Pixel Chamber: a solid-state active-target for 3D imaging of charm and beauty


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Silicon trackers in particle detector

Tracks at collider experiments are based on cylindrical or planar layers of silicon sensors. This kind of detectors satisfy the stringent requirements in terms of material budget, granularity, power consumption, readout speed and radiation hardness.

Silicon detectors are key for the detection of charm and beauty particles. Located close to the interaction point, they provide precision measurement of particles produced in the interaction points (primary vertices) and in decay vertices (secondary vertices). Their intrinsic limitation is the finite distance between the sensors and the particles production points. The Pixel Chamber project aim is the production of a bubble-like, solid state active target capable to perform continuous tracking to detect primary and secondary vertices inside the detector with a very high precision.

Pixel Chamber

We want to pioneer the first silicon 3D active-target ever built based on silicon pixel sensors. The main idea is to create and validate an ultra-high granular stack of hundreds of very thin monolithic active pixel sensors (MAPS) glued together, providing continuous, high-resolution 3D tracking: the first solid state bubble chamber.

R&D towards first prototypes

R&D to build the first A9 stack is ongoing in collaboration with CERN and Geneva University. We built the first stack of 3 ALPIDE with a flip chip bonding machine at the physics department of Geneva University.

Cooling studies

The increase of temperature of a stack made of 216 ALPIDE can be critical and merits detailed studies to estimate probable effects and practical solution. A preliminary study on cooling has been carried out with COMSOL Multiphysics to keep the temperature of the entire stack to less than 40°C.

Future perspectives

Applications for Pixel Chamber are countless. In particle physics experiments, its coupling to a silicon telescope has the potential to allow a measurement of the charm cross section in proton-silicon interactions at CERN SPS energies. The possibility of using Pixel Chamber for medical and astrophysical applications as scatterer of a Compton camera will be also explored.

A Compton camera consists of two position- and energy-sensitive sub-detectors: scatterer and absorber. Several gammas from the same source point are needed to determine the source position. The larger the number of gammas, the better the point resolution. Pixel Chamber has the potential to reconstruct tracks and directions of recoiled electrons with very high precision and can therefore give the possibility to reduce by orders of magnitude the number of gammas needed to perform online and fast imaging in hadron therapy and astrophysics (PRIN submitted in 2023).

R&D to produce large area (~1.5x2.5 cm²) stitched sensors is under way for the construction of a new ALICE IT53 at CERN. A pioneering development would be the first three-dimensional stack with large area monolithic pixel sensors ever built to overcome the current limitations related to the small size of the sensors. It would be very important in medical imaging, particle physics and astrophysics.

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