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**INTERNATIONAL NUCLEAR DATA COMMITTEE**

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CO-ORDINATED RESEARCH PROGRAMME  
ON MEASUREMENT AND ANALYSIS OF 14 MeV NEUTRON NUCLEAR DATA  
NEEDED FOR FISSION AND FUSION REACTOR TECHNOLOGY

Summary Report  
of the Third and Final Research Co-ordination Meeting  
organized by the  
International Atomic Energy Agency  
and held at Interuniversity Centre, Dubrovnik, Yugoslavia  
26-31 May 1986

Prepared by  
M.K. Mehta  
Nuclear Data Section  
International Atomic Energy Agency

June 1986

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**IAEA NUCLEAR DATA SECTION, WAGRAMERSTRASSE 5, A-1400 VIENNA**



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## I. Summary of the Meeting

### Introduction

The third and final Research Co-ordination Meeting (RCM) of the participants in the IAEA Co-ordinated Research Programme (CRP) on Measurement and Analysis of 14 MeV Neutron Nuclear Data needed for Fission and Fusion Reactor Technology was convened by the IAEA Nuclear Data Section at Dubrovnik, Yugoslavia, during 26-31 May 1986. The Ruder Boskovic Institute of Zagreb was the host, who also organized an International Conference on Fast Neutron Physics concurrently with the meeting. This Conference was co-sponsored by IAEA. The RCM was run by the Scientific Secretary M.K. Mehta with the assistance of the local organizing committee and the local secretary D. Miljanic.

### Objectives

The objectives of this co-ordinated research programme are the measurement and analysis of scattering and reaction cross sections and of secondary particle energy and angular distributions for 14 MeV neutrons available from neutron generators via the  $^3\text{H}(d,n)^4\text{He}$  reaction. The measurements are to be made on elements and their isotopes which are the constituents of fission and fusion reactor structural, coolant, absorber, shielding, reprocessing and neutron flux/fluence monitoring materials.

The principal objectives of this third and final Research Co-ordination Meeting (RCM-III) were; to discuss and evaluate the final results of the measurement and analysis carried out by the participant laboratories, prepare final reports on all fast neutron nuclear cross sections measured under this CRP, review the status and remaining gaps in the need for such data and if necessary define the scope of a new CRP to fill these gaps.

### Organization of the meeting

The Agenda for the meeting followed the previous practice and is listed in Appendix I.

Also following the practice established at the previous RCM's, the Ruder Boskovic Institute organized concurrently with this meeting an International Conference on Fast Neutron Physics. The combined programme of the RCM and the Conference spanned four and a half days. A boat excursion was arranged on the free afternoon followed by a dinner hosted by the Institute.

The programme of the concurrent Conference on Fast Neutron Physics included invited and contributed papers on the following topics: models for neutron reactions, data for biomedical applications, few body studies, techniques and neutron sources and fast neutron reactions. As all the topics relevant to the CRP were covered in this Conference programme, and as this was the final RCM of the CRP, the RCM programme was totally devoted to the CRP activities, consisting of presentation and discussion of the final reports from individual participating laboratories, presentation and discussion of the drafts of the final reports of the working groups and discussion and approval of conclusions and recommendations. This programme was distributed over ten sessions.

The activities of the CRP have been co-ordinated through the following five working groups:

- |                      |   |
|----------------------|---|
| (1) Working Group A  | Activation Measurements<br>Chairman - J. Csikai   |
| (2) Working Group B  | Charged particle emission cross section measurement<br>Chairman - H. Vonach                         |
| (3) Working Group C1 | Double differential neutron emission cross section measurements<br>Chairmen - K. Seidel/D. Seeliger |
| (4) Working Group C2 | Prompt gamma ray measurement<br>Chairman - P. Oblozinsky  |
| (5) Working Group D  | Nuclear reaction model calculations<br>Chairman - A. Marcinkowski                                   |

All the chief scientific investigators had sent their final reports and results to the respective chairmen of the Working Groups well before this RCM as decided at the RCM-II at Chiang Mai last year (Summary Report of RCM-II INDC(NDS)-172/GI) to enable each chairman to prepare drafts of the final reports which were presented and discussed. These reports will be published under the IAEA TECDOC series as they are likely to be used by the scientific community as reference material.

About hundred activation cross section measurements are reported in the W.G.A report. Some of the data have to be corrected for the latest values of the decay life times of the concerned activities, and minor adjustment is required in a few cases. All the measurements are very relevant to the latest WRENDA list, filling many gaps and have considerably improved the data status for these isotopes. However, there is still need for (n,n' $\alpha$ ) type of reaction cross section measurements especially at other energies. According to the report of the W.G.B, as a result of the charged particle emission cross section measurements reported under the CRP the status of data required for calculation of gas production in structural and blanket materials is now very good and no important gaps are remaining in the availability of good quality data for this purpose. The report of the W.G.C1 will contain, in addition to all the neutron spectrometry data measured under the CRP, recommended sets of data on neutron emission spectrum from natural lead under 14 MeV neutron bombardment and differential cross sections for elastic and inelastic neutron scattering from carbon at 14 MeV bombarding energy. These recommended data would be useful as reference standards to those new laboratories who are starting such work. The report points out that there are still many gaps and more work is necessary. The reports of W.G.C2 and D include appraisals of the work done under the CRP and reviews of the current status and recommendations for further work.

#### Meeting attendance

During the final year there have been nine research contracts and seven research agreements under this CRP. The Institute of Atomic Energy, Beijing

joined the CRP with a research agreement during 1985. Fifteen chief scientific investigators or their nominees participated at the meeting. One research contract holder could not participate due to unavoidable local circumstances. One consultant was invited by the Agency to participate who was a research agreement holder during the first two years of the CRP and whose contribution to the discussions at the final meeting was desirable. A number of attendees of the International Conference on Fast Neutron Physics also attended the RCM sessions. The total number of participants at the Conference (including 16 RCM participants) was 65. The list of RCM participants is given in Appendix II. The Appendix III lists the participants at the Conference including those who attended the RCM-III.

## II. Meeting programme

The programme of the RCM was distributed over the following ten sessions:

- |              |   |
|--------------|---|
| Session I    | Adoption of agenda<br>Discussion of formats of the reports<br>Chairman - M.K. Mehta                                   |
| Session II   | Reports from participating laboratories: Austria,<br>Bangladesh, China, Czechoslovakia, FRG<br>Chairman - A.M. Ghose  |
| Session III  | Reports from participating laboratories: GDR, Hungary,<br>Morocco, Malaysia, Pakistan, Poland<br>Chairman - H. Vonach |
| Session IV   | Reports from participating laboratories: Viet Nam,<br>Thailand, USA, Yugoslavia<br>Chairman - H. Vonach               |
| Session V    | Report of Working Group A<br>Chairman - J. Csikai   |
| Session VI   | Report of Working Group B<br>Chairman - H. Vonach   |
| Session VII  | Report of Working Group C1<br>Chairman - K. Seidel  |
| Session VIII | Report of Working Group C2<br>Chairman - P. Oblozinsky  |
| Session IX   | Report of Working Group D<br>Chairman - A. Marcinkowski   |
| Session X    | Plenary: Conclusions & Recommendations<br>Chairman - M.K. Mehta   |

### III. Conclusions

The participants of the RCM agreed on the following conclusions and recommendations:

(1) The two main objectives of the CRP were to improve the status of the 14 MeV neutron nuclear data required for fission and fusion reactor technology and to bring about transfer of technology of fast neutron cross section measurements to a few laboratories in the developing countries. Judging by the reports from individual laboratories and final reports of the five working groups the CRP has been very successful in fulfilling these objectives to a considerable extent.

The cross sections measured under the CRP are very relevant to the WRENDA request list. A few of the data measured under the CRP have been evaluated and are already included in the evaluated data files of one of the nuclear data centres which is a part of the international nuclear data centres network.

(2) The numerical data produced as a result of this CRP will be contained in the final reports of the five working groups, which will be prepared by the respective chairmen based on the inputs from individual laboratories and the discussion at the final RCM. The reports contain a critical appraisal of the work with a recommended set of data in a few important cases and general conclusions regarding the improvement in the status of data. These reports will be published by the IAEA in the TECDOC series and are expected to be used by the scientific community as reference material.

(3) Working Group A. All the results have been by now submitted to the chairman who will prepare a draft of his final report before the end of June which will be circulated amongst the participants by NDS and comments and suggestions by the participants if any will be incorporated into the final report.

(4) Working Group B. After a few results which have still to be submitted to the chairman (first year report from LLL, fission results from Debrecen and Beijing), the draft report will be prepared. This draft will be circulated amongst the respective participants before final publication.

(5) Working Group C1. The chairman has still to receive the copy of the final report from LLL which will be sent to him through NDS. He will also receive a set of recommended data for the neutron differential cross section of carbon from LLL. The report will consist of numerical data produced under the CRP and/or summary of progress achieved at individual laboratories, guidelines for double differential neutron emission cross section measurements and recommended data for neutron emission spectra from lead and neutron differential cross section data for carbon under 14 MeV neutron bombardment. For this purpose the latest data from Osaka, and IRK data of 1980 which will be sent to the chairman before the end of August, will also be included.

(6) Working Group C2. This report as summarized by the chairman was approved and it was agreed that there was no need to circulate a draft report before publication.

(7) Working Group D. The report as presented by the chairman was accepted.



#### IV. Recommendations

##### (1) Follow up CRP

(a) The participants noted that as a result of this CRP large numbers of cross sections have been measured through activation techniques. However, there is still need for measurements of the cross sections for reactions of type  $(n, n'\alpha)$  where  $\alpha$  could be proton or alpha particles. Similarly there is need for cross section measurement for isomeric states production. These measurements could be made with activation technique but are a little more difficult. These cross sections are needed at 14 MeV as well as lower neutron bombarding energies.

(b) Similarly as noted in the report of the Working Group C there are still large gaps in the data for double differential neutron emission cross sections. The data are needed both to understand the reaction mechanism and for applications in fusion reactor technology. The need is for data at 14 MeV as well as lower neutron energy.

(c) The participants were of the unanimous opinion that the transfer of technology of high quality nuclear cross section measurements, one of the objectives of the current CRP, has been a very successful result of the CRP. However, the participating laboratories from the developing countries were just beginning to make such measurements now and need continued interaction with their peers from the advanced laboratories. A discontinuation of coordinated research programme at this stage will affect them adversely and will considerably slow down their progress towards generating highly trained manpower and establishing the core of the infrastructure required for an applied research programme in nuclear techniques.

Considering all the three points together the participants came to a conclusion that a follow up CRP, smaller in number of participants and with very specific programme goals may be established which will fulfill the needs expressed in (a) & (b) above and at the same time provide appropriate incentive and technical help to the participant laboratories from the developing countries as discussed in (c).

The scope of the CRP should be limited to measurement of  $(n, n'p)$  &  $(n, n'\alpha)$  reaction cross sections, cross sections for isomeric productions, and double differential neutron emission spectra under neutron bombardment of specified materials. These measurements should be carried out at 14 MeV but those laboratories who have appropriate facilities should do this at lower neutron energies, especially in the energy region of 8-12 MeV. It will be most appropriate to start this CRP during 1987.

It is recommended that the INDC may approve this proposal for such a follow up CRP in principle at the forthcoming INDC meeting and the NDS may then work out the detailed scope, programme and participation of the laboratories, which may be approved by the INDC through correspondence.

##### (2) Spare parts for neutron generator

During the discussions at this and earlier RCM, it was realised that many of the laboratories from developing countries were experiencing serious technical problems especially due to lack of availability of spare parts from the

original suppliers of the neutron generators. The participants were informed that there was a working paper to be discussed at the forthcoming INDC meeting on this subject prepared by Dr. G. Paic, the content of which were discussed during the working group sessions at the RCM. The participants strongly supported the recommendations in that paper.

Co-ordinated Research Programme on Measurement and Analysis of 14 MeV  
Neutron Nuclear Data needed for Fission and Fusion Reactor Technology  
Third & Final Research Co-ordination Meeting, Dubrovnik, 26-30 May 1986

Adopted Agenda

1. Opening statements, announcements, adoption of agenda
2. Reports from CRP participants
3. Presentation and adoption of draft reports of Working Group  
chairmen
4. Conclusions and recommendations

Co-ordinated Research Programme on Measurement and Analysis of 14 MeV  
Neutron Nuclear Data needed for Fission and Fusion Reactor Technology  
Third & Final Research Co-ordination Meeting, Dubrovnik, 26-30 May 1986

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Dr. Haight attended as a consultant. Dr. Rahman participated as a nominee of Dr. Molla and Dr. Zongyuan was a nominee of Dr. Li Jingwan. Dr. Garlea from Romania could not attend due to unavoidable circumstances.

Co-ordinated Research Programme on Measurement and Analysis of 14 MeV  
Neutron Nuclear Data needed for Fission and Fusion Reactor Technology  
Third & Final Research Co-ordination Meeting, Dubrovnik, 26-30 May 1986

List of Participants at the International Conference on Fast Neutron Physics  
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