Agenzia nazionale per le nuove tecnologie,
l'energia e lo sviluppo economico sostenibile

Istituto Nazionale
di Fisica Nucleare
Sezione di Bologna

Proposal for a new evaluation of the Erbium capture cross sections

ENEA, INFN and UNIBO
(*n_TOF collaboration*)

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n_TOF Italian Meeting, 23/11/2020

Motivations (Erbia vs Gadolinia)

- Scientific aspects:

  – Lower thermal absorption cross sections (***Er: 162 b; Gd: 2.5E+05 b***) not downgrade the power distribution;

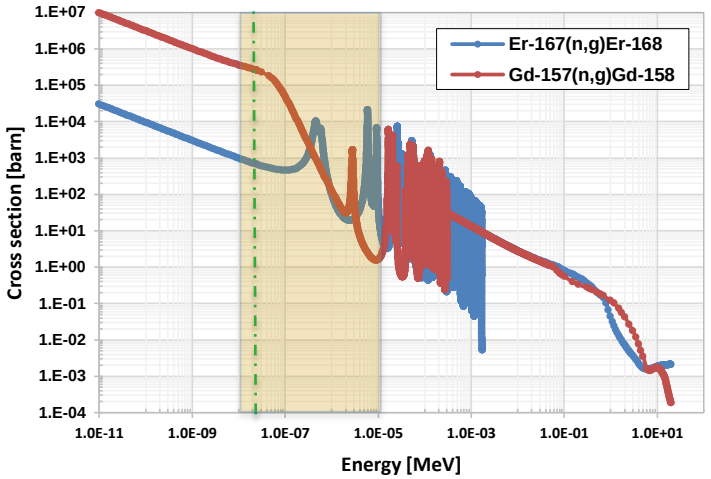
  – More negative temperature feedback coefficient (***α=δk/δT***) higher reactor core safety;

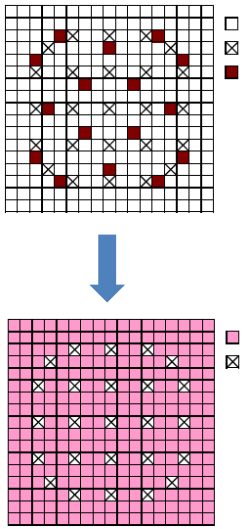
  – Higher and more energy extensive resonance integrals better control of transient phases;

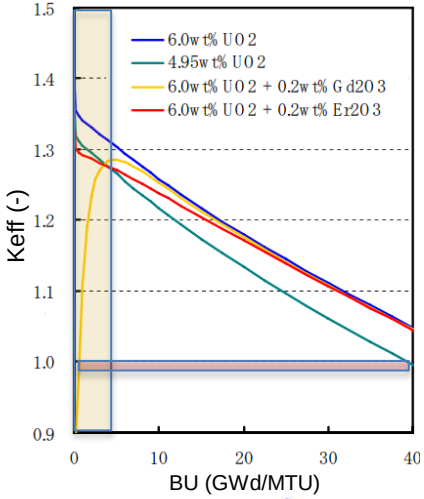
- Nuclear safety and economical aspects:

  – Er-Super High Burnup fuel concept (BU>70 GWd/MTU, erbia>0.2 wt%, U-235> 5 wt%) was adopted in some exp. campaigns:

  - Low content of Erbia is add into all UO2 (>5 wt%) powder just after the re-conversion process;
  - Fuel enrichment is greater than 5 wt% but at BOL is equivalent to 5 wt%;
  - Fuel can be handle with existing fabrication facilities with **an improvement of the criticality safety** and a **reduction of the fuel cost**

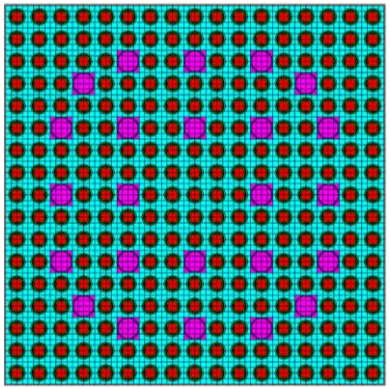






S&U Analysis & Available data

- S&U studies (Er-SHB FA):



Eri(n,g) are one of the major contributors to the uncertainty after U reactions.

Er-167	dk/k (-)	dk(pcm)
	9.25E-04	123(17.8%)

Er-166	dk/k (-)	dk(pcm)
	1.72E-04	23(3.3%)

Er-168	dk/k (-)	dk(pcm)
	8.48E-05	11(1.6%)

Er-170	dk/k (-)	dk(pcm)
	7.01E-05	9 (1.3%)

The overall uncertainty due to Eri(n,g) is equal to **126 pcm** roughly **18.2%** of the overall Xs(n,j) uncertainty contribute (i.e., **688 pcm**).

- Evaluated data (ENDF/B-VII.1):

Er-166	
eV	%
0.5	**7.25**

Er-167	
eV	%
0.5	**2.35**

Er-168	
eV	%
0.5	**12.00**

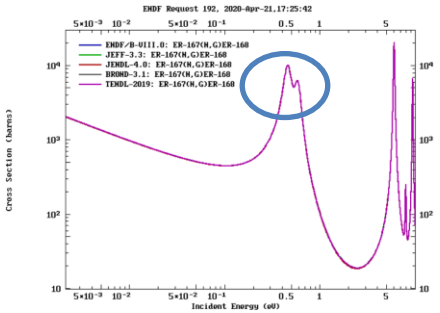
Er-170	
eV	%
0.5	**15.28**

Only one evaluated point in the Xs high sensitivity region, namely **between 0.5 and 5 keV!**

- Exp. data (EXFOR, Er-167):

Age	Data (thrm. point)	Data Error	Data Error	Dev from average
[year]	[b]	[b]	[%]	[%]
1958	620.0	125	20.2	-6.0
1967	699.0	20	2.9	5.9
1968	658.0	30	4.6	-0.3
1998	644.4	2.4	0.4	-2.3
1958-1998	655.4	STD: 33.1 b	**STD: 5.1%**	-

Data with values below of 10% from the average have a **STD major than 5%!**



Only one resonance data used for several Er-167(n,g) evaluation!

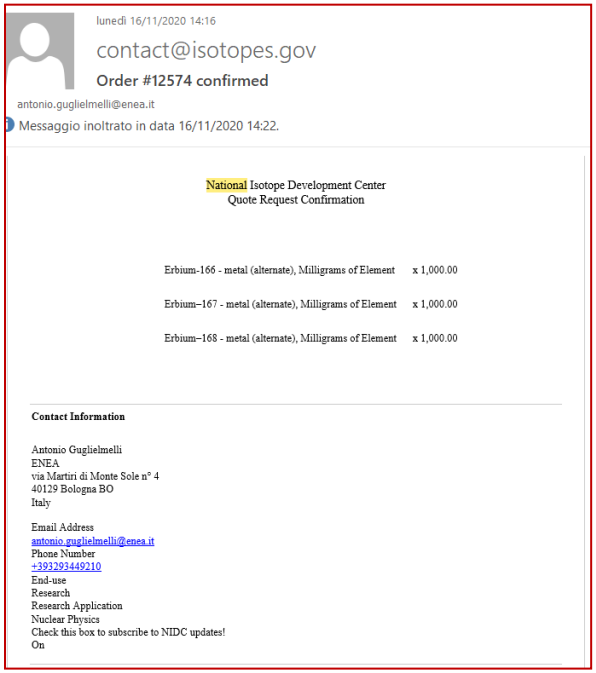
- Resonance parameter (Er-167):

Reference	Γγ (0.46) (meV)	Unc (meV)	gΓn (0.58) (meV)	Unc (meV)
T. Wang et al.	94.72	0.94	0.002	
Danon et al.	87.12	0.16	0.1082	0.0015
Mughabghab	87.12	0.16	0.1082	0.0003
Landolt-Bornstein	88	1	0.12	0.0005
ENDF/B-VII.0	87.12	-	0.1082	0.015
ENDF/B-VII.1	87.12	-	0.1082	-
Average	88.53		0.0925	
STD [%]	**3.45**		**48.20**	

In progress…

- **Proposal:** New measurement of the erbium Xs (at least Er-167 and Er-166) with an overall uncertainty below 3% in the thermal range (0.1 ÷ 100 eV) and new evaluation of the erbium (at least Er-167) resonances in the thermal region.
- **Erbium cost:** Er-166 (95.33%) 4.10 €/mg, Er-167 (91.49%) 4.87 €/mg **[1]**.

- **Check of high-enriched isotopes cost (Er-166, Er-167, Er-168):** Official Request submitted to U.S. National Isotope Development Center (NIDC).
- **Design optimization** of an Er-SHB FA to increase the CRW reduction effect in a Er-doped FA.
- **Timing for the measurements: ?**
- **Manpower: ?**



lunedì 16/11/2020 14:16

contact@isotopes.gov

Order #12574 confirmed

antonio.guglielmelli@enea.it

Messaggio inoltrato in data 16/11/2020 14:22.

National Isotope Development Center
Quote Request Confirmation

Erbium-166 - metal (alternate), Milligrams of Element	x 1,000.00
Erbium-167 - metal (alternate), Milligrams of Element	x 1,000.00
Erbium-168 - metal (alternate), Milligrams of Element	x 1,000.00

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[1] Erbium cost of pure isotopes available on-line from:

https://it.institut-seltene-erden.de/unser-service-2/metall-preise/preise-fuer-stabile-isotope/

Grazie per l'attenzione!

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