1 Calorimetry

Calorimetry is envisaged in support of two subsystems, one measuring the spectrum of produced e^+e^- pairs from interactions with the laser and a second one, a forward photon detector, designed to measure high intensity nonlinear Compton scattering and monitor the intensity of the outgoing beam in the vicinity of the beam-dump.

The distribution of the impact point of the produced e^+ or e^-, after exiting from the dipole magnet, has a shape of a " butterfly" with the high energy particles congregating closer to the original electron/photon beam direction. The spread of the wings depends on the magnetic field and the distance at which the detectors are positioned. Compact tungsten/silicon sensor calorimeters will be placed right behind the trackers. Their role will be to identify overlapping tracks, to assist in the measurements of the energy for tracks which enter the magnetic field under different angles and different energies but hit the detectors at the same impact point. The expected occupancy, especially in the initial runs is expected to be low enough so that within the small Moliere radius of the calorimeter, individual showers can be reconstructed. In the initial stage of the experiment, the existing prototype of the luminosity calorimeter for future e^+e^- colliders (described below) can be used. The size of the existing silicon sensor plane is sufficient to cover the wings of the "butterfly". Each of the two calorimeters will consist of 10 to 15 tungsten plates, and there is enough sensor planes to equip such calorimeters. The expected spacial resolution is of the order of 440 μm, with an energy resolution of 20% in the energy range considered here.

For monitoring of the outgoing beams and measuring nonlineaar Compton scattering, the idea is to use the correlation between the deposited energy by an electromagnetic shower and the amount of backscattering. While the details of the "monitor" still have to be worked out, a few tungsten plates (of order 3) equipped with the silicon sensors will be positioned close to the beam line to register the backscattered particles.

1.1 Prototype of the existing luminosity calorimeter

The existing prototype of the luminosity calorimeter is a sampling calorimeter composed of 20 layers of 3.5 mm ($1X_0$) thick tungsten absorbers and silicon sensors placed in a one-millimeter gap between absorber plates.

The sensor is made of a 320 μm thick high resistivity n-type silicon wafer. It has the shape of a sector of a 30° angle, with inner and outer radii of the sensitive area of 80 mm and 195.2 mm, respectively. It comprises four sectors with 64 p-type pads of 1.8 mm pitch. A picture of a sensor is shown in Figure 1.

The bias voltage is supplied to the n-side of the sensor by a 70 μm flexible Kapton-copper foil, glued to the sensor with a conductive glue. The 256 pads of the sensor are connected to the front-end electronics using a fan-out made of 120 μm thick flexible Kapton foil with copper traces. The inner guard ring is grounded. Ultrasonic wire bonding was used to connect conductive traces on the fan-out to the sensor pads. A support structure, made of carbon fibre composite with a thickness of 100 μm in the sensor-gluing area, provides mechanical stability for the detector plane. Special fixtures

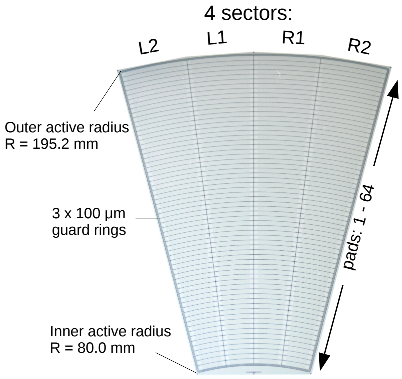

Figure 1: A LumiCal silicon sensor.

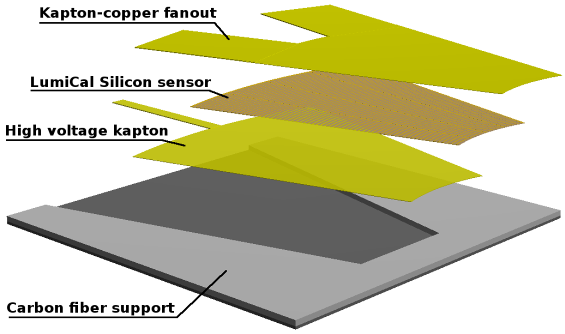

Figure 2: Detector plane assembly. The thickness of adhesive layers (not shown) between components is within 10 - 15 μm. The total thickness is 650 μm.

were designed and produced to ensure the necessary thickness and uniformity of three glue layers between different components of the detector plane all over the area of the sensor. A sketch of the structure of the detector plane is shown in Figure 2 and a photo of a completed plane in Figure 3.

Figure 3: A thin detector plane. The black part is the carbon fibre support. The silicon sensor is covered by the Kapton fan-out which has two connectors for front-end boards.

The prototype was tested at DESY with an electron beam in the range of 1 - 5 GeV and the resulting effective Moliere radius at 5 GeV was determined to be (8.1 $\pm$ 0.1 (stat) $\pm$ 0.3 (syst)) mm, a value well reproduced by the Monte Carlo (MC) simulation (8.4 $\pm$ 0.1) mm. Further details can be found in [1].

References

[1] H. Abramowicz et al., *Performance and Moliere radius measurements using a compact prototype of LumiCal in an electron test beam,* arXiv:1812.11426(2018).