PART I Outline of NRDF

1. Introduction

Recently, the charged particle nuclear reaction data(CPND) go on increasing rapidly and data bases of CPND have been produced in several countries with the support of the International Atomic Energy Agency (IAEA). The differential cross sections and the physical quantities of charged particle reactions are accumulated, compiled and stored by our group in Japan. The data base management system(DBMS) for them was also developed by us so as to be fitted to the data structure. Our data base is named NRDF, including its management system.

Our group is called Charged Particle Nuclear Reaction Data Group of Japan. The group started in 1974 with the support of the project entitled 'Advanced Information Processing of Large Scale Data over a Broad Area'. The project was organized for the developement of the information science which involves the scientific information. The starting members of the group were seven physicists and one information scientist. The theoretical physicists among them received approval of the Kakuriron-Kondankai, the meeting of Japanese theoretical nuclear physicists for the activity of NRDF, and the experimantal physicists that of the Kakubutsuri-Iinkai, the committee of the Japanese experimental nuclear physicists. The project of Advanced Information ended in March 1976.

In succession a new project started from April 1976. The new project was entitled 'Formation Process of Information Systems and the Organization of Scientific Information'. As the title shows, the branch of scientific information was very much developed in the project. The plan of NRDF was a subproject of this new project. Both projects were under the sponsorship of the Japanese Ministry of Education, Science and Culture through the Grant-in-Aid for Scientific Research. After the two projects, the plan of NRDF has been under the above sponsorship except in 1979. The members of our group have almost unchanged during the project and are listed below. The numbers in the parentheses show the the intervals of their participation in the NRDF project.

Chairman	Prof. H. Tanaka	Hokkaido University (1974~)
	Dr. K. Kato	Hokkaido University (1980~)
	Mr. M. Togasi	Hokkaido University (1974~)
	Prof. T. Hasegawa	The University of Tokyo (1974~)
	Prof. M. Muraoka	The University of Tokyo (1974~)
	Prof. H. Ohnuma	Tokyo Istitute of Technology (1974~)
	Prof. M. Yamada	Waseda University (1976~1978)
	Prof. Y. Abe	Kyoto University (1974~)
	Prof. H. Ikegami	Osaka University (1974~)
	Prof. S. Takagi	Osaka University (1980~)
	Prof. M. Kawai	Kyushu University (1974~)

In 1983 about fifteen persons are engaged in various works of NRDF. Mrs. T. Nojiri has been a staff from the beginning of NRDF work. Since three years ago, our group has been benifited from the Hokkaido University Computing Center(HUCC) for using the computer system and for making machine readable data. Up to now, neither the national center nor any section of physics institutes has been established for the activity of CPND in Japan. Our group is an ensemble of pioneers and our work is then obliged to be limited to the preparation for their activity. Our group is regarded internationally as a research group. At the present time (March 1983), data from 463 documents are accumulated on the charged particle nuclear reactions. Most of the data produced with Japanese accelerators are stored into NRDF but as for the data with foreign accelerators they are limited to those of proton induced reactions. Up to March 1983, the stored data amount to 16.23MB and 40~50 KB per document, where the portion of the text is about 5KB.

Each document of CPND includes two kinds of information: numerical data and texts of the explanation for them. The main parts of the former are composed of many kinds of cross sections and the polarization quantities. Almost always the authors of the documents demonstrate various physical quantities derived from their measured quantities in the graphs. The latter comprise bibliographic information, experimental apparatus and information about the analysis of the measured quantities. These are all stored in NRDF. Therefore NRDF is oriented to nuclear physics researchers. Experimental nuclear physicists can retrieve the measured quantities with information about the experimental conditions and theoreticians can receive information on the analysis of the measured quantities as well as the raw data themselves by using NRDF. However the data structure of NRDF becomes inevitably complex as a result that a large amount of distinct information has to be freely linked in order to satisfy wide demands of researchers. Therefore, DBMS of NRDF has to be adjustable to a special type of data structure. This is the reason why DBMS was originally developed by our group instead of using commercial DBMS. The DBMS was desgined and implemented by one of the authors (M. T.).
NRDF is, in principle, open for use from the beginning of the development and practically open to everyone who has the right to use the seven Interuniversity Large Computer Centers since April 1983. Retrieval of NRDF can be done on line. There is no barrier in our group for installing NRDF on a computer system of any nuclear research institute in universities in Japan if the institute wants it. The file organization of NRDF is based on VSAM (Virtual Storage Access Method). So that, probably, any computer system of M-series may be able to accept NRDF.

NRDF has its own data format and accordingly it must be translated into the format available for the international data exchange which makes NRDF usable in countries other than Japan. The format of data exchange was already fixed by international agreemnt in 1969 for neutro neutron reaction data and the format was extended so as to fit to CPND in 1975. It is called 'EXFOR'(computerized EXchange FORmat). Our group planned to develop the translation program from NRDF data to EXFOR data. The development of the program named NTX(Nrdf To eXfor), has been accomplished in March 1983 by Mr. M. Chiba, Dr. T. Katayama and one of the authors(H. T.) except for the registration of some spcific terms of each format, NRDF and EXFOR. The translated data are available worldwide.
The translation from NRDF to EXFOR is very much helpful to find out data errors in NRDF. When the data are entered into NRDF, syntactical errors are checked out but data errors often remain as they are. Data of NRDF are corrected until the errors disappear when they are translated by NTX. The translated data are checked by the System Specification for NDS dictionary and the EXFOR checking program which was sent from IAEA.

NRDF is produced through following four steps.

i) to take out necessary data from literature published in scientific journals or proceedings, fill in coding sheets of NRDF and transform them to machine readable data.

ii) to read necessary graphs in the literature with a 2-dimansional coordinate digitizer and get machine readatble data.

iii) to scale the measured values of the graph, combine the above two

kinds of machine readable data, correct logical errors and input them into devices used.
The work of this step is done as an input operation.
iv) to translate the combined data to the EXFOR format and correct errors appearing in the translation step.

It might not be clever to produce a data base of numerical data by the use of literature. Measurement systems of nuclear experiments always have an automatical recording system as an essential part of their apparatus and machine readable data are automatically recorded in a recording system without any trouble. However there are several difficult problems in using such automatically recording data.
Data in a data base can be used in scientific researches only with the condition that the data have cleared an authorized judgement. If someother system of evaluating CPND worked, we could refer to the system and take a different procedure as a starting step of data-base production.
There are essentially different situations in CPND (namely, the data on nuclear reactions) comparing with the data on nuclear structure. An incident energy of a projectile, in priciple, varies continuously and the conditions in measurment steps also change continuously. Moreover the number of types of nuclear reactions is also enormous. As a result there are few nuclear reactions of which the experimental conditions are almost the same with respect to the following items, that is, types of reactions, energy and beam strength of projectile and physical conditions of the measurement. As is well known the evaluation of the data does not always stand up in the case of time-series data. Such is also the case with the nuclear reaction data.
This may be a characteristic feature of phenomenological data on nuclear reactions in contrast to the data on nuclear structure as substance. Another reason why literature is used is that nuclear physicists keep the original raw records only for a short period. Even though the data are preserved, meaningful and meaningless data are generally to be mixed in raw data and the units thereof are peculiar to the measurement system. It is the above facts that make us in the present work to take CPND out of the literature and not of the machinery recording data.

Twenty types of coding sheets are ready for coding work.
Each coding sheet is so designed as to be easily filled in with necessary data in accordance with the syntax of NRDF.
An example of coding sheets are shown in section 2.2.1 of part II.
Nuclear physicists are engaged in the coding step, who select figures to be stored as necessary data from the graphs in the literature. Each plot in the selected figures is read with a digitizer. Here type of the coordinate system, for example semi-logalithmic etc., and plotting form of experimental errors are assigned to the selected figures.
As the procedure is manual in the first and second steps, there is a possibility that many errors arise in each step. However the probability of errors appearing seems to be fairly small in reading plots with a digitizer except for misordering of plots which happens frequently in reading complicated graphs. The errors in the coding work can be mostly found out in the first and fourth steps which are shown at the beginning of this section. The assigned information of the graphs to be read is very important in the sense that if it is not correct or misread, the corresponding numerical data taken from the graphs become useless despite of the fact that the data pass two checking gates of NRDF and NTX.
The quality of NRDF depends on the coding work, that is, whether the necessary and important information can be adequately taken out of the literature or not. Detailed steps of the work are illustrated in section 3.2 of part II.

The whole work is performed by the following members in 1983.

i) Coding: More than five physicists of the Hokkaido, Tokyo and Osaka Universities.

ii) Graph reading : Three students in the graduate course and three students in the fourth year of the Hokkaido University

iii) Input operation: Two students in the graduate course.

iv) Transformation to EXFOR: The work was tried as a research till March 1983.

Since our system for producing NRDF has been established, each step will be carried out more smoothly from now on. It is hoped that some definite system for CPND would be settled. If such a system is realized, it will bring full results immediately without any standing-up time.

2. Management system of NRDF

2.1 Information representation

2.1.1 Set representation of event records

One "logical" record in the system consists of data table and information about its production environment such as experimental condition. The record is represented as set of "sections" and is called "data set". THe data sets have some overlapping sections to other data sets if they are related each other.

Sections do not share any part of them to other sections. Symbolic pointers to data sets to which the section belongs are attatched to each section.

Data table itself is included in DATA section as a subsection, and non numerical information can be added out of the subsection in the the section.

A data table has data headings and data units in first and second line respectively. The number of columns of the table is implicitly represented by the number of headings.

One characteristic feature of the data tables in the system is that each data may be associated with, or itself is, symbolic pointers linking to other data and/or comments out of the table, as seen in case table within published papers.

The other contents in section is coded data based on a specific type of language devised for free format coding of source data.

There are three types of sections:

(1) BIB section

BIB section contains bibliographic information about:

Journal name, Volume, Page, Year,
Title, Author, Institution,
Reactions treated.

(2) EXP section

This section describes experimental conditions and includes information about:

Reaction, Target, Incident beam, Particle detection
Analysis, Physical quantities

(3) DATA section

DATA section includes numerical data table with its descriptive parameters:

Incident energy, Excitation energy,
Final states of the reaction

In data table, headings and units of columns appear followed by data lines.

2.1.2 Syntax of input data

```
+---------------------------------------------------------------------------+
| <data_stream> ::= <section><section> .. <section>¥¥END;                   |
| <section>     ::= <BIB_section>                                           |
|   or          ::= <EXP_section>                                           |
|   or          ::= <DATA_section>                                          |
| <BIB_section> ::= <BIB_header><section_body>                              |
| <EXP_section> ::= <EXP_header><section_body>                              |
| <DATA_section>::= <DATA_header><section_body>                             |
| <BIB_header>  ::= ¥¥BIB,<dataset_list>;                                   |
| <EXP_header>  ::= ¥¥EXP,<dataset_list>;                                   |
| <DATA_header> ::= ¥¥DATA,<dataset_list>;                                  |
| <dataset_list>::= <dataset_No.>,<dataset_No.>,....,<dataset_No.>          |
|   or          ::= <dataset_No.>~<dataset_No.>                             |
| <dataset_No.> ::= integer                                                 |
| <section_body>::= <term><term>...<term>                                   |
| <term>        ::= <statement>;                                            |
|   or          ::= <data_table>                                            |
|   or          ::= <comment>                                               |
| <statement>   ::= <single_statement>                                      |
|   or          ::= <multi_statement>                                       |
| <single_statement>                                                        |
|               ::= <field_name>=<field_value>                              |
| <multi_statement>                                                         |
|               ::= (<single_statement>,<single_statement>,,.)              |
|   or          ::= (<single_statement>,<single_statement>,,.)'<flag>'      |
| <field_name>  ::= system_defined_code_name                                |
| <field_value> ::= <single_value>                                          |
|   or          ::= <multi_value>                                           |
| <multi_value> ::= (<single_value>,<single_value>,,..)                     |
|   or          ::= (<single_value>,<single_value>,,..)'<flag>'             |
| <single_value>::= <value>                                                 |
|   or          ::= <value>'<flag>'                                         |
| <value>       ::= system_defined_code_name                                |
|   or          ::= /<free_text>/                                           |
|   or          ::= name_of_person                                          |
|   or          ::= number                                                  |
|   or          ::= number_with_unit                                        |
|   or          ::= /<free_text>/                                           |
| <flag>        ::= <pointer>                                               |
|   or          ::= <pointer>,<pointer>,...,<pointer>                       |
| <pointer>     ::= one_or_two_uppercase_letters.                           |
|   or          ::= one_or_two_digits                                       |
| <free_text>   ::= text_written_in_english                                  |
| <comment>     ::= /*<free_text>*/                                         |
| <data_table>  ::= ¥DATA;<heading_line><unit_line><data_lines>¥END;        |
| <heading_line>::= <heading_name><b><heading_name><b>..<heading_name>      |
| <unit_line>   ::= (<unit_name>)<b>(<unit_name>)<b>..<unit_name>           |
| <data_lines>  ::= <data><b><data><b><data>..<data>                        |
| <data>        ::= number                                                  |
|   or          ::= number'flag'                                            |
|   or          ::= system_defined_code_name                                |
|   or          ::= system_defined_code_name'flag'                          |
|   or          ::= 'flag'                                                  |
| <b>           ::= one_or_more_spaces                                      |
+---------------------------------------------------------------------------+
```

The whole structure of source data is shown in the next page.

```
 Data stream                           Section
+----------+          +----------------------------+
| section  |          | ¥¥BIB,1,2,3;            ---|----> BIB header
+----------+          |  A=B; C=D'1'            ---|----> statements
| section  |          |  E = (F,G,H)'2';           |
|----------|          |  (I=J,Z=W);                |----> BIB section
| section -|------>|          /* abcdefg */     ---|----> comment
|----------|          +----------------------------+
| section  |                      or
+----------+          +----------------------------+
¥¥END;                | ¥¥EXP,1,2;              ---|----> EXP header
                      |  A=B; C=D;                 |----> EXP section
                      |  ..........                |
                      +----------------------------+
                                  or
                      +----------------------------+
                      | ¥¥DATA,1;               ---|----> DATA header
                      |  A=B; ...                  |---->DATA section
                      |  ........                  |
                      | ¥DATA;                  ---|----> control statement
                      | +-----------------------+  |
                      | |   AAA    BBB    CCC --|--|----> heading line
                      | |  (UUU)  (VVV)  (WWW) --|-|----> unit line
                      | |   1.0   10.0    0.5   |  |
                      | |   2.0   15.0    0.3   |  |
                      | |   3.1   17.0    0.2   |--|----> data table
                      | |   5.0   18.6    0.7   |  |
                      | |   ...   ....    ...   |  |
                      | +-----------------------+  |
                      | ¥END;                   ---|----> control statement
                      |  ........                  |
                      +----------------------------+
```

2.1.3 Example of input data

An example of input data coded in avobe format is shown bellow.

```
::::::::::::::::::::: example of data ::::::::::::::::::::::::::::::::::

¥¥BIB,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22;
D#=D170;
TITLE=/@1@/;
ATH=(T.YAMAYA'1,2',K.UMEDA'1',T.SUEHIRO'3',K.TAKIMOTO'4',R.WADA'4',
E.TAKADA'4',M.FUKUDA'4',J.SCHIMIZU'5',Y.OKUMA'6');
INST-ATH=(2JAPTOH'1',1USATAM'2',2JAPTOI'3',2JAPKTO'4',2JAPIPC'5',
2JAPRCN'6');
REF=PL/B;
VLP=90(1980)219;
RCTS=(12C(D,6LI)12C,24MG(D,6LI)20NE,40CA(D,6LI)36AL,58NI(D,6LI)54FE);
¥¥EXP,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22;
ACC=(CYC);
INST-ACC=2JAPRCN;
INC-ENGY-RANGE=(54.25MEV);
DELTA-INC-ENGY=XKEV;
ERS-PRJ=XKEV;
BEAM-INTNSTY=XUA;
POL-PRJ=NO;
DET-PARTCL=(6LI);
DET-SYS=(CNTR-TLSCP);
SOLID-ANGL=XMSR;
ERS-DET=XKEV;
```

```
ANL=(DWBA,SHELL-MODEL,CLUST-MODEL);
PHQ=(ANGL-DSTRN,DSIGMA/DOMEGA,SPEC-FCTR);
¥¥EXP,1,2,3,4,5,6,7;
RCT=58NI(D,6LI)54FE;
BAC=SELF;
¥¥DATA,1;
INC-ENGY=54.25MEV;
EXC-ENGY=0.0MEV;
J-PI=0+;
SPEC-FCTR=0.067;
/*FIG.1-(1)*/
/* D170                          FIG 1-(1)                              */
/* SER#=     1           */
/* XSCALE=LINEAR      YSCALE=LOG         */
/* XMAX= 8.000E+01    YMAX= 1.000E+01 */
/* XMIN= 0.000E+00    YMIN= 1.000E-02 */
/* FOLLOWING DATA ARE TAKEN FROM GRAPH */
¥DATA;
          THTC       DSIGMA/DOMEGA DELTA-DSIGMA/DOMEGA
          (DEG)         (UB/SR)       (UB/SR)
           8.29         1.22E+00      2.19E-01
          10.84         1.28E+00      1.94E-01
          15.94         2.05E+00      2.57E-01
          18.49         1.54E+00      3.66E-01
          21.04         2.66E+00      4.78E-01
          26.14         9.61E-01      2.00E-01
          31.87         8.95E-01      1.61E-01
          36.97         1.19E+00      1.49E-01
          42.39         2.88E-01      1.32E-01
          47.81         4.84E-01      1.43E-01
          52.91         1.56E-01      1.25E-01
          57.69         1.23E-01      7.89E-02
          63.11         3.24E-01      1.37E-01
¥END;
¥¥DATA,2;
INC-ENGY=54.25MEV;
EXC-ENGY=1.408MEV;
J-PI=2+;
SPEC-FCTR=0.034;
/*FIG.1-(2)*/
/* D170                          FIG 1-(2)                              */
/* SER#=     2           */
/* XSCALE=LINEAR      YSCALE=LOG         */
/* XMAX= 8.000E+01    YMAX= 1.000E+01 */
/* XMIN= 0.000E+00    YMIN= 1.000E-02 */
/* FOLLOWING DATA ARE TAKEN FROM GRAPH */
¥DATA;
          THTC       DSIGMA/DOMEGA DELTA-DSIGMA/DOMEGA
          (DEG)         (UB/SR)       (UB/SR)
           8.29         1.58E+00      2.40E-01
          10.84         3.53E+00      4.43E-01
```

- - - - - - - - - - - - - (omitted) - - - - - - - - - - - - - - - - - -

```
¥¥DATA,22;
INC-ENGY=54.25MEV;
EXC-ENGY=11.4MEV;
J-PI=4+;
SPEC-FCTR=1.27;
/*FIG.1-(22)*/
```

```
/* D170                              FIG 1-(22)                          */
/* SER#=    23               */
/* XSCALE=LINEAR      YSCALE=LOG          */
/* XMAX= 8.000E+01    YMAX= 1.000E+02 */
/* XMIN= 0.000E+00    YMIN= 1.000E+01 */
/* FOLLOWING DATA ARE TAKEN FROM GRAPH */
¥DATA;
          THTC        DSIGMA/DOMEGA
          (DEG)          (UB/SR)
          11.89         2.32E+01
          16.06         1.91E+01
          19.28         1.30E+01
          23.13         2.00E+01
          26.67         2.61E+01
          29.88         2.80E+01
          33.09         3.57E+01
          36.63         3.57E+01
          40.80         3.01E+01
          44.34         2.67E+01
          47.87         2.26E+01
          50.76         2.15E+01
          54.30         2.26E+01
          56.87         2.15E+01
          61.04         2.05E+01
          64.58         1.47E+01
          67.79         1.91E+01
          71.00         1.91E+01
¥END;
¥¥END;
@@1;
THE (D,6LI) REACTION ON 12C,16,24MG,40CA AND 58NI AT 54.25MEV
@@;
```

:::::::::::::::::::: end of example :::::::::::::::::::::::::::::::::::

2.2 Information structure

Three types of files namely, X1, X2 and X3 are used for managing CPNDs; X2 is the main file holding data sets, X1 is a collection of sections, and X3 inverted index.

2.2.1 X1

X1 is a collection of sections as text image data. A serial internal number is issued to every sections for identification. Data set ID numver that works as symbolic pointers to belonging data sets are converted into unique serial number within the file system.

Record of X1 has form of:

```
+----------------------------------------------------------------------+
|  <section ID><section in text image>                                 |
+----------------------------------------------------------------------+
```

where <section ID> is unique key of the record for access.

2.2.2 X2

X2 holds data sets. Actually, each data set is represented as a list of pointers to sections. The pointer is not physical but logical one. Data sets have ,in general, intersection with each other. Existence of data sets are implicitly represented in stage of information representation of X1. By scanning sections in input time, "element_to_sets" relationships is inverted to "set_to_elements"

relationships. Data set ID is identifier of a set and corresponding list of IDs of setctions to be included within the set.
General form of the record of X2 is:

```
+--------------------------------------------------------------------+
|  <data set ID > <set of section IDs>                               |
+--------------------------------------------------------------------+
```

where the data set ID is a unique key of the file X2.
There are various methods of representing sets. Here we employe both integer_lists and bit_maps, where one method is seitched to another dynamically according to its size.

2.2.3 X3

X3 is inverted index to data sets in X2. An entry of the index points a set of data sets, i.e. a subset of X2.
The subset pointed from the entry consists of those sections that contains some common key-information specified by the entry.
It is defined at system generation time that which field name is to beemplyed as key field and is indexed when input data is processed.
Form of records in X3 is:

```
+--------------------------------------------------------------------+
|  <key-information> <set of IDs of data sets>                       |
+--------------------------------------------------------------------+
```

where, needless to say, key-information is unique key of X3.
Contents of the key information varies according to each key field, i.e. that may be the name of data author, type of the accelerator and so on. X3 is, exactly speaking, an aggregation of subfiles, each of which corresponds to a key field.
It should be noted that indexing is done for data sets not for sections. The key information is extracted regarding the data set as a unit of processing. This assures quickness of searching data sets through X3 at the sacrifice of non-redunancy and low level of analizing power of the index.

2.2.4 Relationship among X1, X2 and X3.

Interrelation of X1, X2 and X3 is shown in the figure bellow.
Each record in inverted index X3 represents a subset of X2 regarding X2 as a set of records. Each element of the subset has somewhat common key-information in it. This is also the case for X2 in relation with X1. Every data set is a subset of X1. And each element fo the subset has common key-information though it might be inplicitly represented, saying that it relates to an identical data table.
This means that X2 is a kind of inverted file for X1.
To resume the situation, a collection of subsets on base set X1 makes X2, a collection of subsets ofon base set X2 makes X3.
This is read as "X1 is inverted into X2, and X2 into X3". For this reason, we call this file system as "doubly inverted file".

```
          +------------------------------------------+
          | +----------------+     +----+----+----+  |
          | | ATH | A.B.JONES |--->| D10 | D33 | D..| |   Inverted index
  X3      | +----------------+     +----+----+----+  |        to
   ¬      |      ......             .........        |     data sets
   |      |                                          |
   |      +------------------------------------------+
Inversion
```

```
  |       +-------------------------------------------------+
  |       | +------+    +----------------------------+      |
  |       | | D10  |--->| S25 | S26 | S27 | S29 | S...|     |   Directory
 X2       | +------+    +-----+-----+-----+-----+-----+     |      of
  ¬       |  .....         ..................               |   data sets
  |       |                                                 |
  |       +-------------------------------------------------+
Inversion
  |       +-------------------------------------------------+
  |       | +------+    +----------------------------+      |
  |       | | S25  |--->| ¥¥BIB,10,11,12             |      |
  |       | +------+    | TITLE=/......./;           |      |
  |       |             | ATH=(A.B.JONES,C.D.SMITH); |      |
  |       |             |                            |      |
  |       |             | .......................... |      |
  |       |             +----------------------------+      |
  |       |                                                 |
  |       | +------+    +----------------------------+      |
  |       | | S26  |--->| ¥¥EXP,10,11;               |      |
  |       | +------+    | RCT=12C(P,P)12C);          |      |
  |       |             | ACC=CYC;                   |      |
  |       |             | INST-ACC=......;           |      |
 X1       |             | .......................... |      |   Section body
          |             +----------------------------+      |
          | +------+    +----------------------------+      |
          | | S27  |--->| ¥¥DATA,10;                 |      |
          | +------+    | .....                      |      |
          |             | ¥DATA;                     |      |
          |             |    THTC   xxxxxx   xxx     |      |
          |             |   (DEG)   (xxx)   (xxx)    |      |
          |             |    10.0    xxx     xxx     |      |
          |             |    xxx     xxx     xxx     |      |
          |             | ¥END;                      |      |
          |             | .......................... |      |
          |             +----------------------------+      |
          |                                                 |
          |   .......                                       |
          |                                                 |
          |   .......                                       |
          |                                                 |
          +-------------------------------------------------+
```

3. Format translation from NRDF to EXFOR

NRDF employes its original format for representing CPNDs and no other data centers of CPND can't hadle the data in NRDF without original software developed by the Japanese group. On the other hand, ther is an international format for exchnanging nulear data agreed among consultants' meeting of worldwide nuclear data centers conducted by International Atomic Energy Agency (IAEA). The international format is called "EXFOR" (EXchange FORmat), which had originally been used for exchanging neutron nuclear data (NND) and is modified to match with CPND. A characteristic point of EXFOR is that it expects computing environments of small scale computers with basic Fortran compilers while NRDF expects rather larger scale of computers with PLI and VSAM softwares. Information structuring in the EXFOR is definite and simple, in that it emplyes two level hierarchy of data blocks and column fixed format for each lines of coded data which is easier to edit both in manual and using a program.

The structure of EXFOR data is illustrated:

```
 TRANS tape          entry              subentry
+-----------+      +-----------+      +-----------+
| TRANS     |      | ENTRY     |      | SUBENT    |
+-----------+      +-----------+      +-----------+
|           |      |           |      | BIB       |
|-----------|      |-----------|      |-----------|
|          -|----->|          -|----->|           |
|-----------|      |-----------|      | bib. data |
|           |      |           |      |           |
+-----------+      |-----------|      |-----------|
| ENDTRANS  |      | ENDENTRY  |      | ENDBIB    |
+-----------+      +-----------+      |-----------+
                                      | COMMON    |
                                      |-----------|
                                      | common    |
                                      | data      |
                                      |-----------|
                                      | ENDCOMMON |
                                      |-----------|
                                      | DATA      |
                                      |-----------|
                                      | data      |
                                      | table     |
                                      |-----------|
                                      | ENDDATA   |
                                      |-----------|
                                      | ENDSUBENT |
                                      |-----------|
```

lines in BIB section have a format of:

```
1         11                                                 66 67          80
+--------------------------------------------------------------------------+
| keyword | | (coded value) free text                         | record ID   |
+---------+----------------------------------------------------------------+
            for pointer
```

COMMON data has a format of:

```
1         11         22         33                          66 67          80
+--------------------------------------------------------------------------+
| heading | | heading | | heading | | .....                 | record ID   |
|--------------------------------------------------------------------------+
|  unit     |  unit     |  unit     | .....                 | record ID   |
+--------------------------------------------------------------------------+
|  data     |  data     |  data     | .....                 | record ID   |
+--------------------------------------------------------------------------+
```

the talbe in cludes only one line of data point.
11th colume of each headings is used for pointer.

lines in data table have a format of:

```
1         11         22         33                          66 67          80
+--------------------------------------------------------------------------+
| heading | | heading | | heading | | .....                 | record ID   |
|--------------------------------------------------------------------------+
|  unit     |  unit     |  unit     | .....                 | record ID   |
+--------------------------------------------------------------------------+
|  data     |  data     |  data     | .....                 | record ID   |
+--------------------------------------------------------------------------+
|  ....     |  .....    |  .....    | .....                 | record ID   |
+--------------------------------------------------------------------------+
```

Translation is performed in four levels.

(1) code level translation
In this level, NRDF-EXFOR code dictionary is uded. Almost all of codes are in one-to-one correspoindence.

(2) record level translation
Keywords of EXFOR not always correspod to those of NRDF.
So that, some of them are composed from several terms of MRDF, others are treated as comments of EXFOR.

(3) section level translation
One subentry is constructed from related EXP sections and DATA sections of NRDF with COMMON data from discriptional terms in EXP sections.
In some cases an EXP section of NRDF may be distributed to subentries to adjust to two level structure of subentries in EXFOR.

(4) overall translation
Set structure of NRDF is stranslated into two level hierarchical structure of EXFOR. In this step, some redandundcy is likely to be introduced by duplication of EXP sections mentioned above.

An example of NRDF-EXFOR translation is shown in the next page.

::::::::::::::::: example of translated data ::::::::::::::::::::::::::

```
TRANS               E001      821015                                E00000
ENTRY              E0001      821015                                E00010
SUBENT          E0001001      821015                                E00010
BIB                   10          20                                E00010
TITLE        THE (D,6LI)REACTION ON 12C,16,24MG,40CA AND 58NI AT    E00010
             54.25MEV                                               E00010
AUTHOR      (T.YAMAYA,K.UMEDA,T.SUEHIRO,K.TAKIMOTO,R.WADA,E.TAKADA,E00010
            M.FUKUDA,J.SCHIMIZU,Y.OKUMA)                            E00010
INSTITUTE   (2JAPTOH,1USATAM,2JAPTOI,2JAPKTO,2JAPIPC,2JAPRCN)       E00010
REFERENCE   (J,PL/B,90,219,80) THEORETICAL ANALISIS                 E00010
FACILITY    (CYCLO,2JAPRCN) INCIDENT-ENERGY-RANGE = (54.25MEV).     E00010
             UNCERTAINTY-IN-THE-ABSOLUTE-ENERGY = NOT GIVEN.        E00010
             BEAM-ENERGY-SPREAD = NOT GIVEN.                        E00010
             BEAM-INTENSITY = NOT GIVEN.                            E00010
             BEAM-POLARIZATION = NO.                                E00010
DETECTOR    (TELES) SOLID-ANGL = NOT GIVEN.                         E00010
             OVERALL ENERGY RESOLUTION = NOT GIVEN.                 E00010
PART-DET    (3-LI-6)                                                E00010
ADD-RES      MEASURED AND/OR DEDUCED QUANTITIES ARE                 E00010
             ANGULAR-DISTRIBUTION, DSIGMA/DOMEGA,                   E00010
             SPECTROSCOPIC-FACTOR.                                  E00010
COMMENT      MODELS OR APPROXIMATIONS USED IN THE ANALYSIS ARE      E00010
             DWBA, SHELL-MODEL, CLUSTER MODEL.                      E00010
HISTORY     (821015T) CONVERTED FROM NRDF                           E00010
ENDBIB                20                                            E00010
NOCOMMON                                                            E00010
ENDSUBENT             23                                            E00010
SUBENT          E0001002      821015                                E00010
BIB                    4           4                                E00010
REACTION    (28-NI-58(D,3-LI-6)26-FE-54,,DA)                        E00010
SAMPLE       BACKING = SELF.                                        E00010
COMMENT                                                             E00010
STATUS      (CURVE)                                                 E00010
ENDBIB                 4                                            E00010
COMMON                 5           3                                E00010
EN          E-EXC      SPIN J     PARITY     SPEC-FCTR              E00010
MEV         MEV        NO-DIM     NO-DIM     NO-DIM                 E00010
54.25       0.0        0.         +1.        0.067                  E00010
ENDCOMMON              3                                            E00010
DATA                   3          13                                E00010
ANG-CM      DATA       DATA-ERR                                     E00010
ADEG        MU-B/SR    MU-B/SR                                      E00010
       8.29  1.22E+00   2.19E-01                                    E00010
      10.84  1.28E+00   1.94E-01                                    E00010
      15.94  2.05E+00   2.57E-01                                    E00010
      18.49  1.54E+00   3.66E-01                                    E00010
      21.04  2.66E+00   4.78E-01                                    E00010
      26.14  9.61E-01   2.00E-01                                    E00010
      31.87  8.95E-01   1.61E-01                                    E00010
      36.97  1.19E+00   1.49E-01                                    E00010
      42.39  2.88E-01   1.32E-01                                    E00010
      47.81  4.84E-01   1.43E-01                                    E00010
      52.91  1.56E-01   1.25E-01                                    E00010
      57.69  1.23E-01   7.89E-02                                    E00010
      63.11  3.24E-01   1.37E-01                                    E00010
ENDDATA               15                                            E00010
ENDSUBENT             28                                            E00010
SUBENT          E0001003      821015                                E00010
BIB                    4           4                                E00010
REACTION    (28-NI-58(D,3-LI-6)26-FE-54,,DA)                        E00010
```

```
SAMPLE       BACKING = SELF.                                                  E00010
COMMENT                                                                       E00010
STATUS      (CURVE)                                                           E00010
ENDBIB                  4                                                     E00010
COMMON                  5          3                                          E00010
EN          E-EXC        SPIN J     PARITY      SPEC-FCTR                     E00010
MEV         MEV          NO-DIM     NO-DIM      NO-DIM                        E00010
54.25       1.408        2.         +1.         0.034                         E00010
ENDCOMMON               3                                                     E00010

        . . . . . . . . . . . . . . . . . . . . . . . . . . . .
        . . . . . . . . ( omitted ) . . . . . . . . . . . . . .
        . . . . . . . . . . . . . . . . . . . . . . . . . . . .
        . . . . . . . . . . . . . . . . . . . . . . . . . . . .

ENDSUBENT              32                                                     E00010
ENDENTRY               23                                                     E00019
ENDTRANS                1                                                     E99999
ENDTRANS                1                                                     E99999
ENDTRANS                1                                                     E99999
ENDTRANS                1                                                     E99999
ENDTRANS                1                                                     E99999
ENDTRANS                1                                                     E99999
ENDTRANS                1                                                     E99999
ENDTRANS                1                                                     E99999

:::::::::::::::::::::::: end of example ::::::::::::::::::::::::::::::::::
```