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Proposals for the new measurements for the IRDFF community and for inclusion in the NEA HPRL

I. Spectrum Averaged (SPA) cross sections

Following the action of 1st RCM (see Report INDC(NDS)-0639, page 15) and analysing the available SPA data measured in fields:

Cf-252(s.f.) - available measured data and C/E plots
U-235(n_{th},f) - available measured data and C/E plots
MACS(30 keV) - available measured data and C/E plots

we formulate a list of Not-Measured, Outliers or "Discrepant" data for IRDFF community and for submission to HPRL:

NB.1. Since it is difficult to measure the (n,γ) cross sections due to impact of room and set-up returned neutrons, only the threshold reactions from Not-Measured (marked as **bold)**, Outliers and Discrepant reactions we primarily recommend to measure and to include in HPRL.

NB.2. SPA for **high threshold (above ≈ 10 MeV) dosimetry reactions**, which may serve to "measure" the unknown high energy part of ^{252}Cf(s.f.) and ^{235}U(n_{th},f) spectra, will require intensive source and probably new detection techniques (e.g. AMS) alternative to the conventional activation one. For more details see proper information .

1. SPA in Cf-252(s.f.) field

Not Measured yet (26 reactions):

Sc-45(n,γ), Li-6(n,t)He-4, Nb-93(n,γ), Fe-58(n, γ), Ag-109(n, γ), U-235(n, γ), B-10(n,a), U-238(n, γ), W-186(n, γ), **Am-241(n,f), P-31(n,p), Zn-67(n,p), Fe-54(n,α), In-115(n,2n), Pr-141(n,2n), As-75(n,2n), Y-89(n,2n), Cr-52(n,2n), Ti-47(n,np), Na-23(n,2n), Ti-49(n,np), Ti-48(n,np), Fe-54(n,2n), Bi-209(n,3n), Tm-169(n,3n), Co-59(n,3n), ^{117}Sn(n,n')^{117m}Sn**

Outliers (4 reactions):

Co-59(n,γ), Mo-92(n,p), Ni-60(n,p), Ti-46(n,2n)

Large Discrepancies or Uncertainties (2 reactions):

Th-232(n,f), U-238(n,2n)

2. SPA in U-235(n_{th},f) field

Not Measured yet (22 reactions):

Sc-45(n,γ), Nb-93(n,γ), Fe-58(n, γ), Ag-109(n,γ), U-235(n,γ), Ta-181(n,γ), Th-232(n,γ), W-186(n,γ), **Am-241(n,f), In-115(n,2n), Pr-141(n,2n), Cu-65(n,2n), Cr-52(n,2n), Ti-47(n,np), Na-23(n,2n), Ti-49(n,np), Ti-48(n,np), Ti-46(n,2n), Fe-54(n,2n), Bi-209(n,3n), Tm-169(n,3n), Co-59(n,3n), ^{117}Sn(n,n')^{117m}Sn**

Outliers (5 reactions):

Mn-55(n,γ), U-238(n, γ), La-139(n, γ), P-31(n,p), U-238(n,2n)

P.S.: Li-6(n,t)He-4, B-10(n,α)Li-7 are not outliers due to ≈30-20% contribution from (n,n'α) and (n,t2α)

Large Discrepancies or Uncertainties (6 reactions):

Rh-103(n,n'), U-238(n,γ), Cu-63(n,γ), Tm-169(n,2n), Mn-55(n,2n), Ni-58(n,2n)

3. MACS (30 keV) field

Not Measured yet (4 reactions):

Ag-109(n,γ)Ag-110m, Th-232(n,γ)Th-233, U-235(n,γ)U-236, U-238(n,γ)U-239

II. Point–wise cross sections (reaction excitation functions)

1. Low threshold reactions

The new reaction ^{117}Sn(n,n')^{117m}Sn was proposed for inclusion IRDFF by RCM-2:

available measurements for ^{117}Sn(n,n')^{117m}Sn https://www-nds.iaea.org/IRDFFtest/Sn117(n,n)Sn117m.pdf

(no one measurement on plateau so far !)

This dosimeter has been already experimentally tested employing the enriched Tin foil (93% at. ^{117}Sn) in different reactor spectra at CEA (see C. Destouches "Progress of the CEA contribution to IRDFF validation: experimental data and codes", https://www-nds.iaea.org/publications/indc/INDC(NDS)-0682.pdf , p. 29).

However, the microscopic nuclear data for this reaction suffer of lack measurements on plateau (5 - 10 MeV), discrepancies between library evaluations, lack of uncertainties … prevent this reaction to be used.

2. High threshold (n,xn) reactions (point and energy-integrated cross sections)

CRP strives to evaluate and eventually add to the IRDFF library the high threshold reactions with cross section plateaus located between 20 and 100-200 MeV to meet the requirements of the high neutron energy accelerator driven sources such as ADS.

It is known that a set of several reactions of the (n,xn) type on one of isotope do exist which produce residuals suitable for detection in dosimetry applications:

^{89}Y, ^{59}Co, ^{93}Nb. ^{103}Rh, ^{139}La, ^{169}Tm, ^{175}Lu, ^{197}Au, ^{209}Bi.

Due to this, already one foil can serve for the multiple neutron fluence monitoring and spectrum unfolding.

The figures illustrating the status of such reactions:

^{209}Bi(n,3-8n)	https://www-nds.iaea.org/IRDFFtest/Bi(n,xn).pdf
^{89}Y(n,2-4n) & (n,p)	https://www-nds.iaea.org/IRDFFtest/Y89(n,xn).pdf
^{59}Co(n,3-5n)	https://www-nds.iaea.org/IRDFFtest/Co(n,xn).pdf
^{197}Au(n,3-5n)	https://www-nds.iaea.org/IRDFFtest/Au(n,xn).pdf
^{175}Lu(n,2-4n)	https://www-nds.iaea.org/IRDFFtest/Lu(n,xn).pdf
^{169}Tm(n,2-3n)	https://www-nds.iaea.org/IRDFFtest/Tm(n,xn).pdf
^{93}Nb(n,3-4n)	https://www-nds.iaea.org/IRDFFtest/Nb(n,xn).pdf
^{54}Fe(n,2n)	https://www-nds.iaea.org/IRDFFtest/Fe54n2n.pdf
^{139}La(n,4-10n)	*will be prepared ...*
^{103}Rh(n,4-8n)	*will be prepared …*
^{nat}Fe(n,x)^{54}Mn , ^{51}Cr	*will be prepared …*
^{nat}Ti(n,x)^{46}Sc, ^{47}Sc, ^{48}Sc	*will be prepared ..*

See additionally implemented applications and overviews:

F.Maekawa et al.: INDC(JPN)-0185/U, 2000, p.226.

S.Simakov, P.Bem et al.: FED 82(2007)2510, ISRD-13 Reactor Dosimetry State of the Art 2008, p.532,

V.Pronyaev RCM-1 (2013): https://www-nds.iaea.org/IRDFFtest/RCM1/Pronyaev-nxn-high-en-dos.pdf

III. Common Request for experimental UNCERTAINTIES for reactions listed above

The new measurements should make effort **to reach uncertainty 2-5% ($E_{50\%}$ < 15 MeV) or 5-10% ($E_{50\%}$ > 15 MeV)**, as in the best previous experiments.