MEMO CP-C/15

Date: July 12, 1977

From: V. McLane, T. Burrows, C. Dunford

Subject: I. Decay Data, Reaction Products, Product Yields

II. Fission

III. Spallation

IV. Particle Dictionaries

V. Report coding

VI. MONIT-REF

Reference: Memos CP-D/27, CP-D/28, CP-D/29, CP-B/9, CP-B/11, CP-B/12

I. Decay Data, Reaction Products, Product Yields

1) We support KACHPAG's proposal to add the Data-Heading Keyword BIBFLAG as the easiest and clearest way to specify decay data for the variable product nucleus. We propose a small modification: to code the flag, in its own parenthesis, inside the parenthesis of the DECAY-DATA code.

Example:

```
BIB
 :
 :
DECAY-DATA    ((1.).....)
              ((2.).....)
 :              •
 :
DATA
EN     MASS     DATA    BIBFLAG
---    NO-DIM   ---     NO-DIM
---     ---     ---       1.
---     ---     ---       2.
```

The double parenthesis would signal the presence of the flag. Decay data for a single reaction product would be coded as it is presently.

The following would be added to EXFOR, Section VI; 'Links between BIB, COMMON, and DATA.'

10. RAD-DET, DECAY-DATA

Entries under these keywords may be linked to one (or several) lines in the data table using the Data-Heading Keyword BIBFLAG. The fixed point numbers entered into the BIBFLAG data column must be repeated under the associated Information-Identifier Keyword, enclosed in parenthesis, before the coded information for that keyword.

The following would be added to EXFOR, Section VIII, under DATA, RAD-DET.

"An optional first field may be added to code to link the DECAY-DATA string to one or more lines in the data table. This field consists of the fixed point number as given in the BIBFLAG data column, enclosed in parenthesis.

Example:

DECAY-DATA ((n.) nuclide, half-life, radiation)

or respectively

RAD-DET ((n.) nuclide, radiation

Revised LEXFOR entries for FLAG and Decay Data are attached.

2) After further consideration, we prefer not to introduce the Data-Heading Keyword ISØMER. Defining the reaction products by their half-lives is much less ambiguous. Therefore, we suggest using the Data-Heading Keyword HL instead.

3) We have rewritten the addition to page VIII.3 on Reaction Products proposed in Memo CP-D/27 as a LEXFOR entry, incorporating suggestions from memo CP-B/11. (See attached Reaction Products and Product Yields). Information to be included in Section VIII should be much briefer; we will include that in our draft Section VIII, to follow.

4) We agree to leave the codes PY and FY as previously defined. We cannot think of any other use for 'Yield' except fission yield.

5) Philosophical discussion on Specification of Variable Product Nuclei

a.) The tabular representation for reaction products was originally proposed to handle in an efficient manner, those reactions or processes which are normally described by a nuclear charge/mass distribution. It is generally true in such cases that a unique reaction of the type A + B → C + D is impossible to specify, so that only a distribution of final products has any meaning. Fission is such a case.

Another case where the exact reaction is usually not known (or is known only over a portion of the incident particles energy range) is the nuclide production cross section. The use of the 'X' process code meaning "all possible reactions" is appropriate. In general, the data table form will not be needed for particle

production.

The convenience from a compiler standpoint of coding multiple particle production such as (p,2n) (p,3n) (p,4n) in a single table using the product mass in the data table to identify the exact reaction is recognized. It has the obvious disadvantage of not giving the known reaction fully in the REACTION keyword, but requiring further processing, either mental or digital to recover the exact reaction being measured. As we recall, one of the strong arguments for the REACTION keyword was that, although it contained redundancies in many cases (the product nucleus for example), this was universally recognizable and convenient for compilers and users. I would not like to back away from this concept and adopt the KACHAPAG suggestion for coding multiple reactions as described above. If KACHAPAG wishes to compile in a more compact format and translate to accepted conventions before transmitting, as they do in some cases now, we, of course, would have no objection.

b.) Use of the codes ELEM and MASS does not lose any information for a future index. If necessary, an indexing program can generate an index entry for every ZA combination in the COMMON and DATA tables in a very simple way which would be equivalent to having the data for each product in a separate subentry with the product explicitly given in the REACTION keyword. Furthermore, there is no inherent advantage in finding a Z, or A in the REACTION keyword, and finding the other in the data tables as could be the case if the proposal in CP-B/9 were accepted.

c.) As we have previously stated mass yields, charge yields, etc., are really different quantities, therefore, they should be differentiated in the quantity fields.

5) We can see no advantage to the addition of PROD to SF4. We would prefer to leave SF4 blank for the precess codes TOT,ABS and NON, and do not think it is worthwhile to introduce it to be used only with the process code F. (Note: added: Memo CP-B/13 just received. Agree to leave FF as optional in SF4 for fission cross sections).

II. Fission

We have rewritten the proposed LEXFOR entry on Fission (Memo CP-D/27) with a more generalized definition, and excluding product yield examples which should go into Fission Yields.

[See attached]

III. Discussion of Spallation and the Proposed Use of "SPL" in SF5

The reader is referred to CP-C/8 for a general discussion of spallation. We will limit this discussion to the justification of the use of "SPL" in SF5, rather than SF3. A proposed LEXFOR page is attached.

For heavy-ion and high-energy reactions, the borderline between various processes such as fission, spallation, fusion, quasifission, and fragmentation among many others, becomes very fuzzy and the resultant analysis depends heavily on theory. Therefore, we feel that it is more useful to place such process codes in subfield 5 in a manner similar to "CN" and "DI", and propose that all such codes introduced in the future be place in SF5. In general, this would also increase search and retrieval capabilities. For example, (82-PB-208(P,4N)83-BI-205,SPL,...) would allow retrieval on either the outgoing particles, "4N", or on the process "SPL".

We realize that this produces an inconsistency in the case of the process code for fission, "F". However, "F" is so strongly imbedded in SF3 we are reticent to propose moving the code to SF5, unless there is support from the neutron Centers. This inconsistency will create problems in the future. For example, 800-MeV protons incident on ^{238}U produces a secondary neutron energy distribution which, below approximately 20 MeV, is dominated by fission neutrons, but is essentially spallation neutrons between 20 MeV and 800 MeV. Similarly, the mass and charge distribution would be distorted from that expected for a pure (p,f) reaction by the induced spallation.

Attached is a LEXFOR entry on Spallation.

IV. Particle Dictionaries

1.) Dictionary 13 should be kept for use with the QUANTS only.

2.) We can see a problem with adding the code for gammas as a reaction product to Dictionary 8 as there will be two symbols for Z=0. Programmers should take note.

3.) Instead of the addition of 3 particle dictionaries (making a total of 4), we would prefer to see one dictionary with a set of flags specifying legal use. (As we have done for Dictionary 24 and Dictionary 25).

A code with 3 fields would be sufficient:

Col 64 : = I - may be used in SF2 or SF3
Col 65 : = S - may be used in SF7 or EN-SEC
Col 66 : = P - particle, may be used with PART-DET, RAD-DET, DECAY-DATA, DECAY-MON
R - radiation, may be used with RAD-DET, DECAY-DATA, DECAY-MON.

A proposed particle dictionary is attached.

4.) We would like to change the definition of the code FF from 'fission fragment' to 'fragment'.

5.) With the adoption of these proposals to coding rules for the REACTION keyword particles would be as follows:

SF1: Z-S-A-X
SF2: particle code from Dictionary 33, where Column 64=I or, for particles heavier than alpha, Z-S-A-X
SF3: process code from Diction ary 30
or particle code from Dictionary 33, where Col 64=I
or, for particles heavier than alpha, Z-S-A-X
SF4: code of the form Z-S-A-X, or, for variable product nuclei codes ELEM and/or MASS.
SF7: particle code from Dictionary 33, where Col 65=S.

V. Report Coding

We agree with Memo CP-D/29 in the need for more detailed specifications of report coding. We have incorporated it into our new version of Section VIII, slightly restructured.

VI. MONIT-REF

We do not agree that MONIT-REF should be obligatory. There are many cases, especially for thermal cross sections measured relative to gold and cobalt standards, where no reference is given by the author. In this case the keyword is not necessary.

Following is a proposed EXFOR manual entry to go in Section VIII.

MONIT-REF (REACTION formalism only)

1. This keyword is used to give information about the reference from which the monitor used in the experiment is taken.

2. Keyword is optional, but if present must include coded information.

3. The general format of the code contains three main fields
   (subaccession #, author, reference)

   Subaccession Number. EXFOR subaccession number of monitor data.

   Author. The first author (coded as under AUTHOR), followed by '+' when more than author exists.

   Reference. Coded exactly as under REFERENCE

   In case the subaccession number and/or authors are omitted, the corresponding commas must be given,
   e.g.: (,, reference)

4. In the case of more than one monitor reference, each must be coded separately, starting in Col. 12. Entries under MONIT-REF and MONITOR may be linked by pointers.

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Decay Data

DECAY-DATA Under this keyword, decay-data pertinent to the table given in the DATA section, are entered in the sequence

decaying nucleus,
half-life (value and unit),
type of radiation,
energy of radiation in keV,
abundance of the radiation measured

these data may be given for more than one decay mode. See page VIII.? for coding rules.

Decay-data are entered

- in order to define a metastable state,
- when used as basic parameters for deducing the data given in the DATA section,
- or as additional information resulting from or related to the experiment.

Free text explanation will often be desirable, for example to state whether the decay data were obtained from the experiment or quoted from another source.

Note: Half-lives may also be coded in the COMMON or DATA section, see Half-lives.

Decay Data for Variable Product Nuclei

In the case of variable product nuclei, where the Reaction Product is defined in the data using the Data-Heading Keywords ELEMENT and MASS, the decay data information is coded as strings of information under the keyword DECAY-DATA. These strings are linked to the relevant nuclei using the Data-Heading Keyword BIBFLAG. (See page VI.? and VIII.?)

If the half-life values are the only type of decay information to be given they may be entered as a data column under the Data-Heading Keyword HL.

DECAY-MON Under this keyword decay data assumed by the author for the monitor used in the experiment are given. The coding rules are the same as for DECAY-DATA.

Fission

Definition: The sum of all interactions where, spontaneously or by capture of an incident nucleus, particle or gamma, a highly excited and deformed nucleus decays by scission into at least two reaction products both having a mass greater than 6, or, in the case of an incident nucleus of mass greater than 6, both having a mass greater than the incident mass.

See also: Fission Yields, Ternary Fission, Fission-Neutron Spectra Data

Compare: Spallation

Quantity codes:

in ISO-QUANT formalism: NF = fission cross-section
see Dict. 14 for more detailed quantity codes

in REACTION formalism: code "F" in SF3. Special rules apply for the Reaction Product to be coded in SF4 (see under Reaction Product)

Examples:

(92-U-235(N,F),,SIG) = fission cross section
(92-U-235(N,F),,DA,FF) = ang. distr. of unspecified fission fragments
(92-U-235(N,F)2-HE-4, TER,DA,A) = ang. distr. of ternary fission alphas
(92-U-235(N,F)54-XE-124,,YLD) = yield of the fission-product Xe-124
(92-U-235(N,F)54-XE-133-G,CUM,SIG) = cumulative production cross-section for the fission-product Xe-133 g

FLAG

Flags are used to link information in the BIB-section to specific lines in the data table.

There are presently in EXFOR two types of flags in uses.

1. To link free-text comments in the BIB-section with one or more lines in the data table, fixed point number are coded under the Data-Heading Keyword FLAG with units NO-DIM. There may be more than one column with the heading FLAG (see EXFOR page V.9).

   The meaning of the flags are given under the Information-Identifier Keyword FLAG, where the actual flags are given in parenthesis, each on a separate line, starting in column 12, followed by a free text comment. (See EXFOR, page VIII.?)

2. To link coded information in the BIB-section with one or more lines in the data table, fixed point numbers are coded under the Data-Heading Keyword BIBFLAG with units NO-DIM.

   The data lines are linked to the appropriate coded information by repeating the actual flags, enclosed in parenthesis, as the first field in the coding string.

   Use is presently limited to the Information-Identifier Keywords DECAY-DATA and RAD-DET.

Note: Flags should not, in general, be used for entire subworks or for one line data tables. They should never be used in the COMMON section. An exception would be where the BIB-information is given in the common subentry (SAN=1) and, for some, but not all, of the following subentries, the first condition would occur.

Product Yields

[Use in REACTION formalism]

Definition

Product yield data shall be defined as all data for which the reaction as specified may lead to more than one reaction product and for which the reaction product is one of the parameters of the data presented.

Note: Currently the processes for which this applies are fission and production data (F or X in SF3).

See also: Fission Yields, Spallation

Specification of the product nucleus

a.) In the case where there is one specific reaction product given for the data table, the product may be coded as specified for reaction SF4. (See Reaction Products).

b.) In the case where the data age given for more than one nucleus, the nuclei will be specified in the COMMON and DATA sections using the Data-Heading Keywords ELEMENT and MASS.

In this case SF4 contains the code:

ELEM - if the column-heading ELEMENT is used in the DATA table

MASS - if the column-heading MASS is used in the DATA table

ELEM/MASS - if the column-headings ELEMENT and MASS are used in either the COMMON section or the DATA table.

SF4 is the only subfield that may become a variable by using this formalism. All other subfields of the REACTION code must apply unchanged for the given subentry.

Note: For CPND this "Variable Product Nucleus" formalism must not be used until the time that an improved indexing resp. retrieval program becomes available, which considers not only the REACTION code but also the Product Nuclei given under the column-headings ELEMENT, MASS, ISOMER.

Examples for coding product-nuclei as variables in the DATA tables:

(8-O-16(P,X)ELEM/MASS,,SIG) = cross section of specified product nuclei which are given in the DATA table under the column headings ELEMENT and MASS and (if applicable) ISOMER. If the DATA table contains only isotopes of a single element, the column ELEMENT may be given in the COMMON section. Similarly, if a "charge dispersion" is given, MASS may appear in the COMMON section with ELEMENT as a variable in the DATA table.

(92-U-235(N,F)MASS,CHN,YLD) = "chain yield" of several mass-numbers given in the DATA table under the column heading MASS (compare under Fission Yields). The DATA table may consist of only a single line, when the "chain yield" for only one mass-number is given.

Reaction Product

[Use in REACTION formalism]

Definition:

In general, the heaviest of all identifiable products of the reaction is defined as the Reaction Product (also called Residual Nucleus) to be coded into SF4 of the REACTION keyword.

Exceptions or special cases are:

a.) If the sequence of outgoing particles is meaningful (i.e., SF5 contains the code SEQ), the heaviest of the final products should be coded in SF4. This may not be the heaviest of all products.

Example: 5-B-10(N,A+T)2-HE-4,SEQ,SIG

b.) If the reaction product is not defined as in the case of the total cross section (TOT in SF3), absorption and nonelastic processes (ABS and NON in SF3), and, in some cases, for the fission process (F in SF3), e.g., total fission cross section, SF4 is left blank.

c.) When quantities are given for the yield of specified nuclides, particles or radiations. (F or X in SF3), the product considered is coded in SF4 (regardless of whether it is the heaviest reaction product). See Product Yields.

Coding

a.) The Reaction Product as defined above is coded in SF4 in the form Z-S-A-X as defined on page VIII.?. If light particles or gammas are defined as Reaction Product, these are coded in SF4 in the Z-S-A form identical to the coding in the target-field SF1. In addition, the code

0-G-0 for gammas

is used in analogy to the codes

1-H-1 for protons, or

0-NN-1 for neutrons,

Thus, the particle codes (A,HE3,T,D,P,N,G) are not used in SF4.

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Examples:

(92-U-235(N,F)54-XE-124,CUM,YLD) = cum.yield of Xe-124

(92-U-235(N,F)2-HE-4,TER,DA,A) = ang.distr. of ternary fission alphas

but: (92-U-235(N,F),,DA,FF) = and distr. of unspecified fiss-fragments

(28-NI-0(N,X)0-G-0,,SIC) = gamma production cross section

b.) Variable Product Nucleus

In the case where a process results in the production of more than one nucleus, and the data are given a function of these product nuclei, the reaction products may be entered into the data table as variables under the Data-Heading Keywords ELEMENT and/or MASS.

In this case SF4 contains the code:

ELEM - if the column-heading ELEMENT is used in the DATA table

MASS - if the column-heading MASS is used in the DATA table

ELEM/MASS - if the column-headings ELEMENT and MASS are used in either the COMMON section or the DATA table.

Note: At present this is limited for use with the process codes F and X in SF3.

SPALLATION

SPALLATION

Definition: An interaction between two nuclei which has as its main feature that the primary interaction occurs between the individual nucleons of the two interacting nuclei.

Compare: Direct Interaction and Compound-Nucleus Interaction, Fission.

See also:

Quantity Codes:

ISO-QUANT formalism: Not coded

REACTION formalism: Code "SPL" in SF5

Examples:

(6-C-12(P,X),SPL,SIG) = Spallation cross section

(6-C-12(P,X)MASS,SPL,SIG) = Spallation production cross sections of the specified masses given in the DATA table under the heading MASS.

(82-PB-208(P,4N)83-BI-205,SPL,SIG) = Cross section for the spallation product ^{205}Bi

(82-PB-208(P,X),SPL,DA/DE,FRG) = ,$d^2\sigma/d\Omega dE$ of the spallation fragments

(82-PB-208(P,X)0-NN-1,SPL,DA,N) = Angular distribution of the spallation neutrons.

(92-U-238(P,F)0-NN-1,SPL,DE,N) = Neutron energy distribution produced by proton-induced fission and spallation of ^{238}U.

Spallation Product Yield: Cross section for the production of specified product nuclei by the process of spallation. See LEXFOR Product Yields

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DICTION              33                                          30000 33
0           (-) NONE                                           I 30000 33
G           (GAMMA)                                           ISP30000 33
N           (NEUTRON)                                         ISP30000 33
P           (PROTON)                                          ISP30000 33
D           (DEUTERON)                                        ISP30000 33
T           (TRITON)                                          ISP30000 33
HE3         (HE-3)                                            ISP30000 33
A           (ALPHA)                                           ISP30000 33
FF          (FRAGMENTS)                                        SP30000 33
DN          (DELAYED NEUTRONS)                                 SP30000 33
PN          (PROMPT NEUTRONS)                                  SP30000 33
XR          (X-RAYS)                                            R30000 33
DG          (DECAY GAMMAS)                                      R30000 33
AR          (ANNIHILATION RADIATION)                            R30000 33
B-          (DECAY BETA-)                                       R30000 33
B           (DECAY BETA)                                        R30000 33
B+          (DECAY BETA+)                                       R30000 33
E           (ELECTRON)                                          R30000 33
            (ELECTRON CAPTURE)                                  R30000 33
SF          (SPONTANEOUS FISSION FRAGMENTS)                    SP30000 33
ENDDICTION
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