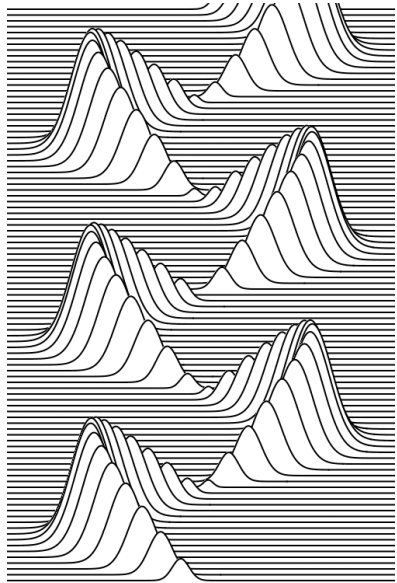
Investigating the swapped anode 2 and anode 3 runs

Alexander Deisting

13$^{\text{th}}$ of January, 2019



Introduction

- Last year we showed some preliminary $^{55}\mathrm{Fe}$ vs background plots. These slides are a less messy follow up
- After the meeting we discovered that the anode 2 and anode 3 signal inputs were swapped at the preamplifier inputs. Having these channels swapped implies:
  - In the slides last meeting/year I compared signals form different anodes
  - All digitiser settings (dc offset, trigger threshold etc) for anode 2 (anode 3, respectively) are now applied to anode 2 signals and vice versa
  - This affects the data acquisition and may have larger effects on the amplitude spectra than just plotting the wrong quantities in the same plot
  - Last year still, we re-took one setting with the anodes connected to their normal preamplifier and hence digitiser channel
  - In these slides I compare swapped and non swapped runs at otherwise the same settings to examine possible effects on the spectra
- An analysis of the $^{55}\mathrm{Fe}$ vs background data will follow after the discussion on the swapped anodes

XML settings used throughout all runs

```
<channel  id='4' type='CSP' readout='Anode_3' gain='CR-112' enabled='true'>
  <vmin       type='int'      unit='mV'>      -500      </vmin>
  <vmax       type='int'      unit='mV'>      1500      </vmax>
  <dc_offset type='int'  units='mV' > 30  </dc_offset>
  <trigger_threshold  type='int'  units='mV' > 35   </trigger_threshold>
  ....
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  <vmin       type='int'      unit='mV'>      -200      </vmin>
  <vmax       type='int'      unit='mV'>      1800     </vmax>
  <dc_offset type='int'  units='mV' > -67   </dc_offset>
  <trigger_threshold  type='int'  units='mV' > 30 </trigger_threshold>
  ....
</channel>
```

Checking individual runs and waveforms

- As a first check I looked at 4 random runs: 1352095 (background data taking, swapped anodes, anode 3 at 7.4 kV), 1354009 (background data taking, normal, anode 3 at 7.4 kV), 1354020 (background data taking, normal, anode 3 at 7.6 kV), 1340171 (^{55}Fe data taking, normal, anode 3 at 7.4 kV)

Run no	swapped?	source?	V_{a3}	mean baseline (a1/a2/a3) [mV]	baseline RMS (a1/a2/a3) [mV]
1352095	yes	no	7.4 kV	1/-4/-1	4/3/7
1354009	no	no	7.4 kV	-1/-5/-1	3/8/3
1354020	no	no	7.6 kV	0/-3/-1	3/7/2
1340171	no	yes	7.4 kV	-1/-4/-1	4/7/3

Table: Analysis done on `hpdaq2` – 30 waveforms are included for each anode in each run.

- In conclusion: The baselines stay at reasonable values, its RMS changes when anodes are swapped. The RMS is due to the oscillations on the anode 2 (3) signal have an amplitude of ~ 25 mVpp (~ 10 mVpp).

Checking individual runs and waveforms, conclusions continued – 1/2

- The baselines staying at about ~ 0 can be understood as well, since the preamplifiers are still connected to the digitizer channels, they have been connected to before. The offset is thus a "preamplifier feature". (See the Slack discussion on 06.01.2020, `general`).
- The main difference is thus the change in trigger threshold – on anode 2 (3), the channel with the higher (smaller) oscillations, the threshold changes from 30 mV to 35 mV and vice versa
- I checked 30 individual waveforms per anode each in runs 1352095 (background, swapped) and 1354009 (background, normal). About half all triggers are actual signals (1352095: $(56 \pm 14)\,\%$, 1354009: $(40 \pm 12)\,\%$)
- The baselines are centred around zero
- **No negative signals on anode 2 are observed in the run where everything was connected in a normal manner. In the other run, however, half of the signals are signals with a negative anode 2 pulse.**

More comments on individual waveforms:

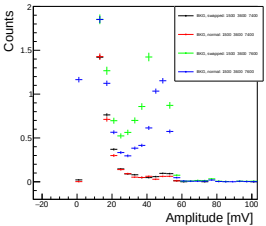
- In case the anode 2 signals have negative amplitude, the anode 1 signals have negative amplitude as well, but with a very small amplitude as compared to the absolute value of the amplitude on anode 2 and anode 3. These are quite comparable.
- In both runs we observe about 20 % of signals with a **larger amplitude on anode 2 than on anode 3** (positive polarity): A small signal on anode 2 (about 50 mV), a slightly smaller signal on anode 3 (run 1354009: (20 ± 9) %, run 1352095: (13 ± 7) %) and nothing on anode 1.

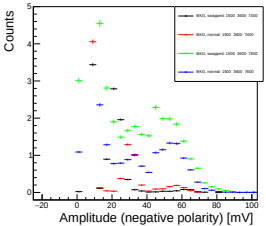
Amplitude spectra

- In the following amplitude spectra for the three anodes and different cuts are shown
- On the vertical axis counts are shown, normalised to one event (*i.e.* a 2 s exposure)
- We compare 4 group of background data runs – Run **1352091 to 1353014: swapped** anode 2 and 3, run **1354007 to 1354017: normal** configuration, both groups with anode 3 at 7400 V and run **1354001 to 1354006: swapped** anode 2 and 3, run **1354018 to 1354029: normal** configuration, both groups with anode 3 at 7600 V
- We corrected the anode IDs in software: Everything you see in a plot labelled *e.g.* anode 2 originates from anode 2 in the detector

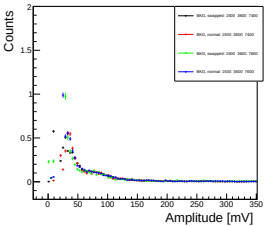
Anode amplitude spectra for swapped/normal background runs

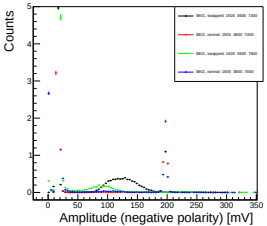
Anode 1



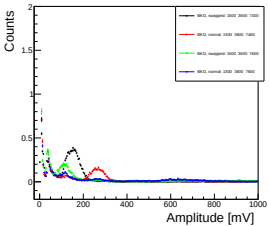


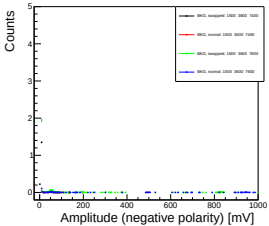
Anode 2





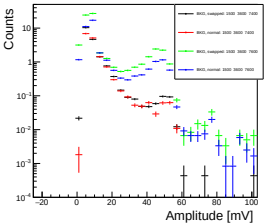
Anode 3

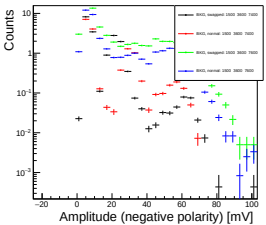




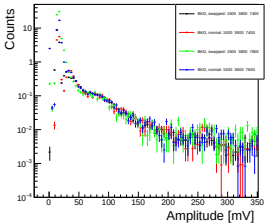
Anode log(amplitude spectra) for swapped/normal background runs

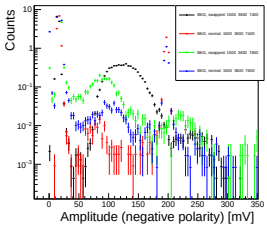
Anode 1



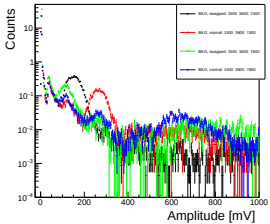


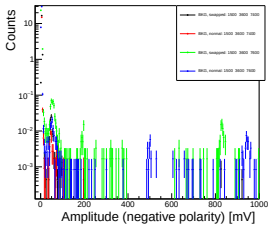
Anode 2





Anode 3

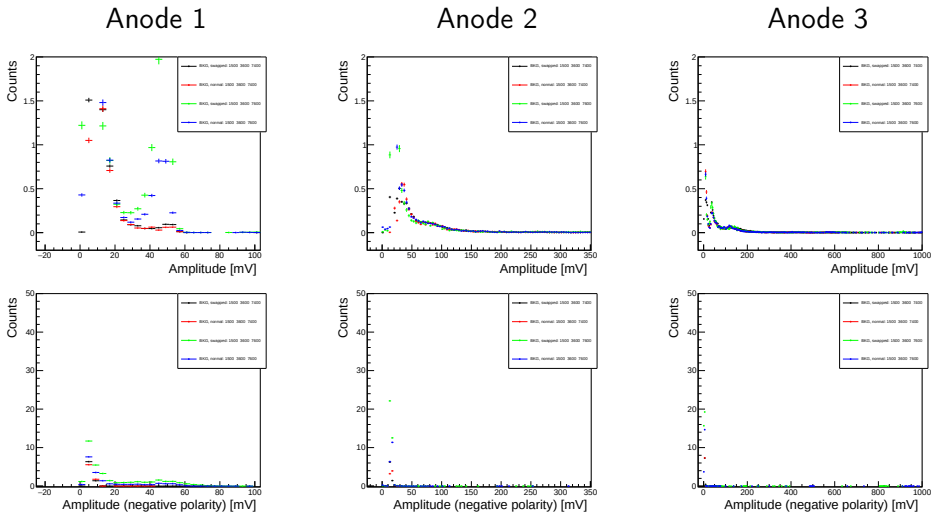




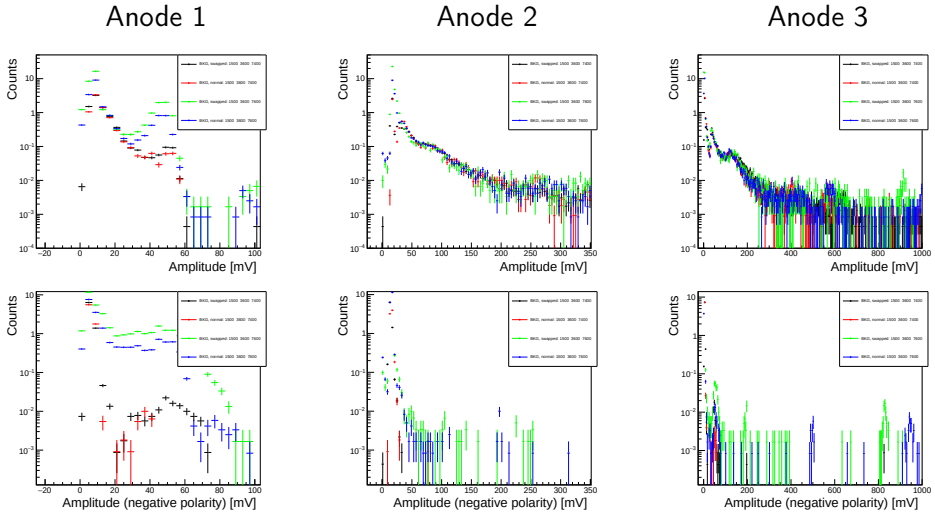
Anode amplitude spectra: Comments

- Anode 1 amplitude spectra – not affected by the change – have similar shape when comparing the two $V_{a3} = 7.4\,\text{kV}$ runs as well as the two $V_{a3} = 7.6\,\text{kV}$ with each other
- From $V_{a3} = 7.4\,\text{kV}$ to $V_{a3} = 7.6\,\text{kV}$ the shapes stay approximately the same, but there are more counts in the latter plot
- The positive amplitude anode 2 and the negative amplitude anode 3 spectrum are quite similar, the negative anode 2 (positive anode 3) amplitude spectra show quite substantial differences for amplitudes higher than $\sim 30\,\text{mV}$ ($\sim 70\,\text{mV}$)
- Peaks appear, which do not have a corresponding peak in most of the other spectra
- When distinguished between `AmplitudeAnode2 > NegAmplitudeAnode2` and `AmplitudeAnode2 < NegAmplitudeAnode2` – only positive anode 2 signals and only negative anode 2 signals, it becomes visible that the **extra peaks appear only in events with negative anode 2 signals**. (*Cf.* next four slides)

Cut: Anode 2 signal **positive** – spectra for swapped/normal runs

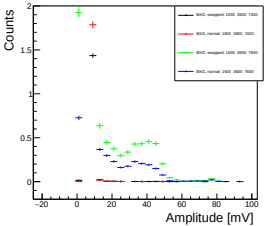


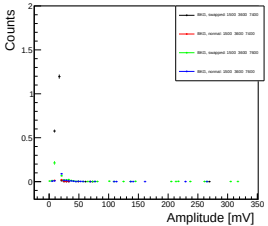
Cut: Anode 2 signal **positive** – log(spectra) for swapped/normal runs

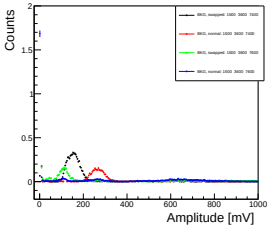


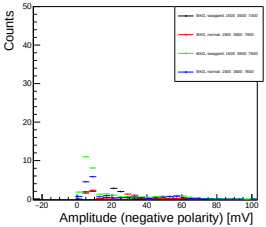
Cut: Anode 2 signal **negative** – spectra for swapped/normal runs

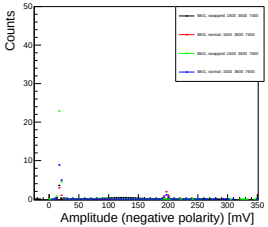
Anode 1 | Anode 2 | Anode 3

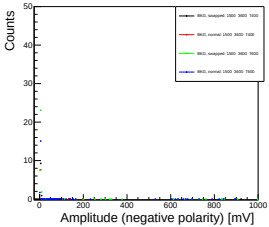




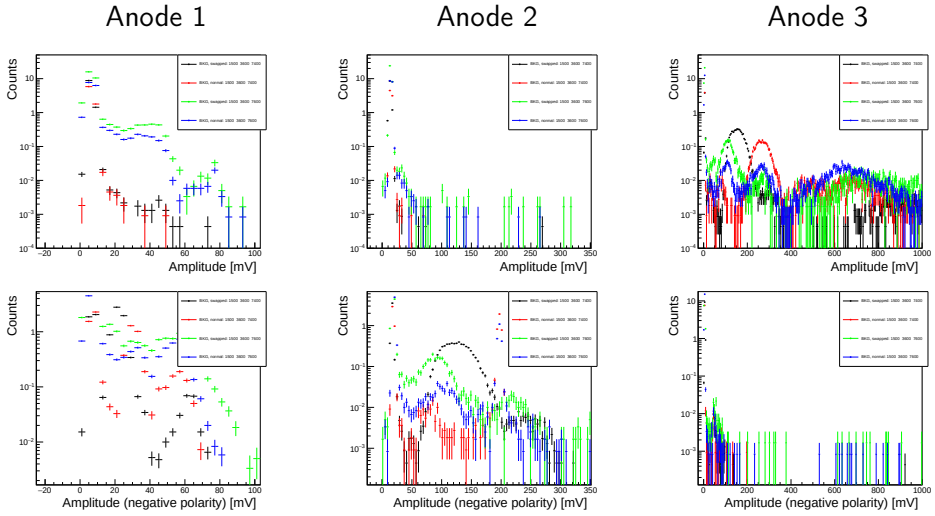








Cut: Anode 2 signal **negative** – log(spectra) for swapped/normal runs



Summary: What happened and has been done

- Form the 13^{th} of December (run 1347001) until 20^{th} of December (run 1354006) the anode 2 signal went into the anode 3 preamp and vice versa
- In terms of data taking, all ^{55}Fe data on 13.12.2019 is affected, as well as most of the background data taking. (Exceptions: The runs Harrison re-took leading up to the holiday)
- In data, this can be recovered by changing the anode IDs accordingly
- We used four runs to examine whether taking data with the swapped settings has a major effect on data quality
- These runs are chosen at two different voltage settings, for both settings we use one run with the swapped and one with the normal configuration

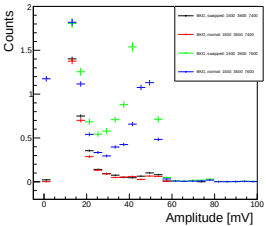
Summary: Results

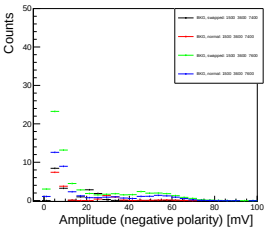
- We do not observe a change of the baseline offset – the only effect of using a different `xml` configuration is a effectively to a difference of $+$ $(-)$ 5 mV in trigger threshold on anode 2 (3)
- Comparing the different runs, it appears that there is a series of peaks in the anode 3 amplitude spectrum, which are not the same between the four runs
- These peaks in the anode 3 amplitude spectrum originate exclusively from events with a negative amplitude peak on anode 2
- It seems unlikely that this effect results from the change in trigger threshold
- Even if: It shows us that we have to understand the possible signal regions and where these peaks come from. Using the negative anode 2 signals seems to be not ideal
- Work in progress:
  - ☐ What process generates negative amplitudes on anode 1/2 and positive ones on anode 3
  - ☐ What is our signal region?

Backup

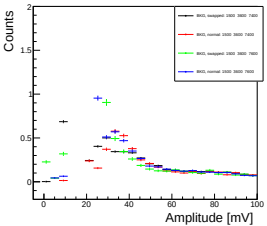
Anode amplitude spectra for swapped/normal background runs

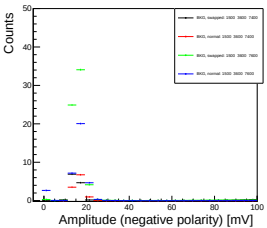
Anode 1



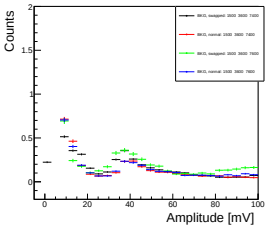


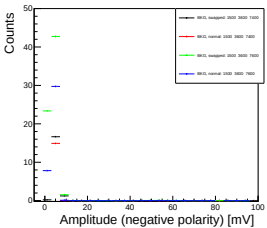
Anode 2





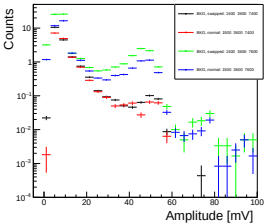
Anode 3

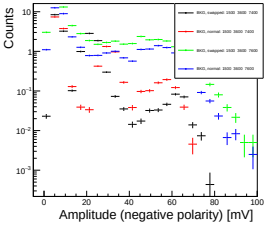




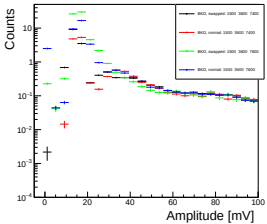
Anode log(amp. spectra) for swapped/normal background runs

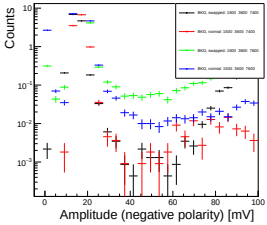
Anode 1



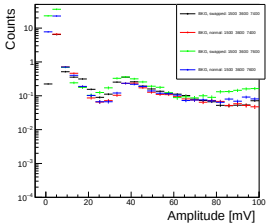


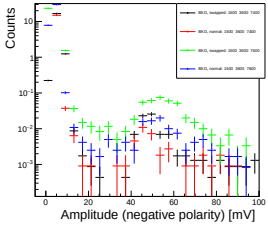
Anode 2



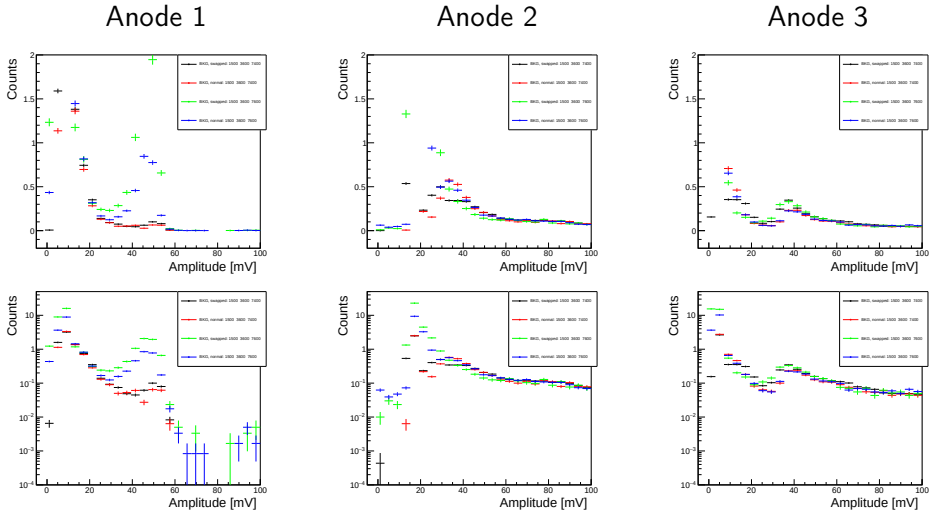


Anode 3

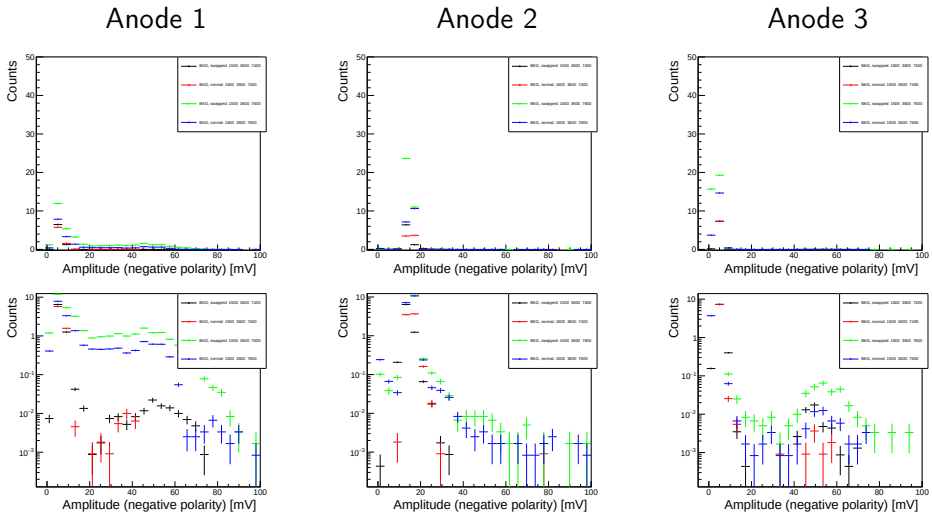




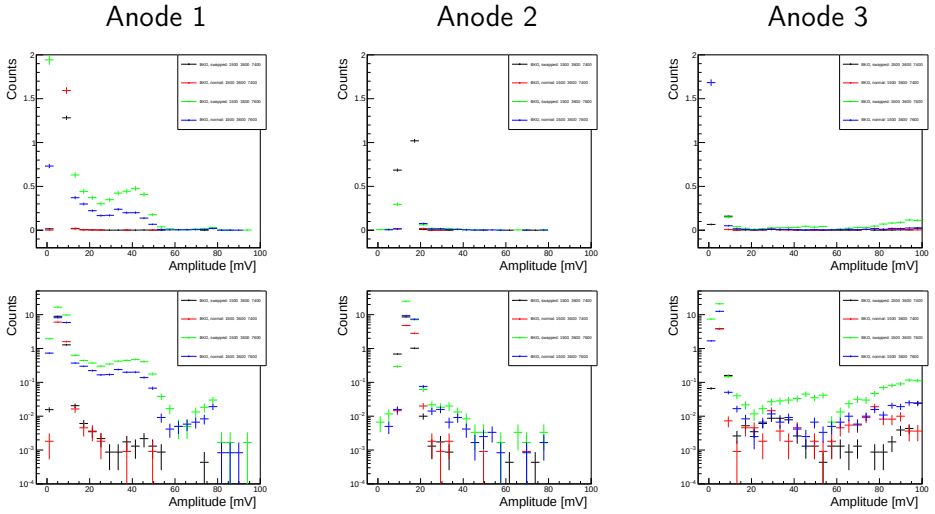
Cut: Anode 2 signal positive – spectra for swapped/normal runs



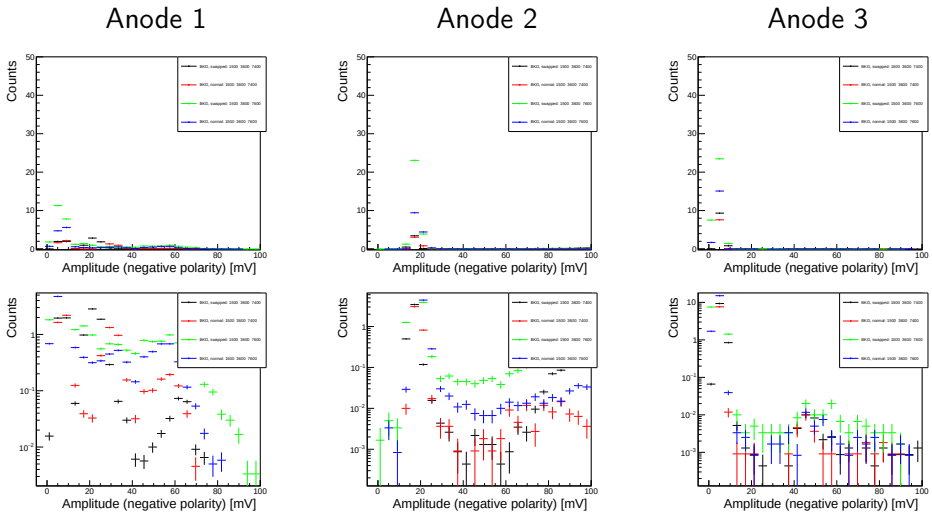
Cut: Anode 2 signal positive – spectra for swapped/normal runs



Cut: Anode 2 signal negative – spectra for swapped/normal runs



Cut: Anode 2 signal negative – spectra for swapped/normal runs



ToDo's
Week 46 – Waveform RMS: Data ($^{55}\mathrm{Fe}$) vs background (no source)

Closing remarks

- There is a good indication that the peaks in the RMS are due to the source
- The nice spectra from anode 2 and anode 1 may result from negative polarity signals
  $\Rightarrow$ ☑ Check for negative signals in the analysis code
- Amplitude and RMS correlation looks as if we could calibrate that
- I don't have yet Ed's triptych code to check the different regions as well
  $\Rightarrow$ ☐ Do triptych's for the three signal regions

☐ Still pending: $\sin$-fit correction on pre-selected waveforms

ToDo's
Week 36 – Waveform analysis

Analysis overview

- A fraction of the August data - pure Ar and $\mathrm{Ar\text{-}CO_2}$ at various pressures has been analysed using exponential smoothing as well as a `sin` fit to subtract periodic noise

On the noise-fit:

- ☐ Check more advanced fit-functions than just a plane `sin` fit
- ☑ Check whether the fit range can be changed to improve the overall results
- ☐ Do detailed χ^2 cuts and checks with the current data set to see where the fit improves the analysis

$\Rightarrow$ A more detailed presentation will follow

ToDo's
Week 30 – Hardware report

General HPTPC news:

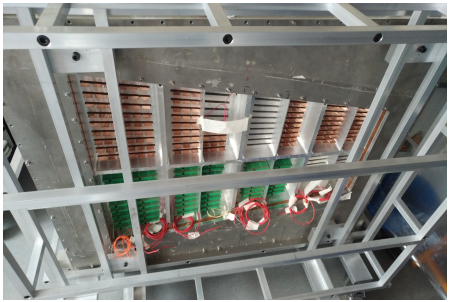
- Over the last week-end we took data until the DAQ decided to not take data anymore. (This cost us the highest voltage setting)
- On Monday we had once more Imperial man-power ⇒ See the slides on the OROC holder test
- Evacuation over the rest of Monday, and the full Tuesday
- Right now we are back to about Ar-CO_2 (88-12) at 1 atm
- Data taking at these voltages is still pending

Coming up:

- **Power outage in the HPTPC lab on Mon, T111 probaly more than one day**
- ☑ Couple test pulses in one of the meshes and readout the other preamplifiers
- ☑ Look into changing the T111 and T133 clean room filters

OROC updated

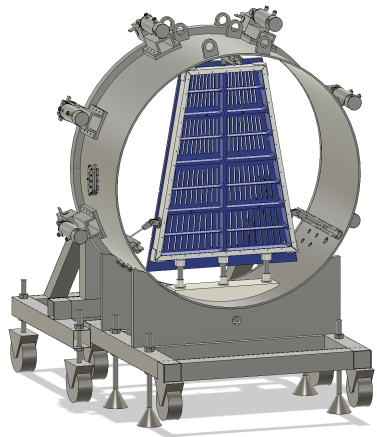
- All shortening cards are in place
- The OROC is back in its box and awaits testing
- Everything needed for the HV distribution boxes I have in hand
- The following list of OROC ToDo's applies:
  - ☑ Put cooper shims
  - ☑ Do the HV distribution network
  - ☑ HV tests in air
  - ☑ Pulser test in air
  - ☐ Construction of the field line termination plane



- We ordered pre-mixed $\mathrm{Ar\text{-}CO_2}$ (85-15) – as soon as this arrives and the tests in air are done, we will start flushing

OROC holder tests

- The production of the OROC holder for the vessel is progressing well
- In the pictures you see a fitting test to the vessel
- The full holder should be completed in the next weeks



Readout Electronics update

- ☑ Two digitiser board with the APV assembled
- ☑ Components for the attenuation/protection board arrived at Imperial and the assembly is under-way
- ☑ First iteration of the firmware written (@Imperial)
- ☐ Felix integration tests with the digitiser board only (@Imperial)
- ☐ Commissioning with a small detector ...

Bias T sparking

- At about 3.5 kV on anode 3 sparking in the anode 3 bias T occurred
- Previously higher voltages had been achieved, all components in the anode 3 bias T are rated for high voltage
- It turns out that the *signal-to-preamp* (which should be at ground potential) leg of bias T discharged against the nearest ground
- The same could be observed at the anode 2 bias T for high voltages
- As a measure the anode 3 *signal-to-preamp* leg has been connected to ground via a 3 MΩ resistor to provide a path to ground in case there is some charging up
- We observed once more discharges in a bias T, but could not determine whether it was in the anode 3 one

- ☐ We'll keep an eye....
- ☐ Check that there are no effects on the signal readout with the extra resistor

OROC

- All shortening cards which we could put, are in place
- The OROC is back in its box and awaits testing
- We have the aircon again running in the MWPC and MPGD lab
- Copper shims should arrive tomorrow or next week
- A slightly reduced list of the usual OROC ToDo's still applies:
  - ☑ Put cooper shims
  - ☑ Do the HV distribution network
  - ☑ HV tests in air
  - ☑ Pulser test in air
  - ☐ Construction of the field line termination plane

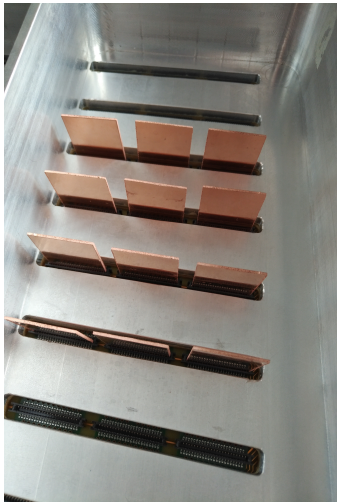
ToDo's
Hardware report week 29

A word on high frequency noise

- There is 1.35 MHz noise in the data
- However: It turns out that is only there at certain instances and permanently, uncorrelated with changes to the HPTPC $\rightarrow$ Possibly something else in the building is responsible
- In other news: The signal from the preamp at anode 2 looks different, because the evaluation board there has a different capacitor
- Hence:
  - ☑ Test the response of the modified preamp to test pulses on the test input
  - ☒ Do the same, but with pulses coupled into the real input using a capacitor
  - ☒ Drive the preamps into saturation (check first on the old scope as a safety measure)
  - ☒ Do the same test with a non modified preamp
  - ☑ Drive **only** standard preamps into saturation (check first on the old scope as a safety measure)

OROC

- The first samples for the copper shims arrived, they fit and the rest is ordered
- Annora measured dust counts and I did a clean of the floor in T111 – We will see whether this helped
- The next OROC step:
  - ☑ Put shortening cards (cooper shims)
  - ☑ Mount the OROC back to the lid of the test box (copper shims can also be placed after this)
  - ☑ Do the HV distribution network
  - ☑ HV tests in air
  - ☑ Pulser test in air
  - ☐ Construction of the field line termination plane



ToDo's
Hardware report week 26

HPTPC

- Jocelyn fixed the burst disk:
  - We discovered where was a puncture in the burst disk
  - It was replaced with a 5 barG burst disk
- $^{55}\mathrm{Fe}$ is in the vessel now $\rightarrow$ We will explore with one fill if we can see a peak related to this source

☑ Filling the vessel again

☐ Decision on a gas mixture / pressure for a diffusion measurement will be made when we have first insights from the light gain analysis

☑ Talk to FIKE what they think is the best solution for our use case (possibly another pressure relive valve)

ToDo's
Waveform report week 25

Update on the toy Monte-Carlo to model the energy deposited in the detector

- Using the known decay energies the $^{241}\mathrm{Am}$ sources (α, γ) and the $^{137}\mathrm{Cs}$ (β, γ) decay energy spectra are modelled
  - $^{137}\mathrm{Cs}$ β-spectrum: Based on interpolated IAEA data
  - γ- and α-spectra: Approximated using Gaußians with an arbitrary width
- The γ absorption as well as charged particle ranges are extracted from ESTAR, PSTAR and XCOM
- γs and αs are assumed to depose their full energy in the detector

☑ Currently cosmic μ are added

☑ Garfield/heed will be used for the energy deposit of charged particles

☑ Furthermore the detector geometry is being put in

☑ $^{55}\mathrm{Fe}$ is added