Verification of the fission product yields from the neutron induced fission of ^{235}U, ^{238}U, and ^{239}Pu based on the delayed neutron characteristics

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All characteristics of delayed neutrons (DN) can be evaluated, if we know the cumulative yield CYi of each DN precursor, the half-life Ti for its beta-decay and the probability Pi of neutron emission after beta-decay. Of course, we need such data for all precursors, contribution of which can not be negligible.
The total DN yield is defined in this case as

$$\nu_d = \sum_i CY_i \cdot P_{ni},$$

and the average half-life time can be estimated as

$$< T_{1/2} > = \sum_i Pn_i \cdot CY_i \cdot T^i_{1/2} \Big/ \sum_i Pn_i \cdot CY_i,$$

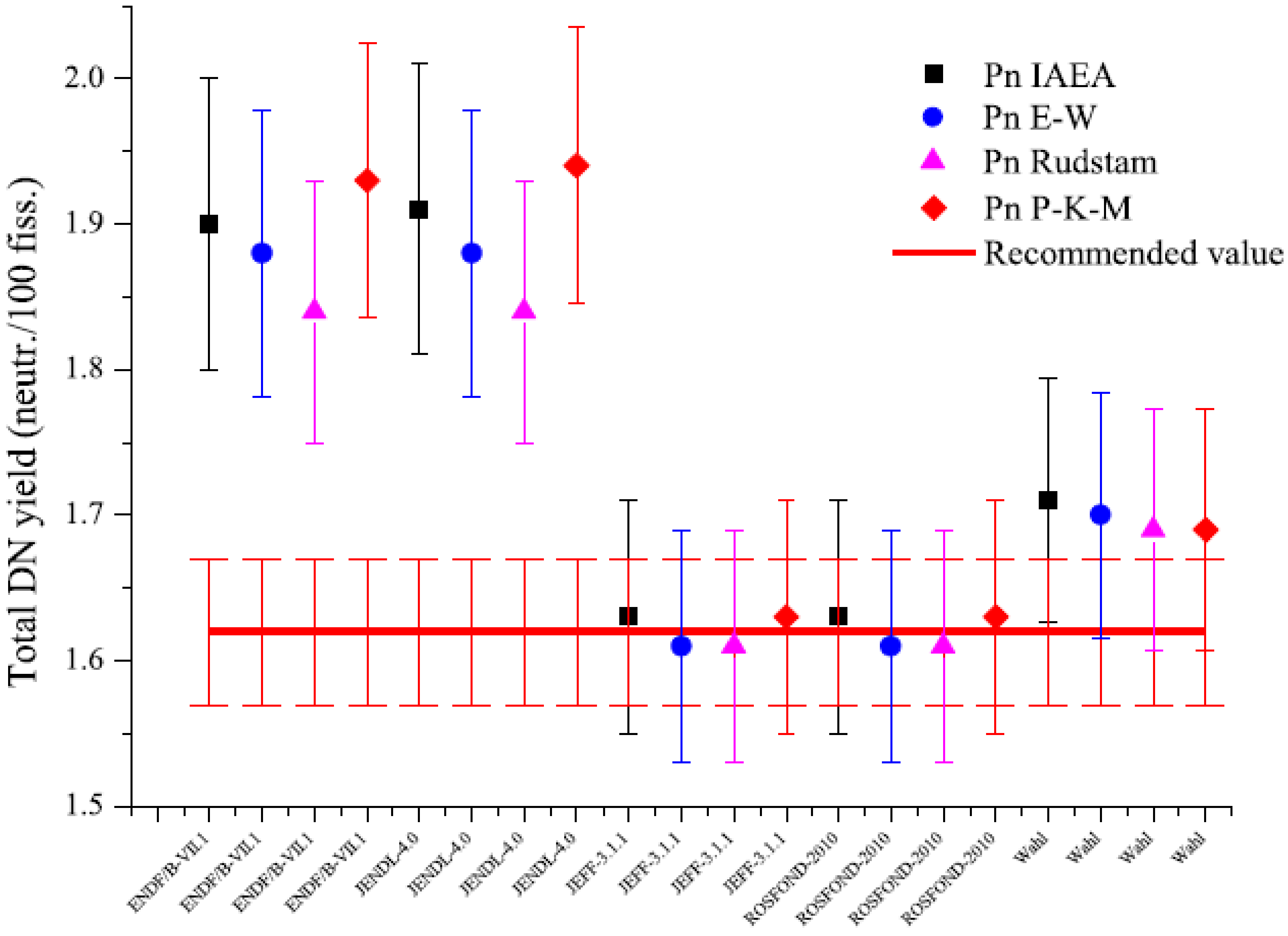
Data sets

The summation method was used to determine the most reliable data sets of the fission product yields, presented in the modern data libraries. The total DN yields and the average half-lives were calculated and compared with the experimental and recommended data

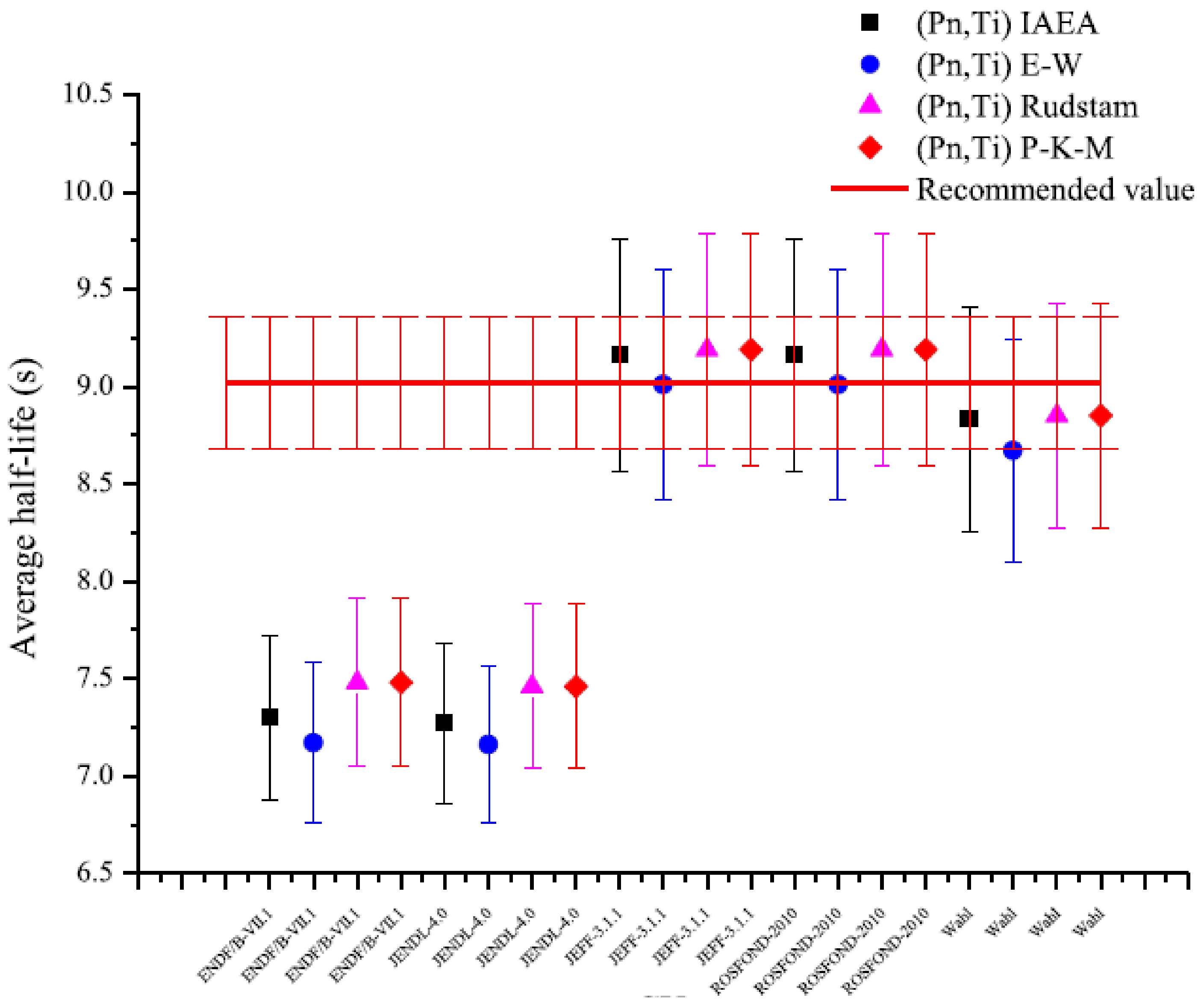
The cumulative yields for 368 DN precursors from the JEFF-3.1.1, ENDF/B-VII.1, JENDL-4.0, ROSFOND-2010 libraries and the Wahl evaluations (IAEA, 2000) were used as the input data.

Four data sets were used for the precursor half-lives and the neutron emission probabilities: the Rudstam data compilation (Rudstam et al., 1993), the Pfeiffer-Kratz-Herrmann systematics (Pfeiffer et al., 2002), the Wilson-England systematics (2002), and the IAEA compilation of experimental and evaluated data (Abriola et al., 2011) .

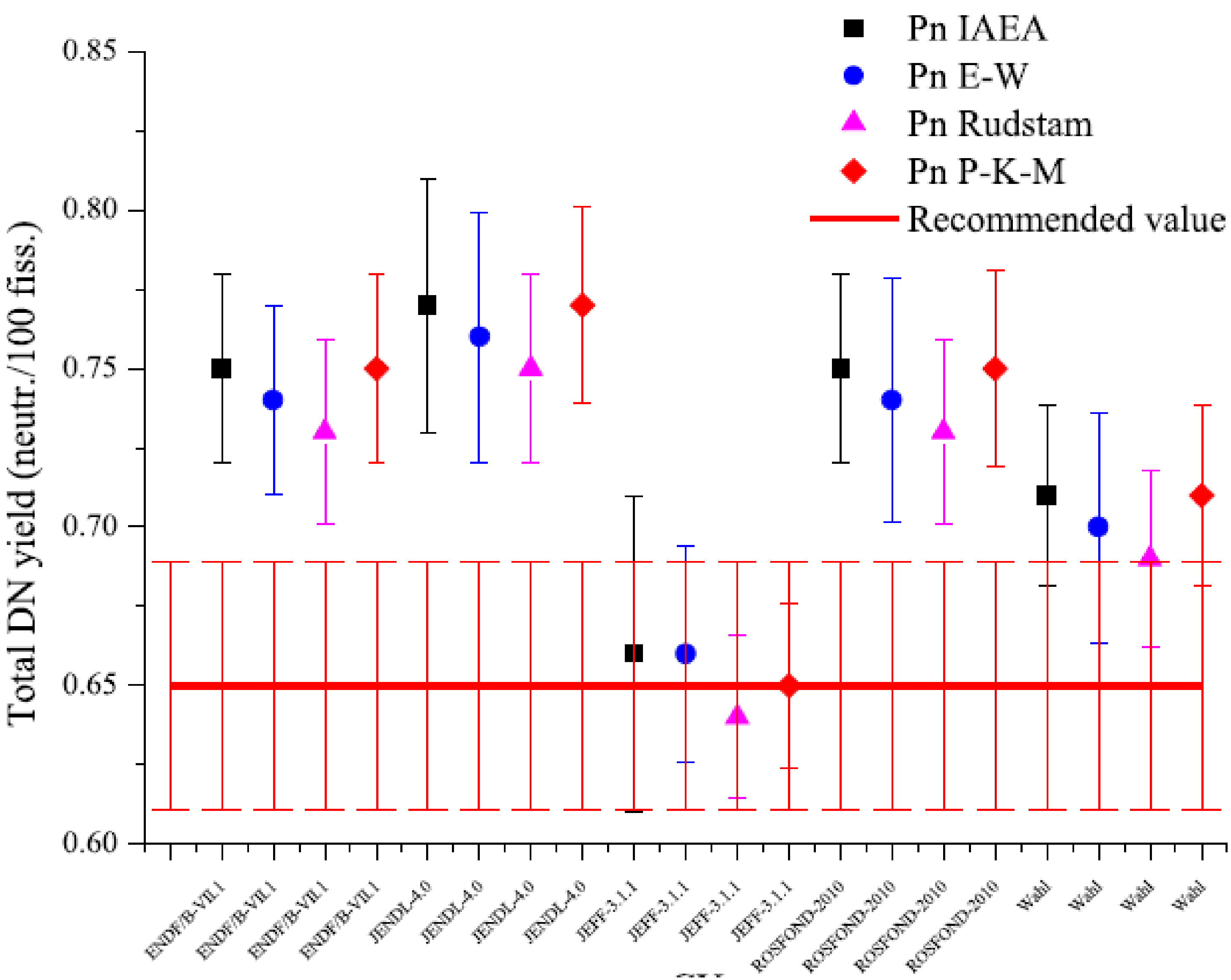
Total DN yields calculated for different sets of (Pn, T1/2) compared with evaluations for the thermal neutron fission of ^{235}U



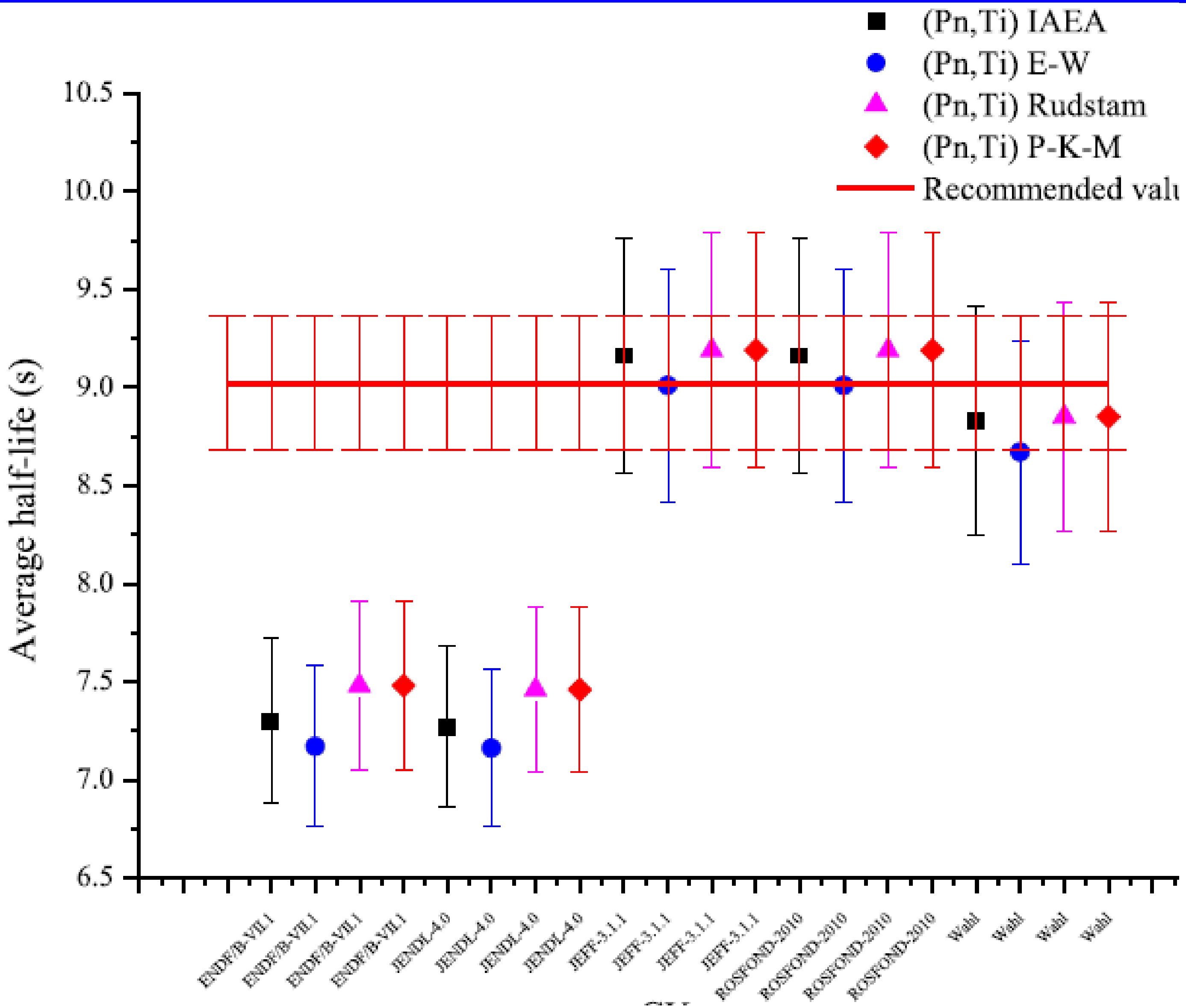
Average half-lives of delayed neutrons calculated for different sets of (Pn, T1/2) compared with evaluations for the thermal neutron fission of ^{235}U



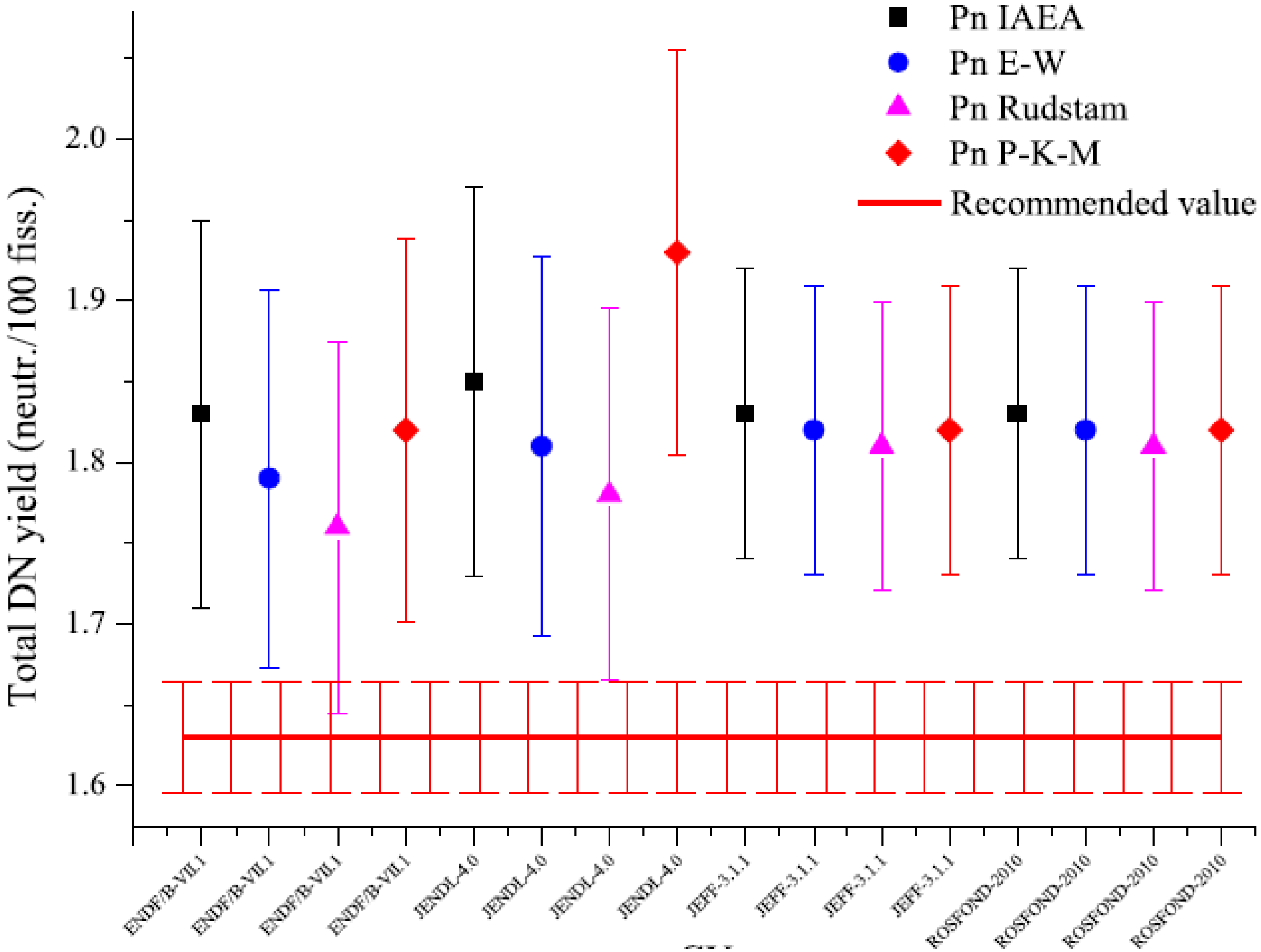
Total DN yields calculated for different sets of (Pn, T1/2) compared with evaluations for the thermal neutron fission of ^{239}Pu



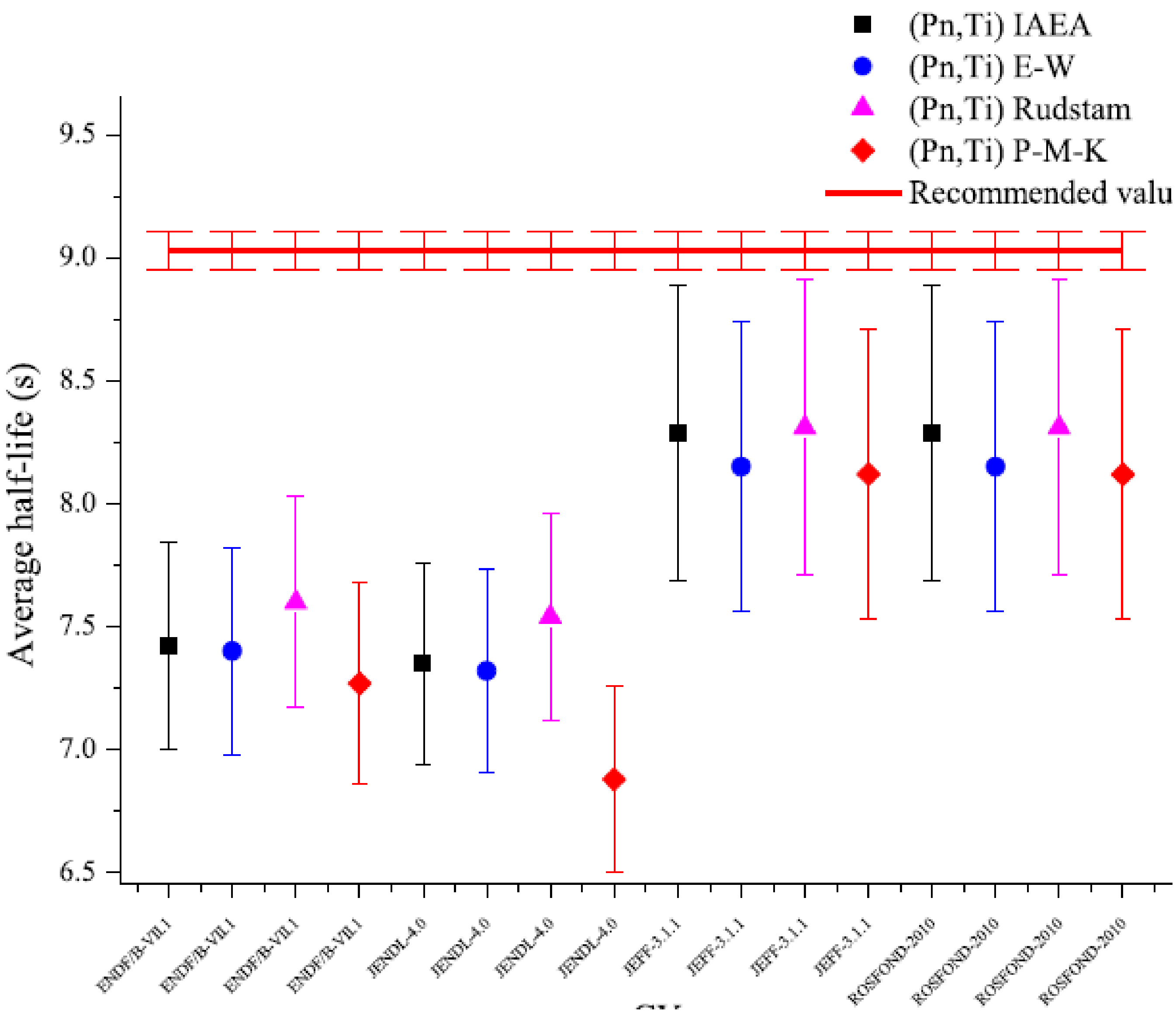
Average half-lives of delayed neutrons calculated for different sets of (Pn, T1/2) compared with evaluations for the thermal neutron fission of ^{239}Pu



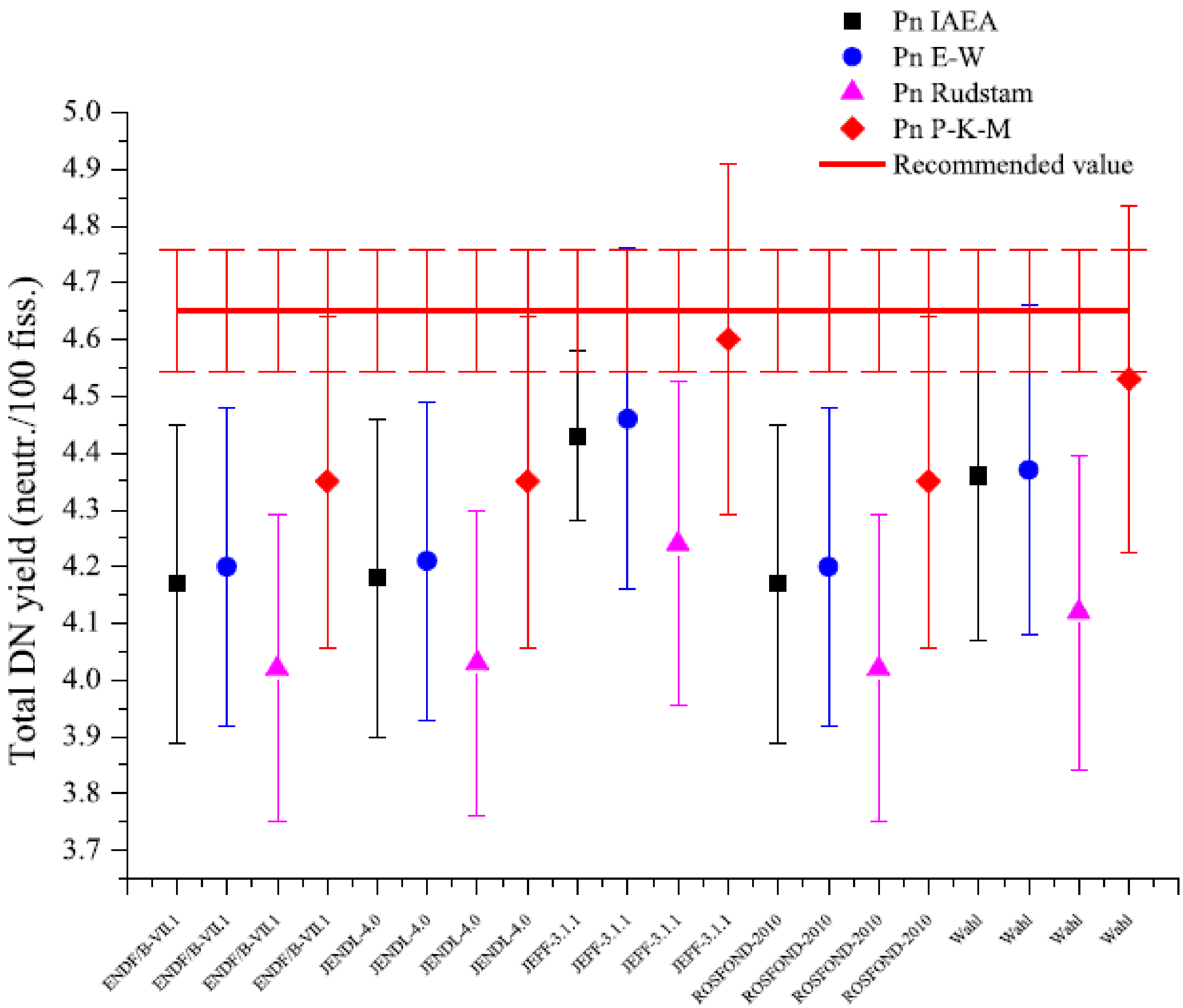
Total DN yields calculated for different sets of (Pn, T1/2) compared with evaluations for the fast neutron fission of ^{235}U



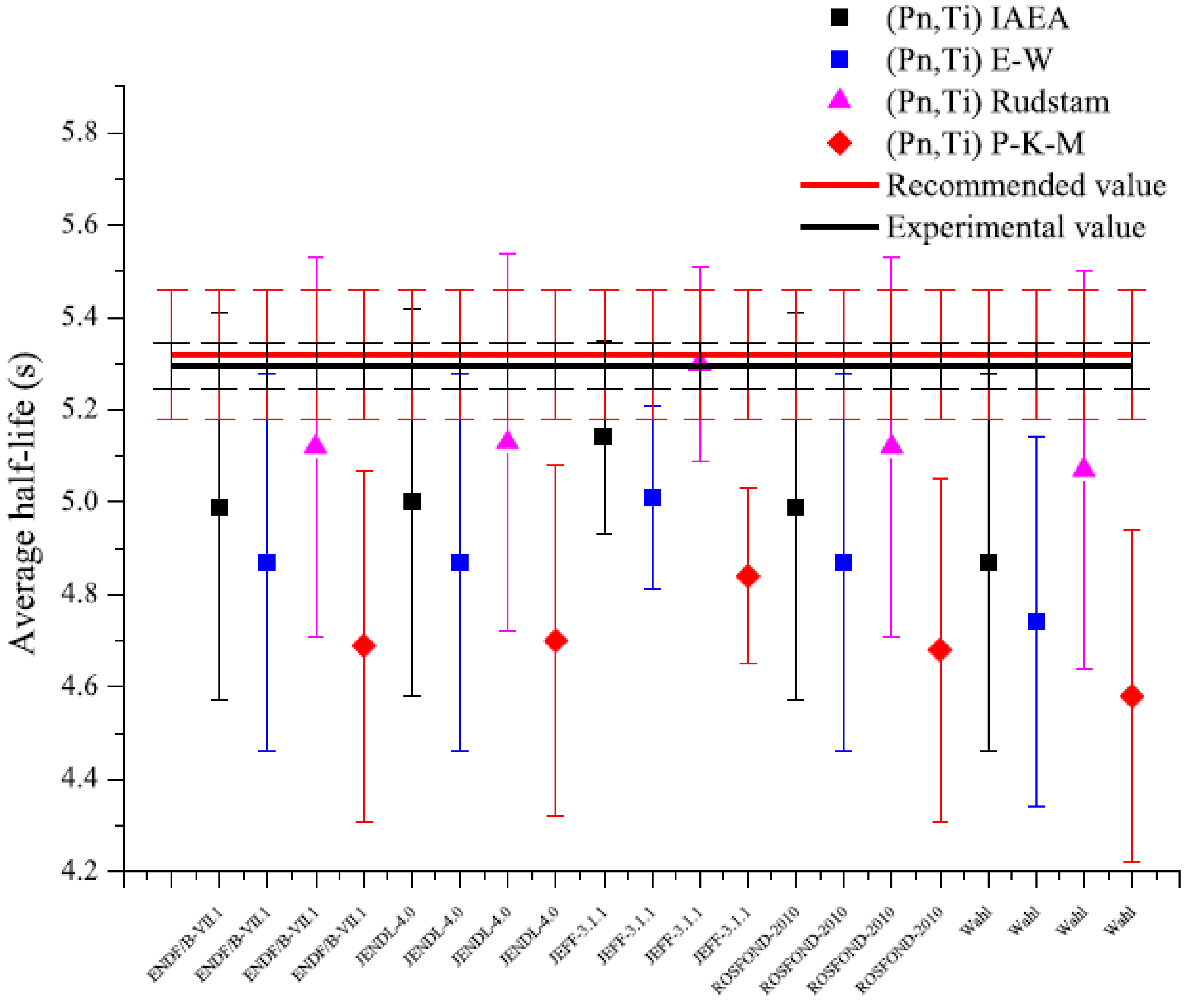
Average half-lives of delayed neutrons calculated for different sets of (Pn, T1/2) compared with evaluations for the fast neutron fission of ^{235}U



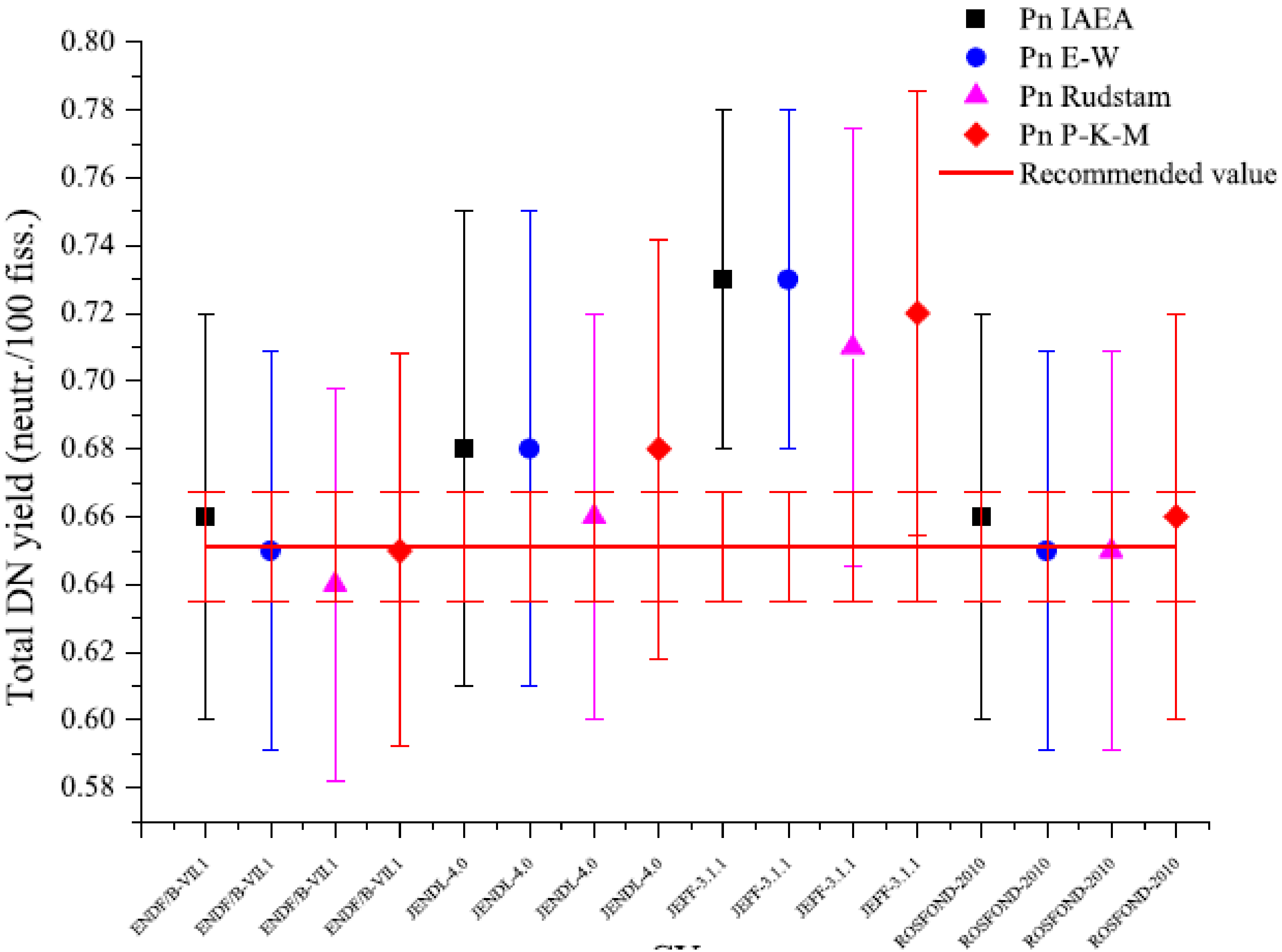
Total DN yields calculated for different sets of (Pn, T1/2) compared with evaluations for the fast neutron fission of ^{238}U



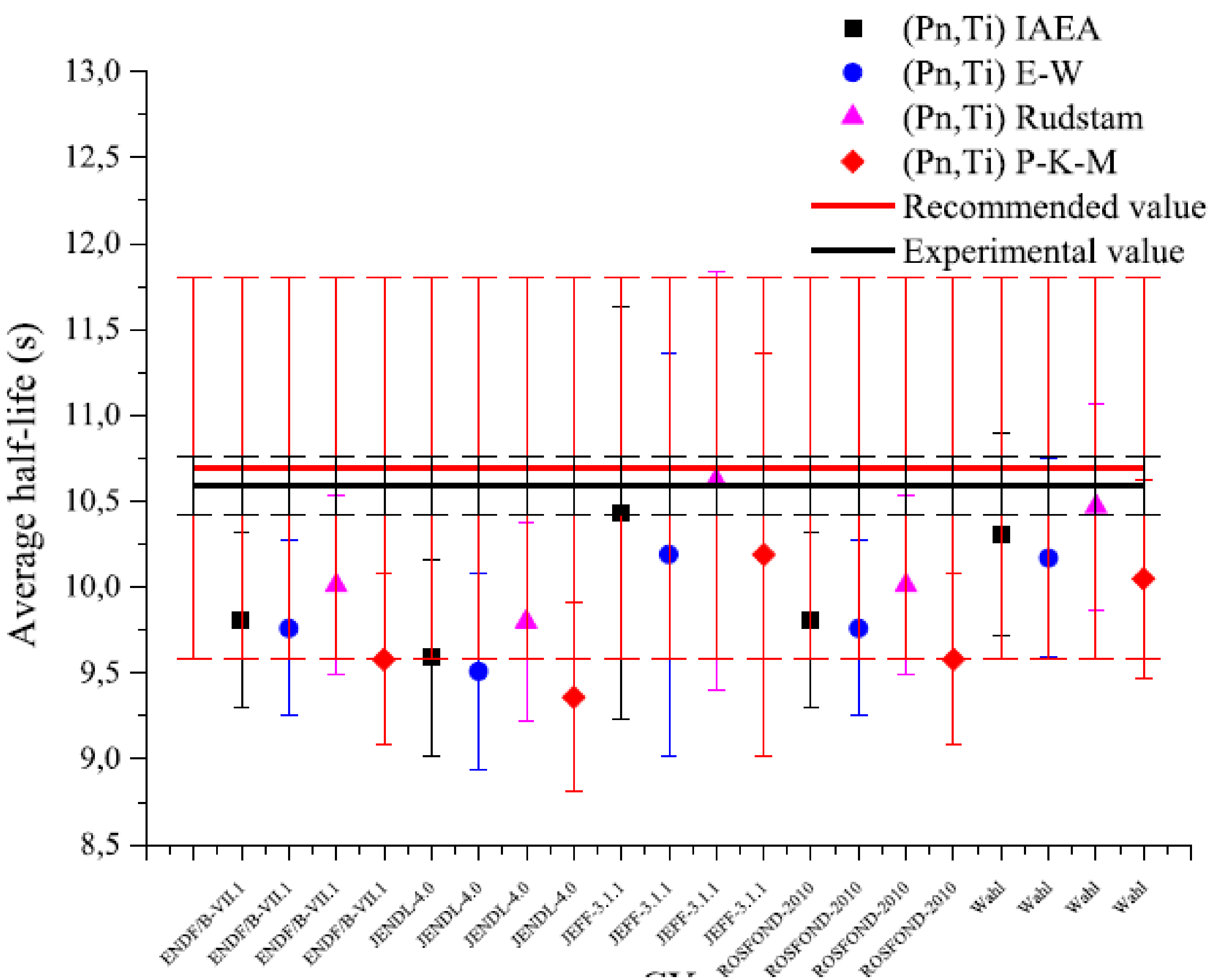
Average half-lives of delayed neutrons calculated for different sets of (Pn, T1/2) compared with evaluations for the fast neutron fission of ^{238}U



Total DN yields calculated for different sets of (Pn, T1/2) compared with evaluations for the fast neutron fission of ^{239}Pu



Average half-lives of delayed neutrons calculated for different sets of (Pn, T1/2) compared with evaluations for the fast neutron fission of ^{239}Pu



Preferable data sets

The most consistent data sets of the fission product yields, the probability of delayed neutron emission and half-life of the DN precursors for the determination of ν_d.

Input data	Origin of the CY and (P_n,$T_{1/2}$) data sets				
	$^{235}U(n_{th},f)$	$^{235}U(n_f,f)$	$^{238}U(n_f,f)$	$^{239}Pu(n_{th},f)$	$^{239}Pu(n_f,f)$
CY	JEFF-3.1.1	ENDF/B-VII.1	JEFF-3.1.1	JEFF-3.1.1	ENDF/B-VII.1
(P_n,$T_{1/2}$)	All sets	Rudstam[a]	P-K-M[b]	All sets	All sets

The most consistent data sets of the fission product yields, the probability of delayed neutron emission and half-life of the DN precursors for the determination of $\langle T_{1/2} \rangle$.

Input data	Origin of the CY and (P_n,$T_{1/2}$) data sets				
	$^{235}U(n_{th},f)$	$^{235}U(n_f,f)$	$^{238}U(n_f,f)$	$^{239}Pu(n_{th},f)$	$^{239}Pu(n_f,f)$
CY	JEFF-3.1.1	JEFF-3.1.1	JEFF-3.1.1	JEFF-3.1.1	ENDF/B-VII.1
(P_n,$T_{1/2}$)	All sets	IAEA[a], Rudstam[b]	Rudstam[b]	IAEA[a], Rudstam[b]	IAEA[a], E-W[c], Rudstam[b]

Conclusions

None of the available libraries for fission-product yields describes consistently the recommended DN yields and the average DN half-lives.

The JEFF-3.1.1 fission-product yields look preferable for the thermal neutron fission of ^{235}U and ^{239}Pu, but for the fast neutron fission are preferable the ENDF/B-VII.1 data.

The systematic difference between the calculated and experimental data for ^{238}U indicates on a need of the critical revision of main characteristics for the short-life precursors. The neutron emission probabilities are the first order candidate for such revision.

The similar differences for the fast neutron fission of ^{235}U indicate on a possible higher value of the total DN yield. Additional measurements should be recommended to justified the recommended values, very important for the fast reactors.