# Use of Shielding Integral Benchmark Archive and Database for Nuclear Data Validation

## WPEC Subgroup 47 (SG47)

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# Agenda

1. Welcome and introductions — Chair
2. Review of actions — Chair
3. Benchmarking of SuperMC by using different libraries with reactor shielding experiments in SINBAD — B. Li
4. Compilation of Nuclear Data Experiments for Radiation Characterisation – CoNDERC — J-Ch. Sublet
5. KIT contribution to SG-47: progress since June 2019 — S. Simakov
6. UKAEA experience and involvement with SINBAD — A. Valentine
7. Update of SINBAD status and reminder of SG47 objectives — I. Kodeli
8. Progress on development of additional inputs and CAD models for SINBAD — S. Lilley
9. Interpretation of the ASPIS and JANUS shielding experiments — G. Rimpault
10. Quantifying the indicators of the ageing under irradiation — M. Brovchenko
11. Validation of computer code TORT using RC Rez Iron Spherical Assemblies producing neutron and gamma mixed fields — B. Jansky
12. Using LLNL Pulsed Spheres for Nuclear Data Validation — D. Neudecker
13. Discussion

1. **Benchmarking of SuperMC by using different libraries with reactor shielding experiments in SINBAD**

**B. Li (INEST)** described the Monte-Carlo computer code SuperMC for particle transport and Bateman calculations. The validation presented last year using a large series of SINBAD fusion experiments such as Oktavian, FNS, FNG, IPPE and Kant was successfully extended to new benchmarks including VENUS-3 showing good C/E agreement. Experimental activities include benchmarks performed in the HINEG facility, such as DFLL TBM. This and other benchmarks would be of interest for SINBAD.

2. **Compilation of Nuclear Data Experiments for Radiation Characterisation – CoNDERC**

**J-Ch. Sublet** presented the IAEA NDS forum where institutions can provide, establish, share protocols, databases for validation and verification of nuclear model and code systems for inventory and transport. Experimental integral radiation characterization benchmark information including spectral indices, reaction rates, decay heat, resonance integral, particle counts, and fluxes are compiled into computer format ready for verification, dissemination and assimilation. Included are computer code data for different Boltzmann solvers (MCNP6, TRIPOLI4, OpenMc, SERPENT) and Bateman solvers (FISPACT-II, ORIGEN). The database was recently extended to include shielding benchmarks ASPIS Iron88 and TIARA. More data are to come.

**3. KIT contribution to SG-47: progress since June 2019**

**S. Simakov** presented work done since 2019 in the use of several shielding experiments available in SINBAD and elsewhere:

- Action 3. Provide KFK-1977 gamma measurement data for potential SINBAD evaluation

KFK 1977 iron sphere experiments are not in SINBAD; Late 2019 Prof. Shiang-Huei Jiang provided measured $\gamma$ spectra from bare $^{252}$Cf(s.f.) source and from Ø25, 30 and 35 cm Fe spheres in numerical form. They can be made available for SINBAD evaluation.

- Action 4. Contribute models for Oxygen ORNL broomstick benchmark and 91.44 cm liquid O data if of interest (sufficient quality) for SINBAD.

152.4cm ORNL Tower Shielding oxygen measurements was studied. MCNP models were prepared and found consistent with the analytical solution probably used in the past taking into account uncollided contribution only. Benchmarks could be useful for total cross section validation; uncertainties in n. source, density ??

No neutron transmission spectra data for 24” (60.96cm) and 36”(91.44cm), no MCNP model. (Action to ORNL)

- Action 5. Issue of for scaling the data in the FNS oxygen experiment by cosine i of the detector angle s still pending.

## 4. UKAEA experience and involvement with SINBAD

**A. Valentine** presented an overview of activities at the UKAEA and Applied Radiation Transport group, several fusion technology projects (JET, ITER, DEMO, MAST-U, STEP) and the experience with SINBAD for neutronics code benchmarking. Serpent-2 code was benchmarked against MCNP using fusion-relevant SINBAD experiments (FNG HCPB) and EU DEMO calculations. The analysis of FNG Bulk shield and future FNG WCLL benchmarks are ongoing. Serpent-2 variance reduction methods are studied.

Several remarks were made related to the SINBAD input decks, noting a lack of quality control, lack of computer code inputs and lack of commenting and documentation.

The UKAEA could contribute Serpent-2 inputs to SINBAD.

Photon & photonuclear, n/g heating benchmarks would be of interest for fusion community.

## 5. Update of SINBAD status and reminder of SG47 objectives

**I. Kodeli** reminded the objectives of SG47. Few SINBAD benchmarks updated in 2019, but many old updates performed in the past still need to be done, including quality reviews. FNG Cu is under review under ICSBEP/SINBAD group, SuperMC input data for 24 SINBAD fusion benchmarks were received from INEST, Hefei to be included in SINBAD. New SINBAD evaluations are almost in standstill since over 10 years.

New and ongoing activities: WWW acceleration cards, ND sensitivity profiles, CAD geometry, different transport code analysis (MCNP, Serpent, Tripoli, SuperMC, Geant, Dort/Tort, ...)

Several data are available in WPEC SG47 Git repository (FNG Cu, FNS, Oktavian, LLNL, Aspis-Fe88, Tiara)

CCFE is interested is further development and quality review of SINBAD. Remaining an open database is believed to contribute to quality improvement & development.

Several benchmarks of potential interest for future SINBAD evaluations were identified.

## 6. Progress on development of additional inputs and CAD models for SINBAD

**S. Lilley** recalled the benefits of including CAD models in SINBAD. This would speed up , allow a more consistent model generation for different codes, allow automation and facilitate the testing. Workflows including different codes such as Fluka, MCNP, PHITS, GEANT were presented and illustrated on the example of IPPE Th and ASPIS Fe88 benchmarks.

In spice of some issues the process seems very promising.

**7. Interpretation of the ASPIS and JANUS shielding experiments**

**G. Rimpault** presented the work done by Amine Hajji in the analysis of ASPIS and JANUS benchmarks carried out from 1980s and 1990s using NESTOR reactor as neutron source. This includes the Iron88 and several JANUS benchmarks (Phase 2 and 7) which are not yet available in SINBAD since clearance was not resolved yet. TRIPOLI and Serpent models were built and conclusions presented on the C/E agreement for different nuclear data including JEFF-3.1.1, 3.2, ENDF/B-VIII, JENDL-4.0.

Importance of sensitivity & uncertainty analysis was pointed out.

**8. Validation of computer code TORT using RC Rez Iron Spherical Assemblies producing neutron and gamma mixed fields**

**B. Jansky** presented the analysis of the measurement of leakage neutron and gamma spectra on pure iron spherical assemblies using the TORT deterministic transport code with the BUGLE-B7 library. Five sets of Fe spherical geometry were calculated with 20, 30, 40, 50 and 100 cm diameter iron spheres with a Cf-252 neutron source located in the center of the Fe sphere. Neutron spectra were measured by the proton recoil method (stilbene and proportional hydrogen detector), and gamma spectra with stilbene. Cylindrical r-theta-z model was used. Both using TORT and MCNP the results for neutron spectra were found to be ins. better agreement then for gammas. The evaluation of this benchmark in SINBAD is recommended.

**9. Quantifying the indicators of the ageing under irradiation**

**M. Brovchenko** presented the activities of IRSN in the field of safety assessment for nuclear reactor lifetime extension and new reactors. MCNP accelerated by WWG, ADVANTG and DSA methods is used for the quantification of the indicators of the ageing of materials (Fluence, DPA, …). VENUS-3 and Robinson HB benchmarks from SINBAD were used for the experimental verification.

**10. Using LLNL Pulsed Spheres for Nuclear Data Validation**

**D. Neudecker** presented the conclusions of the simulating of 75 LLNL pulsed-sphere neutron-leakage spectra for 20 different materials using ENDF/B-VII.1 and ENDF/B-VIII.0 and MCNP input decks prepared by S. Frankle. Some deviations in C/E were identified for several isotopes and it is suggested that LLNL sphere measurements are valuable for ND validation, in particular if combined with the sensitivity profiles which were calculated by O. Cabellos with FRENDY, SANDY and MCSEN. A detailed analysis of the uncertainties associated with the measurements is needed and ongoing at LLNL

# Actions of 12 May 2020 SG47 Meeting

1. (**Bin Li**, FDS): potential FDS shielding benchmarks to be considered for SINBAD, e.g. DFLL TBM (ASAP)

2. (**S. Simakov**, KIT): Provide KFK-1977 gamma measurement data for potential SINBAD evaluation

3. (**S. Simakov**, KIT): Contribute models for Oxygen ORNL broomstick benchmark and 91.44 cm liquid O data if of interest (sufficient quality) for SINBAD

4. (**ORNL**): investigate the availability of Broomstick experimental data for 24" and 36" O spheres.

5. (**A.Valentine, CCFE, G. Rimpault,** CEA, All): Contribute Serpent, TRIPOLI and other computer code input data of shielding benchmarks to WPEC SG47 and/or IAEA repository (2021 meeting).

6. (**D.Neudecker,** LANL, O. Cabellos, UPM): Contribute MCNP input data & sensitivities for LLNL benchmarks to WPEC SG47 (2021 meeting).

7. (**S. Lilley** - UKRI STFC**, I. Kodeli**) Provide CAD geometry for IPPE, FNS, FNG, ASPIS and ISIS benchmarks

8. (**B. Jansky**, CVREZ) Contribute TORT & MCNP input data of Rez Fe sphere and slab benchmarks to WPEC SG47 and/or IAEA repositories (ASAP)

9. (**J.C. Sublet**, IAEA) Provide instructions for IAEA repository, review & independent verification procedure (ASAP)

# Actions of 24 June 2019 SG47 Meeting

1. (**G. Lomakov**, IPPE): Provide comments and review of the FNG Cu benchmark evaluation (DONE
2. (**G. Lomakov**, IPPE): Provide information on the Neutron transmission experiments (1960th) to be included in SINBAD (next meeting)
3. (**S. Simakov**, KIT): Provide KFK-1977 gamma measurement data for potential SINBAD evaluation Reported at 32th WPEC meeting (ongoing)
4. (**S. Simakov**, KIT): Contribute models for Oxygen ORNL broomstick benchmark and 91.44 cm liquid O data if of interest (sufficient quality) for SINBAD Reported at 32th WPEC meeting (ongoing)
5. (**Simakov, Kodeli, Milocco**): resolve the issue of dividing by cosine for FNS-O. ongoing
6. (**Y-K. Lee**, CEA): Contribute TRIPOLI input data of few SINBAD benchmarks to WPEC SG47.
7. (**Y.-K. Lee**, CEA): Present a description of the Mn bath experiment for potential inclusion in SINBAD
8. (**S. Lilley** - UKRI STFC**, I. Kodeli**) Provide CAD geometry for IPPE, FNS, FNG, ASPIS and ISIS benchmarks Reported at 32th WPEC meeting (ongoing)
9. (**Jun Zou**, FDS): Provide SuperMC inputs for the set of SINBAD benchmarks (OKTAVIAN, FNS, FNG, IPPE, Kant) (beginning 2020) DONE
10. (**J. Zou**, FDS): Proposals of potential FDS shielding benchmarks to be included in SINBAD,
11. (**H. Wu**, CIAE) Contribute 14 MeV Fe benchmark data to SINBAD (ASAP)
12. (**B. Jansky**, CVREZ) Contribute Rez Fe sphere and slab benchmark data to SINBAD (ASAP)
13. (**C. Murphy**, Winfrith) Investigate possible release of ASPIS benchmark data not yet in SINBAD
14. (**O. Cabellos**, UPM) Provide MCNP models and sensitivity profiles for LLNL, FNS, Oktavian benchmarks DONE (Oktavian & FNS)
15. (**I. Kodeli**, IJS) Provide updated SINBAD data for ASPIS Fe88 benchmarks Ongoing