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Inner component of Japan's upgraded particle accelerator nears completion

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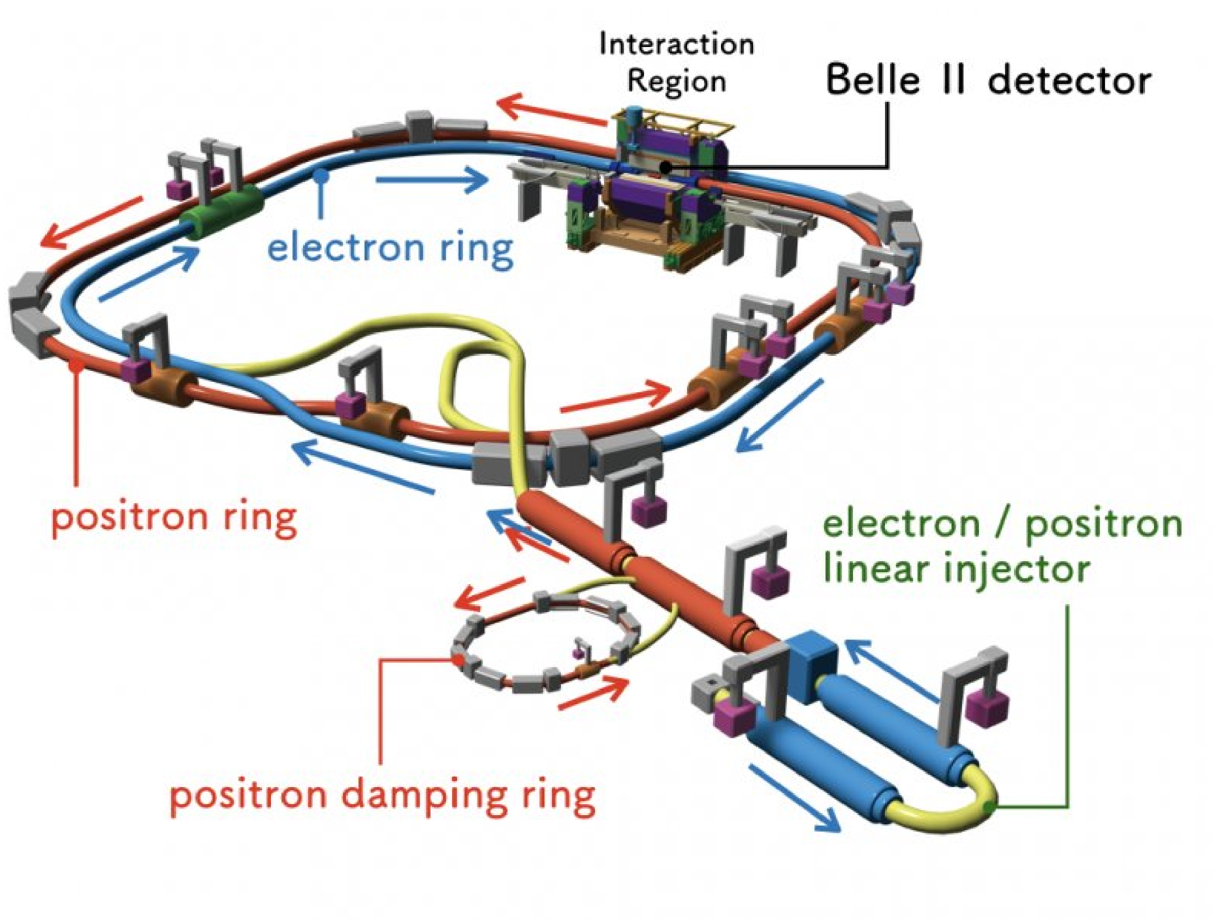


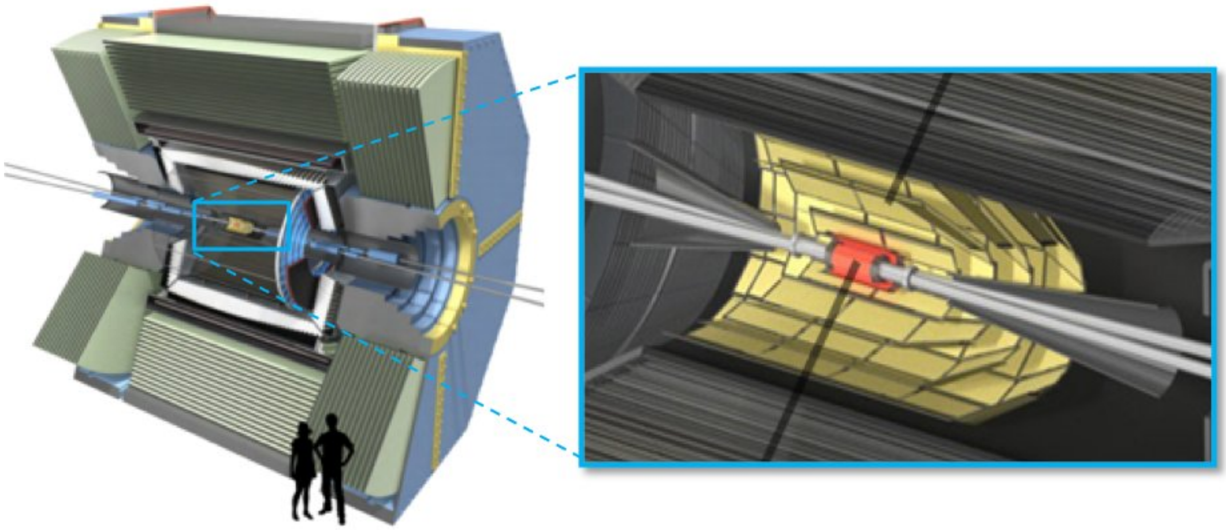
Schematic drawing of the SuperKEKB accelerator and the Belle II detector in place where particle collisions will occur. Credit: KEK

An international team of researchers has announced the completion of the outermost shell of the Silicon Vertex Detector (SVD) on May 24 after six years of work. The completed SVD will be placed inside one of Japan's biggest particle accelerators later this year.

The SVD currently under construction is part of the Belle II experiment, hosted by the High Energy Accelerator Research Organization (KEK) in Tsukuba, north of Tokyo, which aims to search for physics beyond the Standard Model of particle physics. While the Standard Model has helped explain the behavior of elementary particles in the universe, it does little to explain other equally significant phenomena that have shaped the universe, including the nature of dark matter. If scientists are to fully understand how the universe was created, they must find a new theory of particle physics.

The SVD will pinpoint precise locations of particles with 35 micrometer precision. Researchers will analyze the particles created by colliding particles inside KEK's newly-upgraded particle accelerator SuperKEKB. If any undiscovered particles exist, they should appear in locations unpredicted by current theories.

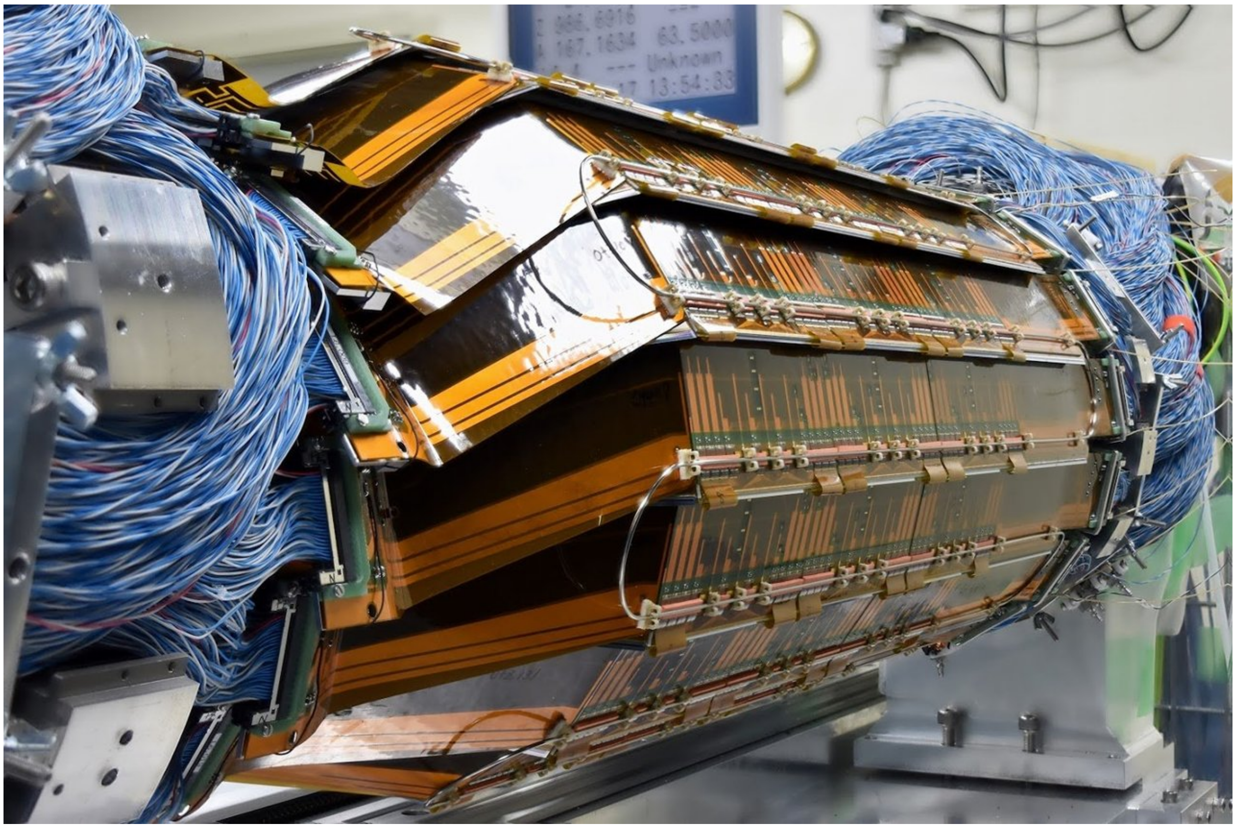
The high performance of the detector is due to its innovative design and to the high mechanical precision achieved by the researchers who built it, including the team at the Kavli Institute for the Physics and Mathematics of the universe (Kavli IPMU), who have been building the outermost layer of the SVD since 2012.



The SVD will be placed at the center of the Belle II detector. At the very center, colored in red, is the pixelated silicon detector. The surrounding yellow components are the four layers making up the SVD. Kavli IPMU researchers built the fourth most outer layer. The facilities at Kavli IPMU were also used by the Indian researchers to build part of the second layer of the SVD. Credit: Belle II Collaboration / Rey.Hori

The SVD is made up of 16 ladders overlapping one another to create its signature lantern shape, each ladder acting as a sensor to determine the location of a particle. The ladders are built using trapezoidal or rectangular semiconducting silicon sensors, and each has 512 strips cut along its front side, and 768 strips cut along its backside. When a particle passes through the SVD, its location is recorded by an electric signal released from the strips closest to the contact point.

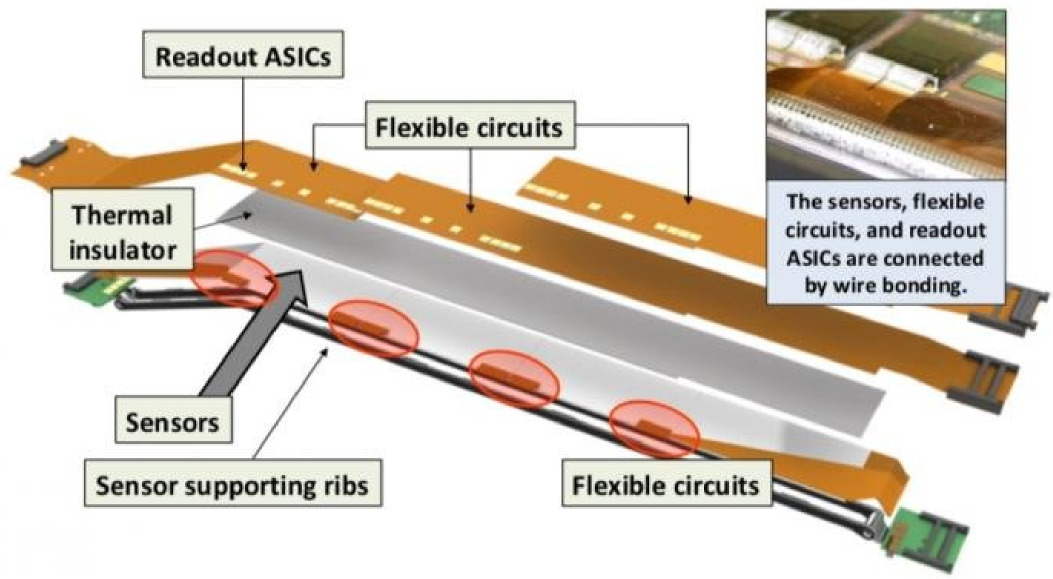
While the design sounds simple enough, the team at Kavli IPMU, lead by Associate Professor Takeo Higuchi, had to overcome a mountain of challenges, like developing and building jigs specifically tailored for ladder assembly, establishing procedures to control glue viscosity, and developing a precise electrical wire bonding procedure that could assure high efficiency and pull force.



A partially completed SVD showing eight ladders assembled together like a lantern. The ladder folds inwards, becoming smaller, allowing the SVD to cover more area around a particle collision than a conventional cylindrical sensor. Credit: Belle II Collaboration

By 2016, the team had created one prototype ladder, but a more rigorous protocol had to be introduced to produce the remaining 15 SVD ladders and three spares. This included increased use of machine equipment to maintain high quality and minimize human error, the development of a 100-page manual, several checkpoints spread across the development period to ensure any mistakes could be identified quickly, detailed record-taking of when and where building parts were bought and shipped, and training researchers to become SVD ladder construction professionals.

The SVD is scheduled to be placed inside SuperKEKB in November this year with the hope of beginning data analysis by February 2019.



Schematic of an individual ladder. The readout integrated circuit has been placed on top of the sensor as opposed to the edge. This “chip on sensor” design was developed to minimize electric wiring and reduce noise. The red circles indicate areas where the flexible fanout circuit has been folded like origami (called the “origami concept”) so that the signals on the backside of the circuit could be read out. Credit: Belle II Collaboration

Provided by Kavli Institute for the Physics and Mathematics of the Universe