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A triple GEM gamma camera for medical application

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Abstract

A Gamma Camera for medical applications $10 \times 10\,\text{cm}^2$ has been built using a triple GEM chamber prototype. The photon converters placed in front of the three GEM foils, has been realized with different technologies. The chamber, High Voltage supplied with a new active divider made in Frascati, is readout through 64 pads, $1\,\text{mm}^2$ wide, organized in a row of 8 cm long, with LHCb ASDQ chip. This Gamma Camera can be used both for X-ray movie and PET-SPECT imaging; this chamber prototype is placed in a scanner system, creating images of $8 \times 8\,\text{cm}^2$. Several measurements have been performed using phantom and radioactive sources of ^{99m}Tc (140 keV) and ^{22}Na (511 keV). Results on spatial resolution and image reconstruction are presented.

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Keywords: GEM; Gamma camera; Medical application; Medical imaging

1. Introduction

Our goal is to have a multipurpose gamma camera for clinical use. The aim is to detect both low energy X-ray of transmission radiography and gamma rays of nuclear medicine. A triple GEM [1] technology is a well consolidated way to amplify few electrons to obtain a detectable signal. We have studied different gamma converters trying to produce electrons from gamma rays up to hundreds of keV; the electrons are therefore drifted and multiplied through the triple GEM structure and a signal is induced on pads $1\,\text{mm}^2$ wide.

2. The chamber construction

The triple GEM chamber is a prototype used in R&D for R1M1 Muon station of LHCb experiment and is described elsewhere [2]. Replacing the cathode with a gamma converter we are able to detect gamma rays with an energy range between 6−600 keV with a variable efficiency. For this task several solution have been tested: single or double GEM foils or a Large Electron Multipliers (LEM) made with 0.5 mm thick G10 layer drilled with 0.5 mm holes. All these solutions are able to convert gamma in electrons through photoelectric or Compton effect but the efficiency measured are always below few percent. In any case with these gamma converter we are able to reconstruct images with low acquisition time. An array, 8 cm long, of 64 pads $1 \times 1\,\text{mm}^2$ wide has been realized on a $10 \times 10\,\text{cm}^2$ PCB. The pads are readout on the PCB back plane through LHCb ASDQ FEE [3]. A VME DAQ, with scalers, reads the rates produced by gamma irradiation, in a defined time period. A 5 mm lead screen with 2 mm holes is put in front of the gamma camera for background reduction and collimation purposes.

3. X-ray movies

Putting this gamma camera in a scanner system we have tested first of all the possibility to realize X-ray movies. Due to the fact that low energy gammas interact

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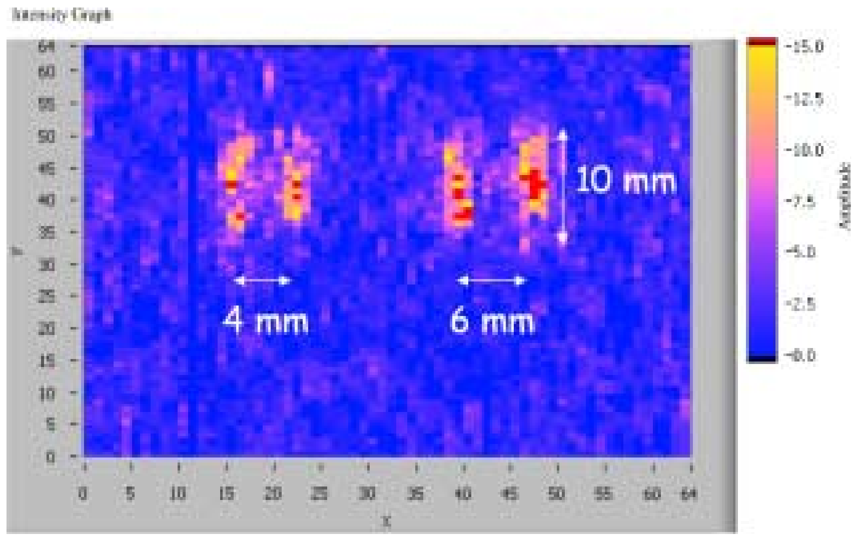

Fig. 1. Images of four ^{99m}Tc sources.

with high efficiency on metallic surface of gamma converter or directly on gas, the acquisition time is of the order of 0.1 s with a maximum counting rate of 700 Hz for each pad; so it was easy to get a movie of a rotating object illuminated by a 6 keV source. The filament current was very low (30 μA) well below the typical values used for medical imaging (the movie is available on the web site ⟨http://www.lnf.infn.it/ddg/⟩). The X-ray movies could be more useful than single images from the diagnostic point of view, due to the fact that having several images taken under different angles makes the clinical report more reliable.

4. SPECT image

The images displayed in Fig. 1 has been obtained with the same gamma camera set on a time gate of 4 s; the maximum rate measured on a single pad is 15 Hz with a background less than 2 Hz. Four ^{99m}Tc (140 keV) sources $10 \times 2\,mm^2$ wide have been put in front of the scanner system at a distance of 3 cm from the camera: first two sources are 4 mm apart and the next two are 6 mm apart. Studies are underway using scintillating fibers embedded in a lead collimator.

5. Conclusions

A Gamma camera for medical applications has been built using triple GEM technology. Different photon converters have been tested (double GEM, LEM). The first measurements performed using radioactive sources of ^{99m}Tc (140 keV) and ^{22}Na (511 keV) have shown good capability to resolve few mm^2 objects. Tests are in progress for higher gamma detection efficiency using scintillating fibers embedded in a lead collimator and, on electronics side, for a better spatial resolution and a faster data acquisition. More realistic measurements are in progress using phantoms with a radioactivity distribution closer to the signal to noise ratio typical of clinical cases.

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