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# Response to Recommendation on Magnet

Based on the work of:

P. Bernardini, S. Biagi, C. Distefano, N. Mauri, M. Pozzato, P. Sala, A. Surdo, M. Tenti, F. Terranova, s.b.

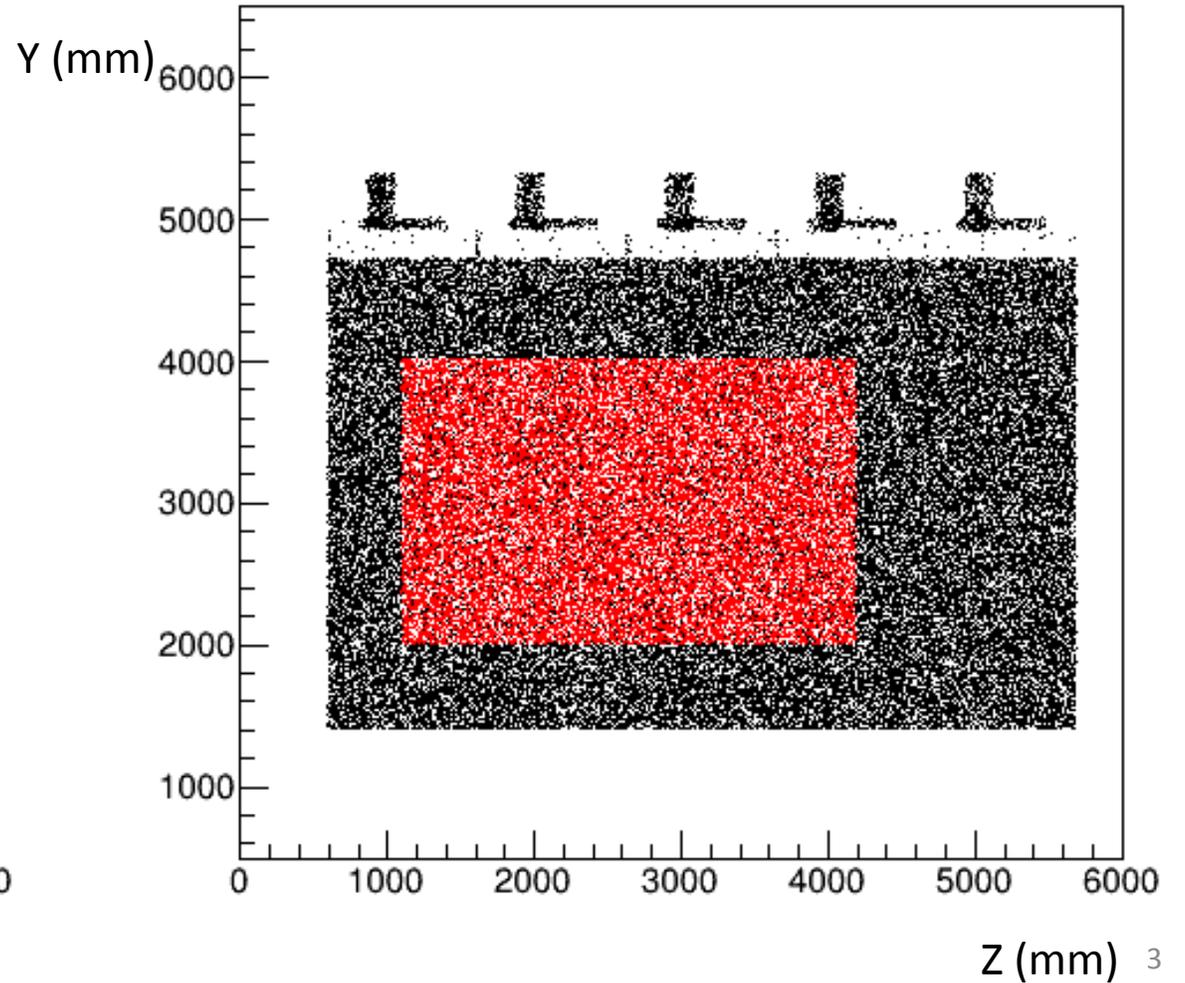
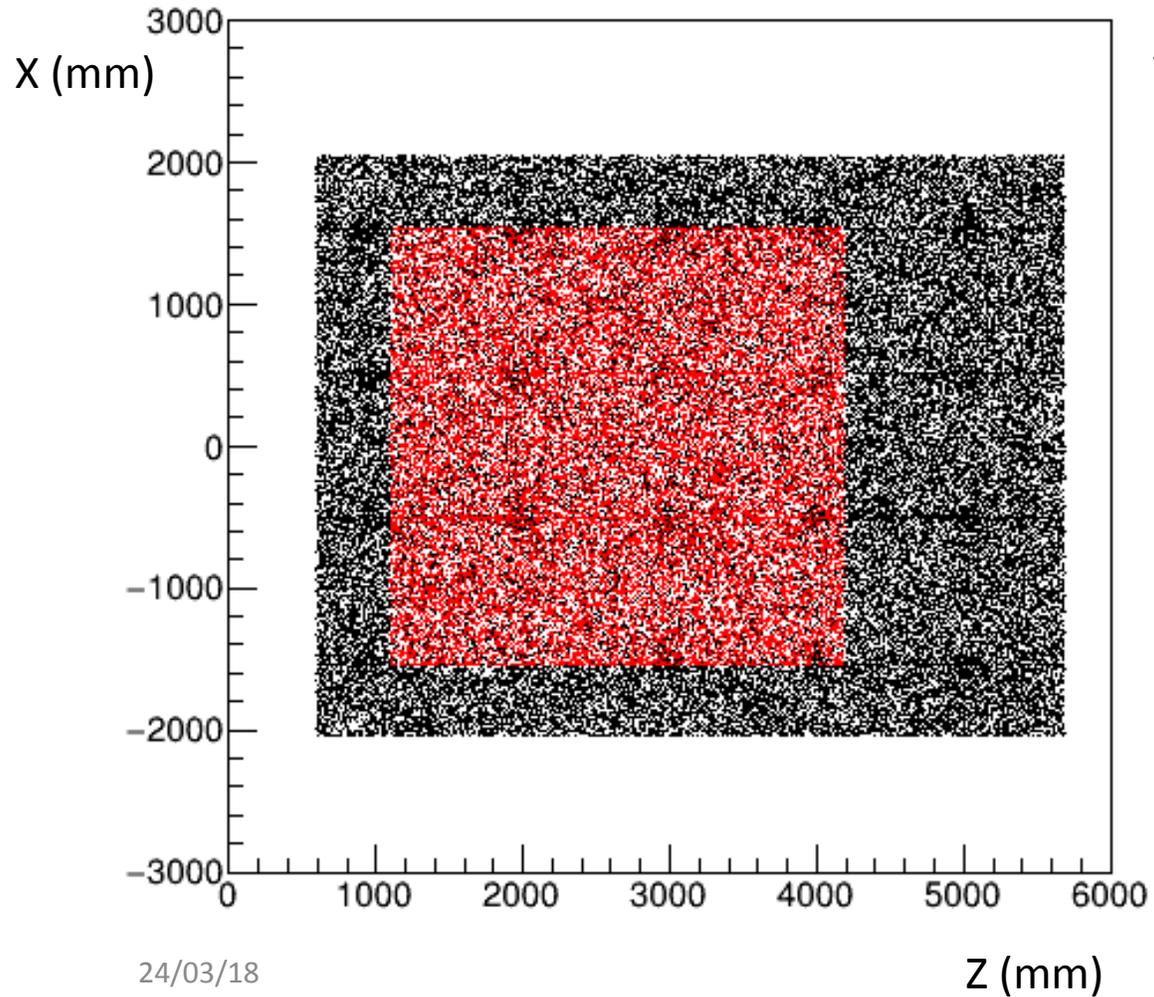
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University of Bologna and INFN

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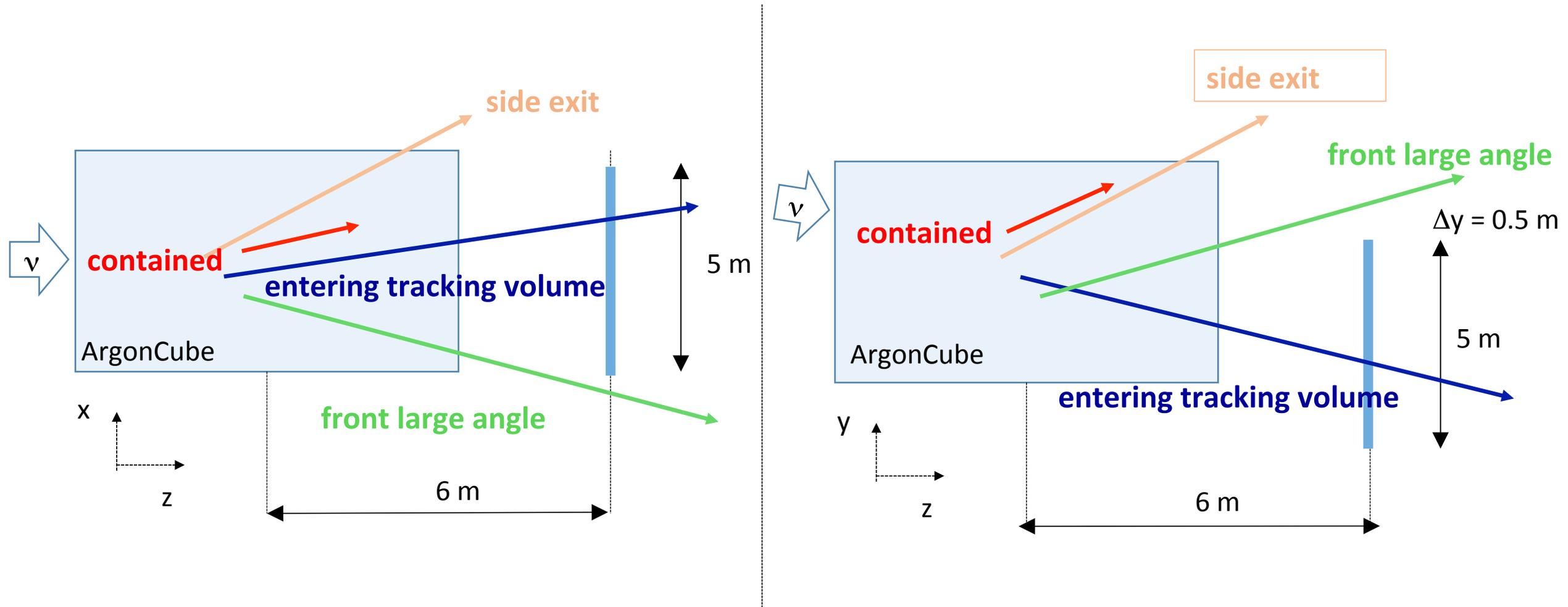
# Draft Recommendation

Based on scientific considerations, the DUNE Near Detector Concept Study recommend to a **new-build dipole magnet** for the multi-purpose spectrometer downstream of the Liquid-argon TPC (LAr TPC).

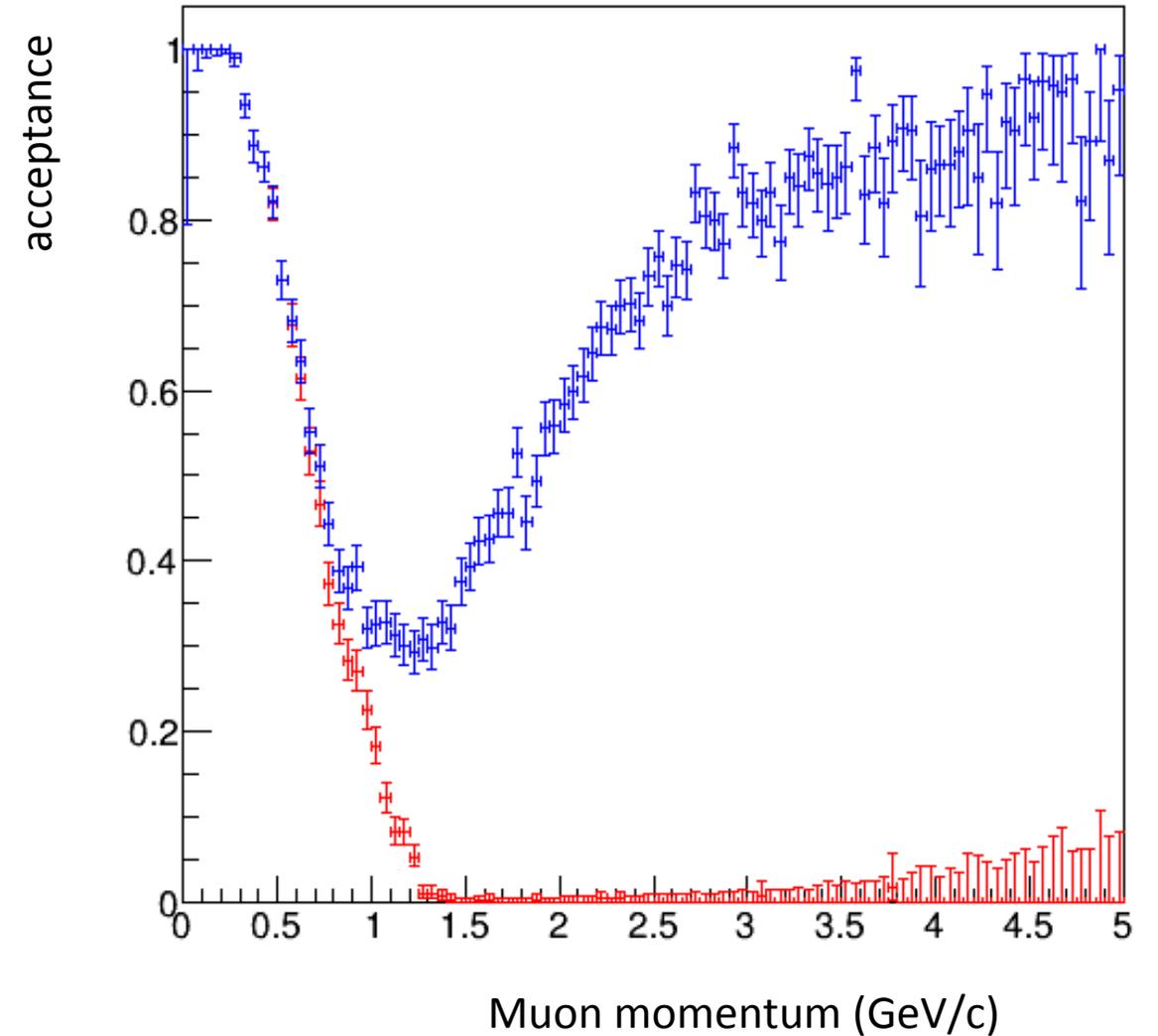
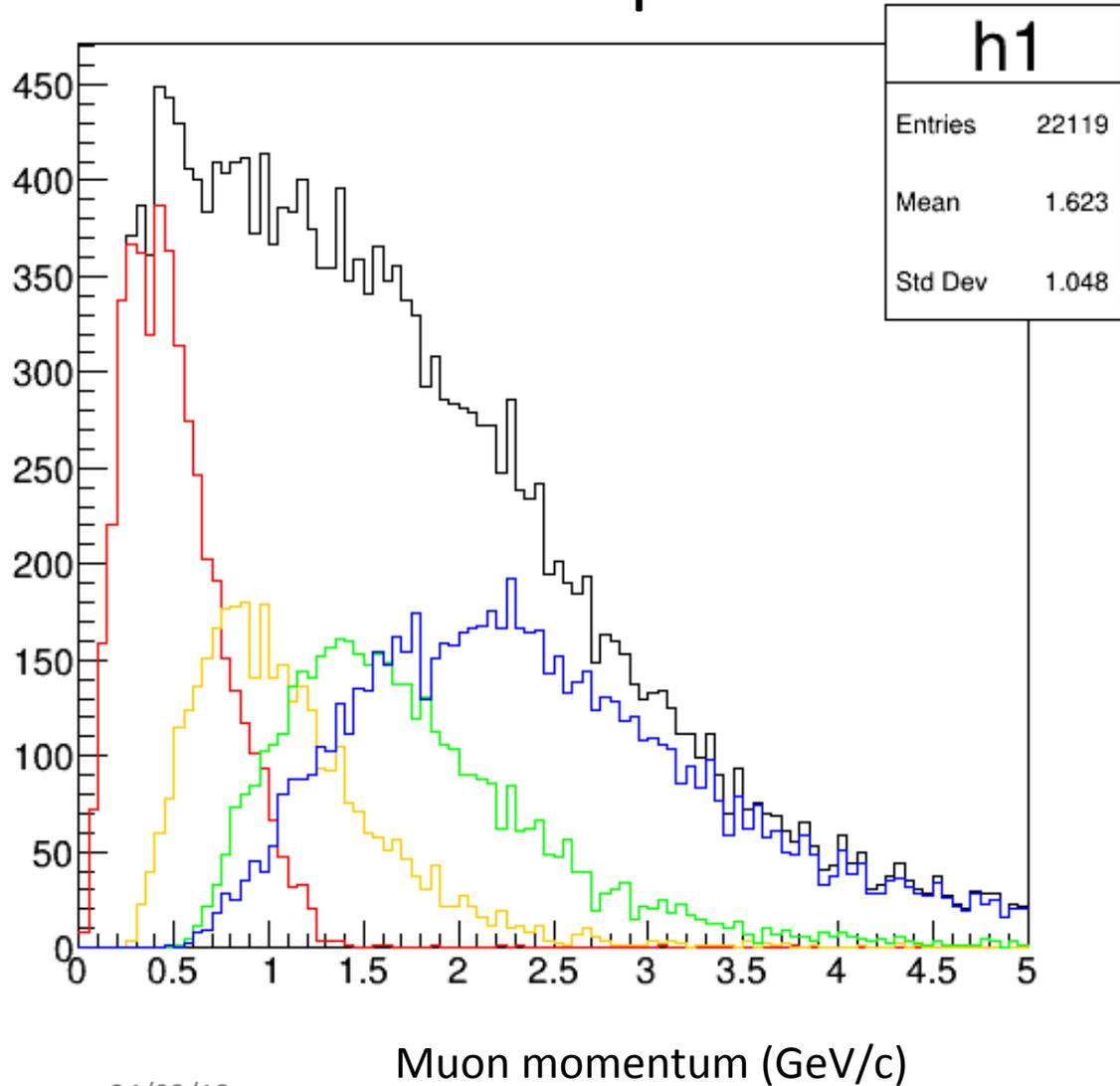
# ArgonCube Fiducial Volume



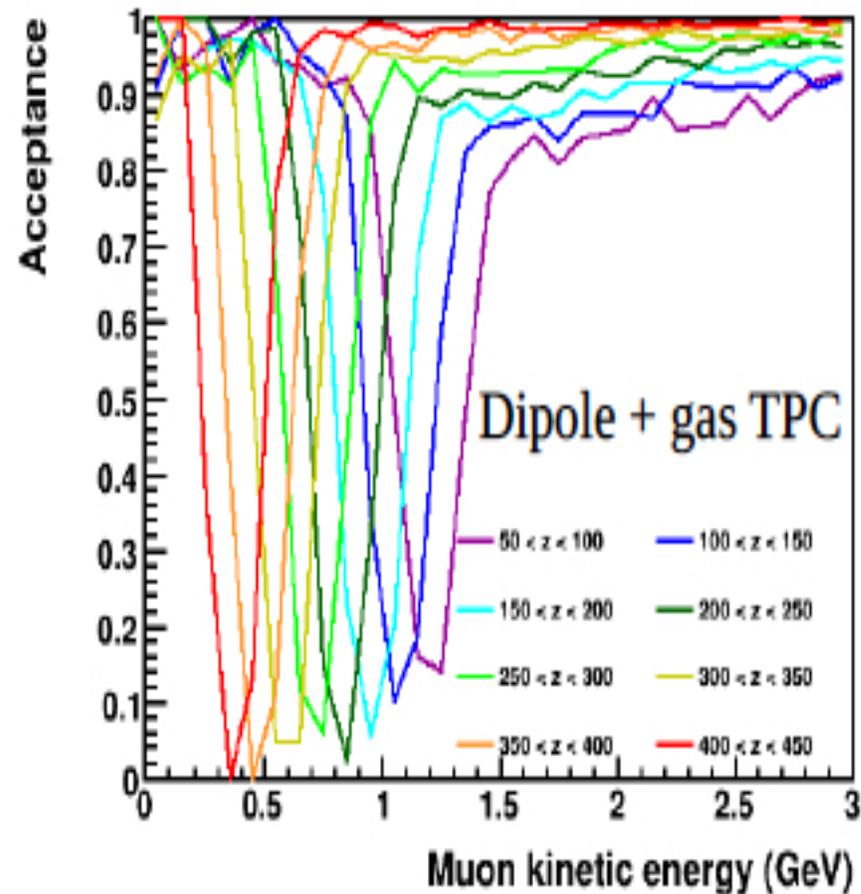
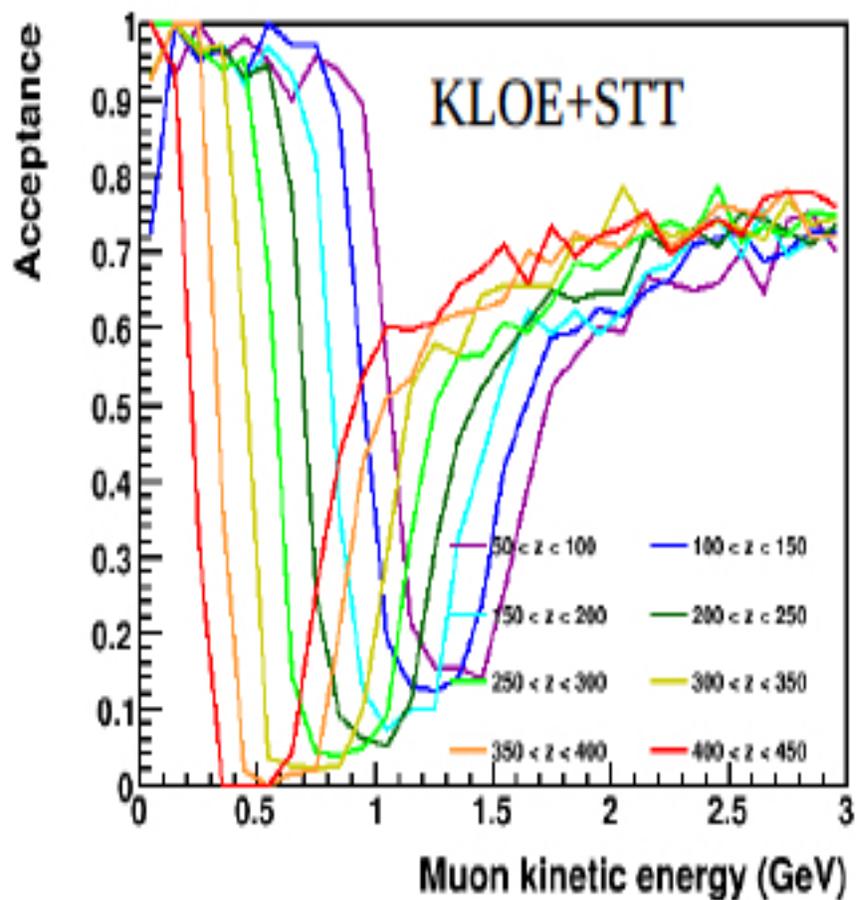
# The destiny of a muon



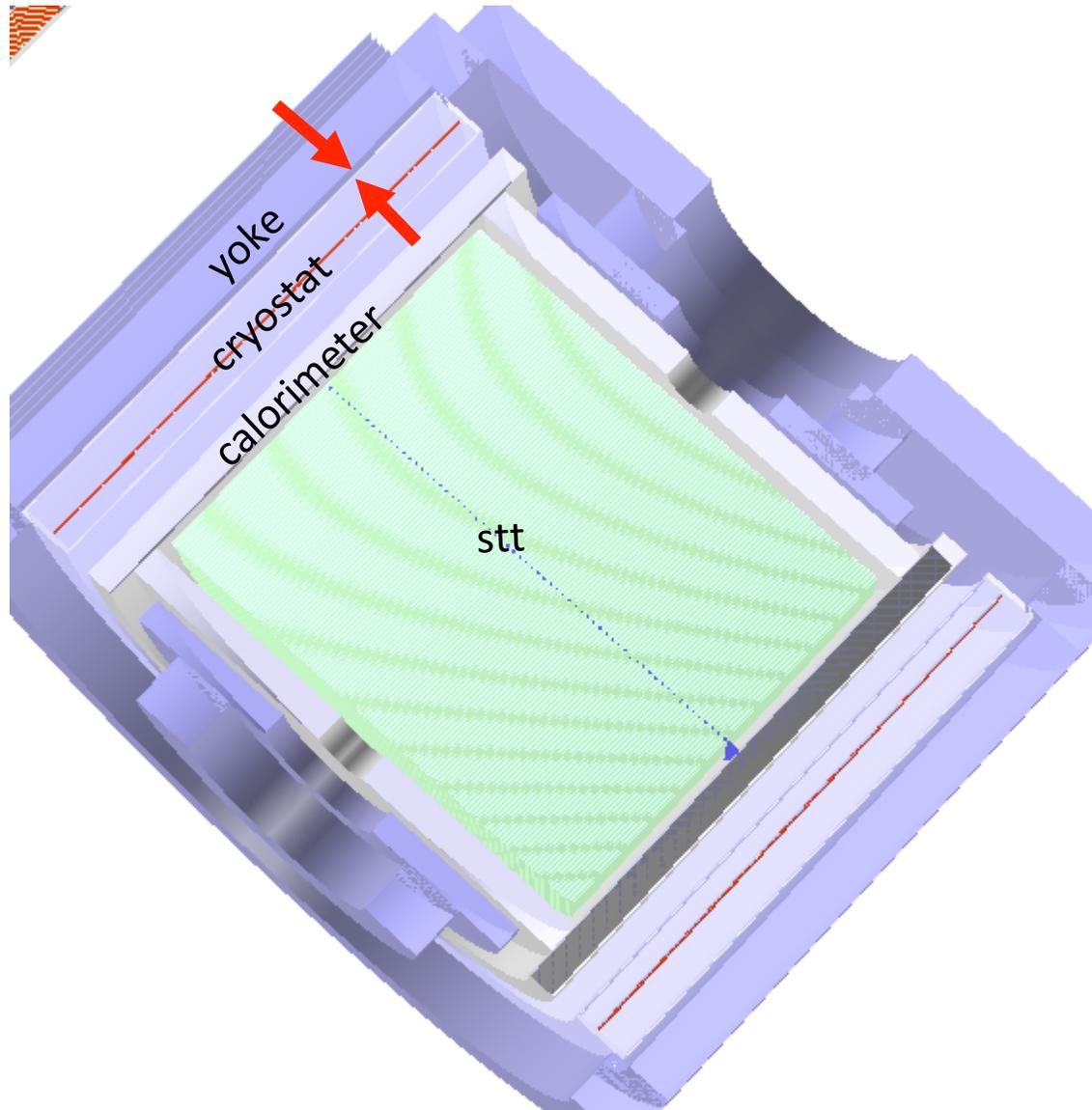
# Muon acceptance



# Similar conclusion in the draft recommendation



# Internal tracker

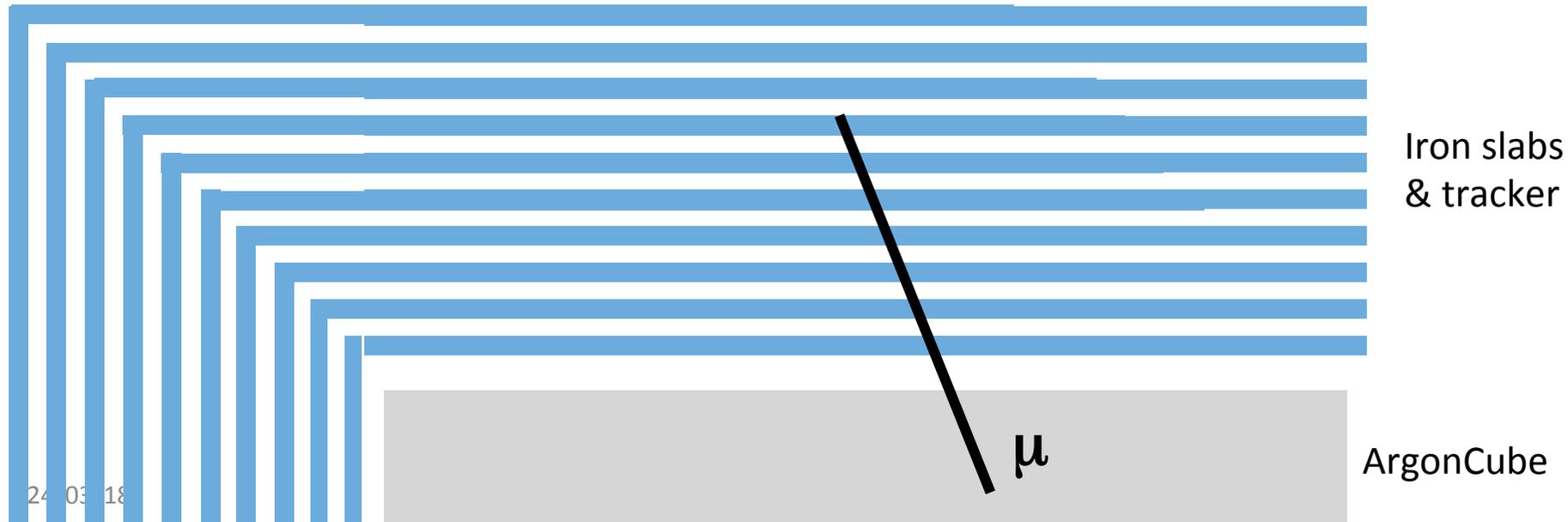


- Additional tracker in the space between yoke and cryostat

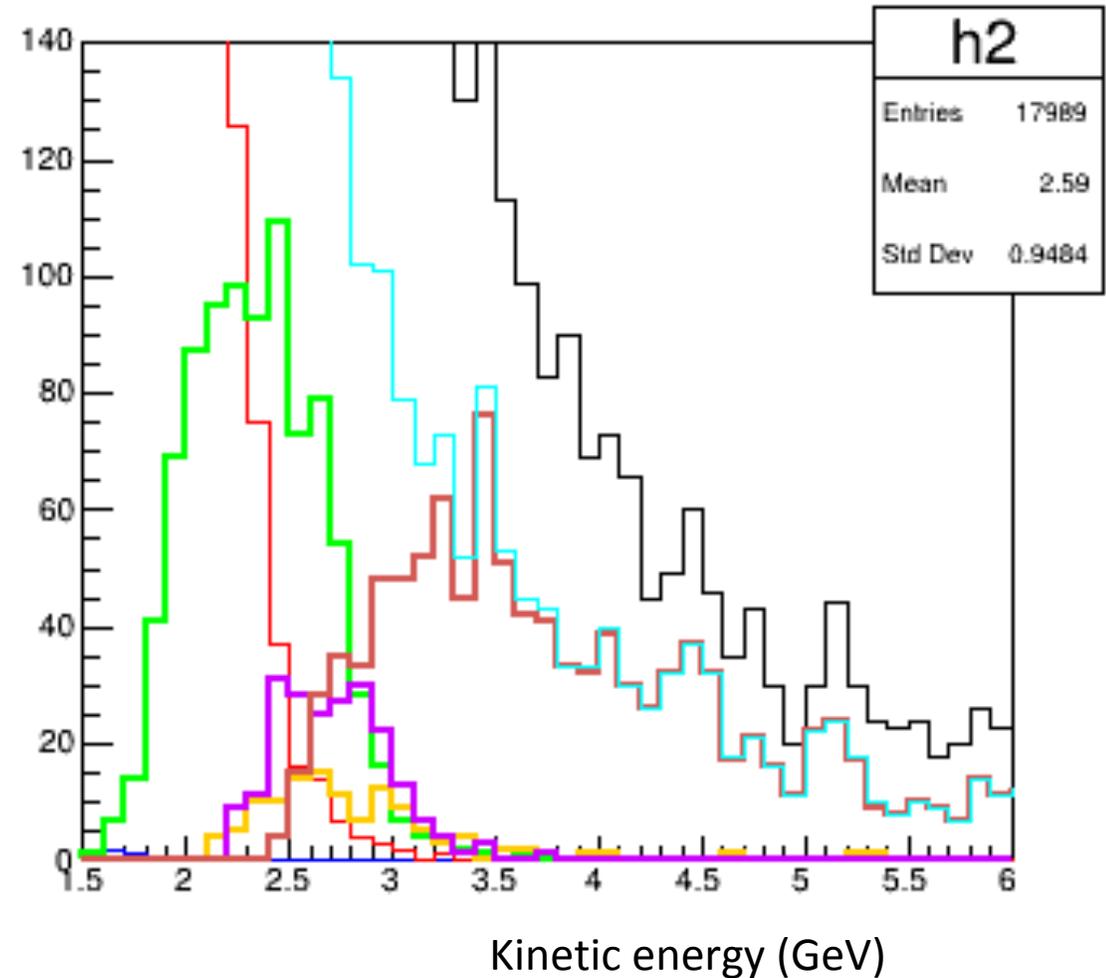
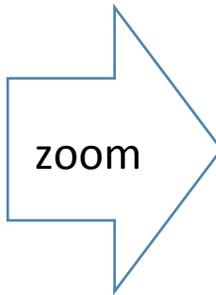
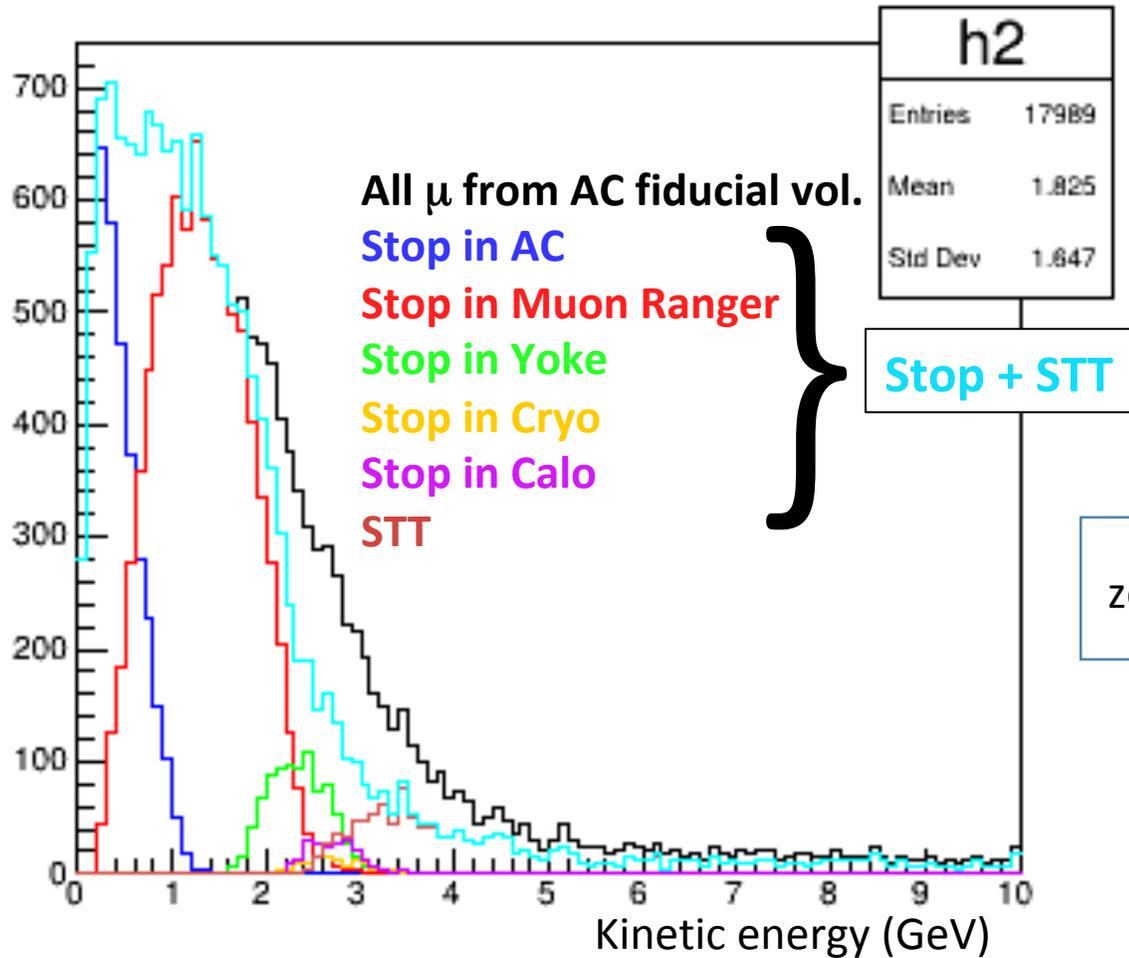
# A very crude muon ranger

Measure kinetic energy of escaping muons through **range**

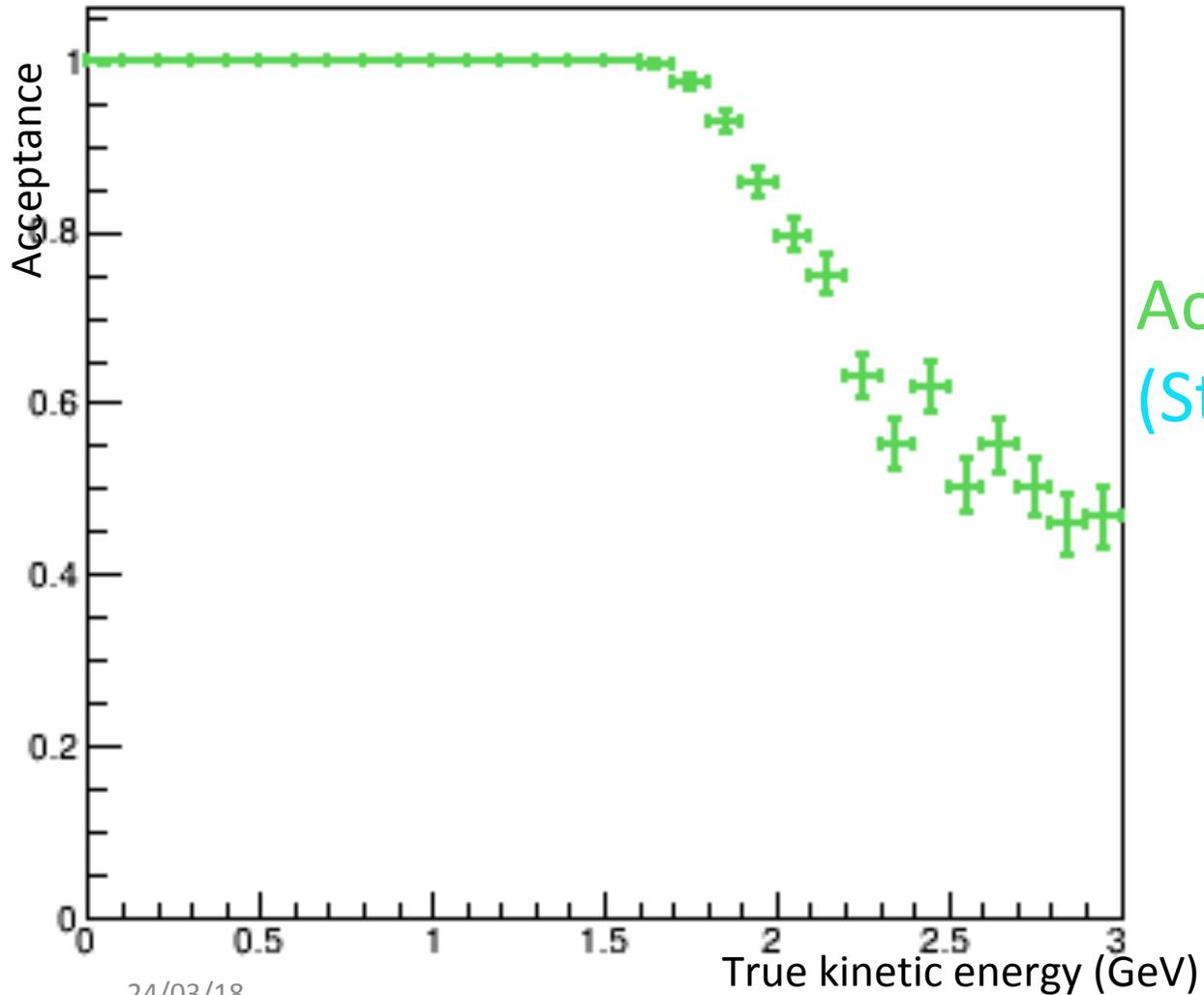
- **10 iron slabs** (10cm thick) around AC with interleaved **trackers** (5cm) to connect the tracks emerging from AC



# Acceptance

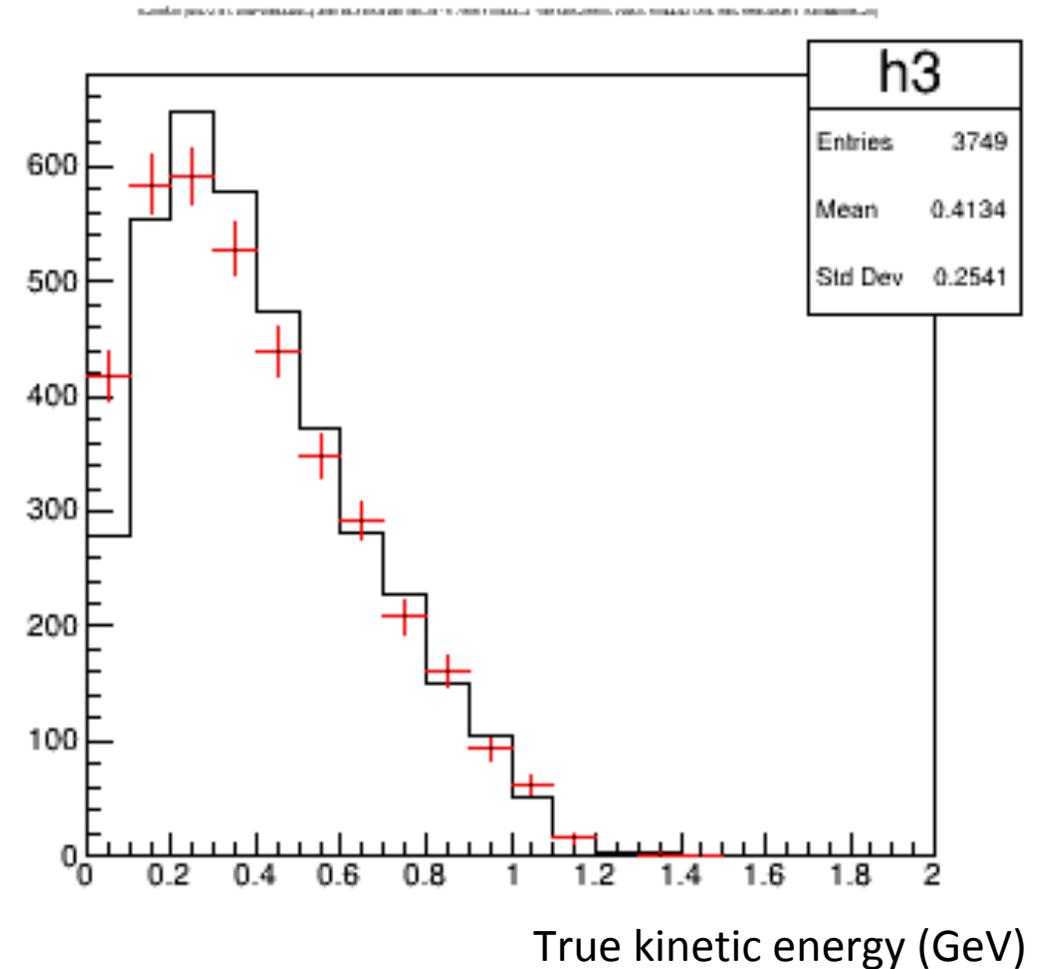
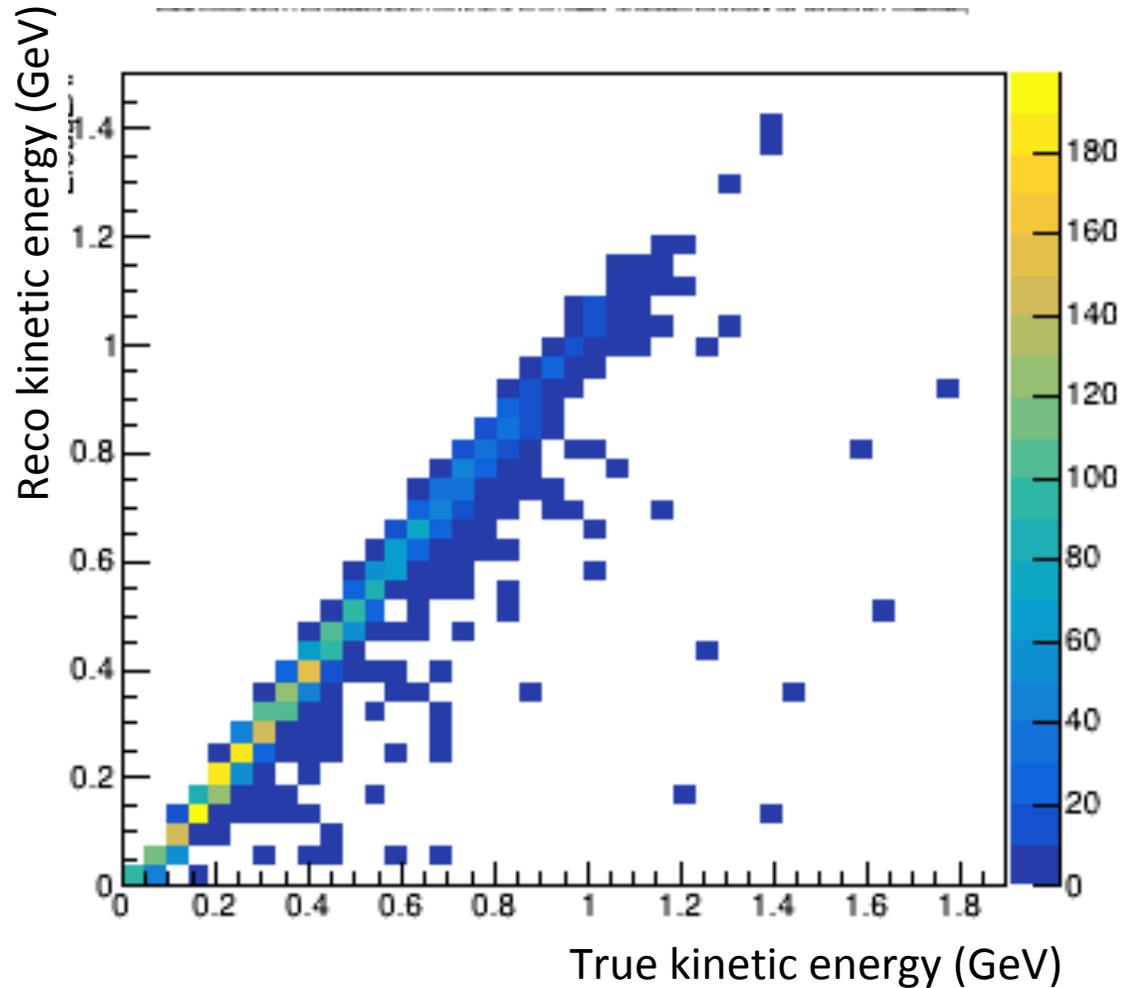


# Acceptance (Monte Carlo truth)

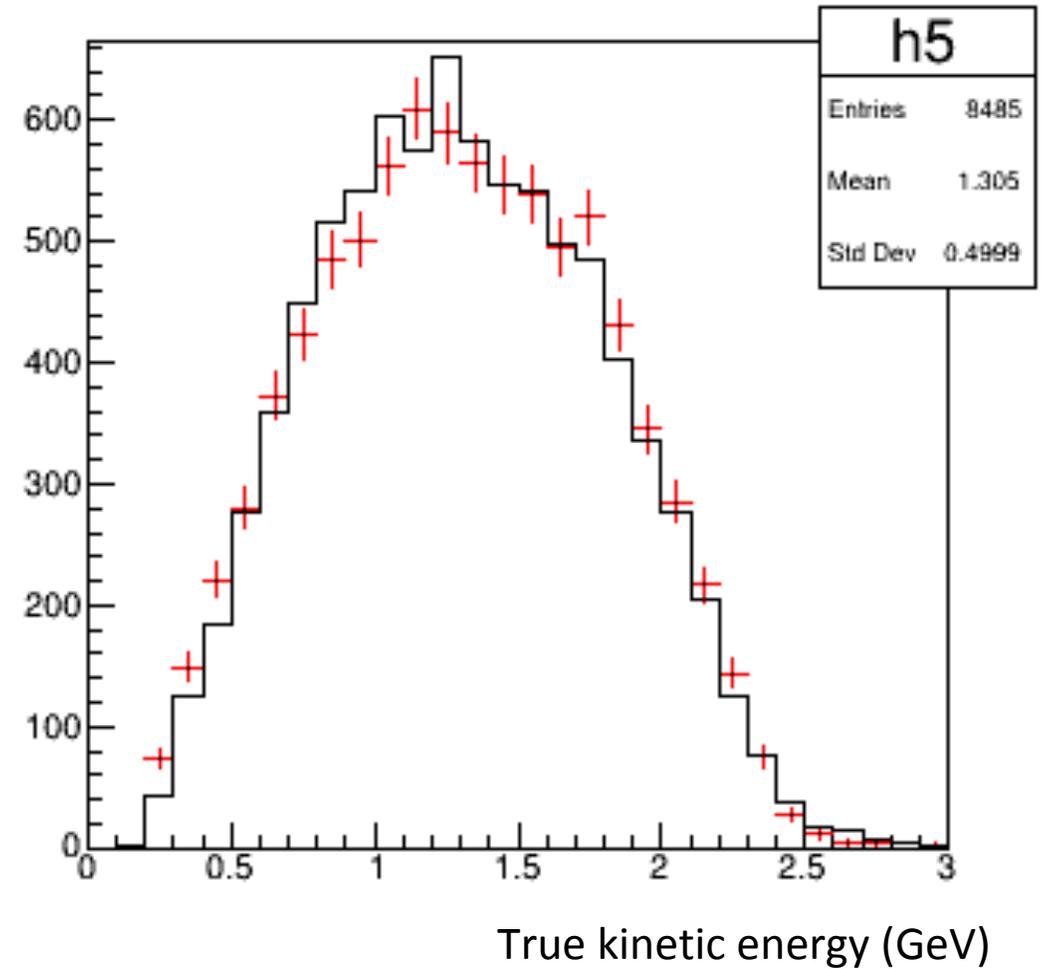
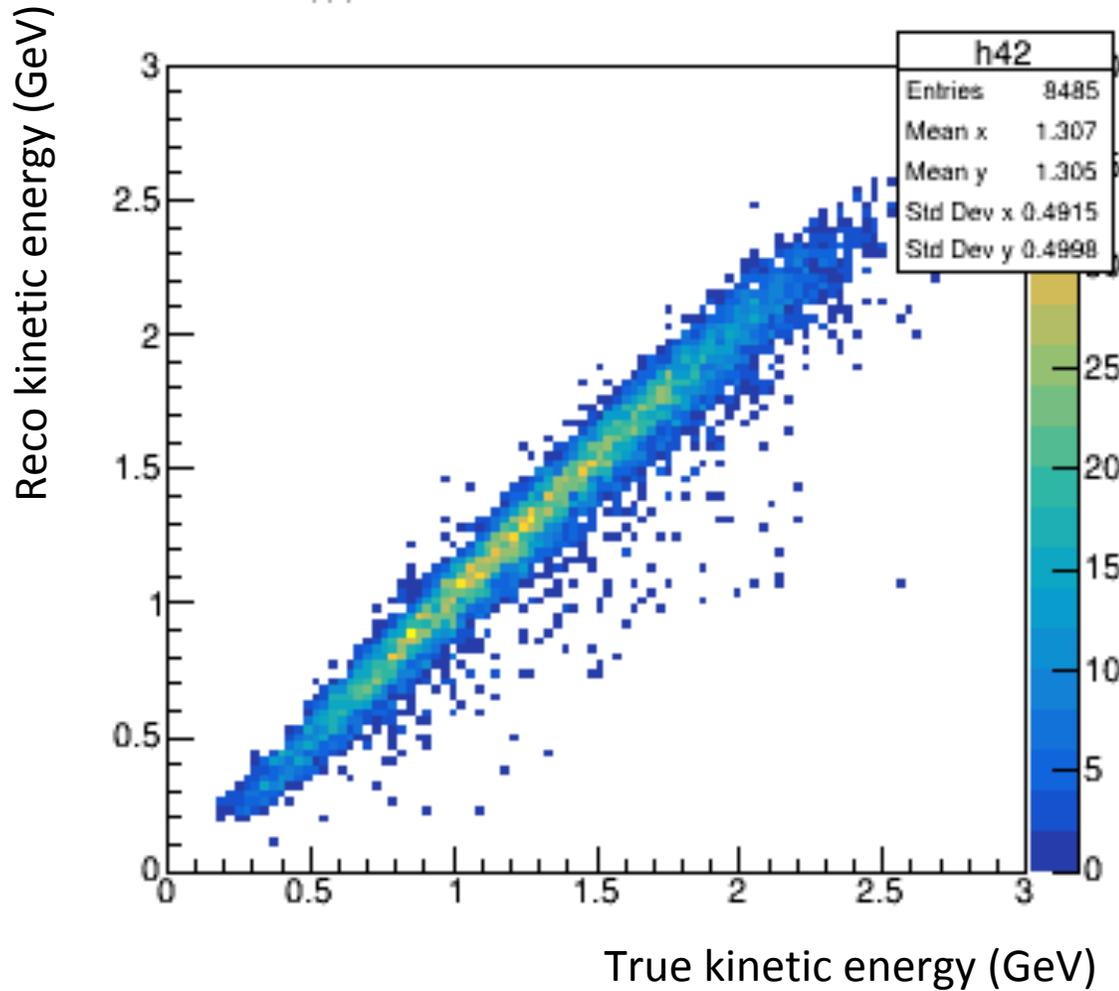


Acceptance =  
(Stop + STT) / (all  $\mu$  from AC fiducial vol.)

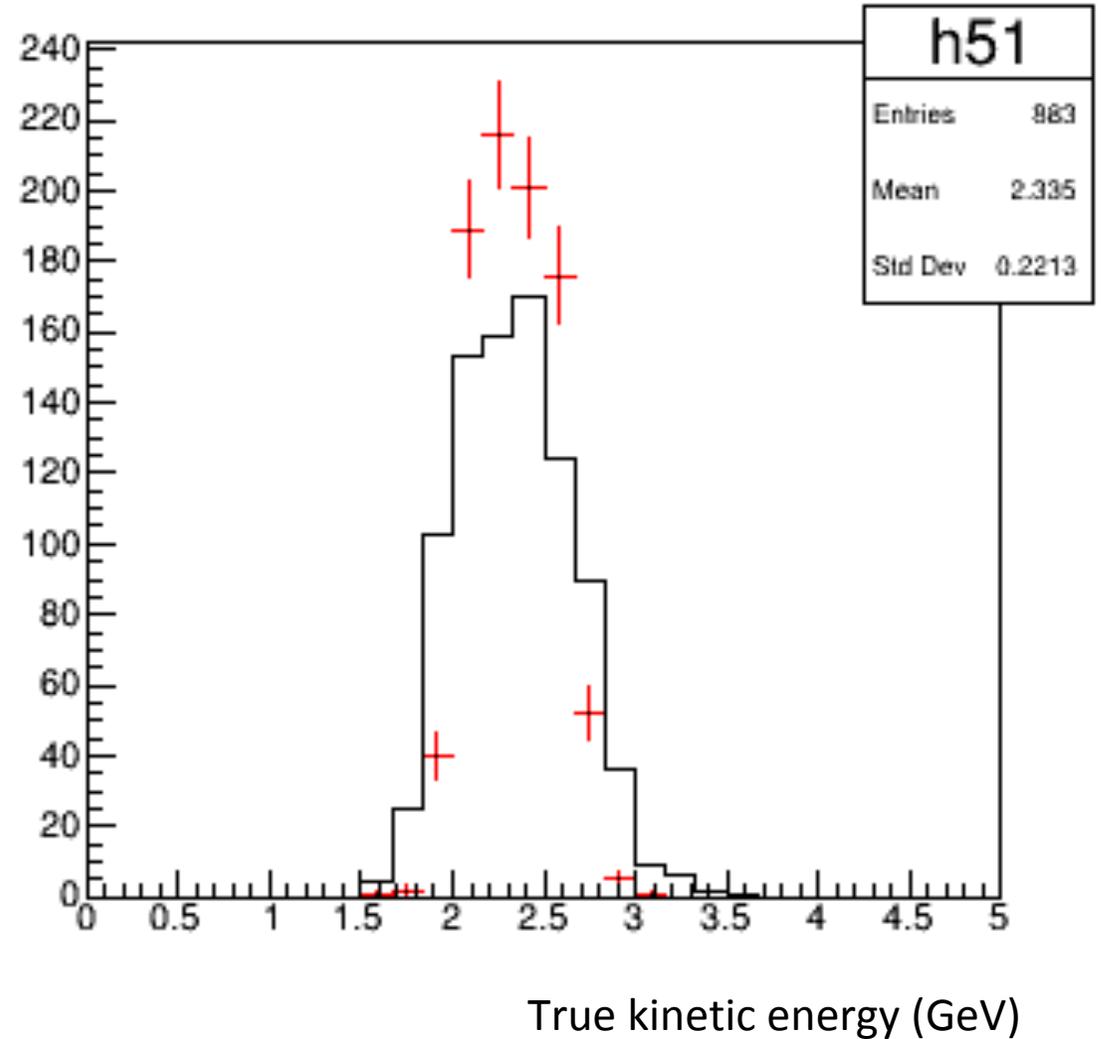
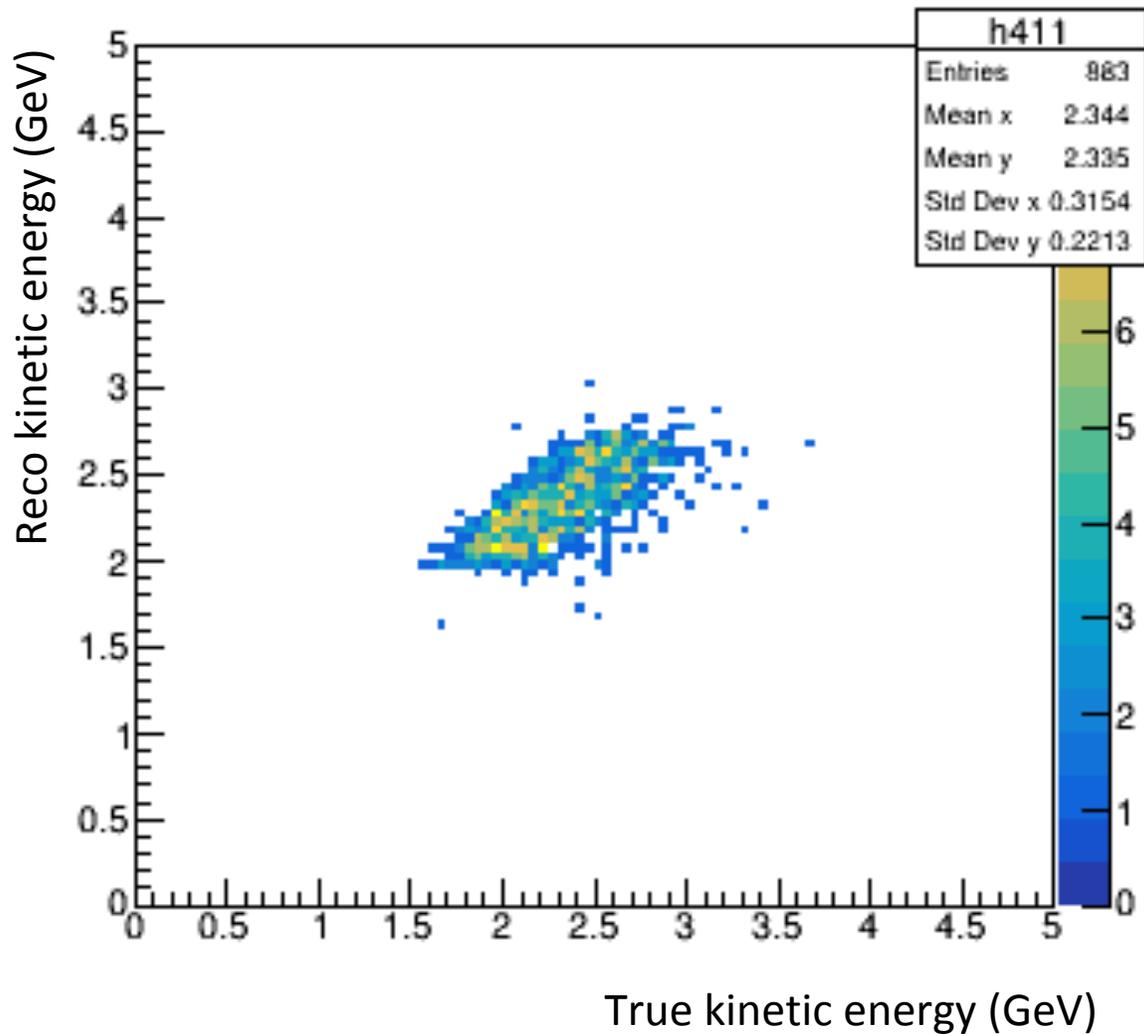
# Muon momentum reconstruction: $\mu$ stopping in AC ( $\sim 21\%$ )



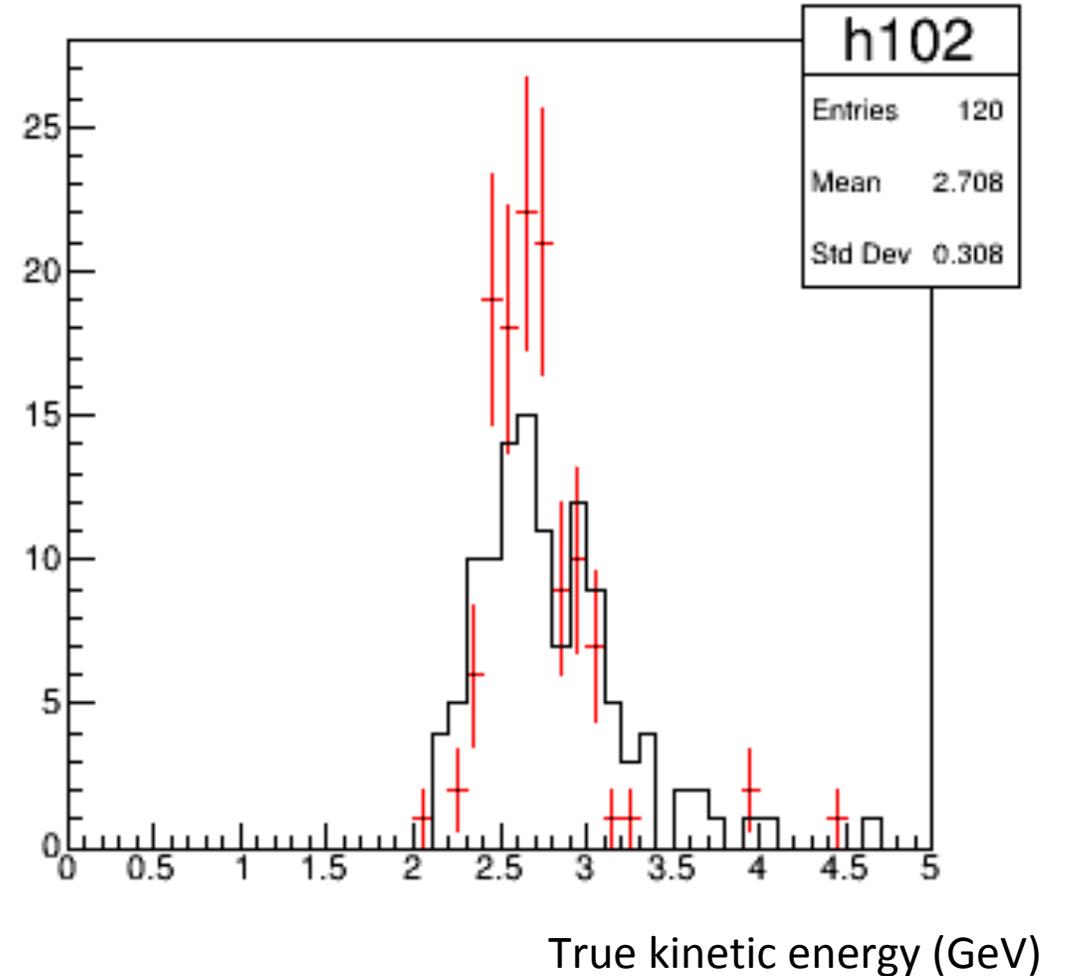
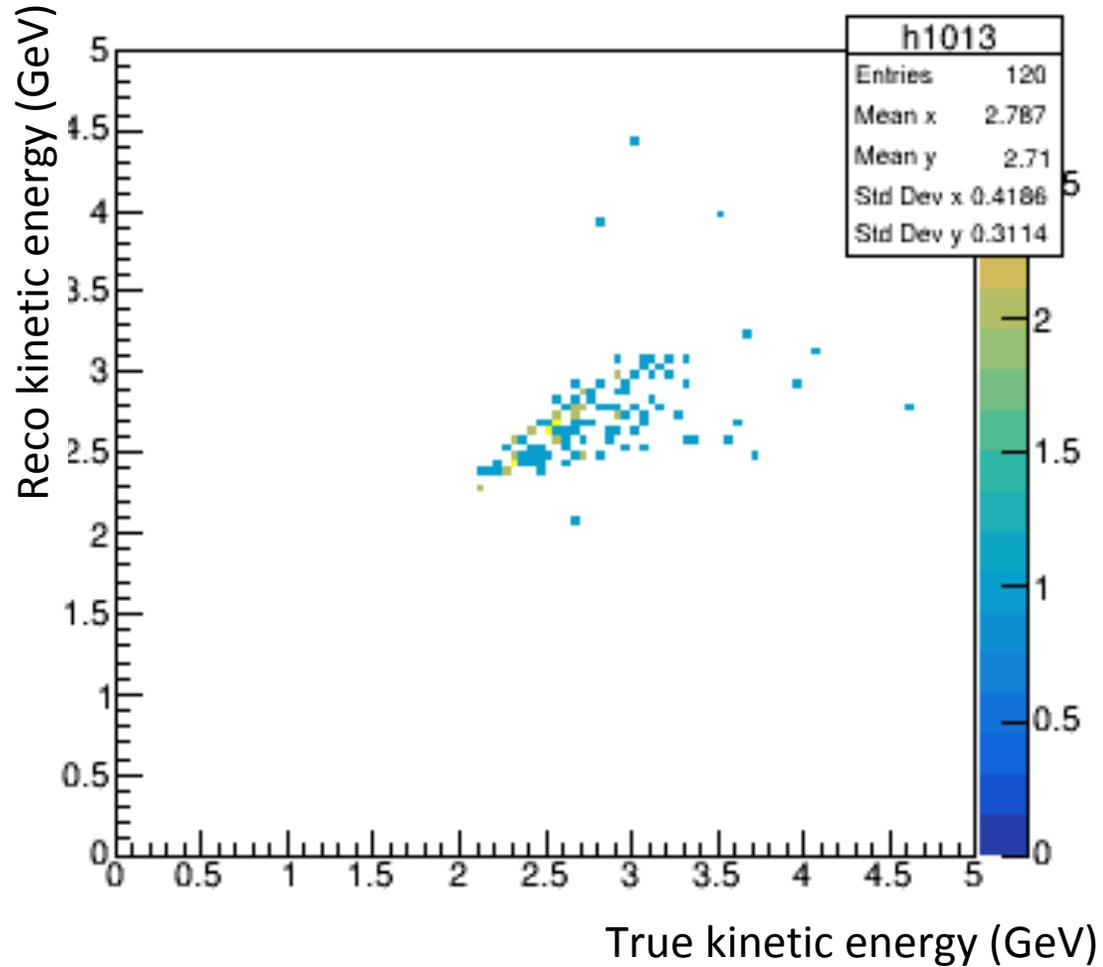
# $\mu$ stopping in the muon ranger ( $\sim 47\%$ )



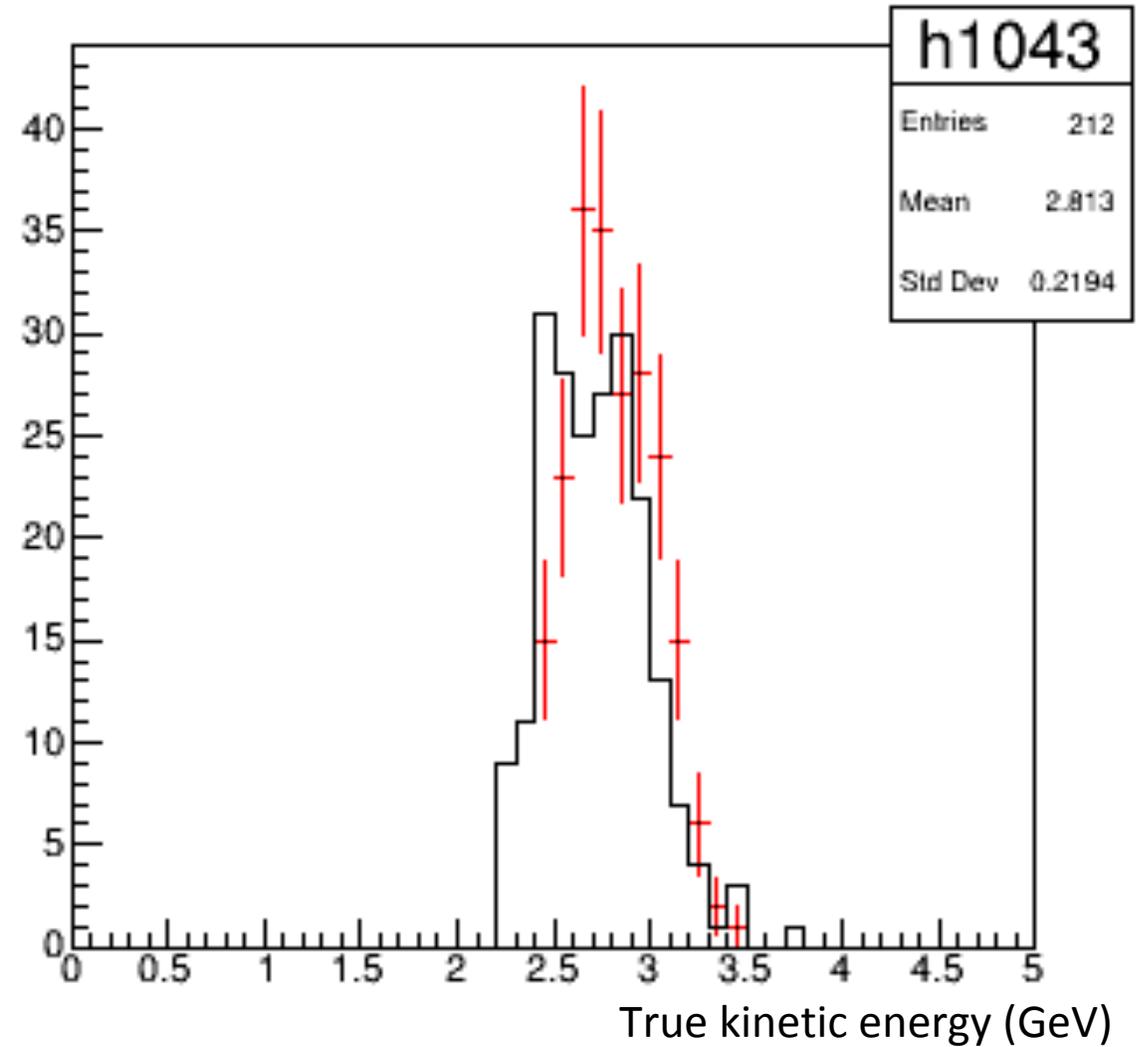
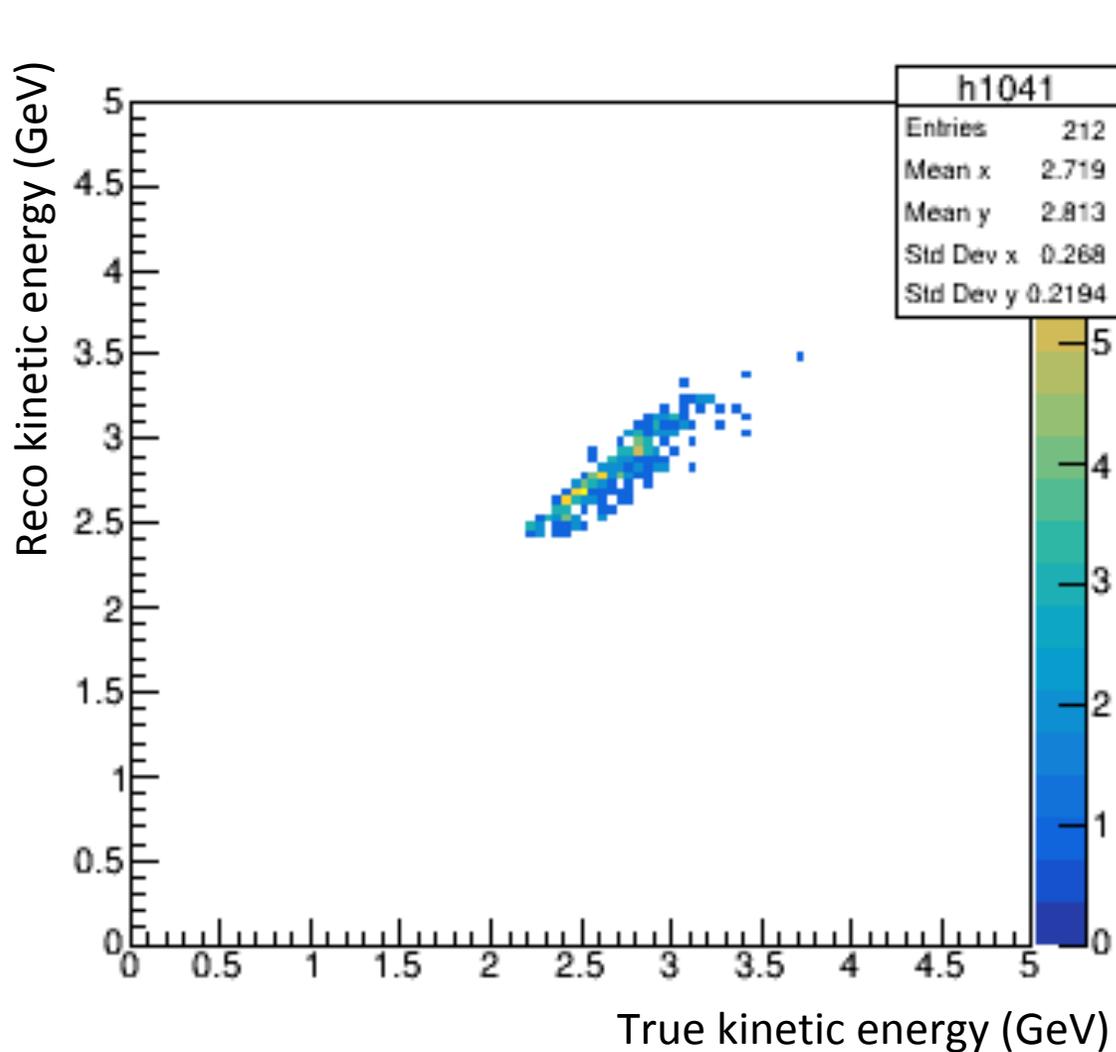
# Stopping in Yoke ( $\sim 5\%$ )



# Stopping in the cryostat ( $\sim 0.7\%$ )

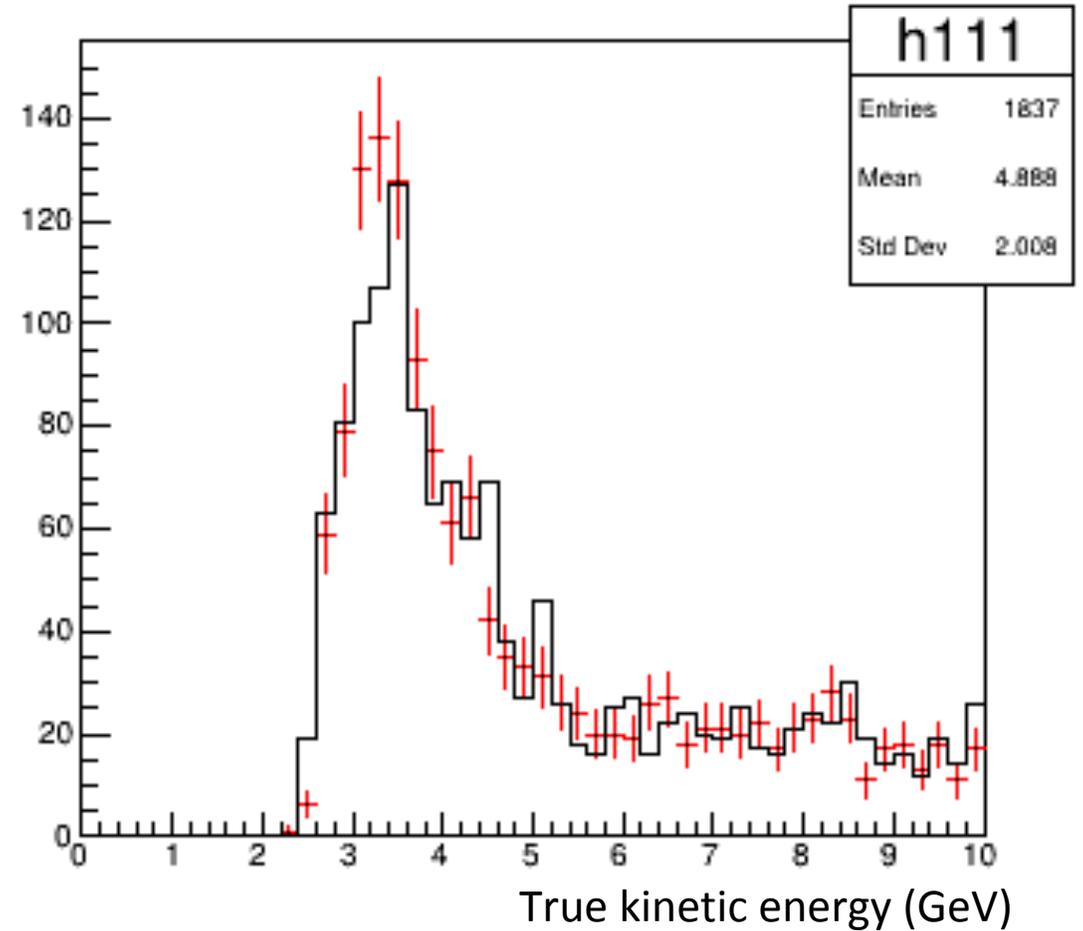
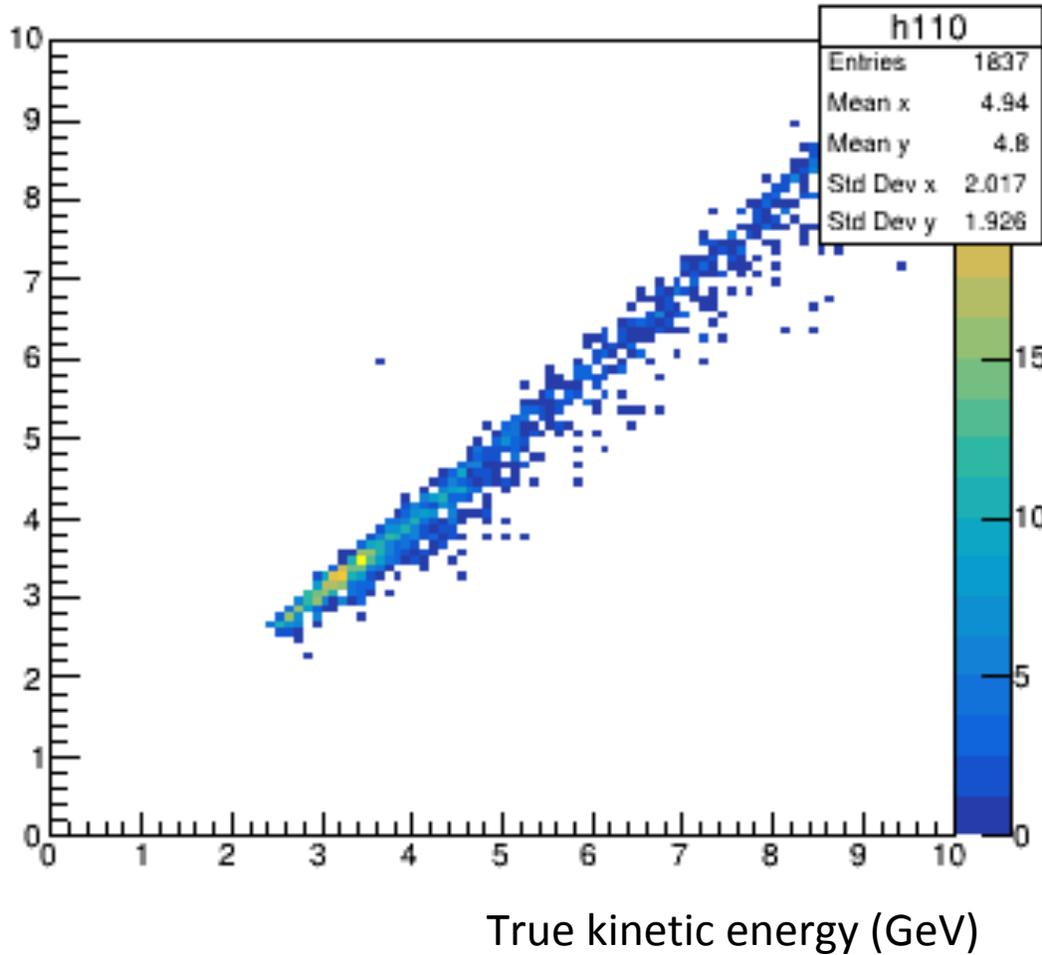


# Stopping in the Calorimeter ( $\sim 1.2\%$ )

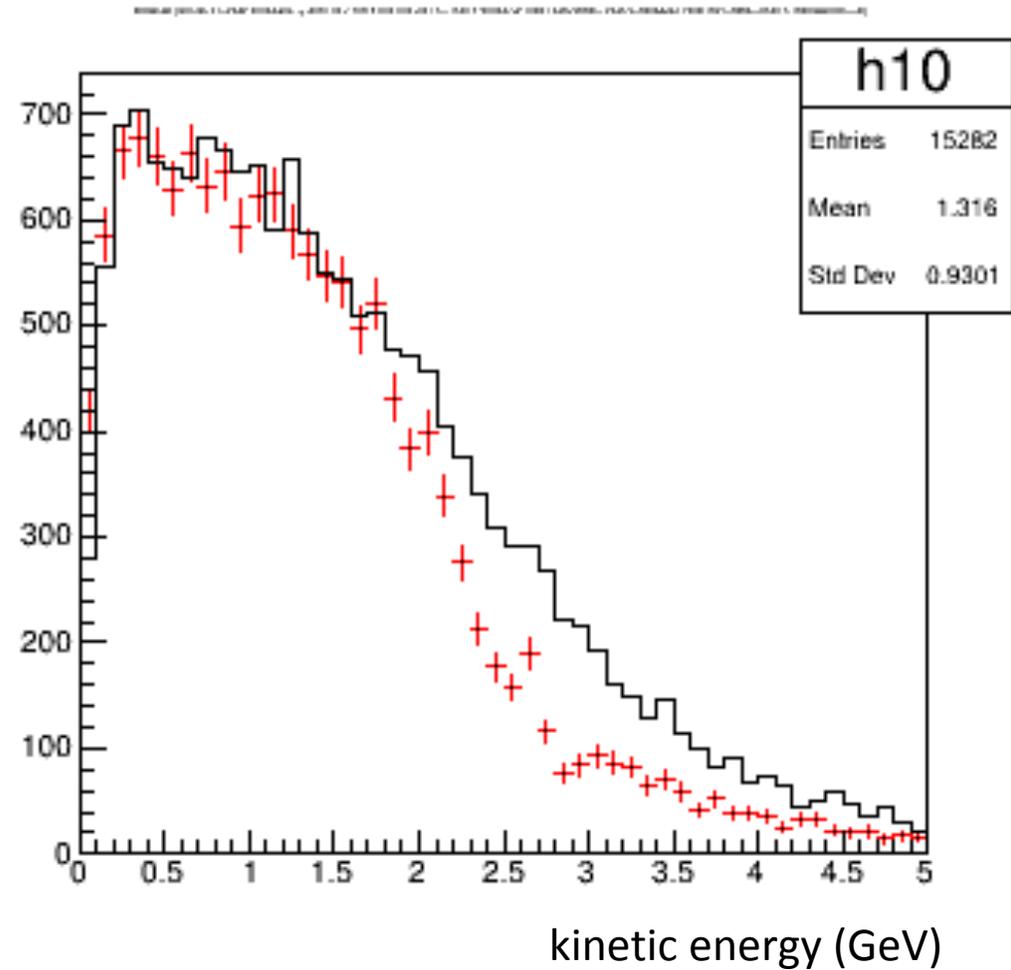
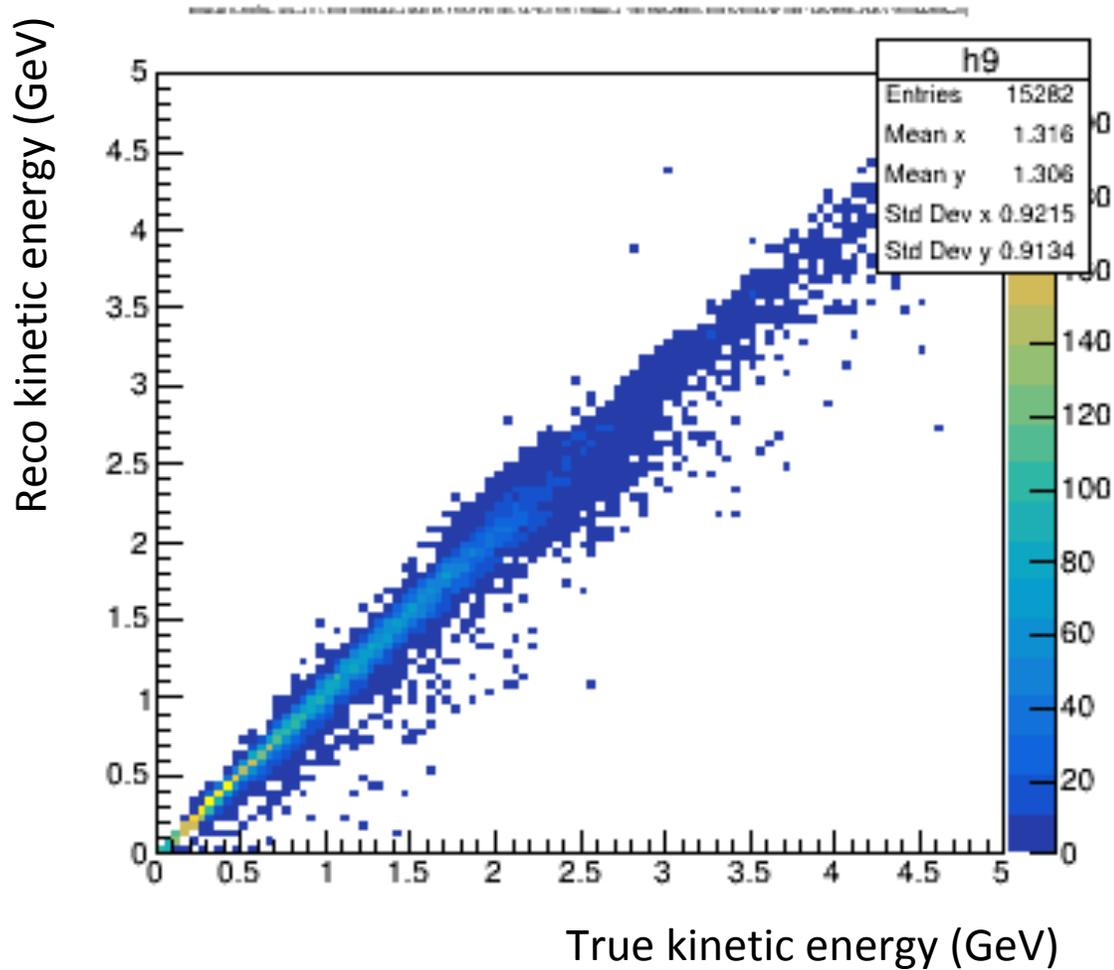


# Going through the STT (~ 10%)

Reco kinetic energy (GeV)

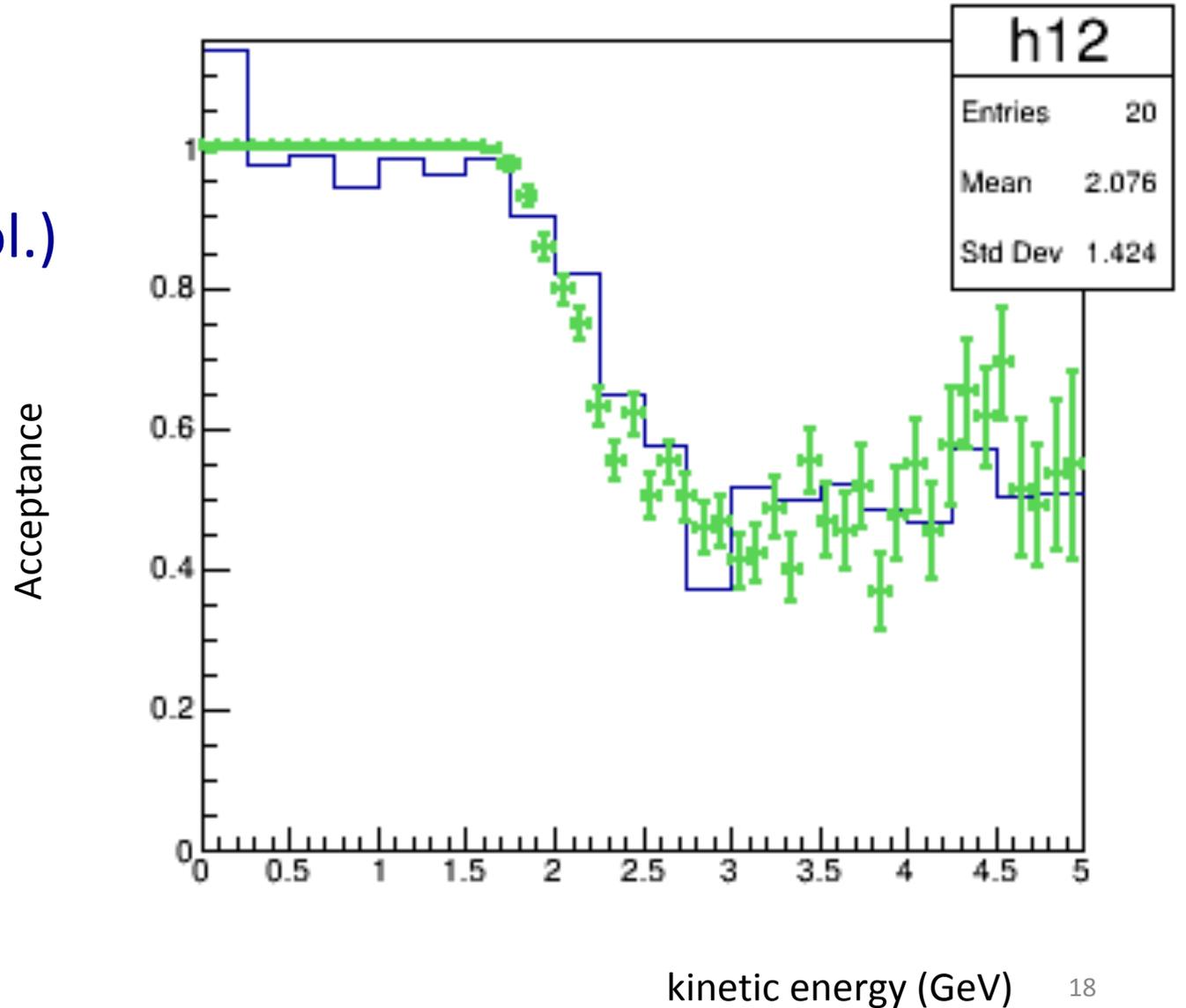


# All together (~ 85%)



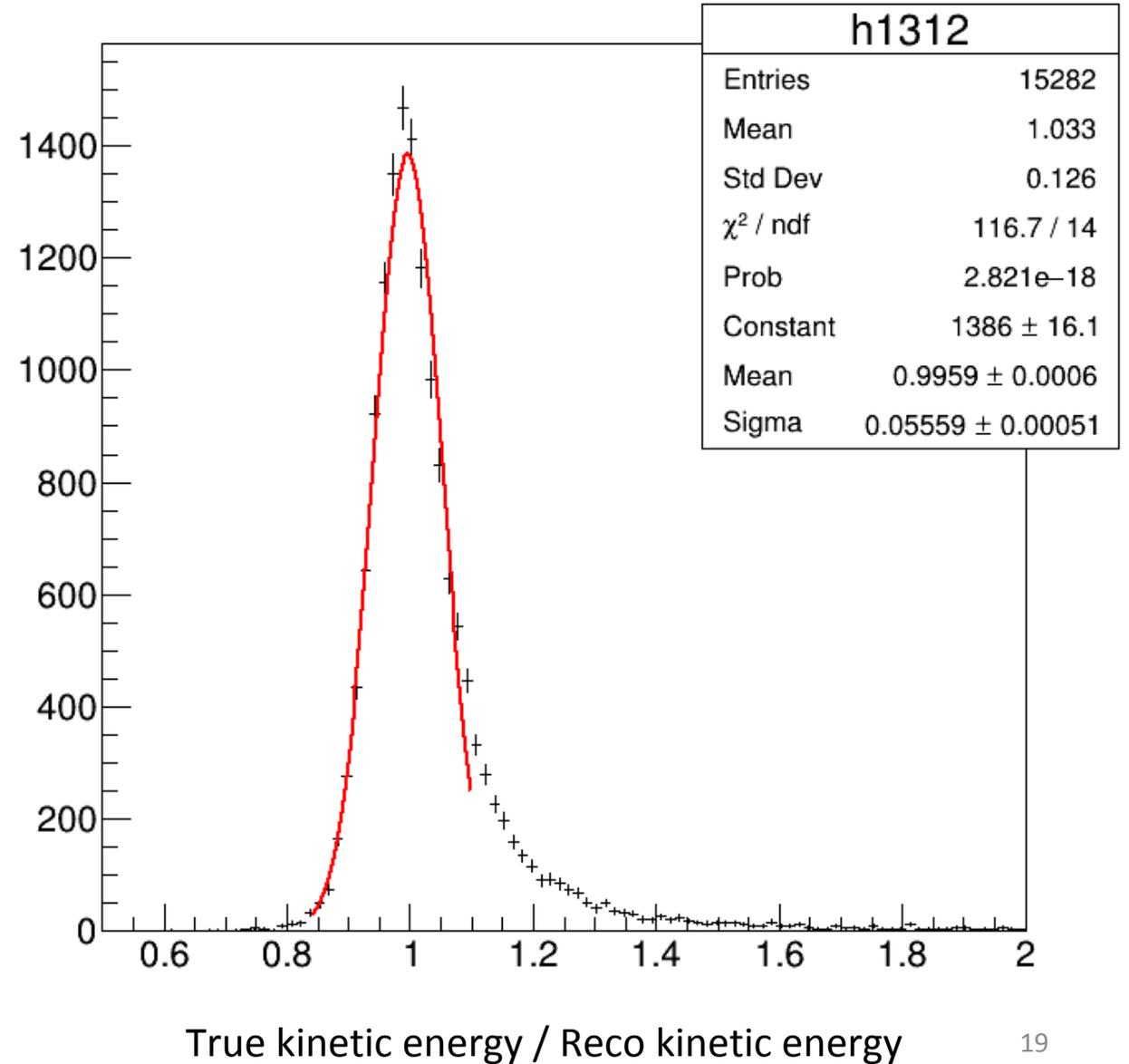
# Acceptance

- Acceptance =  $(\text{Stop} + \text{Stt}) / (\text{AC fiducial vol.})$
- True kinetic energy
- Reco kinetic energy



# Overall resolution

$$\sigma_E/E \sim 5.5 \%$$



... as a consequence

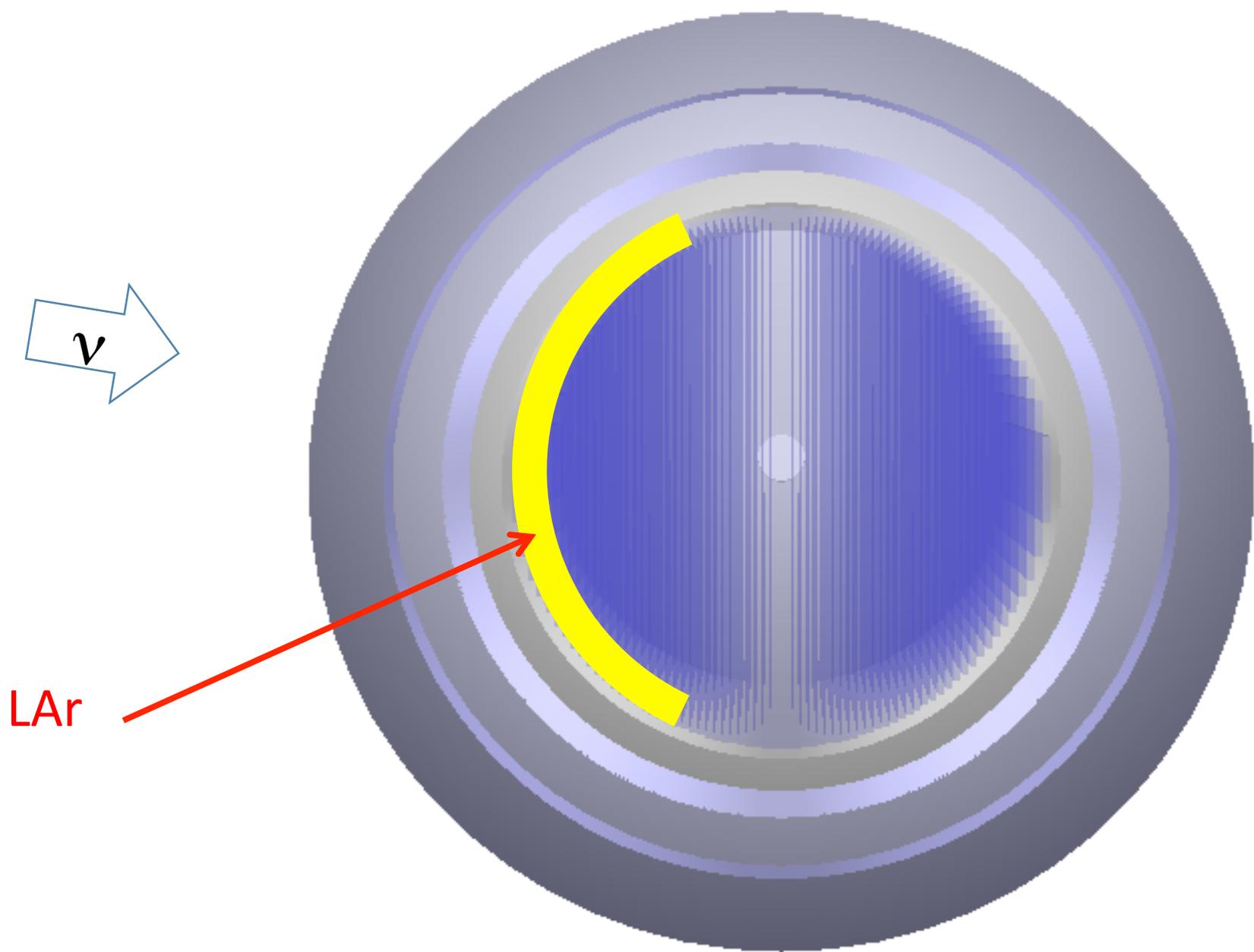
- **We strongly disagree with the recommendation**
- We propose to continue the study of the KLOE option, until proven insufficient for the physics requirements of a Hybrid Near Detector

To this extent, quoting Alfons:

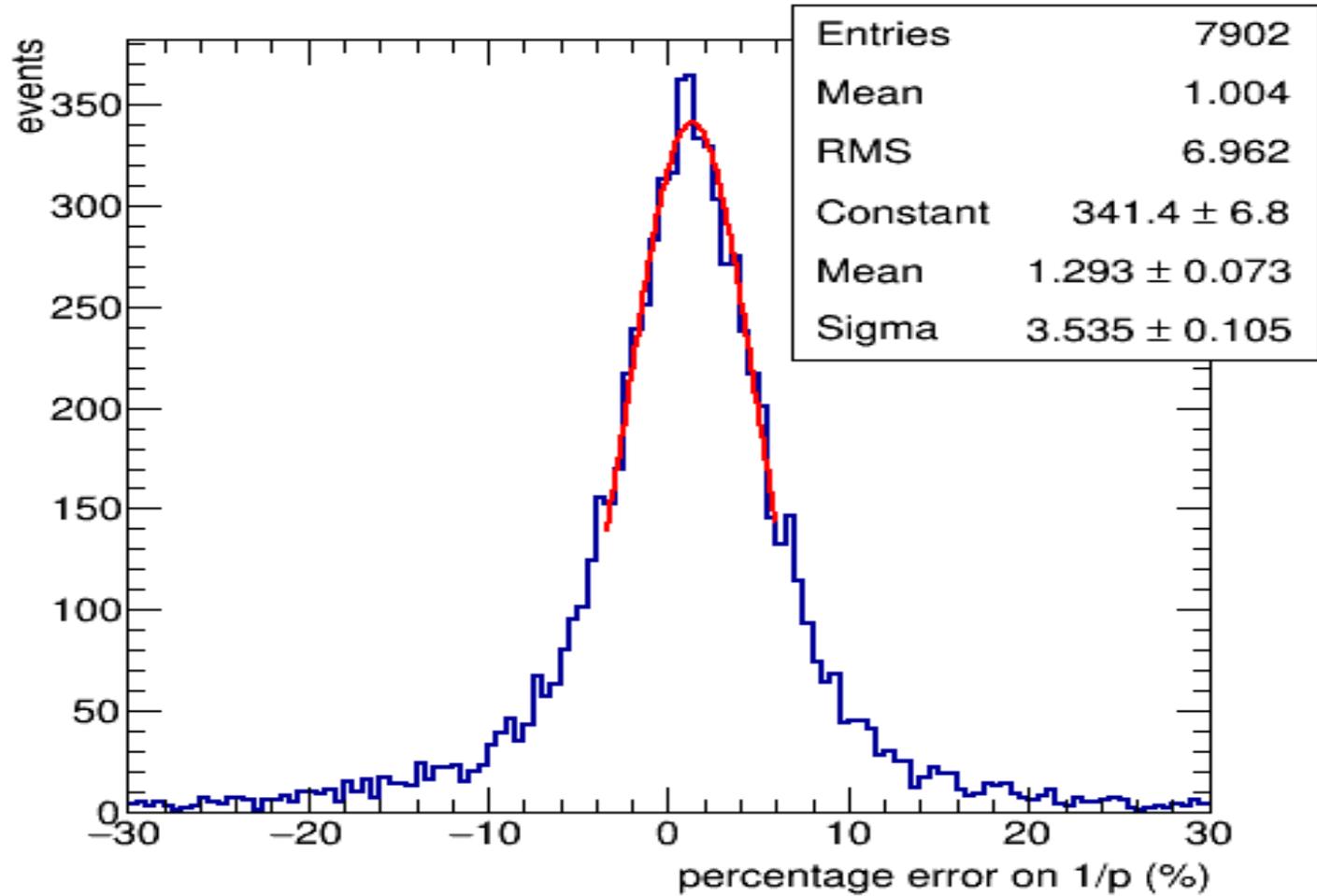
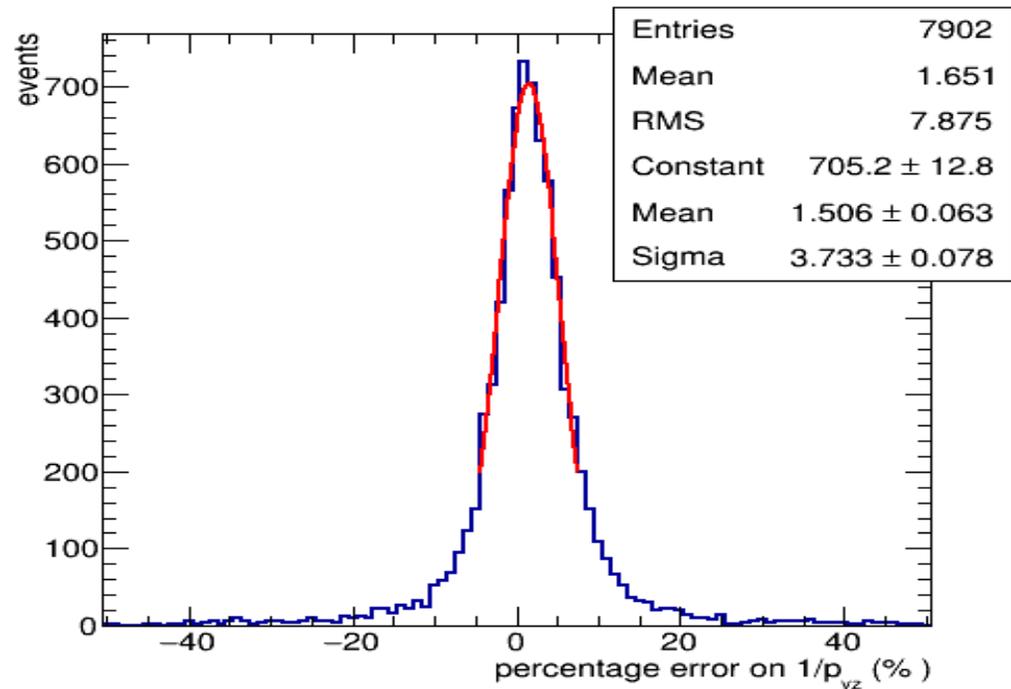
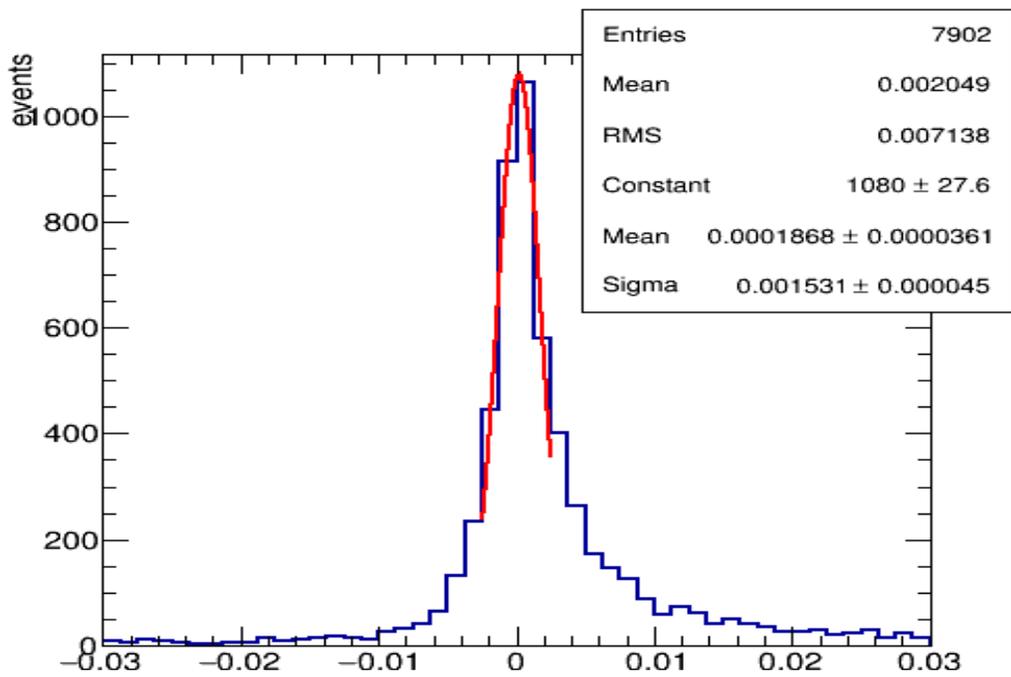
$$\frac{\frac{dN_{\nu_e}^{far}}{dE_{rec}}}{\frac{dN_{\nu_\mu}^{near}}{dE_{rec}}} = \frac{\int P_{\nu_\mu \rightarrow \nu_e}(E_\nu) * \phi_{\nu_\mu}^{near}(E_\nu) * F_{far/near}(E_\nu) * \sigma_{\nu_e}^{Ar}(E_\nu) * D_{\nu_e}^{far}(E_\nu, E_{rec}) dE_\nu}{\int \phi_{\nu_\mu}^{near}(E_\nu) * \sigma_{\nu_\mu}^{Ar}(E_\nu) * D_{\nu_\mu}^{near}(E_\nu, E_{rec}) dE_\nu}$$

we intend to progress in the study of KLOE + STT introducing :

- a thin ( $\leq 1X_0$ ) LAr target inside the magnetic volume
- the digitization of energy and time response of the calorimeter
- more refined reconstruction algorithms
- .....



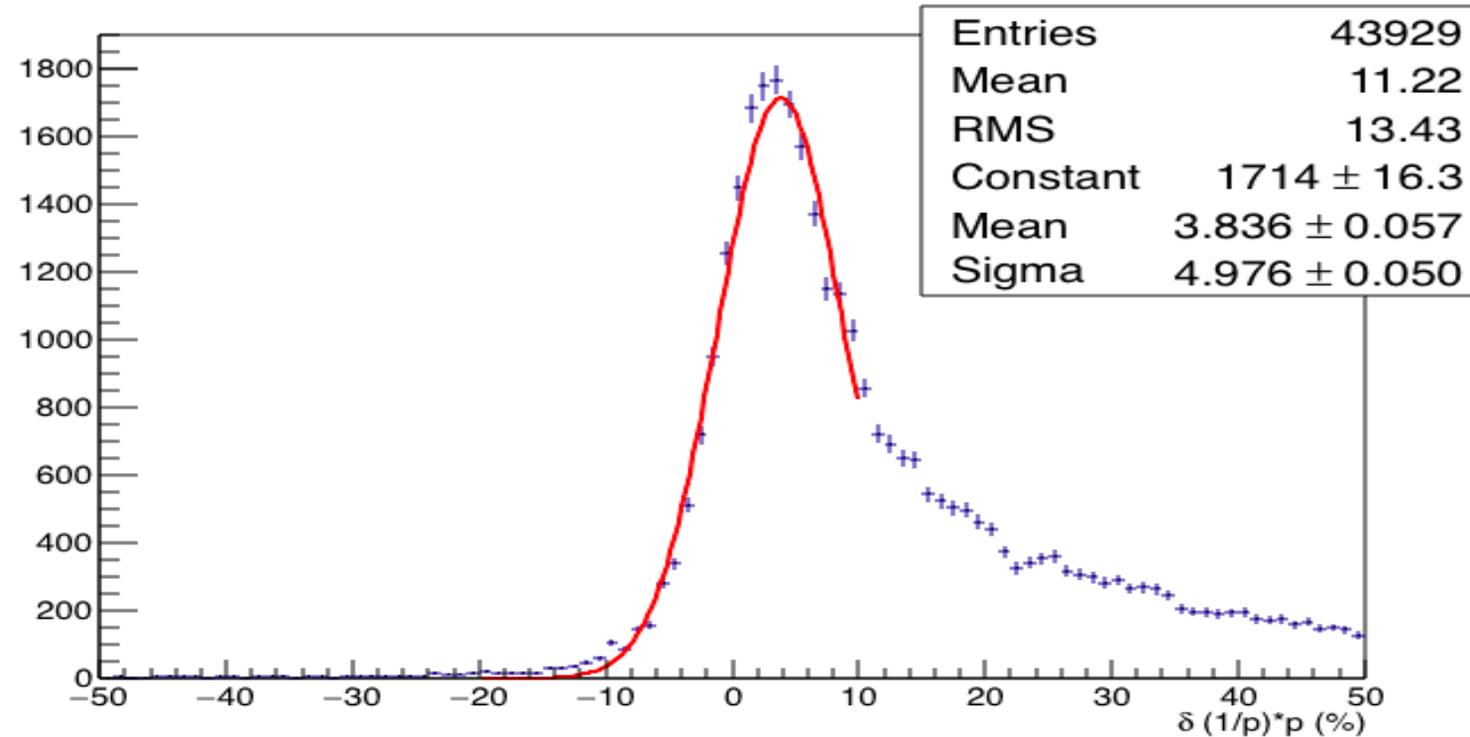
# CC events in the KLOE volume, muons



# Electrons: momentum resolution

GENIE+Edep-Sim

p: total momentum

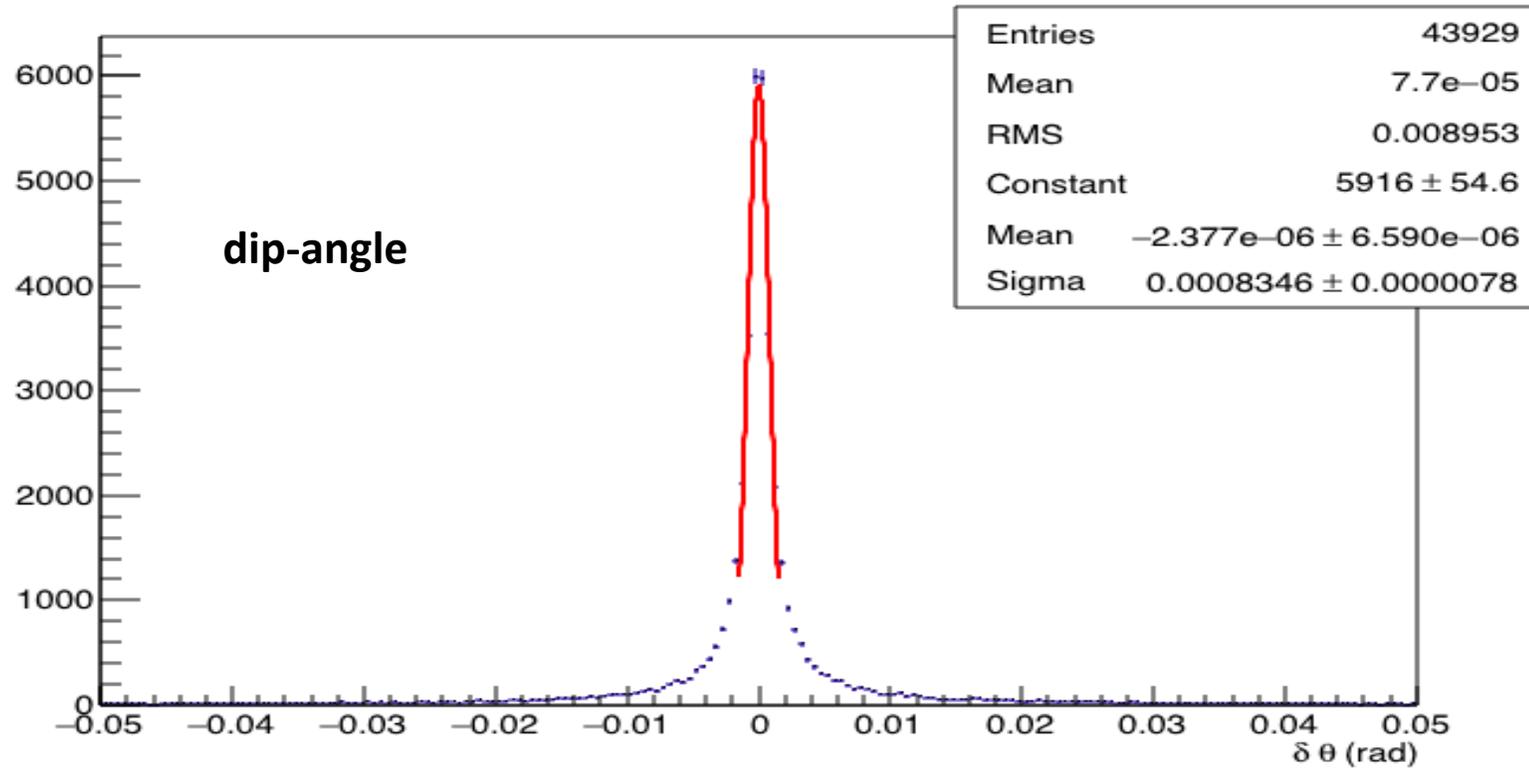


Gaussian Fit:  
Mean  $\cong$  3.8 %  
Sigma  $\cong$  5 %

$\eta = \text{wrong sign charges} / \text{all measured charges} = 0.18 \%$

# Electrons: angular resolution

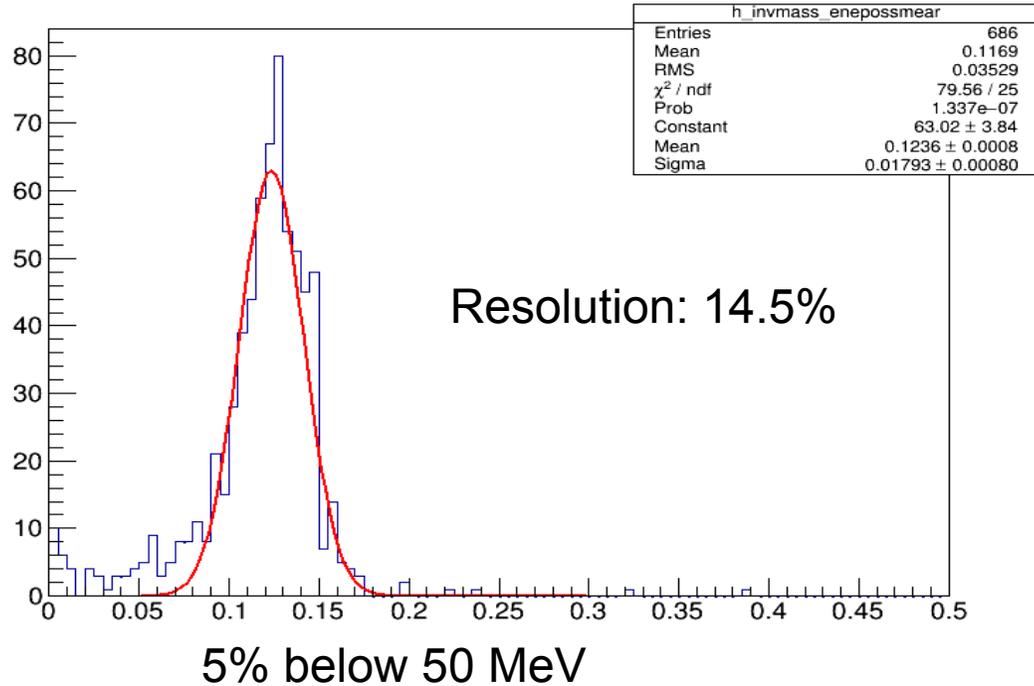
GENIE+Edep-Sim



Gaussian Fit on  $\theta$ :  
Mean  $\cong$  0 mrad  
Sigma  $\cong$  0.8 mrad

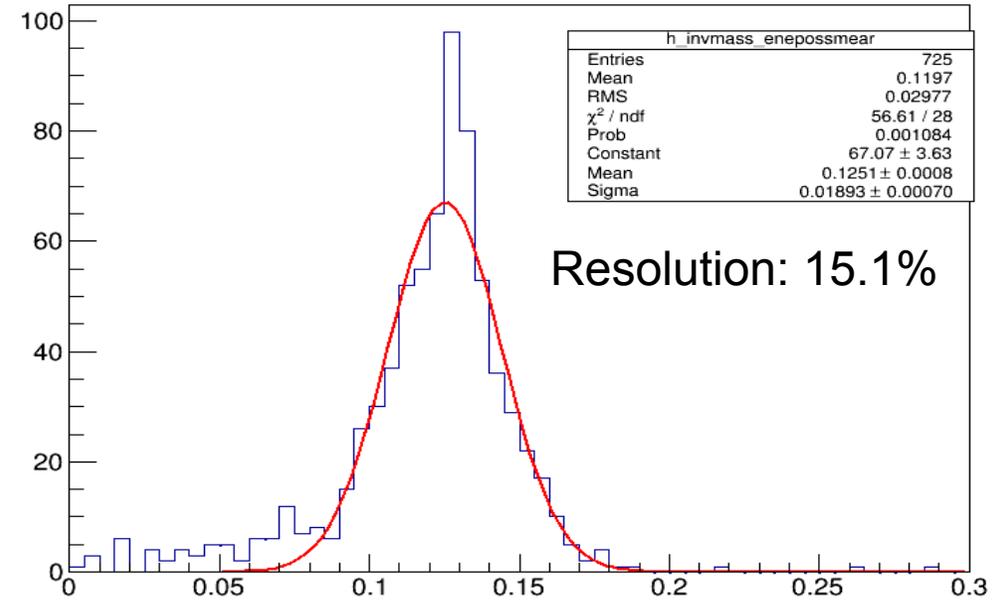
# $\pi_0$ Invariant mass

rec invariant mass with smeared pos and ene



$\Delta x < 20$  cm and  $\Delta\phi < 5$  deg.

rec invariant mass with smeared pos and ene



$\Delta x < 30$  cm and  $\Delta\phi < 10$  deg.

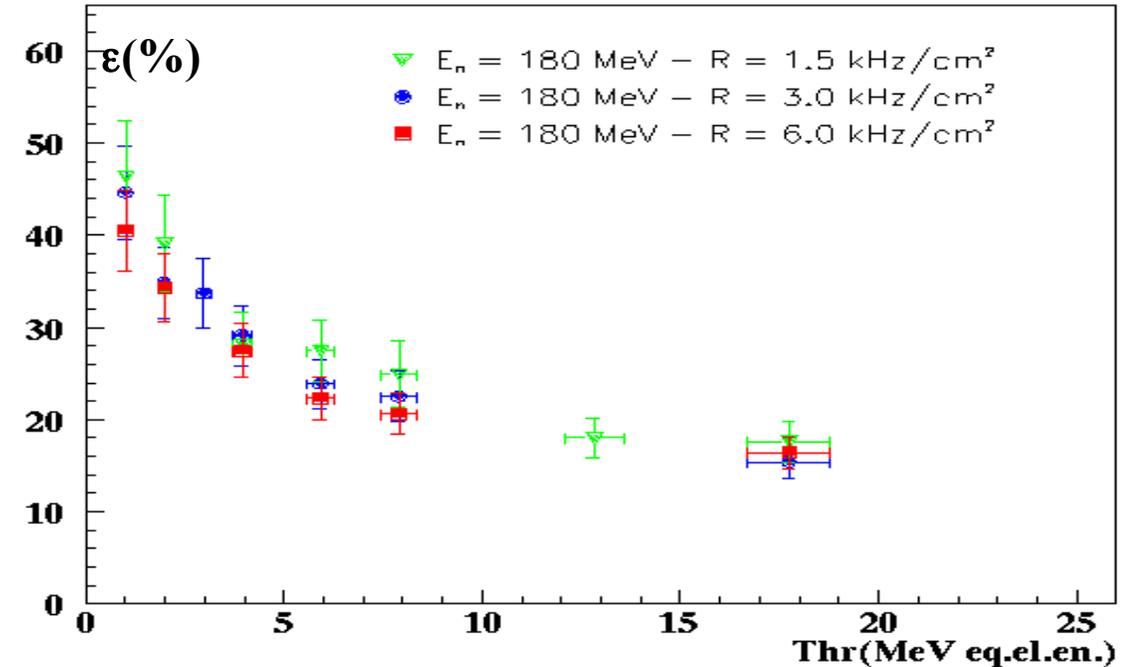
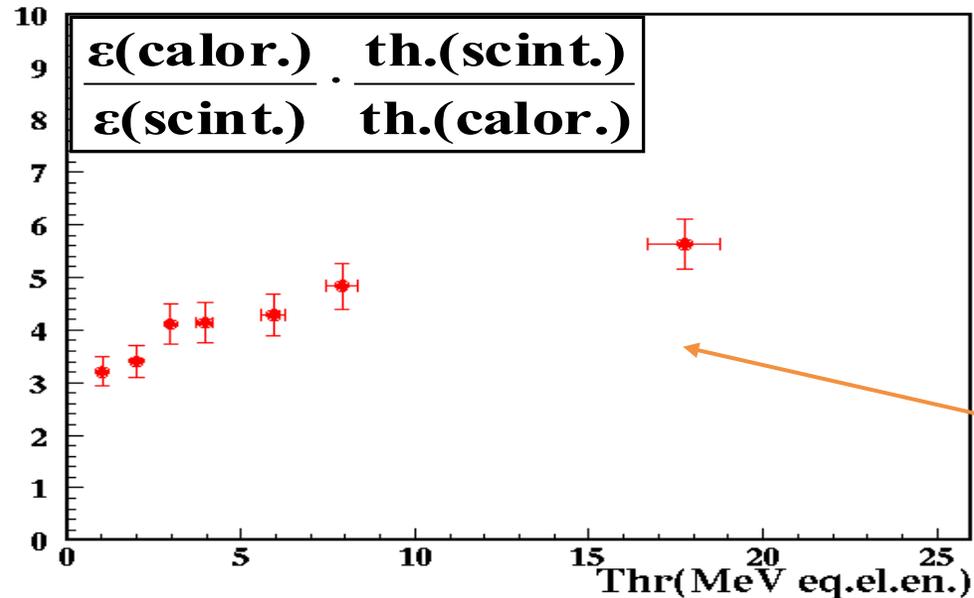
Resolution stays to about 15% but we have a low energy tail

The tail is due to either

- ✓ collinear gamma with a isolated hit from the debris of the photon shower picked up as a shower or
- ✓ gamma in calo with another gamma converted and either e- or e- rangeout

# Neutron efficiency

- $E_{\text{peak}} = 180 \text{ MeV}$
- Stable for different run conditions
- Very high efficiency w.r.t. the naive expectation ( $\sim 10\%$  @ 2 MeV thr.)



Comparison with our scintillator normalized to the same active material thickness

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**THANK YOU**

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