Direction de l'Energie Nucléaire

Revised evaluation of the ^{241}Am isotope: summary

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Need for ^{241}Am evaluated data?

- ✓ Fuel inventory (^{241}Am, ^{242m}Am, ^{242}Cm, ^{242}Pu,..)
- ✓ Pu ageing (negative reactivity in MOX pins at start-up)
- ✓ Transmutation

Main idea:

Make a consensus between microscopic (differential and integral) experimental data and validation feedback.

X-sections: Resolved Range

- Fioni, Marie et al.(2001) : (696±48)b
- Maidana et al.(2001) : (672±10)b
- Belanova et al.(1976) : 622 b
- Adamchuck et al.(1955): 600 b

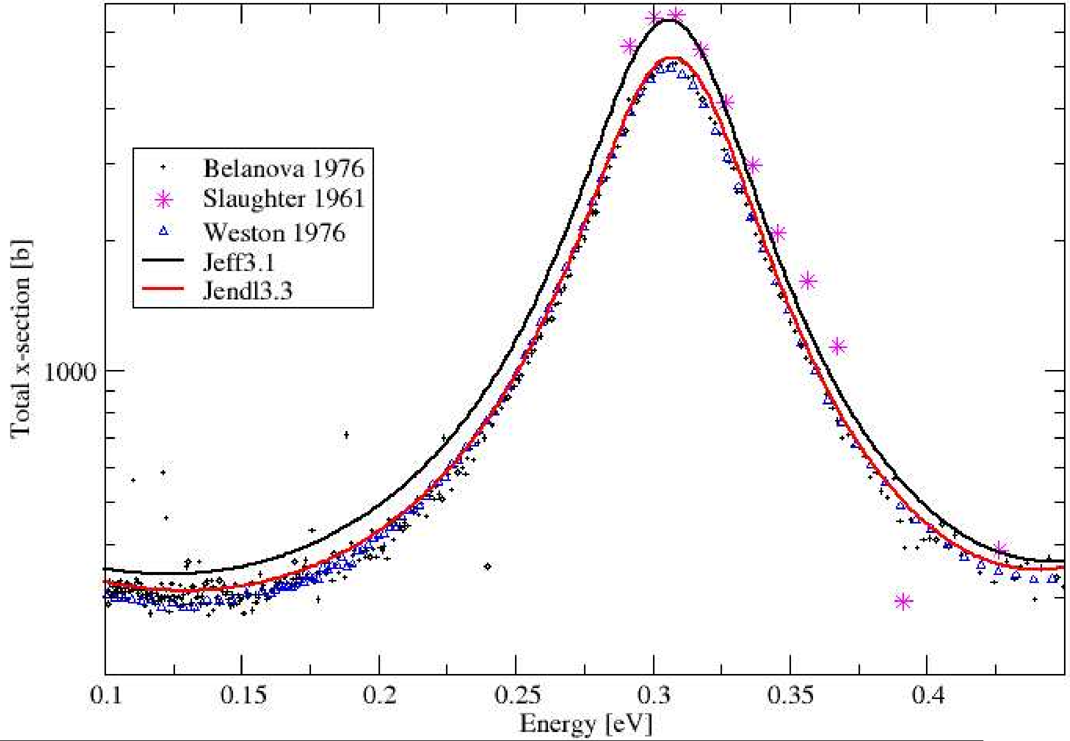
Re-normalisation:
(2 bound levels (J=2⁻ and J=3⁻))

$$\sigma_\gamma^{2200} = 647b \quad \equiv +5\%$$

↗ I_R^{Epi} [0.1-2.2eV] = +15.7%
(based on the P.I.E trend (15±3)%)

[0.15 - 0.45eV] = +22.6%
[0.45 - 0.75eV] = +14.7%
[0.75 - 1.65eV] = -0.3%
[1.65 - 2.2eV] = +7.0%

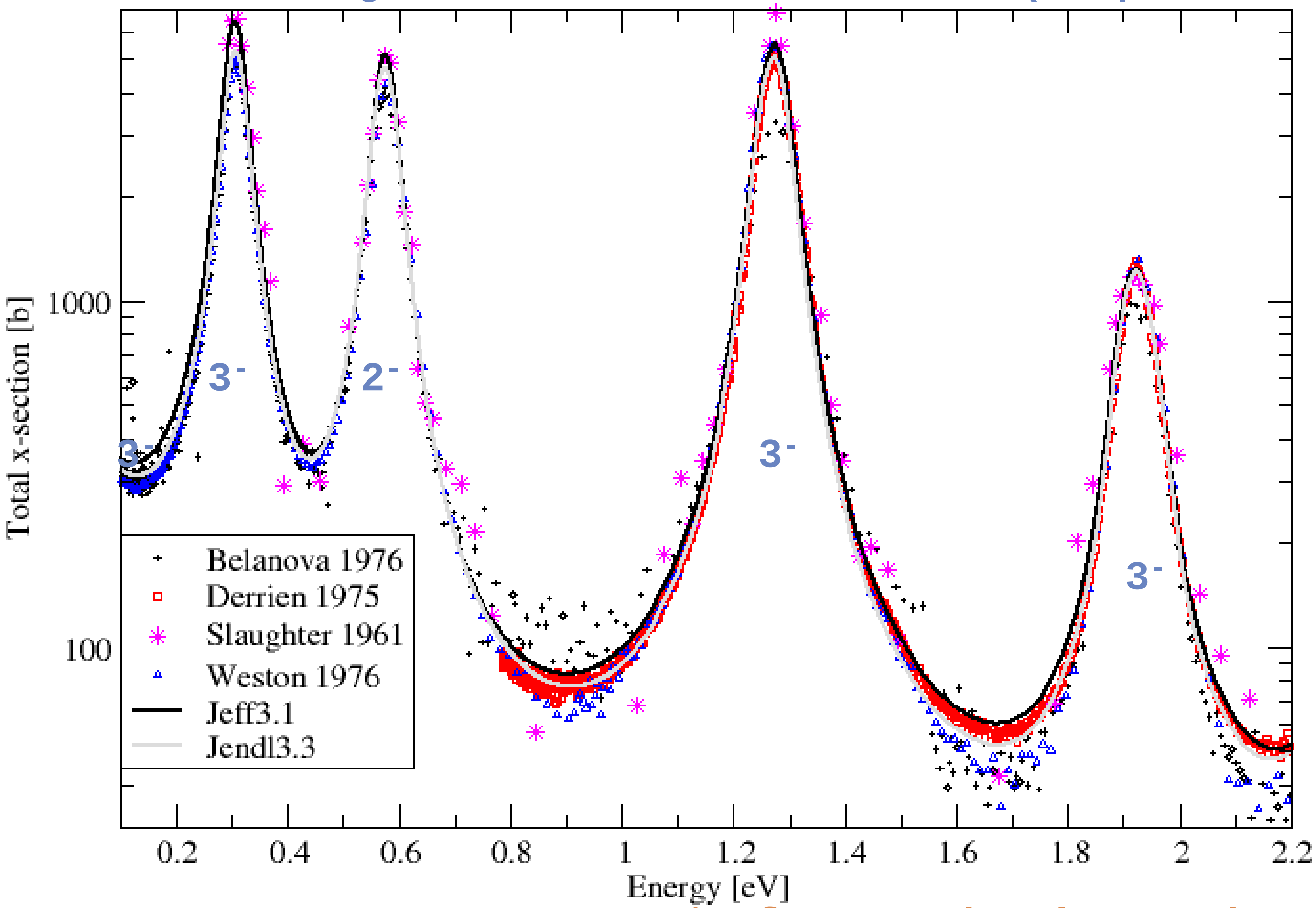
I_R = +5.6%



X-sections: Resolved Range

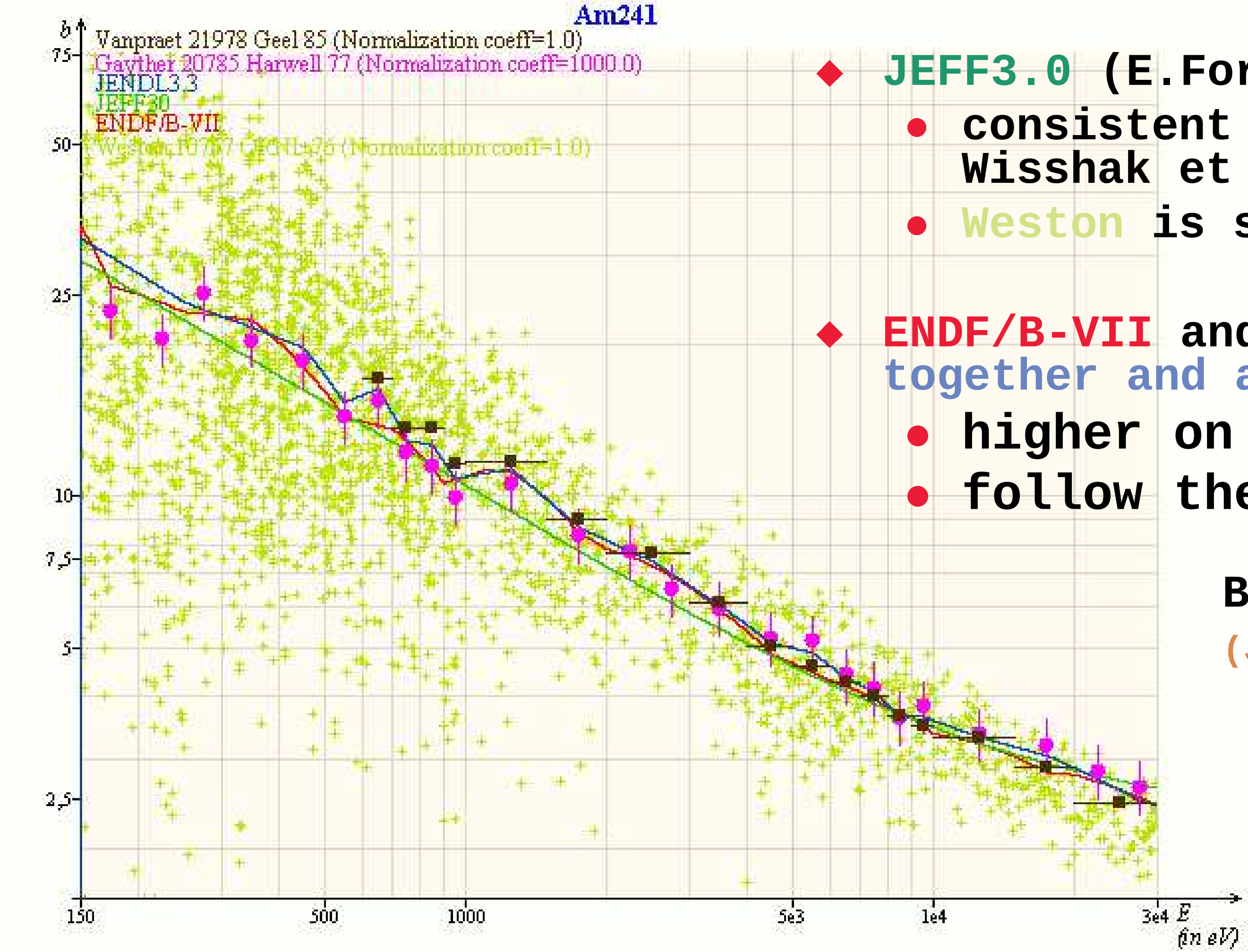
SAMMY fit using a consistent differential data base (energy scale, normalisation, background and spurious data points),

S-wave resonances assigned from statistical laws (2 spins J=2⁻ or 3⁻).



'reference data'= Derrien [0.78eV-1keV]

URR:capture x-section 150 eV ≤ E ≤ 30 keV



- ◆ JEFF3.0 (E.Fort/FISINGA code)
  - consistent with Gayther/Thomas and Wisshak et al. (not drawn),
  - Weston is smaller (10-20%),
- ◆ ENDF/B-VII and JENDL3.3 are close together and are
  - higher on average,
  - follow the fluctuations.

BUT PIE feedback:

(J.Tommasi /PROFIL/150eV-820keV)

half-sensible to this range

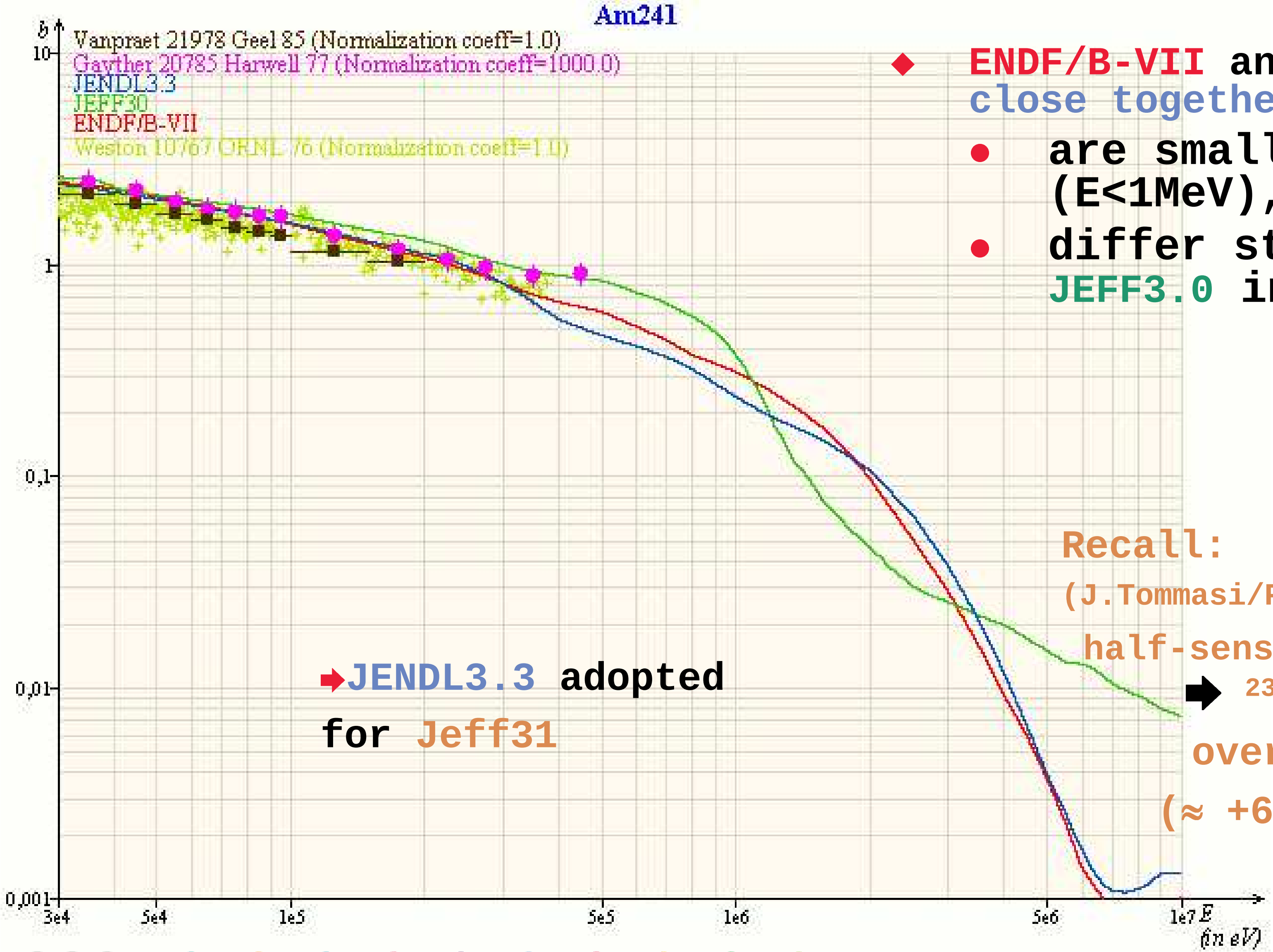
➡ ^{238}Pu build up

over-estimation

(≈ +6% on average)

Jeff31 = { ⇒ Infinitely dilute x-sections: Jeff30
⇒ Self-shielding factors: Jendl33 }

Continuum (E > 30 keV) : capture x-section



- ENDF/B-VII and JENDL3.3 are close together and
  - are smaller than JEFF3.0 (E<1MeV),
  - differ strongly with JEFF3.0 in shape(E>1MeV).

Recall:

(J.Tommasi/PROFIL/150eV-820keV)

half-sensible to this range

➡ ^{238}Pu build up over-estimation

(≈ +6% on average)

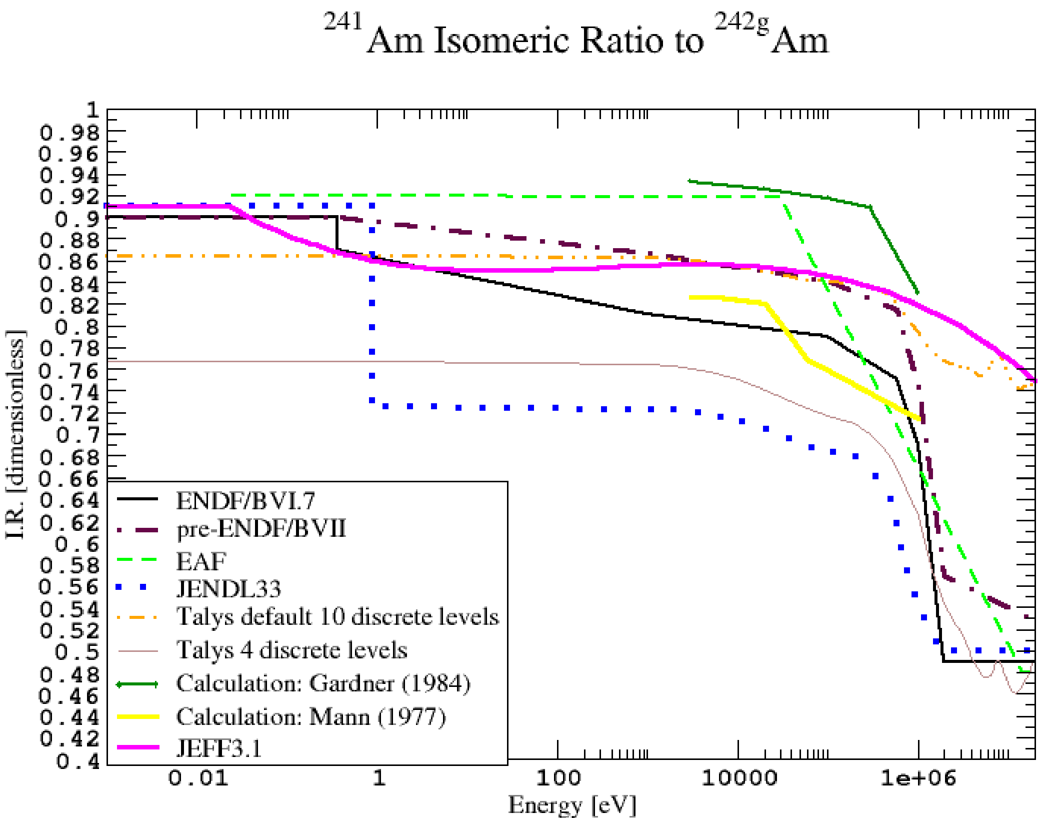
➡JENDL3.3 adopted for Jeff31

Capture Isomeric Ratio (IR)

- Recall: no IR supplied in JEFF3.0 (no 9-102 file),
- JENDL3.3 based on the doubtful measurement of Wisshak(0.65±0.05)at 30keV,
- PIE feedback:
  - Melusine, LWR: 0.86 epithermal range
  - Phenix: 0.85 fast range

⇒ JENDL3.3 is likely wrong,

⇒ ENDF/B-VII and VI.8 can still be improved, in magnitude and/or in energy dependency



⇒ straight forward solution for JEFF3.1: 3 degrees error weighted polynomial fit between all available experimental data

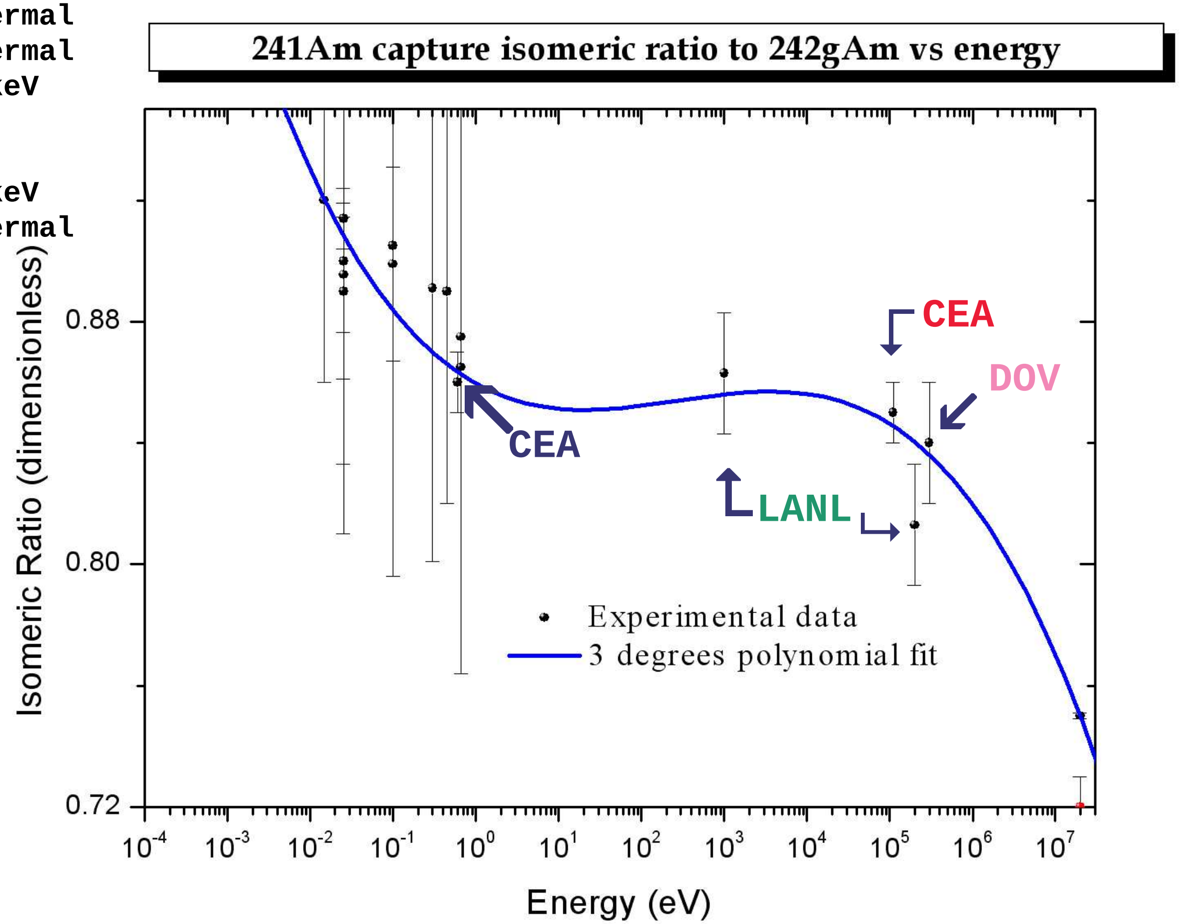
But

✓ Low energy asymptotic value IR=0.91 E<0.022 eV

✓ High energy normalisation IR=0.75 at E=20MeV

IR fit: experimental data base

◆ Wisshak et al.	0.92±0.06	0.01475eV
◆ Shinohara et al.	0.90±0.09	Thermal
◆ Fioni et al.	0.914±0.007	Thermal
◆ Gavrilov et al.	0.914±0.081	Thermal
◆ Maidana et al.	0.8955±0.019*	Thermal
◆ Dovbenko et al.	0.89±0.029	Thermal
◆ Harbour et al.	0.899±0.032	Thermal
◆ Bak et al.	0.905±0.109	Thermal
◆ Ihle et al.	0.891±0.09	Thermal +& Epith.
◆ Shinohara et al.	0.89±0.07	Epithermal
◆ Harbour et al.	0.865±0.101	Epithermal
◆ Bak et al.	0.875±0.111	Epithermal
◆ Dovbenko et al. (DOV)	0.84±0.02	300keV
◆ Tommasi(CEA)	0.85±0.01	110keV
◆ Bernard et al. (CEA)	0.86±0.01	Epithermal
◆ LANL chemistry (LANL)	2 points	Fast



IR variances (40-102 file)

✓ **E<0.022eV**

$$1/Var(\overline{IR}) = \sum_i 1/Var(IR_i)$$

i∈thermal data

✓ **0.022eV < E < 300keV**

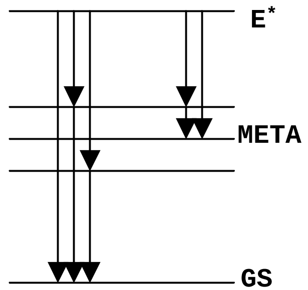
Directly from the fit

✓ **E>300keV**

$$Var_{total} = Var_{Fit0.75} + \left[\frac{(IR_{Fit0.75} - IR_{Fit0.5})}{2}\right]^2$$

Range [eV]	(IR)/IR (^{242g}Am) [%]	(RIC)/RIC (^{242m}Am) [%]
1.E-5 - 0.022	0.69	7.05
0.022 - 0.1	0.42	3.54
0.1 - 0.45	0.49	3.38
0.45 - 0.8	0.58	3.88
0.8 - 1.6	0.64	4.06
1.6 - 2.1	0.68	4.56
2.1 - 150.	0.71	4.08
150. - 4.E+4	0.54	3.15
4.E+4 - 3.E+5	0.51	2.75
3.E+5 - 1.E+6	1.75	8.47
1.E+6 - 2.E+7	11.36	38.77

Isomeric Ratio (IR) Calculations via a Compound Nucleus (CN) process



$$\lambda = \lambda_\gamma + \lambda_e \sim \lambda_\gamma$$

- **γ-cascade stories calculated using GDR model,**
- **Electric and Magnetic transitions (E1,E2,M1,M2)owing to spin-parity selection rules,**
- **First 89 low lying levels of $^{242}Am^*$ are considered.**

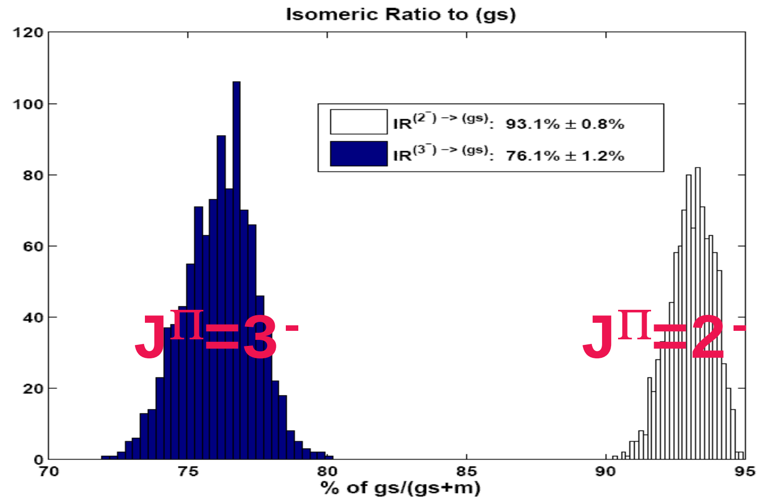
$$BR \equiv \frac{\sigma_{CN}(^{242}Am^*)\left|\left\langle ^{242m}Am \left| T \right| ^{242}Am^* \right\rangle\right|^2}{\sigma_{CN}(^{242}Am^*)\left|\left\langle ^{242gs}Am \left| T \right| ^{242}Am^* \right\rangle\right|^2}$$

and

$$IR = 100 * \left(\frac{gs}{gs+m}\right) = 100 * \left(\frac{1}{1+BR}\right)$$

The Branching Ratio (BR) depends on

- **the spin-parity of the excited level (^{241}Am+n resonance),**
- **the spin-parity values of the low lying levels.**



Beyond JEFF3.1: IR proposal for a given set of (^{241}Am+n) resonance spins