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EVALUATION OF $^{54}Fe(n,2n)^{53m+g}Fe$ REACTION CROSS SECTIONS FOR HIGH ENERGY DOSIMETRY APPLICATIONS

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The new evaluation of excitation function for the high energy threshold $^{54}Fe(n,2n)^{53m+g}Fe$ dosimetry reaction in the energy range from the threshold to 20 MeV is briefly described. The cross section uncertainties and the covariance matrix were estimated simultaneously from the analysis. The adopted curve is compared to the available processed experimental data and the existing FEI-93, ENDF/B-VI and JENDL-3.2 evaluations. The ENDF-6 formatted data file is available from the Web site of the Russian Nuclear Data Center (RNDC) online (http://www.rndc.ippe.obninsk.ru).

Introduction

Several threshold neutron activation reactions/detectors have been proposed [1] to measure the higher than 16 MeV neutron flux including $^{54}Fe(n,2n)^{53m+g}Fe$ reaction as candidate. The accuracy requested is about 20%. The energy range is from threshold to 20 MeV. The lack of reliable evaluations for this reaction in national data bases stimulated effort to construct a new excitation function for inclusion to the Russian Reactor Dosimetry File (RRDF-98). This RRDF-98 evaluation supersedes previous preliminary FEI-93 evaluation performed by authors in 1993 [2] for the following reasons. First and foremost, in the course of previous evaluation [2], the cross section data for $^{27}Al(n,p)^{27}Mg$ monitor reaction have been taken according to the obsolete recommendation [3]. Consequently, it was necessary to make corrections of experimental data measured relative to $^{27}Al(n,p)^{27}Mg$ reaction. Furthermore, the previous evaluated curve FEI-93 did not take into account experimental data measured by Andreev&Serov [4]. Moreover, high precision measurements covering wide energy ranges from 15.2 to 18.3 MeV and from 16.07 to 20.36 MeV have been reported recently by Fessler [5].

Analysis and processing of experimental data

The threshold of $^{54}Fe(n,2n)^{53m+g}Fe$ is 13.626 MeV. In the energy range from threshold to 16.63 MeV $^{54}Fe(n,2n)$ reaction leads to the ^{53}Fe formation in the ground state. At neutron energies exceeding 16.63 MeV the 3.04 MeV isomer level of the ^{53}Fe ($J=19/2^-$, $T_{1/2}=2.58$ min) is excited. The transition from isomer level to ground state is realized with a probability of 100%.

The $^{54}Fe(n,2n)^{53m+g}Fe$ reaction cross-section measurements cover range from the threshold to 20.36 MeV. All used the activation technique. The list of examined experiments [4-28] for the $^{54}Fe(n,2n)^{53m+g}Fe$ reaction cross-section is given in Table 1. Columns 1, 2 contain the lower and upper limits of the energy range under consideration in the experiment and the number of experimental points within this range. Methods used for measurements of induced activity and neutron flux monitoring are described in columns 3, 4. The columns 5 and 6 list the names of the first author of the publication and reference number. The original experimental data are shown in Fig. 1.

The original experimental data have been renormalized, if necessary, to the up-to-dated recommended standard cross-sections [3,29,30], quantum and positron yields [31]. Cross section data for the monitor reaction $^{27}Al(n,p)^{27}Mg$ were taken from the recent re-evaluation [32]. This new re-evaluation gives the cross section data in the energy range 13-16 MeV with accuracy from 1.34 to 1.8%. The changes in half-lives of radioactive nuclei have been taken into account by means of the increasing of cross-section errors.

The careful inspection of available experimental data disclosed that in the energy range from threshold to 15 MeV results of recent Greenwood's and Viennot's experiments [24,27] are consistent with each other. The measurements of Katoh et al. [26] do not contradict to Greenwood's and Viennot's data but exceed them below 14.7 MeV. The measurements of Qaim [17] and Bahal & Smither [23] at energy 14.7 MeV practically coincide. They are also in agreement with results of experiments described above. The same is true for measurements reported by Chittenden et al. at 14.8 MeV [10] and Depraz et al. at 15.0 MeV [8]. In spite of corrections the results of many experiments in the energy range from threshold to 15 MeV [6,9,11,13,14,18,20,25] are inconsistent with both theoretical model calculations and measurements considered above. In particular, cross-sections measured in those experiments are higher by a factor of 2 to 4 than Greenwood's and Viennot's data. By this reason they have been disregarded.

Terrel et al. [7] data measured at 16.89 and 17.89 MeV have been corrected introducing the F_c=0.5 coefficient, because authors used double decreased value for positron yield. Andreev & Serov performed two sets of measurements to obtain the cross section data for $^{54}Fe(n,2n)^{53m+g}Fe$ reaction for neutron energies from 13.87 to 17.4 MeV [4]. Both these two sets of absolute values of data are diverged from other data being strongly large. Analysis of Andreev's experimental data shows that relative cross section experimental curve looks rather well. Therefore, Andreev's data have been renormalized using preliminary evaluated integral cross section value in the neutron energy interval from 15.0 to 16.5 MeV. Renormalized experimental data by Andreev & Serov are well consistent with measurement results as well as with new experimental data for $^{54}Fe(n,2n)^{53m+g}Fe$ reaction measured recently by Fessler [5] at Geel (see Fig. 2.). Relative behavior of $^{54}Fe(n,2n)^{53m+g}Fe$ excitation function measured by Bormann et al. [20] in energy range from 14.05 to 18.23 MeV contradicts to most of other data sets as well as to theoretical calculation results. Therefore, Bormann et al. experimental data [20] have not been used for evaluation of excitation function for $^{54}Fe(n,2n)^{53m+g}Fe$ reaction. The resulting experimental data for the $^{54}Fe(n,2n)^{53m+g}Fe$ reaction cross-section are given in Table 2 and shown in Fig. 2. Table 2 includes information about average energy and energy spread of incident neutrons, the uncertainty of average neutron energy, cross-sections values and their uncertainties given by authors, corrected cross-sections and their uncertainties. For all experimental sets included in data bases the analysis of cross section error components has been performed and average correlation coefficient for each experimental data set has been calculated (see Table 3). In doing so, according to the information reported by authors, two independent sets (A and B) of measurements performed by Andreev & Serov [4], Ryves et al. [21.22] and Fessler [5] have been used to calculate the average correlation coefficients for each data set.

Table 1.

SUMMARY OF EXPERIMENTS FOR THE REACTION ^{54}Fe (n,2n)$^{53m+g}$ Fe

Energy-range [MeV]		Nr. of data points	Method of measurement	Monitor	References		Ref.
14.10	14.10	1	Act, Prop. Counter, Beta+	Cu63(n,2n)Cu62	Allan	56	[6]
16.89	17.89	2	Act, GEMUC, Beta-	Fe56(n,p)Mn56 norm at 14.30 MeV	Terrell+	58	[7]
15.00	15.00	1	Act, Prop. counter, Beta	Cu63(n,2n)Cu62	Depraz+	60	[8]
14.40	14.40	1	Act, Two NaI(Tl), Ann.Gammas coinc.	Cu63(n,2n)Cu62	Rayburn	61	[9]
14.80	14.80	1	Act, B+	Al27(n,a)Na24 and Cu63(n,2n)Cu62	Chittenden+	61	[10]
14.10	14.10	1	Act,Boric acid counter+NaI(Tl),Gamma	NO INFORMATION GIVEN	Pollehn+	61	[11]
14.50	14.50	1	Activation method	Al27(n,a)Na24	Cross+	63	[12]
14.10	14.10	1	Act, Two NaI(Tl) ,Ann.Gammas Coinc.	Cu63(n,2n)Cu62	Carles	63	[13]
14.70	14.70	1	Act, NaI(Tl), Gamma	Cu63(n,2n)Cu62	Strain+	65	[14]
14.05	16.75	2	Act., NaI(Tl) det., Ann. Gamma	NO INFORMATION GIVEN	Salisbury+	65	[15]
14.60	14.60	1	Act., NaI(Tl) det., Gamma	Cu63(n,2n)Cu62	Csikai	65	[16]
13.87	17.40	10	Act, Solid Scint., Ann. Gamma	Cu63(n,2n)Cu62 norm at 14.30 MeV	Andreev+	68	[4]
13.87	17.40	10	Act, Solid Scint., Ann.Gamma coinc.	Cu63(n,2n)Cu62 norm at 14.30 MeV	Andreev+	68	[4]
14.70	14.70	1	Act. method, Ge(Li) det., Ann.Gamma	Al27(n,p)Mg27	Qaim	72	[17]
14.60	14.60	1	Act., NaI(Tl) det., Gamma	Cu63(n,2n)Cu62	Araminowicz+	73	[18]
14.80	14.80	1	Act. method, Ge(Li) det., Ann.Gamma	Al27(n,p)Mg27	Sigg+	75	[19]
14.05	18.23	11	Act, NaI, Gamma and G-G coincidence	1-H-1(n,n)1-H-1 norm at 14.30 MeV	Bormann+	76	[20]
15.30	18.95	6	Act, 4PI Beta-Gamma coinc. counter	1-H-1(n,n)1-H-1 norm at 14.77 MeV	Ryves+	78	[21]
14.65	19.00	6	Act, 4PI Beta-Gamma coinc. counter	Fe56(n,p)Mn56	Ryves+	78	[22]
14.70	14.70	1	Act. method, Ge(Li) det., Gamma	Al27(n,p)Mg27	Bahal+	84	[23]
13.95	14.64	6	Act, Ge(Li), Gamma	Al27(n,p)Mg27 and Al27(n,a)Na24	Greenwood+	85	[24]
14.60	14.60	1	Act. method, Ge(Li) det., Gamma	T(d,n)He4 assoc.pt. norm at 14.40 MeV	Zhou Muyao+	87	[25]
13.70	14.87	5	Act., HPGe, Gamma	Al27(n,p)Mg27	Katoh+	89	[26]
13.93	14.83	5	Act. method, Ge(Li) det., Gamma	Al27(n,p)Mg27	Viennot+	91	[27]
14.60	14.60	1	Act. method, HP Ge detector, Gammas	Al27(n,a)Na24	Ercan+	91	[28]
15.22	18.30	7	Act. method, HP Ge detector, Gammas	Al27(n,p)Mg27 + 2 monit. reactions	Fessler+	98	[5]
16.07	20.36	5	Act. method, HP Ge detector, Gammas	Al27(n,p)Mg27 + 2 monit. reactions	Fessler+	98	[5]

Table 2.

CROSS SECTION DATA USED FOR THE EVALUATION of ^{54}Fe (n,2n)$^{53m+g}Fe$ EXCITATION FUNCTION

NR.	E-NEUTR [MeV]	ERR.CENTR [MeV]	WIDTH [MeV]	SIGMA (ORIG) [mb]	ERROR (ORIG) [mb]	CORR.APPL.	SIGMA (CORR) [mb]	ERROR (CORR) [mb]	REFERENCE
1	13.700	0.050	0.000	0.220	0.198	1 5	0.215	0.215	Katoh+ 89
2	13.870	0.098	0.490	12.800	6.501	5 6 8	6.088	3.107	Andreev+ 68
3	13.870	0.098	0.490	1.300	7.400	5 6 8	0.673	3.831	Andreev+ 68
4	13.930	0.030	0.120	0.800	0.800	1 5	0.780	0.780	Viennot+ 91
5	13.950	0.070	0.200	0.680	0.095	1 3 5	0.633	0.227	Greenwood+ 85
6	14.010	0.070	0.200	0.800	0.144	1 3 5	0.742	0.286	Greenwood+ 85
7	14.010	0.150	0.000	2.100	0.441	1 5	2.044	1.177	Katoh+ 89
8	14.050	0.210	1.050	2.830	0.050	4 8	2.830	1.920	Salisbury+ 65
9	14.300	0.104	0.520	9.300	7.300	5 6 8	4.424	3.480	Andreev+ 68
10	14.300	0.104	0.520	15.100	9.901	5 6 8	7.817	5.140	Andreev+ 68
11	14.300	0.035	0.140	2.100	0.900	1 5	2.009	0.884	Viennot+ 91
12	14.310	0.070	0.200	2.550	0.153	1 3 5	2.312	0.677	Greenwood+ 85
13	14.350	0.150	0.000	5.300	1.060	1 5	5.114	1.994	Katoh+ 89
14	14.460	0.070	0.200	3.700	0.111	1 3 5	3.319	0.903	Greenwood+ 85
15	14.470	0.043	0.170	3.600	1.000	1 5	3.403	0.982	Viennot+ 91
16	14.500	0.100	0.000	8.500	0.801	1 5	8.566	2.162	Cross+ 63
17	14.600	0.000	0.000	9.000	2.001	1	9.032	2.008	Ercan+ 91
18	14.610	0.070	0.200	5.050	0.303	1 3 5	4.484	1.260	Greenwood+ 85
19	14.640	0.070	0.200	5.850	0.175	1 3 5	5.184	1.400	Greenwood+ 85
20	14.640	0.150	0.000	9.000	1.800	1 5	8.648	3.329	Katoh+ 89
21	14.650	0.100	0.100	11.900	0.300	1 58	11.864	2.592	Ryves+ 78
22	14.700	0.030	0.300	8.000	1.600	1 4 8	7.429	1.399	Qaim 72
23	14.700	0.040	0.000	7.900	0.700	1 3 6 8	7.391	1.653	Bahal+ 84
24	14.730	0.058	0.230	7.100	1.801	1 5	6.585	1.830	Viennot+ 91
25	14.800	0.090	0.900	7.900	0.800	1 5	7.901	1.700	Chittenden+ 61
26	14.800	0.060	0.200	15.000	8.670	1 3 5	12.681	7.770	Sigg+ 75
27	14.830	0.062	0.250	8.100	1.801	1 5	7.466	1.908	Viennot+ 91
28	14.870	0.150	0.000	10.900	2.180	1 5	10.452	3.627	Katoh+ 89
29	15.000	0.040	0.400	7.000	7.000	1	7.376	7.369	Depraz+ 60

CONTINUE OF TABLE 2

NR.	E-NEUTR [MeV]	ERR.CENTR [MeV]	WIDTH [MeV]	SIGMA (ORIG) [mb]	ERROR (ORIG) [mb]	CORR. APPL.	SIGMA (CORR) [mb]	ERROR (CORR) [mb]	REFERENCE
30	15.100	0.114	0.570	36.900	9.302	5 6 8	17.551	4.511	Andreev+ 68
31	15.100	0.114	0.570	19.500	10.003	5 6 8	10.095	5.203	Andreev+ 68
32	15.220	0.030	0.220	22.600	2.000	0	22.600	2.000	Fessler+ 98
33	15.300	0.200	0.300	24.000	2.302	1 5 8	23.876	6.055	Ryves+ 78
34	15.470	0.026	0.130	57.500	9.901	5 6 8	27.350	4.904	Andreev+ 68
35	15.470	0.026	0.130	50.000	12.700	5 6 8	25.885	6.702	Andreev+ 68
36	15.640	0.030	0.270	26.600	2.000	0	26.600	2.000	Fessler+ 98
37	15.820	0.058	0.290	56.400	9.701	5 6 8	26.827	4.805	Andreev+ 68
38	15.820	0.058	0.290	60.000	11.400	5 6 8	31.061	6.103	Andreev+ 68
39	16.000	0.034	0.170	59.000	9.304	5 6 8	28.063	4.642	Andreev+ 68
40	16.000	0.034	0.170	54.100	10.604	5 6 8	28.007	5.666	Andreev+ 68
41	16.040	0.036	0.180	75.000	10.800	5 6 8	35.674	5.437	Andreev+ 68
42	16.040	0.036	0.180	74.600	12.607	5 6 8	38.620	6.809	Andreev+ 68
43	16.060	0.300	0.300	44.700	2.302	1 5 8	42.713	8.188	Ryves+ 78
44	16.070	0.020	0.200	39.100	3.000	0	39.100	3.000	Fessler+ 98
45	16.510	0.250	0.250	56.000	3.702	1 5 8	53.759	7.096	Ryves+ 78
46	16.510	0.030	0.300	48.200	3.700	0	48.200	3.700	Fessler+ 98
47	16.530	0.050	0.250	95.800	11.506	5 6 8	45.567	5.928	Andreev+ 68
48	16.530	0.050	0.250	94.200	14.902	5 6 8	48.766	8.090	Andreev+ 68
49	16.550	0.100	0.240	58.000	12.400	1 5 8	57.700	12.619	Ryves+ 78
50	16.750	0.110	0.550	50.400	5.000	4 8	50.400	6.200	Salisbury+ 65
51	16.890	0.160	0.320	120.000	36.000	1 6	60.000	16.980	Terrell+ 58
52	16.980	0.056	0.280	97.400	12.506	5 6 8	46.328	6.384	Andreev+ 68
53	16.980	0.056	0.280	116.000	16.820	5 6 8	60.052	9.212	Andreev+ 68
54	17.000	0.100	0.220	49.000	6.502	1 5 8	48.747	6.639	Ryves+ 78
55	17.060	0.020	0.220	61.100	4.600	0	61.100	4.600	Fessler+ 98
56	17.350	0.200	0.200	73.100	2.902	1 5 8	71.928	6.308	Ryves+ 78
57	17.370	0.100	0.220	65.000	6.006	1 5 8	64.664	6.259	Ryves+ 78
58	17.400	0.060	0.300	132.300	14.103	5 6 8	62.928	7.407	Andreev+ 68
59	17.400	0.060	0.300	130.100	18.734	5 6 8	67.351	10.264	Andreev+ 68
60	17.540	0.030	0.290	63.100	5.200	0	63.100	5.200	Fessler+ 98

CONTINUE OF TABLE 2

NR.	E-NEUTR [MeV]	ERR.CENTR [MeV]	WIDTH [MeV]	SIGMA (ORIG) [mb]	ERROR (ORIG) [mb]	CORR.APPL.	SIGMA (CORR) [mb]	ERROR (CORR) [mb]	REFERENCE	
61	17.820	0.030	0.250	71.400	6.200	0	71.400	6.200	Fessler+	98
62	17.860	0.100	0.210	86.000	9.107	1 5 8	85.556	9.112	Ryves+	78
63	17.890	0.040	0.080	170.000	51.000	1 6	85.000	24.055	Terrell+	58
64	17.910	0.030	0.300	69.400	6.900	0	69.400	6.900	Fessler+	98
65	18.060	0.190	0.190	87.100	4.303	1 5 8	85.615	5.625	Ryves+	78
66	18.210	0.040	0.400	72.600	4.800	0	72.600	4.800	Fessler+	98
67	18.300	0.040	0.320	75.600	4.900	0	75.600	4.900	Fessler+	98
68	18.950	0.100	0.210	85.000	5.907	1 5 8	84.561	5.936	Ryves+	78
69	19.000	0.190	0.190	98.700	5.902	1 5 8	98.719	5.726	Ryves+	78
70	19.150	0.030	0.300	81.400	7.700	0	81.400	7.700	Fessler+	98
71	20.360	0.040	0.350	88.200	7.200	0	88.200	7.200	Fessler+	98

Correction codes:

0) No correction applied.
1) Cross-section renormalized to the new recommended values of reference cross-section used in measurement.
2) Uncertainty in the reference cross-section data is included in the total cross-section data error.
3) Cross-section renormalized to the new recommended decay data (half-life, emission probability etc.)
4) Uncertainty in the decay data is included in the total cross-section data error.
5) Error given in publication did not include some partial errors. See text for details.
6) Special correction. See text for details.
7) The center of energy resolution function was shifted. See text for details.
8) Uncertainty in neutron energy is included in the total cross-section data error.
9) Total uncertainty in the cross-section data was evaluated.

Table 3.

Average correlation coefficients (F-corr) for the experimental data used for the evaluation of the $^{54}Fe(n,2n)^{53m+g}$ reaction excitation function

	Experimental data		F-corr		Experimental data		F-corr
1	Terrell+	58	0.24	10	Ryves+	78A	0.22
2	Depraz+	60	0.00	11	Ryves+	78B	0.61
3	Chittenden+	61	0.00	12	Bahal+	84	0.00
4	Cross+	63	0.00	13	Greenwood+	85	0.80
5	Salisbury+	65	0.30	14	Katoh+	89	0.69
6	Andreev+	68A	0.50	15	Viennot+	91	0.37
7	Andreev+	68B	0.44	16	Ercan+	91	0.00
8	Qaim	72	0.00	17	Fessler+	98A	0.29
9	Sigg+	75	0.00	18	Fessler+	98B	0.28

Evaluated $^{54}Fe(n,2n)^{53m+g}Fe$ reaction excitation function

After considering and processing all experimental data collected in Table 1 a smooth curve was drawn through these data points (given in Table 2) as calculated using the generalized least square method [33]. The adopted curve is compared to the available processed measurements of Table 2 from the threshold to 15 MeV in Fig. 3 and to 20 MeV in Fig. 4.

As shown in Figs. 5 and 6 the existing ENDF/B-VI and JENDL-3.2 evaluations diverge from the adopted RRDF-98 curve. Both run higher on 10-12% in the important for dosimetry energy range from threshold to 15.5 MeV (Fig. 5). The JENDL-3.2 curve has a rather strange shape strongly deviating from the experimental data (30-35%) and from both RRDF-98 and ENDF/B-VI evaluations in the energy range from 16.5 to 20 MeV (Fig. 6). Fig. 7 shows comparison of the preliminary FEI-93 curve and adopted RRDF-98 excitation function in comparison with processed experimental data.

The evaluated group cross-sections and their correlations are given in the Tables 4 and 5. Uncertainties given in the Table 4 were calculated for confidence level P=0.95 (2σ).

Table 4.

Group cross-sections and their uncertainties for the reaction $^{54}Fe(n,2n)^{53m+g}Fe$

ENERGY GROUP [MeV] to [MeV]	GROUP NUMBER	CROSS-SECTION [mb]	ERROR [mb]	ERROR [%]
13.700 - 13.900	1	0.41	0.21	52.28
13.900 - 14.100	2	1.11	0.32	28.84
14.100 - 14.300	3	2.30	0.46	20.00
14.300 - 14.500	4	4.02	0.61	15.12
14.500 - 14.700	5	6.28	0.77	12.33
14.700 - 14.900	6	9.08	0.96	10.60
14.900 - 15.100	7	12.41	1.16	9.38
15.100 - 15.300	8	16.21	1.36	8.40
15.300 - 15.500	9	20.43	1.55	7.58
15.500 - 16.000	10	28.60	1.84	6.42
16.000 - 16.500	11	40.90	2.27	5.55
16.500 - 17.000	12	52.77	2.72	5.15
17.000 - 17.500	13	63.19	3.04	4.80
17.500 - 18.000	14	71.69	3.20	4.47
18.000 - 19.000	15	80.69	3.65	4.52
19.000 - 20.000	16	87.81	5.51	6.27
20.000 - 21.000	17	91.15	8.06	8.84

Table 5.

Correlation matrix of group cross-sections for the $^{54}Fe(n,2n)^{53m+g}Fe$ reaction
Correlations are given in percentages

ENERGY GROUP [MeV] to [MeV]	GROUP NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
13.700 - 13.900	1	100																
13.900 - 14.100	2	19	100															
14.100 - 14.300	3	25	11	100														
14.300 - 14.500	4	28	67	82	100													
14.500 - 14.700	5	30	61	78	89	100												
14.700 - 14.900	6	30	53	70	84	92	100											
14.900 - 15.100	7	29	44	61	77	89	95	100										
15.100 - 15.300	8	27	36	52	69	83	92	96	100									
15.300 - 15.500	9	26	30	44	61	76	86	93	97	100								
15.500 - 16.000	10	22	21	32	47	61	73	82	89	95	100							
16.000 - 16.500	11	15	12	17	26	37	47	58	67	77	91	100						
16.500 - 17.000	12	9	8	9	12	18	25	33	43	54	74	74	100					
17.000 - 17.500	13	5	8	7	6	8	12	18	26	37	57	82	96	100				
17.500 - 18.000	14	5	10	8	7	7	9	13	19	27	44	68	85	95	100			
18.000 - 19.000	15	6	10	13	15	16	18	19	21	23	29	40	52	67	85	100		
19.000 - 20.000	16	9	7	14	22	27	30	30	27	24	16	7	8	20	43	84	100	
20.000 - 21.000	17	9	4	13	24	31	35	35	32	26	12	-6	-13	-4	18	65	96	100

Conclusion

As expected and illustrated in Table 4, the greatest uncertainties of evaluated cross sections for the $^{54}Fe(n,2n)^{53m+g}Fe$ reaction were estimated for the nearthreshold energy range 13.7-14.5 MeV and varies from about 50 to 15%. Because of the importance of $^{54}Fe(n,2n)^{53m+g}Fe$ reaction for high energy dosimetry applications, we feel that additional precise measurements from 13.7 to 14.5 MeV are required.

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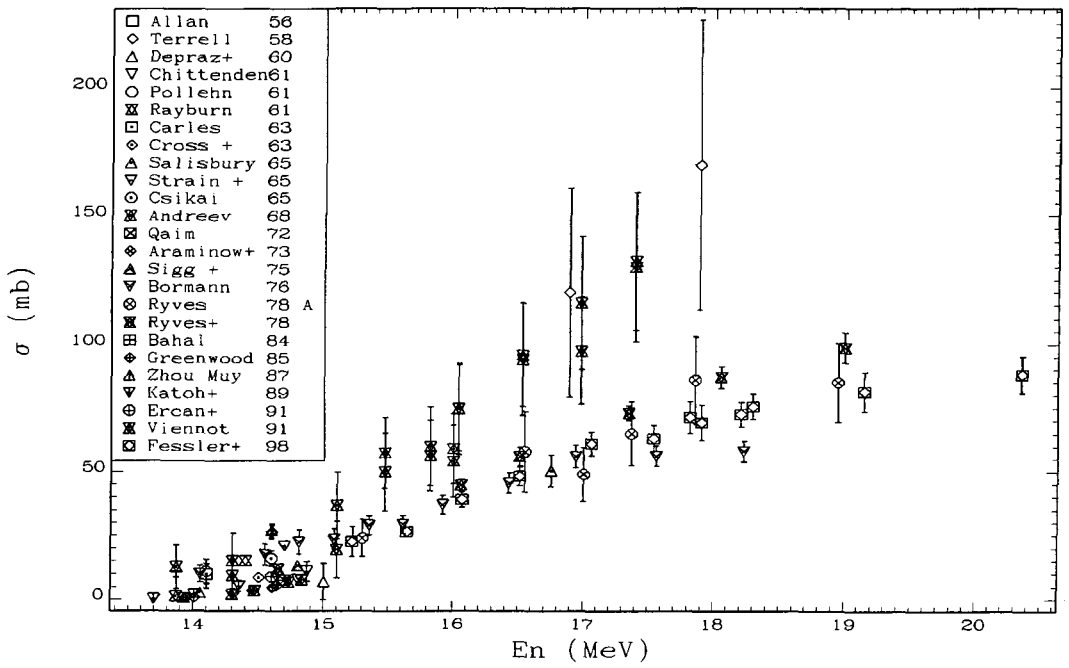

Fig. 1. The original experimental data for the $^{54}Fe(n,2n)^{53g+m}Fe$ reaction excitation function in the energy range from threshold to 20 MeV.

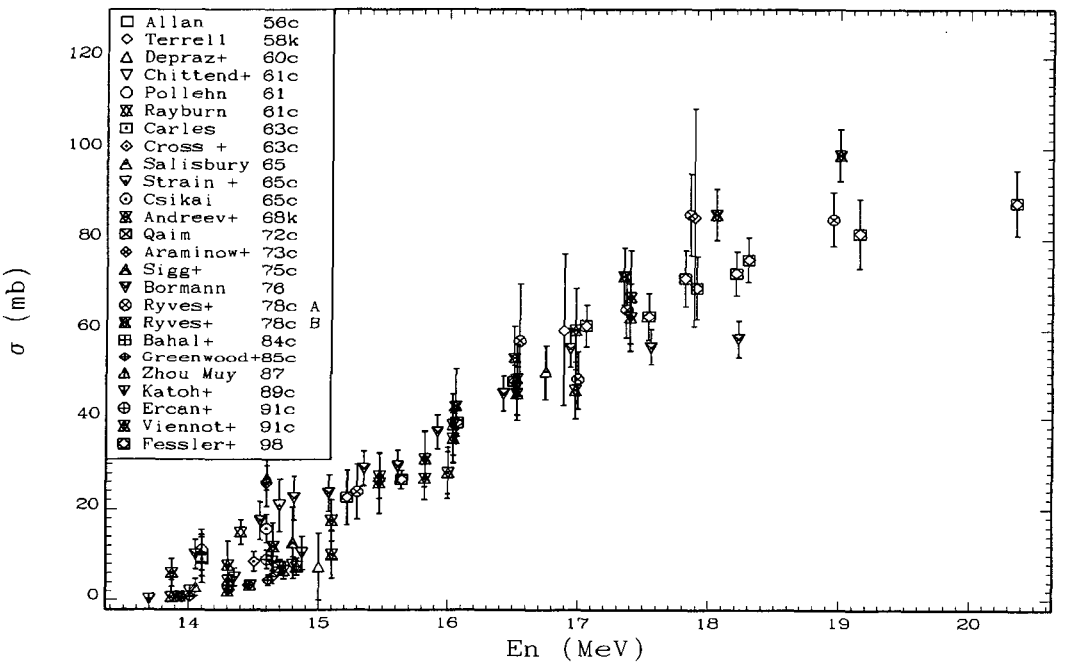

Fig. 2. The corrected experimental data for the $^{54}Fe(n,2n)^{53g+m}Fe$ reaction excitation function in the energy range from threshold to 20 MeV.

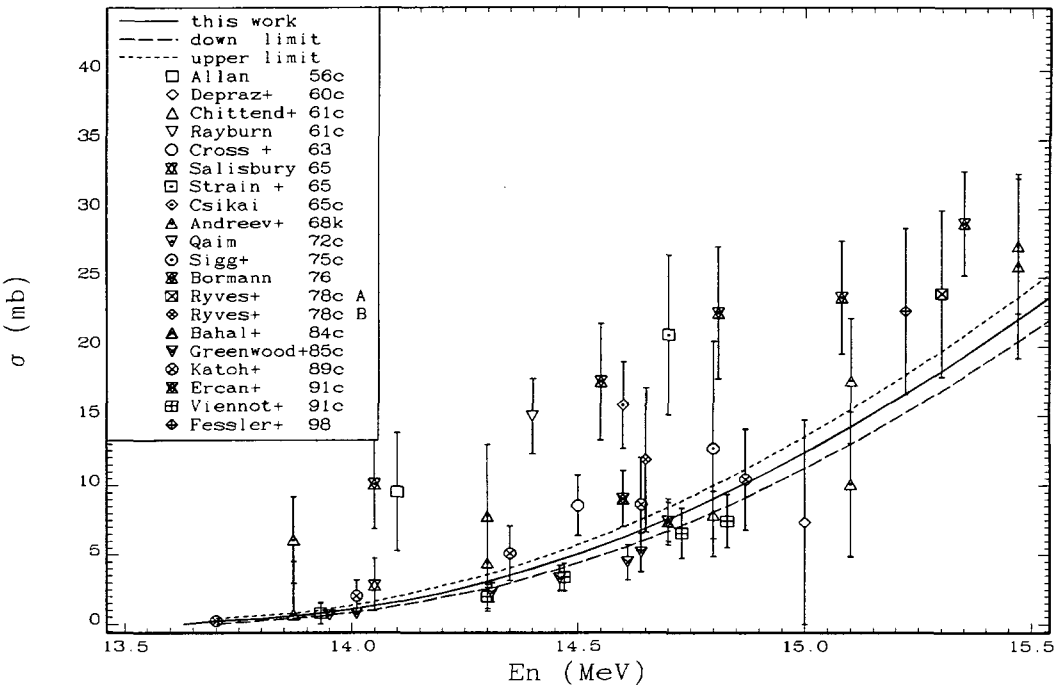

Fig. 3. The results of cross-section evaluation for the reaction $^{54}Fe(n,2n)^{53m+g}Fe$ from this work in the energy range from threshold to 15 MeV (dashed lines display 1 standard deviation error of evaluation).

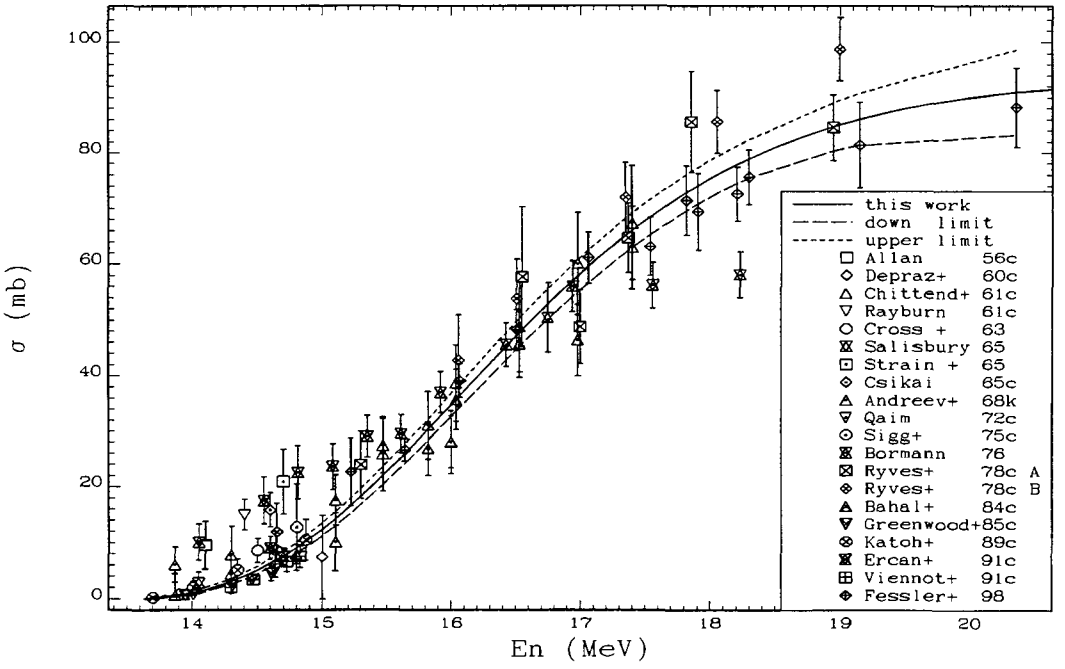

Fig. 4. The results of cross-section evaluation for the reaction $^{54}Fe(n,2n)^{53m+g}Fe$ from this work in the energy range from threshold to 20 MeV (dashed lines display 1 standard deviation error of evaluation).

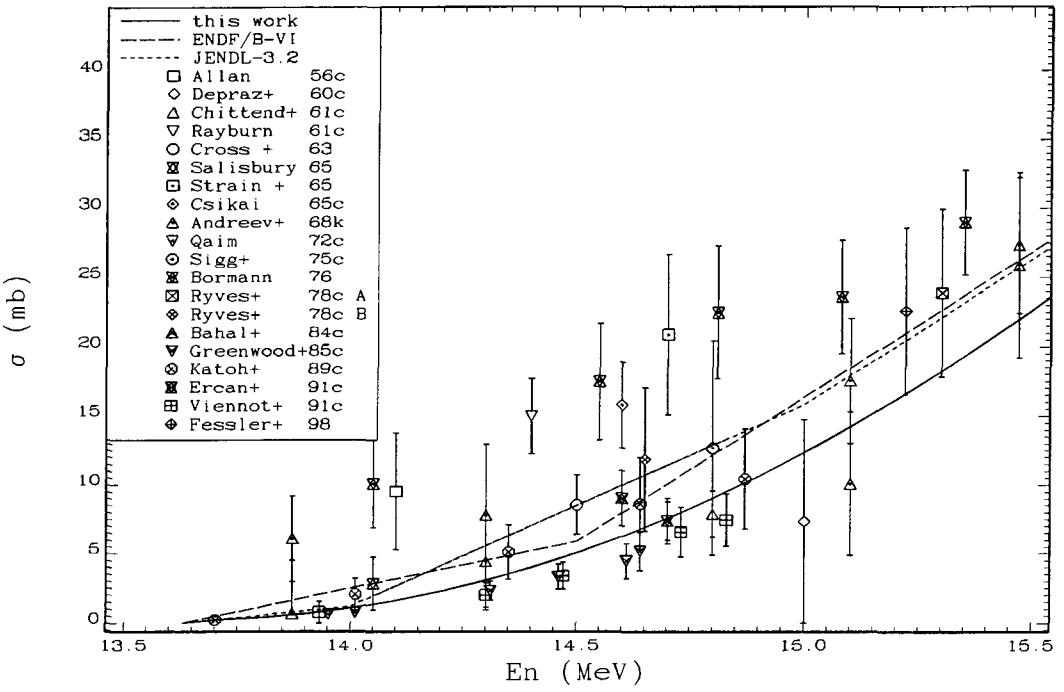

Fig. 5. The evaluated cross-section for the reaction $^{54}Fe(n,2n)^{53m+g}Fe$ in comparison with the experimental data and the JENDL-3 and ENDF/B-VI evaluations in the energy range from threshold to 15 MeV.

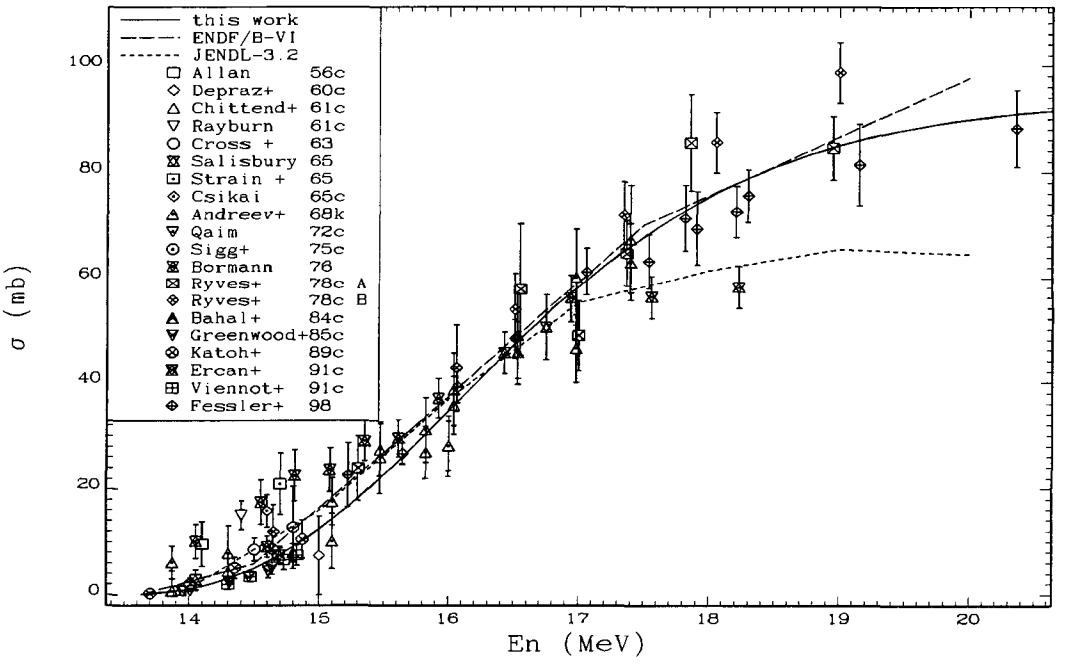

Fig. 6. The evaluated cross-section for the reaction $^{54}Fe(n,2n)^{53m+g}Fe$ in comparison with the experimental data and the JENDL-3 and ENDF/B-VI evaluations in the energy range from threshold to 20 MeV.

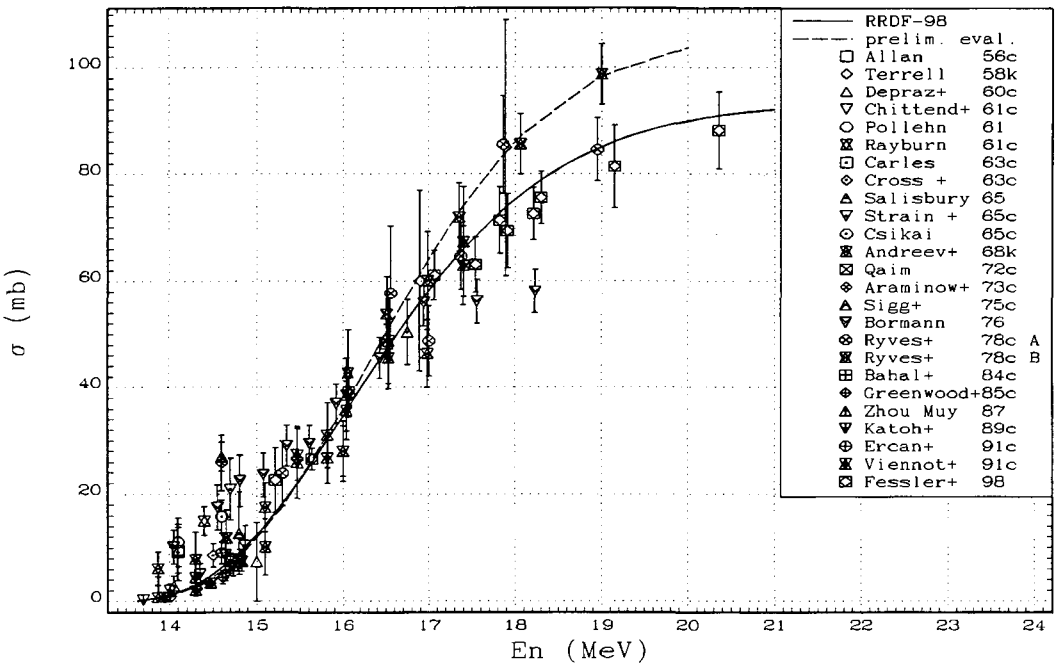

Fig. 7. The results of new evaluation in the comparison with data from preliminary FEI-93 evaluation [2].