Recent Activities of MA Cross-Section Measurements

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High Level Waste (HLW)

Fission Products (FP)

^{99}Tc, ^{129}I, ^{137}Cs, ^{90}Sr, ^{129}I….

Minor Actinides (MA)

^{237}Np, ^{241}Am, ^{243}Am, ^{244}Cm….

↓

Public Acceptability
of Nuclear Power Reactors
Waste Management
Environment

↓

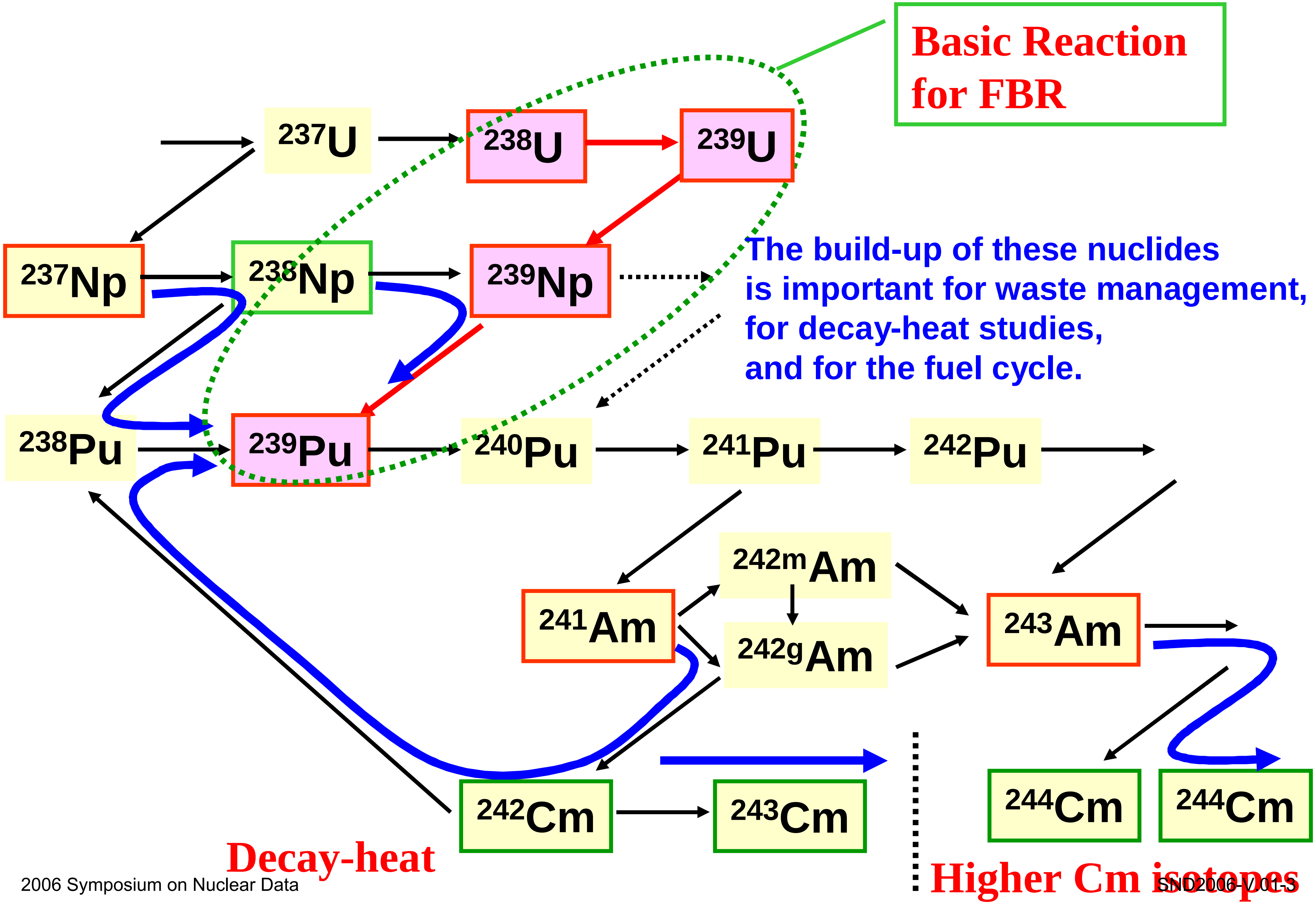
Nuclear Transmutation

Cross Section Measur.

- Activation Method
- Time-Of-Flight
- Prompt γ-rays

……. etc.

Chart of the nuclides



Motivation

^{243}Am → ^{244m,g}Am → ^{244}Cm → ^{245}Cm, ^{246}Cm,…

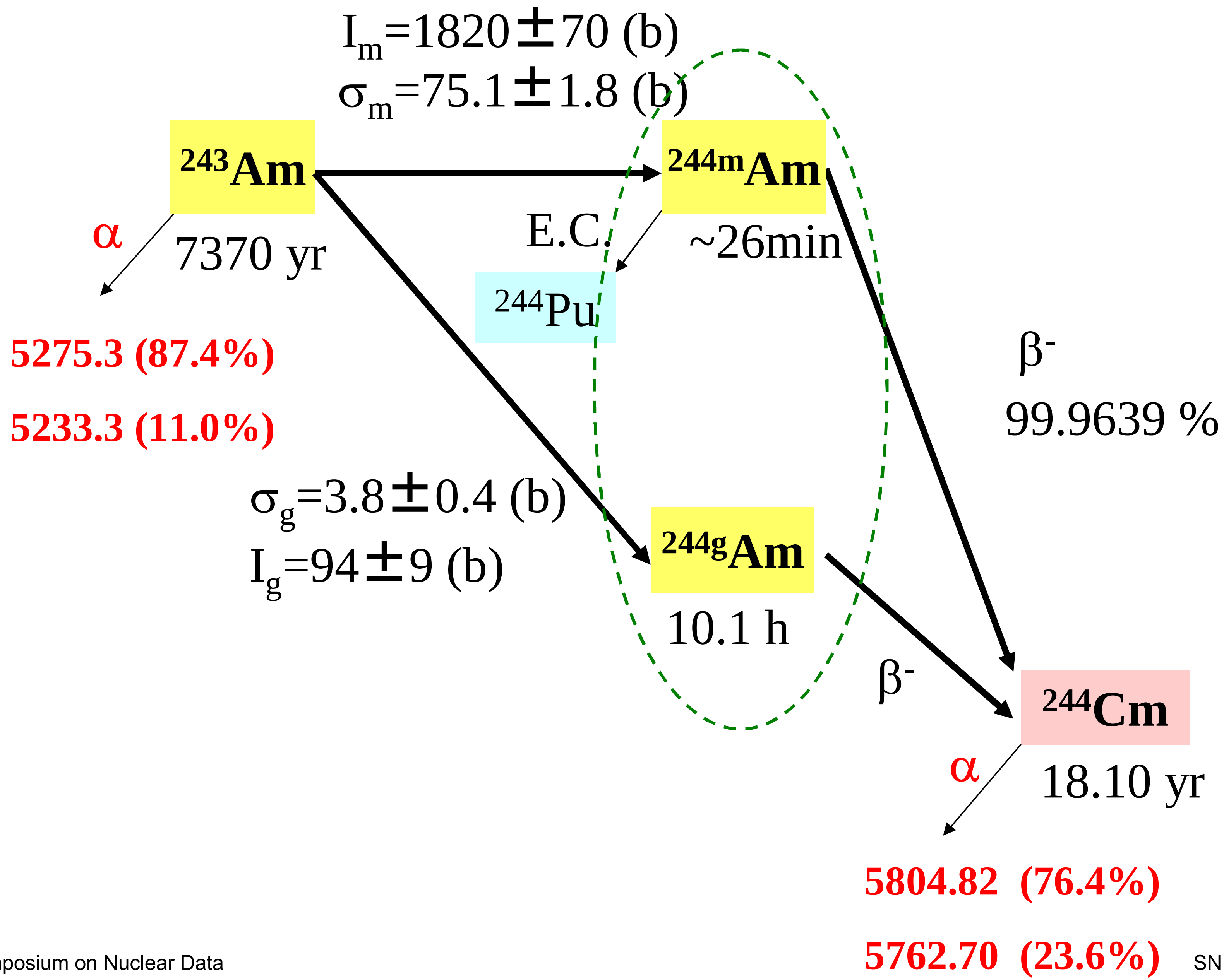
7370yr 18yr 8500yr 4730yr

- Long-half life 7370yr.
- Production of long-lived Cm isotopes
- Discrepancies among the cross section data

～about 10%

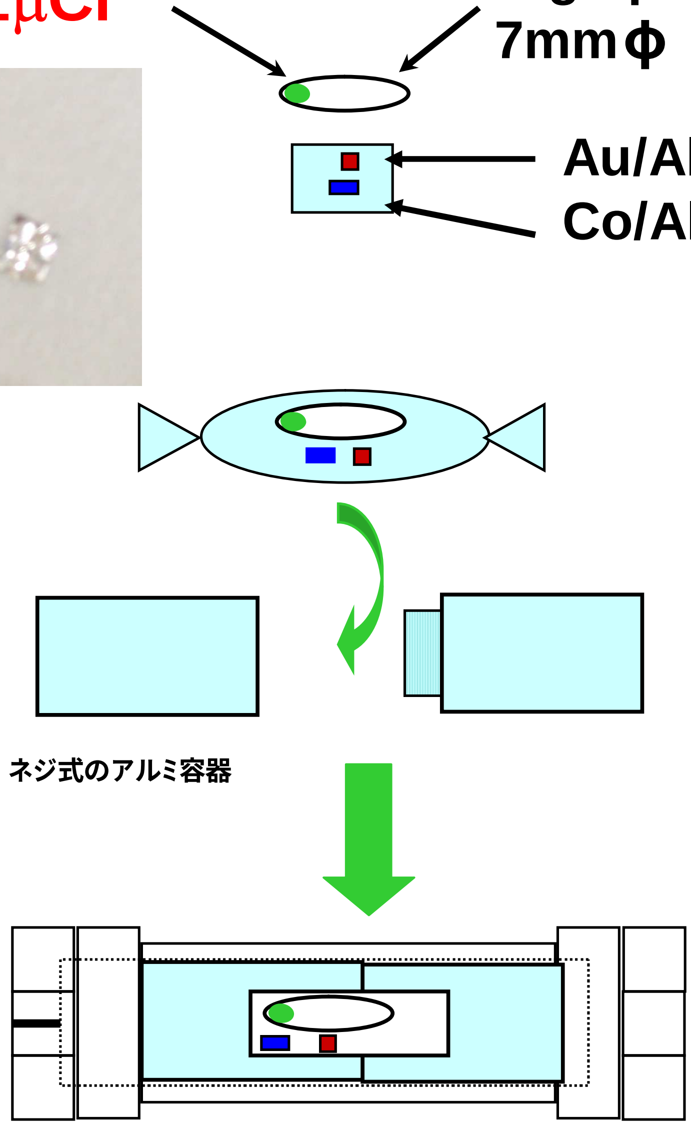
	σ_m(b)	σ_g(b)	σ_{m+g}(b)
JENDL-3.3	ー	ー	76.7
Mughabghab	71.3±1.8	3.8±0.4	75.1±1.8
Letourneau	ー	5.2±1.7	81.8±3.9
Schuman	ー	5.9	ー
Ice	80	4.3	84.3
Street	50	ー	ー

Partial Decay Scheme of ^{243}Am



^{243}Am Sample for irradiation @KUR

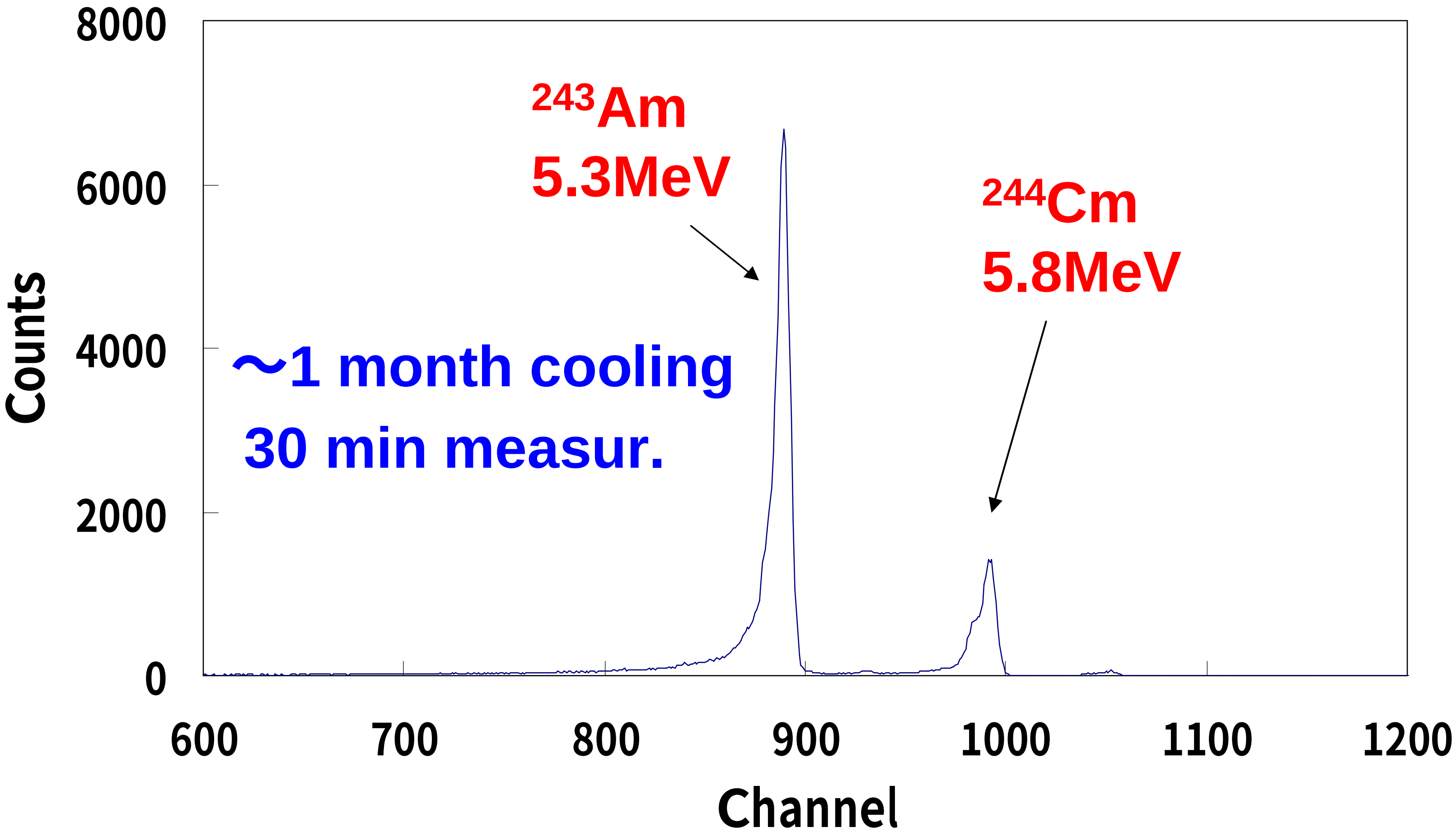
^{243}Am 1μCi



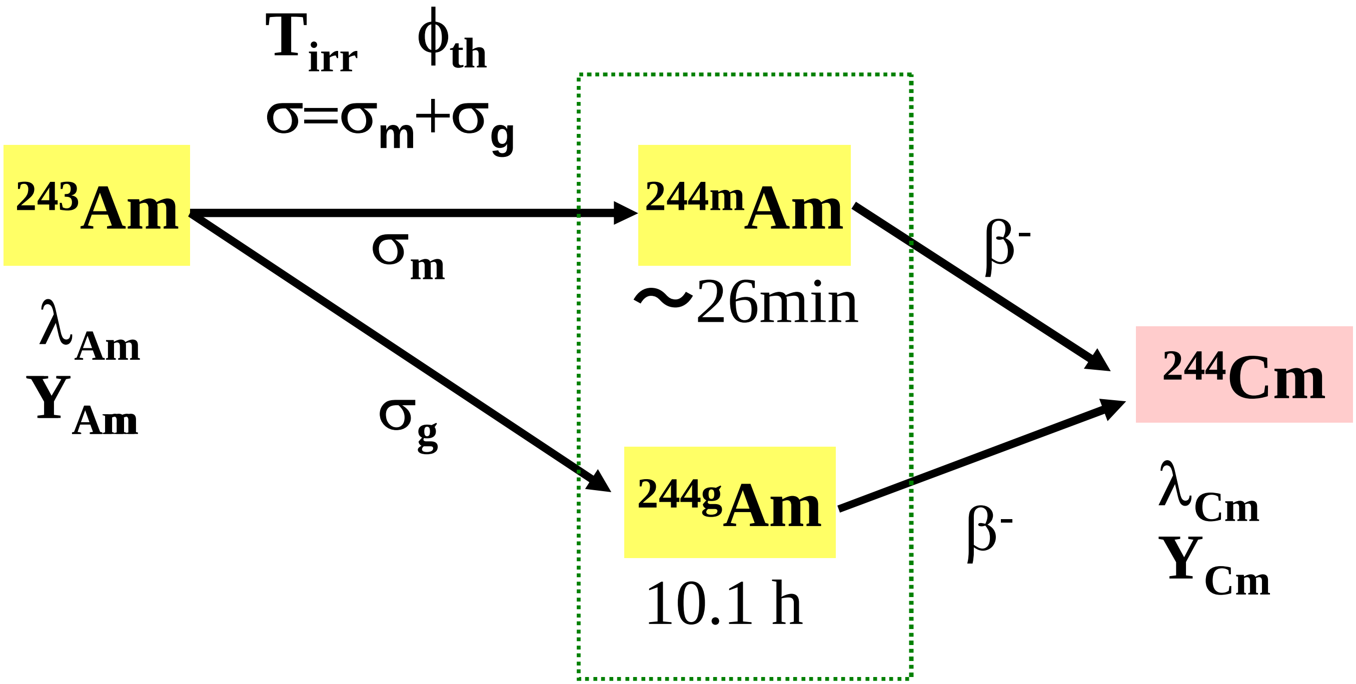
KUR @Hyd.
10H Irrad.

Irradiation capsule for Hyd.

α-ray spectrum of irradiated ^{243}Am sample



Analysis of effective cross-section



Reaction Rate: $$R = \frac{\lambda_{Am}}{\lambda_{Cm}} \cdot \frac{Y_{Cm}}{Y_{Am}} \cdot \frac{1}{T_{irr}}$$

Effective Cross Section: $$\sigma_{eff} = R / \phi_{th}$$

Results of effective cross section for the $^{243}Am(n,\gamma)^{244m+g}Am$ reaction

	$\hat{\sigma}_{m+g}$
This Work*	**174.0±5.3**
JENDL-3.3 (2002)	**150**
Mughabghab (1984)	**158±7**

*M.Ohta *et al*.: J.Nucl.Sci.Technol.,**43**, 1441, (2006).

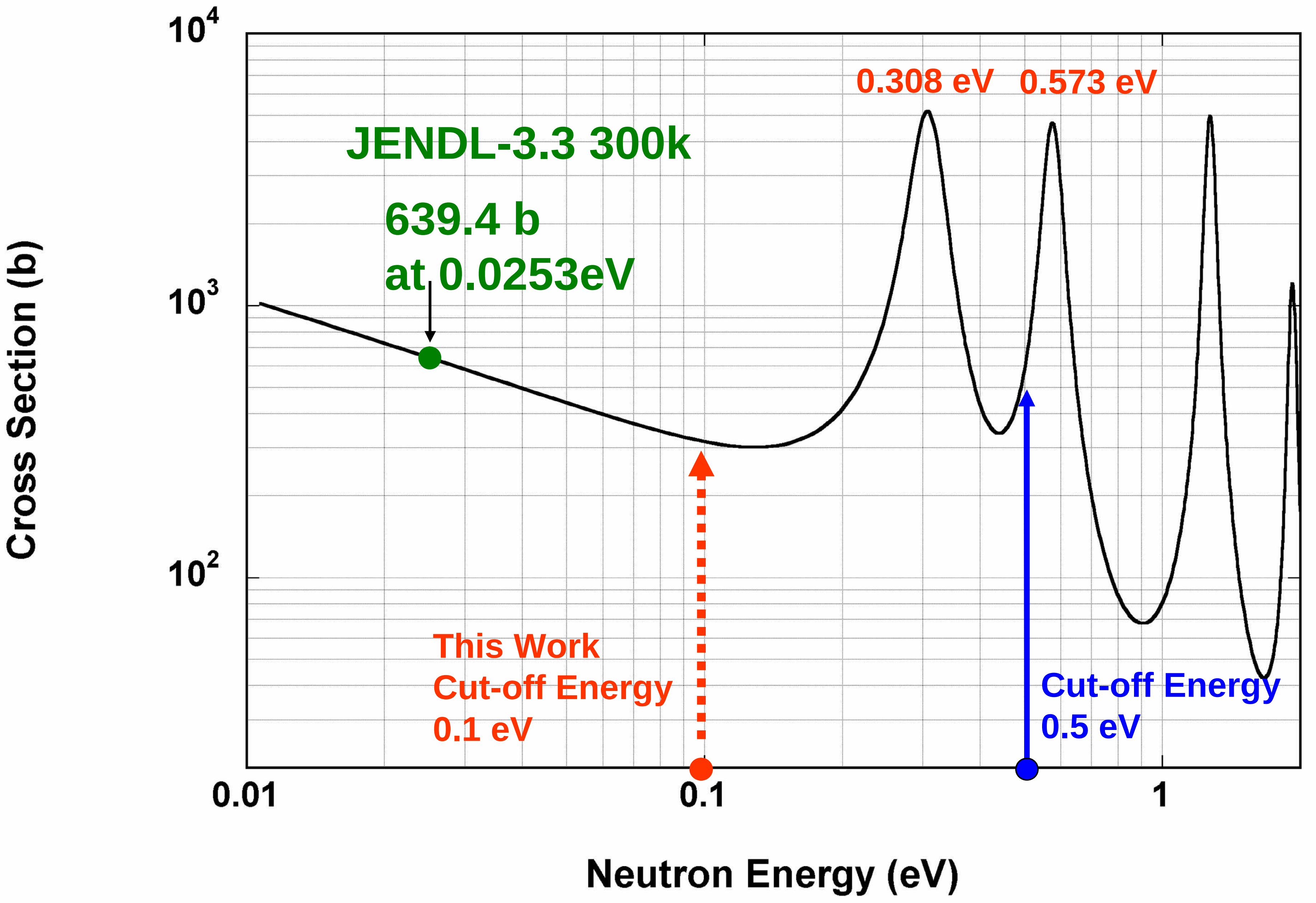
Motivation

^{241}Am → ^{242m,g}Am → ^{242}Cm → ^{238}Pu

- Related to production of ^{239}Pu
- Production of long-lived Cm isotopes
- Problem of decay heat ^{242}Cm (163 day)
- Discrepancies among the reported data: σ_0

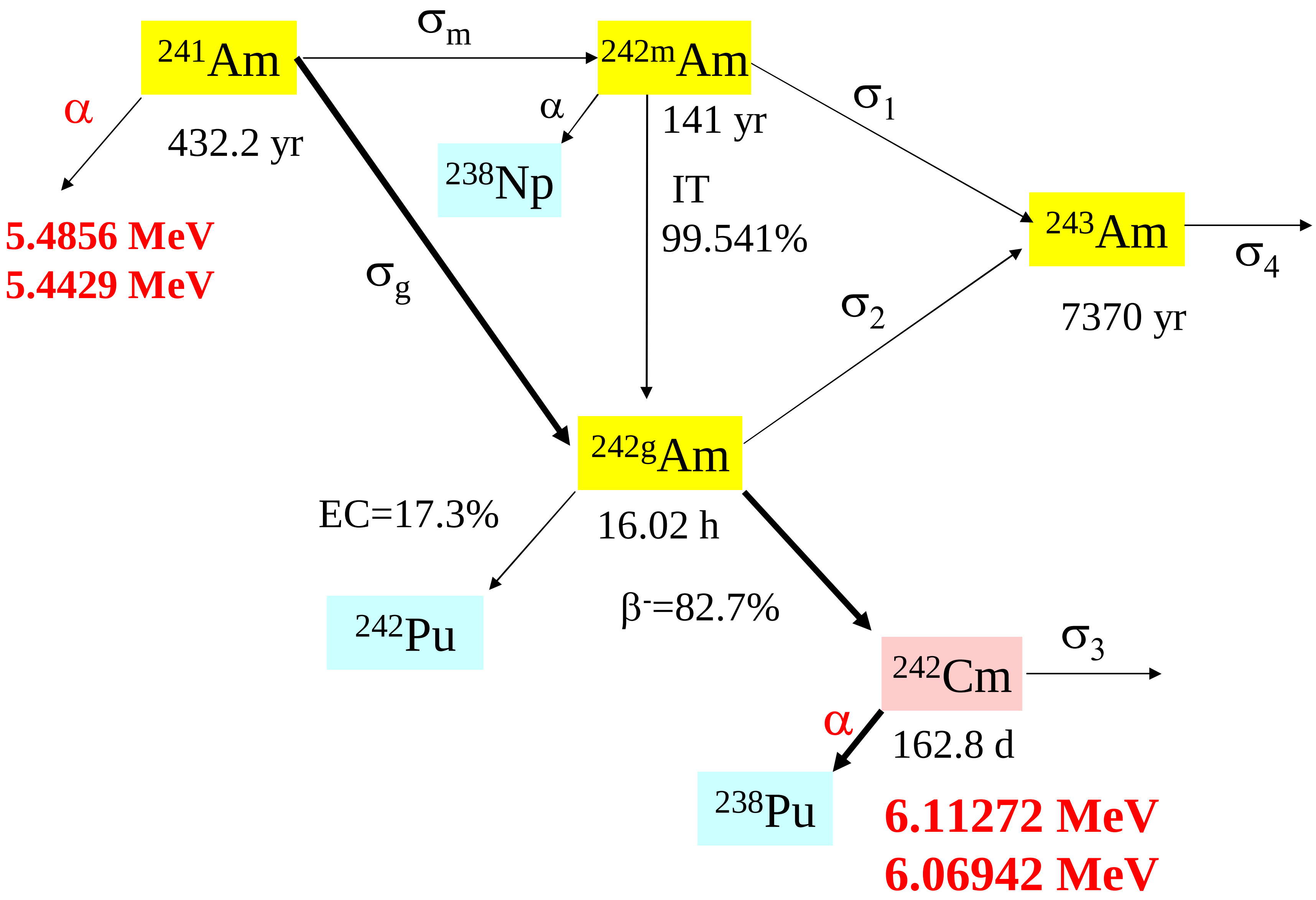
〜more than 20%

Refernces	Year	σ_0 (b)	I_0 (b)
Maidana et al.	(2001)	602±9	1665±91
Fioni et al.	(2001)	636±46	------
Shinohara et al.	(1997)	768±58	1694±146
Gavrulov et al.	(1977)	780±50	------
Harbour et al.	(1973)	748±20	1330±117
Bak et al.	(1967)	670±60	2100
Deal et al.	(1964)	770	------



JENDL-3.3 300k
639.4 b
at 0.0253eV
0.308 eV
0.573 eV
This Work
Cut-off Energy
0.1 eV
Cut-off Energy
0.5 eV
10^4
10^3
10^2
0.01
0.1
1
Cross Section (b)
Neutron Energy (eV)

Partial Decay Scheme of ^{241}Am



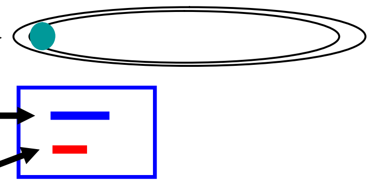
^{241}Am Samples for irradiation @KUR

Am-241 100Bq

2.5μl solution

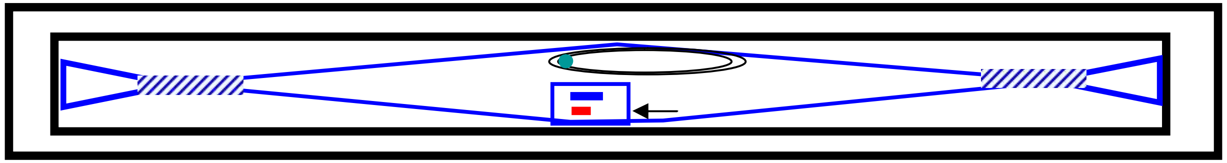
Co/Al 1 mm

Au/Al 0.5 mm



High purity quartz tube
8mmf, 50mm in length

KUR@Long-Irrad. Plug
1week (68H) Irrad.



Two folds of
Al enclosure rods

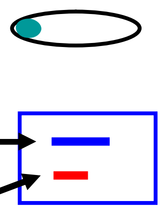
Am-241 500Bq

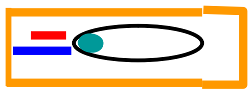
12.5μl solution

Co/Al 1 mm

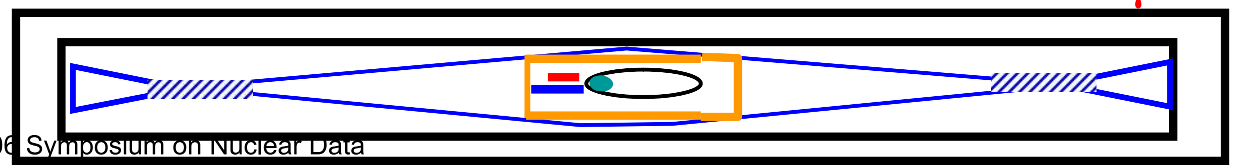
Au/Al 0.5 mm

20mm in length



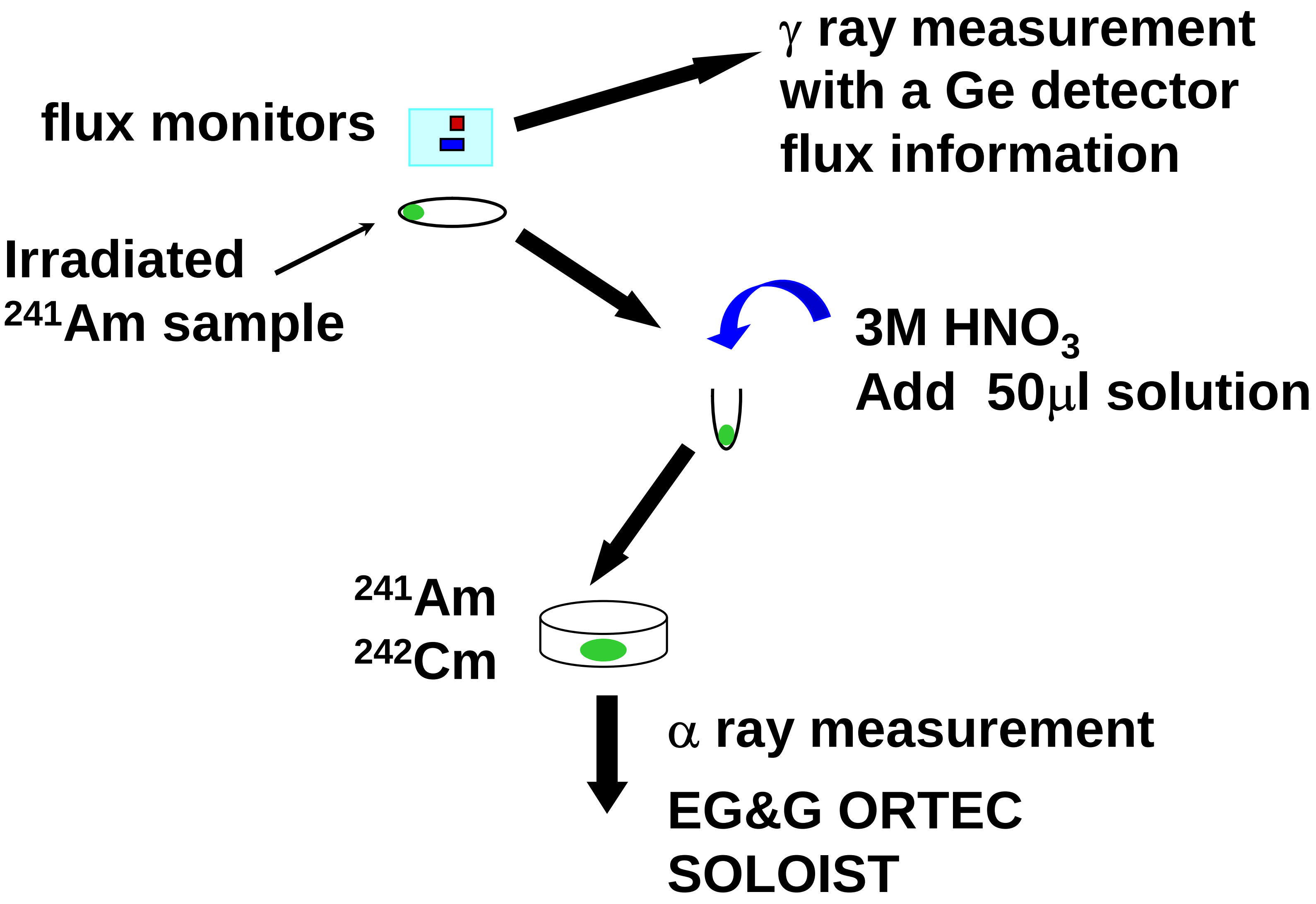


Gadolinium capsule
10mmf, 30mm in length
25μm in thickness

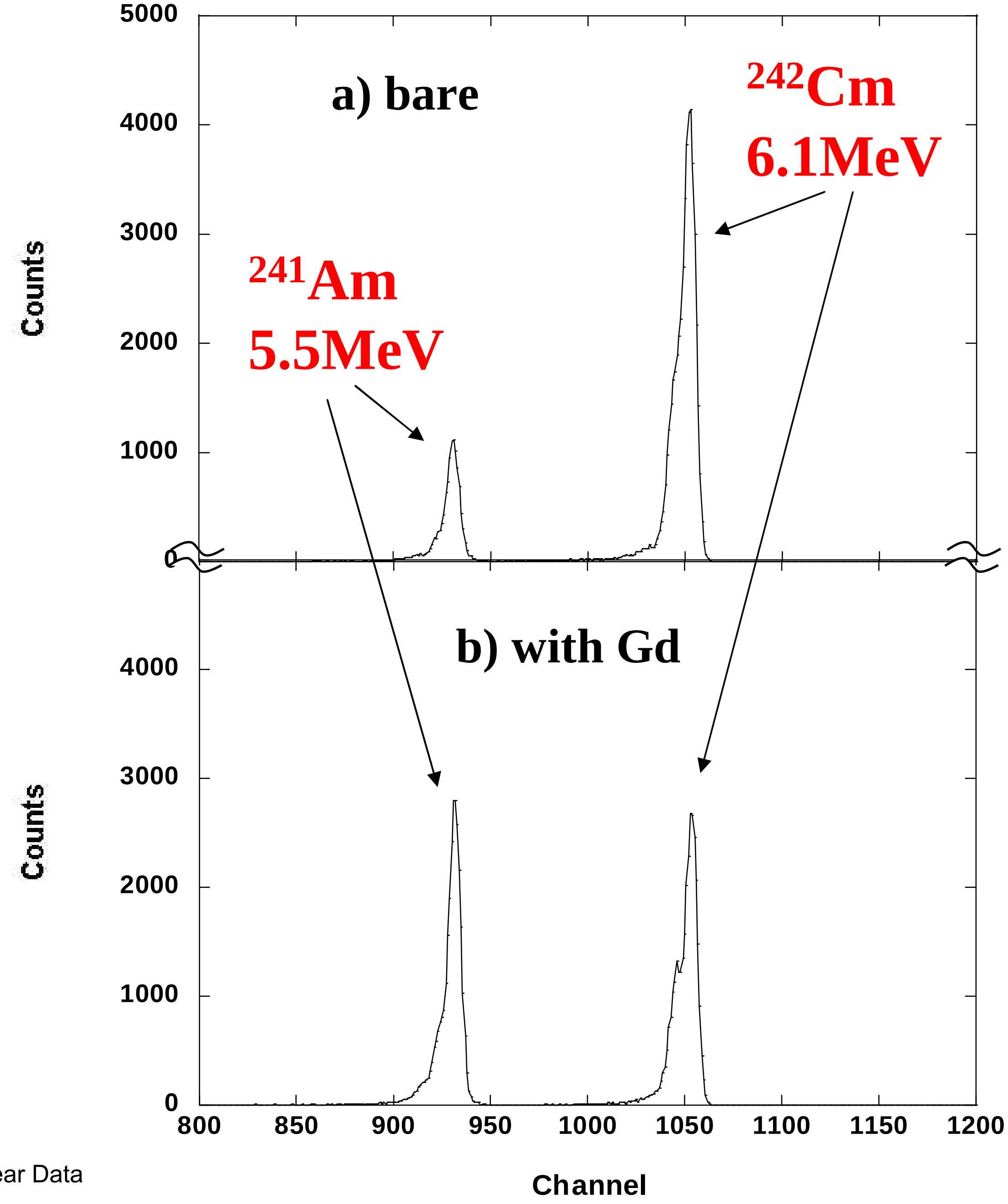


Measurement of sample

20 Days Cooling after Irrad.



α-ray spectrum of irradiated ^{241}Am sample



Modifying the Westcott's convention

$$\frac{R}{\sigma_0} = \phi_1 G_{th} + \phi_2 \cdot s_0 G_{epi}$$

for irradiation without a Cd shield,

$$\frac{R'}{\sigma_0} = \phi'_1 G_{th} + \phi'_2 \cdot s_0 G_{epi}$$

for irradiation with a Cd shield.
where

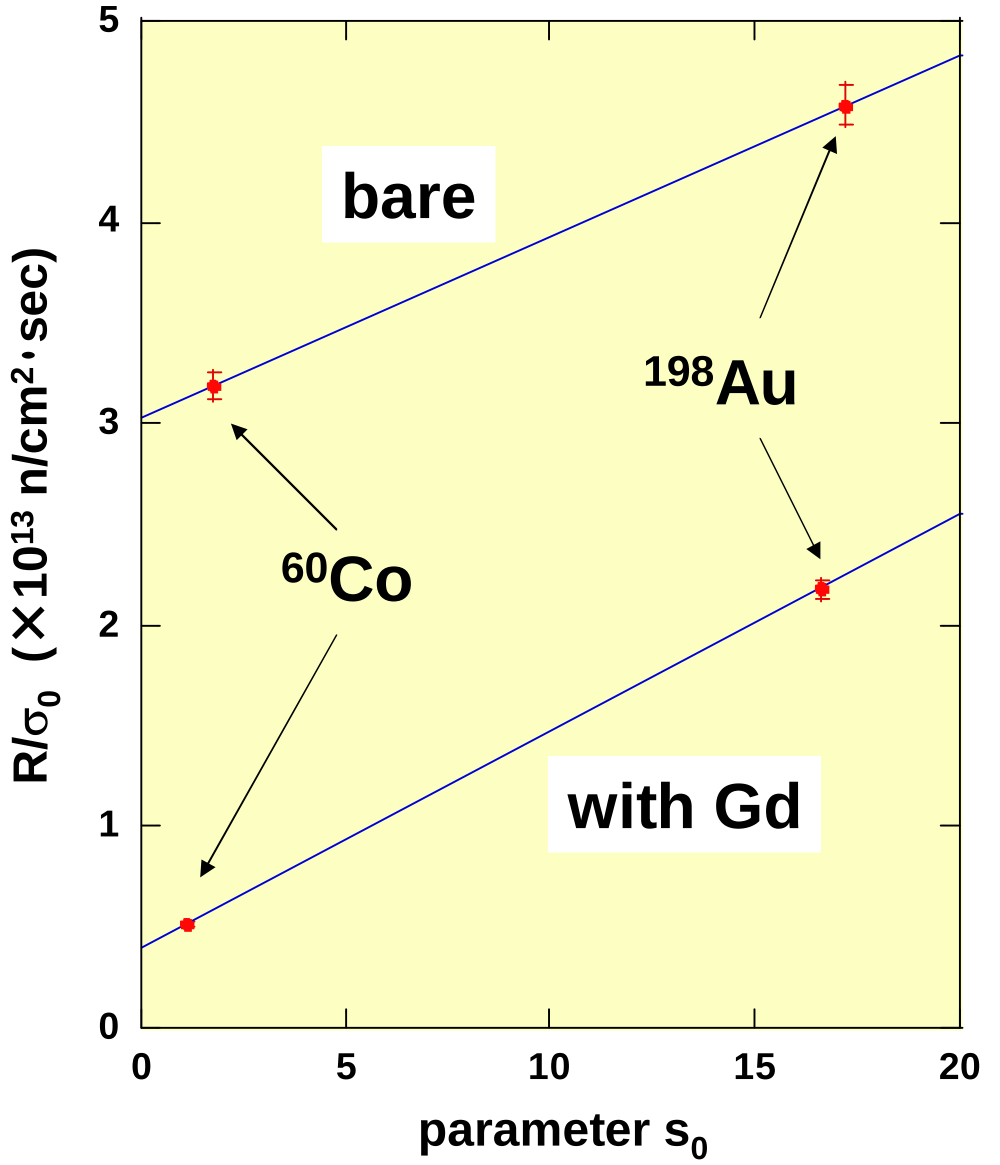
$$s_0 = \sqrt{\frac{4}{\pi}} \cdot \frac{I'_0}{\sigma_0}$$

I_0' is the resonance integral
after subtracting the 1/υ component

Resonance Integral I_0

$$I_0 = I_0' + 1.006\sigma_0$$

for cut-off energy of 0.1 eV



Results of σ_0 and I_0 for the $^{241}Am(n,\gamma)^{242g}Am$ reaction

Tentative !

	σ_0 (b)	I_0 (b)	Cut-off E
This Work	628±22	3.5±0.3 k	0.1eV
JENDL-3.3 (2002)	639.4	1456	
Maidana et al. (2001)	602±9	1665±91	0.5eV
Fioni et al. (2001)	636±46	----	
Shinohara et al(1997)	768±58	1694±146	0.5eV
Gavrulov et al. (1977)	780±50	---	
Harbour et al. (1973)	748±20	1330±117	0.369eV
Bak et al. (1967)	670±60	2100	
Deal et al. (1964)	770	---	

Summary

- $^{241}Am(n,\gamma)^{242g}Am$ **Reaction:**

  σ_{0g} = 628±22(b), I_{0g} = 3.5±0.3(kb) Ec=0.107eV

- $^{243}Am(n,\gamma)^{244m+g}Am$ **Reaction:**

  σ_{eff} = 174.0±5.3(b) in Hyd.@KUR

- **Evaluated data for ^{243}Am is 13% smaller than the present result.**

JAEA's Data for MA Cross-Sections

Nuclide	Half-life	Past Data (Author, Year)	JAEA Data	References
^{237}Np	2.14×10^{6} y	$\sigma_0 = 158 \pm 3$ b $I_0 = 652 \pm 24$ b (Kobayashi 1994)	$\sigma_0 = 141.7 \pm 5.4$ b $I_0 = 862 \pm 51$ b (2003) $\sigma_0 = 169 \pm 6$ b (2006)	Katoh *et al.*, *JNST*, 40(2003) Harada *et al.*, *JNST*,43,No11(2006)
^{238}Np	2.1 d	No Data !	$\sigma_{eff} = 479 \pm 24$ b (2004)	Harada *et al.*, *JNST*, 41(2004)
^{241}Am	432 y	$\sigma_{0g} = 768 \pm 58$ b $I_{0g} = 1694 \pm 146$ b (Shinohara 1997)	$\sigma_{0g} = 628 \pm 22$ b $I_{0g} = 3.5 \pm 0.3$k b	Nakamura *et al.*, *JNST*, to be submitted
^{243}Am	7370 y	$\sigma_{0m} = 80$ b , $\sigma_{0g} = 4.3$ $\sigma_{0m+g} = 84.3$ b (Ice 1966)	$\sigma_{eff} = 174.0 \pm 5.3$ b (2006)	Ohta *et al.*, *JNST,43,No.12*(2006)