Development of a Solar Cell Fission Fragment Detector Array ◇

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Experimental studies of the nuclear structure in the second minimum of the potential energy surface in actinides require an efficient trigger on delayed fission events. Recent experiments on ^{240f}Pu ($t_{1/2}$ =3.8 ns) made successful use of a recoil shadow technique to suppress quantitatively the dominating background from prompt fission [2]. However, when aiming at investigating the odd-N fission isomer ^{237f}Pu with an isomeric lifetime of 110 ns and an order of magnitude smaller population cross section ($\sigma_{\rm del}$ $\sim$1μb in the ^{235}U(α,2n)^{237f}Pu reaction) an improvement of the delayed fission fragment detection efficiency (presently $\sim$20 %) is needed. With conventional silicon surface barrier detectors a larger solid angle coverage could only be achieved at high costs. However, commercially available silicon solar cells offer an attractive alternative not only in view of their moderate costs but also due to their rather simple handling without bias voltage due to the low resistivity of the base material (<2 Ω/cm^2).

An array of solar cell modules has been designed and built for the detection of delayed fission fragments. Fig. 1 schematically shows the complete array, including the fission isomer catcher foil and the preamplifier boards. With an active surface of 120x100 mm^2 about 70 % solid angle coverage can be achieved for the isomeric fission detection.

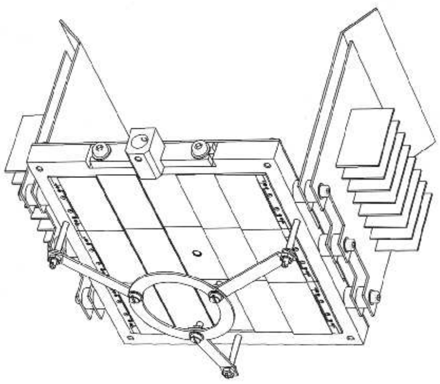

Fig. 1: Schematical view of the solar cell based fission fragment detector array, including the preamplifier boards and the holder for a catcher foil in front of the detector surface.

Several types of monocrystalline high-performance silicon solar cells have been tested to select the optimum signal yield from a ^{252}Cf spontaneous fission source. From their commercial use in space-flight and satellite-based applications they are initially equipped with TiO anti-reflex layers that would deteriorate the fission fragment mass resolution. Therefore this layer was removed via etching with a 10 % HF solution. A typical energy spectrum from ^{252}Cf spontaneous fission as obtained with a solar cell module is shown in Fig. 2. The array consists of 15 individual solar cell modules (thickness 300μm, outside dimensions 40x20 mm^2, type 2PR-200 from RWE Solar GmbH, Heilbronn). Each cell is mounted on a carrier board providing the electrical contacts for thin coaxial cables. The 15 modules are mounted on a supporting frame made of polyimide (Vespel) for electrical isolation and temperature resistance in view of the high beam currents that will be applied in the envisaged experiments.

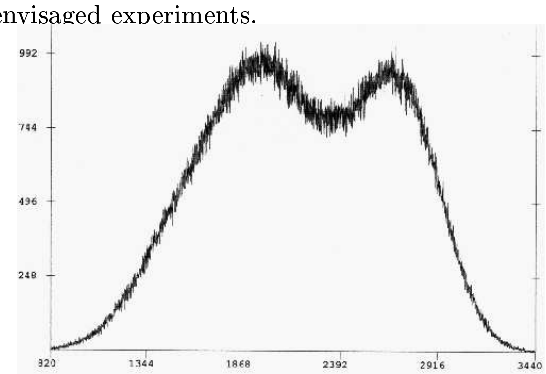

Fig. 2: Typical pulse height spectrum spectrum from ^{252}Cf(sf) measured with a solar cell module.

An annular detector was developed for the center of the array, where the α beam will pass from the back side through a 4 mm hole that carries the ^{235}U target with a diameter of 3 mm (see Fig. 3).

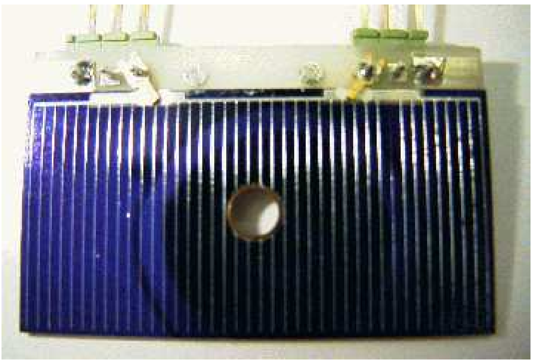

Fig. 3: Annular solar cell detector module.

The inside edge of the 4 mm hole in the solar cell is covered by a Vespel ring against direct detection of beam particles and prompt fission products. A 1 mm thick Ta-plate with a 3 mm central hole shields the back side of the detector array. At a distance of 15-25 mm in front of the detector surface a catcher foil ($\sim$30μm Mylar) with a central hole for the non-reacting beam can be positioned, where long-lived fission isomers will be implanted while still allowing to detect their delayed fission decay with high efficiency. Close to the detector modules, hybrid preamplifiers are mounted on two motherboards attached to the support frame of the detector array and shielded from the beam by two 1 mm Pb cover plates. Finally shaping amplifiers (shaping constant 1.5 μs) will prepare the energy signals for digitization. Thus modularity, performance, handling and price make this type of fission fragment trigger detector ideally suited for building large-area detectors in variable geometries as needed for both conversion electron and γ-ray spectroscopy experiments in the second and third minimum.

References

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[2] D. Gassmann et al., Phys. Lett. B **497** (2001) 181

◇ in: N. Holzapfel, Facharbeit Gymn. Landshut (2002)