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Very Forward Calorimeters readout and machine interface

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Abstract. The paper describes the requirements for the readout electronics and DAQ for the instrumentation of the forward region of the future detector at the International Linear Collider. The preliminary design is discussed.

Keywords. LumiCal, BeamCal, front-end, readout, DAQ, ILC

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1. Introduction

The purpose of the FCAL Collaboration is to develop the design for the instrumentation of the very forward region of the future detector at the International Linear Collider. To fulfil this three detectors covered the polar angles from a few 100 μrad to 92 mrad are presently considered: LumiCal, BeamCal and PhotoCal. The requirement for LumiCal is to enable a measurement of integrated luminosity based on Bhabha scattering process with a relative precision of 10^{-4}. The BeamCal can be used to monitor the variation in luminosity and can provide a fast feedback to the machine control system. The purpose of PhotoCal, placed at a distance of few hundred meters from IP, is to analyze beamstrahlung photons distribution which is sensitive to the beam parameters. More details can be found in [1–3].

2. Readout electronics, DAQ and machine interface

The LumiCal readout electronics, especially the preamplifiers must be designed to fulfil the extreme requirements. The dynamic range of the signal from the silicon sensors will be, base on the Monte Carlo simulation (Fig. 1a.), in order of 1 :

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20 000 including the request for the test beam operation (1 MIP resolution). For the reconstruction of the Bhabha events during the real e^+ e^- beam operation the necessary dynamic range is less than 1 : 1000. This induces us to design the readout electronics using switched gain preamplifier or two shapers with different gains and switched output to the ADC. The charge sensitive preamplifier should have an equivalent noise less than a few thousand electrons to be suitable for test beam measurements also. Switched capacitors in the feedback loop are foreseen for gain change. A shaper, or two shapers with different gains, should have a peaking time of less than 100 ns to avoid pileup. The 10 bit flash ADC multiplexed to the group of channels (probably every 10 channels will have one ADC) is foreseen. The digital link based on LVDS chips will transmit data to the DAQ. Proposed solution is shown in Fig. 2. For the BeamCal the similar readout scheme will be needed.

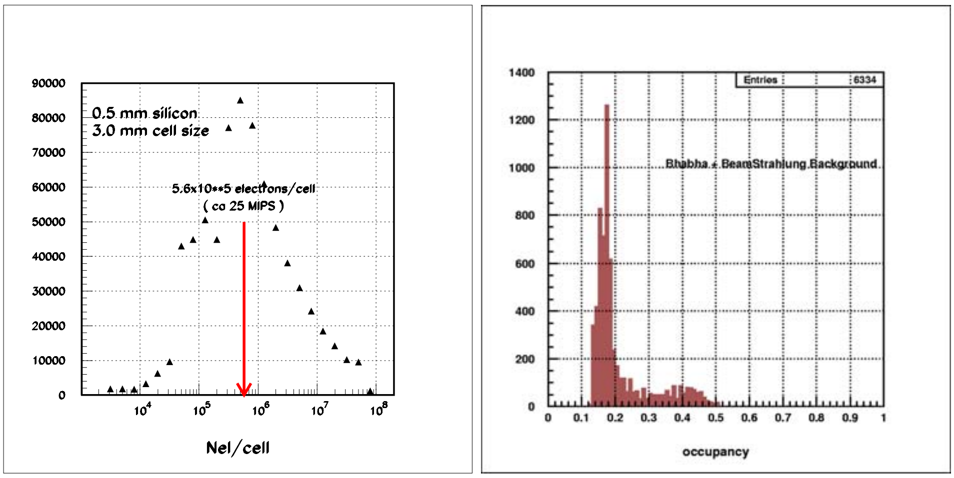

Figure 1. Signal deposit in one pad (a), Occupancy in LumiCal (b)

LumiCal has to provide a raw luminosity measurement every minute. The MC studies shows only a few Bhabha events hitting detector in one bunch train. For that reason it is not possible to measure luminosity more often with sufficient statistics. The digital data transmission from the calorimeter to the DAQ can be done in the breaks between bunch trains. The mean occupancy in LumiCal is about 20% (Fig. 1b.) so data suppression will not benefit a lot; all detector has to be readout every bunch crossing. The amount of data per bunch train is about 1 Gb per detector. The necessary digital transmission speed is approx. 3 Gb/s. Taking to account existing now LVDS links with a speed of 0.6 Gb/s, data transmission will need only 5 digital links, but from the technical reasons (30 active layers of detector each divided to two half planes) there will be 60 digital link. It is clearly seen, that digital transmission will be not a main problem.
BeamCal has to provide the information about luminosity variation and beam parameters (σx, σy, σz and $\Delta\sigma x$, $\Delta\sigma y$, $\Delta\sigma z$, xoffset, yoffset and Δxoffset, Δyoffset, bunch rotation, number of particles/bunch) after each bunch crossing. The BeamCal signal processing should have a fast system, based on a dedicated DSP or FPGA farm, for the direct feedback to the Beam Delivery System (machine control).

There is a limited space for electronics (~ 270 cm^2) at the outer diameter of the LumiCal. The BeamCal will be more compact. The large amount of readout electronics favors the integration of the preamplifiers, shapers, multiplexers and ADC's with the detector. The heat dissipation and cooling parameters should be calculated carefully. Connection from each pad or strip to the readout electronics can be made using the traces on the kapton flexfoil, thin glass or ceramic support (prefered). The wire bonding to the pad can be made through the small hole in the flexfoil, glass or directly to the ceramic surface; this allows to avoid the bump bonding. To ensure minimal cross talk from signals in adjacent sensors a additional grounded traces between signal lines are proposed. On one sensor half plane up to 720 channels of the readout electronics should be placed requiring highly integrated chips. One possibility is to use a specialized readout chips with 64 or 128 channels each.

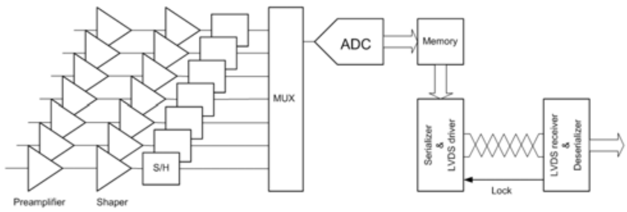

Figure 2. Proposed block diagram of the readout electronic

3. Conclusions

Front end electronics and DAQ for LumiCal and BeamCal has to read out data for each bunch crossing simultaneously with bunches. A fast signal processing system has to deliver beam diagnostic information online directly to the Beam Delivery System to give the machine control feedback. The FCAL readout system and machine interface are different to the rest of the Detector DAQ.

References

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