EC-H2020 SANDA Project, EURATOM Call 2018

Supplying Accurate Nuclear Data for Energy and Non-energy Applications

WP5 – Nuclear data validation and integral experiments

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Items to be covered, per Enrique's request

- Detailed descriptions of activities, (what will be actually done)
- Institutions, (Which institutions and contact persons are involved on the different actions)
- Laboratories, (Where the experiments will be performed, what instruments are proposed)
- How much effort (person months and EC K€) is assigned to each tasks as contribution for the different partner
- Commitments, (what results are expected)
- Deliverables, (how these results will be provided)
- Milestones, (indication of significant intermediate events before achieving the results)
- Dates, (when the actions are expected to start, when the results and deliverables will be available and when the intermediate milestones will be achieved)

SANDA WP5 objectives

- *The WP5 "Validation and integral experiments" addresses the ND validation step using integral experiments and benchmarks, in connection with the end-user needs and applications. This will include the use of existing integral experiments (possibly with a new analysis), including criticality and shielding experiments. The WP will also include performing new data validation experiments in existing experimental facilities, in particular on actinides and structural materials. In addition, the WP will include sensitivity analyses and impact studies, for both generic and specific systems, and will derive quantitative statements as to the performance of the WP4 nuclear data files for such systems*.

- SANDA four-year work plan, **aligned with JEFF-4.0 work plan (2018-2023)**

- **WP5 practical goal**
  - Get reliable estimates of ND errors and uncertainties for selected nuclides-reactions → JEFF4 needs
  - Assess impact on selected applications → End-user needs + missing expts.

WP5 rationale (1/2)

- **General validation process**
  - ND validation = subset of broader VVUQ process of Modelling & Simulation
  - Nuclear data are just one set of model parameters among others
  - VVUQ implies metrics, performance criteria, application domain, low-level sub-tiers to full-scale plant models,…
  - End-user requirements are expressed in terms of high-level systems responses
  - In principle, sensitivity and uncertainty analyses have to be performed for each tier
  - Needs for representative experiments are inferred, from simple-physics to full-scale multi-physics
  - But actually…

WP5 rationale (2/2)

- **Practical approach in SANDA WP5**
  - Impractical to aim for a catch-all validation approach: too many applications, very different sensitivities, missing covariances,…
  - More reasonable, limited WP5 goal: validate ***selected*** nuclear data (actinides, coolants, structurals, FPs) for ***some*** applications = a set of different nuclear systems for which significant pre-design work has already been done: JHR, MYRRHA, ESFR/ASTRID, ALLEGRO, SAMOFAR… starting from already-established openly-available reactor models
  - **Focus on data/reaction for which the past (JEFF-3) validation efforts were inconclusive or showed some shortcomings**
  - Not straightforward!
  - Limited resources → No commitment to do comprehensive data adjustment or assimilation in WP5

WP5 tasks and objectives

- **Task 5.1: Sensitivity analyses, impact studies, uncertainty estimates, and expected gains** (no experimental data are involved in this task)
  Objective is to relate improvements in (JEFF-3.3) nuclear data to performance gains in the operation, design, licensing of (i) innovative reactors or concepts ESFR/ASTRID, MYRRHA, JHR, possibly also ALLEGRO, ALFRED/LEADER, MSFR, adv. LWRs, and (ii) fuel cycle facilities (spent fuel storage, waste streams)

- **Task 5.2: Validation studies for the above applications,** by performing analyses of available relevant integral experiments and inferring trends in nuclear data
  Objective is validation of (WP4) nuclear data files and identification of gaps in validation domain

- **Task 5.3: New validation experiments and needs for new integral data**
  Objective is to find some means of obtaining missing validation data, by performing innovative experiments in existing facilities

Task 5.1 – Impact studies, sensitivity analyses, and assessment of needs for various applications

Partners: CIEMAT (P. Romojaro), CEA/DEN, CNRS/LPSC, SCK-CEN, JSI, KIT, UPM, IRSN

Budget = 127 k€

Subtask 5.1.1 – Impact studies and sensitivity analyses

Under this task, the impact of (JEFF) nuclear data uncertainties and systematic errors on reactor engineering design and safety parameters will be evaluated in a quantitative manner. The focus is on innovative nuclear systems (and fuel cycles): sodium-cooled fast reactors such as ASTRID or ESFR, lead-cooled fast reactors such as MYRRHA or ALFRED, the JHR water-cooled MTR under construction in France. Other reactors which have also undergone at least some preliminary engineering design work will be included, if the project can leverage external resources: advanced light-water cooled reactors, ALLEGRO gas-cooled fast reactor, thorium-^{233}U fuelled molten salt reactor (MSFR/SAMOFAR project).

Deliverables: 4 reports at M24

Task 5.1 – Impact studies, sensitivity analyses, and assessment of needs for various applications

Partners: CIEMAT (P. Romojaro), CEA/DEN, CNRS/LPSC, SCK-CEN, JSI, KIT, UPM, IRSN

Budget = 127 k€

Subtask 5.1.2 – Assessment of (JEFF) nuclear data needs

At the conclusion of Subtask 5.1.1, the findings will be compiled and cross-analyzed in a synthesis document, which will be published. This document may be viewed as an update of the well-known OECD/WPEC/SG26 report, based on more recent data and on better-substantiated reactor models.

We will discuss the importance of the a priori covariance data used, and the implications of the results. Recommendations will be made as to which nuclear data are in need of improvement and what "performance" gains can be expected as a consequence.

These results will be communicated to the OECD/NEA for consideration by the JEFF community (JEFF-4 perspective) and for inclusion in the HPRL.

Deliverable: Report at M36 = **milestone**

Task 5.2 – Validation studies (using existing experiments)

Partners: UPM (N. García-Herranz), CEA/DEN, CIEMAT, JSI, KIT, NRG, IRSN

The various actions in this Task 5.2 will make systematic use of the JEFF-3.3 evaluated files, with their associated covariances. As new evaluations will progressively become available from **WP4**, they will be substituted and the validation calculation will be repeated.

Budget = 118 k€

Subtask 5.2.1 – Assessing correlations in integral experiments

While a considerable effort has been given to nuclear data covariances in recent years, much less attention has been paid to correlations in integral experiments used in validation, adjustment, and assimilation studies.

Although this project will not attempt to produce adjusted nuclear data libraries nor to assimilate validation information, CIEMAT, JSI, CEA/DEN, and UPM will share their best experts' opinions on the "missing correlations in integral experiments" problem, with the goal of assessing its impact on nuclear data validation studies. Simulations will be made to estimate the correlations between the experimental uncertainties of integral experiments and quantify their impact on some reactor concept.

Deliverable: Report at M36

Task 5.2 – Validation studies (using existing experiments)

Partners: UPM (N. García-Herranz), CEA/DEN, CIEMAT, JSI, KIT, NRG, IRSN

Budget = 118 k€

Subtask 5.2.2 – C/E validation and trends

UPM and CEA/DEN will use a carefully-selected set of reactor physics experiments (from reactor benchmarks or models in IRPhE or other sources such as reactor startup experiments, etc.) for performing nuclear data validation. JEFF-3.3-based C/E results will be analyzed for possible biases and reactor performance. The same set of experiments will be analyzed again with new (WP4) evaluations when they become available, and trends will be inferred.

JSI will perform cross section sensitivity/uncertainty analysis of selected shielding benchmarks (from the SINBAD database in particular), known to be more sensitive to scattering reactions than criticality experiments. New WP4 evaluations will be compared with JEFF-3.3, and the reasons for the differences will be investigated.

NRG will perform Monte Carlo calculations and C/E calculations of criticality benchmarks. The benchmarks will be grouped according to sensitivity profiles, to facilitate the C/E analysis.

IRSN will perform a similar study for a subset of their large suite of criticality-safety benchmarks.

CIEMAT will use a Monte Carlo procedure recently developed in the CHANDA project to validate FP nuclear data against MINERVE/CERES pile oscillation experiments available in IRPhE.

The results derived from these studies will be combined in such a way that the same experimental information is not included twice. Gaps in the validation will be identified and discussed.

Deliverables: 3 reports at M42 + 1 report at M48

Task 5.3 – New integral experiments

Partners: CEA/DEN (P. Blaise), CVREZ, ENEA (Additional contributions are welcome!)

Budget = 113 k€

Subtask 5.3.1 – Experiments at GELINA, JRC and CEA/DEN

The proposed experiments will consist in performing neutron transmission measurements at the JRC Geel GELINA facility using the same samples as those used in the CEA Cadarache MINERVE reactor as part of the past CERES Burnup Credit programme. Preliminary studies show that such experiments should be feasible. Each sample is made of a UO_2 matrix with a small admixture of a fission product: Sm, Nd, Cs, Mo, Ru, Eu, Gd, or Rh. The expected outcome will be a set of transmission data for each sample. These data will be first used to determine the amount of contaminants in the samples by Neutron Resonance Transmission Analysis (NRTA).

Deliverable: Report at M42

Task 5.3 – New integral experiments

Partners: CEA/DEN (P. Blaise), CVREZ, ENEA (Additional contributions are welcome!)

Budget = 113 k€

Subtask 5.3.2 – Experiments at LR-0, CVREZ and CEA/DEN

The flexible zero-power LR-0 critical facility at Rez and its well-defined neutron spectrum will be used to create benchmark-quality nuclear data validation conditions:

- Full characterization of a critical ^{235}U-fuelled configuration (criticality, power distribution and spatial distribution of flux and reaction rates) for an IRPhEP-quality type benchmark

*- Direct and indirect measurements of the ^{235}U prompt fission neutron spectrum by neutron spectrometry and low-uncertainty flux monitors. Some of the neutron detectors developed under **WP1** could also be tested on that occasion*

- Measurements of spectrum-averaged cross sections in well-characterized neutron spectra (from fast to thermal), obtained by spectrum shaping arrangements

- Other measurements: e.g., delayed neutrons

Deliverables: Report at M42 + Report at M48

Task 5.3 – New integral experiments

Partners: CEA/DEN (P. Blaise), CVREZ, ENEA (Additional contributions are welcome!)

Budget = 113 k€

Subtask 5.3.3 – Experiments at TAPIRO, ENEA and CEA/DEN

*The TAPIRO fast neutron source reactor at the ENEA Casaccia centre near Rome will be used to measure minor actinide spectrum-averaged cross sections. The program, called AOSTA, will consist of minor actinide irradiations and fission cross section measurements. Reference major actinides will be also measured in the same spectral conditions. Delayed gamma peak spectrometry will be used to infer capture cross sections, while dedicated miniature fission chambers containing pure deposits of actinides will be used to measure fission cross sections. As for Subtask 5.3.2, the AOSTA program could provide the opportunity to test some of the neutron detectors developed in **WP1**.*

At the outcome of this Task 5.3, valuable new validation data are expected and will be made available broadly. The subsequent use of this experimental information for nuclear data validation will provide some indication of the remaining gaps to improve evaluated files and meet target performance. Recommendations will be made as to the best course of action to bridge this gap, knowing that there is only a very small number of zero-power experimental reactors still in operation worldwide.

Deliverable: Report at M42

Overview of WP5 tasks and subtasks

	Task / Subtask	Partners	EC k€
T5.1	**Impact studies, sensitivity analyses, and assessment of needs for various applications**	**CIEMAT**, CEA/DEN, CNRS/LPSC, SCK-CEN, JSI, KIT, UPM, IRSN	122
T5.1.1	Impact studies and sensitivity analyses		
T5.1.2	Assessment of (JEFF) nuclear data needs		
T5.2	**Validation studies (using existing experiments)**	**UPM**, CEA/DEN, CIEMAT, JSI, KIT, NRG, IRSN	113
T5.2.1	Assessing correlations in integral expts.		
T5.2.2	C/E validation and trends		
T5.3	**New integral experiments**	**CEA/DEN**, CVREZ, ENEA, JRC	124
T5.3.1	Experiments at GELINA		
T5.3.2	Experiments at LR-0		
T5.3.3	Experiments at TAPIRO		
All	Total		358

Overview of WP5 contributions

Task	CEA	CIEMAT	CNRS	CVREZ	ENEA	IRSN	JRC	JSI	KIT	NRG	SCK	UPM	Total EC k€
T5.1	11.5	25.4	18					15	25		15.5	17	**127.3**
T5.2	11.5	39.8				15		14.5		25		12.5	**118.2**
T5.3	46.6			51	15		0						**112.6**
Total k€	**69.5**	**65.1**	**18**	**51**	**15**	**15**	**0**	**29.5**	**25**	**25**	**15.5**	**29.5**	**358.1**
Total PM	**8.7**	**15.2**	**3**	**16.3**	**3**	**1.9**	**0**	**6**	**3**	**3.9**	**1.1**	**7.1**	**69.2**

WP5 deliverables and milestone

M24

T1

D.5.1 Report on sensitivity analysis methods; *CIEMAT*, LPSC, UPM, CEA; M24

D.5.2 Report on ESFR, MYRRHA, and ALFRED sensitivity and impact studies; *SCK*, CEA, UPM; M24

D.5.3 Report on JHR sensitivity and impact study; *CEA*; M24

D.5.4 Report on HLW sensitivity and impact study; *KIT*; M24

D.5.5 Report on assessment of nuclear data needs; *CEA*, CIEMAT, UPM, SCK, KIT; M36

T2

D.5.6 Report on correlations between integral experiments; *CIEMAT*, JSI, CEA, UPM; M30

D.5.7 Report on reactor and shielding C/E validation and nuclear data trends; *UPM*, JSI, CEA; M42

D.5.8 Report on critical benchmark C/E validation and nuclear data trends; *NRG*, IRSN; M42

D.5.9 Report on C/E validation and nuclear data trends; *UPM*, CEA, JSI, NRG, IRSN; M48

D.5.10 Report on experiments at JRC Geel using MINERVE samples; *CEA*; M42

T3

D.5.11 Report on integral experiments at LR-0; *CVREZ*, CEA; M42

D.5.12 Report on integral experiments at TAPIRO; *ENEA*, CEA; M42

D.5.13 Report on new integral experiments and needs; *CEA*, JRC, CVREZ, ENEA; M48

M42/48

The first partner listed for each deliverable is the responsible for the deliverable.

WP5 timeline