USING A CONVOLUTIONAL NEURAL NETWORK TO RECONSTRUCT DEAD CHANNELS IN MICROBOONE

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MicroBooNE

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OVERVIEW

I. Goal of Infill Network

II. Network model and Training

III. Network Results

IV. Future Plans

THE MICROBOONE DETECTOR

- The MicroBooNE LArTPC contains 3 wire readout plans
  - U,V : induction planes
  - Y: collection plane
- The resulting data consists of 3 2D images of wire vs. time.
- The pixel intensity represents the deposited charge (ADC)

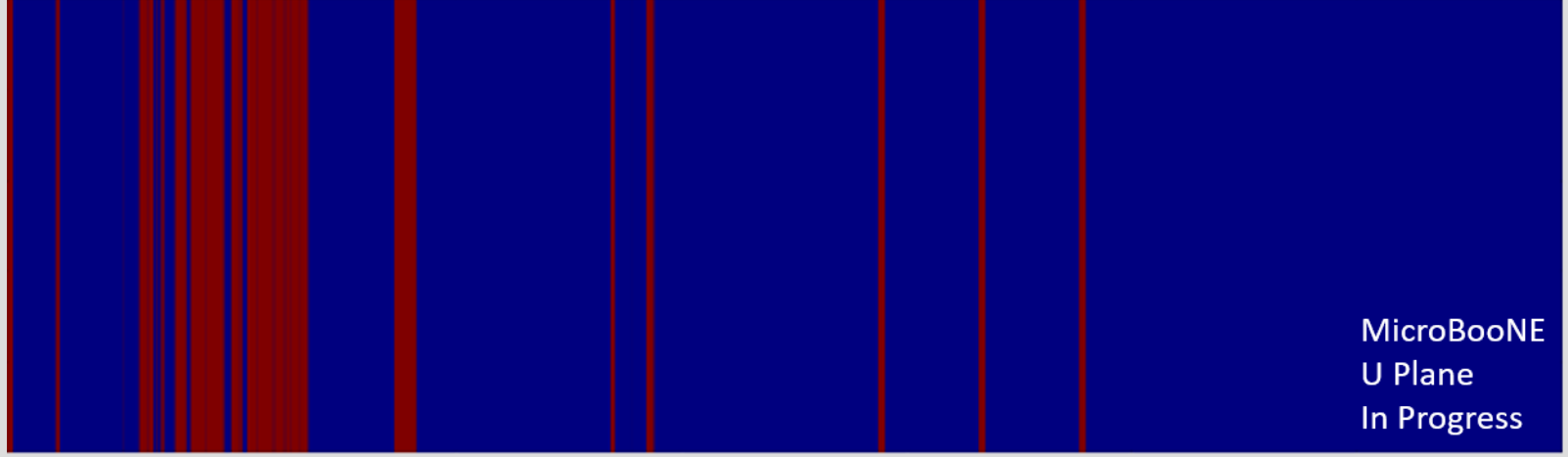
For more details see: Ionization Electron Signal Processing in Single Phase LArTPCs I. Algorithm Description and Quantitative Evaluation with MicroBooNE Simulation, The MicroBooNE Collaboration, https://arxiv.org/abs/1802.08709

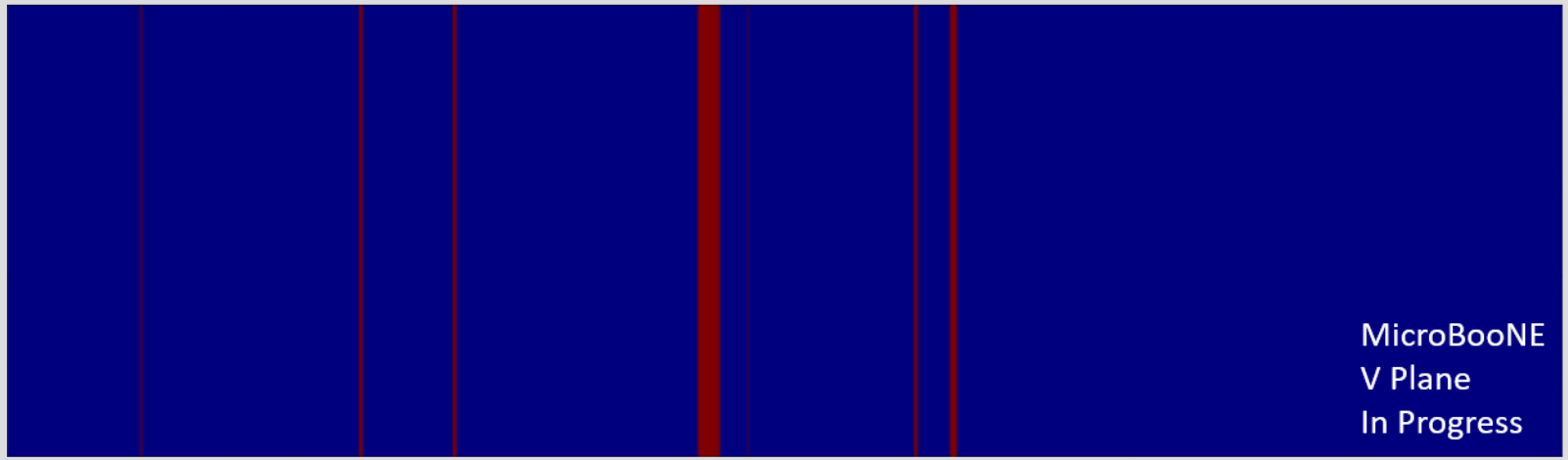
WIRE STATUS OF EACH PLANE

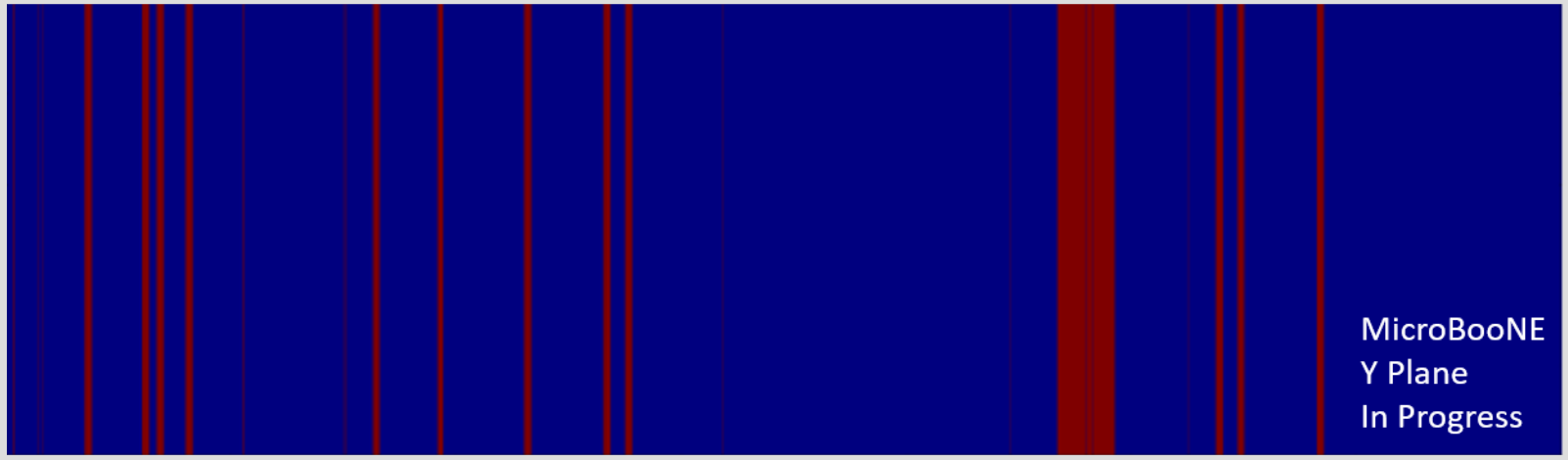
In each plane there are readout wires that are "dead". This includes:

- Unresponsive wires
- "Chirping" wires
- Wires with inconsistent readout over time

Goal: to create a network that fills in these dead wires with realistic ADC charge.







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NETWORK MODEL

The network is sparse, using submanifold convolutional layers

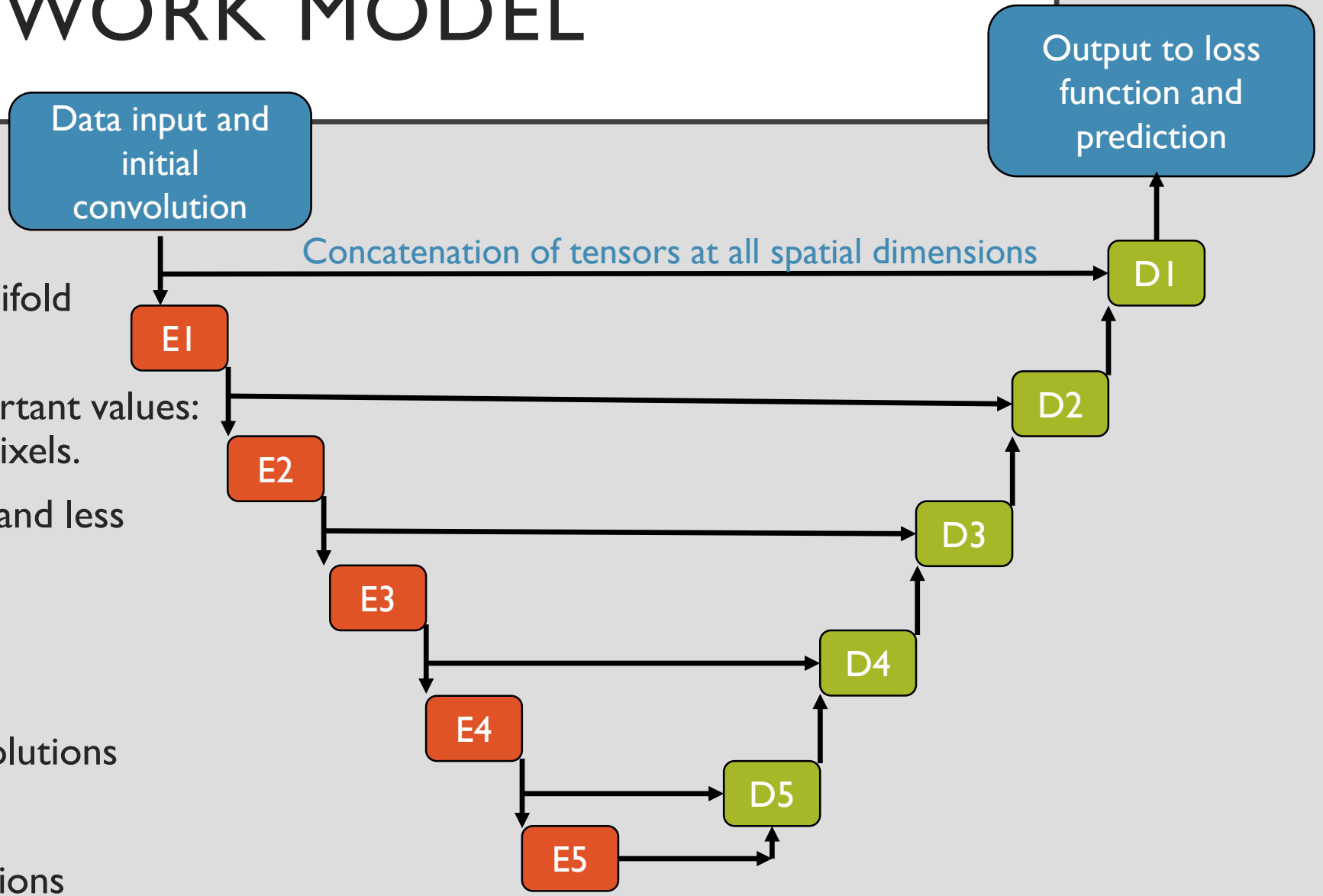
- Sparse networks only save important values: non-zero pixels and dead wire pixels.
- This allows for faster run times and less memory usage.

E = encoding layer:

- Down-sampling + ResNet convolutions

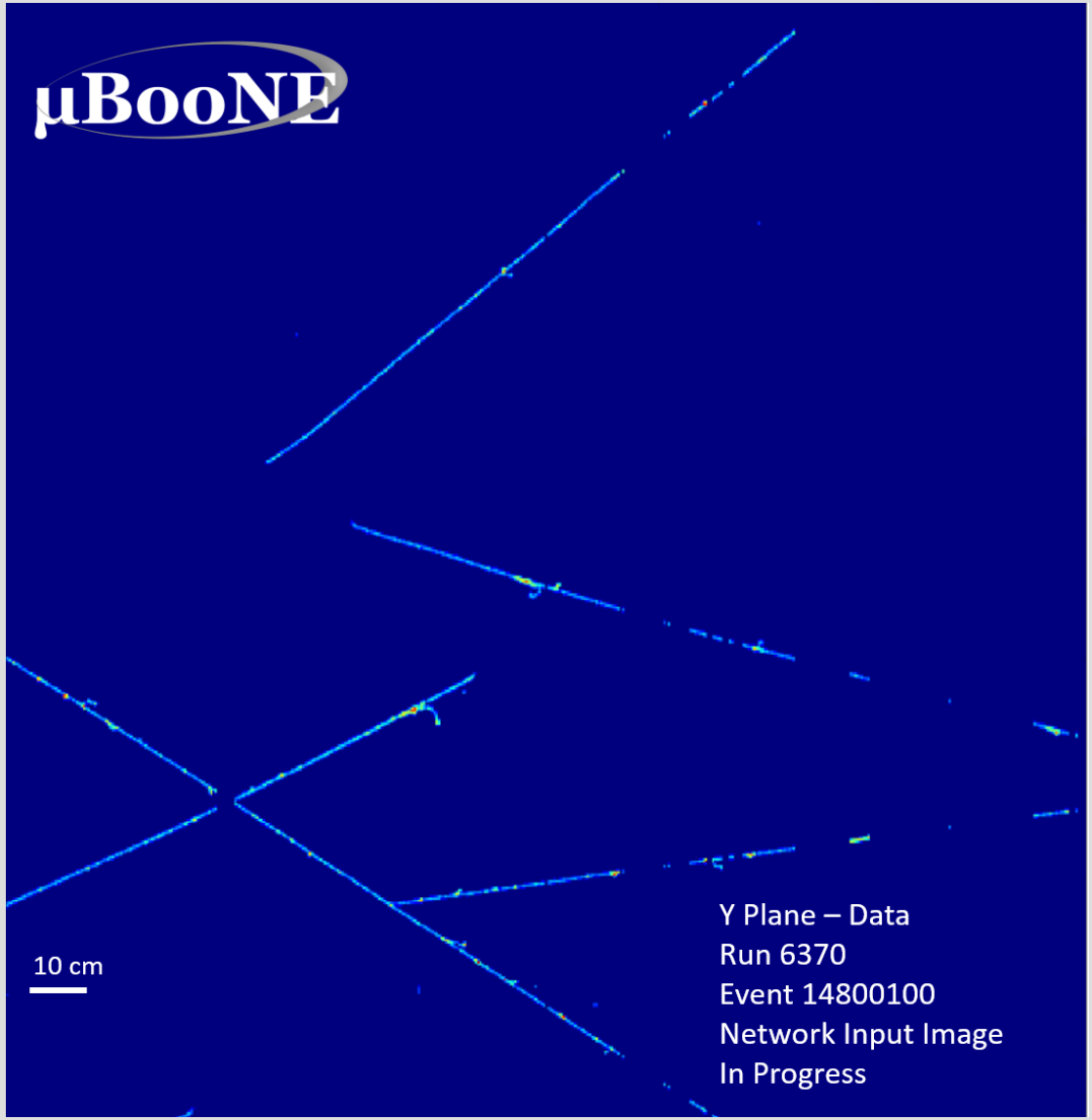
D = decoding layer:

- Up-sampling + ResNet convolutions



TRAINING IMAGES

- Infill has been trained on **cosmic data**.
  - A crop (496x512) is taken from part of the plane that does not have any dead wires.
  - A pattern of dead wires from elsewhere in the plane is overlaid on the image to create a training image.
  - This results in "true" images and network input images.
  - The network was trained on 160k crops from a set of cosmic data



NETWORK TRAINING AND TESTING

- The network was trained on each plane independently. This is to account for the different dead wire patterns.

- The loss function is an L1 loss with different weights categories.
  - non-dead pixels
  - dead pixels, true ADC = [0,10)
  - dead pixels, true ADC = [10,40)
  - dead pixels, true ADC = [40,70)
  - dead pixels, true ADC > 70

- The network is tested over a set of crops (from the same file set), that it never encountered in training.

NETWORK TRAINING AND TESTING

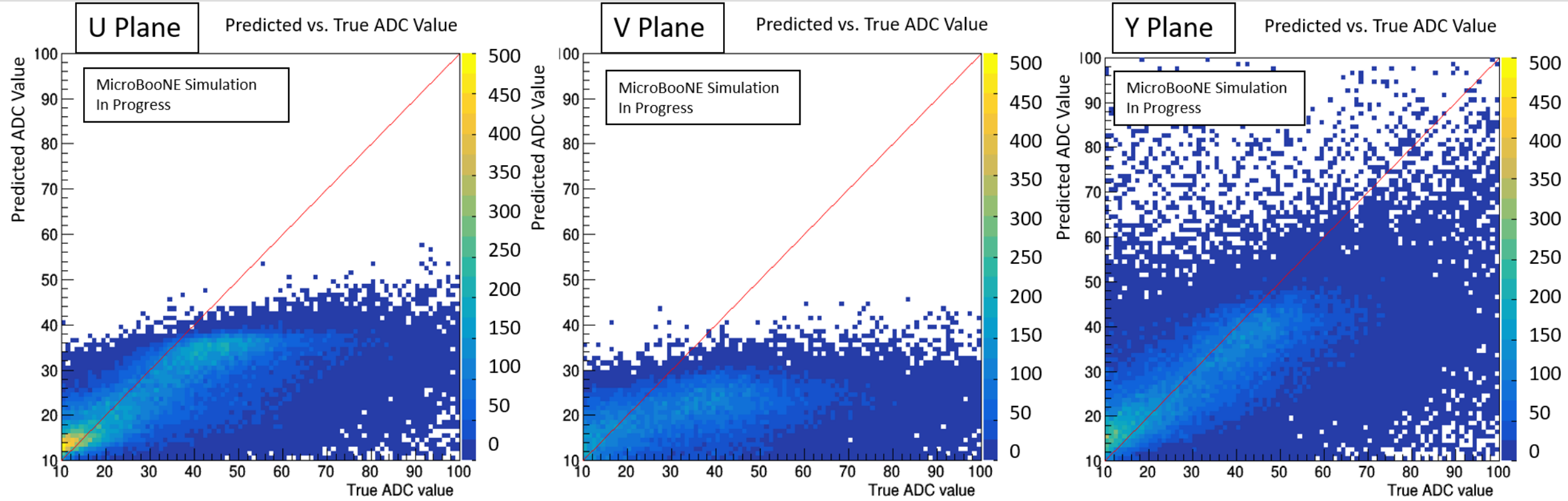
	U Plane (3 epochs)	V Plane (3 epochs)	Y Plane (4 epochs)
Within 2 ADC	27.24%	20.22%	25.20%
Within 5 ADC	45.33%	37.36%	43.83%
Within 10 ADC	66.82%	56.37%	66.73%
Within 20 ADC	84.47%	75.14%	84.88%
Binary Accuracy	98.40%	99.13%	99.16%

First four rows: Accuracy taken in dead channels where true ADC > 0

Last row: Binary accuracy about whether or not the network placed charge >10 where true ADC >10 (only in dead channels)

Differences in ADC Values

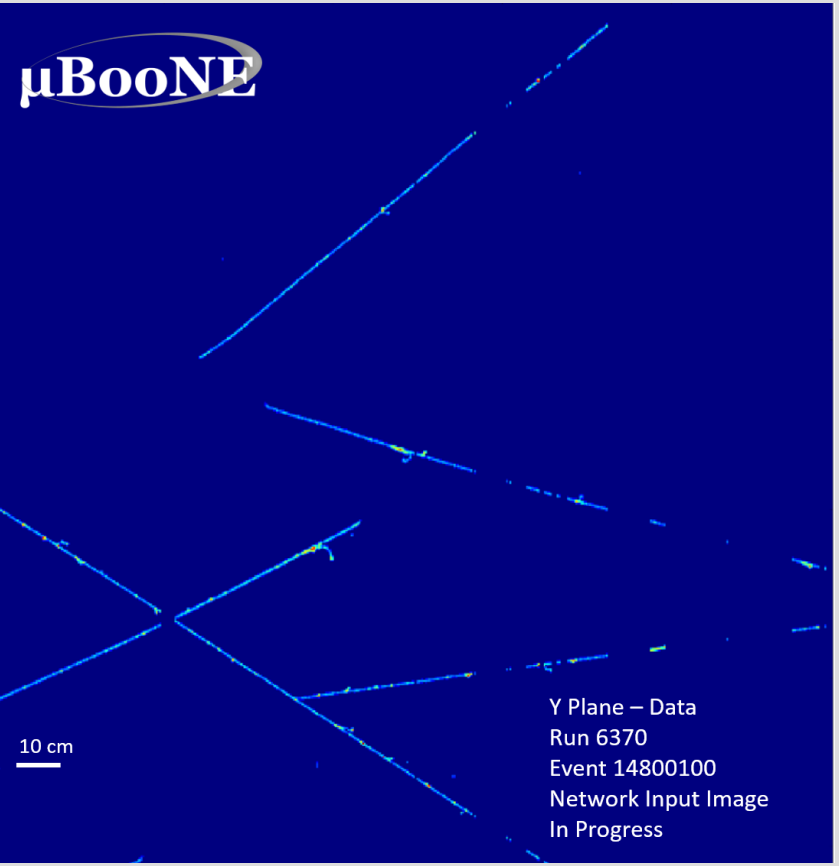
- Only pixels in dead regions are plotted
- The histograms have a threshold at 10 to mimic the final output

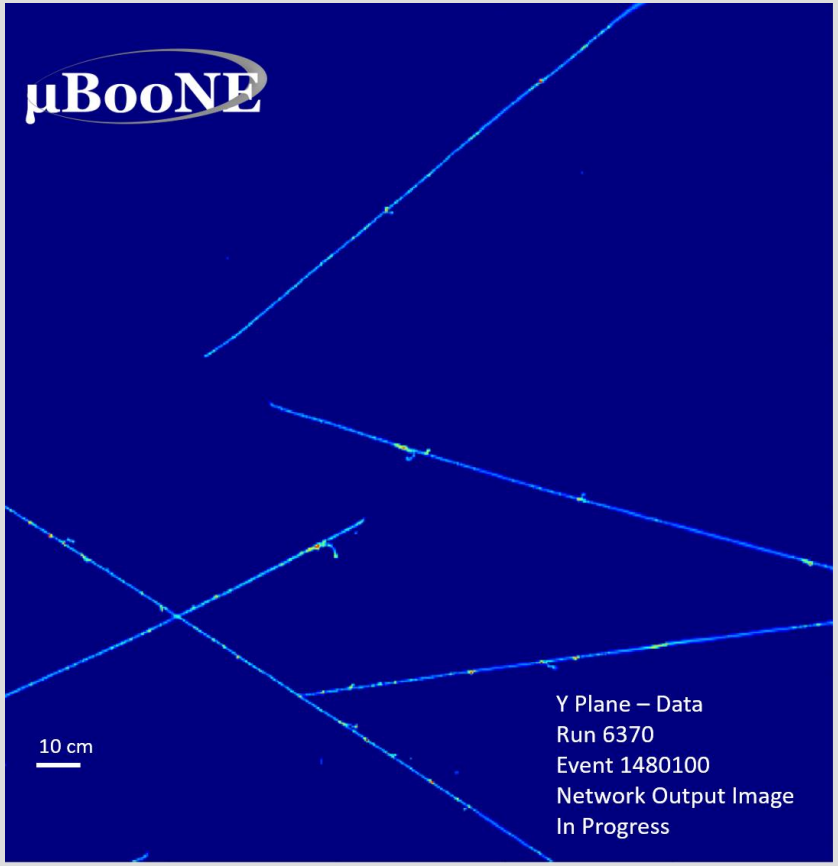


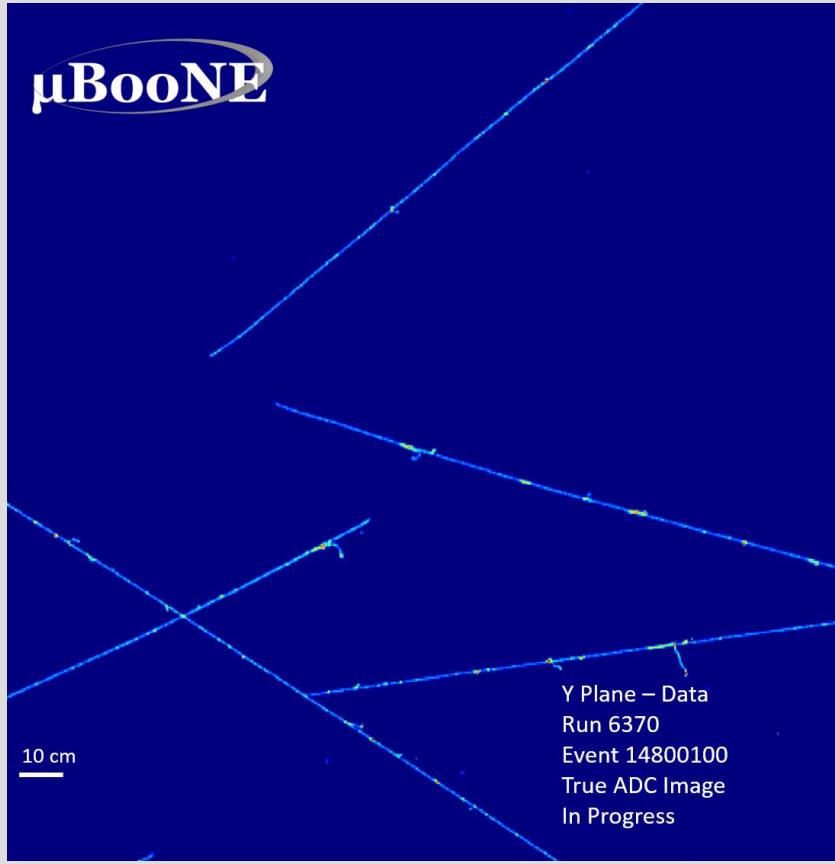
NETWORK OUTPUT IMAGES

- The direct output of the network is overlaid on the input image.
- Only pixels in dead wires are allowed to change.
- The entire image has a threshold of 10 ADC

Y Plane Example

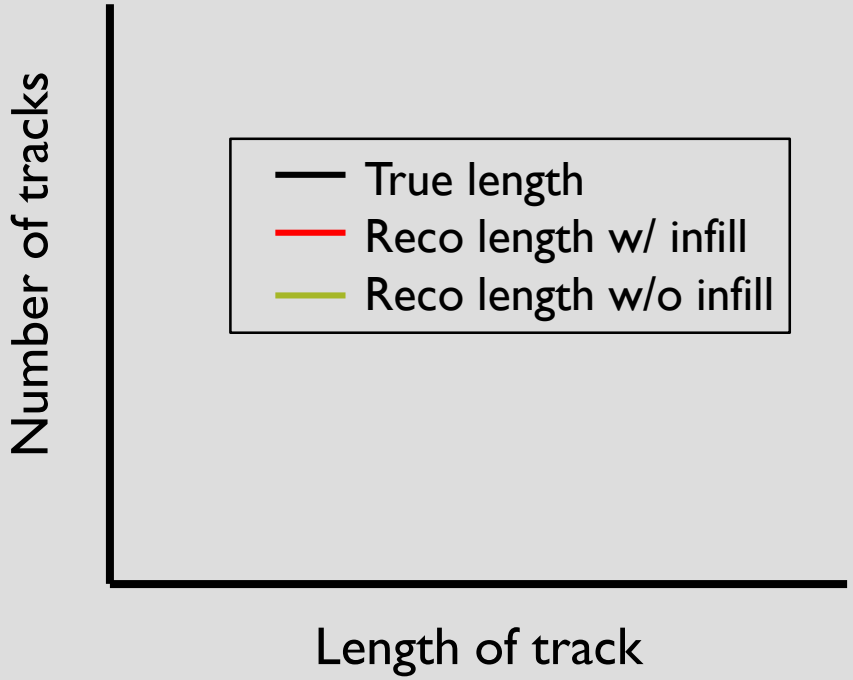






NEXT STEPS

- Test performance of track reconstruction with and without infill applied



- Incorporate with other MicroBooNE DL Networks (see talks by Joshua Mills, Ralitsa Sharankova, Rui An, Nick Kamp, Ran Itay)

THANK YOU!

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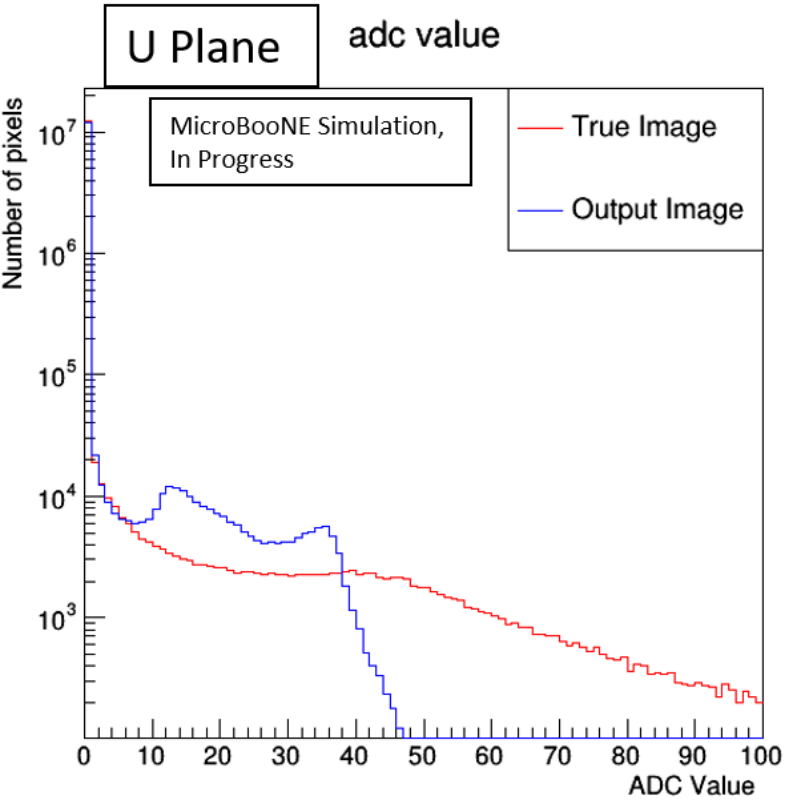
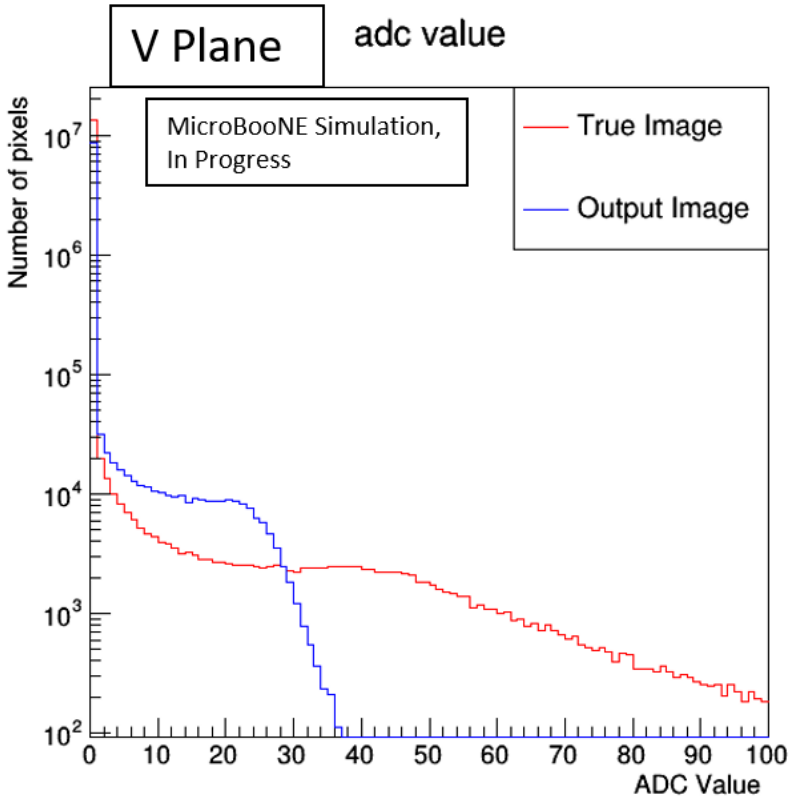
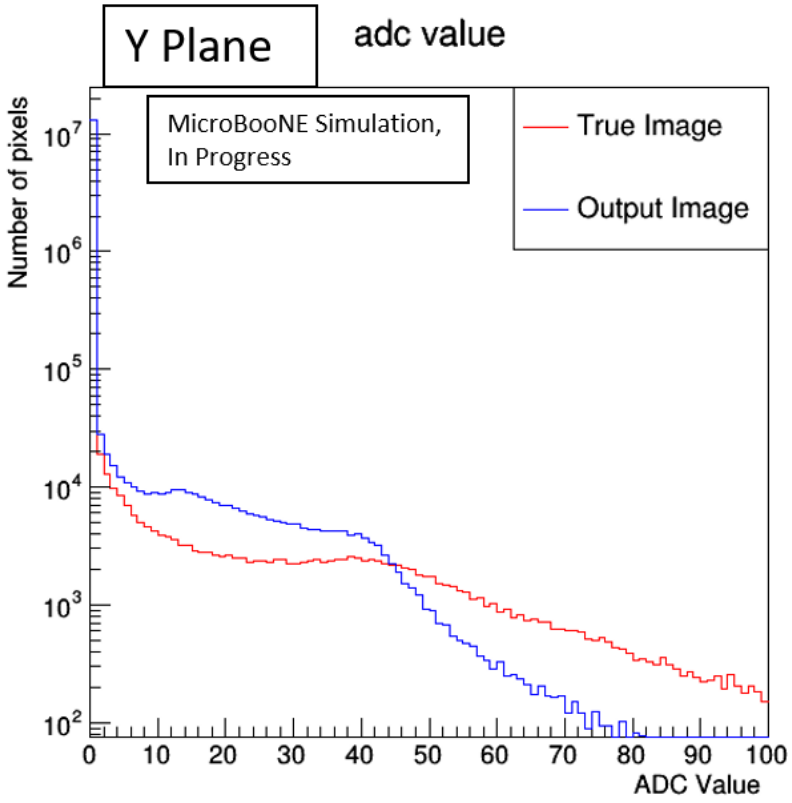
ADC Distribution

ADC Distribution in the dead channels, added over 228 test crops

- Training was focused on the 10-40 ADC region.

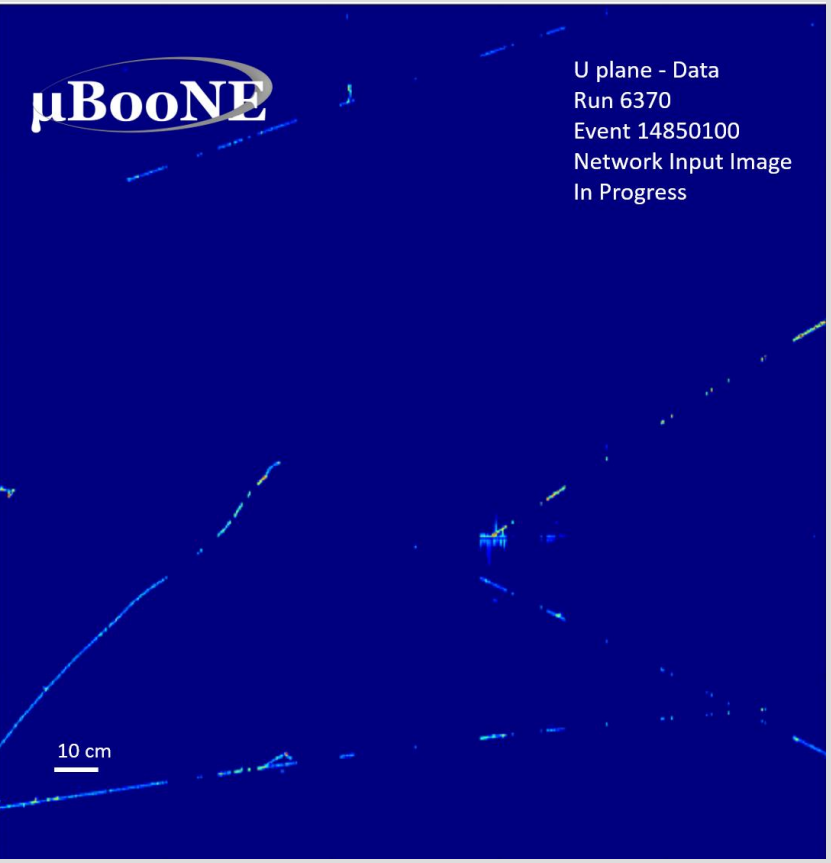


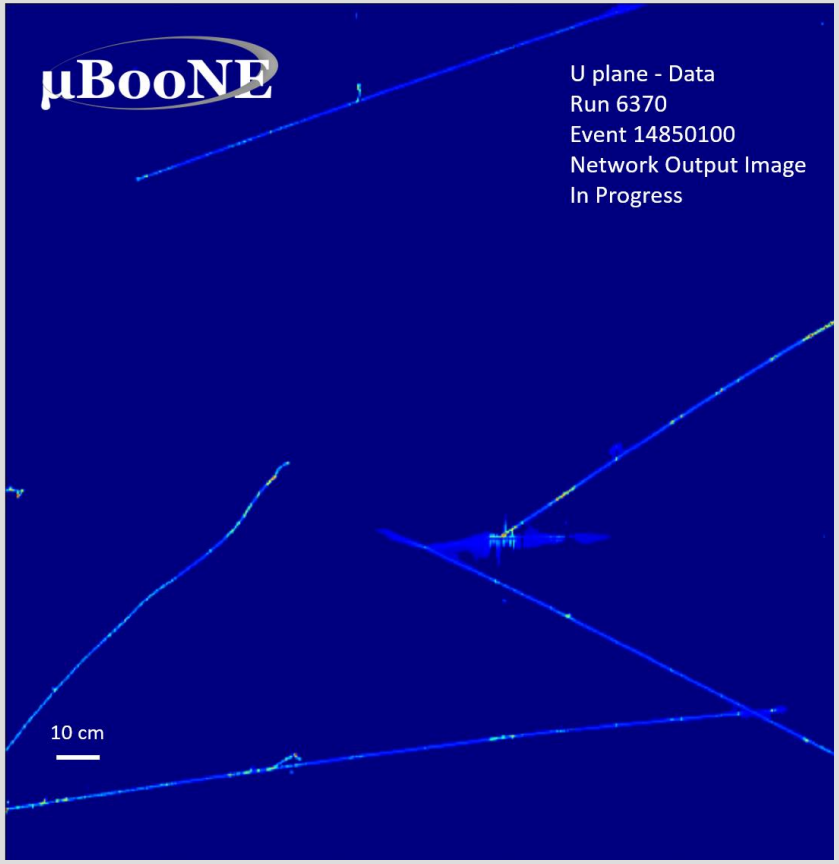


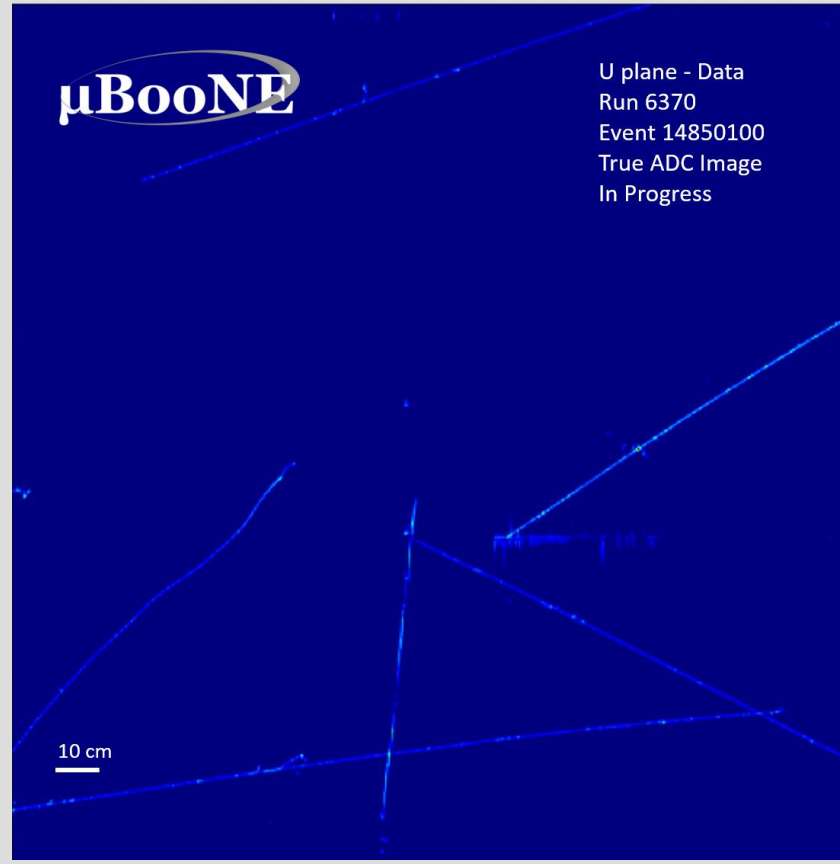


BACKUP

U Plane Example







V Plane Example