SAPhIR STATUS

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1 Description of the photovoltaic cells

The photovoltaic cells we are using are commercially available photovoltaic cells made by the German firm ASE. Two models have been considered: TZZ1250 and TZZE4020. Only one half of the TZZ1250 is used, leading to a total surface of 3 cm^2 while the full surface (8cm^2 !) of the TZZE4020 has been maintained. The model TZZ1250 has a polycrystalline silicon structure and the TZZE4020 consists of a monocristalline silicon structure. Both type are n+p junctions in p type silicon substrate . The front face of the cell carries a comb-like conducting grid covered with a thin antireflective titanium oxide layer ($\simeq$ 500 Å), a thin conducting film is evaporated on the rear face of the cell. These photovoltaic cells operate without any applied bias leading to a very small depletion depth ($<$ 0.2 μm), consequently light charged particles (e, p, α) loose only a small fraction of their energy in the depletion zone. Photovoltaic cells are able to detect heavy charged particles with A $>$ 50 and E $>$ 30 MeV.

2 Performances of the photovoltaic cells

The geometry of SAPhIR has been designed to detect in kinematical coincidences the 2 fission fragments. The mass identification of the fragments is done using the double-energy method, namely, the masses are derived from the energies of the fragments while the measured quantities are the pulse height delivered by the photovoltaic cells, as their pulse height to energy relation was not known, a carefull study of the characteristics of photovoltaic cells for fission fragment has been realized.

At first, a global study has been done using a thin open source of ^{252}Cf. The pulse height spectra delivered by the 2 photovoltaic cells under investigation are shown on the figure 1 altogether with the typical spectrum delivered by 3 cm^2 surface barrier detector, in both cases, the peaks corresponding to the heavy group (H) and the light group (L) are clearly identified.

A shape analysis of these spectra has been performed following the Schmitt-Pleasanton procedure for surface barrier detectors, this analysis is based on 8 parameters which have been reported on table 1 : one can note that the relevant parameters for the monocristalline photovoltaic cell (TZZE4020) compare quite well with the surface barrier ones. It is well known that the energy response of the surface barrier detectors depends of the fission fragment mass: at a given energy(E) , the pulse height (X) decreases as the mass (M) of the incoming fragment increases, this so-called pulse height defect has been studied intensively by H.H.Schmitt who propose the following energy response relationship: $E = (a_0 + aM)X + b_0 + b \cdot M$ with a through b being constants characterizing the detector.

A similar investigation has been performed for the two models of photovoltaic cells. For these studies, the Lohengrin mass separator of the Institute Laue-Langevin has been used to obtain fission fragment separated according to their masses and energies. The fragment energy versus pulse height plots (for both photovoltaic cells) are shown in fig 2 for several masses, one can see that , for a fixed mass M , the pulse height (X) varies linearly with the fragment energy, on the other hand we have verified that , for a fixed pulse height, the fragment energy depends also linearly on the fragment mass (M). The pulse height defect is clearly seen for different masses of the same energy (E).

We can conclude that the relation proposed by H.H.Schmitt for solid state detector should hold for photovoltaic cells too. For practical purpose, the energy calibration function has been expressed in terms of the average pulse height P_L (light group) and P_H (heavy group) of a ^{252}Cf(sf) source , one obtains from the first relation given above:

$$E = \frac{a_0}{P_L - P_H}(X - P_L) + \frac{a}{P_L - P_H}(X - P_L) + b_0 + b \cdot M \qquad (1)$$

The quantities (a_0, a, b, b_0) characterize the intrinsic response of the detector. They have been reported in table 2 altogether with the recommended values for surface barrier detectors.

3 EUROBALL III experiment

The aim of the experiment 97.50 performed in 1997 at Legnaro was to study neutron-rich fission fragments produced by the induced fission reaction ^{12}C + ^{238}MeV at 90 MeV bombarding energy. The SAPhIR setup consisted of 32 cells in a barrel geometry with a geometric efficiency of $\simeq$ 50 %. For the electronics, we used 2 Lecroy 4300 Fera QDC connected with the Bordeaux FVI module (Fera VXI Interface). We used a 25 μs common dead time mode. The noise level was excellent. SAPhIR was used as a trigger for EUROBALL. During this experiment, we suffered of many problem with VXI rack cooling, acquisition problems and storm damage. We were however able to collect $\simeq$ one third of the expected statistics.

$93 \cdot 10^6$ fission-delayed$\gamma \cdot \gamma$ and $60 \cdot 10^6$ fission-delayed$\gamma \cdot \gamma \cdot \gamma$ events were collected. From the analysis, we have identified 46 isomeric level scheme; 18 of them are new. The analysis of this experiment is still in progress.

4 VXI electronics

Tests and production of VXI cards dedicated to the SAPhIR detector have started in 1998. These cards developed by CEA Saclay DAPNIA/SEI-SIG (with a collaboration of CSNSM Orsay) can deal with 16 detectors and includes time and energy channel. A brief presentation of this card can be found in *"Ancillary detectors and devices for Euroball", The SAPhIR detector.*

The first prototype and preserial card have been tested with the programmable pulse generator. An automatic test procedure allows full test and diagnostic of the card (ADC and DAC linearity, diaphony, automatic threshold adjustment, ...). Additional test have also been performed with a Germanium detector (in this case, the external amplifier mode has been used) and a resolution of 2 keV at 1.3 MeV has been obtained. The production of 4 card has started and should be finished mid 1999.

4 cards + 1 spare (64 + 16 channels) will be available for experiments with SAPhIR, as well as with other detectors requiring a time and electronic chain.

5 In beam test of SAPhIR with VXI electronics

In December 1998, the first experiment with photovoltaic cells and VXI electronics has been performed at Orsay Tandem. The aim of this experiment initiated by CSNSM Orsay (M.G. Porquet) was to study induced fission of ^{182}Pt (^{44}Ti + ^{138}Ba, ^{32}Si + ^{150}Sm). The experimental setup consisted of 16 photovoltaic cells and one Germanium detector. Two SAPhIR VXI card were used and the acquisition consisted of one STR8080 VXI Readout Engine, one D2VB VME interface and one SUN station.

This electronics and acquisition setup was running perfectly during the 4 days of experiment without any problem. As an example, we show in figure 3 a bidimensional spectra obtained on-line during the experiment.

References

Some references can be found in *Ancillary detectors and devices for Euroball.* The list bellow is an update.

[1] C. Gautherin *et al.* Eur. Jour. A1, 391 (1998)
[2] M. Houry *et al.* AIP proceedings 447, p 220 (1998).
[3] Ch. Theisen *et al.* AIP proceedings 447, p 143 (1998).

Spectrum parameters	Expected limit	Reasonable limit	Cell TZZ1250	Cell TZZE2040	Surface Barrier
NL/NV	$\simeq$2.9	>2.85	2.31	2.77	2.78
NH/NV	$\simeq$2.2	$\simeq$2.2	1.88	2.19	2.13
NL/NH	$\simeq$1.3		1.23	1.26	1.30
ΔL/(L-H)	$\simeq$0.36	<0.38	0.48	0.39	0.37
ΔH/(L-H)	$\simeq$0.44	<0.45	0.52	0.46	0.43
(H-HS)/(L-H)	$\lesssim$0.69	<0.70	0.79	0.71	0.70
(LS-L)/(L-H)	$\lesssim$0.48	<0.49	0.50	0.51	0.51
(LS-HS)/(L-H)	$\simeq$2.17	<2.18	2.29	2.22	2.21

Table 1: Shape analysis of a ^{252}Cf fission fragment spectrum (definition of the parameters is given in figure A.4, page 55 of the document *"Ancillary detectors and devices for Euroball"*)

	a_0	a	b_0	b
cell. TZZM1250 (300 mm^2)	24.630	0.0257	88.00	0.1535
cell. TZZE4020 (800 mm^2)	22.500	0.0377	84.66	0.155
Surface barrier.	24.300	0.0283	90.397	0.115

Table 2: Schmitt parameter for photovoltaic cells. The parameters were obtained during a calibration performed at Institute Laue-Langevin.

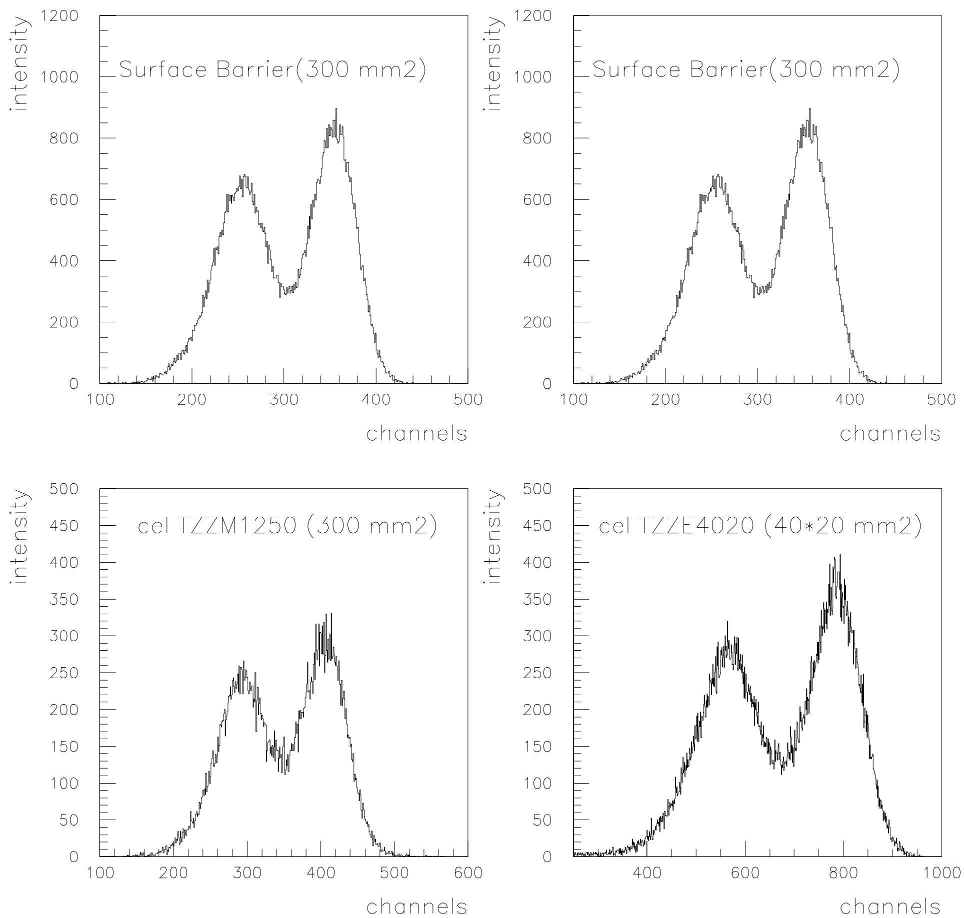

Figure 1: Pulse height spectra of ^{252}Cf obtained for two models of photovoltaic cells, compared with surface barrier.

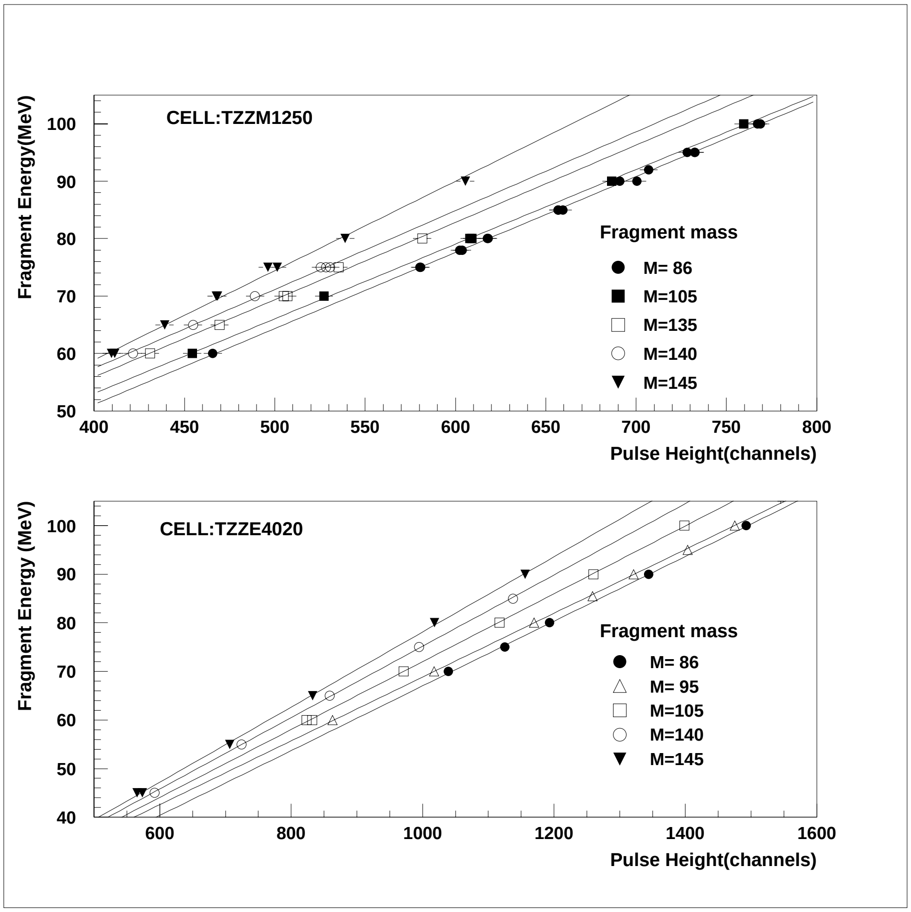

Figure 2: Fragment energy versus pulse height obtained during calibration performed at Institute Laue-Langevin.

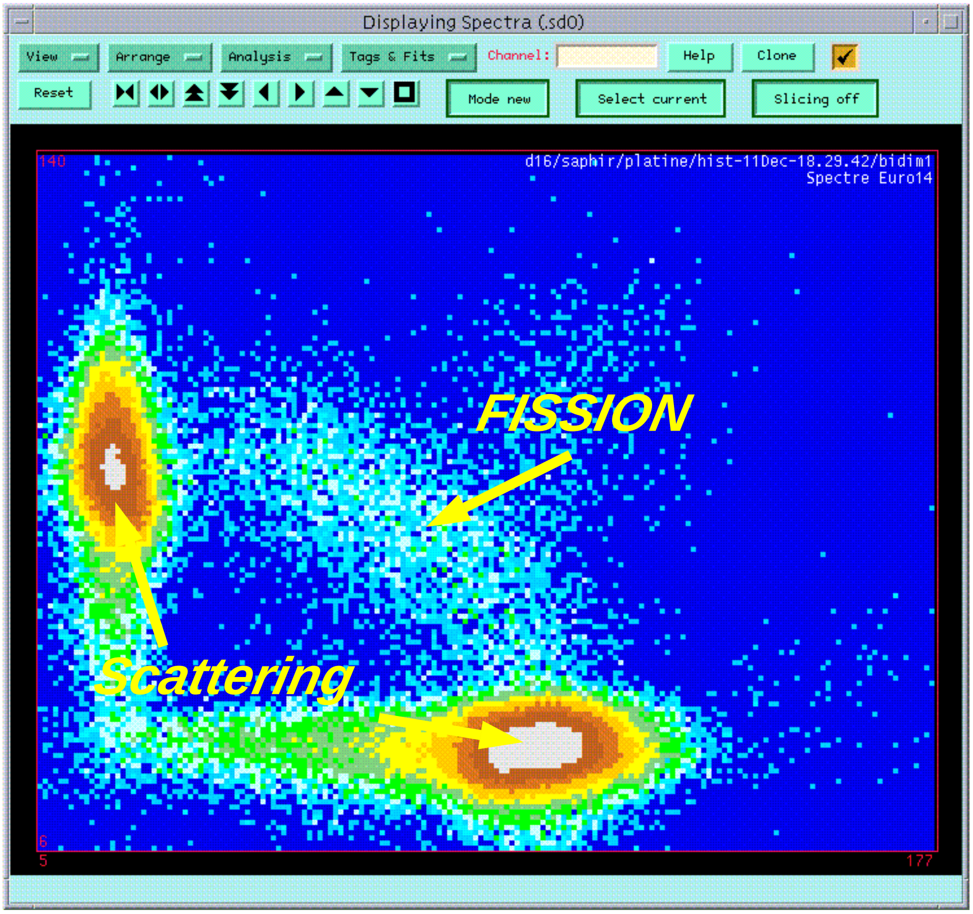

Figure 3: Bidimensional spectrum obtained on-line during December 1998 experiment at Orsay. Fission and scattering events are observed.