Recent Developments in Neutron Metrology, Neutron Dosimetry and Related Areas at the Physikalisch-Technische Bundesanstalt (PTB)

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1. Neutron Metrology

As mentioned already in the last progress report, the most urgent problems for the PTB neutron metrology group is the procurement of new tristearin or polyethylene radiators for the PTB proton recoil telescopes. A final solution could not be found so far, but discussion with the sample preparation group at IRMM are ongoing to set up a collaboration for manufacturing and characterising new tristearin or polyethylene radiators. The material used to make the old radiators presently in use at PTB is still available at IRMM. In first step this material was reanalysed at the Institute for Pharmaceutical Chemistry of the Technical University of Braunschweig. The result of the elemental analysis showed that the measured H/C ratio agreed with the nominal value within the uncertainty of 0.3%. However, the O/C ratio could not be measured using the analyser available at this institute. Hence, either another analyser has to be used or polyethylene sample have to be employed. Moreover, the question of the strict traceability of chemical measurements still remains open.

Within the framework of the EFNUDAT project a comparison of several ^{238}U and ^{235}U fission ionisation chambers of IRMM with the fission chambers H21 (^{238}U) and H19 (^{235}U) of PTB was carried out. In addition to the fission chambers, a well-characterised 2"$\times$2" liquid scintillation detector and the recoil proton telescope RPT1 of PTB were used. This comparison was performed at neutron energies of 8.4 and 15 MeV using pulsed deuteron beams. The normalised fluence values measured using these instruments showed a standard deviation of about 1%. Hence, this comparison demonstrates that the characterisation of the 10 mg/cm² tristearin radiator of RPT1 is still valid.

A memorandum of understanding was signed by iThemba Laboratories, University of Cape Town and PTB on the co-operation in high-energy neutron metrology. Unfortunately, it turned out to be impossible to include the South African NMI NMISA in this collaboration. Under this agreement, PTB made equipment available which will be permanently deployed at the iThemba neutron beam facility. In particular, a ^{238}U fission chamber was obtained from IRMM, re-characterised at PTB relative to the recoil proton telescope RPT1 and deployed at iThemba as the reference instrument for fluence measurements. The South African partners were successful in obtaining funding from the South African National Research Funds (NRF) for purchasing electronic modules and a multi-parameter data acquisition system for the neutron beam facility. The facility is now well equipped which reduces considerably the overhead necessary for using the facility.

The operation of the FRG1 reactor of the GKSS research centre in Geesthacht near Hamburg stopped in April 2010. Therefore the thermal reference beam operated by PTB is no longer available. Because of the ongoing staff reductions at PTB there are presently no plans to set up a new thermal reference at one of the other German research reactors which has the same metrological quality as that at GKSS.

A new californium source is to be purchased for the radionuclide source facility. The new source will contain 250 µg of ^{252}Cf and have a source strength of $5 \cdot 10^{8}$ s^{-1}.

2. Neutron dosimetry

To compensate the shutdown of the thermal reference beam at GKSS at least partially, a new thermal field will be set up at PTB. This field will be produced by a set of Am/Be sources inserted in a graphite pile. According to MCNP simulations, about 80-90% of the neutron fluence should be thermal neutrons. The dose equivalent rates will range around 1 µSv/h at typical irradiation positions and the photon dose fraction will be around 10%. Hence, this field will not substitute for the GKSS field which was virtually free of epithermal neutrons and photons, but it will be valuable for testing developing radiation protection instruments, in particular personal neutron dosemeters.

3. Applications of fast neutrons in science and technology

The EU-funded EFNUDAT project ended in November 2010. It supported the use of accelerator facilities and reactors in Europe for measurements of nuclear data relevant for innovative reactor systems. Within this framework, the PTB accelerator facility attracted five projects and provided 370 hours of beam time. The follow up of EFNUDAT will be the ERINDA project which supports access to infrastructure along the same line as EFNUDAT. More information can be obtained from the website www.erinda.org.

The PTB group also participates in the TRAKULA project which is financed by the German Ministry for Education and Research (BMBF). This project brings together several German research institutes and universities working on nuclear data for transmutation of long-lived nuclear waste. Within this project, a postdoctoral fellow will work on setting up a 14 MeV neutron fluence standard at PTB using the time-correlated associated particle method. The main motivation for this project is the need to cross-check the characterisation of artefacts such as radiators or fissile layers.

4. Technical development of the accelerator facility

Significant problems occurred at the PTB 3.7 MV Van-de-Graaff accelerator at the end of the year 2009. This accelerator is a KN 3750 machine manufactured by High-Voltage Engineering BV (HVE). The last available original charge transport belt for the accelerator was lost just before Christmas 2009. Subsequently, the accelerator staff tried to find a replacement from materials used for normal conveyer belts. Although this search had been successful for several other Van-de-Graaff accelerators in the past, it was extremely difficult to find a material which had the required mechanical and electrical properties for the PTB machine. In this process, many modifications were made to the machine to adapt to the properties of the belt materials. Finally a material was found which was manufactured by a Swedish company. A belt of this material is now running on the PTB machine which allowed to achieve again the same specifications as with the original HVE material, including also operation in pulsed mode for time-of-flight measurements.

The plans to procure a 5 MV tandetron machine as a replacement for the ageing single-ended Van-de-Graaff were accepted by the presidential board of PTB and the federal ministry of economy. Funding is included in the budget for year 2014.

To reduce our dependence on external target laboratories, a new UNIVEX evaporation stand was procured which is equipped with a thermal evaporator as well as an electron gun. This setup makes it possible to produce also layers of refractory materials such as scandium or calcium flouride. It also enables the production of targets with two layers without breaking the vacuum. This is of interest in cases where diffusion of reactive material into the backing is a problem. To enhance our target characterisation capabilities, a new HPGe detector was obtained which will, among other tasks, be used for more routine characterisations of targets using the NRA method, e.g. the $^{7}Li(\alpha,\gamma)$ reaction for lithium and lithium fluoride targets.