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SDC
SOLENOIDAL DETECTOR NOTES

BW3 - BW2 RADIAL SEPARATION STUDIES

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This brief note summarizes some calculations on the effects of decreasing the radial separation between the two muon chamber stations which lie on the outside of the barrel muon toroid. We concentrate on momentum resolution, muon confusion, and changes in alignment tolerances as the spacing between BW2 and BW3 is varied. All studies reported here assume the presence of two, projective θ planes in each of the three muon stations and two ϕ layers(1) placed in just BW1(2).

The below tables summarize the assumed nominal geometry(3) used in these studies:

Table 1 : Radial Geometry

	R_{in}	R_{out}
Calorimeter(4)	2.1 m	4.32 m
BW1	5.67	6.27
Toroid	6.45	7.95
BW2	8.18	8.53
BW3	9.78	10.66

This nominal geometry assumes a 1.25 meter separation(5) between BW2 and BW3. This memo studies how various performance parameters of the system depend on this separation.

1. Momentum Resolution

Figures 1 and 2 give the fractional momentum resolution ($\sigma P_t/P_t$) as a function of the BW3 - BW2 separation distance(5) at P_t of 100 , 200 , 400 , & 600 GeV. The momentum is measured using the θ planes of the muon system as a

stand alone system. This momentum resolution is relevant to both a second level (θ) trigger as well as for off line applications such as the use redundant momentum measurement in order improve muon matching and reduce punch through. Figure 1 is for $\eta = 0$ muons; Figure 2 is for $\eta = 1.5$ muons.

These figures show that increased BW2 - BW3 lever arm appears to significantly improve stand-alone momentum resolution only for muons with $P_t > 300$ GeV. The figures also illustrate the point that barrel toroid performance is better at large η than small η. At low P_t where the momentum measurement is MCS dominated, one can show that $\sigma P_t/P_t \propto 1/\sqrt{sin\ \theta}$

2. Muon Matching

In an October 31 memo entitled *Muon Matching Studies* by Steve Errede, Rob Gardner, & Jim Wiss, we discuss a quantity called the *confusion volume* which serves as a sort of "Rayleigh criterion" as to when a candidate track has track parameters which are too close to those of a muon track to be resolved within the muon system. We assume that the off line matching of the muon chamber hits with a possible CTD track is performed using a χ^2 test to the extrapolated track trajectory. A track is matched if it has a minimum, acceptable confidence level to the muon chamber hits. Confusion results when an adjacent track has sufficiently similar track parameters that its extrapolation satisfies the muon confidence level cut. We define a *confusion volume* as the volume[6] of the space of parameter differences which gives a χ^2 change of 1 unit.

Figure 3 shows the matching confusion volume: $P_\perp \times (\Delta P_\perp\ \Delta\phi\ \Delta\theta)$ as a function of $P_\perp$ of the candidate track at $\eta = 0$ for the case of the nominal BW2 - BW3 spacing (solid curve) and for the case of zero separation (dashed curve) where the inner boundary of BW3 just touches the outer boundary of BW2. Below $P_t < 100$ GeV, there is essentially no difference in muon matching confusion. Even at P_t of 1 TeV, muon confusion increases by only 31 % if the BW2 - BW3 separation is reduced to zero. We note that our assumed chamber layout (ϕ layers in BW1) has been chosen to minimize matching confusion.

3. Misalignment Tolerances

Table 2 compares the maximum error normalized momentum biases ($\Delta P_t/\sigma P_t$) induced by rigid body misalignments of BW3 in fits where the barrel toroid is used as a stand alone system for $P_t = 100$ GeV and $P_t = 2$ TeV muons. A more complete description of rigid body alignment momentum biases is presented in my October 29th memo *Muon System Alignment Studies.* For pitches, rolls and transverse shifts, the maximum normalized bias occurs at the most extreme η; for z shifts the maximum bias occurs at $\eta = 0$. The alignment biases generally approximate sinusoidal distributions in ϕ. The table below gives maximum bias found after scanning over all ϕ.

Table 2 : BW3 Misalignment– Toroid Stand Alone

Max Δ/σ vrs BW3 - BW2 Separation

	100 GeV	100 GeV	2 TeV	2 TeV
	1.25 Sep	0 Sep	1.25 Sep	0 Sep
.5 mm shift x	0.15	0.24	1.02	0.97
.5 mm shift z	0.27	0.41	1.14	1.06
.1 mrad pitch	0.80	1.18	5.47	4.72
.1 mrad roll	0.12	0.18	0.83	0.71

For the case of $P_\perp = 100$ GeV muons, reducing the BW2 - BW3 spacing to zero, induces an ≈ 1.5 increase in the error normalized momentum bias due to BW2 - BW3 alignment. On the other hand a reduction of this separation may make it easier to align BW3. The $P_\perp = 100$ GeV case is probably most relevant to 2nd level triggering considerations. At $P_t = 2$ TeV, a case relevant to offline analysis, reduction of the BW2 - BW3 separation results in a slight decrease in error normalized momentum biases. I believe that this reflects the increase in the momentum error rather than a decrease in the momentum bias as one reduces BW2 - BW3 separation.

4. Conclusions

A series of studies are presented on the effects of reducing the BW3 - BW2 radial separation. For muons with P_t's up to several hundred GeV, the only deleterious effect I was able to find was an increased sensitivity ($\times 1.5$) in BW3 rigid body alignment. Beyond $P_t > 300$ GeV a noticeable degradation occurs in the fractional momentum resolution obtained using the stand-alone muon system as one reduces the BW2 - BW3 separation. Muon confusion studies show that muon confusion should be relatively insensitive to the BW2 - BW3 separation up to very large P_t. These studies assume[3] a relatively thick BW3 package of 88 cm.

Footnotes

[1]We model this as two independent ϕ measurements separated by an $\approx 30cm$ lever arm. In reality four physical ϕ layers might be used because of drift time and ambiguity considerations.

[2]One θ layer is placed close to the inside radius of each BW package and the other is placed on the outside radius. The ϕ layers are sandwiched in between the two θ layers with a maximum possible spacing between them.

[3]The nominal geometry is based on the SDC integration group document Dated 9/23/91 , distributed at the October ORNL SDC meeting, **except** we assume a 60 cm thick BW1 station rather than the 35 cm assumed in that document.

[4]We model the calorimeter (for scattering purposes) as a 2.22 meter thick slab of iron.

[5]Throughout this memo, the separation is defined as the radial distance between the outer boundary of BW2 and the inner boundary of BW3. The nominal separation is 1.25 meters.

[6]This is the volume enclosed by an ellipsoid whose principle axes depend on the fit matrix of the candidate track.

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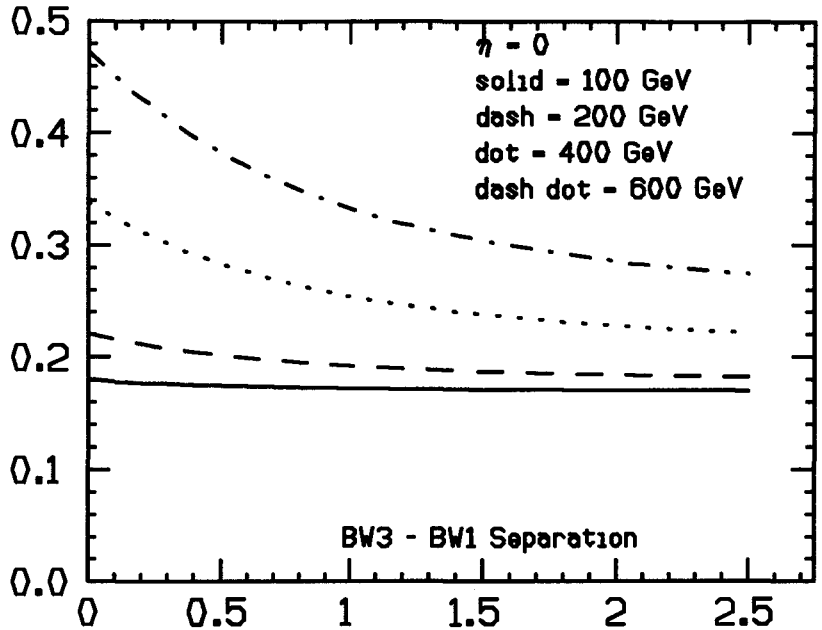
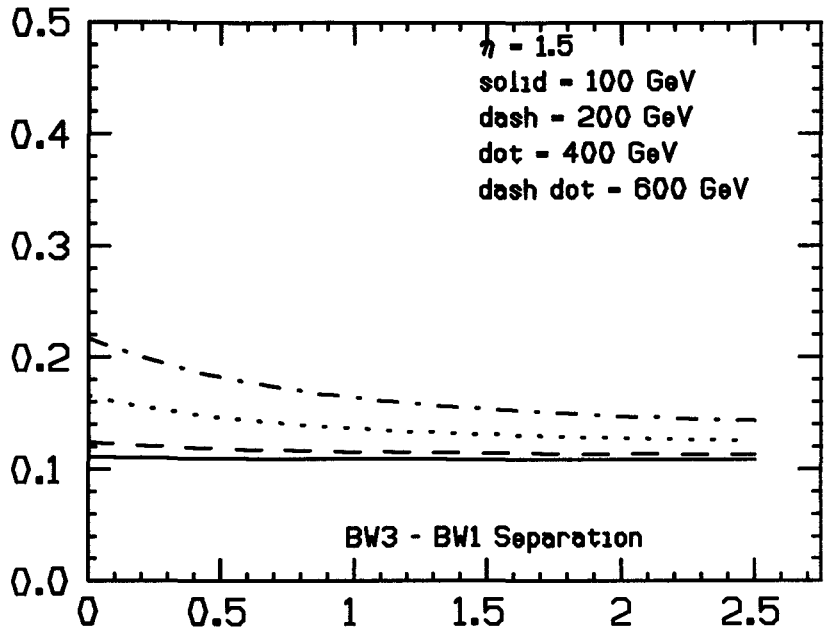
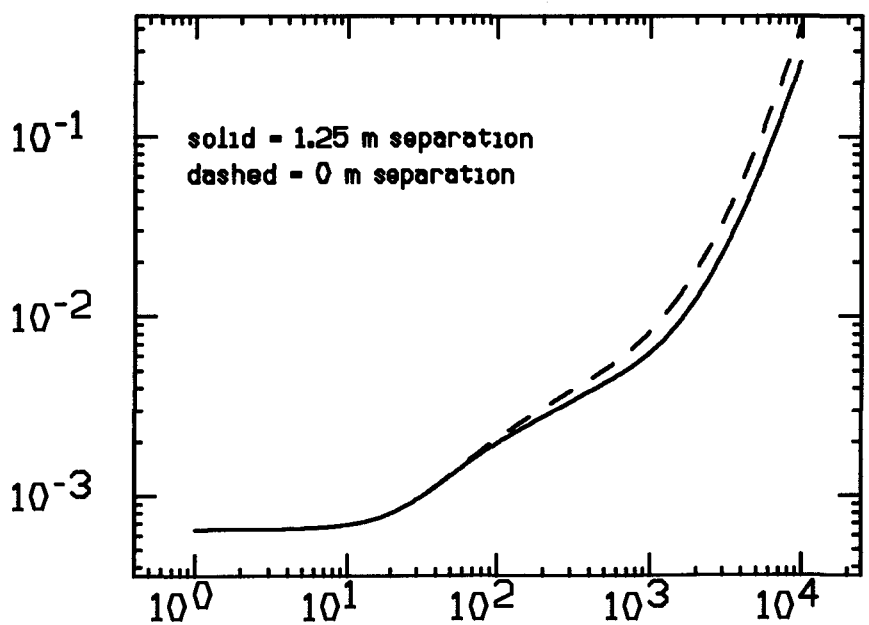
σPt/Pt vrs Δ



σPt/Pt vrs Δ



Confusion volume (Δφ ΔQ/P Δθ)-match