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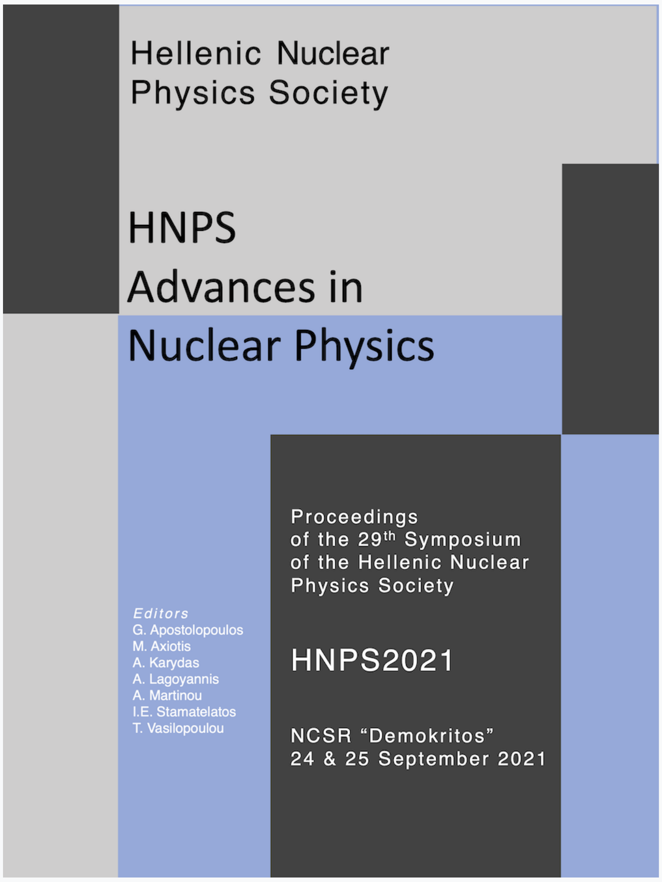

Preparing Phase 4 of the n_TOF/CERN facility

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Abstract After CERN's Long Shutdown 2, the n_TOF facility infrastructure was largely upgraded. The biggest change is the installation of a new lead spallation target, the performance of which needs to be carefully examined. During Summer 2021, the facility's two flight paths were characterised in terms of neutron beam energy distribution, profile and resolution. In this work, the characterisation of the facility is described, and the first results are given.

Keywords n_TOF, CERN

INTRODUCTION

The n_TOF facility at CERN is a neutron facility for time-of-flight measurements based on a pulsed proton beam impinging on a lead spallation target. It is designed to study neutron induced reactions important for a variety of scientific fields, from fundamental research to nuclear astrophysics [1,2] and nuclear technology applications [3,4]. n_TOF started out with a horizontal fight path 185 m in length, which was later complimented by a second, vertical 20 m flight path.

The facility's 185 m flight path provides an excellent energy resolution, reaching as low as ΔE/E ~ 10^{-4} for the eV region [5]. The energy range it covers stretches from a few meV up to the GeV region, allowing for significant extension of cross section data. The newer 20 m flight path provides a high instantaneous flux allowing the measurement of low mass, low cross-section samples [6].

The core of the facility, its lead spallation target, was a water-cooled single block of lead only optimised for the initial 185 m flight path. After CERN's Long Shutdown 2, it was replaced with a new nitrogen-cooled target consisting of several slabs of lead, this time optimised also for n_TOF's vertical beamline.

After this major change, the performance of the new target needs to be closely inspected, the new characteristics of the now optimised 20 m flight path need to be studied while it must be ensured that the performance of the horizontal beam-line has not significantly changed. This as achieved during n_TOF's "Commissioning" Phase in Summer 2021.

In addition, a new experimental area, the "NEAR" Station was developed. NEAR is a measurement area outside the target-moderator assembly's shielding, situated 3m from the lead target. During the 2021 Commissioning Phase, the neutron beam of NEAR was characterised via multifoil activation in various experimental setups.

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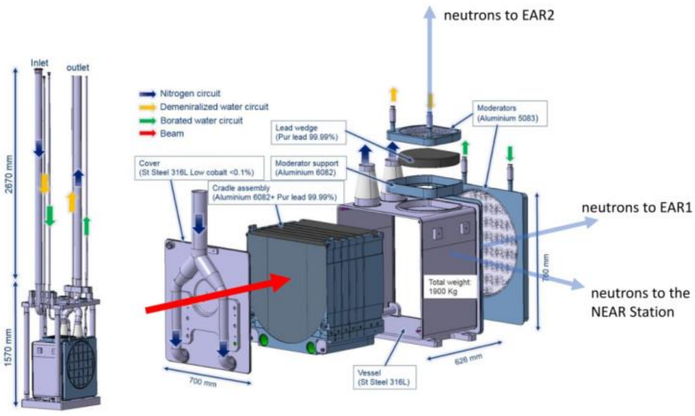

Fig. 1. Schematic representation of the new n_TOF spallation target

EXPERIMENTAL DETAILS

The characterisation of the facility requires two different experimental set-ups, one to measure the neutron energy distribution and one to measure the flight path's energy resolution. The first set-up contains mainly fission detectors while the second one g-ray detectors.

To extract the neutron beam energy distribution, a variety of detectors was used to measure standard reactions with very well-known cross-sections. The first detector was a silicon monitor (SiMon), consisting of a LiF sample in beam and four silicon detectors placed symmetrically around it. Based on the Li(n,t)He, the SiMon can provide data up to 1 MeV neutron energies. The fission detectors used were the Parallel Plate Avalanche Counter (PPAC), the micromegas detectors (uMGAS) and the PTB fission chamber. All of them are based on the standard ^{235}U(n,f) reaction and can provide high quality data up to the high energy part of the spectrum. Additionally, the uMGAS chamber contained a boron sample to provide data based on the ^{10}B(n,a) reaction, which has a high and very smooth cross-section in the low energy part of the spectrum, being a standard up to 1MeV. Furthermore, the PPAC is a position sensitive detector which can provide detailed information on the beam profile.

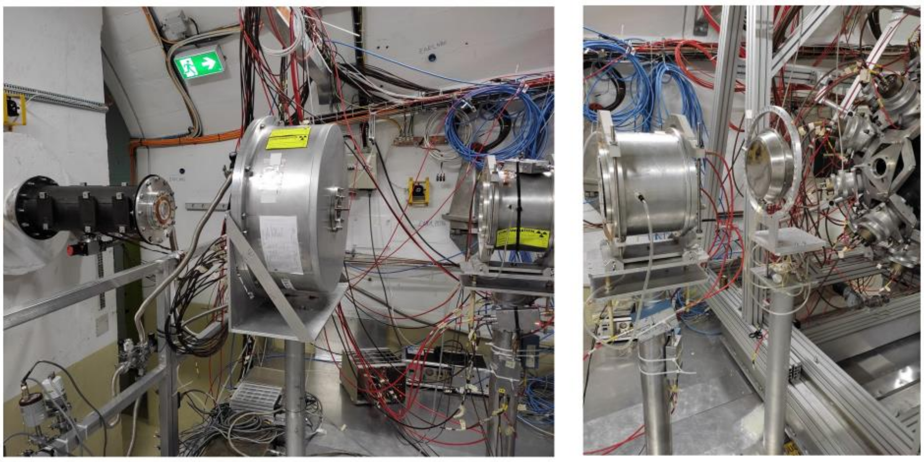

Fig. 2. *Experimental set-up for the measurement of the neutron flux in EAR1*

The way to estimate the effect of the energy resolution of the two n_TOF flight paths is to study the resonances of well-known neutron capture reactions such as neutron capture on gold. The detectors utilised for this are liquid scintillators housed in carbon fiber, so that the least and lightest possible material is present in the experimental hall.

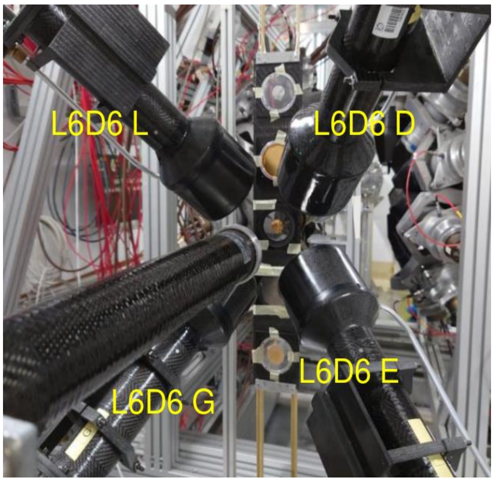

Fig. 3. C6D6 liquid scintillators for capture measurements

To complement the experimental studies, extensive Monte Carlo simulations were carried out and were bench-marked by the experimental results.

PRELIMINARY RESULTS AND DISCUSSION

The analysis of the Commissioning Phase data is still ongoing but the preliminary results show no significant change in the neutron flux; on the contrary, the flux has slightly increased, compared to the previous n_TOF phase.

The exchange of target and moderator didn't alter characteristics of the horizontal flight path, which maintains its excellent energy resolution. The optimisation for the vertical flight path notably improved its performance, especially its energy resolution, paving the way for new challenging measurements.

CONCLUSIONS

After its major upgrades during CERN's Long Shutdown 2, the n_TOF facility's unique characteristics were further improved and enhanced. n_TOF can serve high precision cross-section measurements for a large variety of neutron induced reactions ranging from capture to fission in stable or highly radioactive samples in a wide energy range.

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