Available online at www.sciencedirect.com
SCIENCE DIRECT
ELSEVIER
Nuclear Instruments and Methods in Physics Research A 552 (2005) 224–231
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A
www.elsevier.com/locate/nima

What can be learned from the BABAR Silicon Vertex Tracker running experience

V. Re[a], D. Kirkby[b], M. Bruinsma[b], S. Curry[b], J. Berryhill[c], S. Burke[c], D. Callahan[c], C. Campagnari[c], B. Dahmes[c], D. Hale[c], P. Hart[c], S. Kyre[c], S. Levy[c], O. Long[c], M. Mazur[c], J. Richman[c], J. Stoner[c], W. Verkerke[c], T. Beck[d], A.M. Eisner[d], J. Kroseberg[d], W.S. Lockman[d], G. Nesom[d], A. Seiden[d], P. Spradlin[d], W. Walkowiak[d], M. Wilson[d], C. Bozzi[e], G. Cibinetto[e], L. Piemontese[e], H.L. Snoek[f], D. Brown[g], E. Charles[g], S. Dardin[g], F. Goozen[g], L.T. Kerth[g], A. Gritsan[g], G. Lynch[g], N.A. Roe[g], C. Chen[h], W. Houlsbergen[h], C.K. Lae[h], V. Lillard[h], D. Roberts[h], A. Lazzaro[i], F. Palombo[i], L. Ratti[j], P.F. Manfredi[j], E. Mandelli[j], C. Angelini[k], G. Batignani[k], S. Bettarini[k], M. Bondioli[k], F. Bosi[k], F. Bucci[k], G. Calderini[k,*,1], M. Carpinelli[k], M. Ceccanti[k], F. Forti[k], M.A. Giorgi[k], A. Lusiani[k], P. Mammini[k], G. Marchiori[k], M. Morganti[k], F. Morsani[k], N. Neri[k], E. Paoloni[k], A. Profeti[k], M. Rama[k], G. Rizzo[k], G. Simi[k], J. Walsh[k], P. Elmer[l], A. Perazzo[m], P. Burchat[n], A.J. Edwards[n], S. Majewski[n], B.A. Petersen[n], C. Roat[n], M. Bona[o], F. Bianchi[o], D. Gamba[o], P. Trapani[o], L. Bosisio[p], C. Cartaro[p], F. Cossutti[p], G. Della Ricca[p], S. Dittongo[p], S. Grancagnolo[p], L. Lanceri[p], L. Vitale[p], M. Datta[q], A. Mihalyi[q]

[a] *INFN-Pavia and Università di Bergamo, Italy*
[b] *University of California, Irvine, CA, USA*
[c] *University of California, Santa Barbara, CA, USA*
[d] *University of California, Santa Cruz, CA, USA*
[e] *INFN-Ferrara and Università di Ferrara, Italy*
[f] *NIKHEF, National Institute for Nuclear Physics and High Energy Physics, Amsterdam, The Netherlands*
[g] *Lawrence Berkeley National Laboratory, Berkeley, CA, USA*
[h] *University of Maryland, MD, USA*
[i] *INFN-Milano and Università di Milano, Italy*
[j] *INFN-Pavia and Università di Pavia, Italy*
[k] *INFN-Pisa and Università di Pisa, Italy*
[l] *Princeton University, Princeton, NJ, USA*
[m] *Stanford Linear Accelerator Center, Stanford, CA, USA*

*Corresponding author. Tel.: +39 050 2214 372; fax: +39 050 2214 317.
E-mail address: calderin@slac.stanford.edu (G. Calderini).

doi:10.1016/j.nima.2005.06.071

[n]Stanford University, Stanford, CA, USA
[o]INFN-Torino and Università di Torino, Italy
[p]INFN-Trieste and Università di Trieste, Italy
[q]University of Wisconsin, Madison, WI, USA

Available online 27 July 2005

Abstract

The Silicon Vertex Tracker (SVT) of the BABAR experiment at SLAC is a crucial tool to measure with precision the decay position of B mesons produced in the PEP-II electron–positron collisions. It is structured in five layers made of double-sided, AC coupled silicon microstrip sensors. In this paper, a review of some of the technical solutions chosen in the detector design phase is presented. In particular, we focus here on those elements which turned out to be sources of problems during the installation and the first few years of operation; the solutions adopted to solve the problems are presented together with recommendations and proposals for alternate future designs.

PACS: 29.40.Gx; 29.40.Wk

Keywords: Silicon detectors; Strip detectors; Tracking; Radiation damage

1. Introduction

The main physics objective of the BABAR experiment [1] at the SLAC B factory is the precise measurement of CP violating asymmetries and rare branching fractions in neutral B meson decays. The Silicon Vertex Tracker (SVT) is specifically designed to reconstruct B and D decay vertices with a precision of 80 μm along the meson flight direction and to achieve tracking capability with an efficiency larger than 80% for low transverse-momentum ($<120\,\mathrm{MeV}/c$) particles, such as soft pions from D^1 decays. The short bunch spacing and the head-on collisions require a special design of the interaction region, with permanent magnets only a few centimeters apart from the beam spot. This has imposed the integration of the Silicon Tracker with accelerator elements. This design represents a challenging solution not only from a mechanical point of view, and has several consequences. The largest machine background component in the SVT region is due to off-beam particles over-bent by the final focusing elements and driven into the detector; this mechanism is responsible for a dose largely exceeding the predictions. The requirement of a good radiation hardness for both the SVT sensors and the front-end electronics has been one of the key features in the detector design. In addition, the access to the detector requires the removal of all the portion of beamline around the interaction region, a very long and delicate operation. For this reason, the detector has been thought to provide a high degree of reliability and redundancy. This paper will review the most relevant problems experienced during the commissioning phase and the first years of data-taking and the solutions adopted, trying to identify the elements which could be improved in the design of similar future trackers.

2. Description of the SVT and most relevant failure modes

The SVT is structured in five layers of double-sided, AC-coupled silicon strip detectors. Each layer is built of 6–18 modules, composed of 300 μm thick silicon sensors glued together. The modules are mechanically supported by kevlar/carbon-fiber ribs, and flexible fanout circuits are used to carry the signals from the silicon strips out to the front-end electronics. The sensors are composed by a

[1]Invited talk given by G.Calderini at the 5th International Conference on Radiation Effects on Semiconductors Materials Detectors and Devices (Florence, Italy, October 10–13, 2004).