Implementation of the ELIGANT neutron and gamma detector arrays at ELI-NP

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Abstract. ELIGANT is one of the main set of instruments for nuclear physics experiments with the versatile gamma-beam system that will be available at ELI-NP. One of the devices in the ELIGANT collection of instruments is the ELIGANT-GN, comprising of both neutron and γ-ray detectors. The description and details of the mechanical structure designed to hold the ELIGANT-GN neutron detectors is discussed in this report. In addition, the progress of the implementation of this structure will be shown.

1. Introduction
Within the framework of the Extreme Light Infrastructure - Nuclear Physics (ELI-NP) facility, a gamma-beam system of exceptional energy, bandwidth, and intensity will be provided for nuclear physics experiments and applications [1]. Some of the instruments designed to take advantage of the gamma-beam system are implemented under the ELI Gamma Above Neutron Threshold (ELIGANT) experiment [2]. The main focus of ELIGANT is the physics cases involving the emission of one or more neutrons from a target after the interaction with the gamma-beam. One of the setups designed for ELIGANT has the purpose to detect coincidences between prompt γ-rays and neutrons emitted from the target. This setup, ELIGANT-GN, consists of a large number of various scintillator detectors arranged around the interaction point. In particular the γ-ray detectors are arranged in a semi-sphere close to the target, while the neutron detectors are positioned at a larger distance surrounding the γ-ray detectors. An overview of the detector arrangement and the the two structures is shown in Fig 1. General information, the detector configuration and some details of the ELIGANT-GN neutron-support structure will be reported.

2. Conceptual design
One of the main requirement for the ELIGANT-GN setup is to detect the emitted neutrons and to determine their energy. In order to extract the energy of the detected neutrons, a time-of-flight technique is applied, in a similar way as used in the EDEN array, described in Ref. [3, 4], or in the MONSTER array [5]. In order to cover a broad detection energy-range together with a fast detection response, two types of neutron detectors have been bought; 33 liquid-scintillator EJ301 detectors, having good detection efficiency for neutrons with a kinetic energy above 1 MeV, and 29 GS20 (6Li glass) detectors, to cover the energy spectrum below 1 MeV. The neutron detectors are held far enough from the target to be able to achieve a
Figure 1. (color online) CAD design of the neutron-detectors support-structure surrounding the $\gamma$-ray detectors support-structure (left panel). Photograph of the two structures at the actual implementation stage (right panel).

good energy resolution from the time-of-flight technique, and the amount of detector should be enough to cover the surface around the target to avoid losing in efficiency. To determine the optimal configuration, several simulations have been performed, as described in Ref. [6]. As an example, the simulated resolution power of the time-of-flight technique at the chosen distance is shown in Fig. 2. The distance from the target can be adjusted, depending on the experimental requirements. In particular the EJ301 have a 1.5 m to 1 m distance range, while the GS20 have a 1 m to 0.5 m distance range. The $\gamma$-ray detectors are constituted by a mix of LaBr(Ce) and CeBr scintillators.

Figure 2. Neutron time-of-flight at two possible distances as a function of the neutron kinetic-energy and energy resolution (from Ref. [6]).
3. The mechanical structure

The floor projection of the mechanical structure is a circumference, having 3.2 m as diameter. The structure comprises of two geometrical elements: one cylinder 2.5 m tall, composed of 10 pillars and two truncated rings; and a dome sitting on the pillars. Each pillar is anchored to the floor by four screws. The maximum height of the full structure is 3.8 m. The skeleton of the mechanical structure is made of steel, in order to provide a steady support for the detectors. To minimize neutron scattering and secondary material activation, the amount of material around the detectors has been minimised and materials with a small neutron cross-section, like aluminium, have been used. In particular the detectors are held in aluminium cages mounted on 750 mm long telescopic-rods, connected to the structure by aluminium arms. The rods are made in aluminium with a steel soul, in order to sustain the detectors without inflexion. The design of the rods allows the regulation of the distance of the detector from the target. The CAD drawing of the telescopic detector supports is shown in Fig. 3.

![Figure 3](color online) On the left panel, the CAD drawing of the element connecting the skeleton of the structure to the telescopic support. The red element is the clamp for the rod of the detector supports. The bottom part of the arm is screwed in the skeleton of the structure. On the right panel, the CAD drawing of the telescopic detector supports. In the top part the support for the GS20-type detectors, in the bottom one the support for the EJ301 type is shown. The yellow rod is clamped into the element connecting to the structure shown in the left panel.

In Fig. 3, the arm connecting the telescopic rod to the structure is shown. The pivot element has been designed to allow two degrees of movement to the detectors: rotation around the arm own axis and detector height-adjustment. The pivot rotation capability will be used for the fine alignment of the axis of the detectors to the target.

4. Implementation status

The first step of the implementation of the neutron structure in the designated experimental hall was to determine its position inside the room. The position was chosen taking into account the beam line and the ceiling clearance. Using a laser tracker device, the target position and the pillar screw positions were marked, to ensure the symmetry of the array with respect to the beam line. To check the manufactured parts and to discuss the delivery of the parts to ELI-NP, a preliminary visit to the manufacturing site of the structure was made. The parts of the mechanical structure have been delivered to ELI-NP the 14th of June 2019 (Fig. 4).

The first step mounting the structure was to build the cylindrical part. This included anchoring the pillars to the floor, linking the truncated rings, and confirming that the pillars were vertical. The following step was the construction of the dome on the floor, and the lifting of the dome on top of the pillars. A photograph of the positioning of the dome on the pillars of the structure inside the designated experimental room is shown in Fig. 4. The dome was then
Figure 4. (color online) Arrival of the components of the mechanical structure at ELI-NP (left panel). Positioning of the dome on top of the pillars (right panel).

aligned with the cylindrical part of the structure, in order to keep the symmetry with respect to the beam line direction.

The detectors are currently being mounted in the structure, and the full-scale source commissioning of the ELIGANT-GN array will be performed in spring 2020 using a $^{252}$Cf radioactive source.

5. Summary

A neutron-detector mechanical-structure is under implementation for the ELIGANT-GN experiment at ELI-NP. The design has been optimised to achieve good performance from the detectors in terms of efficiency and energy resolution. The mechanical parts of the structure have been delivered to ELI-NP in June 2019. The skeleton of the structure is mounted, together with part of the detector holders. Some mechanical stress tests have been carried out. The full capabilities of the structure and the mounting of all detectors are under preparation.

References

[1] Gales S, Tanaka K A, Balabanski D L, Negoita F, Stutman D, Tesileanu O, Ur C A, Ursescu D, Andrei I, Ataman S, Cernaianu M O, DAlessi L, Dancus I, Diaconescu B, Djourelov N, Filipescu D, Ghencu P, Ghita D G, Matei C, Seto K, Zeng M and Zamfir N V 2018 Rep. Prog. Phys. 81 094301
[2] Camera F, Utsunomiya H, Varlamov V, Filipescu D, Baran V, Bracco A, Colò G, Gheorghe I, Ghotari T, Matei C and Wieland O 2016 Rom. Rep. Phys. 68 539
[3] Laurent H, Lefort H, Beaumel D, Blumenfeld Y and Fortier S 1993 Nucl. Instrum. Meth. A 326 517
[4] Cavallaro M, Tropea S, Agodi C, Assi M, Azaiez F, Boiano C, Bondi M, Cappuzzello F, Carbone D, Napoli M D, de Srville N, Foti A, Linares R, Nicolosi D and Scarpaci J 2013 Nucl. Instrum. Meth. A 700 65
[5] Garcia A, Martinez T, Cano-Ott D, Castilla J, Guerrero C, Marin J, Martinez G, Mendoza E, Ovejero M, Reillo E, Santos C, Tera F, Villamarín D, Nolte R, Agramunt J, Algora A, Tain J, Banerjee K, Bhattacharya C, Pentilla H, Rinta-Antila S and Gorelov D 2012 JINST 7 C05012
[6] Krzysiek M, Camera F, Filipescu D, Utsunomiya H, Colò G, Gheorghe I and Niu Y 2019 Nucl. Instrum. Meth. A 916 257