Status EM shower analysis for ProtoDUNE

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DUNE-France analysis workshop

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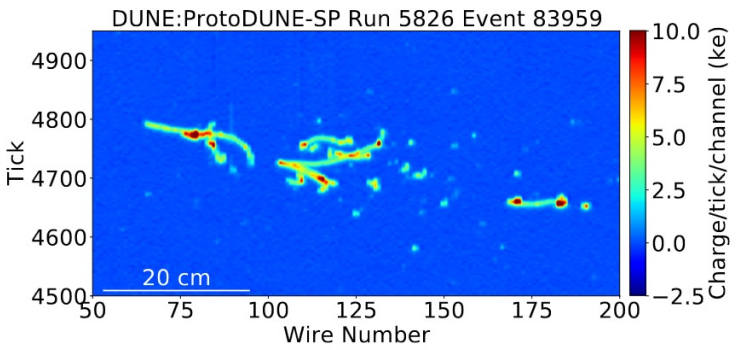
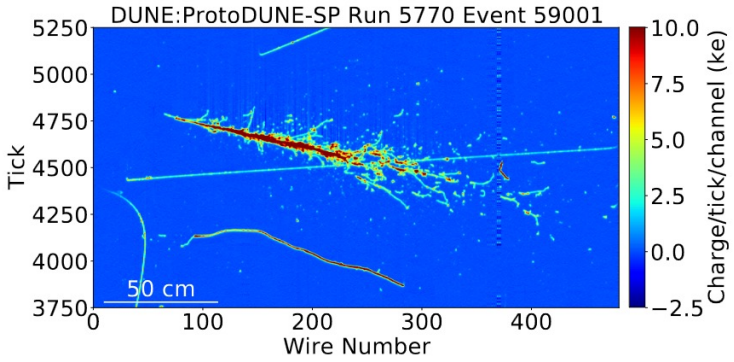


(a) A 0.5 GeV/c electron candidate.

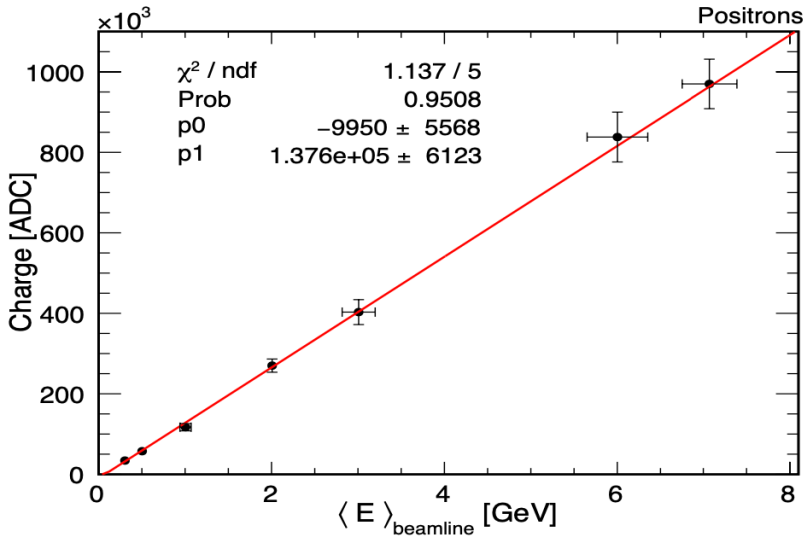


(b) A 6 GeV/c electron candidate.

Historical perspective

- PDSP data taking: fall 2018
- Aaron Higuera technical note April 2020
  https://docs.dunescience.org/cgi-bin/private/RetrieveFile?docid=18355&filename=technote_v2.pdf&version=2

Run	Momentum
5834	0.3 GeV/c
5826	0.5 GeV/c
5809	1.0 GeV/c
5824	2.0 GeV/c
5786, 5777	3.0 GeV/c
5770, 5771	6.0 GeV/c
5145, 5205	7.0 GeV/c



$< E > [GeV]$	σ [%]
0.160	12.9
0.295	11.2
0.851	5.1
1.77	4.1
2.65	3.9
5.49	3.9
6.37	4.3

Table 4: Mean and sigma values.

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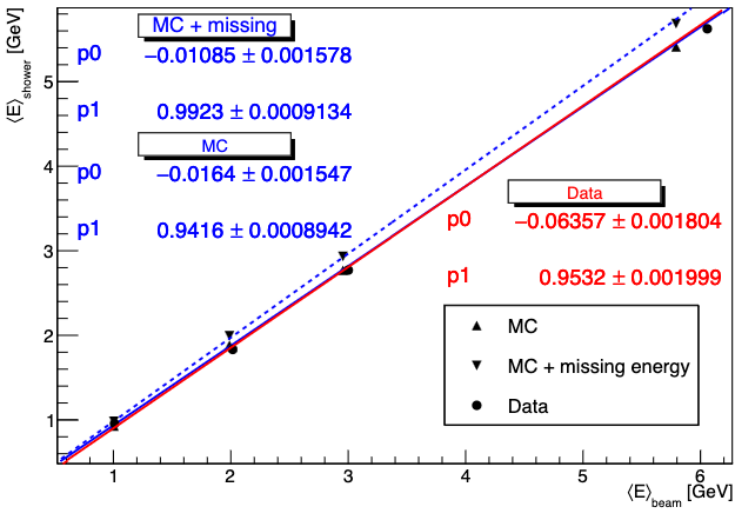

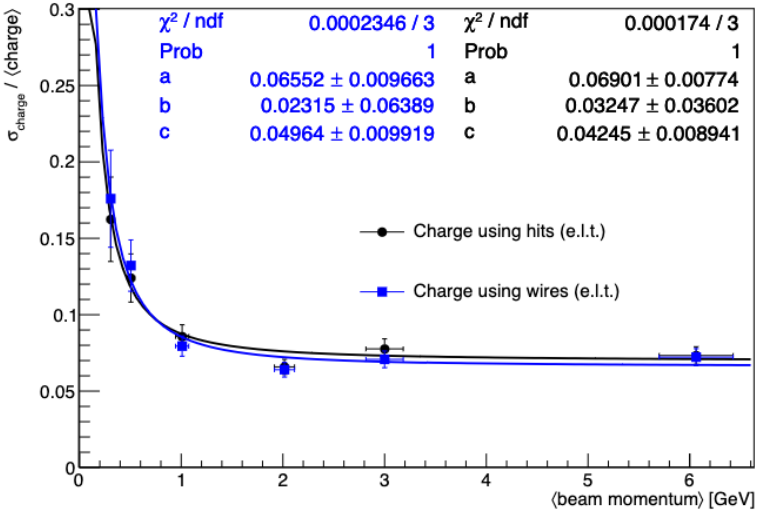

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Conclusions

- Constant term: fluctuation in beam momentum
- Stochastic term: fluctuations in ionization and missing energy caused by reconstruction threshold
- Noise term: fluctuation in upstream energy loss

Historical perspective

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- Linhui Gu started investigated this analysis in summer 2023 using original code from Ewerton B.
- Jan. 2024, discussed with Tingjun Y., Leigh W. & Linhui G. at CERN and initiated an EM shower analysis activity at IJClab with Mateo B., taking over Ewerton's work, in light of the upcoming PDVD data taking

Some glimpse into the analysis

- Details of the waveform deconvolution and calorimetry are key to the overall deposited energy reconstruction

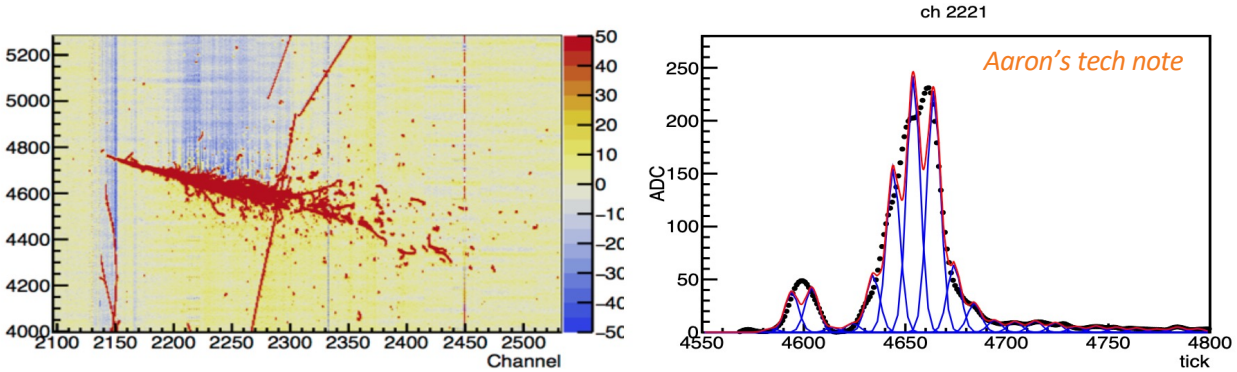


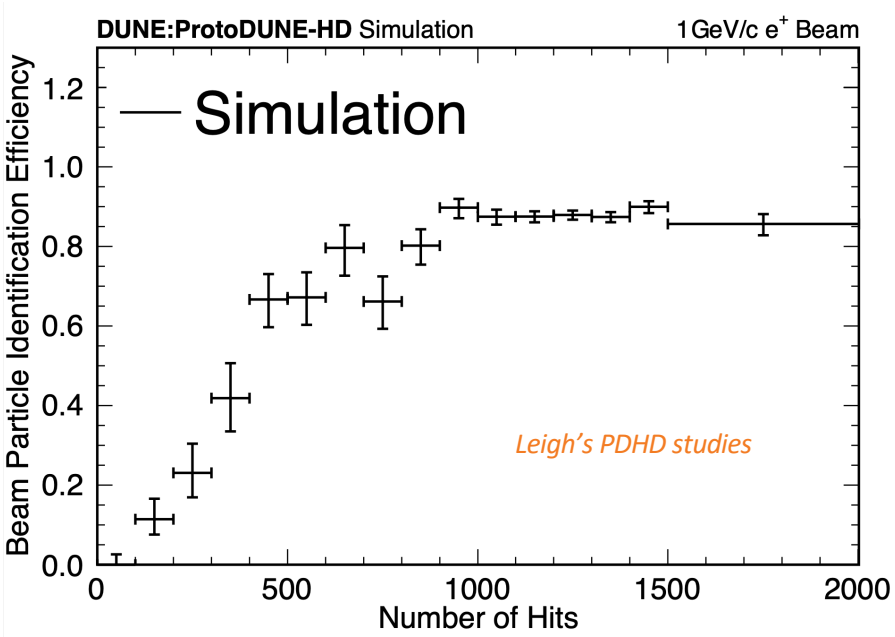
Figure 11: Event display (left). A waveform from `recob::wire` and charge integral from gaussian hits.

- Tick-by-tick e^- lifetime correction picked-up from database
- Reconstruct dE/dx to cut π^0 induced background (x2 dE/dx)

$$\left(\frac{dQ}{dx}\right)_{\text{calibrated}} = \frac{1}{C_{\text{cal}}}\left(\frac{dQ}{dx}\right) \times (\text{norm factor}) \times (X\text{corr factor}) \times (YZ\text{corr factor}), \quad (1)$$

Pandora shower ID at work!

- Extensive use of the Pandora PID capabilities



Aaron's tech note

Run	No. of hits grater than	Momentum
5834	200	0.3 GeV/c
5826	350	0.5 GeV/c
5809	1100	1.0 GeV/c
5824	2100	2.0 GeV/c
5786, 5777	2800	3.0 GeV/c
5770, 5771	5000	6.0 GeV/c
5145, 5205	5100	7.0 GeV/c

Table 2: Number of hits required by the primary shower.

- Typical identification performances in PDSP/PDHD

Pandora shower ID at work!

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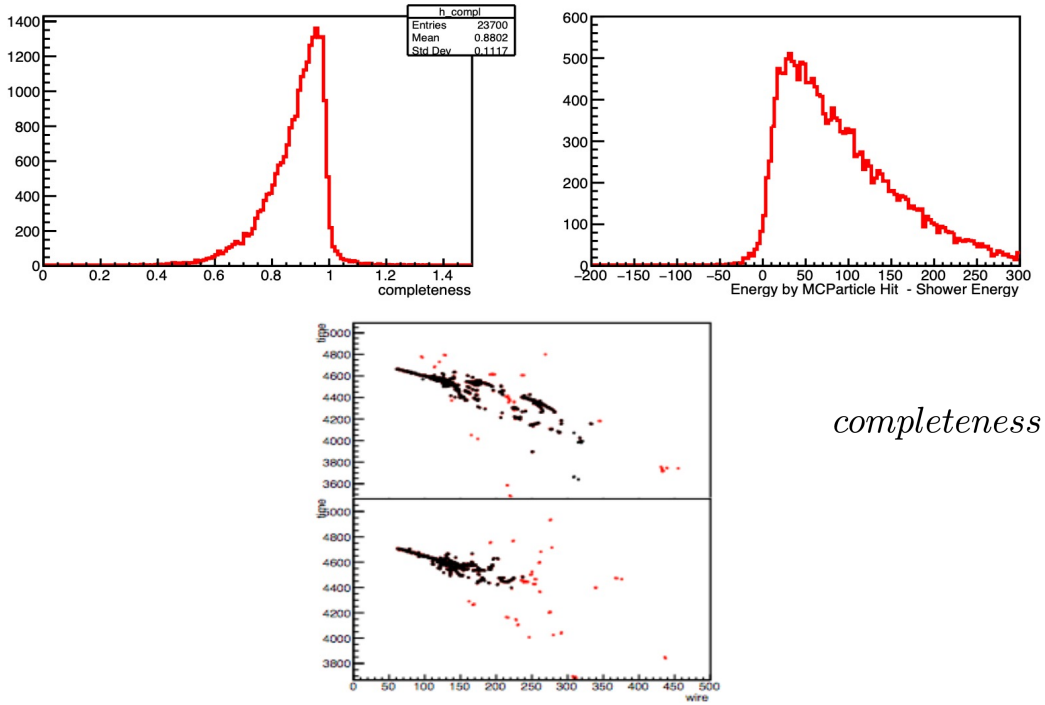

Aaron's tech note

$$completeness = \frac{\sum_i \text{pandora reco hit charge}_i}{\sum_i \text{MC particle hit charge}_i}.$$

Figure 10: Shower completeness (left). Energy loss due to shower reconstruction (right). Event displays where black markers are associated to a reconstructed shower and red markers are hits not associated to the reconstructed shower.

- NB: performances might be better by now!

Tasks to come

- Latest anaysis code under `protoduneana/singlephase/EMTaskForce` (module, scripts) made available by Ewerton

- Ewerton's code is not compatible with new `dunesw` versions (developed with `dunetpc v08_55_01`) and in particular the `Prod4a` of PDSP reconstruction

- Mateo refurbished the « historical » module to make it compatible with state of the art `dunesw` and started looking into the analysis steps (+getting familiar with manipulating Pandora objects)
- Runs on `Prod2` & `Prod4` files

- Latest production files should be made available from rucio
  Currently only MC but DUNE data-management asked for data