

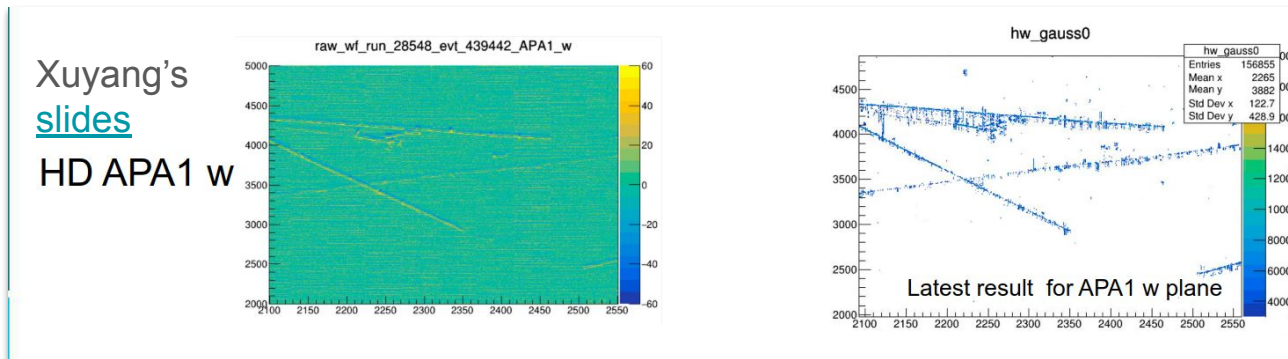
ML Approach to APA1 SigProc

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Introduction

We have an estimate of the APA1 field response with the W plane unpowered

- Even with this, traditional ROI finding struggles
 - This has knock-on effects for downstream reco i.e. hit finding/disambiguation/Pandora
- Here I present some progress attempting to ameliorate this with a DNNROI-style network

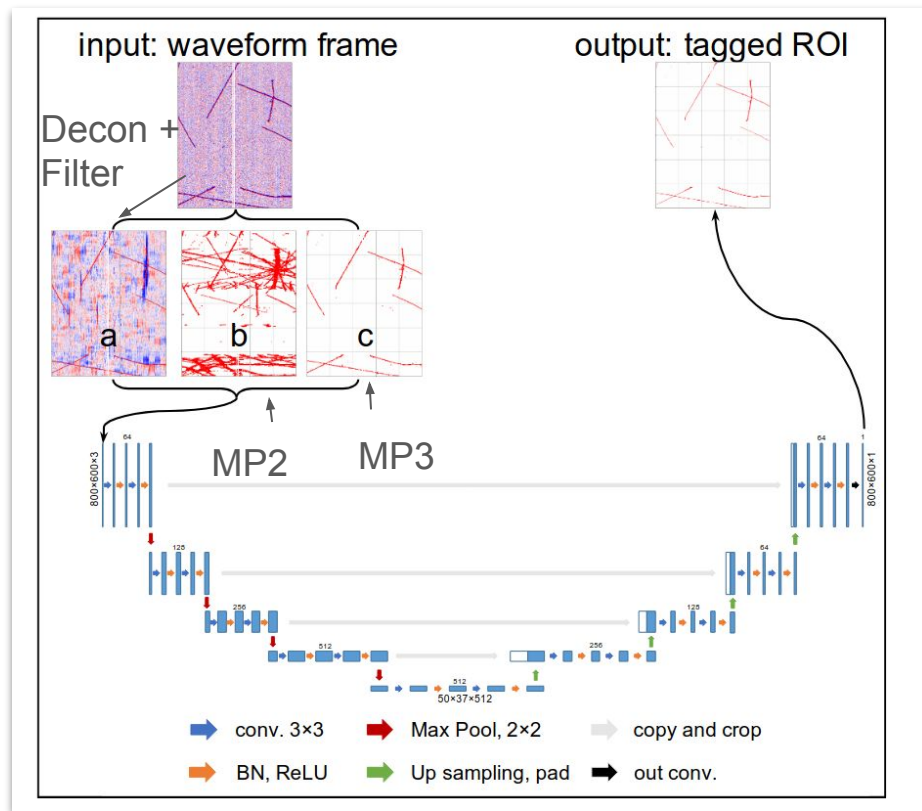


ROI Finding network

Last year, I presented an attempt to use a hybrid CNN/GNN approach to do ROI finding in an end-to-end ML approach which includes geometric information (usually given by MP2/3 in DNNROI)

After another attempt at a complicated network I realized starting simpler was more effective

- Start with just DNNROI w/ dense waveforms

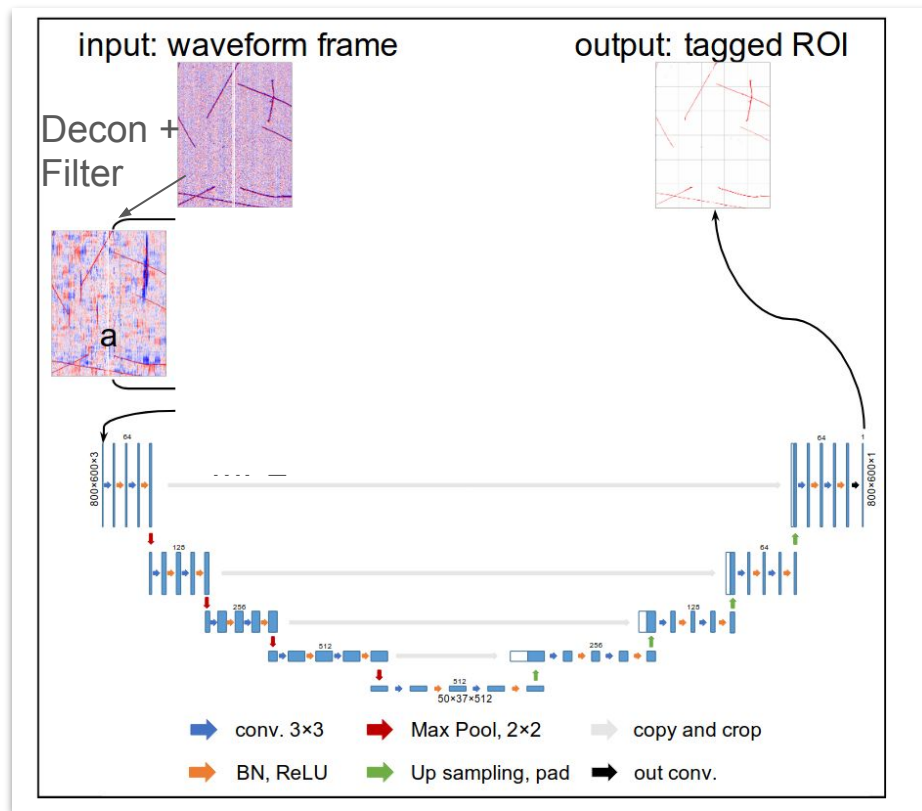


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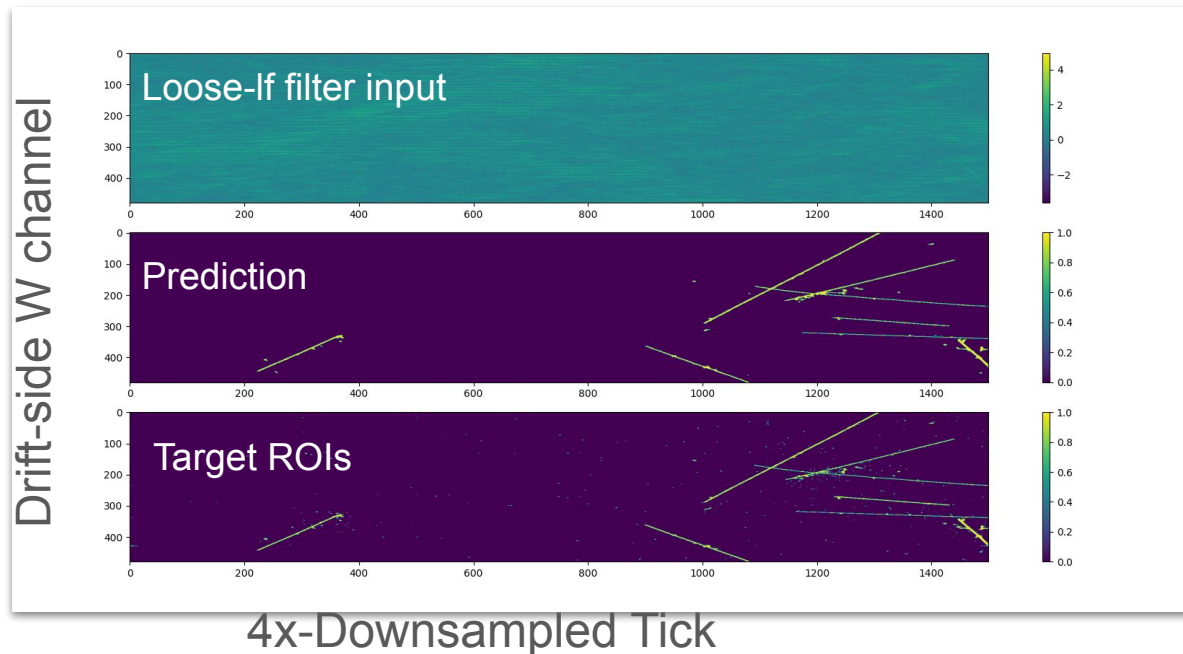
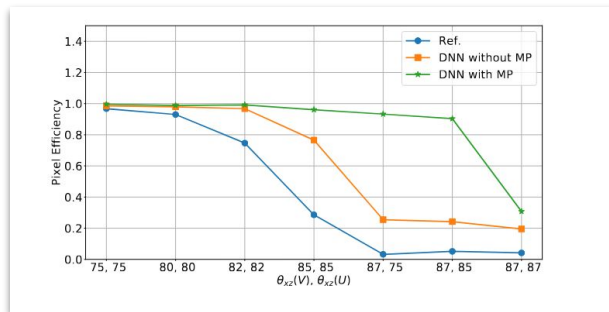


ROI Finding results

I retrained DNNROI with only dense input from simulated APA1 W plane cosmic events

We can see it does very well on this event

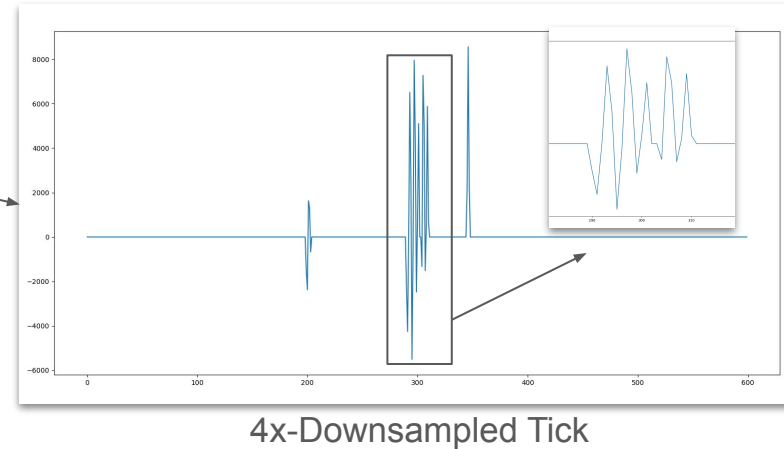
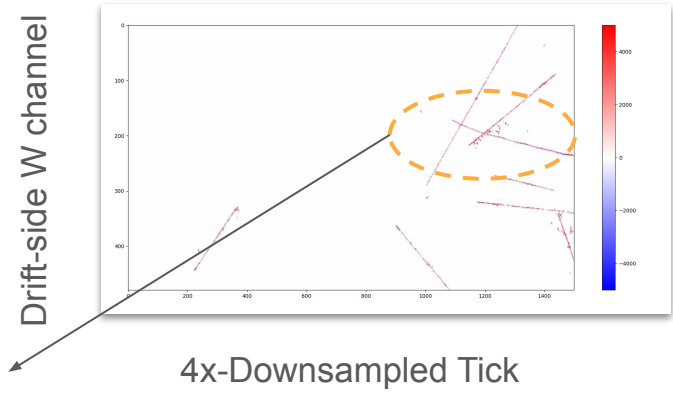
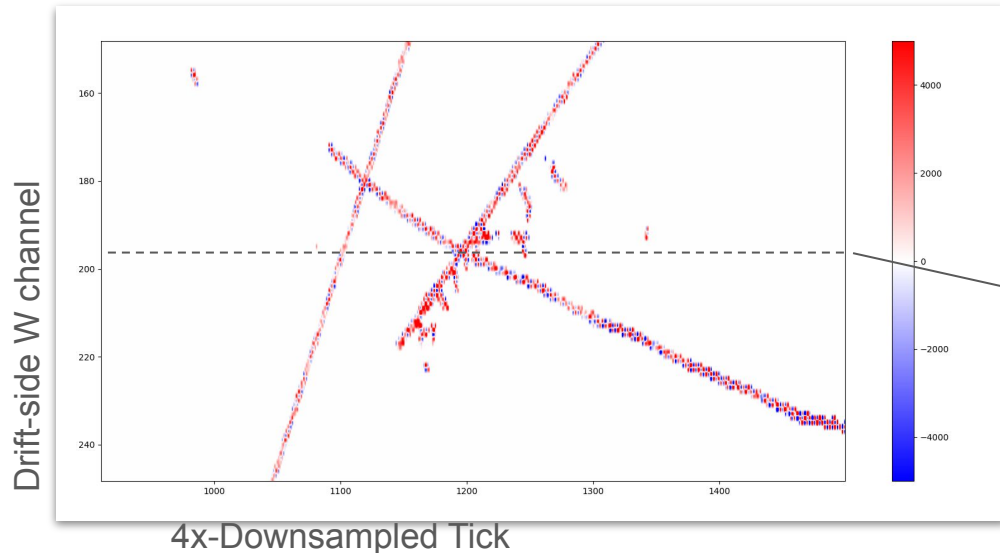
- The MP information gives benefit for highly-prolonged tracks (see 'spdir' plot from [DNNROI paper](#) top-right)
- At this point: I wanted to see how this looked when applying it to the Gauss-filtered waveforms (input to hit finding)



Applying to Gaussian waveforms

A lot of high frequency noise remains

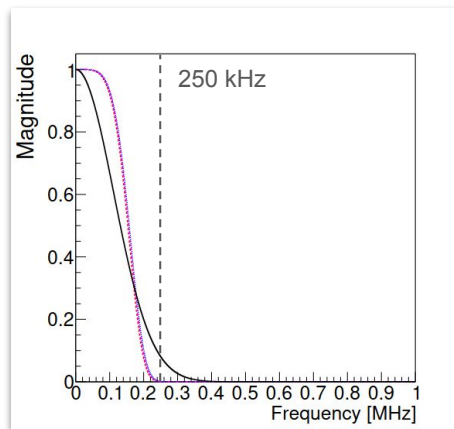
- Seems like it would be a big issue for hit finding



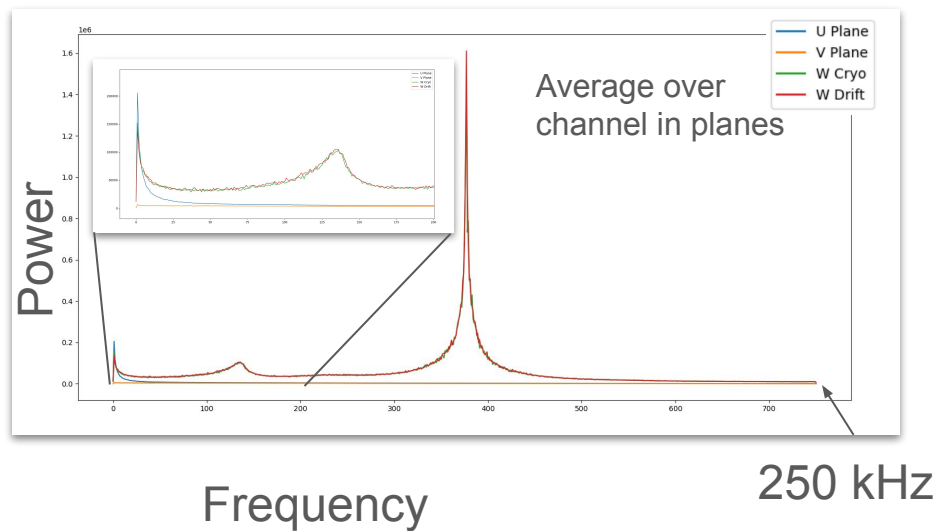
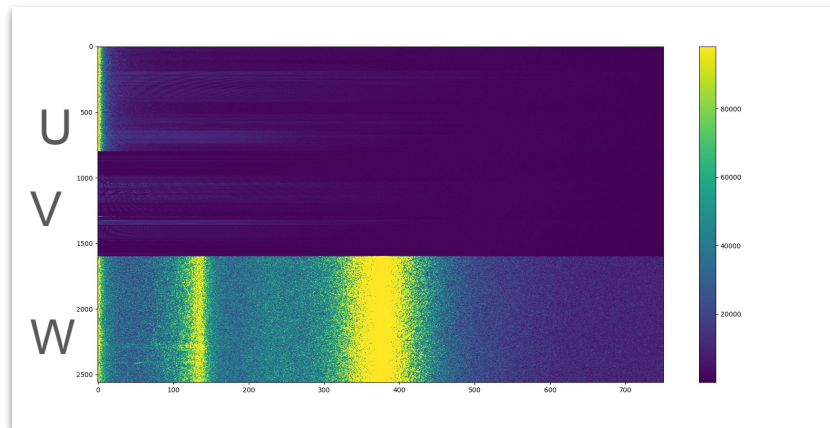
Power spectra

W-plane noise explodes after deconvolution due to its small response

- Preserved by Gaussian filter



Channels



Proposed solution

For normal detector operations, the approach of being conservative with ML approaches is understandable

- Understand physics of the detector → Informed reconstruction/processing choices → Less chance of bias sneaking into reconstruction (i.e. charge measurement)

For APA1:

- Tuning ROI finding for this case seems like a small return on investment
 - Limited use in future if DUNE FD APAs operate normally
- Noise enhancement after decon seems like an unavoidable issue

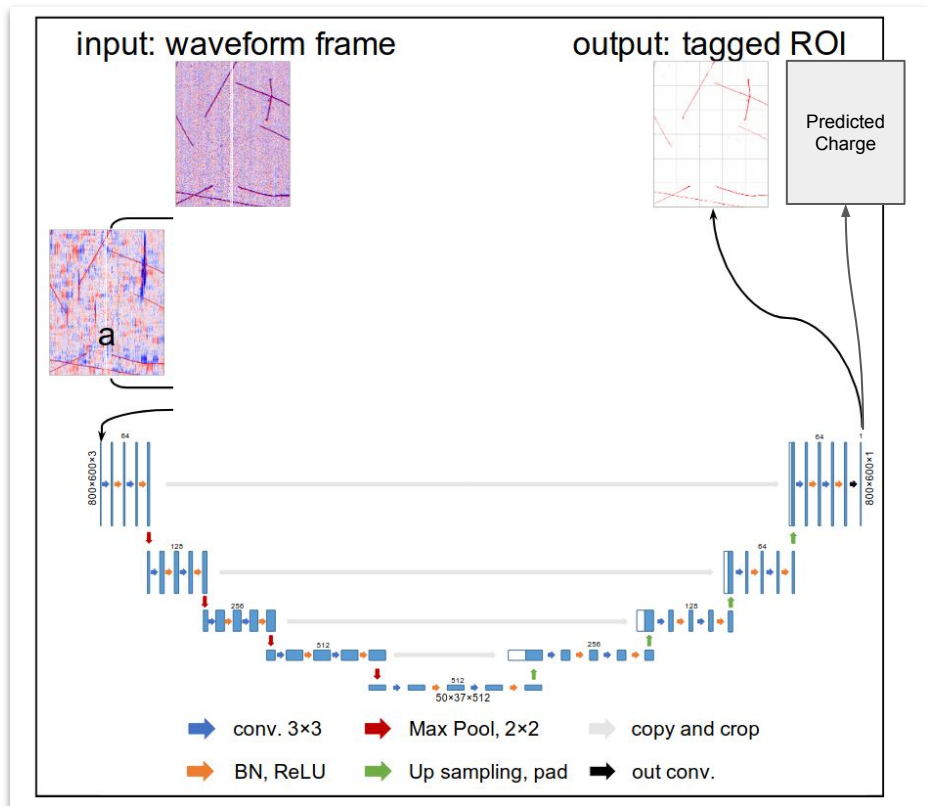
Solution: ML ROI finding & charge reconstruction for APA1 W plane for hit/3D reconstruction (Make sure analyzers never use it for calorimetry)

New Network: ROI & Charge Regression

- Add a head to the output of DNNROI
 - ROI Head: Classify ROI yes/no
 - Charge Head: Regress Charge waveforms
 - Separate loss terms
 - Normal BCE* for ROI
 - Mean-Square-Error for charge
 - Only where true ROI present in truth

$$\text{Loss} = \text{Loss}_{\text{ROI}} + \lambda * \text{Loss}_{\text{Charge}}$$

- Note: λ loss factor will require hyperparameter optimization

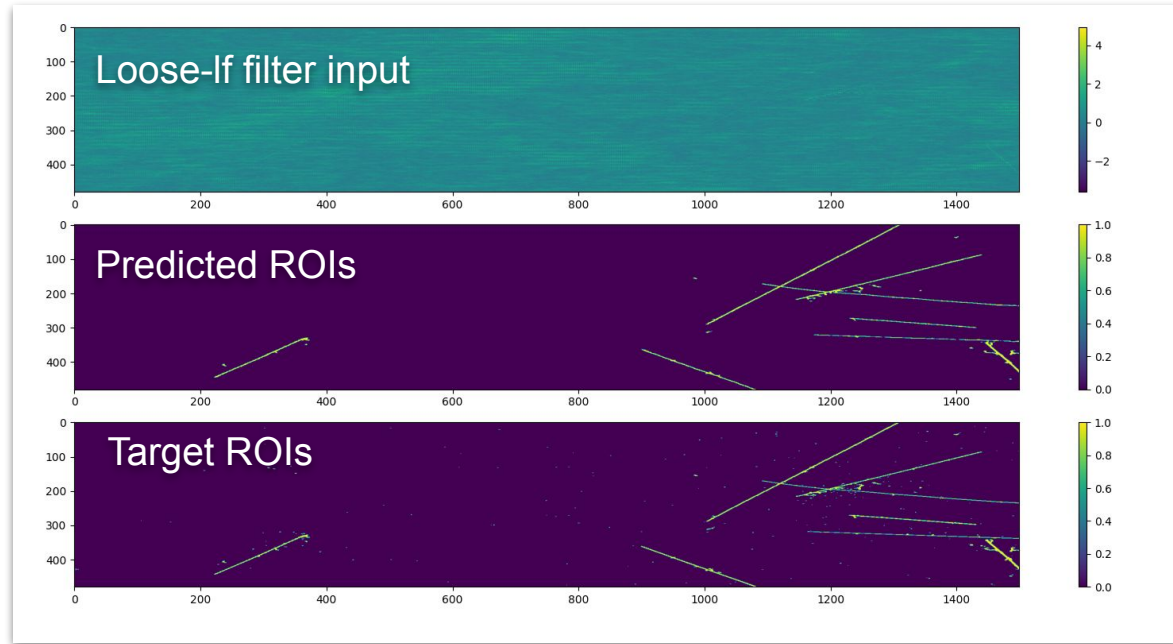
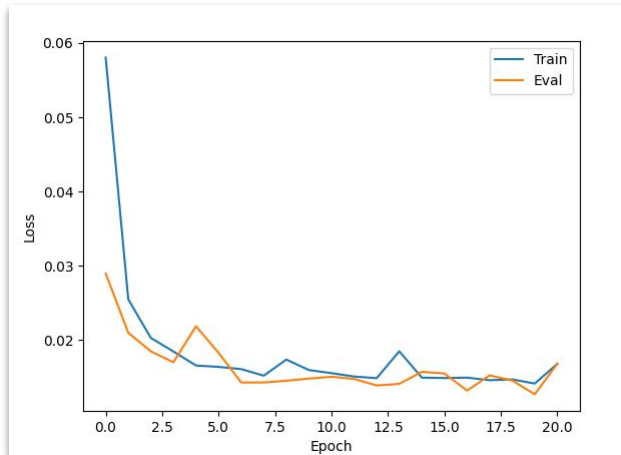


*BCE: Binary Cross Entropy

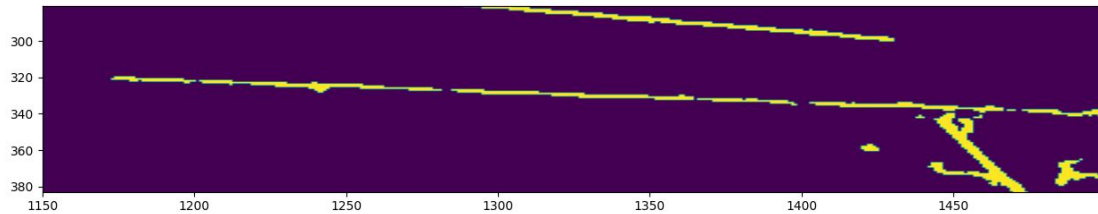
Testing – ROIs

Trained on 488 cosmic events for 21 epochs

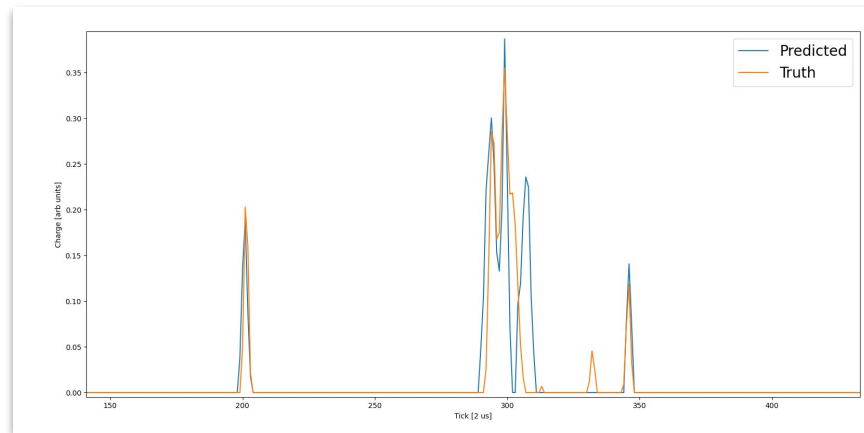
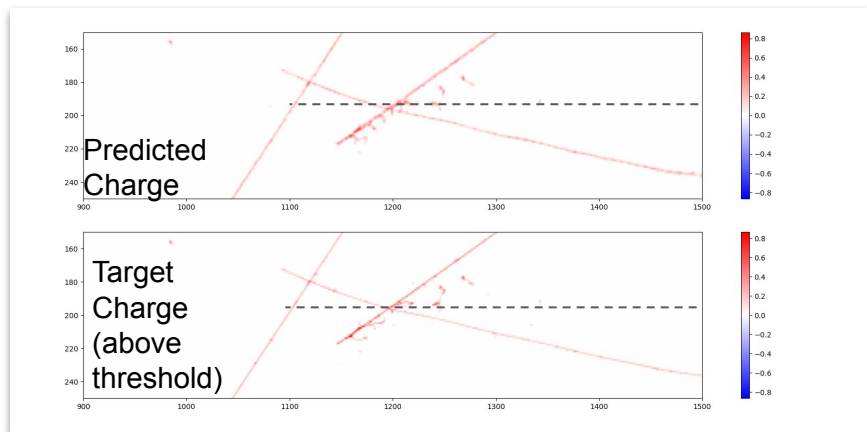
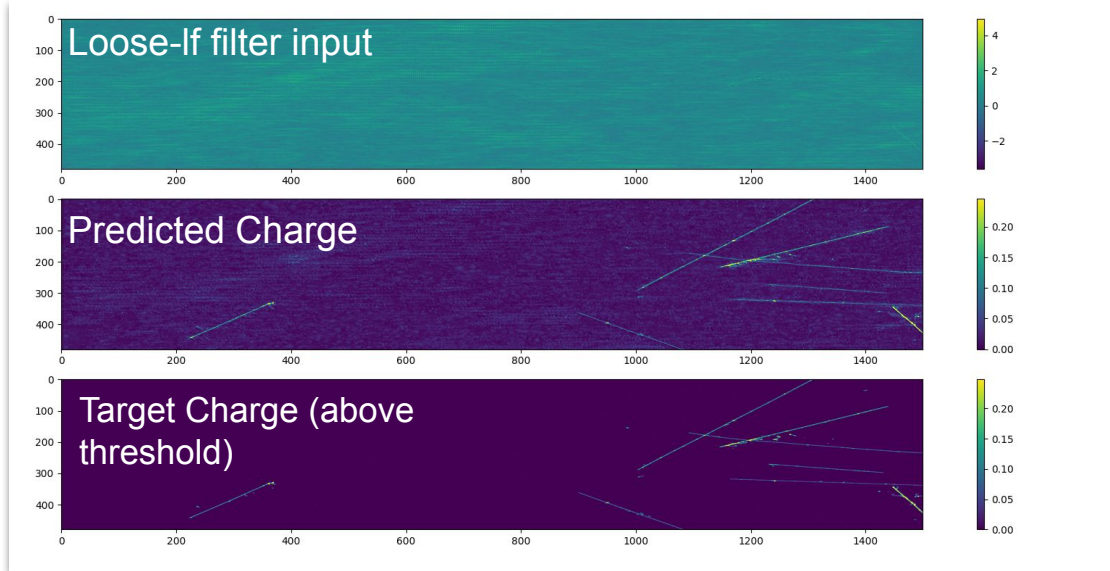
- Training curve indicates more training data needed?



Some ROI finding failures



Testing – Charge



Conclusion

Demonstrated an attempt to reconstruct charge on APA1 W plane using a slightly modified DNNROI

- Preliminary results show proof of concept, indicate more training data is needed

I'd also like to test hit this with hit finding

- Implemented model in SPNG branch of wire-cell-toolkit, needs a new spdlog release before it can be used in larsoft

Feedback/concerns welcome