# Expectations of nuclear data from Spanish end-users

F. Álvarez-Velarde on behalf of E. M. González-Romero

CIEMAT

enrique.gonzalez@ciemat.es

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# General view

ND activities have been very important for the Spanish nuclear physics R&D during the last 20 years:

- Coordination/leadership of international experimental programmes on nuclear data (cross sections and decay data).
- Definition of international nuclear data needs.
- Efforts to improve nuclear data quality.

Coordination and large participation in the last four EC Nuclear Data projects: EUROTRANS-NUDATRA FP6, ANDES FP7, CHANDA FP7, SANDA H2020.

Strong engagement in international efforts:

- Strong participation in several expert groups/consultants meetings and CRPs of the International Atomic Energy Agency.
- NEA WPEC subgroups.
- Development of Monte Carlo tools: GEANT4.

National research facilities

# User groups

Scientific community:

- Research centres (CIEMAT and CSIC)
- Universities (Madrid, Barcelona, Santiago, Seville…)

Industry:

- Utilities
- Nuclear power plant design
- Engineering services
- Non-energy applications (medical, industry)
- Fusion

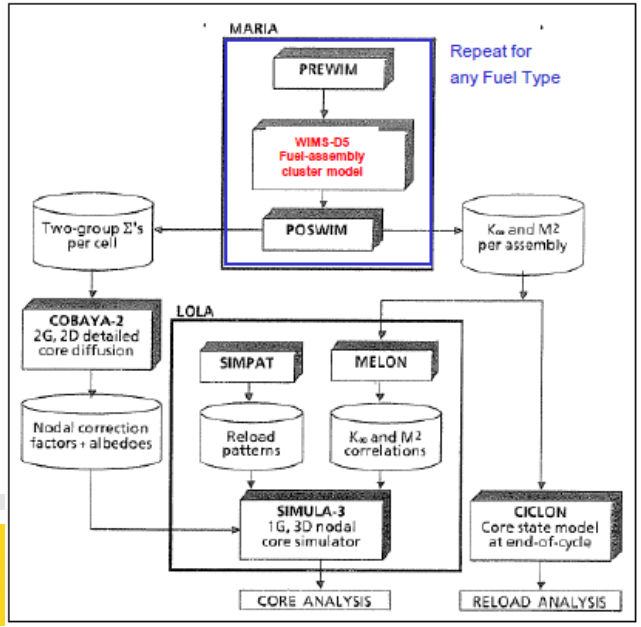
Regulatory body (Consejo de Seguridad Nuclear)

Waste management company (ENRESA)

# Activities with nuclear data (1/2)

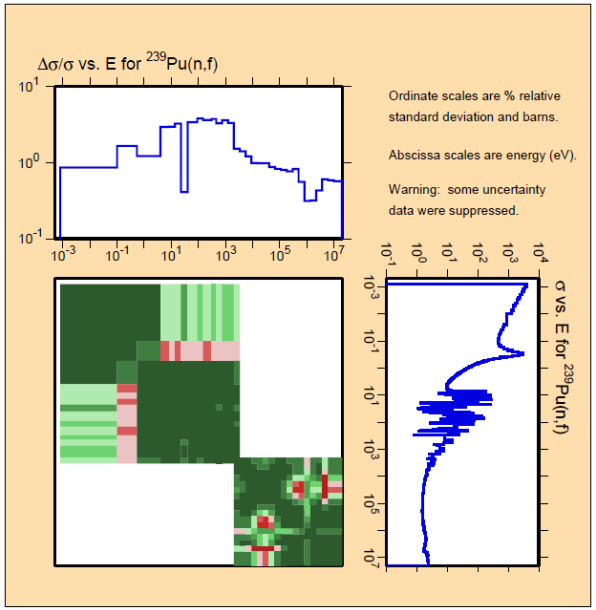
- Design and safety analyses of nuclear power plants/facilities.
- Operation of nuclear power plants.
- Fuel cycle analyses.
- Burn-up credit.
- Nuclear waste management via partitioning and transmutation.

PWR core analysis




Vitrified waste generation with P&T

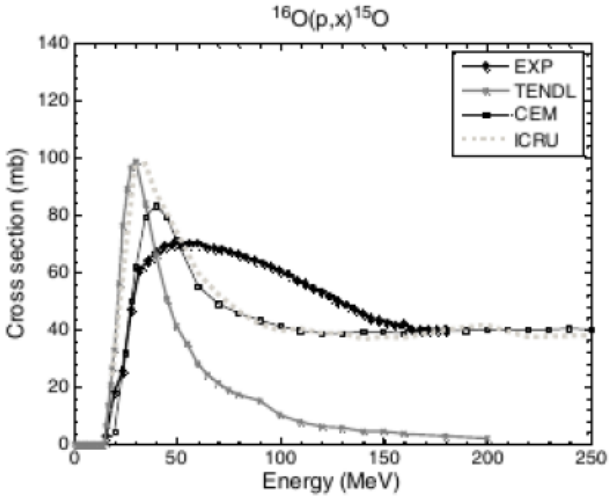
Uncertainties and correlations of $^{239}$Pu(n,f)



# Activities with nuclear data (2/2)

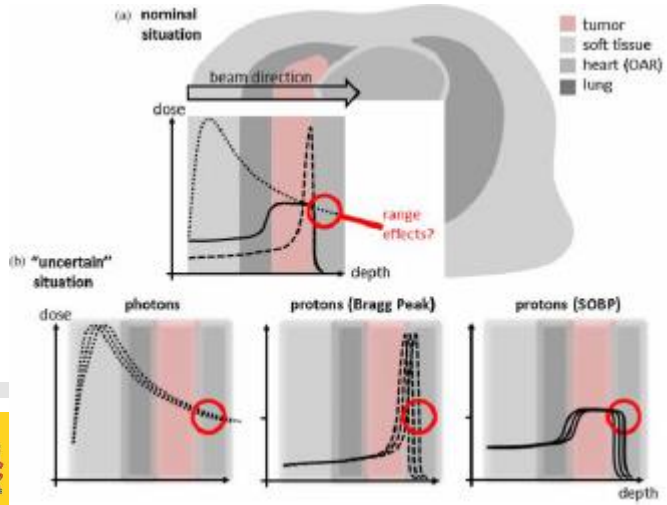
- Astrophysics.
- Industrial applications.
- Nuclear medical techniques (diagnosis and treatment).
- Shielding.
- Radioprotection.
- Fusion applications.

PET isotopes production

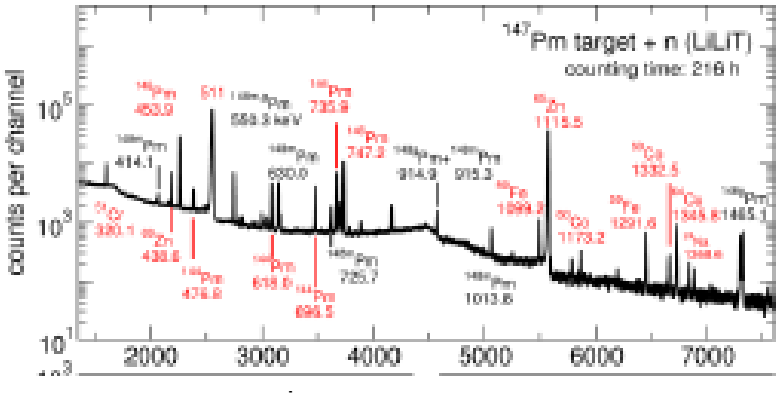



Big discrepancies in production cross sections

Proton therapy



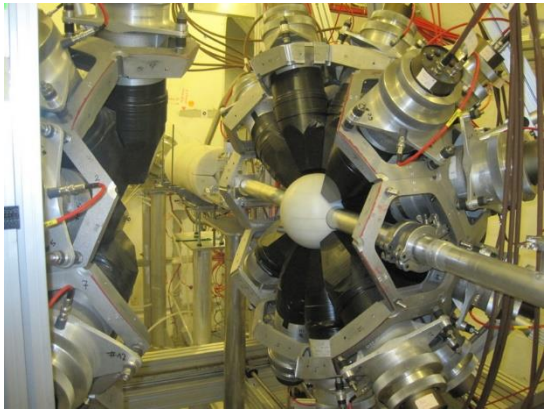

Activation experiments for astrophysics



# Experimental programme

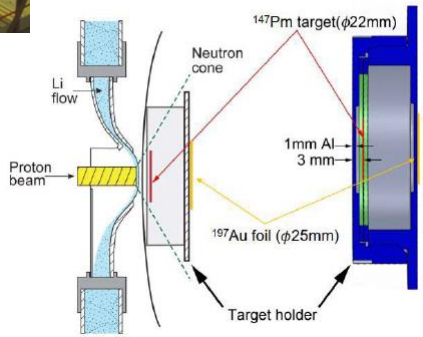
Nuclear data experiments at the most relevant international facilities and national infrastructures:

- n_TOF facility at CERN
- ISOLDE facility at CERN
- GSI and FAIR (Germany)
- IRMM (JRC)
- CEA and GANIL (France)
- PTB (Germany)
- University of Jyväskylä (Finland)
- LNL (Italy)
- LiLiT (Israel)
- National Accelerator Centre (Spain)
- Canfranc Underground Laboratory (Spain)
- CMAM (Spain)



TAC detector @CERN

LiLiT @Israel



# International efforts

EC projects supported by Framework Programmes coordinated by CIEMAT.

**2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023**

**NUDATRA** | **ANDES** | **CHANDA** | **SANDA**

International Atomic Energy Agency.

- CIELO
- INDEN
- β-delayed neutrons

Nuclear Energy Agency.

Development of the GEANT4 Monte Carlo simulation code.

# SANDA objectives

The proposal addresses aspects of nuclear data research to produce accurate and reliable tools including data, codes and methodologies that are used for simulating, analysing, optimising, exploiting and evaluating the safety of nuclear energy and non-energy applications.

The proposal is built taking into account the High Priority Nuclear Data needs list from OECD/NEA and IAEA to provide the final users with immediately usable data and tools for the cases where this is feasible during the project duration.

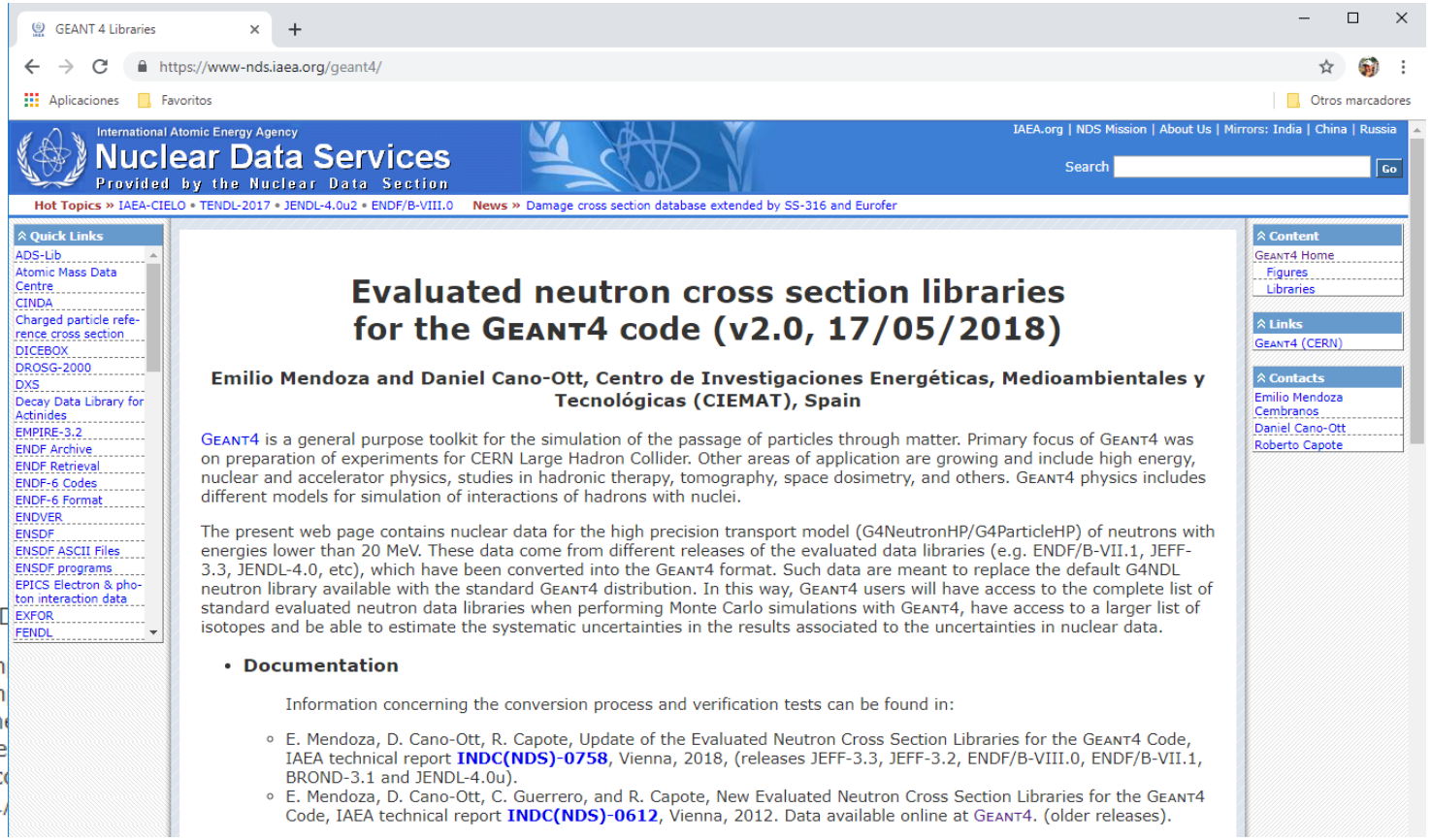
Also the proposal aims to prepare experimental infrastructures, detectors, measurement capabilities and methodologies to enable the European nuclear data community to be able to provide the data to meet other high priority needs within the shortest possible delay.

The proposal has been prepared in close contact with OECD/NEA, the IAEA Nuclear Data Section and the various organizations contributing to the JEFF project.

The project will strongly collaborate with the ARIEL proposal for access to Nuclear Data related facilities also approved by EURATOM WP 2018 NFRP7.

# International cooperation

- CIEMAT is responsible of the library-driven nuclear transport model in GEANT4.




- **Neutron data libraries**

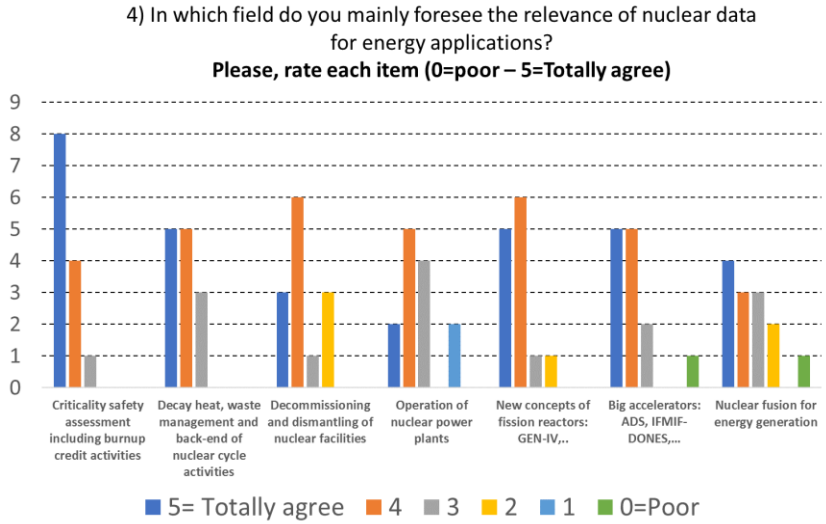
Neutron data libraries in the G4ND

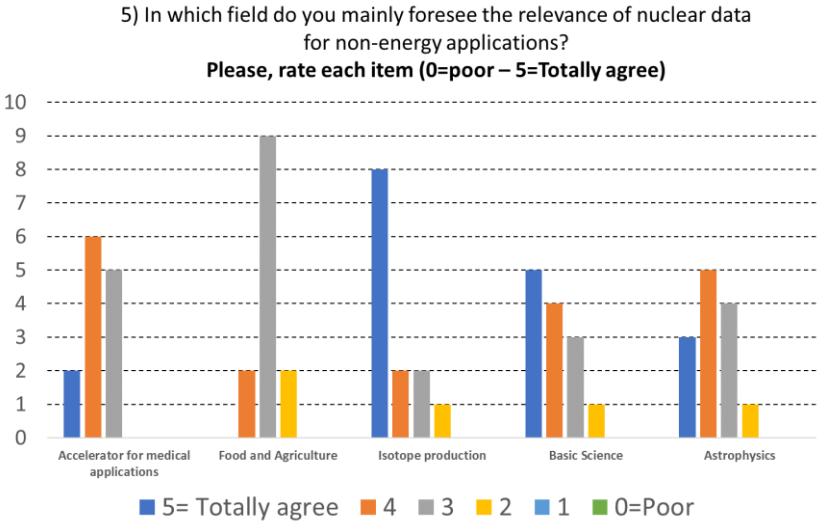
- JEFF-3.3 (download the com
- JEFF-3.2 (download the com
- ENDF/B-VIII.0 (download th
- ENDF/B-VII.1 (download the
- BROND-3.1 (download the c
- JENDL-4.0u (version 2016/1/

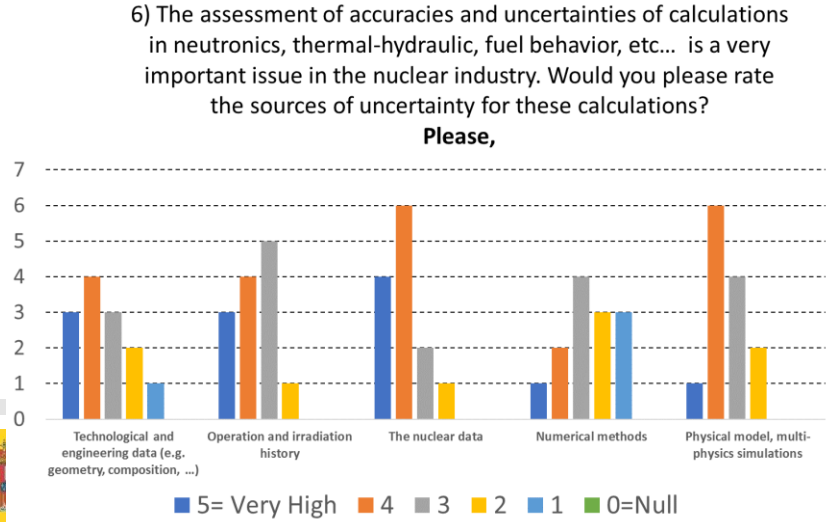
- BROND-2.2 (download the compressed library as BROND-2.2.tar.gz)
- CENDL-31 (download the compressed library as CENDL-31.tar.gz)
- ENDF-B/VI.8 (download the compressed library as ENDF-VI8.tar.gz)
- ENDF-B/VII.0 (download the compressed library as ENDF-VII0.tar.gz)
- JEFF-3.0 (download the compressed library as JEFF30N.tar.gz)
- JEFF-3.1 (download the compressed library as JEFF31N.tar.gz)
- JENDL-3.3 (download the compressed library as JENDL330.tar.gz)
- JENDL-4.0 (download the compressed library as JENDL-4.0.tar.gz)

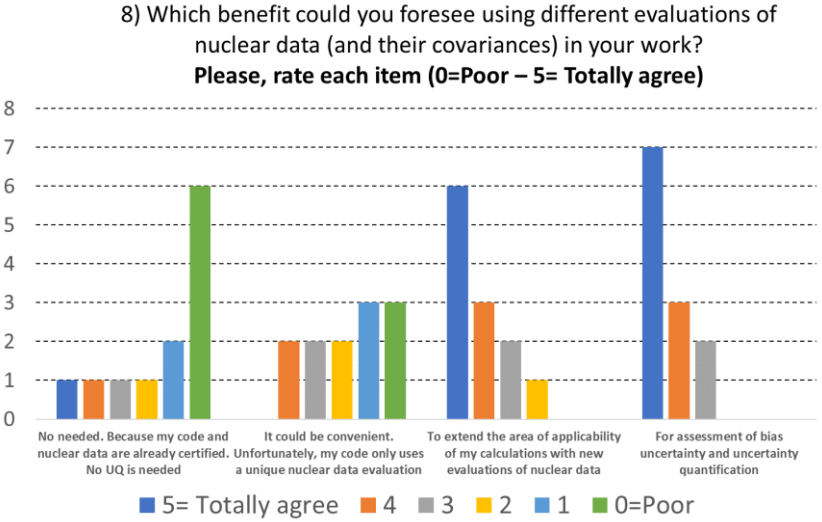
# Nuclear data questionnaire

- Created in the framework of the Spanish CEIDEN technology platform.



# Suggestions for JEFF (1/4)

As general suggestions:

- 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.

- To provide a nuclear data library for universal use without compromising the current level of quality for energy applications.

# Suggestions for JEFF (2/4)

As particular suggestions:

- Improving the inelastic cross section of the dominant present nuclear fuel isotopes, including $^{238}U$, $^{239}Pu$.
- Clarification of capture cross sections for main nuclear fuel actinides, including $^{235}U$, $^{239}Pu$.
- Improve the status Fission, capture and other absorption reaction cross sections for the characterization and prediction of the open cycle inventories (e.g. simulation of neutron damage in lifetime extension, …) 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 (for reactor operation and back-end of the nuclear fuel cycle).
- New data needed for Accident Tolerant Fuel (e.g. $U_3Si_2$, coated cladding, TSLs,… lack of integral criticality experiments for benchmarking,…).

# Suggestions for JEFF (3/4)

- Enhance the quality assurance of the processing of evaluated nuclear data in different formats: ACE, AMPX… to be officially distributed by OECD/NEA.
- Commercial codes are having difficulties to implement recent nuclear-data evaluations (e.g. 8 neutron families in JEFF-3.3 instead of common 6 families in ENDF/B).
- Enlarge benchmarking suites to other different to criticality-$k_{eff}$ (e.g. ICSBEP) including IRPHEP, SINBAD and SFCOMPO.
- Importance of nuclear data (and uncertainty quantification) in burnup credit activities.
- Impact of the nuclear data in the prediction of isotopes at high burnup (e.g. minor actinides - Cm,… fission products – $^{90}$Sr, $^{95}$Mo, ….).
- Provide credible covariances for S/U and UQ … extended covariances (and correlations) for cross-sections, TSLs, FYs, Decay Data,…
- Provide nuclear data covariances (correlations) in different formats (including random files).

# Suggestions for JEFF (4/4)

- Compilation of needs from different communities of end-users: medical applications, radio-protection, isotope production, fusion applications…
- 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 for other types of experimental therapies like BNCT.
- Improving the models and cross section values of deuteron induced reactions related to fusion applications.
- Involve different groups of interest in this activity. A key user is the “Safety Authority” who will be demanding new activities for licensing future nuclear designs (e.g. intense laser-driven neutron sources, new fuels, new reactors, …). These licensing activities should cover calculations with different evaluations of nuclear data, uncertainty quantification due to nuclear data uncertainties, benchmarking and validation with integral experiments,…