Solar Cell Based Large Area Fission Detectors for Shape Isomer Studies ◇

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Fission isomers result from a superposition of microscopic shell corrections on top of the macroscopic liquid drop potential (Fig.1). Fission isomers offer the low spin approach to studying rotational and vibrational properties of superdeformed nuclei with a much cleaner separation between rotational and vibrational excitations in contrast to superdeformed nuclei in the high spin regime. Due to the low angular momentum the Coriolis mixing for these low spin states is small. The aim of this project is to study single-particle (Nilsson) orbitals at the deformation of the second minimum of an odd-neutron (^{237f}Pu) fission isomer, using γ-ray and conversion electron spectroscopy. Thus nuclear models in the heavy-element regime can be tested and refined. Moreover, an identification of downsloping orbitals from the superheavy-element mass region would allow to study nuclear structure properties from a regime presently not accessible at moderate deformations [1].

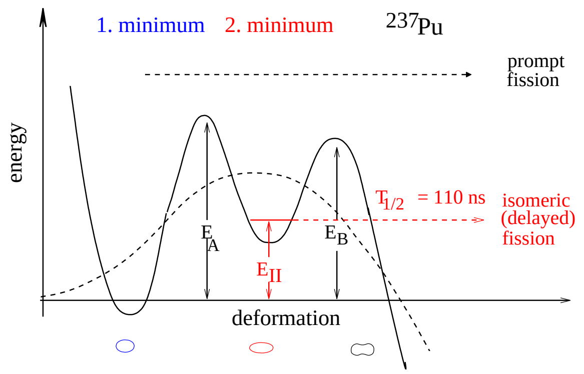

Fig. 1: Double humped fission barrier for ^{237}Pu ($E_A = 5.9 \pm 0.3\,MeV$, $E_B = 5.2 \pm 0.3\,MeV$). The dashed line describes the progression of the potential as described by the macroscopic liquid drop model [2].

Fission isomer studies with low reaction cross sections require efficient fission fragment detection systems. The main requirements are: A good time resolution, as using a pulsed beam (Δt $\simeq$ 400 ns) in coincidence with fission fragments one has to distinguish between the prompt and the delayed fission component where for ^{237f}Pu $T_{1/2} = 110\,ns$. The energy resolution should allow to identify fission fragments from background contributions such as e.g. scattered beam particles. The reaction chosen to investigate ^{237f}Pu is the ^{235}U(α,2n)^{237f}Pu reaction ($E_\alpha \simeq 24\,MeV$). Furthermore the low population cross sections for ^{237f}Pu ($\sim$1 μb) compared to ^{240f}Pu ($\sim$10 μb) [3], requires maximum solid angle coverage.

Due to our experimental boundaries, a cost effective detector which covers a large solid angle, that is easy to handle and maintain, is required. For these reasons monocrystalline silicon solar cells were tested in different geometries for lifetime ($\geq$72 hours with $\sim$300 fission/s from ^{252}Cf without a change in resolution), time resolution ($\leq$20ns can be achieved [4]) and energy resolution (ΔE/E $\simeq$ 30 %) [5,6]. The consequence of these tests was that, large area solar cell based arrays were developed for fission isomer studies (see Figs. 2 and 3). In each set up, solar cells of dimensions 20×40 mm^2 are used.

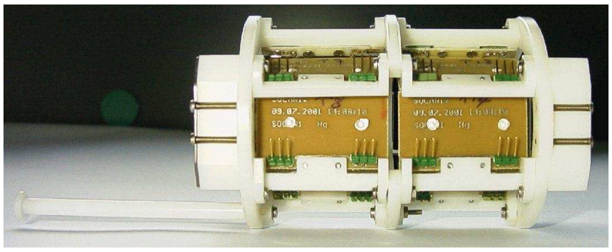

Fig. 2: A 4π solar cell detector array which is to be used as the trigger detector for the γ-spectroscopy studies in the MINIBALL set up.

For γ-spectroscopic measurements a thick metallic ^{235}U-target of $\sim 5mg/cm^2$ is used, this will be inserted into the slit of the detector array shown in Figure 2, defining the origin of the reaction. The detector consists of 16 solar cells, two at each end cap and 12 in two hexagonal rings. This experiment will be performed using the MINIBALL detector array at the IKP in Cologne [7]. The detector shown in Figure 3 will be implemented as a trigger detector into a MINI-ORANGE detector system for electron conversion spectroscopy measurements [3].

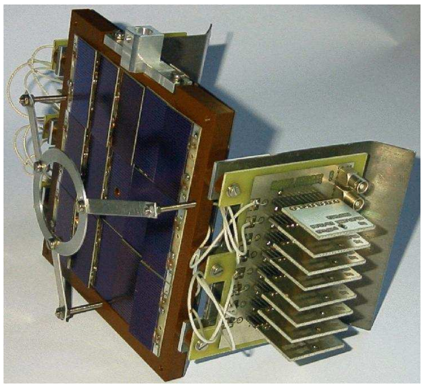

Fig. 3: The solar cell array designed for conversion electron spectroscopy.

It consists of 15 solar cells covering a solid angle of 70 %. The ring in the middle of the detector will be used to mount a thin, annular polyethylene foil to catch and implant the fission isomers, using the recoil shadow technique, as the target used for conversion electron spectroscopy is very thin (U_2O_3 with $\sim$ 40 μg/cm^2 on C backing). It is mounted $\sim$30 mm from the centre of the target. At both sides preamplifier boards are attached to the detector frame [6]

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