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AN ATTEMPT FOR REVISION OF JNDC FP DECAY DATA FILE

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An Attempt for Revision of JNDC FP Decay Data File

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Some improvement of JNDC FP Decay Data File is tried by reexamining the decay scheme for several nuclides, since slight discrepancies are seen in detailed comparison of decay powers. As a results, it is found that the average beta- and gamma-energies should be modified for ^{88}Rb and ^{143}La among the nuclides reexamined in the present study. The JNDC file modified in ^{88}Rb and ^{143}La gives better agreement in most cases with experiments than the original JNDC file for cooling times longer than a few thousands seconds. However, the discrepancy for cooling times from a few hundreds to about 1500 seconds still remains.

Keywords: Decay Heat, Fission Product, Decay Data, Summation Calculation, Average Beta Energy, Average Gamma Energy

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ＪＮＤＣ核分裂生成物崩壊データ・ファイル改訂のための試計算

日本原子力研究所東海研究所シグマ研究委員会
片倉 純一・秋山 雅胤*・吉田 正**
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ＪＮＤＣによる核分裂生成物崩壊データ・ファイル（ＪＮＤＣファイル）を改訂するために，数核種について崩壊形式を検討した。その結果，^{88}Rbと^{143}Laについては，ＪＮＤＣファイルで採用しているベータ線及びガンマ線の平均エネルギーを修正すべきであることが分った。^{88}Rbと^{143}Laの平均エネルギーを修正したファイルを用いた崩壊熱の計算は，数1000秒以降の冷却期間において，実験値により一致するようになった。ただし，数100から1500秒に見られた不一致を改善するには致らず，今後に残された課題である。

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CONTENTS

目　次

1. Introduction

The JNDC FP Decay Data File[1] has been made up in 1981 by working group on evaluation of decay heat of Japanese Nuclear Data Committee, and it has been successfully applied to summation calculations of decay heat from thermal and fast fissions of several fissioning nuclides[2),3)]. The characteristic of this file is the adoption of the theoretical average beta- and gamma-energies for short-lived fission product nuclides with large Q_β-value[4], since the experimental information on decay scheme of these nuclides is generally incomplete. As the result of the use of this file, the excellent agreement between calculated and experimental decay power curves has been achieved.

However, detailed comparison with experimental decay power curves reveals slight discrepancies which seem to be seen in common for most fissioning nuclides. That is, for example, the summation calculation based on the JNDC file underestimates the gamma decay power for cooling times from a few hundreds to about 2000 seconds and overestimates it at longer cooling times than about 2000 seconds. Particularly, the calculated gamma decay power from thermal fission of ^{235}U is about 26% higher than experimental one at cooling times around 5000 seconds if it is compared with ORNL experiment[5], although the situation seems to be considerably amplified in this case.

In order to remove or diminish the discrepancies mentioned above, it may be worthwhile to reexamine the decay scheme for some typical nuclides which have large contribution to the decay power for cooling times between 10^2 and 10^4 seconds. Although it is required to update the various nuclear data included in the JNDC file, the present study is concerned with the only decay scheme, and the complete updating is left over for the moment. In sections 2 and 3, several attempts to improve the agreement are descrived. The results of summation calculations based on modified JNDC file are compared with experimental decay powers in section 4.

2. Reexamination of nuclides with $Q_\beta > 5.0$ MeV

In the JNDC file, the average beta- and gamma-energies ($\bar{E}_\beta$ and $\bar{E}_\gamma$) have been calculated by means of gross theory of beta decay for 87 nuclides with $Q_\beta > 5.0$ MeV although the experimental decay schemes were available apart from their propriety. If the calculated $\bar{E}_\beta$ and $\bar{E}_\gamma$ for these 87 nuclides were replaced by those derived from experimental decay schemes, overestimation of gamma decay power for cooling times longer than a few thousands seconds is reduced by a few to ten percents, but the discrepancies at shorter cooling times becomes, as a matter of cause, quite large. This is shown in Fig. 1 which compares the calculated curves with experimental gamma decay power from fast fission of ^{235}U[3]. This figure suggests that the calculated $\bar{E}_\beta$ and $\bar{E}_\gamma$ values should be kept foı short-lived nuclides, and that some nuclides with relatively long half-life, say $T_{1/2} > 100$s, among the above 87 nuclides should be reexamined to improve the situation at cooling times longer than a few hundreds seconds. The results of summation calculation when the calculated $\bar{E}_\gamma$ values for nuclides with $T_{1/2} < 100$s were used as same as the original JNDC file is also shown by dotted curve in Fig. 1.

In Table I, such nuclides with half-life longer than 100 seconds are listed, and values of $\bar{E}_\beta$ and $\bar{E}_\gamma$ adopted in JNDC file and measured experimentally are compared. The most prominent feature in Table I is seen for ^{88}Rb and ^{116}Ag, i.e., the ratios of adopted $\bar{E}_\gamma$ to measured $\bar{E}_\gamma$ are 3.919 for ^{88}Rb and 3.259 for ^{116}Ag (or, ratios of adopted $\bar{E}_\beta$ to measured $\bar{E}_\beta$ are 0.571 and 0.513 for ^{88}Rb and ^{116}Ag, respectively). Therefore, these two are considered to be the first candidate for nuclides to be reexamined.

Table II shows the value of Q_β, energy of the highest level fed by beta-decay (E_L), and the ratio E_L/Q_β for nuclides listed in Table I.

The value of E_L/Q_β offers a measure for the missing of highly excited states in the daughter nuclide which causes underestimation of $\bar{E}_\gamma$ (or overestimation of $\bar{E}_\beta$). The ratio E_L/Q_β of 0.513 for ^{116}Ag, as seen in Table II, suggests that many highly excited states must be missed in the decay scheme proposed from experimental information. This seems to be reflected in the ratio, adopted $\bar{E}_\gamma$/measured $\bar{E}_\gamma$, of 3.259 (or adopted $\bar{E}_\beta$/measured $\bar{E}_\beta$ is 0.513) in Table I. Therefore, adoption of the calculated $\bar{E}_\gamma$ ($\bar{E}_\beta$) instead of the experimental one is rather reasonable in the case of ^{116}Ag.

Recently, Nuclear Data Sheets[10)] and also ENSDF[11)] (Evaluated Nuclear Structure Data File) refer the experimental data by W. Bruchle (referred as private communication in Nuclear Data Sheets). According to this data, $\bar{E}_\gamma$ and $\bar{E}_\beta$ are 2.107 and 1.591 (or, the ratios of adopted to measured values are 1.341 for $\bar{E}_\gamma$ and 0.878 for $\bar{E}_\beta$). The value of E_L/Q_β becomes, in this case, 0.642. After this fact, our discussion is considered to be still profitable.

For ^{88}Rb, the ratio E_L/Q_β is 0.914 and many excited levels of ^{88}Sr are found in ^{88}Rb decay. In such a case, the experimental information is considered to be fairly reliable, and uncritical replacement of experimental $\bar{E}_\gamma$ (or $\bar{E}_\beta$) by the calculated one may be questionable. According to the experiments on ^{88}Rb decay, the intensity of beta-transition to the ground state of ^{88}Sr has been directly measured as 78%. Therefore the intensities of gamma-rays and thus the average gamma-energy $\bar{E}_\gamma$ must be reduced considerably. This also favors the use of the experimental $\bar{E}_\gamma$ and $\bar{E}_\beta$ rather than the calculated values adopted in the JNDC file, taking account of the fact that the ratio of adopted $\bar{E}_\gamma$ to measured $\bar{E}_\gamma$ is 3.919 (or adopted $\bar{E}_\beta$/measured $\bar{E}_\beta$ is 0.571) as is seen in Table I.

Reexamination for other nuclides in Table I or Table II has been made in the same way as the case of ^{88}Rb and ^{116}Ag, but definite decision has not been reached. As trials, however, the results of summation calculations based on the JNDC file with following modifications have been compared with the experimental decay power from fast fission of ^{235}U[3]:

1) Use of measured $\bar{E}_\beta$ and $\bar{E}_\gamma$ for ^{88}Rb.
2) Use of measured $\bar{E}_\beta$ and $\bar{E}_\gamma$ for ^{88}Rb, ^{90m}Rb and ^{90}Rb.
3) Use of measured $\bar{E}_\beta$ and $\bar{E}_\gamma$ for ^{88}Rb, ^{90m}Rb, ^{90}Rb and ^{104}Tc.
4) Use of measured $\bar{E}_\beta$ and $\bar{E}_\gamma$ for ^{88}Rb, ^{90m}Rb, ^{90}Rb, ^{138m}Cs and ^{138}Cs.

These are shown in Figs. 2 - 7. It is clear from these figures that the discrepancy at cooling times longer than about 1000 seconds is considerably diminished by using the measured $\bar{E}_\beta$ and $\bar{E}_\gamma$ for ^{88}Rb, and that further modification is not necessarily effective so far as the only nuclides listed in Table I or Table II are considered.

3. Reexamination of some nuclides with $Q_\beta < 5.0$ MeV

Among several nuclides which have large contribution to the decay power at cooling times around 1000 seconds, ^{93}Sr (Q_β = 3.95 MeV), ^{94}Y (Q_β = 4.882 MeV) and ^{143}La (Q_β = 3.30 MeV) have been reexamined, since the experimental $\overline{E}_\beta$ and $\overline{E}_\gamma$ adopted in the JNDC file for these nuclides disagree considerably with those of ENSDF or ENDF/B-V as seen in Table III. In examining the effect of different adopted values, the gamma-decay power from fast fission of ^{235}U are calculated based on the JNDC file, JNDC file modified in ^{88}Rb as mentioned in the previous section (modified JNDC file), and modified JNDC file replaced by the most different $\overline{E}_\gamma$ value taken from ENSDF or ENDF/B-V.

For ^{93}Sr, the replacement of $\overline{E}_\gamma$ value in modified JNDC file by that of ENSDF improves the discrepancy for cooling times between a few hundreds and 1000 seconds, as shown in Fig. 8. In the experiment on ^{93}Sr decay, however, the original paper[6] adopted by ENSDF has reported 2 excited levels at the energy higher than 3.95 MeV, Q_β of ^{93}Sr by Wapstra and Bos[7], and has proposed a decay scheme assuming Q_β = 4.3 MeV. So, it is not consistent to use the $\overline{E}_\gamma$ value of ENSDF as long as the Q_β value of Wapstra and Bos is adopted. Thus the problem here in ^{93}Sr is substituted by that of Q_β value, i.e., which Q_β should be adopted 3.95 MeV or 4.3 MeV?

Figure 9 shows the apparent improvement of the gamma-decay power for cooling times between a few hundreds and about 1500 seconds by changing $\overline{E}_\gamma$ value of ^{94}Y in modified JNDC file to that of ENSDF. The $\overline{E}_\gamma$ value of ENSDF, however, has been deduced from rather old experimental decay scheme cited in 1973 Nuclear Data Sheets (the ratio E_L/Q_β = 0.730), while modified JNDC file has adopted more recent data (1978) of which E_L/Q_β = 0.957. Therefore, such replacement is not acceptable.

As seen in Table III, the $\overline{E}_\gamma$ value of ^{143}La are considerably scattered among JNDC file, ENDF/B-V and ENSDF. If the smallest $\bar{E}_\gamma$ value adopted in modified JNDC file was replaced by the largest one adopted in ENDF/B-V, the discrepancy in the gamma-decay power for cooling times between a few hundreds and about 1000 seconds is improved by about 3%, as seen in Fig. 10. On the one hand, the value of the JNDC file has been calculated based on the experimental data (1976) cited in the 7-th edition of Table of Isotopes. This experimental information, however, is considered to be not so adequate, since the ratio E_L/Q_β is 0.600 and merely quite a few excited levels in ^{143}Ce have been populated. On the other hand, the value of ENDF/B-V seems to be theoretically estimated one. According to the experimental information, however, the intensity of beta transition to the ground state and/or 18.9 and 42.3 keV levels in ^{143}Ce is about 94%. This must cause considerable reduction in intensities of gamma rays and thus the $\bar{E}_\gamma$ value. In such a case, the theoretical estimation often gives too large value for $\bar{E}_\gamma$, so that the adoption of the $\bar{E}_\gamma$ value in ENDF/B-V is not suitable.

The $\bar{E}_\gamma$ value of ENSDF is based on recent experimental data (1977) supported by the most recent experiment[8)] which has reported many excited levels in ^{143}Ce and the ratio of E_L/Q_β is 0.856. The result of replacement of $\bar{E}_\gamma$ in modified JNDC file by that of ENSDF is also compared in Fig. 10. Although the effect of this replacement is indistinguishable, the use of the experimental information adopted by ENSDF or reported by the most recent paper[8)] is recommended to revision of the JNDC FP Decay Data File.

4. Summation calculatios of decay powers based on modified JNDC file

It is clear from the present study that the original JNDC FP Decay Data File should be revised for ^{88}Rb and ^{143}La at any rate, although reexamination of many other nuclides are left over. In comparing the results of summation calculations with experimental decay powers from thermal fission of ^{235}U and ^{239}Pu[5] and from fast fission of ^{232}Th, ^{233}U, ^{235}U, ^{238}U and ^{239}Pu[3], the JNDC file modified in ^{88}Rb and ^{143}La and the JNDC file modified in only ^{88}Rb are used since latter has been used as version 1.5 of the JNDC file in our previous studies[9]. These are shown in Figs. 11 - 27.

Fast fission of ^{233}U. For beta-decay power (Fig. 11), the agreement between calculated and experimental results is not improved but becomes worse even if modified JNDC file was used, since the calculated curve based on the original JNDC file has been in so good agreement with experiment that no further modification is required. In the case of gamma-decay power (Fig. 12), however, the discrepancy at cooling times longer than a few thousands seconds is largely diminished by the use of the modified JNDC file. As a result, the discrepancy at cooling times longer than a few thousands seconds in total ($\beta+\gamma$) decay power is diminished by 1 - 4%, as seen in Fig. 13.

Fast fission of ^{235}U. Comparisons between calculated and experimental results of beta-, gamma- and total decay powers are shown in Figs. 14, 15 and 16, respectively. Although the agreement is slightly worse ($\sim$1%) at cooling times around 1500 seconds for beta-decay power, the discrepancy at cooling times longer than a few thousands seconds are considerably diminished for beta-, gamma- and total decay powers by the use of the modified JNDC file. In particular, the use of the modified JNDC file is quite effective in gamma-decay power (Fig. 15) at cooling times longer than about 2000 seconds.

Fast fission of ^{239}Pu. Although a little improvement seems to be seen at cooling times around a few thousands seconds in the case of beta-decay power (Fig. 17), the discrepancy at cooling times longer than 10^4 seconds becomes fairly large if the modified JNDC file was used. On the contrary, the calculated gamma-decay power (Fig. 18) based on modified JNDC file reproduces the experimental one fairly well at cooling times longer than a few thousands seconds. The resultant total decay power (Fig. 19) is improved in some degree by the use of the modified JNDC file.

Fast fissions of ^{232}Th and ^{238}U. The experimental results are available on only gamma-decay power for these nuclides. As seen from Fig. 20 (for ^{232}Th) and Fig. 21 (for ^{238}U), the improvement of agreement with experiments is not necessarily achieved by the use of the present modified JNDC file.

Thermal fission of ^{235}U. The use of the modified JNDC file slightly improves the agreement with experiments at cooling times longer than about 1000 seconds in all cases which are shown in Fig. 22 for beta-, in Fig. 23 for gamma- and in Fig. 24 for total decay powers. In the case of gamma-decay power, however, considerably large discrepancy ($\sim$23%) between calculated and experimental results still remains at cooling times around a few thousands seconds. It seems to be difficult to diminish this discrepancy unless other nuclear data such as fission yield are reexamined.

Thermal fission of ^{239}Pu. The calculated decay powers are compared with experimental ones in Fig. 25 for beta-, in Fig. 26 for gamma- and in Fig. 27 for total decay powers. In all cases, the agreement at cooling times longer than a few thousands seconds is improved a little by the use of modified JNDC file.

5. Conclusions

As a result of the present reexamination on decay scheme, it is concluded that the original JNDC FP Decay Data File should be revised at least in ^{88}Rb and ^{143}La, i.e., experimental $\bar{E}_\beta$ and $\bar{E}_\gamma$ should be used instead of calculated ones for ^{88}Rb, and $\bar{E}_\beta$ and $\bar{E}_\gamma$ of the JNDC file should be replaced by those of ENSDF for ^{143}La. The results of summation calculations are fairly affected by the modification of ^{88}Rb data, but are little affected by the replacement of ^{143}La data. Comparison of the calculated decay powers based on the modified JNDC file with those of experiments for several fissioning nuclides shows that the discrepancy at cooling times longer than a few thousands seconds is considerably diminished in most cases, but no improvement is seen for cooling times between a few hundreds and about 1500 seconds. In order to remove or diminish the discrepancy for cooling times from a few hundreds to about 1500 seconds, further reexamination and updating of nuclear data seem to be required.

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Table I Average beta- and gamma-energies for nuclides with Q_β > 5 MeV and $T_{1/2}$ > 100 s

Nuclide	Half Life(s)	$\bar{E}_\beta$ (MeV) JNDC	Experiment	Ratio	$\bar{E}_\gamma$ (MeV) JNDC	Experiment	Ratio
^{68m}Cu	2.25×10^2	0.1970	0.1883	1.046	0.9560	0.9791	0.976
^{74}Ga	4.95×10^2	1.2880	1.0245	1.257	2.4010	3.0479	0.788
^{88}Rb	1.068×10^3	1.1930	2.0911	0.571	2.4940	0.6364	3.919
^{90m}Rb	2.58×10^2	1.5440	1.2888	1.198	2.6660	3.3503	0.796
^{90}Rb	1.53×10^2	1.5710	1.8875	0.832	2.759	2.1641	1.275
^{104}Tc	1.092×10^3	1.2440	1.6758	0.742	2.6780	1.8422	1.454
^{116}Ag	1.608×10^2	1.3970	2.7232*)	0.513	2.8250	0.8668*)	3.259
^{132}Sb	1.68×10^2	1.1970	1.1976	0.999	2.7280	2.5743	1.060
^{138m}Cs	1.74×10^2	0.2800	0.4014	0.698	0.7340	0.5272	1.392
^{138}Cs	1.932×10^3	1.0890	1.2474	0.873	2.6800	2.3314	1.150

*) According to private communication by W. Bruchle (cited as 79BRZT in 81NDS), $\bar{E}_\beta$ = 1.591, $\bar{E}_\gamma$ = 2.107 and the ratios become 0.878 and 1.341, respectively.

Table II The Q_β value and energy of measured highest level in daughter nuclide for nuclides with Q_β > 5 MeV and $T_{1/2}$ > 100 s

Nuclide	Q_β-value (MeV)	Energy of the highest level in daughter (E_L) (MeV)	Ratio of Level Energy to Q_β value (E_L/Q_β)
^{68m}Cu	5.34	3.97	0.743
^{74}Ga	5.40	4.70	0.870
^{88}Rb	5.31	4.85	0.913
^{90m}Rb	6.47	5.83	0.901
^{90}Rb	6.36	5.82	0.915
^{104}Tc	5.62	3.78	0.673
^{116}Ag	6.10	3.13*)	0.513*)
^{132}Sb	5.60	3.30	0.589
^{138m}Cs	5.42	2.42	0.446
^{138}Cs	5.34	4.63	0.867

*) According to private communication by W. Bruchle (cited as 79BRZT in 81NDS), E_L = 3.961 and the ratio becomes 0.642.

Table III Comparison of average bata- and gamma-energy for ^{93}Sr, ^{94}Y and ^{143}La

Nuclide	$\bar{E}_{\beta}$ (MeV)			$\bar{E}_{\gamma}$ (MeV)		
	JNDC	ENDF/B-V	ENSDF	JNDC	ENDF/B-V	ENSDF
^{93}Sr	0.688	0.697	0.666	1.978	1.930	2.214
^{94}Y	1.813	1.798	1.700	0.772	0.772	1.111
^{143}La	1.371	1.085	1.327	0.031	0.709	0.091

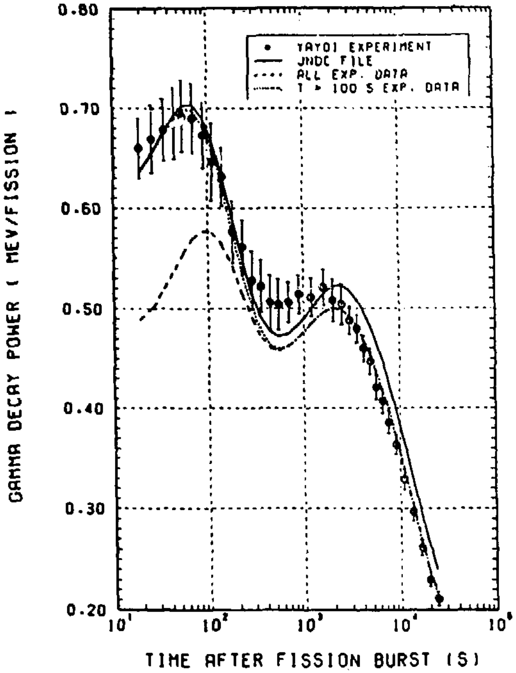

Fig.1(a)

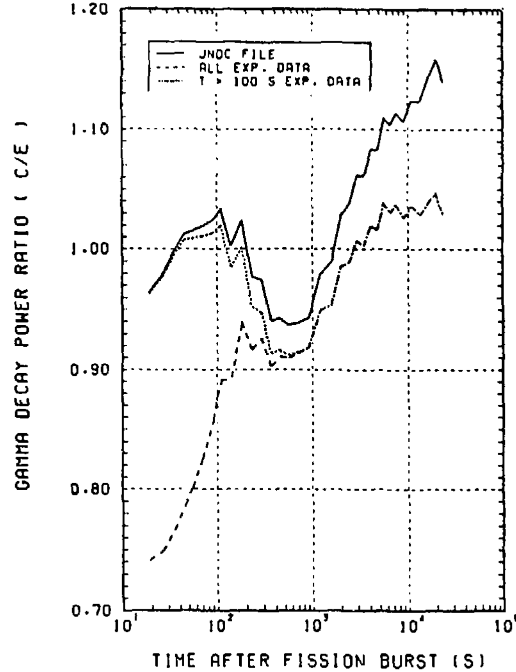

Fig.1(b)

(a) Direct comparison between the calculated and the measured powers .

(b) Ratios of the calculated tc the measured powers.

Fig. 1 Comparison of calculated gamma-decay power with measured reasuls at University of Tokyo (YAYOI) for the burst fission of ^{235}U by fast neutrons. The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energies for 87 nuclides with $Q_\beta > 5$ MeV and by using those for 10 nuclides with $Q_\beta > 5$ MeV and $T_{1/2} > 100s$, respectively.

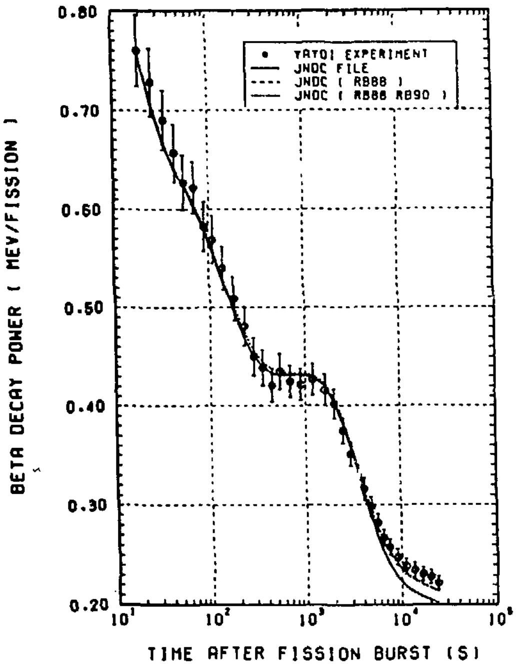

Fig.2(a)

(a) Direct comparison between the calculated and the measured powers.

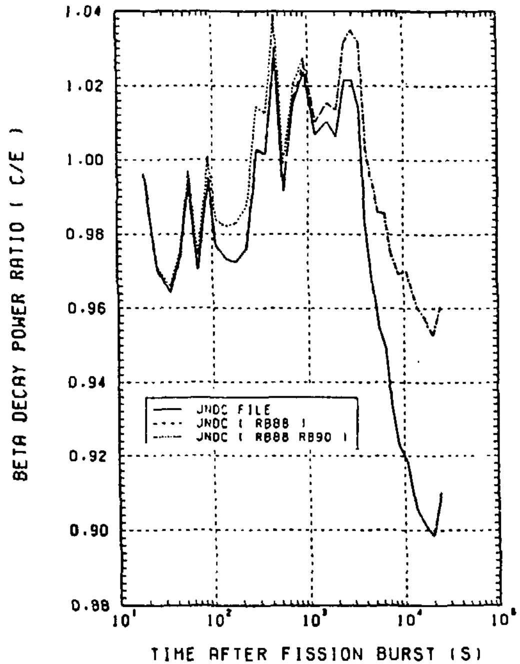

Fig.2(b)

(b) Ratios of the calculated to the measured powers.

Fig. 2 Effects of ^{88}Rb, ^{90m}Rb and ^{90}Rb on beta-decay power for the burst fission of ^{235}U by fast neutrons.
The calculated powers are shown by solid, broken and dotted lines.
The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using those for ^{88}Rb, ^{90m}Rb and ^{90}Rb, respectively.

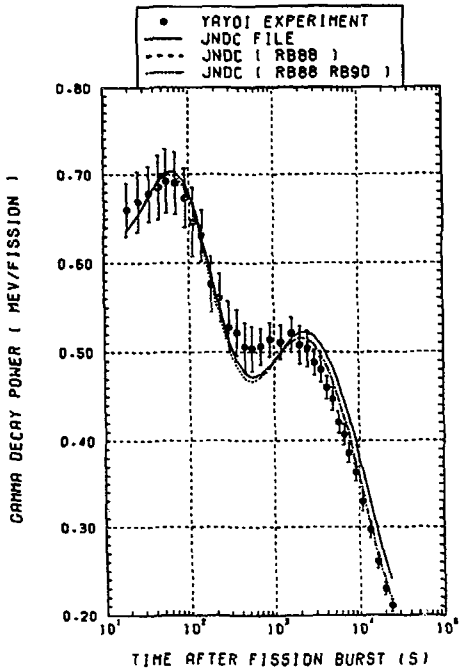

Fig.3(a)

(a) Direct comparison between the calculated and the measured powers.

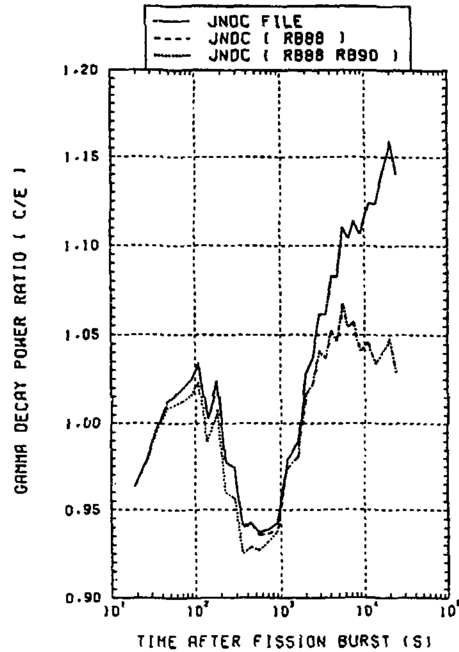

Fig.3(b)

(b) Ratios of the calculated to the measured powers.

Fig. 3 Effects of ^{88}Rb, ^{90m}Rb and ^{90}Rb on gamma-decay power for the burst fission of ^{235}U by fast neutrons.
The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using those for ^{88}Rb, ^{90m}Rb and ^{90}Rb, respectively.

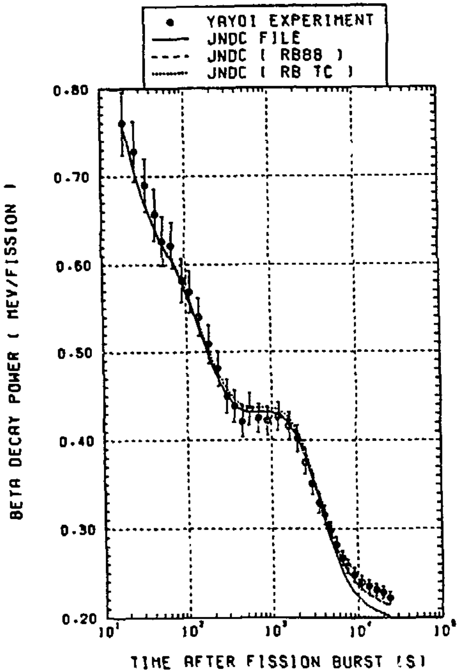

Fig.4(a)

(a) Direct comparison between the calculated and the measured powers.

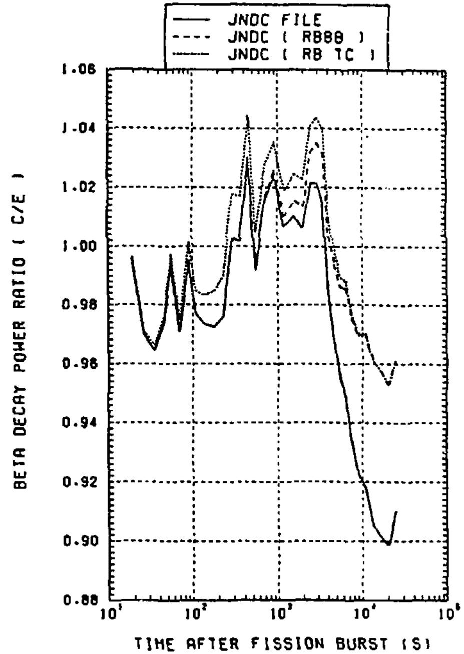

Fig.4(b)

(b) Ratios of the calculated to the measured powers.

Fig. 4 Effects of ^{88}Rb, ^{90m}Rb, ^{90}Rb and ^{104}Tc on beta-decay power for the burst fission of ^{235}U by fast neutrons.
The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using those ^{88}Rb, ^{90m}Rb and ^{104}Tc, respectively.

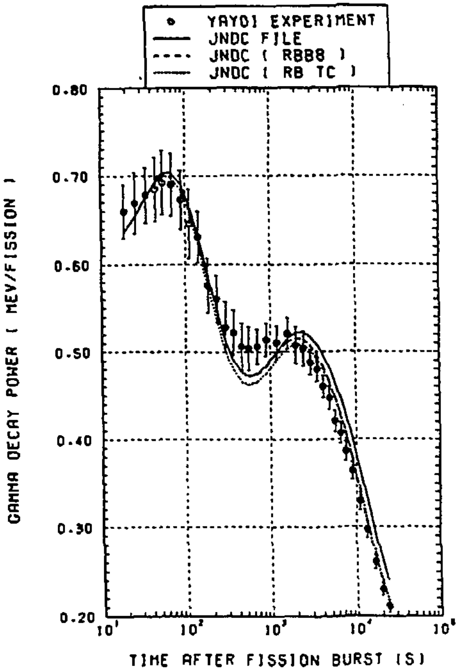

Fig.5(a)

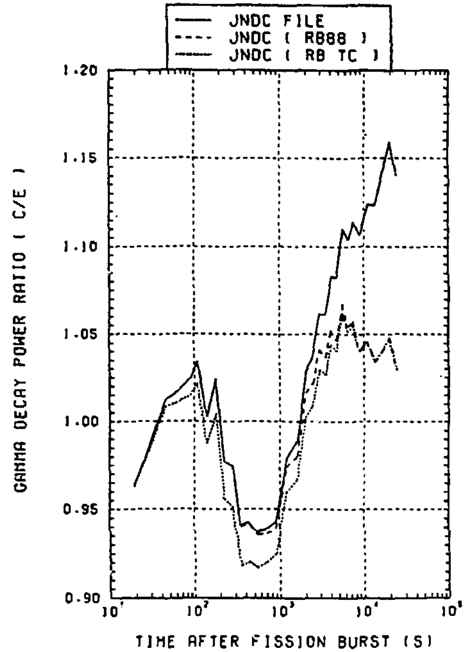

Fig.5(b)

(a) Direct comparison between the calculated and the measured powers.

(b) Ratios of the calculated to the measured powers.

Fig. 5 Effects of ^{88}Rb, ^{90m}Rb, ^{90}Rb and ^{104}Tc on gamma-decay power for the burst fission of ^{235}U by fast neutrons.
The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using those for ^{88}Rb, ^{90m}Rb and ^{104}Tc, respectively.

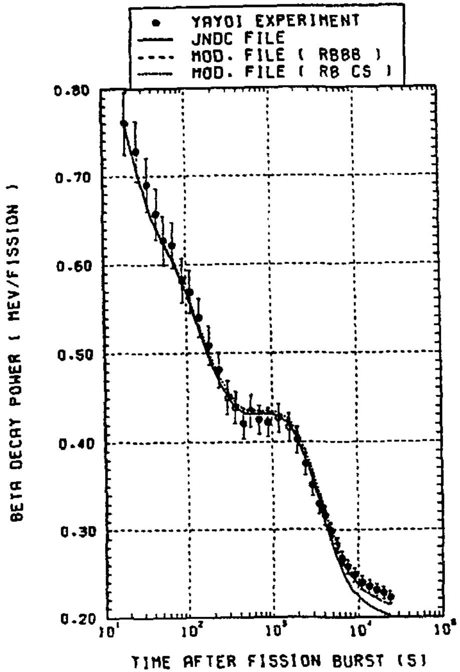

Fig.6(a)

(a) Direct comparison between the calculated and the measured powers.

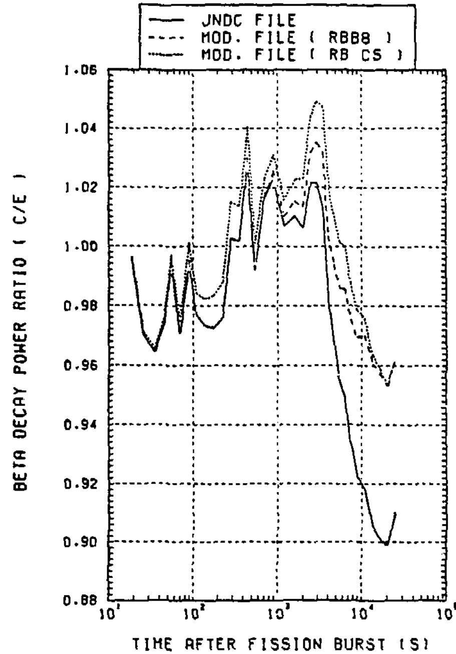

Fig.6(b)

(b) Ratios of the calculated to the measured powers.

Fig. 6 Effects of ^{88}Rb, ^{90m}Rb, ^{90}Rb, ^{138m}Cs and ^{138}Cs on beta-decay power for the burst fission of ^{235}U by fast neutrons.
The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original *JNDC* file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using those for ^{88}Rb, ^{90m}Rb, ^{90}Rb, ^{138m}Cs and ^{138}Cs, respectively.

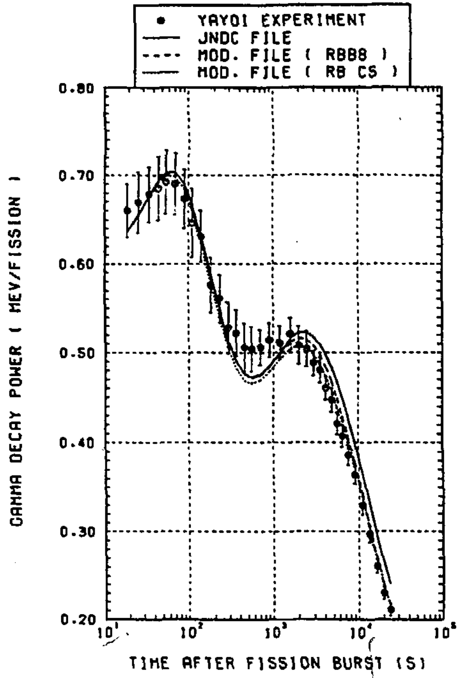

Fig.7(a)

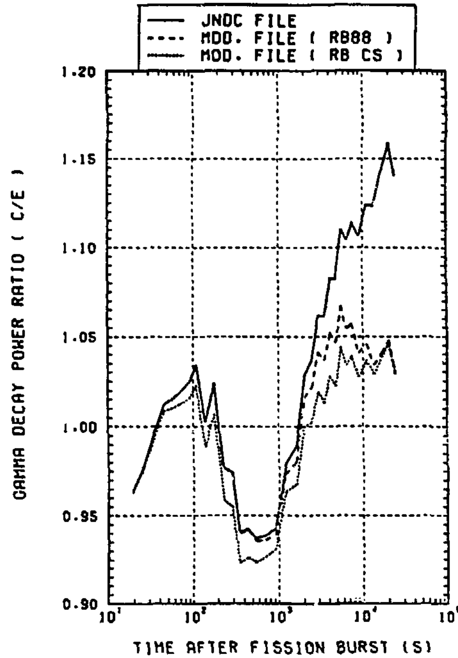

Fig.7(b)

(a) Direct comparison between the calculated and the measured powers.

(b) Ratios of the calculated to the measured powers.

Fig. 7 Effects of ^{88}Rb, ^{90m}Rb, ^{90}Rb, ^{138m}Cs and ^{138}Cs on gamma-decay power for burst fission of ^{235}U by fast neutrons.
The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using those for ^{88}Rb, ^{90m}Rb, ^{90}Rb, ^{138m}Cs and ^{138}Cs, respectively.

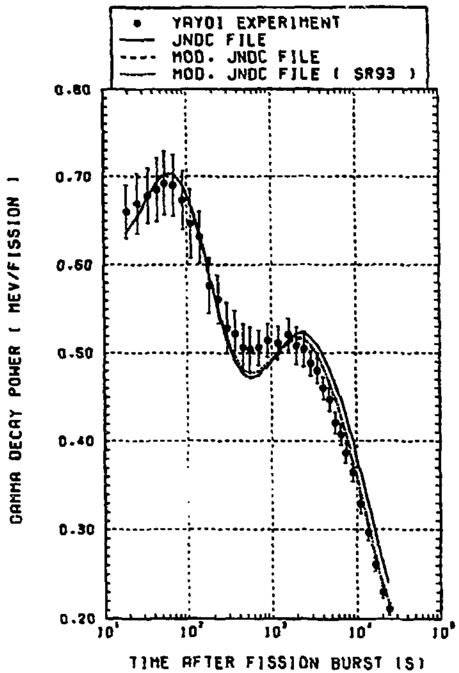

Fig.8(a)

(a) Direct comparison between the calculated and the measured powers.

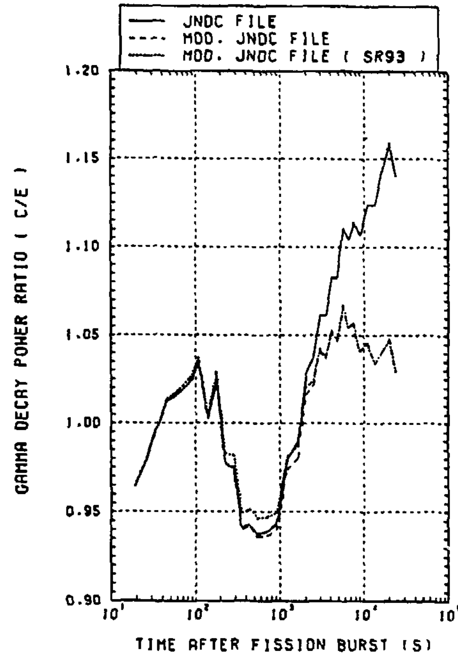

Fig.8(b)

(b) Ratios of the calculated to the measured powers.

Fig. 8 Effects of ^{88}Rb and ^{93}Sr on gamma-decay power for the burst fission of ^{235}U by fast neutrons.
The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using that for ^{88}Rb and the average energy of ENSDF for ^{93}Sr, respectively.

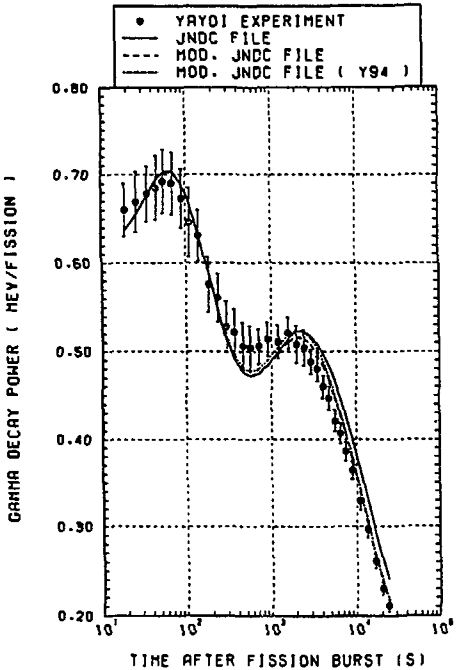

Fig.9(a)

(a) Direct comparison between the calculated and the measured powers.

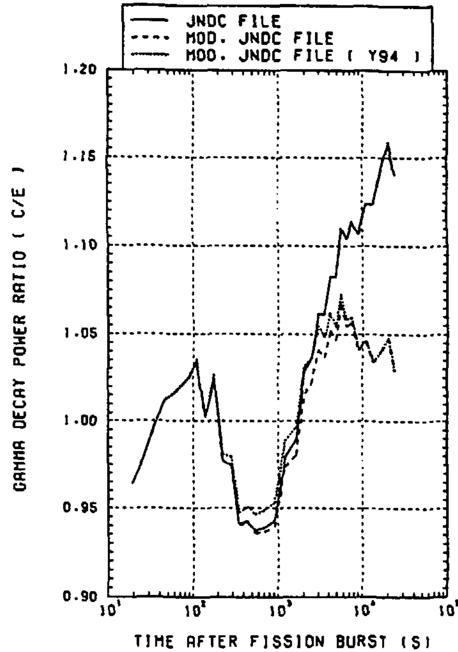

Fig.9(b)

(b) Ratios of the calculated to the measured powers.

Fig. 9 Effects of ^{88}Rb and ^{94}Y on gamma-decay power for the burst fission of ^{235}U by fast neutrons.
The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using that for ^{88}Rb and the average energy of ENSDF for ^{94}Y, respectivley.

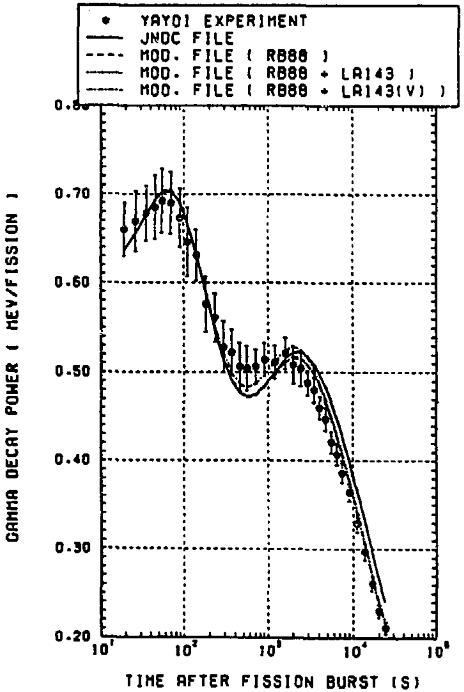

Fig.10(a)

(a) Direct comparison between the calculated and the measured powers.

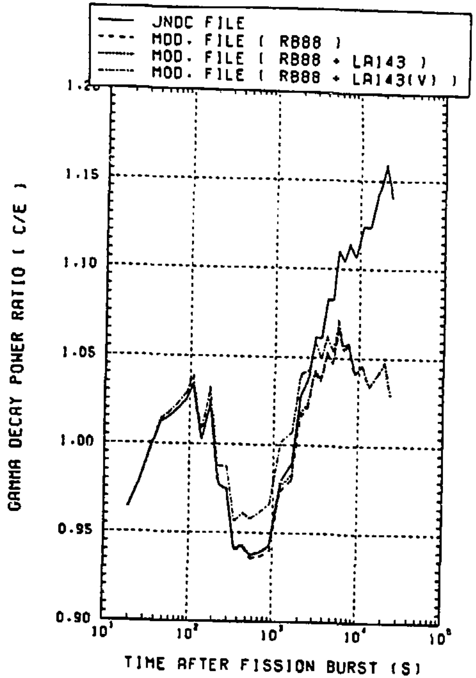

Fig.10(b)

(b) Ratios of the calculated to the measured powers.

Fig. 10 Effects of ^{88}Rb and ^{143}La on gamma-decay power for the burst fission of ^{235}U by fast neutrons.
The calculated powers are shown by solid, broken, dotted and dotted-dash lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using that for ^{88}Rb and the average energy of ENSDF for ^{143}La, respectively. The result using the average energy of ENDF/B-V for ^{143}La is shown by dotted-dash line.

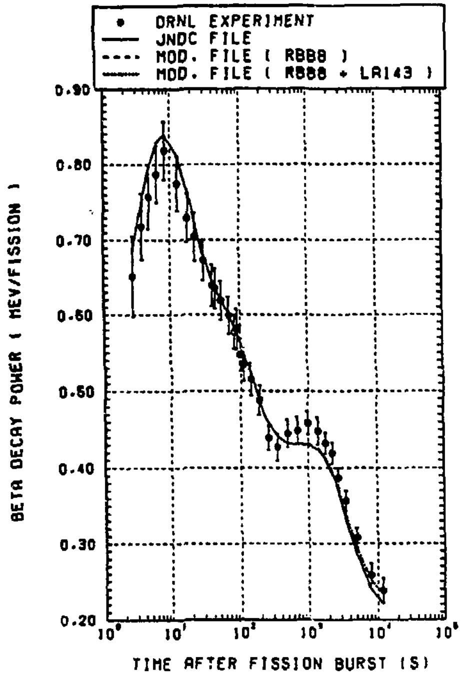

Fig.11(a)

(a) Direct comparison between the calculated and the measured powers.

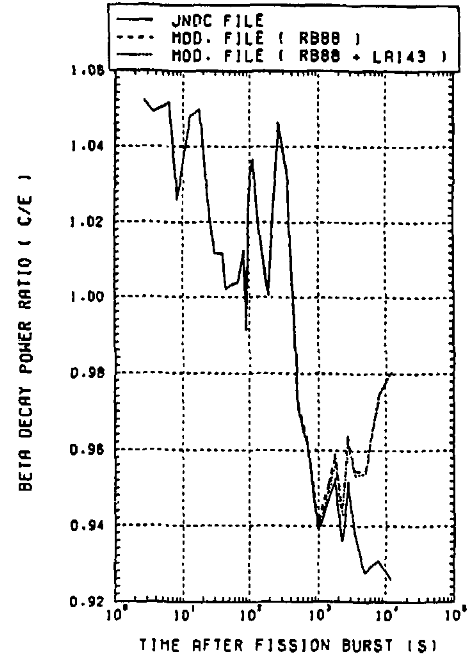

Fig.11(b)

(b) Ratios of the calculated to the measured powers.

Fig. 11 Comparison of calculated beta-decay power with measured results at ORNL for the burst fission of ^{235}U by thermal neutrons.
The calculated powers are shown by solid, broken and dotted lines.
The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using that for ^{88}Rb and the average energy of ENSDF for ^{143}La, respectively.

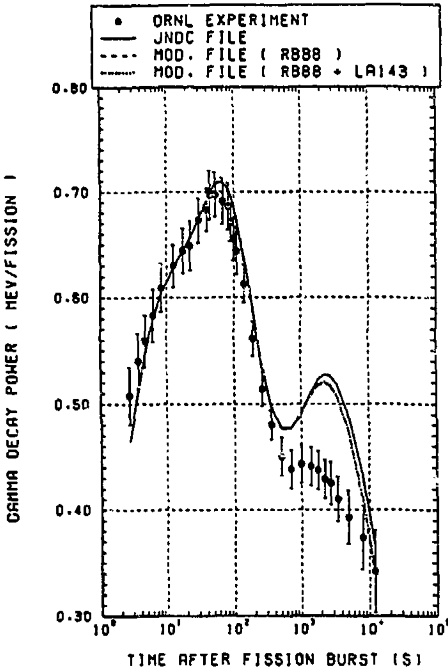

Fig.12(a)

(a) Direct comparison between the calculated and the measured powers.

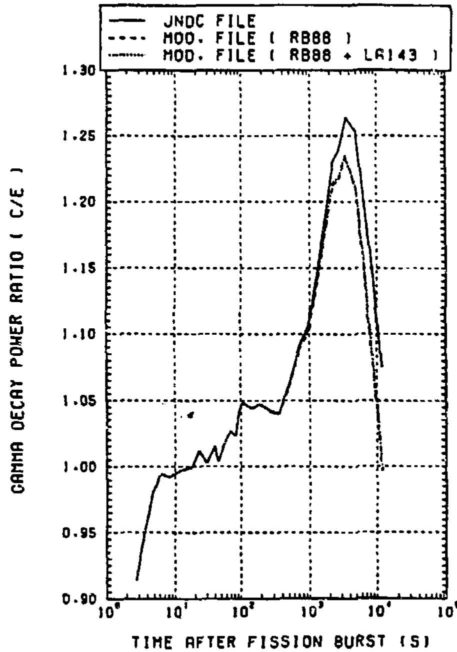

Fig.12(b)

(b) Ratios of the calculated to the measured powers.

Fig. 12 Comparison of calculated gamma-decay power with measured results at ORNL for the burst fission of ^{235}U by thermal neutrons.
The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using that for ^{88}Rb and the average energy of ENSDF for ^{143}La, respectively.

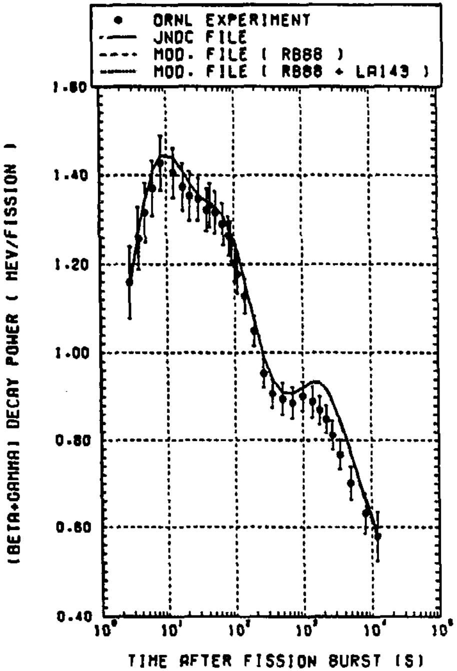

Fig.13(a)

(a) Direct comparison between the calculated and the measured powers.

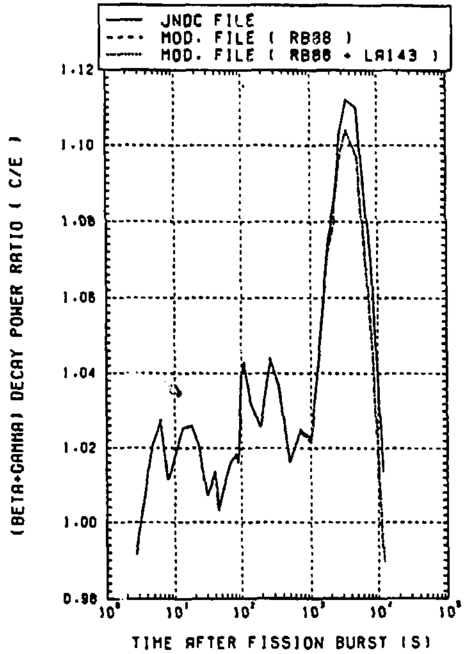

Fig.13(b)

(b) Ratios of the calculated to the measured powers.

Fig. 13 Comparison of calculated total decay power with measured results at ORNL for the burst fission of ^{235}U by thermal neutrons.
The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using that for ^{88}Rb and the average energy of ENSDF for ^{143}La, respectively.

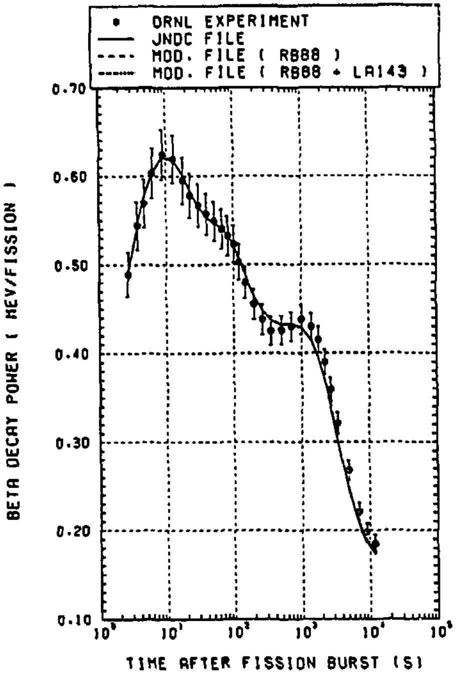

Fig.14(a)

(a) Direct comparison between the calculated and the measured powers.

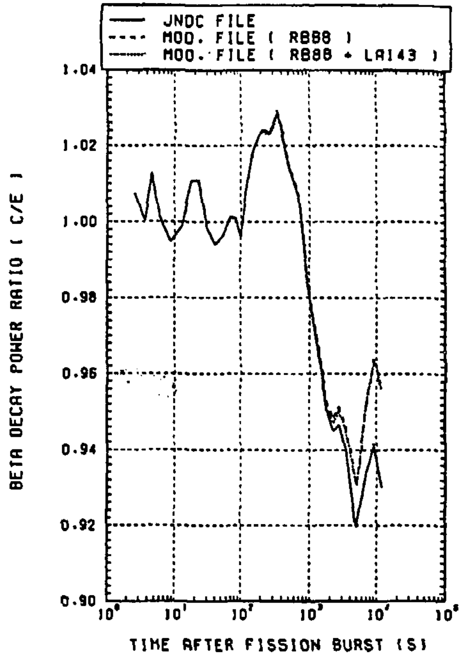

Fig.14(b)

(b) Ratios of the calculated to the measured powers.

Fig. 14 Comparison of calculated beta-decay power with measured results at ORNL for the burst fission of ^{239}Pu by thermal neutrons.
The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using that for ^{88}Rb and the average energy of ENSDF for ^{143}La, respectively.

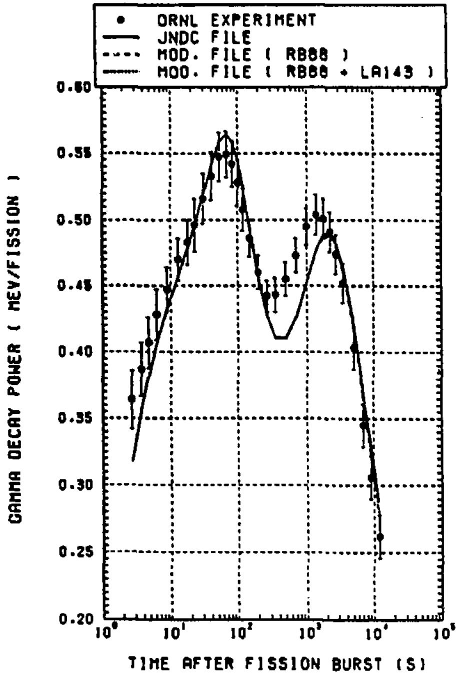

Fig.15(a)

(a) Direct comparison between the calculated and the measured powers.

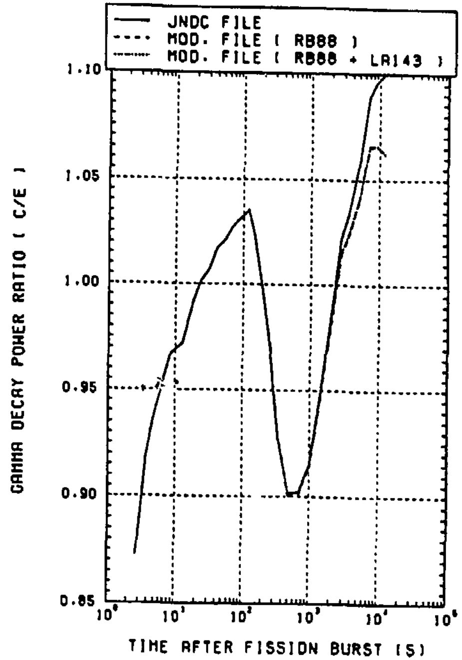

Fig.15(b)

(b) Ratios of the calculated to the measured powers.

Fig. 15 Composition of calculated gamma-decay power with measured results at ORNL for the burst fission of ^{239}Pu by thermal neutrons. The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using that for ^{88}Rb and the average energy of ENSDF for ^{143}La, respectively.

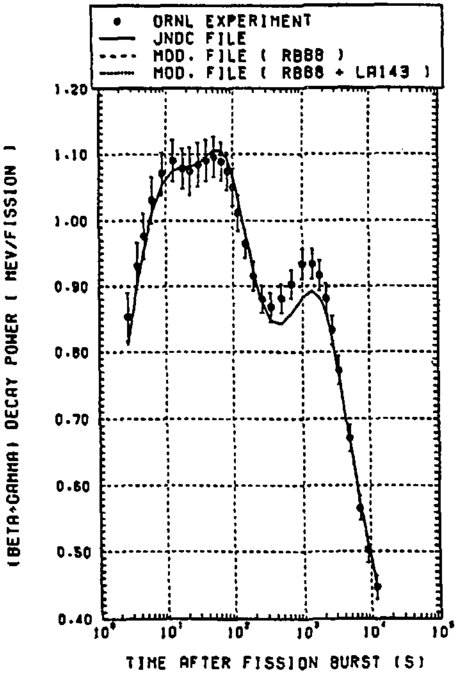

Fig.16(a)

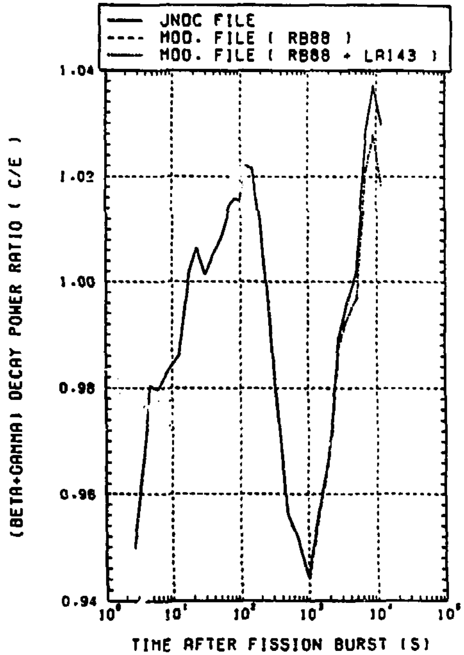

Fig.16(b)

(a) Direct comparison between the calculated and the measured powers.

(b) Ratios of the calculated to the measured powers.

Fig. 16 Comparison of calculated total decay power with measured results at ORNL for the burst fission of ^{239}Pu by thermal neutrons. The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using that for ^{88}Rb and the average energy of ENSDF for ^{143}La, respectively.

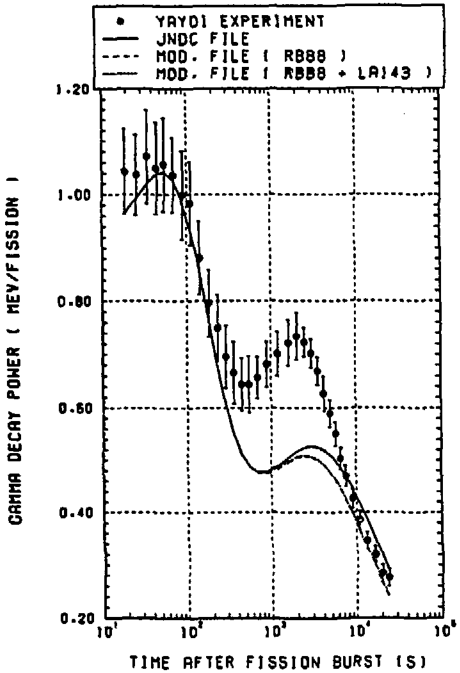

Fig.17(a)

(a) Direct comparison between the calculated and the measured powers.

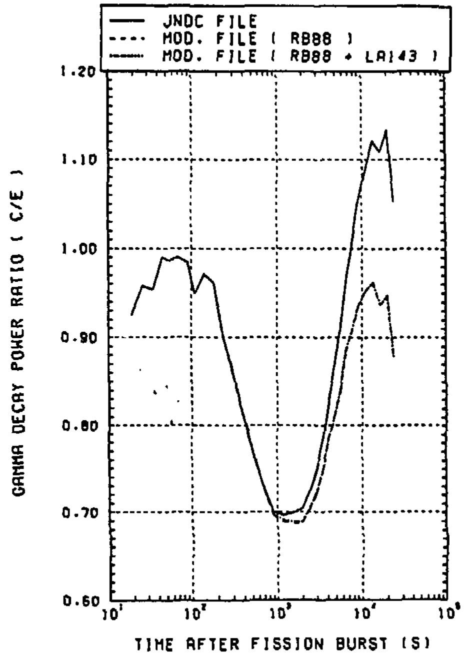

Fig.17(b)

(b) Ratios of the calculated to the measured powers.

Fig. 17 Comparison of calculated gamma-decay power with measured results at University of Tokyo (YAYOI) for the burst fission of ^{232}Th by fast neutrons.
The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using that for ^{88}Rb and the average energy of ENSDF for ^{143}La, respectively.

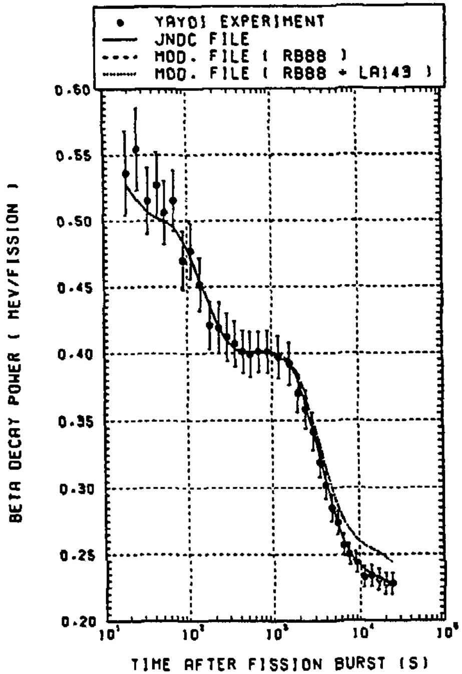

Fig.18(a)

(a) Direct comparison between the calculated and the measured powers.

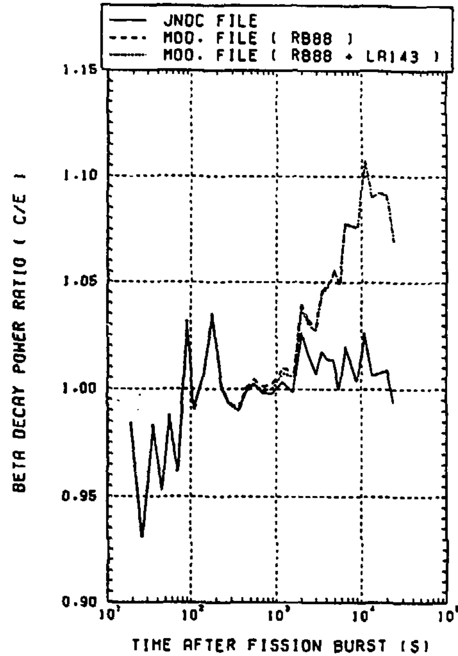

Fig.18(b)

(b) Ratios of the calculated to the measured powers.

Fig. 18 Comparison of calculated beta-decay power with measured results at University of Tokyo (YAYOI) for the burst fission of ^{233}U by fast neutrons.
The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using that for ^{88}Rb and the average energy of ENSDF for ^{143}La, respectively.

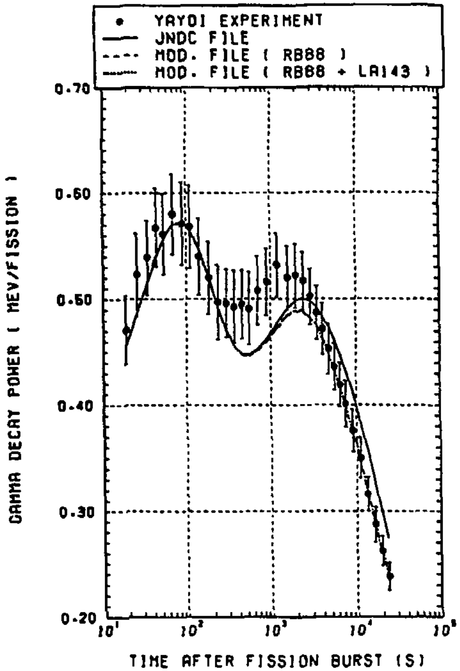

Fig.19(a)

(a) Direct comparison between the calculated and the measured powers.

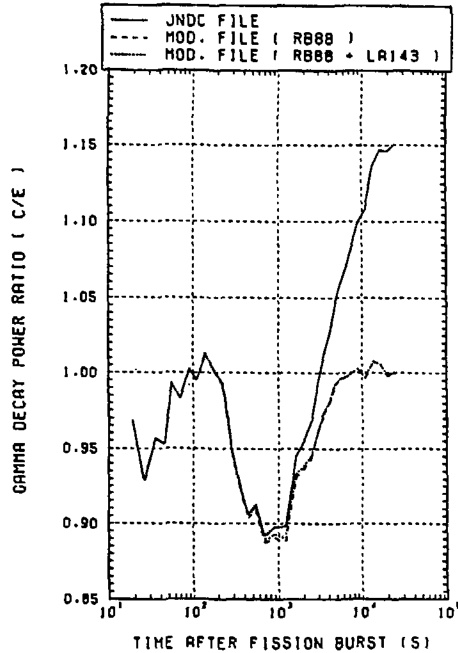

Fig.19(b)

(b) Ratios of the calculated to the measured powers.

Fig. 19 Comparison of calculated gamma-decay power with measured results at University of Tokyo (YAYOI) for the burst fission of ^{233}U by fast neutrons.
The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using that for ^{88}Rb and the average energy of ENSDF for ^{143}La, respectively.

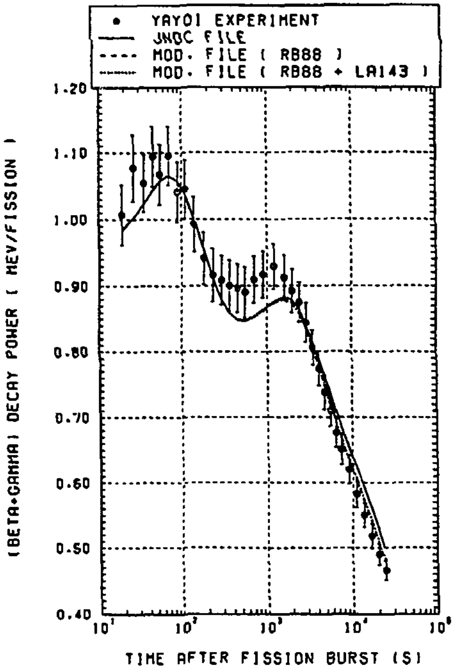

Fig.20(a)

(a) Direct comparison between the calculated and the measured powers.

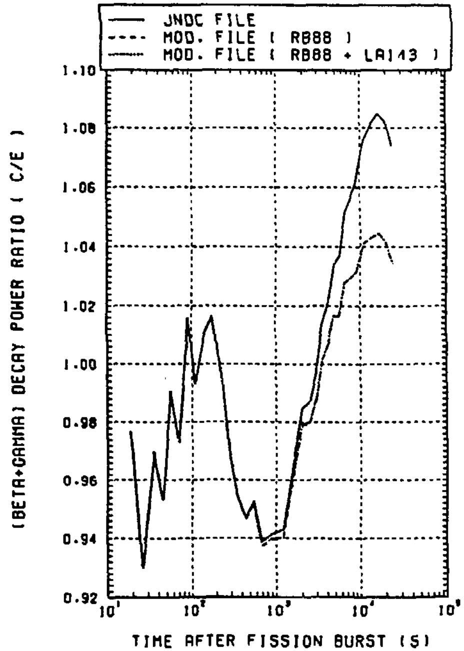

Fig.20(b)

(b) Ratios of the calculated to the measured powers.

Fig. 20 Comparison of calculated total decay power with measured results at University of Tokyo (YAYOI) for the burst fission of ^{233}U by fast neutrons.
The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using that for ^{88}Rb and the average energy of ENSDF for ^{143}La, respectively.

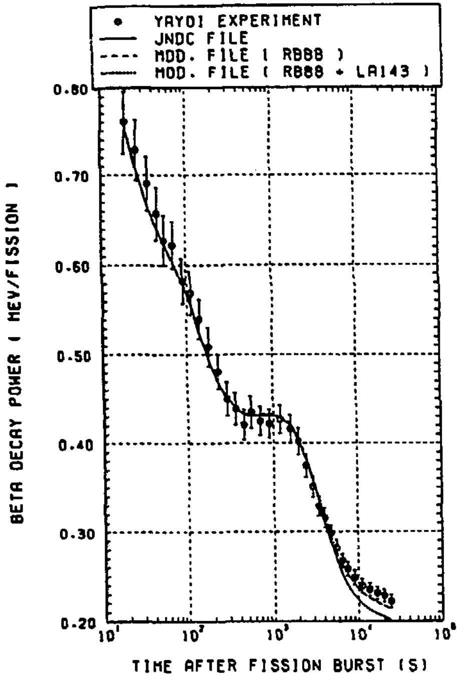

Fig.21(a)

(a) Direct comparison between the calculated and the measured powers.

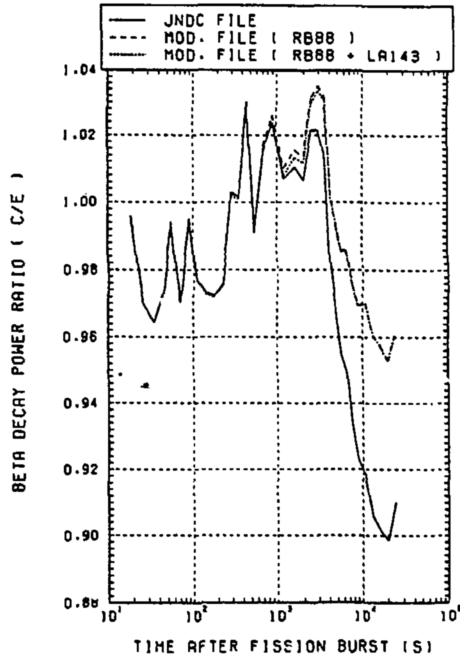

Fig.21(b)

(b) Ratios of the calculated to the measured powers.

Fig. 21 Comparison of calculated beta-decay power with measured results at University of Tokyo (YAYOI) for the burst fission of ^{235}U by fast neutrons.
The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using that for ^{88}Rb and the average energy of ENSDF for ^{143}La, respectively.

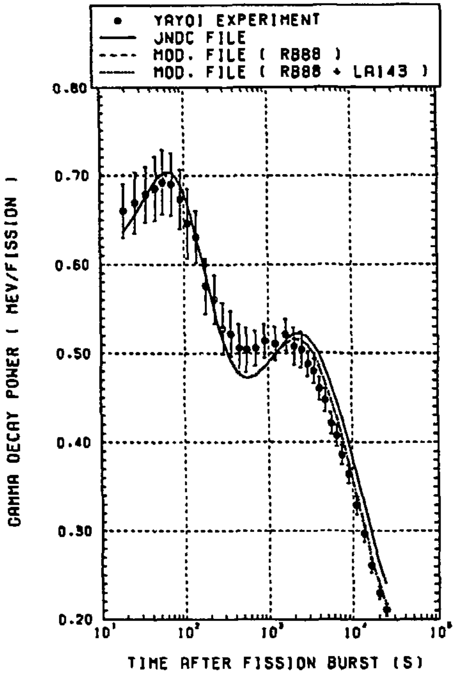

Fig.22(a)

(a) Direct comparison between the calculated and the measured powers.

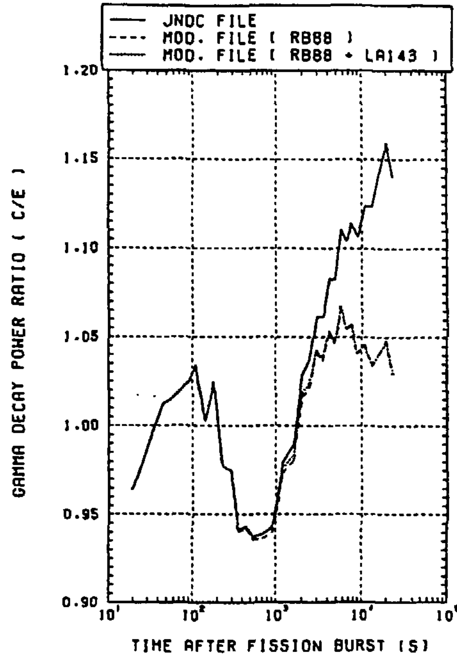

Fig.22(b)

(b) Ratios of the calculated to the measured powers.

Fig. 22 Comparison of calculated gamma-decay power with measured results at University of Tokyo (YAYOI) for the burst fission of ^{235}U by fast neutrons.
The calculated powers are shown by solid, broken and dotted lines.
The solid line is calculated with the original JNDC file. The broken and and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using that for ^{88}Rb and the average energy of ENSDF for ^{143}La, respectively.

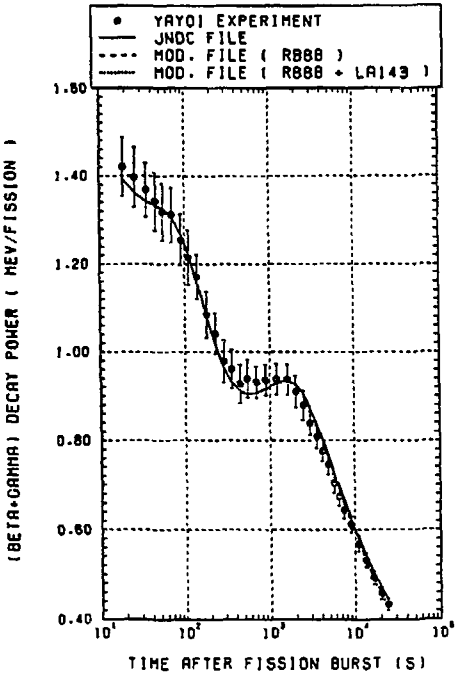

Fig.23(a)

(a) Direct comparison between the calculated and the measured powers.

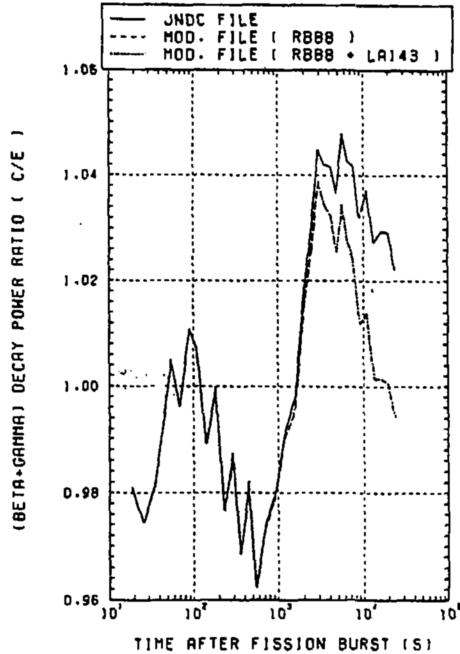

Fig.23(b)

(b) Ratios of the calculated to the measured powers.

Fig. 23 Comparison of calculated total decay power with measured results at University of Tokyo (YAYOI) for the burst fission of ^{235}U by fast neutrons.
The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using that for ^{88}Rb and the average energy of ENSDF for ^{143}La, respectively.

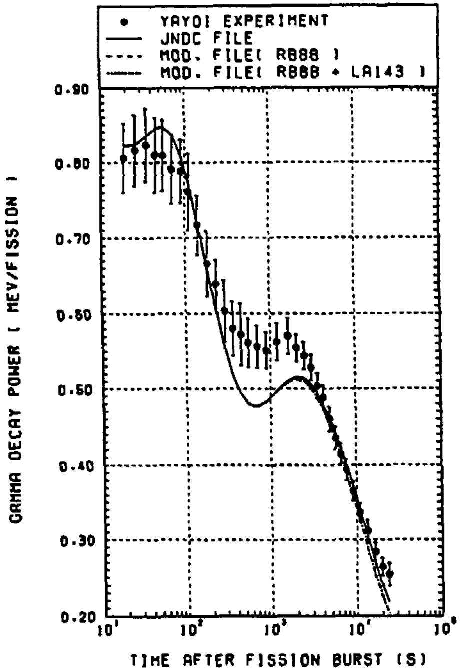

Fig.24(a)

(a) Direct comparison between the calculated and the measured powers.

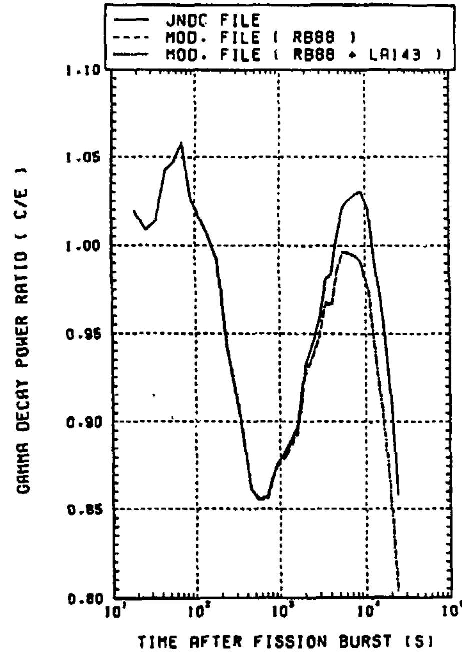

Fig.24(b)

(b) Ratios of the calculated to the measured powers.

Fig. 24 Comparison of calculated gamma-decay power with measured results at University of Tokyo (YAYOI) for the burst fission of ^{238}U by fast neutrons.
The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using that for ^{88}Rb and the average energy of ENSDF for ^{143}La, respectively.

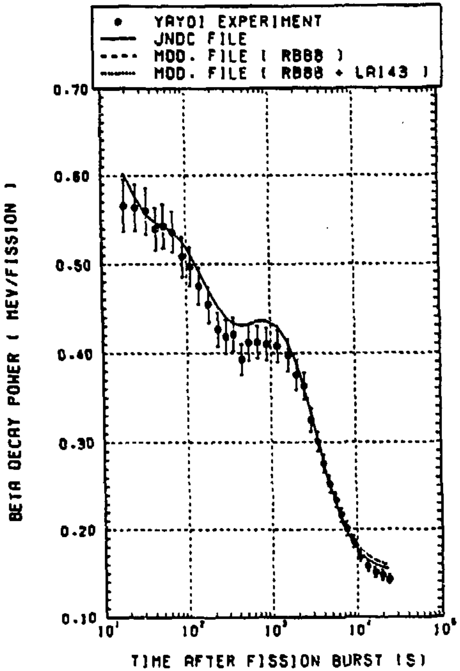

Fig.25(a)

(a) Direct comparison between the calculated and the measured powers.

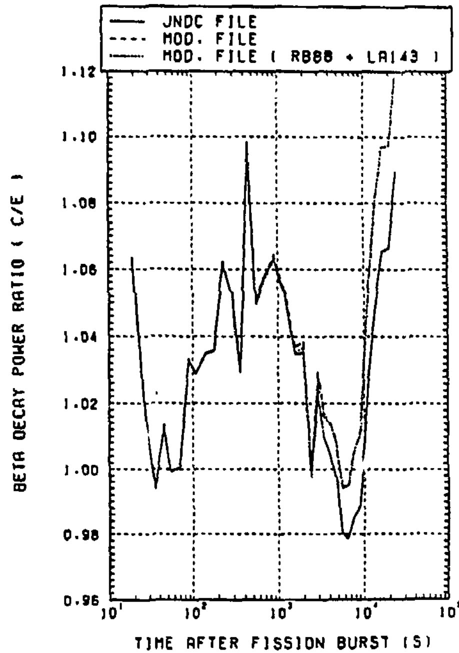

Fig.25(b)

(b) Ratios of the calculated to the measured powers.

Fig. 25 Comparison of calculated beta-decay power with measured results at University of Tokyo (YAYOI) for the burst fission of ^{239}Pu by fast neutrons.
The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using that for ^{88}Rb and the average energy of ENSDF for ^{143}La, respectively.

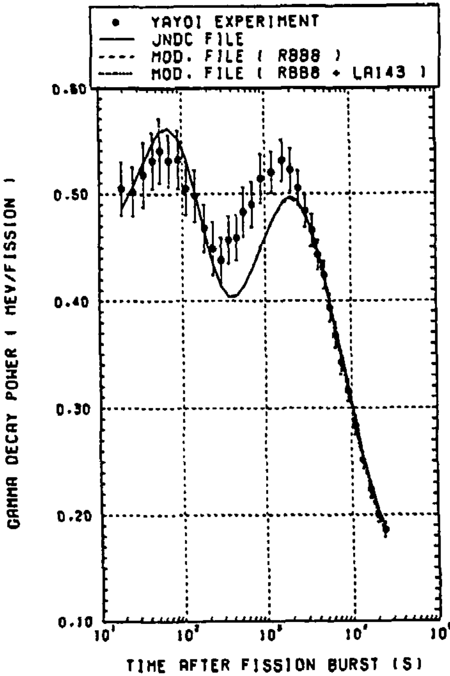

Fig.26(a)

(a) Direct comparison between the calculated and the measured powers.

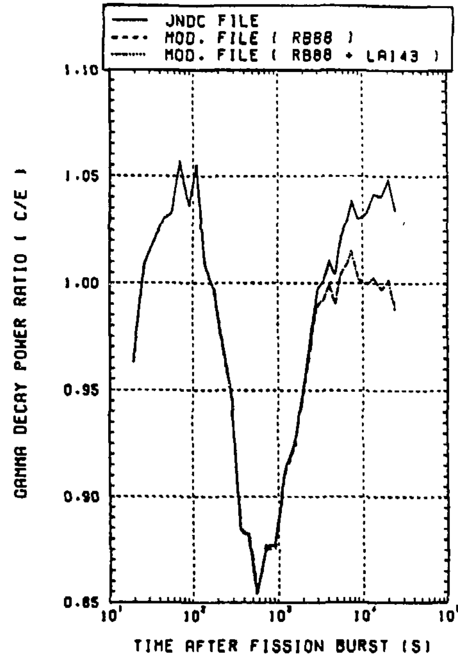

Fig.26(b)

(b) Ratios of the calculated to the measured powers.

Fig. 26 Comparison of calculated gamma-decay power with measured results at University of Tokyo (YAYOI) for the burst fission of ^{239}Pu by fast neutrons.
The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using that for ^{88}Rb and the average energy of ENSDF for ^{143}La, respectively.

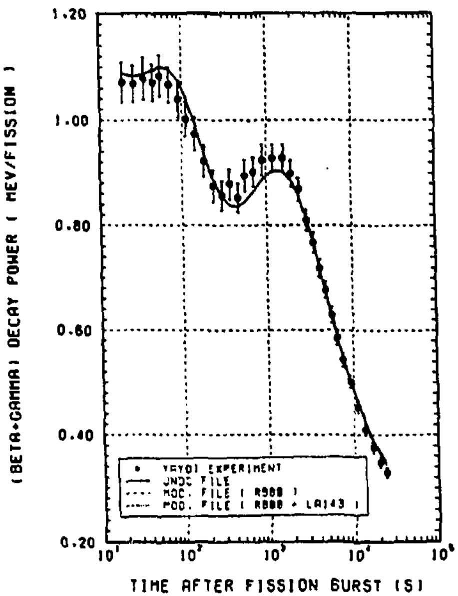

Fig.27(a)

(a) Direct comparison between the calculated and the measured powers.

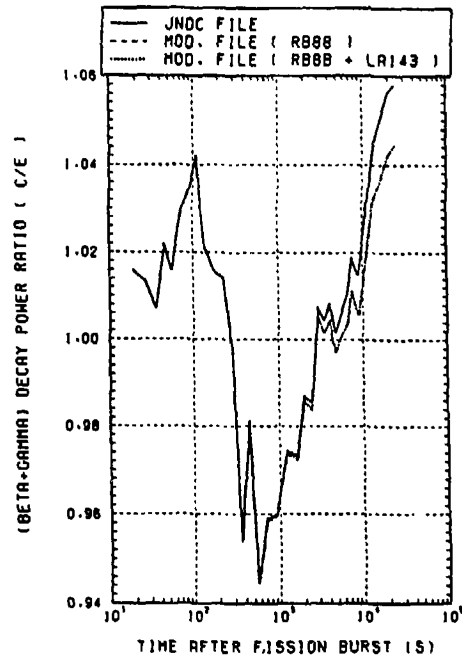

Fig.27(b)

(b) Ratios of the calculated to the measured powers.

Fig. 27 Comparison of calculated total decay power with measured results at University of Tokyo (YAYOI) for the burst fission of ^{239}Pu by fast neutrons.
The calculated powers are shown by solid, broken and dotted lines. The solid line is calculated with the original JNDC file. The broken and dotted lines are calculated by using the experimental average energy for ^{88}Rb and by using that for ^{88}Rb and the average energy of ENSDF for ^{143}La, respectively.