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Position-sensitive spectroscopy of ^{252}Cf fission fragments

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Abstract

The fission fragments from spontaneous fission of ^{252}Cf have been measured with the spectrometric and position-sensitive semiconductor pixel detector Medipix2. Fragments are identified by pattern recognition of clusters generated in the Medipix2 pixel matrix sensor upon heavy particle hit. From analysis of cluster area, the distribution of kinetic energy of fission fragments is obtained. Together with a novel USB readout interface, the Medipix2/USB system operates as active nuclear emulsion in single-quantum and on-line tracking mode.

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1. Introduction

The hybrid semiconductor Medipix2 detector [1] has found ample application in real-time imaging using X-rays, electrons, alpha particles and neutrons [2–5]. Medipix2 consists of a silicon semiconductor *sensor chip* bump-bonded to a *readout chip*. The sensor chip is equipped with a single common back-side electrode and a front-side matrix of electrodes (256×256 square pixels with pitch 55 μm) of $1.4 \times 1.4\,\mathrm{cm}^2$ total active area. Each element of the matrix (pixel) is connected to its respective preamplifier, double discriminator and digital counter integrated on the readout chip. The back-side pulse of the detector chip is analyzed by a 12-bit ADC. Running frequency reaches 200 MHz for a complete data readout rate of 200 μs (via 32-bit parallel) or 5 ms (via serial) interface. In addition, Medipix2 can be triggered or also can generate trigger.

On-line operation of this device and data readout visualization is made possible by the newly developed USB-based readout interface [6] which links by standard USB port into any PC. Operation and monitoring of the system is driven by the Windows-compatible software package Pixelman [7]. Data stream acquisition and storage proceed on-line at overall rate of about 5 frames per second. This compact and portable radiation camera operates as an active nuclear emulsion [3] also for heavy charged particles in the MeV range for which Medipix2 ensures 100% detection efficiency, noiseless digital integration (single-quantum counting), wide (unlimited) and linear dynamic range.

Study of nuclear fission demands fast response and precise position and energy sensitive spectroscopy. Investigations include systematics and variations in fragment-mass and kinetic-energy distributions of spontaneous fission [8,9] as well as measurements of rare fission processes such as ternary and quaternary fission [10,11] which require precise coincidence spectroscopy in terms of energy resolution and angular correlation.

In this paper we examine the response of Medipix2 to spontaneous fission products of ^{252}Cf. Measurements were made in vacuum with a thin source containing low activity of ^{252}Cf. Clusters of pixels formed upon impact of single particles were analyzed with the aim to obtain information about position and energy. Complementary information

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on the energy of the individual particles is provided by the amplitude of back-side pulse which carries information about the total charge generated in the entire detector. Using a linear calibration, the kinetic-energy distribution of fission fragments is extracted. The main aim of this paper is to demonstrate, that the device can be used for precise and flexible experiments of position-sensitive and event-by-event spectroscopy of fission fragments and heavy ions in the range 10–120 MeV.

2. Experimental

We measured the spontaneous fission fragments of ^{252}Cf from a source of (spontaneous fission) activity of about 100 Bq mounted on a 60 $\mu g\,cm^{-2}$ foil backing of Al_2O_3 and coated with a thin layer of gold (of less than 10 $\mu g\,cm^{-2}$). The source thickness is assumed to be uniform to within 20%. The fission products were detected in vacuum by the Medipix2/USB camera operating in real-time,

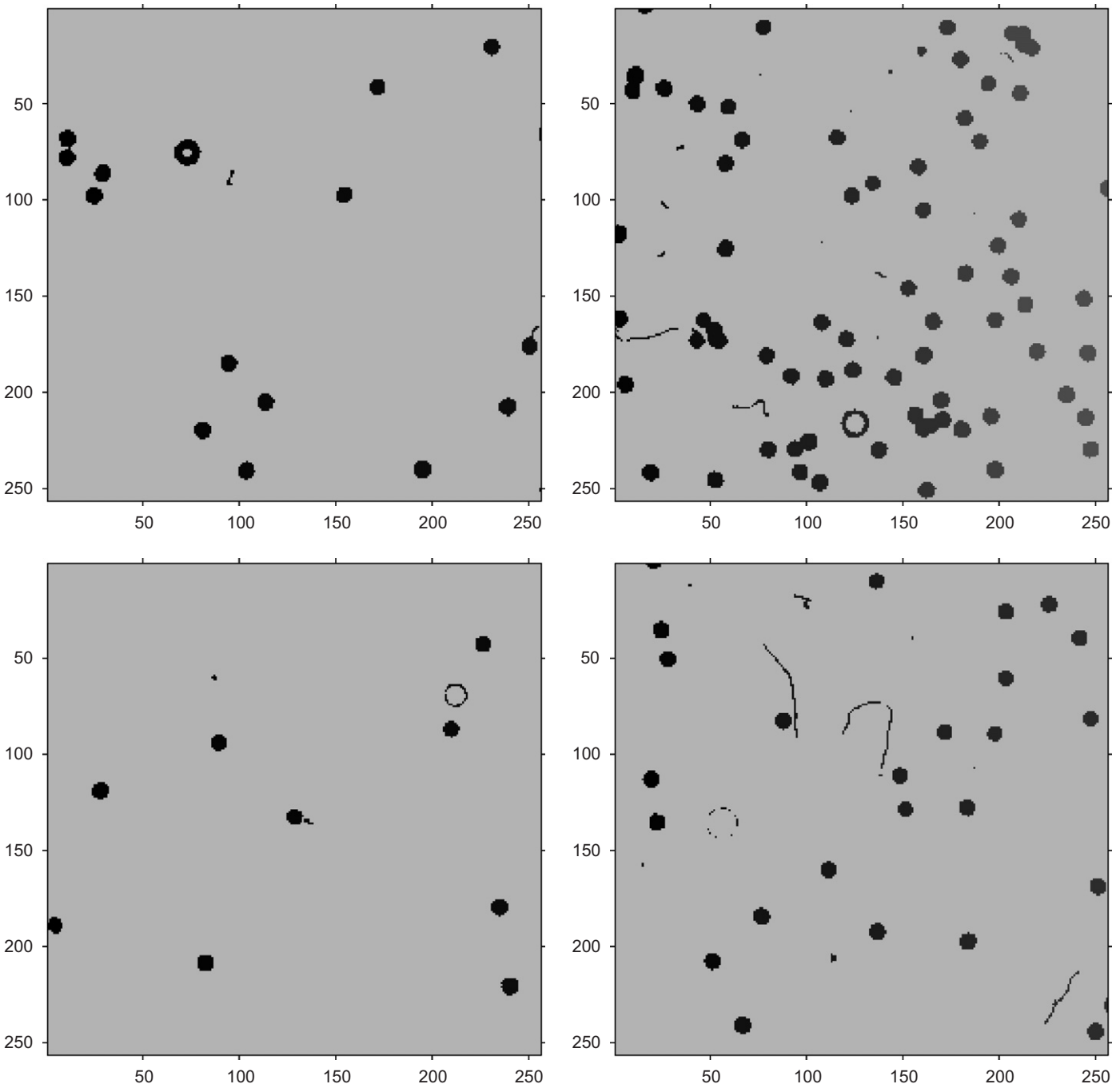

Fig. 1. Fission fragments (empty large rings) and alpha particles (small compact clusters) of ^{252}Cf as seen by the 256 × 256 pixel array matrix of Medipix2. The frames shown were collected by one Medipix2 detector with *varying* shutter close time which result in the heavy fission fragments being registered as rings with varying contour thickness. Electrons (long tracks) and X-rays (small dots) are observed too.