Karlsruhe Institute of Technology

Remarks from use of SINBAD

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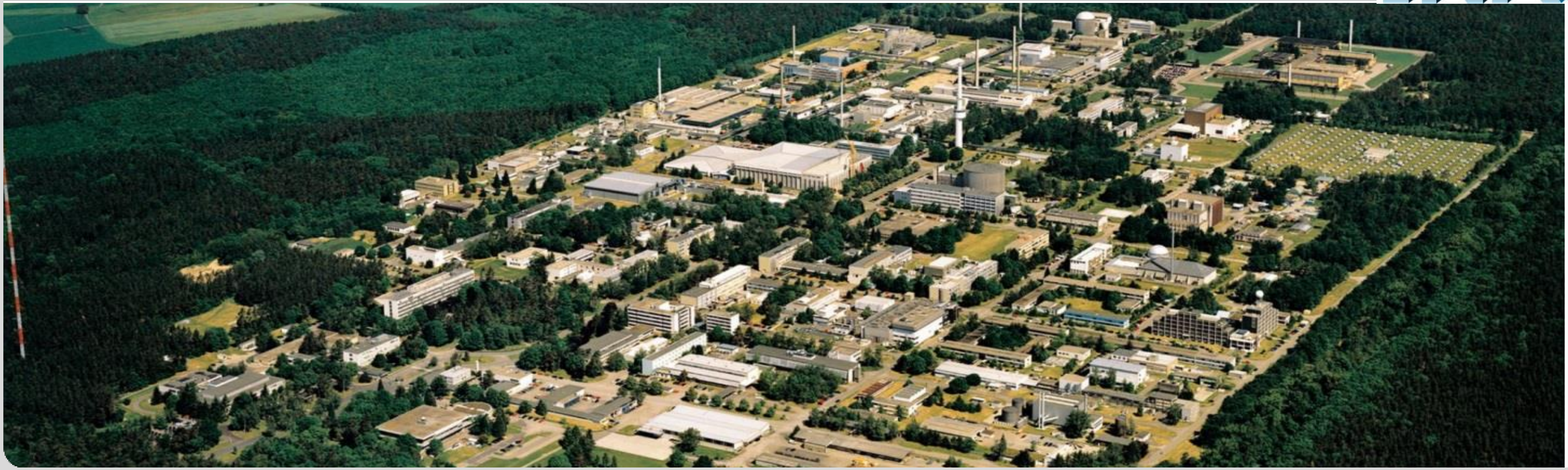
contribution to Subgroup 47:
"Use of Shielding Integral Benchmark Archive and Database for Nuclear Data Validation"

INSTITUTE for NEUTRON PHYSICS and REACTOR TECHNOLOGY (INR)



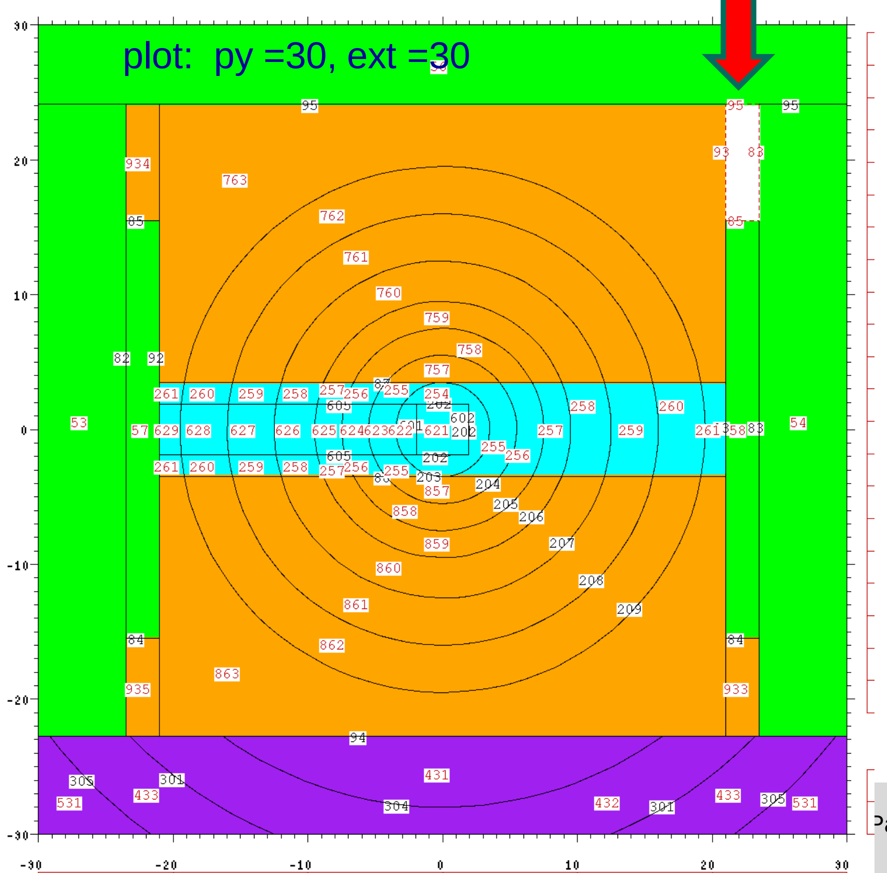
I. **Tungsten: Geometry Error in the MCNP model** in SINBAD

NEA-1553/47 „FNG/TUD Tungsten Experiment (spectra measurements)"

NEA-1553/47: file #10 = mcnp.inp = 3-D model for MCNP-4C code

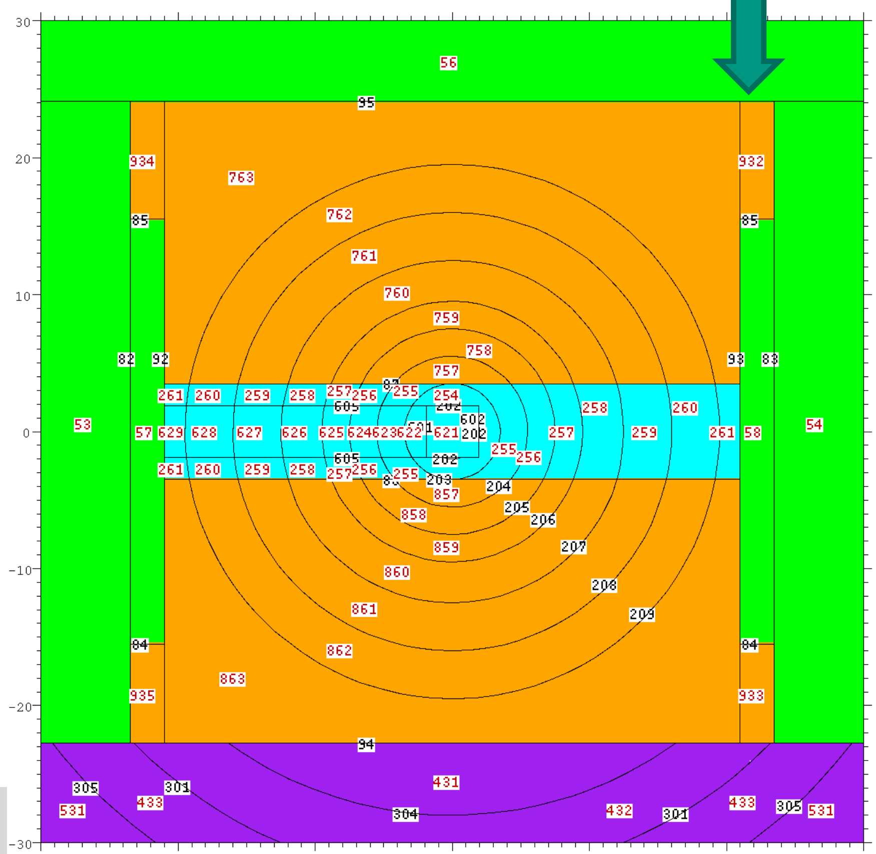
original SINBAD mcnp.inp file:

862 7 -17.70 114 -115 208 -209 -86
863 7 -17.70 114 -115 209 -86 92 -93 94 -95
cell here is not described (?)
933 7 -17.70 114 -115 -84 94 -83 93
934 7 -17.70 114 -115 85 -95 82 -92



our correction (inserting the cell 932):

862 7 -17.70 114 -115 208 -209 -86
863 7 -17.70 114 -115 209 -86 92 -93 94 -95
propose: 932 7 -17.70 114 -115 85 -95 -83 93
933 7 -17.70 114 -115 -84 94 -83 93
934 7 -17.70 114 -115 85 -95 82 -92

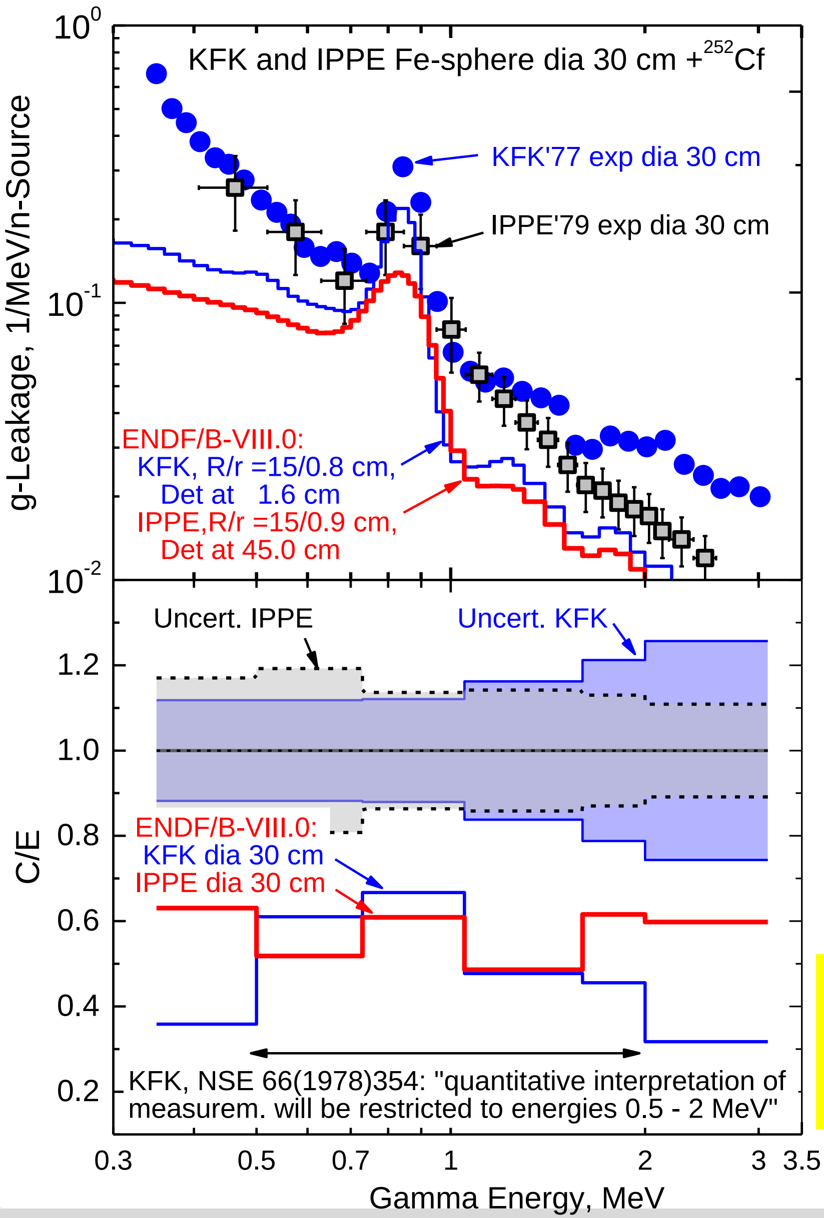


II. Iron *(slide - from EFFDOC-1373, 27-30 Nov 2018):*

Lab: Years	n-source Energy	Assembly, sizes cm	Me-thod		Main References and Numerical Data
KFK: 1975	^{252}Cf(s.f.) 7E+7 n/s E ≈ 2.1 MeV	6 spheres: dia. = 15, 20, 25, 30, 35 and 40 cm	Pulse Height + Unfold	***Neutrons:*** 2 proton recoil (1.08 m): E = 0.06 – 0.86 MeV, E = 0.31 – 2.35 MeV 1 proton recoil (1.53 m): E = 0.92 – 5.24 MeV 1 ^{3}He/Si sandwich (surf): E = 0.10 – 7.85 MeV	H. Werle, H. Bluhm et al. - KFK-2219 (1975) - NEACRP-U-73 (1976)8 SINBAD: *NEA-1553/43*
KFK: 1977	^{252}Cf(s.f.) 5.5E+7 n/s (± 5%) (also ^{232}Th)	3 spheres: dia. = 25, 30, 35 cm (also Iron pile: 100*100*87cm)	Pulse Height + Unfold (± 10%)	***Gammas:*** Si(Li) compton spectr. - at 1.02m (bare source) - on surface (spheres) Energy range E = 0.34 – 3.11 MeV NOT in SINBAD	S.-H. Jiang, H. Werle - KFK-2444 (1977) = PhD - NEACRP-L-196(1977) - NSE 66(1978)354 Data are presented only in Plots - we digitized !
NIST: 2000	^{252}Cf(s.f.) 5.5E+7 n/s (± 5%)	1 sphere: dia. = 50 cm	Pulse Height +Unfold	***Neutrons:*** 2 proton recoil (1.00 m): E = 0.06 – 0.86 MeV, E = 0.31 – 2.35 MeV	B. Stanka et al. - NSE 134(200)68 not in SINBAD yet
IPPE: 1985	^{252}Cf: ≈ 2.1 MeV	6 spheres: dia. = 10, 20, 40, 50, 60, 70 cm	Pulse Height (PH)	***Neutrons:*** H-prop. 5 – 700 keV Stilben 0.2 - 17 MeV ***Gammas:*** Stilben 0.4 - 10 MeV	*ICSBEP/DICE*: *ALARM-CF_FE-SHIELD-001*

II. Gamma from Iron spheres with Cf-252 source

(slide - from EFFDOC-1373, 27-30 Nov 2018):

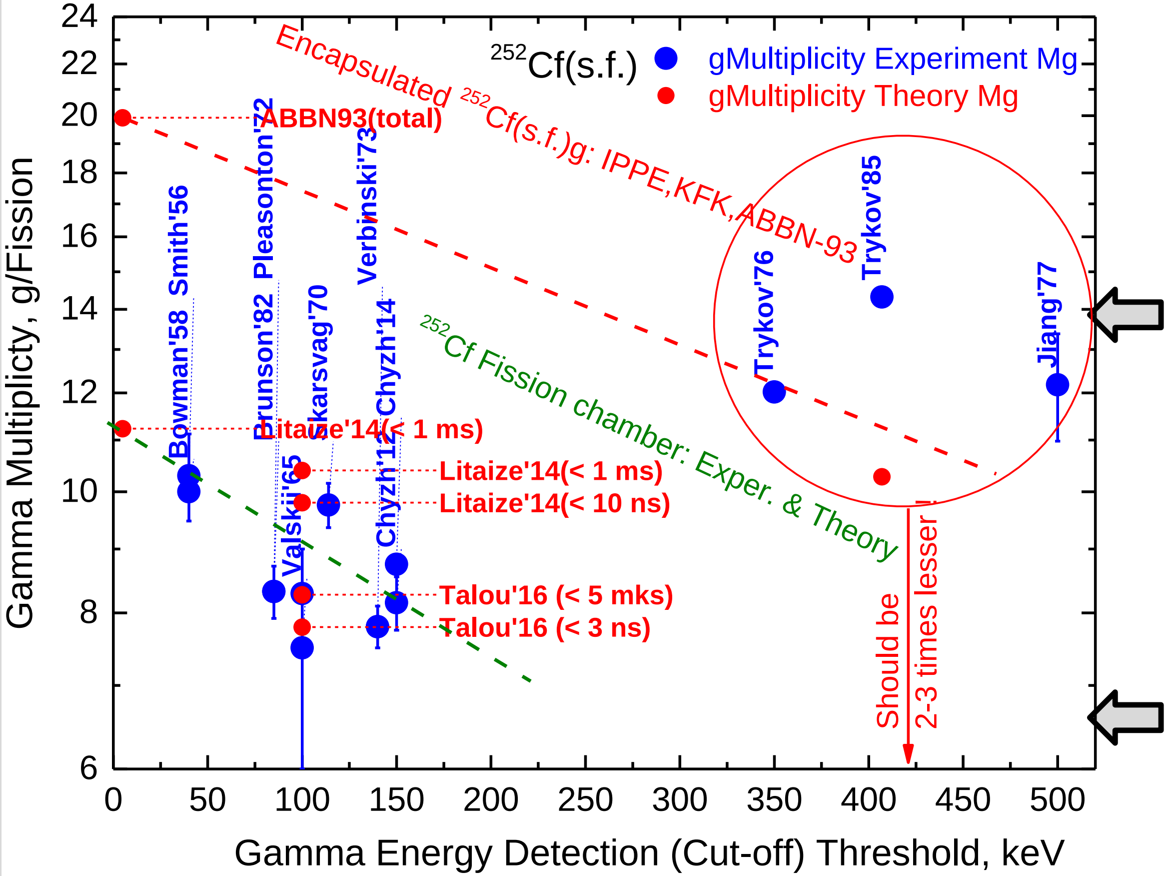


<= KFK cf. IPPE Ø30 cm:
g-Leakage spectra

Observations for γ-Leakage from Fe spheres:

- KFK and IPPE Fe sphere of equal Ø30cm gives same C/E = 0.5 - 0.7 for Eg = 0.5 – 2.0 MeV

II. KFK and IPPE bare ^{252}Cf γ-sources: comparison with known exper. and theory Prompt Fission Gamma Multiplicity for ^{252}Cf(s.f.)



IPPE bare ^{252}Cf source = capsule 3.2 mm Fe + 2.3 mm Cu
(L. Trykov'85, FEI-1730):
Mg (Eg > 400 keV) = 3.8 g/n
then *3.7676 n/f = 14.3 g/f
Mg (ABBN'93,Eg>0) = 5.3 g/n
then *3.7676 n/f = 19.9 g/f

KFK bare ^{252}Cf source = capsule 2.5mm SiO_2 +2mm ZrSn +2mm Al
(S.-H. Jiang'77, KFK-2444):
Mg (Eγ > 500 keV) = 3.2 g/n
then *3.7676 n/f = 12.1 g/f

- Measurements with ^{252}Cf fission chambers & coincid./counting FF
- Theory/Modelling

Observations: Gamma over Neutron Multiplicities = Mg/Mn for ^{252}Cf(s.f.), extrapolated to Eγ > 100 keV:

- **all known measurements (Cf fission chamber) and theory ≈ (8 - 10)/3.7676 = (2.1 - 2.7) – if it's truth !**
- **IPPE and KFK (encapsulated Cf) ≈ (18 - 20)/3.7676 = (4.7 - 5.3) – then why ?**

More Information and Analyses see in EFFDOC-1373, 27-30 Nov 2018

III. Oxygen *(slide – from IAEA TM "Long Term Collaboration", 18 Dec 2017):*

SINBAD NEA-1517/59: **"ORNL, Tower Shielding Facility, 1967"**

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Uncollided transmission through Liquid Oxygen

(length: 24in = 60.96 cm & 36in = 91.44 cm; dia: 4in = 10.16 cm)

irradiated by TSR-II reactor spectrum ranged 1.9 to 8.6 MeV

No Data in SINBAD!

N

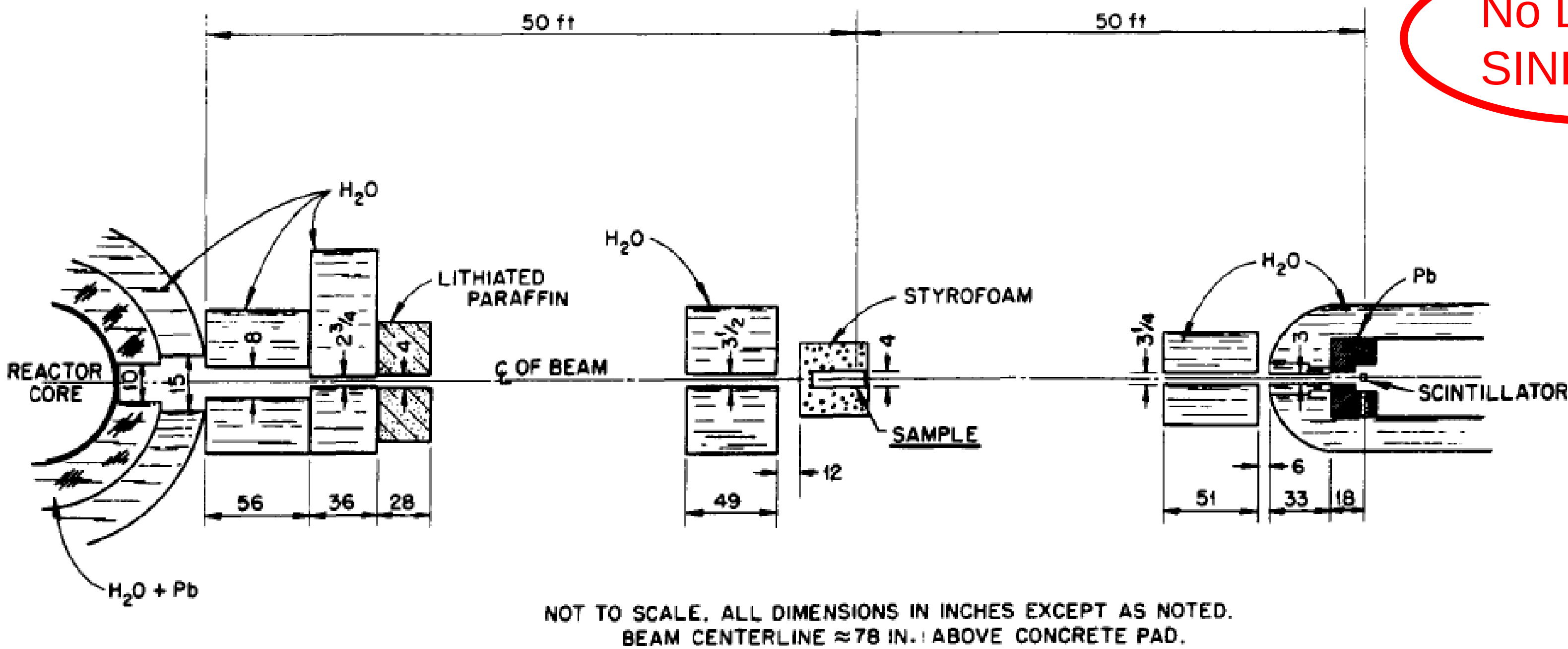

Fig. 1. Schematic diagram of experimental arrangement.

Description of Experiment is available in:

- *e.g.: C.Clifford et al., NSE 27(1967)299; E.Straker ORNL-TM-2242(1968), -3868(1972)*
- *SINBAD NEA-1517/59: description + numerical data (only 60 in. = 152,4 cm),* ***no MCNP model***

III. Oxygen *(slide – from IAEA TM "Long Term Collaboration", 18 Dec 2017):*

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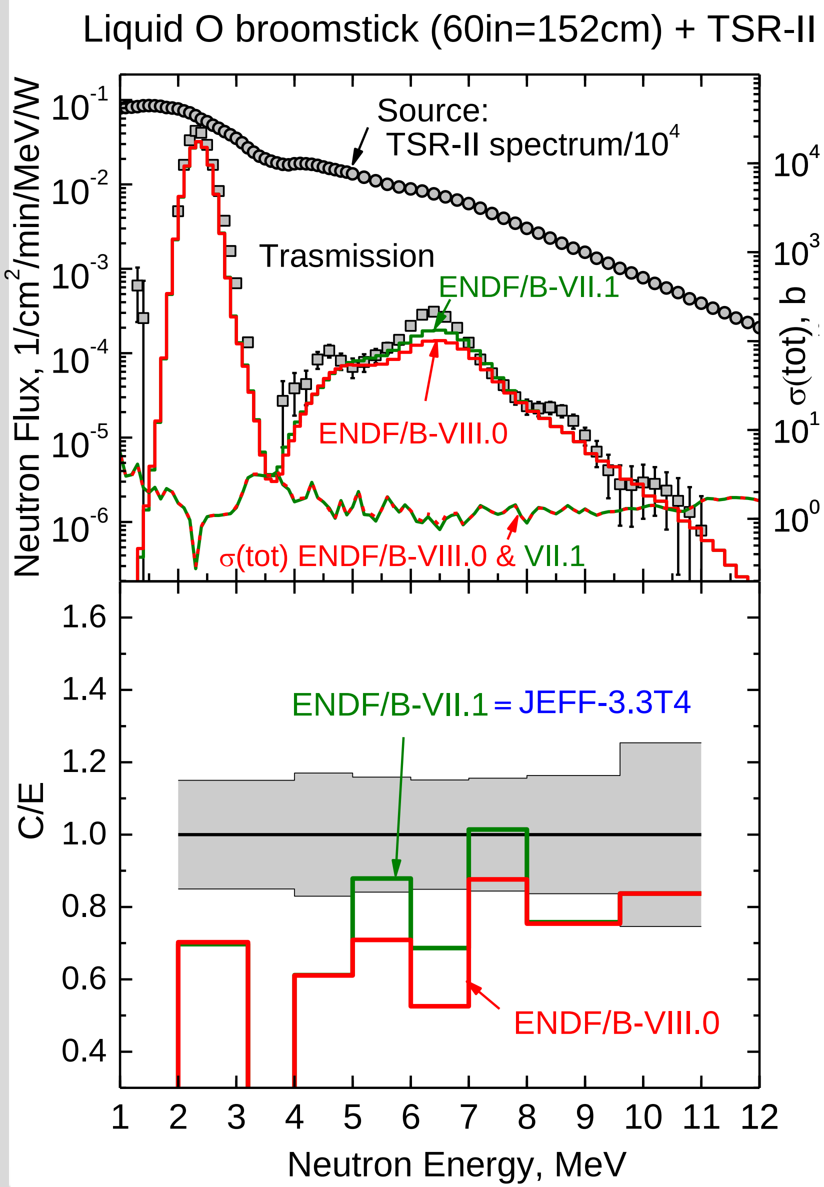


Observations but with preliminary own set-up Model:

- This Reactor Spectrum Transmission Experiment indeed sensitive only to Uncollided Neutrons, i.e. to σ_{tot}: the fraction of Collided Neutrons seen by detector amounts only ≈ 5 10^{-6}

- It is insensitive to the change of Oxygen Temperature from boiling 90.2°K (-183°C) to room one: σ_{tot} changes only below 1 eV

- 152 cm of liquid Oxygen reduce Neutrons by 10^{-4} !,
$\Delta\sigma/\sigma = (n\, l\, \sigma)^{-1}\, \Delta T/T = 6.5\, \Delta T/T$!
e.g.: 10% change of ΔT/T will demand $\Delta\sigma_{tot}$ ≈ 0.65 b !

- JEFF-3.3T4 is practically identical to ENDF/B-VII.1

- ENDF/B-VIII.0 gives 10% less then VII.1 only for 5-8 MeV or similar trend which we observe for FNS/JAERI slab and LLL sphere

III. Oxygen *(slide – from EFFDOC-1342, 20-23 Nov 2017):*

Lonely available spectral benchmark with pure Oxygen FNS/JAERI, NEA-153/61:

(other one NEA-1517/59 is a uncollided transmission to test σ_{tot} in range 1.9 – 8.6 MeV)

Neutron Leakage Spectra at 0, 12, 25, 42, 67 deg.
from Liquid Oxygen Disc (ℓ=20 cm × Ø60 cm)
irradiated by pulsed 14 MeV source

Information about Experiment is available in:
- e.g.: Y.Oyama et al., NDST 1991, p.337 Fig.3 =>
- Details/Data: see SINBAD NEA-1553/61

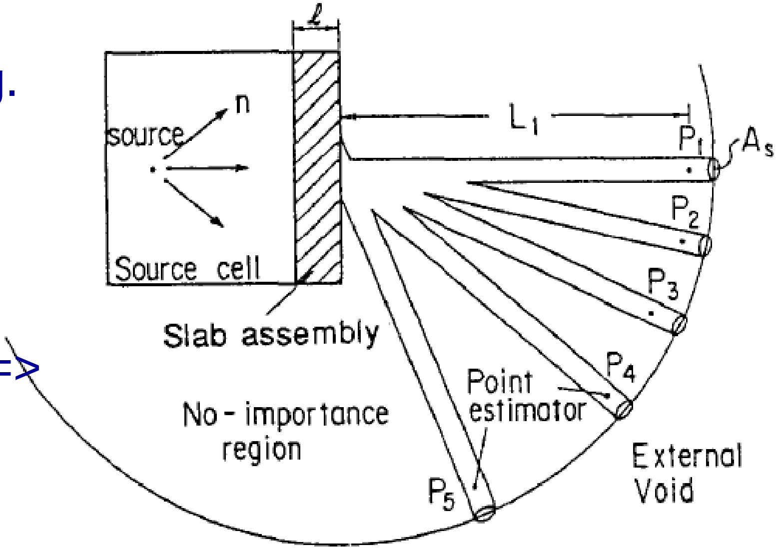


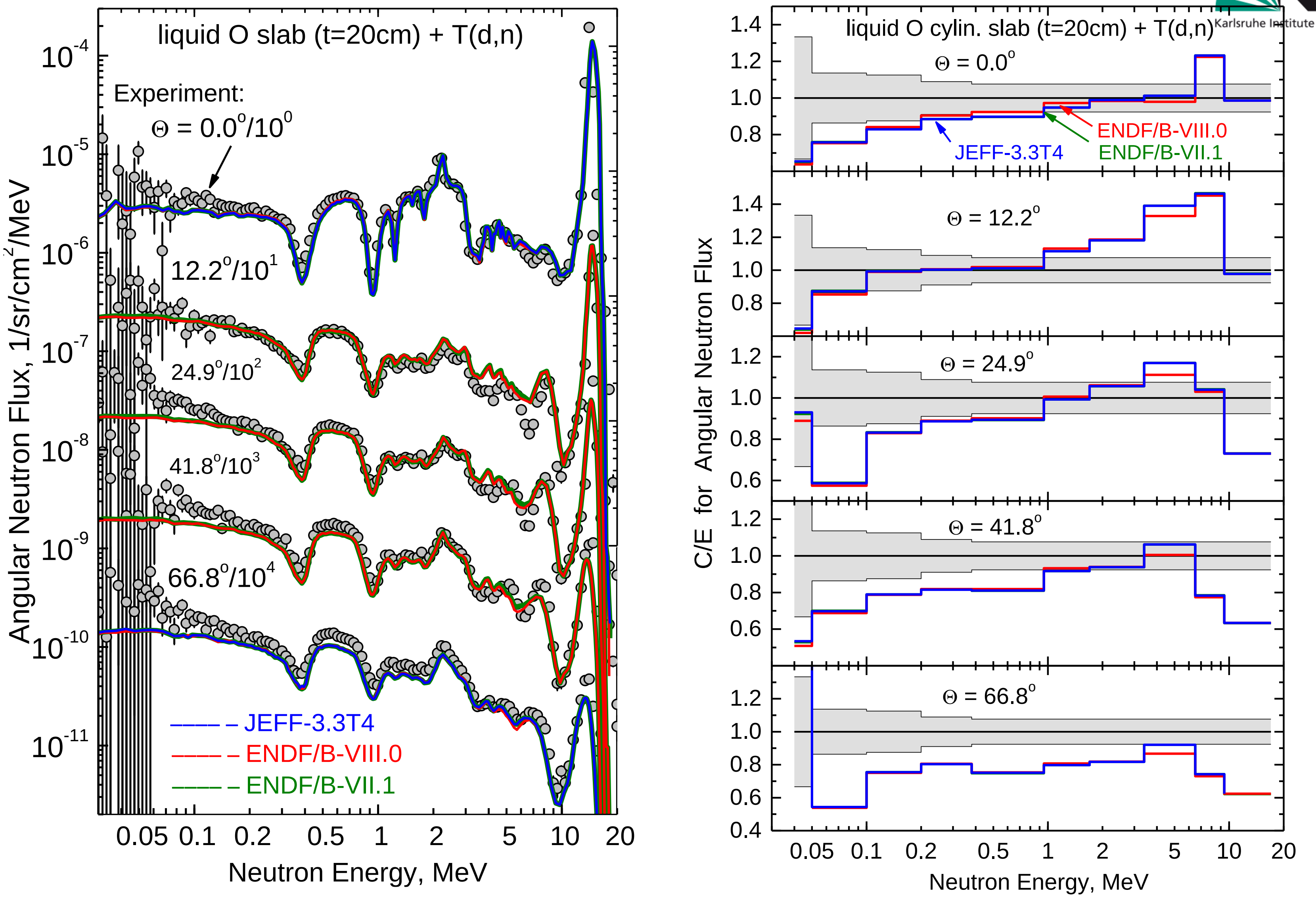
Fig.3 Calculational model for MCNP

"The Quality Assessment of the FNS Benchmark Experiments" by A.Milocco, I.Kodeli,
recommendation on page 38:

"Thus, the scaling factor should be calculated by squaring L and dividing by the effective measured area and the cosine of the detector angle. With this procedure good agreement in flux magnitude is obtained at 66.8° ..."

Our results but without dividing by cosine of the detector angle (?) on next slide =>

III. Oxygen *(slide – from , from EFFDOC-1342, 20-23 Nov 2017):*



Findings: ***- JENDL-3.3T4 = ENDF/B-VII.1 and ENDF/B-VIII.0 are practically indistinguished***
- however among them, the ENDF/B-VIII.0 is slightly better

IV. Tantalum *(slide - from EFFDOC-1342, 20-23 Nov 2017):*

Ta is not presented in SINBAD, however relevant Benchmarks exist:

1. Livermore Lab (LLNL, Livermore) Pulsed Spheres
= neutron leakage spectra from two Ta spheres with **14 MeV source**

Information about Experiment is available in:
- *NSE 92(1986)382: Ta spheres sizes, leakage energy spectra*
- *UCRL-51144 (1972), LA-12885 (1994): T(d,n) neutron source specification, TOF leakage spectra and MCNP input decks for 28 spheres, except Ta*

2. Lewis Research Center (LRC, Ohio) Sphere
= neutron leakage spectra from one Ta sphere with **Am-Be source**

Information about Experiment is available in:
- *D.Bogart et al. NSE 53(1974)285: Ta sphere sizes, Neutron Source and Leakage Energy Spectra*

NOT in SINBAD

Summary = Recommendations

- Found error in SINBAD MCNP input for FNG/TUG - have to be corrected

- Different from recommended in SINBAD interpretation of Experiments (Oxygen FNS)

- No MCNP input and Experimental data in SINBAD Oxygen ORNL, Tower Shielding

- Benchmarks relevant but missed in SINBAD (Fe-NIST, Fe-KFK gamma, Ta-LRC) have to included since publications have sufficient information

- Livermore Pulsed Spheres are not included in any database

- Recent/new Benchmarks:
  a. Research Center Rez: Fe spheres with 252Cf source
     B.Jansky, J.Rejchrt, JEFFDOC-1957; M.Schulc, M.Kostal et al., NIM A914(2019)53
     presentation on this Meeting
- b. Ohio University: Fe spheres with D(d,n) 7-10 MeV neutron source
     S.Dhakal, C.R.Brune, T.N.Massey et al., NSE 2019
- c. ....