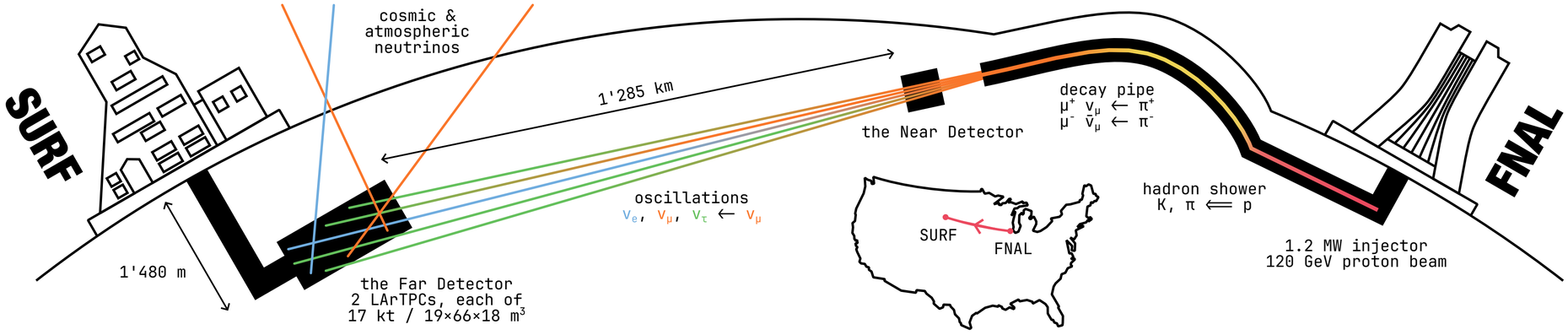
Michel electrons energy reconstruction in DUNE Prototypes: Simulations and Data

IRN Neutrino, June 2nd 2026

Jérémy Quélin Lechevranton
quelin-lechevranton@ijclab.in2p3.fr

The Deep Underground Neutrino Experiment (DUNE), starting operations *c.* 2030

- Long baseline, beam **neutrino oscillations** experiment



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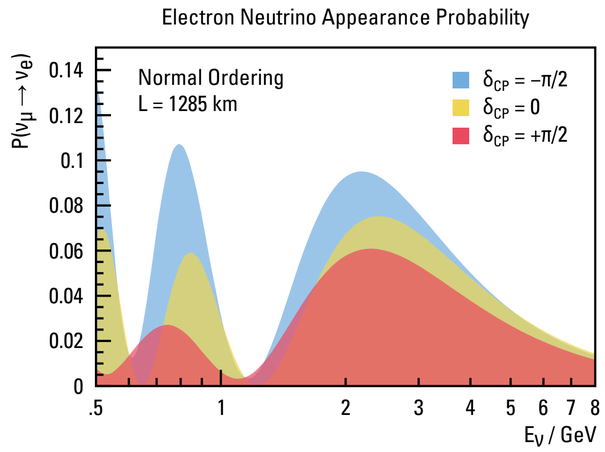
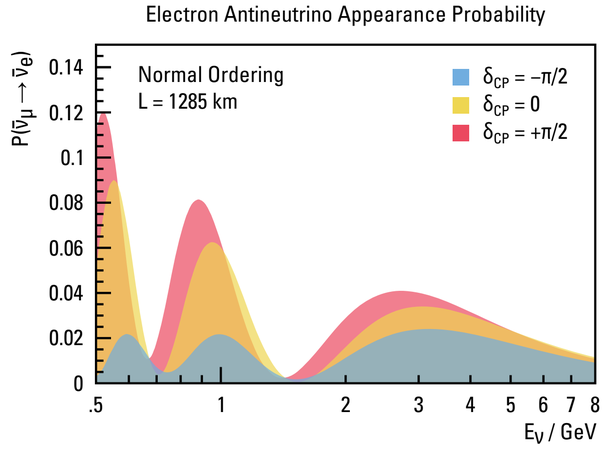
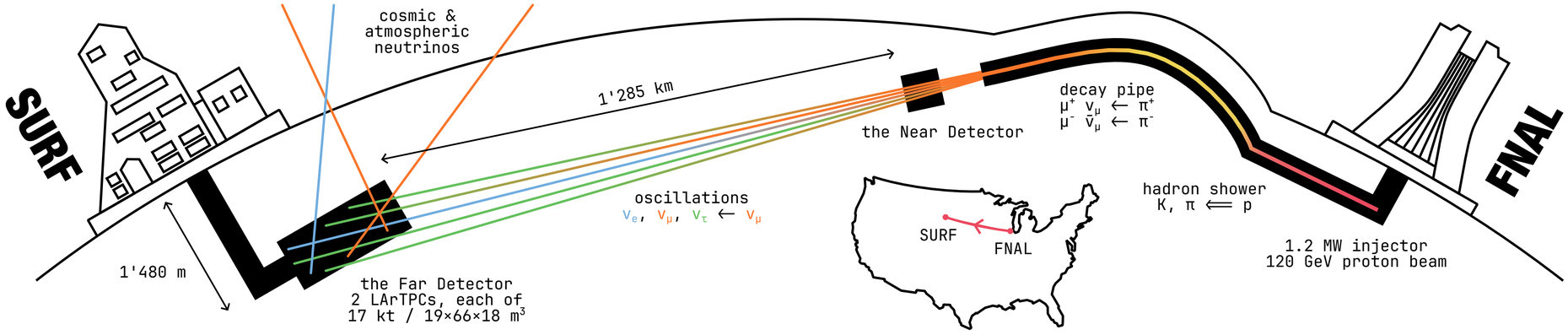




@DUNE Collab. / arXiv:2006.16043



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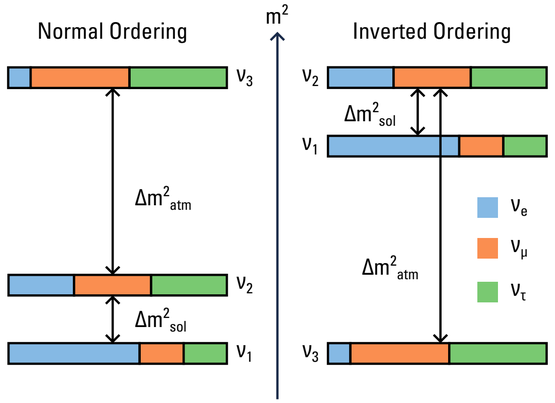

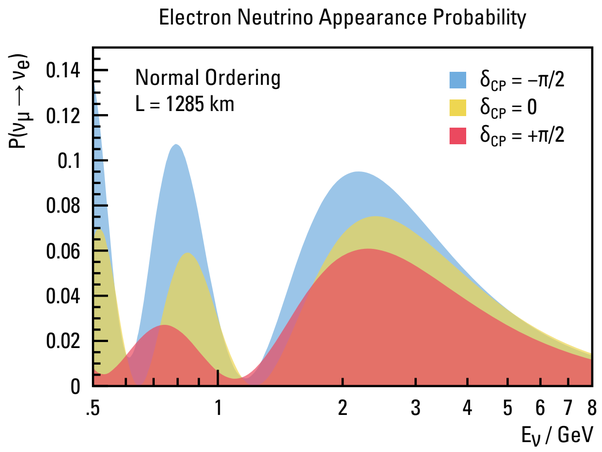

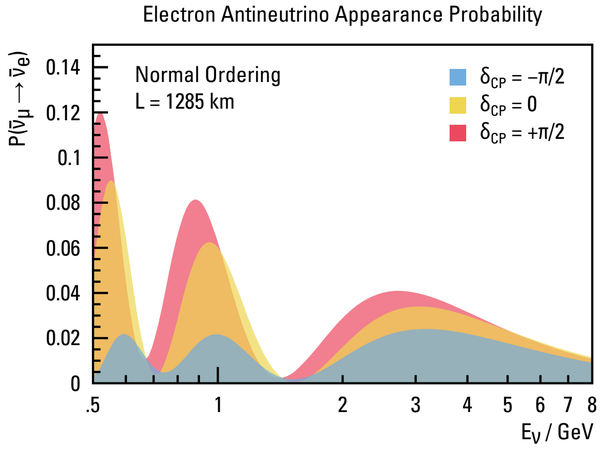

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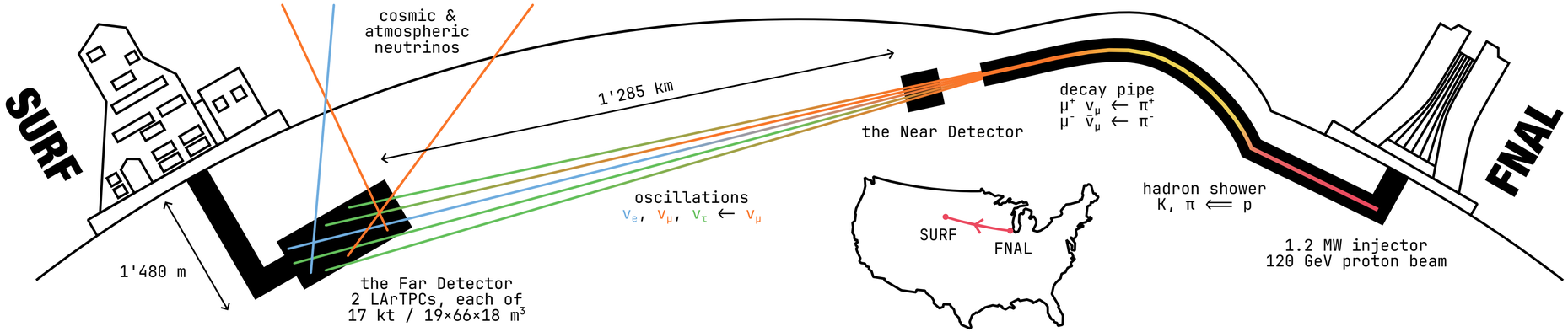

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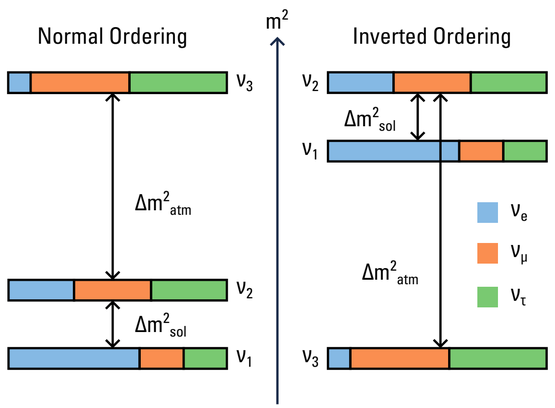

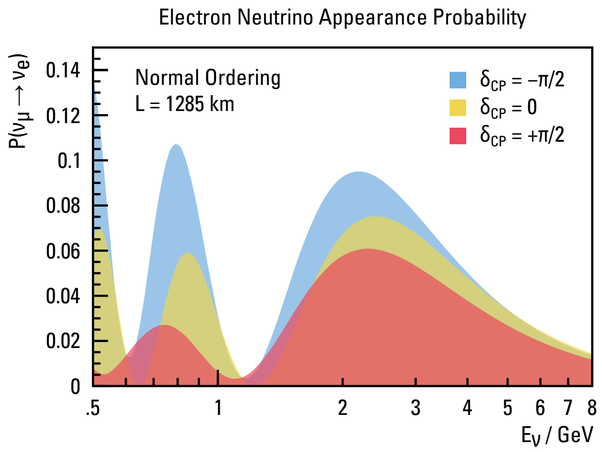

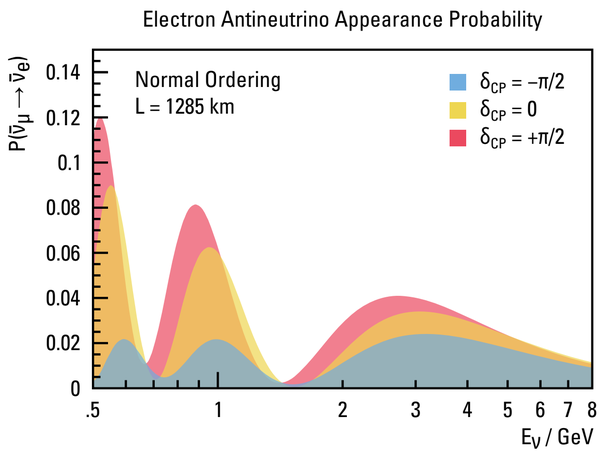

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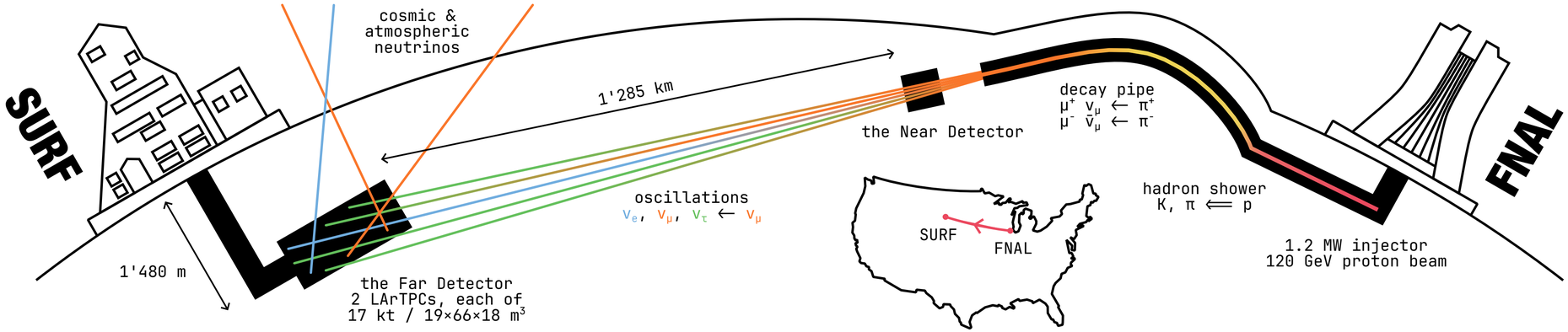

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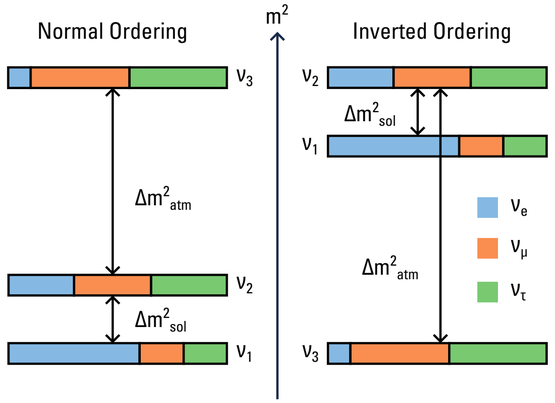
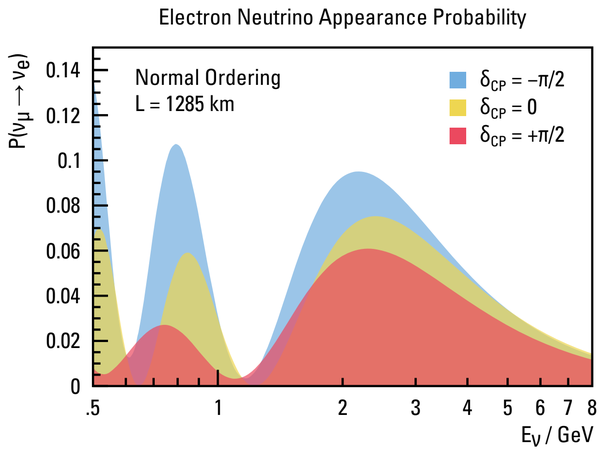
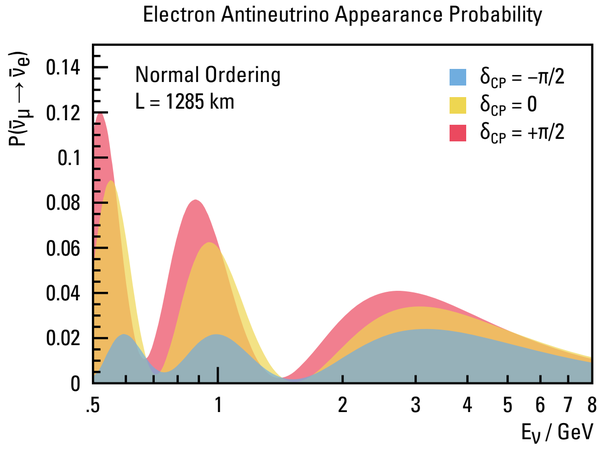
observed **once** (SN 1987A) with **few** events
low energy ~10 MeV







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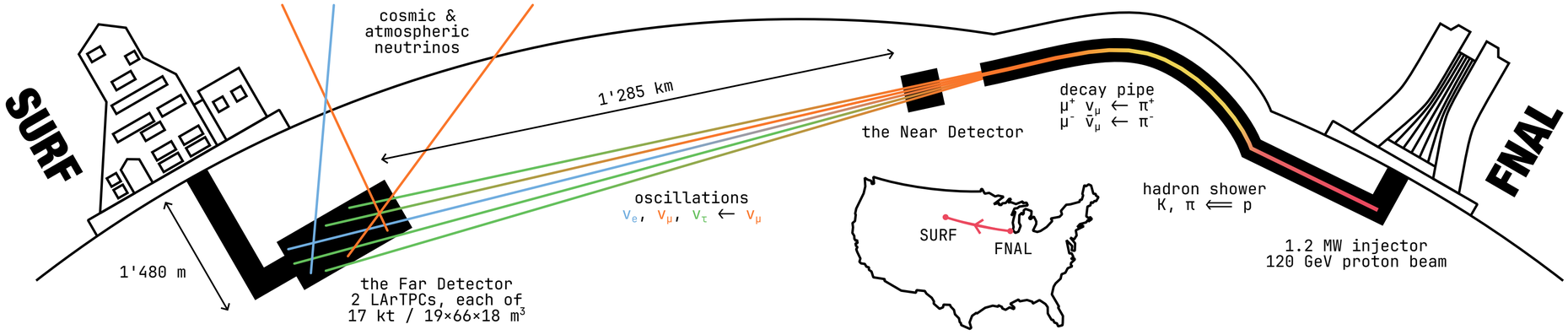
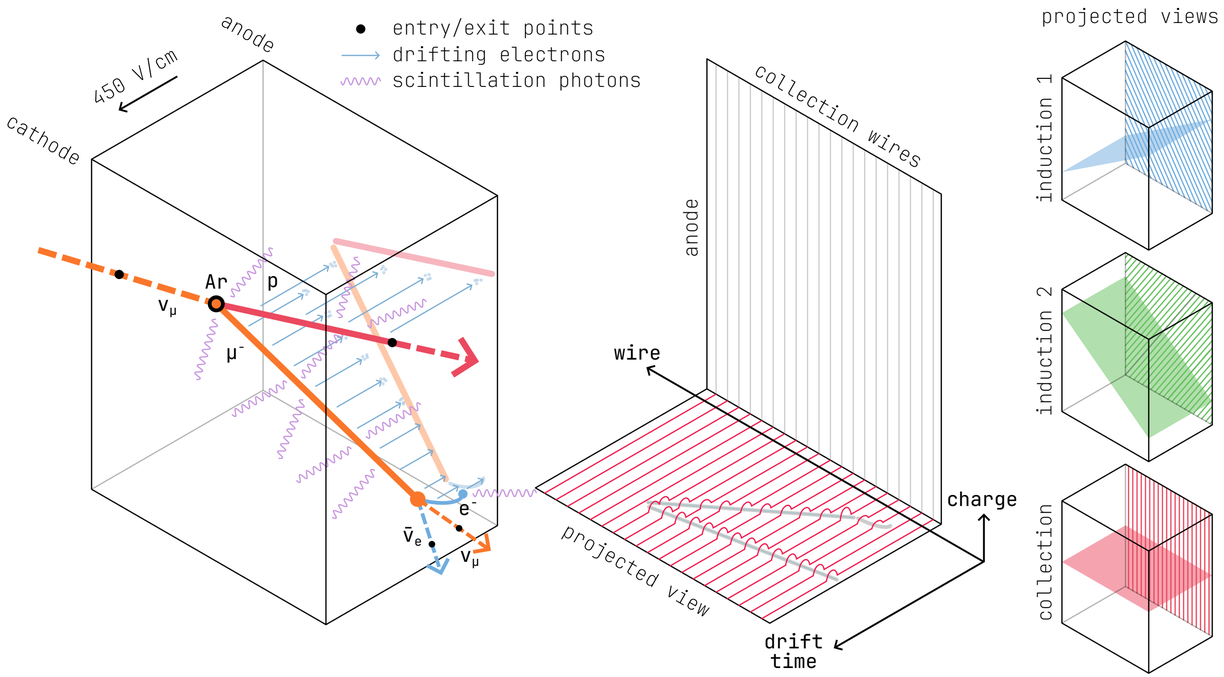


Two far detector prototypes at CERN, ProtoDUNE Horizontal Drift and Vertical Drift

- Time projecting chambers filled with liquid Argon

Time projecting chamber principle



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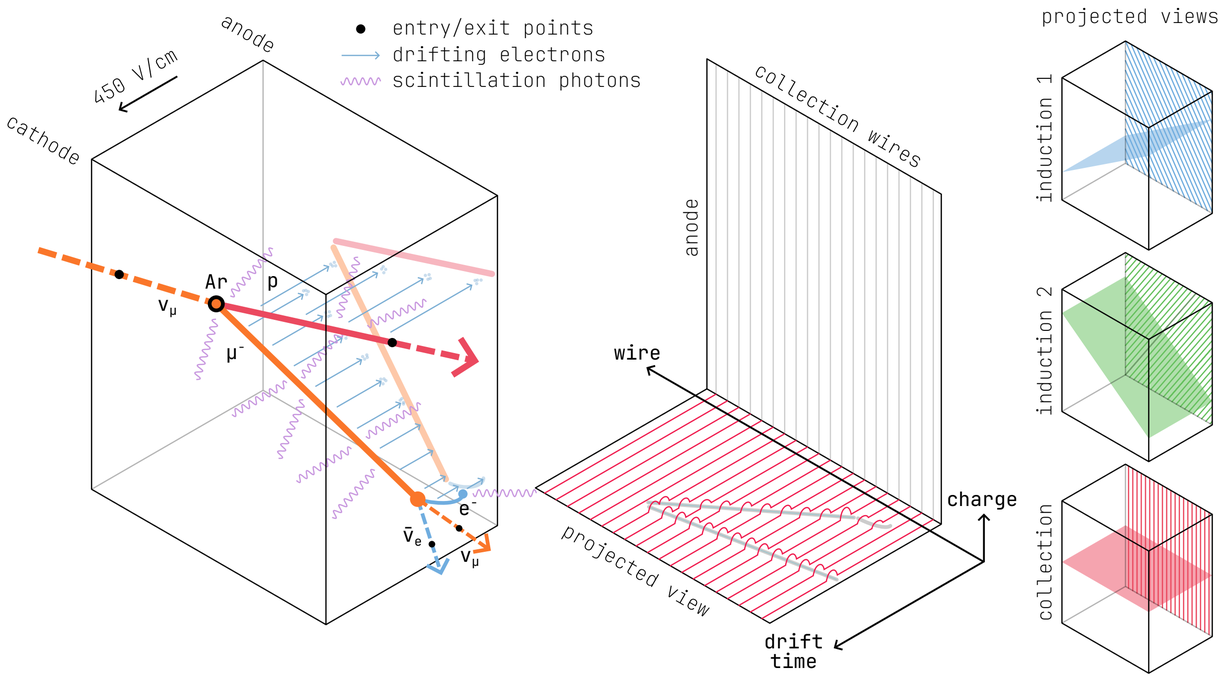

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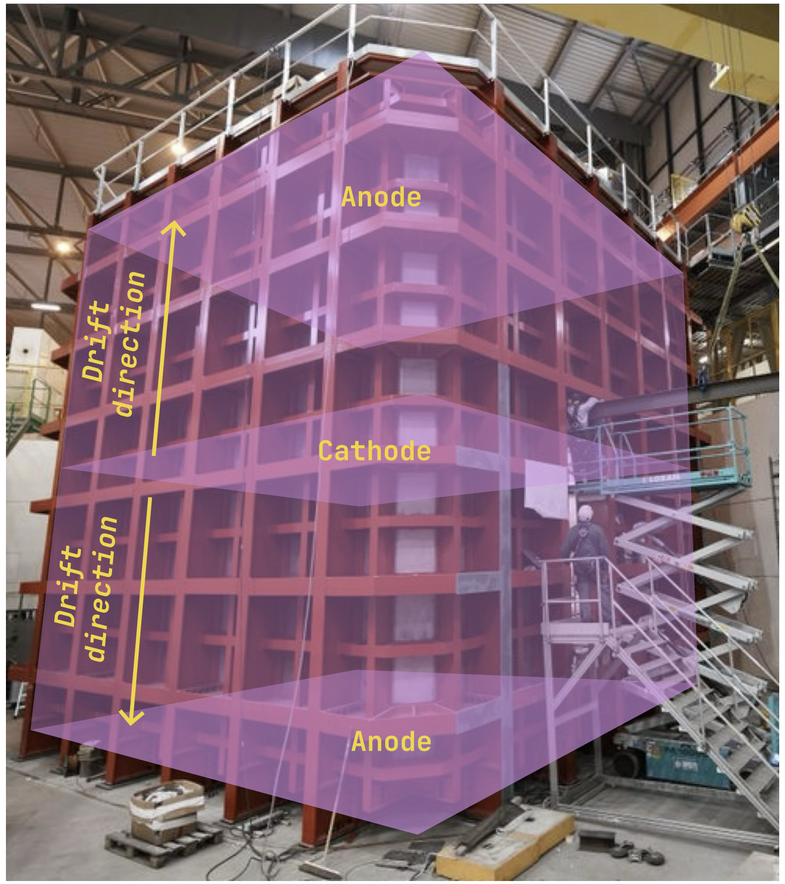

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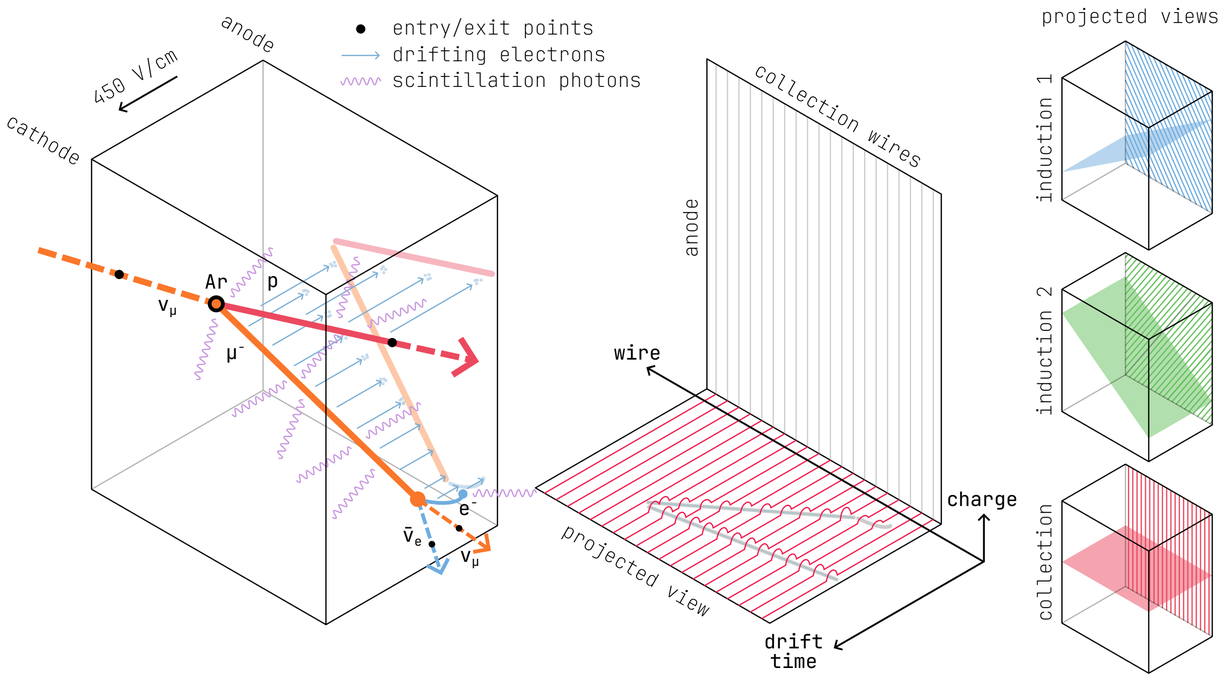
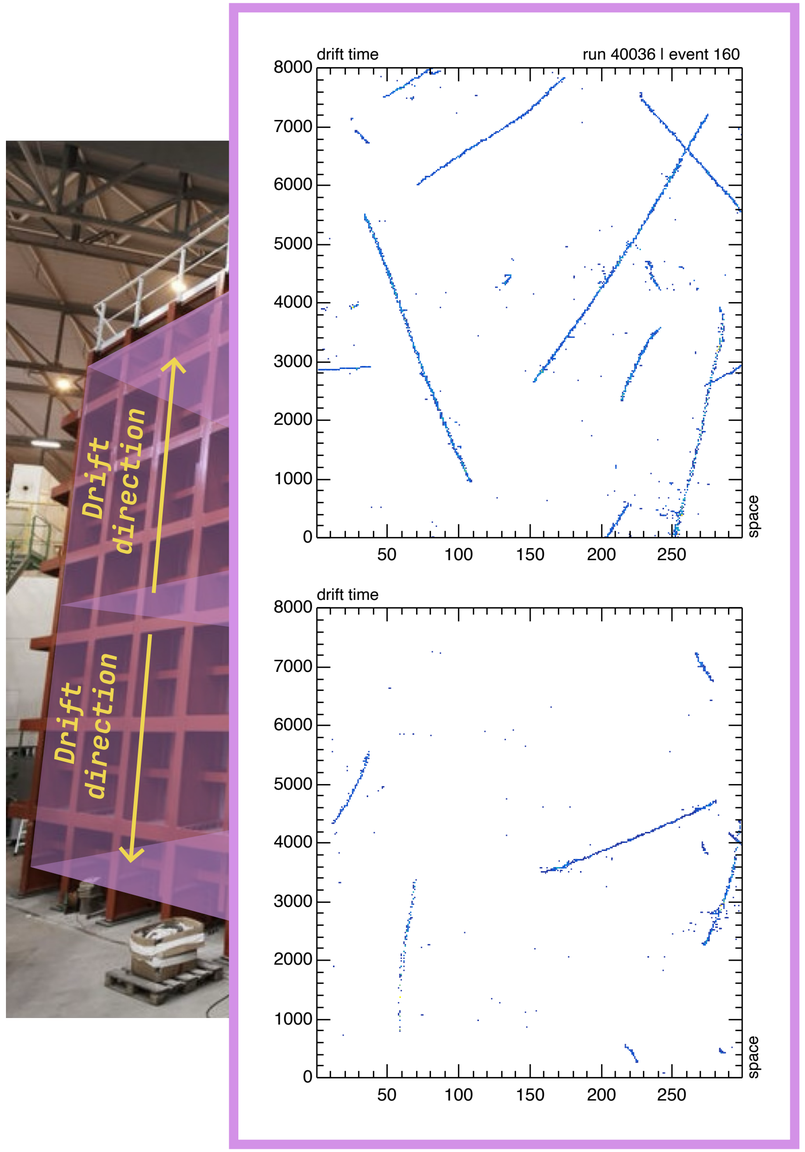


Typical 1-view event display



Michel Electrons

Michel electrons

- $\mu^{\pm} \rightarrow$ **$e^{\pm}$** $\nu_{\mu}\, \nu_{e}$ with E_e = 0-50 MeV
- Abundant in cosmics: ~1 /cm^2/s
- Ideal for **low-energy calibration**
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  - Map of the EM field

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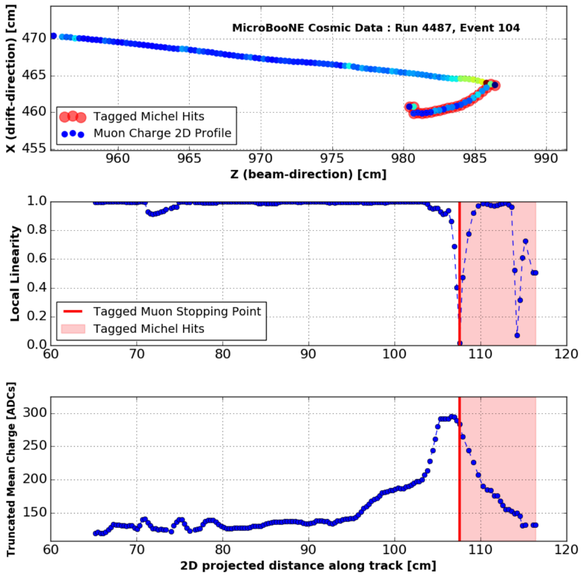
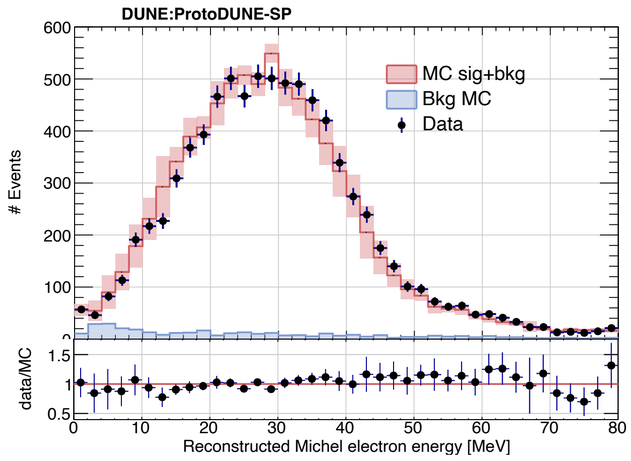
MicroBooNE



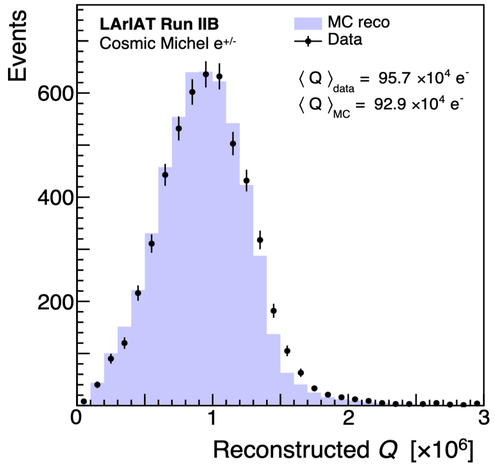
@ MicroBooNE Collaboration / arXiv:1704.02927

ProtoDUNE-SP



@ DUNE Collaboration / arXiv:2211.01166

LArIAT



@ LArIAT Collaboration / arXiv:1909.07920

My work in ProtoDUNE-HD and -VD (LArSoft module based on Pandora)

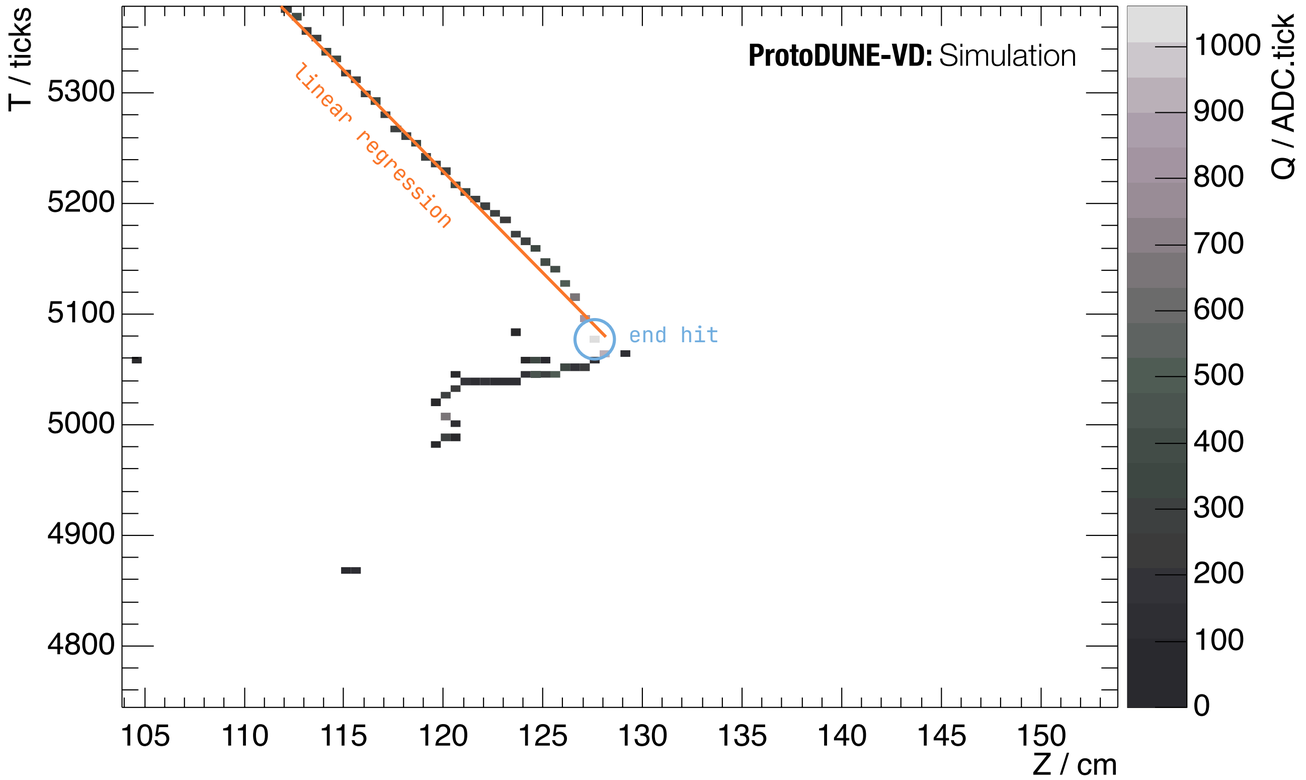
`MichelAnalysis_module.cc`

Stopping Muon Selection

Select well reconstructed **stopping muon** candidates

Using **Pandora track** reconstruction

Michel electron illustration



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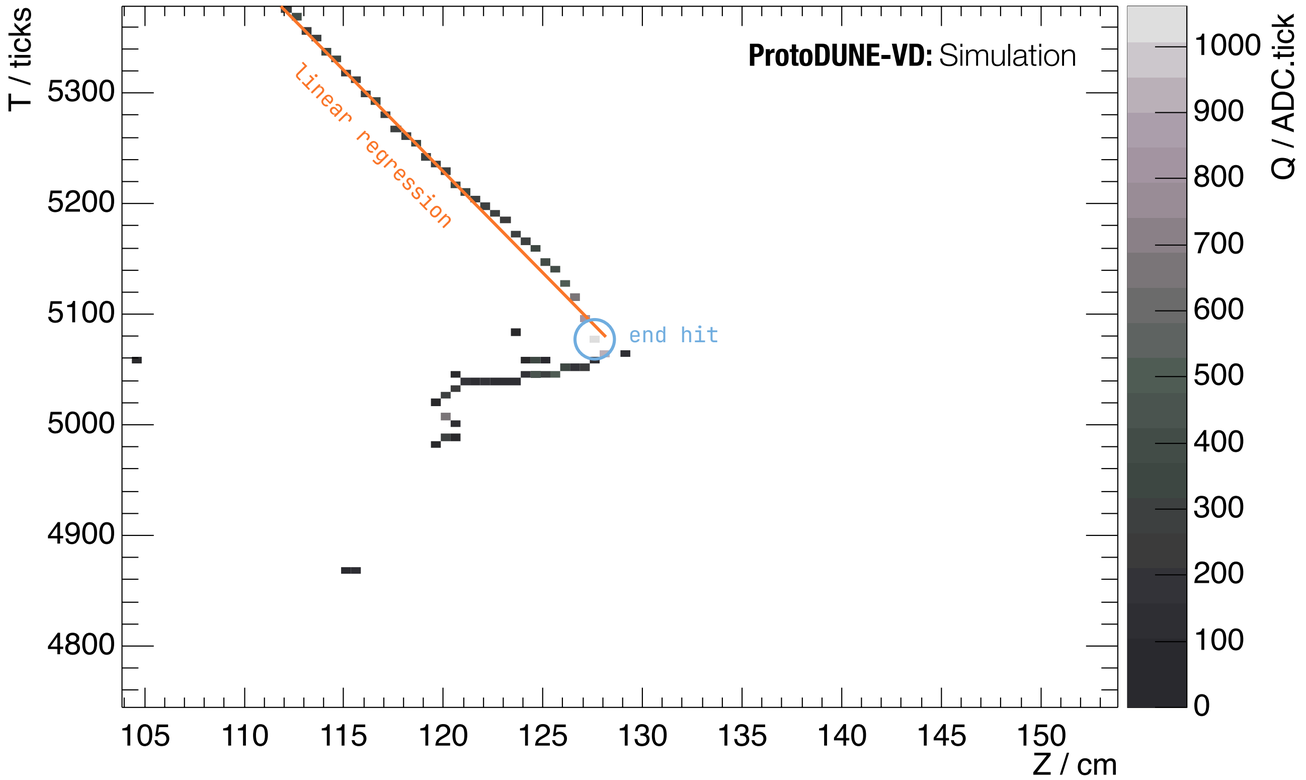

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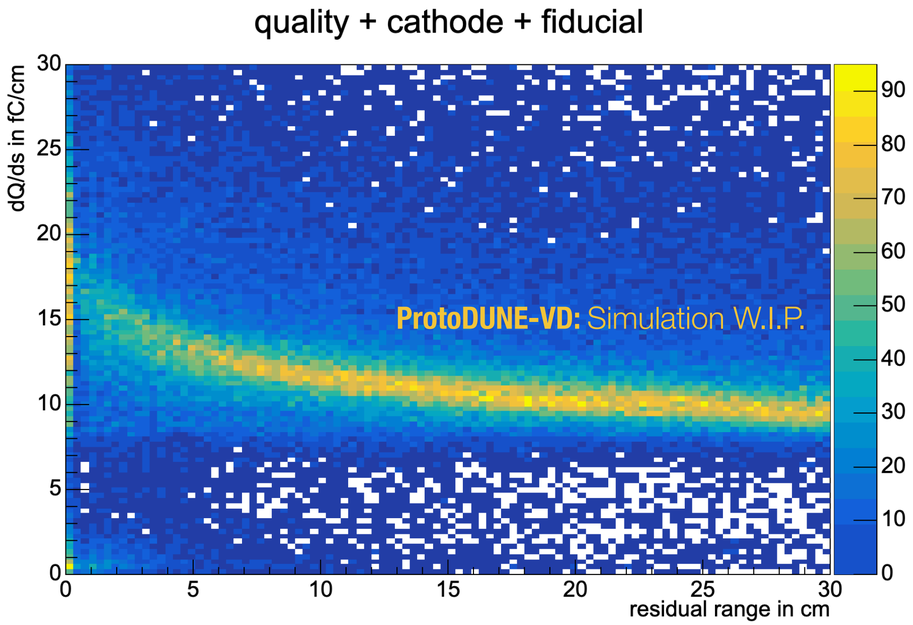

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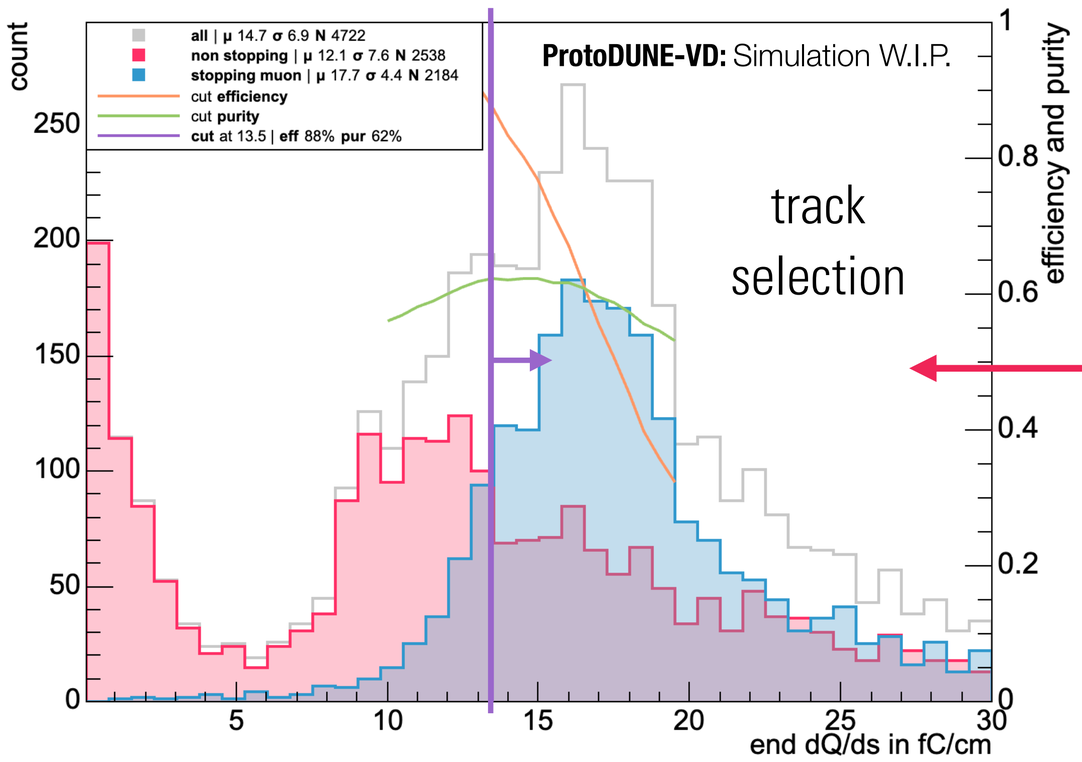
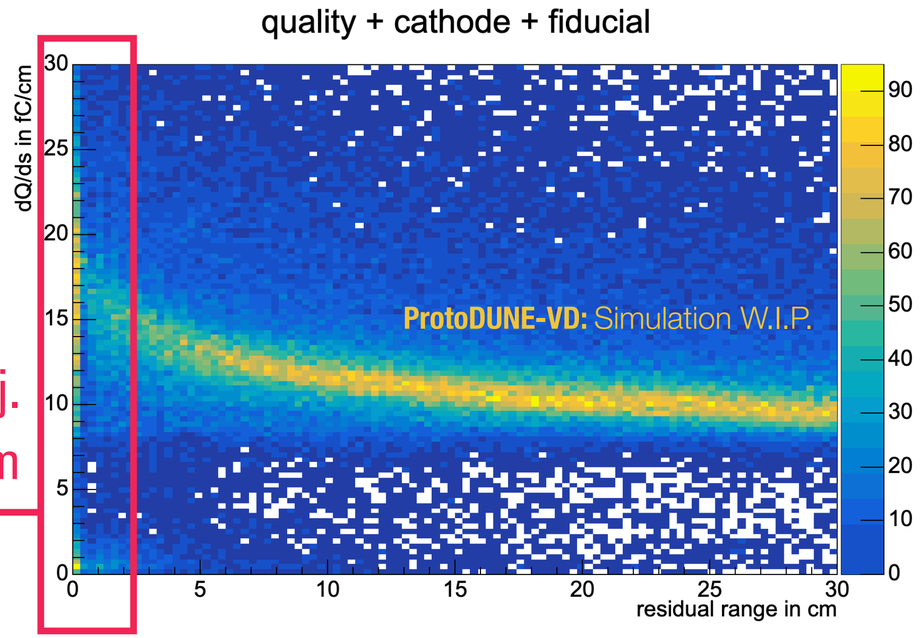


Y proj. on 0-2 cm



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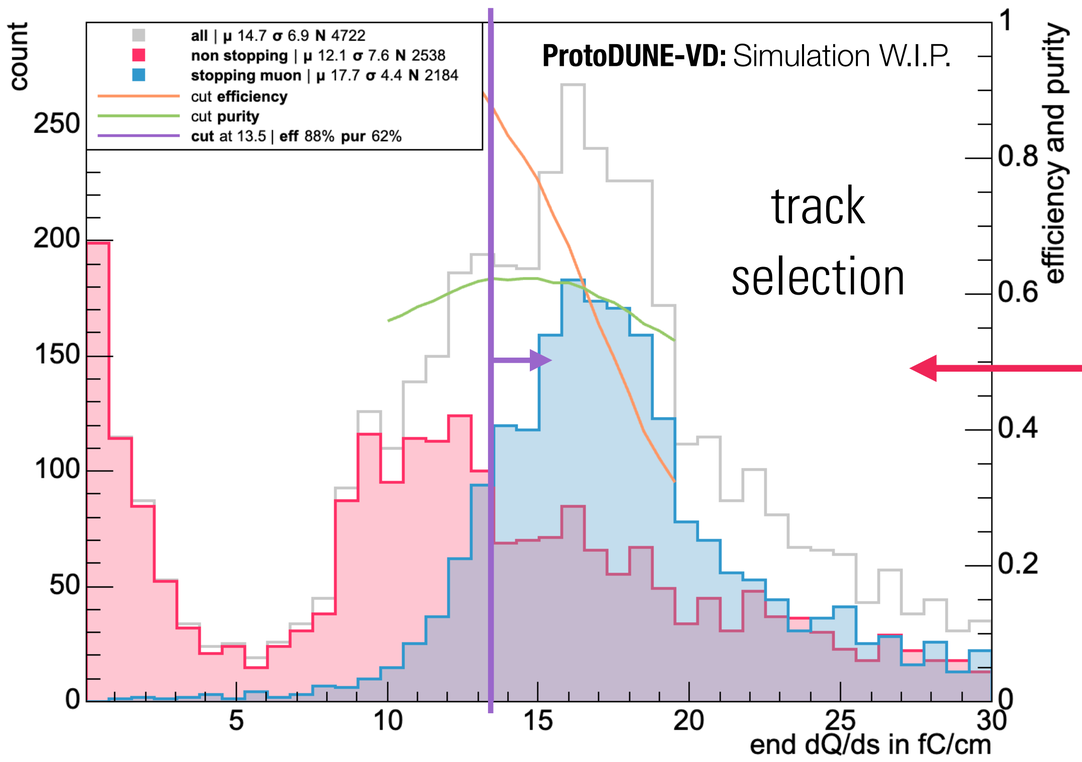

track selection

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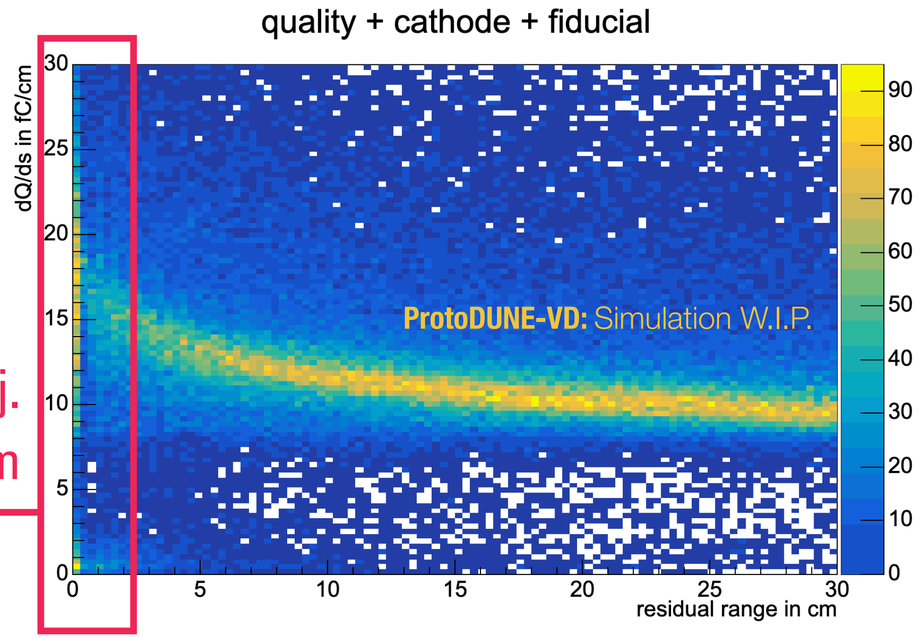
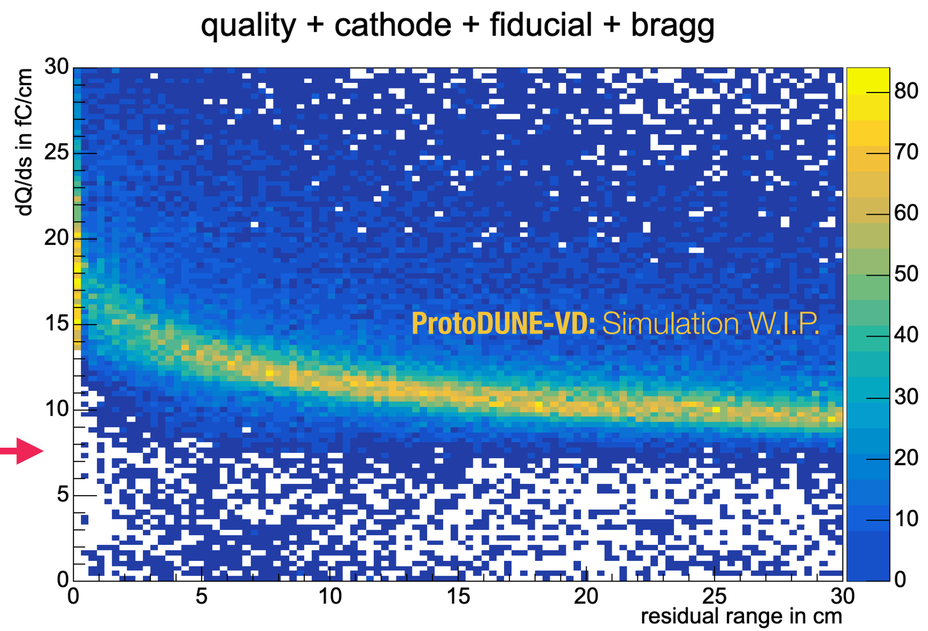


after Bragg cut



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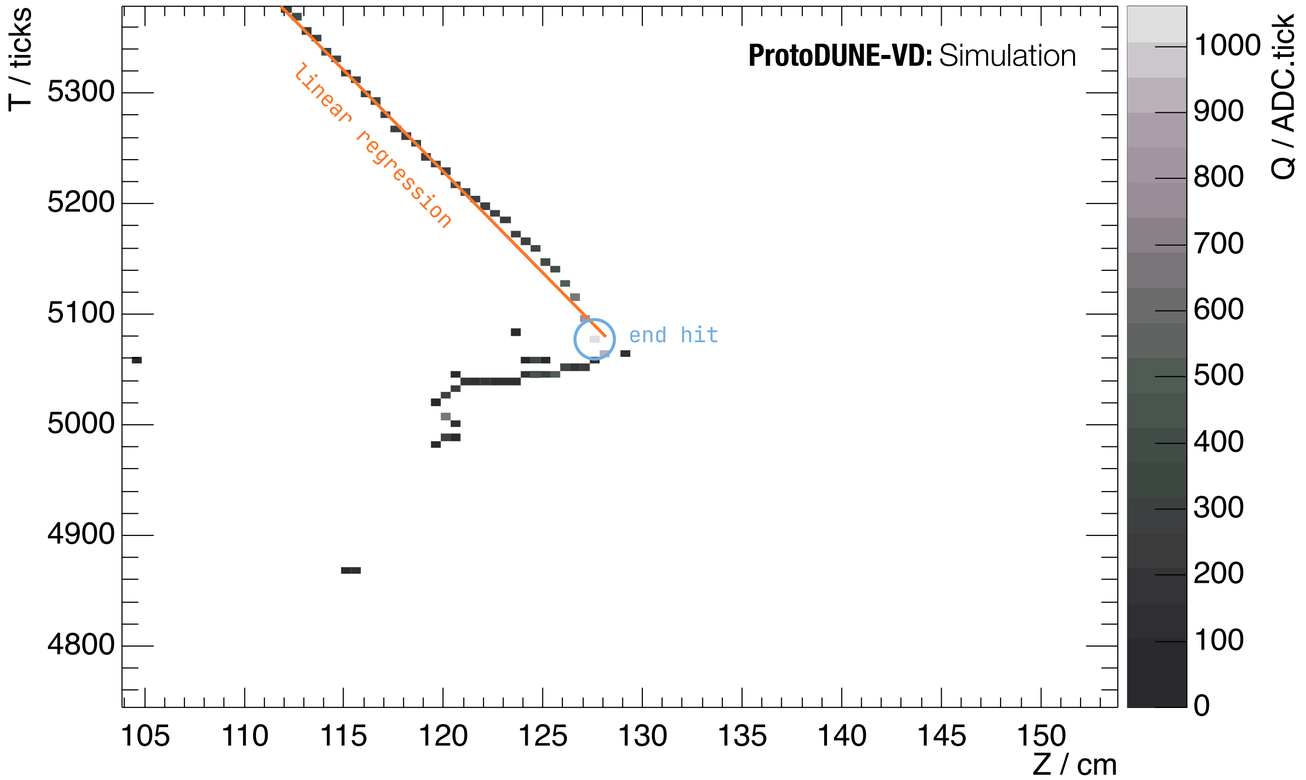

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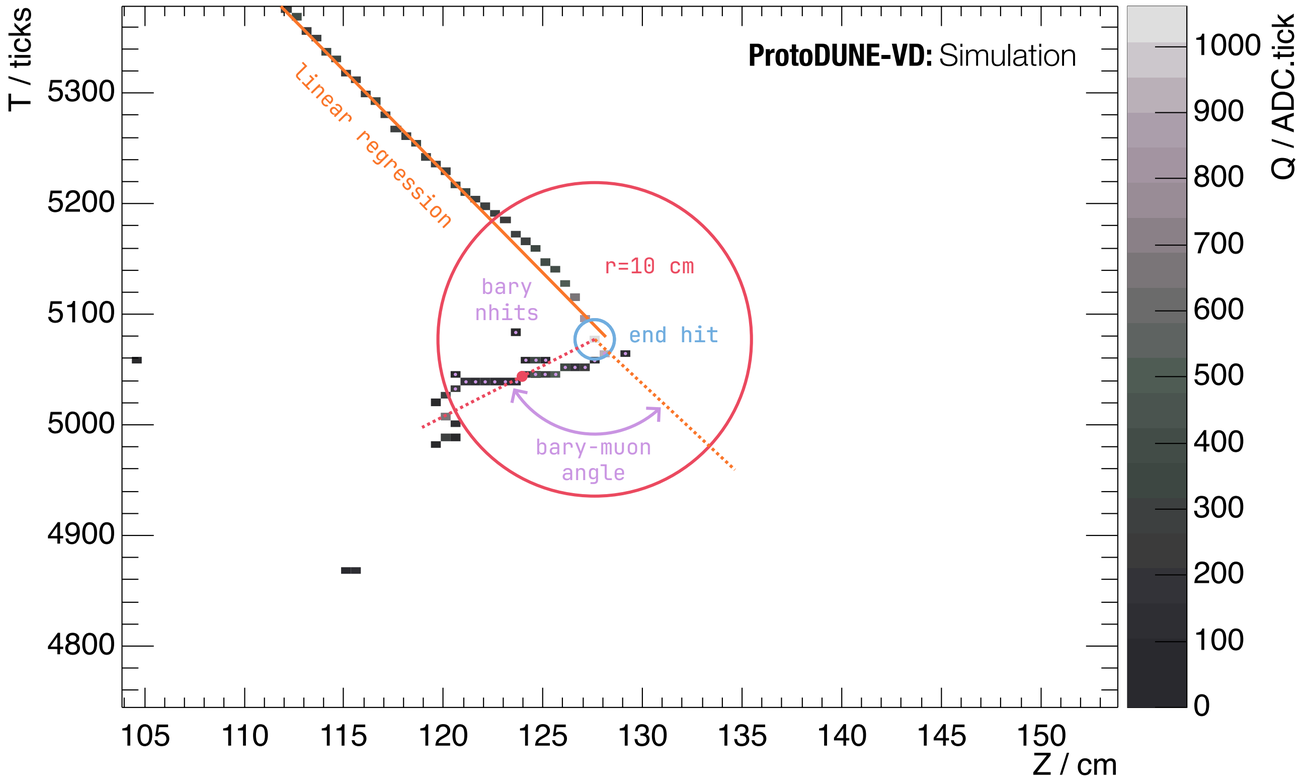

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	all tracks	full selection
all tracks	374'342	699
truly stopping muons	30'272	664
truly decaying muons	20'871	611

ProtoDUNE-HD: Simulation W.I.P.

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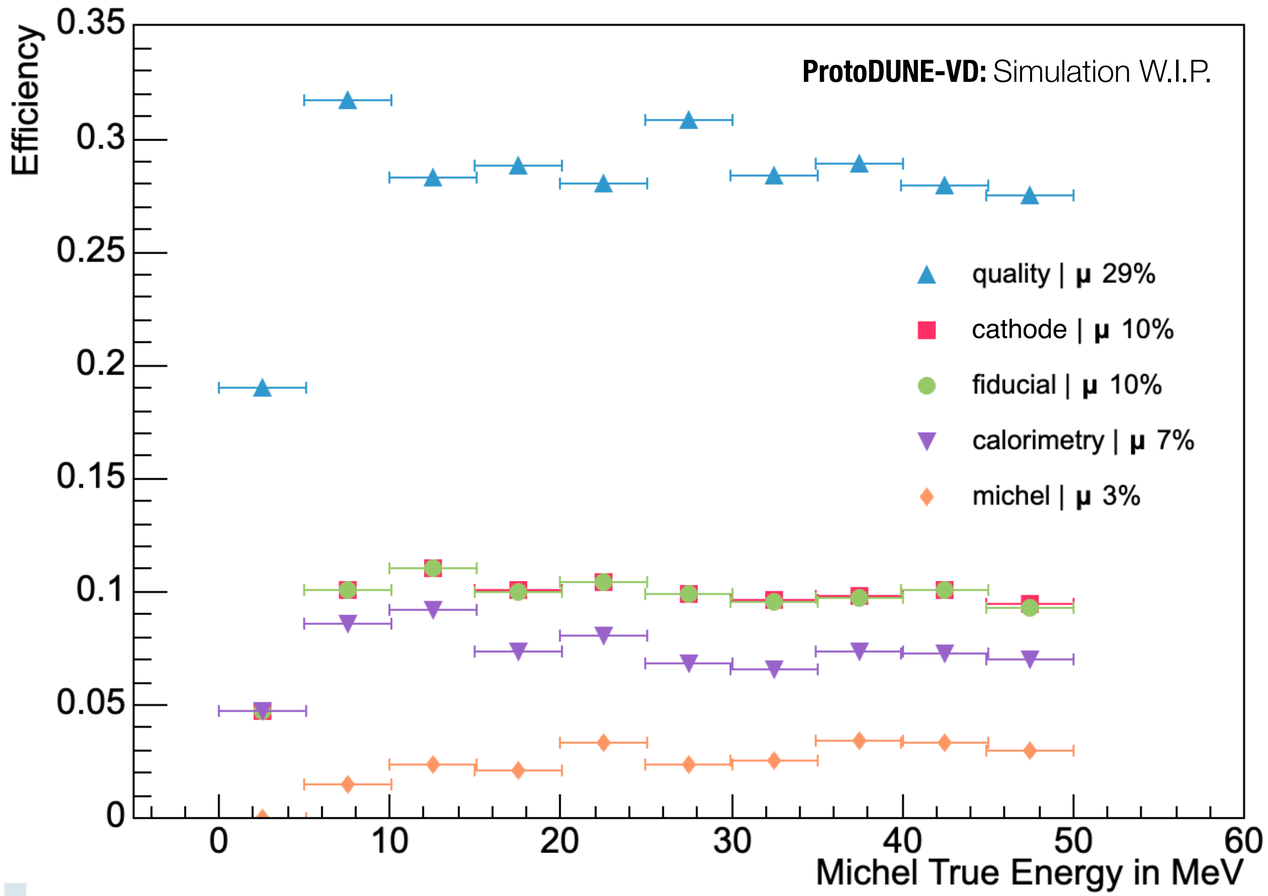
Michel Electron Selection

Selection efficiency bias



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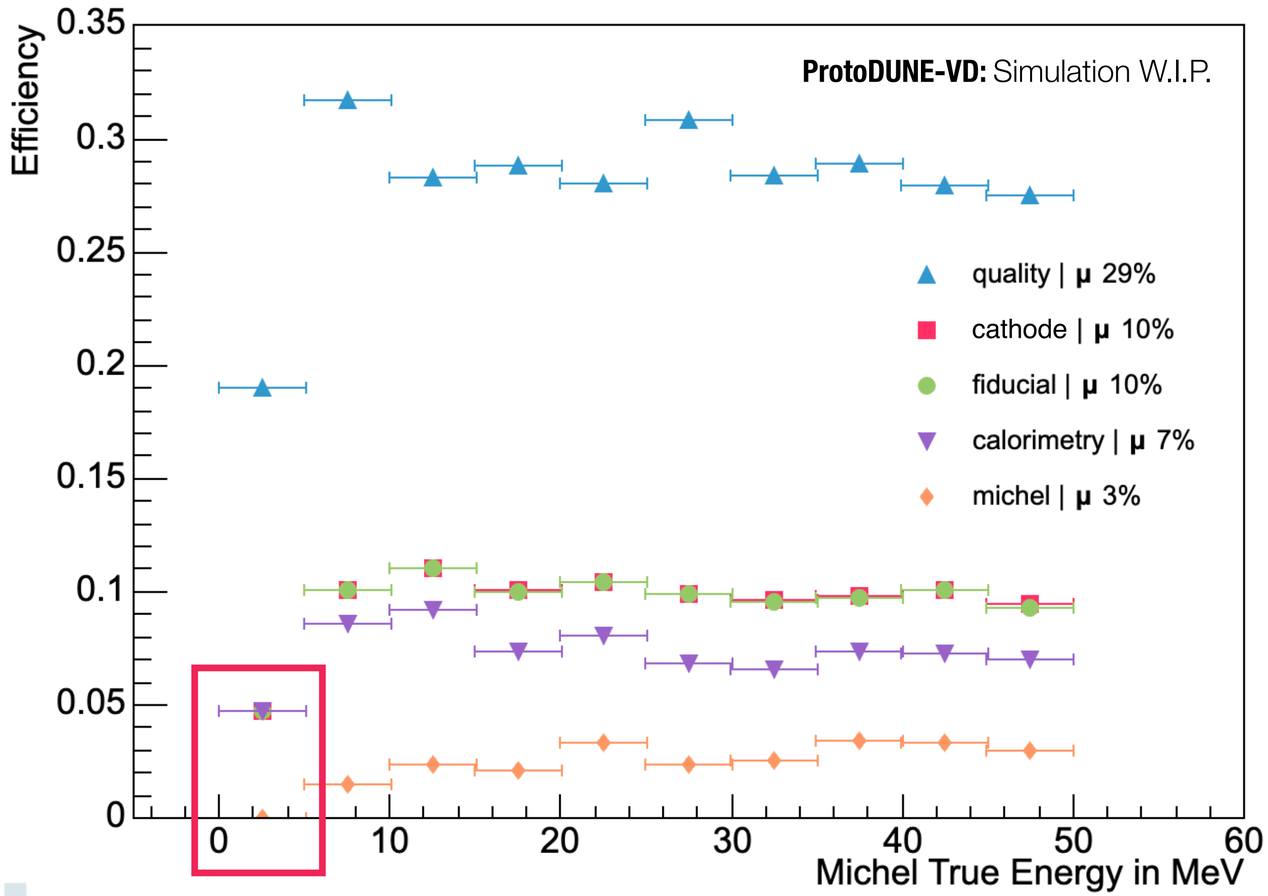

no reconstructed Michel electrons below 5 MeV

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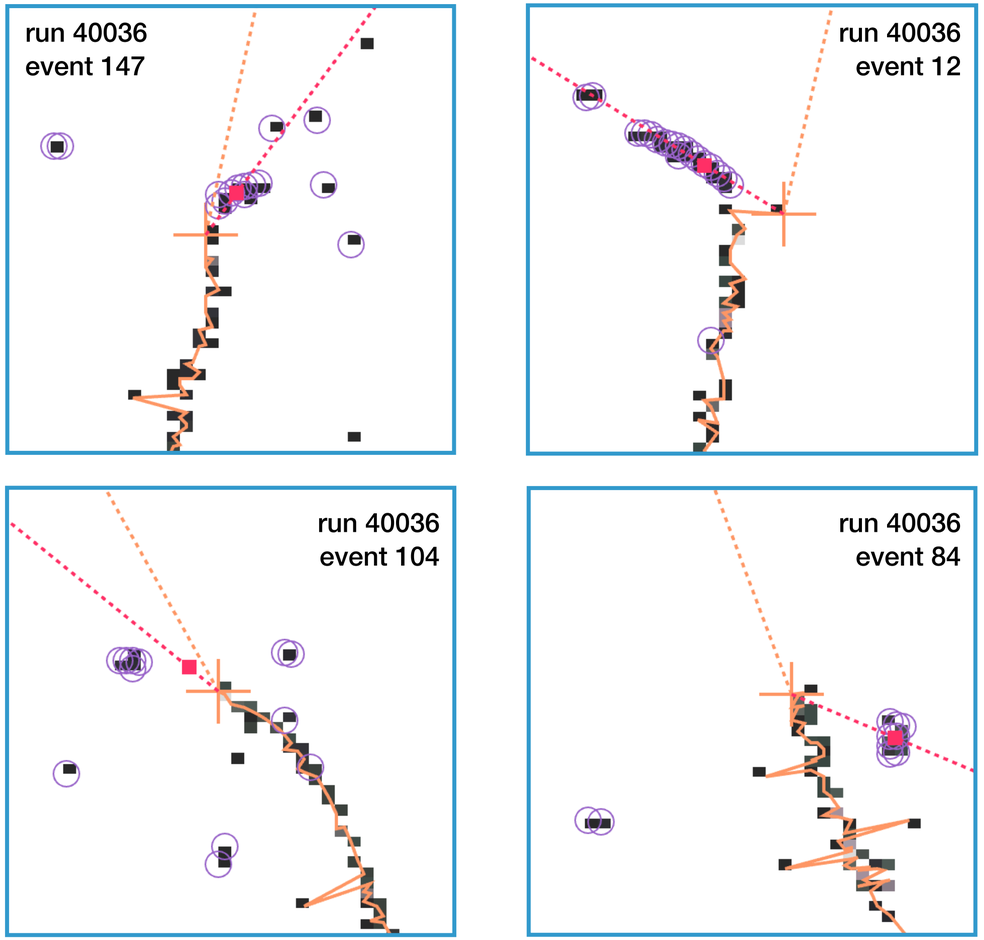
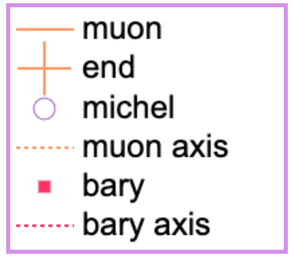
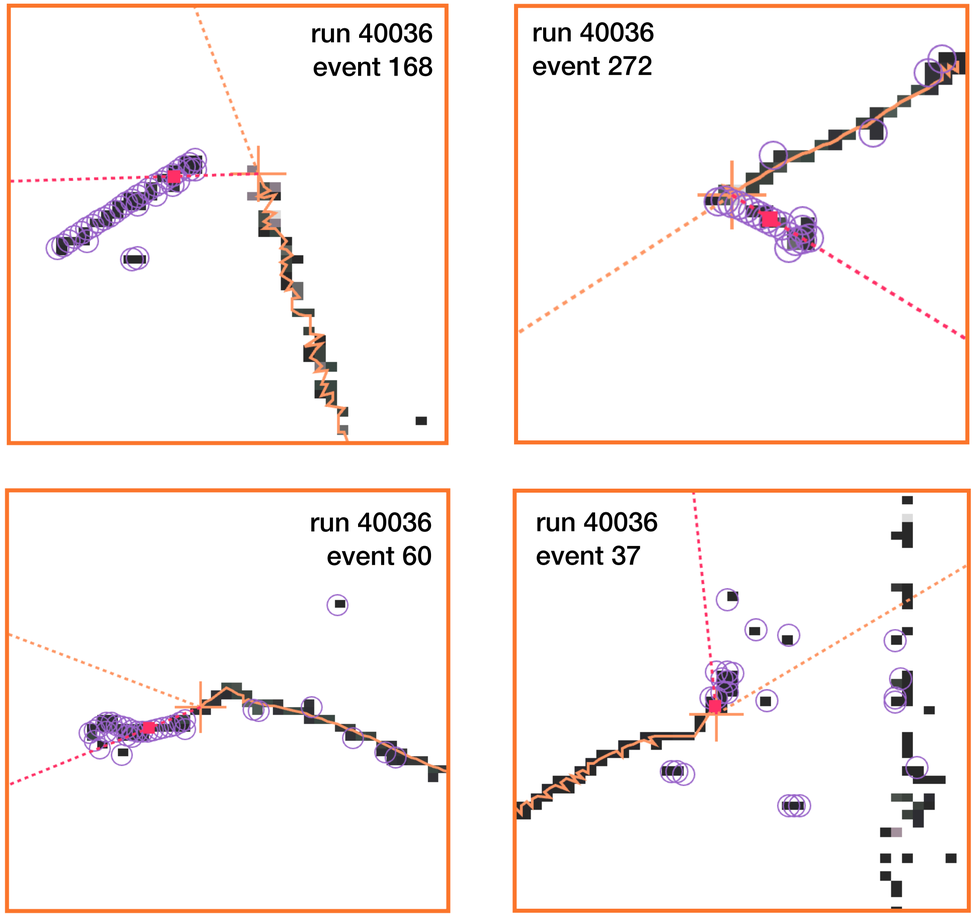
Random reconstructed events passing selections in ProtoDUNE-VD

E = 10 - 30 MeV





E = 30 - 45 MeV



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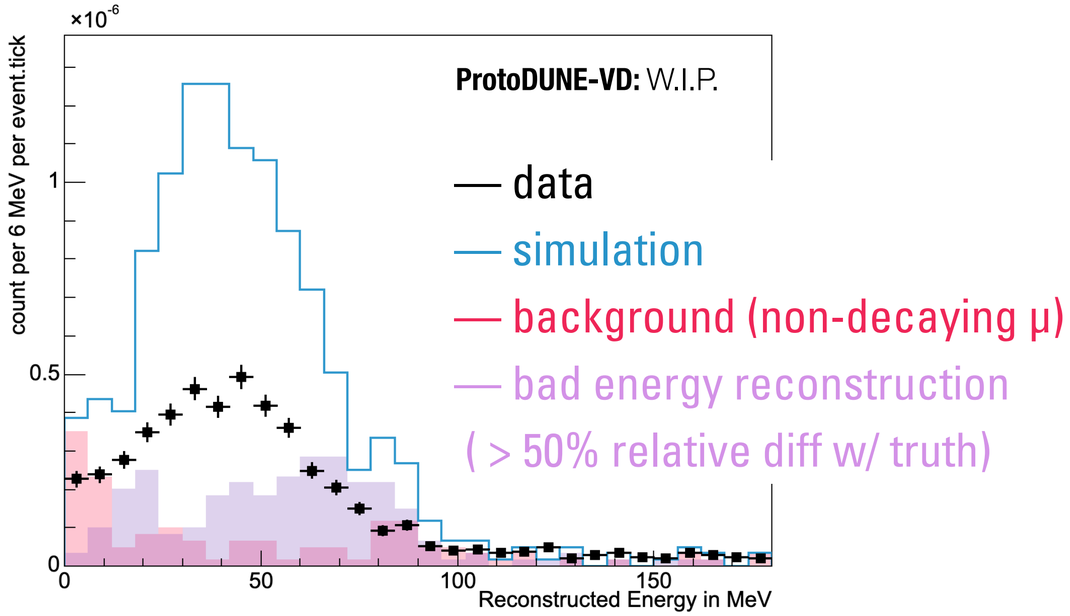

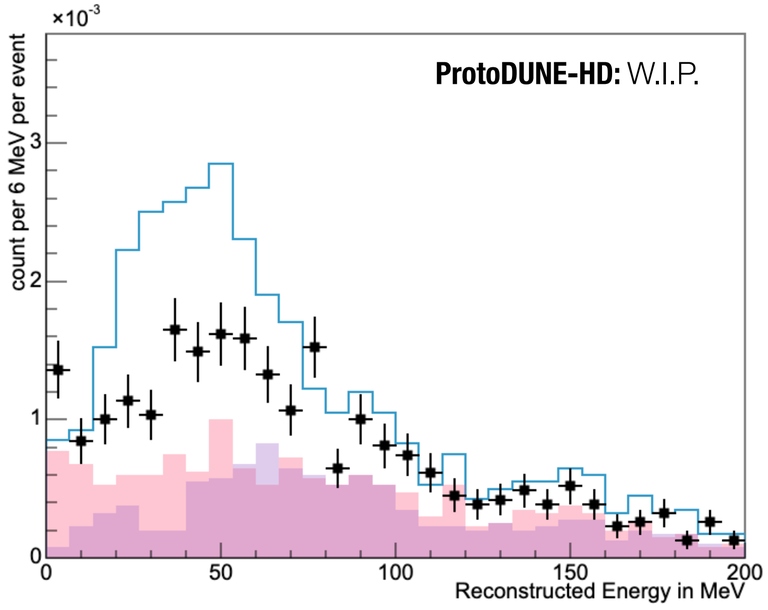

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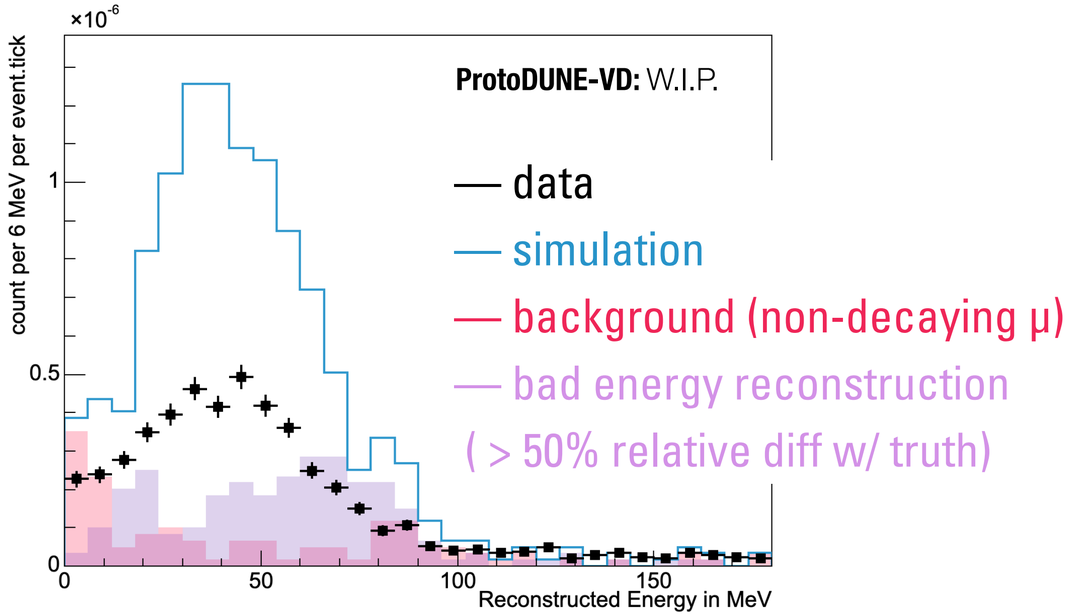
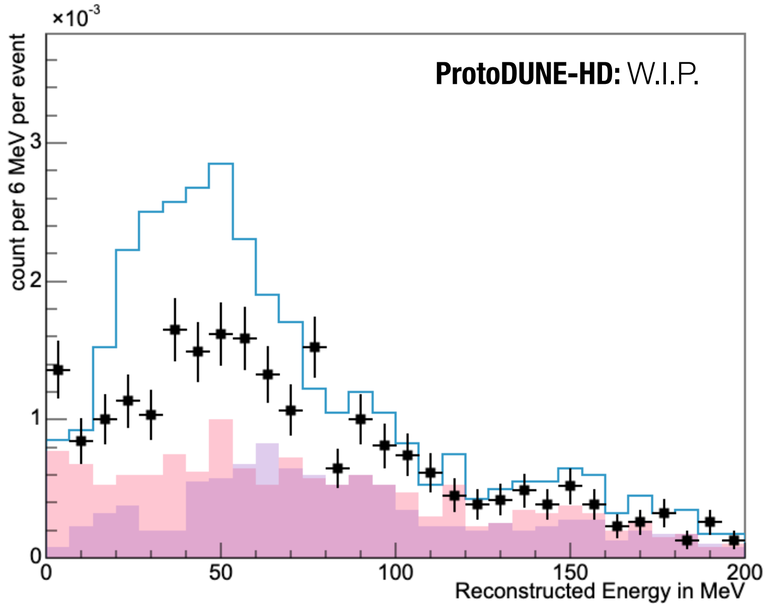
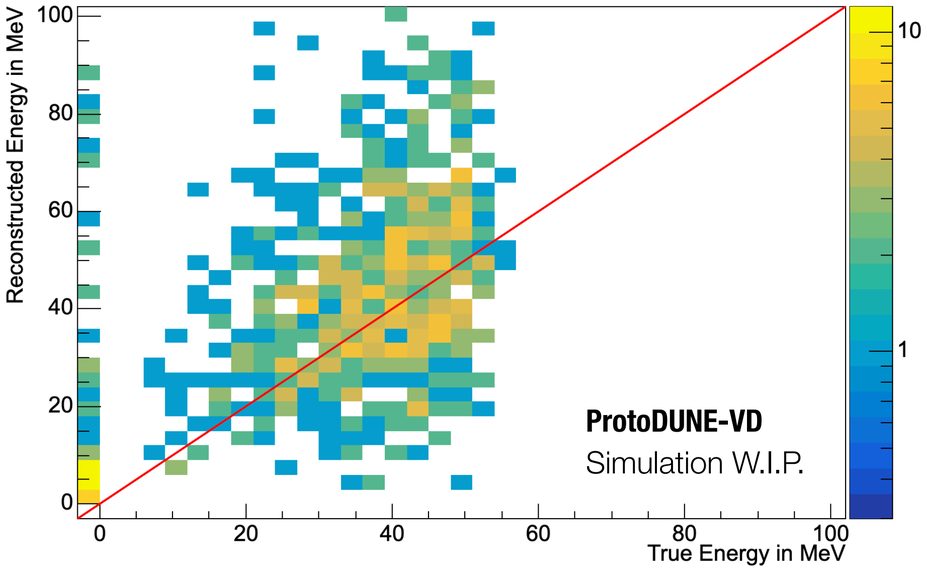
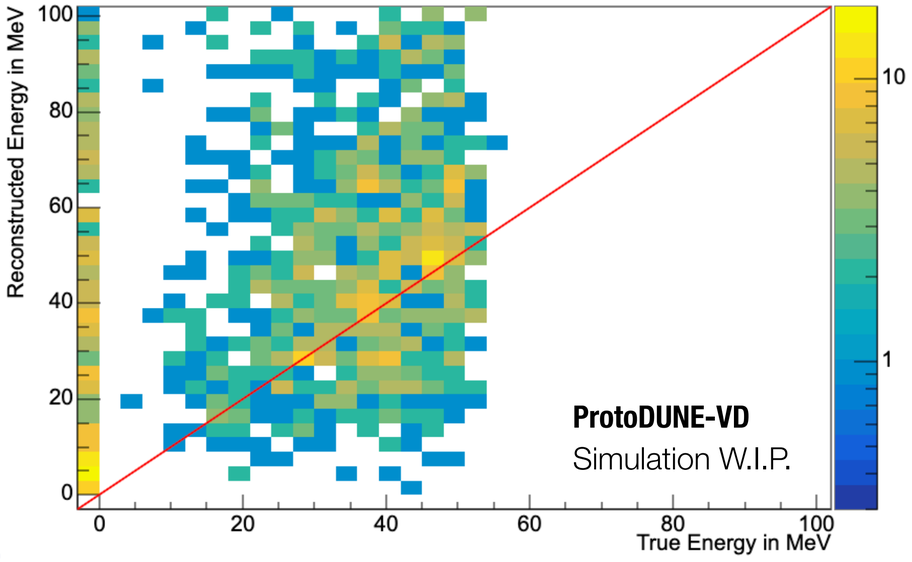
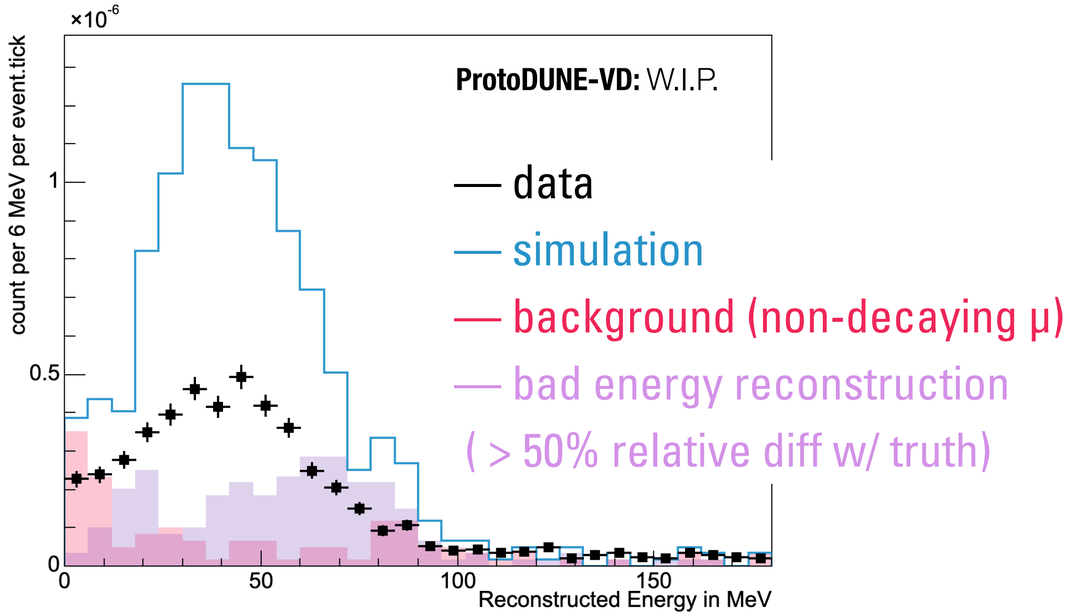


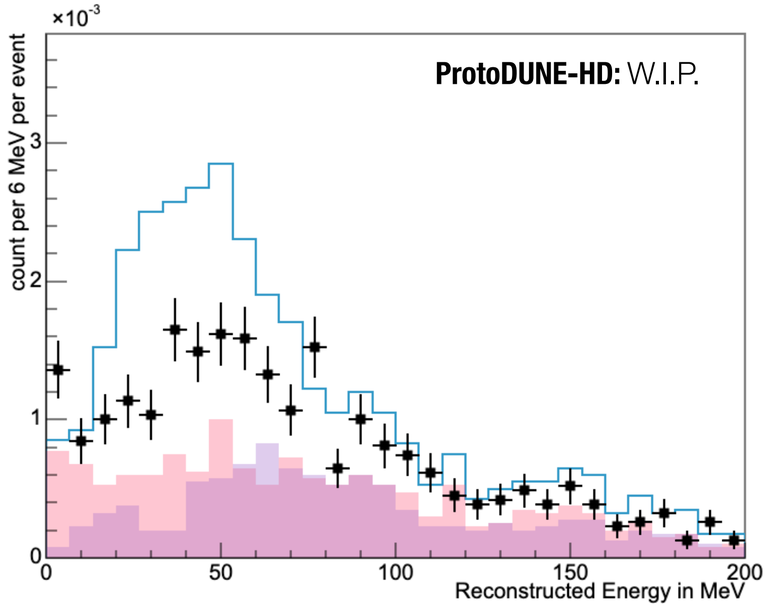


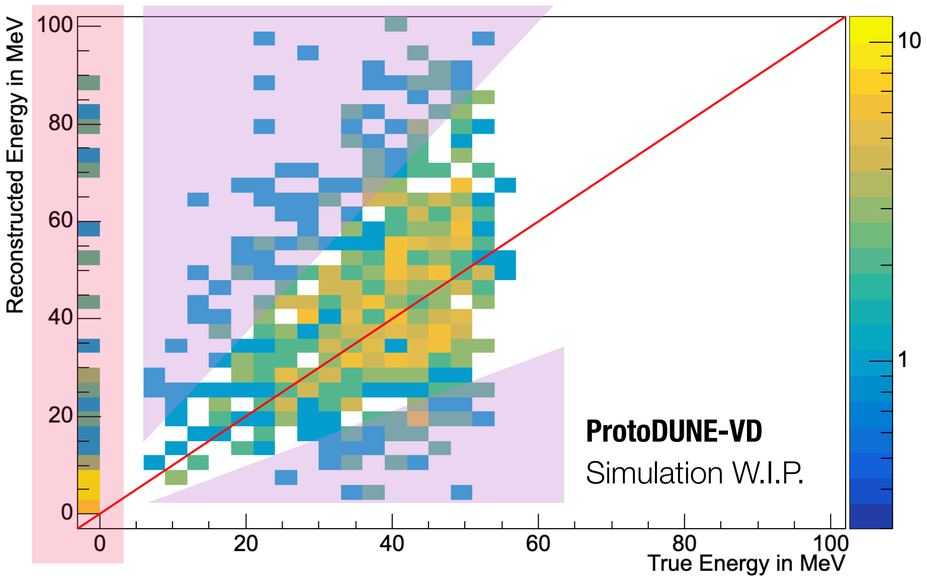


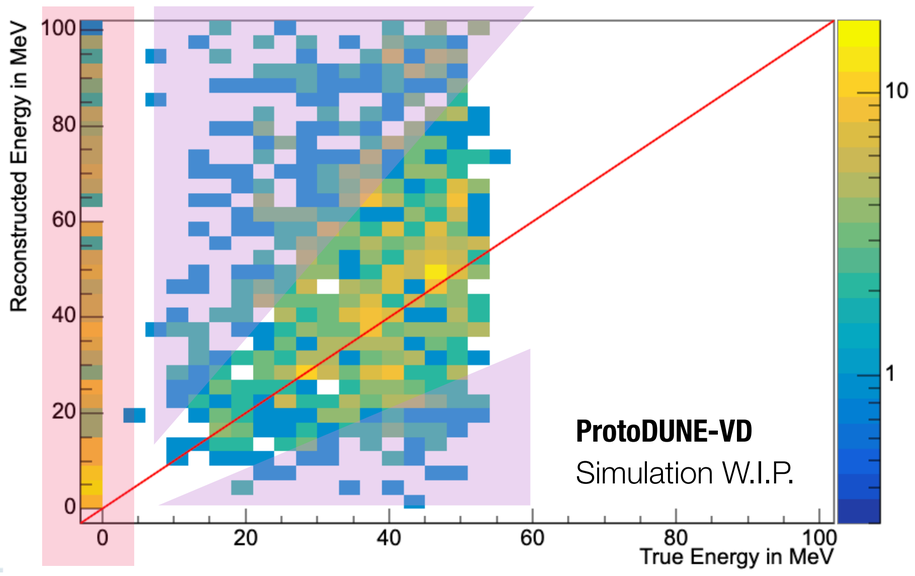


Michel Electron Energy Spectra









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SPINE is a machine learning tool for event reconstruction

- Can offer a much higher efficiency compared to traditional algorithms
- Give "shape" identification out of the box: `TRACK`, `MICHEL`…

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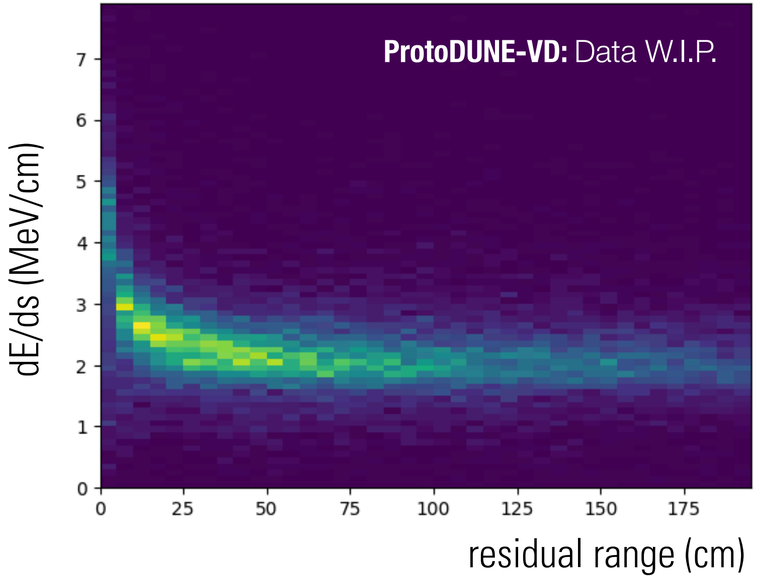

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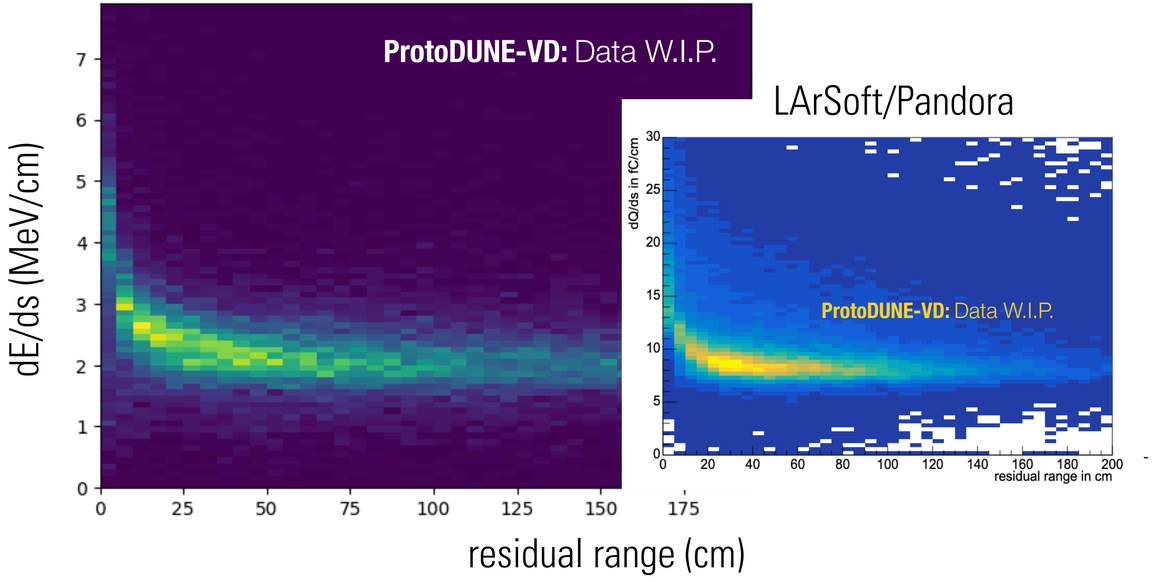

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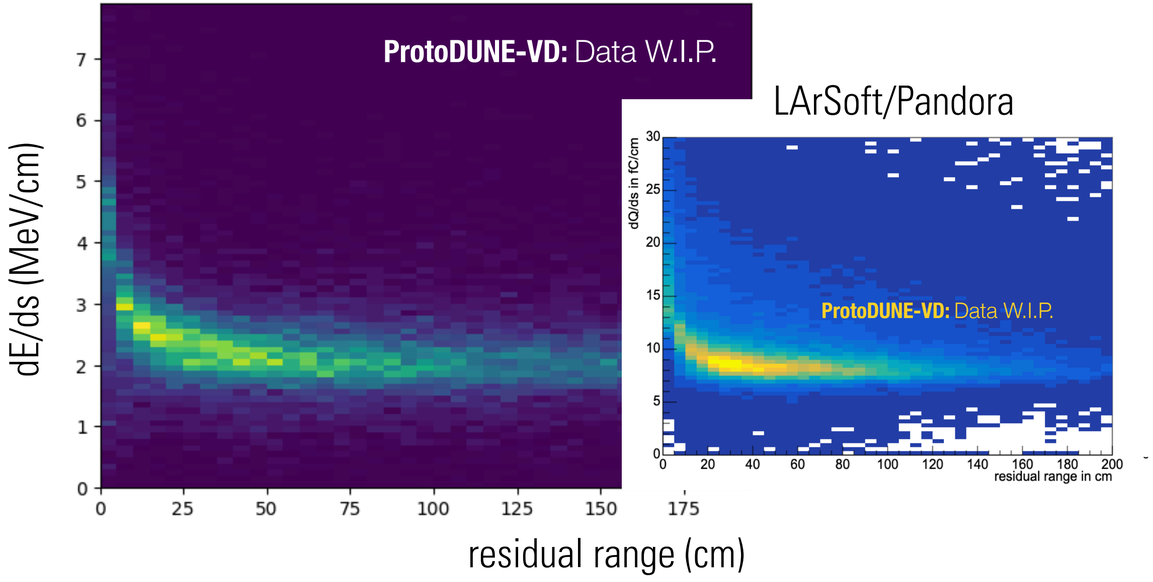
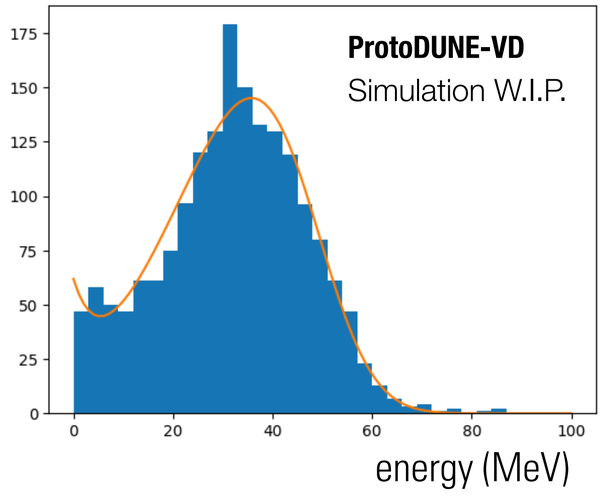
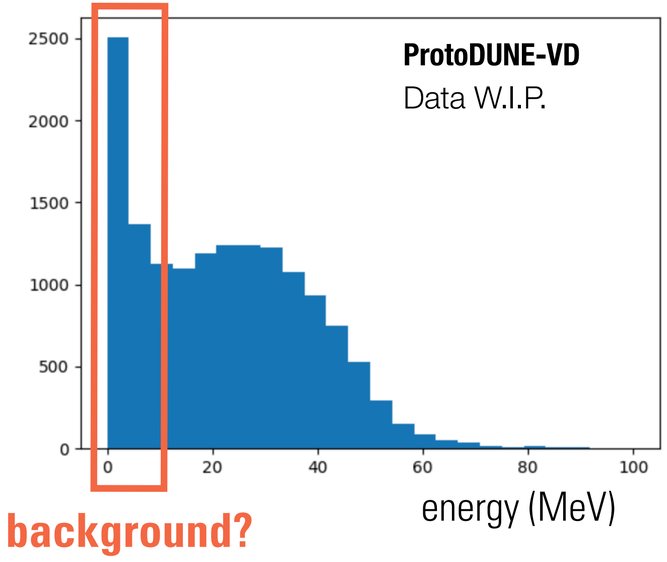


Michel electron energy spectrum





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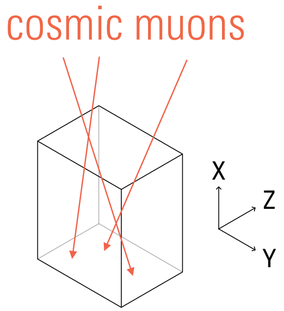
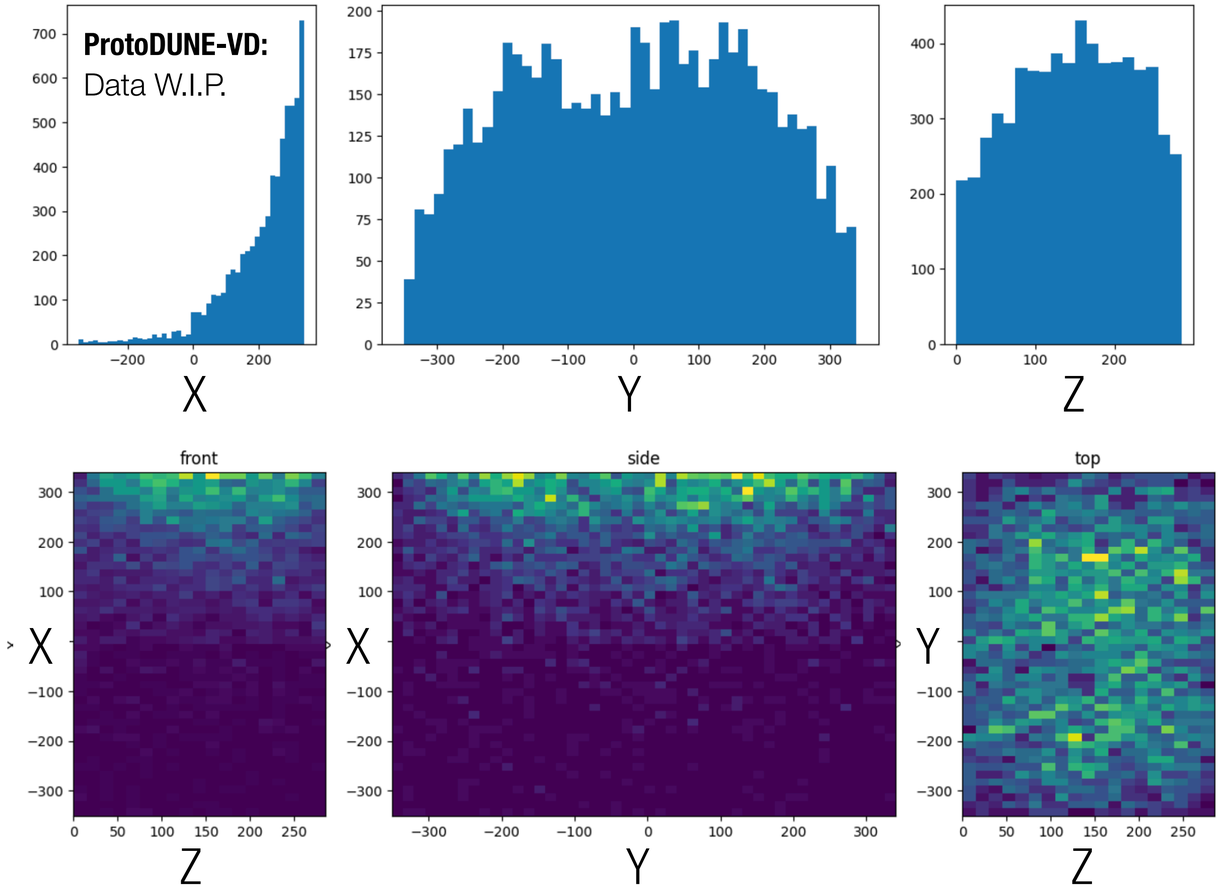


Reconstructed Michel electron position



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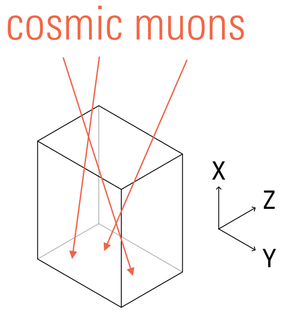

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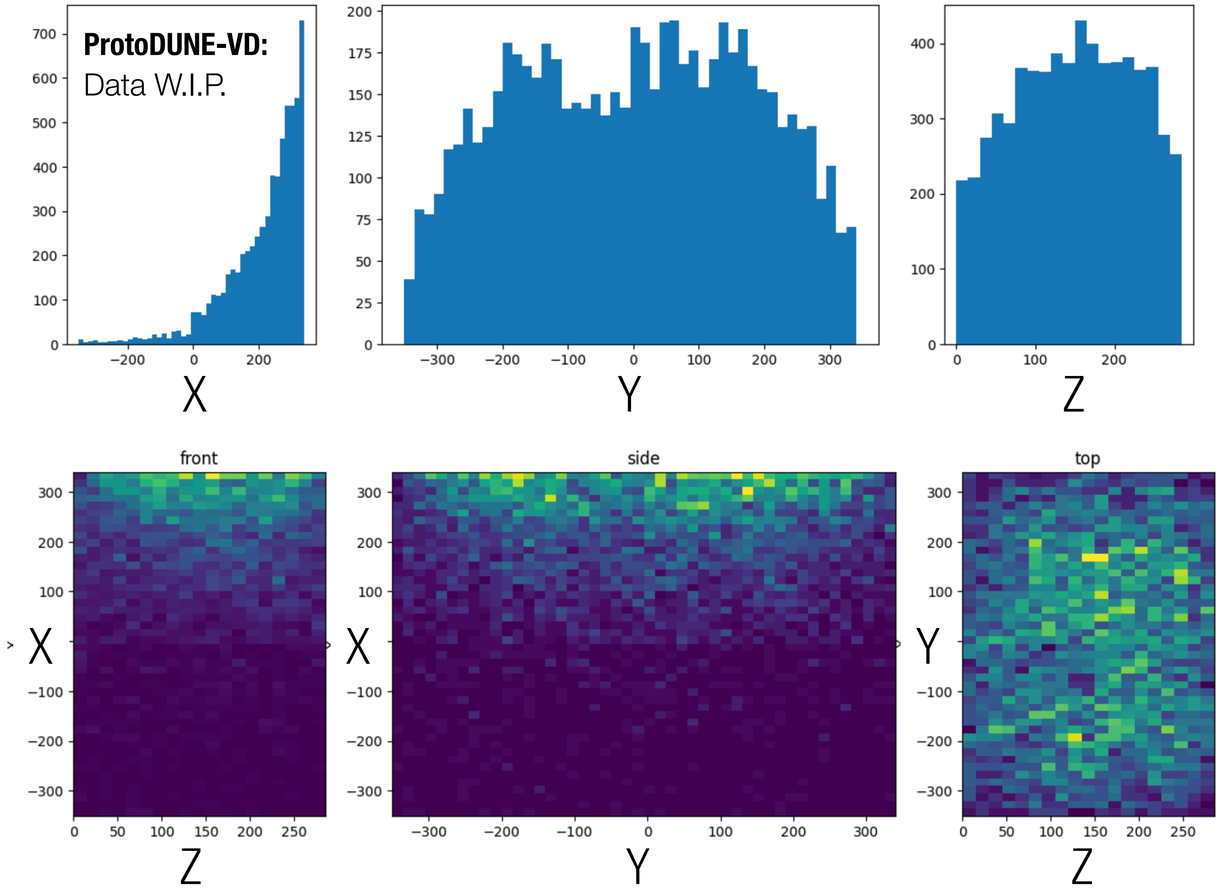
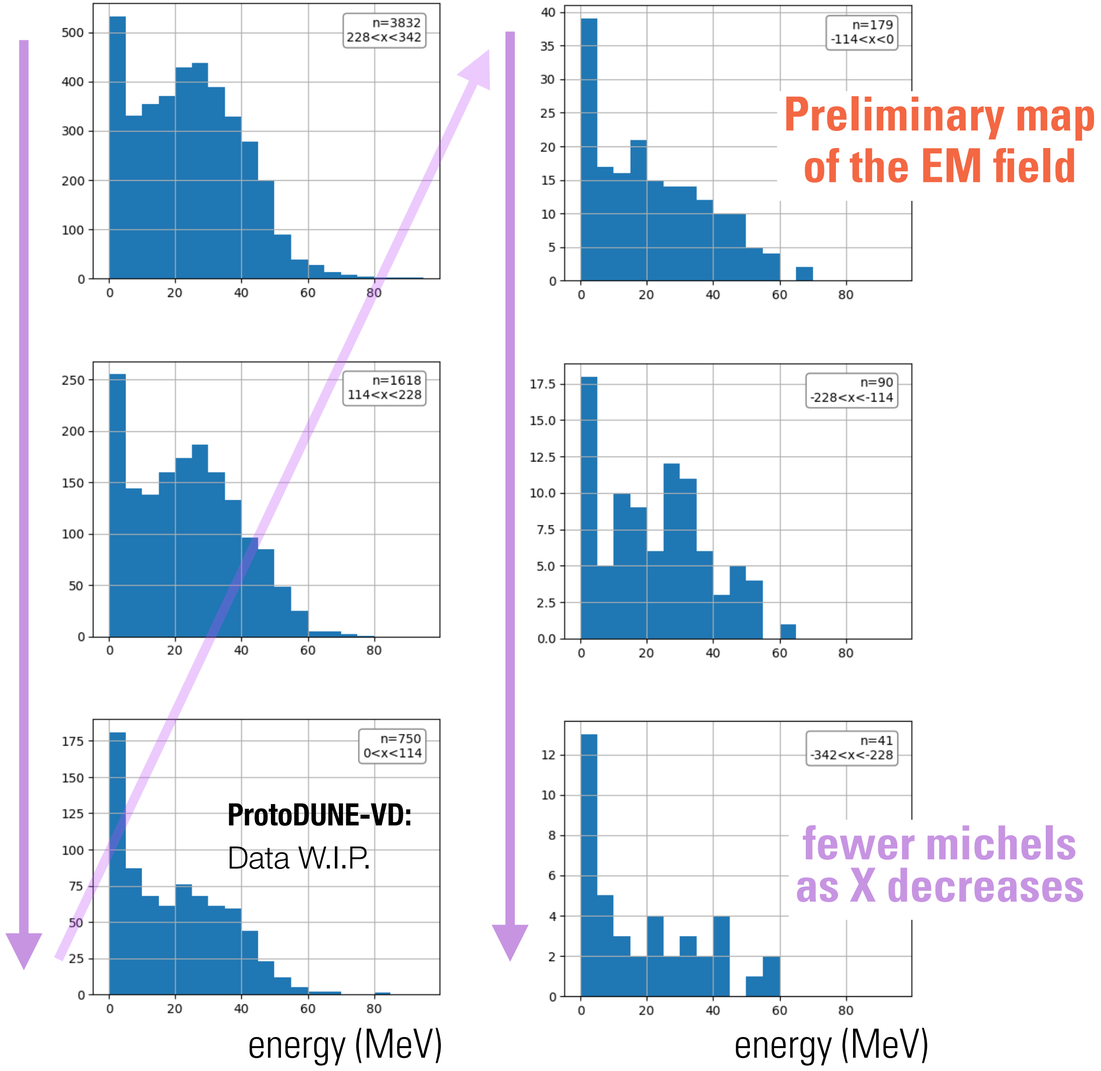


Energy spectra with X decreasing



Conclusion

Key point

- First Michel electron spectra in ProtoDUNE-VD and ProtoDUNE-HD

Perspectives

- Event by event comparison of LArSoft/Pandora and SPINE with a unique truth source (simulations)
- Michel electrons reconstruction as a benchmark for SPINE reconstruction
- Michel electrons as a probe to DUNE low energy sensitivity
- Improve current estimations of DUNE supernovae signal reconstruction capabilities with SPINE?

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Thank you for your attention!