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At the Cutting Edge of Nuclear Data Information Storage and Retrieval Systems
and its Relationship to CINDA, EXFOR and ENDF

Norman E. Holden

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Energy Sciences & Technology Department

**National Nuclear Data Center
Brookhaven National Laboratory**

P.O. Box 5000
Upton, NY 11973-5000
www.bnl.gov

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A Short History of CSISRS

At the Cutting Edge of Nuclear Data Information Storage and Retrieval Systems and its Relationship to CINDA, EXFOR and ENDF

Norman E. Holden

National Nuclear Data Center, Brookhaven National Laboratory, Upton, NY 11973

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Abstract

A short history of CSISRS, pronounced 'scissors' and standing for the Cross Section Information Storage and Retrieval System, is given. The relationship of CSISRS to CINDA, to the neutron nuclear data four-centers, to EXFOR and to ENDF, the evaluated neutron nuclear data file, is briefly explained.

1. Experimental Neutron Cross-Section Data

In early 1949, Donald Hughes came to the Brookhaven National Laboratory's Physics Department, as Head of the Neutron Physics Measurement Group, from the Metallurgical Laboratory or Met Lab (later renamed Argonne National Laboratory), where he had been the Director of the Nuclear Physics Division. In 1951, the task of compiling of neutron cross-section data was started at the Brookhaven Laboratory, with Hughes as the Director, (it was considered to be an informal supplemental activity to the neutron measurement program of Hughes). This program of collecting and collating neutron cross-section data was called the Sigma Center. When Hughes died in 1960, the Neutron Cross Section Compilation Group (Sigma Center) was moved to the Nuclear Engineering Department. At the same time, a companion group was organized, which was named the Cross Section Evaluation Group.

By 1962, the amount of information that was stored at the Sigma Center consisted of a file of half a million "IBM" machine-readable punched data cards. It was estimated that 200 000 more data cards would be added each year in the future. As a result of this large amount of data that had to be handled, a magnetic tape oriented system was proposed to place all of these data that were on punched cards onto a magnetic tape. In 1964, the "Sigma Center Information Storage and Retrieval System (SCISRS)" was created.

There was a major disadvantage to this original SCISRS system. The program had been written in machine language for the IBM 7094 computer, which was then in use at BNL. At the time that it was designed, it had not been foreseen that there would be groups, other than the members of the Sigma Center, who would wish to use the SCISRS system's output on their own laboratory's computers. This SCISRS program would not be as useful to other laboratories, that would be interested in receiving these data, but

who did not use the same machine language programming system. The next generation of the main frame computers (both with a faster speed of calculations and a larger memory capacity) were beginning to become available at the various reactor design laboratories around the USA. The IBM computers, 704, 7090, 7044 and 7094, in use at that time, were beginning to be replaced by the computers of the Control Data Corporation (CDC), the CDC-6600 machine and somewhat later the CDC-7600 machine. Among some other disadvantages of this SCISRS library and programming system were the inefficiencies in the use of space, with much repetition of the data and the limited amount of machine-recognizable information that the system contained.

By the mid to the late 1960s, work had already been underway to develop an improved system for the storage and retrieval of neutron cross-section data. By 1971, a revised program, which was called the “Cross Section Information Storage and Retrieval System or (CSISRS)” had been prepared, along with a user’s manual. A preliminary version of this revised CSISRS’ computer system had already been in use by some laboratories in the USA and elsewhere in order to input their data to the Brookhaven Cross-Section Center. By this time, the experimental neutron data library consisted of more than one million data points and the library file was continuing to expand at the rate of 120 000 additional data points each year.

Both the SCISRS system and the CSISRS system had the same pronunciation, “scissors”. This had been done purposely to try to keep the data library and system for the exchange of neutron nuclear data, among the laboratories receiving these experimental data, as transparent as possible in the transition between the two systems. Brookhaven would continue with this effort to assure users of the CSISRS data library and programming system that nothing would be changed, as far as the output of the CSISRS system was concerned, even as the effort on the international exchange of experimental neutron nuclear data was developing. In order to avoid some initial confusion for the potential users, the SCISRS program was referred to, for a time, as SCISRS-I and the improved CSISRS program was referred to during that time period as SCISRS-II or as CSISRS-II.

In addition to the SCISRS program that had been developed at Brookhaven, there were a number of different nuclear data storage and retrieval programs that were being developed elsewhere during this time period. In the 1966 to 1967 time period, the Lawrence Radiation Laboratory in Livermore, California completed the ECSIL programming system for the storage and retrieval of experimental neutron nuclear data. This ECSIL system was written in the Fortran-II (Formula Translation) language (version 2), which was not tied to a particular computer or computer system.

The major neutron nuclear data centers, see below, created their own systems for both the storage and retrieval of experimental nuclear data to be used at their centers.

In addition to this effort of compiling experimental neutron nuclear data, there had been a longstanding activity in the compilation of the bibliographic information on neutron cross sections, which was called CINDA.

In 1956, Herbert Goldstein was working at the Nuclear Development Corporation of America (NDA). He developed a scheme for keeping track of neutron cross-section measurements in the bibliographic sense. He called his machine-readable IBM punched card index, “Central Intelligence – Nuclear Development Corporation of America” or CINDA. These cards indexed both the published and the unpublished literature on microscopic neutron cross section measurements in a form such that: 1) searching for information, 2) keeping the index up to date and 3) providing periodic accumulations, could be done quickly and mechanically. By 1963, the lack of external financial support at NDA caused the index to become out of date. Goldstein renamed his bibliographic effort, the “Card Index of Neutron Data” with the same acronym and he solicited external readers to help scan the neutron nuclear data literature that was published in the major journal publications and bring CINDA back up to date. With the eventual demise of the punched IBM cards for computer input, the same acronym evolved into the “Computer Index for Neutron Data”. The scanning of the world’s scientific literature would eventually be performed via an agreement among the four major neutron nuclear data centers (see below).

2. The Neutron Nuclear Data Four-Centers

In September 1967, the Brookhaven National Laboratory merged the two groups, the Sigma (Data Compilation) Center and the Cross Section Evaluation Group to form the National Neutron Cross Section Center (NNCSC). The NNCSC was made a Division within the BNL Department of Applied Science. During the mid 1970s, the NNCSC began to include the compilation and the evaluation of nuclear structure data, as well as neutron nuclear data, within its purview. As a result of this additional activity, the name of the data center was changed to the National Nuclear Data Center (NNDC) in 1977.

In 1963, the USSR State Committee on the Utilization of Atomic Energy established the Nuclear Data Information Center, (NDIC), (which was later renamed the Nuclear Data Center - CJD), at the Institute of Physics and Power Engineering (FEI) in Obninsk, the USSR. The task of this center was to collect neutron data from all of the laboratories in the Soviet Union.

In 1964, the European Nuclear Energy Agency (ENEA) created, at the French Atomic Energy Commission’s Centre for Nuclear Studies (CEA-CEN) Laboratory in Saclay, France, (just outside of Paris), the Neutron Data Compilation Centre (CCDN) to collect neutron data measured in the ENEA countries and in Japan. This Center is now called the NEA Data Bank, an agency of the Organization for Economic Development (OECD).

Also in 1964, the International Nuclear Data Scientific Working Group, which was the predecessor of the International Nuclear Data Committee as an advisory committee to the United Nations’ (UN’s) International Atomic Energy Agency (IAEA), saw the need for and had recommended to the IAEA that it create the Nuclear Data Unit (NDU) at the IAEA administrative headquarters in Vienna, Austria with a two fold purpose; 1) to initiate and promote systematic international data exchange and 2) to establish a

compilation center for those areas of the world, which was not already collaborating in a neutron nuclear data compilation activity. Thus, this IAEA-NDU would act as liaison between the CJD and the other neutron nuclear data centers. In 1969, the NDU was renamed the IAEA Nuclear Data Section (NDS). These four neutron data centers were collectively referred to as the “four-centers”.

At the IAEA-NDS, the Data Storage and Retrieval System, “DASTAR” was produced for the storage and retrieval of neutron data. This DASTAR system was also used at the CJD center to transmit nuclear data information between the IAEA-NDS and the CJD center.

At the ENEA-CCDN, the Neutron Data Direct Access System, “NEUDADA” was introduced in 1969 to make the maximum use of the direct access storage feature of the CCDN center’s IBM-360/30 computer system. The NEUDADA system was used with the CCDN center’s data libraries, which were coded in the SCISRS format. Compiled neutron data were transmitted between the ENEA-CCDN and the BNL-NNCSC in the SCISRS format.

Beginning in 1966, the four-centers held annual meetings that were organized and sponsored by the IAEA-NDS and each of the four centers rotated as the site for these meetings and serving as the hosts of these meetings.

One of the many topics that were discussed at that time was the format for the exchange of experimental neutron data between all four of these centers. In 1969, there was an agreement in principle on an exchange format, which was called “EXFOR”, an acronym for exchange format. EXFOR was a computer compatible set of agreed upon definitions and conventions, designed for transmission of experimental nuclear data information between the four nuclear data centers. EXFOR was designed to meet the diverse needs of the four neutron data centers and had also been designed for flexibility rather than for the optimization of data processing. July 1970 was chosen as the starting date for the routine transmission of “new” data between the four-centers in the EXFOR format. “New” data referred to experimental data compiled on or after July 1970. The effort to translate all of the existing experimental neutron nuclear data, which were coded in the SCISRS format, into the EXFOR format would be done by the various centers at some later time.

With the advent of the EXFOR format, the centers at the ENEA-CCDN and at the IAEA-NDS wrote translation codes to convert their data file, which were written in NEUDADA and DASTAR, respectively, into the EXFOR format. Over the years, this exchange of experimental neutron reaction data evolved into the EXFOR library.

As a function of time, the CINDA bibliography would begin to include an index and data line to the storage of experimental neutron nuclear data in the EXFOR library.

In the USA, the NNDC began to provide access to its databases and to provide retrieval services via electronic means using computer networks, such as the INTERNET, or by telephone. Beginning in 1986, online access had been provided for the computerized numeric and bibliographic nuclear database information available at NNDC. Initially, this

nuclear database information included the neutron bibliographic data available in CINDA, as well as the bibliographic and numeric nuclear structure data files.

Starting in 1988, both the experimental and evaluated neutron data files were added to the online access list. Since by that time the EXFOR library was identical to the CSISRS library. The term CSISRS would still continue to be used for the experimental neutron nuclear data file in the USA online data system at NNDC to reassure users that they would continue to receive the same product. This pioneering telnet technology has now been replaced by web service.

3. Evaluated Neutron Nuclear Data and ENDF

Initially, the users of neutron nuclear data were interested in experimental information. Within a matter of a few years, there was an interest in evaluated neutron nuclear data. Various laboratories performed their own evaluations on the experimental nuclear database. A concern had been raised because the results of these various evaluations could not be easily compared with one another.

In 1964, Henry Honeck was interested in developing a system for storage and retrieval of evaluated nuclear data to be used in the design of nuclear reactors, which would be application-independent and well documented. Honeck developed the Evaluated Nuclear Data File (ENDF), while he was at the Brookhaven National Laboratory. The purpose of this ENDF library was to place data sets from many different sources into a common format for use in nuclear reactor calculations. His ENDF system would establish a link between the data library and the processing codes.

The ENDF library had two parts, ENDF/A and ENDF/B, each of which used the same format. The ENDF/A library is a storage system of fully or partially evaluated nuclear data. ENDF/A had data sets that may or may not have been extensively tested. For each isotope, there may be more than one data set for a particular reaction from which to choose and there may not be data sets for all of the important reactions through the energy range of interest. As the ENDF library was being developed, ENDF/A was a convenient place to collect partial evaluations produced by nuclear data evaluators from both foreign and different USA laboratories. The data were stored in the order that they were received by the Center at NNCSC and no selection was made of the data in the ENDF/A file. All of the data were accepted and were added to the master file. Thus, many alternative evaluations might be available in ENDF/A. These partial or older evaluations could be used as building blocks to generate complete evaluations.

The ENDF/B library would provide a complete reference set of nuclear data for use in nuclear calculations. The data, to be stored in the ENDF/B library, would be ordered by their material number, by their data type and by their reaction type. One complete set of data for a given material, would be stored and updated at regular intervals. There would be complete sets of evaluated point data that could be used to compute multi-group sets of data or as direct input to reactor codes.

There was also an unsuccessful ENDF/C project. This project involved an effort to design a format that could accommodate a wide variety of additional nuclear data, which might be needed to be included into the ENDF system, in some later revision of the ENDF/B library in the future. Charlie Dunford at the Brookhaven National Laboratory was one of those involved in this project for almost half a decade. At the conclusion of this effort, the method that was finally chosen to incorporate these additional data types into the ENDF system was to merely extend the existing formats of ENDF/B to accommodate the new data types and the whole ENDF/C concept was eventually cancelled.

The first version of ENDF/B-I was released in 1968. It contained evaluations that had been taken from pre-existing evaluations from various laboratories and converted into the ENDF format. In 1970, the second version, ENDF/B-II, was released, which contained some re-evaluations, some upgraded evaluations and some new evaluations. By this point, there was little interest in the need for partial evaluations to be coded into the ENDF/A library. All evaluation efforts were directed toward the production of complete evaluations for the ENDF/B library.

In 1968, there was an effort to use the experimental nuclear data from a SCISRS tape as the basis for an evaluation of a cross section. A Fortran program would process the data and display it on a screen and a light pen could be used to select the experimental data to be included in the analysis. Spline curves would be fit to the experimental data and a file produced in ENDF/A format. More recent information on ENDF may be found at www.nndc.bnl.gov/csewg.

4. Conclusions

Over the past half-century, there has been significant improvement in the development of computers, in the storage and the retrieval of information from data files and databases and also in the various processing codes, since the computer age began. SCISRS or CSISRS, no matter how you wish to refer to the system, stands in the forefront in the history of information storage and retrieval systems. It was an early leader in the handling of very large databases.

CSISRS, alias EXFOR, is still in use after forty years for the storage and retrieval of neutron nuclear data information and reassuring users that they still continue to receive the same basic quality data product.