Limits on Upsilon Mass Resolutions in PHENIX Muon Arms

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1 Introduction

The upsilon mass resolution, as measured by the PHENIX Muon Arms is limited by 1) the multiple scattering and energy straggling in the absorber material in front of the tracking stations, 2) the multiple scattering within the tracking volumes, and 3) the resolution of the tracking chamber planes. This paper gives the quantitative limits of the mass resolution caused by these effects. It also gives the mass resolution comparison of tracking stations which are composed of either three or six fine resolution planes at each station, as well as the mass resolution if there are three fine resolution planes at the first and last stations and six fine resolution planes in the middle station.

2 Mass Resolution Limits

2.1 Geometry

Figure 1 shows the geometry of the muon arms in the PHENIX detector. The material that particles pass through before reaching the muon tracking stations consists of a copper nose cone (which is 28 cm thick in the North arm and 12 cm in the South arm) and the central magnet return yoke which is 59 cm of steel. The first and last muon tracking stations in each arm contain chambers made of honeycomb material which are approximately 5.7% radiation lengths thick and the central tracking stations are low-mass chambers

	North Arm Resolution ($\mathrm{MeV/c^2}$)	South Arm Resolution ($\mathrm{MeV/c^2}$)
Perfect Spectrometer	180	148
Add Spectrometer Material	183	185
Add Chamber Resolution	205	252

Table 1: Upsilon mass resolutions obtained by the North and South muon arms, with a perfect spectrometer (no material and perfect resolution), with material added but still perfect chamber resolutions, and with chamber resolutions added.

which are approximately 0.3% radiation lengths thick. The baseline tracking stations each consist of three cathode strip chambers (CSCs) which are comprised of one fine cathode plane, with a resolution of approximately 100 μm, one coarse cathode plane which is at a stereo angle of 22.5^o to the fine cathode plane and has a resolution of approximately 3 mm and an anode plane which is perpendicular to the fine cathode plane and has a resolution of approximatley 3 mm. This gives a station resolution on the order of 100μm/sqrt(3) or 58 μm.

2.2 Mass Resolution Limits

Table 1 shows the contributions to the upsilon mass resolution for the North and South muon arms. The contribution from the multiple scattering and energy straggling in the material in front of the tracking stations was determined by using the true momentum vector at the first tracking station and tracking back to the vertex. If the tracking stations are then given perfect resolution, but the particle is tracked all the way from the last tracking station to the vertex, then the limit from the multiple scattering in both the material in front of the tracking stations as well as the air and chamber material in the tracking volume is obtained. Lastly, the expected finite chamber resolution was added to the simulation to give the mass resolution when all material and detector resolutions are taken into account. The expected resolution is 100 μm per fine resolution plane and three fine resolution planes per station.

The North muon arm upsilon mass resolution is limited to 180 $\mathrm{MeV/c^2}$ by the multiple scattering and energy straggling in the material in front of the

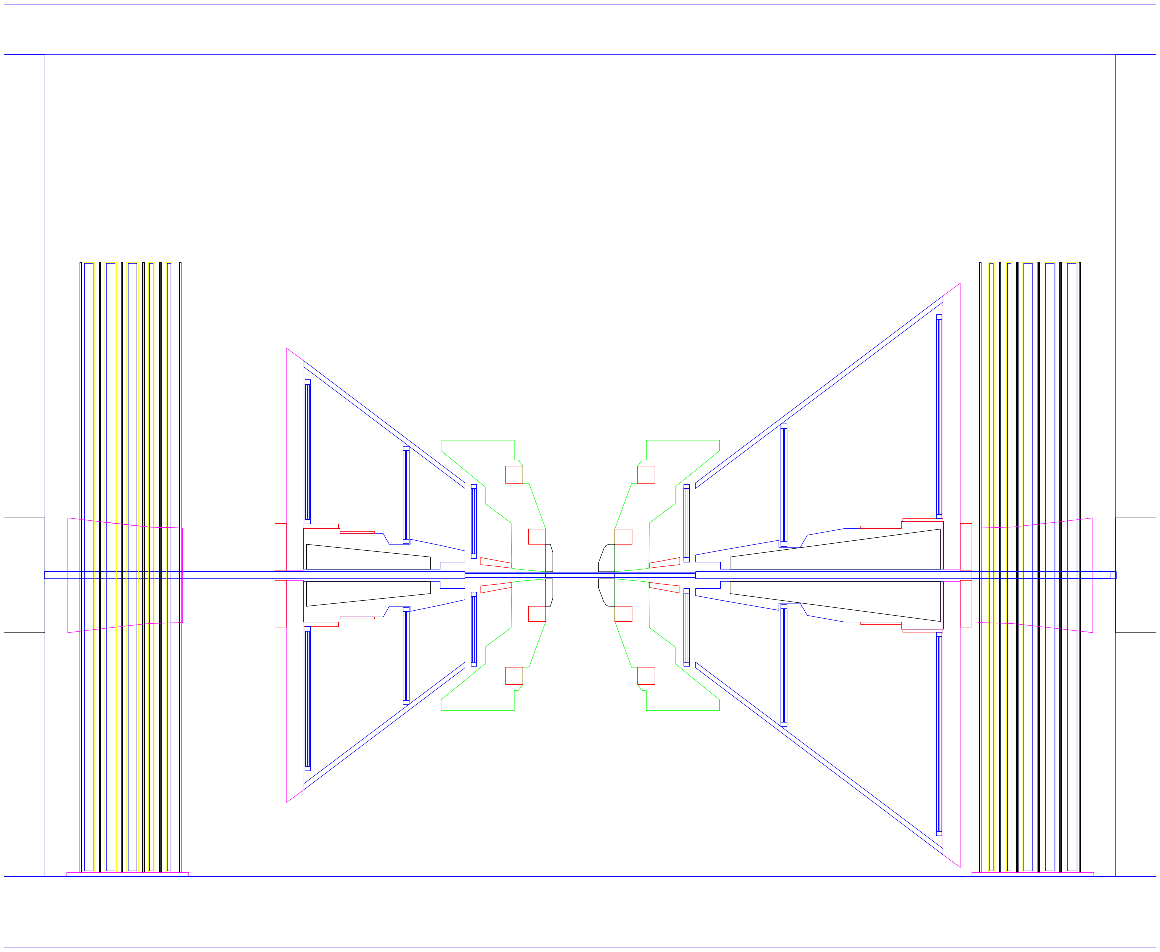

Figure 1: The absorber materials and muon arms of the PHENIX detector, as represented in the simulations. The left side is the South muon arm and the right side is the North muon arm.

tracking stations. The South arm is limited to only 148 MeV/c^2 because of the shorter nosecone. However, because the lever arm is significantly shorter in the South arm than in the North arm the sagitta (or kick) is significantly smaller in the South arm than in the North arm for the same momentum particle. This means that the chamber resolutions and multiple scattering in the spectrometer material more strongly affect the momentum resolution in the South arm than in the North arm. The shorter length of air causing multiple scattering only slightly compensates for this. The result is that the multiple scattering in the air and chamber material in the South arm increases the upsilon mass resolution from 148 MeV/c^2 to 180 MeV/c^2 while leaving the mass resolution in the North arm relatively unchanged. The baseline chamber resolutions further degrade the upsilon mass resolution in the South arm to 250 MeV/c^2 while degrading the North arm resolution to only 205 MeV/c^2. Because the chamber resolution is still contributing to the upsilon mass resolution in both arms, we have investigated improving the chamber resolution by changing the number of fine cathode planes in each station. This is presented in the next section.

2.3 Mass Resolution with Different Cathode Planes

Table 2 shows the upsilon mass resolutions that are obtained for the North and South muon arms for the baseline chamber configuration, a configuration where all coarse cathode planes are replaced by fine cathode planes, and a configuration where just the coarse cathode planes at station two are replaced by fine cathode planes. The last two configurations give very similar mass resolutions for the North muon arm because the station two chamber resolution contributes twice as much to the error in the perpendicular momentum measurement as do stations one and three. Therefore, improving the station two resolution has more significant impact on the momentum resolution unless the resolution of station two is already a factor of two better than the resolution of the other two stations. For both of these configurations, the upsilon mass resolution in the North muon arm is reduced to approximately the limit due to multiple scattering and energy straggling in the absorber material in front of the tracking stations.

For the South muon arm, the mass resolution does not improve noticeably if just station two has all fine cathodes, but it does improve if all stations are changed to have all fine cathodes. If fine cathode planes are put into all

	North Arm Resolution (MeV/c^2)	South Arm Resolution (MeV/c^2)
Baseline Spectrometer	205	252
All Fine Cathodes	183	219
All Fine Cathodes at Station 2	182	250

Table 2: Upsilon mass resolutions obtained by the North and South muon arms, with the baseline spectrometer chambers, chambers with all fine cathodes, and all fine cathodes just in station 2.

three stations then the mass resolution improves from 250 MeV/c^2 to 220 MeV/c^2.