The RIPEN Array for Neutron Spectroscopy

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INTRODUCTION

Neutron energy spectra, angular distribution and multiplicity are key observables for reaction dynamics and will become more relevant when neutron-rich rare beams from SPES will be available for experiments.

The previous observation is the motivation for upgrading the RIPEN setup at LNL. RIPEN [1] is a modular array of BC501 liquid scintillators for neutron spectroscopy built in the early '90s by the group of INFN Bari. The detectors installed at the moment in the array are 24 and some spares are available at LNL. The original electronics and DAQ system became obsolete and were dismounted some years ago.

We recently tested the performance of all the detectors with standard analogical electronics from our laboratory [2]. In this contribution we report the results of these tests.

First results on digital electronics test for neutron-gamma discrimination via Pulse Shape Analysis (PSA) and timing performances for TOF measurements are reported elsewhere in this Annual Report [3].

Trigger detectors and their relative electronics will be the same used for GARFIELD and 8πLP (CORSET-like TOF arms for Fission Fragments, PPACs for residues selection) that can be easily mounted in the scattering chamber and coupled to the RIPEN modules.

The vacuum system and the target step motor of the scattering chamber were recently tested and are properly working. A limited maintenance work should be envisaged and scheduled.

Our goal is to perform a first test of the new digital electronics by the end of 2011.

TESTS OF THE BC501 SCINTILLATORS

A picture of the RIPEN set-up installed in the Experimenal Hall III of the Laboratori Nazionali di Legnaro is reported in figure 1. All 24 BC501 detectors were tested during 2010 with radioactive gamma and neutron sources using standard electronics in order to check the functionality of the phototubes (PMT) and to determine the energy threshold for n-γ discrimination that we can achieve via PSA to be compared with those reported in ref. [1]. In our tests, the signal from the PMT is sent to a QDC with two different gates: one integrates the whole signal, giving information on the total light output produced, the other integrates only the first part of the signal (fast output). The comparison of the two, total and fast, outputs makes it possible the n-γ discrimination, as it is shown in the following.

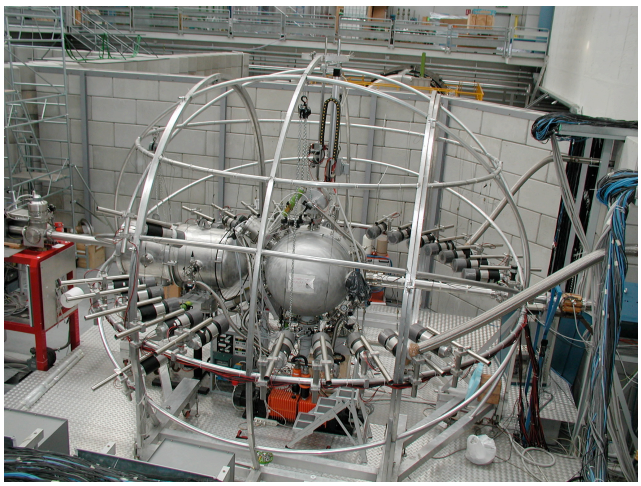

Fig. 1. The RIPEN set-up in the Experimental Hall III at LNL.

First of all, we have checked the linearity of the PMTs from 1200 to 1500 V, which is a good dynamical range for typical neutron measurements at the TANDEM-ALPI energies. For this purpose the light output for different gamma sources (^{137}Cs, ^{60}Co, ^{54}Mn and ^{88}Y) were measured. In figure 2 we report a typical light output spectrum obtained with a ^{88}Y source, showing the peaks due to the Compton edge of the two emitted gammas.

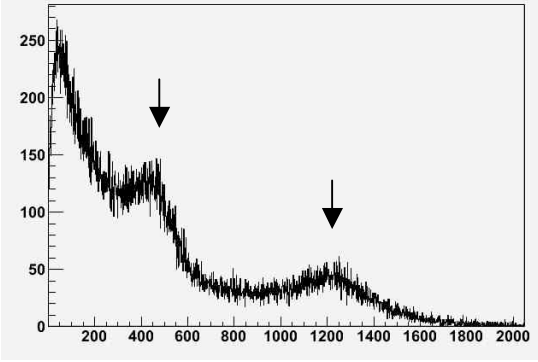

Fig. 2. Total light output spectrum of a typical RIPEN BC501 scintillator, obtained with a ^{88}Y gamma source. The two peaks marked by the arrows correspond to the Compton edge of the 898 keV and 1836 keV gamma lines. The HV of the PMT was set to 1400 V.

In figure 3 we report, for the 1400 V case, the typical plot of the relationship between the light output (in channels) and the position of the Compton edge of the different sources (in keV ee).

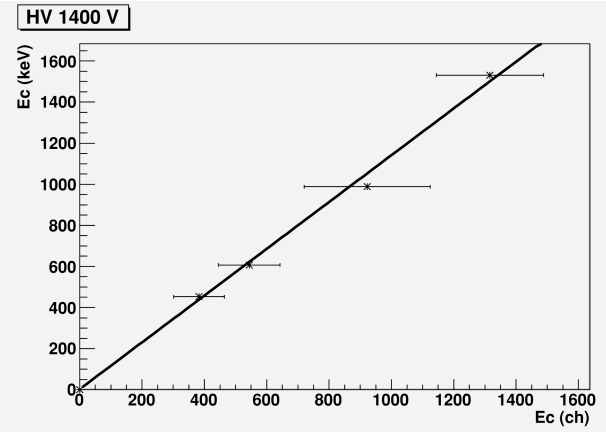

Fig. 3. Linearity plot of the light output with respect to the deposited energy in keV ee for a typical RIPEN detector.

From the figure, we observe a good linear relationship between deposited energy and light output. The calibration line is also shown in the same figure.

In figure 4 we report a typical plot of the total light output in keV ee versus the fast output (not calibrated) measured with an Am-Be source which produces neutrons via the reaction $\alpha + {}^{9}\mathrm{Be} \rightarrow {}^{12}\mathrm{C} + \mathrm{n}$. As can be observed, the upper band, corresponding to gamma events, and the lower band, corresponding to neutron events, are well separated for light outputs as low as about 250-300 keV ee. Neutron-gamma discrimination thresholds in the range between 250 and 500 keV ee were found for all 24 detectors tested. These threshold values are good enough for most of the reaction-mechanism studies.

In conclusion, during 2010 we checked all the BC501 detectors of the RIPEN array and we found that the performances of the detectors and coupled PMT are still good and n-γ discrimination thresholds match very well the values reported in the original paper, which describes the whole apparatus [1].

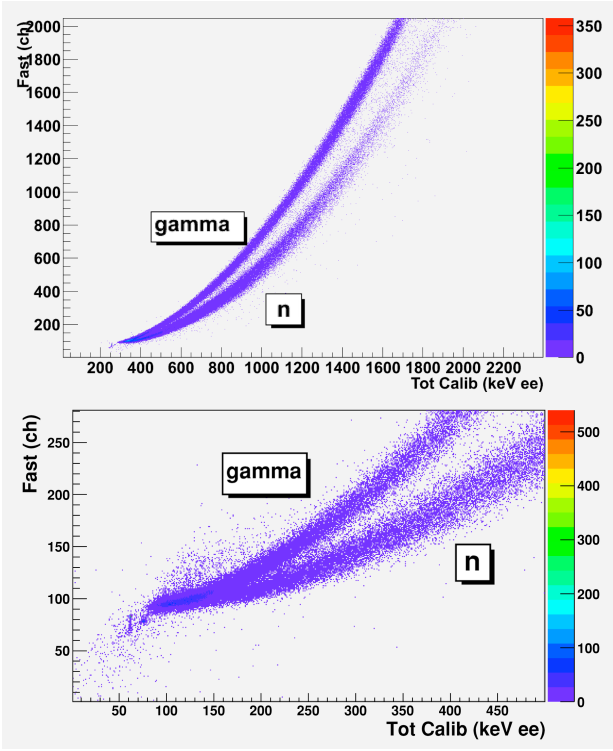

Fig. 4. n-γ discrimination spectrum obtained with an Am-Be source for a typical RIPEN detector (top panel). In the lower panel, a zoom of the whole spectrum is shown to evidentiate the discrimination threshold.

[1] N. Colonna et al., Nucl. Instr. and Meth., A381 (1996) 472.
[2] G. Guastalla, Master Thesis, Univ. of Bologna, Italy, 2010.
[3] T. Marchi et al., this Annual Report.