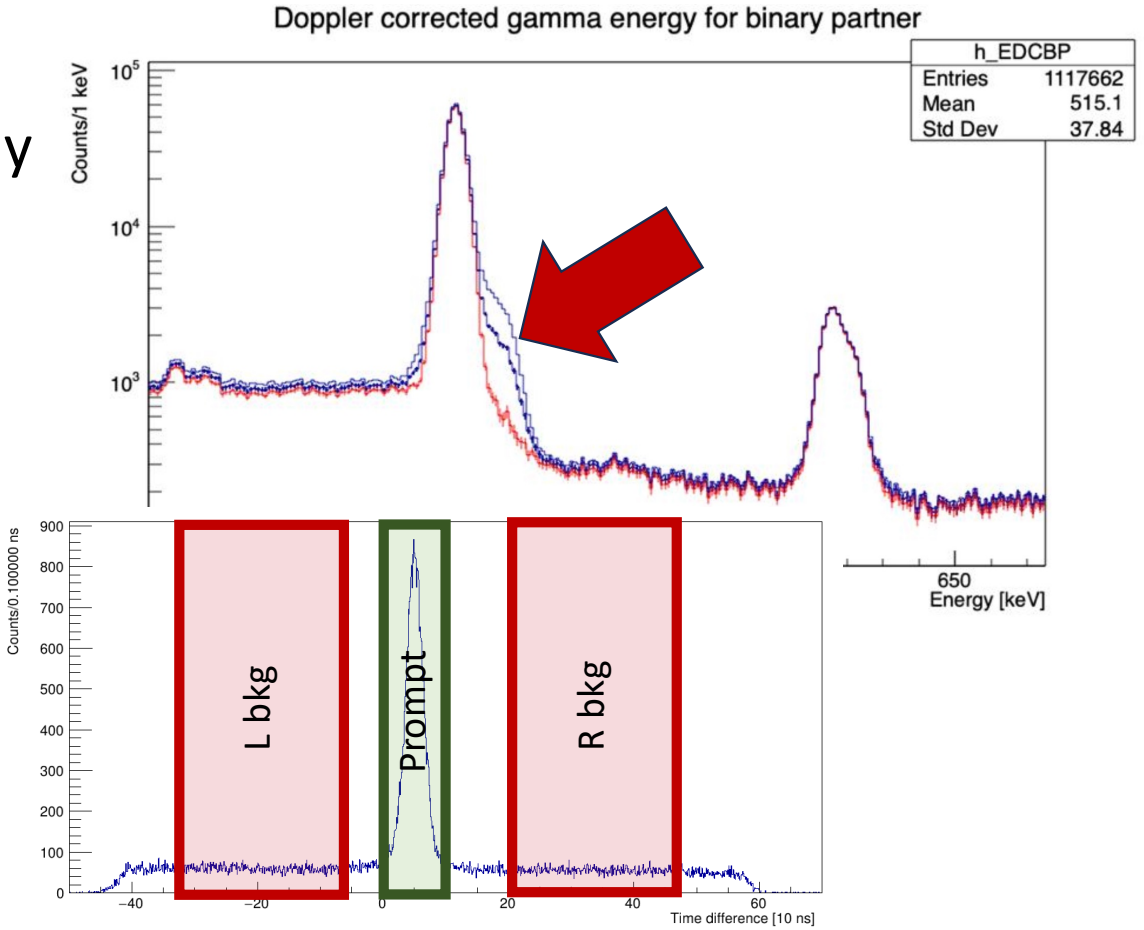
Time coincidences

- All ancillary detectors need to be time-gated
- All coincidences will have a time difference histogram that is used to select the gate in the ***_CONF
- Some detectors such as Euclides, Agata have an internal time gate
- All time gates are set with the parameter:
  - COINC_W_LEFT
  - COINC_W_RIGHT



Background subtraction and other features

- The selector has a background subtraction option that can really improve the results in some cases
- Other things to check/features are the energy loss evaluations and kinematic reconstructions



Background subtraction: details

- Each coincidence and detector has three time gates:

```
#-----------------------------------------------------------
AGATASPIDER_CONF
COINC_W_RIGHT_RIGHT_BKG         0       #       Right Background time window on the right side of the coincidence peak
COINC_W_LEFT_RIGHT_BKG          0       #       Left Background time window on the right side of the coincidence peak
COINC_W_RIGHT_LEFT_BKG          0       #       Right Background time window on the left side of the coincidence peak
COINC_W_LEFT_LEFT_BKG           0       #       Left Background time window on the left side of the coincidence peak
COINC_W_LEFT                    -6      #       Time window left
COINC_W_RIGHT                   4       #       Time window right
```

- The selector with the option - - subtract_bkg will run three times one for the left background, one for the right background and once for the prompt peak
- It will then rescale the background based on the time interval and add the total with a negative sign
- Note that if you want to subtract the random AGATA-SPIDER coincidences, the left and right background should be set only in the AGATASPIDER_CONF. In the other time gates, such as the one in AGATA, the interval of left and right background should be the same as the prompt

LUT

- The default LUTs can be found in User/EXP/Template/Conf/LUT/.
- The name of a channel+board combination is important for the analysis
- Generally, they allow to add an energy threshold (low, high), a time offset for alignment, and a N-degree polynomial calibration
- The remaining parameters are detector dependent and include angles or positions in space

LUT_LABR.dat 1.16 KiB — Edit

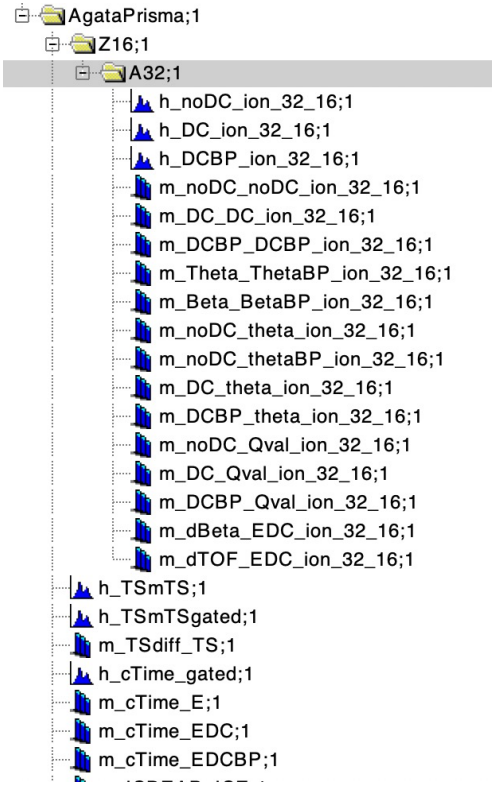
```
#LaBr Co+Cs
#board (V1730)  channel map     name    thr_lo  thr_hi  theta   phi     TimeOffset      npar_gl p0_ql   p1_q2   npar_qs p0_qs   p1_qs
1       0       0       D0      0       16000   90.422684  124.92098    0       2       -8.590549465 0.5683940043  2     -16.614035 0.584031
1       1       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
```

Detector specific analysis

Agata-Prisma analysis

See Filippo's presentation

- The analysis of PRISMA is handled by the prisma library or the selector
- The selector produces most of the histograms necessary for the analysis also for the prisma library
- It then handles the coincidences
- Ion-gated histograms can be found in the Z##/A## folder.
- Important histograms include:
  - The DC(BP)_Qval which allows to gate on the total excitation energy of the system
  - The DC(BP,noDC)_Theta(BP) that allows to check the Doppler correction as a function of the angles
  - The various gamma-gamma matrices

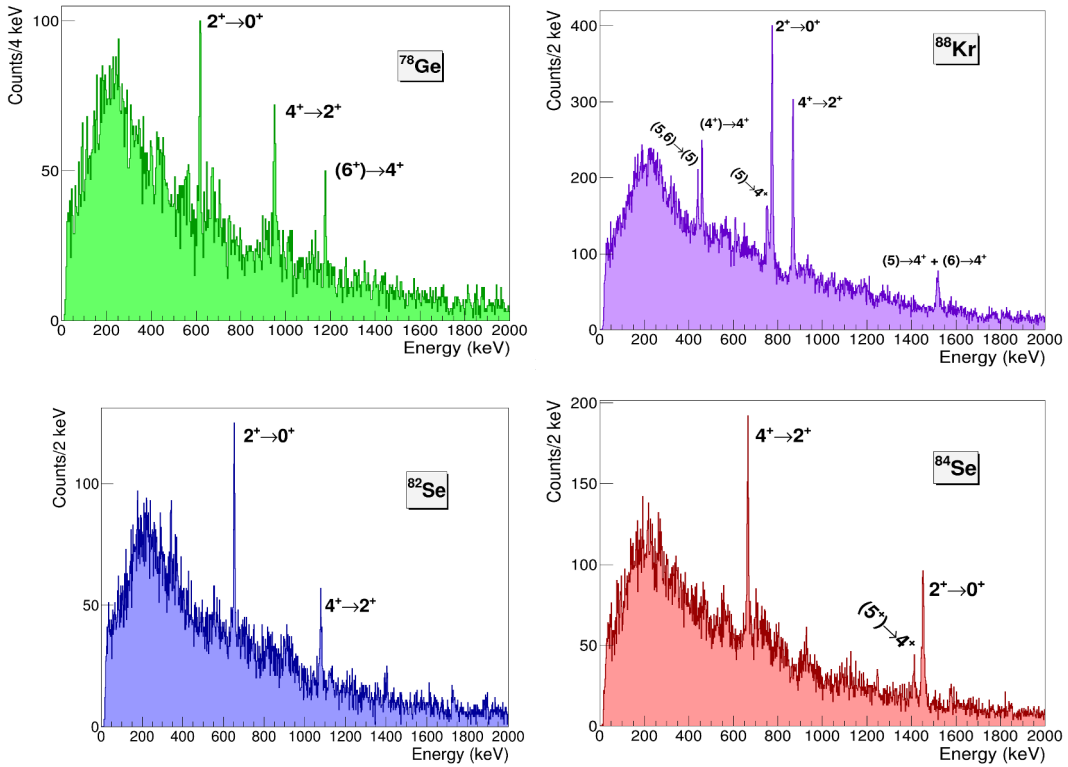


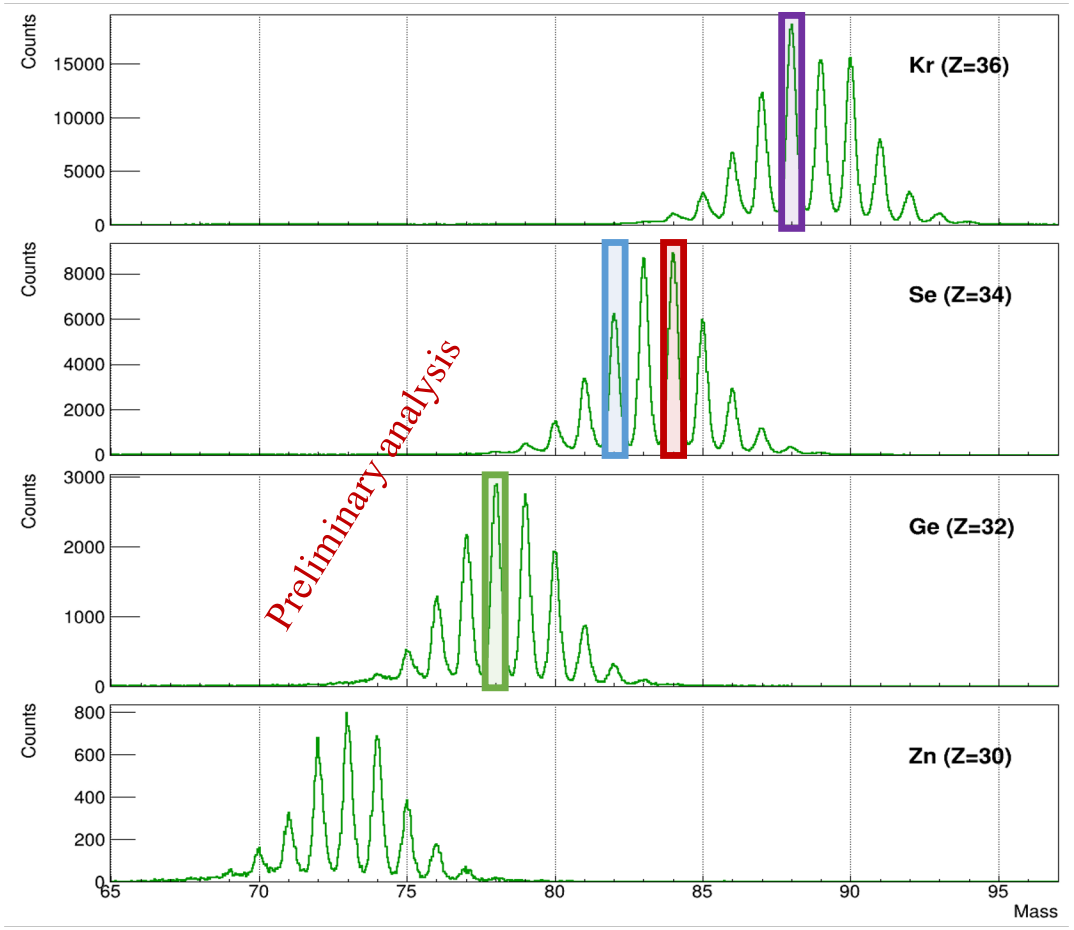
Prisma

- Broken IC or PPAC channels can be disabled
- The TOF offset can be set in the selector to optimize the Doppler correction without disrupting the identification
- One can require or discard some parameters such as TOF_OK, IC_OK to perform the analysis
- Cuts in Z can be placed in Conf/CUT/Prisma/IC/ to produce histograms in coincidence
- In AGATAPRISMA_CONF it is possible to set EX_VALUES to gate on specific values of TKEL and generate additional histograms

Prisma: some examples

- Example of identification

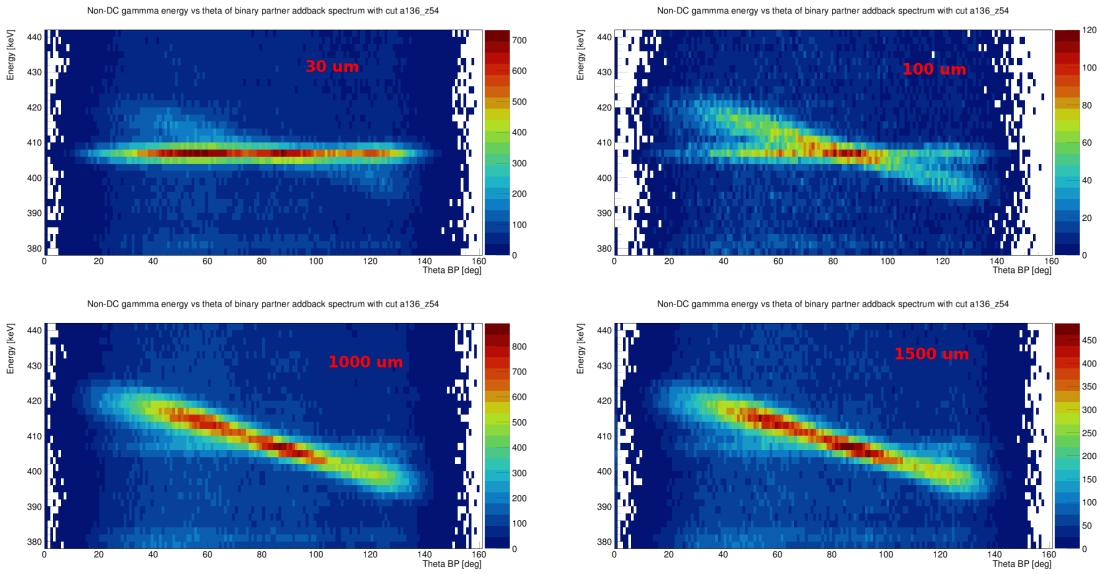




F. Angelini PhD Thesis

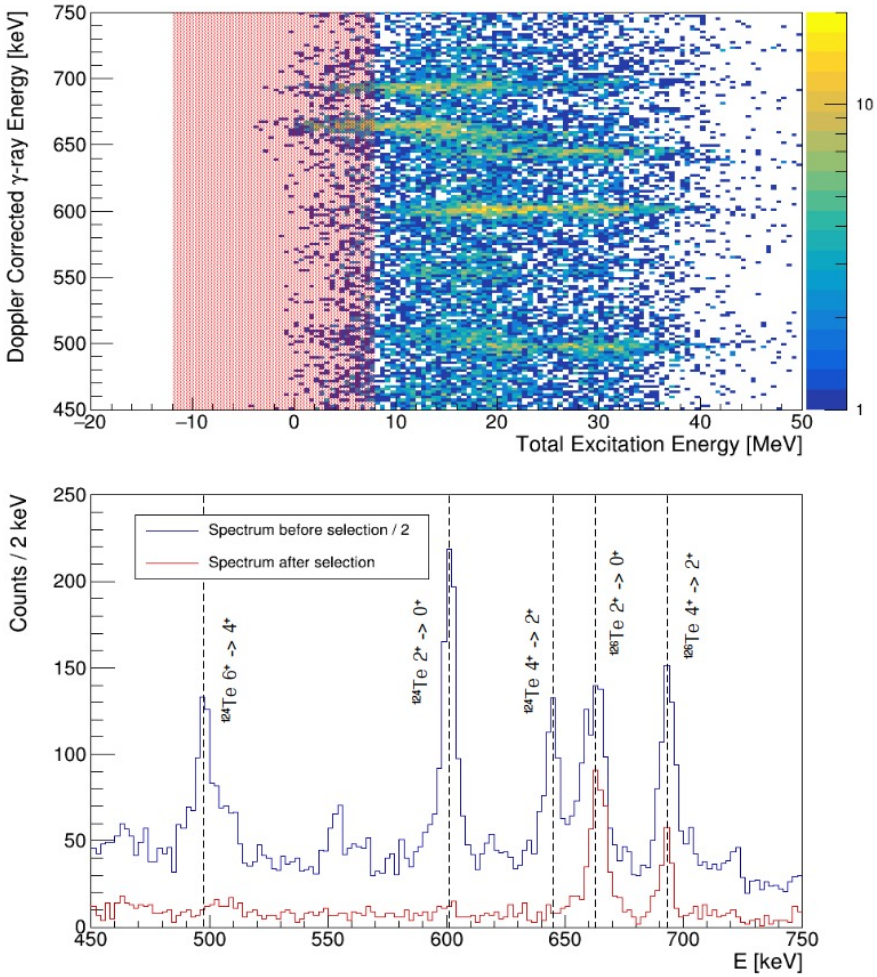
Prisma example

- Prisma provides the possibility of a fine kinematics reconstruction
- The Q-value matrices are often a very powerful tool
- The angle reconstruction is also great



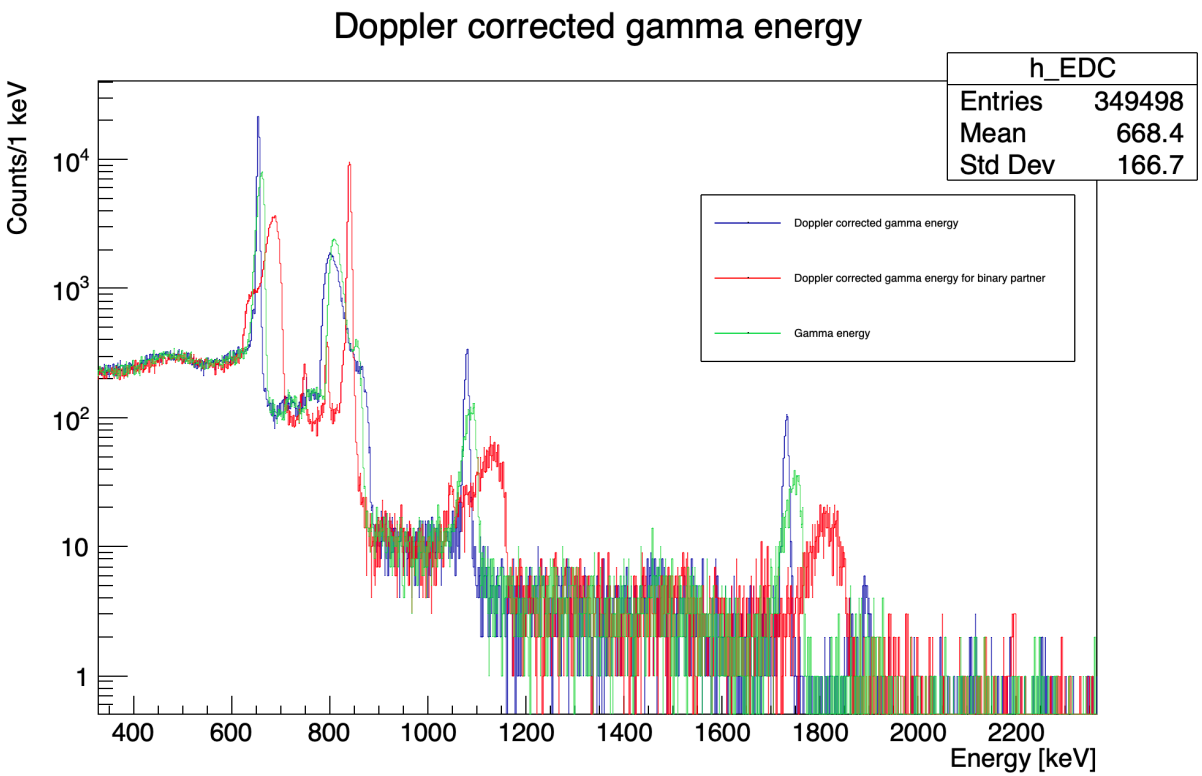
See Filippo's presentation

E. Pilotto Master Thesis



Spider

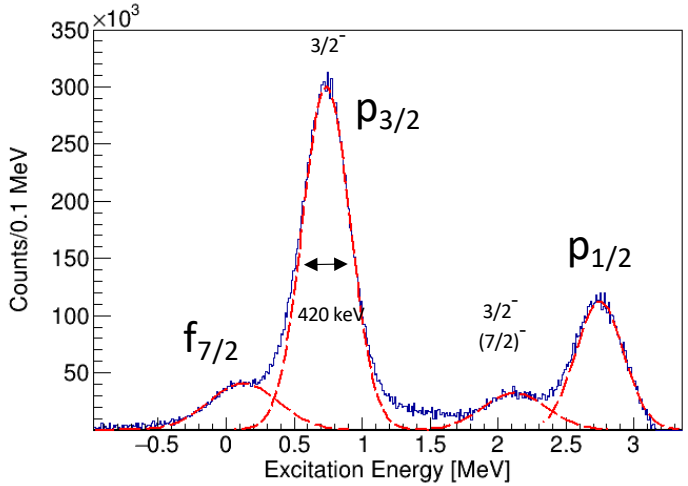
- Spider uses the measured energy and angles to reconstruct the reaction kinematics
- You can set the assumed detected ion with the ION keyword
- The basic output are doppler corrected spectra for the various ions

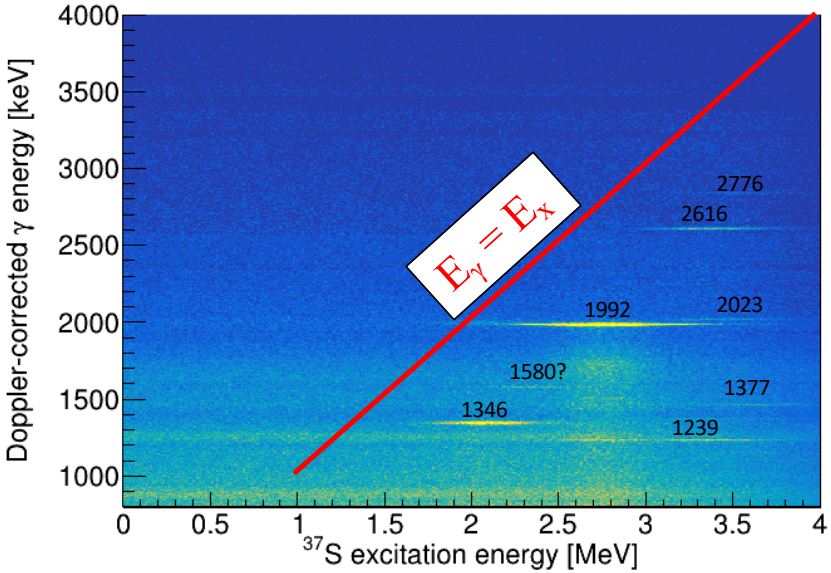


Spider

- Since we reconstruct the kinematics, we also calculate the excitation energy
- This can be useful, depending on the reaction
- Also four Coulomb excitation it can be helpful to remove contaminants from fusion evaporation from contaminants in the target

L. Zago PhD Thesis





Spider

- Detector dependent parameters:
  - Theta
  - Phi
- Channel names are not important but are helpful for the user
- Global rotation and shifts are set in the selector.conf and can be optimized (more on that later)

LUT_SPIDER.dat 4.93 KiB

```
1  ####### SPIDER ######
2  #
3  # the "map" number conversion into detector and strip:
4  # strip = (map % 10) + 1
5  # detector = (map / 10) + 1
6  #
7  # Board   channel    map   name   thr_lo   thr_hi   theta   phi   TimeOffset   pcalpar   calpars
8  1   0    1    D2S2   0.2    100   155.2   103.99   0   2   -0.725279350 0.009017265
9  1   1    0    D2S1   0.2    100   159.6   103.99   0   2   -0.737257684 0.008884174
10 1   2    3    D2S4   0.2    100   146.0   103.99   0   2   -0.720283915 0.009107212
11 1   3    2    D2S3   0.2    100   150.6   103.99   0   2   -0.731441192 0.008929393
12 1   4    5    D2S6   0.2    100   136.8   103.99   0   2   -0.782888331 0.009167317
13 1   5    4    D2S5   0.2    100   141.4   103.99   0   2   -0.711211883 0.008914951
14 1   6    7    D2S8   0.2    100   128.0   103.99   0   2   0.439492218 0.008844957
15 1   7    6    D2S7   0.2    100   132.3   103.99   0   2   -0.774363174 0.008928424
16 1   8    11   D1S2   0.2    100   155.2   52.56    0   2   -0.755972829 0.008866296
17 1   9    10   D1S1   0.2    100   159.6   52.56    0   2   -0.758290619 0.009060886
18 1   10   13   D1S4   0.2    100   146.0   52.56    0   2   -0.796959980 0.009098155
19 1   11   12   D1S3   0.2    100   150.6   52.56    0   2   -0.789661853 0.009081235
20 1   12   15   D1S6   0.2    100   136.8   52.56    0   2   -0.913507112 0.009238220
21 1   13   14   D1S5   0.2    100   141.4   52.56    0   2   -0.812225239 0.009063498
```

Things you care about: the calibration parameters

Spider

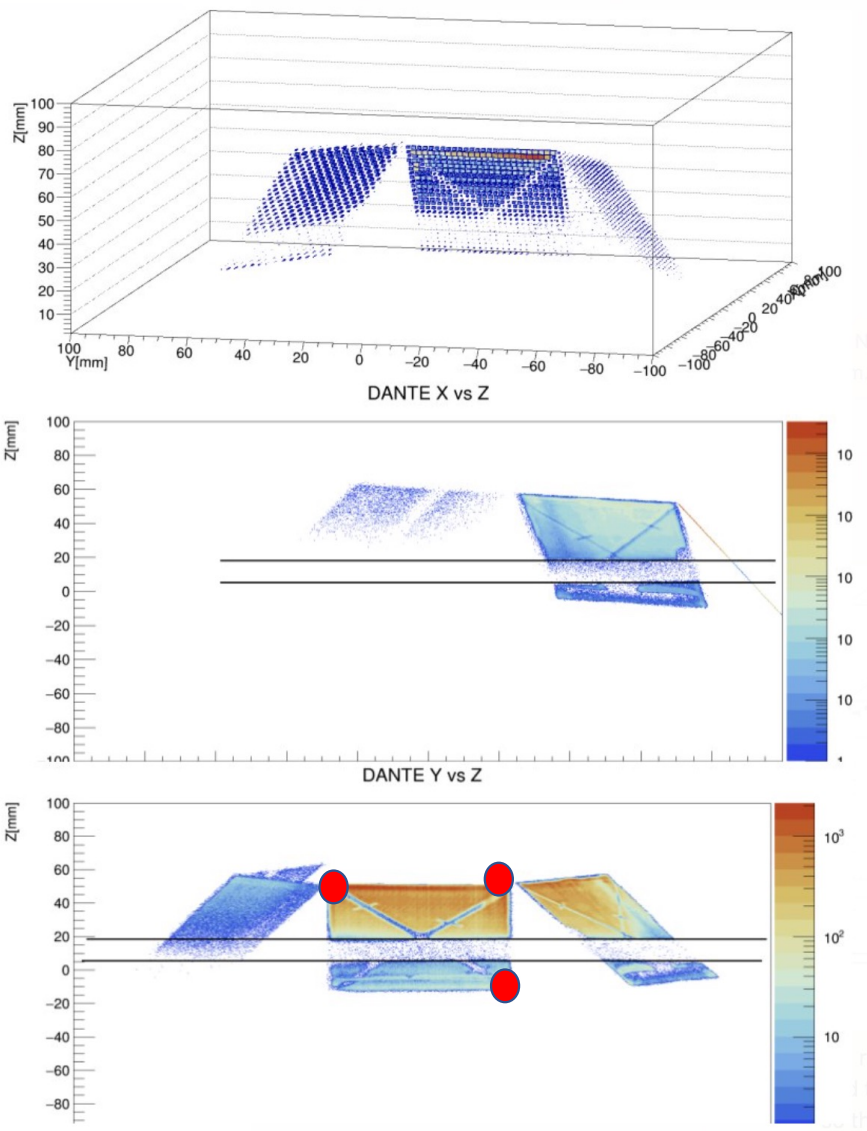
- The EX_VALUES keyword allows to generate histograms gated on a specific excitation energy value
- Additionally, it is possible to gate on a gamma-ray to generate additional histograms in coincidence with it such as additional gamma-gamma matrices with the keyword GAMMA_GATE of AGATASPIDER_CONF
- Kinematic line TCuts can be placed in the Conf/CUT/SPIDER/ThetaLabELab folder
- To extract the optimal results it is possible to tune theta and phi of each spider channel to optimize the Doppler correction. This feature is under construction and testing and can be compiled running cmake with the option –DSPIDER_ANGCAL=On (for more info contact Matus)
- Another option is to use a specific user selector called LUT_OPTIMIZER, refer to the readme for more information: https://baltig.infn.it/gamma/agataselector/-/tree/main/User/EXP/LUT_OPTIMIZER?ref_type=heads

Dante

- In general, a “perfect” Dante event should contain at least 3 events, corresponding to x, y (TACS) and T (cfd logic signal)
- Additionally, a TAC can be placed between Dante and Prisma, this is also handled by the analysis
- This does not happen all the time and the selector should handle this, some options are present in the selector.conf file
- The spatial calibration is performed by selecting the (x,y) points of the extremities of the
- The analysis should be expanded and improved for Dante

DANTE

- DANTE can be used as a standalone detector (for DANTE-DANTE coincidences) or combined with PRISMA
- The selector handles both cases
- It is possible to set gates in Conf/Cuts/PrismaDante/TOF_TKEL
- In this case of the triple coincidence AGATA-PRISMA-DANTE it is necessary to set two time gates: agata-prisma and agata-dante

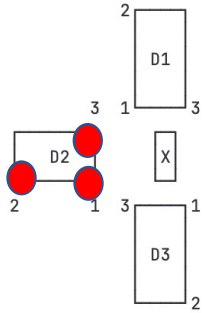


Dante Lookup table

- Detector dependent parameters:
  - P1, P2, P3
  - pos1, pos2, pos3
- Channel names distinguish X, Y, T and TOF

main / agataselector / User / EXP / Template / Conf / LUT / LUT_DANTE_3det_0deg.dat — Find file | Blame | History | Permalink

LUT_DANTE_3det_0deg.dat 2.75 KiB — Edit



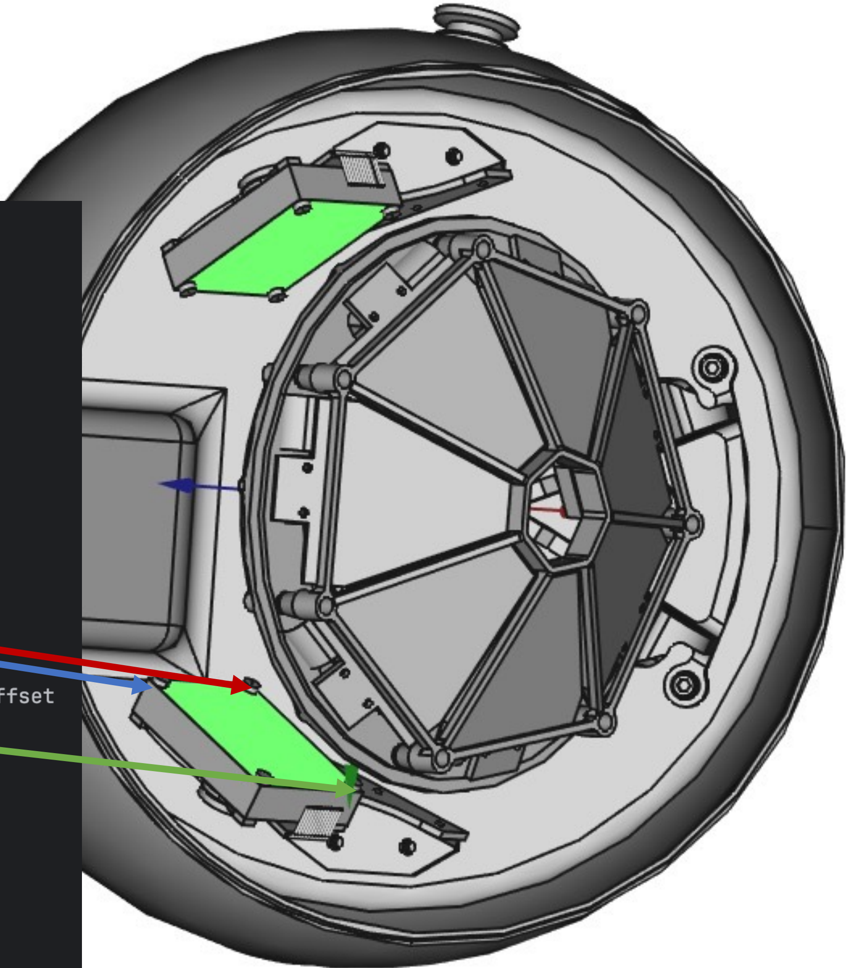

```
#                                    X          Y          Z
#                          D1P1    72.8361    25.3272    23.7575
#                          D1P2    41.2708    77.7189   -11.2993
#                          D1P3    35.3073    25.3272    57.5486
#
#                          D2P1    72.8935   -25.2499    23.7059
#                          D2P2    80.2628   -25.2499   -46.4078
#                          D2P3    72.8935    25.2500    23.7059
#
#                          D3P1    35.3073   -25.3272    57.5486
#                          D3P2     3.7420   -77.7189    22.4917
#                          D3P3    72.8361   -25.3272    23.7575
#
#
#Board  channel name    thr_lo  thr_hi  P1(x,y,z)   P2(x,y,z)   P3(x,y,z)   pos1   pos2   po3    Time Offset
1       0       D1X     4726    6700    72.8361     41.2708     35.3073     6700   4726   6700   0
1       1       D1Y     3110    4535    25.3272     77.7189     25.3272     3110   3110   4535   0
1       2       D1T     0       2000    23.7575    -11.2993     57.5486     0      0      0      0
#
1       4       D2X     4060    5990    72.8935     80.2628     72.8935     5990   4060   5990   0
1       5       D2Y     3850    5570   -25.2499    -25.2499     25.2500     3850   3850   5570   0
1       6       D2T     0       2000    23.7059    -46.4078     23.7059     0      0      0      0
#
1       8       D3X     4381    6597    35.3073      3.7420     72.8361     6597   4381   6597   0
1       9       D3Y     3605    5625   -25.3272    -77.7189    -25.3272     3605   3605   5625   0
1       10      D3T     0       2000    57.5486     22.4917     23.7575     0      0      0      0
#
1       12      D4X     10000   5000    36.0146    -24.5866     59.1902     5000   2200   5000   0
1       13      D4Y     10000   3500   -27.7491    -60.1032    -52.9991     2100   2100   3500   0
1       14      D4T     0       2000    56.3766     40.5354     19.2878     0      0      0      0
```

The lookup table also performs the 3D position reconstruction of DANTE, mapping 2D points (pos1, pos2, pos2) to 3D points (P1, P2, P3)

DANTE

- The positions of the points of reference are extracted from the CAD, you should probably not change this points

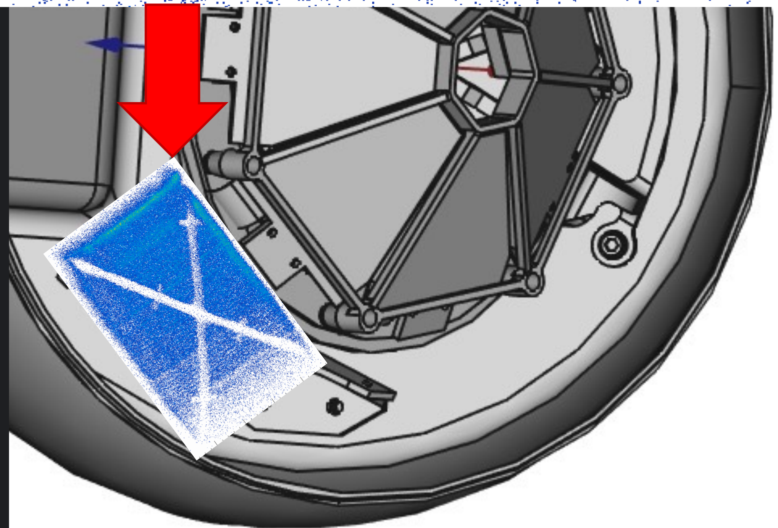
```
#           2┌───┐              X            Y            Z
#            │   │    D1P1    23.331110    68.437477    76.067215
#            │D1 │    D1P2    22.363780    100.43748    20.650030
#            │   │    D1P3   -20.662189    68.437477    76.835121
#           1└───┘3
#
#             ┌┐
#             │X│
#             └┘
#           3┌───┐1
#            │   │    D0P1   -20.662189   -68.437477    76.835121
#            │D0 │    D0P2   -21.629499   -100.43748    21.417936
#            │   │    D0P3    23.331110   -68.437477    76.067215
#            └───┘2
#
#Board  channel name      thr_lo  thr_hi  P1(x,y,z)   P2(x,y,z)   P3(x,y,z)   pos1   pos2   po3    Time Offset
5       4       D1X       5000    30000    23.331110   22.363780  -20.662189  29013  7518   29328   0
5       5       D1Y       5000    30000    68.437477  100.43748    68.437477  5396   5396   27773   0
5       6       D1T       0       65000    76.067215   20.650030   76.835121  0      0       0      0
#
5       0       D0X       5000    30000   -20.662189  -21.629499   23.331110  27290  4472   27023   0
5       1       D0Y       5000    30000   -68.437477  -100.43748  -68.437477  29396  29396  5410   0
5       2       D0T       0       65000    76.835121   21.417936   76.067215  0      0      0      0
#
5       8       D1TOFDANTE    0   16000   -127        0.01714     0           0      0      0      0
```



DANTE

- The thresholds are set to remove the retrigger and consider only positions that do make sense

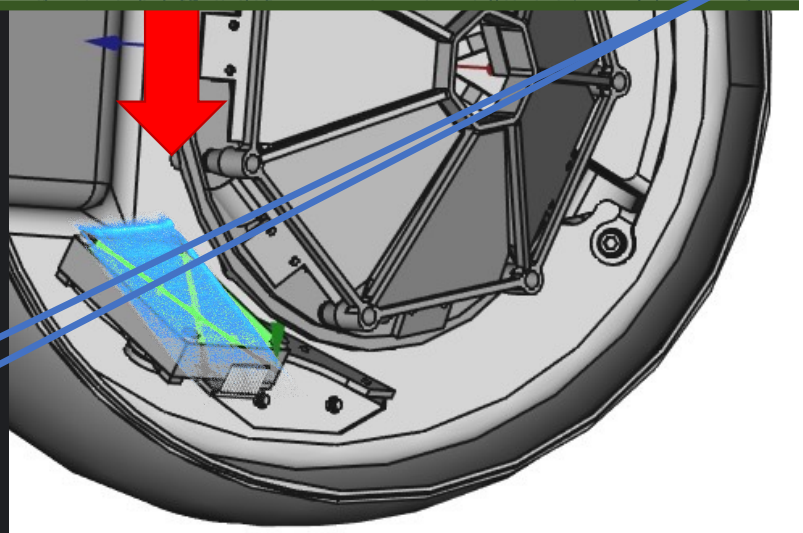
```
#           2┌───┐                 X           Y           Z
#            │   │    D1P1    23.331110    68.437477    76.067215
#            │D1 │    D1P2    22.363780    100.43748    20.650030
#            │   │    D1P3   -20.662189    68.437477    76.835121
#           1└───┘3
#
#             |X|
#
#           3┌───┐1
#            │   │    D0P1   -20.662189   -68.437477   76.835121
#            │D0 │    D0P2   -21.629499   -100.43748   21.417936
#            │   │    D0P3    23.331110   -68.437477   76.067215
#            └───┘2
#
#Board  channel name      thr_lo   thr_hi   P1(x,y,z)    P2(x,y,z)    P3(x,y,z)    pos1    pos2    po3     Time Offset
5       4       D1X       5000     30000     23.331110    22.363780   -20.662189   29013   7518    29328    0
5       5       D1Y       5000     30000     68.437477   100.43748     68.437477   5396    5396    27773    0
5       6       D1T       0        65000     76.067215    20.650030    76.835121   0       0       0        0
#
5       0       D0X       5000     30000    -20.662189   -21.629499    23.331110   27290   4472    27023    0
5       1       D0Y       5000     30000    -68.437477   -100.43748   -68.437477   29396   29396   5410     0
5       2       D0T       0        65000     76.835121    21.417936    76.067215   0       0       0        0
#
5       8       D1TOFDANTE    0    16000    -127         0.01714      0            0       0       0        0
```



DANTE

- The thresholds are set to remove the retrigger and consider only positions that do make sense

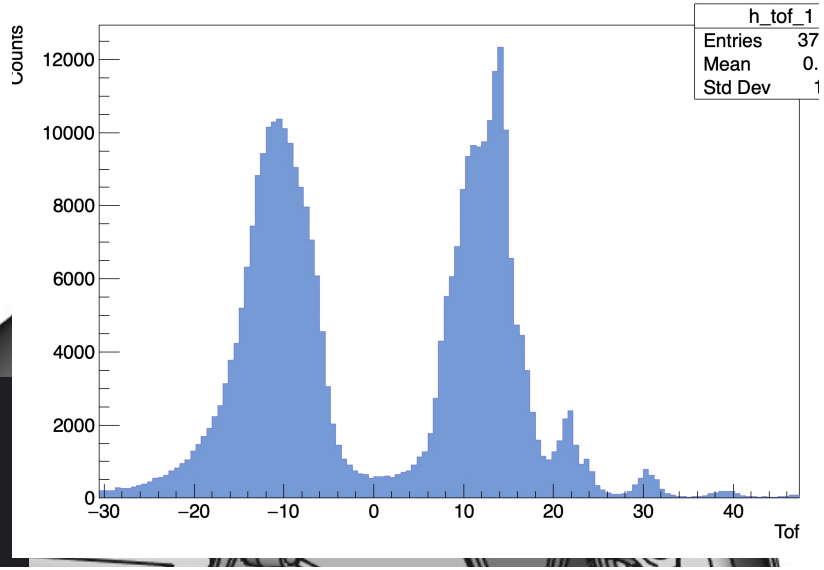
```
#                2                        X            Y            Z
#                                 D1P1    23.331110    68.437477    76.067215
#                  D1             D1P2    22.363780    100.43748    20.650030
#                                 D1P3   -20.662189    68.437477    76.835121
#              1       3
#
#                X
#
#              3       1
#                                 D0P1   -20.662189   -68.437477   76.835121
#                  D0             D0P2   -21.629499   -100.43748   21.417936
#                                 D0P3    23.331110   -68.437477   76.067215
#                2
#
#Board  channel name     thr_lo  thr_hi  P1(x,y,z)    P2(x,y,z)    P3(x,y,z)    pos1   pos2   po3    Time Offset
5       4       D1X     5000    30000    23.331110    22.363780   -20.662189    29013   7518   29328    0
5       5       D1Y     5000    30000    68.437477    100.43748    68.437477    5396    5396   27773    0
5       6       D1T     0       65000    76.067215    20.650030    76.835121    0       0       0       0
#
5       0       D0X     5000    30000   -20.662189   -21.629499    23.331110    27290   4472   27023    0
5       1       D0Y     5000    30000   -68.437477   -100.43748   -68.437477    29396   29396  5410     0
5       2       D0T     0       65000    76.835121    21.417936    76.067215    0       0       0       0
#
5       8       D1TOFDANTE   0    16000   -127      0.01714      0            0       0       0       0
```

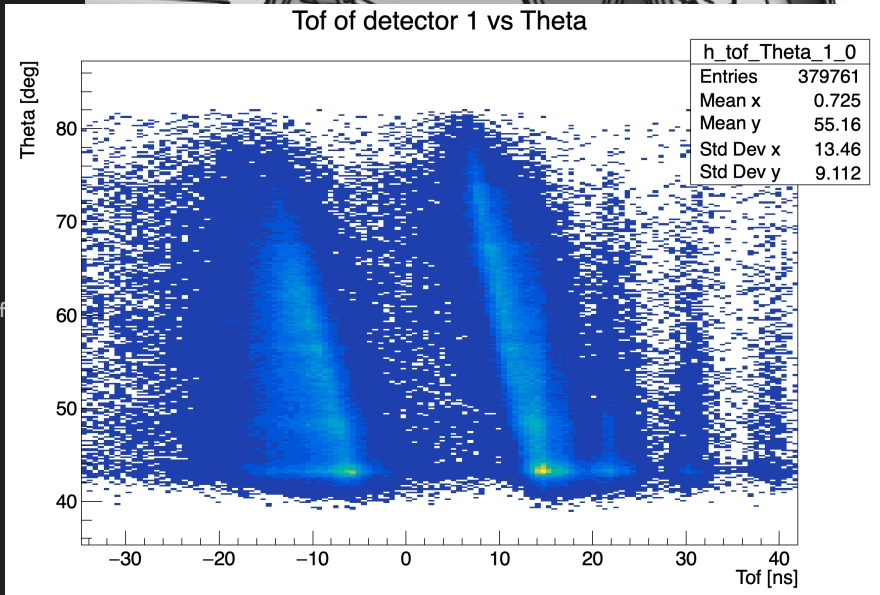


DANTE

- The TOF between two symmetric DANTEs should be centered in 0 and calibrated to the right scale based on simulations

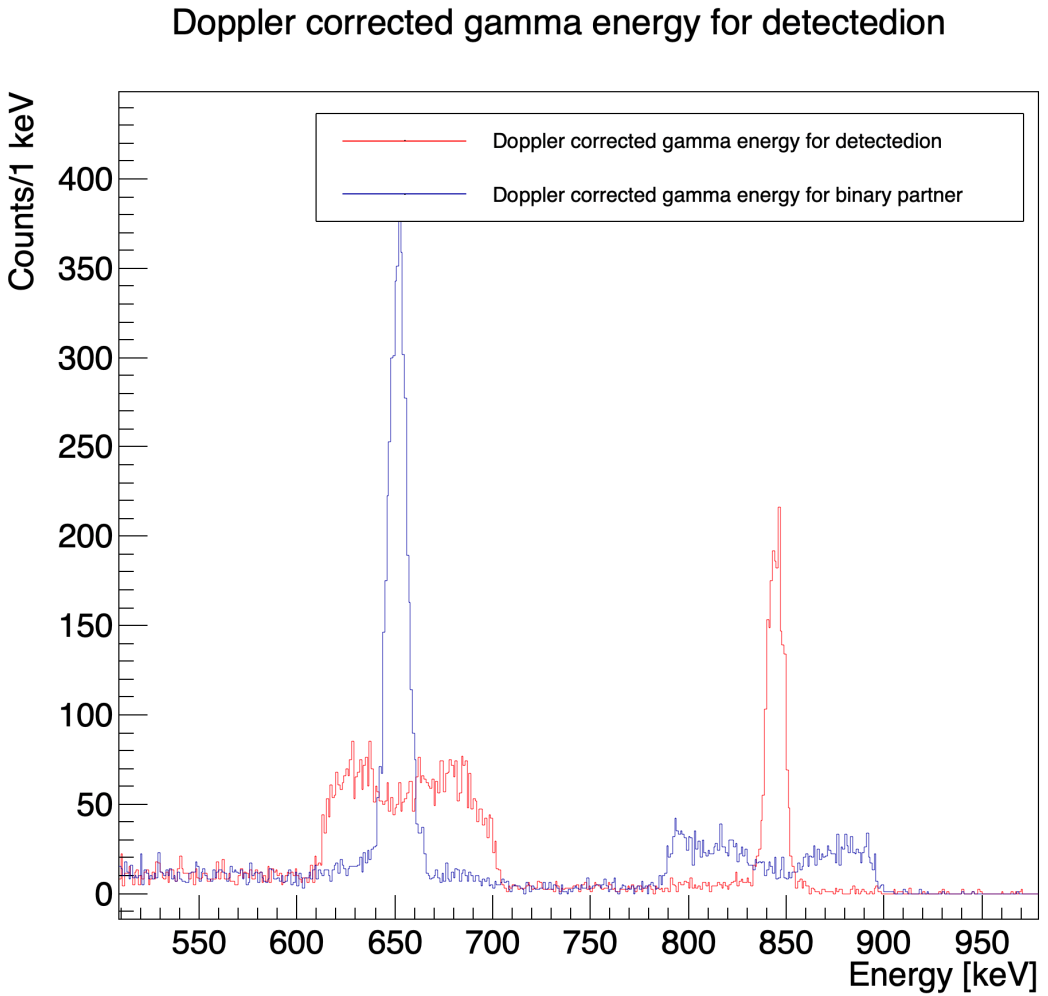
```
#                2                        X             Y             Z
#                                  D1P1    23.331110     68.437477     76.067215
#                 D1               D1P2    22.363780     100.43748     20.650030
#                                  D1P3   -20.662189     68.437477     76.835121
#              1      3
#
#                X
#
#              3      1
#                                  D0P1   -20.662189   -68.437477    76.835121
#                 D0               D0P2   -21.629499   -100.43748    21.417936
#                                  D0P3    23.331110   -68.437477    76.067215
#                2
#
#Board  channel name     thr_lo  thr_hi  P1(x,y,z)    P2(x,y,z)    P3(x,y,z)    pos1    pos2    po3     Time Of
5       4       D1X     5000    30000    23.331110    22.363780   -20.662189    29013   7518    29328    0
5       5       D1Y     5000    30000    68.437477    100.43748    68.437477    5396    5396    27773    0
5       6       D1T     0       65000    76.067215    20.650030    76.835121    0       0       0        0
#
5       0       D0X     5000    30000   -20.662189   -21.629499    23.331110    27290   4472    27023    0
5       1       D0Y     5000    30000   -68.437477   -100.43748   -68.437477    29396   29396   5410     0
5       2       D0T     0       65000    76.835121    21.417936    76.067215    0       0       0        0
#
5       8       D1TOFDANTE   0    16000   -127         0.01714      0            0       0       0        0
```





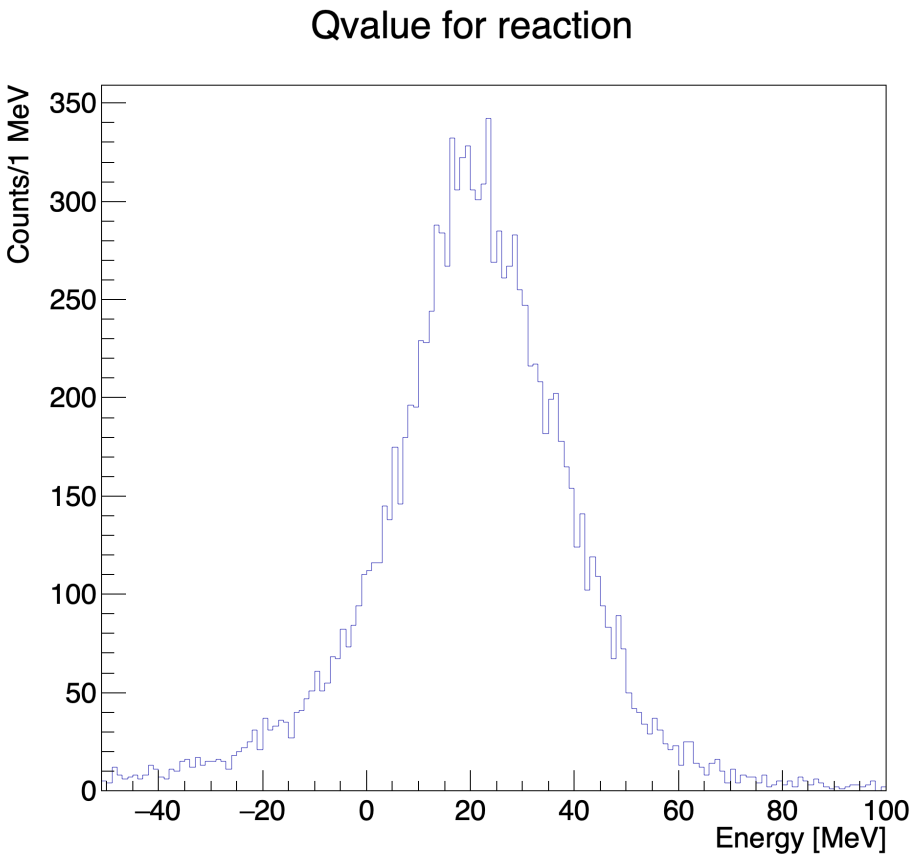
DANTE Gates

- For DANTE-DANTE coincidences you can set a gate on the TOF vs Theta matrix. In this case you can use the - - set_gates option to set them interactively
- For DANTE-PRISMA coincidences, you can set the gates in the Conf/Cuts/PrismaDante/TOF_TKEL folder, but it will soon be standardized with the - - set_gates option



DANTE Gates

- For DANTE-DANTE coincidences you can set a gate on the TOF vs Theta matrix. In this case you can use the - - set_gates option to set them interactively
- For DANTE-PRISMA coincidences, you can set the gates in the Conf/Cuts/PrismaDante/TOF_TKEL folder, but it will soon be standardized with the - - set_gates option



LaBr

- They share the same base class of Agata: GammaDetector
- As a consequence, the analysis of coincidences with Agata is exactly the same, so you can perform the same analysis as for Agata.
- In some cases, they were acquired without external trigger, meaning that they will have a lot of data. In this case you can use the --labr_slave option of ReadCaenRaw and/or the mandatoryKey of femul to process their data only if it is in coincidence with other ancillaries in the first case or femul in the second.
- In the case of experiments with Prisma, we discovered that they are strongly affected by the magnetic field despite the shielding so they require a calibration when the magnet was on

Labr

- Detector dependent parameters:
  - Theta
  - Phi

main ▾ agataselector / User / EXP / Template / Conf / LUT / LUT_LABR.dat Find file | Blame | History | Permalink

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       [illegible]     2       [illegible]
1       1       1       D1      0       16000   84.308418  97.489398    0       2       4.994643769  0.441859949    2       0.570262 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       .609657 0.481297
1       9       9       D5      0       16000   94.007297  1.3778600    0       2       0            1              2               1
1       5       5       D6      0       16000   99.883486  -28.723198   0       2       10.52197059  0.4435828877   2       8.918459 0.444711
1       6       6       D7      0       16000   86.180070  -45.908423   0       2       12.53667474  0.4240481389   2       8.411274 0.421525
1       7       7       D8      0       16000   91.699165  -66.505287   0       2       16.78408614  0.3897415818   2       5.049303 0.387539
1       8       8       D9      0       16000   85.591641  -95.344627   0       2       -12.39452343 0.4289130669   2       8.673472 0.452371
##########
1       15      15      monitor 0       16000   0                    0       0       2       0               1       2       0               1
```

Things you care about: the calibration parameters

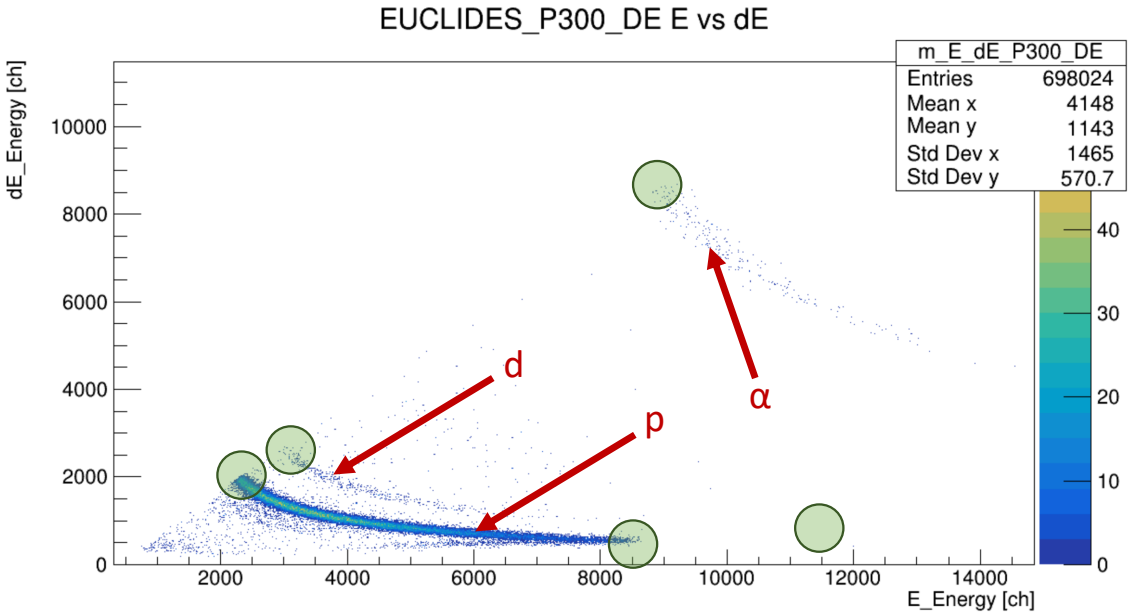
- The calibration coefficients are needed for the short and long integration
- Another parameter that can tuned is the timestamp offset
- Be careful with PRISMA: the source data might/will have different gains with respect to the data due to the magnets

Other ancillaries

Euclides

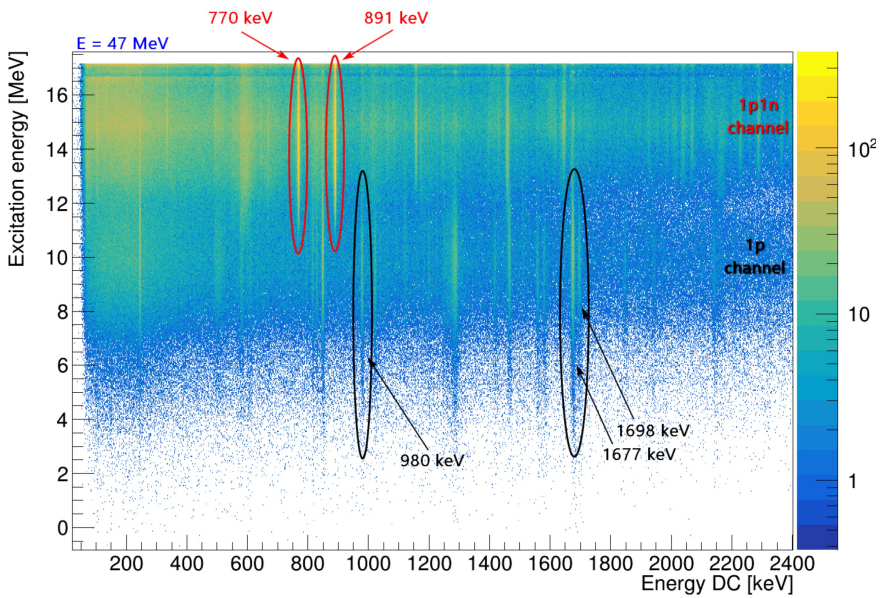
- Set gates for all telescopes in Conf/CUT/EUCLIDES/EdE/
- The naming scheme to adopt should be z1_m1_mapnr for while for alphas it should be z2_m2_mapnr
- Check the time alignment
- Calibrate with alpha run or with punch trough points
- In this case the reaction of interest could be a Nbody reaction. In this case the ions of interest need to be specified with:

  IONS A1 Z1 A2 Z2 A3 Z3 END Comment

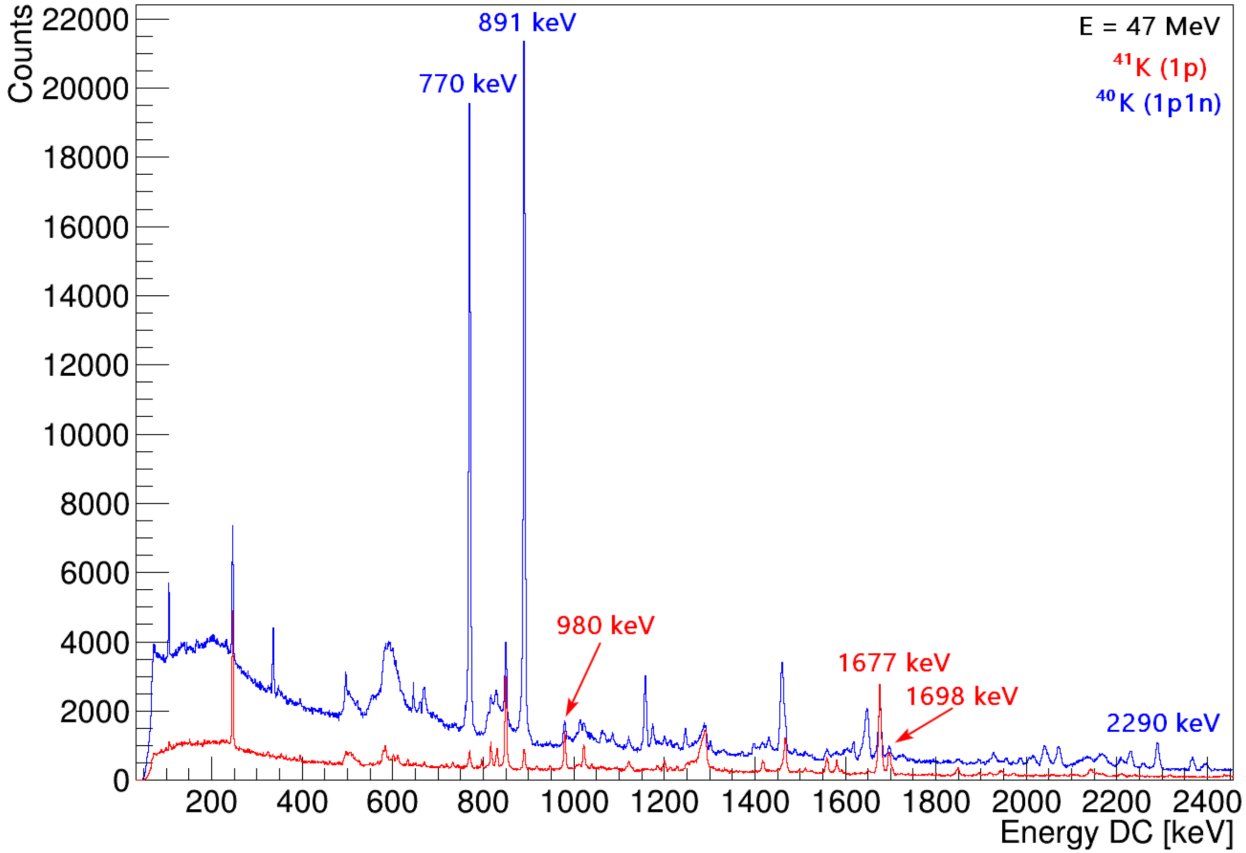


Mirco Del Fabbro PhD Thesis

Euclides



Mirco Del Fabbro PhD Thesis

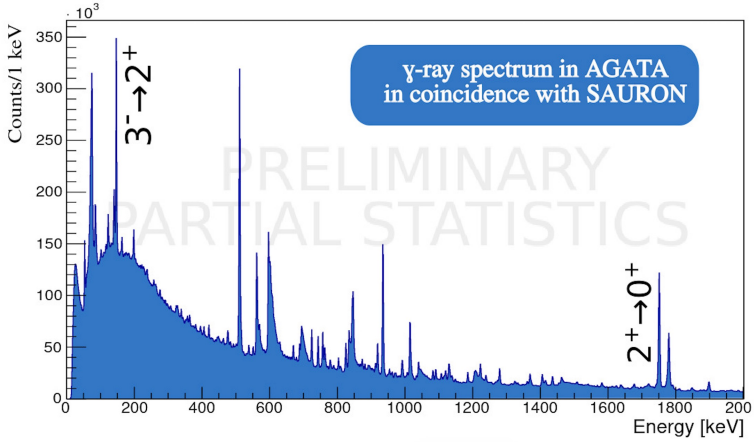


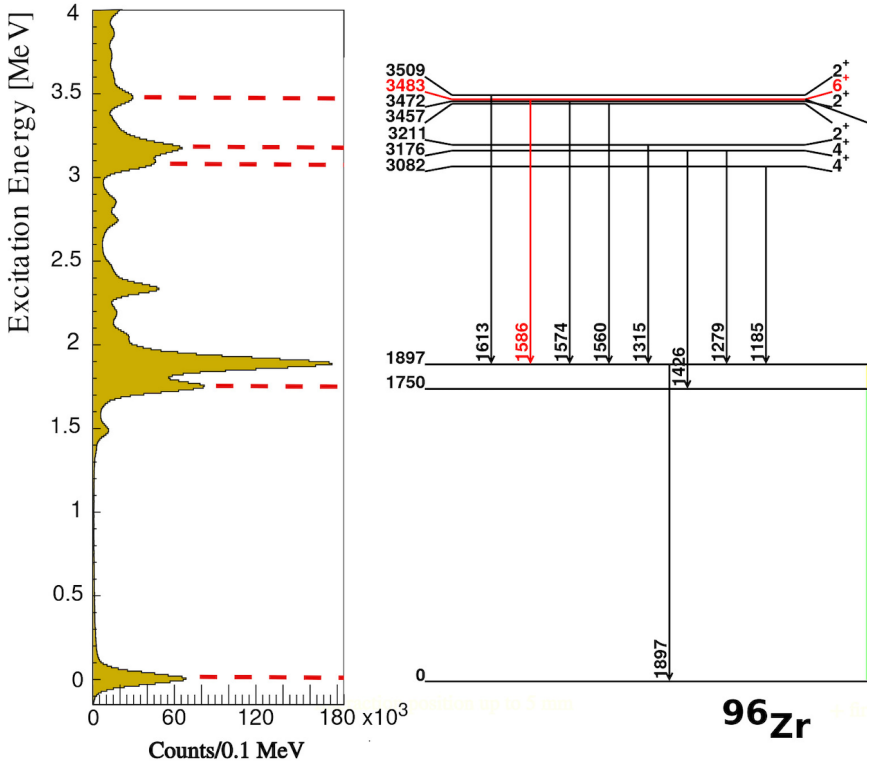
- Constructing a “rough” compound system excitation energy it is possible to discriminate not only protons, deutrons and alphas but also the 1p1n channel from the 1p channel (as an example)

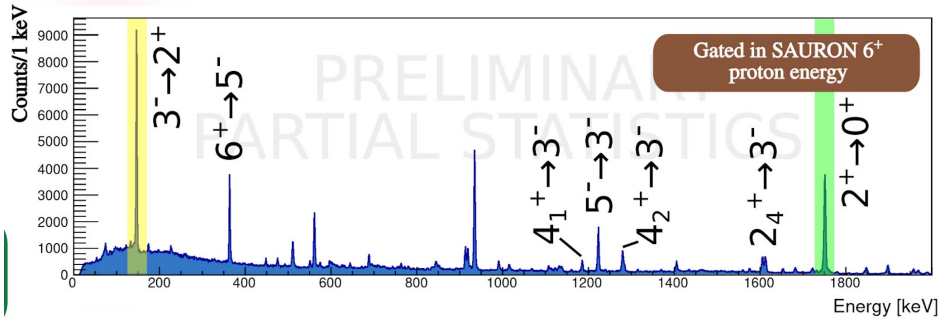
D. Stramaccioni

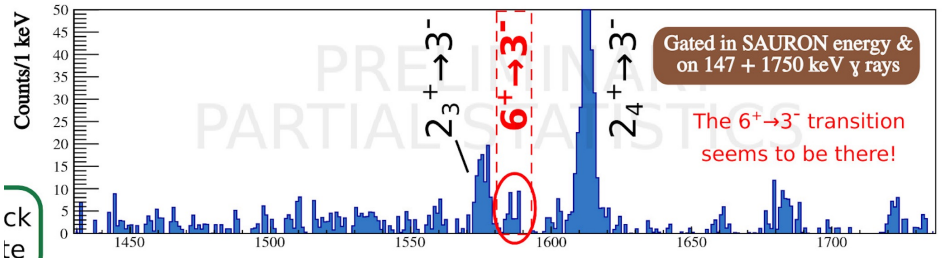
Sauron

- 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



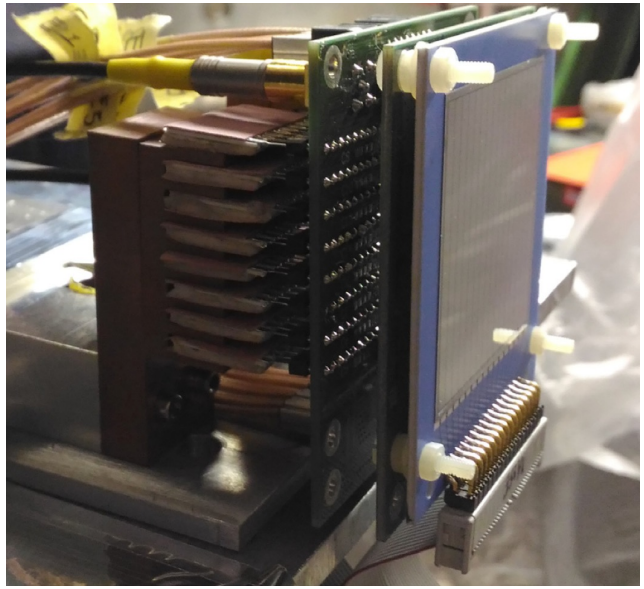


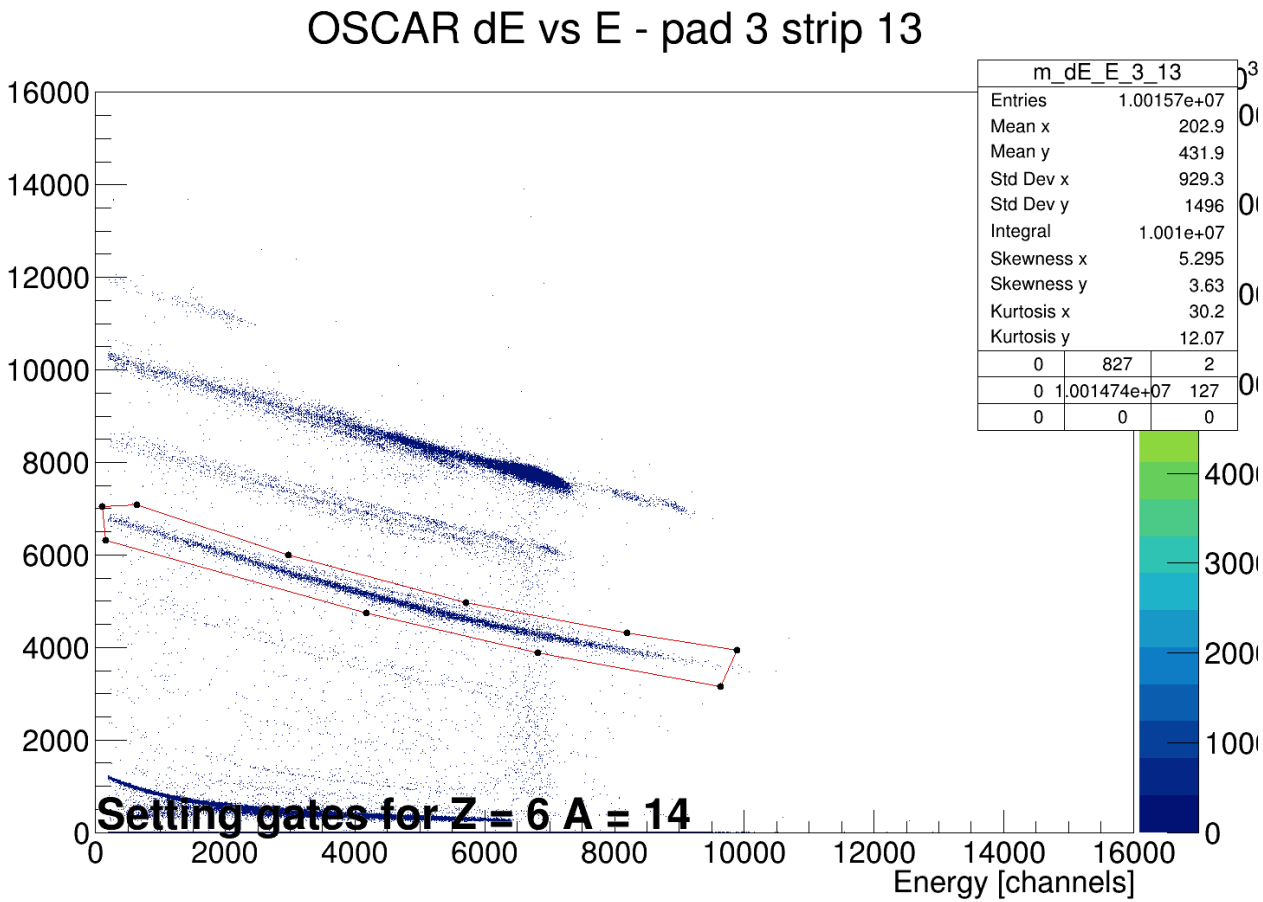




Oscar

- Particle identification with ΔE-E correlation matrix
- Good position sensitivity thanks to stripped ΔE detector
- The analysis is developed in the selector but will probably need refinements

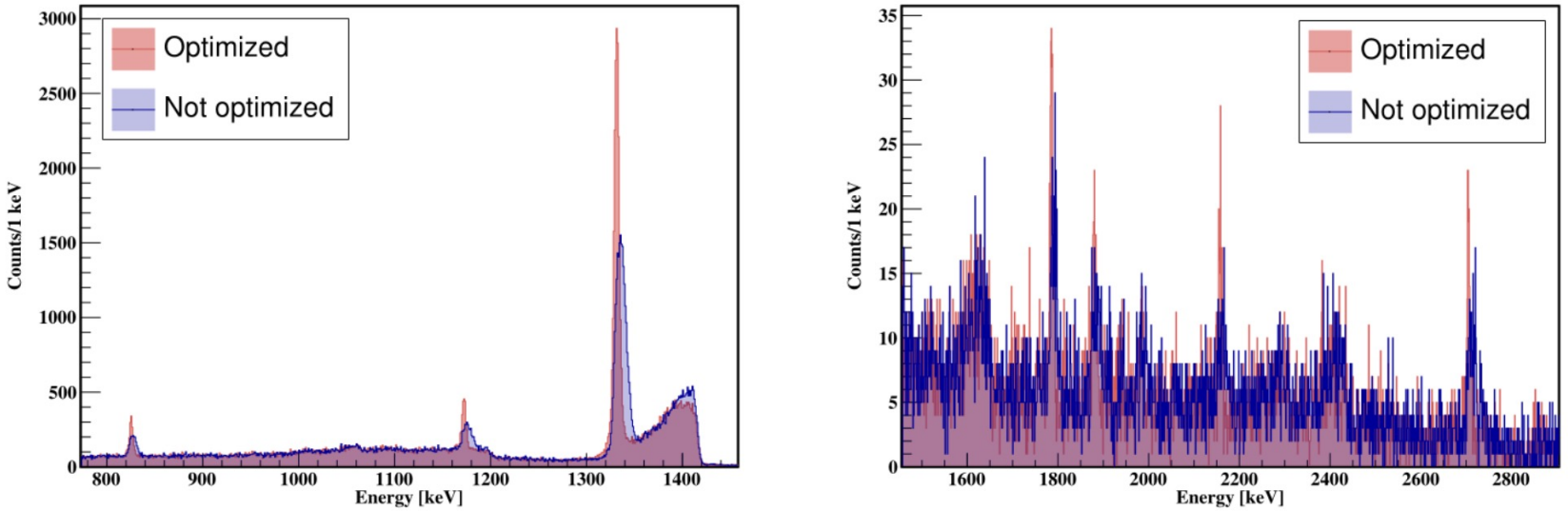




Optimization

The optimization procedure

See Elia's talk



- 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

The optimization procedure

- Checkout the “OPTIMIZER_CONF” parameters in the selector.conf
- Any parameter contained in the selector.conf that is a single float number can be optimized (target thickness, angles, calibration coefficients). Parameters are minimized simultaneously
- This can be used to improve the doppler correction or the q-value/excitation energy to the right position based on the user’s insight
- It is done with a root minimizer (multiple ones are available: Migrad, Simplex, …)

Reducing the data

- Since the selector will run multiple times, one must reduce the data to the one of interest. To do so, it is possible to apply a reduction condition on the data such as:

  ./RunSelector --reduction_cond nbTrack\>0\&\&Z_Nr\>0 262

- For every input file, a reduced file will be created in the folder where the original tree is, called red_TREENAME_####.root. The files can be then added to create a single file with the data of interest of few MB that will allow the selector to run with high frequency.
- The optimizer should be run on this file by changing the input file pattern in the selector.conf

Running the optimizer

- The parameter(s) to be optimized can be specified adding one (or multiple lines) in the selector.conf:

  PARAMETER |detector|par_name|initial_value|min|max|step| ->

  PARAMETER AGATA_CONF ANGLE 31 25 25 1 deg
  PARAMETER TARGET_CONF THICKNESS 1 0.5 2 0.1 mg/cm2

- The “line(s)” to optimize can be specified adding one (or multiple lines) in the selector.conf :

  TRANSITION |folder|spec_name|centroid|sigma|tail|bias ->
  TRANSITION /AgataPrisma/Z16/A32 h_DC_ion_32_16 2230 4 0.1 0.5 keV

- The fit can be done without a tail, with a left, right, left+right and left+right symmetric tail (parameter TAIL).
- The SIGMA_WEIGHT is a parameter that goes from 0 to 1. It adds weight to the sigma in the cost function.
- The SCAN option will create a root file with the gradient scanned by the parameter, multiple scans can be performed.

Checking the results

- If the Conf/Optimizer/parameters.dat is present it will be created. If it is present the parameters for the fit (mean, sigma, tau, xmin, xmax, integral) will be read from there, otherwise the default ones will be used. You can simply remove it to start from the default ones.
- At each step some lines will be added to the Conf/Optimizer/log.txt with the current value of each parameter as well as the current cost (gradient value)
- At the end an optimized conf will be created in the folder based on the optimial value.
- The results of the fit can be checked step by step with the option:

  -- debug_canvas

Reading raw data and building ancillary events

Generating the .adf files from the raw data

- The script to read the raw data and build ancillary events is contained in Scripts/AncMerging. To build it, run “cmake -DBUILD_SCRIPTS=On .”
- It builds events within the ancillary within a window
- It handles coincidences also with prisma+other ancillary
- It adds time offset based on the necessary delays
- It applies the correct key for each detector
- The output can then be used by femul to build Agata+ancillary events

Configuration options

ReadCaenRaw.set_labrdantespider 2.63 KiB

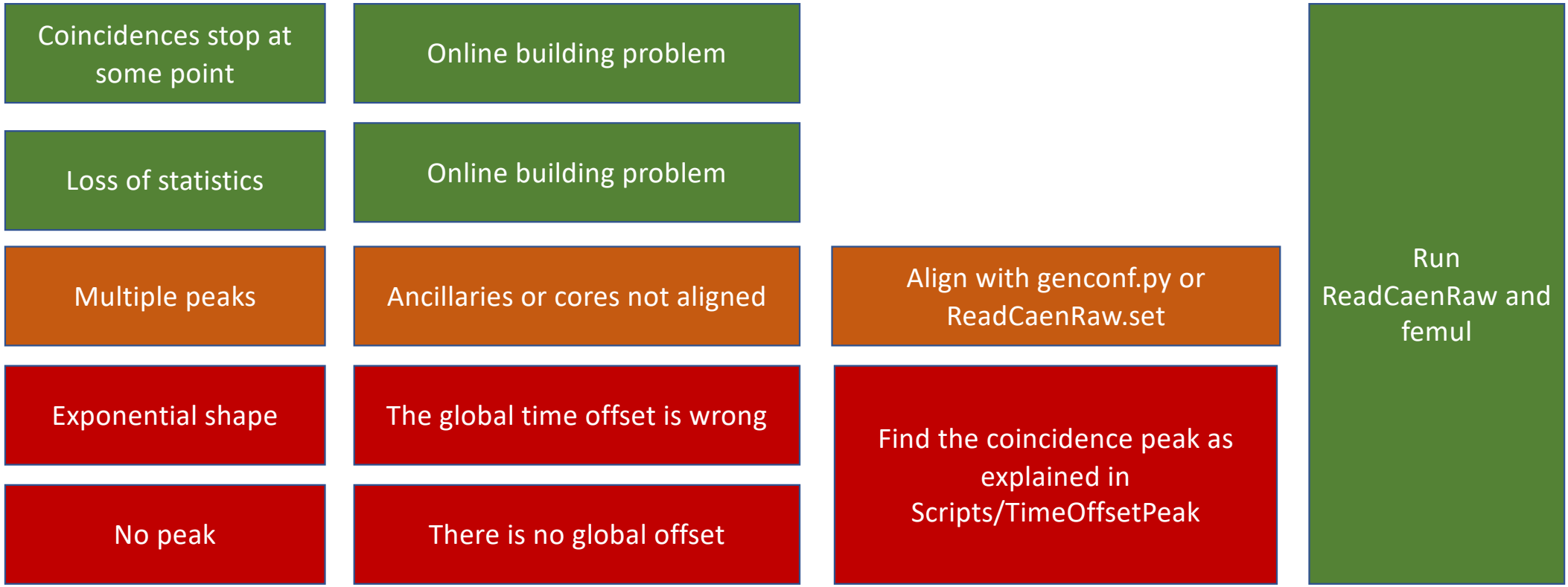
```
#window: width of the time window used for the event building (in ns)
window 500

#boardDef:
# arg 1: boardId
# arg 2 :boardVersion(V1725/V1730==1 - VX2740 ==2)
# arg 3 :number of channels
# arg 4: FWVersion (PHA or PSD)
# arg 5: ns per timestamp
# arg 6: ns per sample
# arg 7: data key: 0xFA0201A2 = SPIDER ; LABR = 0xFA0201A5 ; DANTE = 0x
boardDef 0 1 16 PSD 2 2 labr
boardDef 1 2 64 PHA 8 8 spider
boardDef 5 1 16 PHA 4 4 dante


#minFold:
# arg 1: minFold for this detector
# arg 2: keep only events if coincidence with other board
minFold 2 0
minFold 1 0
minFold 1 0


# board   channel   timeOffset
tsoffset   0   0      121
tsoffset   0   1      121
tsoffset   0   2      121
```

See Elia's presentation for all the details

- **window** [time window width in nanoseconds, usually around 500]
- **board** [board number] [firmware version: 1 or 2] [number of channels: normally 16 or 64] [firmware type: PSD or PHA] [nanoseconds per timestamp] [nanoseconds per sample] [detector name]
- **tsoffset** [board number][channel] [value of offset in timestamps (multiples of 10 ns)]
- **minfold**: [board number] [minimum fold of a board to write an event in the output]

Troubleshooting

See Elia's presentation for all the details



Finding the coincidence peak

- It is not straightforward and is strongly dependent on the trigger processor settings
- If LaBr are present and acquired as slaves of other ancillaries they can be used to find the right offset
- The offset can be found by randomly correlating all events as explained in Scripts/TimeOffsetFix:

Finding the offset

You should have the agapro package installed with the `ListFrames` program installed. Locate your ancillary BU file whith should be named like `ancillaryBU_i***_****_0000.adf`. Chose one good AGATA crystal and locate the `psa_0000.adf` file under the data folder such as `Data/00A/psa_0000.adf`.

Modify the script `generate.sh` to point to those files and run it with `sh generate.sh`. Two files called `anc.txt` and `agata.txt` should be generated.

Now it's the time to run `./fix` which will read these two files and generate a root file called `out.root`. Inside this file there should be a big histogram, locate the peak in the histogram and note precisely the x-axis position. This is your offest number. You may have to modify the fix.C script to change the limits and binning of the histogram of the dimension of the vectors in case no peak is present. Then recompile the script.

You can use the macro `drawHist.cxx` for help in finding the peak.

Applying the offset

Now that you have an offset, use the `ReadCaenRaw` as you normally would but with the option `--global-anc-tsoffset value`, where value is the position of the peak.

Other useful scripts

Generation of SRIM tables

README.md

Energy loss table production using SRIM

`ELoss_table_for_AgataSelector.bat` is windows script, which uses module of `SRIM` called `SRModule.exe` to produce tables of energy loss tables used by AgataSelector

Running the script

Locate your installation of `SRIM` and its subdirectory `SR Module`, which you can copy wherever you want to run it

Make sure that files `SNUC03.dat` and `SCOEF03.dat` are present and named accordingly

Copy files `ELoss_table_for_AgataSelector.bat` and `target.dat` into your `SR Module` folder

Edit `target.dat` file with parameters of your target in the form: A Z name Density(g/cm3)

Open `cmd` (press `win+R`, type `cmd` and press enter) and navigate to your `SR Module` folder by `cd /d X:\path\to\your\folder`

Run command `ELoss_table_for_AgataSelector.bat Amin Amax Zmin Zmax Emax`, where from Amin to Amax is mass number range of impinging ions, where from Zmin to Zmax is proton number range of impinging ions and Emax is maximum energy in keV of impinging ion to be calculated.

The output are .txt files named as Target-A-Z_Ion-A-Z.txt for each ion - target combination. This files needs to be transferred to `agataselector/User/EXP/Your_EXP_NAME/Conf/EnergyLoss` folder and you are good to go

MPI

- The selector can be distributed on multiple machines if they have a common file system and boost-mpi installed.
- To enable MPI compile with:

```
cmake -DCMAKE_CXX_COMPILER=mpic++ -DUSE_MPI=On .
```

- It is also necessary to add a file called “hfile” with the ip of each machine that will contribute
- To distribute simply add the option - -distribute when launching the selector.
- Note that the machine where you launch it from will be only assigning jobs and thus will not be under load.

Perspectives and foreseen updates

- S1 (Sauron) and Oscar will be added to the analysis
- Tests should be added for other detectors
- If you find a bug or have a feature please help us, it benefits the community! You can contact us by email or open an issue on baltig: https://baltig.infn.it/gamma/agataselector/-/issues