Director CD-2 review: Mu2e Calorimeter

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Outline

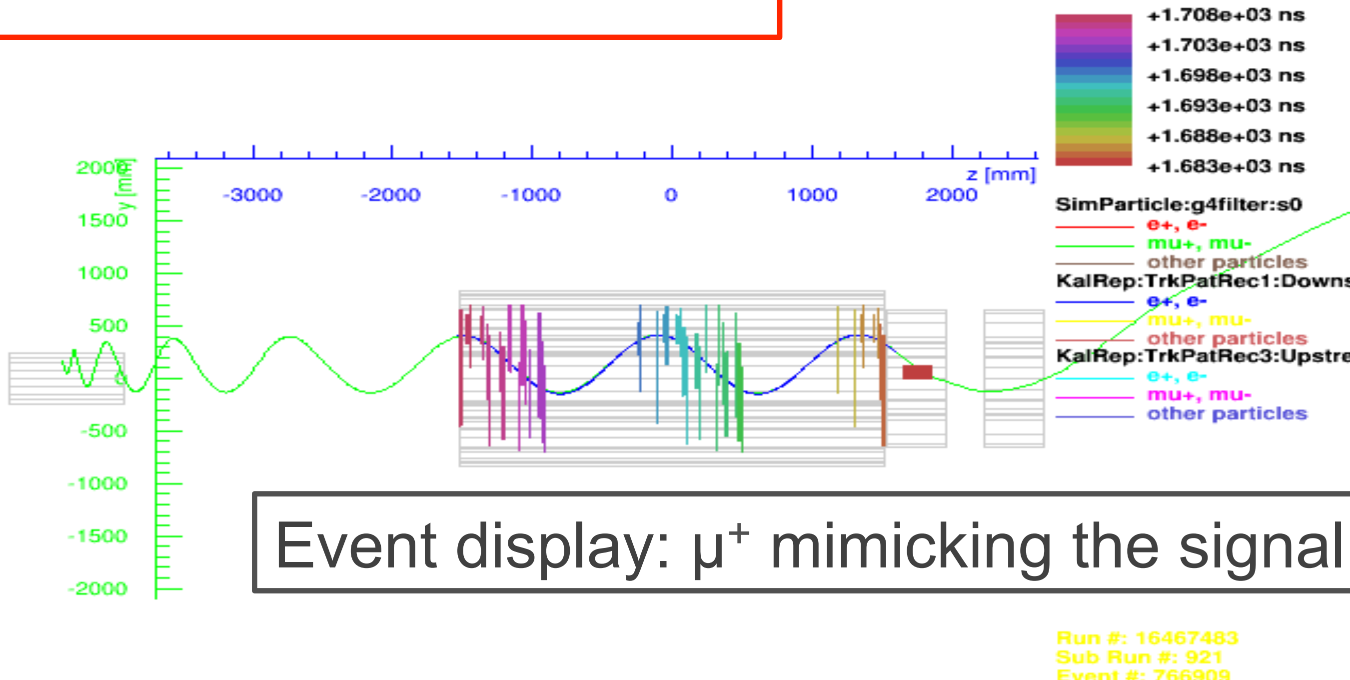
- **Particle Identification** (PID)

- **Calorimeter driven pattern recognition**

PID – Requirement

- CRV studies showed:
  - Assuming a CRV inefficiency of 10^{-4}
  - To of have < 0.1 fake events from atmospheric particles

➢ *μ* rejection factor ~ 200 is needed!



Event display: μ^+ mimicking the signal

PID – Cosmic rays background

- Cosmic rays can either interact or be captured in the Detector solenoid, mimicking the signal in several ways:
  1. Positive particles (**e^+, μ^+**) moving upstream, reconstructed as downstream tracks
  2. Negative particles (**e^-, μ^-**) moving downstream and reconstructed as downstream particles

- **Positive particles** can be clearly identified just comparing the calo-cluster time with the track impact time
- The **irreducible** part is from e^-: only the CRV can veto that!

- How can μ- be identified?

PID – Cosmic rays background

- μ's with p = 104.97 MeV/c are no longer relativistic particles!

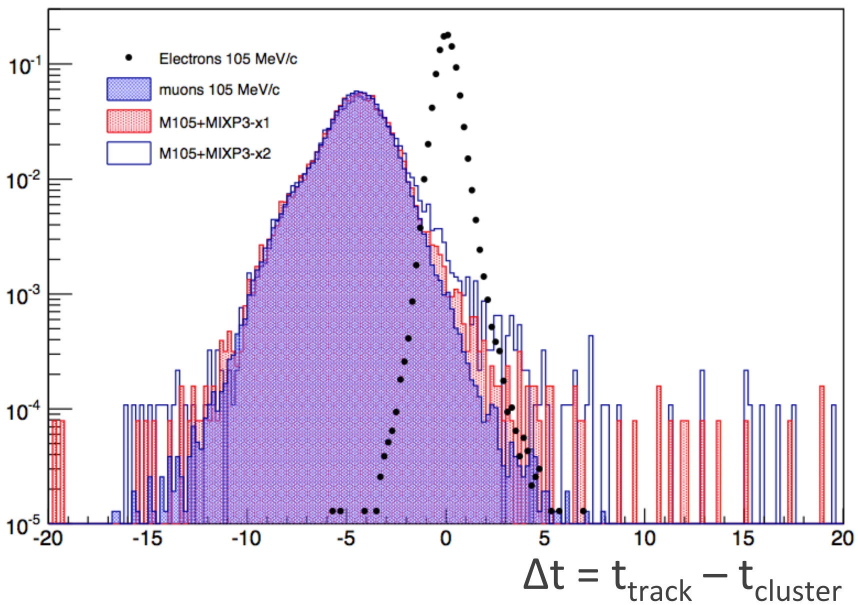
- This implies also that their kinetic energy is too low!

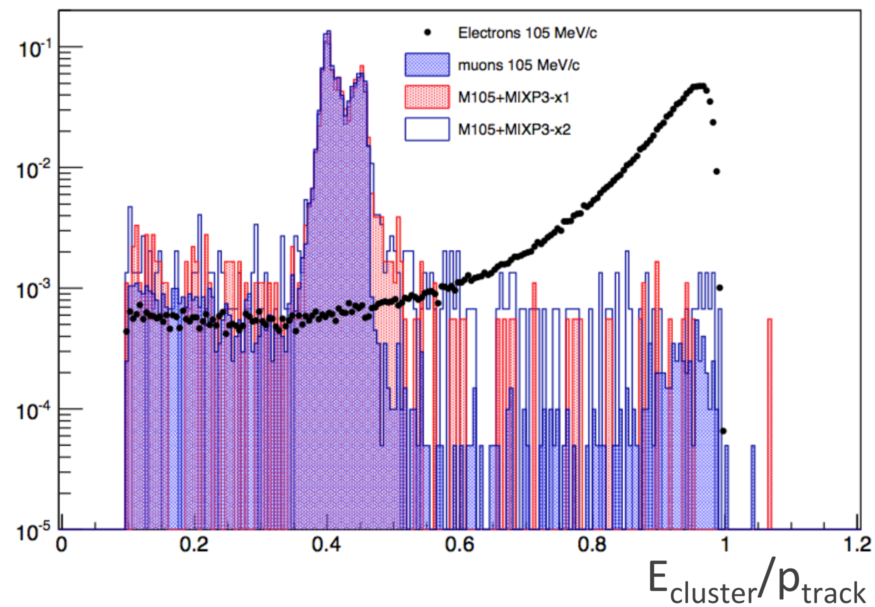
$$\beta = \frac{p}{E} \sim 0.7,\ E_{kin} = E - m \sim 40\ \text{MeV}$$

- **Timing** and **energy** information result to be very good discriminant parameters for tagging μ!

PID – basic idea

- Compare the reconstructed track and calorimeter information:
  - $E_{cluster}/p_{track}$
  - $\Delta t = t_{track} - t_{cluster}$, where t_{track} is the track time extrapolated to the calorimeter and $t_{cluster}$ is the reconstructed cluster time





PID – Algorithm

Two steps used for doing the PID:

1. Define a likelihood using distributions in $E_{cluster}/p_{track}$ and Δt:

$$\ln L_{e,\mu} = \ln P_{e,\mu}(\Delta t) + \ln P_{e,\mu}(E_{cluster}/p_{track})$$

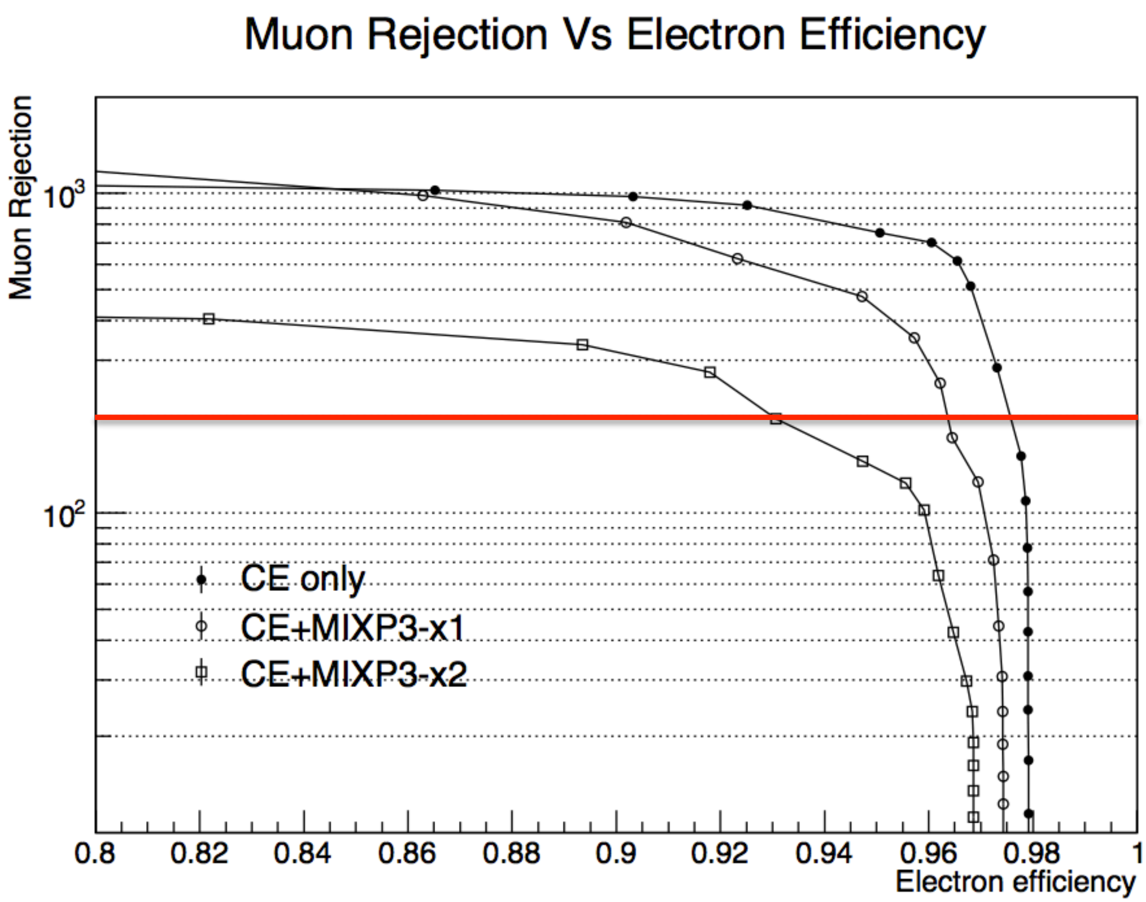
$P_{e,\mu}(\Delta t)$ and $P_{e,\mu}(E/p)$ are the pdf for e and μ respectively

2. The ratio of the likelihoods is the final parameter used:

$$\ln L_{e/\mu} = \ln \frac{L_e}{L_\mu} = \ln L_e - \ln L_\mu$$

PID – Performance

- *μ* rejection of 200 results in an e^- efficiency of ~ 96 %
- background occupancy x2 scales the e^- efficiency at ~93%



PID – Calorimeter assumptions

- Toy MC used for evaluating the PID performance with respect to the expected calorimeter timing and energy resolutions

- The adopted procedure follows:

  1. Smear the E/p and Δt distributions with Gaussian functions according to the calorimeter resolution

  2. Remade the pdf for μ and e

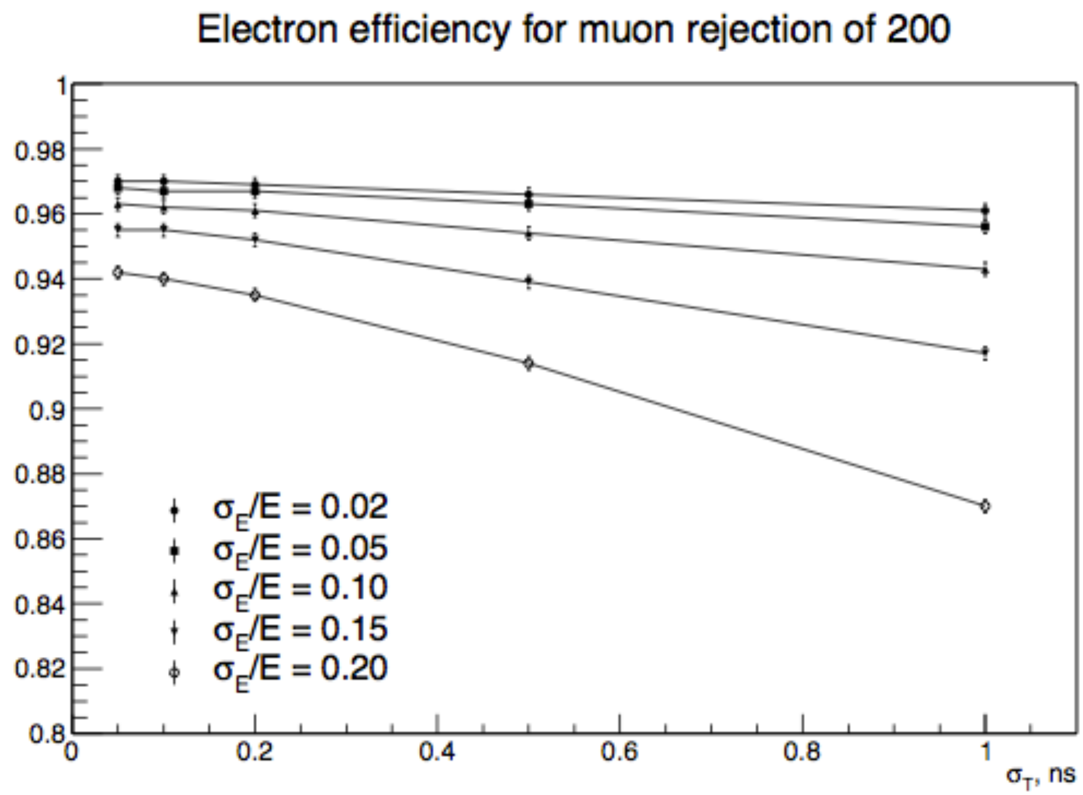
  3. Evaluate the likelihood ratio using pseudo experiments

PID – Resolutions vs e⁻ efficiency

- In the expected range of resolution:

$$\sigma_E/E < 0.1,\ \sigma_t < 0.5\ \text{ns}$$

the e^- efficiency is stable up to 2%

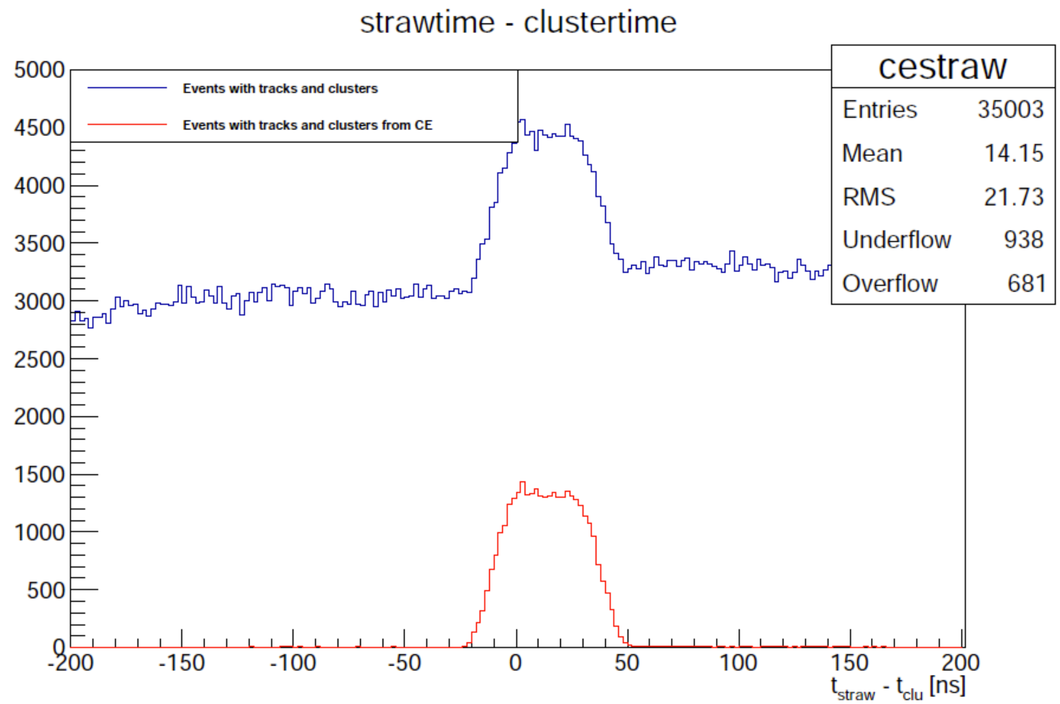


PID – Conclusion

- Calorimeter timing and energy information provide a good *μ* identification satisfying the experiment requirement
- Worst scenario with bkg occupancy x2 scales e^- efficiency of about 3%
- Toy MC showed that in the range of the expected calorimeter resolutions the e^- efficiency is stable up to 2%

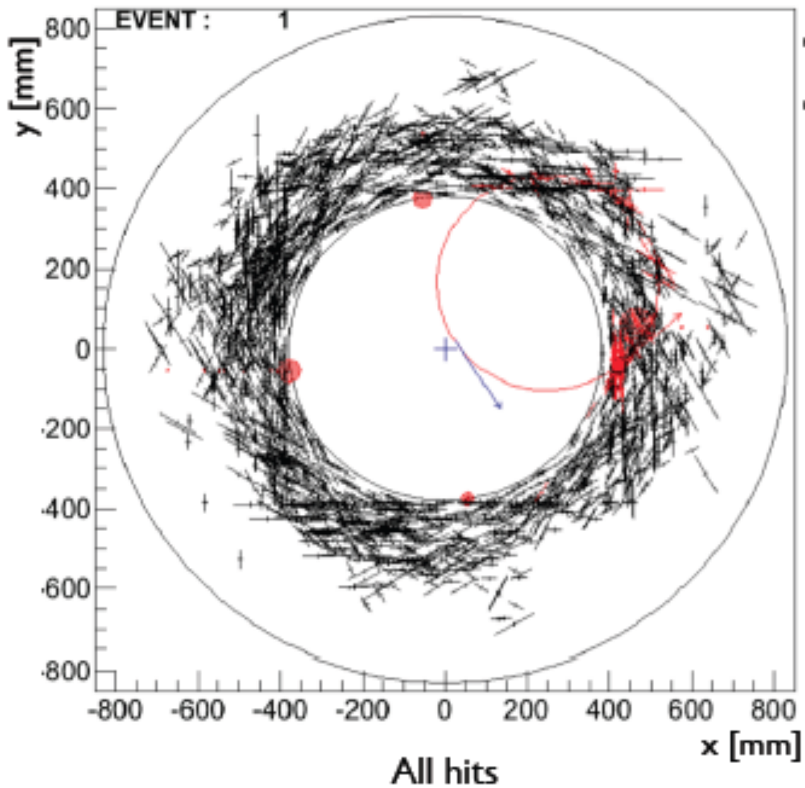
Why a calo-based Pattern Reconstruction?

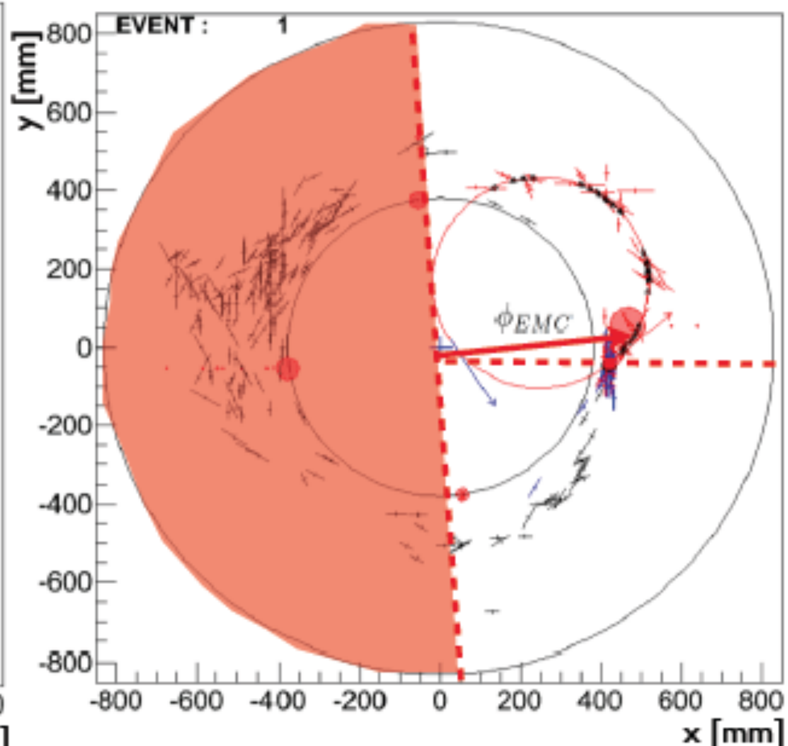
- Pattern recognition in the tracker does NOT use any assumption on the track-t_0 (crossing time of the middle of the tracker)
- Straw hits and calorimeter cluster of the same track have strong correlation!



CalPatRec – Event display

- **Patter recognition**: cluster time and position used to select the right pattern of straw hits



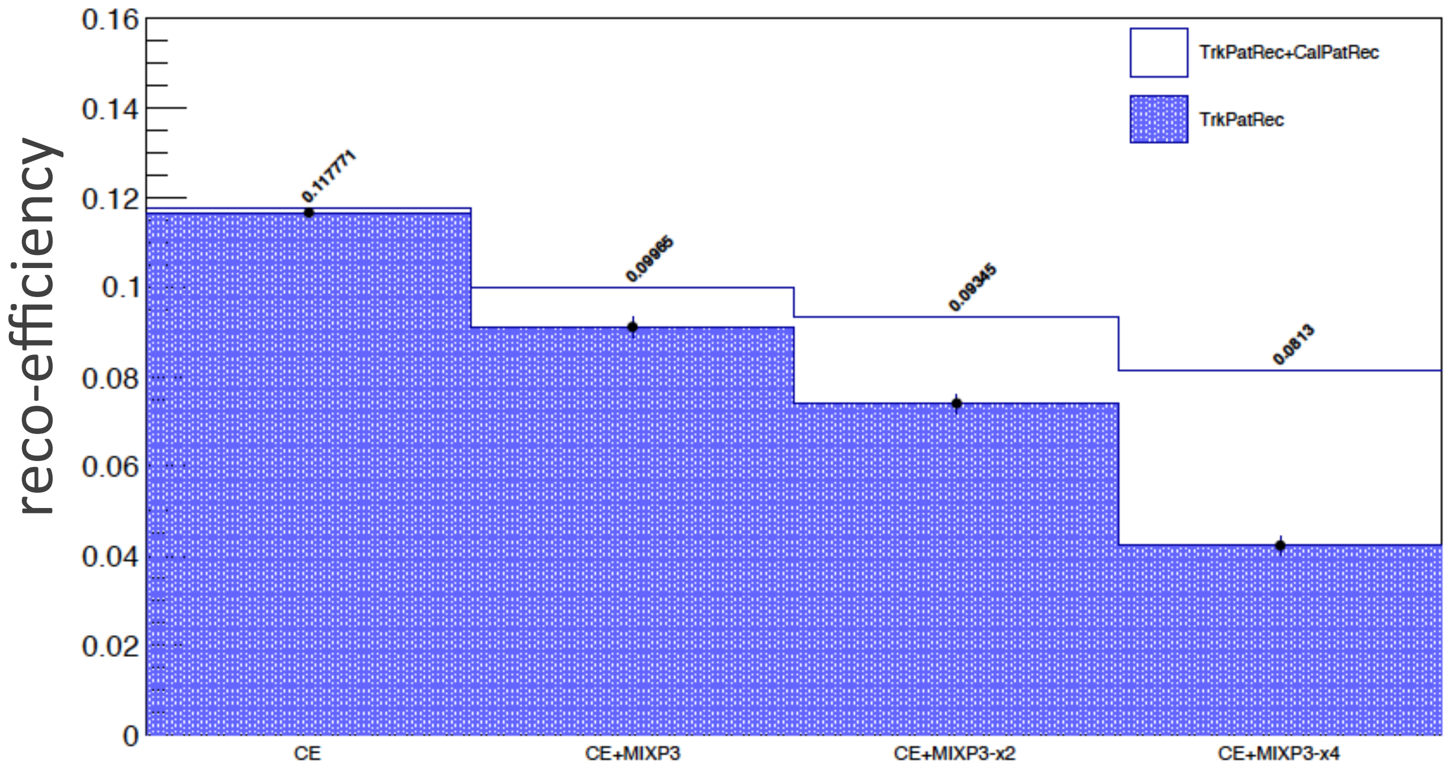


only hits with: $|\phi_{hit} - \phi_{EMC}| < 90°$

$|t_{hit} - t_{EMC}| < 50$ ns

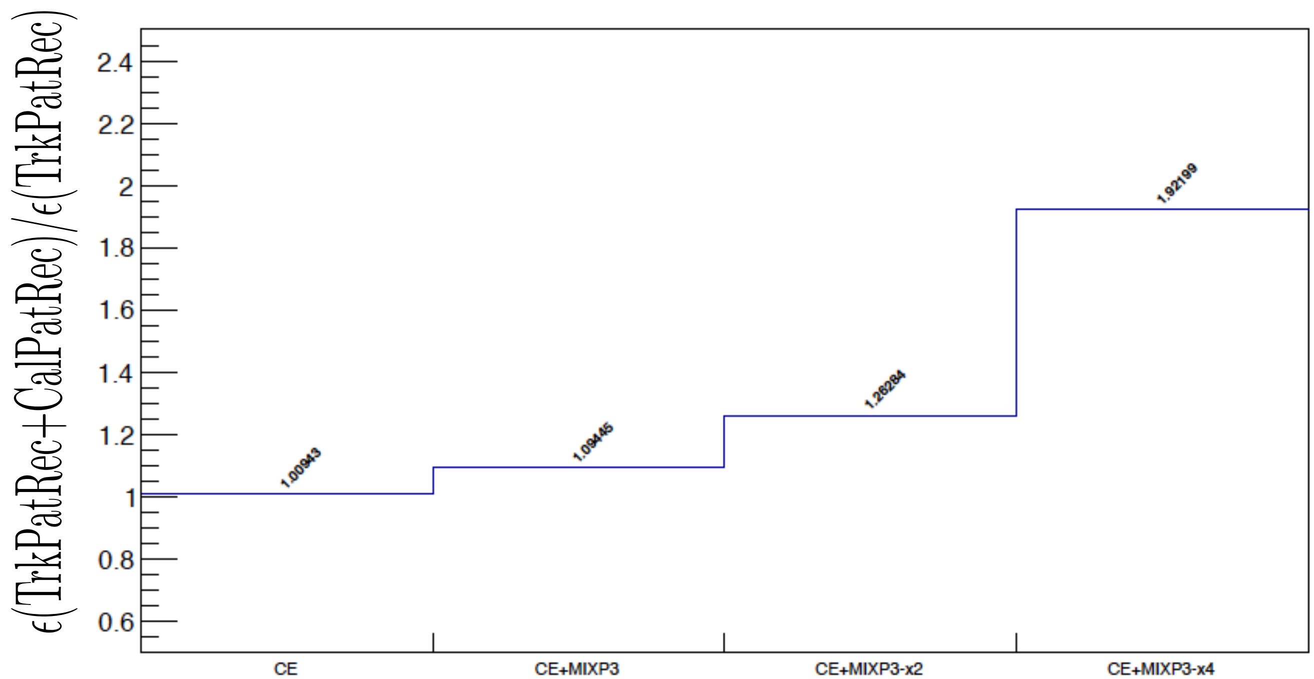
CalPatRec - Results

- Using the or of CalPatRec and the default (TrkPatRec) efficiency scales from ~ 12% to ~ 8% up to occupancy x4
- Wo CalPatRec efficiency goes down to ~ 4%



CalPatRec - Results

- With the expected background occupancy CalPatRec adds ~10% (relative)
- At occupancy x4 CalPatRec improves the reco-efficiency by a factor 1.9



CalPatRec - Conclusion

- CalPatRec allows to recover 10% of the default reconstruction efficiency

- CalPatRec makes the reco-algorithm more stable also in higher occupancy scenarios

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Backup slides