MILO VERMEULEN — 27-2-2020

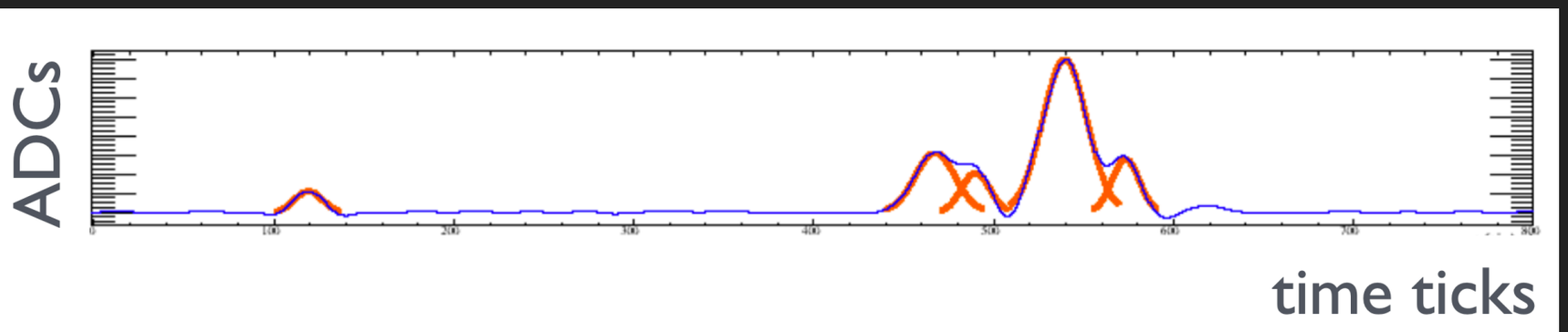
PHOTON SHOWER DE/DX

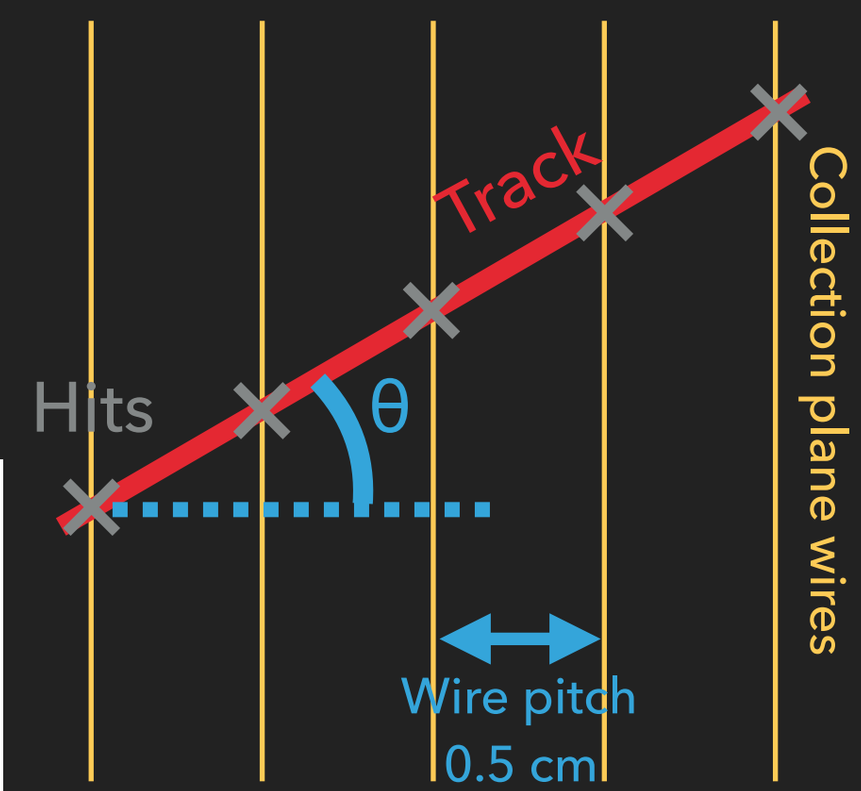
CONTENTS

- What is dE/dx?
- Goal of track and shower dE/dx
- Shower dE/dx determination method
- Photon shower dE/dx results
  - Comparison with positron showers

WHAT IS DE/DX?

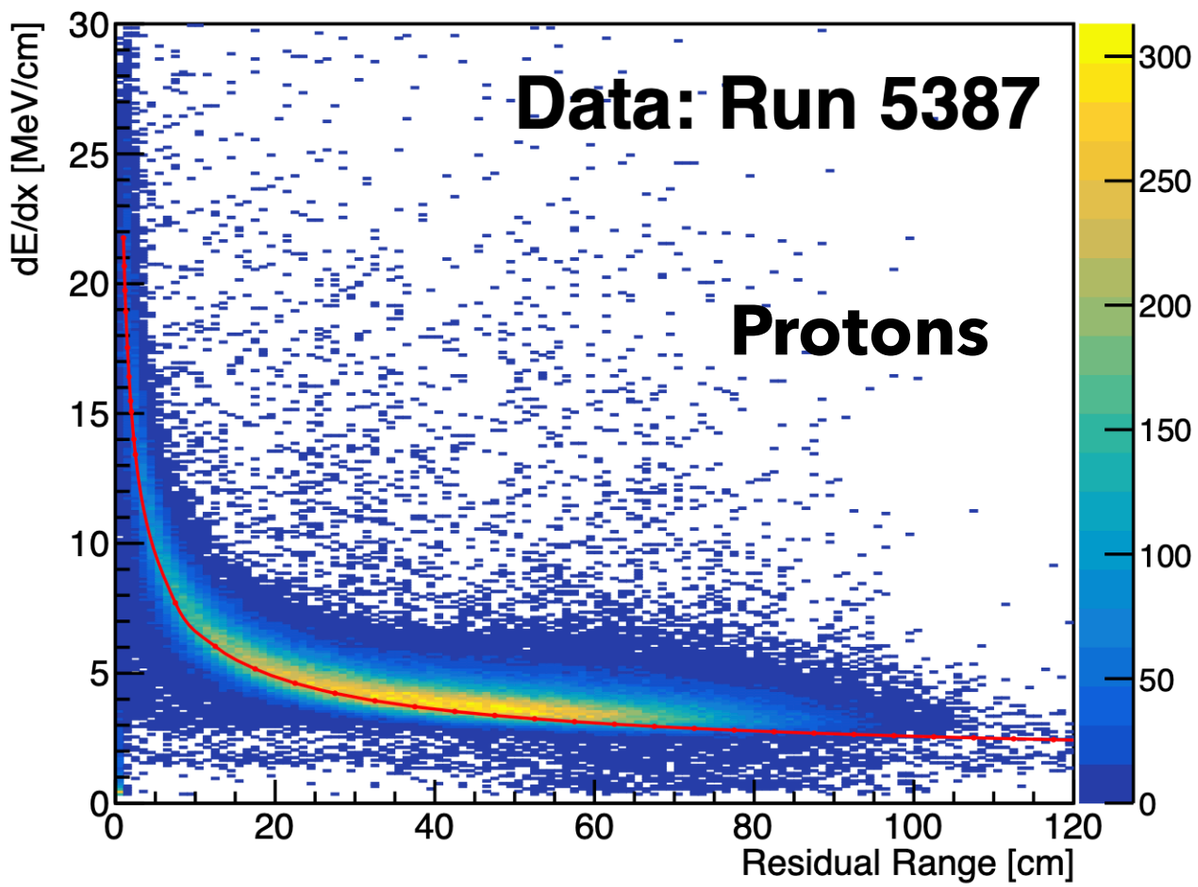
- dE/dx is the energy deposition (dE) divided by the distance travelled (dx) of one given particle
- dE/dx is typically calculated per hit from its dQ/dx:
  - dQ = integral of deconvolved hit
  - dx = wire pitch / cos(θ)
- Thanks to Aaron for help and advice

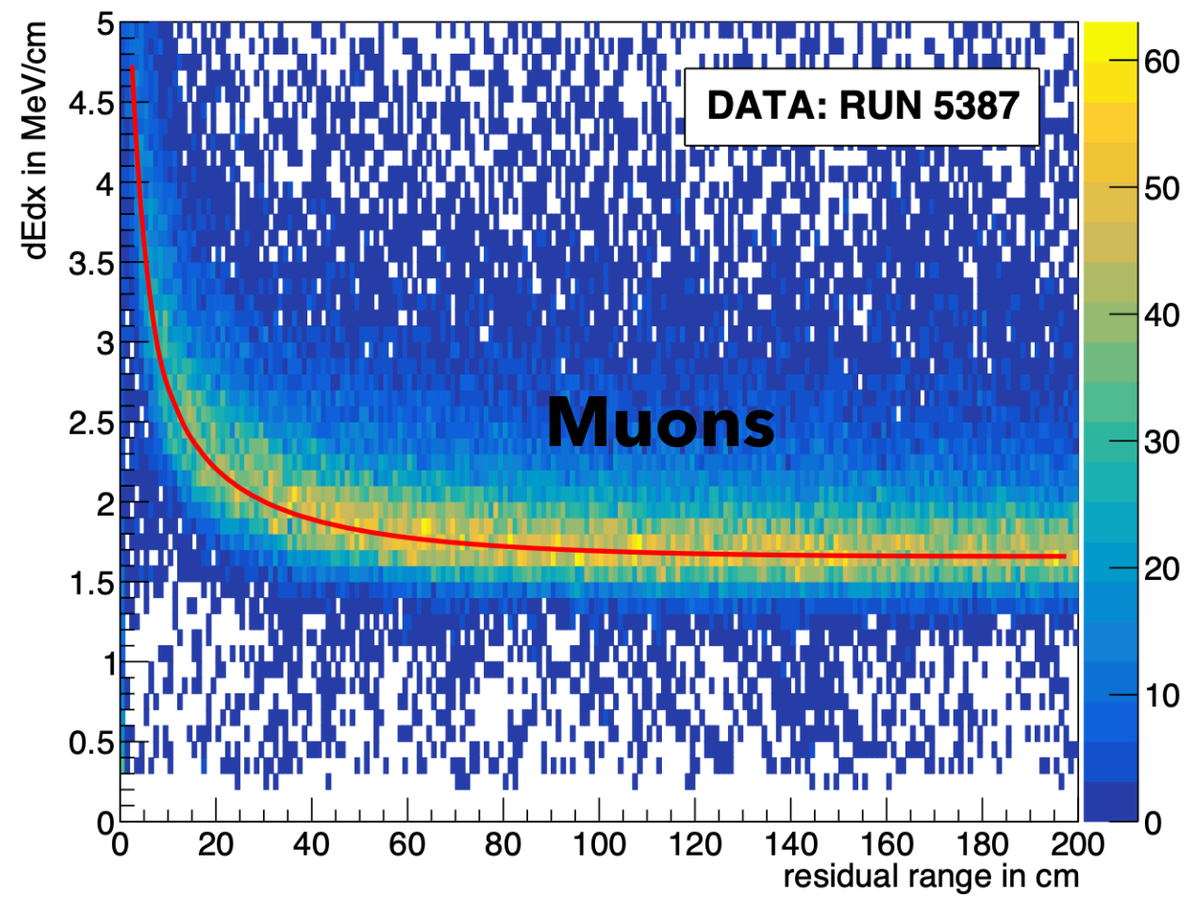




GOAL OF TRACK AND SHOWER DE/DX

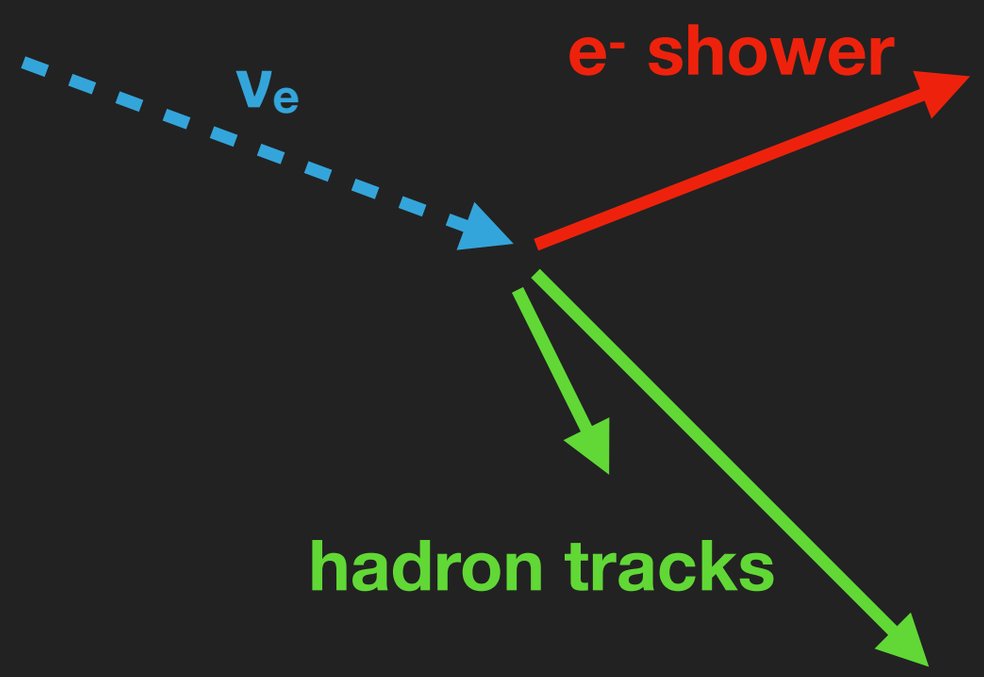
- Identifying particles based on their energy deposition is one of the technical goals of DUNE
- Example from DUNE TDR Vol. 2:



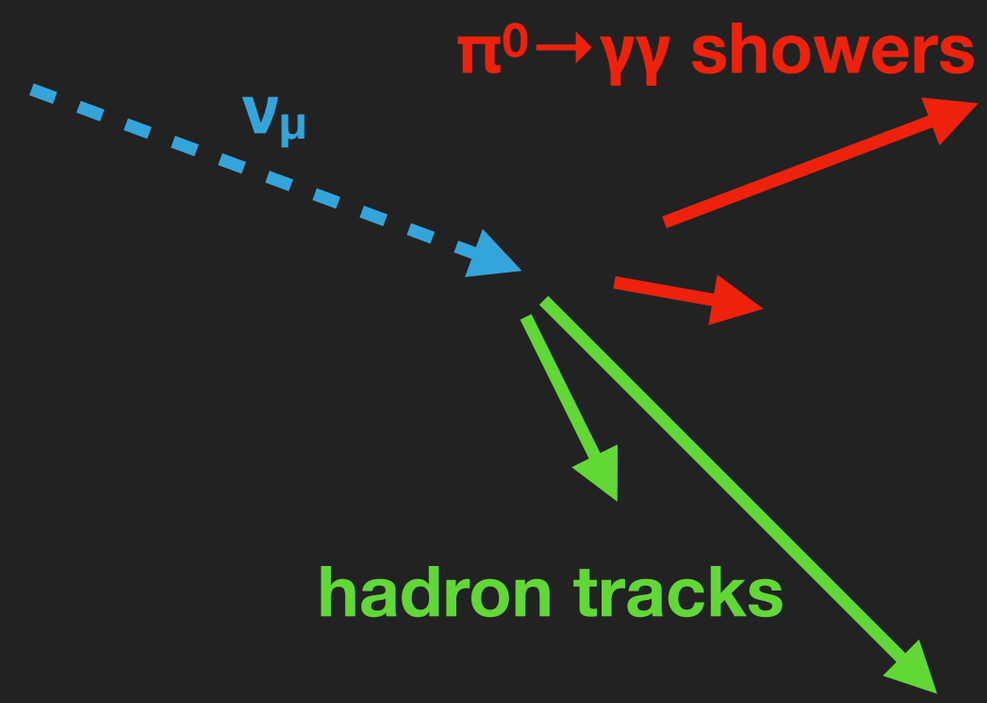


GOAL OF TRACK AND SHOWER DE/DX

Oscillation signal: CC ν_e appearance



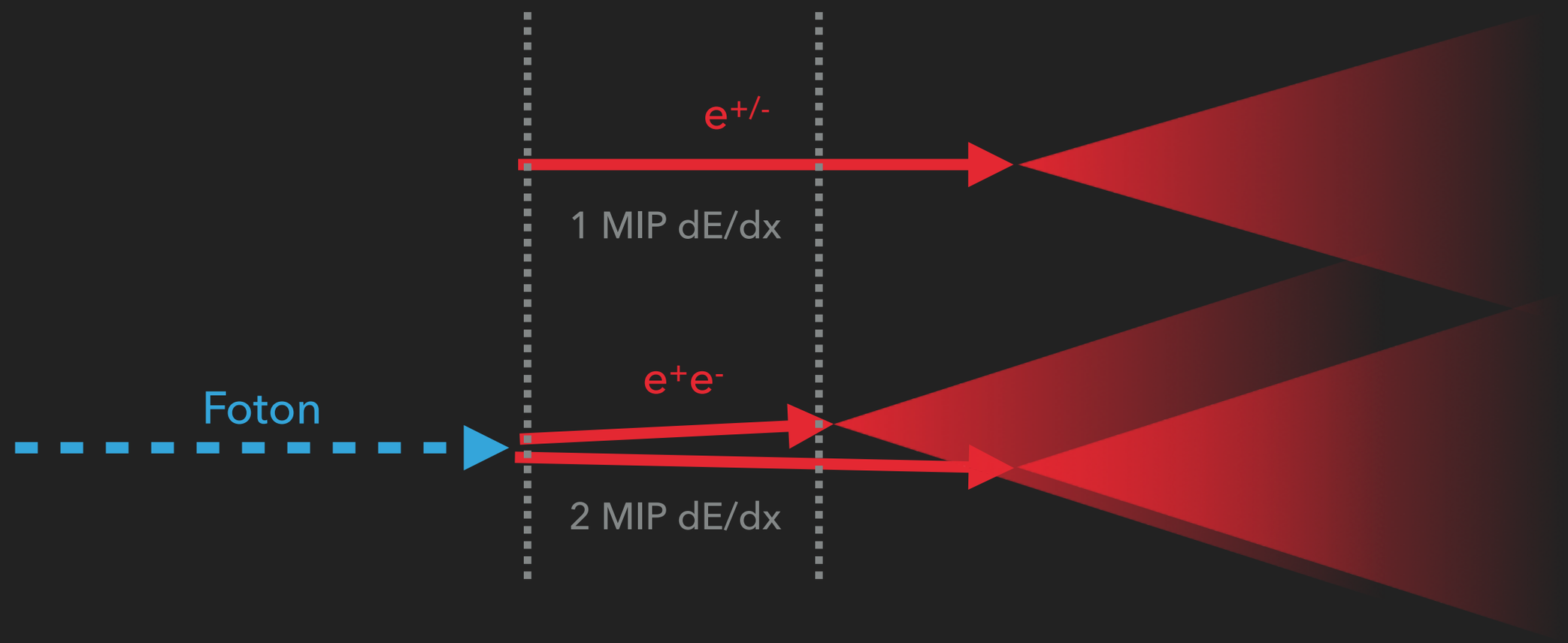
Background: NC ν_μ



- NCν forms a background to CCν_e interactions in DUNE
- Distinction between $e^{+/-}$ and γ showers useful

GOAL OF TRACK AND SHOWER DE/DX

- Focus on the start of a shower where the difference should be largest



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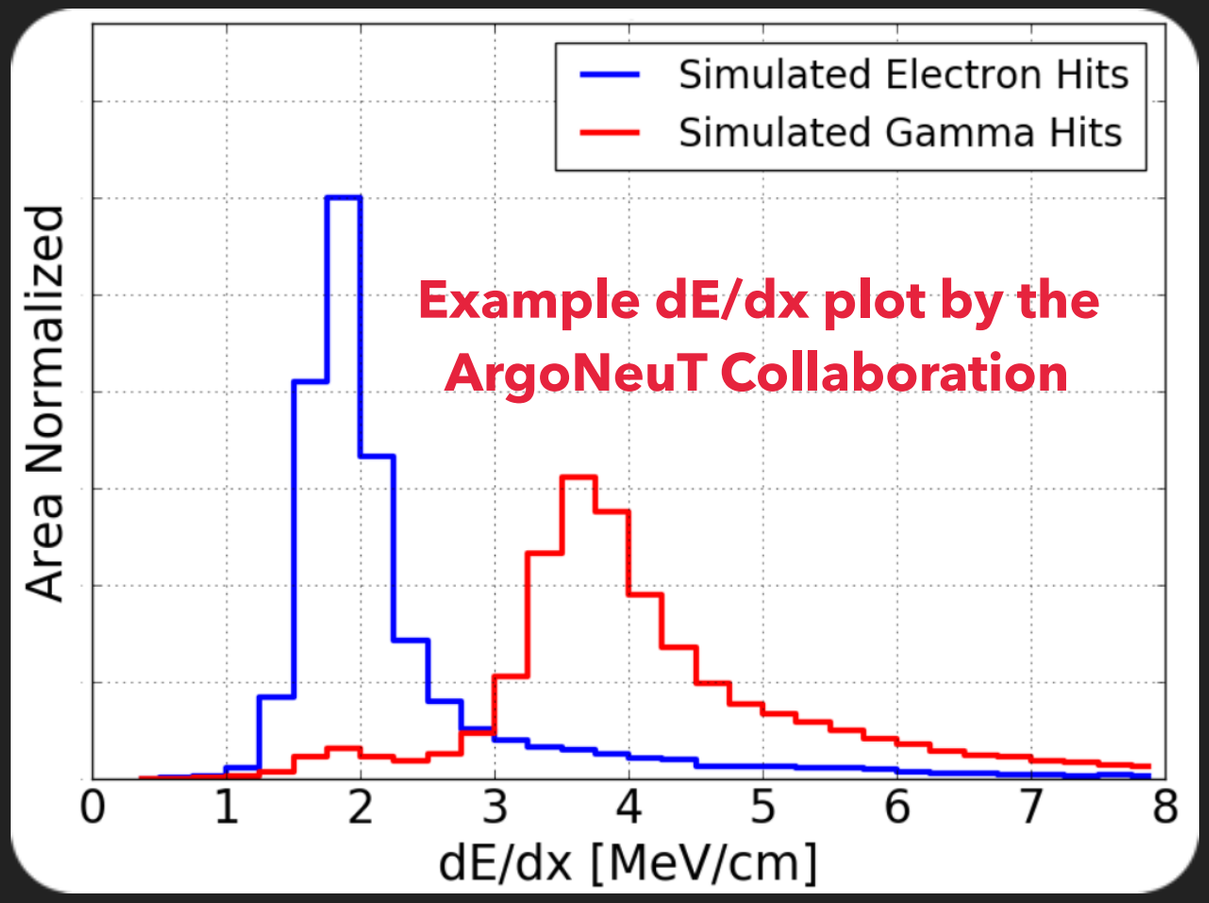

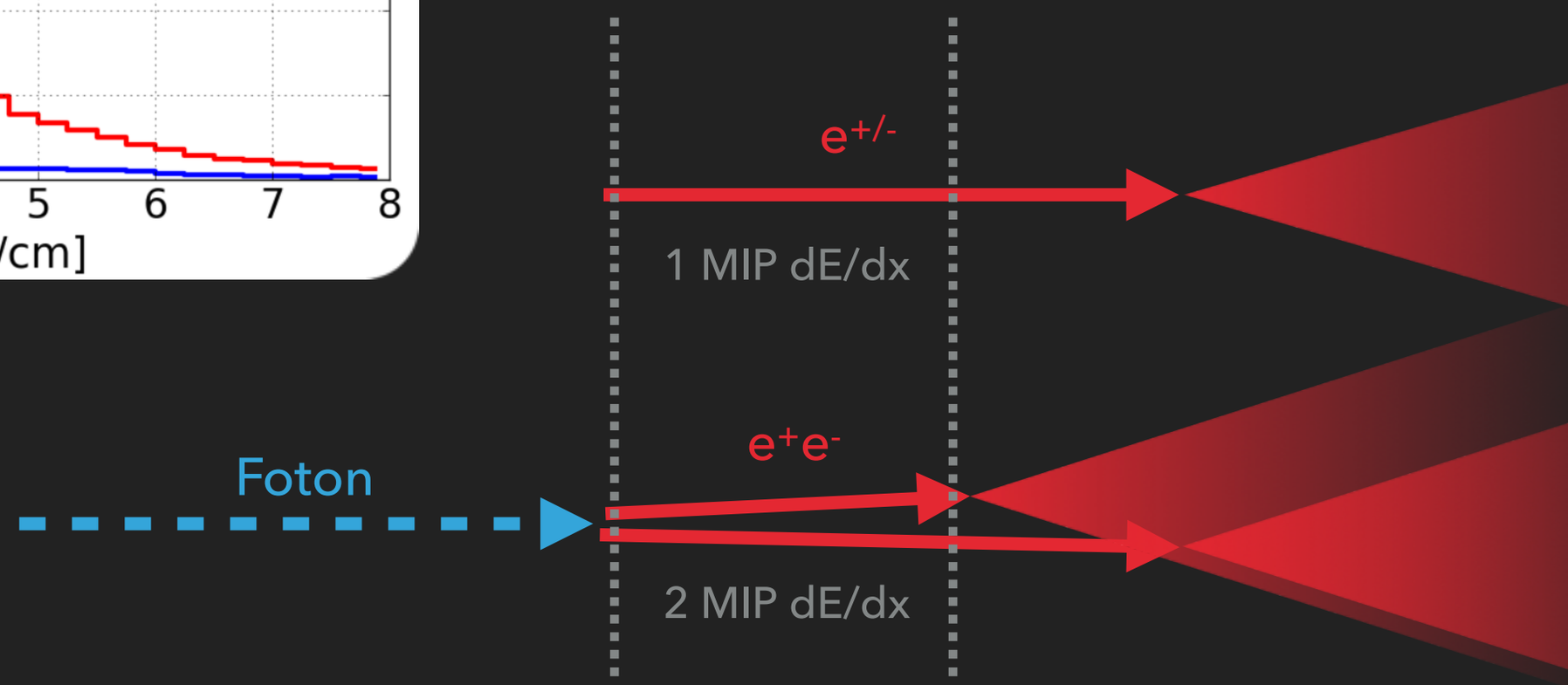

SAMPLE

- Same as sample used for π0 analysis
- ~100k MC and ~100k data events
  - MC: PDSPProd2_MC_6GeV_reco_sce_datadriven
  - Data: protodune-sp_runset_5770_reco_v08_27_XX_v0

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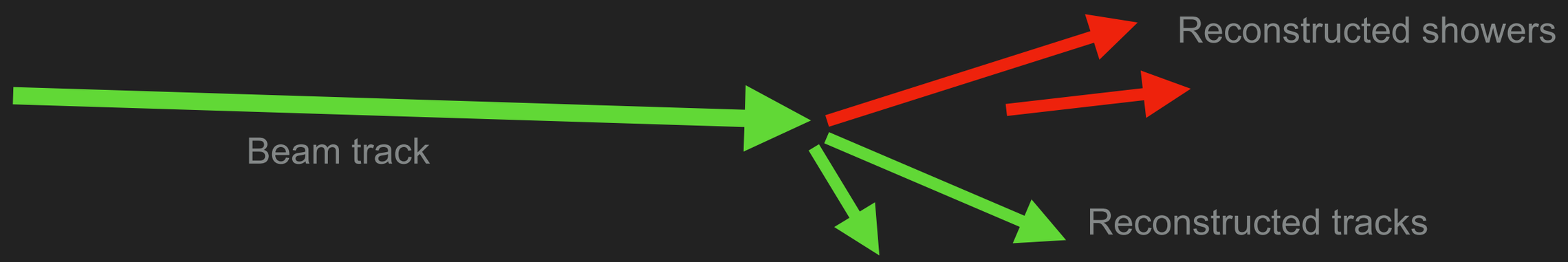
  - MC: PDSPProd2_MC_6GeV_reco_sce_datadriven
  - Data: protodune-sp_runset_5770_reco_v08_27_XX_v0
- 6 GeV/c beam particles
  - Only select events with primary track
  - Only select daughters classified as shower by Pandora



METHOD

- Apply some cuts as in π^0 selection, differences:
  - Opening angle does not improve photon purity, just helps to match photons from one π^0 to each other
  - Shower distance to vertex cut turned out to be redundant: electrons are already removed with number of hits cut

Number of shower hits	> 100
Shower CNN score	> 0.8
Opening angle	< 1
Shower distance to vertex	> 10 cm

π^0 selection cuts

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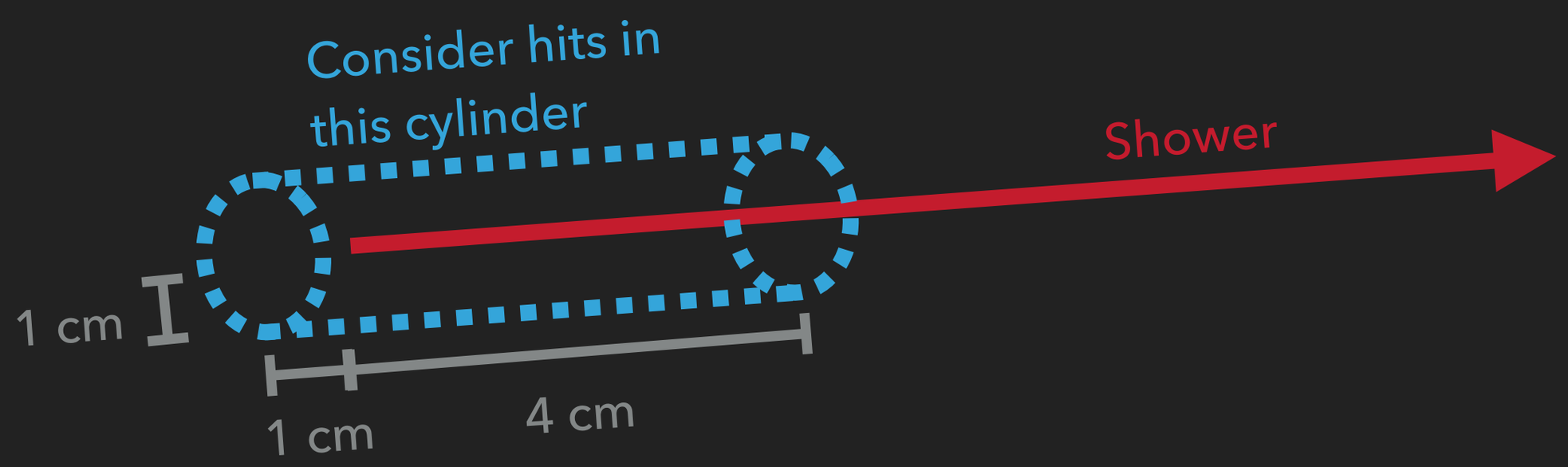
photon selection cuts

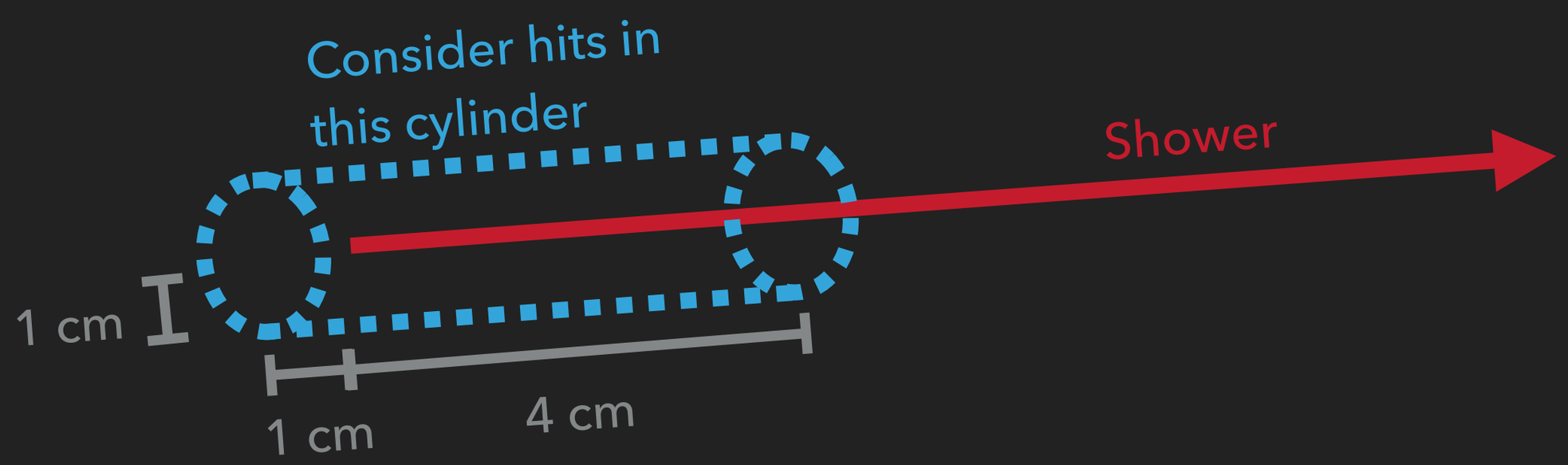
METHOD

- Consider hits in initial part of shower
- Cylinder dimensions identical to that in positron studies
  - These dimensions seem to work well: good balance between purity and statistics



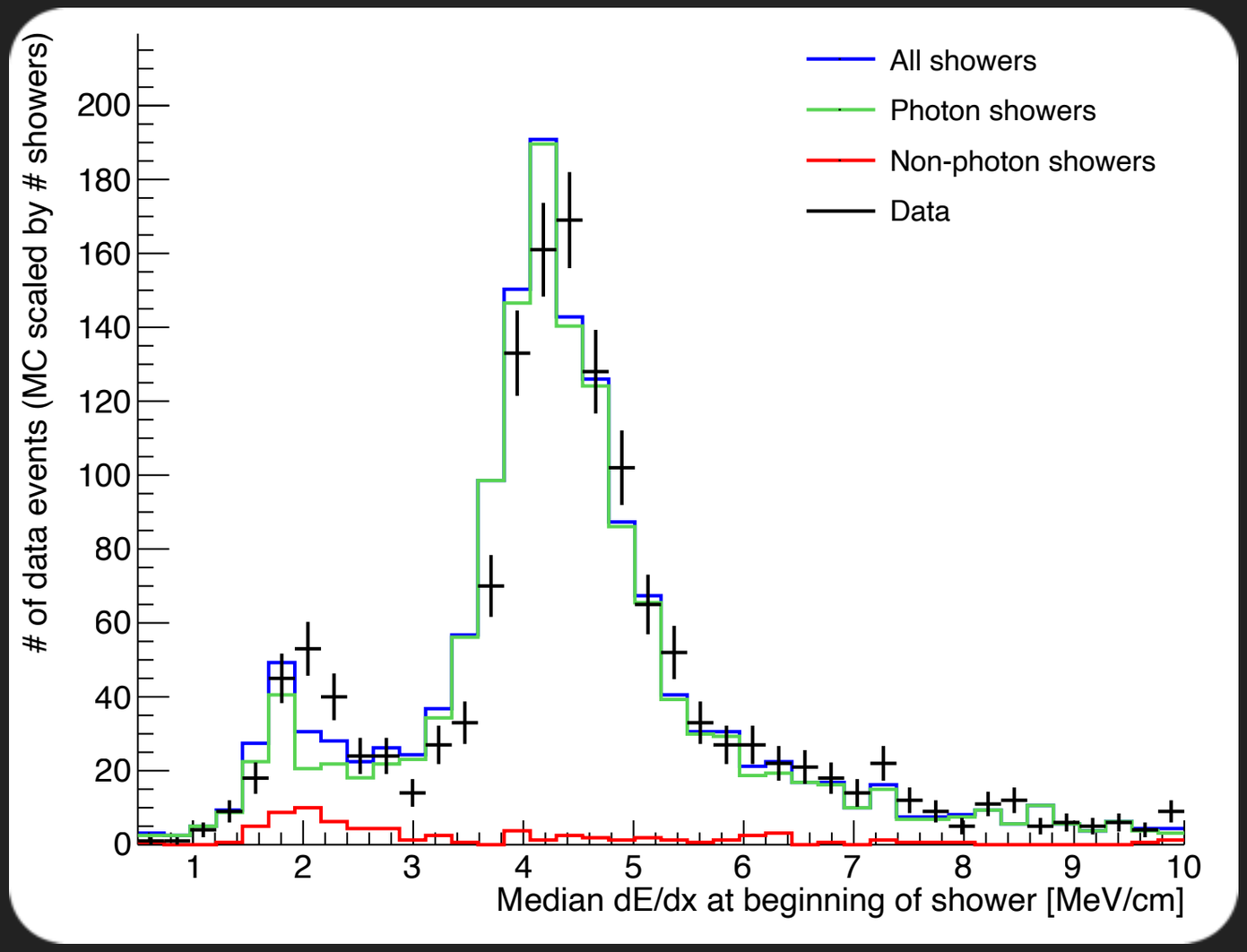
METHOD

- Determine median of all hit dE/dx in cylinder
- Require > 4 hits in cylinder
  - Assures good representation of shower start
  - Selects well-reconstructed showers



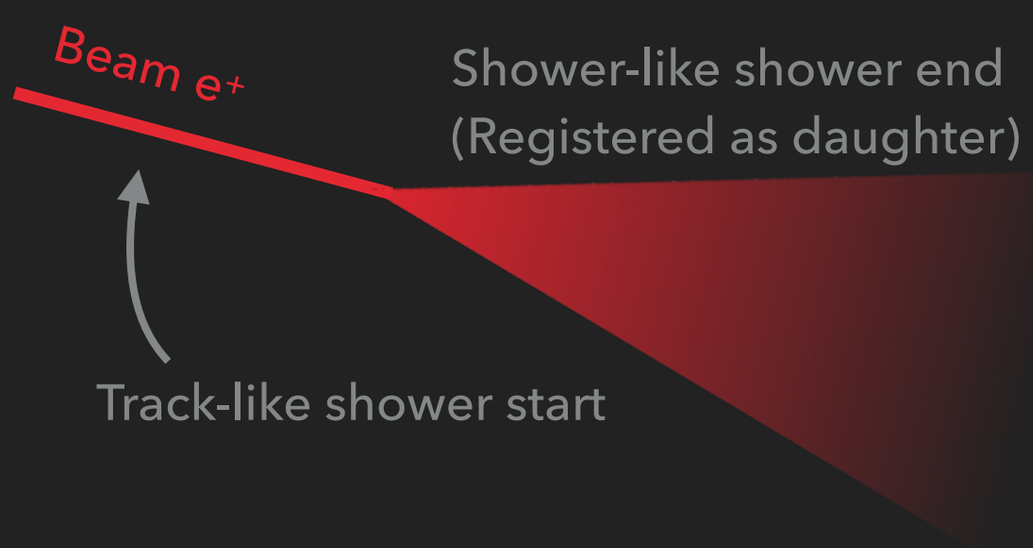
RESULTS

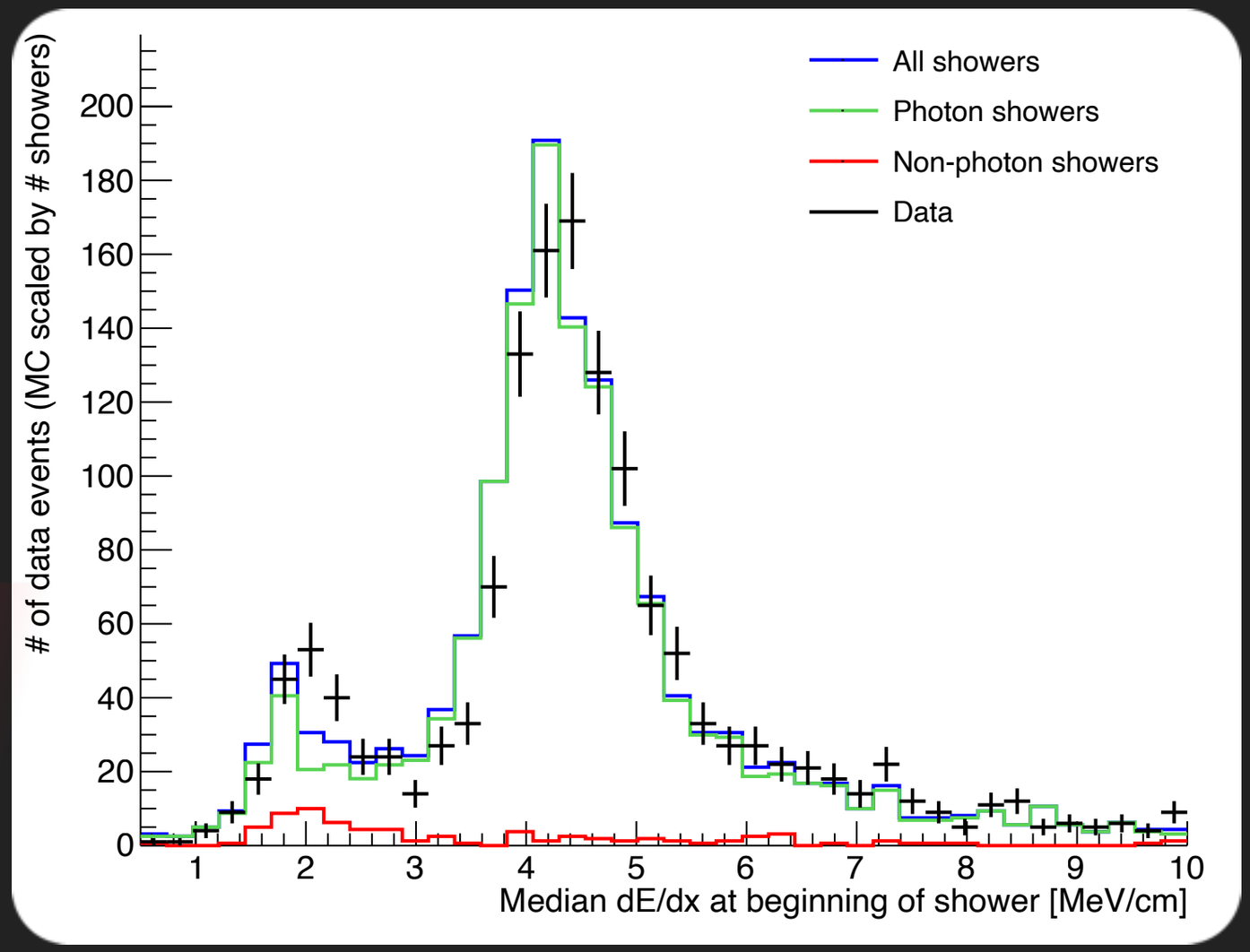
- Results look very promising



RESULTS

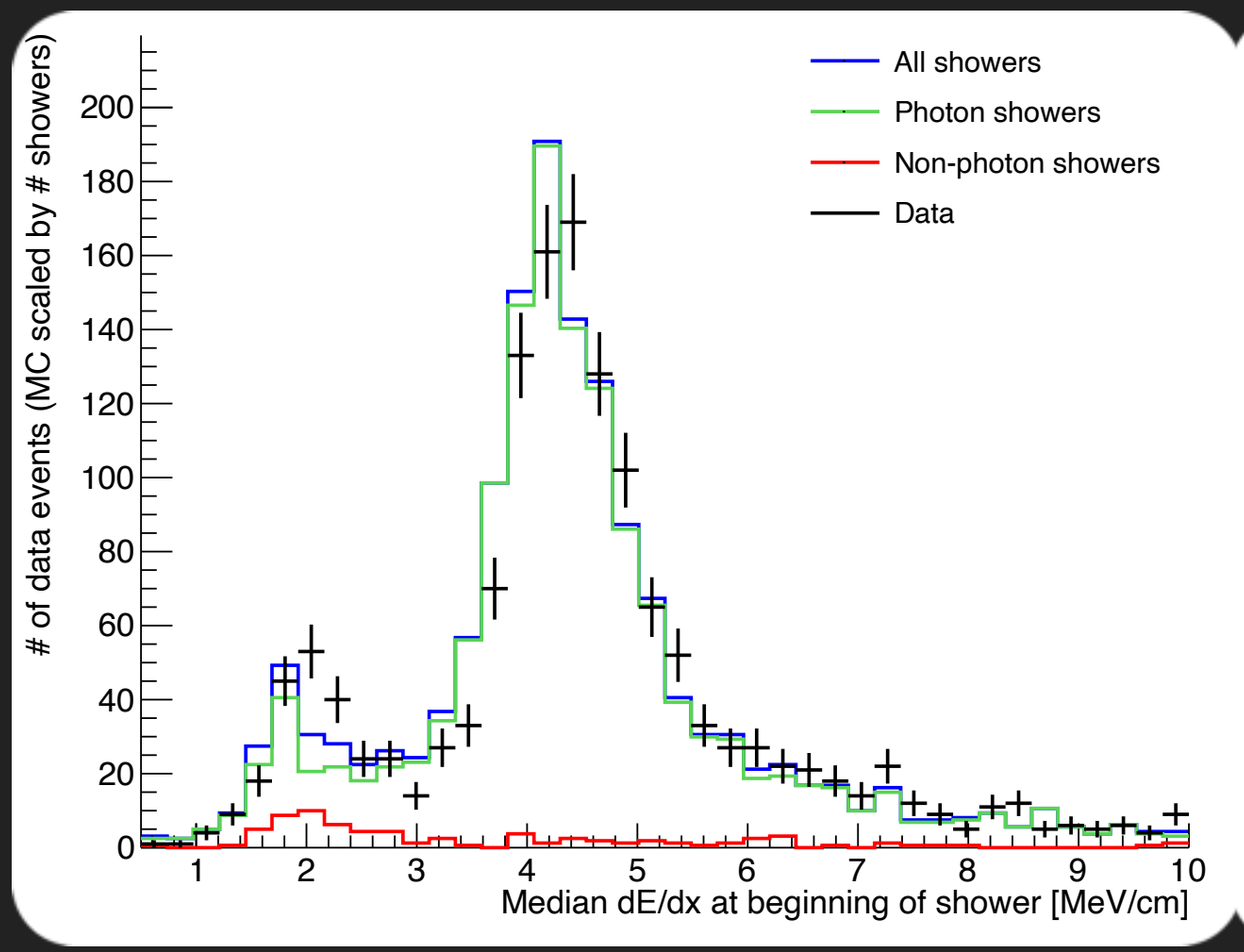
- Results look very promising
- Purity is good:
  Background mostly primary positrons

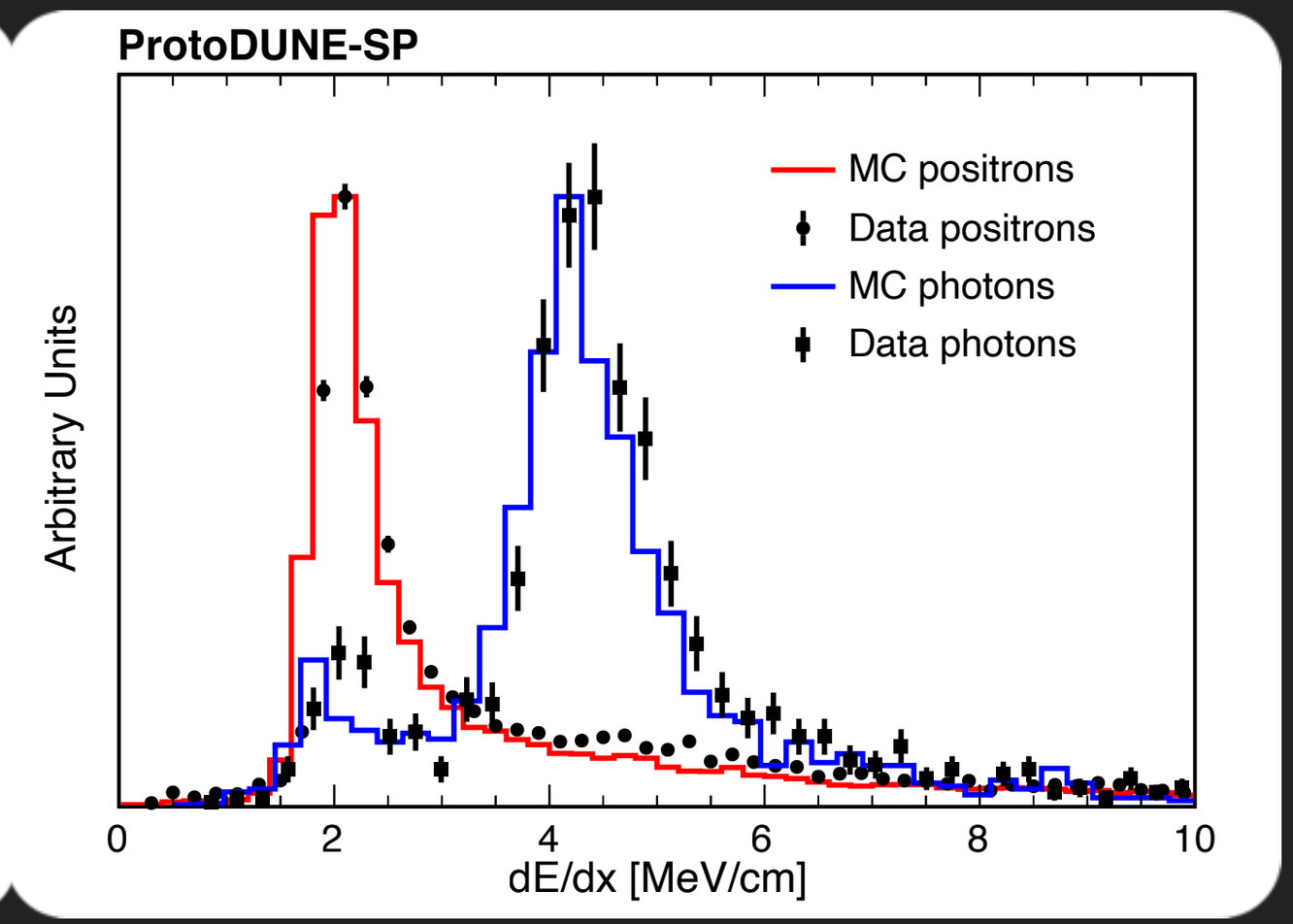




RESULTS

- Separation between photons and positrons is very apparent

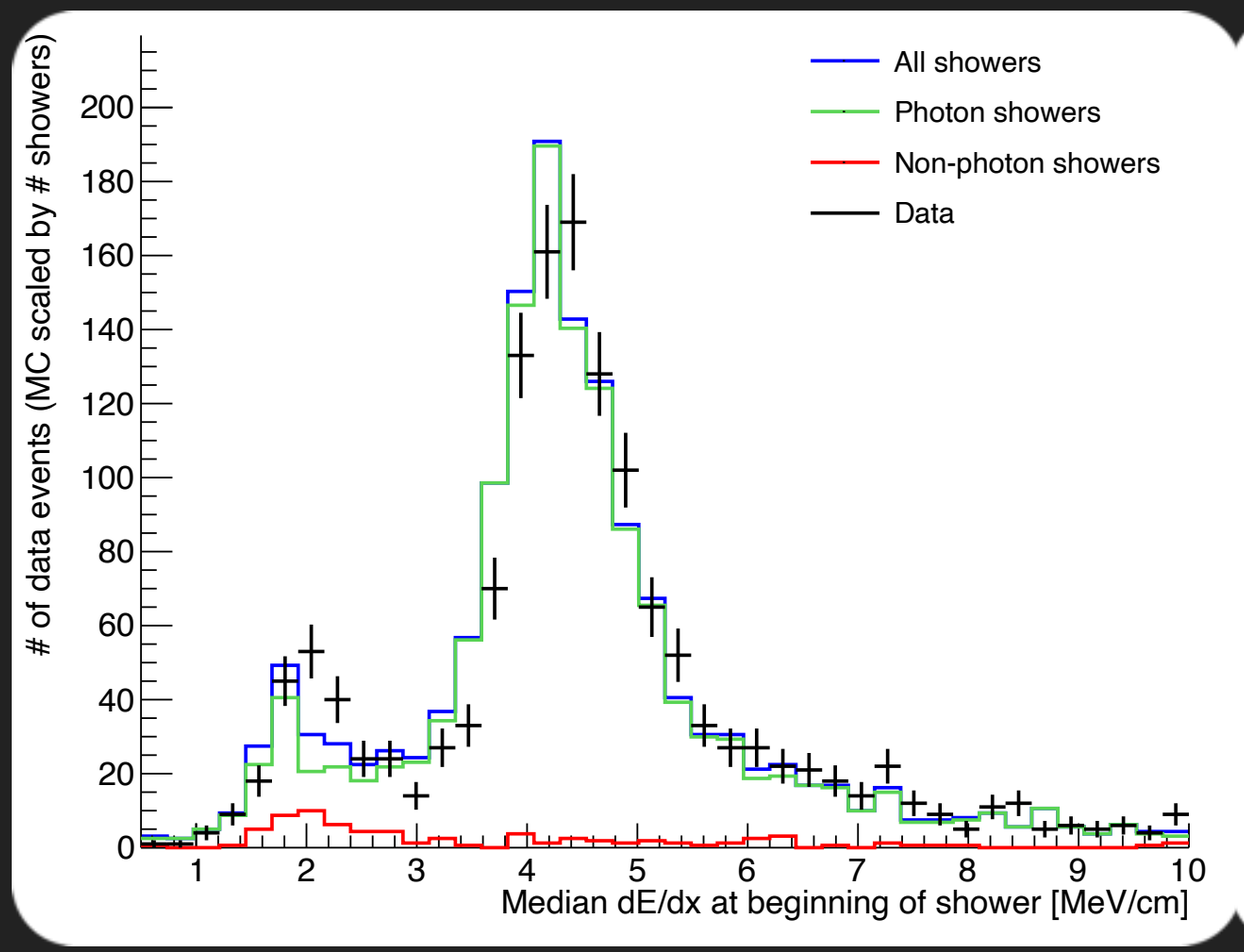


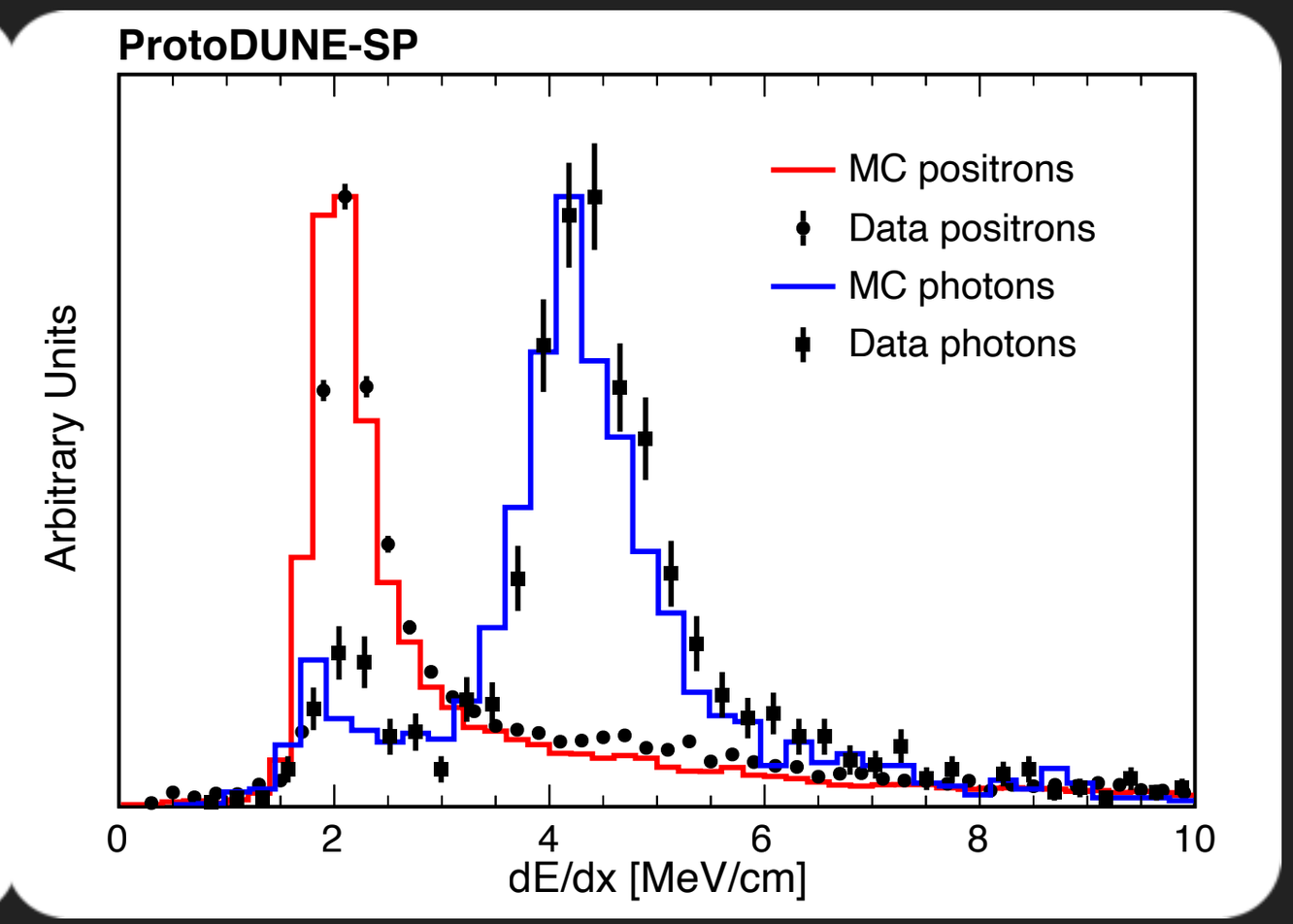


Comparison by Aaron

DISCUSSION

- MC and data do not match up exactly
- Due to calorimetry constants?





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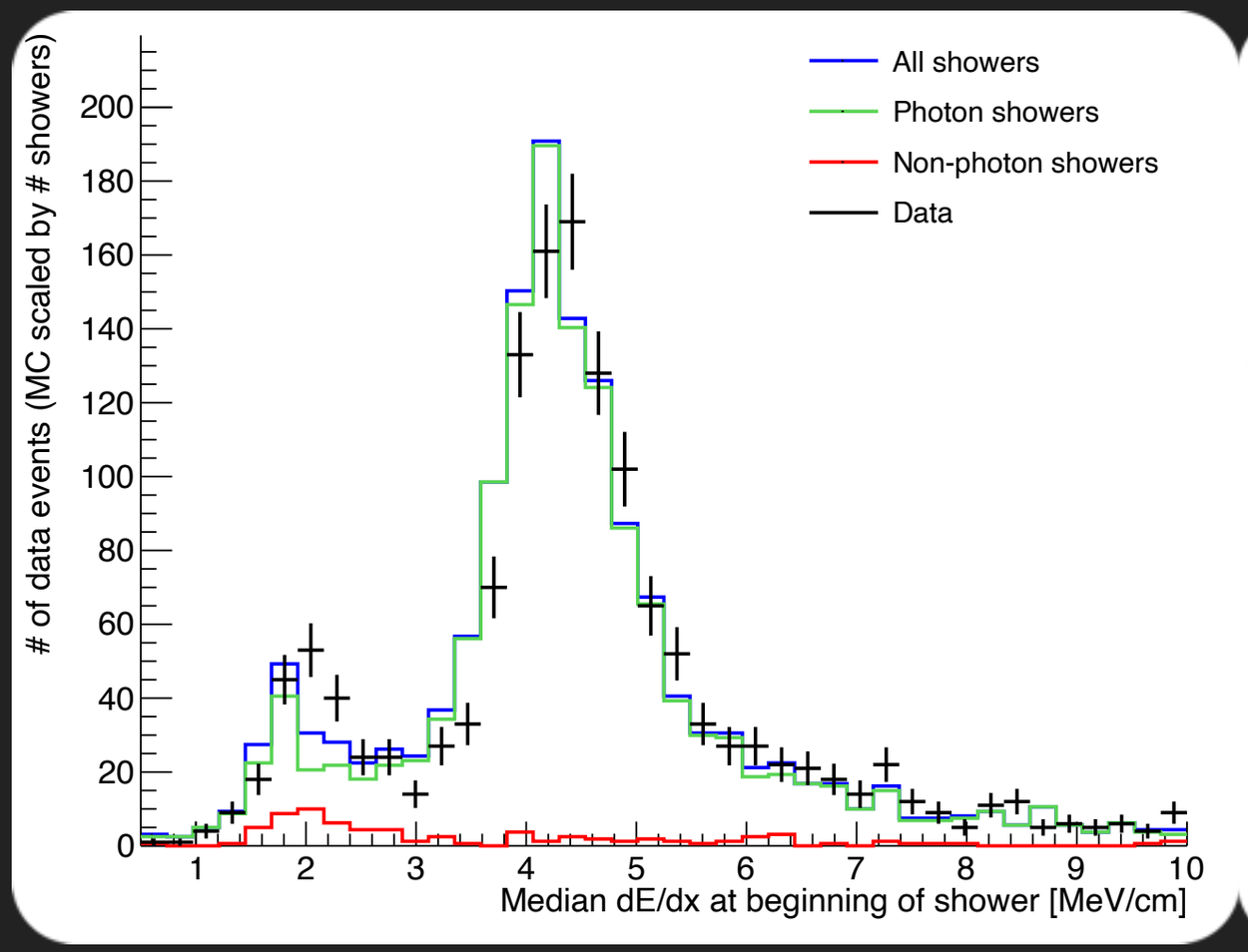
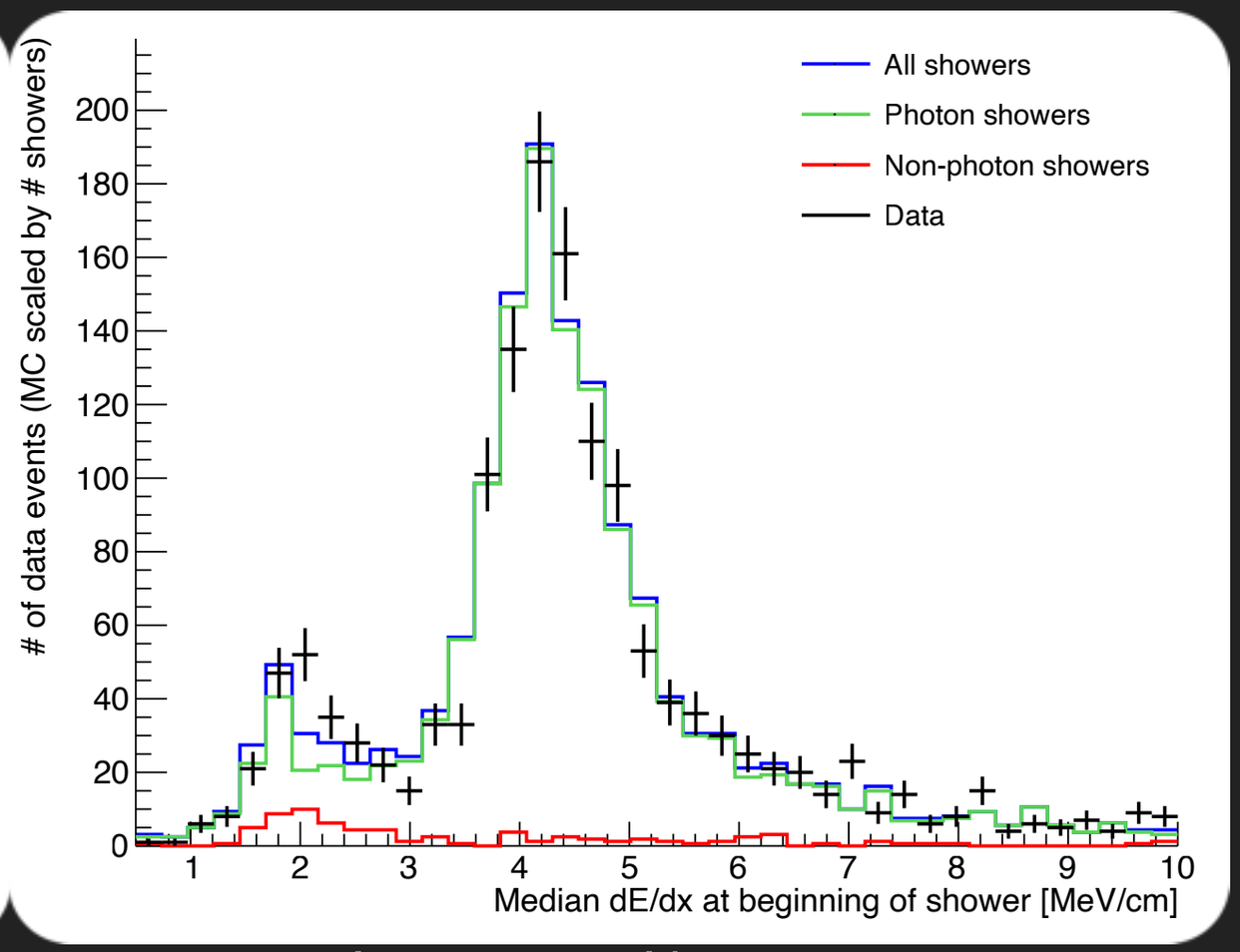




Normalisation or calibration constant of data changed by ~1.5%

FUTURE WORK

- Reduce background by cutting on primary track CNN score
- Look at other beam momenta
  - Compare to 6 GeV/c sample, possibly combine
- Investigate peak around 2 MeV/cm

SUMMARY

- Determined the photon shower dE/dx in a method analogous to previous positron results by Aaron
- Good separation between photons and positrons
- Mismatch data and MC possibly solved with slightly modified calorimetry constants?

BACKUP

WHAT IS DE/DX?

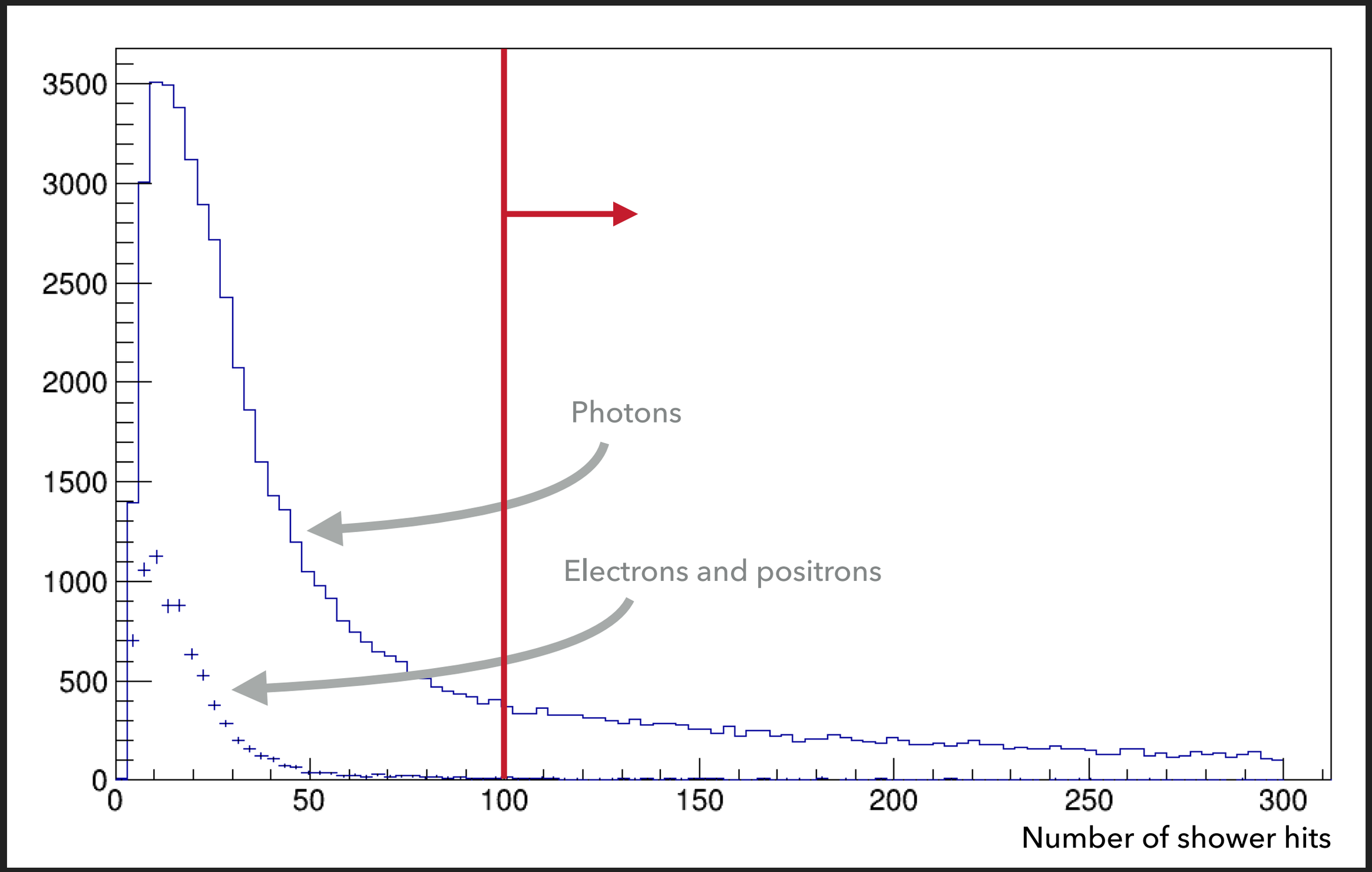
- dQ/dx → dE/dx:
  - Normalisation factor: Convert charge on collection plane to charge in detector
  - Space charge effects: build-up of ions in detector changes electron transport
  - Calibration factor: Convert ADC/cm to MeV/cm

WHAT IS DE/DX?

- dQ/dx → dE/dx:
  - According to modified box model
  - $\frac{dQ}{dx} = \frac{Q_{hit}}{\text{pitch}/\cos\theta}$ norm $\sigma(\vec{x})$ / calib
  - $\frac{dE}{dx} = \left(\exp\left[\frac{dQ}{dx}\frac{\beta_P}{\rho E_f(\vec{x})}W_{ion}\right] - \alpha\right)\frac{\rho E_f(\vec{x})}{\beta_P}$

DUNE docDB by Ajib Paudel 15974

NUMBER OF HITS CUT



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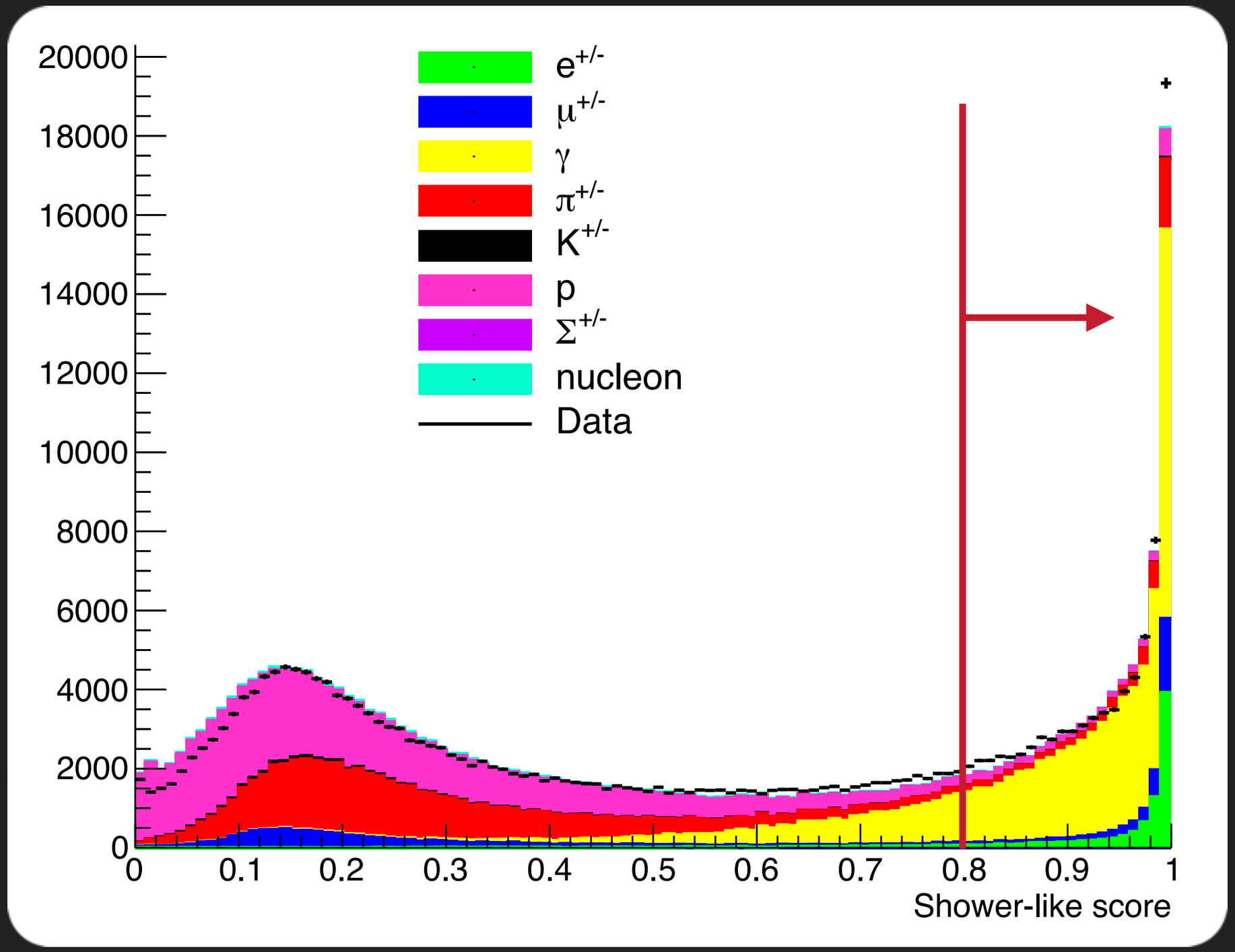

NORMALISATION: NUMBER OF HITS IN DE/DX CYLINDER