
ID de Contribution: **7** Type: **Non spécifié**

# Shedding new light on the structure of $^{56}$Ni using (n,3n) reaction at NFS

*mercredi 17 janvier 2024 17:35 (25 minutes)*

Systematic studies of nuclear reactions are essential to the development of modern nuclear physics. Understanding and predicting the evolution of nuclear structure and the formation of novel phenomena in atomic nuclei can be improved by studying atomic nuclei in the phase space of Shell structure, magic numbers, angular momentum, and excitation energy. Prompt $\gamma$-ray spectroscopy of discrete states is a powerful method to achieve this goal. We want to re-investigate the nuclear structure of the doubly magic nuclei $^{56}$Ni using the (n,3n) reaction from $^{58}$Ni. The nuclei near $^{56}$Ni are of particular interest as they are amenable to different microscopic theoretical treatments while studying the competition between single-particle and collective excitation. The collective states in $^{56}$Ni involve multiparticle multi-hole excitations across the $N = Z = 28$ shell gap from the 1f$_{7/2}$ shell to the 2p$_{3/2}$, 1f$_{5/2}$, and 2p$_{1/2}$ orbits. Excitation to the higher lying 1g$_{9/2}$ orbit are necessary to explain the observed rotational bands in Cu and Zn. At high excitation energies, reaction studies have revealed evidence for hyper-deformed resonances in the $^{56}$Ni compound. While the structure of $^{56}$Ni has been intensively investigated using charged particle or heavy ions collisions, the pure neutron probe was never used. The (n,xn) reactions are a long standing reaction mechanism used in the nuclear data evaluation but rarely used in the framework of nuclear structure. For the first time, using the unprecedented neutron flux at $\sim$20 - 30 MeV at the NFS facility of GANIL-Spiral2, $^{56}$Ni can be populated from $^{58}$Ni in a (n,3n) reaction with a cross-section of 2 mb opening a new probe and possibly new aspect of the nuclear structure of this doubly magic nucleus. Co isotopes are also produced involving (n,p/d/t) reaction and comparison with pure neutron channels can be studied. In this project, we propose to perform a prompt gamma spectroscopy of $^{56}$Ni using the EXOGAM array at NFS using the (n,3n) reaction. Such new spectroscopic information is also relevant for nuclear reaction mechanism formalism (like TALYS) and nuclear data evaluation. For nuclear structure, the main motivation is the search for low spin (J=2 or 4) states from 3 to 10 MeV excitation energy possibly populating the $0^+$ states at 3956 keV, 6654 keV and 7903 keV observed only in $^{58}$Ni(p,t)$^{56}$Ni reactions. The TALYS cross-section calculation as a function of incident neutron energy is shown in Fig. 1.

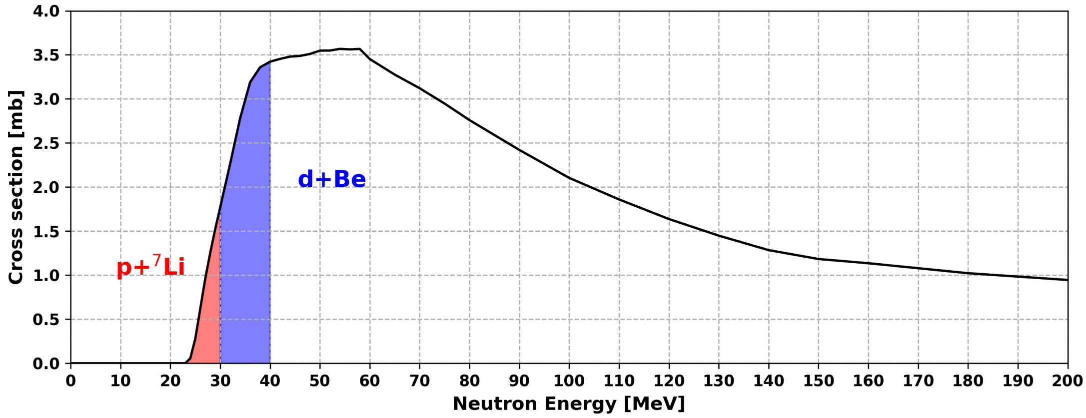


Figure 1: $^{56}$Ni cross section as a function of neutron energy from $^{58}$Ni. The red area shows the neutron beam energy covered by p-induced reaction at NFS and the blue area corresponds to d-induced reaction.

The maximum cross section is predicted to be at 40 MeV, slightly higher than the end-point of NFS. p+Li/Be allows to reach up to the [20-30] MeV range, whereas d+Be up to a broader [25-40] MeV range.The experiment was performed in October 2023. During 2 weeks, a high energy neutron beam produced by a primary beam of 10 $\mu$Amps of $^{2}$H, bombarded a 1mm thick Ni target. The prompt gamma rays selected on the fastest neutron using the Time of Flight information have been detected by 12 EXOGAM clovers placed at 15 cm off the beam axis. About $1.6 \times 10^{10}$ $\gamma\gamma$ coincidences have been sorted after the AddBack procedure. $^{56}$Ni decay was observed and a large amount of $\gamma\gamma$ coincidences Co have been sorted. The very preliminary analysis of the experiment will be presented. Limitation of the use of large germanium volume detector with fast neutron will be also shown.

This experiment is a pioneering work in the study of the nuclear structure studies using large gamma-array and fast neutron and is only possible at GANIL-Spiral2 today. If successful, this program will open new opportunity at the NFS facility.


**Auteurs principaux:** CLEMENT, Emmanuel (ganil); SENGAR, Hemantika (GANIL)

**Orateur:** SENGAR, Hemantika (GANIL)


**Classification de Session:** Session 2