Visual investigation of possible degradation in GEM foil under test

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Introduction & Motivation

- Gas Electron Multiplier (GEM) is used in High Energy Physics (HEP) experiments as a tracking device
 - \rightarrow Good position resolution (~ 30 µm)
 - \rightarrow High rate handling capability (~ 1 MHz/mm²)
- Long-term stability is one of the important criteria for any detectors in HEP experiments
- During the long-term study of a Single Mask (SM) triple GEM chamber it is observed that the detector suddenly stopped giving the signal
 - \rightarrow After investigation, it is found that some short paths are created in the 3rd GEM foil of the chamber by measuring the foil resistance (~ 40 k Ω)
- The damaged foil (3rd GEM foil) is investigated using an optical microscope
- The damaged foil is cleaned using different techniques
 - \rightarrow Water bath using millipore water
 - \rightarrow Ultrasonic bath with millipore water
- The leakage current of the foil is measured after the cleaning of the foil







SM triple GEM chamber under testing at **HEP detector lab of Bose Institute**

a) Microscope setup to measure the GEM hole diameter and pitch, b), c) & d) Microscopic images of the GEM hole showing imperfections at different magnifications, e) Measurement of GEM hole diameter and pitch, f) Distribution of GEM hole diameter, g) Distribution of GEM hole pitch

Methodology for cleaning of the GEM foil & leakage current measurement

- The resistance of the GEM foil is measured after removing the foil from the chamber and is found to be ~ 40 k Ω
- The foil is immersed in the millipore water
 - \rightarrow The foil is immersed in the water bath for ~ 60 minutes
 - \rightarrow The foil is taken out and kept for drying under continuous heat flow ~ 30 minutes and after that the foil resistance is found to be $\sim 1 \text{ M}\Omega$
- The foil is cleaned using ultrasonic (~ 20 kHz) bath with millipore water
 - \rightarrow The foil is kept in the ultrasonic bath for ~ 5 minutes





Cleaning of the GEM foil using water bath (left) and using the ultrasonic bath (right) with millipore water as the medium

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		∆V = 300 V
		RH ~ 50%

- \rightarrow The foil is dried for \sim 30 minutes under continuous heat flow and after that the resistance of the foil was found to be high
- The leakage current of the foil is measured with the continuous flow of Ar/CO₂ gas mixture using Keithley picoammeter after cleaning with the ultrasonic bath
- The leakage current performance of the foil is found to be reasonable (at $\Delta V \sim 300$ V, RH ~ 50%, leakage current ~ 0.3 nA)



Setup of leakage current measurement (left) and variation of leakage current as a function of time (right)

Reference & Acknowledgement

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Summary

- During the long-term study of a SM triple GEM chamber, the 3rd GEM foil of the chamber is found to be damaged
- The measured resistance is found to be ~ 40 k Ω
- Optical inspection of the GEM foil revealed imperfections in the GEM holes
- The short paths in the GEM foil are removed by using an ultrasonic bath
- The leakage current of the GEM foil is measured and found to be reasonable after cleaning