TRACKING EFFICIENCY AND IMPACT PARAMETER RESOLUTION FROM A GEANT SIMULATION OF THE DO DETECTOR

G. Rahal-Callot
SUNY - Stony Brook, NY 11794

T. Trippe
Lawrence Berkeley Laboratory, Berkeley, CA 94720

D. Zieminska
Indiana University, Bloomington, IN 47405

The capability of a detector to study B physics depends on the ability to identify and reconstruct leptons in the central detector. In this report we study the efficiency of connecting a muon track from the muon detector (MU) through the central drift chamber (CDC) and vertex detector (VTX). We also estimate the ability to distinguish muons originating in heavy particle decays from muons coming from the main vertex.

Events Sample, Detector Simulation, and Tracking Parameters

We have used a set of QCD two-jet ISAJET events containing a muon, satisfying a simulated DO muon trigger. More detail on the Monte Carlo sample can be found in a separate report by Hedin et al [1]. Reference [1] also contains a discussion of B quark physics and an estimate of rates and backgrounds of B physics signals for DO detector.

For this tracking study the ISAJET events were passed through the DO detector simulation program DOGEANT to simulate the response of the VTX and CDC. The VTX and CDC are cylindrical layers of jet type drift chambers with sense wires along the beam direction z and with the drift direction roughly perpendicular to the tracks. The VTX has three layers lying between a radius of 3 and 17 cm while the CDC has four layers lying between 50 and 75 cm. Each layer has 32 phi sectors except the innermost VTX layer which has 16. Each VTX phi sector has eight sense wires with charge division readout for z. Helical cathode strips in the VTX give an independent z measurement. The CDC phi sectors each have seven sense wires and use delay lines to measure the z coordinate.

The simulation included the inert material of the beryllium beam pipe and the transition radiation detector (TRD) that lies between the VTX and the CDC as well as that of the CDC and VTX themselves. Effects of multiple Coulomb scattering, interactions and decay of long lived particles, finite resolution, and detector inefficiency were taken into account. The following realistic assumptions based on test data or conservative estimates were made for the efficiencies and resolutions. For the efficiency studies, the measured VTX two hit resolution function was used [2]. Conservative guesses were made for the requirements for a good track.

Chamber Parameters	CDC	VTX Sense Wires	VTX z-strip
Global efficiency	0.95	0.97	0.90
two hit r-phi resolution (mm)	2	0.7	5
two hit drift time separation (ns)	50	84	600
single hit resolution (mm)	0.2	0.05	unused
drift velocity (microns/ns)	38	8.4	8.4
Tracking Parameters			
hits/wires for good track in layer	4/7	5/8	---
good/total layers for good track	3/4	2/3	3/5

Efficiency to Track Muon through Central Detector

For each muon we defined a one sigma road coming from the MU back through the calorimeter toward the CDC to represent the effect of the multiple Coulomb scattering in the calorimeter and MU iron toroid. We estimated the efficiency for reconstructing the muon track in the CDC and the probability for an unambiguous match. The CDC track was then projected using a three sigma m.C.s. road into the center of the transition radiation detector (TRD) for matching with VTX tracks. We estimated the reconstruction efficiency in the VTX and the probability for an unambiguous VTX track match. In the above procedure we assumed that the road from the MU into the calorimeter was centered on the ISAJET muon (i.e. extrapolated from the vertex) rather than on the muon after m.C.s. through the calorimeter because it was too time consuming to simulate the calorimetry. We have included a 68% efficiency for the MU --> CDC match.

The track multiplicities and efficiencies for each step are as follows:

Two jet event pT range (GeV/c)	80-200	40-80	20-40
Multiplicity in CDC	53	37	29
Approximate multiplicity in VTX	106	74	58
MU --> CDC match (1 sigma road)	.68	.68	.68
CDC efficiency	.80+-.04	.88+-.04	1.00+-.02
CDC match unambiguous (1 track in road)	.89+-.04	.86+-.05	.88+-.05
VTX efficiency	.51+-.07	.45+-.08	.78+-.07
VTX match unambiguous (1 track in road)	1.00+-.03	1.00+-.05	1.00+-.03
Combined efficiency (product of above)	.25+-.04	.23+-.04	.47+-.05

These muon efficiencies are from a low statistics study. The low VTX efficiency for the 40-80 GeV sample may be a statistical fluctuation. A study of the efficiencies for all tracks from this sample agrees with the above values except for this value which appears to be several sigma low.

No effort has been made to optimize the road widths and tracking criteria to improve the efficiency. The one sigma road width for the MU --> CDC match should probably be increased to optimize the number of unambiguous matches. The VTX efficiencies are the dominant factor as is expected since the VTX covers a pseudorapidity range of about +-2, about twice that of the CDC. In addition, the VTX assumptions made here are pessimistic with respect to the two track resolution of the z-strips (in the absence of proof of performance) so a good charge division measurement is needed for the z projection of the track.

We could get a significant increase in efficiency by not requiring z information in the VTX but requiring only the r-phi projection. This is because the r-phi measurement uses the leading edge of the pulse so that only tracks ahead of the measured pulse interfere, whereas charge division z measurements use the pulse area and thus tracks ahead or behind the measured track interfere, effectively doubling the two track resolution.

Impact parameter studies with the Vertex Chamber

In order to assess the feasibility of identifying muons coming from heavy particle decays we did track reconstruction in the VTX and compared distributions of impact parameter for primary tracks with those of tracks coming from decay of particles containing a b or c quark. We used all charged particle tracks to increase statistics.

For this study we used a sample of two-jets events in the pT range 40-80 GeV/c. Figure 1 shows the impact parameter distribution of all tracks coming from the primary vertex and from b/c decays. The distribution for tracks coming from the primary vertex (solid line) is normalized to unity. The distribution of tracks coming from b/c decays (dashed line) is normalized so that the maximum bin contents are equal in both distributions. The two distributions are very similar, largely due to the error introduced by the multiple Coulomb scattering in the Tevatron beam pipe and in the material between the layers of the chamber. In Figure 2 we compare the same impact parameter distributions for tracks with pT > 2 GeV/c. The number of tracks in this plot from the primary vertex and from the b/c decays is 264 and 155, respectively. We find that for impact parameter greater than 400 microns more than 90% of tracks come from the decay vertex.

Conclusion and Acknowledgement

This preliminary study shows that the D0 detector can track muons from B decay with an efficiency of at least 50% and probably significantly better for pT 20-40 GeV jet events. For tracks whose momentum can be measured in D0 (muons and isolated tracks) cuts on pT and impact parameter can yield a relatively pure sample of events with heavy particle decays.

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References

1. D.Hedin, T.Kramer and K.Roberts, "B physics at DO", this proceedings.

2. A.R.Clark, F.Goozen, L.T.Kerth, C.Klopfenstein, S.C.Loken, M.Strovink, T.G.Trippe, Nucl. Instr. and Meth. A261, 420 (1987).

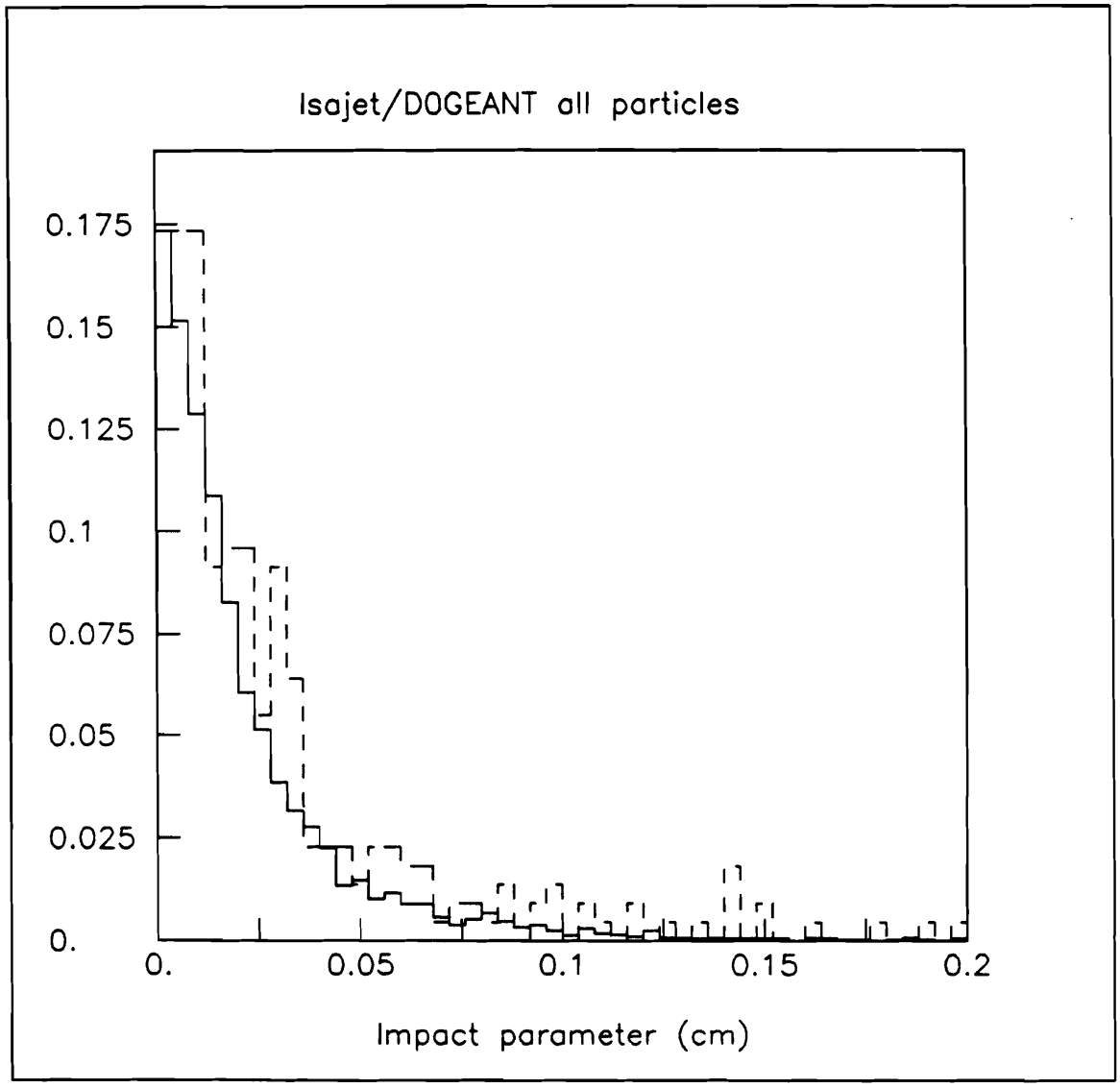

Figure 1. Impact parameter distribution for tracks coming from the primary vertex (solid line) and from decay of particles containing a b or c quark (dashed line).

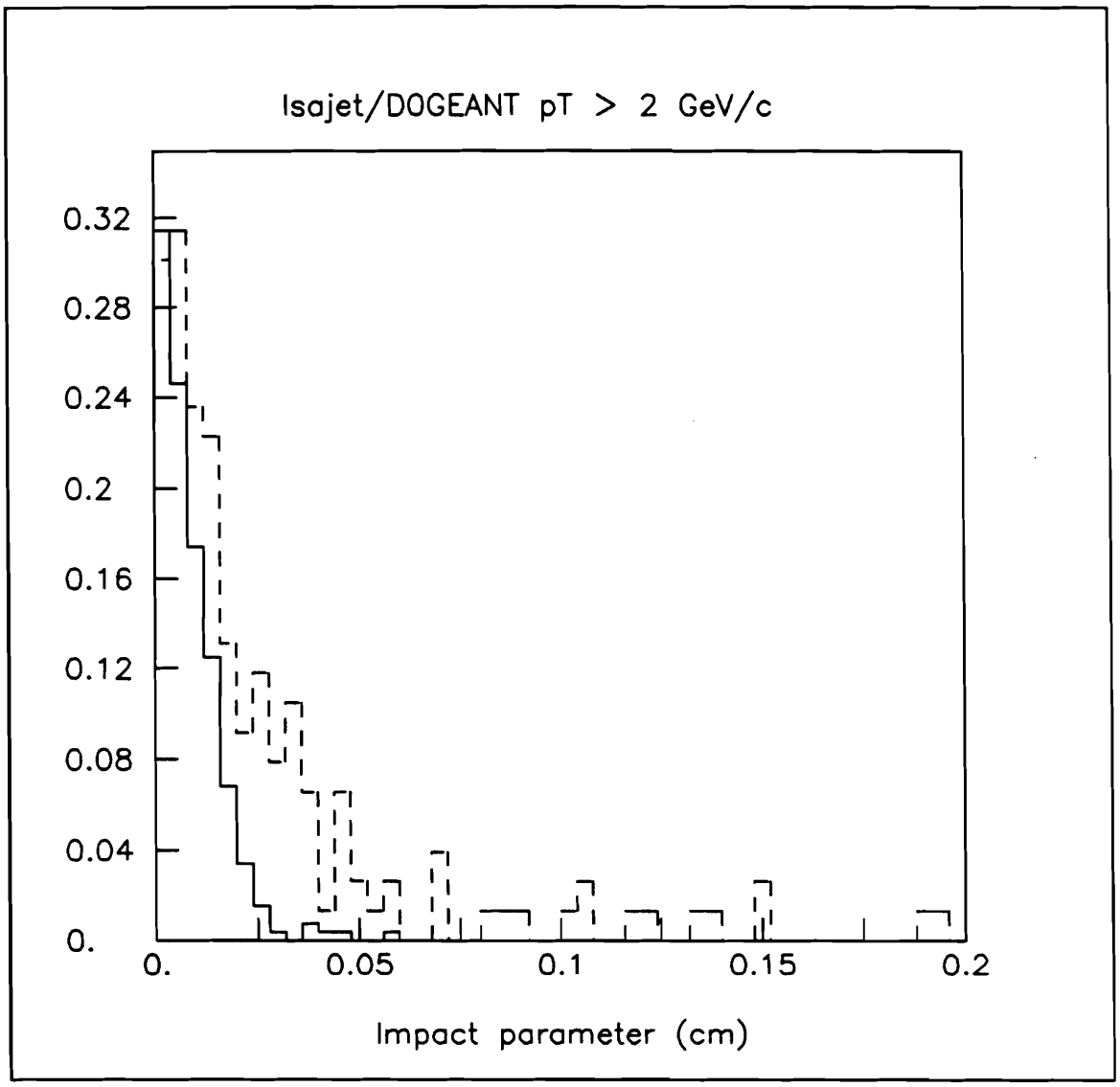

Figure 2. Impact parameter distribution for tracks with pT > 2 GeV/c, coming from the primary vertex (solid line) and from decay of particles containing a b or c quark (dashed line).