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Construction and Test of the First Belle II SVD Ladder Implementing the Origami Chip-on-Sensor Design

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The Belle II Silicon Vertex Detector consists of four layers of double-sided silicon detectors (DSSDs), composed of ladders with two to five sensors each.
All sensors are individually read out by APV25 chips with the Origami chip-on-sensor concept for the central DSSDs of the ladders. The chips sit on flexible circuits, which are glued on the top of the sensors. This concept allows for low material budget and efficient cooling of the chips by a single pipe per ladder.
We present the construction of the first SVD ladders and results from precision measurements, cooling and beam tests.

Summary

Precise vertexing is important for the Belle II experiment at the SuperKEKB B-factory in Tsukuba, Japan. Therefore, the material budget of the inner tracking devices must be as low as achievable to minimize the effect of multiple scattering. At the same time, the increased rate and levels of background at Belle II compared to Belle require a readout chip with short shaping time and integrated pipeline, to ensure low occupancy and dead time.

For the Belle II Silicon Vertex Detector (B2SVD) APV25 chips (originally developed for CMS) are used to read out the double-sided silicon detectors (DSSDs).
To minimize the noise caused by the capacitive load on the input amplifiers, the APV25 chips need to be placed as close to the sensor strips as possible.
In the Origami chip-on-sensor concept the APV25 chips for both sides of a DSSDs are thinned to 100µm and attached to 3-layer flexible circuits, which for their parts are glued on top of the sensors. The top-side strips of a sensor are directly connected to the chips by wire-bonding and a small pitch adapter, while those of the bottom-side are attached by two flexible circuits, bent around the edge of the sensor.
Hence the Origami concept ensures both low noise and material budget, respectively.

The B2SVD consists of four layers of DSSDs, composed of ladders with two to five sensors each. The ladders are supported by two carbon fiber reinforced ribs with a very light-weight styrofoam core (Airex). To allow individual readout of every sensor while keeping material low, the Origami chip-on-sensor design is implemented for the central sensors of the SVD ladders.
All APV25 chips of the SVD are cooled by a highly efficient two-phase CO2 system. Since the chips on the Origami flexible hybrid boards are aligned in a row, only a single cooling pipe per ladder is required for the cooling of all chips in the sensitive volume.

The feasibility of the concept was demonstrated in 2010 on an Origami module with one 6" DSSD and in 2012 by the assembly of a module with two consecutive 6" DSSDs, both read out by Origami flexes.
In the meantime the concept and the assembly procedure have been refined and extended to build full ladders including the very forward and backward sensors, which are read out by amplifier boards located on both ends of the ladders.
Recently we completed the first fully equipped and electrically functional B2SVD ladder – an important milestone before the start of the production of the SVD ladders in autumn 2015.

We review the design and the assembly procedure of fully equipped SVD ladders. Moreover we present results from precision measurements as well as cooling and beam tests performed on the first B2SVD ladders.

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