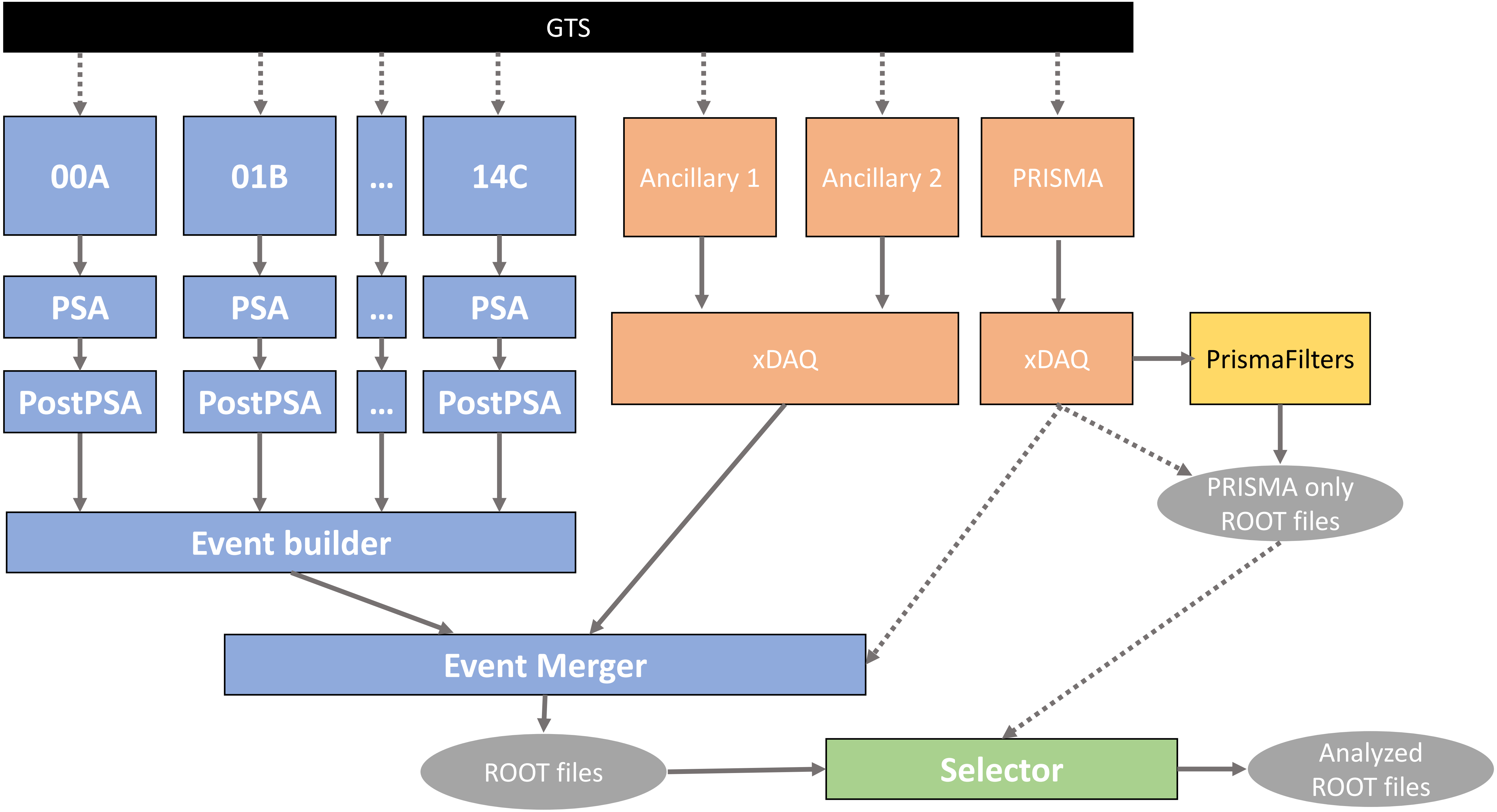
Istituto Nazionale di Fisica Nucleare
LABORATORI NAZIONALI DI LEGNARO

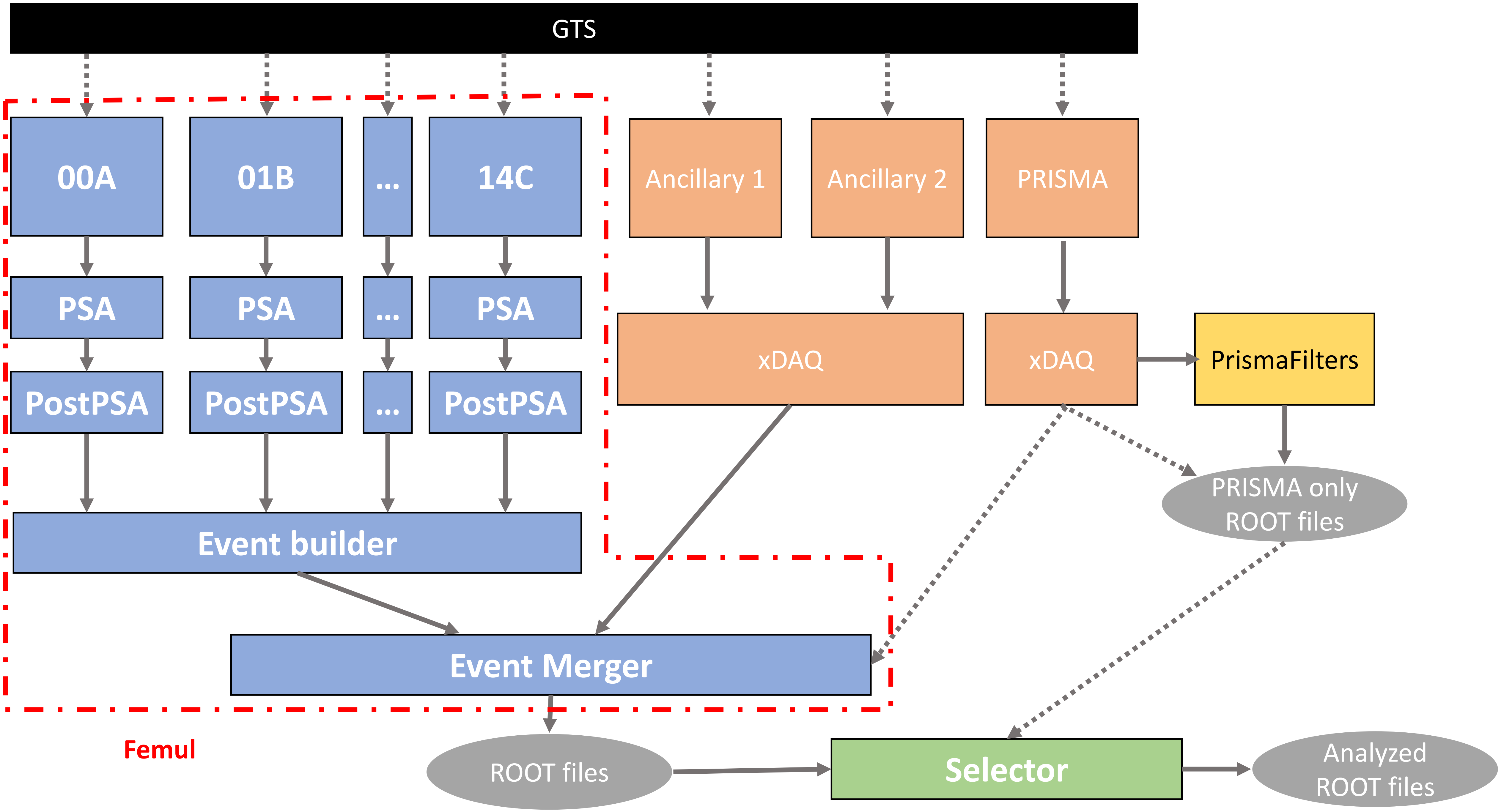
AGATA analysis workshop 2025

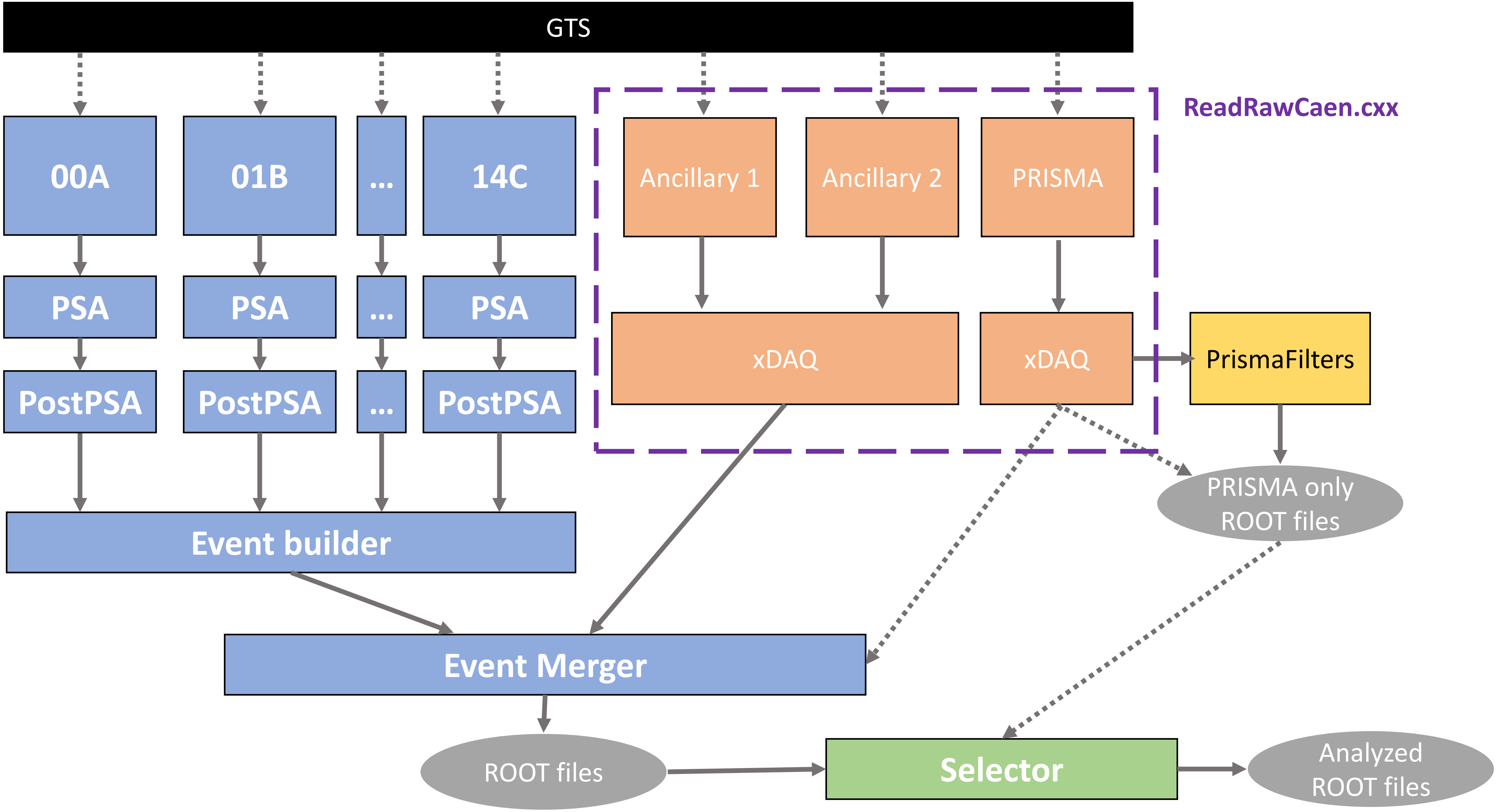
Ancillaries of AGATA

M. Balogh *on behalf of Gruppo Gamma*

matus.balogh@lnl.infn.it


GTS
00A
01B
...
14C
Ancillary 1
Ancillary 2
PRISMA
PSA
PSA
...
PSA
PostPSA
PostPSA
...
PostPSA
xDAQ
xDAQ
PrismaFilters
PRISMA only ROOT files
Event builder
Event Merger
ROOT files
Selector
Analyzed ROOT files


GTS
00A
01B
...
14C
PSA
PSA
...
PSA
PostPSA
PostPSA
...
PostPSA
Event builder
Event Merger
Femul
Ancillary 1
Ancillary 2
PRISMA
xDAQ
xDAQ
PrismaFilters
PRISMA only ROOT files
ROOT files
Selector
Analyzed ROOT files

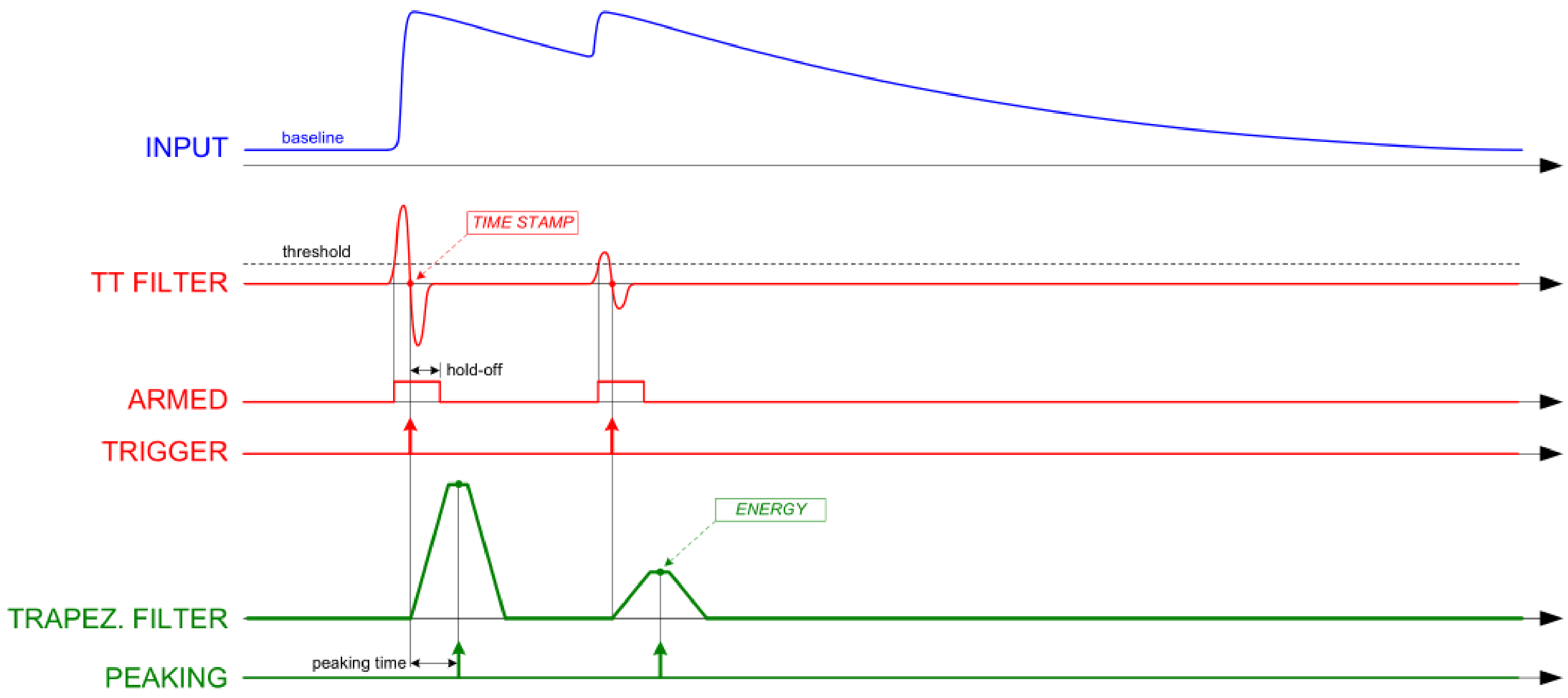

GTS
00A
01B
...
14C
PSA
PSA
...
PSA
PostPSA
PostPSA
...
PostPSA
Event builder
Ancillary 1
Ancillary 2
PRISMA
xDAQ
xDAQ
ReadRawCaen.cxx
PrismaFilters
PRISMA only
ROOT files
Event Merger
ROOT files
Selector
Analyzed
ROOT files

Ancillary digitizers

Digitizer firmware

DPP-PHA

Digital Pulse Processing for the Pulse Height Analysis

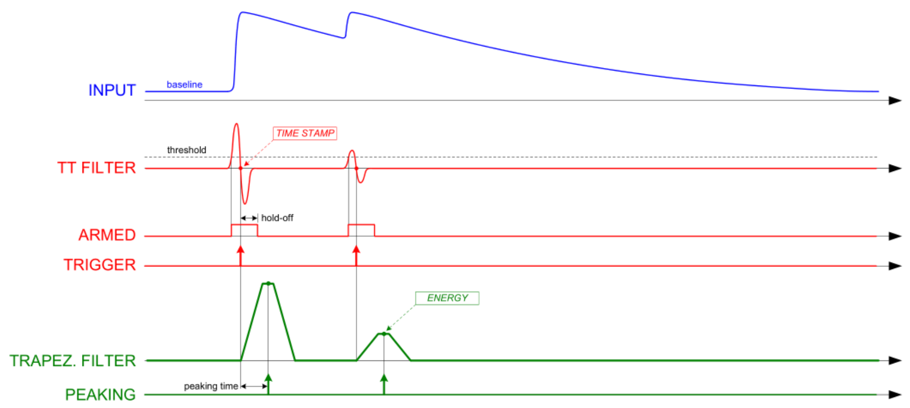


Ancillary digitizers

Digitizer firmware

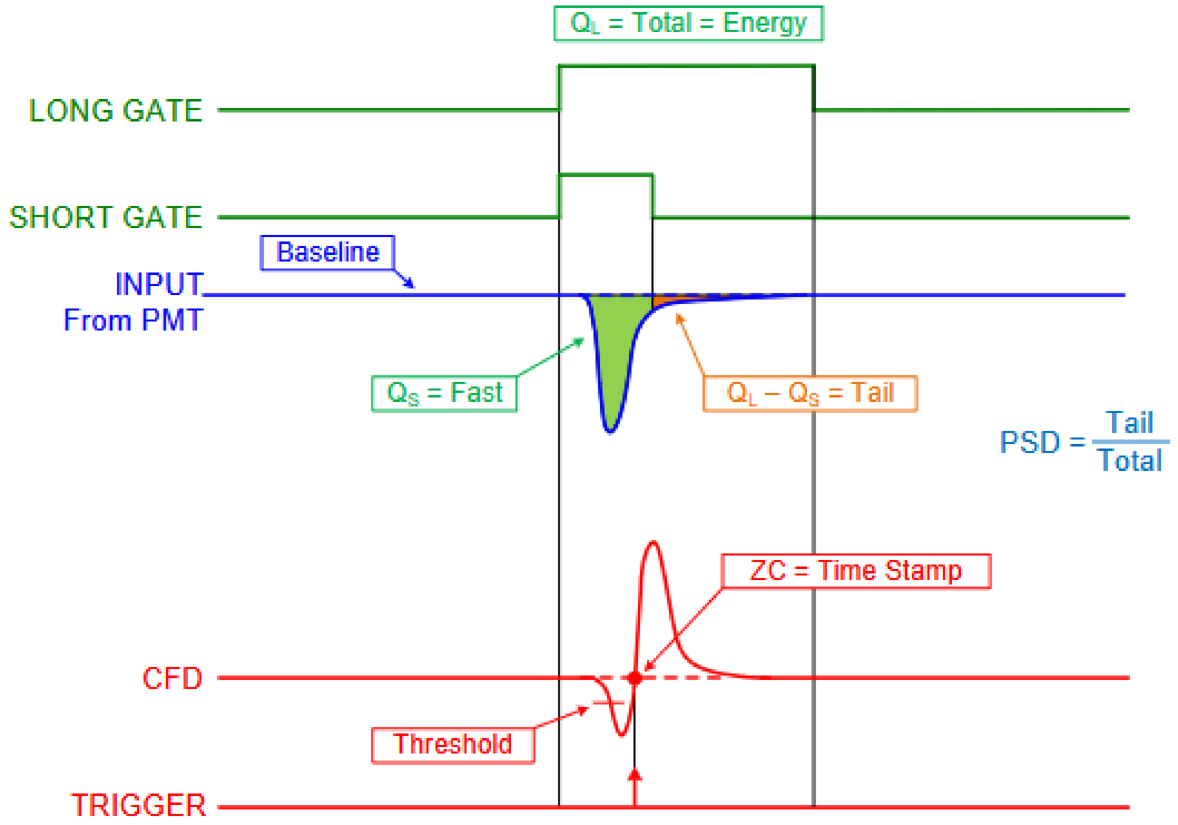
DPP-PHA

Digital Pulse Processing for the Pulse Height Analysis



DPP-PSD

Digital Pulse Processing for Charge Integration and Pulse Shape Discrimination



Ancillary digitizers

Digitizer firmware

DPP-PHA

Digital Pulse Processing for the Pulse Height Analysis

DPP-PSD

Digital Pulse Processing for Charge Integration and Pulse Shape Discrimination

Digitizer models

Different firmware versions!

CAEN V1725

14bit, 250MS/s

- ~~SPIDER~~
- DANTE
- OSCAR
- beam monitor(s)

CAEN V2740

14bit, 125MS/s

- SPIDER
- EUCLIDES
- SAURON (S1)
- TRACE

CAEN V1730

14bit, 500MS/s

- LaBr array
- neutron detector

Ancillary digitizers

Digitizer firmware

DPP-PHA

Digital Pulse Processing for the Pulse Height Analysis

DPP-PSD

Digital Pulse Processing for Charge Integration and Pulse Shape Discrimination

---

Digitizer models

Different firmware versions!

CAEN V1725
14bit, 250MS/s

- ~~SPIDER~~
- DANTE
- OSCAR
- beam monitor(s)

CAEN V2740
14bit, 125MS/s

- SPIDER
- EUCLIDES
- SAURON (S1)
- TRACE

Peak sensing ADC

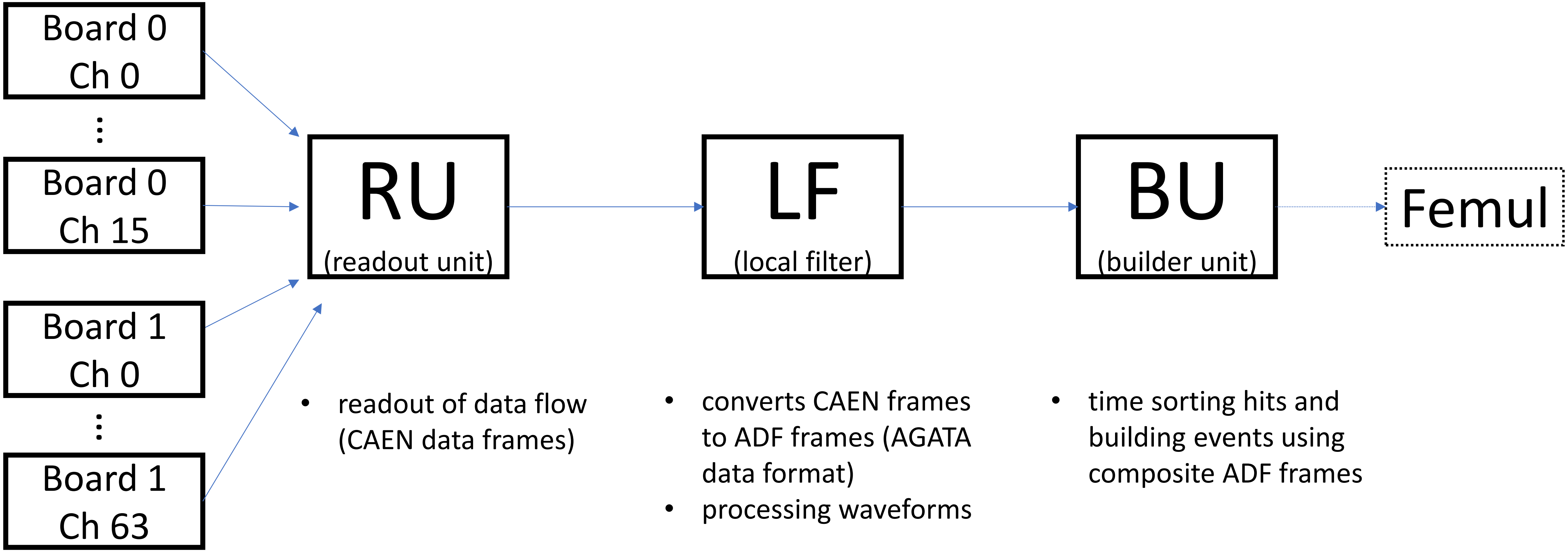
- DANTE

CAEN V1730
14bit, 500MS/s

- LaBr array
- neutron detector

Ancillary processing chain

- all ancillary, including PRISMA
- based on XDAQ made for CMS
- processing distributed to workers



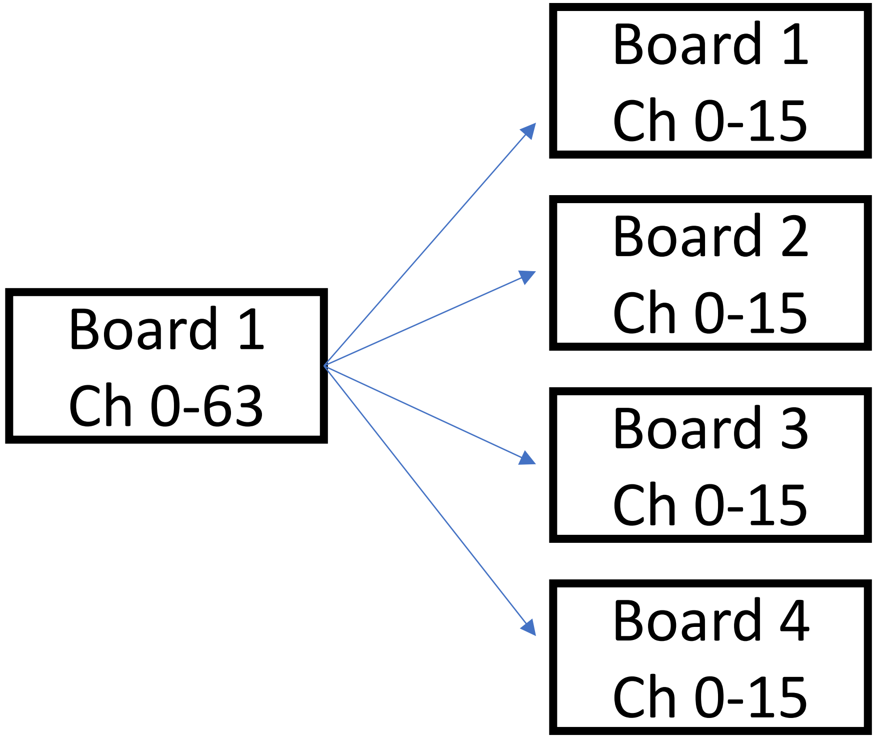
- readout of data flow (CAEN data frames)

- converts CAEN frames to ADF frames (AGATA data format)
- processing waveforms

- time sorting hits and building events using composite ADF frames

Ancillary digitizers

- due to historical reasons, xDAQ treats all digitizers as if they have 16 channel
- 64 channel digi is treated as 4 unique digitizers, e.g.:
  - Board 1 [ch 0-63] -> Board 1 [ch 0-15], Board 2 [ch 0-15], Board 3 [ch 0-15], Board 4 [ch 0-15]



Ancillary data

- all workers (can) dump data on disk as (specific arrangement depends on the experiment)
- e.g. latest folder arrangement:

X – index (redundant info)
Y – run number
Z – file number (max file size 4GB)

Readout unit + Local filter

*AGATAD_P2_EXP_019/run_0102_TIME/**Data/caen_digitizers/RU_caendig_iX_Y_Z.caendat***

*AGATAD_P2_EXP_019/run_0102_TIME/**Data/caen_digitizers/LF_caendig_iX_Y_Z.adf***

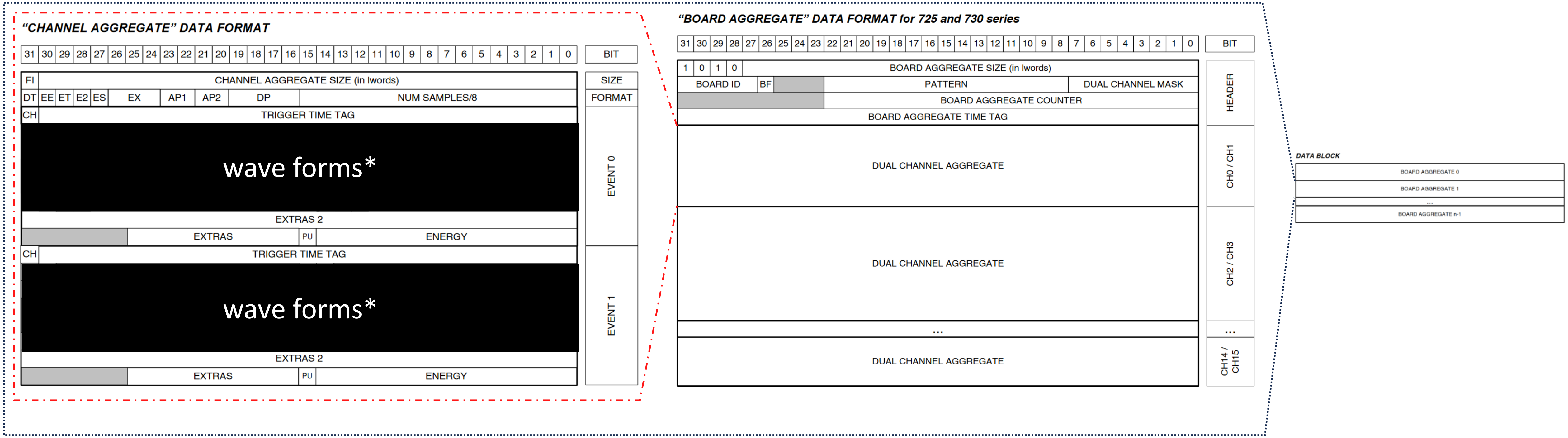
Builder unit

*AGATAD_P2_EXP_019/run_0102_TIME/**Data/ancillaries/BU_ancillaries_iX_Y_Z.adf***

RU data format - .caendat

- programable using registers, may vary between experiments
- different for PHA and PSD boards
- may differ between firmware versions
- file contain xDAQ header and possibly other small changes

Example for PHA of CAEN V1725



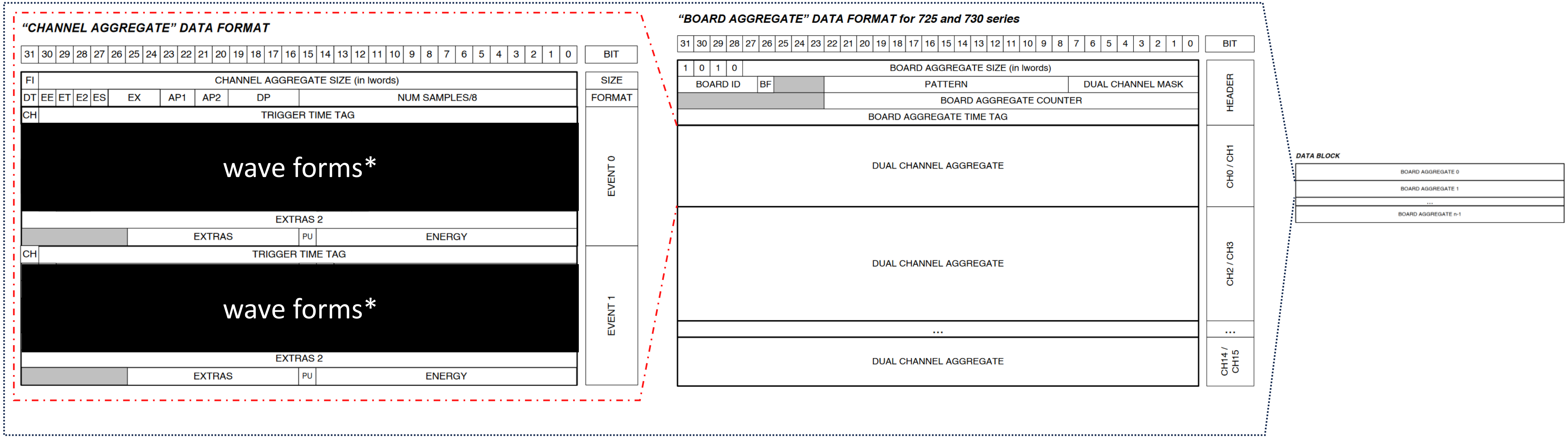
* So far, only for SAURON (RU output might have been disabled)

RU data format - .caendat

- programable using registers, may vary between experiments
- different for PHA and PSD boards
- may differ between firmware versions
- file contain xDAQ header and possibly other small changes

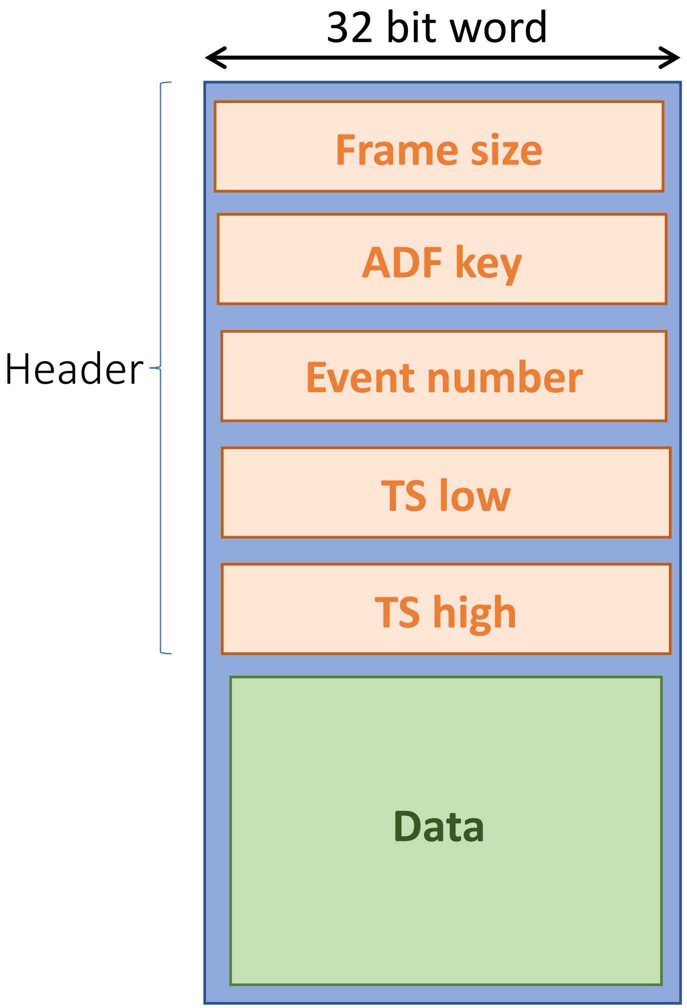
Example for PHA of CAEN V1725

can be read using [ReadCaenRaw.cxx]() code, part of AGATA selector!

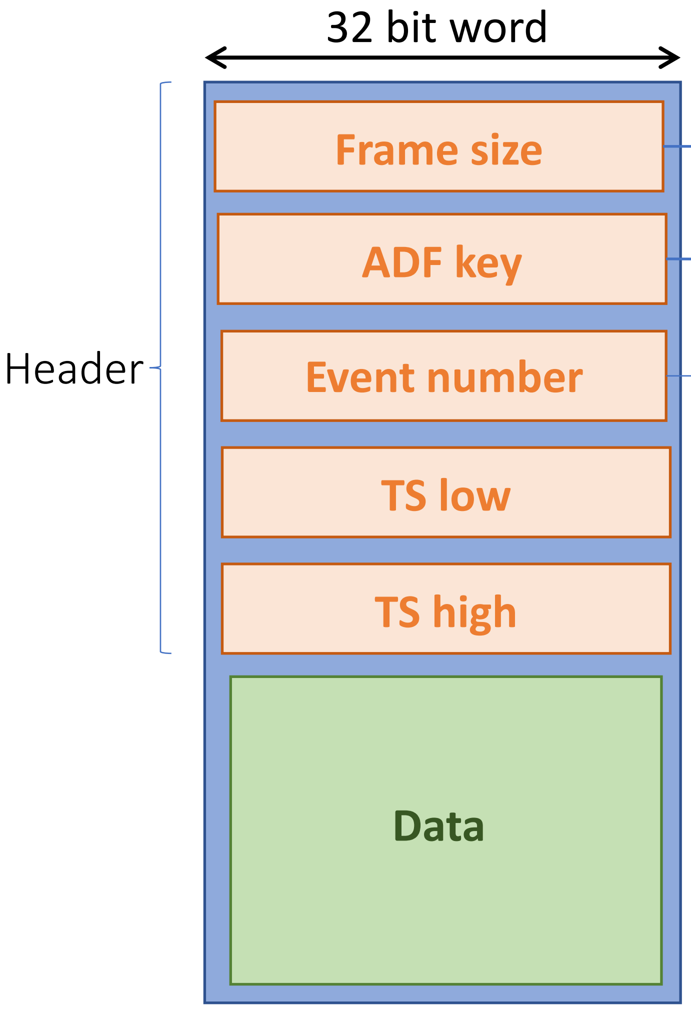


* So far, only for SAURON (RU output might have been disabled)

LF data format - general ADF



LF data format



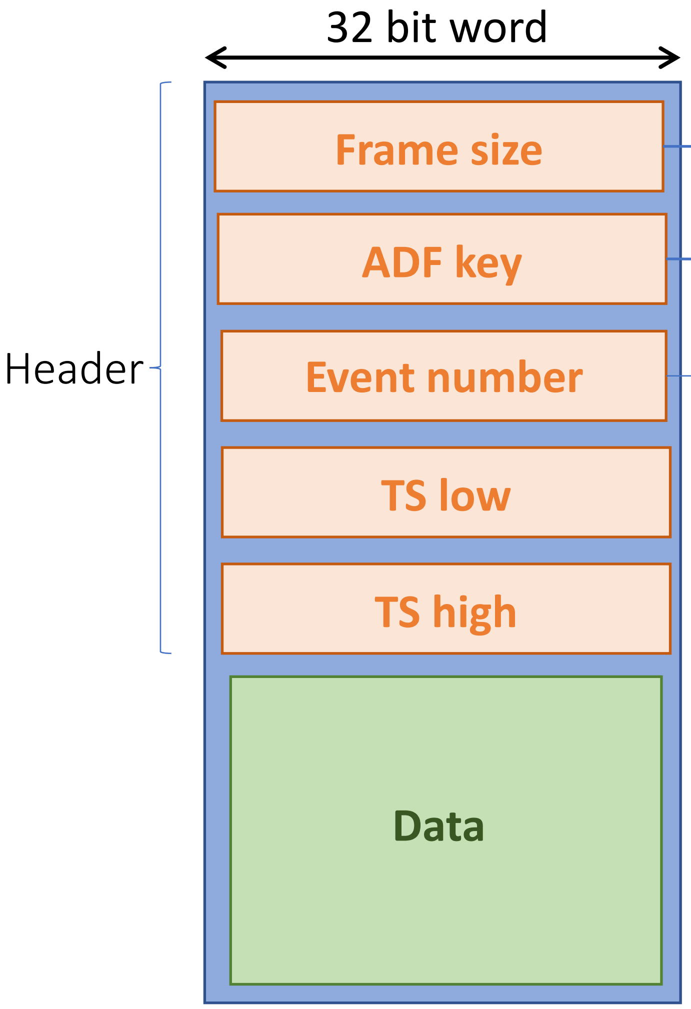
Frame size → size of the whole frames in bytes, including header and data

ADF key → **unique** for different detectors:

0xFA0201A0	Prisma RAW
0xFA0201A1	Prisma Analyzed
0xFA0201A2	SPIDER
0xFA0201A3	DANTE
0xFA0201A4	EUCLIDES
0xFA0201A5	LaBr3
0xFA0201A6	SAURON
0xFA0201A7	OSCAR

Event number → Repurposed to contain **channel** and **board numbers**

LF data format



Frame size → size of the whole frames in bytes, including header and data

ADF key → **unique** for different detectors:

0xFA0201A0	Prisma RAW
0xFA0201A1	Prisma Analyzed
0xFA0201A2	SPIDER
0xFA0201A3	DANTE
0xFA0201A4	EUCLIDES
0xFA0201A5	LaBr3
0xFA0201A6	SAURON
0xFA0201A7	OSCAR

Event number → Repurposed to contain **channel** and **board numbers**

can be read using **ListFrames** command!

LF data format - ListFrames

- part of AGATAPRO package:
  gammaSoftware/agapro/ListFrames

```
[prototype@agata-nearline-2 caen_digitizer]$ ListFrames -f LF_caendig_i1990_0016_0000.adf -n 5
#
# Wed Jan 15 00:25:51 2025
# ListFrames
#  -f LF_caendig_i1990_0016_0000.adf -n 5
#
#
# Analysis can be stopped by typing CTRL_C
#
#    event   bOffset     bSize  0xKeyADF   eventNum   (rel)timeStamp     dTstamp    keyADFname
         0         0        24  fa0201a3       1284     793749278778
         1        24        24  fa0201a3       1285     793749305432       26654
         2        48        24  fa0201a3       1284     793749305433           1
         3        72        24  fa0201a3       1285     793749306722        1289
         4        96        24  fa0201a3       1284     793749306722           0
#
#
#            5 events in 0 seconds
#
```

LF data format - ListFrames

- part of AGATAPRO package:

  gammaSoftware/agapro/ListFrames

```
[prototype@agata-nearline-2 caen_digitizer]$ ListFrames -f LF_caendig_i1990_0016_0000.adf -n 5
#
# Wed Jan 15 00:25:51 2025
# ListFrames
#  -f LF_caendig_i1990_0016_0000.adf -n 5
#
#
# Analysis can be stopped by typing CTRL_C
#
#    event    bOffset      bSize  0xKeyADF   eventNum   (rel)timeStamp      dTstamp     keyADFname
         0          0         24  fa0201a3       1284     793749278778
         1         24         24  fa0201a3       1285     793749305432        26654
         2         48         24  fa0201a3       1284     793749305433            1
         3         72         24  fa0201a3       1285     793749306722         1289
         4         96         24  fa0201a3       1284     793749306722            0
#
#
#           5 events in 0 seconds
#
```

```
        28        672         24  fa0201a3       1285     793749447008            1
        29        696         24  fa0201a3       1285     793749461678        14670
        30        720         24  fa0201a3       1284     793749461677 18446744073709551615
        31        744         24  fa0201a3       1285     793749516620        54943
        32        768         24  fa0201a3       1281     793749306720 18446744073709341716
        33        792         24  fa0201a3       1280     793749306723            3
        34        816         24  fa0201a3       1281     793749309805         3082
```

LF data are not time ordered!

LF data format - .adf

PHA dataframe

(SPIDER, EUCLIDES, DANTE, OSCAR)

<table>
<tr><th>bits</th><th>32</th><th>31</th><th>30</th><th>29</th><th>28</th><th>27</th><th>26</th><th>25</th><th>24</th><th>23</th><th>22</th><th>21</th><th>20</th><th>19</th><th>18</th><th>17</th><th>16</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><th rowspan="5">Header</th><td colspan="33">frame size</td></tr>
<tr><td colspan="33">ADF key</td></tr>
<tr><td>E</td><td>D</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>C</td><td>B</td><td>A</td><td colspan="8">board nb</td><td colspan="8">channel nb</td></tr>
<tr><td colspan="33">Timestamp_0</td></tr>
<tr><td colspan="33">Timestamp_1</td></tr>
<tr><th>Data</th><td colspan="17">time (CFD)</td><td colspan="16">energy</td></tr>
</table>

data types

<table>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td>bitarray<16></td><td>uint8_t</td><td>uint8_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td>uint16_t</td><td colspan="2">uint16_t</td></tr>
</table>

Repurposed Event number to save space

Flags

- A Pile-up rejection
- B Trapezoidal saturation
- C Input saturation
- D Board fail (PLL unlock or temperature)
- E IDLE

ADF keys

0xFA0201A0	Prisma RAW
0xFA0201A1	Prisma Analyzed
0xFA0201A2	SPIDER
0xFA0201A3	DANTE
0xFA0201A4	EUCLIDES
0xFA0201A5	LaBr3
0xFA0201A6	SAURON
0xFA0201A7	OSCAR

LF data format - .adf

PHA dataframe

(SPIDER, EUCLIDES, DANTE, OSCAR)

<table>
<tr><th>bits</th><th>32</th><th>31</th><th>30</th><th>29</th><th>28</th><th>27</th><th>26</th><th>25</th><th>24</th><th>23</th><th>22</th><th>21</th><th>20</th><th>19</th><th>18</th><th>17</th><th>16</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><th rowspan="5">Header</th><td colspan="33">frame size</td></tr>
<tr><td colspan="33">ADF key</td></tr>
<tr><td>E</td><td>D</td><td colspan="12"></td><td>C</td><td>B</td><td>A</td><td colspan="8">board nb</td><td colspan="8">channel nb</td></tr>
<tr><td colspan="33">Timestamp_0</td></tr>
<tr><td colspan="33">Timestamp_1</td></tr>
<tr><th>Data</th><td colspan="17">time (CFD)</td><td colspan="16">energy</td></tr>
</table>

data types

<table>
<tr><td colspan="4">uint32_t</td></tr>
<tr><td colspan="4">uint32_t</td></tr>
<tr><td colspan="2">bitarray<16></td><td>uint8_t</td><td>uint8_t</td></tr>
<tr><td colspan="4">uint32_t</td></tr>
<tr><td colspan="4">uint32_t</td></tr>
<tr><td colspan="2">uint16_t</td><td colspan="2">uint16_t</td></tr>
</table>

Flags

A	Pile-up rejection
B	Trapezoidal saturation
C	Input saturation
D	Board fail (PLL unlock or temperature)
E	IDLE

ADF keys

0xFA0201A0	Prisma RAW
0xFA0201A1	Prisma Analyzed
0xFA0201A2	SPIDER
0xFA0201A3	DANTE
0xFA0201A4	EUCLIDES
0xFA0201A5	LaBr3
0xFA0201A6	SAURON
0xFA0201A7	OSCAR

LF data format - .adf

PHA dataframe

(SPIDER, EUCLIDES, DANTE, OSCAR)

<table>
<tr><th>bits</th><th>32</th><th>31</th><th>30</th><th>29</th><th>28</th><th>27</th><th>26</th><th>25</th><th>24</th><th>23</th><th>22</th><th>21</th><th>20</th><th>19</th><th>18</th><th>17</th><th>16</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td rowspan="5">Header</td><td colspan="33">frame size</td></tr>
<tr><td colspan="33">ADF key</td></tr>
<tr><td>E</td><td>D</td><td colspan="12"></td><td>C</td><td>B</td><td>A</td><td colspan="8">board nb</td><td colspan="8">channel nb</td></tr>
<tr><td colspan="33">Timestamp_0</td></tr>
<tr><td colspan="33">Timestamp_1</td></tr>
<tr><td>Data</td><td colspan="17">time (CFD)</td><td colspan="16">energy</td></tr>
</table>

data types

<table>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td>bitarray<16></td><td>uint8_t</td><td>uint8_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td>uint16_t</td><td colspan="2">uint16_t</td></tr>
</table>

PHA dataframe analyzed waveforms

(SAURON, TRACE)

<table>
<tr><th>bits</th><th>32</th><th>31</th><th>30</th><th>29</th><th>28</th><th>27</th><th>26</th><th>25</th><th>24</th><th>23</th><th>22</th><th>21</th><th>20</th><th>19</th><th>18</th><th>17</th><th>16</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td rowspan="5">Header</td><td colspan="33">frame size</td></tr>
<tr><td colspan="33">ADF key</td></tr>
<tr><td>E</td><td>D</td><td colspan="12"></td><td>C</td><td>B</td><td>A</td><td colspan="8">board nb</td><td colspan="8">channel nb</td></tr>
<tr><td colspan="33">Timestamp_0</td></tr>
<tr><td colspan="33">Timestamp_1</td></tr>
<tr><td rowspan="4">Data</td><td colspan="17">time (CFD)</td><td colspan="16">energy</td></tr>
<tr><td colspan="33">waveform CFD</td></tr>
<tr><td colspan="33">I_MAX</td></tr>
<tr><td colspan="33">PSD</td></tr>
</table>

data types

<table>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td>bitarray<16></td><td>uint8_t</td><td>uint8_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td>uint16_t</td><td colspan="2">uint16_t</td></tr>
<tr><td colspan="3">float32_t</td></tr>
<tr><td colspan="3">float32_t</td></tr>
<tr><td colspan="3">float32_t</td></tr>
</table>

Flags

A	Pile-up rejection
B	Trapezoidal saturation
C	Input saturation
D	Board fail (PLL unlock or temperature)
E	IDLE

ADF keys

0xFA0201A0	Prisma RAW
0xFA0201A1	Prisma Analyzed
0xFA0201A2	SPIDER
0xFA0201A3	DANTE
0xFA0201A4	EUCLIDES
0xFA0201A5	LaBr3
0xFA0201A6	SAURON
0xFA0201A7	OSCAR

LF data format - .adf

PSD dataframe

(LaBr, neutron det.)

<table>
<tr><th>bits</th><th>32</th><th>31</th><th>30</th><th>29</th><th>28</th><th>27</th><th>26</th><th>25</th><th>24</th><th>23</th><th>22</th><th>21</th><th>20</th><th>19</th><th>18</th><th>17</th><th>16</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td rowspan="5">Header</td><td colspan="33">frame size</td></tr>
<tr><td colspan="33">ADF key</td></tr>
<tr><td>E</td><td>D</td><td colspan="12"></td><td>C</td><td>B</td><td>A</td><td colspan="8">board nb</td><td colspan="8">channel nb</td></tr>
<tr><td colspan="33">Timestamp_0</td></tr>
<tr><td colspan="33">Timestamp_1</td></tr>
<tr><td rowspan="2">Data</td><td colspan="17">Qshort</td><td colspan="16">Qlong</td></tr>
<tr><td colspan="33">CFD</td></tr>
</table>

data types

<table>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td>bitarray<16></td><td>uint8_t</td><td>uint8_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td>uint16_t</td><td colspan="2">uint16_t</td></tr>
<tr><td colspan="3">float32_t</td></tr>
</table>

Flags

A	Pile-up rejection
B	Trapezoidal saturation
C	Input saturation
D	Board fail (PLL unlock or temperature)
E	IDLE

ADF keys

0xFA0201A0	Prisma RAW
0xFA0201A1	Prisma Analyzed
0xFA0201A2	SPIDER
0xFA0201A3	DANTE
0xFA0201A4	EUCLIDES
0xFA0201A5	LaBr3
0xFA0201A6	SAURON
0xFA0201A7	OSCAR

LF data format - PRISMA .adf

raw PRISMA dataframe

<table>
<tr><th>bits</th><th>32</th><th>31</th><th>30</th><th>29</th><th>28</th><th>27</th><th>26</th><th>25</th><th>24</th><th>23</th><th>22</th><th>21</th><th>20</th><th>19</th><th>18</th><th>17</th><th>16</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td rowspan="5">Header</td><td colspan="33">frame size</td></tr>
<tr><td colspan="33">ADF key (0xFA0201A0)</td></tr>
<tr><td colspan="33">Event number (0x0)</td></tr>
<tr><td colspan="33">Timestamp_0</td></tr>
<tr><td colspan="33">Timestamp_1</td></tr>
<tr><td>Data 1</td><td colspan="17">ADC value</td><td colspan="8">board</td><td colspan="8">channel</td></tr>
<tr><td>Data 1</td><td colspan="17">ADC value</td><td colspan="8">board</td><td colspan="8">channel</td></tr>
<tr><td>...</td><td colspan="17"></td><td colspan="8"></td><td colspan="8"></td></tr>
<tr><td>Data N</td><td colspan="17">ADC value</td><td colspan="8">board</td><td colspan="8">channel</td></tr>
</table>

data types →

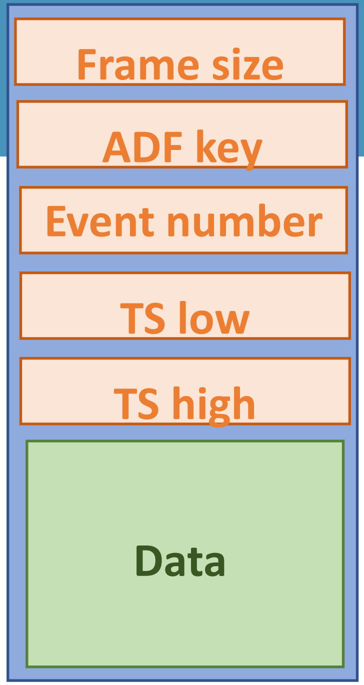
<table>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td>uint16_t</td><td>uint8_t</td><td>uint8_t</td></tr>
<tr><td>uint16_t</td><td>uint8_t</td><td>uint8_t</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>uint16_t</td><td>uint8_t</td><td>uint8_t</td></tr>
</table>

LF data format - ListFrames

od –tx4 –w4 LF_caendig_iX_Y_Z.adf

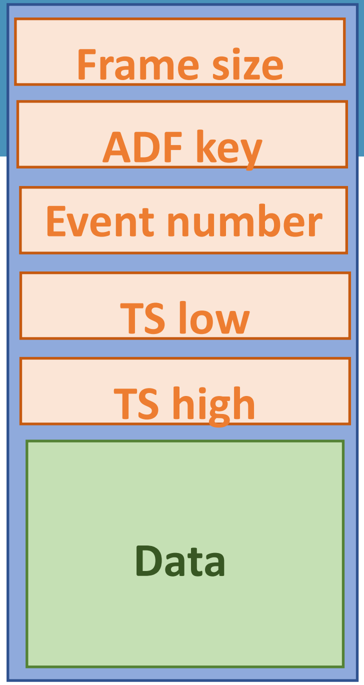
Byte offset Value

```
0000000 00000018
0000004 fa0201a3
0000010 00000504
0000014 cf24d03a
0000020 000000b8
0000024 1f407060
0000030 00000018
0000034 fa0201a3
0000040 00000505
0000044 cf253858
0000050 000000b8
0000054 00001d55
```



LF data format - ListFrames

od –tx4 –w4 LF_caendig_iX_Y_Z.adf



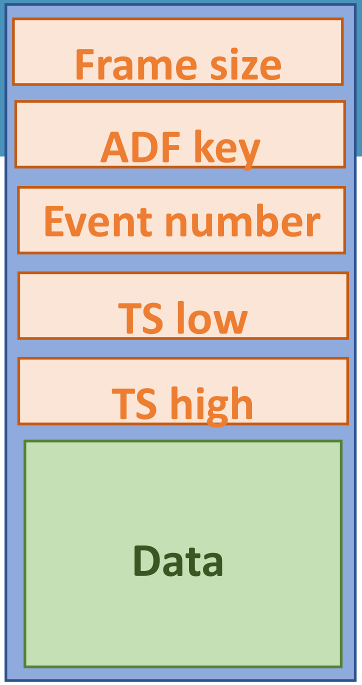
Byte offset **Value**

```
0000000 00000018
0000004 fa0201a3
0000010 00000504
0000014 cf24d03a
0000020 000000b8
0000024 1f407060
0000030 00000018
0000034 fa0201a3
0000040 00000505
0000044 cf253858
0000050 000000b8
0000054 00001d55
```

size in bytes (in hexadecimal $18_{16} = 24_{10}$)

LF data format - ListFrames

od –tx4 –w4 LF_caendig_iX_Y_Z.adf



Byte offset **Value**

```
0000000 00000018
0000004 fa0201a3
0000010 00000504
0000014 cf24d03a
0000020 000000b8
0000024 1f407060
0000030 00000018
0000034 fa0201a3
0000040 00000505
0000044 cf253858
0000050 000000b8
0000054 00001d55
```

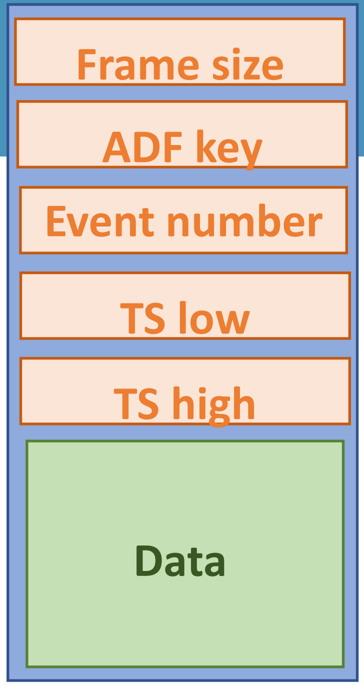
→ **size** in bytes (in hexadecimal $18_{16} = 24_{10}$)

→ **unique** key of DANTE

<table>
<tr><th>bits</th><th>32</th><th>31</th><th>30</th><th>29</th><th>28</th><th>27</th><th>26</th><th>25</th><th>24</th><th>23</th><th>22</th><th>21</th><th>20</th><th>19</th><th>18</th><th>17</th><th>16</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td rowspan="5">Header</td><td colspan="33">frame size</td></tr>
<tr><td colspan="33">ADF key</td></tr>
<tr><td>E</td><td>D</td><td colspan="12"></td><td>C</td><td>B</td><td>A</td><td colspan="8">board nb</td><td colspan="8">channel nb</td></tr>
<tr><td colspan="33">Timestamp_0</td></tr>
<tr><td colspan="33">Timestamp_1</td></tr>
<tr><td>Data</td><td colspan="17">time (CFD)</td><td colspan="16">energy</td></tr>
</table>

<table>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td>bitarray<16></td><td>uint8_t</td><td>uint8_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td>uint16_t</td><td colspan="2">uint16_t</td></tr>
</table>

LF data format - ListFrames



od –tx4 –w4 LF_caendig_iX_Y_Z.adf

Byte offset **Value**

```
0000000 00000018
0000004 fa0201a3
0000010 00000504
0000014 cf24d03a
0000020 000000b8
0000024 1f407060
0000030 00000018
0000034 fa0201a3
0000040 00000505
0000044 cf253858
0000050 000000b8
0000054 00001d55
```

→ **size** in bytes (in hexadecimal $18_{16} = 24_{10}$)

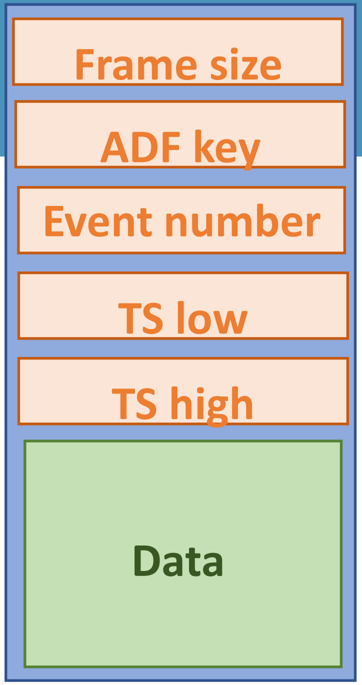
→ **unique** key of DANTE

→ **geo location** 00000000 00000000 00000101 00000100_2 (board 5: 00000101, channel 4: 00000100)

<table>
<tr><th>bits</th><th>32</th><th>31</th><th>30</th><th>29</th><th>28</th><th>27</th><th>26</th><th>25</th><th>24</th><th>23</th><th>22</th><th>21</th><th>20</th><th>19</th><th>18</th><th>17</th><th>16</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><th rowspan="5">Header</th><td colspan="33">frame size</td></tr>
<tr><td colspan="33">ADF key</td></tr>
<tr><td>E</td><td>D</td><td colspan="12"></td><td>C</td><td>B</td><td>A</td><td colspan="8">board nb</td><td colspan="8">channel nb</td></tr>
<tr><td colspan="33">Timestamp_0</td></tr>
<tr><td colspan="33">Timestamp_1</td></tr>
<tr><th>Data</th><td colspan="17">time (CFD)</td><td colspan="16">energy</td></tr>
</table>

<table>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td>bitarray<16></td><td>uint8_t</td><td>uint8_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td>uint16_t</td><td colspan="2">uint16_t</td></tr>
</table>

LF data format - ListFrames



od –tx4 –w4 LF_caendig_iX_Y_Z.adf

Byte offset **Value**

```
0000000 00000018
0000004 fa0201a3
0000010 00000504
0000014 cf24d03a
0000020 000000b8
0000024 1f407060
0000030 00000018
0000034 fa0201a3
0000040 00000505
0000044 cf253858
0000050 000000b8
0000054 00001d55
```

- **size** in bytes (in hexadecimal $18_{16} = 24_{10}$)
- **unique** key of DANTE
- **geo location** 00000000 00000000 00000101 00000100_2 (board 5: 00000101, channel 4: 00000100)
- **timestamp** 000000b8 $cf24d03a_{16} = 793\ 749\ 278\ 778_{10}$

<table>
<tr><th>bits</th><th>32</th><th>31</th><th>30</th><th>29</th><th>28</th><th>27</th><th>26</th><th>25</th><th>24</th><th>23</th><th>22</th><th>21</th><th>20</th><th>19</th><th>18</th><th>17</th><th>16</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td rowspan="5">Header</td><td colspan="33">frame size</td></tr>
<tr><td colspan="33">ADF key</td></tr>
<tr><td>E</td><td>D</td><td colspan="12"></td><td>C</td><td>B</td><td>A</td><td colspan="8">board nb</td><td colspan="8">channel nb</td></tr>
<tr><td colspan="33">Timestamp_0</td></tr>
<tr><td colspan="33">Timestamp_1</td></tr>
<tr><td>Data</td><td colspan="17">time (CFD)</td><td colspan="16">energy</td></tr>
</table>

<table>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td>bitarray<16></td><td>uint8_t</td><td>uint8_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td colspan="3">uint32_t</td></tr>
<tr><td>uint16_t</td><td colspan="2">uint16_t</td></tr>
</table>

LF data format - ListFrames

od –tx4 –w4 LF_caendig_iX_Y_Z.adf

Frame size
ADF key
Event number
TS low
TS high
Data

Byte offset **Value**

```
0000000 00000018
0000004 fa0201a3
0000010 00000504
0000014 cf24d03a
0000020 000000b8
0000024 1f407060
0000030 00000018
0000034 fa0201a3
0000040 00000505
0000044 cf253858
0000050 000000b8
0000054 00001d55
```

size in bytes (in hexadecimal $18_{16} = 24_{10}$)

unique key of DANTE

geo location 00000000 00000000 00000101 00000100_2 (board 5: 00000101, channel 4: 00000100)

timestamp 000000b $81f407060_{16}$ = 790 798 299 232_{10}

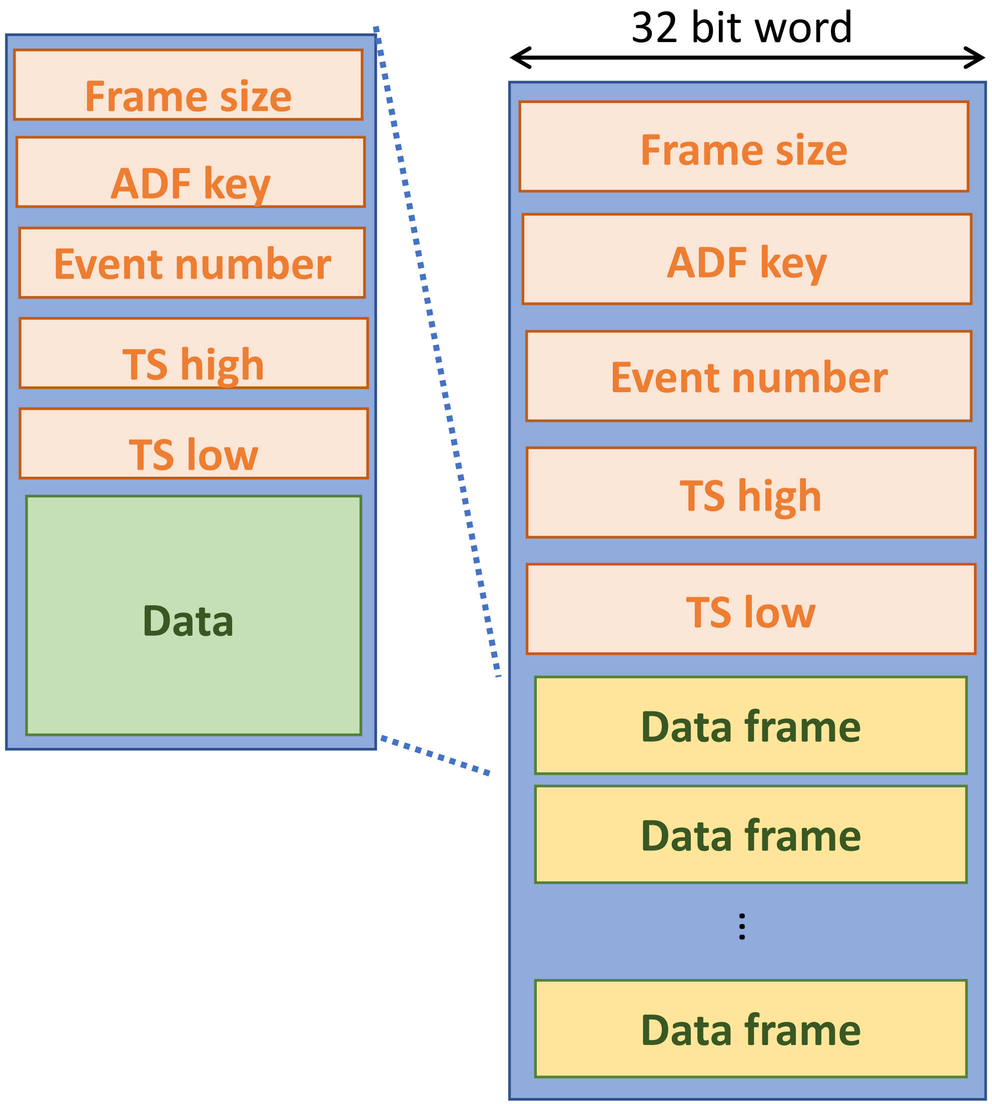
energy 7060_{16} = 28 768_{10}

CFD $1f40_{16}$ = 8 000_{10}

bits	32	31	30–19	18	17	16	15–8	7–0
Header	frame size							
	ADF key							
	E	D		C	B	A	board nb	channel nb
	Timestamp_0							
	Timestamp_1							
Data	time (CFD)						energy	

uint32_t		
uint32_t		
bitarray<16>	uint8_t	uint8_t
uint32_t		
uint32_t		
uint16_t	uint16_t	

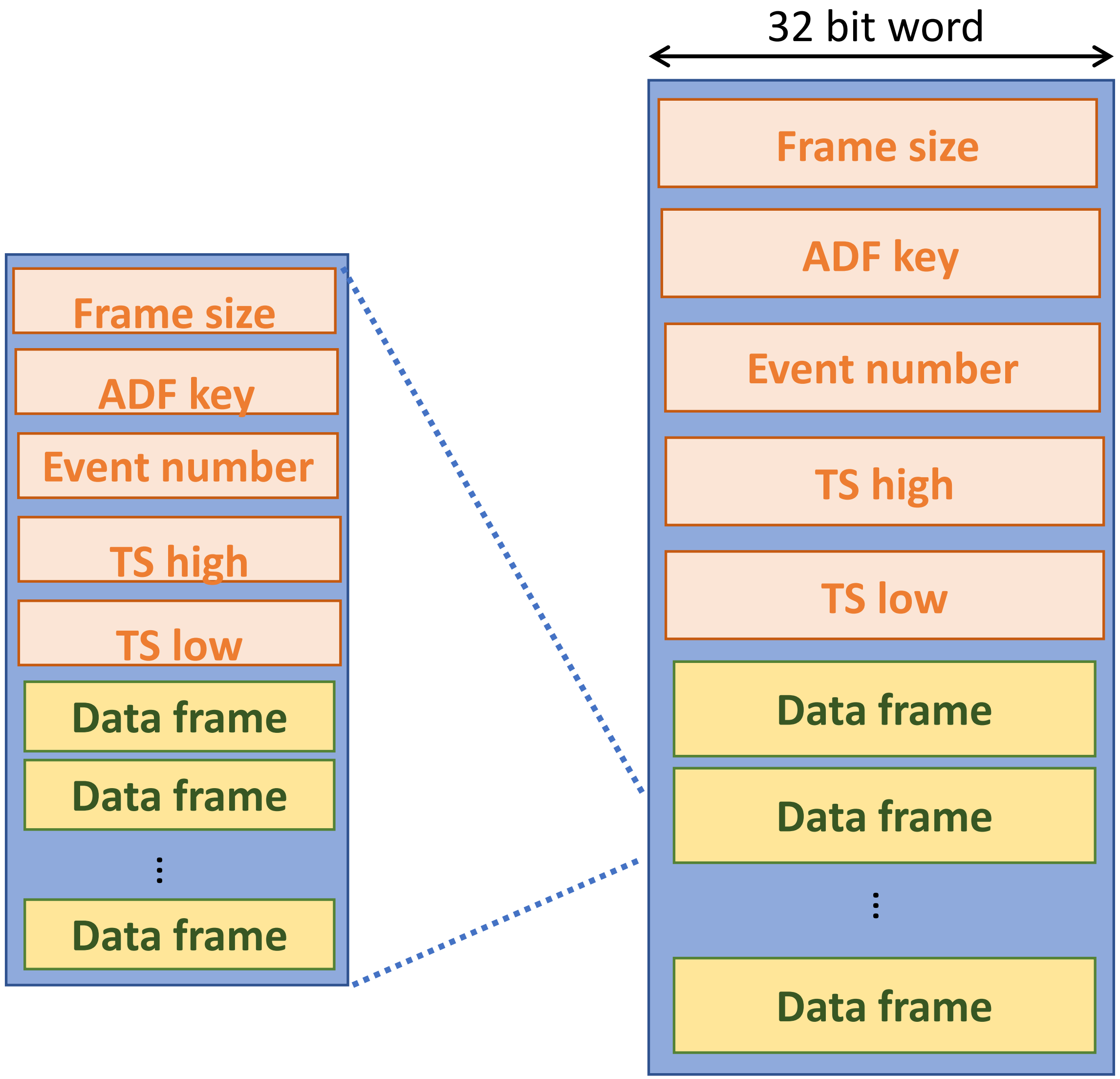
BU data format - general ADF



size of the whole frames in bytes

key **0xCA??????** denotes composite frame

BU data format - general ADF



size of the whole frames in bytes

key **0xCA??????** denotes composite frame

composite frame can contain other composite frames

BU data format - ListFrames

#	event	bOffset	bSize	0xKeyADF	eventNum	(rel)timeStamp	dTstamp	keyADFname
	0	0	44	ca020100	1	793749240860		event:ranc
			24	fa0201a2	262405	0		.data:ranc2
	1	44	48	ca020100	1	793749174399	18446744073709485155	event:ranc
			28	fa0201a5	7	0		
	2	92	48	ca020100	1	793749235868	61469	event:ranc
			28	fa0201a5	3	0		
	3	140	48	ca020100	1	793749263594	27726	event:ranc
			28	fa0201a5	2	0		
	4	188	48	ca020100	1	793749266116	2522	event:ranc
			28	fa0201a5	0	0		
	5	236	48	ca020100	1	793749266923	807	event:ranc
			28	fa0201a5	2	0		
	6	284	48	ca020100	1	793749275949	9026	event:ranc
			28	fa0201a5	1	0		
	7	332	48	ca020100	1	793749277724	1775	event:ranc
			28	fa0201a5	4	0		
	8	380	44	ca020100	1	793749278344	620	event:ranc
			24	fa0201a2	262656	0		.data:ranc2
	9	424	92	ca020100	3	793749278773	429	event:ranc
			24	fa0201a3	1282	0		
			24	fa0201a3	1284	5		
			24	fa0201a3	1288	13		
	10	516	48	ca020100	1	793749282227	3454	event:ranc
			28	fa0201a5	6	0		
	11	564	116	ca020100	4	793749305425	23198	event:ranc
			24	fa0201a3	1284	8		
			24	fa0201a3	1285	7		
			24	fa0201a3	1286	0		

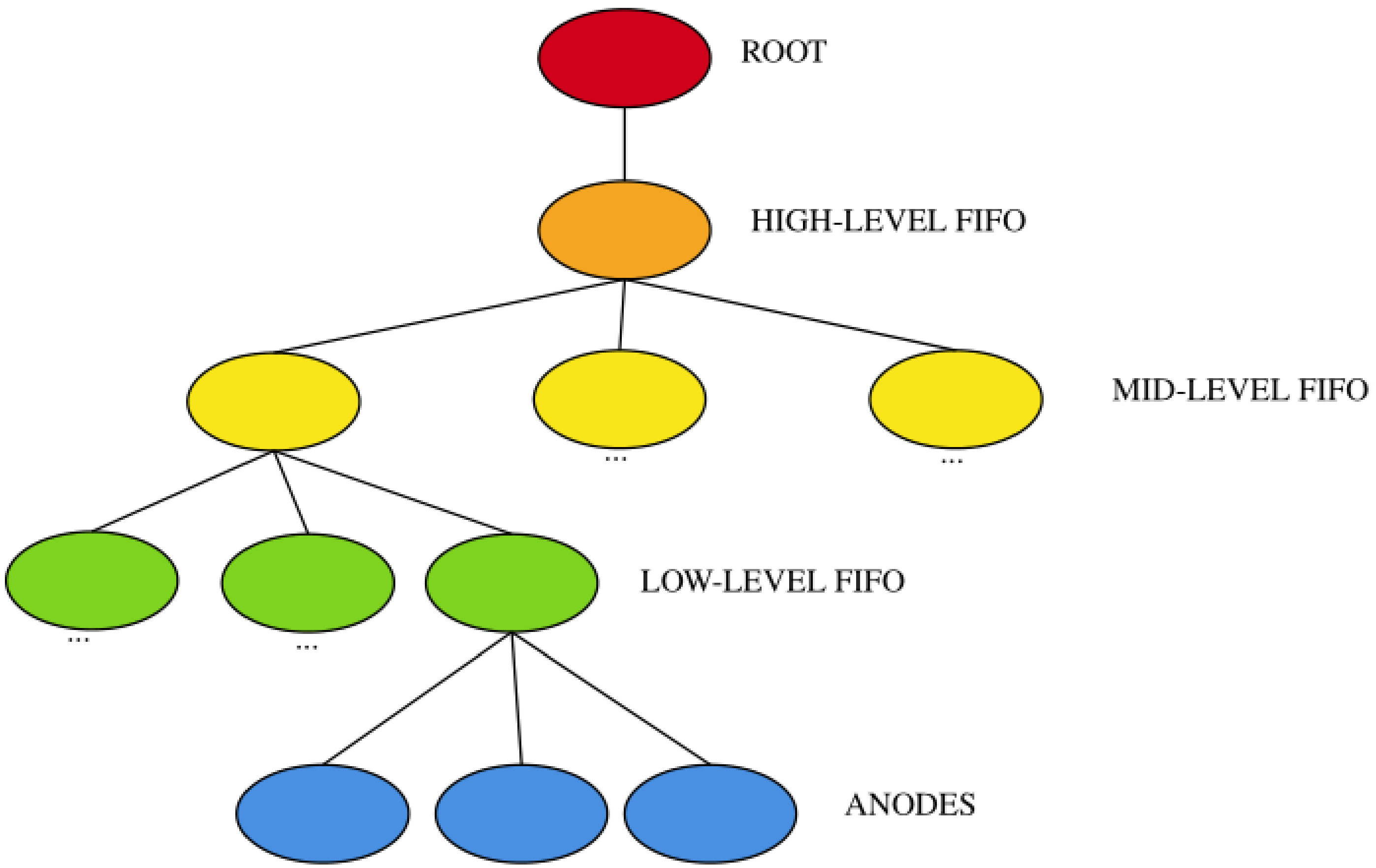
BU data format – PRISMA .adf

	Type	What	Comment
Header	uint32_t	**Size**	25*4
	uint32_t	**Key**	0xFA0201A1
	bitset<32>	**flags**	flags on valid events (mcp_ok, side_ok, traj_ok, ...)
	uint32_t	**TSTAMP_0**	AGAVA - local TS - low part
	uint32_t	**TSTAMP_1**	AGAVA - local TS - high part
Data	float	**monitor_0**	MONITOR 0 energy
	float	**monitor_1**	MONITOR 1 energy
	float	**mcp_x**	MCP X [mm]
	float	**mcp_y**	MCP Y [mm]
	float	**mcp_q**	MCP Charge
	float	**mcp_theta**	MCP Theta for PRISMA Analysis (degree)
	float	**mcp_phi**	MCP Phi for PRISMA Analysis (degree)
	float	**x_fp**	Position X focal plane [mm]
	float	**y_fp**	position Y focal plane [mm]
	float	**tof**	Time of flight [ns]
	float	**ic_e**	Total Energy [a.u.]
	float	**ic_de_a**	Energy loss first raw [a.u.]
	float	**ic_de_ab**	Energy loss first two raws [a.u.]
	float	**ic_range**	Range of the ion in the IC [a.u.]
	float	**ic_drift**	Drift time on the C-section [a.u.]
	uint8_t	**ic_a_numpads**	Number of pads A hit
	uint8_t	**ic_b_numpads**	Number of pads B hit
	float	**theta**	Recoil Theta in the AGATA frame of reference for Doppler Correction [deg]
	float	**phi**	Recoil Phi in the AGATA frame of reference for Doppler Correction [deg]

Data	float	**beta**	Recoil Beta for DC [v/c]
	float	**length**	calculated Trajectory length [mm]
	float	**radius**	Calculated trajectory radius in the dipole [mm]
	float	**rbeta**	Beta for DC [v/c]
	float	**a_over_q**	Calculated A/q
	float	**qvalue**	Calculated Q-Value for the event [MeV]
	float	**theta_bp**	Binary partner Binary partner Theta in the AGATA frame of reference for Doppler Correction [deg]
	float	**phi_bp**	Binary partner Phi in the AGATA frame of reference for Doppler Correction [deg]
	float	**beta_bp**	Binary partner Beta for DC [v/c]
	float	**tac_lt_ts**	TAC between LT and VTS [ns]
	uint8_t	**z_nbr**	Atomic number corresponding to the gate on the IC (IC_DE(A) vs IC_E or IC_DE(AB) vs IC_E or
	uint8_t	**q_nbr**	Charge state corresponding to the gate put on Radius*Beta vs IC_E (after Z-gate)
	uint8_t	**a_nbr**	Mass corresponding to the cut on A/q*q vs x_fp (after Z and q gates)
	bool	**mcp_ok**	
	bool	**tof_ok**	
	bool	**traj_ok**	
	bool	**side_ok**	
	bool	**ic_ok**	
	bool	**z_ok**	
	bool	**q_ok**	
	bool	**a_ok**	

Clock distribution

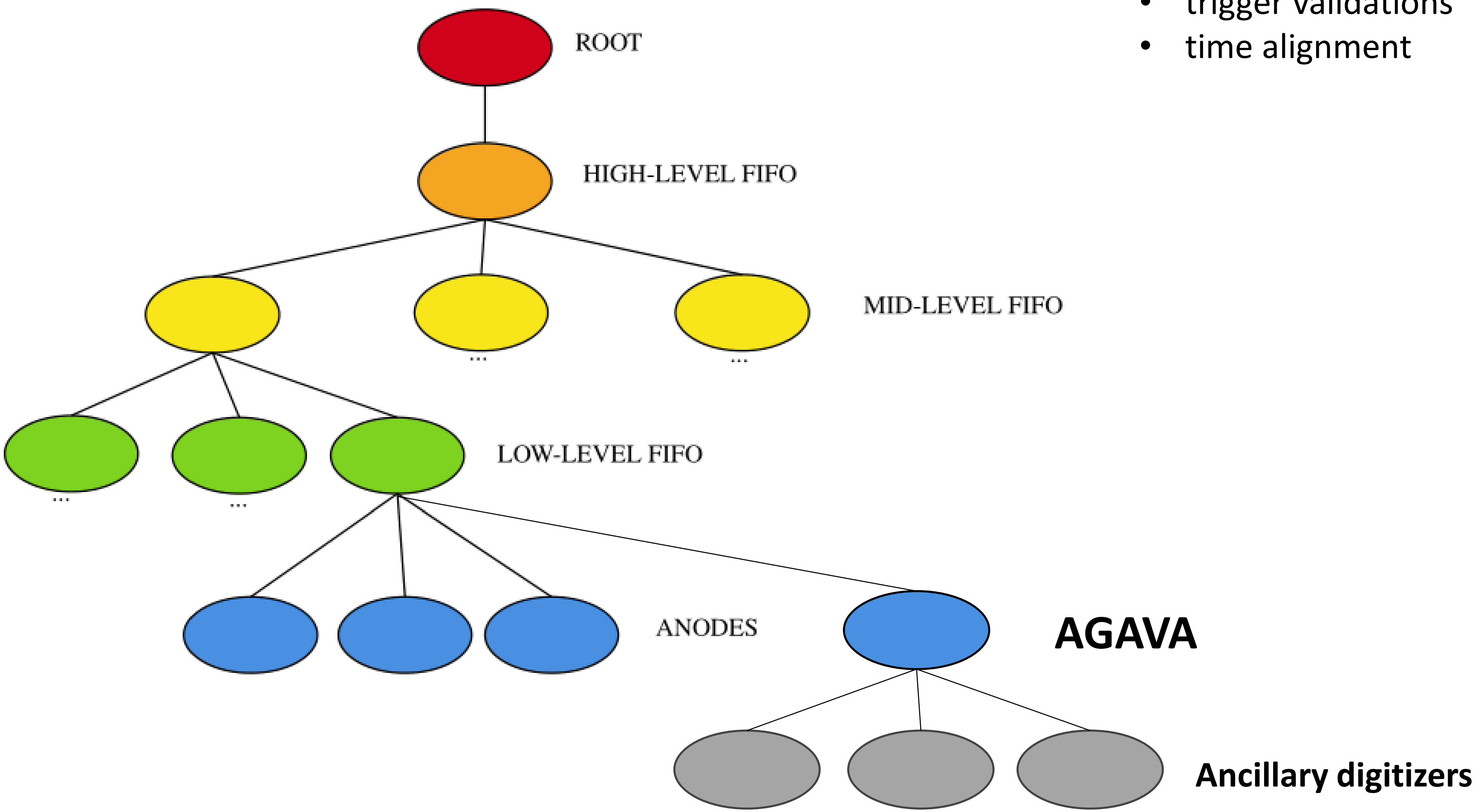
GTS tree



- 100 MHz clock
- trigger requests
- trigger validations
- time alignment

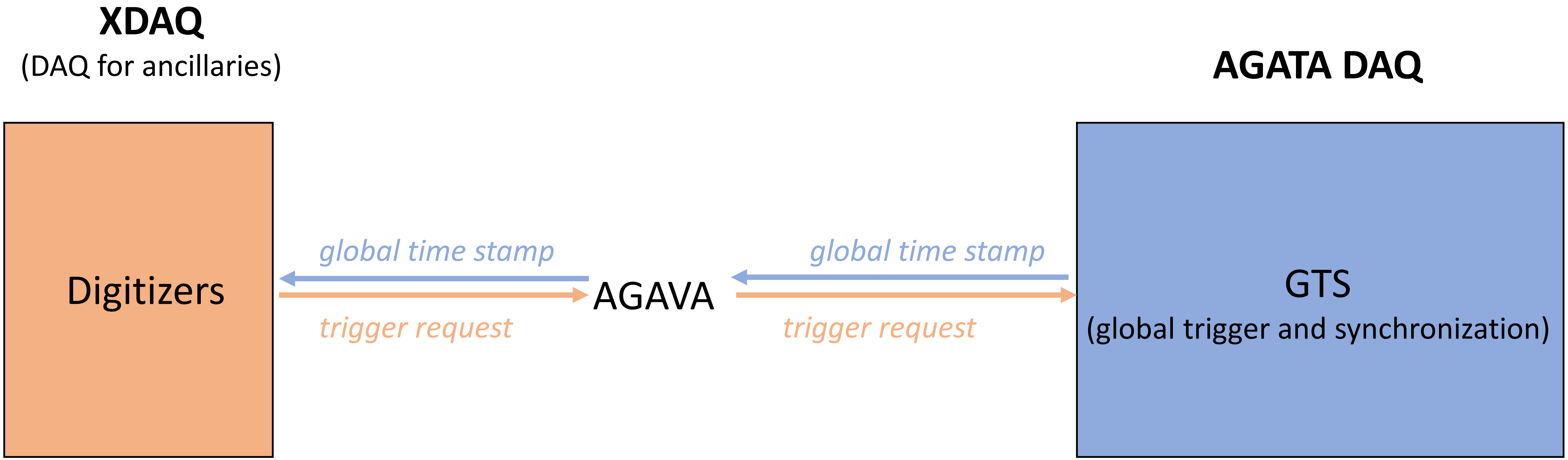
Clock distribution

GTS tree



- 100 MHz clock
- trigger requests
- trigger validations
- time alignment

Timestamp problem

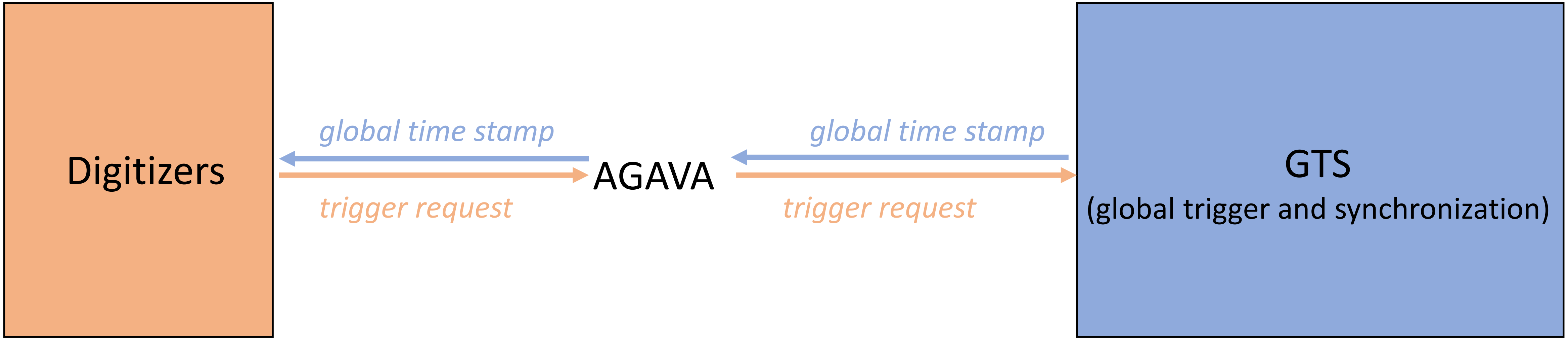


Timestamp problem

XDAQ

(DAQ for ancillaries)

AGATA DAQ

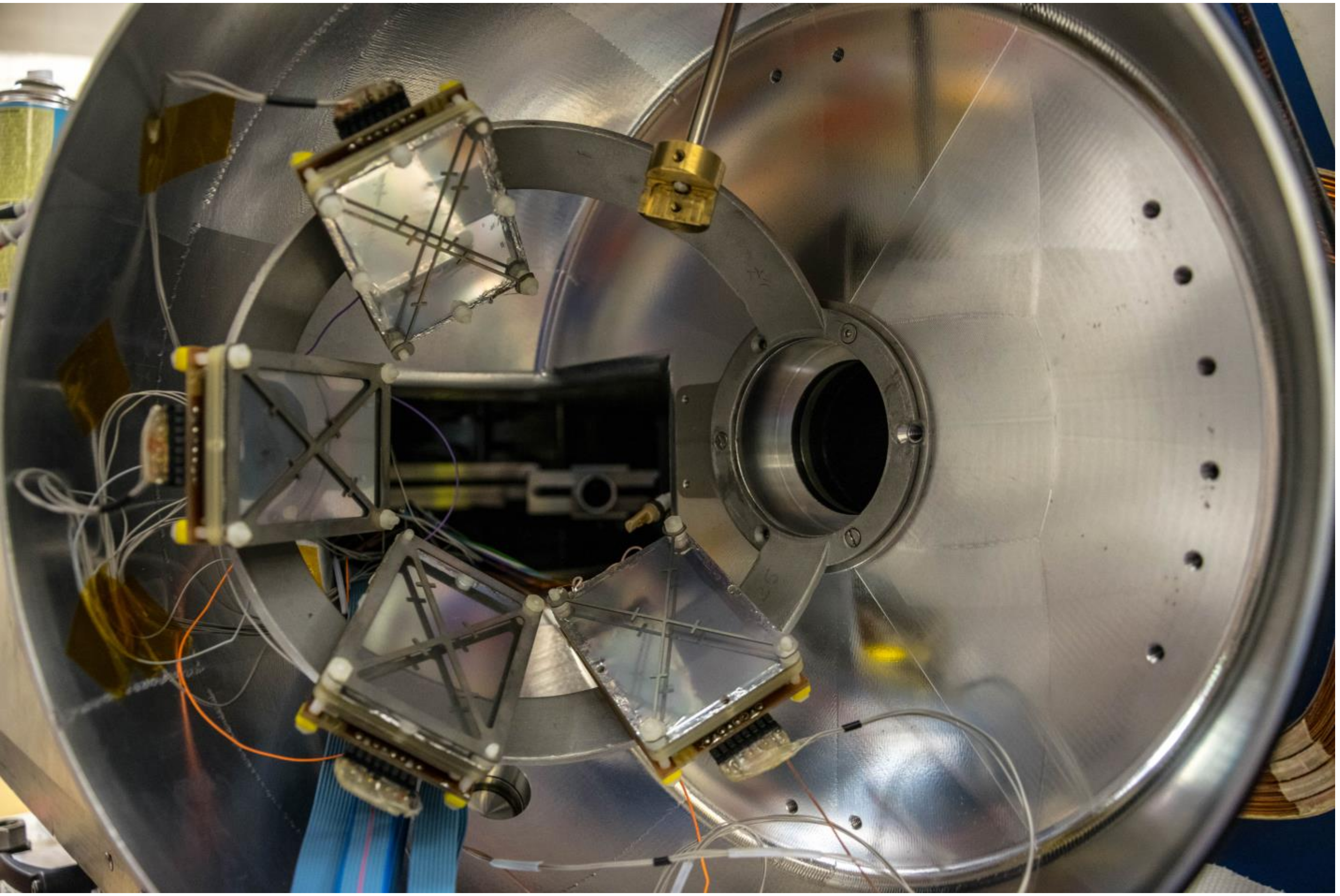


It can happen that AGAVA board is in busy state while starting run – it will not propagate the initial time stamp

<u>Ancillaries will start with timestamp 0!!!</u>

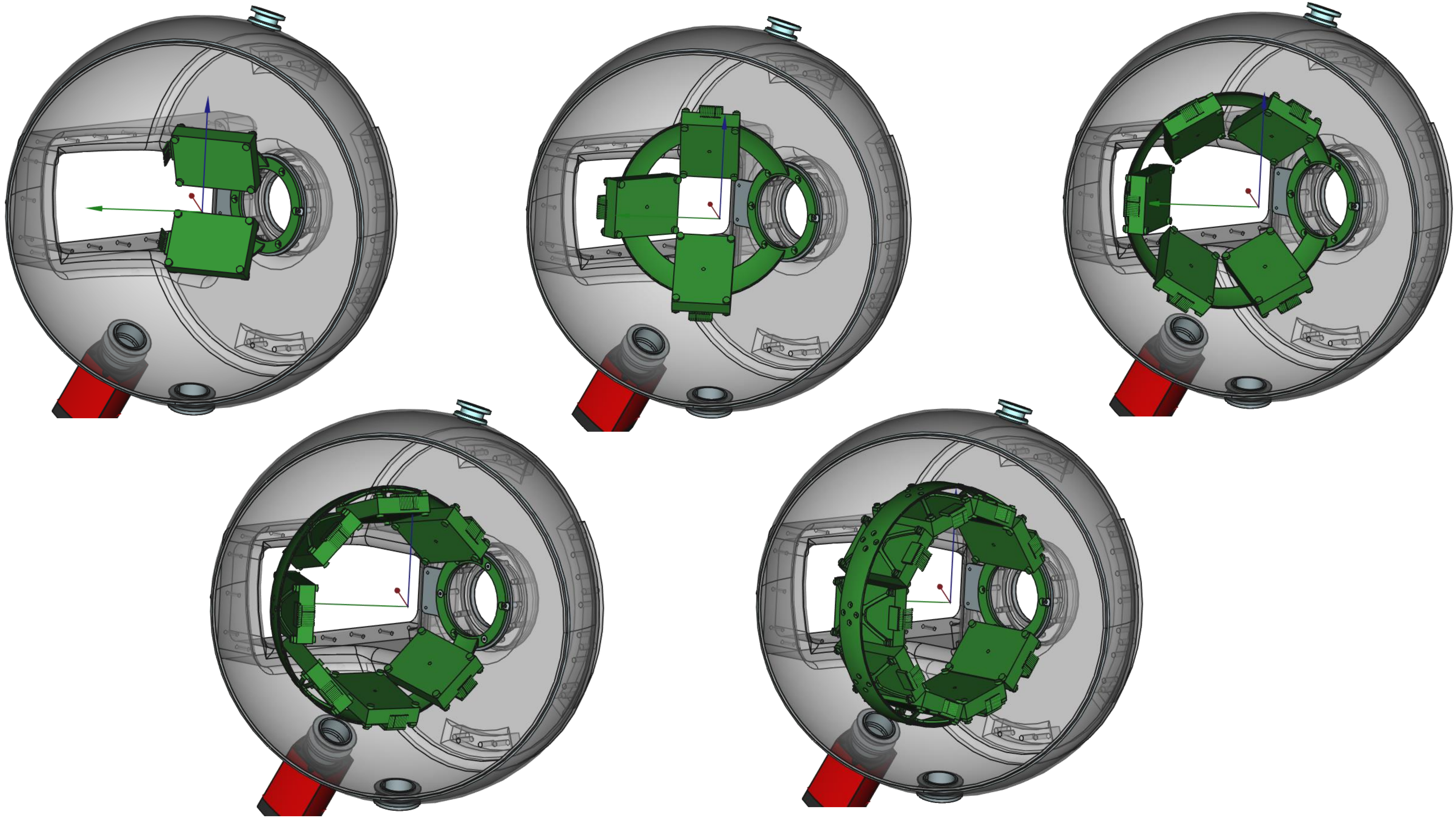
Detectors

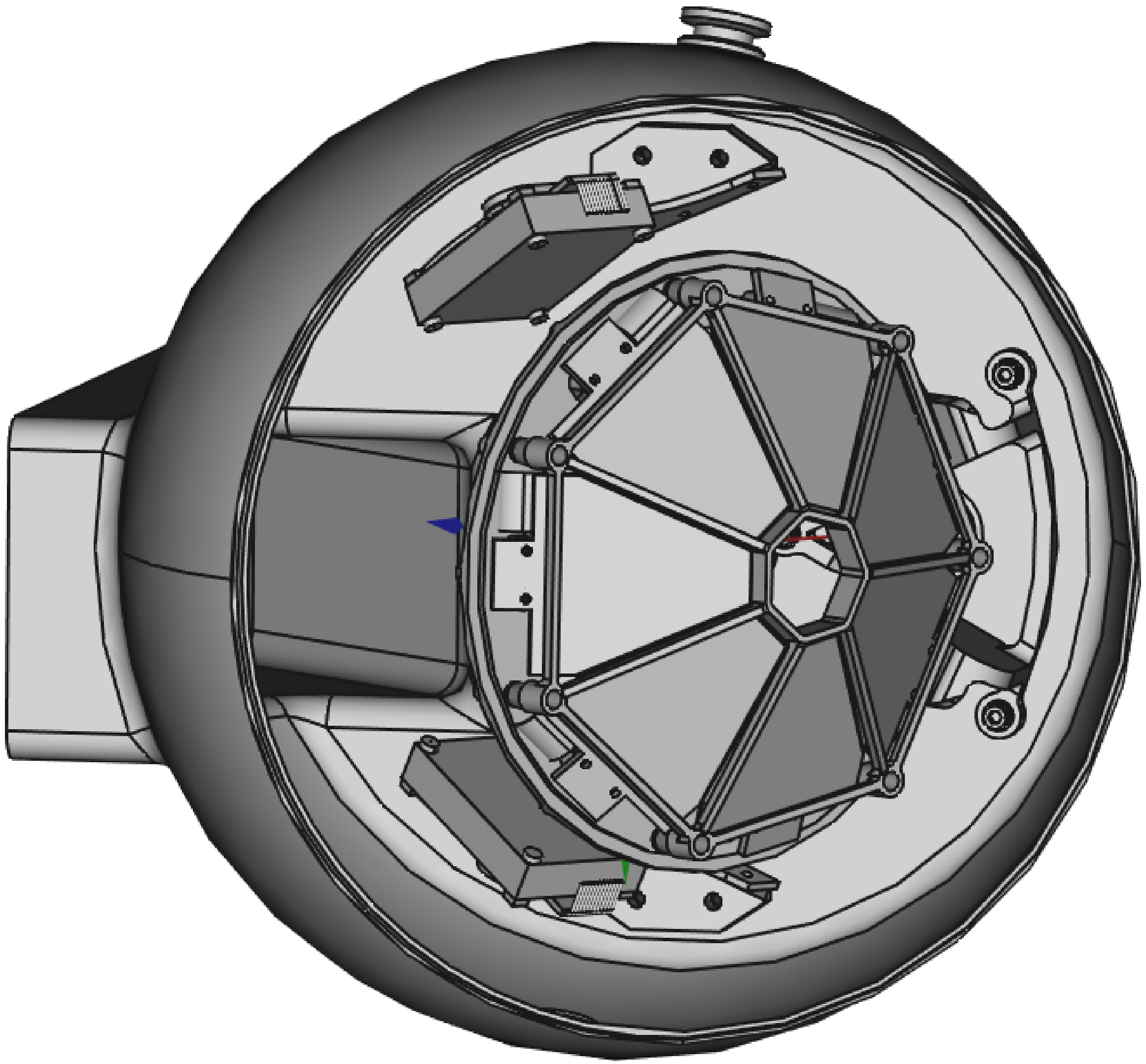
DANTE

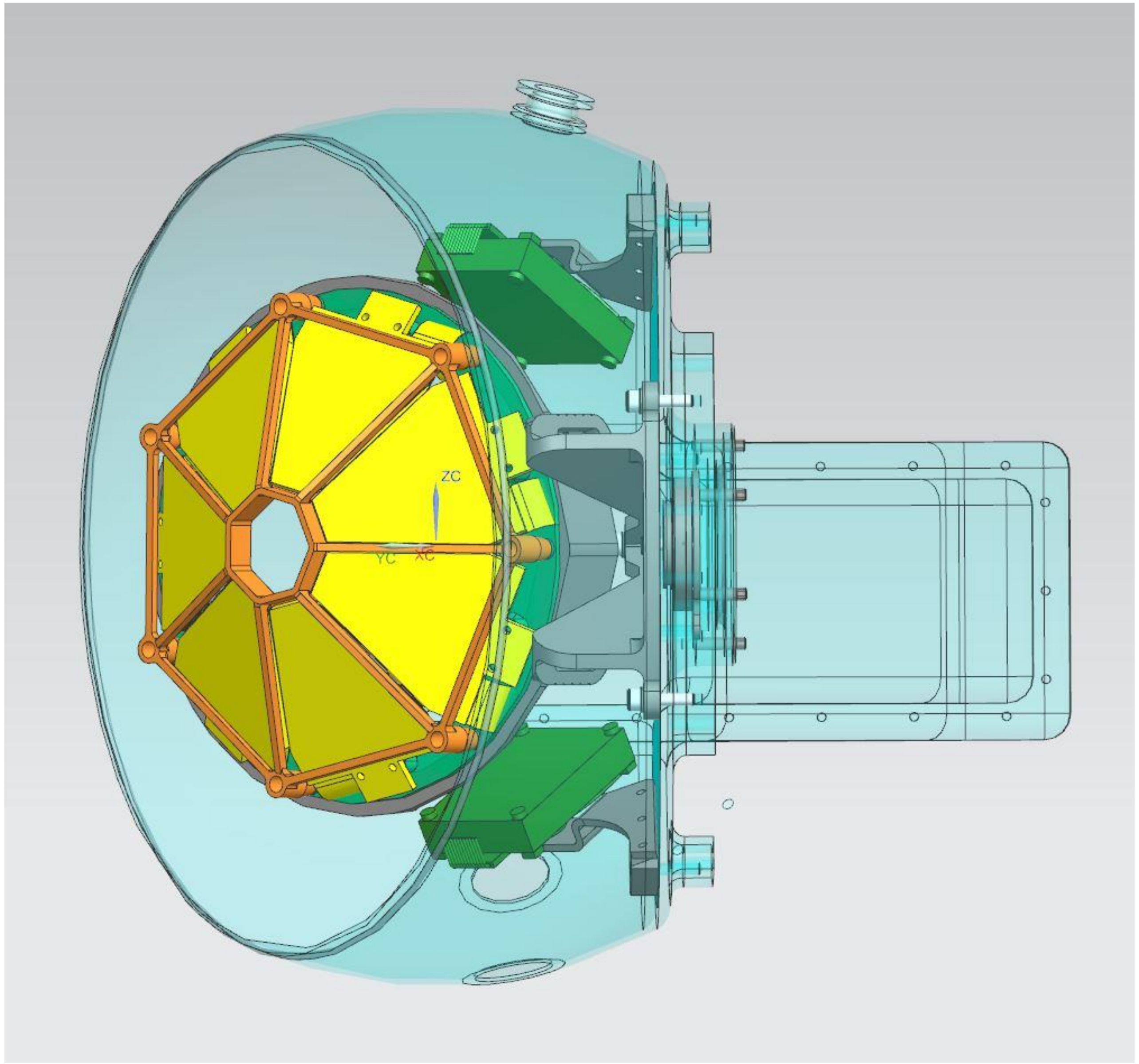


DANTE

- MCP detectors
- size 40x60mm
- time resolution 200ps
- spatial resolution 1mm






ZC
YC
XC

DANTE look-up table

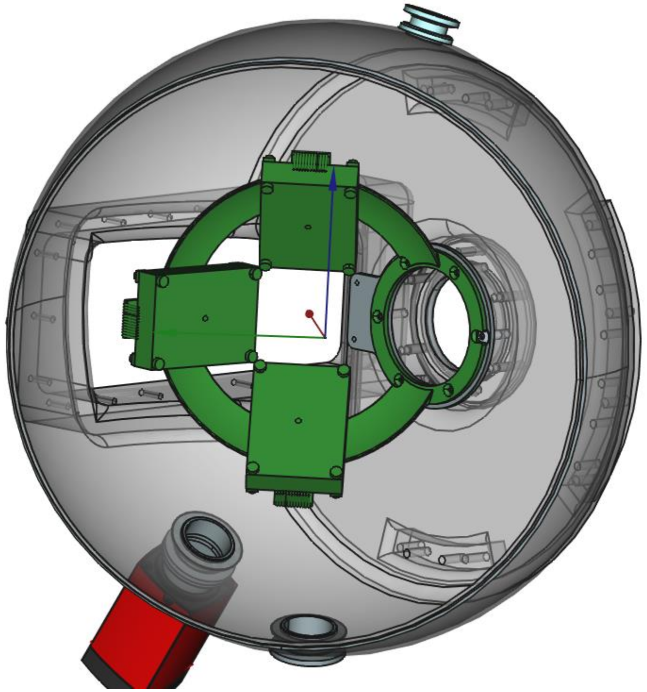
Detector number fixed based on the configuration (2,3,5,… detectors)

- points 1,2,3 represents screws
- exact P1, P2, P3 taken from CAD
- pos1, pos2, po3 calibration points

main ⌄ agataselector / User / EXP / Template / Conf / LUT / LUT_DANTE_3det_

LUT_DANTE_3det_0deg.dat 2.75 KiB

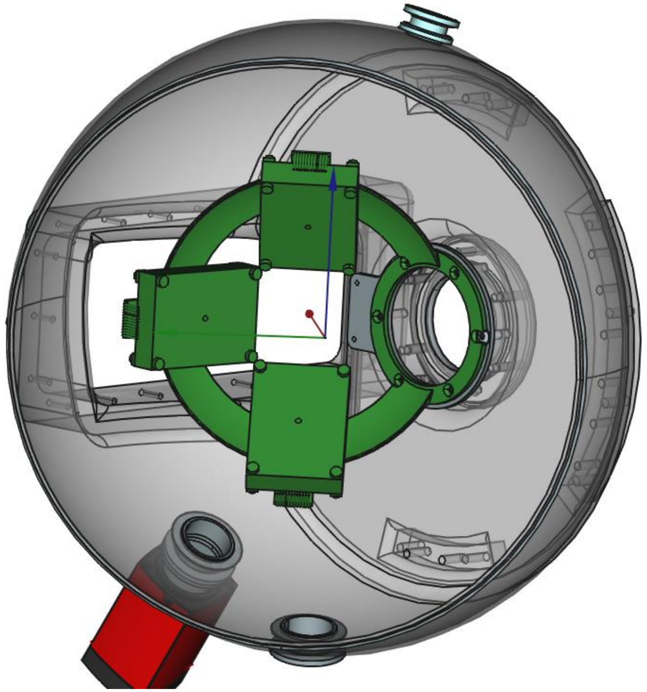
```
#                2                   X          Y          Z
#                        D1P1   72.8361    25.3272    23.7575
#                D1      D1P2   41.2708    77.7189   -11.2993
#                        D1P3   35.3073    25.3272    57.5486
#             3  1   3
#                        D2P1   72.8935   -25.2499    23.7059
#     D2          X      D2P2   80.2628   -25.2499   -46.4078
#                        D2P3   72.8935    25.2500    23.7059
#  2          1  3   1
#                        D3P1   35.3073   -25.3272    57.5486
#                D3      D3P2    3.7420   -77.7189    22.4917
#                        D3P3   72.8361   -25.3272    23.7575
#                    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
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
```



DANTE look-up table

Detector number fixed based on the configuration (2,3,5,… detectors)

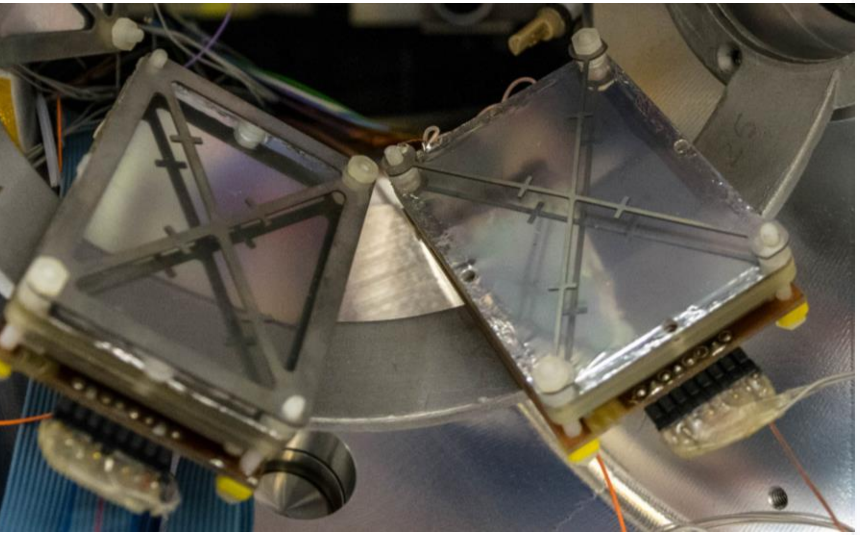
- points 1,2,3 represents screws
- exact P1, P2, P3 taken from CAD – **screw centers**
- pos1, pos2, po3 calibration points



main ⌄ agataselector / User / EXP / Template / Conf / LUT / LUT_DANTE_3det_(

LUT_DANTE_3det_0deg.dat 2.75 KiB

```
#                2                          X          Y          Z
#                    D1         D1P1    72.8361    25.3272    23.7575
#                    D1         D1P2    41.2708    77.7189   -11.2993
#                               D1P3    35.3073    25.3272    57.5486
#            3   1      3
#                               D2P1    72.8935   -25.2499    23.7059
#      D2            X          D2P2    80.2628   -25.2499   -46.4078
#                               D2P3    72.8935    25.2500    23.7059
#  2         1   3      1
#                               D3P1    35.3073   -25.3272    57.5486
#                    D3         D3P2     3.7420   -77.7189    22.4917
#                               D3P3    72.8361   -25.3272    23.7575
#                       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
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
```



DANTE look-up table

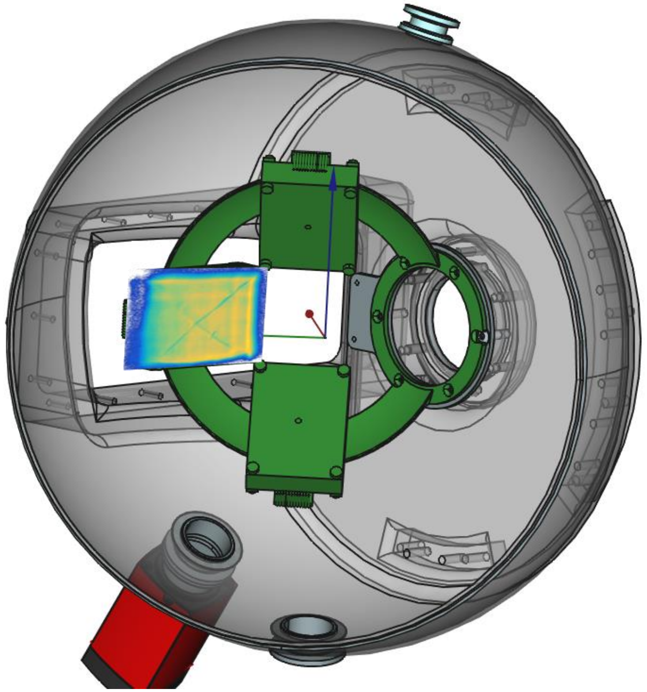
Detector number fixed based on the configuration (2,3,5,… detectors)

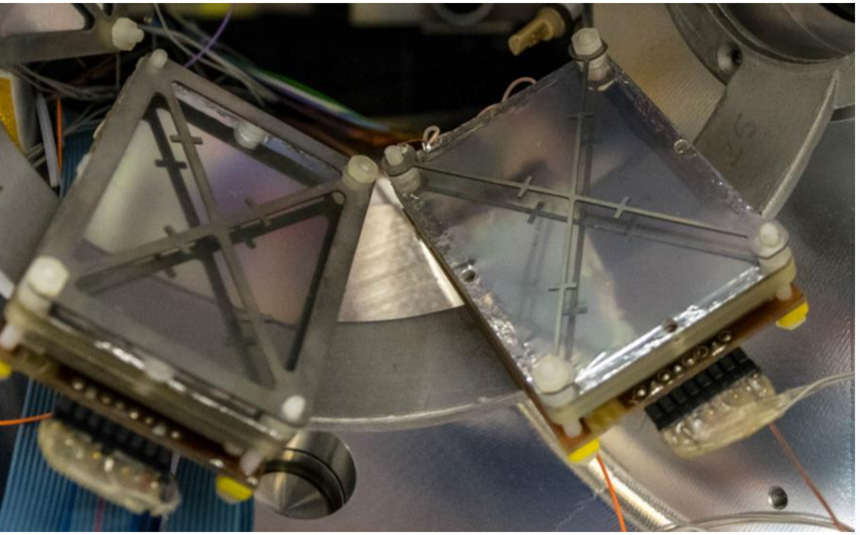
- points 1,2,3 represents screws
- exact P1, P2, P3 taken from CAD – **screw centers**
- pos1, pos2, po3 calibration points

main ⌄ agataselector / User / EXP / Template / Conf / LUT / LUT_DANTE_3det_(

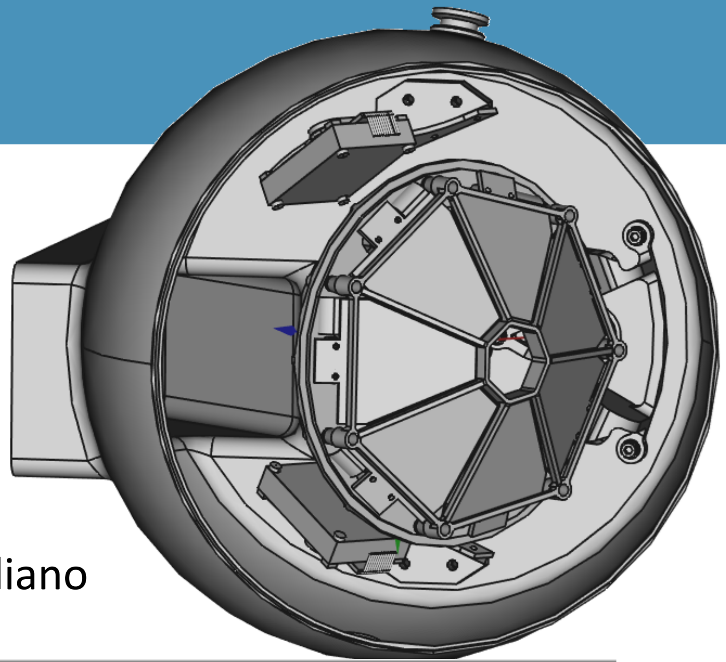
LUT_DANTE_3det_0deg.dat 2.75 KiB

```
#                  2 ┌──┐                      X          Y          Z
#                    │  │        D1P1     72.8361    25.3272    23.7575
#                    │D1│        D1P2     41.2708    77.7189   -11.2993
#                    │  │        D1P3     35.3073    25.3272    57.5486
#                3  1└──┘3
#     ┌──────┐       ┌─┐         D2P1     72.8935   -25.2499    23.7059
#     │  D2  │       │X│         D2P2     80.2628   -25.2499   -46.4078
#     └──────┘       └─┘         D2P3     72.8935    25.2500    23.7059
#   2        1    3 ┌──┐1
#                   │  │         D3P1     35.3073   -25.3272    57.5486
#                   │D3│         D3P2      3.7420   -77.7189    22.4917
#                   │  │         D3P3     72.8361   -25.3272    23.7575
#                   └──┘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
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
```



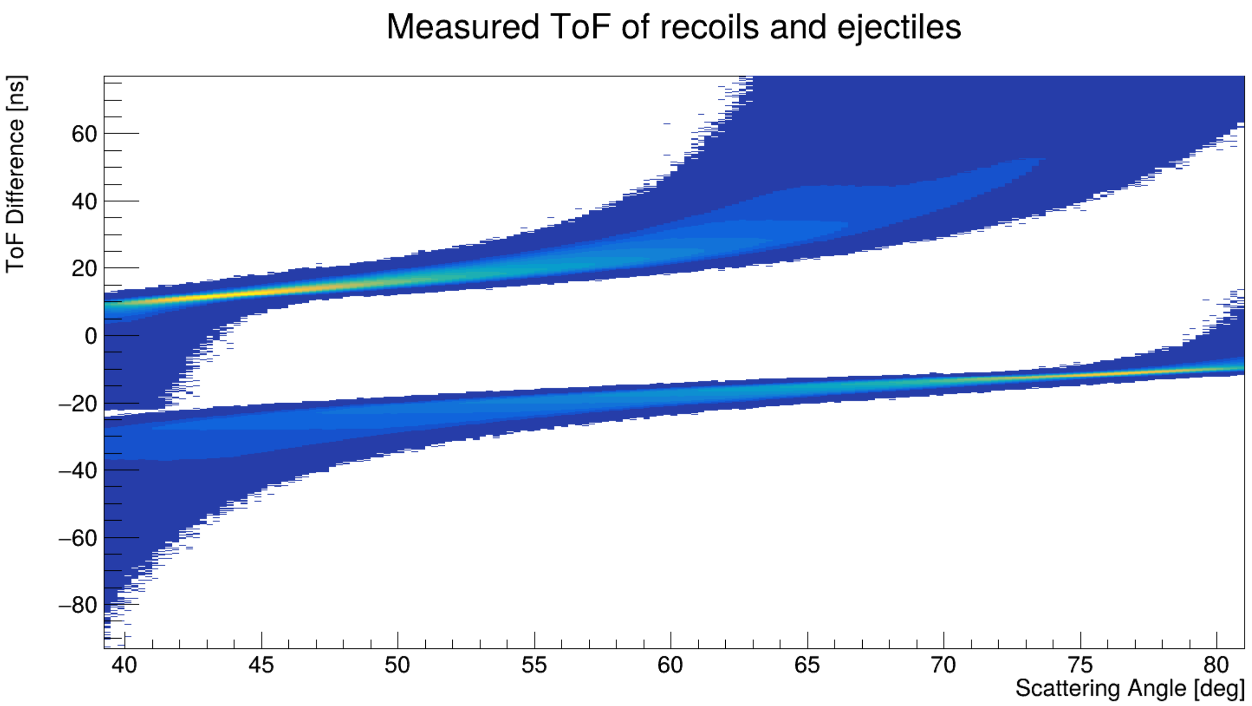


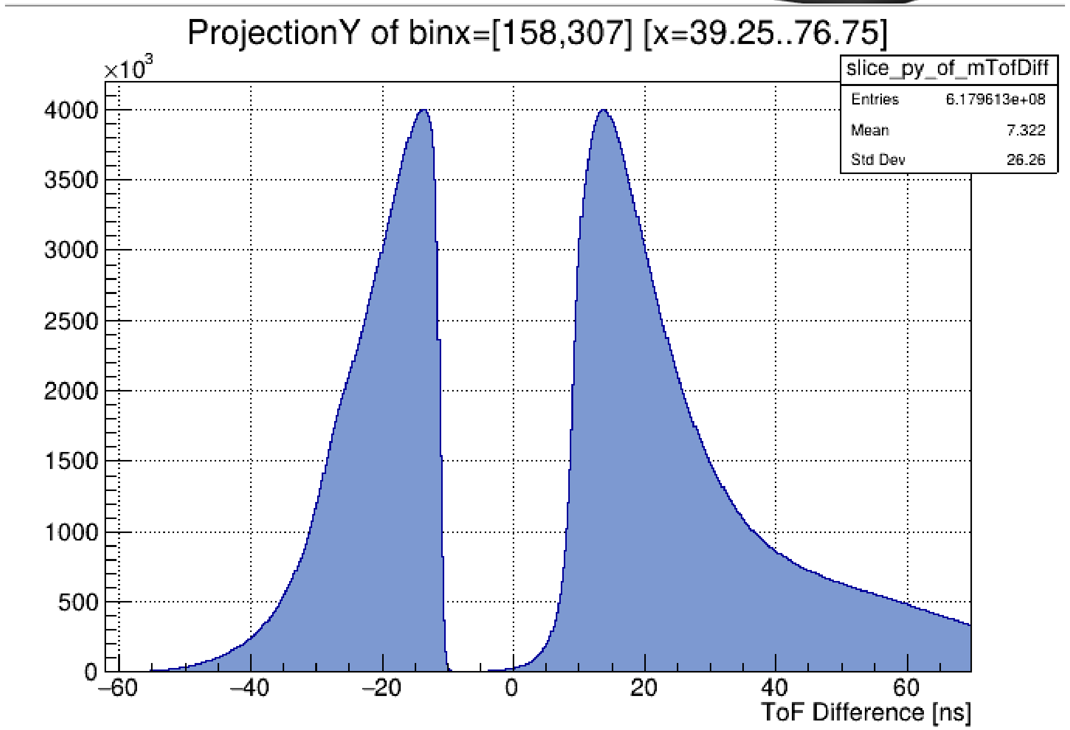
DANTE ToF discrimination



- covering 40-80deg
- 10 cm from target

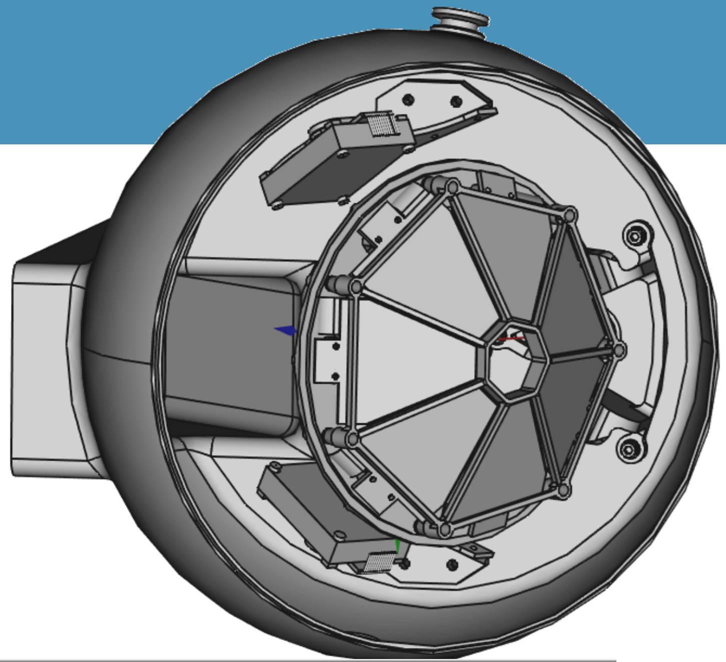
Calculations for $^{64}Zn+^{208}Pb$ @220MeV by Marco Siciliano

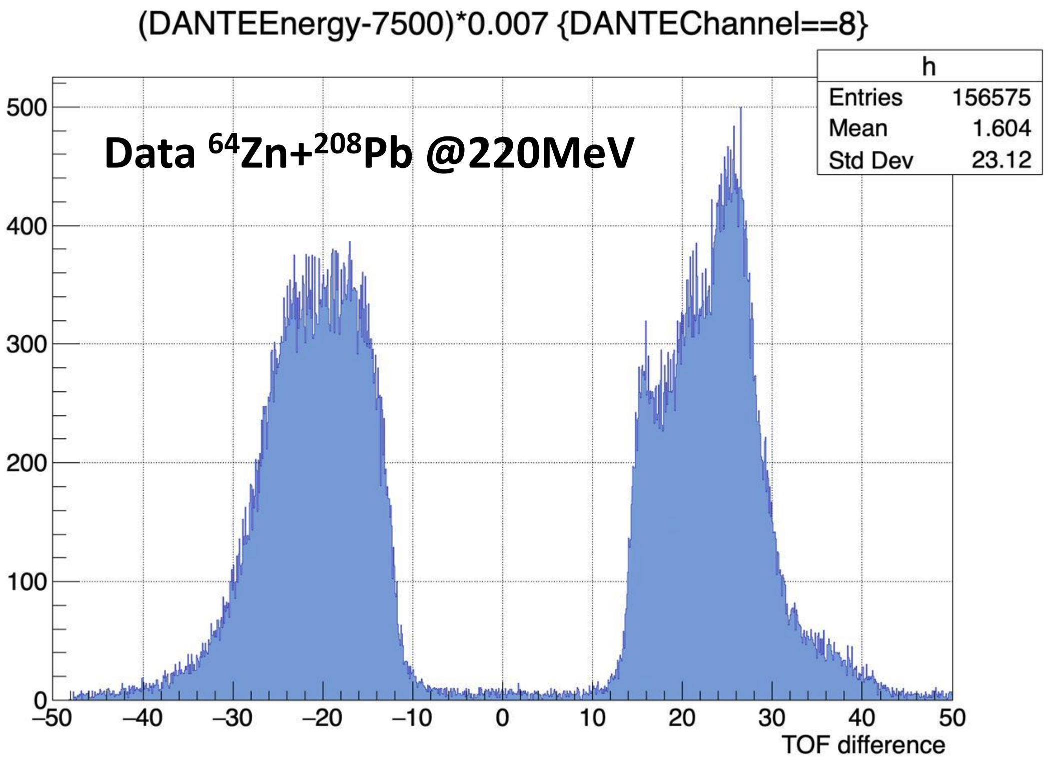


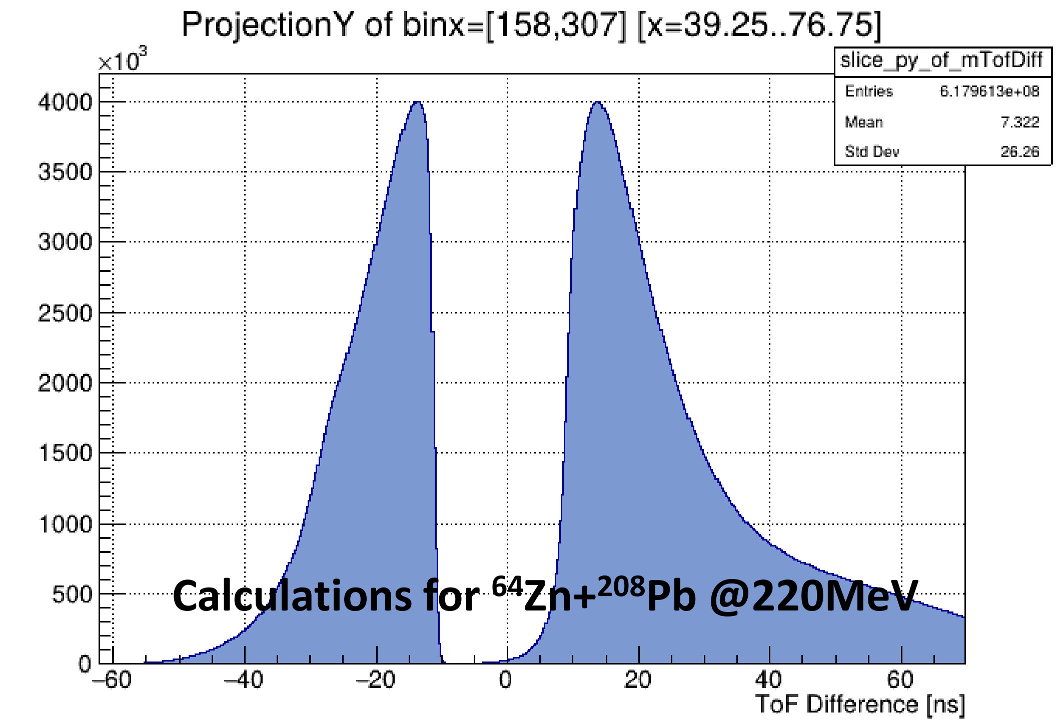


DANTE ToF discrimination

- covering 40-80deg
- 10 cm from target

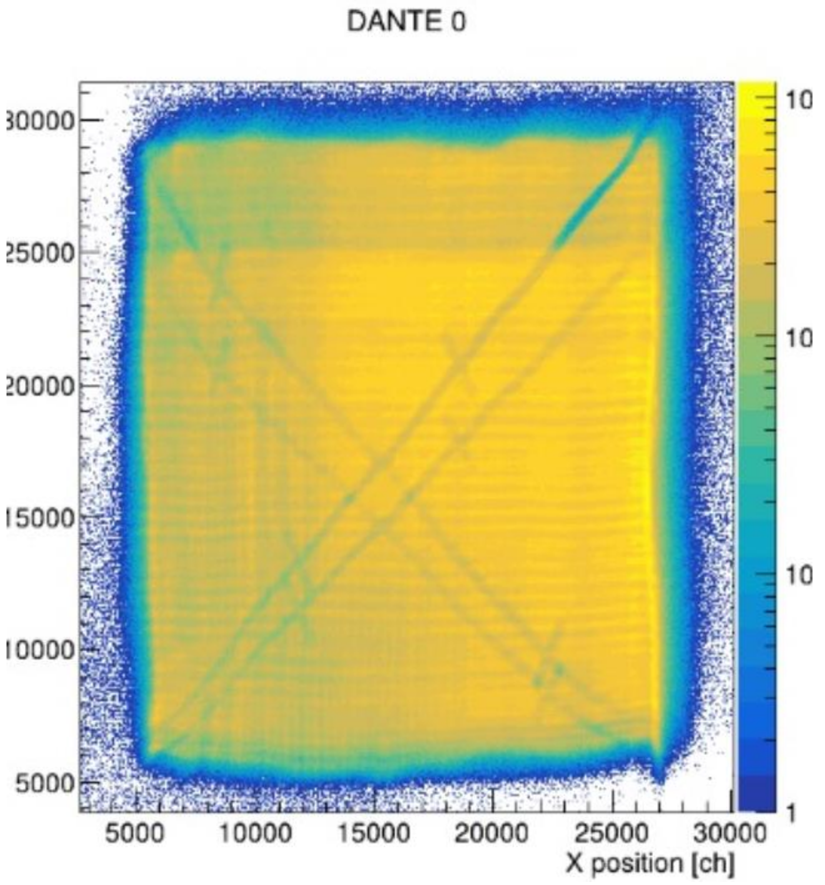




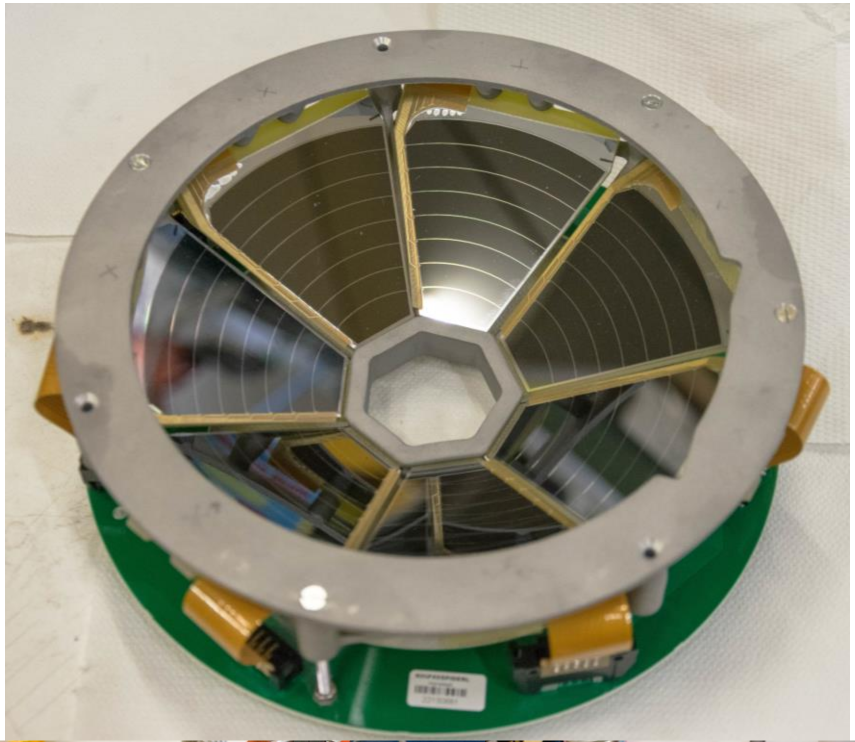


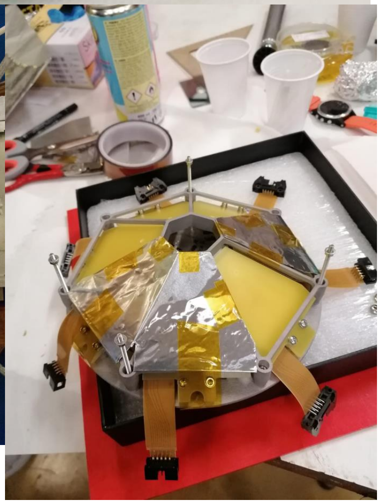
DANTE Problems

Jumping TAC – gain change in X,Y or T



SPIDER



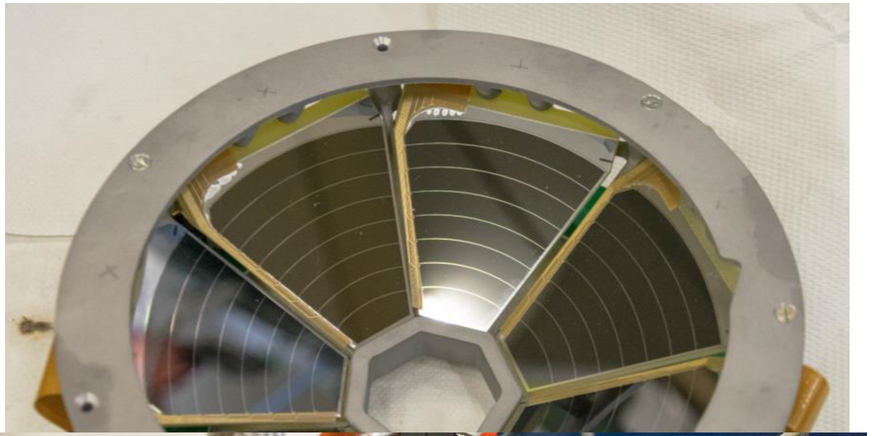


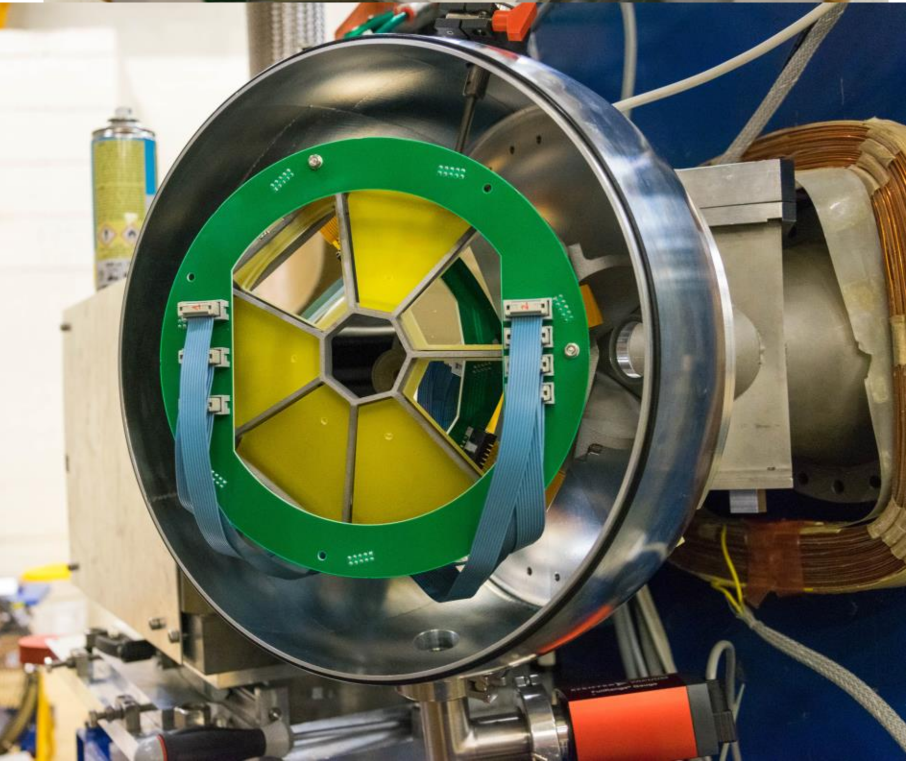
Silicon PIe DEtectoR

- 7 trapezoidal detectors, each segmented to 8 strips
- $300\mu m$ thick
- FWHM ***from*** 30keV@5.5MeV

[Reference paper 10.1016/j.nima.2020.164030]

SPIDER





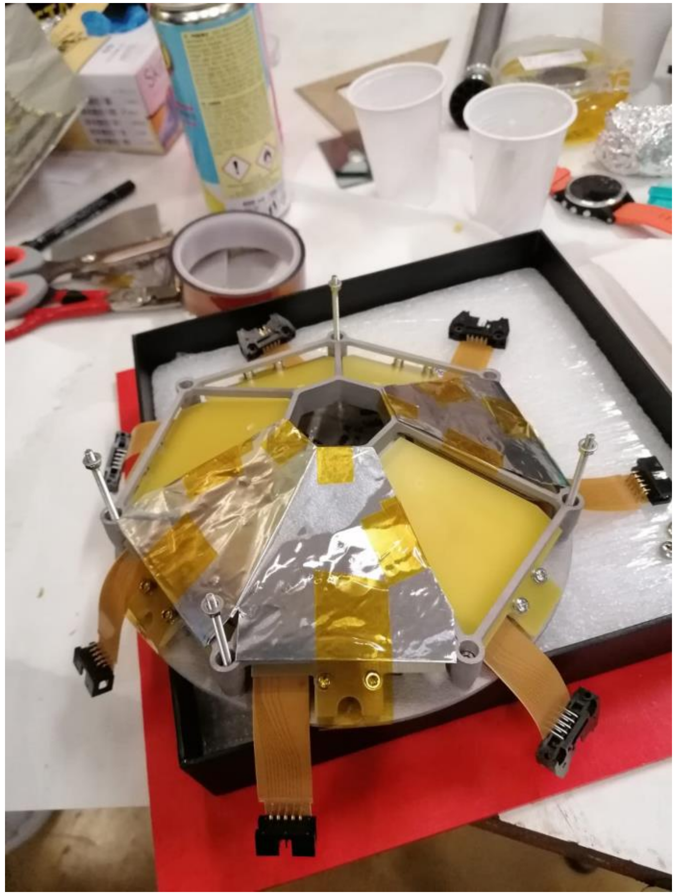
Silicon PIe DEtectoR

- 7 trapezoidal detectors, each segmented to 8 strips
- $300\mu m$ thick
- FWHM from 30keV@5.5MeV

Hardware issues

No backing on several detectors

- getting hit with scattered beam/electrons
- now fixed

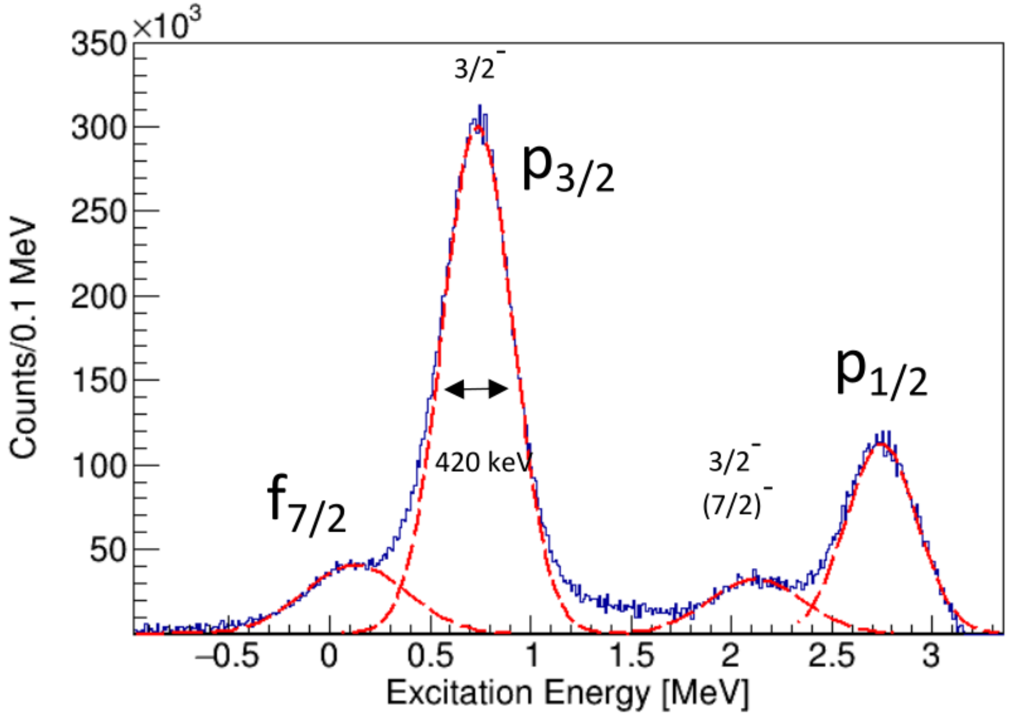


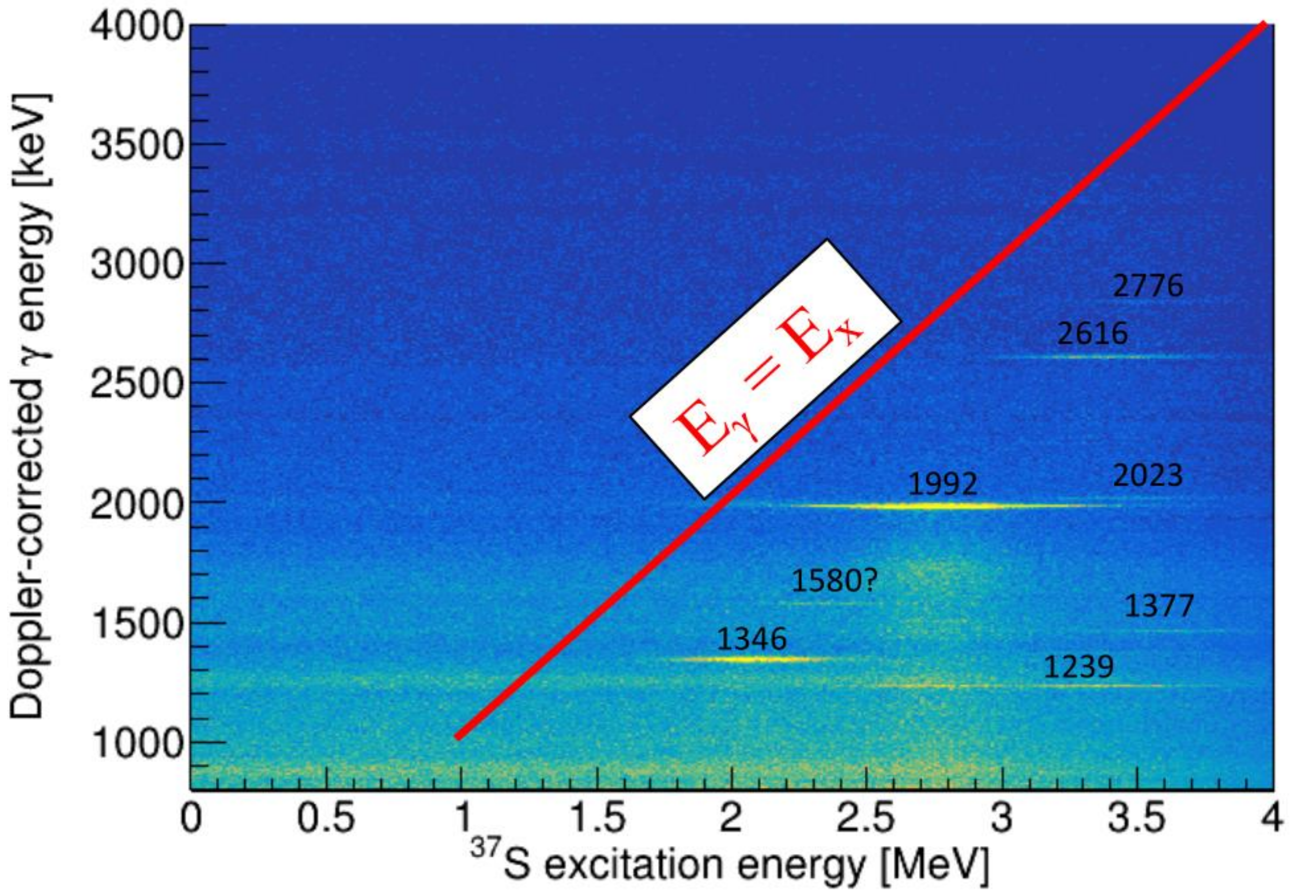
SPIDER

Excitation energy

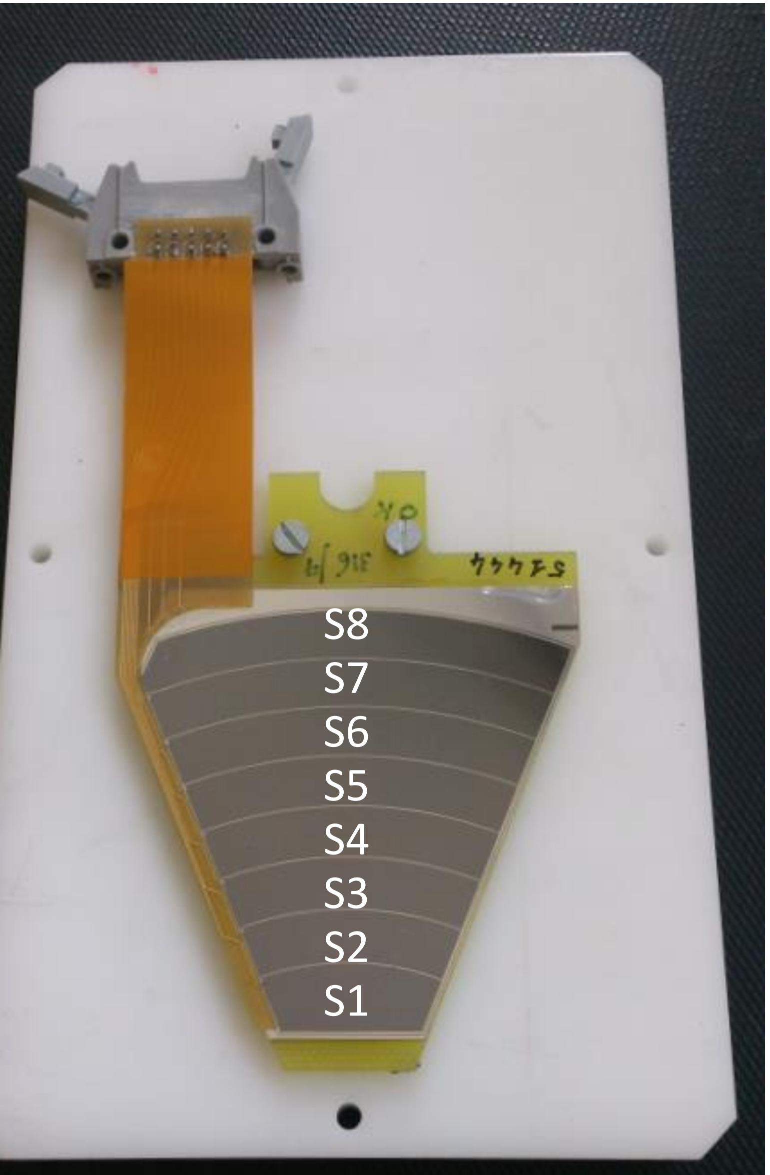
^{37}S

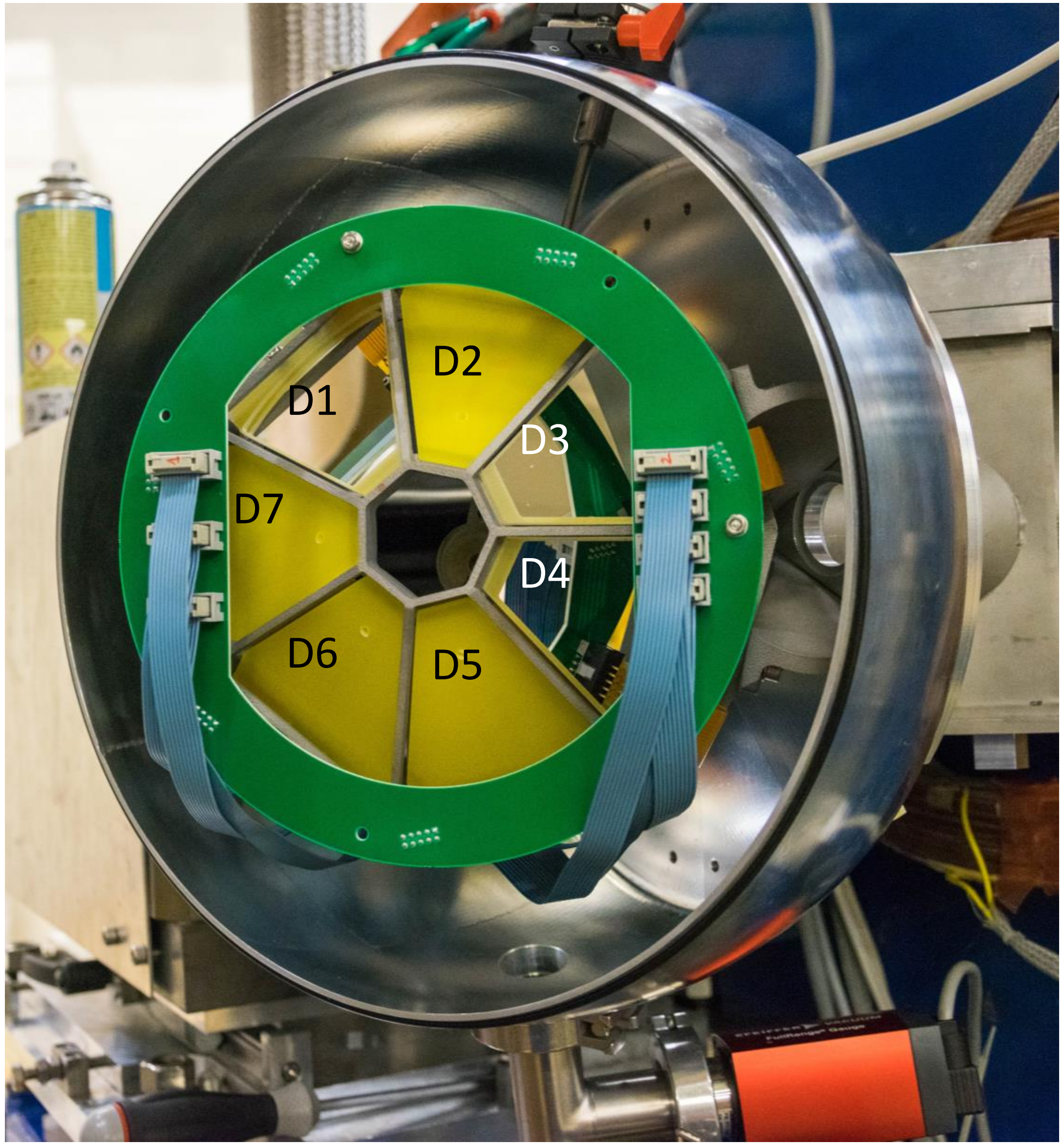
PhD thesis of L. Zago

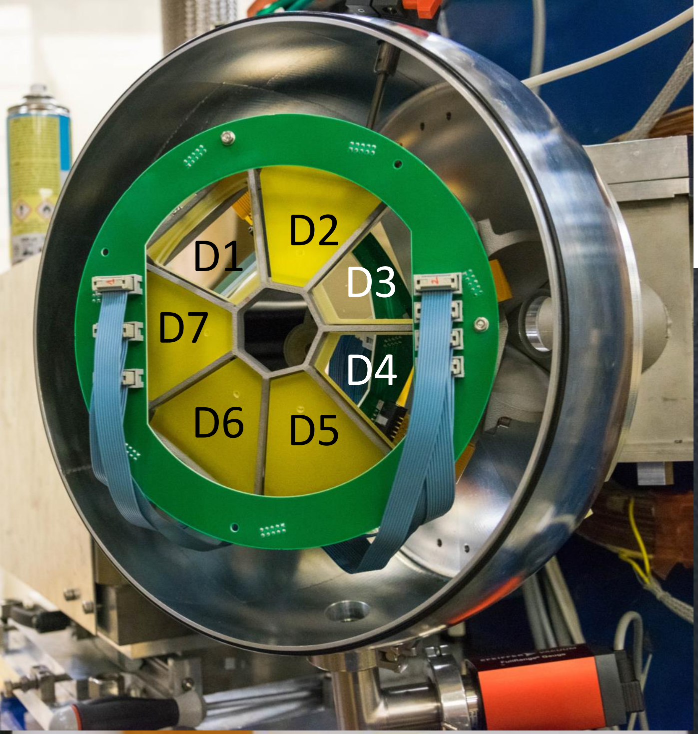


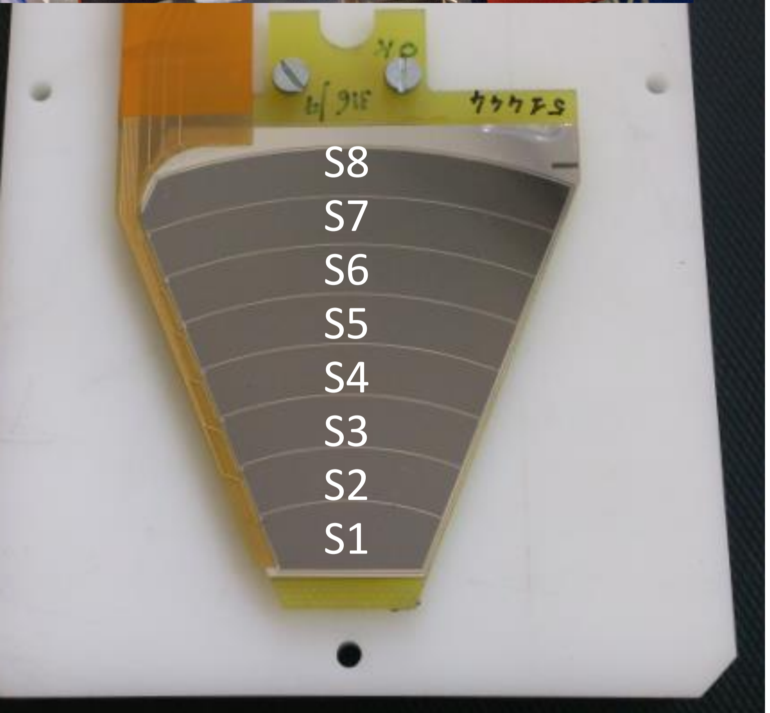


“sitting on beam”, looking at the target





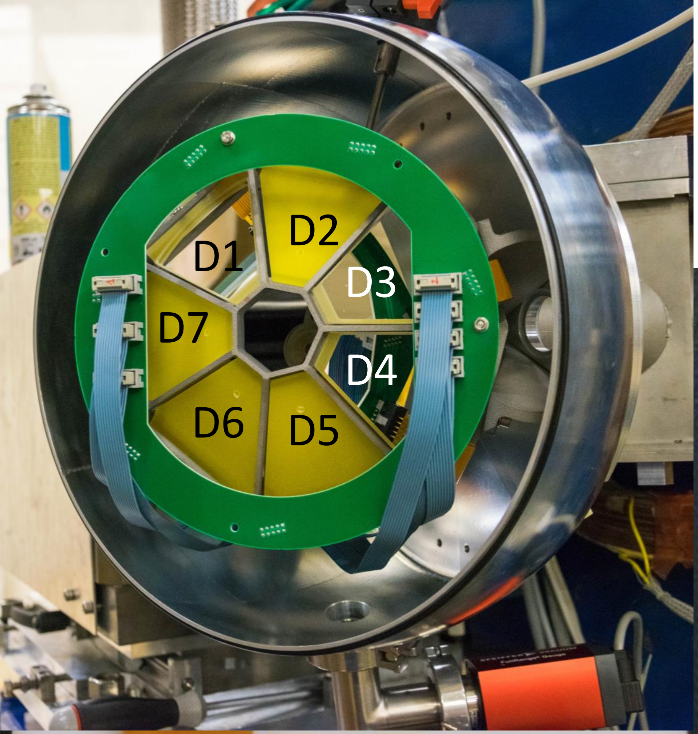


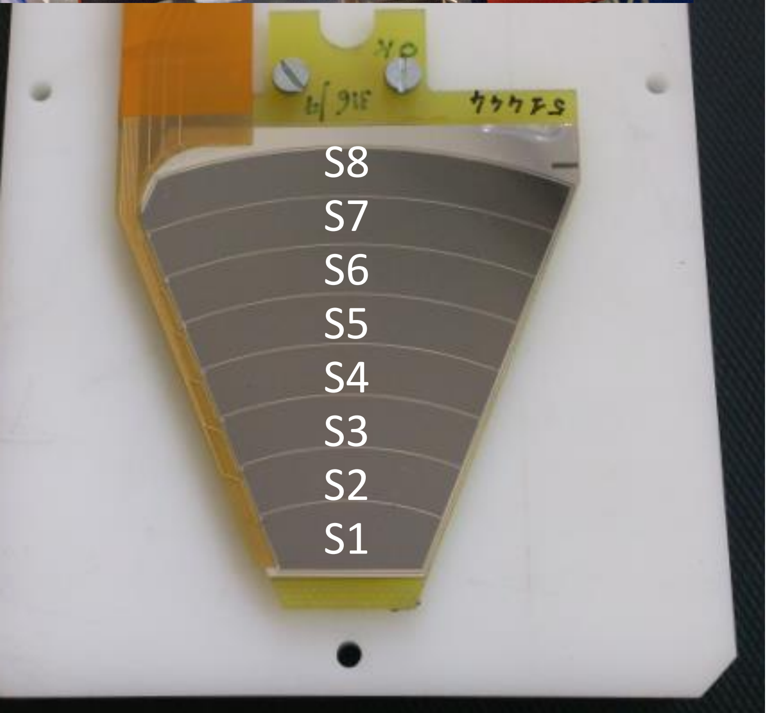


Look-up table

```
####### SPIDER ######
#
# Board channel map      name     thr_lo  thr_hi  theta    phi TimeOffset  ncalpar calpars
2   0   11  D2S2    5.00    200.00  155.2   103.99  0   2   0.015509 0.007579
2   1   10  D2S1    5.00    200.00  159.6   103.99  0   2   -0.007763 0.007412
2   2   13  D2S4    5.00    200.00  146     103.99  0   2   -0.106650 0.007794
2   3   12  D2S3    5.00    200.00  150.6   103.99  0   2   -0.053865 0.007696
2   4   15  D2S6    5.00    200.00  136.8   103.99  0   2   0.024495 0.007678
2   5   14  D2S5    5.00    200.00  141.4   103.99  0   2   -0.105075 0.008076
2   6   17  D2S8    5.00    200.00  128     103.99  0   2   0.596364 0.006813
2   7   16  D2S7    5.00    200.00  132.3   103.99  0   2   -0.007975 0.007406
2   8   1   D1S2    5.00    200.00  155.2   52.56   0   2   -0.020980 0.007575
2   9   0   D1S1    5.00    200.00  159.6   52.56   0   2   0.020538 0.007667
2   10  3   D1S4    5.00    200.00  146     52.56   0   2   -0.074459 0.007833
2   11  2   D1S3    5.00    200.00  150.6   52.56   0   2   0.069455 0.007586
2   12  5   D1S6    5.00    200.00  136.8   52.56   0   2   0.069455 0.007586
2   13  4   D1S5    5.00    200.00  141.4   52.56   0   2   0.002820 0.007616
2   14  7   D1S8    5.00    200.00  128     52.56   0   2   -0.068986 0.007928
2   15  6   D1S7    5.00    200.00  132.3   52.56       0   2     -0.069752 0.007978
3   0   21  D3S2    5.00    200.00  155.2   155.42  0   2   -0.092525 0.007750
3   1   20  D3S1    5.00    200.00  159.6   155.42  0   2   0.019792 0.007567
```

geo location [board, channel]



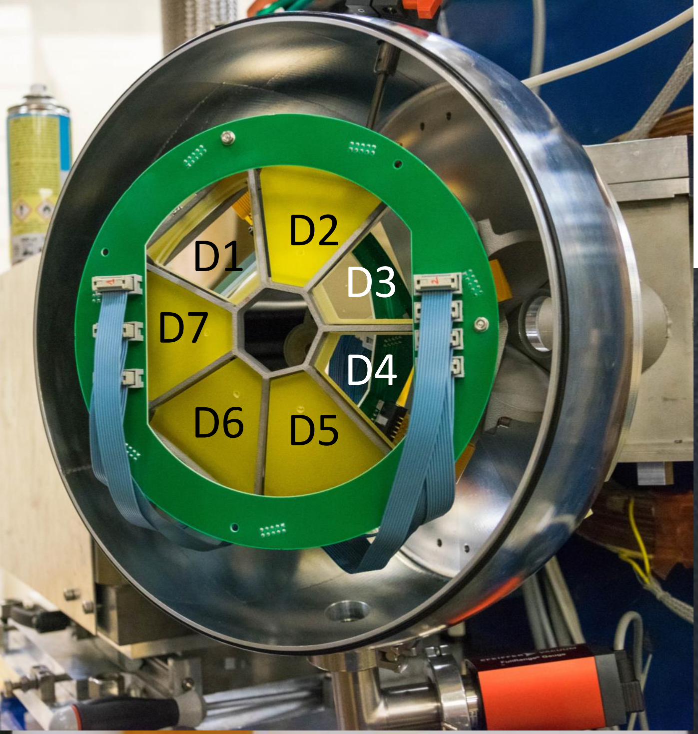


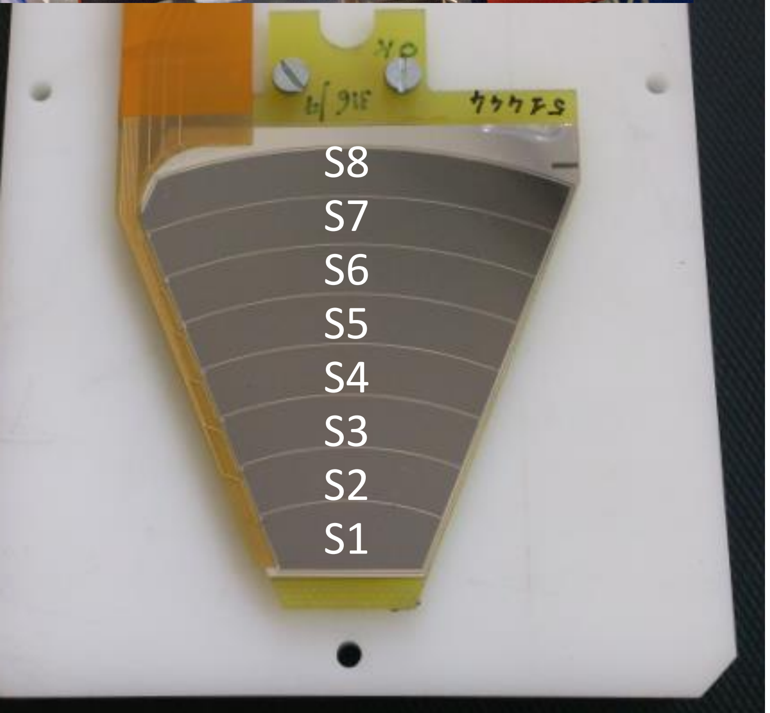
Look-up table

```
####### SPIDER ######
#
# Board channel map     name    thr_lo  thr_hi  theta    phi TimeOffset  ncalpar calpars
2   0   11   D2S2   5.00    200.00  155.2   103.99  0    2    0.015509 0.007579
2   1   10   D2S1   5.00    200.00  159.6   103.99  0    2    -0.007763 0.007412
2   2   13   D2S4   5.00    200.00  146     103.99  0    2    -0.106650 0.007794
2   3   12   D2S3   5.00    200.00  150.6   103.99  0    2    -0.053865 0.007696
2   4   15   D2S6   5.00    200.00  136.8   103.99  0    2    0.024495 0.007678
2   5   14   D2S5   5.00    200.00  141.4   103.99  0    2    -0.105075 0.008076
2   6   17   D2S8   5.00    200.00  128     103.99  0    2    0.596364 0.006813
2   7   16   D2S7   5.00    200.00  132.3   103.99  0    2    -0.007975 0.007406
2   8   1    D1S2   5.00    200.00  155.2   52.56   0    2    -0.020980 0.007575
2   9   0    D1S1   5.00    200.00  159.6   52.56   0    2    0.020538 0.007667
2   10  3    D1S4   5.00    200.00  146     52.56   0    2    -0.074459 0.007833
2   11  2    D1S3   5.00    200.00  150.6   52.56   0    2    0.069455 0.007586
2   12  5    D1S6   5.00    200.00  136.8   52.56   0    2    0.069455 0.007586
2   13  4    D1S5   5.00    200.00  141.4   52.56   0    2    0.002820 0.007616
2   14  7    D1S8   5.00    200.00  128     52.56   0    2    -0.068986 0.007928
2   15  6    D1S7   5.00    200.00  132.3   52.56        0    2    -0.069752 0.007978
3   0   21   D3S2   5.00    200.00  155.2   155.42  0    2    -0.092525 0.007750
3   1   20   D3S1   5.00    200.00  159.6   155.42  0    2    0.019792 0.007567
```

unique identifiers [map, name]

the "map" number conversion into detector and strip:
strip = (map % 10) + 1
detector = (map / 10) + 1

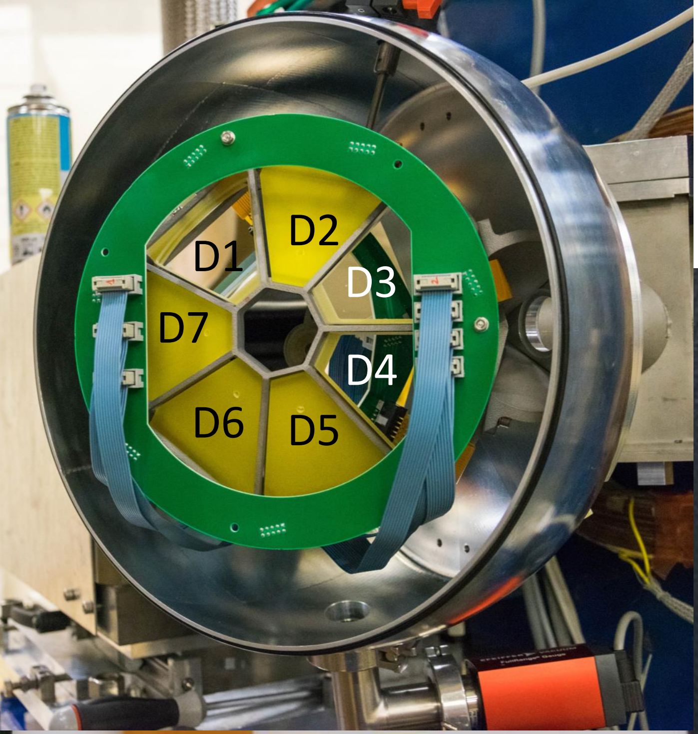


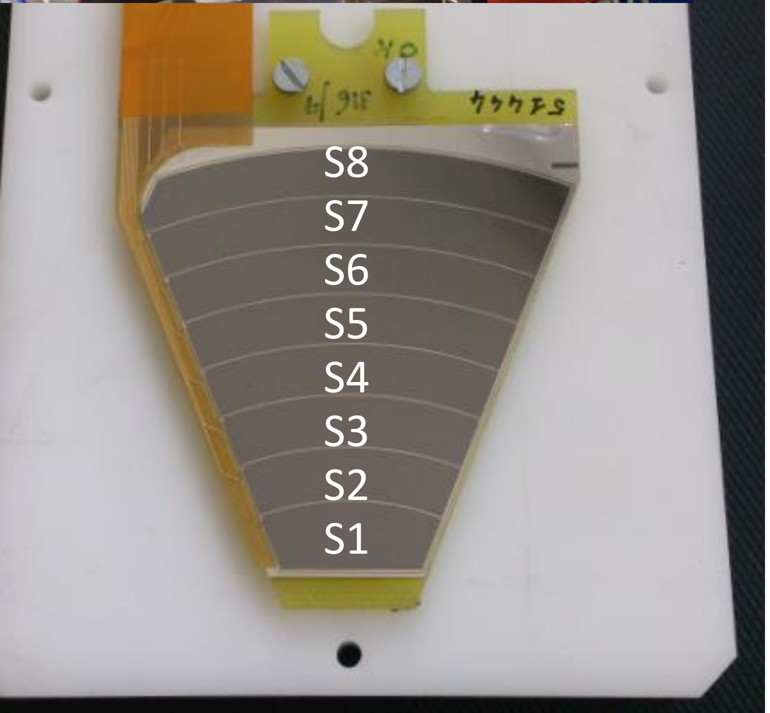


Look-up table

```
####### SPIDER ######
#
# Board channel map     name     thr_lo  thr_hi  theta    phi TimeOffset  ncalpar calpars
2    0    11   D2S2     5.00     200.00  155.2    103.99  0    2     0.015509 0.007579
2    1    10   D2S1     5.00     200.00  159.6    103.99  0    2     -0.007763 0.007412
2    2    13   D2S4     5.00     200.00  146      103.99  0    2     -0.106650 0.007794
2    3    12   D2S3     5.00     200.00  150.6    103.99  0    2     -0.053865 0.007696
2    4    15   D2S6     5.00     200.00  136.8    103.99  0    2     0.024495 0.007678
2    5    14   D2S5     5.00     200.00  141.4    103.99  0    2     -0.105075 0.008076
2    6    17   D2S8     5.00     200.00  128      103.99  0    2     0.596364 0.006813
2    7    16   D2S7     5.00     200.00  132.3    103.99  0    2     -0.007975 0.007406
2    8    1    D1S2     5.00     200.00  155.2    52.56   0    2     -0.020980 0.007575
2    9    0    D1S1     5.00     200.00  159.6    52.56   0    2     0.020538 0.007667
2    10   3    D1S4     5.00     200.00  146      52.56   0    2     -0.074459 0.007833
2    11   2    D1S3     5.00     200.00  150.6    52.56   0    2     0.069455 0.007586
2    12   5    D1S6     5.00     200.00  136.8    52.56   0    2     0.069455 0.007586
2    13   4    D1S5     5.00     200.00  141.4    52.56   0    2     0.002820 0.007616
2    14   7    D1S8     5.00     200.00  128      52.56   0    2     -0.068986 0.007928
2    15   6    D1S7     5.00     200.00  132.3    52.56        0    2     -0.069752 0.007978
3    0    21   D3S2     5.00     200.00  155.2    155.42  0    2     -0.092525 0.007750
3    1    20   D3S1     5.00     200.00  159.6    155.42  0    2     0.019792 0.007567
```

Thresholds in MeV [min,max]





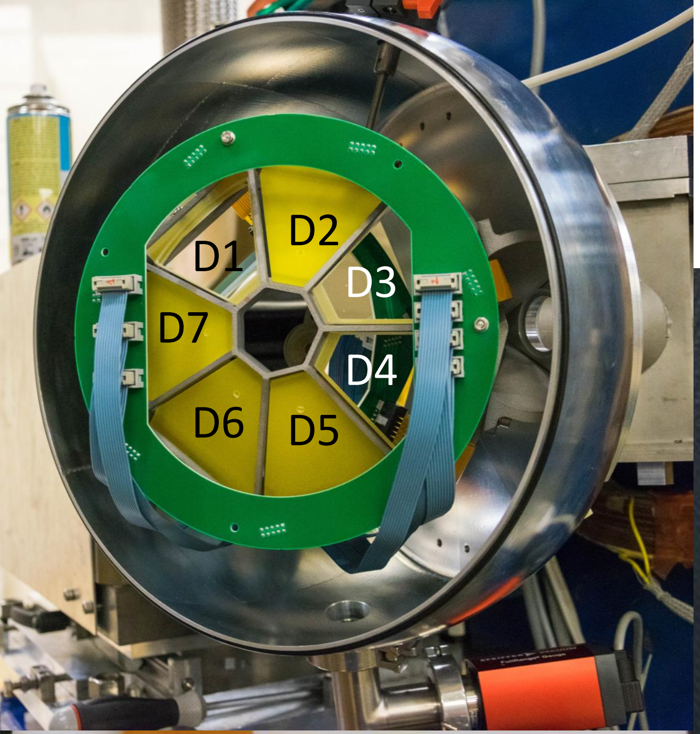
Look-up table

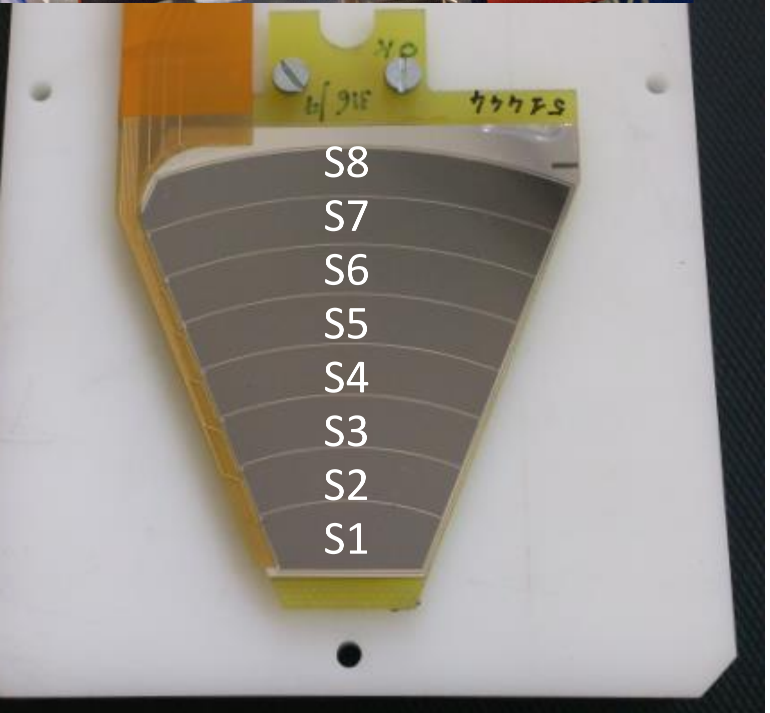
####### SPIDER ######

#

# Board	channel	map	name	thr_lo	thr_hi	theta	phi	TimeOffset	ncalpar	calpars
2	0	11	D2S2	5.00	200.00	155.2	103.99	0	2	0.015509 0.007579
2	1	10	D2S1	5.00	200.00	159.6	103.99	0	2	-0.007763 0.007412
2	2	13	D2S4	5.00	200.00	146	103.99	0	2	-0.106650 0.007794
2	3	12	D2S3	5.00	200.00	150.6	103.99	0	2	-0.053865 0.007696
2	4	15	D2S6	5.00	200.00	136.8	103.99	0	2	0.024495 0.007678
2	5	14	D2S5	5.00	200.00	141.4	103.99	0	2	-0.105075 0.008076
2	6	17	D2S8	5.00	200.00	128	103.99	0	2	0.596364 0.006813
2	7	16	D2S7	5.00	200.00	132.3	103.99	0	2	-0.007975 0.007406
2	8	1	D1S2	5.00	200.00	155.2	52.56	0	2	-0.020980 0.007575
2	9	0	D1S1	5.00	200.00	159.6	52.56	0	2	0.020538 0.007667
2	10	3	D1S4	5.00	200.00	146	52.56	0	2	-0.074459 0.007833
2	11	2	D1S3	5.00	200.00	150.6	52.56	0	2	0.069455 0.007586
2	12	5	D1S6	5.00	200.00	136.8	52.56	0	2	0.069455 0.007586
2	13	4	D1S5	5.00	200.00	141.4	52.56	0	2	0.002820 0.007616
2	14	7	D1S8	5.00	200.00	128	52.56	0	2	-0.068986 0.007928
2	15	6	D1S7	5.00	200.00	132.3	52.56	0	2	-0.069752 0.007978
3	0	21	D3S2	5.00	200.00	155.2	155.42	0	2	-0.092525 0.007750
3	1	20	D3S1	5.00	200.00	159.6	155.42	0	2	0.019792 0.007567

Physical position [theta,phi]

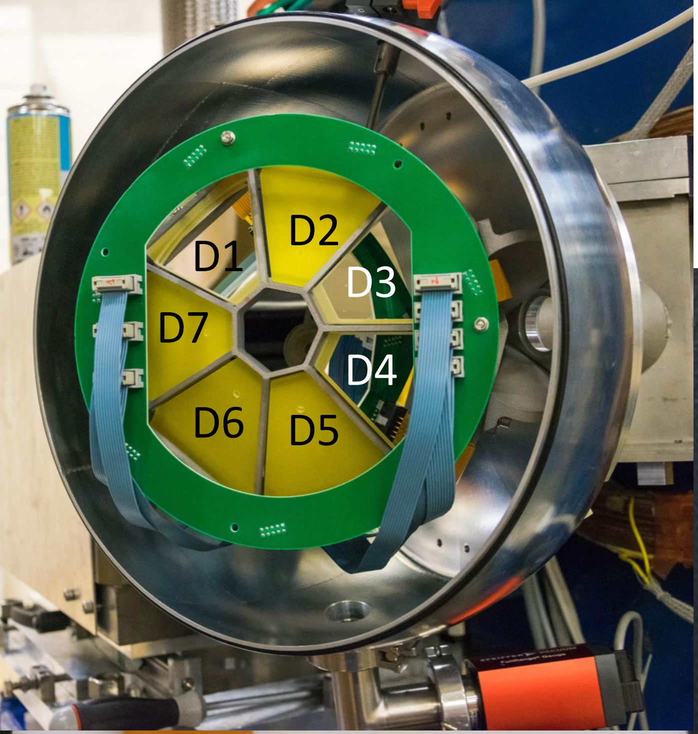


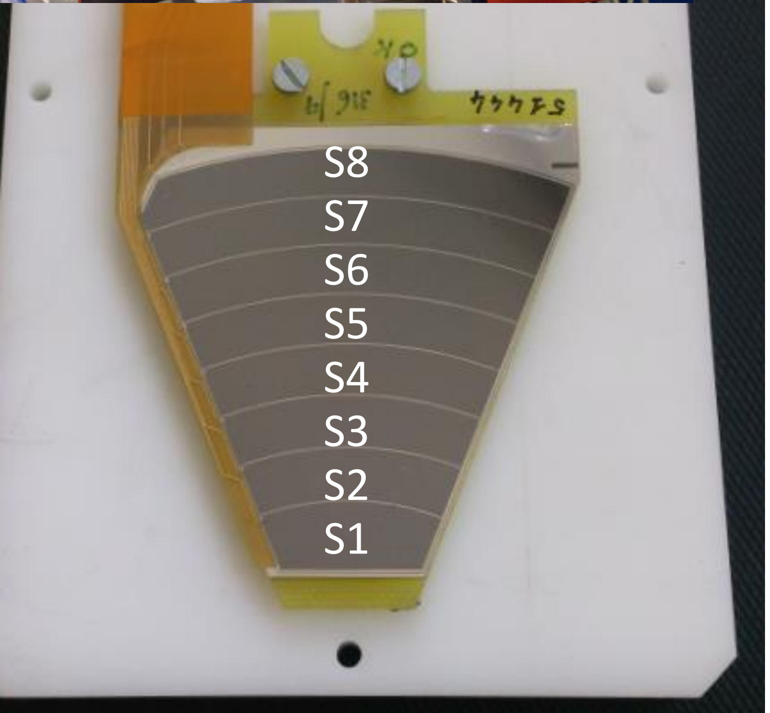


Look-up table

```
####### SPIDER ######
#
# Board channel map     name    thr_lo  thr_hi  theta   phi TimeOffset  ncalpar calpars
2   0   11  D2S2    5.00    200.00  155.2   103.99  0   2   0.015509 0.007579
2   1   10  D2S1    5.00    200.00  159.6   103.99  0   2   -0.007763 0.007412
2   2   13  D2S4    5.00    200.00  146     103.99  0   2   -0.106650 0.007794
2   3   12  D2S3    5.00    200.00  150.6   103.99  0   2   -0.053865 0.007696
2   4   15  D2S6    5.00    200.00  136.8   103.99  0   2   0.024495 0.007678
2   5   14  D2S5    5.00    200.00  141.4   103.99  0   2   -0.105075 0.008076
2   6   17  D2S8    5.00    200.00  128     103.99  0   2   0.596364 0.006813
2   7   16  D2S7    5.00    200.00  132.3   103.99  0   2   -0.007975 0.007406
2   8   1   D1S2    5.00    200.00  155.2   52.56   0   2   -0.020980 0.007575
2   9   0   D1S1    5.00    200.00  159.6   52.56   0   2   0.020538 0.007667
2   10  3   D1S4    5.00    200.00  146     52.56   0   2   -0.074459 0.007833
2   11  2   D1S3    5.00    200.00  150.6   52.56   0   2   0.069455 0.007586
2   12  5   D1S6    5.00    200.00  136.8   52.56   0   2   0.069455 0.007586
2   13  4   D1S5    5.00    200.00  141.4   52.56   0   2   0.002820 0.007616
2   14  7   D1S8    5.00    200.00  128     52.56   0   2   -0.068986 0.007928
2   15  6   D1S7    5.00    200.00  132.3   52.56       0   2     -0.069752 0.007978
3   0   21  D3S2    5.00    200.00  155.2   155.42  0   2   -0.092525 0.007750
3   1   20  D3S1    5.00    200.00  159.6   155.42  0   2   0.019792 0.007567
```

Time offset in 10ns



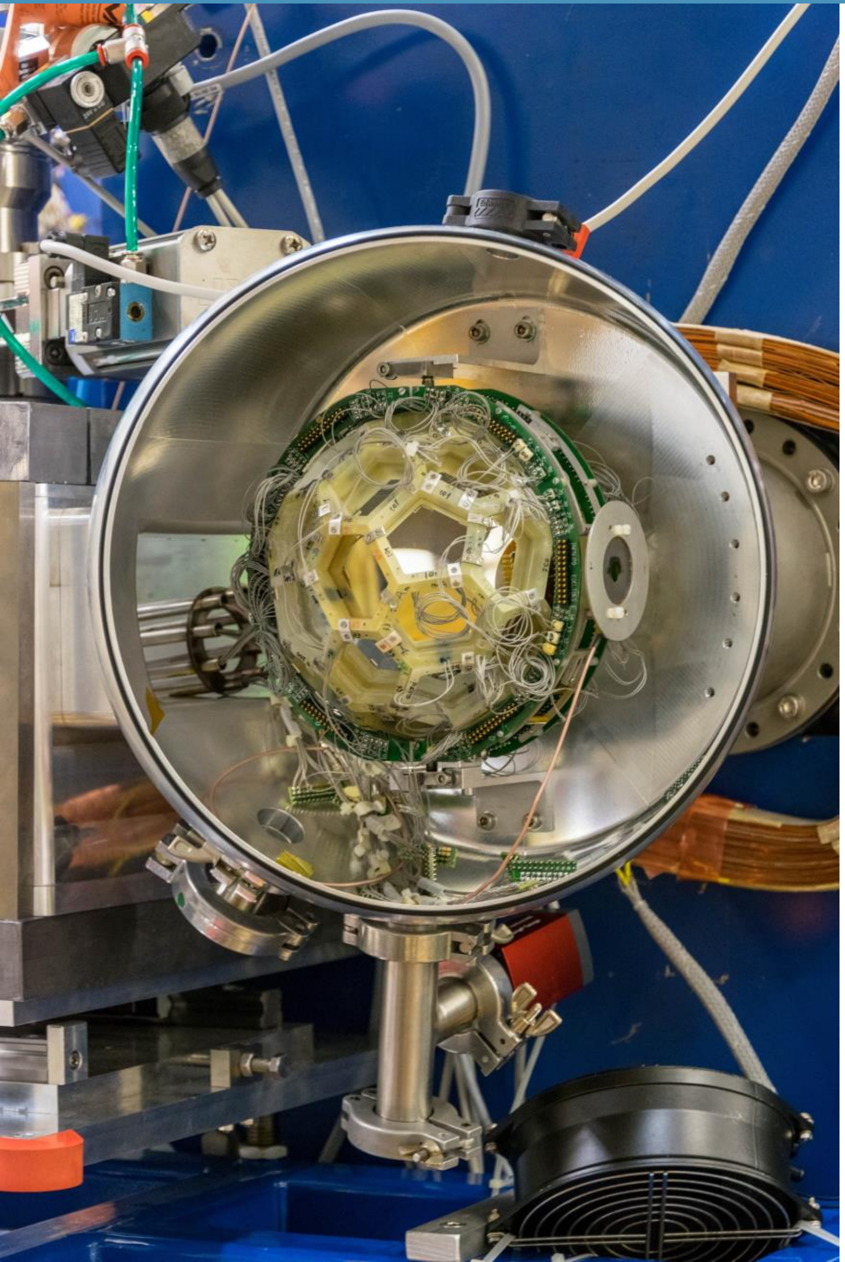


Look-up table

```
####### SPIDER ######
#
# Board channel map      name     thr_lo  thr_hi  theta    phi TimeOffset  ncalpar calpars
2    0    11   D2S2    5.00    200.00  155.2    103.99  0    2    0.015509 0.007579
2    1    10   D2S1    5.00    200.00  159.6    103.99  0    2    -0.007763 0.007412
2    2    13   D2S4    5.00    200.00  146      103.99  0    2    -0.106650 0.007794
2    3    12   D2S3    5.00    200.00  150.6    103.99  0    2    -0.053865 0.007696
2    4    15   D2S6    5.00    200.00  136.8    103.99  0    2    0.024495 0.007678
2    5    14   D2S5    5.00    200.00  141.4    103.99  0    2    -0.105075 0.008076
2    6    17   D2S8    5.00    200.00  128      103.99  0    2    0.596364 0.006813
2    7    16   D2S7    5.00    200.00  132.3    103.99  0    2    -0.007975 0.007406
2    8    1    D1S2    5.00    200.00  155.2    52.56   0    2    -0.020980 0.007575
2    9    0    D1S1    5.00    200.00  159.6    52.56   0    2    0.020538 0.007667
2    10   3    D1S4    5.00    200.00  146      52.56   0    2    -0.074459 0.007833
2    11   2    D1S3    5.00    200.00  150.6    52.56   0    2    0.069455 0.007586
2    12   5    D1S6    5.00    200.00  136.8    52.56   0    2    0.069455 0.007586
2    13   4    D1S5    5.00    200.00  141.4    52.56   0    2    0.002820 0.007616
2    14   7    D1S8    5.00    200.00  128      52.56   0    2    -0.068986 0.007928
2    15   6    D1S7    5.00    200.00  132.3    52.56        0    2    -0.069752 0.007978
3    0    21   D3S2    5.00    200.00  155.2    155.42  0    2    -0.092525 0.007750
3    1    20   D3S1    5.00    200.00  159.6    155.42  0    2    0.019792 0.007567
```

energy calibration [Npar, par1,..., parN]

EUCLIDES



EUCLIDES

- array of dE-E telescopes, 130μm and 1000μm thick
- 4π coverage
- 5 rings composed of pentagonal or hexagonal detectors
  - forward most ring has 4-way segmented hexagons

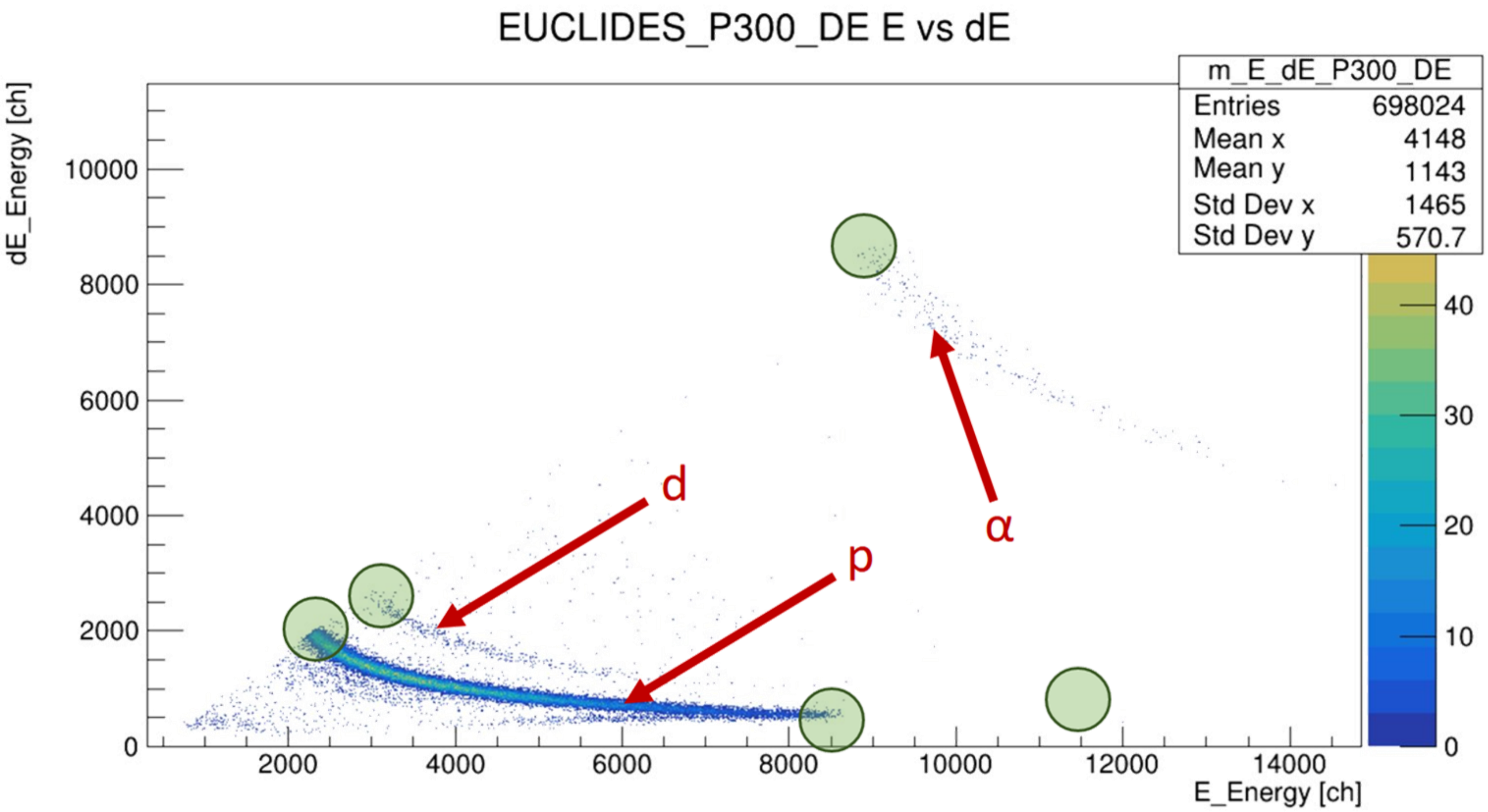
[Reference paper 10.1140/epja/i2019-12714-6]

EUCLIDES

Energy calibration

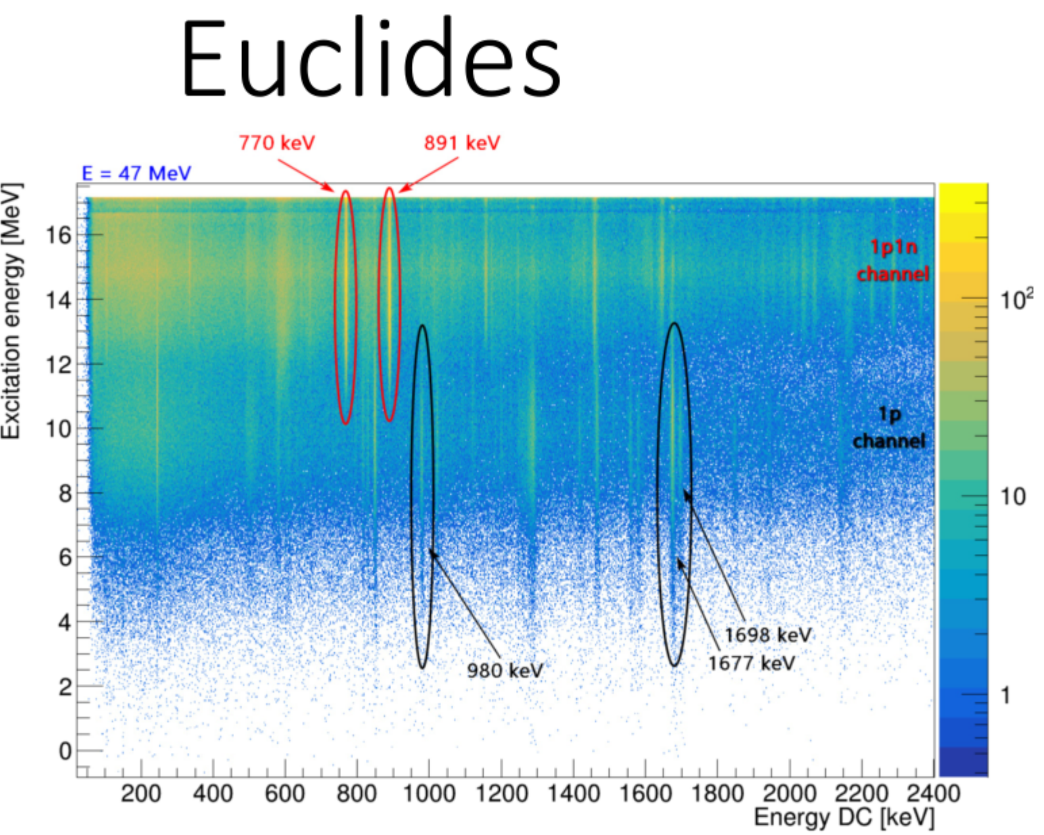
PhD thesis of M. del Fabbro

- alpha source
- elastic channel
- punch-through

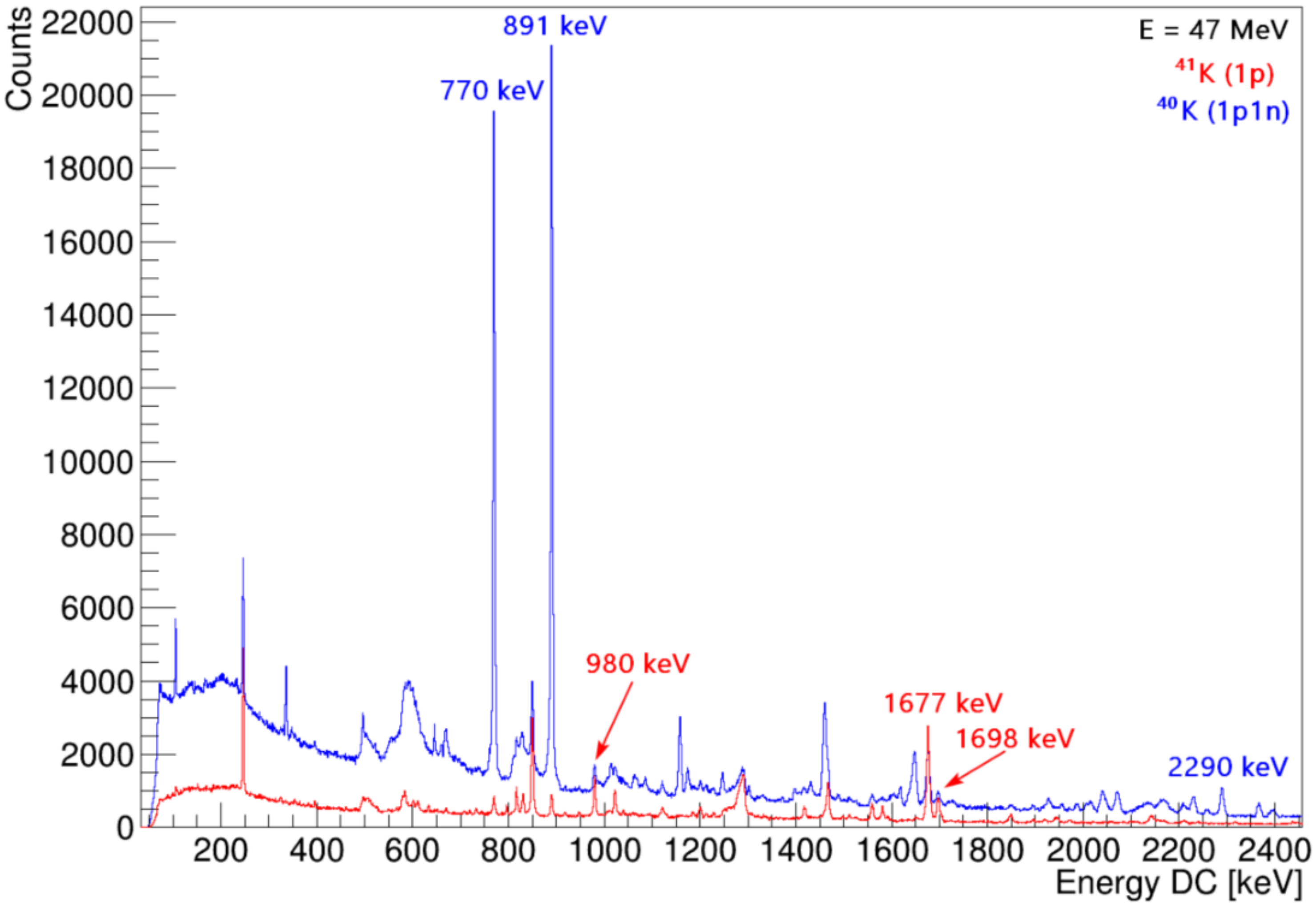


EUCLIDES

Separation of 1p and 1p1n channels with rough compound system excitation energy.



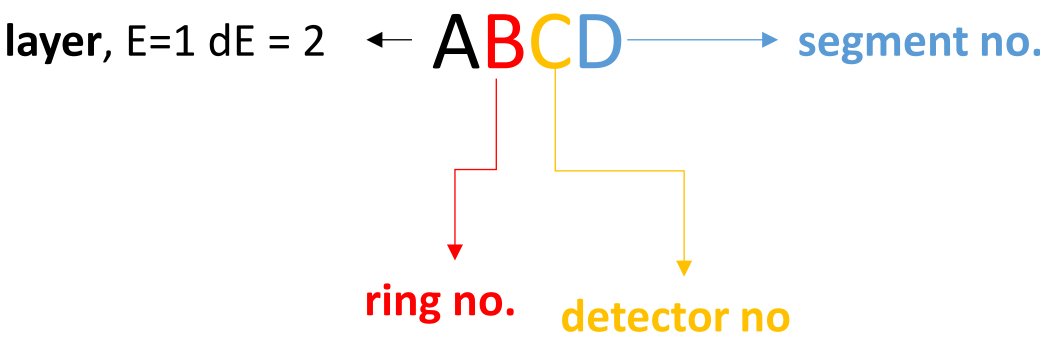
PhD thesis of M. del Fabbro

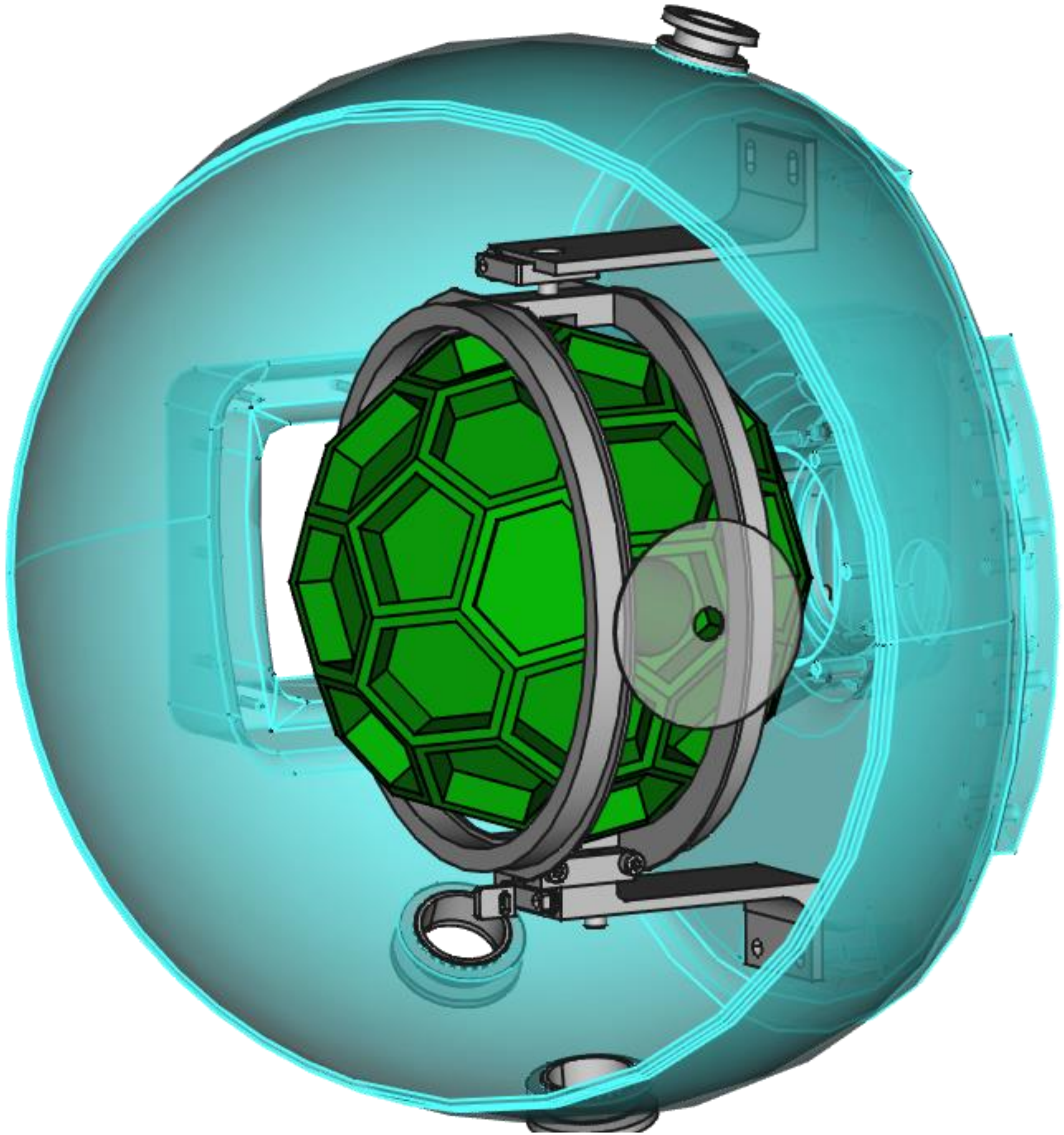


EUCLIDES

```
#       Board   channel map     name     thr_lo  thr_hi  theta   phi     TimeOffset      ncalpar calpars
#       2       0       1000    ring0_det0_E    5       100000  148.281 90      0       2       0.0000  1.0000
#       2       0       2000    ring0_det0_dE   5       100000  148.281 90      0       2       0.0000  1.0000
#       2       0       1010    ring0_det1_E    5       100000  148.286 161.999 0       2       0.0000  1.0000
#       2       0       2010    ring0_det1_dE   5       100000  148.286 161.999 0       2       0.0000  1.0000
#       2       0       1020    ring0_det2_E    5       100000  148.279 -125.995        0       2       0.0000  1.0000
#       2       0       2020    ring0_det2_dE   5       100000  148.279 -125.995        0       2       0.0000  1.0000
#       2       0       1030    ring0_det3_E    5       100000  148.279 -54.005 0       2       0.0000  1.0000
#       2       0       2030    ring0_det3_dE   5       100000  148.279 -54.005 0       2       0.0000  1.0000
#       2       0       1040    ring0_det4_E    5       100000  148.286 18.001  0       2       0.0000  1.0000
#       2       0       2040    ring0_det4_dE   5       100000  148.286 18.001  0       2       0.0000  1.0000
#
#       5       0       1100    phiphin_E       5       100000  116.565 90      0       2       0.0000  1.0000
#       5       0       2100    phiphin_dE      5       100000  116.565 90      0       2       0.0000  1.0000
        2       2       1110    P800_E  5       100000  121.72  125.996 0       2       0.0000  1.0000
        2       3       2110    P800_dE 5       100000  121.72  125.996 0       2       0.0000  1.0000
        5       6       1120    P500_E  5       100000  116.564 162.003 0       2       0.0000  0.00169
        5       7       2120    P500_dE 5       100000  116.564 162.003 0       2       0.0000  0.00189
#       2       0       1130    H7A_E   5       100000  121.717 -162.006        0       2       0.0000  1.0000
#       2       0       2130    H7A_dE  5       100000  121.717 -162.006        0       2       0.0000  1.0000
        5       4       1140    P101_E  5       100000  116.562 -125.999        0       2       0.0000  1.0000
        5       5       2140    P101_dE 5       100000  116.562 -125.999        0       2       0.0000  1.0000
        5       2       1150    H551_E  5       100000  121.719 -90     0       2       0.0000  1.0000
        5       3       2150    H551_dE 5       100000  121.719 -90     0       2       0.0000  1.0000
        5       0       1160    H0_E    5       100000  116.562 -54.001 0       2       0.0000  1.0000
#       5       1       2160    H0_dE   5       100000  116.562 -54.001 0       2       0.0000  1.0000
        0       8       1170    P10_E   5       100000  121.717 -17.994 0       2       0.0000  0.00176
        0       9       2170    P10_dE  5       100000  121.717 -17.994 0       2       0.0000  0.00177
        0       12      1180    H29_E   5       100000  116.564 17.997  0       2       0.0000  0.00178
        0       13      2180    H29_dE  5       100000  116.564 17.997  0       2       0.0000  0.00195
        0       6       1190    P600_E  5       100000  121.72  54.004  0       2       0.0000  0.00161
        0       7       2190    P600_dE 5       100000  121.72  54.004  0       2       0.0000  0.00192
#
```

Look-up table structure same as SPIDER





Using “map” value to identify detector:

layer, E=1 dE = 2 ← ABCD → **segment no.**

ring no. (B)

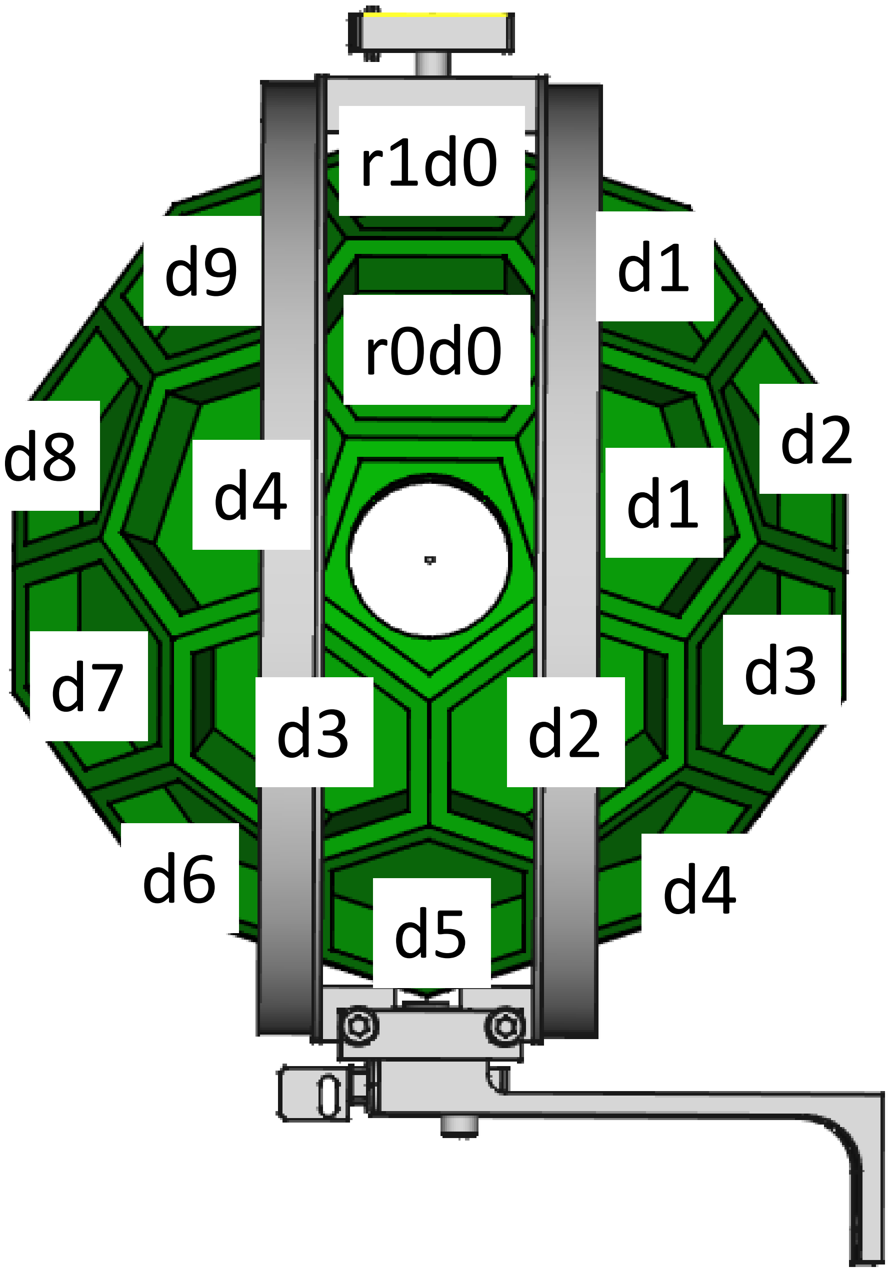
detector no (C)

Rings are numbered from back (0) to front (4)

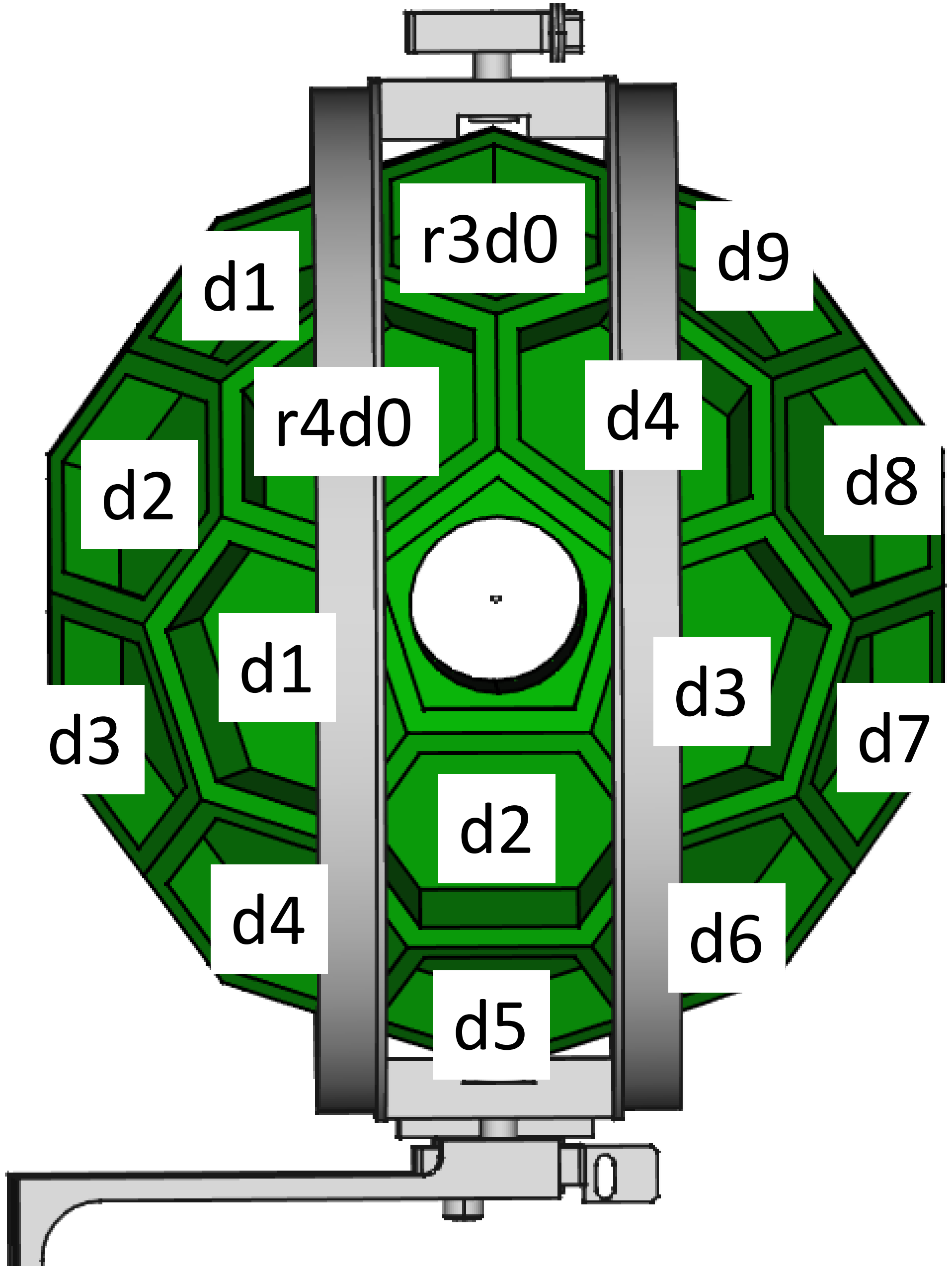
Detector number: from 0 clockwise, starting from the top. If the top has 2 detectors, count from the right one

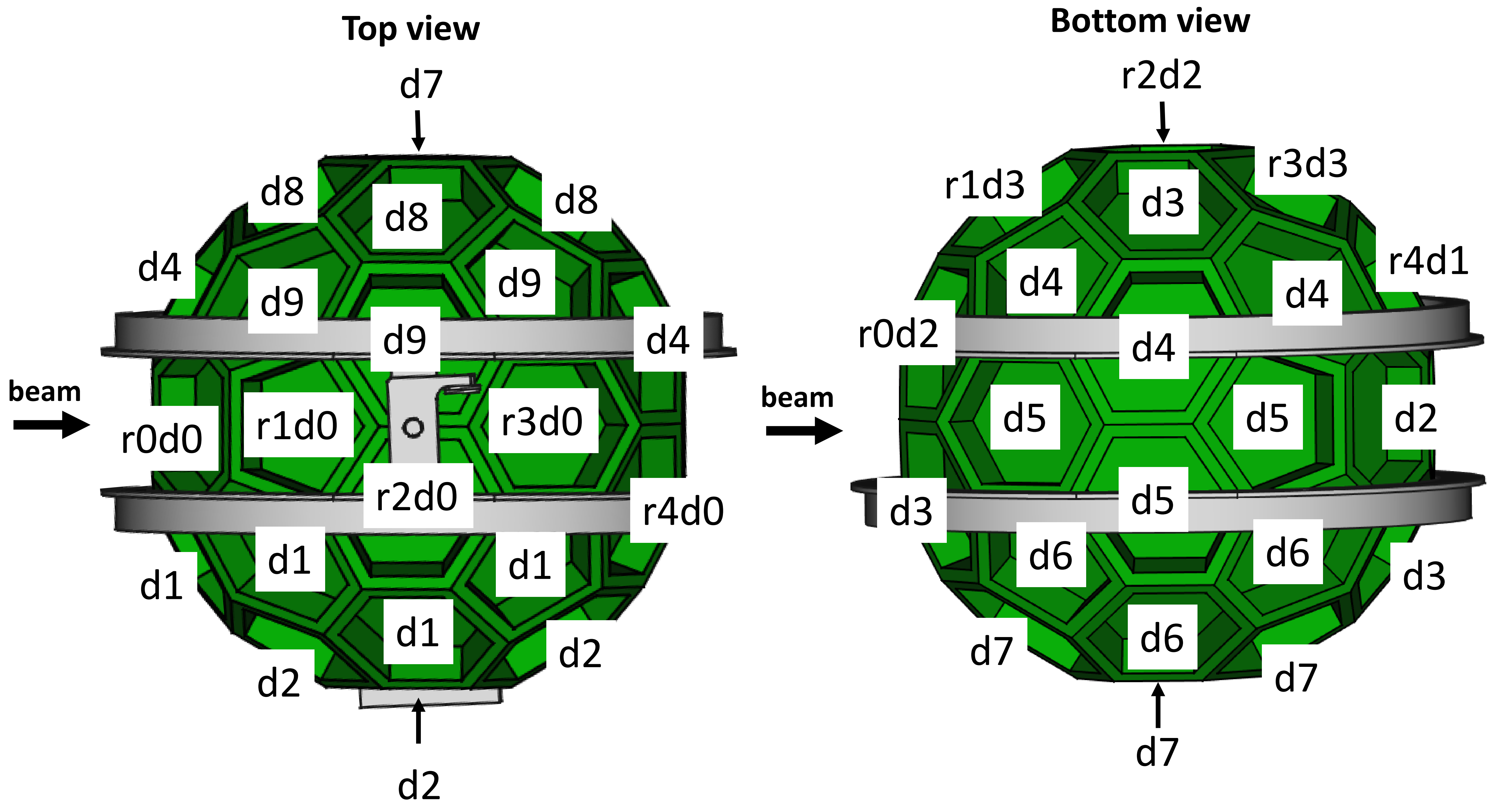
Segment 0 = not segmented, 1-4 segments A-D

Front (beam entering) view



Front (beam exiting) view

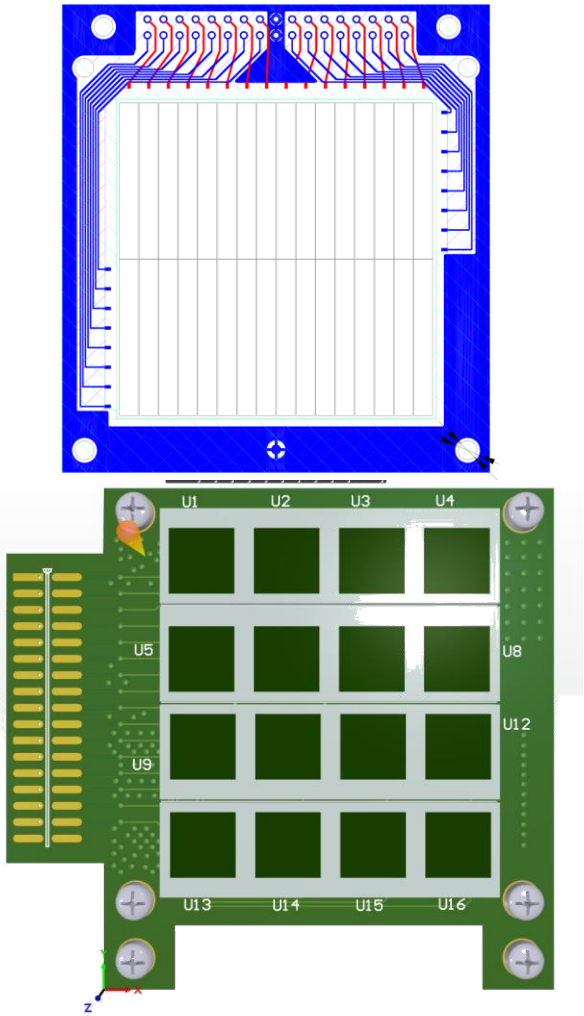




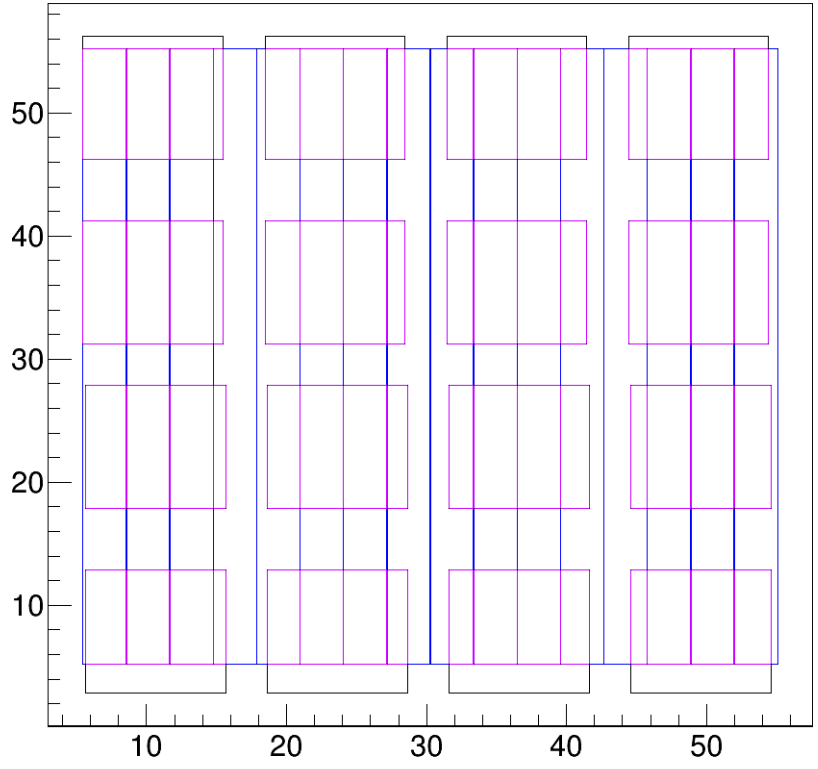
Top view
d7
d8
d8
d8
d4
d9
d9
d9
d4
beam
r0d0
r1d0
r3d0
r2d0
r4d0
d1
d1
d1
d1
d2
d2
d2
Bottom view
r2d2
r1d3
d3
r3d3
r4d1
d4
d4
r0d2
d4
beam
d5
d5
d2
d3
d5
d6
d6
d3
d7
d6
d7
d7

OSCAR

- Two dE-E telescopes
- overlapping 16 strip dE (20um) with 16 pads (500um)
- not a property of INFN LNL

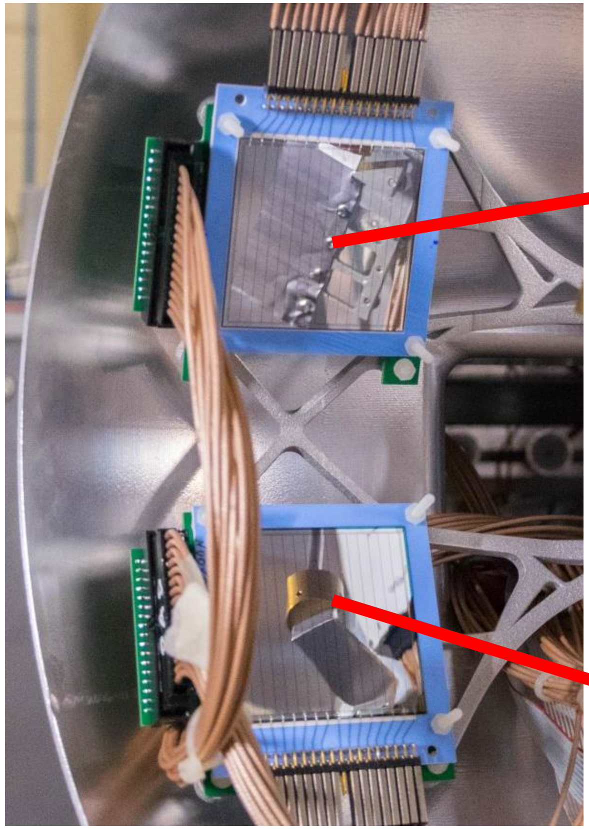


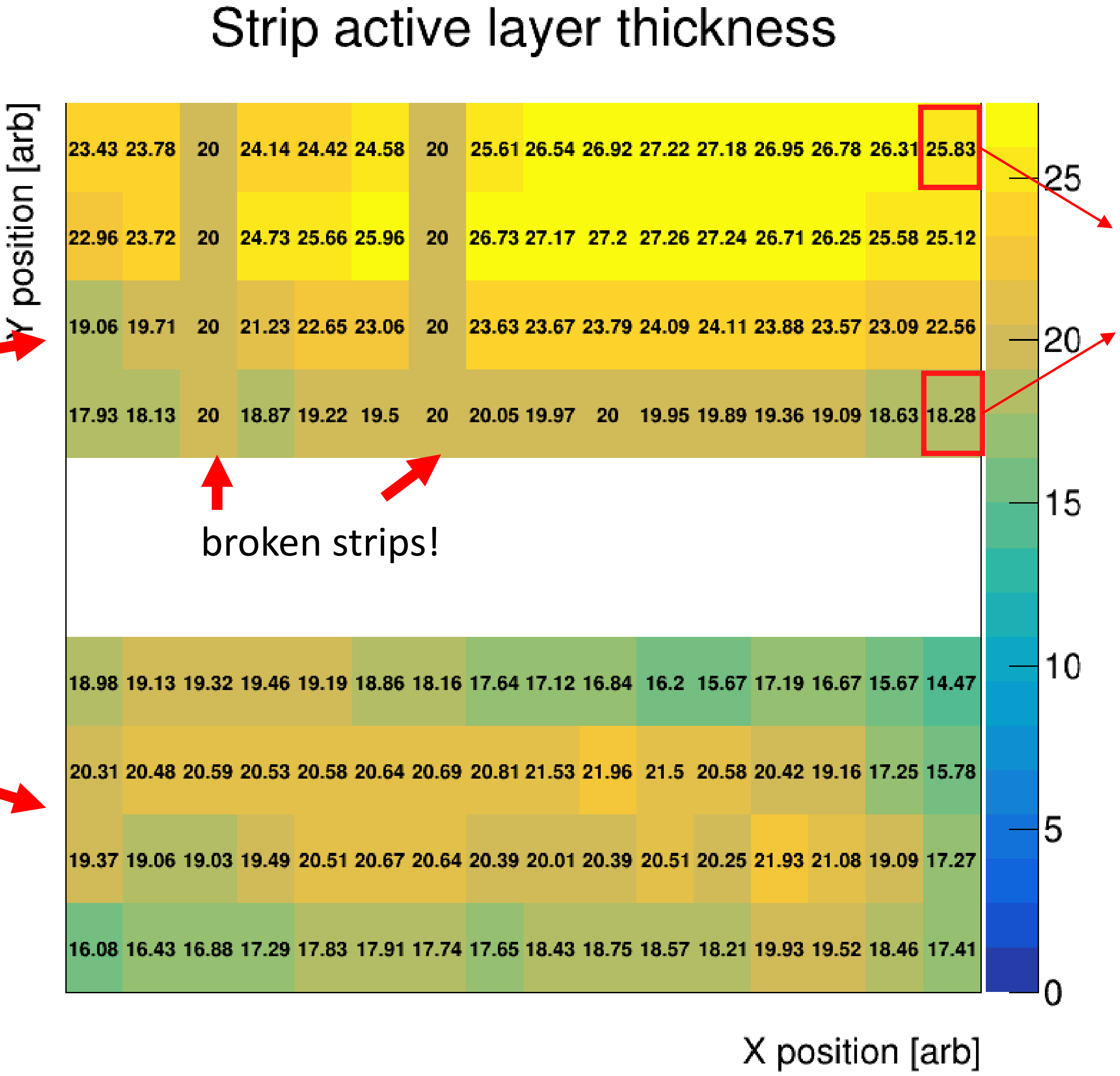
Overlap of strips and pads



https://www.sciencedirect.com/science/article/pii/S0168900217310161

OSCAR – dE thickness variability



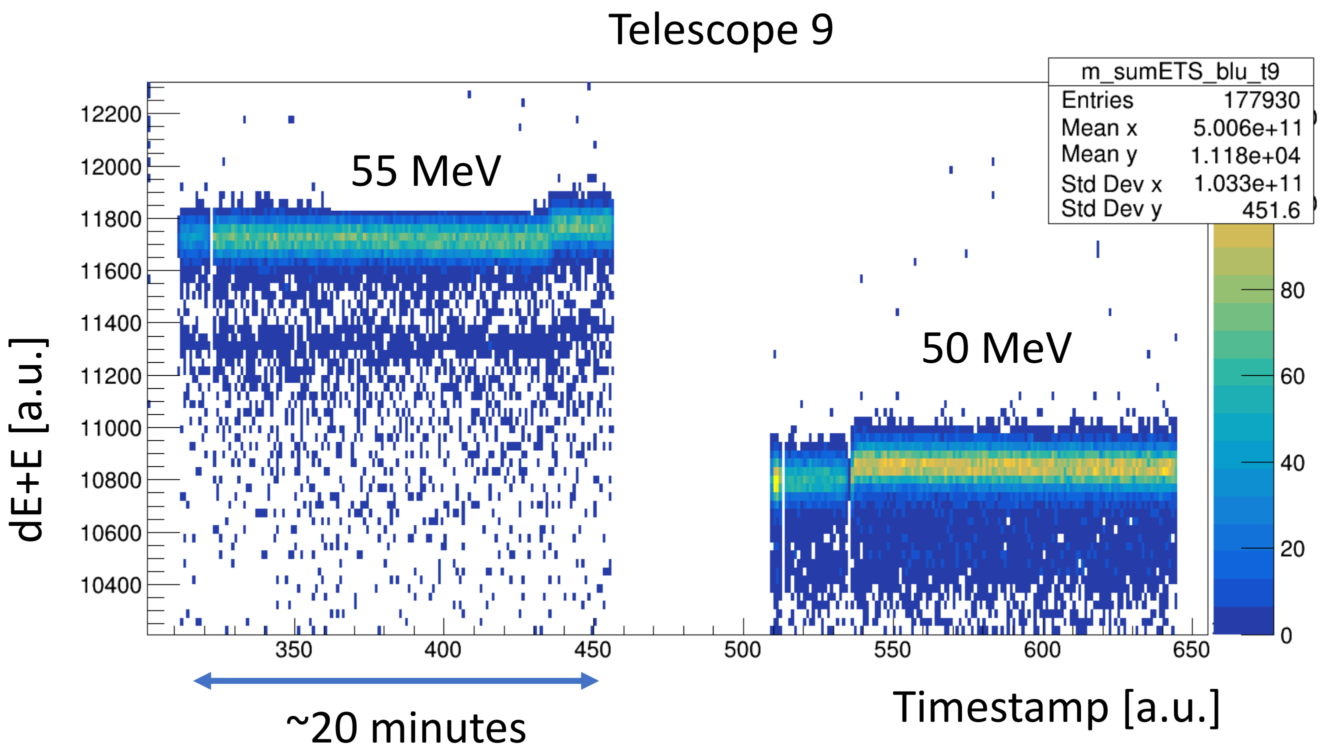


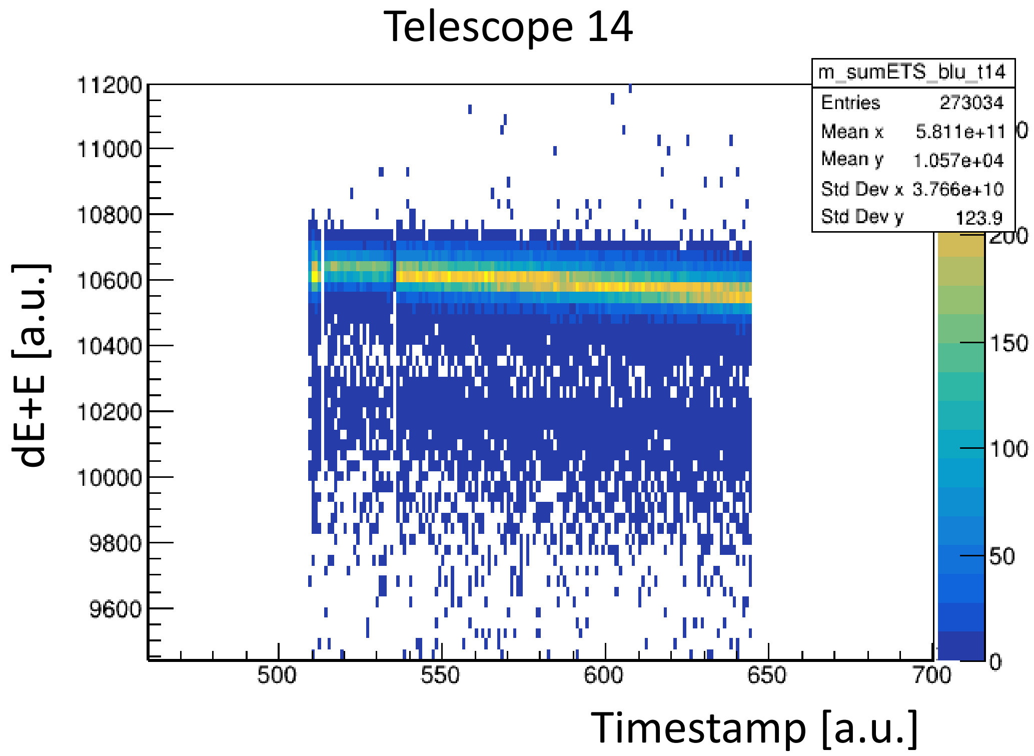
4 MeV difference for ^{14}C@60MeV

6 MeV difference for ^{14}C@40MeV

OSCAR – energy drift over time

Gain drift during calibration…





https://www.sciencedirect.com/science/article/pii/S0168900217310161

LaBr

- Exact number of detectors may vary in the experiment
- usually 5 large (3”x3”) and 4 smaller (2”x2”)
- use digitizers with PSD

reference paper 10.1016/j.nima.2013.07.084

LaBr

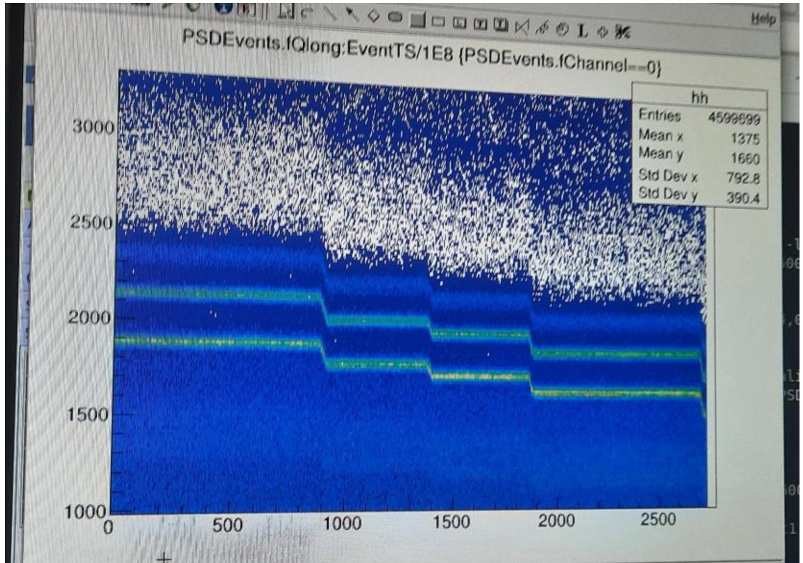
- Exact number of detectors may vary in the experiment
- usually 5 large (3”x3”) and 4 smaller (2”x2”)
- use digitizers with PSD

reference paper 10.1016/j.nima.2013.07.084

Known issues

Calibration is dependent on magnetic field

- added more mu-metal for shielding
- if PRISMA is used, plot time vs energy matrix to verify calibration during the experiment



LaBr

Look-up table

#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

energy calibration of Qlong,
Npar, par1, … parN

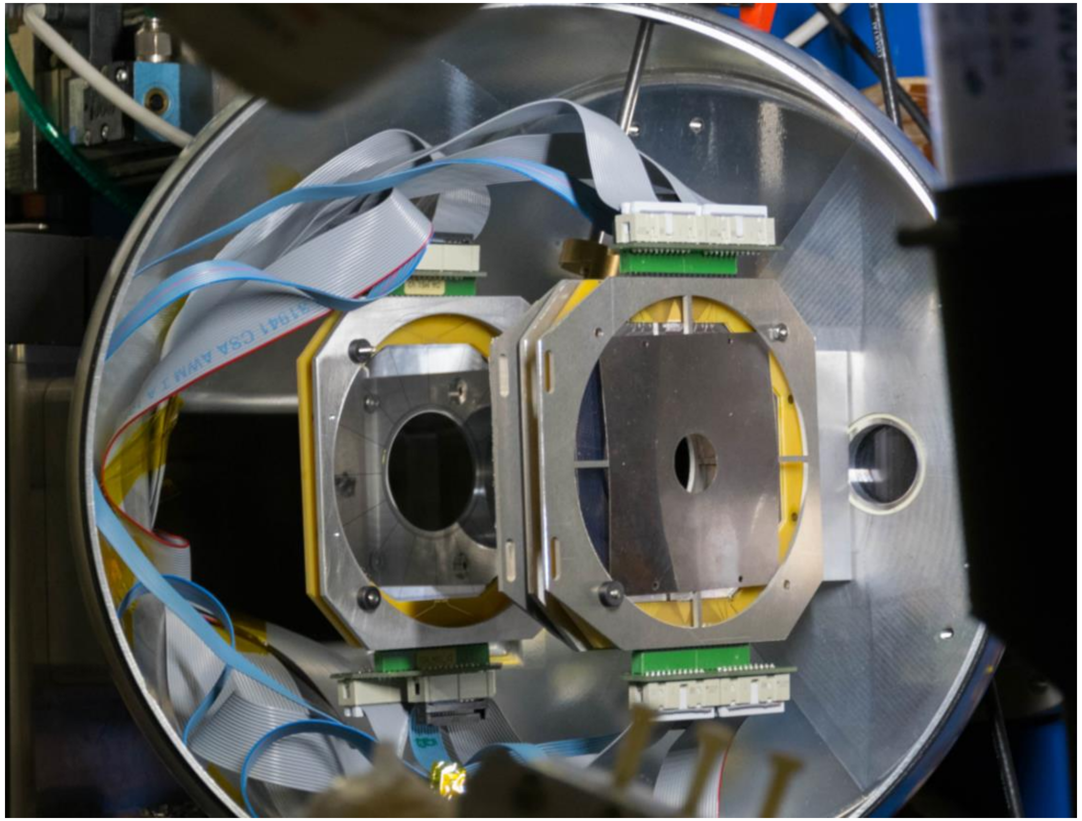
LaBr

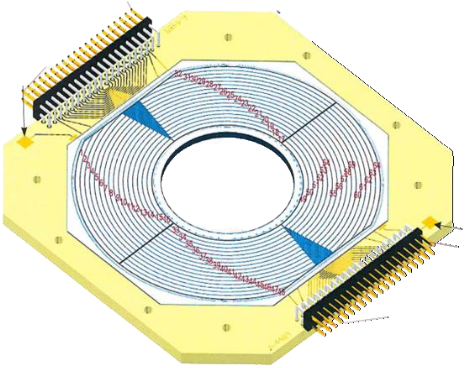
Look-up table

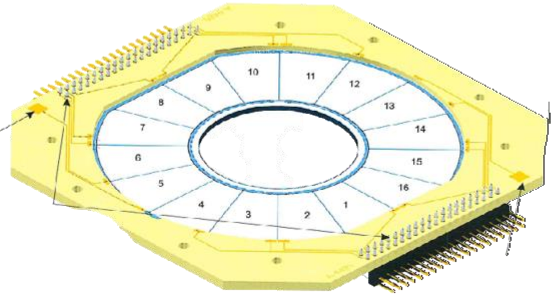
#board (V1730)	channel	map	name	thr_lo	thr_hi	theta	phi	TimeOffset	npar_gl	p0_ql	p1_q2	npar_qs	p0_qs	p1_qs
1	0	0	D0	0	16000	90.422684	124.92098	0	2	-8.590549465	0.5683940043	2	-16.614035	0.584031
1	1	1	D1	0	16000	84.308418	97.489398	0	2	4.994643769	0.441859949	2	10.570262	0.443247
1	2	2	D2	0	16000	90.572804	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

energy calibration of
Qshort,
Npar, par1, … parN

SAURON







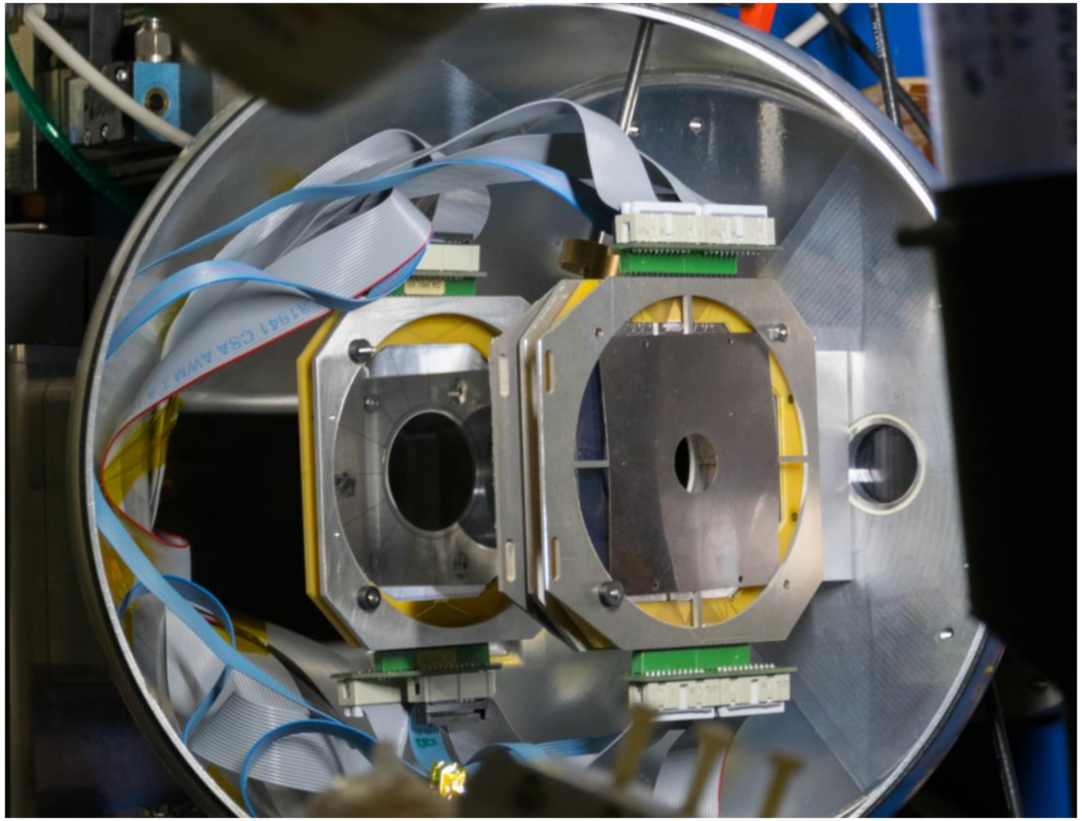
SAURON (Silicon AnnUlar stRipped iON detector)

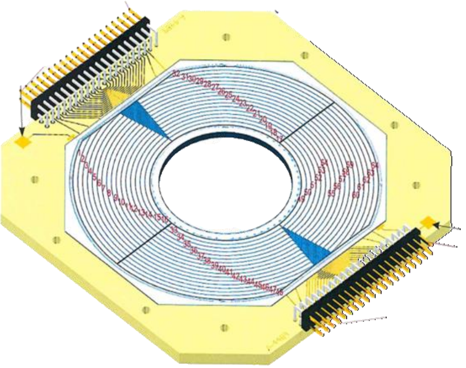
- annular DSSSD:
    - junction (P) side: 4 quadrants, each with 16 radial strips
    - ohmic (N) side: 16 polar pads
    - total of 256 sub-strips/pixels
- available thickness 300, 500, 1000, 1500µm
- strip resolution 1% @5.5MeV for **NEW** detector

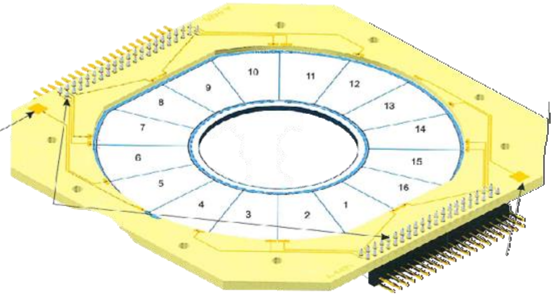
- nominal position 5cm from target
    - 25-45°
    - 135-155°

- max 2 detectors active
    - front + back configuration
    - dE+E configuration (not tested)

SAURON





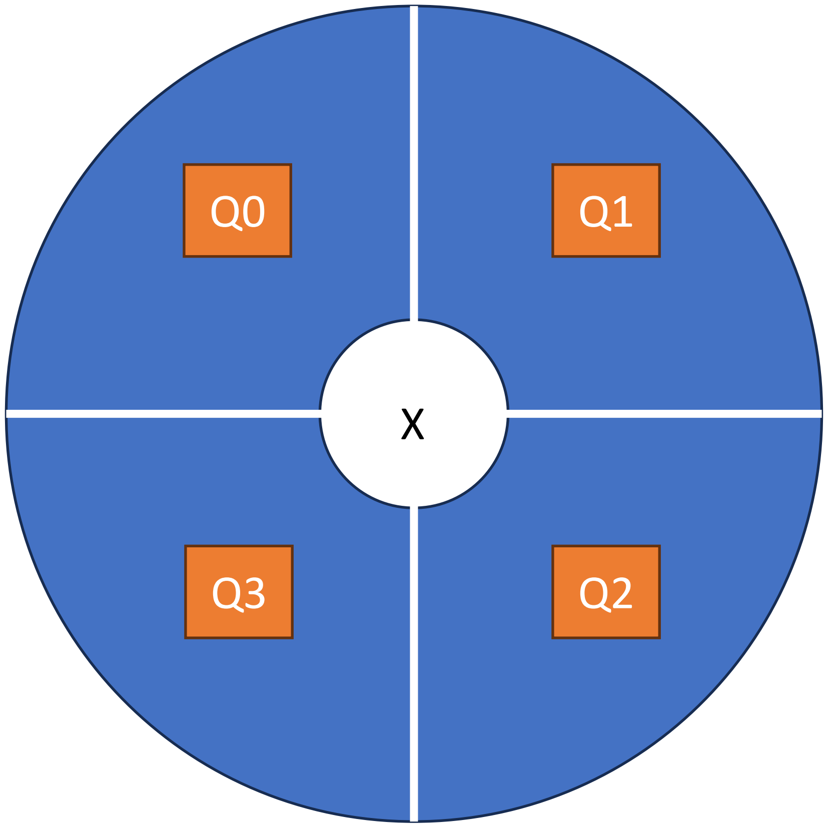


```
####### SAURON FORWARD ######
#
#       PSIDE = annular strips (junction side)
#       NSIDE = radial pads    (ohmic side)
#
#       Quadrants starts from "12 o'clock" and continue clockwise:
#       Q3 Q0
#       Q2 Q1
#
#       IN THIS CONFIGURATION DETECTOR IS FACING TARGET WITH THENSIDE/OHMIC SIDE/RADIAL PADS
#
# ABC
# A - side P=0 N=1
# BC - channel (quadrant ch/4 for Nside ch/16 for PSIDE)
#
#
# Board   channel map    name    thr_lo   thr_hi   radius(mm) phi(deg) TimeOffset   ncalpar   calpars
1       0       014     PSIDE_Q0_CH14   0.1     200     45.75   45      0 2     0       0.002
1       1       015     PSIDE_Q0_CH15   0.1     200     47.25   45      0 2     0       0.002
1       2       012     PSIDE_Q0_CH12   0.1     200     42.75   45      0 2     0       0.002
1       3       013     PSIDE_Q0_CH13   0.1     200     44.25   45      0 2     0       0.002
1       4       010     PSIDE_Q0_CH10   0.1     200     39.75   45      0 2     0       0.002
1       5       011     PSIDE_Q0_CH11   0.1     200     41.25   45      0 2     0       0.002
1       6       008     PSIDE_Q0_CH08   0.1     200     36.75   45      0 2     0       0.002
1       7       009     PSIDE_Q0_CH09   0.1     200     38.25   45      0 2     0       0.002
1       8       006     PSIDE_Q0_CH06   0.1     200     33.75   45      0 2     0       0.002
1       9       007     PSIDE_Q0_CH07   0.1     200     35.25   45      0 2     0       0.002
1       10      004     PSIDE_Q0_CH04   0.1     200     30.75   45      0 2     0       0.002
1       11      005     PSIDE_Q0_CH05   0.1     200     32.25   45      0 2     0       0.002
1       12      002     PSIDE_Q0_CH02   0.1     200     27.75   45      0 2     0       0.002
1       13      003     PSIDE_Q0_CH03   0.1     200     29.25   45      0 2     0       0.002
1       14      000     PSIDE_Q0_CH00   0.1     200     24.75   45      0 2     0       0.002
1       15      001     PSIDE_Q0_CH01   0.1     200     26.25   45      0 2     0       0.002
2       0       016     PSIDE_Q1_CH00   0.1     200     24.75   135     0 2     0       0.002
2       1       017     PSIDE_Q1_CH01   0.1     200     26.25   135     0 2     0       0.002
```

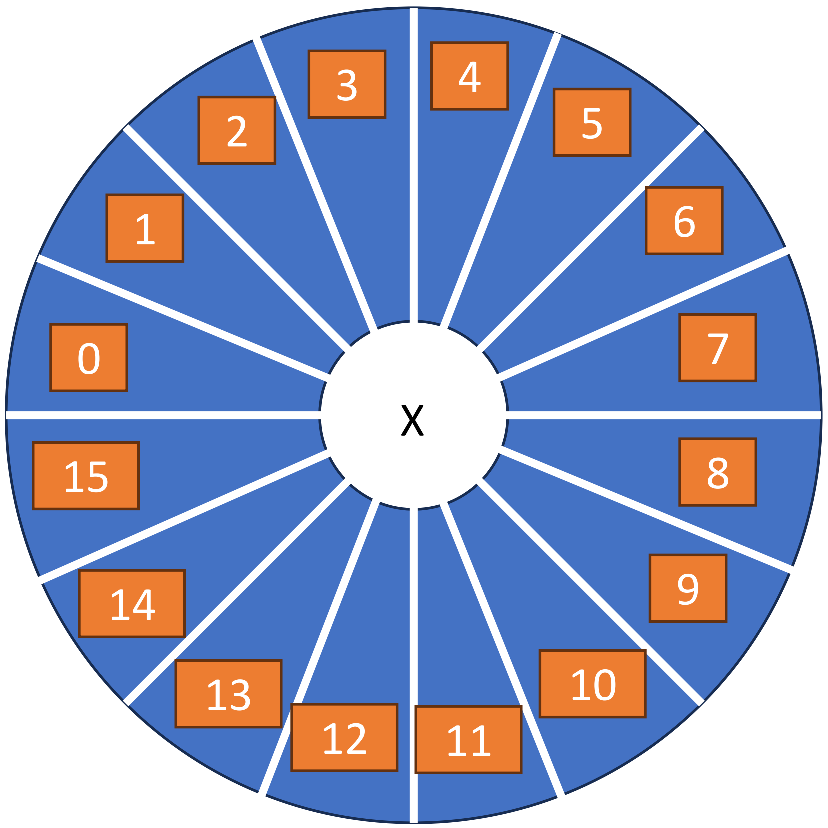
radius and phi!

SAURON – view in direction of the beam

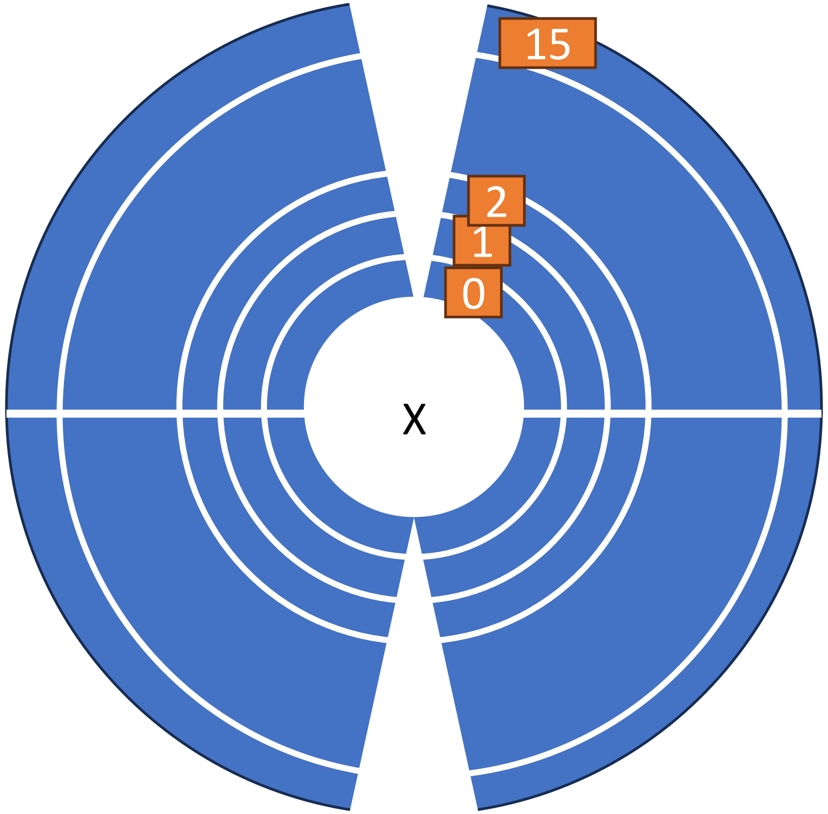
Basic division to quadrants



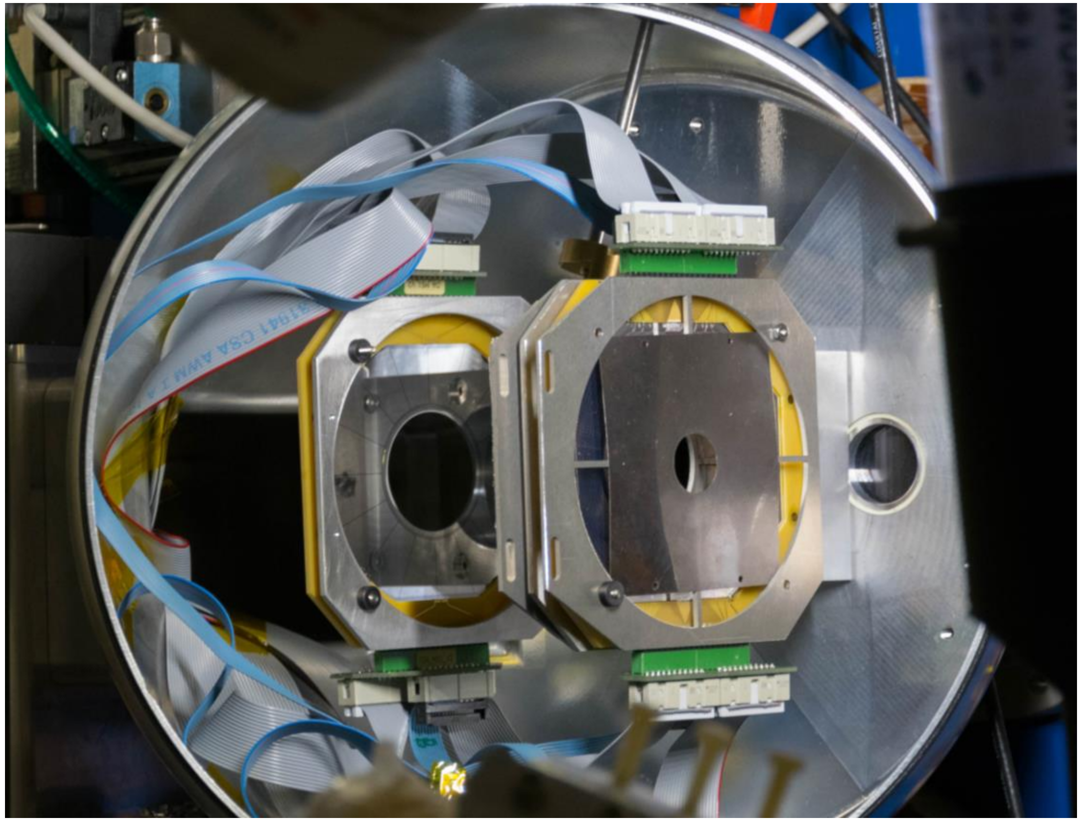
Pads
(ohmic side)

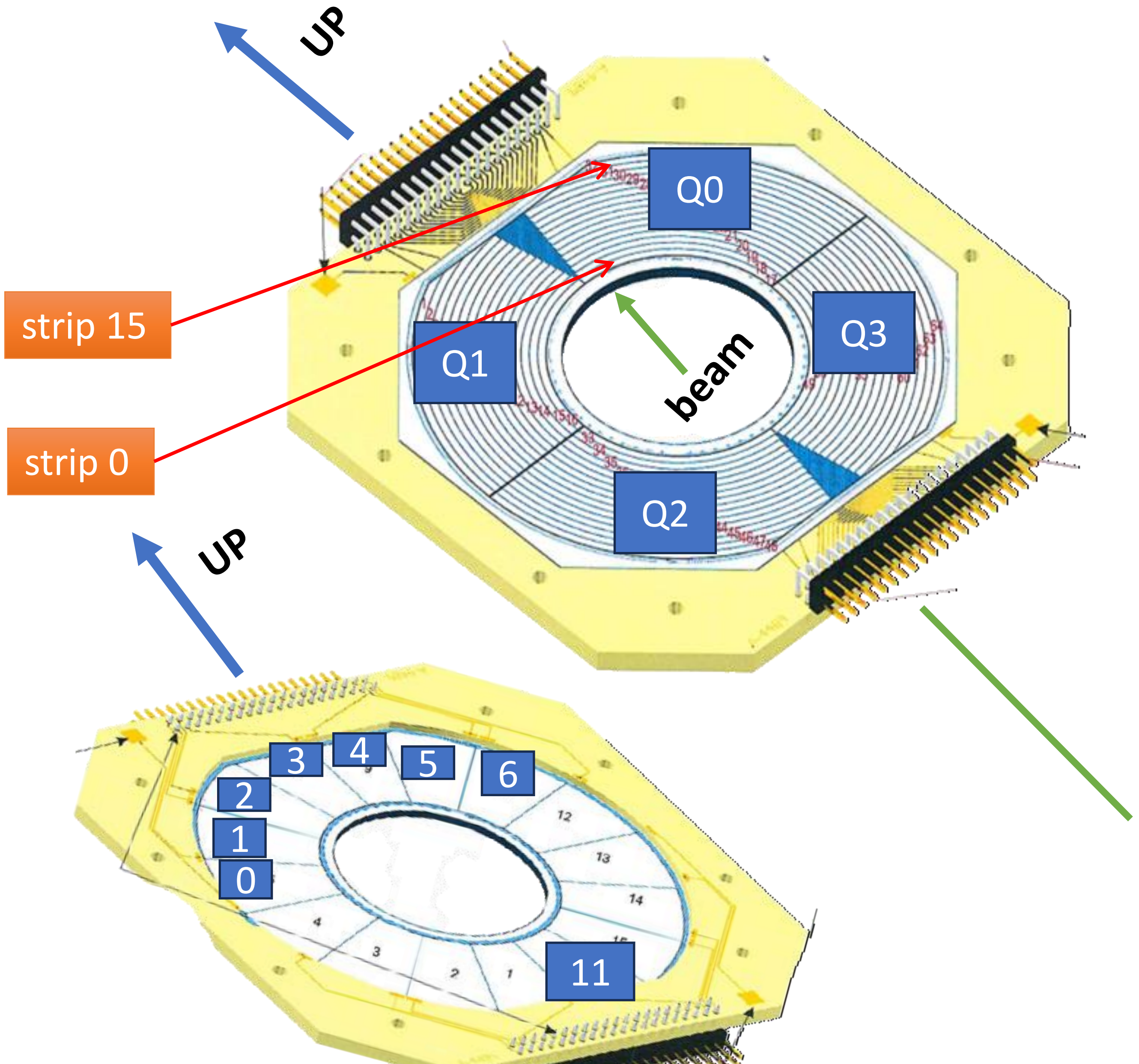


Strips
(juncton side)



SAURON – look-up table Forward detector



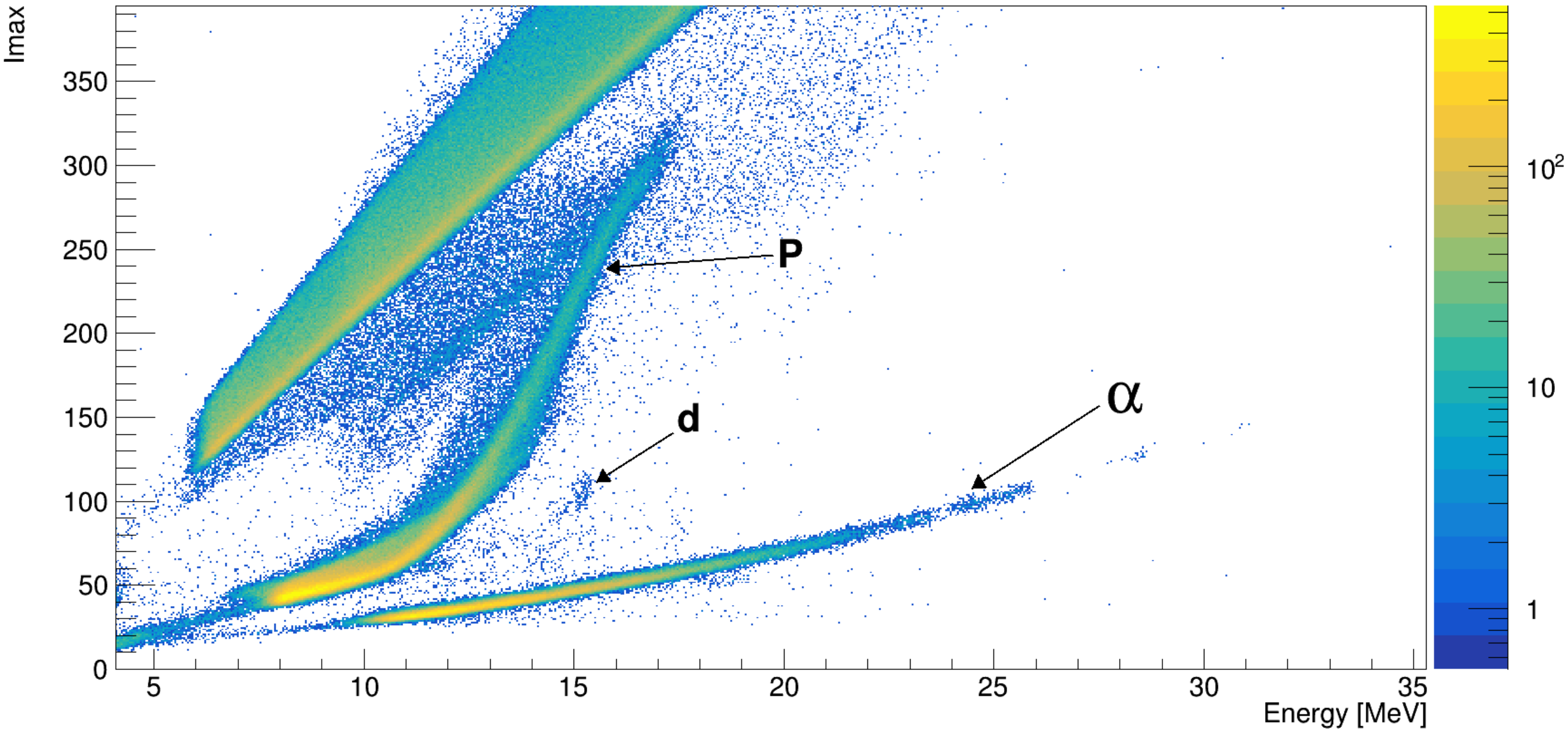


SAURON

PSA/PID

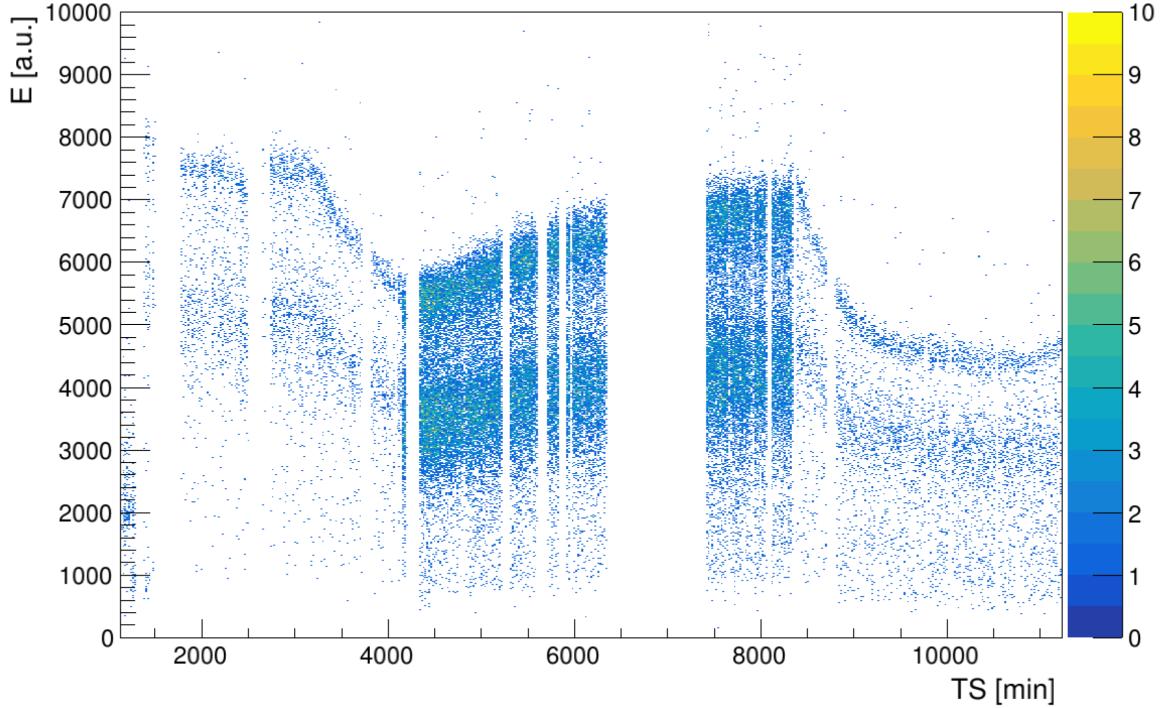
- I_{max} integrated

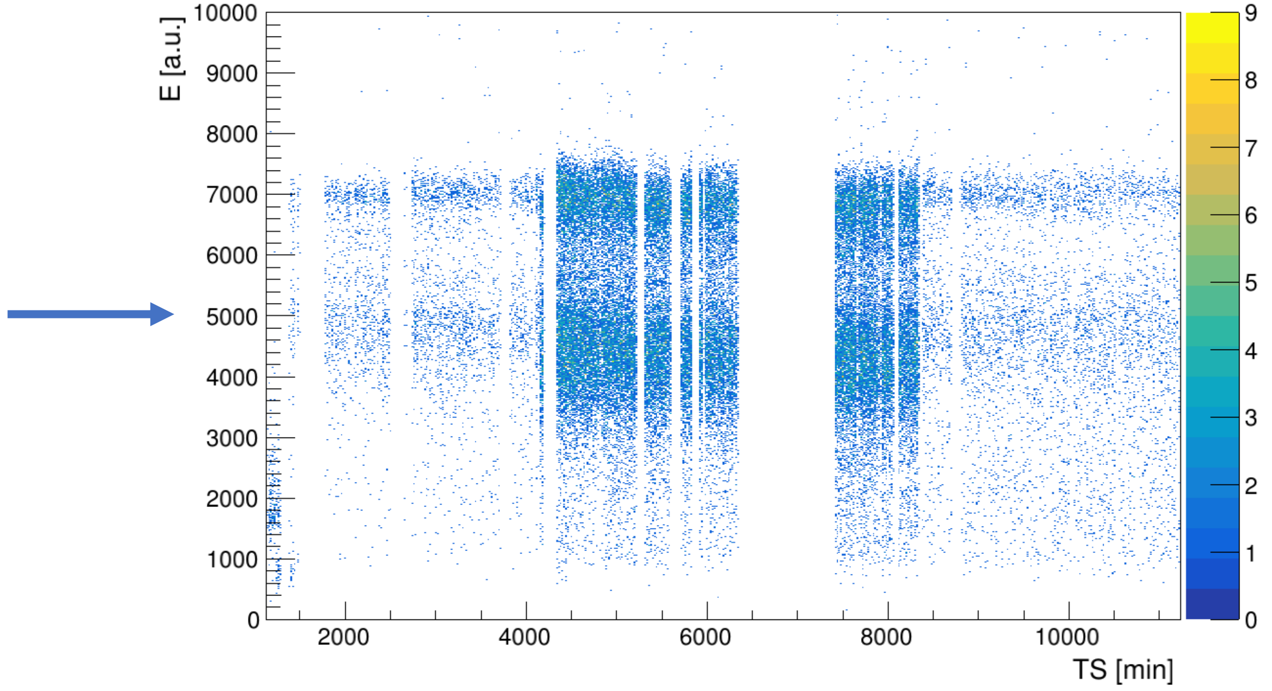
M. del Fabbro



Time instability in Silicon detectors

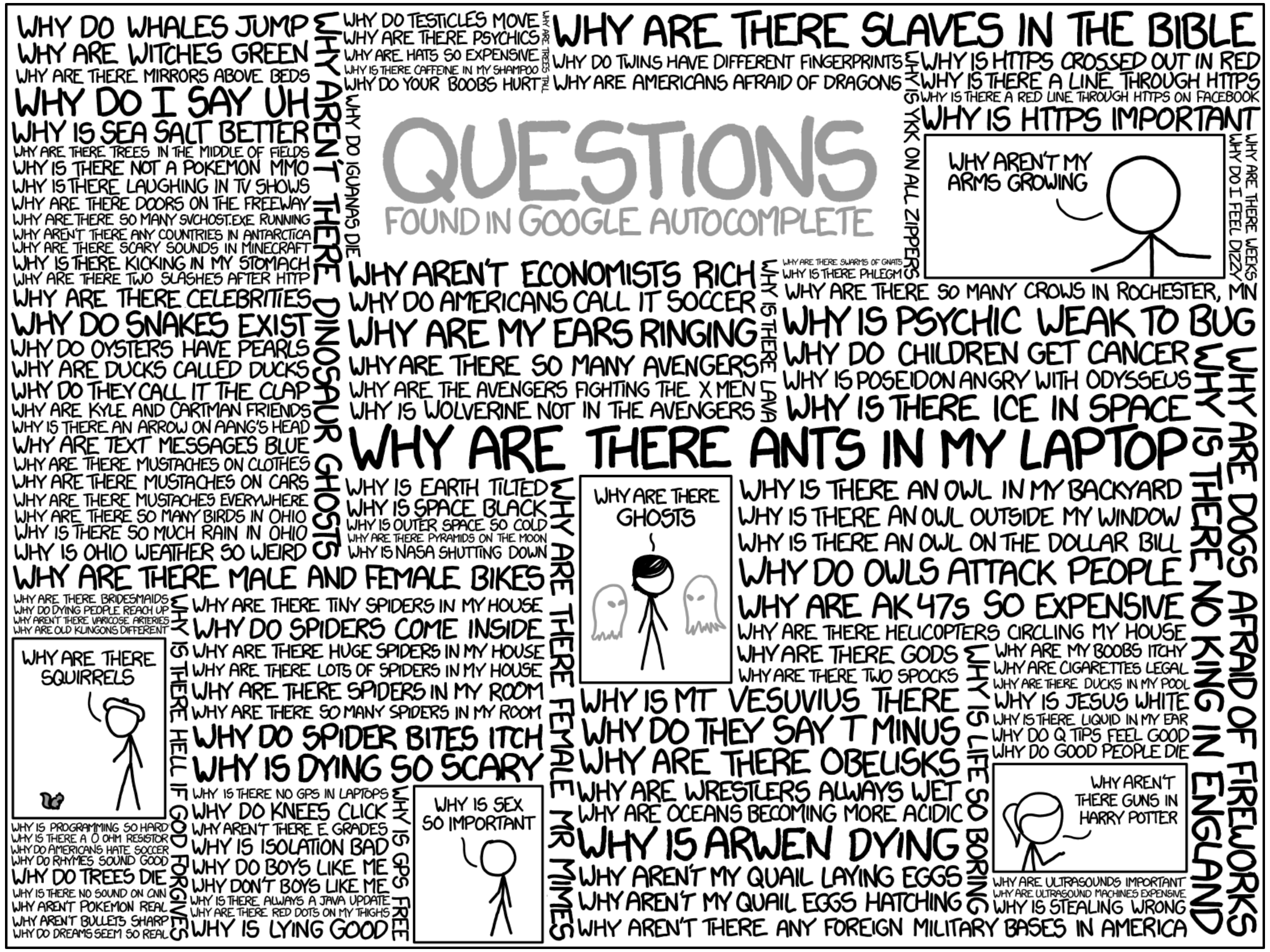
SAURON, single channel





Caused likely by **Temperature + humidity** (detector & electronics), **leakage current** (decreases effective voltage)

Questions?



INFN Istituto Nazionale di Fisica Nucleare
LABORATORI NAZIONALI DI LEGNARO