CM on next FENDL 2025

📣 Welcome addresses

Welcome address by Section Head (A. Koning). Reason about this CM. FENDL update/SW related. Dinner information by Kira. General Information and meeting formalities by Georg.

- Rapporteur: Saerom (Georg already asked in advance)
- Chair person: Andrej (Tuesday), Sara (Wednesday), Marco/Yuefeng (Thursday)

Opening slide presented by Georg:

- FENDL progress. FENDL large paper (NDS) and minor updated version (FST). Some discussion topic for the meeting (adopt and create evaluations, benchmark selection, data/code and goverance, stackholder, practicalities for a major release... comment by Roberto: further actions like CRP, TM... could be decided by IAEA.

Chair person (Andrej) manages the flow.

🔶 Presenter 1-1: S. Lopez Aldama (title: Overview of FENDL: Library, processing methods and tools)

Key points:

- Overview the recent progress
- Main updates in evaluations from FENDL-3.2b to FENDL-3.2c (not only neutron induced data, but also proton and deuteron induced data as well)
- Main updates in processing point of view (NJOY2016.74 + NDS/IAEA patches - HEATR, PURR, ACER, GROUPR and RECONR).
    - W-184 heating number - LCT-2 (LAB -> CoM) should be considered for the correct process
    - another issue on charged particles on d+d from ENDF/B-VIII.1 (not for FENDL)
    - 5 MeV deuteron integral test (d+Cu and d+Li... showed different results by the process)
- Tools developed at NDS/IAEA in the frame of FENDL, the tools might be helpful for other libraries; endf-parserpy, endf-userpy, etc.

- Future work towards a major release of FENDL: assessment of new evaluations, activation data for FISPACT-II and/or ACAB-2008, Uncertainty quantification, TSL for moderator materials, V&V, Tools for nuclear data management...

Discussion/Comments:

- Arjan: updates about NJOY for FENDL-3.2c. it is general? only particular for FENDL-3.2c.
- Daniel: still particular
- Andrej: possible to make a bridge by IAEA with LANL for NJOY updates
- Roberto/Daniel: manpower is the problem
- Yuefeng/Daniel: charged particle related, JENDL - ciemat? used JENDL-5 but processed by CIEMAT NJOY, but not clear which kind of version they used.
- Yuefeng/Daniel: plan for update the charged particle from TENDL-2011 to another one. Generally JENDL is better.
- Sara/Daniel: 1D calculation, heating ratio between ENDF/B-VIII.0 and FENDLs. not so cricial issue.
- Georg/Daniel/Roberto: The trace can be possible on NJOY patches (clear).

Decisions/Action Items: ✔️

🔶 Presenter 1-2: S. Kwon (title: To the next major FENDL)

Key points: - Some suggestions for the next FENDL updates on the issues pointed out at the last FENDL meeting (2023), especially iron, copper (63Cu) and Be TSL data - Introduction on the kind of processing issue on tungsten file when users use the specific phys card option in MCNP - 199 group structure to be added MATXS for lower energy region

Discussion/Comments:

- Sara: what about previous evaluations on Tungsten FNG experiment (FENDL-2.1)?
- Sara/Saerom: how to use the proper TSL data on Be. make sure that what kind of characteristics on "your" Be
- Roberto: TSL data on Be. the case presented is very specific usage, needs to think about whole energy region for the update.
- Yuefeng/Saerom/Roberto: TSL data on Be. usage in mcnp. TSL is not "parameter" it's another data library files which JENDL and/or ENDF (JEFF) already have, not FENDL yet.
- Davide: results on phys:n for higher energy setting
- Marco: wants to check other materials used in ITER heating calculation

Decisions/Action Items:

✔️ check using ENDF/B-VIII.1 (Fe evaluation)

✔️ check the previous evaluation on W FNG exp (Sara's questions)

✔️ check phys:n for higher energy setting e.g. 50 MeV

🔶 Presenter 1-3: S. Nakayama (title: Recent advances in Deuteron Nuclear Data Evaluation for Structural Materials: Iron isotopes)

Key points:

- d+Fe data for LIPAc (IFMIF-EVEDA project) prepareted by DEURACS
- evaluated with EXFOR (isotope production xs and emitted neutron spectra)
- 54,56,58Fe+d isotope production showed a good agreement between EXFOR and d+Fe data prepared
- natFe+d: 56Mn production xs showed discrepancy, Co production good agreement.
- Doubt on 56Co production cross section (EXFOR data), similar cases found for lower energy region of some nuclei .
- Validation of neutron spectra with TTNY (experiment stainless steal 304) done (reliable).
- Comment by Roberto: Q-value to be checked (break-up reaction senstive)?
- Future work: energy extending up to 50 and 200 MeV and other important materials

Discussion/Comments:

- Yuefeng/Nakayama: Plan for the future work. high priority? 50 MeV for iron data
- Yuefeng/Nakayama: Copper data also attractive
    - To be shared the data as much as he can
- Roberto: include other available deuteron induced data in IAEA web site (medical isotope database)
- Daniel: covariance data included?

Decisions/Action Items: ✔️

(presenter changed due to a technical issue from Ruirui Xu)

🔶 Presenter 1-4: A. Trkov (title: Recent updates to the evaluated nuclear data files of structural materials)

Key points: Expectation for FENDL community based on INDEN application conclusions (Dec.2024 + alpha)

- ENDF/B-VIII.1 related, JEFF-4.0 to be released soon
- Advantages of the improved evaluations and focus on Fe, Cu, Si, F, Cr
- Issues with neutron leakage in Fe CIELO (details in NDS paper on ENDF/B-VIII.1)
- Iron validation presented at INDEN meeting.
    - (Roberto comment) data availability in the INDEN web page to be checked
    - several features for the FENDL update introduced
- Copper validation with the bulk transmission from Rez. ENDF/B-VIII.1 includes new resonance parameter, improved elastic angular distributions in the specific energy region, and covariance data
    - adopt ENDF/B-VIII.1 with covariance data
- Si validation
    - adopt ENDF/B-VIII.1
- F validation (Teflon neutron leakage): Morgan 76 data adopted << Broader data 19F(n,enl) reduced by ~40% from 300 keV. anyhow a full evaluation necessary
- Cr validation (to be desired): new resonance analysis, keep the consistent covariance data, etc.

Discussion/Comments:

- Yuefeng/Andrej/Roberto: maximum energy of available copper data, 20 MeV probably. Useful to consider high energy region. possible to share up to 60 MeV (as the minimum). Rez, Oktavian, FNG, etc. experiments can be considered for the higher energy region
- Davide/Andrej/Roberto: Tungsten? IAEA already did for ENDF/B-VIII.1 (mainly). Also JENDL is also okay.
- Daniel/Roberto/Andrej: how many evaluation in INDEN. F is not included, but partly Cu included without convarnce data (resonance parameter), not consistent covarance yet.
- Yuefeng/Roberto/Andrej: covariance data above 20 MeV. TENDL could provide, but doubt on the quality. the data up to 60 MeV can be provided
- Roberto: Beyond 20 MeV, not so many data we can use for the evaluation. Minimum/maximum energy to be determined for FENDL-4.0 (one of requirements)
- Marco/Roberto: general recommendation for others; depends on the "performance", also being completed (up to desired energy region). this is a kind of open question (for evaluator).
- Roberto: we need to focus on evaluation transport files this time.

Decisions/Action Items: ✔

🔶 Presenter 1-5: R. Xu (The evaluated nuclear reaction data for fusion at CNDC)

Key points: Nuclear reaction study and perspective

- CNDC's main role: CENDL evaluation
- CENDL-4.0 to be released in Dec.2025: 30 neutron induced data to be improved
- Theoretical model (neutron-proton scattering evalution, NDL of light nucleus (e.g. n+d system) - beyond R matrix, n+13C - consider possible reaction channels, n+23Na, n+27Al, n+Fe (updated with INDEN activity), n+Cr (Oktavian benchmark), n+238U evaluated based on experimental data analysis and new theoretical evaluation
- Covariance data study to get a "honest" data: LS to broad mass range and unified monte carlo for n+48Ti conducted
- AI related study: machine learning conducted in nuclear physics (Coupled Phase Shift Deep Neutral Network approch for resonances, (n,2n) cross section adopting ANN/DT for extending energy region

Discussion/Comments:

- Georg/Ruirui: deep neutral network only used for resonance. energy calibration not conducted yet, only for the data.
- Roberto/Ruirui: large amount evalution CNDC performed, not available else where. possibility to be used for others for testing
- Georg/Ruirui: all done at CNDC or collaboration in China? 90% done at CNDC. Chinese collaboration network did together.

Decisions/Action Items: ✔️

🔶 Presenter 1-6: J. Malec (Evaluation of Cross sections for fast ion reactions with Be in He and H fusion plasmas)

Key points: S-function fitting

- Be data validation work related to the neutron source for fusion plasma (Žohar et al., 2024)
- Cross sections of 9Be(p,ng)9B, 9Be(3He,ng)11C, 9Be(p,d)2a, 9Be(p,a)6Li
- Evaulated uncertainties on them (discard 0.1% unphysical results, MC fit sampling, added 2% systematic uncertanty), generate covariance data
- 9Be(p,ng)9B - fitted in two energy region at 2.5 MeV, good agreement confirmed
- 9Be(3He,ng)11C - available data only in TENDL, the fitting makes the data for better agreement with EXFOR dataset
- 9Be(p,d)2a, 9Be(p,a)6Li - similar conclusion as above

- Not evaluted yet on 9Be(d,ng)10B, 9Be(a,ng)12C due to low density of data
- "New measurement recommended for validation and extention" for making dense dataset

Discussion/Comments:

- Georg: The pipeline, fitting code, procedure, etc. make as public? python code used to make ENDF-6 format file, to be published (still local). could be shared (the ENDF data prepared)
- Roberto: it should be a future evaluation, it's not transport evaluation
- Georg/Roberto/Andrej: should consider about "consistency" between transport (general purpose) and activation (or neutron dosimetry, special purpose). it makes thing problematic (very complex)
- Roberto: not push everything into "one" data library
- Marco/Georg/Roberto: possibility to make a pipeline. the current pipeline (JEFF, TENDL etc.) has a different purpose. FENDL is living project (could be an expendable pipeline). ultimate goal is the performance. Fusion community has been targeted from 14 eV evaluations to expended ones. To improve technical procedure removing the trials already did.
- Yuefeng: FENDL has own advantage because of the feature of "compilation" even though it does not have common work flow (procedure, not easy to have) like TENDL and other evaluated data libraries.
- Marco: check consistency by scoring (A. Milocco will present tomorrow about iron)
- Kostal: cross checing would be helpful for all benchmarks. the small gap in the calculation could change the result around a few percentage.
- Marco/Roberto: integral results and differential ones could show the differences
- Daniel/Andrej: Evaluation, Processing, Validations (transport calculations as well) should be considered on the same table. Automatic V&V (F4E JADE).
- Roberto/Davide/Andrej: Importance of selection of the benchmark (high risk task...). F4E provides the code (e.g. JADE) then evaluators could provide the benchmark which can be trusted for the code.
- Last protocal to conclude passinate discussion by Georg: several performance by human is necessary, then automatic code can support. manual/automatic is co-existence.

Decisions/Action Items: ✔️

🔶 Presenter 1-7: L. Gesson (Improving nuclear cross-sections with deep learning: DINo algorithm)

Key points: DINo - Deep learning Intelligence for Nulcear reactiOns developed

- Nuclear reactions prediction with deep learning (dense neutral network) from an idea of DNR
- Proton induced reaction on 12C (TENDL-2021)
- Nuclear reaction prediction could be implemented into Gean4

Discussion/Comments:

- Sara: integration into Gean4. talking with Geant4 in France about implementation DINo instead of physics model as a physics library
- Roberto: this study started with TENDL, the goal beyond TENDL? Difficulties on prediction about many channels
- Davide: how well repoduced experimental data? a kind of integral experimental data to be considered, even though the DINo is a kind of black box.
- Georg/Levana: trained data on total cross section from TENDL. incident energy can be changed in the input on the corresponding the total cross section. challenge on the open source, errors on the algorithm thinking about the future collaboration
- Sara/Levana: usage of the experimental data. The uncertainty has not been considered in the algorithm.
- Jan/Levana: why the connection conducted between charge change cross section and total cross section. main in the community

Decisions/Action Items: ✔️

Chair person (Sara) manages the flow.

🔶 Presenter 2-1: Y. Fujii (title: Benchmark experiment for large angle scattering cross section of 14 MeV neutrons)

Key points:

- iron and tungsten experiments performed at OKTAVIAN (DT fusion neutron source) especially for large angle scattering cross section
- shadow bar and activation foil system for measurement
- (Roberto/Yamato) all boundaries of the experimental room considered
- different type of experiments performed considering possible pathways
- results of reaction rates of Nb: iron -> ENDF/B-VIII.0 best (but JENDL-5 not tried), tungsten -> JENDL-5 and JEFF-3.3 good agreement
- currently he focuses on lithium target, Hf foil: but experimental error study to be

continued

- activation foil section also studied for lower statistical error (better than Hf) in lithium experiment
- the benchmark experiment for Li to be performed with the improved system

Discussion/Comments:

- (Roberto) activation foil selection. Mg is for the lower energy neutron. elastic and inelastic should be showed together.
- (Yuefeng/Yamato) statistic error. which one is the main impact? background of gamma ray and short of half lives of the foils.
- (Alex/Yamato) plan for publish of the data. iron/tungsten already done. Si, Oxygen and others under review.

Decisions/Action Items: ✔️

🔶 Presenter 2-2: M. Kostal (title: Rez contribution to fusion research: Broomstick and Teflon leakage experiments)

Key points:

- 4 research reactors (LR-0, LVR-15, VR-1, AKR-2), 252Cf, neutron spectrometry, gamma spectrometry systems (well validated) in Rez
- Broomstick experiments
  - pinhole beam (3 cm)
  - alignment study done: spectra consistent, background determination done
- Copper results: total cross section on ENDF/B-VIII.1 good, but JEFF-3.3 and JENDL-5 not
- Cr results: total cross section on ENDF/B-VIII.1 good, but JEFF-3.3 and JENDL-5 not, comparison with variance evaluations (broomstick and leakage)
- Broomstick can do the total cross section validation with small experimental assembly (15-20 cm of block, leakage 50 * 50 * 50 cm3)
- Al leakage results: underprediction is lower energies on the spectra, 115In(n,n') and 58Ni(n,p) reaction rates a bit underestimation
- W leakage results: ongoing measurement, JEFF-3.3 overestimate < 5 MeV
- W broomstick results: JEFF-3.3 overestimate, JENDL-5 and ENDF/B-VIII.0 better agreement
- PTFE leakage: new approved ICSBEP evaluation, mostly underestimation tendency for lower energy regions
- issues in 19F cross section below 2 MeV
- Quasi monoenergetic field validataion performed

- Graphite leakage, calculation in progress, to be published soon
- other experiments introduced (prompt gamma measurement, gamma spectrum measurement in TRIGA and epithermal dosimetry, etc.)
- many possibilities for fusion relevant studies

Discussion/Comments:

- (Alberto/Michal) stilbene scintilator. For iron sphere experiment, the same crystal detector used. Small crystal not for gamma. seperation of neutron/gamma contribution. overlapping region treatment.
- (Alberto/Michal) stilbene scintilator. unfolding performance using with calibration parameters. calculated parameters used for unfolding, vector from the matrix (primary is 252Cf)

Decisions/Action Items: ✔️

🔶 Presenter 2-3: R. Villari (title: Recent and future benchmark experiments at the FNG)

Key points:

- (2022-2023) tungsten shielding experiment
  - tunsgten, water and stainless steal
  - 20 years ago performed. FENDL-2.1 improved for fast neutron flux
  - nuclear heting was the problem
  - (Roberto/Davide/Daniel) FENDL-3.2c should be fixed it, but not really confirmed in F4E calculation. the previous data (FENDL-3.2b) had a processing issue
  - Re-performed DEMO oriented tungsten shielding experiment (to be published)
    - Activation foil results shared
    - Two thermal RR (Au, W) decrease inside slabs
    - higher energy regions good agreement even though FENDL-3.2 underestimates in last part
    - (Daniel) TSL data to be used for checking especially Polyethelene
- (2025-2026) concrete shielding experiment
  - pre-analysis ongoing
  - WPENS for IFMIF DONES
  - ordinary and heavy concrete
  - (Andrej/Dieter/Yuefeng) composition of concretes. assessed chemical composition conducted
  - optimized activation foils configuration studied
  - (Andrej/Roberto) 56Fe(n,p), Mn contribution to be considered carefully, like Ni foil

has Co contribution
    - (Roberto/Sara) strange behavior on FENDL-3.2 underestimation (comparing JEFF-3.3) to be checked the reaction rates for epithermal region in Ordinary concrete analysis
    - (Andrej/Sara) IRDFF used for RR
    - The reasons to be specified for thermal neutrons of RR in ordinary concrete

- future plans: heavy concrete, Cr, ACP, GENeuSIS tests, WCLB blanket mock up for TBR measurement in WCLL, Divertor mockup, Shielding and activation, Streaming and SDDR, FNG-burn (irradiation at high temperature), etc.
- FNG can support for additional measurement

Discussion/Comments:

- Cr experiment desired for the future, but too high cost expected
- (Andrej) excellent lower energy resonance studies performed at old facility, but not available anymore
- (Davide/Sara/Marco) new experiment (W) showed worse C/E results, reason? not only clean W experiment this time, not the exact same condition of the experiment, "shielding experiment", not for pure W benchmark
- (Michal) concrete experiment. water contribution changed in seasons
- (Michal) new experiment (W). should think the contamination by thermalization
- (Roberto/Andrej) IRDFF. it is noted that the capture quality is not the same the one of threshold one, uncertainty should be considered when the energy spectra changed (slowing down) inside the assembly. Spectra needs to be checked carefully.
- (Ivo) thermal neutron travels in short, only specific area

Decisions/Action Items: ✔️

🔶 Presenter 2-4: I. Kodeli (title: FNG tungsten benchmark analysis using pointwise and multigroup FENDL-3.2 data)

Key points:

- FNG-W 2002 (nuclear data validation) vs 2023 (DEMO design oriented)
- MCNP, DORT and TWODANT codes
- XSUN2023 nuclear data
- sensitivity completely different between FNG-W-2002 and 2023
- MCNP vs DORT: "tendency" almost same not 197Au(n,g) (sigma_zero is not correct)
- (Roberto) dosimetry, IRDFF used in the calculation
- (Ivo to Sara) mcnp input error found out (to be checked in Nb, In RRs) in FNG-W-2023
- Foil density also sensitive

- DORT code and multigroup ND still useful for sensitivety, trend analysis and V&V.

Discussion/Comments:

- (Dieter) MCNP vs DORT agreement, most cases are good, except Indium, W, Au position defendency should be considered
- (Roberto) IAEA encourages own input management system. SINBAD standard should be considered. It makes another confusing moment for other analses as well.
- (Michal) detailed description can support to keep the quality of the input
- (Marco, Roberto, Michal) IAEA repository, CONDOR finished, INDEN one is useful for version control (now freezing). ICPBEP is not open source
- (Marco/Dieter/Sara) policy the data (new W shielding). to be implemented SINBAD. practical problem is that manpower and time for prepartion (fulfill SINBAD requirement)
- (Roberto) open "input" data is good for tracebility, not judge on the quality of the input.
- Uncertainty recapping done in SINBAD, it could be useful for JADE

Decisions/Action Items: ✔️

(Indico agenda to be modified)

🔶 Presenter 2-5: R. Capote Noy (title: INDEN activities for FENDL: Fe, Ni, W, F)

Key points:

- purpose INDEN project
  - Evaluation pipeline establish under international collaboration
  - Share knowlegde each other

- CIAE DT benchmarks: Graphite, Be, Fe, SiC, W (Chinese contribution of high quality)
  - DD and DT contribution (CIAE testing & setup), importance on elimination of DD contribution published. DD contribution dependence on irradiation time ~150 ns
  - Tungsten: studied earlier in 2019. R. Han et al., EPJ Web of Conferences 239, 18009 (2020)
  - Tungsten: study time dominancy considered. Y. Nie et al., Annals of Nuclear Energy 136 (2020) 107040.
  - JEFF-3.3: total cross section re-evaluation can make better C/E which pointed out so far. JEFF-4.0 (final version) conducted ENDF/B-VIII.0

- Comments on differential and integral benchmarks of W
  - many lesson learned. think not only specific NDL

Discussion/Comments:

- (Ivo) CENDL-3.2 shows better performance, already checked. The angular distribution on Iron sphere, old FENDL is better than the new one. Sharing the data would be helpful. Roberto will contact them.

Decisions/Action Items: ✔️

🔶 Presenter 2-6: M. Fabbri (title: FENDL-3.2c: V&V and impact over ITER analysis)

Key points:

- FENDL-3.1d still used until an official IAEA recommendation
- D1S-ACE libraries (using FENDL-3.2b + TENDL-2017) generated and V&V done
- ITER wants the better points of FENDL-3.2c (from FENDL-2.1) on each nuclei data
- D1S predominant way in ITER SDDR (FENDL-3.1d + EAF-2010)
- F4E library, TENDL-2017 picked not FENDL-3.0/A (EAF-2010) for the D1S ACE library
- more SDDR experiments necessary (now only two, F4E D1S ACE libraries shows 20-40% of underprediction)
- TENDL-2017 misses many details in the resonance region
- (Roberto) EAF data based on experimental data (generally), TENDL was not at that time
- Cross sections of the (specific) reaction in IRDFF is the best one we have, even it was not developed by the purpose
- (Yuefeng/Roberto/Dieter) About the recent TENDL libraries (as the activation). not easy to make a decision to use which version, it's depending on the data and timing and nuclides.
- Transport library -> FENDL-3.2c, Activation library -> no decision yet
- For the next FENDL-4.0
    - HDF5 nuclear data for OpenMC
    - 54 missing isotopes to be added in the next version
    - 20 isotopes have zero gamma production
    - Missing TSL in Be (and other important isotopes), V&V for deuteron, workforce from PhD (not funding), frequent FENDL meeting, JEFF model, etc.

Discussion/Comments:

- (Andrej/Jan) useful script exist in NEA gitlab (for OpenMC libraries), Jan already reported.
- (Davide) as a recent trend, HDF5 data should be releaed with ENDF and ACE in the web page.
- (Roberto/Georg) Github useful for clear tracibility. comprehensive aspect or community aspect based on JEFF model => "point of view on trace"

- (Roberto) TSL data for "Fusion" to be determined
- (Dieter/Marco) spherical benchmark on TENDL-2017 is for SDDR benchmark
- (Dieter) ITER data strategy changes, then updated results could be required
- Tricky parts, ITER wants a clear recommendation from IAEA, but IAEA can do it if there's a clear path. IAEA can do for FENDL (general purpose), but not for activation library

Decisions/Action Items: ✔️

🔶 Presenter 2-7: Y. Qiu (title: Nuclear data validation and verifications for IFMIF-DONES)

Key points:

- all data in FENDL checked using by JADE, a few important isotopes for IFMIF/DONES investigated
- (Andrej/Yuefeng) difference mentioned in the presentation, comparing with JEFF-3.3
- 56Fe improved a lot from FENDL-3.1d to FENDL-3.2b (INDEN evaluation)

> - FENDL-3.2b (or later) good for neutron transport calculation

- DPA uncertainties studied including covariance data ~ 23% (overall averaged)
- gas production uncertainties, missing cross section? (no, see the comment below)
- (Roberto/Daniel/Andrej) many data for gas production above 20 MeV included in MT=5, not included into each MT# (e.g. MT=203-207). Data is there but not processed properly to calculate the gas production
- (Dieter) DPA not changed, only gas production changes on higher energy?
- (Roberto/Andrej) nuclide production included in MF=10 (JEFF-4). gas production information to be desribed well for users by "evaluator"

> - deuteron libraries - JENDL-5 data to be used as much as possible, other possible library TENDL-2021

Discussion/Comments:

- (Davide/Yuefung/Jan) Happy to see another JADE user (outside of F4E, UKAEA). energy extension and removing unnecessary tallies would be helpful. Maintenance will be continued
- (Sara) reason for picking TENDL-2021. For activation, TENDL-2023 is almost similart to TENDL-2021, not a bit changed from TENDL-2017.
- (Andrej) try to use TENDL-2023 then compare with old ones to figure out script mistake as a simple test
- (Davide) F4Enix could be useful for the trial

- **(Roberto) strong recommendation for activation of the charged particle (5 people for 10 years to make the database), ENDF-6 format available:** https://www-nds.iaea.org/medical/index.html
- (Yuefeng/Roberto) deuteron activation library in FENDL would be helpful, the charged particle activation to be tried first, or go to TENDL libraries. Anyhow find the needs first
- (Roberto) 10,11B in the lastest FENDL improved be implemented with IRDFF, not W yet

Decisions/Action Items: ✔️

🔶 Presenter 2-8: M. Fabbri (title: Application of the TUD-W Benchmark for Nuclear data and code validation)

Key points:

- Little excersise performed with TUD-W in SINBAD analyses performed using MCNP and OpenMC (csg2csg used for conversion the input)
- OpenMC works on the analysis "well" (not big different comparing MCNP) of neutron and photon spectra results
- primary gamma makes the peaks above 6 MeV
- Benchmark added into JADE
- Impurity study to be continued

Discussion/Comments:

- (Jan/Marco/Alex) weight window method in OpenMC (magic method used). Still issued. ADVANTG tried in OpenMC. Parameter about
- (Roberto/Georg) criticality calculation agreement. few agreement confirmed (not enough but did).
- (Roberto/Marco) comparison not only nuclear data but also codes (transport)
- (Michal) experimental data to be compared together as well
- (Roberto) nuclear data valiadtion is the highest priority, not the code one.
- (Marco/Sara) In a few years, OpenMC can be on the same page of MCNP (GPU improvement). OpenMC will be more useful.
- (Sara) Importance to think the impurity and composition, especially about Ni, Fe
- (Michal) if incorrect substraction of background was there, photon spectra could be affected
- (Roberto) Gamma is problematic one (comparing to neutron, evaluation, processing, validation, etc.)
- (Sara) Plotting the nuclear heating distribution would be good to understand

Decisions/Action Items: ✔️

🔶 Presenter 2-9: A. Milocco (title: Ranking of iron nuclear data performance for fusion application using a suite of benchmark experiments)

Key points:

- Objective: development of a general method for raking performances and contribute further V&V of FENDL
- integral experiments in SINBAD, ICSBEP, CoNDERC databases for DT, Cf252, 800 MeV proton spallation (ISIS) and U235 fast fission (ASPIS-88, lowest energy) sources
- (Roberto) capture cross section to be treated carefully, even they are in "IRDFF (the best one we have)"
- two key performance index (KPI) conducted - Mean weighted percentage relative absolute deviation (MWP-RAD) and mean weighted Chi-squared (X2)
- JADE developments in the current framework (pre-processing of mcnp input, suite of new Fe benchmark and post-processing such as TOF, X2)
- X2 approach
    - unrealistic experimental uncertainties
    - different between shielding and criticality benchmarks
- sensitivity and uncertainty analyses for establishing the weights of the KPIs, correction between experiments, normalization and uncertainties associated to KPIs to be addressed, some definitions (metrics, norm) to be tested
- General criterium for classification for assessment of nuclear data performances along with integral benchmarking models

Discussion/Comments:

- (Ivo) reaction rates should be considered to study some trends
- (Ivo) doubt on the weighted functions
- (Dieter) weighted functions. There's a lot of human factors in the assessment (experts judgement) in general.
- (Alberto) some energy range, limited number of experiments exist (e.g. TIARA - 40 and 65 MeV)
- (Sara) exclusion impact to be checked
- (Roberto/Michal) it seems that the energy broadening not implemented, but it's critical. Effect on resonance region should be considered.
- (Michal/Roberto) independently by detectors, not put into together. Energy binning.
- (Georg) separate discussion should be carried out as a point of view for the meeting topic

Decisions/Action Items: ✔️

Chair person (Marco) manages the flow.

🔶 Presenter 3-1: H. Khater (title: Simulation of the Radiation Enviroment at the NIF)

Key points:

- FENDL applicability in 3D detailed MCNP model of NIF (dose and diagnostics usage)
- Automated ALARA-MCNP interface (new tool to estimate post-shot dose rates)
- TOF (used to understand fusion spectra), high yield of the beam can be a significant source of background
- Silver conducted to reduce D-T signal, limited data for 107,109Ag (0.5 - 30 MeV)
- Real time neutron activation detectors (RTNADs) for measuring neutron yield (Zr cap+LaBr3), 90Zr data okay, but 79Br inelastic data (81Br is not suitable)
- inelastic scattering neutron above 6 MeV for development of gamma detectors (C, Al, Si, W, etc. but not enough experimental data, and how accurate)
- For Reaction in flight (RIF) diagnostics, 169Tm, 209Bi reactions are used to measure

Discussion/Comments:

- (Roberto/Hesham) cross sections from ENDF, not IRDFF? mostly FENDL-2.1 activation data used. FENDL recommends to use for dostimetry, IRDFF (e.g. 169Tm, 209Bi and 90Zr as well)
- (Roberto) Ag has no good evaluation yet.
- (Michal) Indium cross section good, for the measurement using with Al could be helpful to avoid the low melting point of Indium.
- (Andrej) 90Zr(n,2n). high gamma production problem on the NIF usage? IRDFF should be used for the calculation for the reaction (well evaluated).
- (Alex/Hesham) 3D plotting tool. part of MCNP code (old fashioned style).
- (Alex/Hesham) SDDR method. sum-based model conducted.
- (Dieter) effective neutron energy distribution on high density shots. general spectra.
- (Dieter/Hesham) neutron emission from plasma source

Decisions/Action Items: ✔️

🔶 Presenter 3-2: D. Laghi (title: JADE v4, a more robust and expandable architecture for neutronics V&V)

Key points:

- Github, search with "JADA V&V" not only JADE
- Histrorical recap of JADE and features

- Reason for JADE v4
  - code-lib to code-lib comparison
  - full implementation of OpenMC
  - clear isolation structure
  - no additional programings on benchmarks
  - etc.

- 25 benchmark included (total 149 experiments)
- (Marco) a bit progressed but still missing information of inputs
- keep implementing new benchmarks, CHI2 and KPIs for further features

Discussion/Comments:

- (Roberto/Davide) different measurment benchmark (e.g. experiments in Rez), reaction rates treatment. separated treatment conducted already
- (Roberto/Davide) Verification strategy. e.g. SINBAD input being used with a small modification.
- (Daniel) happy to participate checking things (inputs of MCNP, OpenMC etc.), unification is important
- (Roberto/Georg/Michal/Davide) open benchmark repository (open=published one). some inputs are available IAEA web.
- (Jan/Davide) open benchmark in gitlab (Paul Romano's) can be added? but license?
- (Alex/Roberto/Georg) ConDerc is still alive, though project had finished, duplication is not big problem. IAEA web fully open.
- (Yuefeng/Davide) new benchmark implementation (input and sdef etc.)
- SINBAD two licenses: NEA and the US benchmarks

Decisions/Action Items: ✔️

🔶 Presenter 3-3: A. Valentine (title: Application of JADE as a complete tool for automated nuclear data and particle transport code validation)

Key points:

- Many neutronics activities in UKAEA adopted FENDL
- UKAEA involved into JADE V&V for clear uptake MCNP alternative code and NDLs for array of applications
- EUROfusion WPBB (breeding blanket) in-kind UK contribution
- OpenMC in JADE
  - JADE helpu to identify differences and gaps between MCNP and OpenMC
  - openmc.py - seperate module. further other codes implementaion forseen such as

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- IAEA open benchmarks Github (https://github.com/IAEA-NDS/open-benchmarks, NEA Gitlab (SINBAD) and F4E Gitlab (others) for JADE benchmarks
- note: no surface tally in OpenMC, preparing very thin cell tally implemented for comparing with the result by MCNP
- (Roberto/Daniel) "processing code" should be checked for treating the ptable (unresolved region), it could make a big difference
- most results shown in the latest FENDL paper which just submitted on 14-May-2025 by Georg
- (Daniel) original NJOY vs IAEA NJOY can make different data

Discussion/Comments:

- (Andrej) numerical benchmark, adding gamma tally is useful (gamma emission spectra).
- (Yuefeng/Davide) material density. standards value used, isotope ones use NIST ones (sometimes needs a small tweakings). values can be found in the JADE documentation
- (Yuefung/Alex) higher energy part can be tested
- (Roberto/Alex) uncertaintly difference by running particles

Decisions/Action Items: ✔️

🔶 Presenter 3-4: T. Stainer (title: The nuclear data arsenal and new approaches)

Key points:

- an exploration into web assembly for nuclear data processing
- many tools are there, but some issues (installation, versioning, not always open source, debug and maintainablity, etc.)
- possible approaches raised such as python wrapper, binding fortran to C, APIs and web assembly
- Web assembly (use existing code based and run in the brower)
  - Wasm: fast, safe, open and portable
  - https://wasmtime.dev/
  - some demos https://git.oecd-nea.org/stainer_t/demo-wasm

Discussion/Comments:

- (Davide) JADE has tried also web based application.
- (Roberto/Arjan) IAEA already maintains some codes like PREPRO. TALYS running the code in client side would be a next step (now running IAEA server)

Decisions/Action Items: ✔️

Chair person (Yuefeng) manages the flow.

🔶 Presenter 3-5: S. Okumura (title: The IAEA Nuclear Reaction Dataexplorer)

Key points:

- EXFOR related work for filling the gaps between experts and users, because it takes time to understand only the format of nuclear data libraries
- Developed "Dataexplorer" to solve it
- https://www-nds.iaea.org/dataexplorer/reactions/xs?targetelem=Zr&targetmass=90&reaction=n%2Cg
- Cross section plotter, exfor viewer, other useful functions available
- Many web APIs also avaiable (EXFOR, parserEXFOR dictionary, dicrete level, etc.)
- ENDF-6 viewer will come powered by DeCE (developed by T. Kawano (LANL))
- Easy treatment on the data and data access (EXFOR related)

Discussion/Comments:

- (Marco/Shin/Arjan/Roberto) FENDL missing? to be added soon. All nuclear data libraries should be added as much as possible.
- (Andrej/Shin) Dataexplorer is completely seperated from classic EXFOR. duplicated? Dataexplorer will have more data, but think about the storage
- (Roberto/Shin/Arjan) selecting the SIG and SPA? now you can select the plot "exlusion"
- (Davide/Shin) API. any limitation? NDS does not have, but agency would have.
- (Davide/Shin/Roberto) how fast to make atlas. depends on the data points

Decisions/Action Items: ✔️

🔶 Presenter 3-6: G. Schnabel (title: Making FENDL interplanetary)

Key points:

- How can we make FENDL acceccible for everyone (not only FENDL community)
- Choose proper "language (JSON this talk, YAML whatever)" then have interplanetary naming, file system and version control
- Proto-type (yet)
- https://github.com/CodeVisionaries
- https://github.com/iaea-nds/endf-parserpy

Discussion/Comments:

- (Alberto/Georg) block-chain? temperproof
- (Davide) why GIT
- (Sara) why JSON format (additional step). NJOY parser
- (Roberto) similar approach of GNDS
- (Yuefeng) ENDF -> JSON conversion
- (Alberto) multi hash
- Maybe, not very suitable to make deep discussions in this meeting, but important issue considering nuclear data in the future

Decisions/Action Items: ✔️

🔶 Presenter 3-7: A. Koning (title: TALYS and TENDL for the future of FENDL)

Key points:

- Isolated progress on TENDL, which can be helpful for FENDL
- Initial TENDL, fully theoritical model based. Now many experiments implemented into the TALYS model
- JEFF-4.0: 80% of isotopes from TENDL-2025, 106 nuclides not from TENDL because of no reproducible system for light and structure nuclides and actinides.
- A few issues solved step by step
- Missing isotopes data could be adopted from TENDL-2025 in the tranport library
- (Roberto) experimental uncertainty 58Ni(n,2n)
- (Marco/Arjan/Alberto) criteria of scoring? averaged c/e. Frms
- YANDF (Yet Another Nulcear Data Format)

Discussion/Comments:

- (Davide) sometimes skips TENDL due to render process (too many isotopes data)
- (Alberto) not whole data, isotopes data in FENDL are enough
- (Davide) Test of JEFF-4.0 could be the same the test of TENDL-2025 (even 20% isotopes are not from TENDL)
- (Sara/Arjan) TENDL-2017 vs the latest one. Main changes? Resonance range much better than before. Isomeric production realistic now
- (Michal/Roberto/Arjan) decay heat in TENDL-2017 good, but TENDL-2025 be a start point considering dosimetry application (activation)
- TENDL-2017 vs 2025 (with the level of EXFOR) should be checked
- deuteron induced data
    - (Yuefeng/Arjan/Roberto) feasible to make a kind of special library? complicated,

but could be done, require time. Could be done as a practice
    - (Roberto) priority of deuteron induced data should be (clearly) determined in advance. activation or transport?
    - Possible way: A few isotopes from JENDL-5, another few from ENDF/B-VIII.1, others could be covered by TENDL?
    - (Yuefeng/Arjan) Work flow compatible with Rumania? complicated.

Decisions/Action Items: ✔️

🔶 Presenter 3-8: T. Eade (title: Nuclear data considerations for STEP)

Key points:

- STEP: A UK prototype fusion energy plant (tokamak) targeting 2024, path to commercial viability of fusion to be constructed in West Burton, North Notts in the UK
- Defining guidelines of nuclear analyses of STEP
    - MCNP, OpenMC (for V&V), FISPACT-ii, MCR2S N1S for SDDR, Custom plasma source routine converted from JETTO code
    - FENDL-3.2c + ENDF/B-VIII, mcplib84 for photon, activation not decided

- Magnet lifetime assessment, fast neutron flux to calculate a lifetime. MC method for quantifying uncertainties
- Total monte carlo conducted for nuclear data uncertainty
    - **covariance data** is a key part to understand uncertainties in the designs

- Nuclear heating in coil
    - **Indium** cross section, heating values should be added in FENDL

- Coolant activation
    - Activation data on Oxygen, 16,17N decay neutrons will activate other surrounding materials, **17O(n,p)** different cross section among NDLs

- TBR burnup
    - **Secondary reaction data of 6,7Li and 9Be** on available in CENDL-3.2

Discussion/Comments:

- (Georg) covariance data to be added as much as possible
- (Daniel) Other imporatnt isotope, Indium as well
- (Roberto) CENDL-3.2c, unique evaluation for light nuclides, tritium production related (Li) in IRDFF. Formatting different but xs useful. Lithium data in FENDL has mt=5
- (Dieter/Tim) Uncertainty propagation. fluence is major issue.

Decisions/Action Items: ✔️

🔶 Presenter 3-9: M. Rajput (title: Nuclear data needs for Spherical tokamaks)

Key points:

- high temperature superconducting (HTS) magnets, 20 T at 20 K
- Key parameters on neutronics analyses for ST design
  - neutron flux
  - reaction rates (tritium production, gas production)
  - transmutation reaction channels
  - radiation damage and KERMA
- Lithium breeder and vanadium based alloy for blanket functional materials, Fe, Cr and V for structural materials
- Nuclear data (heating, DPA, gas production, transmutation) for YBa2CuO7, Ag, Cu buffer and substrate layers in HTS material
- 12C(n,n'2a) reaction data for helium production
- 10B(n,a) reaction data for shielding
- 186W(n,g) and 180Hf(n,g) for plasma faced components and shielding
- Activation library missing in FENDL for FISPACT
- High energy electron cross section

Discussion/Comments:

- (Roberto/Andrej) Not proper comparison e.g. 186W(n,g) reaction. Low resolution in resonance region.
- (Dieter) 12C alpha reaction. recently a new test evaluation done by UKAEA. JEFF-4.0 may include it.
- (Daniel) FENDL-3.2c should be used, not FENDL-3.1d.

Decisions/Action Items: ✔️

For a last day of this meeting:

- Activation library
- Covariance data
- Recommendations (guidelines)
- Discussion at the last FENDL meeting
- Decide the priority***