Experimental report

23/01/2024

Proposal: 3-01-710 **Council:** 10/2022

Title: Investigation of the pulse shape discrimination capability of nTD andstandard Si detectors

Research area: Physics

This proposal is a new proposal

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Samples:

Instrument	Requested days	Allocated days	From	To
PN1	4	4	31/10/2023	06/11/2023

Abstract:

Neutron induced reactions emitting charged particles (cp) are of great interest for a large number of research fields. In particular, accurate (n,cp) data are highly required for new nuclear technologies, nuclear astrophysics and nuclear medicine. A dedicated experimental campaign is being planned at the n_TOF facility, with a new setup based on nTD annular silicon detector and the use of dedicated Pulse Shape techniques for particle discrimination. We propose to perform an extended characterization of the recently developed setup exploiting the ILL Lohengrin spectrometer, since it could provide charged particles in the mass and energy regions of interest. Moreover the Pulse Shape Analyzing (PSA) software for particle identification, based on neural network algorithms and currently under development, will be fine tuned thanks to the wide collections of well identified waveforms that we aim to acquire, in order to be used for the training phase.

Objectives of the experiment

The purpose of this experiment was to investigate the pulse shape discrimination capability of nTD Si and SiC detectors. This experiment is strongly tied to the fine tunning of the parameterization of the Pulse Shaping Analysis (PSA) code developed at INFN-LNS in Catania. The pulse recognition of the routine is achieved by machine learning algorithms based on artificial neural networks, which is essential for the discrimination capabilities among particles. On this ground, the most suited facility for this experimental investigation was the LOHENGRIN recoil separator at ILL. LOHENGRIN is an ideal instrument for reproducible characterizations since it provides different nuclides with masses and atomic number of interest for our purpose.

In more detail, the main achievements of the experiment were:

1) Preparation of the experiment, setting up phase, and check of the silicon detectors.
2) Selection of different beams in terms of particle and energy. (From light particles like p, t, α up to fission fragments)
3) Acquire more than 300 files for different combination of particles/energies/impinging angles.

Through this experimental campaign, we help in characterizing the detection system as well as recording dedicated pulses for each particle ID (Z, A) to use them as a prototype for artificial intelligence software. The software of the Pulse Shape Analysis routine will be fine-tuned within this work, which will facilitate us to study utterly unknown differential and total cross-sections for the past and forthcoming experiments at n_TOF and other facilities. This software will be used for particle discrimination studies.

Main achievements and difficulties of the experiment

- nTD Si detector and SiC detector:

Figure 1: Specs of the square nTD silicon detector

A large variety of light and heavy ion beams provided as mass- and energy-selected beams were provided by the LOHENGRIN recoil spectrometer:

- protons from 0.5 up to 12 MeV, deuterons, tritons, ^{4}He, ^{6}He, ^{10}Be, light and heavy FF.

in an attempt to quantify the pulse height defect and to study the pulse shape as function of (Z,A,E). The detected energies and the whole waveforms were registered with the ILL data acquisition system using Caen V1724, 100 MHz, 14 bit ADC read out by NOMAD.

Part of the experiment was successful. More that 300 files for different particles, energies and impinging angles were collected. These files will be used for fine tuning the PSA code in terms of particle identification.

However, it has been realized that due to very fast rise time compared to the 100 MHz data sampling rate only very few data points were available to analyse the pulse shape of the rise time. This shape could be studied much better with a faster ADC (V1730 with 500 MHz sampling rate or V1751 with 1 GHz sampling rate). Such DAQ cards are already available at ILL and a waveform readout by NOMAD should be implemented soon.

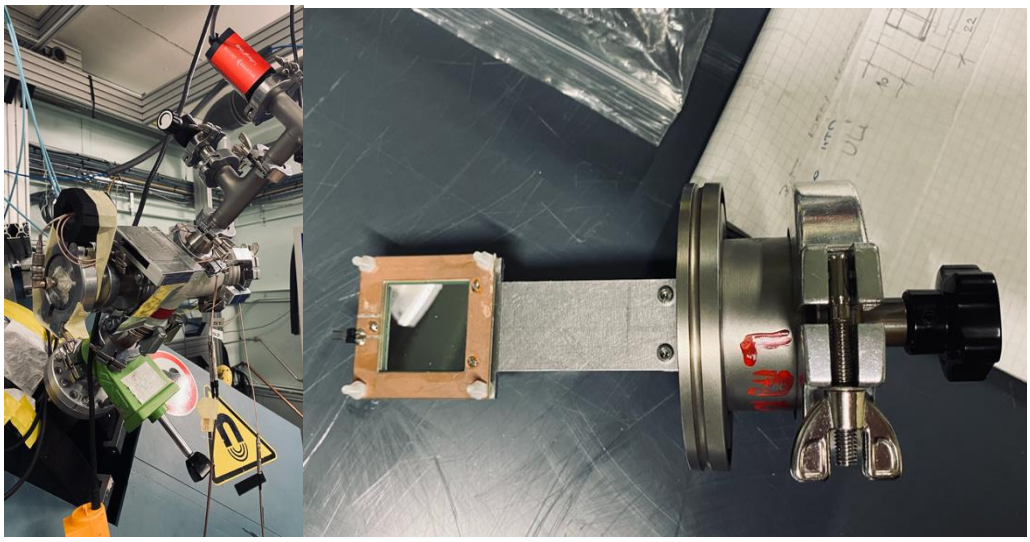

Figure 2: Pictures of the detector installation at LOHENGRIN