EUROfusion
TECHNOLOGY TRANSFER PROGRAMME

Gamma spectrometry for radioactive material characterization

The National Center for Scientific Research "Demokritos" (CNRD) has developed specific facilities and methodology for the radiological characterization of nuclear materials! Indeed, nuclear fusion research requires the investigation of the radiological properties of ITER material samples after neutron irradiation, the validation of neutron streaming and material activation calculations at positions close and far from the plasma source and finally the development of a new activation detector for neutron fluence measurements and spectrum evaluation in the breeding blanket of future fusion power plants. Radiation measurements of materials, in conjunction to radiation transport simulations, are available at their lab for use in nuclear, environmental, industrial and medical applications, where accurate non-destructive measurements of radioactivity in samples of up to several liters in volume are required.

Description of the technology

Radiation measurement studies in fusion energy relevant materials and the assessment of their neutron activation properties is of great importance for the development of advanced materials presenting low-activation properties, since this is strongly related to radiation protection of the personnel during fusion plant maintenance and operation, as well as for the optimization of material recycling and radioactive waste management after the end-of-life of the plant.

To understand the radiological properties of fusion materials and make predictions for their behaviour under neutron irradiation in the extreme conditions encountered in a fusion power plant, the NCSRD team uses a combination of radiation measurement technologies. The available capabilities include several fully operational HPGe-based gamma spectrometry systems, each adapted to perform a specific type of measurements, such as:

- Large sample analysis, with coarse resolution gamma scanning option available
- Compton continuum suppression spectrometry
- High activity sample analysis
- In situ gamma spectrometry

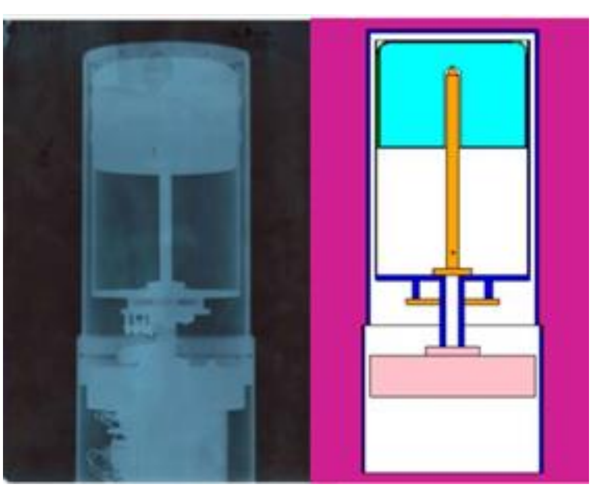

Figure 1 HPGe detector X-ray scan and simulation model

Figure 2 Compton Suppression Spectrometer

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Description of the technology

All detectors are calibrated using reference gamma sources and Monte Carlo simulations, taking into account different sample types, shapes and sizes, as well as different measurement geometry configurations.

The strength of this technology offer lies in the possibility to combine the above mentioned experimental gamma spectrometry techniques and capabilities , with the extensive experience of the team in modelling all kinds of radiation measurement configurations, allowing integrated studies for all classes of materials and over a wide range of sample volumes. The core research team comprises a Research Director and a Senior Researcher with more than twenty five years of experience in gamma measurements, neutron activation analysis, radiation protection and radiation transport simulations, as well as two post-doctoral researchers specialized in the area of radiation measurement applications. Moreover, collaboration and contribution from other research teams at NCSRD are in place and can be utilized for addressing specific applications, i.e. materials science, biosciences, nuclear physics and technology, as well as informatics.

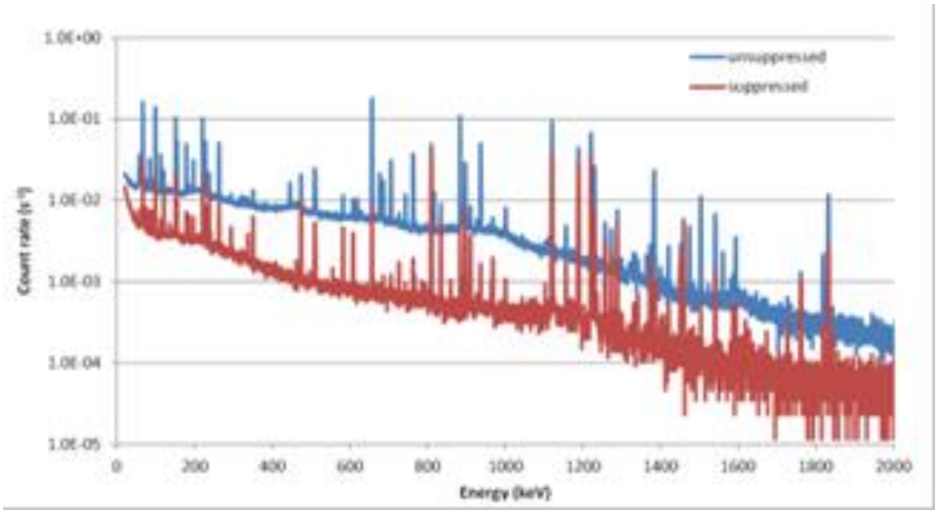

Figure 3 Typical gamma spectrum of an activated neutron detector

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Innovation and advantages of the offer

The innovative aspects of the technology offered include the optimization of the gamma spectrometry technique and methodology for the solution of a specific spectrometry problem and the provision of the appropriate theoretical support by detailed radiation transport calculations which are performed utilizing state-of-the-art simulation codes and nuclear data. In addition, gamma measurements can be combined with other material characterization techniques offered by their research group -or other NCSRD groups- to enable an in depth understanding of the radiological properties of fusion and non-fusion materials in a range of applications.

Non-fusion Applications

The described facilities and methodologies have been developed primary for applications in fusion. Nevertheless, their applications have been extended to the nuclear technology domain to perform neutron dosimetry using activation detectors, characterization of activated and contaminated materials in nuclear reactor facilities for decommissioning, radioactive waste characterization, as well as environmental monitoring applications. Moreover, collaborations have been established with nuclear physics groups from Greek Universities, pursuing accurate measurements of neutron induced activities in specific radionuclides for cross-section measurements. A growing need for radiation measurements of materials, in conjunction with radiation transport simulations, is also met in other nuclear, environmental, industrial and medical applications, where accurate non-destructive measurements of radioactivity in samples of up to several litters in volume are required.

EUROfusion Heritage

The developed facilities and methodology has been applied in the framework of EUROfusion research activities in order to: 1) investigate the radiological properties of ITER material samples after neutron irradiation at the Joint European Torus (JET),experimentally determine their induced activities under realistic D-D, T-T and D-T fusion conditions and benchmark predictions of state-of-the-art computation codes and data used in ITER design. 2) validate neutron streaming and material activation calculations at positions close and far from the plasma source at JET 3) develop a novel activation detector for neutron fluence measurements and spectrum evaluation in the breeding blanket of future fusion power plants. The significant experience gained from the participation in all these fusion projects and activities has now been incorporated into an integrated and innovative approach with significant added value in other applications, as well.

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