UK country report

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News:

UKAEA have made some progress analysing a large database of high-resolution gamma-spectroscopy measurements for samples irradiated at the ASP 14 MeV neutron accelerator-based source. 8 experiments on molybdenum (out of more than 300 available) were processed in detail and compared to TENDL-2019 cross sections of production for several short-lived radioisotopes. The results were favourable and demonstrated how the ASP data could be utilised in the future (Gilbert et al. Nuclear Fusion 60 (2020) 106022).

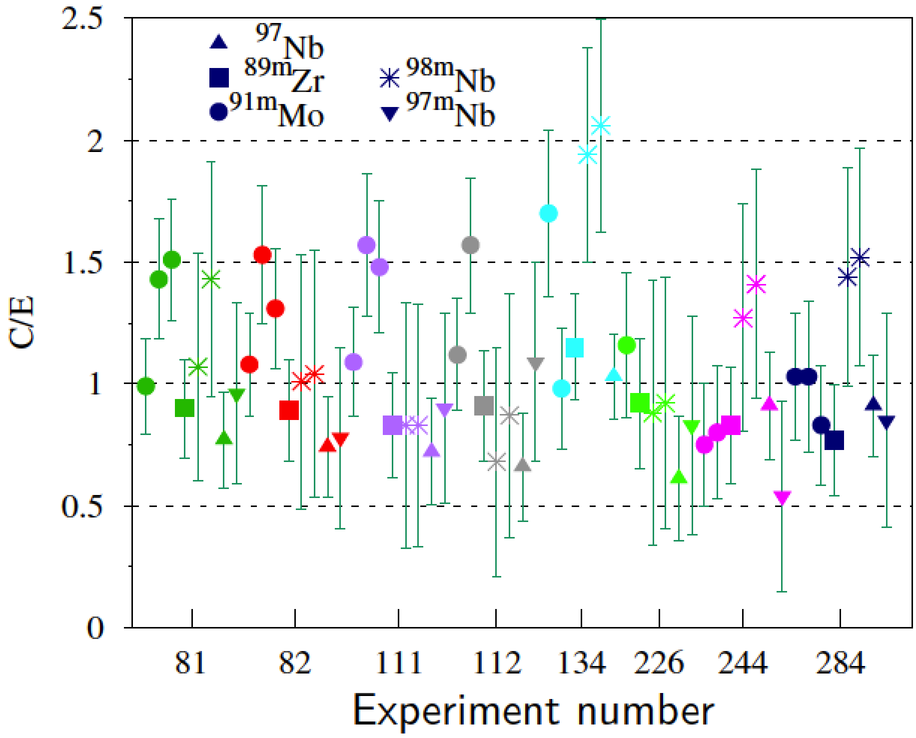

Figure 1C/E values for different radionuclides across several ASP irradiation of Mo

Recent analysis of fusion decay-heat experiments has identified discrepancies in the neutron multiplication xs on ^{186}W (and potentially others). This is important for fusion engineering as the decay-heat impacts on maintenance planning. An apparent overestimate of the cross section at 14 MeV (particularly to ^{185m}W) warrants further analysis (Nuclear Fusion 59 (2019) 086045).

National Nuclear Laboratory is part of the Advanced Fuel Cycle Programme (AFCP), which is aimed and developing the capabilities for the development of advanced fuels – focus on high temperature gas and liquid metal fast reactors. Research includes work to improve the angular distribution evaluations for fission of ^{236}U, measurement of (n,a) in bulk fuel, optioneering of novel cladding, and development of FISPIN. NNL have also performed a review of criticality and reactor benchmarks identifying a lack of data suitable to verify nitride fuels in thermal reactors (sufficiently for UK regulations); scattering cross sections for ^{14}N and ^{15}N are poor in the thermal range. Also issues with (n,p) and capture xs of ^{14}N.

Wood (formerly Amec Foster Wheeler) sold its nuclear business to Jacobs in March 2020. The ANSWERS software service has released (in 2021) WIMS11 (reactor physics), MONK11 (criticality), MCBEND12 (shielding) with JEFF-3.3, ENDF/B-VIII.0 and IRDFF-II data libraries. Jacobs have an upcoming collaboration on neutron cross section measurement with EC-JRC Geel, ORNL and university of Manchester.

STFC (including RAL and ISIS) have continued work on scattering kernel development with the CNEA Bariloche, including experiments on several organic ring structure materials, and have upcoming experiments on mixtures of different materials. Have plans to review the status of data for spallation and activation of molybdenum.

IRDFF libraries are the benchmark standard for dosimetry studies, including for recent JET experiments (Packer et al. Nuclear Fusion 58 (2018) 096013) of ITER materials. Thus, fusion has a strong interest in performing validation studies to compare IRDFF-II to other sources of reaction data, including previous versions of IRDFF (e.g. 1.05). Using a subset of the FNS decay heat benchmark (i.e. only those experiments testing reactions that appear in IRDFF) we noted a few changes in IRDFF-II that meant it performed less well than IRDFF-1.05 – this needs further analysis.

Experimental activities relevant to nuclear data are continuing at JET, led by UKAEA, as part of a EUROfusion-funded project to irradiate further ITER material samples. These samples, which include a range of steels from different manufacturers, CuCrZr alloys, W alloys and specialist low activation steels, will be irradiated in the JET neutron environment during a tritium experimental campaign, followed by a deuterium-tritium experimental campaign in 2021/22. These experiments will take advantage of the large neutron yields that are expected during this time (around 1E21 neutrons in total). The samples, together with dosimetry foil reactions, will be measured via gamma spectrometry techniques post-irradiation and will be compared with inventory simulations to serve as a tokamak fusion technology-oriented benchmark data set. Recently acquired results for ITER samples to deuterium plasma neutrons in a 2019 experimental campaign. UKAEA will report on these activities in detail at the IAEA Fusion Energy Conference in May.

Future needs and interests:

UKAEA have recently identified the critical experimental capability needs for fusion (as part of discussions on a new neutron source in the UK). These include:

- Alpha reaction cross sections at 3.5 MeV to support efforts to develop diagnostics for alpha-losses from fusion plasmas. Examples include Ge(n,a) xs, but we would encourage a dedicated effort to explore the availability of alpha-induced reaction data across the periodic table to enable feasibility and optioneering studies of alpha-diagnostics.
- Gas production measurements under neutron irradiation. Needed in general, but particularly, for example, on ^{12}C where (n,n3a) competes with (n,a) at 14 MeV and

might have significant impact on the viability for fusion materials containing carbon (e.g. W-C, SiC).

- Transmutation measurements for direct comparison to the outputs of inventory codes such as FISPACT-II. Irradiations and then measurement of composition changes using mass spectroscopy or advanced techniques such as Energy-dispersive X-ray spectroscopy (EDX) and Atom-probe-tomography (APT).

The UK had a strong involvement in the recent IAEA consultancy meeting on the new and improved nuclear data forms needed for the monitoring, characterisation, dismantling, decommissioning and disposal (McDDD) of the current and future generations of nuclear systems. Rolls-Royce have an ongoing need to improve modelling of advanced fuel systems to support the development of the compact reactors of the future, while UKAEA needs reduced uncertainty in nuclear code predictions to enable realistic design engineering of the next generation of fusion reactor experiments and power plants, particularly for decommissioning and maintenance planning.