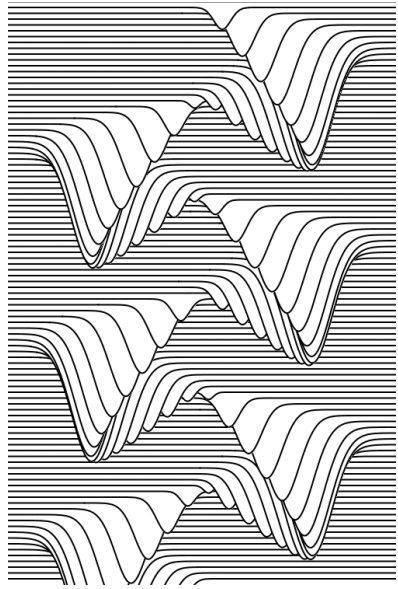
A negative view on the waveform analysis

Alexander Deisting

8^{th} of November, 2019



These slides:

- As Ed showed in his triptych^{TM} code, there are quite substantial negative pulses
- Also the nice anode 1/2 spectra in the waveform RMS analysis – as opposed to the non existing spectra in the anode 1/2 amplitude analysis, showed that there is something going on that our code focusing on positive polarity signals does not catch
- I put in the negative pulse analysis, but since this involved changing many things, I wanted to make sure:
  i. The actual positive polarity analysis is still working
  ii. The new negative polarity analysis is working
  iii. Bonus: See what effect having negative polarity signals has on the positive polarity pulse analysis
- To do so I went back to a set of known signals: MC simulation of 11.000 pulses with positive and negative polarity each

Reminder: Input spectrum, $^{55}\mathrm{Fe}$ & cosmics [A. Deisting, week 43 slides]

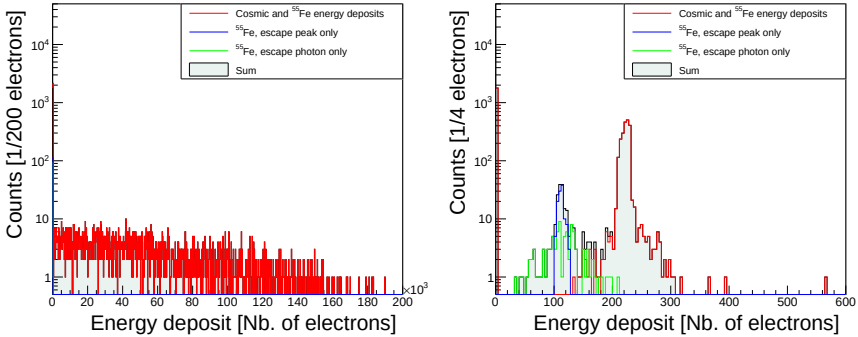
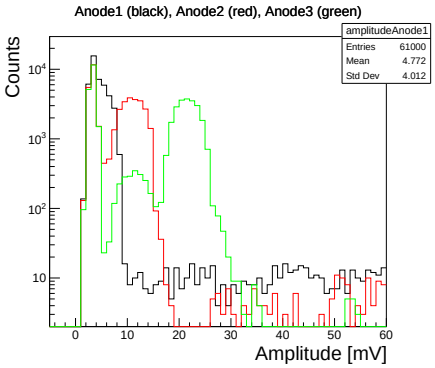


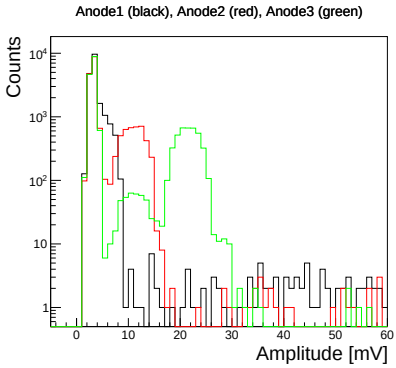
Figure: Expected energy deposits of $^{55}\mathrm{Fe}$ decay radiation and cosmic muons inside a gas volume filled with $\mathrm{Ar\text{-}CO_2}$ (98-2). This is the result of a toy Monte-Carlo using the approximate layout of a quarter of the HPTPC, the heed package in Garfield++, and information from the ESTAR and XCOM databases. The right plot is a zoomed view of the left plot.

Amplitude spectra, all pulses

Previously shown:



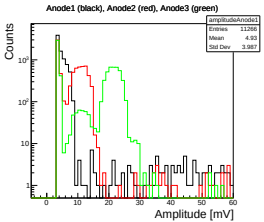
Current analysis:



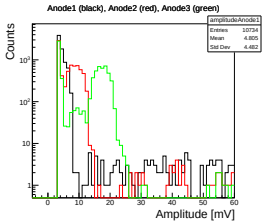
Noise periods: 10×10^{-6} µs and 5×10^{-6} µs

- Seems as if the standard analysis is not broken

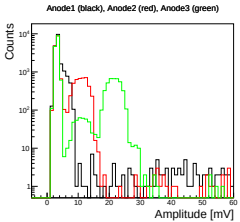
Amplitude spectra



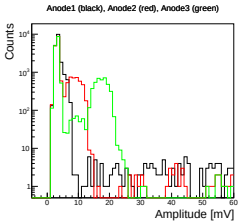
positive amplitude > negative amplitudes



negative amplitude > positive amplitudes



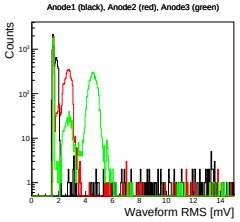
all positive amplitudes



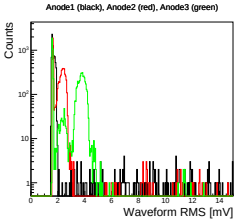
all negative amplitudes

- The negative (positive) amplitude pulses mainly contribute to the noise peak when one looks only for positive (negative) pulses
- Even while adding noise, and mixing positive and negative amplitude spectra, the input distributions are recovered when requiring a simple cut as *e.g.* "positive amplitude > negative amplitudes"

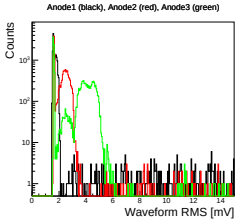
Waveform RMS



positive amplitude $>$ negative amplitudes



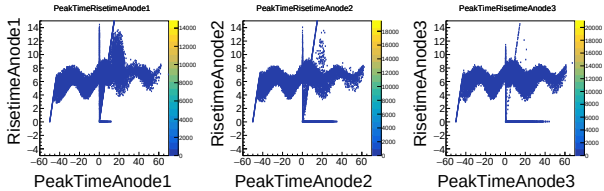
negative amplitude $>$ positive amplitudes



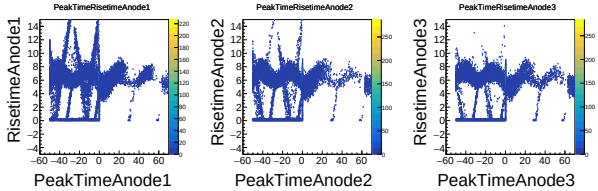
all amplitudes

- As observed previously: The waveform RMS spectra seem to have better energy resolution when the amplitude spectra
- A reasonable distribution is recovered while requiring a simple cut as *e.g.* "positive amplitude $>$ negative amplitudes" during the analysis of data containing positive and negative polarity pulses.
- Broader/double peaks appear in the RMS spectrum when no amplitude is selected

Previously shown:



Current analysis:



Summary:

- Amplitude analysis works for negative, positive and mixtures of negative and positive amplitudes
- The time analysis still works for positive polarity pulses ...
- ... however in case of the negative polarity pulses, there still seems to be a bug

(I intended to run this on data as well for today, but I had some rapTORR issues. To be worked out.)

Backup

Anode parameter overview, positive polarity pulses

Parameter	anode 1	anode 2	anode 3
channel ID	1	2	3
gain	"CR112"	"CR112"	"CR112"
V_{min} [mV]	-200.0	-200.0	-200.0
V_{max} [mV]	1800.0	1800.0	1800.0
preamp clipping value [mV]	1600.0	1600.0	1600.0
DC offset [mV]	-20	30	-12
trigger threshold [mV]	20	20	20
trigger polarity falling	false	false	false
pulse polarity falling	false	false	false
channelName	"Anode_1"	"Anode_2"	"Anode_3"
G_{preamp}	12	12	12
G_{meshes}	10000	25000	50000

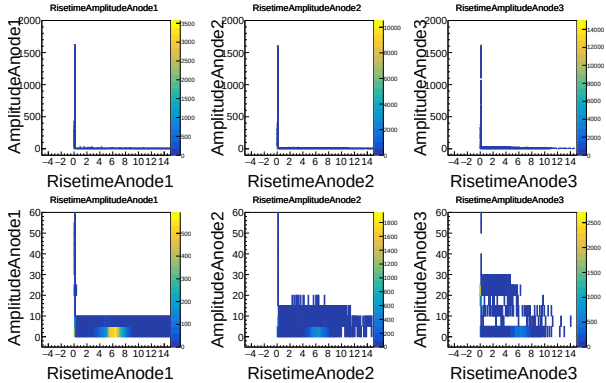
Parameters in italics are currently not used for anything.

Anode parameter overview, negative polarity pulses

Parameter	anode 1	anode 2	anode 3
channel ID	1	2	3
gain	"CR112"	"CR112"	"CR112"
V_{min} [mV]	-200.0	-200.0	-200.0
V_{max} [mV]	1800.0	1800.0	1800.0
preamp clipping value [mV]	1600.0	1600.0	1600.0
DC offset [mV]	-20	30	-12
trigger threshold [mV]	20	20	20
trigger polarity falling	false	false	false
pulse polarity falling	false	false	false
channelName	"Anode_1"	"Anode_2"	"Anode_3"
G_{preamp}	12	12	12
G_{meshes}	8000	20000	40000

Parameters in italics are currently not used for anything.

Time checks


RisetimeAmplitudeAnode1
AmplitudeAnode1
RisetimeAnode1
RisetimeAmplitudeAnode2
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AmplitudeAnode3
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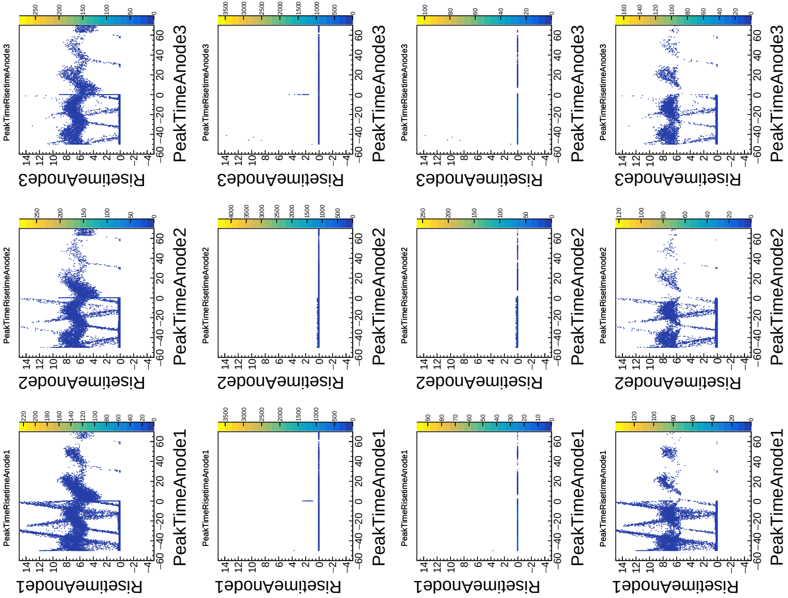
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PeakTimeAnode1
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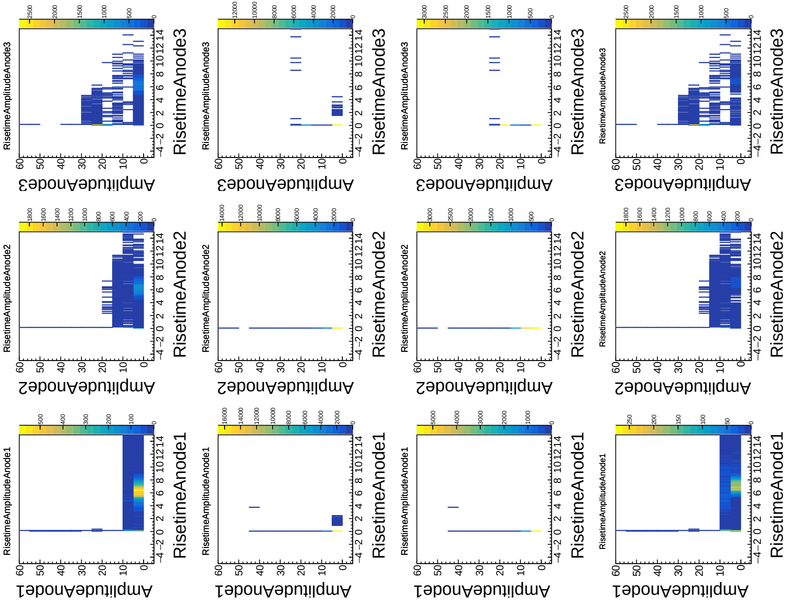
PeakTimeAnode3
RisetimeAnode3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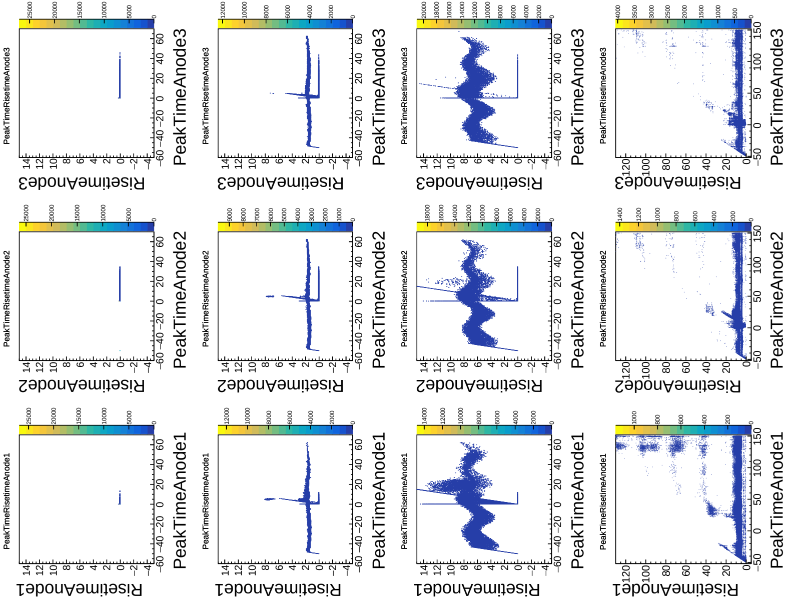
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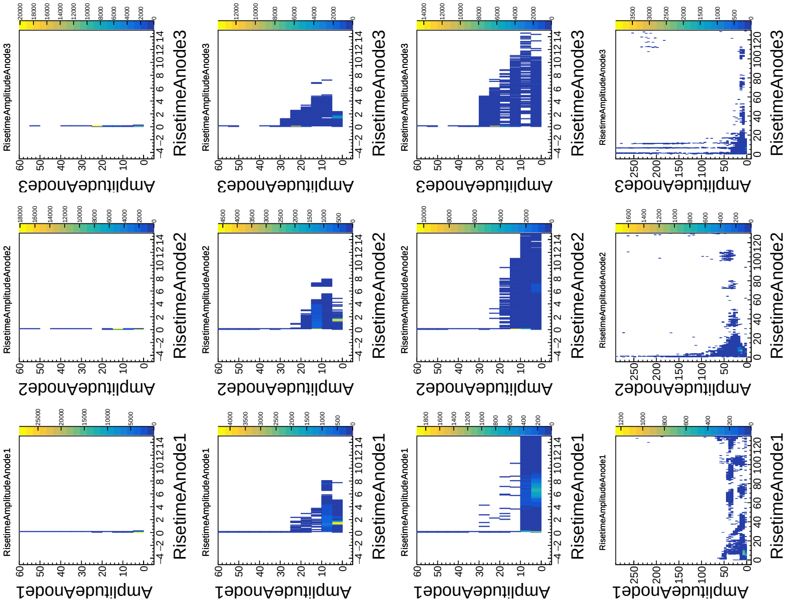
RisetimeAmplitudeAnode1
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RisetimeAnode1
RisetimeAnode2
RisetimeAnode3
AmplitudeAnode1
AmplitudeAnode2
AmplitudeAnode3

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

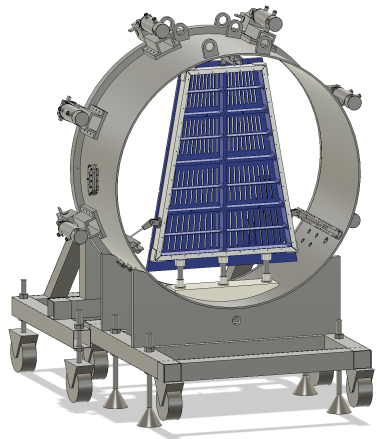
OROC updated

- 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

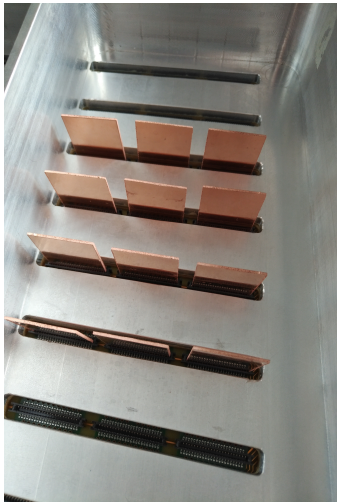
ToDo's
Hardware report week 29

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