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Spotting and Curing Noise Issues in the Silicon Vertex Detector of the Belle II Experiment

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The Belle II experiment will use a Silicon Vertex Detector based on DEPFET pixel (PXD) and double-sided microstrip (SVD) technology. In 2014 at a combined SVD/PXD beam test we observed electrical noise in the SVD system which caused many headaches for more than two years. Since then Electromagnetic Compatibility (EMC) tests using some of the best equipment available in an EMC tight hall, but also using cheap and even self-made probes helped to improve the SVD prototype. At another combined beam test in April 2016 we finally identified the noise source. It was not the suspected PXD…

Summary

A new silicon detector based on two different technologies is planned to be installed in the Belle II experiment at the High Energy Accelerator Research Organization (KEK) in Tsukuba, Japan. It consists of several modules and Front End Electronics (FEE) arranged cylindrically in 6 layers around the interaction point. The inner two layers are based on DEPFET pixel technology (PXD), the outer four layers on double-sided microstrip technology (SVD).

The SVD consists of 172 silicon sensors. A total of 1748 readout chips (APV25) process and send the analog signals over 15 meter long copper cables to 48 A/D Converter (FADC) boards located in crates on top of the Belle II detector structure. From the FADCs the data are then sent out to the central DAQ by optical fibers.

Several power supply units located near the FADC crates provide the High Voltages (+/-50V) required to bias the sensors, and the Low Voltages (LV, 10V) to power the FEE. Fifteen meter long cables transport the power into the magnetic and radiation zone to dock boxes, where DC/DC converters transform the LV into 2.5V and 1.25V, which are then fed into the the APV25 chips on the sensor hybrids by 2.5 meter long cables.

A combined SVD/PXD beam test in January of 2014 at DESY in Hamburg, Germany, revealed excessive noise in the SVD system which rendered the data almost useless. No-one of the involved persons was prepared; no-one really knew how to measure and to handle it systematically; it has been cured partially using some grounding wires as a trial-and-error-approach with the success that the data taken were at least somehow usable. The main suspect for the source of this noise then was the PXD for more than two years.

After this experience the Electromagnetic Compatibility (EMC) of the SVD system has been investigated systematically, mostly 2015 in a semi-anechoic hall in Zaragoza, Spain, using some of the best EMC measurement equipment available, but also in the HEPHY laboratory using relatively cheap and even self-made equipment. The conclusions were implemented into the SVD system afterwards. The system has been tested without noise issues at two test beams at CERN.

In April 2016 the next combined SVD/PXD beam test took place again at DESY. The noise was observed again, but the SVD system now proved to be immune against it. Despite that the SVD noise susceptibility has been measured systematically using a dedicated spectrum analyzer, but also some affordable equipment: self-made inductive probes and self-made current shunts on an USB oscilloscope. As a result, the noise source finally was located. It was not the PXD. And it probably would not have been found using only a spectrum analyzer…

This presentation shows on the Belle II SVD system how conducted noise can be identified systematically, how EMC test equipment can be used, how some of it even can be self-made, and how we immunized our system.

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