Excitation Energy for Inclusive Reaction (SF3=X)

(N. Otsuka, O. Schwerer, CP-D/813 Rev.2, 2014-03-04 and updated)

Introduction – E2135.002

In some EXFOR double-differential cross section (DDX) data sets, the excitation energy is defined for an inclusive reaction, for example,

```
SUBENT          E2135002   20130309
…
REACTION    (28-NI-58(P,X)0-NN-1,,DA/DE)
EN-SEC      ANG-CM is polar angle (c.m.) between beam and neutron
            (E-EXC,29-CU-58)
…
EN          EN-RSL     ANG-CM
MEV         MEV        ADEG
 198.        0.3        0.
…
E-EXC       DATA-CM
MEV         MB/SR/MEV
 -3.02210    0.00077
```
…

The incident proton energy (E_p=198 MeV) is enough higher than the (p,2n) reaction threshold (E_p=22 MeV), and therefore the data set must be treated as ^{58}Ni(p,n+x) rather than ^{58}Ni(p,n)^{58}Cu in general. But the energy spectrum is given as a function of the excitation energy of ^{58}Cu calculated by the two body kinematics, and the heading `E-EXC` is related with ^{58}Cu (see `EN-SEC`) even though this nuclide is not always produced by the reaction process expressed by the `REACTION` code.

It should be noted that

- without the `EN-SEC` entry, `E-EXC` would refer to `0-NN-1` in SF4 (!);
- even with the `EN-SEC` entry, this way of coding introduces an inconsistency, as the coding `(P,X)0-NN-1` implies that there is no single heavy reaction product defined, and therefore the data should not depend on a parameter of ^{58}Cu.

A similar data set has been sometimes coded in a different way. For example, Dr. K. Miki (EXFOR E2382 [1]) informed JCPRG that his (t,^{3}He+x) DDX data sets (E_t=300 MeV/A, θ~0) must be related with the two body (t,^{3}He) reaction because he regards that the direct process is dominant. This opinion is taken into account in this EXFOR entry, for example,

`(40-ZR-90(T,HE3)39-Y-90,,DA/DE)`

instead of

`(40-ZR-90(T,X)2-HE-3,,DA/DE)`.

It could be difficult for EXFOR compilers to make a right decision (especially when the authors are not available). For example, EXFOR F1183 [2] gives angular distributions (25 deg <θ_{cm}<165 deg) of DDX for ^{65}Cu(α,p+x) at E_α=24.4 MeV and a constant excitation energy of ^{68}Zn derived by the two body kinematics. The threshold energy of the (α,2p) reaction is about 13 MeV.

Proposal

A possible solution could be use of a new branch code (say, `ICL`), for example

`(28-NI-58(P,N)29-CU-58,ICL,DA/DE,N/RSD)`.

For E2135.002. The new branch code expresses that the data are not corrected for other channels emitting the same outgoing particle considered. When necessary, one may also propose a similar code

`(ICL)`: uncertain if the data sets are corrected for the many body final states.

Dictionary 31 (Branch codes)

`ICL` Not corrected for other channels emitting the same particle

Dictionary 236 (Quantities)

`ICL,DA/DE,*/RSD` Double diff. cross section d2/dA(*)/dE(residual nucleus) not corrected for other channels emitting the same particle

Quantity	Reaction Type	Dimension	Subentry
ICL,DA/DE,*/RSD	DAE	DAE	E2135.002-008 F1183.002-005,010-011 O0223.002-009

Addition to LEXFOR "Production and Emission Cross sections"

Production Cross Section defined with Excitation Energy

Sometimes the production cross section is given as a function of the excitation energy of the reaction product from a specific process (*e.g.*, two body reaction). This may happen when the contribution of the direct process is expected to be dominant (*e.g.*, data at forwarded angle). In this case the production cross section may be coded with the specific process considered by the author under `REACTION` with a branch code `ICL`.

Example:

`(28-NI-58(P,N)29-CU-58,ICL,DA/DE,N/RSD)`

Double differential cross section $d\sigma/d\Omega_n dE_x(^{58}Cu)$ for $^{58}Ni(p,n+x)$ reaction.

Problematic entries

In this occasion, I went through EXFOR entries where

- REACTION SF3=`X` and SF6=`*DE*` and the secondary energy is coded under `E-EXC`
- REACTION SF3=`X` and the secondary energy is coded under `Q-VAL`.

Problematic entries are summarized at the end of this memo with proposed corrections.

References

[1] K. Miki et al., Phys. Rev. Lett. **108** (2012) 262503 (EXFOR E2382).

[2] A.V. Smirnov et al., Izv. Akadem. Nauk. USSR, Ser. Fiz. **49** (1985) 138 (EXFOR F2135).

Many data sets listed in Memo CP-D/813 have been already corrected, and deleted in this working paper (2014-04-29)

Error list 1: REACTION SF3=X and SF6=*DE* and the secondary energy is coded under E-EXC

		REACTION	Proposed correction
C0728	002	(2-HE-3(P,X)0-NN-1,,DA/DE)	E-EXC → E-RL; add (E-RL,P+P+P) under EN-SEC. (Excitation energy measured from 3 proton mass energy)
	003	(2-HE-3(P,X)0-NN-1,,POL/DA/DE,,ANA)	
J1601	002	(6-C-12(PIP,X)1-KP-0,,IPA/DE)	? The current Z-S-A formalism does not support hyper nuclei (e.g., ${}^{12}{}_{\Lambda}C$)

Error list 2: REACTION SF3=X and the secondary energy is coded under Q-VAL.

		REACTION	Proposed correction
22077	014	(29-CU-0(N,X)0-NN-1,PAR,DA)	Use (29-CU-0(N,INL)29-CU-0,PAR,DA)??
	029	(22-TI-0(N,X)0-NN-1,PAR,DA)	Use (22-TI-0(N,INL)22-TI-0,PAR,DA)??
	044	(40-ZR-0(N,X)0-NN-1,PAR,DA)	Use (40-ZR-0(N,INL)40-ZR-0,PAR,DA)??