Spanish report on nuclear data needs and activities for the 32th INDC meeting on June 2021

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Nuclear data needs

Nuclear data needs in Spain had been identified form scientists in various fields of research and applications, including nuclear fission technology, fusion research, health applications, astrophysics, and basic nuclear physics.

Most requests had been identified by CIEMAT, CSIC, CNA and several Universities (USC, UPM, UPC, USE, UCM, UGR, ...) working on nuclear data measurement and validation, physics research and, on the other hand, by users of evaluated data for the design and safety analysis of nuclear fission reactors, optimization of fuel cycles, including nuclear waste minimization by partitioning and transmutation, research for ITER, IFMIF and other options for fusion, optimized nuclear medical techniques for diagnosis and treatment, as well as shielding and radioprotection.

Some of the identified nuclear data needs include:

- To continue providing a generalized improvement of the uncertainties and covariance data for cross sections and other nuclear data relevant for simulation applications, and particularly for those related to safety parameters,
- Clarification of capture cross sections for main nuclear fuel actinides, including ^{239}Pu.
- Fission, capture and other absorption reaction cross sections for the characterization and prediction of the open cycle inventories and for the optimization of advanced fuel cycles, including medium lived Pu, Am and Cm isotopes (like ^{238}Pu, ^{241}Am, ^{243}Am, ^{243}Cm, ^{244}Cm, ^{245}Cm,...)
- Continue the improvement of nuclear data on the delayed neutron emission and decay heat from fission fragments
- Data for new radio-isotope production, in particular by proton induced reactions,
- Data for hadrontherapy, including double differential proton induced reaction cross sections with production of neutrons,
- Data for (n,ch.p.) reactions that could complement B(n,α) for cancer therapy,
- Improving the models and cross section values of deuteron induced reactions related to IFMIF and other fusion related applications
- Automated computer access (API) to the main libraries (EXFOR, ENDF, ENSDF) for open access to the data.

Recent nuclear data activities

During the last 25 years there has been a growing attention in Spain for nuclear data needs and a consequent growing involvement on the participation on nuclear data measurements and international efforts to improve nuclear data quality.

The limited experimental capabilities available at Spain for nuclear data measurements resulted on the concentration of the Spanish activities on international experimental facilities, notably at CERN, in the experiments n_TOF and ISOLDE, and at GSI, but also with some activities at IRMM (JRC), LNL (Italy), CEA and GANIL (France), Jyväskylä JYFL (Finland), PTB (Germany) and other facilities in Europe.

The activities at n_TOF included the contribution to key elements of the facility, like the neutron collimation optics, the second and third target design, the characterization of the advanced detectors and the conception of an advanced data acquisition system. More recently they have provided significant contributions to the design of the third target to be deployed during the coming long stop of CERN. Different Spanish R&D groups working at n_TOF coordinated a number of capture and fission measurements, notably in actinides, potential isotopes for structural materials like Pb, Bi or Fe isotopes and (n,α) measurements. Furthermore, several of the Spanish groups have also participated in experiments for nuclear data useful for astrophysics that had already been reported in previous editions of the INDC meeting. The Spanish contribution to n_TOF represents about 20% of the collaboration.

The experiments at GSI involving Spanish institutions, have concentrated on the characterization of the spallation process induced by protons of different energies on heavy elements targets using reverse kinematics and evaluating spallation yields and total fission cross sections. Recent efforts of the Spanish groups in this area are focusing in the contribution to detector developments for FAIR, with relevant shares on AGATA, and in the NUSTAR experiments HISPEC, DESPEC, MATS and R3B. Some of the detectors being developed for FAIR might be used in other facilities.

Another important activity of the Spanish groups has been the support and preparation of evaluated nuclear data to be used by GEANT4 end the enhancement of functionalities of this code for neutron and heavy charge particles. The resulting material is already available from the NDS IAEA web page.

Particular attention has also been devoted to developing tools to be able to use nuclear data uncertainties in fuel cycle calculations, and to identify the nuclear data needed to reduce the uncertainties in this type of calculations by developing the required sensitivities.

Most of the increasing involvement of Spanish institutions in those international experiments and facilities has been performed in the framework of different EURATOM nuclear data projects. Indeed, CIEMAT has coordinated the ANDES project (Accurate Nuclear Data for nuclear energy sustainability - FP7) that was completed on October 2013 and the CHANDA (Solving Challenges in Nuclear Data for the Safety of European Nuclear Facilities) project that started on December 2013 and has finish on May 2018.

More recently, CIEMAT coordinates the SANDA (Supplying Accurate Nuclear Data for energy and non-energy Applications) H2020 EURATOM project and participates on the complementary action ARIEL for transnational access to facilities related to nuclear data research. SANDA started its activities on September 2019 and has a duration of at least 4 years. CHANDA is dedicating significant resources to perform new differential and integral measurements, to improve the measurement methods and detectors, to further develop the evaluation tools and the tools to facilitate the integration of the new data and their uncertainty into routine neutronic simulations. The detailed description of SANDA activities is openly available at the SANDA web page (http://www.sanda-nd.eu/) and the progress is also publicly available at the indico web page of the recent 2021 annual meeting (https://indico.cern.ch/category/11566/).

Besides the detector development of several of the Spanish participants in nuclear data projects, there are 2 significant Spanish facilities for nuclear data: the National Accelerator Centre, CNA, (located at Seville) and the CUNA, Canfranc Underground Nuclear Astrophysics laboratory. The National Accelerator Centre includes several small accelerators, including tandem and Cyclotron of up to 18MeV, and other experimental facilities, and is able to produce neutron beams for Maxwellian-averaged cross-section (MACS) at kT = 5 – 100 keV. The CNA will also make measurements of neutron and proton induced reactions of interest for health applications.

Since 2019 the Spanish technological platform for nuclear fission research, CEIDEN, has setup a working group to promote and disseminate the Nuclear data research between the Spanish nuclear research community. This group is organizing annual events to exchange information and priorities between the different research groups. The first event was organized in may 2019, and included presentations on NEA, IAEA, EURATOM activities as well as reports of the research at CIEMAT, Seville Univ., Madrid polytechnic Univ (UPM). The audience included a wide representation of research, academia and industry. The discussion of the meeting highlighted:
- Needs for Quality Assurance tests on distributed libraries including final user formats (ACE, AMPX,…), avoiding the need for user processing of libraries.
- Need to understand the limits of quality of available data for present reactors (compensation of errors, regions/components with little instrumentation,…).
- Difference between the perception of nuclear data needs from industry, regulator and research.
- Potential needs of new nuclear data for ATF for LWR.
- Further dissemination of good practices for nuclear data processing and use.
- Continue efforts of detailed evaluations and tools for integral benchmarks of different types (SINBAD, SFCOMPO, FR prototypes, …).
- Impact of nuclear data on the spent fuel isotopic content and management.
- Benchmarking and assessment of the impact of nuclear data impact on the understanding and simulation of the back-end of the nuclear fuel cycle.
- Credible and comprehensive uncertainties and correlations data bases.
- Further attention to nuclear data for non-energy application.

The 2020 annual event of the CEIDEN nuclear data group was devoted to nuclear data needs for ATF. The event, although mainly national, was open to international contributions including reports from JRC and NEA, NNL/UK, PSI/CH and GRS/DE in addition to the Spanish contributions. The meeting showed significant attention and effort on the topic. The main conclusions from the meeting were:
- Attention to nuclear data for ATF cladding materials: Ti, Nb, Fe, Mo, Si, Cr.
- Nuclear data for ATF fuel materials: Be, N(n,p), N(n, γ), ^{28}Si(n,γ), ^{95}Mo(n,γ)
- Nuclear data for high burnup : ^{143}Nd(n, γ), ^{155}Eu(n, γ), ^{244,246}Cm(n, γ)
- Neutron Thermal Scattering Laws: graphite, SiC
- More integral experiments (UN, U_3Si_2, …) for nuclear data validations of ATF concepts.
- Review future needs in nuclear applications using higher enrichment: for current LWRs (5-10%), for advanced, SMRs, and research reactors (20%).

The Spanish R&D teams are also active on several projects and activities of the NEA and IAEA.