Report from the work in Krakow in 2012 within WP5 in GANAS

Tests of LaBr3-NaI phoswich detector with high energy gamma-rays

M. Ziębliński[a], M. Ciemała[a], M. Jastrząb[a], S. Brambilla[d], P. Bednarczyk[a], A. Maj[a], M. Kmiecik[a], M. Dudeło[b], K. Hadyńska-Klęk[b,c], P. Napiorkowski[b], B. Genolini[e], Ch. Schmitt[f], N. Yavuzkanat[g]

[a]IFJ PAN, Kraków, Poland; [b]Heavy Ion Laboratory, University of Warsaw, Poland;
[c]University of Warsaw, Poland; [d]INFN Sez. di Milano, Italy; [e]IPN Orsay, France;
[f]GANIL, Caen, France, [g]University of York, York, United Kingdom

The response of the phoswich detectors to high energy gamma rays was studied. The set-up, consisting of 3 phoswiches and a single LaBr3:Ce detector, was exposed to 6.129 MeV gammas from a ^{244}Cm - ^{13}C source, and 10.763 MeV photons emitted in the ^{27}Al(p,)^{28}Si reaction. The in-beam measurement was conducted with a 992 keV proton beam from the Kraków Van de Graff accelerator.

We used the discrimination method provided by an Advanced Pulse Stretcher (APS) module developed in Milano [1]. The APS module supplies two Gaussian signals: "fast" proportional to the amplitude of the rapid signal component only (LaBr3:Ce), and "slow" which is proportional to the energy of the entire signal (LaBr3:Ce and NaI:Tl). Both of the signals were fed to the multichannel CAEN V785 ADC, as shown in the diagram of Fig. 3. The resulting spectra were acquired in the Kmax environment [2]. During the in-beam test, a fast active splitter was used to duplicate the PMT signal which was digitized at different frequencies, by the CAEN V1729 (12 bits, 1 GS/s), and the Acqiris DC252 (10 bits, 4 GS/s) digitizers. An example of 2D analysis is shown in Fig. 1.

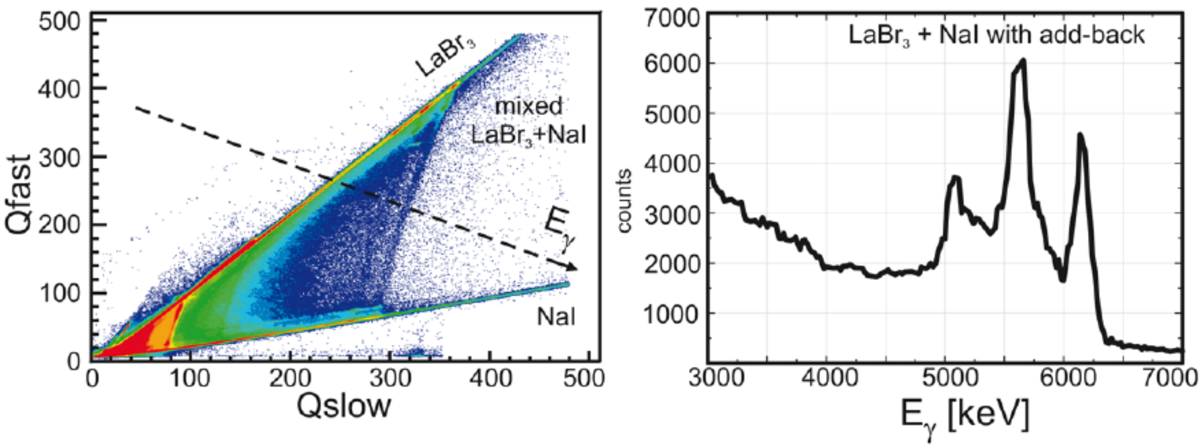

Fig.1. Left: The charges collected in fast and slow gates of phoswich detector measuring 6.13 MeV gamma-rays. Right: The obtained add-back γ-spectrum.

The 2D plot of "Qfast" vs. "Qslow" amplitudes, registered with the APS module, shows a clear separation between the $LaBr_3$:Ce and NaI:Tl components. The two semi diagonal stripes contain events corresponding to the energy release in the $LaBr_3$ crystal or in the NaI crystal only. Located between these stripes are events in which the energy deposition was shared between two scintillators. As both crystals had different energy gains, in order to obtain the total energy spectra, we defined a tilted axis that corresponds to gain matched gamma energies (indicated as a dashed line in Fig. 1 left). A projection of the matrix points on this axis provides the full add-back spectrum (see Fig. 1 right). The signals from PMT were collected. Typical PMT signals, corresponding to $LaBr_3$:Ce and NaI:Tl for 6.13 MeV full absorption peaks, selected by two-dimensional conditions on the "Qfast"-"Qslow" matrix, are presented in Figs. 2a and 2b. An exponential fit provided decay times τ describing the waveforms of reference. These parameters were observed to be valid also for signals induced by photons of E = 1.3 MeV and E = 10.76 MeV. In Fig. 2c an example of a complex signal produced by a 6.13 MeV photon interacting in both parts of the phoswich is shown.

It turned out that a multi-component fit of the signal amplitudes (at fixed decay times deduced from the signals of reference) accurately reproduced the registered waveforms. The -ray energy spectra corresponding to the $LaBr_3$-like, NaI-like, and mixed events are shown along with the representative phoswich signals. One can see that in the spectrum of scattered photons (Fig. 2c) the double escape peak is significantly reduced, what illustrates an increase of efficiency of the phoswich with respect to the individual scintillators.

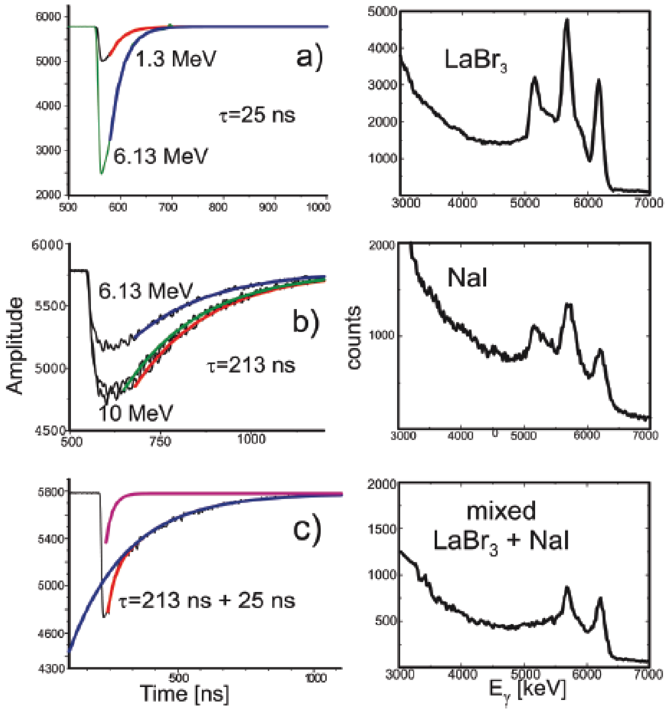

Fig.2. Signals from PMT corresponding to different regions of Qfast-Qslow matrix and gamma spectra reconstructed by charge integration of the filtered detector pulses.

[1] C. Boiano et al., IEEE Transaction on Nuclear Science, 53, 444 (2006).
[2] S. Brambilla et al., Sparrow Corporation Data Acquisition Conference and Workshop , 22-24 March 2005, Daytona Beach, FL (2005).