# First results of the measurement of the Ta(n,γ) cross-section at n_TOF, CERN (ID: #76)

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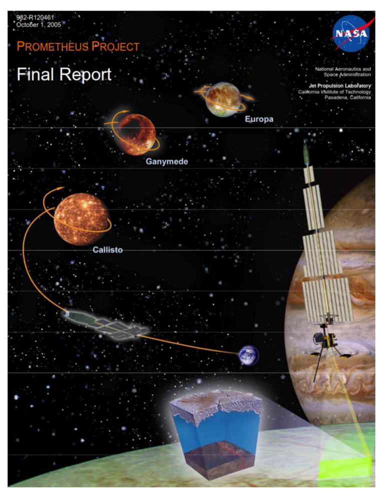
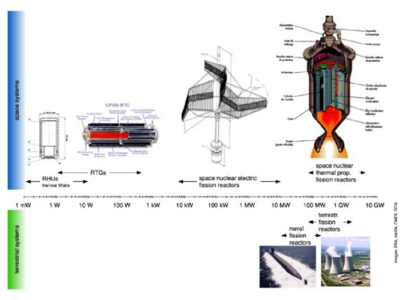
## Motivation

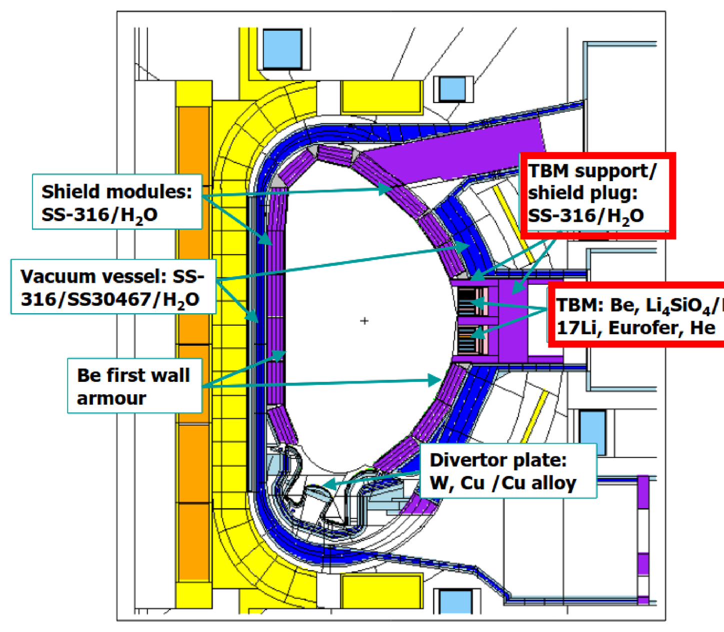




Metallic alloys or metals with high melting points such as tantalum are being considered for the development of nuclear reactors for space. In recent critical experiments using highly-enriched uranium or plutonium fuels, moderators, and tantalum, large discrepancies have been found between the predicted and measured $k_{eff}$ (i.e., needed critical masses). These observed discrepancies have been attributed to larger than reported uncertainties in the nuclear data of the materials involved, mainly tantalum, plutonium, and graphite.

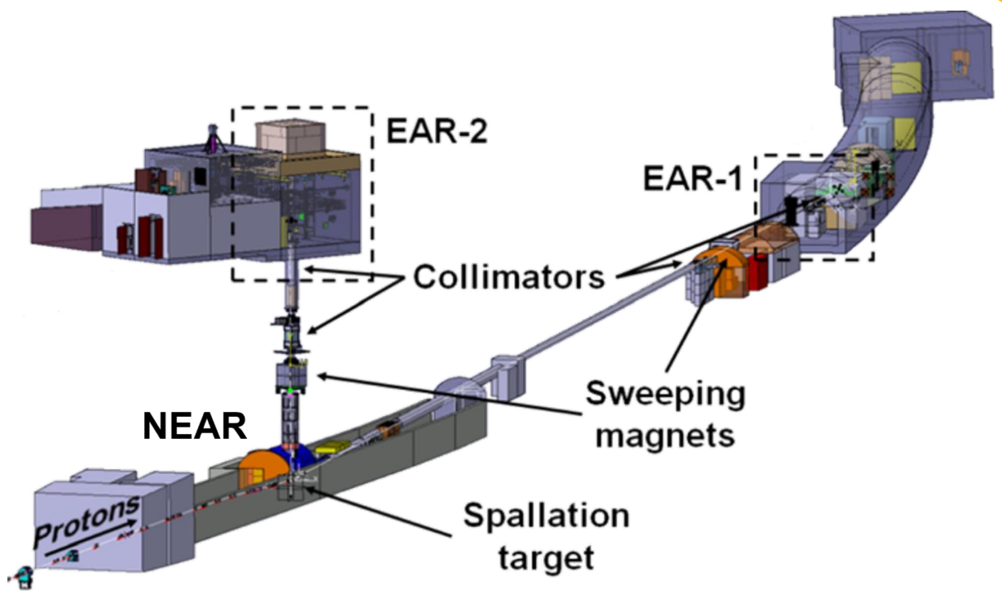
The Ta(n,γ) cross section has also been reported as an important contributor to the uncertainty in the activation and heating of magnets used in large fusion reactors. The different measurements of the Ta neutron capture cross section used in the evaluations are discrepant and affected by important experimental corrections such as self-shielding and angular correlations between γ-rays.

**The ITER reactor**




## n_TOF

n_TOF is a neutron time-of-flight facility located at CERN. The neutron beam is produced by spallation of a 20 GeV/c protons in the lead target.

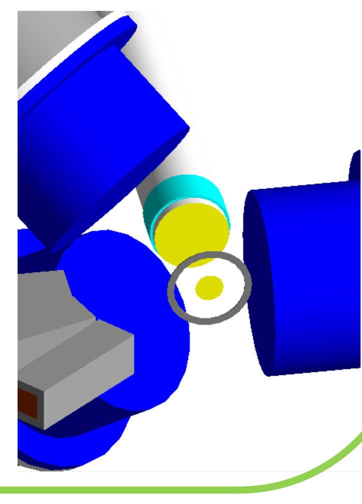



The facility has three experimental areas: EAR1, EAR2, and NEAR, located at different distances from the target. The facility is characterized by a high instantaneous neutron flux (especially in EAR2) and high energy resolution (especially in EAR1). The Ta experiment have been performed at EAR1.

## Detection setup

Different kinds of $C_6D_6$ liquid scintillator detectors have been used: the BICRON and the sTED, with 0.614 l and 0.047 l of active volume, respectively. The sTEDs are placed at different angles to measure the anisotropies in the γ-ray emission. The setup consists of:

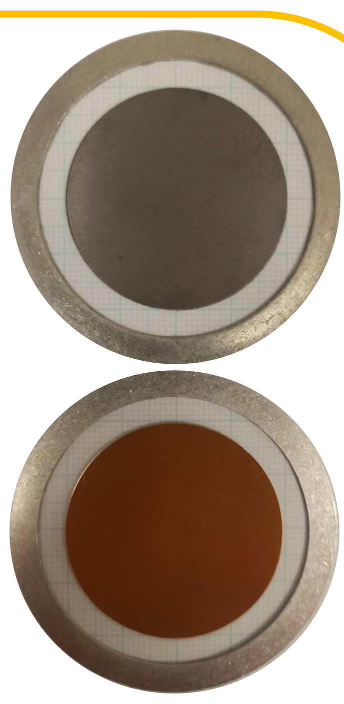
- 1 BICRON at 3.7 cm and 90° from the beam.
- 2 BICRON at 9.0 cm and 125° from the beam.
- 3 sTEDs at 10 cm and 90°, 110°, and 130° from the beam.



The Pulse Height Weighting Technique will be used in the analysis. Therefore, simulations of the detection setup are needed to determine the detector response.

## Samples

Three metallic, high-purity (99.999 %), natural Ta samples of 500, 100, and 10 µm thickness and 4 cm diameter provided by GoodFellow have been used. The different thicknesses will be useful to obtain the cross section in different energy regions, to normalize, and to verify the multiple corrections. Also, samples of 2 cm diameter have been measured to check the effect of the beam profile.

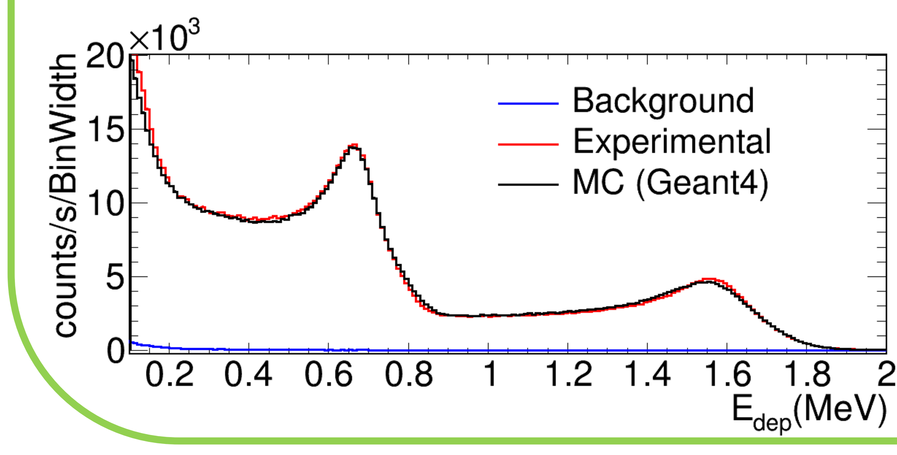


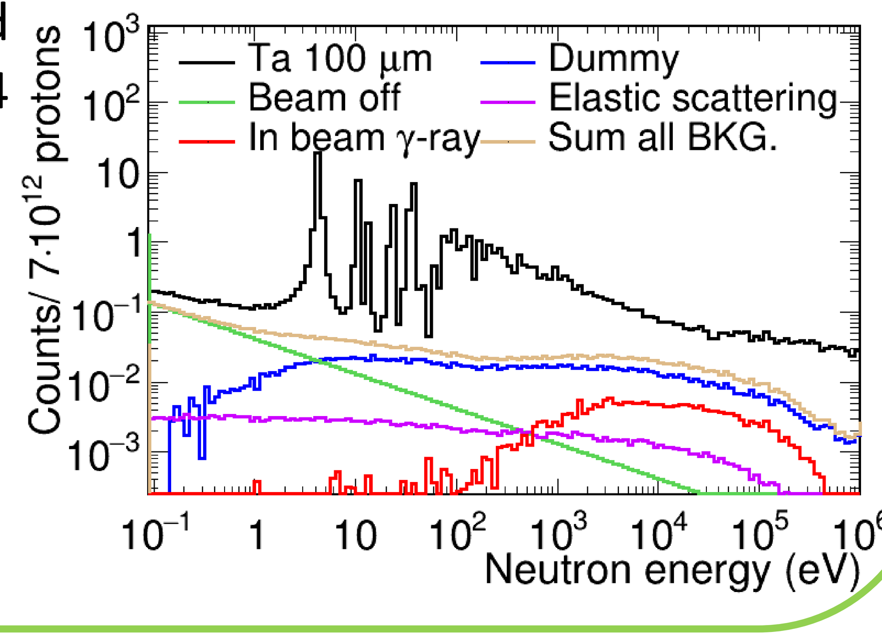
In addition to the Ta samples, other samples have been measured to determine the different background components: $^{197}$Au (to check the normalization), dummy (to determine the background due to the beam), carbon (for the elastic background), and lead (for the in-beam γ-rays).

## Experimental campaign

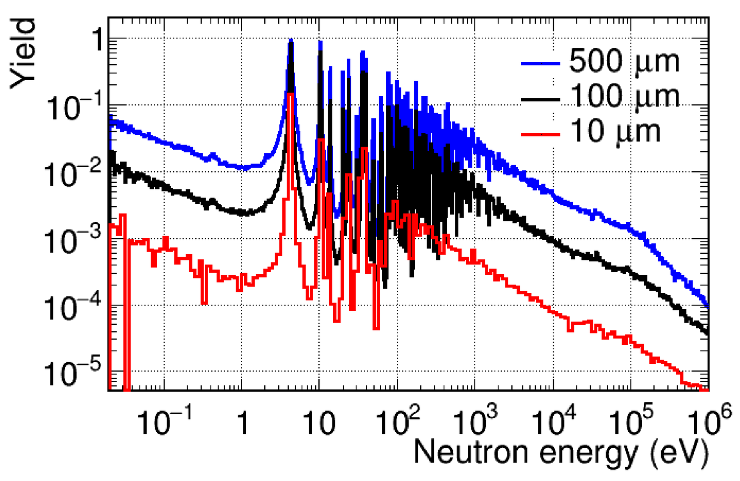
The experimental campaign was carried out in May of 2024, with a total of $3{\cdot}10^{18}$ protons. The different backgrounds have been estimated with the auxiliary measurements properly normalized. The main background contributor above 5 eV is the one due to the beam (Dummy).

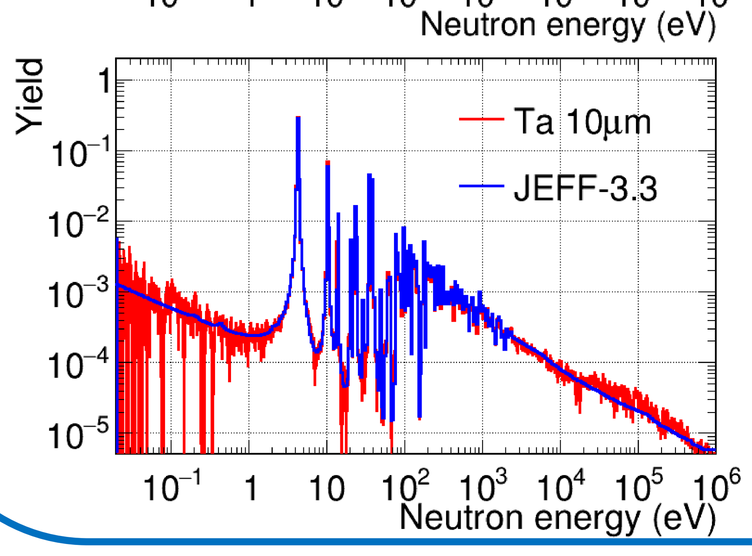
The detector response obtained experimentally and with Geant4 agree for an $^{88}$Y source.




## Results




The preliminary analysis of the data obtained with the Ta samples has been performed up to 1 MeV. The results obtained with the different samples are compared with JEFF-3.3 in the figures shown on the sides.

There are some corrections that have not been applied yet. For example, the attenuation of the γ-rays on the sample, the correction due to the inelastic channel that starts to be relevant above around 200 keV, or the possible anisotropies in the γ-ray emission.

The different capture yields will be fitted using the R-Matrix formalism with SAMMY. The various samples will be used for fitting the resonances in different energy ranges. For example, the thin sample (10 µm) is suited to measure the resonances from 1 to 100 eV; in this energy range, the resonances saturate for the other two samples. Above 100 eV, there is not enough statistics to fit the resonances with the thin sample.