Science Board Meeting 08/02/17

Calorimetric Reconstruction in FD-DP

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Outline

- Introduction
  - What is LarSoft
  - DP implementation in LArSoft
  - A first comparison between QSCAN and LArSoft

- Muon energy calibration crosscheck and energy reconstruction efficiency

- Shower energy reconstruction efficiency

- First study on electron/gamma separation

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- **Introduction**
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LArSoft

A first look at reconstruction for ProtoDUNE-DP in LArSoft

- LArSoft is installed on the CENF computers (Version used for this talk): https://twiki.cern.ch/twiki/bin/view/CENF/NeutrinoClusterCERN

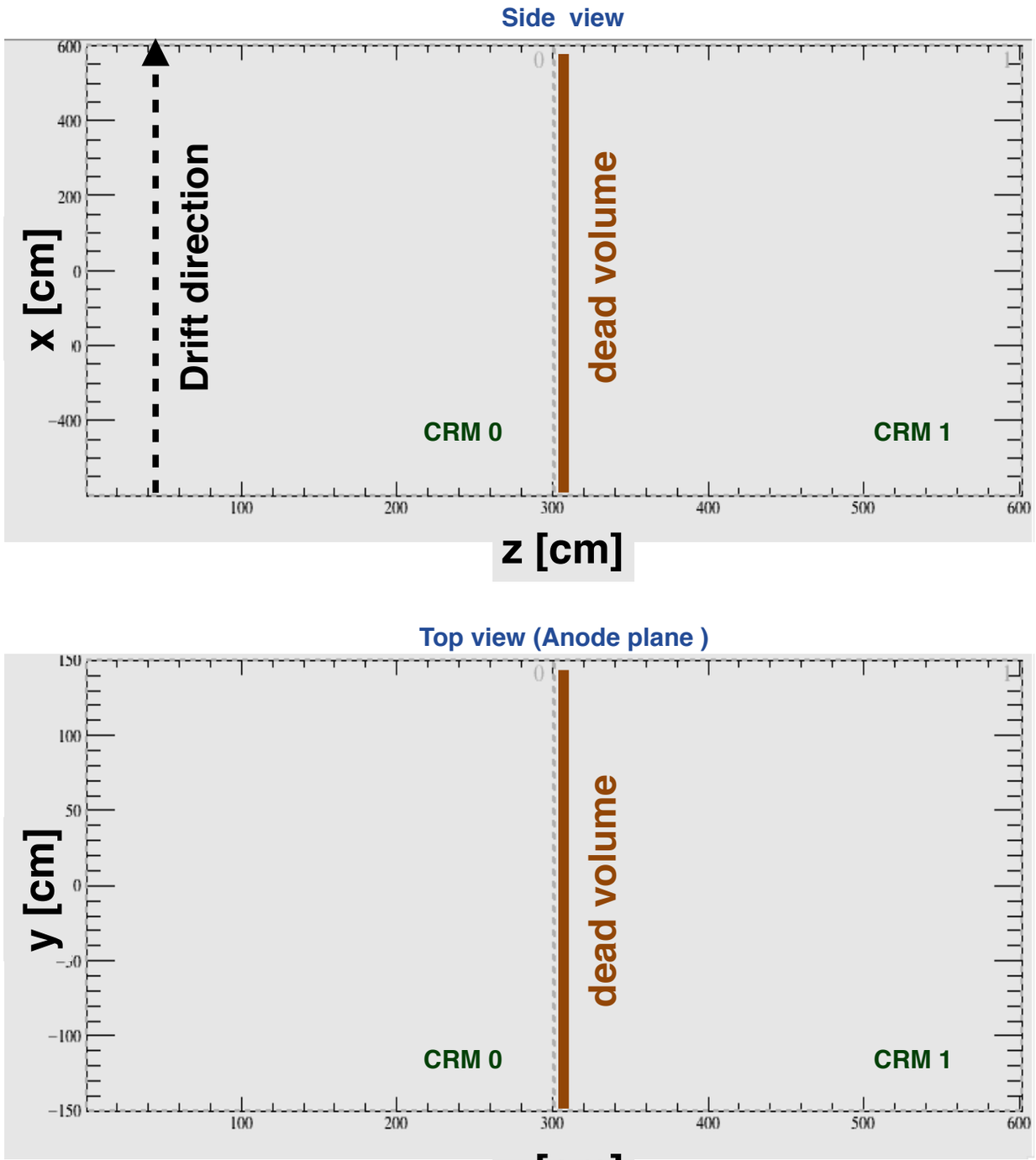
- On October 31st CERN hold a one-day LArSoft tutorial: https://indico.cern.ch/event/575069/

- It is the framework chosen for ProtoDUNE-SP

It is a solid framework in Single Phase configuration. Has just moved its first steps for Dual Phase.

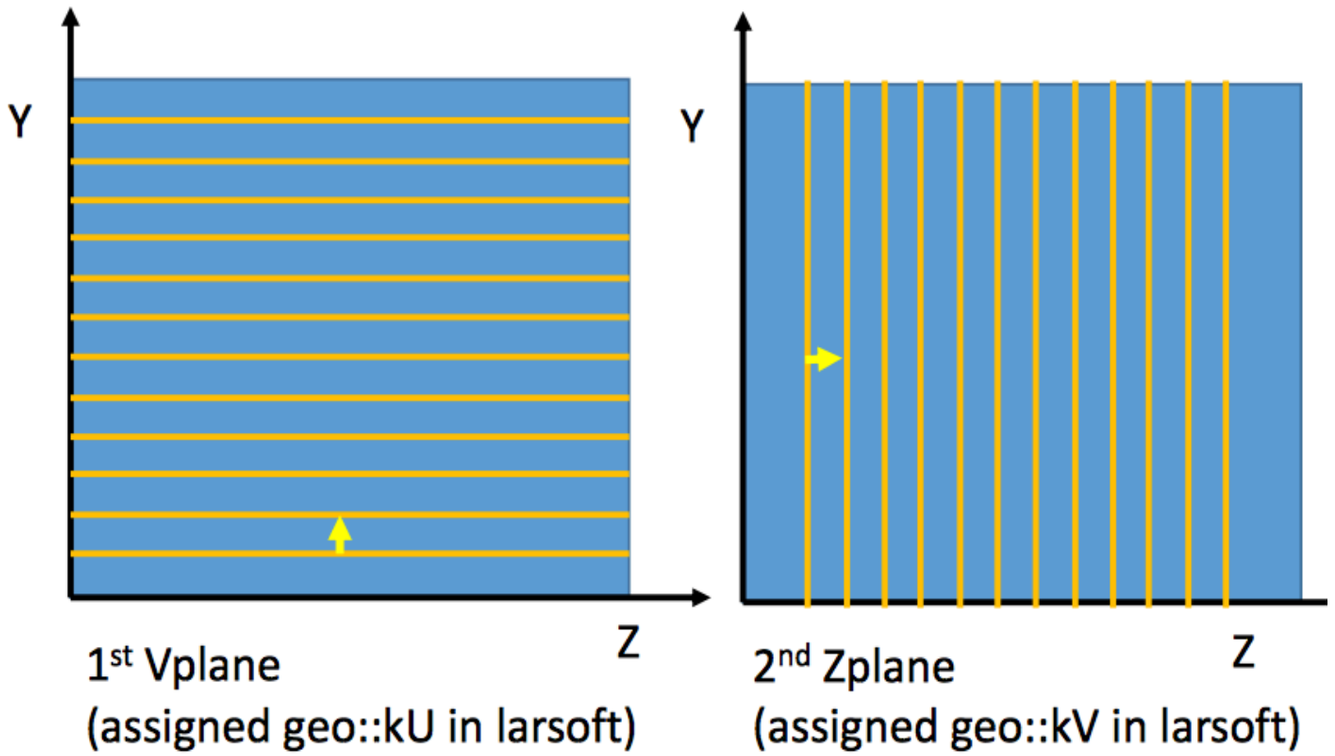
DP Geometry in LArSoft

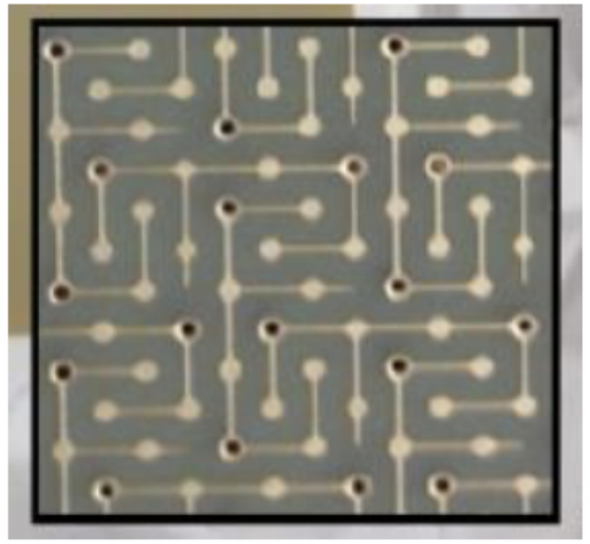
- DP geometry for DUNE 10kt DP is already present in LArSoft (by **Slavic Galymov**)
- DP geometry for ProtoDUNE recently implemented (by **Christoph Alt**, not used for this talk)
- Use of a "**Working space**" geometry to reduce computational time
  - **Two CRMs** 3x3 m^2 each
  - **Drift length** along **X :**12 m
  - 1 cm thick **dead volume** between the CRMs



DP Geometry in LArSoft

- Collection planes: implemented in LArSoft as “wire”-planes in analogy with the SP geometry
- The actual readout is done with multilayered PCB with 2D pattern of strips





Real PCB

Details about the Dune 10kt Dual-Phase geometry can be found here: https://indico.fnal.gov/getFile.py/access?contribId=2&resId=0&materialId=slides&confId=11402

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QSCAN Comparison

- A first comparison between LArSoft and QSCAN in single hits distribution for tracks.

- Used an analogue data sample as from Elisabetta Pennacchio slides on benchmarking (@ WA105 SB meeting, July 6th 2016)*

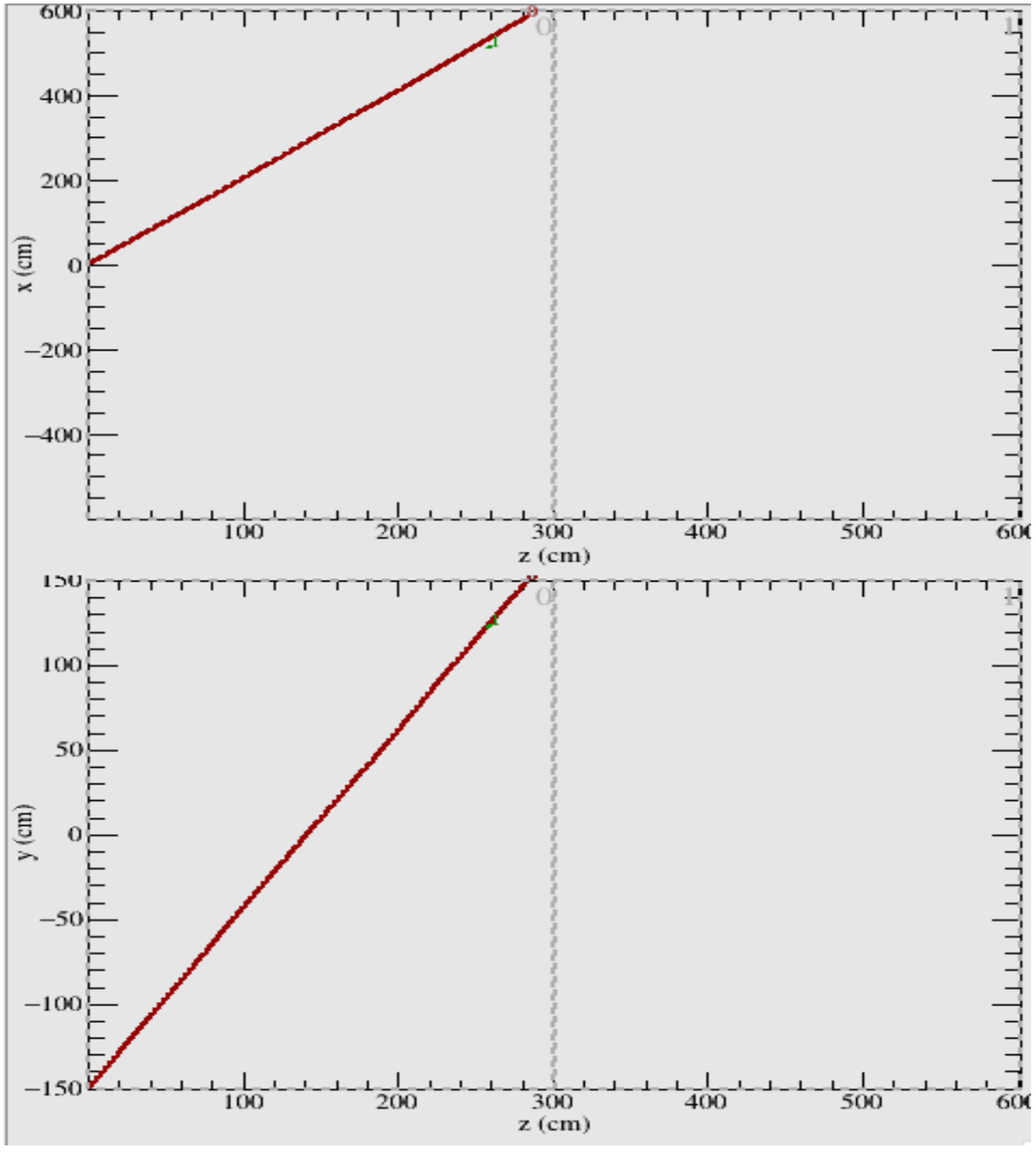
- Generated the events sample in LArSoft in the most similar condition possible. However:
  - Different Geometry (“Workspace” geometry in LArSoft, full 6x6x6 detector geometry in QSCAN)
  - Different track reconstruction algorithms (“Pmtrack" in LArSoft, Hough transform in QSCAN)

*Link to slides: https://indico.fnal.gov/getFile.py/access?contribId=2&resId=0&materialId=slides&confId=12481

QSCAN Comparison

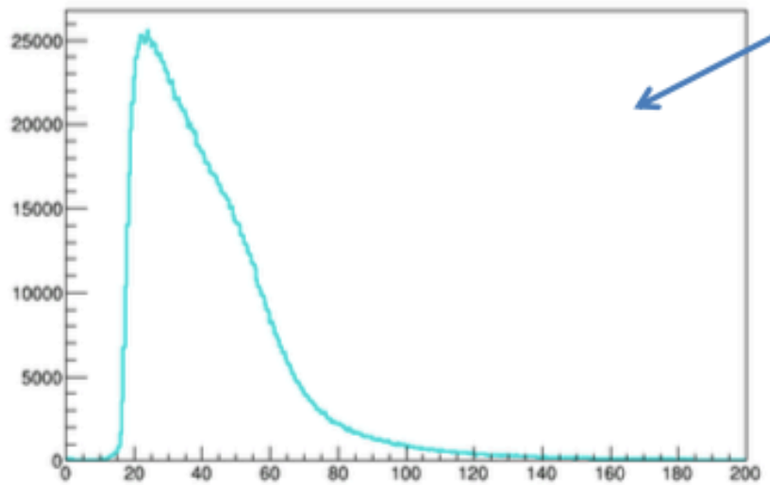
Used the same geometry and energy as the samples in Elisabetta's slides:

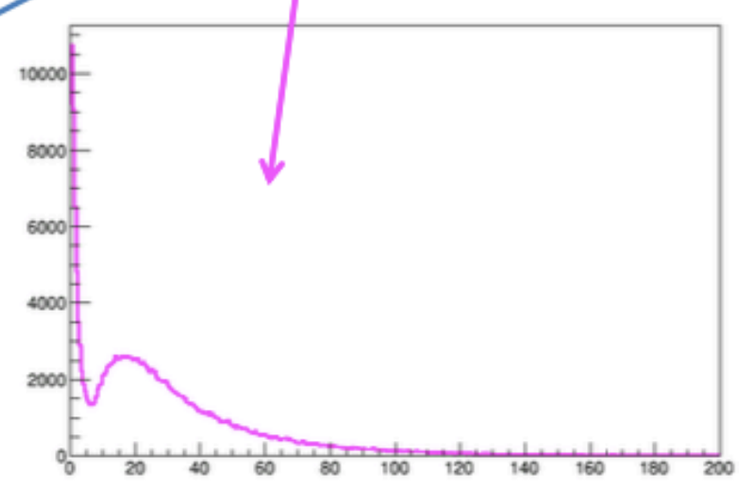
- Only one CRM
- Drift length: 6 meters
- Angle θyz: 45˚
- 2K muons @ 4GeV
- Left: event display of how this geometry appear in LArSoft



QSCAN Comparison

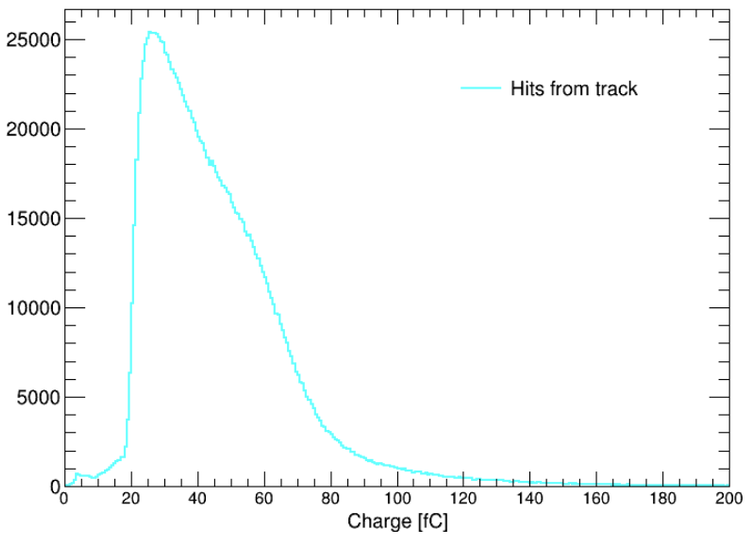
Before moving to the purity measurement, it is useful to remind that the charge collected using track reconstruction information is obtained from hits and delta rays associated to the track

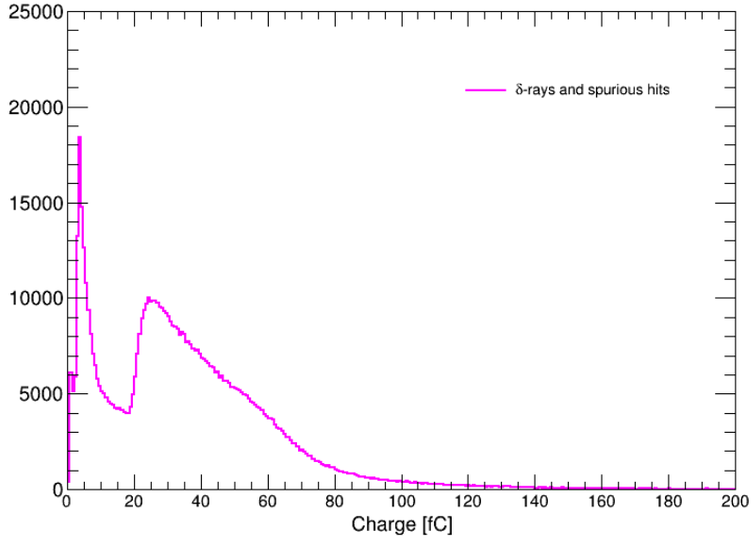




QSCAN

(From: Elisabetta Pennacchio)





LArSoft

δ ray tagging is different in LArSoft. Distribution includes spurious hits

➡ **This comparison is not exhaustive.**

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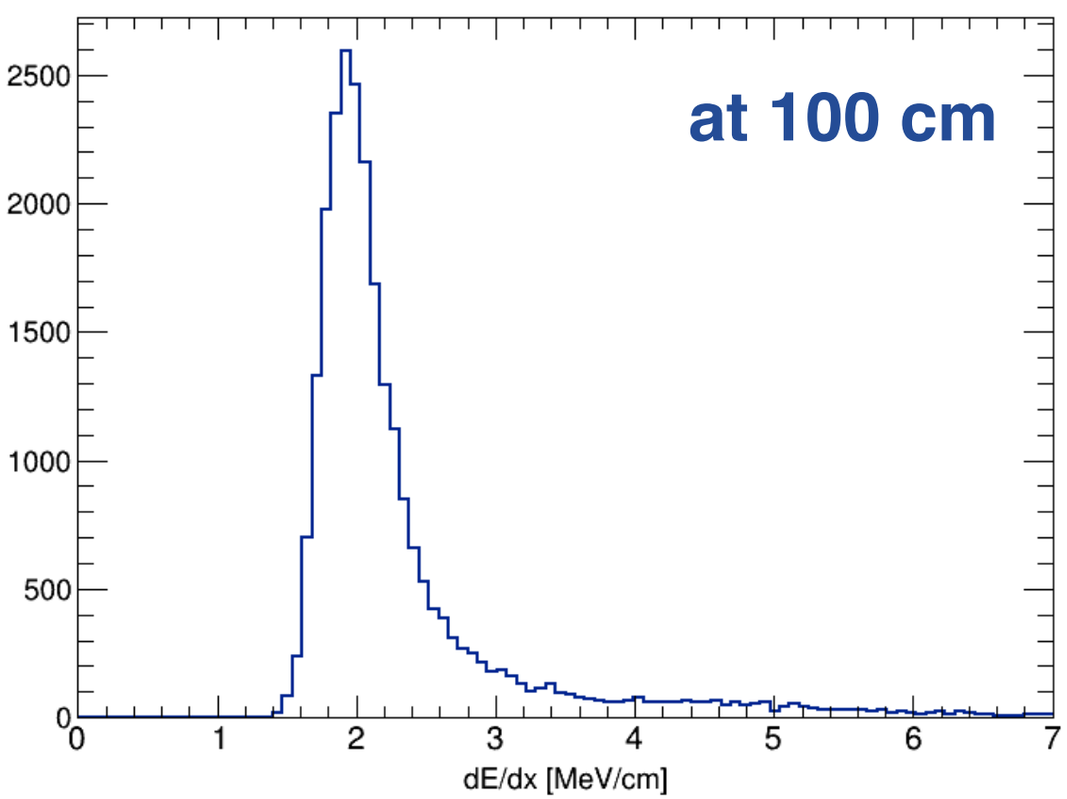
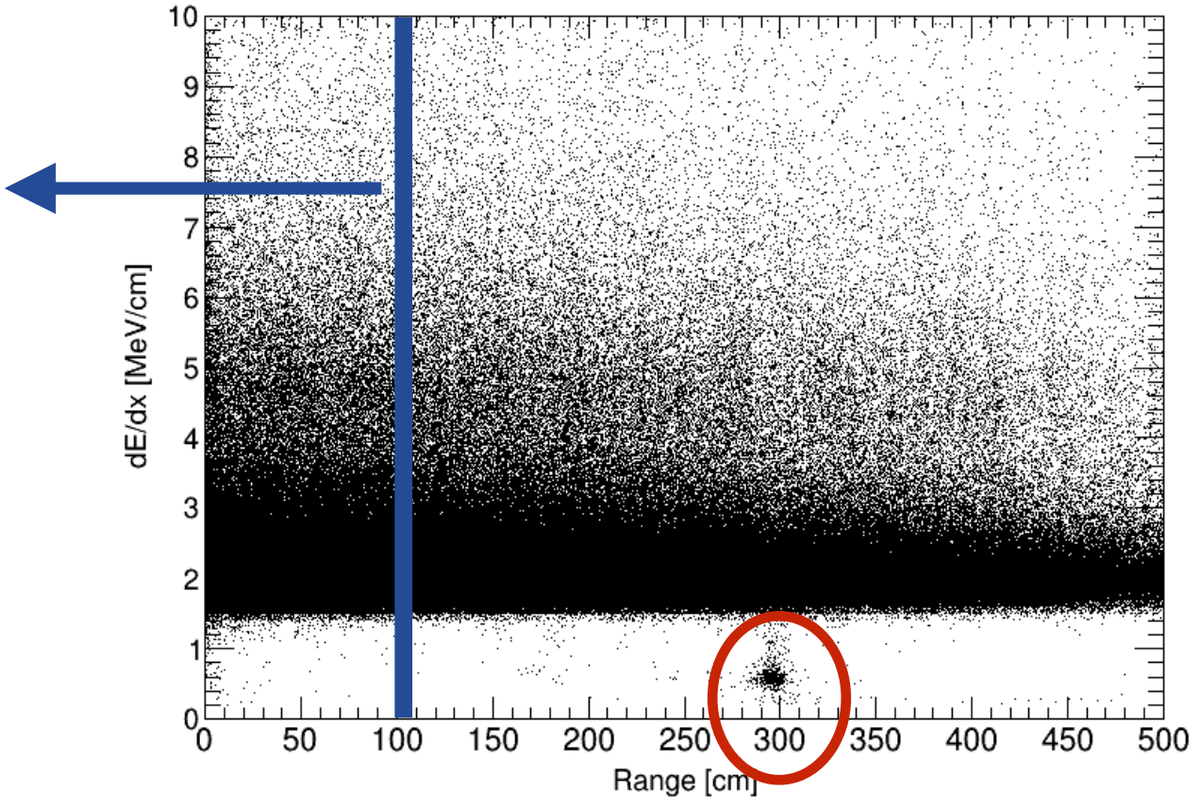
Muons: Stopping Power

- New Samples of muons from **0.5 - 5 GeV**, same initial position and direction of the central muons sample
- Stopping Power vs Range and Stopping Power at 100 cm

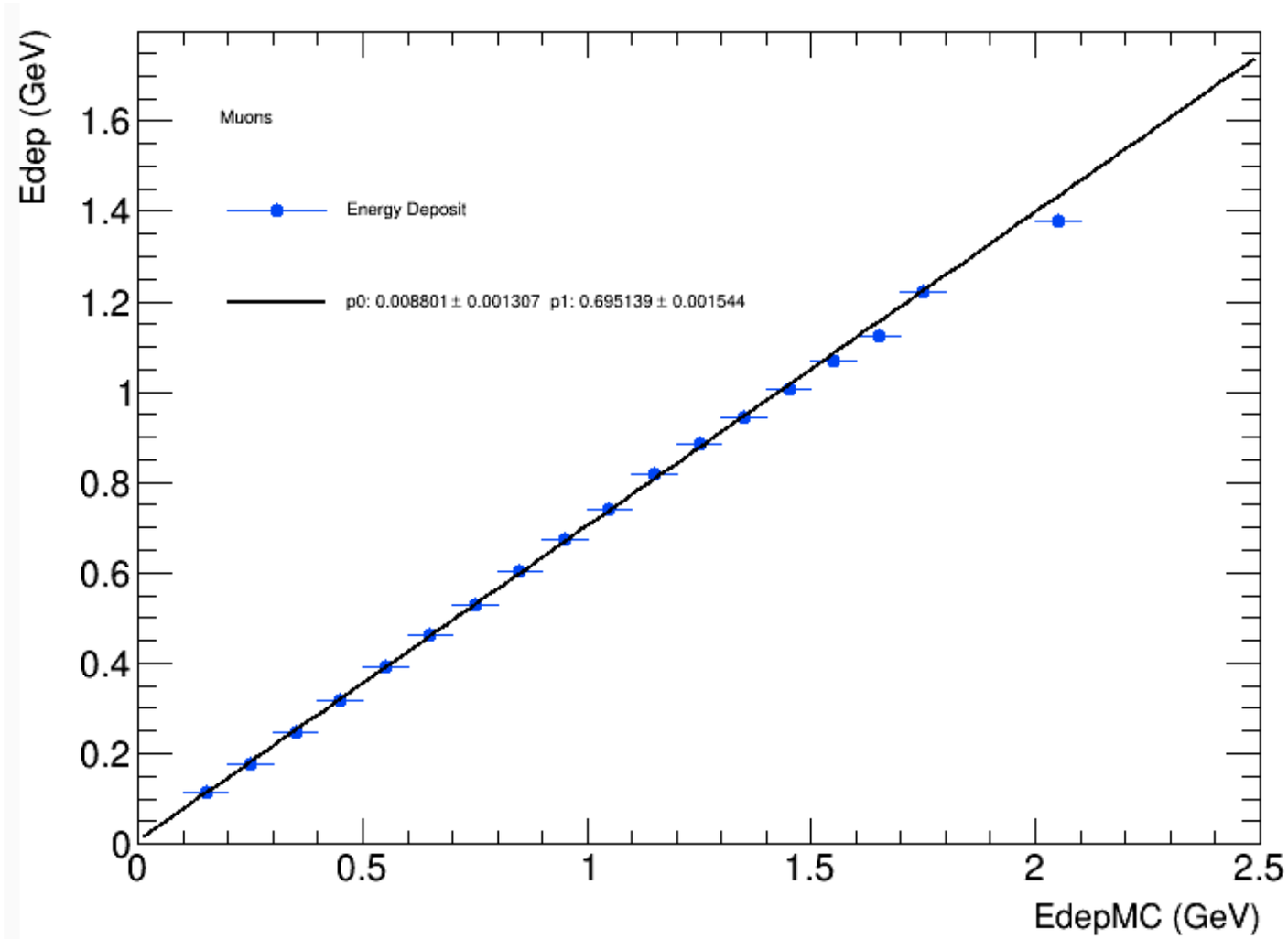




➡ Artifact due to the Dead Volume of the DP implementation in LArSoft

Muons: Calibration factor

- Muons above 2 GeV are not contained.
- **Energy deposit vs Truth energy deposit -> Calibration factor from the slope ~ 0.7** (EdepMC is before recombination)



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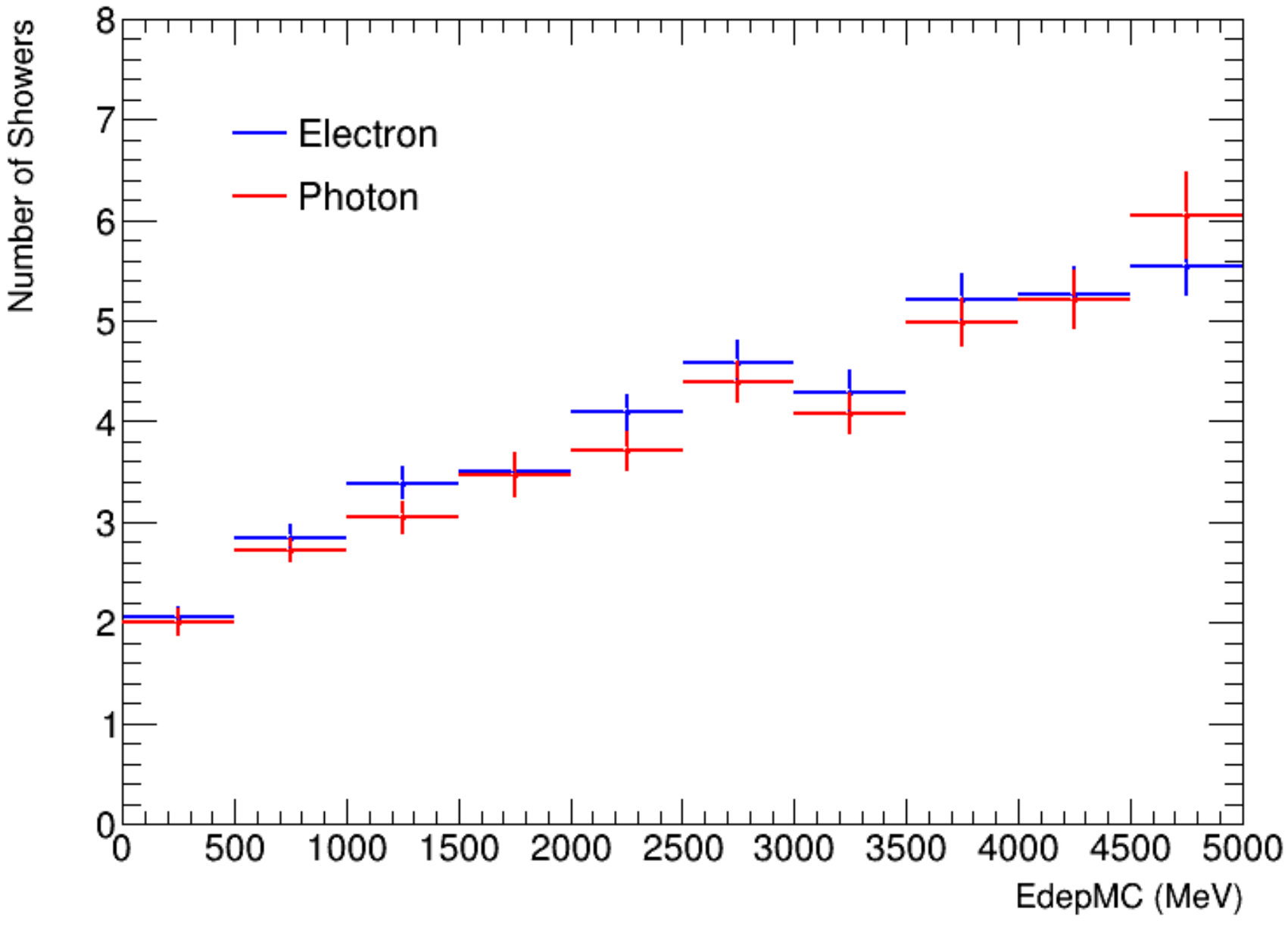
Samples: Electrons and photons

- **Electrons**: isotropic (position +direction), initial momentum 0.1 - 5 GeV
- **Photons**: isotropic (position + direction), initial momentum 0.1 - 5 GeV
- **1k events** each samples
- Reconstruction using “**emshower**”

Showers: Reconstruction

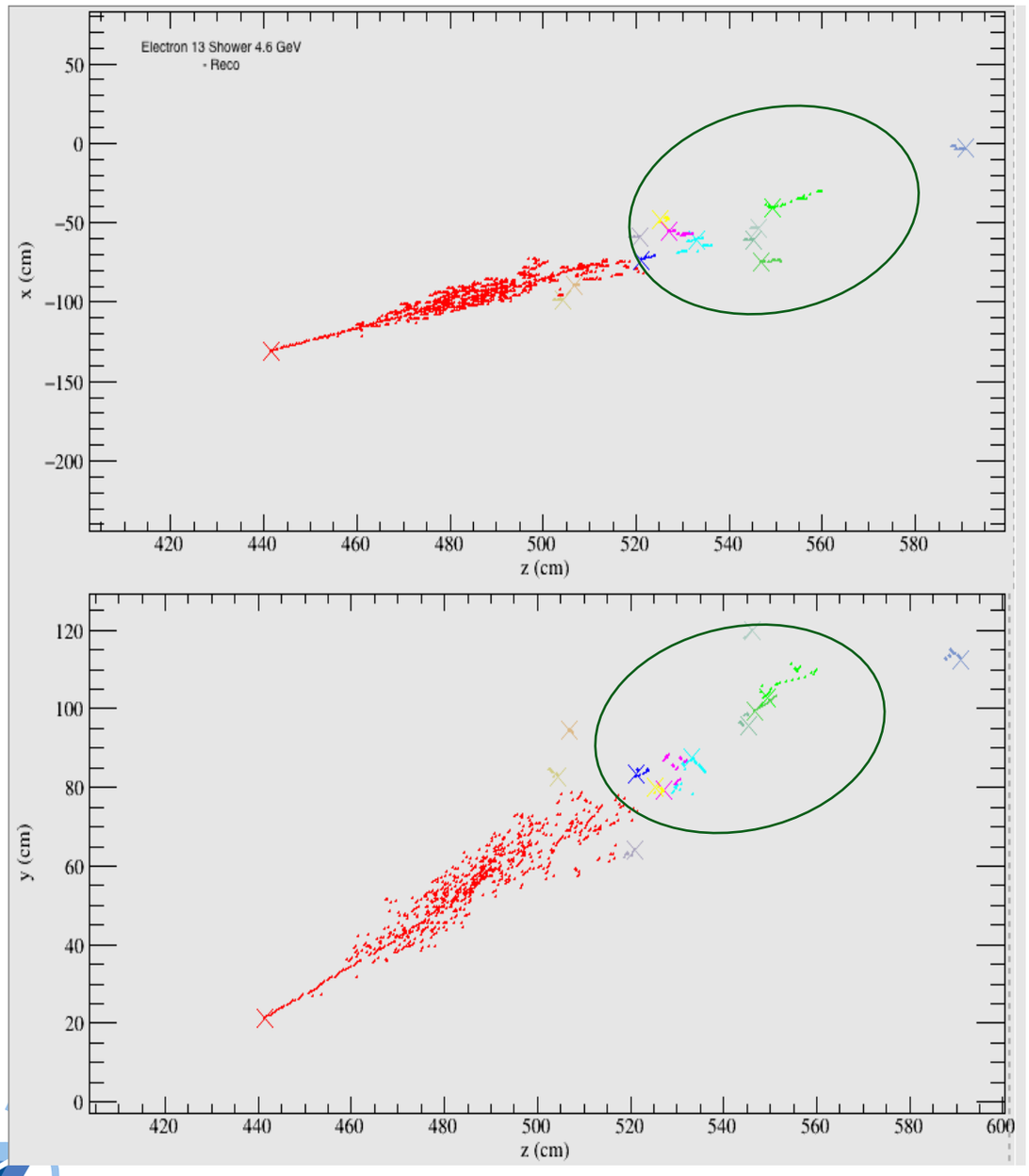
- More than one shower-like object is reconstructed. Dependency on the Energy

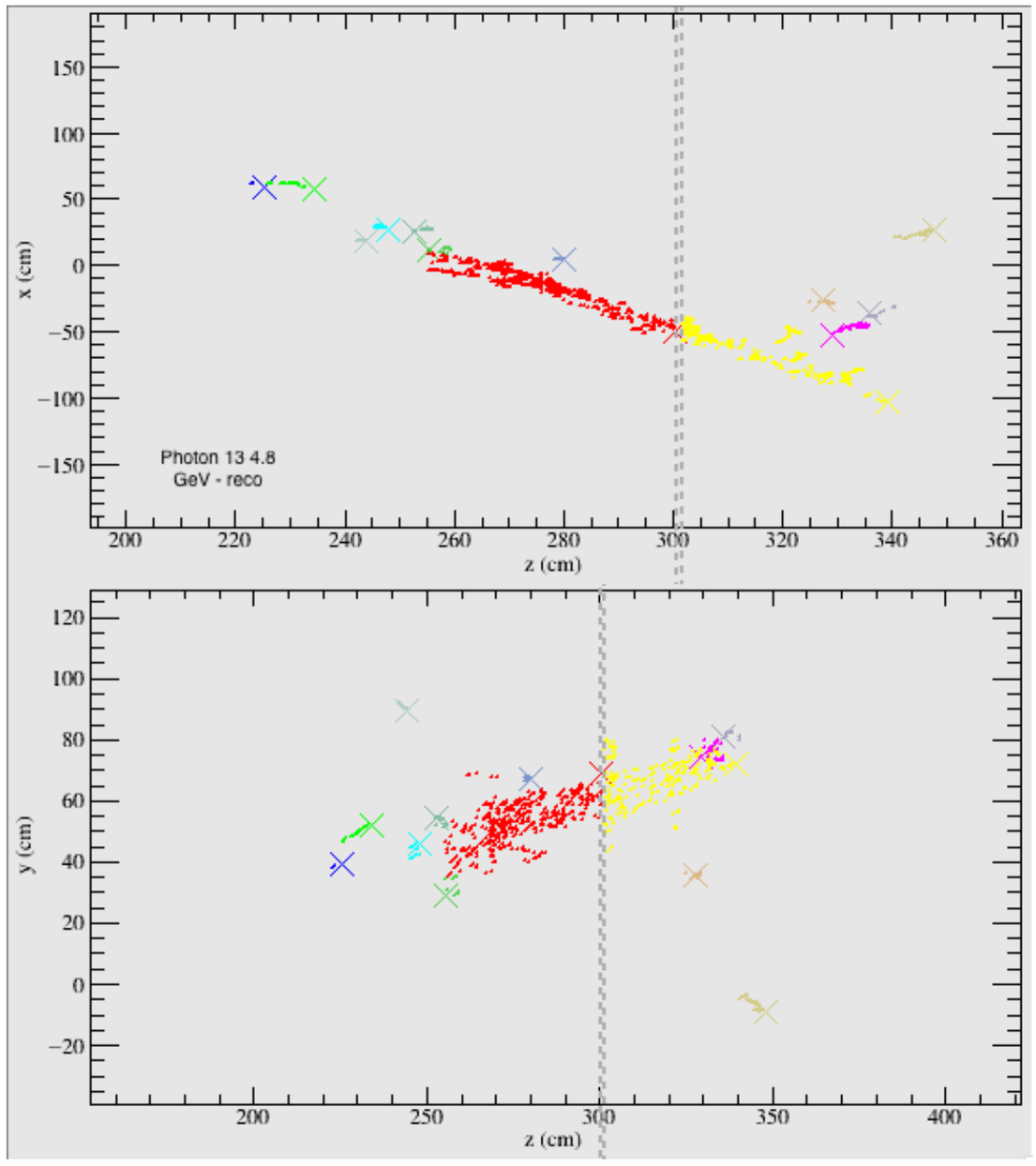


Event display

Left: **many secondary showers** far from the principal one

Right: shower crossing the dead volume (two main showers are reconstructed: **Red** and **Yellow**)





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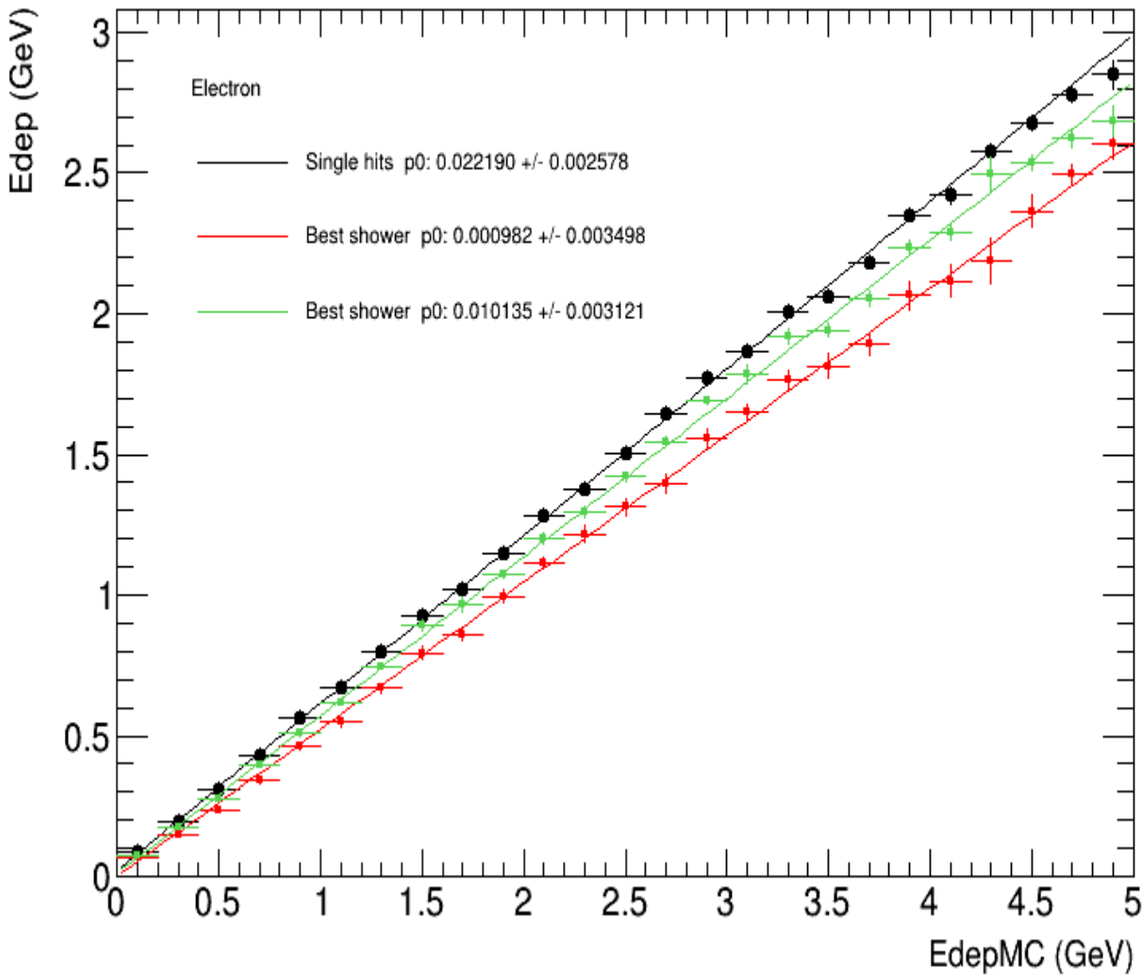
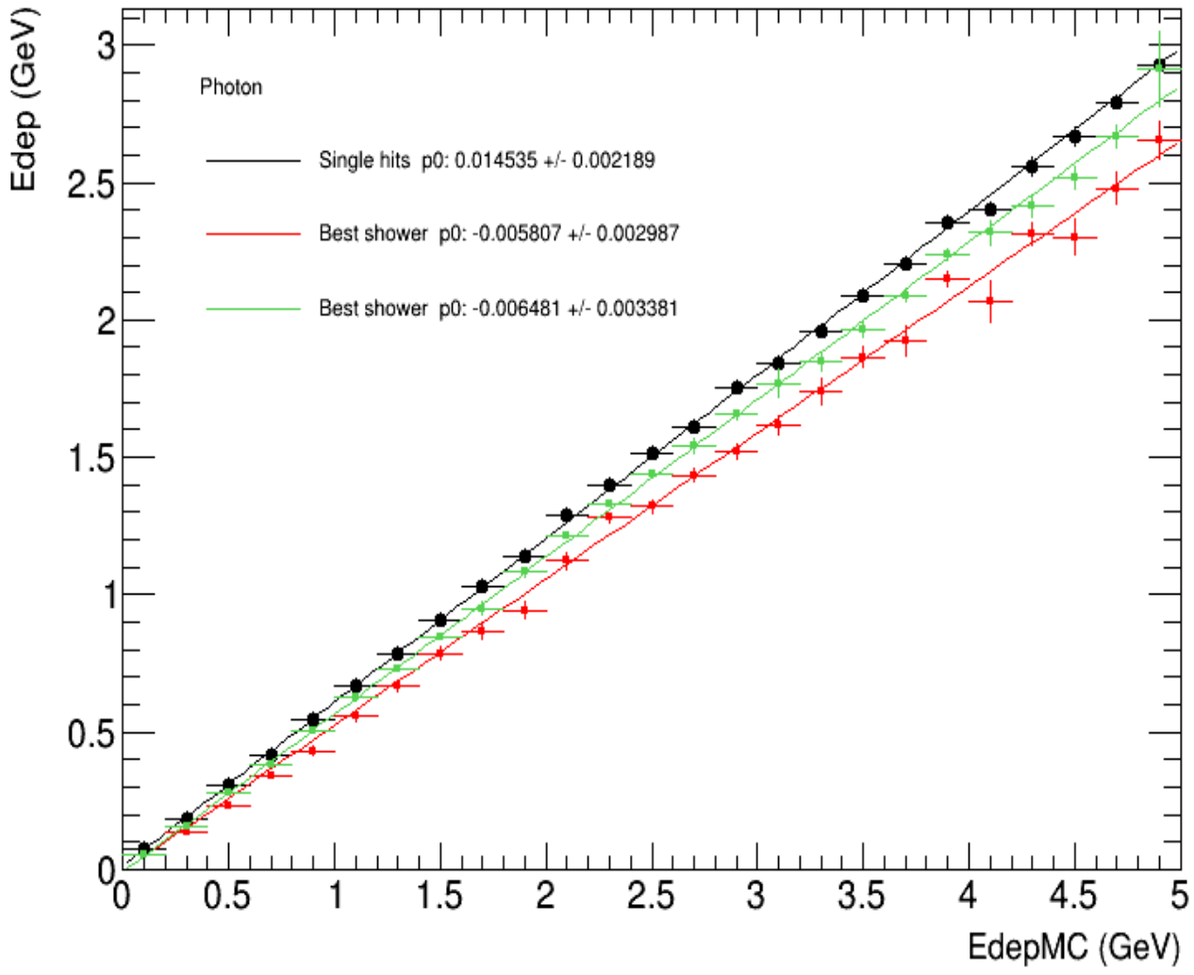
Showers: Edep vs EdepMC

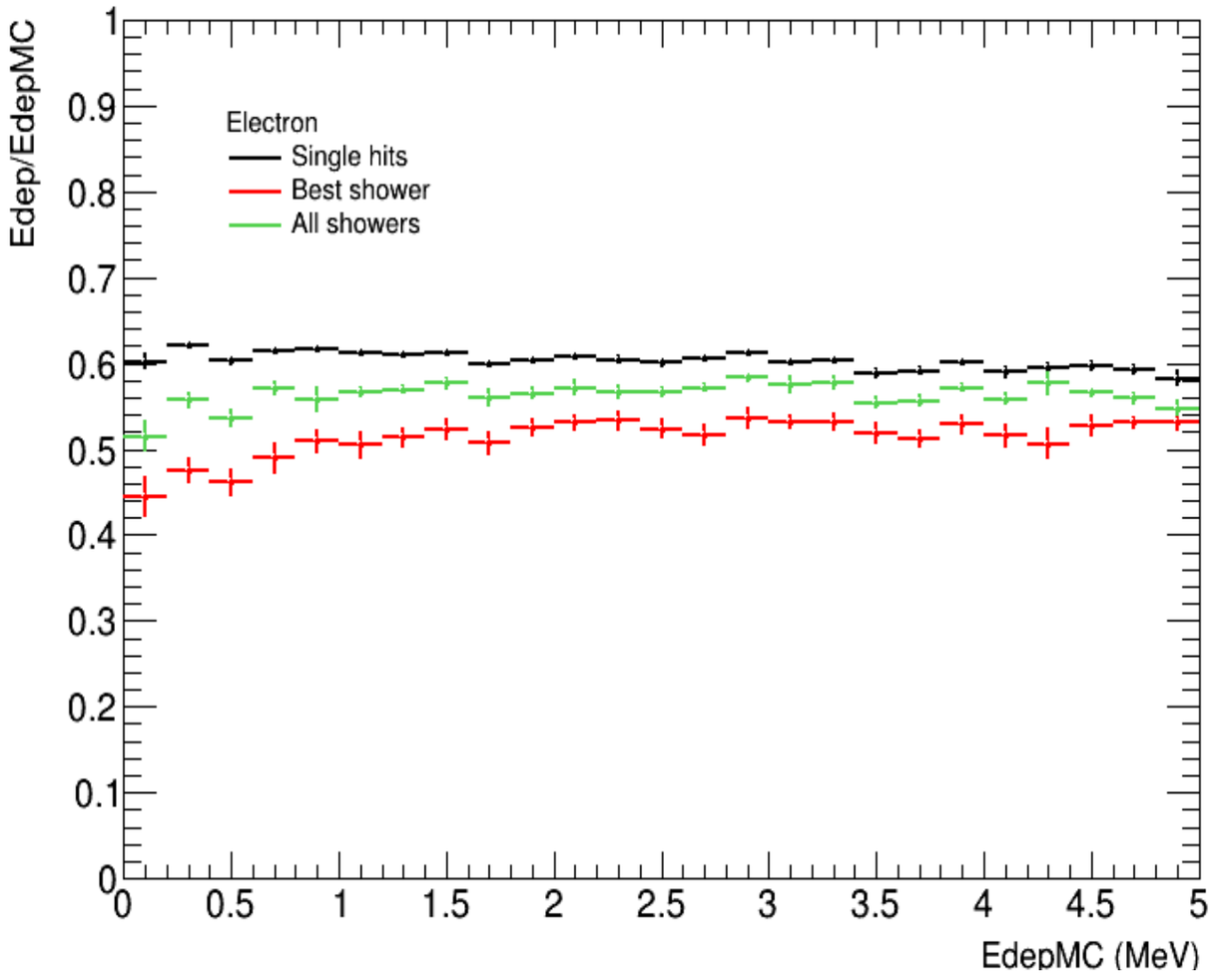
- Energy reco vs. Energy truth for the **single hits,** the **best shower** (shower with more hits) and the **sum of all the showers**
- 25 bins, 0.2 GeV/bin , ~40 events each bin -> **more statistic is need**

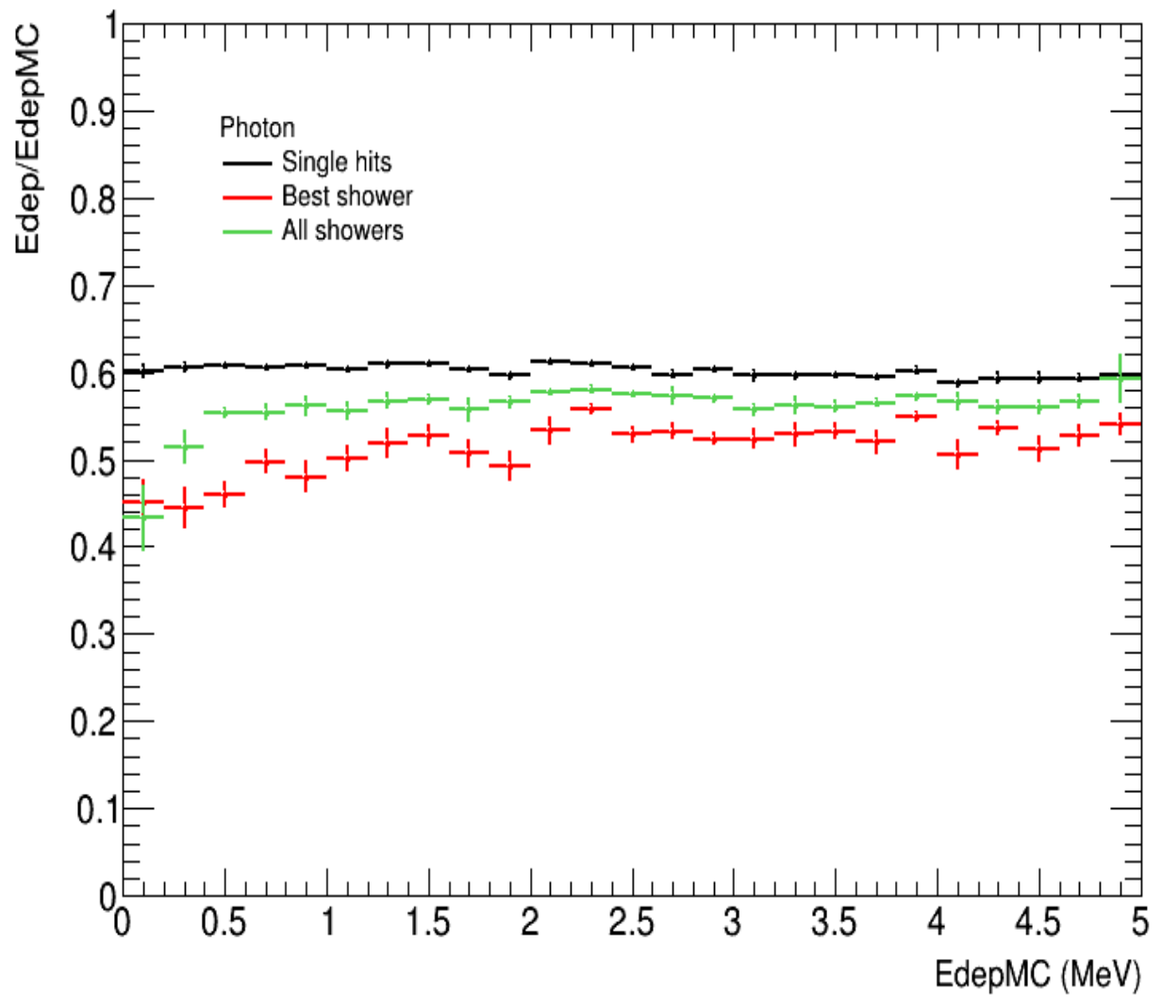




Showers: Calibration factor

- **Calibration factor = ratio between Edep/EdepMC**
- **EdepMC > 1 GeV —>** ratio between **0.5 and 0.6** (statistical fluctuations)
- **EdepMC < 1 GeV —>** missing energy with respect to single hits.





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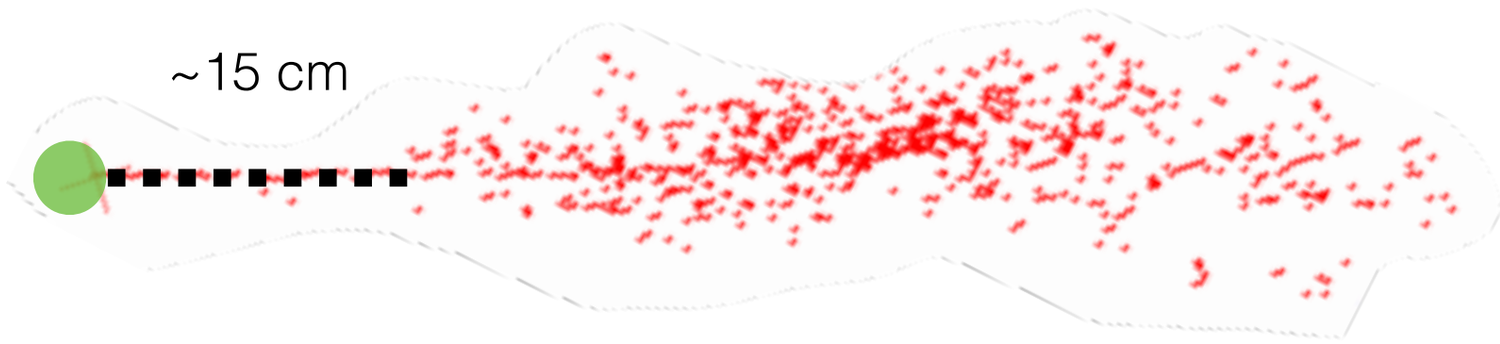
e/γ separation

- **γ conversion induced cascaded** are a source of background for **ν_eCC (signal) event (electron induced cascades)**.

- **dE/dx at the beginning of the cascade is discriminating between signal and background events** (double m.i.p. from γ conversion)

- Study of the **average dE/dx** in the first part of the shower using ShSeg module:
  - Truth information on shower direction: initial true track
  - Reconstructed hits (projected on the initial truth-track)
  - Smearing on initial position to simulate difficult vertex region



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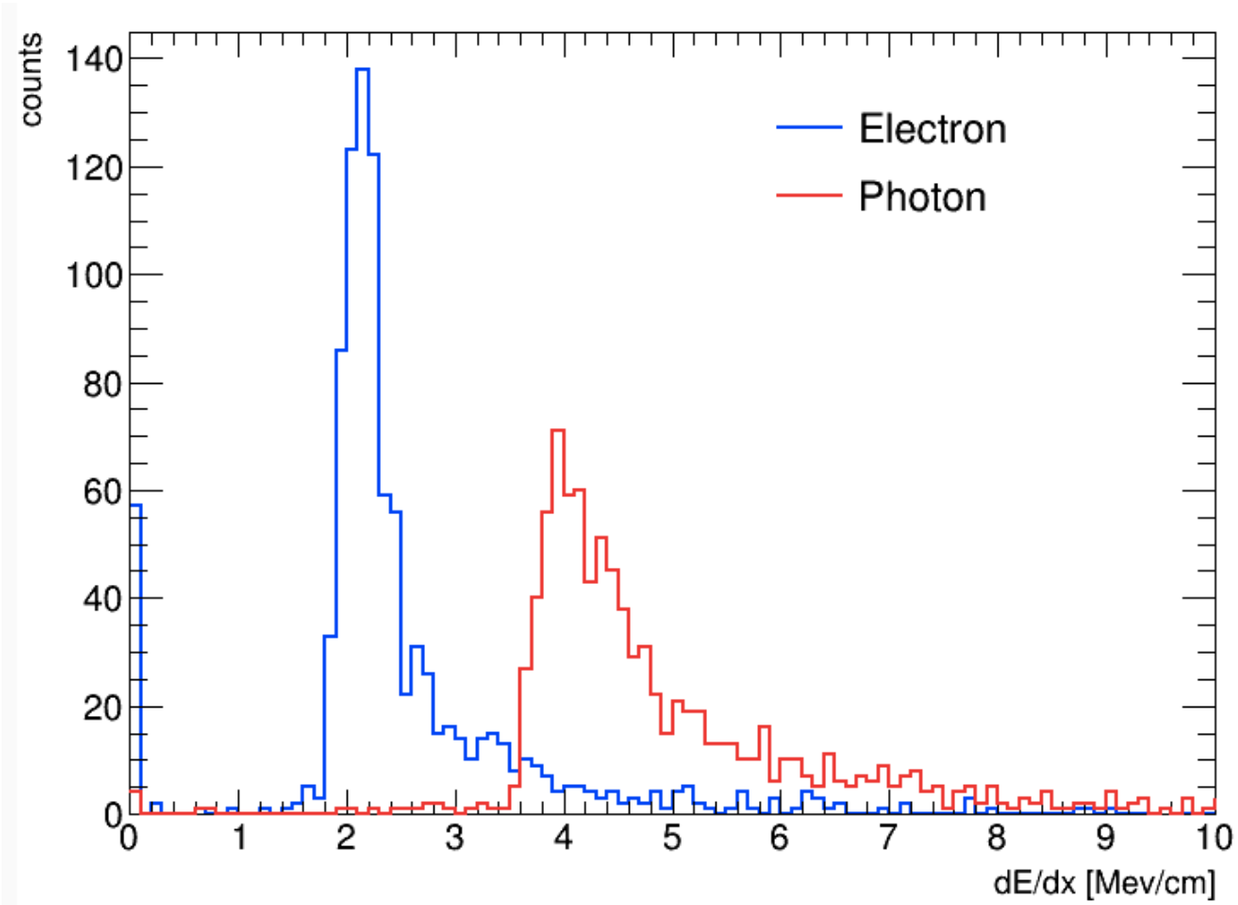
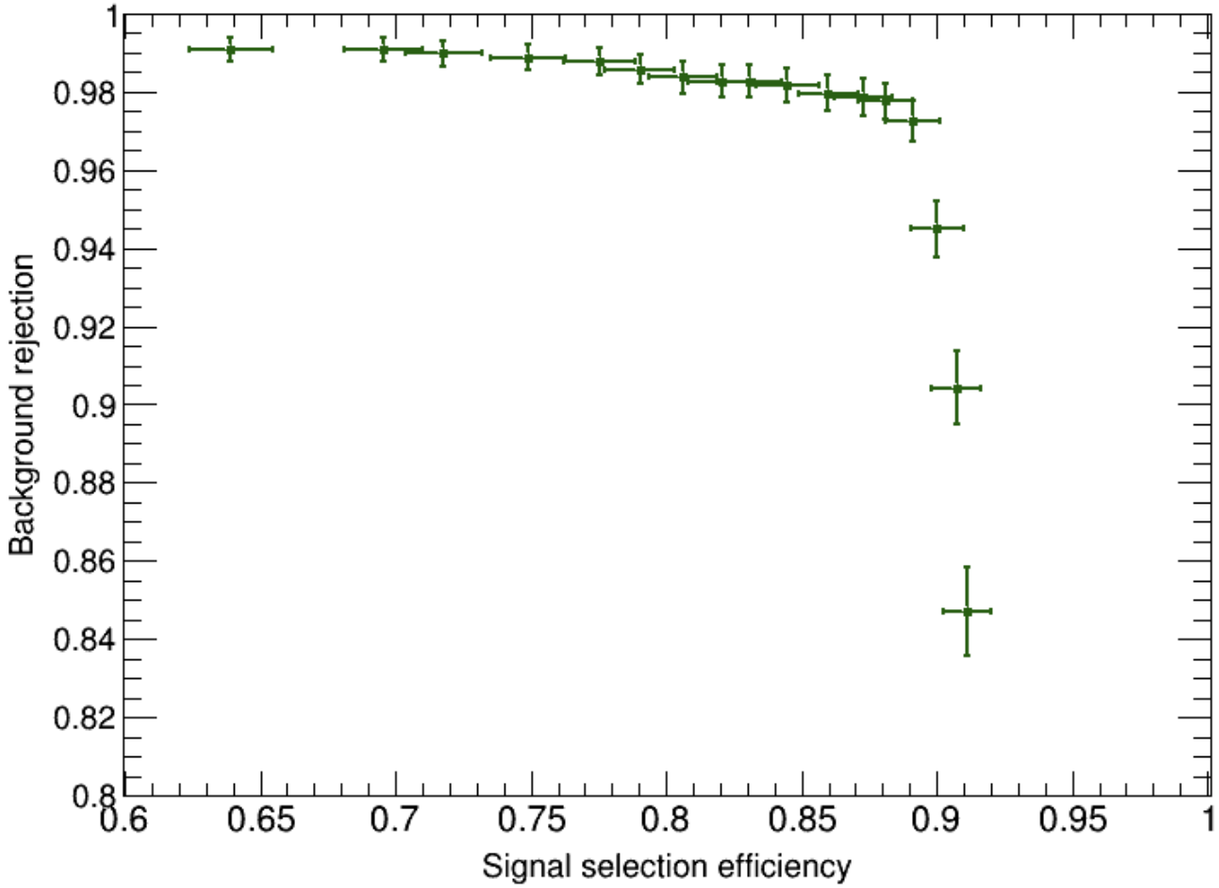
e/γ separation

- E/γ separation preliminary study
- Signal selection efficiency curve vs. background rejections (right): comparable with SP. Signal efficiency of 90% with a background rejection of 98%





Conclusions and outlooks

- **LArSoft is** still not **much used nor tuned** for **DP**
- DP geometry for DUNE FD and protoDUNE-DP exists in LArSoft. Needs more improvements
- **A basic comparison with Qscan has been performed**, more detailed studies are needed

Preliminary results on reconstruction for ProtoDUNE-DP in LarSoft:

- Muons energy reconstruction works nicely. **Edep/EdepMC ~0.7**
- Showers: **Edep/EdepMC** between **0.5 and 0.6 above 1 GeV**
- Electron/gamma separation: signal efficiency comparable with protoDUNE-SP. (more statistic is needed)

Next steps:

➡Continue my studies on electron/gamma separation using reconstructed information for the initial track

➡ More exhaustive comparison with QSCAN

Thanks for your attention!

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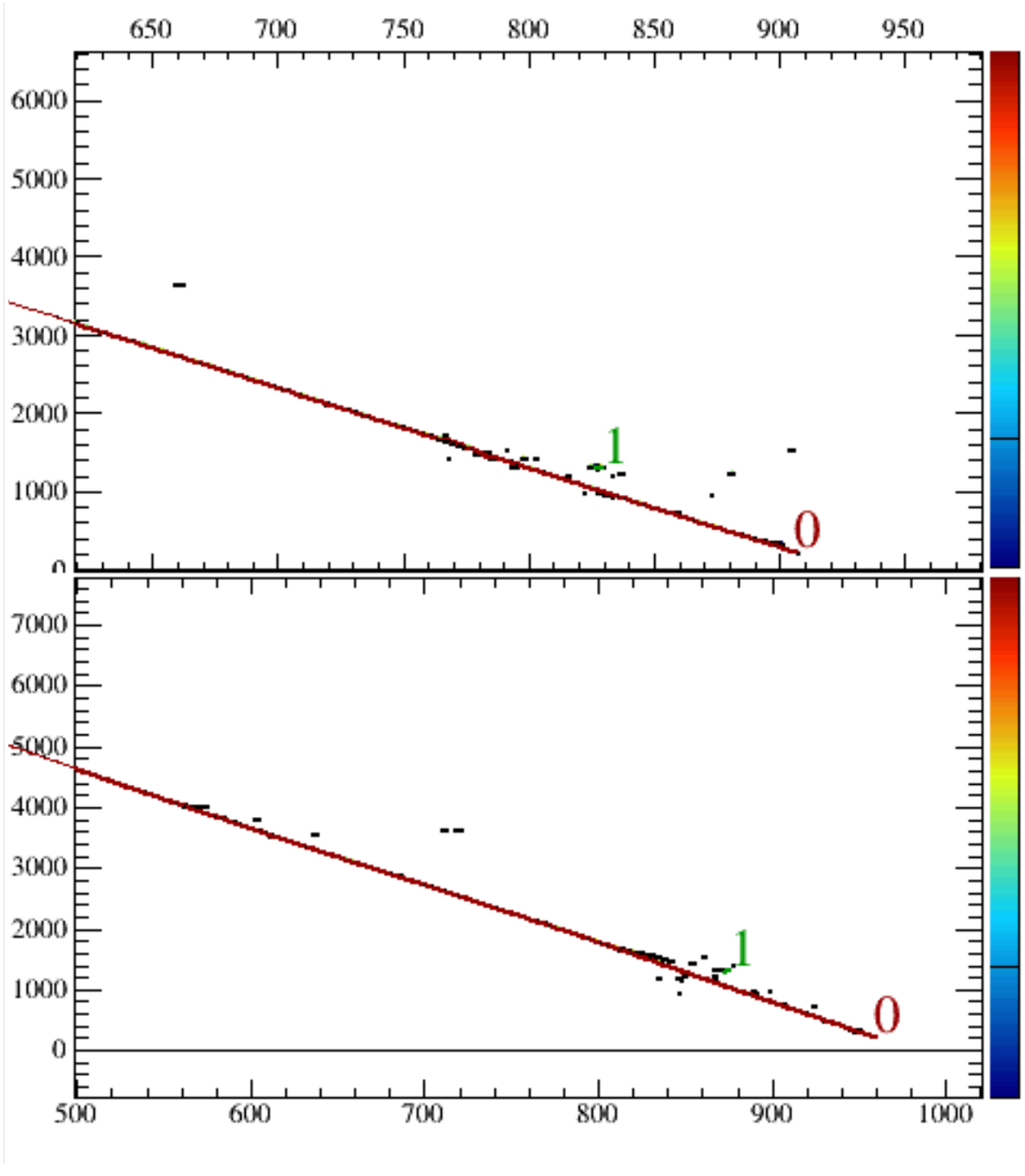
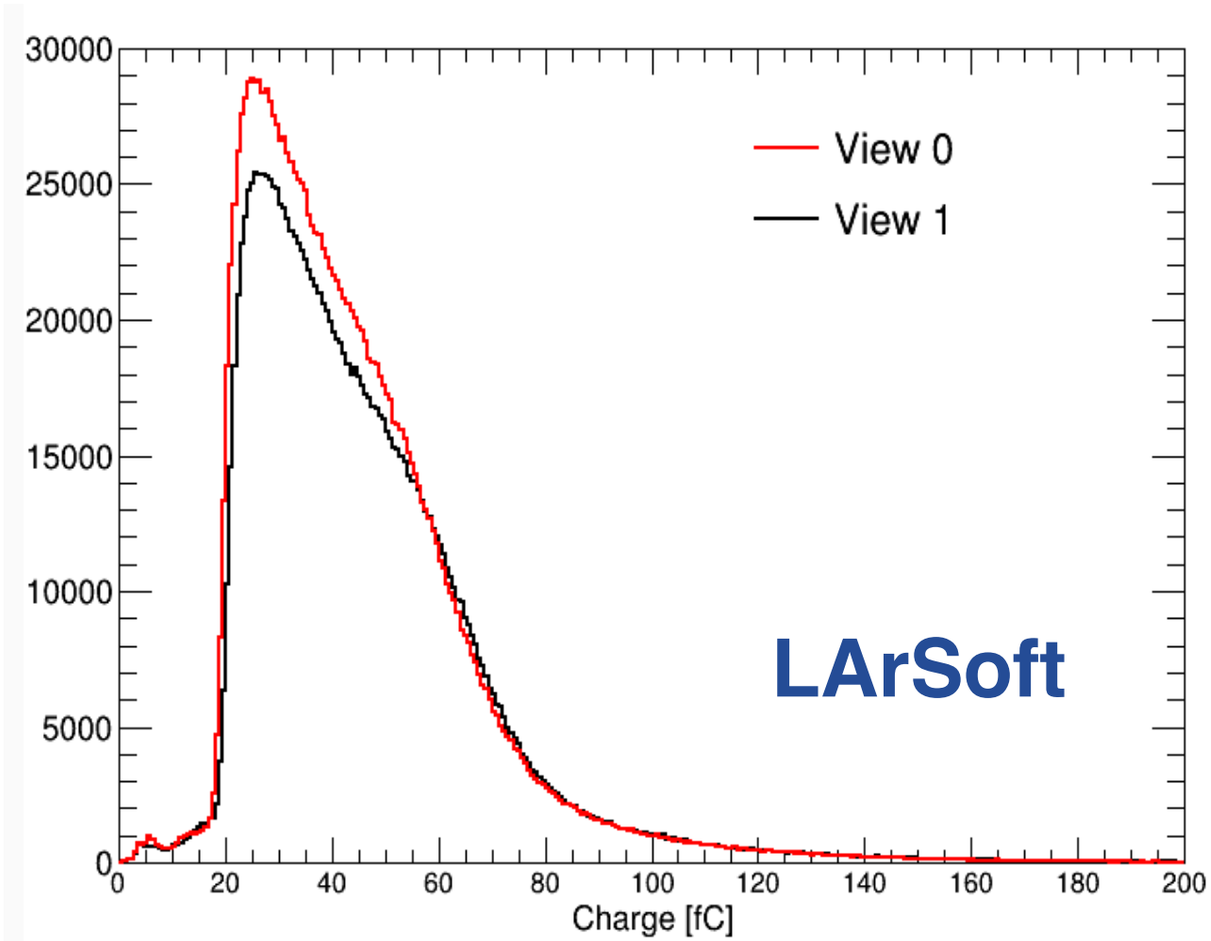
Backup Slides

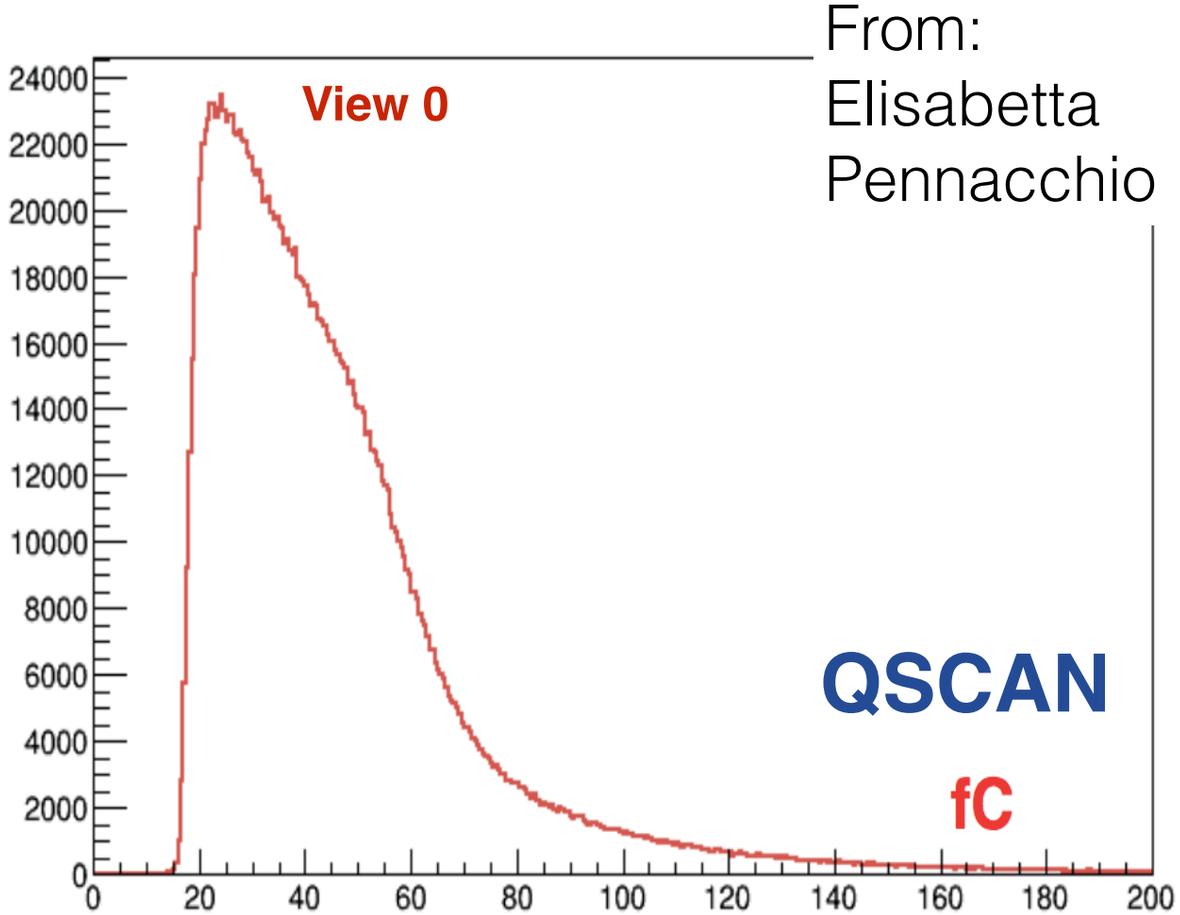
QSCAN Comparison



QSCAN Comparison

Distribution of single hits in tracks





From: Elisabetta Pennacchio

QSCAN Comparison

Low charge peak: **not only delta Rays**

- Drift time (left) predominant at **early time** (ionization close to the track origin)
- Low energy Peak disappear after energy correction (right)
- **Spurious hit** are at higher energies while **δ rays** are responsible of the low energy part only