EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Letter of Intent to the ISOLDE and Neutron Time-of-Flight Committee

The new n_TOF NEAR Station

The n_TOF Collaboration
(www.cern.ch/n_TOF)

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Requested number of protons: none

Due to operational requirements, the shielding around the spallation target of the n_TOF facility has been modified during the CERN Long Shutdown 2, in order to allow inspection and access to the target pit [1]. Then, the possibility to setup a new experimental zone, very close to the spallation target and just outside the shielding wall of the target-moderator assembly has been considered (see Figure 1a). The aim of this new station, the n_TOF NEAR Station, will be to take advantage of the extremely high neutron fluence expected at a position very close to the spallation target (of the order of 3 m), to perform activation measurements on extremely small-mass samples and on radioactive isotopes. The idea and concept behind this new measuring station have been briefly outlined in the document on the European Strategy [2], and in a presentation to the INTC [3]. The neutron beam will be simply transported in the NEAR Station through a hole in the shielding wall, supplied with a suitable, movable collimator/moderator system. No additional construction and/or installation with respect to the present configuration of the target and shielding is required for operating the new station. The NEAR Station can operate in parallel with the n_TOF EAR1 and EAR2 and no additional primary proton beam needs to be dedicated to the measurements proposed in this LoI.

Extensive simulations have been performed to determine the expected characteristics of the neutron beam in the NEAR Station area, in terms of flux and energy distribution, for various combinations of the collimator/moderator system [4]. The simulations have indicated that, with a suitable choice of moderator material and dimension, a Maxwellian-like neutron spectrum could be produced (see Figures 2a and 2b), corresponding to thermal energies in the range of astrophysical interest (from a few keV to a few tens of keV) that would allow to derive Maxwellian Average Cross Sections (MACS) by means of activation technique. Additional shaping of the neutron energy distribution can be achieved with the use of filters. The possibility to experimentally determine MACS for short-lived unstable nuclei will open the possibility to investigate with enhanced reliability the branching points in the s-process, as well as some explosive scenarios such as the weak r-process.

An important advantage of the NEAR Station is its proximity to the ISOLDE facility, from which sample material to be irradiated could be produced. This synergy has been already recently established [5] while its full exploitation is presently under study.

Another possible application of a physics program at the NEAR Station, with a different choice of the moderator (or even without any moderator), would be for non-metallic material irradiation with a wide-spectrum neutron beam, including the high-energy tail, of interest for a variety of applications, in particular for energy production (fusion and fission reactors), radiation damage and others.

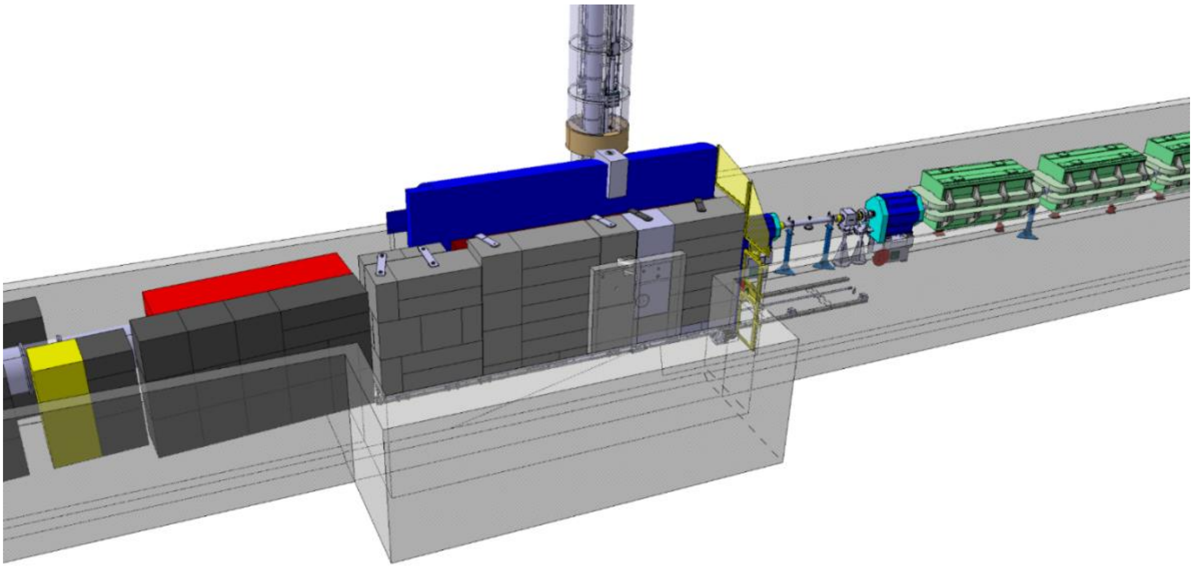

Figure 1a: The NEAR Station area, close to the n_TOF target/moderator assembly (located behind the blue-colored wall).

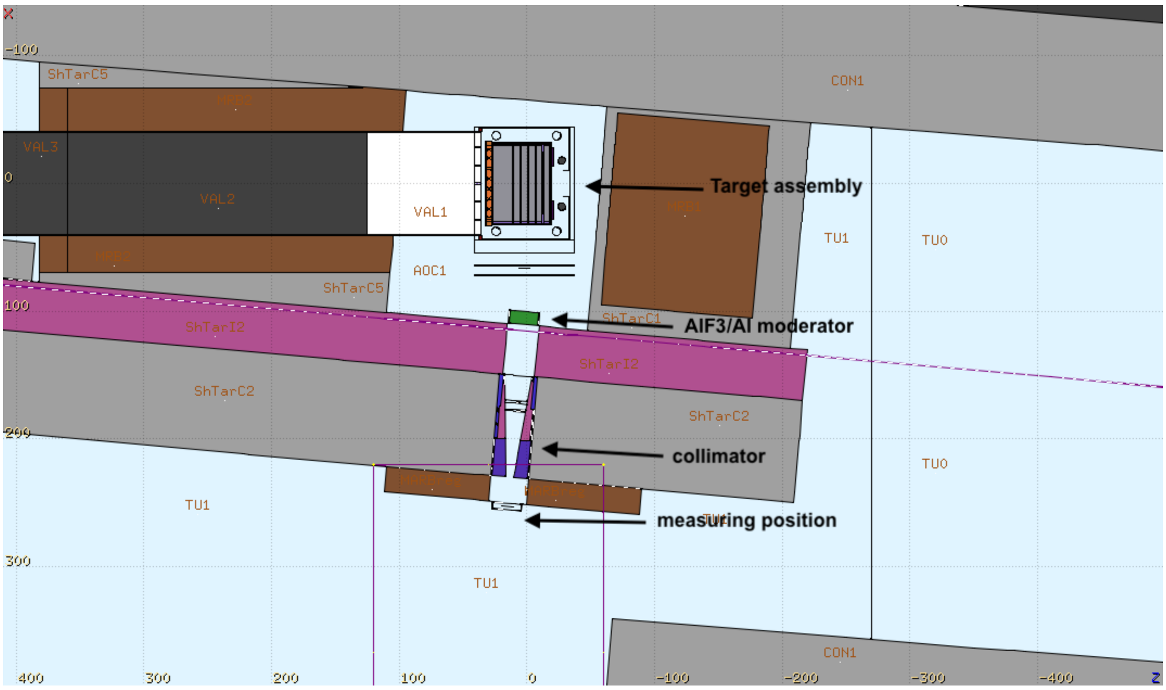

Figure 1b: View from the top of the NEAR Station area. Different moderator materials have been considered in the simulations (AlF3 and pure Al are indicated in the figure). The collimator aperture, in the outer side of the shielding, at the exit of the collimator, has a diameter of 6 cm. The activation foils for the neutron beam characterization will be placed at measuring position.

The installation will be suitable also to provide information on the behavior of non-metallic materials for accelerator and experiments in radiation fields. The radiation field present in the experiments and accelerators can damage non-metallic materials (e.g. polymers, lubricants, etc.) posing a threat to the adequate operation of the systems they form part of. Therefore, there is a need for irradiating such materials and/or equipment up to levels compliant with their lifetime requirements, and to verify that they are still capable of fulfilling their intended function (e.g. insulation, structural, etc.).

While extensive Monte Carlo simulations, performed under various assumptions, indicate the viability of the NEAR Station concept, its exploitation for physics measurements is subject to a preliminary feasibility study and characterization. The aim of this LoI is two-fold: on one hand it is necessary to verify that the transport of the neutron beam through the shielding, with or without a collimator/moderator system, does not pose radiation protection or other safety issues associated to the operation of the n_TOF facility. A radiation protection assessment has been already performed to validate the new shielding layout and is currently being documented in a dedicated technical note [6]. Here, we anticipate that a series of ad-hoc measurements will be performed to this aim during the Commissioning of the new n_TOF Target, in collaboration with the CERN Radiation Protection team.

In addition to the characterization of the NEAR Station area in terms of dose rates and safety, we propose to perform a series of measurements aimed at determining the neutron fluence in the new area. We will start with measuring the neutron fluence outside the shielding (measuring position in Figure 1b), without any moderator. This will provide the basic information on the neutron beam characteristics, to be later used as input for the design and optimization of the moderator systems. In particular, the measurements are intended to validate the Monte Carlo simulations performed so far.

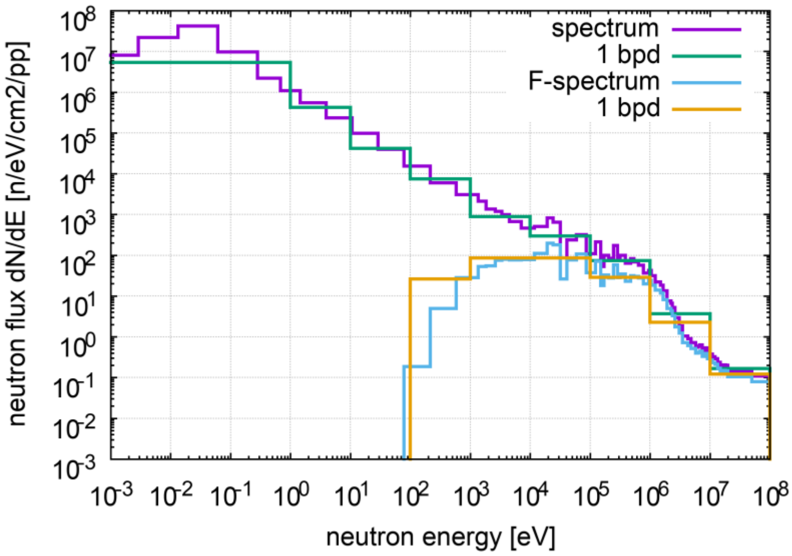

Figure 2a: Expected neutron flux in the NEAR Station area, at the measuring position (see Figure 1b), with no moderator. The F-spectrum is filtered with a 1.5 cm thick Boron filter.

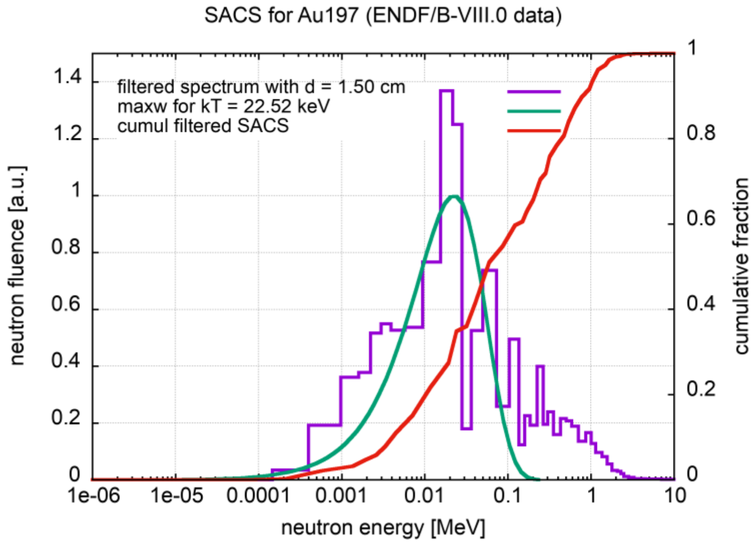

Figure 2b: Expected neutron flux shape in the NEAR Station area, at the measuring position (see Figure 1b), with no moderator. The neutron beam is filtered with a 1.5 cm thick Boron layer. The spectrum is compared to a pure maxwellian spectrum of thermal energy kT = 22.52 keV. The cumulative spectral average (SACS) fraction, as a function of neutron energy, is shown for the ^{197}Au neutron capture cross section.

We plan to measure the neutron fluence characteristics in the NEAR station by means of the multi-foil activation technique, a standard methodology typically used at neutron sources of various types (see examples performed by the n_TOF teams at Demokritos [7] and at the LENA Triga reactor [8]). Recently, this technique was used to characterize the neutron beam in the ChipIr station of the ISIS spallation neutron source [9], a facility that presents a neutron energy distribution similar to the one expected in the NEAR station. With this technique, foils of various elements will be inserted in the beam for a suitable time and the products of activation are subsequently analyzed off-line with a HPGe detector. To this end, the Collaboration is planning to setup a dedicated station for activity measurements, equipped with a high-performance HPGe detector. The isotopes to be irradiated will be chosen on the basis of the dependence of their cross section as a function of neutron energy and on the half-lives of the activated products.

An additional method which we plan to use to determine the neutron fluence is the moderation-absorption technique, based in the thermalization of neutrons using different moderator thicknesses to determine the magnitude and shape of a neutron flux. We have performed MCNP simulations in order to investigate the possibility of using a cylindrical block of polyethylene to thermalize the neutron beam together with activation samples to measure the neutron flux (energy dependence + absolute value). The same technique has already been designed and validated by Muñiz *et al.* [10], with a different geometry of the polyethylene matrix and also different activation samples (TLDs).

In conclusion, a first characterization of the experimental conditions for performing neutron irradiation and reaction cross section measurements near the n_TOF target area (the NEAR Station) will be performed during the commissioning of the n_TOF facility, after LS2. Based on the results of this first step, a detailed plan for the commissioning of the neutron beam in the NEAR Station will be prepared and submitted to the INTC at due time as a dedicated proposal.

No dedicated protons are required to perform the measurements described in this LoI

References

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