# Time over Threshold (TOT) Studies

Xin Chen, Eduardo do Couto e Silva

Analysis Meeting

November 3, 2003

# Outline

- Monte Carlo study of TOT distributions for various types of particles in a FULL TOWER
  - TOT could be used to distinguish between $\gamma$ and backgrounds statistically
- Study of EM data (MINI TOWER)

# Why is the TOT useful?

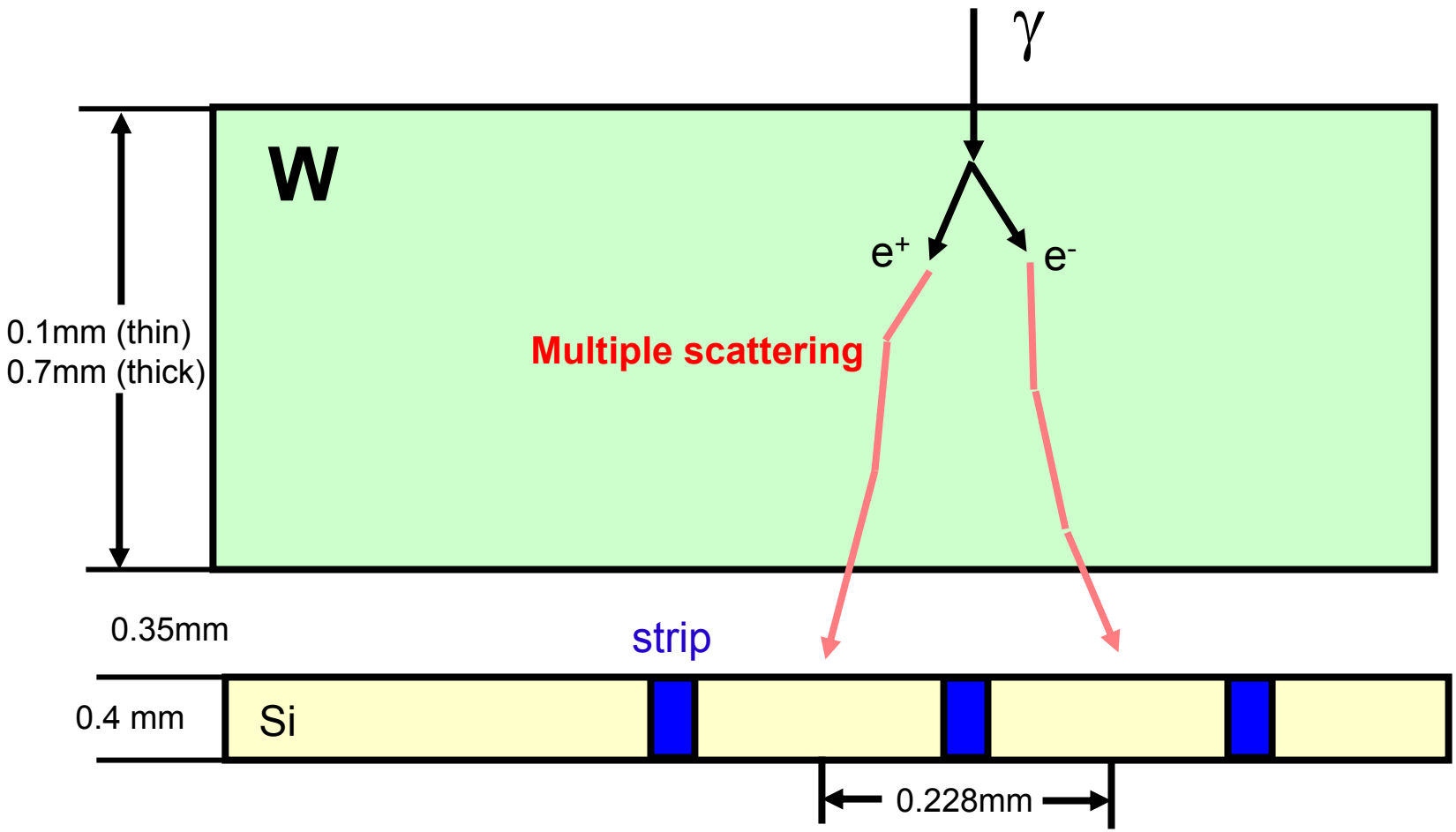
$$TOT \sim E_{strip} \sim 1\ MIP$$

$$\gamma \rightarrow e^+ e^- \sim 2\ MIPs$$

( if both particles fall onto the same strip)

$$TOT_{\gamma} \sim 2\ TOT_{\mu,\ e^-,e^+}$$

# Is it possible for two particles to go into the same strip?



# Can 2 particles hit the same strip?

- **Assumptions:**
  - Photon converts at the top of the W layer
  - Opening angle is sum of angle between pair conversion products given by the MC truth and the calculated multiple scattering from PDG

| Energy | Thin W | | | Thick W | | |
|---|---|---|---|---|---|---|
| | Opening angle | | Track separation at SSD below converter | Opening angle | | Track separation at SSD below converter |
| (MeV) | (rad) | (deg) | (mm) | (rad) | (deg) | (mm) |
| 17.6 | 0.540 | 30.94 | 0.25 | 0.920 | 52.71 | 1.05 |
| 100.0 | 0.112 | 6.42 | 0.05 | 0.180 | 10.31 | 0.19 |
| 500.0 | 0.022 | 1.26 | 0.012 | 0.040 | 2.29 | 0.02 |

Si strip pitch = 0.23 mm

# Method

- It is possible that e+/e- produced by the $\gamma$ go into a single strip, especially at relatively high energy

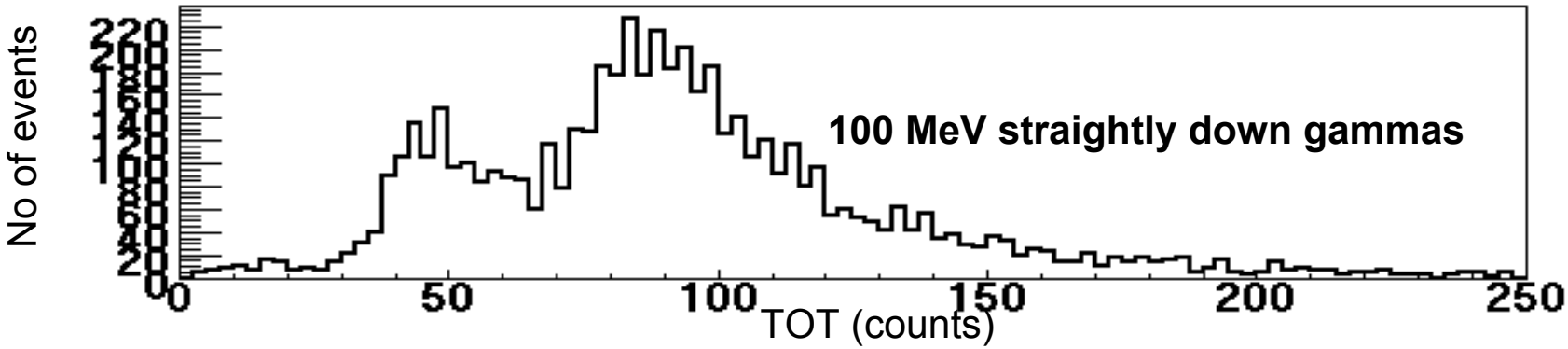
- How to use the TOT to distinguish statistically between $\gamma$ signal and background?
  1. Determine conversion position
     - With reconstruction
       - Use recon to find vertex
       - Correct TOT for path length dependence
     - Without reconstruction
       - Simply deem the first hit layer from the top as the layer where $\gamma$ converts
  2. Use maximal TOT value obtained from the XY bilayer below the conversion point

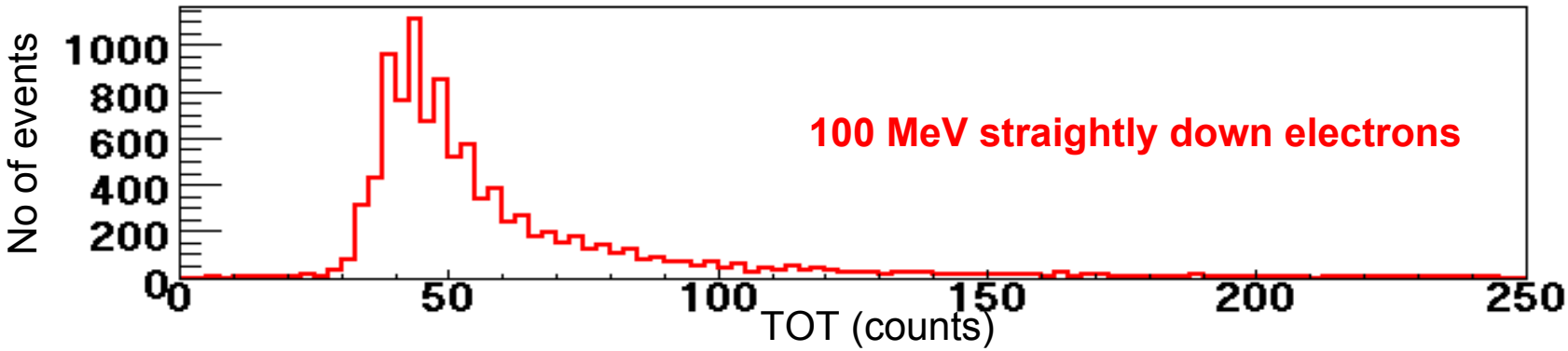
# TOT distributions

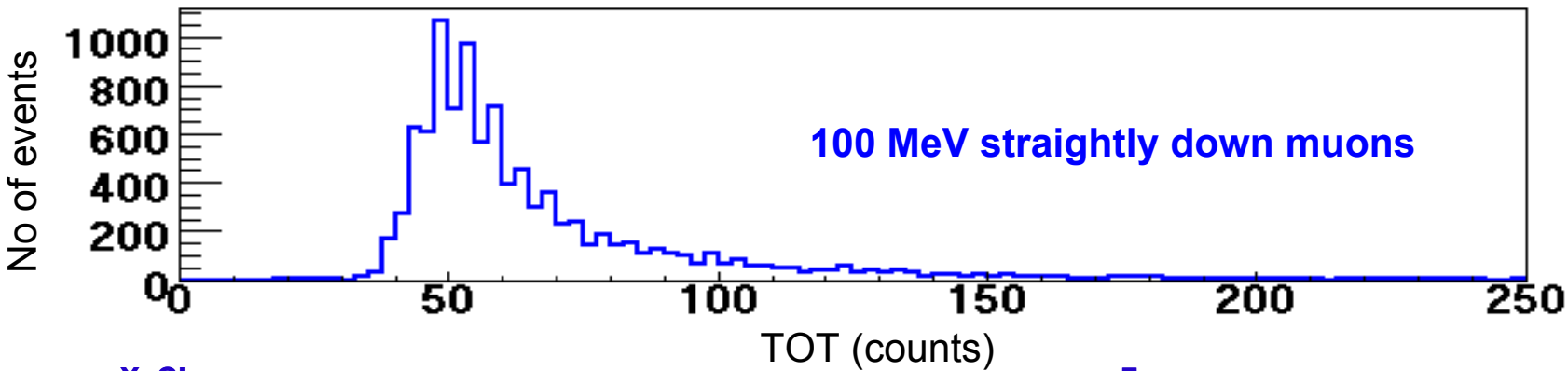


**Conversion layer is determined by the reconstruction**

**FULL TOWER Monte Carlo Simulation**



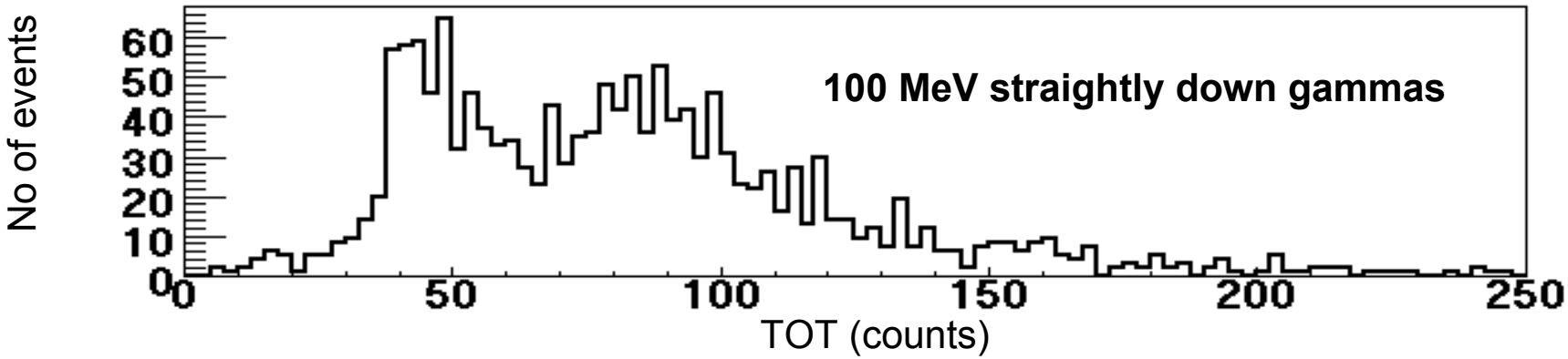



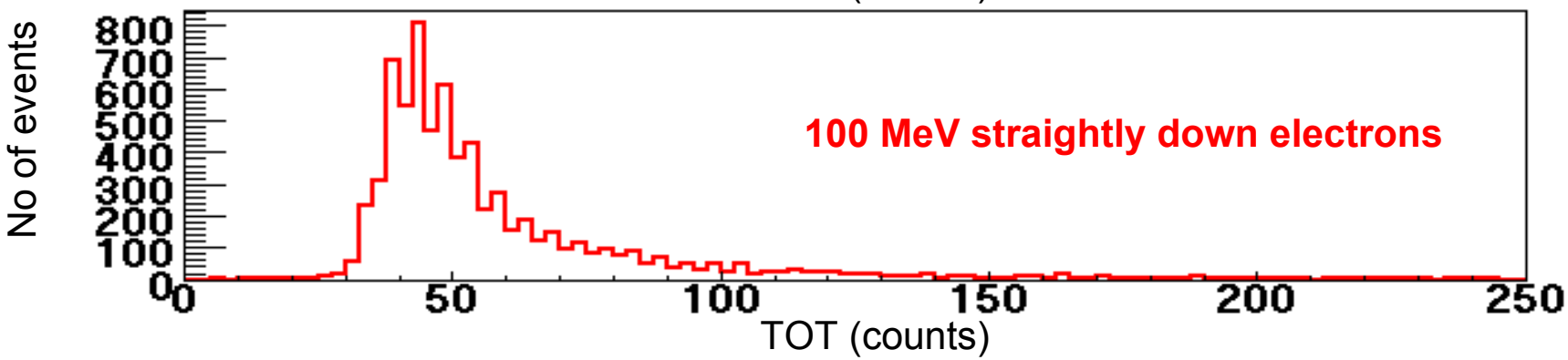



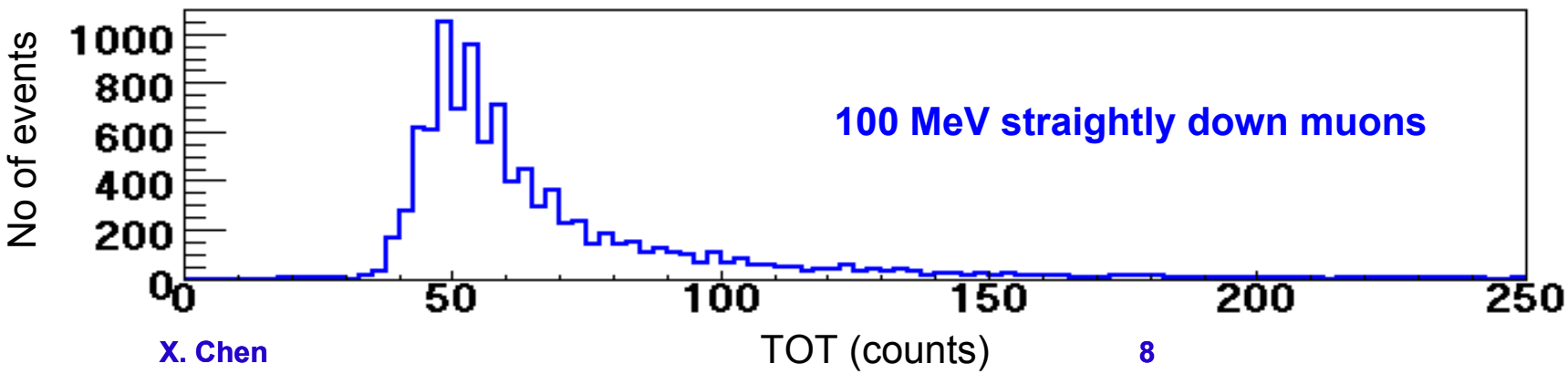
# TOT distributions, 1 track only

**Conversion layer is determined by the reconstruction**

**FULL TOWER Monte Carlo Simulation**



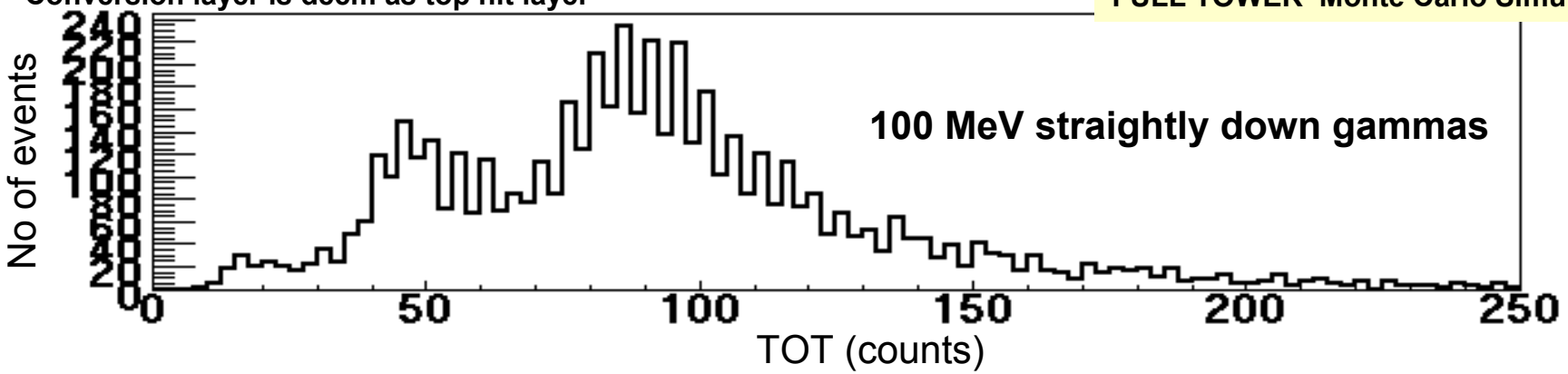



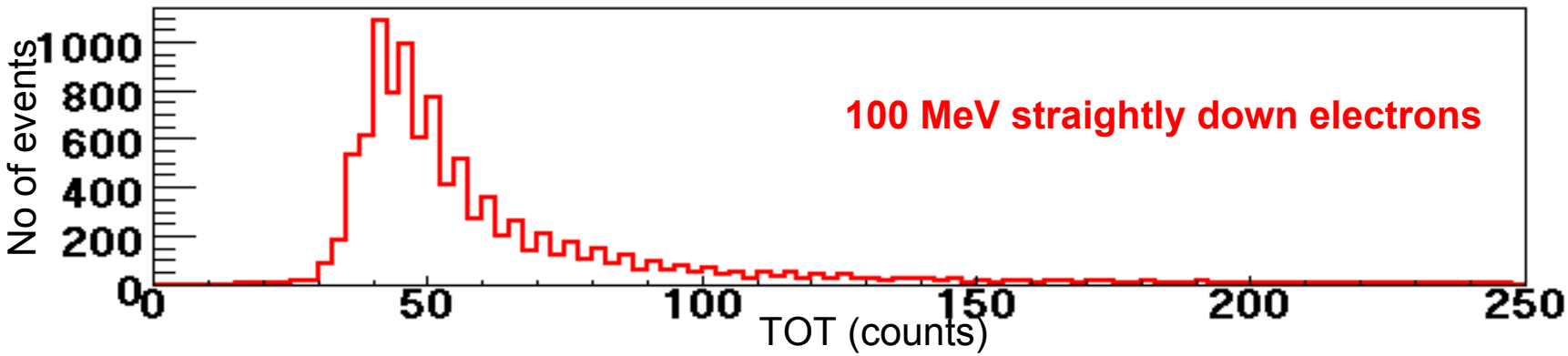



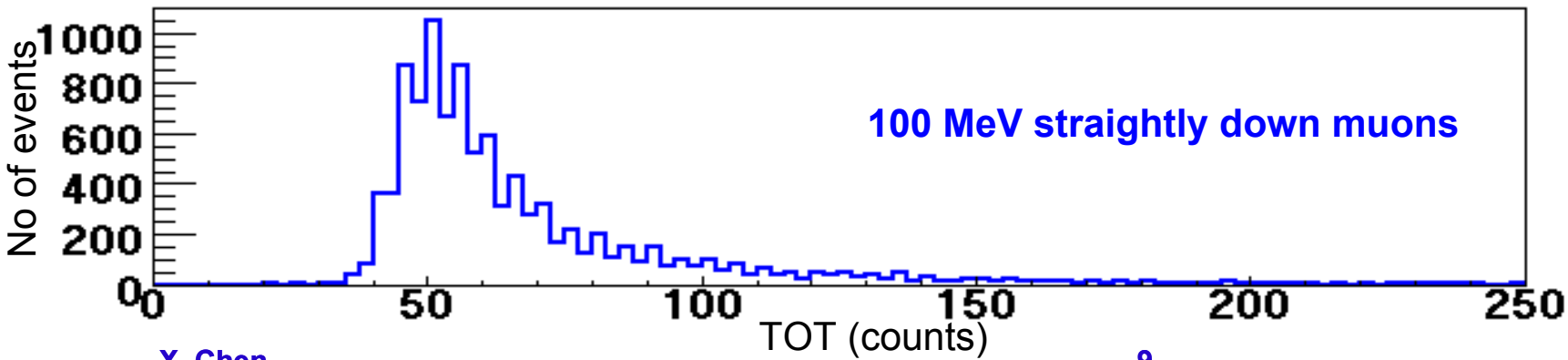
# TOT distributions, recon NOT used

Conversion layer is deem as top hit layer

FULL TOWER Monte Carlo Simulation



# Monte Carlo Runs

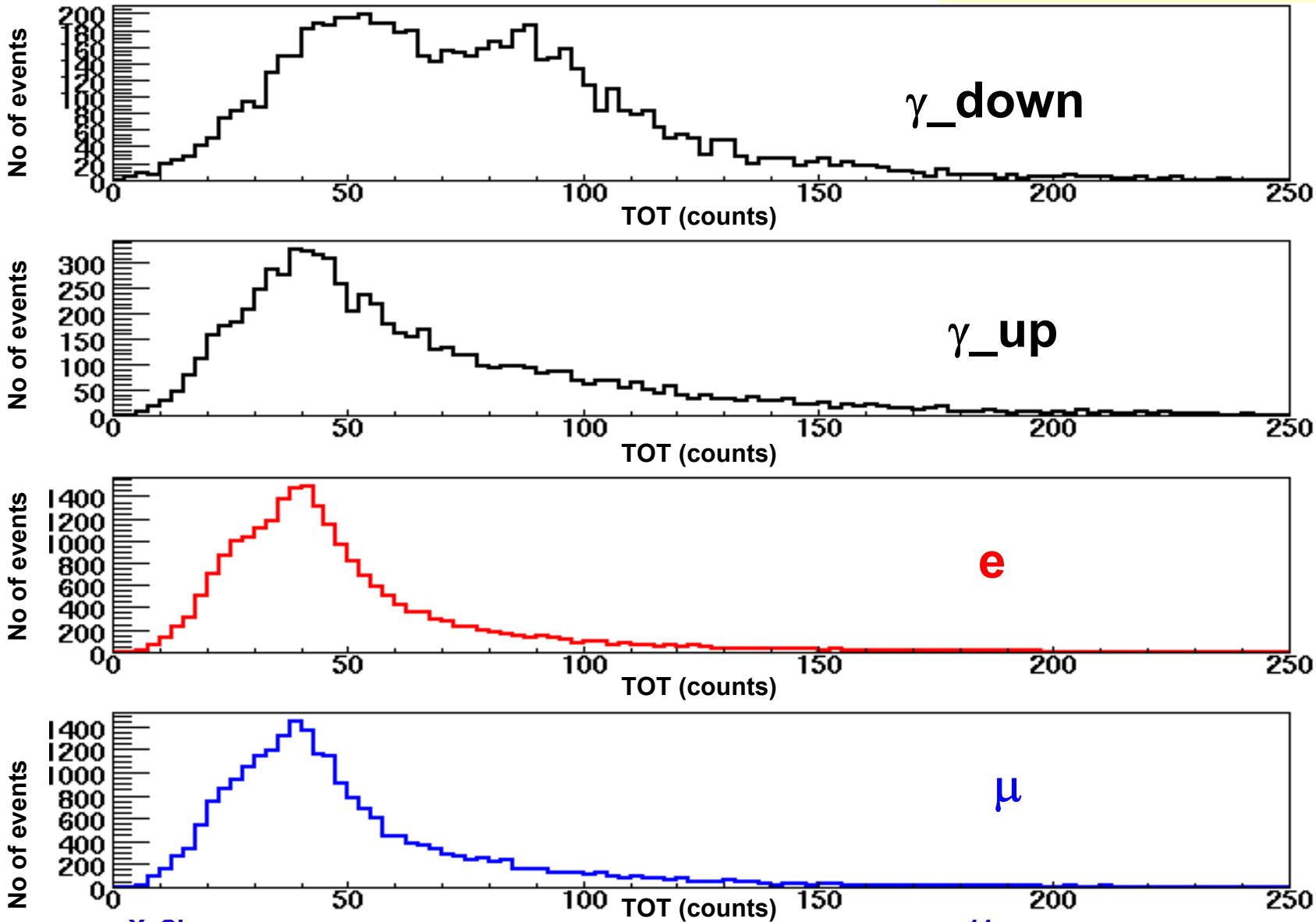
- **Assumptions:**
  - **Particle spectrum simulated as 1/E**
  - **One full tower only**

| Source Particle | Flux direction | E min (GeV) | E min (GeV) |
|---|---|---|---|
| | | | |
| $\gamma$ | all directions from upper hemisphere | 0.018 | 18 |
| $\gamma$ | all directions from lower hemisphere | 0.018 | 18 |
| e- | all directions from 4 pi | 0.018 | 18 |
| $\mu$ | all directions from 4 pi | 0.018 | 18 |

# TOT distributions

Conversion layer is determined by the reconstruction

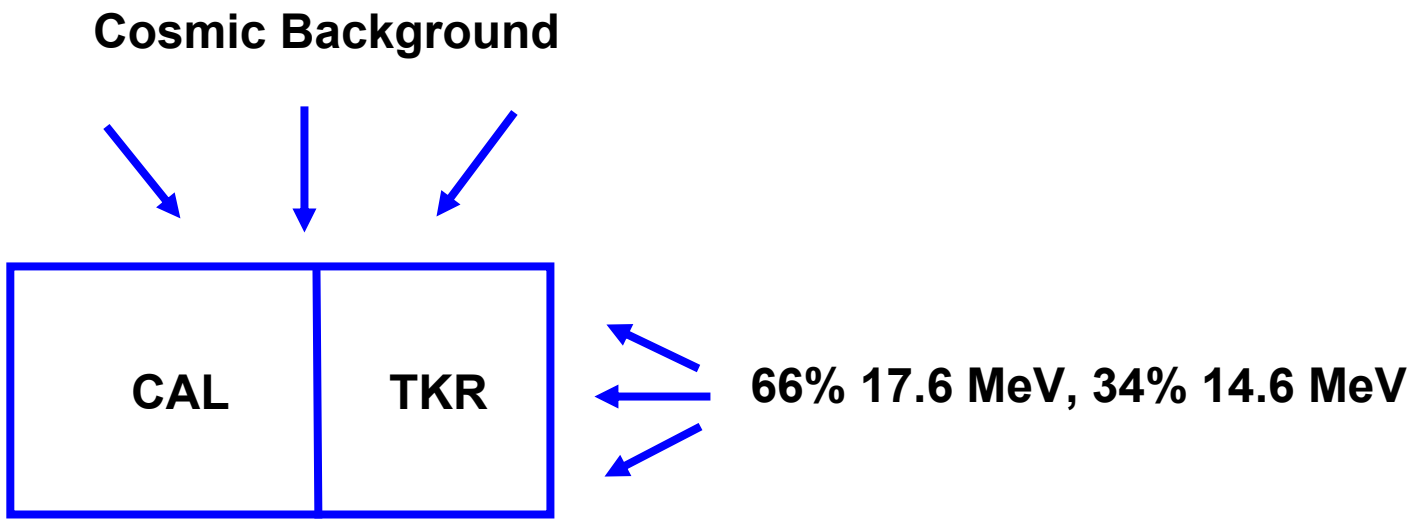
FULL TOWER Monte Carlo Simulation



# Summary of MC study

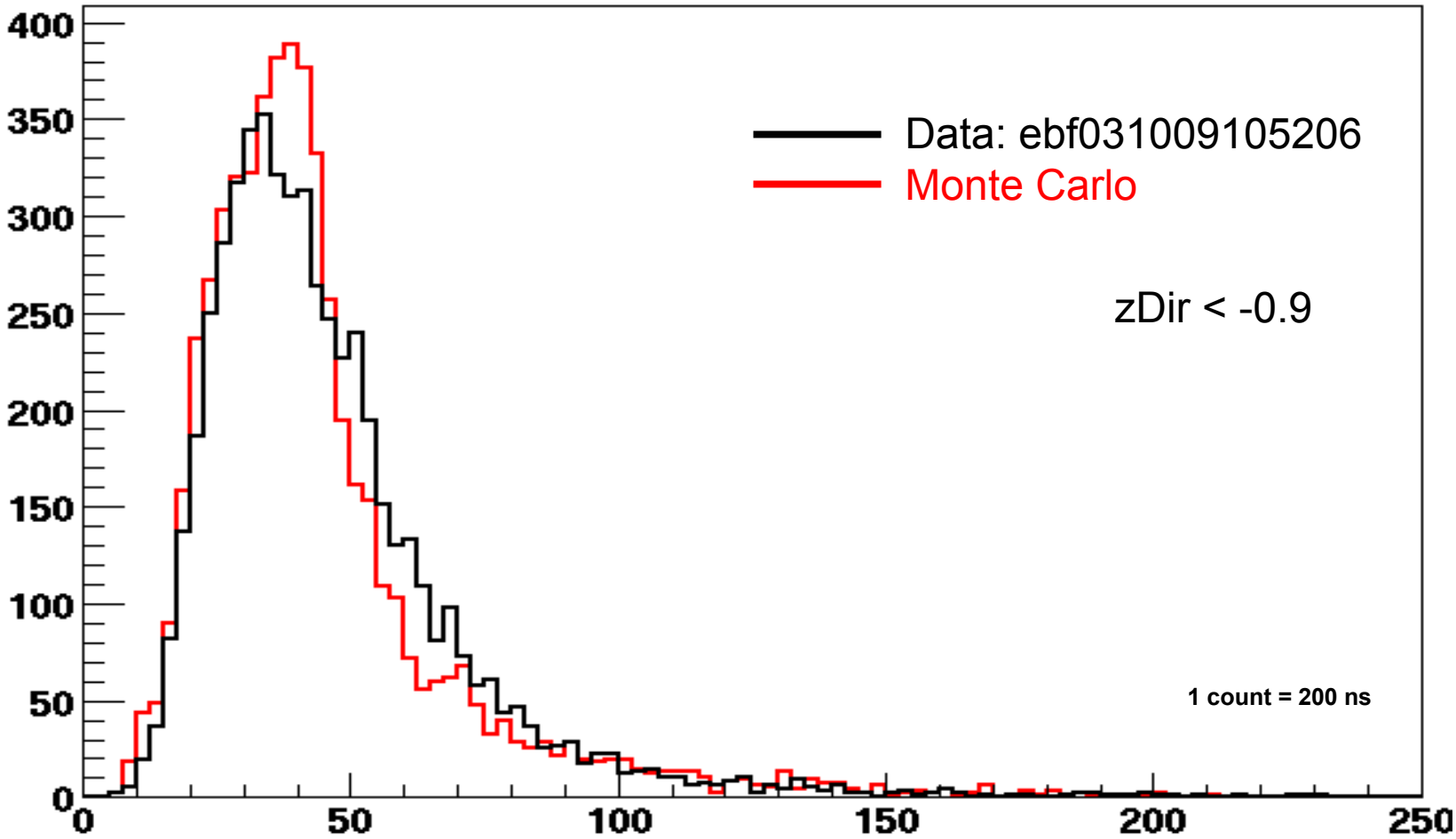
- Preliminary MC studies indicate that the TOT distributions can be used to distinguish statistically between $\gamma$ signal and background, especially at relatively high energy

# VDG on the EM



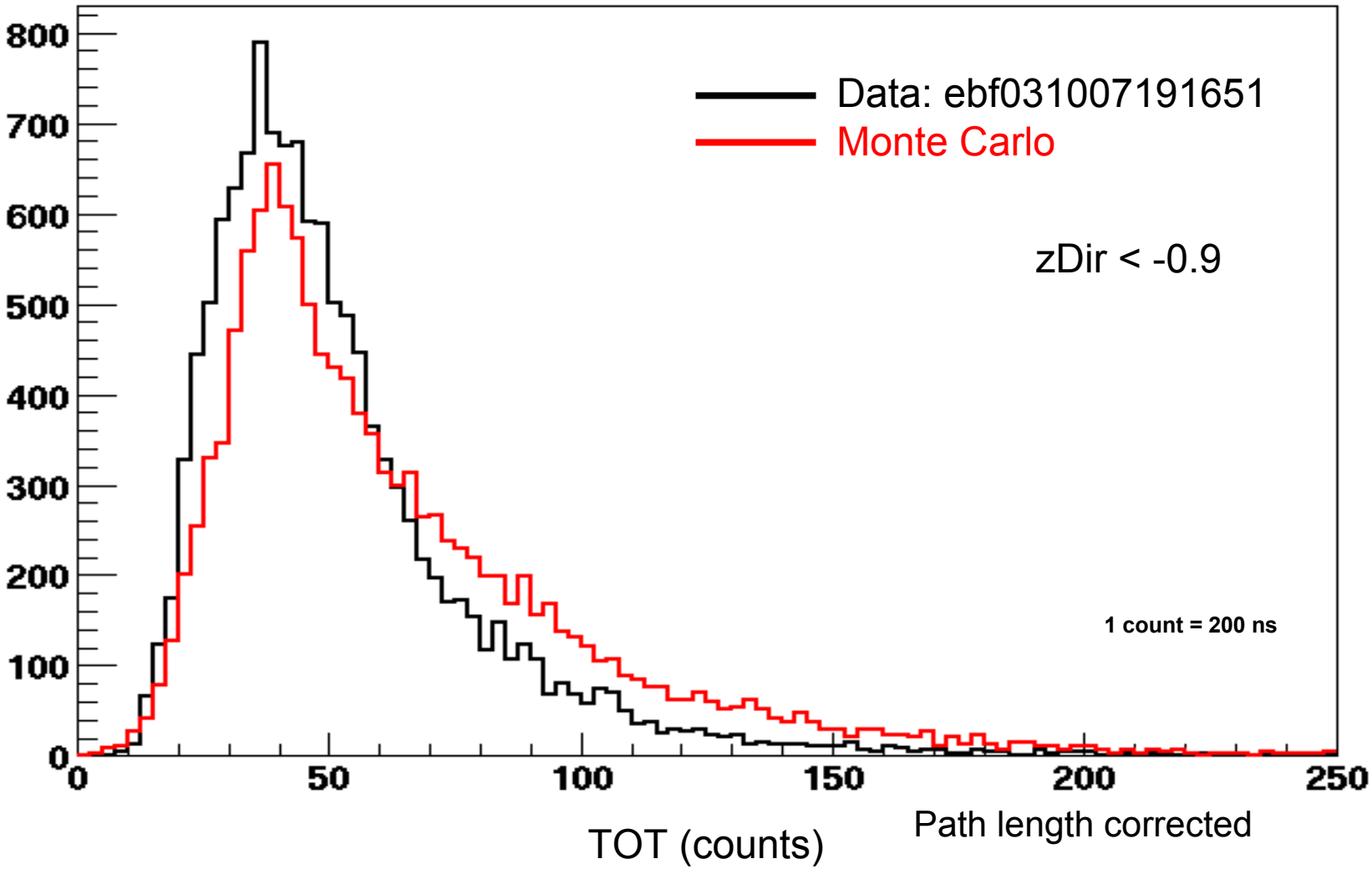
# TOT distributions , cosmic rays

Reasonably good agreement between DATA and MC



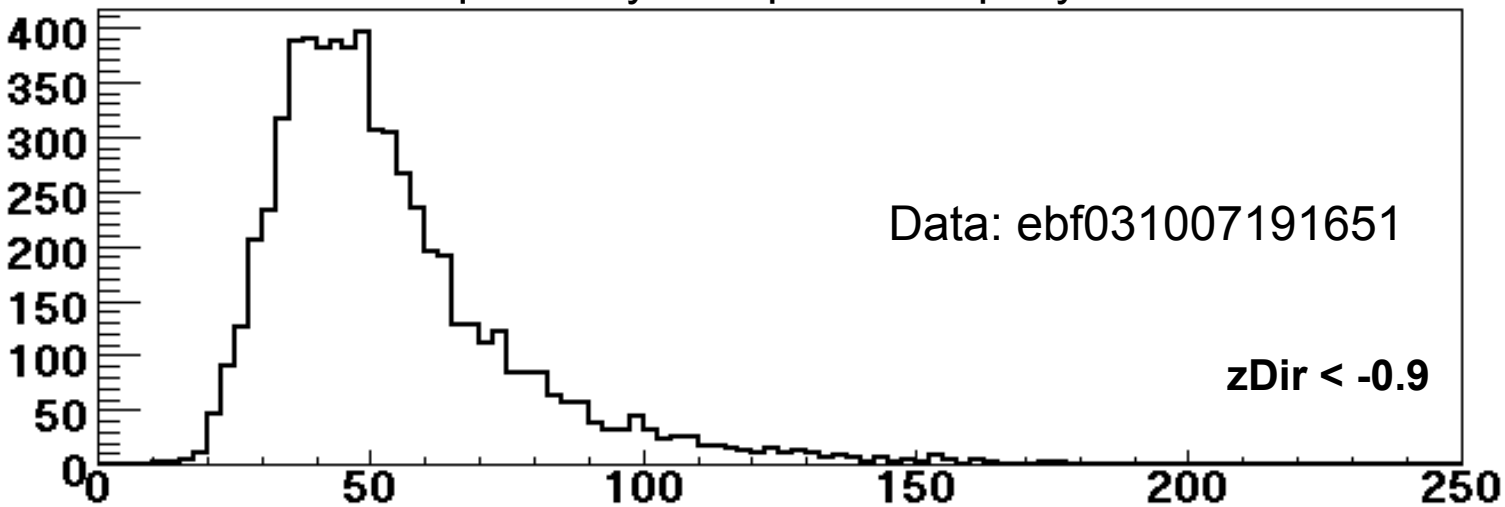
# TOT Distributions, γ + cosmic rays

Agreement between DATA and MC is not as good as in cosmic rays only

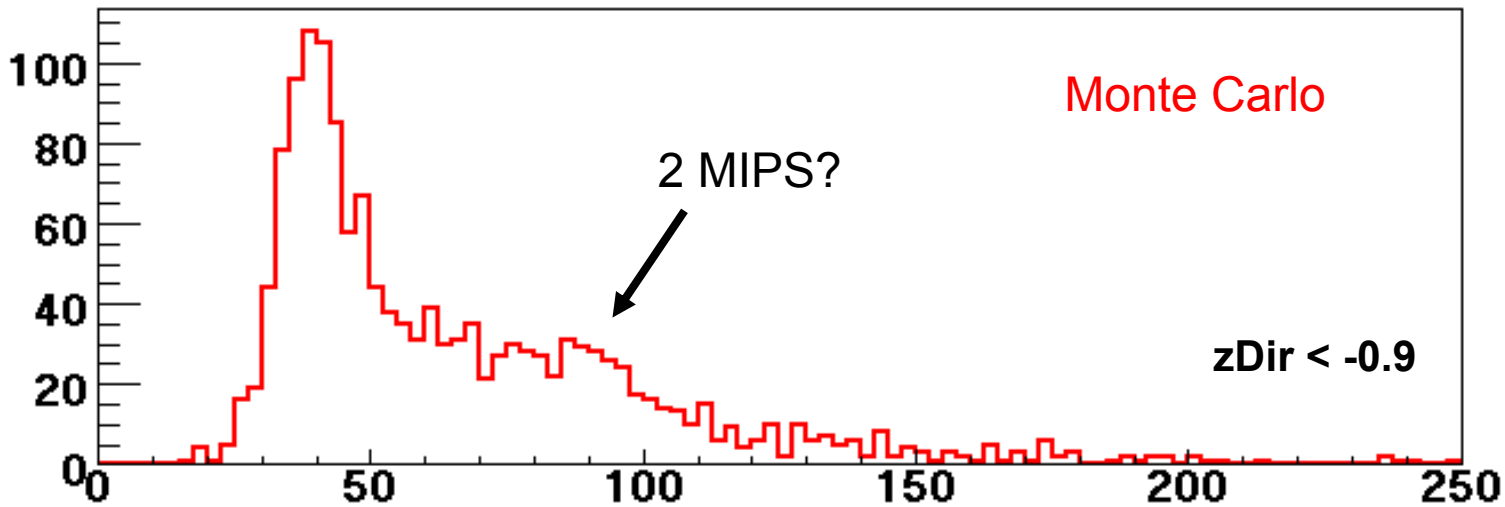


# TOT Distributions, γ + cosmic rays

Require only 1 strip hit on top layer




BariDigi produces similar results as SimpleDigi



# VDG and TOT

- Preliminary studies indicate that it is hard to extract the TOT $\gamma$ signal from the ~20 MeV $\gamma$ because of the following reasons
  - Experimental set-up
    - There is a steel shield (~7% radiation lengths) in front of the accelerator. It produces lots of electrons, which could overwhelm $\gamma$ events
  - Compton Scattering
    - At such low energies, ~20% of photons produce single electron by Compton scattering, thus creating a TOT no different to that of a single electron
  - Multiple Scattering
    - At such low energies, both opening angle and multiple scattering angle of the e-/e+ become large, thus makes it less likely two particles hit the same strip
- At such low energies, almost everything such as reconstruction becomes harder

# Conclusion

- **Preliminary Monte Carlo simulation studies indicate that**
  - **for a FULL tower, the TOT could be used to separate $\gamma$ from backgrounds statistically for a range of energies from 18 MeV to 18 GeV.**
  - **For the EM (minitower), Monte Carlo predictions at very low energy do not agree well with data**
- **Work is in progress to quantify the observations above**