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Study of concrete activation with IFMIF-like neutron irradiation: status of EAF and TENDL neutron activation cross-sections

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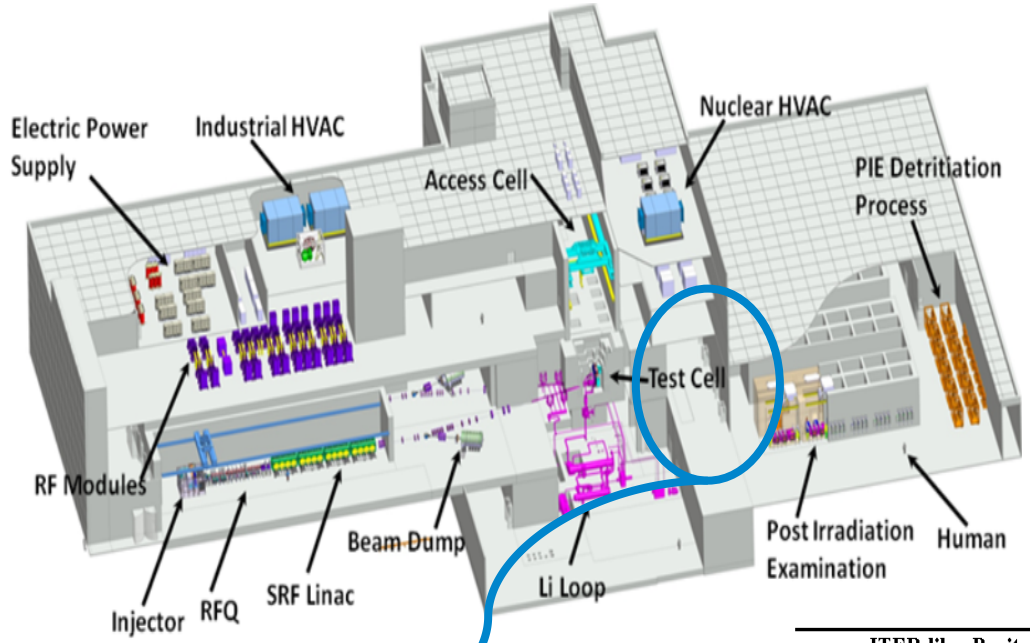
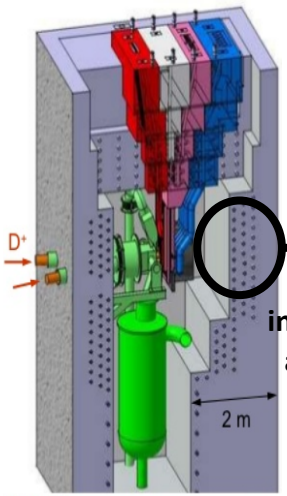
Introduction: Relevance of the work, Methodology and Goals





Location of the concrete slab where the neutron spectra was computed by KIT
(cubic-shaped slab 20 thickness in the direction of the accelerator beam and 50 cm of height, 50 cm of width)

IFMIF nominal irradiation conditions (125 mA of deuteron at 40 MeV) 2 years full power

Detail of the Test Cell

	ITER-like	Barite	Magnetite
H	0,55	0,36	0,31
O	49,75	31,16	33,05
Na	1,71		
Mg	0,26	0,12	0,93
Al	4,69	0,42	2,35
Si	31,47	1,05	2,57
S	0,13	10,79	0,14
K	1,92	4,75	
Ca	8,28	5,02	7,10
Ti			5,43
V			0,31
Cr			0,17
Mn			0,20
Fe	1,24		47,43
Ba		46,34	
Total	100,00	100,00	100,00

Concretes composition in mass fraction (%)

- Reliability of activation-related quantities is essential for design of activities in nuclear facilities like IFMIF.
- We check reliability of some EAF & TENDL activation libraries for estimation of Activity and CDR under neutron irradiation of Test Cell concretes
- 3 different concretes analyzed: ITER-like, barite and magnetite.
- We performed a preliminary quality assessment of most relevant activation cross-sections
- Relevant reactions found as “needed for improvement” are highlighted

Major Radionuclides and Pathways

Reactions		Contribution 1h	1d	12d
ITER-like concrete				
Na23 (n, g)	Na24	X	X	
Si30 (n, g)	Si31	X		
Ca40 (n, a)	Ar37	X	X	X
Ca44 (n, g)	Ca45		X	X
Barite concrete				
Ba130 (n, g)	Ba131	X	X	X
Ba138 (n, g)	Ba139	X		
S32 (n, p)	P32	X	X	X
Magnetite concrete				
Fe54 (n, g)	Fe55	X	X	X
Mn55 (n, g)	Mn56	X		
Fe56 (n,2n)	Fe55	X	X	X
Ca40 (n, a)	Ar37		X	X

Dominant reactions contributing to the activity

X (cross) means relevance (contribution to Activity or CDR higher than 5 %)

This information is independent of the activation library used: EAF2007, EAF2010 or TENDL2014

Reactions		Contribution 1h	1d	12d
ITER-like concrete				
Na23 (n, g)	Na24	X	X	
Na23 (n,2n)	Na22			X
Fe58 (n,g)	Fe59			X
Fe54 (n,p)	Mn54			X
Fe56 (n,2np)	Mn54			X
Barite concrete				
Ba130 (n,g)	Ba131	X	X	X
K41 (n,g)	K42	X	X	
Magnetite concrete				
Mn55 (n,g)	Mn56	X		
Fe56 (n,p)	Mn56	X		
Fe58 (n,g)	Fe59		X	X
Fe54 (n,p)	Mn54		X	X
Fe56 (n,2np)	Mn54		X	X
Al27 (n,a)	Na24		X	
Ti48 (n,p)	Sc48		X	
Mg24 (n,p)	Na24		X	

Dominant reactions contributing to the CDR

Main pathways (contributing to Activity or CDR > 50% at some cooling time sorted by responsible concrete:

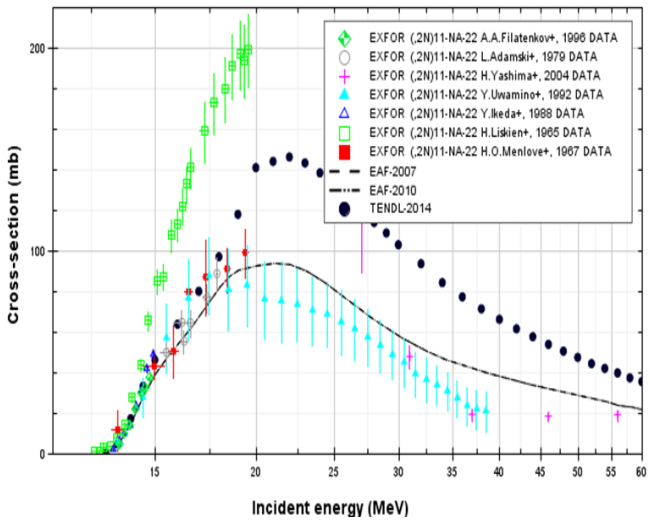
i) $^{23}Na(n,g)^{24}Na$ & $^{23}Na(n,2n)^{22}Na$ (ITER-bioshield concrete)
ii) $^{130}Ba(n,g)^{131}Ba$ (barite concrete)
iii) $^{55}Mn(n,g)^{56}Mn$ & $^{54}Fe(n,g)^{55}Fe$ (magnetite concrete)

Next slide we check quality of XS for this 5 pathways using differential experiments by EXFOR

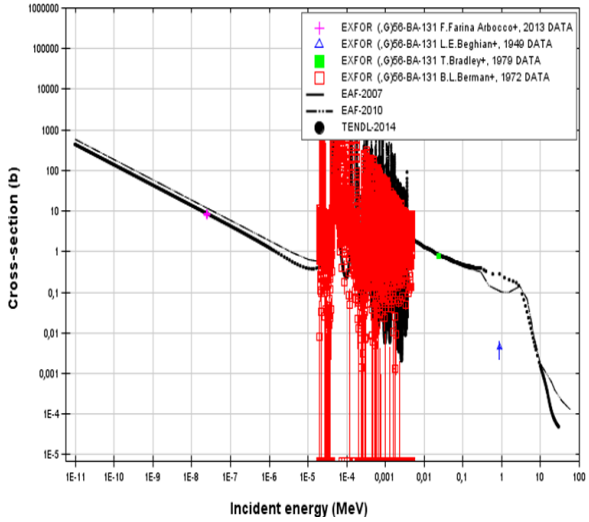
Pathway	Maximum contribution to Activity or CDR at some time (%)
Na23 (n,g) Na24	> 80 %
Ba130 (n,g) Ba131	> 80 %
Na23 (n,2n) Na22	50% - 80 %
Mn55 (n,g) Mn56	50% - 80 %
Fe54 (n,g) Fe55	50% - 80 %
K41 (n,g) K42	20% - 50 %
Ca40 (n,a) Ar37	20% - 50 %
Ca44 (n,g) Ca45	20% - 50 %
Fe54 (n,p) Mn54	20% - 50 %
Fe56 (n,2n) Fe55	20% - 50 %
Fe58 (n,g) Fe59	20% - 50 %
Ba138 (n, g) Ba139	20% - 50 %

Pathways producing radionuclides contributing more than 20% to Activity or CDR at some cooling time

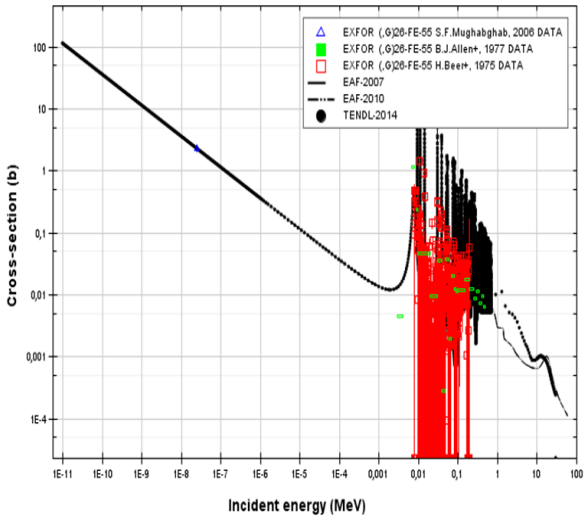
Preliminary quality assessment of major pathways: EAF2007, EAF2010, TENDL2014 vs. differential experiments



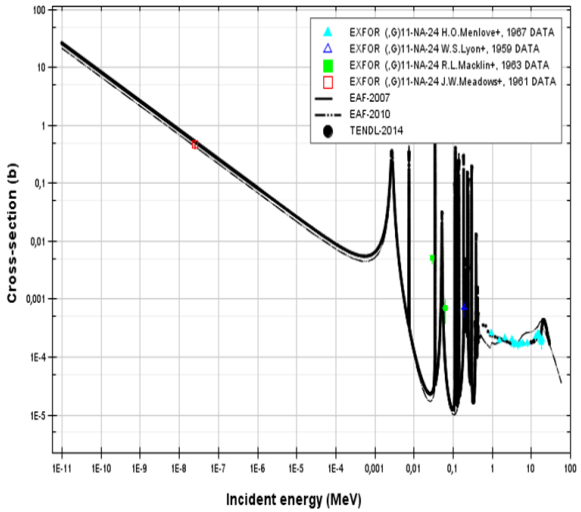
Na23(n,2n)Na22: *Discrepancies EAFs vs TENDL*
Disparity among diff. exp.: need for clarification



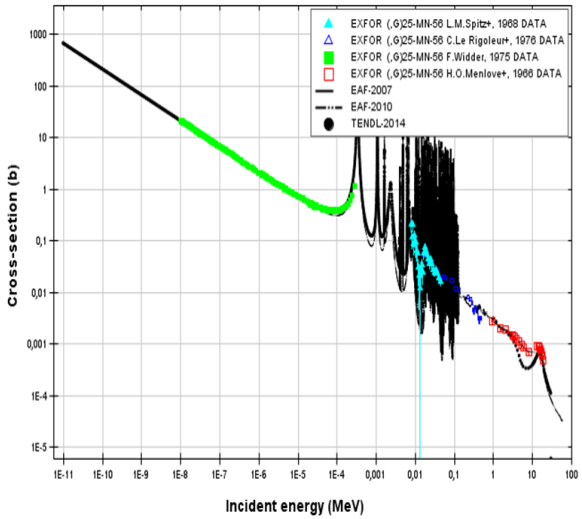
Ba130(n,g)Ba131: *Discrepancies EAFs vs TENDL*
Diff. experiments E>100 keV needed



Fe54(n,g)Fe55: *Needs for E>1 MeV: no diff. exp. at this range*



Na23(n,g)Na24: *Good agreement*
Diff. experiments E>20 MeV useful



Mn55(n,g)Mn56: *Good agreement*
Diff. experiments E>20 MeV useful

CONCLUSIONS

Priority needs for improvement of EAFs and TENDL:

i) $^{23}Na(n,2n)^{22}Na$

ii) $^{130}Ba(n,g)^{131}Ba$

iii) $^{54}Fe(n,g)^{55}Fe$

Remark: TENDL2014 & TENDL2015 (last released version) are identical for these 5 reactions