Segmentation optimization for the MUCH detector

A. Prakash[1], *P P Bhaduri*[2], *B K Singh*[1], *and S. Chattopadhyay*[2]

[1]Department of Physics, Banaras Hindu University,Varanasi-221 005,India; [2]Variable Energy Cyclotron Centre,1/AF,Bidhan Nagar,Kolkata-700 064, India

We present a simulation for the optimization of the MUCH segmentation using the CBM simulation framework cbmroot [1]. The tools used for the simulations are the same as in [2]. We employed the 18-layer geometry as optimized in [2].

The detection procedure involves the reconstruction of the track parameters in STS and extrapolation to the muon detecting stations through the absorbers. We considered tracks passing through 15 layers as valid muon candidates from low-mass vector meson decays. The study of segmentation is important for a) the determination of occupancy, which eventually determines the feasibility of tracking and the efficiency of muon measurements; b) the total number of pads, which influences the cost; and c) the smallest pad size, important from the point of view of fabrication and signal strength.

Table 1: Minimal and maximal pad sizes and total number of pads for the different segmentation schemes

Scheme	min. size	max. size	N_{pads}
1	4×4 mm^2	3.2×3.2 cm^2	791,040
2	2×4 mm^2	3.2×3.2 cm^2	989,184
3	5×5 mm^2	3.2×3.2 cm^2	567,459

We segmented the detector into pads of varying size from 4×4 mm^2 to 3.2×3.2 cm^2 depending on the radial distribution of particle density. The minimal and maximal pad sizes are listed in Table 1. Figure 1 (left) shows the radial distribution of occupancy in station 1, the highest occupancy being $\approx$4.5%. Even though the framework provides the option to divide a layer into pads of varying size, we used a constant pad size throughout each layer. The minimal and maximal pad sizes mentioned here refer to the pad size in the first and in the last station, respectively. The reconstruction efficiency and the signal-to-background ratio (S/B) for ω mesons were calculated in a $\pm 2\sigma$ window around the signal invariant-mass peak and are presented in Tables 2 and 3 for central Au+Au collisions at $8A$, $25A$ and $35A$ GeV beam energy. Normalized invariant-mass spectra for the segmentation option 1 for three different beam energies are shown in Figure 1 (right). The combinatorial background is calculated using the event mixing technique. Our studies indicate that at all energies low-mass vector mesons can be identified above the combinatorial background, which is dominated by muons from weak pion decays. The efficiency does not change significantly for the three different segmentation options, whereas the S/B is reduced by 10% to 40% when going from segmentation option 1 to 3. The increase in S/B from option 1 to option 2, however, is marginal and even reversed at $8A$ GeV beam energy. We therefore conclude that a minimal pad size of 4×4 mm^2 is the preferable option, given the fact that pads of this size are relatively easy to fabricate.

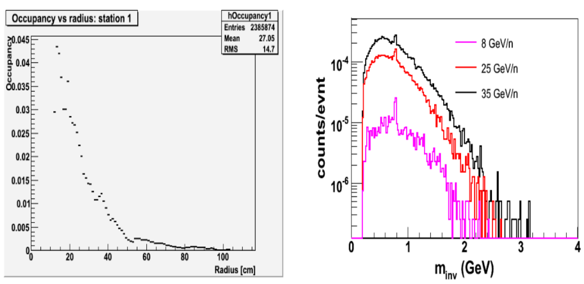

Figure 1: (Left) Occupancy in the first station (Au+Au @ 25A GeV beam energy) with segmentation option 1. (Right) Invariant-mass spectrum of muon pairs for the three different segmentation schemes.

Table 2: Reconstruction efficiency for ω in central Au+Au collisions at $8A$, $25A$ and $35A$ GeV beam energies for different segmentations

Energy [A GeV]	Efficiency [%]		
	Seg-1	Seg-2	Seg-3
8	0.86	0.86	0.78
25	1.58	1.61	1.43
35	1.81	1.82	1.7

Table 3: S/B ratio for ω in central Au+Au collisions at $8A$, $25A$ and $35A$ GeV beam energies for different segmentations

Energy [A GeV]	S/B		
	Seg-1	Seg-2	Seg-3
8	1.41	1.03	0.94
25	0.49	0.497	0.3
35	0.31	0.34	0.28

References

[1] http://cbmroot.gsi.de

[2] P. P. Bhaduri, A. Prakash and S. Chattopadhyay, *MUCH layout optimization for SIS-100*, this report