TIME COINCIDENCE TECHNIQUE AND THE ΔE-E METHOD WITH THIN ΔE DETECTOR AND THE TIMEPIX PIXEL DETECTOR

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The per-pixel time sensitivity of the Timepix pixel detector allows applying the time coincidence technique together with the position information. In order to enhance the heavy charged particle type sensitivity, namely introduce Z-sensitivity, we decided to investigate the applicability of the ΔE-E method with the Timepix pixel detectors using a 12 μm thin silicon detector. The thin silicon detector is used for ΔE measurement and the Timepix detector for E measurement. In order to find coincidences between the detectors, the Timepix detector equipped with a 300 μm thick silicon sensor was used in the time of arrival mode.

THE PIXEL DETECTOR TIMEPIX

Timepix is a hybrid pixel detector from Medipix family of hybrid semiconductor pixel detectors. Timepix can provides information about energy, position and interaction time of single particles. Each pixel can operate in one of three modes [1]:

1. Event counting (Medipix mode): the number of particles detected in a pixel is counted.
2. Time of arrival (TOA mode): the particle's interaction time is recorded.
3. Time over threshold (TOT mode): the deposited energy per pixel is measured.

Each pixel can be configured independently in any of these 3 different modes. The Timepix detector is readout by the integrated FITPix interface [2]. The detector is connected to a PC via USB and controlled with the help of the Pixelman software [3].

The Timepix detector is planned to use for investigation of rare fission processes, such as ternary or quaternary fission [4]. For this aim the Timepix has been tested in combination with 12 μm thin silicon detector (ΔE).

EXPERIMENT

Before assembly, the Timepix and the ΔE detectors were separately tested using a red laser. A pulse generator with two synchronized outputs was used. The signal from the fist channel of the pulser was fed into the laser and from the second channel was used as the trigger for the Timepix and the ΔE detectors. The signal from the ΔE detector was read out by using a charge sensitive preamplifier, spectroscopic amplifier and the 250 MHz DT5720 CAEN digitizer. Timepix was read out with the standard interface FITPix. The results are shown in Fig. 1.

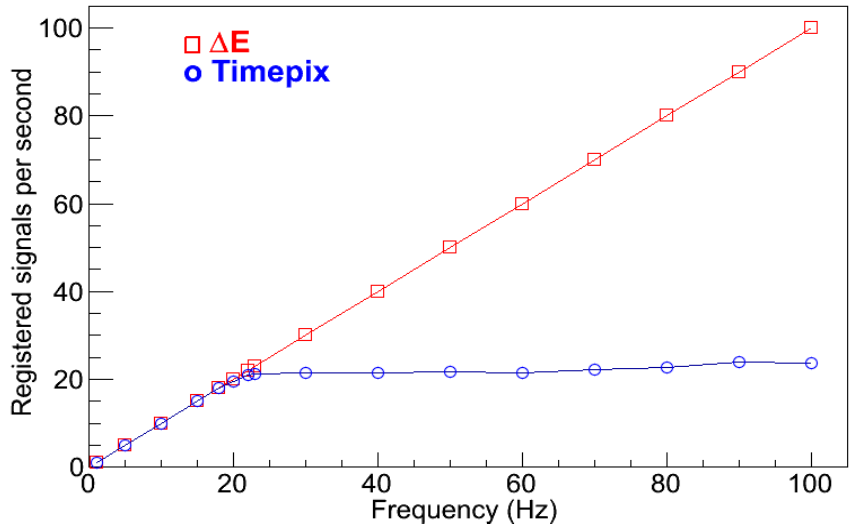

Fig.1. Dependence of registered signals on frequency. A test laser was used. □- dependence of the ΔE signals on frequency; ○- dependence of the Timepix frames on frequency

As shown in Fig.1, there is a linear dependence between Timepix and the ΔE detector up to the pulser frequency of about 20 Hz. The dead time in Timepix arises after 20 events per second. It means that the Timepix can be triggered from the ΔE detector

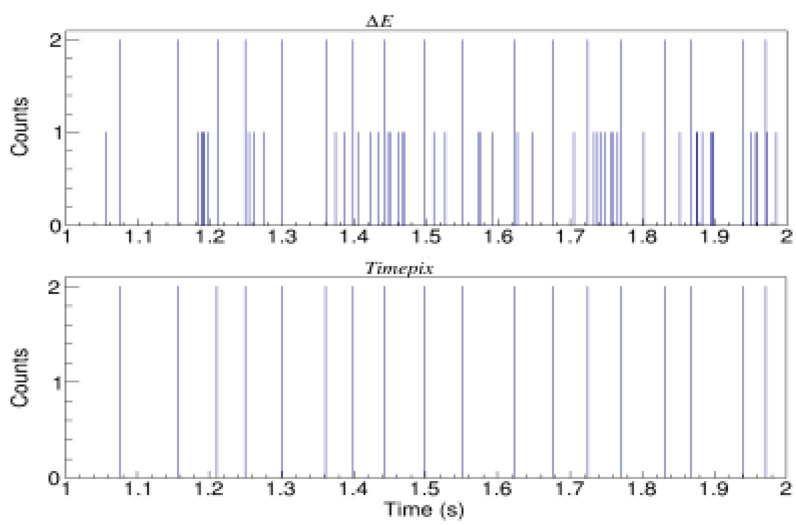

Fig. 2. Coincidence spectra when triggering Timepix from the ΔE detector. A 244Cm alpha source was used.

synchronously if the frame rate is up to 20 fps. The digitizer, however, can register about 2000 signals/sec, albeit full dependence is not shown in Fig.1.

Coincidence spectra when triggering the Timepix from the ΔE detector are shown in Fig.2. A ^{244}Cm alpha radioactive source (E_α=5.8 MeV) was used instead of the red laser. Timepix was triggered from the ΔE detector. Distance between the detectors was 3 mm. The alpha source was placed at a distance of 5 cm from the ΔE detector. The ΔE detectors registered about 50 alpha particles per second. As shown in Fig.2, Timepix skips events which fall into its dead time zone while the ΔE detector registers all. Coincidence events are artificially counted as two in the figure in order to show time coincidence between detectors.

For the registration of all signals from the Timepix and in order to obtain the time coincidence between Timepix and the ΔE detector, we use the internal timestamp of a CAEN digitizer and the time of arrival mode of operation of the Timepix. The internal timestamp of the digitizer allows to measure the time of arrival of the signal with accuracy of the order of 16 ns. Both, ΔE and Timepix detectors were read out independently using their own acquisition systems (CAEN digitizer and FITPix, respectively), and the data were saved on a PC as two independent data streams, which could be analyzed off-line. The experimental scheme is depicted in Fig.3.

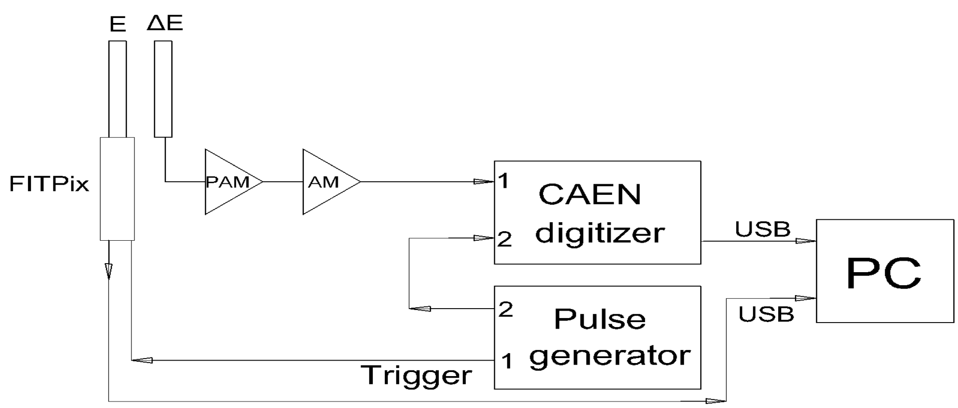

Fig.3. Experimental layout for time coincidence setup. The first channel of a dual pulse generator was used as external start for the FITPix interface. The second channel was used for synchronization.

In order to syncronize these two data streams an external pulse generator was used. The first channel of the pulse generator was served as an external start for the FITPix interface. At the same time, signal from the synchronized second channel of the pulse generator was fed into a second channel of the CAEN digitizer, which was read synchronously with the ΔE channel. Thus the digitizer registered all signals from the ΔE detector in channel 1 and trigger signals for the Timepix detectors in channel 2 in the same timescale. As the Timepix detector was operating in the time-of-arrival mode, the time of each detected signal in the detector could be measured relative to the trigger signal. But since the time of arrival of each trigger signal was measured by the CAEN digitizer, it was possible to determine the absolute time of arrival of the Timepix events in the same time scale as the ΔE events. A special calibration measurement was performed in order to determine precisely the time scales of the Timepix readout interface and of the CAEN digitizer.

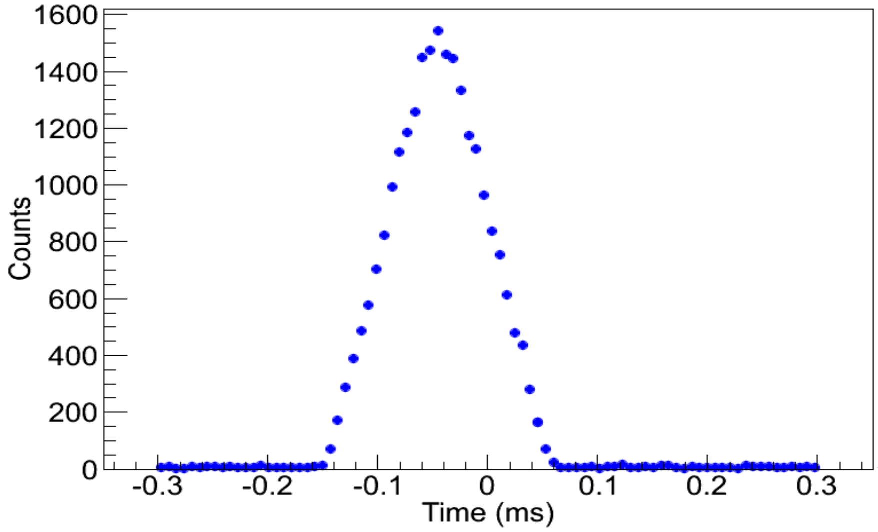

Fig. 4. Time coincidence spectrum between Timepix and the ΔE detector

The frequency of the external pulse generator could be adjusted depending on the Timepix clock and the coincidence count rate. The time coincidence spectrum is shown in Fig. 4. The coincidence time resolution is about 100 μs FWHM. The pulse generator was used as external trigger source (start time for every frame) in the experiment. The ΔE-E spectrum that belongs to the time coincidence spectrum is shown in Fig 5.

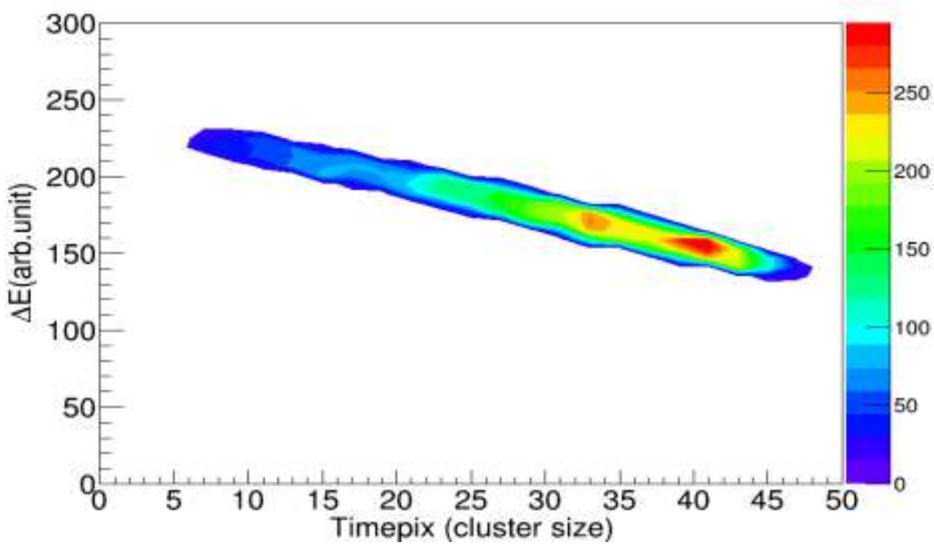

Fig. 5. The ΔE-E spectrum from a ^{244}Cm alpha source

As shown in Fig.5, the alpha particle energy loss (ΔE) increases with decreasing energy in Timepix (E_rest). Different energies of alpha particles were obtained by changing the pressure in vacuum chamber. Another test of the ΔE-E method was performed with a ^{252}Cf spontaneous fission source. Distance between the detector system and the source was 5 mm. A 31 μm Al foil was placed between the source and the detector system to absorb background alpha particles from natural alpha decay of ^{252}Cf (6.2 MeV) and the fission products. Only ternary particles could penetrate though the absorber foil [5]. The experiment was carried out at a constant pressure of 0.5 mbar. The ΔE-E spectrum from this ^{252}Cf source is shown in Fig.6.

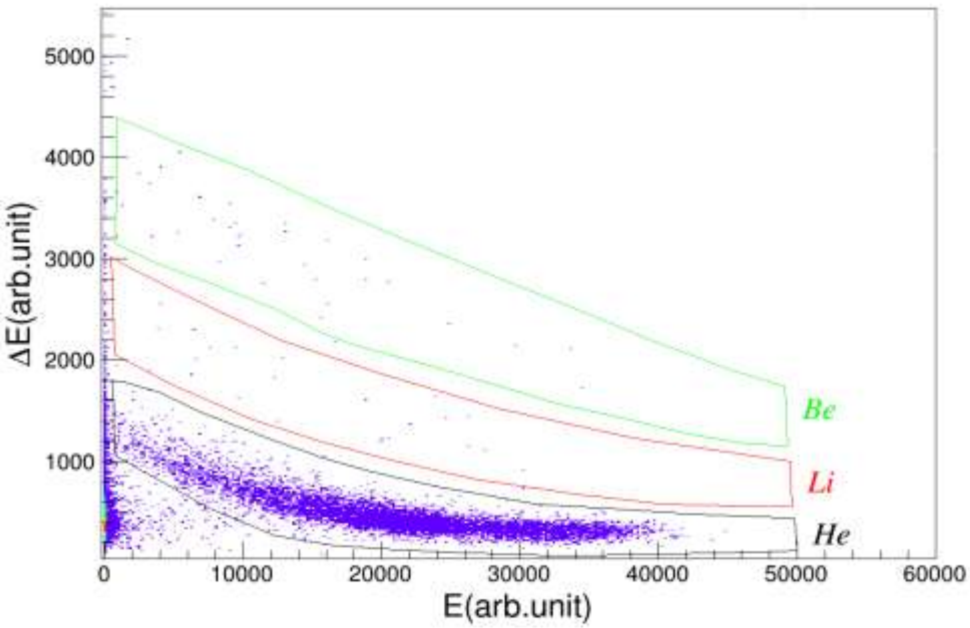

Fig. 6. The ΔE-E spectrum from a Cf-252 spontaneous fission source. Only rare ternary fission fragments are selected. Background alphas and binary fission fragments are suppressed by stopping foil.

Ternary particles were identified as shown in Fig.6. The plot shows isotopes from He to Be. Because of the high energy threshold in the ΔE detector, H isotopes are not seen in Fig.6.

CONCLUSIONS

The adaptation and coupled operation of thin ΔE detectors with Timepix was successfully performed. The obtained results show that the ΔE-E method can be applied to Timepix pixel detectors. One can obtain time coincidence between the Timepix readout system FITPix and other readout systems. Applying the ΔE-E method to the Timepix detector makes possible to obtain information not only about particle energy and position [6], but also about interaction time and particle type (charge), simultaneously.

ACKNOWLEGMENTS

Research is carried out in frame of the Medipix collaboration. Work partially supported by grant of the Planipatentiary of the Czech Committe for Cooperation with JINR Dubna.

REFERENCES

[1]. Llopart, X., et al. “Timepix, a 65 k programmable pixel readout chip for arrival time, energy and/or photon counting measurements”, Nucl. Instr. Meth. Phys. Res. A 581 (2007) 485-494.

[2]. Kraus, V., Holík, M., Jak ubek, J., Kroupa, M., Soukup, P., Vykydal, Z. “FITPix fast interface for Timepix pixel detectors”, J. Instrum. 6 (2011) C01079.

[3]. Turecek, D.., Holy, T., Jakubek, J., Pospisil, S., Vykydal, Z.. “Pixelman: a multiplatform data acquisition and processing software package for Medipix2, Timepix and Medipix3 detectors”, J. Instrum. 6 (2011) C01046.

[4]. Gönnenwein F., Mutterer M., Kopatch Yu., “Ternary and quaternary fission”, Europhysics News 36 (1) 11 (2005)
DOI: 10.1051/epn:2005104

[5]. C. Wagemans, “The Nuclear Fisson Process” , CRC Press, Boca Raton, USA, 1991.

[6]. Granja, C., Vykydal, Z., Kopatch Y., et al., 2007. “Position-sensitive spectroscopy of Cf-252 fission fragments”. Nucl. Instr. Meth. Phys. Res. A 574, 472e478.