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Information

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Memo CP-B/9

Subjects: I. Coding of Reactions with Multiple Residual Nuclei
1. General Statements
2. Coding of REACTION SF4 (Residual Nucleus)
3. Coding of Outgoing Particles in REACTION SF3
4. Coding of Processes in REACTION SF3
5. Links between the DATA- and BIB-Section

II. Generalized Use of Pointers

References: Item I: CP-B/5; B/8; C/5; C/8; D/11; Kiev Meeting
Item II: CP-B/6; Kiev Meeting

I. Coding of Reactions with Multiple Residual Nuclei

1. General Statements

After the discussion in Kiev about the possibilities of defining multiple product nuclei observed in an experiment in the DATA-section we have reviewed the different proposals and tried to find a compromise between them retaining the advantages of most of them. At the beginning we would like to compile some mostly known general statements and conditions:

a) We are very interested to introduce such a coding formalism into the Exfor system, because it will ease the life of the compiler, reduce the extent of the file etc.

b) The formalism must be applicable for all reaction types, where for multiple endproducts (normally coded in REACTION SF4) the entries in REACTION SF1, 2 and 5 - 9 are identical (it seems to be reasonable to restrict the applicability to cases where not more than 3 projectile energies have been applied to retain clearness of the DATA-table). We see no reason why not coding e.g. a number of (p,xn)-reactions with x = 1,2,3, ... within one subentry, thus reducing the compiling effort as well as the extent of the file.

c) It must be clearly distinguished between cases where only mass chain yields (for a single or several A-values as specified in the DATA-table) or element yields (for one or several elements) have been measured, and cases where individual nuclides have been identified with a defined equation for each reaction.

d) For defined reactions the nonspecified outgoing particles in SF3 can be calculated by balancing SF1, 2 and 4 which should be done to ensure as far as possible completeness of an index with respect to a special type of reaction. Since such a general balancing can regard only nucleons it seems to be not meaningful for too many emitted particles which certainly occur partly as larger entities (e.g. the residual fission fragment(s) not coded in SF4 or the DATA-table). Therefore, a balancing should be restricted in the respective program to cases with $\leq$ 16 outgoing particles.

e) We expect that the programs for retrieval, indexing and editing, which include the facilities mentioned above, will be provided by the experts from Vienna and/or Brookhaven.

On this basis we propose the following concept for coding reactions with one target isotope resulting in multiple residual nuclei, which is in our opinion a compromise of several proposals on this subject and tries to include some aspects of indexing and retrieval.

2. Coding of REACTION SF4 (Residual Nucleus) cf. the following table

a) The characters Z or A point to respective columns in the DATA-table under the headings MASS or ELEMENT.

b) The code PROD - possibly either preceded or followed by Z or A (or an explicit number) - indicates that unspecified products or integral (chain) yields with or whithout a respective Z or A column in the DATA-table were measured. No specific nuclides have been identified.

c) The code EL, obligatory preceded and followed by Z and A (or an explicit number) indicates that defined nuclides have been identified and a Z and/or A-column is given in the DATA-table.
The following table compiles the different probabilities.

d) This formalism is only permitted if

- the entries in REACTION SF1, 2 and 5-9 are identical for all end products and
- the data for the multiple endproducts are given only for 3 or less projectile energies.

Code in SF4	DATA section specifies Z	A	Explanation
PRØD	no	no	Unspecified Products replaces FF,SPF, because processes are specified in SF3
			Integral (Chain) Yields* (no balancing for outgoing particles possible)
PRØD-A	no	yes	mass-chain yields for different masses
PRØD-54	no	no	mass-chain yield for one mass (54)
Z-PRØD	yes	no	Z-yields for different elements
14-PRØD	no	no	yield for the isotopes of one element (Mg)
			Defined Final Nuclides (balancing for outgoing particles from SF1,2,4 possible)
Z-EL-A	yes	yes	Z and A specified in DATA table
Z-EL-27	yes	no	A = 27 isotopes of different elements, specified in DATA-table
14-EL-A	no	yes	Different Mg isotopes, specified in DATA table
14-Mg-28	no	no	^{28}Mg, single residual nuclide, treated as before

* means either cross section or thick target yield etc. as specified in REACTION SF6

3. Coding of Outgoing Particles in REACTION SF3

Giving any code in SF3 is obligatory. If no outgoing particles can be specified (explicitly or according to the following rules) and no process code applies (cf. item 4. below), the code X must be used.
When coding the outgoing particles, one has to discriminate two cases:

a) Unspecified products or integral Z or A yields (code PROD in SF4). In this case the outgoing particles can not be specified and must be coded by X and/or a process code (see item 4. below).

b) Defined nuclides (code EL in SF4). Here, the outgoing particles for each residual nucleus can be calculated in principle by balancing SF1, 2 and 4 taking the respective Z and/or A-value from the DATA-Table. This case should be coded by XNYP (and possibly a process code) where X and Y are explicitly inserted by an index program which must be able to split up the multiple reaction code into single defined reactions giving explicit outgoing particles and residual nuclei.

   Since a balancing which calculates only the overall number of protons and neutrons emitted, neglecting larger entities, is not meaningful for too many emitted nucleons (where larger entities certainly contribute) the following restrictions should be given (and included into the indexing program):

   1. A balancing to calculate the number of outgoing neutrons and protons is only performed if X + Y is ≤ 16. For larger numbers the index program should print an appropriate message.

   2. If composed particles have been definitely identified in the experiment they must be given in SF3 (e.g. XNYP+A, XNYP+8-O-16). In balancing, this particle has to be taken into account and must be kept in the index as the same entity.

   3. If such larger entities are not identical for all final nuclides, the differing reactions must be coded in separate subentries.

4. Coding of Processes in REACTION SF3

Firstly, we want to repeat our objections to give codes for reaction mechanisms at all (except for the case of fission), since in our opinion a clear distinction between different reaction types is not possible. Furthermore, as already mentioned, the formalism of coding multiple residual nuclei must be applicable generally, independent of the special reaction mechanism. However, we can accept process codes

in SF3, mostly combined with an outgoing particle code (see item 3. above) and separated from it by a slash under the following conditions:

a) Process codes indicating a reaction mechanism, may be used in addition to codes for outgoing particles (explicit particle code, XNYP, X etc) or as the only code in SF3 (especially in case of fission).

b) The use of process codes in SF3 is not obligatory (except in case of fission). If a code is given, this should be considered as a mere hint for users of the KACHAPAG-file, and any retrievals on these codes, if performed at all, should be clearly stated as to be far from complete.

c) Since there is no reason why two kinds of reactions should be favoured (fission, spallation), there should be introduced further optional process codes, e.g. for fragmentation, compound nuclear reactions (including precompound emission), direct reactions (like nucleon transfer, projectile break up etc.) etc.

5. Links between the DATA- and BIB-Section

To ensure unambiguity in defining the end products for REACTION's with multiple residual nuclei, a definitive link between lines in the DATA-table and BIB-keywords (especially DECAY-DATA) is necessary. Basing on our proposal of a DATA-HEADING 'POINTER' connected with the usual pointers for the BIB-keywords, the discussion in Kiev revealed the following improved concept which avoids the disadvantage to have only 10 pointers available:
Those entries under all BIB-keywords which are related to one (or several) lines of the DATA-table start with (n.) in column 12 of the information field (n is a maximal two digit integer)*). The number 'n.' is repeated in the respective line of the DATA-table under the new HEADING 'BIBFLAG'.

Example:

```
REACTION        (79-AU-197(P,XNYP)Z-EL-A,,SIG)
DECAY DATA      (1.)(.....)
                (2.)(.....)
RAD-DET         (1.)(.....)
                (2.)(.....)
   :
   :
DATA
EN        MASS     ELEMENT     DATA     BIBFLAG
..        ....     .......     ....     .......
```

Alternative possibilities for coding the BIBFLAG are e.g.
(1., code) or
(1.)
(code) } where the coded information starts again with its opening parenthesis in Col. 12. Regarding the different amount of programming effort we would like to ask the programmers for comments and advice.

*) The general rules of application are the same as for the use of pointers

II. Generalized Use of Pointers

As discussed in Kiev and already proposed in Memo CP-B/6 (p.2) we would like to introduce an extension of the applicability of pointers as links between REACTION and the DATA-section or the residual BIB-section as well as between the residual BIB-section and the DATA-section. Taking into account the objections made in Kiev we propose the following extended rules:

1. Multiple reactions coded under REACTION and discriminated by pointers:
   The respective pointers must occur in the appropriate columns of the DATA-section and/or respective other BIB-keywords (cf. example 1 below).
   Only those pointers are permitted for other BIB-keywords or DATA-columns which are defined by the respective reaction (cf. example 2 below).

2. Only one reaction coded under REACTION:

   a) Pointers linking any of the other BIB-keywords to each other are permitted without restrictions.

   b) If more than one column of the DATA-section (with the headings DATA, SUM, RATIO etc.) are to be linked to other BIB-keywords, the information field under REACTION must be repeated and each identical field flagged with the respective pointer (cf. example 3 below).

   c) An exception is the link between the keyword MONITOR (and the new MON-REF, DECAY-MON) and respective DATA-columns MONIT, if all monitor reactions and the respective MONIT-data refer to a single reaction and DATA-column with heading DATA, SUM etc. In this case, the REACTION-information is not repeated (cf. example 4 below).

3. Reactions with multiple endproducts:
   In this case the new 'BIBFLAG' is used as link between BIB- and DATA-section as proposed in item I. 5. of this Memo (cf. example given with item I.5 above).

Example 1

```
REACTION     1(Z-S-A(P,2N)Z'-S'-A'-M,,SIG)
             2(Z-S-A(P,2N)Z'-S'-A'-G,,SIG)
DECAY-DATA   1(.....)
             2(.....)
RAD-DET      1(.....)
             2(.....)
   .
   .
   .
DATA
EN           DATA      1      DATA      2
..           ..........       ..........
```

Example 2: This case is not permitted, also if both detectors and types of radiation detected refer independently to both of each reaction

```
REACTION      1(............)
              2(............)
RAD-DET       3(.....)
              4(.....)
DETECTOR      3(.....)
              4(.....)
    :
    :
DATA
EN            DATA   1      DATA   2
..            ........      ........
```

Example 3:

```
REACTION      1(29-CU-63(P,N)30-ZN-63,, SIG)
              2(29-CU-63(P,N)30-ZN-63,, SIG)
RAD-DET       1(30-ZN-63,DG)
DECAY-DATA    1(30-ZN-63,DG,.....)
PART-DET      2(N)
DETECTOR      1(....)
              2(....)
    :
    :
DATA
EN            DATA   1      DATA   2
..            ........      ........
```

Example 4:

```
REACTION      (Z-S-A(P,N)Z'-S'-A,, SIG)
MONITOR       1(.........)
              2(.........)
MON-REF       1(.........)
              2(.........)
    :
    :
DATA
EN            DATA   MONIT   1      MONIT      2
..            ....   .........     ...........
```

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