EANDC 35 "L"

EUROPEAN AMERICAN NUCLEAR DATA COMMITTEE

TECHNICAL MINUTES OF THE SIXTH MEETING

11th to 15th November, 1963 — Atomic Energy Centre, Democritus
Athens, Greece

Compiled by

R. Batchelor (A.W.R.E., Aldermaston)
Executive Secretary

aided by

A. Simopoulos, (Democritus Centre, Athens)

Reproduced by the
O.E.C.D. European Nuclear Energy Agency
38, bd. Suchet, Paris 16e

March, 1963

Preface to the Technical Minutes
EANDC 35"L"

This version of the minutes of the sixth 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 The conclusions are, however, of an interim nature in many cases, and the document is therefore marked "Not for Publication" and should neither be quoted in publications nor listed by abstract journals.

TABLE OF CONTENTS

MINUTES OF THE SIXTH MEETING OF EANDC

held in

Athens, 11th to 15th November, 1963

There were present:

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

Observers: N. Starfelt, Sweden
C.H. Westcott, IAEA, Vienna

INTRODUCTION

The Chairman called the meeting to order by introducing Mr. S. Boukis, Director of External Relations, Greek AEC, Mr. A. Simopoulos, the Local Secretary and Dr. N. Starfelt as an observer.

1. INFORMATION ON FACILITIES AND PROGRAMMES

1(a) Programme Status Reports

Spaepen called for brief comments on salient points in the various progress reports.

(i) EANDC (Can 17)

Hanna said that NRU will be shut down for approximately 6 months and hence work on the scattering law project would be interrupted. Work was now in hand to make a furnace for measurements on Uranium Oxide at high temperatures.

It is possible that a modified chopper similar to that at the Brookhaven HFBR will be installed. The Pu^{241} σ_{nT} experiment was complete except for chemical analysis of the sample.

In reply to a question by Story concerning σ-measurements at Chalk River, Hanna said that a further run on U^{235} was planned since their result, which came out higher than values obtained from fuel analyses was causing some concern.

(ii) EANDC(E)49

Spaepen said that there had been trouble in getting the specified 10 mA into a 0.7 nsec pulse with the Geel Van de Graaff. At first the current was limited to 4 mA because of beam spread between the machine and the bunching magnet, but the fault has now been cured and the specified performance has been reached.

He said that measurements on the U^{235} and Pu^{239} fission cross-section in the thermal region had been completed and gave preliminary data as follows:

Energy (ev)	U^{235} σ_{nf}	Pu^{239} σ_{nf}
0.0322	529 barn	640 barn
0.0626	-	509 "
0.275	-	3415 "

2.

Bretscher asked if the French had further information on the distributions of Γ_γ for U^{235}. Joly replied that the values obtained appear to belong to two families corresponding to the two spin states, each with a Porter-Thomas distribution, but there were too few data for significant statistics.

Concerning the Belgian programme, Nève drew attention to the measurements on $Li^6(n,\alpha)$ cross-section at the University of Liège and to the discrepancies in the g-values for the 0.096 ev and 0.87 eV resonances in Sm^{149} obtained at Mol. He considered that the Mol value was correct but further work was required to clear the matter up.

Batchelor commented on the discrepancy in σ_{nT} Na^{23} in the region 1 to 2 Mev between data obtained at the University of Louvain and those reported by Towle and Gilboy (see page 42 EANDC-E-49). He agreed to try to arrange for Towle and Gilboy to repeat their measurements with an unshielded detector. Nève also agreed to ask Deconinck to send tabulated results to Goldstein, and to look for a possible explanation of the discrepancy between his results and the Aldermaston measurements.

(iii) EANDC(OR)22

Kofoed-Hansen drew attention to the development of a material contained cadmium whose melting point is 660 °C and which can easily be machined. Such material would be very useful in certain applications e.g. measuring Cd ratios in high flux positions.

(iv) EANDC(OR)23

Starfelt said that a study of fast neutron scattering by carbon had now been started by Wiedling and co-workers at Studsvik. In Stockholm, a programme on the measurement of fission neutron spectra had been started and this could probably be extended. In addition, the measurement of the $Be^9(n,2n)$ cross-section in the threshold region had commenced. Some measurements of the neutron spectra in large spheres of Al, Fe and U^{238}, with neutron sources of 3 MeV and 14 MeV placed at the centres, had been made. The results had been compared with calculated values using a Monte Carlo programme and theoretically derived cross-sections. In general good agreement had been obtained. Taschek held the opinion that in these cases $\sigma_{nn}(\theta)$ would have a more important effect than σ_{nn}, but Goldstein considered this would only apply if some hydrogenous material was mixed in with the metal.

(v) EANDC(OR)25

Weinzierl said that work on fission fragment yields of U^{233} and U^{235} using a mass spectrometer had now been started in Austria. The yields from neutron induced fission are different in the two cases and it was hoped that the information obtained could be applied to the measurement of the amount of U^{233} and U^{235} in a highly irradiated fuel element.

(vi) EANDC(UK)28

Concerning Aldermaston work, Batchelor said that Maslin had now completed measurements on the thermal fission cross-section of U^{235} using foils of 0.5 mg/cm^2 and 0.1 mg/cm^2, each with the neutron counter placed at two angles with respect to the incident beam. A preliminary value of 583.1 $\pm$ 6.7 barn was quoted.[x] Batchelor also drew attention to the measurements on the fast fission cross-section of U^{235} where in the region between 100 keV and 500 keV, the values obtained were 7 per cent lower than the BNL 325 curve, and also to the measurements on Pu^{240} in the subthreshold region where agreement with Russian values (Nesterov V.G and Smirenkin G.N. 1962. J. Nuclear Energy 16, 51) had been obtained. Experiments on fast neutron scattering by U^{238} at Harwell and Aldermaston were referred to and Bretscher circulated graphical data obtained by Ferguson in the region threshold to 1.5 MeV. Good agreement with the data of A.B. Smith (ANL) had been obtained.

---

x The most recent value is quoted as 574 $\pm$ 6b.

Bretscher commented on the measurement of the p-wave strength function for U^{238} (see Appendix 8) and circulated graphical data on the level spacing distribution for Pu^{239} (see AERE-PR/NP 4).

(vii) EANDC(US)41

Goldstein drew attention to the large amount of fast neutron scattering data now being obtained at ANL e.g. elastic angular distributions had been measured for 30 elements with 20 keV resolution and at 50 keV intervals between 300 keV and 1.5 meV. Clearly these data could not all be published externally but Smith (ANL) is willing to send the data to anyone requiring it.

Concerning α-measurements, Taschek said that the data for U^{235} were now in quite good shape; good agreement has been reached in the overlap region between Linac and Van de Graaff measurements. ORNL and General Atomics were jointly planning measurements on U^{233} and Pu^{239}. The sample purification problems were being tackled at ORNL and the measurements would be made at G.A. where better equipment (both accelerator and scintillation tank) was available.

Havens said that a report of the Columbia development on recoil discrimination in a He^3 spectrometer would be sent for publication in Rev. Sci. Instr. He mentioned that resonances in TH^{232} and U^{238} had been located up to 4 keV from total cross-section measurements, but theory was inadequate to explain the statistics. Mehta and Melkonian have now shown that the kinetic energy of the fission fragments in the slow neutron fission of U^{235} varies from level to level. The effect they observed was approximately 13 per cent. Their experiment emphasized the high energy and of the fission spectrum, and the effect they observed could be explained by assuming that the kinetic energy of the fission process varies from level to level by less than 1 MeV. Havens expected this work to be written up in a Ph.D. thesis by the end of 1963 and promised to get it distributed to EANDC members.

(viii) EANDC(US)44

Goldstein reported that work on Pa^{233} at MTR was progressing but the results published so far were preliminary since Mn impurity in the sample had been troublesome. A second sample of 250 mg, free of Mn, had now been prepared and measurements at thermal and resonance energies had been made but a final result could not be quoted since the sample may have Sm impurities. The extent of these will be determined by re-measuring when the Pa^{233} has decayed. The indications were that the thermal value of σ_{nT} lay between 50 and 75b. In December 1963, a 1 g sample would be prepared and further measurements made.

Taschek said that Cranberg had obtained considerable success in comparing fast neutron scattering data for medium weight nuclei with the Perey Buck and Hauser Feshbach theories.

1(b) New Facilities

Bretscher commented that document EANDC(UK)25 only gave specifications and performance figures for the Harwell mass spectrometers and separators. Concerning Hermes he said that its running cost was £80,000 per year. A liner, which should reduce losses, was now installed and the separation programme would first be on Th^{230} and then on Americium. A decision would then be taken on whether to make very pure isotopes starting with a feed of highly enriched material.

According to custom Spaepen called for comments on new facilities within the various countries.

Spaepen — Geel expects to have a new Tandem mass spectrometer (Nuclide Analysis Associates) and a spectrometer (Atlas) specially designed for heavy water analyses.

Kofoed-Hansen — Risø will shortly modify the crystal spectrometer for solid state application.

Bretscher

A second hydrogen loop will soon be installed in DIDO and will be used to provide a better understanding of the thermalisation process. Glasgow University expects a 150 MeV electron LINAC giving a peak current of 1 Amp, which will be used mainly for photon work.

Kolstad

reported that the X10 reactor at ORNL had now been closed down. The isochronous cyclotron is now in operation and ORNL still hopes for a Linac. It is hoped that money will be appropriated for a double MP Tandem at Brookhaven and plans for supplying a direct feed line for He^6 to the cyclotron and possibly the tandem from the HFBR reactor, which is under construction, are being considered. The University of Texas is now equipped with a king size Tandem with a 5 MV Injector, ANL is asking for a new injector for its Tandem, thereby increasing the overall single charge energy to 18 MeV, and HVEC has announced a proposal for a 10 MV conventional Van de Graaff.

Kolstad said that computer facilities to be used in conjunction with accelerators were being increasingly employed.

Taschek

LASL Chemistry Division has ordered an isotope separator to be used mainly for short half life β -decay studies but will, in addition, be used for manufacture of thin targets. The Tandem accelerator has passed the acceptance tests; the terminal has been taken up to 9 MV and 1 μA Amp current has been obtained at 15 MeV. Three cavities were now in operation on the electron accelerator, and fully loaded the machine delivered 10 A at 22 MeV. It was expected that with further development, 100 A could be obtained.

Weinzierl — The rotating crystal spectrometer at Seibersdorf was now in operation and was being applied to lattice vibration studies. A Compton γ-spectrometer using a solid state detector had been developed giving a resolution of 1.5 per cent and an efficiency of about 10^{-8} in the MeV range. Weinzierl also mentioned that an order of magnitude improvement on the purity of a thermal neutron beam had been obtained by using a split reactor core [see EANDC(OR)26].

Hanna — Plans for the Chalk River MP Tandem were going ahead and the existing Tandem would eventually be transferred to a Canadian University as yet not specified. Tavendale had recently succeeded in getting a resolution of 8.3 keV on a γ-ray line of energy 5 MeV using a lithium drifted germanium detector.

At the invitation of the Committee Dr. Kanellopoulos, head of the Democritus Centre, gave a short talk on the work of the Centre. His remarks are included in Appendix 7.

1(c) Status of $\bar{\nu}$ Measurements

Batchelor opened the discussion and explained that in recent years $\bar{\nu}$ measurements had been made at LASL, ANL, Harwell, Aldermaston and Stockholm. Three of these laboratories (LASL, Harwell and Stockholm) had measured absolutely the prompt $\bar{\nu}$ value for Cf^{252} spontaneous and the values obtained, 3.780 ± 0.030, 3.76 ± 0.038 and 3.808 ± 0.034, were in good agreement. The $\bar{\nu}$ values for other isotopes were generally made relative to Cf^{252} spontaneous. The Harwell absolute measurements were made with the Boron pile (see EANDC-UK-30) and effort had been concentrated on obtaining precise thermal data. Although final values could not yet be quoted it was expected that the error would be between 1/2 per cent and 1 per cent.

LASL, ANL, Harwell and Aldermaston had measured $\bar{\nu}$ (E) for U^{235}, and in the region up to 4 Mev, where all laboratories had made contributions, the agreement between data was excellent. Aldermaston had covered the region up to 8 Mev and Batchelor considered that some measurements between 8 Mev and 14 Mev would be useful since there was some difficulty in fitting the measured 14 Mev point to the extrapolated low energy curve.

Measurements of $\bar{\nu}$ up to 4 MeV for several uranium and plutonium isotopes were now in progress at Aldermaston and the results on the U isotopes indicated that $\bar{\nu}$ was not very dependent on A for a given Z. More data on the Pu isotopes was required, however. Taschek said that LASL had measured U^{235}, U^{233} and Pu^{239}, and the U^{233} data could be made to fit the U^{235} curve if the energy axis was shifted by 456 keV.

Starfelt said that Condé (Stockholm) had recently worked on Th^{232}, U^{238} and U^{235}. His results for U^{238} also fell, within errors, on the U^{235} curve. A value of 2.442 $\pm$ 0.032 for $\bar{\nu}$ prompt U^{235} (thermal) relative to 3.799 for Cf^{252} was quoted.

It was generally agreed that the $\bar{\nu}$ problem was in good shape and for some isotopes the data available were nearly sufficient to meet reactor needs. In particular it was felt that the request for U^{235} had now been met.

1(d) U^{235} fission cross-section in the Resonnance region

Recent work by Bowman et al (EANDC-US-36) suggests that the generally accepted fission cross-section of U^{235} in the region 5 to 60 eV is about 20 per cent too large. Accordingly a sub-committee, consisting of Havens, Bretscher, Joly and Hanna was set up to consider this discrepancy and make recommendations.

On behalf of the sub-committee Havens said that it was considered that the data of Michaudon et al. (J. Phys. Radium. 21, 432, 1960) are the best to date and gave the following reason.

Some doubt is cast on the Bowman normalisation since the heights of the peaks are less than and the heights of the valleys are greater than observed in previous work. This is attributed to scattering from material in the region of the detector, but no corrections for scattered background have been applied.

The decision to accept Michaudon's data rather than Bowman's data was not clear cut, however, since in EANDC(Can 20) Hanna and Walker had concluded that if they had used the former to calculate the fission resonance integral and combined it with the total cross-section data of BNL 325 (2nd Edition), it would have led to a negative value of σ in the region of 100 eV, which is impossible. However, Uttley and Jones (EANDC-UK-28 page 12) give a value of α = 0.43, using the Michaudon data and recent total cross-section measurements obtained at Harwell. Consequently the results of Hanna and Walker are regarded as not pertinent. The total cross-section data published in BNL 325 must be used with caution. Since the resonances are not resolved, the measured cross-section depends on both the resolution and the thickness of the sample.

The sub-committee urged that the new data obtained by Uttley and Jones be published as soon as possible.

1(e) Specific Research Activities

(i) EANDC(US)44 - see Item 3(a).

(ii) EANDC(OR)21

Kofoed-Hansen said that this report described the measurement of the total cross-section of He^3 from 0.0003 eV to 10 eV and that measurements on the $He^3(n,p)T$ reaction are now in progress. He described the proportional counter used and emphasized the difficulties in gas handling, etc. when precision measurements are required. When asked if a measurement could be undertaken at about 100 keV, Kofoed-Hansen said that it was not possible at Risø since they didn't have a suitable source. Bretscher suggested that Kofoed-Hansen should consider the possibility of using the facilities of another laboratory.

Batchelor suggested that a measurement with the counter filled with a mixture of helium-3 and hydrogen would be very useful since it would permit a direct comparison between the $He^3(n,p)$ and the n,p scattering cross-section to be made and Kofoed-Hansen agreed to look into this possibility.

(iii) EANDC(OR)24

Weinzierl pointed out that this report should only be regarded as a draft since he had not yet received information on all the separators in use in Continental Europe. He hoped to have complete information soon.

(iv) EANDC(OR)27 and EANDC(UK)23. No comments.

2. CONSIDERATION OF DISCREPANCIES

(i) EANDC(UK)27

Story explained that the value of σ for Pu^{239}(thermal) previously reported by Cabell in AERE - R 4173 had now been corrected, taking into account Hanna's suggestions given in EANDC 28 page 17. The result of Cabell's measurements is now given as $\sigma(Pu^{239}) = 0.356 \pm 0.013$ for neutrons of 2200 m/sec. Hanna and Story agreed that measurements in a purer spectrum were still to be desired. Chalk River is presently using a spectrum with a cadmium ratio three times greater than that used by Cabell.

(ii) EANDC(E)46

Beckurts said that this report should be regarded as background information for the Doppler effect problem and that it was preliminary to the extent that the theory used in the overlapping resonance region is doubtful and the Wigner spacing distribution had been assumed. In the last part of the report the status of nuclear data in relation to Doppler effect calculations is discussed. It is concluded that the U^{238} s-wave strength function is now sufficiently well known but more accurate information is required on the U^{238} p-wave strength function and Γ_γ and the Pu^{239} s and p-wave strength functions and Γ_γ Present uncertainties in nuclear data lead to an overall uncertainty of about 40 per cent in the Doppler coefficient whereas a 10 - 20 per cent accuracy is required.

II.

Bretscher supplied comments by Rae on this document and these are reproduced in Appendix 8.

Havens said that experimental work on the Doppler effect was in progress at Atomic International. It had been found that the U^{235} temperature coefficient is negative, and this was in agreement with theoretical predictions although the Bowman data on σ_{nf} had been used in the calculations.

Taschek then introduced a topic which was concerned with discrepancies in the compilation field. He said that Miss Stewart of LASL had found considerable difficulty in evaluating data for the $Li^6(n, \alpha)$ cross-section due to inaccuracies which had been perpetuated in data compilation. Miss Stewart's comments to Taschek are reproduced in Appendix 9.

Other discrepancies which were brought to the attention of EANDC are those compiled by Rae and reproduced in Appendix 10. Nève also promised to pass information on discrepancies in the data on spins and g-values of the resonances in the samarium isotopes to Goldstein, [see Section 1(a)ii].

3. NEW AND AMENDED PRIORITY I REQUESTS

Spaepen first asked the delegations to make some comments on any changes in their new request lists. He said that Euratom had now discarded a few old requests, but some new measurements on threshold reactions were requested by the dosimetry group. Spaepen promised to circulate a document, which had been prepared by this group explaining the need for these new requests. Hanna pointed out that good relative measurements on these reactions were in progress at Chalk River and hence if a precise (2 per cent) measurement of $S^{32}(n,p)$, which is usually regarded as a standard, could be made, most of the requirements could be met. Spaepen said that some work on this reaction had been started at Geel but the energy range is very limited. It was suggested that the topic of threshold reactions receive thorough discussion at the next meeting.

Hanna said that changes in the Canadian request list were slight and mainly reflected the need for more data on resonance integrals. Story enquired if some measurements on resonance integrals could be undertaken in Sweden since a very careful study of the reactor spectrum had been made. Starfelt undertook to look into the matter.

Goldstein reported that the US priority I requests were now aimed mainly at the fissile materials. In the low energy region there was much more emphasis on the measurement of cross-sections as a function of energy rather than measurements at thermal energy. Resonance parameters were important and accuracies of about 5 per cent were required. The USA was now asking for information on the (n,p) cross-section both for natural Zr and the various isotopes. The presently assumed cross-section around 5 MeV is unnaturally high. Better values could very substantially improve the possibilities of light-water thermal breeders with Zr clodding.

Spaepen then took the committee through the items relating to fissile elements in the old combined request list (EANDC 25). Comments were made as follows:

Th^{232}	Γ_γ	Columbia data published in EANDC(US)41. French have resolved a doublet at 69.2 eV using cooled sample technique. Bretscher agreed to provide a summary of Harwell data for next meeting.
Pa^{233}	$\sigma_{nA}(E)$	Discussed under item 1(a). Bretscher asked if MTR could use a radio-chemist from another laboratory to help in the measurements and Goldstein promised to find out and inform him.
	$\sigma_{n\gamma}$	Weinzierl thought a thermal measurement could possibly be made by mass separation of an irradiated sample and detecting Pa^{234} by γ-spectrometry.

U^{233}	σ_{nf}	Hanna thought that the thermal value was now known to about 1 per cent.
	$\alpha(E)$	see Item 1(a).
U^{235}	$\sigma_{nn}(\theta)$	Story said that UK were now requesting 10 per cent measurements between 50 keV and 1.5 MeV. Agreed that the request is nearly satisfied by recent data of Smith (ANL) and low energy (about 100 keV) measurements presently in progress in Sweden. UK also called for the measurement of the fission spectrum for incident energies of up to 10 MeV but Story agreed that this needed clarification. Starfelt and Hanna had experiments under consideration.
	σ_{nf}	See Item 1(a) for Aldermaston data.
	$\bar{\nu}(E)$	Request probably satisfied /see Item 1(c)/. Some doubt about values in the resonance region.
	$\alpha(E)$	Hanna suggested that since ORNL and GA were jointly planning more refined α measurements, they ought to be persuaded to remeasure for U^{235}. Taschek promised to see if this isotope was on their programme.
	$\Gamma_n, \Gamma_f, \Gamma_\gamma$	The level spacing distribution obtained from the Saclay data does not follow the Wigner distribution. Approximately 20 per cent of the levels are missed up to 50 eV.
U^{238}	σ_{nn} $\sigma_{nn'}$	As a result of work carried out at ANL, Harwell and Aldermaston, data to an accuracy of about 5 per cent are now available up to 4 MeV.

	$\sigma_{n\gamma}$	Recent data obtained at Aldermaston between 120 keV and 8 MeV is in good general agreement with previous work and is accurate to about 5 per cent. Data below 100 keV available from Harwell.
	Γ_n and Γ_γ	Columbia work will be published soon.
Pu^{239}	σ_{nf}	See Item 1(a) for Euratom measurement. Hanna considered that confirmation of the result by an independent experiment would be desirable.
Pu^{240}	σ_{nf}	Recent Aldermaston data are just outside requested accuracy. Karlsruhe plan measurement using pulsed beam technique.
Pu^{241}	σ_{nf}	MTR has recently been allocated a 250 mg sample for measurements in the resonance region. LASL plans measurements in Mev region. Harwell data extend up to 3 keV.

4. TARGET AND FOIL PREPARATION

Report on a meeting concerning target and sample preparation

Spaepen said that at the meeting recently held in Belgium (see EANDC-E-48) it had become clear that ORNL, Harwell and BCMN operated on different lines with respect to foil and target manufacture. ORNL dealt with routine production and did not provide an assay service whereas BCMN avoided routine production and concentrated on the manufacture and accurate assay of special foils. As far as he could tell Harwell operated in between the two extremes. At the meeting, arrangements had been made to keep the three laboratories in contact and a tentative proposal had been made to exchange staff between ORNL and BCMN, perhaps at the end of 1964.

Spaepen explained that the Geel facilities were mainly being used to satisfy Euratom requirements but some work for other EANDC countries was in hand. The staff, now present, was overloaded with requests. Taschek considered that there would be an increasing demand for Pu foils and hoped that BCMN could undertake most of the work.

Batchelor enquired if BCMN could undertake the manufacture of thin (0.0001") uniform Ni foil suitable for use as gas target windows. The material presently available had variations in thickness of up to 20 per cent and this affected the energy resolution of some experiments. Spaepen agreed to investigate the matter.

5. STANDARDS

5(a) Heavy Water Standards

At the last meeting Spaepen had reported that Meier (Switzerland) was prepared to exchange very pure heavy water for less pure material. The purity of the Swiss material was now quoted as better than 99.99 per cent D_2O. Spaepen said that Meier had suggested that a nominal 200 litre quantity be exchanged and BCMN did not presently have the financial approval to buy this amount. Interest was still maintained however, and he hoped to take the matter up again at a later date.

Spaepen also said that an agreement had been reached between Savannah River and BCMN that, in future, intercalibration and distribution of heavy water standards will be undertaken by BCMN. Dr. Babeliowsky had been appointed as the man in charge. Spaepen asked that this be brought to the notice of Local Data Committees.

5(b) Report on the Symposium on Flux Measurements in the 1 - 100 keV range

Spaepen remarked that this Symposium arranged by Aldermaston and held in Oxford, had proved to be a successful and enjoyable venture and called on Batchelor to make comments.

Batchelor said, that although an immediate solution to the problem did not come up at the meeting, many of the difficulties would be overcome if action was taken on the recommendations made in the Symposium summary. Several proposals had come forward for measuring the cross-sections of standard reactions but the problems of detectors based on these cross-sections remained acute. Batchelor also mentioned an experiment to measure the fission cross-section of U^{235} with a well calibrated Sb-Be source and he proposed to negotiate with NBS (Washington), NPL (Teddington) and BCMN for collaboration in this. Taschek mentioned that such an experiment had been carried out many years ago but agreed, that with modern techniques, it could be done more precisely.

In order to follow up the recommendations made at Oxford and to see that action is taken, EANDC formed a watchdog sub-committee - to be called the Working Group on Flux Measurements in the Kev region - consisting of Batchelor, Spaepen, Havens, Beckurts and Starfelt. At Joly's request a list of standard reactions requiring urgent study is reproduced in Appendix 12.

EANDC agreed to Smets' proposal to make document EANDC-33 available to the next meeting of INDSWG.

5(c) <u>Intercalibration of fissile foils</u>

Batchelor said that document EANDC(UK)22 resulted from an action put on him at a previous meeting. It described the assay work carried out at Aldermaston on painted and vacuum evaporated foils varying in thickness from about 100 $\mu g/cm^2$ to 1 mg/cm^2. The work showed that alpha assay is reliable provided low geometry is used, and that great care has to be taken in fission counting calibrations. In the case of painted foils discrepancies had been observed which were not fully understood but were possibly due to non-uniformities in the foils. Taschek reported that LASL had observed a similar effect in the case of thinner foils made by electrodeposition.

Bretscher asked if Aldermaston had intercompared foils from other laboratories. Batchelor said that measurements were now in progress at Aldermaston on two sets of foils made by the electrospray technique at BCMN.

6. CONFERENCES

6(a) Conference on Data Handling

Beckurts said that Karlsruhe had been pleased to organise this conference, as suggested at the last EANDC meeting, and the dates 13th-17th July had now been fixed. Sessions on data acquisition systems, automatic data handling, data reduction, hardware and small versus large computers would be included in the programme. A panel of six consisting of two experts each on nuclear physics (Havens and Joly), electronics (Pearson and Wells) and computers (Millar and Linde) had been set up as an Organising Committee. Admission would be by invitation only and would be restricted to 150 people. Beckurts asked if ENEA could help in sponsoring the Conference but Smets was doubtful, both from the financial and organisational points of view. He would, however, seek ENEA's endorsement to it. Spaepen said that Euratom could probably supply organisational help if it was really needed.

Commenting on document EANDC(US)37, the Proceedings of the UMPA Conference, Havens said that the Conference had been extremely useful and he believed more development on programming on-line computers was now required. He was confident that by next July, there would be many interesting facts to report in connection with data handling.

6(b) Conference on Neutron Interactions

Bretscher said that, as a result of an action put on him at the last meeting, he had made some tentative proposals for a Conference on Neutron Interactions. He had envisaged one on the lines of the 1957 Columbia Conference and thought that it should be held sometime in 1965.

EANDC agreed that such a Conference is desirable and appointed a sub-committee, consisting of Kofoed-Hansen (Chairman Bretscher, Nève and Havens to organise it. Mol was considered as a suitable venue for the Conference.

7. TIME AND PLACE OF NEXT MEETING

The Committee accepted Beckurt's invitation to hold the next meeting in Karlsruhe from 20th - 24th July, 1964. This would follow the Conference on Low Energy Nuclear Physics in Paris, 2nd - 7th July and the Conference on Data Handling in Karlsruhe 13th - 17th July.

8. ADJOURNMENT

On behalf of the Committee, Spaepen thanked the Greek AEC for their hospitality and expressed appreciation for the work of Mr. A. Simopoulos, the Local Secretary, and Mr. S. Boukis.

A vote of thanks was passed for the retiring Chairman and for the Secretary for their work during the last two years.

APPENDIX 1

List of General Documents

No	Classification	Title	Author
EANDC 28	A	Complete Minutes of fifth meeting of Committee.	Batchelor R
EANDC 29	U	Distribution of Committee documents.	
EANDC 30	A	List of members.	
EANDC 31	A	Cumulative list of EANDC documents.	
EANDC 32	Special Distribution	Minutes of second meeting of EANDC Compilation Study Group held in Brussels on 9-13 September, 1963.	James M.F.
EANDC 33	U	Symposium on the absolute determination of Neutron Flux in the Energy Range 1 - 100 keV.	
EANDC 34	A	Sample Requests	Spaepen J.

APPENDIX 2

List of Canadian Documents

No	Classification	Title	Author
EANDC(Can)17	L	Progress Report	Hanna G.C.
EANDC(Can)18	L	Request List	Hanna G.C.
EANDC(Can)19	L	Fission Resonance Integrals of U^{233}, U^{235}, Pu^{239} and Pu^{241}.	Bigham C.B.
EANDC(Can)20	L	The capture and fission Resonance Integrals of U^{235}.	Hanna G.C. and Walker W.H.

APPENDIX 3

List of Euratom Documents

No	Classification	Title	Author
EANDC(E)45	L	Reactivity Effects due to Variations in Nuclear Parameters in a Thermal Power Reactor.	Cesini G. Pailton M.
EANDC(E)46	L	Influence of nuclear data uncertainties on the theoretical prediction of Doppler coefficients in fast and intermediate reactors.	Schmidt J.J.
EANDC(E)47	L	Compilation of Requests for Nuclear Cross-section measurements from Euratom countries.	Spaepen J.
EANDC(E)48	A	Minutes of a meeting on isotope supply and sample preparation.	Spaepen J.
EANDC(E)49	L	Euratom Progress Report.	Spaepen J.

APPENDIX 4

List of Documents from other O.E.C.D. countries

No	Classification	Title	Author
EANDC(OR)20	U	Inherent Uncertainties in calculated uranium resonance integrals.	Vernon R.
EANDC(OR)21	U	Slow neutron cross-sections for He^3, B and Au.	Als-Nielsen J. Dietrich O.
EANDC(OR)22	U	Progress Report from Danish AEC Research Establishment Risø for Period until September 1963.	Kofoed-Hansen O.
EANDC(OR)23	L	Progress Report from Sweden.	
EANDC(OR)24	L	The use of electromagnetic mass separation for cross-section measurements in Continental Europe.	Weinzierl P. Viehbork F.P.
EANDC(OR)25	L	Progress in Nuclear data activities in Austria since Autumn 1962.	Weinzierl P.
EANDC(OR)26		Investigations on the Effect of a Split Reactor-Core on the Purity of Thermal Neutron Beams.	Tisljar M. Woloch F.
EANDC(OR)27	A	Messung der F^{18} Aktiveirung im Kern eines Wassergekuhlten Reaktors.	Von Balcarezyk Kim K.H. Lanzel E.
EANDC(OR)28	A	Progress Report to EANDC from Norway.	

APPENDIX 5

List of UK documents

No	Classification	Title	Author
EANDC(UK)22	L	Intercomparison of foils of fissile nuclides	White P.H. Perkin L.
EANDC(UK)23	U	Resonance parameters of U^{238}.	Firk F.W. Lynn E. Moxon M.C.
EANDC(UK)24	L	Mass spectrometer and isotope separator facilities at AWRE.	Daly N.R.
EANDC(UK)25	L	Mass spectrometer and isotope separator facilities at AERE.	McIlroy R.W.
EANDC(UK)26		Review of evaluation of neutron cross-sections available at September 1963.	Parker K.
EANDC(UK)27	U	The ratio of thermal neutron capture to fission for Pu^{239}.	Cabell M.J. Slee L.J.
EANDC(UK)28	U	Progress reports	Evans J.E.
EANDC(UK)29	A	Proposed international punched card/magnetic tapes format for evaluated nuclear cross-section data.	Parker K.
EANDC(UK)30	U	The accurate measurements of $\bar{\nu}$ by the boron pile	Colvin D.W. Sowerby M.G.
EANDC(UK)31	A	Provision of Separated Isotopes for Nuclear Data Measurements of interest for reactor calculations.	Bretscher E.

APPENDIX 6

List of US Documents

No	Classification	Title	Author
EANDC(US)36	U	The fission cross-section of U^{235}.	Bowman C.D. Auchampaugh G.F. Fultz S.C.
EANDC(US)37	U	Proceedings of the Conference of Utilisation of multi-parameter Analysers.	
EANDC(US)38	U	Report to the NCSAG - Rice University 2/25/63.	Stehn J.R.
EANDC(US)39	U	Angular Distributions in Neutron Induced Reactions (Two Volumes - BNL 400)	Goldberg M.D. May V.M. Stehn J.R.
EANDC(US)40	L	Stable isotope Cross-Section Research Pool Inventory - 1st July, 1963.	
EANDC(US)41	U	Reports to the NCSAG (WASH-1044)	Smith A.
EANDC(US)42	U	Request Compilation	Smith A.
EANDC(US)43	A	ORNL Plutonium Inventory as of 6/30/63.	
EANDC(US)44	L	Status of Measurements of the Total Cross-section of Pa-233.	Burgess W.H. Simpson F.B.
EANDC(US)45	U	Off Site Nuclear Cross-sections Measurement Programme.	
EANDC(US)46	U	U.S. Facilities for making low energy neutron cross-section measurements.	Harvey J.A. Rogosa G.L.

No.	Classification	Title	Author
EANDC(US)47	A	Informal Notes on use of On-Line Computers in Physics research in USA	
EANDC(US)48	A	Neutron cross-section Measurements for Nuclear Structure and Nuclear Energy.	Havens W.W. Kofoed-Hansen O
EANDC(US)49	A	Fast Neutron Cross-section requirements for Nuclear Energy applications.	Goldstein H.

APPENDIX 7

INFORMATION ON THE GREEK ATOMIC ENERGY CENTRE "DEMOCRITUS"

by T. Kanellopoulos

Atomic Energy was considered first in Greece in 1954 when an AEC Committee was set up. It was not until 1958 that the construction of the Reactor building was started. Meanwhile young scientists were sent abroad on ICA fellowships for training in nuclear science, in order to form the first nucleus of the scientific staff for the Nuclear Centre that was decided to be established. In 1961 the Reactor became critical and since then the Establishment has increased in size and at quite a fast rate.

It was soon realised that the training which was given to the scientists on short-term fellowships (up to 12 months) was inadequate for a research Centre of international level. Therefore, serious efforts were made to attract scientists from abroad and to establish long term scholarships. Since 1961, after the reactor had gone critical, these efforts started giving results. The following numbers show the results:

Up to 1960 there were only three scientists of the Ph.D. level in the Centre. In 1961, four more came. This number was increased to 10 in 1962, while in 1963, 22 more scientists of Ph.D. level were added to the staff. For 1964 we estimate that another 30 scientists from abroad will be joining the scientific staff of DEMOCRITUS.

The total scientific staff is at present 105, out of which 40 are of the Ph.D. level while 15 are abroad completing their studies towards Ph.D.

The first budget which was allocated by the Greek Government, to the G.A.E.C. in 1955 amounted only to $1000. From 1956 onwards the budget was increased as follows (approximately):

1956	$ 83,000
1957	$ 240,000
1958	$ 560,000
1959	$ 860,000
1960	$ 1060,000
1961	$ 1400,000
1962	$ 3000,000
1963	$ 2700,000

DEMOCRITUS is the only Nuclear Centre in Greece, and it consists of the following Divisions:

Reactor Division, Physics, Chemistry, Radiation Technology, Biology, Electronics, Health Physics, Geology and Library, as well as Post Graduate School of Physics and Philosophy of Science.

In the Reactor division there is a 1 MW swimming pool reactor (AMF manufacture) and a sub-critical assembly. Work is going on in the following fields:

Dosimetry, reactor kinetics, studies of the reactor basic parameters on the sub-critical assembly, and delayed neutron studies.

Physics: This division includes theoretical physics, low energy nuclear physics, solid state physics, and neutron physics, as well as high energy physics. There is a Van de Graaff (400 KeV), an X-ray apparatus, a fast chopper, two crystal monochromators and a liquid nitrogen loop will shortly be installed.

Chemistry Division: This includes five groups in nuclear and radio chemistry, radio chemical and nuclear analysis, radio isotope production, radiation chemistry and radio isotope applications.

Radiation Technology: The Radiation Technology Division deals with the application of radiation and isotopes in inorganic, organic, physical, analytical and food chemistry.

Biology: This is the largest division ranging from medical science to agriculture. At present there have been developed laboratories in biochemistry, soil science, entomology, microbiology, plant biology, and plant improvement and breeding.

Electronics Division: They undertake the maintenance of the instruments, development and construction of instruments and work on semi-conductors, servomechanisms, analogue computers and fast electronics.

Centre for higher Physics and Philosophy of Science: It includes 4-year graduate studies leading to Ph.D.

APPENDIX 8

Comments on EANDC(E)-46 "L"

by J. J. Schmidt (Karlsruhe)

This paper is basically concerned with the Doppler effect in fast reactors but contains a review of the nuclear data presently available on U^{238} and Pu^{239}. The review is comprehensive and thoughtful, and the conclusions reached are basically similar to those reached by Story and Codd at Winfrith in a series of papers to the Uranium/Plutonium Working Party over the past year or two.

A large fraction of the data used by Schmidt originated in Harwell, and due to a lack of close liaison between Harwell and Karlsruhe, two of the parameters quoted by Schmidt were erroneous. These were the following:

(1) S_1 for U^{238} Schmidt quotes the value of $(1.0 \pm 0.2) \times 10^{-4}$ given by Uttley and Jones at the Saclay conference, and due largely to this result, he recommends a value of S_1 of 1.0×10^{-4} $\pm$ 200 per cent, the large positive error being due to the result published by Lynn of $(2.5 \pm 0.4) \times 10^{-4}$ and the theoretical work of Kreuger and Margolis which suggests 3.0×10^{-4}.

Uttley's measurement of average transmission presented at Saclay was good, but his interpretation of it was based on mean values of the s-wave parameters and did not take into account the Porter-Thomas distribution of the neutron widths. Lynn's analysis did take this into account, and this explains the remarkable discrepancy. Later, a thin sample measurement by Uttley, where the effect of the distribution of neutron widths is minimised, also yielded a value of 2.5×10^{-4}, and he is presently collaborating with Lynn in doing a proper analysis of his thick sample data which he is confident will also yield a value $\sim 2.5 \times 10^{-4}$. It would seem therefore that there is really no discrepancy here, either between the experimenters, or between experiment and theory at least as regards the Harwell work.

(2) $\bar{D}$ for Pu^{239} The value of 1.8 for $\bar{D}$ quoted from Egelstaff's work is erroneous, since this is due to interpreting the multilevel cross section in terms of single levels which inevitably introduces spurious extra resonances. Story's estimate of the level spacing from Egelstaff's data is $\bar{D} = 2.2 \pm 0.4$ eV which is not seriously different from Bollinger's measurement of 2.9 ± 0.6 eV. Uttley's estimate, based on resolving 100 levels (Egelstaff and Bollinger resolved $\sim$ 20) is 2.6 ± 0.3 eV which lies within the limits of error of both previous measurements.

E.R. Rae

APPENDIX 9

Los Alamos Scientific Laboratory,
University of California,
Los Alamos, New Mexico.

To: R.F. Taschek, P DO

From: Lee Stewart

Subject: EANDC(E)18 "U"

Symbol: P-10

The above report entitled "A Survey of Neutron Cross Section Values for $Li^6(n,\alpha)T$ Reaction" was written in April (1961). Since some of the cross sections have been reproduced many times though found to be incorrect many years ago, the following comments may be of interest in clearing up a few discrepancies.

1. The Rice data below 100 keV, (labelled Rice 16 in BNL 325, Supplement to Second Edition), are not the data as published in The Physical Review, although BNL gives Phys. Rev. as the reference.

2. All of Ribe's data (LA ac 30) should be corrected as pointed out by Schmitt and Macklin in 1959, although the latter seem to be reproduced correctly in the same BNL report. Corrected table enclosed.

3. ANL-ac 1 is listed as unpublished, without reference to the type of cross section. The same symbol in BNL is used for σ_t and $\sigma_{n,\alpha}$. $\sigma_{n,\alpha}$ originated from the work of Blair and Holland after revaluation in 1955 by Joe Devaney, LASL. Through the years, however, users have lost sight of the fact that Blair and Holland quoted extremely large errors on their data and emphasized two facts.

(a) The results of measurements on normal lithium and Li^6 gave

$$\frac{[\sigma_{n,\alpha}\ (Li)]}{\sigma_{n,}\ (Li^6) \times 7.4\%} = 1.82 \pm 0.09$$

(b) Early counting rate ratios (reference to "25") could not be reproduced in later measurements, nor could the differences be resolved at that time.

4. NWU-2: Measurements of triton angular distributions were integrated and then normalised to Ribe's data or to the Blair and Holland results. Since both of the experiments were later found to be wrong, NWU-2 is therefore incorrect. Note that NWU-2 data are given in BNL-400 with the comment, "Renormalised to total (n,t) σ of BNL-325, Second Edition". The renormalised data, however, appear as σ (n,t) total on the latest BNL tape listing as ANL experimental measurements, renormalised:

5. The Russian data Soviet Phys. --Doklady 1, 705 (1956) are usually high and the peak appears at a higher energy. The authors quote large errors which would give overlapping error flags. Bame found reasonable agreement with an arbitrary decrease in the energy scale and the cross section values.

6. Evidently the real differences which presently exist are evident in the comparison of the Rice and Oak Ridge data above 1 MeV.

Li^6(n, σ) Correction of Ribe Phys. Rev. 103, 741 (1956)

E_n	σ (mb) Uncorrected	σ (mb) Corrected for long counter response
0.88 ± 0.01	262 ± 28	323 ± 35
1.40 ± 0.01	229 ± 24	284 ± 30
1.86 ± 0.01	215 ± 23	259 ± 27
2.39 ± 0.01	189 ± 22	218 ± 26
2.90 ± 0.01	148 ± 18	158 ± 20
4.44 ± 0.12	97 ± 14	97 ± 14
5.53 ± 0.07	72 ± 13	70 ± 13
6.52 ± 0.04	59 ± 10	55 ± 10
2.50 ± 0.03	188 ± 27	188 ± 27
2.50 ± 0.03	192 ± 27	219 ± 30
14.1 ± 0.08	26 ± 4	26 ± 4
	(Plotted BNL 325, Suppl 1)	(BNL Corrected 6-1963)

APPENDIX 10

NOTE ON DISCREPANCIES

(1) Discrepancies. Recent intensive studies have brought to light a number of important discrepancies.

(a) $\langle \Gamma_\gamma \rangle$ for Th^{232} All the Harwell work taken together (T, σ_c, σ_s,) suggests a value of $\sim$ 20 mev as against $\sim$ 35 mev in the barn book. More recent work at Columbia confirms the lower value, but work by Haddad and Palevsky (reported by Haddad during his visit last week) at G.A. (on σ_c and σ_T by self-indication) is yielding a value $\sim$ 30 meV. See also note (d) below. Bollinger is working on this problem but will not admit any numbers.

(b) σ_f for U^{235} As you know, Brook's work, like that of Sukhoruchkin's group at Moscow, confirms the Sailor curve up to 4 eV and is distinctly different from that recently proposed by Livermore. (URCL 7061). Further work on comparison of resonance areas at higher energies is now in progress following Fultz' visit last week.

(c) α (E) for U^{235} The measurements of Weston and de Saussure using the RPI Linac confirm Brooks' η (E) measurements up to $\sim$ 25 eV, but deviate systematically above that energy leading to nearly a factor of 2 discrepancy at $\sim$ 50 eV. Brooks' computer programmes are now working and we should soon see whether the two sets of data converge again at higher energies. The ORNL data at 50 eV seem more plausible as their mean value of α is similar to that at 20 eV, but against this, Brooks' values are closer to those predicted from the individual cross section measurements. They are also based on many runs, and are consistent with the original trial measurement which he and I carried out on the 15 MeV Linac where a different neutron spectrum and different detector were used. The ORNL result is based on a single run.

(d) Au(n, γ) The gold discrepancies are too well known to need restating but Haddad has remeasured it at G.A. using the B^{10}(n, α) reaction to obtain the shape of his spectrum, and taking his measurement down to thermal. The result is an extremely good agreement with the thermal data at one end, and with Moxon's results (based on B^{10}(n, $\alpha\gamma$) at the other. This would seem to rule out variations in (σ_1 / σ_0) for B^{10}, previously thought to be a possible systematic source of error in the Harwell and ORNL data which both used the B^{10}(n, $\alpha\gamma$) reaction to obtain their spectral shape. It should be pointed out here that in our opinion Haddad's thorium data are suspect because of the intense radioactivity from his thick (calibration) sample which enforced the use of a 4 MeV bias on the tank (the binding energy of a neutron in Th^{233} is only 5 MeV). In the case of gold, however there was no such difficulty and the bias was set at $\sim$ 2 MeV. (as compared with a binding energy $>$ 6 MeV).

(e) $B^{10}(n, \alpha)$ and $B^{10}(n, \alpha\gamma)$ The discrepancy here occurs at above $\sim$ 70 keV where Bonner's results suggest a deviation from the $1/v$ cross section which increases to $\sim$ 25 per cent by 300 keV. Newson's measurements however indicate strict agreement with the $1/v$ law over this region. Bergman and Shapiro's measurements also suggest that the (n, α) cross section falls below the the $1/v$ shape, indicating a constant term (-0.4b) in the (n, α) cross section.

E. R. Rae.
24th September, 1963.

APPENDIX 11

List of cross-sections required to flux measurements in the 1 keV - 100 keV range

$H(n,n)$

$B^{10}(n, \alpha)$

$B^{10}(n, \alpha_o)/B^{10}(n, \alpha)$

$B^{10}(n,n)$

$B^{10}(n,p)$

$B^{10}(n,t)$

$Li^6(n, \alpha)$

$Li^6(n,n)$

$He^3(n,p)$

$U^{235}(n,f)$

$Au^{197}(n, \gamma)$