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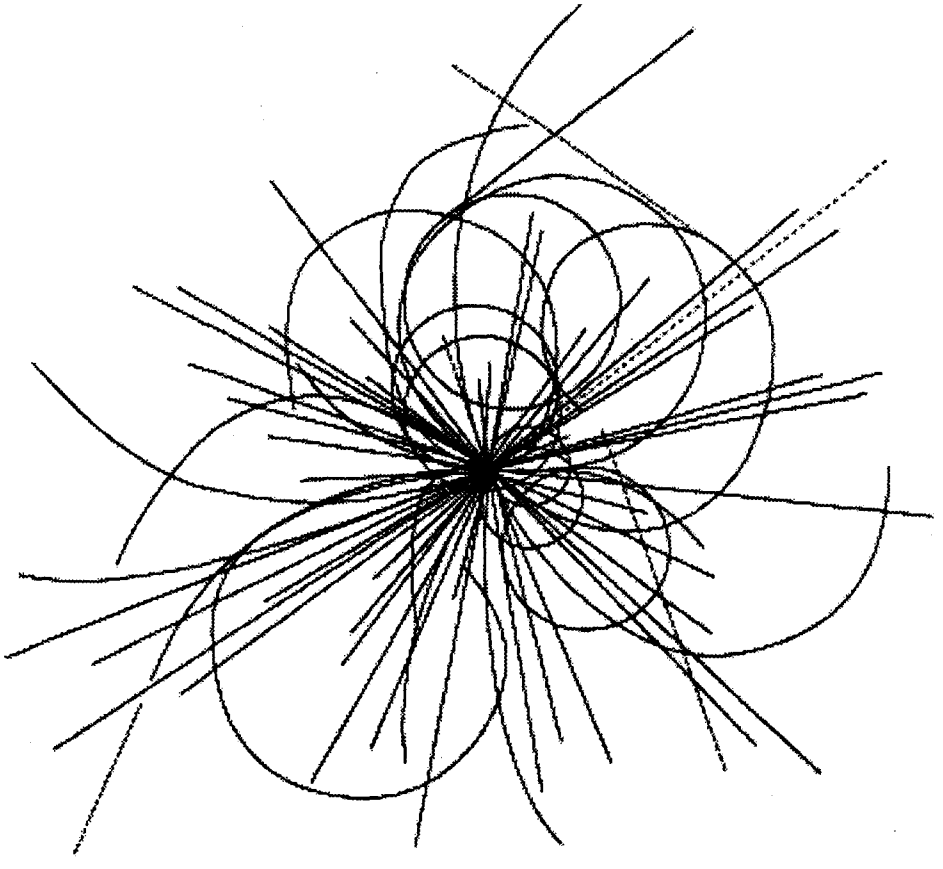

Superconducting Super Collider Laboratory

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SDC Tracking Capabilities for B Physics*

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SDC Tracking Capabilities for B Physics

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1. INTRODUCTION

The $b\bar{b}$ production cross section is estimated[1] to be 1 mb at $\sqrt{s} = 40\ TeV$, implying 10^{12} produced $b\bar{b}$ pairs at an SSC luminosity of $10^{32}\mathrm{cm}^{-2}\mathrm{sec}^{-1}$ ($.1 \times$ design). SDC has the potential to exploit this high rate to explore a number of B physics topics, in particular, CP violation in the neutral B meson. This note describes the SDC particle tracking design (Section 2) and its predicted performance parameters relevant to B physics (Section 3).

2. DESIGN

The SDC central tracking design[2] is shown in Fig. 2.1. At the innermost radius is the vacuum beampipe, currently taken as 4 cm radius and 1 mm thick Beryllium. To date, this design has not been optimized with B physics in mind, which would drive it towards a thinner smaller-radius design.

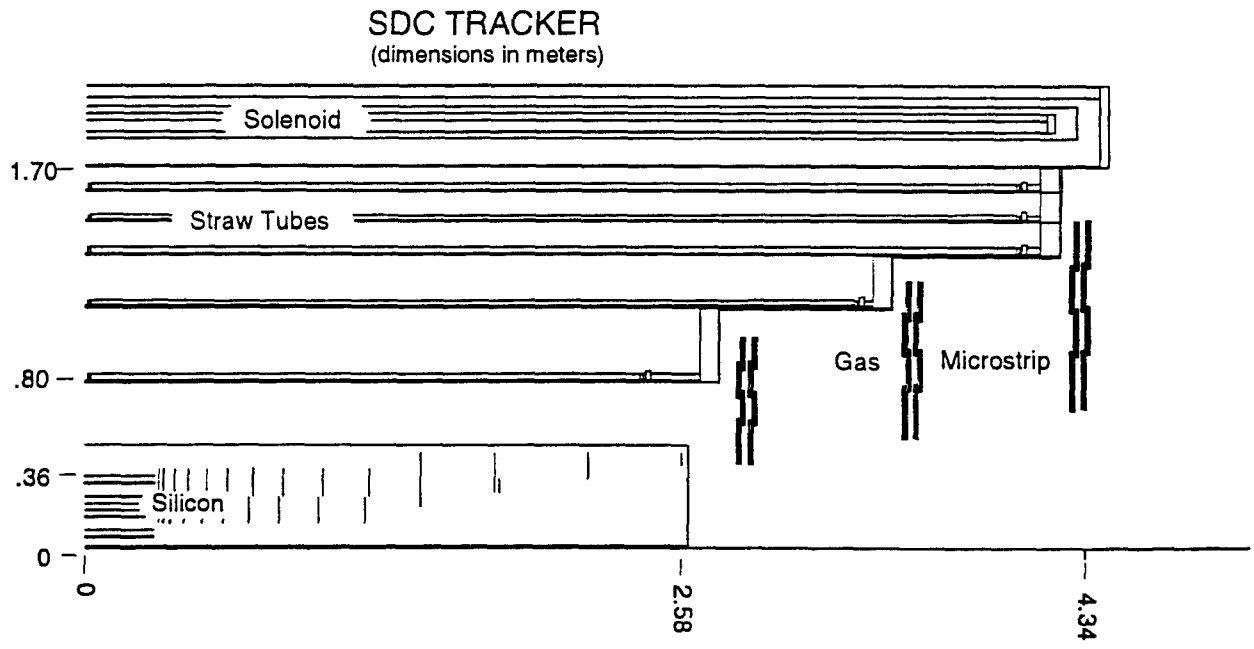

Figure 2.1: The SDC tracking detector.

Outside the beampipe, a silicon system made up of barrels and forward disks provides the bulk of the pattern recognition and vertexing capabilities. Outside the silicon, in the region $|\eta| < 1.8$, a 5-superlayer straw tube tracker provides momentum resolution for high p_t tracks and level-1 triggering. For $|\eta| > 1.8$, the same functions are provided by a gas microstrip detector with 3 superlayers. The components are situated inside a 2 Tesla superconducting solenoid with a 1.7 m inner radius.

The silicon detector consists of 8 barrels of double-sided silicon, one side with axial strips and the other with strips at a 10 mrad stereo angle. The inner barrel layer is at a radius of 9 cm from the beamline and the outer layer is at 36 cm. There are 13 layers of double-sided forward disks on each end of the barrel. Strip pitch is 50 microns for the barrel detectors and 32-58 microns for the wedge-shaped disk detectors. The resolution per barrel superlayer is predicted to be 17 microns, including an estimate of mis-alignment contributions.

A pixel option being considered by SDC would replace the inner 2 barrel silicon layers with 2 pixel barrel layers at radii of 6 and 8 cm and possibly 2 small disks at both ends of the barrel. The pixel size is 50 microns in $r - \phi$ and 250 microns in z. Charge sharing across pixels should improve the resolution to significantly better than $(pixel\ size)/\sqrt{12}$.

The straw tube tracker has 5 superlayers, each containing 8 straw layers for axial superlayers (1, 3 and 5) and 6 straw layers for the 10 mrad stereo superlayers (2 and 4). The per tube resolution is estimated to be roughly 120 microns and the superlayer resolution (including estimates of mis-alignment contributions) is predicted to be 85 microns.

The gas microstrip detector covers the region $|\eta| > 1.8$ with 3 superlayers, each consisting of 2 layers of radial strips and 2 stereo layers at ± 100 mrad. The strip pitch is 200-450 microns, with a predicted resolution per superlayer of 60-100 microns.

3. PERFORMANCE

The resolution of various track parameters are shown in Fig. 3.1 as a function of η. The pixel option makes a small improvement in impact pararmeter resolution due to its smaller radius but significantly improves the resolution in the z component of the track extrapolation to the beamline (z0) from $\sim$ 1mm to $\sim 100\mu m$. These track resolutions translate into invariant mass resolutions shown in Fig. 3.2 for the J/ψ mass in the decay $B \rightarrow J/\psi K \rightarrow \mu^+\mu^- K$ and the B meson mass in the decay $B \rightarrow \pi^+\pi^-$. There is a minimum p_t cut of 4 GeV/c for muons and 2 GeV/c for pions. These results come from a GEANT simulation of the SDC tracking detector. The reconstructed mass resolutions in Fig. 3.2 are not vertex-constrained, which will improve the resolution slightly.

As is clear in Fig. 3.1, the p_t range of interest in B physics (2-20 GeV/c) suggests that multiple scattering will affect vertexing capabilities. To look at SDC vertexing performance we consider at a decay mode of particular interest for CP violation, namely $B_d^0 \rightarrow \pi^+\pi^-$. This B decay mode was generated using ISAJET and input to a GEANT simulation of the SDC tracker and a track and vertex reconstruction algorithm. We then form the vertex chi-square (χ_V^2) between the secondary vertex reconstructed with the $\pi^+\pi^-$ and the primary vertex, assumed in this study to be known to infinite precision. This assumption is reasonable at the SSC since the 5 by 5 μm transverse size of the beam is small compared to the mean tranverse displacement of the secondary B decay vertex ($\sim 2mm$). B_d^0 that travel some distance before decaying will have a large χ_V^2. Fig. 3.3 shows the integral

of the normalized χ^2_V distribution for $B \rightarrow \pi^+\pi^-$ and for pairs of charged pions from minimum bias. This plot then gives the acceptance as a function of the minimum cut on χ^2_V. One can cut at large values of χ^2_V (100-200) to suppress the background while retaining reasonable acceptance for $B^0_d \rightarrow \pi^+\pi^-$ (.3-.4). The minimum bias cross section is, of course, much larger than the signal. An evaluation of the background is beyond the scope of this study, requiring a detailed simulation that includes non-gaussian effects such as track mis-reconstruction and additional cuts to suppress $\pi^+\pi^-$ backgrounds.

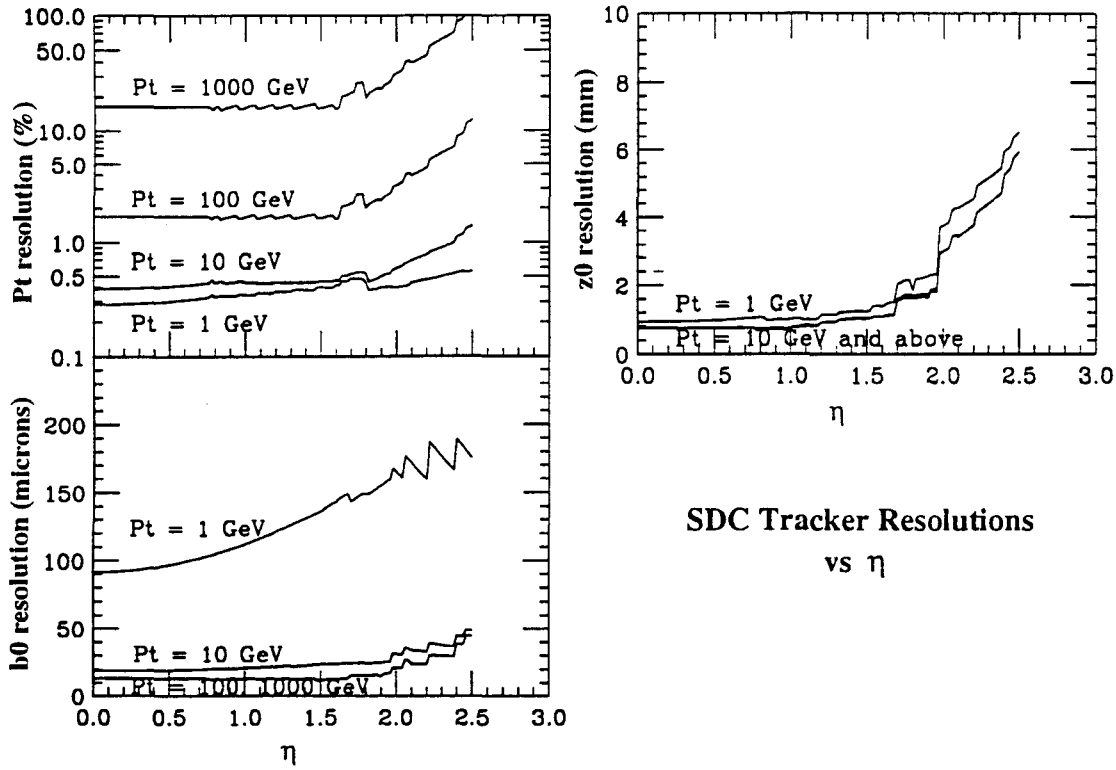

Figure 3.1: SDC single track resolutions versus pseudo-rapidity (η). Shown are resolutions for p_t and track impact parameter (b0) and z position (z0) at distance of closest approach to beamline.

4. CONCLUSIONS

The SDC design of its central tracker is well-suited for doing B physics. A number of design options exist to further enhance these capabilities, namely replacing the inner silicon layers with pixels and/or moving the inner layers closer to the interaction region with a smaller-radius thinner beam pipe. Further studies of the SDC potential for B physics are in progress.

5. REFERENCES

1. E.L. Berger and R. Meng,Phys. Rev. D46, 169 (1992).
2. SDC Technical Design Report, SSCL-SR-1215 (1992).

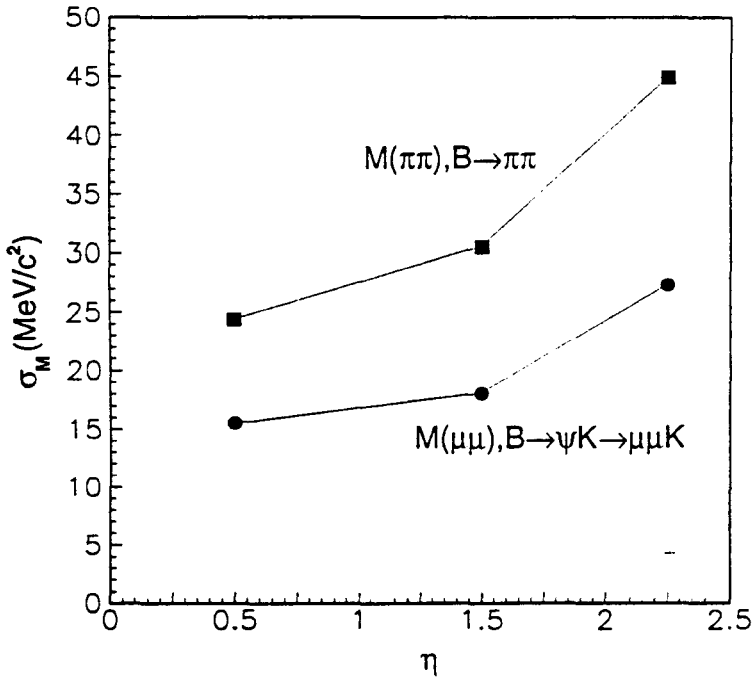

Figure 3.2: SDC resolution in the reconstructed J/ψ mass for $B \rightarrow J/\psi K \rightarrow \mu^+\mu^- K$ and the reconstructed B mass for $B \rightarrow \pi^+\pi^-$ versus pseudo-rapidity (η). The tracks are required to have a minimum p_t of 4 GeV/c for muons and 2 GeV/c for pions.

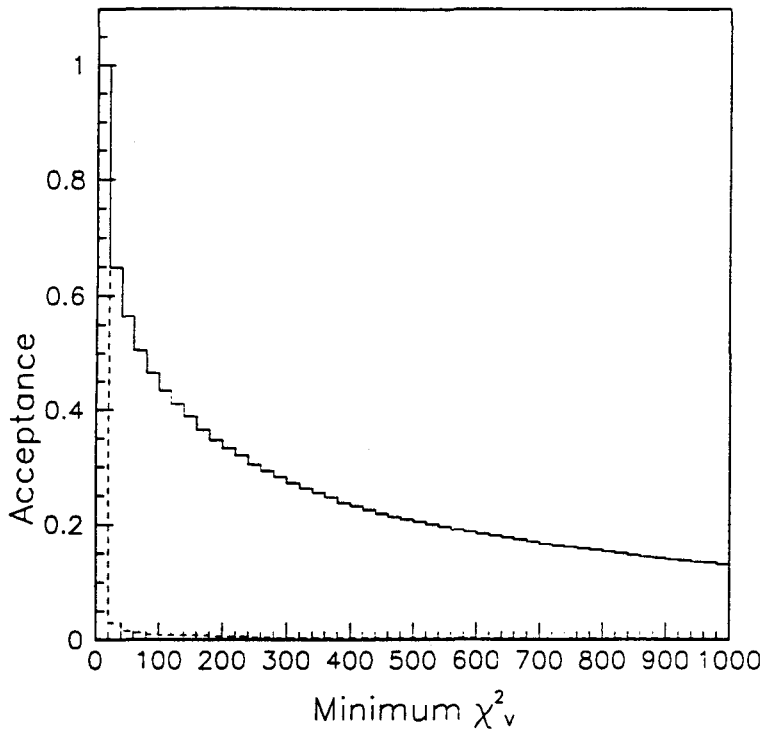

Figure 3.3: Acceptance versus minimum vertex chi-square for $B \to \pi^+\pi^-$ (solid) and pairs of charged pions from minimum bias events (dashed).