Update of CEA DES Criticality-Safety Activities and Perspectives

DE LA RECHERCHE À L’INDUSTRIE

NCSP TPR MEETING, 2022 FEBRUARY THE 15TH

DES (DIRECTION OF ENERGIES) SERMA (SACLAY)-SPRC (CADARACHE)
DES/ISAS/DM2S – DES/RESNE/DER

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A key player in research, development and innovation in four main areas: defense and security (CEA DAM), **low carbon energies (CEA DES nuclear and renewable energies)**, technological research for industry (CEA DRT), fundamental research in the physical sciences and life sciences (CEA DRF). 20181 employees, 9 research centers, 5 billion euros budget (2019). cea.fr/english
Neutronics @ CEA DES: reactor physics, fuel cycle, criticality-safety, radiation protection and shielding
From R&D to nuclear facilities

Neutronics @ CEA DES 140 permanent staff + 40 PhD + 50 interns/yr.

For criticality safety, CEA is closely working with IRSN on the CRISTAL* criticality-safety package, embedding codes from both institutions

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Together they are in charge of a whole set of modeling and simulation tools for neutronics: nuclear data evaluation and processing, transport codes development, calculation sequences edition, verification, validation and uncertainty analysis. Advanced user groups are in charge of specific nuclear analysis in reactor physics, fuel cycle, criticality-safety, radiation shielding and nuclear instrumentation for CEA and its partners, at all stages of nuclear facilities life cycle (from design to D&D).

A dedicated team to support the CEA nuclear facilities with regards to criticality safety: the CEA Criticality Safety Expert Team (CST)

Some signature codes and sequences: the APOLLO cell and lattice code, the TRIPOLI Monte Carlo code (https://www.cea.fr/energies/tripoli-4), CONRAD for nuclear data evaluation and GALILEE for their processing, calculation sequence for PWR and SFR core physics, all are production level

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www.cristal-package.org and NEA-1903 package
https://www.oecd-nea.org/tools/abstract/detail/nea-1903/
CEA DES as a nuclear operator: ~30 facilities handling fissile material on Saclay, Marcoule and Cadarache: experimental reactors, dry storages, pools, shielded cells, glovebox, storage facilities, waste management.

People involved: CST (Saclay) 9; CCE 4; QCE: ~30 and CS 3
EXAMPLES OF CEA DES R&D AND CHALLENGES LINKED WITH CRITICALITY SAFETY
• The next version of the CRISTAL criticality-safety package is being actively prepared.

• The reference Monte Carlo route will be based on TRIPOLI-4® V12, whose release is expected this Fall’2022.

• One of the new features of T412 concerns stochastic geometries. It is also the purpose of a new NEA WPNCS subgroup to study benchmarks for transport in random geometries, with applications to criticality (among others).

Example of realization of a Poisson geometry (Larmier et al)
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Like previous versions of the package (the most recent one is CRISTAL V2.0.3, see paper by Entringer et al @ NCSD 2022), the V&V of CRISTALV21 will be based on a number of ICSBEP benchmarks.

A careful revision of the benchmark database will be conducted (SERMA/Giffard). Automation of the launch sequence of the database, as well as automation of the V&V report edition will be done with the public CEA tool VALJEAN (SERMA Mancusi/Le Menedeu).

https://github.com/valjean-framework/valjean

New ICSBEP benchmarks will be included, for example TexPU (PMM-002). Preliminary results with T411/CEA512 on case 3: $k_{eff} = 1.00320$, std dev= 11 pcm (SERMA Dupas/Borrod)

New calculations and interpretation of HMF-080 will be included in the report (SERMA Casoli/Borrod)
TOTAL ABSORPTION GAMMA SPECTROSCOPY (TAGS)

CEA participates to Decay Data evaluations (LNHB) for the JEFF-library.

TAGS measurements reduce discrepancies between experimental values and calculations at short cooling times. Particularly important for Decay Heat because there is no integral measurement < 45 min of cooling.

Free from the Pandemonium effect (overestimation of the $<E_β>$, under-estimation of $<E_γ>$).

Measured De-excitation
Real de-excitation

TAGS measurements
Decay Data evaluations
Improvement of DH calculations

239Pu th Elementary fission burst
NEED FOR NEW MEASUREMENTS (TAGS, EFB, DH(A),...)

- The IAEA – INDC(NDS)-0676 (2015) report “Total Absorption Gamma-ray Spectroscopy for Decay Heat Calculations and Other Applications” → 78 nuclides identified and prioritized, 47 without TAGS measurements (among them 23 priority 1) \(\rightarrow\) Need for experiments

- Best way to perform experimental validation of evaluated nuclear data of interest for Decay Heat applications are Elementary Fission Burst experiments (old, inaccurate, lack of consistency between sets of data) \(\rightarrow\) need for new measurements with low uncertainties

- TAGS detectors could be used for other applications such as decay heat measurements by mass A of fission products on a facility such as the mass spectrometer Lohengrin@ILL

- TAGS detectors in the US:
  - Greenwood’s detector at CARIBU-ATLAS (ANL)
  - MTAS@HRIBF (ORNL)
  - ...?

CEA is willing to participate / collaborate on such issues: detector design, experiments, analysis and evaluation, DH validation by combining TAGS measurements with Fission Yield variance-covariance matrices
POSSIBLE COLLABORATION WITH THE US DOE NCS PROGRAM
Hands-on training session: CEA personnel trained in partnership with the NCS Program => one CEA member to be trained @Sandia 8-19 August 2022 😊😊😊

Benchmark modelling:
- Monte Carlo & Nuclear Data benchmarking
- Independent calculation and interpretation of US benchmarks (ICSBEP)

Nuclear data:
- Nuclear Data issues for Decay heat calculation: detector design, perform experiments, analysis and evaluation, DH validation by combining TAGS measurements with Fission Yield variance-covariance matrices
- ND covariances assessment methods: comparison of analytical methods

P. Tamagno, «Conservative covariance for general-purpose nuclear data evaluation», European Physical Journal A 57, art. number 61, 2021
THANK YOU FOR YOUR ATTENTION