UK Atomic Energy Authority

UKAEA

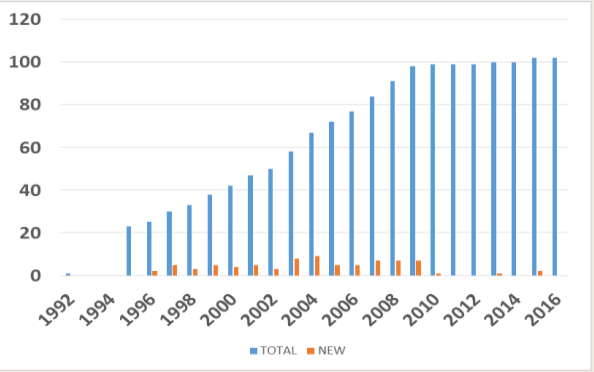
Status and priority list for new SINBAD evaluations

- Ivo Kodeli

WPEC SG47 Webex Meeting, May 11, 2021

SINBAD - Radiation Shielding Experiments Scope and Objectives

- Compilation of high quality experiments for validation and benchmarking of computer codes and nuclear data used for radiation transport and shielding problems encompassing:
  - reactor shielding, PV dosimetry (48)
  - fusion blanket neutronics (31)
  - accelerator shielding (23)
- Contains 102 experiments
- Available from OECD/NEA and RSICC.
- Low and inter-mediate energy particles applications.



https://www.oecd-nea.org/science/wprs/shielding/sinbad/

Candidates for future SINBAD evaluations – Focused meeting on new SINBAD evaluations

- **FNG-Cu & -HCLL**: F4E evaluation, under review IRPhE/ICSBEP/SINBAD
- **FNG-WCLL**: ongoing experiment (EUROfusion)
- **Rez spheres** (Fe, H2O) (1m) AmBe source, under review IRPhE/ICSBEP/SINBAD
- **LLNL** spheres: 75 pulsed-sphere neutron-leakage spectra for 20 different materials
- **CIAE** leakage spectra from SiC, **Fe**, graphite, Bi (14 MeV neutrons), TOF measurements at different angles
- **HINEG** benchmark experiments (DFLL TBM)
- **FNS Cu**, Mo, Ti, Li_2O: **copyright issues between QST and JAEA (action to NEA)**
- **OKTAVIAN**: LiF, CF_2, Ti, Cr, Co, Cu, As, Se, Zr, Nb, Mo;
- **IPPE**: BTiH, U, …
- **NESDIP 4 & 6, JANUS II-VII:** clearance needed
- VENUS-1, VENUS-2 PV dosimetry experiment
- **JET:** SDR experiment (2012-2013), streaming, dose rate
- Neutron Penetration through Fe & Concrete for 140-350-MeV Quasi-Monoenergetic Neutrons, RCNP, Osaka University (Prof. Takashi Nakamura)
- JASMIN: Japanese-US Study of Muon Interactions & Neutron Detection FERMILAB (Prof. Takashi Nakamura)
- Measurements of reaction rates and induced activity in concrete exposed to secondary particles produced by intermediate energy heavy ions on Fe target HIMAC (NIRS).
- **KFK-1977**: gamma fields in iron with ^{228}Th & ^{252}Cf source (proposed by S. Simakov)

JANUS experimental Fast reactor programme (1984-87, AEA Reactor Services Winfrith & CEA Cadarache):

- **Phase 1: 40.4 cm SS, 56.7 cm MS**
- Phase 2: 22.4 cm SS, 91.4 cm Na
- Phase 3: 25.0 cm SS, 91.4 cm Na
- Phase 4: 10 cm SS, 5 cm B4C. 10 cm SS, 90 cm Na
- Phase 5: 15 cm SS, 5 cm B4C. 5 cm SS, 90 cm Na
- Phase 6: 10 cm SS, 10 cm B4C. 5 cm SS, 90 cm Na
- Phase 7: 50 cm B4C, 120 cm Na
- **Phase 8: 282 cm Na**
- Phase 9: 26 cm SS, 10 cm B4C, 22 cm SS, 90 cm Na

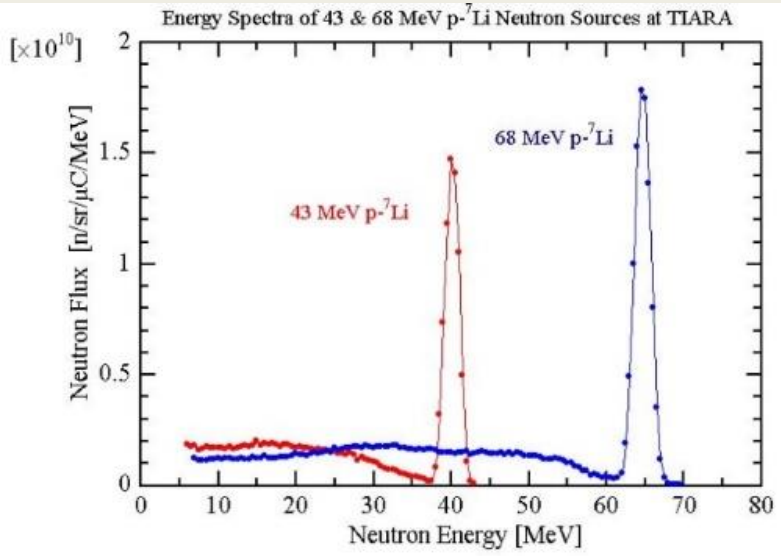
Clearance needed from UK/Winfrith

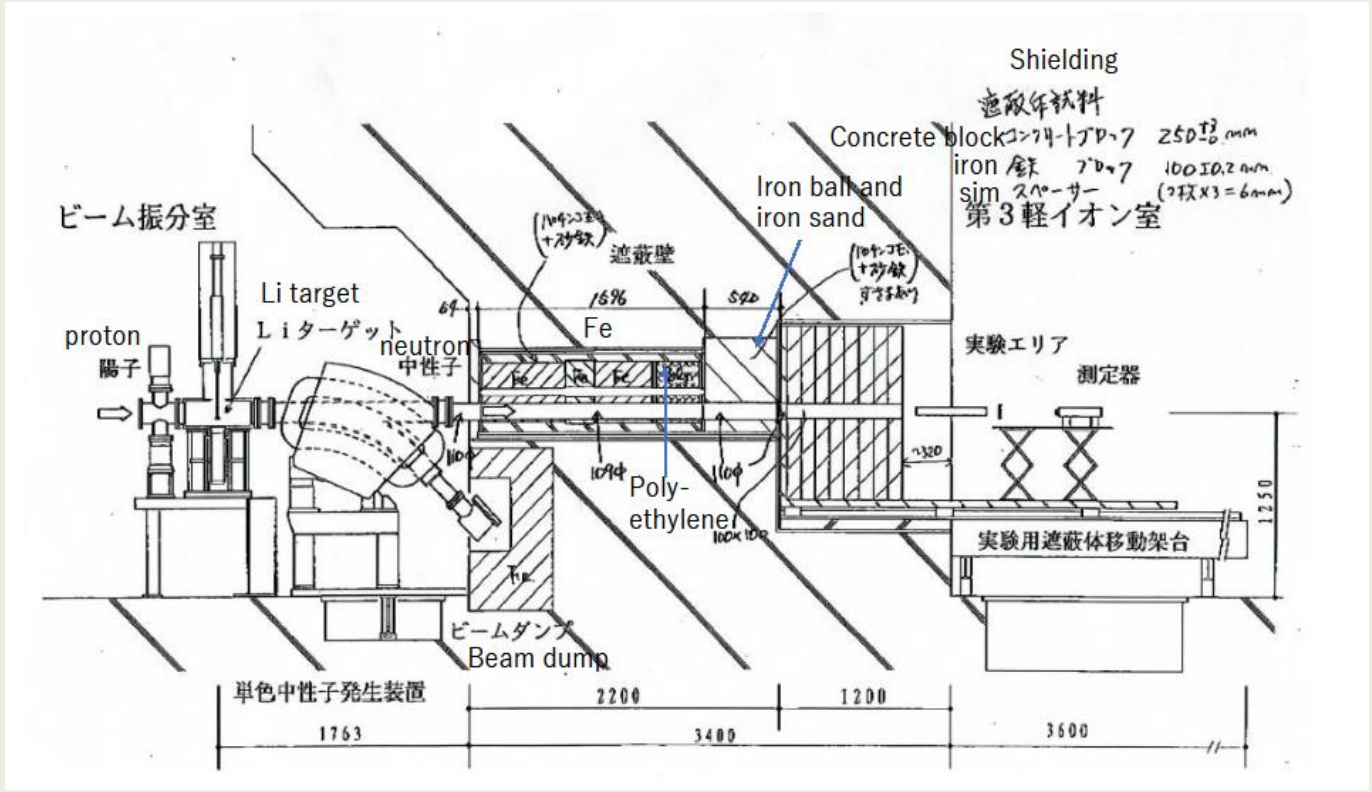
Clearance and access to the following data would be valuable:

- **ASPIS: JANUS 2-8, NESDIP 4 and 6**
- **FNS series of 14MeV neutron benchmarks:** several already in SINBAD, clearance for some recent measurements such as **Mo and Cu** is needed
- **OKTAVIAN:** several benchmarks in SINBAD, data for many are available and need compilation & review, access to some more recent measurements would be appreciated
- **Pending SG47 action on ORNL:** investigate availability of **Broomstick** experimental data for **24" and 36" Oxygen spheres (S. Simakov)**
- **…**

TIARA facility

Yosuke Iwamoto 2021/05/10

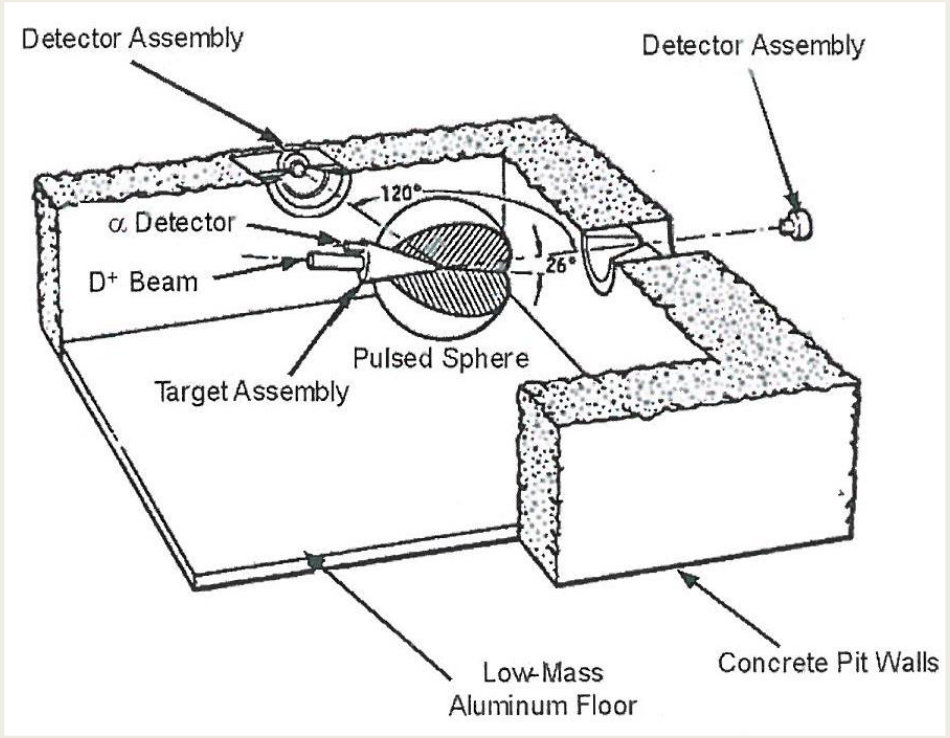


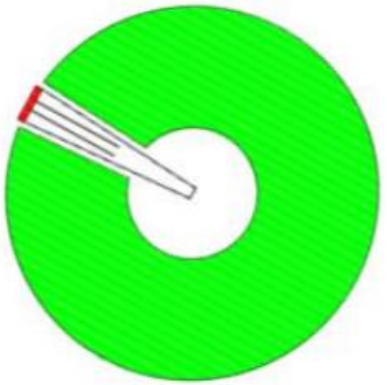


Projectile: 43 & 68 MeV protons on Li-7 target
Shield: Fe (130 cm), concrete (< 200 cm), polyethylene (< 180 cm)
Measurement: neutron spectra and reaction rates by BC501A liquid scintillator, Bonner spheres, fission counters, TLD and SSNTD
Organisation: TIARA/JAERI

More information needed on the surroundings, target, source, beam dump and collimator. Details needed to model the dosimeters (bonner spheres, fission counters, spectrometers).

LLNL Pulsed Spheres

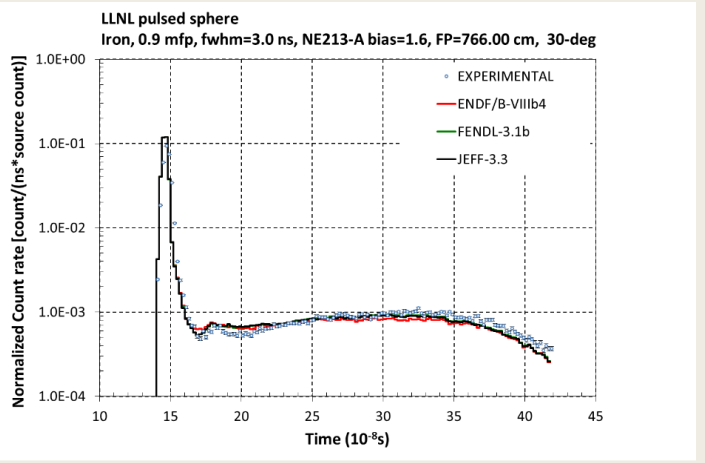




COG Model of Target Assembly and 1.8 MFP Thick Polyethylene Sphere.

Soon S. Kim, et al., Evaluation of Polyethylene and Blank Pulsed Sphere Experiments Using Deuteron Transport Feature in COG, PHYSOR 2022

Evaluation of DD contribution.



Denise Neudecher (LANL), Oscar Cabellos (UPM): S/U profiles

Projectile: 400 keV deuteron beam on titanium tritiate target
Shields: 75 spheres of different radius & 31 materials (H_2O, Teflon, C, N_2, Al, Si, Ti, Fe, Cu, Ta, W, Au, Pb, ^{232}Th, ^{235}U, ^{238}U, ^{239}Pu, …), 148 different experiments
Measurement: TOF neutron/gamma spectra by NE213 detector
Organisation: LLNL

Other Issues requiring further investigations

- **FNS (Liquid Oxygen**): definition of measured quantity - flux or current; feedback from experimentalists needed and/or systematic study (Stanislav, Alberto, myself)
- **KFK 1977** gamma spectra in Fe spheres (S. Simakov, Serpent model by Victor de Buat)
- **Oxygen Broomstick**: review & updates needed, MCNP or analytic input (S. Simakov)
- **PCA benchmark**: presentation of Steven van der Marck at Nov. 2020 JEFF meeting (action to provide data)**.**

Action on FNS Liquid Oxygen flux definition

- Definition of measured quantity at 0, 12.2, 24.9, 41.8, 66.8^0 - flux or current (action Stanislav, Chikara, Alberto, myself)
- Extract from JAERI-M 88-101, -M 90-092 and Nucl. Sci. Eng. 115, 24-37 (1993) (reports kindly provided by Fujio Maekawa):

The measured angular flux spectrum at angle Ω was reduced to the following quantity, which corresponds to the averaged neutron angular flux at the rear surface center of the slab as illustrated in Fig. 3:

$$\phi(\Omega,E) = \frac{C(E)}{\epsilon(E)\cdot\Delta\Omega\cdot A_s\cdot S_n\cdot T(E)}$$

(n/sr/m^2/lethargy/source neutron) , (2)

where

$C(E)$ = detected neutron counts

$\epsilon(E)$ = differential neutron detection efficiency

$\Delta\Omega$ = solid angle subtended by the detector to the point on the center of slab surface ($= A_d/L^2$, where A_d = detector area and L = distance from the slab surface to the detector)

A_s = effective measured area defined by the detector-collimator system on the plane perpendicular to its axis

S_n = source neutrons emitted during the measurement

$T(E)$ = attenuation correction due to neutron scattering by air in the flight path.

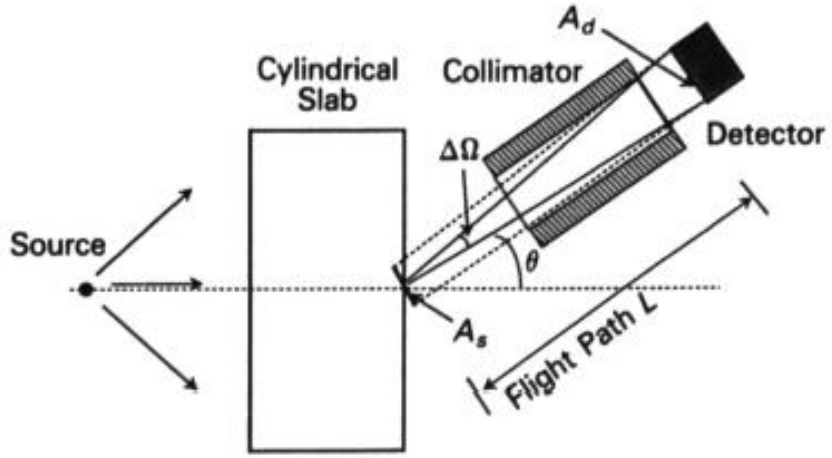
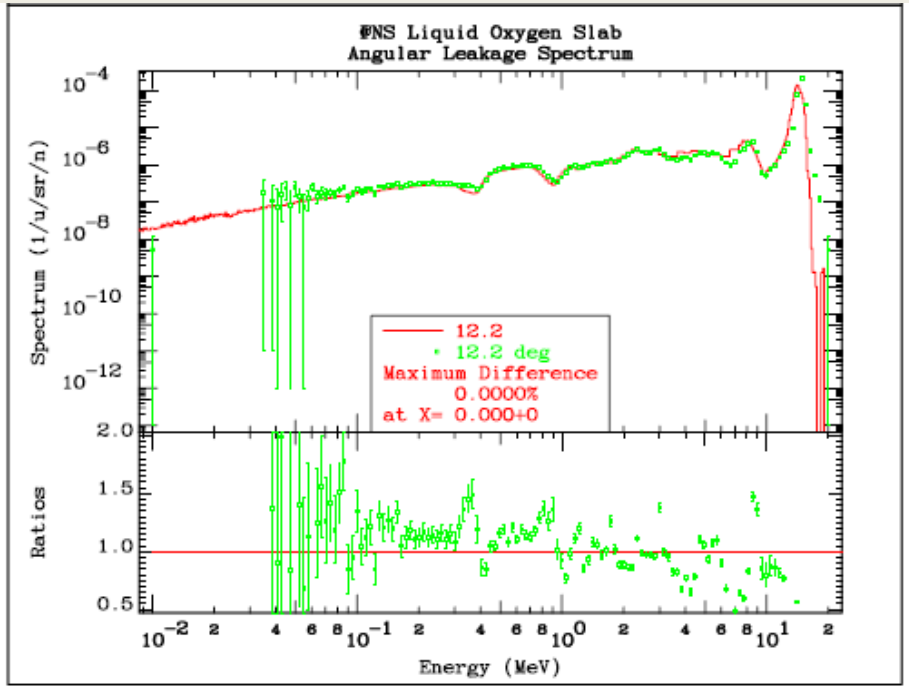


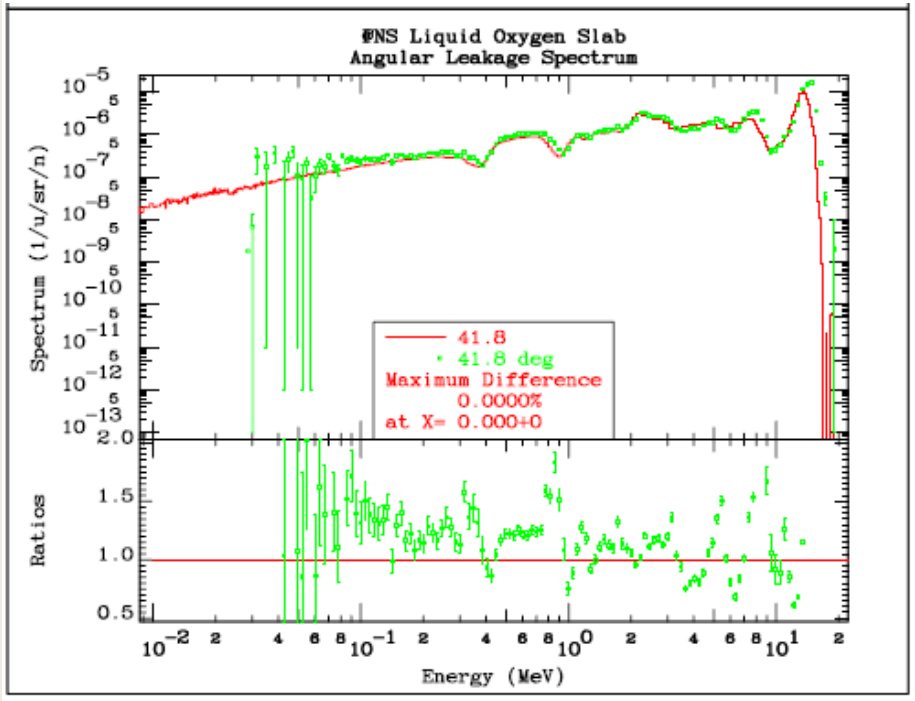
Fig. 3. Definition of the parameters used for data reduction.

$A_s \sim A_{true} * \cos(\Theta)$

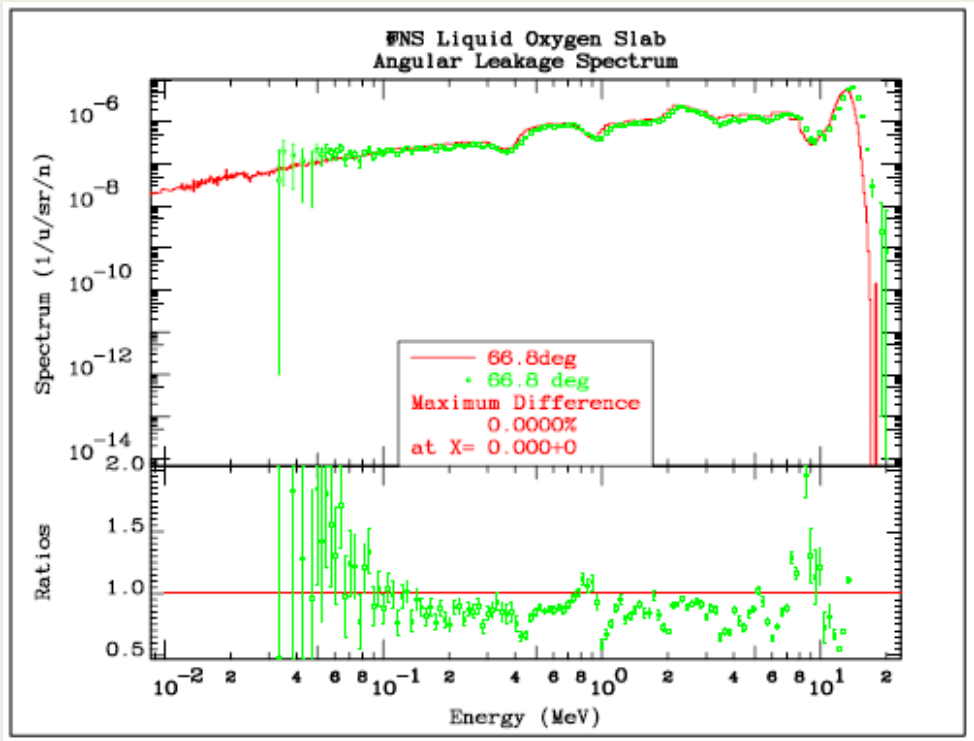
Inconsistency between MCNP and DORT models

FNS Liquid Oxygen benchmark





- **14 MeV D-T** neutron facility at FNS/JAERI
- Measurement of angular neutron leaking spectra from a 20 cm slab of liquid oxygen in 0.05 - 15 MeV energy range.
- Angular fluxes at
0, 12.2, 24.9, 41.8 and 66.8 degrees were measured.
- **JEFF3.3 results**



Quality review of SINBAD benchmarks

- Started around 2008 to review geometry and source description simplifications, reliability and completeness of uncertainty information and conclude on **how useful (older) benchmarks are to improve today's high quality cross section evaluations**
- **Old benchmarks give lessons on how to perform new benchmarks**. Detained information on the quality, eventual drawbacks should be included in SINBAD.
- Quality note and a list of missing items if any are listed
- 51 SINBAD benchmarks went though QR, some still not included in SINBAD (4 accelerators from 2013, could NEA **check the status**)
- **QR of the remaining 51 benchmarks is needed ASAP, including review of RSICC benchmarks (US contribution would be welcome)**

New benchmarks should be evaluated in benchmark databases ASAP, not only published in journals ! Example FNG benchmarks.

***	**valid for nuclear data and code benchmarking**
**	**suitable for education & training**
*	**benchmarks of historical interest**

Relevance to other OECD/NEA and International activities

- EGPRS - Expert Group on Physics of Reactor Systems (EGPRS)
- WPEC - Working Party on Evaluation Cooperation:
  - SG45: Validation of Nuclear Data Libraries (VaNDaL) Project
  - SG46: Efficient and Effective Use of Integral Experiments for ND Validation
- CHANDA & SANDA projects of EC, JEFF project
- European Fusion Programme – Fusion for Energy (F4E) & EUROfusion
- ICSBEP/IRPhE: joint ICSBEP/IRPhE/SINBAD review meetings
- Shielding benchmark repartition between SINBAD and ICSBEP;
  - BAIKAL, VENUS-3, Alarm systems, ongoing (Rez spheres, FNG HCLL, LLNL, HIMAC)

Conclusions

Focused meeting on new evaluations:

- ***Recommendations on updating SINBAD evaluations***
- ***Evaluation of new shielding benchmarks:*** *priority list of new evaluations according to ND needs*
- ***Quality evaluations and classification*** *done for ~50% of SINBAD benchmarks between 2008 and 2015. Needed for the remaining ~ 50 benchmarks*
- ***SINBAD updating and distribution policy*** *& availability need clarification*
- *Coordination with other WPEC (SG46) to promote good practice in use of benchmarks for ND V&V*

WPEC SG47 objectives:

- *Provide feedback on present SINBAD benchmarks and recommendations for improvements based on the experience, needs and expectations of the nuclear data community*
- *Priority list for future evaluations*
- *In cooperation with EGPRS WPRS and TRG participate in future evaluations*

MERCI DE VOTRE ATTENTION