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NEUTRON DATA COMPILATION

REPORT OF A PANEL
SPONSORED BY THE
INTERNATIONAL ATOMIC ENERGY AGENCY
AND HELD IN BROOKHAVEN,
10-14 FEBRUARY 1969

A TECHNICAL REPORT PUBLISHED BY THE
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FOREWORD

The IAEA organized and convened a Panel on Neutron Data Compilation. This Panel was organized by the Agency following the recommendations made by the International Nuclear Data Committee (INDC) which agreed that a general review of world neutron data compilation activities was desirable.

In this context neutron data compilation encompasses the collection, storage and dissemination of bibliographic information and of qualitative and numerical data on the interaction of neutrons with nuclei and atoms for all incident energies. Such information and data have important applications in low energy neutron physics and many important areas of nuclear technology.

The principal objective of the Panel on Neutron Data Compilation, which was held at Brookhaven National Laboratory during 10-14 February'69, was to review how the world's principal data centers located at Brookhaven, Saclay, Obninsk and Vienna could ideally meet the demands and needs of experimental and theoretical neutron physicists, evaluators, reactor physicists as well as other existing and potential users. This Panel consisted of 31 scientists drawn from 12 countries, the European Nuclear Energy Agency (ENEA) and the IAEA.

Fourteen papers were considered during formal sessions of the Panel and are reported on the following pages. The members of the Panel separated into five working groups to consider specific terms of references and make recommendations. Their reports were discussed by the full Panel and, after amendment and editing at the meeting and by correspondence, constitute the substance of the final Panel report. This final report is expected to be published in Technical Report Series before the end of 1969 and will include general findings, conclusions and recommendations of the Panel.

Summaries of the Panel meeting will be submitted to the journals: "Nature", "Physics Today" and "Vestnik of the Academy of Sciences of the Belorussion SSR".

The Agency has decided to issue this informal publication containing all the available papers presented at the Panel. The texts of these papers have been supplied by the authors, and no editing has been done by the Agency. A closer study of these papers is recommended to specialists in neutron data compilation and related fields and to the principal data centers.

The Agency would particularly like to thank the authors of the papers for their valuable contributions to the Panel and the authorities of the Brookhaven National Laboratory who extended their hospitality to the meeting. The unfailing devotion and tireless efforts of the BNL staff concerned was of great help to the Panel participants before, during and after the formal meeting.

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Neutron Data Compilation - Progress in the Sixties and Questions for the Seventies

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Abstract

The task before the Panel is related on the one hand to different types of scientist concerned with neutron data in and for reactor design and on the other to the way the world's principal neutron data centres have developed during the sixties. The variation in time and intensity of the impact of computer developments on various stages of the neutron data acquisition and application process is noted as are some of the differences in responsibilities and methods of working of the centres. The paper concludes by listing some questions relating to the future of neutron data compilation in general and the centres in particular.

1. The Task Before Us

The Panel on Neutron Data Compilation has been called together at the suggestion of the International Data Committee (INDC) to provide a forum at which representatives of the world's principal neutron data centres at Brookhaven, Obninsk, Saclay and Vienna and of their users can together examine how these centres can ideally meet the demands and the needs of those who measure neutron cross sections, of evaluators, of reactor physicists and of others.

The present Panel is not the first of its kind although it is possibly the most representative, certainly on a geographical basis. Whenever scientists interested in neutron physics and its applications meet together, which is pretty often nowadays, the question of neutron data compilation is likely to be discussed although often in a nebulous and inconclusive way. Here there is a need to reach rather firm conclusions and make recommendations to the Agency, the centres and other interested parties. The need to produce an agreed report by the end of the week should provide the necessary discipline. Nor should the task be as difficult as some may imagine. Those who attended the European-American Nuclear Data Committee (EANDC) Compilations Study Group meetings at Winfrith in October 1962 and at Brussels in September 1963, which led to the inauguration of the Centre de Compilation de Données Neutroniques (CCDN) at Saclay, will agree that the job can be done.

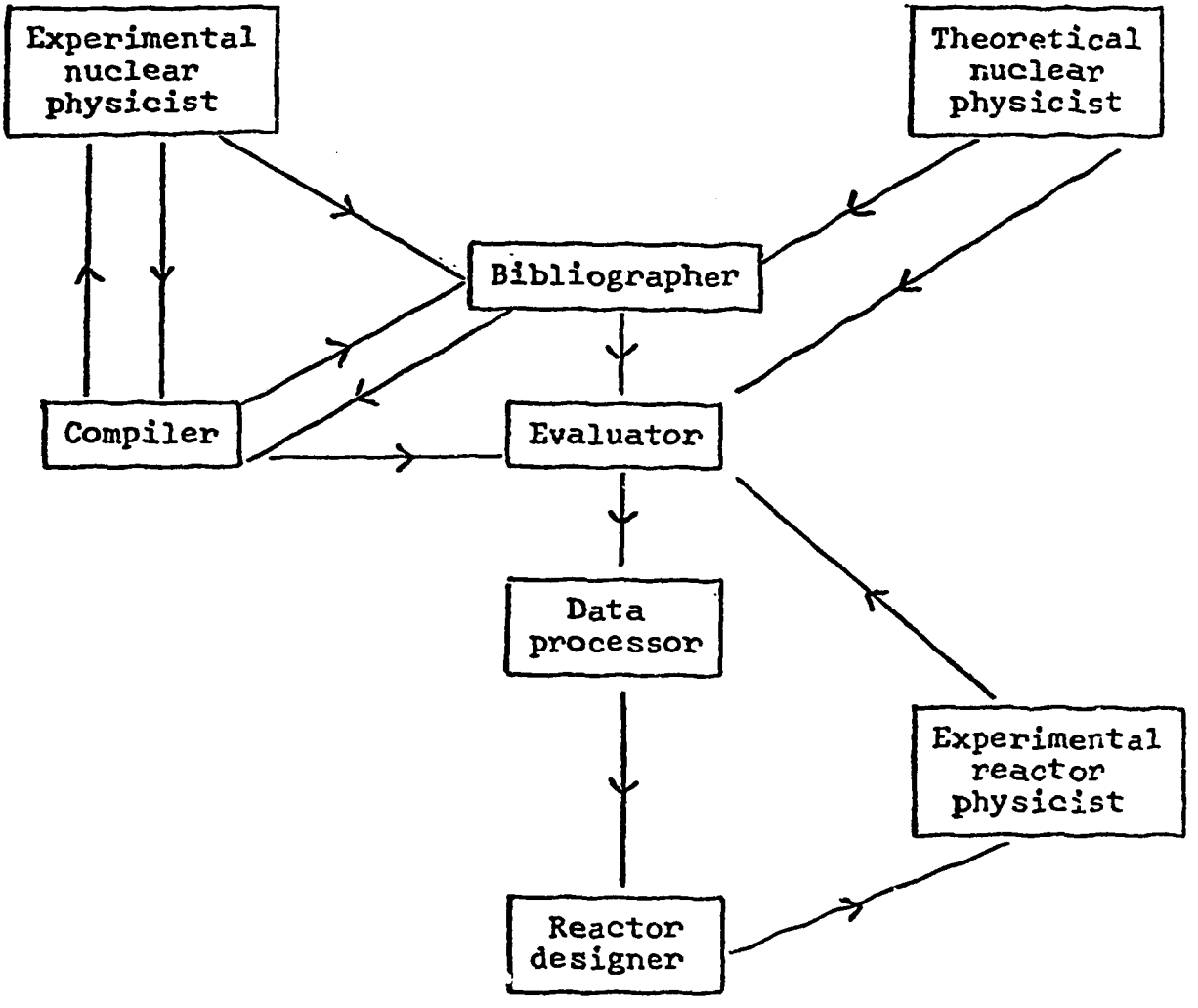
The task before us can be more clearly defined by taking a brief look at the way the four principal neutron data compilation centres have developed, their similarities and differences and the way in which computer developments have influenced their work and neutron physics in general.

2. Why Compile Neutron Data?

The need to meet neutron data requirements of nuclear technologists, particularly reactor designers has provided the basic driving force leading to the evolution of the world's principal data centres in the form we know them today. In a paper considered at the EANDC Compilations Study Group meeting held at Winfrith in 1962 I attempted to enumerate the different types of scientist concerned with neutron data in and for reactor design. Ten different types were identified, notwithstanding the inclusion of compilers and evaluators - as we know them today - under the same head! How does the picture look in 1969? The reactor designer is still predominantly concerned with the neutron economy of his designs and uses both deterministic and statistical methods of calculation which are capable of very high accuracy, given powerful computers and sound neutron data. It is seldom that evaluated neutron data can be used directly in calculations; they must be processed to give (energy) group cross sections or other forms required

by the neutronics codes. After the reactor physicist had harnessed the computer and passed from one or two group calculations to multigroup calculations the data processer, concerned with the preparation of neutronics data, also turned to computers-for aid. In turn there arose a need for computer readable libraries of neutron cross section data on punched cards or magnetic tape; the evaluator came into his own. Not only had the evaluator to assess and reconcile often conflicting experimental and theoretical evidence; he had also to ensure that his data sets were logically complete so that the ultimate fate of any neutron in any medium could be calculated. This involved estimating unmeasured quantities and ensuring the internal consistency of the evaluated data - partial cross sections summing to totals, energy conservation and so on. An important test of evaluated cross sections is provided by comparing the measured and calculated properties of simple critical and sub-critical assemblies - integral systems studied by the experimental reactor physicist. Only gradually has the evaluator become heavily involved with computers. Probably his first indirect contact was in his use of results and methods provided by the theoretical nuclear physicists. Gradually the use of such tools as the nuclear optical model and the Hauser-Feshbach theory of partial cross sections has become routine. The recording of his information sources has passed from the notebook/filing card stage to the computer produced index, CINDA. Experimental data are available on magnetic tape in SCISRS as a result of the work of the compiler, now to be distinguished from the evaluator and perhaps logically from the bibliographer, responsible for CINDA and similar material. Now with the development of computer graphics the computer is beginning to make a real impact on the core of the evaluator's work. Last, but by no means least, is the experimental nuclear physicist, the source of the compiler's data but sometimes only a minor user of his work. His increasing use of computers to multiply data output is yet another reason why the neutron data compilation centres have turned increasingly to the use of computers in their work.

In considering the work of the principal neutron data centres it seems useful to summarise the types of scientists involved directly or indirectly with their work and to consider the links between them. Perhaps the Panel will identify new types, new links and new needs; after all, that is one of its functions.



3. Development of the World's Principal Neutron Data Centres - Progress in the Sixties

Of the world's four principal neutron data centres two - Brookhaven and Obninsk - are based at strong national laboratories, one - Saclay - is an international centre with an international staff sited at a national laboratory but with its own facilities and administration, and one - Vienna - is an international centre with an international staff sited at the administrative headquarters of the International Atomic Energy Agency and sharing its computer and other facilities. It is not surprising that one detects differences in philosophy and methods.

Brookhaven has a long and distinguished history of neutron data compilation and evaluation activity stretching back to the days of Hughes and before. It was in business before computers were; their coming was not exactly painless! The changes which have taken place in recent years culminating in the formation of the National Neutron Cross Section Center in September 1967 have been in response to the data explosion and to the many and diverse needs of the centre's United States and Canadian customers, particularly

in the multitude of United States laboratories. Even now the CINDA indexing work, which certainly falls within the Panel's terms of reference, is based at the USAEC Division of Technical Information Extension (DTIE), Oak Ridge whereas the other three centres combine CINDA and compilation activities. On the other hand Brookhaven now has specific and heavy responsibilities in the evaluation field whilst at Saclay and Vienna involvement in evaluation has been minimal. It has also endeavoured, with increasing difficulty, to disseminate data by means of conventional publication - in the various editions of BNL 325 and BNL 400.

The Nuclear Data Information Centre at Obninsk exists to serve the USSR, which, like the United States, has many national laboratories. From its inception, apparently in the early sixties, the Centre has had an interest in group cross sections and has been responsible for the preparation of the well known 26-group constants used in Russian fast reactor calculations. The Centre has also published several bulletins giving neutron cross sections (and other reactor data) in tabular and graphical form. These activities are additional to the collection of experimental data and the handling of CINDA within the USSR.

A distinctive feature of the CCDN at Saclay, created in 1964, is the deliberate planning which went into its creation as an international collaborative venture following the Study Group meetings referred to in section 1. This has led to the centre being given rather precise terms of reference, which are varied from time to time on the advice of a Centre Committee. Apparently the centre's main customers are only three or four West European evaluation groups but between them they use a tremendous amount of data and provide the principal economic justification for the Centre's existence. Apart from CINDA and compilation activities the Centre acts as a distribution point for evaluations of neutron cross sections and has recently computerised the compilation of EANDC requests for neutron data measurements under the code name RENDA. It is at Saclay where many of the technical problems of exchanging data compilations first become apparent. The difficulties of translating SCISRS and similar systems across the Atlantic and between computers have been many and will no doubt be mentioned during the Panel's deliberations; indeed they should be one of our major concerns. In spite of these difficulties the Saclay Centre is now well established and enthusiastically supported. The organisation provides close links between the Centre's staff and its customers and data sources.

The fact that the Vienna and Saclay centres were both created in 1964 is not altogether coincidental. Given the existence of Saclay, Brookhaven and Obninsk it was rather natural that the International Nuclear Data Committee (INDC)* should see the need for an IAEA Nuclear Data Unit (NDU) having the dual functions of promoting co-operation

*Or rather its predecessor, the International Nuclear Data Scientific Working Group.

between the four principal neutron data centres and of collecting and disseminating references and data to IAEA member states not covered by the three other centres. (Eastern Europe, except USSR, Asia, Australia, Africa, Central and South America and IAEA itself.)

Whilst Vienna has worked along more or less exactly the same lines as DTIE and Saclay, computer differences and other considerations led the NDU to develop the free format data storage and retrieval system DASTAR for which CINDU (Catalogue of the IAEA Nuclear Data Unit) provided a bibliography and contents list. Since attempts have been made to use CINDA to indicate data contained in SCISRS, there is a certain similarity between CINDU and parts of CINDA. However CINDA currently refers to much information, often qualitative in nature, which is not readily included in SCISRS, DASTAR or any of the other data storage systems developed at Saclay, Livermore and Brookhaven. A major activity of the NDU involves working in conjunction with Obninsk to solve the machine compatibility problems in transferring data and bibliographic information between Russian and non-Russian computers. The 4-centre meetings, which are held periodically, are organised by the NDU and are producing increasing co-operation between the centres as is shown in the joint paper they have prepared for the Panel.

4. Neutron Data Compilation in the Seventies - Some Questions to be Answered

The discussion in sections 2 and 3 is far from complete. Nevertheless sufficient information is assembled there to suggest that many pertinent questions on the future of neutron data compilation may be posed by examining three areas:

(i) The different groups of scientists involved in the acquisition and application of neutron data.

(ii) The differing function of the four principal neutron data centres.

(iii) The varying degrees to which the centres and their clients and suppliers have exploited computers of varying capabilities.

Typical of such questions are the following:

1. For how long is a major neutron data compilation effort likely to be needed?

2. What are the foreseeable needs and are they capable of being met by the four principal neutron data centres as presently organisated? If not, what changes in organisation and operation merit serious consideration?

3. Are the major users of compiled data a small group of evaluators making a small number of very large demands for data?

4. In what ways can the centres be made more useful to existing customers and attract new customers without increasing the effort deployed?

5. How useful are the bibliographic activities? Can CINDA be replaced by any kind of CINDU type index to compiled data? Should bibliographic and data compilation activities be linked and in what way?

6. Should the centres be encouraged to indulge in new activities - for example, evaluation where this is not already one of their responsibilities?

7. Should the centres disseminate their in-house working codes and tapes to customers with suitable computers who wish, say, to attempt automated evaluation using SCORE type systems?

8. Can a real incentive be found which will encourage experimenters to send that data more readily (and spontaneously) to the centres?

9. Do the centres presently provide substantial services for experimenters? Might the centres prepare and disseminate best values of standard cross sections as such a service (the IAEA Panel on Nuclear Standards needed for Neutron Cross Section Measurements, May 1967, recommended that IAEA continue and extend support for standard cross section evaluation work)?

10. How can the format of data tapes supplied to customers be standardised and maintained for a reasonable time, allowing for computer hardware and software changes by the centre concerned and by the customer and changes in the inter-centre exchange arrangements?

11. Is it possible to devise a logical complete scheme of definition and classification for neutron cross sections which can be used for both bibliographic and data compilation purposes? Is it perhaps preferable to accept a less complete system capable of dealing with most reactions and, say, 99.9% of all data points?

12. How far should descriptions of compiled data duplicate information readily available in the literature bearing in mind the disproportionate effort possibly required for its inclusion on data tapes? In other words should the data centres concentrate their effort on the <u>numerical</u> data, increasingly voluminous and increasingly unavailable in normal publication media?

13. What kind of conventional publication work - newsletters, BNL 325 etc - should be undertaken by the centres in addition to supplying data on computer media (including printer listings)?

These and similar questions are the ones which the Panel must try and pose - to try and answer!