UK Atomic Energy Authority

UKAEA

Priority list for new SINBAD evaluations and updating activity

- Ivo Kodeli

WPEC SG47 Webex Meeting, June 16, 2021

WPEC Subgroup 47 (SG47) on
Use of Shielding Integral Benchmark Archive and Database for ND Validation

Objective: promote & facilitate wider use of shielding benchmarks.

Main topics and improvements needed:

- **Provide feedback on SINBAD and recommendations for improvements based on the experience, needs and expectations of ND community**
- **Priority list for future evaluations:**
- **In cooperation with EGPRS WPRS participate in future evaluations** (new benchmark evaluations practically on hold since > 10 years);
- **Quality evaluations:** assessment of measurement uncertainty, completeness of experimental information, quality standards for modern ND V&V
- **Computer code input data:**
  - **Provide additional inputs & feedback from users on model validation,**
  - **Variance reduction ww cards** to reduce CPU time (bringing it closer to critical benchmark),
  - **Extend the list of computer codes used for analysis,**
- **CAD geometry and material composition** description as detailed as reasonably possible; Code dependent vs. code specific approach.
- **Sensitivity profiles.**

WPEC Subgroup 47 (SG47) on
Use of Shielding Integral Benchmark Archive and Database for ND Validation

- Use of selected integral benchmarks is recommended for developing cross-section libraries and compute codes.
- Primary objective of benchmark databases is to provide a framework for storing standard and validated sets of experiments needed for validation and verification of nuclear data and models in computer.
- HOWEVER: Careful verification of benchmark information is mandatory:
    - correct and complete interpretation of measured results and understanding of the corresponding uncertainties
    - computational model accurately describes the experimental arrangement.

Recommendations and feedback on:

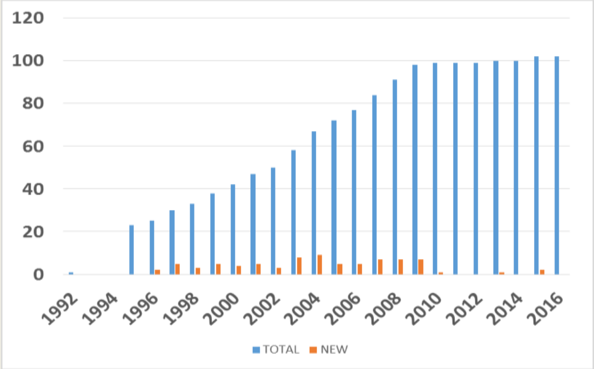
- SINBAD present status and how to proceed in future,
- Recommendations for improvements and updating of SINBAD
- Organisation of future evaluation activities and efforts

CCFE/UKAEA Interest in Shielding Benchmarks & Related Activities

- JET, MAST-U, STEP, ITER, DEMO
- **Review document on shielding benchmarks** available in SINBAD and candidate benchmarks for future evaluations; **starting with fusion** benchmarks
- CAD formats (STEP), availability of benchmark data and computational models
- Examples of fusion relevant materials: W, Cu, Fe, V, Mo, Cr, Y, Ti, C, Zr, Li, Pb, Be, Si,…
- A clear vision of future SINBAD development would be appreciated.

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/

SINBAD - Radiation Shielding Experiments: **Contributing Institutions**

- AEAT, United Kingdom
- CEA, France
- CERN SPS
- ENEA, Italy
- European Commission JRC Ispra
- FZDresden, Germany
- FZKarlsruhe, Germany
- Georgia-Tech, USA
- IAEA, Vienna
- IPPE Obninsk, Russian Federation
- IRI Delft, Netherlands
- JAEA, Japan
- JNC, Japan
- JSI, Slovenia
- KEK, Japan
- LANL, USA
- Lawrence Berkeley Nat. Lab. USA
- MEPhI, Moscow , Russian F.
- Michigan State Univ. USA
- NIRS, Japan
- NIST, USA
- ORNL, USA
- PSI, Switzerland
- RAL, UK
- RIKEN, Japan
- SCK-CEN Belgium
- Tohoku University, Japan
- TU Budapest ,Hungary
- TU Dresden, Germany
- University of Illinois, USA
- University of Osaka, Japan
- University of Pavia, Italy
- University of Tokyo, Japan
- VNIITF (RFNC), Snezhinsk, RF
- FDS, INEST, Hefei, China

SINBAD News & Ongoing activities

- **Quality review** & MCNP inputs by A. Milocco (2015) added in updated SINBAD: Janus-1 & -8, Nesdip-2, Aspis water, Aspis n/g, Aspis graphite, Aspis Fe, PCA Replica. Updating of NESDIP-3, ASPIS-Fe88 is ongoing;
- **Quality review and new SINBAD evaluations:** SINBAD evaluation & independent review ongoing within **ICSBEP/IRPhE/SINBAD TRG meeting (Oct. 2021 and after):**
  - **Rez Fe spheres (M. Košťál)**
  - **FNG Copper (I. Kodeli)**
  - **FNG-HCLL (P. Ortego)**
  - **HIMAC (S. Tsuda)**
  - **TIARA (Y. Iwamoto)**
  - **CIAE leakage spectra from Fe (Y. Ding)**
  - **KFK 1977 gamma fields in iron spheres with ^{228}Th & ^{252}Cf source (S. Simakov)**
  - **Oxygen Broomstick (S. Simakov)**
- **Other pending updates, data received:**
  - **SuperMC/INEST Hefei:** Oktavian (Al, Fe, W, Si, Ni), FNS (C, O, V, W, Skyshine, Dugled Duct), FNG (SiC, SS, Bulk shield, Str., Dose rate, W), TUD (W, Fe, SiC, Bulk shield), IPPE (Th), Kant (Be), ISPRA Fe
  - **SERPENT: CCFE, KIT, JSI:** FNG benchmarks, **CEA Cadarache:** ASPIS-Fe88
  - **ASPIS Fe88:** MCNP, DORT/TORT inputs from **IJS, ENEA Bologna**

CAD files prepared for GitLab repository

[**ASPIS – Iron88** (**Ž. Deutschbauer, B. Kos, A. Valantine)**

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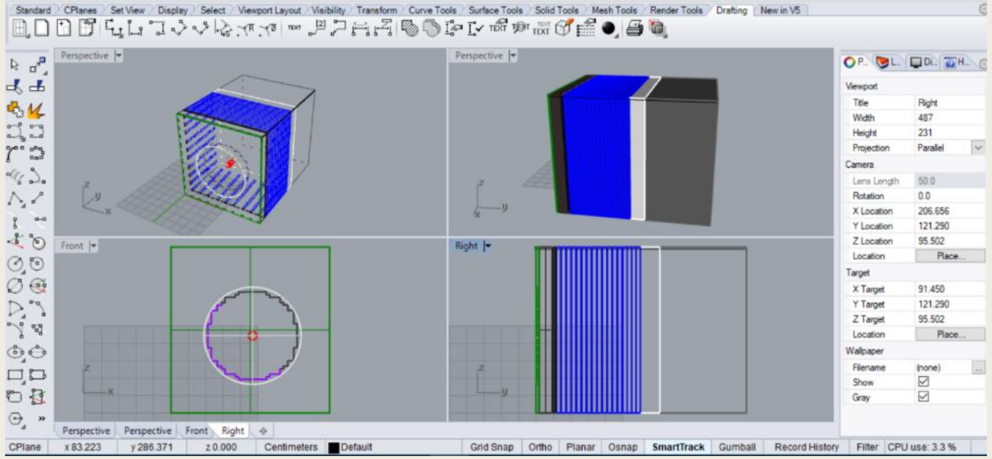
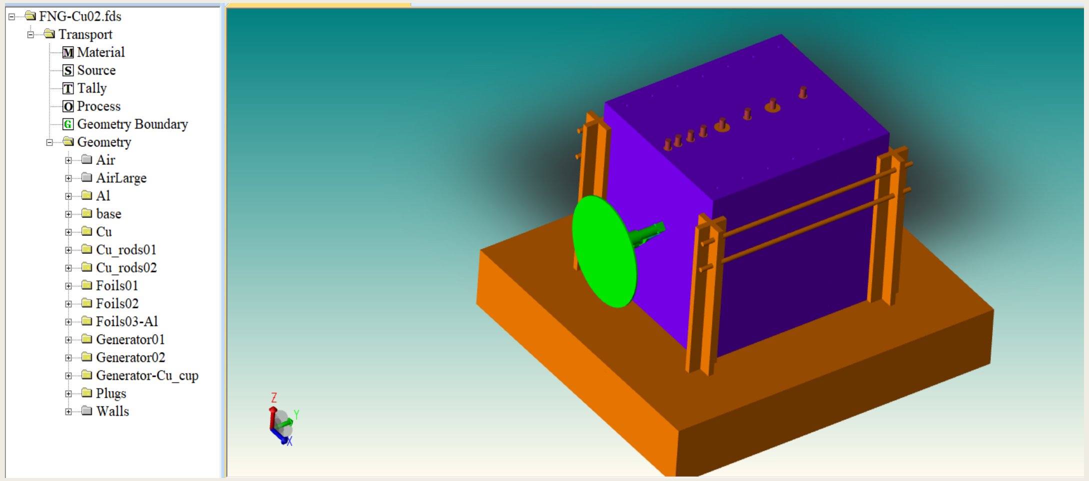
https://git.oecd-nea.org/science/wpec/sg47/contrib



FNG Cu: FDS format



- **Ongoing and proposed future SINBAD evaluation and updating activities**

FISSION Benchmarks

- **KFK-1977:** gamma fields in iron spheres with ^{228}Th & ^{252}Cf source (proposed by S. Simakov)
- **Oxygen Broomstick**: review & updates needed, MCNP or analytic input (S. Simakov)
- **CROCUS** transmission measurements (EPFL, Lausanne)
- **PCA & PCA Replica benchmarks**: presentation of Steven van der Marck & I. Kodeli at 2020/2021 JEFF meetings.
- **NESDIP 4 & 6, JANUS II-VII:** clearance needed
- **Rez spheres (Fe, H_2O) (1m)** AmBe source, under review IRPhE/ICSBEP/SINBAD
- **VENUS:** -3 in SINBAD, PV dosimetry experiment data for Venus 1 & 2 are available and need compilation & review,
- **KAMINI reactor** neutron attenuation measurements in fast reactor shield materials: Ferro Boron, Ferro-tungsten, mild steel shielding;
- SKODA neutron leakage from Fe spheres with ^{252}Cf source (1982/1995)
- **NIST** neutron leakage from Fe spheres with ^{252}Cf source
- **LRC Ohio** Neutron leakage spectra from Ta sphere with Am -Be source

Clearance and access to some experimental data needed

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

NESDIP PV surveillance experimental programme (~1980's, AEA Winfrith):

- **NESDIP 2:**
- **NESDIP 3:**
- NESDIP 4:
- NESDIP 6:

KAMINI reactor measurements of neutron attenuation in possible fast reactor shield materials

- Indira Gandhi Centre for Atomic Research, India & Ghana Atomic Energy Commission
- Experiments in neutron beam of KAMINI reactor on the fast, epithermal and thermal neutron flux attenuation
- Advanced shield materials for fast reactors: Ferro-boron, boron carbide (B4C), Ferro-tungsten and mild steel
- Attenuation over a thickness of 20-30 cm measured using reaction rates of ^{195}Pt(n,n’)^{195m}Pt, ^{111}Cd (n,n’)^{111m}Cd, ^{103}Rh (n,n’)^{103}Rh, ^{115}In (n,n’)^{115m}In, ^{180}Hf (n,n’)^{180m}Hf, ^{63}Cu(n,a)^{64}Cu, ^{23}Na (n,g)^{24}Na, ^{55}Mn (n,g)^{56}Mn & ^{197}Au (n,g)^{198}Au reactions.

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Available online at www.sciencedirect.com
ScienceDirect
Energy Procedia 7 (2011) 273–278
Energy Procedia

Asian Nuclear Prospects 2010

Experimental Measurements of Neutron Attenuation in the Advanced Shield Material Ferro Boron in KAMINI Reactor

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Abstract

Shields around core and blankets form major part of reactor assembly in fast reactors. Among the advanced shield materials considered for use in future FBRs, planned to be constructed in India, Ferro-boron is a cheap and indigenously available material. This paper reports the results of experiments conducted in the south end neutron beam of KAMINI reactor on the fast, epithermal and thermal neutron flux attenuation behaviour of Ferro-boron with different percentages of boron as well as boron carbide. The attenuation factors were found over a thickness of 20-30 cm for the measured reaction rates of Pt^{195} (n,n’) Pt^{195m}, Cd^{111} (n, n’) Cd^{111m}, Rh^{103}(n,n’) Rh^{103}, In^{115} (n,n’) In^{115m}, Hf^{180}(n,n’)Hf^{180m}, Cu^{63} (n,γ) Cu^{64}, Na^{23} (n,γ) Na^{24}, Mn^{55} (n,γ) Mn^{56} and Au^{197} (n,γ) Au^{198} reactions representative of fast, epithermal and thermal neutron fluxes. A comparative analysis with the neutron attenuation behaviour measured in boron carbide powder is also made.

Key words: Fast reactor; Neutron shielding; Attenuation measurements; Ferro boron

1. Introduction

Reactor core shielding constitute an important part of fast reactor assembly. Reduction of neutron flux to acceptable levels has always been a challenging problem. An important objective of future FBR is improved economics and reduction of volume of shields. Ideal shield materials which absorb both fast and slow neutrons at equally high rates do not exist. A shield material which brings down the energy of neutrons by elastic and inelastic scattering along with absorption will be more effective. Ferro boron is identified as a promising shield material through literature survey and scoping calculations. The neutron spectrum at the south beam end of KAMINI reactor is fairly similar to the neutron spectra at the outer shield and sodium regions of PFBR[1]. So experiments were conducted in the south beam end of KAMIN reactor to understand the effectiveness of prospective shield material Ferro-boron [2,3] as an in-core shield material for future FBRs. The experimental measurements are useful for further

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Experimental neutron attenuation measurements in possible fast reactor shield materials

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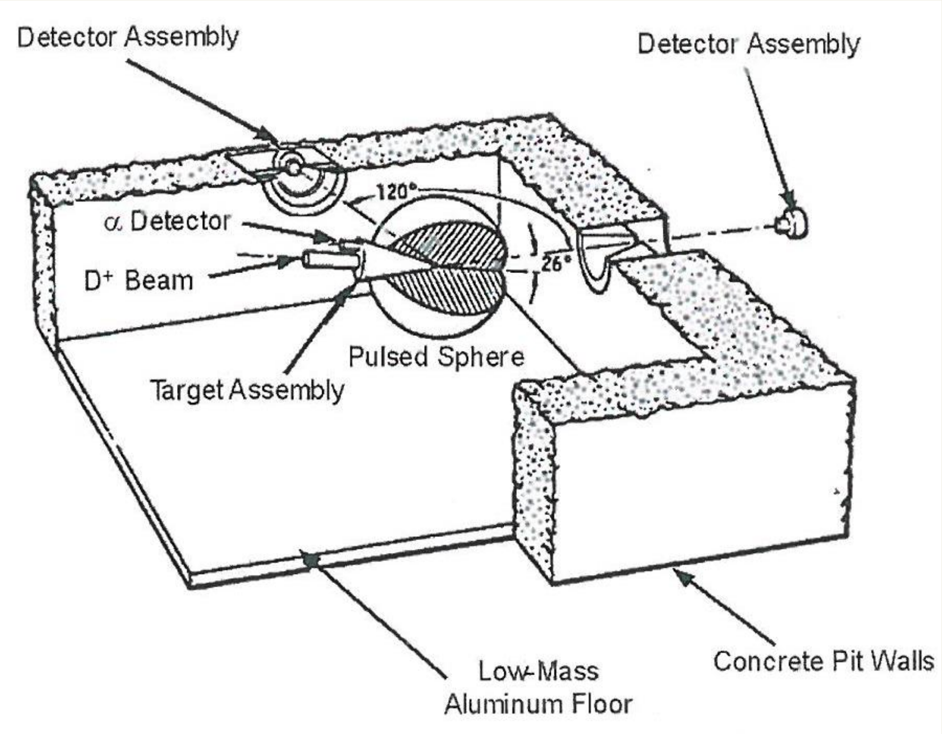
ABSTRACT

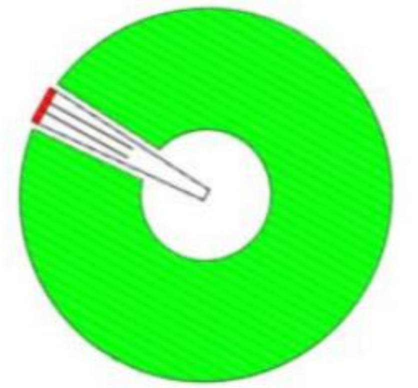
Neutron attenuation properties of shield materials that have prospective use in fast reactors have been studied in this research. Activation foils were employed to study neutron attenuation behavior of Ferro tungsten powder and mild steel slabs in the south neutron beam end of KAMINI Reactor. The results reveal that epithermal neutron attenuation in Ferro tungsten is better than in mild steel from plots of attenuation versus areal density and attenuation versus areal atom density. Fast neutron attenuation in Ferro tungsten is comparable to mild steel from plot of attenuation versus areal density. Ferro tungsten however shows higher fast neutron attenuation in plot of attenuation versus areal atom density. It can be deduced that, Ferro tungsten would be a better neutron attenuator compared to steel if its bulk density is increased. Ferro tungsten would therefore not only be an effective shield material than steel but a better substitute for steel in high temperature applications.

FUSION Benchmarks

- **FNS series of 14MeV neutron benchmarks:** several already in SINBAD, for some recent measurements such as FNS Cu (2001 & 2015 by S. Kwon, S. Sato, M. Ohta, K. Ochiai, C. Konno), Mo (M. Ohta, S. Sato, S. Kwon, K. Ochiai, C. Konno), Ti, Li_2O: copyright issues between QST and JAEA,
- **OKTAVIAN:** several benchmarks in SINBAD, data for many are available and need compilation & review, access to some more recent measurements would be appreciated (LiF, CF2, Ti, Cr, Co, Cu, As, Se, Zr, Nb, Mo)
- **LLNL spheres:** 75 pulsed-sphere neutron-leakage spectra for 20 different materials
- **CIEA:** leakage spectra from SiC, Fe, graphite, Bi (14 MeV neutrons), TOF measurements at different angles
- **FNG-Cu & -HCLL:** F4E evaluation, under review IRPhE/ICSBEP/SINBAD
- **FNG-WCLL:** ongoing experiment (EUROfusion)
- **IPPE:** BTiH, U, …
- **JET:** SDR experiment (2012-2013), streaming, dose rate

LLNL Pulsed Spheres

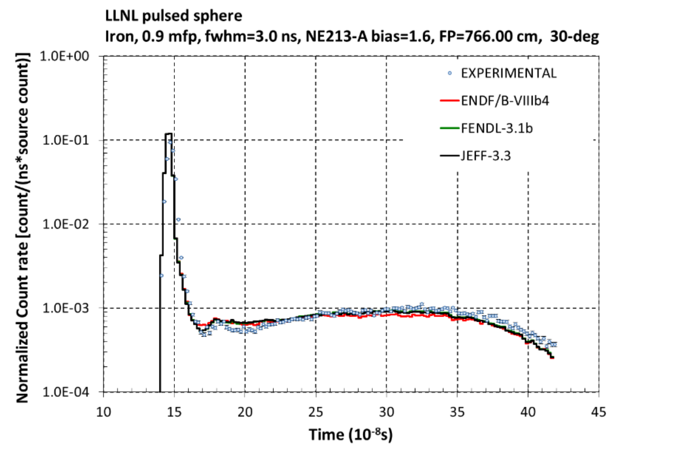




COG Model of Target Assembly and 1.8 MFP Thick Polyethylene Sphere.

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

Reports & OCR data included in SINBAD, evaluation & review needed

FNS (Fujio Maekawa)

- Integral Experiment on Iron Cylindrical Assembly (1994)
- Integral Experiment on Copper Cylindrical Assembly (1994)
- Angular Neutron Flux Spectra Leaking from Slabs: Li_20, Be, C, Fe and Pb (1985-1990)
- Integral Experiment on Graphite Cylindrical Assembly (1984)
- Integral Experiment on Li_20 Cylindrical Assembly (1983)
- Integral Experiment on Beryllium Cylindrical Assembly (1988)

OKTAVIAN (14 MeV Neutrons)

- Tritium Breeding Ratio in Li, Pb-Li, Pb-Li-C, Be-Li, Be-Li-C, Spheres Measured with Li_2C0_3 Pellets and/or LiF TLDs (1987-1990)
- Leakage Neutron Spectra from Be Sphere and Be-Li Sphere (1991)
- Gamma Spectra Emitted from Spheres with 14 MeV Neutron Source: Al, Si, Ti, Cr, Mn, Co, Cu, Nb, Mo, W, Pb, LiF and CF_2 (Teflon) (1987-1989)
- Leakage Neutron Spectra from Spheres: LiF, Mn, Cu, Zr, Mo, TEFLON, Al, Ti, Cr, Co, As, Se, W, Si, Nb (1984-1988)

<u>The compilation and review need to be carried out. Contributions are highly appreciated.</u>

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:

$$\phi(\Omega,E) = \frac{C(E)}{\epsilon(E)\cdot\Delta\Omega\cdot A_s\cdot S_n\cdot T(E)} \quad \text{(n/sr/m}^2\text{/lethargy/source neutron)}, \quad (2)$$

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.

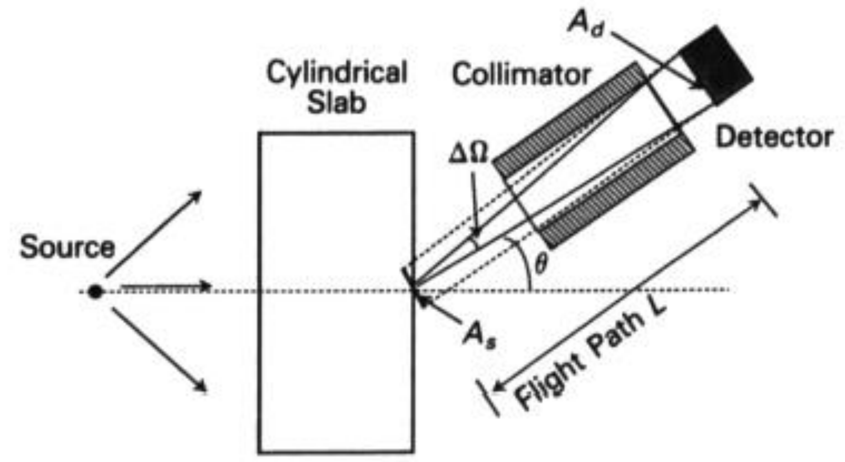
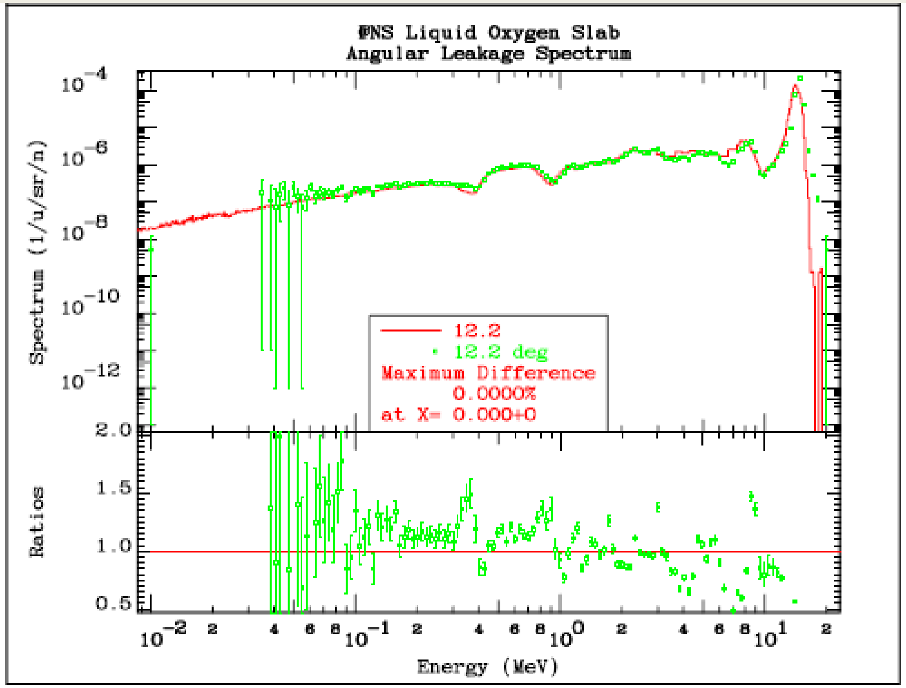


Fig. 3. Definition of the parameters used for data reduction.

A_s ~ A_{true} * cos(Θ)

Inconsistency between MCNP and DORT models

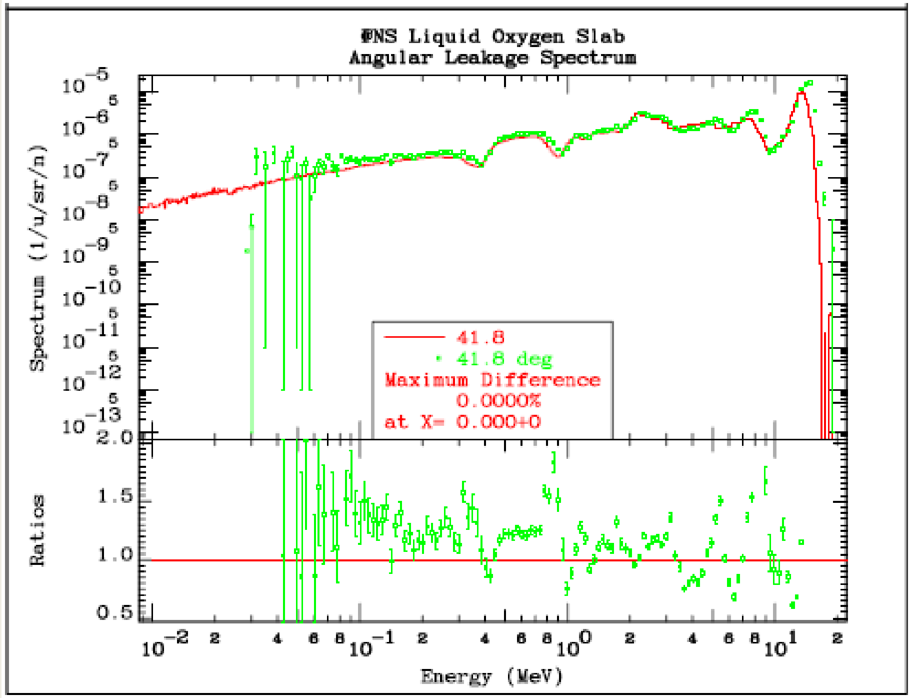
FNS Liquid Oxygen benchmark

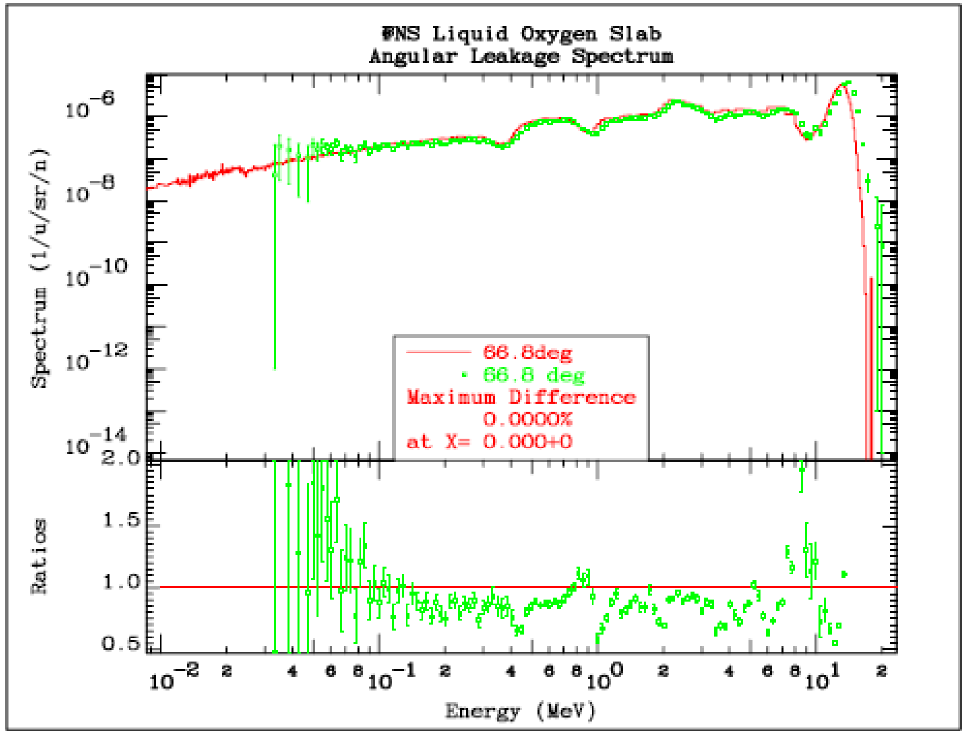


- **14 MeV D-T** neutron facility at FNS/JAERI
- Measurement of angular neutron leaking spectra from a 20 cm slab of liquid oxygen in 0.05 - 15 MeV energy range.
- Angular fluxes at

0, 12.2, 24.9, 41.8 and 66.8 degrees were measured.

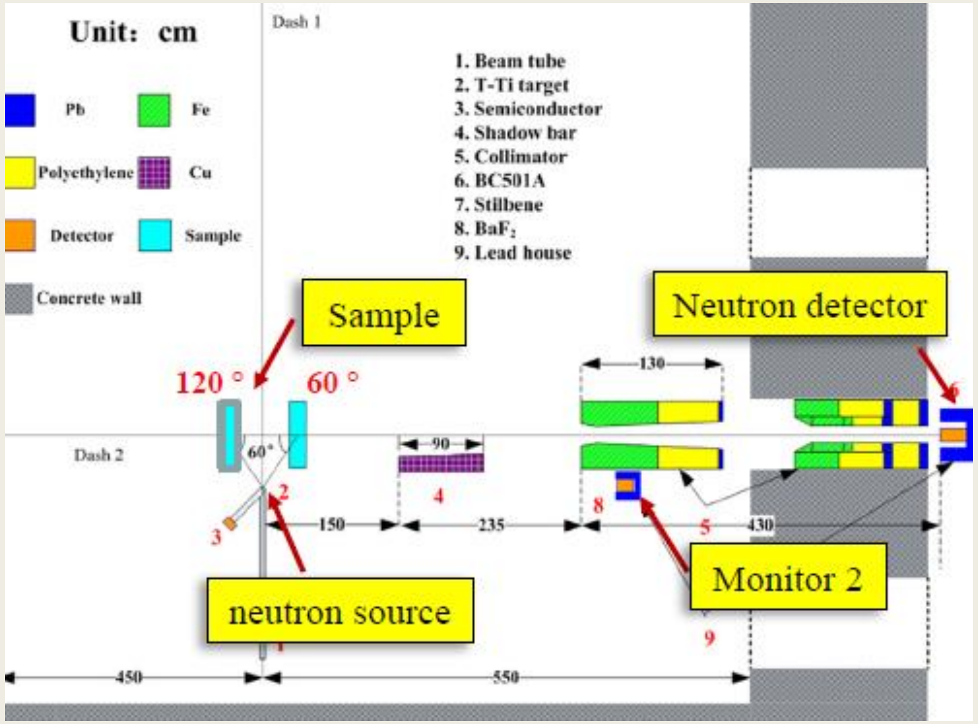
- **JEFF3.3 results**
- **Cosine corrections between 1.0 and 0.4**

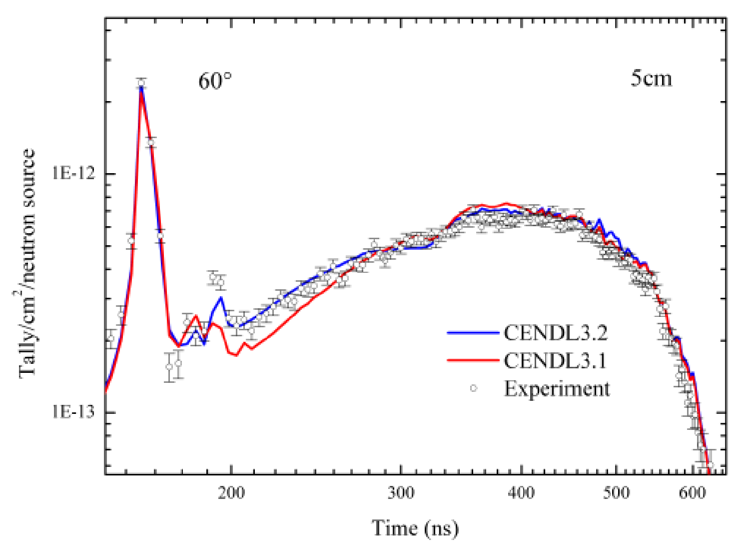




Benchmark experiment on iron with D-T neutrons at CIAE, Yanyan Ding (CIAE)

- CIAE Neutron leakage spectra measurements from iron slab with D-T neutrons were presented, including the uncertainty quantification (systematic, random) and computational models. TOF spectra were measured at 60^0 and 120^0. C/E for CENDL-3.1, ENDF/B-VIII.0, JENDL-4.0 and JEFF-3.3 were shown and discussed.
- SINBAD evaluation in preparation to be presented at ICSBEP/IRPhE/SINBAD TRG meeting.
- CIEA performed benchmarks on ^{238}U, Be, Fe, Ga, W, C, SiC, Pb, Pb-Bi, ThO_2, Bi, Nb.





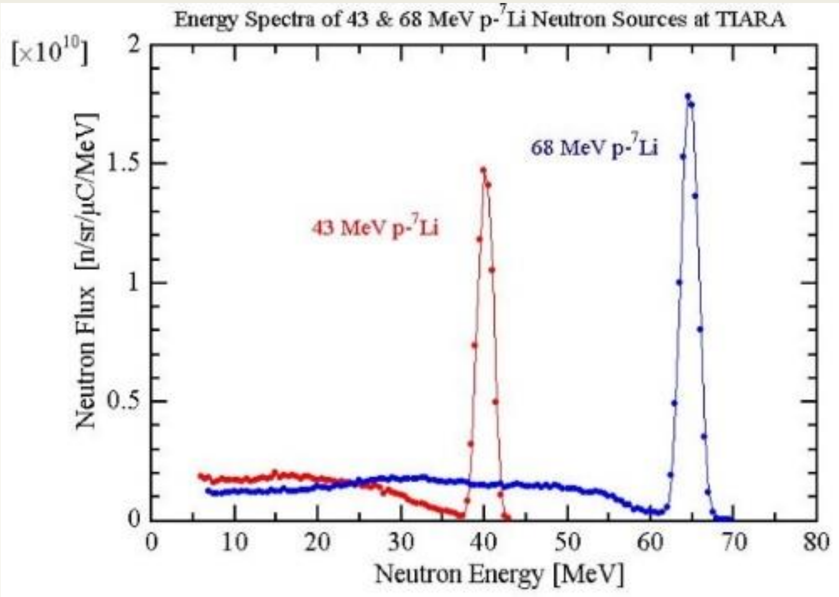
ACCELERATOR Benchmarks

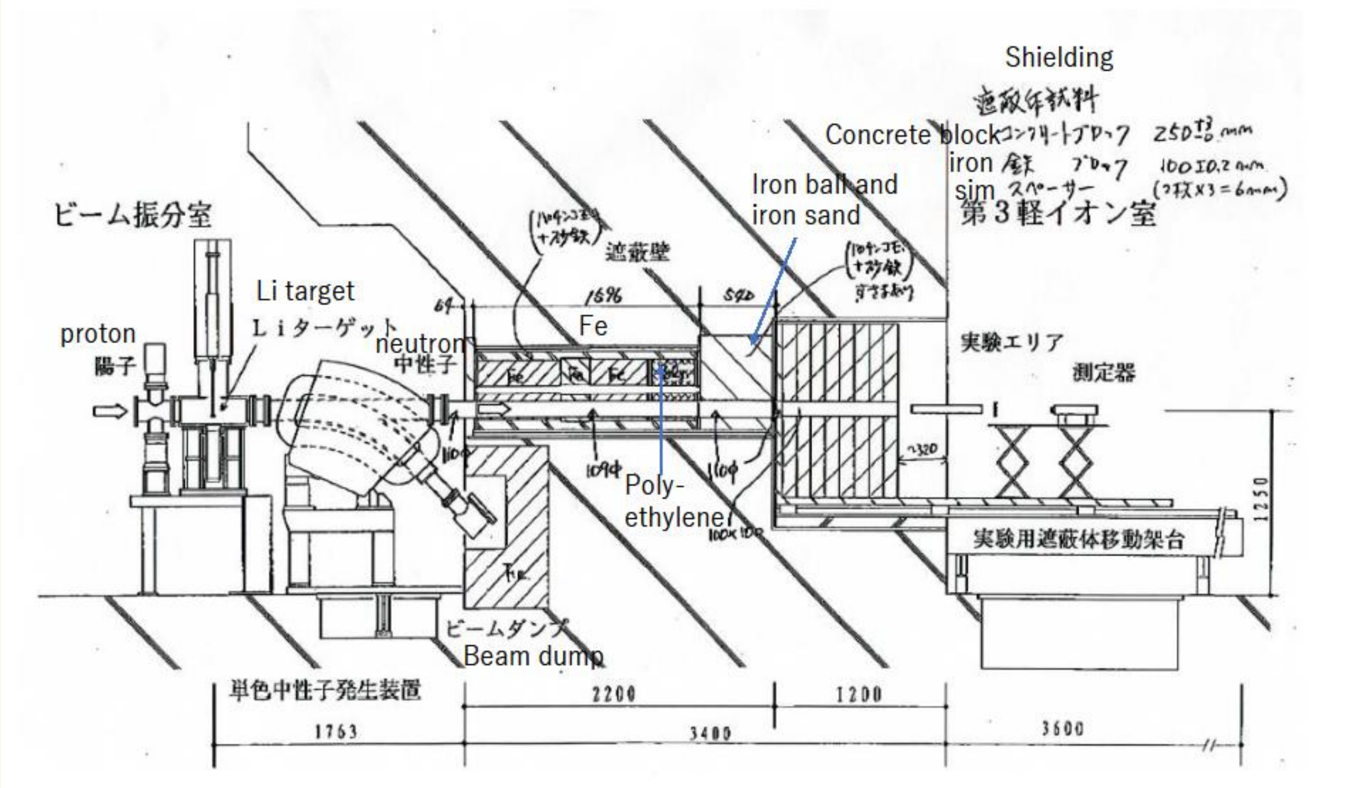
- Neutron transmission through Concrete Shields (AVF Osaka Univ.)
- 30- and 52-MeV Protons on thick targets (C, Fe, Cu, Pb) (INS Tokyo Univ.)
- 68 MeV P on thick Cu target (JAERI)
- Reaction Rate in Thick Concrete Shield Irradiated by 6.2 GeV Protons (LBL-1965)
- Experiment using 4 m concrete at KENS/KEK 500 MeV Proton Accelerator (KENS/KEK)
- Cosmic ray induced n spectrum at Zugspitze 2660m & Chacaltaya 5240m;
- CERF measurements (GSF, Neuherberg)
- TOF N spectra & radioactivity induced in Li, Be, Cu, C, Al, for 25-40 MeV d (Tohoku Univ.)
- Neutron spectra from 20cm Fe slab, D2O(He3,xn) reaction at 40 MeV (NPI Rez)
- Residual Product Yields in Thin Targets Irradiated by 100-2600 MeV P (ITEP, Moscow)
- SLAC experiment using 28.7 GeV electrons (SLAC)
- Penetration through Fe & Concrete of 140-350-MeV Neutrons (RCNP, Osaka Uni.)
- JASMIN: Jap-US Study of Muon Interactions and Neutron Detection (FERMILAB, Japan)

Accelerator Experiments in SINBAD

- BEVALAC Experiment with Nb Ions on Nb & Al Targets
- CERN Roesti I, III: 200 GeV/c hadrons on Fe and Pb (100 cm)
- CERN Roesti II: 24 GeV/c protons on 100 cm Fe
- HIMAC - He, C, Ne, Ar, Fe, Xe, Si ions on C, Al, Cu, Pb targets
- HIMAC - High energy neutron (<800 MeV) measurements in iron
- HIMAC - High energy neutron (<800 MeV) measurements in concrete
- INS U-Tokyo Transmission of n,γ from 52 MeV Protons through C, Fe, H2O & concrete (up to 115 cm)
- Osaka University Transmission of n,γ from 65 MeV Protons through C, Fe, Pb & concrete (10-100 cm)
- ISIS Deep Penetration of Neutrons through Concrete (120cm) & Iron (60cm)
- MSU experiment with He & C ions on Al target
- PSI Neutron Spectra Generated by 590-MeV Protons on Pb Target
- RIKEN 70-210 MeV quasi-monoenergetic neutron spectra
- TEPC-FLUKA Intercomparison for aviation dose
- TIARA 40 & 65 MeV neutron transmission through Fe, Concrete, $(CH_2)_n$

TIARA facility (1995)





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
Code inputs: MCNP, (PHITS, MORSE, DORT)

TIARA facility (1995)

History of evaluations:

- Sinbad evaluation in 2000 by I. Kodeli & N. Nakao
- QA & Monte Carlo code MCNPX v.2.6.0 by P. Ortego (2012): experiment is adequate for ND & code benchmarking (MCNP model with p-^{7}Li source, including target, accelerator window, collimators, shielding block and detector; inconsistent results for n. spectra);
- C. Konno, S. Kwon (2012-2019), MCNP-5, -6.1.1 & DORT, source neutron spectrum measured in the experiments was used as a neutron source for the analysis
- MCNP-5 analysis by B. Kos (2019) detailed model for n. spectra & r. rates (on & off-exes), measured neutron source spectrum was used as source in MCNP, variance reduction parameters
- Re-evaluation to be submitted to OECD NEA TRG meetings for ICSBEP/SINBAD in 2022 (Yosuke Iwamoto)

Open issues in the modelling:

- More information needed on the surroundings, target, source, beam dump and collimator. Attempts were made to include explicite modelling of (p,n) source and collimator in the model (P. Ortego, B. Kos), however the available information on the geometry around the shielding block is not sufficient to allow meaningful results.
- Geometrical details needed to model the dosimeters (Bonner spheres, fission counters, BC 501A spectrometers), surrounding concrete structure, detector stands and detectors support.

Reports & OCR data included in SINBAD, evaluation & review needed

Intermediate and High-Energy Accelerator Shielding Benchmarks (H. NAKASHIMA, JAEA)

Neutron production data from thick targets due to proton, alpha and electron, and three kinds of shielding data for secondary neutron and photon generated by proton:

- **Thick Target Neutron Yield Problems**
  - **Neutron Yields from Stopping-Length C, Al, Fe and Depleted U Targets for 256-MeV Protons (LAMPF LANL-1989)**
  - **Neutron Angular & Energy Distributions from 710-MeV Alphas Stopping in H_2O, C, Steel and Pb (SREL 1980)**
  - **Photoproduction of 150 to 270 MeV Neutrons in Thick Lead Targets by Electrons (Uni. Mainz 1973)**
- **Secondary Neutron and Photon Transmission Problems**
  - **Transmission Through Shielding Materials of Neutrons and Photons Generated by Intermediate-Energy Protons (1 & 2)**
  - **Secondary Neutron Fluxes inside and around Iron Beam Stop for 500 MeV Protons (KEK-1979)**

<u>The compilation and review need to be carried out. Contributions are highly appreciated.</u>

NEUTRON PENETRATION THROUGH IRON AND CONCRETE SHIELDS FOR QUASI-MONOENERGETIC NEUTRONS

TOF Beam at Research Center for Nuclear Physics (RCNP), Osaka University

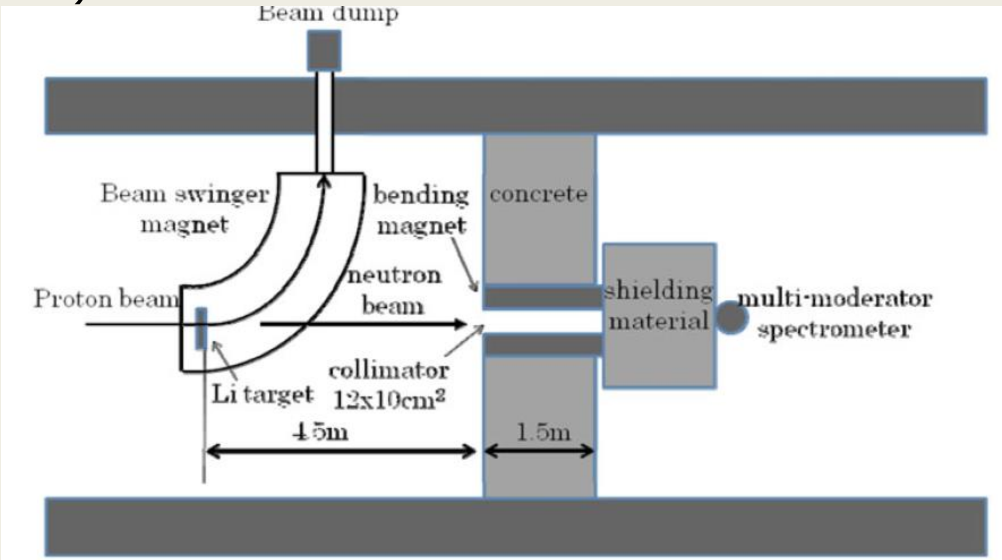
Source: 140-, 250-, and 350-MeV p-Li neutrons

Detectors: ^{3}He proportional counter

NE213 organic liquid scintillator (140-MeV protons)

Shield: Concrete and iron shield with XS area 120 x 120 cm and shield walls with thicknesses 25 cm to 2 m for concrete and 10cm to 1 m for iron.

Nucl.Tech. **168**, Nov. 2009, 298-303 & 304-309 (T. Nakamura)



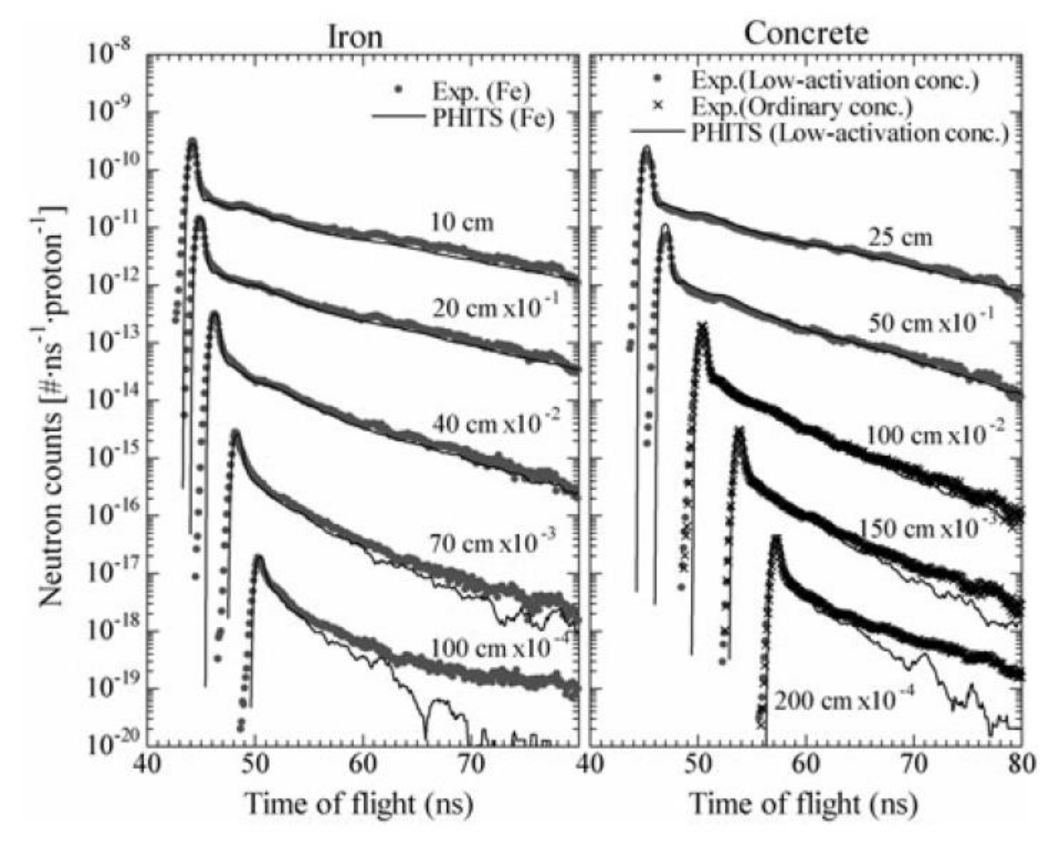


Fig. 2. Comparison of the neutron TOF spectra transmitted through (a) the iron shield and (b) two kinds of concrete shields with various thicknesses for the 140-MeV p-^{7}Li quasi-monoenergetic neutrons between the experiment and the PHITS calculation.

JASMIN: Japanese-American Study of Muon Interactions and Neutron detection

Fermi National Accelerator Laboratory (FNAL)

Irradiation of targets with 120 GeV protons for antiproton and neutrino production, and for measuring nuclear data & detector responses

Purpose: benchmarking the PHITS and MARS15 codes

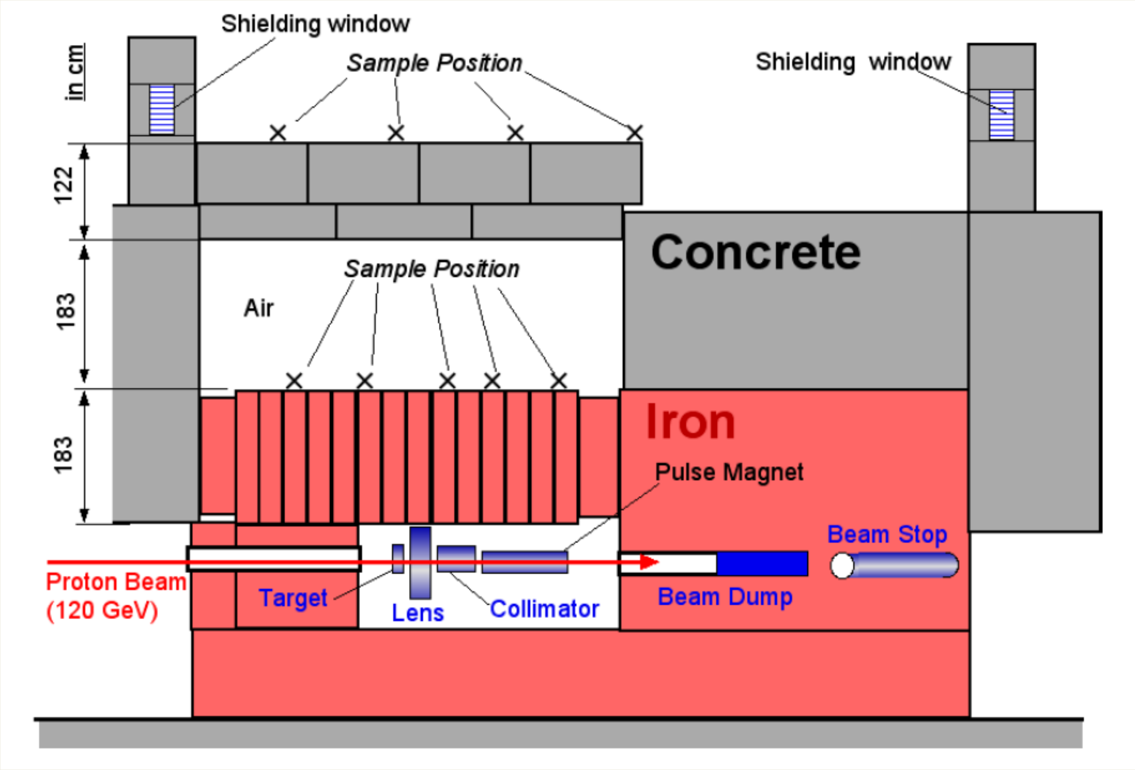
(1) Measurement of neutron flux inside and outside the iron and concrete shields.

(2) Measurement of activities around the Pbar target.

(3) Measurement of air and water activation in vault.

(4) Measurement of streaming particle passing through duct from vault to outside.

Fermilab-Conf-10-330-APC, Aug. 2010 (T. Nakamura)



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**)
- **<u>QR of the remaining 51 benchmarks is needed ASAP,</u> 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**

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 evaluation, updating and distribution policy** 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
- Recommendations for future evaluations
- In cooperation with EGPRS WPRS and TRG participate in future evaluations

THANK YOU FOR YOUR ATTENTION