Framing and testing of large GEM foils for ALICE TPC upgrade

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Introduction

The ALICE experiment at the Large Hadron Collider (LHC), CERN is dedicated to the study of quark-gluon plasma (QGP), a new form of matter produced in heavy-ion collisions at ultra-relativistic energies. In ALICE, Time Projection Chambers (TPC) is the main tracking and particle identification detector. ALICE has been taking data since 2009. With the increase of beam energy and luminosity of the LHC, the Pb-Pb collision rate will increase to 50 kHz after the Long Shutdown 2 in year 2020. The present gating grid based Multi Wire Proportional Chambers (MWPC) in TPC can handle collision rate of 2.3 kHz at most. For the future, the TPC readout and electronics will be upgraded to cope with high collision rates.

Gas Electron Multiplier (GEM) detector, was introduced by F. Sauli [1] in 1997 and has been widely improved in last two decades for applications to high energy physics experiments and imaging. The detector consists of a thin kapton foil, with copper on both sides, having regular array of holes. GEM detectors have several advantages, like good spatial resolution (~100 μm), high detection efficiency (>98%), high rate handling capability (~10^5 Hz/mm^2) and reasonable time response (~5 ns) [2]. This makes it ideal for ALICE TPC upgrade. In this article, we discuss framing and testing of large GEM foils.

New TPC Readout Chambers

The ALICE TPC is the largest detector of its kind. It is a cylindrical barrel of length 5m and diameter 5m. The center of the cylinder is operated at -100kV and the end planes are covered with readout chambers. The entire readout is divided into two sections, inner read out chambers (IROC) and outer read out chambers (OROC). OROC is further divided into three sections, namely OROC1, OROC2, and OROC3 depending on the dimensions. OROC3 is the largest in size among all the GEM stacks of the TPC. OROC3 is trapezoidal in shape. The detail dimensions are given in Fig. 1. Each OROC3 GEM foil has 24 segments. Each stack contains 4 GEM foils for multiplication of the charges to produce a detectable signal.

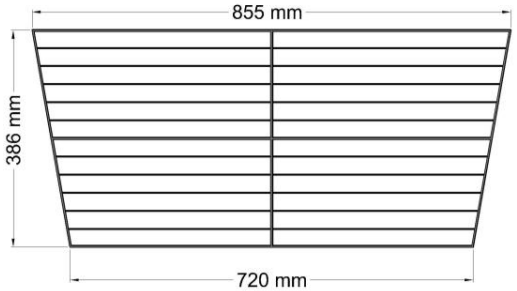

Fig. 1 Dimensions of OROC3 GEM foil.

Quality Study of GEM Foils

To begin with we obtained 8 unframed GEM foils, produced at CERN for assembling the OROC3 chambers and testing it before final production of OROC starts. We tested each GEM foil before framing. Optical inspection using microscope and current measurement of individual sectors of the GEM were done. The specification of a good foil is that the current of each sector is below 500pA at 500V without any spark in a dry environment (<0.6% humidity). We tested each foil for 30 minutes before qualifying the foils as good ones.

We have tested each GEM foil in two steps, one, before framing and another is after framing. Before framing the foils, 500V are applied to all sectors and currents for individual sectors are

measured. The foils are framed, i.e., stretched and glued to the trapezoidal frame. The curing is done in dry environment using N_2 gas flow. Once the foils are framed, optical inspection is carried out under a microscope to confirm that no glue spills into the holes of the foils. Then those framed foils are put into a dry environment using N_2 flow. Once the humidity goes down to 0.6% the currents are measured following the previous steps for 30 minutes. In Fig. 2 the voltage test set up is shown.

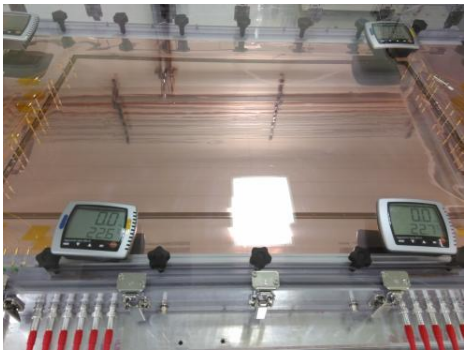

Fig. 2 Voltage test set up of the GEM foils.

Test Results

Results of current measurements of one of the unframed foils are shown in Fig. 3. The currents of all 24 sectors are within the specified limits. At the beginning and at end the currents are high because of the finite capacity of GEM foil.

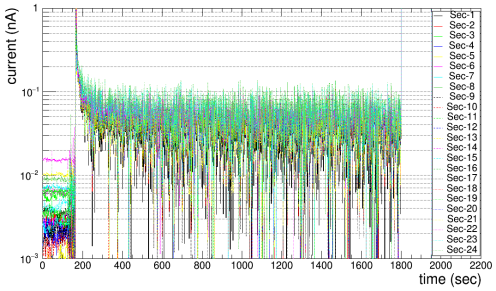

Fig. 3 Currents measurements of unframed GEM foils of OROC3.

In Fig. 4 measured current is shown as a function of time of each sector after the framing of the foils. Here also currents are within limits.

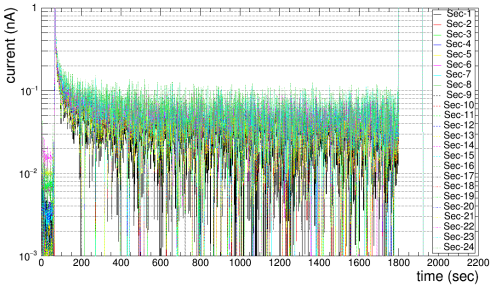

Fig. 4 Currents measurements of framed GEM foil of OROC3.

During the tests, the effects of normal light of current measurement had been noticed. During the measurement time when light was on, a higher current to all the sectors had been observed. This can be seen in Fig. 5 below, but the currents are still below the specified limit.

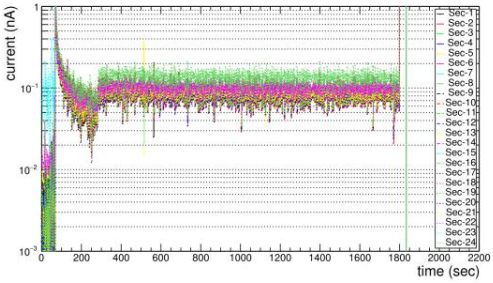

Fig. 5 Effect of light on current measurement.

Summary

We have framed the GEM foils for OROC3 pre-production of ALICE TPC. We checked each foil optically using microscope. Gluing was perfect for all those foils. We did voltage test before and after framing the foils. Light effect was noticed in current measurement. All these test results are important before assembling and testing the OROC3 detector for final fabrication of the detectors for ALICE TPC.

References

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[3] ALICE-TPC Upgrade, ALICE-TDR-016, CERN-LHCC- 2013-020, March 3 2014.