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The new vertical neutron beam line at the CERN n_TOF facility design and outlook on the performance

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ABSTRACT

At the neutron time-of-flight facility n_TOF at CERN a new vertical beam line was constructed in 2014, in order to extend the experimental possibilities at this facility to an even wider range of challenging cross-section measurements of interest in astrophysics, nuclear technology and medical physics. The design of the beam line and the experimental hall was based on FLUKA Monte Carlo simulations, aiming at maximizing the neutron flux, reducing the beam halo and minimizing the background from neutrons interacting with the collimator or back-scattered in the beam dump.

The present paper gives an overview on the design of the beam line and the relevant elements and provides an outlook on the expected performance regarding the neutron beam intensity, shape and energy resolution, as well as the neutron and photon backgrounds.

1. Introduction

The neutron time-of-flight facility n_TOF at CERN [1,2] is a pulsed white neutron source for high-accuracy neutron cross-section measurements over a wide neutron energy range. The neutrons are produced in a monolithic Pb-spallation target, where a pulsed 20 GeV/c proton beam provided by the CERN Proton Synchrotron (PS) [3] impinges with a maximum repetition rate of 0.8 Hz. The primary proton beam has a width of rms = 7 ns. The Pb-target is surrounded by an additional moderator layer to generate a neutron beam with energies ranging from thermal up to several GeV. At the facility in operation since 2000 the measurements take place in an experimental area placed at the end of a horizontal beam line, 200 m in length. The experimental conditions and neutron beam characteristics at this horizontal flight path are presented in full detail in Ref. [4].

The horizontal 200 m flight path, with its record instantaneous neutron beam intensity, has allowed very important cross-sections to be measured, getting unprecedented energy resolution in both neutron capture [5,6] and fission [7] as well as extending the measurement range to previously unreachable neutron energies [8]. However, there are more challenging experiments that require an even more intense neutron beam.

In order to extend the experimental possibilities at the n_TOF facility for cross-section measurements of very low mass samples (< 1 mg), reactions with small cross-sections or highly radioactive samples [9], an additional vertical flight path of 20 m with a significantly higher neutron flux was designed and constructed in 2014. The design and implementation of this new beam line, with an outlook on the expected performance are the subject of this paper. In Section 2 the final beam line configuration, as in operation at CERN since July 2014, is presented with a description of the different elements. The expected characteristics of the neutron beam and the background conditions, determined by means of FLUKA Monte Carlo simulations, are discussed in Section 3.

2. General layout and technical description

The n_TOF spallation target is installed in the TT2A tunnel at CERN. The spallation target was lowered to its current position through an existing vertical shaft via a service gallery. This shaft was now used to install the bottom part of the vertical beam line which is presented here. From the roof of the service gallery, at 12.6 m from the target center, to the ground, a new concrete shaft with an inner diameter of 800 mm was built during 2013. At ground level, 18.16 m above the spallation target, a new building was constructed, hosting the bunker with the experimental area, an electronics room and two preparatory rooms. The beam dump for this new vertical flight path is installed on the roof of the bunker. The existing service gallery is used to house the magnet and the filter box of the beam line, as well as to allow the access to the 1st collimator.

The general layout with the different beam line elements is shown in Fig. 1. The distance to the spallation target center for the different beam line elements, which are described in further detail below, are listed in Table 1.

2.1. The beam line at the level of the spallation target

The n_TOF spallation target consists of a Pb cylinder 400 mm in length and 600 mm in diameter, surrounded by a layer of demineralized water acting as coolant and, only in the forward

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