Thermal performance of carbon foams used as heat sink for the pixel MVD-Panda.

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The Micro Vertex Detector (the MVD) for the Panda experiment at GSI-DARMSTADT is optimized for the detection of the secondary vertices and for maximum acceptance close to the interaction point. The experimental setup requires sophisticated solutions for the detector integration in order to maintain a stringent material budget. The thermal power produced by the “on board” read-out electronics is fast removed using carbon foam as heat sink. Two types of carbon foam are under evaluation. Both, the mechanical and thermal properties behaviour under radiating field are studied. Results from finite element thermal analyses and test bench are also presented.

For the cooling system design a material with low density, high thermal conductivity, low thermal expansion coefficient, machinable, stable at different temperatures and radiation resistant has been searched. The material which compiled to all these requirements was the carbon foam: the open pore structure in graphite creates a material with high thermal properties at low density.

The tests for the Young’s modulus estimation consisted on the irradiated carbon foam specimens tensionned to a set of loads. For the evaluation of the Young’s modulus, strain gauges have been glued on the specimens. Test results show the variation of the elastic modulus at different radiation loads.

Four half-disk of 75mm of diameter, dissipating 75W and eight half-disk of 150mm of diameter, dissipating 746W, constitute the pixel disk-group of the Panda MVD.

The cooling system for the disks consists of a 2mm external diameter tube, made by Nickel-Cobalt alloy (Ni52Co48MP35N), inserted in a 1mm-thick carbon foam half-disk, on which detectors are directly glued on both sides. FEM simulations have been conducted, considering different carbon foam thicknesses, tube diameters, flow rates and cooling tube number, with the aim to assess the most thermal efficient configuration for the half disk. Test results on prototypes validates FEM analyses.

The MVD consists of four cylindrical layers of silicon detectors located in the backward region (called barrel), and six planar layers located in the forward region (called disks). Hybrid silicon pixel detectors compose the two innermost layers of the barrel, while the two outermost layers are equipped with double side silicon micro strips. The barrel layers are arranged around the beam pipe axis. Concerning the forward part, the four disks nearest to the interaction point are equipped with pixel detectors, while the last two ones are both pixel detectors, in the area close to the beam pipe axis, and strip detectors in the external area. The pixel part and the strip part of the disks are perpendicular to the beam pipe axis. The MVD accepts a 400 mm long cylindrical volume with external diameter of 385 mm, in which 900 pixel detectors, and relative chips, dissipate 1935W, with a total thermal power of about 1.4 kW.

With the aim of measuring the properties of the material at different radiation levels, specimens of the two types of carbon foam, POCO FOAM and POCO HTC, were irradiated in a radiation field at the TRIGA MARK II reactor in Pavia. Five specimens per foam type are immersed in the irradiating field at different reactor power for a time of 1000-3500h, while one sample per type was non irradiated and used as reference.

The tests for the thermal conductivity estimation consists on the same irradiated carbon foam specimens located on one side by resistors and cooled on the other side. For the evaluation of the thermal conductivity, two thermocouples, arranged at a well known distance, have been glued on the specimen. Test results show stable thermal conductivity values at different radiation loads.

Two layers of detectors, cylindrically disposed at 25 and 75mm from the beam pipe, dissipating 75W on the first layer, and 500W on the second layer, constitute the pixel barrel group of the Panda MVD.

The cooling system for the barrel consists of a 2mm external diameter tube, made by Nickel-Cobalt alloy (Ni52Co48MP35N), inserted and glued in a sandwich of carbon foam and a carbon fiber omega structures, to provide both the drain of heat and mechanical support. The detectors and relative electronics are directly glued on the carbon foam. FEM analysis have been used to find out the most efficient solutions and test results are presented.