Reconstruction of Michel Electrons from Muon Decay in SBND

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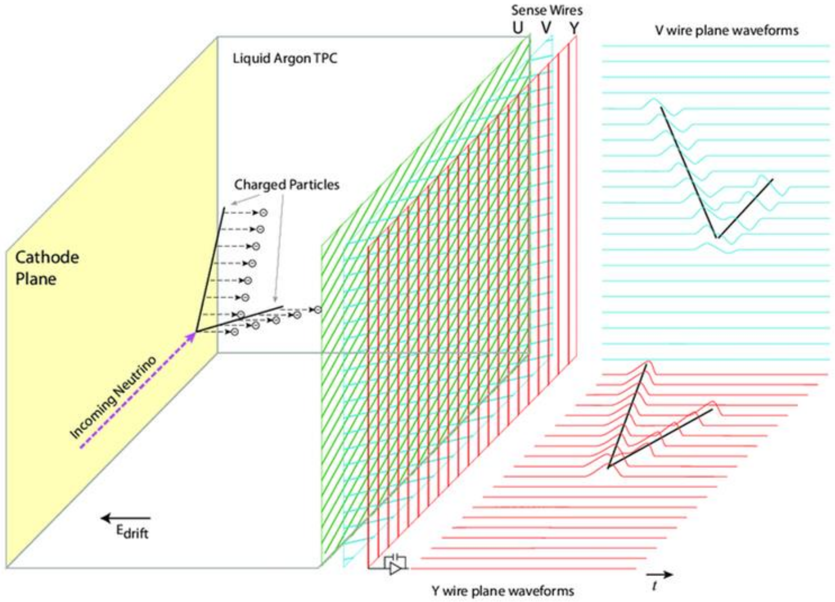
Final Presentation 8/1/2024

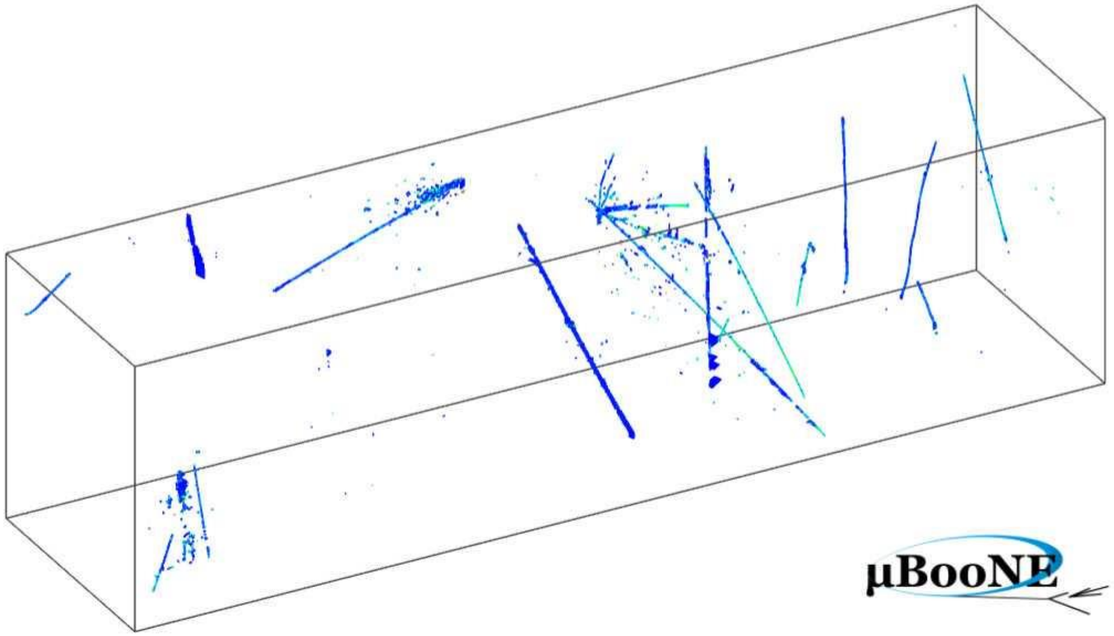
LArTPC

- Neutrinos interact with the argon creating charged particles

- Measuring arrival
  times and amplitudes of signals the position and trajectories of particles can be reconstructed

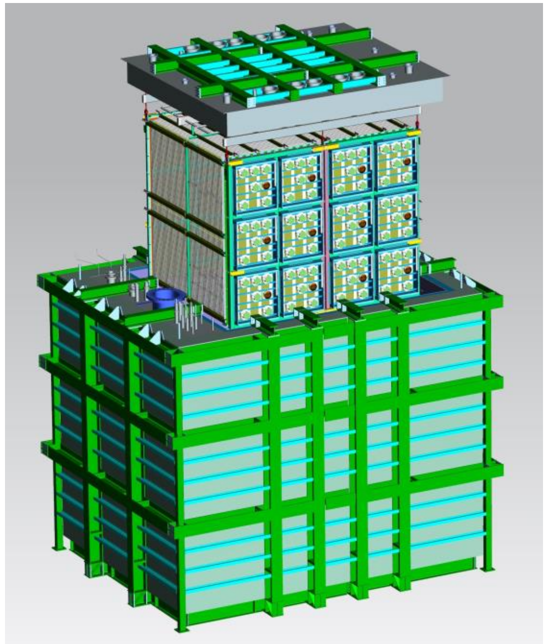
- Particles
  leave different signatures which allow for identification



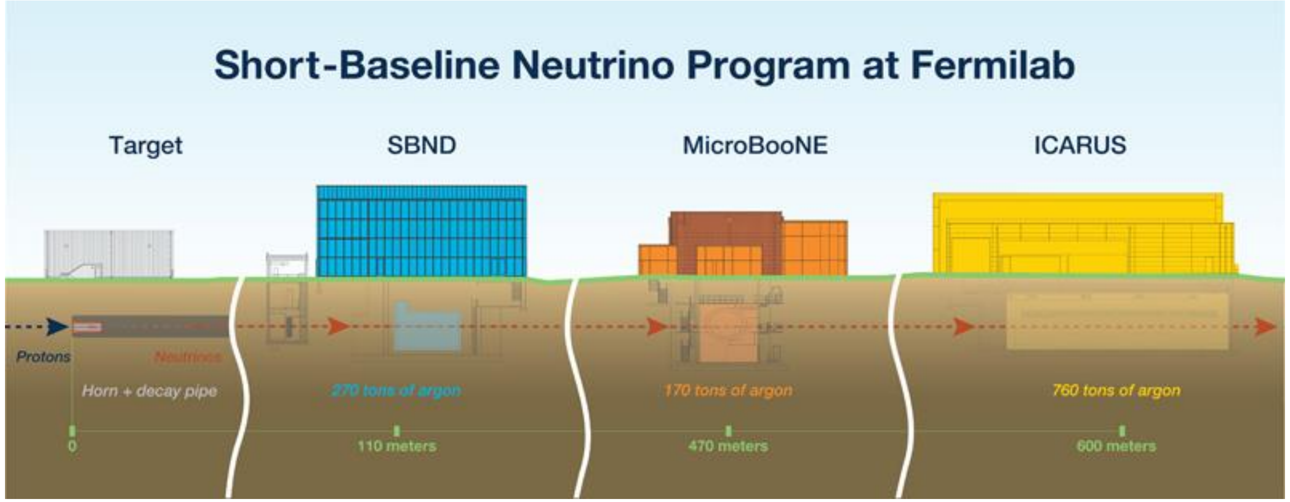


https://www.bnl.gov/newsroom/news.php?a=212311

SBND

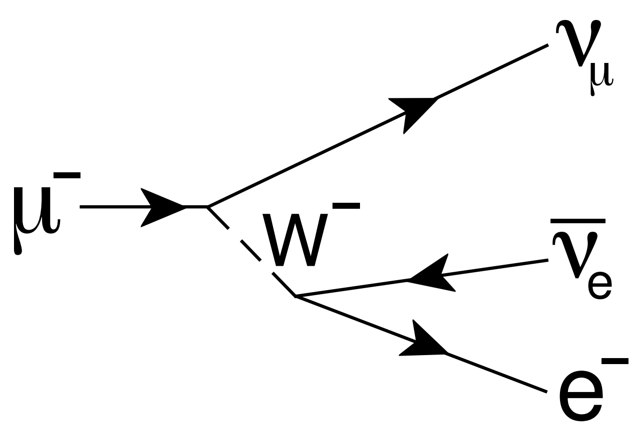


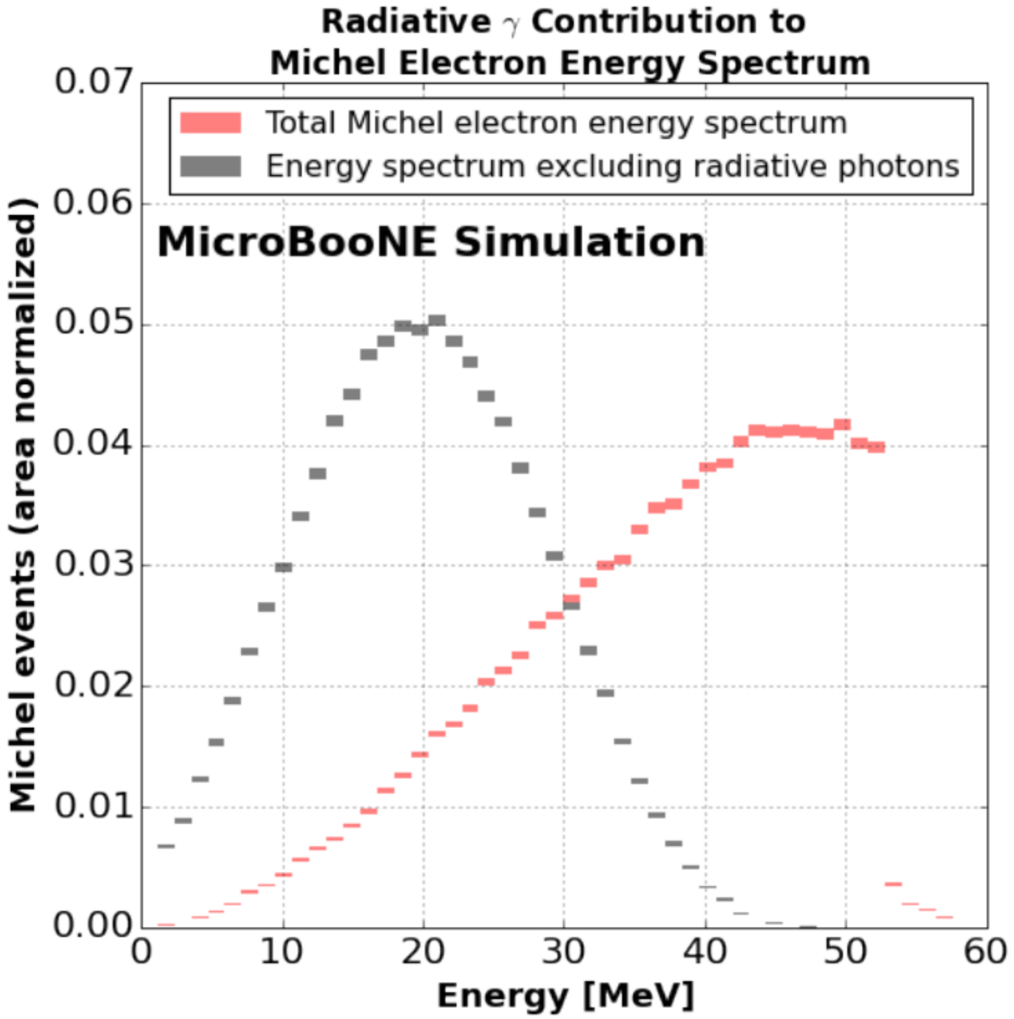
- LArTPC
- Measuring oscillations of neutrinos
- Short-baseline Near Detector
  - 112-ton active volume
  - Measuring un-oscillated content of booster neutrino beam
  - Mostly muon neutrinos



Michel Electron

- Named after Louis Michel
- Muons mainly produced by cosmic rays
- Michel Energy Spectrum





arXiv:1704.02927v2

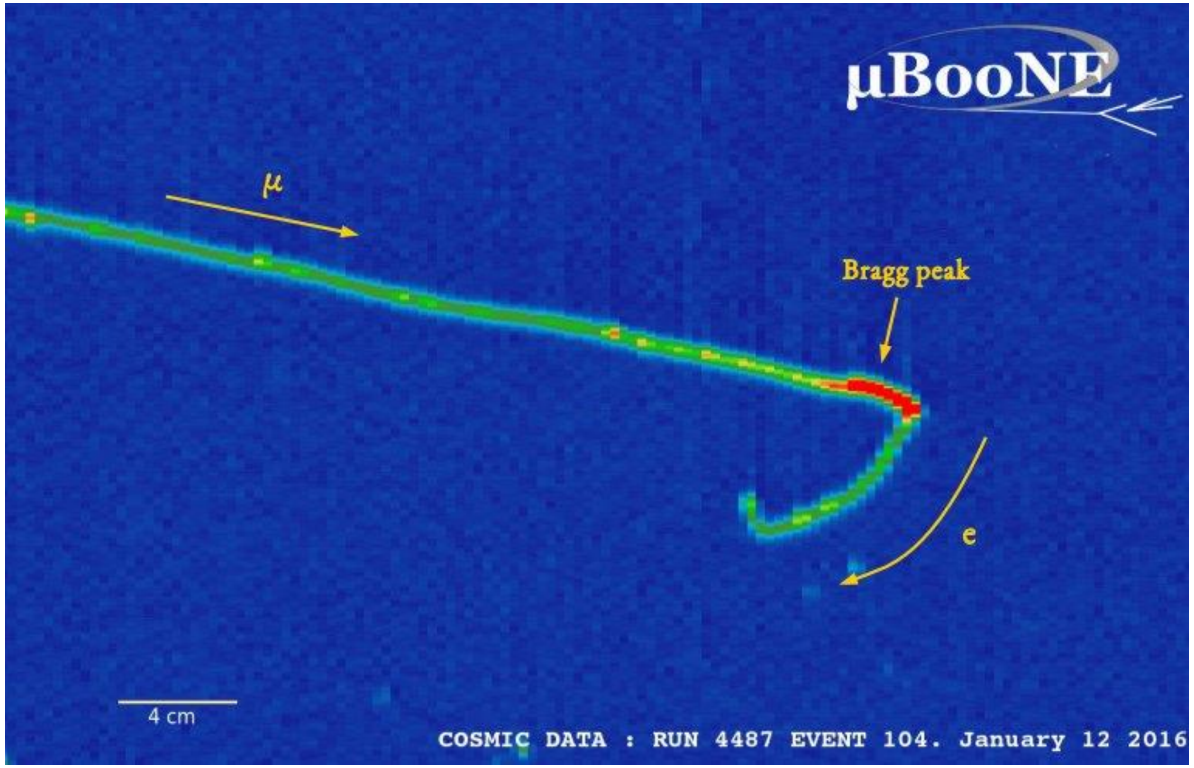
Why Michels?

- Well-defined energy spectrum

- Detector response

- Michel spectrum acts as a benchmark for low energy calibration

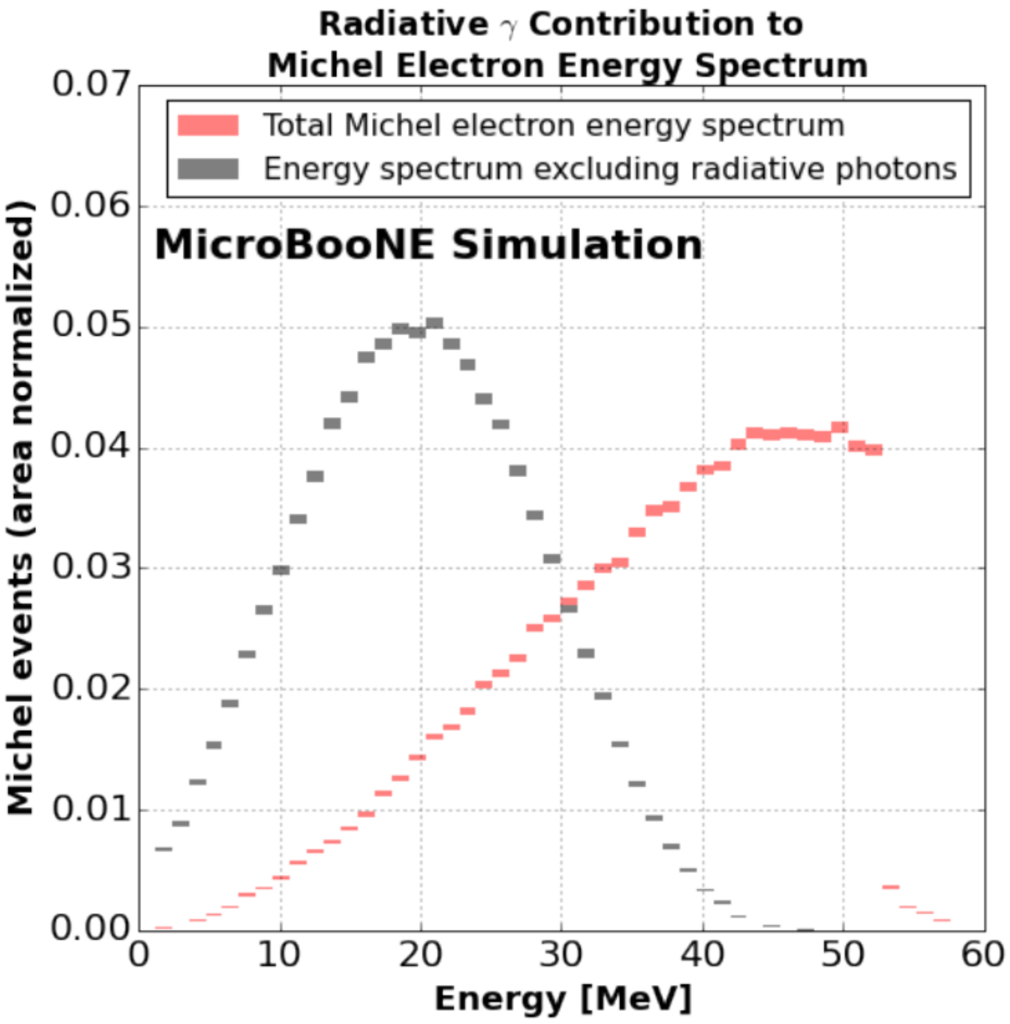
    - Ability to identify low-energy electromagnetic showers



Daisy Kalra and for the MicroBooNE Collaboration 2022 J. Phys.: Conf. Ser. 2374 012163

Goals

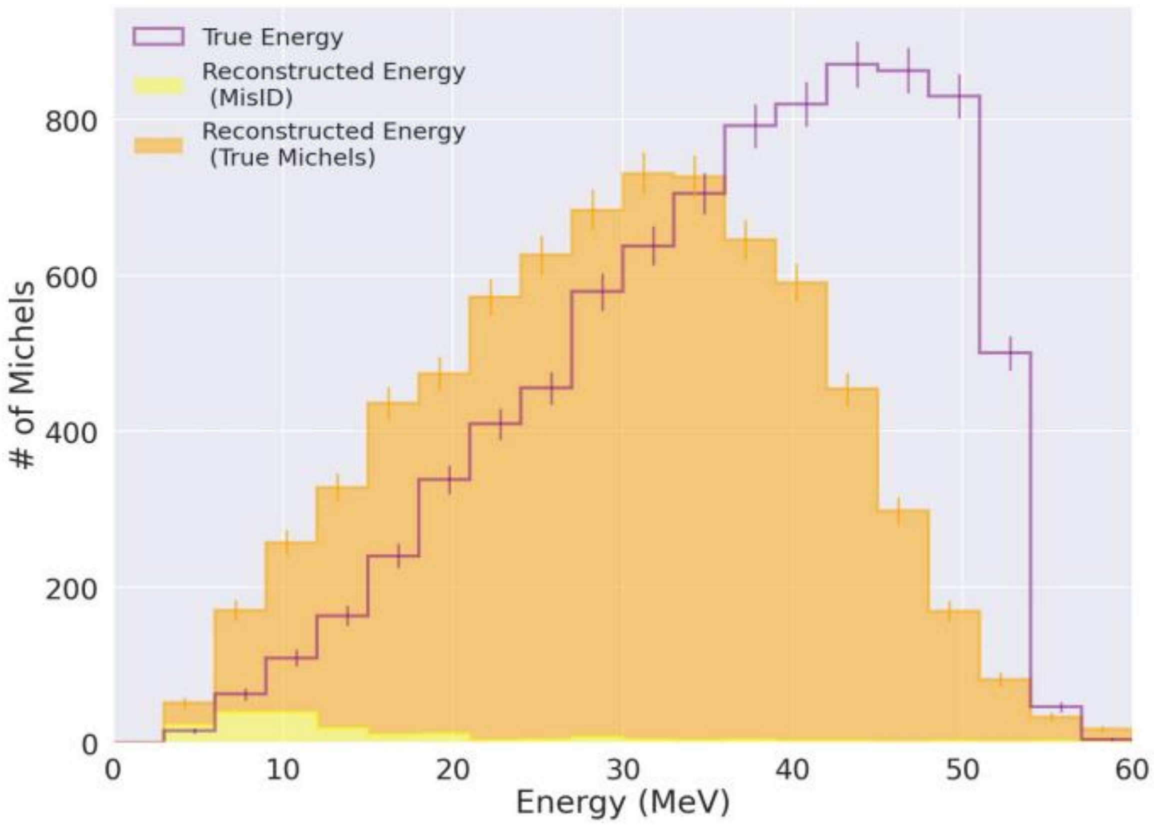
- Try and match the well-defined energy spectrum
- Improve selection methods
- Improve understanding of low energy showers



https://arxiv.org/abs/1704.02927

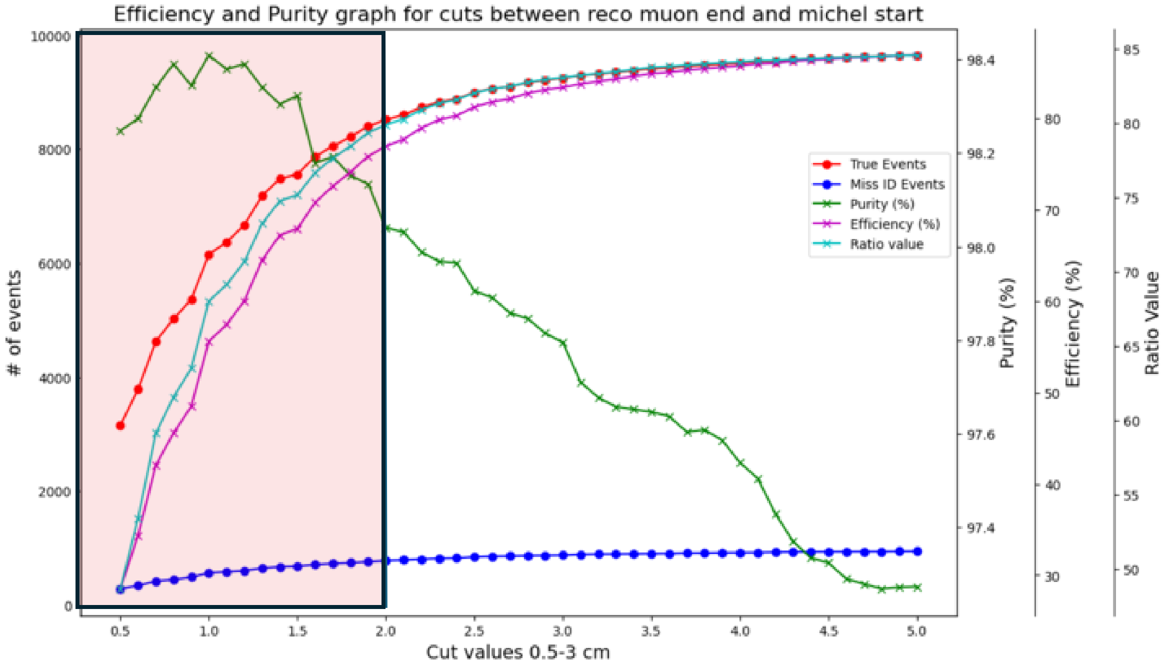
Existing selection

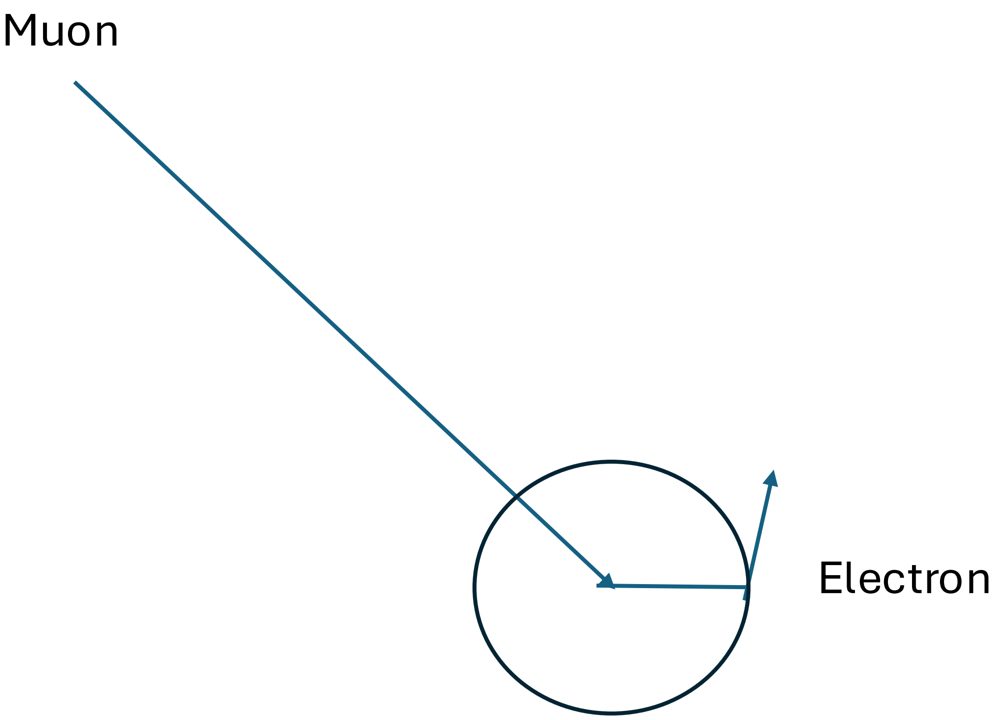
- Distance between Muon end and closest Michel pixel < 3cm
- Required number of pixels in Michel Cluster > 10
- Efficiency of 84.93% (# of matched / # of predicted)
- Purity of 97.46% (# of matched / # of True)



Updating Selection

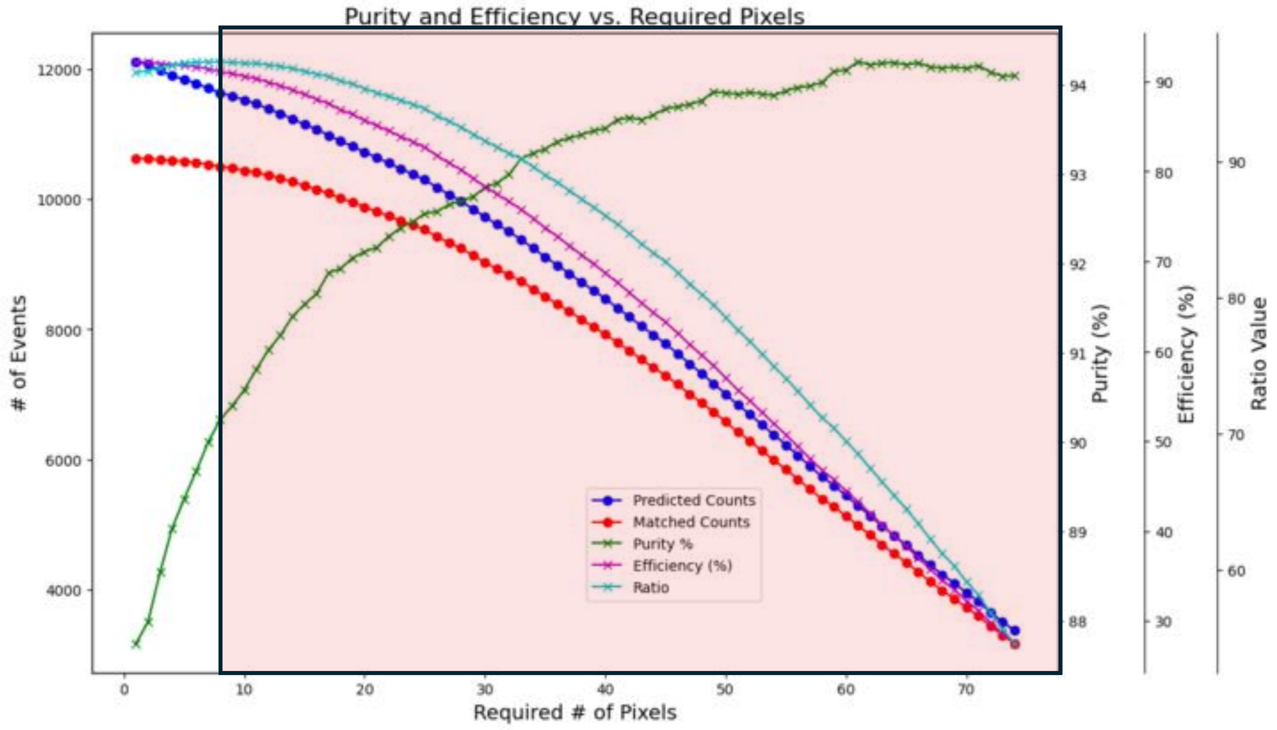
- Distance between Muon End and Michel Start
  - Eliminates possibility of including background events

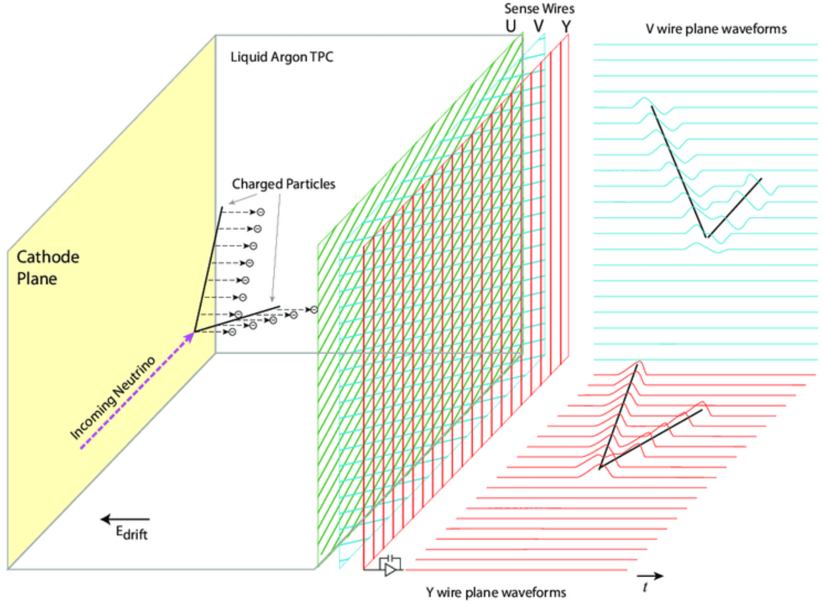




Pixels

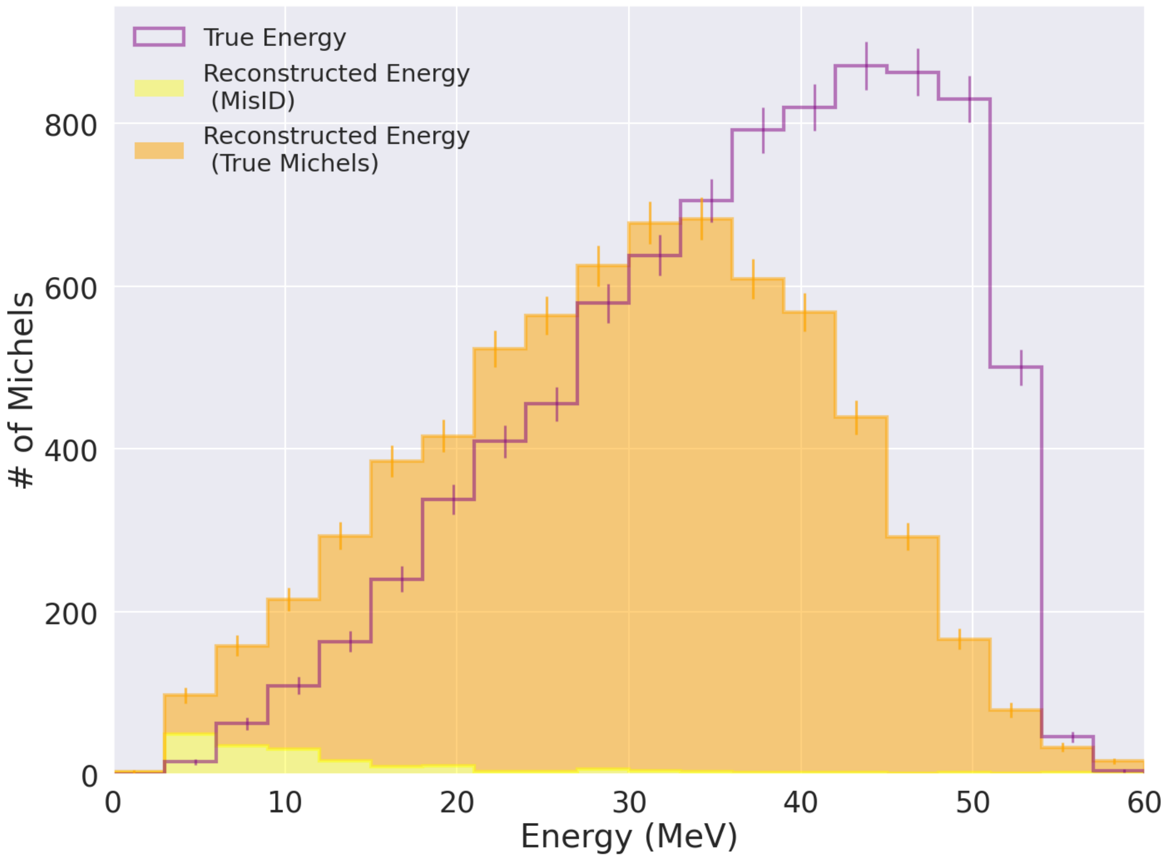
- Hits in detector in Michel cluster
- Eliminates Mis-ID'd low energy and delta ray particles





Resulting Efficiency and Purity

- Distance between Muon end and closest Michel pixel < 2cm
- Required number of pixels in Michel Cluster > 7
- Efficiency of 72.70% (# of matched / # of predicted)
- A loss of 12.23%
- Purity of 97.19% (# of matched / # of True)
- An increase of 0.27%

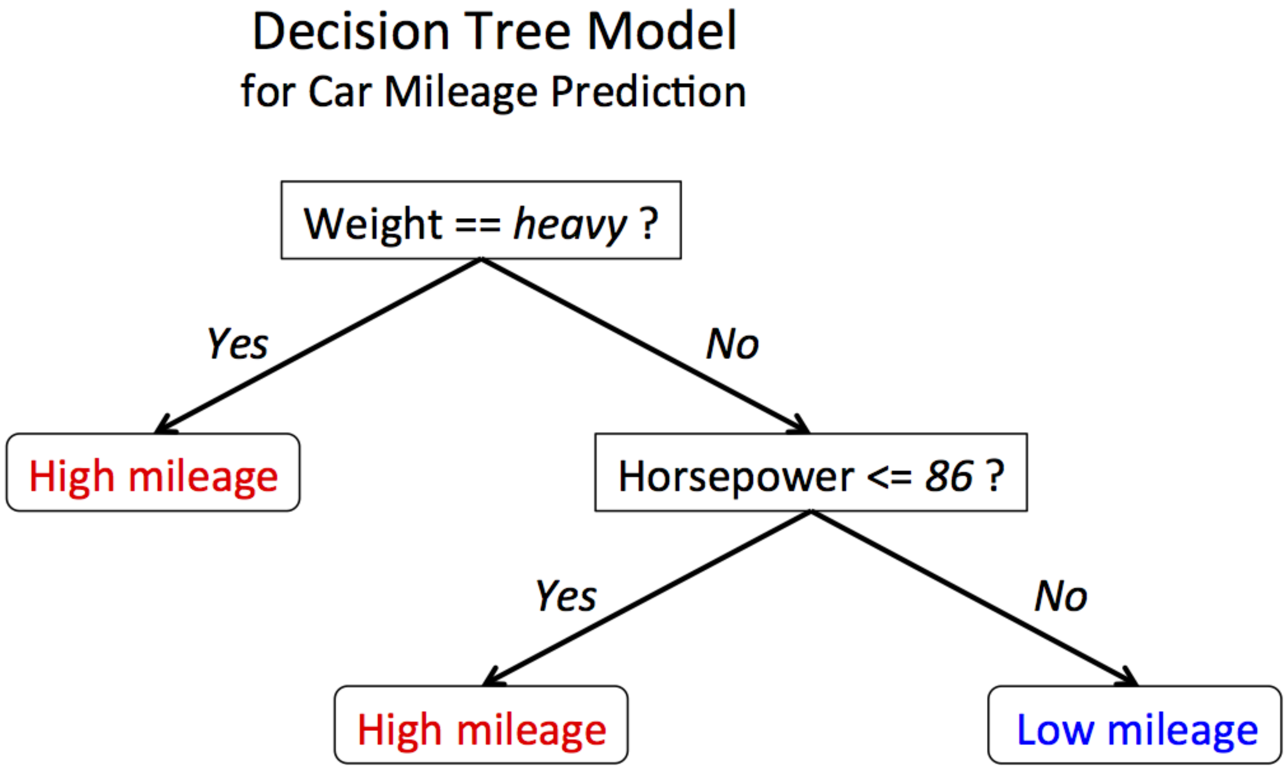


Boosted Decision Tree

Event 1	Data	1
Event 2	Data	1
Event 3	Data	0

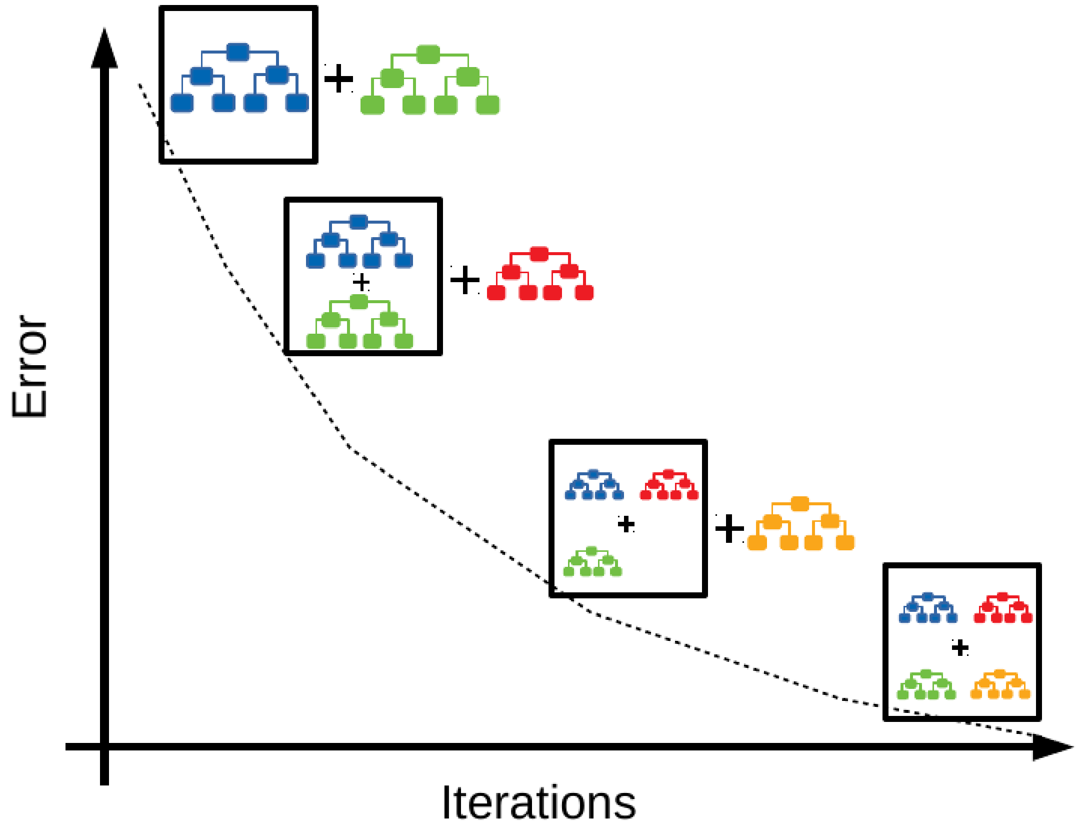
- Singal Event = 1
- Background Event = 0

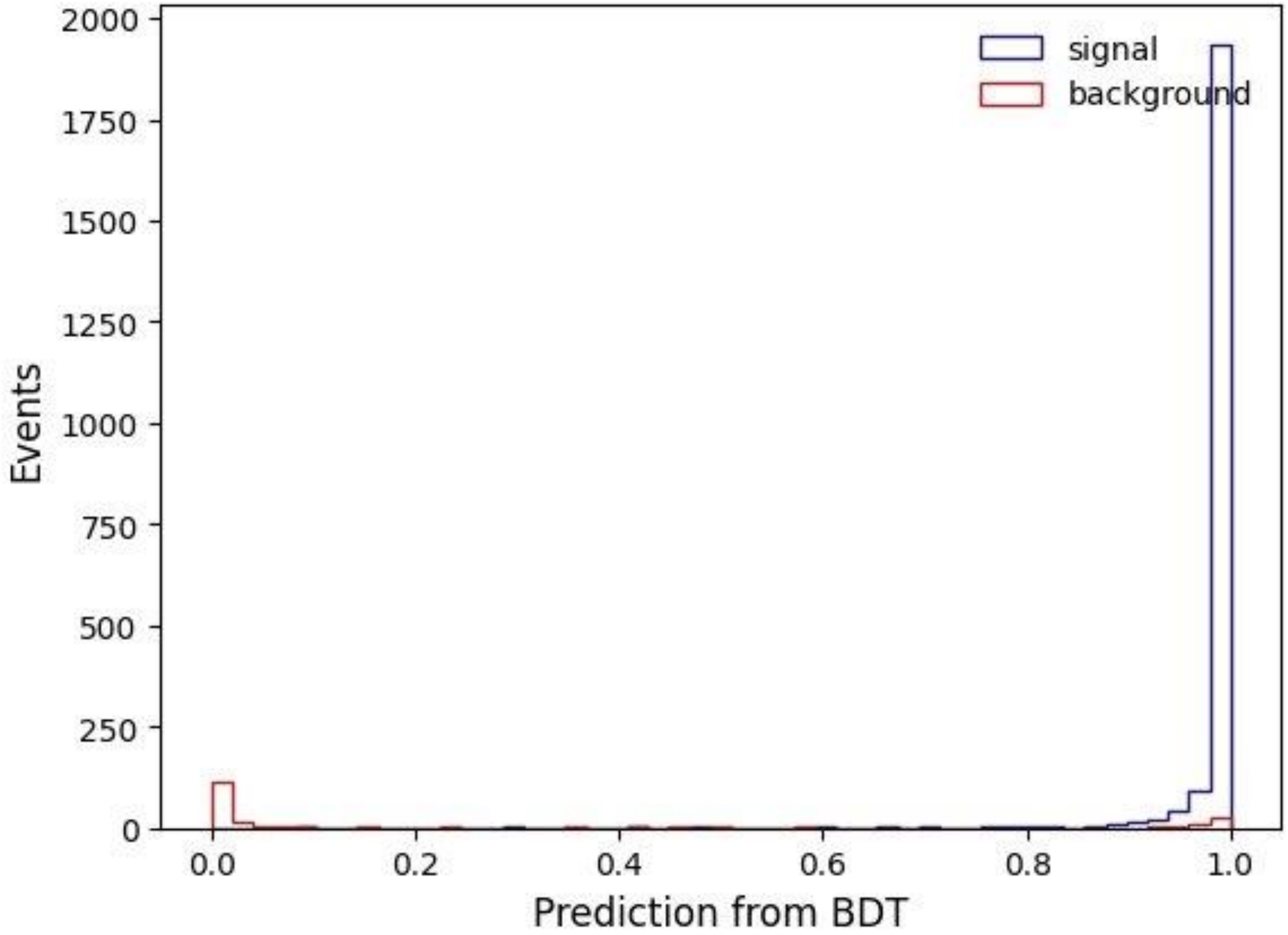
New Prediction = Current Prediction + (Learning Rate * Tree Prediction)



BDT(Boosted Decision Tree) and Machine Learning

1. Starts with an Initial prediction
2. Calculates the difference between actual and predicted (Residual)
3. Train a new decision tree to predict updated residuals
4. Update predictions by adding predictions from the new trained tree





2000
1750
1500
1250
1000
750
500
250
0
Events
0.0
0.2
0.4
0.6
0.8
1.0
Prediction from BDT
signal
background

Results

Purity = 99.76% (# of matched / # of predicted)

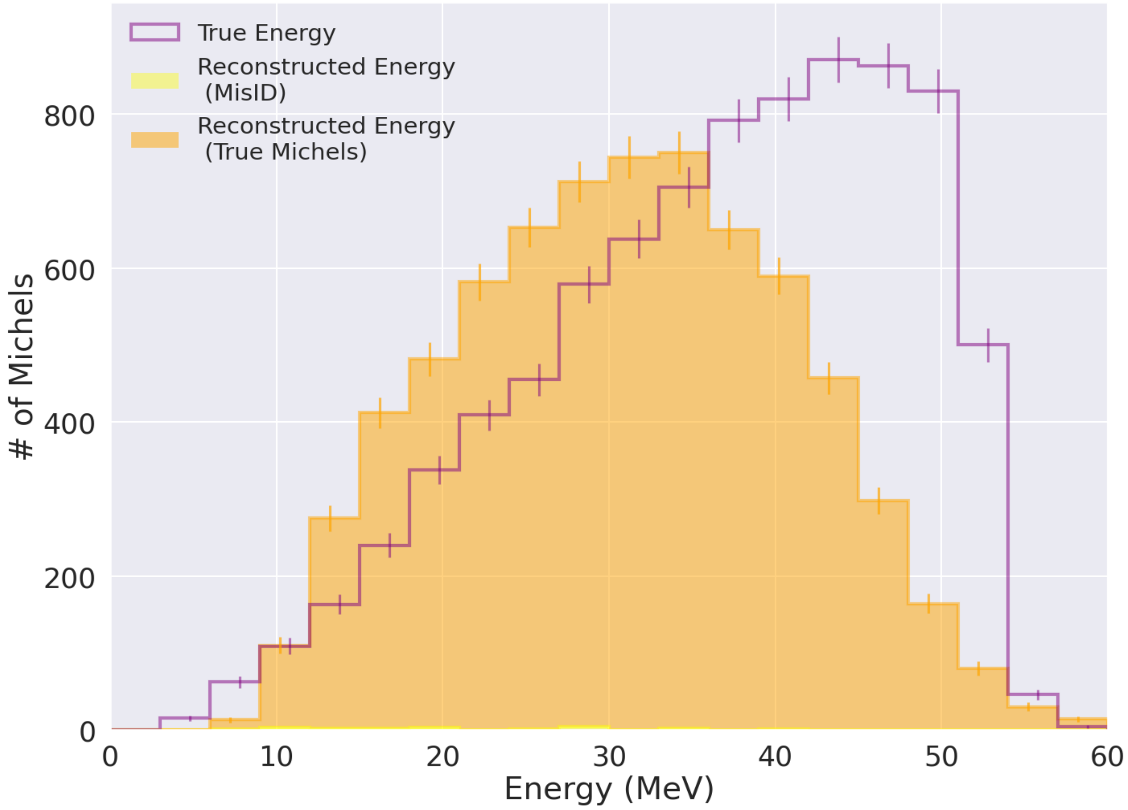
Increase of 2.3%

Efficiency = 82.20%(# of matched / # of True)

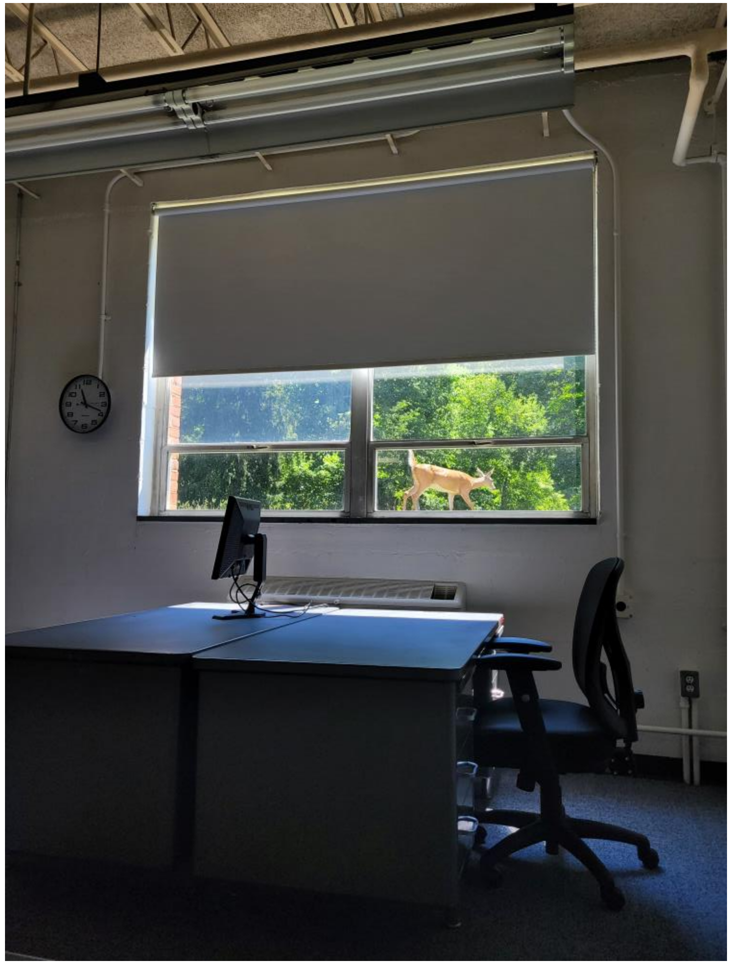
Loss of 2.73%

Future:

- Compare to Data
- Improve BDT by increasing sample size
- Improve Reconstruction



Acknowledgments



Thank you:

- Georgia Karagiorgi
- Nupur Oza
- Ibrahim Safa
- Michael Shaevitz
- Karan Kumar

This material is based upon work supported by the National Science Foundation under Grant No. PHY-2349438