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I N D C INTERNATIONAL NUCLEAR DATA COMMITTEE

Summary Report of a Technical Meeting on

COVARIANCES OF NUCLEAR REACTION DATA: GANDR PROJECT

IAEA Headquarters
Vienna, Austria
11 – 13 April 2005

Prepared by

Andrej Trkov
IAEA Nuclear Data Section, Vienna, Austria

April 2005

IAEA NUCLEAR DATA SECTION, WAGRAMER STRASSE 5, A-1400 VIENNA

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Nuclear Data Section
International Atomic Energy Agency
PO Box 100
Wagramer Strasse 5
A-1400 Vienna
Austria

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Abstract

Highlights of the technical meeting are given with respect to the detailed study of the feasibility of creating a tool for the Global Assessment of Nuclear Data Requirements (GANDR) based on sensitivity and uncertainty analysis. GANDR was concluded to be fully practical on a modern computer of the desktop class. Participants debated their requirements and formulated recommendations and proposals for implementation. Specific tasks were assigned to participants with an estimated time for their execution.

April 2005

TABLE OF CONTENTS

Introduction

When judging the adequacy of the nuclear data used as input to design-relevant *neutron transport calculations*, one finds that there is a very complex relationship between the accuracy of the input data and the accuracy of the calculated results. Because of this complexity, there is a need for computerized tools to assist data experts in the ranking of competing proposals for new measurements of nuclear data for applications. A number of research groups in the 1970s proposed the use of perturbation-theory based sensitivity and uncertainty analysis for this purpose. Progress was largely prohibited by the requirement of tracking of what seemed at the time to be an impossibly large amount of correlation information. With the enormous advances in computer technology, the equivalent of what once was considered a very powerful supercomputer facility (multi-gigabyte memories, multi-GHz processor speeds, hundreds of gigabytes of hard disk space) is now available on the desktop for under $5000. This remarkable development suggests taking a fresh look at this subject.

The GANDR project for the assessment of the impact of new experimental information on evaluated cross sections and integral parameters was initiated in 2001. The software system has been developed and installed on an NDS computer by an external consultant, and functional tests of the system were successful.

The primary objectives of the meeting were to assess the functional performance of the current version of the GANDR system, identify potential limitations, suggest extensions and advise the Agency on the prospects of utilizing the system for a consistent assessment of uncertainties in nuclear data, including the results from both differential and integral experiments and for experiment planning.

Meeting Summary

Muir presented the global overview of the design and performance characteristics of GANDR, followed by a practical demonstration in real time.

Discussions evolved about the adequacy of considering the experimental data alone and ignoring the "accumulated knowledge", whereby one can make assumptions about the variations of the uncertainties and the cross sections in energy gaps where no experimental data are available, considering that cross sections are expected to have a smooth behaviour. The use of covariance data from model calculations was suggested as a possibility for defining the "prior" information for the GANDR statistical analysis.

Vonach described the current methodology for generating covariance matrices at the University in Vienna. The details of this methodology were described at the conference on Nuclear Data for Science and Technology in Santa Fe, September 2004.

Kodeli presented some examples of the large differences in the covariance data of existing evaluated nuclear data libraries, with reference to the SINBAD database of shielding benchmarks and the SUSD-3D package for cross section sensitivity analysis.

Ignatyuk presented a brief review of differences between uncertainties in the covariance data included in the main evaluated nuclear data libraries for the most important fissile materials. There is a very strong need to understand better the reasons for such large differences.

Conclusions

The following questions were raised:

1. Do we need a global evaluation tool such as GANDR?
   - Local databases of covariance information exist in various laboratories that specialise in nuclear data evaluation. They may provide the basis for experiment planning, related to the nuclides for which the covariance data are available.
   - At present, such databases are of local nature and difficult to implement in other laboratories.

2. Should we encourage further development of GANDR?
   - The shortcoming of the current EXFOR database is that it cannot be used without a thorough review. This would impose significant manpower investment into the construction of the GANDR database. To some extent, the effort could be alleviated if evaluators would provide evaluated/corrected databases of experimental information.
   - Medium and long-range correlations cannot be implemented from the experimental data alone in the present version of GANDR. The problem could be addressed by including covariance data derived from nuclear model calculations.
   - The strong feature of GANDR is that the code can take into account integral measurements for which detailed sensitivity studies are available. Such information is valuable because additional constraints on the overall uncertainties are implemented in a consistent manner.

Possible development options include:

a) Finalise the documentation, archive the software and terminate the project.
b) Continue development to remove the shortcomings and demonstrate the applicability of the system on an example involving a small number of materials with sensitivities over a limited energy range.
c) Proceed with filling the GANDR database with the present version.

Recommendations

The participants agreed unanimously that the GANDR system has the potential to be a useful tool and the approach should be developed further. Option b) is recommended as the next step in the development of the GANDR system.

The GANDR Users' Manual should be released as an IAEA-NDS document, and the software could be made available on request.

Proposal for implementation

The goals of the exercise are to implement enhancements to the GANDR system, to partly fill the associated database (as necessary) and to demonstrate the capabilities of GANDR on a practical problem.

- Choose tungsten as the first test case because of the availability of both well-documented benchmarks and evaluated experimental data.
- Muir will revise the GANDR reaction definition tables to accommodate a more detailed treatment of the inelastic reaction, following interactions with Vonach (2 weeks).
- Vonach and Tagesen will provide the evaluated adjusted/corrected experimental database (list of EXFOR entries, comments about adjustments - if any - and the assigned covariances).
- Muir will develop tools for importing/exporting covariance matrices into/from the GANDR database (2 weeks+).
- Trkov will enter the data into the GANDR database with the help of Muir (2 weeks). Muir will implement the capability to enter elemental data (1 week).
- Kodeli will run the calculation of the FNG-Tungsten benchmark from the SINBAD database with the FENDL-2.1 library, which adopts ENDF/B-VI Rel.8 data. The deliverables are the sensitivity coefficients of the calculated monitor activities to the reaction cross sections in the GANDR database (2 weeks).
- Trkov and Muir will enter the information into the GANDR database (2 weeks).
- Trkov will use the correction factors from GANDR to adjust the cross sections from the ENDF/B-VI Rel.8 library, and generate an adjusted application library similar to FENDL-2.1 (1 week).
- Kodeli will re-run the calculations to produce updated sensitivity coefficients and an updated estimate of monitor activities, if adjustment coefficients change significantly (2 weeks).Trkov and Muir will apply the non-linear option in GANDR to update the database, if necessary (2 weeks).

- The results will be used to study the impact of the adjusted library on some important calculated performance parameter, such as heating or dose rate.

Deadlines for completion of the tasks will be determined by correspondence, subject to the approval of the project by the Agency.

Appendix 1

International Atomic Energy Agency

Technical Meeting on

Covariances of Nuclear Reaction Data
(GANDR Project)

IAEA Headquarters, Vienna, Austria

11 – 13 April 2005

Meeting Room A1246

AGENDA

Monday, 11 April

08:30 – 09:30 **Registration** (IAEA registration desk, Gate 1)

09:30 – 10:00 **Opening Session**

Opening and introductory remarks (N. Ramamoorthy, DIR-NAPC)

Election of Chairman and Rapporteur

Discussion and adoption of the Agenda (Chairman)

10:00 – 10:45 **Coffee break and Administrative matters**

10:45 – 12:00 **Session 1: Introduction to the GANDR system**

D.W. Muir

12:00 – 14:00 **Lunch**

14:00 – 15:30 **Session 2: Introduction to the GANDR system (continued)**

D.W. Muir

15:30 – 16:00 **Coffee break**

16:00 – 17:30 **Session 2 (cont'd): Introduction to the GANDR system (continued)**

Tuesday, 12 April

08:30 – 10:00 **Session 3: Presentations by meeting participants**

10:00 – 10:30 **Coffee break**

10:30 – 12:00 **Session 3 (cont'd): General discussion**

12:00 – 14:00 **Lunch**

14:00 – 17:00 **Session 4: General discussion (continued)**

Wednesday, 13 April

08:30 – 12:00 **Session 5: Drafting of recommendations**

12:10 – 14:00 **Lunch**

14:00 – 15:30 **Session 6: Final review of the recommendations**

Appendix 2

International Atomic Energy Agency

Technical Meeting on

"Covariances on Nuclear Reaction Data (GANDR Project)"

IAEA Headquarters, Vienna, Austria
11 – 13 April 2005

Meeting Room A1246

LIST OF PARTICIPANTS

AUSTRIA
Siegfried Tagesen
Institut für Isotopenforschung und
Kernphysik der Universität Wien
Währingerstrasse 17/607
A-1090 Wien
Tel: +43 1 4277 51755
Fax: +43 1 4277 51752
E-mail: Tagesen@ap.univie.ac.at

Herbert K. Vonach
Institut für Isotopenforschung und
Kernphysik der Universität Wien
Währingerstrasse 17/607
A-1090 Wien
Tel: +43 1 4277 51757
Fax: +43 1 4277 51752
E-mail: Vonach@utanet.at

RUSSIAN FEDERATION
Anatoly Ignatyuk
Institute of Physics and Power Engineering
Bondarenko Square 1
249020 Obninsk, Kaluga Region
Tel: +7-084-399-8035
Fax: +7-095-230-2326
E-mail: ignatyuk@ippe.ru

UNITED STATES OF AMERICA
Douglas W. Muir
P.O. Box 452
Kittery, ME 03904
Tel: +1 207 439 1531
E-Mail: DWMuir@mailaps.org

OBSERVER
Michal W. Herman
National Nuclear Data Center, Bldg. 197D
Brookhaven National Laboratory
P.O. Box 5000
Upton, NY 11975-5000
Tel. +1 631-3440 2802
Fax. +1 631-3440 2806
E-mail: mwherman@bnl.gov

IAEA
Ivan Alexander Kodeli
OECD NEA
Le Seine Saint Germain
12, Boulevard des îles
F-92130 Issy-les-Moulineaux
Tel: +33 1 4524 1074
E-mail: IvoKODELI@oecd.org

IAEA
Andrej Trkov
Nuclear Data Section
Division of Physical and Chemical Sciences
Room A2316
Tel. +43 1 2600-21712
Fax: +43 1 26007-21712
E-mail: A.Trkov@iaea.org

Nuclear Data Section
International Atomic Energy Agency
P.O. Box 100
A-1400 Vienna
Austria

e-mail: services@iaeand.iaea.org
fax: (43-1) 26007
cable: INATOM VIENNA
telex: 1-12645
telephone: (43-1) 2600-21710