Trigger efficiencies in the muon spectrometer

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Outline

1. Introduction and definitions

2. Trigger tracks method
   - Description
   - Systematics

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The absolute cross section for a process is given by:

$$\sigma = \frac{N_{det}}{\mathcal{L}\, t\, (\times BR)} \times \frac{1}{Acc \times \varepsilon}$$

$\mathcal{L}\, t$ = integrated luminosity; Acc = acceptance; ε = efficiency.

In our case the efficiency is the convolution of tracker and trigger efficiencies.

A possible strategy to compute trigger efficiency is:

- Determine the map of the intrinsic efficiencies of the detectors.
- Plug the map in the simulations.
- Tune simulation inputs (especially particle distributions) to reproduce data.
- Get trigger efficiency as:

$$\varepsilon(p_t, y) = \frac{\frac{dN_\mu}{dp_t\, dy}(\text{triggered})}{\frac{dN_\mu}{dp_t\, dy}(\text{triggerable})}$$

Trigger efficiency: motivation and strategy

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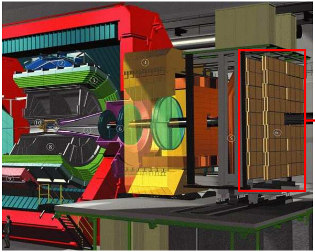
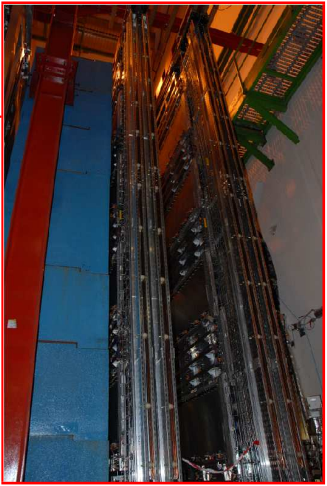
Spectrometer acceptance:

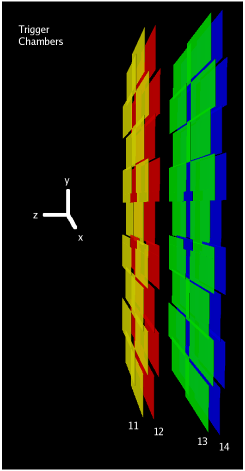
- $p \gtrsim 4\ \mathrm{GeV}/c$
- $-4 < \eta < -2.5$

Trigger p_{t} cut for single muons:

- $1\ \mathrm{GeV}/c \rightarrow$ charmonia.
- $2\ \mathrm{GeV}/c \rightarrow$ bottomonia.



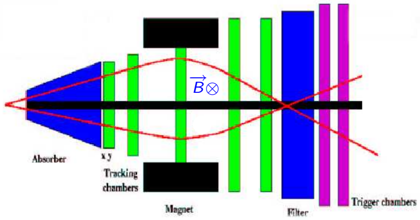




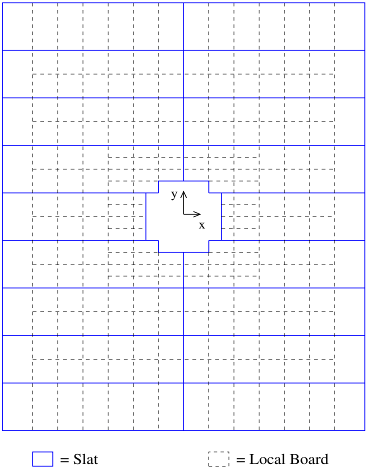
- Four trigger chambers organized in two stations.
- Each chamber is constituted of 18 slats of Resistive Plate Chambers (RPCs) gas detectors.

- Trigger chambers are disposed in a projective geometry w.r.t. impact point.

- Two read-out planes on each chamber:
  - bending plane measures y position ($\perp$ to magnetic field)
  - non-bending plane measure x position ($\parallel$ to magnetic field)



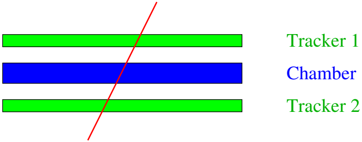
- Trigger electronics is organized in local boards (searching for single tracks pointing approx. back to the interaction vertex. Hits in at least 3/4 chambers are needed to define a track).



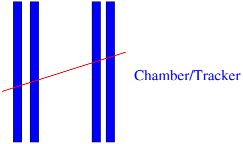
The aim is to provide a fine efficiency map (up to 1 eff. value per local board).

$$\varepsilon = \frac{\#\text{ of times chamber gives signal}}{\#\text{ of times a muon crosses the chamber}}$$

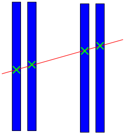
In laboratory:

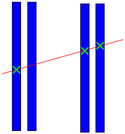


Muon Spectrometer:



The trigger algorithm searches for hits in at least 3 out of 4 trigger chambers. One can define:

$N_{4/4} =$ 

$N^{12}_{3/3} =$ 

The efficiency for chamber $a = 12$ (for example) is given by:

$$\frac{N_{4/4}}{N^a_{3/3} + N_{4/4}} = \frac{N_{4/4}/N_{tot}}{(N^a_{3/3} + N_{4/4})/N_{tot}} = \frac{\varepsilon_{4/4}}{\varepsilon^a_{3/3} + \varepsilon_{4/4}} = \frac{\varepsilon_{11}\varepsilon_a\varepsilon_{13}\varepsilon_{14}}{\varepsilon_{11}\varepsilon_{13}\varepsilon_{14}} = \varepsilon_a$$

\# of triggered tracks if chamber a were switched off.

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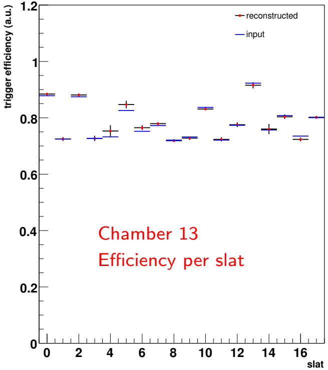
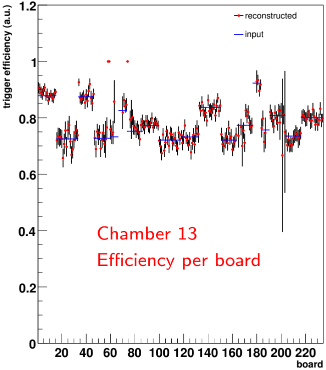
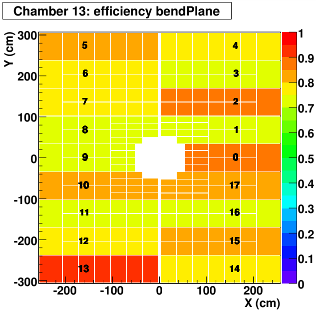
- During reconstruction, tracks are created out of local trigger response.
- The efficiency algorithm implemented searches back for matches between the reconstructed track and the digits: $N_{4/4}$ and $N^{a}_{3/3}$ can be determined.
- Efficiency is calculated separately for bending and non-bending planes.
- By restricting the sample of tracks to the ones crossing the same slat (board) in all chambers, the efficiency per slat (board) can be provided.

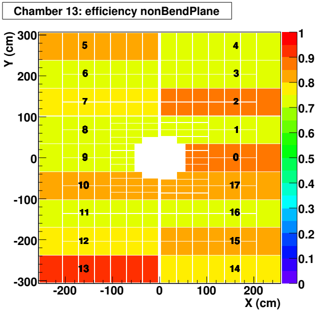




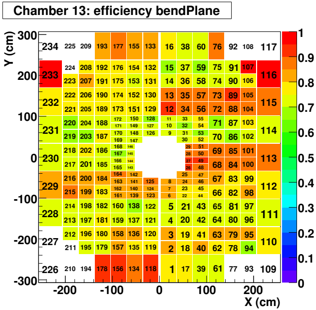
(Simulations obtained by shooting single muons on chambers. Cluster size is taken into account).

CAVEAT: Input efficiency NOT from RPC measurements but randomly assigned to each slat ($70\% < \varepsilon < 95\%$). The aim is to test that algorithm gives good results independently of the slat/board efficiency value.



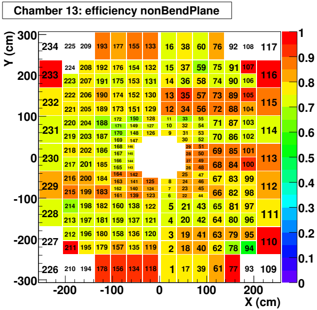


Slat	Input eff.(%)
0	88
1	72
2	87
3	73
4	73
5	83
6	75
7	77
8	72
9	73
10	84
11	72
12	77
13	92
14	76
15	81
16	74
17	80



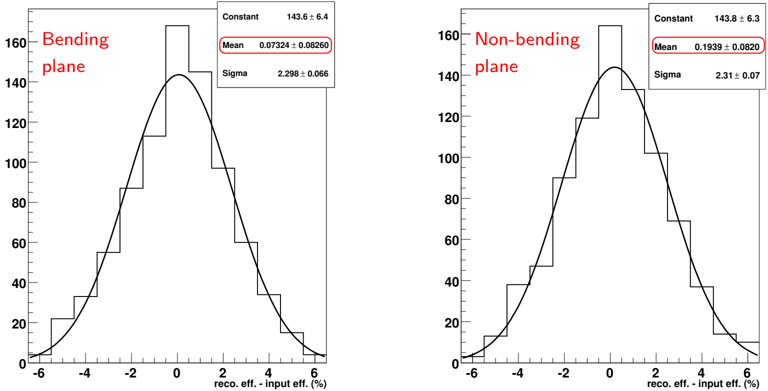
Efficiency for boards far from the center is evaluated with lower precision (low statistics)...

...but the contribution of such boards to the global trigger probability is negligible!



To determine a systematic over or under-estimation of efficiency:

- Plot the distribution of reconstructed efficiency – input efficiency.
- Fit with a gaussian.
- Take the mean value as an estimate of the systematics.



- Efficiency of a strip can be over-estimated when another particle hits the strip or its neighbours. Over-estimation increases with:
  - length of strips (note: strips in non-bending plane are bigger than in bending).
  - particle multiplicity.

Systematics vs multiplicity

- Particle multiplicity on chambers was simulated by increasing the number of muons per event and the hit density (due to low energy particles).

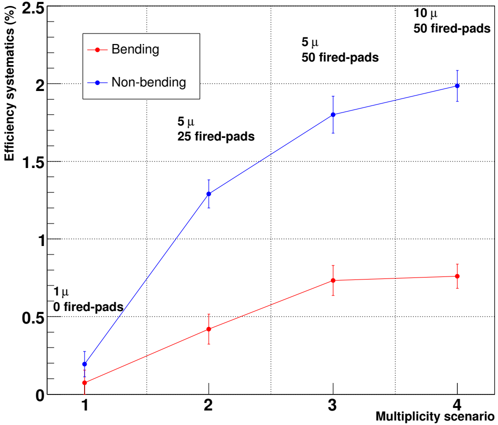
- 4 different scenarios considered:

Scenario #	# of μ/event	# of fired-pads/chamber/event
1	1	0
2	5	25
3	5	50
4	10	50

- Scenario 1 roughly simulates conditions in pp collisions.
- Conditions in PbPb collisions are expected to be in between scenario 2 and 4, since:
  - The average number of muons on chambers is $\sim 6^*$.

* F. Guerin, F. Yermia, P. Dupieux, P. Rosnet and E. Vercellin, ALICE Muon Trigger Performance, ALICE-INT-2006-002

Systematics vs multiplicity



Systematics obtained with a trigger chamber efficiency randomly ranging from 70 to 95%.

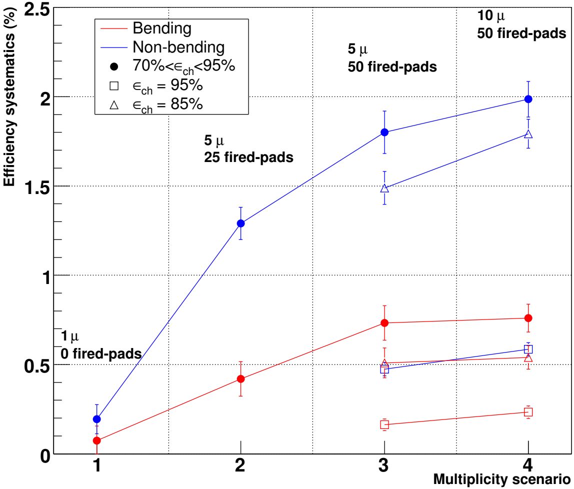
It is worth noting that:

- Systematics depends on chamber efficiency (syst. $\to 0$ when $\varepsilon_{ch} \to 1$).
- The real p_{t} distribution is expected to be softer than the flat one used in simulations $\Rightarrow$ reduced number of showers (and hence hits on chambers).

$\Downarrow$

Systematics for real data are expected to be lower.

- For high multiplicity scenarios, simulations were performed again with the same chamber efficiency for all boards of:
  - 85%
  - 95% ($\sim$ nominal chamber efficiency).



As expected the systematics decreases with increasing chamber efficiency.

Conclusions

- Trigger chamber efficiency can be determined directly from data, providing:
  - the screenshot of chamber status for the data set considered.
  - a necessary information for muon trigger probability studies.

- The method implemented for chamber efficiency determination:
  - provides mapping at the level of slats and local trigger boards.
  - uses information from all data.
  - is applied track-by-track.

  (uses information from all data + is applied track-by-track) $\Rightarrow$ high statistics.

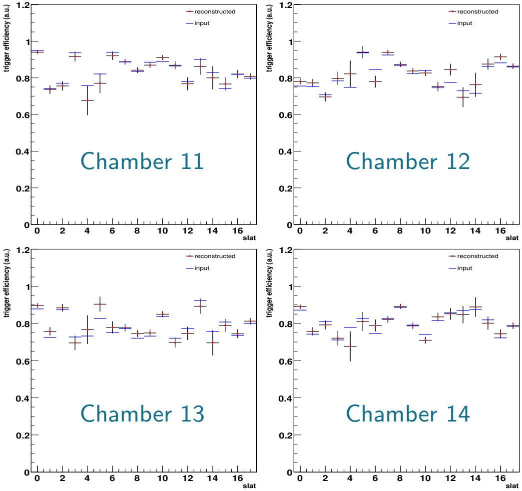
- The systematics are under control (almost 0 for pp collisions and under 2% for PbPb collisions).

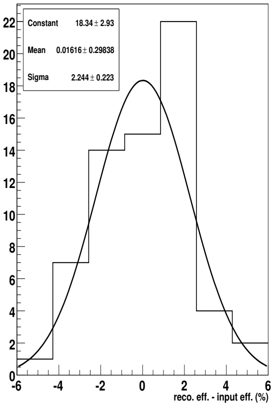
Outline

Slat efficiency: bending plane

The method was tested with:

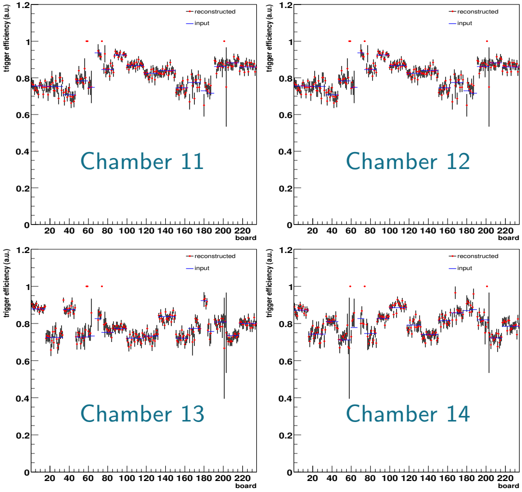
- Muon sources from PDC06. Cluster size taken into account.
- Random efficiency assigned to each slat in the range $0.7 < \varepsilon < 0.95$.

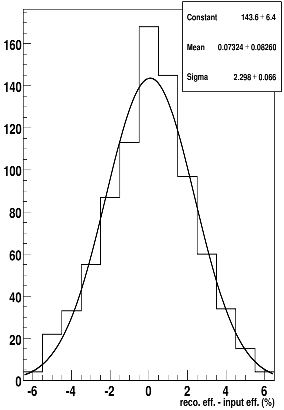




The method was tested with:

- Single muon in a box. Cluster size taken into account.
- Random efficiency assigned to each slat in the range $0.7 < \varepsilon < 0.95$.





Board efficiency: Non-bending plane

The method was tested with:

- Single muon in a box. Cluster size taken into account.
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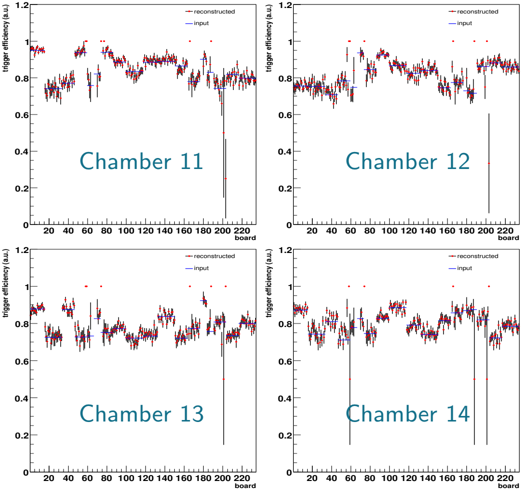
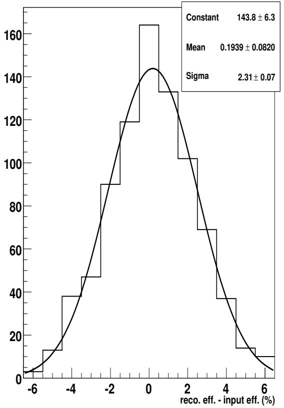




Matching simulations with data

Triggerable track definition

"True" (simulation)

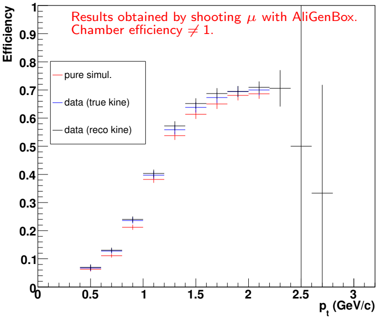
Muon track crossing the active volume of 3/4 chambers (trackRef info).

"Operative" (data)

Muon (= reconstructed track identified as muon from its hit pattern in trigger chambers) track crossing the active volume of 3/4 chambers (from extrapolation of AliESDMuonTrack).

The "operative" definition is biased since:

- there are correlations between triggered and reconstructed tracks.
- reconstructed p_t is affected by track resolution.



Use "operative" definition when matching simulations with data.