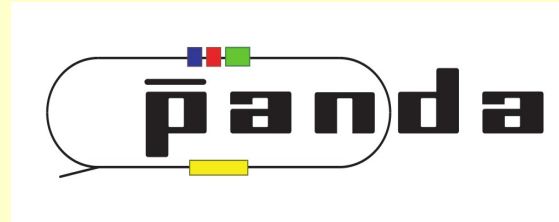


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# Update on simulations concerning time-like form factors from

$$\bar{p} p \rightarrow \mu^+ \mu^-$$

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# Motivation

- The differential cross section<sup>1</sup> for the muonic channel  $\bar{p} p \rightarrow \mu^+ \mu^-$  gives access to the moduli of the **time-like electromagnetic form factors**

$G_E$  and  $G_M$ :

$$\frac{d\sigma}{d \cos \theta_{CM}}(s, \theta) = \frac{\alpha^2 \pi}{2 \cdot s} \cdot \frac{p_{\Gamma}}{\bar{p}} \cdot |G_M|^2 \left[ \frac{4M_p^2}{s} (1 - \beta^2 \cos^2 \theta_{CM}) \cdot R^2 + \left( 1 + \frac{4m_l^2}{s} + \beta^2 \cos^2 \theta_{CM} \right) \right]$$

- Extract  $|G_E|$  and  $|G_M|$
- Strong hadronic background, mainly  $\bar{p} p \rightarrow \pi^+ \pi^-$

$$R = \frac{|G_E|}{|G_M|}$$

$$\frac{\sigma(\mu^+ \mu^-)}{\sigma(\pi^+ \pi^-)} \propto 10^{-6}$$

- Goal: Background suppression  $\sim 10^{-8}$

1) first derived by A.Zichichi et al., Nuovo Cimento XXIV,170 (1962)

# Simulations & Analysis: First tests

- **Test simulations** for both **signal and background** ( $10^6$  events) at beam momenta of 1.5 GeV/c and 3.0 GeV/c
  - Simulations were performed @ HIMSTER (cluster of the Helmholtz-Institut Mainz)
  - PandaRoot release apr13 (linked to external packages sept12)

Event generators:

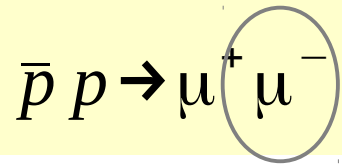
**PndLepLepGenerator**       $\bar{p} p \rightarrow l^+ l^-$   
**PndPiPiGenerator**         $\bar{p} p \rightarrow \pi^+ \pi^-$

(Event generators developed by Manuel Zambrana, HIM)

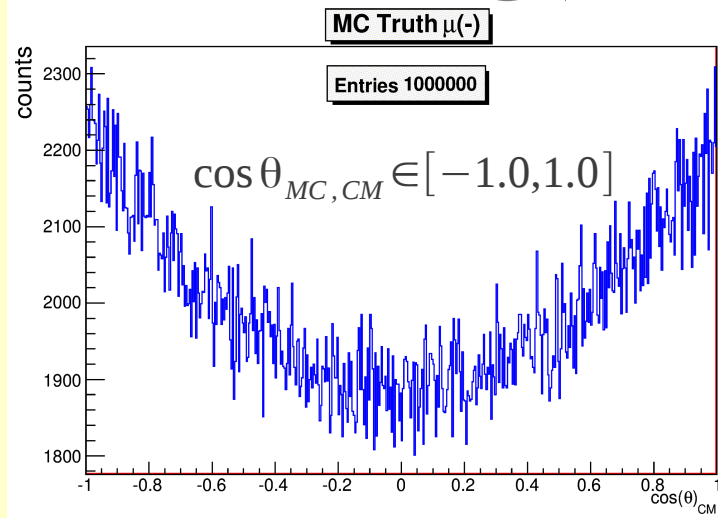
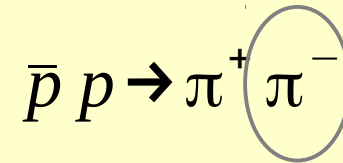
—► <http://panda-wiki.gsi.de/cgi-bin/view/PANDAMainz/EventGenerators> (PANDA report)

- **Analysis:** Different PID criteria, PID algorithms and cuts to achieve good **background suppression**

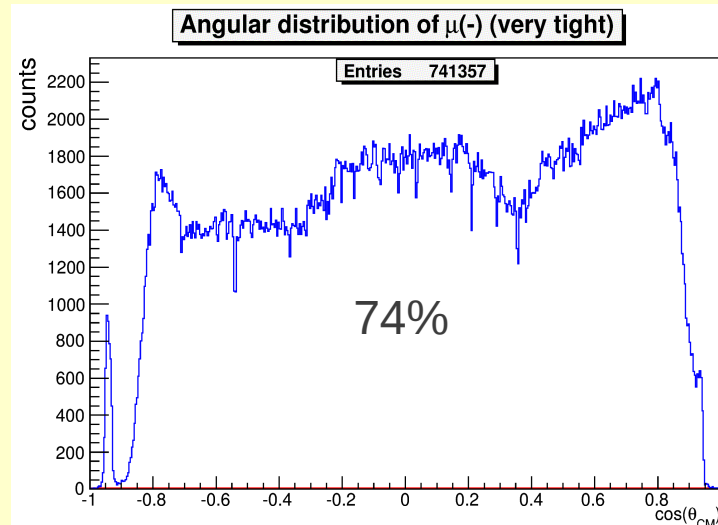
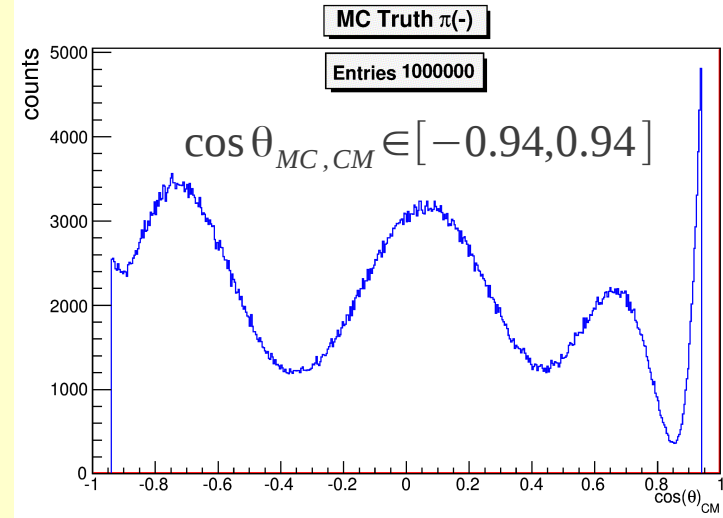
# Simulation of signal & background



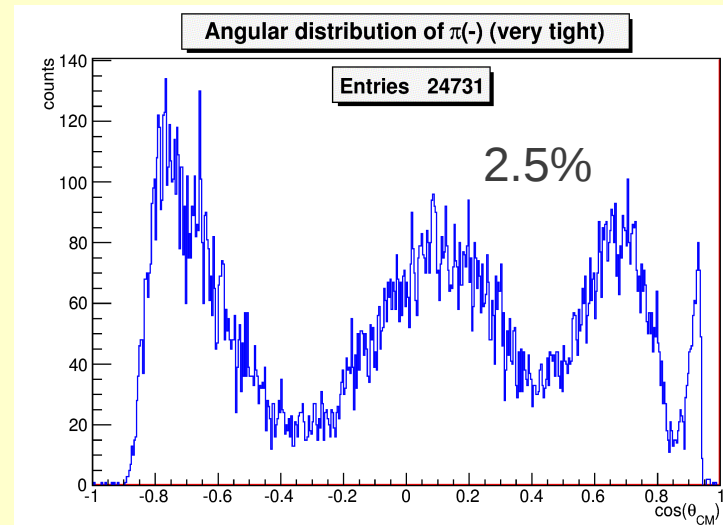
1.5 GeV/c  
beam momentum



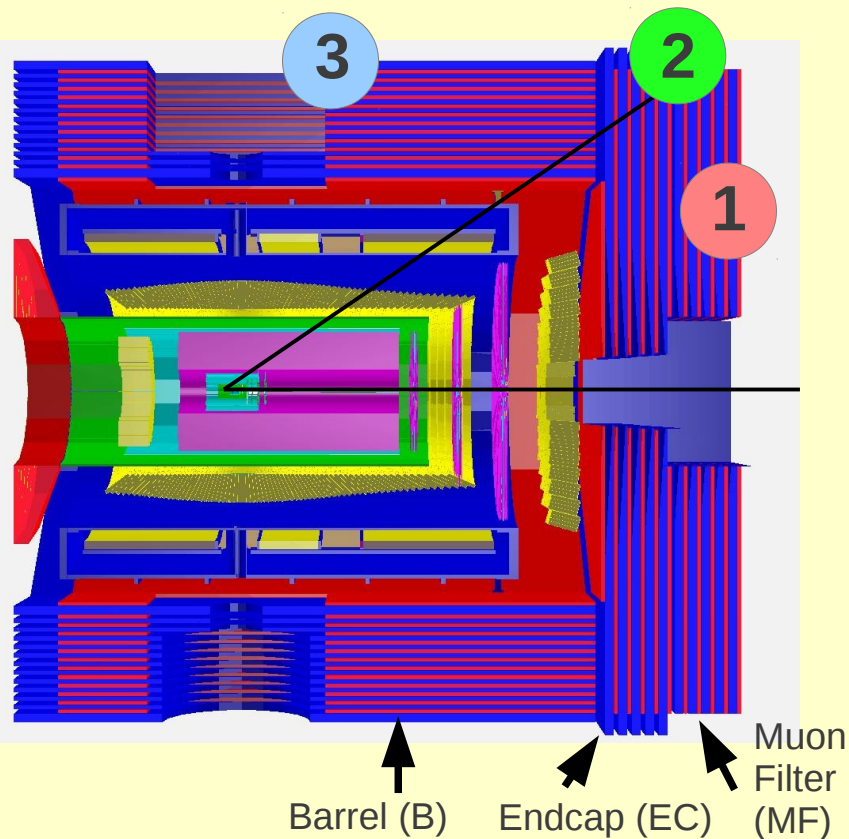
Monte Carlo  
 $10^6$  events



After PID  
muon  
"very tight"



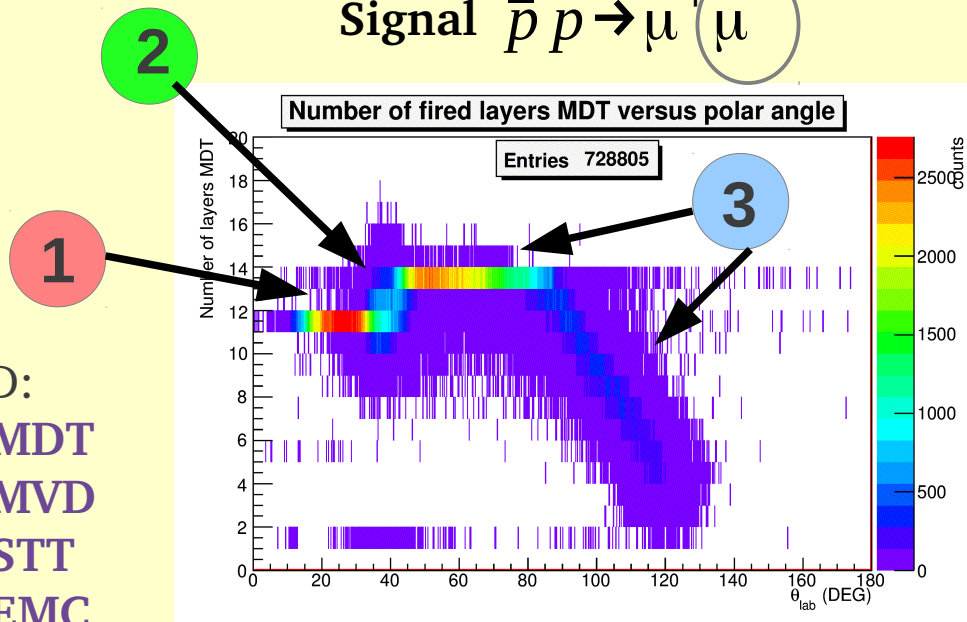
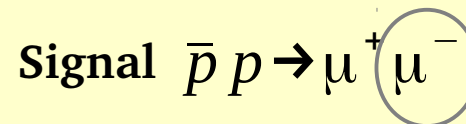
# What is the particles' behaviour inside the Muon System?



Barrel (B)    Endcap (EC)    Muon Filter (MF)

- 1** EC & MF: 11 detection layers of Mdt's
- 2** ~40° polar production angle: overlap region B& EC: "Hybrid tracking"
- 3** B: 13 detection layers
- 4** Forward Range System (FRS) (not shown): 16 detection layers

1.5 GeV/c beam momentum

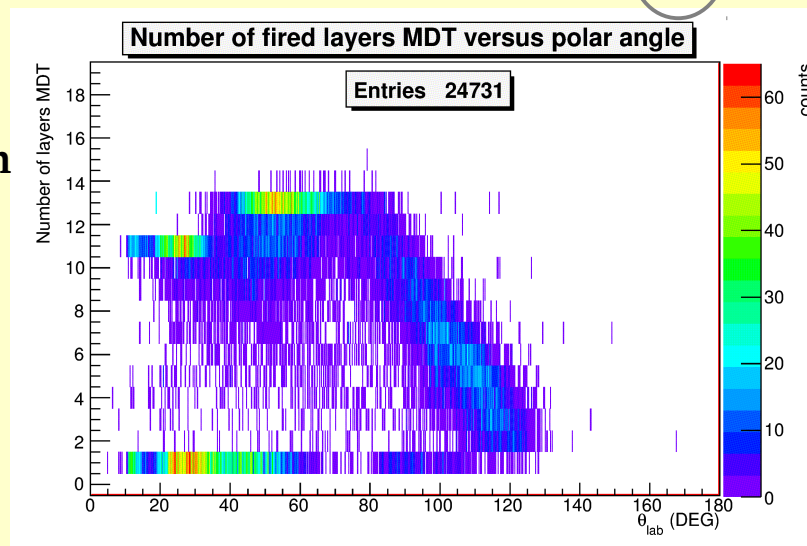
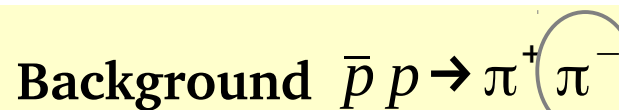


PID:

- MDT
- MVD
- STT
- EMC
- DIRC
- DISC

No 4-momentum conservation checked

PID criterium "very tight"



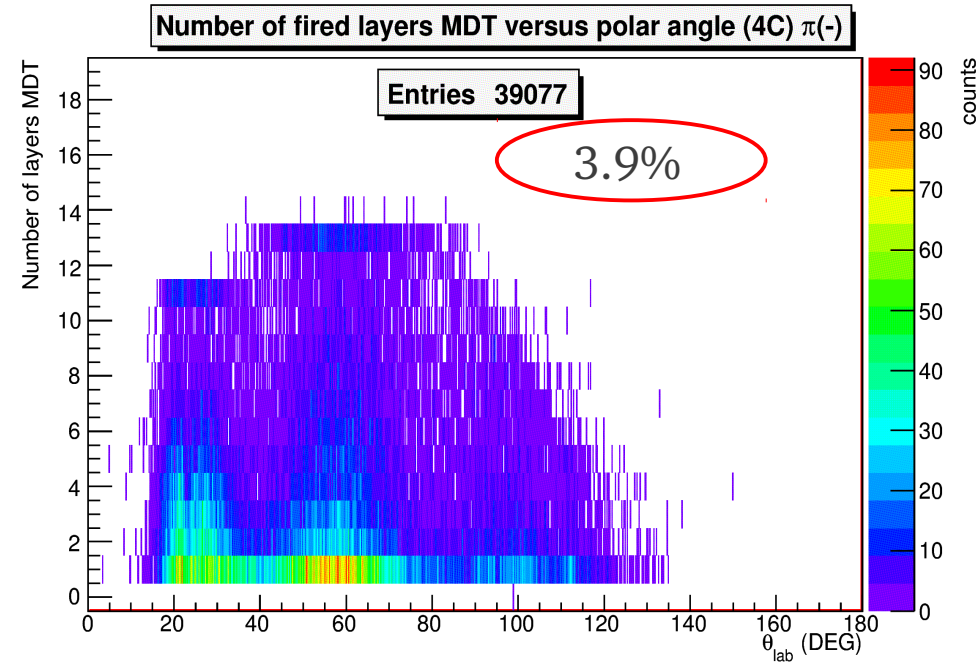
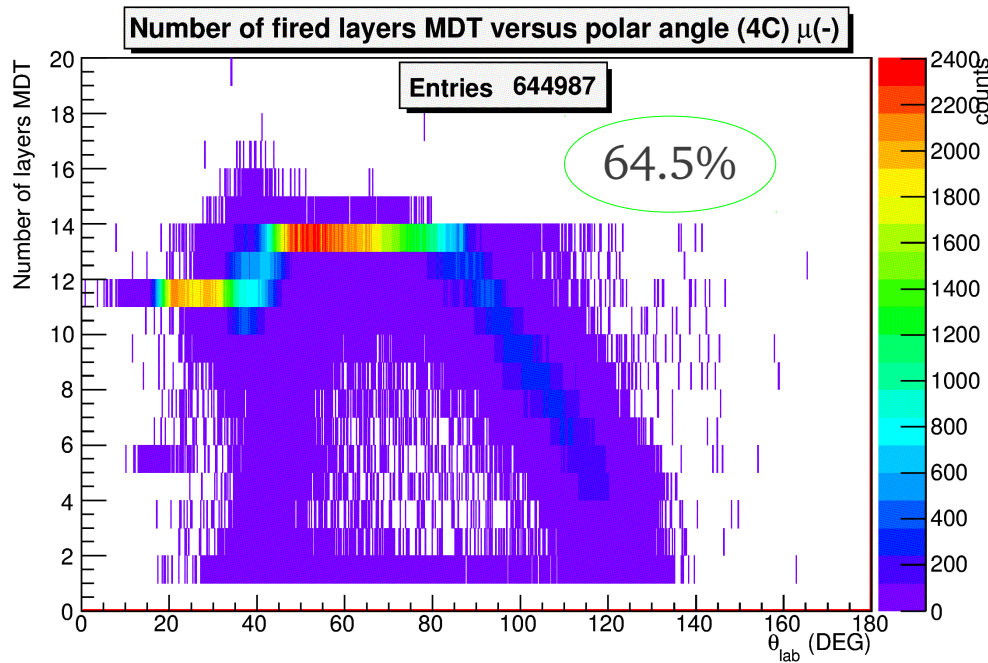
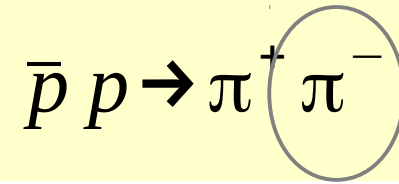
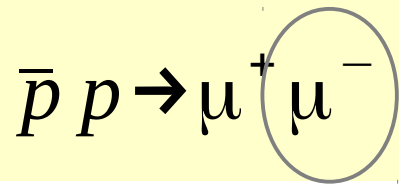
# Analysis

- 4-momentum conservation
- PID criterium “very loose”

PID algorithms:

- MDT
- MVD
- STT
- EMC
- DIRC & DISC

1.5 GeV/c beam momentum

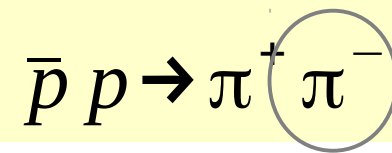
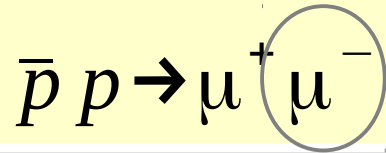


Background suppression  $\sim 10^{-2}$



# Analysis

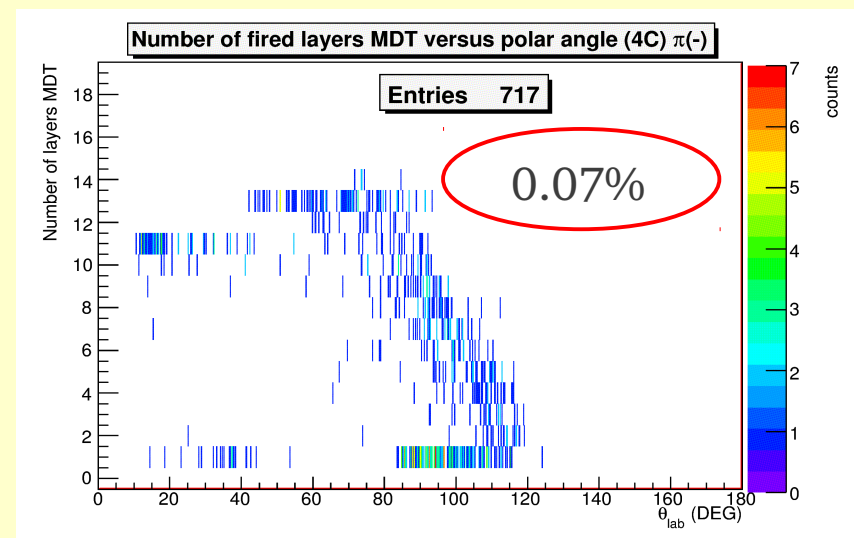
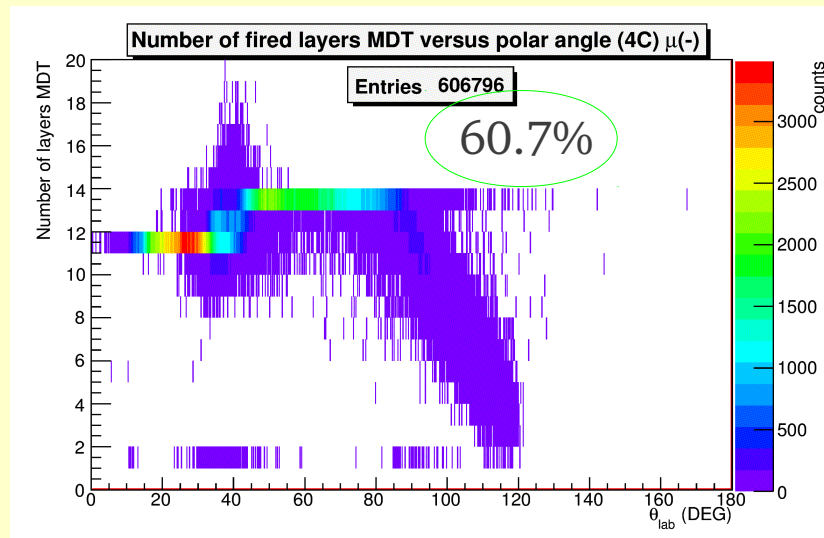
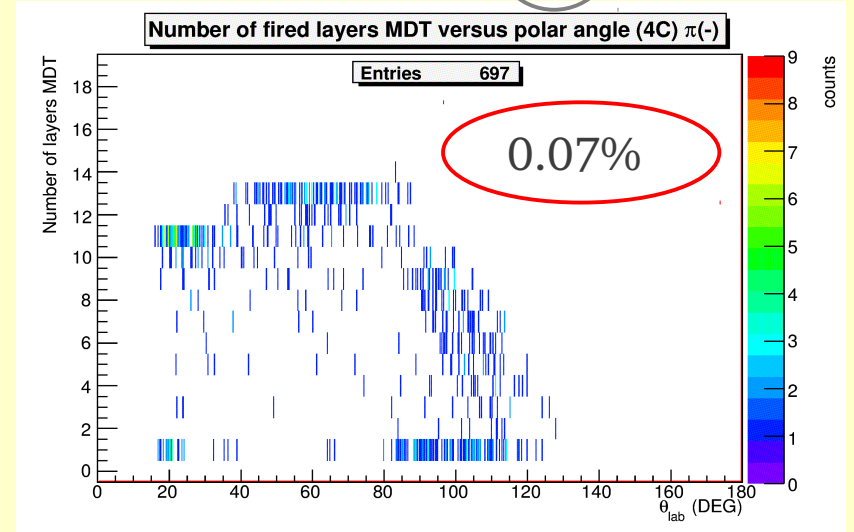
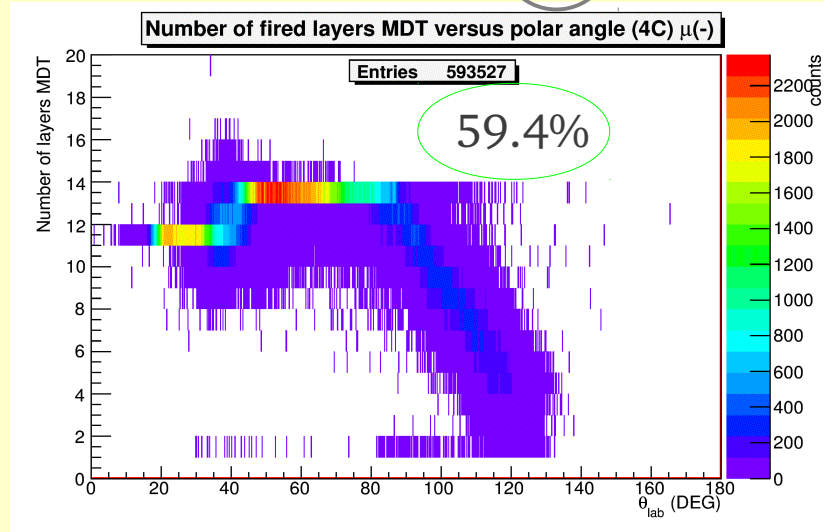
“very tight” & 4-momentum conservation



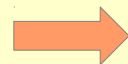
1.5 GeV/c

- MDT
- MVD
- STT
- EMC
- DIRC
- DISC

3.0 GeV/c



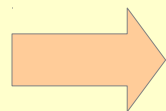
06/26/13



Background suppression  $\sim 10^{-4}$

# Test simulations: Preliminary results

1.5 GeV/c beam momentum	#No. of signal events	#No. of surviving background events
Monte Carlo Simulation	$10^6$	$10^6$
After PID “very loose” + 4-momentum conservation	644987 (~64.5%)	39077 (~3.9%)
After PID “very tight” + 4-momentum conservation	593527 (~59.4%)	697 (~0.07%)
After PID “very tight” + 4-momentum conservation + cut: (+) & (-) must reach 8 detection layers Mdt	471867 (~47.2%)	177 (~0.02%)

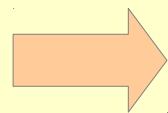


Test results: Background suppression factor  $\sim 10^{-4}$   
**Further investigation necessary!**



# Test simulations: Preliminary results

3.0 GeV/c beam momentum	#No. of signal events	#No. of surviving background events
Monte Carlo Simulation	$10^6$	$10^6$
After PID “very tight” + 4-momentum conservation	606796 (~60.7%)	717 (~0.07%)
After PID “very tight” + 4-momentum conservation + cut: (+) & (-) must reach 8 detection layers Mdt	582975 (~58.3%)	158 (~0.02%)



Background suppression factor  $\sim 10^{-4}$ .  
Further investigation needed!

# Summary

- **Test simulations for 1.5 GeV/c and 3.0 GeV/c beam momentum using muon tracking have been done**
- **At present: Pion suppression factor of  $10^{-4}$** 
  - factor 100 improvement in comparison to first test analysis
  - But: Still 100 times more background than signal
  - **Goal: background suppression of  $10^{-8}$** 
    - **Further work is necessary**