IRSN
INSTITUT DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

UPDATES FROM IRSN

NUCLEAR DATA WEEK
30 NOVEMBER 2020 TO 4 DECEMBER 2020

L. Leal
Institut de Radioprotection et de Sûreté* Nucléaire (IRSN)
Service de neutronique et du risque de criticité (SNC)
Fontenay-aux-Roses, 92260, France

MEMBRE DE ETSON

*Institute for Radiological Protection and Nuclear Safety

Presentation Roadmap

- Criticality Safety Assessment
- Nuclear Data Evaluation at IRSN (short review)
- Concluding Remarks

Institut de Radioprotection et de Sûreté Nucléaire* – IRSN

(Established on February 22, 2002 with a contingent workforce of about 1700 specialists)

MISSIONS:

- Provide support for the public authorities in nuclear safety and radiation protection for civil and defense activities, and safety of nuclear facilities and materials...
- Make available an emergency response center that can be called in at all times, together with field response teams…
- Define and implement national and international research and study programs…
- Contribute to radiological monitoring of the national territory and workers exposed to ionizing radiation...
- Contribute to providing the public with information in the field of radiological and nuclear risks…

***Institute for Radiological Protection and Nuclear Safety**

Criticality Safety Assessment

Safety Parameter:

$\boldsymbol{k_{eff}}$

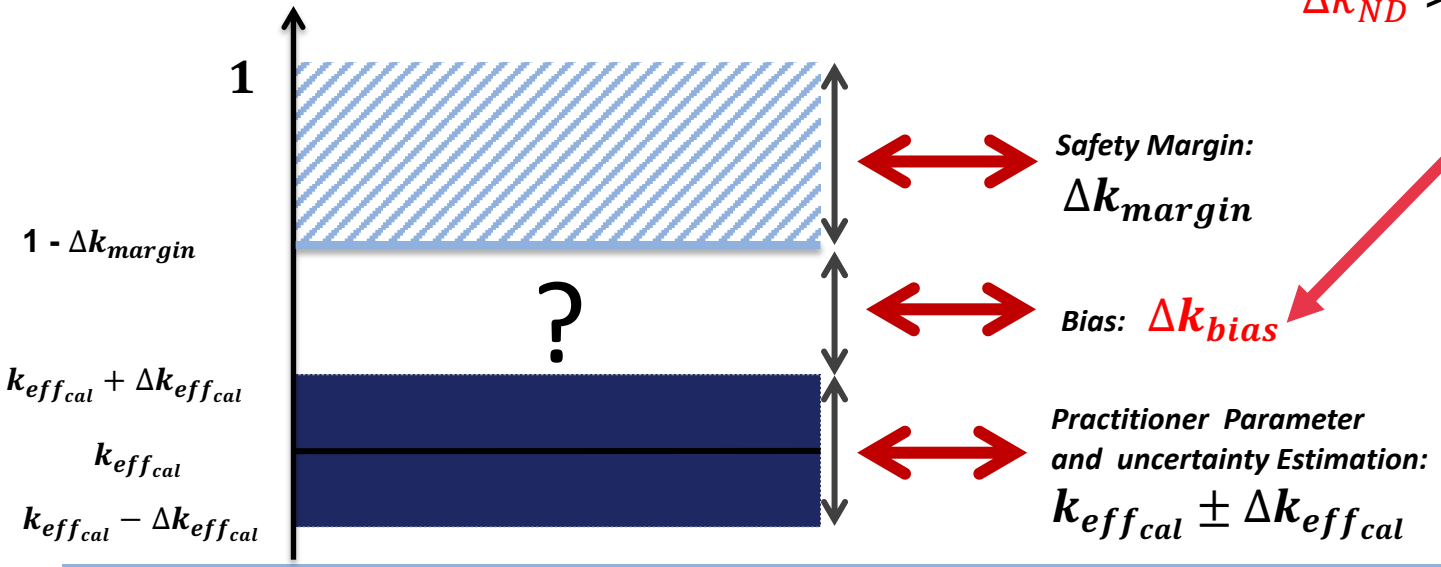
Subcritical Limit Threshold

$$1 - \Delta k_{margin} - \Delta k_{bias} > k_{eff_{cal}} + \Delta k_{eff_{cal}}$$

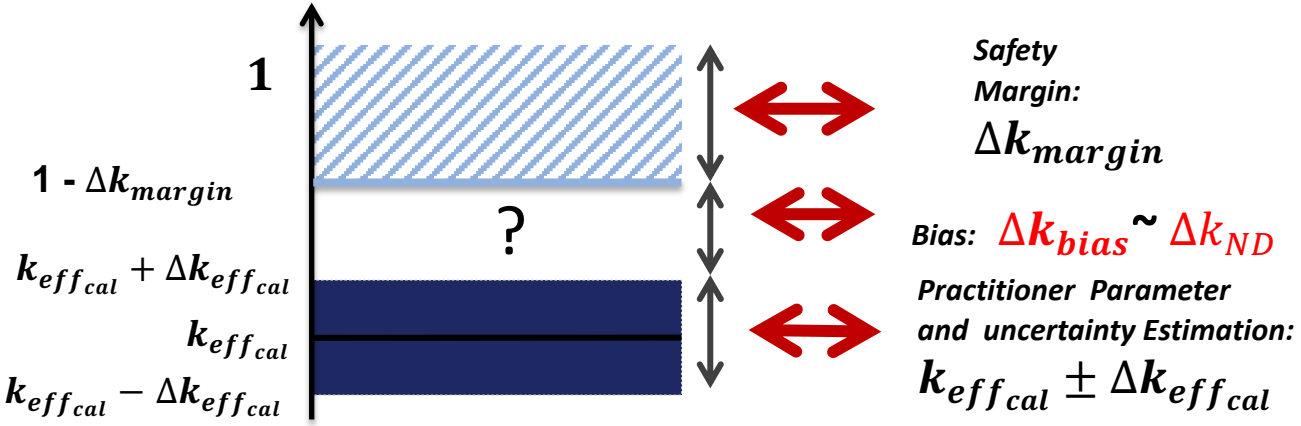
$$\Delta k_{bias} = \Delta k_{ND} + \Delta k_{calc\_schem}$$

Assumption:

$\Delta k_{ND} >> \Delta k_{calc\_schem}$



Criticality Safety Assessment



Parameters Values:

a) Δk_{margin}(common used values)

Normal configuration: 0.95 corresponding to 5000 pcm (10^5 x 0.05) Where 1 pcm = percent mille (1 pcm = 10^5)

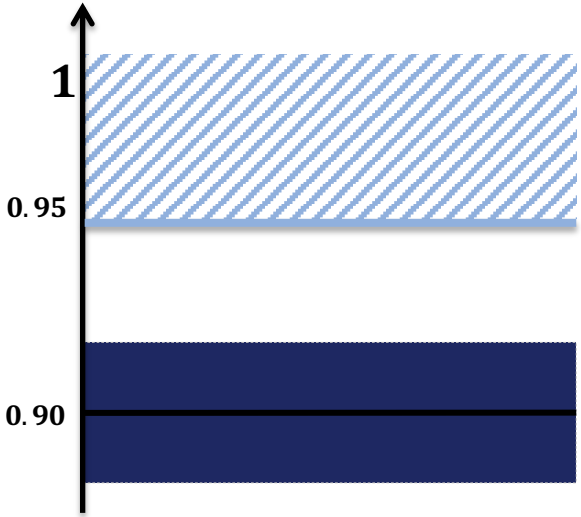
Abnormal configuration: 0.97 – 0.98 corresponding to 3000 to 2000 pcm

b) $\Delta k_{eff_{cal}}$(controlled quantity thru a Monte Carlo Calculation (MC)

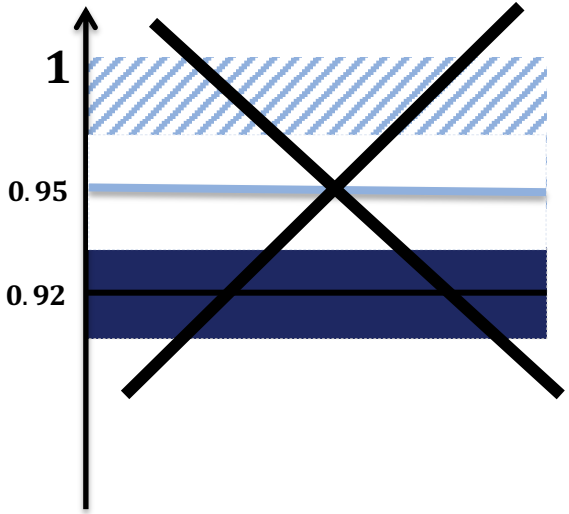
n_Sigma standard deviation in a MC. Values used is n=3 (in France)

c) Δk_{bias} derived from differences of calculated K_{eff} and experimental K_{eff}, that is(C –E). This is where data measurement, evaluation, validation, uncertainty quantification play an extremely important role !!!

Criticality Safety Assessment

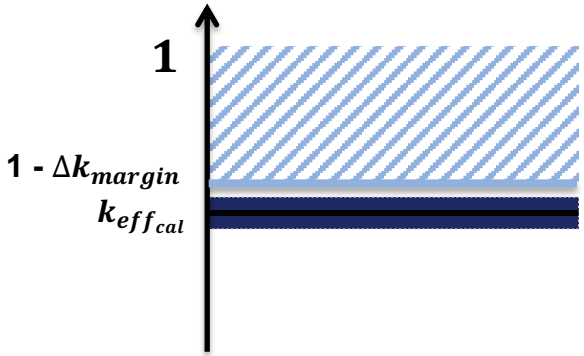


Acceptable but not very efficient



Not acceptable

Criticality Safety Assessment



In this scenario the application k_{eff} ($k_{eff_{cal}}$) is very close to the k_{eff} corresponding to the safety margin (1 - Δk_{margin}).
The nuclear data uncertainty will be such that:

$$1 - \Delta k_{margin} = k_{eff_{cal}} + \Delta k_{bias} + \Delta k_{eff_{cal}}$$

IRSN Evaluation Work

- ^{155}Gd, ^{157}Gd: resolved resonance evaluation. Unresolved evaluation underway;
- ^{103}Rh: resolved resonance evaluation. Unresolved evaluation underway;
- ^{16}O: resolved resonance evaluation: addition of new total and (n,alpha) measurements.
- ^{235}U: resolved resonance evaluation. Further testing use update PFNS.

Note: Resonance parameter covariance available.

^{103}Rh Resonance Evaluation

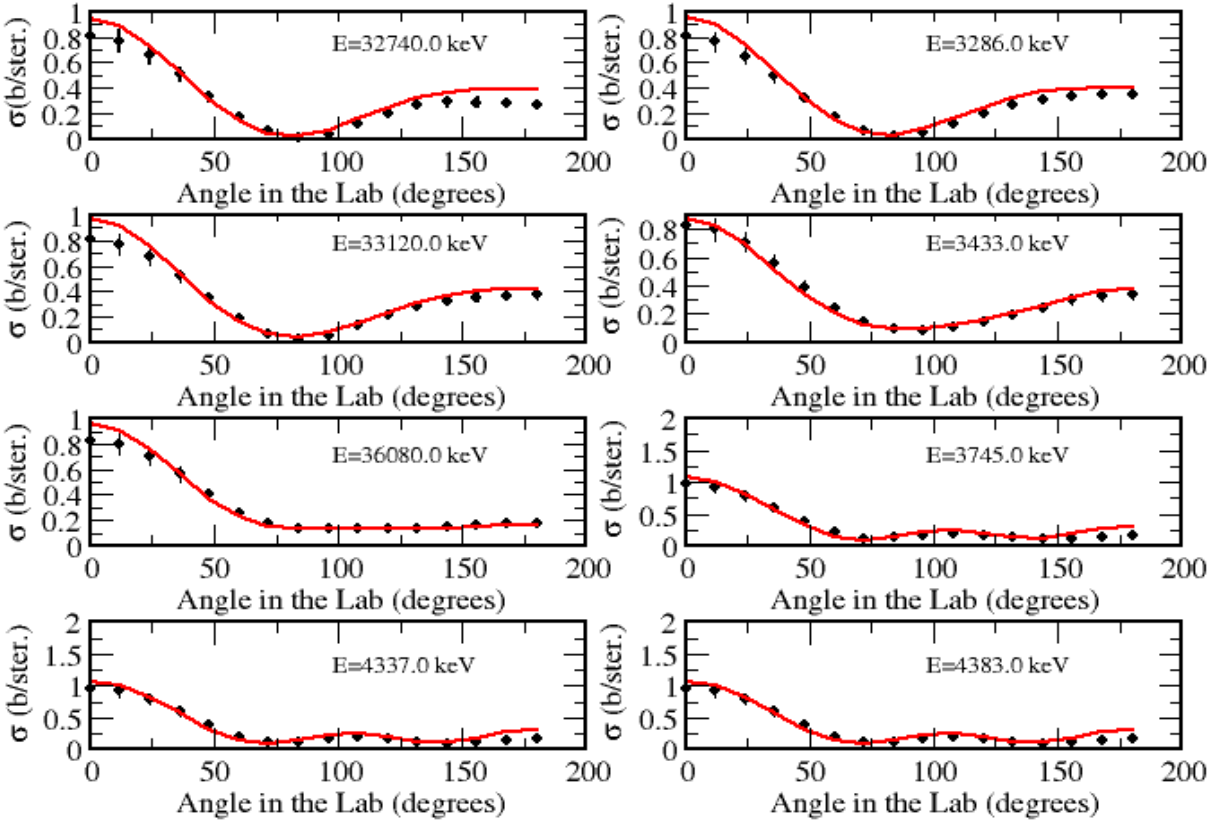
Motivation:

- Issues with resonance spin representation (channel spin);
- Few capture data used on previous evaluations;
- Extension of the resonance region from 4 keV to 8 keV;
- R-matrix analysis (SAMMY/CONRAD);
- Transmission, capture data from GELINA used to extend the evaluation up to 8 keV;
- Uncertainty information and resonance parameter;
- Covariance generation.

^{16}O Resonance Evaluation

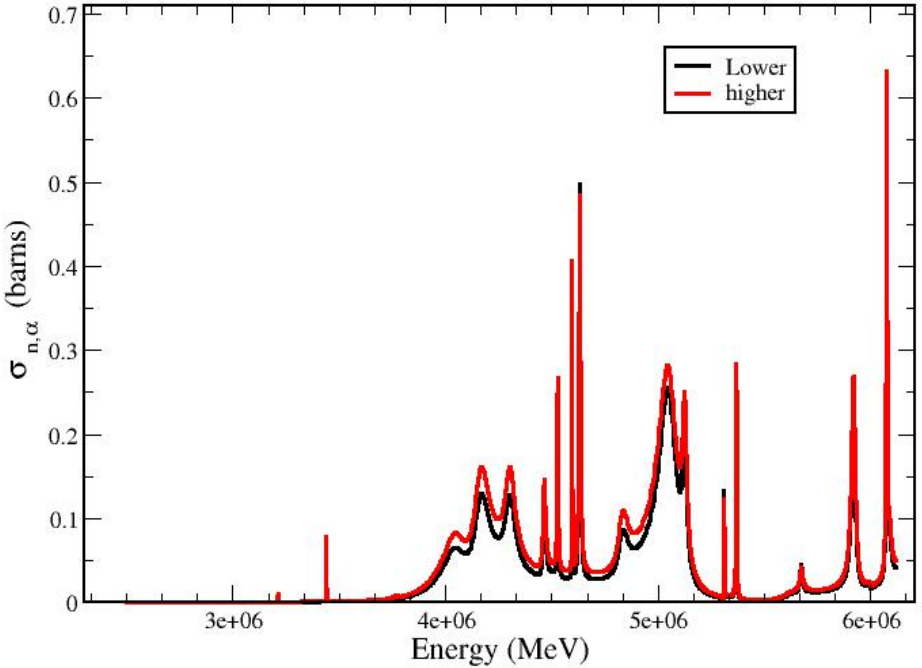
Experimental Data	Flight-Path (meters)	Energy Range (MeV)	Data Reference	Year
Capture Cross Section	-	Thermal	Firestone	2015
Coherent Scattering Length	-	-	Sears	1992
Total Cross Section	79.46	2.0 – 6.3	ORELA (Larson)	1980
Total Cross Section	249.75	2.0 – 6.3	RPI (Danon) [14]	2015
Total Cross Section	41.0 and 47.0	0.6 – 4.3	ORNL Van de Graaff (Fowler, Johnson, and Feezel)	1973
Total Cross Section	189.25	3.14 – 6.3	KFK cyclotron (Cierjacks)	1980
(n,alpha) extracted from (alpha,n)	-	3.2 – 6.3	ORNL Van de Graaff (Bair and Hass)	1973
(n,alpha) extracted from (alpha,n)	-	3.0 – 6.3	Tandem Accelerator Universtät Bochum (Harissopulos)	2005

Fits of the ^{16}O differential elastic cross section of Lister and Sayers



Issues with experimental (n,α) cross-section

^{16}O(n, a) data (Giorginis, et al., IRMM) and ^{13}C(a, n) data (Harissopulos, et al.) give about 30% lower ^{16}O (n, a) cross section values than the Bair-Haas



Task underway:

- New transmission data from HZDR
- Review of (n,α)

^{235}U Resonance Evaluation

- Improving Thermal Benchmark Performance;

- Adjustment of the fission thermal cross-section according to suggested standard values;

^{235}U Thermal Values

Quantity	« Standard »	JEFF3.3 (barns)	^{235}U (Rev) (barns)
σ_f (barns)	586.4 ± 1.5	584.44	586.44
$\sigma\gamma$ (barns)	99.1 ± 2.1	99.62	99.12
σ_s (barns)	14.03 ± 0.22	14.088	14.076
ν	2.4257 ± 0.0047	2.4254	2.4254
K1	-	717.58	720.85

work underway

- ^{19}F: resolved resonance evaluation;
- Thermal scattering for HF; (Vaibhav Jaiswal)
- ^{95}Mo, ^{96}Mo : resolved resonance evaluation. (Nicolas Leclaire)
- ^{54}Fe, ^{56}Fe, ^{57}Fe: resolved resonance evaluation (angular data fitting);
- ^{207}Pb, ^{208}Pb : resolved resonance evaluation;
- ^{233}U: resolved + unresolved resonance evaluations (extension to 2 keV);
- ^{239}Pu: resolved resonance evaluation (RR extended to 4 keV);
- Thermal scattering for light water and ice (SNS data); (Vaibhav Jaiswal)
- New approach for resonance evaluation when only few experimental data are known (unstable and short-lived isotopes);

Concluding Remarks

- IRSN/SNC has worked on data evaluation for internal and external uses. The evaluations include uncertainties;
- IRSN evaluations will be available for inclusion in the data projects;
- New methodologies and approach being developed at IRSN/SNC: New processing capability for URR, approach for unstable and short-lived isotope evaluation, etc.
- New generation of nuclear data evaluators trained at IRSN;