Status report on

DNNROI sigproc

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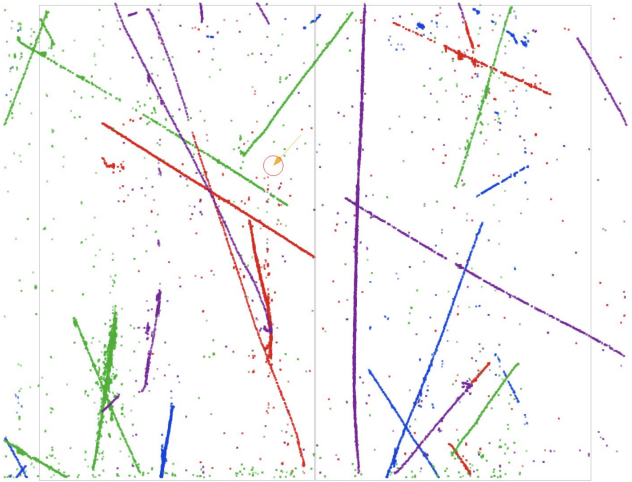
3D imaging with DNN ROI

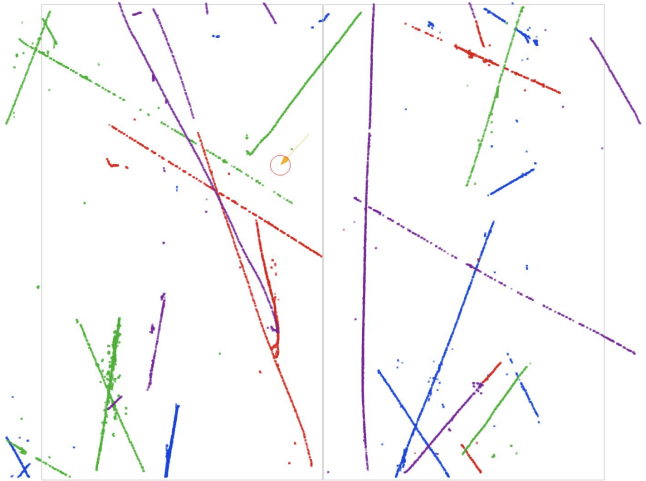
- wcls-nf-sp-img.jsonnet → wcls-nf-**dnnsp**-img.jsonnet
- img.jsonnet → img_**dnnroi**.jsonnet
  - need to update img.jsonnet to support both Trad. ROI and DNN ROI
- What I changed to use DNN ROI as inputs
  - ChargeErrorFrameEstimator
    - intag: gauss → dnnsp
    - outtag: gauss_error → dnnsp_error
  - CMMModifier
    - trace_tag: gauss → dnnsp
  - FrameQualityTagging
    - trace_tag: gauss → dnnsp
  - FrameMasking
    - trace_tags: gauss → dnnsp, wiener → **NONE**
  - MaskSlice
    - wiener_tag and summary_tag: wiener → dnnsp
    - charge_tag: gauss → dnnsp
    - error_tag: gauss_error → dnnsp_error
  - Updated PlaneSelector.cxx to transfer summary tag

3D imaging with DNN ROI

- 3D imaging w/o DNN ROI
  - Event 27380-1963: https://www.phy.bnl.gov/twister/bee/set/5e5a809c-35c9-44b5-b10d-38112c4e0b52/event/0/
  - Event 26763-589: https://www.phy.bnl.gov/twister/bee/set/0bebdda4-8273-49c1-b720-5fb790f54a6b/event/0/
- 3D imaging w/ DNN ROI
  - Event 27380-1963: https://www.phy.bnl.gov/twister/bee/set/5e5a809c-35c9-44b5-b10d-38112c4e0b52/event/0/
  - Event 26763-589: https://www.phy.bnl.gov/twister/bee/set/2b31c1b4-a4be-464e-b716-ee2ae0619381/event/0/



❑ Case 1. Trad. ROI side view



❑ Case 2. DNN ROI side view

Software Filter Study

- Confirming if the parameters I set are actually used
  - /exp/dune/data/users/hnam/wire-cell-hnam/pdvd-sim/test_cosmic_mproi_0204/filter_pdvd.log
  - /exp/dune/data/users/hnam/wire-cell-hnam/pdvd-sim/test_cosmic_mproi_0204/filter_pdsp.log

```
[OmnibusSigProc][filter-params] stage=decon_2D_init_wire filter=Wire_ind sigma=2.82095 power=2 flag=0 max_freq=1
[OmnibusSigProc][filter-params] stage=runtime_hf filter=Wiener_tight_U sigma=0.000148788 power=3.76194 flag=1 max_freq=0.001
[OmnibusSigProc][filter-params] stage=runtime_lf filter=ROI_tighter_lf max_freq=0.001 tau=6e-05
[OmnibusSigProc][filter-params] stage=runtime_lf filter=ROI_tight_lf max_freq=0.001 tau=1.4e-05
[OmnibusSigProc][filter-params] stage=runtime_lf filter=ROI_loose_lf max_freq=0.001 tau=2e-06
[OmnibusSigProc][filter-params] stage=decon_2D_ROI_refine filter=Wiener_tight_U sigma=0.000148788 power=3.76194 flag=1 max_freq=0.001
[OmnibusSigProc][filter-params] stage=runtime_hf filter=Wiener_tight_V sigma=0.000159657 power=4.36125 flag=1 max_freq=0.001
[OmnibusSigProc][filter-params] stage=decon_2D_ROI_refine filter=Wiener_tight_V sigma=0.000159657 power=4.36125 flag=1 max_freq=0.001
[OmnibusSigProc][filter-params] stage=decon_2D_init_wire filter=Wire_col sigma=5.6419 power=2 flag=0 max_freq=1
[OmnibusSigProc][filter-params] stage=runtime_hf filter=Wiener_tight_W sigma=0.00013623 power=3.35324 flag=1 max_freq=0.001
[OmnibusSigProc][filter-params] stage=runtime_hf filter=Wiener_wide_U sigma=0.000186765 power=5.05429 flag=1 max_freq=0.001
[OmnibusSigProc][filter-params] stage=runtime_hf filter=Gaus_wide sigma=0.00012 power=2 flag=1 max_freq=0.001
[OmnibusSigProc][filter-params] stage=runtime_hf filter=Wiener_wide_V sigma=0.0001936 power=5.77422 flag=1 max_freq=0.001
[OmnibusSigProc][filter-params] stage=runtime_hf filter=Wiener_wide_W sigma=0.000175722 power=4.37928 flag=1 max_freq=0.001
```

❑ Case 1. PD-SP HfFilter

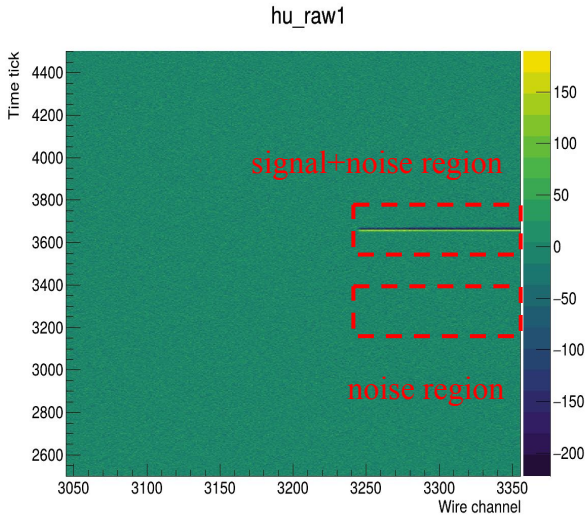
```
[OmnibusSigProc][filter-params] stage=decon_2D_init_wire filter=Wire_ind sigma=2.82095 power=2 flag=0 max_freq=1
[OmnibusSigProc][filter-params] stage=runtime_hf filter=Wiener_tight_U sigma=0.000286735 power=8.07074 flag=1 max_freq=0.001
[OmnibusSigProc][filter-params] stage=runtime_lf filter=ROI_tighter_lf max_freq=0.001 tau=6e-05
[OmnibusSigProc][filter-params] stage=runtime_lf filter=ROI_tight_lf max_freq=0.001 tau=1.4e-05
[OmnibusSigProc][filter-params] stage=runtime_lf filter=ROI_loose_lf max_freq=0.001 tau=2e-06
[OmnibusSigProc][filter-params] stage=decon_2D_ROI_refine filter=Wiener_tight_U sigma=0.000286735 power=8.07074 flag=1 max_freq=0.001
[OmnibusSigProc][filter-params] stage=runtime_hf filter=Wiener_tight_V sigma=0.000289041 power=9.94129 flag=1 max_freq=0.001
[OmnibusSigProc][filter-params] stage=decon_2D_ROI_refine filter=Wiener_tight_V sigma=0.000289041 power=9.94129 flag=1 max_freq=0.001
[OmnibusSigProc][filter-params] stage=decon_2D_init_wire filter=Wire_col sigma=5.6419 power=2 flag=0 max_freq=1
[OmnibusSigProc][filter-params] stage=runtime_hf filter=Wiener_tight_W sigma=0.000207127 power=4.13956 flag=1 max_freq=0.001
[OmnibusSigProc][filter-params] stage=runtime_hf filter=Wiener_wide_U sigma=0.000186765 power=5.05429 flag=1 max_freq=0.001
[OmnibusSigProc][filter-params] stage=runtime_hf filter=Gaus_wide sigma=0.00012 power=2 flag=1 max_freq=0.001
[OmnibusSigProc][filter-params] stage=runtime_hf filter=Wiener_wide_V sigma=0.0001936 power=5.77422 flag=1 max_freq=0.001
[OmnibusSigProc][filter-params] stage=runtime_hf filter=Wiener_wide_W sigma=0.000175722 power=4.37928 flag=1 max_freq=0.001
```

❑ Case 2. PD-VD HfFilter

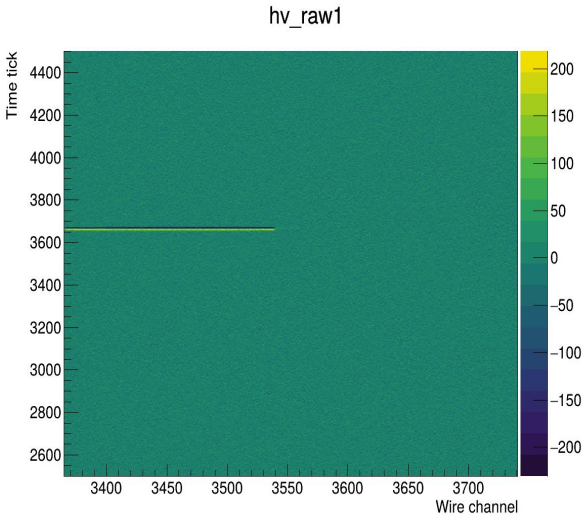
- Need to check how the decon waveform is affected by changing the parameters of the Wiener filter

Software Filter Study

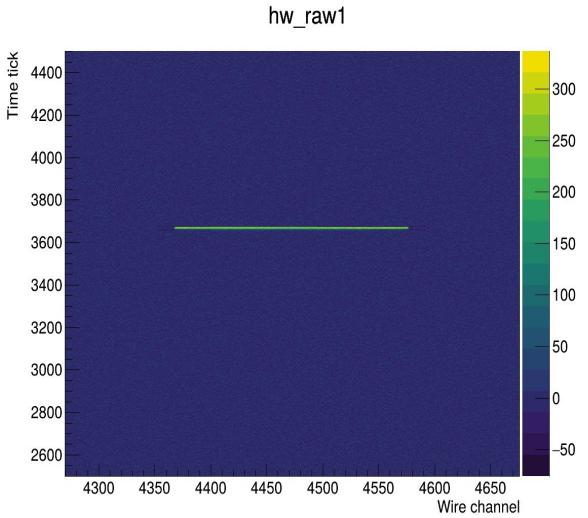
- Confirming the method to get parameters is correct



p0 = 0.168801
p1 = 3.11267



p0 = 0.18197
p1 = 5.35323

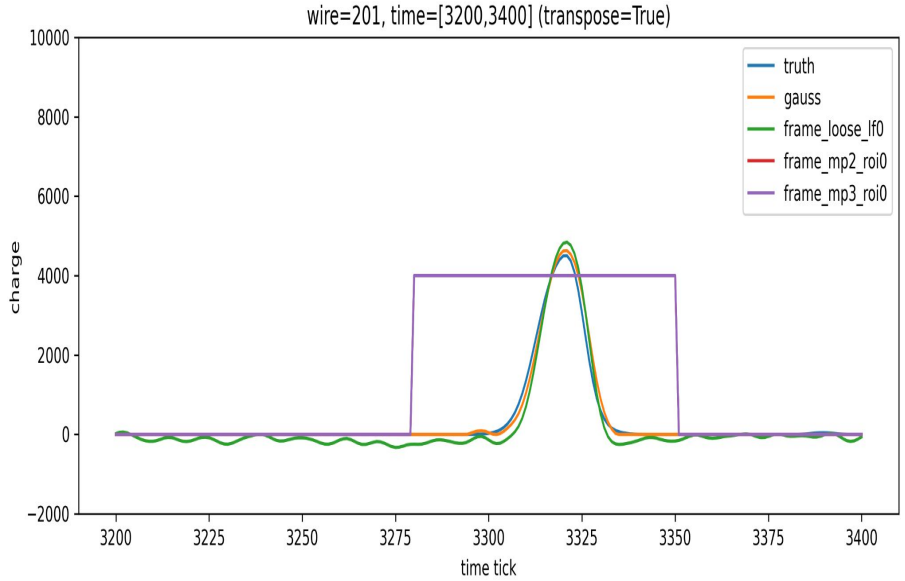


p0 = 0.155818
p1 = 2.73558

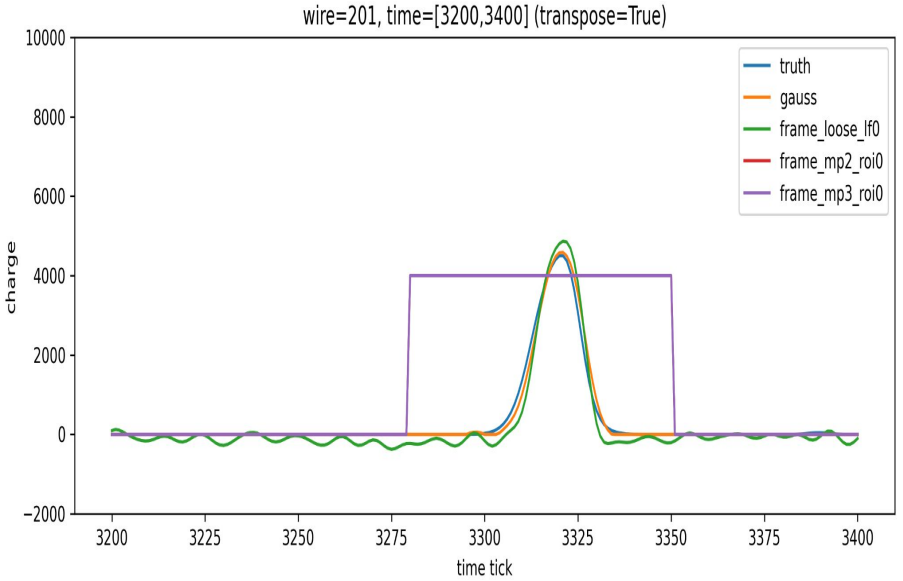
- The fitted parameters are different from PD-HD HfFilter we used

Software Filter Study

- Even the fitted parameters are different, the waveform is well aligned



❑ Case 1. My parameters

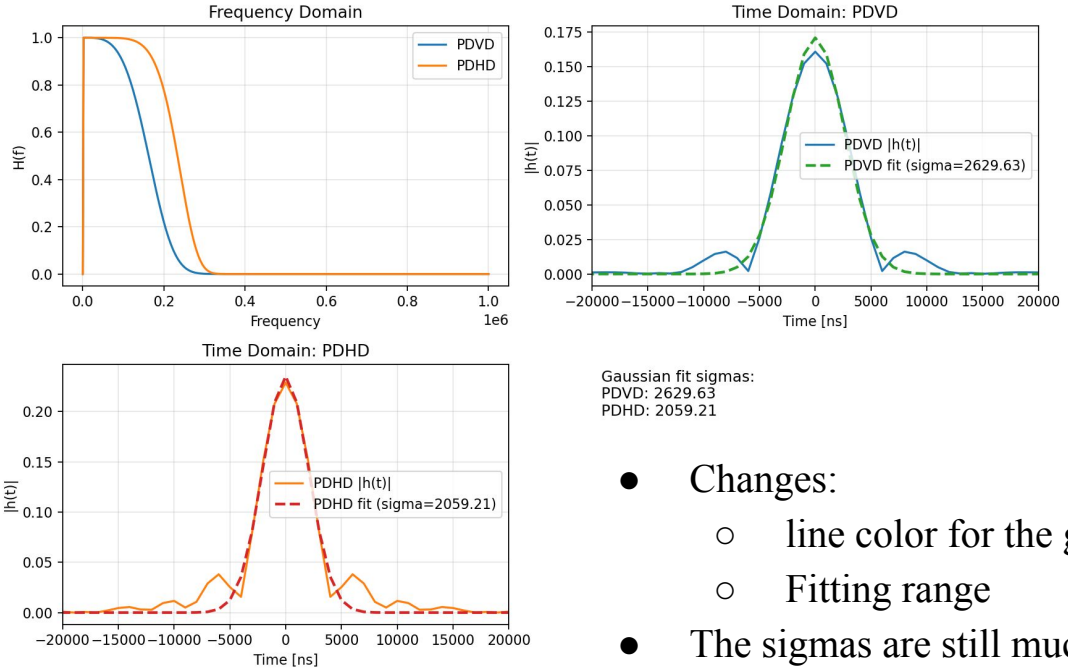


❑ Case 2. Wenqiang's parameters

```
[OmnibusSigProc][filter-params] stage=runtime_hf filter=Wiener_tight_U sigma=0.000168801 power=3.11267 flag=1 max_freq=0.001
```

Truth Smearing Study

- Frequency domain Wiener filter → IFFT → Time domain signals → Gaussian fit



Gaussian fit sigmas:
PDVD: 2629.63
PDHD: 2059.21

- Changes:
  - line color for the gauss fit to prevent misreading
  - Fitting range
- The sigmas are still much larger than the parameter used in the cfg
- Currently studying Brett's morse test tool to make it work for PD-VD

Back Up

Software Filter and Truth Smearing

- PD-HD and PD-VD are using different software filter (Wiener tight)
- For the truth smearing, they are using the same values
- PD-HD HfFilter: Optimized
- PD-VD HfFilter: parameters from PD-SP

❑ PD-HD HfFilter

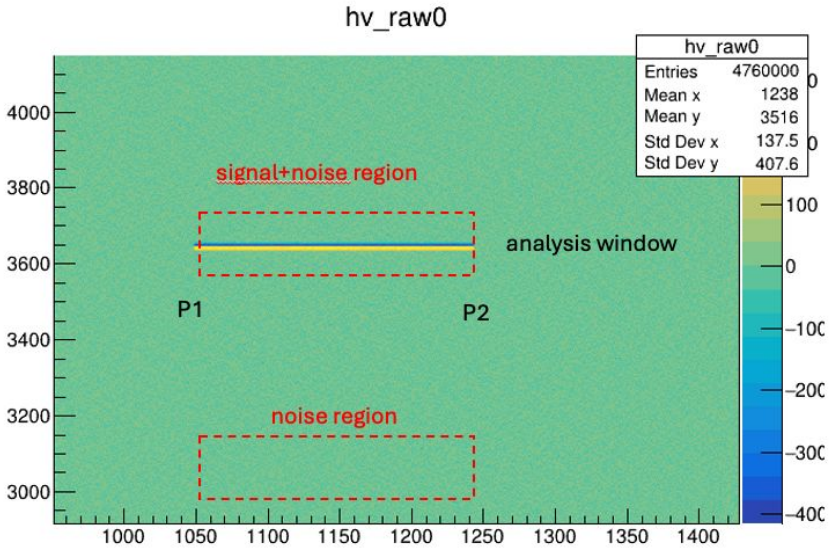
❑ ~~PD-VD HfFilter~~

❑ PD-SP HfFilter

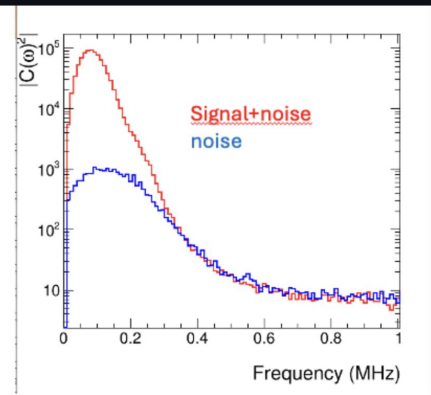
❑ Smearing

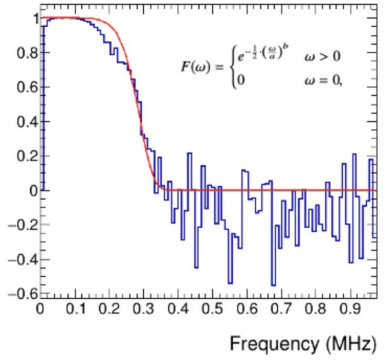
Software Filter Optimization

- There is a tool to get the optimized sigma and power for the HfFilter
  - https://github.com/WireCell/wire-cell-toolkit/blob/feature/xn_WF_fitter_script/root/test/calcFilter.C
  - https://github.com/WireCell/wire-cell-toolkit/blob/feature/xn_WF_fitter_script/root/docs/calcFilter.org
- Isochronous track sample is needed



1. **c1**: Power spectral density comparison
   - Red: Signal + noise power density
   - Blue: Noise-only power density
2. **c2**: Wiener filter response
   - Normalized to maximum value of 1
   - Fitted with function: `exp(-0.5*(x/p0)^p1)`
   - Fit parameters printed to console



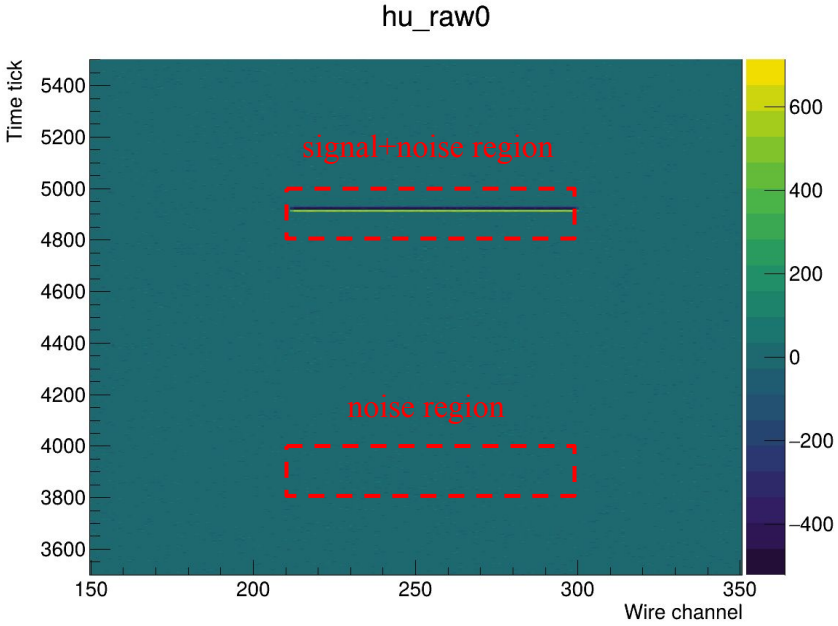


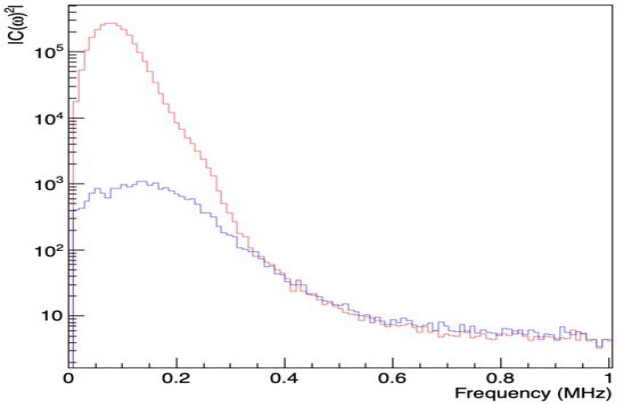
EXT NO.	PARAMETER NAME	VALUE	ERROR	STEP SIZE	FIRST DERIVATIVE
1	p0	2.69885e-01	3.74802e-02	2.98269e-05	3.55623e-02
2	p1	8.34938e+00	6.86118e+00	5.42952e-03	-2.51530e-04

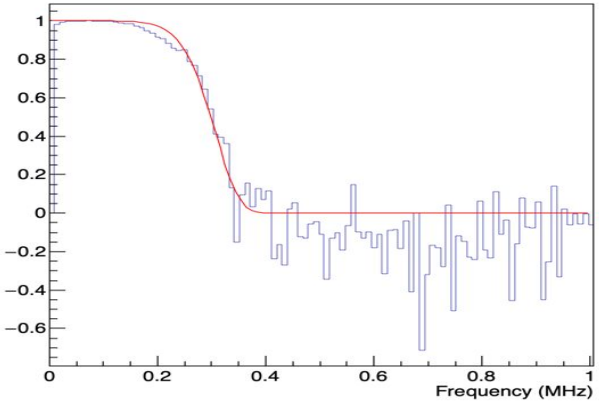
Software Filter Optimization

- Fitted values for PDVD bottom electronics (CRU0)
- u plane; p0 (sigma), p1 (power)

```
p0                      =      0.286735   +/-   0.0417082
p1                      =      8.07074    +/-   9.90182
```



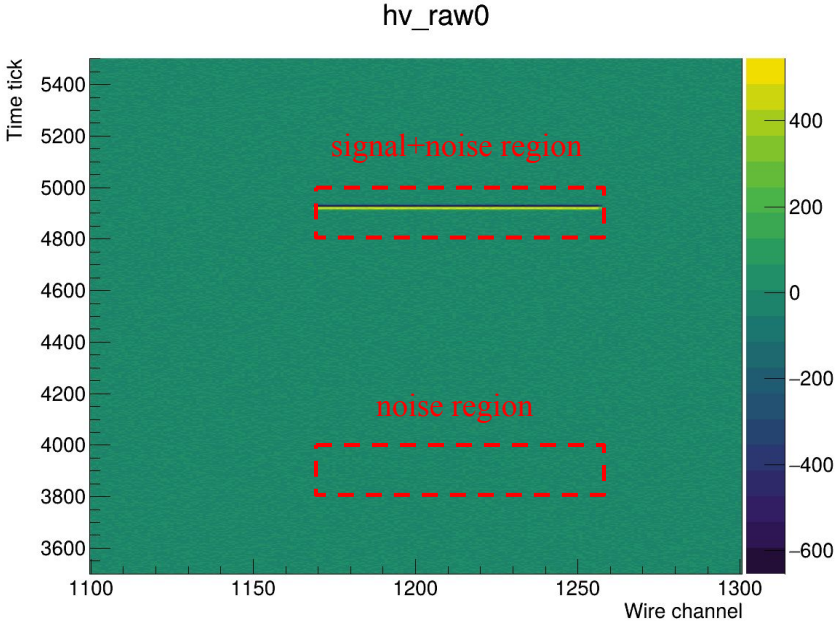


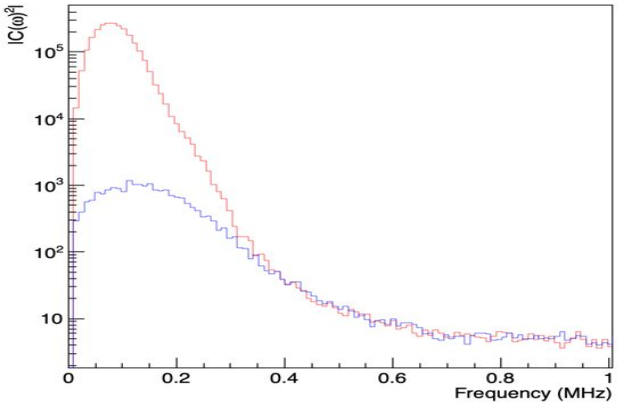


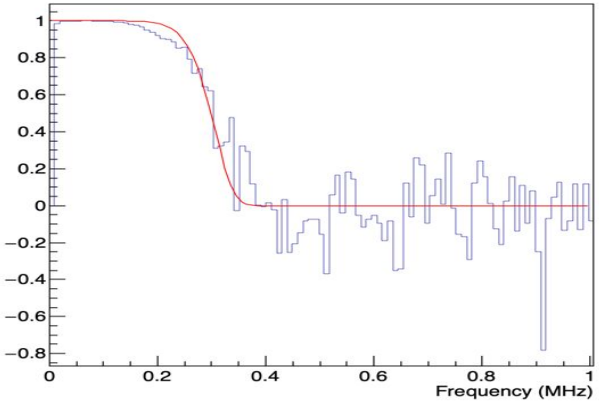
Software Filter Optimization

- Fitted values for PDVD bottom electronics (CRU0)
- v plane; p0 (sigma), p1 (power)

```
p0                      =      0.289041   +/-   0.0341532
p1                      =      9.94129    +/-   9.32916
```



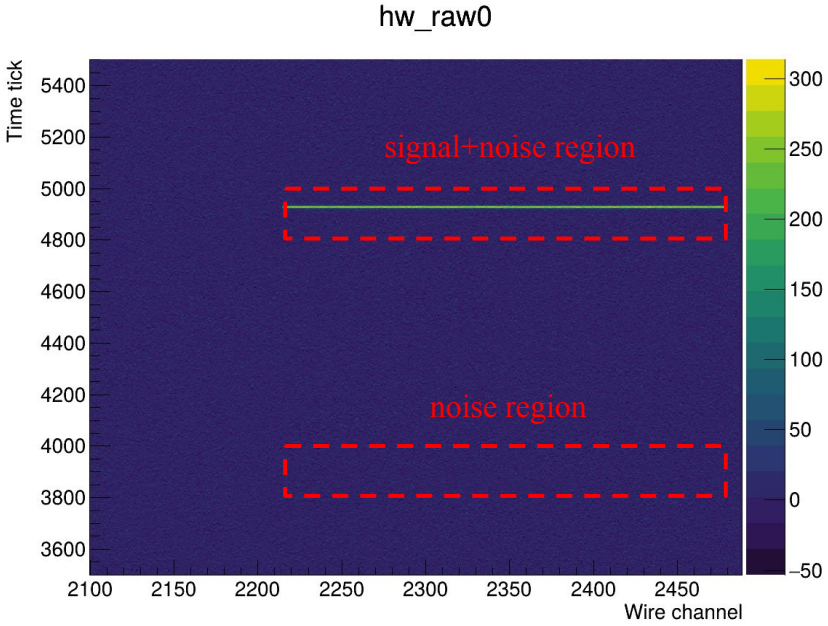


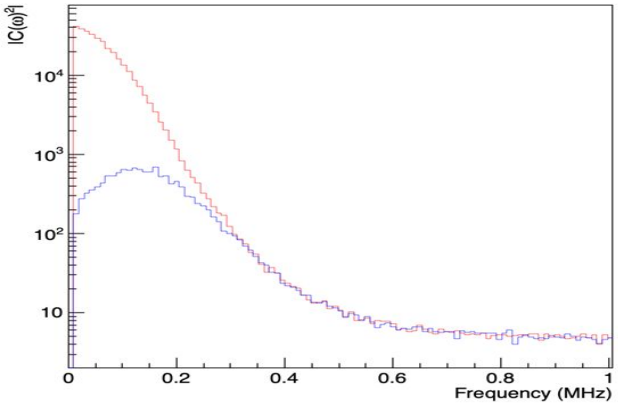


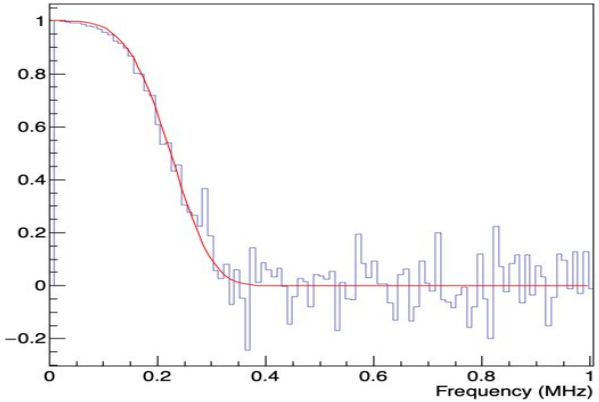
Software Filter Optimization

- Fitted values for PDVD bottom electronics (CRU0)
- w plane; p0 (sigma), p1 (power)

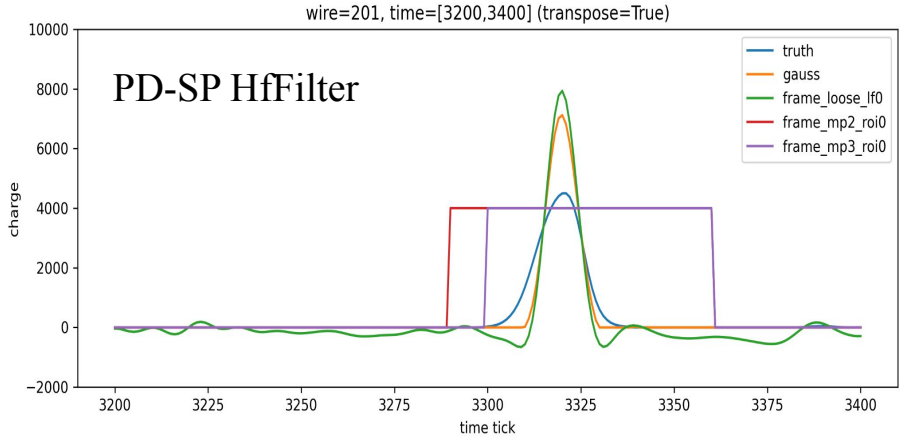
```
p0                        =      0.207127
p1                        =      4.13956
```

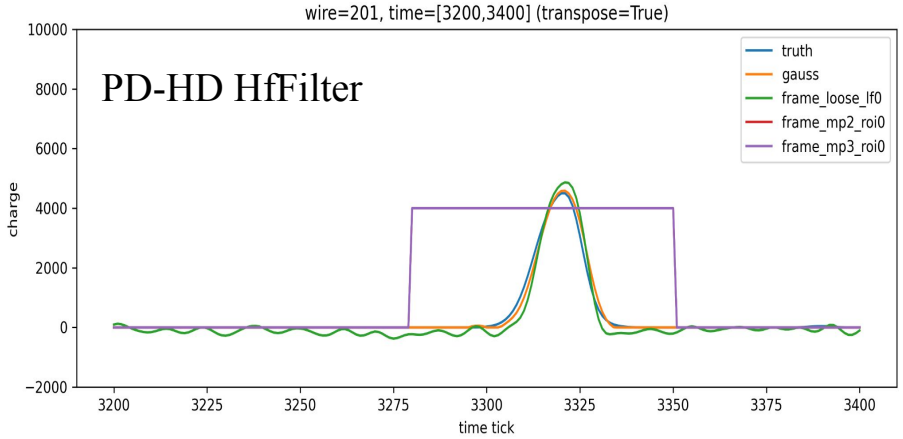


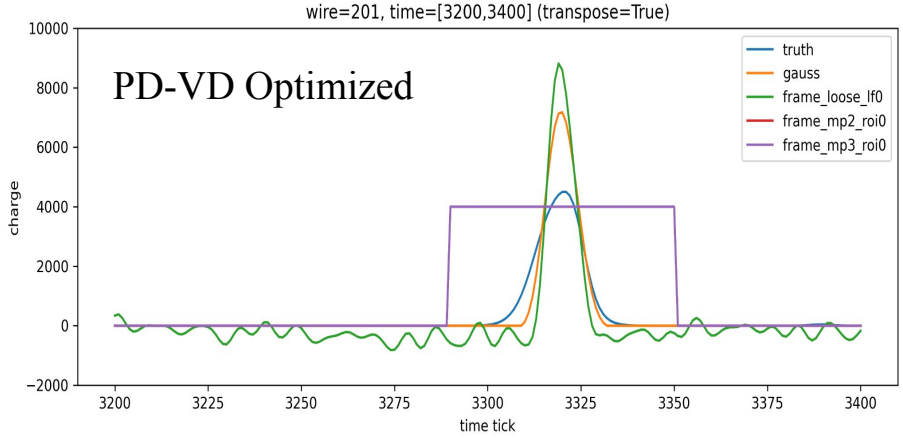




Software Filter Comparison



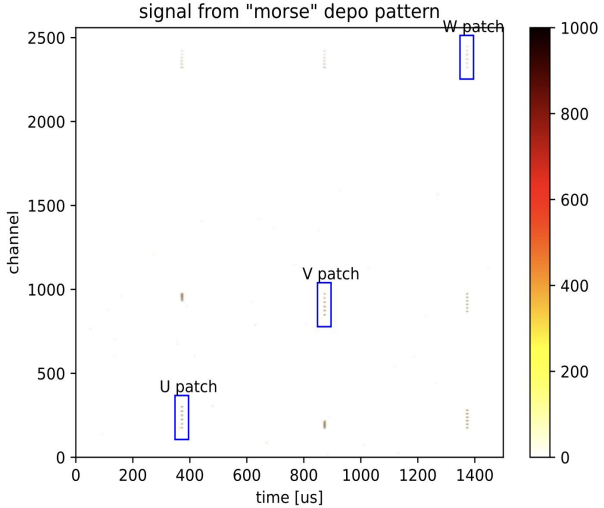


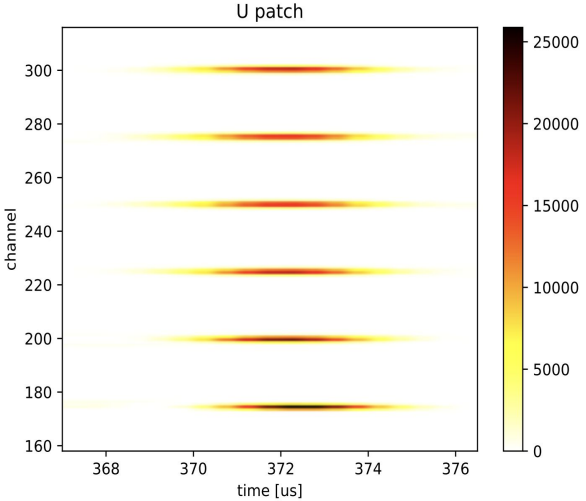


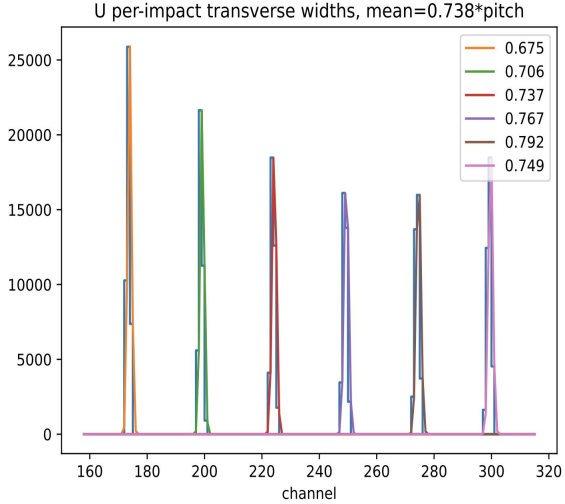
- Optimized filter gives tighter and higher loose_lf
- Also noisier than PD-SP and PD-VD on u plane
- If we keep the truth smearing value as current, the discrepancy still exists

Truth Smearing - Approach 1

- Morse test tool provided by Brett
  - https://github.com/WireCell/wire-cell-toolkit/blob/master/test/scripts/bats-debug
  - https://github.com/WireCell/wire-cell-toolkit/blob/master/test/test/test-morse-pdsp.bats



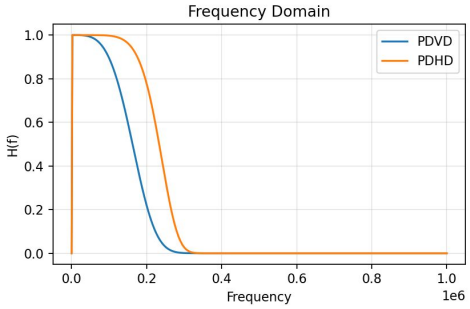


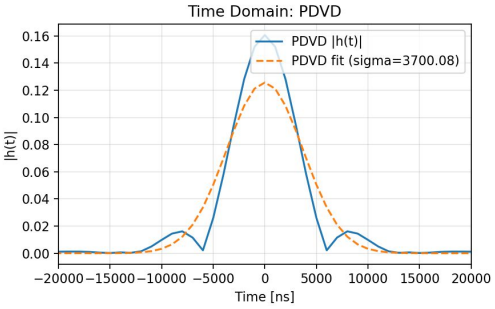


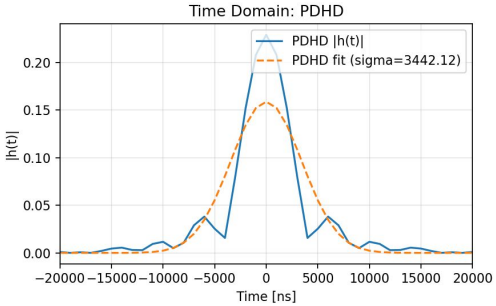
- The tool is not fully ready for PD-VD
- Would be precise, but need to understand how to use

Truth Smearing - Approach 2

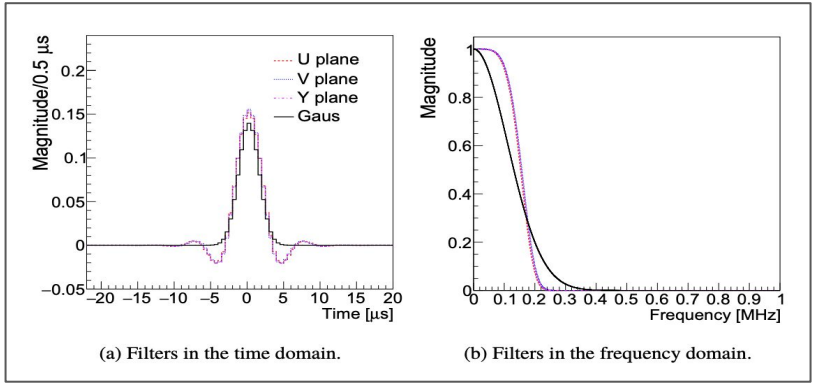
- Frequency domain Wiener filter → IFFT → Time domain signals → Gaussian fit







Gaussian fit sigmas:
PDVD: 3700.08
PDHD: 3442.12



(a) Filters in the time domain. (b) Filters in the frequency domain.

https://arxiv.org/abs/1802.08709

- The shape looks similar with the one from MicroBooNE paper
- Relatively easy, but still need to understand how to get right numbers
- Support from Hanyu Wei may be needed

Future tasks

- Memory check
  - Is the high peak at the last really due to the APA1?
  - Tag Selector test and validation
  - Remove the unneeded datasets from the HDF5 and check the file size
- Comments from the 2026 DUNE CM @ CERN
  - Jake: noise level (PDHD vs PDVD)
  - Xin: generalize the model, train the model with loose_lf only → performance

- PD-VD sample production
  - PD-HD wiener filter optimization -> check consistency
  - Add decon waveform and remove mp2_roi, improve visibility
  - cout lines added to OmnibusSigProc.cc and results to ensure the filter params are set correctly
  - Current sim is only using Bottom? Top? electronics response
  - HDF5 compression issue.., needed to be tested with recent version? or check params..
  - Pick up a similar track from the real data and see the noise level and waveform