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First results from the neutron (nTOF) facilty at CERN

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A new high-flux spallation neutron source, the neutron Time-Of-Flight facility (nTOF), recently became operational at CERN. The neutron energy ranges from the thermal GeV range. Performance results from the commissioning are reported.

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First results from the neutron (nTOF) facility at CERN

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Abstract A new high-flux spallation neutron source, the neutron Time-Of-Flight facility (nTOF), recently became operational at CERN. The neutron energy ranges from the thermal to the GeV range. Performance results from the commissioning are reported.

1 Introduction

The aim of the neutron Time-Of-Flight (nTOF) facility at CERN is the measurement of cross-sections needed for the design of innovative Accelerator Driven System (ADS) applications such as incineration of nuclear waste, energy production, radioisotope production for medical applications and for many other basic science subjects, in particular astrophysics. A complete overview of the physics potential is given in Refs. [1,2]. Therefore, a nTOF facility has been built at the CERN PS, delivering a maximum intensity of 3×10^{13} protons in four pulses within a 14.4 s supercyle at a momentum of 20 GeV/c. The source is followed by a 182 m flight basis. This allows neutron cross-sections of almost any element to be studied systematically and with excellent resolution using targets of very modest mass — necessary for unstable or otherwise expensive materials — in the interval from 1 eV to 250 MeV.

2 The nTOF facility

The simulation of the detailed geometry of the lead target has been performed to estimate the neutron flux at 200 m. Two Monte Carlo codes were used successively: FLUKA [3] and the EA-MC Monte Carlo code [4].

Following an overall optimisation between neutron flux and $\Delta\lambda$ resolution (λ = effective neutron path), the spallation target was chosen to be a lead block of $80 \times 80 \times 40$ cm^3, followed by a water moderator of 5 cm thickness [2]. In the final design [5] the neutron emission takes place at an angle of 10° with respect to the proton beam direction and the target is made of pure lead blocks already used in the TARC experiment [6]. A thin single metallic window (aluminium alloy) of 1.6 mm thickness is the interface between the moderator and the vacuum in the nTOF tube [5].

The time-of-flight tube (Fig. 1) starts directly behind the window and ends where the sloped floor of the TT2A tunnel (1.18% gradient) touches the tube, thus allowing a length of 200 m. The pressure in the vacuum tube is ≈ 1 mbar. The tube is made up of four different sectors, the first one (Ø = 80 cm), closest to the target, is made of aluminium alloy whereas the others (Ø = 80, 60 and 40 cm) are made of stainless steel [5].

Two collimators were installed to reduce the radius of the neutron beam. The first one, 2 m in length (beam shaping collimator), is located at 136.7 m and the second one is placed at 178 m. A 2 m long dipole magnet, located at 145 m, is used to sweep away charged particles.

3 The commissioning

Two commissioning phases took place, one in November 2000 and another one at the beginning of April 2001, aimed at checking the performance of the facility and at comparing the data with the simulation. The incident proton beam delivered by the PS was monitored in intensity by current transformers and in shape by digitisation of CCD cameras. Additional measurements were related to safety aspects, namely the temperature of the

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target, the temperature of the cooling water and the activity of the resin filters, and different positions inside the tunnel.

We restrict ourselves to the second commissioning period where two parallel-plate ionisation chambers with fissile deposits, one with ^{235}U and another with ^{238}U, were used. These detectors are inter-comparison instruments and were provided by PTB Braunschweig. A full description of these fission chambers can be found in Ref. [7]. The detection efficiency of these detectors is practically constant and equal to 95% up to neutron energies of 10 MeV. In both commissioning phases pairs of gold foils were irradiated, followed by their gamma activation measurement.

The raw time-of-flight spectrum was corrected run by run for small shifts in the t_0 value, since the PS timing signal was sometimes not constant. Next the contributions from α particles and other charged particles produced by high-energy neutrons were eliminated by cutting in the flash ADC spectrum where a very clear separation was observed from the fission products. An additional correction had to be applied owing to the presence of tantalum, on which the ^{235}U is evaporated, and of platinum, which is the material of the electrodes. After all these corrections, the neutron fluence was obtained by dividing the data with the expected values from the ENDF [8] database. The preliminary result is shown in Fig. 2 for the ^{235}U and ^{238}U fission detector.

In the case of the ^{235}U detector a clear disagreement with the expectation is observed at the highest energies whereas for the ^{238}U detector, which is only sensitive to high-energy neutrons, the agreement is good. Recent measurements in the experimental zone revealed the presence of a γ background, presumably coming from the slowing down of fast neutrons with subsequent capture and for which the origin is not yet known. These background neutrons might be responsible for the excess of data at high energies.

4 Conclusion

The preliminary results from the commissioning measurements show a good agreement between the data and expectation. More measurements and calculations, mainly concerning the background, are now being performed before the facility is ready to make precise physics measurements.

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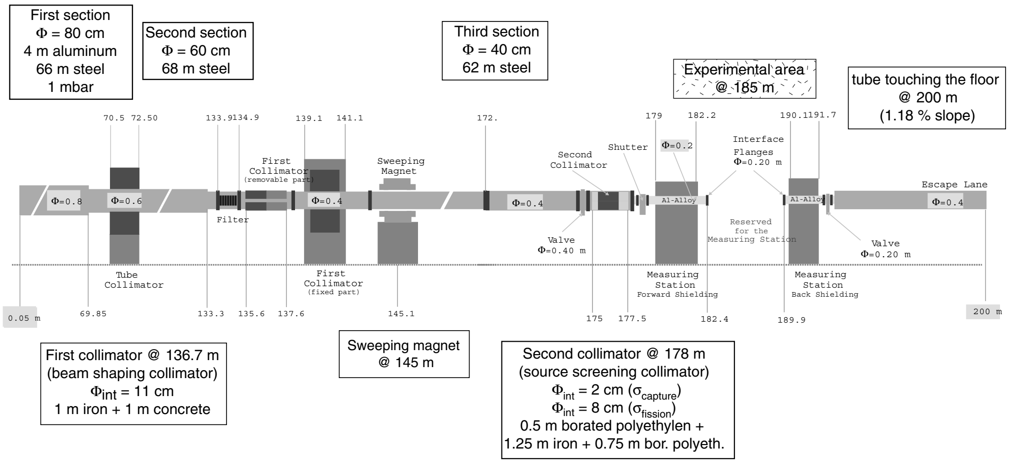

Fig. 1 Time-of-flight tube sections up to the end of the TT2A tunnel (200 m).

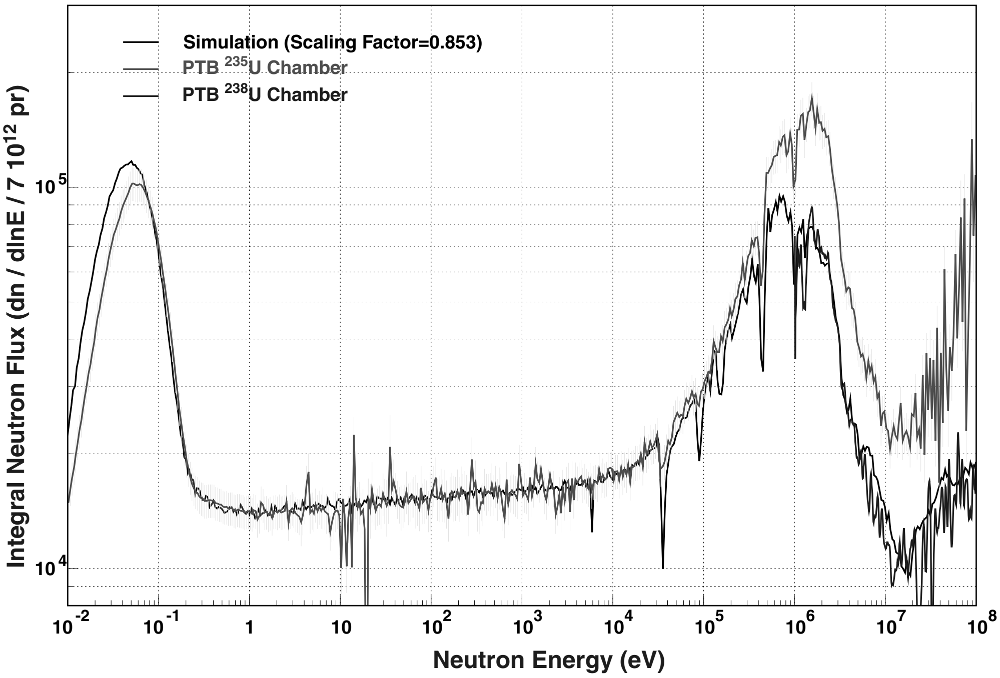

Fig. 2 Preliminary integrated neutron fluence from the ^{235}U (upper data curve) and ^{238}U (lower data curve) fission detector together with the expectation.