**Nuclear Data Section**

**International Atomic Energy Agency**

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**Memo CP-D/1143**

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**To:** Distribution

**From:** N. Otsuka, A. Konobeyev

**Subject: Review of REACTION SF4-SF5 for production of isomeric pairs**

As presented in the 2024 Vienna EXFOR workshop by one of us (AK), proper coding of the isomeric flag (e.g., -G) and branch code (e.g., M+) helps evaluators of charged-particle activation cross sections. We reviewed the EXFOR datasets providing production cross sections for (lcp,xn) reactions (lcp: light charged particles) for the products up to 82Rb, and summarized suggestions on improvement of the REACTION coding below. The full summary is also appended.

|  |  |  |
| --- | --- | --- |
| **Dataset #** | **REACTION (current)** | **Proposal** |
| A0253.002 | 34-SE-76(P,N)35-BR-76-G,,SIG | SF4: Remove -G. |
| A0253.005 | 34-SE-76(D,2N)35-BR-76-G,,SIG | SF4: Remove -G. |
| A0253.008 | 33-AS-75(HE3,2N)35-BR-76-G,,SIG | SF4: Remove -G. |
| A0253.011 | 33-AS-75(A,3N)35-BR-76-G,,SIG | SF4: Remove -G. |
| A0393.002 | 17-CL-35(A,N)19-K-38,,SIG | SF4: Add -G. |
| A0510.307 | 24-CR-50(A,2N)26-FE-52,,SIG | SF4-SF5: Add -G. |
| A0510.412 | 32-GE-70(A,N)34-SE-73,,SIG | SF4-SF5: Add -G,M+. |
| A0510.419 | 32-GE-72(A,3N)34-SE-73,,SIG | SF4-SF5: Add -G,M+. |
| B0052.010 | 35-BR-79(P,N)36-KR-79-G,M+,SIG | SF4-SF5: Delete -G,M+. |
| B0061.009 | 35-BR-79(P,N)36-KR-79-G,M+,SIG,,,EXP | SF4-SF5: Delete -G,M+. |
| C0062.010 | 24-CR-52(P,N)25-MN-52-G,(M),SIG | SF4-SF5: Remove -G,(M). |
| C0180.003 | 17-CL-35(A,N)19-K-38,,SIG | SF4: Add -G. |
| C2722.004 | 20-CA-44(P,N)21-SC-44,,SIG | SF4-SF5: Add -G,(M). |
| D4006.002 | 18-AR-38(P,N)19-K-38,,SIG | SF4: Add -G. |
| D4018.002 | 26-FE-58(P,N)27-CO-58-G,M+,SIG | SF4-SF5: Remove -G,M+. |
| D4018.009 | 25-MN-55(A,N)27-CO-58-G,M+,SIG | SF4-SF5: Remove -G,M+. |
| F0501.010 | 33-AS-75(HE3,N)35-BR-77,,SIG,,,DERIV | SF4-SF5: Add -G,(M). |
| F0535.002 | 19-K-41(A,N)21-SC-44,,SIG | SF4-SF5: Add -G,(M). |
| P0033.008 | 34-SE-82(P,N)35-BR-82-G,,SIG | SF4: Remove -G. |

Additional remarks:

C0062.010:

The authors mention in p.83 that

“*Pour les nucléides de période courte, les mesures ont commencé de 30 s a 1 mn après la fin de l'irradiation et ont porté sur quatre périodes quand la période était simple. Quand plusieurs périodes étaient présentes, nous avons employé la méthode classique de décomposition.*” (For short-lived nuclides, measurements began 30 s to 1 min after the end of irradiation and covered four periods when the half-life was simple. When several half-lives were present, we used the classical decomposition method.)

The decomposition method could mean decay curve analysis for separation of the two states.

F0501.010:

The metastable state production cross section is compiled separately in 011.

**Appendix**

Task:

Corrections of the REACTION codes relevant to isomeric transition contribution (e.g., addition or removal of -G,M+) for EXFOR datasets compiling proton, deuteron, helion or alpha activation cross sections without charged particle emission (e.g., (p,n), (p,2n), (d,2n), (a,3n)).

Reaction:

P,N; P,2N; D,N; D,2N; T,N; T,2N; HE3,N; HE3,2N; A,N; A,2N; A,3N

Quantity (SF5-SF8):

,SIG; ,SIG,M+; ,SIG,(M)

Products:

Sc-44\* (for example)

Legend of the report:

#: Comment for registration in the Feedback List

Ok?: The coding could be ok but it is difficult to draw a clear conclusion.

Ok!: Its partial (g and m) cross sections compiled separately.

Nuclide T1/2 (G) T1/2 (M) IT

19-K-38 7.7 min 0.92 s 0.0%

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# A0393.002 17-CL-35(A,N)19-K-38,,SIG SF4: Add -G.

# C0180.003 17-CL-35(A,N)19-K-38,,SIG SF4: Add -G.

# D4006.002 18-AR-38(P,N)19-K-38,,SIG SF4: Add -G.

21-SC-44 4.0 h 59 h 99%

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\* C1280.002 19-K-41(A,N)21-SC-44,,SIG Ok!

# C2722.004 20-CA-44(P,N)21-SC-44,,SIG SF4-SF5: Add -G,(M).

# F0535.002 19-K-41(A,N)21-SC-44,,SIG SF4-SF5: Add -G,(M).

\* O2423.004 20-CA-44(P,N)21-SC-44-G,(M),SIG Ok

25-MN-52 5.6 d 21 min 1.8%

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\* A0072.002 24-CR-52(P,N)25-MN-52,,SIG Ok?

\* A0292.004 24-CR-52(P,N)25-MN-52,,SIG Ok!

\* B0043.005 24-CR-52(P,N)25-MN-52,,SIG Ok?

\* B0071.002.S 24-CR-52(P,N)25-MN-52,,SIG Ok!

# C0062.010 24-CR-52(P,N)25-MN-52-G,(M),SIG SF4-SF5: Remove -G,(M).

\* C0269.012 24-CR-52(P,N)25-MN-52,,SIG Ok?

\* F1214.007 23-V-51(A,3N)25-MN-52,,SIG Ok?

\* O0076.007 24-CR-52(P,N)25-MN-52,,SIG Ok?

\* S0060.004 24-CR-52(D,2N)25-MN-52,,SIG Ok?

Additional remark on C0062.010:

The author mention in page 83 that "For short-lived nuclides, measurements began 30 s to 1 min after the end of irradiation and covered four periods when the period was single. When several periods were present, we used the classical decomposition method." This "decomposition method" could be decay curve analysis for separation of the two states.

26-FE-52 8.3 h 46 s 0.0%

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# A0510.307 24-CR-50(A,2N)26-FE-52,,SIG SF4-SF5: Add -G.

26-FE-53 8.5 min 2.5 min 100%

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\* A0510.306 24-CR-50(A,N)26-FE-53-G,M+,SIG SF4-SF5: Remove -G,M+?

\* D4052.004 24-CR-50(A,N)26-FE-53-G,(M),SIG SF4-SF5: Remove -G,(M)?

\* F0315.002.1 24-CR-50(A,N)26-FE-53,,SIG Ok?

27-CO-58 71 d 9.1 h 100%

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\* A0159.016 25-MN-55(A,N)27-CO-58,,SIG Ok

\* A0419.002 26-FE-58(P,N)27-CO-58,,SIG Ok

\* A0419.003 26-FE-58(P,N)27-CO-58,,SIG Ok

\* A0510.055 26-FE-58(P,N)27-CO-58,,SIG Ok

\* A0510.320 25-MN-55(A,N)27-CO-58,,SIG Ok

\* A0630.002 25-MN-55(A,N)27-CO-58,,SIG Ok

\* C0329.004.1 26-FE-58(P,N)27-CO-58,,SIG Ok

\* D0063.003.1 26-FE-58(P,N)27-CO-58,,SIG Ok

\* D0063.005 25-MN-55(A,N)27-CO-58,,SIG Ok

# D4018.002 26-FE-58(P,N)27-CO-58-G,M+,SIG SF4-SF5: Remove -G,M+.

# D4018.009 25-MN-55(A,N)27-CO-58-G,M+,SIG SF4-SF5: Remove -G,M+.

\* D6161.002 25-MN-55(A,N)27-CO-58,,SIG Ok

\* D6304.002 26-FE-58(P,N)27-CO-58,,SIG Ok

\* O0076.003 26-FE-58(P,N)27-CO-58,,SIG Ok

\* O0243.002.4 26-FE-58(P,N)27-CO-58,,SIG Ok!

\* O0243.003.4 26-FE-58(P,N)27-CO-58,,SIG Ok!

\* P0056.002 25-MN-55(A,N)27-CO-58,,SIG Ok

\* P0064.002 25-MN-55(A,N)27-CO-58,,SIG Ok

34-SE-73 7.2 h 40 min 73%

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# A0510.412 32-GE-70(A,N)34-SE-73,,SIG SF4-SF5: Add -G,M+.

# A0510.419 32-GE-72(A,3N)34-SE-73,,SIG SF4-SF5: Add -G,M+.

35-BR-76 16 h 1.3 s 100%

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\* A0184.008.S 33-AS-75(A,3N)35-BR-76,,SIG Ok

\* A0232.002 33-AS-75(HE3,2N)35-BR-76,,SIG Ok

\* A0232.007 33-AS-75(A,3N)35-BR-76,,SIG Ok

# A0253.002 34-SE-76(P,N)35-BR-76-G,,SIG SF4: Remove -G.

# A0253.005 34-SE-76(D,2N)35-BR-76-G,,SIG SF4: Remove -G.

# A0253.008 33-AS-75(HE3,2N)35-BR-76-G,,SIG SF4: Remove -G.

# A0253.011 33-AS-75(A,3N)35-BR-76-G,,SIG SF4: Remove -G.

\* A0510.132 34-SE-76(P,N)35-BR-76,,SIG Ok

\* A0510.137 34-SE-77(P,2N)35-BR-76,,SIG Ok

\* B0071.007 34-SE-77(P,2N)35-BR-76,,SIG Ok

\* D0083.002 34-SE-76(P,N)35-BR-76,,SIG Ok

\* D0164.007 34-SE-76(P,N)35-BR-76,,SIG Ok

\* D0164.009 34-SE-77(P,2N)35-BR-76,,SIG Ok

\* D0568.004 34-SE-77(P,2N)35-BR-76,,SIG Ok

\* F0501.009 33-AS-75(HE3,2N)35-BR-76,,SIG,,,DERIV Ok

\* O2337.002 33-AS-75(A,3N)35-BR-76,,SIG Ok

35-BR-77 57 h 4.3 min 100%

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\* A0184.007.S 33-AS-75(A,2N)35-BR-77,,SIG Ok

\* A0232.005 33-AS-75(HE3,N)35-BR-77,,SIG Ok

\* A0232.006 33-AS-75(A,2N)35-BR-77,,SIG Ok

\* A0243.002 33-AS-75(A,2N)35-BR-77,,SIG Ok

\* A0346.002 33-AS-75(A,2N)35-BR-77,,SIG Ok!

\* A0510.136 34-SE-77(P,N)35-BR-77,,SIG Ok

\* A0510.141 34-SE-78(P,2N)35-BR-77,,SIG Ok

\* B0071.006 34-SE-77(P,N)35-BR-77,,SIG Ok

\* D0164.010 34-SE-77(P,N)35-BR-77,,SIG Ok

\* D4239.002 34-SE-77(P,N)35-BR-77,,SIG Ok

\* D4239.003 34-SE-78(P,2N)35-BR-77,,SIG Ok

\* D5079.008 34-SE-77(P,N)35-BR-77,,SIG Ok

# F0501.010 33-AS-75(HE3,N)35-BR-77,,SIG,,,DERIV SF4-SF5: Add -G,(M).

\* O2337.003 33-AS-75(A,2N)35-BR-77,,SIG Ok

Additional remark on F0501.010:

The metastable state production cross section is compiled separately in 011.

35-BR-80 18 min 4.4 h 100%

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\* D5079.010 34-SE-80(P,N)35-BR-80,,SIG Ok

\* O2446.005.1 34-SE-80(P,N)35-BR-80,,SIG Ok

35-BR-82 35 h 6.1 min 98%

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\* A0510.147 34-SE-82(P,N)35-BR-82,,SIG Ok?

\* C2392.003 34-SE-82(D,2N)35-BR-82,,SIG Ok?

\* C2392.004 34-SE-82(D,2N)35-BR-82,,SIG Ok?

\* C2392.005 34-SE-82(D,2N)35-BR-82,,SIG Ok?

\* O0849.004.S 34-SE-82(P,N)35-BR-82,,SIG Ok?

\* O2031.002 34-SE-82(D,2N)35-BR-82,,SIG Ok?

\* O2031.011 34-SE-82(P,N)35-BR-82,,SIG Ok?

\* O2446.006.1 34-SE-82(P,N)35-BR-82,,SIG Ok?

# P0033.008 34-SE-82(P,N)35-BR-82-G,,SIG SF4: Remove -G.

36-KR-79 35 h 50 s 100%

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# B0052.010 35-BR-79(P,N)36-KR-79-G,M+,SIG SF4-SF5: Delete -G,M+.

# B0061.009 35-BR-79(P,N)36-KR-79-G,M+,SIG,,,EXP SF4-SF5: Delete -G,M+.

37-RB-81 4.6 h 31 min 98%

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\* A0452.002 35-BR-79(A,2N)37-RB-81,,SIG Ok?

\* A0489.003 36-KR-82(P,2N)37-RB-81,,SIG Ok?

\* A0510.459 35-BR-79(A,2N)37-RB-81,,SIG Ok?

\* D4084.002 36-KR-80(D,N)37-RB-81,,SIG Ok?

\* O2032.010 35-BR-79(A,2N)37-RB-81,,SIG,,REL Ok!

not checked yet:

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37 RB 84M 1.22400E+03 S 1 3 0 1.00000E+00

37 RB 86M 6.10000E+01 S 1 3 0 1.00000E+00

...

**Distribution:**

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