Benchmarking of the modelling tools within the EUROSOL DS project

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The European Community decided to support the design study and R&D for a next generation ISOL RIB facility able to increase by a few orders of magnitude, as RIA in the US, the exotic beam intensity and availability in Europe. Forty institutes and laboratories within Europe, North America and Asia are taking part in this initiative, named EURISOL DS project (European Isotope Separation On Line Design Study) [1]. The envisaged increase of beam intensities, by several orders of magnitude compared to actual facilities, means a drastic increase of the radioactive inventory and corresponding radioprotection related issues. In brief, EURISOL is aiming at ~1 GeV proton driver (4 MW CW beam power) and ~10^{15} fissions/s in the RIB production target. Both solid and liquid high power technologies are envisaged.

Although some valuable experience is already available from presently operating ISOL facilities world wide, the design of a new generation RIB factory requires specific and validated modelling tools. In this context, detailed simulations should be performed in order to optimise the RIB production in terms of target geometry and materials, incident particle types and their energy, etc. Equally, the radioprotection and safety issues should be addressed and will be based on detailed calculations of particles fluxes, induced radioactivity and resulting dose rates.

We started the above work by benchmark calculations within pre-defined EURISOL conditions, i.e. ~1 GeV protons interacting with different materials (U, Pb, W, Hg, Fe, Be, C, …) and choosing neutron, charged particle and residual nuclei production as observables to be tested against available experimental data.

We benchmarked up to 10 physics model combinations available in the transport code MCNPX [2], i.e. three intra-nuclear cascade (INC) options (Bertini, Isabel and INCL4) coupled with three possible de-excitation models (Dresner associated with RAL or ORNL for fission, and ABLA). In addition, we also tested the CEM model being a stand alone combination within MCNPX. Different model predictions were extensively compared with available experimental data on thin and thick targets, so both physics models and particle transport could be examined in detail. One should note in particular the usefulness of the European HINDAS project and also some ISTC projects, which resulted in valuable experimental data sets related to spallation reactions.

After extensive comparison of different model predictions with data we are able to recommend the "best" physics parameter set within MCNPX for further design studies of EURISOL. The importance of this exercise is illustrated by a number of realistic geometry calculations and consequences in RIB beam intensity predictions and safety and radioprotection issues in particular.

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[1] For more info the reader is asked to check the information available the EURISOL Design Study web page at http://www.eurisol.org (April 2006).

[2] MCNPX- Monte Carlo N-Particle Transport Code System for Multiparticle and High Energy Applications; http://mcnpx.lanl.gov/ (April 2006).