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Characterization of the new PGAA and PGAI facility at the research reactor FRM II

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In April 2007 we have started first test measurements at the Prompt Gamma-Ray Activation Analysis (PGAA) station at the research reactor FRM II in Garching near Munich, Germany. We have measured the neutron flux intensity, which is probably the highest cold neutron flux in the world now, and the cold neutron spectrum distribution. With this knowledge, we started to analyze the background caused by the neutron beam and proceeded to the first experiments. Here we describe the characteristics and parameters of the PGAA instrument.

Keywords – PGAA, PGAI, FRM II, neutron guide design, elliptical tapering, ballistic guide, Ancient Charm, cold neutron flux

I. INTRODUCTION

A new PGAA instrument [1] has been built at the research reactor FRM II in Garching near Munich, Germany [2]. The neutron flux measured at the exit of the neutron guide is 6.0×10^{9} n/cm^{2}s with a mean wavelength of 6.7 Å. This neutron flux intensity corresponds to about 2.2×10^{10} n/cm^{2}s of thermal equivalent neutron flux. Since the last 5.8 m of the neutron guide follow a ballistic geometry of a half-elliptical shape, the focal point for the neutrons is located at the sample position about 30 cm far from the exit window. It yields in intensity up to about 7.3×10^{9} n/cm^{2}s with useful beam dimensions of 14 mm × 38 mm. This is more than sufficient for the standard PGAA samples, their weight is usually in range of mg – g.

The neutron guide can be extended by a 1.1 m long Helium gas-flushed guide which follows exactly the same elliptical geometry and focuses the neutrons to a spot of about 4 mm × 11 mm at a 9 cm distance from its end. This brings a yield in the cold neutron intensity up to 2.0×10^{10} n/cm^{2}s (7.4×10^{10} n/cm^{2}s thermal neutron equivalent). However, this value still relies on the simulations, because we have not yet confirmed the value by a measurement with gold-foil activation for its geometrical complexity.

II. EXPERIMENTAL

For the data acquisition, standard Compton-suppression spectrometer is in use. With such a high neutron flux, we have to be very careful in choosing appropriate material for the gamma as well as neutron shielding and any material close to the neutron beam to avoid unnecessary scattering and creation of Compton background or fast neutrons, which may affect the resolution and performance of the new 60% n-type HPGe detector. In January 2008 we made an improvement in this task and decreased the background counts to about 650 cps in the whole spectrum range going from 100 keV up to 11 MeV. This countrate value is still higher compared to the PGAA facility in Budapest [3] and to their neutron flux, however only by a factor of about 5.

Next step was to make the detector efficiency calibration to analyze first samples. This work will be described at this conference in more detail by L. Canella [4] who will also present the limits of detection reached by the current set-up at the PGAA instrument.

III. OUTLOOK

With the help of the thorough PGAA analysis of the current beam background spectrum we could identify neutron capturing materials which still have to be replaced by other shielding materials to lower the background. Our goal is to reduce the background counts also by changing the collimating system of the instrument to reach generally better limits of detection. As soon as this part is satisfactorily completed, we will start to test and use the 1.1 m guide to focus the neutrons at one spot for the Prompt Gamma Activation Imaging (PGAI), which is a part of the challenging EU project called ANCIENT CHARM [5]. For this research project, valuable archaeological objects shell be analyzed. The position sensitive PGAA will be performed with up to 1 mm^2 precision and compared to the results of other currently developing neutron imaging techniques. The acquired results summarize all non-destructively available information about chosen spots in the objects and their combination is of the interest for the archaeologists.

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