# Source and In-Beam Tests of the MINIBALL Prototype Detector

C. Fischbeck, D. Weisshaar [a], D. Rudolph, M. J. Chromik, J. Eberth [a], D. Gassmann, D. Habs, P. G. Thirolf, and H. G. Thomas [a]

[a] Institut für Kernphysik, Universität zu Köln, D-50937 Köln

To exploit weak radioactive beams, dedicated Ge-$\gamma$-detector arrays in close geometry are being built: Miniball and Exogam [1]. The basic element of Miniball is a six-fold segmented encapsulated Ge-detector of Euroball shape [2]. The capsules will be used individually, or packed to clusters of either three or seven to provide a high level of flexibility of the set-up [1,3]

The first prototype was shipped to Munich in spring 1997. Unfortunately, the encapsulation of this Ge-crystal failed – the crystal and the cryostat had a common vacuum alike normal Ge-detectors – and the delivered pre-amplifiers proved extremely sensitive. Therefore, only basic tests [4] could be performed, and dedicated data aquisition and off-line analysis software could be prepared.

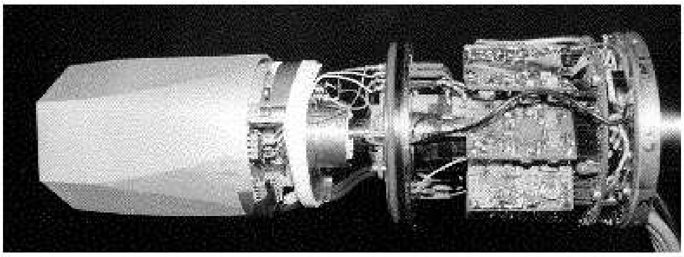

Fig. 1: Mounted Miniball capsule and pre-amplifiers.

Mid 1997 the first working encapsulated prototype was delivered. With a strong effort it was hooked to the cryostat and equipped at the University of Cologne with new SMD pre-amplifiers developed there. Shortly after, the detector worked properly and could be moved to Munich for further off- and in-beam tests. Fig. 1 shows a photo of this prototype.

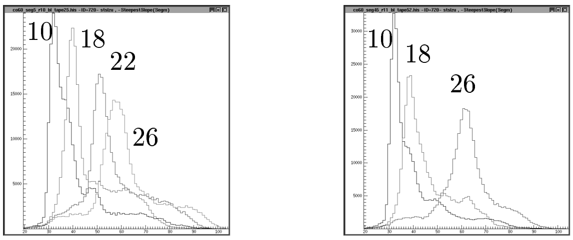


Fig. 2: Deduced time-spectra for $\gamma$ rays incidenting at different radii (given in mm) and positions (left: middle of segment; right: borderline between two segments) with respect to the center of the crystal.

Measurements with collimated sources have been performed to check the response of the prototype against Geant-simulations, including pulse-shape analysis to elucidate radial position sensitivity. Predicted and measured basic features are in very good agreement [4], and the derived position resolution illustrated in Fig. 2 is comparable to previous studies (e.g., [5]). The energy resolution of 2.2 keV at 1.3 MeV of the central contact (cold FET) is common for Cluster detectors while the value of an individual segment (warm FET) is, as expected, some 50 % larger due the higher capacity.

Data points at high $\gamma$-ray energies (up to 7 MeV) were added by measuring the $^{24}$Al $\beta^+$ decay following the reaction $^{24}$Mg$(p,n)$ at the Munich Tandem, using an additional Cluster capsule as a reference. Fig. 3 shows the photopeak efficiency of the central contact and one segment as well as the fold distribution of the number of segments fired. The slight turnover around 4-5 MeV can be understood in terms of the more localized effect of pair production.

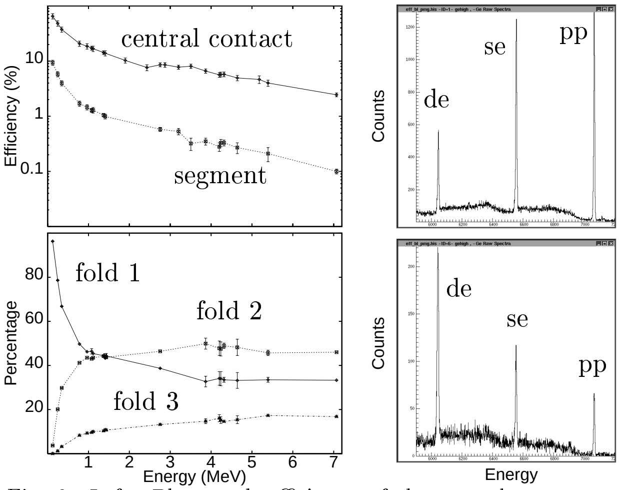


Fig. 3: Left: Photopeak efficiency of the central contact and one segment and the fold distribution of the segments. Right: Single- (se) and double (de) escape peaks of a 7.1 MeV (pp) transition; top: central contact; bottom: segment.

The fusion reaction $^{32}$S+$^{24}$Mg at 130 MeV provided a realistic test ($v/c$=5 %) to investigate the Doppler-broadening of incident $\gamma$ rays. The detectors were placed at a close distance of 10 cm. $\gamma\gamma$-coincidence spectra were inspected to determine the energy resolution using (*i*) only the common Doppler correction with an average recoil velocity, (*ii*) employing the knowledge of the angle of the segment with the largest energy deposition, and (*iii*) switching on radial position information. Moving from (*i*) to (*ii*) revealed the expected reduction of 40-50 % of the peak width. However, the pulse-shape analysis (*iii*) showed only a marginal effect. Most likely, this can be attributed to the angle spread of the recoiling nuclei which is of the same order as the opening angle of the individual segments. Another possibility is the non-parallel source-detector geometry in the experiment. Upcoming non-parallel source tests and in-beam Coulex experiments with charged-particle detection shall elucidate this problem. The potential for polarization measurements is also to be tested. More sophisticated off-line analysis in connection with new detectors (segmented also in the longitudinal dimension) shall give way to $\gamma$-ray tracking studies.

## References

[1] D. Habs *et al.*, Prog. Part. Nucl. Phys **38** (1997) 111
[2] J. Eberth *et al.*, Prog. Part. Nucl. Phys **38** (1997) 29
[3] P. G. Thirolf, Jahresbericht 1996, p. 102;
C. Fischbeck, Jahresbericht 1996, p. 103
[4] C. Fischbeck, diploma thesis, LMU München, 1997
[5] Ch. Gund, diploma thesis, Heidelberg, 1996