EUROPEAN-AMERICAN NUCLEAR DATA COMMITTEE

TECHNICAL MINUTES OF THE THIRTEENTH MEETING OF THE COMMITTEE

Bournemouth, England, 6th-10th October, 1969

Compiled by

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(Executive Secretary)

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PREFACE TO THE TECHNICAL MINUTES

EANDC 83 "U"

This version of the minutes of the eleventh meeting of the European-American Nuclear Data Committee is produced for general distribution to those concerned with measurements 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 The conclusions are, however, of an interim nature in many cases, and the document is therefore marked "Not for Publication" and should neither be quoted in publications nor listed by abstract journals.
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App. 2: Report of the EANDC Sub-committee on Standards for Neutron Measurements
1. PROGRESS ON IMPORTANT NUCLEAR DATA

Discussion of the latest results and current work related to some of the most important data for reactors yielded the following conclusions:

Pu 239: A general consensus is in view on the high capture to fission ratio (i.e. alpha) for Pu 239 in the 1 - 30 keV neutron energy range. This is based both on recent integral measurements and on additional differential measurements: what remains to be done seems mainly to consist of reaching an agreement on normalization. Regarding the absolute D value (i.e. average number of secondary neutrons per fission) in the neutron resonance energy region, no progress was mentioned. However, new accurate measurements of D in the energy range 40 keV - 1.5 MeV have been made in France and in the U.K.

Fast Neutron Fission: In the neutron energy range from about 50 keV to 1.5 MeV, a number of recent results are now in fair agreement as regards the relative values (namely, the ratio of the fission cross sections of U 233, U 235 and Pu 239, and also the ratio of U 238 capture to U 235 and Pu 239 fission), but the accuracy of the absolute values of each of these data is still unsatisfactory. Several independent measurements on these are under way or planned for the near future.

Fast Neutron Total Cross Sections: A large number of high resolution total cross section results on important elements (such as C, Fe, Na, Al, Mo, V, Cr etc...) have been obtained at Karlsruhe (in the 0.5 to 32 MeV neutron energy range) and at several laboratories in the U.S. (in the 0.15 to 1.5 MeV range). There is good agreement on the very important data for Fe.

Fission Neutron Spectrum: Disagreement on the exact shape of the energy spectrum of the prompt fission neutrons (from U 235 and Pu 239 fission) has recently arisen between various experimenters, and consequently, a critical review of this point will be prepared for the next EANDC meeting.
**U 238 Inelastic Neutron Cross Section:** A new measurement has been performed at Argonne, and these results have been used for a re-evaluation of the U 238 data.

**Standards:** The work in this field is slow because of the very large effort needed to reach the desired accuracy of 1% or less. Good progress was reported, among others, on the B 10 (n, α) cross section at low and intermediate neutron energy, on the absolute value of the Li 6 (n, α) cross section at thermal energy, and on the U 234 half-life (this last data is needed for evaluating the absolute fission cross section of U 235). An international comparison of U 235 fission foils is under way with a view improving the assay of their uranium content.

2. **DATA REQUESTS, INDEXING, COMPILING AND EVALUATION**

The Request List for Nuclear Data was not discussed, as this had been done extensively nine months earlier at the previous EANDC meeting, and an extensively revised list is in preparation. Instead, the way of reviewing the new list before and during the next meeting was discussed, and what is believed to be an improved procedure was agreed and will be applied.

The Committee was informed by the IAEA observer that a data request list from non-EANDC countries had been compiled by the IAEA and would be edited early in 1970.

The Committee discussed with the IAEA observer the gradual take-over by IAEA of the responsibility for publication of CINDA (i.e. the compilation of all references pertaining to nuclear data of interest for reactors), which had previously been shared by the Brookhaven and Saclay Nuclear Data Centres. The various steps of this take-over, and some general guidelines for the future of CINDA, were agreed upon.

The importance of evaluation was noted several times during the meeting: reports on the evaluation of some important data were presented and discussed, the need of a meeting of the Joint EANDC-EACRP Sub-committee on Evaluation around mid 1970 was stressed, and at the end of the meeting a half-day topical discussion was devoted to evaluation.
MINUTES OF THE THIRTEENTH MEETING OF EANDC
held at
Carlton Hotel, East Cliff, Bournemouth, England
6th - 10th October 1969

List of participants:

EANDC MEMBERS:
P. WEINZIERL, Seibersdorf, Austria (Chairman)
R. BATCHelor, AWRE, Aldermaston, U.K.
K.H. BECKURTS, Karlsruhe, Germany
H. CONDE, Stockholm, Sweden
G.C. HANNA, Chalk River, Canada
W.W. HAVENS, Jr., Columbia University, U.S.A.
R. JOLY, CEA, Saclay, France
T. MOMOTA, JAERI, Japan
M.S. MOORE, Los Alamos, U.S.A.
M. NEVE de MEVERGNIES, Mol, Belgium (Executive Secretary
E.R. RAE, AERE, Harwell, U.K.
J. ROSEN, ENEA, Paris, France
A. SMITH, Argonne, U.S.A.
J. SPAEPEN, Euratom, Geel, Belgium
J. STORY, AEE, Winfrith, U.K.

OBSERVERS:
Madame SOLANES, ENEA, Paris, France
W.T. POTTER, ENEA, Paris, France
W. GOOD, IAEA, Vienna, Austria
J.J. SCHMIDT, Karlsruhe, Germany
The Chairman opened the meeting at 10 o'clock in the Purbeck Suite of the Carlton Hotel.

He first welcomed the new members, namely Dr. M. Moore from Los Alamos, Mr. J. ROSEN as well as Madame SOLANES and Mr. W. POTTER from the ENEA in Paris who were attending as observers. He then paid a tribute to Dr. R. PERRET, former member of the EANDC who died in Paris on 14th May 1969. He stressed Dr. Perret's very valuable contribution to the present efficient operation of the Committee, especially as regards the administrative and political implications of the Committee's activities. He also pointed out his contribution to the general field of nuclear data, having had a large responsibility in the foundation and subsequent operation of the CCFN, and in the editing of the EANDC-Requests List (RENDA-document). Both were now extremely useful tools for a large number of scientists. Last but not least, Dr. Perret's skill and sense of humour during the Committee's meetings had always been very much appreciated.

1. INTRODUCTORY ITEMS
(a) Consideration of the minutes of the twelfth meeting

The minutes (EANDC-81 "A") were accepted as published except for two changes: on page 26, the reference pertaining to request numbers 10.41 and 10.42: the reference to EANDC(CAN)-39 should read EANDC(CAN)-38. On page 16, line 11, change to, "It is intended to build an Isochronous Cyclotron at the Research Institute of Physics etc..."
2. REPORTS ON FACILITIES AND RECENT MEASUREMENTS

(a) Changes in Nuclear Data Facilities

The following recent changes or progress were mentioned.

Germany: The length of neutron flight tube at the Karlsruhe Isochronous cyclotron has been increased up to 180 m; the resolution is 6 ns/km and preliminary data collection is underway. The Franco-German High Flux Reactor at Grenoble is proceeding very well and should be completed by July 1, 1971. A Heavy Ion Accelerator will be built at Darmstadt, in a new research centre. It will be a linear accelerator of the UNILAC type developed by Schmelzer at Heidelberg. It should reach 8 MeV/nucleon and be capable of accelerating all elements up to \( Z = 92 \). Several versions of accelerator structures are under consideration.

U.S.

Argonne National Laboratory

Reactor Physics Division

The Fast Neutron Generator (Tandem Dynamitron) is being shipped to the ANL site and the components are being installed as they arrive. Specifications are for both tandem (8 MV) and single ended (4 MV) modes of operation. Pulsed and DC capability is available in both modes. In DC mode factory tests, proton currents of \( \sim 200 \) microamps have been observed. Various large experimental facilities associated with the programme at the new facility are under construction and installation; for example, time-of-flight collimators with flight paths to 7 meters at angles of \(+160^\circ\) to \(-140^\circ\). Hopefully, Christmas 1969 will see full research operation.

Physics Division

The Argonne 4 MV Dynamitron is now in operation. To date, protons and deuterons have been accelerated and helium ions will be used in the immediate future. Until experience has been obtained in handling large currents of energetic ions, most experiments will be designed to use currents of less than a few hundred microamperes.

The energy resolution of the ion beam is at least as good as that of the old 4 MV Van de Graaff. The beam quality and positional stability is exceptionally good. At beam currents of less than 100 \( \mu \)A a beam spot less than 3 mm is obtained both near to and at a considerable distance from the accelerator.
A new data room has been added to the facility. An on-line computer is now operating. Provisions have been made for up to thirteen beam lines. A pulsed ion source including Klystron bunching has been purchased and will be installed during the autumn.

Brookhaven National Laboratory
Tandem Van de Graaff Project

The assembly of the accelerators started early 1969. This effort has gone quite well to date.

MP-7 has now met or exceeded all of the performance specifications that any previous MP accelerator has ever had to meet. There is still one remaining test to complete which has to do with a special requirement for the Brookhaven machines and involves the ion source characteristics rather than the accelerator. The completed tests represent 95% of the performance capabilities of the machine and show that the Van de Graaff accelerator performs quite well.

MP-6 is now completely assembled and the test programme has been started.

Duke University
Injector Cyclotron

A second set of slits has been installed in the cyclotron vacuum chamber to decrease the R.F. phase acceptance for particles accelerated to full radius. As a result the cyclotron may be tuned for 30 keV energy spreads routinely, and energy spreads in the extracted beam of the order of 20 keV may be obtained with minimum beam. An additional advantage of the two slit combination has been an improvement in tuning reproducibility due to the additional constraint upon orbit pattern.

Measurements of output pulse time characteristics have been made using commercially available equipment and have proven to be of great value in achieving optimum tuning conditions. Installation of a separate cyclotron target area presently under way will facilitate future cyclotron development work.

Major projects for the near future include continuing improvement of the reliability of individual cyclotron components, development of an external feedback system to improve the transverse stability of the extracted beam, and investigation of improved dee voltage control with various feedback possibilities. Work is presently under way in all of these areas. An improvement in resolution by the Corona control system should be observed after sending the cyclotron beam through the tandem. This effect has been found in a preliminary measurement, but the effect is small.
The Livermore Electron Accelerator Facility

The new electron accelerator being installed at the Lawrence Radiation Laboratory, Livermore, consists initially of five S-band sections with room and provision to expand to seven sections. The first five sections are powered by R.F. modulators constructed by the Applied Radiation Company, and the last two will be modified forms of the SLAC design. The accelerator installation has been completed and the accelerator sections are being tested under R.F. power. The first beam was expected on October 1, 1969.

The accelerator will be operated in a choice of three modes. These are as follows:

(a) The Steady State Mode: Pulse lengths ranging from 5 nsec to 3 μsec are available, with a duty cycle of 10⁻³. The energy for five sections is to be continuously variable from 10 to 80 MeV at a full peak load current of 700 mA.

(b) The Transient Mode: For this mode the accelerator will be loaded with currents from 10 to 15 A. The pulse width will be approximately 5 nsec or less, with a pulse repetition rate as high as 1800 pps. Maximum power with 5 sections is 55 kW.

(c) Positron Accelerator: The positrons are to be created at the end of the third section (at approximately 60 MeV) and accelerated in the fourth, fifth, and subsequent sections. Initially positrons of energy ranging from 10 to 80 MeV, will be available. With future expansion the energy will reach 170 MeV. By placing a converter at the end of the first section the positron energy will be extended to 250 MeV, with considerable loss of intensity. The peak current will be approximately 1 mA with an average current of 1 μA.

Further characteristics of the five-section accelerator are given in Table A1 below.

<table>
<thead>
<tr>
<th>Energy (MeV)</th>
<th>Peak Current (Amp.)</th>
<th>Max. Pulse Width (μSec.)</th>
<th>Max. Pulse Rep. Rate (pps.)</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-80</td>
<td>0.700</td>
<td>0.10</td>
<td>660</td>
<td>Steady State</td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td>1.0</td>
<td>420</td>
<td>&quot;</td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td>3.0</td>
<td>300</td>
<td>&quot;</td>
</tr>
<tr>
<td>10-140</td>
<td>10.0-15.0</td>
<td>0.005</td>
<td>1800</td>
<td>Transient</td>
</tr>
<tr>
<td>10-100</td>
<td>0.100</td>
<td>0.10</td>
<td>1800</td>
<td>Peak R.F. Power</td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td>1.00</td>
<td>840</td>
<td>reduced to half</td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td>3.00</td>
<td>600</td>
<td>&quot;</td>
</tr>
<tr>
<td>10-80</td>
<td>0.001</td>
<td>3.0</td>
<td>300</td>
<td>Positron mode</td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>Full R.F. average power</td>
</tr>
</tbody>
</table>

TABLE A1
**Beam Transport System**

This will consist initially of six beam lines expandable to a maximum of nine. The six beam lines will be realized through the use of 14 bending magnets, eight quadrupole pairs and about five singlet lenses. A power slit will be located after the first 22.5° bend, which will make available momentum spread for photonuclear experiments as small as 0.05%. Two large experimental caves have been constructed to the north and south of a magnet room. High electron beam currents will not be permitted in these caves, in order to avoid activation of the walls and beam transport equipment.

Two of the beam lines are required to pass a momentum spread of + 15%. These lines go to neutron producing targets and must have a high transmission for electron beams with a high momentum spread. Because of aberrations, second order corrections to the quadrupole fields must be calculated to retain the achromatic features and small focal spots at the targets.

**Target Cooling**

All high power targets will be cooled by a closed loop system containing a heat exchanger, ion exchange column and hydrogen recombiner. It will be possible to switch these units from one target to another without the necessity of their being duplicated.

**Time-of-flight Facilities**

The accelerator may be used as a pulsed neutron source both below ground and above ground. Below ground there are six neutron drift tubes with maximum lengths of 20 m, and a minimum length of 4 m. There will be two target positions below ground for the production of neutrons. The neutron yield will be approximately $10^{14}$ neutrons/sec. Above ground the flight tubes will have lengths of 15 m, 66 m and 240 m. About half of the accelerator time will be devoted to neutron time-of-flight experiments.

**University of Maryland Cyclotron**

Work on the Cyclotron Project during the first half of 1969 has been primarily associated with the completion of the extraction system, the installation of the beam handling system, and beam development and extraction studies. The first extracted beam of 60 MeV alpha particles was achieved on August 14, 1969. Considerable improvements have also been made in the stability of the RF system and various magnet power supplies.
Power supplies for the steering coils and solenoids are being designed and fabricated at MIT. Construction is presently under way. All of the Varian water loads, rf windows and terminal loads have been delivered. The rectangular wave guides have been completed.

The major hardware components have been designed. Among those thus far procured are the bending magnets, quadrupole magnets, power supplies, vacuum pumps, cooling system components, instrumentation and special vacuum chambers.

Preliminary tests on the injector gun and filament have been completed satisfactorily. Design and fabrication of the remainder of the components is proceeding slightly behind schedule. The injector test facility at MIT is complete and some of the support components have been installed.

On August 25, 1969, the electron linear accelerator was accepted by ORNL and experiments were officially started. The accelerator has met or exceeded all its performance specifications (except that the peak current at 2.5 nsec was 13.2 A) which were:

- 140 MeV average energy
- 15 amperes peak current 2.3 to 24 nseconds
- 2.3 to 4000 nanosecond pulse
- 50 joules/pulse
- 1000 pps
- 50 kilowatts
- $<10$ microamp dark current during rf burst

The reliability runs were modified in order not to further delay the use of the accelerator for neutron cross section measurements. The accelerator was operated for the first week at a reduced repetition rate since the first experiments could not tolerate a high repetition rate. During the first week the accelerator operated 44.3 hours out of a scheduled 45 hours and produces 17.5 A pulses at 28 ns at 100 pps and 75 joules/pulse at 30 pps. A new electron gun was installed in the accelerator on August 22 since the emission of the old gun (which had been used for 8 months) had dropped by a factor of two.

The data acquisition system (two SEL-computers) and peripheral equipment are operating reliably and data can be accumulated into the memory of the computer. The software to store data into the 800,000 and 400,000 word disks were completed.
by the end of September 1969. Four bids for the immediate analysis computer were received in August and are being evaluated.

Experiments which are in progress, being de-bugged, or being installed on the linac include:

(a) $\eta$ of U 233 from thermal to 10 eV
(b) capture cross section of U 238 up to several keV using an 800-gallon liquid scintillator
(c) high-resolution transmission measurements up to 100 keV; total cross section measurements on transplutonium isotopes up to a few keV in cooperation with Savannah River,
(d) gamma-ray spectra measurements from neutron capture in individual resonances using a Ge (Li) detector
(e) capture cross section measurements from 5 to 500 keV
(f) fission measurements with aligned nuclei and transmission and fission measurements with polarized neutrons and polarized nuclei.

Joly asked if a neutron-facility was still foreseen with the LAMT. The answer was positive.

Canada  The FM Tandem at McMaster University has been accepted and is working well at present. The "TRIUMF" Meson Factory Project at Vancouver is progressing.

Japan  Since the last EANDC meeting, two Van de Graaff accelerators have begun operation. One installed at the Nagoya University is a 2 MV machine and will mainly be used for reactor physics work. The other installed at the Tokyo Institute of Technology is a 4 MV machine and will be used for nuclear physics experiments including neutron data work.

The JAERI Linac has become so old that it is going to be replaced by a new machine of 32 MeV and 500 mA within half a year.

Sweden  With regard to the Isochronous Cyclotron mentioned at the last EANDC meeting as "under construction" at Stockholm, this should be changed as mentioned above (item 1 (a)), since final approval of the project is still pending.

United Kingdom  The Harwell Synchro-cyclotron has been modified successfully. The present specifications are: 150 MeV protons, 4 ns pulse length, about $3.10^4$ n/s in the burst (i.e. increase of intensity by 5 with respect to previous situation) 800 bursts/s. The maximum flight path length is 100 m.
OR Countries  A report on the Swiss meson factory will be sent to all members.

(b) Progress Reports

The current measurements and programs were extensively reviewed and discussed. The review was based on the progress reports (CAN)-40 "L", (E)-115 "U", (J)-13 "L", (OR)-85 "L", (OR)-86 "L", (OR)-87 "L", (OR)-88 "L", (OR)-89 "L", (OR)-90 "L", (OR)-91 "L", (UK)-110 "AL", (US)-120 "U" and (US)-122 "U" (a new US-progress report is in reproduction).

Spaepen gave the following information about recent measurements at Geel, not mentioned in (E)-115 "U":

- Pu 241 : measurements of $\sigma_{\text{tot}}$ (1 eV - 35 keV) and $\sigma_f$ (1 eV - 3 keV) have been made and the analysis is under way.
- U 233 : the measurements of $\sigma_f$ from 0.02 eV to 1.2 keV have been finished and will be published soon.
- Am 241 : a $\sigma_f$-measurement has been made ($E_n > 1$ keV) aiming at a detection of near-barrier fission (as indicated by the Petrel-results of L.A.) ; no evidence for it was found.
- Np 237 : a fission measurement has been started in order to find any evidence of ($n, \gamma f$) processes - no conclusions yet.
- $\beta^-$ : the total cross section has been measured with high accuracy in the MeV region : no evidence of oscillations (reported by a Hungarian laboratory) was found.
- Standards : to be reported under agenda item 5 (c).

(c) Research Papers

A number of recent EANDC-research papers were reviewed and discussed (some of them were discussed later under the appropriate agenda item).

- (CAN)-41 "AL": this study was used in the evaluation of 2000 m/s fundamental data, performed by a IAEA working group and was to be reported in the topical discussion following the EANDC meeting.
- (E)-114 "U": Schmidt said that these recommendations were very preliminary and meant to stimulate further more systematic thought on this matter (see section 7 (d)).
- (E)-119 "L": Joly said that this was the document justifying the French requests for fast reactors (main requests : fission and capture of Pu 239, capture of U 238). Story found the assessment by Barre of the accuracy of the various cross sections somewhat arbitrary.
- (E)-120 "L": Schmidt said that such calculations were very useful for getting a hint on the energy regions or nuclei for which better data were needed, but the conclusions should not be overstressed.
Beckurts pointed out that only those data available in the CCDN files were plotted. The reasons for the discrepancies with results from other laboratories were resolution effects, some systematic effects (like dead-time correction) and errors in the exact neutron energy values. The best agreement was found for Fe (cfr. Fig. 2, 3, 4: \( E_n \) from 0.50 to 0.90 MeV). Smith said that such checks of total cross sections were very important; there were still some very disturbing discrepancies. However, one had to be cautious with some SCISRS-files: some data have to be screened by looking into the original publication. Moore added that an additional source of discrepancy was sample thickness, which might explain the differences in peak heights between Cierjacks' and Carlson's data for Fe around 0.85 MeV (Fig. 4) and 0.55 MeV (Fig. 5).

Answering Nève, Havens said that the list of neutron reference energies (see above, action 3) would only go up to 0.5 MeV.

Nève commented on Table II and III, which compared the conclusions about some low energy U 235 resonance spins drawn from various types of measurements and cast serious doubts on the validity of the \( \gamma \)-multiplicity method for this nucleus. Moore and Havens said that the analysis of scattering measurements had to be done very carefully; Nève agreed and said that, for this reason, a shape analysis was presently being applied to the CEN-BCMN scattering measurements.

Condé mentioned that the experimental cross section error was 5% except for Mn where it amounted to 7%.

The error of the experimental value obtained for the capture cross section of gold-198 for Maxwellian neutrons (25,102 ± 3716) is smaller by a factor 3 compared with previous results.

Rae pointed out that using the B 10 scattering results reported here, and the B 10 total cross section results of Diment (AERE-R-5224), the shape of the resulting \((n, \alpha)\) cross section agreed with the Bergman-Shapiro expression which involves a constant term in addition to the \(1/\nu\) term (see also Fig. 3 of (UK)-113 "AL").

Moxon's results agree in shape with those from Karlsruhe (Menlove and Poenitz), but the value is 13% lower around 30 keV. Rae asked if this disagreement would not be due to improper knowledge of the neutron spectrum at Karlsruhe. Smith and Beckurts answered that this had been checked and was found to be a small part of the error quoted. Beckurts added that if the U 238 capture was indeed lower by 13% than the Menlove and Poenitz's value, then it would have a serious impact on fast reactor physics. Rae considered that some good evaluation work should be done now. Lynn had made some theoretical calculations and found a value intermediate between ANL and Harwell data.
Story said that the accuracy of theoretical calculations was probably not better than 15% (other parameters, like the nuclear radius, were involved). Havens mentioned that in resonance analysis, one could get a good self-consistent set of results, but this did not yield the true experimental accuracy; an example was the difference between average $\Gamma_\gamma$ values quoted by different authors. Other committee members mentioned that further work on U 238 was under way at BCMN ($\sigma_{\text{tot}}$ from 65 to 600 eV) and Harwell ($\sigma_{\text{tot}}$, low energy region) or planned at Mol ($\sigma_{\text{ao}}$, low energy region).

- **(UK)-114 "AL"**: Story mentioned that this evaluation work was needed for neutron "age" calculations. There was a 6% spread among the available data on the bound coherent scattering amplitude of D$_2$O, and in addition age measurements and calculations indicated that the free-atom scattering cross section of D$_2$O should be increased rather than decreased.

- **(UK)-115 "U"**: This evaluation work indicates (cfr. Table II, pg. 16) that mass-excess data are in excellent agreement with the TOF data, and not with the solid-state detector measurements. It is concluded that further accurate measurements of the fragment kinetic energies are needed.

- **(UK)-116 "U"**: This evaluation points out the need for reliable measurements of $\Gamma_\gamma$'s and thermal neutron capture cross sections for all the Zr isotopes.

- **(UK)-117 "U"**: This evaluation indicates a serious lack of knowledge of the thermal absorption cross section ($\sigma_{\text{abs}} = 100$ to 200 mb) and excess resonance integral (0.01 to 1.5 b.) of natural Si. It is most probable that a number of neutron resonances are still to be discovered. Measurements have been carried out at Harwell.

- **(US)-124 "A"**: Hanna remarked that the half-life of $(2.439 \pm 0.014) \times 10^5$ obtained at ANL for U 234 would bring the BCMN value for $\gamma$ & (U 235) up to 589 b., but the value recommended by the IAEA working group would only be increased by about 1 b. (from 580.2 ± 1.8 b.).

- **(US)-125 "A"**: The value for the Be 7 branching ratio reported in this document (i.e. 0.1051 ± 0.0018) agrees with the older Canadian value of 0.1032 ± 0.0016 (obtained by Taylor and Merritt). Spaepen mentioned that a preliminary value obtained at the BCMN agreed with this ANL value.

- **(US)-126 "A"**: The value of $(934 \pm 6)$ b. reported for the thermal absorption cross section of Li 6 agrees with the Harwell results of $940.3 \pm 3.2$ b. (see EANDC-81 "U" page 30). Spaepen mentioned that BCMN was planning to make a direct measurement at 2200 m/s.

In addition to these reports, Smith commented on two preprints from Argonne:
- A measurement of $\sigma_{\text{tot}}$ (Carbon from 100 keV up to 1.5 MeV, by Meadows and Whalen: a good fit had been obtained with parameters somewhat different from those obtained in Japan.
- A measurement by Cox (related to the Safeguards Program) of the delayed neutron yields from U 235 and Th 232 fission at $E_n$ from 1.2 MeV to 2.5 MeV: the yield had been found to be constant (in disagreement with the results from Obninsk, USSR).

Momoita distributed and commented on a preliminary version of the Japanese evaluation on $\sigma$, by Nishimura et al. and on report (J)-15 "AI".

(d) Reports on new results on the alpha value of Pu 239

Smith mentioned that some integral measurements had been performed by C. Redman at Argonne (in the 2-25 keV neutron energy range) and would be published in Nucl. sc. and Engineering.

Moore said that at Idaho Nuclear, a scandium-filtered beam had been used to measure $\alpha$ at 2 keV, using very thin samples. The result extrapolated to zero thickness was $\alpha = 1.26$ (cfr. US Progress Report, in print).

Joly said that a measurement of total and fission cross section on a Pu 239 sample at liquid $N_2$ temperature had been performed at Saclay. Data were now available for $\Gamma_n$ and $\Gamma_{\gamma}$ up to 660 eV and $\Gamma_{\gamma}$ up to 300 eV. In addition, an irradiation experiment of Pu 240, Pu 239 and U 238 samples in a flux spectrum peaked at 25 keV had been performed and the analysis, presently under way, should yield an $\alpha$-value at 25 keV.

(e) Reports on new results on fast fission of Pu 239 and U 235

The discussion covered essentially three reports submitted to this meeting.
- (US)-128 "A" was presented by Smith. In the energy range studied (130 to 1400 keV) the ratios $U$ 238 $(n, \gamma)/U$ 235 $(n, f)$ and Pu 239 $(n, f)/U$ 235 $(n, f)$ agreed with previous measurements, and the data were over determined so as to check the internal consistency. At present, absolute $U$ 235 $(n, f)$ measurements were under way at a few selected energies between 30 keV and 1 MeV with $(\gamma, n)$ sources.
- (E)-121. "AL" was presented by Beckurts. The ratios Pu 239 (n, f)/U 235 (n, f) and U 233 (n, f)/U 235 (n, f) had been measured from 5 keV up to 1 MeV. The agreement with (US)-128 and Davey's evaluation was good. Beckurts added that fission cross section measurements on Pu 241 and Np 237 were planned at KFK.

Joly mentioned that absolute σ f (U 235) measurements in the region 5 keV - 2 MeV had been performed at Cadarache. Preliminary results fell between Ferguson's and White's data (in fact, somewhat closer to Ferguson's higher values). The flux measuring techniques were checked by reproducing them at BCMN.

Beckurts said that, taking the ratios as well known, this would imply a higher capture cross section of U 238, which contradicts the latest Harwell results of Moxon (cfr. (UK)-113 "AL").

Rae said that the Harwell measurements on U 238 with the linac would be extended to higher energies using a scintillation tank detector. If it were practicable, the "black" detector would be used to calibrate auxiliary flux detectors in a separate experiment.

It was concluded from the discussion that although the ratio measurements looked fairly good, the absolute U 235 fission cross section was still a very open problem. As measurements on this quantity were under way at Argonne, Karlsruhe and Cadarache, Smith, Beckurts and Joly were asked to try to produce status reports for the next meeting.

3. CONFERENCES

(a) Second Conference on the Physics and Chemistry of Fission, Vienna, July 1969

Good said that the "Proceedings of the Conference" should come out in January 1970 and will contain the full text of the invited papers, a condensed version of the contributions presented orally, and the abstracts of all the contributions submitted.

Kolstal read extracts of a summary written by Bogda (AEC observer at the Conference). Schmidt added that a remarkable fact had been the impact of Strutinski's model; about one third of all the contributions were more or less related to the "double-humped" fission potential barrier.

Concerning data of more direct interest to the EANDC, he pointed out the discrepant results from RPI and Dubna on σ in the Pu 239 resonances, the smooth behaviour of delayed neutron yield in the 14-15 MeV region found in the US and in Germany, in disagreement with the Obninsk results, and the theoretical calculation of delayed neutron spectra performed at Saclay.
(b) International Conference on Fast Reactor Physics, London, 24-26 June 1969

This conference was summarized by J. Story. It had been organized by the British Nuclear Energy Society and was attended by about 270 people from 25 countries. 33 papers were presented and may be grouped under three headings.

1. Physics measurements with zero power assemblies.
3. Operation of power reactors.

The first heading attracted half the papers presented. Namely:
- measurements with zero power assemblies
- comparison of results with calculations
- adjustment of nuclear data to force better agreement of calculations with integral data.

There seemed to be a fair measure of agreement about the main adjustments needed, but this may be no more than a reflection of the fact that everyone tends to use more or less the same set of integral experiments.

Most of the integral measurements reported related to large plutonium-fuelled fast reactors. The critical assemblies considered were MASURCA in France, SNEAK in Germany, the JAERI fast critical assembly in Japan, PRO in Sweden, ZEBRA and VERAL in the U.K., and ZFR 3, 6 and 9 in the U.S.A. In addition measurements were made in fast spectrum test zones driven by thermal reactors.

Comparisons of theory with experiment related to critical size, reaction rate ratios at core centre, core centre perturbation data, and central void coefficients.

There had been a well-attended panel meeting on data adjustment one evening. Least squares adjustment procedures had been developed, with some diversity in the treatment of errors. Barre's methods were described in detail in EANDC-(E)-120. John Rowlands would describe his work on the EANDC topical discussion on 10th October 1969. (Story added further that the time-scale of fast reactor development had forced the adoption of adjustment procedures for interpolation purposes. Least-squares fitting programmes had already been developed for this purpose, and the possibility was open of using these programmes for diagnostic purposes. What really needed careful consideration was how to drive this machine so that it gave the best diagnoses, in contrast with its use for integral interpolation).
Neutron spectrum measurements had been reported from France, Germany, Sweden and the U.K., using a variety of methods. Story's understanding was that measurements above 1 MeV were still not good enough.

Much attention had been paid to Pu 239 alpha, especially for the region below 15 keV. There seemed to be an increasing measure of agreement with the differential data (see section 3 (f)).

Heterogeneity corrections seemed still to be a possible source of error, though attempts had been made to measure average cross sections (non-local values, rather than highly localised values).

There seemed to be differences in absolute reactivity calibrations based for example on central perturbations with fissile samples and calibrations based on absolute delayed neutron yields. This uncertainty of about 30% affected all kinds of absolute reactivity measurements including Doppler and sodium coefficients, and control rod worths.

Of the various Doppler experiments the activation method introduced by the Swedes seemed especially worthy of note, because it reduced the heterogeneity problem.

(c) Conference on the Properties of Nuclear States, Montreal, 25-30 August 1969

This conference was summarized by G.C. Hanna. There were 630 participants from 29 countries; about 370 papers were submitted, and about 30 review or invited papers were presented. The summary was given by E.P. Wigner who stressed the need for greater concentration on fundamental concepts. New experimental developments were discussed, and heavy ion accelerators and the prospect of studying superheavy elements were emphasized. The Proceedings were planned to appear 10 weeks after the conference.

(d) Symposium on Neutron Capture Gamma Ray Spectroscopy, Studsvik, 11-15 August 1969

This conference was summarized by H. Condé. The symposium had about 110 participants from 20 countries. About 70 papers had been presented of which 52 dealt with thermal neutron capture and 18 with fast capture. The symposium had 9 different sessions covering both experimental techniques and theory.

Preprints had been given of the reports and the final proceedings would appear as an IAEA publication (Spring 1970?).

An introductory talk had been given by Prof. A. Bohr (Copenhagen) about the theory of nuclear dipole modes.
Several new techniques and improvements had been reported in the technical sessions, e.g., neutron guide tubes, internal pair spectrometer, and improvements of bent crystal spectrometers at ANL and Risø.

An impressive amount of data had been presented at the thermal capture sessions from measurements on about 50 different isotopes ranging from Mg 24 to U 235.

The scattering of γ-rays from (n, γ)-reactions had been successfully used to study both highly excited levels near the neutron binding energy and low energy level schemes.

Before the final sessions devoted to fast neutron and resonance capture Dr. A. Lane (Harwell) had given a review talk about the theory of neutron capture where he especially discussed the channel capture theory.

The "5.5 MeV anomaly" observed in fast neutron capture spectra of heavy elements near closed shells had been discussed. A qualitative agreement with experiments had been reported from calculations based on the semi-direct capture mechanism.

Finally, there had been a discussion about the future of the "Slow Neutron Capture Gamma Ray News Letter" with the conclusion that the News Letter would continue (editor Dr. E.D. Earle, Chalk River).

(e) Conference on Computer Systems in Experimental Nuclear Physics, Skytop, Pennsylvania, March 3-6, 1969

Report (US)-123 "L" entitled "Résumé of Impressions of the Skytop Conference", as observed by W. Havens (Columbia University), J.R. Pasta (University of Illinois), R.B. Lazarus (Los Alamos) and A. Smith (Argonne), was presented by Smith and Havens and discussed.

The conclusions of the Report are the following:

1. Computers have made a great impact on experimental physics but they have not basically altered experimental philosophy nor has their potential been exploited fully. Particular attention should be given to establishing the essential characteristics of systems operating in general problem areas with the intent of providing guidance for future usage.

2. The emergence of a new specialty in experimental nuclear physics, computer applications, is in evidence. Continued attention must be given to coordinating this specialty with the basic field of nuclear physics and with computer sciences.
3. At present there is an immense variety of approaches to essentially similar problems. Some of these amount to establishing central computing facilities fraught with familiar problems. There is little evidence the physicist has any unique answers.

4. The economics of computer usage in the experimental context are not quantitatively known. There is need for a realistic accounting of costs if reasonable fiscal planning is to be achieved.

5. The use of computers in experimental nuclear physics is stabilizing and the same judgements applicable to the acquisition and operation of any major piece of experimental equipment apply. This is inclusive of the decommissioning of obsolete or ineffective computer systems.

6. Standardization of interface hardware and software should receive prompt, continuing, and detailed attention by competent groups. In particular the standardization of interfacing should be referred for immediate attention to the established AEC-NIM Committee.

(f) IAEA Meeting on Alpha of Pu 239, Winfrith, U.K.,
30 June - 1 July 1969

This meeting was reported by J. Schmidt.

IAEA had called together specialists from France, F.R. of Germany, Japan, USSR, UK and USA, besides ENEA and IAEA representatives. The main conclusions and recommendations had been the following.

(1) Differential measurements

The agreement between the different series of differential measurements had improved during the past year and the accuracy was now about ± 5% in \( \langle \sigma_f \rangle \). 

\[ \frac{\Delta \sigma}{\sigma_a} \]

(This is equivalent to an accuracy of ± 10% in alpha, when alpha is equal to unity). Possibly some of the main remaining discrepancies were due to differences in primary normalisation. It was agreed that in order to aid in the solution of the normalisation problem the resonance alpha values used for normalisation should be based on eta and/or alpha measurements extending into the thermal energy range. After having obtained the sets of the resonance alpha values used for normalisation in the various experiments, it was recommended that the experimentalists involved attempt to get out a common standard set of resonance alpha values and renormalise their measurements to these. The renormalised average alpha values should be made available to the specialists attending the meeting and other interested people. The experts finally recommended to the IAEA to continue, through its Nuclear Data Unit and in
co-operation with the other centres, to help in providing the necessary information and data for the comparison of the various Pu 239 alpha measurements.

(2) Alpha values deduced from data adjustments

Some cross section adjustment studies had been made at Cadarache and Winfrith, but the conclusions were somewhat uncertain, as the adjustments may depend on the uncertainties for data other than $\alpha$(Pu 239), and on inaccuracies in the calculation methods themselves.

(3) Integral experiments

Several integral experiments had been performed and analysed in the US (Argonne and Brookhaven), UK (Dounreay), Germany (KFK) and France (Cadarache). In the energy range 1 - 10 keV, they were well fitted by the latest Harwell (Schomberg, Sowerby and Evans, (UK)-100 "AL") and Gwin (not yet published) results. In the 10 keV - 1 MeV range, the evidence from integral experiments for an increase in alpha-value was still inconclusive, and further work was needed.

As a general conclusion, it could be said that, although some further work was needed (and was in fact underway at several laboratories) agreement seemed in view.

(g) Other scheduled conferences

Regarding the IAEA conferences, Good gave some information about the next Conference on Nuclear Data for Reactors, to be held at Helsinki on 15-19 June 1970. The preliminary announcement came out in July 1969. The program committee would try to have the conference more biased towards reactor application than had been the previous similar Paris Conference. The sessions headings would be: general aspects of the needs and use of nuclear data, high-accuracy measurements, data in thermal and resonance energy region for $A > 220$; the same for $A < 220$, data above resonance region for $A > 220$, the same for $A < 220$, relations between microscopic and integral data, evaluation, and instruments and methods. A few special subjects would be treated by invited speakers (nuclear data for astrophysics by Fowler, nuclear data for controlled thermonuclear energy by Golovin, and theory of nuclear reactions by Lynn). A total of 14 invited speakers was foreseen.

Following a question by Beckurts, Good said that there were no IAEA plans for holding a neutron physics conference similar to the 1965 Antwerp Conference.

Havens mentioned that there was a proposal for holding a IUPAP conference on the statistics of neutron resonances, at the State University of New York, Albany, in 1971. Good asked if a session on this subject should not be included on the program of the Helsinki Conference, or alternatively whether
a meeting on this subject with limited attendance could possibly take place in Leningrad just before Helsinki. The opinion of Havens on this was negative. The subject was too specialized for the Helsinki Conference, it was too late to get something done, and the US attendance would be very limited.

Kolstad had been informed by Dolnicar (IAEA) that a panel on instrumentation for low energy neutron inelastic scattering would be held in November 1969.

Good added that the panel meetings for 1971 and 1972 at the next INDC meeting would be discussed at the IAEA Reactor Division would be discussed. The IAEA Physics Division were planning a small symposium on charged particle radiative capture in 1970, and a study group meeting on the use of small accelerators.

4. REQUESTS FOR NUCLEAR DATA

(a) General Remarks

The problem of a "world-wide" request list was discussed. Kolstad remarked that as long as a request list from non-OECD countries, similar to the DANDC-RENDA list, had not been distributed and discussed, no decision for a world-wide list could be taken. The Committee agreed with this.

Good reported progress in this matter. The IAEA had asked the non-OECD countries for lists of requests for reactor and other applied needs and RENDA has been distributed to them as a model. Following this enquiry, the IAEA had received since June 1969, 135 requests from the USSR, Finland, East-Germany, Hungary, India, South-Africa, Pakistan etc... Most of them (110 out of 135) were new requests, i.e. not appearing as such in the latest RENDA. However, some countries had said that they would be ready to join some of the RENDA requests. Accordingly, the IAEA was now asking the non-OECD countries explicitly what RENDA requests they would support jointly. No supporting document had been asked for (the timing imposed did not allow for it), but only comments. It could be inferred from these if the request was needed for reactor technology or for some other purposes (e.g. activation analysis).

It was suggested to Good that a supporting document might be asked for from the non-OECD requestors for the next INDC meeting, and that the requests for non-reactor needs might be grouped in a separate list.

Good said that he was planning to have the IAEA request list sent to the ENEA for editing around January 1970, with a view to printing it by May 1970.
(b) Lists of Requests from the various EANDC regions

(1) US Request List

Moore circulated a first draft of the new US request list, computer printed. Besides trivial printing errors, it still has to be checked by the Local Data Committee, and will be sent to the ENEA by the end of November; it will not include a fully updated status report. Regarding the "high accuracy" requests, Spaepen asked in which neutron energy range they fell. Moore answered that for most of them, it was the fast neutron energy range.

Moore was asked to have the new US list distributed to all the Committee members by the end of November.

(2) Euratom Request List

Spaepen said that this list had been discussed by the Euratom Data Committee. Each class of requests had been screened by various specialists and this step was now nearly finished. The revised list would be sent to the ENEA very soon.

(3) UK Request List

The revision of this list had not yet started, and it did not seem possible to have it revised and sent to ENEA sooner than 15 January 1970.

(4) Canadian Request List

Hanna said that the revised list would be ready by the end of 1969.

(5) Japanese Request List

The new list is available (EANDC(J)-14). Momota indicated that the errors quoted for some requests had to be reduced by a factor of 10 due to an error in transcription.

(6) OR Request List

A revised request list from Sweden is available and was distributed to the Committee members.

A request list from Switzerland had been received.

Conclusions

All members are asked to send the revised lists to Madame Solanes as soon as possible, and in any case not later than January 15, 1970. Where no revised lists have been received by this deadline, the older requests will be retained.

Madame Solanes asked all members to give detailed information for each requestor (initials, address etc...).
The most appropriate way to review the next RENDA at the 14th EANDC Meeting was discussed later. The conclusions and actions are reported in section 11 (a).

(c) EACRP recommendations

A list of specific EACRP requests or recommendations to EANDC had been quoted at the previous Meeting (cfr. EANDC-81 "A" p. 37). The following comments were given at the present meeting.

(1) Prompt fission neutron spectrum of U 235 and Pu 239

Nève said that, according to information from Benzi, a measurement had been started at Bologna, using an elaborate proton recoil counter.

Moore said that some work had been started at NBS, using a converter plate in a reactor thermal column and both activation and direct measurements. Some work was also under way at Argonne with TOF techniques (cfr. Wash 1127).

An action was put on the US and Euratom delegates, to report on the US work and the Italian work, respectively, at the next meeting (see also section 5 (d)).

(2) Inelastic scattering by U 238 in the 0.8 to 2.0 MeV range

Smith said that a measurement of this quantity had been performed at Argonne, in addition to theoretical work. It had been found that the hypothesis of a statistical distribution of levels was good above 1.5 MeV. In addition, very good agreement between theory and experiment had been found for the excitation curves of some individual levels. The agreement between evaluated and measured total \((n, n')\) and \((n, n)\) cross section had also been good (the full angular distribution was measured, while previous measurements, e.g. those of Harwell, were limited to one angle). It had been concluded that at present the knowledge of the elastic scattering cross section should be improved. The evaluation work would appear as a Laboratory Report and would be included in the ENDF.

The Committee asked Smith to give an EANDC distribution to the Laboratory Report.

(3) Resonance capture measurements on U 238

Havens said that new measurements of the total and capture cross sections would start soon at Columbia.

Rae referred to the Harwell work by Moxon, reported in (UK)-113 "AL".
Nève said that scattering measurements were planned at Mol and Geel, at the BR2 and BOMN Linac. Rae added that these measurements would be very useful, as the absorption integral was proportional to the product \( \langle T_n \rangle \langle \nu \rangle \), i.e. to \( \langle T_n \rangle \) for low-lying resonances for which \( \langle T_n \rangle \ll \langle \nu \rangle \).

(4) **Capture by U 238 in the keV to 100 keV range**

This had been discussed under agenda item 2 (c). Batchelor added that measurements at a few selected neutron energies were being carried out by Axton at NPL (between 30 keV and 1 MeV), using a Li (p, n) source and a Mn bath.

(5) **Alpha of Pu 239**

This had been discussed under agenda items 2 (d) and 3 (f).

(6) **Subcommittee on Evaluation**

This was discussed later under agenda item 7 (e).

5. **INTERNATIONAL CO-OPERATION IN THE MEASUREMENT OF NUCLEAR DATA**

(a) **Co-operative efforts on U**

This field was reviewed by Condé.

Besides the recent IAEA compilation by Hanna et al. (on some fundamental nuclear data at 2200 m/s; cfr. Atomic En. Rev., Dec. 1969), Colvin had submitted a paper on the present status of U at the Second IAEA Conference on the Physics and Chemistry of Fission (only the abstract is available) which gave for the ratio of total (prompt + delayed) fission neutrons \( \sigma \) (Pu 239) / \( \sigma \) (Cf 252) = 0.7653 \pm 0.0020 (against 0.7648 \pm 0.0022 in the IAEA evaluation).

Regarding the absolute \( \sigma \) (Cf 252): besides the NPL results reported at the Geel Topical discussion (Jan. 1969) additional measurements have been done at Argonne (cfr. latest US Progr. Rep. and ANS Meeting, San Francisco, Nov. 1969). These two measurements now seem to be in better agreement.

An offer had been made by NPL to distribute gold foils with Cf 252 for intercalibration of primarily the fission rates (see J. Nucl. En. 23, 467, 1969). Foils had been sent to BOMN, ANL and Stockholm. No results were yet available.

Regarding the neutron-energy dependence of \( \sigma \), widely discrepant results in the Pu 239 resonances had been presented at the last Fission Conference by RPI and Dubna. In the KeV region, measurements were in progress at AWRE and in France. For the latter (by Soleilhac), the range was from 200 keV up
to 1.5 MeV; TOF techniques were being used. For U 235, the results yielded a structure (of up to 1.5% amplitude) superimposed on the overall linear behaviour vs $E_n$; for Pu 239, there was some indication for a structure, but much weaker than for U 235. It was planned to try to measure below 200 keV.

At Aldermaston, spot measurements, each covering a fairly broad energy band, in the energy region from 40 keV to 1.5 MeV were in progress. No TOF technique was being used.

There was no recent news from Boldeman (Australia).

The Committee suggested that Soleilhac meet the AWRE measurers and that both prepare a short EANDC-document comparing their results for the next meeting.

Schmidt asked if it would be useful that the IAEA Agency call together a small meeting of specialists on these and other problems in the $\gamma$ field. The Committee fully supported this proposal.

(b) Co-operative efforts on elastic and inelastic scattering

Smith reported that:

- Six newsletters had appeared since January 1969
- Preprints, Reports etc... had been exchanged
- Co-operative work with South Africa had been completed, and further work was planned (the Univ. of Kentucky would also join)
- Computer programs had been exchanged between the U.S. and B.C.M.N.
- Samples had been exchanged (mainly among the U.S. labs).

The question of costly samples was discussed by the Committee. They could be costly either because of isotopic requirements or because of fabrication costs (or both). Answering Spaepen, Kolstad said that bilateral agreements applied to the loan of samples prepared in the U.S., but the recipient was required to send the sample back to ORNL which was responsible.

It was agreed that Smith (for the US) Condé (for Sweden) and Spaepen (for BCPN) should prepare a list of rare samples suitable for scattering measurements, which would be available for exchanges.

(c) Report of the Standards Sub-committee

This report is reproduced as Appendix 2.

Among the conclusions, the need for a meeting on Standards was stressed. This should be devoted to the assessment of what has been accomplished in recent years, and
to the definition of future needs.

It was proposed to hold the meeting just before an EANDC meeting and in a not too distant future. The EANDC strongly supported this proposal.

(It was later agreed to hold the meeting immediately before the next EANDC meeting - see item 11 (b)).

(d) Other areas of international cooperation

Spaepen reported on the fission foil exchange programme between Idaho, Chalk River and Geel. Foils had been prepared and α-counted by BCMN, and sent to Chalk River and Idaho for α-counting and chemical assay (by isotopic dilution). This programme was under way. People volunteering to join were still welcome.

Hanna raised the possibility of international cooperation on the problem of prompt fission neutron spectra. After some discussion, it was suggested to Schmidt that the NDU of the IAEA be left to collect all the data on this problem and possibly issue a report on our present knowledge of N(E).

Hanna was also asked to produce a working document for the next EANDC meeting, compiling the information he had and commenting on it.

6. INFORMATION ON OTHER NUCLEAR DATA COMMITTEES

(a) Meeting of the EACRP, London, 10–14 February 1969

This was reported by Rae, who attended the meeting as EANDC observer.

A paper by Went (Holland) had been devoted to a comparative study of Th, U and Pu fast reactor systems. It pointed out that $\eta$ (U 233) was more favourable than $\eta$ (Pu 239) in the KeV-region, and concluded that the cross sections important for the Th fuel cycles should also be looked at carefully. (Beckurts mentioned that there were some data requests pertaining to the Th cycle, namely from Italy).

The usefulness of measurements on separated fission products had been discussed but no clear conclusion had emerged, except that in the case of a sample conflict between an integral and a differential measurement, preference should be given to the latter. Beckurts added that fission product samples had been requested by KFK for differential measurements, but that up to now no answer from AEC had been received.
Meeting of the INDC, May 1969

Good summarized the meeting, and gave the list of recommendations that were agreed upon.

(1) The Committee recommends that one of its members or a suitable alternate attend as an observer at CODATA meetings to keep the Committee informed on CODATA activities (i.e.: international cooperation for the compilation of all nuclear data, other than neutron data).

(2) The Committee strongly recommends that the IAEA publish all of the papers accepted for the Helsinki Conference on Nuclear Data for Reactors.

(3) The Committee recommended that the IAEA consider making budgetary provision for supplying, especially to developing member states, needed samples for cross section measurements. The Committee will be willing to advise the Director General on the merit of specific proposals.

(4) The Committee recommends that the IAEA plan to sponsor a small symposium not later than 1973 on the collection, compilation, indexing, evaluation and distribution of nuclear data, especially other than neutron data but also including neutron data.

(5) The Committee recommends that the IAEA assume the responsibility for the printing and distribution of CINDA from January 1971 onwards.

During the course of the discussions, the INDC advanced the following suggestions for actions by the NDU:

(6) The following Panel Topics represent urgent needs and should be considered for the Agency's future program:

(i) Cross Sections and Standards for High Precision Neutron Measurements
(ii) Methods of Evaluation
(iii) Discrepancies between Microscopically and Integrally Measured Quantities
(iv) Properties of Nuclear States
(v) Resonance Parameters
(vi) Transactinium Nuclides

Of highest priority to reactor applications are Methods of Evaluation suggested for 1971 and Cross Sections and Standards for High Precision Neutron Measurements suggested for 1972. Items (iv) and (vi) are of general interest and could conceivably be justified in addition to items (i) and (ii).
The Agency should have a Liaison Officer in each member state (which has an interest in Nuclear Data and individuals technically qualified for the assignment).

The Committee should be supplied for consideration at its Third Meeting (in advance) with a working paper which outlines an Agency evaluation activity to appropriately follow the Review of Cross Sections at 2200 m/sec.

The listing of non-European-American needs for measurements should be treated, for the time being, as a separate supplement. A new effort should be made to secure contributions to the supplementary list of requests envisaging a revised concept, viz., requests should be stated independently of a prior listing in order that the extent of need can be realized. Some identification of each requester should appear in the printed listing. Measurements in progress (to fill listed needs) should be treated in the same manner as the measurement requests.

Regarding item (7), all EANDC delegates were asked to suggest appropriate names to Good.

Regarding item (3), Good said that a budget would be provided for in 1971, but the amount was still vague, and he asked for suggestions. At present there was no more than one request per year, but there would certainly be an increase if funds were available. INDC would act as advisor to screen the demands. At present, a sum of about $25,000 was being considered for 1971. Moore and Smith thought this would be adequate for 2 to 3 samples per year.

Good added that the capabilities of Geel and ORNL would be communicated to all IAEA member countries. Spaepen showed an updated EGIN document on this and was asked to send one copy to all EANDC members.

7. INFORMATION ABOUT DATA INDEXING, COMPILING AND EVALUATION

(a) IAEA activities

Good reported on these activities.

A Meeting would be held in November 1969 in Moscow, grouping representatives of the Data Centers of Brookhaven, Saclay, Obninsk and Vienna. This implied the underlying recognition of 4 major Centers, which was important for IAEA. The question of the exchange format would be extensively discussed. This common format should apply to the data themselves, and to all the auxiliary information needed for understanding the data. The other point to be discussed was and international data index, which should be in adequate format for retrievals by any centre. It would list data available in all the centres.
The Brookhaven Panel Meeting (Feb. 1969) had been more concerned with general information on the working arrangements and capabilities of each centre.

THE CINDA index (i.e.: list of exchanged data and of data available at Vienna) would be republished. The next edition would appear in January 1970.

Good raised the question of the take-over of CINDA by the IAEA. The editing would be done under contract by CCDN, and the printing and distribution by Vienna. An appropriate IAEA budget would be available in 1971, but was not available for 1970. From 1971 onwards, the subscription rate would lie between 5 and 10 $ per copy, but the present free distribution list would remain unchanged.

The problem of the 1970 gap and of the future editing scheme was discussed. An ad-hoc sub-committee headed by Moore, was designated to give the matter further study and subsequently made the following proposals, which were supported by the Committee:

(i) It is recognized that the present version of CINDA (CINDA-69) contains a number of omissions of results obtained prior to 1955, as well as entries which are misleading or incorrect. The task of completing and correcting CINDA should rightly be carried out with a lower priority than that of entering new information. However, an effort should be made to complete, insofar as possible, the task of clean-up before December 1970, the closing data for CINDA-71.

(ii) Because of expense incurred in providing a single complete volume of CINDA on a frequent time scale, and because of the bulk of the present version, CINDA-71 should be the last version of CINDA to contain the entries prior to December 1970. Subsequent supplements to CINDA-71 (or CINDA, Vol. I) will contain entries made later than January 1, 1971.

(iii) Supplements to CINDA should be cumulative. In this way, the inconvenience to users of having multiple documents will be minimized. At no time will there be more than two volumes of CINDA in current use: CINDA-71 and the current supplement. (As the current supplement approaches the size of CINDA-71, consideration may be given to another closing date for Volume II of CINDA).

(iv) The second supplement for CINDA-69, perhaps to be known as CINDA-70, should also be cumulative in the sense that it should contain the entries made for the first supplement of CINDA-69.

The Chairman will inform the Director General of ENEA and the Chairman of INDC about these proposals.
Regarding the financial aspects of the problems, Kolstad informed that the U.S.A.E.C. would take charge of the 1970 Supplement. As the IAEA would be taking care of CINDA-71 (Vol. I), continuity seemed secured.

(b) ENEA activities

The CCDN activities were reported by Rosén as follows:

1. Experimental data

A major development during the past year at the CCDN has been the introduction of a new data storage and retrieval system to enable fuller and more rapid use to be made of the SCISRS file. This computer system, which has been called NEUDADA, has been developed to make the fullest use of the direct access storage features of the 360/30 computer. At present it is available for use with the current NNCSC/CCDN data library which incorporates the most recent CCDN compilations prepared to the information content level of SCISRS II. Dissemination of data on request from this library was started in January 1969 and an extended retrieval facility to retrieve on any combination of a number of retrieval parameters* has recently been incorporated.

A supporting system of programmes was also developed for preparing an edited version of the internal data file index for publication as a CCDN Newsletter. This work involved checking and correcting the reference abbreviation and principal author for each entry in the file, required in order to know the precise contents of the data library and to make possible the subsequent automatic correlation of this library with CINDA. In particular, Newsletter No. 8 was distributed in April 1969 giving details of the library's contents on 15th March 1969, and a revised edition of this Newsletter will be published in November 1969 as Newsletter No. 11 giving details of the contents of the data library on 15th October 1969.

In addition, a modified version of the ECSIL bibliographic system called CREED (Compilation of References to Experimental Data) has been developed for use as a book-keeping system for the CCDN data compilation activity.

In conjunction with this system development work, there have been discussions among physicists (both experimentalists and evaluators) on extending and defining the amount of supporting information which should be compiled for each data set and also on the development of a new reaction

* Retrievals can be made on any combination of the following parameters defining data sets: Z, A, reaction, status, method, standard, laboratory, source, year, reference abbreviation and energy range.
classification scheme. It is intended that agreement on these developments will be reached in the forthcoming four-centre meeting to be held in Moscow on 17th-21st November.

In addition, in order to further the exchange of compiled experimental data between the four data centres, the CCDN is engaged in the development of computer programmes for the translation of data between the NEUDADA transmission format and the four-centre exchange format. It is hoped that data exchange on the basis of this exchange format will be initiated towards the end of 1969.

2. CINDA

In March 1969 a supplement to CINDA 68 was distributed, while the full 1969 print-out (CINDA 69) was distributed in July. This print-out included all entries received up to the beginning of May 1969.

Most of the past year's work on CINDA at the CCDN has been devoted to finding and filling gaps in the coverage before about 1962 and to bringing the last remaining European entries in the old format up to current standards. This has been in preparation for a second attempt during the coming year to consolidate multiple entries for the same work. Back coverage will be extended further, both by systematically checking main journals and by reference to private card files held by K. Parker and J. Story.

Although other commitments have prevented any changes to the CINDA programmes, much of the necessary ground work for its automatic checking against the data file has been done. As an interim measure, CINDA 69 contained a list of all references from which data had been stored in the CCDN file at the time of the Centre's Newsletter No. 8.

CCDN proposals for the reprogramming of CINDA have been submitted to the other participating centres, and it is intended to define the physical and operational parts of a new CINDA system before the end of 1969.

3. Evaluated data

An information sheet giving details of the evaluated data files which are available at CCDN for distribution in participating countries was circulated at the end of 1968. Although the distribution list for this document was quite small, several copies were sent to each recipient, who was asked to arrange circulation and distribution within individual laboratories of participating countries.

The CCDN received the KEDAK library in card image format in March 1969, and distribution has now started.
An updated version of the compilation of evaluations of neutron cross sections was published in May 1969 as CCND Newsletter No. 9.

A system of programmes has been developed for the storage on disc of the United Kingdom Nuclear Data Library and for subsequent retrieval from this file by nuclide or by process. The system also includes options for plotting cross section data and for the superposition of evaluated cross section data on plots of the available experimental data retrieved from the data library.

In reply to questions Rosen provided the following additional information. Regarding the format used for the exchange of data, NEUDADA was being used by CCND, but the Brookhaven Centre had complained that this was very inconvenient. In the case of US data, they were received by CCND in SCISRS II format and translated into NEUDADA. For the evaluated data, the question of the format was still a serious obstacle for exchanges, the present position being that they were exchanged as received.

Regarding personnel, Rosen said that Liskien (from BCMN) would be replacing Schwartz, who was leaving ENEA. The Centre was at present short of programmers (some work was having to be contracted out) but this problem would probably be solved in the near future.

(c) U.S. activities

These were reported by Kolstad as follows.

NNCSC Computer

A Digital Equipment Corporation PDP-10 computer has been installed in the National Neutron Cross Section Center. The new computer will improve the accuracy and reliability of the NNCSC data files. The addition of interactive graphics equipment is planned to facilitate the evaluation of neutron data.

SCISRS

All old data are now stored on tape. The author proof system consisting of listings and computer plots sent to the experimenter has been in effect since January 1969. There has been excellent cooperation from the experimenters, with response times averaging two weeks. New data are being compiled in the new Center-to-Center Transmission Format. These data will be sent to the other Centers and will also serve as input to the SCISRS-II system. A proposal for the content of the Transmission Format has been submitted for approval at the forthcoming 4-Center Meeting, November 17-21, 1969.
ENDF

The second version of the ENDF/B library will be issued during the fall of 1969. The revised files will include new data for D, O, C, Fe, Ni, Cr, U 235, U 238, Pu 239, Pu 240 and Pu 241. The fissile and fertile elements were evaluated simultaneously in order to provide self-consistent data sets by a special Task Force of experimenters and evaluators. The simultaneous display of ENDF/B evaluated data and SCISRS experimental data on 35 mm film was used to assist the re-evaluation of the ENDF/B library.

In a September 24-26 meeting of the Cross Section Evaluation Working Group, a draft was prepared to revise ENDF/B specifications and a description of its content (BNL 50066).

Joly asked if the U 235 and Pu 239 data included in the ENDF/B were the recent Los Alamos evaluations. The answer was negative.

(d) Other activities

Schmidt presented briefly two KFK reports, namely:

- (E)112-U (KFK 880) describing the translation of the internal format of the KEDAK magnetic tape file into a "card-image" format for external use.

- (E)114-U (KFK 941) giving some requirements for advanced neutron data storage and retrieval systems (physical documentation of the data held in the file, etc...)

A general discussion took place about the number of Data requests for the regions covered by the various Data Centres.

The IAEA-NDU had an average of about 100 data requests per year; for BNL, it was about 70 times higher. On the other hand, it seemed that on the average each Centre received about 500 CINDA entries per year, meaning about 500 "neutron data producers" for each area.

The U.S. delegation and the ENEA representative were asked to be prepared to give details at the next EANDC meeting of the number of CINDA entries and of Data entries and requests for the last year for the Brookhaven and Saclay Centres.
8. **NEXT EANDOMC MEETING**

(a) **Procedure for the discussion of the Requests List**

The Committee was of the opinion that discussion of the next RENDA should be an important item of the meeting. The way this had been dealt with at previous meetings (i.e. discussion of the items sorted out according to the nature of the data requested), was still thought to be the most useful one. But instead of asking each reviewer to do most of the work, it was decided to try to have this work done largely by the various Local Data Committees.

In accordance with these views, the following series of actions were agreed:

1. ENEA should print and distribute (U-distribution should be given) the new RENDA not later than April 1970 (see action VII). This document would only list the requests according to Z and A (i.e.: like pages 1-80 of EANDC-78 "AL").

2. At the same time ENEA should prepare a listing in the computer output format of the requests according to the classes given hereunder (cfr. step 4). A number of copies will be needed and should be sent to:
   - J. Spaepen (2 copies), for Euratom
   - E. Rae (2 copies), for the U.K.
   - G. Hanna (1 copy) for Canada
   - P. Weinzierl (2 copies), for the OR countries
   - M. Moore (who will inform ENEA of the number of copies needed) for the U.S.
3. Each of these persons will ensure that the local data committee of his respective area:
   - comments on current work performed in its area about requests from any area.
   - screens (i.e. eventually deletes or changes) the requests from its own area.

4. Following this step, the same persons will ensure that all these comments are sent (not later than September 1st) to the following people:
   - regarding U requests, to H. Condé
   - regarding moderators, to J. Story
   - regarding thermal cross-sections, to G. Hanna
   - regarding resonance parameters, non fissile elements, to E. Rae
   - regarding fissile elements, resonance parameters and fast neutron fission, to R. Joly
   - regarding fast neutron capture, to K. Beckurts
   - regarding scattering cross-sections, to A.B. Smith
   - regarding threshold reactions, to J. Spaepen

5. Those indicated should prepare written reports on the respective items for distribution at the next EANDC meeting.

Following a review of the situation at that time ENEA will proceed with the preparation of a comprehensive document containing all the retrievals and a list of the requests deleted with respect to the previous RENDA (EANDC-78 "AL) together with the reason for deletion (implemented, programme changed, etc.).

The following subsidiary actions were also discussed and agreed:
   - The ENEA should send 60 copies of the next RENDA to the IAEA.
   - The Chairman should ask the INDC Chairman to include a discussion of the new RENDA in the agenda for the next INDC meeting.
(b) **Place, Date, Topical Discussion**

According to the pattern followed in the past, the next meeting should take place in the U.S., and the U.S. delegation proposed to hold it at Argonne.

Considering that a meeting of the Nuclear Physics Division of the A.P.S. will be taking place at Houston (Texas) on the 14-16 October, it was decided that the EANDC meeting should take place on the 26-29 October (with possibility of extending it to the 30th), the Sub-Committee meetings taking place on Saturday 24th, and the topical discussion being a small 3-day symposium on "Standards" on the 21-23 October.
APPENDIX 1

LIST OF EANDC DOCUMENTS ISSUED SINCE THE
12th EANDC MEETING IN BRUSSELS (January 1969)

(a) Committee Paper EANDC-X
   81-A Complete Minutes of the Twelfth Meeting of
      the Committee
   81-U Technical Minutes of the Twelfth Meeting of
      the Committee

(b) Canadian Documents – EANDC(Can)-X
   (Can)40-L Progress Report, January 1969 to September
      1969, compiled by G.C. Hanna
   (Can)41-AL A Study of the Accuracy of g-Factors for
      Room Temperature Maxwellian Spectra for U
      and Pu isotopes, by C.H. Westcott (AECL-3255)

(c) Euratom Documents – EANDC(E)-X
   (E)112-U Card Image Format of the Karlsruhe Evaluated
      Nuclear Data File KEDAK, by D. Woll
   (E)113-U Analysis of Fast Critical Assemblies and
      Large Fast Power Reactors with Group-Constant
      Sets Recently Evaluated at Karlsruhe, by
      H. Küsters, J.J. Schmidt, C.H.M. Broeders,
      E. Eisemann, M. Metzenroth, K.E. Schroeter,
      D. Thiem
   (E)114-U Basic Requirements of Advanced Neutron Data
      Storage and Retrieval Systems (CSISRS), by
      J.J. Schmidt
   (E)115-U Progress Report on Nuclear Data Research in
      the Euratom Community for the period January
      1 to December 31, 1968
   (E)117-U Aktueller stand der physikalischen kenntnis
      der wichtigsten reaktor kerndaten, by
      J.J. Schmidt (KPK-966, EUR-4172 D)
Evaluation of fast critical experiments by use of recent methods and data, by E. Kiefhaber, H. Kuesters, J.J. Schmidt, H. Bachmann, B. Krieg, E. Stein, D. Thiem and K. Wagner (KFK-969, EUR 4173 E)

Influence des incertitudes dans les données neutroniques sur quelques paramètres caractéristiques d'un réacteur à neutrons rapides, by J.Y. Barre

Utilisation d'expériences intégrales pour améliorer le jeu de sections efficaces Cadarache - Jeu version 2 - Application à Phénix, by J.Y. Barre, J. Ravier

Measurement of fission cross section ratios Pu 239: U 235, U 233: U 235, by E. Pfletschinger; F. Köppeler

Trends in Neutron Total Cross Section Data, by S. Cierjacks

Variation of the Binary-to-Ternary Fission Ratio for U 235 in the Resonance Region, by A.J. Deruytter, C. Wagemans

Progress Report (November 1968 to July 1969 inclusive), by T. Momota, F. Fuketa and K. Okamoto

Japanese List of Requests for Measurement (September 1969)

Evaluation of Pu 239 data in keV and resolved resonance region (JAERI 1162), by C. Durston and S. Katsuragi

Progress Report to EANDC from Danish AEC Research Establishment Risø, by H. Bjerrum Møller (March 1969)

Progress Report to EANDC from Spain

Progress Report to EANDC from Greece, by M. Dritsa (Sept. 1969)

Progress Report to EANDC from Norway
(OR)89-L  Progress Report to EANDC from Turkey
(OR)90-L  Progress Report to EANDC from Switzerland, by T. Hürlimann (June 1969)
(OR)91-L  Progress Report to EANDC from Portugal, by F. Gamma Carvalho (August 1969)
(OR)92-L  Neutron elastic scattering cross section experimental data and optical model cross section calculations, by B. Holmqvist and T. Wiedling

(f) U.K. Documents — EANDC(UK)-X

(UK)110-AL  U.K. Nuclear Data Progress Report up to mid-1968, by E.R. Rae
(UK)111-AL  Gamma-ray spectrometric measurements of the capture cross section of gold-198 for reactor neutrons, by M.J. Cabell and M. Wilkins
(UK)112-AL  The low energy scattering cross section of B 10, by A. Asami and M.C. Moxon (AERE-R 5980)
(UK)113-AL  The neutron capture cross section of U 238 in the energy range 0.5 to 100 keV, by M.C. Moxon (AERE-R 6074)
(UK)114-AL  Slow neutron scattering by deuterium, D2O and oxygen, by J.S. Story
(UK)115-U  Energy released in fission, by M.F. James (AEEW-M 863)
(UK)116-U  An evaluation of the neutron cross section data for zirconium and its stable isotopes, in the resolved resonance range, by J.S. Story and A.L. Pope (AEEW-M 921)
(UK)117-U  The thermal neutron absorption cross sections, resonance integrals and resonance parameters of silicon and its stable isotopes, by J.S. Story (AEEW-M 933)

(g) Documents from the United States — EANDC(US)-X

(US)120-U  Reports to the AEC Nuclear Cross Sections Advisory Committee, compiled by M.S. Moore
(US)121-U  Proceedings of Conference on Use of Computers in Experimental Nuclear Physics, Skytop, Penn., March 1969. (This document will not be available until late November)
Reports to the NCSAC, Houston, Texas

Résumé of impressions of the Skytop Conference Conference on computer systems in experimental nuclear physics, Skytop, Penn., 3-6 March 1969

The alpha half-life of U 234, by J.W. Meadows

Determination of the Branching Ratio of Be 7, by W.P. Poenitz and A. Devolpi

The Thermal Absorption Cross Section of Li 6, by J.W. Meadows and J.F. Whalen

Multilevel parameters for the Pu 239 Fission Cross Section from 40 to 100 eV, by P. Lambropoulos

Measurement of the Cross Section Ratios of U 235 (n, f), U 238 (n, γ) and Pu 239 (n, f) in the Energy Range 130-1400 keV, by W.P. Poenitz

Gamma-ray Production Cross Sections for Nitrogen and Oxygen, by V.J. Orphan and C.J. Hoot, January 1969 (GA-8005)

High Resolution Measurements of the Total Cross Sections of Nitrogen and Iron, by A.D. Carlson and R.J. Cerbone, March 1969 (GA-9147)

Fission Barrier and Transition State Spectra for Th 232, Th 234, U 238, U 239, Pu 242 and Pu 244 from (t, pf) reactions, by J.D. Cramer (LA-4198)

Preliminary isotope inventory, October 1969
APPENDIX 2

FANDO—SUB-COMMITTEE ON STANDARDS FOR NEUTRON MEASUREMENTS

Report of the Meeting held at Bournemouth (October 8, 1969)

J. SPAEPEN

There were present: Batchelor, Beckurts, Hanna, Havens, Rae, Smith, Spaepen (Chairman).

The following agenda was adopted:

1. Neutron flux standards in the 1 - 100 keV region (Rae)
2. Neutron flux standards above 100 keV (Spaepen)
3. Precise thermal data (Hanna)
4. Compilation of standard cross sections (Spaepen)
5. Isotopic standards (Spaepen)
6. Miscellaneous

Although during the last few years important new work has been accomplished (such as Li and B cross sections below 100 keV and n-p cross sections at higher energies) the accuracy needed for some requested measurements has not yet been reached. Plans for improvement of standards and of the methods by which they have to be applied have been mentioned (e.g. H total cross section down to 40 keV).

1. Flux standards 1 - 100 keV (Rae)

\[ B_{10}(n,\alpha) \]

The \( B_{10} \) absorption cross section, as determined from the difference between the total cross section measurements of Diment and the scattering measurements of Asami and Moxon, is found to deviate by \( \sim 5\% \) below the \( 1/\nu \) law in the energy range 20 - 30 keV, returning to the \( 1/\nu \) curve at around 100 keV. Thus the statement in an earlier report of the Standards Sub-Committee that the cross section follows the \( 1/\nu \) law to \( \pm 5\% \) was essentially correct. The cross section is now thought to be known to an accuracy \( \leq 2\% \) below 10 keV, the accuracy falling to \( \sim 6\% \) at 100 keV.
**Li**$^6$ (n, α)

The Li$^6$ absorption cross section has been determined by Uttley from a theoretical fit to an accurate total cross section measurement. The structure of the Li$^6$ cross section is extremely simple compared to that of B$^{10}$, which permits an easy interpretation of the shape of the cross section below 100 keV in terms of a 1/ν component, a potential scattering component, the tail of the p-wave resonance at 250 keV, and a very small "Shapiro constant" in the reaction cross section. Uttley regards the Li$^6$ cross section as forming a much better basis for a standard than that of B$^{10}$ on account of its simple structure, and estimates that his fitting procedure gives the shape of the Li$^6$ cross section to ≤ 3% up to 100 keV, and the value at thermal energy as 940 ± 3 b. This latter value has now been confirmed by Meadows and Whalen, who obtain the value 934 ± 6 b.

Using Uttley's determination of the Li$^6$ cross section, together with the B$^{10}$/Li$^6$ ratio measurements of Sowerby and Patrick, gives independent information on the shape of the B$^{10}$ absorption cross section. This confirms the departure from 1/ν in the 20-30 keV region and agrees with the α/γ measurement within the errors of the measurements.

We note with interest that a second accurate high resolution measurement of the total cross section of Li$^6$ is planned at ANL. At Geel it is planned to use detection of the α-particles from B$^{10}$ (n, α) and Li$^6$ (n, α) to perform a direct ratio measurement of the two cross sections, possibly using the Harwell booster as a pulsed neutron source to minimise gamma flash problems. At Harwell, the B$^{10}$-vaseline sphere detector has been constructed and angular distribution measurements on the γ-rays from the B$^{10}$ (n, αγ) reaction are starting.

**Fission cross sections**

While recognising that the fluctuations in the U$^{235}$ (n, f) cross section render it rather unsuitable for use as a standard, the sub-committee felt reluctant to drop the use of a fission cross section as a subsidiary standard on account of its simplicity in practical use. Consequently it was felt that it might be worth considering the substitution of U$^{233}$ for U$^{235}$ in this role. This cross section should be relatively free from intermediate structure because both of its spin states have fully open fission channels. If U$^{233}$ is to be used as a standard, however, its cross section will have to be carefully studied.

**Poenitz Grey Detector**

Two new measurements have been made at ANL and Chalk River of the Be$^7$ branching ratio following the Li$^7$ (p, n) reaction. These are confirmed by the preliminary measurements from Geel thus removing the source of uncertainty in the calibration of the Grey Detector. This has now been calibrated...
over the energy range from 30 keV to 1.6 MeV and the resulting points agree with the theoretical efficiency curve to ±3% (Nucl. Instr. Meth. 72, 120, July 1969).

2. Flux above 100 keV (Spaepen)

New measurements have been performed by Langford and Clements of the neutron-proton total cross section in the energy range between 0.8 to 5.8 MeV, with an accuracy between about 0.3 and 0.5%. The results bear out those of Engelke et al. at Columbia in lying about 0.7% higher than the earlier data. The new values are given in the following table.

<table>
<thead>
<tr>
<th>Energy (MeV)</th>
<th>Cross Section</th>
<th>Statistical Error</th>
<th>Systematic Uncertainties</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8408</td>
<td>4.690</td>
<td>0.005</td>
<td>0.008</td>
</tr>
<tr>
<td>1.1615</td>
<td>3.947</td>
<td>0.004</td>
<td>0.007</td>
</tr>
<tr>
<td>1.4535</td>
<td>3.493</td>
<td>0.004</td>
<td>0.008</td>
</tr>
<tr>
<td>1.7503</td>
<td>3.156</td>
<td>0.003</td>
<td>0.007</td>
</tr>
<tr>
<td>2.0453</td>
<td>2.893</td>
<td>0.003</td>
<td>0.008</td>
</tr>
<tr>
<td>2.3463</td>
<td>2.674</td>
<td>0.003</td>
<td>0.007</td>
</tr>
<tr>
<td>2.7188</td>
<td>2.439</td>
<td>0.003</td>
<td>0.007</td>
</tr>
<tr>
<td>3.3239</td>
<td>2.154</td>
<td>0.003</td>
<td>0.007</td>
</tr>
<tr>
<td>4.3746</td>
<td>1.796</td>
<td>0.003</td>
<td>0.007</td>
</tr>
<tr>
<td>5.8581</td>
<td>1.455</td>
<td>0.003</td>
<td>0.008</td>
</tr>
</tbody>
</table>

Work is under way on an alternative detector which it is hoped will enable measurements to be made down to 100 keV.

The authors have submitted a letter to Physics Letters concerning the reported oscillations in the n-p total cross section, showing that if such oscillations are present, their magnitude must be less than 6 mb. Results obtained by Liskien and Paulsen at Geel, by Cierjacks at Karlsruhe and further at NBS did not show such oscillations either.
\( C(n, n) \) and \( C(n, T) \)

Geel (Knitter and Coppola) has available \( C(n, n) \) angular distributions between 0.75 and 2 MeV, obtained by comparison with \( H(n, n) \). Data are being completed down to 500 keV.

ANL (Meadows and Whalen) has obtained the total cross section of carbon between 0.1 and 1.5 MeV with an accuracy of 3%. Utley at Harwell has measured the same cross section between 100 eV and 10 MeV. Rae will ask Utley to draft the results of this work in a final form.

\( U_{235} (n, f) \) and \( Pu_{239} (n, f) \)

The new measurements obtained by Poenitz (ANL) and Pfletschinger et al. (Karlsruhe) were discussed by the full Committee (see item 2 (c)).

3. Precise thermal data (Hanna)

Regarding precise thermal values, the sub-committee took note of the recent measurement of Li 6 \( (n, \alpha) \) by Meadows (EANDC(US)-126) who obtained a value of 938 \( \pm \) 4 b by a neutron pulse decay method using separated Li 6 (or 934 \( \pm \) 6 b if the result obtained with natural lithium is included); previously this important cross section was uncertain by about \( \pm \) 3%. Meadows' result is in excellent agreement with the value of 940.3 \( \pm \) 3.2 b obtained from linac measurements at AERE (EANDC 81 page 35).

In a similar experiment Meadows obtained a value of 3855 \( \pm \) 26 b for the thermal B 10 \( (n, \alpha) \) cross section, which agrees with the more precise Geel evaluation 3834 \( \pm \) 5 b (\( \gamma \) error). Hanna presented the results of the revised IAEA least squares fit of 2200 m/s data for \( U_{233} \), \( U_{235} \), \( Pu_{239} \), and \( Pu_{241} \). They agree with the earlier (1965) fit within the errors of that set. For \( Pu_{241} \), new experimental measurements have led to a significant improvement in the accuracy, but for the other three nuclei the errors of most of the output values have not improved much because the effect of some new accurate measurements has been offset by increases in the uncertainties assigned to \( \gamma \)-decay half lives and to the \( g \) factor of \( Pu_{239} \). The methods of chemical analysis for Uranium in use at Geel (CPC, isotopic dilution, weighing of vacuum evaporated sources) on the accuracy of which the \( U_{234} \) half life depends (as on the other hand on low geometry and liquid scintillation counting), are being checked by an international comparison. These samples standardized by alpha counting are being sent to other laboratories for Uranium mass determination. Work has already started at Chalk River, and Idaho Falls will receive samples shortly.
The spread of $U_{\text{total}}$ (Cf) values is even wider than in 1965: they range from $3.830 \pm 0.037$ (Asplund - Nilsson et al. 1963) to $3.700 \pm 0.020$ (Axton et al. 1969). The necessarily arbitrary treatment of this very discordant set of data gives a weighted-mean input value of $U_{\text{total}}$ (Cf) of $3.743 \pm 0.016$ and the output value $3.765 \pm 0.010$ (in the table of recommended values all errors are increased by 12.5% and this error becomes $\pm 0.012$). Omitting all absolute $U$ measurements from the input data (i.e. relying entirely on $\eta$ measurements for absolute neutron emission probabilities) leads to $U_{\text{total}}$ (Cf) = $3.784 \pm 0.014$.

The IAEA least-squares fit (LSF) assumed a value of $2.488 \times 10^5$ for the $U$ 234 half-life, but recent measurements at Geel reported by Spaepen, and at ANL by Meadows (EANDC-US)-124) strongly indicate a value of $2.44 \times 10^5$. Making this change would increase Deruytter's 1968 measurement of $\sigma_f$ (235) by 2% (i.e. to $589 \pm 5$ b), and the LSF output value by about 1 b (from $580.2 \pm 1.8$ b). A similar 2% decrease in the $U$ 233 half-life would further increase the LSF value by about 1 b. Hanna pointed out that a value of $\sigma_f$ (235) as high as $589$ b would be very difficult to reconcile with the apparently well established (transmission) measurements of $\sigma_{\text{total}}$ (235) or (because of the accurate $\sigma_f$ ratio data) with $\sigma_{\text{total}}$ (235). On the other hand the very preliminary Geel result for $\sigma_f$ (239) is not in disagreement with the LSF value.

4. Compilation of standard cross sections (Spaepen)

The sub-committee has taken note of the compilation of the total cross section of carbon by a Japanese Group and the members will report to the Chairman after they have had the opportunity of studying the compilation in detail.

5. Isotopic standards (Spaepen)

The NBS is preparing a series of depleted isotopic standards of uranium.

6. Miscellaneous

The sub-committee would like to see a symposium organised, devoted to the assessment of what has been accomplished in recent years and to help to define the needs for the future. Such a symposium would have to be held just before an EANDC-meeting. The attendance should be of the order of 30 people. It would probably refer to the $1 - 1000$ keV-region.