THE GERMANIUM WALL OF THE GEM DETECTOR SYSTEM*

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The GEM-detector system was developed to investigate meson production and meson–nucleus interaction with the external proton beam of the COSY accelerator at Jülich. GEM is a hybrid system consisting of the GErmanium Wall and the modified Magnetic spectrometer BIG KARL. The Germanium Wall is a stack of up to four annular position-sensitive semiconductor detectors made from high purity germanium. Its design makes GEM a 4π-detector system for recoiling nuclei from reactions close to the production threshold [1]. In this contribution the design and the actual status of the Germanium Wall is described.

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1. Introduction

The modification of BIG KARL allows momentum measurements as well as ray tracing in x- and y-direction with an resolution better than 10^{-3}. However, BIG KARL is limited in angular acceptance to 25 mrad in x- and 100 mrad in y-direction. Therefore we will use the Germanium Wall close behind the target which will increase the acceptance by a factor of ten (287.5 mrad) and should have a similar resolution in energy and position as the magnetic spectrometer (see Fig. 1).

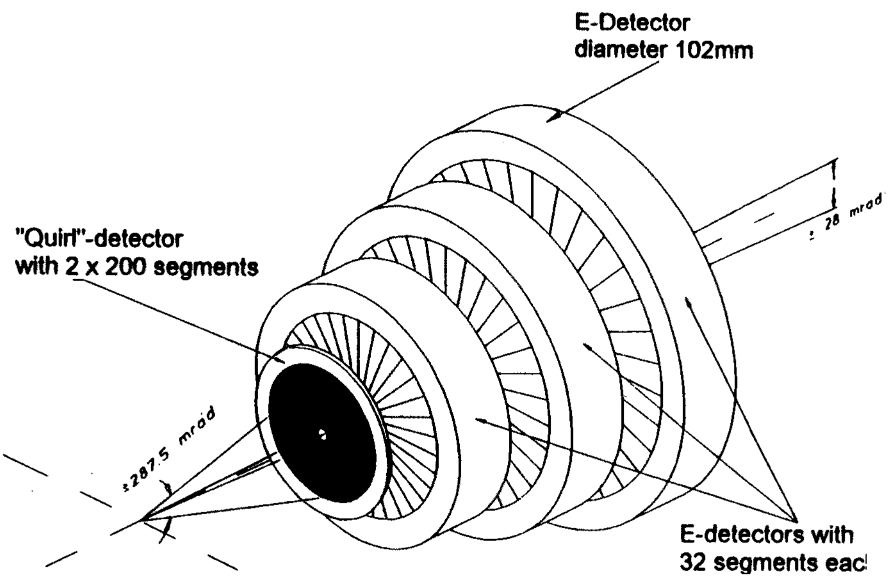

Fig. 1. Detectors of the Germanium Wall

The first detector is 1.5 mm thick and has a position-sensitive structure of 200 Archimedes' spirals with opposite orientation on each side. It will be used for position determination and for ΔE measurements. This detector is followed by up to three Ge diodes of about 17 mm thickness and a pie-chart structure on the front side. They will allow precise energy measurements. The total thickness is about 50 mm which will allow the stopping of *e.g.* 150 MeV protons. The central holes in the diodes serve as an exit for the primary COSY beam. Reaction particles scattered into this region will be detected by BIG KARL. Therefore the diameters of the holes were optimized with respect to the expected beam dimensions and the acceptance of the magnetic spectrometer.

All detectors are manufactured in house [2]. At this stage the third E-detector and a first prototype of the ΔE-detector are ready.

2. The Quirl-detector

As already mentioned the first detector of the Germanium Wall is used for both, ΔE and position measurements. This diode has a diameter of 63 mm, the central hole amounts to 4 mm. The spiral structure is already used in several plastic scintillator hodoscopes (JETSET at LEAR, PROMICE/WASA at CELSIUS and TOF at COSY) and is now applied for the first time to semiconductor detectors. As in the case with these hodoscopes we call the detector *"Quirl"*.

200 Spirals with opposite orientation on each side are defining 40000 pixels within a diameter of 36 mm, minus those which are replaced by the central hole. As the pitch increases from 47 μm near the hole to 170 μm at the outer radius, the pixel size also varies by a factor of ten. Therefore every pixel covers approximately the same solid angle. Because of the spiral structure one expects similar counting rates on every segment in experiments with a symmetric ϕ-distribution of events. Including the single readout of every channel experiments with high counting rates are possible. Furthermore, the spirals allow that each segment on both sides can be provided with a contact at the outer circumference of the structure.

A first prototype of a Quirl was fabricated and tested with a collimated α-source with respect to crosstalk due to the splitting of charge carriers collected in adjacent detector elements. This effect was found to depend on the pitch and on the applied detector voltage. But this does not necessarily impair the position determination: If it is possible to calculate the center of gravity of the charge distribution the position resolution might become better than the pitch of the detector [3].

3. The E-detector

The third E-detector has a diameter of 102 mm with a central hole of about 7.2 mm. To the best of our knowledge this is the largest planar germanium detector ever built. The position-sensitive region covers up to

87 mm and consists of 32 pies on the p^+-side. Due to the pie structure the detector is well suited for experiments with high counting rates because every channel is read out separately. The structure makes its possible to avoid ambiguities in position determination due to double hits.

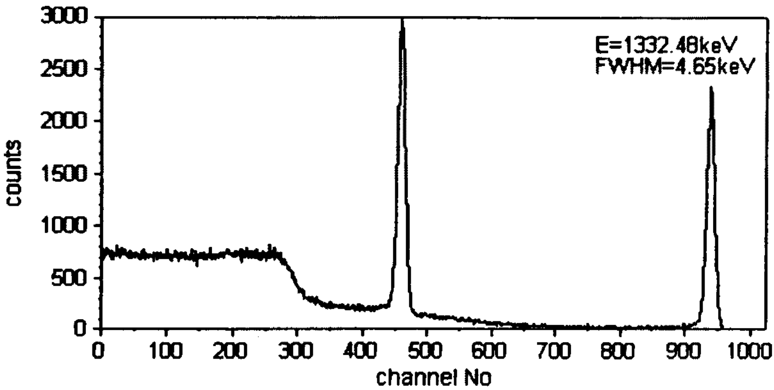

Fig. 2. ^{60}Co-spectrum obtained with the third E-detector. The applied bias voltage was 1000 V, 200 V more than the depletion voltage.

The detector is depleted at a bias voltage of 800 V. It was tested with a ^{60}Co-source at 1000 V (see Fig. 2). Except for one element we found a satisfactory energy resolution, the best value obtained was $\Delta E_{\mathrm{FWHM}} = 4.65$ keV, $\Delta E/E = 3.5 \times 10^{-3}$ respectively.

4. The cryostat

The modular cryostat, which will allow solid angle optimization for different experiments, is shown in Fig. 3. In the moment a setup for either four or only two detectors is possible. The cryostat also houses the target. In the first experiments a liquid hydrogen/deuterium target with appropriate thin windows will be used [4].

In order to minimize the material surrounding the detectors we constructed the feedthrough for the signal readout of 500 channels with Kapton ribbons with printed leads. These ribbons are ring shaped which allows to press them between Viton seals at the flanges of the cryostat. In this way 500 feedthroughs are made possible for which a vacuum of 5×10^{-8} mbar has been reached. Outside the cryostat the ribbons are directly connected to plugs on printed boards with preamplifiers.

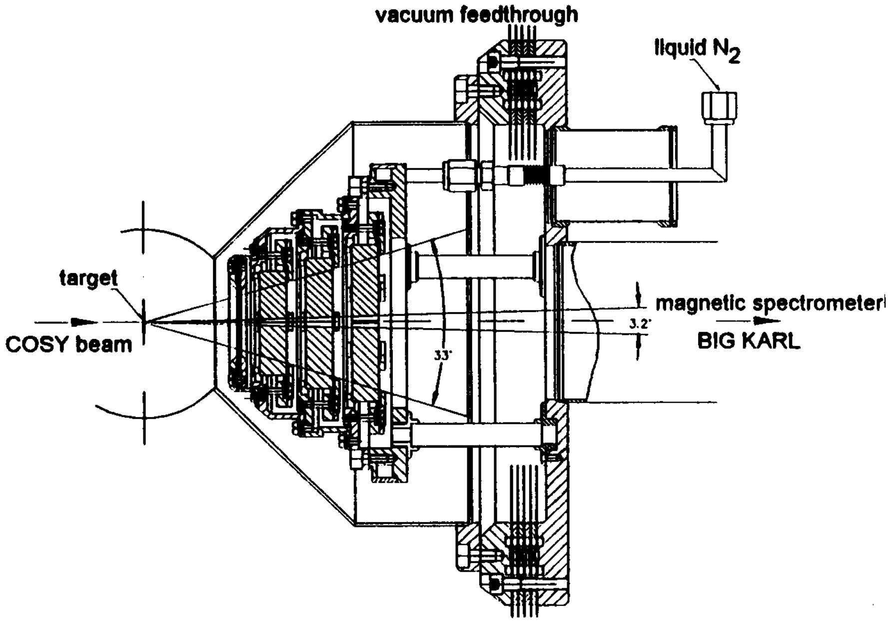

Fig. 3. Cryostat for HPGe-detectors and liquid hydrogen/deuterium target.

5. Discussion

We have shown that the Germanium Wall is an appropriate detector to complement the BIG KARL magnetic spectrometer in order to get a 4π-detector system. We obtained an energy resolution of $\Delta E/E = 3.5 \times 10^{-3}$ with a radioactive source. In terms of energy loss we should be able to detect charged particles with an energy resolution of about 10^{-3}. At least in the data analysis it seems to be possible to reach a position resolution better than the pitch of the Quirl detector.

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