Complementary Detectors: NEDA + DIAMANT

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on behalf of the NEDA - DIAMANT collaborations

University of Padova - INFN Padova

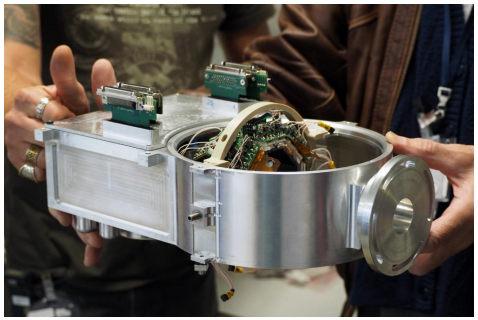
Agata Analysis School 2019
Jan. 23, 2019

UNIVERSITÀ
DEGLI STUDI
DI PADOVA

Dipartimento
di Fisica
e Astronomia
Galileo Galilei

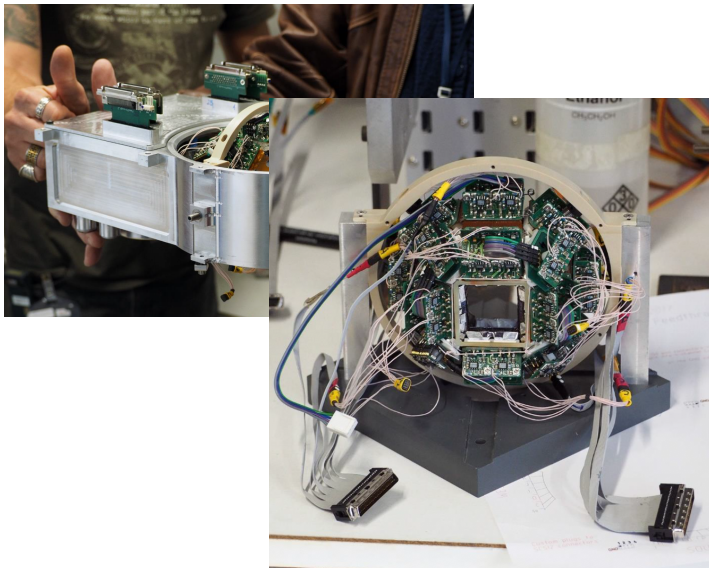
GENERALITIES

The DIAMANT array



- **60 CsI detectors**

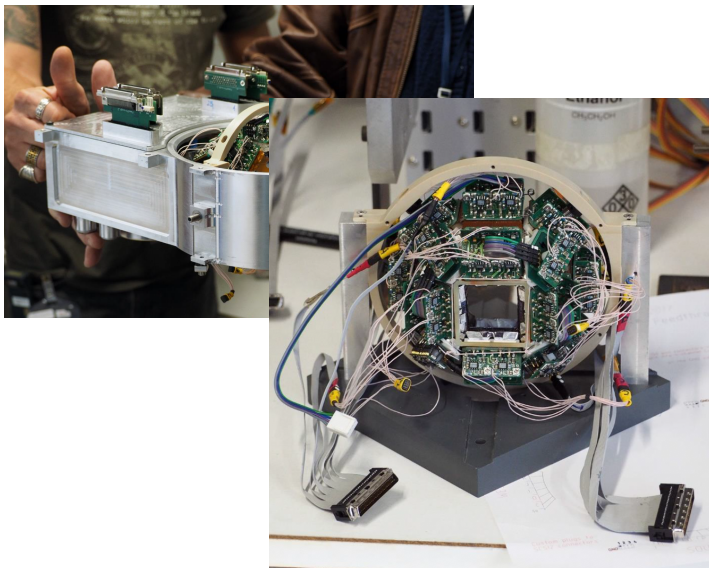
The DIAMANT array

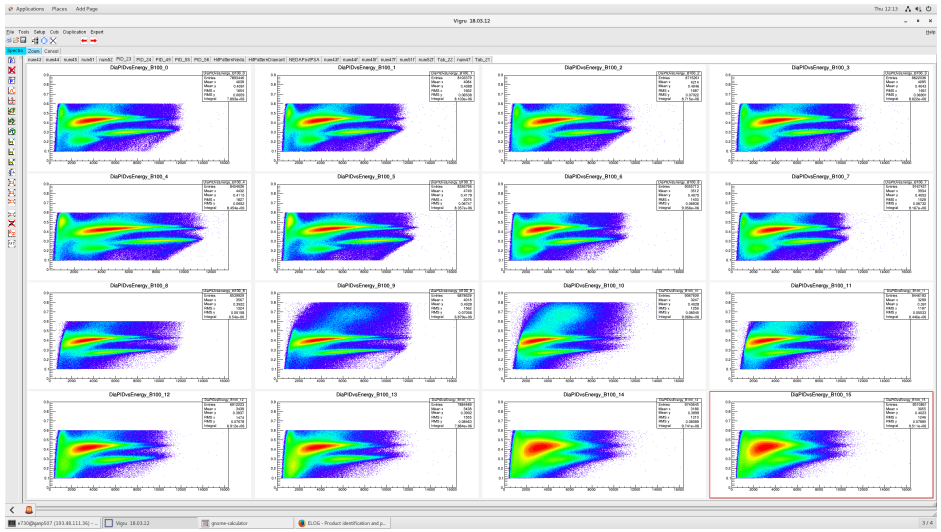


- **60 CsI detectors**

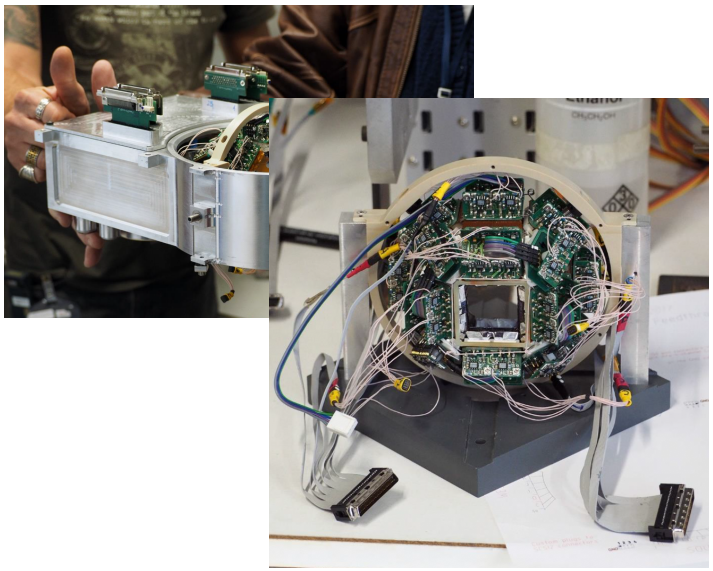
The DIAMANT array

- **60 CsI detectors**
- Particle identification through 2 Tpz. Filter

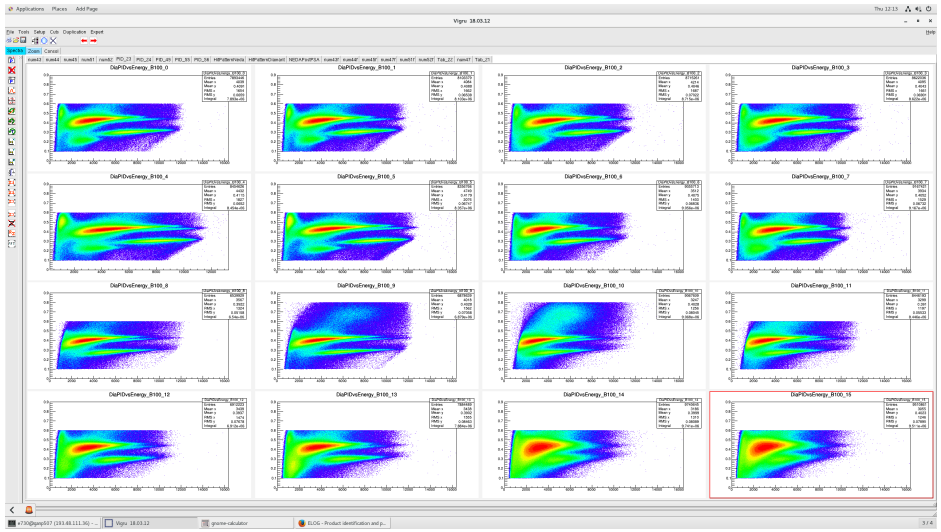




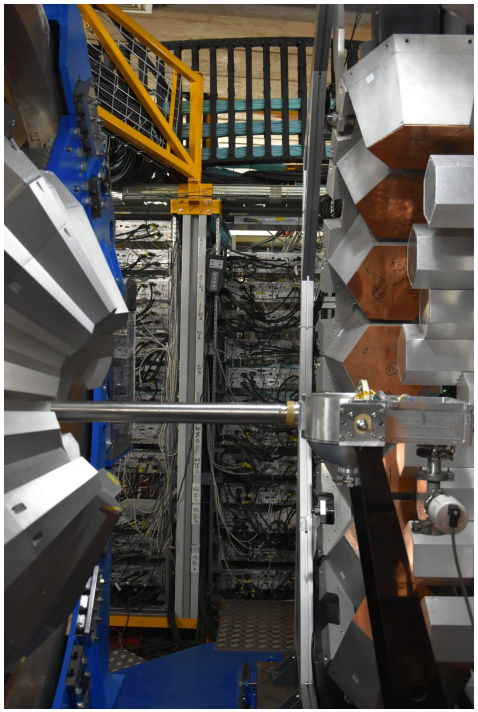
The DIAMANT array



- **60 CsI detectors**
- Particle identification through 2 Tpz. Filter
- Completely trigger less

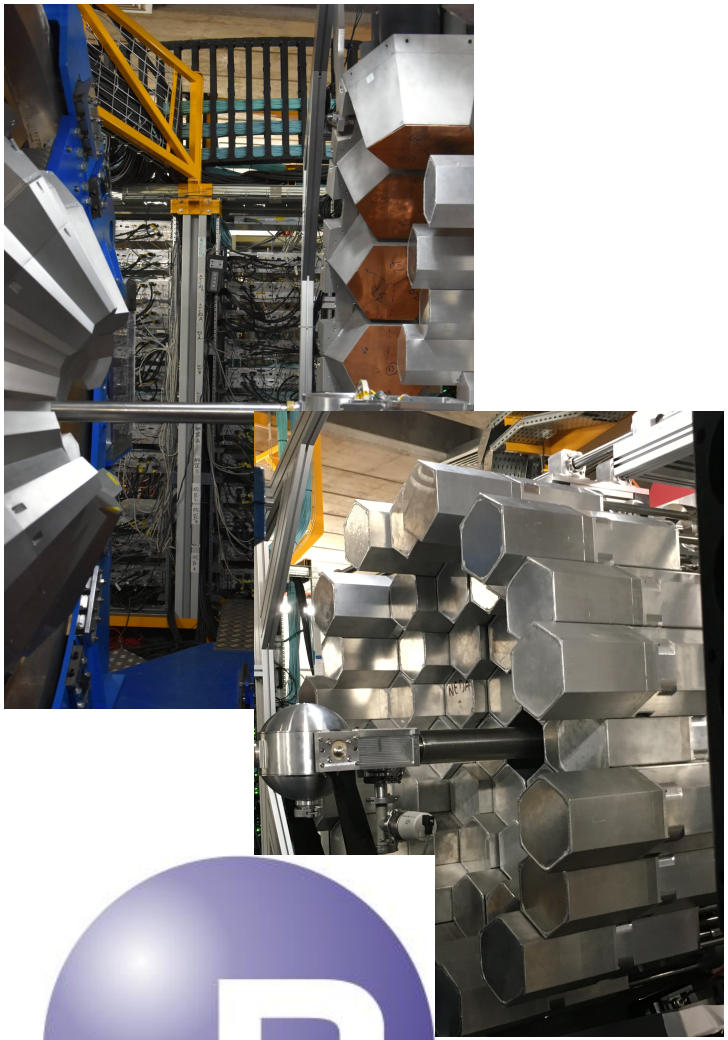


The NEDA-NeutronWall array



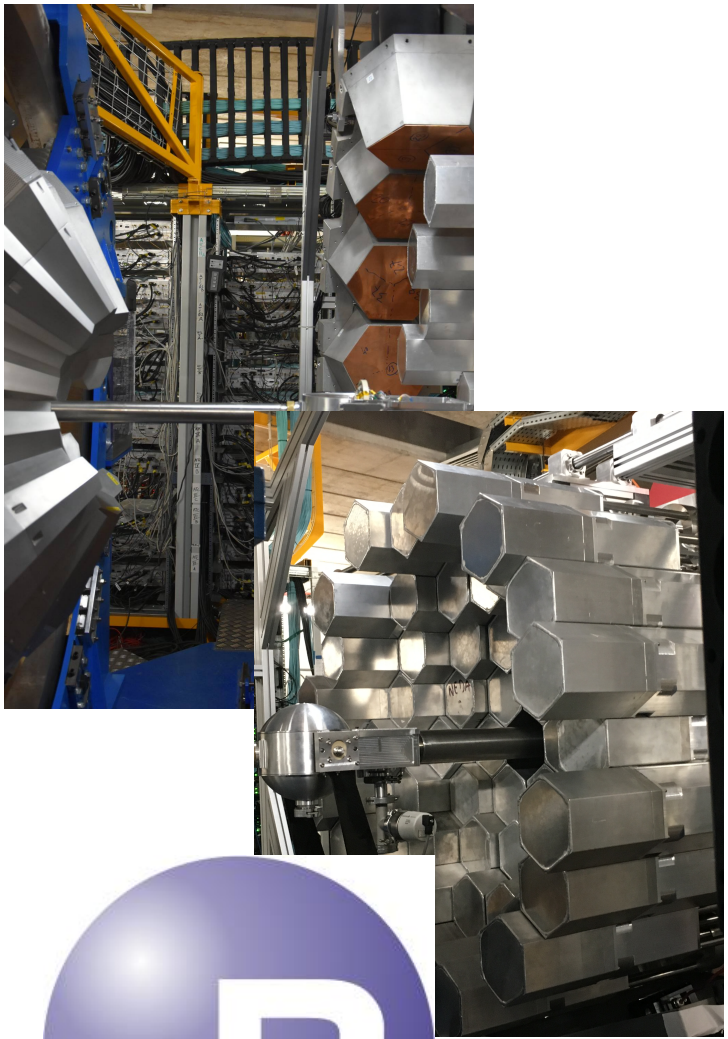
- **96 detectors** :
  - 42 NeutronWall (650 mm)

The NEDA-NeutronWall array



- **96 detectors** :
  - 42 NeutronWall (650 mm)
  - 54 NEDA (510 mm)

The NEDA-NeutronWall array



- **96 detectors** :
  - 42 NeutronWall (650 mm)
  - 54 NEDA (510 mm)
- High quality home made detectors

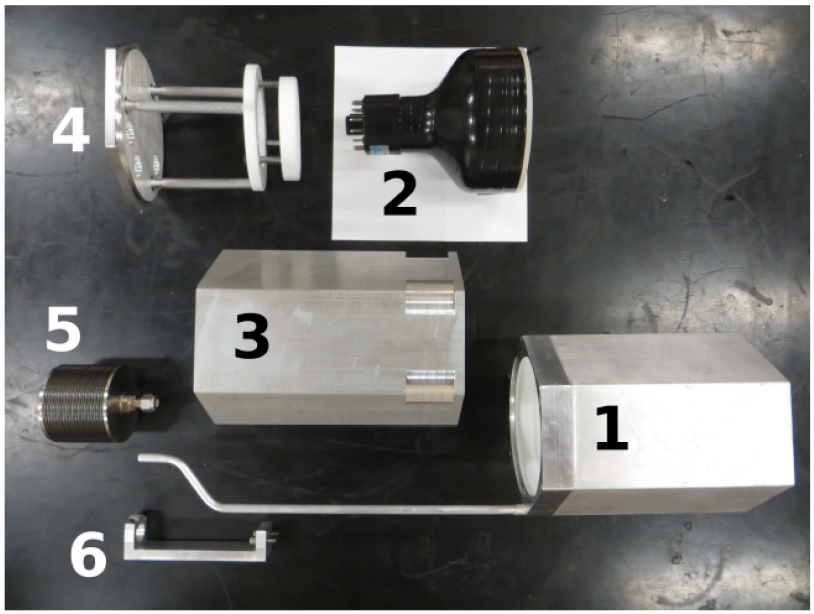
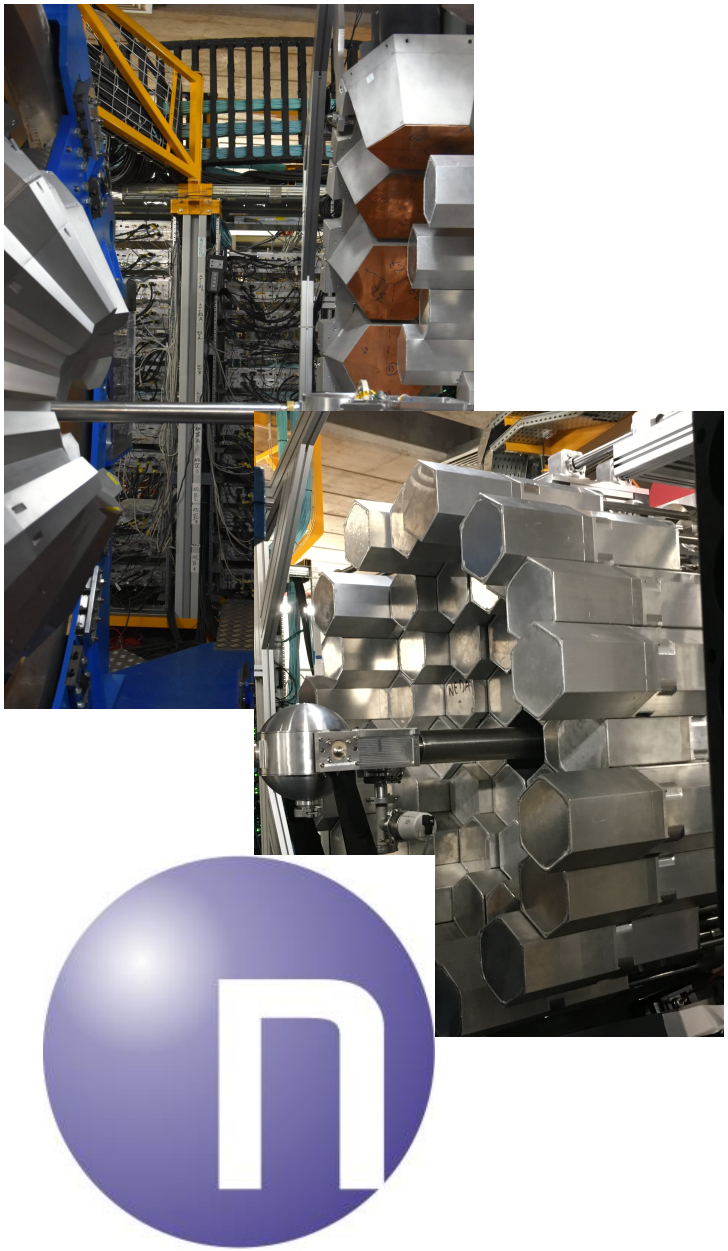


Fig. 1. Elements used for the construction of the NEDA detector: detector cell, with extension pipe (1); PMT (2); PMT housing (3); PMT pusher (4); the bellow (5) and the support for the bellow (6).

The NEDA-NeutronWall array



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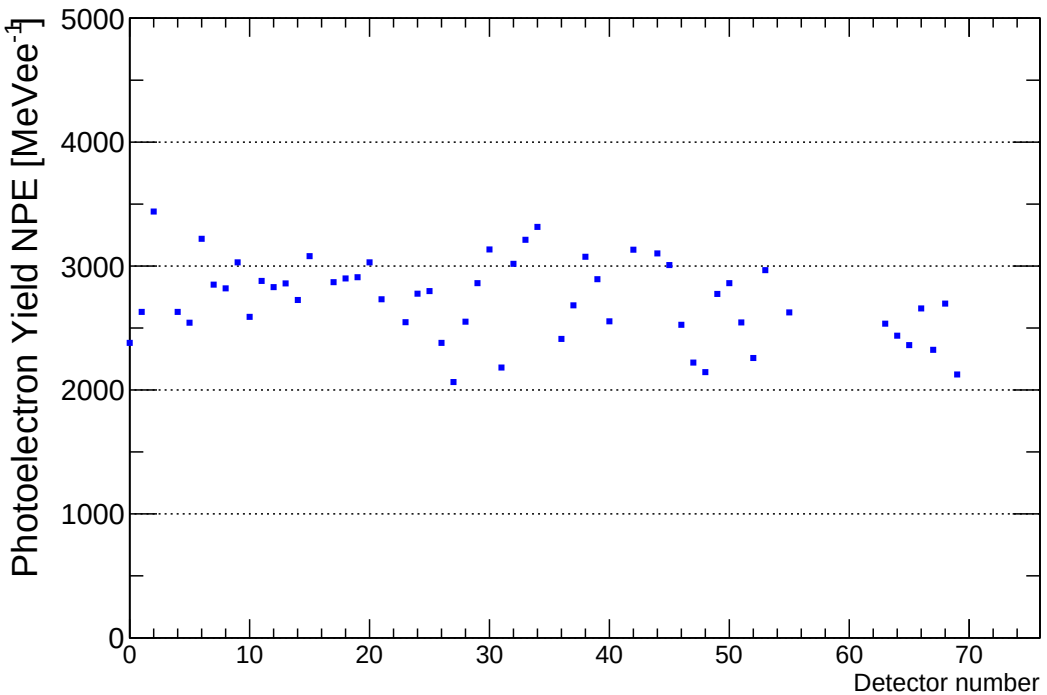
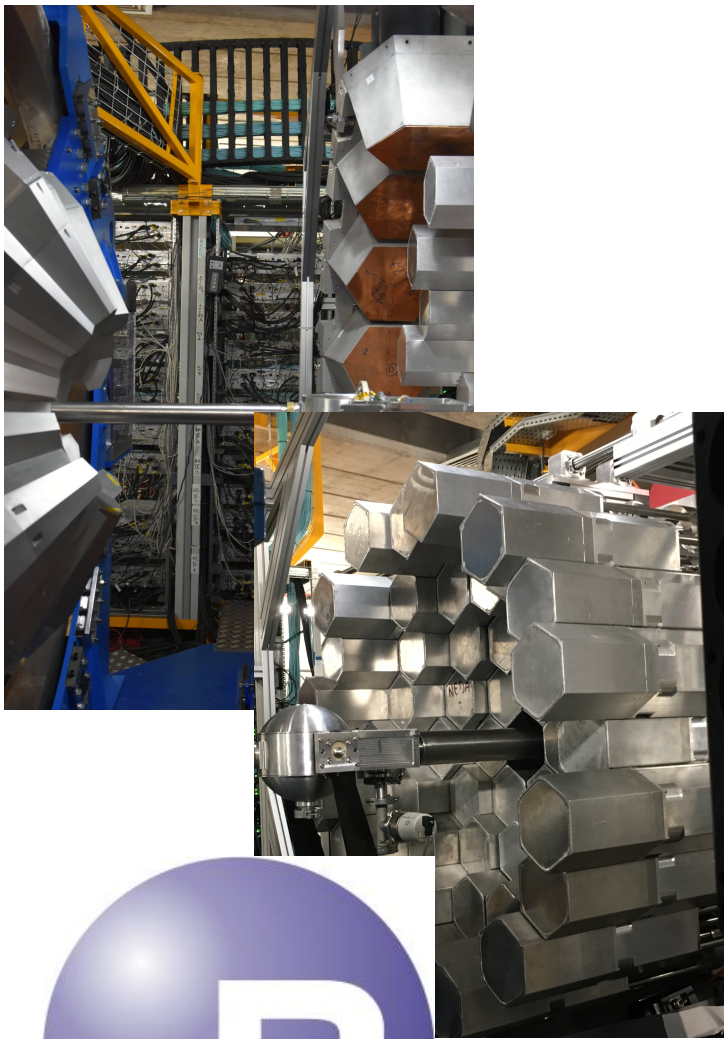
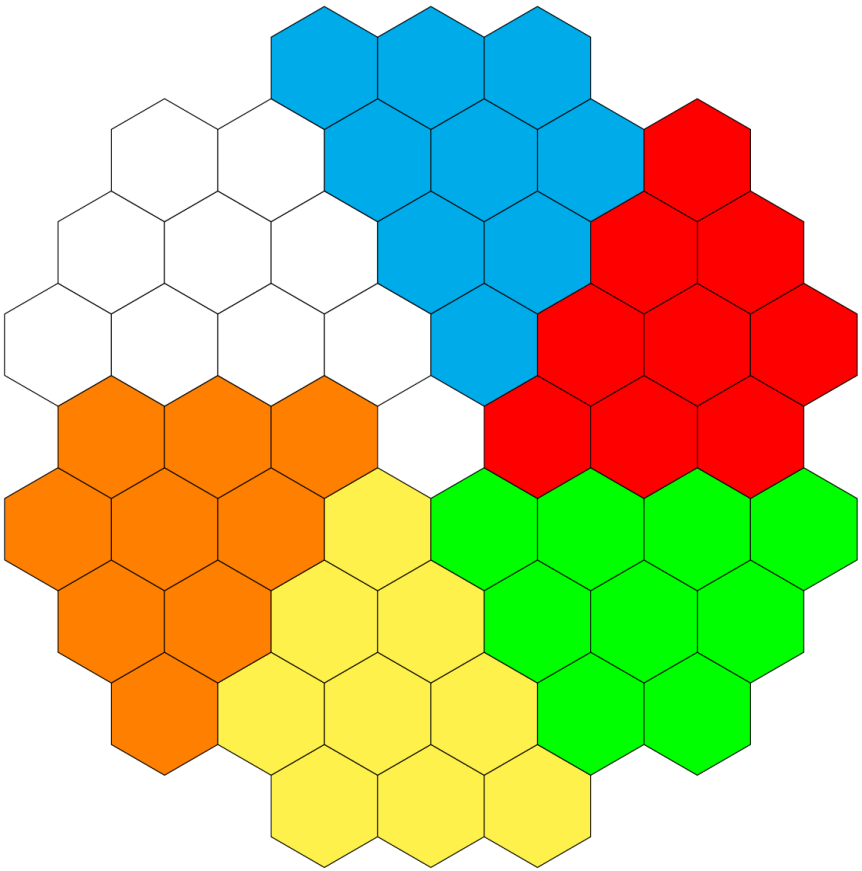


The NEDA-NeutronWall array



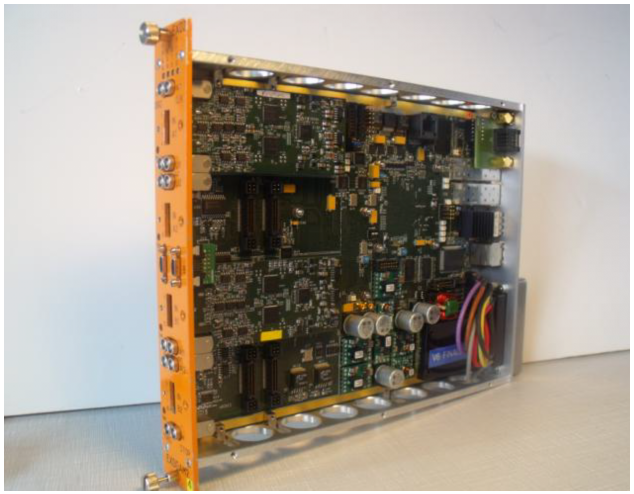
- **96 detectors** :
  - 42 NeutronWall (650 mm)
  - 54 NEDA (510 mm)
  - **Mixed on the electronic channels !**
- High quality home made detectors



The NEDA and DIAMANT FEE : NUMEXO2

NUMEXO2 Digitizers :

- 16 channels NIM modules :
  - 4 differential channels / mezzanine



The NEDA and DIAMANT FEE : NUMEXO2

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- 16 channels NIM modules :
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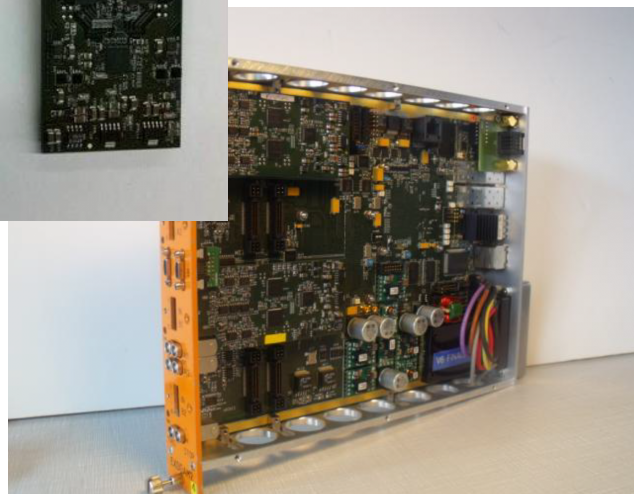
  - 4 mezzanines / board
  - HDMI inputs



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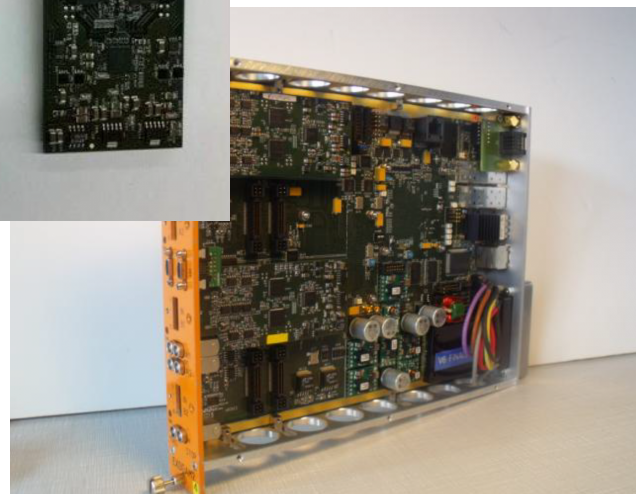
- Programmable FPGAs :
  - Signal processing : Xillinx Virtex6
  - Time-stamping & Readout : Xillinx Virtex5



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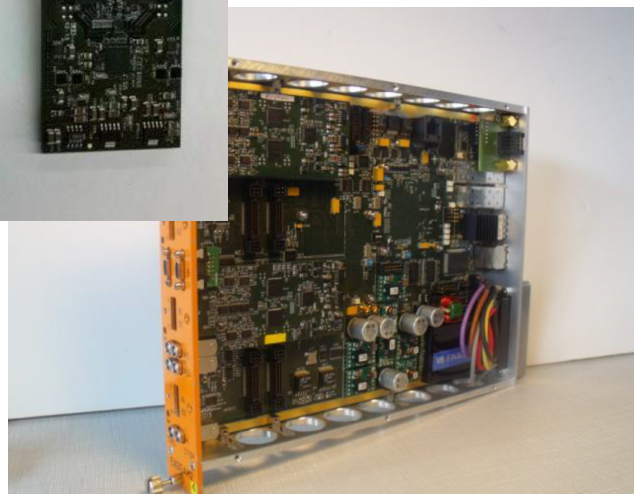
- Readout :
  - Ethernet ($\Longrightarrow$ DIAMANT)
  - Optical Fiber ($\Longrightarrow$ NEDA)



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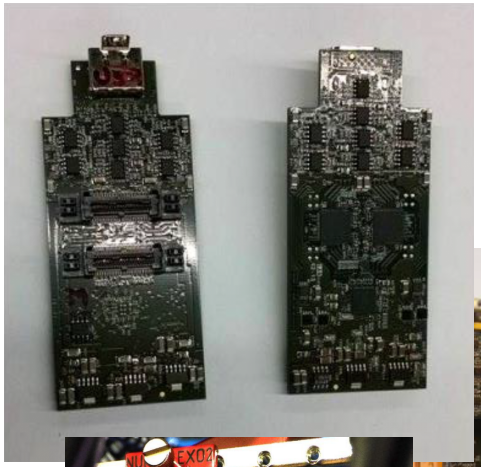
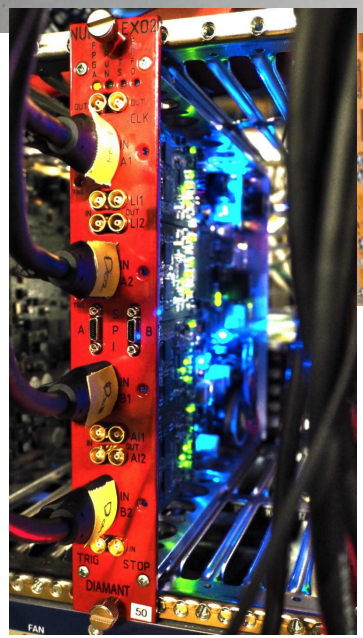
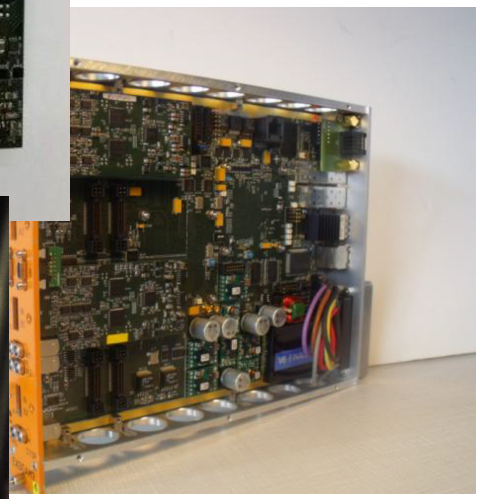
- Readout :
  - Ethernet ($\Longrightarrow$ DIAMANT)
  - Optical Fiber ($\Longrightarrow$ NEDA)
- GTS leaf implementation







Coupling with AGATA

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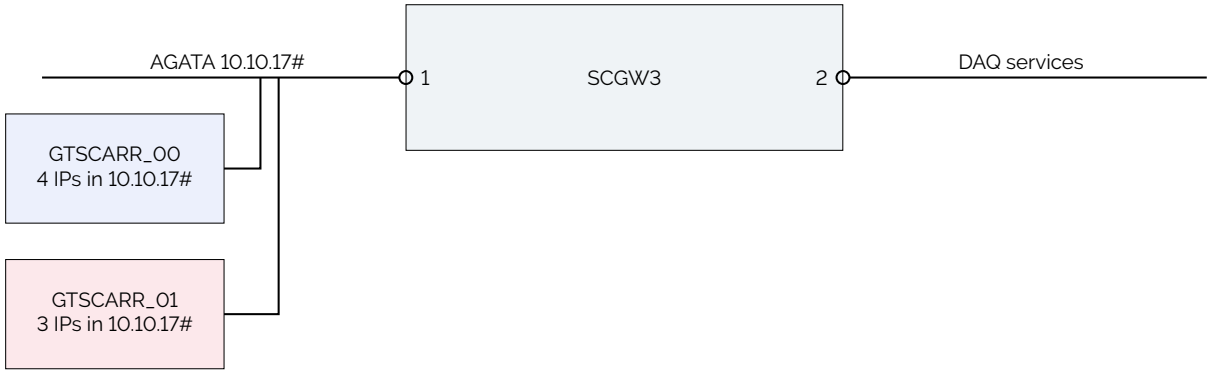
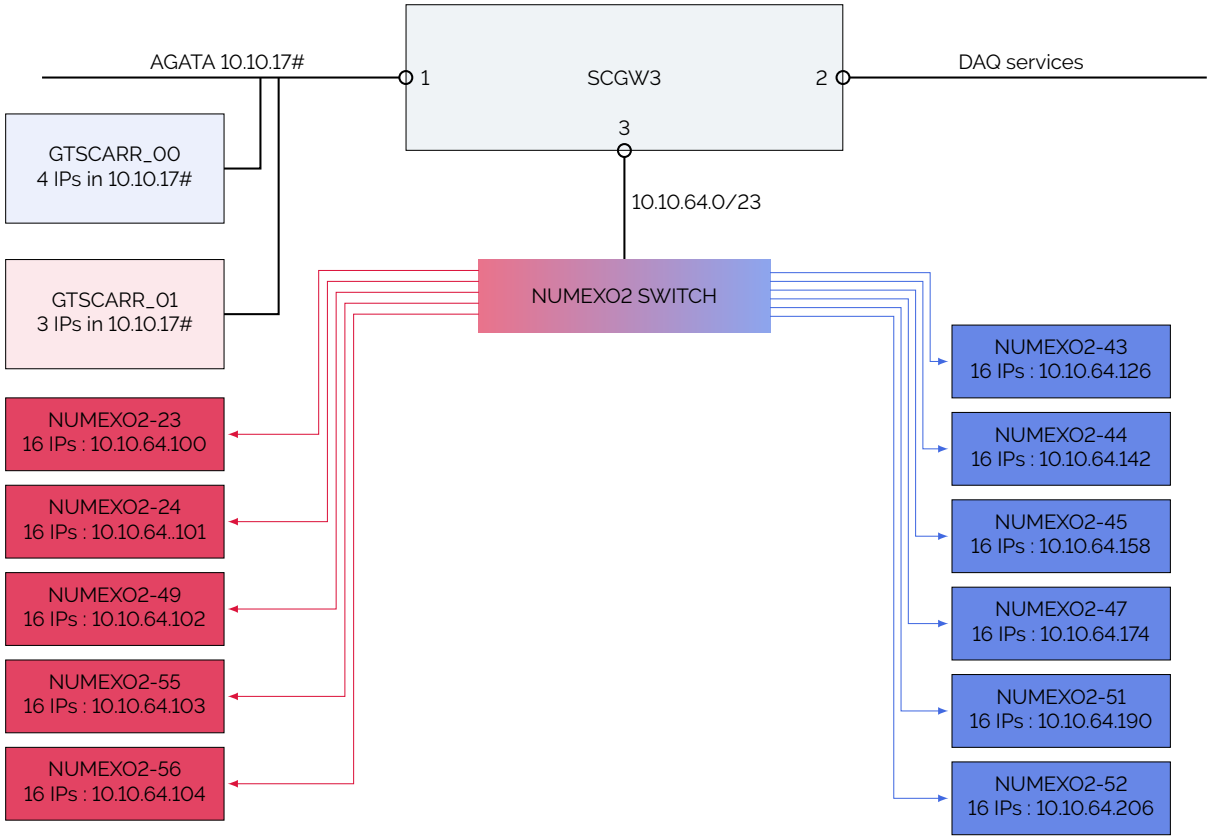
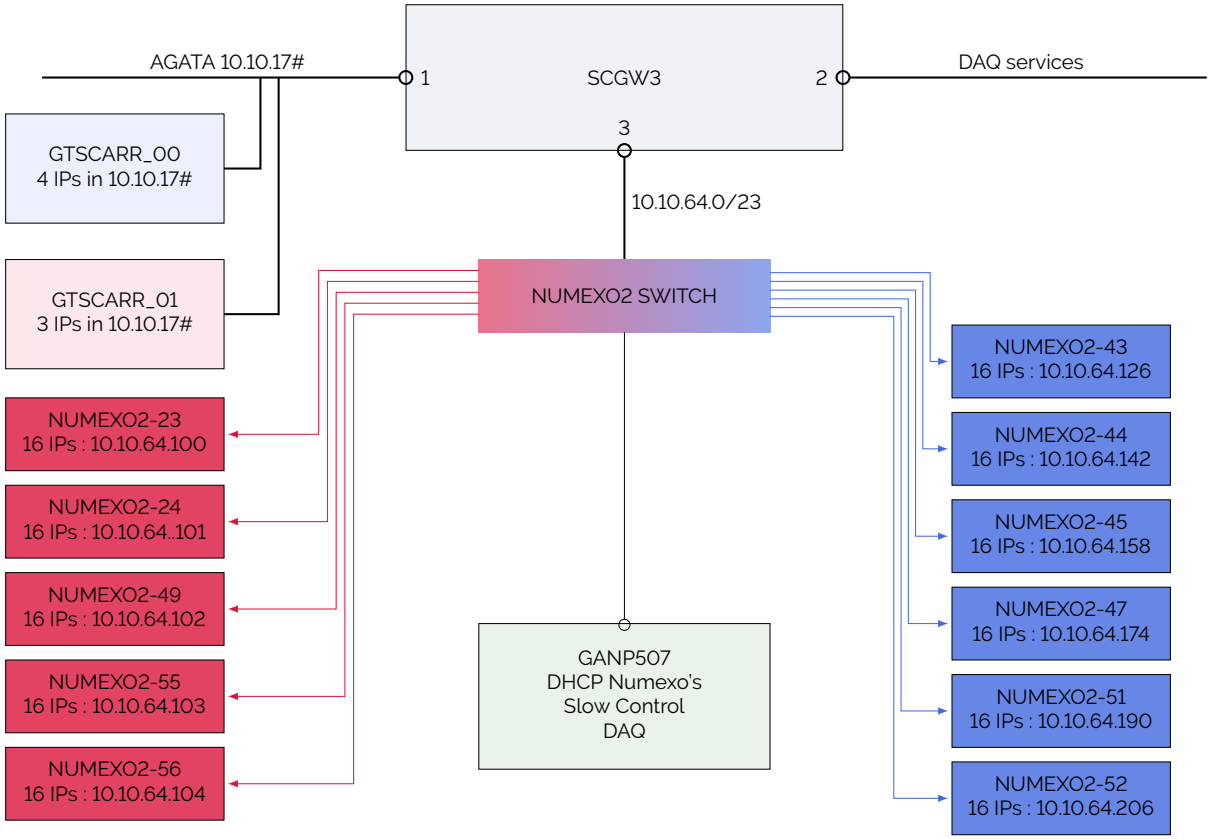


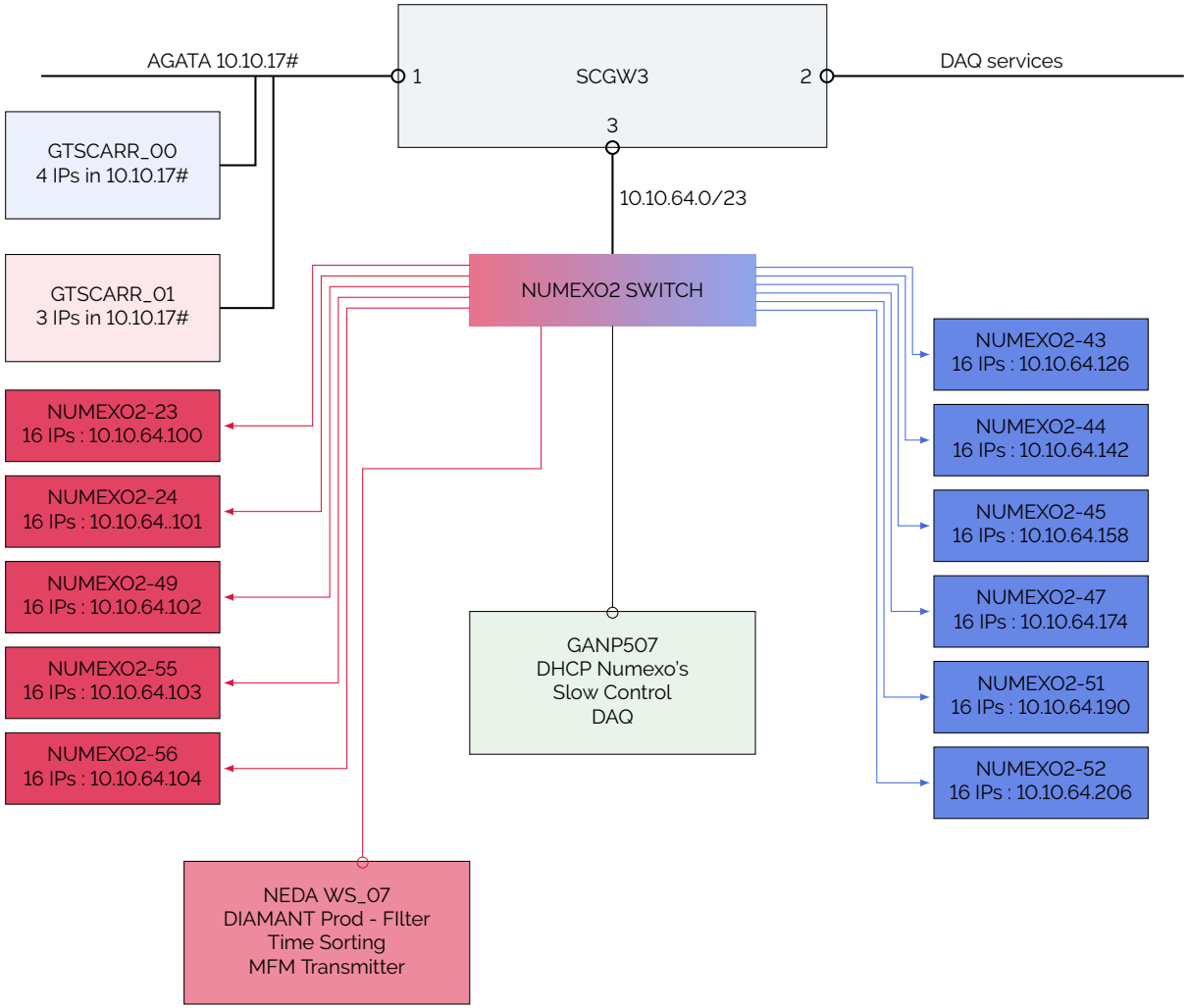
Coupling with AGATA



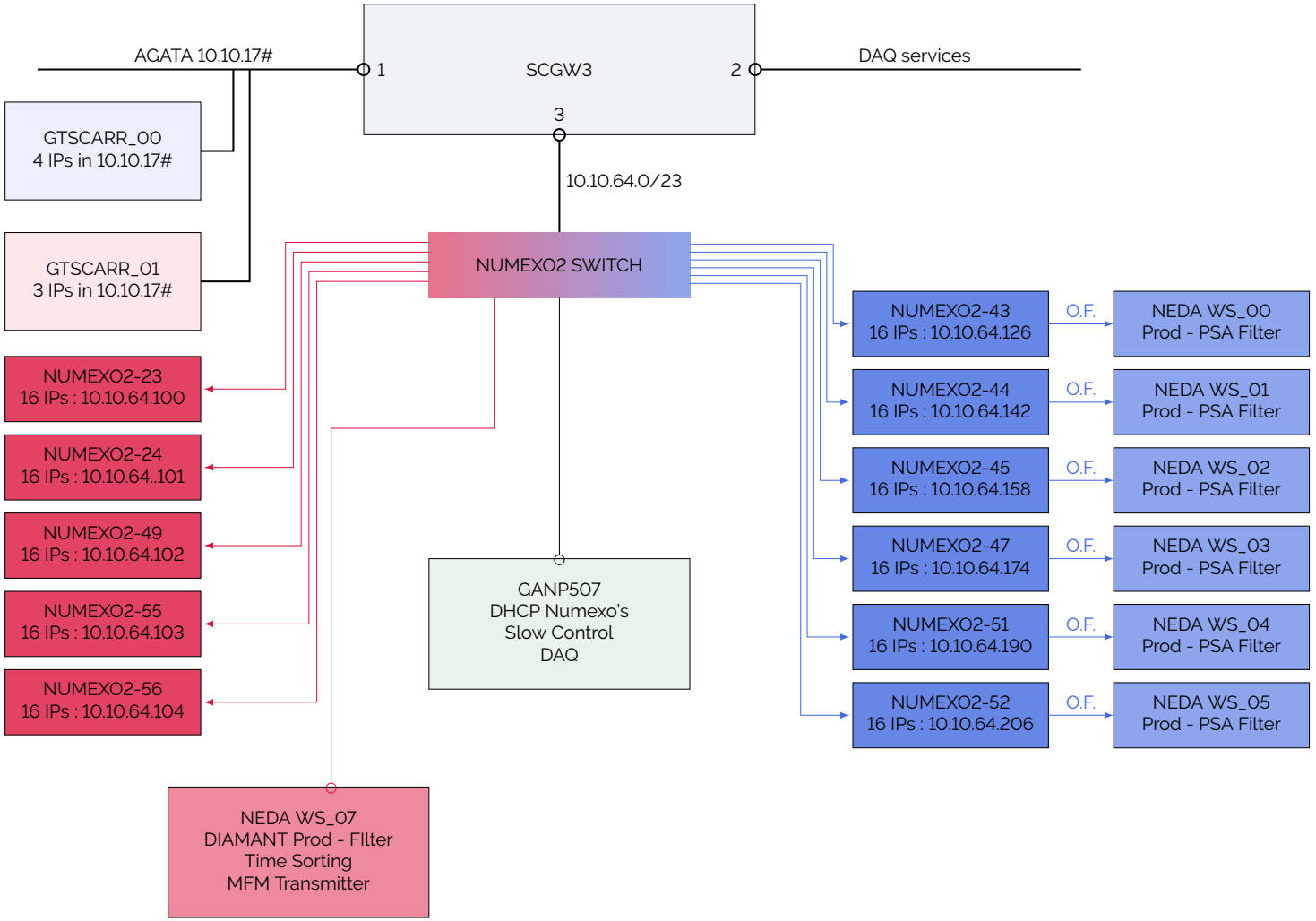
Coupling with AGATA



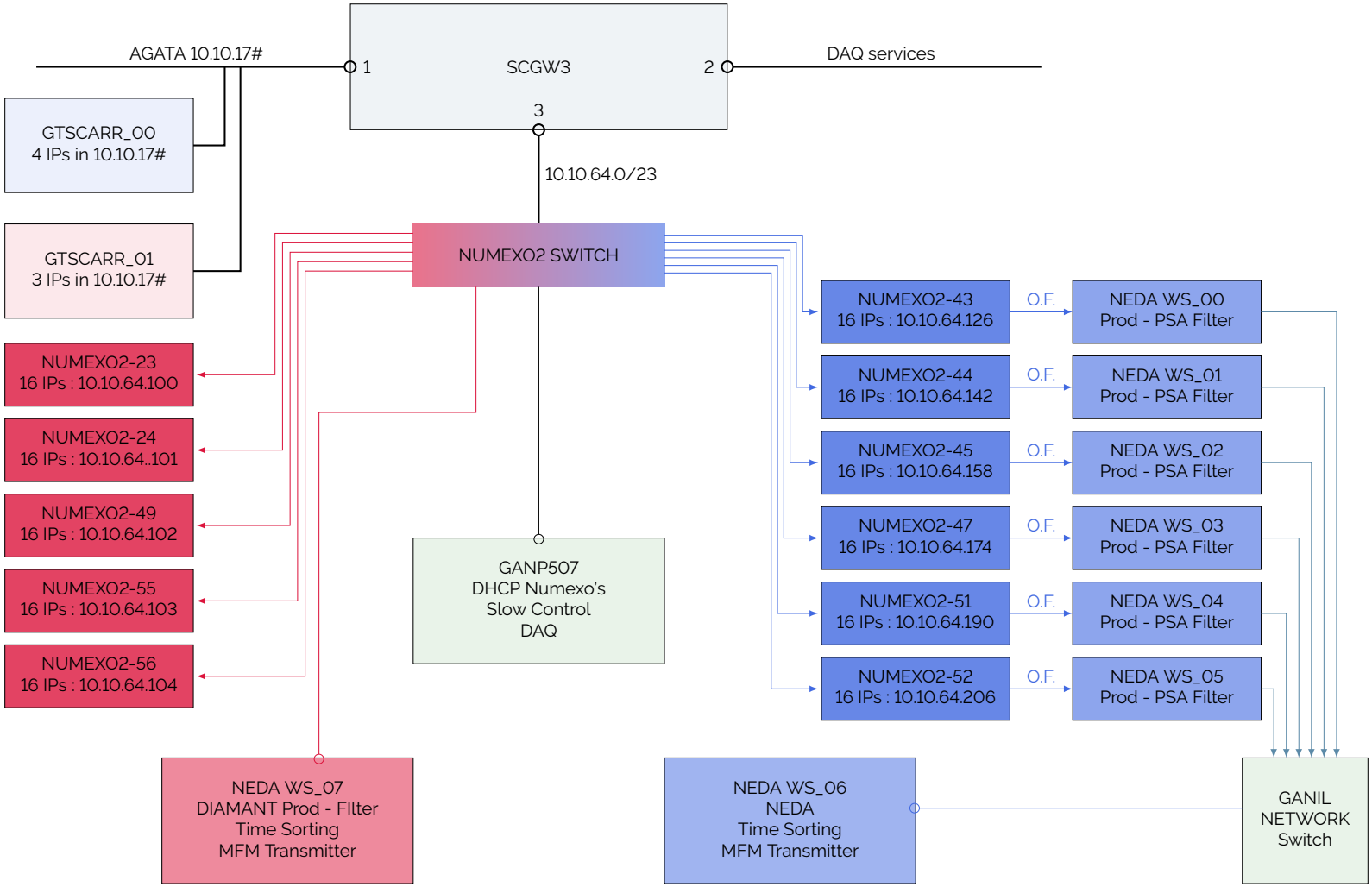
Coupling with AGATA



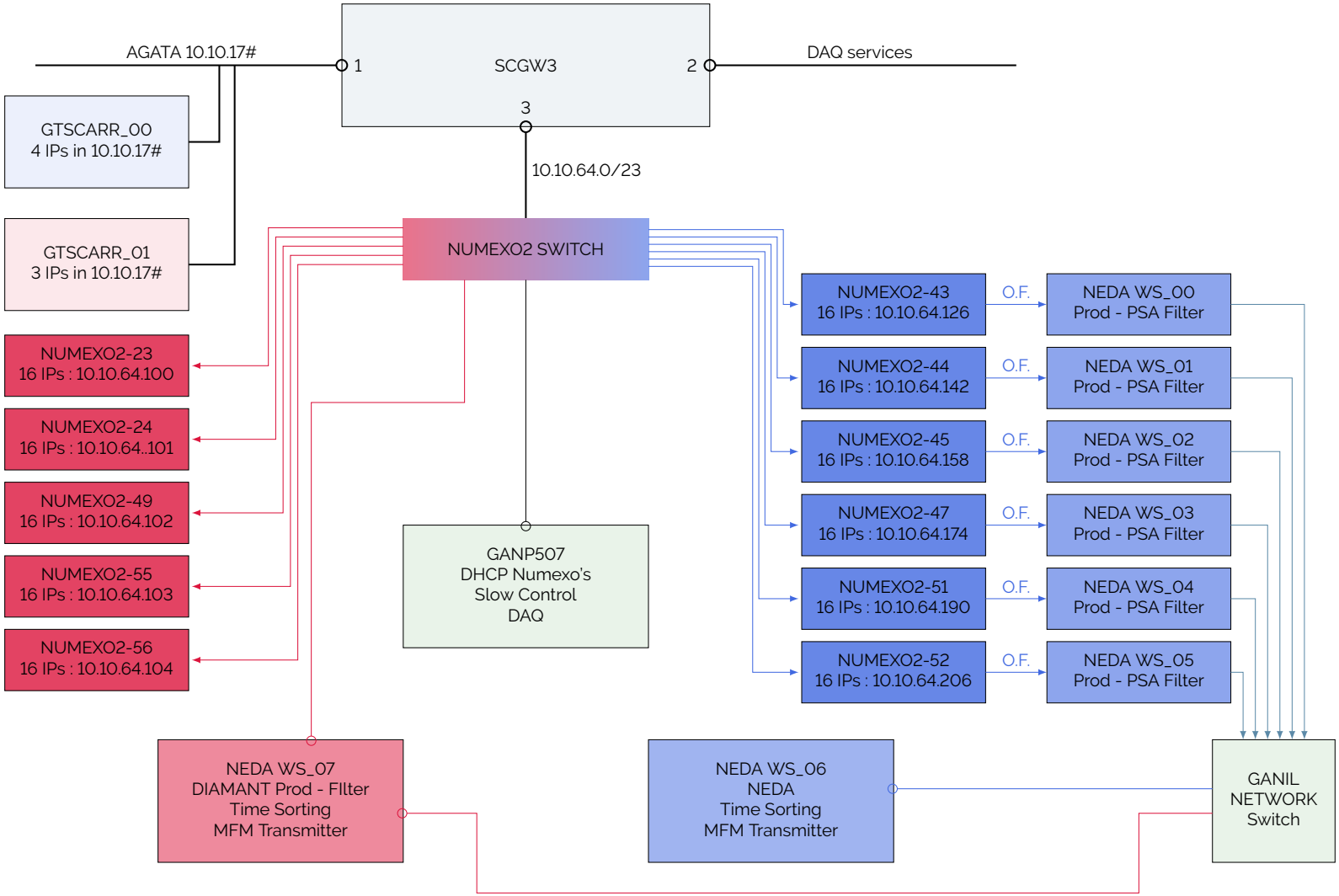
Coupling with AGATA



Coupling with AGATA



Coupling with AGATA



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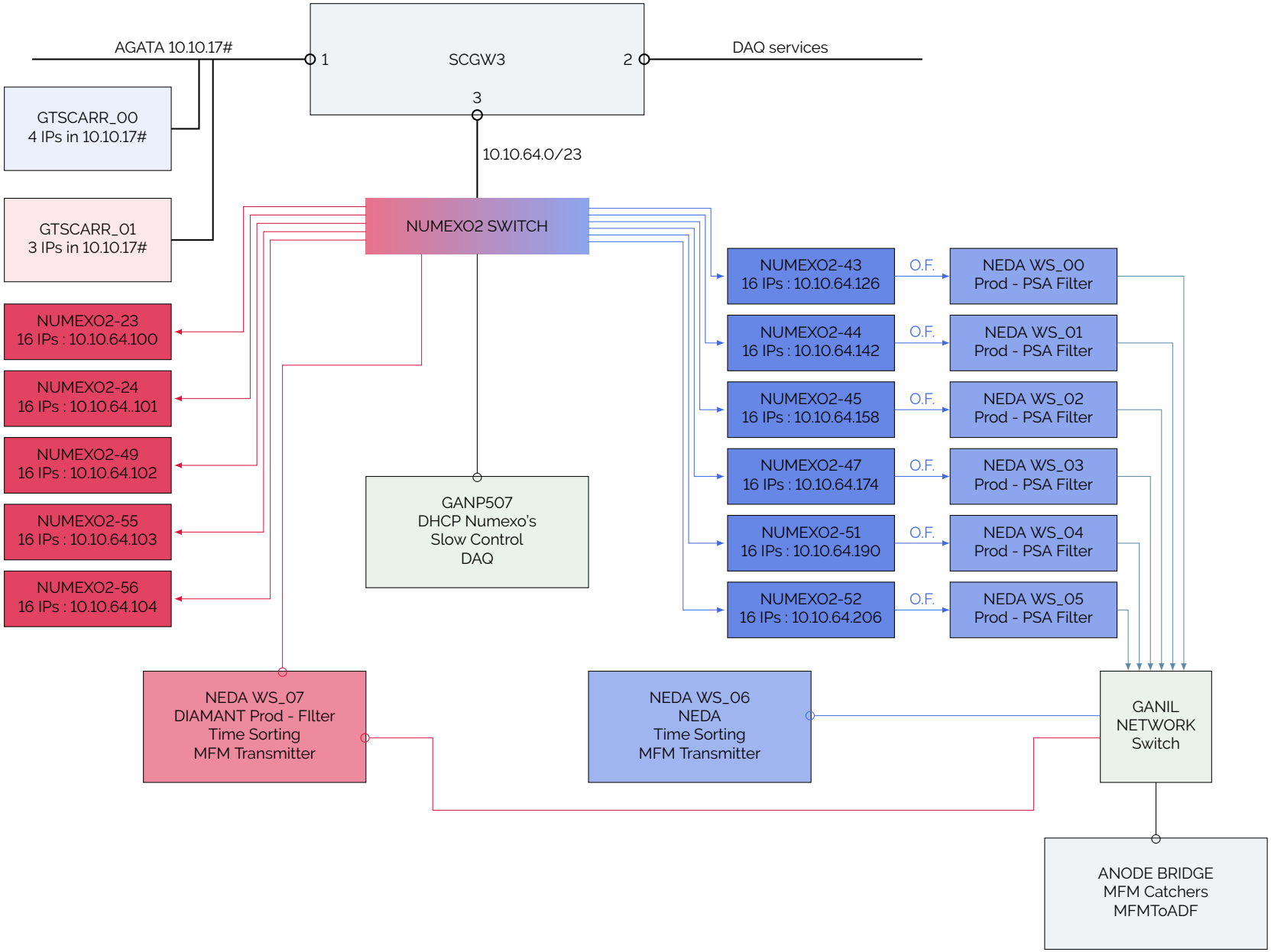
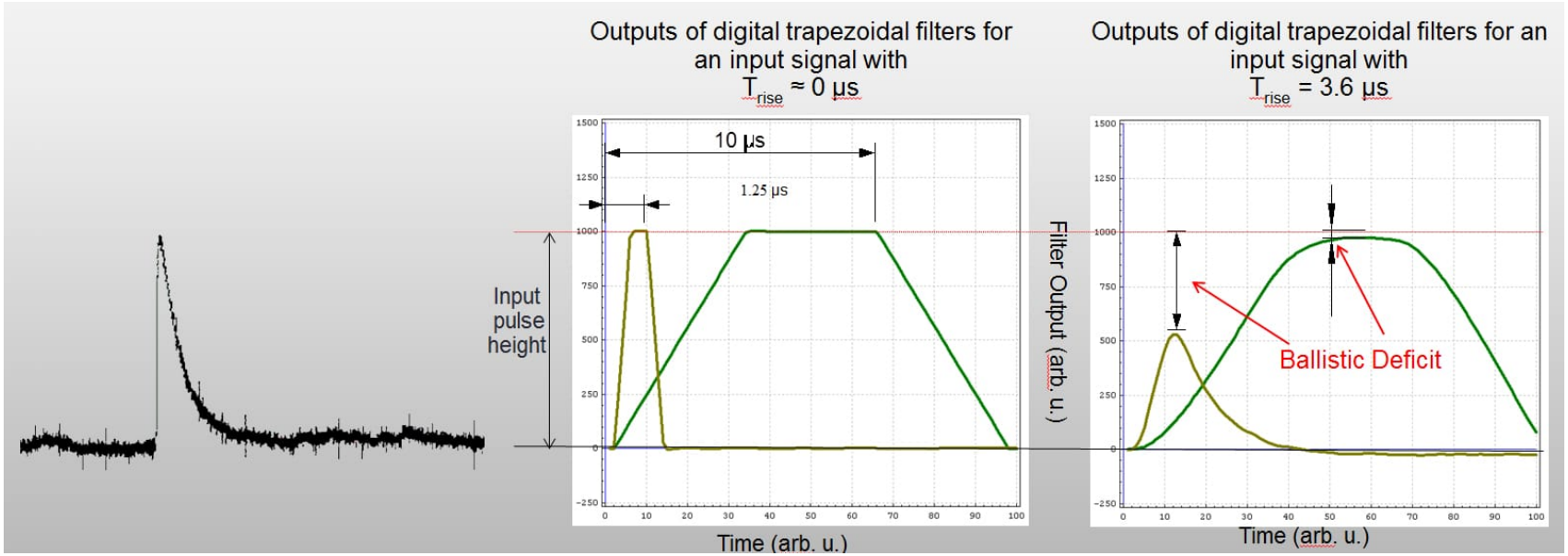


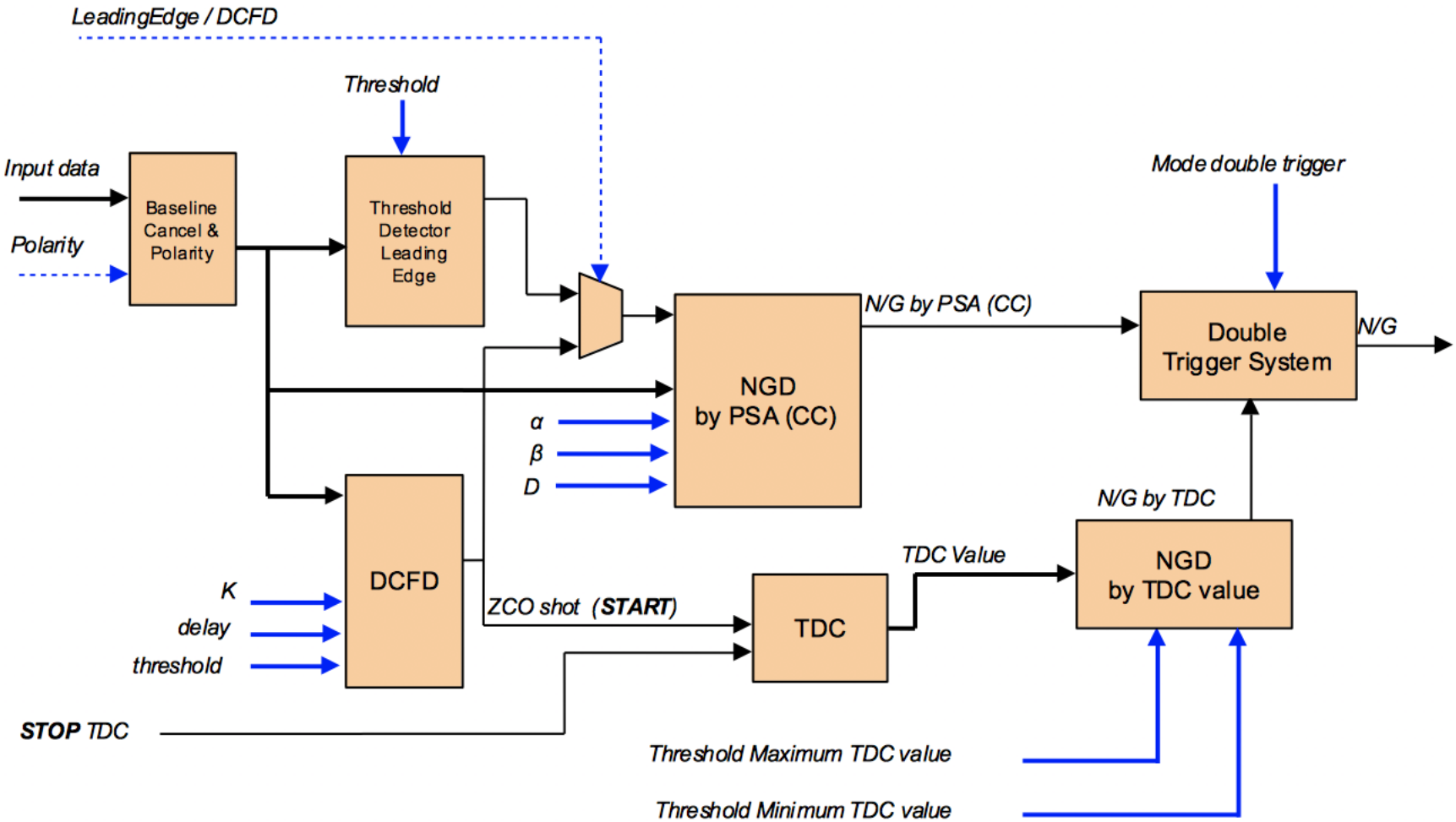
PARTICLE DISCRIMINATION AT THE FPGA LEVEL

The DIAMANT Virtex 6 firmware



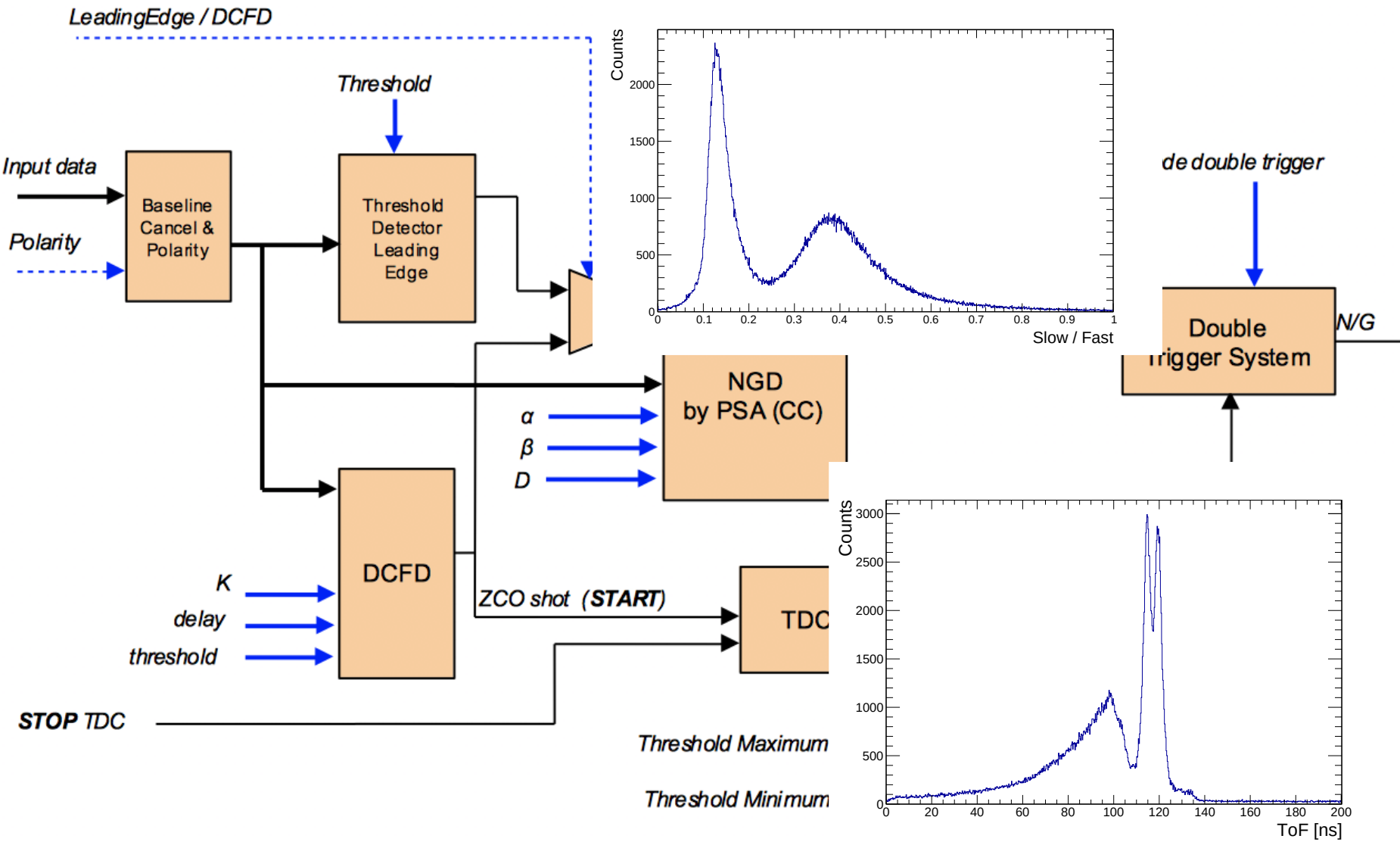
Courtesy of i. Kuti

The NEDA Virtex 6 firmware



Courtesy of J. M. Deltoro

The NEDA Virtex 6 firmware



Courtesy of J. M. Deltoro

NEDA AND DIAMANT FRAMES

The NEDA Frames

2 different frames :

- MFM NEDA Frame (From the board, 512 bytes)
  - Key (Frame Type, Length, TS, Channel, Board ID, ...)
  - TDC, Position of the CFD, LE, Slow and Fast Integration
  - Signal : 232 Samples

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  - Key (Frame Type, Length, TS, Channel, Board ID, ...)
  - TDC, Position of the CFD, LE, Slow and Fast Integration
  - Signal : 232 Samples

```
-- Read frame in file : nb = 1 ------------------------------------------------------
MFM header, Type :MFM_NEDA_FRAME_TYPE
   MetaType = 129(0x81)  Blob = 0  unitBlockSize = 2  frameSize = 512(0x200)  dataSource = 0(0x0)
   FrameType = 18(0x12)  revision = 1(0x1) pointer = 0x1f23100
   HeaderSize = 44  ItemSize = 2  NbItems = 232
   EN = 40093   TS = 35784725046560
   Board = 126 | Channel = 14 | LeInter = 52 | ZcoInterval = 61
   Tdc =  128 | Slow Integ = 141 | FastIntegral = 788 | Bitfield = 192| AbsMax = 200
 Event is neutron = 1 | Valid CFD = 0 | Parity = 1

    0 :  81 00 01 00 00 12 00 01 16 00 02 00 E8 00 00 00   ................
   16 :  EE 07 9D 9C 00 00 20 25 D3 C7 8B 20 34 3D 80 00   ...... %... 4=..
   32 :  00 00 8D 00 00 00 14 03 C0 C8 99 00 F5 39 F3 79   ............9.y
   48 :  F6 39 F6 79 F4 39 F6 79 F6 39 F5 79 F5 39 F6 79   .9.y.9.y.9.y.9.y
   64 :  F6 39 F4 79 F7 39 F4 79 F5 39 F4 79 F1 39 F2 79   .9.y.9.y.9.y.9.y
   80 :  F6 39 F6 79 F2 39 F3 79 F5 39 F3 79 F3 39 F5 79   .9.y.9.y.9.y.9.y
   96 :  F4 39 F4 79 F4 39 F2 79 F7 39 F3 79 F9 39 F0 79   .9.y.9.y.9.y.9.y
  112 :  F5 39 F7 79 F1 39 F3 79 F4 39 F5 79 F2 39 F3 79   .9.y.9.y.9.y.9.y
  128 :  F3 39 F5 79 F3 39 F2 79 F7 39 F2 79 F8 39 F4 79   .9.y.9.y.9.y.9.y
  144 :  F3 39 F2 79 E5 39 AF 79 69 39 44 79 65 39 8D 79   .9.y.9.yi9Dye9.y
  160 :  C1 39 D3 79 D6 39 E2 79 EC 39 E5 79 EA 39 ED 79   .9.y.9.y.9.y.9.y
  176 :  EF 39 EE 79 F0 39 EB 79 F3 39 F0 79 EA 39 F0 79   .9.y.9.y.9.y.9.y
  192 :  F1 39 F5 79 F1 39 E9 79 EF 39 F3 79 F3 39 F4 79   .9.y.9.y.9.y.9.y
  208 :  F0 39 ED 79 EB 39 F3 79 F1 39 F3 79 F3 39 F4 79   .9.y.9.y.9.y.9.y
  224 :  F5 39 F1 79 F2 39 F1 79 F8 39 F6 79 F0 39 F3 79   .9.y.9.y.9.y.9.y
  240 :  F2 39 F2 79 F3 39 F3 79 F5 39 EF 79 F1 39 F6 79   .9.y.9.y.9.y.9.y
  256 :  F8 39 F6 79 F4 39 F2 79 F9 39 F2 79 F5 39 F2 79   .9.y.9.y.9.y.9.y
  272 :  F6 39 F3 79 F7 39 F5 79 F6 39 F4 79 F1 39 EF 79   .9.y.9.y.9.y.9.y
  288 :  F0 39 F4 79 F0 39 F5 79 F7 39 F3 79 F3 39 F5 79   .9.y.9.y.9.y.9.y
  304 :  F7 39 F4 79 F2 39 F8 79 F3 39 F5 79 F2 39 F4 79   .9.y.9.y.9.y.9.y
  320 :  F7 39 F5 79 F6 39 F3 79 F3 39 F3 79 F4 39 F7 79   .9.y.9.y.9.y.9.y
  336 :  F5 39 F6 79 F5 39 F5 79 F5 39 FA 79 F6 39 F4 79   .9.y.9.y.9.y.9.y
  352 :  F2 39 F9 79 F4 39 F3 79 F6 39 F4 79 F3 39 F8 79   .9.y.9.y.9.y.9.y
  368 :  F4 39 F8 79 F5 39 F3 79 F5 39 F4 79 F8 39 F6 79   .9.y.9.y.9.y.9.y
  384 :  F3 39 F5 79 F3 39 F6 79 F3 39 F4 79 F5 39 F5 79   .9.y.9.y.9.y.9.y
  400 :  FA 39 F8 79 F5 39 F6 79 F3 39 F6 79 F8 39 F4 79   .9.y.9.y.9.y.9.y
  416 :  F4 39 F3 79 F2 39 F1 79 F4 39 F7 79 F4 39 F3 79   .9.y.9.y.9.y.9.y
  432 :  F4 39 F4 79 F6 39 F3 79 F5 39 F5 79 F5 39 F5 79   .9.y.9.y.9.y.9.y
  448 :  F3 39 F5 79 F6 39 F6 79 F2 39 F2 79 F8 39 F5 79   .9.y.9.y.9.y.9.y
  464 :  F4 39 F4 79 F2 39 F8 79 F4 39 F1 79 F5 39 F2 79   .9.y.9.y.9.y.9.y
  480 :  F3 39 F4 79 F9 39 F4 79 F5 39 F5 79 F5 39 F3 79   .9.y.9.y.9.y.9.y
  496 :  F5 39 F1 79 F3 39 F4 79 F3 39 F4 79 F0 F0 F0 F0   .9.y.9.y.9.y....
```

The NEDA Frames

2 different frames :

- MFM NEDA Frame (From the board, 512 bytes)
  - Key (Frame Type, Length, TS, Channel, Board ID, ...)
  - TDC, Position of the CFD, LE, Slow and Fast Integration
  - Signal : 232 Samples

- MFM Compressed NEDA Frame (after the PSA, 42 bytes)
  - Key (Frame Type, Length, TS, Channel, Board ID, ...)
  - TDC, Position of the CFD, LE
  - PSA outputs : (NN), IRT, Slow and Fast Integration

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```
-- Read frame in file : nb = 0 ------------------------------------------------------
MFM header, Type :MFM_NEDACOMP_FRAME_TYPE
   MetaType = 193(0xc1)  Blob = 1  unitBlockSize = 2  frameSize = 42(0x2a)  dataSource = 0(0x0)
   FrameType = 19(0x13)  revision = 1(0x1) pointer = 0xd900f0
   EN = 40093   TS = 35784725046560
   Board = 126 | Channel = 14 | TdcCorValue = 16184 | Time = 35515 | IntRaiseTime =  2563
   Slow Integ = 122 | FastIntegral = 798 | NeuralNetWork = 0 | NbZero = 0 | NeutronFlag = 0

    0 :  C1 15 00 00 00 13 00 01 9D 9C 00 00 20 25 D3 C7   ............ %..
   16 :  8B 20 EE 07 7D 03 BB 8A 38 3F 7A 00 00 00 1E 03   . ..}...8?z.....
   32 :  00 00 03 0A 00 00 00 00 00 00   ..........
```

The DIAMANT frame

- MFM DIAMANT Frame (From the board, 32 bytes)
  - Key (Frame Type, Length, TS, Channel, Board ID, ...)
  - Energy, Top

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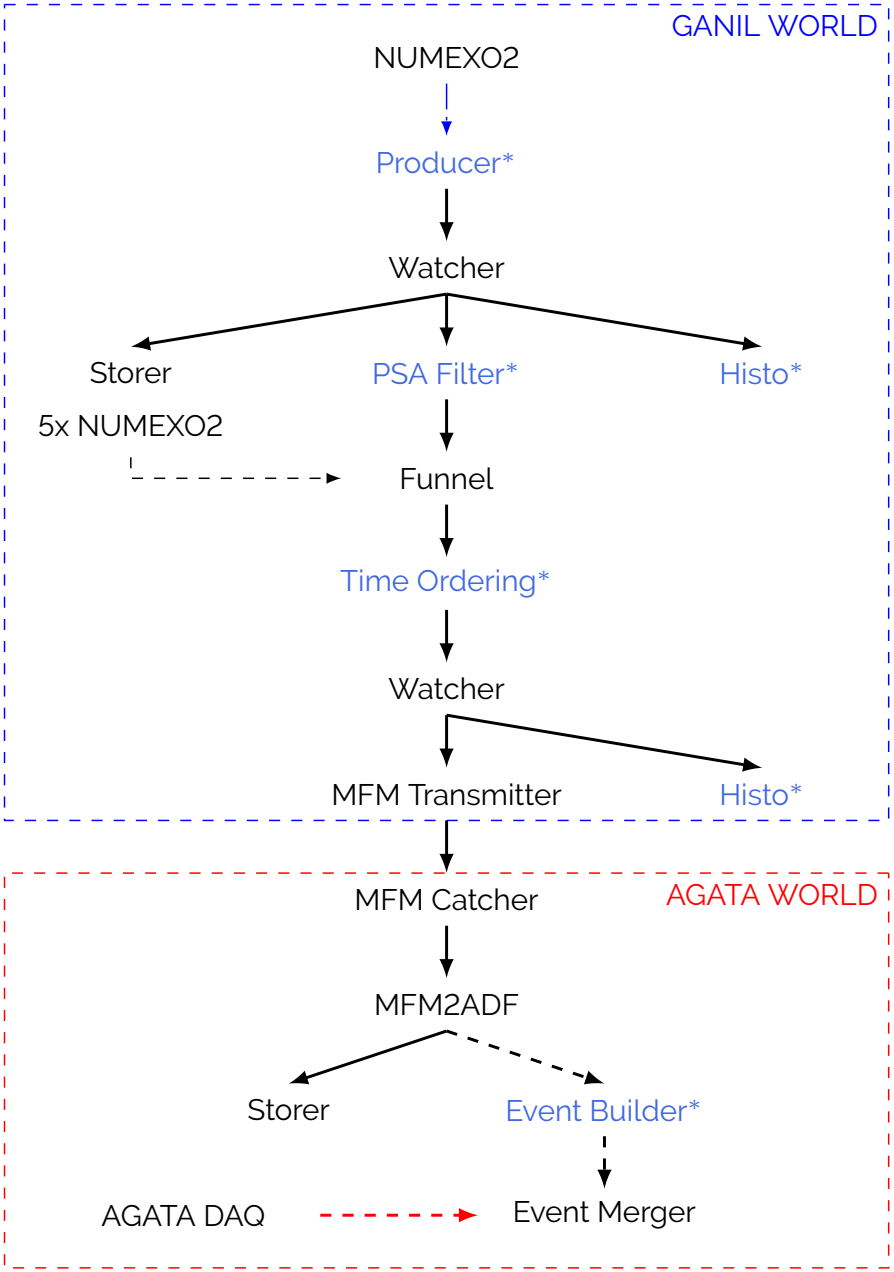
  - Key (Frame Type, Length, TS, Channel, Board ID, ...)
  - Energy, Top

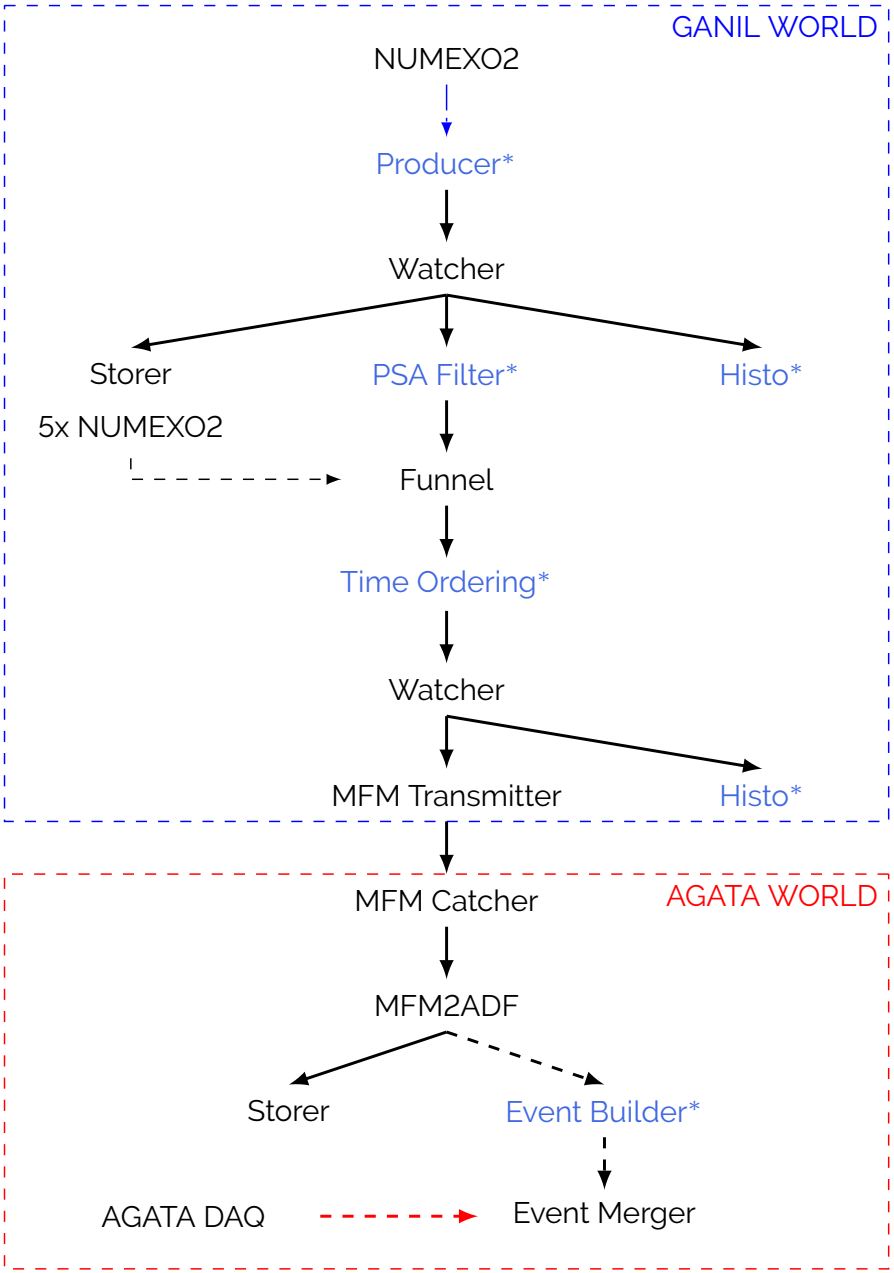
```
-- Read frame in file : nb = 1 ------------------------------------------------------
MFM_DIAMANT_FRAME_TYPE
   MetaType = 66(0x42)  Blob = 1  unitBlockSize = 4  frameSize = 32(0x20)  dataSource = 0(0x0)
   FrameType = 22(0x16)  revision = 0(0x0) pointer = 0x20570f0
   EN = 0   TS = 21642995842298
   Board = 100 | Channel = 6
   Energy = 1485078 | Top = 109370
    0 :  42 00 00 08 00 00 16 00 00 00 00 00 13 AF 27 14   B.............'.
   16 :  3C FA 0C 86 00 00 00 16 A9 16 00 01 AB 3A B8 F5   <.............:..
```

DATA ACQUISITIONS

Data Acquisition - NEDA



Data Acquisition - NEDA



Expected rates for the typical experiment :
$\sim$ 180 Hz / detector / 1 pnA (1γ-1n trigger)
$\Longrightarrow$ $\sim$ 1.5 MB/s of traces / board

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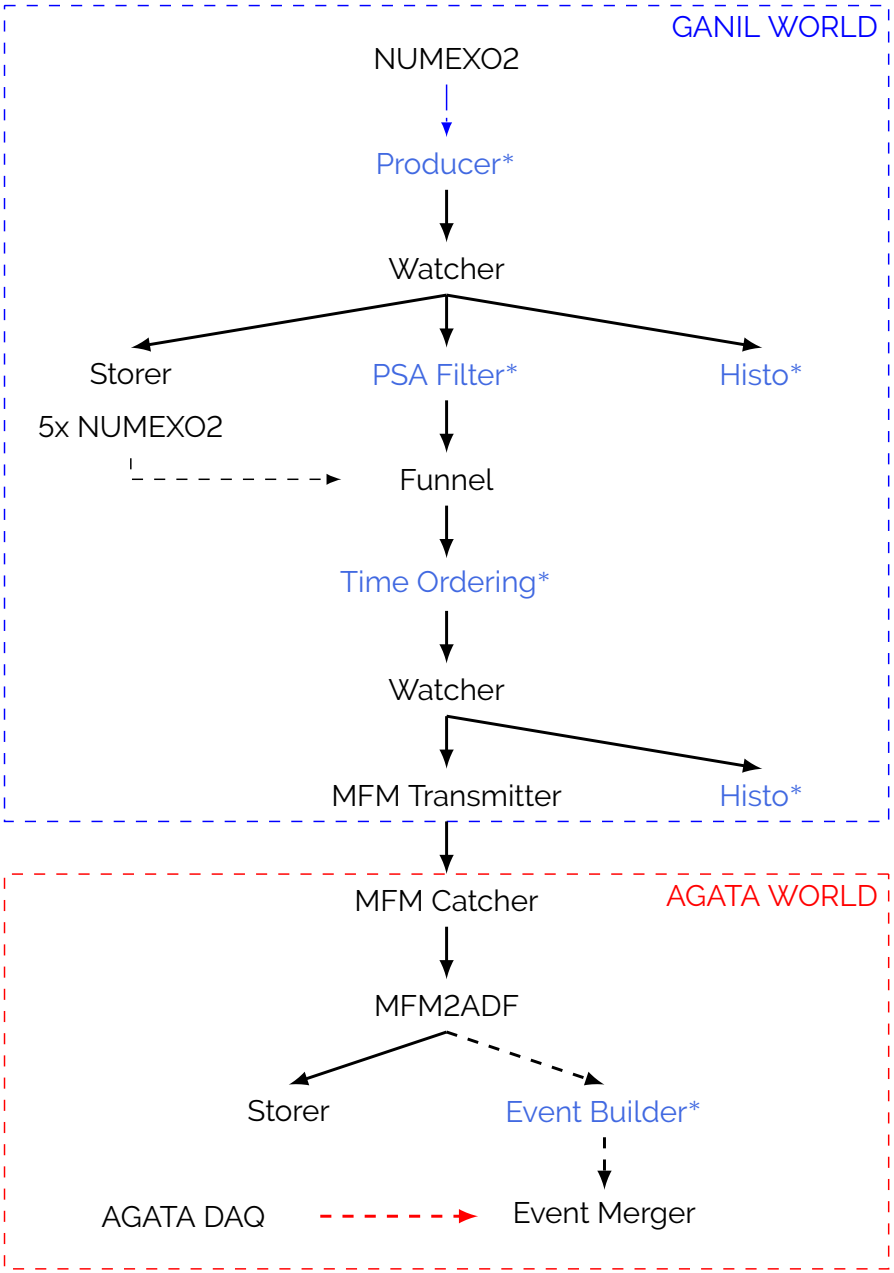

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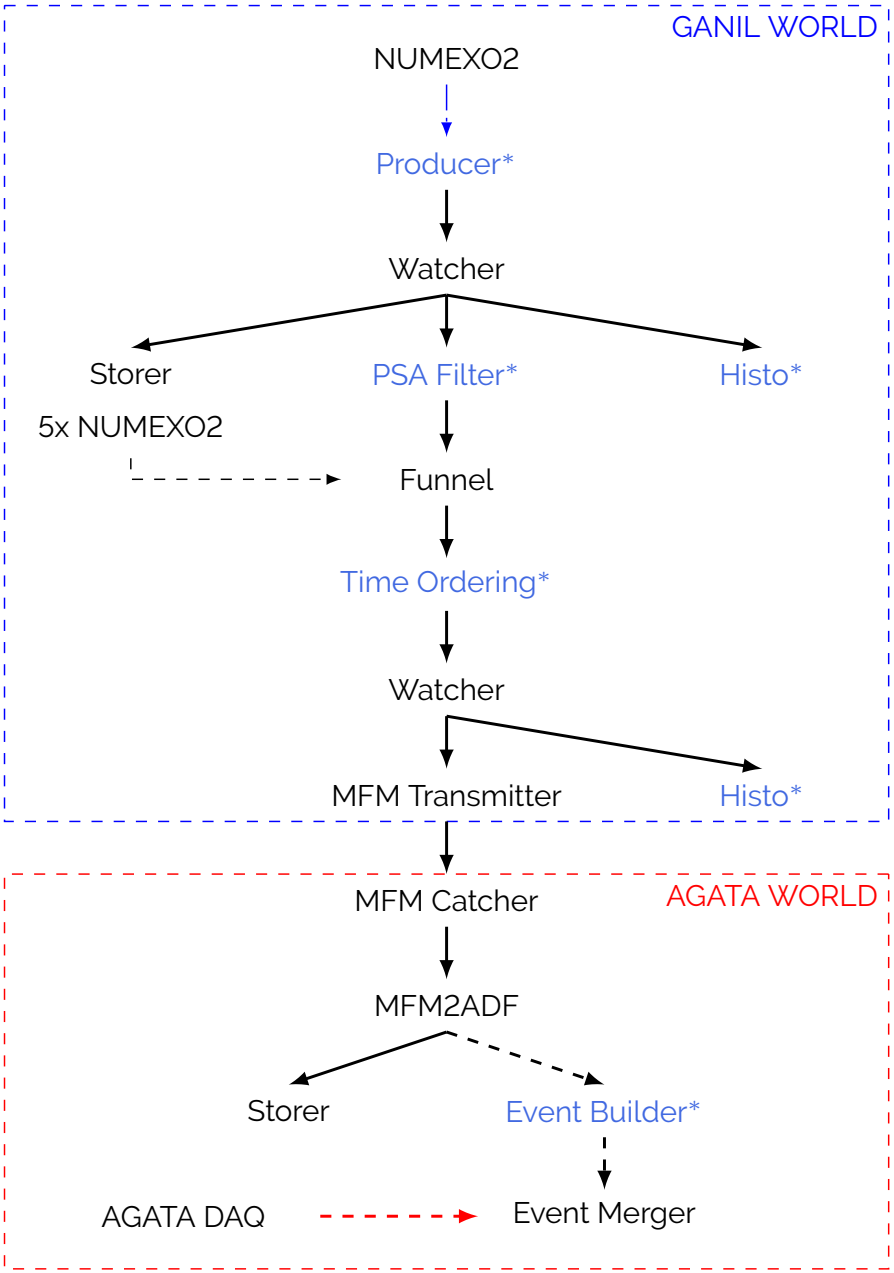

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- 300-400 Hz / NeutronWall

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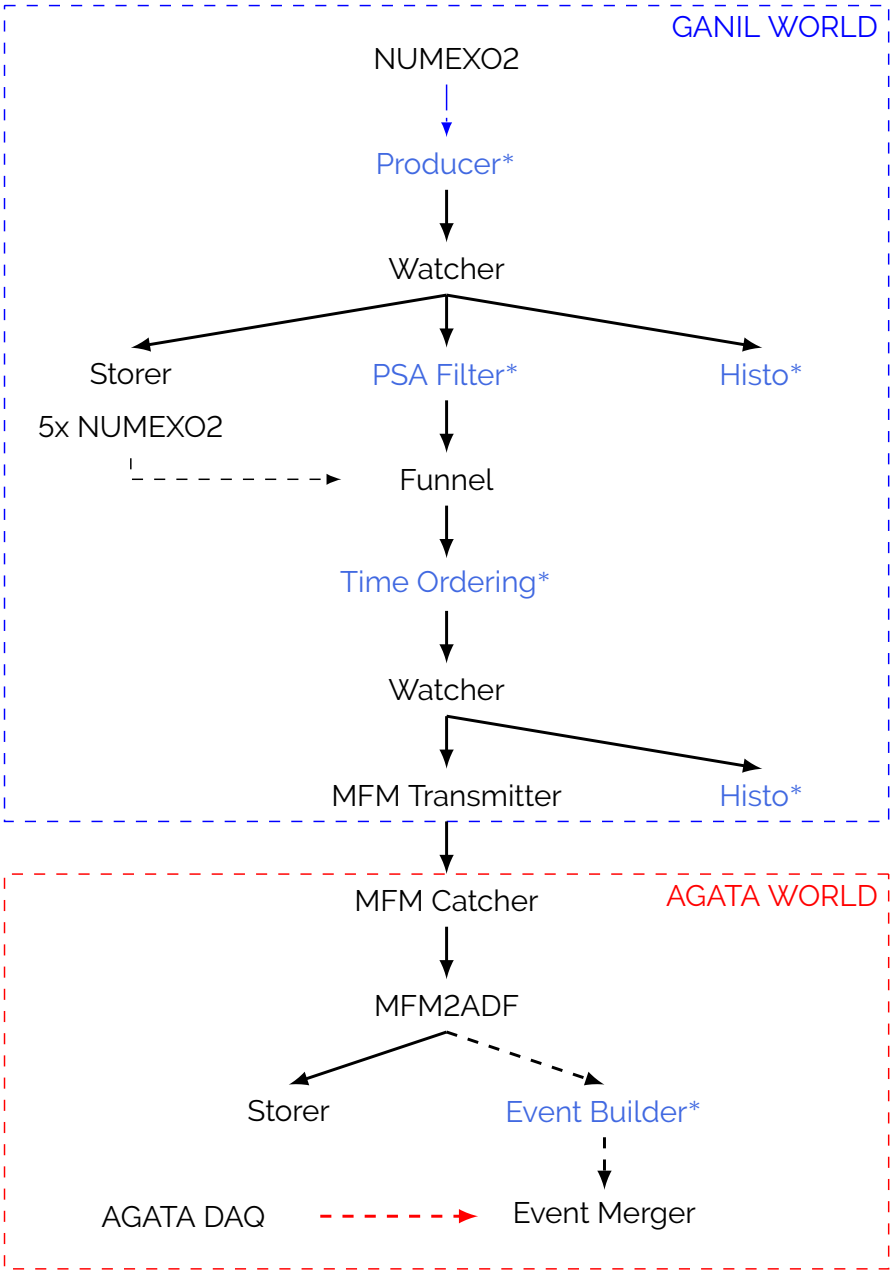

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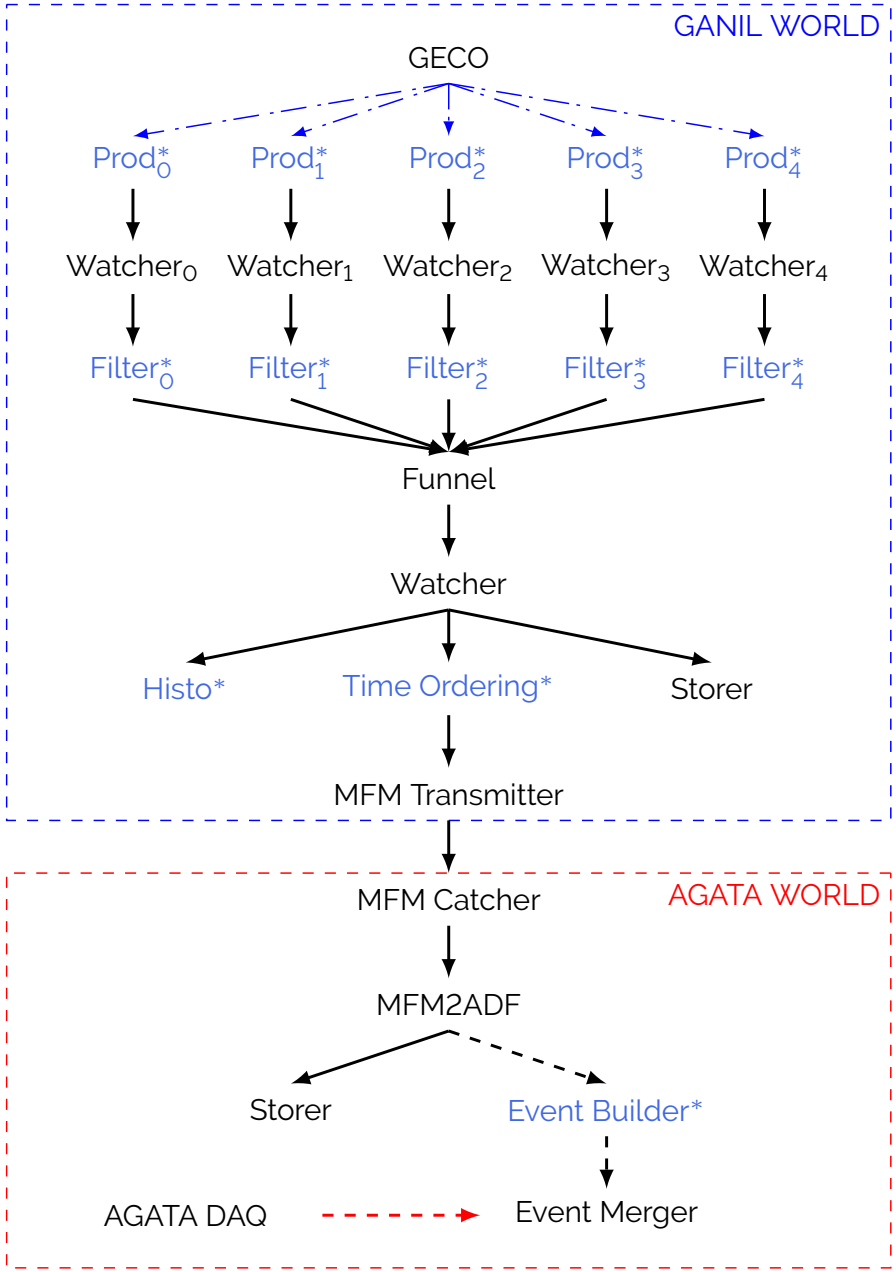
TP Validations : About 50-60 % of the neutrons
$\Longrightarrow$ $\sim$ 1.6 MB/s of traces (/board)
$\Longrightarrow$ $\sim$ 0.15 MB/s of post-PSA
$\Longrightarrow$ $\sim$ 0.24 MB/s on ADF Storer

Data Acquisition - DIAMANT



WHAT DO YOU DO WITH THOSE WONDERFUL TBs OF DATA ?

At the local level ...

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Only for NEDA

Why to bother saving the traces?

- Time resolution of the raw TDC value

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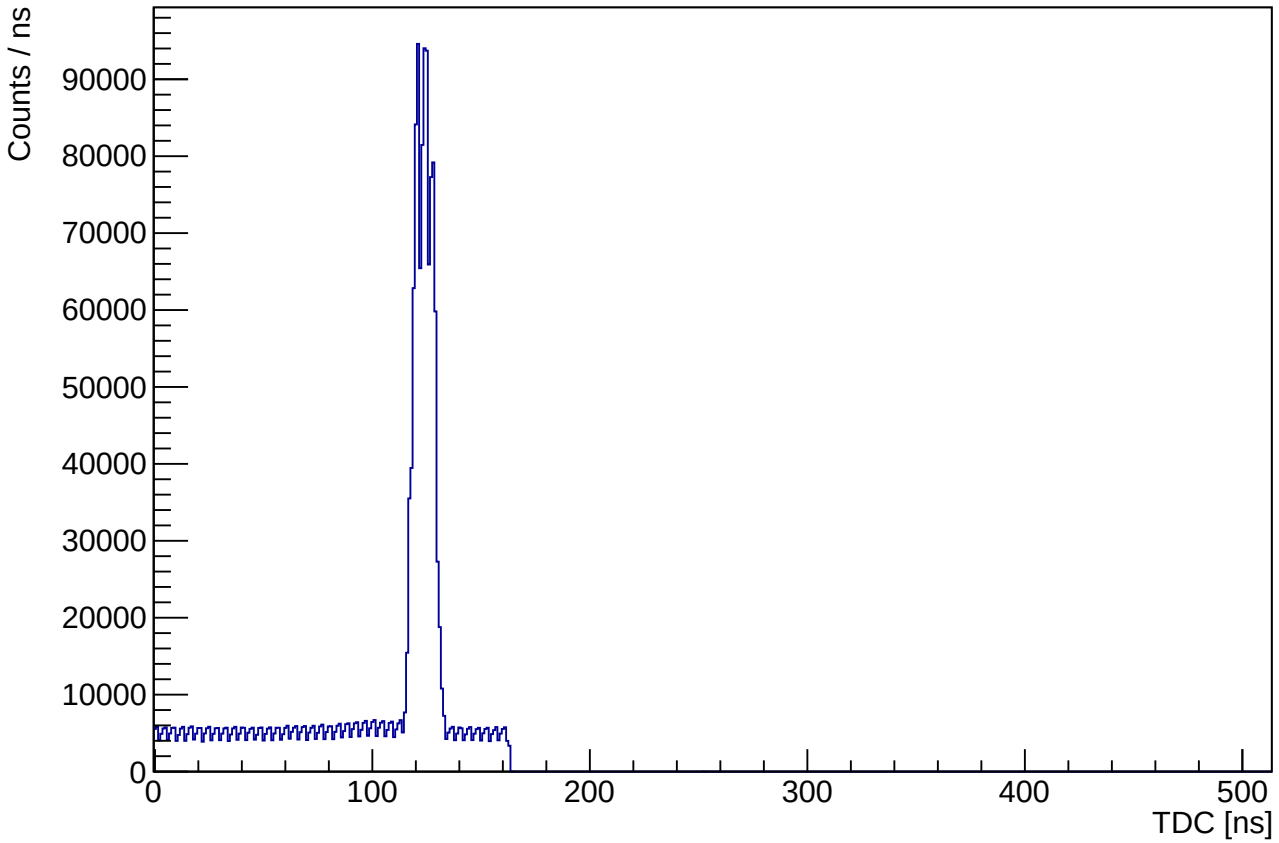
  - Correction of the TDC and resolution :
    - raw TDC FHWM$_\gamma$ $\sim$ 15 ns



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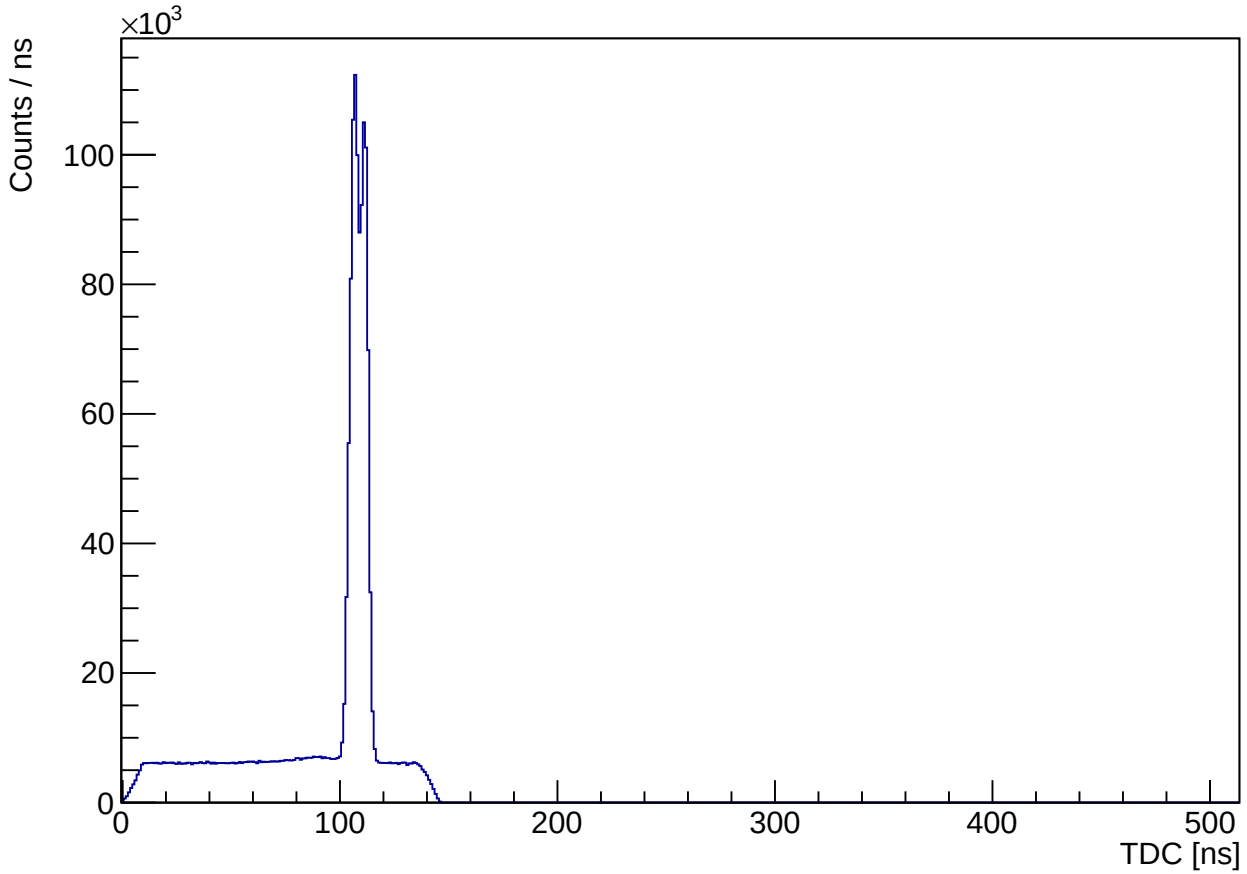
    - raw TDC + Interpolation FHWM$_\gamma$ $\sim$ 10 ns



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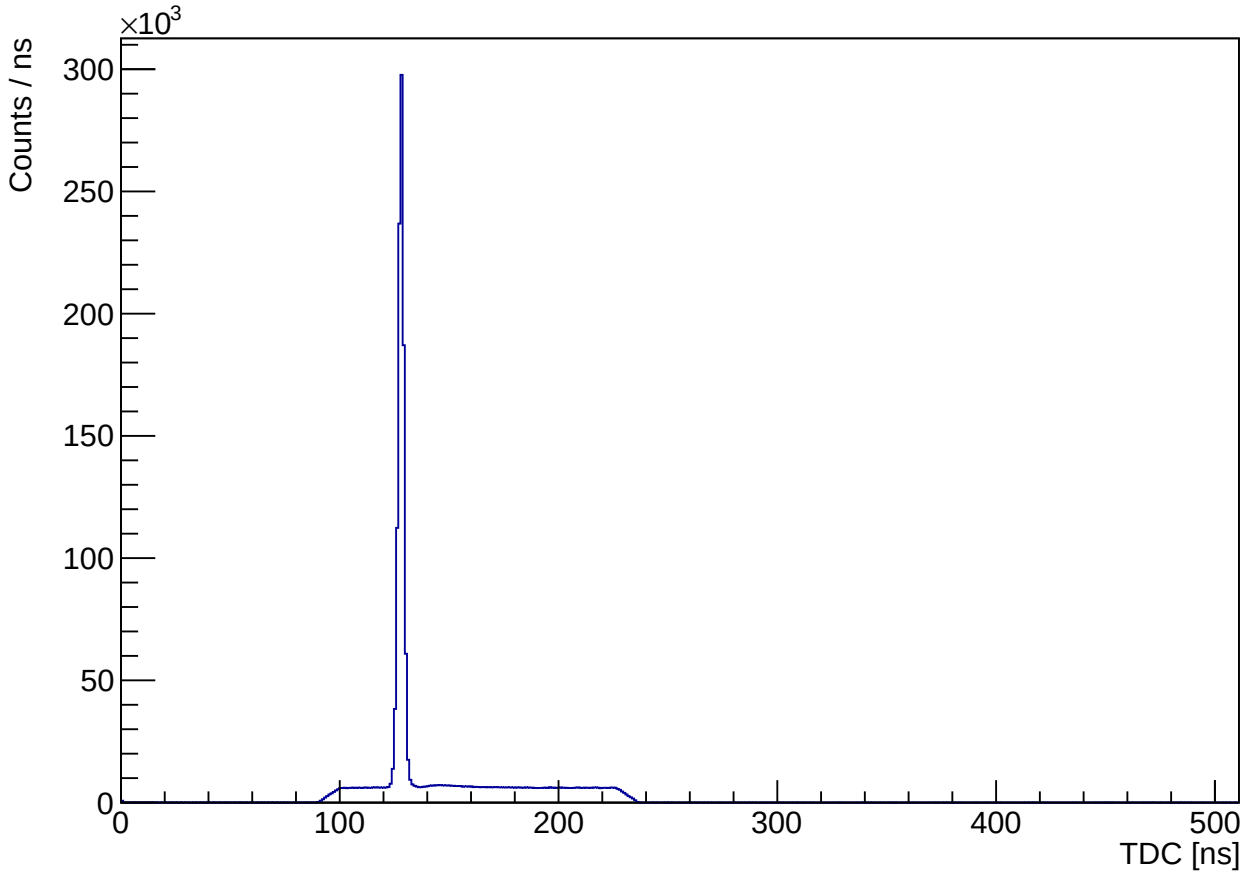

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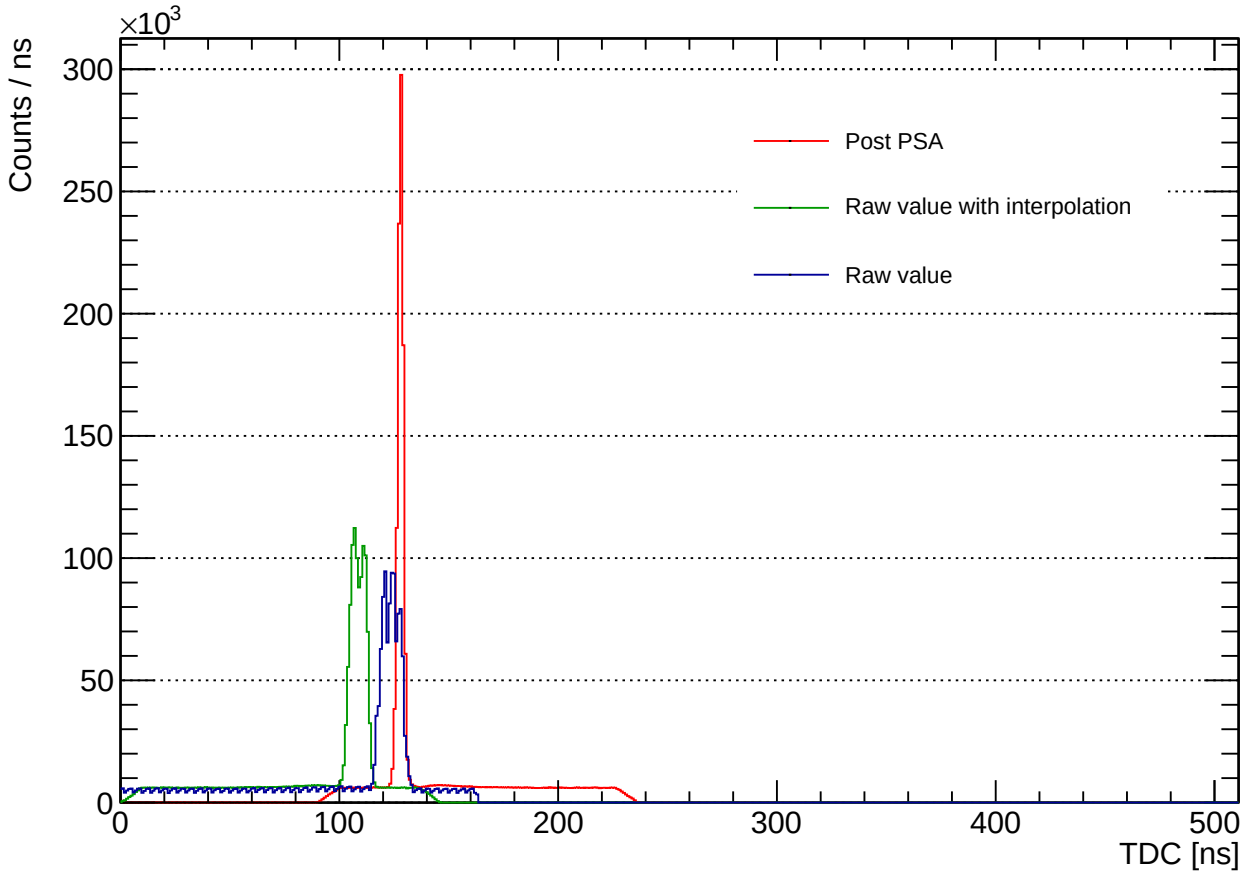
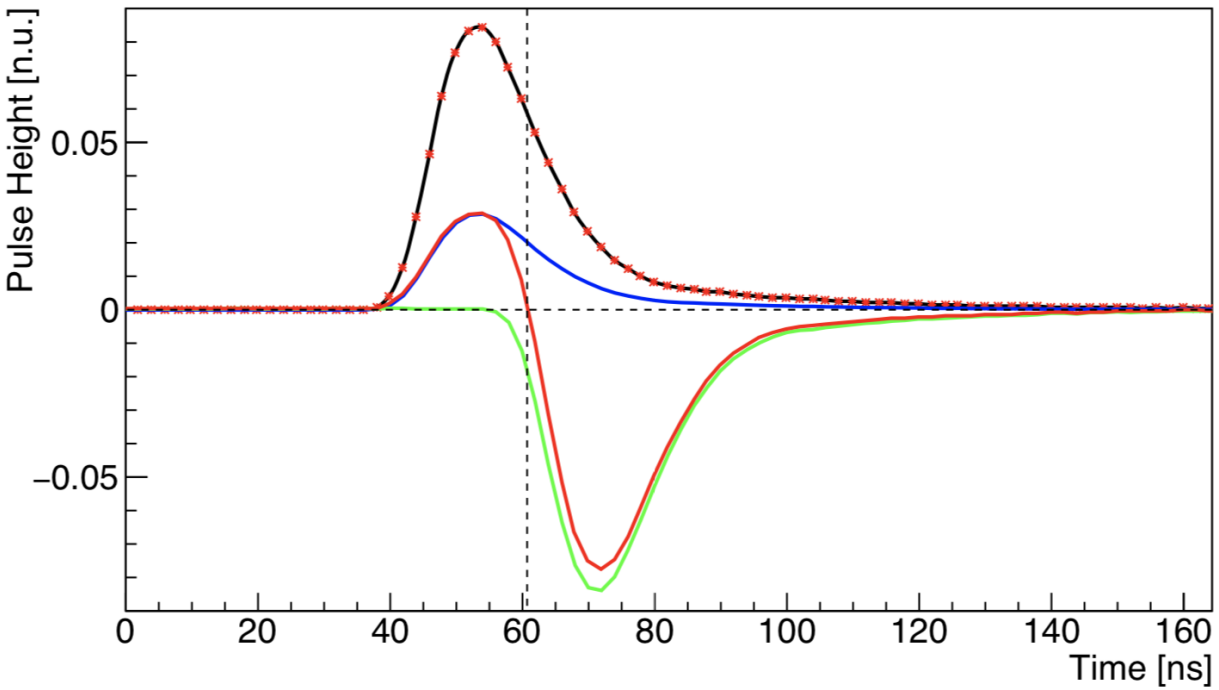


CFD optimization



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Three important parameters in the CCPSA (same in NNPSA)

- **Delay**
- **Fraction**
- **Crossing line**

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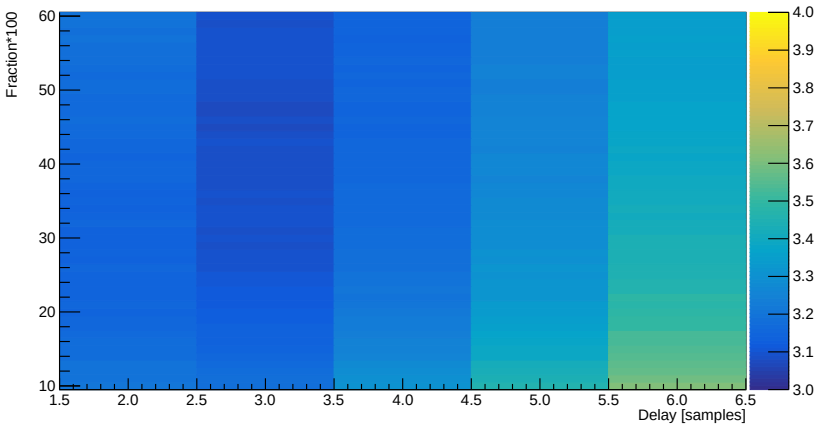

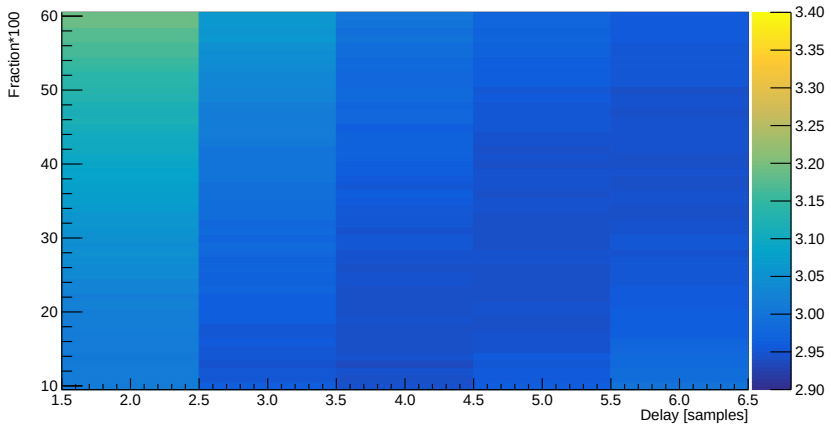

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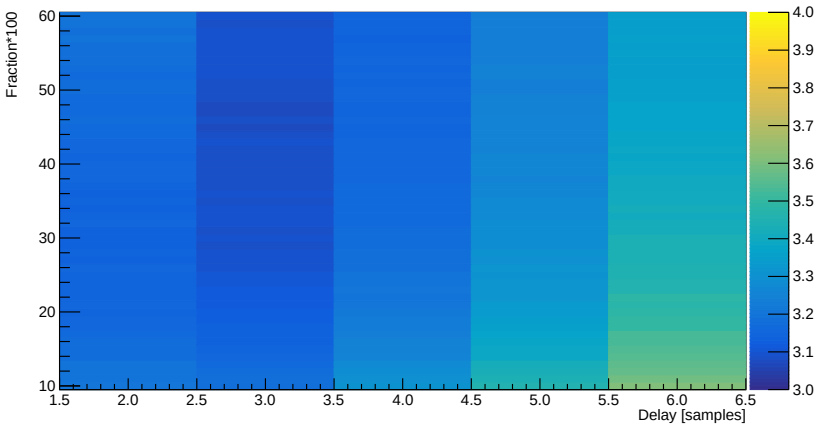

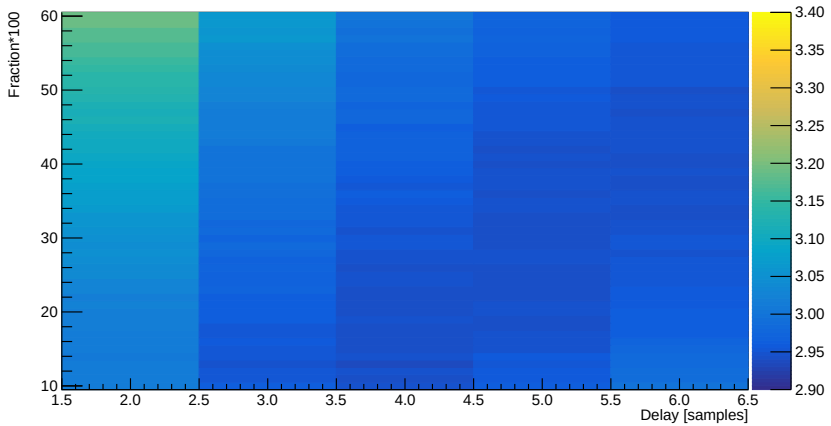

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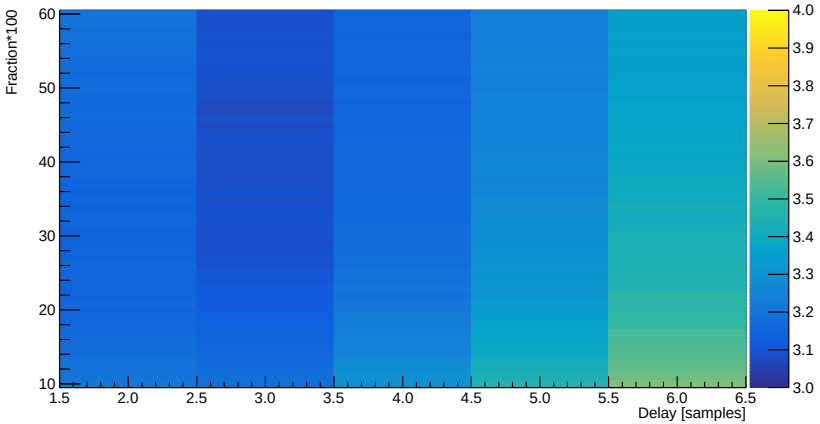
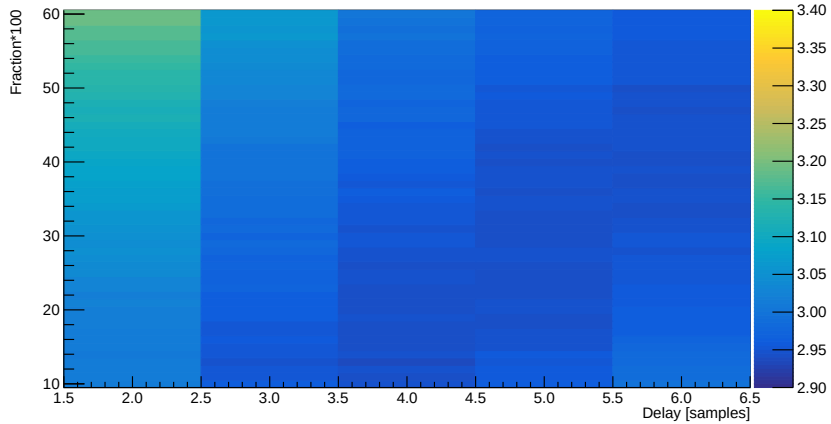
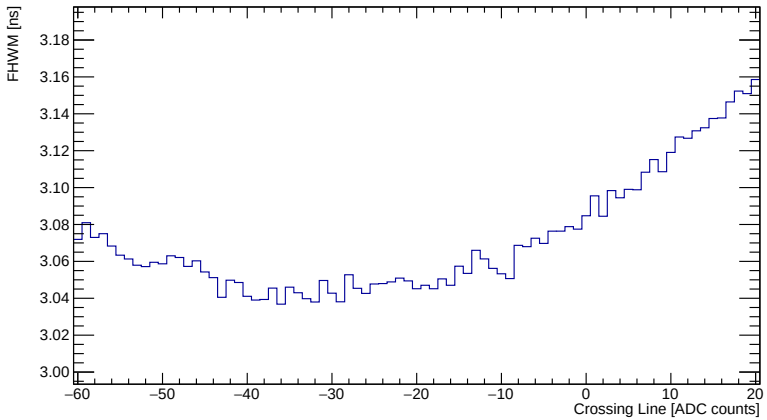
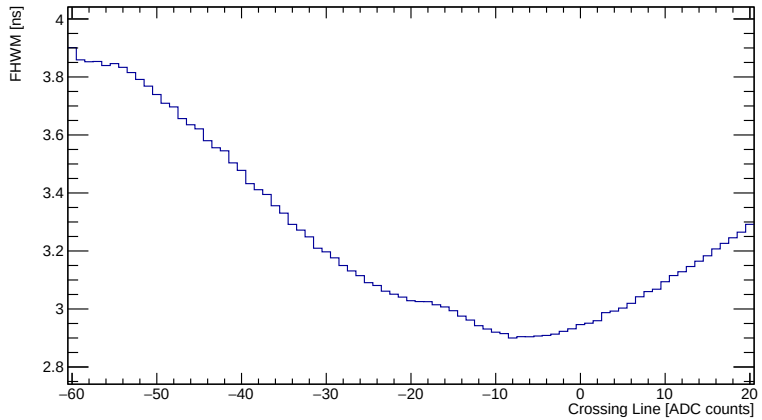




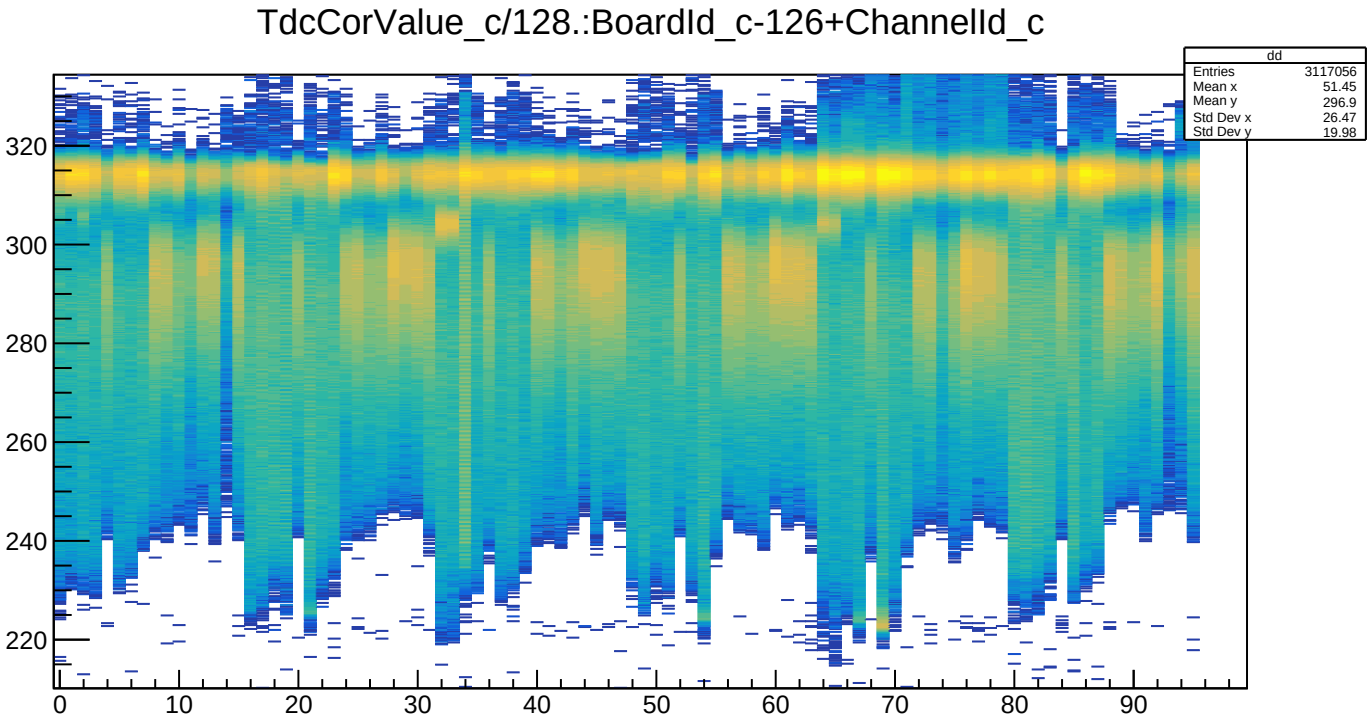




CFD optimization (the last one on this)

The TDC needs to be aligned :

- because it looks nicer on the final plot ?



CFD optimization (the last one on this)

The TDC needs to be aligned :

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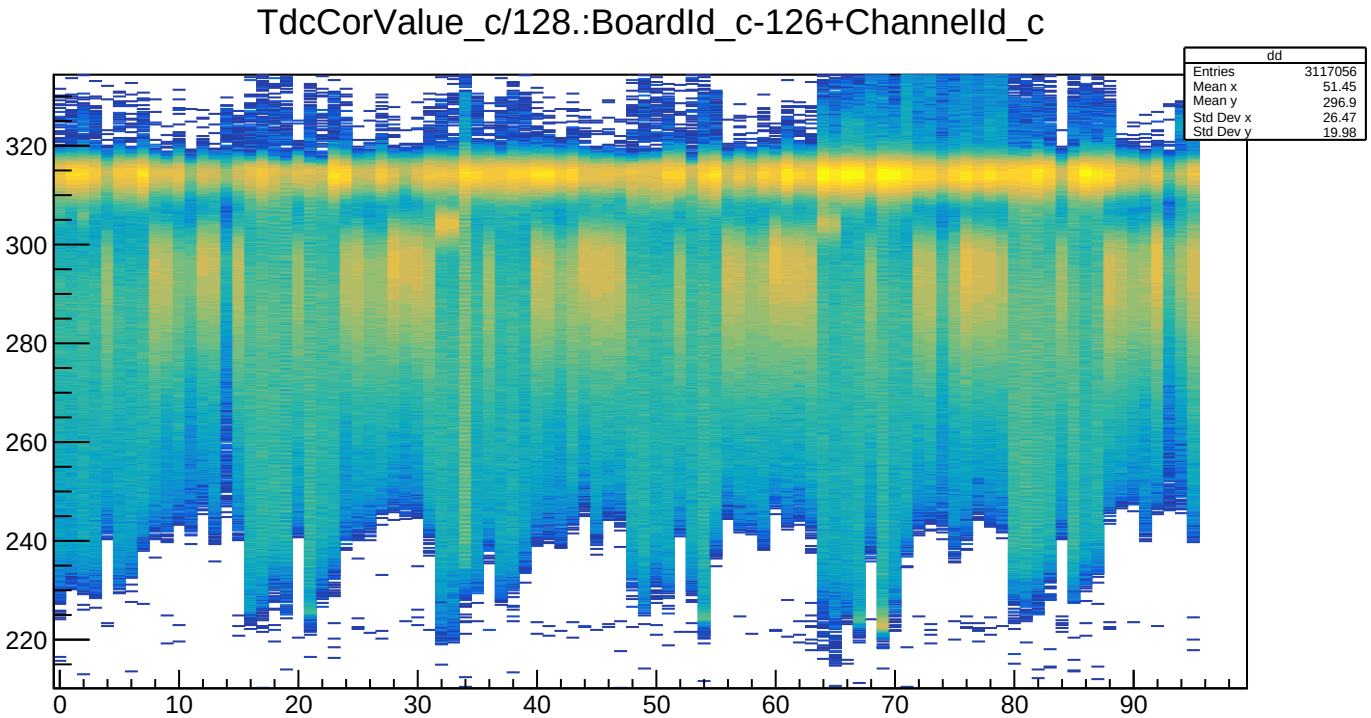
- reduce the quantity of work to set the neutron gates ?



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The TDC needs to be aligned :

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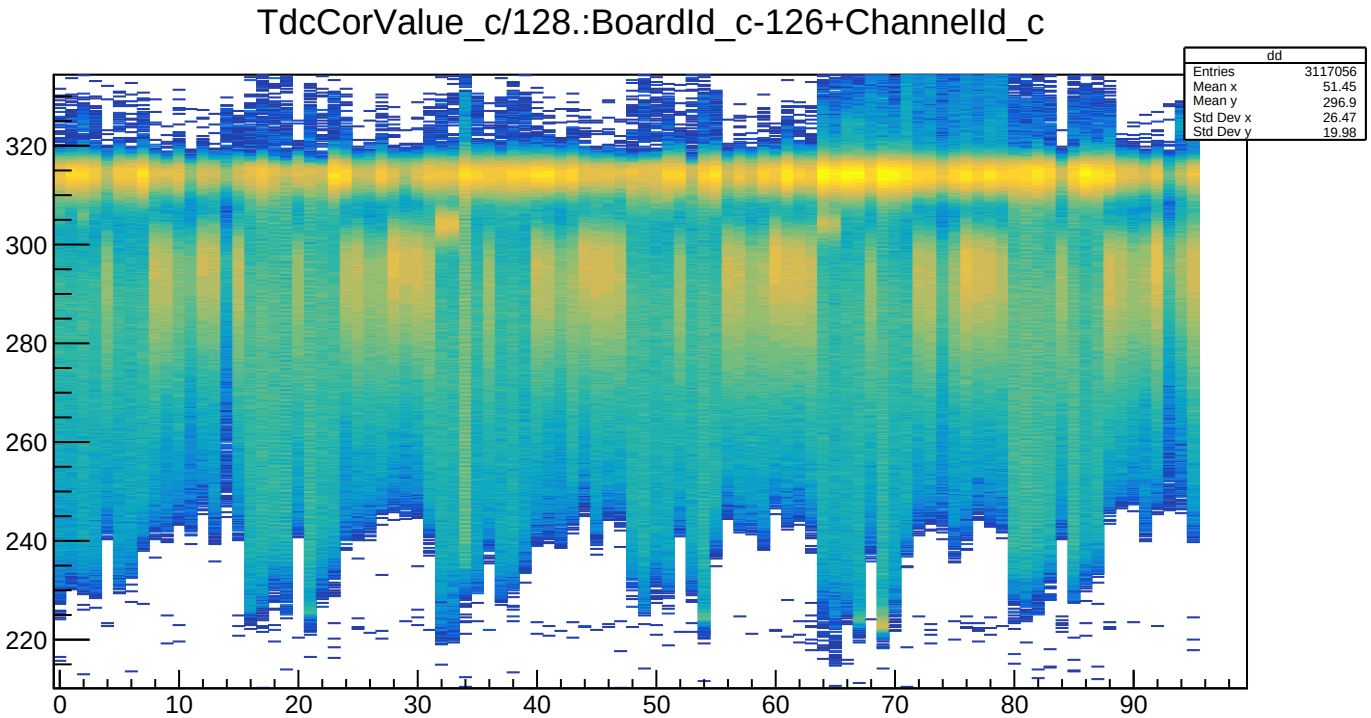
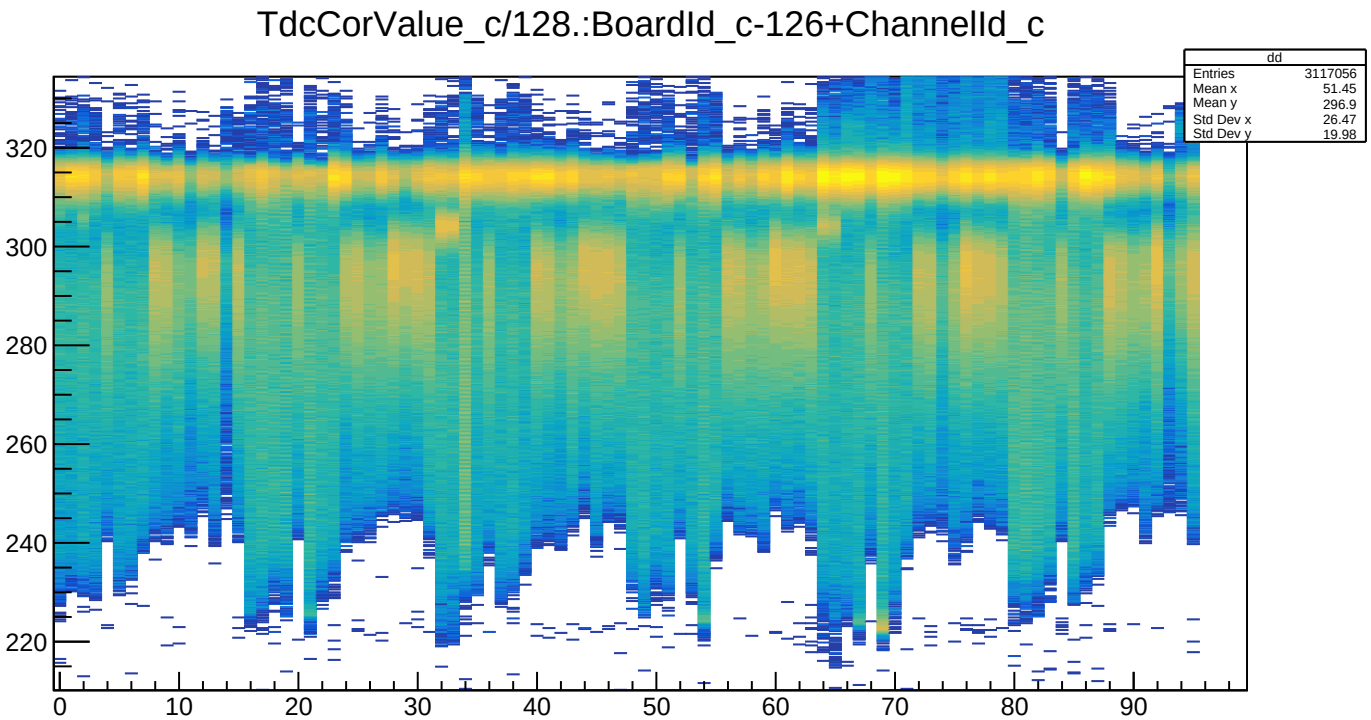


CFD optimization (the last one on this)

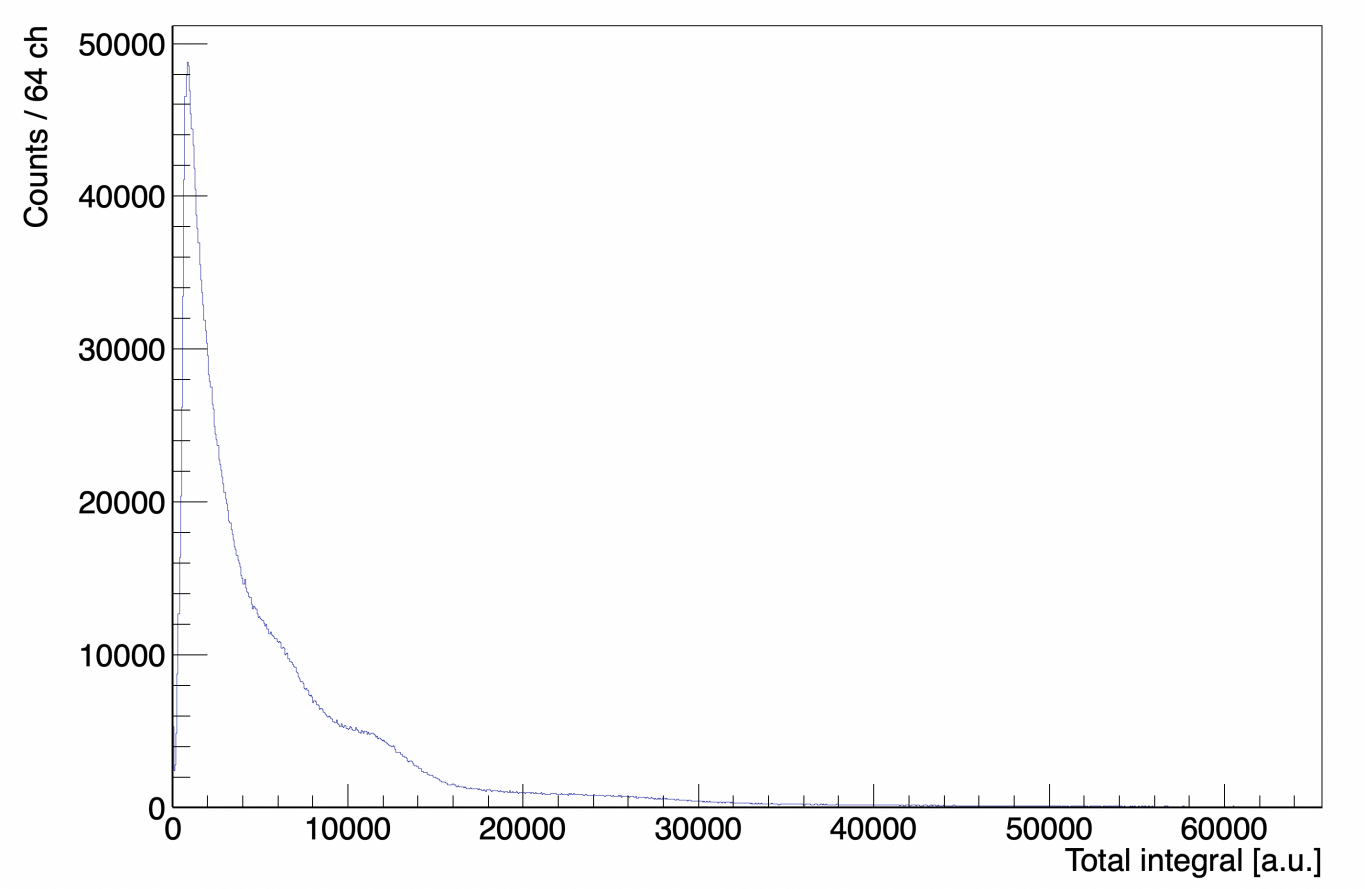
The TDC needs to be aligned :

- because it looks nicer on the final plot ?
- reduce the quantity of work to set the neutron gates ?
- ...
- **You need to have to do TDC differences for the neutron scattering !!**



CFD optimization (or maybe it was not)

While doing the CFD optimization keep monitoring the Slow, Fast and/or total energy spectrum



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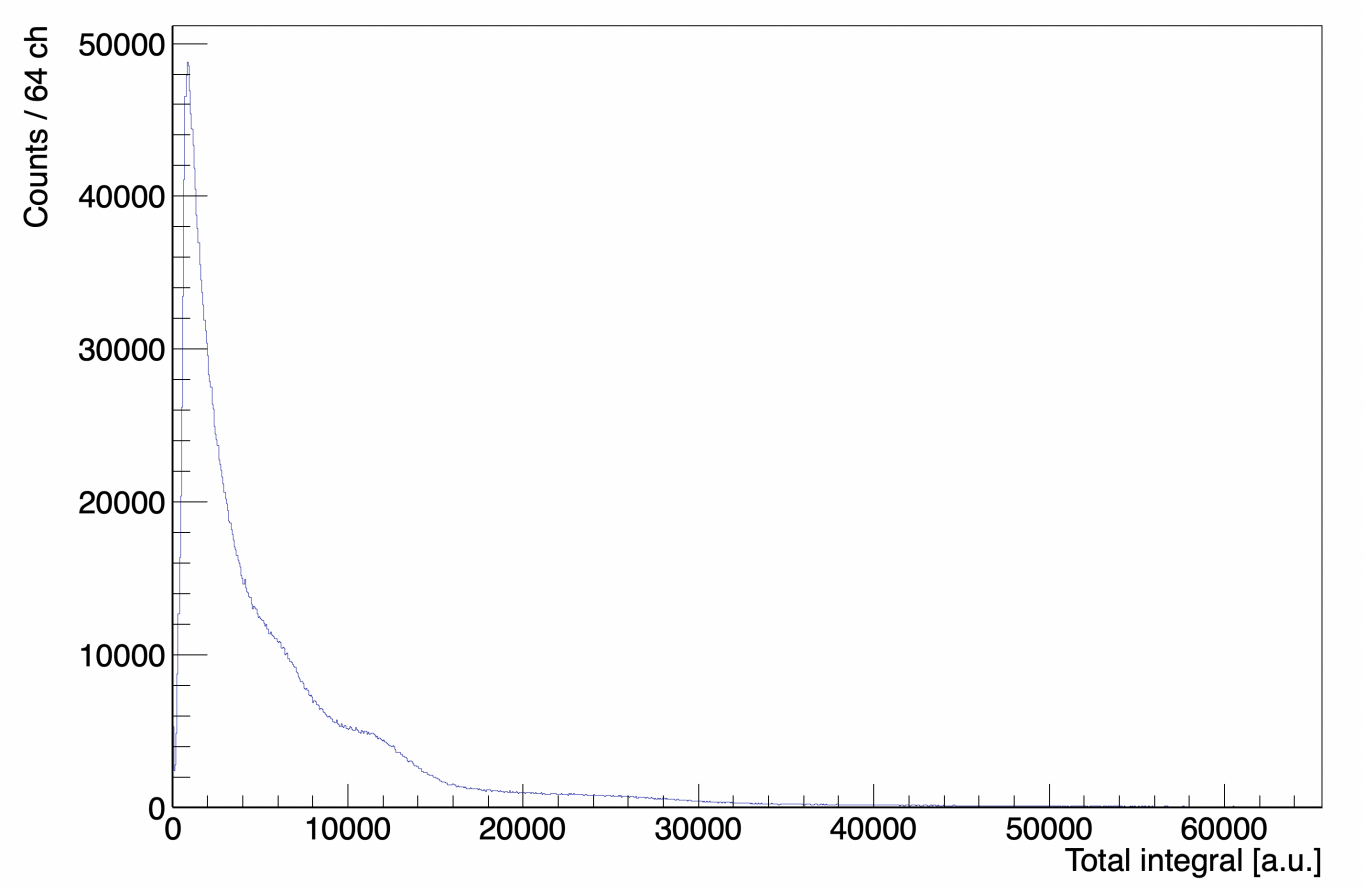

If the CFD thresholds (yes threshold**s**) are too high

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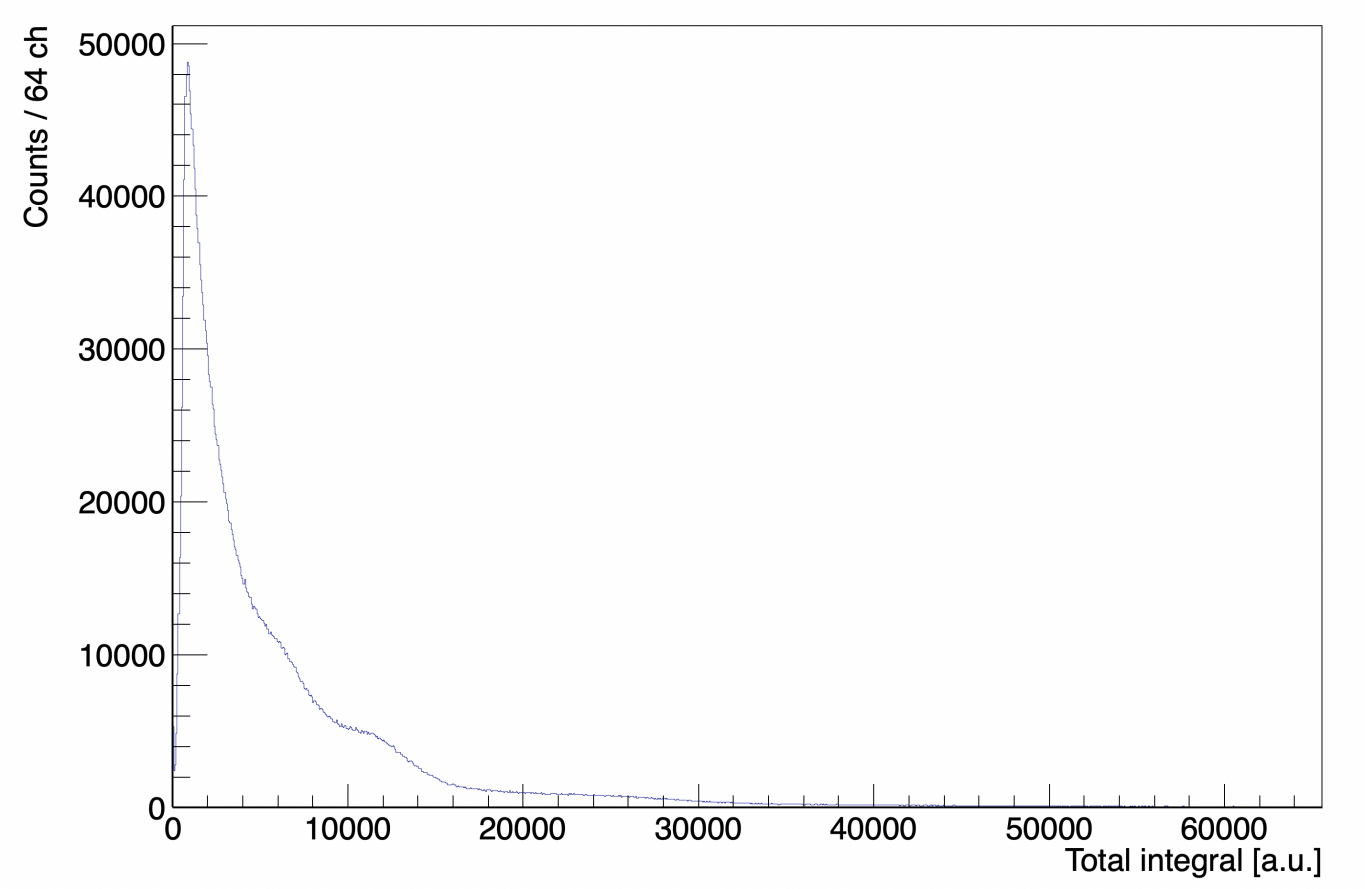
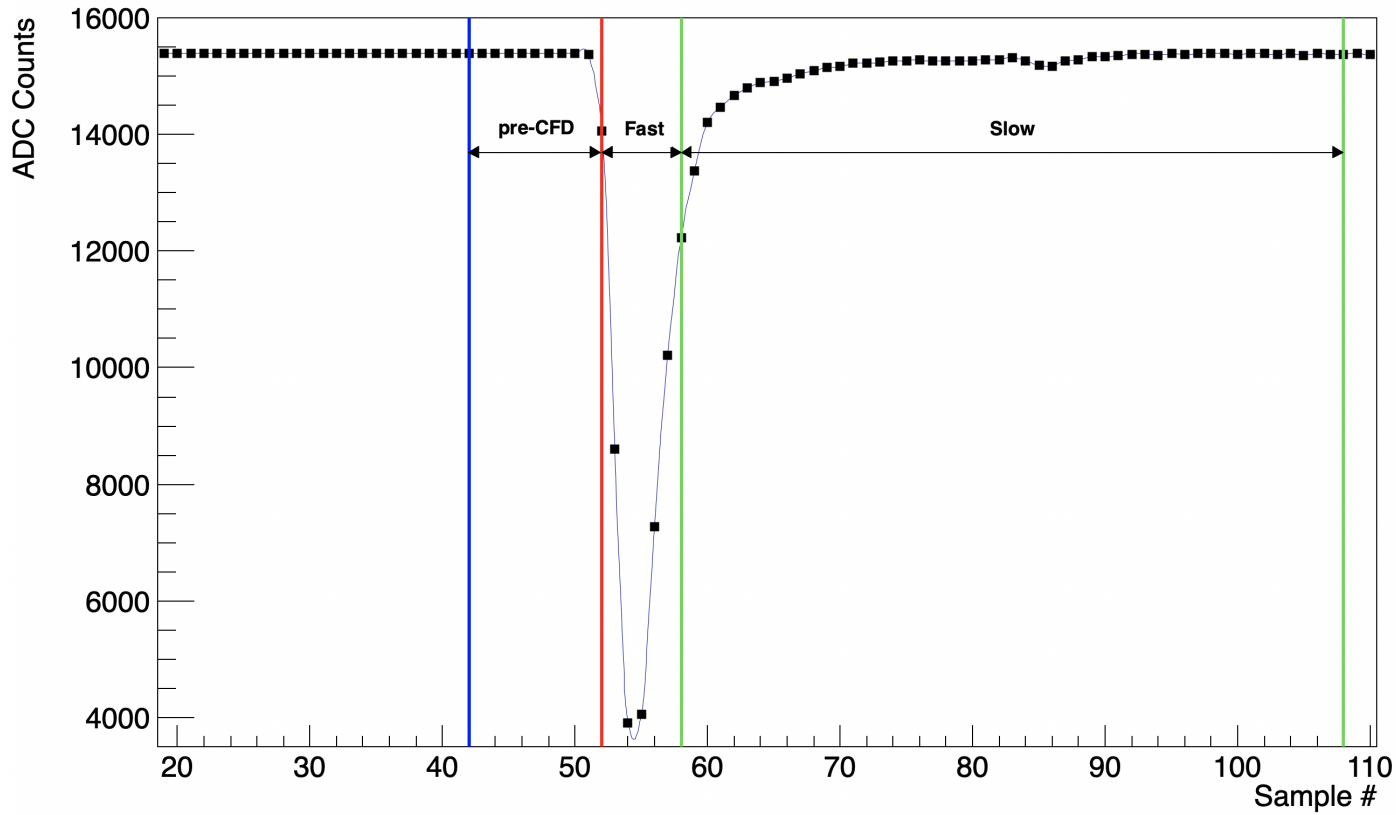


If the CFD thresholds (yes threshold**s**) are too high-> Peak at $E = 0$

Charge comparison optimization

Three important parameters in the CCPSA (same in NNPSA) :

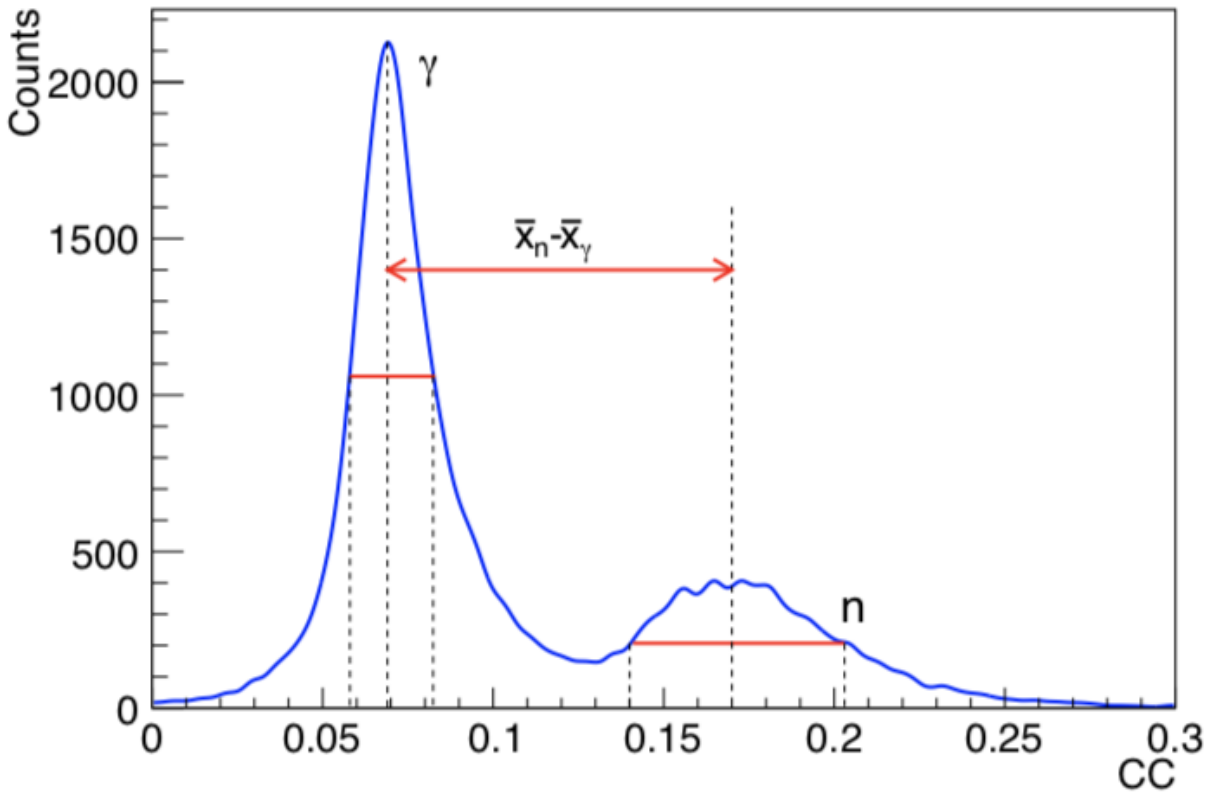
- CFD position
- Length of the fast gate
- Length of the slow gate
- Length pre-CFD gate



Charge comparison optimization

Optimization on the figure of merit :

$$\mathrm{FOM} = \frac{\overline{x}_n - \overline{x}_\gamma}{\mathrm{FHWM}_n + \mathrm{FHWM}_\gamma} \tag{1}$$



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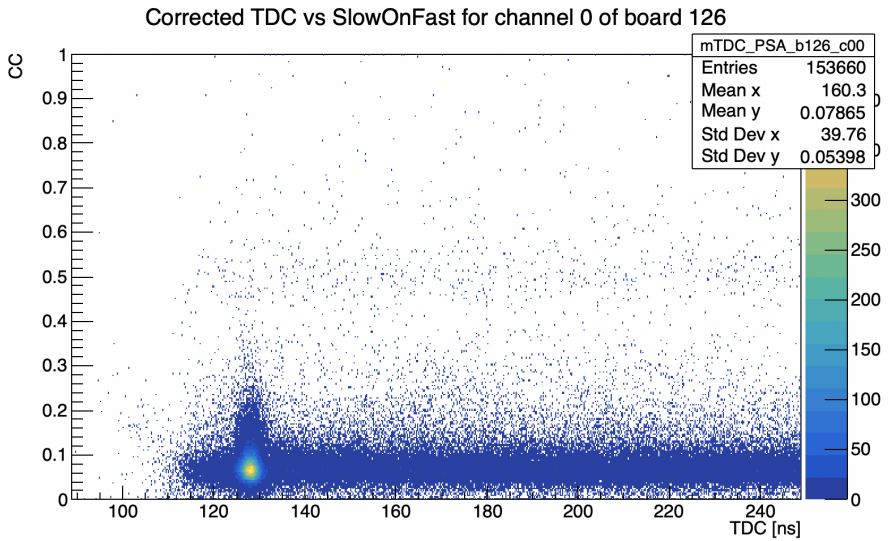
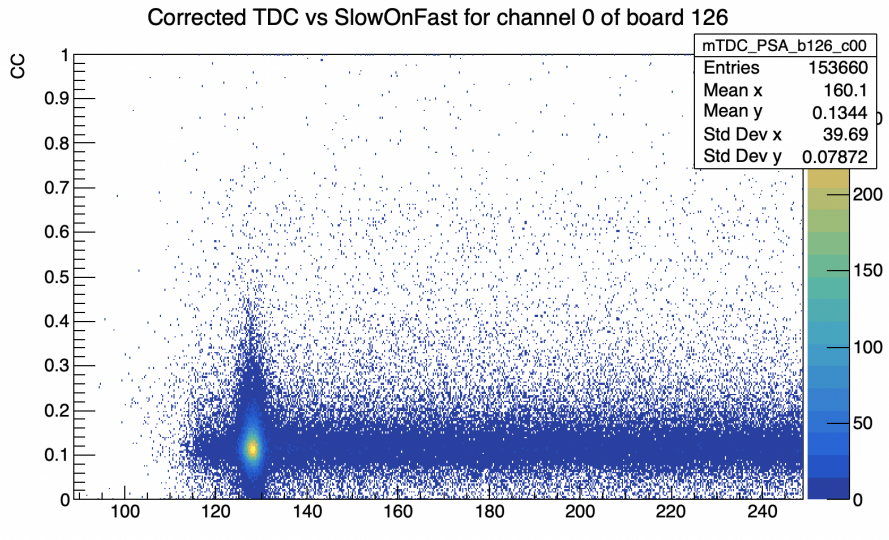
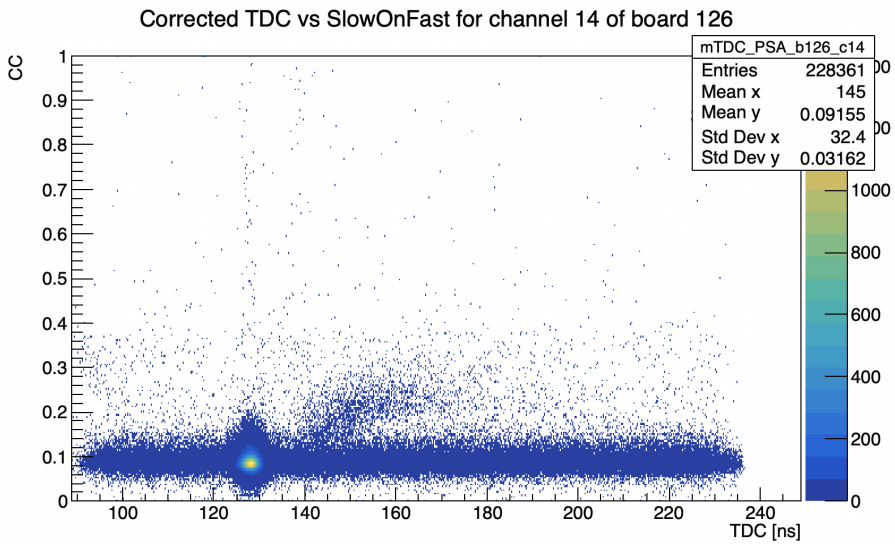
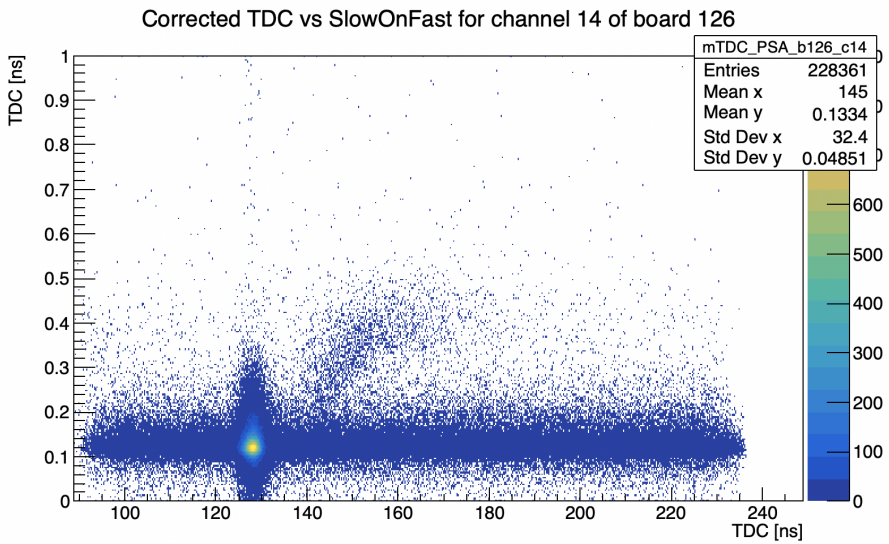
Charge comparison optimization





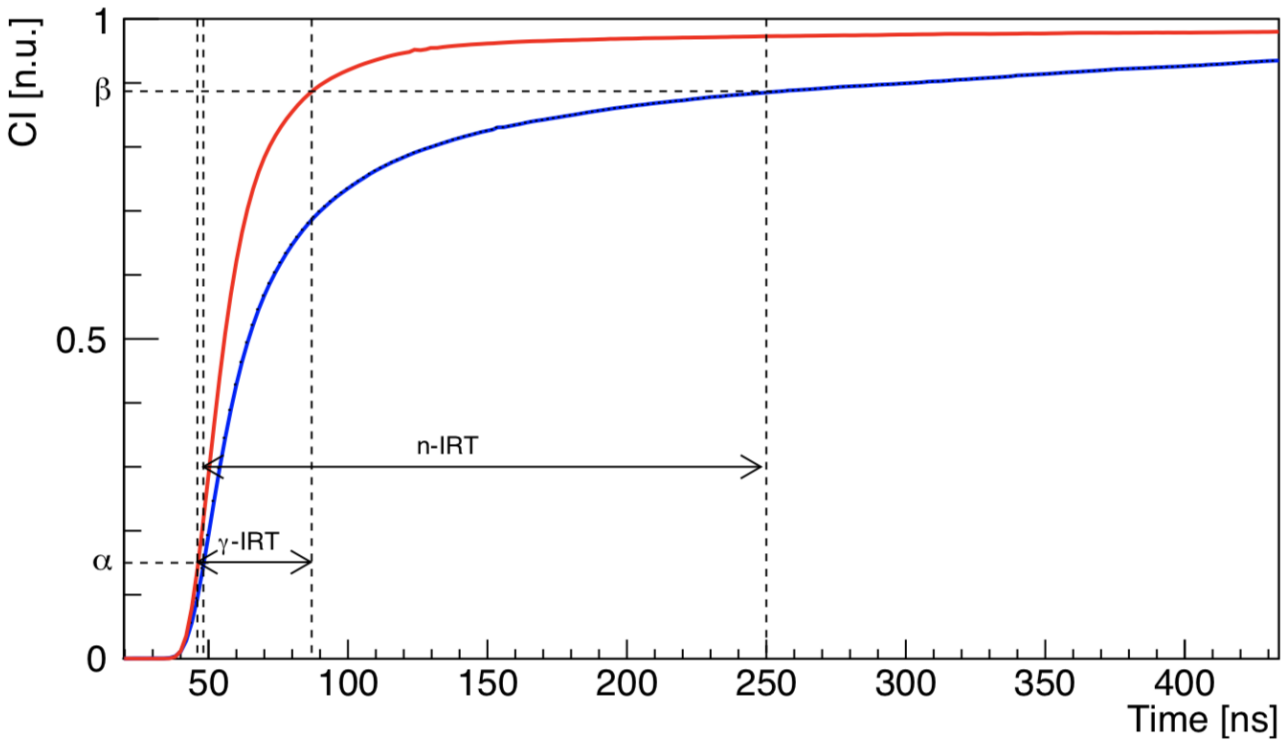




Integrated Rise Time optimization

Only one important parameter in the CCPSA (same in NNPSA) :

- CFD position
- Fraction of the integrated signal



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