STUDY OF COMBINATORICAL BACKGROUND IN THE DECAY $B_d^0 \to \pi^+\pi^-$ FROM p-p INTERACTIONS AT $\sqrt{s} = 40$ TeV

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1. INTRODUCTION

The $b\bar{b}$ cross section at the SSC is predicted to be 1–3 mb, and 1–3% of the p-p interactions will produce a $b\bar{b}$ pair.[1] Based on the experience of the CDF collaboration it has been established that the $B \to J/\psi X$ modes can be found with acceptable background levels in a hadron collider.

This paper reports studies of the efficiency for reconstructing the decay $B_d^0 \to \pi^+\pi^-$ and of rejection of background due to $b\bar{b}$. Identification of this decay mode is expected to be more difficult than the $B \to J/\psi X$ modes due to severe combinatoric backgrounds. Nonetheless, two aspects of B decays will make it possible to extract the $B_d^0 \to \pi^+\pi^-$ signal at a hadron collider. The relatively long lifetime of the B meson allows the vertex for the decay $B_d^0 \to \pi^+\pi^-$ to be easily isolated from the primary vertex. In addition, the pions from this decay have the maximum momentum of daughters from any B decay and so are more readily separated from low-P_T hadron backgrounds.

The results reported here are based on detailed simulation of pattern recognition in vertex fitting using information from a silicon vertex detector. However, the separate issue of track pattern recognition is not addressed, and it is assumed that detector hits are all properly associated with tracks. A study that combines the issues of track and vertex pattern recognition has been reported in Ref. 2.

2. DETECTOR PARAMETERS

We simulated a vertex detector that consisted of 3 coaxial silicon barrels and 33 silicon disks normal to the beam, 21 of which were interleaved with the barrels. The vertex detector surrounded a beryllium beam pipe. The detector is symmetrical about z=0 with the central 21 discs spaced uniformly in length and the rest uniformly in pseudorapidity with $|\eta| < 5$. The simulated detector has been described in more detail in Ref. 3.

3. EVENT GENERATION

Based on previous experience we have concluded that the main source of background for this decay mode comes from other B decays, and not from minimum-bias events or charm decays. ISAJET was used to generate 1,040,000 $b\bar{b}$ events at 40 TeV center of mass energy.[4] The detector simulation-package GEANT was used to track and decay the particles taking into account multiple scattering, nuclear interactions, and electromagnetic cascades. Roughly 42% of the $b\bar{b}$ events contained B_d^0 mesons; these were forced to decay to $\pi^+\pi^-$. The detector simulation contained a beam pipe, a silicon vertex detector and no magnetic field. The simulation was run on Intel iPSC/860 processors at U. Pennsylvania and the SSC Laboratory.[5] Up to 16 independent processors (nodes) were used simultaneously.

4. VERTEX RECONSTRUCTION

Only charged tracks with at least three hits in either the barrels or the disk detectors were used for vertex reconstruction. A hit was defined as a track intercepting a silicon detector at an angle of incidence $< 55°$. The hits were smeared with Gaussian errors based on angle dependent resolution.[6] A straight line was then fit to the hits for each track returning a slope, intercept, and error matrix based on an estimate of multiple scattering. The momentum of the particle was assumed known due to an outer detector (not simulated). Fitted tracks with a $P_T > 0.6$ GeV/c and $|\eta| < 4$ were passed on to the CERN program library routine VERTEX. All selected tracks were initially fit to the hypothesis of a single vertex and those contributing a $\chi^2 > 3$ were excluded from this vertex. In the next iteration this set of previously excluded tracks were considered to come from a single vertex and the whole procedure repeated until no more vertices were found. All secondary vertices with two oppositely charged tracks were considered as $B_d^0 \rightarrow \pi^+\pi^-$ candidates.

5. ANALYSIS

Only 11% of the true $B_d^0 \rightarrow \pi^+\pi^-$ events passed the inital set of cuts and the vertexing algorithm described above, after which three additional cuts were used:

1. The closest-distance-of-approach (CDA) cut, where CDA is the distance between between the reconstructed primary vertex and the three-momentum of the B_d^0 . Where CDA is required to be < 0.01 cm.

2. The vertex-separation cut ($S/\Delta S$), where S is the two dimensional displacement of the fitted vertex from the beam and ΔS is the error on this quantity. $S/\Delta S$ is requried to be >15.

3. The track-P_T cut. This cut was on the P_T of both the charged tracks from the secondary vertex. P_T is required to be >1.75 GeV/c.

The efficiencies and the background rejection of each cut is shown in the table given below:

Table 1. Efficiency and Background Rejection of the Cuts.

CUT	EFFICIENCY	BACKGROUND REJECTION
$P_T > 1.75$ GeV/c	67%	98%
CDA<0.01cm	95%	50%
$S/\Delta S > 15$	48%	97%

No background remains in a ± 0.25 GeV/c^2 window about the B_d^0 mass, after all cuts are applied. Assuming a branching ratio of 10^{-5} for the decay $B_d^0 \rightarrow \pi^+\pi^-$, we calculate a signal-to-noise ratio of greater than 1, at a confidence level of 90%.

6. CONCLUSIONS

We have studied the feasibility of observing the decay mode $B_d^0 \rightarrow \pi^+\pi^-$ in a hadron collider such as the SSC, using the ISAJET Monte Carlo and GEANT detector-simulation package. The large combinatoric background from other B decays was the main concern. After cuts, principally on secondary-vertex quality, we achieved an efficiency for finding $B_d^0 \rightarrow \pi^+\pi^-$ decays of 4% and a signal-to-noise ratio of > 1.0, 90% CL. This simulation indicates that the SSC collider environment provides an opportunity to detect a large sample of $B_d^0 \rightarrow \pi^+\pi^-$.

7. REFERENCES

1. E.L. Berger and R. Meng, *Heavy Quark Cross Sections at Hadron Collider Energies*, ANL-HEP-PR-92-11 (January 1992).
2. *Response to the SSC PAC*, (July 11, 1990). *Bottom Collider Detector: A Low- and Intermediate-P_t Detector for the SSC*, SSC-240 (Sept. 30, 1989); *Bottom Collider Detector, Expression of Interest* (EOI008), submitted to the SSCL (May 25, 1990).
3. L.A. Roberts, *Monte Carlo Simulation of Vertex Detector for Bottom Collider Detector*, Fermilab preprint FN-488 (June, 1988).
4. F.E. Paige and S.D. Protopopescu. *ISAJET 6.36*, Brookhaven National Laboratory.
5. P.T. Keener *et al.*, *Porting of Standard High Energy Physics Physics Codes to the Intel iPSC*, submitted to Comp. Phys. Comm. (June 1992).
6. M. Lambrecht *et al.*, *Beam Tests of Silicon Microstrip Detectors with VLSI Readout*, IEEE Trans. Nucl. Sci. **NS-38** (1991).