Quantitative evaluation of muon track matching efficiency with Muon Forward Tracker and Muon Spectrometer at ALICE

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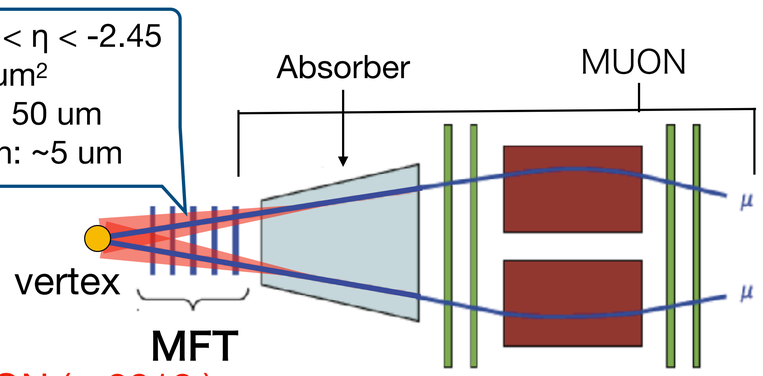
Muon Forward Tracker (MFT)

New sillicon pixel detector installed between vertex and hadron absorber of Muon Spectrometer (MUON) for LHC-Run3

Acceptance: -3.6 < η < -2.45
Pixel size: 29*27 um^2
Sensor thickness: 50 um
Position resolution: ~5 um



Red: Only MUON (- 2018)
Blue: MFT + MUON (2021 -)

<u>Improvement:</u>
Muon track information around vertex region can be gained by matching between MFT and MUON
→ ・Good mass resolution (Chiral nature of phase transition)
・Rejection of muons from hadron decay (S/N improvement)

*** Tracking performance depends on matching.**

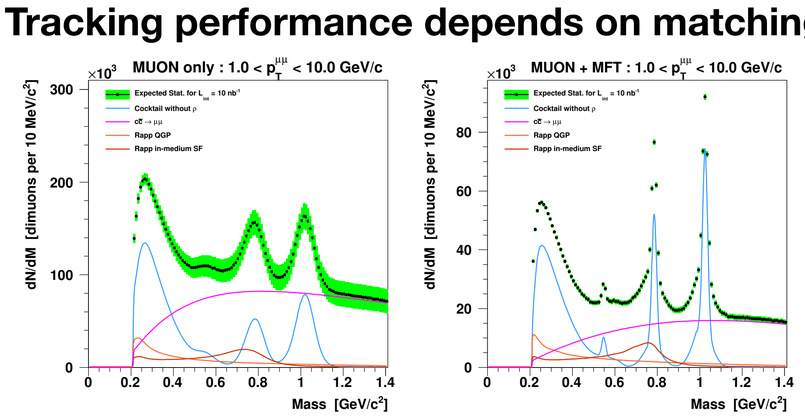


fig: Expected low mass dimuon spectrum in 0-10% central Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.5 TeV [1]

Analysis: Tracking with MFT and MUON

(1) Determine MFT track corresponding to MUON track

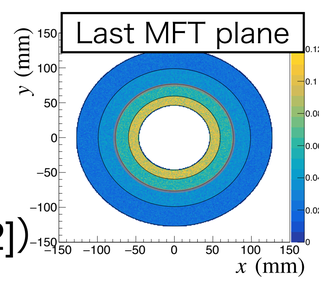
1.Tracks are reconstructed by MUON and MFT separately.
2.MUON tracks are extrapolated through the absorber towards vertex.
3.Search window is determined at the last MFT plane taking into account **multiple scattering** in the absorber.
4.MFT tracks in the search window are candidates.

Rough estimation: the number of candidates estimated from multiple scattering

$$< N > = \sigma(r) * h_x * h_y$$

where $\sigma(r)$: Number of incident particles per unit area (calculated from multiplicity [2])

$h_{x,y}$: Width of search window (calculated from multiple scattering)



e.g. $p_T = 1$ GeV/c at $\eta = 3$

$\epsilon_{xy} \sim 80\,\%$ (equivalent to 90% in 1D)

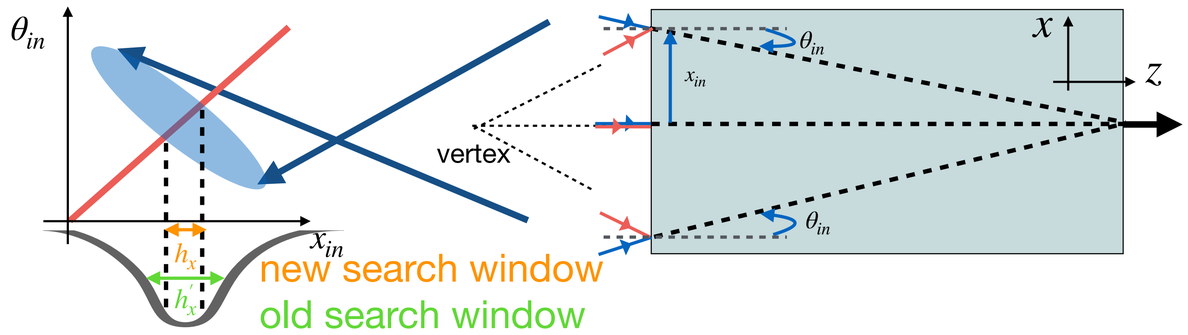
$\sigma_{\eta=3} \sim 0.049$ mm^{-2} , $h_{x,y} = 47.4$ mm

$< N > = 0.049 * 47 * 47 \sim$ **110**

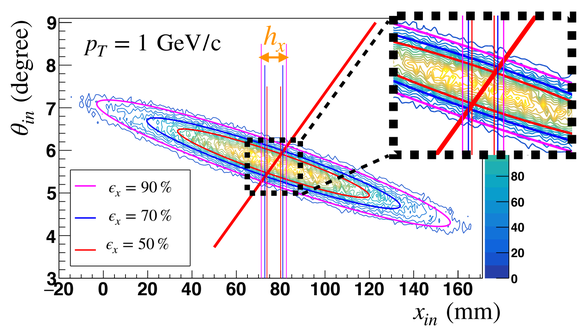
→ **Too many candidates**
→ **To reduce BG, correlation b/w position and angle can be used. (Analysis-2)**

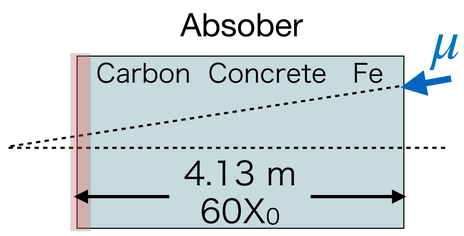
(2) Matching method using the correlation between track position and angle

- Muon passes x=0 at the exit of absorber has a correlation distribution of position and angle (blue ellipse in left figure).
- Only muons which originate near vertex are of interest (red arrow in right figure).
- The range of overlap between extrapolation from vertex to absorber (red line in left figure) and blue distribution defines a new search window. GEANT4 (G4) simulation is performed to get a distribution.



G4 setup: Muons are injected from the right side at η=3 (θ~5.7°).
Output: position and angle on the left side of absorber



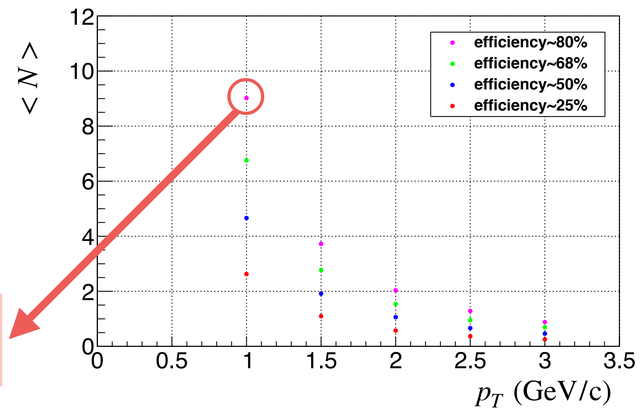


Result: Number of candidates determined from correlation

$$\frac{p_T = 1 \text{ GeV/c at } \eta = 3}{\epsilon_{xy} \sim 80\,\%}$$

(equivalent to 90% in 1D)

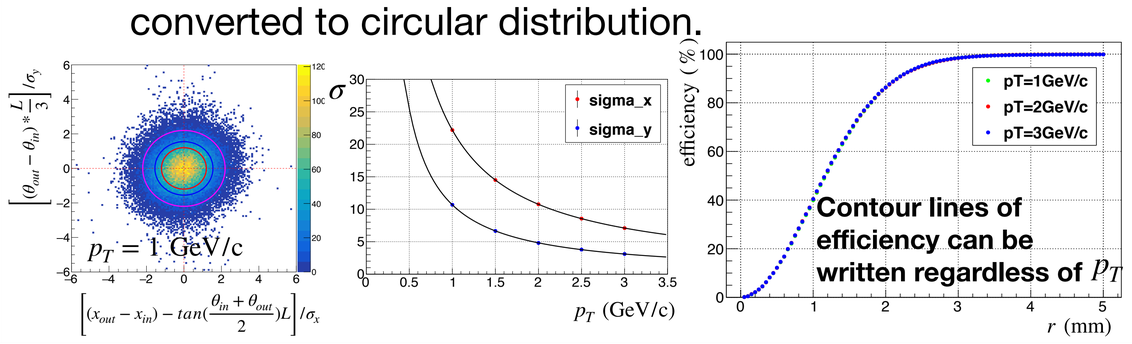
$< N > = 0.049 * 14 * 14 \sim$ **9.0**



Background can be significantly reduced by correaltions between position and angle (about 12 times). Furthermore, BG can be reduced by the sign of charged particle and rough momentum matching between MFT and MUON.
→ Next step: evaluation for more realistic situation

Preparation for evaluation of matching algorithm

- **Quantitative evaluation of likelihood of MFT tracks using correlation, momentum and charged sign matching**
- **Correlation matching needs to be implemented in algorithm.** MFT track which is closer to the center of distribution is more likely to match with MUON track.
  → Difficult to calculate distance from center of ellipse
  → To make analysis easier, elliptical distribution is converted to circular distribution.



Summary and Outlook

- Muon Forward Tracker (MFT) is a new sillicon pixel detector between vertex and Muon Spectrometer (MUON) for LHC-Run3 (2021-).
- Track matching between MFT and MUON is important to improve mass resolution and S/N.
- Matching method using correlation between track position and angle can improve S/N significantly (about 12 times) with high efficiency.
- To make analysis easier, elliptical distribution of position and angle are converted to circular distribution.
- Algorithm to evaluate likelihood of MFT tracks using correlation, momentum and charged sign matching will be implemented.

[1] ALICE collaboration, The MFT LoI, CERN-LHCC-2013-014
[2] ALICE collaboration, Phys.Lett. B772 (2017) 567-577

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