WP2022-29

Neutron quasi-elastic scattering data coded with SF3=EL

(S. Simakov, N. Otsuka, 2022-06-06, Memo 4C-3/0420 Rev.)

This paper proposes a new action to NDS to prepare a short list summarizing required corrections.

Notes:

(1) Such quasi-elastic scattering data can be coded as partial scattering data (SF3=SCT and SF5=PAR) when the unresolved low-lying levels are specified by the authors. How to spell REACTION when the authors do not specify the levels? Introduce a new branch code? **LEX** – uncorrected for excitation to low-lying level like (92-U-238(N,EL)92-U-238,LEX,DA)?

(2) When the authors give energy resolution, it could approximate the upper boundary of the excitation level energies, and could be coded under a new heading? **E-EXC-MX-A** (approximate value of E-EXC-MAX)?

(3) It would be also better to check if the datasets coded with SF3=SCT without SF5=PAR are really for total scattering. (e.g., EXFOR 22121, which REACTION codes are questionable though the source article does not provide enough information.). N.B. Total scattering looks reasonable for old measurements with boron neutron counters.

The neutron scattering cross sections compiled with EL in REACTION SF3 in EXFOR entries often include contribution of inelastic scattering to low-lying excitation levels due to insufficient energy resolution. It disturbs people who performs evaluation with models, and it has been urged to improve the situation. Therefore, we performed review of the relevant EXFOR entries by the following **Tasks**:

1. extracting EXFOR entries compiling neutron elastic scattering angular differential and integrated cross sections which (1) incident energy is higher than 1.5 MeV, (2) excitation energy of the 1st level less than 200 keV, and (3) target mass heavier than 40 (Ca);
2. checking their source articles to find if there is any description on inclusion of the inelastic scattering contribution;
3. summarize the suggestions for update of each EXFOR entry.

1. Explanations and general information to the recommendations for the EXFOR Entry corrections

The extraction of the EXFOR entries compiling the neutron elastic scattering angular differential and integrated cross sections from EXFOR Master Ver. 2021-10-01 were performed automatically with the criteria formulated above in the first item of **Tasks**. The found 234 sub-Entries were written in the Excel file "*EL-20211001-extract.xlsx"*. The content of each one was then analysed by checking their source articles and information already available in Entries to find if there are any details about the separation or inclusion of the inelastic scattering contribution. The final recommendations are given below in Section 2. The present section summarizes the explanations to recommendations as well as the general information on the experimental resolving of elastically and inelastically scattered neutrons.

The analysed **(sub) Entries** are listed in the ascending mode and are hyperlinked to the EXFOR retrieval system on the NDS/IAEA web site. The latter allows to open each Entries by one click and consult with information which was available there in the time period when the present work was performed (until May 2022).

The first **author and publications** are explicitly given to refer from where the detailed information about the experiment was taken to decide whether the EL or SCT process was measured and by which way. Several Entries have references only to the short or abstract description of experiment, e.g. in the Bulletin of the American Physical Society. In such cases more descriptive publications were searched in internet that sometimes resulted in success.

The given final **recommendations** for the reaction field SF3, as either **EL** or **SCT**, are highlighted by colour for convenience: green colour does not require modification, red - does. When SCT is identified the additional changes of the REACTION string is proposed. Thus, for identification of how many excited levels are included in the scattering the level numbers LVL-NUMB, level excitation energy (Ex) E-LVL or the maximum excitation level E-LVL-MAX are additionally given. *Italic font in this case means that values for E-LVL or E-LVL-MAX are not given explicitly by authors but are extracted from presently adopted nuclear level schemes (NDS/IAEA Livechart) or from the auxiliary information in publications and own analysis.*

The maximum excited level number or its energy Ex, inelastic scattering to which was not separated from elastic, is often not specified by the authors of the experiment. In such cases we tried to find the total energy resolution of spectrometer, which is usually characterized by the Full Width at Half Maximum (FWHM) and has to include all factors: incident energy spread, scattered neutron detection resolution or registration threshold. Then we assumed that all residual nucleus levels up to the excitation energy Ex less than FWHM were not separated from transition to the ground state, i.e. the elastic scattering, and hence the measured data are the partial scattering (SCT) cross section for all levels within interval $0 \le Ex \le FWHM$.

As an illustration, Fig. 1 displays two Gaussian lines: one is the elastically scattered neutrons with mean energy E_{elas} = 10.5 MeV and the second – "inelastically" scattered neutrons with energy E_{inel} = 9.5 MeV. The resolution (FWHM) for both is equal to 1 MeV and thus exactly coincides with the difference between their mean energies, from which the discrete level excitation energy could be estimated as Ex = E_{elas} - E_{inel} = 1 MeV. To mimic the differential scattering at various angles the three elastic peaks with different amplitudes are considered, whereas the inelastic one was assumed to be the angle independent. As seen in Fig. 1, in the case when Ex ≤ FWHM the elastic and inelastic peaks start to fuse into one peak, i.e. will be experimentally observed as one group of neutrons. In this situation an analytical treatment of the scattering peak (e.g., fitting by combination of two peaks of the pre-known shapes, subtracting the peak measured with bare neutron source, etc,) still may allow to separate the contribution of elastic and inelastic processes (that however was not always done by authors).

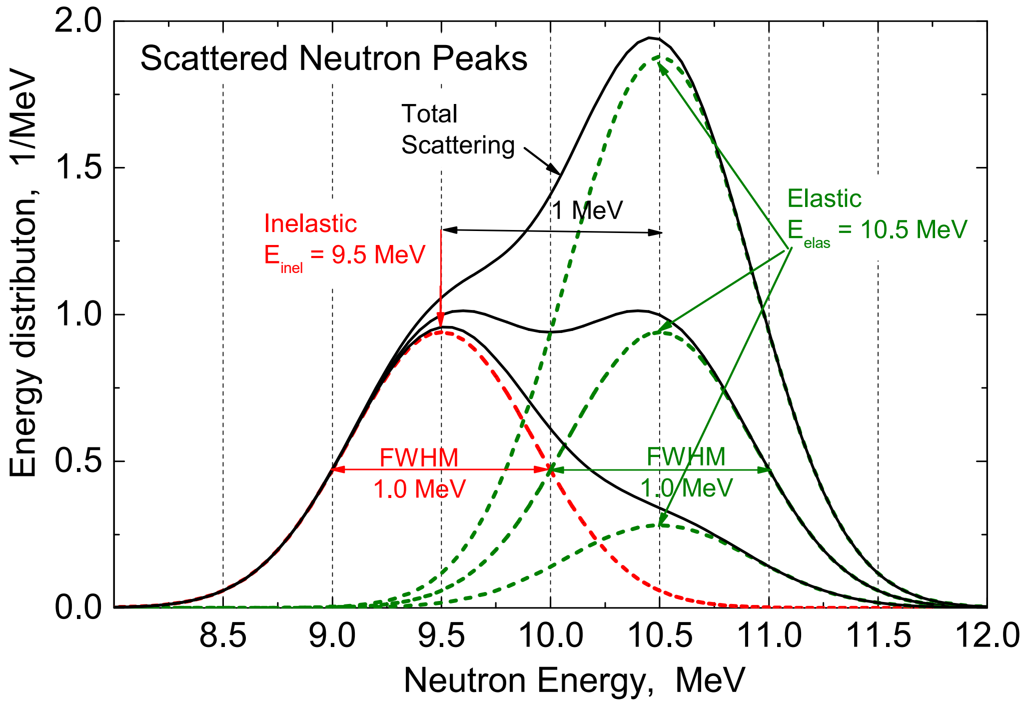

Fig. 1. The energy distribution (line shape) of elastic peak of various amplitude with the mean energy E_{elas} = 10.5 MeV and FWHM = 1 MeV (green dash line), and of the "inelastic" peak with E_{inel} = 9.5 MeV and FWHM = 1 MeV (red dash line). Their sum, i.e. total scattering peak is plotted by the black solid line.

It is obvious that the value of FWHM, the separation criteria Ex ≤ FWHM and the found nearest level E-LVL-MAX are not high accuracy quantities but rather serve for approximate quantification of how many excited levels probably were not resolved from the ground state. Some original publications do not contain the definitive values for Ex or for the overall energy experimental resolution. In such cases we still try to estimate it from the incomplete information we have found in source documentation, that may bring an estimate but only as the limit or range for Ex.

For the incident neutron energies above several MeV, the typical experimental energy resolution amounts (5 – 10)% that results in the large FWHM value up to 1 MeV. The latter may exceed the first level in many middle or heavy mass nuclei, so the issue "EL or SCT" may also concern the other elements which were measured by authors but were not found by the EXFOR automatic search and not listed in file "*EL-20211001-extract.xlsx*". Such sub-Entries were analysed too, and proper recommendations were given.

As was shown in the several publications, for the forward small angles (up to ≈ 30 degrees) the neutron scattering on the middle or heavy mass nuclei, the differential elastic cross section exceeds the inelastic ones to the unresolved levels by several orders of magnitude. It means that elastic and scattering cross sections are practically equal, especially considering the measurement uncertainties which are at level of a few percent in the best cases. In the present analysis such cases are considered as SCT.

Justifications which were copied from the original publications are included in the quotation marks, but those formulated by us – as a normal text. When EL is required to be replaced by SCT, the text of justification could be (partially) copied in CRITIQUE or elsewhere in Entry to explain the decision taken and to help the EXFOR users.

Further corrections of the Entry, found during analysis, comprise: (i) an important information about the experiment which is still missing in the particular Entry; (ii) recommendation to replace EL by SCT for other reactions (sub-Entries) which were not listed in the file "*EL-20211001-extract.xlsx*" but will require this basing on the analysis performed. The phrases in red are recommended for inclusion in Entry under the identified KEYWORDs.

Remarks to the EXFOR collection of publications (library *x4pdf*) were made when authors' publications needed for the analysis of the Entries were not included there. The name of the proper document was highlighted in red (the remark in green means that NDS/IAEA has operatively provided them).

General information on the neutron elastic scattering experiments and possible admixture of inelastic scattering.

1. From the view of measuring technique all experiments reporting the elastic angular differential cross section or polarization data could be arranged in two groups.

To the first one the measurements without neutron spectrometry, i.e. without determination of energy, could be ascribed (see for example, Entries 21858, 22029, 40706, etc.). Typically they have used the scintillation (i.e., hydrogen containing) detectors, which are characterized by the quasi flat distribution of pulse heights in response to the monoenergetic neutrons. To reduce the impact of the inelastic scattering neutrons and to suppress the sensitivity to the γ-rays, the discrimination level was set rather high but still below the high energy end of the pulse height distribution caused by the incident neutrons. Only counting rate of the detector was measured. Such experimental method was rather often used for the measurement of angular distribution and polarization power of the elastically scattered neutrons in the narrow forward directions, i.e. at angles up to ≈ 10º - 20º. The inelastic scattering differential cross section was supposed to be substantially lower than elastic and thus was ignored. This approach was used in the experiments carried in the time period ≈ 1950 - 1970.

The second group of experiments uses the neutron energy spectrometry. The energy of the scattered neutrons could be determined by the measuring of distribution of the pulse heights (PH) or by Time of Flight (TOF). Both are characterised by the final energy resolution, that is important in the present context. The most advanced and often used technique is TOF (see for example the data of Holmqvist' group in Entries 20019, 20162, 20346). In this method the neutron energy E is derived from the measured time t which neutron requires to fly from the sample to the detector located at flight path distance L (non-relativistic kinematics approximation):

$$E\,[MeV] \approx (72.3\,L[m]\,/\,t[ns])^2 \qquad (1).$$

The TOF or derived energy spectrum of the scattered neutrons principally allows to observe the elastic and inelastic groups of neutrons. This capability depends, however, on the overall energy resolution ΔE of the TOF spectrometer, which is a derivative of the neutron energy E, incident neutron energy E_0, time of flight t, beam time bunching Δt_b, detector resolution Δt_D, flight path length, sizes of the scattering sample ΔL_S and neutron detector ΔL_D, and the incident neutron energy spread ΔE_0. Differentiation of Eq. (1) results in:

$$\Delta E = E\sqrt{\Delta E_0^2/E_0^2 + 4(\Delta t_b^2 + \Delta t_D^2)/t^2 + 4(\Delta L_S^2 + \Delta L_D^2)/L^2} \qquad (2).$$

It has to be stressed that in the present context we interpret the uncertainty ΔX for every variable X in Eq. (2) as the resolution, i.e. the Full Width at Half Maximum (FWHM). Additionally other factors may impact on the overall resolution: asymmetric or non-gaussian time response of spectrometer, multiple neutron scattering in the sample. Since the later factors are unknown, even when all resolution components are reported by author, our calculations according to Eq. (2) still may underestimate the total energy resolution.

If the overall energy resolution achieved in the experiment is comparable or less than energy spacing between the ground and the first excited state Ex, the corresponding groups of neutrons are clearly separated or could be still resolved by fitting the peak shapes, see Fig. 1. In this case the author report the genuine elastic differential cross sections and (n,n') to the excited single or grouped levels. On contrary, the worse resolution results to overlapping of elastic and inelastically scattered neutrons. Still in this case, some experimentalists try to clean the observed "elastic" neutron scattering. For this the shape or response to the monoenergetic neutrons is determined by measuring the neutron flux from the bare neutron source or scattered by heavy nucleus with high first excited state, e.g. ^{208}Pb. Then this shape is fitted to the high energy half part of "elastic" peak, where the contribution of (n,n') is supposed to be absent. However, it is obviously not valid when Ex << ΔE, i.e. when the peaks from (n,n'$_1$) and (n,n$_{el}$) are superimposed without notable energy shift. As an example, the nuclei ^{181}Ta with Ex = 6.2 keV or ^{235}U with Ex = 0.076 keV could be mentioned.

In both approaches when elastic and inelastic scattering to the first levels could not be separated the experimentalist sometimes tried to derive the elastic cross section by subtracting the (n,n') cross section found in the literature, measured in the same experiment etc. after its dividing by 4π. The validity of such procedure is often questionable since it depends on many factors: whether the angular distribution is really isotropic, are the required (partial) inelastic cross sections well known, etc.

2. Many elastic scattering data have been measured with 14 MeV neutrons produced via interaction of the 100 – 300 keV deuterons with the tritium absorbed in solid material, usually titanium (see for example Entries 12069, ...). The mean neutron energy, yield and spread (i.e., FWHM of the peak in the energy distribution) depend on neutron emission angle. The energy spread was estimated by J. Csikai et al. in paper "Investigation on the properties of D+D and D+T neutron sources", Report IAEA-TECDOC-0410, p. 296. There Figure 6 shows the dependence of ½ FWHM versus the neutron emission angle Θ at several deuteron energies E_d varying from 125 and 220 keV. For example, at E_d = 175 keV, FWHM decreases from maximum value ≈ 400 keV at Θ = 0°, to the value ≈ 240 keV at Θ = 45° and then to the minimum ≈ 120 keV at Θ ≈ 105°. The neutron experiments presently analysed have utilized the neutron beam at between zero or 90 degrees, that means the spread of the initial neutron energy can varies in range 400 to 120 keV.

Besides the energy spreading due to deuteron stopping in the solid target and due to the T(d,n) reaction kinematics, an additional energy spread arises from the variation of the mean neutron energy within the angle subtended by the sample. The latter depends on the experimental set-up, i.e. the finite sizes of sample and distance to the solid target. This also is often the main reason of the scattering angle uncertainty which experimentalists try to minimize when they measure the angular differential neutron elastic scattering.

2. Recommendations for the SF3 field and other improvements of Entries content.

Entries: 10034.002 (67-HO-165(N,EL)67-HO-165,,SIG) and
10034.003 and (67-HO-165(N,EL)67-HO-165,,DA,,LEG/RS)

Ex of 1st level (MeV): 0.0947

Author and Publication: J. Meadows et al., zp_243_171_1971_.pdf

Recommendation for SF3: **EL**

Justification: There is no doubt below 1 MeV: "resolution was sufficient below 1 MeV". Above 1 MeV the authors still separated the elastic and inelastic neutrons and properly increase the cross section uncertainty: “As the incident energy increased the resolution became less definitive in the context of the more complex scattered neutron spectrum. … The larger uncertainties occurred at higher energies where the resolution of elastic and inelastic contributions was more difficult.”

Further correction of Entry: (.002) ERR-ANALYS: The uncertainty in the total elastic scattering cross section was estimated to be ≈ 8%. (.003) ERR-ANALYS: The relative uncertainties in the individual differential cross section measurements varied from 3-10 %.

Entries: 10179.003 (94-PU-240(N,EL)94-PU-240,,SIG) and
10179.004 (94-PU-240(N,EL)94-PU-240,,DA,,LEG/RS)

Ex of 1st level (MeV): 0.0428

Author and Publication: A. Smith et al., nse_47_19_1972_.pdf

Recommendation for SF3: **EL**

Justification: "The scattered neutron resolution was not generally sufficient at incident energies of > 1.0 MeV to differentiate the elastic neutron group from inelastic neutrons resulting from the excitation of the 42-keV state in 240Pu. Careful measurements at selected angles with an improved resolution of ~ 0.75 nsec/m qualitatively established the inelastic component to ~1.3 MeV. Assuming an isotropic inelastic neutron distribution and interpolating and extrapolating measured inelastic values with theoretical guidance (see below) the measured elastic cross sections were corrected for inelastic neutron contributions above ~1.0 MeV. This correction was small at forward scattering angles but appreciable at large scattering angles.”

Entries: 10234.006 (73-TA-181(N,EL)73-TA-181,,DA)

Ex of 1st level (MeV): 0.0062

Author and Publication: S. Pearlstein et al., jne_ab_19_497_1965_.pdf

Recommendation for SF3: **SCT:** (73-TA-181(N,SCT)73-TA-181,PAR,DA) with *E-LVL-MAX ≈ 1.8 MeV*

Justification: “For the scattering geometry used, the energy resolution is 13 per cent at 14.1 MeV”, i.e. FWHM ≈ 1.8 MeV. It was supposed that levels with excitation energy up to 1.8 MeV will not be resolved from the elastically scattered neutrons. Fig. 2 (“Experimental scattered neutron energy distributions”, see Ta) of jne_ab_19_497_1965_.pdf graphically confirms this.

Entries: 10264.002 (79-AU-197(N,EL)79-AU-197,,DA) and
10264.003 (79-AU-197(N,EL)79-AU-197,,DA)

Ex of 1st level (MeV): 0.0774

Author and Publication: M. Hoffman et al., la-5552_1974.pdf ; 71knox_2_868_1971.pdf

Recommendation for SF3: **EL** below 80 keV, but above – total **SCT:** (79-AU-197(N,SCT)79-AU-197,,DA)

Justification: The source was a moderated nuclear explosion, the TOF method was used for the incident neutron energy determination. At the bombarding neutron energy below 80 keV, i.e. the opening of the inelastic scattering to the first excited level in 197Au, the data in these subentries are the elastic scattering cross sections. Above 80 keV and until 2.75 MeV they are scattering cross sections since the used 3He scintillator detectors in current mode have registered both elastic an inelastically scattered neutrons. Since "the scattered foils and detectors were completely enclosed by a shielded of neutron moderating and absorbing material", probably efficiency of neutron detector drops down but only below 10 eV (as seen in Fig. 3 of la-5552_1974.pdf). It means that scattering (elastic + total inelastic) cross sections were measured above 80 keV.

Entries: 10366.004 (93-NP-237(N,EL)93-NP-237,,SIG)

Ex of 1st level (MeV): 0.0332

Author and Publication: M. Semon et al., bap_21_655(je3)_1976.pdf

Recommendation for SF3: **EL** below 35 keV, but above – total **SCT:** (93-NP-237(N,SCT)93-NP-237,,DA)

Justification: Neither single referencing document bap_21_655(je3)_1976.pdf nor this Entry 10366 does not report how the neutron elastic scattering was measured, which detector was used, ... (search of other relevant publications in the internet was unsuccessful; two Hoffman' letters dated 06.08.1975 and 30.03.1976 are not helpful too). Following the description given by M. Hoffman et al. for Au197(n,el) (la-5552_1974.pdf and 71knox_2_868_1971.pdf; Entry 10264.002), it might be recommended to consider these data as elastic cross section below 35 keV and as total scattering above this energy, when the inelastic scattering to the first excited level in Np237 opens and the scattered neutrons are counted by practically non-threshold detectors.

Entries: 10370.005 (73-TA-181(N,EL)73-TA-181,,DA)

Ex of 1st level (MeV): 0.0062

Author and Publication: P. Benenson et al., np_a_212_147_1973_.pdf

Recommendation for SF3: **SCT:** (73-TA-181(N,SCT)73-TA-181,PAR,DA) with *E-LVL-MAX = 4.0 MeV*

Justification: "The time window permitted inelastically scattered neutrons corresponding to excitation energies of approximately 4 MeV to give valid counts. Since forward inelastic scattering differential cross sections are typically three orders of magnitude lower than elastic for En ~ 15 MeV, no correction for the former was included." It means that inelastic cross sections for the levels up to ≈ 4 MeV excitation energy are experimentally presented in these data.

Entries: 10473.002 (92-U-238(N,EL)92-U-238,,DA) and 10473.005 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: L. Beghian et al., nse_69_191_1979_.pdf

Recommendation for SF3: **EL**

Justification: Extensive efforts were undertaken to obtain an energy resolution of ~ 20 keV (half of 1st level excitation) especially at higher bombarding neutron energies. Moreover, when the first two neutron groups could not always be resolved completely, an unfolding procedure was applied using an empirically determined prompt neutron profile.

Further correction of Entry: (.001) CORRECTION: Unfolding procedure was applied to resolve elastically and inelastically scattered neutrons.

Entries: 10510.003 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: W. Bucher et al., prl_35_1419_1975_.pdf , nim_111_237_1973_.pdf

Recommendation for SF3: **SCT**: (92-U-238(N,SCT)92-U-238,PAR,DA) with *E-LVL-MAX = 210 keV* (at EN = 7.0 MeV), 270 keV (at EN = 9.0 MeV), 330 keV (at EN = 11.0 MeV) or 420 keV (at EN = 14.0 MeV)

Justification: The experiment was optimized for the forward neutron elastic scattering cross section measurements at energy 7 – 14 MeV. The NE type scintillation detector and moderate flight path 3 m are not sufficient to resolve the first inelastically scattered neutron components in the case of U238 target by TOF. From the Fig. 7 of nim_111_237_1973_.pdf it is possible to define the energy resolution of spectrometer FWHM ≈ 30%. Supposing that U238 levels up to excitation energies FWHM will not be resolved from ground state, the maximum E-LVL-MAX ≈ 0.210 MeV (at EN = 7.0 MeV), ≈ 0.270 MeV (at EN = 9.0 MeV), ≈ 0.330 MeV (at EN = 11.0 MeV) and ≈ 0.420 MeV (at EN = 14.0 MeV).

Entries: 10570.003 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: L. Yu et al., bap_20_1496(bd9)_1975.pdf, Nucl. Phys. A324(1979)160

Recommendation for SF3: **EL**

Justification: The small angle neutron scattering with a good angular resolution was a goal of this experiment. Since the incident neutron spectrum was continuum, TOF was used to determine only bombarding neutron energy within energy interval 0.6 – 2.2 MeV. The overall flight path 10 m and 1.5 ns pulsed proton beam were only sufficient for getting the cross section averaged over rather wide energy bins 100 keV. The used NE218 scintillator detector is not capable to resolve elastic and inelastic scattered neutrons which have an energy different only by 45 keV. However, the authors did make the proper correction in following way: "Cross sections for 238U were corrected for inelastic scattering with the previously measured inelastic cross sections summarized by Lambropoulos. The magnitude of this correction at 1.5 deg ranged from about 10% at low energies to less than 1% at high energies. Use of a more recent set of evaluated cross sections would not substantially alter the results."

Further correction recommended for Entry (.001):

REFERENCE and TITLE, add this: L.L. Yu, J.C. Overley, Small-angle neutron scattering from Pb and 238U between 0.6 and 2.2 MeV, Nucl. Phys. A324 (1979); DOI: 10.1016/0375-9474(79)90085-X

INC-SOURCE (P-LI), replace by this: 1.5 ns pulsed 4 MeV proton beam stroked thick lithium metal target and produced neutron energy continuum spectrum.

METHOD (TOF), add this: Time-of-flight. Neutron flight paths from source to scatterer and from scatterer to detector were each 5 m. Data were averaged over 100 keV incident energy bins.

DETECTOR: NE218 scintillator. Bias levels were set to reject events corresponding to recoil protons of less than 0.4 MeV and greater than 6 MeV. Pulse shape discrimination against y-rays was also employed.

CORRECTION, add this: Cross sections for ^{238}U were corrected for inelastic scattering with the previously measured inelastic cross sections summarized by Lambropoulos. The magnitude of this correction at 1.5 deg ranged from about 10% at low energies to less than 1% at high energies. Use of a more recent set of evaluated cross sections would not substantially alter the results. Inelastic scattering corrections for lead were negligible.

Entries: 10633007 (25-MN-55(N,EL)25-MN-55,DI,DA), 10633011 (41-NB-93(N,EL)41-NB-93,,DA), 10633018 (67-HO-165(N,EL)67-HO-165,,DA), 10633019 (73-TA-181(N,EL)73-TA-181,,DA)

Ex of 1st level (MeV): 0.1359 (Mn55), 0.0308 (Nb93), 0.0947 (Ho165), 0.0062 (Ta181)

Author and Publication: J. Ferrer et al., np_a_275_325_1977_.pdf

Recommendation for SF3: SCT:

(25-MN-55(N,SCT)25-MN-55,PAR,DA) with LVL-NUMB = 0, 1 (E-LVL = 0, 126 keV)
(41-NB-93(N,SCT)41-NB-93,PAR,DA) with LVL-NUMB = 0, 1 (E-LVL = 0, 31 keV)
(67-HO-165(N,SCT)67-HO-165,PAR,DA) with E-LVL-MAX = 360 keV
(73-TA-181(N,SCT)73-TA-181,PAR,DA) with E-LVL-MAX = 360 keV

Justification: "The overall energy resolution of the system for 11 MeV neutrons was 360 keV (FWHM). … With the energy resolution of the present experiment, neutrons inelastically scattered from low-lying excited states of V, Mn, Nb, In, Ho and Ta were not resolved from the elastic peak." It could be supposed that inelastically scattered neutrons to the levels with excitation energy FWHM = 360 keV were not resolved from elastic scattering.

Further correction recommended for Entry: SCT instead of EL in subentries

.006 (23-V-51(N,SCT)23-V-51,PAR,DA) with LVL-NUMB = 0, 1 (E-LVL = 0, 321 keV)
.016 (49-IN-0(N,SCT)49-IN-0,PAR,DA) with LVL-NUMB = 0, 1 (E-LVL = 0, 336 keV In115, 392 keV In113)

Entries: 10718.006 (62-SM-152(N,EL)62-SM-152,,DA)

Ex of 1st level (MeV): 0.1218

Author and Publication: D. Coope et al., pr_c_16_2223_1977_.pdf

Recommendation for SF3: **EL**

Justification: "The time resolution of the system, as can be seen in the TOF spectrum of Fig. 2, was good enough to resolve well the first excited state of 152Sm at 122 keV excitation energy from the elastic scattering peak."

Entries: 10803.005 (74-W-182(N,EL)74-W-182,,DA), 10803.006 (74-W-184(N,EL)74-W-184,,DA),
10803.007 (74-W-186(N,EL)74-W-186,,DA), 10803.008 (74-W-182(N,EL)74-W-182,,SIG),
10803.009 (74-W-184(N,EL)74-W-184,,SIG), 10803.010 (74-W-186(N,EL)74-W-186,,SIG)

Ex of 1st level (MeV):, 0.1001 (W-182), 0.1112 (W-184), 0.1226 (W-186)

Author and Publication: T. Guenther et al., pr_c_26_2433_1982_.pdf

Recommendation for SF3: **EL**

Justification: Following explanations of authors and their Figs. 2 and 3 definitely prove that EL was measured: "The primary problem in the elastic-scattering measurements was the resolution of the elastic neutron group from the inelastic components corresponding to the excitation of the ≈ 110 keV level. Most of the measurements were made with flight paths of ≈ 5.4 m. At higher energies some measurements were made with ≈ 20 m flight paths in order to improve the resolution of the elastic scattered components and the results were also used to correct the shorter-flight-path values, measured at similar energies, for unresolved inelastic-neutron contributions."

Entries: 10807.016 (60-ND-150(N,EL)60-ND-150,,DA), 10807.017 (60-ND-150(N,EL)60-ND-150,,DA,,LEG), 10807.026 (60-ND-150(N,EL)60-ND-150,,SIG)

Ex of 1st level (MeV): 0.1302

Author and Publication: D. Coope et al., bap_24_854(gc10)_1979.pdf

Recommendation for SF3: **EL**

Justification: From the short information given in single publication bap_24_854(gc10)_1979.pdf "Differential cross sections for neutron elastic and inelastic scattering to excited levels of even-A Nd isotopes have been measured for an incident energy of 2.5 MeV", it follows that both elastic and inelastic neutron groups were resolved. It is confirmed by subentry 10807.018 of the same author for reaction (60-ND-150(N,INL)60-ND-150,PAR,DA), i.e. inelastic excitation of the first level

0.132 MeV. Additionally, this experiment seems was performed at the same facility of University of Kentucky as those by D. Coope et al., pr_c_16_2223_1977_.pdf, **Entries:** 10718.006 (62-SM-152(N,EL)62-SM-152,,DA).

Entries: 10876.003 (47-AG-107(N,EL)47-AG-107,,DA), 10876.004 (47-AG-107(N,EL)47-AG-107,,SIG)

Ex of 1st level (MeV): 0.0931

Author and Publication: A. Smith et al., np_a_332_297_1979_.pdf, anl-ndm-46_1979.pdf

Recommendation for SF3: **EL**

Justification: "The experimental scattered-neutron velocity resolution with flight paths of ≈ 5 m was sufficient to resolve the elastically scattered neutron component from all known inelastic-neutron groups to incident energies of ≈ 3 .0 MeV. The resolutions were less favourable at energies > 3.0 MeV. However, selected measurements with better resolution obtained with 20 m flight paths indicated that inelastically scattered neutrons did not appreciably contaminate the "elastic" neutron groups observed at the shorter (5 m) flight paths." Additional justification: separated subentry 10876.005 reports (47-AG-107(N,INL)47-AG-107,PAR,SIG) for separated levels Ex = 0.103 MeV, 0.425 MeV and higher.

Entries: 10899.002 (94-PU-242(N,EL)94-PU-242,,DA), 10899.003 (94-PU-242(N,EL)94-PU-242,,SIG)

Ex of 1st level (MeV): 0.0445

Author and Publication: D. Drake et al., la-7855-ms_1979.pdf

Recommendation for SF3: **EL**

Justification: At bombarding neutron energies 0.57 MeV and 1.0 MeV the total energy resolution of the TOF spectrometer was sufficient to separate the inelastic scattering to the first excited state of ^{242}Pu (Ex = 45 keV and 148 keV) from elastic (as shown in Figs. 3 - 5 and Table I). However, at incident neutrons 1.5 MeV "it was impossible to separate elastically scattered neutrons from those inelastically scattered by low-lying excited states, so we analyzed the observed scattering as if it were one state. From these differential cross sections, we subtracted the 46 mb/sr that were estimated as the isotropic differential cross sections of the first two excited states" (see Fig. 7 and Table I). Exactly this information is already given as FLAG in these sub-entries for incident energy 1.5 MeV.

Entries: 11202.017 (41-NB-33(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308

Author and Publication: J. Hopkins et al., nse_36_275_1969_.pdf, np_a_107_139_1968_.pdf

Recommendation for SF3: **SCT:** (41-NB-93(N,SCT)41-NB-93,PAR,DA) with *E-LVL-MAX = 30.8 keV*

Justification: The description of experiment is given in: np_a_107_139_1968_.pdf. There the energy resolution is quantified as "the neutron energy spreads were 62 keV, 47 keV, 230 keV and 170 keV for incident neutron energies of 3.35 MeV, 4.83 MeV, 5.74 MeV and 7.5 MeV, respectively". Obviously, the energy spread 170 – 230 keV was not sufficient to separate the 1st excited level 31 keV of ^{93}Nb at incident neutron energy 5.95 to 7.47 MeV. An indirect confirmation is given by the following authors' statement for the n + ^{7}Li data: "the 5.74 MeV and 7.5 MeV data include the scattering to the first excited state at 0.478 MeV" - these data are correctly compiled in sub-Entry 11153.014 (3-LI-7(N,SCT)3-LI-7,PAR,DA).

Since the second 686 keV and higher excited levels of ^{93}Nb have the energies exceeding the spectrometer energy spread, probably they were separated from (n,el + n1) and included in inelastic.

Entries: 11215.046 (79-AU-197(N,EL)79-AU-197,,SIG) and
11215.049 (79-AU-197(N,EL)79-AU-197,,DA)

Ex of 1st level (MeV): 0.0774

Author and Publication: M. Walt et al., pr_98_677_1955_.pdf

Recommendation for SF3: **SCT:** (79-AU-197(N,SCT)79-AU-197,PAR,SIG) and (79-AU-197(N,SCT)79-AU-197,PAR,DA) **with *E-LVL-MAX = 0.9 MeV***

Justification: The incident "neutrons of 4.1 MeV with an energy spread of about 80 keV were produced ... ". Additionally to this spread, the energy sensitive scintillation neutron detector was operated at three biases (thresholds): "In order to obtain estimates of the energy lost by the neutrons in inelastic collisions the detector was operated at three different biases having detection thresholds at about 2.0, 2.6, and 3.2 MeV. Thus, the presence of neutrons which lost less than 2 MeV in inelastic collisions would be indicated by differences in the cross sections obtained at the three biases." The measured angular differential scattering cross sections are presented for these three biases, for Au – in Fig. 7. Comparison of the numerical data given in sub-Entry 11215.046 (79-AU-197(N,EL)79-AU-197,,SIG) with Fig. 7 proves that compiled data are those measured with the highest bias of neutron detector, i.e. 3.2 MeV. It means that all inelastically scattered neutron leaving ^{197}Au at excitation energy approximately up to (4.1 – 3.2) MeV = 0.9 MeV are partially included in (n,el) process.

Entries: 11223.005 (73-TA-181(N,EL)73-TA-181,,DA)

Ex of 1st level (MeV): 0.0062

Author and Publication: L. Rosen et al., pr_107_824_1957_.pdf

Recommendation for SF3: **SCT**: (73-TA-181(N,SCT)73-TA-181,PAR,DA) with *E-LVL-MAX ≈ 2.0 MeV*

Justification: In this experiment the nuclear emulsions situated at some distance from scatter was employed as neutron detectors. "The scatterer detector geometry and selection criteria afford a maximum angular spread of ± 8° and a maximum energy spread of ± 7%", however "no corrections were made for the finite angular and energy resolution presented by the target-detector geometry." Thus, the 14% energy resolution at 14.0 MeV results to FWHM ≈ 2.0 MeV. I suppose that levels with excitation energy up to approximately 2.0 MeV will not be resolved from the elastically scattered neutrons. Such E-LVL-MAX ≈ 2.0 MeV is confirmed by Fig. 5 (the energy distribution of the neutrons from 14-MeV neutrons on Ta) and by Fig. 3 (angular distributions of the nonelastic neutrons from 14-MeV neutrons on Ta, obtained as integration up to 12 MeV, i.e. 14.0 – 2.0 MeV).

CORRECTION: the paper has a dedicated "Section III. Corrections" which describes a set of corrections applied – information from there is recommended to include in Entry.

Further correction recommended for Entry: similar as for Ta-181 but now for Bi-209 (see Figs. 4 and 6)
SCT instead of EL in subentry .011 (83-BI-209(N,SCT) 83-BI-209,PAR,DA) *with E-LVL-MAX ≈ 2.0 MeV*

Entries: 11287.027 (45-RH-103(N,EL)45-RH-103,,SIG), 11287.028 (45-RH-103(N,EL)45-RH-103,,DA)

Ex of 1st level (MeV): 0.0398

Author and Publication: R. Wilenzick et al., np_62_511_1965_.pdf

Recommendation for SF3: **SCT**: (45-RH-103(N,SCT)45-RH-103,PAR,DA) with *E-LVL-MAX ≈ 2.0 MeV*

Justification: "The average energy of the neutrons incident on the scatterer was determined as 6 04 MeV, with an energy spread which was approximately triangular and whose full width at half-maximum was 230 keV". "For most medium and heavy nuclei a continuous spectrum of inelastically scattered neutrons is observed, since the time resolution is insufficient to resolve the neutrons from the many levels in the residual nucleus (see fig 3)". However, the authors noted: "since the elastic and inelastic neutron groups were not perfectly resolved, it was necessary to perform a subtraction by fitting a known the shape to the elastic peak. … The decomposition of the elastic and inelastic groups was performed manually". Still "the inelastic cross sections were determined using only neutrons within the energy range 0.5 to 4.0 MeV, the data above 4 MeV being considered unreliable because of uncertainties associated with the decomposition of the observed spectra into its elastic and inelastic parts". Considering all this information it looks unrealistic to separate the 39.8 keV inelastic peak from elastically scattered on ^{103}Rh. For other nuclei in this Entry such separation looks more reliable if the 1st level lay higher than 230 keV.

Further correction recommended for this Entry (.001):

MONITOR (6-C-12(N,SCT)6-C-12,,SIG) => (6-C-0(N,TOT)6-C-0,,SIG), 1.12 ± 0.02 b at 6.04 MeV.

All sample were natural materials. Then should it be in .003: REACTION (6-C-12(N,EL)6-C-12,,DA) or C-0 ?

Entries: 11495.008 (25-MN-55(N,EL)25-MN-55,,DA), 11495.018 (33-AS-75(N,EL)33-AS-75,,DA),
11495.028 (41-NB-93(N,EL)41-NB-93,,DA), 11495.036 (53-I-127(N,EL)53-I-127,,DA),
11495.050 (79-AU-197(N,EL)79-AU-197,,DA), 11495.060 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.1259 (Mn-55), 0.1986 (As-75), 0.0308 (Nb-93), 0.1259 (I-127), 0.0774 (Au-197)

Author and Publication: D. Thomson, pr_129_1649_1963_.pdf

Recommendation for SF3: **SCT**: (25-MN-55(N,SCT) 25-MN-55,PAR,DA), (33-AS-75(N,SCT)33-AS-75,PAR,DA), (41-NB-93(N,SCT)41-NB-93,PAR,DA), (53-I-127(N,SCT)53-I-127,PAR,DA), (79-AU-197(N,SCT)79-AU-197,PAR,DA), (41-NB-93(N,SCT)41-NB-93,PAR,DA) with *E-LVL-MAX ≈ 1.0, 1,25, 1,50 and 1.75 MeV at incident energies 4, 5, 6 and 7 MeV correspondingly.*

Justification: "Counts corresponding to elastically scattered neutrons were subtracted by fitting an appropriate monoenergetic neutron line shape to the elastic peak of the time spectrum. It was found that the spectrum for indium at 4.0 MeV gave a strong elastic peak at forward angles which agreed in shape with the gamma-ray peak within a few percent for each channel having an amplitude of 5% or more of the peak channel. … An example of the subtraction procedure is shown in Fig. 11. The original time spectrum was plotted on a log scale, and the gamma-ray line shape was plotted on another log sheet. The two plots were superimposed and fitted so that the gamma-ray line was normalized to the height of the peak corresponding to the energy of the elastically scattered neutrons. All of the neutron counts in the normalized curve were assumed to be elastic and were subtracted. … Typical resolution functions, which include both target thickness and burst duration, are shown in Fig. 10." In this Figure the FWHM could be estimated as ≈ 1 MeV at neutron energy E = 4 MeV. Employing the ratio FWHM/E = 25%, we come to E-LVL-MAX ≈ 1.0, 1,25, 1,50 and 1.75 MeV at incident energies 4, 5, 6 and 7 MeV correspondingly.

Further correction recommended for Entry: similar as for As-75, Nb-93, I-127, Au-197 the corrections SCT and PAR instead of EL *with E-LVL-MAX ....* has to be implied for all other elements and sub-Entries (but excluding Pb-206) since their first excited levels have energy less then FWHM: Al-27 (Elvl1 = 0.8438), V-0 (0.3208), Fe-0 (0.8468, and low levels in other isotopes …), Cu-0 (0.6699, …), Se-0 (0.3885, …), Se-0 (0.3885, …), In-0 (0.3362, …), La-0 (0.1659, …), Ta-0 (0.0062, …), W-0 (0.1001, …), Tl-0 (0.2037), Bi-209 (0.8963).

Entries: 11511.008 (25-MN-55(N,EL)25-MN-55,,DA), 11511.016 (33-AS-75(N,EL) 33-AS-75,,DA),
11511.031 (59-PR-141(N,EL)59-PR-141,,DA)

Ex of 1st level (MeV): 0.1259 (Mn-55), 0.1986 (As-75), 0.1454 (Pr-141)

Author and Publication: R. Becker, np_89_154_1966_.pdf

Recommendation for SF3: **EL**

Justification: The authors have definitely stated "pulse-height discrimination was used to exclude inelastically scattered neutrons". It is possible without TOF, however the pulse height measurement method has also own energy resolution. Regrettably but any relevant information about such details are absent in paper. Only the incident energy resolution is given: "a calculated neutron energy in the forward direction of 3200 keV with an r.m.s. energy variation of about 100 keV".

Supposing a typical relative energy resolution for "detector, a scintillation counter employing stilbene or NE 213 liquid mounted … on photomultiplier …" at level ≈ 5% will result to ΔE = FWHM = 5% * 3.2 MeV = 160 keV. Consequently, for most of 36 elements compiled in this Entry 11511 the EL has to be replaced by SCT with exception for Co-59 (Elvl1 = 1.099 MeV) and Bi-209 (Elvl1 = 0.8963). However, since 5% energy resolution is merely our suggestion which provokes a contradiction to the authors statement "pulse-height discrimination was used to exclude inelastically scattered neutrons", we refused from such modification or recommendation.

Entries: 11638.011 (90-TH-232(N,EL)90-TH-232,,DA)

Ex of 1st level (MeV): 0.0494

Author and Publication: S. Darden, pr_100_1315_1955_.pdf

Recommendation for SF3: **SCT**: (90-TH-232(N,SCT)90-TH-232,PAR,DA)
with E-LVL-MAX ≈ 0.3, 0.4 or 0.5 MeV at incident energy 0.50, 1.00 and 1.55 MeV, correspondingly.

Justification: The authors have specified only the incident energy spread: "Differential cross section elastic have been measured for several elements at neutron energies 0.5, 1.00 and 1.55 MeV with a neutron energy spread of about 100 keV". The scattered neutrons were registered in the following way: "for a neutron energy of 1 MeV, data were taken at two biases set so that no neutrons with energies less than 660 and 790 keV, respectively, were detected. … At 0.50 MeV, the two biases were set to discriminate against neutrons having energies less than 200 and 300 keV, respectively. At 1.55 MeV, the data presented were taken with discriminator set such that neutrons of energy less than 1.1 MeV were not detected".

It means that up to excitation energy Ex = 0.5 – 0.25 = 0.25 MeV at initial energy E_0 = 0.50 and Ex = 1.0 – 0.73 ≈ 0.37 MeV at E_0 = 1.0 and Ex = 1.55 – 1.1 ≈ 0.45 MeV at E_0 = 1.55. Quadratically summing with initial energy spread 0.1 MeV and rounding to the first significant digit we will get Ex ≈ 0.3, 0.4 and 0.5 MeV, correspondingly.

Further correction recommended for this Entry 11638: consequently, for the next elements Ti-0 (Ti-47 Elvl1 = 0.1594 MeV), Fe-0 (Fe-57 Elvl1 = 0.0144 MeV), Ag-0 (Ag-109 Elvl1 = 0.0880 MeV), Cd-0 (Cd-111 Elvl1 = 0.2454 MeV), Sn-0 (Sn-119 Elvl1 = 0.0238 MeV), Sb-0 (Sb-121 Elvl1 = 0.0371 MeV) and Ta-0 (Ta-181 Elvl1 = 0.0062 MeV) the EL has to be replaced by SCT since the excitation energy of the first level in the one of stable isotopes is below Ex.

SF3 should remain EL for elements Cu-0 (Cu-63 Elvl1 = 0.6693 MeV), Zr-0 (Zr-94 Elvl1 = 0.9188 MeV), Cr-0 (Cr-136 Elvl1 = 0.5520 MeV), Pb-0 (Pb-207 Elvl1 = 0.5697 MeV) and Bi-209 (Elvl1 = 0.8963), since incident energy is less than minimal first level excitation energy among stable isotopes and thus only elastic scattering will be kinematically allowed.

Entries: 11854.005 (41-NB-93(N,EL)41-NB-93,,DA,,LEG/RS), 11854.006 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308

Author and Publication: D. Reitman et al., np_48_593_1963_.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA,,LEG/RS),
(41-NB-93(N,SCT)41-NB-93,PAR,DA) with *LVL-NUMB = 1*

Justification: For ^{93}Nb it was clearly stated by authors: "in no instance was an inelastic component corresponding to the excitation of the first state at 0.029 MeV observed. Such a group could have been experimentally resolved only if it were relatively intense at incident neutron energies below

0.7 MeV. Any inelastic component leading to the excitation of this first level was included in the elastic group. Such a contribution is expected to be small on theoretical grounds …”.

In the case of natural Zr “the only levels which could be expected to be observed in this experiment are those in Zr^{94}, and Zr^{92} and possibly in Zr^{91} at ~ 0.92 MeV”. The inelastic scattering to such high excitation energies are well resolved from elastic scattering as seen in Fig. 1 and following comments of authors: “the remaining group shown in this portion of the figure corresponds to inelastically scattered neutrons which leave the Zr nucleus in an excited state at 0.92 MeV”. Thus the SF3 field in the (40-ZR-0(N,EL)40-ZR-0,…) sub-entries should be left as EL.

Entries: 11877.003 (41-NB-93(N,EL)41-NB-93,,DA), 11877.007 (59-PR-141(N,EL)59-PR-141,,DA)
11877.009 (79-AU-197(N,EL)79-AU-197,,DA), 11877.012 (90-TH-232(N,EL)90-TH-232,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93), 0.1454 (Pr-141), 0.0774 (Au-197), 0.0494 (Th-232)

Author and Publication: S. Buccino et al., zp_196_103_1966_.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA), (59-PR-141(N,SCT)59-PR-141,PAR,DA), (79-AU-197(N,SCT)79-AU-197,PAR,DA), (90-TH-232(N,SCT)90-TH-232,PAR,DA) with *E-LVL-MAX ≈ 0.450 MeV*

Justification: The energy spread of incident 5 MeV neutrons is given by authors: “the average energy spread in the deuterium beam due to energy loss in the gas and inhomogeneity of the foil (~ 10%) was 320 keV”. An energy resolution of the TOF spectrometer we can calculate as 310 keV from following information: “a flight path of 1.4 m and an overall resolution of 7 nsec for the scattered neutrons were sufficient to separate the elastic peak from the inelastic continuum in the time spectra. The elastic peak was not perfectly symmetrical but included a "tail" on the side nearest the continuum. Since the tail was not resolved from the continuum, the relative yield was determined by symmetrizing the entire peak around the centroid of the upper portion of the peak”. Then quadratically summing both, we get the total energy resolution FWHM = 445 keV. It means that all elastically and inelastically scattered neutrons within peak of ≈ 0.450 MeV width were separated from other (n,n’) continuum and interpreted by authors as elastic scattering.

Further correction recommended for this Entry 11877: The same consideration and corrections (SF3 = SCT) of REACTION should be applied to the following natural elements Ag, Sb, Ta, Tl and U. However, SF leaves to be EL for: Zr-0 (min Elvl1 = 0.9188 MeV in ^{94}Zr), Ce-0 (min Elvl1 = 0.5521 MeV in ^{136}Ce), Pb-206 (Elvl1 = 0.803 MeV).

Entries: 11977.004 (79-AU-197(N,EL)79-AU-197,,DA), 11977.006 (90-TH-232(N,EL)90-TH-232,,DA)

Ex of 1st level (MeV): 0.0774 (Au-197), 0.0494 (Th-232)

Author and Publication: F. Kuchnir et al., pr_176_1405_1968_.pdf

Recommendation for SF3: **EL**

Justification: “These data were corrected ... and for the presence of inelastically scattered neutrons. … The contribution from inelastically scattered neutrons was evaluated from the known energy dependence of the detector efficiency and the measured inelastic scattering cross sections under the assumption that these neutrons are distributed isotropically in angle. Inelastic scattering contributed about 0.10 b/sr to the measured differential cross sections for U, Th, and W, about half as much for Au, and a negligible amount for Cd and Pb. The measured cross sections of U and Th were not corrected for the effect of fission neutrons since this contribution was estimated to be negligible for our experimental conditions”. From this it follows that correction for contribution of (n,n’) was applied by authors – that is also reflected under keyword CORRECTION of each sub-Entry.

Entries: 12039.002 (53-I-127(N,EL)53-I-127,,DA,,LEG/RS), 12039.003 (53-I-127(N,EL)53-I-127,,SIG)

Ex of 1st level (MeV): 0.0576

Author and Publication: A. Smith et al., eandc(us)-62_1965.pdf, 65antwerp_509(36)_1965.pdf

Recommendation for SF3: EL

Justification: "The experimental scattered neutrons resolutions were tailored to the specific requirements of the individual measurements with particular attention to the resolution of the elastically and of the inelastically scattered components". For Iodine the authors has declared "incident neutron energy spread 20 - 30 keV". This looks to be sufficient to separate neutron groups populating 57.6 keV and g.s. of ^{127}I.

Similarly SF3 leaves to be EL for other natural elements this Entry 12039: Yb-0 ("incident neutron energy spread ≈ 20 keV", min Elvl1 = 0.0667 MeV in ^{171}Yb) and Pb-0 ("incident neutron energy spread 20 keV", min Elvl1 = 0.5697 MeV in ^{207}Pb).

Remark to the EXFOR pdf collection: 65antwerp_509(36)_1965.pdf is not available.

Entries: 12054.002 (57-LA-139(N,EL)57-LA-139,,DA), 12054.003 (57-LA-139(N,EL)57-LA-139,,DA,LEG), 12054.004 (57-LA-139(N,EL)57-LA-139,,SIG), 12054.005 (59-PR-141(N,EL)59-PR-141,,DA),
12054.006 (59-PR-141(N,EL)59-PR-141,,DA,LEG), 12054.007 (59-PR-141(N,EL)59-PR-141,,SIG)

Ex of 1st level (MeV): 0.1659 (La-139), 0.1454 (Pr-141)

Author and Publication: D. Bernard et al., 68wash_2_755_1968.pdf

Recommendation for SF3: **SCT**: (57-LA-139(N,SCT)57-LA-139,PAR,DA), (57-LA-139(N,SCT)57-LA-139,PAR,DA,LEG), (57-LA-139(N,SCT)57-LA-139,PAR,SIG), (59-PR-141(N,SCT)59-PR-141,PAR,DA), (59-PR-141(N,SCT)59-PR-141,PAR,DA,LEG), (59-PR-141(N,SCT)59-PR-141,PAR,SIG) with *E-LVL-MAX ≈ 0.800 MeV*

Justification: The authors wrote: "No effort has been made to extract inelastic contributions to the elastic neutron groups as evidence indicates that such contributions are small and within statistical counting uncertainties. … it was assumed that the contribution of the most energetic inelastic neutrons (leaving praseodymium in its 0.140 MeV excited state) to the elastic peak was negligible. Similar results were obtained with the lanthanum scatterer". Caption to Fig. 3 specifies that "the neutron energy resolution is about 800 keV".

Remark to the EXFOR pdf collection: 68wash_2_755_1968.pdf is not available.

Entries: 12069.002 (41-NB-93(N,EL)41-NB-93,,DA), 12069.010 (41-NB-93(N,EL)41-NB-93,,SIG)

Ex of 1st level (MeV): 0.0308

Author and Publication: G. Western et al., afwl-tr-65_216_2_1966.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA), (41-NB-93(N,SCT)41-NB-93,PAR,SIG) with *E-LVL-MAX ≈ 0.700 MeV*

Justification: For Nb and V the authors wrote: "the data were integrated over energy to obtain the differential cross section … for nonelastic scattering … for 4.5 ≤ E ≤ 14 MeV". It looks that neutrons in the energy group 14.0 ≤ E ≤ 14.7 and higher were included in the elastic scattering. We use the difference 14.7 – 14.0 MeV as estimation for Ex = 0.7 MeV. Additionally, it could be noticed that such Ex is larger than energy resolution 0.060 MeV of the TOF spectrometer (computed with flight path 2.9 m and time resolution Δt = 1.6 ns plotted in Fig. 5.3) and the spread of "the energy of neutrons entering the scatterer is 14.7 ± 0.2 MeV".

Further correction recommended for this Entry 12069: The same consideration and corrections (SF3 = SCT) of REACTION should be applied for V-0 (Elvl1 = 0.2262 and 0.3201 MeV in ^{50}V and ^{51}V) in sub-Entries .003 and .011. The SF3=EL should be left for C-0 (12069.004) in sub-Entries .004 and .012: "… the channel separation of the elastic and inelastic (Q = 4.433 MeV) peaks in the time spectrum of neutrons scattered from carbon".

Entries: 12175.002 (73-TA-181(N,EL)73-TA-181,,DA), 12175.003 (73-TA-181(N,EL)73-TA-181,,SIG),
12175.004 (73-TA-181(N,EL)73-TA-181,,DA,,LEG/RS)

Ex of 1st level (MeV): 0.0062

Author and Publication: A. Smith et al., anl-6727_1963.pdf

Recommendation for SF3: **SCT**: (73-TA-181(N,SCT)73-TA-181,PAR,DA), (73-TA-181(N,SCT)73-TA-181,PAR,SIG), (73-TA-181(N,SCT)73-TA-181,PAR,SIG) with LVL-NUMB = 0, 1

Justification: "Throughout this experiment, the resolution was insufficient to distinguish the reported first excited, $9/2^-$, state at 6 keV in ^{181}Ta from the ground state. As a result, any processes possibly involving this first level were referenced the ground state instead". The inelastic neutron scattering to the several next excited levels in ^{181}Ta are resolved and reported separately.

Entries: 12180.005 (90-TH-232(N,EL)90-TH-232,,SIG), 12180.006 (90-TH-232(N,EL)90-TH-232,,DA)

Ex of 1st level (MeV): 0.0494

Author and Publication: C. Hudson et al., pr_128_1271_1962_.pdf

Recommendation for SF3: **SCT**: (90-TH-232 (N,SCT) 90-TH-232,PAR,DA),
(90-TH-232 (N,SCT) 90-TH-232,PAR,SIG) with *E-LVL-MAX ≈ 1.800 MeV*

Justification: "With the 179-cm flight path used in this experiment, and for 15.2-MeV neutrons, the time resolution of 3 nsec corresponds to an energy resolution of 2.5 MeV. In the actual data reduction, an integral number of channels of the time-of-flight spectrum were used as the "elastic scattering peak," corresponding to a spread in flight time of slightly more than 3 nsec. Figure 3 gives the relative efficiency for detection of neutrons of energy E for the time-of-flight system used in this experiment. If the energy resolution is defined as the energy loss for which neutrons are detected with 50% efficiency relative to elastically scattered neutrons, the system has an energy resolution of 1.8 MeV".

Further correction recommended for this Entry 12180: the same consideration and corrections (SF3 = SCT) of REACTION should be applied for Ta-0 (Elvl1 = 0.0062 MeV in ^{181}Ta), Bi-209 (Elvl1 = 0.8963 MeV) and U-0 (Elvl1 = 0.0130 MeV in ^{235}U and 0.0449 MeV in ^{238}U).

Entries: 12191.003 (79-AU-197(N,EL)79-AU-197,,DA)

Ex of 1st level (MeV): 0.0774

Author and Publication: W. Day, Priv. Comm: Day (1965)

Recommendation for SF3: description of experiment is not given, however likely SF3 should be **SCT**:
(79-AU-197 (N,SCT)79-AU-197,PAR,DA), with LVL-NUMB = 0, 1

Justification: This Entry has neither information about how this experiment was done nor reference to any publication. An attempt was made to find the relevant information in internet. Following document was found at osti.org: WASH-1033 "REPORTS TO THE AEC NUCLEAR CROSS SECTIONS ADVISORY GROUP MIT AND YALE", by J.R. Stehn, August 29-31, 1961. This document is available as pdf on Google book WASH-1033, where the page 29 tells us:

"A. NEUTRON REACTION

1. Elastic Neutron Scattering Levin, Day

Data have been taken at neutron energies of 1.0, 2.5, and 4.1 MeV for the elastic scattering angular distributions of Au, Tl, Pb^{206}, Pb^{207}, Pb^{208}, and Bi^{209}. Similar data are being taken at 0.5 MeV. In general, the data have a statistical accuracy of 1% and a systematic error of the order of 3%. Further work at higher energies is being deferred until next year when the bunching magnet arrives since the present system does not have adequate resolution to resolve the elastic scattering from the inelastic scattering at higher energies."

From the last sentence one may suppose that for nuclei with extremely low first level excitation energy, like ^{197}Au or Tl, the measured cross sections was a sum of elastic and inelastic scattering, i.e. the scattering.

Further correction recommended for this Entry: add reference to WASH-1033, p. 29 and information available there.

Entries: 12240.002 (79-AU-197(N,EL)79-AU-197,,DA,,LEG/RS),
12240.003 (79-AU-197(N,EL)79-AU-197,,DA)

Ex of 1st level (MeV): 0.0774

Author and Publication: J.A.M. De Villiers, zp_183_323_1965_.pdf

Recommendation for SF3: EL

Justification: from the following authors' explanations, it is clear that elastic scattering cross sections were explicitly separated or properly corrected for the inelastic one: "The optimum scattered neutron energy resolution was 15 - 20 keV. … At incident neutron energies of less than ~ 1.0 MeV the velocity resolution was sufficient to resolve the elastic groups from essentially all inelastic components. … At incident neutron energies of greater than 1.0 MeV, the inelastic contributions were determined at one angle with the best possible resolution and the elastic angular distributions determined with less resolutions corrected for their inelastic content assuming isotropy in the inelastic processes.… In this work the 77 (1/2 +) state in Au was clearly resolved."

Entries: 12277.002 (90-TH-232(N,EL)90-TH-232,,DA),
12277.004 (90-TH-232(N,EL)90-TH-232,,SIG)

Ex of 1st level (MeV): 0.0494

Author and Publication: A.B. Smith, pr_126_718_1962_.pdf

Recommendation for SF3: EL

Justification: from explanations given by author, it is clear that elastic scattered neutrons were explicitly separated or corrected for the inelastic group: "In Fig. 2 elastically scattered neutrons and inelastically scattered neutrons resulting in the excitation of the first excited state of 50 ± 2 keV are clearly resolved. These two components are distinguishable up to incident neutron energies of 1.0 MeV. … The measurements above an incident neutron energy of 1.0 MeV have been corrected for the contribution of the first inelastic group using the extrapolated inelastic cross section given in Fig. 10 (which will be discussed later). At lower incident energies the elastic component is experimentally resolved from all inelastic components."

Entries: 12892.003 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308

Author and Publication: X. Wang, np_a_465_483_1987_.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA), with E-LVL-MAX ≈ 0.400 MeV

Justification: "The time resolution was about 2.0 ns which corresponds to an energy resolution of ~ 400 keV for 7 MeV neutrons." Consequently, the measured elastic cross sections have to include the inelastic excitation of levels up to 400 keV.

Entries: 12935.008 (41-NB-93(N,EL)41-NB-93,,DA), 12935.011 (73-TA-181(N,EL)73-TA-181,,DA)
12935.012 (79-AU-197(N,EL)79-AU-197,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93), 0.0062 (Ta-181), 0.0774 (Au-197)

Author and Publication: L. Hansen et al., pr_c_31_111_1985_.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA), (73-TA-181(N,SCT)73-TA-181,PAR,DA), (79-AU-197(N,SCT)79-AU-197,PAR,DA), with *E-LVL-MAX ≈ 0.120 MeV*

Justification: There are no information in the paper about energy resolution or subtraction of the inelastically scattered neutrons, except this: "The beam was bunched, 1—2 ns wide, and swept at a 2.5 MHz burst rate. … In the present work the elastic differential cross sections were measured between 9.2° and 159° and the flight path was 10.75 m for all the detectors. The neutron detector bias was 5.4 MeV, and pulse-shape discrimination was used to reduce the gamma-ray background". Using 2 ns as a deuteron beam burst width and 10.75m flight path to 5.1 cm long detector, we can estimate the energy resolution ΔE ≈ 22 keV for the 14.6 MeV neutrons. C. Wong et al. in PR_C26(1982)889 described the LLNL TOF spectrometer, mentioning "Fig. 2. … The prompt gamma ray time width is 2.7 ns, corresponding to an energy resolution of 0.16 MeV for 8 MeV neutrons". Using 2.7 ns for the total spectrometer time resolution we got ΔE ≈ 30 keV at 14.6 MeV or 22 keV at 8.0 MeV, that essentially underestimates 160 keV given by C. Wong.

Thus, the most reasonable estimate of the energy resolution (FWHM) would be ΔE (14.6 MeV) = 160 keV (8.0 MeV) * sqrt(8.0MeV/14MeV) ≈ 120 keV.

Entries: 12995.002 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93)

Author and Publication: R. Pedroni et al., pr_c_43_2336_1991_.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA), with E-LVL-MAX ≈ 0.190 – 0.094 MeV as EN varies from 8 to 14 MeV and with E-LVL-MAX ≈ 0.300 MeV at EN = 17 MeV

Justification: "The experimental resolution was not sufficient to extract σ(Θ) or A(Θ) values for inelastic scattering to discrete states in ^{93}Nb, so only values for elastic scattering were determined. Any yield from inelastic scattering to the first excited state at 0.030 MeV would not be distinguished from elastic scattering. However, as discussed later, the contribution from this inelastic group is negligible. … The total energy spread … decreases monotonically from 190 to 94 keV from energies 8 to 14 MeV. The energy spread at 17 MeV is 300 keV because a high energy was used at this energy".

Entries: 13011.002 (79-AU-197(N,EL)79-AU-197,,DA)

Ex of 1st level (MeV): 0.0774 (Au-197)

Author and Publication: S. Cox, anl-7910_20_1972.pdf

Recommendation for SF3: **EL**

Justification: Author did not describe the experimental procedure but stated that it was the same as in the previous experiment at incident neutron energy ~ 1 MeV, see Report ANL-7935(1972). There the author wrote: "To obtain the accurate elastic scattering cross sections for all elements, inelastically scattered neutrons must be eliminated from the data. Because of the way the discrimination level is set on the detector outputs, the detection system is insensitive to neutrons inelastically scattered from levels > 300 keV above the ground state. For levels < 300 keV above the ground state, a correction must be made. The correction is based on known inelastic scattering cross sections and the measured efficiency curves of the detectors. … The correction to the differential scattering cross section varies from zero for most of the lighter even-Z/even-A nuclides to as high as 100 mb for uranium."

From this information it is seen that author has corrected the elastic scattering for contribution of inelastic scattered neutrons. Since there are no detailed information and we can not quantitatively estimate the energy resolution and hence E-LVL-MAX, the only reasonable recommendation seems to be to leave these data as they are, i.e. elastic.

Entries: 13503.002 (90-TH-232(N,EL)90-TH-232,,DA)

Ex of 1st level (MeV): 0.0494 (Th-232)

Author and Publication: G. Goswami et al., nse_100_48_1988_.pdf

Recommendation for SF3: **EL**

Justification: The authors have applied a lot efforts to separate experimentally or resolve overlapping the elastic and two first inelastic (excitation of 49 keV and 162 keV states) neutron groups, that is confirmed by detailed information and Figures in their paper.

Entries: 13532.002 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93)

Author and Publication: W. Finlay et al., Priv. Comm. (1991)

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA), with E-LVL-MAX ≈ 0.400 MeV

Justification: This entry contains elastic cross sections at 20 MeV for ^{93}Nb and ^{209}Bi, which were privately communicated without referring to any document. On other side, the same group of authors have reported in another Entry 13521 the neutron emission spectra for the same targets ^{93}Nb and ^{209}Bi at the same incident energy. From the referenced paper of A. Marcinkowski et al. (np_a_530_75_1991_.pdf) it becomes practically obvious that the (n,n) and (n,xn) data were obtained concurrently in the same experiment. Paper np_a_530_75_1991_.pdf states: “The overall energy resolution of the spectrometer was better than 600 keV”. Both entries, approved by authors, declare however the energy resolution 400 keV.

From this information we recommend to assign SF3 = SCT and E-LVL-MAX = 0,4 MeV in case of the ^{93}Nb(n,n) elastic data but leave SF3 = EL for ^{209}Bi(n,n), since first excited state of residual Elvl1 = 0.896 MeV.

Entries: 13547.002 (21-SC-45(N,EL)21-SC-45,,DA), 13547.003 (21-SC-45(N,EL)21-SC-45,,DA)

Ex of 1st level (MeV): 0.0124 (Sc-45)

Author and Publication: A. Smith et al., jp_g_19_655_1993_.pdf, anl-ndm-125_1992.pdf

Recommendation for SF3: **SCT**: (21-SC-45(N,SCT)21-SC-45,PAR,DA), with E-LVL = 0 and 0.0124 MeV

Justification: “Incident neutron energy spreads varied from ≈ 300 keV at 4.5 MeV to ≈ 100 keV at 10 MeV. … Another problem inhibiting the inelastic scattering measurements is the presence of a very low-lying excited level in ^{45}Sc (12.4 keV, 3/2+). … Moreover, in no observations were the neutrons due to the inelastic excitation of the 12.4 keV (3/2+) level resolved from the elastically scattered contribution. ... As noted above, this level could not be resolved experimentally from the elastically-scattered component. …The second and third excited levels in "Sc are at 377(3/2-) and 543(5/2+) keV, respectively. Scattered neutrons due to the excitation of these two levels have energies very close to those resulting from elastic scattering of the second neutron group from the ^{7}Li(p,n)^{7}Be source reaction. As a result, corrections for the second component of the source reaction were made using the Monte Carlo correction procedures …”.

From this it is obvious that elastic data include the inelastic excitation of the first level 12.4 keV but exclude the second (377 keV) and higher levels. It is true for both subentries .002 and 0.003.

Entries: 13552.003 (76-OS-190(N,EL)76-OS-190,,DA)

Ex of 1st level (MeV): 0.1867 (Os-190)

Author and Publication: S. Hicks, thesis_Hicks_1987.pdf

Recommendation for SF3: **EL**

Justification: “The energy resolutions for the two experiments were found to be 72 keV and 108 keV at 2.53 and 4.64 MeV, respectively”. Such resolution was quite sufficient for author to separate elastically scattered neutrons from those inelastically scattered to the first 2+ and higher levels in ^{190}Os, which are compiled in subentry .004.

Entries: 13589.002 (45-RH-103(N,EL)45-RH-103,,DA)

Ex of 1st level (MeV): 0.0398 (Rh-103)

Author and Publication: A. Smith et al., jp_g_20_795_1994_.pdf

Recommendation for SF3: **SCT**: (45-RH-103(N,SCT)45-RH-103,PAR,DA), with E-LVL = 0.0. 0.0398 and 0.0930 MeV

Justification: "The first two excited states in ^{103}Rh are at 39.8 (7/2+) and 93.0 (9/2+) keV [2]. The corresponding inelastic-scattering cross sections are small. However, in all of the present measurements neutrons due to the inelastic excitation of these two states were not resolved from the elastically scattered component. Herein. what is termed 'elastic' scattering is actually a composite of the elastically and the first two or more inelastically scattered neutron groups, as defined below." Starting from level 295 keV the "inelastically-scattered neutron groups were observed corresponding to excitations of 0.334 ± 0.013, 0.536 ± 0.010, 0.648 ± 0.025 …" and are probably compiled in 12796.005.

Entries: 13804.008 (41-NB-93(N,EL)41-NbB-93,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93)

Author and Publication: E. Christodoulou et al., nse_132_273_1999_.pdf

Recommendation for SF3: **SCT**: (45-RH-103(N,SCT)45-RH-103,PAR,DA), with *E-LVL-MAX = 0.4 MeV*

Justification: The authors have not reported implicitly the total energy resolution of its TOF spectrometer. Only several components are given: "The overall resolution achieved for 14-MeV neutrons with the NE-213 neutron detector is 2.4 ns. … Flight path 8.62 m, Detector length 7.6 cm. …". If we will use this information, then will get an energy resolution ΔE(FWHM) = 0.034 MeV, which is too small. An alternative option to estimate the real energy resolution of this experiment – to use information given in "Fig. 13. Experimental data of the elastic and first inelastic (Q = -0.85 MeV) neutron scattering peaks of natural iron, at 80.5 deg, fitted with the function given by Eqs. (2) and (3)". This plot shows that elastic peak has a FWHM approximately = ½ of distances between itself and the inelastic group which corresponds excitation of the first level 0.85 MeV in ^{56}Fe. From this, we estimate E-LVL-MAX = ΔE(FWHM) ≈ 0.85/2 ≈ 0.4 MeV.

Entries: 13965.002 (73-TA-181(N,SCT)73-TA-181,PAR,DA)

Ex of 1st level (MeV): 0.0062 (Ta-181)

Author and Publication: A. Smith et al., ane_32_1926_2005_.pdf, anl-ndm-160_2005.pdf

Recommendation for SF3: **SCT**: (73-TA-181(N,SCT)73-TA-181,PAR,DA), with E-LVL = 0.00 and 0.062 MeV up to EN = 1.0 MeV; plus E-LVL = 0.136 and probably 0.158 MeV up to 1.5 MeV; then E-LVL-MAX = 0.338 MeV above 4.5 MeV.

Justification: The author, A. Smith, has clearly described the meaning of the 'elastic' scattering measured by himself and also has professionally commented this issue in general: "All of these 'elastic' distributions certainly include contributions due to the inelastic excitation of the 6.2 keV level. It is not technologically feasible to experimentally resolve these two scattered components. In some cases considerably more inelastic contamination is included in the measured 'elastic' distributions due to excitation of higher-lying levels and lesser experimental resolution. The scattered neutron resolutions are reasonably known for the present measurements. All of those results up to incident energies of approximately 1.0 MeV include only elastic and first-inelastic components. For incident energies of ≈ 1.0 – 1.5 MeV some of the present measurements were estimated to include the elastic component plus inelastic contributions from the excitation of ≈ 6, ≈ 136 and ≈ 158 keV levels. Above incident energies of ≈ 4.5 MeV the present 'elastic' results include inelastic contributions due to the excitation of all levels up to and including the 338 keV state. The measurements reported in the literature certainly have similar inelastic-scattering contamination but

it is difficult to assay, particularly in the older measurements with less resolution. Where these literature results were used in the model determinations the inelastic contributions were subjectively estimated as best as possible."
Presently the subentry 13965.002 declares SCT as a transition to the two levels 0.0 and 6.2 keV that is true but only up to EN = 1 MeV. Above this energy the corrections are required as recommended.

Entries: 13966.002 (74-W-182(N,EL)74-W-182,,DA), 13966.003 (74-W-184(N,EL)74-W-184,,DA)

Ex of 1st level (MeV): 0.1001 (W-182), 0.1112 (W-184)

Author and Publication: J. Annand et al., np_a_442_234_1985_.pdf

Recommendation for SF3: EL, but adding (e.g., in CRITIQUE) the authors' warning "At forward angles elastic scattering dominates and it was not possible to reliably extract 2+ cross sections forward of 20° for the 6 MeV experiment and beyond 30° for the 4.87 MeV experiment".

Justification: The authors have reached rather good "resulting energy resolutions for elastically scattered neutrons were 65 keV and 75 keV, respectively, the limiting factor being the energy spread in the source reaction". This has allowed them to observe many low excitation energy states in ^{182,184}W and separated them from elastic scattering: "The upper spectrum shows 0+, 2+, 4+, 6+, 2'+ groups scattered from ^{182}W for incident energy 6.00 MeV and 72.5 ° scattering angle. It is noticeable that the 2+ peak is much stronger at this angle than the elastic peak. At forward angles elastic scattering dominates and it was not possible to reliably extract 2+ cross sections forward of 20° for the 6 MeV experiment and beyond 30° for the 4.87 MeV experiment. … Cross sections were calculated from the areas under the appropriate time-of-flight peaks, which were determined using non-linear least squares fitting techniques. The skewed line shape shown in fig. 1, with something of a low-velocity tail, was optimized to fit well-determined single peaks. Fig. 1 shows the individual lines as well as the sum of the lines used to fit the experimental spectra".
Thus it would be reasonable to recommend to leave SF3 = EL, with addition of the authors' warning "At forward angles elastic scattering dominates and it was not possible to reliably extract 2+ cross sections forward of 20° for the 6 MeV experiment and beyond 30° for the 4.87 MeV experiment."

Entries: 14002.003 (79-AU-197(N,EL)79-AU-197,,DA,,REL)

Ex of 1st level (MeV): 0.0774 (Au-197)

Author and Publication: M. O'Connor, 94gatlin_1_260_1994.pdf

Recommendation for SF3: **EL**

Justification: This Gatlinburg conference paper reports the first results and has few information about the energy resolution of spectrometer, except "The FWHM of the zero degree neutron time-of-flight peak indicated that the targets had a thickness 20 – 30 keV". Obviously, it was sufficient to separate the inelastically scattered neutrons leading to the excitation of the 77-keV and higher states in ^{197}Au, which are also presented in this paper and are compiled in sub-entry .002.

This group of authors has also measured the similar cross sections but at other incident energies, see "Neutron scattering measurements in ^{197}Au from 850 keV to 2.0 MeV", https://www.osti.gov/biblio/255511 – this document has to be found and considered for compilation. – NDS has found the thesis of O'Connor "Fast neutron scattering cross sections of ^{197}Au" appeared in 1996

Entries: 14033.002 (79-AU-197(N,EL)79-AU-197,,DA)

Ex of 1st level (MeV): 0.0774 (Au-197)

Author and Publication: A. Smith, nse_155_74_2007_.pdf, anl-ndm-161_2005.pdf

Recommendation for SF3: **SCT**: (79-AU-197(N,SCT)79-AU-197,PAR,DA), with E-LVL = 0.000, 0.077, 0.269 and 0.279 MeV

Justification: “The present experimental results consist of 12 elastic scattering distributions approximately equally spaced in incident energy between ≈ 4.5 and 10.0 MeV. The scattered-neutron experimental resolutions were ≈ 0.3 MeV so these elastic distributions certainly included inelastic contributions due to the excitation of the 77 keV (1/2+), 269-keV (3/2+), and 279-keV (5/2+) states in ^{197}Au”.

It is obvious that SF3 should be SCT, i.e. it has to include the partial (n,n’) cross sections for excitation of 3 levels in ^{179}Au: 77, 269 and 279-keV.

Entries: 14329.046 (41-NB-93(N,EL)41-NB-93,,DA), 14329.089 (92-U-235(N,EL)92-U-235,,DA), 14329.114 (92-U-238(N,EL)92-U-238,,DA), 14329.138 (94-PU-239(N,EL)94-PU-239,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93), 0.0001 (U-235), 0.0449 (U-238), 0.0079 (Pu-239)

Author and Publication: J. Kammerdiener, ucrl-51263_1972.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT) 41-NB-93,PAR,DA), (92-U-235(N,SCT)92-U-235,PAR,DA), (92-U-238(N,SCT)92-U-238,PAR,DA), (94-PU-239(N,SCT)94-PU-239,PAR,DA) with *E-LVL-MAX ≈ 0.800 MeV*

Justification: The author’s PhD has no numerical information on the total TOF spectrometer resolution, except reporting some components: “Time resolution was less than 1.5 nanoseconds FWHM (full-width half-maximum) at 831 centimeters flight path”. Using this information, the calculated energy resolution will be only 22 keV. This estimate is substantially less than what we can derive from following statement of author: “The 2+ levels of Fe and Ni were clearly resolved but 3- levels expected at similar excitation energies in ^{239}Pu, ^{238}U, ^{235}U were not seen”. The excitation energies of the first 2+ levels are 848 keV in ^{56}Fe and (1173 – 1454) keV in ^{58,60,62,64}Ni, the first 3- level in ^{238}U - 732 keV. From this we may suppose that the total energy resolution for the 14 MeV neutrons was approximately 800 keV.

Entries: 20019.081 (25-MN-55(N,EL)25-MN-55,,SIG), 20019.082 (25-MN-55(N,EL)25-MN-55,,DA), 20019.090 (25-MN-55(N,EL)25-MN-55,,DA,,LEG)

Ex of 1st level (MeV): 0.1259 (Mn-55)

Author and Publication: B. Holmqvist et al., ae-366_1969.pdf, af_38_403_1968_.pdf

Recommendation for SF3: **EL**

Justification: The authors have reported that the spectrometer time resolution was 3 ns, scatterer-detector distance 300 cm and detector length 5 cm. Additionally, Report AE-375 (1969) says “the total energy spread for the T(p,n) and D(d,n) reactions was ± 50 keV and ± 90 keV, respectively. Included in these figures are the energy spreads caused by the loss of energy in the gas, charged particle straggling in the nickel foil, and energy spread of the target neutrons, taking into account the finite solid angle subtended by the target-scatterer system.” (the latter 50 and 90 keV are compiled in sub-entries as EN-RSL-HW). Using these values we compute the energy resolution ΔE(FWHM) = 110 keV at 2.47 MeV and 200 keV at 8.05 MeV.

Fortunately the specific details about separation procedure are presented in several publications of this group.

(1) Paper af_38_403_1968_.pdf:

“6.1. The methods of analysis of the data.

The experimental results collected in the time-of-flight measurements were converted to punched tape for processing on a computer, i.e. for normalization, background subtraction, and plotting of the spectra. The area of a peak representing a certain neutron group in a time-of-flight spectrum was determined by calculating an area limited and defined by the tangents of the high and low energy slopes and the time axis. This method of analysis is of course, straight-forward when the peaks of a spectrum are well separated from each other. However, in a number of cases elastic and inelastic scattering peaks were overlapping because of insufficient energy resolution.

The analysis of a spectrum consisting of one inelastic peak partly overlapping the elastic one can be performed if the line shapes of the peaks are known. The use of this method usually becomes more difficult as the energy separation decreases. However, assuming that the inelastic excitation function as well as inelastic angular distributions have been measured at neutron energies where the elastic and inelastic peaks are separated, the contribution of the inelastic effect at higher energies can be estimated by extrapolation making the assumption that the inelastic cross section varies smoothly with the energy. For the cases studied here, for which this method of analysis must be applied the assumptions made above are relevant.

When there is more than one inelastic peak partly overlapping the elastic peak, the technique of using known line shape is difficult and impracticable. A measure of the elastic scattering contribution has been obtained from the high energy part of the elastic peak defined as the area above an energy defined by the position of the maximum of the elastic peak in the time-of-flight spectrum on the assumption that the high energy tails of the inelastic peaks do not give contributions by overlapping. However, this method may be difficult to use when the inelastic cross sections are much larger than the elastic one, since the contribution from the high energy tails of the inelastic peaks may then be considerable. But this has not been the case in any of the analyses performed here.

6.2. The analyses of the data

The analyses of S, Ca and Ni have-been simple and straightforward since the elastic and inelastic peaks have been well resolved in the time-of-flight spectra at all energies. Thus the elastic contributions have been obtained for these elements by calculating the total areas of the corresponding peaks. For Al, Cr, Fe, Co and Zn good energy separation has been obtained up to 4.6 MeV neutron energy. Above 4.6 MeV energy the elastic scattering effects have been obtained for these elements, as well as for C and Bi, by calculating the areas of the high energy part of the elastic peaks. However, for Al, Cr, Fe and Cu at 7 and 8 MeV neutron energies the high energy tails of the first inelastic peaks may interfere somewhat with the high energy part of the elastic peaks. (These inelastic peaks correspond to the excited states at 0.84 MeV for Al^{27}, 056 MeV for Cr^{53} (9.5 per cent abundance), 0.67 MeV and 0.77 MeV for Cu^{63} (69 per cent abundance) and Cu^{65}, and 0.85 MeV for Fe^{56} (92 per cent abundance) [53]). But the contributions from the neutron groups leading to the lowest excited states of Al^{27}, Cr^{53}, Cu^{63} and Cu^{65} have been observed to be small and are estimated to be negligible from the extrapolation of the excitation functions of the inelastic scattering. On the other hand for Fe^{56} the intensity of the neutron group of the lowest state is of about the same magnitude as that of the elastic one at some angles. At an illustration a time-of-flight spectrum observed for Fe at 8.05 MeV and at scattering angle of 110^o is shown in Fig. 7. The analysis by means of known line shape is shown in the figure. For comparison the shadowed area represents the high energy part of the elastic peak which was used as a measure of the scattering effect. It is seen that the high energy tail of the inelastic peak contributes somewhat to that part of the elastic peak and must be corrected for.

The analysis of Mn is somewhat complicated because of the very low-lying excited state of 0.126 MeV [53]. Time-of-flight spectra of Mn at the neutron energies 2.47, 3.49 and 4.56 MeV and 90^o scattering angle are plotted in Fig. 8, showing the analyses by means of a known line shape. By extending this analysis to several angles the inelastic angular distribution of the 0.126 MeV state has been found to be isotropic within the experimental errors at each energy between 2.47 and 4.56 MeV. The corresponding excitation function is included in Fig. 8, showing that the inelastic cross section decreases smoothly with increasing neutron energy. The differential elastic cross sections have been determined up to 4.56 MeV from the shadow peak areas properly corrected for the contributions of the high energy tails of the inelastic peaks. Above 4.56 MeV neutron energy, when the inelastic contributions could not be graphically corrected for, the inelastic scattering effects were taken into account simply by subtraction of the inelastic cross sections obtained by extrapolation of the excitation function. Since the inelastic cross section is small and decreasing (only about l0 mb/sr at 4.56 MeV), the error introduced by this procedure is negligible."

(2) Report AE-375, 1969 and paper Nucl. Phys. A146(970)321 (for ^{51}V): "The time resolution was not sufficient to enable individual levels in the residual nucleus to be resolved at all neutron energies. However, neutron groups leading to the excitation of the 0.320, 0.930, 1.609, 1.813, 2.409, 2.545, 2.675, 2.699 and 2.790 MeV levels in ^{51}V have been observed in the time-of-flight spectra (Figs. 5 and 6). … At 3.00 MeV neutron energy and above the inelastic scattering peak corresponding to the 0.320 MeV state interferes with the elastic one. The interference effect was avoided by taking only the high energy part of the elastic peak (shaded in Fig. 6) as a measure of the elastic scattering effect. At neutron energies above 4.56 MeV the inelastic scattering peaks corresponding to the 0.320 MeV state and even the 0.930 MeV state would interfere with the high energy part of the elastic peak, but the contributions are negligible because of the small inelastic cross sections".

(3) Conference paper 70Helsinki 2(1972)349 (for ^{93}Nb and ^{209}Bi): "The resolution of the time-of-flight spectrometer is demonstrated in Fig. 1, showing two typical spectra of scattering from Nb recorded at 2.50 MeV primary neutrons and Bi at 3.78 MeV". In Fig. 1 it is seen that 29 keV level in ^{93}Nb (inelastic scattering) is not resolved from g.s. (elastic).

Summary.

From the information given specifically for ^{55}Mn it follows that at incident neutron energy EN ≤ 4.56 MeV the inelastic scattering to the first level was separated by the graphical analysis of overlapping neutron lines in the TOF spectra. At higher energies the found (n,n$_1$) cross sections were extrapolated and subtracted too. Thus, SF3 could be left EL.

Extreme case of the lowest first level Ex = 6.2 keV for ^{181}Ta. It is likely the corresponding sub-Entries with the ^{181}Ta data 20019.199 (73-TA-0(N,EL)73-TA-0,,DA), 20019.198 (73-TA-0(N,EL)73-TA-0,,DA,,SIG) and 20019.206 (73-TA-0(N,EL)73-TA-0,,DA,,LEG) have to be corrected as: SF3 = SCT with *E-LVL-MAX = 0.300 MeV below 3 MeV and = 0.900 MeV above 4.56*, since there are no relevant information for this nucleus in publications.

Remark to the EXFOR pdf collection: it has not B. Holmqvist, "A systematic study of fast neutron elastic scattering in the energy region 1.5 to 8.1 MeV", Arkiv Fysik 38 (l969) 403 – later was provided by NDS

Entries: 20036.002 (92-U-235(N,EL)92-U-235,,DA), 20036.012 (94-PU-239(N,EL)94-PU-239,,DA)

Ex of 1st level (MeV): 0.0001 (U-235), 0.0449 (Pu-239)

Author and Publication: R. Batchelor et al., awre-o-55_69_1969.pdf

Recommendation for SF3: **SCT:** (92-U-235(N,SCT)92-U-235,PAR,DA),
(94-PU-239(N,SCT)94-PU-239,PAR,DA),
with *E-LVL-MAX ≈ 0.55 MeV at EN = 2.0 and 3.00 MeV; E-LVL-MAX ≈ 1.25 MeV at EN = 4.00 MeV*.

Justification: The authors have described the procedure of the elastic cross section extraction from the measured secondary neutron emission spectra: "The first step in the analysis of the secondary neutron spectra is to estimate the differential cross sections for those neutrons in the peaks. This was done by interpolating each continuous non-elastic spectrum underneath the elastic 'peak' and subtracting to give counts in the peak. If the interpolation is a true representation of the non-elastic spectrum (this would not be the case if the excitation of low-lying levels is enhanced by direct interactions), the subtracted counts represent only true elastic counts. The continuous non-elastic time spectra resulting from the subtraction of the elastic peaks are then converted to the energy spectra in histogram form, each energy band corresponding roughly to a resolution width (in fact, about 0.8 of a resolution width for energies above 1 MeV)".

From this we conclude that the interpolation underneath the elastic peak and subtraction of the inelastic excitation of low-lying levels made by authors may be not a physically correct procedure (since, as we know now, there are indeed enhancement by direct interactions etc.). The maximum excitation energy of such levels E-LVL-MAX we found from the difference of incident neutron energy EN and lower energy boundary of that band which the elastic neutrons belong to (see Table 3 or 20036.009 for ^{235}U and Table 4 or 20036.019 for ^{239}Pu): E-LVL-MAX = 2.000 - 1.429 = 0.57 MeV at EN = 2.0 MeV, E-LVL-MAX = 3.000 – 2.460 = 0.53 MeV at EN = 3.00 MeV and E-LVL-MAX = 4.000 – 2.744 = 1.25 MeV at EN = 4.00 MeV.

Further correction recommended for this Entry: replace E-EXC-MAX and E-EXC-MIN by the secondary emission neutron energies E-MAX and E-MIN in the sub-entries with energy spectra (DE).

Entries: 20162.005 (33-AS-75(N,EL)33-AS-75,,SIG), 20162.006 (33-AS-75(N,EL)33-AS-75,,DA), 20162.007 (33-AS-75(N,EL)33-AS-75,,DA,,LEG), 20162.008 41-NB-93(N,EL)41-NB-93,,SIG), 20162.009 (41-NB-93(N,EL)41-NB-93,,DA), 20162.010 (41-NB-93(N,EL)41-NB-93,,DA,,LEG), 20162.023 (79-AU-197(N,EL)79-AU-197,,SIG), 20162.024 (79-AU-197(N,EL)79-AU-197,,DA),
20162.025 (79-AU-197(N,EL)79-AU-197,,DA,LEG)

Ex of 1st level (MeV): 0.1986 (As-75), 0.0308 (Nb-93), 0.0774 (Au-197)

Author and Publication: B. Holmqvist et al., ae-430_1971.pdf, jne_27_543_1973_.pdf, np_a_146_321_1970_.pdf; M. Salama ae-452_1972.pdf,

Recommendation for SF3: **EL**

Justification: In this Entry as well as in 20019 (see above), the authors have gave the same information about the experimental procedure (the author' reports or papers refer back to same primary publications). Due to this the justification and recommendations are generally similar to those given for the abovementioned Entry 20019.

Report ae-452_1972.pdf additionally informs: "The method used for the determination of the area under the elastic peak of the time-of-flight spectrum, is described elsewhere [19 = *AF 38(1968)403*]. From the sample spectra shown in fig. 9 it can be seen that the inelastic scattering contributions from the different nuclear levels are well resolved in the cases of Cr, Fe and Ni. However, in the cases of As, Nb, Mo, Cd, Sb, Hf, Au, Radiogenic lead and Pb at the 8.05 MeV measurements, the analyses were somewhat more complicated since the nearby inelastic peaks were partly overlapping the elastic peaks because of insufficient energy resolution. In the case of good energy resolution, the area under a peak was defined by the tangents of the high and low energy slopes and the time axis. This method was used in the analysis of Cr, Fe and Ni. However, in case of one or more inelastic peaks partly overlapping the elastic one, the application of the line shape technique is difficult and impracticable. In that case the high energy part of the elastic peak can be used (shaded in fig. 10) as a measure of the elastic scattering effect. This method was used in the analyses of As, Nb, Mo, Cd, Sb, Hf, Au, Radiogenic lead and Pb, However, the high energy tail of the inelastic peak may interfere somewhat with the high energy part of the elastic peak but this contribution has been observed to be small and negligible because of the small inelastic cross sections". Fig 10 shows the "Time-of-flight spectrum observed for Au at 8.05 MeV and at a scattering angle of 90°. The curves drawn represent the analysis by means of known line shapes. The shadowed area is the part of the elastic peak used to determine the differential cross section when corrected for the contribution due to the high energy tail of the inelastic peak" – it is seen that authors have separated the contribution of inelastic excitation of 0.077 MeV level of ^{197}Au to the elastic.

Following the detailed information given in Report ae-452_1972.pdf, we may could state that inelastic scattering was separated (was not directly resolved but was analytically subtracted applying the described procedures) from elastic one for nuclei As, Nb, Mo, Cd, Sb, Hf, Au, Radiogenic lead and Pb even at highest incident energy 8.05 MeV, i.e. SF3 = **EL**.

Remark to the EXFOR pdf collection: it doesn't have M. Salama et al. Reports AE-452 (1972) and M. Etemad AE-485 (1974) – later was provided by NDS.

Entries: 20195.022 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449 (U-238)

Author and Publication: G. Deconninck et al., jpr_22_652_1961_.pdf

Recommendation for SF3: **SCT:** (92-U-238(N,SCT)92-U-238,PAR,DA) with *E-LVL-MAX ≈ 0.57 MeV*

Justification: The measurements have been carried out by the transmission technique. The 28.4 MeV neutrons were produced by the (d,n) reaction in the tritium gas target. "L'énergie des deutérons au moment de la réaction est d'environ 11 MeV et les neutrons émis à 0° par rapport au faisceau ont une énergie de 28,4 MeV. L'étalement en énergie des neutrons issus de la réaction est dû principalement à l'étalement du faisceau à la sortie du cyclotron (environ 150 kV) et au straggling dans la cible. On peut estimer cet étalement à' environ 2% ce qui est négligeable pour des mesures de σ_{tot}". - From this we conclude that the energy spread of neutrons (FWHM) was around 28.4 MeV * 2% = 0.57 MeV.

The main purpose of this work was to measure the total cross sections by transmission in a good geometry: "A cause de la bonne géométrie, on peut en effet supposer que tous les neutrons sont diffusés à 0°". However the correction for contribution of the elastic scattered neutrons at 0° degree was needed and authors have estimated it by supplemented measurements at 5°: "Les valeurs de $d\sigma_{el}/d\omega(0°)$ sont inconnues à cette énergie. Afin de pouvoir estimer la correction, nous avons mesuré cette valeur pour un angle de 5°. L'appareillage utilisé est celui de la référence [4]. La mesure a été effectuée pour 3 corps de poids atomiques différents: ^{12}C, ^{118}Sn et ^{238}U, pour les autres corps on a procédé à une interpolation." - These results are given in the author paper's Table and are compiled in 20195.022, .020 (C) and .021 (Sn).

The authors have used NE102 scintillator detector of neutrons with suppression of γ-rays. They rather shortly described the determination of detector threshold and the minimal energy up to which the inelastically scattered neutrons were counted: "La figure 3 montre l'excellente linéarité du détecteur entre 14 et 28 MeV et permet de déterminer le seuil de détection dans nos expériences. Les points expérimentaux correspondent à l'endroit de mihauteur du spectre. … Les mesures ont été effectuées à l'aide d'un analyseur 400 canaux type RIDL. L'intérêt de cette méthode est de détecter à chaque mesure le plateau de neutrons et d'éviter ainsi la détection de γ ou neutrons de break up. De plus, elle permet d'éviter les erreurs dues à un glissement de l'électronique ainsi qu'à l'effet d'empilement des impulsions, effet qui varie suivant le taux de comptage, ainsi que suivant le pouvoir d'absorption de l'échantillon pour les γ. On réduit toutes ces erreurs en ne comptant que les impulsions situées, dans la partie horizontale du plateau éliminant ainsi la queue du spectre." – From this it is difficult to derive the exact value of threshold or minimum energy used (it could be a half of EN or 14 MeV ?), hence we omit this component of E-LVL-MAX (could be 28.4 – 14 MeV = 14 MeV ?).

Finally, we estimate the maximum excitation energy of such levels E-LVL-MAX from the value of FWHM of EN, i.e. as 0.57 MeV.

Further correction recommended for this Entry: the similar correction should be certainly done for 20195.021: **SCT:** (50-SN-0(N,SCT)50-SN-0,PAR,DA) with *E-LVL-MAX ≈ 0.57 MeV*.

Entries: 20337.008 (59-PR-141(N,EL)59-PR-141,,DA), 20337.009 (59-PR-141(N,EL)59-PR-141,,DA,,LEG)

Ex of 1st level (MeV): 0.1454 (Pr-141)

Author and Publication: S. Tanaka et al., np_a_179_513_1972_.pdf

Recommendation for SF3: **EL**

Justification: The authors have rather clearly described the relevant issues: "The energy spreads of the neutrons incident on the samples were about 40 keV in the energy region above 2 MeV and 60 keV below this energy. … Unresolved peaks in the time spectra were separated by a peeling-off method." They also clearly stated that among all studied nuclei the elastic scattering includes (n,n_1) only for Er: "In fig. 4 open circles indicate that the inelastic cross sections for the first levels in erbium isotopes are combined with the elastic data, since the first levels are too close-lying to the ground levels to be resolved". Additional confirmation: the ^{141}Pr(n,n1) cross sections are compiled in separated sub-Entries.

Entries: 20346.002 (33-AS-75(N,EL)33-AS-75,,SIG), 20346.003 (33-AS-75(N,EL)33-AS-75,,DA), 20346.004 (33-AS-75(N,EL)33-AS-75,,DA,,LEG), 20346.005 41-NB-93(N,EL)41-NB-93,,SIG), 20346.006 (41-NB-93(N,EL)41-NB-93,,DA), 20346.007 (41-NB-93(N,EL)41-NB-93,,DA,,LEG), 20346.017 (79-AU-197(N,EL)79-AU-197,,SIG), 20346.018 (79-AU-197(N,EL)79-AU-197,,DA), 20346.019 (79-AU-197(N,EL)79-AU-197,,DA,LEG)

Ex of 1st level (MeV): 0.1986 (As-75), 0.0308 (Nb-93), 0.0774 (Au-197)

Author and Publication: M. Etemad et al., ae-482_1973.pdf , ae-430_1971.pdf, ae-366_1969.pdf, ae-385_1971.pdf, jne_27_543_1973_.pdf, np_a_146_321_1970_.pdf

Recommendation for SF3: **EL**

Justification: In report **ae-482_1973.pdf**, the authors have described the separation of the elastic neutrons as following: "The time-of-flight ermined by calculating an area under the peak limited by the tangents of the high and low energy slopes and the time axis. This method of analysis is straight-forward when the peaks of a spectrum are well separated. However, in a number of cases the time resolution was not sufficient for the complete separation of elastically scattered neutrons from those scattered inelastically to low-lying excited states. In these cases, the time-of-flight spectra were unfolded using known spectrometer line shapes. This technique is described more fully in a previous report [5 = Etemad AE-481] dealing with neutron inelastic scattering measurements".

The cited report **ae-482_1973.pdf** writes:

"The time-of-flight spectra were then plotted by hand. The area of a peak representing a certain neutron group in a spectrum was determined by calculating an area under the peak limited by the tangents of the high and low energy slopes and the time axis.

This method of analysis is straightforward when the peaks of a spectrum are well separated. However, in a number of cases the inelastic scattering peaks overlapped because of insufficient energy resolution. In these cases the analyses of the spectra were performed by subtracting the contributions of the neighbouring peaks assuming that the line shapes of the peaks were known. The known line shapes were taken from the time-of-flight spectra of the other elements measured under exactly the same experimental conditions. The line shape is dependent upon the energy of the scattered neutrons and the mass of the target nucleus. Therefore, those line shapes were used which represented the same neutron energy as the overlapping peaks and they were taken from the time-of-flight spectra of elements having mass numbers close to those of interest. Care was taken in the choice of these line shapes, i.e. only those lines were chosen which represented single neutron groups and which were well separated from other peaks. The time resolution in the present measurements was not sufficient to enable all the individual levels in the residual nucleus to be resolved at all primary neutron energies. In such cases cross sections were determined for groups of levels.

3.2 The analysis of the data.

The data analyses for the elements Al, V, Mn, Fe and Bi were comparatively simple. In these cases, the different peaks representing different neutron groups in the time-of-flight spectra were either separated from each other or were only slightly influenced by the high or low energy tails of neighbouring peaks. Thus, the contributions of neutron inelastic scattering corresponding to different states of these elements were analysed on the basis of known line shapes when the excitation energies were below 2 MeV. On the other hand, above 2 MeV excitation energy some of the levels could not be resolved with that technique and the cross sections were determined for groups of levels. The method of analysis used for the elements mentioned above is illustrated in Fig. 4 which shows time-of-flight spectra for Al at the neutron energies 2.5, 2.77 and 3.01 MeV.

More complicated spectra were obtained for the other elements. In the case of natural Ti, for instance, the inelastic contributions corresponding to energy levels of the individual isotopes of Ti could not be separated due to the complex level schemes of its isotopes (^{46,47,48,49,50}Ti). Therefore, the inelastic cross sections were determined for groups of transitions belonging to the natural element. Furthermore, the data analysis for Ti could not be continued for primary neutron energies higher than 3.25 MeV because of the complexity of the neutron time-of-flight spectra. Rather complex spectra were also obtained for the elements Ni and Nb at higher neutron energies. Therefore, the data analyses of these elements were limited to neutron incident energies below 3.25 and 3.5 MeV, respectively. The time-of-flight spectrum obtained for Nb at 2.5 MeV neutron primary energy is given in Fig. 5 and shows the complexity of the spectrum.

Samples of natural lead (Pb) and radiogenic lead (Pb_r) were used to measure the cross sections of the lead isotopes. Radiogenic lead was chosen because of its large content of Pb (88.2 %) which enables a measurement of the cross sections for levels of that nucleus. These data were also used to analyse time-of-flight spectra observed for natural lead. However, for this element the inelastic cross sections were only determined for neutron transitions to excited states having excitation energies below about 1.6 MeV. Above this energy rather complicated spectra were obtained because of the complex level diagrams of lead isotopes."

Relying on the methodology described in these reports and in all another documents of Holmqvist' group (see Entries 20019, 20162) we suppose that the undertaken efforts had to results in effective separation of inelastic neutron scattering from elastic, i.e. SF3 = **EL**

Remark to the EXFOR pdf collection: it has not [5] M.A. Etemad, "Neutron Inelastic Scattering Cross Sections in the Energy Range 2 to 4.5 MeV. Measurements and Calculations", Report AE-481 (1973) – was afterwards provided by NDS.

Entries: 20761.006 (53-I-127(N,EL)53-I-127,,DA)

Ex of 1st level (MeV): 0.0576

Author and Publication: R. Galloway et al., np_a_318_173_1979_.pdf

Recommendation for SF3: **SCT:** (53-I-127(N,SCT)53-I-127,PAR,DA) with E-LVL-MAX = 0.745 MeV

Justification: The authors have clearly stated that "… the Fe, Cu and Pb values have been corrected for inelastic scattering while no such correction could be applied to the I and Hg values in view of the lack of appropriate data (table 2)." Specifically for Iodine they wrote: "5.3. THE NUCLEUS I … since the data could not be corrected for any inelastic contribution, the inelastic differential cross sections were also calculated using the program CINDY for the nine states which can contribute neutrons above the 1.9 MeV discrimination level applied to the neutron detectors. The nine inelastic differential cross sections were scaled by appropriate relative detection efficiencies for the neutron energies concerned and combined with the elastic calculations for comparison with the experimental data".

From this it is obvious that inelastic excitation of the "9 states from 0.057 → 0.745" in ^{127}I were not subtracted from elastic scattering.

Similarly the SF3 has to be changed to SCT for Hg in sub-Entry 20761.008: (80-HG-0(N,SCT)80-HG-0,,DA) with E-LVL-MAX = 0.610 MeV. It is justified by: "5.4. THE NUCLEUS Hg … Since the data could not be corrected for any inelastic contribution, it is compared with calculation in the same way as for the case of I above, taking the calculated inelastic contribution into account. The complication is the need to make calculations for the six principal isotopes" and "6 states from 0.160 → 0.610".

About the Polarisation data compiled in this Entry. The authors have carried out the proper investigations: "The possible influence of the inelastic component on the polarization value can be assessed if it is assumed that the inelastically scattered neutrons are unpolarized. … These factors applied to the polarization values in table 1 make no significant change in the angular dependence of polarization. Indeed, the angular dependence of polarization deduced directly from the experimental asymmetry data is little changed by any of the corrections applied". Relaying on this the SF3 = **EL** coding could be considered as a valid for the POL/DA sub-Entries.

Entries: 20801.004 (90-TH-232(N,EL)90-TH-232,,DA), 20801.005 (90-TH-232(N,EL)90-TH-232,,DA,,LEG)
20801.016 (92-U-238(N,EL)92-U-238,,DA), 20801.017 (92-U-238(N,EL)92-U-238,,DA,,LEG)

Ex of 1st level (MeV): 0.0494 (Th-232), 0.0449 (U-238)

Author and Publication: G. Haouat, indc-fr-0029L.pdf

Recommendation for SF3: EL

Justification: The authors have minimized the overall energy resolution (28 keV) to distinguish experimentally the elastic and inelastic scattered neutrons for even-even nuclei: "Angular distributions were obtained for elastic scattering by ^{208}Pb, ^{232}Th and ^{238}U and for inelastic scattering to the first 2^+ and 4^+ states of Th and U. It is the first time that the inelastic scattering to the first 2^+ and 4^+ states of Th and U is experimentally resolved from the elastic scattering at 3.4 MeV."

Entries: 20806.005 (67-HO-165(N,EL)67-HO-165,,DA)

Ex of 1st level (MeV): 0.0947

Author and Publication: V. Giordano et al., np_a_302_83_1978_.pdf, nim_135_483_1976_.pdf

Recommendation for SF3: **SCT:** (67-HO-165(N,SCT)67-HO-165,PAR,DA) with *E-LVL-MAX ≥ 0.120 MeV*

Justification: Both author' papers have no information about the energy resolution or energy threshold of the TOF spectrometer, nor one word about the possible contribution of inelastic scattering or attempt to separate it. The authors have obviously neglected the impact of inelastic scattering at small angles ±2.1° to ±9.1°, where they measured the scattering cross sections and polarization.

From "the width of the proton beam pulses within 1.5 ns at half-maximum", the given incident energy resolution "(ΔE ≈ ± 0.05 MeV)", flight path and detector thickness one may estimate the lowest limit for energy resolution as ≈ 120 keV. On other side, from the sentence: "the second group of neutrons from the $^7Li(p,n)^7Be^*$ reaction to the first excited state at 430 keV in ^7Be appears well separated" one may estimate the highest limit for the energy resolution as surely less than 430 keV.

Thus, the overall energy resolution is possible to estimate only as limits: 120 keV < FWHM << 430 keV. Hence it is very likely that excitation of the first level 94.7 keV is included in elastic, whether it is also true for the higher states 209.8 keV, 344.9 keV, … - is questionable.

Entries: 20839.003 (90-TH-232(N,EL)90-TH-232,,DA), 20839.006 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0494 (Th-232), 0.0449 (U-238)

Author and Publication: G. Haouat, indcfr013L.pdf

Recommendation for SF3: EL

Justification: Similar to their measurements at 3.4 MeV (Entry 20801), the authors have separated elastic and inelastic scattering also in this experiment at 2.5 MeV: "The overall neutron energy resolution was about 30 keV and, therefore, neutrons scattered by the ground state and the first 2^+ and 4^+ excited states of ^{232}Th and ^{238}U were experimentally resolved".

Entries: 21019.003 (90-TH-232(N,EL)90-TH-232,,DA), 21019.005 (92-U-238(N,EL)92-U-238,,DA),
21019.006 (90-TH-232(N,EL)90-TH-232,,SIG), 21019.011 (92-U-238(N,EL)92-U-238,,SIG)

Ex of 1st level (MeV): 0.0494 (Th-232), 0.0449 (U-238)

Author and Publication: R. Batchelor et al., np_65_236_1965_.pdf

Recommendation for SF3: **SCT:** (90-TH-232(N,SCT)90-TH-232,PAR,DA), (92-U-238(N,SCT)92-U-238,PAR,DA), (90-TH-232(N,SCT)90-TH-232,PAR,SIG), (92-U-238(N,SCT)92-U-238,PAR,SIG) with E-LVL-MAX = 0.57, 0.75, 1.5 and 2.6 MeV at 2, 3, 4 and 7 MeV incident neutron energy, respectively

Justification: "The time resolution is not sufficient to enable individual levels in the residual nucleus to be resolved. At 2 MeV incident energy, for example, the 2^+, 4^+ and 6^+ levels of the ground state rotational band are not resolved from elastic scattering. The two inelastic groups are due to the excitation of groups of levels around 0.6 to 0.8 MeV excitation and 1.0 to 1.2 MeV excitation, respectively. ... Figs. 5 and 6 and tables 1 and 2 give the corrected data for the differential elastic cross-sections. In the case of the 2 MeV data these cross-sections include the excitation of the first four members of the ground state rotational band (i.e. levels up to 570 keV excitation). At higher incident energies the elastic counts were taken to be those counts in the 'elastic' peak above the smooth curve extrapolation of the non-elastic spectrum. Therefore, if this extrapolation is a true representation of the non-elastic spectrum, the data in figs. 5 and 6 will represent true elastic data. Since the region of low excitation (less than approximately 2 MeV) is not a continuum region and direct interactions can enhance the excitation of low-lying levels at high incident energies, the extrapolation is not truly representative of the non-elastic spectrum and this leads to an error if the data for 3 MeV and above in figs. 5 and 6 are regarded as true elastic data. We have empirically assigned this error as equal to the counts under the extrapolated portion of the non-elastic curve. The low-energy limits of the extrapolations correspond approximately to excitations of 0.75, 1.5 and 2.6 MeV at 3, 4 and 7 MeV incident neutron energy, respectively".

From this information one may conclude that the cross sections reported in the paper as elastic for both ^{232}Th and ^{238}U do include the inelastic scattering up to excitation energies of 0.57, 0.75, 1.5 and 2.6 MeV at 2, 3, 4 and 7 MeV incident neutron energy, respectively.

Further correction/improvement recommended for this Entry: the partial DA for $^{238}U(n,n')$ plotted in "Fig. 12. Differential cross-sections for excitation of levels between 0.57 and 0.87 MeV and between 0.87 and 1.38 MeV excitation in U-238 at 2 MeV incident neutron energy" should be compiled.

Entries: 21086.002 (92-U-235(N,EL)92-U-235,,DA,,4PI)

Ex of 1st level (MeV): 0.0001 (U-235)

Author and Publication: B. Armitage et al., 66paris_1_383_1967.pdf

Recommendation for SF3: **EL** but maybe with addition in form of CRITUQUE "*The Pb-shape peak subtraction of inelastically scattered neutrons probably not valid for the first level of ^{235}U with excitation energy 0.08 keV which is substantially lower than the spectrometer resolution 25 keV.*"

Justification: The authors have described and applied the procedure of subtracting of inelastically scattered neutrons: "Due to the existence of low-lying levels, the 'elastic' peak contains components due to inelastic scattering. To separate these, the spectrum of neutrons scattered from a natural lead sample was measured. This shape was normalized to the high energy edge of the observed 'elastic' peak and the area of the normalized 'lead shape' was used in determining the true U^{235} elastic scattering cross-section".

From this information one may conclude that the cross sections reported in the paper are basically elastic since the procedure of normalization and subtraction of the Pb elastic peak shape was at least applied. However, the suspicion about the validity of this procedure may arise for the case when the excitation energy is much less than overall resolution. Thus, in this experiment: the first two levels of ^{235}U are 0.08 and 13.03 keV, whereas "at 550 keV, which is experimentally favourable, a run was made with resolution of 25 keV. ... For another energies the resolution was in general worse than this ...".
The final recommendation would be to leave this sub-Entry as EL. but adding as CRITUQUE "The Pb-shape peak subtraction of inelastically scattered neutrons probably not valid for the first level of ^{235}U with excitation energy 0.08 keV which is substantially lower than energy resolution 25 keV".

Further critique for this sub-Entry 21086.002. Actually there: DATA "STATUS FROM FIGURE 3" and DATA Units = b. However Fig. 3 of 66paris_1_383_1967.pdf presents the "Differential cross section for elastic scattering of neutrons from ^{235}U. Scattering angle 90°" (likely the unit = barn on Y-axis is a typo and should be b/sr). The data in Fig. 3 do agree with the ENDF/B-VIII.0 data: at incident energy E = 1.04 MeV and $\Theta = 89.754°$ $d\sigma/d\Omega = 0.181$ b/sr. The data presently compiled in 21086.002: for example at 1.0 MeV $d\sigma/d\Omega = 1.95$ b/4π = 0.155 b/sr is visibly lower than the point in Fig. 3: $d\sigma/d\Omega \approx 0.2$ (b/sr).
Probably "STATUS .FROM FIGURE 3." should be removed.

Further correction recommended for another sub-Entry 21086.003 (92-U-235(N,INL)92-U-235,PAR,DA,,4PI): replace E-MIN and E-MAX by the excitation energies E-EXC-MIN and E-EXC-MAX – see Table 1 of 66paris_1_383_1967.pdf.

Remark to the EXFOR pdf collection: 66paris_1_383_1967.pdf is not available (I have extracted it from 66PARIS_1_1967.pdf).

Entries: 21242.003 (73-TA-181(N,EL)73-TA-181,,DA)

Ex of 1st level (MeV): 0.0062

Author and Publication: A. Remund, hpa_29_545_1956.pdf

Recommendation for SF3: EL, but would be better to add CRITUQUE *"The differential elastic cross section should be used with great concern because of the large contribution of inelastic scattering and non-reliable subtraction procedure".*

Justification: The energy of the scattered neutrons was not measured (e.g., by TOF), but only the total neutron yield was counted by two Anthracene scintillation detectors with n-γ discrimination to suppress gammas. The energy threshold of detectors was not reported in the paper. Likely the threshold was rather low, since the author has recognized that the inelastic scattering makes very large contribution: "Der Anteil der inelastisch gestreuten Neutronen am Wirkungsquerschnitt ist für unsere Neutronenenergie so gross, dass σ_{inel} für einen quantitativen Vergleich der gemessenen Winkelverteilung mit der Theorie in Betracht gezogen werden muss." The author has recognized that σ_{inel} should be measured somehow and then it could be subtracted after dividing by 4π (assuming the inelastic angular isotropy): "Für die inelastische Streuung darf mit gutem Recht eine isotrope Winkelverteilung σ_{inel} angenommen werden. Die Korrektur entspricht dem winkelunabhängigen Betrag von $\sigma_{(inel+\gamma)}$ / 4π, der vom gemessenen Wert σ_{total}(ß) zu subtrahieren ist". To find the value of

$\sigma_{(inel+\gamma)}$ the author has used rather complicated procedure of the graphical integration of the measured angular distributions from 30° to 150° and comparison with transmission measurements: “Die experimentell aufgenommene Kurve der Winkelverteilung ergibt durch grafische Integration über alle Streuwinkel den totalen Wirkungsquerschnitt. Vergleiche mit den mittels Transmissionsexperimenten direkt gemessenen Werten von σ_{total} erlauben, den Anteil der inelastisch gestreuten Neutronen und der γ-Strahlung zu bestimmen ....”. Little useful information on relevant issue is also available in the previous papers: hpa_27_313_1954.pdf, R. Ricamo, Helv. Phys. Acta 24 (1951) 419.

Regarding this information the SF3 could be left as EL but addition of CRITUQUE “The differential elastic cross section should be used with great concern because of the large contribution of inelastic scattering and non-reliable subtraction procedure” may have sense.

Entries: 21292.004 (59-PR-141(N,EL)59-PR-141,,DA), 21292.005 (59-PR-141(N,EL)59-PR-141,,DA)

Ex of 1st level (MeV): 0.1454 (Pr-141)

Author and Publication: R. Singh et al., zp_a_272_47_1975_.pdf

Recommendation for SF3: **EL**

Justification: The authors have rather clearly described the relevant issue: “At 1.7 and 1.9 MeV the elastic scattering cross sections include the contribution of the inelastic scattering from the first excited state at 145 keV. However, in the time-of-flight spectrum observed at 1.2 MeV with a flight path of 2.27 m, it was possible to separate the inelastic peak from the elastic one. In this way, the value of the differential inelastic scattering cross section for 145 keV state was determined to be 89 ± 18 mb/sr. Assuming the inelastic scattering angular distribution to be isotropic, the necessary correction was made to the elastic angular distribution at this energy”.

From this explanation it follows that SF3 should be **EL** for sub-Entries 004 (EN = 1.7 MeV), 005 (1.9 MeV) and 003 (1.2 MeV).

Entries: 21337.004 (62-SM-152(N,EL)62-SM-152,,DA)

Ex of 1st level (MeV): 0.1218 (Sm-152)

Author and Publication: M. McEllistrem et al., pr_c_15_927_1977_.pdf

Recommendation for SF3: **EL**

Justification: The authors have rather clearly described the issue of separation: "For ^{152}Sm the first excited and ground state groups were too close to each other to be separated except by Gaussian fitting procedures. The peak widths and positions for both groups were determined by using parameters determined from an adjacent ^{150}Sm run, such as that of Fig. 2. In this way good fits were obtained for the composite ^{152}Sm peak, and reliable yields were extracted for both ground state and excited level groups.”

From this explanation it follows that SF3 should be EL.

Entries: 21338.006 (60-ND-150(N,EL)60-ND-150,,DA), 21338.016 (60-ND-150(N,EL)60-ND-150,,SIG)

Ex of 1st level (MeV): 0.1302 (Nd-150)

Author and Publication: G. Haouat et al., pr_c_20_78_1979_.pdf

Recommendation for SF3: **EL**

Justification: The authors have rather clearly described the relevant issue: "For ^{150}Nd the 130 keV energy separation of these two states was about the energy resolution; yields for the two scattered neutron groups were separated by line fitting procedures.”

From this explanation it follows that SF3 should be **EL** The same is true for all other Nd isotopes (or sub-Entries): “The total energy spread at the neutron detectors was about 120 keV. This was sufficient to resolve the first excited 2^+ state from the ground state easily for ^{142,144,146,148}Nd.“

Entries: 21564.004 (33-AS-75(N,EL)33-AS-75,,SIG), 21564.005 (53-I-127(N,EL)53-I-127,,SIG),
21564.009 (33-AS-75(N,EL)33-AS-75,,DA,,LEG), 21564.010 (53-I-127(N,EL)53-I-127,,DA,,LEG)

Ex of 1st level (MeV): 0.1986 (As-75), 0.1259 (I-127)

Author and Publication: B. Ramstein et al., jpr_37_651_1976_.pdf

Recommendation for SF3: **SCT**: (33-AS-75(N,SCT)33-AS-75,PAR,SIG), (53-I-127(N,SCT)53-I-127,PAR,SIG), (33-AS-75(N,SCT)33-AS-75,PAR,,DA,,LEG), (53-I-127(N,SCT)53-I-127,PAR,DA,,LEG) with E-LVL-MAX = 0.3 MeV.

Justification: In the case of As and I, as authors wrote, the first levels excited up to 300 keV are too close to the ground state that the corresponding groups of neutrons to be separated by apparatus: "Dans le cas de As et I, les premiers niveaux excités, jusqu'à 300 keV, sont trop proches des fondamentaux pour que les groupes de neutrons correspondants soient séparés par notre appareillage".

Thus for ^{75}As and ^{127}I the SF3 should be **SCT** with E-LVL-MAX = 0.3 MeV. SF3 remains to be **EL** for another isotopes/sub-entries: ^{31}P (Ex = 1.266 MeV), ^{59}Co (Ex = 1.099 MeV) and ^{209}Bi (Ex = 0.896 MeV),

Entries: 21664.012 (53-I-127(N,EL)53-I-127,,DA)

Ex of 1st level (MeV): 0.1259 (I-127)

Author and Publication: A. Begum et al., np_a_332_349_1979_.pdf

Recommendation for SF3: **EL** with advise to add (only for DA subentries) CRITUQUE "The differential elastic cross section may content contribution of inelastic scattering to the excitation energy up to ≈ 6.0 MeV"

Justification: In this experiment the authors have set the neutron detection threshold at 10 MeV (that corresponds to Ex = 16.1 - 10.0 ≈ 6.0 MeV): "Pulse-shape discrimination against gamma-rays and an energy discrimination bias of 10 MeV to reduce the importance of inelastically scattered neutrons were applied to each detector". They have used the TOF technique but "Because of the short distance between scatterer and detectors it was not possible to distinguish between elastic and inelastic scattering in the time-of-flight spectra, so that correction was also necessary for the inelastic component in the experimental data. The importance of inelastic scattering was however reduced by the 10 MeV discrimination bias applied to the detectors." Still they have applied a proper correction by subtracting the inelastic cross sections known at that time: "Correction for flux attenuation in the scattering sample and for multiple scattering was by the Monte Carlo program and for inelastic scattering used the data [9, 18 – 21, 23] referred to above in connection with polarization evaluation".

Since correction for inelastic scattering contribution was applied, the SF3 could be left as **EL**. However it has sense to add to all DA subentries following CRITUQUE "The differential elastic cross section may content contribution of inelastic scattering to the excitation energy up to ≈ 6.0 MeV".

The impact of inelastic scattering on polarization data (compiled in the POL/DA subentries) was shown by authors does play negligible role: "If a polarization P(Θ) is deduced for a mixture of elastically scattered neutrons of polarization $P_e(\Theta)$ and inelastically scattered neutrons of asymmetry $P_i(\Theta)$, then ... For all of the nuclei of concern here except for C, it was reasonable to assume $P_i = 0$ since P_i was an average over many excited states and in most cases over several isotopes". This statement removes the necessity to have abovementioned CRITIQUE for the polarization data too.

Entries: 21722.038 (25-MN-55(N,EL)25-MN-55,,DA), 21722.045 (33-AS-75(N,EL)33-AS-75,,DA)

Ex of 1st level (MeV): 0.1259 (Mn-55), 0.1986 (As-75)

Author and Publication: I. Fujita, nst_9_301_1972_.pdf

Recommendation for SF3: **SCT**: (25-MN-55(N,SCT) 25-MN-55,PAR,DA), (33-AS-75(N,SCT)33-AS-75,PAR,DA) with *E-LVL-MAX ≈ 3.3 - 4.2 MeV*.

Justification: The authors have recognized that "The present values of elastic cross sections may contain some contributions from low-lying levels". Crucial however is that they did not attempt to correct for, that was probably a reason of disagreement with known measurements for several nuclei: "The present values for Cr, Fe, Ni and Zn shown in Table 6 are considerably larger than those of Stelson et al. and Anderson et al. However, the present values might be acceptable if account is taken of the contributions from 1.3 and 4.2 MeV states for Cr, 1.2 and 4.2 MeV states for Ni, and 0.92 and 3.3 MeV states for Zn and also the effect of the large angular resolution of the present experiment".

The drawback of this 14 MeV experiment is very short flight path 1 m. Calculation of energy resolution with "2.5 ns overall time resolution" brings FWHM ≈ 0.3 MeV, that is already higher than first excitation level in ^{55}Mn and ^{75}As.

Finally, one may expect a contribution of inelastic scattering (authors did not even attempt to correct) with excitations up to 3.3 – 4.2 MeV to all nuclei in this Entry (sub-entries with EL and DA) and hence have to declare SF3 = SCT for them. PS: COMMENT existing in Entry has already proper statement but of qualitative character: "The values given may include some contributions from low-lying excited levels".

Entries: 21725.003 (92-U-238(N,EL)92-U-238,,SIG), 21725.004 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: J. Voignier et al., cea-r-3503_1968.pdf

Recommendation for SF3: **SCT:** (92-U-238(N,SCT)92-U-238,PAR,SIG), (92-U-238(N,SCT)92-U-238,PAR,DA) with *E-LVL-MAX ≈ 2.0 MeV*.

Justification: The authors did not mention in their report that they have corrected elastic scattering for the possible admixture of inelastic neutrons. Rather they seem just integrated the counts with energies above 12 MeV: "Les bornes d'intégration expérimentales sont 1 MeV et 12 MeV d'une part, 25° et 150° d'autre part". Fig 20 shows the measured energy spectra of scattered neutrons (after integration over angles) and confirms that elastic peak is asymmetric, i.e. it has contribution from (n,n'), and its tail extends down to 12 MeV.
From this it is clear that EL data do include contribution from inelastic scattering up to excitation energy 14.1 - 12.0 ≈ 2 MeV

Remark to the EXFOR pdf collection: cea-r-3503_1968.pdf is not available (I have download it from Internet).

Entries: 21782.003 (90-TH-232(N,EL)90-TH-232,,DA), 21782.008 (90-TH-232(N,EL)90-TH-232,,SIG),
21782.012 (92-U-233(N,EL)92-U-233,,DA), 21782.016 (92-U-233(N,EL)92-U-233,,SIG),
21782.023 (92-U-238(N,EL)92-U-238,,DA), 21782.028 (92-U-238(N,EL)92-U-238,,SIG),
21782.040 (94-PU-242(N,EL)94-PU-242,,SIG), 21782.045 (94-PU-242(N,EL)94-PU-242,,DA),
21782.046 (94-PU-242(N,EL)94-PU-242,,DA)

Ex of 1st level (MeV): 0.0494 (Th-232), 0.0404 (U-233), 0.0449 (U-238), 0.0445 (Pu-242)

Author and Publication: G. Haouat et al., nse_81_491_1982_.pdf

Recommendation for SF3: **EL**.

Justification: The authors have succeeded in achieving of sufficient energy resolution: "The flight paths, which were between 6 and 10 m, the incident neutron energy spread due to lithium target thickness, and the other experimental parameters were fixed so as to achieve a neutron overall energy resolution, at the energies of the measurements of, respectively, ≈ 8 keV at 0.6 and 0.7 MeV, ≈ 15 keV at 1.0 MeV, ≈ 18 keV at 1.5 MeV, ≈ 23 keV at 2.0 MeV, ≈ 27 keV at 2.5 MeV, and ≈ 28 keV at 3.4 MeV". Due to this they have got following results. "**^{232}Th Results**. The spectrometer energy resolution was sufficient to allow an easy separation of the elastic and inelastic scattering neutron groups at all energies". "**^{233}U Results**. Measurements on ^{233}U were performed at 0.7- and 1.5-MeV incident neutron energies. The energy spacing of the low-lying levels of this odd-mass nucleus is of the same order of magnitude as that of the even-even actinides (see Fig. 1), so that cross sections were obtained separately at 700 keV for the elastic scattering ($5/2^+$) and the inelastic scattering to the $7/2^+$ (40-keV) excited state, and at 1.5 MeV for the ground state and the $7/2^+$ (40-keV) and $9/2^+$ (92-keV) excited states". "**^{238}U Results**. Differential cross sections for ^{238}U were measured at 0.7-, 1.5-, 2.5-, and 3.4-MeV incident neutron energies. Angular distributions were obtained for elastic and inelastic scattering to the first 2^+ (45-keV) and 4^+ (148-keV) states ...". "**^{242}Pu Results**. Measurements on ^{242}Pu were completed at the incident neutron energies of 0.6, 1.0, 1.5, 2.0, 2.5, and 3.4 MeV. Differential cross sections were obtained for the elastic and the inelastic scattering to the 2^+ (45-keV) and 4^+ (147-keV) excited states."

From these explanations it clearly follows that SF3 should be **EL** for considered nuclei and sub-entries.

The energy resolution was however not enough for ^{235}U: "**^{235}U Results**. For ^{235}U, data were taken at 0.7 and 3.4 MeV. Because at both energies the experimental resolution was larger than the energy spacing of some levels of this nucleus (see Fig. 1), cross sections were extracted for two bunches of levels: ($7/2^-$ at ground state, $1/2^+$ at 75 eV, and $3/2^+$ at 13 keV) and ($9/2^-$ at 46 keV and $5/2^+$ at 52 keV)"; and for ^{239}Pu: "**^{239}Pu Results**. Cross sections for ^{239}Pu were measured at 0.7- and 3.4-MeV incident neutron energies. Since the experimental resolution at 3.4 MeV was insufficient to resolve all the scattered neutron groups, angular distributions were obtained for three bunches of levels: ($1/2^+$ at ground state and $3/2^+$ at 8 keV), ($5/2^+$ at 57 keV and $7/2^+$ at 76 keV), and ($9/2^+$ at 163 keV and $11/2^+$ at 173 keV) ...". Corresponding sub-Entries correctly reflects these data as SCT or EL.

Entries: 21858.010 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: G. Deconninck et al., ass_75_102_1961.pdf, ass_74_136_1960.pdf

Recommendation for SF3: **SCT:** (92-U-238(N,SCT)92-U-238,PAR,DA) with *E-LVL-MAX ≈ 2.5 MeV*.

Justification: The authors have written in their paper ass_74_136_1960.pdf that they have chosen a threshold corresponding to a neutron energy of 11.5 MeV to achieve the sensitivity to neutrons inelastically scattered by the excited levels of the studied element practically negligible: "Nous avons choisi un seuil correspondant à une énergie de neutrons de 11.5 Mev, la sensibilité aux neutrons diffuses inélastiquement par les niveaux excites de l'élément étudié est donc pratiquement négligeable". In the paper with results ass_75_102_1961.pdf, they have once again stressed that the experimental method itself could suffer from the detection of inelastically scattered neutrons, however they believe that inelastic scattering cross sections are generally of another order of magnitude than the elastic scattering cross sections: "La méthode expérimentale elle-même pourrait être incriminée à cause de la détection de neutrons diffuses inélastiquement, cependant les sections efficaces de diffusion inélastique sont généralement d'un autre ordre de grandeur que les sections efficaces de diffusion élastique".

From this it becomes clear that reported elastic angular distribution may contain partial contribution from (n,n') which leads to the excitation energy En – Threshold = 14.0 – 11.5 MeV ≈ 2.5 MeV. Thus, SF3 should be SCT**.**

Further correction recommended for Entry: SF3 = SCT with *E-LVL-MAX ≈ 2.5 MeV* instead of EL in all other subentries in this Entry, since the excitation energy of the first level in all these nuclei is lower than 2.5 MeV.

Entries: 22029.007 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: J. Annand et al., jp_g_11_1341_1985_.pdf, nim_206_431_1983_.pdf

Recommendation for SF3: **SCT:** (92-U-238(N,SCT)92-U-238,PAR,DA) with *E-LVL-MAX ≤ 0.8 MeV*

Justification: The authors wrote in their paper jp_g_11_1341_1985_.pdf: "Proton recoil spectra were collected with pulse shape discrimination against gamma rays and pulse height discrimination to reduce detection efficiency for inelastically scattered neutrons. ... Where possible, inelastic scattering contributions were rendered negligible by application of a suitably high pulse height bias. For the strongly excited first 2^+ states of ^{238}U and the tungsten isotopes this was not possible and the corrected analysing power data contain inelastic contamination." The section with optical model analysis further confirms this: "For ^{238}U, calculations for 0^+, 2^+ and 4^+ states were combined". In the paper nim_206_431_1983_.pdf, which describe spectrometer, they have written: "Recoil spectrum integration was performed starting with a lower energy limit of 1.5 MeV and raising the limit in 0.1 MeV steps up to 2.9 MeV. Differential cross sections and analysing powers were calculated after each integration and as would be expected if inelastically scattered neutrons have also been counted, the calculated cross sections initially fell, and the analysing powers rose slightly as the lower limit was raised as illustrated in fig. 12. The lower limit where calculated values had ceased to change rapidly was chosen as the final value. This was in general around the 2.2 MeV mark. ... The analysing power and differential cross section for the elastic scattering of 3.0 MeV neutrons from ^{209}Bi are presented in figs. 13 and 14. ... This nucleus has a high first excited state at 0.875 MeV and so a lower integration limit 2.2 MeV on the proton recoil spectra will exclude inelastic events almost completely."

From this information it is possible to deduce that reported elastic angular distribution may contain partial contribution from (n,n') leading to the excitations up to En – Threshold = 3.0 – 2.2 MeV ≈ 0.8 MeV. This value may vary from nuclei to nuclei, but regrettably the authors did not specify them more exactly. Thus, SF3 should be SCT.

Further correction recommended for this Entry: SF3 should be SCT with *E-LVL-MAX ≤ 0.8 MeV* instead of EL for U-238 sub-entry .013 (DOL/DA), for W-0 sub-entries .002 (DA) and .008 (POL/DA).

Entries: 22136.004 (41-NB-93(N,EL)41-NB-93,,DA), 22136.008 (73-TA-181(N,EL)73-TA-181,,DA),
22136.016 (41-NB-93(N,EL)41-NB-93,,DA), 22136.018 (41-NB-93(N,EL)41-NB-93,,SIG),
22136.020 (73-TA-181(N,EL)73-TA-181,,DA), 22136.023 (73-TA-181(N,EL)73-TA-181,,SIG)

Ex of 1st level (MeV): 0.0308 (Nb-93), 0.0062 (Ta-181)

Author and Publication: A. Takahashi et al., oktav-a-92-01_1992.pdf, indc-jpn-0118.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA), (73-TA-181(N,SCT)73-TA-181,PAR,DA), (41-NB-93(N,SCT)41-NB-93,PAR,SIG), (73-TA-181(N,SCT)73-TA-181,PAR,SIG), with *E-LVL-MAX ≤ 0.5 MeV*

Justification: The report oktav-a-92-01_1992.pdf is simply a compilation of the measured data, whereas report indc-jpn-0118.pdf has more details about the Nb and Ta experiments: "Angle-differential cross sections (ADX) for resolved discrete excited states in the measured DDX data were deduced by calculating peak area within the energy bins that were specified with the energy resolution of the present experiment (± 0.2 MeV)". For **Nb** the "ADX data for 'resolved peaks' were reduced for the elastic, the '1.08 MeV state' and the sum-peak of '2.18 - 2.98 MeV states', and are shown in Figs. 6a and 6b. .... The presently reduced ADX data for the 1.08 and 2.18 - 2.98 MeV states may correspond to those of their 0.93 and 2.34 MeV states". **Ta**: "In the case of ^{181}Ta, however, the measured spectrum in the 6 - 13 MeV region is rather 'monotonous', although a 'bump' is seen at about 10 MeV. These facts tell us that so many discrete states are directly excited with comparable magnitudes in this energy region, for ^{181}Ta. The present experiment has not been able to resolve these many discrete states."

From this description it follows that the authors did not analyse deeply the quasi-elastic 14 MeV peak shape, rather they have got the elastic yield by summation of emission DDX over several 0.2 MeV wide energy bins around 14 MeV. For Nb the inelastic peak of the '1.08 MeV state' corresponding to excitation of 0.93 MeV state was separated (and compiled separately in sub-Entry 005). This means that energy resolution ΔE was about 1.08 MeV /2 ≈ 0.5 MeV and inelastic neutrons exciting the first level 0.0308 MeV were surely summed together with real elastic neutrons. To which quasi discrete neutron group do belong the 2nd (0.6868 MeV), 3rd (0.7440) ... levels is not clear. Thus *E-LVL-MAX ≤ 0.5 MeV.* There is even less information about Ta, except that neutrons below 13 MeV are assigned to inelastic, that points to maximum Ex could be 14.1 – 13.0 ≈ 1 MeV. Since the total energy resolution was reported to be 2 MeV * 0.2 = 0.4 MeV, our final rough estimate could be within interval *0.4 MeV < E-LVL-MAX < 0.5 MeV*.

Entries: 22155.082 (25-MN-55(N,EL)25-MN-55,,DA), 22155.099 (25-MN-55(N,EL)25-MN-55,,SIG)

Ex of 1st level (MeV): 0.1259 (Mn-55)

Author and Publication: A. Takahashi et al., oktav-a-92-01_1992.pdf,
J. of Nucl. Sci. Techn. 25(1986)215, indc-jpn-0131.pdf

Recommendation for SF3: **SCT**: (25-MN-55(N,SCT) 25-MN-55,PAR,DA),
(25-MN-55(N,SCT)25-MN-55,PAR,SIG) with *LVL-NUMB = 0, 1.*

Justification: Additionally to the information given in our analysis for the previous Takahashi' Entry 22136, the report indc-jpn-0131.pdf confirms that "Incident neutron energy is 14.1 ± 0.2 MeV ..." and informs additionally about Mn: "Results for Mn are shown in Fig. 16 through Fig. 31 compared with JENDL-3T. Three peaks of the discrete inelastic scatterings (0.984, 2.822, and 4.41 MeV levels) and the elastic scattering peak could be resolved".

From this we may once again conclude that Ex ≈ 0.984 MeV / 2 ≈ 0.5 MeV or at least the first level Ex = 0.1259 MeV was summed with elastic scattering (the (n,n'$_2$) cross sections for the second level 0.984 MeV are reported and compiled separately in sub-Entry 0.083, 0.100).

Entries: 22278.010 (33-AS-75(N,EL)33-AS-75,,DA)

Ex of 1st level (MeV): 0.1986 (As-75)

Author and Publication: M. Gotoh and A. Takahashi, jaeri-m-92-027_301_1992.pdf

Recommendation for SF3: **SCT**: (33-AS-75(N,SCT)33-AS-75,PAR,DA), with *E-LVL-MAX ≤ 0.5 MeV*

Justification: Report jaeri-m-92-027_301_1992.pdf says about **Germanium**: "Some peaks can be seen; the largest one corresponds to elastic peak, and the others to discrete inelastic proceses. In fugure 1, it will be hard to distinguish a peak (Q = - 0.9 MeV) from elastic peak. However at the background angle, peak appears to be distinguished we do not show on this paper". Then the authors add about **Arsenic**: "Atomic number of arsenic is 33, compared with 32 of germanium. The spectra resemble much each other on the viewpoints of shape, magnitude and Q-values of discrete inelastic scattering. Almost the same things with the germanium data can be said as for arsenic".
From this and information given in previous analysis of Takashi' experiments in Entries 22136 and 22155, we recommend for Arsenic: SF3 = SCT with *E-LVL-MAX ≤ 0.5 MeV* (with this resolution value probably the first six excited levels are summed with elastic).

Further correction recommended for Entry: similar correction is recommended for Germanium (DA data in sub-Entry .008).

Entries: 22513.002 (74-W-182(N,EL)74-W-182,,DA), 22513.004 (74-W-183(N,EL)74-W-183,,DA),
22513.006 (74-W-184(N,EL)74-W-184,,DA), 22513.002 (74-W-186(N,EL)74-W-186,,DA)

Ex of 1st level (MeV): 0.1001 (W-182), 0.0465 (W-183), 0.1226 (W-184), 0.1112 (W-186)

Author and Publication: J. Delaroche et al., pr_c_23_136_1981_.pdf

Recommendation for SF3: **EL**

Justification: The authors have achieved sufficient resolution for their spectrometer: "The flight path from the sample to each detector was 8 m for the even-A W measurements and 10 m for the ^{183}W measurements, and the total energy resolution of the spectrometer was ≤ 50 and ≤ 28 keV, respectively. A time-of-flight spectrum for the ^{186}W sample is shown in Fig. 2 to illustrate the experimental resolution and the good separation of the scattered neutron peaks". This has allowed them to separate elastic scattering from inelastic excitation of the first excited levels: “The elastic scattering cross sections, measured at E_n = 3.40 MeV neutron incident energy, for the even-A isotopes ^{182,184,186}W are plotted in Fig. 3 ... That these nuclei have very similar scattering properties is also reflected in the inelastic scattering cross sections to the first excited 2^+ state (Fig. 4) and 4+ state (Fig. 5). ... For the odd nucleus ^{183}W the data for elastic scattering ($1/2^-$) and inelastic scattering to the first $3/2^-$, and $5/2^-$ excited states are presented in Fig. 6.”

Entries: 22726.002 (64-GD-155(N,EL)64-GD-155,,DA), 22726.003 (64-GD-156(N,EL)64-GD-156,,DA),
22726.004 (64-GD-157(N,EL)64-GD-157,,DA), 22726.005 (64-GD-158(N,EL)64-GD-158,,DA),
22726.006 (64-GD-160(N,EL)64-GD-160,,DA)

Ex of 1st level (MeV): 0.0600 (Gd-155), 0.0890 (Cd-156), 0.545 (Cd-157), 0.0795 (Cd-158), 0.0753 (Cd-160)

Author and Publication: E. Bauge et al., pr_c_61_034306_2000_.pdf

Recommendation for SF3: **EL**

Justification: The authors have achieved sufficient resolution for their spectrometer: “The flight path from scattering sample to detector was 10 m long for all measurements. ... This flight-path length, the incident neutron energy spread due to target thickness, the beam pulse width and the other experimental parameters were fixed so as to achieve a neutron overall energy resolution of 40 and 27 keV at 4.10 and 2.5 MeV incident neutron energies, respectively”. This has allowed them to separate elastic scattering from inelastic excitation of the first excited levels: “Net yields were obtained for isolated peaks in the spectra both by direct summation of counts above a line fitted to the residual background in the neighbourhood of the peaks, and also by fitting Gaussian shapes to the peaks. The two methods yielded results consistent to within 3% for strong, well isolated peaks. For peaks too close to each other, as were the elastic ($3/2^-$) and first inelastic ($5/2^-$) peaks of ^{155}Gd (60 keV) and ^{157}Gd (54 keV) in the TOF spectra, especially at 4.10 MeV, yields were obtained by Gaussian-shape fitting procedures only. The peak widths and positions were determined by using parameters deduced from adjacent ^{156}Gd and ^{158}Gd runs. In this way, good fits were obtained for the composite ^{155}Gd and ^{157}Gd peaks, and reliable yields were extracted for both ground-state and excited level groups.”

Entries: 30463.041 (25-MN-55(N,EL)25-MN-55,,DA), 30463.042 (25-MN-55(N,EL)25-MN-55,,SIG), 30463.043 (25-MN-55(N,EL)25-MN-55,,DA,,LEG)

Ex of 1st level (MeV): 0.1259 (Mn-55)

Author and Publication: T. Schweitzer et al., zfk-262_33_1973.pdf

Recommendation for SF3: **SCT:** (25-MN-55(N,SCT)25-MN-55,PAR,SIG), (25-MN-55(N,SCT)25-MN-55,PAR,SIG), (25-MN-55(N,SCT)25-MN-55,PAR,DA,,LEG) *with LVL-NUMB = 0, 1*

Justification: It has to be noted that authors tried to separate the overlapping peaks, see zfk-324_39_1976.pdf: “The main problem in data preparation is to reduce strong overlapping neutrons peak. The overlap is naturally caused by the final energetical resolution of the experimental system. ...3. Partition in groups of experimental reference peaks which contain special structure of the equipment. .... We have used analytical functions of the nonsymmetrical Gaussian type, which give a sufficient representation of the time-of-flight peaks.”

However, among several publications referred in this Entry, only zfk-262_33_1973.pdf has presented the ^{55}Mn data and only in the graphical form: Abb. 1 “Flugzeitspektren der elastischen und unelastischen Streuung an ^{23}Na and ^{55}Mn unter 55° bei E_n = 3.44 MeV; eingezeichnete Zahlenwerte: J^π und Anregungsenergie”. It is seen that neutrons exciting 0.116 MeV ($7/2^-$) level overlaps even at middle angles with neutrons populating the g.s. ($5/2^-$). The next level 0.983 MeV ($9/2^-$), as seen, is well separated (corresponding DA are compiled in sub-Entry .044).

From this we conclude that first excited was not resolved, i.e.: SF3 = SCT with *LVL-NUMB = 0, 1*.

Entries: 30711.002 (41-NB-93(N,EL)41-NB-93,,SIG), 30711.003 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93)

Author and Publication: Li Jingde et al., cnp_7_106_1985.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,SIG),
(41-NB-93(N,SCT)41-NB-93,PAR,DA), with *E-LVL-MAX ≥ 0.1 MeV*

Justification: Since the paper cnp_7_106_1985.pdf is short and written in Chinese, it is impossible to get necessary information about this experiment. Still, the lowest limit for the TOF spectrometer energy resolution ΔE can be estimated from the time resolution Δt = 1 ns, flight path L = 2.30 m and its uncertainties ΔL (square root sum of sample diameter 3 cm and detector thickness 5 cm). These values, which were taken from Entry 30711 and paper cnp_7_106_1985.pdf, eventually result to ΔE ≈ 0.090 MeV. Obviously, it is the lowest limit since the incident energy spread ΔE_0 is not given by authors, etc.

Even with ΔE ≈ 0.090 MeV, the inelastic excitation of the first level of ^{93}Nb will be not resolved from elastic neutrons. Therefore SF3 = SCT with *E-LVL-MAX ≥ 0.1 MeV.*

Entries: 30716.002 (92-U-238(N,EL)92-U-238,,DA), 30716.003 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: Shen Guanran et al., cnp_6_193_1984.pdf

Recommendation for SF3: **SCT**: (92-U-238(N,SCT)92-U-238,PAR,DA),
(92-U-238(N,SCT)92-U-238,PAR,SIG), with E-LVL-MAX ≈ 1.0 MeV

Justification: The paper cnp_6_193_1984.pdf is written in Chinese and rather short to get necessary information about this experiment. However, Fig. 9, which compare obtained differential elastic cross sections with other measurements, contains remark "Q = - 1.0 MeV". Additionally the Entry 30716 informs: "ANALYSIS Due to limitation of energy resolution the elastic scattering angular distribution measured includes the contribution from low level (below 1 MeV) inelastic scattering."
.

From this we conclude that SF3 = SCT with E-LVL-MAX ≈ 1.0 MeV.

Further correction recommended for Entry: there should be mm instead of cm in "DETECTOR (SCIN) Liquid,105*50 cm,ST-451 type. China made."

Entries: 30762.011 (92-U-238(N,EL)92-U-238,,DA), 30762.019 (92-U-238(N,EL)92-U-238,,SIG,,,DERIV)

Ex of 1st level (MeV): 0.0449

Author and Publication: Ma Gonggui, Li Jingde et al., cnp_11_1_19_1989.pdf, INDC(CPR)-011 p. 135, cnp_8_245_1986.pdf

Recommendation for SF3: **SCT**: (92-U-238(N,SCT)92-U-238,PAR,DA),
(92-U-238(N,SCT)92-U-238,PAR,SIG), with *E-LVL-MAX ≥ 0.1 MeV*

Justification: The paper cnp_11_1_19_1989.pdf (and report INDC(CPR)-011 p. 135) report: "The neutron energy threshold of the spectrometer was 3 MeV and its time resolution corresponding to source neutrons was 0.94 ns. ... The peak of elastic scattering neutrons was corrected in accordance with the shape of the primary neutron spectrum, with contribution of the inelastic scattering neutrons subtracted". cnp_8_245_1986.pdf and report INDC(CPR)-011 p. 135 are single documents, which present data on ^{238}U(n,el), in form of plot and table. However, they do not provide any quantitative information about the potential impact of inelastic scattering. We can only estimate the lowest limit for the TOF spectrometer energy resolution ΔE from the time resolution Δt = 0.94 ns, flight path L = 2.20 m, its uncertainties ΔL (square root sum of sample diameter 2.5 cm and detector thickness 5 cm): ΔE ≈ 0.070 MeV.

Even with ΔE ≈ 0.070 MeV, the inelastic excitation of the first level of ^{238}U will be not resolved from elastic neutrons. Therefore SF3 = SCT with rounded *E-LVL-MAX ≥ 0.1 MeV.*

Entries: 31263.002 (57-LA-139(N,EL)57-LA-139,,DA,,LEG/RS), 31263.006 (57-LA-139(N,EL)57-LA-139,,SIG), 31263.007 (59-PR-141(N,EL)59-PR-141,,DA,LEG/RS), 31263.011 (59-PR-141(N,EL)59-PR-141,,SIG), 31263.012 (57-LA-139(N,EL)57-LA-139,,DA), 31263.014 (59-PR-141(N,EL)59-PR-141,,DA)

Ex of 1st level (MeV): 0.1659 (La-139), 0.1454 (Pr-141)

Author and Publication: J. Malan et al., np_a_124_111_1969_.pdf

Recommendation for SF3: **EL**

Justification: The authors have declared that sufficiently good energy resolution of spectrometer is a goal of this experiment: "Previous data on the energy levels of ^{139}La are scanty, while most of the work on ^{141}Pr suffers from poor resolution. In addition, there has been considerable uncertainty about the existence of levels between 500 and 1100 keV in either nuclei. The present work was initiated in order to clarify and extend the available knowledge on their level schemes. Inelastic neutron scattering was employed using techniques designed to achieve adequate energy resolution of neighbouring levels". Nevertheless, at the highest incident energies the issue of resolving has arisen but was solved: "The angular distributions measured at 232 keV, 749 keV and 1105 keV are shown in fig. 6. Short flight paths (1.1 - 1.4 m) were used, therefore scattering from the first excited states could not be resolved from the elastic peak in the measurements at 874, 1105 and 1571 keV. At these energies, the cross sections for scattering to the first excited states were measured at 90° using longer flight paths, and corrections made to the combined measurements with the justified assumption of isotropy for inelastic scattering (see subsect. 4.2). The additional uncertainty introduced in this way was duly taken into account. ... 4.2. INELASTIC SCATTERING. From the present work on the level schemes, it seemed that the 166, 1228, 1264 and 1388 keV levels in ^{139}La, and the 145, 1131 and 1302 keV levels in ^{141}Pr would be amenable to a Hauser-Feshbach analysis. Therefore, excitation functions at 90° and angular distributions for scattering from these levels were measured".
The numerous details given in the paper (in particular "Fig. 1. Spectra of scattered neutrons observed at a long flight path in order to measure the cross sections for scattering to the first excited states of ^{139}La and ^{141}Pr at an incident neutron energy of 1.700 MeV" and scattering angle 90°) and (n,n_1) data compiled in sub-Entries .014, .016 (^{139}La) and .015, .017 (^{141}Pr) serve as a confirmation.

Entries: 32001.026 (41-NB-93(N,EL)41-NB-93,,SIG), 32001.027 (41-NB-93(N,EL)41-NB-93,,DA), 32001.028 (41-NB-93(N,EL)41-NB-93,,DA,,LEG)

Ex of 1st level (MeV): 0.0308 (Nb93)

Author and Publication: M. Adel-Fawzy, D. Schmidt et al., zfk-385_17_1979.pdf, nse_96_159_1987_.pdf, indc-ccp-0221.pdf, np_a_440_35_1985_.pdf, indc-gdr-0018.pdf, np_a_440_35_1985_.pdf

Recommendation for SF3: SCT: (41-NB-93(N,SCT)41-NB-93,PAR,SIG), (41-NB-93(N,SCT)41-NB-93,PAR,DA), (41-NB-93(N,SCT)41-NB-93,PAR,DA,,LEG) with *E-LVL-MAX ≈ 0.25 MeV*

Justification: The single paper with the ^{93}Nb measured data, zfk-385_17_1979.pdf, reports too few information: "Die Peakflächenbestimmung für die Peaks der elastisch gestreuten Neutronen in den Flugzeitspektren erfolgte mit Hilfe des Programms ASYVAR". Report indc-gdr-0018.pdf explains the procedure ASYVAR used by this laboratory for unfolding of the overlapping elastic and inelastic peaks. There in "Fig. 12 Angle-integrated energy spectra of the ^{93}Nb(n,n') reaction ..." at 7.0 and 7.23 MeV it is seen that all studied unfolding methods do not separate the peaks within first several hundreds keV of the excitation energy. From the DA/DE data compiled in sub-Entries .029, .032 and .035 we see that ^{93}Nb(n,n') spectra are given above the excitation energy (which equals to incident neutron energy minus outgoing neutron energy) or above 0.25 MeV.

From the publications with ^{6,7}Li data, indc-ccp-0221.pdf and nse_96_159_1987_.pdf, we may get an estimate for the TOF spectrometer resolution ΔE ≥ 0.478 MeV: "The insufficient energy resolution of the spectrometer prevented us from separating the group of elastically scattered neutrons from the group of inelastically scattered neutrons corresponding to the Li level excitation at 0.478 MeV".

Finally, relying on resolution for the ^{93}Nb(n,n') experimental data rather than on ^{6,7}Li(n,n_1) we would recommend to use SF3 = **SCT** with *E-LVL-MAX ≈ 0.25 MeV*.

Entries: 32517.002 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: Wan Dairong et al., cnp_6_193_1984.pdf

Recommendation for SF3: **SCT**: (92-U-238(N,SCT)92-U-238,PAR,DA) with *E-LVL-MAX ≥ 0.1 MeV*

Justification: The paper cnp_6_193_1984.pdf is written in Chinese. It is impossible to derive even minimal relevant information (flight path L = ?, Δt = 0.85 ns ?, ΔE_0 = ?) needed for estimation of at least the low limit for energy resolution ΔE .... The report INDC(CPR)-011, May 1988, p. 131 (in English) does not specify the flight path too.
Due to this, it is proposed to use for *E-LVL-MAX ≥ 0.1 MeV* which was recommended for the same reaction measured in the same laboratory (Sichuan Univ., Chengdu) at similar facility and compiled in 30762.011.

Further correction recommended for Entry: add to REFERENCE (R,INDC(CPR)-011,131,198803)

Entries: 32521.003 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93)

Author and Publication: Cao Jianhua, Wan Dairong et al., INDC(CPR)-011, p. 125, 1988

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA) with *E-LVL-MAX ≥ 0.1 MeV*

Justification: The short report INDC(CPR)-011, p. 125, 1988 does not provide information even about flight path L = ?, Δt = ?, ΔE_0 = ? needed for estimation of at least the lowest limit for energy resolution ΔE ...
Due to this, it is proposed to use for *E-LVL-MAX ≥ 0.1 MeV* which was also recommended for the similar measurements in the same laboratory (Sichuan Univ., Chengdu) at similar facility and compiled in 30762.011.

Further correction recommended for Entry: For ^{93}Nb and ^{nat}Mo the incident neutron energy EN should be 14.2 MeV instead of 14.7 MeV.

Entries: 32523.003 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93)

Author and Publication: Wan Dairong, private communication

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA) with *E-LVL-MAX ≥ 0.1 MeV*

Justification: There are neither publication nor sufficient information in the Entry itself about this experiment.
Due to this, it is proposed to use for *E-LVL-MAX ≥ 0.1 MeV* which was recommended for the similar measurements in the same laboratory (Sichuan Univ., Chengdu) at similar facility and compiled in 30762.011.

Entries: 32603.002 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: Qi Huiquan et al., cnp_13_343_1991.pdf, 91beijin_13_1991.pdf

Recommendation for SF3: **SCT**: (92-U-238(N,SCT)92-U-238,PAR,DA) with *E-LVL-MAX ≥ 0.1 MeV*

Justification: The paper cnp_13_343_1991.pdf reports that flight path L = 2.494 m, Δt = 2 ns and the U sample thickness and position sensitive scintillator diameter, but does not report the incident energy resolution ΔE_0. Employing these known values we estimate the lowest energy limit for the TOF spectrometer resolution as around 0.1 MeV at 12 – 14 MeV neutron energies.
Since there is no more relevant information, it is proposed to use for *E-LVL-MAX ≥ 0.1 MeV*.

Entries: 32605.002 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: Qi Huiquan et al., cnp_13_343_1991.pdf, 91beijin_13_1991.pdf, 88mito_799_1988.pdf, indc(cpr)-30_1_1993.pdf, nse_111_309_1992_.pdf, cnp_14_15_1992.pdf

Recommendation for SF3: **SCT**: (92-U-238(N,SCT)92-U-238,PAR,DA) with E-LVL-MAX ≈ 1 MeV

Justification: The paper 88mito_799_1988.pdf reports "The energy resolution of the measurement system was about 1 MeV. It could not separate the neutrons scattered elastically and the neutrons scattered inelastically from low-lying excited levels. So the results of present measurement include the contribution of such inelastic neutrons."
From this it follows that SF3 = SCT and E-LVL-MAX ≈ 1 MeV.

Entries: 32616.012.1 (92-U-238(N,EL)92-U-238,,DA), 32616.012.2 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: Qi Bujia, Tang Hongqing et al., 91beijin_32_1991.pdf, 94gatlin_2_901_1994.pdf, 91juelic_436_1991_.pdf

Recommendation for SF3: **SCT**:
32616.012.1 (92-U-238(N,SCT)92-U-238,PAR,DA) with *E-LVL-MAX ≈ 0.74 MeV*
32616.012.2 (92-U-238(N,SCT)92-U-238,PAR,DA) with *E-LVL-MAX ≈ 0.23 MeV*

Justification: The conference papers 91beijin_32_1991.pdf and 94gatlin_2_901_1994.pdf report that "The energy resolution is about 2.4% for 10 MeV neutrons measured by the normal TOF spectrometer and about 12% for 4 MeV neutrons measured by the abnormal TOF spectrometer". From this we get the energy resolution for 9.6 MeV incident neutrons ΔE = 9.6 MeV * 0.024 = 0.230 MeV for the normal TOF spectrometer. For the abnormal TOF spectrometer ΔE = 4.0 MeV * 0.12 = 0.480 MeV at 4.0 MeV, then extrapolation to the higher energies results to ΔE = sqrt(9.6/4.0) * 0.480 MeV ≈ 0.74 MeV at 9.6 MeV. The higher energy resolution for the abnormal TOF spectrometer is qualitatively confirmed by Fig. 8 in 91beijin_32_1991.pdf: "Double differential neutron emission spectra of ^{238}U induced by 10 MeV neutrons at 45° ..." measured by both spectrometers (similar Fig. 3 - in 94gatlin_2_901_1994.pdf).
The recommendation would be SF3 = SCT with *E-LVL-MAX ≈ 0.74 MeV* for 32616.012.1 (abnormal spectrometer), *E-LVL-MAX ≈ 0.23 MeV* for 32616.012.2 (normal spectrometer).

Further recommendations or corrections for the EXFOR pdf collection or Entry: (1) The first two pages in the pdf file "94gatlin_2_901_1994.pdf" are the scan of other paper – these two pages were deleted by NDS; (2) It would be desirable to refer additionally to (C,91JULIC,,436,1991...) graphs only in REFERENCE.

Entries: 40066.013 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93)

Author and Publication: N. Biryukov et al., FEI-272 (1971)

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA) with *E-LVL-MAX = 0.6 MeV*

Justification: The single referenced report FEI-272 is not available in the EXFOR pdf collection. However, the subentry has information about Incident projectile energy resolution (Half width) EN-RSL-HW = 0.3 MeV.
From this, it would be recommended for SF3 = SCT and for *E-LVL-MAX = 0.6 MeV*.

Remark for the EXFOR pdf collection: include their report FEI-272.

Entries: 40101.009 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93)

Author and Publication: V. Popov et al., 71kiev_1_223_1971.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA) with *E-LVL-MAX = 0.280 MeV*

Justification: The conference paper 71kiev_1_223_1971.pdf informs that “Spectrometer resolution was 280 keV including target thickness.” Additional but indirect confirmation of the 280 keV resolution, could be the reported discrete inelastic cross sections in Table 2: the minimal excitation energy of resolved level is 440 keV in ^{24}Na.
From this, it would be recommended for SF3 = SCT and for *E-LVL-MAX = 0.280 MeV*.

Entries: 40179.022 (41-NB-93(N,EL)41-NB-93,,DA,,LEG) , 40179.023 (41-NB-93(N,EL)41-NB-93,,SIG)

Ex of 1st level (MeV): 0.0308 (Nb-93)

Author and Publication: I. Korzh et al., bas_35_757_1972.pdf, INDC(CCP)-15,56,1971, ufz_13_1781_1968.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA,,LEG),
(41-NB-93(N,SCT)41-NB-93,PAR,SIG) with *E-LVL-MAX = 0.18 MeV*

Justification: The paper bas_35_757_1972.pdf informs that “The neutron energy spread of ± 90 keV was determined mainly by the target thickness”. Additionally, ufz_13_1781_1968.pdf informs that the detector threshold was set so high that “The inelastically scattered neutrons were practically totally cut off”. On other hand it is obvious that all scattered neutrons with energies close to incident energy En = (1.5 ± 0.09) MeV should be countered by such detectors.
From this, it would be recommended for SF3 = SCT and for *E-LVL-MAX = 2 * 0.09 MeV = 0.18 MeV*.

Entries: 40221.017 (41-NB-93(N,EL)41-NB-93,,DA), 40221.018 (41-NB-93(N,EL)41-NB-93,,SIG),
40221.029 (53-I-127(N,EL)53-I-127,,DA), 40221.030 (53-I-127(N,EL)53-I-127,,SIG)

Ex of 1st level (MeV): 0.0308 (Nb-93), 0.0576 (I-127)

Author and Publication: G. Gorlov et al., spd_9_806_1965.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA,,LEG),
(41-NB-93(N,SCT)41-NB-93,PAR,SIG) with E-LVL-MAX = 1 MeV

Justification: The paper spd_9_806_1965.pdf reports that “Here we present briefly main results for neutrons of energy 4.00 ± 0.05 MeV”. Additionally, it informs: “The flux arising from inelastic scattering (energy loss not less than 1 MeV) was corrected for on the assumption that the differential cross section for inelastic scattering is isotropic over the range from 50 to 150°”. We understand the latter author’s sentence as the subtraction of inelastic scatting but only those part that leads to

excitation of levels above 1 MeV. The reason for the much worse energy resolution for outgoing neutrons (≈ 1 MeV) than for incoming (≈ 0.05 MeV *2 = 0.1 MeV) is the spectrometer used: "The scattered neutrons were detected by six scintillation counters (stilbene crystals working onto FEU-33) ... . The neutron energies were deduced from the pulse spectra recorded by six-channel analyzers". Probably only six-channels used for analysis of pulse height distribution ... has resulted to the relatively poor resolution ≈ 1 MeV / 4 MeV = 25% for scattered neutrons.
From this, it would be recommended for SF3 = SCT and for E-LVL-MAX = 1 MeV.

Further recommendations or corrections for the EXFOR pdf collection or Entry: (1) (J,DOK,158,(3),574,196409) is not available in pdf collection – later was provided by NDS; (2) spd_9_806_1965.pdf reports that "... neutrons of energy 4.00 ± 0.05 MeV, whereas in this Entry: EN-ERR = 0.5 MeV.

Entries: 40603.003 (73-TA-181(N,EL)73-TA-181,,DA)

Ex of 1st level (MeV): 0.0062 (Ta-181)

Author and Publication: S. Simakov et al., yk_49_17_1982.pdf, indc(ccp)-197_17_1982.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA,,LEG),
(41-NB-93(N,SCT)41-NB-93,PAR,SIG) with E-LVL-MAX ≈ 1 MeV

Justification: The paper yk_49_17_1982.pdf reports that "Separation of the elastic and inelastic scattering was carried out in the TOF spectra, the line of elastically scattered neutrons have been derived from the spectrum of neutrons measured with bare neutron source". However this procedure has limits due to: (a) "at larger energies and forward angles the uncertainty of subtraction reaches (5 – 20)%"; (b) validity until the high-end secondary neutron energy limit. The corresponding maximal excitation energy E-LVL-MAX could be found as a difference between the incident energy and the highest secondary neutron energy which are given in the DA/DE sub-Entry .007: 5.19 MeV - 4.15 MeV = 1.04 MeV, 6.47 - 5.47 = 1.00 MeV, 7.49 - 6.38 = 1.11 MeV, 7.94 - 6.71 = 1.23 MeV. Regarding the proximity of this estimation, the averaged excitation value will be 1.1 MeV.
From this, it would be recommended for SF3 = SCT and for E-LVL-MAX ≈ 1.1 MeV.

Entries: 40623.003 (41-NB-93(N,EL)41-NB-93,,DA)

Ex of 1st level (MeV): 0.0308 (Nb-93)

Author and Publication: S. Simakov et al., snp_37_477_1983.pdf

Recommendation for SF3: **SCT**: (41-NB-93(N,SCT)41-NB-93,PAR,DA) with E-LVL-MAX ≈ 1.1 MeV

Justification: Similar as for Entry 40603.003, the corresponding maximal excitation energy E-LVL-MAX could be found as a difference between the incident energy and maximal secondary neutron energy which are given in the DA/DE sub-Entry .004: 5.23 MeV - 4.35 MeV = 0.88 MeV, 6.22 - 5.26 = 0.96 MeV, 7.23 - 6.02 = 1.21 MeV, 8.01 - 6.75 = 1.26 MeV. Regarding the proximity of this estimation, the averaged value will be 1.1 MeV.
From this, it would be recommended for SF3 = SCT and for E-LVL-MAX ≈ 1.1 MeV.

Entries: 40643.004 (92-U-238(N,EL)92-U-238,,DA)

Ex of 1st level (MeV): 0.0449

Author and Publication: B. Guzhovskiy et al., sja_11_1041_1962_.pdf

Recommendation for SF3: **SCT**: (92-U-238(N,SCT)92-U-238,PAR,DA) with *E-LVL-MAX ≈ 0.94 MeV*

Justification: The paper sja_11_1041_1962_.pdf reports: "Neutrons with an average energy of 15 ± 0.4 MeV were formed from bombardment of a thick zirconium-tritium target with deuterons that had been accelerated up to an energy of 290 keV in an electrostatic generator. ... This method, which is based on the use of an organic scintillator as a coarse neutron spectrometer, assured an energy resolution equal to approximately 500 keV; thus it permitted us to a considerable extent to exclude the effect produced by inelastically scattered neutrons and γ-rays". We estimate the total energy resolution from incident neutron spread and organic detector resolution ΔE = sqrt((2 * 0.4 MeV)**2 + (0.5 MeV)**2) = 0.94 MeV.

From this, it would be recommended for SF3 = SCT and for *E-LVL-MAX ≈ 0.94 MeV*.

Entries: 40706.002 (90-TH-232(N,EL)90-TH-232,,SIG), 40706.012 (41-NB-93(N,EL)41-NB-93,,SIG), 40706.016 (53-I-127(N,EL)53-I-127,,SIG), 40706.023 (25-MN-55(N,EL)25-MN-55,,SIG), 40706.024 (73-TA-181(N,EL)73-TA-181,,SIG)

Ex of 1st level (MeV): 0.0494 (Th-232), 0.0308 (Nb-93), 0.0576 (I-127), 0.1259 (Mn-55), 0.0062 (Ta-181)

Author and Publication: L. Kazakova et al., eandc-50-s_2_200_1965.pdf, 65antwerp_576(202)_1965.pdf

Recommendation for SF3: **SCT**: (90-TH-232(N,SCT)90-TH-232,PAR,SIG), (41-NB-93(N,SCT)41-NB-93,PAR,SIG), (53-I-127(N,SCT)53-I-127,PAR,SIG), (73-TA-181(N,SCT)73-TA-181,PAR,SIG) with *E-LVL-MAX ≥ 0.100 MeV*

Justification: The paper eandc-50-s_2_200_1965.pdf reports: "The mean incident neutron energy was 2 MeV with a spread of about 100 keV. .... The energy threshold of detectors was chosen so that the neutrons with the energy below 1 MeV were not detected. This threshold provided in most cases practically full discrimination against inelastic scattering of neutrons. When this threshold is being insufficient, the contribution of inelastic scattering was calculated on the basis of the published spectra of inelastic scattering and detector efficiency curve and then it was subtracted from measured cross-sections. Inelastic scattering was assumed to be isotropic". Fig. 2 shows detector efficiency rising from zero at 1 MeV up to maximum at 2 MeV. It is unbelievable that in 1965 the authors had enough and consistent data about σ(n,n') in this energy interval for reliable subtraction from the measured scattering cross sections. Having no more information from this paper, we have to declare that inelastic scattering, which result to the excitation of the levels at least within initial energy spread 100 keV, could be admixed in this experiment results.

From this, it would be recommended for SF3 = SCT and for *E-LVL-MAX ≥ 0.100 MeV*.

Further recommendations for Entry: why the angle differential cross sections, plotted in Fig. 3 of eandc-50-s_2_200_1965.pdf, are not compiled ? As a confirmation, it is worth to cite: "... intensity of scattered neutrons was measured as function of the scattering angle by the two detectors", i.e. firstly DA was measured, then SIG was derived by integration over the angle.

Entries: 40772.002 (92-U-238(N,EL)92-U-238,,DA), 40772.002 (92-U-238(N,EL)92-U-238,,DA), 40772.004 (94-PU-239(N,EL)94-PU-239,,DA), 40772.005 (94-PU-239(N,EL)94-PU-239,,DA)

Ex of 1st level (MeV): 0.0449 (U-238), 0.0079 (Pu-239)

Author and Publication: G. Anikin et al., sja_60_66_1986_.pdf, AE 60(1986)51

Recommendation for SF3: **EL**

Justification: The specific difference of this experiment from all others considered in present analysis: the incident neutrons were not monoenergetic but having the wide energy distribution, since they were produced by the fast reactor BR-10. Both the incident on sample and scattered neutron spectra were measured by scintillation detector. Their pulse height distributions were parabolic smoothed, differentiated and eventually the cross section as a function of neutron energy was derived from the ratio of scattered and incident spectra. The neutron scattered spectra obviously contain the cumulative neutron yields from all nuclear reactions on target nucleus: elastic, inelastic, fission etc. To this issue the author's paper sja_60_66_1986_.pdf additionally reports: "Corrections are introduced into the final data on the cross sections shown in Tables 2 - 4 for multiple and inelastic scattering, for fission neutrons, and for plutonium, and for scattering by the sample container. These corrections were calculated by the Monte Carlo method with the BRAND program [10] using the NEDAM and BNAB-78 nuclear constants. The total value of the corrections varies from 20 - 30% in the soft part of the spectrum to 6 - 8% in the hard part".

Conclusion: if the applied Monte Carlo code and evaluated data have correctly taken into account all the physical processes occurring in the sample, detector resolution, etc., then after proper corrections the derived cross sections could be indeed pure elastic.

Further recommendations for Entry: to the existing information "INC-SPECT Well-collimated fast neutron beam" it may be sensible to add the reference given in author' paper to "7. L.A. Trykov et al., 'Energy distribution of neutrons emerging from BR-10 reactor channels,' At. Energ., 39, 56 (1975)" or to L.A. Trykov et al. Soviet Atomic Energy 39 (1975) 631.

x4pdf collection: for better understanding of the experimental details it would useful to have G.V. Anikin and I.I. Kotukhov, "A technique of measuring neutron spectra of powerful sources," At. Energ. 54 (1983) 372.

Entries: 40791.003 (90-TH-232(N,EL)90-TH-232,,SIG)

Ex of 1st level (MeV): 0.0494 (Th-232)

Author and Publication: Yu. Aleksandrov, G. Anikin et al., jet_13_1319_1961.pdf,
jet_6_228_1958_.pdf = JET,33,294,1957,
60vienna_643_1960.pdf

Recommendation for SF3: **SCT**: (90-TH-232(N,SCT)90-TH-232,PAR,SIG), with
E-LVL-MAX > 0.2 MeV at 0.8 MeV (sub Entry 002) and
E-LVL-MAX ≈ 1.8 MeV at 2.8 MeV (sub Entry 003)

Justification: The paper jet_13_1319_1961.pdf reports: "The work was carried out with a fast-neutron reactor. Measurements were made in two energy intervals with average energies of 0.8 and 2.8 MeV. The neutrons, with an average energy of 0.8 MeV, were separated out of a broad spectrum of reactor neutrons by radiotechnical collimation of the recoil protons[4]. The measurement at an average energy of 2.8 MeV were made with a threshold detector (as was done in references 2 and 3)".

Incident Energy 0.8 MeV (sub-Entry 002). The cited paper 4) Г.В. Аникин, Ю.А. Александров и А.С. Солдатов "Спектрометрия быстрых нейтронов с помощью водородной камеры" (60vienna_643_1960.pdf, in Russian) describes the used "... method for separating specific energy groups from a wide neutron spectrum, recorded by a cylindrical, hydrogen-filled ionization chamber. The method is based on the electronic collimation of recoil-protons devised for measurements of the differential neutron-scattering cross-sections using a fast reactor as a neutron source". The neutrons with desired energy were selected by coincidence with the recoiled protons from (n,p) scattered to the specific angle. For this the following property of the hydrogen filled cylindrical ionization chamber was employed: the speed of the signal front growth correlates with the angle between the proton track and central wire-electrode. Naturally this method has internal restrictions that results to the 20 - 25% energy spread at 1 MeV and 2 MeV and even higher at 3 MeV: "Спектры импульсов, соответствующих «лобовым» столкновениям, снятые стоканальным анализатором типа АИ-100 для энергий нейтронов 1 Мэв, 2 Мэв и 3 Мэв, приведены на рис. 3. Как видно из рисунка, при энергиях 1 и 2 Мэв разрешение составляет 20-25%. Уширение пика при энергии нейтронов 3 Мэв связано, по-видимому, с возрастанием роли «эффекта пересечения» нити камеры треком протона отдачи."

Incident Energy 2.8 MeV (sub-Entry 003). The cited paper 2) jet_6_228_1958_.pdf reports "The detector was a cylindrical chamber filled with He^4 to a pressure of 15 atmos. In order to improve the characteristics of the chamber, as well as to determine the energy scale, 5% of N_2 was added to the chamber. ... The counting efficiency was several percent for neutrons of energy on the order of 1.3 MeV. The operation of the chamber was tested by the $N^{14}(n,p)C^{14}$ reaction with thermal neutrons, which gives 600 keV protons. The differential pulse amplitude distribution is shown in Fig. 1. In measuring the angular distribution, the analyzer separated the band from 680 to 890 keV. The energy spectrum of neutrons counted by the chamber was found by calculation, and is shown in Fig. 2. The spectrum was calculated using the data of Adair[3] and Seagrave[4]". Fig. 1 seems depicts the calculated efficiency of the He^4/N_2 detector where one can see that detector threshold is ≈ 1 MeV and maximum at 1.3 MeV.

From this information it follows that the SCT process was measured and reported by authors.

EN = 0.8 MeV, sub-Entry 002: due to the used method of selection of quasi mono-energy 0.8 MeV from the fast reactor spectrum with uncertainty > 25%, the levels up to maximum excitation energy E-LVL-MAX > 0.8 MeV * 0.25 = 0.2 MeV were included.

EN = 2.8 MeV, sub-Entry 003: from the detector threshold ≈ 1 MeV found in Fig. 2 of jet_6_228_1958_.pdf, we could suppose that *E-LVL-MAX ≈ 2.8 MeV - 1.0 MeV = 1.8 MeV*.

Further recommendations for Entry: similar to (90-TH-232(N,EL)90-TH-232,,SIG) the another two sub-Entries 40791.004 (92-U-0(N,EL)92-U-0,,DA) at EN = 0.8 MeV and 40791.005 (92-U-0(N,EL)92-U-0,,DA) at EN = 2.8 MeV have to be corrected correspondingly.

Entries: 40959.003 (92-U-235(N,EL)92-U-235,,DA), 40959.004 (92-U-238(N,EL)92-U-238,,DA),
40959.006 (92-U-235(N,EL)92-U-235,,DA,,,DERIV), 40959.007 (92-U-238(N,EL)92-U-238,,DA,,,DERIV)

Ex of 1st level (MeV): 0.0001 (U-235), 0.0449 (U-238)

Author and Publication: V. Morozov, Yu. Zubov et al., snp_46_778_1987.pdf

Recommendation for SF3:

1.620 – 1.926 MeV data 40959.003 (92-U-235(N,SCT)92-U-235,PAR,DA) with E-LVL-MAX = 3.5 keV,
40959.004 (92-U-238(N,EL)92-U-238,,DA),
40959.006 (92-U-235(N,SCT)92-U-235,PAR,DA,,,DERIV) with E-LVL-MAX = 3.5 keV,
40959.007 (92-U-238(N,EL)92-U-238,,DA,,,DERIV)

4.32 – 5.34 MeV data 40959.002 (92-U-0(N,SCT)92-U-0,PAR,DA) with E-LVL-MAX ≈ 140 keV,
40959.005 (92-U-0(N,SCT)92-U-0,PAR,DA,,,DERIV) with E-LVL-MAX ≈ 140 keV,

Justification: The paper snp_46_778_1987.pdf reports: "Measurements of differential cross sections are reported for the elastic scattering of neutrons by uranium at small angles in the neutron-energy region En = 1.62 – 1.93 MeV with energy resolution 3.5 keV and in the region En = 4.00 – 5.34 MeV with energy resolution ~ 140 keV". Since the paper cited in Entry as "J,PTE,,(6),33,1986) Exp. details only. First author Yu.G. Zubov" is not available, the contribution of other apparatus components to the total energy resolution is not known.

Due to this the actual Recommendation for SF3 is given as see above.

Entries: 41215.002 (90-TH-232(N,EL)90-TH-232,,DA), 41215.008 (90-TH-232(N,EL)90-TH-232,,SIG)

Ex of 1st level (MeV): 0.0494 (Th-232)

Author and Publication: V. Popov, spn_224_1963.pdf, sja_3_1379_1957_.pdf

Recommendation for SF3: SCT: (90-TH-232(N,SCT)90-TH-232,PAR,DA),
(90-TH-232(N,SCT)90-TH-232,PAR,SIG) with *E-LVL-MAX ≈ 0.21 MeV*

Justification: The paper spn_224_1963.pdf presents results for ^{232}Th at initial energy 3.1 MeV. Important details about experimental set-up are given in paper sja_3_1379_1957_.pdf: "The neutron source was a target of heavy ice bombarded by deuterons accelerated to an energy of 150 keV. The mean energy of the neutrons incident on the scatterer was 2.9 ± 0.1 MeV. The neutron detector was a spherical ionization chamber (Fig. 2) with an external electrode diameter of 13 cm, filled with a mixture of 5 atmos of hydrogen and 5 atmos of argon; this ionization chamber registered recoil protons. ... It was possible, with, this chamber, to investigate the spectrum of neutrons with energies from 0.8 to 3.0 MeV with a resolving power of 7% in the energy. ... The spectra obtained were treated by a ratio method involving division of the recoil proton spectrum from the scattered neutrons (after subtracting out the background) by the recoil proton spectrum from unscattered neutrons. ... In addition, this method makes it possible to find the differential cross sections for inelastic scattering in the same relative units for all scattering angles. .... RESULTS Differential elastic scattering cross sections of 2.9-MeV neutrons were measured for iron, copper, lead, and bismuth in the range of scattering angles from 30° to 150° at intervals of 30° (and sometimes 15°). In addition, differential inelastic scattering cross sections were measured for excitation of several levels of these nuclei. ... Figures 5 and 6 give the ratio curves for iron and bismuth. In both cases three neutron groups are well resolved. One of these is the elastically scattered group, and the other two are the inelastically scattered ones corresponding to excitation of the first two nuclear levels in iron and bismuth. These curves are the immediate experimental results. The ratio curve for copper (Fig, 7) can be used for satisfactory separation of the elastically scattered neutron from the inelastically scattered ones, but the resolution is not sufficient to separate the latter into groups related to the two copper isotopes each of which has its own level system. The same reason made it difficult to resolve even the elastic scattering in lead".

These author's detailed and clear explanations allow us to conclude that this experimental method is generally capable to separate inelastic and elastic scattered groups of neutrons, but it depends on the specific values of the spectrometer resolution (ΔE = 3 MeV * 7% = 0.21 MeV) and excitation energy of the first levels in the nucleus of interest. For ^{232}Th it is impossible since Ex of the 1st level (0.0494 MeV) is substantially smaller.

Thus SF3 should be SCT and *E-LVL-MAX ≈ 0.21 MeV*.

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