Performance of ALICE3-MID prototype at test beam

Antonio Paz

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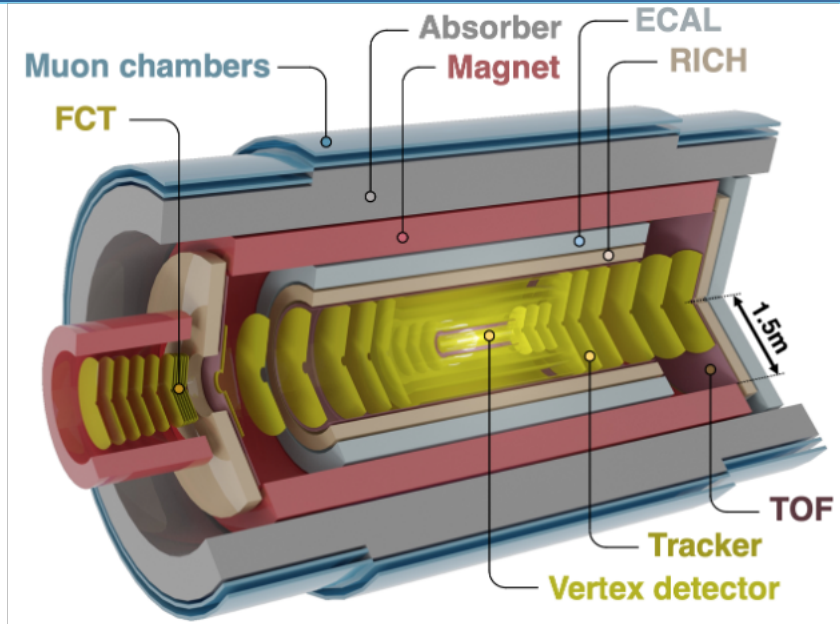
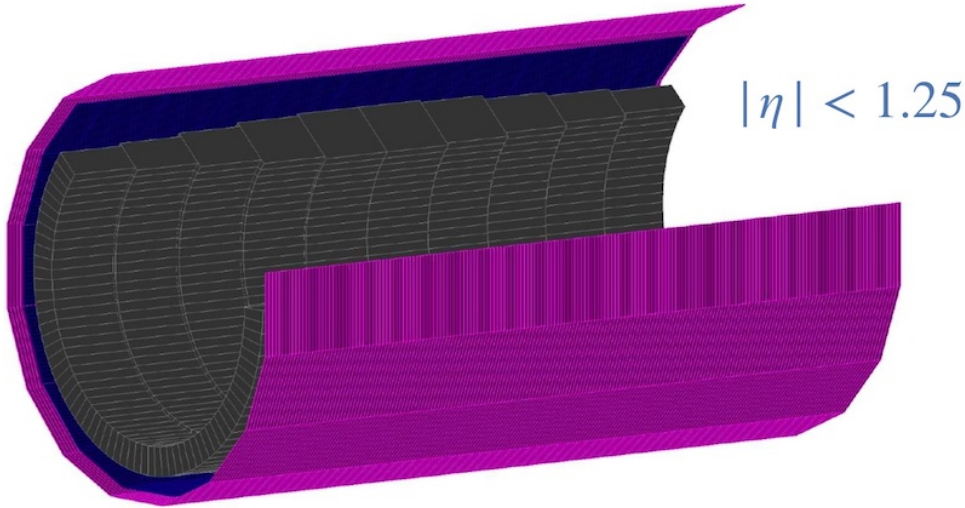
ALICE Mexico Day

MID overview

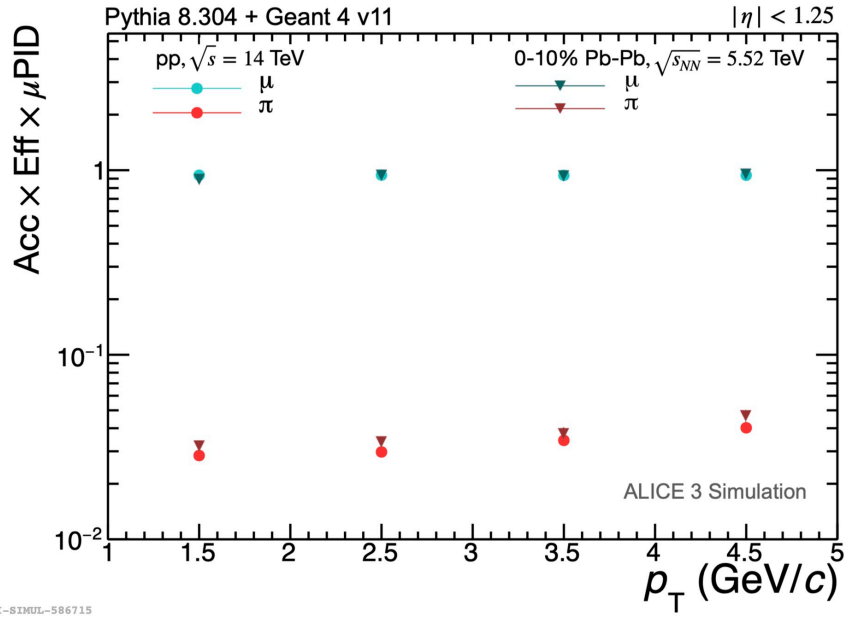


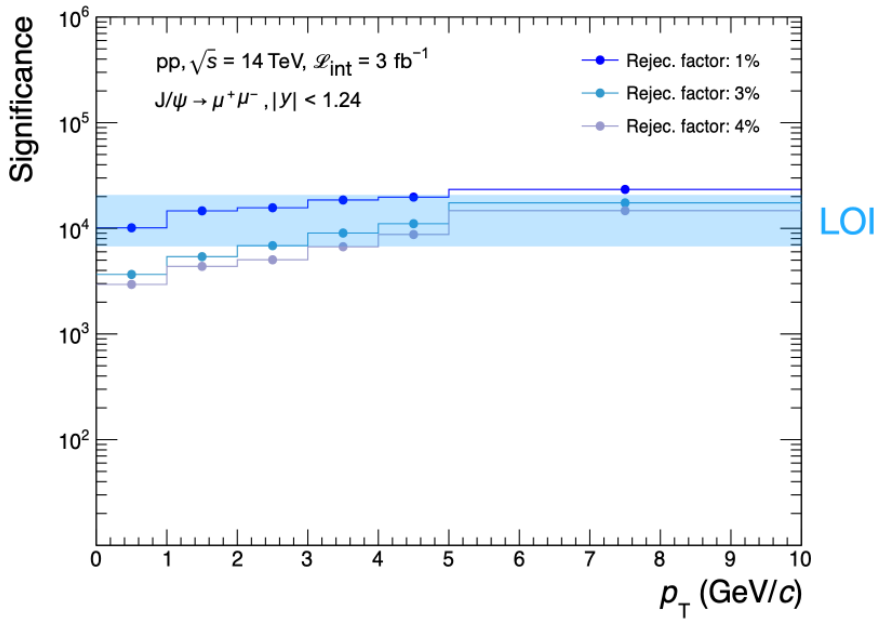
- ALICE has unique capabilities in LHC Runs 5 (ATLAS and CMS: J/ψ >6.5 GeV/c)

- Reconstruct J/ψ down to p_T= 0 ($|y| < 1.24$) in dimuon decay channel
  - Muons down to $p \approx 1.5$ GeV/c at $\eta \approx 0$



ML : Pb-Pb and pp performance





- Muon efficiency 94% for $p_T > 1.5$ GeV/c. Pion rejection at 3-5%
- Pb-Pb rejection factor slightly above the pp rejection factor

- It is above 1000 for rejection factor 4%

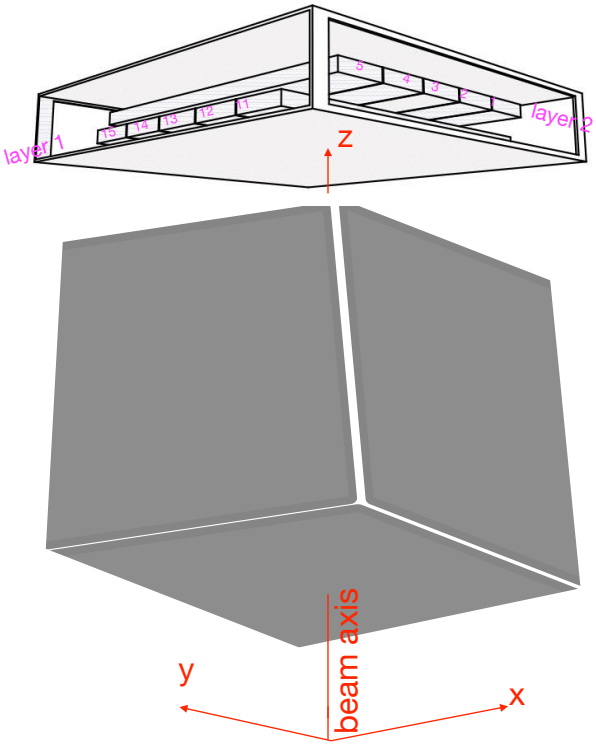
Simulations by Jesús Muñoz
(see presentation at ALICE week)

Prototype design

Scintillator based prototype for MID

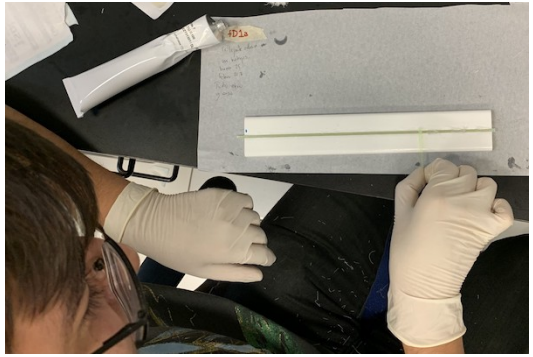
- Extruded plastic scintillator from FNAL-NICADD (low cost, together with WLS fiber offers a good solution for MID, see: R. Alfaro et al., JINST 19 (2024) 04, T04006)
- Hamamatsu SiPMs (serie 13, 3x3mm^2 and 6x6 mm^2)
- 10 channels, bars 4x1x25 cm^3.
  Active area 20x20 cm^2
- Iron absorber, traverse area 60x60 cm^2, different lengths (60, 70, 80, 90, 100 cm)
- Readout: CAEN DT5202

reference for MID



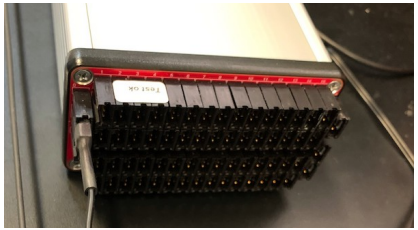
Construction and readout

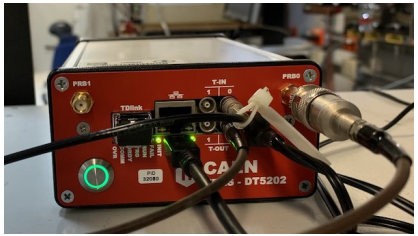
- Fermilab bars
- Fiber 1.5mm Kurarai
- Optical grease (bluesil Paste 7)



Construction and readout

- CAEN DT5202 readout
  - 64 ports
  - Voltage tunable for each port
  - Reading modes: spectrogram, ToT





Setup

Beams:

μ, π

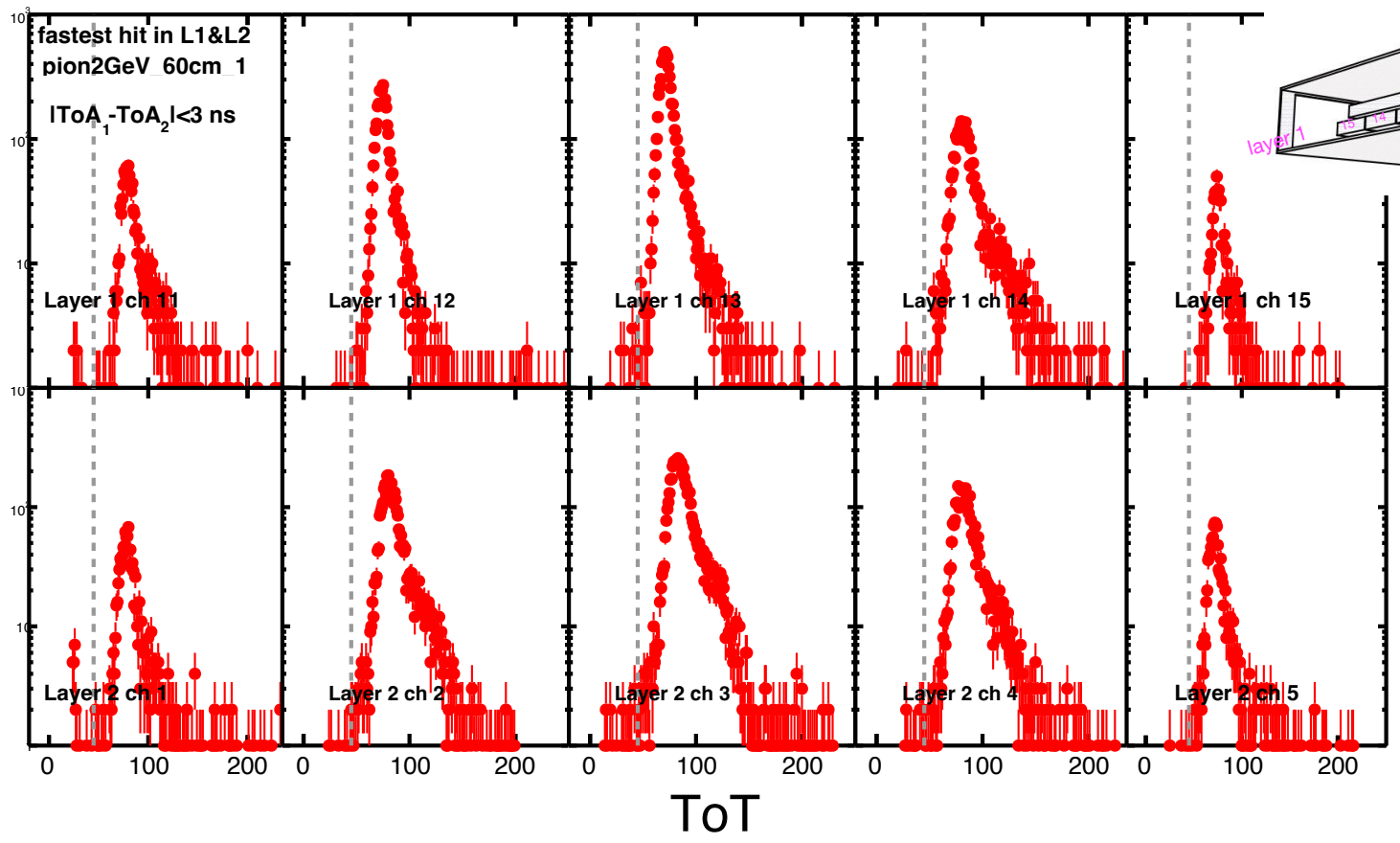
(p=2,3,6 GeV/c)

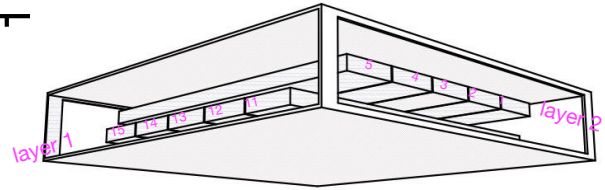
BUAP - THREE BARS

Prototype testing preliminary results (test beam 2024, october 9-16)

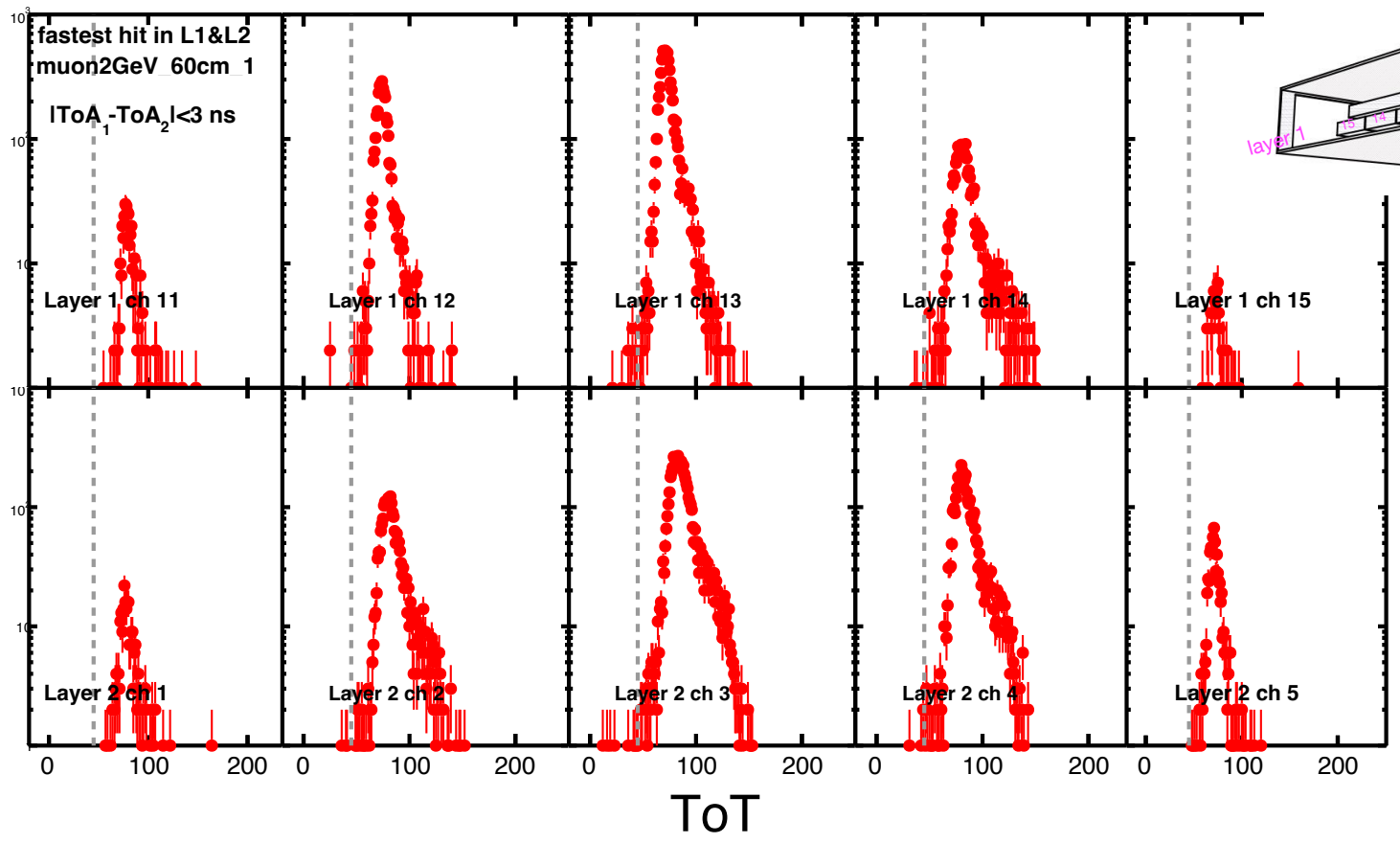
Pion enriched beam, *p*=2 GeV/*c*, abs 60 cm

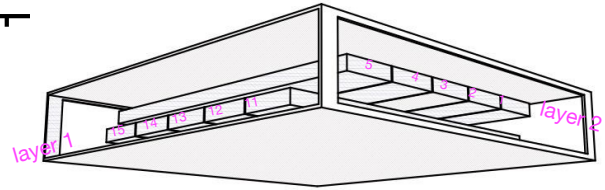
Selected hits (MIPs)





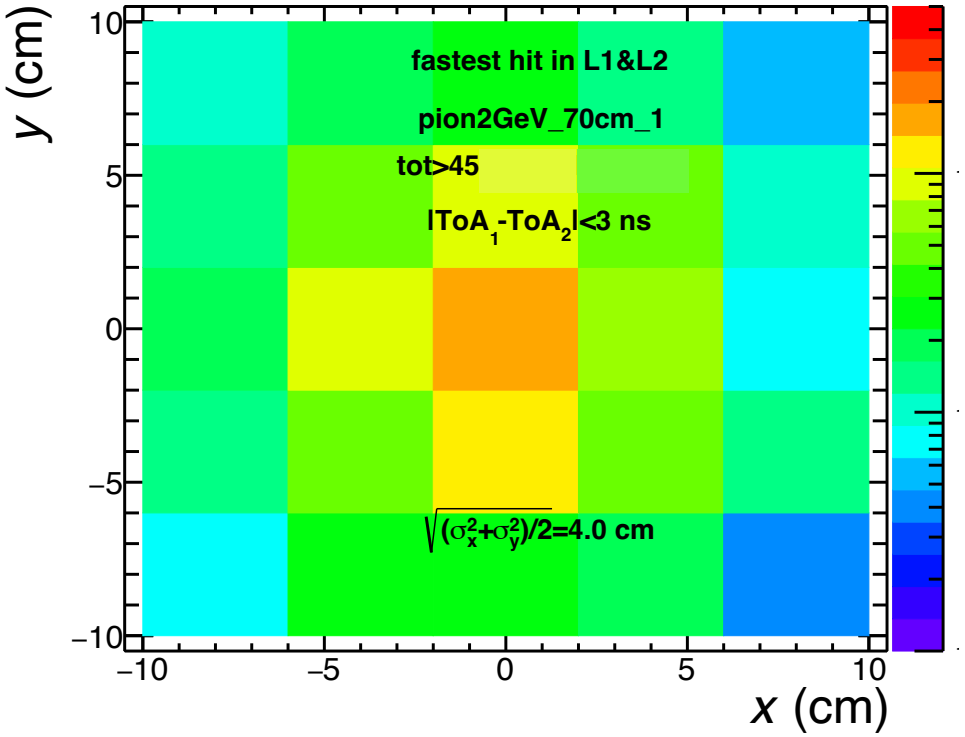
Muon enriched beam, p=2 GeV/c, abs 60 cm



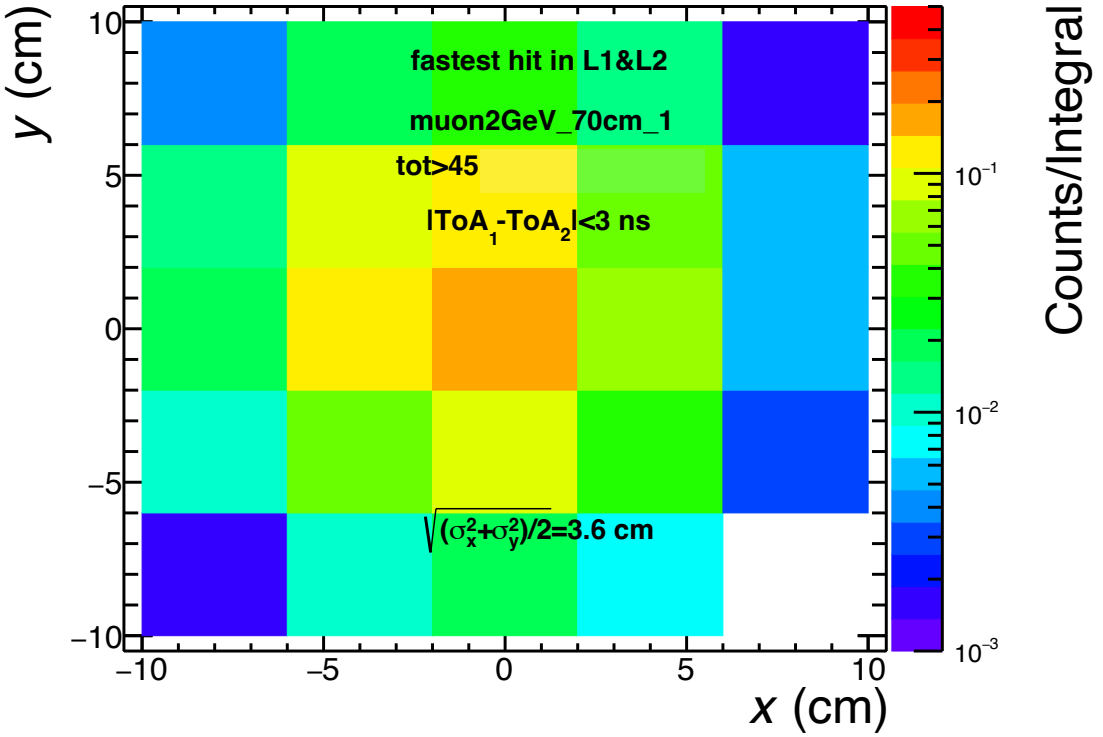


p=2 GeV/c, abs 70 cm

pion beam

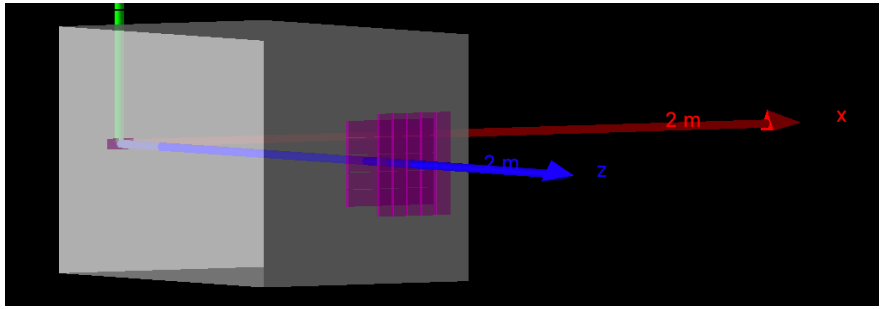


muon beam



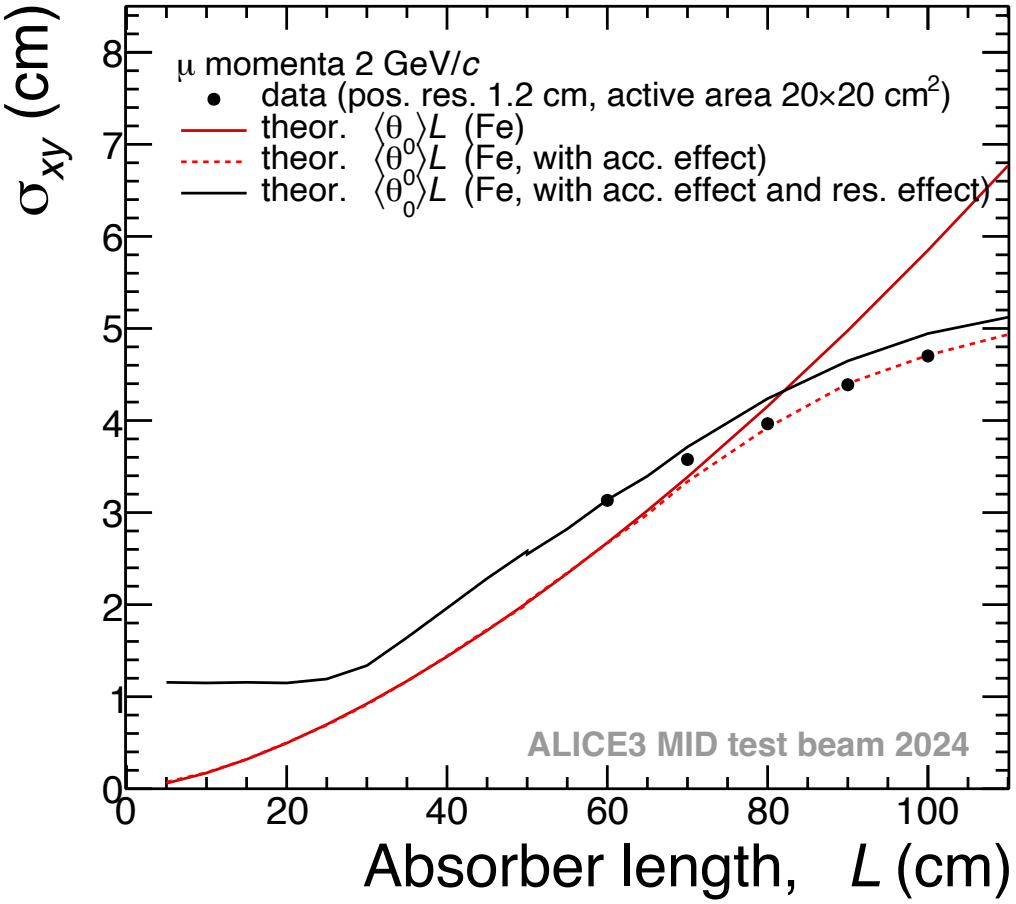
MC toy model

- Particle guns, perfect alignment
- Gap between bars: 2 mm
- Gap between layers: 10 cm.
- Gap chamber-absorber: 10 cm

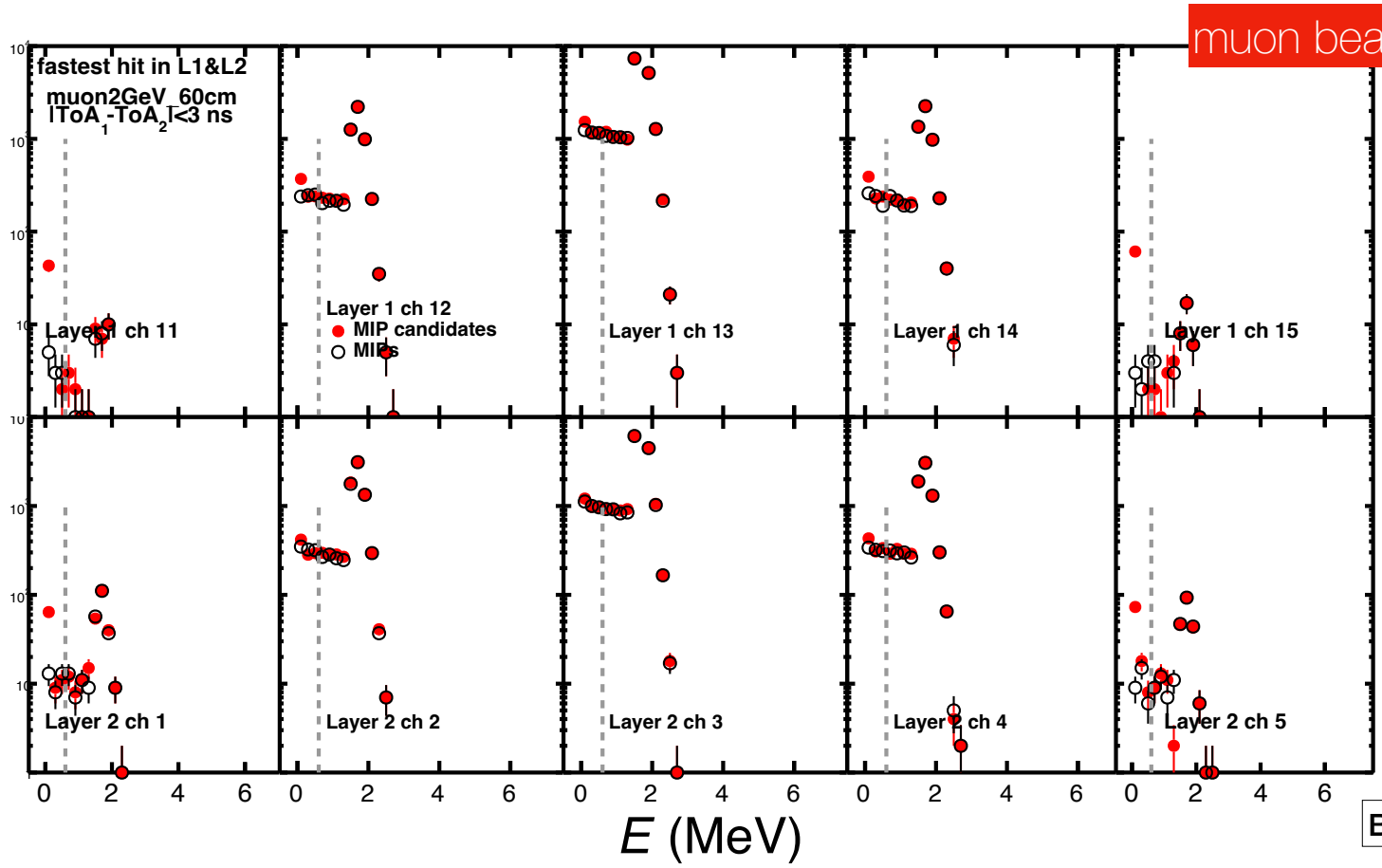


Scattering can be observed

- Remaining difference (data to MC toy) probably due to misalignment



Muon MC simulations p=2 GeV/c, abs 60 cm



Hits produced by muons

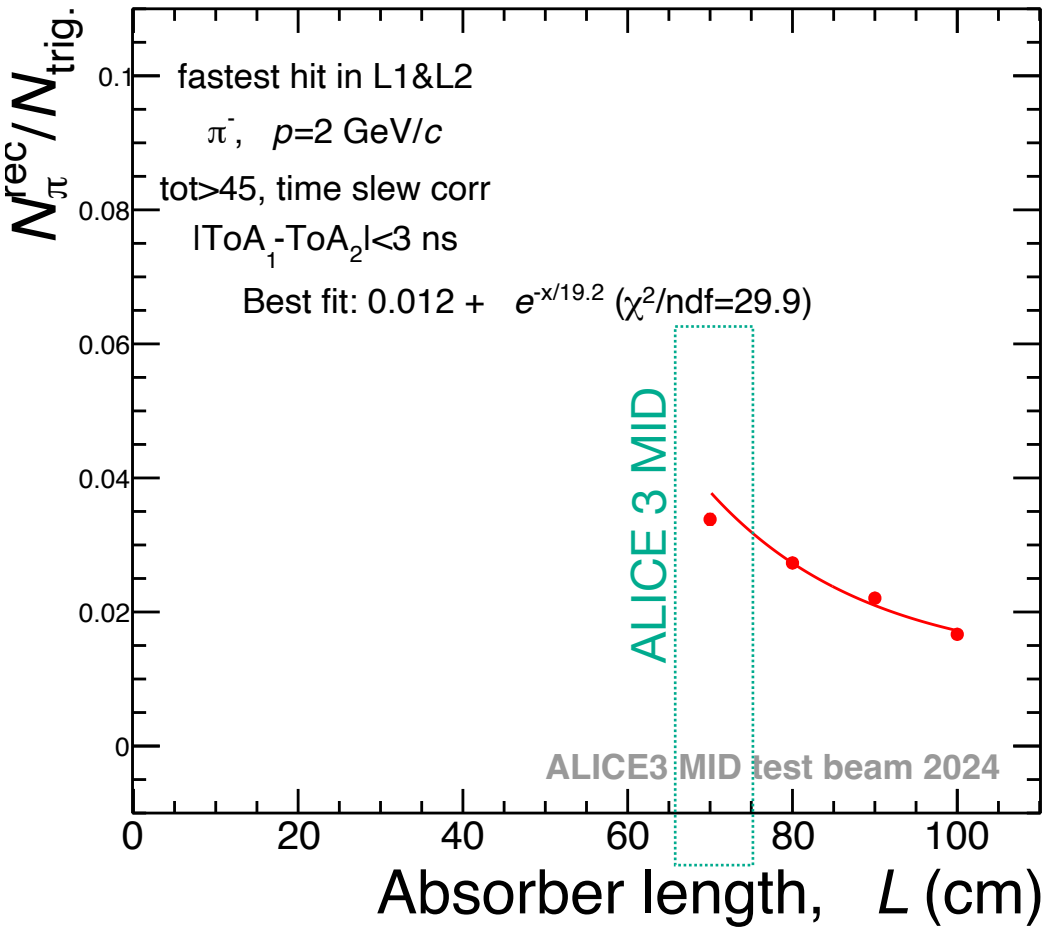
muon candidates (similar selection criteria as data)

Red: timing cuts

Black: muons hits (no timing cu

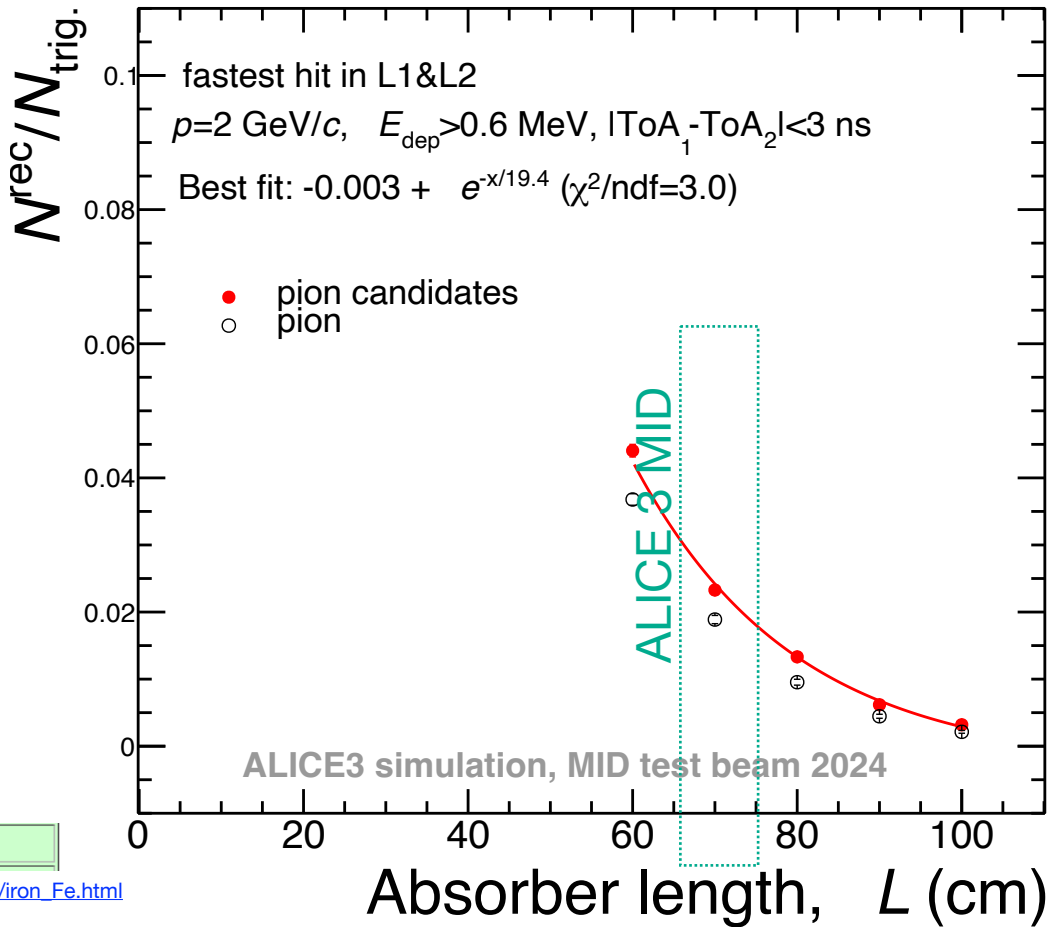
Hadron suppression, Data (2 GeV)

- Differences by:
  - Muon contributions
  - Energy distribution



Hadron suppression, MCtoy (2 GeV)

- Acceptance has to be carefully evaluated with Geant 4



Nuclear interaction length	132.1	g cm^{-2}	16.77	cm

source: https://pdg.lbl.gov/2016/AtomicNuclearProperties/HTML/iron_Fe.html

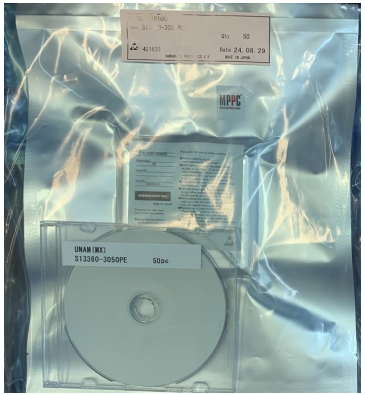
Summary and future plans

Summary

- First attempt to simulate scintillator-based MID prototype:
  - Selection based on time cuts seems to be enough to measure hadron suppression

Summary and future plans

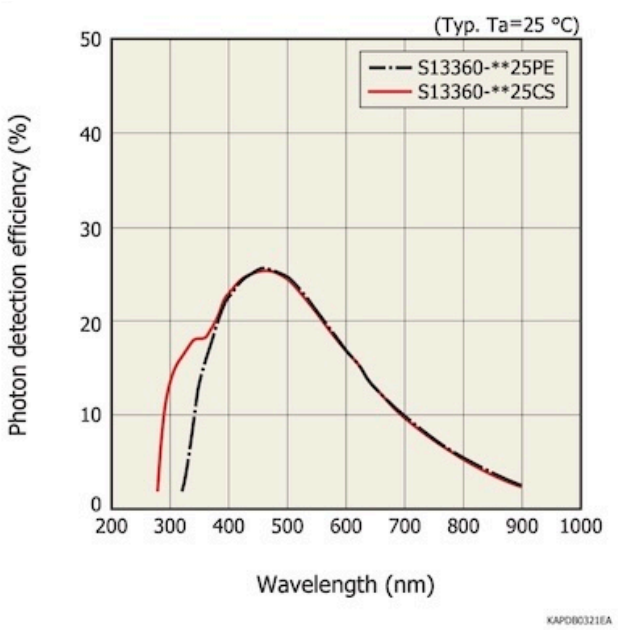
- Full size chamber for Test Beam 2025
  - 1x1m: 40 bars
  - Test fixed SiPM-bar coupling
  - Test mechanics

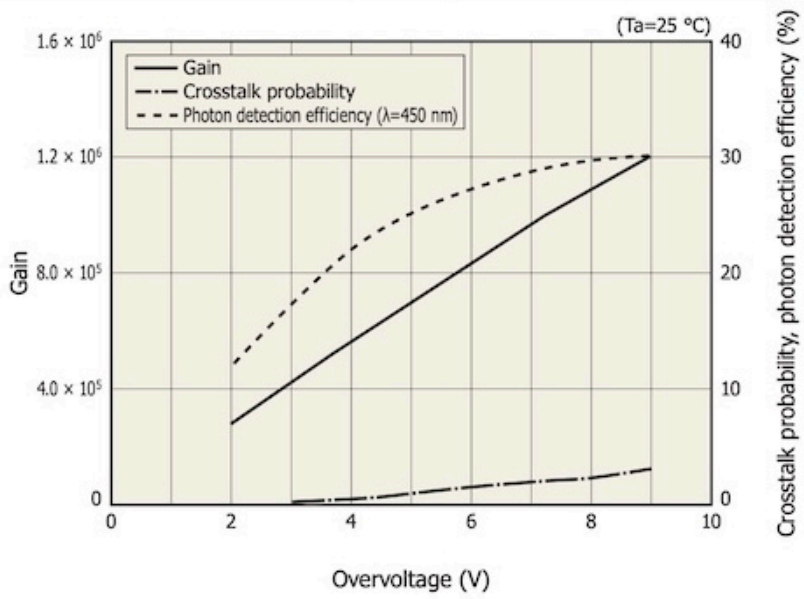


Backup

SiPM performance

- Photon detection efficiency and overvoltage specifications
-





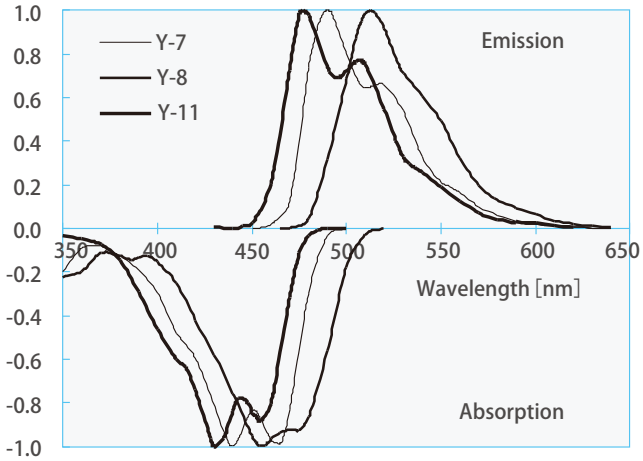
source: Hamamatsu MPC S13360 series

Kurarai fiber

- Absorption and emission spectra

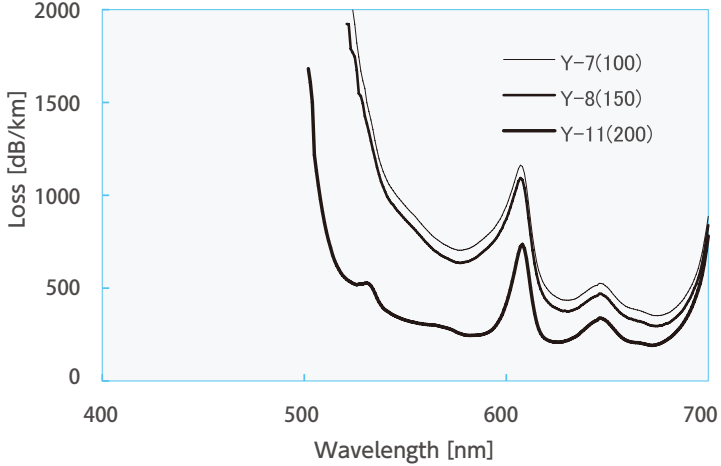
Absorption and Emission Spectra

Y-7, Y-8, Y-11



Transmission Loss

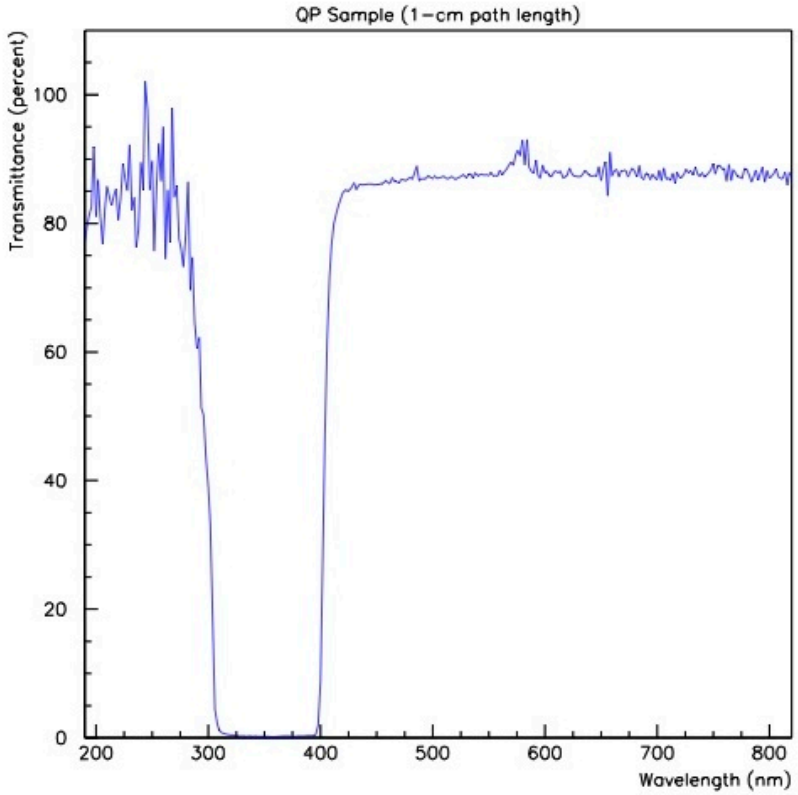
Y-7, Y-8, Y-11



source: kuraray Plastic Scintillating Fibers specs

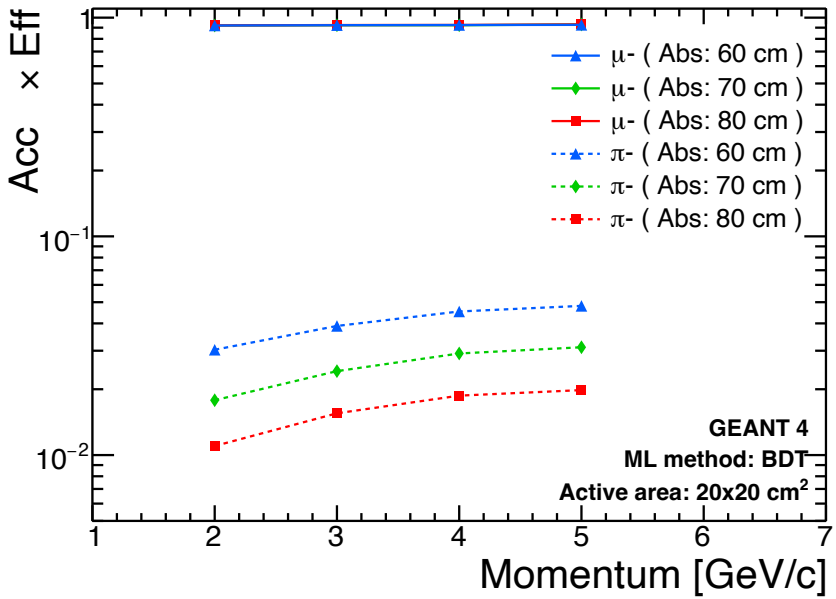
Fermilab scintillator

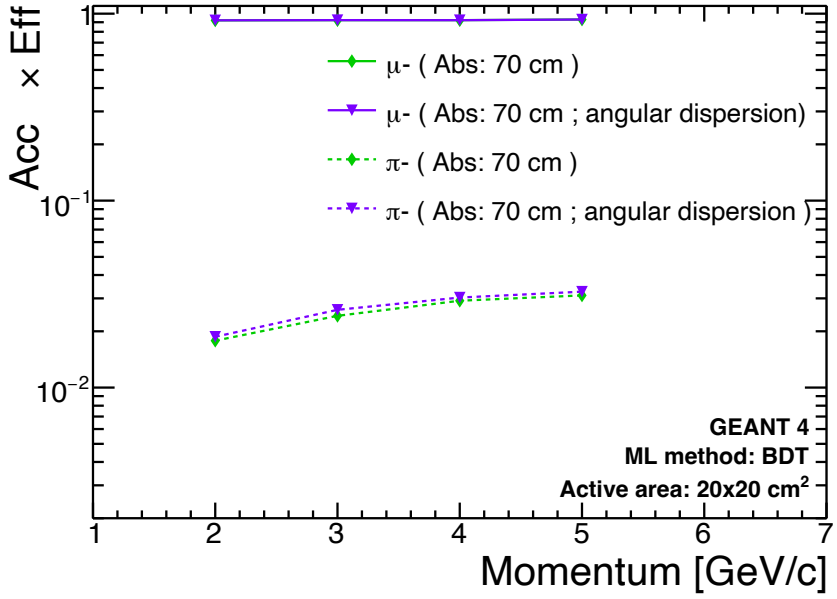
- Transmittance data



source: Fermilab technical document fermilab-pub-00-177-E

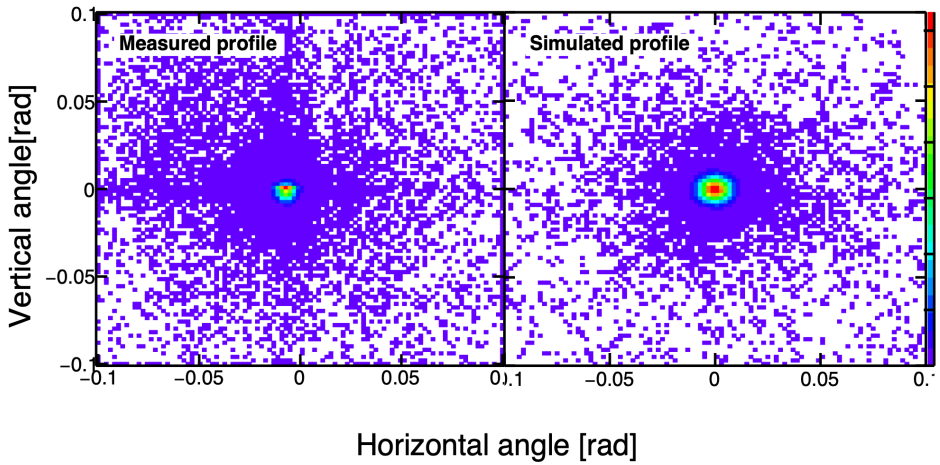
Expected hadron rejection (MC)

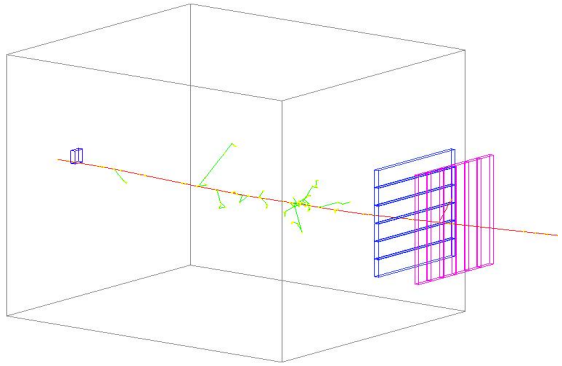




- Absorber thickness can be increased up to 80 (iron blocks will be used to test different absorber thicknesses)
- Finger triggers ensure minimal angular spread of the beam: expected effect is negligible

Beam distribution

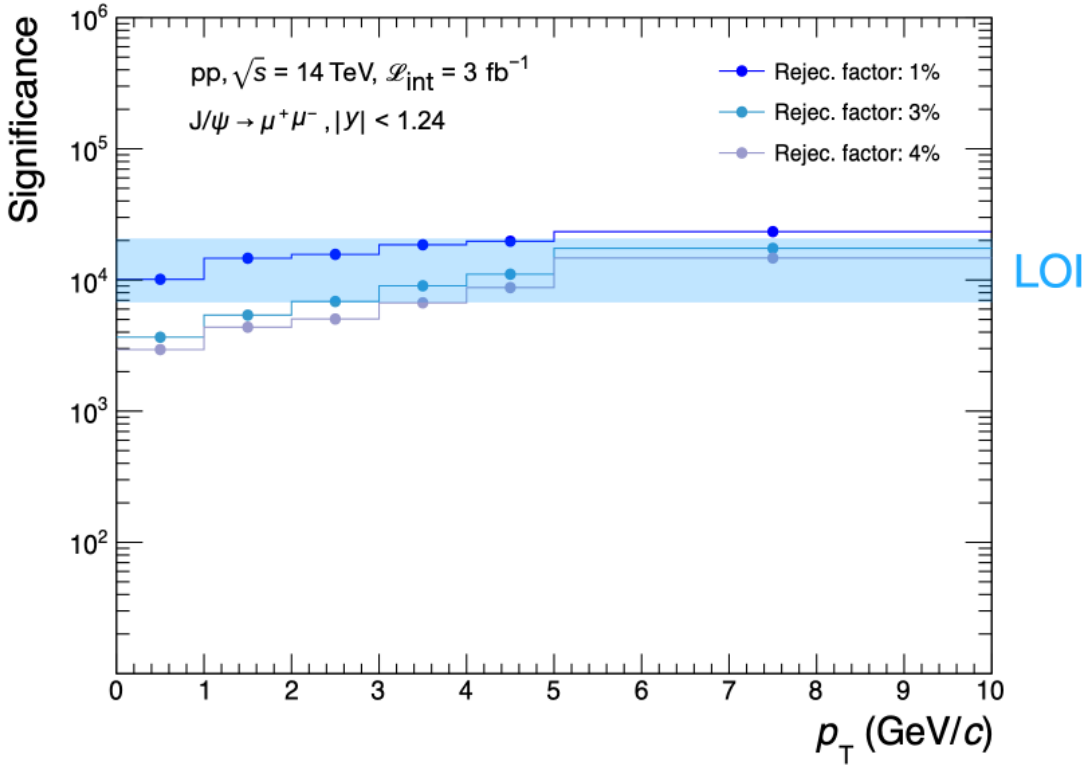




Distributions measured using MWPC

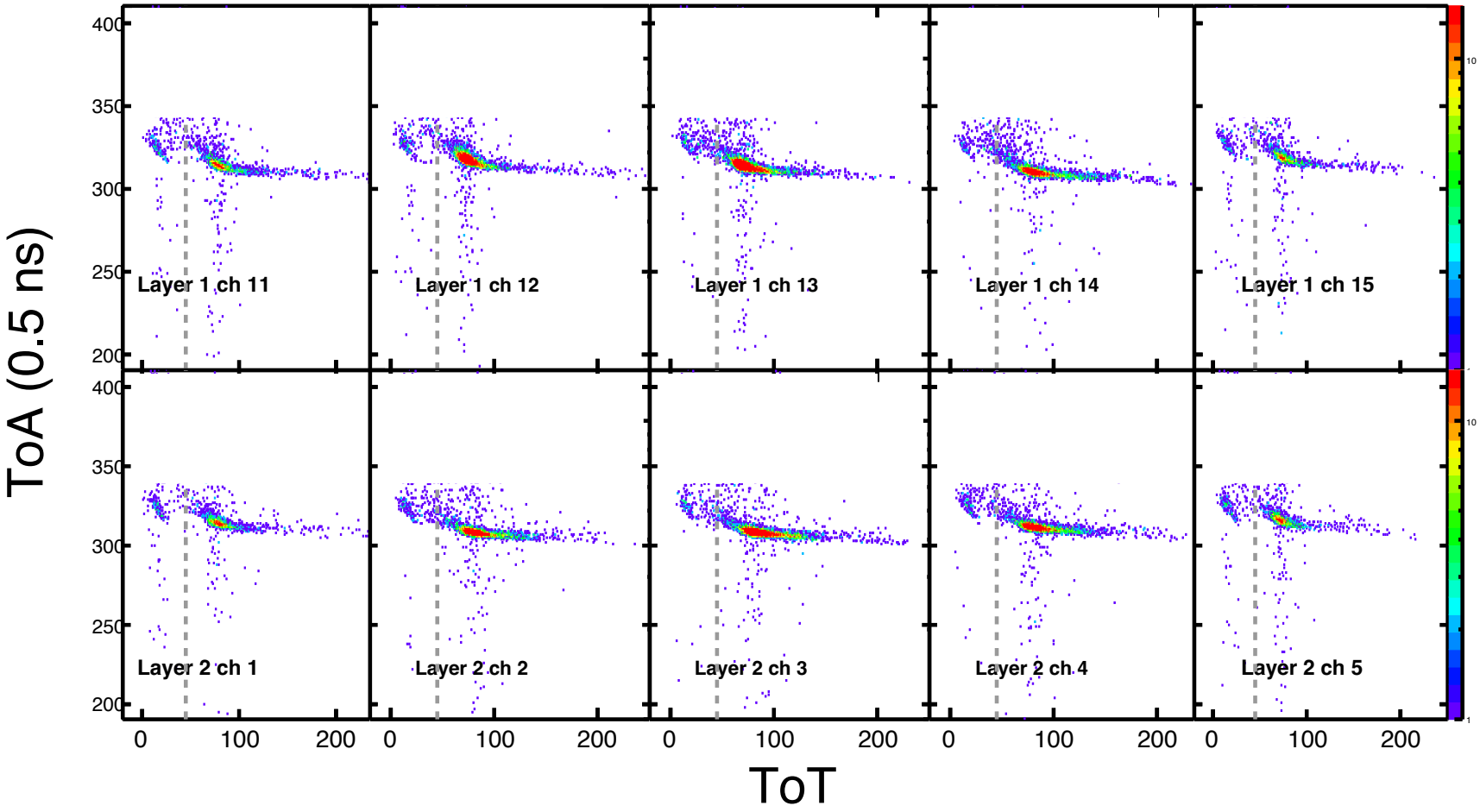
Physics performance - MC simulations

- Significance is above 10
  - 1000 for rejection factor 4%



Pion beam, p=2 GeV/c, abs 60 cm

Hits registered in chamber



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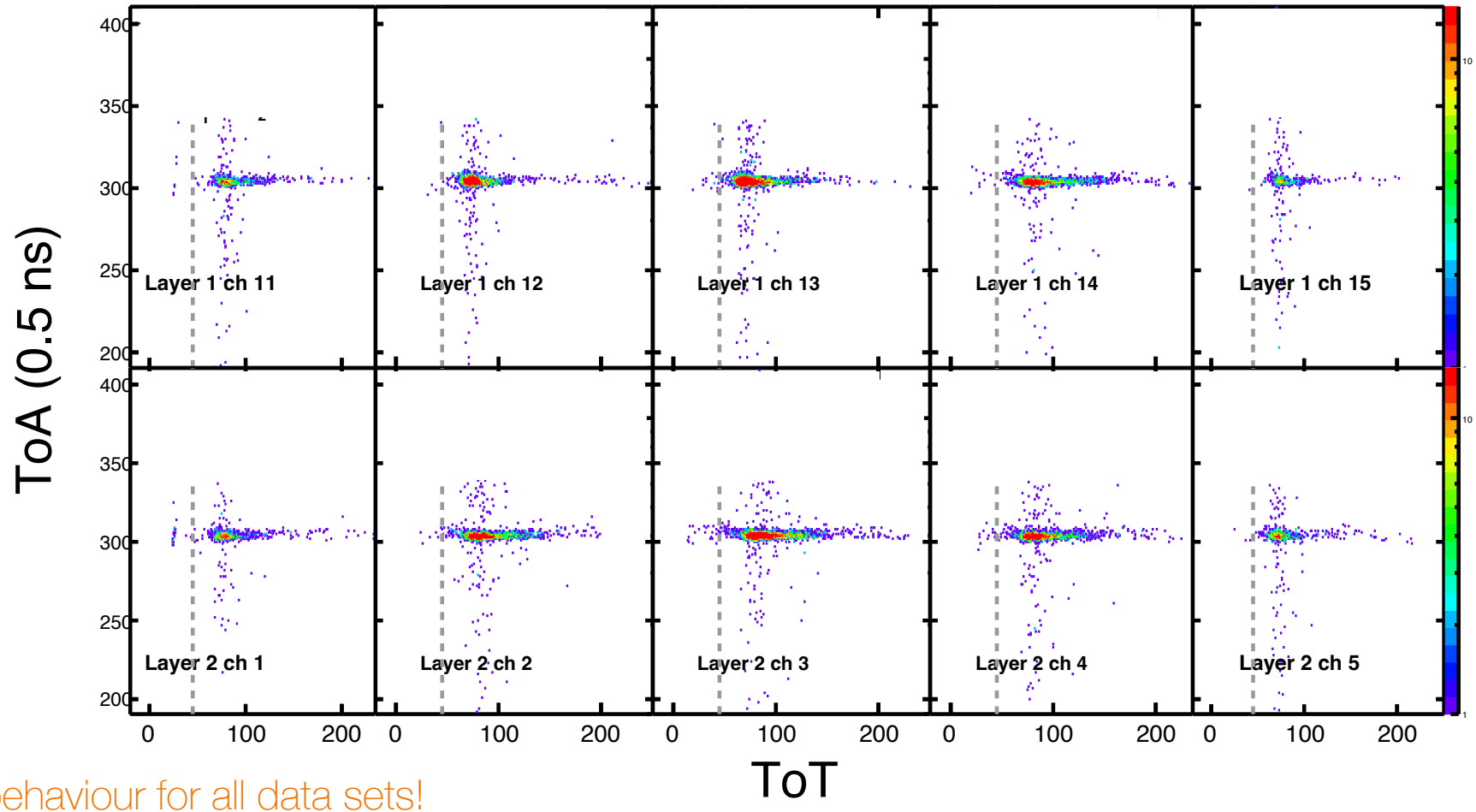

Similar behaviour for all data sets!