IMAGEM
(Imaging with Triple GEM Detectors)

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1 Introduction

The main tasks of this R&D is the development of different detectors basted on GEM technologies essentially for beam diagnostic. The use of GEM foils for detector construction started in Frascati on 2002 with the R&D for LHCb muon chambers M1R1. Ever since several triple GEM chambers have been built for different applications. The results obtained in several beam tests show high performances: high rate capability (> 50 MHz/cm^2), good time resolution (~ 4 ns), good space resolution $O(200\mu\text{m})$, and good aging resistance after 2C/cm^2 of integrated charge. The IMAGEM R&D is devoted not only to the detectors but also to the readout electronics and power supply.

2 Track Luminometer for Dafne Upgrade

In the mainframe of Dafne Upgrade, for the luminosity measurement in e^+e^- collision using the Crab Waist mode , four semi anular detectors for Bhabha events detection have been designed and built. A new GEM foil have been designed as shown in the Figure 1(left) with 32 pads on the anode with a total detector diameter of 20 cm.

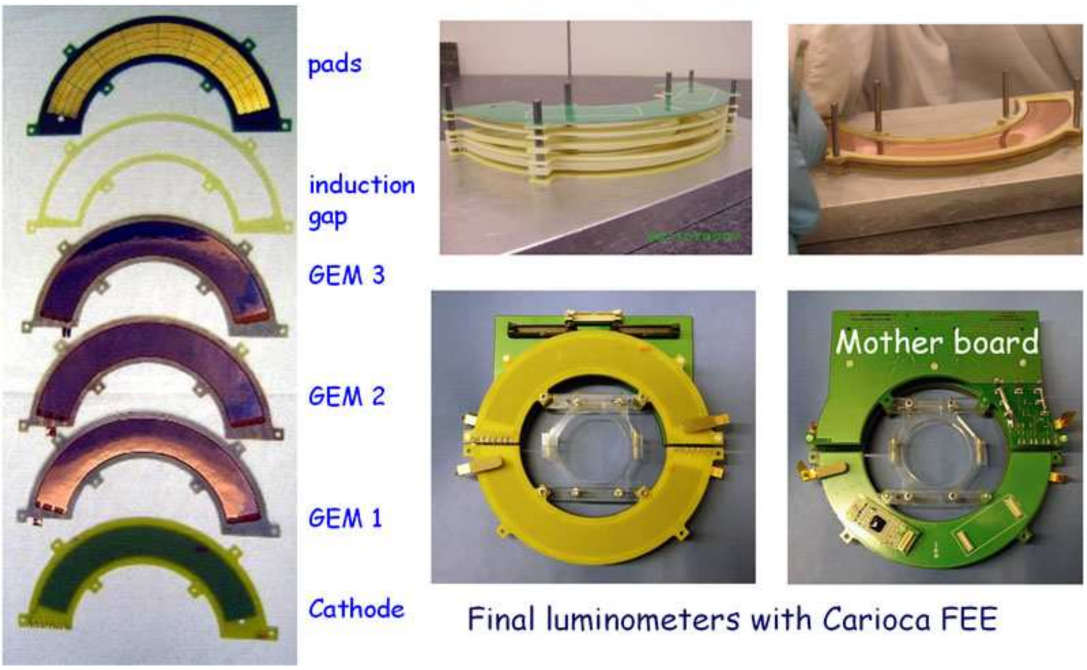

Figure 1: *Assembilng the GEM track Luminometer.*

The pad dimensions are $6 \times 24(32)$ mm^2 depending on the ring radius. On the back side of the anode PCB two small connectors for the front end has been foreseen. These cards have been designed and realized in Frascati using the chip Carioca GEM developed at CERN for the LHCb muon chamber M1R1. The Fig. 1(right) shows the Carioca Card assembled on the back side of the detector. A mother board for the LV and HV power supply is successively plugged on them. The same mother board houses the connectors for LVDS signals coming out from the Carioca cards. The detectors have been installed at the beginning of 2008 near Sidhartha experiment at 18 cm from interaction point of Dafne. They are run for few months furnishing information on machine background (about 700 KHz on the whole detector when a beam current of 500 mA is circulating inside Dafne). In coincidence with the scintillator tail calorimeter placed behind the GEM track luminometer the impact point of electrons and positrons have been measured together with collinearity of the bhabha event (see fig 2).

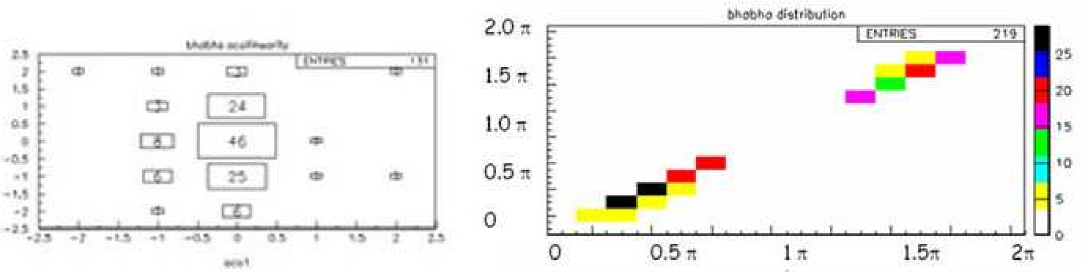

Figure 2: *Collinearity of Bhabha events measured by the GEM track Luminometer.*

The hit cluster size was below 1.2 and the space resolution of the O(1 cm) was in agreement with the pad dimension. The events taken during four months of data taking has shown low noise even if the detectors were close to the beam pipe. Due to the high sensitivity of Siddhartha experiment built around the same interaction region, the installation of a further lead protection just around the beam pipe to screening from the machine background, has required a removal of the GEM detector, preventing the run follow up.

3 TPG: a Time Projection Chamber with a triple GEM readout

A compact time projection chamber (TPC) has been designed, built and tested, for beam monitoring at the Dafne Beam Test Facility (BTF). The Facility provides electron and positron beams in a wide range of intensity, from single particle up to 10^{10} particles per pulse, and energy, from a few tens of MeV up to 800 MeV. The large range of operation of the facility requires the implementation of different detectors, for real-time beam monitoring. The main idea in developing this detector is to place a standard triple GEM detector parallel to the beam and to use it as a time projection chamber, by enlarging the drift gap. In this way the depth of the material crossed by the particle is particularly small and the beam position measurement could be more precise, in the coordinate along the drift O(100 μm), by measuring the time of arrival of the electron clusters. Moreover, a very compact detector can be realized, using standard $10{\times}10$ cm^2 GEM foils and a drift gap of 4 cm. The 128 readout channels organized in a matrix of 8×16 pads allow to obtain a good resolution O(1 mm) also in the other two coordinates. Thanks to a small material budget crossed by the particle and the 3D reconstruction of the particles track, it's use for ion beam monitor in adrotherapy is very promising and under study.

4 Monitor for high intensity neutron flux

In 2008 some beam tests have been done at FNG (Neutron Gun Facility) at ENEA Frascati for the measurements of high neutron flux produced by strong nuclear reaction Deuterium-Deuterium e Deuterium-Tritium. Neutron of 2.4 MeV e 14 MeV are produced by this two reactions. A prototype $10{\times}10$ cm^2 made of a triple GEM with a cathode of alluminum and polietilene has been placed in front of the gun at few centimeter. The neutrons impinging on polietilene are converted in proton that release its final energy inside the gas producing electrons. The 64 readout pads organized in a matrix $16{\times}4$ allow to create an intensity image of the neutron source. The total counting rate has been compared with the measurement done with a liquid scintillator NE213 detector placed 10 meter far from the neutron source showing a good linearity up to 12 MHz/cm^2 (the maximum flux for FNG). As shown in Fig. 3 the detector efficiency is not high (4×10^{-4}) but in any case is not necessary for this type of measurement.

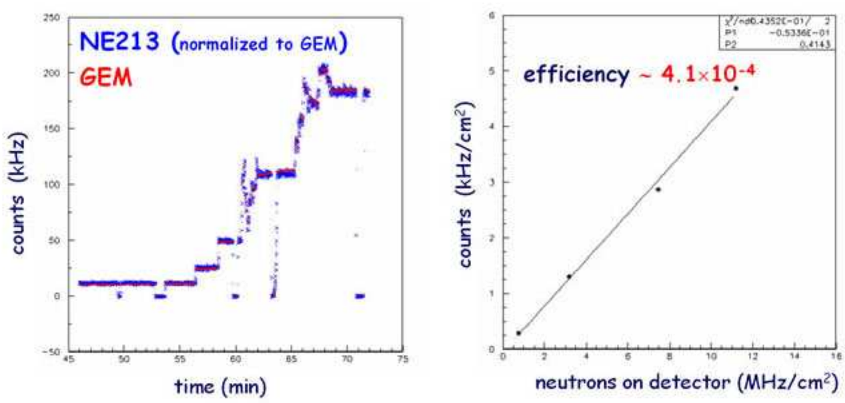

Figure 3: *The flux measurement compared with NE213 and the linearity up to* 12 MHz/cm^2.

Thanks to the strength signal released by the proton inside the gas the low gain settings of the chamber allow to have a good rejection to the photons produced by the radioactivation of material around the gun. At present a second prototype is under construction with 128 channels, more compact and able to measure at the same time the DD and DT component of the neutron flux.

5 High Voltage System for triple GEM detector

A novel High Voltage System for triple GEM detectors has been designed and realized in Frascati in the LHCb framework. The system element is built with seven floating power supply, with a maximum of 1200 V each, and controlled via CANbus, for voltage settings and monitoring. Several HV modules can be installed in a nano-ammeter mainframe already developed in Frascati, realizing a HV crate able to supply up to 24 triple GEM chambers with a 1 nA resolution monitoring system.

Figure 4: *A single HV GEM Module (on the left) and the 4 HVGEM system (on the right).*

A single HVGEM module has been used for several months supplying the detectors placed near the interaction region at Dafne, in radioactive hostile environment, showing good performances and reliability. A system with 4 modules has been realized and used for supply the four GEM track luminometers (see Fig 4) A the moment about 40 modules have produced up to now; some of them have been requested by groups working on GEM detectors.

6 Future

Other groups of INFN, ENEA and CERN are interested in use of these triple GEM detectors. Recently two monitors have been requested at CERN SPS for a crystal channeling collimation experiment. They will be installed before and after the bending crystal, just on the face tank that will contain the protractor, at few cm from the proton beam.

Any other information can been found on the web site

`http : //www.lnf.infn.it/esperimenti/imagem/`

7 List of Conference Talks

1. A. Ferrari, "A GEM based Neutron Flux Monitor for diagnostics in Fusion Reactors", IEEE 2008, Dresden, Germany.
2. F. Murtas, "Beam Diagnostics with GEM detectors", Invited Seminar at IHEP Beijing 26-5-2008.

References

1. F. Sauli, Nucl. Instr. & Meth. A **386** 531 (1997).
2. M. Alfonsi *et al.*, "The Triple-GEM detector for the M1R1 muon station at LHCb", N14-182, 2005 IEEE NSS Conference, Puerto Rico.
3. A. Corradi, F. Murtas, and D. Tagnani, Nucl. Instr. & Meth. A **572**, 96 (2007).