A Digital data acquisition system for PRIN- A Facility for neutron production using Accelerator

E. Vardaci[1], L. Campajola[1], P.K. Rath[2*], G. Larana[1], M. Ashaduzzaman[1], B. De. Canditiis[1,3] and F. Di Capua[1]

[1]*Department of Physics, University of Naples "Federico II" and INFN, I-80125 Napoli, Italy*
[2]*Manipal Centre for Natural Sciences, Manipal Academy of higher education, Manipal 576104, Karnataka, India,*
[3]*University of Strasbourg and CNRS, 67000 Strasbourg, France*

[*]*email: pk.rath@manipal.edu*

Introduction

All most all the nuclear physics experiments involves ion beam (projectile) of different species and energies. The intensity of the beam, the beam energy, the beam uniformity & divergence including stability of the ion beam is of fundamental importance for any Accelerator. In addition with ion beam the study of neutrons are demanding subject now days. There are lack of reliable nuclear data [1], especially around 5 to 14 MeV range and still it is an open field of study. The neutron cross-section data at these high energies are very much important for fusion reactor development. More over there is a need for calibrated neutron (n) detectors to be used for reliable cross-section measurements. In addition to the above the dark matter group wants to investigate the experimental study using recoil range analysis method in liquid Ar/Xe where they need more precise neutron energy and cross-section.

Now days the imaging (neutron imaging) is another emerging field for non-destructive study of many thing starting from industrial to defences research where the high energy neutron cross section are very much important. All the above requirement lead to the development of a dedicated neutron source and dedicated fast data acquisition system which can able to do quick analysis at the site for better understanding. Keeping all the things on mind a dedicated beam line for n production has been developed which uses a two body D(d, n)^{3}He reaction to produce mono energetic neutron [2] of desired energies at 3.3MV Tandem Accelerator (TTT-3) at Department of Physics, University of Naples Federico II [3]. The neutron beam line including specially designed chamber for neutron Production has been shown in Fig.1. There are many other reactions are available to produce neutron whereas D(d, n)^{3}He reaction has some better advantage which will be presented and discussed. To support the above experimental facility a dedicated digital data acquisition system have been installed and new algorithm using ROOT has been developed for the analysis purpose.

Fig.1 The newly developed neutron beam line at Tandem accelerator (TTT-3) at University of Naples Federico II. The quadrupole can be seen clearly. (Inset) A specially designed chamber for D(d,n)^{3}He reaction where the n can be produced.

Experimental detection & test result

The produced neutrons from D(d,n)^{3}He reaction has been detected by an Organic scintillator (BC-501A) and the associated charge particle (3He) has been detected by a silicon surface barrier (SSB) detector. We have used the tagging of

neutron by associated particle detection method (APT).
A VME based data acquisition system has been used to record the data. We have used CAEN-V1720 Digitizer a 12 bit 250 MS/s sampler to record the data [4]. As the detector is sensitive to both neutron and γ, the traditional Pulse shape discrimination method (PSD) has been used to separate the neutron and the γ events. Using the digitizer we not only able to reduces the number of electronic module but also able to record and analysed the digitized output of the waveform instantly. A newly designed algorithms for n-γ discrimination has been used to separate out the different events. The detail of the algorithms will be presented. The BC501A neutron detector with a normalised recorded spectrum has been shown in Fig.2.

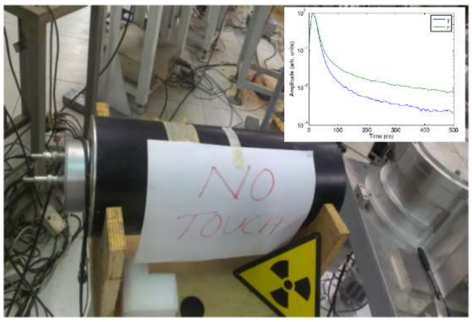

Fig.2 The existing BC501A neutron detector within shielded cover. (Inset) a typical raw spectra after preliminary analysis shows the neutron and gamma events are very clearly separable using their trailing edge.

Each output pulse of the scintillator is composed of a leading and a trailing edge. The leading edge could not be exploited for discrimination purposes. On the other hand, the trailing edge of the neutron signal takes longer to decay than that of the γ signal. The trailing edge has been used in Further analysis. The neutron detector has been tested by γ source (^{152}Eu). In addition with PSD method a time of flight (TOF) method has also used to separate both events. The start signal has been taken from the SSB (^{3}He) and the stop from the neutron detector and extracted the TOF. All the analysis has been done by using the ROOT [5] based data analysis program. The charge comparison method for n,γ separation has been shown in Fig.3 using the same digitized spectra and root based analysis software. The details of the analysis and the methodology will be discussed.

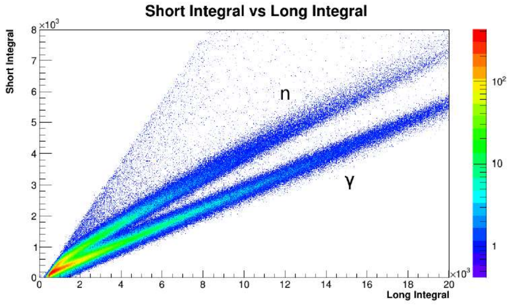

Fig.3 The n-γ separation using charge comparison method. The data has been collected using BC-501A neutron detector & using ^{252}Cf neutron source including standard γ-sources.

Summary and Future Plan

A dedicated and fast digital data acquisition system has been installed at TTT-3 PRIN facility for fast, easy and sophisticated data analysis. The facility can produce neutron up to ~10^{6} n/s and in wide varieties starting from low to high energy range. Specially designed algorithm for the n-γ Separation has been deployed and tested successfully. As the n are tagged very precisely using the APT method, the facility will be used for the dark matter experimental group and also it will open new opportunities for the imaging and development of new algorithm for more advance data processing, analysis.

Acknowledgment

One of the authors (PKR) acknowledges the financial support of University of Naples Federico II, INFN Naples to carry out these investigations during post-doc and expressing the hearty gratitude to all the collaborators for their help and support during the work.

References

[1] NIM. in Physics A269 (1988) 623
[2] The Astrophysical Journal (1996),457,855
[3] AIP Conference Proceedings **1530**, 58 (2013);
[4]http://www.caen.it/csite/Caen
[5] https://root.cern.ch/