Low Mass and Low Radiation Length Support and Readout Structures for the STAR Pixel Detector

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We are developing the support and readout structures for the Heavy Flavor Tracker (HFT) pixel vertex detector for the STAR experiment at BNL's RHIC accelerator. The HFT will significantly enhance the physics capabilities of the STAR detector at central rapidities. The primary motivation for the HFT is to provide precise measurements of heavy quark production in *p+p*, *d+Au* and *Au+Au* collisions, including polarized *p+p*. These are key measurements for the continuing heavy ion and spin physics programs at RHIC. Heavy quark measurements will facilitate the heavy ion program as it moves from the discovery phase to the systematic study of the dense medium created in heavy ion collisions as well as the nucleon spin structure in polarized p+p collisions.

The mass and radiation length are critical parameters in the design of this detector system. Both need to be as low as possible to minimize the effect on the physics measurements. In addition, the entire support system must be able to locate each pixel in the assembly to within 5-10 microns in order to give the required detector resolution. These requirements dictate that these structures be very light, low Z, and very stiff. The basic unit of the HFT detector is a 20 cm long by 2 cm wide ladder that mounts ten 2 cm x 2 cm detectors. These ladders are arranged in 2 concentric cylindrical arrays enclosing the beam interaction region from -1 < eta < 1. The ladders are identical and have 3 main constituents, the detectors, readout cable and support structure.

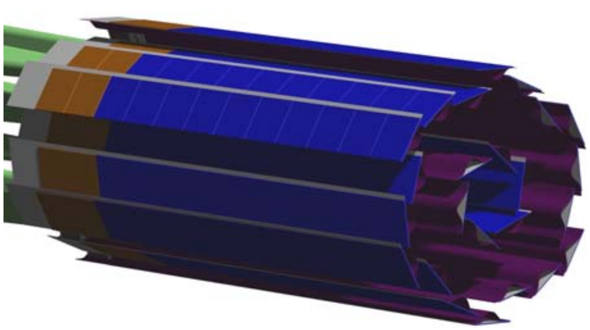

Figure 2. HFT structure

Detector – Each MIMOSTAR CMOS pixel sensor is approximately 2 cm square array 640 x 640 CMOS active pixels. We back-thin each sensor to a thickness of 50 µm to reduce multiple scattering and interaction.

Cable – The baseline detector will have a differential analog readout from the detectors wirebonded to a companion ASIC (also backthinned to 50 µm) read-out chip (RDO) which will perform digitization and logic to perform the initial correlated double sampling analysis and data reduction. The resulting digital data will then be read out via wire bonds to an underlying flex cable. There are approximately 100 traces including signal, control, clock, power and ground. We have designed a 4 layer kapton flex cable with impedance controlled differential signal pairs in a noise shielding configuration. The conductor for the cable is chosen to be Aluminum. The difference in radiation length between Al and Cu as a conductor is sufficient to almost double the overall radiation length of the ladder.

Support structure – The support structure for the detectors and cable makes extensive use of advanced materials. Each carrier consists of a rectangular block of reticulated vitreous carbon foam (RVC) sandwiched between 2 thin layers on unidirectional carbon fiber composite. This arrangement has the combination of stiffness and low mass that allows us to meet the position and radiation length requirements.

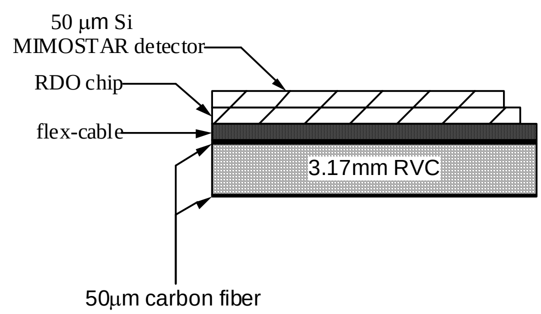

Figure 1. Ladder structure (end view)

The final detector ladder structure meets both the low mass and high stiffness requirements needed for the HFT detector. The following table shows the radiation lengths of the components and the final assembly.

Table 1. Final ladder material radiation lengths

Component	% radiation length	Si equivalent (µm)
RDO chip	0.0534	50
Adhesive	0.0143	13.39
MIMOSA detector	0.0534	50
Adhesive	0.0143	13.39
Cable assembly	0.090	83.92
Adhesive	0.0143	13.39
Carbon fiber / RVC beam	0.11	103
Total	**0.35**	**328**