34. FILE 34. COVARIANCES FOR ANGULAR DISTRIBUTIONS OF SECONDARY PARTICLES

34.1. Introduction

File 34 contains covariances for angular distributions of secondary particles. It is assumed that uncertainties will not be required on all quantities in File 4.

A central question is whether quantities in File 3 may have important correlations with those in File 4, or whether one need be concerned only with correlations of angular distribution parameters as a function of incident energy. It is judged that covariances between the magnitude and shape are likely to be important only when theory plays a strong role in an evaluation. When such covariances occur, the idea, developed below, is that one expresses covariances with the a_0 Legendre coefficients even though $a_0 \equiv 1$ in the ENDF system.

Because of the simplicity of representing the covariances of Legendre coefficients rather than normalized probability components, only the former is considered here even for cases where File 4 has tabulated $p(\mu)$.

In ENDF-6 formats there is no provision for covariance components linking the angular distribution parameters for different materials, though a MAT1(=0) field is provided.

34.2. Formats

The general structure of File 34 follows the normal pattern, with sections for increasing MT values. The LTT flag definition is modified from its meaning for File 4.

The following quantities are defined:

ZA,AWR Standard material charge and mass parameters

LTT Flag to specify the representation used, and it may have the following values in File 34.
LTT=1, the data are given as Legendre coefficient covariances as a function of incident energy, starting with a_1 or higher order coefficients.
LTT=3, the data are given as Legendre coefficients covariances as a function of incident energy, starting with a_0. (This information is redundant in the formats, as specified below, but is considered desirable as an alarm flag.)
LTT=3 if *either* L or L1=0 anywhere in the Section.

NMT1 Number of subsections present in File 34 for various MT1≥MT.

A section of File 34 for a given MT has the form:

```
[MAT,34,MT/ ZA,  AWR, LVT, LTT,  0, NMT1] HEAD          (LVT=0)
              <subsection for MT1 = MT>
            ----------------------------
            ----------------------------
              <NMT1th subsection for largest MT1>
[MAT,34,0/ 0.0,  0.0,   0,   0,  0,    0] SEND
```

Each subsection begins with a control record that identifies the related MT1 and indicates how many Legendre coefficients are covered for the angular distributions for reaction types MT(NL) and MT1(NL), MT1≥MT.

The following quantities are defined:

MT1 "Other" reaction type; this subsection contains data for the covariances COV[$a_L(E_1)$,$a_{L1}(E_2)$] between Legendre coefficients for two reaction types at incident energies E_1 and E_2 for various L and L1.

NL Number of Legendre coefficients for which covariance data are given for the reaction MT. (This value must be the same for each subsection.)
(The first coefficient is a_0 if LTT=3, $a_1 \geq 1$ if LTT=1).

NL1 Number of Legendre coefficients for which covariance data are given for reaction MT1.

L Index of the Legendre coefficient for reaction MT for this sub-subsection. Note that sub-subsections need not be given for all values of L and L1.

L1 Index of the Legendre coefficient for reaction MT1 for this sub-subsection.

NI Number of LIST records contained in this sub-subsection.

LS Flag, recognized when LB=5, to indicate whether the matrix is symmetric (1=yes, 0=no).

LB Flag to indicate the covariance pattern as a function of incident energy. LB values 0,1,2,5 & 6 are allowed, and are defined as for File 33 in Section 33.2.

NT Total number of item ,
For LB=0,1,2, NT=2∗NE;
for LB=5, NT is dependent on LS as given in Section 33.2;
for LB=6, NT=1+NER∗NEC.s in the LIST.

{Data} For LB=5, sequence $\{E_k\}$ $\{F_{k,k}\}$;
for LB=6, sequence $\{E_k\}$ $\{F_{k,l}\}$ (as in File 33).

A subsection has the following form:

```
[MAT,34,MT/ 0.0, 0.0, MAT1,  MT1,    NL,   NL1] CONT          (MAT1=0)
[MAT,34,MT/ 0.0, 0.0,   L1,   L11,    0,   NI1] CONT [1]
[MAT,34,MT/ 0.0, 0.0,  LS1,   LB1,   NT1,   NE1/ {Data1}] LIST
            ---------------------------------
            ---------------------------------
[MAT,34,MT/ 0.0, 0.0, LSNI1, LBSNI1,  NTSNI1, NENI1/{DataNI1}] LIST
            ---------------------------------
            ---------------------------------
[MAT,34,MT/ 0.0, 0.0,  LNSS,  L1NSS,     0,  NINSS ] CONT
[MAT,34,MT/ 0.0, 0.0,  LS1,   LB1,    NT1,   NE1/ {Data1} LIST
            ---------------------------------
            ---------------------------------
[MAT,34,MT/ 0.0, 0.0, LSNINSS, LBNINSS, NTNINSS, NENINSS/ {DATANINSS}] LIST
```

[1] In this first sub-section, L and L1 are the smallest values present of NL and NL1.

The number of sub-subsections NSS for a given MT1 is NL∗NL1, and they are ordered as (L,L1) = (1,1),(1,2),...,(NL,NL1). (Not all L-values need be included). When MT1=MT, redundancy is avoided by giving each sub-subsection only once, when L1≥L. In this case NSS=NL∗(NL+1)/2.

34.3. Procedures

It is strongly recommended that the maximum order of the Legendre expansion for uncertainty representation be minimized.

If there are important cases (*e.g.*, n-p scattering) where the shape of the angular distribution is correlated with the magnitude of the scattering cross section, the convention is that the covariances among scattering (integrated) cross sections must be in File 33 and must not be repeated, so all sub-subsections in File 34 with L=L1=0 would contain null covariance components. This procedure would maintain the convention that covariance components are summed from various portions of the ENDF/B file corresponding to a particular material. (The information contained in File 34 for L *or* L1 nonzero is the motivation for the present procedure). Note that, in the case of correlation between shape and magnitude of a scattering cross section, it is possible for an absorption cross section MT-value to show up in File 34 (with L=0 only).