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A Ge–Si ACTIVE TARGET FOR THE MEASUREMENT OF SHORT LIFETIMES

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A new Ge–Si active target is presently used in the NA1 experiment at CERN to study photoproduction of charmed particles and to measure their lifetimes. Some general comments on the active target technique are made.

Since 1979, the FRAMM Collaboration has made use of active targets to study the photoproduction of charmed mesons and to measure their lifetimes. The first version of the target was a telescope of 40 silicon detectors, 300 μm thick, with 100 μm spacing. Fig. 1 illustrates the operation principle; the multiplicity development of the event can be reconstructed from the ionization loss in the different layers of the telescope. With this target, a measurement of the $D^\pm$ lifetime was performed, leading to [1]

$$\tau_D^\pm = (9.5^{+3.1}_{-1.9}) \times 10^{-13}\,\mathrm{s}.$$

To increase the sensitivity towards shorter lifetimes and to improve the detection efficiency, a new Ge–Si target was developed. Fig. 2 shows a schematic layout of the target. It consists of a monolithic Ge detector, followed by a telescope of 15 Si detectors.

The detection of short decay paths is based on a discrete sampling of the charged multiplicity along the target. The granularity, i.e. the number of samplings per unit length and the effective length of the target, i.e. the part of the target behind the interaction point, set a limit to the shortest and the longest detectable decay paths, respectively. Therefore, the main aim when designing the new target was to extend this interval as much as possible in both directions. At the same time, the total radiation length of the target had to be kept below 30%.

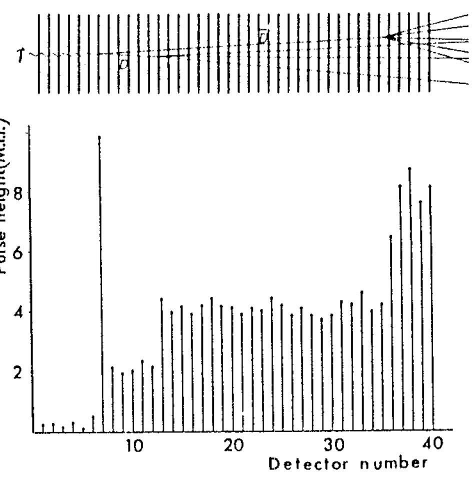

Fig. 1. An example of a D^+–D^- event and the corresponding pulse height pattern in the target.

The Ge–Si configuration meets these requirements well. A germanium detector when crossed by a mini-

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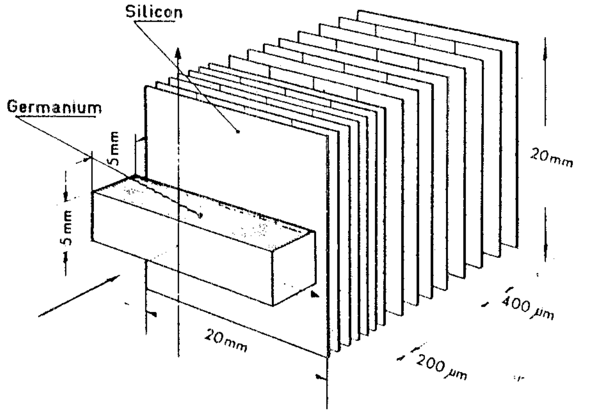

Fig. 2. A picture of the new Ge–Si active target employed in the CERN NaI experiment.

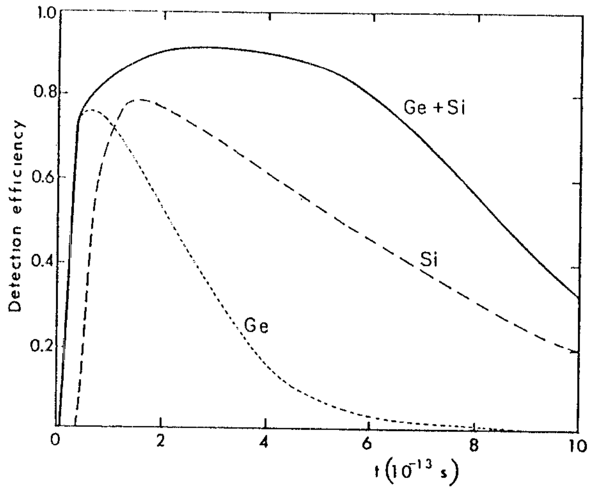

Fig. 3. The expected efficiency of the target in detecting the decay of particles living a given time t.

mum ionizing particle, delivers to the electronics about 2.5 times more charge than a silicon detector of the same thickness. As a consequence, a 50 μm pitch can be used in germanium, giving a fine granularity, together with a reasonable value for the signal to noise ratio. On the other hand, the short radiation length of Ge (2.2 cm) as compared with Si (9.8 cm), sets a severe limit to the total length of a germanium detector in a photon beam. The conversion probability for the γs of the beam or those coming from π^0s produced in hadronic events (the latter can simulate a decay) must be kept low. The silicon telescope placed 1 mm behind the germanium extends the effective length of the target considerably and increases the total radiation length by only a few percent.

Since the interactions take place preferably in germanium, the detection efficiency of the target is practically flat over a wide range of decay paths. This increases the reliability of the lifetime estimation. Moreover, due to the variable granularity of the target, the measurement precision of the decay path is roughly independent of its length.

Using a Monte Carlo program, which simulates the photoproduction of charm pairs at the beam energy of NA1, we evaluate the efficiency of the target in detecting the decay of a particle living a given time t. This efficiency is show in fig. 3 and refers only to decays with an increase of charged multiplicity.

At present, this target is employed in data-taking with a tagged Bremsstrahlung photon beam of 250 GeV top energy in the NA1 experiment at CERN. The Ge detector, $5 \times 5 \times 20$ mm^3 volume, has 96 strips on the top face with a pitch of 50 μm [2]. The Si detectors, 200 μm thick, have an active area split into four sections of 0.5×2 cm^2 [3]. The space between adjacent layers is 200 μm for the first 8 detectors and 400 μm for the remaining ones. The whole target is placed inside a cryostat, which keeps the Ge detector at the liquid nitrogen temperature in a vacuum better than 10^{-8} Torr.

The readout of the channels is performed by electronic chains consisting of hybridized preamplifiers, amplifiers and charge-sensing ADCs. The preamplifiers are placed close to the external wall of the cryostat, while amplifiers and ADCs are in the counting room. Due to the different charge collection times, two versions of electronics are used for the Ge and Si channels respectively [4].

The target was tested with high energy e^- and γ beams. Fig. 4 shows an event with a change in charged multiplicity, probably due to two successive photon conversions. The pulse height distributions for different multiplicities are shown in fig. 5 for one strip of the Ge-detector and in fig. 6 for a silicon layer. They were both obtained with a software selection, where two

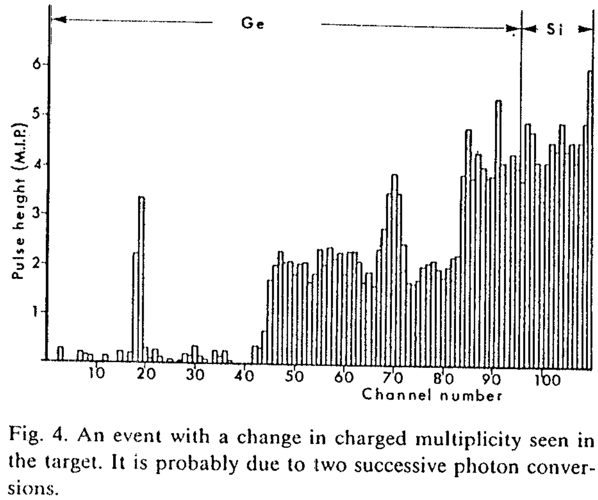

Fig. 4. An event with a change in charged multiplicity seen in the target. It is probably due to two successive photon conversions.

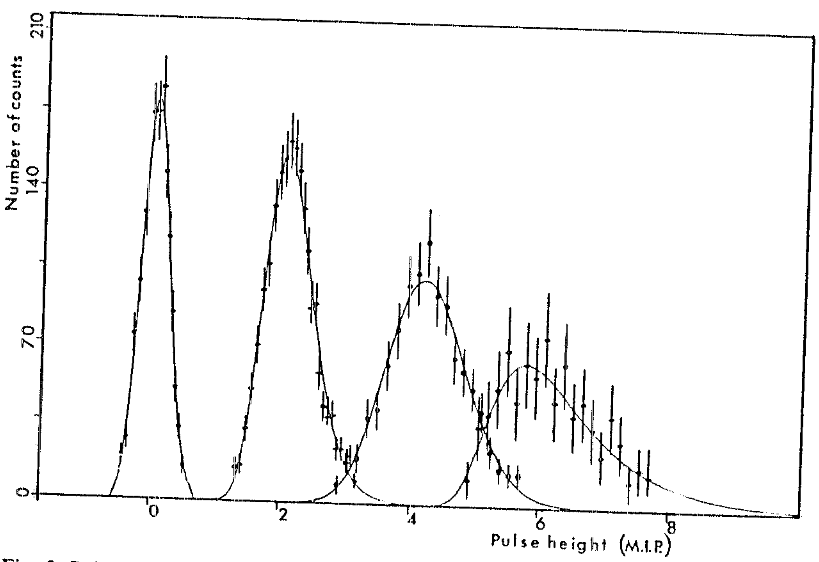

Fig. 5. Pulse height distributions corresponding to 2, 4 and 6 minimum ionizing particles (MIP), as seen by a germanium strip. The fitted Landau distributions are also shown.

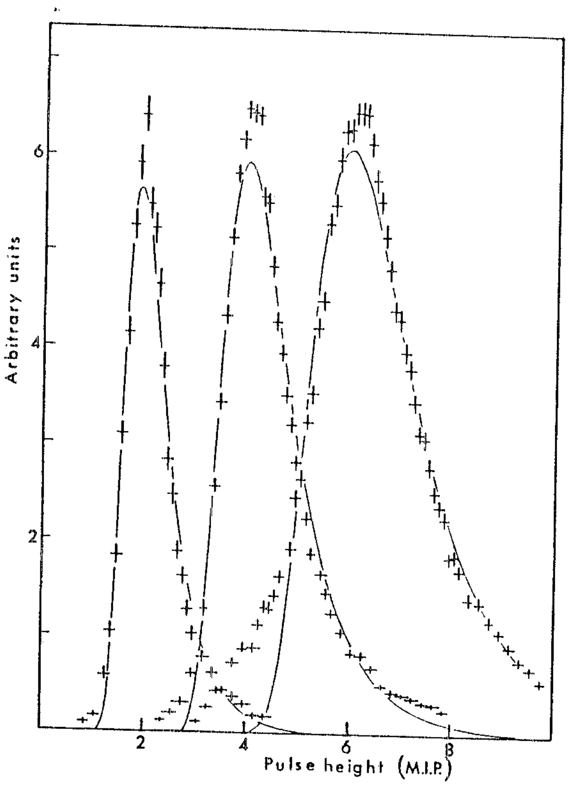

Fig. 6. Pulse height distributions corresponding to 2, 4 and 6 MIP, as seen by a silicon detector. The fitted Landau distributions are also shown.

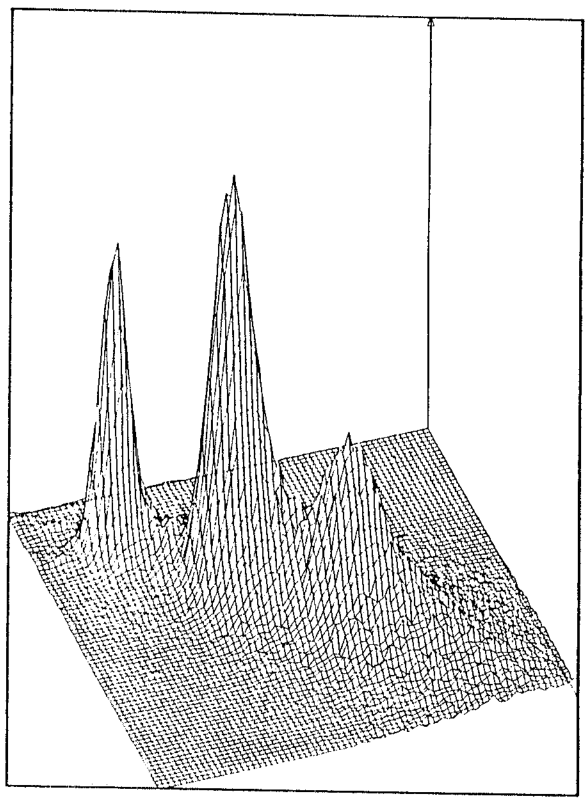

Fig. 7. Correlation plot of the multiplicities seen by any two adjacent Si detectors in the telescope. The 2, 4 and 6 MIP peaks are clearly visible.

detectors in front of and two behind the one studied were requested to have a fixed multiplicity within a small window. They respectively show the multiplicity resolution of a single strip detector. A correlation plot of the multiplicities seen by any two adjacent Si detectors in the telescope for unselected events is given in fig. 7. It shows the capability of the target of measuring the charged multiplicity with only two adjacent silicon detectors.

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