Muon Reconstruction and Identification with the DØ Detector at the TeVatron

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The decay of the Z^0-boson, produced in $p\bar{p}$ collisions, into two muons ($Z^0 \rightarrow \mu^+\mu^-$), is examined with data taken with the DØ detector and used to study the reconstruction and identification of muons and in particular the resolution of their momentum measurement. The muon tracks are detected and reconstructed with the DØ muon system and matched to tracks identified with the central tracking system. The muon detector itself consists of three subsystems. The Proportional Drift Tubes (PDTs) provide tracking coverage for pseudorapidities $|\eta| \leq 1.0$ ($\eta = -ln(tan\frac{\theta}{2})$). Planes of mini-drift-tubes (MDTs) in the forward angle muon tracking system extends the muon detection to $|\eta| = 2.0$. Scintillation counters for triggering and background rejection and toroidal magnets complete the muon system (see also [1]).

The event selection requires two oppositely charged high p_T muons identified by requiring tracks in the central detector that are matched with tracks in the muon chambers. To reduce the background from muon pairs produced in QCD $b\bar{b}$-dijet events, at least one of the tracks is required to be isolated from other tracks in the central detector as well as energy depositions in the calorimeters. Cuts on the scintillation times and on the distance of closet approach of the muon track to the reconstructed vertex in the $\eta - \phi$ plane reduce the background from cosmic-ray muons.

To reproduce the data, the inverse of the simulated transverse muon momentum of $Z^0 \rightarrow \mu^+\mu^-$ events from a full Monte Carlo simulation need to be artificially smeared. This is done using the following ansatz:

$$\frac{1}{p_T} \rightarrow \frac{1}{p_T} \cdot \{1 + (p_T \cdot A(p_T) + B(\eta,\phi)) \cdot G\} \qquad (1)$$

where p_T is the transverse muon momentum, G a Gaussian distribution centered at zero with a width equal to 1 and A and B are parameters. To find the best smearing function, the difference in the Z^0 width has been studied depending on different ranges of p_T and the muon direction. No dependence on p_T and ϕ was found. Therefore $A(p_T)$ remains constant ($A = 0.0018$ [c/GeV]) and $B(\eta,\phi)$ is a function of η only. Three values for three η regions have been found to correct for the difference in the Z^0 width over the six possible η-bin combinations:

region	$\lvert\eta\rvert \leq 0.5$	$0.5 \leq \lvert\eta\rvert \leq 1.1$	$1.1 \leq \lvert\eta\rvert \leq 1.6$
B	0.0009	-0.0128	0.0056

As a measure of the quality of the muon smearing the weighted average of the sum of the width differences between data and Monte Carlo is calculated. Using the smearing function (1), this yields a value of $(0.22 \pm 0.20(stat.))$ GeV. This is an improvement compared to the formarly used smearing function

$$\frac{1}{p_T} \rightarrow \frac{1}{p_T} + 0.002 \cdot G \qquad (2)$$

which results in an average distance of $(0.44 \pm 0.20(stat.))$ GeV.

By using the smeared Monte Carlo, the muon momentum resolution for central, local and global tracks can be determined. Herein central refers to the track in the central tracker, local to the track measured by the muon system only and global refers to a simultanious fit of the tracks in the central tracker and the muon detector. Figure 1 shows the muon momentum resolution for central tracks compared to the design specifications. In Figure 2 the resolutions are shown for two different reconstruction versions p13 (old) and p14 (current) compared to the design resolution given in the technical design report (TDR) [2]. The difference between the TDR and the global resolution could be attributed to misalignement or non complete implementation of dead material in the Monte Carlo. The p_T resolution of the central tracker is better than the resolution in the local muon system, due to multiple scattering in the calorimeter and the magnetic toroid and a worse hit resolution of the drift tubes.

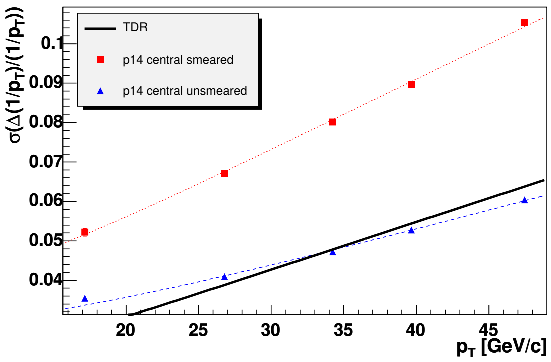

Fig. 1: Muon momentum resolution from Monte Carlo for central tracks compared to the design specifications (TDR); blue triangles: unsmeared Monte Carlo, red squares: smeared Monte Carlo, black: TDR

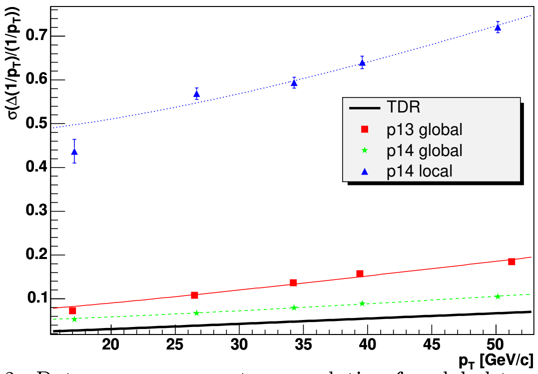

Fig. 2: Data: muon momentum resolution for global tracks reconstructed with p14 (green stars) and p13 (red squares) and local tracks reconstructed with p14 (blue triangles)

References

[1] R. Ströhmer *et al.*, Annual report 2001, p. 43.
T. Christiansen *et al.*, Annual report 2000, p. 34.

[2] DØ Collaboration, D. Adams *et al*, DØ Note 4164, (unpublished)