EUROPEAN
SPALLATION
SOURCE

Channel mapping for the DREAM EndCap detector

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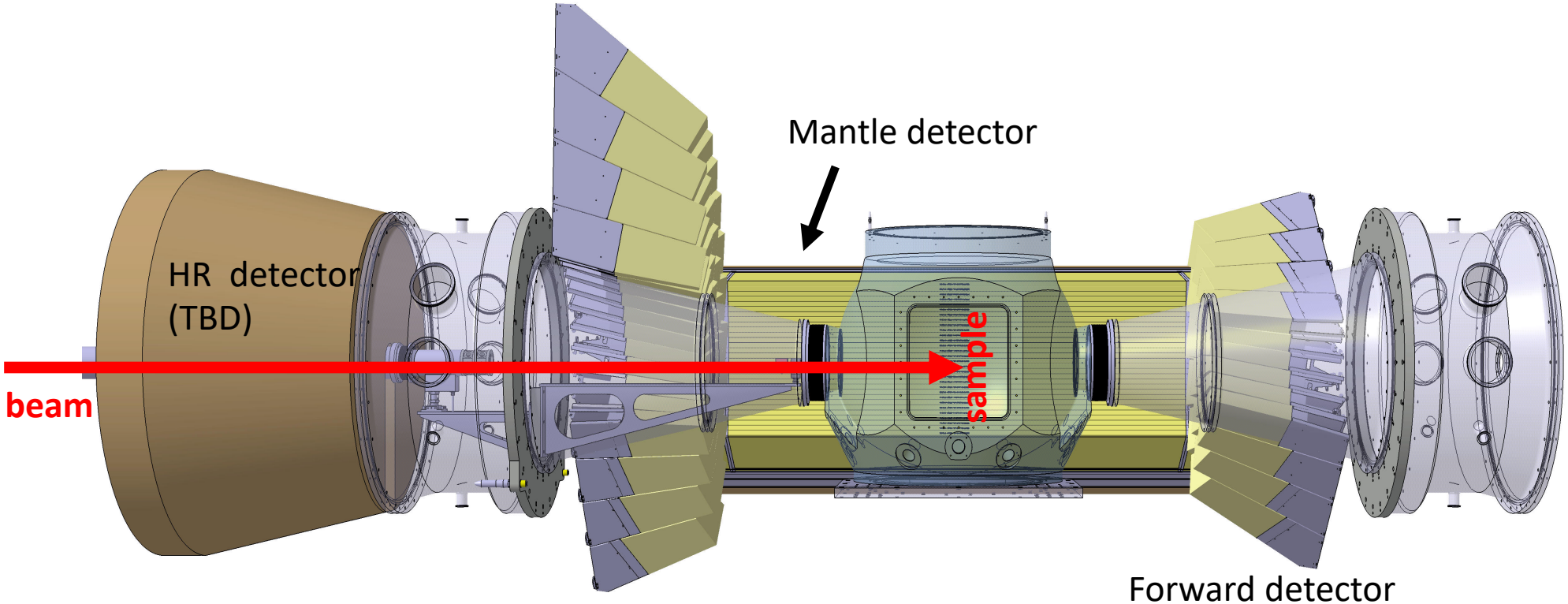
The DREAM sample scattering system

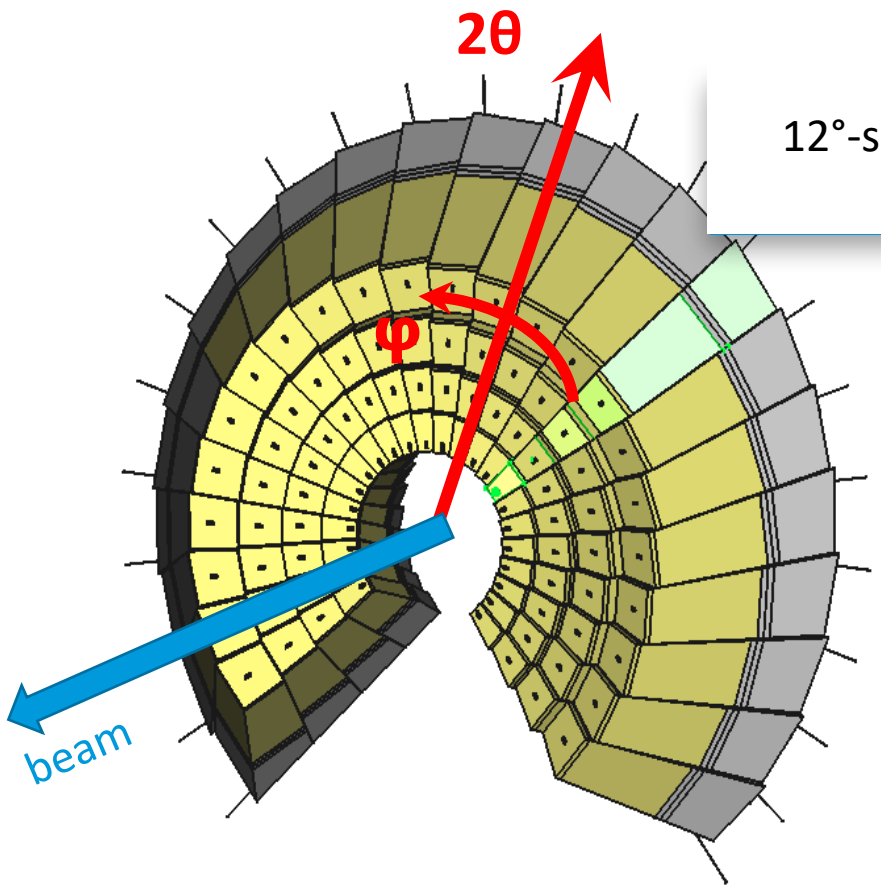


SANS tank +
Detector
(TBD)

All 4 DREAM detectors will be delivered by the CDT company based in Heidelberg, Germany.

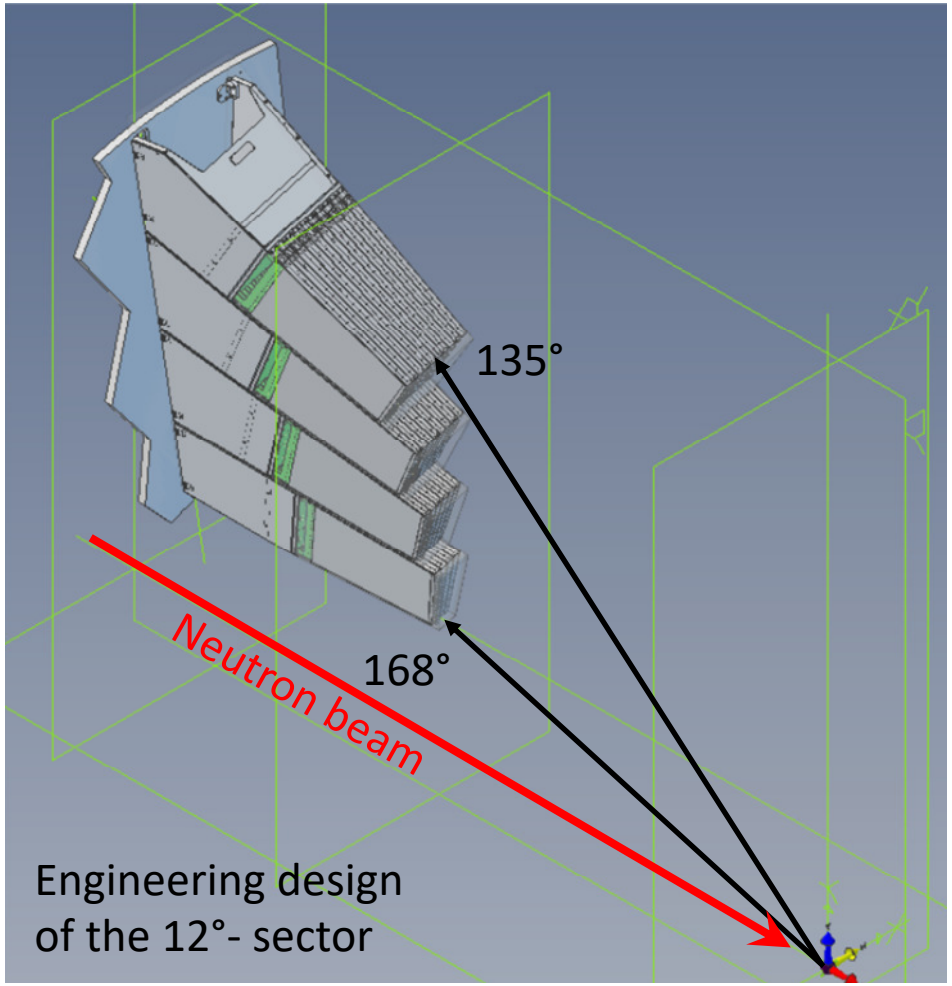
All 4 DREAM detectors will be B-10 based detectors. The mantle and EndCap detectors are from the Jalousie detector family, the design of the High Resolution and SANS detectors is still to be decided.

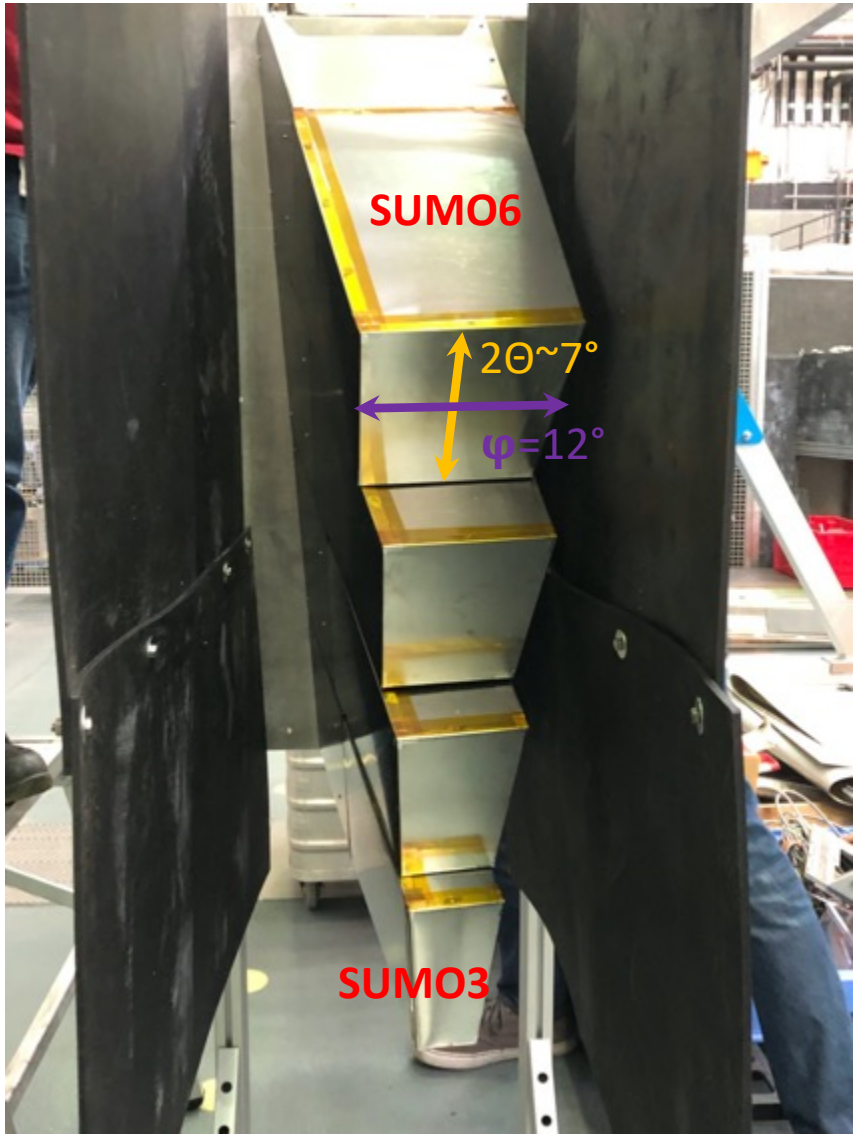
The DREAM EndCap



12°-sector

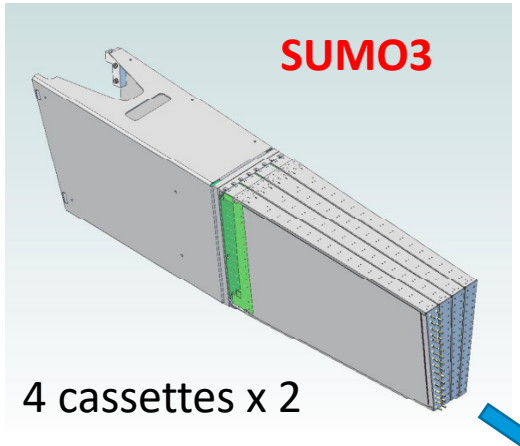
EndCap = assembly of 12°-sectors, each sector consisting of 4 detector modules (SUMOs)

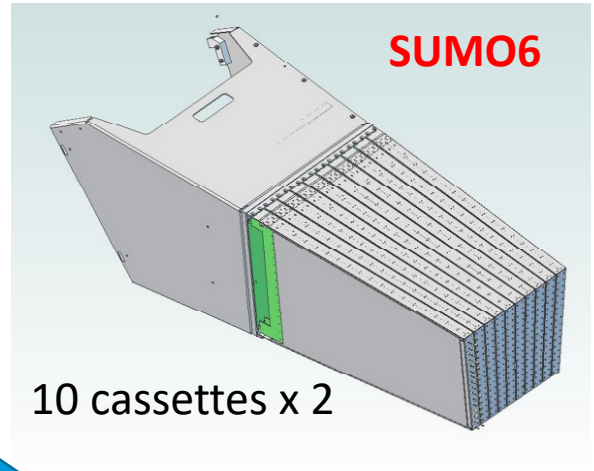


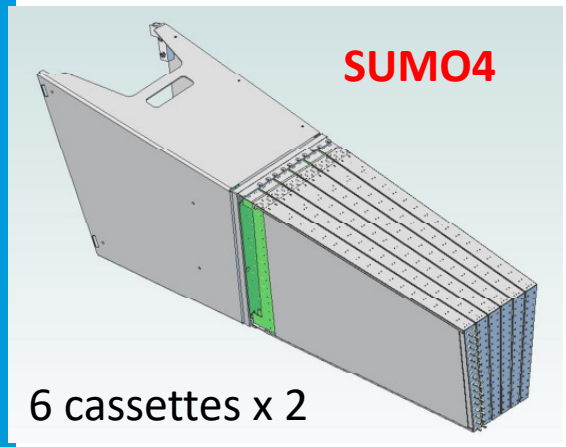


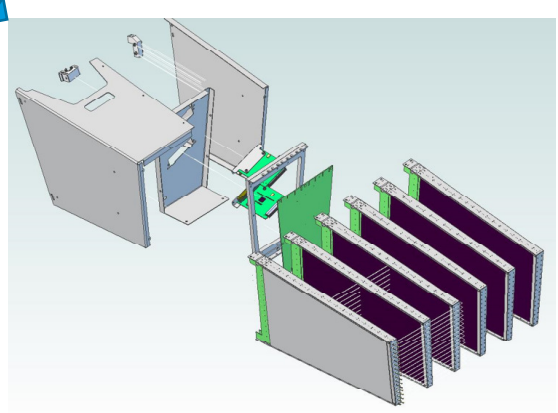
4 SUMO modules (SUper MOdules) mounted on the same backplate = mounting unit

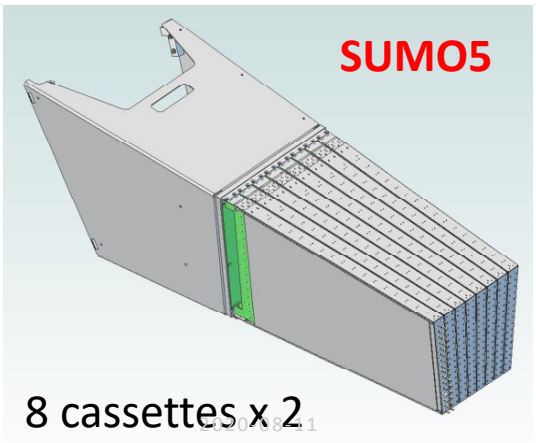
The DREAM 12°- sector @V20


SUMO3
4 cassettes x 2


SUMO6
10 cassettes x 2


SUMO4
6 cassettes x 2




SUMO5
8 cassettes x 2

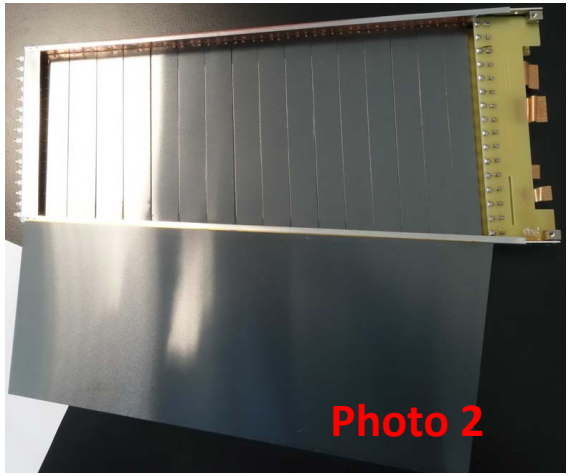


Photo 2

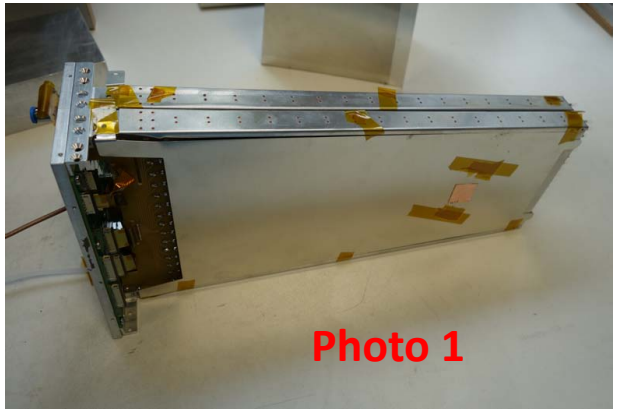


Photo 1

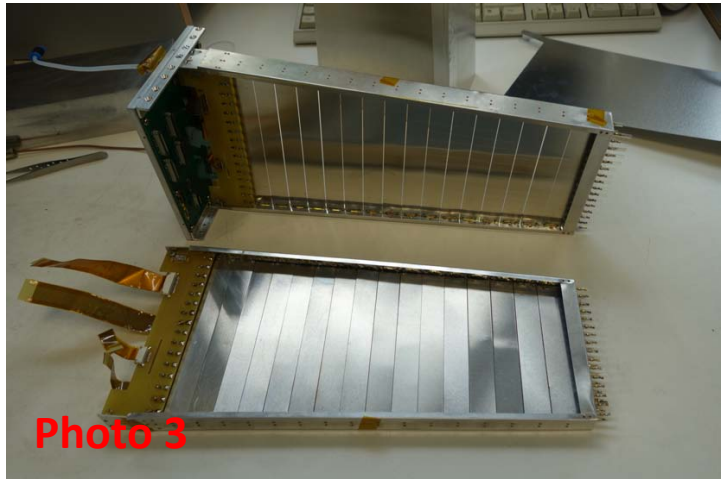
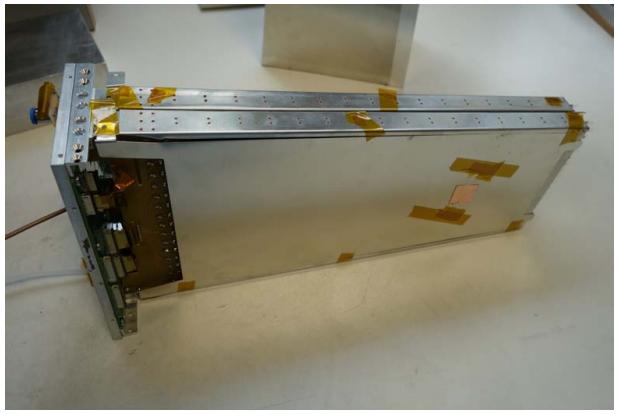
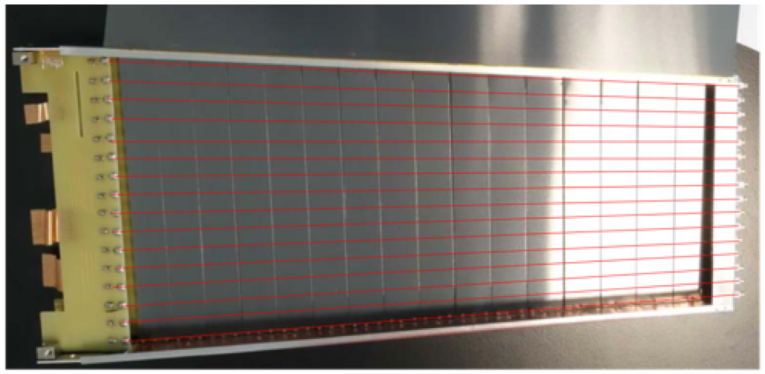


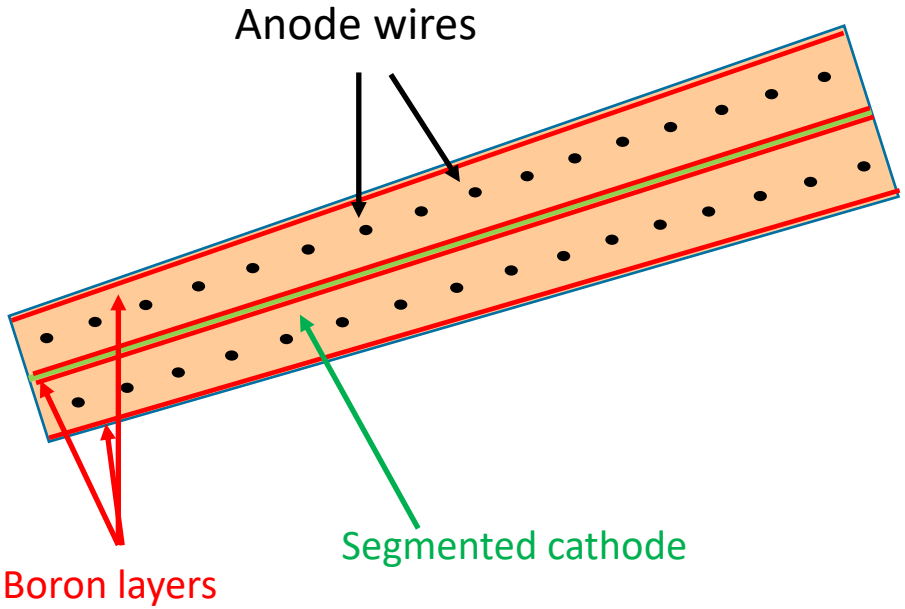
Photo 3





Each segment consists of 2 independent wire counters sharing a common segmented cathode.

16 wires and 16 equal strips in each counter



The wires and the cathode strips are readout independently by 64-channels ASICs

Detectors for DREAM	No of segments per module		No of ASIC channels per segment	Total number of ASIC channels per SUMO module	Total number of voxels per SUMO module
EndCap	SUMO3	4	16 (w) + 16 (s) + 16 (w)	4x3x16 = 192	4*2*16*16 = 2 048
	SUMO4	6	16 (w) + 16 (s) + 16 (w)	6x3x16 = 288	6*2*16*16 = 3 072
	SUMO5	8	16 (w) + 16 (s) + 16 (w)	8x3x16 = 384	8*2*16*16 = 4 096
	SUMO6	10	16 (w) + 16 (s) + 16 (w)	10x3x16 = 480	10*2*16*16 = 5 120

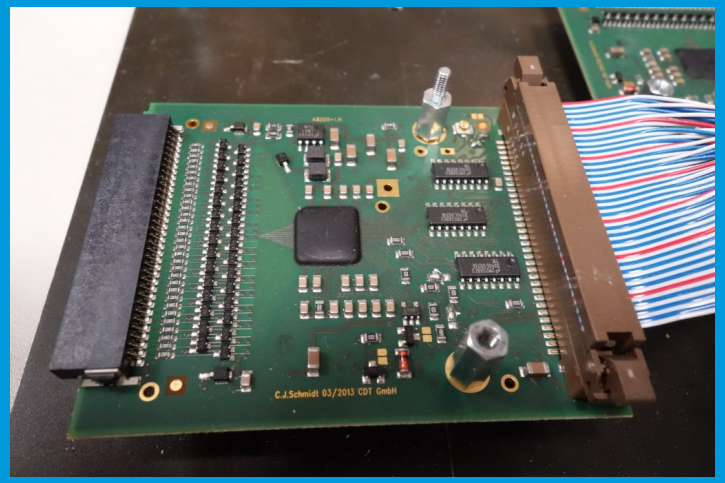
(w) – wire channel
(s) - strip channel

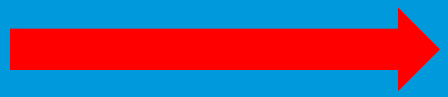
In the raw experimental data the location of a neutron event in the EndCap volume is given by 3 parameters:

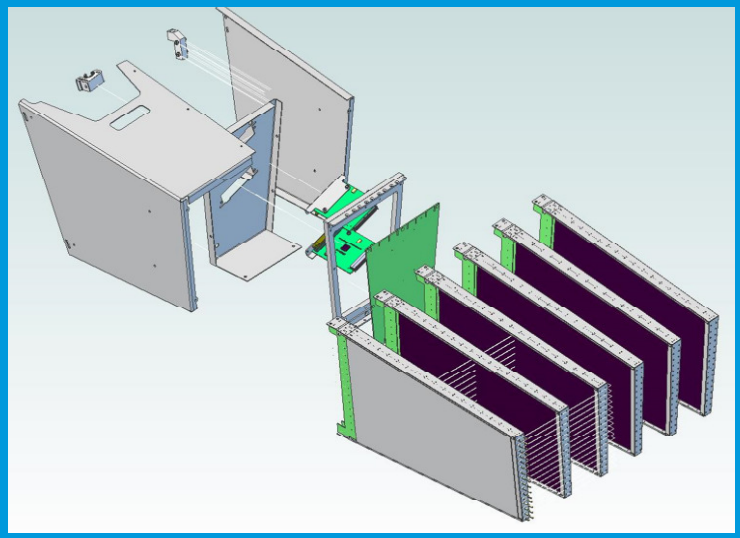
- boardID ➔ which SUMO recorded the hit
- AnodeID ➔ which ASIC channel that reads out the wires fired
- CathodeID ➔ which ASIC channel that reads out the cathode strips fired

➔ For the EndCap the voxel mapping process is done in 2 steps. The first step is the mapping of the ASIC channels to the detector architecture shown in slides 3-5, in the second step the detector architecture is mapped with the voxel coordinates obtained from another source.

1. Mapping the readout channels to the detector architecture







Physical wire grid

ASIC channel# for the wire =‘anodeID’ entry in the data file

ASIC channel# for the cathode strip = ‘cathodeID’ entry in the data file

sumo_voxel_map_20190711

sumoType	wireLayer	anode	cathode	absoluteXPosition	absoluteYPosition
3	0	0	0	0	0
3	0	0	1	0	1
3	0	0	2	0	2
3	0	0	3	0	3
3	0	0	4	0	4
3	0	0	5	0	5
3	0	0	6	0	6
3	0	0	7	0	7
3	0	0	8	0	8
3	0	0	9	0	9
3	0	0	10	0	10
3	0	0	11	0	11
3	0	0	12	0	12
3	0	0	13	0	13
3	0	0	14	0	14
3	0	0	15	0	15
3	0	1	0	1	0
3	0	1	1	1	1
3	0	1	2	1	2

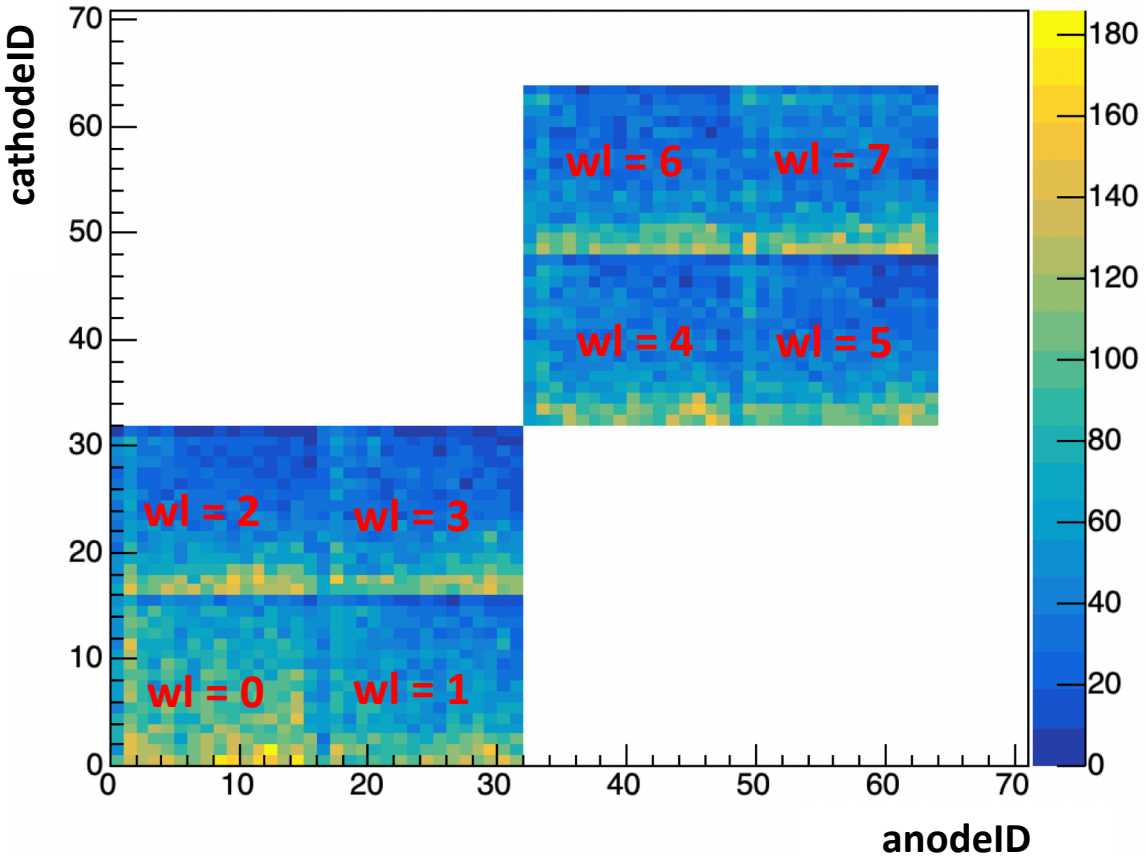
Use these 3 columns to get the plots shown in the next two slides

The information on the wiring of the detector is included in the CVS file sent by CDT in summer 2019:

https://github.com/ess-dg/dream_endcap_analysis/blob/master/documentation/sumo_voxel_map_20190711.csv

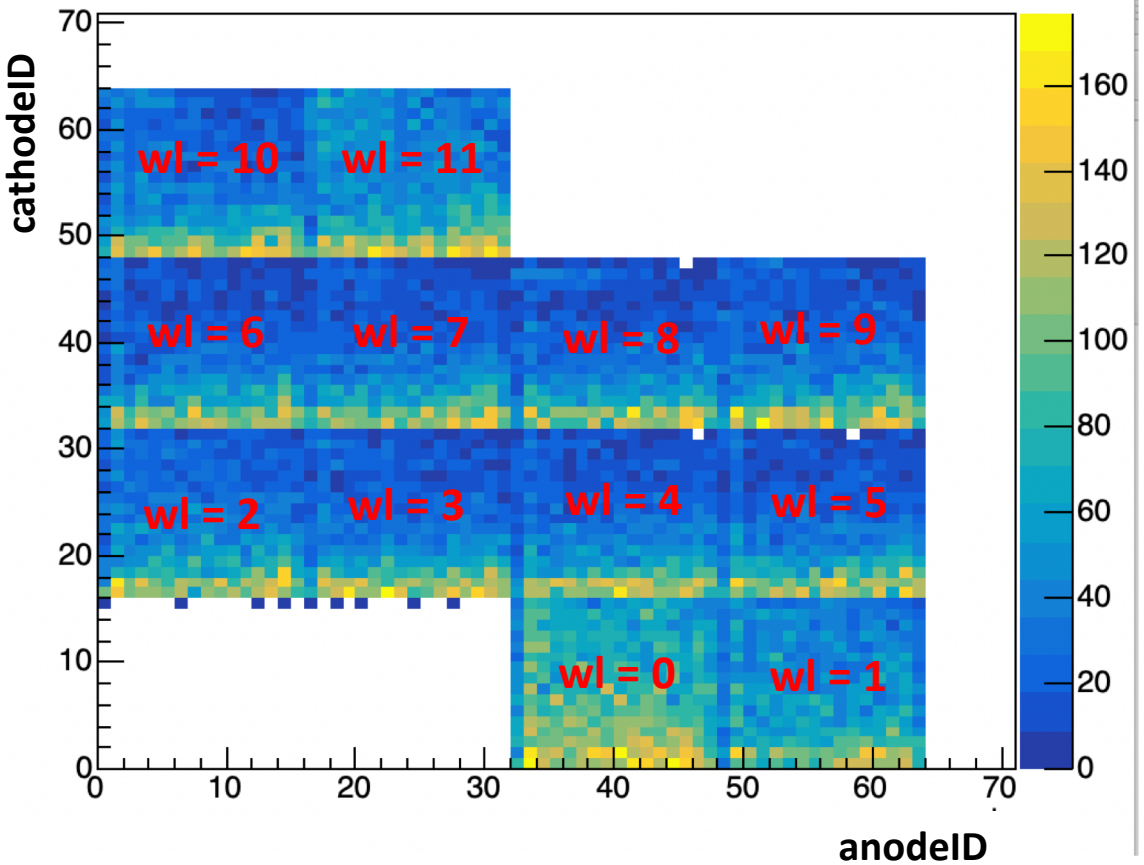
Plot of the events in the V20 data file as 2D histograms anodeID:cathodeID

SUMO3



4 segments x 2 counters/segment = 8 wire layers

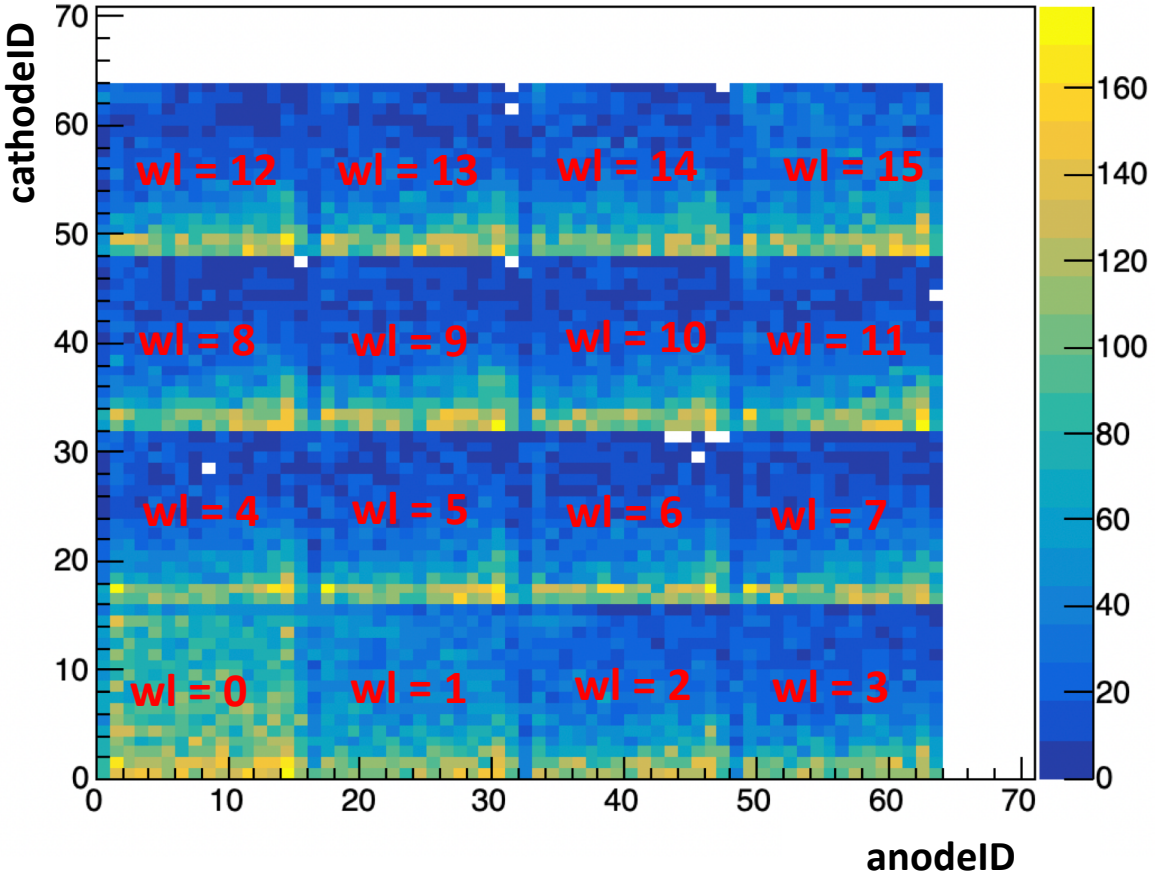
SUMO4



6 segments x 2 counters/segment = 12 wire layers

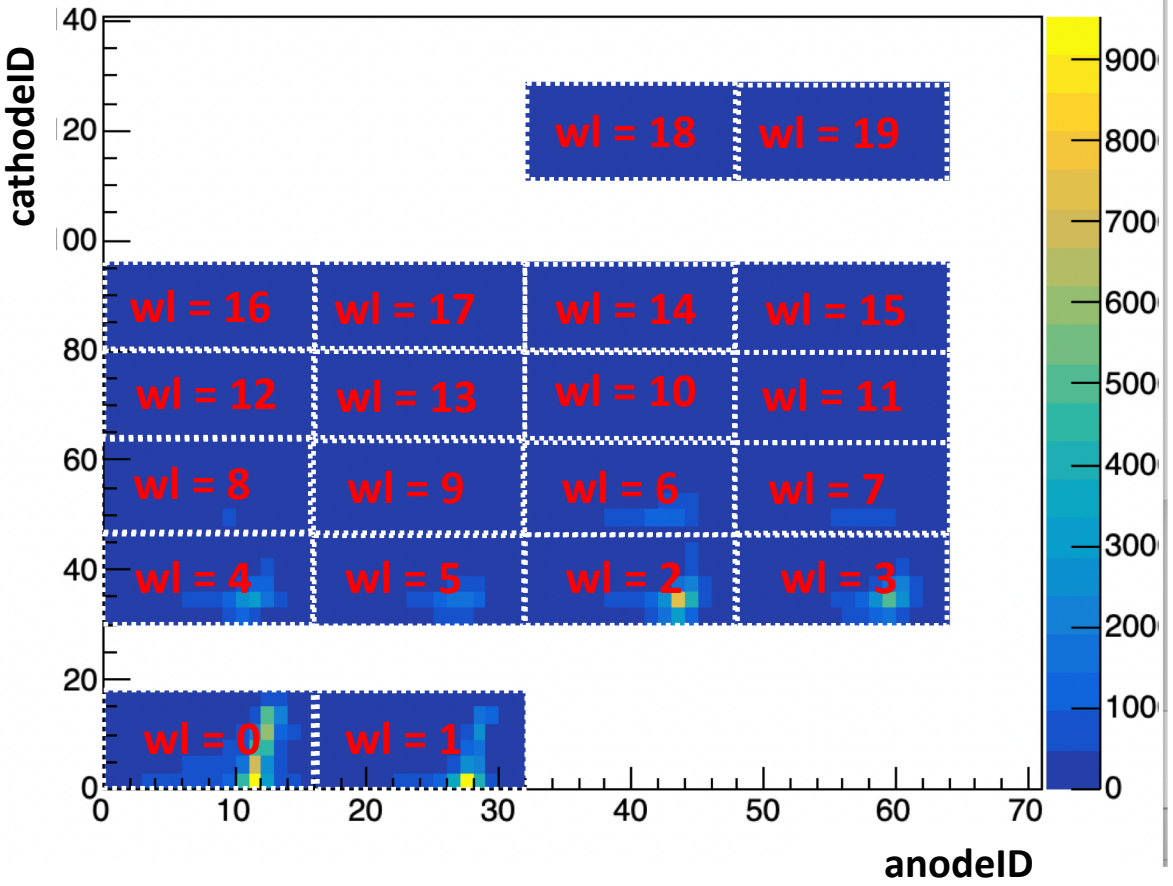
X-axis = absoluteXPosition (5th column in the CDT csv file), Y-axis = absoluteYPosition (6th column in the CDT csv file)
Squares correspond to the wire layer (wl), 2nd column in the CDT csv file

SUMO5



8 segments x 2 counters/segment = 16 wire layers

SUMO6



10 segments x 2 counters/segment = 20 wire layers

This is how this information is used in the code (analysis_cdt.cpp) to convert from ASIC channels and wire layers to user-defined ‘location’ of the neutron event in the detector volume.

The info shown graphically in the last two slides is captured in the code like this:

```
int s3[4][4] = {{0,2,-1,-1}, {1,3,-1,-1}, {-1,-1,4,6}, {-1,-1,5,7}};  //sumo3
int s4[4][4] = {{-1,2,6,10}, {-1,3,7,11}, {0,4,8,-1}, {1,5,9,-1}};  //sumo4
int s5[4][4] = {{0,4,8,12}, {1,5,9,13}, {2,6,10,14}, {3,7,11,15}};  //sumo5
int s6[4][8] = {{0,-1,4,8,12,16,-1,-1},{1,-1,5,9,13,17,-1,-1},{-1,-1,2,6,10,14,-1,18},{-1,-1,3,7,11,15,-1,19}};  //sumo6
```

Wire layer vectors

For-loop through the neutron events

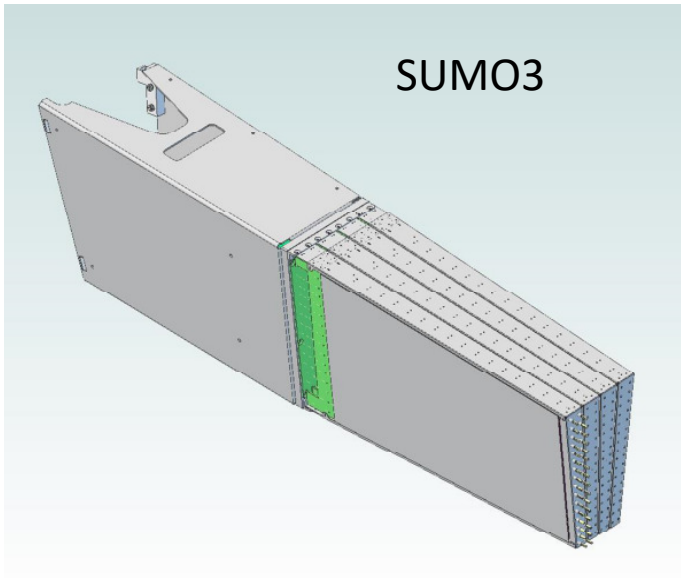
```
factor_a = floor(ncathode/16);
factor_b = floor(nanode/16);

switch (nsumo){

    case 3:
        nw_layer = s3[factor_b][factor_a];
        break;

    case 4:
        nw_layer = s4[factor_b][factor_a];
        break;

    case 5:
        nw_layer = s5[factor_b][factor_a];
        break;

    case 6:
        nw_layer = s6[factor_b][factor_a];
        break;

}

nsegment = floor(nw_layer/2) + 1;
ncounter = nw_layer % 2 + 1;

nwire = nanode - 16*factor_b + 1;
nstrip = ncathode - 16*factor_a + 1;
```

In my analysis code the location of the neutron event in the detector volume is specified by:

- The module (12-deg sector) that was hit (always 1 in this case)
- The SUMO of the module that was hit
- The counter number of the segment that was hit
- The segment number of the SUMO that was hit
- The wire number that collected the charge
- The strip number that collected the charge

Example for SUMO3 which consists of 4 segments and each segment consists of 2 independent wire counters.

```
factor_a = floor(ncathode/16);
factor_b = floor(nanode/16);

switch (nsumo){

    case 3:
        nw_layer = s3[factor_b][factor_a];
        break;

    case 4:
        nw_layer = s4[factor_b][factor_a];
        break;

    case 5:
        nw_layer = s5[factor_b][factor_a];
        break;

    case 6:
        nw_layer = s6[factor_b][factor_a];
        break;

}

nsegment = floor(nw_layer/2) + 1;
ncounter = nw_layer % 2 + 1;

nwire = nanode - 16*factor_b + 1;
nstrip = ncathode - 16*factor_a + 1;
```



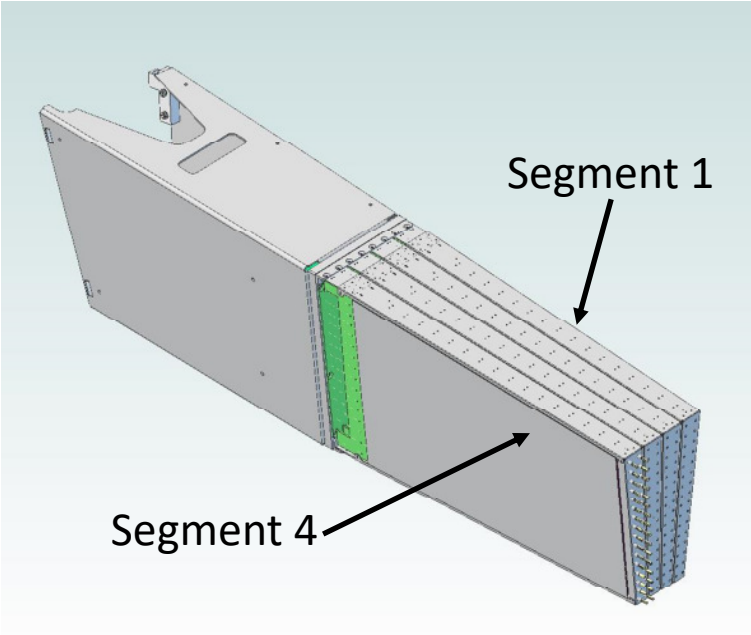
nsegment = 1,..,4

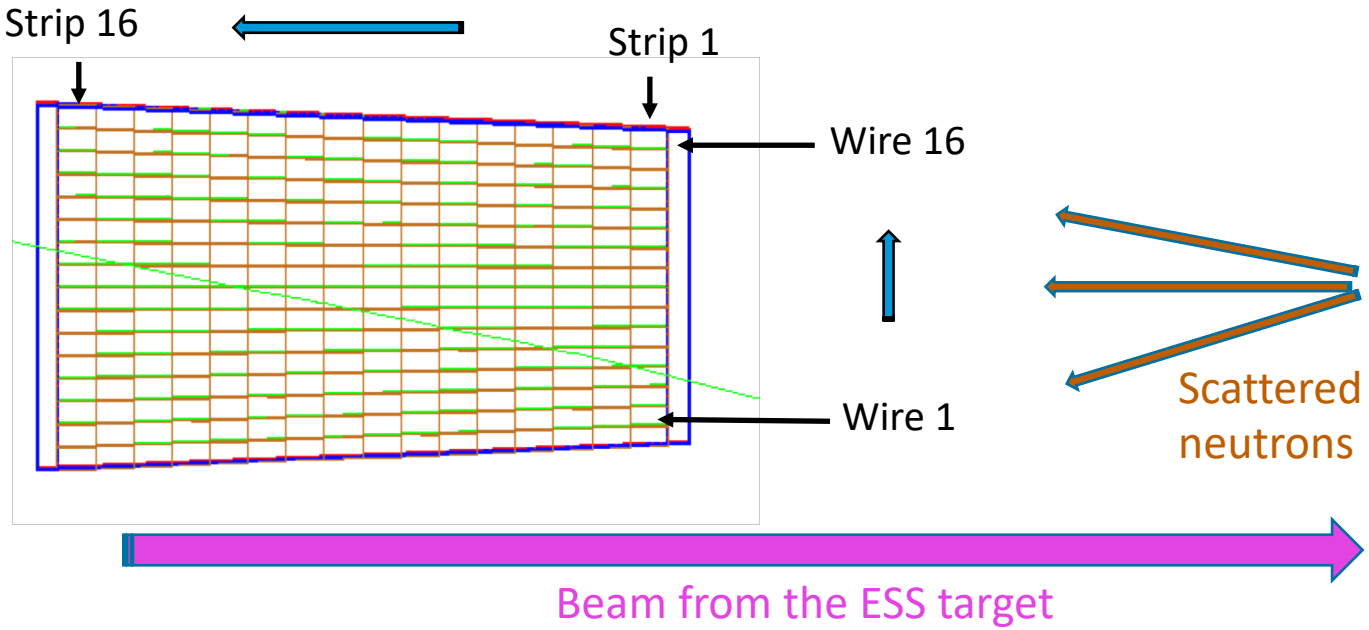
ncounter = 1, 2

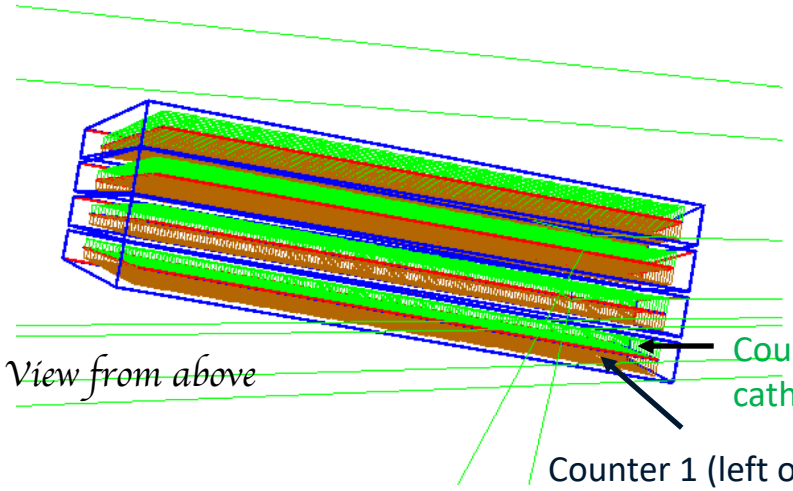
nwire = 1,..,16

nstrip = 1,..,16

Detector geometry, user defined conventions. Example for SUMO3







! Voxel number must be uniquely defined as a function of the following: sector#, module#, segment#, counter#, strip#, wire# !

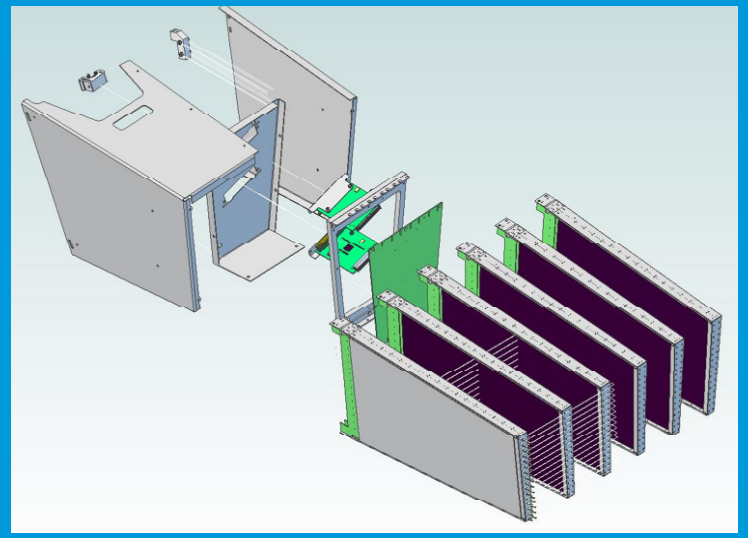
Time-of-flight information

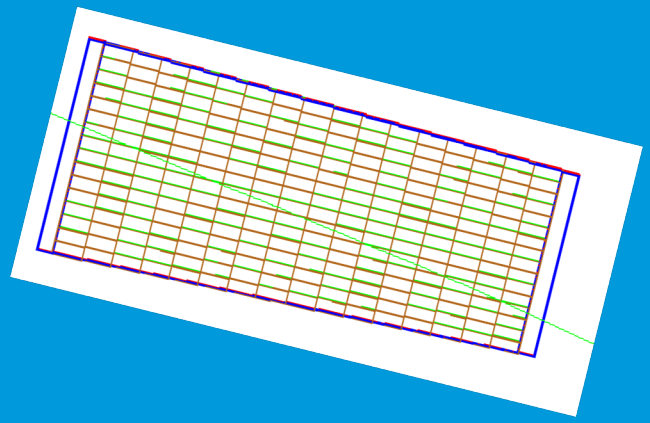
- The neutron time of flight is calculated from the difference of the neutron and chopper timestamps. The time-of-flight obtained from this difference must be corrected in different ways for the runs collected in normal operation mode (full pulse) and Wavelength Frame Multiplication (WFM) mode (the full pulse is split into 6 sub-pulses with the help of a pair of WFM choppers). The time corrections are specific to each instrument (i.e., the time corrections for the V20 data will not be valid for the DREAM instrument.)

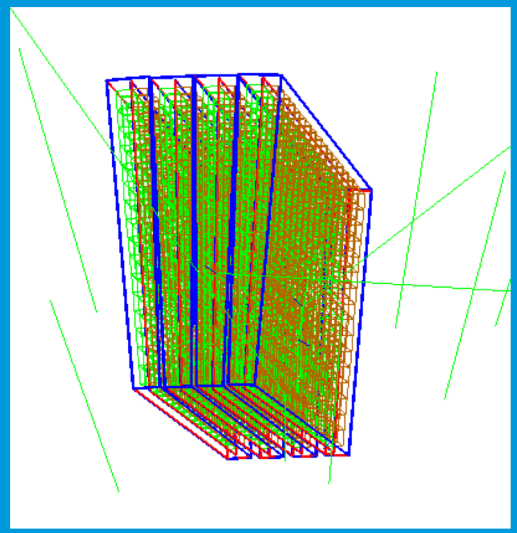
x,y,z-coordinates of the detector voxels

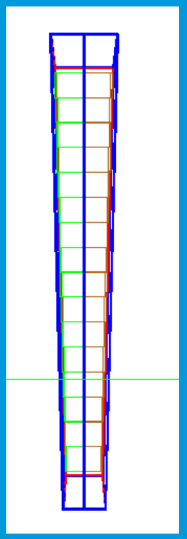
- Specifying the location of the neutron event in terms of (module, SUMO, segment, counter, wire and strip number) is not enough to perform the transformation from the time-of-flight space to the wavelength- and d-spacing-spaces (according to the Bragg law). In order to calculate the wavelength of the detected neutron one needs the information on the coordinates (x, y, z) of the interaction point with respect to the sample position. Currently there are two ways to do this for the Jalousie data.

2. Mapping the detector architecture to voxels coordinates

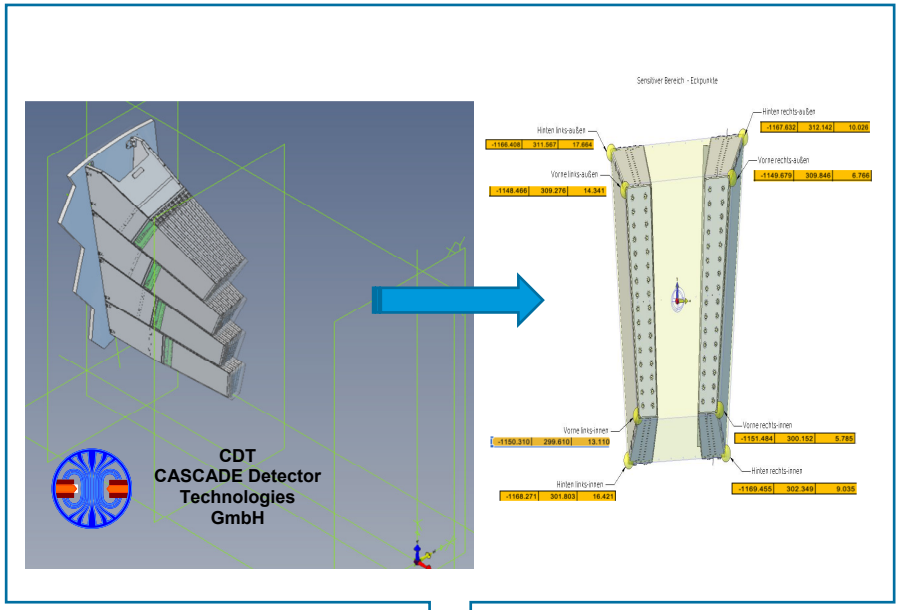








Obtaining the coordinates of the centres of the detector voxels, method 1



Link to the CDT Excel file with the CAD coordinates of the SUMO edges:

https://github.com/ess-dg/dream_endcap_analysis/blob/refactor/documentation/DREAM-vonPOWTEX%20SUMOx-Voxelpositionen26.06.19_withtranslationSumo6.xlsx

Obtain the coordinates of the SUMO edges from the CAD engineering drawings

Python script to calculate/interpolate the positions of the voxel centres

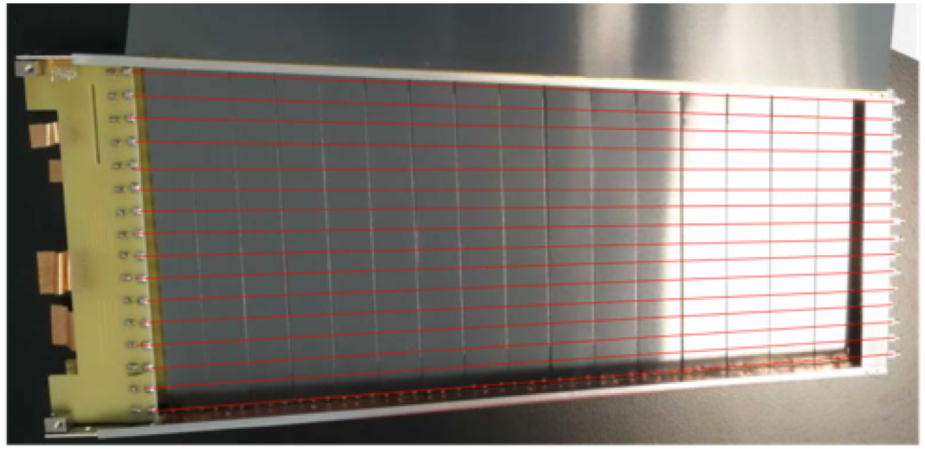
Table with the coordinates of the voxels

Read into the data-analysis code

Jülich data analysis

Done by CDT

Done by FZJ



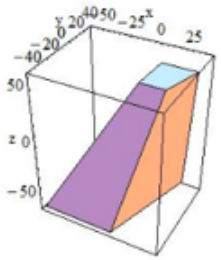
GEANT4 simulation strategy for the Jalousie detectors

See paper on the G4 model of the HEIMDAL detector:

https://iopscience.iop.org/article/10.1088/1748-0221/14/10/P10020

The segments and the gas voxels were hard coded by using the G4Trap class (4 angles and 7 dimensions ➔ hexahedrons).

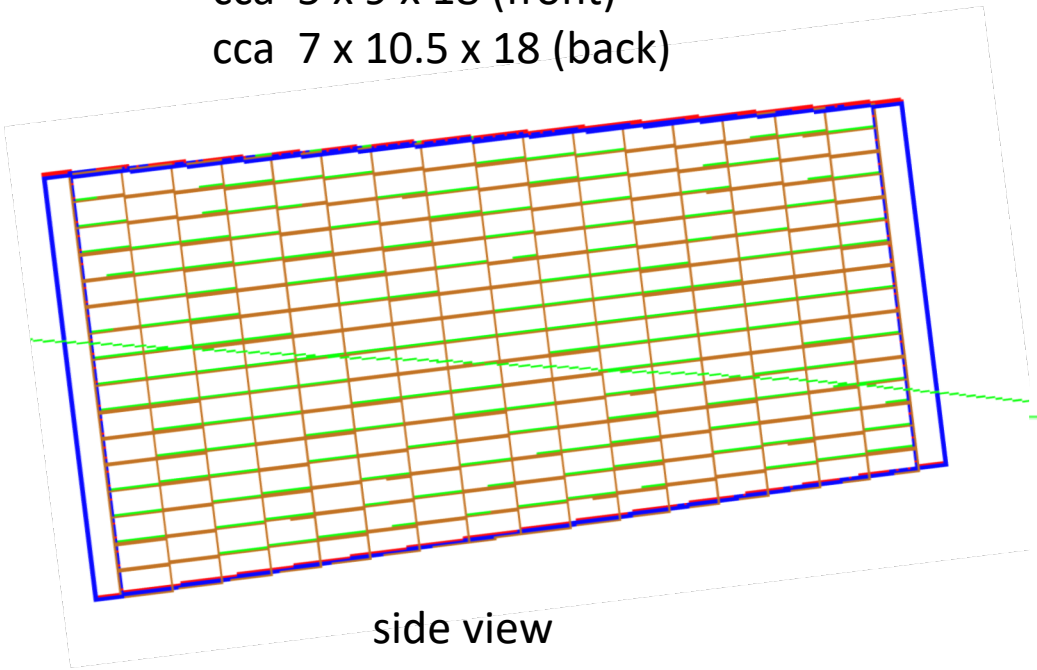
```
G4Trap(const G4String& pName,
       G4double  pZ,
       G4double  pY,
       G4double  pX,
       G4double  pLTX)

G4Trap(const G4String& pName,
       G4double  pDz,    G4double pTheta,
       G4double  pPhi,   G4double pDy1,
       G4double  pDx1,   G4double pDx2,
       G4double  pAlp1,  G4double pDy2,
       G4double  pDx3,   G4double pDx4,
       G4double  pAlp2)
```



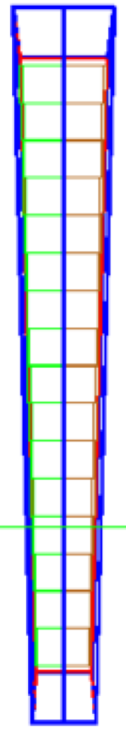
In the picture:

pDx1 = 30, pDx2 = 40, pDy1 = 40, pDx3 = 10, pDx4 = 14, pDy2 = 16, pDz = 60, pTheta = 20*Degree, pPhi = 5*Degree, pAlp1 = pAlp2 = 10*Degree

Voxel size (w x h x d) in mm^3:
cca 5 x 9 x 18 (front)
cca 7 x 10.5 x 18 (back)

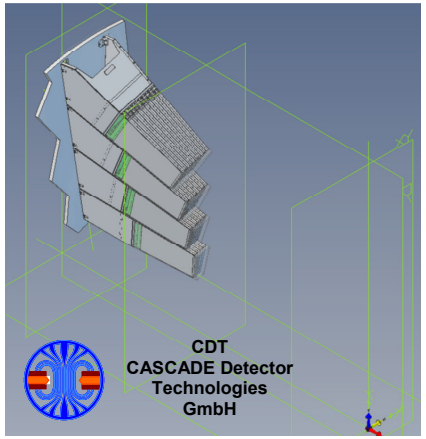


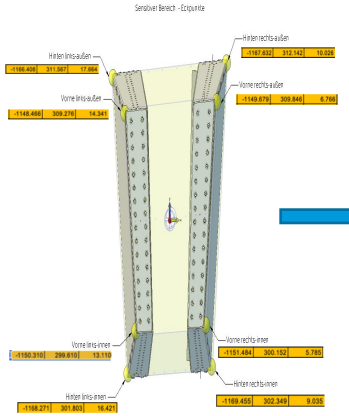
side view

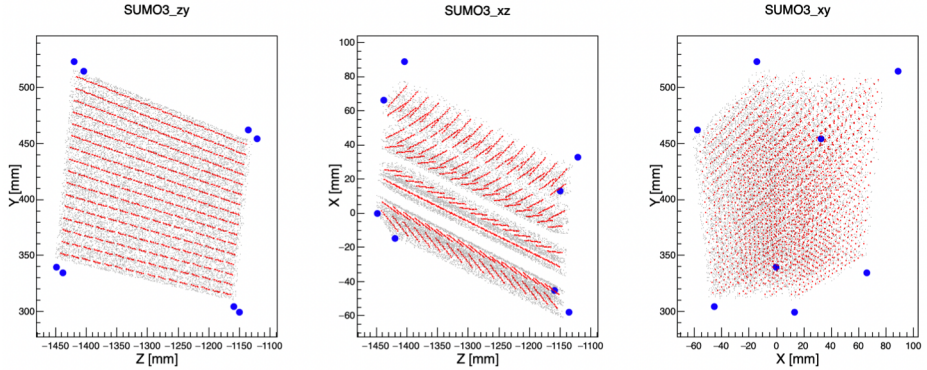


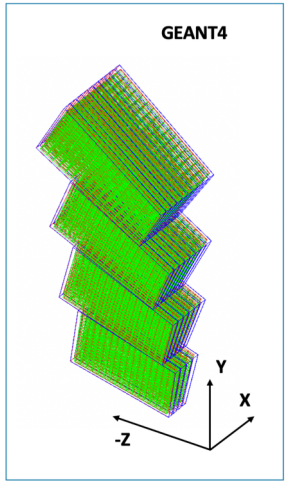
front view

Obtaining the coordinates of the centres of the detector voxels, method 2









Back and red data points are calculated in GEANT4 and correspond to the exact positions of detection of the neutron in the detector and to the centers of the detector voxels, respectively. The blue data correspond to the CAD coordinates of the edges of the detector.

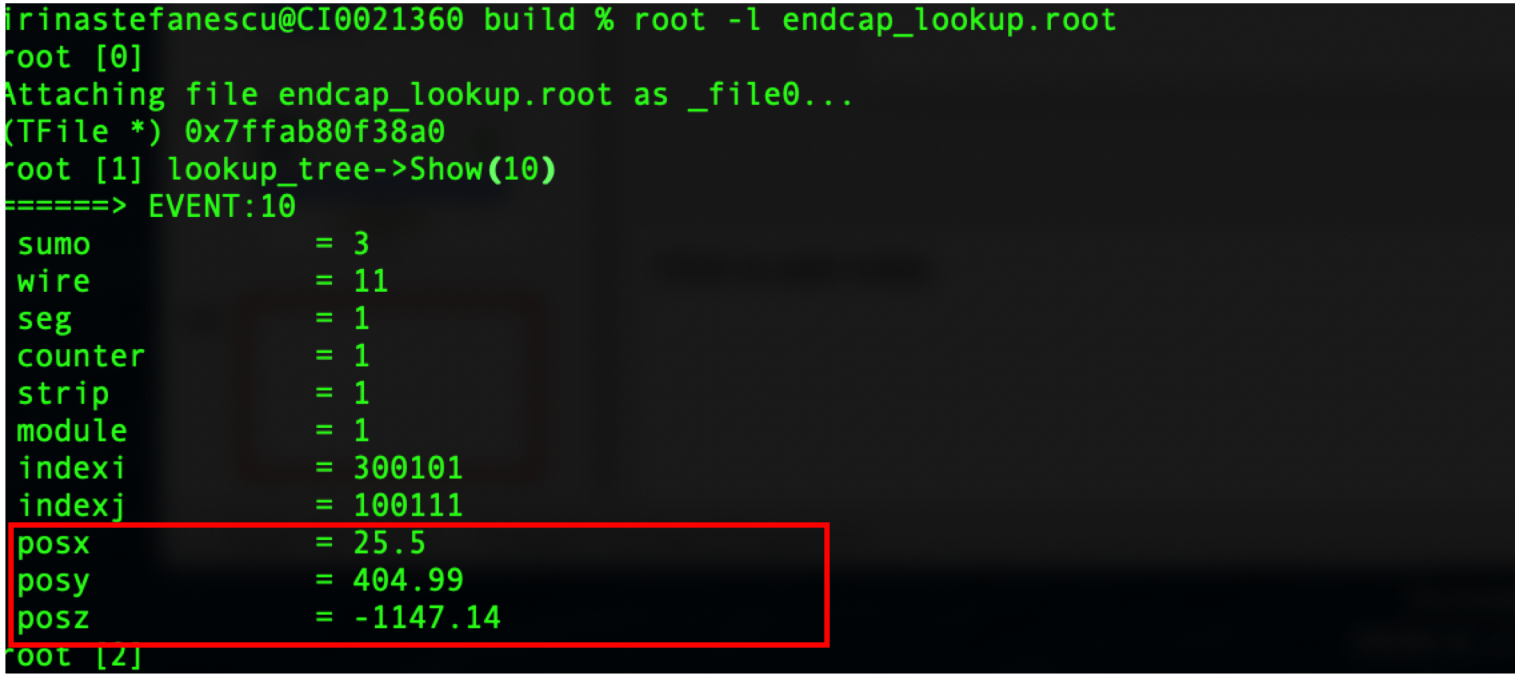
Obtain the coordinates of the SUMO edges from the CAD engineering drawings and match them with the positions of the GEANT4 computer models for the SUMOs (voxel based)

Dump the positions of the voxel centres in a ROOT tree

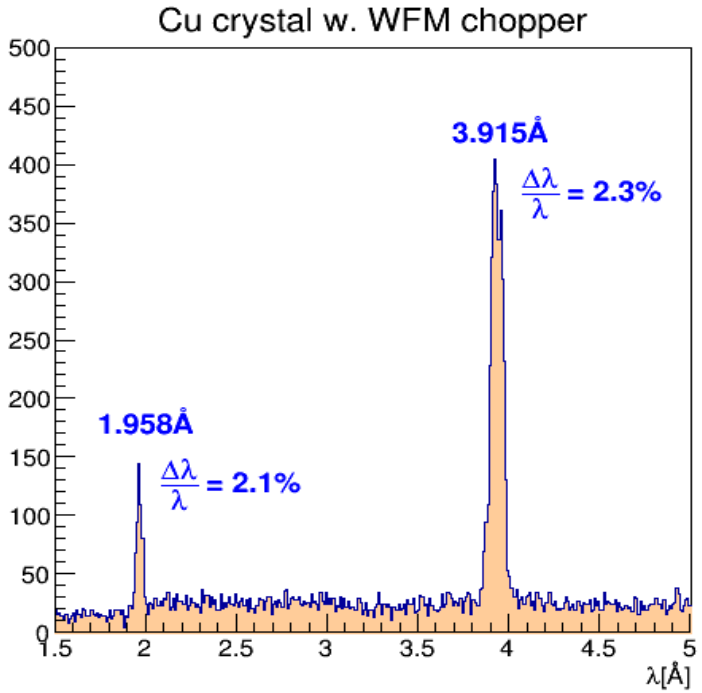
Done in Lund

Read into the data-analysis code
Lund data analysis

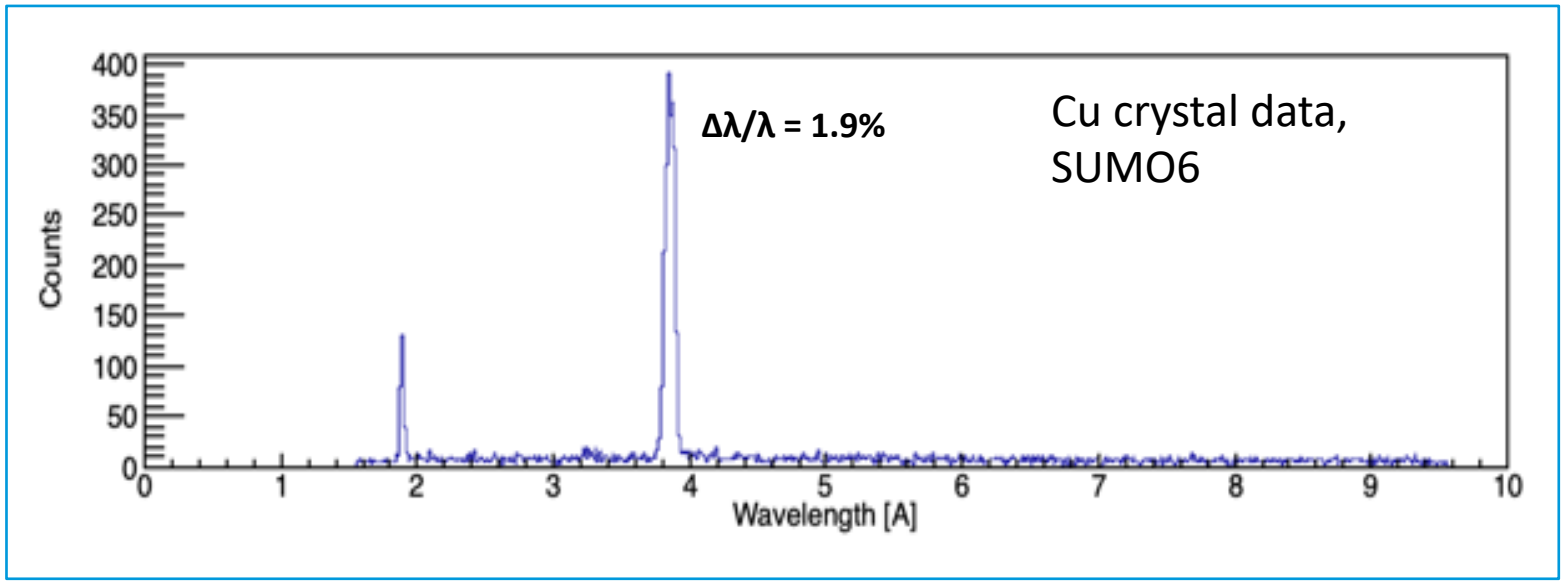
The voxel coordinates generated by the GEANT4 model of ENDCAP are saved in a ROOT file along with other identifiers, but I can save them in any other format.



Example of physics results obtained by using the voxel coordinates from GEANT4



Jülich data analysis & voxel mapping



Lund data analysis & voxel mapping

Finish presentation

2020-08-11