EUROPEAN-AMERICAN NUCLEAR DATA COMMITTEE

TECHNICAL MINUTES OF THE EIGHTH MEETING OF THE COMMITTEE

held at Los Alamos, May 17th-21st, 1965

Compiled by

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Preface to the Technical Minutes

EANDC-47 "U"

This version of the minutes of the eighth meeting of the European-American Nuclear Data Committee is produced for general distribution to those concerned with measurement programmes in the nuclear data field. The conclusions are, however, of an interim nature in many cases, and the document is therefore marked "Not for Publication" and should neither be quoted in publications nor listed by abstract journals.

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MINUTES OF THE EIGHTH MEETING OF EANDC

held in

Los Alamos, USA, 17th to 21st May, 1965

There were present:

E. Bretscher, AERE, Harwell, UK (Chairman)
R. Batchelor, AWRE, Aldermaston, UK (Executive Secretary)
K. H. Beckurts, Karlsruhe, Federal Republic of Germany
H. Goldstein, Columbia University, USA (Corresponding Secretary)
G. C. Hanna, AECL, Chalk River, Canada
W. W. Havens, Columbia University, USA
R. Joly, CEA, Saclay, France
G. A. Kolstad, USAEC, Washington, USA
M. Nève de Mévergnies, Mol, Belgium
H. B. Smets, ENEA, Paris
J. Spaepen, Euratom, Geel, Belgium
N. Starfelt, Sweden,
J. S. Story, AEE Winfrith, UK
R. F. Taschek, LASL, USA
P. Weinzierl, Seibersdorf, Austria

Observers:

Dr. J.L. Crandall, EACRP, Savannah River Laboratory, USA
Dr. R. Lazarus, LASL
Prof. R. Nakasima, JAERI, Japan
Dr. C.H. Wescott, Vienna

Local Secretary:

Dr. H. T. Motz, LASL

INTRODUCTION

Dr. Bradbury, Director of Los Alamos Scientific Laboratory, welcomed members of EANDC to Los Alamos for the eighth meeting of the Committee.

The Chairman welcomed Prof. Nakasima and Dr. Crandall and the Local Secretary and introduced them to the Committee Members.

1. RATIFICATION OF PROCEDURE FOR QUOTING L DOCUMENTS IN CINDA

Goldstein said that although the CINDA listings were planned to be U documents he wished to include references to measurements mentioned in L documents, e.g. progress reports, in the listings. Although experimenters would probably be reluctant to release numerical values he felt that they would be agreeable to having their names and titles of L class reports and extracts quoted in CINDA.

Anyone wishing to use or quote L class information would still have to seek the author's permission. (Taschek pointed out that it would be more appropriate to use the words issuing organisation's permission since the data did not usually belong to the author).

After further discussion during which it was suggested that S class documents should be treated in the same way from the point of view of CINDA, the EANDC agreed to the following proposal:- "That L and S class documents be entered into CINDA provided no numerical results are contained in the entry".

Smets pointed out that a similar problem exists for data compilation and obtained the agreement of the EANDC to the following proposal. "That nuclear data presented in EANDC class L or S documents may be put on data tapes prepared by the ENEA and USA compilation centres only if the author (or issuing organisation) of the document agrees, and with the provision that such data can be removed from the tape at the request of the author (or issuing organisation). The Centres will consult the authors in their respective regions".

2.

2(a) New facilities

Bretscher opened the discussion with some details of new facilities in the UK. He said that a Tandem machine was now in operation at Oxford University and that eventually it was hoped to couple it to a single ended

Van de Graaff built by NIRNS. It was expected that the complete facility would give an output energy for singly charged ions of greater than 20 MeV. The 140 MeV Linac at Glasgow University would probably be brought into operation later this year. Harwell is considering the modification of its cyclotron to give an order of magnitude increase in current and some neutron data measurements are planned with this machine.

Batchelor said that a klystron bunching system had been incorporated into the terminal of the AWRE 6 MV Van de Graaff. Mean pulsed currents of about 10 μamp had been obtained at a repetition rate of 5 Mc/sec, the pulse width being about 1¼ nsec.

Spaepen. During acceptance tests on the Geel linac last December some leaks had appeared and BCMN had requested that more development work be carried out. It was hoped to carry out final acceptance tests soon. Meanwhile the eight flight paths (one of 400 m) plus associated equipments had been installed.

Beckurts reported that there had been trouble with the IBIS machine at Karlsruhe; the beam had showed 2 and 10 Mc/sec components in addition to the expected 1 Mc/sec component. The trouble had now been cured. The bunching system for the 50 MeV cyclotron had been proved to be satisfactory and it was expected that the neutron production would be 10^9 in a 10^{-9} sec burst at a repetition rate of 10^4/sec. It was intended to use the facility for measurements of σ_{TOT} using a flight path of 50 m, which may eventually be increased, and also σ_{np} and $\sigma_{n\alpha}$ by methods involving the detection of the protons and α-particles, respectively. A detection system capable of discriminating between proton and α-particles had been developed. The Julich laboratory had ordered a 150 MeV isochronous cyclotron for nuclear structure studies.

Joly. A third section has been added to the Saclay electron linac, giving an output of 200 mA at 45 MeV and an increase in neutron intensity

of about a factor 3. A 600 MeV linac for meson and photonuclear work is being built at Saclay. A Mobley compression magnet had been made for use with the 5 MV Van de Graaff at Cadarache.

Hanna expected the Chalk River MP Tandem installation to keep to schedule and to give beams next year. A new chopper for capture γ-ray work would be installed at the NRU reactor late this year and the scattering law programme will soon be brought to an end. Chalk River is actively engaged on the consideration of an intense neutron generator project using a separated orbit cyclotron. (This provoked some discussion on the relative merits of SOC's and linear machines for producing intense neutron sources; Taschek thought that the advantages of the SOC over a linac at low current disappear at high currents). Hanna said that the University of Toronto is acquiring a linac which is expected to give 2.5 amps at 35 MeV.

Kolstad drew the attention of the EANDC to the new list of USA facilities in EANDC(US)77A.

Havens said that a design study was in progress to increase the current from the Columbia cyclotron, hopefully by an order of magnitude.

Taschek said that an output energy of 25 MeV for singly charged ions had been obtained with the LASL Van de Graaff facility. The current available at 20 MeV is 2 μamp but it falls off as the energy is increased. It had been proved possible to measure data in the energy range about 10 eV to 15 MeV with an underground nuclear explosion as the neutron source and there will be further application of the method during the summer. Bretscher suggested that this method might be very useful for measuring cross-sections of the fission products.

Crandall said that the high flux reactor at Savannah River is being used to honour many isotope requests. The loadings are made in a flux of 5×10^{15} n/cm^2 sec, and the irradiations last for 1 week in an average flux of 2×10^{15} n/cm^2 sec. The reactivity history indicated no unknown poisons.

Smets said that a new mass spectrometer had been acquired in Norway and that a Tandem Van de Graaff was working successfully in Switzerland.

Nakasima distributed a paper describing Japanese facilities (to be given an EANDC document number*). In answer to a question from Kolstad, Nakasima said that Japan was not able to make separated isotopes in sufficient quantities for neutron data measurements.

2(b) Progress Reports

The Chairman invited discussion on points of particular interest in the progress reports.

(CAN)23 - Canadian Progress Report

In reply to a question by Nève, Hanna promised to investigate whether J. P. Butler and D. C. Santry intend to measure the In $(n,n')In^{115m}$ in the energy region threshold to 2 MeV.

(E)57 - Progress Report of Nuclear Data Research in the Euratom Community

Spaepen agreed to supply Taschek with further details on the (n,n') experiments presently in progress at Casaccia and mentioned on p. 79.

Concerning the Saclay work on the measurement of neutron flux from the $T(p,n)He^3$ reaction by observation of the He^3 particles (p. 125), Joly said that the tritium targets had been made by tritiating (at Saclay) some evaporated thin titanium targets supplied by BCMN. More details would be given at a forthcoming conference on neutron producing targets to be held in Grenoble. Joly promised to send Story a copy of the thesis relating to the Be^9 $(n,2n)$ measurements reported on p. 18).

Story asked if the resonances in the capture cross-section of iron below 1 keV (see p. 53) observed by F. Mitzel and H. S. Plendl (Karlsruhe) were genuine, since, as far as he knew, no resonances below 1 keV had previously been reported. Goldstein and Havens thought that they were probably due to Managanese or Cobalt impurities present in the sample and

* Number given EANDC(J)2"U"

suggested that Beckurts arrange for the sample to be analysed. Beckurts agreed to make the arrangements but said that it was not possible to repeat the experiment since the apparatus had been dismantled.

Neve said that Spaepen and he were considering whether further measurements on Na^{23} σ_{TOT} were required bearing in mind the discrepancy between recent measurements at the University of Louvain (see EANDC(E)63) and previous Aldermaston data.

(OR)35 - Progress Report from Denmark

No comments.

(OR)36 - Progress Report from Sweden

Concerning $\bar{\nu}$, Starfelt said that Sweden had recently measured the ratios of $\bar{\nu}$ Cf^{252} (spontaneous) to $\bar{\nu}$ U^{235} at thermal, 40 keV, 7 MeV and 14 MeV and the results were in excellent agreement with previous data. Attention had now been turned to Pu^{241} measurements and also a critical review of the previous absolute measurement of Cf^{252}, the latter being stimulated by the discrepancy with the recent data of D. Colvin and M. Sowerby (AERE).

In answer to a question from Taschek, Starfelt said that the spherical proportional counters mentioned in item 5, p.2 were of Aldermaston design and were used for spectrum measurements inside the fast reactor.

Goldstein was perturbed by the large variation with energy of the spin-orbit potential (see Table 2 p. 12) and suggested that such a variation is removed if fits are made allowing 7 adjustable parameters at each energy. He also asked if Starfelt had managed to obtain an estimate of a capture cross-section at 7.5 MeV (see item 6 p. 14). Starfelt replied that the cross-section was a few mb for emission of high energy γ-rays.

(OR)37 - Progress Report from Spain

The EANDC noted with pleasure that Spain was now making a useful contribution to the field of neutron data measurements.

(OR)38 - Progress Report from Austria

Weinzierl remarked that the technique of measuring burnup of nuclear fuels by high resolution γ-spectroscopy had proved to be successful, the accuracy being about 10%.

(OR)39 - Progress Report from Norway

The Chairman asked if it was feasible for Norway to undertake a precision neutron data measurement e.g. the Pu^{239} σ_{nf} thermal cross section. Starfelt replied that he thought it was doubtful because of shortage of staff.

(OR)40 - Progress Report from Switzerland

No comments.

Smets said that Turkey had responded to the request for progress in the field of nuclear data measurements and he supplied a list of papers recently published on the topic (see Appendix 7).

(US)70, WASH-1053 - Reports to the AEC Nuclear Cross-Sections Advisory Group

Goldstein briefly reviewed the data measuring activities in the USA. He said that A. B. Smith (ANL) was continuing his elastic scattering programme with measurements on Hg, Au and Tb and A. J. Elwyn (ANL) was studying elastic scattering by B^{10}, B^{11} and Na for incident energies between 70 keV and 500 keV. Sailor et al (BNL) were beginning to use polarisation measurements to infer spin assignments of resonances and attention would soon be focussed on U^{235}. Columbia University was concentrating on obtaining values of $\Gamma\gamma$ for the light and rare earth elements. The measurements on O^{16}(n,n) by D. Lister and A. Sayres are now complete. A study of p-wave effects on separated Mo isotopes is in

progress at Duke University and E. Haddad (General Atomics) has started a measurement of the Nb $\sigma(n\gamma)$ up to several hundred eV. H. Barschall (Wisconsin) had made further σ_{TOT} measurements but had not observed the structure reported by the Hanford group. Lockheed were measuring the $Fe^{54}(n,p)$ and $Y^{89}(n,\gamma)$ cross-sections and capture cross-section measurements were continuing at ORNL. The National Bureau of Standards had entered the data field and the effort was expected to grow especially when the linac facility was operational. Taschek said that W. Stein (LASL) had remeasured the relative fission cross-sections of U^{235}, U^{238} and Np^{237}. The results for Np^{237} were very different from previous data.

(UK)54 - Nuclear Physics Division Progress Report, AERE

Bretscher said that the (n,n') programme with IBIS was continuing with measurements on U^{235} and Pu^{239}. C. A. Uttley had made further measurements on Pu^{239} σ_{TOT} and had shown that the strength functions obtained from individual resonances were less than those calculated by averaging. E. Lynn had been able to explain this effect and the topic will be discussed at the forthcoming Antwerp Conference. Havens still had reservations about the averaging process although he conceded that Pu^{239} was easier to deal with than U^{235} since the resonances are much stronger.

Neve pointed out that Macklin and Gibbons (ORNL) had measured the $B^{10}(n,\alpha)$ branching ratio as a function of energy and had obtained values in reasonable agreement with M. Sowerby. Quoting from an abstract submitted to the Antwerp Conference he said that the Macklin and Gibbons values for $B^{10}(n,\alpha_o)/B^{10}(n,\alpha)$ were 0.084 ± 0.005, 0.077 ± 0.004, 0.072 ± 0.003 and 0.067 ± 0.002 at 160 keV, 110 keV, 30 keV and thermal respectively.

Batchelor gave some details of recent progress at AWRE. He said that neutron scattering measurements had been made on the Li isotopes at 10 MeV using the Tandem T.O.F. spectrometer and that work on $Ni(n,n')$ and $Cr(n,n')$

was in progress using the 6 MV machine. P. H. White was continuing fission cross-section ratio measurements at incident energies above 500 keV and D. Mather was using the giant scintillator to measure (n,2n) cross sections of He^3, T, the Li isotopes and Pu^{239} at 14 MeV. The β-heating experiment is now finished and curves will be available for the β power emitted from 1 sec after fission to beyond 2×10^5 sec. The total β energy released per fission in U^{235} is estimated to be 7.4 ± 0.2 MeV. The neutron capture cross-sections for Pm^{147} and Pm^{148} isomers have been measured by mass spectrometry. The thermal cross-sections are 83.3 ± 7.8 b from Pm^{147} to the 5.4 d Pm^{148} isomer, 73.4 ± 7.4 b to the 41.5 d Pm^{148} isomer and $21,000 \pm 2,500$ from the 41.5 d Pm^{148} isomer to Pm^{149}. The resonance integral cross-sections are 610 ± 100 b from Pm^{147} to the 5.4 d Pm^{148} isomer and 590 ± 100 b to the 41.5 d Pm^{148} isomer. A measurement was also made of the cross-sections for Sm^{147}; these are 50.9 ± 2.5 b for thermal neutrons and 620 ± 50 b for epithermal neutrons.

2(c) Consideration of the various research papers

In this session there was very little discussion on the papers submitted since many were for information only and some (UK)50, 51, 52, 53, and 55 and (OR)34 were relevant to item 2(d).

Referring to (CAN)25 and 26, Batchelor asked Hanna if he thought that further measurements of thermal α for U^{233} and U^{235} were required. Hanna said that although present data were probably adequate, it was desirable to have more from measurements made in a purer spectrum. Chalk River planned to make such measurements in a spectrum with a Westcott r value of 10^{-4}; the temperature would be known and data would be obtained at two temperatures.

2(d) Report of the Sub-committee on Standards

Spaepen explained that the EANDC had always been concerned with standards and the problem seemed to be increasing in importance. Following a suggestion by Havens the Chairman had decided to set up a standing sub-committee on standards and had invited the following EANDC members to serve: Spaepen (Chairman), Havens, Hanna, Taschek and Batchelor. Two outside experts Dr. H. W. Koch (NBS, Washington) and Dr. E. R. Rae (AERE, Harwell) had also accepted the invitation to serve on the sub-committee. Spaepen said that it was expected that the European and N. American groups would meet separately on an ad hoc basis and would meet together just prior to a full EANDC meeting. The European group had met at Harwell on March 4th and the full sub-committee at NBS Washington on May 13th and 14th.

Spaepen asked for EANDC's approval of the frame of reference and this was given. The EANDC also agreed that its working group on flux measurements no longer existed. He then elaborated on the proceedings of the Washington meeting and stressed the following points.

Regarding neutron flux standards in the 1 keV to 100 keV region the sub-committee requested that EANDC take note of the following recommendations.

(i) To press for reports on all outstanding experiments on $B^{10}(n,\alpha)$ and $Li^{6}(n,\alpha)$ to be circulated as soon as possible.

(ii) To initiate new measurements on $B^{10}(n,p)$ and $B^{10}(n,t)$ cross-sections. An action was put on Goldstein (as Chairman of NCSAG) to see if ORNL could be persuaded to take on this work.

(iii) To intiate new measurements on the fission cross-sections of Pu^{239} and Pu^{241}. Batchelor stressed the urgency of these measurements in view of the large discrepancies between recent AWRE data (see (UK)50 and 53) and the BNL 325 curves. Some recent preliminary

linac data obtained by G. D. James (AERE) supported the low AWRE values but the accuracy of the linac data above 1 keV was low and some new precise data were required. Beckurts said that Karlsruhe had plans to measure the Pu^{239} to U^{235} fission cross-section ratio but Batchelor thought that a new absolute measurement was required.

(iv) To obtain the advice of reactor physicists on the accuracy required on U^{235} σ_{nf} and Pu^{239} σ_{nf} in the 100 keV region. The UK is presently requesting a ½% accuracy and if this cannot be relaxed then a very major research effort will be required to satisfy the requests. When the discrepancies are resolved, it is considered that the overall accuracy from present measurements will be about 3%. Story was asked to discuss this point with the requestors and to seek an explanation of why the UK request for Pu^{239} was Priority I and that for U^{235} is Priority III.

Some discussion followed on how a flux could be measured using either the standard $B^{10}(n,\alpha)$ or $Li^{6}(n,\alpha)$ cross sections. Starfelt argued that BCMN should obtain and standardise a lithium loaded glass scintillator but it was pointed out that it might not be necessary to go to this length. If the $Li^{6}(n,\alpha)$ cross section is known from thermal to the MeV region, then a fast flux could be measured with a lithium loaded scintillator which has been calibrated in a known thermal flux. This method would bypass the difficult problem of measuring the Li^{6} content of the glass and the conversion efficiency of the scintillator.

On the question of compilation and evaluation of data related to nuclear energy standards the EANDC agreed that the sub-committee should concentrate on the reactions mentioned in Appendix 10 and suggested the following amendments and additions.

(i) for U^{235} σ_{nf} change energy range to thermal and 10 keV to 3 MeV.

(ii) for Pu^{239} σ_{nf} change energy range to thermal and 10 keV to 3 MeV.

(iii) add U^{238} σ_{nf} from threshold to 15 MeV (suggested because a detector based on this cross-section would not be sensitive to thermal neutrons).

At Beckurts request the sub-committee was also asked to consider adding In $\sigma(n\gamma)$ in the 1 keV to 100 keV region to the list.

Crandall pointed out that the EACRP is also interested in standard cross-sections and could probably suggest cross-sections other than those mentioned in Appendix 10 which ought to be considered. He was invited to raise the matter at the next EACRP meeting and ask if the EACRP could collaborate jointly with EANDC in making a standards list.

Spaepen sought the support of EANDC in the proposed activity of evaluation of standard cross-sections at BCMN. This was agreed although Taschek had some reservations about starting a new evaluation centre. He considered it was feasible for existing evaluation groups to take on this extra work, but Batchelor and Goldstein countered and said that existing groups were fully occupied and standard cross-sections were not primarily their business.

Regarding plutonium isotopic standards, Spaepen asked Crandall to get the EACRP advice on the desirable compositions of such standards from the point of view of burnup studies.

2(e) Round Table Conference on Precision Chemical Analysis

Spaepen said that this was the first of two round table conferences which BCMN planned in relation to the problem of assay of materials of interest to nuclear energy. It was held in Brussels, Jan 18-22, 1965. Discussion had been limited to B, Th, U and Pu and the proceedings are published in EANDC-42S. Spaepen said that one of the benefits of the

conference was that it had made chemists more aware of the needs of physicists and physicists more aware of the difficulties involved in the chemical analysis of the materials they used.

3. DATA INDEXING, COMPILING AND EVALUATING

3(a) IAEA activity

Westcott reported that the IAEA Data Unit had now completed the 2200 m/sec evaluation of the fissile isotopes and that the final report would be published in Atomic Energy Review. The final table of recommended values, supplied by Westcott, is given in Appendix 8. This data provoked some discussion on the present status of $\bar{\nu}$ measurements since the EANDC was aware of the discrepancy between the Colvin and Sowerby data for $\bar{\nu}$ Cf^{252} spontaneous and other data. The figures given by Hanna are:-

(i)	Colvin and Sowerby	3.713 ± 0.015
(ii)	Average of LASL and Swedish values from tank experiments	3.793 ± 0.023
(iii)	Value from η and α of U^{233} and U^{235} and ratios	3.802 ± 0.019
(iv)	Average of (ii) and (iii)	3.797 ± 0.015
(v)	Difference between (iv) and (i)	0.084 ± 0.021

Hanna believed this to be a real discrepancy but Starfelt considered that the overall errors may not have been properly assessed. Goldstein said that the EANDC should regard this as a serious discrepancy and should take steps to improve the situation. Batchelor suggested that it might be useful to arrange a meeting of $\bar{\nu}$ measurers at the time of the Antwerp Conference and was agreed. An action was put on Starfelt to make the arrangements and it was suggested that he invite D.W. Colvin, M.G. Sowerby, B.C. Diven and an AWRE representative to attend.

3(b) Remarks on Evaluation and Multigroup Cross Sections

Dr. R. B. Lazarus (LASL) addressed the EANDC on this topic and a copy of his notes is included in Appendix 9) At the conclusion of the session the Chairman thanked Dr. Lazarus for his most interesting contribution.

4. CONFERENCES

4(a) EANDC-Sponsored Conference on the Study of Nuclear Structure with Neutrons

Nève reported on the status of the arrangements for the EANDC sponsored conference to be held in Antwerp, July 1965. He said that the total number of contributions was 172 which, although large, was manageable since a rapporteur system is to be used. So far there had been 338 applications to attend, 300 being from EANDC countries and 2 from the USSR. The largest contingent (46) was from the Federal Republic of Germany. The North Holland Company had agreed to publish the invited talks, the rapporteurs' reports, the discussions and the abstracts of the original contributions. The actual contributions would be published in a CEN, Mol, report, and the abstracts would be circulated as an EANDC "U" document in June.

On behalf of the EANDC, Bretscher thanked Neve for his large contribution to the organisation of the conference and expressed the hope that the venture would be successful.

4(b) Round Table Conference on Mass Spectrometry and Counting Techniques

Spaepen explained that this conference was the follow up of the conference on precision chemical analysis held at BCMN in January. It was to be held at BCMN at the end of November 1965 and the proposed programme had been circulated to EANDC members in April. An action was put on members to submit names of participants to Spaepen by mid June.

4(c) Harwell Seminar on Making of Isotopic Targets

Batchelor said that arrangements were being made to hold a seminar on making isotopic targets at Harwell October 20-21, 1965. It was intended to concentrate on stable isotopes and there would be sessions devoted to the technique of measuring target thickness. It was also expected to include a session on direct deposition of targets in mass-separators.* EANDC gave its support to this seminar and Batchelor agreed to circulate the programme to members as soon as possible. At Spaepen's request he also agreed to discuss with the organisers the feasibility of publishing the full discussion of the seminar.

4(d) High Intensity Neutron Sources

This topic was opened by Kolstad who said that the USAEC had held a symposium on high intensity neutron sources in Washington in February 1965. The programme included discussions on the needs for high intensity sources and the technique of making such sources. At the conclusion of the symposium, a special panel had met and its preliminary report and recommendations have been issued as EANDC(US)74U. Havens had summarised the proceedings and he volunteered to circulate his summary to EANDC members. In view of the growing interest in the field, Kolstad thought that EANDC might be interested in organising another conference.

Considerable discussion followed during which it became clear that there were many conflicting opinions about such a conference. Some felt that it should be restricted to nuclear physics interests, some that it should encompass all the disciplines associated with the devices. An agreement was eventually reached on the following Kolstad proposal "That

*It is now known that there will not be a session on direct deposition of targets in mass-separators.

the EANDC recommends that a small symposium on very high intensity neutron sources for nuclear energy research be held during the latter half of 1966 and urges the participation of the EACRP in developing the appropriate arrangements and programme".

4(e) Neutron Cross-Section Technology

Havens announced that it was intended to hold a conference on "Neutron Cross-Section Technology in Washington 22-24 March 1966, sponsored by the USAEC, the National Burea of Standards, the American Physical Society and the American Nuclear Society. The arrangements and programme would be formulated in June and Havens promised to circulate the information to EANDC members.

5. REQUEST LISTS

5(a) Pu^{239} Fission Cross Section at 2200 m/sec

Hanna said that there were requests for this parameter to ½% and 1% accuracy and although an inspection of the Westcott recommended values (see Appendix 8) suggests that the requests might be fulfilled, the situation is far from satisfactory. A new measurement had recently been made (Fraysse and Prosdocimi, Paper SM 60/17 of the Salzburg Fission Symposium), but Hanna had some reservations about the reliability of the result and he thought that it was desirable tp programme a new measurement in a monokinetic spectrum. Spaepen agreed with Hanna's remarks and said that Nève and he were planning such a measurement using a different approach from the previous Mol experiment. Batchelor said that Aldermaston planned to measure the ratio Pu^{239} σ nf/U^{235} σ nf using a crystal spectrometer but the expected accuracy on the ratio is 2%.

5(b) Inelastic Scattering

In this item the Chairman called for comments on the status of measurement on Priority I (n,n') items. IBIS type machines were now producing a lot of high resolution data, particularly in the region up to 2 MeV incident energy and higher energy single ended and Tandem machines were being equipped with bunchers so that high resolution work at high energies could be expected in the future.

The following Table summarises the discussion on the (n,n') requests, the item numbers being taken from EANDC 43"U".

Item No.	Quantity	Comments
106	F $\sigma_{nn'}$ to 10 MeV	No comments.
115	Na $\sigma_{nn'}$ to 10 MeV	Data available up to 4 MeV Nuclear Physics 32, 610 (1962) AWRE to make measurements in region of 7 MeV.
142	Al $\sigma_{nn'}$ to 10 MeV	Data available; see EANDC43"U" AWRE to make measurements in region of 7 MeV
366	Zr $\sigma_{nn'}$ 1 to 14 MeV	See EANDC 43"U" for available data
387	Nb^{93} $\sigma_{nn'}$ to 8 MeV	Activation measurement. Hanna to investigate whether Chalk River can measure
394	Mo $\sigma_{nn'}$ to 3 MeV	Joly and Starfelt offered to consider making measurements
418	Rh^{103} $\sigma_{nn'}$ to 10 MeV	In progress at Chalk River
528	Th^{232} $\sigma_{nn'}$ to 10 MeV	Batchelor thought that this request is now fulfilled from data obtained at ANL and AWRE
656 and 657	U^{235} $\sigma_{nn'}$ to 10 MeV	AERE have made measurements up to 1.5 MeV AWRE plan measurements 1.5 MeV to 7 MeV

Item No.	Quantity	Comments
734, 735 and 736	U^{238} $\sigma_{nn'}$ to 14 MeV	Request probably satisfied to 7 MeV from data obtained at ANL, AERE and AWRE. 3% accuracy not achieved and Story to clarify.
782, 783 and 784	Pu^{239} $\sigma_{nn'}$ to 14 MeV	In progress at AERE up to 1.5 MeV. AWRE plan measurements from 1.5 MeV to 7 MeV. (nf) and (n, 2n) become dominant at high energies. In preparation at CBMN up to 2 MeV.

In answer to a question from Bretscher, Goldstein said that from the applied point of view, it was not necessary to resolve levels by (n,n') above 700 keV incident energy for the fissionable isotopes; the statistical approach was good enough above 700 keV. Taschek pointed out however that there might be a good physics reason for resolving higher levels and experiments should be encouraged to follow such interests.

6. PRODUCTION OF BERRYLIUM SINGLE CRYSTALS

Neve said that the document EANDC(E)64S summarises the present status of the beryllium single crystal problem. A crystal has been made by the Metallurgy Division of CEA, Saclay and has given promising results on tests with neutrons at Mol although there is evidence to suggest that it is not a pure single crystal. However it is planned to try to improve the crystal and to manufacture a second crystal under more controlled conditions. If these are successful then Neve will discuss with CEA the question of producing crystals to satisfy the known demands. The EANDC encouraged this investigation to continue.

Smets said that the OR group sought the help of EANDC in establishing a catalogue of producers of good single crystals or owners of unused crystals. Denmark was interested in sodium and potassium and Austria in sodium crystals. Since the crystals were required for solid state studies, the EANDC felt that it could not help in this matter.

NOTE ON TOPICAL DISCUSSION

The morning of Tuesday May 18th was devoted to a discussion on Neutron Capture Reactions. The session was organised by Dr. B.C. Diven of LASL and Dr. E. Haddad, General Atomics, Dr. L. W. Weston (ORNL) and Dr. R. Blose (ORNL) attended as experts.

APPENDIX 1

LIST OF GENERAL DOCUMENTS

For 8th Meeting of EANDC

No.	Classification	Title	Author
EANDC-36	A	Complete Minutes of the Seventh Meeting of the Committee	R. Batchelor W. Michaelis
EANDC-40	A	Cumulative List of EANDC Documents September 1959 - July 1964	
EANDC-41	A	List of Members	
EANDC-42	S	Round Table on High Precision Chemical Analysis of Substances of interest to Nuclear Energy	
EANDC-43	U	Compilation of EANDC Requests	

APPENDIX 2

LIST OF CANADIAN DOCUMENTS

For 8th Meeting of EANDC

No.	Classification	Title	Author
EANDC(Can)23	L	Progress Report	G. C. Hanna
EANDC(Can)24	L	Request List	G. C. Hanna
EANDC(Can)25 AECL-1965	S	A Determination of the Ratio of Capture to Fission Cross Sections of U^{235}	A. Okazaki M. Lounsbury R. W. Durham I. H. Crocker
EANDC(Can)26 AECL-2148	S	A Determination of the Ratio of Capture to Fission Cross Section of U^{233}	A. Okazaki M. Lounsbury R. W. Durham
EANDC(Can)27	S	Fission Data and Nuclear Technology	G. C. Hanna

APPENDIX 3

LIST OF EURATOM DOCUMENTS

For 8th Meeting of EANDC

No.	Classification	Title	Author
EANDC(E)52	S	Cross Sections for the Reactions $Cu^{63}(n,\alpha)Co^{60}$, $Ni^{60}(n,p)Co^{60}$, $Ti^{46}(n,p)Sc^{46}$, and $Na^{23}(n,2n)Na^{22}$	H. Liskien A. Paulsen
EANDC(E)53	S	Automatic Acquisition and Reduction of Nuclear Data - Karlsruhe Meeting	K. H. Beckurts W. Glaser G. Kruger
EANDC(E)54	S	Mesure de la section efficace de capture du Sodium pour des neutrons d'Energie comprise entre 10 keV et 100 keV.	Leroy
EANDC(E)55 KFK 265	L	Eine Messung des isomeren Aufspaltverhältnisses bei Aktivierung in den ersten 3 Indium-Resonanzen	E. Albold P. v. Blankenhagen
EANDC(E)56	S	Excitation Functions of the Reactions $Ni^{58}(n,2n)Ni^{57}$, $Cu^{65}(n,2n)Cu^{64}$ and $Zn^{64}(n,2n)Zn^{63}$ in the Energy Range between 12.5 and 19.6 MeV	A. Paulsen H. Liskien
EANDC(E)57	U	Progress Report on Nuclear Data Research in the Euratom Community for the period 1.7.63 to 31.12.64	
EANDC(E)58	U	Compilation of Requests for Neutron Data from Euratom Countries	
EANDC(E)59 EUR 2247.e	S	Test Equipment for Accurate Determination of Time Relations and its Use for the Measurement of the Timing Accuracy and the Calibration of Fast Photomultipliers	H. Meyer H. Verelst
EANDC(E)60 EUR 2248.e	S	The Correction for Foil Absorption in 4π Counting	W. van der Eijk
EANDC(E)61	S	Cross Sections for the Reactions $^{55}Mn(n,2n)^{54}Mn$, $^{59}Co(n,2n)^{58}Co$, $^{24}Mg(n,p)^{24}Na$, and $^{27}Al(n,\alpha)^{24}Na$ in the 12.6 to 19.6 MeV Energy Region	A. Paulsen H. Liskien
EANDC(E)62 KFK 304	S	Two Compact, High-Intensity Neutron Sources	W. Eyrich A. Schmidt
EANDC(E)63	S	Progress Report in the Field of Neutron Data	G. DeConninck DeVroey
EANDC(E)64	S	Test of a Be Single Crystal	F. Poortmans E. Legrand

APPENDIX 4

LIST OF DOCUMENTS FROM OTHER OECD COUNTRIES

For 8th EANDC Meeting

No.	Classification	Title	Author
EANDC(OR)34 FOA 4 Report A 4393-411	L	A Relative Measurement of the $Li^6(n,\alpha)H^3$ Reaction Cross Section in the Range $1 \leq En \leq 600$ keV	S. Schwarz L. G. Stromberg A. Bergstrom
EANDC(OR)35	L	Progress Report to EANDC from Danish AEC Research Establishment	H. Bjerrum Møller
EANDC(OR)36	L	Progress Report to EANDC from Sweden	N. Starfelt
EANDC(OR)37	L	Spanish Progress Report to the EANDC	
EANDC(OR)38	L	Progress Report to EANDC from Austria	P. Weinzierl
EANDC(OR)39	L	Progress Report on Nuclear Data Measurements in Norway	
EANDC(OR)40	L	Progress Report to EANDC from Switzerland	R. W. Meier

APPENDIX 5

LIST OF UNITED KINGDOM DOCUMENTS

For 8th Meeting of EANDC

No.	Classification	Title	Author
EANDC(UK)46	S	A Neutron Scattering Study of Fe^{56}	W. B. Gilboy J. H. Towle
EANDC(UK)47	S	The Absolute Fission Cross Section of U^{235} for 2200 m/sec Neutrons	E. E. Maslin J. A. Moore J. M. A. Reichelt J. B. Crowden
EANDC(UK)48	S	Neutron Interactions with U^{238} and Th^{232} in the Energy Region 1.6 MeV to 7 MeV	R. Batchelor W. B. Gilboy J. H. Towle

APPENDIX 5 (continued)

LIST OF UNITED KINGDOM DOCUMENTS

For 8th Meeting of EANDC

No.	Classification	Title	Author
EANDC(UK)49	S	Measure of Prompt $\bar{\nu}$ for the Neutron-Induced Fission of Th^{232}, U^{233}, U^{234}, U^{238} and Pu^{239}	D. S. Mather P. Fieldhouse A. Moat
EANDC(UK)50	S	The Fission Cross Sections of U^{233} U^{234}, U^{235}, U^{236}, Np^{237}, Pu^{239}, Pu^{240} and Pu^{241} for 24 keV neutrons	J. L. Perkin P. H. White P. Fieldhouse E. J. Axton P. Cross J. C. Robertson
EANDC(UK)51	S	Measurements of the ^{235}U Neutron Fission Cross Section in the Energy Range 0.04 MeV to 14 MeV	P. H. White
EANDC(UK)52	S	Boron Pile $\bar{\nu}$ Measurements February 1965	D. W. Colvin M. G. Sowerby
EANDC(UK)53	S	Measurements of Fission Cross Sections for Neutrons of Energies in the Range 40-500 keV	P. H. White J. G. Hodgkinson G. J. Wall
EANDC(UK)54 AERE-PR/NP7	S	Nuclear Physics Division Progress Report for Period 1st January 1964 to 30th June 1964.	D. L. Allan Editor
EANDC(UK)55	S	The $^{10}B(n,\alpha)$ Branching Ratio	M. G. Sowerby
EANDC(UK)56	S	The Neutron Confliction of Thorium and the Analysis of the Resonances up to 1 keV.	M. Asghar C. M. Chaffey M. C. Moxon M. J. Pattenden E. R. Rae C. A. Uttley
EANDC(UK)57	S	Neutron Scattering Studies of K^{39}	J. H. Towle
EANDC(UK)58	A	Stock of Plutonium and Thorium Isotopes held by Electromagnetic Group, Chemistry Division, AERE, Harwell.	M. L. Smith
Correction to EANDC(UK)42	L	Eta and Neutron Cross Sections of U^{235} from 0.04 eV to 200 eV.	M. G. Sowerby

APPENDIX 6

LIST OF UNITED STATES DOCUMENTS

For 8th EANDC Meeting

No.	Classification	Title	Author
EANDC(US)68	A	ORNL Plutonium Inventory, 22nd January, 1965	
EANDC(US)70 WASH 1053	U	Reports to AEC Nuclear Cross Sections Advisory Group (ORNL), October 13-14, 1964	A. B. Smith
EANDC(US)71	U	Analysis of (n,2n) Cross Sections for Nuclei of Mass A > 30.	S. Pearlstein
EANDC(US)72 WASH 1056	U	Reports to the AEC Nuclear Cross Sections Advisory Group (Washington, D.C.), March 8-9, 1965	
EANDC(US)73 WASH 1057	U	Compilation of Requests for Nuclear Cross Section Measurements	
EANDC(US)74 WASH 1058	U	Report and Recommendations of Special Panel on Pulsed High Intensity Fission Neutron Sources, February 19, 1965	
EANDC(US)75	U	Least Square Analysis of the 2200 m/sec Parameters of U^{233}, U^{235} and Pu^{239}	R. Sher J. Felberbaum
EANDC(US)76	L	Stable Isotope Cross Section Research Pool Inventory, April 1965 (USAEC)	
EANDC(US)77	A	U.S. Nuclear Physics Research Accelerators (1 MeV - 1 BeV), April 1965 (draft)	

APPENDIX 7

LIST OF REPORTS AND PUBLICATIONS FROM TURKEY

Nuclear Data

All reports are obtainable, from:

The Secretary
Scientific Publications
Cekmece Nuclear Research and Training Center
P.O. Box 1, Airport
Istanbul, Turkey

1. T. Erben and B. Guven: Isotopic and Isotonic Yields in Nuclear Fission, CNAEM rep. 2, 1962, published in The Phys. Rev. 129, 1762-1764 (1963).

2. Z. Guner: Investigations of Experimental Equipment for Inelastic Neutron Scattering Using a Low Flux Reactor, CNAEM rep. 4, 1962

3. T. Erben: Nuclear Charge and Mass Distributions in Low-Energy Fission (Chemistry Research and Chemical Techniques based on Research Reactors, IAEA, Vienna 1963, pp. 61-72

4. T. Erben: Studies on Nuclear Charge and Mass Distributions in Low Energy Fission, presented at the Athens Study Group Meeting, 9-13 September, 1963

5. F. Domanic: Neutron Crystal Spectrometer Project of the CNAEM, presented at the Athens Study Group Meeting, 9-13 September, 1963

6. T. Erben and B. Guven: Systematics of Fission Asymmetry with Respect to Nuclear Charge and Neutron Contents, CNAEM rep. 12, 1963, published in Phys. Rev. 134, No. 5B, 972-976 (1964)

7. Ö. Akyüz, F. Bayvas, C. Cansey, F. Domanic: Crystal Spectrometer Measurement of Cekmece TR-1 Thermal Neutron Spectrum, CNAEM rep. 19 (1964)

APPENDIX 8

RECOMMENDED VALUES FOR FISSILE ISOTOPES

(all cross sections in barns)

	U-233	U-235	Pu-239
σ_a	576.3 ± 2.3	679.9 ± 2.3	1008.1 ± 4.9
σ_f	527.7 ± 2.1	579.5 ± 2.0	742.4 ± 3.5
σ_γ	48.6 ± 1.5	100.5 ± 1.4	265.7 ± 3.7
α	0.0921 ± .0029	0.1734 ± .0025	0.3580 ± .0054
η	2.284 ± 0.008	2.071 ± 0.007	2.114 ± 0.010
$\bar{\upsilon}$	2.494 ± 0.009	2.430 ± 0.008	2.871 ± 0.014
(Cf-252) - 3.772 ± 0.015			

APPENDIX 9

REPORT ON THE USE OF LIBRARIES OF EVALUATED NEUTRON INTERACTION DATA

by R. B. Lazarus

1. The primary interest is in fast systems.

2. The main problem is to calculate, for any nuclide or element, the 5-parameter neutron production cross sections

$$\sigma_{r,m,n,g \to g'} = \int_g dE \left\{ \int_{-1}^{1} d\mu\, P_m(\mu)\, \Phi(E,\mu) \right\} \times \int_{g'} dE' \int_{-1}^{1} d\mu\, \sigma_r(E \to E',\mu)\, P_n(\mu_{Lab}),$$

where r is a reaction (such as n,2n), $\Phi(E,\mu)$ is an estimate of the neutron distribution for the problem at hand, P_m and P_n are Legendre polynomials, and g and g' label energy groups.

10^3 to 10^4 of these cross sections are needed for each nuclide for each (substantially different) application. They can be calculated in a few minutes on a modest computer, assuming good programming.

3. Libraries of $\sigma_r(E \rightarrow E', \mu)$ presently in hand contain a few times 10^5 numbers and are expected to reach 10^6 numbers. They can be contained (if suitably packed) on one reel of magnetic tape, with a random access time of the order of two minutes or less, or they can be contained on $10,000 to $30,000 worth of magnetic disk, with a random access time of the order of 0.2 seconds or less.

4. Requirements for thermal reactors may go to 10^8 numbers of more, but it appears evident that appropriate technological advances in data storage will be forthcoming (e.g. optical memories).

5. Work is in progress for the automatic generation of commensurate plots of experimental and evaluated data, as a tool for the evaluator.

6. Data problems bothering me at present include:

   (a) Updating libraries by <u>correction</u>, rather than <u>replacement</u>, to avoid introduction of errors. (It was correctly pointed out by Herb Goldstein that almost any updating procedure is all right if it avoids direct interaction between humans and those data which are not to be replaced.)

   (b) Data and a format are needed for $\sigma(E \rightarrow E', \mu)$ for other than two-body interactions; Ken Parker of AWRE is believed to have chosen such a format.

   (c) Data and a format are needed for γ-ray production by neutron collision.

APPENDIX 10

TABLE OF FIRST CATEGORY ITEMS FROM THE GEEL ACTIVITY REPORT

Nuclide	Cross Section	Energy Interval
H	(n,n)	up to 15 MeV
He^3	(n,p)	up to 4.5 MeV
C	total	up to 2 MeV
Li^6	(n,α)	up to 2.5 MeV
B^{10}	(n,α)	up to 1 MeV
Au	(n,γ)	thermal
Pb	total	up to 10 keV
U^{235}	(n,f)	thermal and 10 keV-15 MeV
Pu^{239}	(n,f)	thermal and 10 keV-15 MeV
Cf^{252}	$\bar{\nu}$	spontaneous fission