"GAMMA RAY SPECTROMETRY" GRS
(Task Agreement JW7-NEP-MEC-11)

Agata Olariu and Silviu Olariu
National Institute of Physics and Nuclear Energy IFIN-HH
Bucharest

1 General objectives

The project GRS is part of the project of package of diagnostic enhancements to be implemented during the Framework Programme 7. The objective at IFIN Magurele is the availability of intense gamma ray and neutron sources at the tandem accelerator of IFIN, in order to carry out testing of three new spectrometers, with complementary performance: a high energy resolution HPGe spectrometer and two high efficiency, high rate spectrometers with large detection crystal.

2 Obiectives of the progress report

Experimental campaign at the Tandem and Cyclotron accelerators of National Institute of Physics and Nuclear Engineering, Magurele for the calibration of a $LaBr_3$ high rate spectrometer in intense gamma-ray beams

3 Abstract of the progress report

In order to produce the high-intensity gamma-ray beams necessary for the experiments, we have used a 10 MeV proton[1,2] beam incident on a thick target of Aluminum mounted on the MA0 experimental line of the Tandem accelerator, and a 3 MeV α-particle[3] beam incident on a thick Beryllium target at the Cyclotron accelerator. The incident proton current could be increased up to 300 nA, and the α-particle current could be increased up to 5 μA.

The $LaBr_3$ detector and the digital acquisition system have been brought to Magurele by Marco Tardocchi and colleagues from the University of Milan, Italy, and the response of this spectrometric system has been studied as a function of the incident gamma-ray flux whose intensity was changed by varying the distance to the target and by varying the beam current. Total counting rates in excess of 1 MHz have been measured.

For the measurements at the Tandem accelerator, the gamma-ray yield has been measured with the aid of a HPGe detector, and the neutron yield has been measured with the aid of a ^{3}He neutron detector.

4 Scientific and technical description

In order to produce the high-intensity gamma-ray beams, we have used 10 MeV proton beams incident on a thick aluminum target mounted on the MA0 experimental line of the Tandem accelerator. The $LaBr_3$ detector has been placed first to a distance of 3 m from the aluminum target, as shown in Fig. 1.

Fig. 1. $LaBr_3$ detector (left), situated at a distance of 3 meters from the aluminum target (right).

The functiong of the $LaBr_3$ detector has been tested with the aid of optical pulses generated by the optical pulser shown in Fig. 2. The optical pulses are transmitted to the detector by an optical fiber, which can be seen in Figs 2 and 3 as the blue cable.

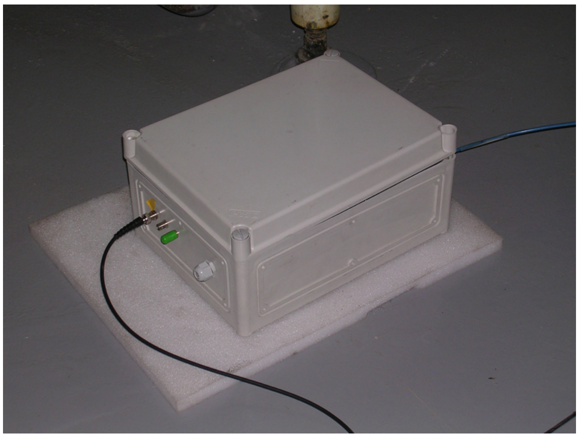

Fig. 2. Optical pulser for the testing of the $LaBr_3$ detector.

In order to increase the counting rate, the detector has been moved in subsequent measurements closer to the aluminum target, as shown in Fig. 3.

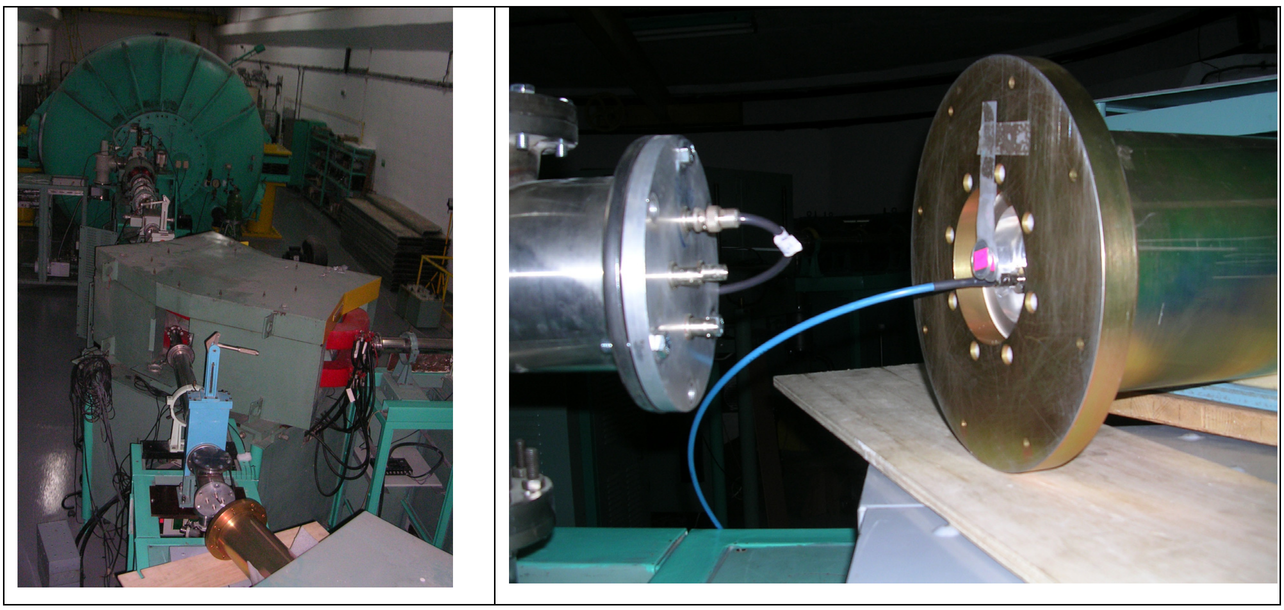

Fig. 3. $LaBr_3$ detector in the vicinity of the aluminum target, seen from above (left) and lateral view (right). The ^{60}Co and ^{137}Cs sources used for calibration are situated on the axis of the $LaBr_3$ crystal.

The electrical signals from the $LaBr_3$ detector have been processed with the aid of a digital acquisition system having a sampling rate of 400 MHz, shown in Fig. 4.

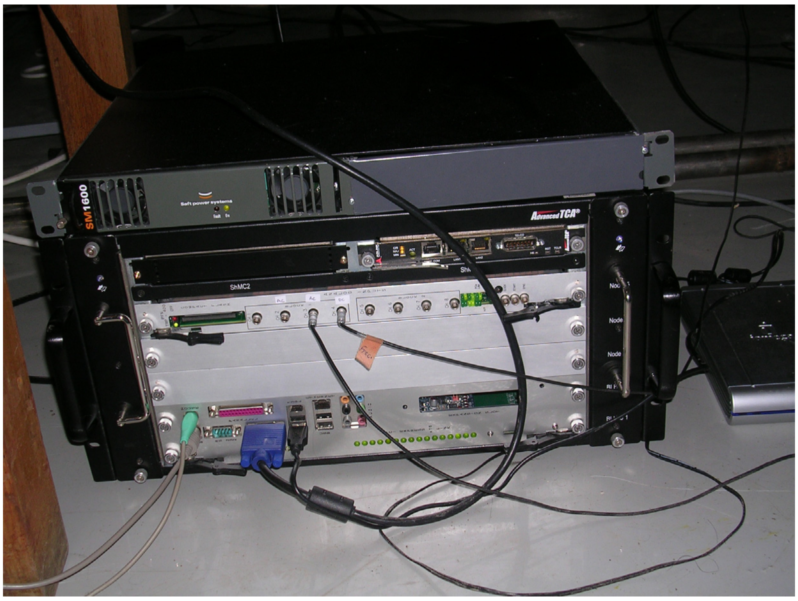

Fig. 4. Digital acquisition module having a sampling rate of 400 MHz.

The signals from the $LaBr_3$ detector have been also monitored with the aid of a conventional acquisition system, shown in the left and right foreground of Fig. 5.

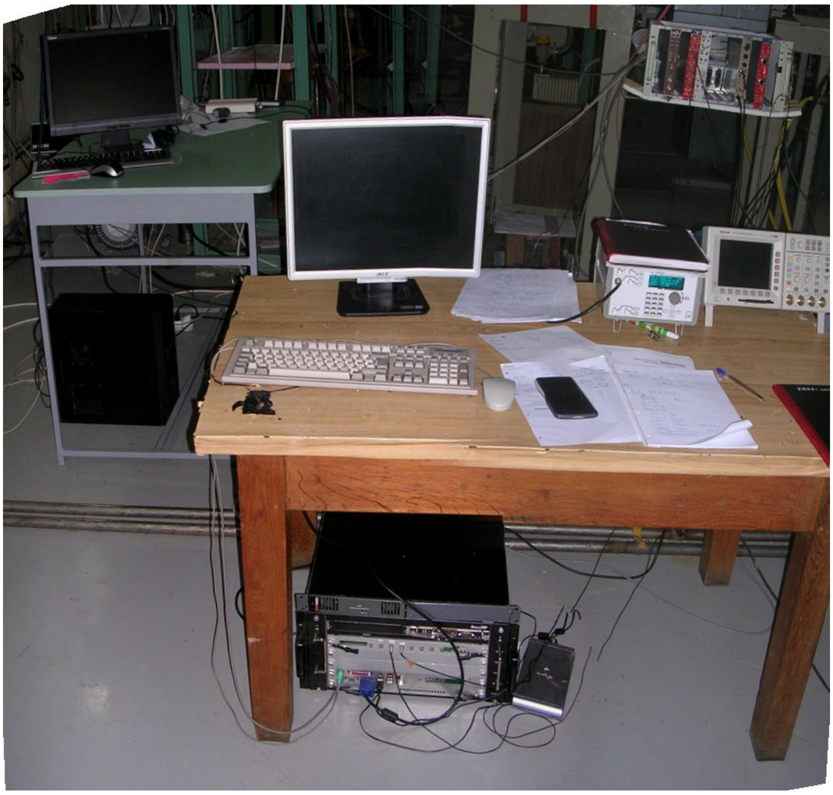

Fig. 5. Conventional acquisition system, shown in the left and right foreground.

The intensity of the gamma-ray beam generated be the10 MeV protons incident on the aluminum target has been monitored with the aid of a GeHP detector situated at a distance of 11.4 m from the target, as shown in Fig. 6. Measurements have been conducted for beam currents of 25, 50, 75, 100, 150, 200, 250 and 300 nA.

Fig. 6. GeHP detector and acquisition system used for monitoring the gamma-ray beam for 10 MeV proton beam intensities of 25, 50, 75, 100, 150, 200, 250 and 300 nA.

The gamma-ray spectra measured as a function of the beam current are shown in Fig. 7.

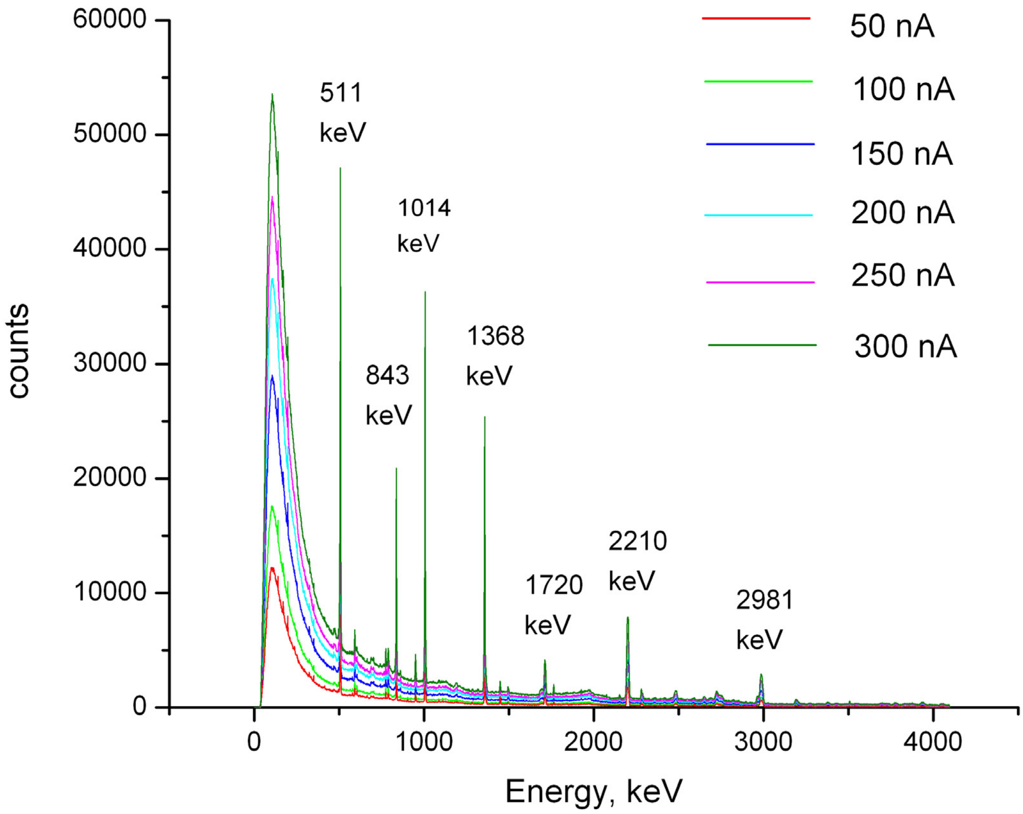

Fig. 7. Gamma-ray spectra for a 10 MeV proton beam incident on an aluminum target as a function of the beam current.

We have also measured the neutron spectrum for the $^{27}Al(p,n)^{27}Si$ reaction with the aid of a ^{3}He neutron detector placed in front of the aluminum target, as shown in Fig. 8.

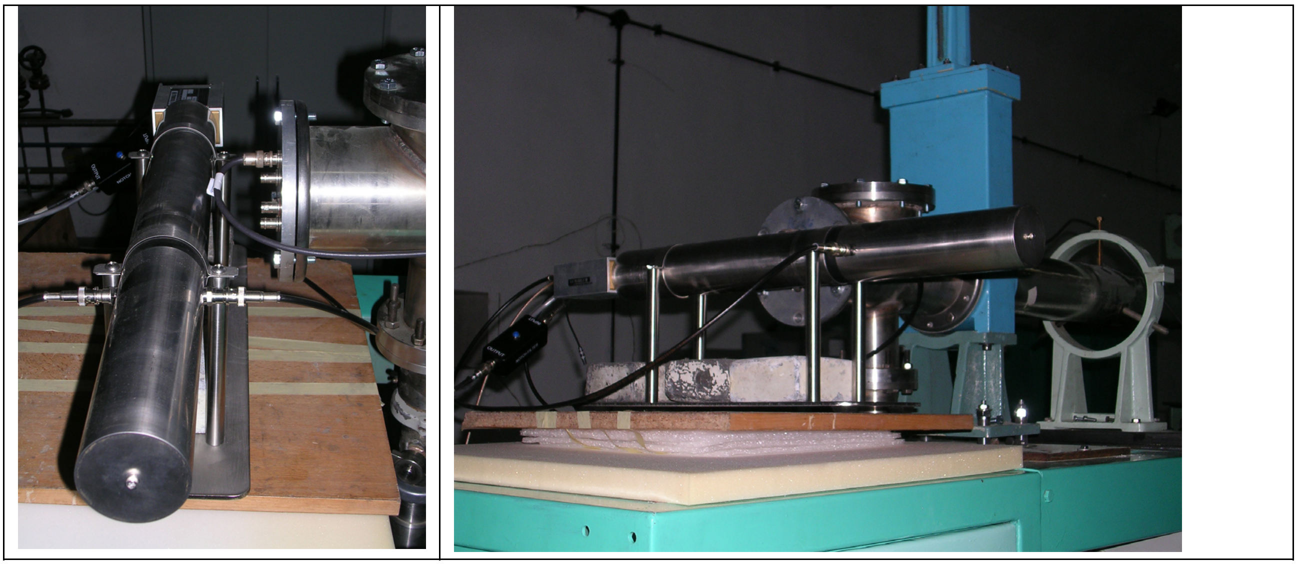

Fig. 8. ^{3}He neutron detector placed in front of the aluminum target.

The neutron spectrum of 7.5 MeV protons incident on the aluminum target is shown in Fig. 9. A layer of paraffin has been placed between the target and the neutron detector.

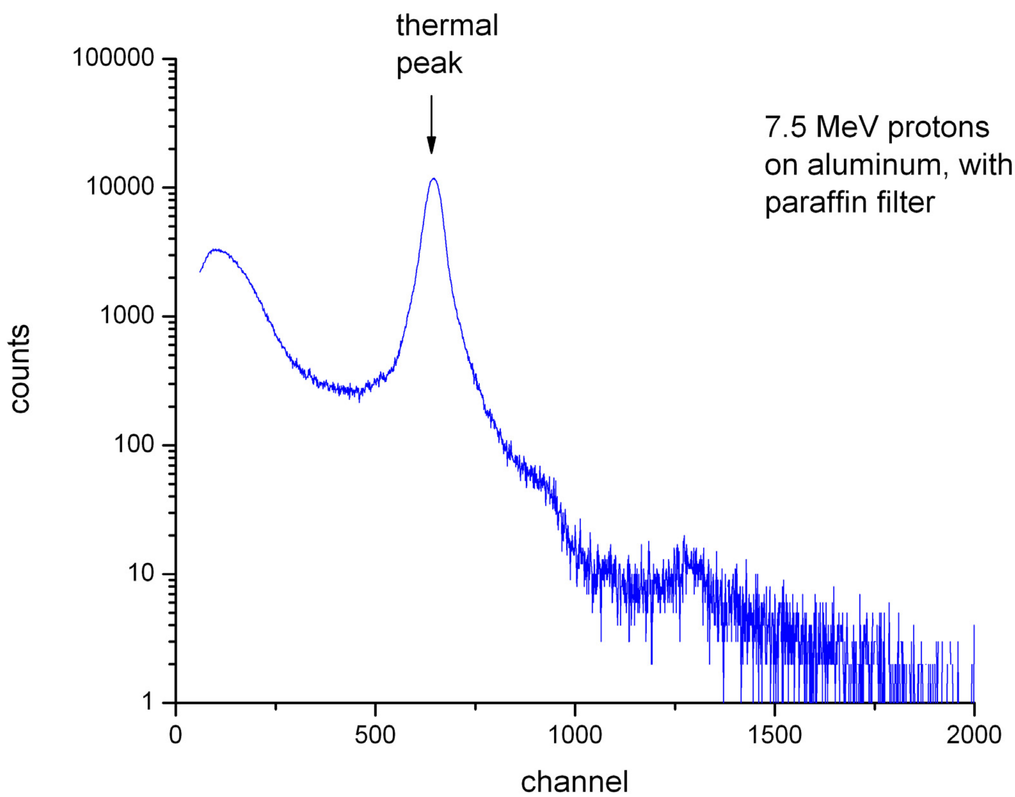

Fig. 9. Neutron spectrum of 7.5 MeV protons incident on the aluminum target. A layer of paraffin has been placed between the target and the detector.

In order to study the reaction $^{9}Be(\alpha,n)$, the $LaBr_3$ detector and the digital acquisition system have been moved to the cyclotron laboratory.The energy of the α particle beam was 3 MeV, and currents up to 5 μA

have been sent on the beryllium target. The $LaBr_3$ detector has been placed in the vicinity of the irradiation chamber containing the beryllium foil, as shown in Fig. 10.

Fig. 10. $LaBr_3$ detector at the cyclotron accelerator (left) and the beryllium foil, seen as a darker surface, inside the irradiation chamber (right).

Spectra have been recorded for several values of the incident beam current. Finally, spectra have been recorded for a set of calibrated sources, and these spectra will make possible absolute measurements of gamma-ray counting rates.

5 Conclusions

The objective of the measurements was to assess the response of the $LaBr_3$ detector to very high counting rates. The acquired spectra will be studied in detail in the next period, but it appears that the digital acquisition system responded as required even at total acquisition rates as high as several megahertz.

6 Bibliography

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