

LArIAT Studies by the W&M 2015 REU

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Kevin Nelson - William & Mary

Stephanie O'Neil - Carnegie Mellon

The logo for Carnegie Mellon University consists of a solid red square. Inside the square, the text "Carnegie Mellon University" is written in a white, serif font, with "Carnegie" on the top line, "Mellon" on the second line, and "University" on the third line.

Carnegie
Mellon
University

LArIAT weekly meeting. August 4th, 2015

Introduction

- Motivation:
 - learning about the data, data quality, preliminary analysis, not worrying about MC
 - Findings may inform the fall run.
- Results from a 4500 event scan
 - Event classification by quality and type
 - Results incorporated into an event selector
- Pulling single events out at FragmentToDigit stage
- Track reconstruction on “good straight” tracks
 - dE/dx analysis
- Analysis of E&M showers
 - Energy response vs momentum
- Event filtering/selection using AuxDetDigits

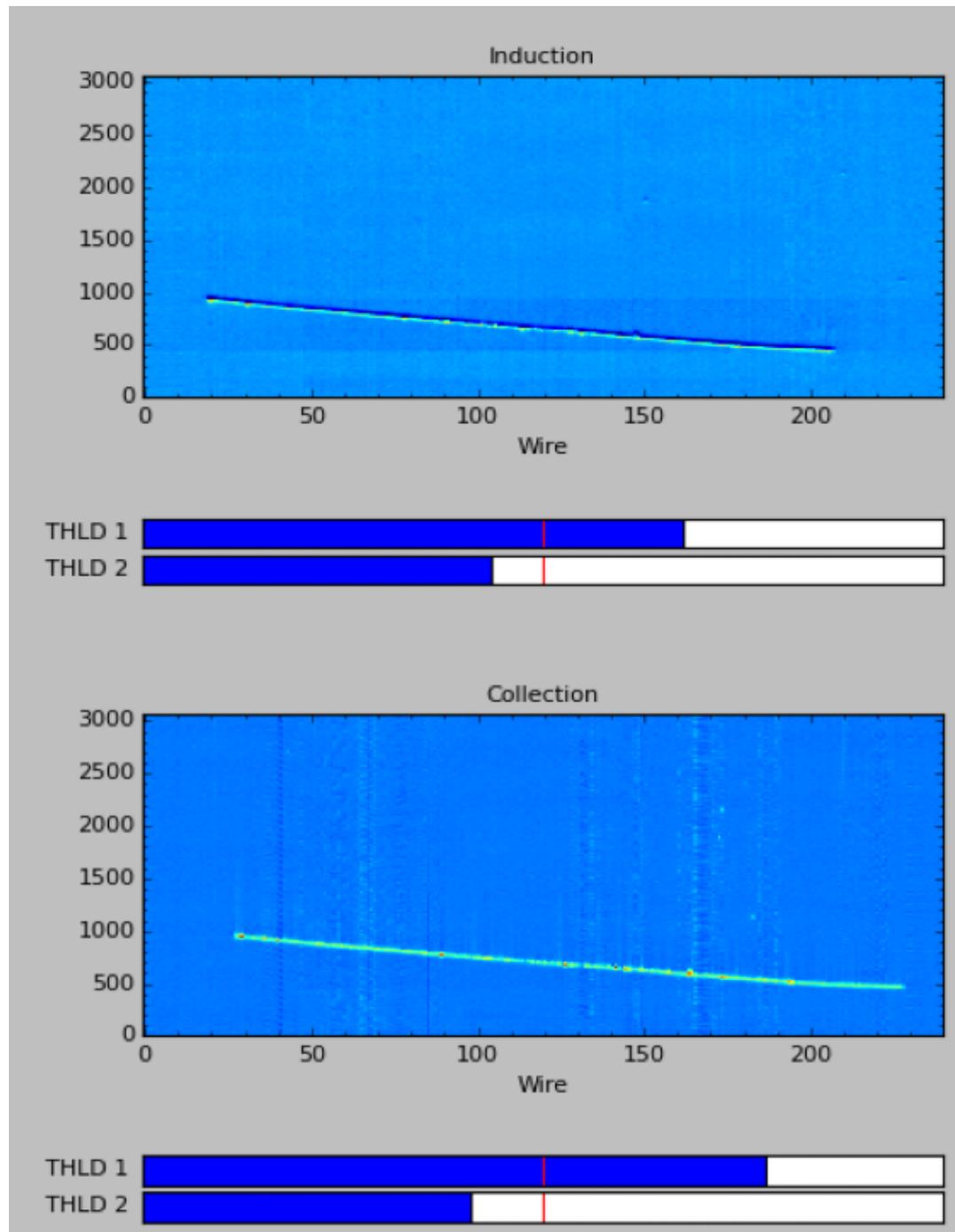
Event scan: motivation & procedure

- Collect a sample of events
 - Can test algorithms and run analyses
- Looked over 6111, 6112, 6145-6
- Looked at an image with BEAMON and sorted into categories
 - Quality: Good, Fair, Pileup, Nothing, Other
 - Behavior: Straight, EMShower, Kinked, Unknown

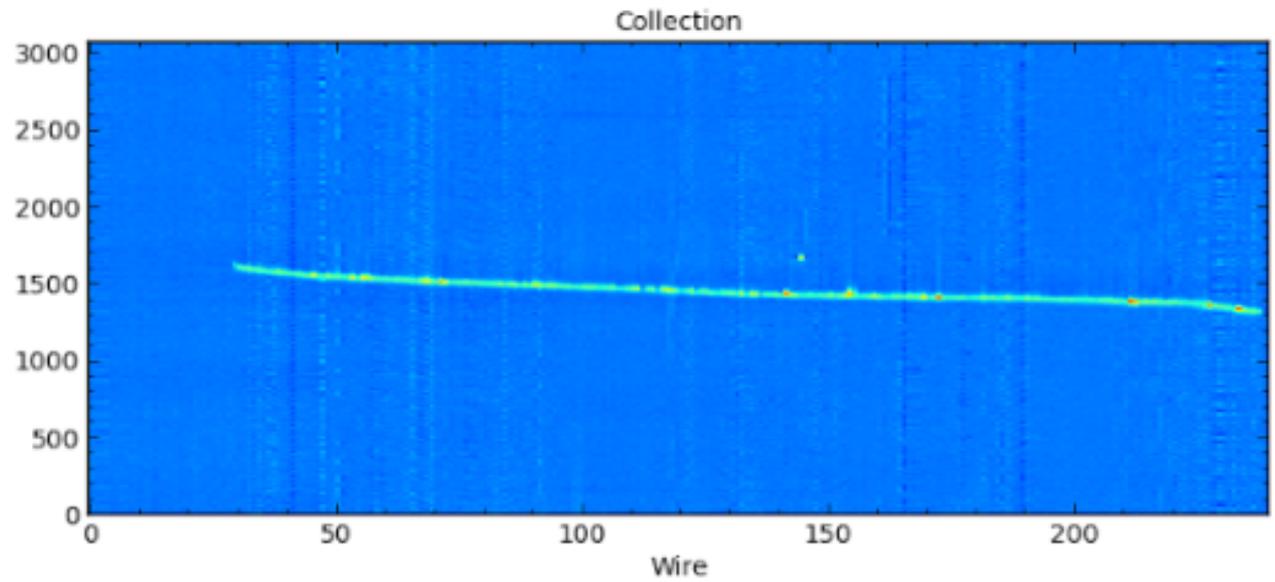
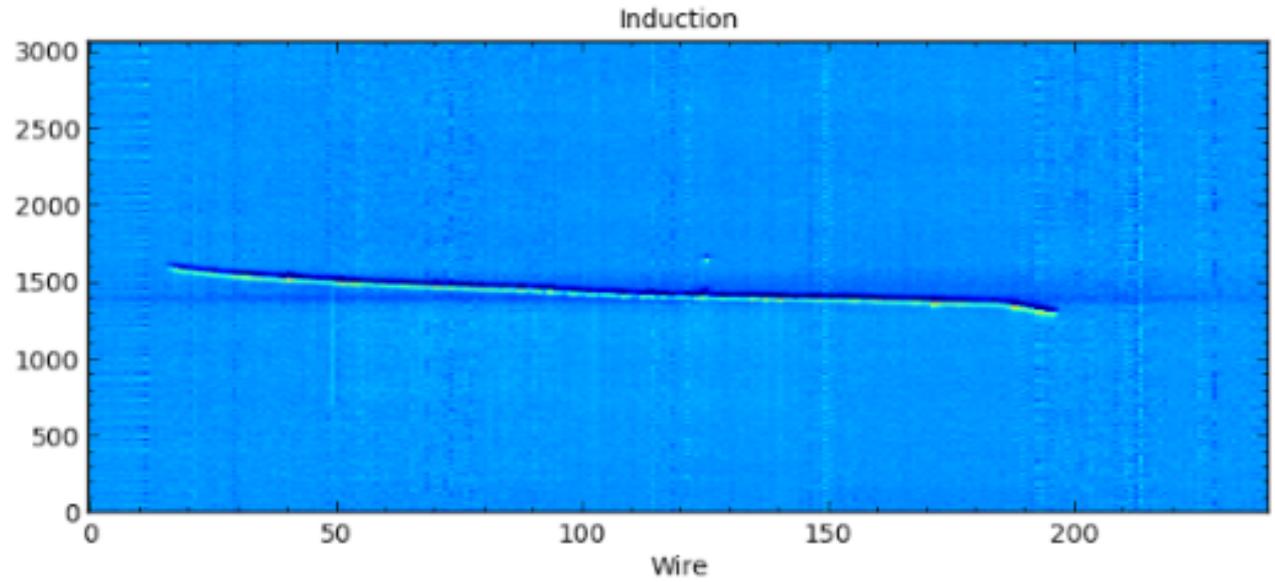
Quality: Good Events

- BEAMON
- One particle coming from the front of the TPC

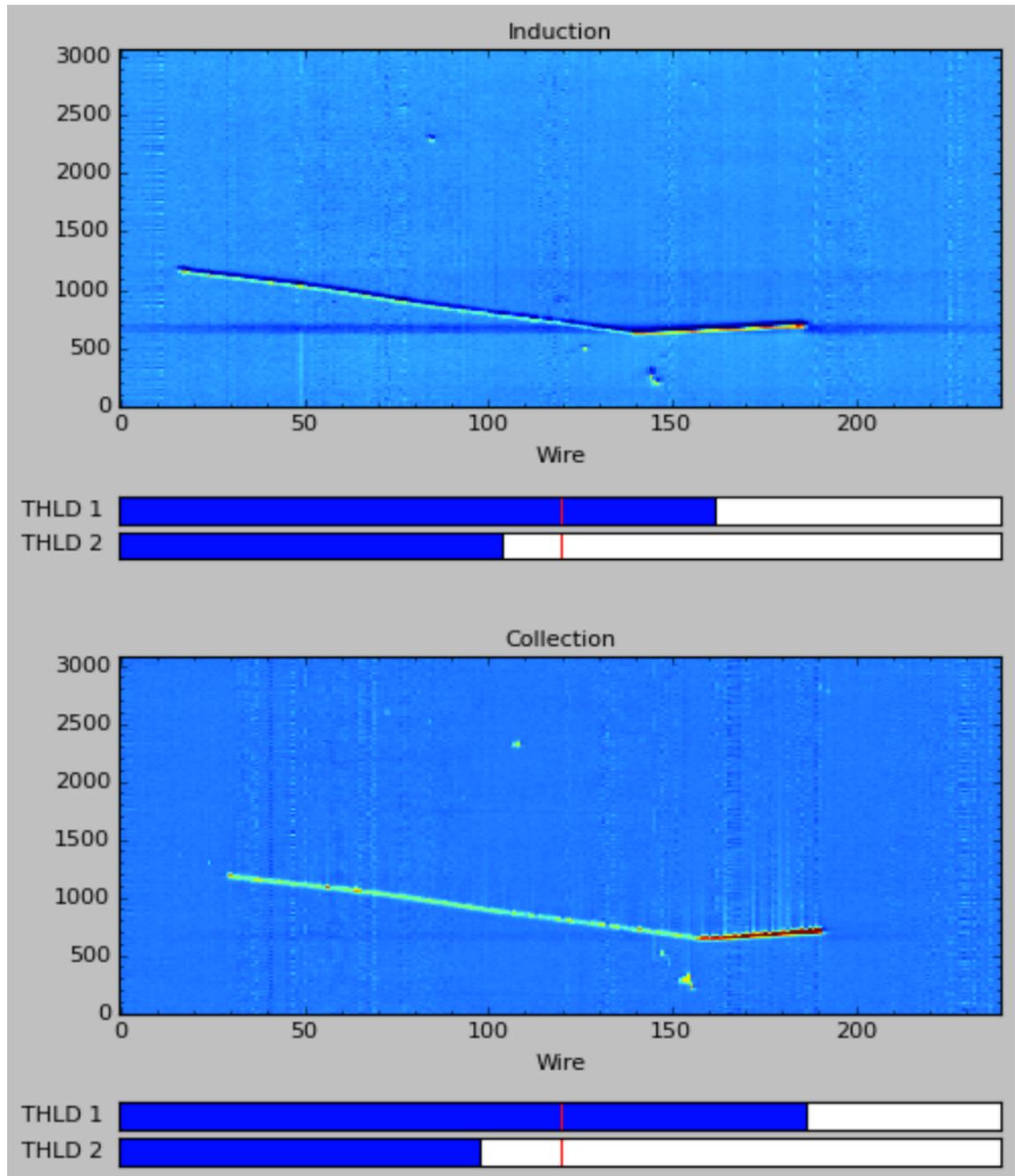
Good Straight



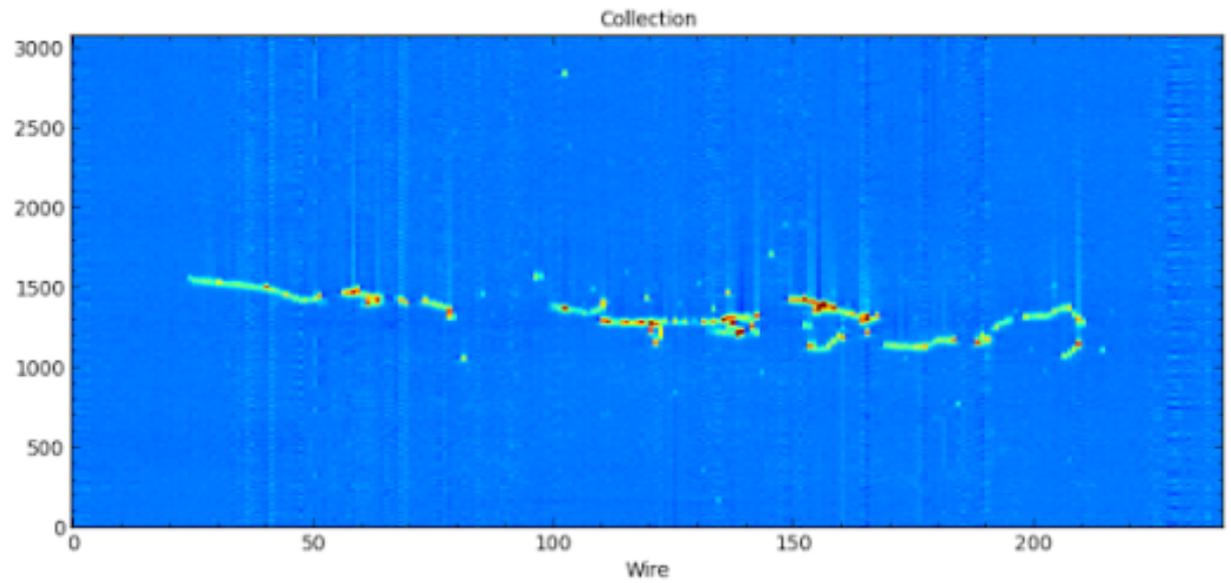
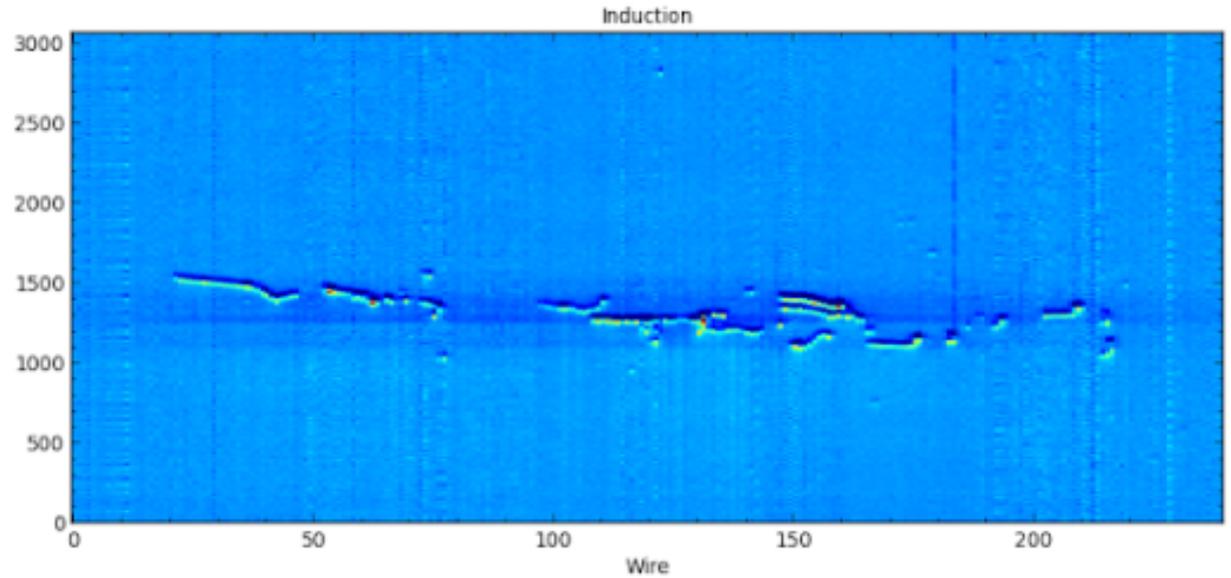
Good Straight



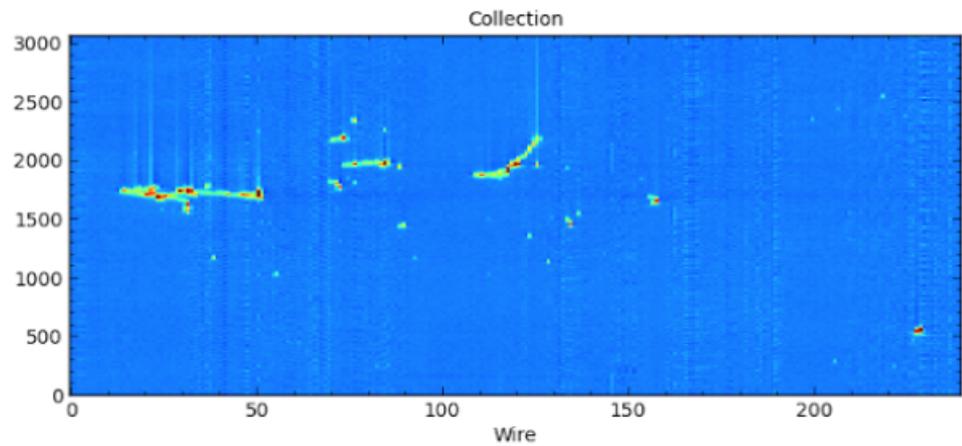
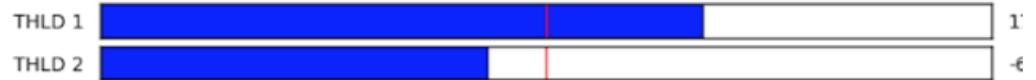
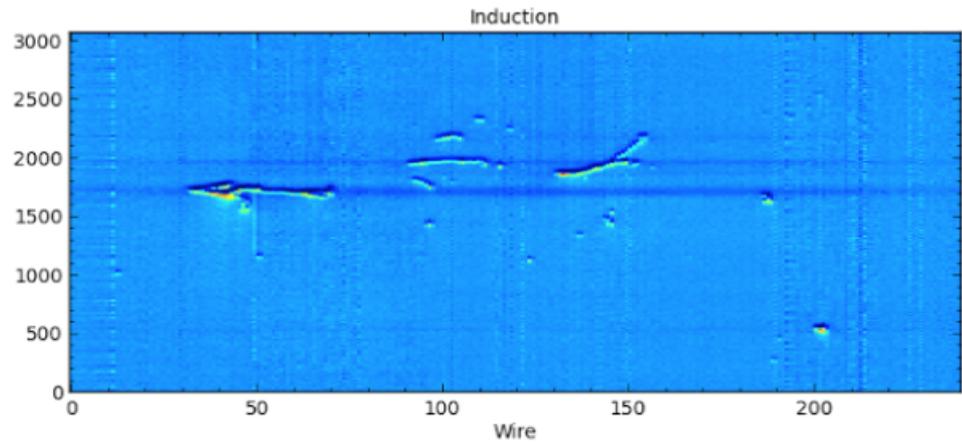
Good Kinked



Good EM



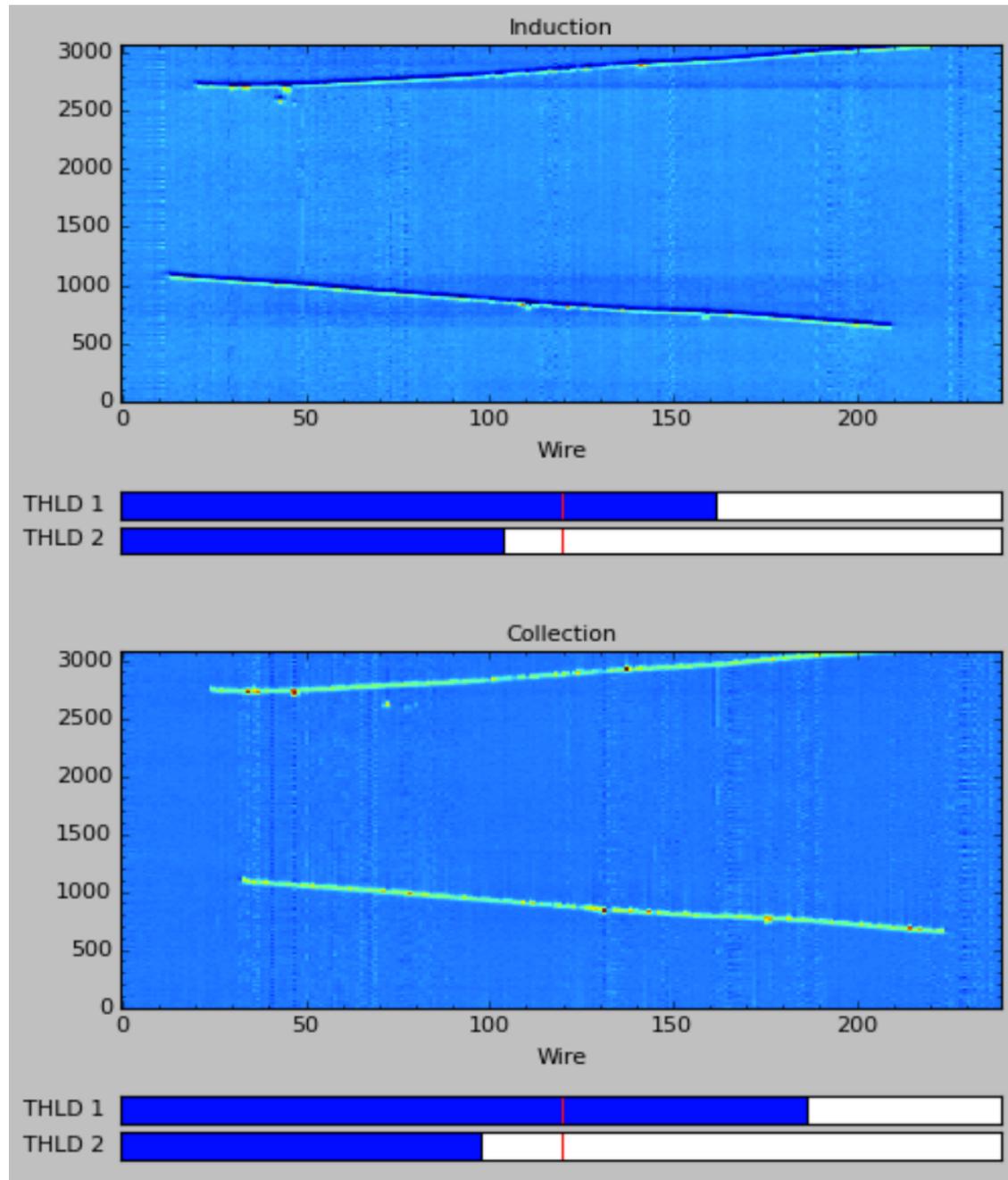
Another Good EM



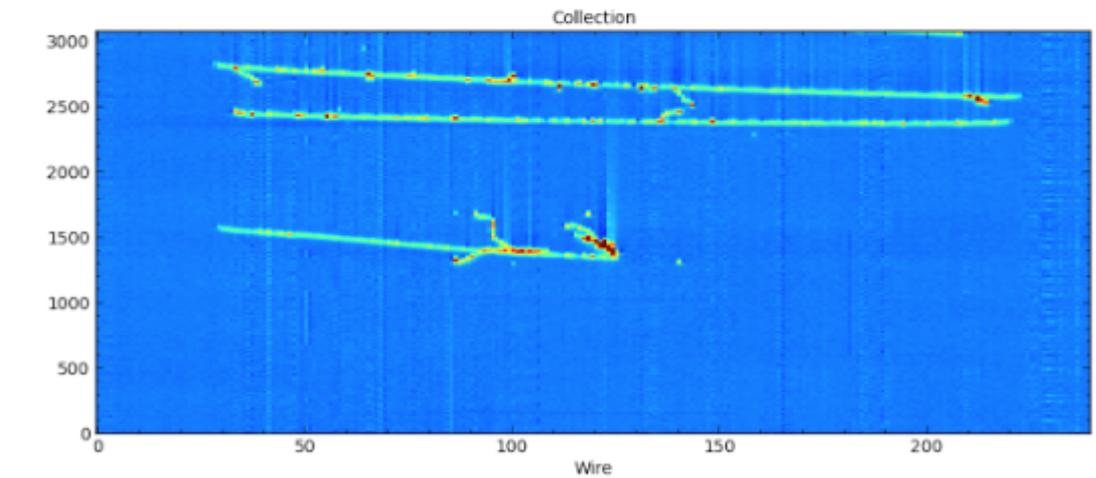
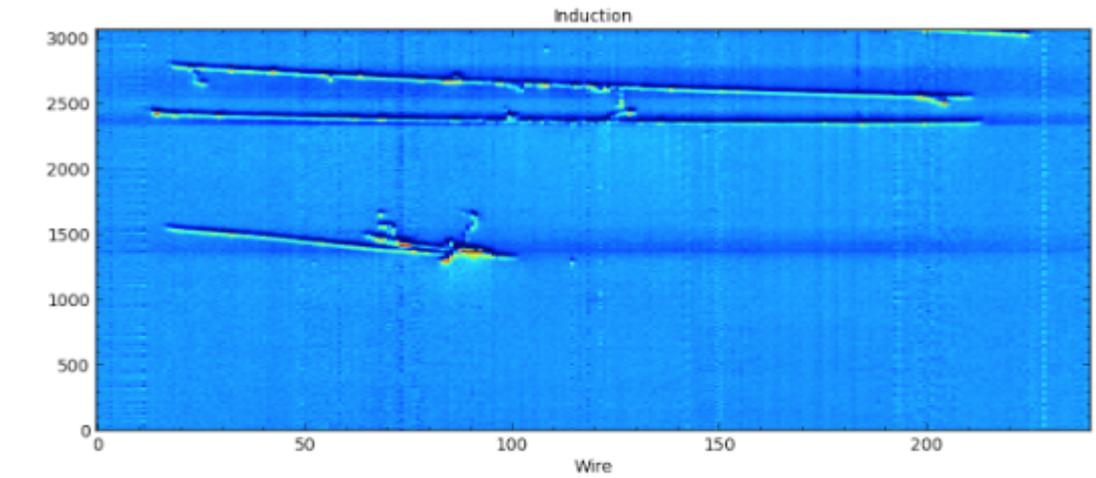
Quality: Fair Events

- BEAMON
- 1 track coming in the front and 1 or 2 additional tracks

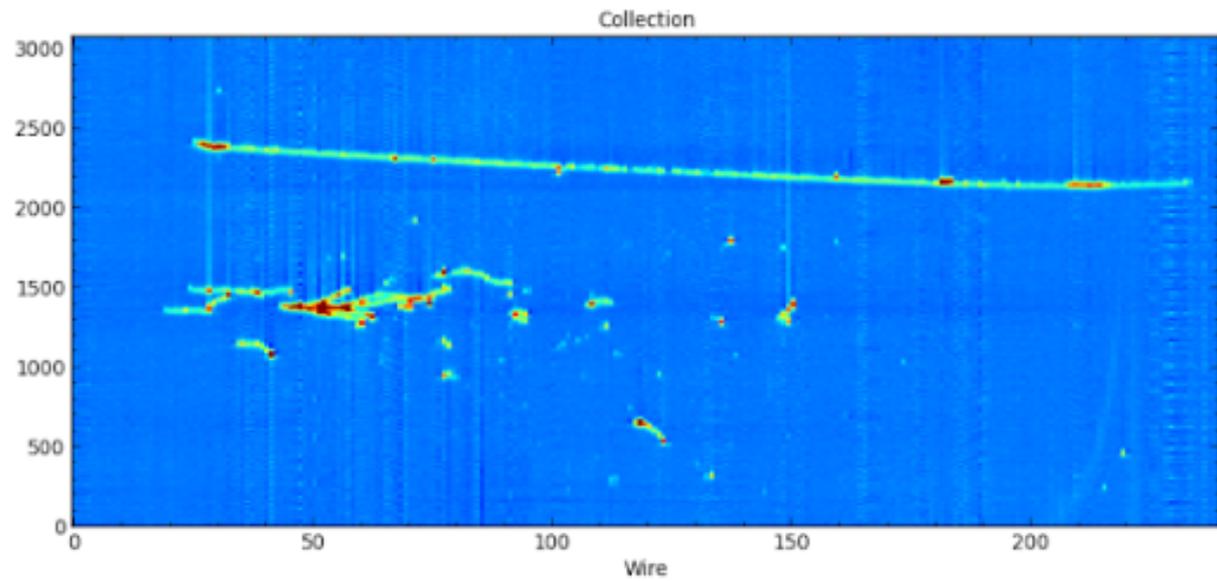
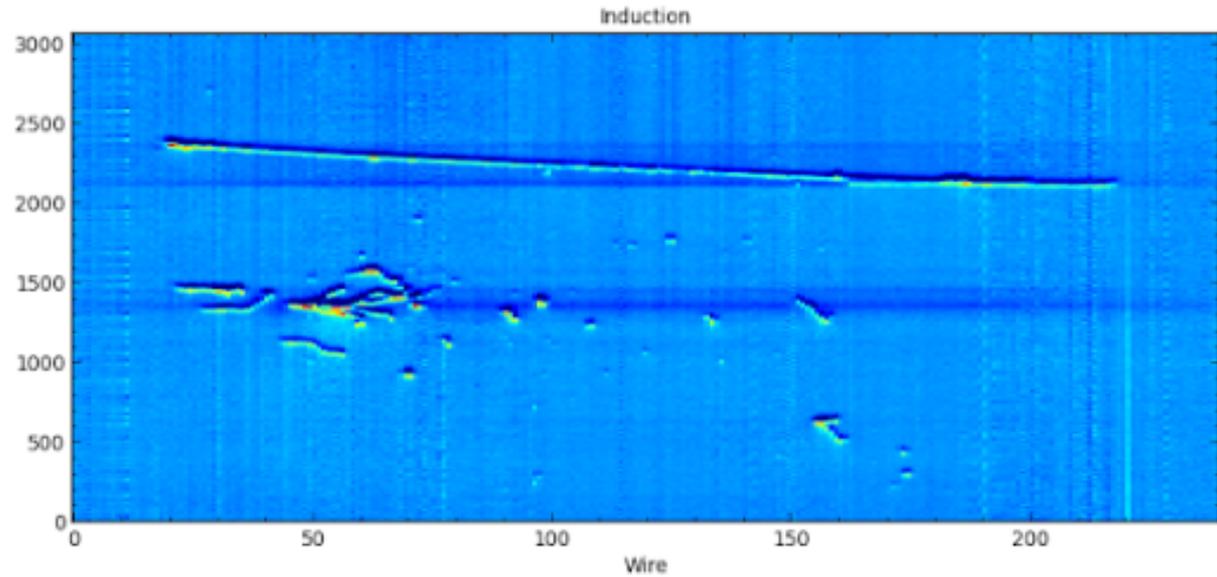
Fair Straight



Fair Kinked



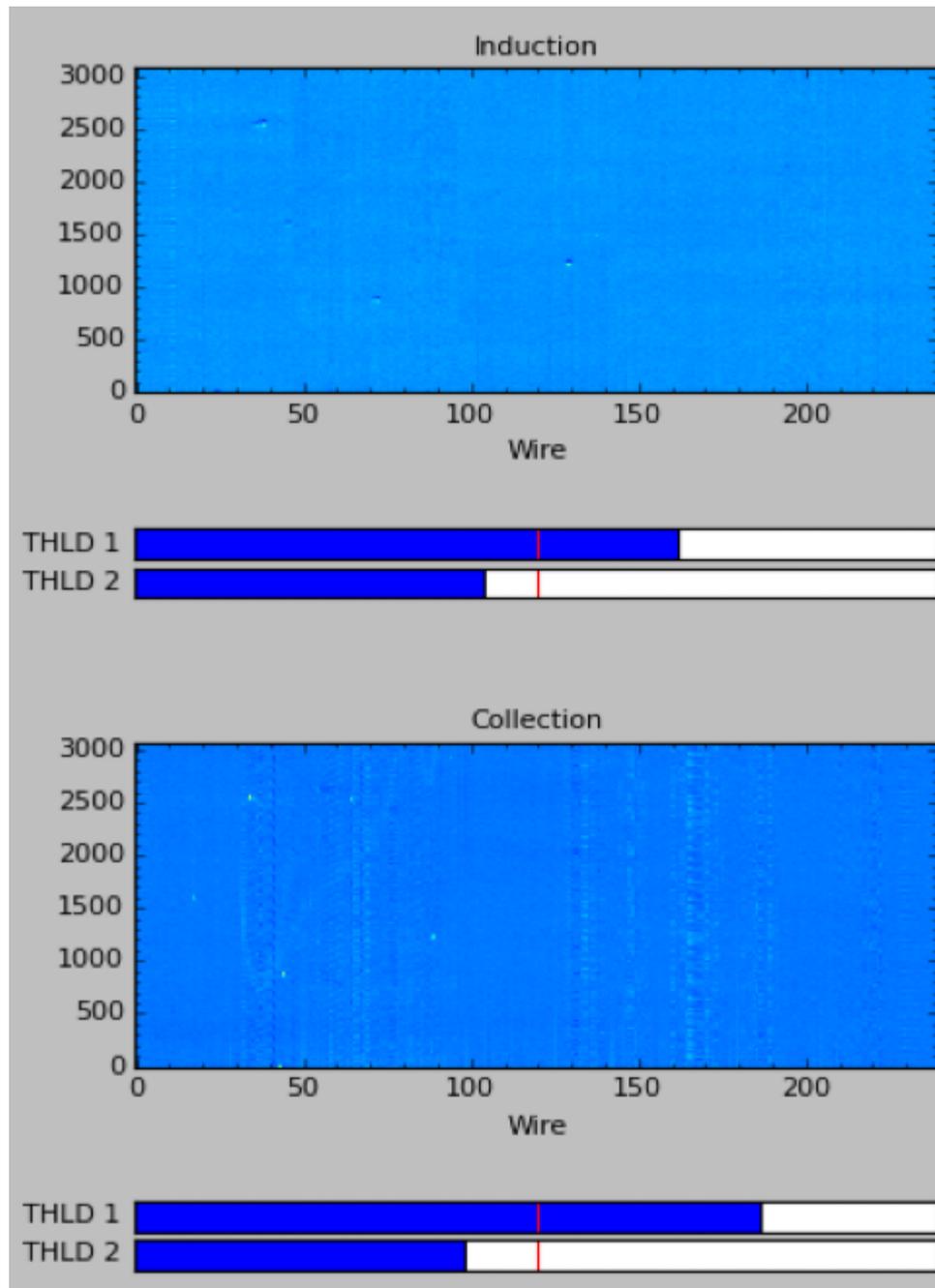
Fair EM



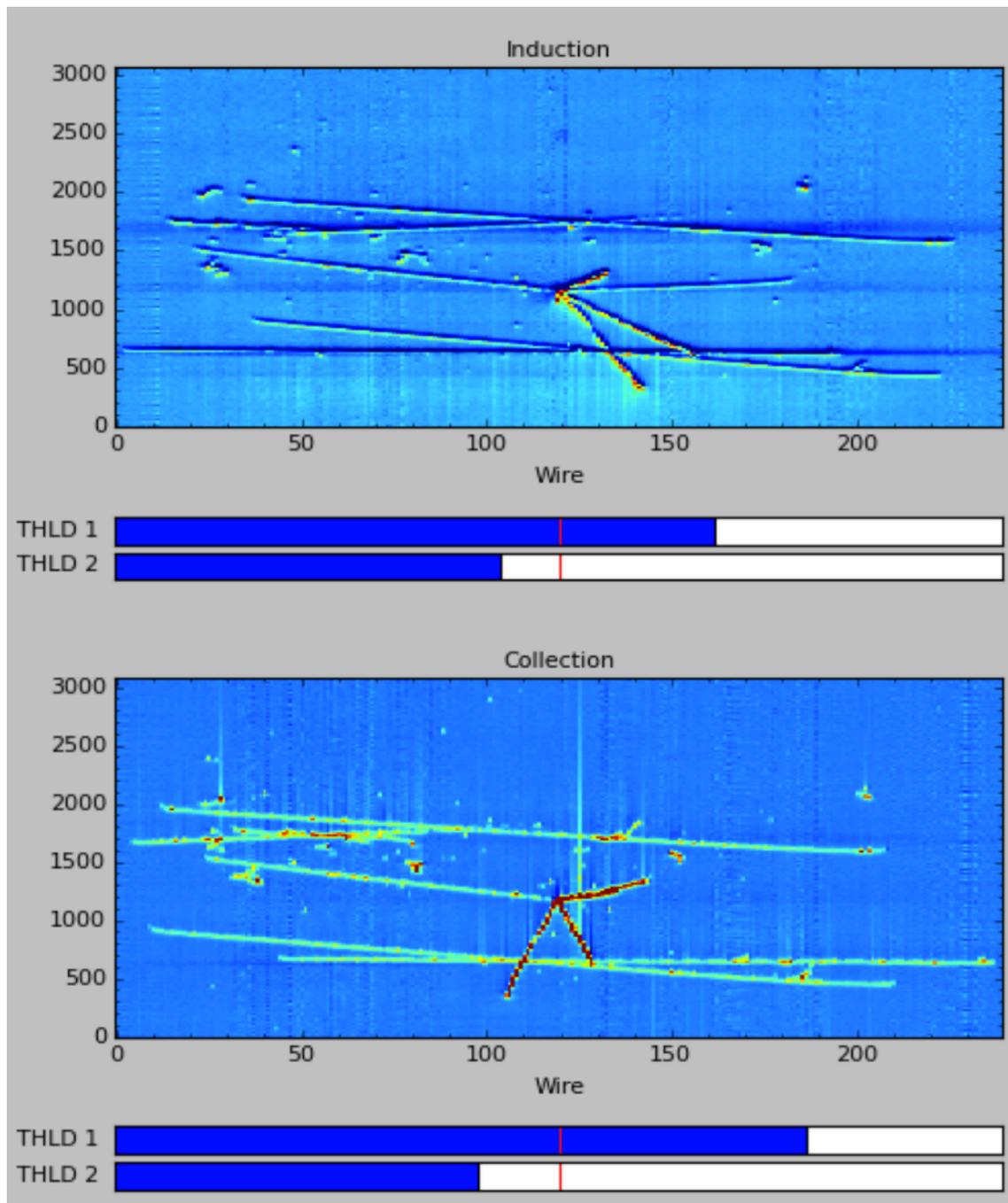
Quality: Pileup, Nothing

- Nothing: no tracks in the TPC
- Pileup: 4 or more tracks in the TPC

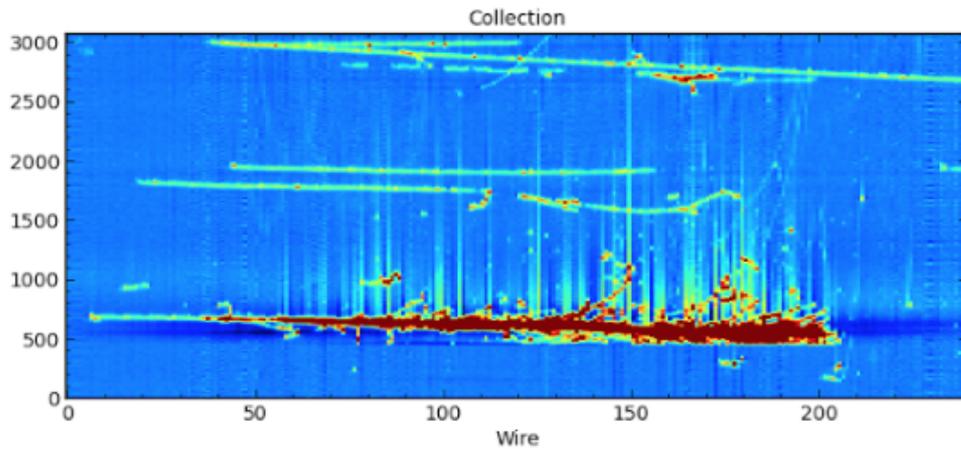
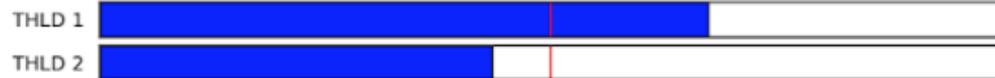
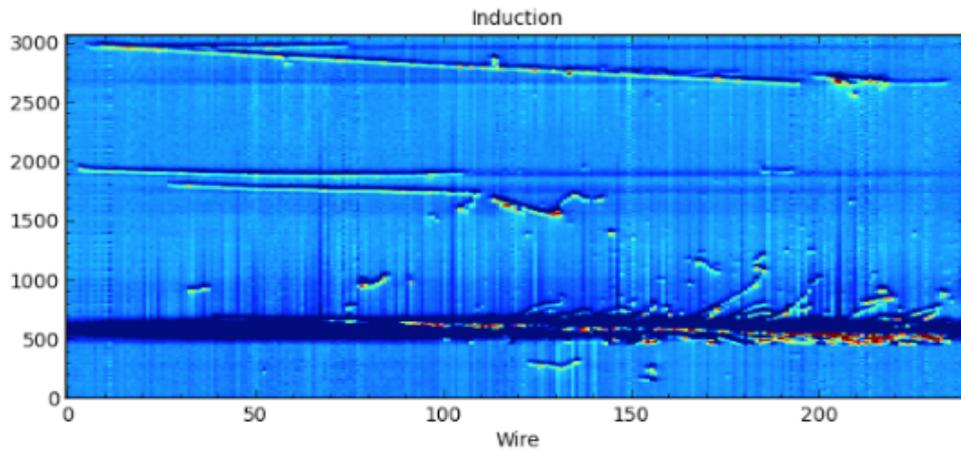
Nothing



Pileup



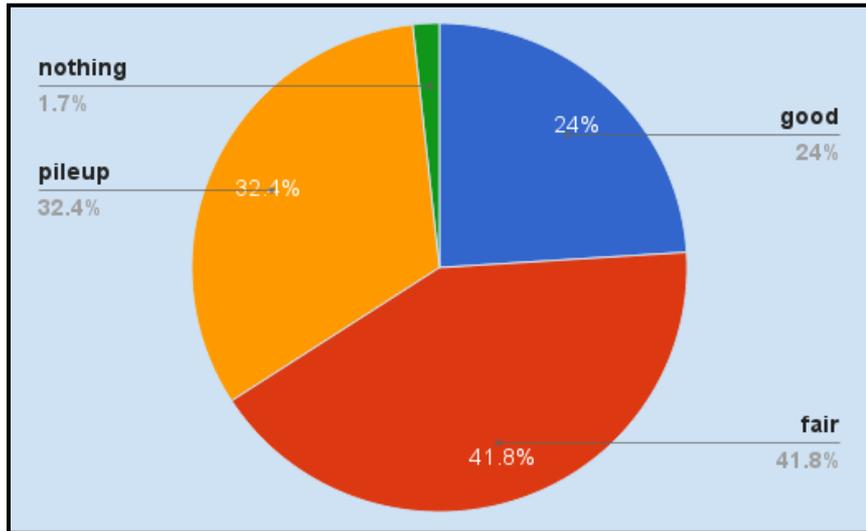
An Interesting Pileup



Event scan: runs used

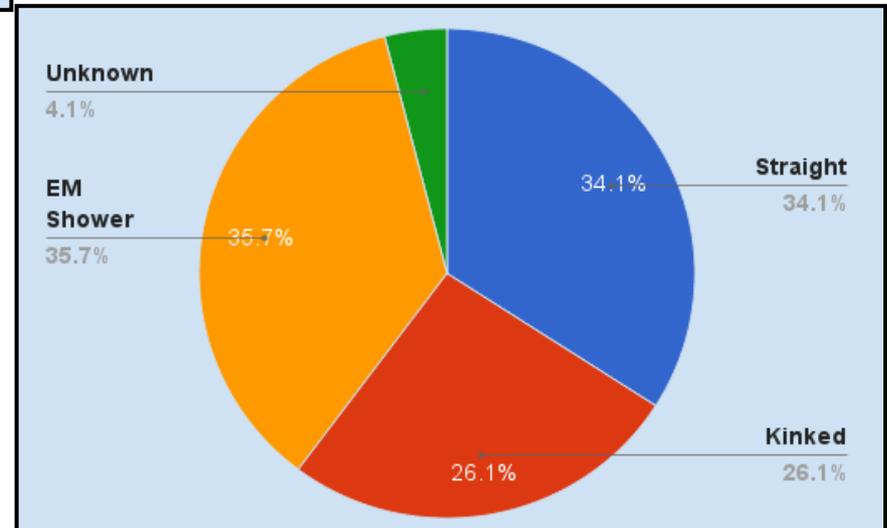
Who	When (approx)	First Run/spill	Last Run	Comments
Kevin	Mon June 15, 2015 2-7AM	6112/1	6112/334	16 GeV pions +60 A magnets SC1: 1e5 cntl 334 spills
Nat	Sun June 14, 9AM - Mon June 15, 2 AM	6111/1	6111/1000	16 GeV pions -60A magnets SC1: 5e4 1000 spills
Stephanie	Wed Jun 17, midnight-6AM	6145/1 6146/1	6145/258 6146/98	32 GeV pions -100A magnets SC1:1e5 356 spills

Event scan: results



Quality breakdown (all events)

Type breakdown (good events)



An event scan based event selector

```
class WMEventScanFilter {
private:

    // Hash table stores scan data for quick lookup
    std::unordered_map <long, std::string> eventTable;

    // Function for combining run, subrun, event numbers before hashing
    long prehash(int r, int s, int e);

public:

    WMEventScanFilter();

    // Return true if event is in scan and matches type given
    // Valid types are 1 or 2 characters (e.g. 'gs', 'p', 'f', 'k')
    bool isGoodEvent( int run, int spill, int event, std::string type );
};
```

Scope is obviously limited (only four runs), but it may be useful for some applications until large-scale filtering is available.

Event filtering: pulling single events

- Added an if clause to check if the specified run, subrun, and trigger was of the desired behavior in a .txt file from manual scan. (This was added in the producer while looping over triggers in `FragmentToDigit_module.cc`.)
- If a trigger failed this boolean check it was ignored.
- Added a `std::string` parameter in the `FragmentToDigit_config.fcl` file parameter set to pass an event behavior string (i.e. “gs”) to the module.

Files produced by filtering events

- This work created 9 files and separated straight, kinked, and em shower events from 3 running conditions.
- The files have been processed through the producers caldata, gaushit, dbcluster, and spacepoints.
- To find these files run:

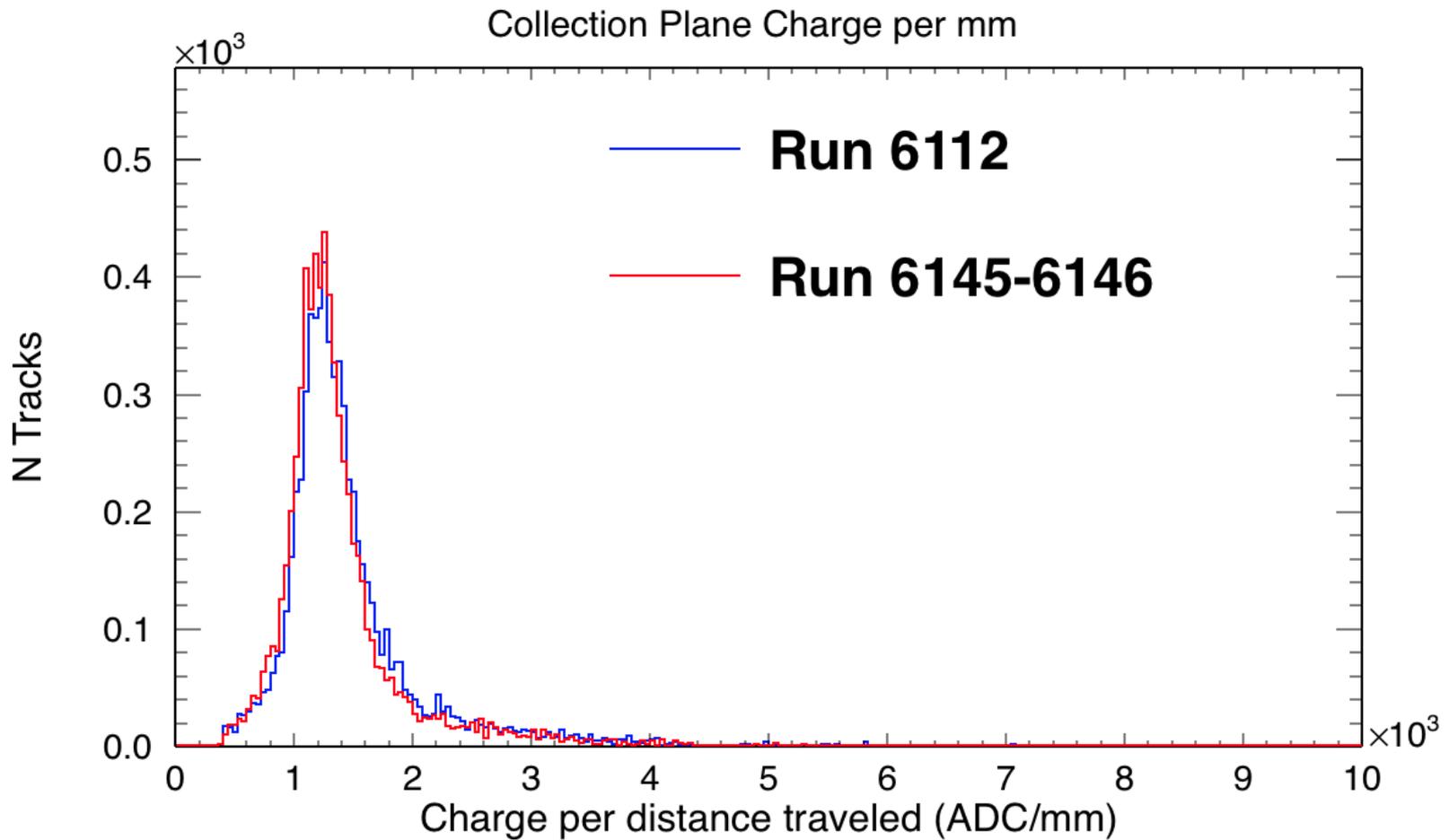
```
ls /lariat/data/users/knelson/eventParse/lariat61*
```

- Or to see my naming conventions and all the files produced read the README.txt in the eventParse folder

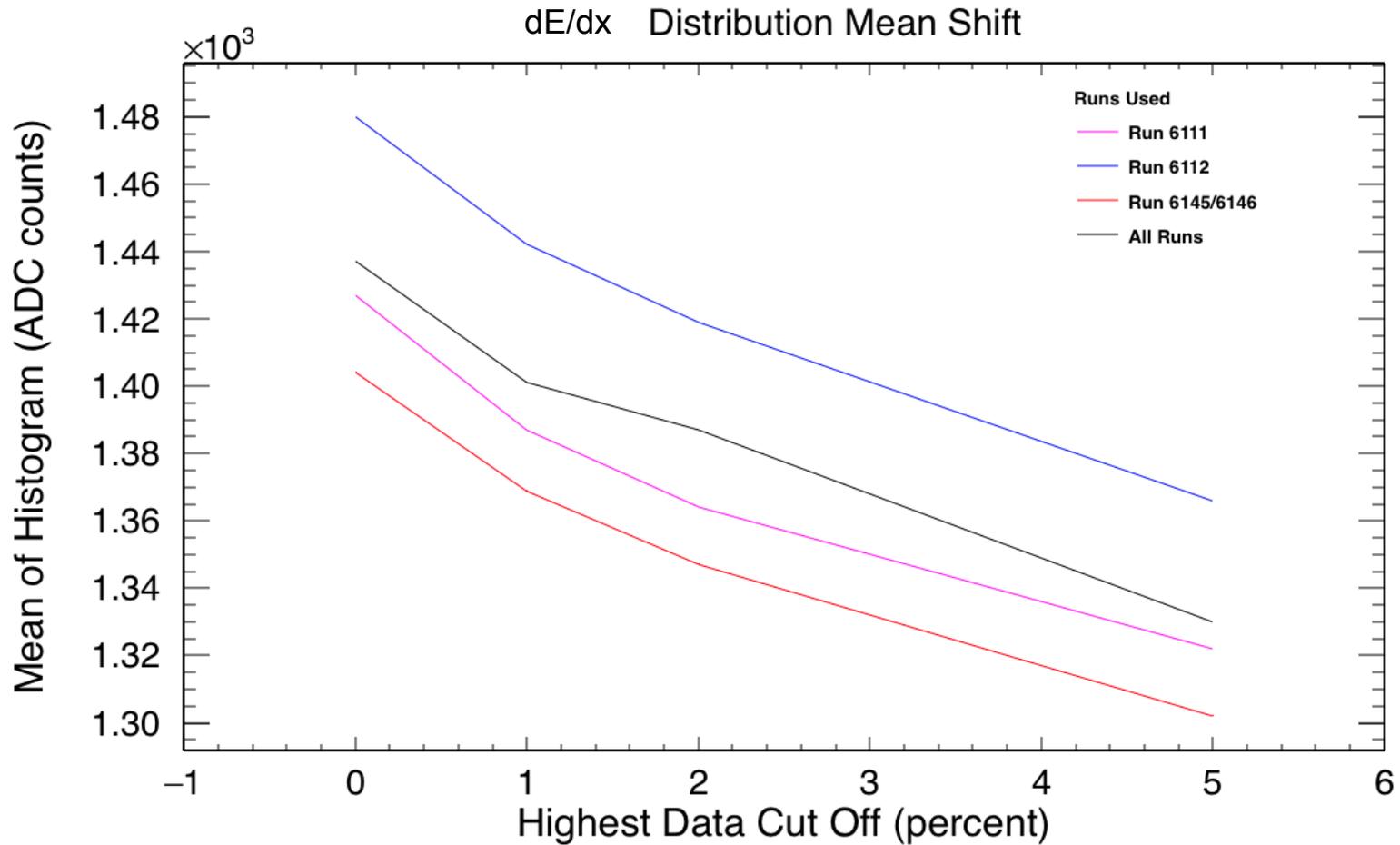
Tracking and dE/dx on good-straight events

- Using data from the manual scan with identifier “gs” for good straight.
- Passed these events through caldata, gaushit, dbcluster, spacepoints, cosmictracker, and wiretrackbuilder
- Quality cut the data to reconstructed tracks that entered through the beam window, begin in the first 5cm of the detector, and terminate in the last 5cm of the detector

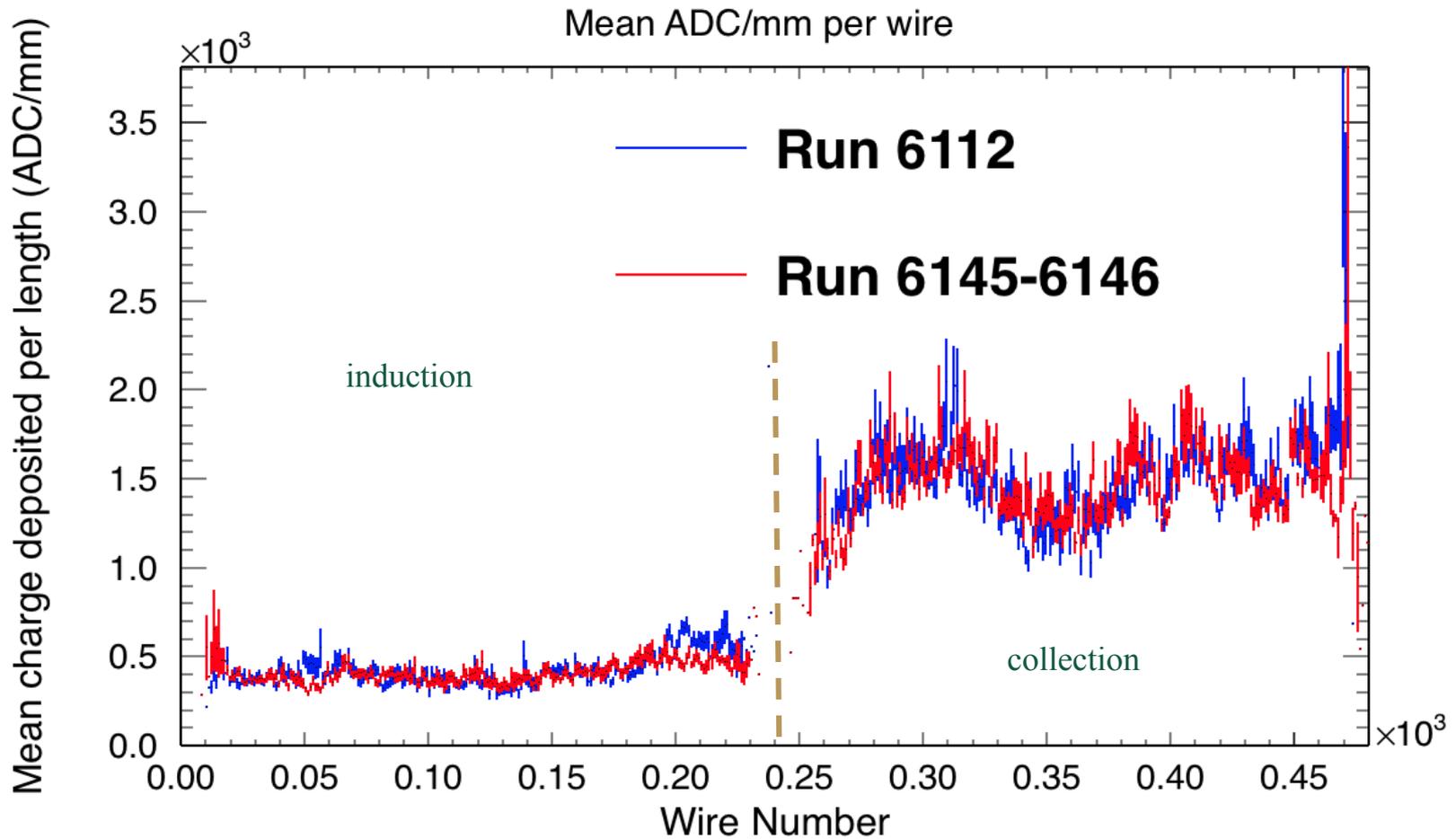
dE/dx distributions (ADC/mm)



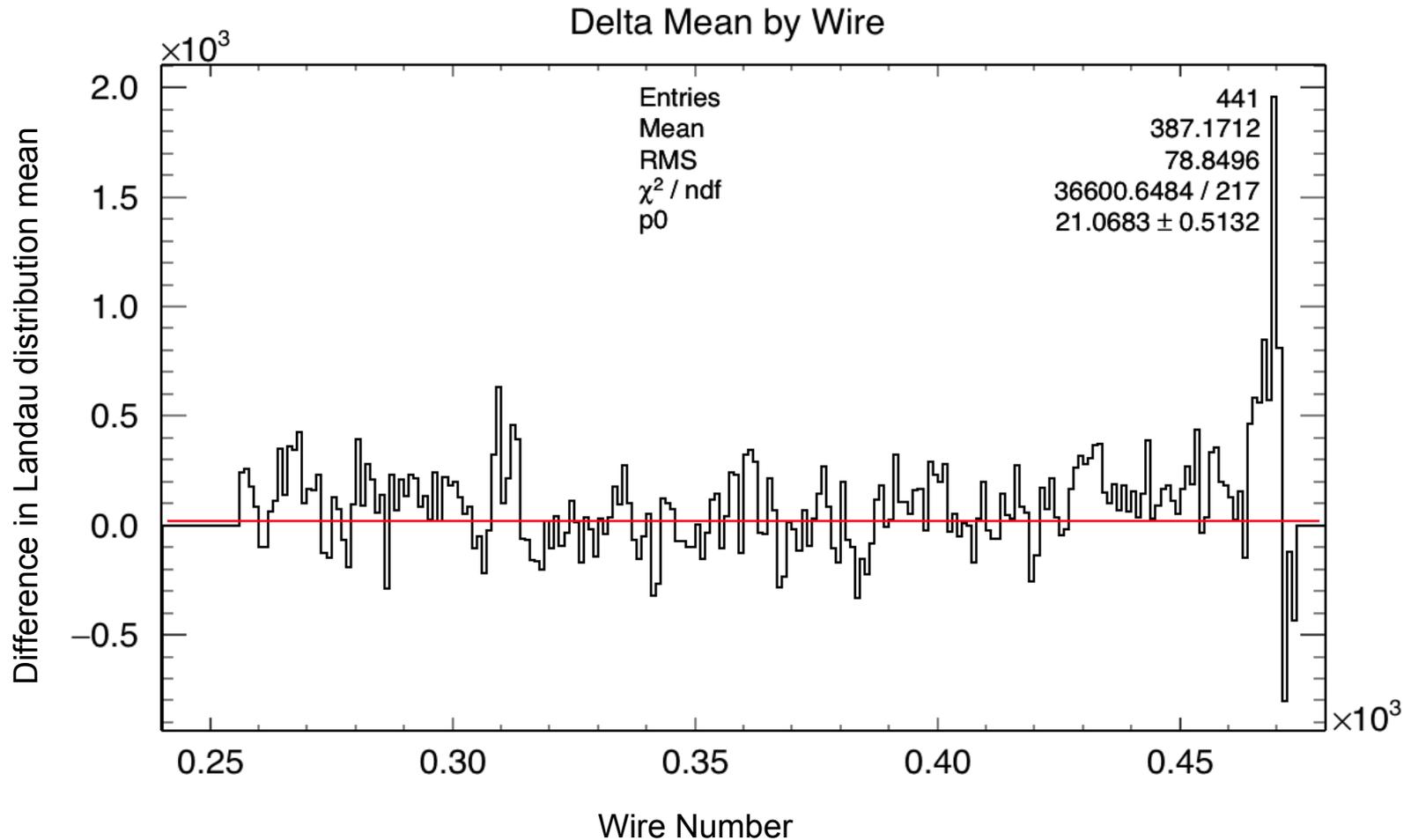
Truncation of highest data



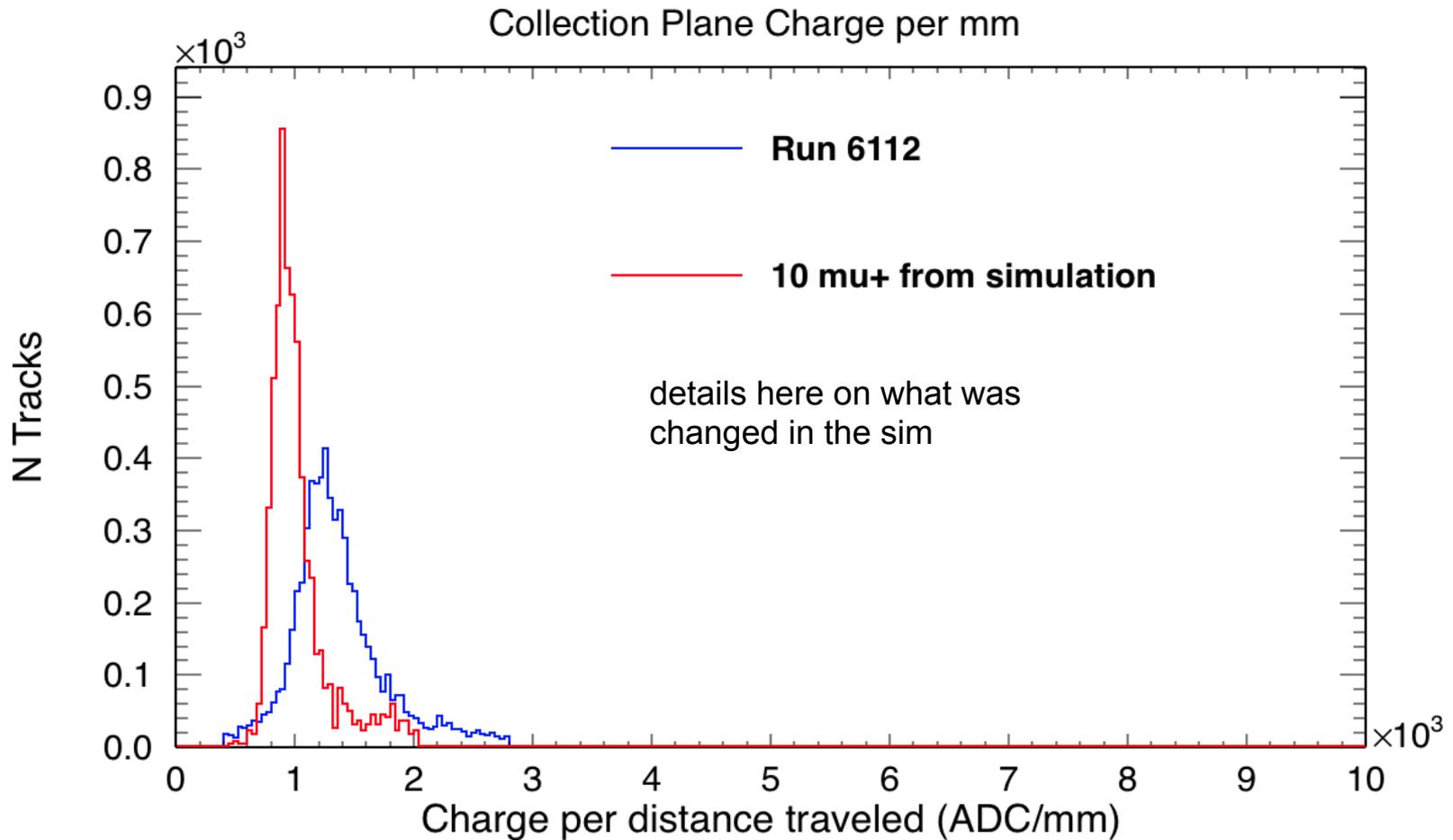
Means dE/dx (Wire by Wire)



Residual (subtracted previous plots)



Simulation (very preliminary)



Detector response for E&M events

- More EM events than expected

docdb
1304
32 GeV MC

	Run: Current, Energy	6111: -60A, 16GeV	6145: -100A, 32GeV
Predicted from simulation	Muon	1	1
	Pion	13	28
	Electron	7	2
	Electrons / (Muons + Pions)	0.5	0.07
	Results from scan		
	Straight (muons)	84	121
	Kinked (pions)	37	102
	EM Shower (electrons)	85	195
	EM / (Straight + Kinked)	0.7	0.87

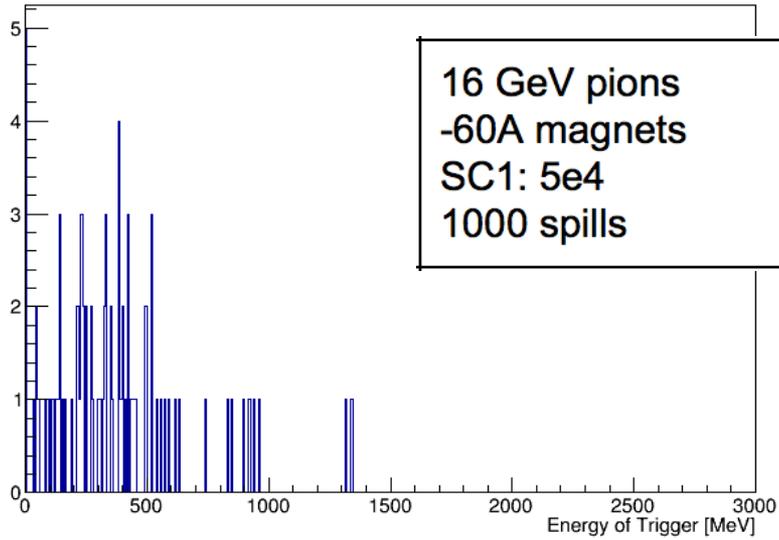
- Examined energy, momentum, position
 - Hypothesis was that many EM showers were low energy
 - Entering the detector due to a larger than simulated acceptance?

Finding Energy

- Used Gaussian hit finder and took the integral of the hit
- Using the fitted straight tracks, found average ADC/mm (cut off at 99%)
- Used 2.1MeV/cm energy loss rate (PDG) to convert ADC to energy to energy
- Used associations with hits, space points, and momentum
 - Knowing the energy of a hit gives an association between space points/energy and momentum/energy

Run 6111

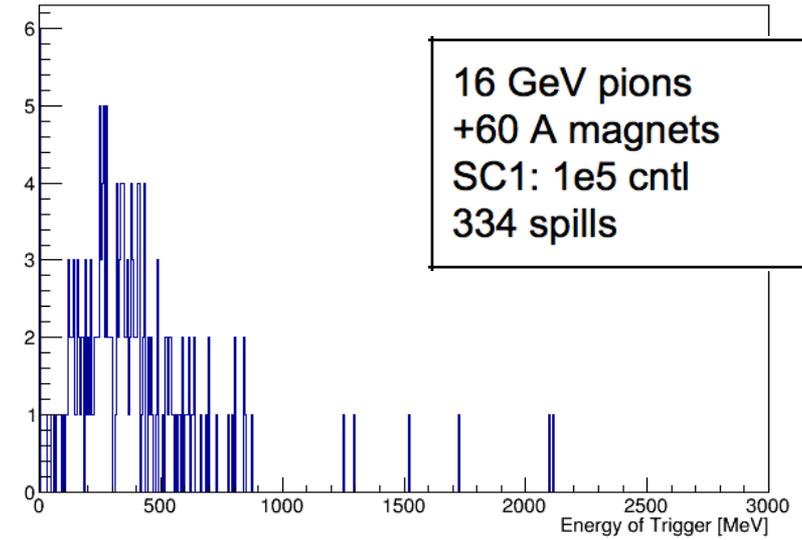
Induction Energy



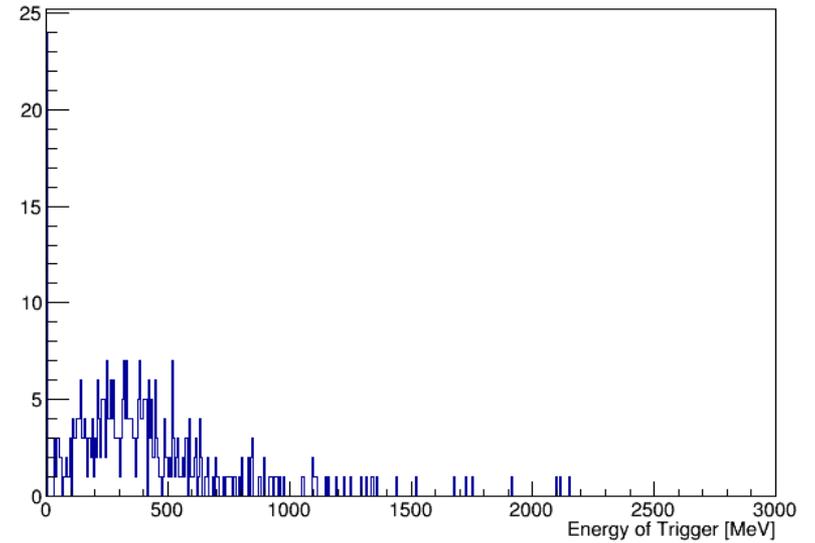
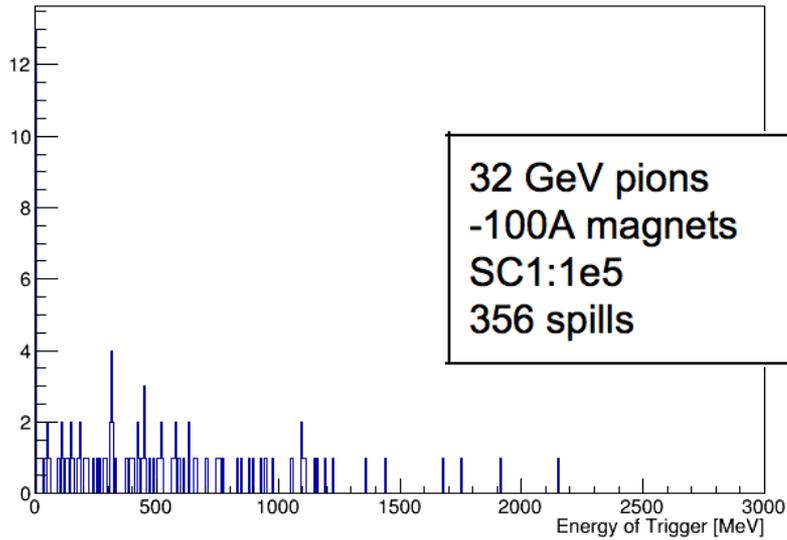
Induction Energy

Run 6112

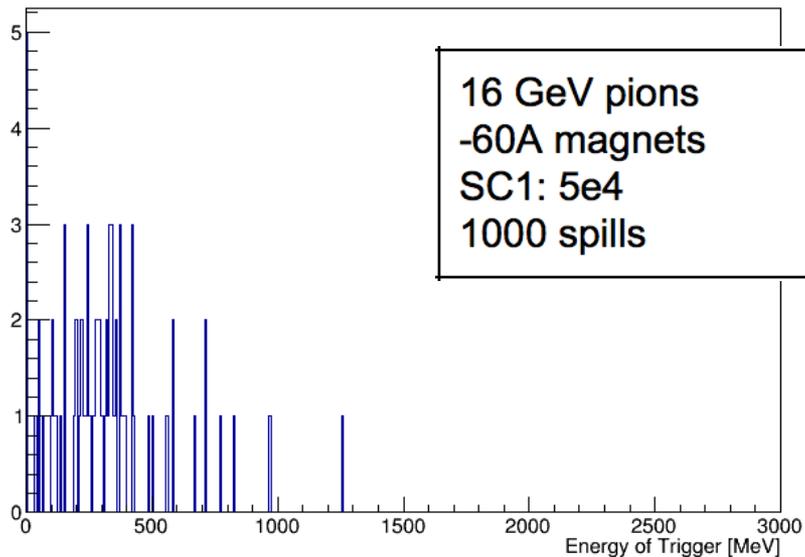
Induction Energy



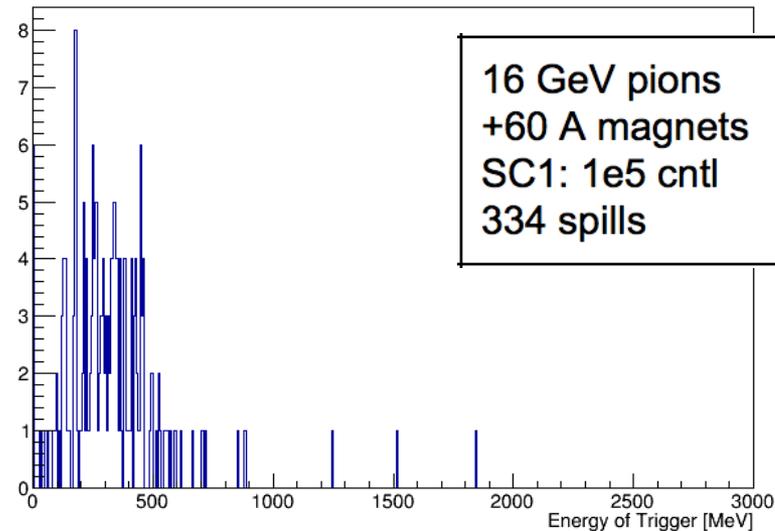
Induction Energy



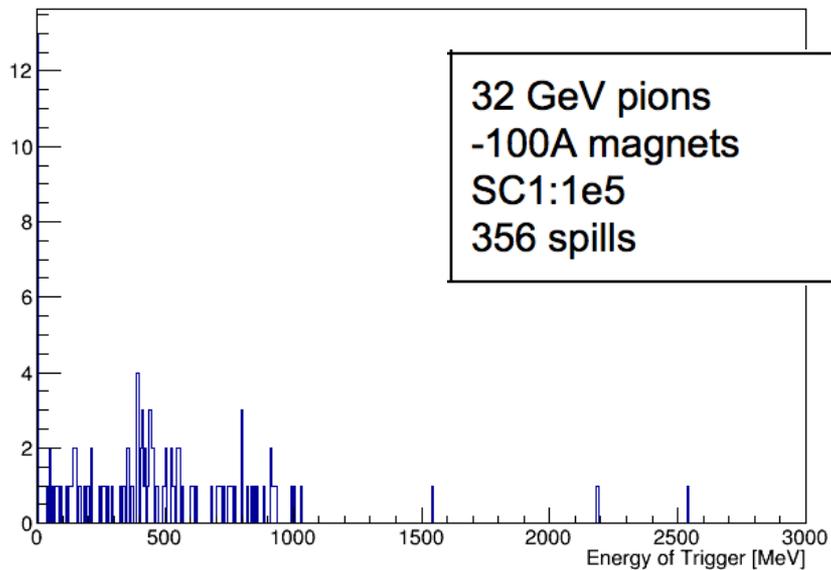
Run 6111
Collection Energy



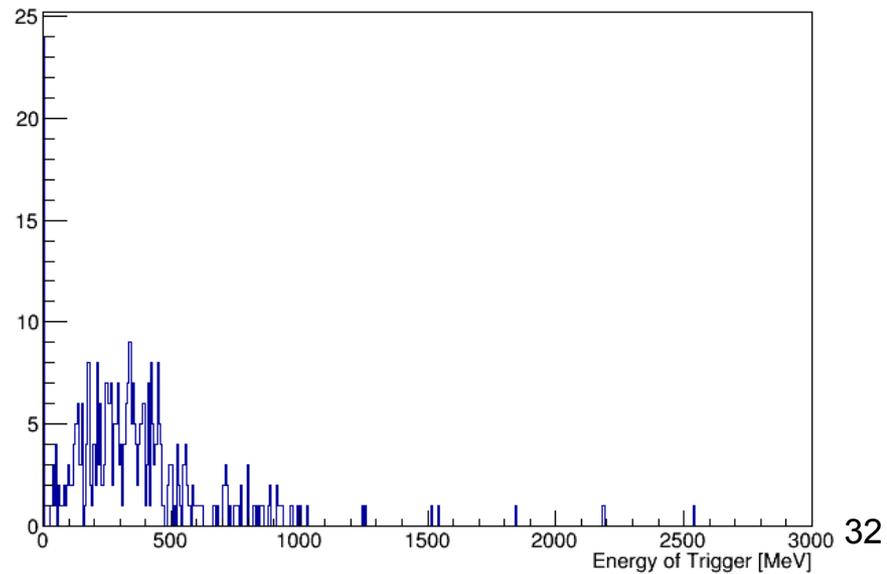
Run 6112
Collection Energy



Run 6145/6
Collection Energy

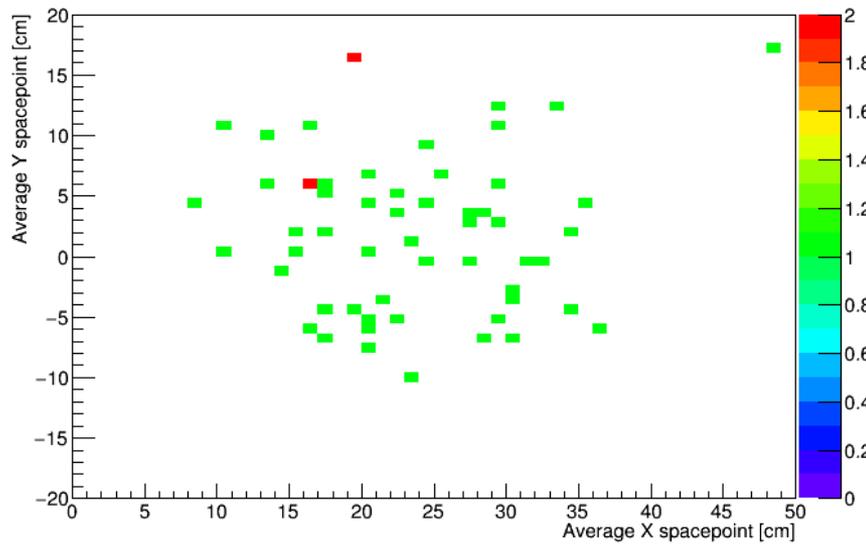


Combined
Collection Energy



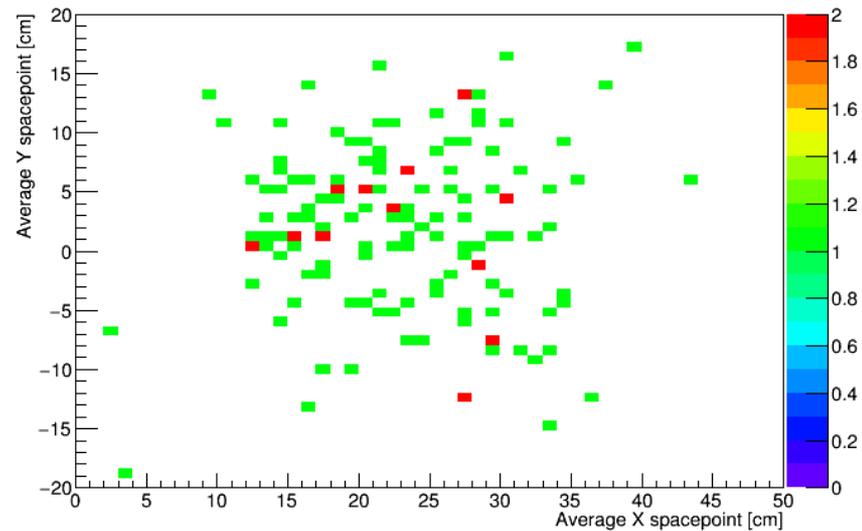
Run 6111

XY Center



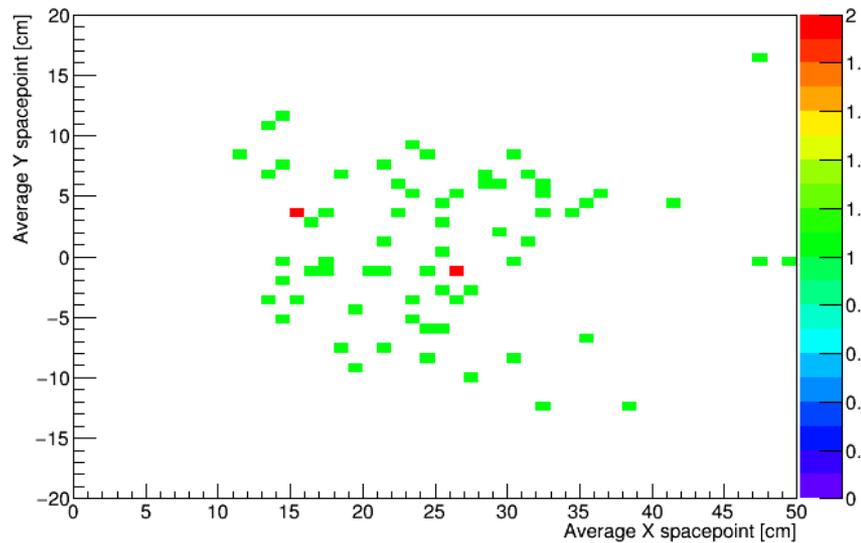
Run 6112

XY Center



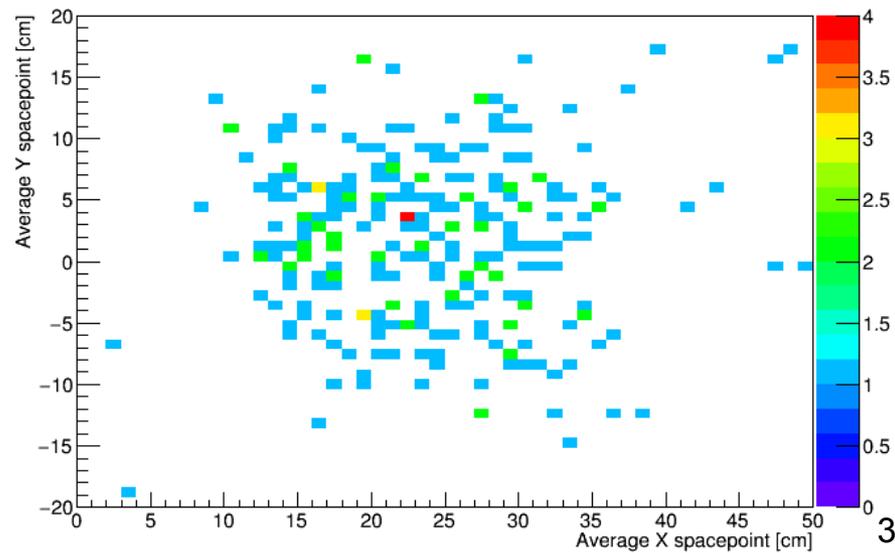
Run 6145/6

XY Center



Combined

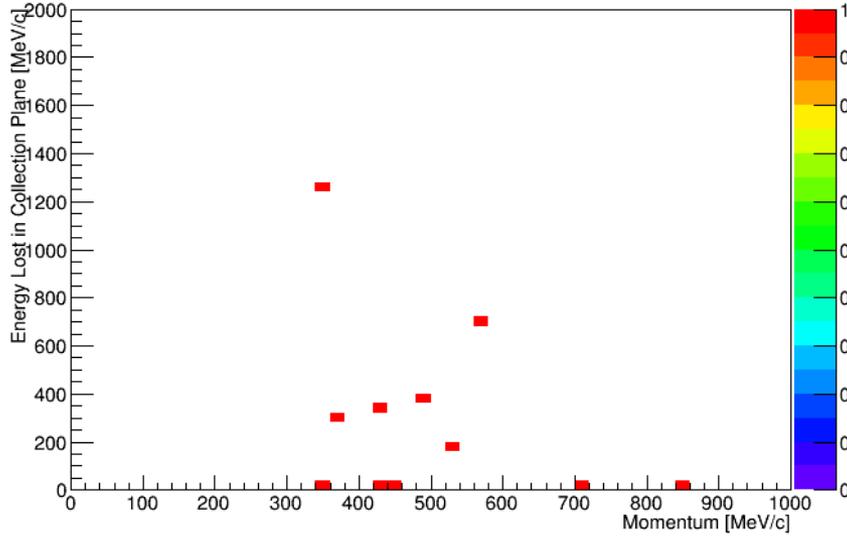
XY Center



WCT Not very efficient - momentum for 56 particles, hit finder worked on 392 EM events

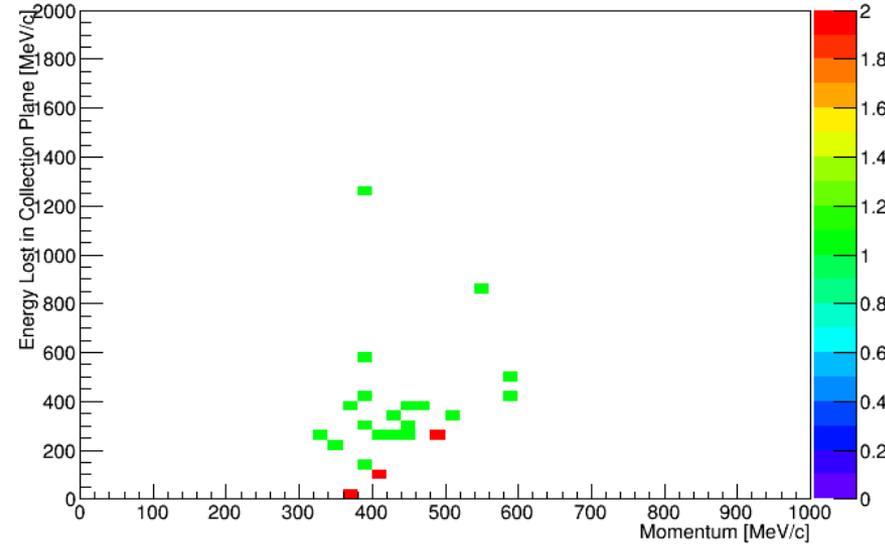
Run 6111

Collection Energy vs. Momentum



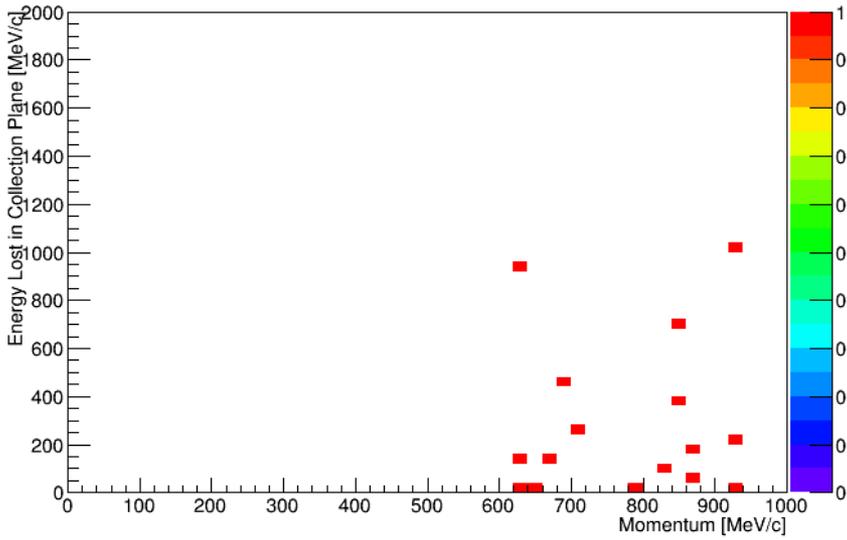
Run 6112

Collection Energy vs. Momentum



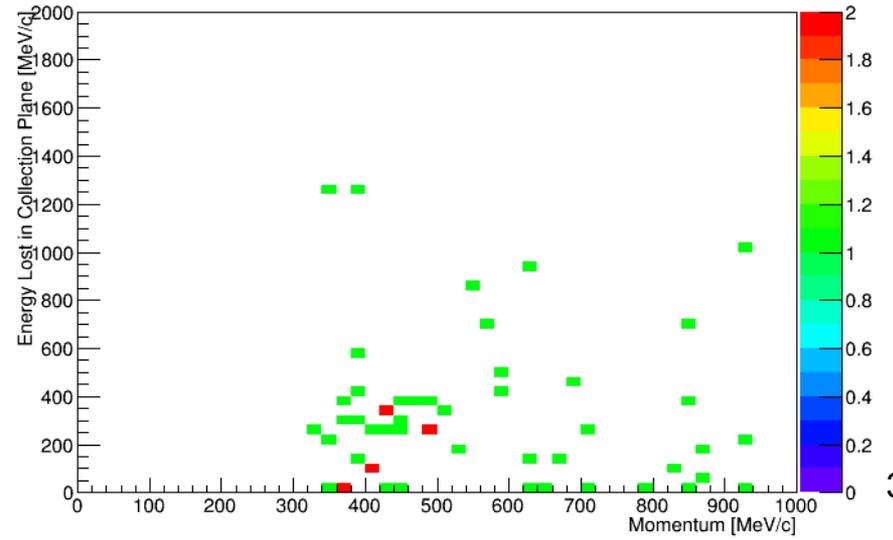
Run 6145/6

Collection Energy vs. Momentum



Combined

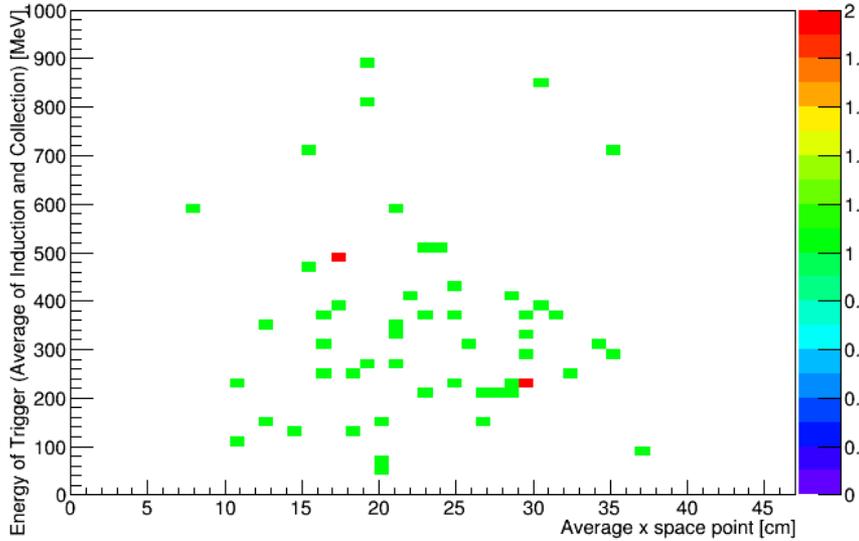
Collection Energy vs. Momentum



Looking for an inversely proportional relationship - higher energy will lead to less beam bending

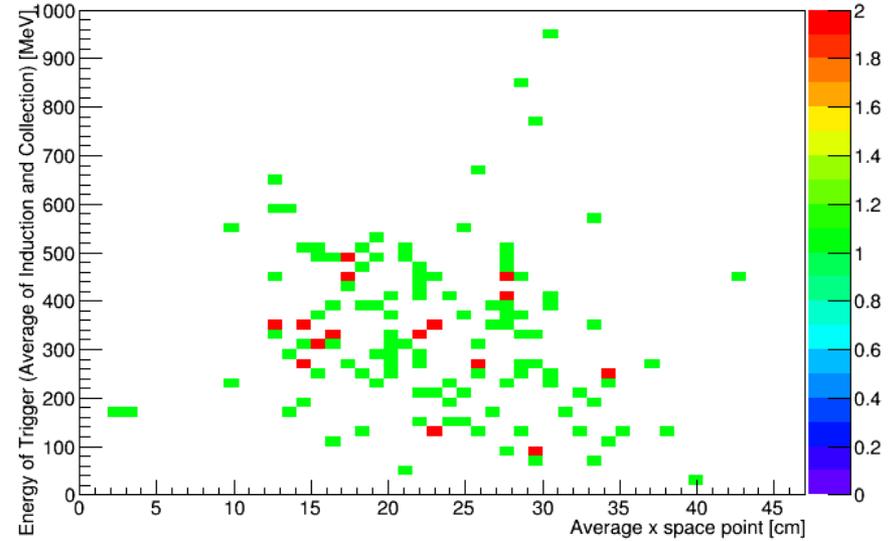
Run 6111

Trigger Energy vs. X



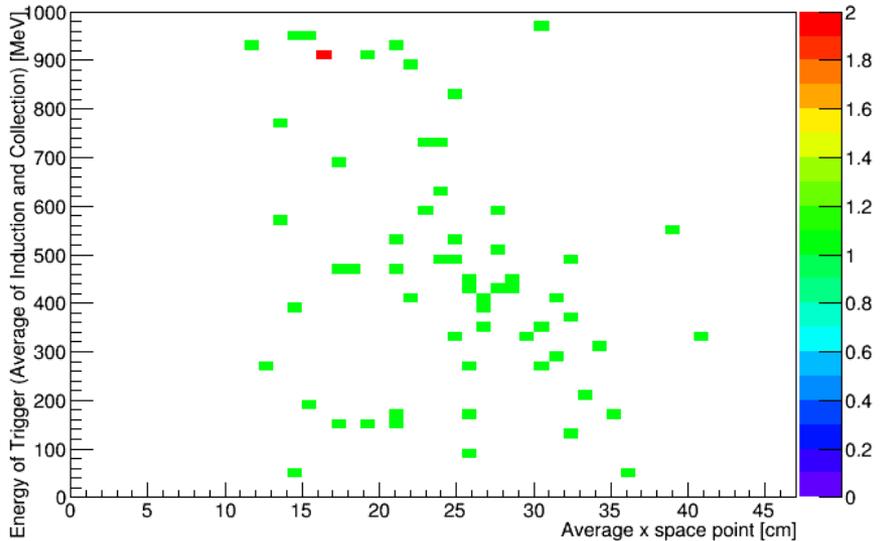
Run 6112

Trigger Energy vs. X



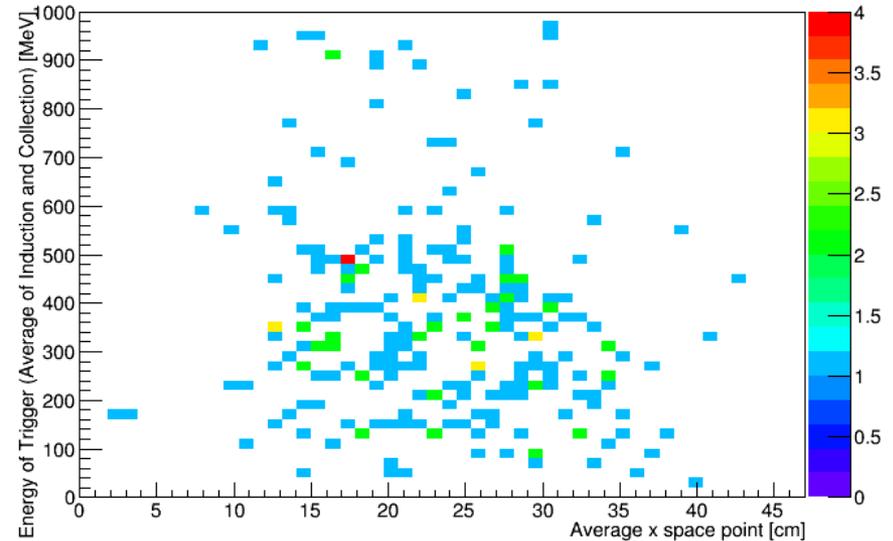
Run 6145/6

Trigger Energy vs. X



Combined

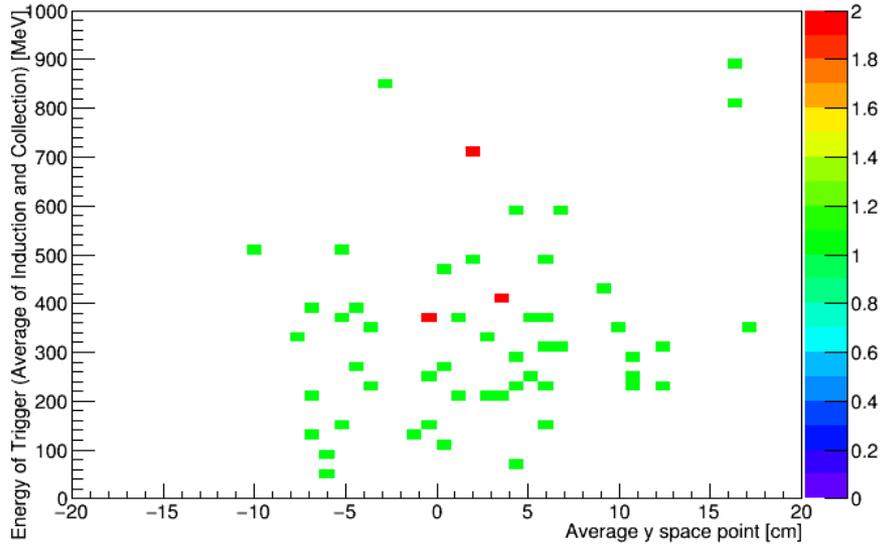
Trigger Energy vs. X



No discernible pattern

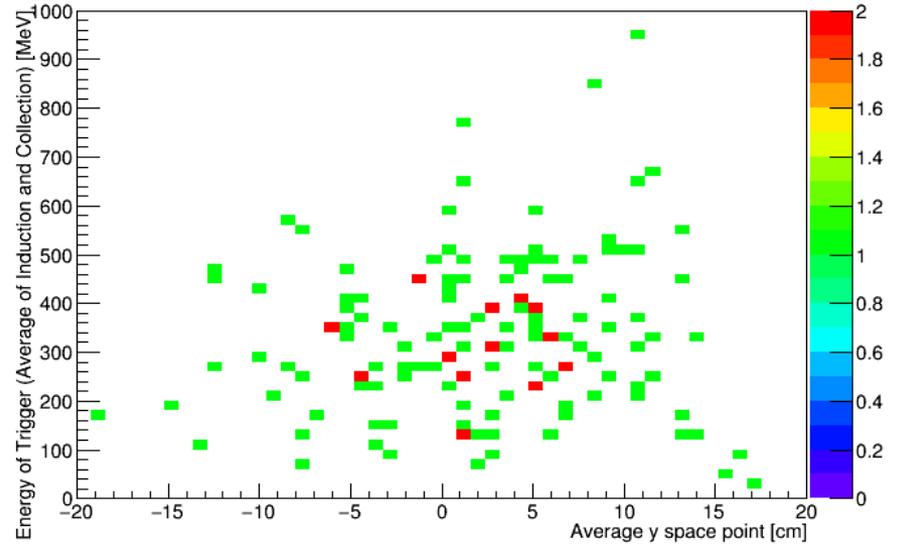
Run 6111

Trigger Energy vs. Y



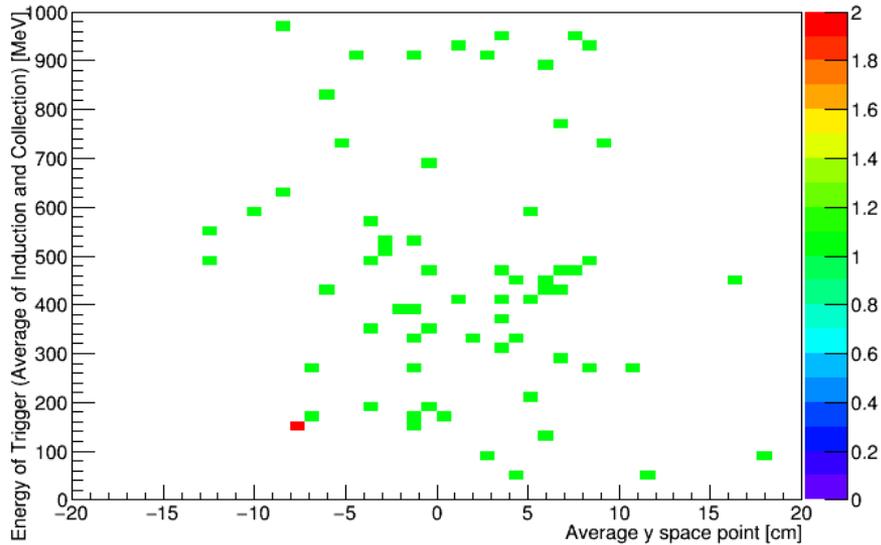
Run 6112

Trigger Energy vs. Y



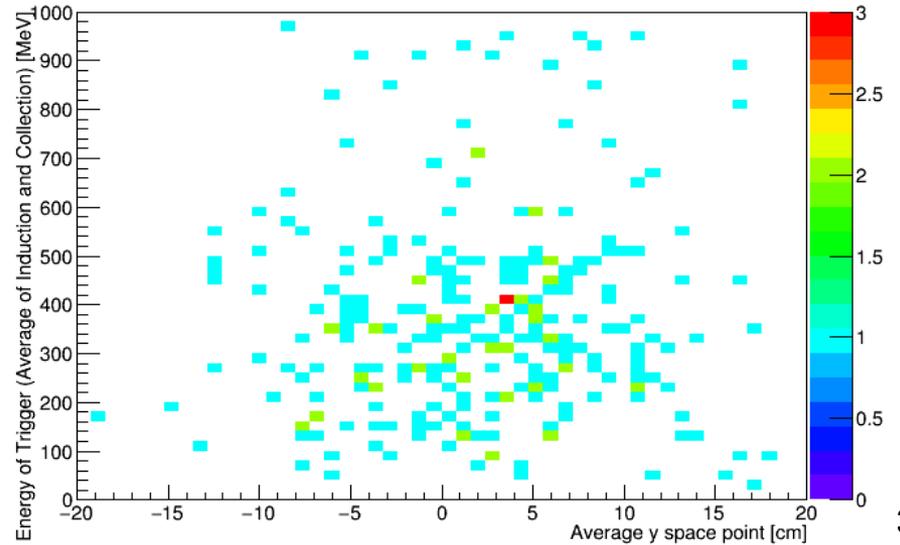
Run 6145/6

Trigger Energy vs. Y



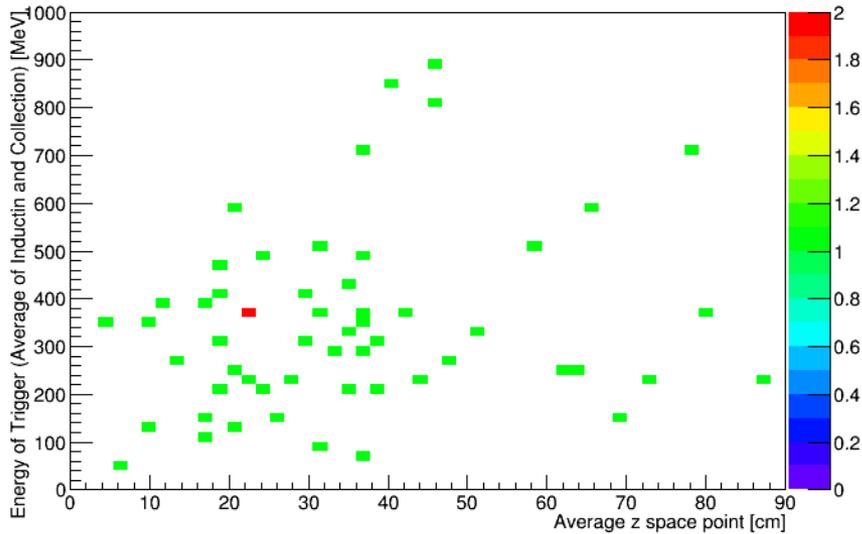
Combined

Trigger Energy vs. Y

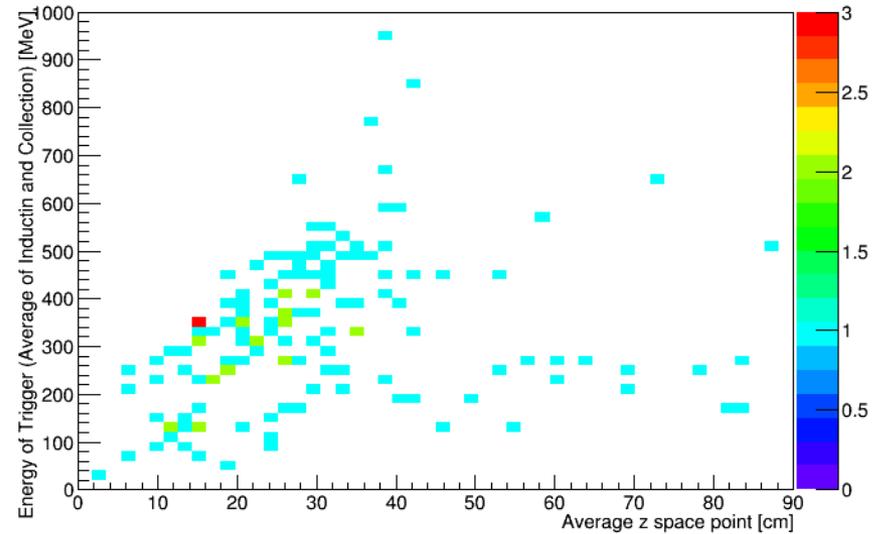


Looking for a proportional relationship - higher energy will penetrate farther into chamber

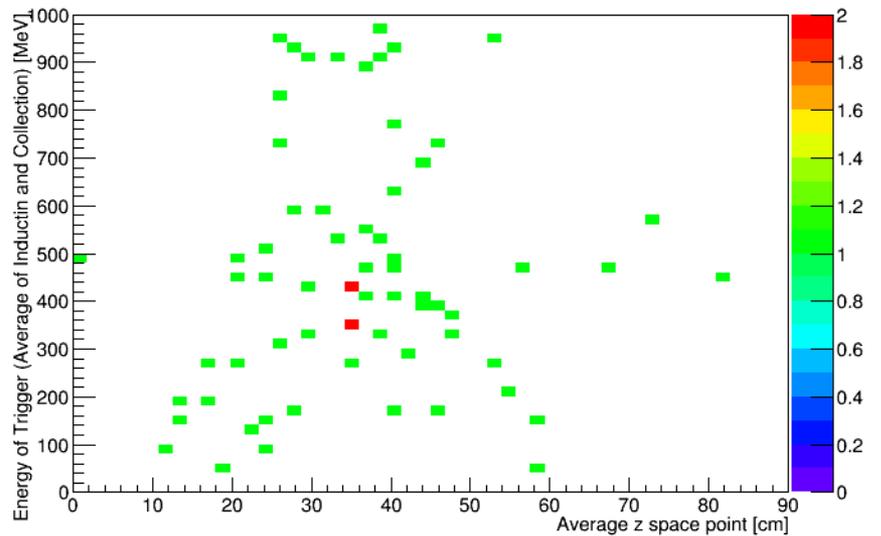
Run 6111
Trigger Energy vs. Z



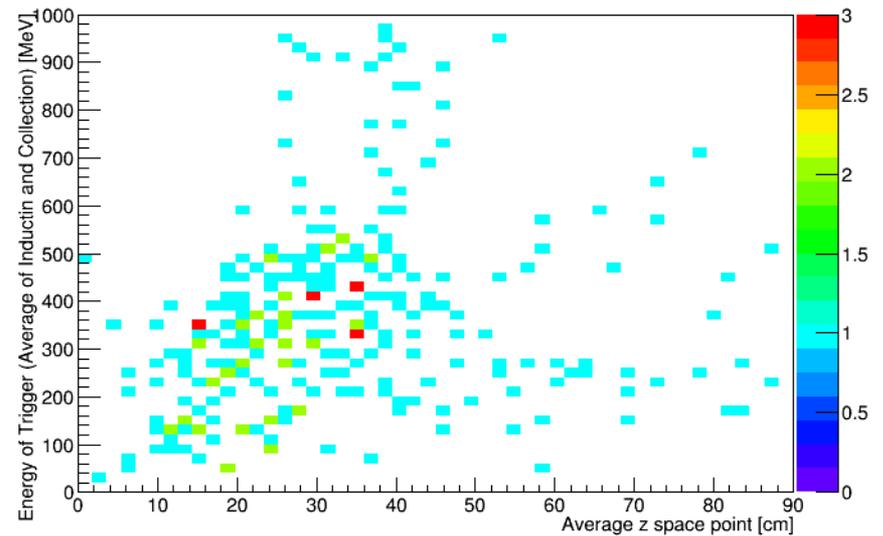
Run 6112
Trigger Energy vs. Z



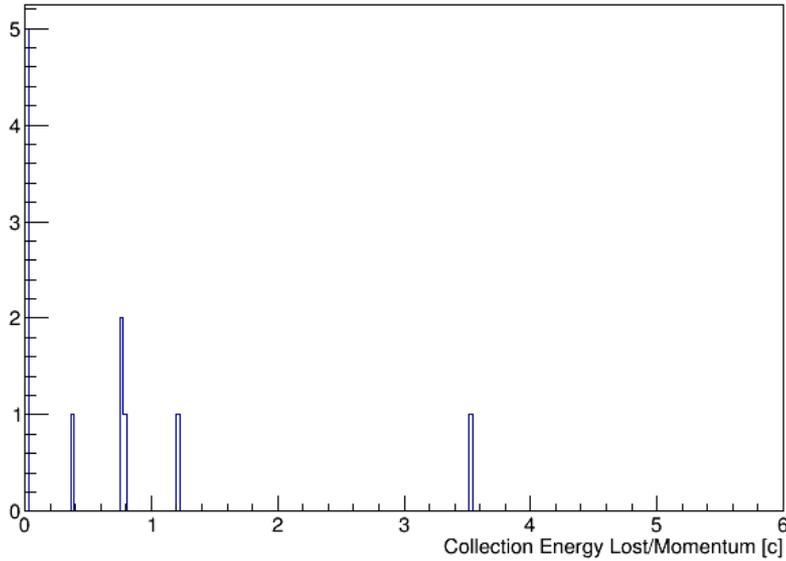
Run 6145/6
Trigger Energy vs. Z



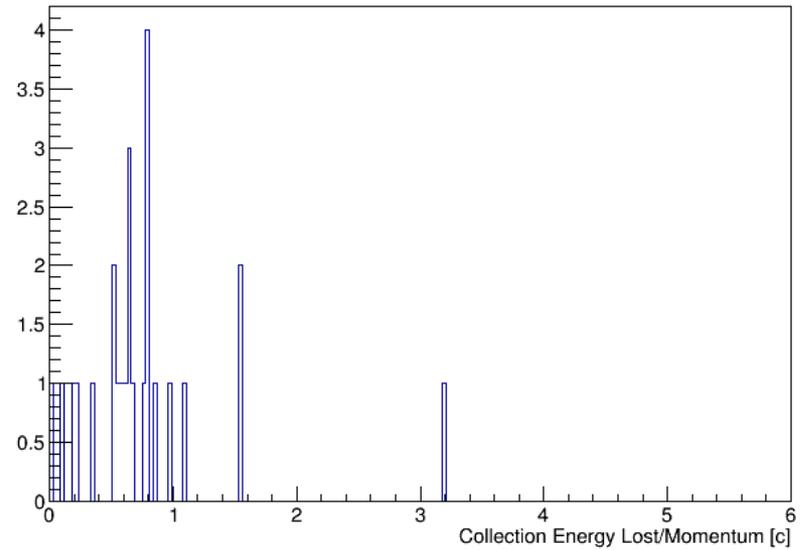
Combined
Trigger Energy vs. Z



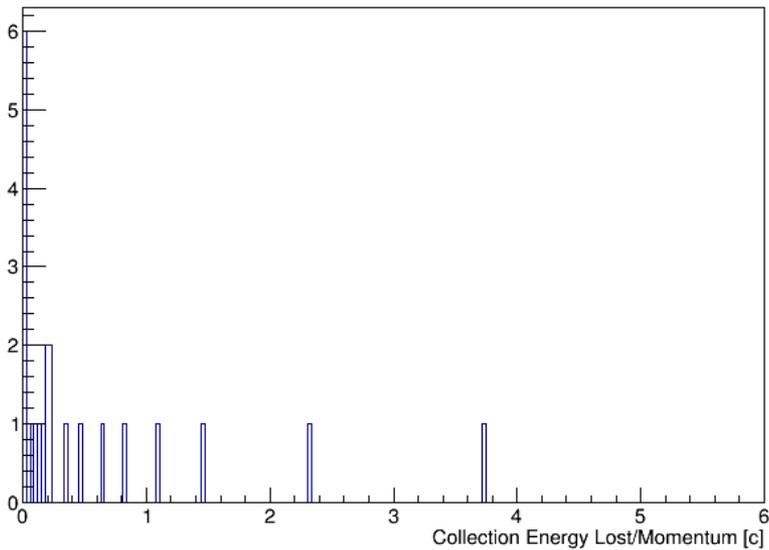
Run 6111
Collection Energy/Momentum



Run 6112
Collection Energy/Momentum

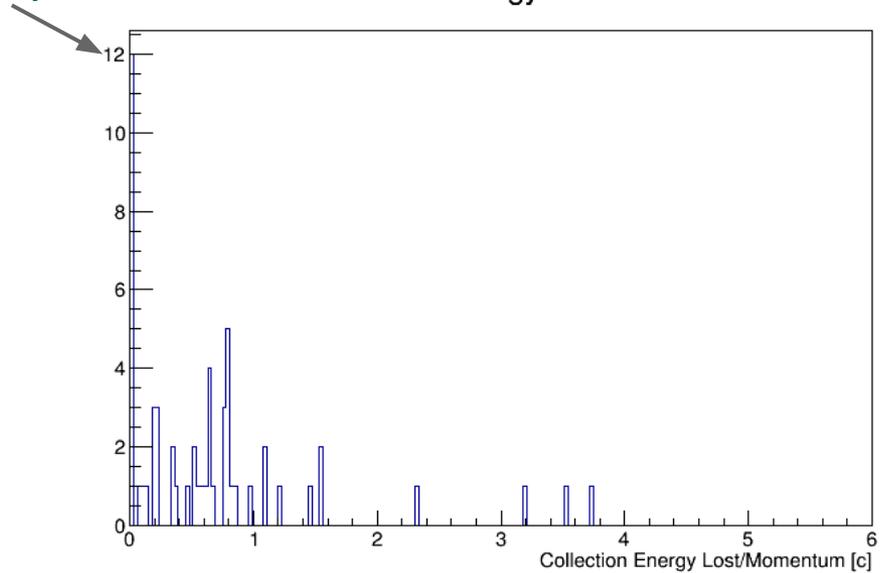


Run 6145/6
Collection Energy/Momentum

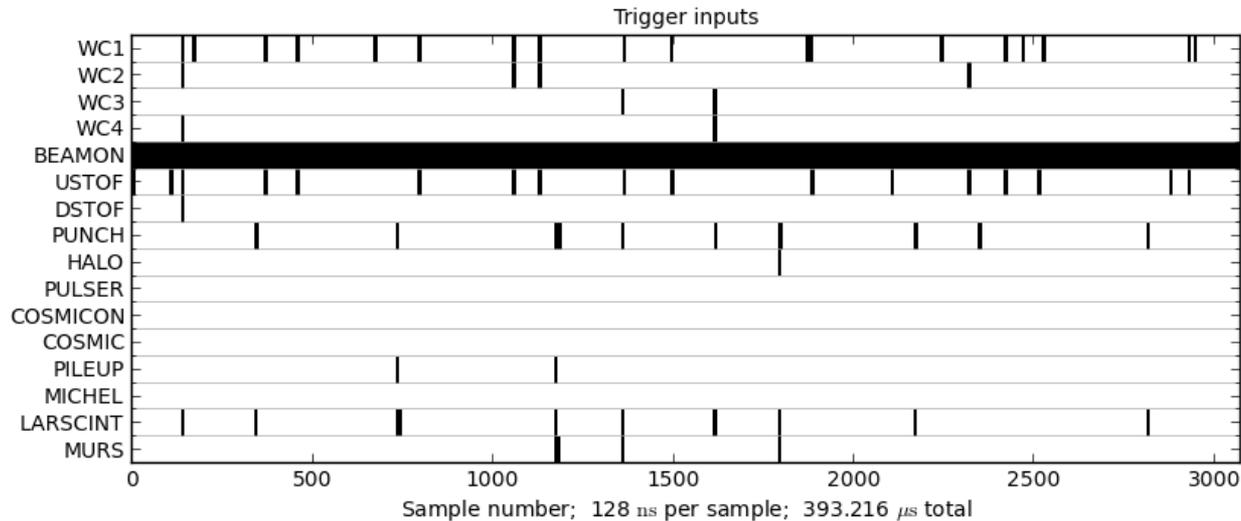


Some number of zeros - not sure why,
possible off-by-one error

Combined
Collection Energy/Momentum

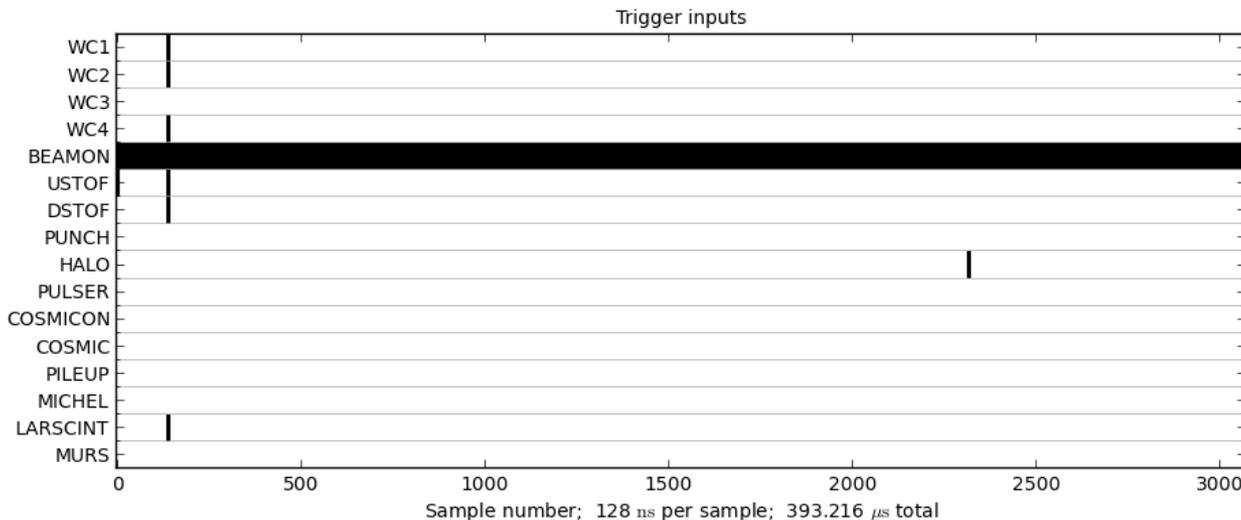


Toward Higher Stats: Algorithmic Filter Using AuxDetDigits



< pileup

Looks like a
good way to tell
them apart.

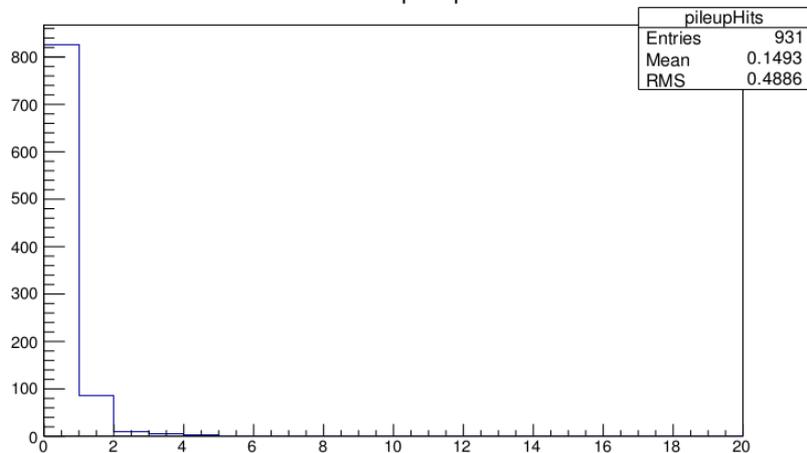


< good event

Picking Cut Parameters (PILEUP and PUNCH/LARSCINT coincidence)

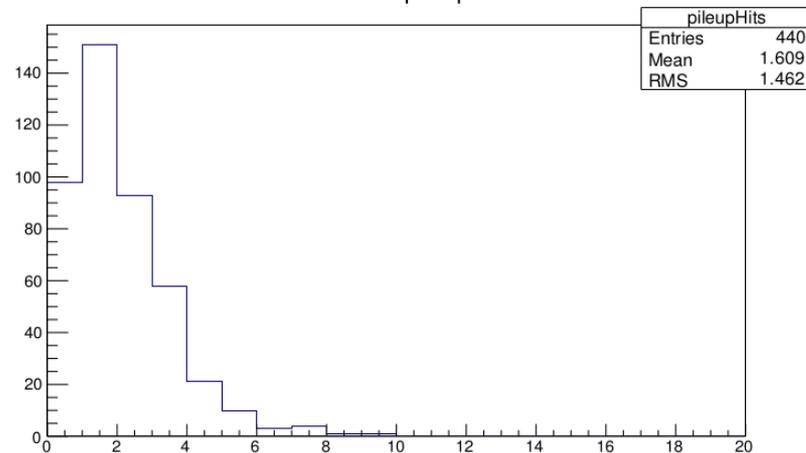
Good events:

Hits on pileup

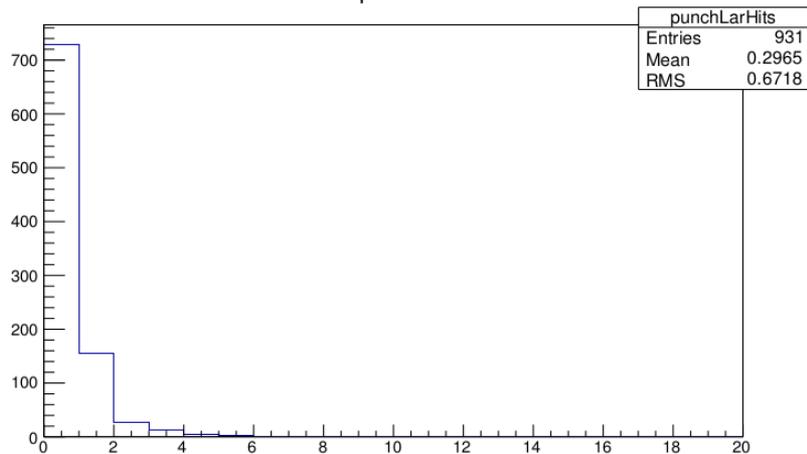


Pileups:

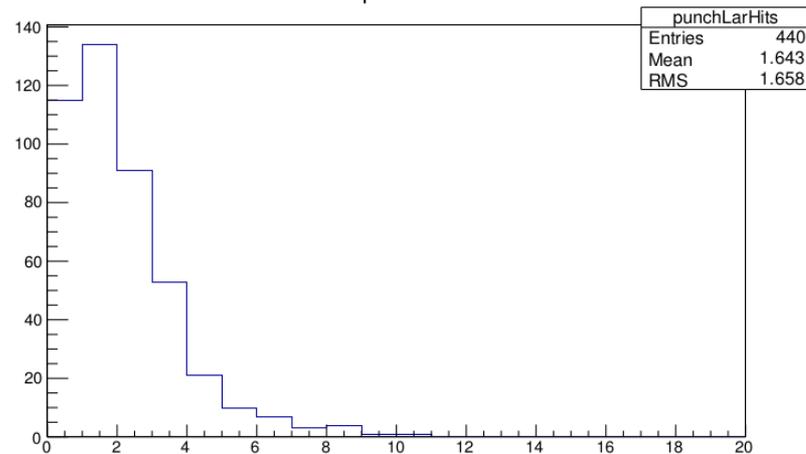
Hits on pileup



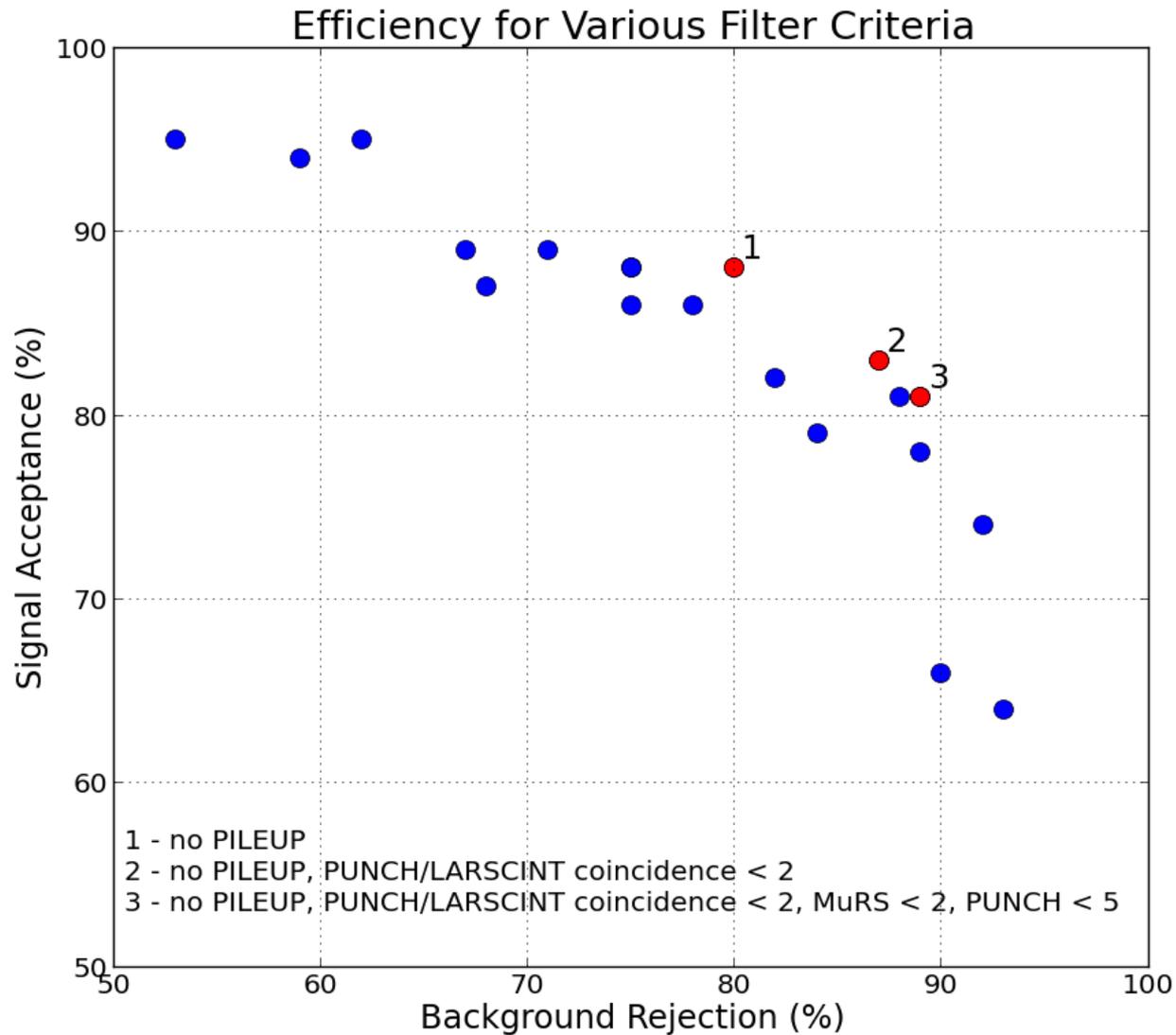
Hits on punch/larscint



Hits on punch/larscint



Filtering Results



Summary, conclusions, future work

- About $\frac{1}{4}$ of the events are good single particles
- $\frac{1}{3}$ EM showers, $\frac{1}{3}$ straight, $\frac{1}{4}$ kinked
- We have an event selection tool that utilizes the scan
- dE/dx analysis sees wire-by-wire differences and drift between runs
- WC tracking is not very efficient right now
- E&M events
 - more than expected; not predominantly low energy
- AuxDetDigit event selector written, will commit to git.