PROCEEDINGS OF SCIENCE

Mechanical design of the sPHENIX Time Projection Chamber (TPC)

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sPHENIX plans to build a world class jet detector at RHIC. Previously inaccessible measurements include jets reconstructed with hadronic calorimeters and fully resolved upsilon states. The current plan includes a highly granular silicon pixel detector (MAPS), a silicon strip detector (INTT) and a time projection chamber (TPC). The tracking system will work in continuous read out, at high data collection rates -15kHz- and will be able to provide momentum resolution. In this poster we present the RND work done towards the mechanical design and construction of the outer field cage of the TPC.

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1. Introduction

TPCs are tracking detectors in which the active volume consisting of liquid/gas is ionized by charge particle leaving behind a trail of ions. The electrons and ions from the ionization trails are drifted to the readout planes by electric field and reconstructed to form the trajectory of the charged particle in 3D space.

2. Mandrel for Outer and Inner Field cage

To build a perfectly cylindrical field cage, we need to have a precise workbench on which we can place the circuit cards and later disassemble after building up the many layers of the field cage. This workbench is called a mandrel and we have designed the outer and inner field cage mandrel differently.

Figure 1: Inventor drawings and construction progress of the mandrel for the outer field cage.

For the outer field cage (OFC) , we build two bicycle wheel like structures connected by long bars out of T-slotted hollow aluminum 80-20 frame. This frame is coupled to a shaft which is turned via a harmonic motor with an encoder for precision. On this we place twenty-four pieces of machinable foam which overall forms a dodecagon (figure 1). This entire assembly is going to be machined to a perfect cylinder on which we will be placing our circuit card. The foam presented above also has small vaccum channels which will be used to keep the circuit card in place before being glued to the next layer. Once the OFC is built, this entire assembly can be dismantled.

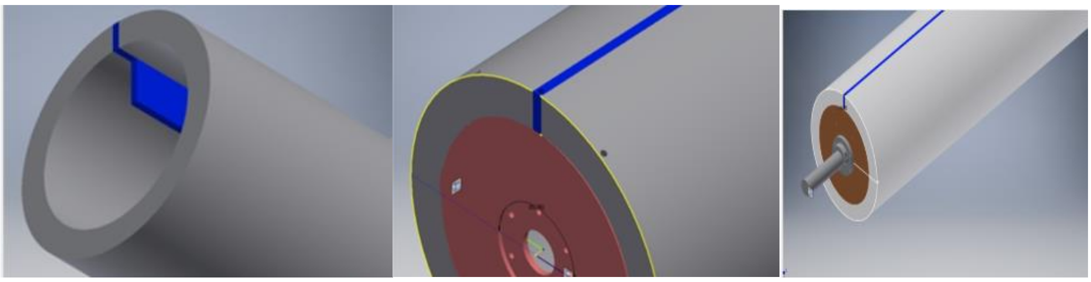

Figure 2: Inventor drawings of the mandrel for the inner field cage.

For the inner field cage (IFC), we are using a 16” long high graded PVC pipe (grey). On this, we will be cutting a narrow 0.125” slot and inserting a PVC bar with a sharp edge (blue) along the slot. Then we attach an aluminum hub on the sides which will have pockets for a collar to attach to the motor and shaft assembly. This setup will then be lathed to the precise radius in a machine shop. Once we have built the field cage, we can disassemble it by removing the aluminum hub and pulling down the blue key forcing the PVC to take a smaller shape thus making it easier to detach off the field cage.

3. Various layers of the field cage.

Both the inner and the outer field cage have the same layer constituents. The IFC will have the circuit card as the outermost layer followed by Kapton and then the Honeycomb + Fr4 sandwich. Whereas the OFC has this order reversed.

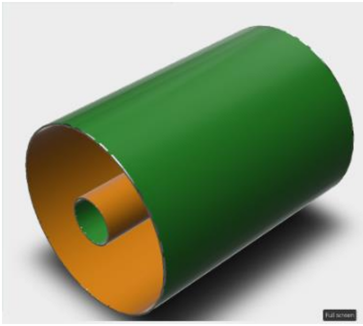

Figure 3: Inventor drawings of IFC and OFC.

3.1 Circuit Card

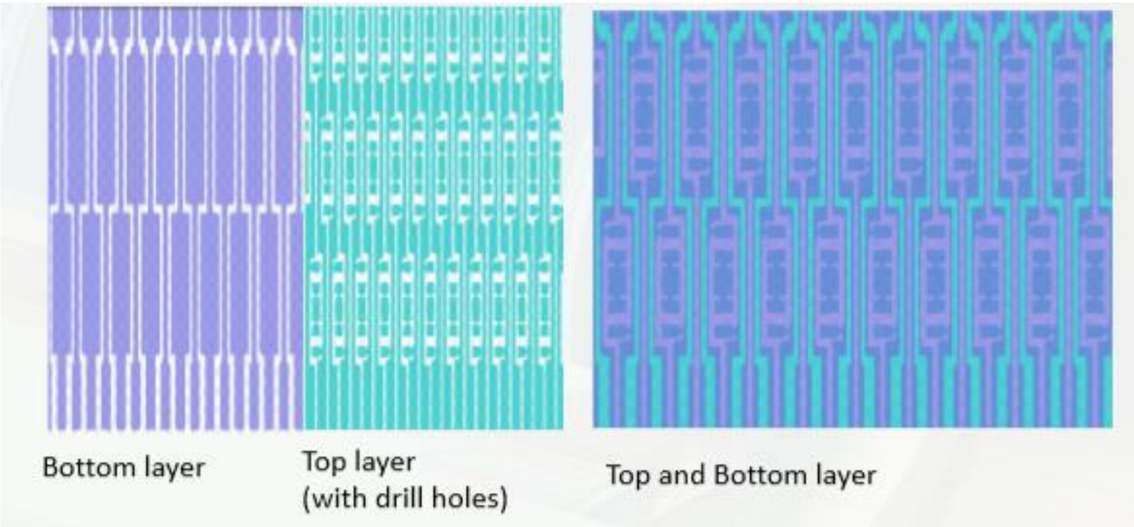

Figure 4: Eagle Schematic of the top and the bottom layer of the circuit card.

The circuit card will have parallel rings of copper which are connected by high voltage surface mount resistor chains. These resistors have an absolute voltage rating of 40kV, surge holding capacity of 15kV and a small temperature coefficient of 25ppm/C.

3.2 Kapton

Due to dimensional constraints set by the BaBar magnet, the TPC in sPHENIX will have a solid insulating layer to hold 40kV between the circuit card and ground. Upon testing a special kind of Kapton (200GA HN), it was noted that it holds the required voltage with just six layers. Adding a measure of safety, we will be wrapping about 15 layers of 0.003” Kapton which has been purchased with 0.002” glue on one side for ease of wrapping.

Figure 5: Testing HV capability of Kapton

3.3 Honeycomb

The structural integrity of the field cage will be provided by honeycomb sandwidched between a thin film of Fr4. This is a light material with very short radiation length and commonly used in many TPCs.

Detector	relative pressure "defelection"	relative gravity "defelection"
ILC	1.73435361	7.230687064
STAR - field cage	21.98526189	89.73576283
STAR - containment vessel	1.998905584	26.80748014
sPHENIX	1	1

Table 1: Comparison of relative pressure and gravity deflection for different gaseous TPC.

After doing some analytical calculation comparing the deflection under both gravity and pressure for TPCs of STAR, ILC and sPHENIX, we decided that 0.5” of honeycomb is sufficient for our needs.

4. Conclusion

The inner and outer field cage design is completely in place and the construction has been going smoothly with no major obstacles. We expect to finish building it end of next year and in parallel work on the amplification and the data readout for the TPC.

References

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