Update on field response check

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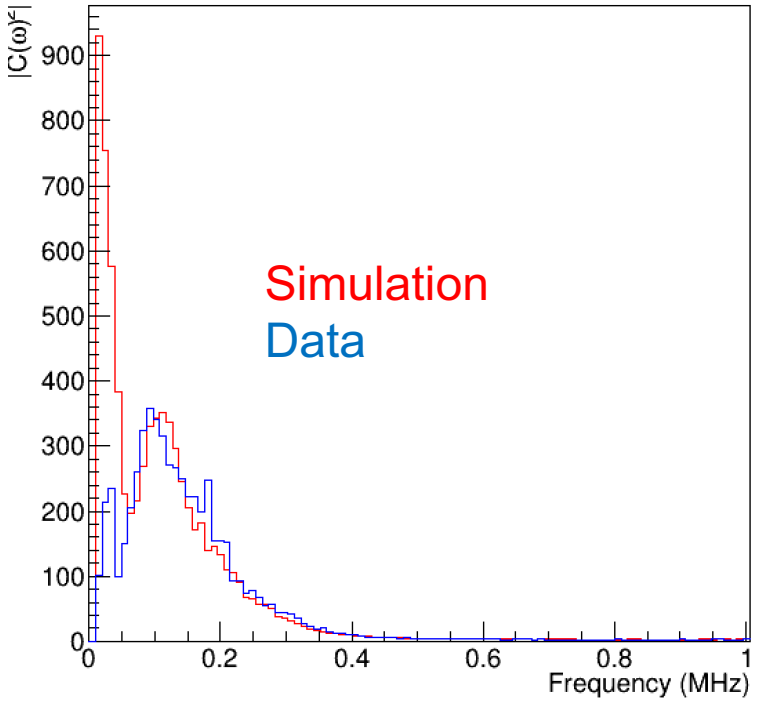
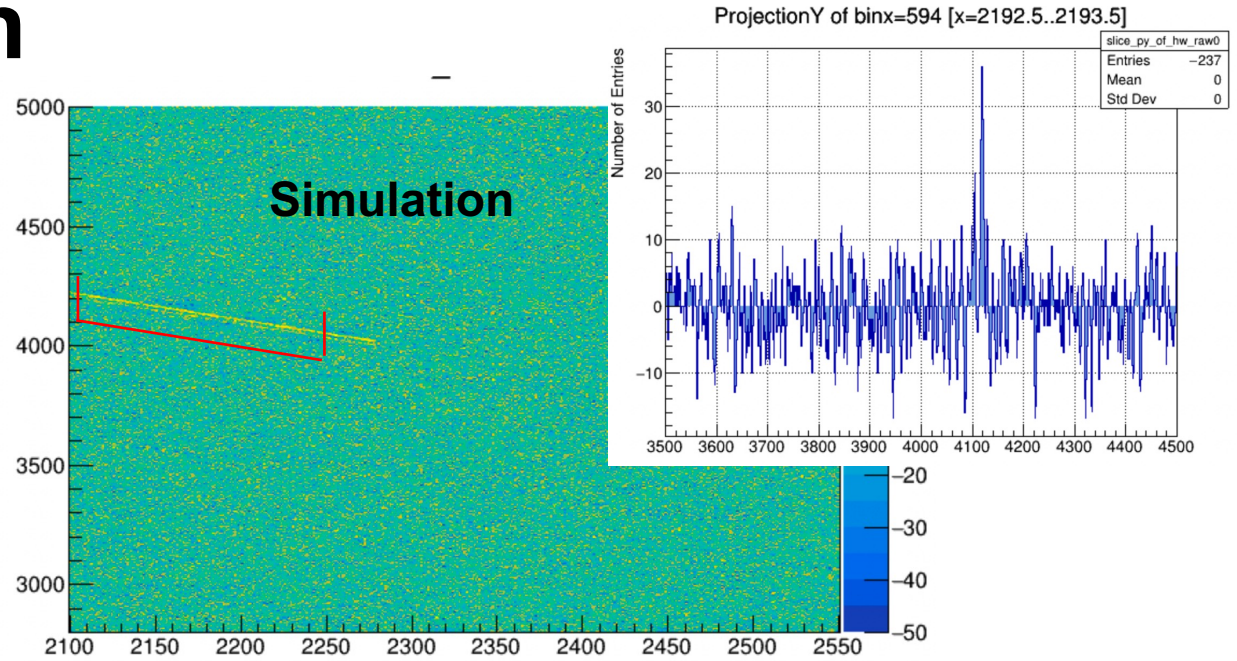
Power spectra comparison





- Field response now has more collection effect compared to the data.
- Derive the DC component from data, which should be the electron collection.

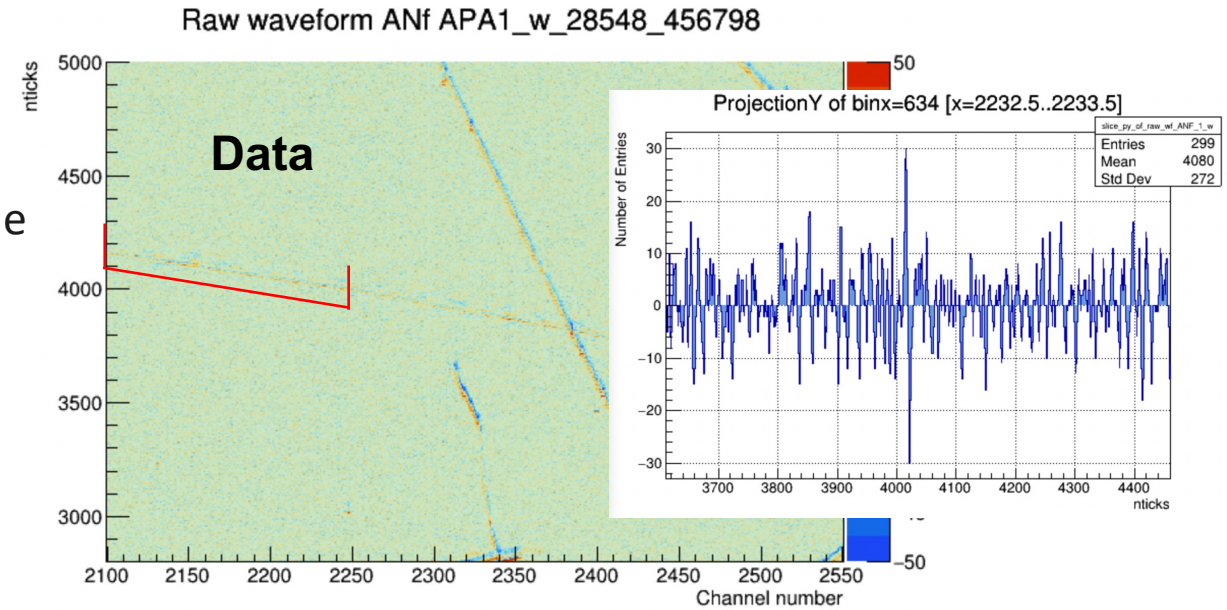
Suggested by Xin

of the charge q_m. Given equation 2.3, the integral of the induced current due to a charge q_m moving along its drift path

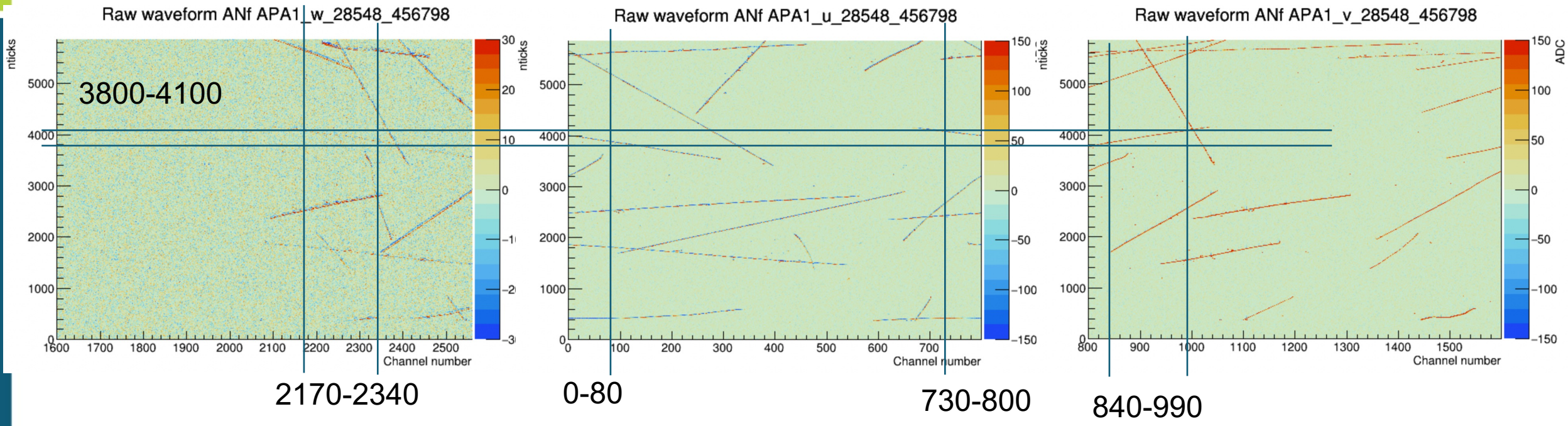
$$\int idt = q_m \cdot \left(V_w^{end} - V_w^{start}\right) \quad (2.4)$$

is proportional to the difference of the weighting potential at the end and start of the path.

arXiv:1802.08709



DC component

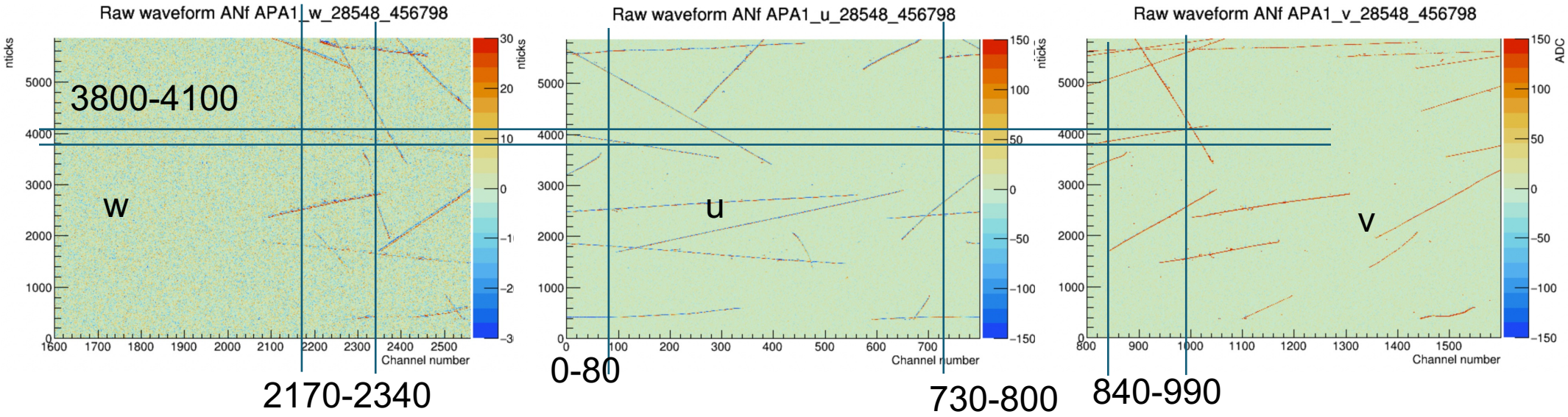


Evaluate DC component for a signal:

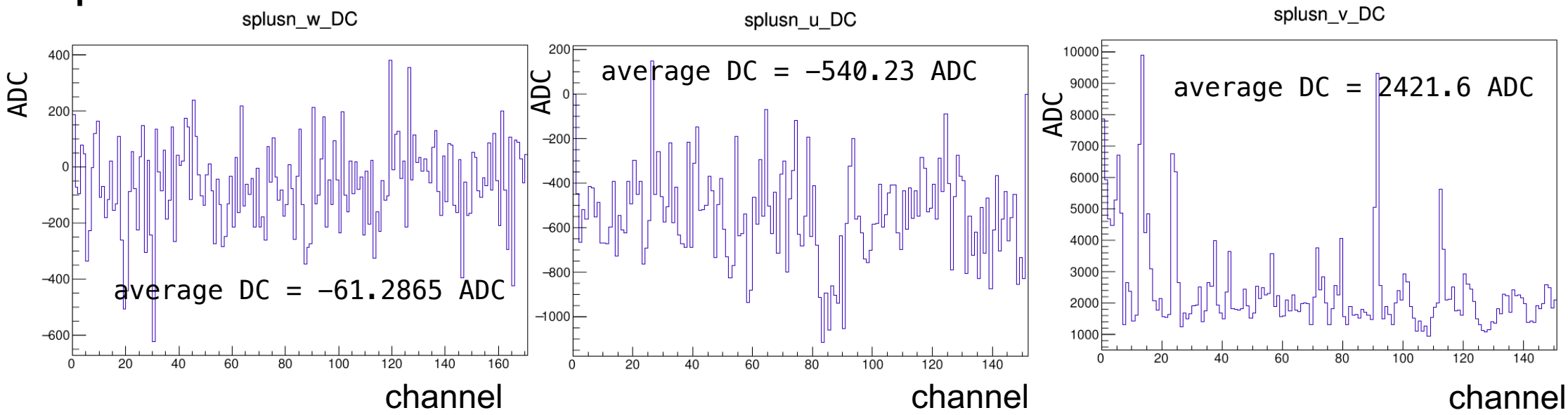
- Select a track from 3 planes, according to time tick, here is 3800-4100;
- Select the channel numbers that the track passed, w(2170-2340), u(0-80,730-800),v(840-990)
- Do integral along each selected channels in selected time ticks

DC component in Data

APA1; beam

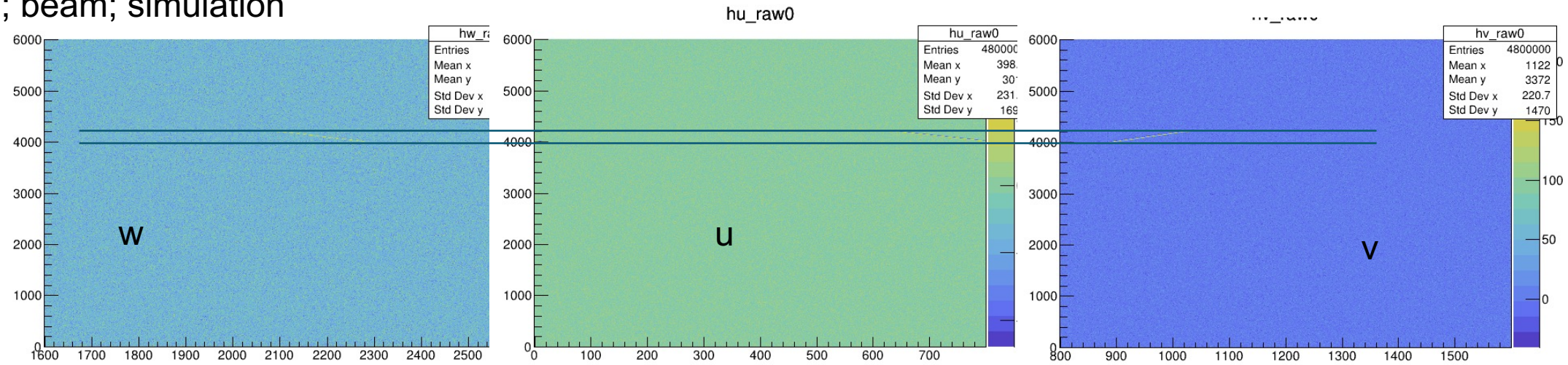


DC component in each channel

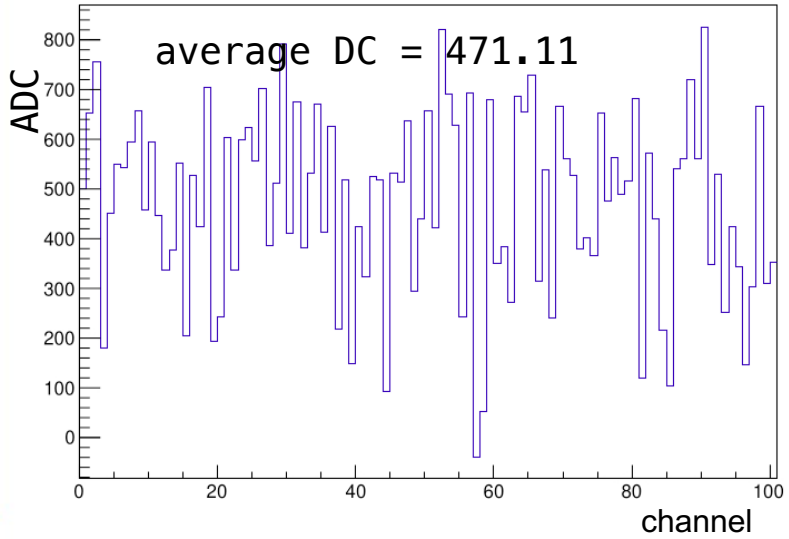


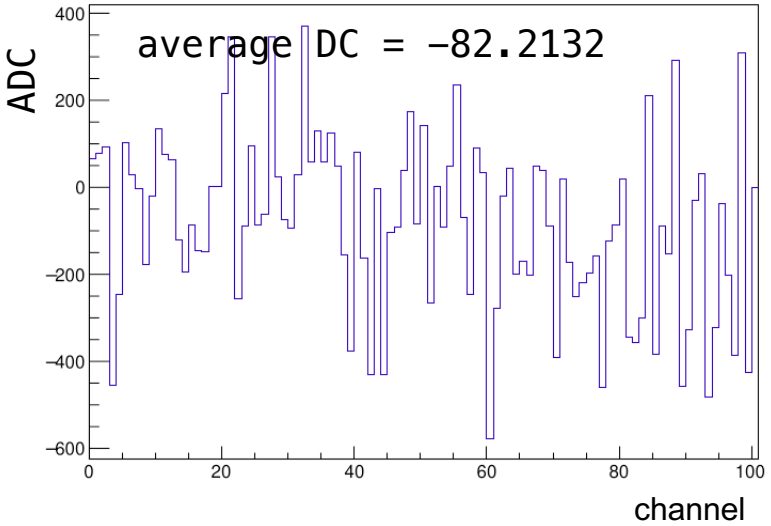
DC component in simulation

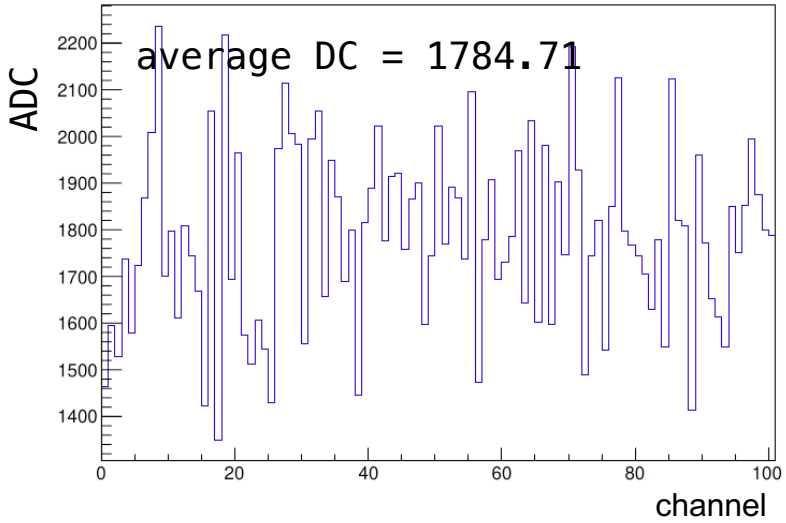
APA1; beam; simulation



DC component in each channel







- In simulation, w plane has a lot more DC component.
- We need to revisit the Garfield simulation

Garfield simulation

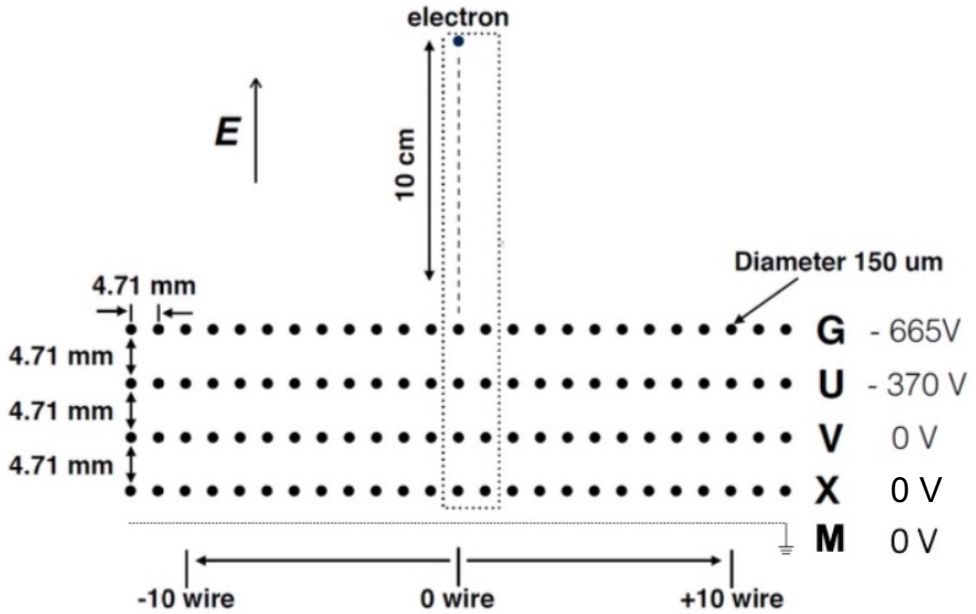
Special thanks to Yichen and Brett

- **gas.gar**: define the property of liquid argon;

- **cell.gar**: define the detector: geometry and voltage
  - Plane: (y = 20.4cm, v = -10151); (y=-0.471cm , v=0);
  - Wire: for each g,u,v,w, 3 groups wire in 40-21-40;
  - $\boldsymbol{V_W}$ = 0 V; $\boldsymbol{V_V}$ = 0 V; $\boldsymbol{V_U}$ = -370 V; $\boldsymbol{V_G}$ = -665 V ;

- **signal.gar**: define the property of drift electrons: number, position, time,
  - define sensitive wires; 21 in middle are sensitive wires.
  - Electron drift length: 10cm
  - save data.

- Output: Direct signal& cross talk on each sensitive wires; time vs current



- 6 electrons drift is simulated between 0 to ½ wire pitch.
- Wire-cell-python; wirecell-sigproc, convert_garfield,
  - Combine result from Garfield to 2D field response(.json.bz2)
- Apply 2D field response(.json.bz2) to params.jsonnet

Reproduce previous result

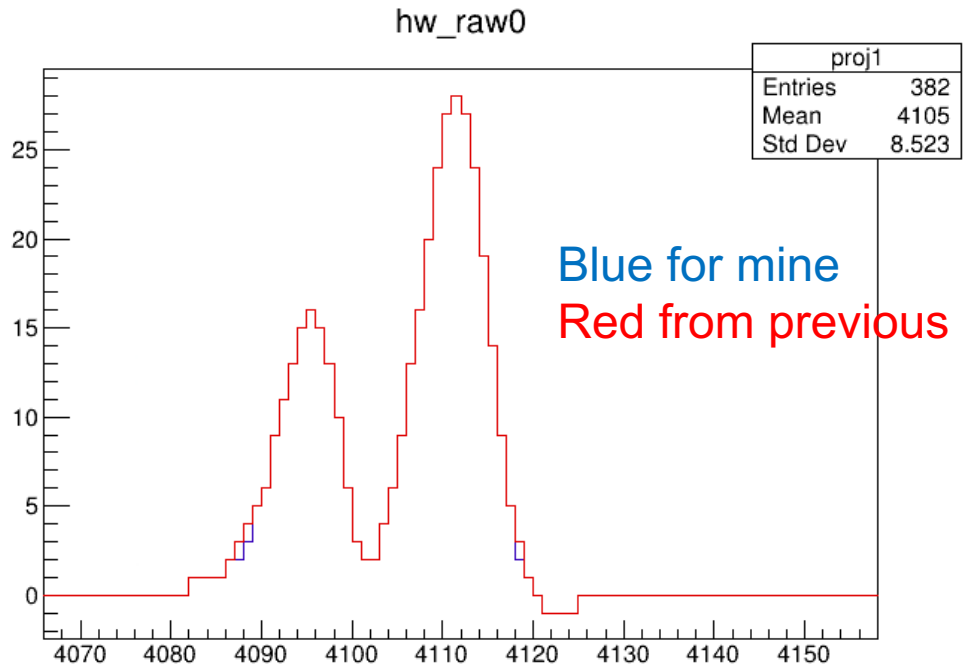
How to check:

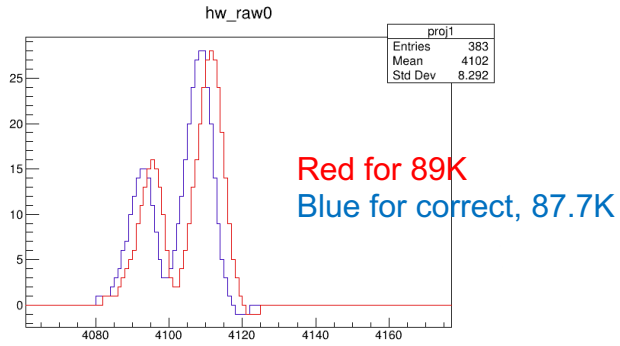
1. Garfield simulation: reproduce same data file;
2. Use my Garfield simulation result to generate simulate signal.(no bkg)

```
xning@dune0002:~/garfield_work/dune_my_0$ diff 1.88_U.dat /lbne/u/yichen/garfield-build/protodune_gnd/1.884_U.dat
2c2
< % Created 17/10/24 At 13.17.37 < none > SIGNAL   "Direct signal, group   1     "
---
> % Created 26/06/24 At 11.40.07 < none > SIGNAL   "Direct signal, group   1     "
1011c1011
< % Created 17/10/24 At 13.17.37 < none > SIGNAL   "Cross-talk, group   1       "
---
> % Created 26/06/24 At 11.40.07 < none > SIGNAL   "Cross-talk, group   1       "
2020c2020
< % Created 17/10/24 At 13.17.37 < none > SIGNAL   "Direct signal, group   2     "
---
> % Created 26/06/24 At 11.40.07 < none > SIGNAL   "Direct signal, group   2     "
3029c3029
< % Created 17/10/24 At 13.17.37 < none > SIGNAL   "Cross-talk, group   2       "
---
> % Created 26/06/24 At 11.40.07 < none > SIGNAL   "Cross-talk, group   2       "
4038c4038
< % Created 17/10/24 At 13.17.37 < none > SIGNAL   "Direct signal, group   3     "
---
> % Created 26/06/24 At 11.40.07 < none > SIGNAL   "Direct signal, group   3     "
5047c5047
< % Created 17/10/24 At 13.17.37 < none > SIGNAL   "Cross-talk, group   3       "
---
> % Created 26/06/24 At 11.40.07 < none > SIGNAL   "Cross-talk, group   3       "
6056c6056
< % Created 17/10/24 At 13.17.37 < none > SIGNAL   "Direct signal, group   4     "
---
> % Created 26/06/24 At 11.40.07 < none > SIGNAL   "Direct signal, group   4     "
7065c7065
< % Created 17/10/24 At 13.17.37 < none > SIGNAL   "Cross-talk, group   4       "
---
> % Created 26/06/24 At 11.40.07 < none > SIGNAL   "Cross-talk, group   4       "
8074c8074
< % Created 17/10/24 At 13.17.37 < none > SIGNAL   "Direct signal, group   5     "
---
> % Created 26/06/24 At 11.40.07 < none > SIGNAL   "Direct signal, group   5     "
9083c9083
< % Created 17/10/24 At 13.17.37 < none > SIGNAL   "Cross-talk, group   5       "
---
> % Created 26/06/24 At 11.40.07 < none > SIGNAL   "Cross-talk, group   5       "
10092c10092
< % Created 17/10/24 At 13.17.37 < none > SIGNAL   "Direct signal, group   6     "
---
> % Created 26/06/24 At 11.40.07 < none > SIGNAL   "Direct signal, group   6     "
11101c11101
< % Created 17/10/24 At 13.17.37 < none > SIGNAL   "Cross-talk, group   6       "
---
> % Created 26/06/24 At 11.40.07 < none > SIGNAL   "Cross-talk, group   6       "
12110c12110
< % Created 17/10/24 At 13.17.37 < none > SIGNAL   "Direct signal, group   7     "
---
> % Created 26/06/24 At 11.40.07 < none > SIGNAL   "Direct signal, group   7     "
13119c13119
< % Created 17/10/24 At 13.17.37 < none > SIGNAL   "Cross-talk, group   7       "
---
```

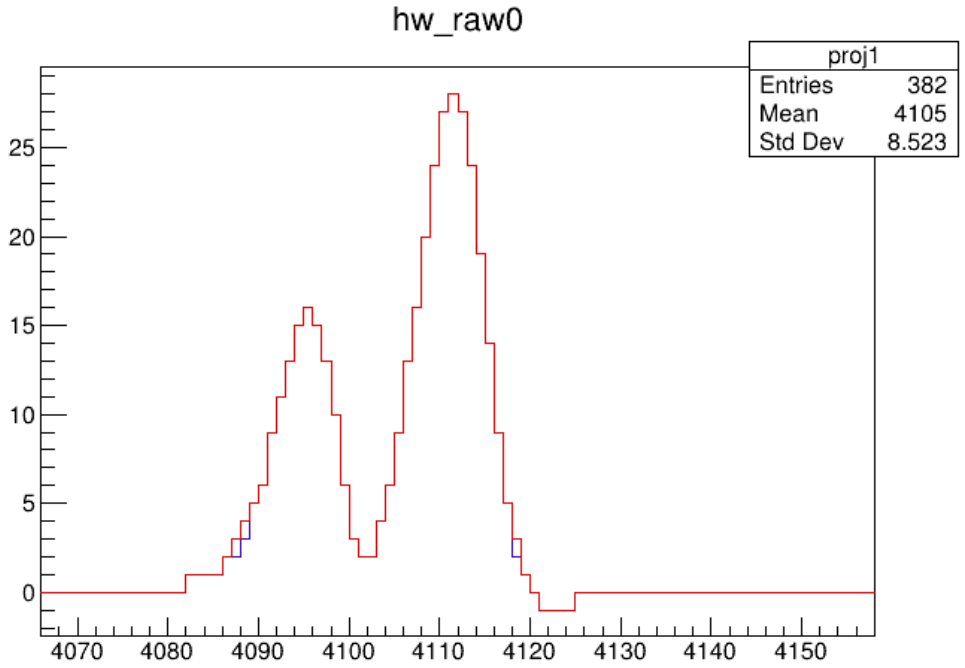
- Successfully reproduced
- Problems: Previous result from Garfield use e drift velocity table at 89K; correct is 87.7K.
- Time shift a little but doesn't change conclusion.

Simulate pure signal based on field response on w plane

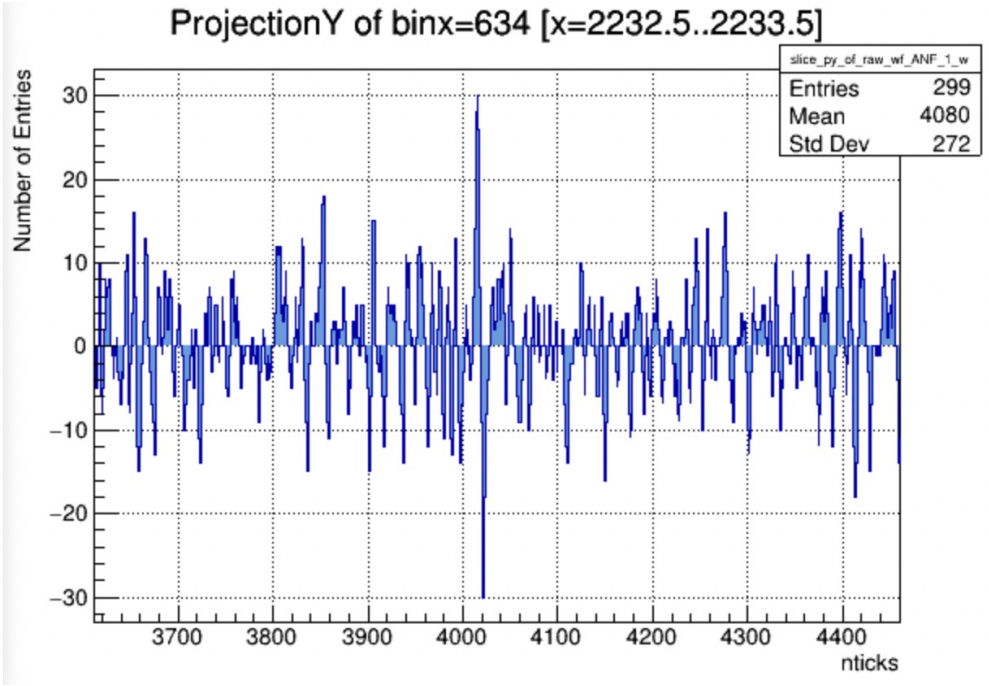




Simulated pure signal on w plane



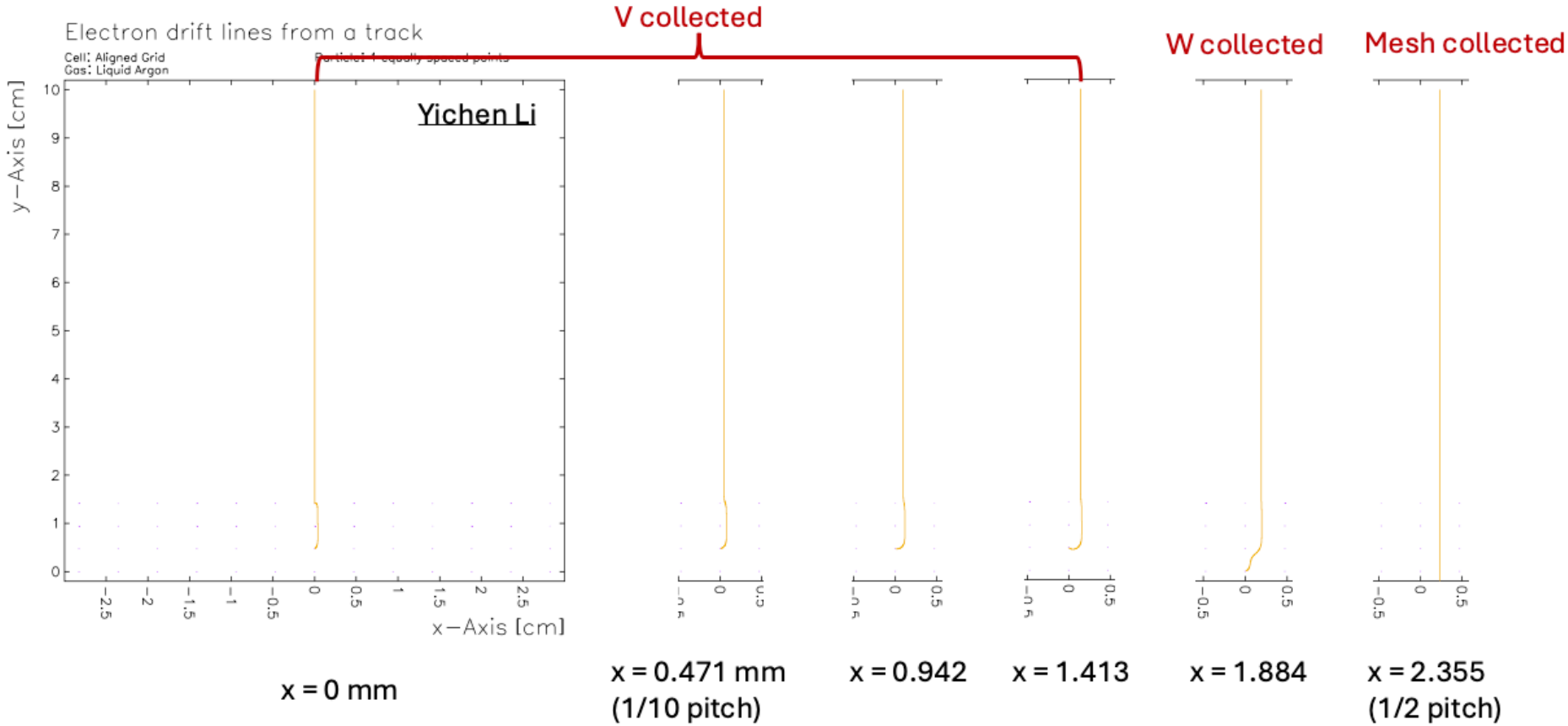
1D waveform from data; APA1 w



In this version, the signal has very rare negative component.

Comment from Bo and our check

Electron drift simulation in GARFIELD

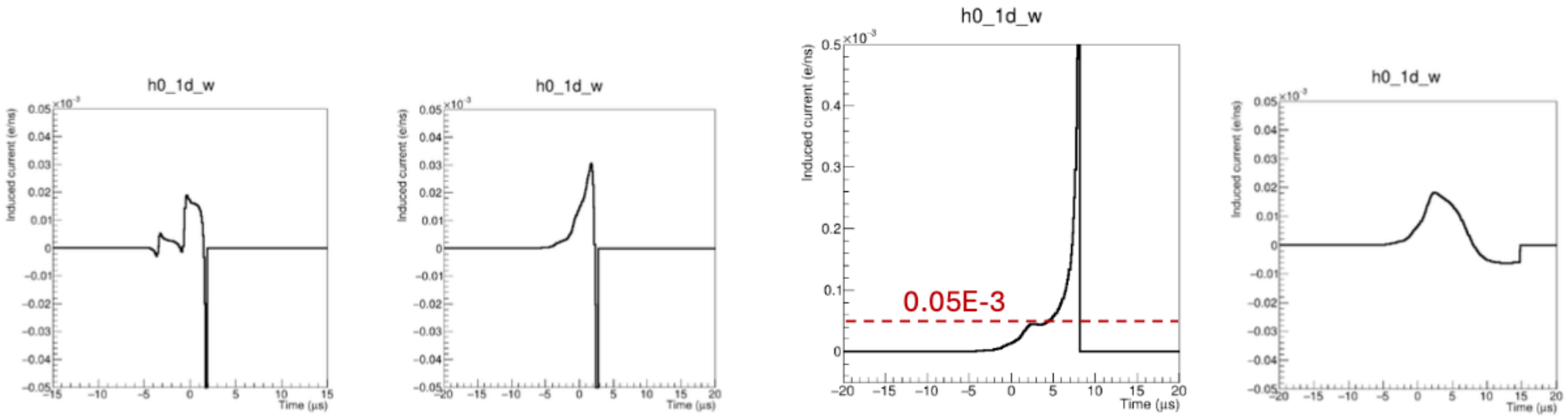


3 major contributors to a W wire signal :

1. Charge arriving to the V wires: W should see positive peak (preamp inverting) followed by negative peak.
2. Charge collecting on W wires: if W is not fully charged, field lines from a narrow region will land on the W wire
3. Charge passing by W wires and landing on wire mesh: a small fraction of charge may pass through the V and W plane and collect on the wire mesh plane. W should a weak and long bipolar signal

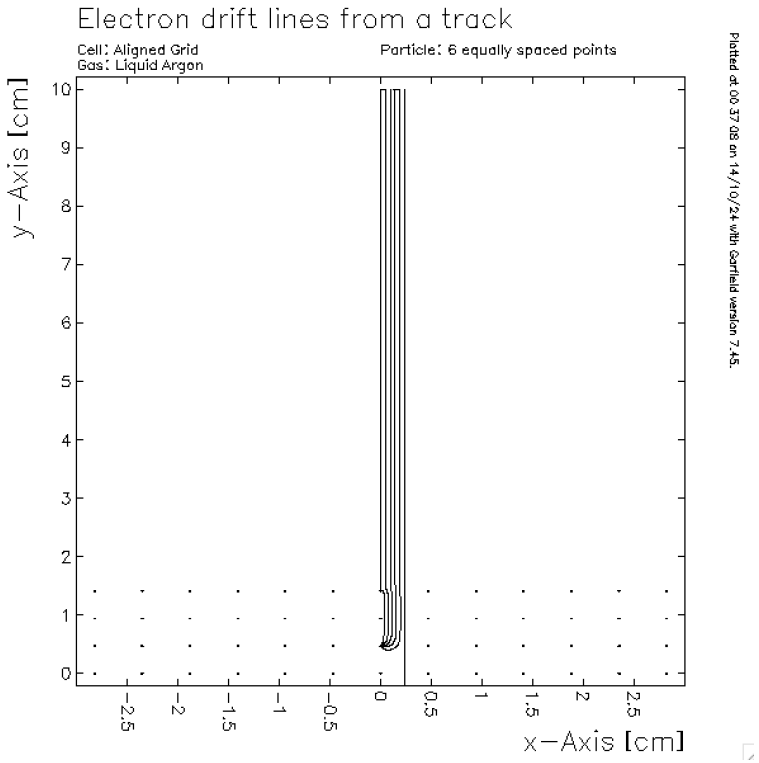
Comment from Bo and our check

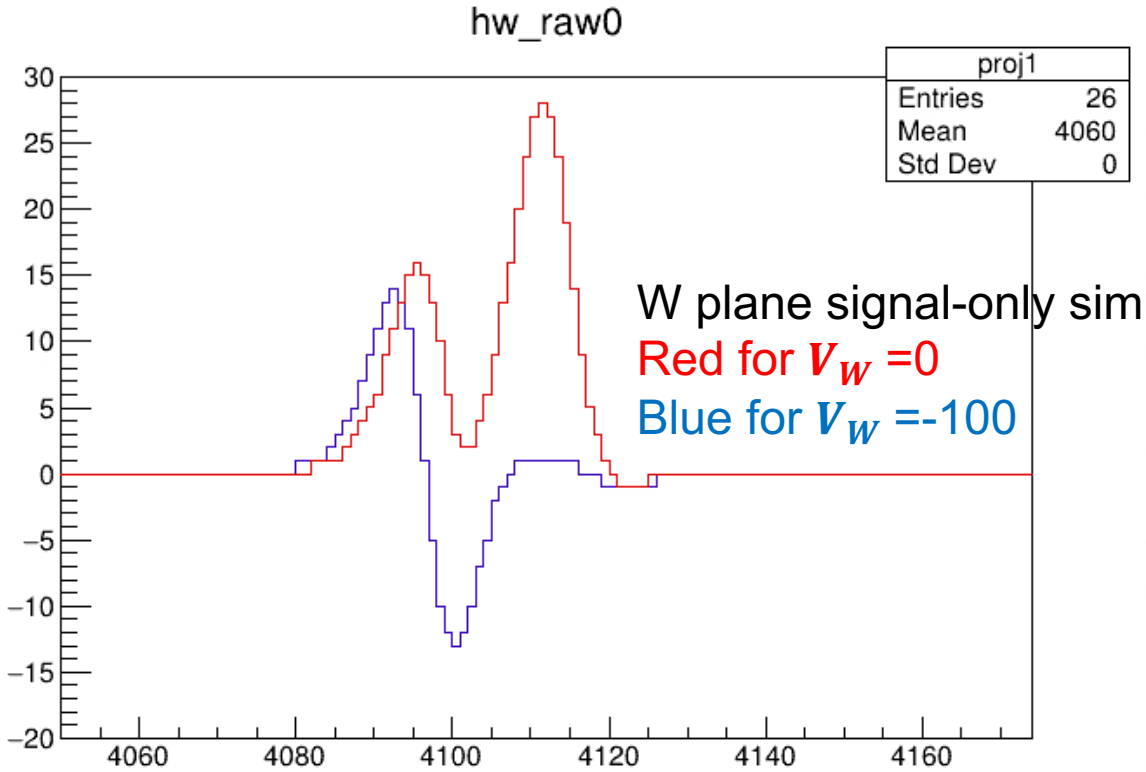
Induced current at different positions: APA1



- In simulation of V_W =0V
  - 73% electron collected on V; **15% on W**; but w will generate (10 times) larger positive current
  - w collection will dominate the signal.
  - We also see no negative pulse in simulated signal.
- Consistence with the conclusion of too much collection on w in simulation.

Set V_W =-100V



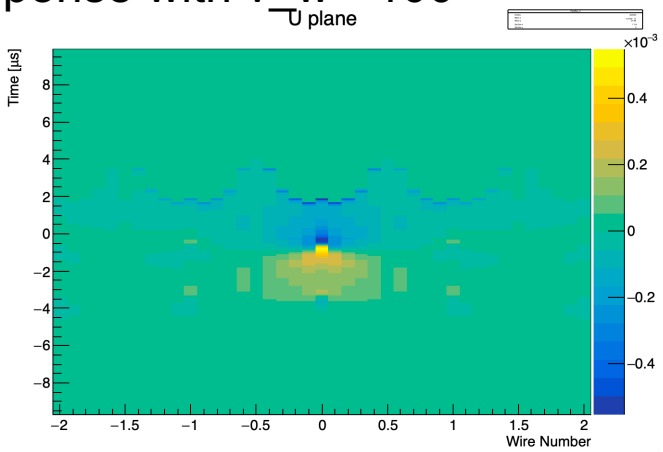


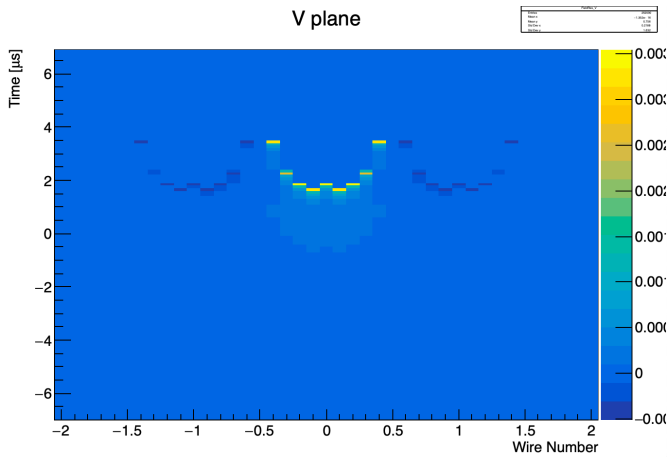
W plane signal-only simulation

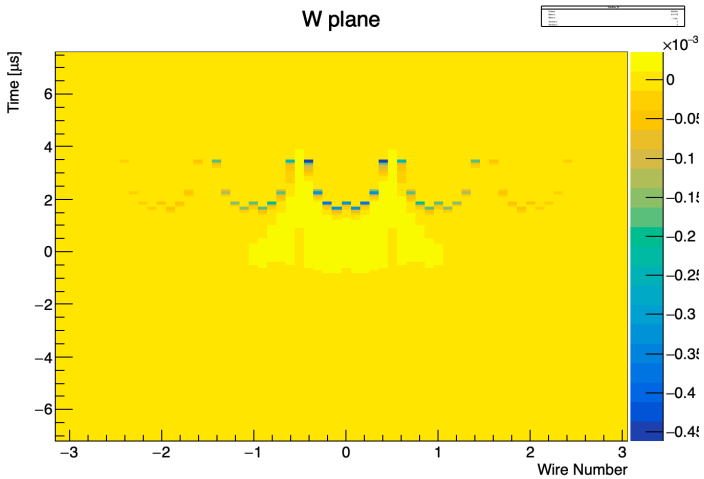
Red for V_W =0

Blue for V_W =-100

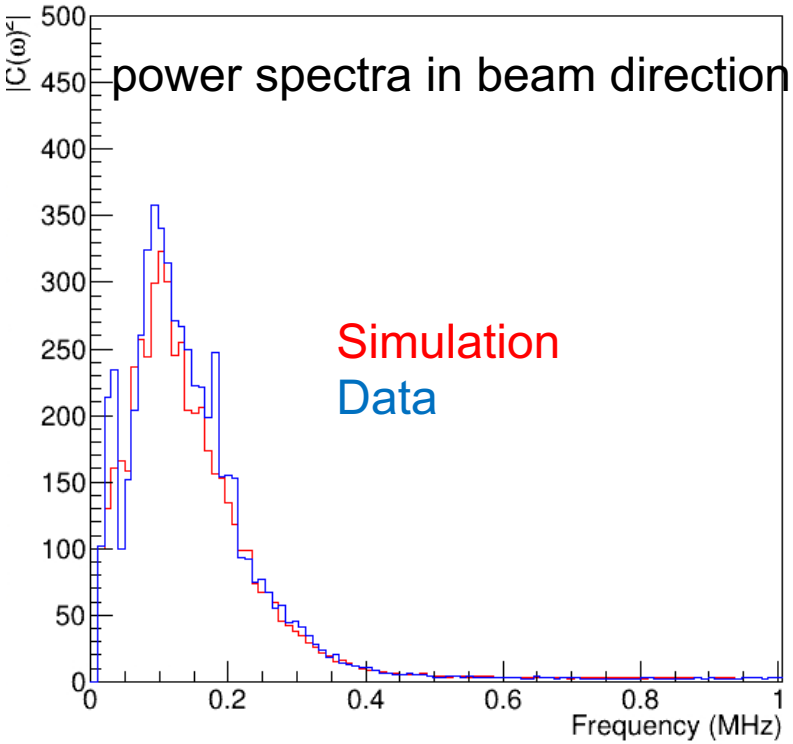
2D field response with v_w=-100

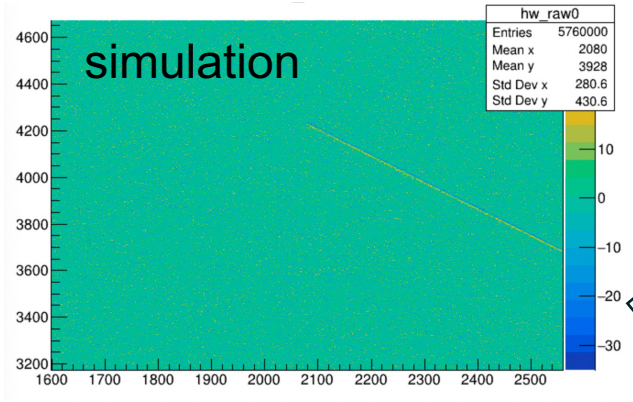


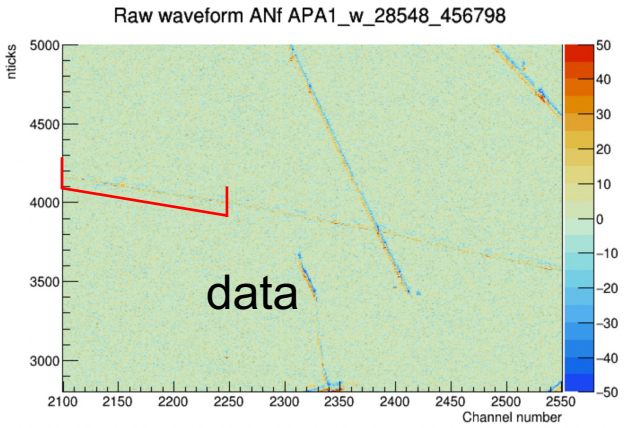




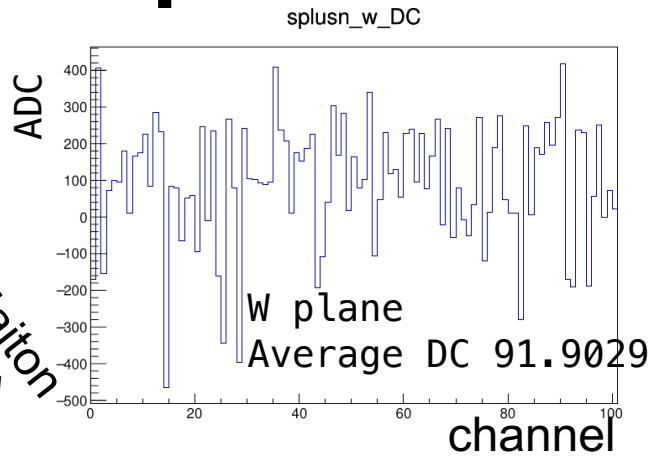
V_W=-100V, compared with data, power spectra

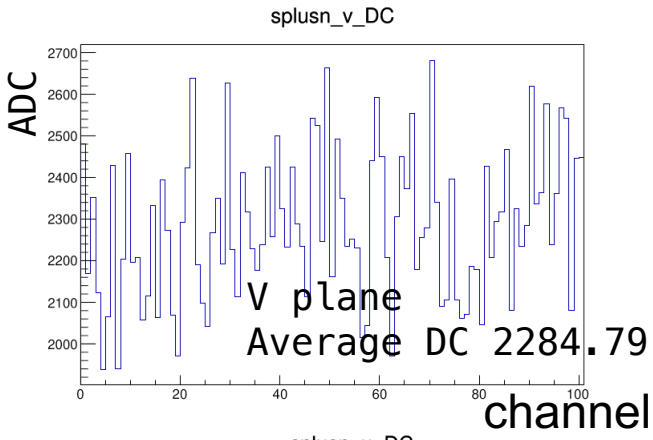


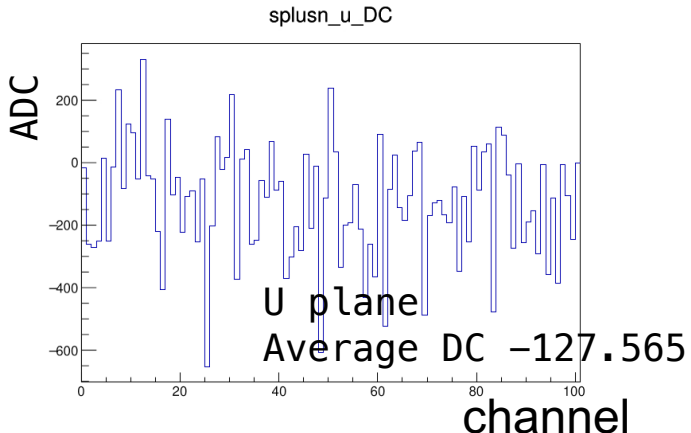




DC; simulaiton



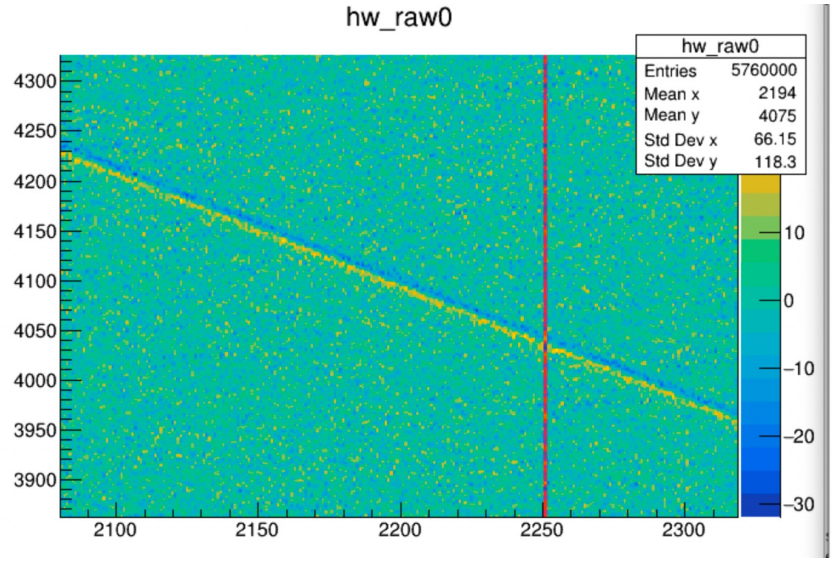


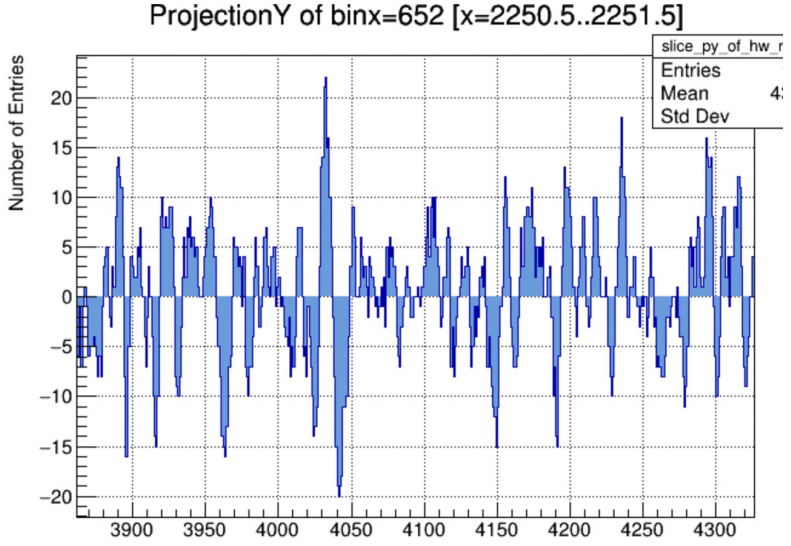


- Power spectrum are more consistent
- w plane has less DC component

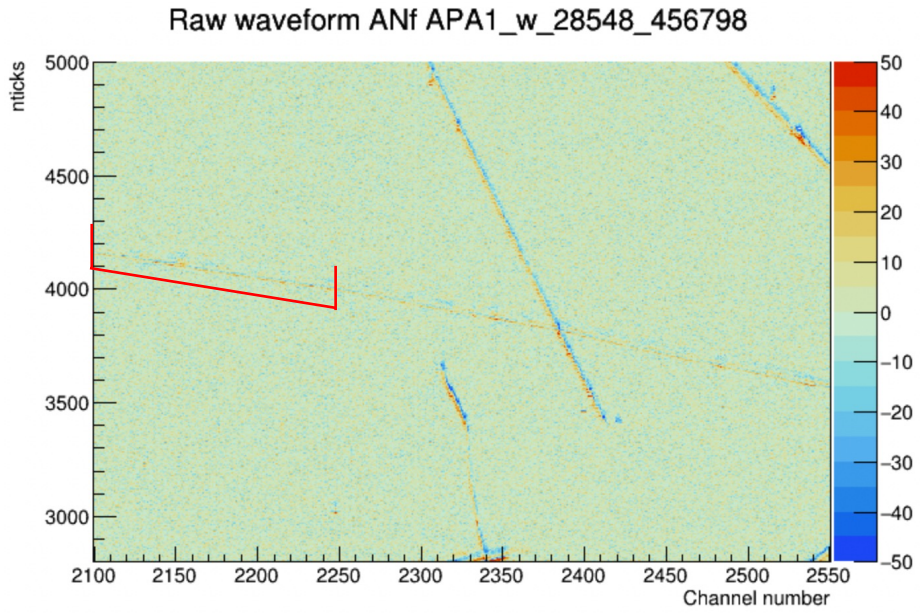
Waveform comparison

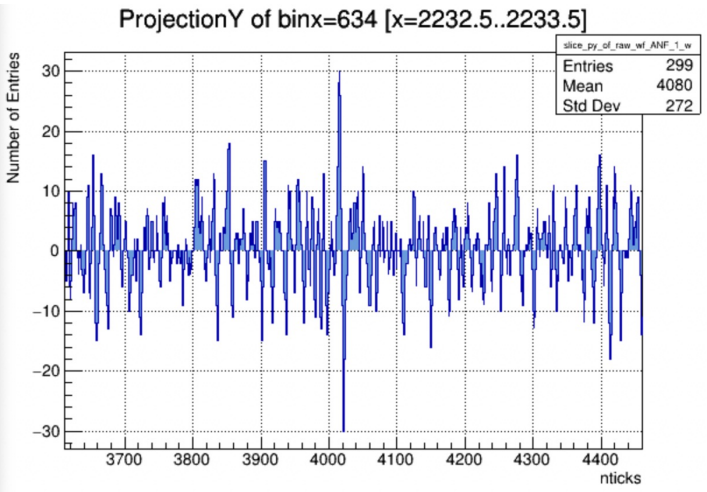
Simulation
APA1 w plane



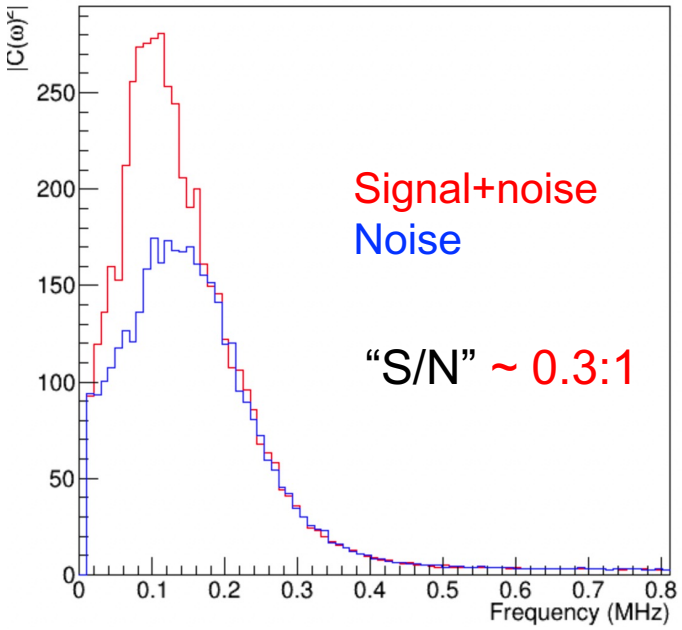


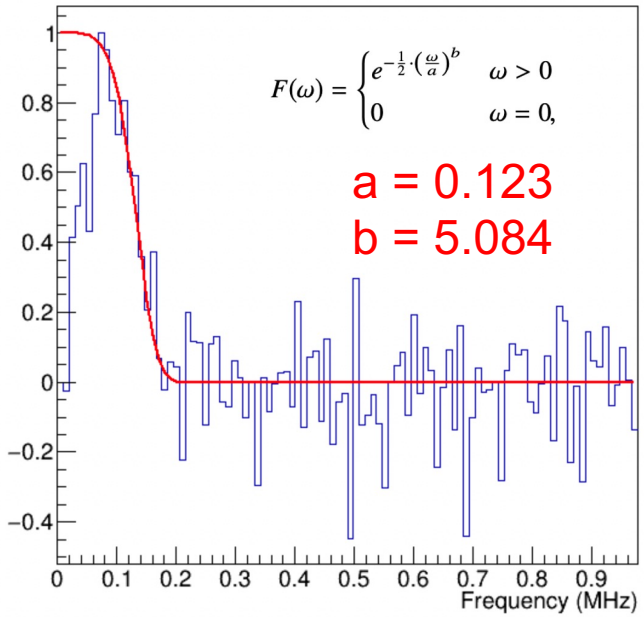
data



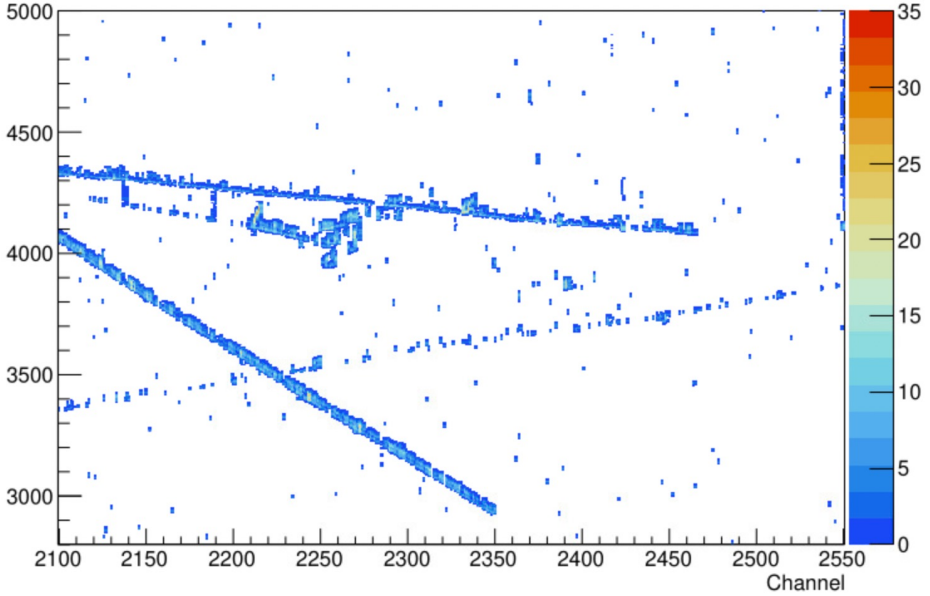


Wiener Filter check, beam direction

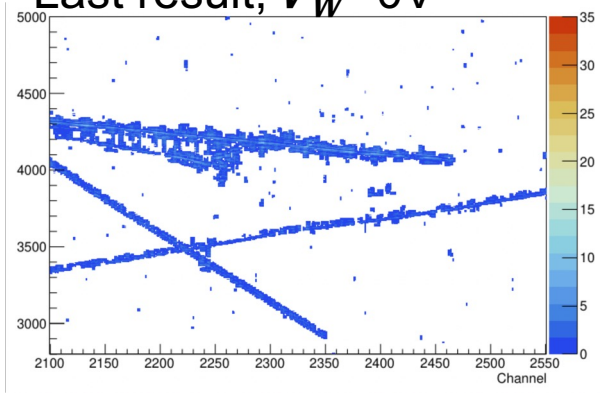




deconvolution charge; V_W=-100V



Last result; V_W=0V



- Very low S/N
- Beam direction track is narrow compared to previous result
- Not so good for other direction.

Summary & Plan

- We checked DC component of beam track in data and simulation
  - More DC component is found in simulation than data.
  - Indicate that $\boldsymbol{V_W}$ = 0V will cause more collection than expected.

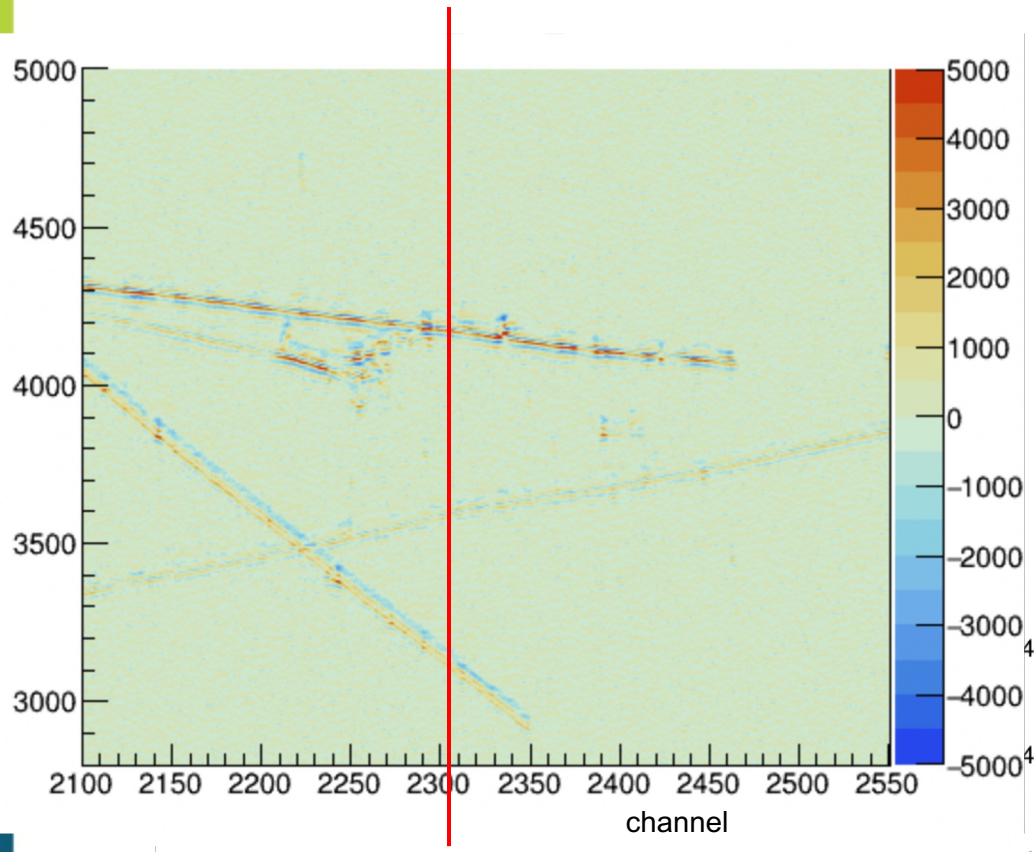
- We revisit Garfield simulation.
  - Reproduce Yichen's result
  - 3 major contributors to a W wire signal : charge arriving V, and mesh cause induction signal, charge arriving w cause collection signal
  - Simulation with $\boldsymbol{V_W}$ = 0V have more collection on w. It'll cause large positive component in signal, while actual data doesn't have it.

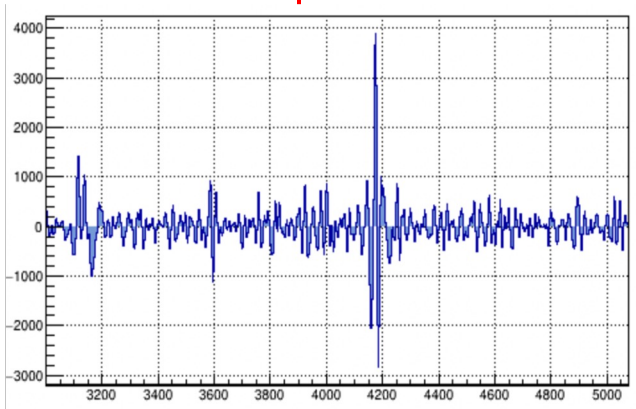
- Updated Garfield simulation with $\boldsymbol{V_W}$ = -100V
  - Power spectra is more consistence with data
  - Lower S/N ratio is found than we expected.

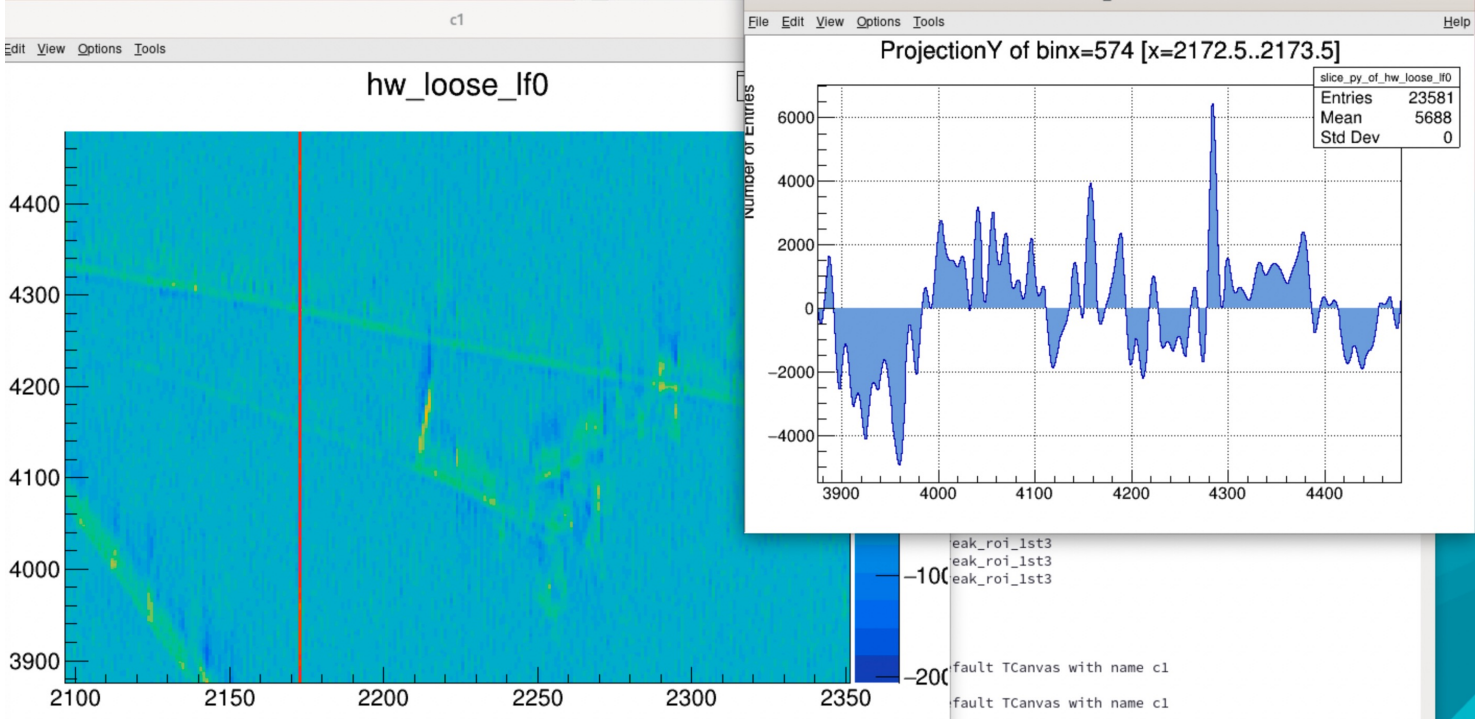
- Next:
  - Understand tracks from other direction.
  - Improve signal processing with DNN ROI

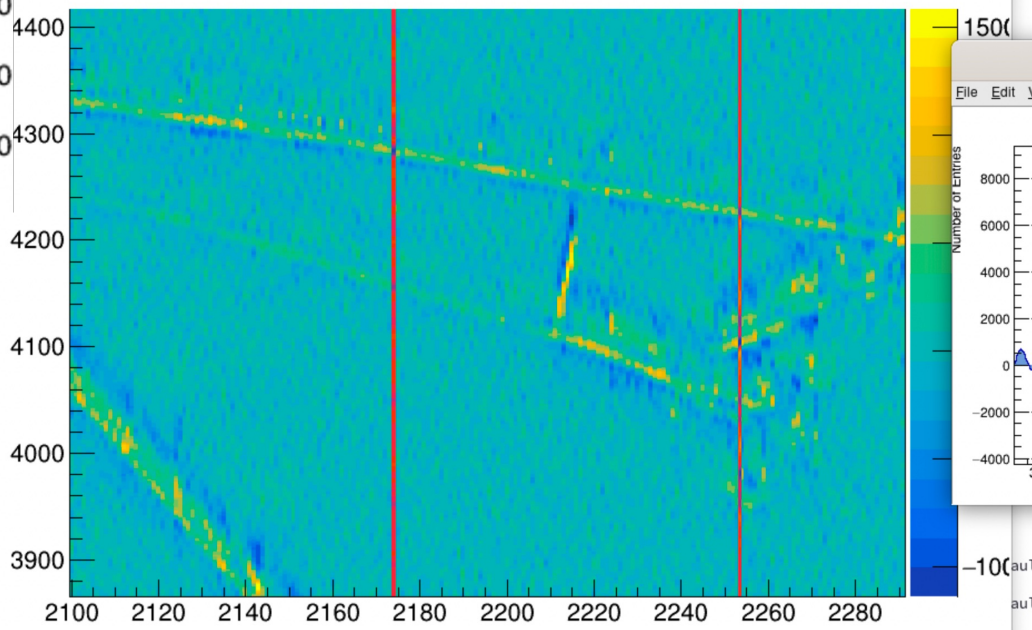
Back up

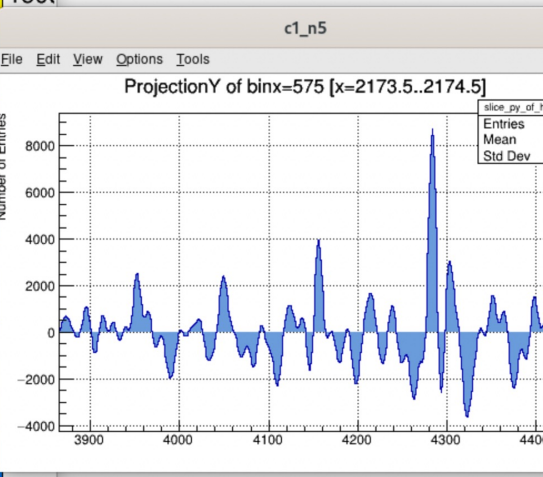
Deconvolution result with Wiener filter & LF applied



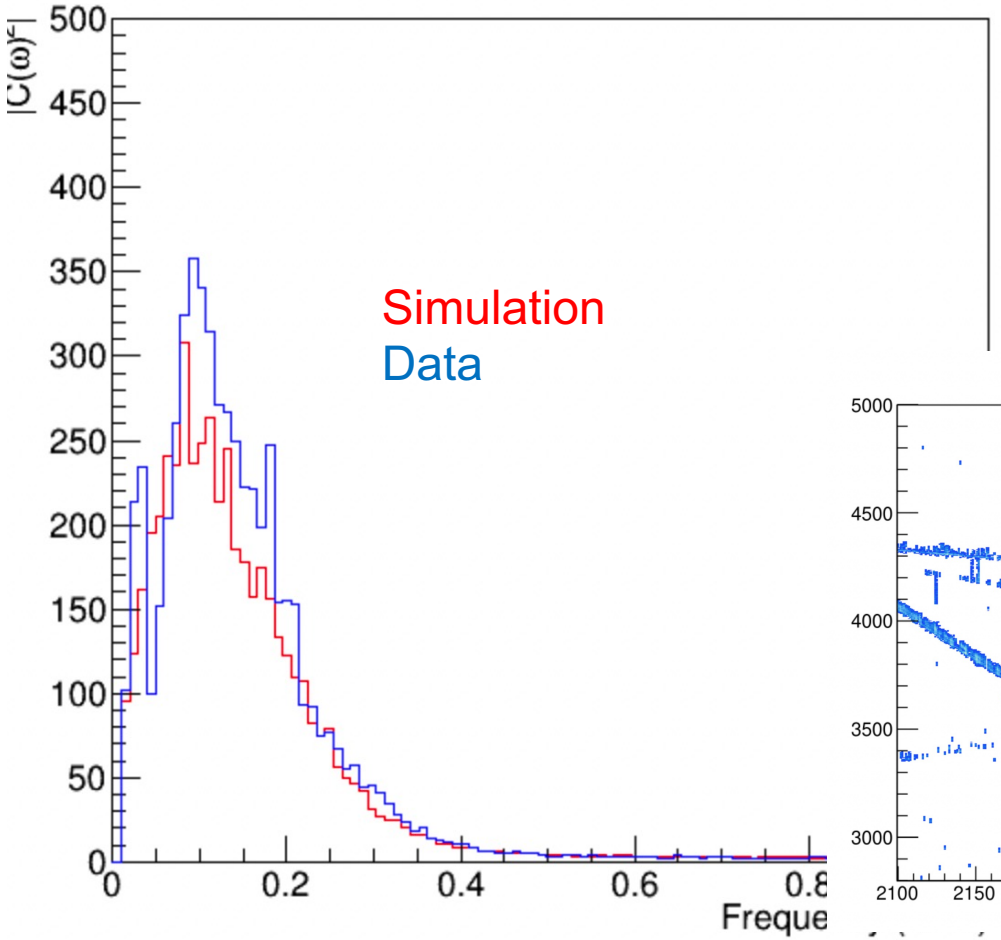








Set V_W =-50V



Simulation

Data

```
root [0]
ocessing calcFilter.C...
119.9
07.25
10629
force scaling with factor: 1.85619
CN=12.0221 FROM MIGRAD    STATUS=CONV
                    EDM=5.06741e-07
EXT PARAMETER
NO.   NAME      VALUE            ERRO
 1  p0           1.40131e-01   3.6443
 2  p1           8.05771e+00   9.76724e+00   7.81966e-03  -3.95173e-05
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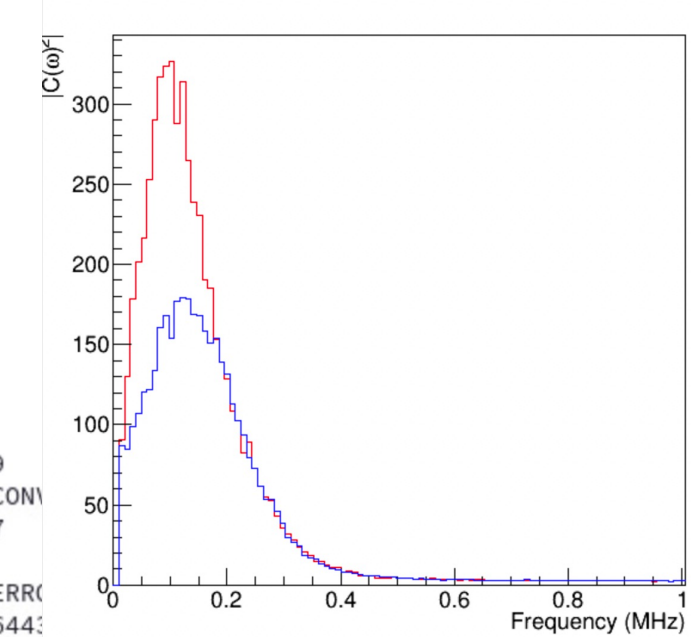
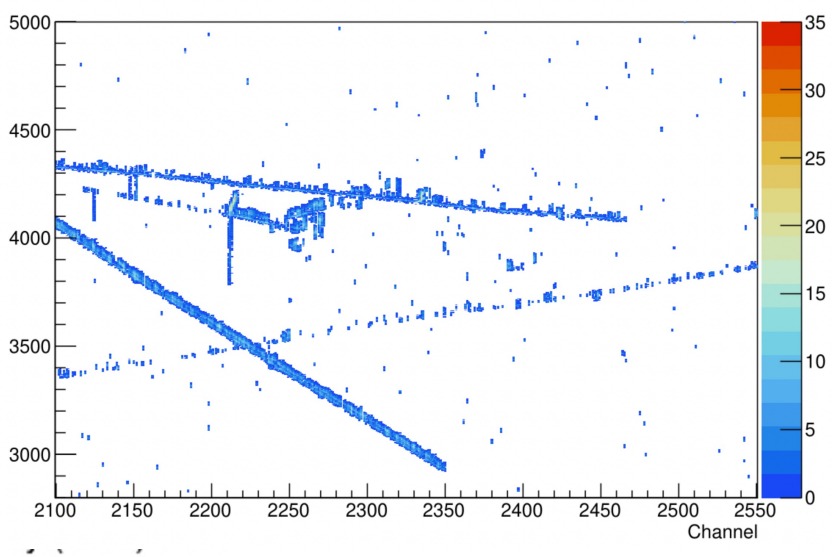
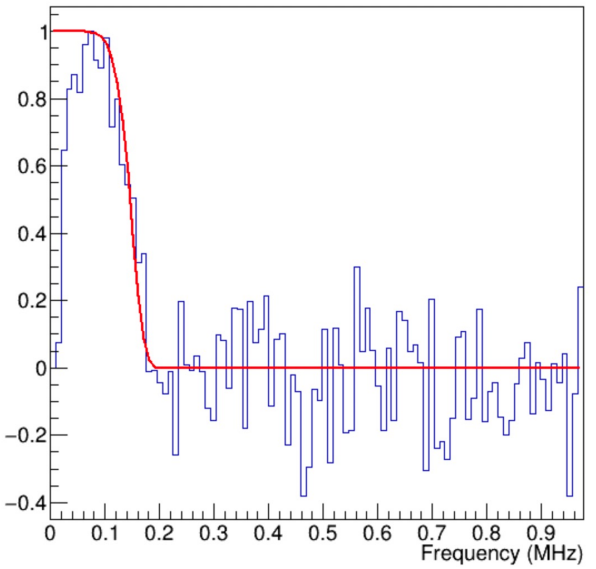
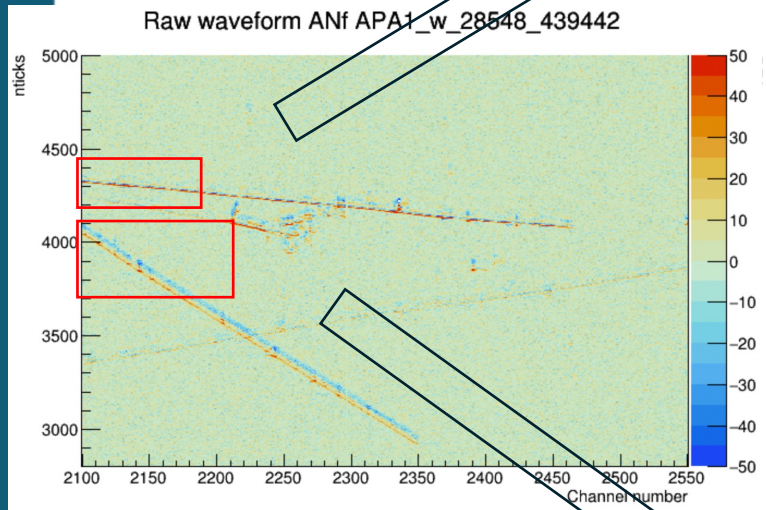


h_decon

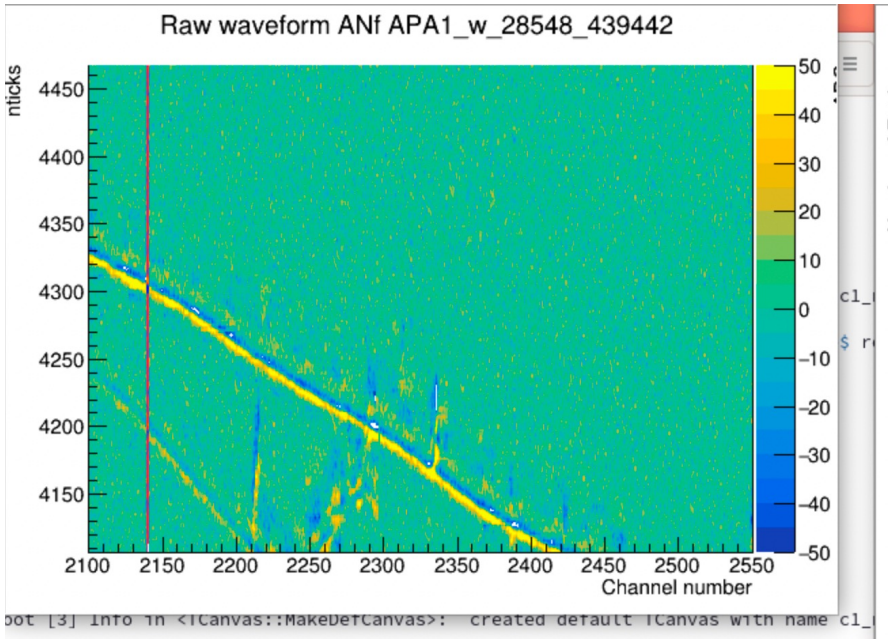


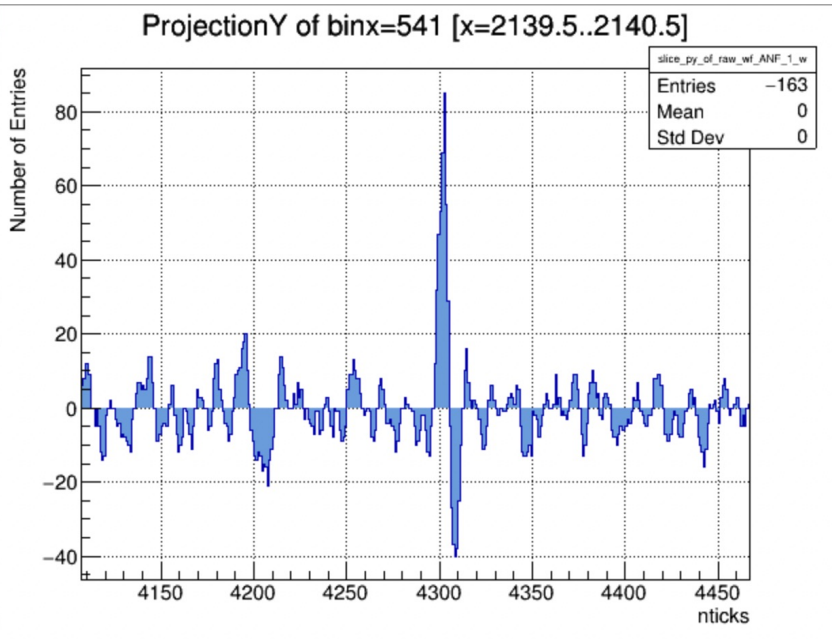


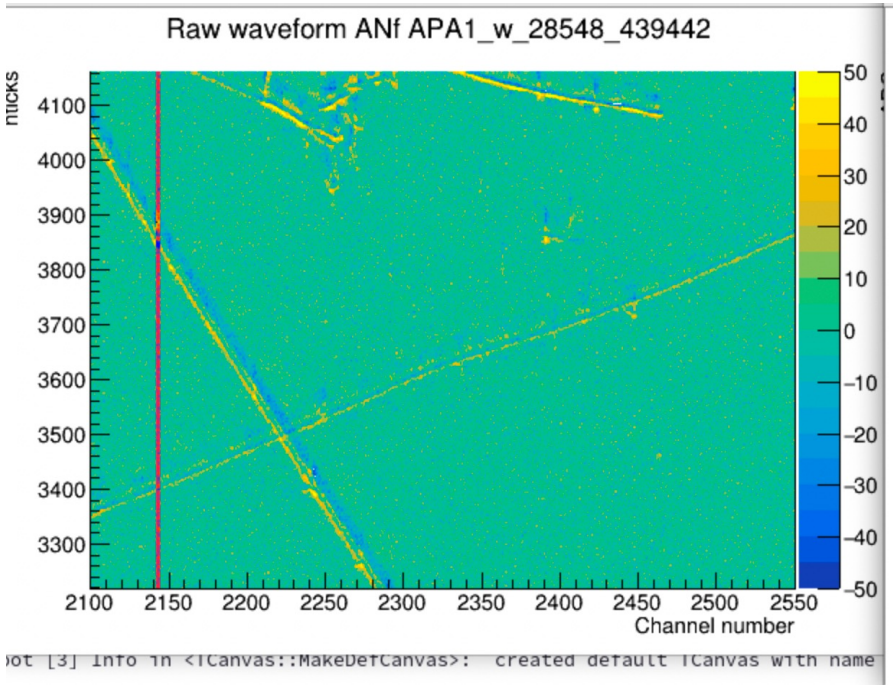
Zoom in

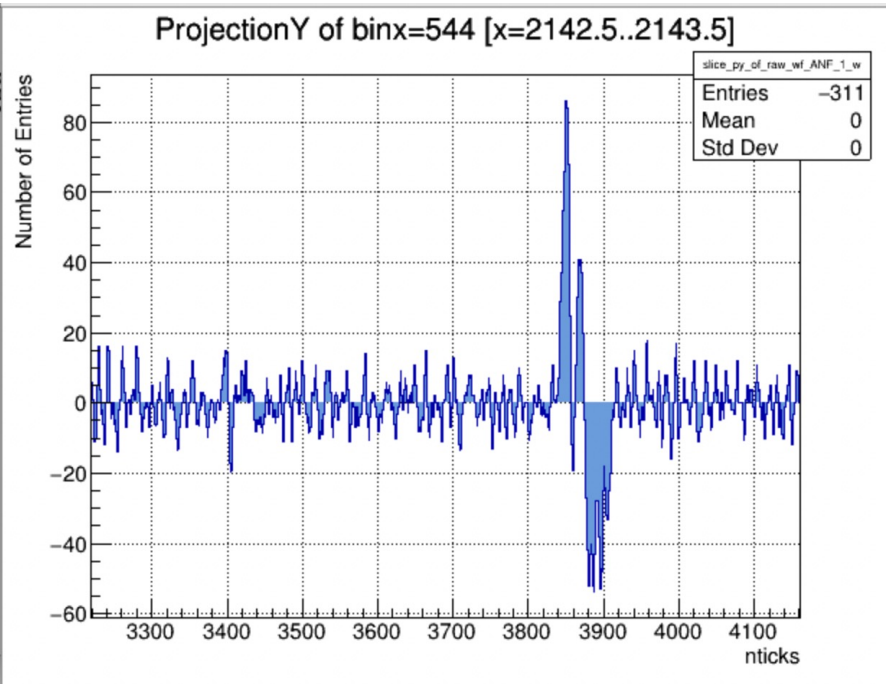


Zoom in









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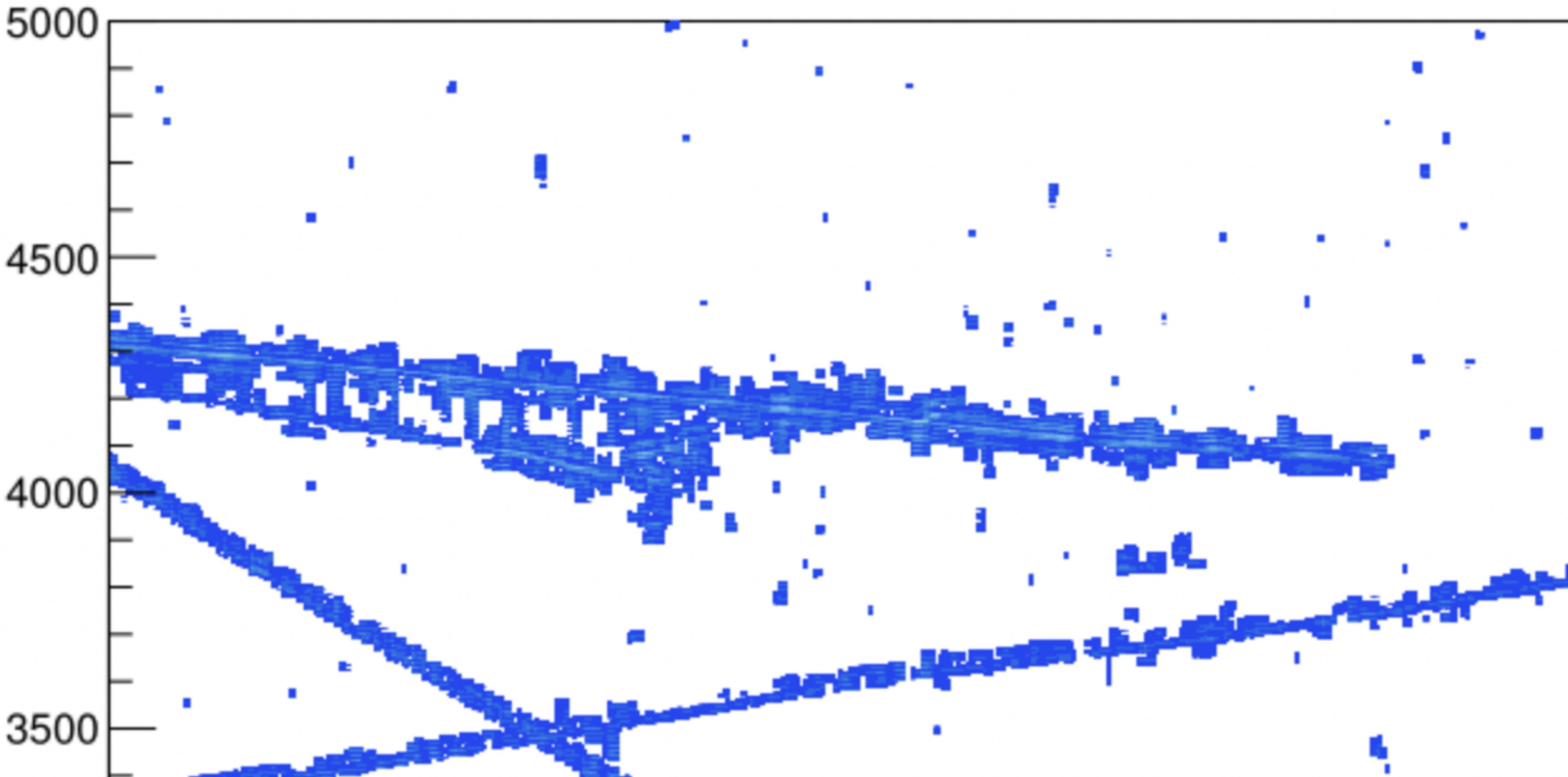
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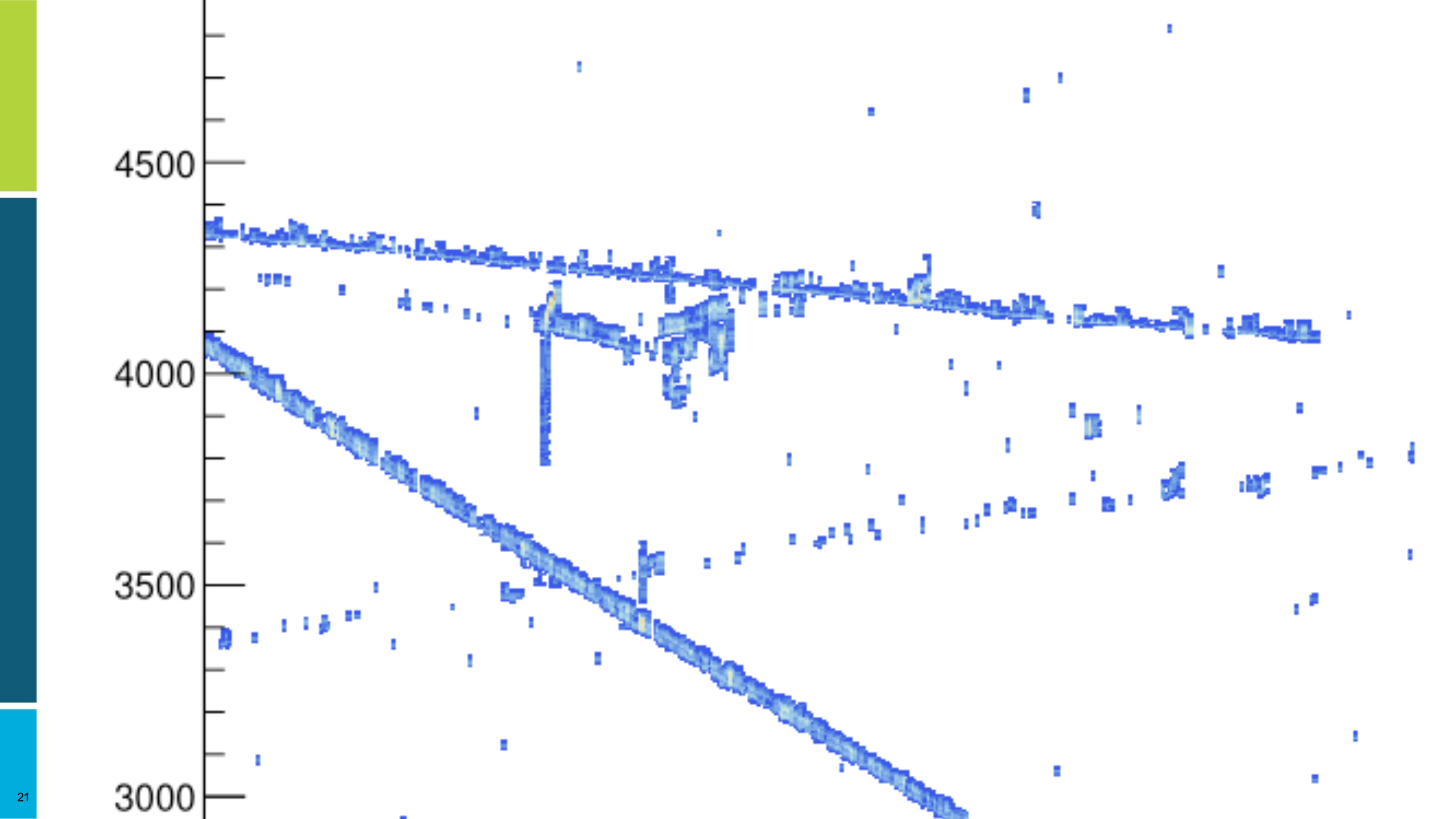
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