*Date: Dec 2013 - Jan 2019*

**Available Experimental (evaluated or original) Spectrum Averaged Cross Sections (SPA) in U-235(ntherm,f) field sorted by E(50%)**

| N | Reaction Name | | | E(50%) | SPA | SPA Uncertainty | | Reference for Recommended | Original Experiment | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | Z | full | short | MeV | mb | % | mb | experimental SPA | Reference | EXFOR | | | |
| 1 | 21 | Sc-45(n,γ)Sc-46 | sc45g | 0.591 | NOT measured yet | | | | | | | | |
| 1 | 3 | Li-6(n,t)He-4 | li6t | 0.662 | 4.560E+02 | 4.39 | 2.000E+01 | NBSIR_85-3151,1986, p.66 = | B.Oliver | 23226.000 | | | |
| 2 | 41 | Nb-93(n,γ)Nb-94 | nb93g | 0.692 | NOT measured yet | | | J.Grundl,ND-1985,p.471 | | | | | |
| 2 | 79 | Au-197(n,γ)Au-198 | au197g | 0.725 | 7.400E+01 | 4.05 | 3.000E+00 | | A.Fabry | 20229.006 | | | |
| 3 | 26 | Fe-58(n,γ)Fe-59 | fe58g | 0.740 | NOT measured yet | | | | | | | | |
| 4 | 47 | Ag-109(n,γ)Ag-110m | ag109g | 0.750 | NOT measured yet | | | | | | | | |
| 5 | 92 | U-235(n,γ)U-236 | u235g | 0.754 | NOT measured yet | | | | | | | | |
| 3 | 25 | Mn-55(n,γ)Mn-56 | mn55g | 0.771 | 3.820E+00 | | | | D.J.Hughes | 13860.012 | | | |
| 6 | 73 | Ta-181(n,γ)Ta-182 | ta181g | 0.840 | NOT measured yet | | | | | | | | |
| 4 | 5 | B-10(n,a)Li-7 | b10a | 0.903 | 5.410E+02 | 4.44 | 2.400E+01 | NBSIR_85-3151,1986, p.66 = | B.Oliver | 23226.000 | | | |
| 5 | 27 | Co-59(n,γ)Co-60 | co59g | 0.914 | 1.100E+01 | | | J.Grundl,ND-1985,p.471 | D.Hughes | 13860.014 | | | |
| 7 | 90 | Th-232(n,γ)Th-234 | th232g | 0.920 | NOT measured yet | | | | | | | | |
| 6 | 92 | U-238(n,γ)U-239 | u238g | 0.929 | 8.500E+01 | 9.41 | 8.000E+00 | | A.Fabry | 20264.007 | | | |
| 7 | 11 | Na-23(n,γ)Na-24 | na23g | 0.962 | 2.600E-01 | | | | D.Hughes | 30400.016 | | | |
| 8 | 29 | Cu-63(n,γ)Cu-64 | cu63g | 0.968 | 1.080E+01 | 23.15 | 2.500E+00 | | A.Fabry | 20264.002 | | | |
| 9 | 49 | In-115(n,γ)In-116m | in115g | 1.021 | 1.245E+02 | 4.25 | 5.290E+00 | K.Zolotarev, INDC(NDS)-0657 | A.Fabry | 20229.004 | | | |
| 8 | 74 | W-186(n,γ) | w186g | 1.033 | NOT measured yet | | | | | | | | |
| 9 | 49 | In-113(n,γ)In-114m | in114g | 1.144 | NOT measured yet | | | | | | | | |
| 10 | 57 | La-139(n,γ)La-140 | la139g | 1.294 | 5.300E+00 | | | K.Zolotarev, INDC(CCP)-0431 | | 11596.011 | | | |
| 11 | 92 | U-235(n,f) | u235f | 1.650 | 1.217E+03 | 1.12 | 2.403E+01 | W. Mannhart 2008 | | | | | |
| 12 | 94 | Pu-239(n,f) | pu239f | 1.730 | 1.831E+03 | 1.65 | 5.220E+01 | W. Mannhart 2008 | | | | | |
| 13 | 93 | Np-237(n,f) | np237f | 2.010 | 1.350E+03 | 1.78 | 2.403E+01 | W. Mannhart 2008 | | | | | |
| 10 | 95 | Am-241(n,f) | am241f | 2.151 | NOT measured yet | | | | | | | | |
| 14 | 45 | Rh-103(n,n')Rh-103m | rh103n | 2.380 | 6.735E+02 | 7.75 | 5.220E+01 | | K.Kobayashi | 22216.013 | | | |
| | | | | | 9.550E+02 | 10.58 | 1.010E+02 | | O.Horibe | 22140.018 | | | |
| | | | | | 7.020E+02 | 4.00 | 2.808E+01 | | E.Grigor'ev | 40848.002 | | | |
| 15 | 49 | In-115(n,n')In-115m | in115n | 2.600 | 1.878E+02 | 1.23 | 2.310E+00 | W. Mannhart 2008 | | | | | |
| 16 | 92 | U-238(n,f) | u238f | 2.660 | 3.094E+02 | 1.13 | 3.496E+00 | W. Mannhart 2008 | | | | | |
| 17 | 41 | Nb-93(n,n')Nb-93m | nb93n | 2.686 | 1.476E+02 | 4.74 | 7.000E+00 | K.Zolotarev, INDC(NDS)-0193 | | | | | |
| | | | | | 1.250E+02 | 22.40 | 2.800E+01 | | K.Sakurai | 21907.002 | | | |
| 18 | 49 | In-113(n,n')In-113m | In113n | 2.731 | 1.668E+02 | 5.13 | 8.560E+00 | K.Zolotarev, INDC(NDS)-0657 | | | | | |
| 19 | 90 | Th-232(n,f) | th232f | 3.005 | 8.300E+01 | 3.10 | 2.573E+00 | | D.Gilliam | 23096.015 | | | |
| 20 | 80 | Hg-199(n,n')Hg-199m | hg199n | 3.100 | 2.787E+02 | 5.30 | 1.477E+01 | K.Zolotarev, INDC(NDS)-0526 | | | | | |
| 21 | 22 | Ti-47(n,p)Sc-47 | ti47p | 3.680 | 1.784E+01 | 1.99 | 3.550E-01 | W. Mannhart 2008 | | | | | |
| 22 | 15 | P-31(n,p)Si-31 | p31p | 3.969 | 3.586E+01 | 2.68 | 9.610E-01 | K.Zolotarev INDC(NDS)-0668 | K.Kobayashi | 21589.004 | 3.350E+01 | 7.46 | 2.500E+00 |
| | | | | | | | | | L.Geraldo | 31447.016 | 3.600E+01 | 3.89 | 1.400E+00 |
| | | | | | | | | | M.S.Dias | 31448.005 | 3.790E+01 | 3.17 | 1.200E+00 |
| 23 | 16 | S-32(n,p)P-32 | s32p | 3.980 | 6.908E+01 | 1.97 | 1.361E+00 | W. Mannhart 2008 | | | | | |
| 24 | 28 | Ni-58(n,p)Co-58 | ni58p | 3.990 | 1.082E+02 | 1.30 | 1.407E+00 | W. Mannhart 2008 | | | | | |
| 25 | 30 | Zn-64(n,p)Cu-64 | zn64p | 4.030 | 3.539E+01 | 3.02 | 1.069E+00 | K.Zolotarev, INDC(NDS)-0657 | | | | | |
| | | | | | 3.889E+01 | 7.25 | 2.820E+00 | K.Zolotarev, INDC(NDS)-0526 | | | | | |
| 26 | 26 | Fe-54(n,p)Mn-54 | fe54p | 4.140 | 7.967E+01 | 1.38 | 1.099E+00 | W. Mannhart 2008 | | | | | |
| | | | | | 7.809E+01 | 1.50 | 1.170E+00 | K.Zolotarev, INDC(NDS)-0657 | | | | | |
| 27 | 30 | Zn-67(n,p)Cu-67 | zn67p | 4.709 | 9.660E-01 | 5.59 | 5.400E-02 | K.Zolotarev, INDC(NDS)-0657 | | | | | |
| 28 | 82 | Pb-204(n,n')Pb-204m | pb204n | 5.042 | 1.890E+01 | 10.58 | 2.000E+00 | | I. Kimura | 20317.018 | | | |
| | | | | | 1.980E+01 | 7.79 | 1.542E+00 | | A.Brodskaya | 40319.013 | | | |
| 29 | 42 | Mo-92(n,p)Nb-92m | mo92p | 5.392 | 6.687E+00 | 2.53 | 1.690E-01 | K.Zolotarev, INDC(NDS)-0657 | | | | | |
| 30 | 27 | Co-59(n,p)Fe-59 | co59p | 5.570 | 1.396E+00 | 2.36 | 3.295E-02 | W. Mannhart 2008 | | | | | |
| 31 | 13 | Al-27(n,p)Mg-27 | al27p | 5.770 | 3.902E+00 | 1.77 | 6.907E-02 | W. Mannhart 2008 | | | | | |
| 32 | 22 | Ti-46(n,p)Sc-46 | ti46p | 5.800 | 1.151E+01 | 1.70 | 1.957E-01 | W. Mannhart 2008 | | | | | |
| 33 | 23 | V-51(n,p)Sc-48 | v51p | 6.200 | 4.968E-01 | 2.62 | 1.302E-02 | W. Mannhart 2008 | | | | | |
| 34 | 29 | Cu-63(n,a)Co-60 | cu63a | 7.030 | 4.918E-01 | 4.91 | 2.415E-02 | W. Mannhart 2008 | | | | | |
| 35 | 28 | Ni-60(n,p)Co-60 | ni60p | 7.055 | 2.180E+00 | 4.77 | 1.040E-01 | K.Zolotarev, INDC(NDS)-0526 | | | | | |
| 36 | 14 | Si-28(n,p) | si28p | 7.226 | 5.470E+00 | 3.07 | 1.680E-01 | K.Zolotarev INDC(NDS)-0668 | | | | | |
| 37 | 26 | Fe-56(n,p)Mn-56 | fe56p | 7.310 | 1.079E+00 | 1.54 | 1.662E-02 | W. Mannhart 2008 | | | | | |
| 38 | 26 | Fe-54(n,a)Cr-51 | fe54a | 7.430 | 8.500E-01 | 5.88 | 5.000E-02 | K.Zolotarev, INDC(NDS)-0193 | | | | | |
| 39 | 27 | Co-59(n,a)Mn-56 | co59a | 8.080 | 1.563E-01 | 2.25 | 3.517E-03 | W. Mannhart 2008 | | | | | |
| 40 | 12 | Mg-24(n,p)Na-24 | mg24p | 8.090 | 1.451E+00 | 1.59 | 2.307E-02 | W. Mannhart 2008 | | | | | |
| | | | | | 1.490E+00 | 1.81 | 2.700E-02 | K.Zolotarev, INDC(NDS)-0526 | | | | | |
| 41 | 22 | Ti-48(n,p)Sc-48 | ti48p | 8.100 | 2.996E-01 | 1.79 | 5.363E-03 | W. Mannhart 2008 | | | | | |
| 42 | 92 | U-238(n,2n) | u2382 | 8.136 | 1.690E+01 | 8.28 | 1.400E+00 | | T.Hashimoto | 20810.002 | | | |
| 43 | 13 | Al-27(n,a)Na-24 | al27a | 8.410 | 7.007E-01 | 1.28 | 8.969E-03 | W. Mannhart 2008 | | | | | |
| 44 | 23 | V-51(n,a)Sc-48 | v51a | 9.610 | 2.429E-02 | 2.29 | 5.562E-04 | W. Mannhart 2008 | | | | | |

| N | Reaction Name | | | E(50%) | SPA | SPA Uncertainty | | Reference for Recommended | Original Experiment | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| N | Z | full | short | MeV | mb | % | mb | experimental SPA | Reference | EXFOR | |
| 45 | 69 | Tm-169(n,2n)Tm-168 | tm1692 | 10.401 | 3.735E+00 | 4.23 | 1.580E-01 | K.Zolotarev, INDC(NDS)-0584 | A. Brodskaja | 40319.011 | |
| | | | | | 4.867E+00 | 4.40 | 2.140E-01 | K.Zolotarev, INDC(NDS)-0584 | R.E.Lewis | 10368.002 | |
| 46 | 79 | Au-197(n,2n)Au-196 | au1972 | 10.430 | 3.392E+00 | 2.35 | 7.971E-02 | W. Mannhart 2008 | | | |
| 47 | 41 | Nb-93(n,2n)Nb-92m | nb932 | 11.170 | 4.645E-01 | 2.52 | 1.171E-02 | W. Mannhart 2008 | | | |
| | | | | | 4.348E-01 | 2.32 | 1.010E-02 | K.Zolotarev, INDC(NDS)-0584 | | | |
| 48 | 53 | I-127(n,2n)I-126 | i1272 | 11.570 | 1.279E+00 | 3.37 | 4.310E-02 | W. Mannhart 2008 | | | |
| | | | | | 1.197E+00 | 3.43 | 4.100E-02 | K.Zolotarev, INDC(NDS)-0526 | | | |
| | | | | | 1.209E+00 | 4.30 | 5.200E-02 | | Burianova 2019 | | |
| 11 | 49 | In-115(n,2n)In-114m | in1152 | 11.600 | NOT measured yet | | (see also) | | | | |
| 12 | 59 | Pr-141(n,2n)Pr-140 | pr1412 | 11.648 | NOT measured yet | | (see also) | | | | |
| 13 | 29 | Cu-65(n,2n)Cu-64 | cu652 | 12.459 | NOT measured yet | | (see also) | | | | |
| 49 | 27 | Co-59(n,2n)Co-58 | co592 | 12.876 | 2.028E-01 | 2.51 | 5.090E-03 | W. Mannhart 2008 | | | |
| 50 | 25 | Mn-55(n,2n)Mn-54 | mn552 | 12.885 | 2.362E-01 | 2.80 | 6.614E-03 | W. Mannhart 2008 | | | |
| | | | | | 2.043E-01 | 3.62 | 7.400E-03 | K.Zolotarev, INDC(NDS)-0546 | Fabry 20178.006 | Kobayashi 21693.002 | |
| | | | | | 1.500E-01 | 11.33 | 1.700E-02 | | O.Horibe | 23223.002 | |
| | | | | | 2.393E-01 | 6.27 | 1.500E-02 | | Burianova 2019 | | |
| 51 | 33 | As-75(n,2n)As-74 | as752 | 12.913 | 3.090E-01 | 6.15 | 1.900E-02 | K.Zolotarev, INDC(NDS)-0193 | | | |
| | | | | | 3.710E-01 | 8.63 | 3.200E-02 | | E.Dorval (2006) | 31591.003 | |
| | | | | | 3.205E-01 | 4.30 | 1.378E-02 | | M.Kostal (2018) | 31771.006 | |
| 52 | 29 | Cu-63(n,2n)Cu-62 | cu632 | 13.599 | 1.184E-01 | 5.91 | 6.997E-03 | W. Mannhart 2008 | | | |
| 53 | 9 | F-19(n,2n)F-18 | f192 | 13.750 | 8.624E-03 | 5.37 | 4.631E-04 | W. Mannhart 2008 | | | |
| 54 | 39 | Y-89(n,2n)Y-88 | y892 | 13.896 | 1.502E-01 | 3.33 | 5.000E-03 | K.Zolotarev, INDC(NDS)-0584 | | | |
| | | | | | 1.720E-01 | 3.30 | | | M.Kostal (2017_3) | 31783.003 | |
| | | | | | 1.690E-01 | 4.60 | | | M.Kostal (2018) | 31785.003 | |
| 55 | 40 | Zr-90(n,2n)Zr-89 | zr902 | 14.190 | 1.027E-01 | 2.69 | 2.763E-03 | W. Mannhart 2008 | | | |
| | | | | | 1.071E-01 | 0.00 | 4.284E-07 | | M.Kostal (2017_2) | 31782.004 | |
| 14 | 24 | Cr-52(n,2n)Cr-51 | cr522 | 14.482 | NOT measured yet | | (see also) | | | | |
| 15 | 22 | Ti-47(n,np)Sc-46 | ti47np | 14.565 | NOT measured yet | | | | | | |
| 56 | 28 | Ni-58(n,2n)Ni-57 | ni582 | 14.710 | 3.433E-03 | 6.70 | 2.300E-04 | K.Zolotarev, INDC(NDS)-0657 | K.Kobayashi | 21693.003 | |
| | | | | | 4.257E-03 | 2.90 | 1.235E-04 | W. Mannhart 2008 | | | |
| | | | | | 4.980E-03 | 7.63 | 3.800E-04 | | O.Horibe | 23223.004 | |
| 57 | 11 | Na-23(n,2n)Na-22 | na232 | 15.181 | 3.840E-03 | 4.50 | 1.728E-04 | | M.Kostal (2016) | 31766.005 | (see also) |
| 16 | 22 | Ti-49(n,np)Sc-48 | ti49np | 15.556 | NOT measured yet | | | | | | |
| 17 | 22 | Ti-48(n,np)Sc-47 | ti48np | 15.450 | NOT measured yet | | | | | | |
| 18 | 22 | Ti-46(n,2n)Ti-45 | ti462 | 15.810 | NOT measured yet | | (see also) | | | | |
| 19 | 26 | Fe-54(n,2n)Fe-53 | fe542 | 16.484 | NOT measured yet | | (see also) | | | | |
| 20 | 83 | Bi-209(n,3n)Bi-207 | bi2093 | 17.779 | NOT measured yet | | (see also) | | | | |
| 21 | 69 | Tm-169(n,3n)Tm-167 | tm1693 | 18.055 | NOT measured yet | | (see also) | | | | |
| 22 | 27 | Co-59(n,3n)Co-57 | co593 | 19.831 | NOT measured yet | | (see also) | | | | |
| 57 | | Number of measured | | | | | | | | | |
| 22 | | Number of not measured | | | | | | | | | |
| 79 | | Total | | | | | | | | | |


**References**

| | | |
|---|---|---|
| W. Mannhart 2008 | CM on Standards, 2008 | http://www-nds.iaea.org/standards-cm-oct-2008/7.PDF |
| W. Mannhart 2002 | INDC(NDS)-0435, 2002, p.59 | http://www-nds.iaea.org/publications/indc/indc-nds-0435.pdf |
| K. Zolotarev 2014 | INDC(NDS)-XXX, 2014 | 28Si(n,p),31P(n,p), 113In(n,γ) |
| K. Zolotarev 2014 | INDC(NDS)-0668, Oct 2014 | 28Si(n,p)28Al, 31P(n,p)31Si, and 113In(n,γ)114mIn |
| K. Zolotarev 2013 | INDC(NDS)-0657, Dec 2013 | 54Fe(n,p), 58Ni(n,2n), 67Zn(n,p), 92Mo(n,p), 93Nb(n,γ), 113In(n,n'), 115In(n,γ), 169Tm(n,3n) |
| K. Zolotarev 2010 | INDC(NDS)-0584, Nov 2010 | 59Co(n,3n), 89Y(n,2n), 93Nb(n,2n), 169Tm(n,2n) and 209Bi(n,3n) |
| K. Zolotarev 2009 | INDC(NDS)-0546, Apr 2009 | 27Al(n,α), 55Mn(n,2n), 59Co(n,p), 59Co(n,2n) and 90Zr(n,2n) |
| K. Zolotarev 2008 | INDC(NDS)-0526, Aug 2008 | 24Mg(n,p),32S(n,p),60Ni(n,p),63Cu(n,2n),65Cu(n,2n),64Zn(n,p),115In(n,2n),127I(n,2n),197Au(n,2n),199Hg(n,n') |
| K. Zolotarev 2004 | INDC(CCP)-0438, Feb 2004 | 27Al(n,p), 56Fe(n,p) and 237Np(n,f) |
| K. Zolotarev 2002 | INDC(CCP)-0431, Aug 2002 | 139La(n,γ), 186W(n,γ) and 204Pb(n,n') |
| K. Zolotarev 1999 | INDC(NDS)-0193, Mar 1999 | RRDF-98 |
| M. Košťál 2016 | App Rad Isot **111(2016)**1 | |
| M. Košťál 2017 | Ann Nucl Energy **100(2017)**42 | |
| M. Košťál 2017_2 | App Rad Isot **128(2016)92** | |
| M. Košťál 2017_3 | Rad Phys Chem **141(2017)**22 | |
| M. Košťál 2018 | Ann Nucl Energy **112(2018)759** | |
| N. Burianova 2019 | RRFM-A0117 | |


**Comments**

| | |
|---|---|
| (green) | difference << sum of uncertainties |
| (yellow) | difference < sum of uncertainties |
| (pink) | difference > sum of uncertainties |
| (purple) | only one experiment |


Go to Cf-252 spectrum
Go to MACS(30keV)
Back to CRP web


**To be included soon**