CONSTRUCTION OF MULTI-NEUTRON CORRELATION SPECTROMETER (MUNCOS) AT PEKING UNIVERSITY

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A neutron detector array-Multi-Neutron Correlation Spectrometer (MuNCoS) composed of 80 detector modules was constructed at Peking University in order to measure simultaneously multi-neutrons with excellent cross-talk rejection capability. MuNCoS was configured in a special spacing setup and applied firstly in a test experiment with 11Be@37A MeV beam at HIRFL-RIBLL facility. Some preliminary results concerning the performance of the spectrometer are obtained and reported here.

1. Introduction

Since ^{6}He, ^{11}Li and some other neutron halo nuclei were discovered, a lot of works have been carried out to study their structures based on the models that treat them as an inert core plus a few valence neutrons. The correlation between the valence neutrons is one of the most important problems studied intensively in the past years[1]. Neutron detector array with good detection efficiency and position resolution, excellent cross-talk discrimination is mandatory in these studies[2]. In neutron detection with a detector array, one incident neutron may cause two or more signals due to the non-stop interaction of the neutron with the detection materials. This is called the Cross-Talk (CT) effect. In the case of multi-neutron detection the CT rejection is important in order eliminate the fake multi-neutron events. CT is usually rejected by the kinetics of the n-p scattering based on the ToF technique with a fast time response detector such as BC-408 and the accurate measurement of the energy deposited by recoiled protons. However, this method rejects also the True two-

Neutron (TN) events which are critical for the analysis of neutron correlation. Multi-Neutron Correlation Spectrometer (MuNCoS) at Peking University is designed to reject most of the CT events, while retaining high TN detection efficiency for neutrons emitted at small relative angles based on careful simulation works[3,4,5].

We report here the detailed design of the MuNCoS and the preliminary results from a test experiment using Coulomb breakup of ^{11}Be on a Pb target at 37A MeV.

2. MuNCoS Design

MuNCoS is composed of 80 plastic scintillator (BC408) modules and was constructed at Peking University. Each module has a size of 200*6*5 cm^3 and is coupled with two PhotonMultiplier Tubes (PMT, Hamamatsu R1828-01) at both ends. Two ends readout technique is adopted to get the timing of the incident neutron (averaged from the two-end signals), the hit position (from the time difference of the two-end signals), and the deposited energy of the actual hit (generated mainly by recoiled protons). The module has a position resolution of 3 cm (FWHM) along the module and a time resolution of less than 200 ps (FWHM) based on cosmic rays tests[6]. Position resolutions at directions perpendicular to the module are given by the module size.

The MuNCoS can be assembled in different configurations with the specially designed support framework to meet various demands in different experiment setups and goals. Its basic configuration includes 8 layers, each of which is composed of 10 scintillation modules. There is a 5 cm gap between the adjacent two modules in one layer, while the distance between two layers is about 50 cm.

3. Experiment Setup

An experiment using secondary beam of ^{11}Be at 37A MeV with an intensity of 10^4 pps and a purity of about 90% was carried out at the Radioactive Ion Beam Line at Lanzhou (RIBLL). The tracks of the secondary beams were recorded by two PPACs and a Double-side Silicon Strip Detector (DSSD1) upstream of the target. A Pb target of 239.1mg/cm^2 thickness and an empty target were used.

A side view of the experimental setup is shown in Fig.1. A zero degree telescope was installed in the target chamber to cover scattering angles of 0° to 11.7° relative to the beam axis. The telescope is constituted of one 0.3 mm thick, 64*64 mm^2 in area Double-side Silicon Strip Detector (DSSD2), one 1.5

mm thick large Size Silicon Detector (SSD) and one 3 cm thick, 100*100 mm^2 in area 4*4 CsI(Tl) scintillator array.

MuNCoS was installed at a distance of about 3.87 m from the target and covered forward angles of -14.5° to 14.5° in horizontal direction and -8° to 8° in vertical direction, respectively. In this experiment, MuNCoS is composed of 54 modules packed into 6 layers. Three large area 10 mm thick thin plastic scintillation detectors were placed in front of the MuNCoS to veto the incoming charged particles. The gap between two modules in one layer and the distance between two layers are 7 cm and 50 cm, respectively. Specially the last layer is 64 cm away from the 5th layer. A cosmic rays run was carried out after the beam experiment to calibrate the position and the deposited energy.

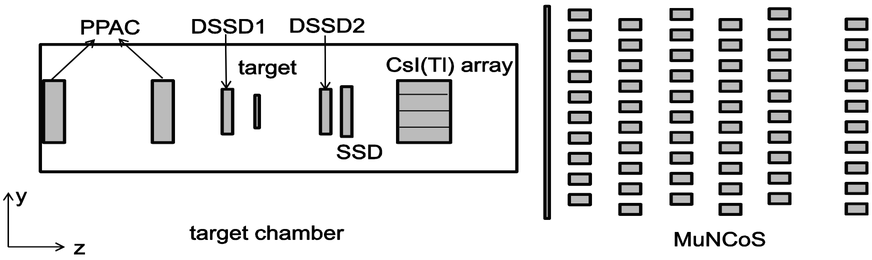

Figure 1. Sideview of experiment setup.

4. Preliminary Results

Coincidence measurement between the ^{10}Be fragment detected by telescope and the neutron detected by MuNCoS with multiplicity = 1 was carried out. Fig.2 shows the *deltaE-E* (energy loss in the DSSD2 vs. energy detected by CsI (Tl)) spectrum taken by the telescope. Left spectrum shows a serious ^{11}Be beam contamination after fragment-neutron coincidence measurement, which makes it hard to identify the ^{10}Be isotopes. A selection of neutron energy from 30 to 40 MeV is applied to depress the contamination. The identification of the ^{10}Be isotopes is shown in the right spectrum. 10 MeV ee (electron equivalent) energy threshold was adopted to reject the background gamma rays.

The geometrical acceptance for coincident ^{10}Be and neutrons was estimated to be 78% by the Monte Carlo simulation with events generated as a function of relative energy *Erel* (0-5 MeV) and inelastic scattering angles θ (0°–6°), both are calculated with the DWBA code[7]. With the known Coulomb breakup cross section and the acceptance, we should be able to extract the detection efficiency of the MuNCoS array at the current neutron energies of 30-40 MeV. The final analysis is still on the way.

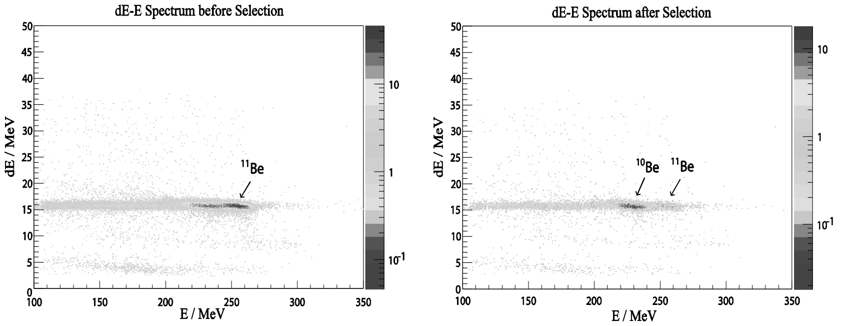

Figure 2. Left figure shows the Particle Identification (PID) before neutron energy selection, while right figure is the PID after the selection (see the text).

5. Discussion

MuNCoS was constructed and firstly applied in the experiment with ^{11}Be beam in a configuration composing of 54 bars in 6 layers. By the selection of emitted neutron energy (30-40 MeV), the ^{11}Be beam contamination can be reduced effectively and the identification of the breakup ^{10}Be isotopes can be realized. MuNCoS's detection efficiency as a function of neutron energy could then be extracted for several selections of different neutron energies. The efficiencies are being analyzed.

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