PROCEEDINGS OF SCIENCE

The SuperB Silicon Vertex Tracker

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SuperB is an asymmetric electron-positron collider planned to operate at very high luminosity ($\gtrsim 10^{36} cm^{-2} s^{-1}$) around the $\Upsilon(4S)$ peak and in an energy range from the τ/charm threshold to the $\Upsilon(5S)$. It is an evolution of the SLAC PEP-II collider and its detector, BaBar. This paper describes the Silicon Vertex Tracker (SVT), one of the key elements of the SuperB detector, concentrating on the modifications and improvements adopted on the strip sensors for the external layers and on the baseline option for the innermost layer (Layer0), a thin (200 μm) double-sided silicon detector with short strips ("Striplets"), oriented at $\pm 45^\circ$ angle to the detector's edge.

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1. Introduction

The Standard Model (SM) has been very successful in explaining the huge amount of experimental result obtained over several decades by a wide variety of high energy physics experiments. In the last decade, the PEP-II and KEK-B asymmetric B-factories and their associated experiments BABAR and Belle played a very important role probing several aspects of the SM.

1. First of all the B-factories have contributed to explore the origin of CP violation. In 2001, they have established for the first time time-dependent CP violation in the neutral B meson decays in the interference of mixing and decay [1, 2], later precisely measured and confirmed in several decay modes. In 2004 they established the direct CP violation in $B^0 \to K^+\pi^-$ decays [3].

2. The B-factories precisely measured parameters of Standard Model related to the CKM quark mixing matrix. They have provided a set of unique, over-constrained tests of the Unitarity Triangle. They have established the $D^0 - \bar{D}^0$ mixing [4, 5].

3. With the analysis of full data sets, they also searched for the effects of physics beyond the Standard Model in loop diagrams. In fact potentially large effects on rates of rare decays, time dependent asymmetries, lepton flavor violation, etc have already been excluded setting strong limits on New Physics (NP) models.

With the LHC in full operation, a wealth of new measurements are exploiting the energy frontier. First of all, the exciting recent observations of the Higgs-like boson by Atlas and CMS, but not only. Very interesting results also on heavy quark physics are obtained for instance by the LHCb experiment. All present measurements are in agreement with SM predictions, reducing the parameter space for NP models. If found, the NP phenomena will need data from very sensitive heavy flavor experiments if they are to be understood in detail. Determining the flavor structure of the NP involved would require the information on rare b, c and τ decays, and on CP violation in b and c quark decays that a very high luminosity asymmetric B-factory can provide [6]. On the other hand, if such signatures of NP are not observed at the LHC, then the excellent sensitivity offered at the luminosity frontier by next generation B-factories provides another avenue to observe NP at mass scales up to 10 TeV or more through the study of rare processes involving B and D mesons and studies of lepton flavor violation (LFV) in τ decays.

With a factor 50-100 luminosity leap with respect to the previous B-factories, Belle2 and SuperB can pursue the above research line in a complementary way with respect to the LHC one.

This paper is organized as follows: Section 2 gives an overview of the SuperB project, main machine parameters, goals and timeline. In Section 3 the concept of the detector is illustrated. Section 4 describes the Silicon Vertex Tracker (SVT) requirements and constraints, the performance studies made (Section 4.1), the design (Section 4.2), the Front End Electronics and signal over noise (S/N) optimization (Section 4.4). Finally, Section 5 is focused on the new innermost Layer0 positioned very close to the beam pipe; its baseline option based on double-sided silicon detectors with short strips ("Striplets") is treated in Section 5.1; other options based on pixel sensors, under development within specific R&D programs, are shortly discussed in Section 5.2. This paper is largely based on [7].

2. The SuperB project

SuperB is a very challenging project, in terms of luminosity, energy range and possibility of including polarized beams [8]. SuperB is an e^+e^- collider based on two separate storage rings, operating at a center-of-mass (CM) energy corresponding to the $\Upsilon(4S)$ peak with a design luminosity of $10^{36} cm^{-2}s^{-1}$ or more. The energy range is spanning from below the $b\bar{b}$ threshold up the $\Upsilon(5S)$ peak. Moreover SuperB will be also able to run at the τ/charm threshold with a luminosity of $10^{35} cm^{-2}s^{-1}$. The luminosity leap with respect to PEP-II is obtained by squeezing down the vertical size of the beam at the Interaction Point (IP) to 35 nm with moderate currents. Large Piwinski angle and "crab waist" collision scheme [9] (successfully tested in 2009 at Frascati-Dafne) allow to overcome the beam-beam luminosity limit. The $\Upsilon(4S)$ will be produced with a sizeable boost in the laboratory frame ($\beta\gamma = 0.24$), but significantly reduced compared to PEP-II ($\beta\gamma = 0.55$).

The Conceptual Design Report [11] has been published and reviewed by an international committee in 2007, Design Progress Reports on the major parts of the project have been written [12]. The project itself was approved in December 2010 by the Italian government with the accelerator site at the University of Tor Vergata in Rome being selected in June 2011. In October 2011, a consortium between INFN and the University of Tor Vergata was formed to manage the construction and operation of the SuperB accelerator and related facilities. The consortium is called the Nicola Cabibbo Laboratory. By the end of 2012 an international committee will give an independent review on the budget and meanwhile the detector Technical Design Report (TDR) [7] will be finalized.

3. The SuperB Detector

The broad set of proposed measurements, in the clean e^+e^- environment, requires a performing and hermetic detector, capable to cope with a reduced CM boost and very different background conditions compared with the previous B-factories. The SuperB detector concept (Fig. 1) is based on the BaBar detector. The modifications necessary to operate at a luminosity of $10^{36} cm^{-2}s^{-1}$, with a reduced boost and improving detector hermeticity and performance require significant R&D.

The BABAR detector, which operated on PEP-II from 1999 to 2008, consists of a tracking system with a five layer double-sided silicon strip vertex tracker (SVT) and a 40 layer drift chamber (DCH) inside a 1.5T magnetic field, a Cherenkov detector with fused silica bar radiators (DIRC), an electromagnetic calorimeter (EMC) consisting of 6580 CsI(Tl) crystals and an instrumented flux-return (IFR) for K_L^0 detection and μ identification.

The SuperB detector concept reuses a number of components from BABAR: the flux-return steel, the superconducting coil, the barrel of the EMC and the fused silica bars of the DIRC. The tracking detectors for SuperB will be new.

4. The SuperB Silicon Vertex Tracker

A crucial part of the physics program relies on time-dependent CP violation measurements, where it is crucial the precise vertex information of the decay position of the B^0 mesons. In order to maintain adequate resolution on the proper time difference (Δt) between the B^0 and the $\bar{B}^0$ decay

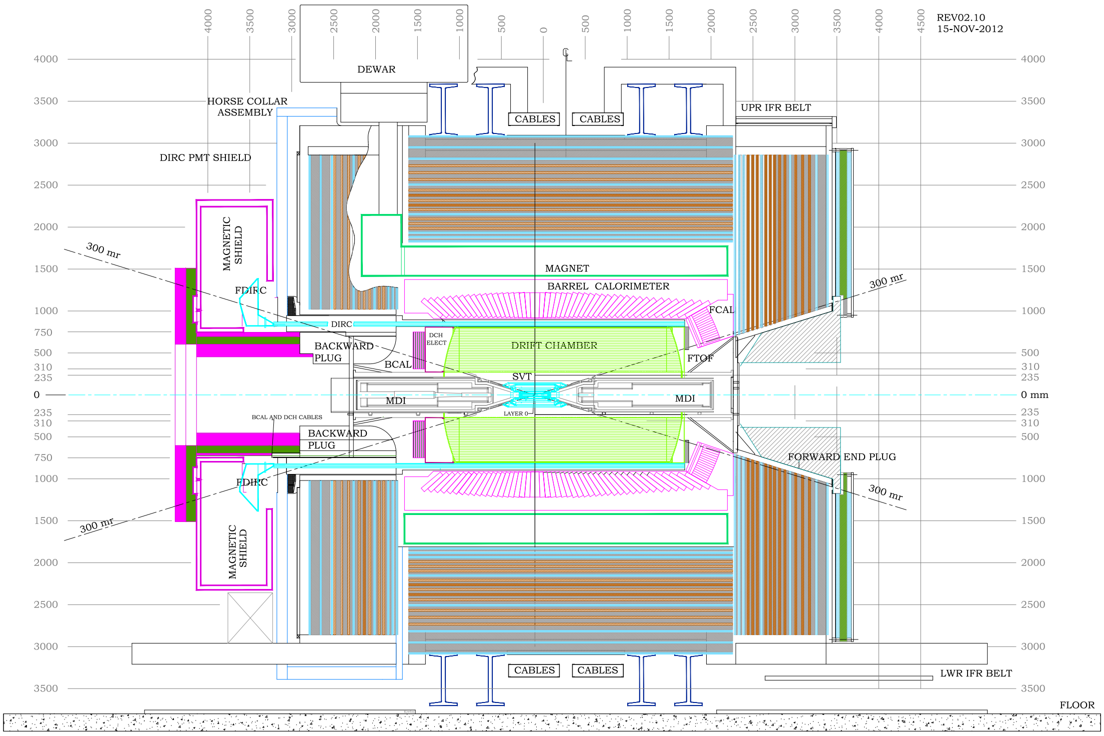

Figure 1: Concept for the SuperB detector.

times, with the SuperB reduced boost of $\beta\gamma = 0.24$, the vertex resolution will be improved. The radius of the beam pipe will be reduced to 1.0 cm and the innermost layer of the SVT will be placed at a radius of about 1.5 cm, about two times closer to the IP than BaBar, as shown schematically in Fig. 2. In addition, charged particles with transverse momenta lower than 100 MeV$/c$ (e.g. slow

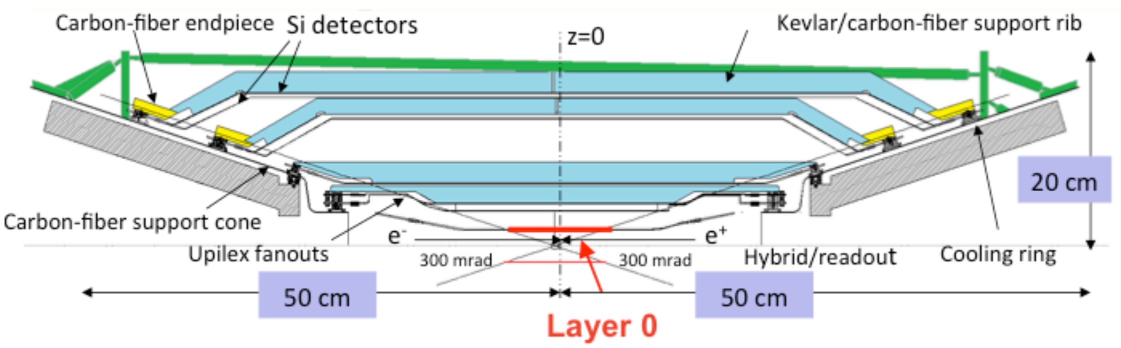

Figure 2: Longitudinal section of the SuperB SVT.

pions from D^*) will not reach the DCH, so for these particles the SVT must provide the complete tracking information. Moreover it should cope with the background rates and with the radiation damage expected over the planned 7.5 years lifetime, including a safety factor of five ($\times 5$).

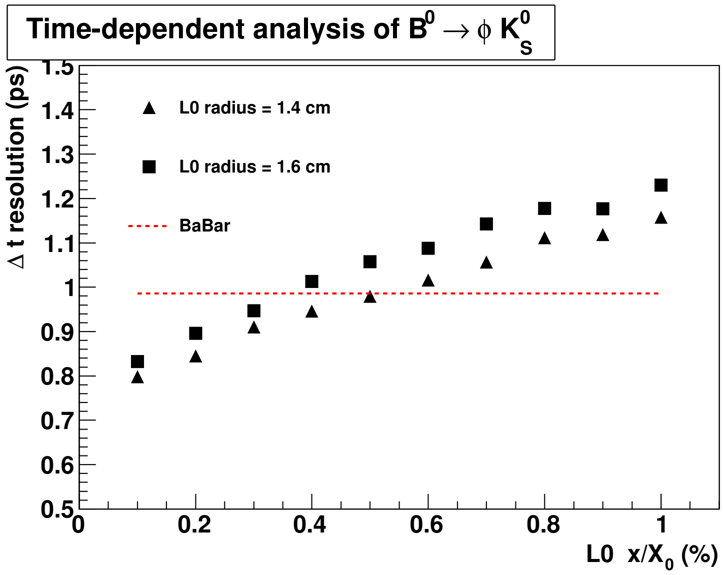

Figure 3: Resolution on Δt for different Layer0 configurations in terms of radius (r_0 = 1.4 and 1.6 cm) and material budget $(x/X_0 = 0.1-1.0\%)$ compared with the reference value of BaBar (dashed line).

4.1 Performance Studies

As mentioned before, the required improvement on track impact parameter and vertex resolution can be achieved in SuperB by reducing the radius of the first measured SVT point by a factor of 2 and keeping a very low mass material budget for the beam pipe (0.45% X_0) and the detector itself (0.4-0.9% X_0). Performance studies [7] have been done, considering: several options for the Layer0 and for the total number of SVT Layers; possible inefficiencies of part of the detector; a factor 5 increase of the background above the present estimates. Two samples of these studies are shown in Table 1 and Fig. 3.

In Table 1 the reconstruction efficiencies for the decay $B^0 \to D^{*-}K^+$ are reported for the 4-, 5- and 6-layer configurations in different running conditions: ideal conditions (A), with a damaged module in Layer3 (B) and with additional hit inefficiency in Layer0 with respect to case B (C).

Table 1: Reconstruction efficiencies for $B^0 \to D^{*-}K^+$ decays for different SVT layouts (4, 5 ,6 layers) and running conditions (A, B, C). Case A corresponds to ideal running conditions, B represents SVT with a damaged module in Layer3 with z hit efficiency of 70%. Case C introduces an additional inefficiency contribution with respect to case B in Layer0: 60% hit efficiency for z and ϕ views.

	A eff. (%)	B eff. (%)	C eff. (%)
6 layers	66.0 ± 0.3	65.0 ± 0.3	64.0 ± 0.3
5 layers	64.0 ± 0.3	62.0 ± 0.3	60.0 ± 0.3
4 layers	60.0 ± 0.3	56.0 ± 0.3	53.0 ± 0.3

At SuperB, the reduced boost value can be compensated by the improved resolution on the mean separation between B vertices Δz, yielding a Δt resolution very similar to BaBar. Fig. 3 shows the Δt resolution obtainable with different Layer0 radii (r_0= 1.4 and 1.6 cm) and material budgets of Layer0 (x/X_0 ranging from 0.1 to 1.0%).

4.2 SVT Design

The SuperB SVT design is based on the BaBar SVT layout with some modifications and improvements. Its main features are listed below, underlying the differences with respect to BaBar:

- five layers of double-sided silicon strip sensors 300 μm thick at 3-15 cm radius (as in BaBar);
- an additional innermost layer (Layer0), two times closer to the IP, at around 1.5 cm radius, having the least achievable material budget <1% X_0; both a strip and a pixel option have been considered as will be described in Section 5;
- an extended polar angle acceptance, up to $\pm$300 mrad (was 520-350 mrad in BaBar);
- improvements in the electronics and sensor design, plus an optimized strip to Front End (FE) connection scheme.

The radii and strip pitches of the 6 layers are listed in Table 2. Such a design allows to attain the required vertex resolution, as well as redundancy and standalone tracking. On the other hand the extended solid angle coverage (around 95% in the $\Upsilon(4S)$ CM frame) implies 30% longer ϕ-side strips and 30% more z-side strips, whose number exceeds that of available electronic channels. As in BaBar, the readout electronics is accommodated outside the sensor region to minimize the material budget in the tracking volume. This choice implies higher strip capacitance and series resistance, and longer traces on z-side fanouts.

Table 2: Summary of expected nominal background in the sensor area. The SVT has been designed to withstand $\times$5 the nominal background. Numbers shown in the table do not include the $\times$5 safety factor. Simulation results for both Layer0 options, Striplets and pixels, the latter being at a slightly lower average radius, are reported. 'TID' stands for Total Ionizing Dose, 'NIEL' refers to 1 MeV neutron-equivalent fluence, assuming an integrated luminosity of 10 ab^{-1}/yr.

Layer	Radius (mm)	Pitch (ϕ–z) (μm)	Total Rate/Area (MHz/cm^2) Track	Cluster	Strip (ϕ–z)	Total Strip Rate (kHz)	TID (Mrad /yr)	NIEL (n/cm^2 /yr)
0 Striplets	15.6	54–54 (u,v)	1.62	4.10	20–20 (u,v)	187–187	2.3	3.6×10^{12}
0 pixel	13.9	50–50	2.82	5.86	30	0.8	3.3	5.2×10^{12}
1	33	50–100	0.217	0.540	2.9–2.4	170–134	0.3	7.9×10^{11}
2	40	55–100	0.163	0.393	1.9–1.7	134–134	0.2	5.1×10^{11}
3	59	100-110	0.079	0.208	0.54–0.71	116–79	0.1	3.0×10^{11}
4	120	100–210	0.022	0.037	0.07–0.05	25–13	0.01	2.0×10^{11}
5	140	100–210	0.014	0.022	0.04–0.03	16–9	0.01	1.8×10^{11}

4.3 Background

Background influences several aspects of the SVT design, including readout segmentation, electronics shaping time, data transmission rate, and radiation hardness (which is particularly severe for Layer0). In Table 2 are reported the background rate for each layer at the nominal luminosity, the total ionizing dose (TID) and the non-ionizing energy loss (NIEL) per year assuming an integrated luminosity of 10 ab^{-1}/yr. Cluster rates are significantly higher than track rates because low momentum tracks are curling, thus crossing several times the same layer. For each cluster several strips/pixels can be fired, depending on the incident angle of the particle with the sensor, therefore the strip/pixel rate can be significantly higher than the cluster rate. In the Layer0, rates are dominated by soft $e^{\pm}$ from QED pairs background ($e^+e^- \to e^+e^-e^+e^-$). Other relevant sources of background are Touschek scattering [13], beam gas and radiative Bhabha interactions.

4.4 Front End Electronics and S/N Optimization

Front-end signal processing will be performed by ICs mounted on the High-Density Interconnect (HDI), a thick-film hybrid circuit fabricated on aluminum nitride (AlN) substrates. The HDI provides the physical support, distributes power and signals, and thermally interfaces the ICs to the cooling system. The signals from the readout strips, after amplification and shaping, are compared to a preset threshold. The time during which they exceed the threshold (time over threshold, or TOT) is an analog variable related to the charge induced on the strip in a pseudo-logarithmic way. The operating parameters of the IC will be programmable over a wide range (e.g. shaping time for Layers 0-3 in the range 25-200 ns, for Layers 4-5 350-750 ns). New custom-designed front-end ICs are currently under development, since none of the existing chips match the the SuperB SVT requirements.

In order to cope with inefficiencies due to pulse overlap, high occupancy and S/N limitations, several peaking times of the Front End chip are being considered, allowing for an optimized choice for every SVT layer. Since the radiation-induced leakage current gives a major contribution to noise (by far dominant with the $\times 5$ safety factor), it might be desirable to have the possibility of cooling the sensors (decreasing the temperature by 8°C gives a factor of two lower leakage current).

Due to the long modules, the strip resistance brings a significant contribution to noise. An increase of metal thickness to 2 μm or more (vs. a standard value of 1 μm or less) is feasible and it has been assumed in evaluating the noise. On the z-side, where the number of readout strips exceeds that of available electronic channels (constrained by the number of chips that can fit in the limited space available), the strip connection to the Front-End has to be optimized [14]. To reduce the number of readout channels, the solution adopted for BaBar was to "gang" together two far apart $z-$side strips to a single readout channel (see Fig. 4), at the expense of a higher capacitance (and series resistance) and of ambiguities in the hit position. Since in the SuperB SVT there are 30% more z-strips, in some layers we are forced to gang together up to three strips. In this situation we propose an alternative connection scheme. We observe that at small polar angle θ (large incident angle with respect to the normal axis of the detector surface) the track traverses several z-strips (up to 9 in the inner layers) and the signal becomes approximately proportional to the strip pitch (smaller than the wafer thickness). This suggests bonding two or more *adjacent* strips to a single fanout trace, effectively increasing the strip pitch and the signal into a readout channel (see Fig. 4),

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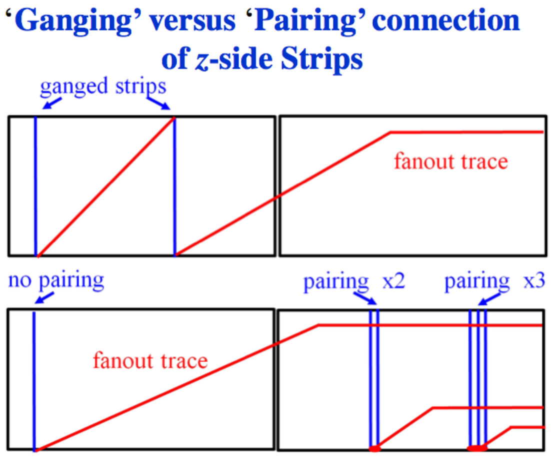

Figure 4: Top: schematic view of two z strips ganged through the fanout circuit. Bottom: pairing is an alternative connection scheme.

with a less than proportional increase in capacitance. This gives better S/N and efficiency at small θ angles compared to ganging far apart strips, where the strip capacitance is proportional to the number of strips ganged together, but the signal is that of a single strip. In addition, at small θ angles, this connection scheme (called "pairing") is expected to give better spatial resolution with respect to "ganging". To preserve spatial resolution, two strips can be paired only when the track projection exceeds 2 times the pitch.

5. The SuperB Layer0

Several options are under study for the Layer0 technology, with different levels of maturity, expected performance and safety margin against background conditions.

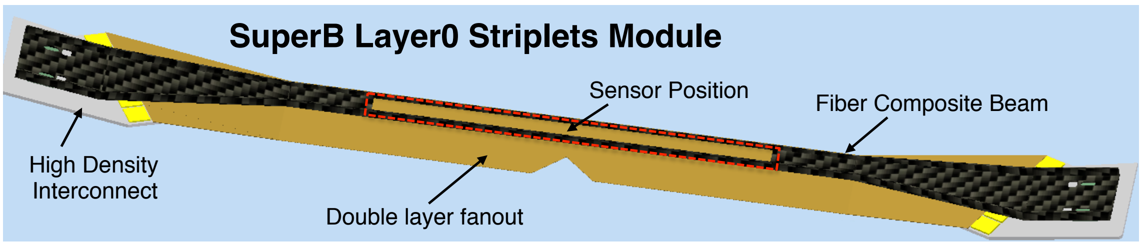

Figure 5: Schematic drawing of the Layer0 Striplets module.

5.1 Baseline: Striplets

The baseline option for the Layer0 is based on short strips ("Striplets") [11], high resistivity double-sided silicon sensors 200 μm thick with 20 mm long strips tilted at $\pm 45^\circ$ angle to the detector's edge. This solution has only $0.45\% X_0$ material budget ($0.21+0.15+0.09\% X_0$ for sensor, fanout and support respectively). It is a mature technology and it is the best solution for the first phase of the experiment in terms of physics performance (high efficiency, low material budget, good space resolution), but with less safety margin against higher background conditions or further increase of luminosity.

In September 2011 a Striplet prototype sensor, read out by the data driven FSSR2 chip [15] (with a 125 ns shaping time) was put on beam at CERN as a detector under test (DUT), to check its performances in terms of efficiency and hit resolution up to 70° incident angles and with different sets of thresholds [16]. This prototype has a 50 μm strip pitch, 200 μm thick substrate and a 60x12.9mm^2 sensor area. The strip capacitance is about 4 pF. The S/N in this setup was measured to be 29 (16) respectively for $p(n)$-sides. This prototype has been realized by the SLIM5 Collaboration [17] and it had already been tested on a 12 GeV/c proton beam, with the first threshold (hit/no-hit) that had been conservatively set to a rather high value, 4400 (6300) e$^-$, corresponding to 27 (40)% of a MIP, respectively for $p(n)$-sides, so that at large angles part of the cluster was lost [18, 19, 20]. In the 2011 beam test thresholds were lowered to 3300 (4800) e$^-$, 20(30)% of a MIP, respectively for $p(n)$-sides assuming at normal incidence 1 MIP = 16 ke$^-$ in 200 μm of silicon. For each track in the acceptance of DUT, the residual was computed for different sets of incidence angle θ in 0–70° range. Efficiency, defined as fraction of track clusters reconstructed by the Stiplets with a residual within a fiducial range (about 5 times the RMS of the residual) in the DUT active region, is above 99.4% at all angles and on both sides. The spatial resolution can be estimated from the Gaussian core of the distribution of residuals, as described in [16]. Preliminary results are shown in Fig. 6 before the subtraction of track extrapolation error, multiple scattering and other systematic effects. As expected, both efficiency and resolution improve when the threshold is lowered.

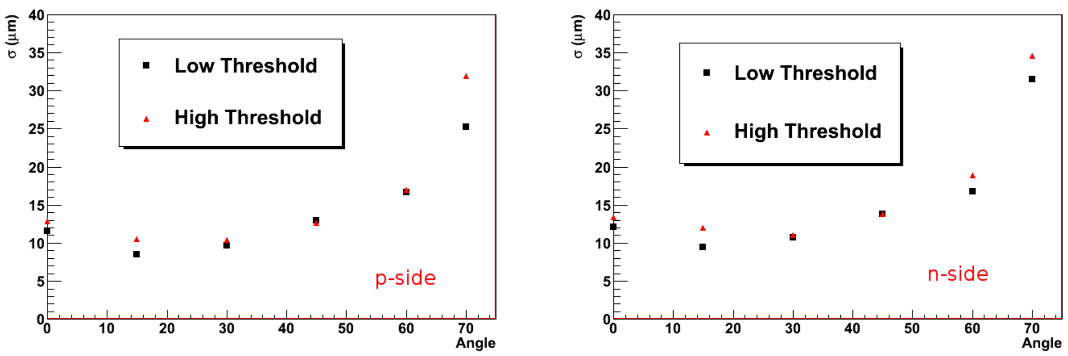

Figure 6: Raw Striplets resolution as a function of the incidence angle before the subtraction of track extrapolation, multiple scattering and other systematic effects.

5.2 Detector options for the Layer0 upgrade

With the machine operating at full design luminosity, the Layer0 will need to cope with a background hit rate of several tens of MHz/cm^2. A pixel detector solution would then be preferable. The two main options under evaluation are thin hybrid pixels with small pitch (50 μm) and CMOS Monolithic Active Pixel Sensor (MAPS). A detailed discussion can be found in [7, 21, 22].

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6. Conclusions

The proposed vertex tracker for SuperB is constituted by a 6-layer silicon detector with low material budget. It is based on the BABAR vertex detector layout, with some improvements and modifications required to operate at an instantaneous luminosity of $10^{36}cm^{-2}s^{-1}$, or more, and with a reduced center-of-mass boost. In particular it will present an extended angular acceptance and improvements in the electronics and sensor design, plus an optimized strip to Front End (FE) connection scheme. An innermost layer (Layer0) closer to the IP will be added, to improve vertex resolution and compensate for the reduced boost. The challenging requirements set on the SVT Layer0 by the sensitivity studies and by the background conditions can be met by the baseline option (Striplets), but with marginal safety margin against high background conditions. Beam test results with a Striplet prototype show that this solution meets the requirements of the first operating phase of SuperB. At full luminosity a pixel solution would be desirable. Hybrid pixels with small pitch or thinner CMOS MAPS are our present best candidates.

In the last phase of writing this paper, the SuperB community received the sad news of a substantial cut of the SuperB program budget. The Italian Ministry for Education, University and Research, while acknowledging "the importance and quality of the program", also stated that "the economic conditions of the country and the limits foreseen by the National Research Plan were incompatible with the estimated cost of the project".

References

[1] B. Aubert et al., [BABAR Collab.], Phys. Rev. Lett. **87**, 091801 (2001).

[2] K. Abe et al., [Belle Collab.], Phys. Rev. Lett. **87**, 091802 (2001).

[3] B. Aubert et al., [BABAR Collab.], Phys. Rev. Lett. **93**, 131801 (2004).

[4] B. Aubert et al., [BABAR Collab.], Phys. Rev. Lett. **98**, 211802 (2007).

[5] M. Staric et al., [Belle Collab.], Phys. Rev. Lett. **98**, 211803 (2007).

[6] The SuperB Progress Report *Physics*. Available online at: [arXiv:008.1541].

[7] The SuperB Technical Design Report, in preparation.

[8] The SuperB Progress Report *Accelerator*. Available online at: [arXiv:1009.6178].

[9] P. Raimondi, 2nd LNF Workshop on SuperB, Frascati, Italy, March 2006, www.lnf.infn.it/conference/superb06/talks/raimondi1.ppt; P. Raimondi, D.Shatilov, M.Zobov, *Beam-Beam Issues for Colliding Schemes with Large Piwinski Angle and Crabbed Waist*, LNF-07-003-IR, Feb. 2007 arXiv :physics/0702033.

[10] M. Zobov, D. Alesini, M. Biagini, C. Biscari, A. Bocci, et al., *Test of crab-waist collisions at DAFNE Phi factory*, *Phys. Rev. Lett.* **104** (2010)174801.

[11] The SuperB Conceptual Design Report, INFN/AE-07/02, SLAC-R-856, LAL 07-15. Available online at: [http://www.pi.infn.it/SuperB].

[12] The SuperB Progress Report *Detector*. Available online at: [arXiv:1007.4241].

[13] C. Bernardini et al., *Lifetime and Beam Size in a Storage Ring*, *Phys. Rev. Lett.* **10**, (1963) 407-409.

[14] I. Rashevkaya et al., *Characterization of strip detector parameters for the SuperB Silicon Vertex Tracker*, *NIM A* (2012), [http://dx.doi.org/10.1016/j.nima.2012.10.019].

[15] V. Re, M. Manghisoni, L. Ratti, J. Hoff, A. Mekkaoui, R. Yarema, *FSSR2, a Self-Triggered Low Noise Readout Chip for Silicon Strip Detectors*, *IEEE Trans. Nucl. Sci.,* **53**, *No.4*, (2006) 2470-2476.

[16] L. Fabbri et al., *Beam test results for the SuperB-SVT thin striplet detector NIM A* (2012), [http://dx.doi.org/10.1016/j.nima.2012.10.086].

[17] SLIM5 Collaboration - Silicon detectors with Low Interaction with Material, [http://www.pi.infn.it/slim5/].

[18] L. Vitale, et al., *SLIM5 beam test results for thin striplet detector and fast readout beam telescope*, *NIM A* **617** (2010) 601.

[19] M. Bomben, *Highly segmented thin microstrip detector with data-driven fast readout*, *NIM A* **623** (2010) 159.

[20] S. Bettarini et al., *The SLIM5 low mass silicon tracker demonstrator*, *NIM A* **623** (2010) 942.

[21] G. Rizzo et al., *Recent Development on CMOS MAPS for the SuperB Silicon Vertex Tracker*, *NIM A* (2012), [http://dx.doi.org/10.1016/j.nima.2012.10.084].

[22] E. Paoloni et al., *Advances in the Development of Pixel Detector for the SuperB Silicon Vertex Tracker*, Proc. of Pixel 2012 Inawashiro, Japan, Sept. 3–7, 2012 to be published in *Nucl. Phys. B*.