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Tables of Contents

Element		Quantity	Energy(eV)		Lab	Type	Reference	Date	Comments
Li	0	(D,X) diff TTY	2.5+07		TOH	Expt	P,INDC(JPN)-194/U,101	Mar05	AOKI+.X=BE7.PURE GE DETECTOR
Li	0	(D,X+N) diff TTY	2.5+07		TOH	Expt	P,INDC(JPN)-194/U,101	Mar05	AOKI+.BEAM SWINGER TOF.ANG=0-90DEG
Be	9	(D,X) diff TTY	2.5+07		TOH	Expt	P,INDC(JPN)-194/U,101	Mar05	AOKI+.X=BE7.PURE GE DETECTOR
Be	9	(D,X+N) diff TTY	2.5+07		TOH	Expt	P,INDC(JPN)-194/U,101	Mar05	AOKI+.BEAM SWINGER TOF.ANG=0-90DEG
Be	9	(N,2N) energy dist	1.4+07		OSA	Expt	P,INDC(JPN)-194/U,97	Mar05	MURATA+.PENCIL-BEAM DT N SOURCE.NDG
Be	9	(N,X+A) double diff	1.4+07		OSA	Expt	P,INDC(JPN)-194/U,96	Mar05	MURATA+.PENCIL-BEAM DT N SOURCE.NDG
Be	9	(N,X+A) double diff	1.4+07		JAE	Expt	P,INDC(JPN)-194/U,42	Mar05	KONDO+.PENCIL-BEAM DT N SOURCE.NDG
Be	9	(N,X+HE6) double diff	1.4+07		JAE	Expt	P,INDC(JPN)-194/U,42	Mar05	KONDO+.PENCIL-BEAM DT N SOURCE.NDG
Be	9	(N,X+T) double diff	1.4+07		OSA	Expt	P,INDC(JPN)-194/U,96	Mar05	MURATA+.PENCIL-BEAM DT N SOURCE.NDG
Be	9	(N,X+T) double diff	1.4+07		JAE	Expt	P,INDC(JPN)-194/U,42	Mar05	KONDO+.PENCIL-BEAM DT N SOURCE.NDG
C	12	(A,X) yield	4.0+08		KEK	Expt	P,INDC(JPN)-194/U,11	Mar05	MATSUMURA+.X=BE7.CFD PHOTOREACT YIELD
C	12	(D,X+N) diff TTY	4.0+07		TOH	Expt	P,INDC(JPN)-194/U,104	Mar05	HAGIWARA+.TOF.DADE.ANG=0-110DEG
C	12	(N,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,71	Mar05	WATANABE+.JENDL HIGH ENERGY FILE
C	12	(N,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,68	Mar05	WATANABE+.JENDL HIGH ENERGY FILE
C	12	(N,X) yield		5.0+08	KEK	Expt	P,INDC(JPN)-194/U,11	Mar05	MATSUMURA+.X=BE7.SPALLATION N SOURCE
C	12	(P,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,71	Mar05	WATANABE+.JENDL HIGH ENERGY FILE
C	12	(P,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,68	Mar05	WATANABE+.JENDL HIGH ENERGY FILE
C	12	(P,X+N) diff TTY	5.0+07		TOH	Expt	P,INDC(JPN)-194/U,101	Mar05	AOKI+.TOF.ANG=0-90DEG.CFD LA150
C	12	(P,X+P) double diff	1.5+08	3.9+08	KYU	Theo	P,INDC(JPN)-194/U,72	Mar05	GAIDAROV+.SEMICLASSICAL DW MODEL.NDG
C	13	(N,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,71	Mar05	WATANABE+.JENDL HIGH ENERGY FILE
C	13	(N,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,68	Mar05	WATANABE+.JENDL HIGH ENERGY FILE
C	13	(P,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,71	Mar05	WATANABE+.JENDL HIGH ENERGY FILE
C	13	(P,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,68	Mar05	WATANABE+.JENDL HIGH ENERGY FILE
N	14	(N,X) cross sect	3.0+07	7.0+07	TOH	Expt	P,INDC(JPN)-194/U,105	Mar05	YASHIMA+.ACT SIG.LI7(P,N) N SOURCE
O	16	(N,X) cross sect	3.0+07	7.0+07	TOH	Expt	P,INDC(JPN)-194/U,105	Mar05	YASHIMA+.ACT SIG.LI7(P,N) N SOURCE
F	19	(N,X+A) double diff	1.4+07		OSA	Expt	P,INDC(JPN)-194/U,96	Mar05	MURATA+.PENCIL-BEAM DT N SOURCE.NDG
F	19	(N,X+D) double diff	1.4+07		OSA	Expt	P,INDC(JPN)-194/U,96	Mar05	MURATA+.PENCIL-BEAM DT N SOURCE.NDG
F	19	(N,X+D) double diff	1.4+07		JAE	Expt	P,INDC(JPN)-194/U,42	Mar05	KONDO+.PENCIL-BEAM DT N SOURCE.NDG
F	19	(N,X+P) double diff	1.4+07		OSA	Expt	P,INDC(JPN)-194/U,96	Mar05	MURATA+.PENCIL-BEAM DT N SOURCE.NDG
F	19	(N,X+P) double diff	1.4+07		JAE	Expt	P,INDC(JPN)-194/U,42	Mar05	KONDO+.PENCIL-BEAM DT N SOURCE.NDG
F	19	(N,X+T) double diff	1.4+07		OSA	Expt	P,INDC(JPN)-194/U,96	Mar05	MURATA+.PENCIL-BEAM DT N SOURCE.NDG

Element	Quantity	Energy(eV)		Lab	Type	Reference	Date	Comments
F 19	(N,X+T) double diff	1.4+07		JAE	Expt	P,INDC(JPN)-194/U,42	Mar05	KONDO+.PENCIL-BEAM DT N SOURCE.NDG
Na 23	(N,X) cross sect	3.0+07	7.0+07	TOH	Expt	P,INDC(JPN)-194/U,105	Mar05	YASHIMA+.ACT SIG.LI7(P,N) N SOURCE
Mg 0	(N,X) cross sect	3.0+07	7.0+07	TOH	Expt	P,INDC(JPN)-194/U,105	Mar05	YASHIMA+.ACT SIG.LI7(P,N) N SOURCE
Mg 24	(N,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,69	Mar05	SUN+.JENDL HIGH ENERGY FILE
Mg 24	(P,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,69	Mar05	SUN+.JENDL HIGH ENERGY FILE
Mg 25	(N,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,69	Mar05	SUN+.JENDL HIGH ENERGY FILE
Mg 25	(P,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,69	Mar05	SUN+.JENDL HIGH ENERGY FILE
Mg 26	(N,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,69	Mar05	SUN+.JENDL HIGH ENERGY FILE
Mg 26	(P,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,69	Mar05	SUN+.JENDL HIGH ENERGY FILE
Al 27	(A,X) yield	4.0+08		KEK	Expt	P,INDC(JPN)-194/U,11	Mar05	MATSUMURA+.X=BE7.CFD PHOTOREACT YIELD
Al 27	(D,X+N) diff TTY	4.0+07		TOH	Expt	P,INDC(JPN)-194/U,104	Mar05	HAGIWARA+.TOF.DADE.ANG=0-110DEG
Al 27	(N,A) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Al 27	(N,P) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Al 27	(N,X) yield		5.0+08	KEK	Expt	P,INDC(JPN)-194/U,11	Mar05	MATSUMURA+.X=BE7.SPALLATION N SOURCE
Al 27	(N,X+A) double diff	1.4+07		OSA	Expt	P,INDC(JPN)-194/U,96	Mar05	MURATA+.PENCIL-BEAM DT N SOURCE.NDG
Al 27	(N,X+A) double diff	1.4+07		JAE	Expt	P,INDC(JPN)-194/U,42	Mar05	KONDO+.PENCIL-BEAM DT N SOURCE.NDG
Al 27	(P,X+N) diff TTY	5.0+07		TOH	Expt	P,INDC(JPN)-194/U,101	Mar05	AOKI+.TOF.ANG=0-90DEG.CFD LA150
Si 0	(N,X) cross sect	3.0+07	7.0+07	TOH	Expt	P,INDC(JPN)-194/U,105	Mar05	YASHIMA+.ACT SIG.LI7(P,N) N SOURCE
Si 28	(N,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,71	Mar05	WATANABE+.JENDL HIGH ENERGY FILE
Si 28	(N,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,69	Mar05	SUN+.JENDL HIGH ENERGY FILE
Si 28	(P,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,71	Mar05	WATANABE+.JENDL HIGH ENERGY FILE
Si 28	(P,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,69	Mar05	SUN+.JENDL HIGH ENERGY FILE
Si 29	(N,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,71	Mar05	WATANABE+.JENDL HIGH ENERGY FILE
Si 29	(N,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,69	Mar05	SUN+.JENDL HIGH ENERGY FILE
Si 29	(P,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,71	Mar05	WATANABE+.JENDL HIGH ENERGY FILE
Si 29	(P,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,69	Mar05	SUN+.JENDL HIGH ENERGY FILE
Si 30	(N,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,71	Mar05	WATANABE+.JENDL HIGH ENERGY FILE
Si 30	(N,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,69	Mar05	SUN+.JENDL HIGH ENERGY FILE
Si 30	(P,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,71	Mar05	WATANABE+.JENDL HIGH ENERGY FILE
Si 30	(P,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,69	Mar05	SUN+.JENDL HIGH ENERGY FILE
K 41	(N,A) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M

Element	Quantity	Energy(eV)		Lab	Type	Reference	Date	Comments
K 41	(N,P) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Ca 0	(N,X) cross sect	3.0+07	7.0+07	TOH	Expt	P,INDC(JPN)-194/U,105	Mar05	YASHIMA+.ACT SIG.LI7(P,N) N SOURCE
Ca 40	(P,X+P) double diff	1.5+08	3.9+08	KYU	Theo	P,INDC(JPN)-194/U,72	Mar05	GAIDAROV+.SEMICLASSICAL DW MODEL.NDG
Ti 47	(N,A) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Ti 47	(N,P) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
V 51	(D,X) cross sect	3.3+07	4.0+07	JAE	Expt	P,INDC(JPN)-194/U,39	Mar05	NAKAO+.X=CR49.ACT SIG.NDG
V 51	(N,A) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
V 51	(N,P) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Mn 55	(N,2N) energy dist	1.4+07		OSA	Expt	P,INDC(JPN)-194/U,97	Mar05	MURATA+.PENCIL-BEAM DT N SOURCE.NDG
Fe 0	(D,X) cross sect	3.3+07	4.0+07	JAE	Expt	P,INDC(JPN)-194/U,39	Mar05	NAKAO+.X=CO55,56.ACT SIG.NDG
Fe 54	(N,A) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Fe 54	(N,P) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Co 59	(N,A) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Co 59	(N,P) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Ni 0	(D,X) cross sect	3.3+07	4.0+07	JAE	Expt	P,INDC(JPN)-194/U,39	Mar05	NAKAO+.X=CO55,CU60,61.ACT SIG.NDG
Ni 58	(N,A) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Ni 58	(N,P) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Ni 61	(N,A) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Ni 61	(N,P) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Cu 0	(A,X) yield	4.0+08		KEK	Expt	P,INDC(JPN)-194/U,11	Mar05	MATSUMURA+.X=BE10.CFD PHOTOREACT YIELD
Cu 0	(A,X) yield	4.0+08		KEK	Expt	P,INDC(JPN)-194/U,11	Mar05	MATSUMURA+.X=BE7.CFD PHOTOREACT YIELD
Cu 0	(N,X) yield		5.0+08	KEK	Expt	P,INDC(JPN)-194/U,11	Mar05	MATSUMURA+.X=BE10.SPALLATION N SOURCE
Cu 0	(N,X) yield		5.0+08	KEK	Expt	P,INDC(JPN)-194/U,11	Mar05	MATSUMURA+.X=BE7.SPALLATION N SOURCE
Cu 65	(N,A) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Cu 65	(N,P) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Zn 0	(P,X) cross sect	2.6+07	6.7+07	TOH	Expt	P,INDC(JPN)-194/U,104	Mar05	TARKANYI+.ACT SIG.STACKED FOIL METHOD
Zn 67	(N,A) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Zn 67	(N,P) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Ga 69	(N,A) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Ga 69	(N,P) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Ge 70	(N,X) Evaluation		2.0+07	JAE	Eval	P,INDC(JPN)-194/U,35	Mar05	IWAMOTO+.FOR ENDF/B-VII

Element	Quantity	Energy(eV)		Lab	Type	Reference	Date	Comments
Ge 72	(N,X) Evaluation		2.0+07	JAE	Eval	P,INDC(JPN)-194/U,35	Mar05	IWAMOTO+.FOR ENDF/B-VII
Ge 73	(N,X) Evaluation		2.0+07	JAE	Eval	P,INDC(JPN)-194/U,35	Mar05	IWAMOTO+.FOR ENDF/B-VII
Ge 74	(N,X) Evaluation		2.0+07	JAE	Eval	P,INDC(JPN)-194/U,35	Mar05	IWAMOTO+.FOR ENDF/B-VII
Ge 76	(N,X) Evaluation		2.0+07	JAE	Eval	P,INDC(JPN)-194/U,35	Mar05	IWAMOTO+.FOR ENDF/B-VII
Se 77	(N,INL) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,86	Mar05	SHIMIZU+.ACT SIG TO META.REL IN115
Br 79	(N,A) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Br 79	(N,INL) cross sect	2.5+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,88	Mar05	SHIMIZU+.ACT SIG.PULSED DD NEUTRONS
Br 79	(N,INL) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,86	Mar05	SHIMIZU+.ACT SIG TO META.REL IN115
Br 79	(N,P) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Sr 87	(N,INL) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,86	Mar05	SHIMIZU+.ACT SIG TO META.REL IN115
Y 89	(N,INL) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,86	Mar05	SHIMIZU+.ACT SIG TO META.REL IN115
Zr 90	(N,INL) cross sect	2.5+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,88	Mar05	SHIMIZU+.ACT SIG.PULSED DD NEUTRONS
Zr 90	(P,X+P) double diff	1.5+08	3.9+08	KYU	Theo	P,INDC(JPN)-194/U,72	Mar05	GAIDAROV+.SEMICLASSICAL DW MODEL.NDG
Nb 93	(N,A) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Nb 93	(N,P) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Mo 0	(P,X) cross sect	2.2+07	6.7+07	TOH	Expt	P,INDC(JPN)-194/U,102	Mar05	UDDIN+.ACT SIG.STACKED FOIL METHOD
		prodacts = 42-MO-93M/99,43-TC-94/95/95M/96,41-NB-90/92M/95/96,40-ZR-86/88/89,39-Y-86/87/88						
Mo 92	(N,A) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Mo 92	(N,P) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Tc 99	(N,0) reson param	5.6+00	2.0+01	KTO	Expt	P,INDC(JPN)-194/U,57	Mar05	KOBAYASHI+.ANALYZED BY KALMAN CODE
Tc 99	(N,G) cross sect	5.0-03	4.7+04	KTO	Expt	P,INDC(JPN)-194/U,57	Mar05	KOBAYASHI+.REL B10(N,A).BGO.TOF
Tc 99	(N,G) cross sect	2.5-02		JNC	Expt	P,INDC(JPN)-194/U,51	Mar05	FURUTAKA+.SIG=22.8+-1.8B
Tc 99	(N,G) reson integ	5.0-01		KTO	Expt	P,INDC(JPN)-194/U,57	Mar05	KOBAYASHI+.RI=330+-19B
Ru 96	(N,A) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Ru 96	(N,P) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,85	Mar05	SHIMIZU+.ACT SIG REL IN115(N,N')IN115M
Ag 0	(A,X) yield	4.0+08		KEK	Expt	P,INDC(JPN)-194/U,11	Mar05	MATSUMURA+.X=BE10.CFD PHOTOREACT YIELD
Ag 0	(A,X) yield	4.0+08		KEK	Expt	P,INDC(JPN)-194/U,11	Mar05	MATSUMURA+.X=BE7.CFD PHOTOREACT YIELD
Ag 0	(N,X) yield		5.0+08	KEK	Expt	P,INDC(JPN)-194/U,11	Mar05	MATSUMURA+.X=BE10.SPALLATION N SOURCE
Ag 0	(N,X) yield		5.0+08	KEK	Expt	P,INDC(JPN)-194/U,11	Mar05	MATSUMURA+.X=BE7.SPALLATION N SOURCE
Ag 0	(P,X) cross sect	1.1+07	8.0+07	TOH	Expt	P,INDC(JPN)-194/U,103	Mar05	UDDIN+.ACT SIG.STACKED FOIL METHOD
		prodacts = 47-AG-105/106M,46-PD-100/101/103,45-RH-99/100/101M/102/105,44-RU-97						

Element	Quantity	Energy(eV)		Lab	Type	Reference	Date	Comments
Ag107	(N,INL) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,86	Mar05	SHIMIZU+.ACT SIG TO META.REL IN115
Ag109	(N,INL) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,86	Mar05	SHIMIZU+.ACT SIG TO META.REL IN115
Cd111	(N,INL) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,86	Mar05	SHIMIZU+.ACT SIG TO META.REL IN115
In113	(N,INL) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,86	Mar05	SHIMIZU+.ACT SIG TO META.REL IN115
Ba137	(N,INL) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,86	Mar05	SHIMIZU+.ACT SIG TO META.REL IN115
Hf179	(N,INL) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,86	Mar05	SHIMIZU+.ACT SIG TO META.REL IN115
Ta181	(D,X) cross sect	3.3+07	4.0+07	JAE	Expt	P,INDC(JPN)-194/U,39	Mar05	NAKAO+.X=TA178,180.ACT SIG.NDG
Ta181	(P,X) cross sect	2.8+07	7.0+07	TOH	Expt	P,INDC(JPN)-194/U,102	Mar05	UDDIN+.ACT SIG.AVF CYCLOTRON
		prodacts = 73-TA-175/176/177/180,72-HF-173/175,74-W-178,71-LU-179						
Ta181	(P,X+N) diff TTY	5.0+07		TOH	Expt	P,INDC(JPN)-194/U,101	Mar05	AOKI+.TOF.ANG=0-90DEG.CFD LA150
W 0	(P,X+N) diff TTY	5.0+07		TOH	Expt	P,INDC(JPN)-194/U,101	Mar05	AOKI+.TOF.ANG=0-90DEG.CFD LA150
Pt 0	(P,X) cross sect	TR	7.0+07	TOH	Expt	P,INDC(JPN)-194/U,103	Mar05	TARKANYI+.ACT SIG.STACKED FOIL METHOD
		prodacts = 79-AU-191/192/193/194/195/196G/196M/196M2/198G,78-PT-188/189/191/195						
		prodacts = 77-IR-188/189/190/192/194M						
Au197	(A,X) yield	4.0+08		KEK	Expt	P,INDC(JPN)-194/U,11	Mar05	MATSUMURA+.X=BE10.CFD PHOTOREACT YIELD
Au197	(A,X) yield	4.0+08		KEK	Expt	P,INDC(JPN)-194/U,11	Mar05	MATSUMURA+.X=BE7.CFD PHOTOREACT YIELD
Au197	(N,INL) cross sect	2.5+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,88	Mar05	SHIMIZU+.ACT SIG.PULSED DD NEUTRONS
Au197	(N,INL) cross sect	2.1+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,86	Mar05	SHIMIZU+.ACT SIG TO META.REL IN115
Au197	(N,X) yield		5.0+08	KEK	Expt	P,INDC(JPN)-194/U,11	Mar05	MATSUMURA+.X=BE10.SPALLATION N SOURCE
Au197	(N,X) yield		5.0+08	KEK	Expt	P,INDC(JPN)-194/U,11	Mar05	MATSUMURA+.X=BE7.SPALLATION N SOURCE
Pb207	(N,INL) cross sect	2.5+06	3.1+06	NAG	Expt	P,INDC(JPN)-194/U,88	Mar05	SHIMIZU+.ACT SIG.PULSED DD NEUTRONS
Bi209	(N,G) cross sect	5.0+03	5.2+05	TIT	Expt	P,INDC(JPN)-194/U,109	Mar05	IGASHIRA+.TOF.LI7(P,N) N SOURCE
Bi209	(N,G) energy dist	5.0+03	5.2+05	TIT	Expt	P,INDC(JPN)-194/U,109	Mar05	IGASHIRA+.TOF.LI7(P,N) N SOURCE
U 238	(O16,X) cross sect	NDG		JAE	Expt	P,INDC(JPN)-194/U,43	Mar05	NISHIO+.X=FM248,249,250.CFD STAT MDL
Np237	(N,G) cross sect	2.0-02	1.0+02	JNC	Expt	P,INDC(JPN)-194/U,52	Mar05	SHCHERBAKOV+.REL B10(N,A).BGO.TOF
Np238	(N,G) cross sect	PILE		JNC	Expt	P,INDC(JPN)-194/U,49	Mar05	HARADA+.SIG=479+-24B.DOUBLE N CAPTURE
Many	(N,X) Evaluation	2.0+07	3.0+09	KYU	Eval	P,INDC(JPN)-194/U,67	Mar05	WATANABE+.JENDL HIGH ENERGY FILE
Many	(P,X) Evaluation		3.0+09	KYU	Eval	P,INDC(JPN)-194/U,67	Mar05	WATANABE+.JENDL HIGH ENERGY FILE

(by JNDC CINDA group)

I. Aichi Shukutoku University

A. Department of Media Theories and Production

I-A-1 Saturation of Asymmetric Nuclear Matter

K. Oyamatsu[1,2,3] and K. Iida[2]
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[2] *The Institute of Physical and Chemical Research (RIKEN)*
[3] *Department of Physics, Nagoya University*

A paper of the title was published in Proc. 2003 Symposium on Nuclear Data, JAERI-Conf 2004-005, pp. 184-189 (2004) with the following abstract.

We examine relations among the parameters characterizing the phenomenological equation of state (EOS) of nearly symmetric, uniform nuclear matter near the saturation density by comparing macroscopic calculations of radii and masses of stable nuclei with the experimental data. The EOS parameters of interest here are the symmetry energy S_0, the density symmetry coefficient L, and the incompressibility K_0 of symmetric nuclear matter at the normal nuclear density. In this study, we also examine the incompressibility of asymmetric matter, which was fixed in a certain functional form in our previous study. This parameter could be important in the description of neutron-rich nuclei and neutron-star matter. In the present study, we treat the incompressibility of the asymmetric matter as a free parameter in fitting the masses and radii, obtain essentially the same EOS parameter values as those in the previous study, and confirm the two important features for symmetry energy; a strong correlation between S_0 and L, and the upper bound of L which is an increasing function of K_0. The present results strongly support the the prediction of the previous study that the matter radii of neutron-rich nuclei depend strongly on L while being almost independent of K_0. This is a feature that will help to determine the L value via systematic measurements of nuclear size.

II. Central Research Institute of Electric Power Industry

A. Nuclear Technology Research Laboratory

II-A-1 Neutron and Gamma Ray Source Evaluation of LWR High Burn-up UO_2 and MOX Spent Fuels

A. SASAHARA[1], T. MATSUMURA[1], G. NICOLAOU[2,*] and D. PAPAIOANNOU[3]

A paper on this subject was published in J. Nucl. Sci. Technol., Vol. 41, No. 4, pp.448-456, 2004 with following abstract.

The axial neutron emission and gamma ray source distribution were measured for LWR high burn-up UO_2 and MOX spent fuel rods. The gamma rays of ^{134}Cs, ^{137}Cs and ^{106}Ru were measured on the fuel rods, and consequently compared with the results of the ORIGEN2/82 calculation, in which both the original library and ORLIBJ32 based on the JENDL-3.2 library were used. The effect of pellet radial gamma distribution on self-shielding factor was considered, and cesium radial migration was also discussed using the ratio of gamma ray intensity of ^{134}Cs to ^{137}Cs. The axial gamma ray measurement and calculation of ^{134}Cs and ^{106}Ru agreed within about 20% and ^{137}Cs agreed within 13% after correction with pellet self-shielding factors. Two types of boundary curves associated with cesium migration were obtained by simple analysis using ^{134}Cs/^{137}Cs gamma intensity ratio. The axial neutron emission calculated by ORIGEN2/82 with ORLIBJ32 was generally smaller than the measured ones. The main neutron source in spent fuel is the spontaneous fission of ^{244}Cm. Small buildup of ^{244}Cm caused the underestimation of neutron emission. The main flow up to ^{244}Cm is ^{241}Pu, ^{242}Pu, ^{243}Pu, ^{243}Am and ^{244m}Am. The (n,γ) cross sections of ^{243}Am on the main flow and ^{244}Cm have strong sensitivity on buildup of ^{244}Cm. The re-evaluation of the (n,γ) cross sections of these nuclides will improve the prediction for ^{244}Cm buildup.

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III. High Energy Accelerator Research Organization

A. Radiation Science Center

III-A-1 Target dependence of beryllium fragment production in neutron- and alpha-induced nuclear reactions at intermediate energies

H. Matsumura[1], T. Sanami[1], K. Masumoto[1], N. Nakao[1], A. Toyoda[1], M. Kawai[1],
T. Aze[2], H. Nagai[2], M. Takada[3] and H. Matsuzaki[4]

A paper on this subject was submitted to Radiochimica Acta in 2005, with the following abstract.

The yields of ^{7}Be on ^{nat}C, ^{27}Al, ^{nat}Cu, ^{nat}Ag, and ^{197}Au targets and ^{10}Be on ^{nat}Cu, ^{nat}Ag, and ^{197}Au targets in alpha- (400 MeV) and neutron- (maximum end-point energy, E_0, = 500 MeV) induced reactions were measured in order to compare them with the photoreaction yields at E_0 = 1000 MeV. The target-mass dependences of the yields of ^{7}Be and ^{10}Be showed very similar trends among alpha-, neutron-, and photon-induced reactions. The fragmentation yields of ^{7}Be decreased more slowly, and those of ^{10}Be increased gradually with an increase in the target mass; both yields intersected at an approximate target mass of 125. The exponential increase in the fragmentation-yield ratios of ^{10}Be to ^{7}Be with an increase in the proton-to-neutron ratio of the targets suggests that pre-formation of the fragments inside the excited nuclei is strongly influenced by the target properties, such as N/Z. Furthermore, the effect of the difference in the incident particle was clearly observed in the yield ratios of ^{10}Be to ^{7}Be on the Cu and Ag targets.

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IV. Hokkaido University

A. Division of Physics

IV-A-1 DARPE: retrieving and plotting tool for the nuclear reaction data

Sergei Korennov and Naohiko Otuka
Japan Charged-Particle Nuclear Reaction Data Group (JCPRG)*

The JCPRG has begun compiling in NRDF format in 1974. More than one thousand data files have been compiled since then. With the rapid expansion of the Internet in the 1990s, it became possible to make a public access to the NRDF database, with a possibility of intelligent search, retrieval and convenient graphical presentation of the data.

DARPE (DAta Retrieving and Plotting Engine) is a user-friendly tool for searching, retrieval and visualization of the nuclear reaction data in the NRDF format. It is based on the Common Gate Interface (CGI). The user accesses the system via the Internet using a conventional browser. No additional software or extra skills are required.

The front page (Fig.1) invites the user to form a query with keywords (from a menu or by typing in a text) with respect to the bibliographical data (author, journal, etc.) or a particular reaction, energy range (a single value or a range) etc. The result of a search (Fig.2) is arranged in a table, where publications (i.e., database entries) and, when applicable, separate data subsets meeting the query criteria are listed. The information can be shown in a brief or verbose mode; the bold font, color and footnotes are used to make it easily understood by the user. With one click of the mouse the user can see a plot related to a particular data table; alternatively, the user can arrange data from various sets (for example, of different experiments) and plot them together for comparison and analysis (Fig.3). The original numerical data tables are also easily accessible.

Although the same data produced by the JCPRG is often available in the EXFOR format maintained by the IAEA, additional information stored in the NRDF data files used by DARPE may be of interest to the user. Due to necessary procedures, the data in the NRDF format becomes available.

New data is added to the database as soon as it is compiled by the JCPRG. Appearance of the same data in the EXFOR format supported by IAEA is somewhat delayed by necessary checks and revisions; thus a DARPE search may produce additional results in comparison with other search engines. For the sake of clarity, the newest data is labelled with a "NEW!" sign.

DARPE has been open for public use and is located at:

http://www.jcprg.org/nrdf/

Reference:

1. S. Korennov and K. Naito, NRDF Annual Report 2002, 39.

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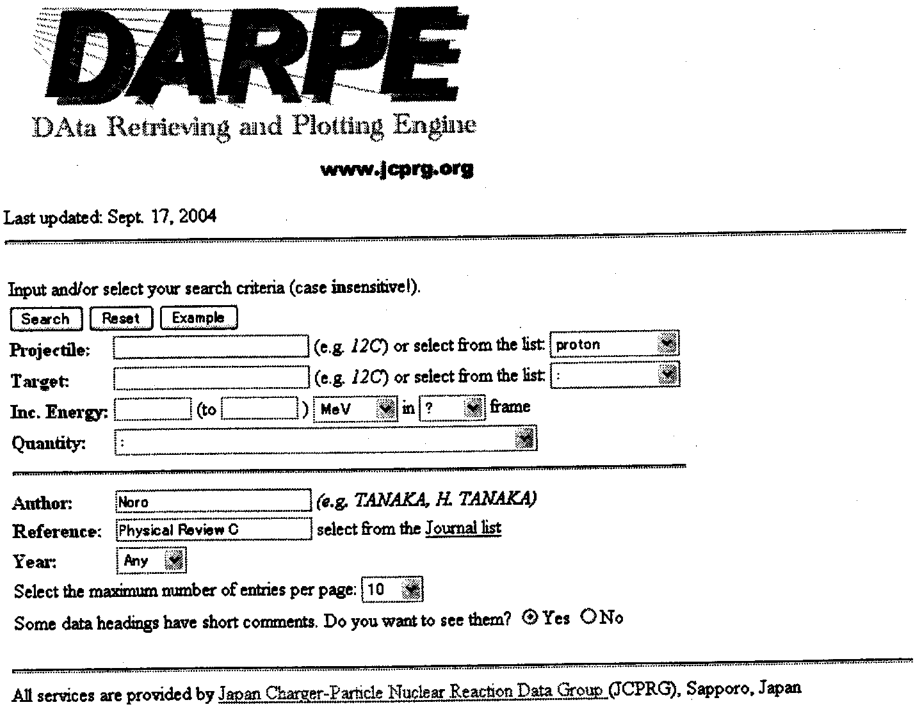
E-mail: services@jcprg.org WWW: http://www.jcprg.org/



DARPE
DAta Retrieving and Plotting Engine
www.jcprg.org

Last updated: Sept. 17, 2004

Input and/or select your search criteria (case insensitive!).

Search | Reset | Example

Projectile: (e.g. *12C*) or select from the list: proton

Target: (e.g. *12C*) or select from the list: :

Inc. Energy: (to) MeV in ? frame

Quantity: :

Author: Noro *(e.g. TANAKA, H. TANAKA)*

Reference: Physical Review C select from the Journal list

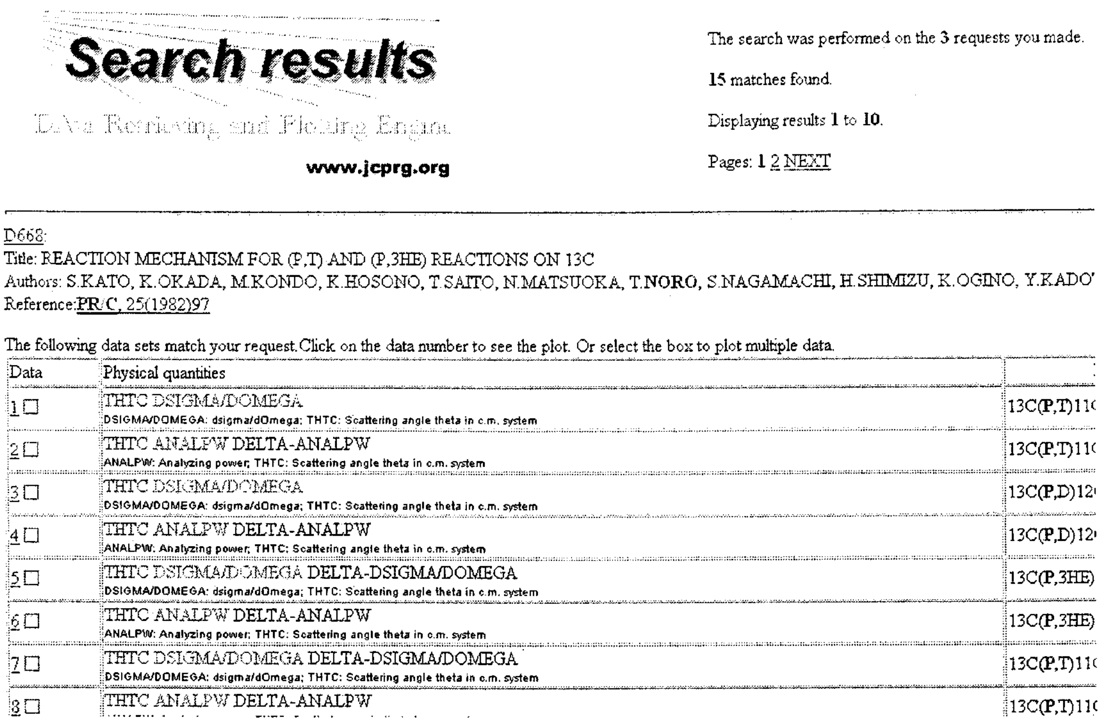
Year: Any

Select the maximum number of entries per page: 10

Some data headings have short comments. Do you want to see them? ⊙Yes ○No

All services are provided by Japan Charger-Particle Nuclear Reaction Data Group (JCPRG), Sapporo, Japan

Fig. 1 Front page of DARPE (http://www.jcprg.org/nrdf/).



Search results

Data Retrieving and Plotting Engine

www.jcprg.org

The search was performed on the 3 requests you made.

15 matches found.

Displaying results 1 to 10.

Pages: 1 2 NEXT

D668:

Title: REACTION MECHANISM FOR (P,T) AND (P,3HE) REACTIONS ON 13C

Authors: S.KATO, K.OKADA, M.KONDO, K.HOSONO, T.SAITO, N.MATSUOKA, T.NORO, S.NAGAMACHI, H.SHIMIZU, K.OGINO, Y.KADO'

Reference: PR/C, 25(1982)97

The following data sets match your request.Click on the data number to see the plot. Or select the box to plot multiple data.

Data	Physical quantities	
1 ☐	THTC DSIGMA/DOMEGA DSIGMA/DOMEGA: dsigma/dOmega; THTC: Scattering angle theta in c.m. system	13C(P,T)11(
2 ☐	THTC ANALPW DELTA-ANALPW ANALPW: Analyzing power; THTC: Scattering angle theta in c.m. system	13C(P,T)11(
3 ☐	THTC DSIGMA/DOMEGA DSIGMA/DOMEGA: dsigma/dOmega; THTC: Scattering angle theta in c.m. system	13C(P,D)12(
4 ☐	THTC ANALPW DELTA-ANALPW ANALPW: Analyzing power; THTC: Scattering angle theta in c.m. system	13C(P,D)12(
5 ☐	THTC DSIGMA/DOMEGA DELTA-DSIGMA/DOMEGA DSIGMA/DOMEGA: dsigma/dOmega; THTC: Scattering angle theta in c.m. system	13C(P,3HE)
6 ☐	THTC ANALPW DELTA-ANALPW ANALPW: Analyzing power; THTC: Scattering angle theta in c.m. system	13C(P,3HE)
7 ☐	THTC DSIGMA/DOMEGA DELTA-DSIGMA/DOMEGA DSIGMA/DOMEGA: dsigma/dOmega; THTC: Scattering angle theta in c.m. system	13C(P,T)11(
8 ☐	THTC ANALPW DELTA-ANALPW	13C(P,T)11(

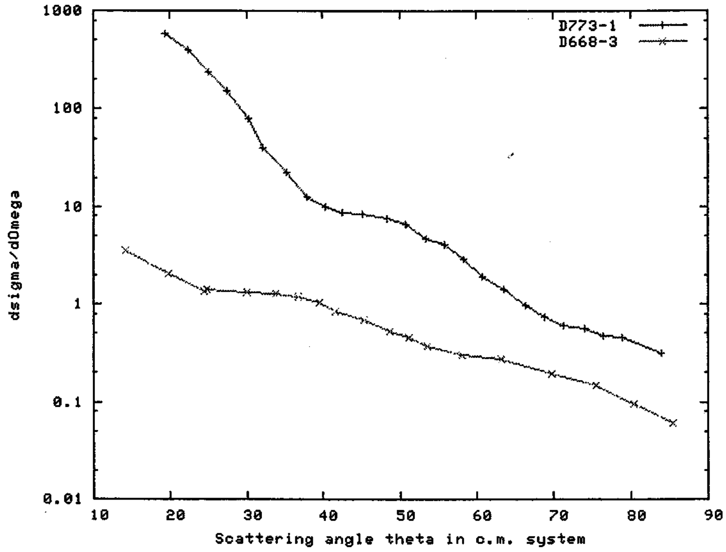
Fig.2 Example of search results. List of data sets is shown for NRDF file D668.

[SEARCH]

Data file

DAta Retrieving and Plotting Engine

www.jcprg.org



[LINER]

D773-1:
X-UNIT = (DEG)
Y-UNIT = (MB/SR)
RCT = 16O(P,P)16O

Fig.3 Comparison of two experimental data sets. Original NRDF file and numerical data are available.

B. Meme Media Laboratory

IV-B-1 GSYS : Development and usage of a software to read-in and digitize the graphical data

A. Minoguchi[1,2], K. Arai[1,3], N. Otuka[4] and K. Naito[5]

Abstract

"GSYS" is the Java application software, which enables users to digitize graphs easily by the mouse and keyboard and obtain the original numerical data precisely. In this report, we present an overview of GSYS and a typical example for usage of this software. GSYS is available from the web site of Japan Charged-Particle Nuclear Reaction Data Group (www.jcprg.org).

1. Introduction

Japan Charged-Particle Nuclear Reaction Data Group (JCPRG) has developed and improved Nuclear Reaction Data File (NRDF). The amount of the nuclear experimental data kept in NRDF has continued to increase remarkably. In order to develop the high-quality database, it is quite important to accumulate a large amount of the precise numerical data. The best way to compile the precise numerical data is to take it directly from the author of the paper. While most of the data published recently are given from the authors, we often need to use some systems to digitize the data published previously because there are many cases that the author lost the old data or it is impossible to contact the author. Practically, a quarter of the amount of the data kept in NRDF is obtained by digitizing the graphical data. Thus, the data digitizing systems have played an important role in accumulating the numerical data. To digitize as much data as possible with accuracy and rapidity, it is necessary to use a good system which can be operated easily by anyone and read-in the numerical data with high accuracy. GSYS developed by Dr. Arai is the superior Java application software to read-in and digitize the graphical data. GSYS is the operating system independent software and can be run on user's PC on relatively high-speed. Particularly, it has the advanced interface. Users can operate GSYS using not only mouse but also keyboard. And it is possible to zoom in the picture and fine-tune the position of the marker which indicate the data point in the figure easily so that the numerical data is read-in precisely. Additionally, GSYS is available from the web site of JCPRG. In following section, how to use GSYS is described in detail.

2. How to use GSYS

Since GSYS is the application software developed with Java language, it is required to install Java platform ver.1.1 or later on PC before users run GSYS. Java platform can be downloaded from the web site of Sun Microsystems (java.sun.com). About GSYS, users can download the source program, class files and manuals from the web site of JCPRG (www.jcprg.org). The source program of GSYS is Gsys.java and users can run this system by the command "java Gsys". Fig.1 shows the application window of GSYS running on Windows2000. A sample picture file is already loaded. The window of GSYS consists of three parts. The left part of the window is the control panel to operate GSYS, the lower right part the main panel to display the loaded picture and the upper right part the information panel to display the description of the button in the control panel and the coordinate point of the data point when a pointer is on the button or the data point. Prepare a picture file to digitize before using GSYS. The supported graphics formats are GIF, JPEG and PNG.

2.1. How to digitize the original data from a picture

GSYS can be operated with a combination of mouse and keyboard. Some of the operations can be performed using some keys instead of clicking the buttons in the control panel. Correspondence between keys and buttons is shown in Table.1. Now, let us explain how to use GSYS on the basis that users operate GSYS mainly using mouse. In order to read-in the graphical data precisely, we recommend to zoom in the picture and fine-tune the position of the marker on the data point carefully.

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[4] Nuclear Data Center, Japan Atomic Energy Research Institute (JAERI)
[5] KBMJ, Inc. Engineer

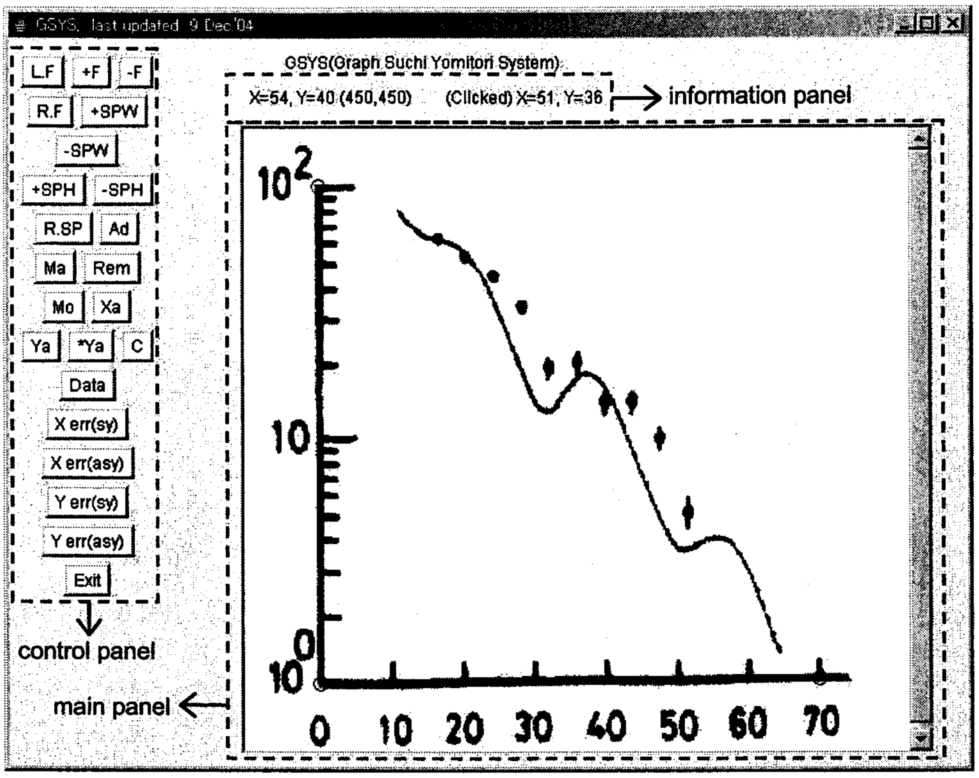

Fig. 1 Application window of GSYS (Sample picture is already loaded.). When "L.F" button is clicked, the dialog box to select a picture file appears. Since the start and end points of X and Y axes (blue open circles) are already determined, X and Y axes are indicated by pink solid lines. The coordinate point of the new point which is pointed by a mouse pointer is displayed in the left side of the information panel. The coordinate point of the last point which is clicked and read-in is displayed in the right side of the information panel.

1) Click "L.F" button on the upper left corner of the control panel to load a picture file. The dialog box to select a picture file appears. The loaded picture is shown in the main panel.

2) Determine the start and end points of X and Y axes of the picture: Click "Xa" button and then click the start and end points of X axis. After that, click "Ya" button and then click the start and end points of Y axis. If the start points of X and Y axes are at the same position on the picture, click "*Ya" button instead of "Ya" button and then click only the end point of Y axis. These points of X and Y axes are indicated by blue open circles and X and Y axes by pink solid lines.

3) Read-in the data points: Click "Ad" button (The color of "Ad" button is changed from white to red.). Click the first data point on the picture and then the point is indicated as a red solid circle. When the new data point is clicked, the new one is indicated as a red solid circle while the former one is as a pink solid circle. The user can point the data points continuously. The pointed data points are indicated as the pink solid circles as shown in Fig. 2. When all the data points are pointed, click "Ad" button again to deactivate the data-input mode (The color of "Ad" button is changed from red to white.) The size of the picture can be enlarged and reduced using "+F" and "-F" buttons, respectively. "R.F" button is used to restore the default size setting of the picture. And also, it is possible to adjust the size of the main panel. The width of the main panel is expanded and narrowed using "+SPW" and "-SPW" buttons. The length of the main panel is extended and reduced using "+SPH" and "-SPH" buttons.

4) In order to mark a given data point, click "Ma" button (The color of "Ma" button is changed from white to red.) and then click the data point. The color of focused data point is changed from pink to red. When "Ma" button is clicked again (The color of "Ma" button is changed from red to white.), the data-focus mode is deactivated. If the position of a data point is to be fine-tuned, mark the data point and then click "Mo" button. Push the arrow keys on a keyboard to move the focused data point every 1 pixels. When "Mo" button is clicked again, the data-move mode is deactivated. To remove a data point, mark the data point and then click "Rem" button to remove the focused data point. Also, the start and end points of X and Y axes can be moved in the way described above. Since, however, the start and end points of X and Y axes cannot be removed in the way described above, the user need to determine

those point again using "Xa", "Ya" and "*Ya" buttons instead.

5) In order to read-in an error bar, mark the data point with the error bar using "Ma" button. In the case of a symmetric X (Y) error bar, click "X err (sy)" ("Y err (sy)") button and click the one end of the error bar. In the case of an asymmetric X (Y) error bar, click "X err (asy)" ("Y err (asy)") button and click the both ends of the error bar. When the position of a data point is moved, that of the error bar is also moved together. To move only the position of a given error bar, mark the data point with the error bar and click "Mo" button. In the next, click any one of "F5"(for symmetric X error bar or one end, which is pointed primarily, of asymmetric X error bar), "F6"(for one end, which is pointed secondarily, of asymmetric X error bar), "F7"(for symmetric Y error bar or one end, which is pointed primarily, of asymmetric Y error bar) and "F8"(for one end, which is pointed secondarily, of asymmetric Y error bar) keys to indicate a red solid circle at the tip of the movable error bar. The error bar is moved using the arrow keys. Since it is impossible to remove only an error bar, remove the data point with the error bar and read-in it anew.

6) In order to clear all the markers for the start and end points of X and Y axes and focused data points to go back to the process 1), click "C" button.

7) Click "Exit" button to exit out of GSYS.

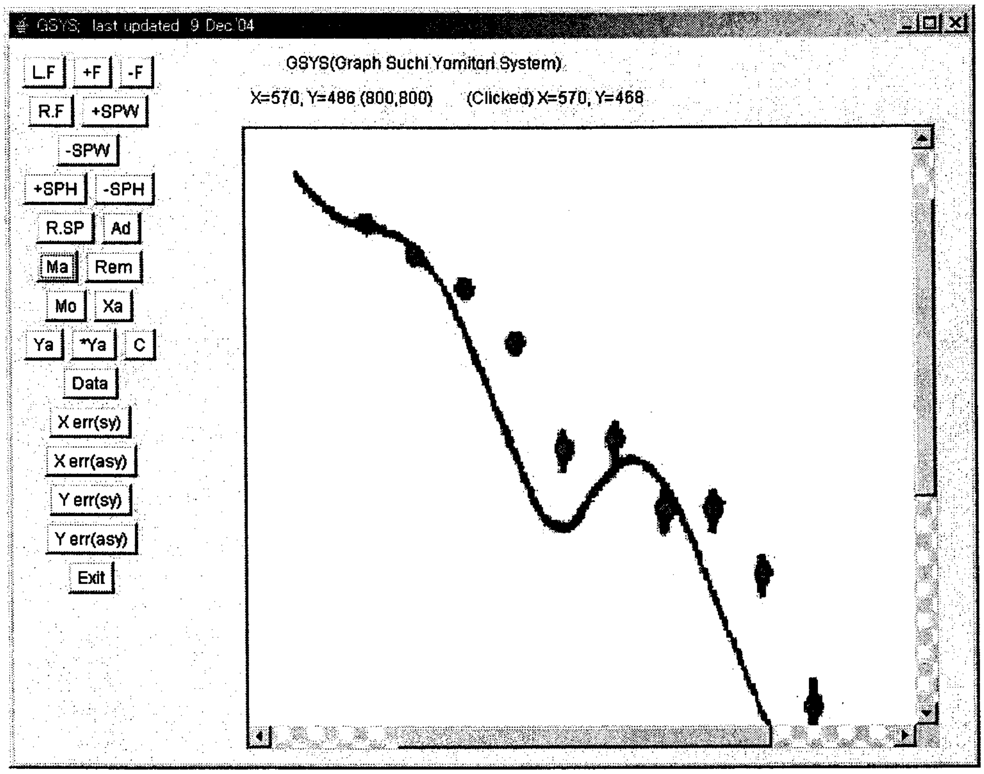

Fig. 2 Sample of reading the data points. The size of the picture is enlarged so that the center of a data point is found precisely. There are four data points without error bars in the left side of the picture and six data points with symmetric Y error bars in the right side of the picture.

Table.1 Correspondence between keys and buttons in the control panel. (*,** : Up and down arrow keys are available for adjusting the size of a picture only if "Mo" button is deactivated.)

Button	*Key*	*Button*	*Key*
+F (zoom in a loaded picture)	**up arrow key***	**Rem** (remove a focused point)	**Esc**
-F (zoom out a loaded picture)	**down arrow key****	**Data** (call data output window)	**O**
R.F (restore default picture size)	**R**	**X err(sy)** (for symmetric X error bars)	**F1**
Ad (activate data-input mode)	**A**	**X err(asy)** (for asymmetric X error bars)	**F2**
Ma (activate data-focus mode)	**M**	**Y err(sy)** (for symmetric Y error bars)	**F3**
Mo (activate data-move mode)	**V**	**Y err(asy)** (for asymmetric Y error bars)	**F4**

2.2. How to give an output of the numerical data

1) Click "Data" button after all the data points are pointed. The new window to output the numerical data appears as shown in Fig.3. The top part is the control panel and the bottom part is the main panel to display the numerical values of the data points. The width and height of the main panel are adjustable by using "+SPW", "-SPW", "+SPH" and "-SPH" buttons.
2) Give the numerical values of the start and end points of X and Y axes at the "x(start)=", "x(end)=", "y(start)=" and "y(end)=" boxes. Select the type of the form about the error bar from the options (No Error or X Error or Y Error or X & Y Error) and the expression of the error value from the options (Relative or Absolute) in "Error value" boxes. Finally, select the type of the scale of X and Y axes from the options (Linear or Log) in "Scale" boxes.
3) Click "Write" button to give the numerical values of the data points in the main panel. A typical example is shown in Fig.3. It is possible to sort the numerical data set so that the X (Y) values are in ascending order using "Sort X" ("Sort Y") button. Click "Write" button again to restore the default order.
4) In order to save the numerical data to a file, click "Save" button. Click "Close" button to close this window.

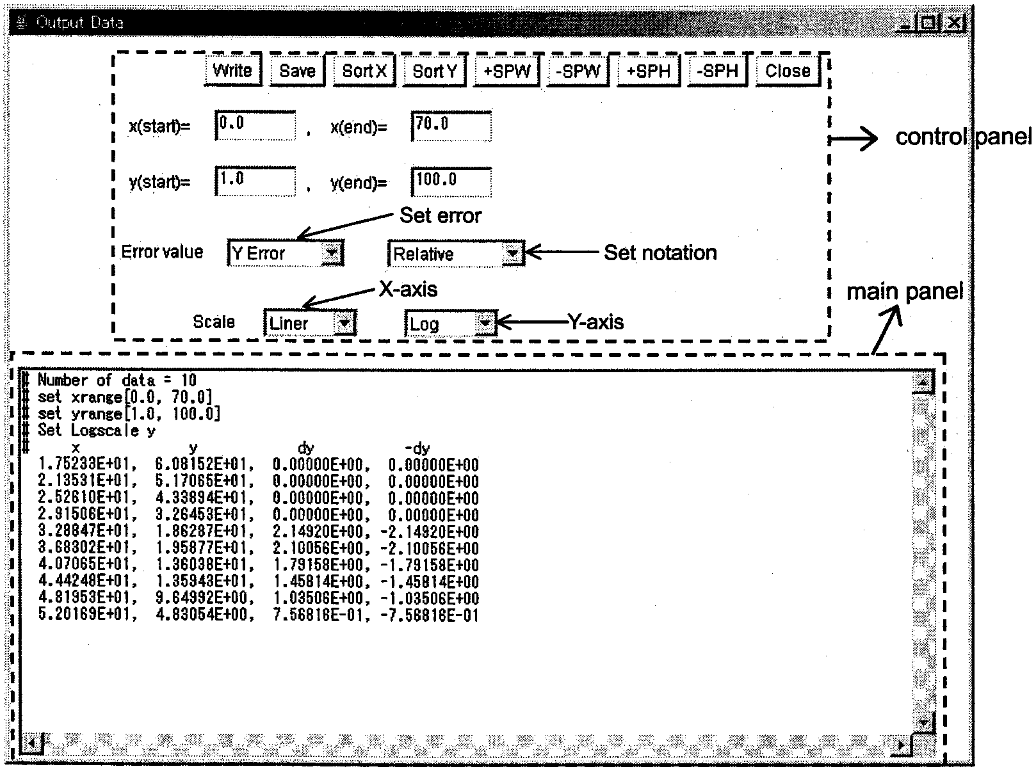

Fig. 3 Sample of output window which displays numerical data values with symmetric Y errors. Starting from the left, X values, Y values and Y error values are displayed in the main panel.

3. Conclusions

In this report, we have present our new system named "GSYS", which is based on Java and therefore can be operated on any kind of the operating system, for digitizing the graphic data on the printed matter. This system can be lightly worked on your PC and easily operated by the mouse and keyboard.

Further improvement and development of GSYS are now in progress. Moreover, not only the class files but also the source program can be downloaded from the web site of JCPRG so that anyone can improve and modify GSYS.

IV-B-2 Database System of the Observed Properties of Stars in the Early Universe

T. Suda [1 2], T. Suwa[2], K. Hayasaki[2 3], M. Aikawa[1 4], & M. Y. Fujimoto[2]

Abstract

We have launched the project of constructing the database of astronomical observations since 2003. The purpose of the project is to accumulate the data to investigate the history of the nucleosynthesis in stellar interior through the nuclear reactions. We aim at understandings of the properties of stars in the early universe by comparing many photometric data, derived parameters of stellar atmosphere, and derived element abundances for individual stars in the Galactic halo. In this report, we present the plan of the construction of the system and the current status of the project.

1 Background and Overview

Recent development of the ground-based 8 m-class telescopes enables us to observe more distant and older stars compared with the earlier 4 m-class telescopes. Stars born in the early universe are thought to have small fraction of iron abundance in the surface of the star relative to that of the sun because Big-Bang cosmology and nucleosynthetic theory suggest that the elements heavier than lithium are made in the star and accumulated in the universe by the reccurence of the birth and death of stars by the stellar wind or supernovae. Therefore, the older the stars, the smaller abundances of iron group elements. Such old and very old stars play an important role in understanding the theory of the history of star formation, galaxy formation and the universe as well as the nucleosynthesis in stars. These stars may survive long time comparable to the age of the universe and may be located in our galaxy and, in fact, many stars having thousand times smaller fraction of iron abundance than the sun are observed today. Among them, the extremely iron-poor star, whose iron abundance is less than that of the sun by the factor of two hundred thousand[1)], was found and it is very the candidate star of second generation star born from the supernova of the first stars[2)] or first generation star[3)].

The project of assembling the data of metal-poor stars is motivated by the growing number of observations and a hot controversy raged on the question of when and how the first stars were born. Although there are many data center for the observations of astronomical research in the world, it is worth giving an eye to the field of stellar abundance analyses which have made rapid progresses in the number of observations as well as in the accuracy. Our project may also give an opportunity to compare the stellar evolution with nucleosynthesis by estimating the nucler reaction cross section compiled by nuclear physicist.

This project focuses on the derived properties from observed stars in the literature, while other database systems accumulate data taken from the observational device without any analyses or the bibliographical information. Our interest includes the evolutionary status of stars derived from the determination of stellar atmosheric models and the composition derived from detailed analyses based on the atomic data. In order to compare the theory and observation, it is important to discuss about these parameters and absolute/relative abundance of detected element for each star. In general, it is not easy for us to get reduced, and analized data taken by the authors of the papers, while spectral and bibliographical data are available in many database systems. In the following sections, we report the current status of the system that we enter the list of publications with regard to the observation of metal-poor stars, input the required data of observed stars, and retrieve from the database.

2 Current Status of the System

2.1 Bibliographical management system

In order to compile data from literature, the list of papers concerning the observation of metal-poor stars is needed. We developed the system for entering the bibliographical information at the database server

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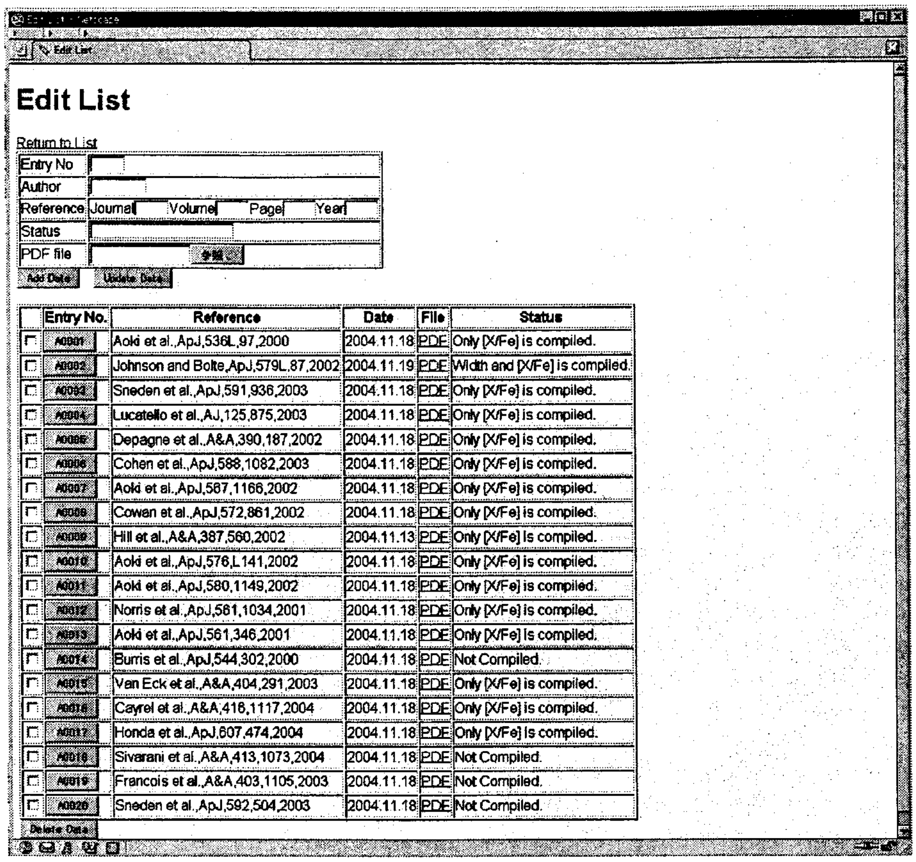
via internet with CGI script and MySQL, latter of which is so called the Relational Database Management System (RDBMS). With this system, users can register, edit and delete the list of publication by the form on the web. In Fig.1, the sample web-page of the system is shown.


Edit List

Return to List

Entry No	
Author	
Reference	Journal Volume Page Year
Status	
PDF file	

Add Data Update Data

	Entry No.	Reference	Date	File	Status
	A0001	Aoki et al.,ApJ,536L,97,2000	2004.11.18	PDF	Only [X/Fe] is compiled.
	A0002	Johnson and Bolte,ApJ,579L,87,2002	2004.11.19	PDF	Width and [X/Fe] is compiled.
	A0003	Sneden et al.,ApJ,591,936,2003	2004.11.18	PDF	Only [X/Fe] is compiled.
	A0004	Lucatello et al.,AJ,125,875,2003	2004.11.18	PDF	Only [X/Fe] is compiled.
	A0005	Depagne et al.,A&A,390,187,2002	2004.11.18	PDF	Only [X/Fe] is compiled.
	A0006	Cohen et al.,ApJ,588,1082,2003	2004.11.18	PDF	Only [X/Fe] is compiled.
	A0007	Aoki et al.,ApJ,567,1166,2002	2004.11.18	PDF	Only [X/Fe] is compiled.
	A0008	Cowan et al.,ApJ,572,861,2002	2004.11.18	PDF	Only [X/Fe] is compiled.
	A0009	Hill et al.,A&A,387,560,2002	2004.11.13	PDF	Only [X/Fe] is compiled.
	A0010	Aoki et al.,ApJ,576,L141,2002	2004.11.18	PDF	Only [X/Fe] is compiled.
	A0011	Aoki et al.,ApJ,580,1149,2002	2004.11.18	PDF	Only [X/Fe] is compiled.
	A0012	Norris et al.,ApJ,561,1034,2001	2004.11.18	PDF	Only [X/Fe] is compiled.
	A0013	Aoki et al.,ApJ,561,346,2001	2004.11.18	PDF	Only [X/Fe] is compiled.
	A0014	Burris et al.,ApJ,544,302,2000	2004.11.18	PDF	Not Compiled.
	A0015	Van Eck et al.,A&A,404,291,2003	2004.11.18	PDF	Only [X/Fe] is compiled.
	A0016	Cayrel et al.,A&A,416,1117,2004	2004.11.18	PDF	Only [X/Fe] is compiled.
	A0017	Honda et al.,ApJ,607,474,2004	2004.11.18	PDF	Only [X/Fe] is compiled.
	A0018	Sivarani et al.,A&A,413,1073,2004	2004.11.18	PDF	Not Compiled.
	A0019	Francois et al.,A&A,403,1105,2003	2004.11.18	PDF	Not Compiled.
	A0020	Sneden et al.,ApJ,592,504,2003	2004.11.18	PDF	Not Compiled.

Delete Data

Fig.1 Edit page of Bibliographical Management System. In the upper panel, users can enter the entry number which is the identifier of each paper, first author, publication date, present compilation status, and path to the uploaded file. Table below represents the registered entries.

2.2 Data input system

Data compilation can also be done on the web. Information entered via the web-form is transferred into the CSV files. Fig.2 shows the sample of Data Input System that actual data is about to be converted into CSV files. We can convert tables for abundance, photometry, and atmospheric parameters in the literature. The kind of data is selected from the list in the top of the form. For each data type, users select the number of required columns that is included in the original table and the physical quantity in the table columns and the corresponding number of column in the middle panel of the form. Next, users put the numerical table by copy and paste from the on-line data which can be taken from other database on the publication in the field of astronomy and astrophysics. The format of the numerical data are text, HTML, latex, XML, and so on and it depends on the database and journal. That is why the users have to select the format of the table. Finally, the button at the bottom of the form is pushed and input data are transformed into CSV file. Converted data files are stored in the MySQL server by running the perl script.

2.3 Data retrieving system

Data on MySQL server are retrieved by users without knowlege of technical language to access database. We are constructing the web-based retrieving system to get spectral, photometric, atmospheric, and abundance data of metal-poor stars. The system is now working only for abundance data. Fig.3 represents the plotted data by the system after sending query and choosing data to be plotted. In this sample, 10 data are plotted that are selected from database table on abundances where data includes information of iron abundance, which is so called 'metallicity', and enhancement of carbon abundance relative to iron. The former is set at x-axis and the latter at y-axis. Figures are drawn by GNUplot and users can adjust the parameters for plotting data. Numerical data and the script for plot are downloaded from the web-page. This system has common platform with the retrival system for EXFOR[4], SPES (Search and Plot Executive System) developed by Japan Charged-Particle Nuclear Reaction Data Group.

The number of data included in the system is the order of hundred and will be increased more and more in the near future and the data on photometry, stellar model, and observation will be retrieved. We are planning to develop the system to compare the observed data with the predicted theoretical models by drawing lines (or plotting points) calculated from the program of nucleosynthesis and stallar evolution.

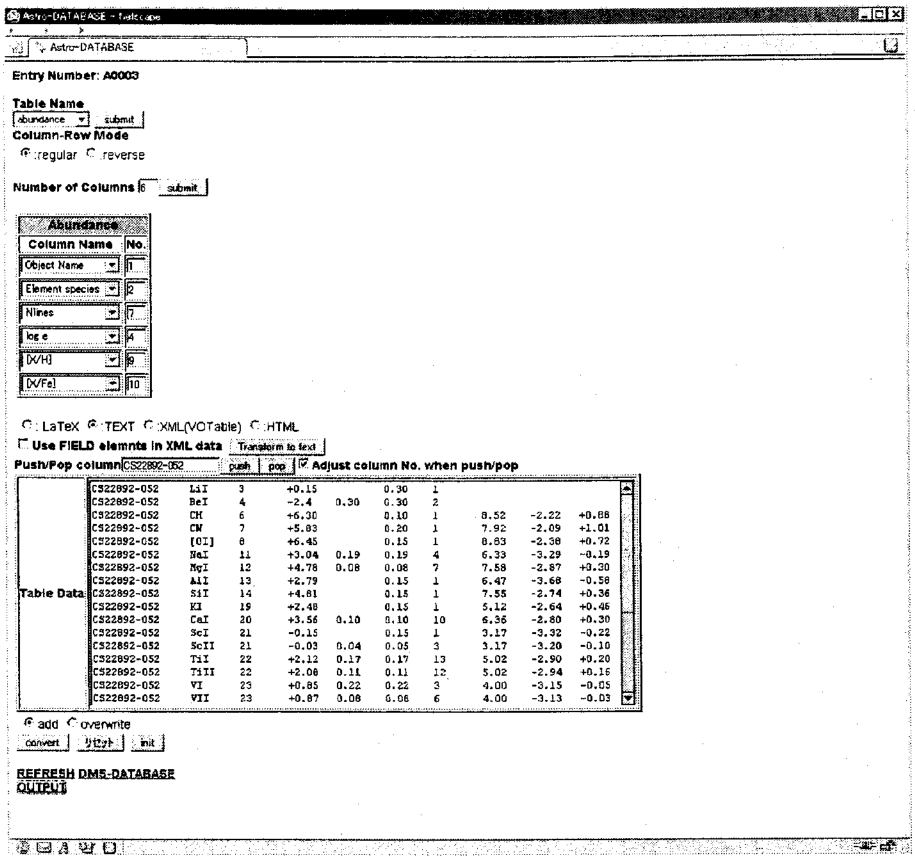


Fig.2 Sample of entering stellar abundance data by tabular form. Users can input data from online table data by copying in latex, text, XML, and html format. Various format and shape of tables in the literature is treated in the same way by choosing the name of columns and entering corresponding row. Registered CSV files can be seen or downloaded on the web.

3 Future Prospect

The system we are developping will help users who have interest in the statistical trend of metal-poor stars to give an insight into the understandings of nucleosynthesis in metal-poor stars and the chemical history of the universe in the standpoint of researchers on stellar evolution and nuclear physics. This project allows us to discuss about the following things:

- Recent observations of heavier elements than iron group elements will enable us to give statistical discussions about the tendency of two sites of nucleosynthesis, one is s-process which undergoes in stellar interior at late stage of evolution, and another is r-process which is driven by supernovae at the end of massive stars' lives, statistically.

- The retrieving system aims at the comparison of observations with theory. This may play an important roles in estimating the data of nuclear reaction cross sections as well as the stellar evolution.

- The systems can be extended to the other field of astronomy like abundance anomalies of stars in Galactic globular clusters and peculiar abundances in stars harboring planets around them.

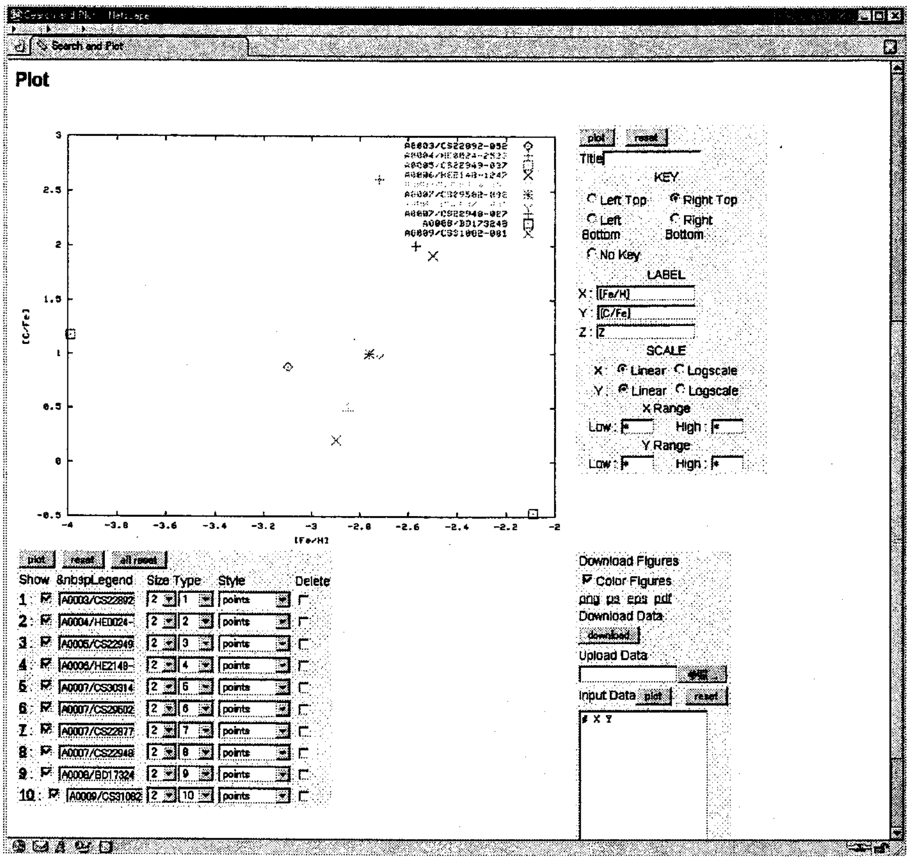


Fig.3 Plot page of Data Retrieving System. Only 10 data are selected from MySQL table where the object includes data of iron abundance and carbon abundance relative to iron. View graph is plotted with GNU plot and its options can be adjusted by the form in the righthand side. Left-bottom panel shows the list of selected list and each line and point can change its shape and size by setting parameters. Each list has a link to numerical data. Right-bottom panel is used to manage files to download figures, data, and script and to upload file and numerical data.

Acknowledgements

This work is in part supported by a Grant-in-Aid for Science Research from the Japanese Society for the Promotion of Science (Grant No. 15204010).

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[1] Christlieb, N. et al., *Nature*, 419, 904 (2002)

[2] Umeda, H. & Nomoto, K., *Nature*, 422, 871 (2003)

[3] Suda, T., Aikawa, M., Machida, M. N., Fujimoto, M. Y., & Iben, I. Jr., *The Astrophysical Journal*, 611, 476 (2004)

[4] Otsuka, N, Aikawa, M., Suda, T., Naito, K., Korennov, S., Arai, K., Noto, H., Ohnishi, A., Katō, K., Nakagawa, T., Fukahori, T., and Katakura, J., Proceedings of *International Conference on Nuclear Data for Science and Technology*, to be published by the American Institute of Physics

V. Institute of Nuclear Safety System, Incorporated

A. Institute of Nuclear Technology

V-A-1 Evaluation of Nuclear Data for Emergency Preparedness System of Nuclear Power Plants — Comparison of Radioactivity Inventories by Newest Nuclear Data and Rather Older Nuclear Data —

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Papers on this subject were published in the INSS Journal[1] and the JAERI conference[2].

The radioactivity inventories for emergency preparedness systems of nuclear power plants calculated by the combination of the generally-used in Japan (general-version), the INSS used by the present authors (INSS-version) and the newest nuclear data library and codes (newest-version) were compared, and the maintaining of conservativeness of the general-version and the INSS-version against the newest-version was examined. And the influences on the radioactivity inventories by the difference between the nuclear cross section and fission yield data, decay data and calculation codes were investigated.

As a result, (1) the radioactivity inventories calculated by general-version and INSS-version were not conservative compared with the newest-version. But the difference was less than 10%, and it would not give large influence to the calculation of the emergency preparedness system of nuclear power plants. (2) The influence of the radioactivity inventories such as ^{135}Xe build-up were observed by the difference of neutron flux level in an operation of reactors that occurred by the variety of nuclear cross section and fission yield data. (3) Little influence by the variety of decay data was confirmed. (4) The ORIGEN2.1 code underestimated the amount of fission products generated by fission of minor actinides. From these results, the radioactivity inventories for the emergency preparedness system of nuclear power plants are recommended to use the calculation results by the combination of the library for ORIGEN2 based on JENDL3.3 and the ORIGEN2.2 code.

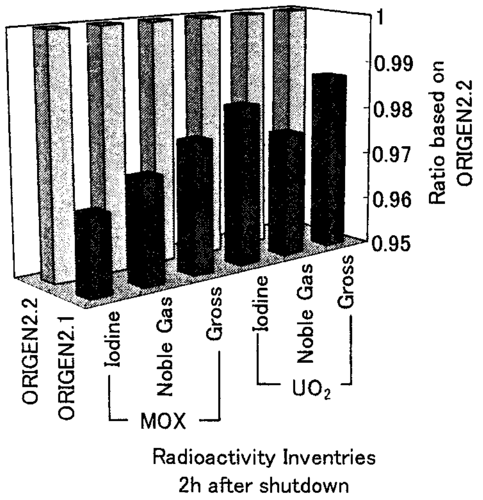

Figure 1 Comparison of calculation codes

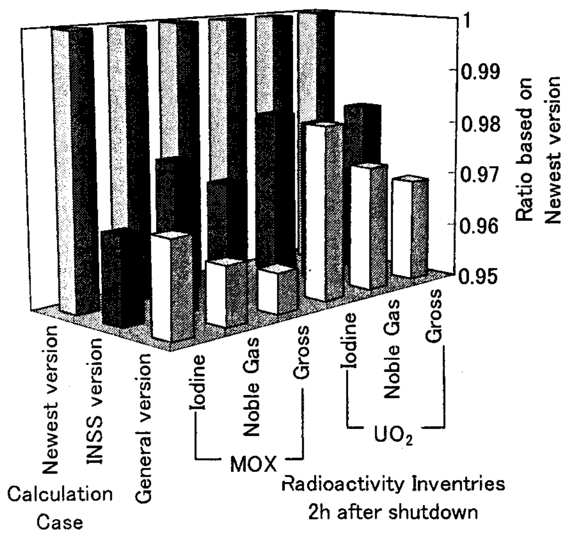

Figure 2 Comparison of data and codes combination

Reference
1) Y. Yoshida and I. Kimura, INSS Journal, vol.11, pp. 214-228, (2004)
2) Y. Yoshida and I. Kimura, JAERI-Conf 2004-005, pp.46-51, (2004)

V-A-2 Generation of an Improved Data Set of Gamma-Ray Buildup Factors by the Method of Invariant Embedding

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[2] NPO Radiation Dose Analysis & Evaluation Network, [3]Japan Atomic Energy Research Institute

Papers on this subject were published in the ICRS-10/RPS2004[1)], the INSS Journal[2)] and the Wakasa Wan Energy Research Center Report[3)].

An improved data set of gamma-ray buildup factors for point isotropic sources in infinite homogeneous media has been generated for 26 materials by the method of invariant embedding. The points of improvement compared with the standard data set ANSI/ANS-6.4.3 include 1) extension of the buildup factors up to depths of 100 mean free paths, 2) improved treatment of bremsstrahlung, 3) addition of the effective dose buildup factors, 4) consistent use of the cross-section PHOTX to all materials and 5) a quantitative evaluation about the accuracy in transport calculation. The data set obtained are compared precisely with the standard data set ANSI/ANS-6.4.3.

As a results, 1) the exposure buildup factors calculated by the IE method without bremsstrahlung based on the cross-section NBS29 for 18 low-Z materials agree excellently with those in the ANS data obtained by the moments method under the same condition. 95% of data out of 450 cases (18 materials x 25 source energies) agrees within a discrepancy of 10% up to depths of 40 mfp. It is confirmed that both the IE method and the moments method are dependable in the attenuation calculation of gamma-ray. It is also confirmed that the IE method is accurate enough to be used to correct some spurious oscillations in the buildup factors obtained by the moments method calculations. 2) The exposure buildup factors of high-Z elements in the energy range above 1.5 MeV in the ANS data are corrected by substantial amount (about factor 3 or less) by the improved treatment of bremsstrahlung used in the present calculation. 3) The exposure buildup factors of high-Z elements in the vicinity of the K edges in the ANS data are corrected by about 30%.

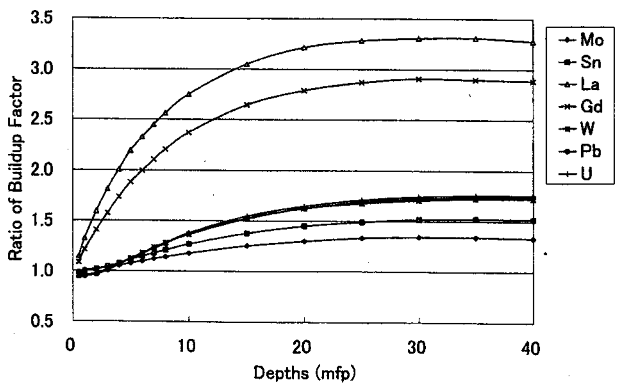

Fig. 1 Ratio of exposure buildup factor in the ANS data to the present data for high-Z elements at source energy of 15 MeV (Both data are calculated with bremsstrahlung based on PHOTX).

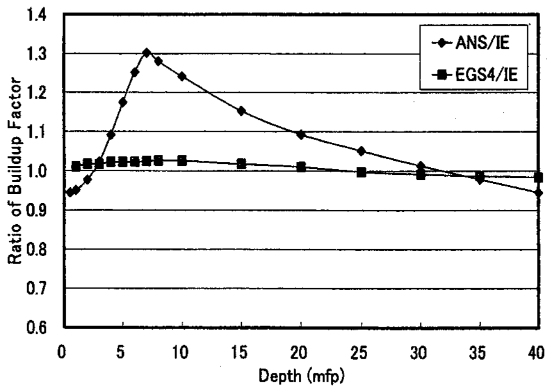

Fig.2 Ratio of exposure buildup factor for lead at source of 0.1 MeV
ANS/IE: Ratio of exposure buildup factor in the ANS data to the present data.
EGS4/IE: Ratio of exposure buildup factor calculated by Hirayama using the EGS4 code to the present data.

Table 1 Comparison of exposure buildup factor in ANS data to that calculated by IE method without bremsstrahlung based on cross section NBS29

Source Energy (MeV) — Difference of exposure buildup factor in ANS data[2)] from that calculated by IE method up to depths of 40 mfp

◎ : no more than 5% ○ : 6～10% △ : more than 10%

Source Energy (MeV)	Be	B	C	N	O	Na	Mg	Al	Si	P	S	Ar	K	Fe	Cu	WAT	CRT	AIR	Total	Fraction (%)
15.0	◎	◎	◎	◎	◎	◎	◎	◎	○	○	◎	◎	○	◎	◎	◎	◎	◎		
10.0	◎	○	○	◎	◎	◎	◎	◎	◎	◎	◎	○	◎	○	○	◎	○	○		
8.0	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎		
6.0	◎	◎	◎	◎	◎	○	○	◎	◎	◎	◎	◎	◎	○	◎	◎	◎	◎		
5.0	◎	◎	◎	◎	◎	◎	△	○	△	○	◎	◎	○	◎	○	◎	○	◎		
4.0	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	△	◎	◎	◎	◎	◎	◎	◎		
3.0	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	○	◎	◎	◎	◎		
2.0	◎	○	◎	△	○	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎		
1.5	◎	○	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎		
1.0	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎		
0.8	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎		
0.6	○	◎	◎	○	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎		
0.5	◎	△	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎		
0.4	◎	△	◎	◎	○	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎		
0.3	○	◎	◎	◎	○	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	○		
0.2	○	◎	◎	◎	○	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	△	◎	◎		
0.15	○	△	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	○	◎	○		
0.10	◎	△	○	○	○	◎	◎	◎	◎	◎	○	◎	◎	◎	◎	○	◎	◎		
0.08	◎	△	○	◎	○	○	○	△	◎	△	○	◎	◎	◎	◎	◎	◎	◎		
0.06	◎	○	○	◎	◎	○	◎	△	◎	◎	◎	◎	◎	◎	◎	◎	△	○		
0.05	○	○	○	○	◎	○	△	○	◎	◎	◎	◎	◎	◎	◎	◎	◎	○		
0.04	○	○	◎	◎	◎	○	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	○		
0.03	○	△	△	○	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	△	◎	△		
0.02	△	△	○	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎		
0.015	△	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎		
◎	16	12	18	19	19	20	21	21	23	22	22	24	23	22	23	21	22	18	366	81
○	7	6	6	5	6	5	2	2	1	2	2	1	2	3	2	2	2	6	62	14
△	2	7	1	1	0	0	2	2	1	1	1	0	0	0	0	2	1	1	22	5

WAT : water, CRT : Concrete, AIR : air

Reference

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3) A. Shimizu, T. Onda, et. al., WERC Report 004-001, (2004).

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VI. Japan Atomic Energy Research Institute

A. Nuclear Data Center

VI-A-1 Neutron Cross-Section Evaluations for $^{70,72,73,74,76}Ge$

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[**]*Nuclear Data Section, IAEA Vienna, Austria*

A paper on this subject was submitted to "*Proceedings of International Conference on Nuclear Data for Science & Technology – ND2004, Santa Fe, September 26 - October 1, 2004*" with the following abstract.

Entirely new evaluations have been performed for neutrons on all isotopes of Ge, from thermal energy up to 20 MeV, with focus on photon production. The resonance parameters were considerably improved compared to earlier evaluations. The fast neutron region has been evaluated using Empire-2.19 code. The results were validated against photon data on Fe and Nb. Isotopic evaluations for Ge were summed up and compared with available measurements on natural Ge. Various quantities related to photon production, showing strong dependence on neutron incident energy, are discussed.

VI-A-2 Covariances of Neutron Cross Sections for ^{15}N, ^{206,207,208}Pb and ^{209}Bi

K. Shibata

Covariances were estimated for the total and elastic scattering cross sections of ^{15}N and the inelastic scattering cross sections of ^{206,207,208}Pb and ^{209}Bi contained in JENDL-3.3. This work was undertaken to provide uncertainties in neutron cross sections for ADS applications.

As for ^{15}N, the covariances of total cross sections were estimated from experimental data by using the least-squares fitting code GMA[1]. The elastic scattering cross section of ^{15}N is almost equivalent to the total cross section below 6 MeV, since the capture cross section is extremely small in the entire energy region and the threshold reaction starts at 5.6 MeV. Therefore, the covariances of the elastic scattering cross section are the same as those of the total cross section below 6 MeV. Above 6 MeV where no experimental data are available, the covariances were estimated from the uncertainties in the optical model parameters which were determined so as to reproduce the total cross sections obtained by the GMA calculations. The optical model code ELIESE-3[2] was used on the covariance evaluation system KALMAN[3].

The covariances of the inelastic scattering cross sections for ^{206,207,208}Pb and ^{209}Bi were estimated using the optical model code ELIESE-3 and the statistical model code CASTHY[4] on KALMAN. The optical model parameters and their covariances were determined so as to reproduce the measured total cross sections of ^{nat}Pb and ^{209}Bi. The covariances of inelastic scattering cross sections were obtained from the covariances of optical model parameters and the sensitivities calculated from the CASTHY code.

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1) W.P. Poenitz: BNL-NCS-51363, p.249 (1981).
2) S. Igarasi: JAERI 1224 (1972).
3) T. Kawano and K. Shibata: JAERI-Data/Code 97-037 (1997) [in Japanese].
4) S. Igarasi and T. Fukahori: JAERI 1321 (1991).

VI-A-3

Historical Overview of Nuclear Data Evaluation in Intermediate Energy Region

Tokio FUKAHORI

A paper on this subject will be published in Proceedings of the International Conference on Nuclear Data for Science and Technology (ND2004), Sep. 26 – Oct. 1, 2004, Santa Fe, USA with the following abstract.

Proton and neutron data as well as photon data are necessary in various intermediate energy applications. To meet these requirements, many groups in the world continue some activities concerning nuclear data evaluation in the energy range above 20 MeV, which is the upper limit of conventional general purpose evaluated nuclear data files. In this paper, reviewed is brief history of intermediate energy nuclear data development as well as Pearlstein's contribution for it. Present status of world evaluated nuclear data files in the intermediate energy region is reported as well as evaluation methodology and sample results of evaluation and integral benchmark tests by using the case of JENDL High Energy File as an example.

B. Center for Proton Accelerator Facilities

VI-B-1 Research Activities on Radiation Safety Design for J-PARC

Hiroshi NAKASHIMA[1], Nobuo SASAMOTO[1], Yoshihiro NAKANE[1], Fumihiro MASUKAWA[1], Yukihiro MIYAMOTO[1], Kazunari SEKI[1], Kouichi SATO[1], Norihiro MATSUDA[1], Tomomi OGURI[1], Yousuke IWAMOTO[1], Kazuya HASHITATE[1], Tokushi SHIBATA[2], Takenori SUZUKI[2], Taichi MIURA[2], Shinichi SASAKI[2], Masaharu NUMAJIRI[2], Noriaki NAKAO[2] and Kiwamu SAITO[2]

A series of papers on this subject was submitted to the proceedings of the 10th International Conference on Radiation Shielding (ICRS10) held at Madeira, OECD/NEA workshop on Shielding Aspects of Accelerators, Targets and Irradiation Facilities (SATIF7) at Portugal and the 11th International Congress of the International Radiation Protection Association (IRPA11) at Madrid in 2004. The brief summary and titles are as follows.

Methodology and benchmarking on radiation shielding design for J-PARC were summarized and some estimation results on residual activity and the related dose were reported. As R&D for J-PARC, a series of benchmark experiments and analyses on deep penetration and radiation streaming was carried out for J-PARC using high and intermediate energy accelerator facilities, and performance of low-activation concrete was studied.

1. Radiation Safety Design for the J-PARC Project
2. Estimation of Radioactivity and Residual Gamma-ray Dose around a Collimator at 3-GeV Proton Synchrotron Ring of J-PARC Facility
3. Establishment of High Energy Neutron Irradiation Facility and Shielding Experiment using 4m Concrete Shield at KENS
4. Measurement and Analysis of Induced Activities in Concrete Irradiated by High Energy Neutrons at KENS Neutron Spallation Source Facility
5. Radiation Streaming Experiment Through a Labyrinth of the 12GeV Proton Accelerator Facility (1) Activation Method
6. Radiation Streaming Experiment Through a Labyrinth of the 12GeV Proton Accelerator Facility (2) TLD Rem Counter Method
7. Benchmark Calculations on Neutron Streaming Through Mazes at Proton Accelerator Facilities
8. Analysis of Induced Radionuclides in Low-activation Concrete Using 12 GeV Proton Accelerator Facility at KEK

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1 Japan Atomic Energy Research Institute, Tokai, Ibaraki 319-1195, Japan

2 High Energy Accelerator Research Organization, Oho, Tsukuba, 305-0801 Japan

C. Department of Fusion Engineering Research

VI-C-1 Measurement of Deuteron-Induced Activation Cross-Sections for Tantalum, Iron, Nickel and Vanadium in 33-40 MeV Region

Makoto NAKAO, Kentaro OCHIAI, Naoyoshi KUBOTA,
Noriko S ISHIOKA and Takeo NISHITANI

A paper on this subject was submitted to JAERI CONF, with the following abstract.

The IFMIF (International Fusion Materials Irradiation Facility) is an accelerator-based D-Li neutron source designed to test fusion reactor candidate materials for high fluence neutron. The IFMIF has two 40 MeV deuteron linear accelerators with each 125 mA beam current and long-term operation that total facility is 70 % at least is required in the design of it. However, deuteron beam activates the structural materials along the beam transport lines, impurity of these and corrosion materials in the Li target. These activation limits maintenance and makes long-term operation difficult. Thus the accurate estimation of deuteron-induced activity and the selection of structural materials are important.

In this work, measurements of deuteron-induced activation cross sections for tantalum, iron, nickel and vanadium were performed by using a stacked-foil technique. Tantalum is candidate material for coating to protect the beam facing materials. Iron is used as the inner material of the drift tube. Nickel is the impurity of the steel and Vanadium is corrosion material. The stacked-foil consisting of these and copper foils were irradiated with 40 MeV deuteron beam at the AVF cyclotron in TIARA/JAERI. After irradiation, the decayed gamma-rays emitted from the foils were observed by Ge detector. The ^{65}Zn activities observed from copper foils and the ^{nat}Cu(d,x)^{65}Zn reaction cross sections were used for monitoring the intensity of deuteron beam. The averaged deuteron energy in each foil position was calculated with the IRACM code. We have obtained the activation cross sections for the reactions ^{181}Ta(d,x) ^{178,180}Ta, ^{nat}Fe(d,x)^{55,56}Co, ^{nat}Ni(d,x)^{55}Co, ^{60,61}Cu and ^{nat}V(d,x)^{49}Cr in 33-40 MeV region. The present results will be compared with other experimental ones and the data in the ACSELAM library.

VI-C-2 Elastic Recoil Detection method using DT neutrons for hydrogen isotope analysis in fusion materials

N. Kubota, K. Ochiai, K. Kondo* and T. Nishitani.

A paper on this subject was submitted to JAERI CONF, with the following abstract.

Hydrogen isotopes show complicated behavior on the surface of plasma facing components in fusion devices, and the study is important for the design of the fuel recycling, the plasma control *etc.* The Fusion Neutronics Source (FNS) of Japan Atomic Energy Research Institute (JAERI) has started the study on the hydrogen isotope analysis for fusion components since 2002 on the basis of the techniques such as the nuclear activation analysis, the ion beam analysis and the imaging plate method. So far, deuterium and tritium distributions as regards the depth from the surface of the JT-60U plasma facing components up to the range of a few micrometers were obtained by means of the deuteron induced nuclear reaction analysis. However, the methods cannot be applied to the analysis beyond the range. In this study, we propose the elastic recoil detection analysis method using the pencil neutron beam to extend the depth of hydrogen isotopes analysis up to several hundreds micrometers.

We constructed an experimental setup for the neutron elastic recoil detection analysis. The 14 MeV-neutrons produced by DT reactions at the target of the 0° beam line of FNS were collimated with a hole of 20mm in diameter. The collimated neutrons, *i.e.* the pencil neutron beam, were incident on the sample from the direction at an angle of 0°. Emitted particles from the sample were measured using a ΔE-E telescope system. A pair of solid state detectors (SSDs) with the depletion layer thickness of 75 and 1500 micrometers was positioned in the direction at 25° with respect to the neutron beam for detection of ΔE and E values, respectively. Output signals from each SSD were analyzed with a multi-parameter analyzer to estimate the particle mass and its energy. The energy calibration of SSDs was corrected based on an ^{241}Am alpha source (5.486MeV). The neutron flux was monitored with a fission chamber located behind the target chamber.

A proof-of-principle experiment was made using the pencil beam of 14 MeV neutrons and a standard sample of deuterated polyethylene film containing a known concentration of deuterium. The deuterated polyethylene film was fabricated using a solvent-cast method. In the result of the experiment, we have obtained recoil deuteron and proton spectra separately on the contour map. The depth distribution and its depth resolution estimated with the deuteron spectrum are discussed.

*Department of Electronic, Information Systems and Energy Engineering, Osaka University, Suita, Japan

VI-C-3 Analysis of Plasma Material Surfaces by Means of Low Energy NRA

K. Ochiai, N. Kubota, K. Kondo* and T. Nishitani.

A paper on this subject was submitted to JAERI CONF, with the following abstract.

Nuclear reaction analysis with ion beams is useful to obtain the light nuclei depth profiles in plasma facing materials. JAERI/FNS has carried out the measurement of the deuterium and carbon-12 depth profiles in the JT-60 carbon tile and deuterium, tritium, lithium isotope depth profiles in a TFTR carbon tile by means of NRA with deuterium ion beam.

The probe beam was a deuteron beam and its energy and current density are adjusted between 150 and 390 keV and 0.1-1μA/cm^2 respectively. In case of carbon sample, the detectable depth is about 1.5 μm by 350 keV deuteron. The size of beam is 6.5 mm in diameter. A silicon solid state detector (SSBD) with a depletion layer of 200 μm, was used to detect high energetic charged particles induced with nuclear reactions. The SSBD energy resolution was determined with a standard α-source (Am-241: E_α = 5.486 MeV) and the FWHM was below 40 keV. To obtain the depth profiles of the deuterium, tritium, lithium-isotope and carbon-12, the proton, triton and α emitted from D(d,p)T, T(d,α)n, ^{6}Li(d,2α) and ^{12}C(d,p)^{13}C nuclear reactions induced between deuteron beam and the nuclei in the JT-60 and TFTR tiles were measured. These nuclear data libraries of the cross section values for these reactions were used FENDL-2 and the S-factors reported from some experimental data.

From the measurements, we have obtained depth profiles of light nuclei in a JT-60 and TFTR tiles. The deuterium retention on a JT-60 tiles surface was about 1 x 10^{16} D/cm^2 and it was found that the ratio of deuterium and carbon retention (D/C) was about 3 %. Also, in case of TFTR tiles, It was found that deuterium, tritium and lithium-6 retentions were about 3.8 x 10^{17} cm^{-3}, 7.2 x 10^{19} cm^{-2} and 3 x 10^{17} cm^{-3} near the surface (~1.2 μm depth) respectively. On this symposium, we mainly introduce the methodology by the NRA.

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VI-C-4 A New Technique to Measure Double-differential Charged-particle Emission Cross Sections Using Pencil-beam DT Neutrons

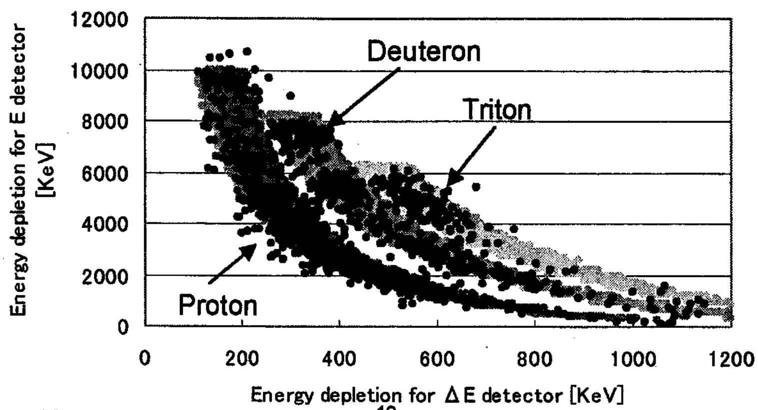
K. Kondo*, S. Takagi,* I. Murata*, H. Miyamaru*, A. Takahashi*,
N. Kubota, K. Ochiai and T. Nishitani

A paper on this subject was submitted to JAERI CONF, with the following abstract.

Double-differential charged-particle emission cross sections (DDXc) are necessary to calculate nuclear heating and fundamental values to evaluate material damages, i.e. PKA spectra, gpa and dpa cross sections. Particularly DDXc data in the whole energy range of emitted charged-particles of light nuclei such as beryllium, carbon and lithium are important for the development of a nuclear fusion reactor. However, only a few measurements have been carried out because of a difficulty of the experiment due to a high background condition. Therefore the development of a new technique for precise measurements of DDXc is quite important.

Recently we successfully developed a new spectrometer for the measurement of DDXc using a pencil-beam DT neutron source of the Fusion Neutronics Source (FNS) in Japan Atomic Energy Research Institute (JAERI). In the measurement system, a telescope system with two silicon surface barrier detectors of ΔE and E, and a two-dimensional multi-channel analyzer are equipped. In the present study we carried out measurements of DDXc of ^{9}Be, ^{19}F and ^{27}Al using the spectrometer. We choose aluminum for standard sample in order to confirm the validity of the new technique. Beryllium-9 is regarded as one of the most important materials in a fusion reactor development, especially in the blanket region.

For the $^{27}Al(n,x\alpha)$ reaction, the total cross section was obtained by integrating DDX over energy and the angular distribution function fitted with Legendre polynomials. The total cross section well agreed with the data of JENDL 3.3. From this result, we conclude that our new technique is valid. For ^{9}Be, we obtained α-particle, ^{6}He and triton emission DDX. Angular distributions for the $^{9}Be(n,\alpha_0)^{6}He$ and the $^{9}Be(n,\alpha_1)^{6}He^{*}_{1st\ Ex.}$ reactions were extracted from obtained DDX. These are compared with evaluated values and past studies.



Measured 2D-spectrum for $^{19}F(n,CP)$ reactions at 30deg.

*Department of Electronic, Information Systems and Energy Engineering, Osaka University, Suita, Japan

D. Department of Materials Science

VI-D-1

Evidence of complete fusion in the sub-barrier $^{16}O+^{238}U$ reaction

K.Nishio[1], H. Ikezoe[1], Y. Nagame[1], M. Asai[1], K. Tsukada[1], S. Mitsuoka[1], K. Tsuruta[1], K. Satou[1], C.J. Lin[1*], and T. Ohsawa[2]

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Evaporation residue cross sections of $^{250,249,248}Fm$ formed in the $^{16}O+^{238}U$ reaction were measured for the energy range from above- to extreme sub-barrier [1]. The cross sections are reproduced by a statistical model calculation, for which partial cross sections are calculated by a coupled-channel taking into account the prolate deformation of ^{238}U. Complete fusion was observed in the collision of the projectile with the tips of the 238U target, in the same way as the side collision.

[1] K. Nishio *et al.*, Phys. Rev. Lett. **93** (2004) 162701.

VII. Japan Nuclear Cycle Development Institute

A. System Engineering Technology Division

VII-A-1 Recent Application of Nuclear Data to Fast Reactor Core Analysis and Design in Japan

M. Ishikawa

A paper on this subject was submitted to Proc. Int. Conf. on Nuclear Data for Science and Technology (ND2004), Sept. 26 – Oct. 1, 2004, Santa Fe, New Mexico, USA, with the following abstract.

Some improvements of the nuclear data application to the fast reactor core field have been accomplished in Japan. The present paper introduces the recent status from three categories, group constant and analytical tools, database of fast reactor experiments, and application to FBR design study. A policy of JNC is to open the products generated from the application study to the world, as much as possible to keep the traceability, reproducibility and accountability.

VII-A-2 ERRORJ – Covariance Processing Code Version 2.2

G. Chiba

A paper on this subject was published as JNC TN9520 2004-003 (2004) with the following abstract.

ERRORJ is the covariance processing code that can produce covariance data of multi-group cross sections, which are essential for uncertainty analysis of nuclear parameters, such as neutron multiplication factor. The ERRORJ code can process the covariance data of cross sections including resonance parameters, angular and energy distributions of secondary neutrons. Those covariance data cannot be processed by the other covariance processing codes.

ERRORJ has been modified and the version 2.2 has been developed. This document describes the modifications and how to use. The main topics of the modifications are as follows.

- Non-diagonal elements of covariance matrices are calculated in the resonance energy region.
- Option for high-speed calculation is implemented.
- Perturbation amount is optimized in a sensitivity calculation.
- Effect of the resonance self-shielding on covariance of multi-group cross section can be considered.
- It is possible to read a compact covariance format proposed by N. M. Larson.

VII-A-3 Validation of MA Nuclear Data by Sample Irradiation Experiments with the Fast Reactor JOYO

S. Ohki

A paper on this subject was submitted to Proc. Int. Conf. on Nuclear Data for Science and Technology (ND2004), Sept. 26 – Oct. 1, 2004, Santa Fe, New Mexico, USA, with the following abstract.

This paper presents validation work on MA nuclear data by PIE analyses in the framework of fast-reactor cycle system development. The PIE analyses are in progress on MA samples (^{237}Np, ^{241}Am, ^{243}Am, ^{244}Cm) irradiated at the experimental fast reactor "JOYO." The preliminary analysis results showed that the isomeric ratio for ^{241}Am capture reaction lies at around 0.85 (g/(g+m)) in the fast-neutron spectra, which suggested the necessity of re-evaluation of the data both in ENDF/B-VI and in JENDL-3.3. From the results on curium isotopes, overestimations could be pointed out for the capture cross section of ^{244}Cm in ENDF/B-VI and that of ^{245}Cm in JENDL-3.3.

VII-A-4 Reduction of Cross-Section-Induced Errors of the BN-600 Hybrid Core Nuclear Parameters by Using BFS-62 Critical Experiment Data

A. Shono, T. Hazama, M. Ishikawa and G. Manturov*

A paper on this subject was published in Proc. of the PHYSOR 2004 -The Physics of Fuel Cycles and Advanced Nuclear Systems: Global Developments, April 25-29, 2004, Chicago, Illinois, USA, (2004) with the following abstract.

The present paper provides evaluation results of predicted uncertainty on nuclear parameters of the BN-600 hybrid core, a feasible option for Russian surplus weapons plutonium disposition. Covariance data for nuclear group constants, analysis errors, as well as experimental errors are considered to predict the uncertainties by applying the nuclear group constant adjustment method. Analysis results of BFS-62 mockup together with other fast reactor core experiments are reflected in the evaluation.

* Institute of Physics & Power Engineering, Obninsk, Russia

B. Waste Management and Fuel Cycle Research Center

VII-B-1 Measurement of Effective Capture Cross Section of ^{238}Np for Thermal Neutron

H. Harada, S. Nakamura, T. Fujii[1], and H. Yamana[1]

A paper on this subject was published in J. Nucl. Sci. Technol., 41, 1 (2004) with the following abstract.

The effective capture cross section ($\hat{\sigma}$) of ^{238}Np for thermal neutron has been measured as data for the burn-up analysis of irradiated fuels and for the study of nuclear transmutation of minor actinides. A sample of ^{237}Np was irradiated for 10 hours at the Kyoto University Reactor. Neptunium-238 and –239 were produced simultaneously via the double neutron capture reaction ^{237}Np(n, γ)^{238}Np(n, γ)^{239}Np. The neutron flux at the irradiation position was monitored using Au and Co monitor wires. The epithermal index $r\sqrt{T/T_0}$ in Westcott's convention was deduced as 0.03. To measure the activities of ^{238}Np and ^{239}Np, a high-purity Ge detector with a BGO ($Bi_4Ge_3O_{12}$) anti-coincidence shield has been developed. The $\hat{\sigma}$ of ^{238}Np was deduced from the ratio of these activities. The result obtained is 479 $\pm$ 24 b for the $\hat{\sigma}$ of ^{238}Np. The result is compared with data in evaluated nuclear data libraries, ENDL-86, ENDF/B-VI, and JENDL-3.3.

*1 Research Reactor Institute, Kyoto University

VII-B-2

A large BGO detector system for studies of neutron capture by radioactive nuclides

O. Shcherbakov, K. Furutaka, S. Nakamura, H. Harada, K. Kobayashi[1]

A paper on this subject was published in Nucl. Instru. Methods A 517, 269 (2004) with the following abstract.

A 16-section BGO scintillation detector having a total volume of 8.54 l and an associated 40 MHz flash-ADC–based data taking system were developed. This detector system is intended for the measurements of neutron capture cross sections of radioactive nuclei by the time-of-flight method. The detector response function, efficiency, gamma-ray and neutron energy resolution, and backgrounds were evaluated experimentally and by calculation. The neutron capture cross section measurements with ^{10}B, ^{197}Au and ^{237}Np samples were carried out in the energy range 1 – 1000 eV to demonstrate the performance of the system.

*1 Research Reactor Institute, Kyoto University

VII-B-3

<u>Prompt Gamma Rays Emitted in Thermal–neutron Capture Reaction by ^{99}Tc and Its Reaction Cross Section</u>

K. Furutaka, H. Harada, S. Raman[*1]

A paper on this subject has been published in J. Nucl. Sci. Technol. Vol. 41, No.11, 1033 (2004) with the following abstract.

We have studied the primary and secondary γ rays (a total of ~1,100) in ^{100}Tc following thermal-neutron capture by the radioactive ^{99}Tc isotope. A fraction of these γ rays have been incorporated into the corresponding level scheme consisting of 36 levels in ^{100}Tc. The determined neutron separation energy (S_n) for ^{100}Tc is 6,765.20±0.04keV. By summing the cross sections of all ground-state transitions, we have obtained 21.37±0.68b as a lower limit of the thermal-neutron capture cross section for ^{99}Tc. We have also determined the capture cross section by examining the 540- and 591-keV γ rays in ^{100}Ru emitted following the β^- decay of ^{100}Tc. The inferred thermal-neutron capture cross section for ^{99}Tc is 22.8±1.8b.

[*1] Oak Ridge National Laboratory (Deceased)

VII-B-4

Measurement of neutron capture cross section of ^{237}Np from 0.02 to 100eV

O. Shcherbakov, K. Furutaka, S. Nakamura, K. Kobayashi[1], S. Yamamoto[1], J. Hori[1], H. Harada

A paper on this subject was accepted for publication in J. Nucl. Sci. Technol. Vol. 42, No.2 (2005) with the following abstract.

The neutron capture cross section of ^{237}Np has been measured relative to the $^{10}B(n,\alpha)^{7}Li^{*}$ cross section by the time-of-flight method in the energy range from 0.02 eV to 100 eV. The 46 MeV electron linear accelerator at the Research Reactor Institute, Kyoto University, was used as a pulsed neutron source. The BGO scintillation detector was employed in conjunction with the flash ADC-based data taking system for measurement and data accumulation. For the first time the capture cross section of ^{237}Np in resonance energy range was measured using the total energy gamma-ray detector. The results of present measurements have been compared with the evaluated capture cross sections of ENDF/B-VI and JENDL-3.3, as well as with the data measured by other authors.

*1 Research Reactor Institute, Kyoto University

VII-B-5

Baseline distortion effect on gamma-ray pulse-height spectra in neutron capture experiments

A.Laptev, H.Harada, S.Nakamura, J.Hori[1], M.Igashira[2], T.Ohsaki[2], K.Ohgama[2]

A paper on this subject was accepted for publication in Nucl. Instru. Methods (2005) with the following abstract.

A baseline distortion effect due to gamma-flash at neutron time-of-flight measurement using a pulse neutron source has been investigated. Pulses from C_6D_6 detectors accumulated by flash-ADC were processed with both standard analog-to-digital converter (ADC) and flash-ADC operational mode. A correction factor of gamma-ray yields, due to baseline shift, was quantitatively obtained by comparing the pulse height spectra of the two data-taking modes. The magnitude of the correction factor depends on the time after gamma-flash and has complex time dependence with a changing sign.

*1 Research Reactor Institute, Kyoto University
*2 Research Laboratory for Nuclear Reactors, Tokyo Institute of Technology

VIII. Kyoto University

A. Research Reactor Institute

VIII-A-1 Neutron Capture Cross Section Measurement of Technetium-99 by Linac Time-of-Flight Method and the Resonance Analysis

Katsuhei Kobayashi [1], Samyol Lee [1*], Shuji Yamamoto [1], Toshihiko Kawano [2**]

A paper on this subject was published in the Nuclear Science and Engineering, **146**, 209-220 (2004) with the following abstract.

The neutron capture cross section of ^{99}Tc has been measured relative to the ^{10}B(n,$\alpha\gamma$) standard cross section by the neutron time-of-flight (TOF) method in the energy range of 0.005 eV to 47 keV using a detection assembly of $Bi_4Ge_3O_{12}$ (BGO) scintillators and a 46 MeV electron linear accelerator (linac) at the Kyoto University Research Reactor Institute (KURRI). The relative measurement has been normalized at 0.0253 eV to the reference value (22.9 ± 1.3 b) measured by Harada et al. The energy-dependent experimental data and the evaluated data in ENDF/B-VI, JENDL-3.2, JENDL-3.3, and JEF-2.2 are in general agreement with the current measurement. In particular, the JENDL-3.3 data, which have been released recently, show better agreement with the measurement in the lower-energy region.

The resonance parameters at 5.6 and 20.3 eV have been analyzed by the KALMAN system using the current TOF data. The resonance integral calculated with the parameters obtained is derived to be 330 ± 19 b, which is close to the data obtained from JENDL-3.3 and evaluated by Mughabghab, although the resonance integrals from JENDL-3.2, ENDF/B-VI and JEF-2.2 are smaller by about 6 to 8 % than the current value. The resonance integral data measured by Harada et al. is larger by about 20 %.

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VIII-A-2 Analysis of Criticality Change with Time for MOX Cores

Ken Nakajima[*1] and Takenori Suzaki[*2]

[*1] Research Reactor Institute, Kyoto University
[*2] Japan Atomic Energy Research Institute

A paper on this subject was published in Proc. of PHYSOR-2004, The Physics of Fuel Cycles and Advanced Nuclear Systems: Global Developments, Chicago, Illinois, April 25-29, 2004 (on CD-ROM), with the following abstract.

In plutonium-uranium mixed oxide (MOX) fuel, the composition changes with time due to the decay of ^{241}Pu (half life of 14.35 y) and build up of ^{241}Am. This change reduces the criticality of a MOX core with time because of the decrease in fissions and the increase in neutron captures. At the Japan Atomic Energy Research Institute (JAERI), a series of critical experiments for MOX cores had been performed, and criticality data as a function of time were obtained for about 7 years to investigate the effect of fuel composition change. We have analyzed the criticality change for those cores with a Monte Carlo code, MVP, employing the Japanese Evaluated Nuclear Data Libraries, JENDL-3.2 and 3.3.

The effective multiplication factors for the TCA critical cores showed the dependence on time, that is, they increased with time. This indicates that there exists some errors in cross sections of ^{241}Am and/or ^{241}Pu.

VIII-A-3

Criticality Analysis of Highly Enriched Uranium/Thorium Fueled Thermal Spectrum Cores of Kyoto University Critical Assembly

Hironobu Unesaki[1], Tsuyoshi Misawa[1], Chihiro Ichihara[1], Keiji Kobayashi[1], Hiroshi Nakamura[1], Seiji Shiroya[1] and Kazuhiko Kudo[2]

[1]*Research Reactor Institute, Kyoto University, Kumatori-cho, Sennan-gun, Osaka 590-0494, Japan*

[2]*Department of Applied Quantum Physics and Nuclear Engineering, Graduate School of Engineering, Kyushu University, Hakozaki, Fukuoka 812-8581, Japan*

A paper on this subject was published in Proc. of PHYSOR-2004, The Physics of Fuel Cycles and Advanced Nuclear Systems: Global Developments, Chicago, Illinois, April 25-29, 2004 (on CD-ROM), with the following abstract.

ABSTRACT

A series of critical experiments on thermal spectrum cores containing highly enriched uranium and thorium have been performed at Kyoto University Critical Assembly (KUCA) of Research Reactor Institute, Kyoto University, Japan. Seven critical cores with systematic variation on neutron spectrum and ^{232}Th/^{235}U ratio have been constructed in the experiment. Analysis of criticality (k-effective) have been performed using continuous energy Monte Carlo code MVP and various nuclear data libraries such as JENDL-3.2, JENDL-3.3, ENDF/B-VI.8 and JEFF3.0.

It has been found that the large overestimation of k-effective observed for JENDL-3.2 is significantly reduced by the use of JENDL-3.3. However, C/E values by JENDL-3.3 range from 1.007 to 1.009 and are significantly larger than C/E values of cores without thorium. Considerable spread among the ^{232}Th cross sections exist and have been shown to have considerable impact on nuclear characteristics of thorium fueled thermal systems. Among the nuclear data libraries considered in this study, ENDF/B-VI.8 showed the best results in terms of criticality prediction.

VIII-A-4 Measurement and Analysis of the Leakage Neutron Spectra from a Spherical Pile of Silicon with Incident 14 MeV Neutrons

Ichihara, C, [1]Yamamoto, J., [2]Hayashi S.A., [3]Kimura, I., and [4]Takahashi, A.

1. Introduction

In D-T fusion reactors, 14 MeV neutrons play various kinds of important roles, such as transferring energy, producing fusion fuel, *i.e.* tritium. On the other hand, high-energy neutrons also produce severe damage to the materials including radiation detectors and the control circuits. In the neutronics calculation, the uncertainty introduced in the reactor design strongly depends on the evaluated nuclear data used in the calculation.

Si is expected as X-ray detectors and electronic devices. There has been a conceptual design in which ceramics including SiC are used as the first wall. The accuracy of the nuclear data for Si is therefore very important. However, the Si nuclear data in the existing nuclear data files differ to a large extent with each other. In the **Table 1**, cross section values of ^{28}Si in JENDL-3.3[1)], JENDL-3.2[2)], ENDF/B-VI[3)](release 5) and EFF-2.4[4)] are listed, together with natural Si data in ENDF/B-VI (release 2). It is seen that there exists considerable difference even in the total cross section values. The total inelastic scattering values have difference as much as 20%, and the continuum inelastic values differ by more than 60%. Despite these facts, it appears that no thorough study has been conducted to validate the Si data files. In the present study, a leakage neutron spectrum from a 60 cm diameter Si sphere was obtained as a benchmark data and the validation on existing nuclear data of Si was conducted by comparing the measured spectrum and the calculated ones.

Table 1 Reaction Cross-section Values of Si at 14 MeV Neutron Energy

	JENDL-3.3	JENDL-3.2	ENDF/B-VI.5	ENDF/B-VI.2 (natural)	EFF-2.4
Total	1.752[a]	1.752	1.755	1.814	1.735
Elastic	0.757	0.758	0.662	0.734	0.758
Total inelastic	0.436	0.436	0.522	0.524	0.436
Continuum inelastic	0.191	0.191	0.224	0.321	0.191

[a] Cross section values are in barns

To obtain sensitivity of the individual partial cross sections to the neutron spectra, a trial calculation was performed employing MCNP-4A[5)] transport code using modified data libraries processed from JENDL-3.2. The sensitivity of each partial cross section to the spectrum was derived and is used for the validation of the nuclear data files.

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2 Experimental

The time-of-flight measurement was conducted at OKTAVIAN[6], of Osaka University. Pulsed neutrons were generated with an air-cooled tritium target located at the center of the pile. The particulate Si sample was packed in a stainless steel spherical vessel, the outer diameter of which was 60 cm with a thickness of 0.5 cm. It is equipped with a central void of 20 cm in diameter and a deuteron beam hole of 11 cm in diameter. The purity of the Si sample was better than 99.9 %. The total amount of Si in the pile was 138.05 kg, and its apparent density was 1.30 g/cm^3.

Neutrons leaking from the outer surface of a spherical sample pile were detected with a liquid scintillation counter composed of an NE-213 scintillator of 12.7 cm in diameter and 5.1 cm long, which located at a distance of 11 m from the center of the pile.

The detailed description of the formulation for obtaining the absolute neutron flux is described elsewhere[7].

3 Theoretical calculations

The theoretical calculations were performed using a three-dimensional continuous energy Monte Carlo transport codes, MCNP-4C and -4A with continuous energy neutron cross section libraries. The Si data libraries processed from JENDL-3.3, ENDF/B-VI.2 ENDF/B-VI.5 and EFF-2.4 were utilized. The source neutron distribution was assumed to be a point source and isotropic. The measured energy distribution of the neutron source was given as the source energy distribution. Since the experimental results were normalized as the total leakage current per source neutron, the surface-crossing tally was adopted.

4 Sensitivity calculations

It is of great importance to get dependence of the leakage neutron spectrum to each partial cross section of Si. The calculations for the sensitivity were carried out using MCNP-4A with modified Si cross section library, FSX/L-J3R2[8]. The discrete inelastic and continuum inelastic scattering cross sections were found dominant and taken into consideration. The procedure for the modification is similar to that given in the reference 7.

As the discrete inelastic scattering cross sections are reduced, partial spectra between 2 and 5 MeV become larger and those between 5 and 13.5 MeV lower. It means that this reaction cross section has a little negative correlation between 2 and 5 MeV and positive correlation between 5 and 13.5 MeV. The reduction of the continuum inelastic scattering cross section makes the partial spectra between 2 and 5 MeV less abundant and that around 8 MeV slightly larger, which means that this reaction has a positive correlation between 2 and 5 MeV and slight negative correlation around 8 MeV, respectively. In the energy range lower than 1 MeV, both continuum and discrete inelastic scattering cross sections have no significant correlations. In the **Table 2,** given are the correlations found in these calculations.

Table 2 Calculated sensitivity

Energy region	0.1 - 1 MeV	1 -5 MeV	5 - 10 MeV	10 MeV -
Discrete inelastic	NC*	negative	positive	positive
Continuum inelastic	NC	positive	NC	NC

NC*: not clear

5. Results and discussion

The measured and the calculated spectra for Si pile are shown in **Fig-2**. The calculations were conducted with JENDL-3.3, ENDF/B-VI.2, ENDF/B-VI.5 and EFF-2.4. The agreement between the measured and the calculated spectra is generally fair. However, the energy values in the lower energy region (below about 200 keV) become slightly lower because the low energy neutrons need more time to travel to the surface of the pile than the fast neutrons. Therefore, the numerical comparison between the calculated and the measured values was conducted using the integrated partial spectra. The calculated to experiment ratios (C/E) of partial spectra integrated over 4 energy regions, 10 MeV<E_n, 5 MeV<E_n<10 MeV, 1 MeV<E_n<5 MeV and 0.1<E_n<1 MeV are shown in **Table 2.**

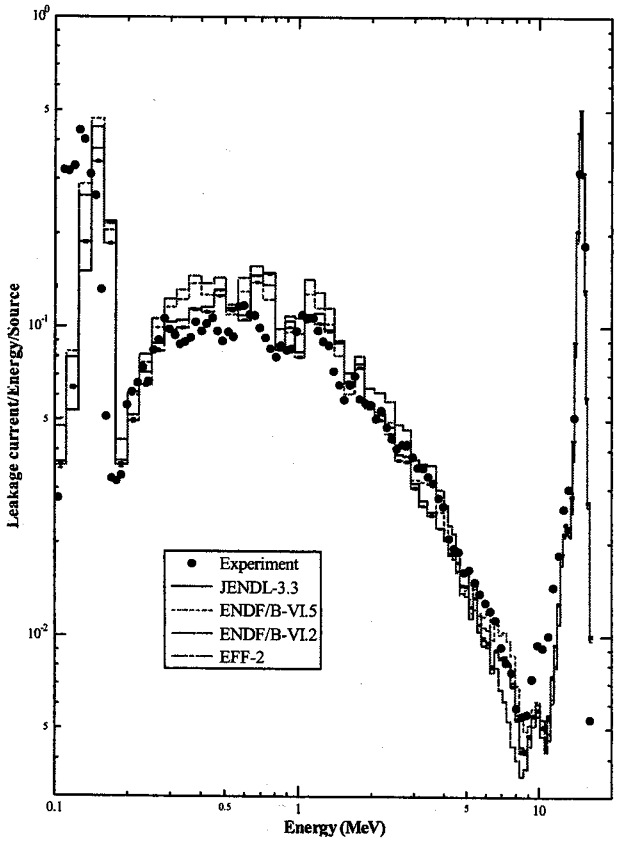

Figure 1 Measured and calculated spectra

The ENDF/B-VI.5 calculation gives the best prediction with less than 10 % difference except in the lowest energy region. The calculations obtained with JENDL-3.3 and EFF-2.4 are similar to each other and both predictions are fair. The calculated spectrum with ENDF/B-VI.2 gives the prediction with slightly larger difference from the measured spectrum than the other calculations.

Table 2 C/E values of partial spectra integrated over 4 energy regions

Energy region (MeV)	JENDL-3.3	ENDF/B-VI. 2	ENDF/B-VI. 5	EEE-2.4
10<E_n<20	1.105	1.058	1.056	1.107
5<E_n<10	0.801	0.746	0.936	0.813
1<E_n<5	1.006	1.186	1.042	0.978
0.1<E_n<1	1.124	1.272	1.186	1.082

As is described in the Table 1, the JENDL-3.3 and EFF-2.4 values are much alike. There is large difference in continuum inelastic scattering cross sections. ENDF/B-VI.2 has the largest values by more than 60 % larger than JENDL-3.3 and EFF-2.4, and is larger than ENDF/B-VI.5 by about 50 %. According to the sensitivity calculation stated before, the continuum inelastic scattering cross section has a distinct positive correlation to the leakage spectrum between 2 and 5 MeV energy region. The ENDF/B-VI.2 C/E value in this energy range is much larger than those with other calculations as listed in Table-2. It can be considered that the continuum inelastic scattering cross section values of ENDF/B-VI.2 are too large. It can be also read that the discrete inelastic scattering cross section values in ENDF/B-VI.2 are smaller. As this cross section has a negative correlation to the leakage spectrum, it can also be considered that the overestimation between 1 and 5 MeV is caused by too small discrete inelastic cross section values. In the energy range between 5 and 10 MeV, ENDF/B-VI.2 underestimates the experiment by a considerable amount. This is not inconsistent with that the discrete inelastic cross section values has a positive correlation. The overestimation by ENDF/B-VI.2 below 1 MeV is not clear. However, it might be caused by the fact that the total cross section values around 0.15 MeV are extremely larger than those of other data files

The JENDL-3.3 and EFF-2.4 calculations are almost satisfactory except the energy range between 5 and 10 MeV, where considerable underestimation exists. The discrete inelastic cross section values are considered to be smaller than those of ENDF/B-VI.5, which gives satisfactory C/E value in the same energy region. It is reasonable to consider that the cause of underestimation is attributed to the too small values of the discrete inelastic cross sectionJENDL-3.3 and EFF-2.4.

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IX. Kyushu University

A. Department of Advanced Energy Engineering Science

IX-A-1 Nuclear data evaluations for JENDL high-energy file

Yukinobu Watanabe and Tokio Fukahori*

A paper on this subject was presented in Int. Conf. on Nuclear Data for Science and Technology, Sept. 26 – Oct.1, 2004, Santa Fe, USA, with the following abstract:

High-energy cross section data above 20 MeV are required for various applications involving high-energy neutrons and protons, *e.g.*, accelerator-driven transmutation of nuclear waste and energy production, radiotherapy of cancer, and soft-error effects in microelectronics, *etc.* In this report, an overview is presented of recent nuclear data evaluations performed for the JENDL high-energy (JENDL-HE) file, in which neutron and proton cross sections for energies up to 3 GeV will be stored for 132 nuclides. The current version of the JENDL-HE file contains neutron total cross sections, nucleon elastic scattering cross sections and angular distributions, non-elastic cross sections, production cross sections and double-differential cross sections of secondary light particles (n, p, d, t, ^{3}He, α, and π), isotope production cross sections, and fission cross sections. The evaluations are performed on the basis of experimental data and theoretical model calculations. Since the experimental data are not enough in the incident energy region above 20 MeV, particularly for neutron-induced reactions, the nuclear model calculations play an important role in the high-energy cross section evaluations. We have developed a hybrid calculation code system utilizing some available nuclear model codes and systematics-based codes. A major code used for the intermediate energy range below 150 to 250 MeV is the GNASH code which is based on statistical Hauser-Feshbach plus preequilibrium exciton models. Optical model calculation codes such as ECIS and OPTMAN are also employed. For higher incident energy range, we use a microscopic simulation code (either JQMD or JAM) based on the quantum molecular dynamics or the intra-nuclear cascade model for dynamical processes and the evaporation model for the following statistical decay processes. The systematics-based codes, TOTELA and FISCAL, are also used for total, elastic scattering and reaction cross sections and angular distributions of elastic scattering, and fission cross sections. The evaluated cross sections are compared with the available experimental data and the other evaluations, with a focus on the influences of recent relevant measurements on the present evaluations. Future plans of our JENDL-HE project are also discussed along with prospective needs of high-energy cross section data.

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IX-A-2 Evaluation of cross sections for neutrons and protons up to 3 GeV on $^{12,13}C$

Y. Watanabe, K. Kosako†, E.S. Sukhovitskiĩ‡, O. Iwamoto¶, S. Chiba¶, T. Fukahori¶

A paper on this subject was presented in Int. Conf. on Nuclear Data for Science and Technology, Sept. 26 – Oct.1, 2004, Santa Fe, USA, with the following abstract:

High-energy neutron and proton nuclear data for carbon are requested with high priority in various applications, such as shielding design of accelerator facilities, dose evaluation in cancer therapy with neutron and proton beams, efficiency calculation of neutron detectors, and nucleosynthesis prediction of light elements, Li, Be, and B. We have performed an evaluation of cross sections on $^{12,13}C$ for both neutrons and protons in the incident energy range extended up to 3 GeV in order to meet the above nuclear data needs. The evaluation is based on predictions from nuclear model calculations and systematics as well as measurements. A nuclear model calculation code system is developed using the GNASH code for energies below 150 MeV and the JQMD code for those above 150 MeV. The evaluated cross sections contain the following data: neutron total cross sections, nucleon elastic scattering cross sections and angular distributions, non-elastic cross sections, production cross sections and double-differential cross sections of secondary light particles (n, p, d, t, ^{3}He, α, and π), and isotope production cross sections. The results are compared with available experimental data and the LA150 evaluation. For validation of these nuclear data, thick-target neutron production spectra from carbon target are calculated for bombardment of 113 MeV and 256 MeV protons using the MCNPX transport code and are compared with the measurements. These evaluated nuclear data are included into the JENDL high-energy file.

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IX-A-3 Evaluation of Nucleon-induced Cross Sections on Magnesium and Silicon Isotopes up to 3 GeV

W. Sun[†], Y. Watanabe, E.S. Sukhovitskiĩ[‡], O. Iwamoto[¶], S. Chiba[¶]

A paper on this subject was presented in Int. Conf. on Nuclear Data for Science and Technology, Sept. 26 - Oct.1, 2004, Santa Fe, USA, with the following abstract:

Nucleon-induced cross sections on magnesium isotopes, ^{24,25,26}Mg, and silicon isotopes, ^{28,29,30}Si, were evaluated for energies up to 3 GeV. The nucleon scattering cross sections were evaluated by a consistent analysis on nuclear level structure and nucleon scattering data, using a unified framework of soft-rotator model and coupled-channels approach. The scattering cross sections for silicon isotopes were re-analized oblate shapes, second the more sophisticated form of optical potential energy dependence was used. The evaluation of the particle emissions was performed by using a nuclear model code system, GNASH code below 150 MeV and JQMD code above 150 MeV. Comparisons of present results with available experimental data and the LA150 evaluation were made.

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IX-A-4 Development of a nuclear reaction database on silicon for simulation of neutron-induced single-event upsets in microelectronics and its application

Yukinobu Watanabe, Akihiko Kodama, Yasuyuki Tukamoto, Hideki Nakashima

A paper on this subject was presented in Int. Conf. on Nuclear Data for Science and Technology, Sept. 26 - Oct.1, 2004, Santa Fe, USA, with the following abstract:

The radiation effects known as single-event upsets(SEUs) in microelectronics have recently been recognized as a key reliability concern for current and future silicon-based integrated circuit technologies. Cosmic-ray neutrons having a wide energy range from MeV to GeV are regarded as one of the major sources of the SEUs in the devices used on the ground or in airplanes. Therefore, nuclear reaction data to describe the interaction of neutrons with the nuclides contained in the devices are highly requested as a fundamental physical quantity necessary for understanding the SEU phenomena and estimating the SEU rate. To meet this demand, we have recently developed a cross section database for silicon, using evaluated nuclear data file (JENDL-3.3, JENDL-HE, and LA150) and QMD calculation, for neutron energies ranging from 2 MeV to 3 GeV. Using the cross section database and the energy loss calculation of secondary ions, one can simulate the initial SEU processes, namely generation of secondary ions via nuclear reactions and initial charge distribution induced in the device. In the present work, a simple device structure with only silicon layers is taken into account, and the SEU cross sections are calculated on the basis of the initial processes simulated in terms of a Monte Carlo method. Two major parameters, the sensitive volume and the critical charge of the device, are included in the calculation. We have analyzed the experimental data for SRAMs and the other simulation result for DRAMs using this model calculation. It is shown that the dependence of SEU cross sections on incident neutron energy is reproduced satisfactorily by adjusting the two parameters. Through these analyses, we investigate the secondary ions generated by nuclear reactions with Si and the incident energy range which have the most important impact on SEUs. The sensitivity of the nuclear reaction data on SEUs is also discussed.

IX-A-5 High-energy neutron and proton nuclear data for applications — Evaluation of cross sections on C and Si up to 3 GeV —

Y. Watanabe, W. Sun†, K. Kosako‡, E.S. Sukhovitskiĩ*, O. Iwamoto¶, S. Chiba¶, T. Fukahori¶

A paper on this subject was published in Proc. of the XV Int. School on Nuclear Physics, Neutron Physics and Nuclear Energy, Sep. 9-13, 2003, Varna, Bulgaria; *BgNS Transaction* **9**, 87-97 (2004), with the following abstract:

We have performed an evaluation of cross sections on ^{12,13}C and ^{28,29,30}Si for both neutrons and protons in the incident energy range extended up to 3 GeV in order to meet nuclear data needs in accelerator-related applications. The evaluation is based on predictions from nuclear model calculations and systematics as well as measurements. A nuclear model calculation code system developed for this purpose is described. The evaluated cross sections contain the following data: neutron total cross sections, nucleon elastic scattering cross sections and angular distributions, non-elastic cross sections, production cross sections and double-differential cross sections of secondary light particles (n, p, d, t, ^{3}He, α, and π), and isotope production cross sections. The results are compared with available experimental data and the LA150 evaluation. For validation of these nuclear data, thick-target neutron production spectra from C target are calculated for bombardment of 113 MeV and 256 MeV protons using the MCNPX transport code and are compared with the measurements. An application of Si data to predictions of neutron-induced single-event upset phenomena in microelectronics is also presented. These evaluated nuclear data are included into the JENDL high-energy library in ENDF-6 format.

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IX-A-6 Backward Proton Production from $(p, p'x)$ Reactions at Intermediate Energies

M.K. Gaidarov†, Y. Watanabe, K. Ogata‡, M. Kohno¶, M. Kawai‡, A.N. Antonov†

A paper on this subject was published in Proc. of the XV Int. School on Nuclear Physics, Neutron Physics and Nuclear Energy, Sep. 9-13, 2003, Varna, Bulgaria; *BgNS Transaction* **9**, 185-191 (2004), with the following abstract:

A semiclassical distorted wave (SCDW) model with Wigner transform of one-body density matrix is presented for multistep direct $(p, p'x)$ reactions to the continuum. The model uses Wigner distribution functions obtained in methods which include nucleon-nucleon correlations to a different extent, as well as Woods-Saxson (WS) single-particle wave function. The higher momentum components of target nucleons that play a crucial role in reproducing the high-energy part of the backward proton spectra are properly taken into account. This SCDW model is applied to analyses of multistep direct processes (MSD) in ^{12}C$(p, p'x)$, ^{40}Ca$(p, p'x)$ and ^{90}Zr$(p, p'x)$ in the incident energy range of 150–392 MeV. The double differential cross sections are calculated up to three-step processes. The calculated angular distributions are in good agreement with the experimental data, in particular at backward angles where the previous SCDW calculations with the WS single-particle wave function showed large underestimation. It is found that the result with the Wigner distribution function based on the coherent density fluctuation model provides overall better agreement with the experimental data over the whole emission energies.

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X. Mitsubishi Heavy Industries, Ltd.

A. Reactor Core Engineering Department

X-A-1 Analysis of MOX Critical Experiments with JENDL-3.3

Takako SHIRAKI, Hideki MATSUMOTO and Makoto NAKANO

A paper on this subject was presented at 2004 Symposium on Nuclear Data, Nov. 11-12, 2004, JAERI, Tokai, Japan with the following abstract:

This paper reports a study to confirm the applicability of the latest version of Japanese Evaluated Nuclear Data Library (JENDL3.3). For this purpose, the criticality calculations using MCNP4C code were performed to evaluate middle and high plutonium content MOX (M-MOX(8.6 w/o (Pu/MOX)) and H-MOX(12.6 w/o (Pu/MOX))) experiments (VIP, VIPO and VIPEX) using the JENDL3.3. Afterward, the calculations with ENDF/B-6 release 8 (ENDF/B-6.8) using the same model as above were performed to be compared with the results from JENDL3.3. Recently, ORNL have reevaluated U235 and U238 cross-sections in thermal and resonance energy. Those evaluated nuclear data were stored in ENDF/B-pre7. The effect of the U235 and U238 cross-sections on both JENDL3.3 and ENDF/B-6.8 were evaluated. The results clarify that JENDL3.3 is superior to ENDF/B-6.8 although both libraries underestimate the criticality. In addition, the ENDF/B-pre7 data for U235 and U238 solves the keff underestimation for experiments with low enrichment.

X-A-2 Recent Activities relating on Nuclear Data

Yoshihisa TAHARA[a], Hideki MATSUMOTO[b], Kazuhiro TANI[a], Hideyuki NODA[a]

A paper on this subject was presented at 2004 Korea Nuclear Society Fall Meeting, Oct. 28-29, 2004 with the following synopsis:

1.Introduction

In the actual reactor power plants, core reactivity prediction is most important from the viewpoint of economics as well as safety. Core design codes together with nuclear data, therefore, are required to give the reliable prediction of core reactivity during the plant operation. In this study, the performance of most recent nuclear data in predicting core reactivity were tested against experiments using a continuous energy Monte Carlo code MCNP, and then the method to generate multi-group cross-sections for core design was studied using a nuclear data processing code NJOY.

[a] Engineering Development Co.
[b] Mitsubishi Heavy Industries, Ltd.

2.Benchmark Calculations and Results

Objectives of this study are to evaluate prediction accuracy of core reactivity by the use of ORNL ^{235}U, ^{238}U nuclear data and to try to find out the cause of the reactivity difference by comparing cross-sections of ORNL data with JENDL-3.3 or ENDF/B-VI R8.

2.1 Critical Experiments and Calculation Modeling

Benchmark problems were picked up from the International handbook of Evaluated Criticality Safety Benchmark Experiments of NEANSC and a set of CEA Vaduck, DIMPLE, RRC Kurchatov, TCA, B&W, Kritz, MATR is used in this study.

The features of this series of benchmark calculations are that 3-D geometrical model was employed in all cases and that moderator temperature covers wide range from cold (20 deg) to high temperature (250 deg), which is close to the no-load hot conditions of PWR's.

In the calculations, MCNP4C3 was used together with JENDL-3.3 based Library generated by NJOY-99.67 to which a patch for JENDL-3.3 was applied.

2.2 Benchmark Results

The calculation results are shown from Fig.1 to Fig.3. We focus the reactivity difference of MCNP from experiment.

Figure 1 shows the dependency of the reactivity difference on fuel enrichment when JENDL-3.3 is used. JENDL-3.3 shows large k_{eff} difference for experiments with low enrichment. The dependency of k_{eff} on ^{235}U enrichment is greatly improved when ORNL ^{235}U and ^{238}U data are used as shown in Fig.2.

Figure 3 shows the dependency of the reactivity difference on H/U in the case that JENDL-3.3

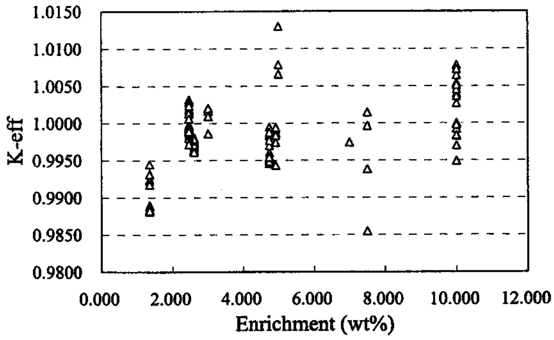

Figure 1. keff vs Enrichment by MCNP4C3(Preliminary) [JENDL-3.3]

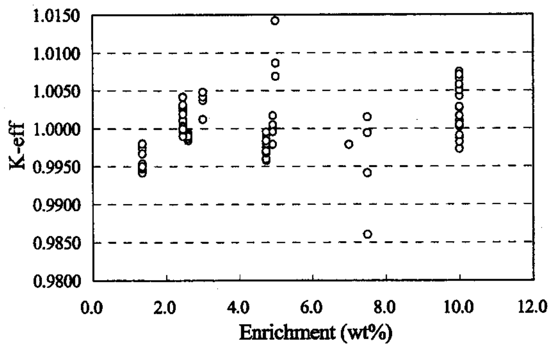

Figure 2. keff vs Enrichment by MCNP4C3(Preliminary) [JENDL-3.3+ORNL(^{235}U,^{238}U)+ENDF/B-VI r8(O,H)]

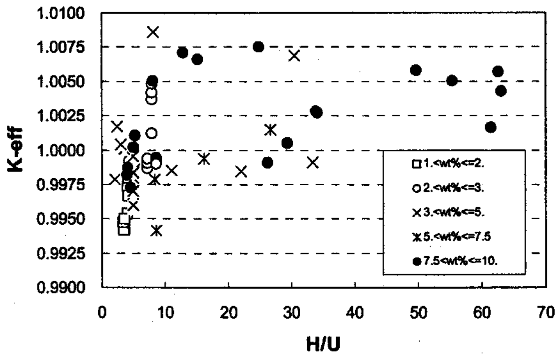

Figure 3. keff vs H/U by MCNP4C3(Preliminary) [JENDL-3.3+ORNL(^{235}U,^{238}U)+ENDF/B-VI r8(O,H)]

and new ^{235}U, ^{238}U data are used. The prediction of k_{eff} is also improved by 0.25% for the lattices with H/U of 7.2 or lower. However, k_{eff} is still lower for the lattice with H/U of 2.1. Therefore, it is recommended that analyses should be extended to tight lattice experiments with H/U less than 2.1 (TCA, TRX, PSI).

3. Multi-group Cross-section Library

3.1How to generate multi-group Cross-sections

The nuclear data processing code NJOY is widely used for generating multi-group cross-sections. However, it is not necessary clear how to generate the best multi-group cross-sections to be applied to PWR core design.

In this study, we investigated the dependency of the reactivity difference between a core design code with multi-group cross-sections and a continuous energy Monte Carlo code to know how many energy groups is needed and what is the best weighting factor. The 70- and 187-energy group structures were tested mainly.

PHOENIX-P was used as a design code, which is deterministic and employs the combined method of Pin Cell Coupling and S4 calculation. For PHOENIX-P, its cross-section library was made based on JENDL-3.3 nuclear data using NJOY. As a statistical code, a Monte Carlo code MVP was used, which was developed by JAERI and for which JENDL-3.3 based cross-section library is supplied by JAERI.

In the calculation of reactivity difference, we used a cell model with a pitch of 1.3133cm to preserve the moderator to fuel volume ratio of a PWR 17 × 17 standard fuel assembly with cell pitch of 1.26 cm.

3.2 Weighting Spectrum

We checked the following three weighting spectrum:

Maxwell+1/E+ χ [IWT=4]

EPRI-CELL PWR Spectrum [IWT=5]

EPRI-CELL PWR Flux + Calculator [IWT=-5]

In the case of IWT=-5, heterogeneous and homogeneous systems were tested by changing the input of NJOY.

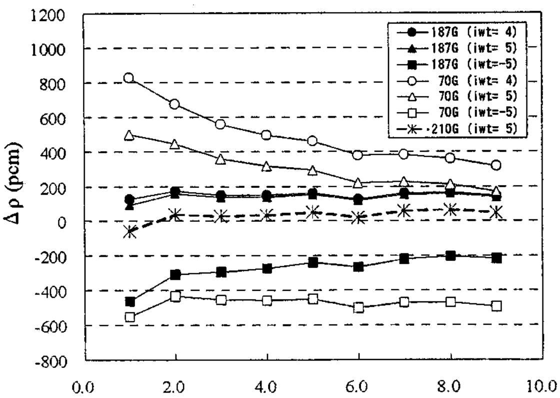

Figure 4. Dependence of reactivity difference between PHOENIX-P and MVP on ^{235}U enrichment (JENDL-3.3)

For heterogeneous cases, heterogeneous factor, denoted as beta, was treated in two ways; one is to keep it constant and the other is to change the value according to moderator to fuel volume ratio. The beta value must be between 0.0 and 1.0 from its physical meaning.

3.3 Dependency of k_{inf} on Enrichment or H/U

The obtained results regarding the dependency of reactivity difference with respect to enrichment or moderator to fuel volume ratio V_m/V_f are shown in Fig.4 and Fig.5.

The 70G-analytic spectra (IWT=4,5) have strong enrichment dependencies. On the contrary, the 187G-analytic spectrum does not show any enrichment dependency. Flux calculator spectrum improves enrichment dependency in 70G (IWT=-5), but reactivity difference moves to minus and k-bias seems to appear. The reactivity difference in 187G also becomes negative when flux calculator is used (IWT=-5). Flux calculator seems to work well to avoid enrichment dependency, but cause reactivity bias. Check is needed using other code.

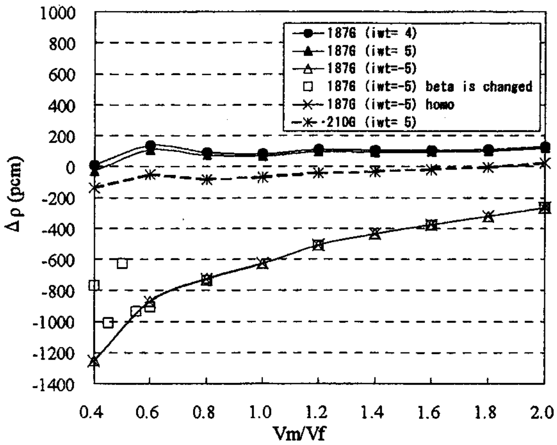

Figure 5. Dependence of reactivity difference between PHOENIX-P and MVP on V_m/V_f (JENDL-3.3)

From Fig.5, we can see analytical spectra do not show any dependency on V_m/V_f . However, when flux calculator is used, a large dependency appears. The issue might be the problem on reactor physics.

4. Conclusions

The reactivity prediction against critical experiments is greatly improved by employing ^{235}U, ^{238}U nuclear data reevaluated by ORNL.

The ^{235}U enrichment dependency will be solved by employing more energy meshes or by using flux calculator. However, when flux calculator is used, k_{inf} bias seems to appear. The more direct comparison using MCNP with cross-sections generated by NJOY is needed.

From the results of V_m/V_f dependency of k_{inf}, the calculation method of effective resonance cross-section might still have problems. More study is needed on this point.

XI. Musashi Institute of Technology

A. Faculty of Engineering

XI-A-1 TAGS and FP Decay Heat Calculations -Impact on the LOCA Condition Decay Heat-

Akira HONMA, Tadashi YOSHIDA

A paper on this subject was presented at the 2004 Symposium on Nuclear Data, November 11-12, 2004, Tokai Research Establishment, JAERI

Introducing the TAGS (Total Absorption Gamma-ray Spectrometer) data, we calculated the FP decay heat for U-233, U-235, Pu-239 and Pu-241 after one-year irradiation. In order to see the impact of the introduction of the TAGS data on LOCA (Loss of Coolant Accident) analysis in LWRs, those results were compared with the calculations based on the original data libraries such as JENDL, JEF-2.2 and ENDF/B-VI which are widely used in the summation calculation of the FP decay heat.

As far as the JENDL total decay heat is concerned, the effect is smaller than 0.6 % even at the maximum in Pu-239. It was concluded that the decay heat calculation introducing TAGS data dose not exert any decisive impact on the LOCA analysis from the practical point of view. Further study is, however, required to validate the reliability of the TAGS data as the input of summation calculations.

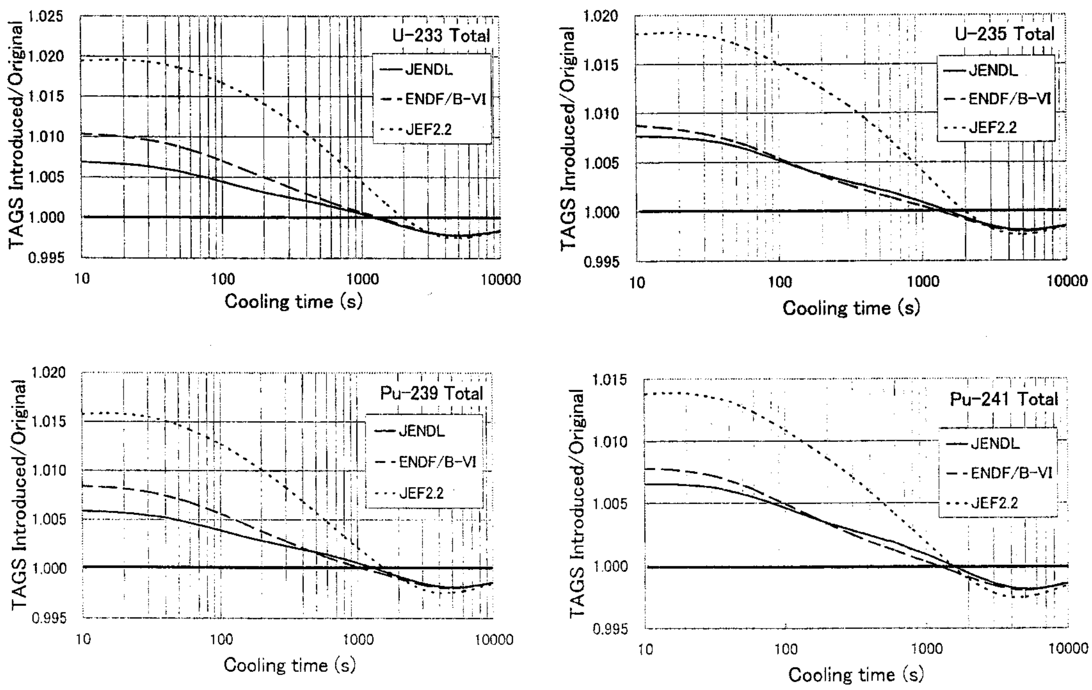

Fig.1 Effect of Introduction of TAGS Energies into Original Summation Calculation (Total or $\beta+\gamma$ decay heat)

XII. Nagoya University

A. Department of Energy Engineering and Science

XII-A-1

Measurements of activation cross sections of (n, p) and (n, α) reactions with d-D neutrons in the energy range of 2.1 to 3.1 MeV

Toshiaki Shimizu, Hitoshi Sakane, Michihiro Shibata,
Kiyoshi Kawade, and Takeo Nishitani[1]

A paper on this subject was published in Annals of Nuclear Energy 31(2004) 975-990, with the following abstract.

Activation cross sections for (n, p) and (n, α) reactions were measured by the activation method in the energy range of 2.1 to 3.1 MeV. The irradiated target isotopes were ^{27}Al, ^{41}K, ^{47}Ti, ^{51}V, ^{54}Fe, ^{59}Co, ^{58,61}Ni, ^{65}Cu, ^{67}Zn, ^{69}Ga, ^{79}Br, ^{92}Mo, ^{93}Nb, and ^{96}Ru. The cross sections for ^{41}K (n, p) ^{41}Ar, ^{61}Ni (n, p) ^{61}Co, ^{65}Cu (n, p) ^{65}Ni, ^{67}Zn (n, p) ^{67}Cu, ^{79}Br (n, p) ^{79m}Se, ^{96}Ru (n, p) $^{96m+g}$Tc, and ^{69}Ga (n, α) ^{66}Cu reactions were obtained for the first time.

Irradiation was from the d-D neutron source of the Fusion Neutronics Source at the Japan Atomic Energy Research Institute. All cross section values were determined relative to those of the ^{115}In (n, n') ^{115m}In reaction. To obtain reliable activation cross sections, careful attention was paid to correct neutron irradiation and to correct the measurement of induced activity as well as to determine the mean neutron energy at the irradiation positions. To measure weak activity levels, a highly efficient measuring technique with a well-type High Purity Germanium detector was applied to the activities.

The present results were compared against the comprehensive evaluated data in JENDL-3.3, -3.2, and -Activation File 96 as well as in ENDF/B-VI, and FENDL/A-2.0. We concluded that the evaluated data for ^{41}K (n, p) ^{41}Ar, ^{51}V (n, p) ^{51}Ti, ^{61}Ni (n, p) ^{61}Co, ^{79}Br (n, p) ^{79m}Se, ^{96}Ru (n, p) $^{96m+g}$Tc, ^{69}Ga (n, α) ^{66}Cu, and ^{93}Nb (n, α) ^{90m}Y reactions were overestimated or underestimated by more than 30%.

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[1]Japan Atomic Energy Research Institute, Tokai-mura, Ibaraki-ken, Japan

XII-A-2

Measurements of activation cross-sections of (n, n') reaction with d-D neutrons in the energy range of 2.1 - 3.1 MeV.

Toshiaki Shimizu, Hitoshi Sakane, Michihiro Shibata,
Kiyoshi Kawade, and Takeo Nishitani[1]

A paper on this subject was published in Annals of Nuclear Energy 31 (2004) 1883-1900, with the following abstract.

Activation cross-sections for (n, n') reaction were measured by the activation method in the energy range of 2.1 to 3.1 MeV with the d-D neutron source of the Fusion Neutronics Source at the Japan Atomic Energy Research Institute. The irradiated target isotopes were ^{77}Se, ^{79}Br, ^{87}Sr, ^{89}Y, ^{107,109}Ag, ^{111}Cd, ^{113}In, ^{137}Ba, ^{179}Hf, and ^{197}Au.

All cross-section values were determined relative to those of the ^{115}In (n, n') ^{115m}In reaction. To obtain reliable activation cross-sections, careful attention was paid to correct neutron irradiation and to correct the measurement of induced activity as well as to determine the mean neutron energy at the irradiation positions. To measure weak activity levels, a highly efficient measuring technique with a well-type High Purity Germanium detector was applied to the activities.

The present results were compared against the comprehensive evaluated data in JENDL-Activation File 96, and FENDL/A-2.0. The evaluated data for ^{87}Sr, ^{107}Ag, ^{113}In, and ^{137}Ba in FENDL/A-2.0 were overestimated by more than 30%.

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[1]Japan Atomic Energy Research Institute, Tokai-mura, Ibaraki-ken, Japan

XII-A-3

An improved pneumatic sample transport system for measurement of activation cross sections with d-D neutrons in the energy range between 2.1 and 3.1 MeV

T. Shimizu, H. Sakane, S. Furuichi, M. Shibata, K. Kawade, and H. Takeuchi[1]

A paper on this subject was published in Nucl. Instr. Meth. A527 (2004) 543-553, with the following abstract.

We have improved a pneumatic sample transport system that enables activation cross sections to be measured by producing short-lived nuclei on the order of sub-millibarns. The irradiation distances between the d-D neutron source and the samples ranged from 20 to 65 mm at six angles of between 0° and 155°. The neutron fluence rates were between 1×10^8 and 5×10^6 n/cm^2/s in the 2.1 to 3.1-MeV range, and these values were between 24 and 3 times higher than those of the previous system, which used a distance of 100 mm, at the Fusion Neutronics Source at the Japan Atomic Energy Research Institute.

The energy spreads at the irradiation positions were calculated by taking into account the slowing of incident 350-keV deuterons, the self-loaded deuteron distribution in the Ti-target and the solid angle subtended by the irradiated sample. At each angle, the acceptably close distance was found to be about 20 mm under the condition of an energy spread of less than about 300 keV. The spreads at about 0° and 180° were determined mainly by the slowing of deuterons in the target, while those at about 90° were determined by the finite solid angle.

The activation cross sections of ^{27}Al (n, p) ^{27}Mg and ^{61}Ni (n, p) ^{61}Co reactions were obtained for test measurements. This was undertaken with the prospect of using the present system to systematically measure the activation cross sections down to a sub-millibarn level.

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[1]Japan Atomic Energy Research Institute, Tokai-mura, Ibaraki-ken, Japan

XII-A-4

Measurement of (n, n') reaction cross sections of ^{79}Br, ^{90}Zr, ^{197}Au, and ^{207}Pb with pulsed d-D neutrons.

Toshiaki Shimizu, Itaru Miyazaki, Kazumasa Arakita, Michihiro Shibata, Kiyoshi Kawade, Jun-ichi Hori[1], and Takeo Nishitani[1]

A paper on this subject was submitted to Annals of Nuclear Energy in 2004, with the following abstract.

Activation cross sections for the (n, n') reaction were measured by means of the activation method at the neutron energy of 3.1, and 2.54 MeV by using pulsed neutron beam. Target nuclei were ^{79}Br, ^{90}Zr, ^{197}Au, and ^{207}Pb whose half-lives were between 0.8 and 8 s. ^{90}Zr (n, n') ^{90m}Zr reaction was obtained for the first time. To confirm the measuring method with pulsed neutron beam, the cross section data of ^{79}Br and ^{197}Au were compared with the previous data that were obtained by using a pneumatic sample transport system. Those results were agreement within 3%. The d-D neutrons were generated by bombarding a deuterated titanium target with a 350 keV d^{+}-beam at the 80-degree beam line of the Fusion Neutronics Source at the Japan Atomic Energy Research Institute. In order to obtain reliable activation cross sections, careful attention was paid to correct the efficiency for a volume source, and the self-absorption of gamma-rays in irradiated sample. The systematics of (n, n') reaction at the neutron energy range 3.0 MeV, which could be predicted within 50%, was proposed on the basis of our data.

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[1] Japan Atomic Energy Research Institute, Tokai-mura, Ibaraki-ken, Japan

XIII. National Institute of Advanced Industrial Science and Technology

A. National Metrology Institute of Japan

XIII-A-1

Fast Neutron Spectrometer Composed of Position-Sensitive Proportional Counters and Si(Li)-SSDs with Excellent Energy Resolution and Detection Efficiency

Tetsuro MATSUMOTO, Hideki HARANO , Akira URITANI and Katsuhisa KUDO

A paper on this subject was presented at the 2004 IEEE Nuclear Science Symposium, Rome, Italy, 16-22 October, 2004. The content is as follows.

In various studies such as neutron-field characterization and thermo-nuclear fusion plasma diagnostics, it is very important to precisely measure fast neutron spectra. Recently, we proposed to use three charge-division-type position-sensitive proportional counters (PSPCs) and Si surface barrier detector in order to achieve excellent energy resolution [1]. In the present study, the spectrometer was reconstructed so as to improve detection efficiency without deteriorating the energy resolution. Figure 1 shows a schematic drawing of the present spectrometer. The spectrometer consists of the three PSPCs (P1-P3), the two Si(Li) surface barrier detectors (Si(Li)-SSD: 50-360-2000SLM (Raytech Co.)) and collimator. The recoil proton generated by interaction between a collimated incident neutron and a hydrogen atom in P1 passes through P2 and P3, and reaches the Si(Li)-SSD. The recoil-proton energy is measured with the PSPCs and one of the Si(Li)-SSD. At the same time, position signals at A and B in Figure 1 are obtained from the outputs of P2 and P3, and give the recoil angles. Finally, the neutron energy is derived from the recoil-proton energy and the recoil angle. The characteristics of the spectrometer were evaluated using 5.0-MeV neutrons at the National Institute of Advanced Industrial Science and Technology. The excellent property of the spectrometer was experimentally shown. The characteristics were also evaluated with a Monte-Carlo simulation. The interactions between the incident neutrons and materials such as elastic neutron scattering on the hydrogen atom in the methane gas were simulated using the evaluated cross section data taken from JENDL-3.3. The data of the energy loss of the recoil proton in the PSPCs were taken from the NIST Physical Reference Data. The experimental and the calculation results were in good agreement with each other. It is possible to predict the characteristics of the spectrometer under other experimental conditions by the simulation.

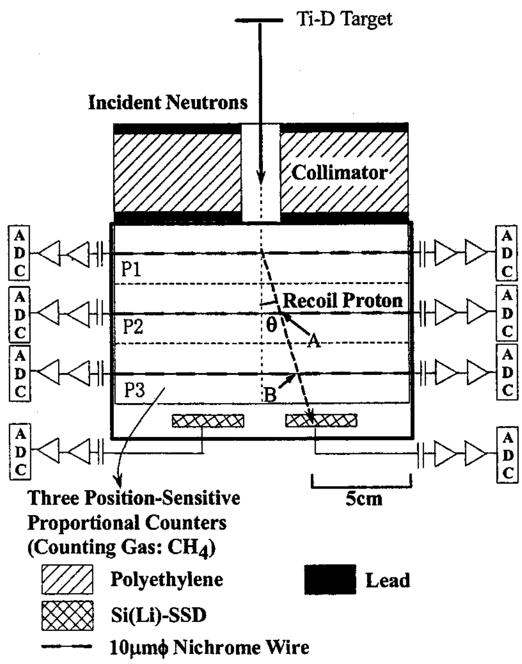

Figure 1: Schematic drawing of the spectrometer improved in the present study.

Reference
[1] T. Matsumoto *et al., Radiat. Prot. Dosim.*, **110**, 223-226 (2004).

XIII-A-2 Improvement of Photon Collection Uniformity from an NE213 Scintillator Using a Light Guide

H. Harano, T. Matsumoto, Y. Shibata, Y. Ito, A. Uritani and K. Kudo

A paper on this subject was presented at the 2004 IEEE Nuclear Science Symposium, Rome, Italy, 16-22 October, 2004. The content is as follows.

The uniformity in collecting scintillation photons to the photomultiplier is one of the key parameters to carry out precise measurement using scintillators. A simple method is proposed to improve the collection uniformity of the scintillation photons just by inserting a light guide between a scintillator and a photomultiplier. The light guide is expected to have a function to reduce the collection efficiency of the scintillation photons generated closer to the photomultiplier due to the larger transmission loss, since a decrease of the angle of incidence raises the fraction of the photons escaping from the sidewall of the light guide. The experiments using an NE213 liquid organic scintillation detector and gamma-ray sources revealed that the light guide functioned as a compensator for the original tendency of the photon collection and improved the photon collection uniformity. The details of the physical mechanism were examined by simulating the behavior of the gamma rays using the EGS4 electron-photon transport Monte-Carlo code and the light propagation process using the ray-tracing program GuideIT. The effects of the light guide were also examined on the whole energy resolution and the discrimination capability to separate gamma rays and neutrons.

XIV. Osaka University

A. Department of Nuclear Engineering

XIV-A-1 Effect of Anisotropic Scattering in UO_2 and MOX Fueled LWR Cells and Cores

T. Takeda and A. Inoue

A paper on this subject was submitted to the proceedings of International Conference on Nuclear Data for Science & Technology(ND2004), September. 26 – October. 1, 2004 with the following abstract.

The effect of anisotropic scattering has been studied in UO_2 and MOX fueled LWR cells and cores. The effect is negligibly small for UO_2 fueled cells, but the effect is remarkable for the MOX fueled cells and cores. For the MOX fuel cells, the anisotropic effect decreases k_{inf} by 0.15 ~ 0.23% $\Delta k/k$ depending on the moderator to fuel volume ratio. For small UO_2 and MOX cores, the anisotropic scattering leads to the flux peaking in water reflectors, and the increase of neutron absorption in the reflector decreases k_{eff} remarkably.

B. Department of Electronic, Information Systems and Energy Engineering

XIV-B-1

Measurement of charged-particle emission DDX for fusion reactor materials with a pencil beam DT neutron source

I.Murata, K. Kondo, S. Takaki, S. Shido, H. Miyamaru, A. Takahashi,
K. Ochiai[1)], and T. Nishitani[1)]

A paper on this subject will be presented in the 7th International Symposium on Fusion Nuclear Technology, May 22-27, 2005, Tokyo, Japan, and published in Fusion Engineering and Design with the following abstract.

For fusion reactor development, nuclear data for the interaction of 14-MeV neutrons with reactor materials are of importance. Double-differential charged-particle emission cross section (DDXc) is needed to calculate nuclear heating and fundamental value for evaluation of material damage, i.e., PKA spectra, GPA and DPA cross sections. In particular use of several light nuclei such as beryllium, carbon and lithium in large quantities is planned in the blanket region of a fusion reactor. Charged-particle emission reactions of these materials are complex due to contributions of sequential decays and multi-body breakup. For this reason, theoretical calculations of energy spectra of emitted particles are difficult. This fact makes precise measurements of DDXc quite important.

Recently we developed a new spectrometer for the measurement of DDXc using a pencil-beam DT neutron source at the Fusion Neutronics Source (FNS) of Japan Atomic Energy Research Institute (JAERI). To distinguish kinds of charged particles, we used a counter-telescope system with a pair of silicon surface barrier detectors of $\triangle$E and E, and a two-dimensional MCA. According as we choose appropriate thickness of $\triangle$E detectors, the energy spectra of emitted proton, deuteron, triton and α-particle were obtained distinctively. The present technique realized good S/N ratio, relatively high-count rate and good energy resolution. Since utilizing an anticoincidence spectrum extended lower limit of measurable energy for α-particle, 600KeV~1MeV for the lower limit was available.

In the present study we carried out measurements of DDXc of ^{9}Be, ^{12}C, ^{19}F, and ^{27}Al using the spectrometer. Beryllium-9 is regarded as one of the most important materials in the blanket region. Carbon-12 contained in SiC is considered to be used for the first wall material. Fluorine-19 is contained in FLiBe (Li_2BeF_4), which is regarded as one of liquid blanket materials.

The present technique was valid from the result of measurement for the ^{27}Al(n,xα) reactions. For ^{9}Be, we obtained α-particle and triton emission DDX. Slight differences appeared between measured data and evaluation or previous experimental values. These results suggest that more detailed analyses of ^{9}Be(n,xα) reactions and ^{9}Be(n,t) reaction are required. For ^{19}F, we obtained proton, deuteron, triton, and α-particle DDX. We observed some peaks reflected the structure of exited states in residual nuclei in the energy spectrum of emitted p, d, and t-particles. Also there were differences between measured data and evaluations.

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1) Japan Atomic Energy Research Institute

XIV-B-2

Spectrum measurement of emitted neutrons from (n,2n) reaction for beryllium with a pencil beam DT neutron source

I. Murata, S. Takaki, K. Kondo, S. Shido, H. Miyamaru, K. Ochiai[1)], T. Nishitani[1)]

The (n,2n) reactions are very important in the design of fusion reactor, because it is a neutron multiplication reaction and has a large cross section value in the energy range of several to 14MeV. In previous experiments, the cross section was measured mainly by the foil activation method or by using a large scintillation detector. However, even now, there are still many elements left of which the experimental values are not obtained. In addition, with these methods, it is not possible to measure the neutron spectrum. In the case of heavy nuclides, the spectrum of emitted neutron from (n,2n) reaction is considered to become evaporation spectrum. But, in the case of light nuclides, the neutron spectrum becomes complicated because evaporation process cannot be applied. So we have established the spectrometer to measure precise neutron spectrum especially for light nuclides.

Spectrum measurement of emitted neutrons from (n,2n) reaction is possible in principle with the coincidence detection method. However, if we use isotropic neutron sources, it is difficult to carry out measurements accurately, because neutrons emitted at the neutron source and scattered by structural materials are detected as noise signals. In the present experiments, the pencil beam DT neutron source at FNS in JAERI has been used. Because the pencil beam neutron source is made by perfectly collimating a very strong point source by a collimator of 2m thick with a hole of 20mm in diameter, we can arrange detectors very close to the sample. These conditions make the coincidence method possible. Two spherical NE213 detectors (4cm in diameter) were used and located at 20cm from the sample. Anode signals of the detectors have been used to pick up the coincidence events. Also, the pulse shape discrimination technique was used to discriminate neutron signals from gamma ray signals. By using this technique we exclude unnecessary coincidence events, for example, one detects neutron and the other detects gamma ray and so on. In this experiment, beryllium was selected as a sample, not only because it is tritium breeder material for fusion reactor but also because it is light nuclide and thus has a lot of nuclear reaction branches which are not well investigated.

Up to now, the measurements with Mn sample, which is regarded as a standard sample, were done to confirm the validity of the present coincidence method. This year we consumed 4 weeks so far to measure angular correlated neutron spectra for beryllium sample. One detector was fixed on the same horizontal plane as the sample at 20cm from it and on the line through the sample position making 90 deg against the neutron beam direction. The other was moved azimuthally and longitudinally on the sphere of 20cm in radius, the center of which is the sample. A lot of angle correlated energy spectra for beryllium have been obtained so far. The precise analysis for the obtained data is now underway.

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1) Japan Atomic Energy Research Institute

XIV-B-3 Study on Fusion-Fission Hybrid Reactor Energy System

I. Murata, S. Shido, Y. Yamamoto, K. Kondo and T. Oya

A paper on this subject was presented at 23rd SOFT Symposium, Venice, on September 20-24, 2004 with the following abstract.

A concept of combining nuclear fuel with fusion reactor, named fusion-fission hybrid system, was proposed for nuclear waste incineration. With this idea, even for a relatively lower plasma condition, neutrons can be well multiplied by fission in the nuclear fuel and tritium is thus bred so as to attain its self-sufficiency. Enough energy multiplication is then expected and moreover nuclear waste incineration is possible.

In this study, 3-dimensional ITER model was used as base fusion reactor. The nuclear fuel (reprocessed plutonium as a fissile material mixed with natural uranium as a fertile material), transmutation materials (minor actinides, i.e., Np-237, Am-241 and Am-243, and long-lived fission products, i.e., Zr-93, Tc-99, Pd-107, I-129 and Cs-135) and tritium breeder (90% Be and 10% Li_2ZrO_3 in which Li-6 was enriched to 30%) were loaded into the blanket. The blanket consists of three layers, 1st one is on the plasma side, 2nd one is in the middle and 3rd one is the outer layer. The neutronics and burn-up calculation were performed by MCNP-4B coupled with ORIGEN2.

For an example of burn-up calculation results, nuclear performance and transmutation efficiency are shown in Table 1. In this case, nuclear fuel including reprocessed plutonium of 15% was loaded in the 3rd layer and 24% of the blanket was used for transmutation.

Table 1 Calculation Result

	Keff	Power	PowerDens.	EnergyMulti.	TBR
year		MW	W/cc		
0	0.755	3426.9	44.1	5.3	1.24
1	0.735	3303.5	42.9	5.1	1.24
2	0.725	3058.4	39.5	4.7	1.22
3	0.711	2867.1	37.3	4.4	1.22
4	0.700	2709.2	35.1	4.2	1.20
5	0.684	2575.7	33.5	4.0	1.19

Transmutation Eefficiency(%)

year	Zr	Tc	Pd	I	Cs
0					
1	0.26	1.58	1.17	2.26	1.01
2	0.51	3.12	2.31	4.47	2.00
3	0.78	4.66	3.44	6.62	2.99
4	1.03	6.19	4.58	8.74	4.00
5	1.29	7.71	5.71	10.77	4.97
Gwty-PWR	3.2	39.6	90.5	51.0	12.9

XV. Tohoku University

A. Cyclotron and Radioisotope Center

XV-A-1 Measurement of Differential Thick-Target Neutron Yields of C, Al, Ta, W(*p,xn*) Reactions for 50-MeV Protons

T. Aoki, M. Baba, S. Yonai, N. Kawata, M. Hagiwara, T. Miura, T. Nakamura

A paper of the title was published in Nucl. Sci. and Engi. 146 (2004) p.200-208, with the following abstract.

Energy-angular differential thick-target neutron yields were measured at 50 MeV for the C, Al, Ta, W(p,n) reactions with a time-of-flight (TOF) method using the Tohoku University k=110-MeV cyclotron equipped with a beam-swinger system and a well-collimated TOF line. Neutron spectrum data have been obtained down to ~0.8 MeV from the highest energy by use of two different experimental setups to extend the dynamic range of the energy range. Data were obtained at six laboratory angles from 0 to 90 deg. The results are compared with the recent data library LA150. LA150 reproduces the general trend of the experimental data fairly well but still shows marked systematic disagreement in particular in high-energy regions.

XV-A-2 Measurements of Differential Thick Target Neutron Yields and ^{7}Be Production in the Li, ^{9}Be*(d,n)* Reactions for 25 MeV Deuterons.

Takao AOKI, Masayuki HAGIWARA, Mamoru BABA, Masayoshi SUGIMOTO[1a], Takako MIURA, Naoki KAWATA, Akira YAMADERA

A paper of the title was published in J. Nucl. Sci. and Technol. 41(April 2004) p.399-405, with the following abstract.

Neutron emission spectra and production rates of radioactive nuclide ^{7}Be in the *(d,n)* reactions on thick lithium and ^{9}Be targets have been measured for 25 MeV deuterons at the Tohoku University AVF cyclotron (K=110) facility to provide basic data for the design of the intense neutron source, International Fusion Reactor Material Irradiation Test Facility (IFMIF).

Neutron spectra were measured with the time-of-flight method at ten laboratory angles between 0^0 and 90^0 by using a beam swinger system. Data were obtained down to ~1 MeV from the highest energy, using a two-gain NE213 detector system. Induced radioactivity of ^{7}Be was measured by detecting the 478 keV γ-rays from ^{7}Be with a pure Ge detector.

The experimental results of neutron spectra revealed clearly the entire shape of the neutron emission spectrum and the angular dependence including so called "high energy tail" extending up to ~40 MeV. The present data at 0^0 are in reasonable agreement with corresponding value by Lone *et al.* at 23 MeV above ~5 MeV, but show large discrepancy in the lower energy region. The results of ^{7}Be production for both nuclei were much larger than expected by the calculation with a recent code IRAC.

[1a] Japan Atomic Energy Research Institute, Tokai-mura, Naka-gun, Ibaraki 319-1195

XV-A-3 Measurement of excitation functions of the proton-induced activation reactions on tantalum in the energy range 28-70 MeV

M. S. Uddin, M. Hagiwara, N. Kawata, T. Itoga, N. Hirabayashi, M.Baba, F. Tarkanyi[1], F. Ditroi[1], J. Csikai[2]

A paper of the title was published in J. Nucl. Sci. and Technol., Supl. 4 (March 2004) p. 160-163, with the following abstract.

Excitation functions for the proton-induced activation reactions on Ta were measured as a function of proton energy in the range 28- 70 MeV using the k=110 MeV AVF Cyclotron of Tohoku University. In this work the production of $^{180,177,176,175}Ta$, $^{175,173}Hf$, ^{178}W and ^{179}Lu radionuclides were investigated. For $^{181}Ta(p,x)^{176}Ta$ and $^{181}Ta(p,x)^{179}Lu$ reactions no data existed and for other reactions only contradictory data existed in the literature. Therefore our measurements have given new data for all of these reactions. In most of the cases, the results of this work are consistent with the available literature values.

XV-A-4 Experimental studies on the proton-induced activation reactions of molybdenum in the energy range 22-67 MeV.

M. S. Uddin, M. Hagiwara, F. Tarkanyi[1], F. Ditroi[1] and M.Baba

A paper of the title was published in Appl. Radiat. and Isot. 60 (2004) p.911-920, with the following abstract.

The production cross-sections of $^{99,93m}Mo$, $^{96,95,95m,94}Tc$, $^{96,95,92m,90}Nb$, $^{89,88,86}Zr$ and $^{88,87,86}Y$ radionuclides for proton-induced reactions on molybdenum were measured with molybdenum targets of natural isotopic composition using a stacked-foil activation technique in the energy range 22-67 MeV. The thick target integral yields were also deduced for each reaction using the measured cross-sections from the respective threshold up to 67 MeV. The results have given new data for all of the investigated radionuclides. The results of the present experiment showed excellent agreement with the earlier reported data in the lower energy region.

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[1] Institute of Nuclear Research of the Hungarian Academy of Science, Debrecen, Hungary
[2] Institute of Experimental Physics, University of Debrecen, Hungary

XV-A-5 Experimental studies on excitation functions of the proton-induced activation reactions on silver.

M. S. Uddin, M. Hagiwara, M.Baba, F. Tarkanyi[1] and F. Ditroi[1]

A paper of the title is in press in Appl. Radiat. and Isot. (2004), with the following abstract.

Excitation functions were measured for the production of $^{106m,105}Ag$, $^{103,101,100}Pd$, $^{105,102,101m,100,99}Rh$ and ^{97}Ru via proton-induced activation reactions on natural silver using a stacked foil technique in the energy range 11-80 MeV. The residual activity measurements were done nondestructively by the high-resolution HPGe gamma-ray spectroscopy. Thick target integral yields were deduced using the measured cross-sections from the respective threshold energies of the investigated reactions up to 80 MeV. The present work gives new results for the investigated radionuclides. The data in MENDL-2P deduced with the theoretical model code ALICE-IPPE are consistent in shape with the measured values, but show disagreement in magnitude.

XV-A-6 Activation cross-sections of light ion induced nuclear reactions on platinum: proton induced reactions

F. Tárkányi[1], F. Ditrói[1], S. Takács[1], J. Csikai[1], A. Hermanne[2], M.S. Uddin, M. Hagiwara, M. Baba, Yu.N. Shubin[3] and A.I. Dityuk[3]

A paper of the title was published in Nucl. Inst. and Meth. Phys. Res. B 226 (2004) p.473-489, with the following abstract.

Cross-sections of proton induced nuclear reactions on platinum were measured by using a standard stacked foil irradiation technique and high resolution gamma-ray spectroscopy. As a result experimental cross-sections and derived integral yields are reported from the respective threshold energy of the investigated reactions up to 70 MeV bombarding energy for the $^{nat}Pt(p,x)^{191,192,193,194,195,196m,g,196m2,198g}Au$, $^{nat}Pt(p,x)^{188,189,191,195}Pt$ and $^{nat}Pt(p,x)^{188,189,190,192,194m}Ir$ reactions. No earlier experimental data were found in the literature. The experimental data are analyzed and compared to the results of the theoretical model code ALICE-IPPE.

[1] Institute of Nuclear Research of the Hungarian Academy of Science, Debrecen, Hungary
[2] Cyclotron Laboratory, Vrije University Brussel, Belgium
[3] Institute of Physics and Power Engineering, Obninsk, Russia

XV-A-7 Activation cross-sections of long-lived products of proton-induced nuclear reactions on zinc

F. Tárkányi[1], F. Ditrói[1], J. Csikai[1], S. Takács[1], M.S. Uddin, M. Hagiwara, M. Baba, Yu.N. Shubin[2], A.I. Dityuk[2]

A paper of the title is in press in Appl. Radiat. and Isot. (2004), with the following abstract.

In the frame of a systematic study of excitation functions induced by medium energy protons, the activation cross-sections on natural zinc were investigated for different applications. Excitation functions for production of ^{66,67}Ga, ^{62,65,69m}Zn, ^{64}Cu, ^{57}Ni, ^{55,56,57,58}Co and ^{52,54}Mn radioisotopes were measured by the stacked foil technique in the energy range of 26–67 MeV. Results were compared with the earlier reported experimental data and theoretical calculations based on the ALICE-IPPE code. Experimental data are presented for the first time for most of the products in the investigated energy range. Applications of the measured data for validating the cross-sections on highly enriched isotopic Zn targets and for thin layer activation method are discussed.

XV-A-8 Experimental studies on the neutron emission spectrum and activation cross-section for 40 MeV deuterons in IFMIF accelerator structural elements

M. Hagiwara, T. Itoga, M. Baba, M. S. Uddin, N. Hirabayashi, T. Oishi, T. Yamauchi

A paper of the title was published in J. Nucl. Mater.329-333 (2004) p.218-222, with the following abstract.

In order to improve the nuclear data required in the safety design of the International Fusion Materials Irradiation Facility (IFMIF), we have measured the neutron emission spectra and the activation cross-sections of the IFMIF accelerator structural elements, C and Al, for 40 MeV deuterons using the Tohoku University AVF cyclotron. Neutron spectra from thick C and Al targets were measured with the time-of-flight method at ten laboratory angles between 0- and 110-deg. using a beam swinger system and a well collimated neutron flight channel. The data were obtained over almost entire energy range of secondary neutrons using a two-detector method. Activation cross-sections were measured by detecting the γ-rays from C and Al targets with a high-pure Ge detector. The stacked target technique was used to obtain the data from 40 MeV down to the threshold energy.

[1] Institute of Nuclear Research of the Hungarian Academy of Science, Debrecen, Hungary
[2] Institute of Physics and Power Engineering, Obninsk, Russia

XV-A-9 Measurement of neutron activation cross-sections for major elements of water, air and soil between 30 and 70 MeV.

Hiroshi YASHIMA, Kazutaka TERUNUMA[1], Takashi NAKAMURA,
Masayuki HAGIWARA, Naoki KAWATA[2], Mamoru BABA

A paper of the title was published in J. Nucl. Sci. and Technol., Supl. 4 (March 2004) p.70-73, with the following abstract.

Neutron activation cross-sections between 30 and 70 MeV were measured by the activation method using a semi-monoenergetic neutron field settled at the AVF cyclotron of the Cyclotron and Radioisotope Center (CYRIC), Tohoku University. Natural samples of N, O, Si, Na, Ca and Mg which are the major elements of water, air and soil were irradiated in this neutron field generated through the $^{7}Li(p,n)^{7}Be$ reaction by 30, 35, 40, 50, 60 and 70 MeV protons on thin Li target. Neutron yields were measured with the time-of-flight method using a calibrated NE213 organic liquid scintillator. From the induced activities measured with the HPGe detectors, we estimated the excitation functions of 15 cross sections.

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Measurements of keV-Neutron Capture Cross Sections and Capture Gamma-Ray Spectra of ^{209}Bi

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A paper of the title was published in J. Nucl. Sci. Technol., **41**, 406 (2004) with the following abstract.

The capture cross sections and capture γ-spectra of ^{209}Bi were measured in a neutron energy region from 5 to 80 keV and at 520 keV, using pulsed keV neutrons from the ^{7}Li(p,n)^{7}Be reaction and a time-of-flight method. The capture γ rays from a bismuth or standard gold sample were detected with a large anti-Compton NaI(Tl) gamma-ray spectrometer. The capture yield of the bismuth or gold sample was obtained by applying a pulse-height weighting technique to the corresponding capture γ-ray pulse-height spectrum. The derived capture cross sections from 5 to 80 keV were in good agreement with recent measurements, but that at 520 keV was about half of previous measurements. This large discrepancy at 520 keV was ascribed to the incorrect background-subtraction in the previous measurements from a comparison between the present and previous capture γ-ray spectra. Strong transitions from the capture states to low lying states of ^{210}Bi were observed in the present γ-ray spectra. The multiplicities of observed γ rays were obtained from the γ-ray spectra.