JEFF-3.2β pre-qualification: ^{9i}Zr and ^{16}O neutron cross-sections improvements

D. BERNARD
david.bernard@cea.fr

A. SANTAMARINA
alain.santamarina@cea.fr

P. LECONTE
pierre.leconte@cea.fr

R. LE TELLIER
romain.letellier@cea.fr

G. NOGUERE
gilles.noguere@cea.fr

M. COSTE-DELCLAUX
mireille.coste-delclaux@cea.fr

S. MENGELLE
stephane.mengelle@cea.fr

C. JOUANNE
cedric.jouanne@cea.fr

NEA Headquarters, Issy-Les-Moulineaux JEF/EFF Meeting: November 26-28, 2007

Summary:

- Need for a new assemblage of ^{9i}Zr cross-sections
- Need for the ^{16}O(n,α) cross-section improvement
- Preliminary Qualification of these new files
- Conclusion

Needs for $^{90,91,92,94,96}Zr(n,\gamma)$ improvement:

• JEFDOC-1122 (D. Bernard, et al., 2005) underlines the huge increase of the 292eV resonance of ^{91}Zr in JEFF-3.1.

• JEFF-3.1 thermal and integral values for ^{nat}Zr differential cross-sections are out of the uncertainty band regarding to the BNL values (isotopic abundances are very well known).

Ex: $\sigma_{0\gamma}$ →

JEFF-2.2:	183mb
JEFF-3.1:	194mb
BNL2006:	185 ± 3 mb

• Keff underprediction (AREVA-NP and CEA feedback) for whole PWR & BWR cores calculation by about:

$$C\text{-}E \pm \Delta E/E = -500 \pm 350\text{pcm}$$

Needs for $^{16}O(n,\alpha)$ improvement:

• WPEC/Sg22 (A. Courcelle, 2006) on LEU-LWR reactivity prediction showed the importance of $^{16}O(n,\alpha)$ cross-section for reactor applications.

• A $^{16}O(n,\alpha)$ request was sent in July 2005 by A. Courcelle to the High Priority Request List → new experiments performed at IRMM are available (ND2007, #481 G. Giorginnis)

• Keff underprediction (AREVA-NP and CEA feedback) for whole PWR & BWR cores calculation by about:

$$C\text{-}E \pm \Delta E/E = -500 \pm 350\text{pcm}$$

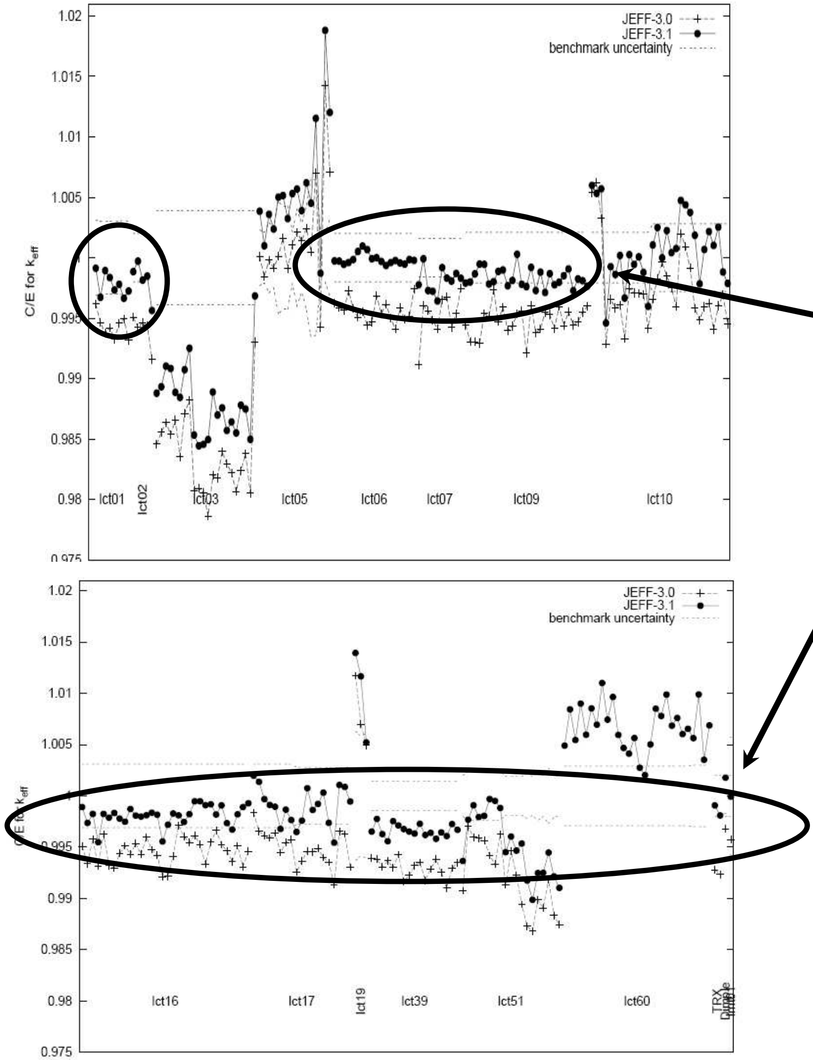
$^{90,91,92,94,96}Zr$ and ^{16}O modifications

See JEFDOC-1208 by G. Noguere for details.

Preliminary Qualification of the JEFF-3.2β $^{91,96}Zr(n,\gamma)$ and $^{16}O\ (n,\alpha)$

1. ICSBEP/LCT Benchmarking
2. LWR-Mock-up Reactors Qualification
3. Whole PWR & BWR Cores Qualification

ICSBEP/LCT: JEFDOC-1107, S. Van Der Marck, MCNP-4C3 calculations



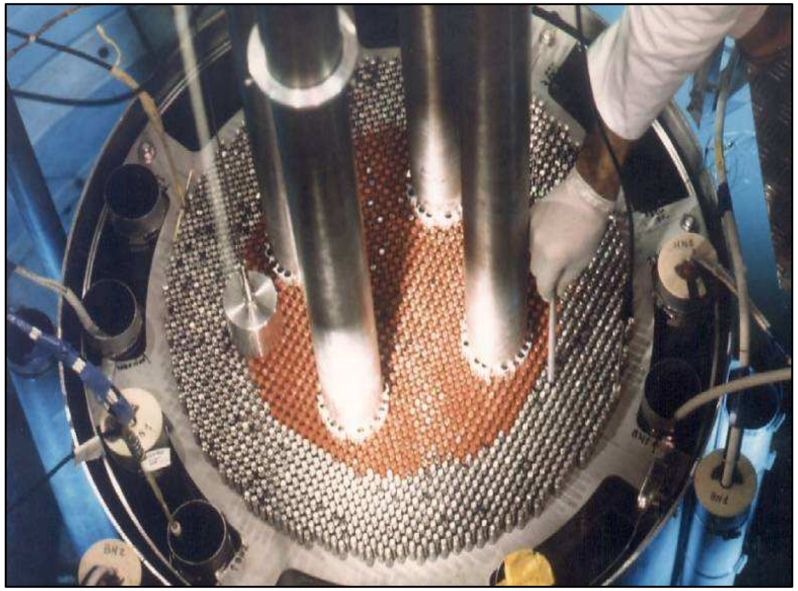
$\langle C/E-1\rangle \pm \Delta E/E \approx -120 \pm 200$pcm

JEFF-3.1 RESULTS

UO_2-LWR-Mock-up Reactor Qualification: JEFDOC-1143, O. Litaize et al., TRIPOLI4 calculations

UH1.2 : C/E-1 $\pm\Delta E/E$ = +225(10) $\pm$ 250pcm

MISTRAL1: C/E-1 $\pm\Delta E/E$ = +140(10) $\pm$ 250pcm



<C/E-1> $\pm\Delta E/E \approx$ +180 $\pm$ 250pcm

JEFF-3.1 RESULTS

JEFF-3.1 RESULTS

Whole PWR & BWR core Qualification:
CEA and AREVA-NP using MCNP or APOLLO2 calculations

	Reactor type	Operating conditions	C/E-1 ±ΔE/E
Saint-Laurent-B1	PWR	HZP-BOC	MCNP: -700(10) ± 350pcm APOLLO2: -600 ± 350pcm
N4-Chooz-B1	PWR	HZP-BOC	APOLLO2: -400 ± 350pcm

PWR

<C/E-1> ±ΔE/E ≈ -500 ± 350pcm

	Reactor type	Operating conditions	C/E-1 ±ΔE/E
Kruemmel	BWR	HFP-BOC	APOLLO2: -420 ± 400pcm
Gundremmingen	BWR	HFP-BOC	APOLLO2: -700 ± 400pcm
Susquehanna	BWR	HFP-BOC	APOLLO2: -200 ± 400pcm

BWR

<C/E-1> ±ΔE/E ≈ -450 ± 400pcm

Impact of Zr(n,γ) and $^{16}O(n,\alpha)$ cross-section modifications for reactor applications:

- the impact of Zr modifications depends on Zr concentration :

  from +40pcm (PWR) to +100pcm(BWR)

- the impact of ^{16}O modifications (MeV region) depends on
  - neutron fission spectrum (^{235}U or ^{239}Pu)
  - the concentration of H_2O (void fraction in BWRs)
  - the neutron leakage (small cores or Power Plant reactors)

  from +50pcm to +120pcm

log(K) in pcm	PWR-UOx 3.7%		PWR-MOx 7%		BWR-UOx 3.14% 0 / 70%TV		Na Cooled FNR-MOx 14% Clad: SS	
	Keff	Kinf	Keff	Kinf	Keff	Kinf	Keff	Kinf
Modif Zr91 & Zr96	+50	+52	+42	+42	+76 / +108	+80 / +111	•	•
Modif O16	+55	+95	+81	+99	+53 / +72	+96 / +96	+97	+117
TOTAL	**+105**	**+147**	**+123**	**+141**	**+129 / +180**	**+176 / +207**	**+97**	**+117**

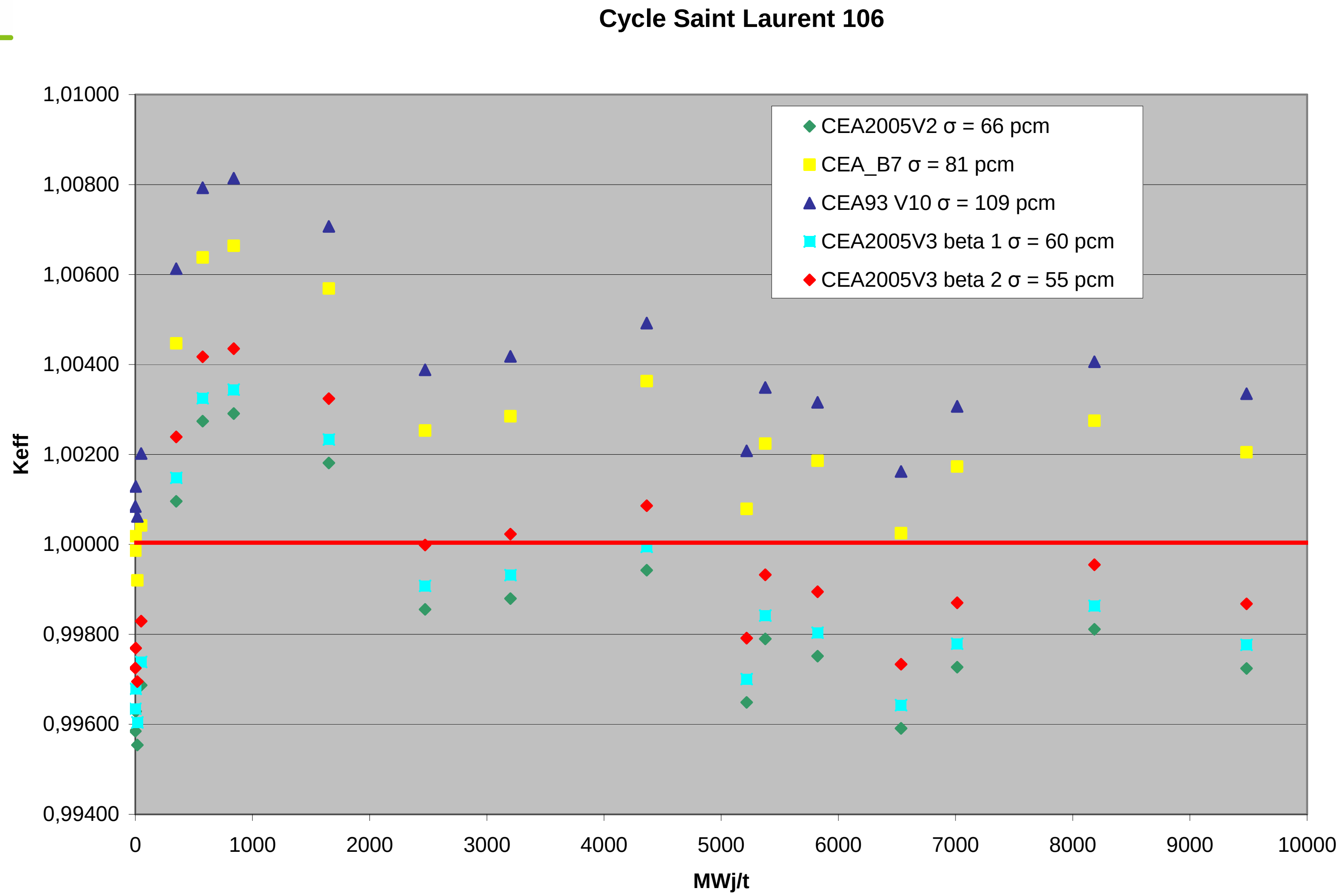
JEFF-3.1 RESULTS

LCT	$\langle C/E-1 \rangle \pm \Delta E/E \approx -120 \pm 200$pcm
Mock-up Cores	$\langle C/E-1 \rangle \pm \Delta E/E \approx +180 \pm 250$pcm
PWR	$\langle C/E-1 \rangle \pm \Delta E/E \approx -500 \pm 350$pcm
BWR	$\langle C/E-1 \rangle \pm \Delta E/E \approx -450 \pm 400$pcm

Preliminary JEFF-3.2β RESULTS

LCT	$\langle C/E-1 \rangle \pm \Delta E/E \approx -70 \pm 200$pcm
Mock-up Cores	$\langle C/E-1 \rangle \pm \Delta E/E \approx +280 \pm 250$pcm
PWR	$\langle C/E-1 \rangle \pm \Delta E/E \approx -350 \pm 350$pcm
BWR	$\langle C/E-1 \rangle \pm \Delta E/E \approx -250 \pm 400$pcm

- Comparisons between ENDF-B7, JEFF-3.1 and JEFF-3.2β
  - SLB core cycle 106 – with depletion
  - Results obtained with APOLLO2.8-CRONOS2.7



- Comparisons between ENDF-B7, JEFF-3.1 and JEFF-3.2β
  - N4 core CHOOZ-B1 (no depletion)
  - Results obtained with TRIPOLI4
    - Δ B7/JEFF-3.1 : +268 pcm
    - Δ B7/JEFF-3.2β : +125 pcm

Conclusion

JEFF-3.2β: ^{9i}Zr and ^{16}O neutron cross-section improvement is shown for reactor applications:

Experimental mock-up are well predicted using JEFF-3.2β (as well as JEFF-3.1)

The pre-qualification of JEFF-3.2β reduces the keff underestimation of PWR & BWR whole cores by about 100 & 200pcm respectively.