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First benchmark analyses of Ta evaluated data for fusion neutron transport calculations

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Objective and Content

- Objective:

  - validation of the Ta evaluated data relevant for the fusion neutron transport calculations

- Content:

  - available evaluations for Ta isotopes
  - available experimental benchmark and DDX data for Ta
  - comparison of transport calculations and DDX with experiments
  - conclusions

Ta isotopes abundances and evaluated cross sections files (available only up 20 MeV)

Tantalum Isotopes	ENDF/B-VI (1972)	JENDL-3.3 (2002)	JEFF-3.1 (2005)	FENDL-2.1 (2004)
Natural Abundancies	adopted ENDF/B-V	updated JENDL-3.2	adopted JENDL-3.3	adopted JENDL-3.3
Ta-180^{m} (10^{15}a) - 0.012%	-	-	-	-
Ta-181 (stable) - 99.998%	Ta-181	Ta-181	Ta-181	Ta-181
Ta-182 (114 d) - 0.0 %	Ta-182	-	Ta-182 (ENDF/B-IV)	-

- No evaluation is available for the stable isotope Ta-180m !
- Only two independent evaluations do exist: ENDF/B-VI and JENDL-3.3 (latter were adopted in FENDL-2.1 and JEFF-3.1)

Experimental Integral and Differential neutron data relevant for Ta evaluated cross sections validation for fusion application

Neutron Transport Benchmarks:

Available only one: made in Livermore (LLNL) in 1986 - neutron leakage spectra from two Ta spheres with 14 MeV central neutron source

Differential cross sections (n,xn):

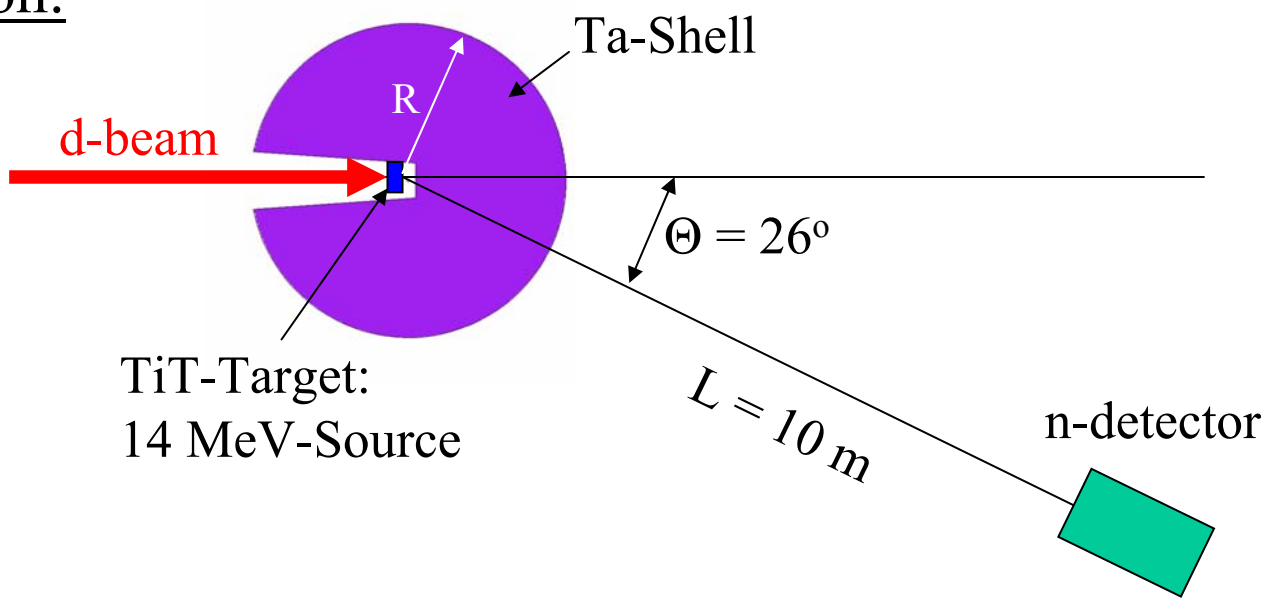
Available many: made in IPPE (Obninsk), IRK (Vienna), OSA (Osaka), TOH (Tohoku), TUD (Dresden) … - secondary neutron energy/angular distributions for incident energies 5 to 20 MeV

LLNL Ta-Shell Neutron Transport Experiment with 14 MeV Neutron Source

Experiment (1986):

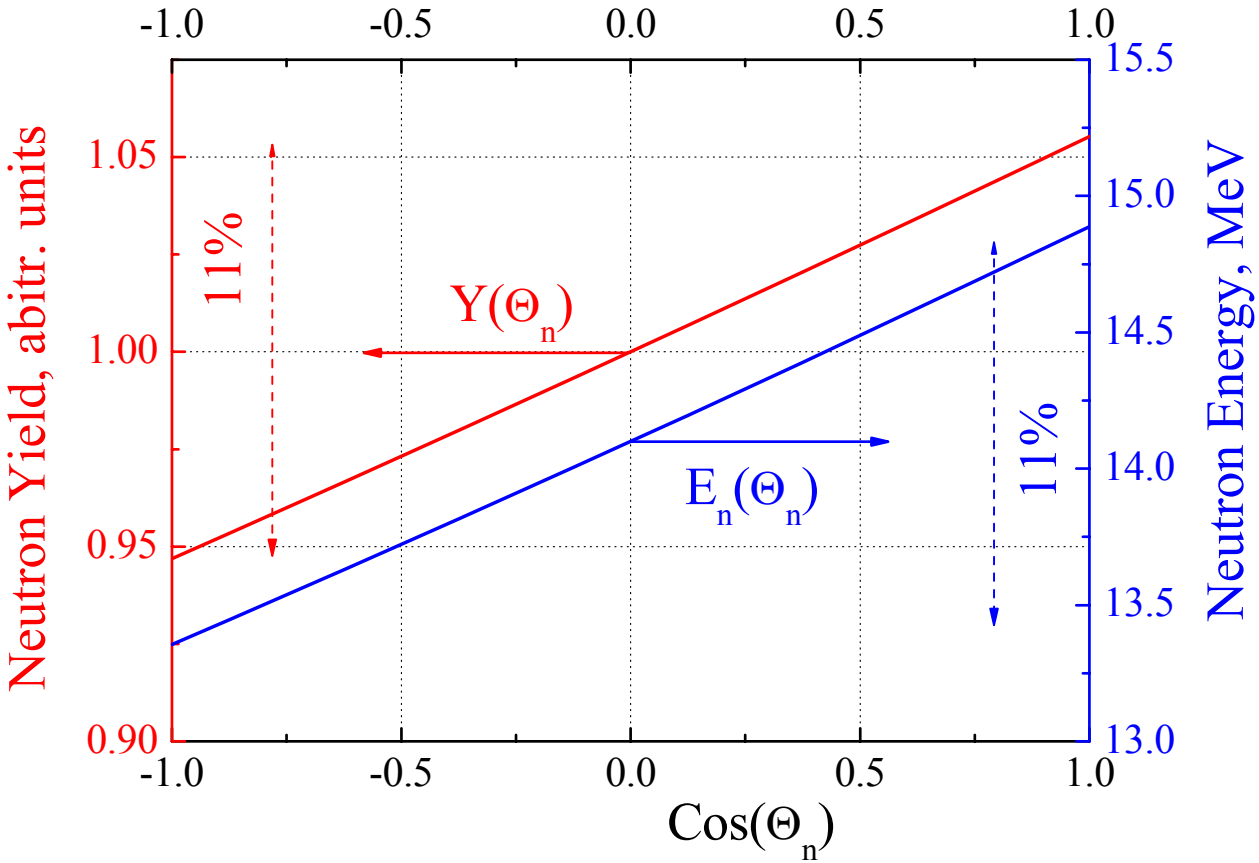
Shell #1: R = 3.4 cm (1 mfp)
Shell #2: R = 10.2 cm (3 mfp)
14 MeV-neutron source: TiT +d, E_d = 400 keV
Method: Time-of-Flight, L = 10 m
n-detector: $\Theta = 26^o$, $E_{thresh} > 1$ MeV

MCNP simulation:



LLNL Ta-Shell Neutron Transport Experiment with 14 MeV Neutron Source (cont.)

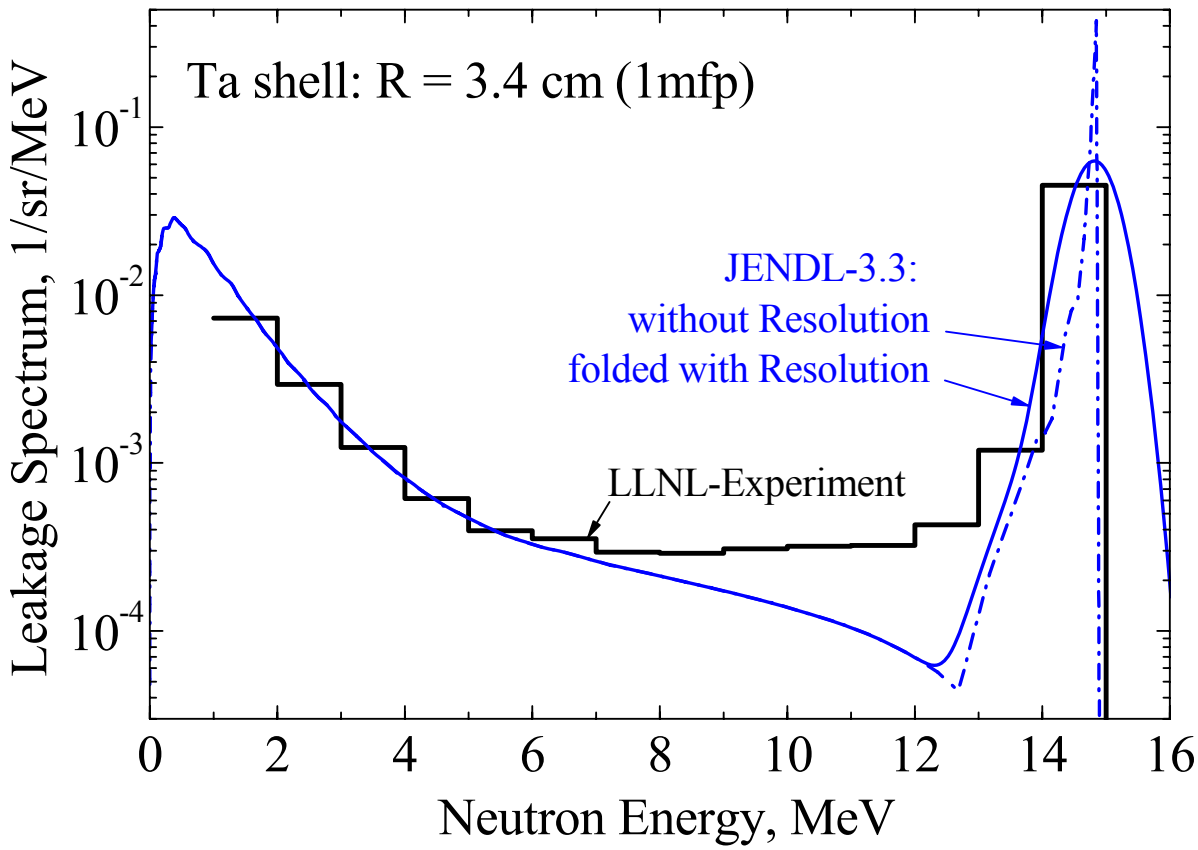
Thick TiT+ d (400 keV) Neutron Source Simulation:



Findings: ***- 11% variation of neutron Yield and Energy vs. emission angle for the T(d,n) source of 14 MeV neutrons***

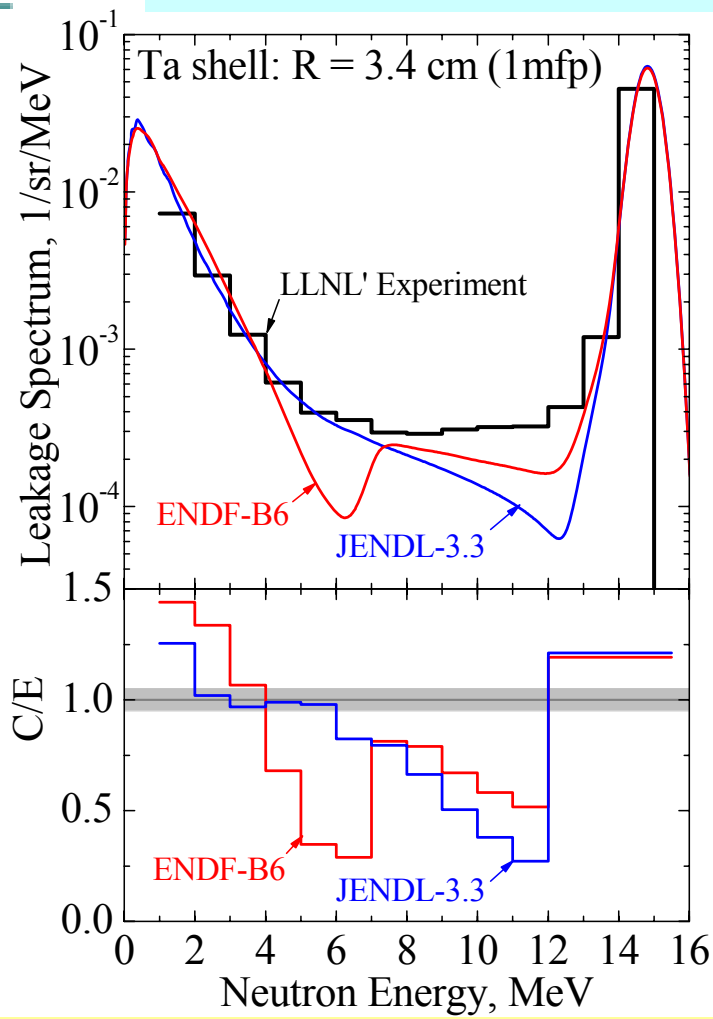
LLNL Ta-Shell Neutron Transport Experiment with 14 MeV Neutron Source (cont.)

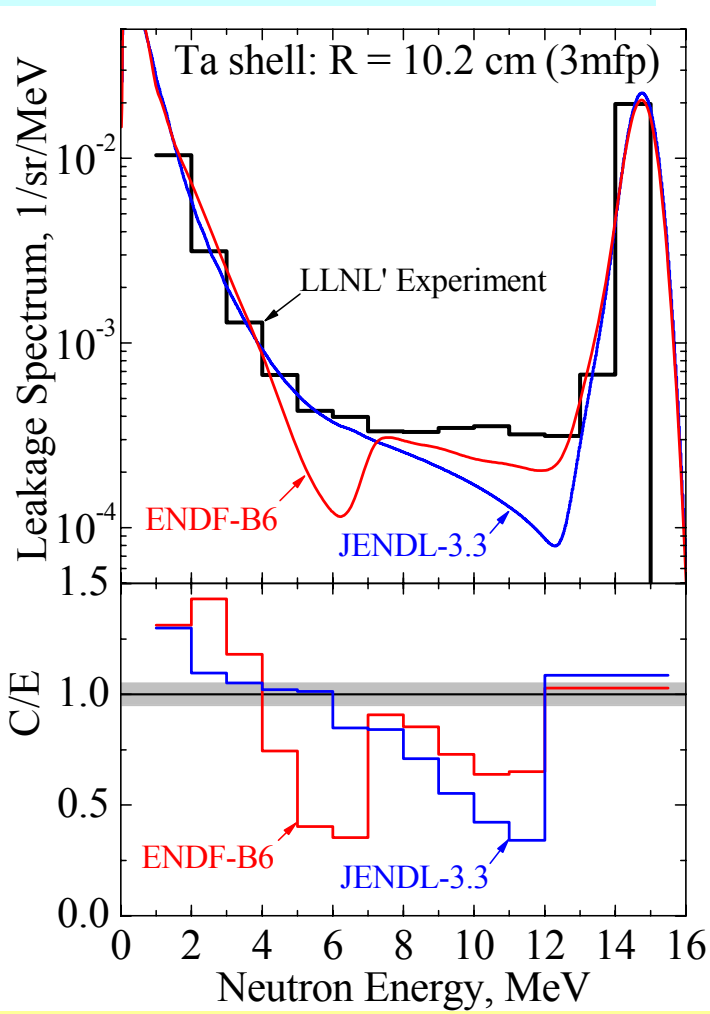
TOF Neutron Spectrometer Resolution: $\Delta E/E = 2\sqrt{(\Delta t/t)^2 + (\Delta L/L)^2}$



***Findings*: - Time/Space uncertainties result in broadening of 14 MeV peak; i.e., only one broad group 12-15 MeV meaningful for source neutrons**

LLNL Ta-Shell Neutron Leakage Experiment with 14 MeV Neutron Source

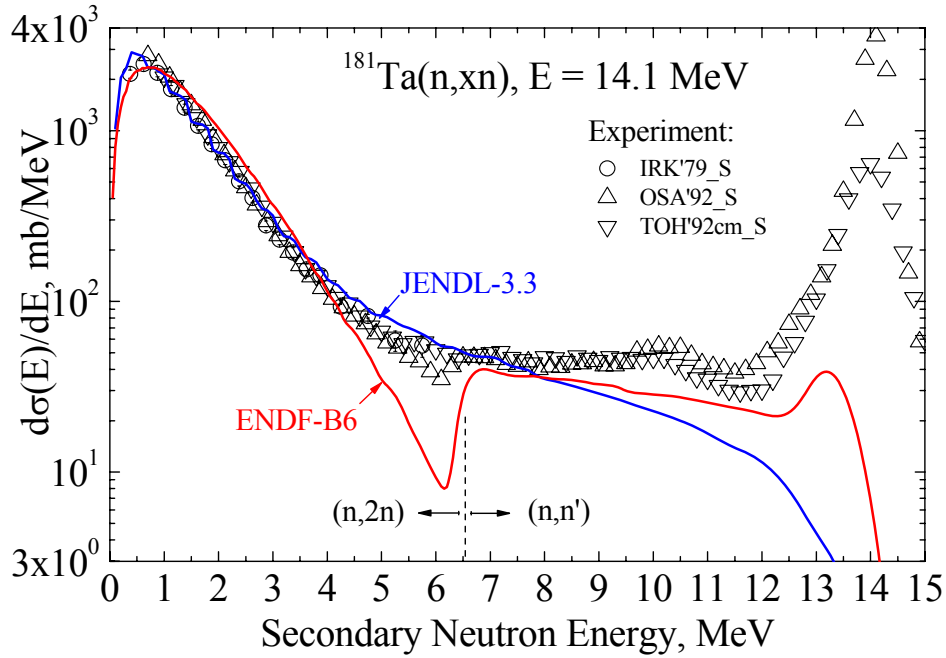




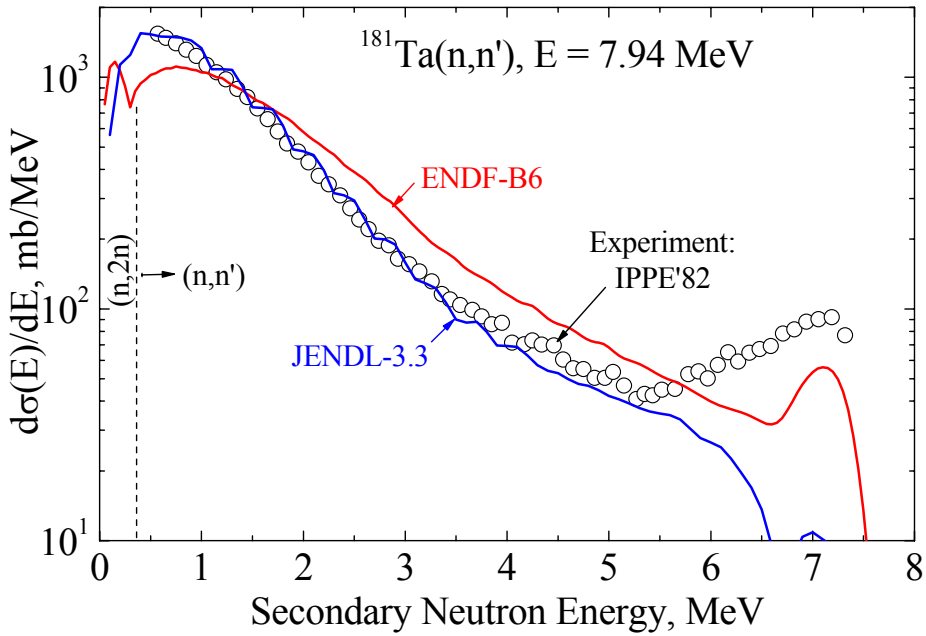
Findings: ***- 20 - 50% overestimation below 2-3 MeV***
- 20 - 70% underestimation from 5 to 12 MeV
- 20% overestimation for 14 MeV neutrons (only thin shell)

Validation against Secondary Neutron Energy Spectra from Ta(n,xn) reaction

Neutron emission spectra at 14 MeV



Neutron emission spectra at 8 MeV



***Findings*: - inconsistency of neutron spectra shapes from (n,n') and (n,2n) reactions in ENDF/B-VI**
- underestimation of high energy tails (preequlibrium/direct processes) from (n,n') reactions in ENDF/B-VI and JENDL-3.3

Conclusions

- Two independent evaluations ENDF/B-VI (rather old 1972) and JENDL-3.3 are presently available for Ta-181, no evaluation does exist for the stable Ta-180m
- Analyses of the single 14 MeV neutron transport benchmark and series of DDX measurements has indicated the need for updating in both evaluations the secondary neutron emission spectra from (n,xn) reactions
- New EFF evaluation for Ta-181 underway up to 150 MeV (see P. Pereslavtsev, EFF-DOC-953)