Title
LESAGE LEVEL SCHEME ANALYSIS AND GRAPHICS USER'S MANUAL

Author
Lederer, C.M.

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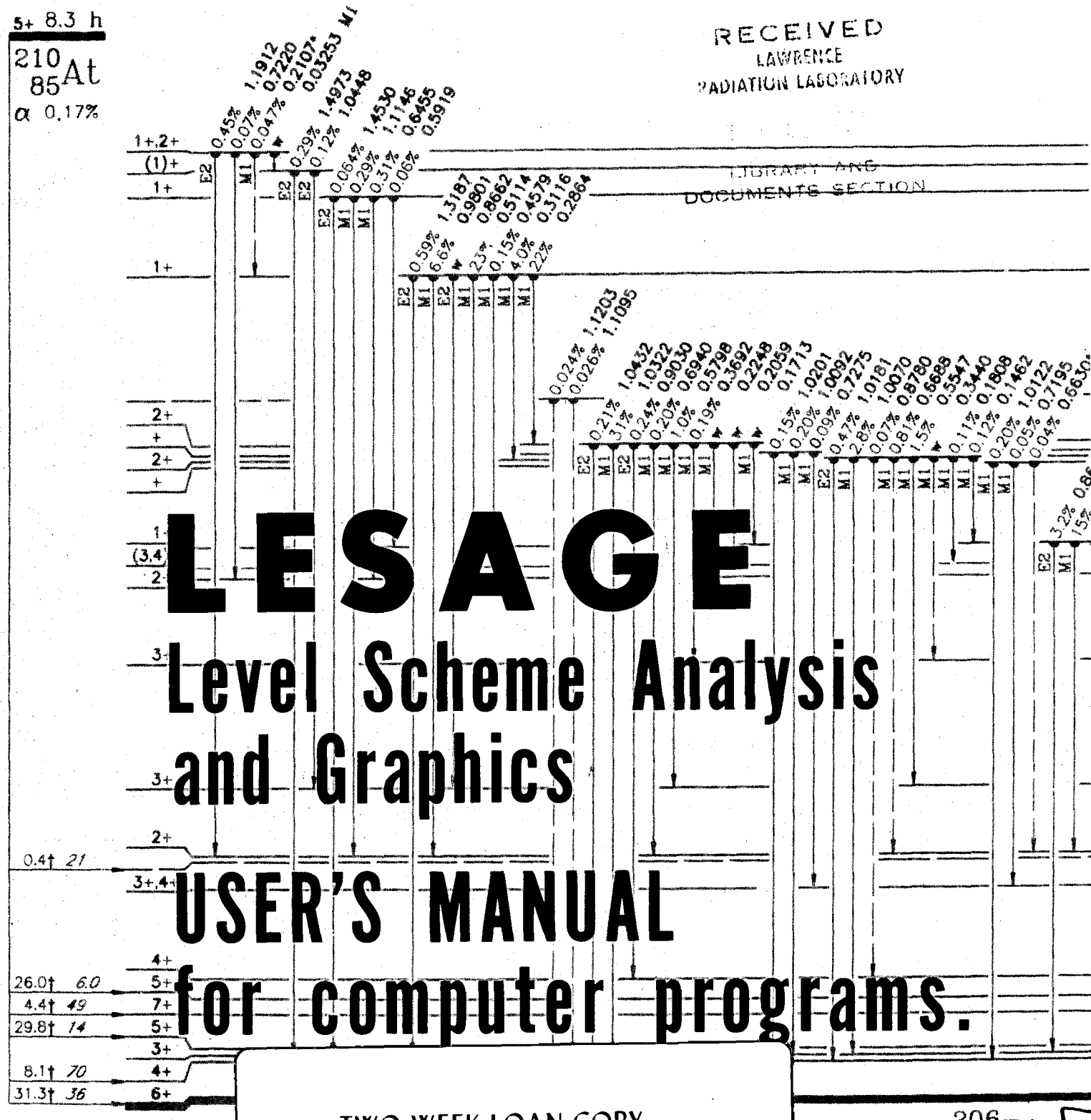

LESAGE

Level Scheme Analysis and Graphics

USER'S MANUAL for computer programs.

DISCLAIMER

Preface

A few of the features described in this manual have not yet been implemented:

1. Particle decay from excited states may be input and checked, but will not be plotted.
2. Stackplots cannot be done. Specification of the STACKPLOT option (see section V.C of this manual) is ignored by the programs.
3. K-Nilsson assignments can be plotted on the level scheme, but not in a separate table. The K=TABLE specification (see section V.E of this manual) is ignored by the programs.

This manual will be revised and re-issued when these features have been implemented and/or other features added.

CML

LESAGE USER'S MANUAL

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LESAGE

Level Scheme Analysis and Graphics[e]

USER'S MANUAL*

C. M. Lederer

November, 1973

I. INTRODUCTION

I.A. Program Functions

LESAGE is a group of computer programs which produce nuclear level-scheme plots from punched-card input. They perform the following operations:

1) Exhaustive checks of the input cards for syntax errors. Listing of the input cards with diagnostics for any errors found.
2) Calculation of log ft values for beta or EC decay and alpha hindrance factors wherever possible.
3) Checks for internal consistency in the physical data, including:
   a) Energy differences vs. transition energies
   b) Spin assignments and multipolarities
   c) Spin assignments vs. log fts and α hindrance factors
   d) Input vs. calculated log ft's, hindrance factors
4) Plotting of the level schemes with a 4000 × 4000 raster. CRT-film plotter. (Multiple frames may be used for large plots.)
5) Storage of large input decks in a permanent, updatable photochip library.
6) Retrieval and editing of stored level scheme data to produce updated or corrected plots.

e Ignore footnote e.

*Work performed under the auspices of the U. S. Atomic Energy Commission and the U. S. National Bureau of Standards.

I.B. General Description of Software

LESAGE consists of two major programs: LVS, which checks input cards, does all physical calculations, and sets up the data for plotting, and SCH, which does the graphics calculations and plots the schemes.

A short auxiliary program, FETCH, sets up retrieval of previously stored input data, if required by the user input.

Several Berkeley system routines are used to index, edit, store, and retrieve data: indexing and editing is done by UPDATE; storage and retrieval are performed by the chipstore programs WRITEMS and COPYMS. Plotting is done by the system routine COMIE.

A control-card deck loads the programs in proper sequence, including the system routines, as required by the user input.

The programs are stored on the Berkeley (7600) permanent-file and data-cell systems. As soon as the 7600 system is modified to permit manipulation of the CONTROL file, the control cards deck will also be stored on the data cell, and will be callable by a few standard control cards.

I.C. Hardware

The programs were written for the BKY CDC-7600 system. Because they require considerable small-core storage, it is not presently practical to run them on the 6000-series machine. Chipstore and plotting routines are staged through the 6000 computers automatically.

Plotting is done by a Stromberg Datagraphics SC 4060 CRT plotter on 35 mm film or 24X microfiche. Storage is done on the Berkeley mass storage facility ("chipstore"), an IBM photo-digital device.

II. USE OF THE PROGRAMS-A FEW SIMPLE EXAMPLES

Several simple examples of level-scheme input are given in figures 1a and 2a. The data is conveniently entered on keypunch forms (obtainable from the Table of Isotopes project). Corresponding printout and level-scheme plots are shown in figures 1b,c, and 2b,c. Note that the first column of each card defines the card function; "I" for reaction identification, "P" for decay-parent identification, "L" for a level, "D" for decay from a level (gamma ray), and Z to specify that a plot be made. X specifies plot-control options. (A few other types of cards can also be used, as described in more detail in section IV.) Data of a specific sub-type (e.g. level energy, spin, half-life) is punched in the proper field (group of columns) on the card.

Following these examples, it should be (barely) possible to make up input for a level scheme. A more complete description of the contents of input cards given in section IV-VI; section III explains the overall structure of the input deck.

III. INPUT DECK STRUCTURE

III.A. Overall Deck Structure-New Input Data

Figure 3a shows the structure of the input deck for "normal" processing of level schemes (without retrieval of previously stored input data).

The first card of the input deck:

*DECK NAME1 (beginning in column 1)

is required for the UPDATE card-indexing system. On the printout, each input card is identified by the "deck name" (NAME1 in the above

example), an alphanumeric identifier of ≤ 5 characters following *DECK [blank] on this card, and a card sequence number (see figures 1a,b and 2a,b). The sequence numbers can be used to identify cards for editing when an input deck that has been stored on the chipstore is subsequently retrieved for editing and replotting. The *DECK ... card(s) itself is removed before the rest of the input cards are processed by the level-scheme program.

The deck structure is illustrated in figure 3a. An example of how a number of level schemes can be logically grouped into an input deck is shown in figure 3b.

[Additional (optional) *DECK NAME2 cards may be inserted anywhere in the input deck (normally between different level schemes or groups of schemes); the only purpose of these is to permit selection of one scheme (or group of schemes) from the stored data for retrieval and plotting. The deck names on different *DECK ... cards must be unique; the following input cards will be identified by the new deck name and a new set of sequence numbers.]

Following the *DECK ... card are input cards which may define one or more level schemes. Each level scheme must begin with an "I-card" (an I in column 1; reaction identification), and ends when

1) An "E-card" or a 7-8-9 record separator is encountered

or 2) A "Z-card" ("do plot") is encountered,

or 3) A completed level scheme is followed by a new I-card, specifying the beginning of the next level scheme.

III.B. Overall Deck Structure-Retrieval and Editing of Stored Input Data

The only differences in the deck structure (figure 3c) for retrieval and editing of stored input are

1) The input deck is preceeded by a single "F-card" ("Fetch input") which specifies the information needed for retrieval from the chipstore, and a 7-8-9 record separator;

2) The input deck consists of editing specifications, as described in section VI. These specifications define insertions and deletions of cards from the stored input deck.

III.C. Structure of a Single Level Scheme

Level schemes consist of an ordered sequence of cards; the character in the first column of each card indicates the type of information on the rest of the card. (An "I-card" denotes a card with an I in column 1.) (Some of the card types and the quantities included on them have already been illustrated in figures 1a and 2a.) A single level scheme is described by the following cards in the sequence indicated (see figure 3d):

1) I - cards define the nucleus and reactions populating it. Each I-card defines one reaction. The 1^{st} card of a level scheme must be an I-card. Additional I-cards define additional reactions to be plotted in a combined scheme.

2) An R - card, following any I-card, lists references associated with the reaction specified on the I-card. If the only R-card follows the last of several I-cards, the reference(s) are assumed to be associated with the reactions specified by all I-cards.

3) P - cards following the I- and R-cards specify the parent nuclei for radioactive decay schemes. Each P-card describes one parent. P-cards are required only for radioactive decay schemes.

4) Q - cards, following the P-cards (or I- and R-cards, if there are no P-cards), describe the mode and daughter of particle (non-gamma) decay from excited states of the nucleus. Each Q-card describes one mode (daughter). Q-cards are used only in the relatively rare cases where excited states decay by particle emission (e.g. "delayed proton emitters" or "long-range" α particles); they are actually required only when one desires to plot particle decay to specific states in the daughter nucleus. The Q-value on a Q-card also permits the program to check that particle decay from excited states is energetically possible.

5) L - cards describe the properties of the levels; each L-card describes one level. L-cards follow the last of the Q-, P-, I-, or R-cards. They must be ordered by ascending energy. A level scheme must contain at least one L-card.

6) D - cards describe the decay of the levels by gamma rays (or particle emission). Each D-card describes the properties of one transition. D-cards are intermixed with the L-cards; a D-card follows the L-card for the level from which the transition originates. A group of D-cards for transitions from one level may occur in any order.

7) A Z-card following the last L- or D-card specifies that a plot be done. If the Z-card is omitted, the input will be checked, but no plot made.

In addition to I, R, P. Q, L, D, and Z cards, there are a number of special-purpose cards that may occur anywhere among the level scheme input cards:

C - cards contain comments. The comments are associated with the level scheme in which they occur.

M- and K- cards (cards with M or K in column 1) define the input energy units (MeV or keV) to be used on all following cards. The units may be changed at any time with another M- or K-card. MeV is assumed if not specified. (The same units should be used throughout a single level scheme.)

The energy units specified for a level scheme are assumed to apply also to succeeding level schemes in the same input deck, unless another M- or K- card is encountered. Output energy units, plotted on the level scheme, may be controlled independently by specifications on an X-card.

X - cards specify a wide variety of plot-control options (scaling, energy units, rounding of numbers, etc.). Default options are provided for each, and will be used if no X-card is included, or if a given option is not specified on an X-card.

One may replot the same scheme with different X-card options, by following a Z-card with one or more [additional] X-cards and another Z-card, etc. Plot-control options are described in section V.

An S-card specifies chip-store storage of the entire input deck. Only one S-card may occur in an input deck; it specifies the parameters required to properly identify the data for storage. Storage, retrieval, and editing of data is described in section VI.

An E-card terminates input processing. [If no E-card is encountered, the entire input deck will be processed, up to

a 7-8-9 (end of record) or 6-7-8-9 (end of job) card.] Note, however, that if an S-card preceeds the [first] E-card, the entire input deck, including cards which follow the E-card and the E-card itself, will be stored. (The E-card can subsequently be edited out.)

III.D. Card Preparation - forms and keypunching

Card input is conveniently prepared with the use of the forms shown in figure 1a and 2a. These forms are available from the Table of Isotopes project. Cards are most conveniently punched on the newer 029 IBM punches. If one is not available, the older 026 punches can be used; table 1 gives the multipunch equivalents for special symbols used by the program which are not included on the 026 keyboard.

TABLE 1

Multipunch Equivalents for Special Characters

Symbols	Multipunch
[	7 8
]	0 2 8
?	6 8
<	+ 0
>	- 7 8
$\leqslant$	5 8
$\geqslant$	+ 5 8
$\neq$ (used for $\approx$)	4 8
'	- 6 8
¬ (used for a line feed in a comment)	+ 6 8

The prime (') may be indicated on some 029 keypunches (and line printers) by "↓". The question mark may be indicated by "%". Check the punches produced by these keys against the table.

IV. FORMAT AND CONTENT OF LEVEL SCHEME CARDS - DETAILED DESCRIPTION

Specific properties, such as isotope name, level energy are placed in designated columns of the input cards, as indicated in figures 1a and 2a. Some of these properties are made up of general types of quantities, such as "numbers" of various types, which are used repeatedly; permissible forms of these quantities are defined in section IV.A. Some physical quantities, such as "half-life" are also used repeatedly. For example, a "half-life" may be used in parent cards to define a parent half-life, on a level card to define a level half-life, or as part of a parent isotope name to define one of several isomers (when it is not known which isomer is the ground state). Quantities of this type are defined in section IV.B. Section IV.C. defines the properties described on most types of input card, give the permissible forms, and defines limitations on the number of each type of card and the relationships between data on different cards.

IV.A. General Quantities (numbers)

IV.A.1. Decimal numbers

"Decimal numbers" are numbers in the normal integer or decimal format with the following restrictions:

a) They must be positive or zero unless otherwise noted

b) If they contain a decimal point, it must not be the last character.

c) There should be no leading zeros, (except as in 0.027; not numbers such as 035).

Examples

Valid	Illegal
123	123.
123.7	-3
0.234	-2.7
0	00123
0.3	
.3 (program converts to 0.3)	

IV.A.2. "Exponent numbers"

An "exponent number" is a positive number in the common scientific notation, e.g. 3.5×10^7. It is input in the simplified form 3.5E7, but will be plotted in the correct format. The following restrictions apply:

a) The decimal part must be a "decimal number" or one-digit integer with a value between 1 and 9.999 ...

b) The exponent must be a positive or negative integer between 1 and 99, with no leading zeros. Do not include the + sign for positive values.

Examples

Valid	Converts to	Invalid
1.358E3	1.358×10^3	1.358E03
7.04E-11	7.04×10^{-11}	704E-9
3E10	3×10^{10}	3E+10
		30.4E10

IV.A.3. Generalized numbers

A "generalized number" is a "decimal number" or an "exponent number" which may be preceeded by one of the following symbols:

$<$

$>$

$\leqslant$

$\geqslant$

$\neq$ (interpreted as $\approx$)

$<\neq$, $\neq<$ (interpreted as $\lesssim$)

$>\neq$, $\neq>$ (interpreted as $\gtrsim$)

In some cases, the numeric part may be restricted to the "decimal" format.

IV.A.4. "Numbers with uncertainty"

These are used only for Q-values and transition intensities. They may be in one of the following formats:

a) n+-m (interpreted as n±m)

b) n+m-l (interpreted as n^{+m}_{-l}) where n, m, and l are "decimal numbers".

The uncertainty is interpreted as follows:

If n and m (and l) are both integers or both have decimal points, m (and l) is the uncertainty in n.

If n has a decimal point but m (and l) does not, m (and l) is the uncertainty in the last place(s) of n.

The number is illegal if:

a) m has a decimal point and l does not

b) l has a decimal point and m does not

c) m (and l) have a decimal point and n does not

d) m (and l) have decimal points, and m (and l) contain a different number of decimal places than n (or than each other).

Examples

Valid		Invalid
105+-3	numerically equivalent	105+-3.0
105.0+-3.0		105.0+-3.00
105.0+-30		105.00+-3.0
105+3-2		105.0+3-2.0
105.0+3.0-2.7		
105.0+30-20		

IV.A.5. Numbers in percent

The "%" is not punched, but is assumed. Used for feeding intensities, absolute transition intensities, and multipole admixtures.

IV.B. Commonly Used Properties

IV.B.1. Isotopes

An isotope name is written in one of the following formats:

Format	Example	Interpretation
A-El	22-NA	^{22}Na
AM-El	110M-AG	^{110m}Ag
AMi-El (i is an integer between 1 and 4)	192M2-Ir	^{192m_2}Ir
A-El($t_{1/2}$)	180-RE(20 H)	^{180}Re(20 h)

The last form is used only when the level order of several isomers is unknown. (See section IV.B.2 for the format of the half-life.) "El" for unnamed elements (currently for Z > 104) is the atomic number. E.g. 261-105 for ^{261}105.

IV.B.2. Half-lives

A half-life consists of a "generalized number" plus one of the following units:

PS
NS
US (interpreted as μs)
MS
S
M
H
D
Y

A blank between the number and the units is optional, and will be inserted by the program if absent.

The number must be of the decimal type unless the unit is Y, and the value is ⩾ 1000 years. i.e., use 3.5 μs rather than 3.5E-6 s. The program requires the numbers to fall in a reasonable range; e.g., use 25.0 h or 1.07 d rather than 1500 m.

IV.B.3. Spins

"Spins" refers generally to level quantum numbers, including I, π, K, Nilsson number ($[Nn_z\Lambda]$), T, and the ℓ-transfer value in direct reactions. They are punched literally, with the exception of the symbol ±, which is punched as +-. Different quantum numbers are preceded by a letter denoting the type (or types), and are separated by blanks. Type designation is as follows:

Quantum Type

S	denotes spin(s) and parity(ies)
K	denotes K (and Nilsson assignment)
T	denotes isospin
L	denotes ℓ-transfer value.

example: S3/2+ K1/2[400]

There must be no blanks within a single quantum-number assignment.

If an assignment is not preceeded by a quantum-type character, it is assumed to represent

1) spins and parities, if it is the first assignment given

or 2) K (and Nilsson) assignment otherwise.

Each quantum type must be given only once.

Spin(s) and parity(ies) may include choices of several values. Parentheses are used to denote probable (not certain) assignments, brackets (rarely) for inferred (and very uncertain) ones. The following restrictions apply:

1) Use of parentheses, brackets, and commas must create an intelligible syntax. Unbalanced parentheses or brackets, or combinations such as

(3/2,)
(3/2+,5/2,-)

are rejected by the program. ± (punch as +-) is permitted but should only be used in combinations such as

3/2+,5/2±

2) Redundant assignments (the same spin repeated) are not permitted.

3) Spins must obey the laws and conventions of physics. 3/2 will not work for a boson (even mass), 10/2 will not work for anything (hint: try 5).

Besides these restrictions, the program checks for "questionable" formats, and for improbably large spins, and issues non-fatal warning diagnostics.

T and L assignments are treated similarly to spins, except that

1) L must always be integral

2) Formats such as 0(+2) are permitted for L; otherwise the range of "non-questionable" formats for L and T is more restricted.

A list of "legal" (not "questionable") formats for S, T, L is printed at the beginning of the output from the program LVS, and is shown in fig. 4.

K and Nilsson numbers may have one of the following formats:

K
K[Nils]
(K[Nils])
K([Nils])

The following additional restrictions apply:

1) K is a single choice (value) which must be half-integral for odd-mass nuclei, integral for even-mass nuclei.

2) K must be less than equal to the spin.

3) A Nilsson number may be given only for an odd-A nucleus. Its parameters must be physically meaningful.

Band structure may be indicated by appending a letter to K to indicate two different bands with the same K. This is unnecessary if bands (in an odd-mass nucleus) are assigned different Nilsson numbers. Examples are

0+	KO	g.s. band
2+	KO	
0+	KOA	1st excited K = 0 band
2+	KOA	
0+	KOB	2nd excited K = 0 band
2+	KOB	

Band structure thus indicated may be shown on the plot by the alignment of spins.

IV.B.4. Decay modes

Decay mode may be one of the following

Mode	Interpretation
SF	Spontaneous fission
N	n
P	p
A	α
B-	β^-
EC+B+	EC+β^+
B++EC	β^++EC
EC(+B+)	EC(+β^+)
B+(+EC)	β^+(+EC)
B+	β^+
EC	EC
K	EC(K)
L+M	EC(L+M)
L	EC(L)
M	EC(M)

IV.B.5. Identifiers

An identifier may be any single character, including a blank. Normally, use letters in sequence. For example, label three reactions plotted on one scheme A, B, and C.

IV.C. Cards for New Level Schemes

IV.C.1. I - Cards

Columns	Quantity	As described in
2 - 21	Isotope name	IV.B.1
22 - 61	Reaction	See note (2) below
62 - 79	Feeding identification	See note (3) below
80	Reaction Identifier	IV.B.5

Notes:

1) The isotope name must represent a ground state. Isotopes on all I-cards for one level scheme must be identical!

2) "Reaction" may be one of the following:

   a) DECAY [radioactive decay]

   or b) COULOMB EXCITATION

   or c) FISSION

   or d) A reaction, listed in the standard format. Isotope names are written as described in IV.B.1. Particle names are written as follows.

Punch or Write	Interpretation
P	p
N	n
D	d
T	t
A	α
G	γ
E	e^+
PI+	π^+
PI-	π^-
PI0	π°
MU+	μ^+
MU-	μ^-
MU0	μ°
KA+	K^+
KA-	K^-
KA0	K°
KA0A	$\tilde{K}^\circ$

In the outgoing particle list, separate isotope names from preceeding or following multipliers by spaces.

Examples:

```
 56-FE(P,NG)
208-PB(A,3NG)
 20-NE(16-O,12-C)
181-TA(P,3PXN)
238-U(232-TH,3 22-NA 16-O 4P7N)
152-GD(16-O,16-O')
```

The reaction must be capable of yielding the nucleus in col. 2 - 21!

3) The feeding identification (columns 62-79) is a label of $\leq$ 10 characters which describes the numeric quantity given under "feeding intensity" (columns 62-71 of an L-card). For example, one might want to give C^2S for a (d,p) reaction, or B(E2) for Coulomb excitation. If this label is present (non-blank),

the label and corresponding numbers will be plotted. Fonting of the characters in the label is indicated in the same manner as for C- (comment) cards. See section IV.C.7 for details.

DO NOT label feeding by radioactive decay; use columns 62-79 only for nuclear reactions.

4) The identifier should be different from that used on any other I- or P-card. On schemes for a single reaction (or decay), the reaction identifier may always be a blank.

5) Maximum number of I-cards: Five (5) per level scheme plot.

IV.C.2. R-cards

The list of references in columns 2 - 80 on the R-card contains individual references separated by a comma or line-feed (punch ¬). When the last non-blank character on the card is a separator, the list is expected to CONTINUE on an RC-card (with RC in columns 1 - 2); the list continues in column 3.

If R-cards (+ RC-cards) follow each of several I-cards, the references on each R (+ RC) card are assumed to be associated with the reaction on the preceeding I-card and will be labeled with that reaction. If a single R-card (+ RC-card(s)) follows the last of several I-cards, the references will not be labeled with the reactions.

For the Table of Isotopes the references, separated by commas, are in one of the normal TOI formats:

```
J V P//NDG-code
J V P//Year
old TOI code
or old TOI code//NDG-code
```

Caution: The references must have no imbedded commas. Capital letters within J, V, or P are indicated by a preceeding asterisk, e.g.

*IZ*F for IzF

*N*P *A106 for NP A106

More complex fonting may be indicated as for comments; see section IV.C.7.

For non-TOI use, the references must be separated by linefeeds (¬), and may contain text consisting of any "fonted" characters, including commas (except $ or * which are used as font indicators). See the description of comments (section IV.C.7) for fonting.

References are printed on a separate frame from the plot.

Maximum R-cards: 5 cards per level scheme. No limit on continuations, but maximum total characters must be < 500.

IV.C.3. P-cards

Columns	Quantity	As described in
2 - 21	Parent isotope	IV.B.1
22 - 31	Decay mode	IV.B.4
32 - 41	Half-life	IV.B.2
42 - 61	Spin	IV.B.3
62 - 79	Q-value	See note (2) below
80	Parent Identifier	IV.B.5

Notes:

1) Decay modes listed in IV.B.4 except SF, N may be used, but EC submodes (L+M, etc.) should not normally be designated unless the Q-value limits ground-state capture to the inner shells. The parent plus decay

mode must yield the nucleus given on the I-cards! For parents with branched decay, the decay mode may be followed by the branching, separated from the mode by a blank. For example:

A 10

means α 10%. (The % is not punched.)

2) The Q-value may be either

   a) A "generalized number" with the numeric part in "decimal" format (IV.A.3)

or b) a "number with uncertainty".

In the first case, the preceeding symbols <, >, etc. will be utilized in the calculation of log ft and HF values. Uncertainties are currently ignored by the program.

3) Spin, half-life, or Q-value may be omitted if unknown (leave blank).

4) The identifier should be different from that used on any other P-card or I-card.

5) Maximum P-cards: Five (5) per level scheme.

IV.C.4. Q-cards

Columns	Quantity	As described in
2 - 21	Daughter Isotope	IV.B.1
22 - 31	Decay mode	IV.B.4
32 - 41	Q-value	See note (2) below
42 - 80	Levels of daughter	See note (3) below

Notes:

1) The daughter isotope must be a ground state and must equal the isotope on the I-cards + decay mode. Any decay mode is acceptable except SF, for which no Q-card is required.

2) The Q-value is a "decimal number" (IV.A.1) which may also be preceeded by a minus sign. A Q-value must be given on a Q-card.

3) "Levels of the daughter" is a list of energies and spins. The energies are "generalized numbers" of the decimal type (IV.A.3), and must be in ascending order. Spins, if given, should be separated from energies by a blank, and must include only a spin-parity assignment (no L, T, or K assignment). The list begins (in or after column 42) with the first energy, and succeeding levels (energy-blank-spin) are separated by a $ sign. Leading and trailing blanks on each level are ignored.

If no levels are given on a Q-card, its only function is to enable the program to check that particle decay from a state is energetically possible.

4) CONTINUATION of the energy-spin list, if necessary, may be done on a "QC"-card with a Q in column 1 and a C in column 2; the level list continues in column 3. The last non-blank character on the preceeding Q (or QC)-card must be a $ sign; i.e., do not split levels across cards.

5) Maxima: Five (5) Q-cards per level scheme, 50 levels total on all Q-cards. No limit on the number of QC-cards other than the 50-level limit.

IV.C.5. L-cards

Columns	Quantity	As described in
2 - 11	Level Energy	See (1) below
12 - 41	Spin	IV.B.3
42 - 51	Half-life	IV.B.2
52	Identification of Feeding parent & mode	See notes (2,5,6,7,8) below
53 - 61	Identification of Feeding parent & mode	See notes (2,5,6,7,8) below
62 - 71	Feeding intensity	See notes (3,8) below
72 - 80	log ft or HF	See note (4) below
Maximum:	150 L-cards, including 300 distinct feedings	

Notes:

1) The energy is a "generalized number" of the "decimal" format (IV.A.3) with the following additions and restrictions.

a) The energy may be followed by one or more of the following symbols, in any order:

Symbol	Meaning
I	Isomer (level drawn heavier)
?	Uncertain level (drawn dashed)
c	Complex level. (Energy will be plotted as 1.305^{c}.)
or	
(c)	Probably complex. (Energy will be plotted as $1.305^{(c)}$.)

b) Different L-cards must have distinct energies and be ordered by ascending value. [$\geqslant$ 3.50 and 3.50 are acceptable as distinct, but 3.500 and 3.50 are not; use 3.500 and $\approx$ 3.50.] Levels with "numerically equivalent" energies, such as $\geqslant$ 3.50, < 3.50 $\approx$ 3.50, etc., will be plotted in order of occurence on the L-cards.

2) Feeding parent and mode identify the source and type of feeding.

For reactions, the reaction identifier placed in column 52 will identify the reaction populating the level.

The identifier used must correspond to a reaction identifier (column 80 of an I-card). A question mark in column 53 indicates uncertain (dashed) feeding.

For decay schemes the parent identifier may be placed in column 52, and the decay mode may be placed in columns 53 - 61. Both parent and mode are not always necessary, but enough information must be given to identify each uniquely. For example, if there are two β^- parents (isomers), the parent must be specified, but mode may be omitted. If the parent mode is "EC+B+", but the feeding intensity for a given level refers to EC only, the mode should be specified; if there are also two EC+β^+ parents, both mode and parent must be specified. The mode may be any of the forms in IV.B.4 except SF or N. It may be followed by "?" to indicate an uncertain (dashed) feeding. For EC, β^+ modes, the mode on an L-card refers to the feeding intensity

given on the same card. It may be, e.g. "EC", or "β^+", even though the mode on the parent card is "EC+β^+". Normally, do not use EC(L+M), EC(M), etc. EC is O.K. for these even when Q_{EC} excludes capture from inner shells.

The parent identifier must correspond to an identifier in column 80 of a P-card. Only one feeding by radioactive decay may appear on a level card. See notes (5-7) below for additional or grouped feeding. For either reactions or decay, columns 52 - 61 may be left blank if there is only one reaction or a pure decay scheme with only one parent.

3) The feeding intensity is a "generalized number" (decimal or exponential format) representing the feeding in percent (the % is not punched, but will be plotted). Decimal format is preferred except for very small numbers. It should represent the intensity for the mode in columns 52 - 61. If it is omitted (columns 62 - 71 blank) and columns 52 - 61 are not blank, a feeding arrow will be drawn but no intensity written on the plot.

If the feeding is preceeded by an R, it is assumed to be relative, rather than %. Relative feedings will be plotted with a following dagger (†) instead of a % sign. If the parent was assigned

a branching (with the decay mode) and the feeding is given as relative, the absolute feeding will be calculated as % branching $\times \frac{\text{relative feeding}}{100}$ for the calculation of hindrance factors or log ft values.

For the Table of Isotopes, the feeding intensity should be blank for reaction feeding. For other purposes, it may be a reaction cross section, spectroscopic factor, etc. For reactions, the feeding intensity is interpreted as the numeric quantity defined in columns 62 - 79 of the I-card; a % sign will not be appended.

4) The log ft or HF may be blank or a "generalized number" in decimal format. The choice of whether to plot this value or the log ft calculated by the program may be specified on a plot control card (see section V.H.).

5) Grouped Feeding. One arrow to several levels may be indicated by following the decay mode (if any) with a "Sn" or "blank Sn", where n is the number of levels fed by the transition. The feeding applies to the last n levels, including the present one, and will be plotted as an arrow to a bracket which includes the n levels. "n" may be a number between 2 and 9, but must not be greater than the number of previously named levels. If no mode is given, or for reaction feeding, Sn should be placed in columns 53 - 54 (columns 54 - 55 if 53 contains a question mark).

6) ADDITIONAL FEEDING (by another parent, mode, or reaction) to a level already established may be given on another L-card with no energy, spin or half-life (all blanks in columns 2 - 51). Columns 52 - 80 contain the same quantities in the same format as normal L-cards. L-cards that specify additional feeding should immediately follow the L-card that defines the level, with no intervening D-cards. Additional feeding may be to a single level or grouped levels (see note (5) above).

Additional feeding by reactions may also be indicated by a more convenient means on the same L-card that defines the level: feeding by the one reaction (the reaction identifier) is placed in column 52, and additional reaction identifiers may be placed in sequence, beginning in column 53, with no imbedded blanks. Each identifier must correspond to a reaction identifier (column 80 of an I-card). This means of indicating additional reaction feeding can be used only under the following restrictions:

1) There must be no intensity given (columns 62 - 71)
2) There must be no question mark in columns 53 - 61 (i.e., all feedings must be definite)
3) The feeding must not be "grouped" (Sn in columns 53 - 61)
4) Blank must not be used as a reaction identifier.

7) ADDITIONAL or GROUPED FEEDING must not be redundant or overlapping. Separate EC and β^+ feeding of the same level(s) is permitted, but should be either single or grouped, not a hybrid of both.

8) Feeding from parent isotopes will be indicated by an arrow on which are written the intensity (if given) and the input or calculated log ft or alpha hindrance factor. (See section V.H. for control of ft, HF printing.)

Feeding by nuclear reactions may be indicated by an arrow (with numeric data), or a small symbol on, or next to the level. See section V.I. for the relevant control features.

IV.C.6. D-cards

Columns	Quantity	As described in
2 - 11	Gamma Energy or decay mode	See notes (1,2,3) below
12 - 26	Absolute intensity	See note (4) below
27 - 41	Relative intensity	
42 - 70	Multipolarity	See note (5) below
71 - 80	Final level energy	See notes (6,7) below

Maximum: 200 D-cards; no other limit on D-cards per level.

Notes:

1) For Gamma Decay, the gamma energy is a "generalized number" of decimal format (see IV.A.1) with the following possible additions:
   a) An asterisk (*) may be appended to indicate that the same transition is used more than once in the scheme. The * will be plotted after the energy.
   b) A "?" may be appended to indicate that the transition is uncertain (drawn dashed). If both "*" and "?" are appended, their order is immaterial.
   c) The energy may be omitted entirely, (or may be just "?"). It is assumed to represent a gamma ray whose energy is not to be written on the plot. (Gamma ray energies may also be surpressed on the plot by use of the plot control card (see section V.M.).)
   d) Grouped decay may be indicated as described in note (3) below.
2) For particle decay the particle energy should not be given; rather columns 2 - 11 contain the decay mode (section IV.B.4) with the following possible additions:
   a) "?" may be appended to indicate an uncertain (dashed) transition.
   b) Grouped decay may be indicated (see note (3) below).

3) Grouped Decay may be indicated for either gamma or particle decay by appending "Sn" or "blank Sn" to the gamma energy (if any) or decay mode. The transition originates at (one of) the last n levels. The restrictions on n are similar to those for grouped feeding (see note (5) under IV.C.5). The gamma must not be redundant with another transition connecting the same initial and final level(s); levels of the initial group must not include the final level. Examples of grouped decay format are

≠0.35S3	(≈ 0.35 gamma originates from the 3 last-named levels)
≠0.35*?S2	(≈ 0.35 multiply used dashed gamma originates from last 2 levels)
PS2	(Proton group from last 2 levels)
P?S2	(dashed proton group from last 2 levels)
?S2	(unlabeled, dashed γ from last 2 levels)

Grouped decay will be indicated by running the levels together at the head of the transition arrow.

4) Intensities (absolute and relative) are "generalized numbers" in decimal format (section IV.A.3), "numbers with uncertainty" (section IV.A.4), or w (for "weak").

For gamma rays, the intensities should normally refer to photons.

One of the following symbols may be appended to the number to indicate conversion-electron intensity [in a specific shell].

Symbol	Interpretation
e	e^-
K	K
L	L
M	M
N	N
O	O
P	P

Parentheses may enclose any of these symbols, if desired. The above symbols will be plotted after the numeric intensity.

"Relative" intensities are plotted above the transition, before the energy, with no sign; "absolute" intensities are plotted <u>on</u> the transition arrow (or above the transition, <u>after</u> the energy, if there is no room on the arrow), with a percent sign. Rounding, renormalization and substitution (for example, conversion of a relative intensities given for each transition to absolute by a single renormalization factor) can be done with one of several renormalization options on a plot-control card (see section V.L.).

5) Multipolarities may be single values, admixtures, or choices. The use of parenthesis, brackets, and commas is similar to that for spins (section III.B.3). <u>Separate an admixture from a multipolarity by a blank</u>.

The % sign is not punched, but will be plotted. Examples of forms are:

FORM	INTERPRETATION
M1	M1
(M1)	Probably M1
M1+E2	M1+E2
M1,E2	M1 or E2
(M1,E2)	Probably M1 or E2
M1(+E2)	M1, probably an E2 admixture
M1+0.5 E2	M1+0.5%E2
M1(+≠0.5 E2)	M1 + probably ≈ 0.5%E2
NOT E1	not E1

Multipolarities will be plotted on the transition arrow, if there is room; otherwise, above the transition after the energy. Legal forms are given in fig. 4.

6) The final level energy identifies where a gamma ray or particle transition terminates. It is a "generalized number" of decimal format (section IV.A.3) (see note (6) below for grouped final levels). For gamma rays the final level must correspond exactly to the energy of a previously named level [including any preceeding sign such as "≠" or ">", but excluding a following ?, I, c, or (c)]. For particle decay it may be absent (decay will be indicated by a short arrow labeled with the decay mode), or may correspond exactly to a daughter level named on the Q-card with the same mode of decay as the transition.

7) GROUPED final levels may be indicated by appending "Sn" or "blank Sn" to the final level energy, for either gamma or particle transitions. The grouping

is subject to the same restrictions as for grouped initial levels (note (2) above). On the plot, grouped final levels will be indicated in the same manner as grouped initial levels.

IV.C.7. Miscellaneous cards

X-cards are described in section V; S- and F-cards in section VI.

M- or K-cards define the input energy units; they may occur anywhere in the input deck. The default is MeV; once changed, the new units are in effect until another M- or K-card is encountered. Normally, the units should be changed before the first use of an energy (the Q-value on a P-card, for example), and not changed again within a level scheme.

Columns 2 - 80 on an M- or K-card are ignored, and may be used for a comment. E.g., punch KEV in columns 1 - 3 if it suits your fancy.

C-cards contain comments in columns 2 - 80, which will be printed on a separate frame. They may occur anywhere in the input deck. Any character is legal except ¬, *, or $, which are used as special control characters:

¬ Signifies a line-feed

* indicates that the next character is to be upper case.

$ ... $ encloses font specification symbols (for the next character). The font specification symbols within the $ ... $ separators may be in any order, except for the 0 (zero); they are given in the following table and examples:

C	Upper case
G	Greek
B	Bold
+	Superscript
-	Subscript
I	Italics
0	Indicates that the font applies to all following characters (until changed again). Must be the first font specification symbol of a group.

Examples:

Punch or write	Meaning
GB	β
4.7$+I$1	4.7^{1}
$0G$ABG	$\alpha\beta\gamma$
$0GC$GDL	$\Gamma\Delta\Lambda$

When the basic font has been changed (by $0 ... $), a subsequent change in font of the type $ ... $ or $0 ... $ defines the entire font for the succeeding characters - i.e.:

$0G$GCGD ⟶ $\gamma G\delta$, not $\gamma\Gamma\delta$

$0C$A$-$I ⟶ A_i, not A_I

However, capitalization indicated for the following character by a * adds to the current basic font:

$0G$G*GD ⟶ $\gamma\Gamma\delta$

Two font specifications in sequence, such as $0G$$C$ ..., or $+$* ... are illegal.

All comment cards within one level scheme, regardless of whether in sequence, are treated as running text; leading

and all but one trailing blanks on each card are ignored. Individual comments may be separated by a line feed character (punch ⊃); they will then be numbered in sequence on the output. A limit of 500 total characters (about 7 full cards) applies to the comments in one scheme.

Comments will be printed on a separate frame from the plot, along with references and the reaction feeding legend, if any.

Z-cards specify that a plot be done. Columns 2 - 80 of a Z-card are ignored, and may be used for comments.

A Z-card terminates a level scheme. No more L- or D-cards may follow, but one of the following is permissible.

1) An E-card or 7-8-9 record separator, which terminates the input processing.

2) An I-card, which begins the next level scheme

or 3) One or more X-cards to change the plot-control options, followed by another Z-card; this causes another plot of the level scheme to be made.

V. PLOT CONTROL

Plot control options are specified by X-cards. X-cards have a "string format" rather than a column-field format, with different specification separated by commas. (Leading and trailing blanks are ignored.) For example:

X FAN, YMAX=3.5, YFACTOR=0.8>1.0, NO LEVELS>3

The specifications are in one of 4 styles, each of which is illustrated in the above example:

1) OPTION
2) SPECIFICATION=OPTION
3) SPECIFICATION=OPTION>ENERGY
4) OPTION>ENERGY

A default is provided for each option. The special option RESET resets all options to their default values.

If successive options are self-contradictory, the last one given is in effect; thus

X YMAX=2, YMAX=3.5

is equivalent to

X YMAX=3.5;

Any option followed by RESET is reset to the default value.

The control features are described below, along with the corresponding X-card syntax. Default options are labelled **.

V.A. Output Film

1. Plots may be done on 24X-microfiche (F) or 35-mm film (35). The latter has better resolution, but slower processing (≈ 24 hrs. vs. 3 hrs.). Use 35-mm film for final plots.
2. Large plots may require more than one frame. (The program automatically uses additional frames as required.) The sections of the plot must be joined after printing. Maxima of 25 total frames per plot, and 7 frames in the y-dimension (on a microfiche) are currently imposed. Two "joining" options are available.
   a) "Reversal" (R) specifies that alternate X-frames will be plotted in mirror image (X → - X), and alternate Y-frames will be mirrored (Y → - Y). This insures better joining of the printed frames, but requires that singly-mirrored frames (in X or Y, but not both) must be printed with the film reversed.
   b) Butting (B) joins the neighboring frames on the film itself. (On 35 mm film, only adjacent X-frames are joined.) The joining is very rough with the present hardware; this mode is recommended only for proofcopy.

The options are specified as follows:

```
      FILM=F
**    FILM=FR
      FILM=FB
      FILM=35
      FILM=35R
      FILM=35B
```

Note that the film type (35 mm or microfiche) can not be changed after it has been once set by an X-card specification or after a plot has been specified (Z-card) with the default (microfiche). Subsequent FILM= ... specifications will change the reversal or butting options, but not the film type.

V.B. Scaling

V.B.1. Overall scaling (magnification) is set by the specification

SCALE=n where n is a decimal number or integer.

The entire plot is scaled by the factor n. The default value,

** SCALE=1.5

is chosen as a minimum value that will provide good resolution, and should be satisfactory for most purposes. Larger values (up to ≈ 2.5) will improve resolution somewhat, at a possible cost of spreading the plot over more frames. Values smaller than 1.0 will seriously degrade the quality of printed characters.

V.B.2. Y-scaling controls the scaling of energy levels. The most useful way of specifying the scale factor is in terms of the number of levels per frame of film:*

YMAX=nL n is an integer or decimal number.

The default option,

** YMAX=AUTOMATIC

sets n to a value determined by the overall scale (SCALE=m) and the plot style (see section V.C):

$n = 45/m$ for fanned plots
$= 90/m$ for non-fanned plots.

There are several other ways to specifying the energy scale factor:

---

*Additional space may be used for labels and parent isotopes, so that the number of levels in a frame may be slightly less than the specified number for the lowest and highest frames.

YMAX=n — sets one frame height to n energy units (MeV or keV, as defined by an M- or K-card)

YMAX=nF — specifies that the plot should fill n frames in the Y-dimension

[in the above examples, n is a decimal number or integer]

YMAX=SAME — specifies the Y-scale factor from the previous plot be retained.

Y-scaling specifications are not checked for reasonability by the input program (LVS); if found to be unreasonable or meaningless (e.g., SAME specified for the first plot), the plot program (SCH) will attempt to rescale the plot.

Y-scaling may also be modified to be non-linear, as described in sections V.B.3 and V.B.4.

V.B.3. Scale changes

The default specification is

** YFACTOR=LINEAR

For plots with large variations in level-density, it may be desirable to introduce scale changes. Up to 9 such changes can be designated by specifications of the form:

YFACTOR=n>E

where n is a scale-change factor (decimal number), and E is the energy (in specified input units) above which the factor applies. Thus,

M
X YFACTOR=0.8>1.0, YFACTOR=0.5>2.5

means that the energy scale is compressed by a factor 0.8 between 1 and 2.5 MeV, and by a factor 0.5 above 2.5 MeV, relative to the scale below 1 MeV.

Note that:

a) The scale-factor multiplier below the lowest energy specified is 1.0.

b) When "fixed-height" scaling (YMAX=n) is used, the scale-change factor for a specified energy region times the scale factor gives the absolute scale factor in that region. Thus, the overall height of the plot is affected by the scale-change factors. When the scaling is adjusted to a constant height (YMAX=nL) or YMAX=mF), the scale changes do not change the overall height, but do alter the relative level densities between the given energy regions.

c) Each additional YFACTOR= ... specification with a new energy adds another scale change; a specification with the same energy as a previous one (but a different scale factor) replaces the previous scale-change factor.

d) The specification YFACTOR=LINEAR erases all scale-change factors.

V.B.4. Scale-changes—daughter levels

When all daughter levels populated by a single particle decay mode (as specified on a Q-card) lie below the ground-

state of the nucleus being plotted (named on the I-card(s)), the y-scaling of daughter levels may be modified by the specification

YQFACTOR=n where n is a decimal number or integer.

Only one such factor can be given for a plot. It does not apply to daughters (Q-card nuclei) whose highest given level is above the ground-state of the main (I-card) nucleus. These will be given the same scaling as the main nucleus; thus scale changes can not be given below the ground-state of the main nucleus.

The default option is

** YQFACTOR=1

V.C. Plot Style

"Fanned" plots have their energy levels fanned at the ends to allow room for energies, spins, and feeding intensities; an example is given in figure 1c. They are generally most useful.

"Non-fanned" plots (see figure 2c) have energies and spins staggered. They are useful for very "tall" reaction schemes, those with many levels but few (or no) γ rays. Numeric level-feedings will be omitted from non-fanned plots.

"Stackplots" afford a way of presenting very "wide" schemes - ones with many γ rays. (The NO GAMMA LABELS specification (section V.M.) can also save horizontal space, to a lesser extent.) However, the γ-ray labels cannot be shown on a stackplot.

The options are specified by

**	FAN	
	NO FAN	
	STACKPLOT	
	FAN IF DECAY	(fan decay schemes only)
	FAN IF FEEDING	(fan if numeric feeding intensities are given)

V.D. Energy Units

Energies to be printed on the scheme may be in MeV, keV, or as input. The options are

	ENERGY UNITS=MEV	
	ENERGY UNITS=KEV	
**	ENERGY UNITS=INPUT	(don't change)

The energy units specification applies to level and γ-ray energy labels, and has no relation to the Y-scaling (which is always specified in the same units as the input data).

V.E. Spins

Several specifications control the inclusion of angular momentum quantum numbers and the style of plotting. The major one is

SPIN=...

Option choices include any combination of S, K, T, and L. The default is all of them, that is

** SPIN=SKTL

If one desires to print only spins and parities,

SPIN=S

would suppress the other quantum numbers (if input). (Plotting of quantum numbers can also be surpressed completely, or suppressed for all levels above a specified energy, as described in section V.M.)

Additional control of band-structure quantum numbers (K, Nilsson numbers) can be effected with the following specifications:

	K=ALL	print all K-quantum numbers (+Nilsson numbers)
**	K=LOWEST	print K (+Nilsson numbers) only on the lowest member of each band
	K=TABLE	print K (+Nilsson numbers) in a separate table, not on level scheme
**	ALIGN	align spins belonging to a band (same K [+Nilsson] numbers
	NO ALIGN	don't align spins
	K OR NILS	print (or tabulate) K whether or not accompanied by a Nilsson number
**	NILS ONLY	print (or tabulate) only K-quantum numbers with Nilsson assignments.

Notes:

1) The specifications ALIGN, K= ..., K OR NILS, NILS ONLY have no effect if K (+Nilsson) numbers were not given as input data.

2) The inclusion of K-quantum and Nilsson numbers on a "NO FAN" plot is inadvisable, as it may waste considerable space. It is better to omit Nilsson numbers in the input, suppress them (SPIN=STL), or plot them in a separate table (K=TABLE).

3) ALIGN displaces spins belonging to different bands slightly, and thus costs a little space in the X-dimension. It has no effect if K or Nilsson assignments are not given in the input data. The ALIGN option is ignored if the NO FAN option is chosen.

4) The spin options control or surpress the display of quantum numbers. They do not affect the input data, nor do they "create" data that isn't in the input.

V.F. Isotope Labels

These specifications allow isotope labels to be printed with or without the atomic number and neutron number. The options are

		Example
	ISOTOPE=A	^{237}Np
**	ISOTOPE=AZ	$^{237}_{93}Np$
	ISOTOPE=AZN	$^{237}_{93}Np_{144}$

Parent isotopes are specified separately by

PARENT ISOTOPE=A [AZ,AZN]

There may be a slight increase in the horizontal space required if the AZN option is chosen for parent isotopes (AZ is again the default option).

V.G. Decay-Parent Positioning

Since Q-values for parent decay may greatly exceed the highest level to be plotted, several options are offered for the placement of feeding parent:

PARENT OPTION=n [n = 1, 2, 3, or 4]

The interpretation is

	PARENT OPTION=1	Plot all parents at a standard height (slightly above the highest level)
	PARENT OPTION=2	Plot all parents at their natural position (decay energy)
	PARENT OPTION=3	Same as n = 2 except α-parents, which will be plotted below their natural position
**	PARENT OPTION=4	Plot each parent at the smaller of (a) Its decay energy, or (b) the "standard" height

When parents are plotted at their natural position (under options 2, 3, or 4), a small half-dot is plotted exactly at the Q-value on the feeding arrow; the isotope label, half-life, and spin are plotted just above the dot.

V.H. Log ft Values and α-Decay Hindrance Factors

There are 2 types of specifications. The first is

```
**  FT=CALC
    FT=INPUT
**  HF=CALC
    HF=INPUT
```

These specify that calculated or input values are to be used on the plot. They differ from the previously described options in that they apply to all log ft or HF values on following input cards. Thus, it is possible to plot the input value for one feeding and the calculated value for the next, by a sequence of cards such as:

```
.
.
.
X  FT=INPUT
L  0.135 ...
X  FT=CALC
L  0.242 ...
.
.
.
```

The second kind of specification controls the conversion of calculated log ft values and hindrance factors, and applies to all calculated values to be printed. These may be printed to a specified number either of decimal places, or of significant figures. The specifications are

FT=nS	n = 1, 2, 3, 4
FT=nSX	n = 1, 2, 3, 4
FT=nD	n = 0, 1, 2, 3, 4

The nS option causes n significant figures to be printed. Non-significant figures to the left of the decimal point are, however retained. nSX does the same, but rounds non-significant figures to the left of the decimal. For example, the number 1357.25718 ... under "2S" becomes 1357; under 2SX it "rounds" to 1400.

The nD option specifies that n decimal places be retained. The options are specified separately for log ft's and hindrance factors. The default options are

```
**  FT=1D
**  HF=2SX
```

Specifications such as FT=INPUT, HF=CALC do not change the current value of the "conversion" specification, and vice versa.

V.I. Reaction feeding options

Reaction feeding may be plotted either QUALITATIVEly (a small symbol along-side or on the level to denote feeding by a given reaction), or QUANTITATIVEly (a feeding arrow with the numeric quantity, if given, labelled by columns 62 - 79 of the I-card for the corresponding reaction). The options are specified by

```
**  REACTION FEEDING=QUALITATIVE
    REACTION FEEDING=QUANTITATIVE
```

Placement of the feeding symbols or arrows may be to the left or right of the levels, or on the levels (symbols only); placement specifications are:

```
      REACTION FEEDING=LEFT
      REACTION FEEDING=RIGHT
      REACTION FEEDING=ON LEVELS
**    REACTION FEEDING=EITHER SIDE
```

Notes:

1. The EITHER SIDE option places the arrows or symbols for all reactions on the side that has the least number of radioactive parents (to the right if there are no parents).
2. The ON LEVELS option is incompatible with the QUANTITATIVE option; if these two are selected, the EITHER SIDE option will be substituted for ON LEVELS.
3. Numeric intensities can be plotted only on fanned plots; the NO FAN option will suppress them.
4. Qualitative feeding will be shown only on plots of > 1 reaction (> 1 I-card). The symbols used to denote different reactions and the corresponding reactions (a reaction feeding "legend") will also be printed in a separate frame from the level plot, along with the references and comments.

V.J. Uncertainties-Style

Numbers with uncertainties (transition intensities) can be printed in several styles. The options are

```
**    UNCERT=LAST PLACES
      UNCERT=TRUE
      UNCERT=NO
```

Uncertainties in the last place(s) are printed in smaller, italic characters:

1.357 *35* 1.357^{+7}_{-2}

"True" uncertainties are printed with a ± sign:

1.357 ± 0.035 $\qquad$ $1.357^{+0.007}_{-0.002}$

The NO option suppresses printing of uncertainties.

These options have no effect on the input format of uncertainties, as described in section IV.A.4, and do not change the input data (which may be stored subeequently).

V.K.1. Rounding specifications

Gamma-ray and level energies, and transition (gamma) intensities may be rounded either (a) to a fixed number of decimal places in the number, (b) a fixed number of significant figures in the uncertainty, or (c) to a fixed error limit in the uncertainty. For numbers input with no uncertainty, an uncertainty may be assigned (for purposes of rounding) by the specifications discussed in section V.K.2.

The means of specifying each of the 3 modes are illustrated for relative intensities below:

(a) Rounding to n decimal places:

ROUNDR=nD n is a one-digit integer (may be zero)

(b) Rounding to n significant figures in the uncertainty:

ROUNDR=nS n is a non-zero, one-digit integer

(c) Rounding to an uncertainty n in the last place(s)

ROUNDR=n n is a non-zero integer of ⩽ 3 digits

Example:

	Specification		
ROUNDR =	1D	2S	5
21.361±0.472 →	21.4±0.5	21.36±0.47	21.4±0.5

A useful example of the type (c) is rounding to an uncertainty of ⩽ 5 in the last place (ROUNDR=5).

Modes (b) and (c) will round to the left of the decimal only if an X is appended:

ROUNDR=nSX
ROUNDR=nX

Examples:

ROUNDR =	1S	1SX	20X	40X
10357.2±350.1 →	10357±35	10400±400	10400±400	10360±350

Rounding of energies (level and γ-ray) and absolute intensities is likewise specified by

ROUNDE=nD
ROUNDA=nD [nS, n, nSX, nX]

No rounding, the default option, is specified by

** ROUNDR=0

and similarly for ROUNDE, ROUNDA.

See note e under the following section for restrictions on replotting.

V.K.2. Rounding-general-uncertainty specifications

An uncertainty may be assigned to all energies (level and γ-ray), and to those intensities (relative or absolute) that do not have an explicit (input) uncertainty.

UNCERTE=n — specifies an uncertainty of n (in input energy units) in all energies

UNCERTR=n, UNCERTA=n — specify a percentage uncertainty of n in the relative or absolute intensity

n is a decimal or integer. The default values are

** UNCERTE=0
** UNCERTR=0
** UNCERTA=0

Note that:

(a) The uncertainties generated by these specifications apply only to rounding of the numbers on the plot; they are printed on the plot only in the case of intensities, and then only if the A option (section V.L.) is specified. They do not alter the input data.

(b) The uncertainties affect only rounding under the nS, n, nSX, and nX modes, not the nD mode.

(c) If the uncertainties are set to the value 0 (default), numbers without explicit uncertainties will not be rounded under the nS, n, nSX, and nX modes, and conversely:

(d) If no rounding (or renormalization) is specified (e.g., ROUNDR=0), the specified uncertainty has no effect.

(e) Rounding and/or renormalization (section V.L.) can be done only once to a given level scheme.

If the same level scheme is replotted (via multiple Z-cards), and rounding (renormalization) was already done for the previous plot, the numbers will not be rounded again.

However, changes in the rounding or renormalization specifications on intervening X-cards remain in effect for following level schemes.

(f) Uncertainty and rounding specifications also apply to renormalization (see section V.L.).

(g) Printing of uncertainties may be suppressed by the UNCERT=NO option (see section V.J.). However, it is often useful to input explicit uncertainties and/or to specify a general uncertainty in order to insure proper rounding. (This is particularly important when renormalizing is to be done.)

The generalized uncertainty specification is useful for saving unnecessary input. For example, if the relative intensities are known to 5% except for a few weak transitions, set UNCERTR=5, and include explicit uncertainties only when they are larger [or smaller] than 5%.

V.L. Renormalization of γ-ray intensities

There are six options for renormalization and control of printing position of γ-ray intensities:

(1) No renormalization, "normal" positions. (Relative intensities, as input, are printed immediately above the transition arrow with no sign; absolute intensities as input with a % sign on the arrow if there is room, or above it, after the energy [and multipolarity], otherwise.)

(2) All intensities printed as absolute (renormalize if required), in the normal position for absolute intensities.

(3) Same as (2), but the absolute intensities will be printed in the position normally used for relative intensities, with no % sign.

(4) Same as (3), with the % sign added to the intensities.

(5) Print relative branching from each level (relative intensities normalized to 100 for each level), only if there is > 1 transition from the level and each has been given an intensity. [An intensity "w" (weak) counts as given, with a value of 0.]

(6) Print relative branching as in "mode (5)", and, in addition,

a) For each level from which the branching is complete (all γ's have a numeric intensity or a "w"), print the largest absolute intensity on the arrow.

b) For levels with only one transition or an incomplete set, print the absolute intensity of each transition on the arrow.

For purposes of renormalization, the program (LVS) recognizes the following "intensity patterns"* in the input intensities:

All absolute: no relative intensities were input; input values in the absolute columns (12 - 26) of a D-card are assumed to be absolute.

All relative: no absolute intensities were input; the normalizing factor is assumed to be unknown.

---

*The intensity pattern is noted in the output following the transition energy-level difference comparison table.

All relative + normalizing absolute : one numeric (not "w") absolute value was input for a transition which also has a numeric value for the relative intensity. The ratio (and the uncertainty on the absolute intensity) will be used to renormalize the rest of the relative intensities to absolute under options 2, 3, 4, and 6.

"Inconsistent": Any other combination of absolute and relative intensities.

Renormalization and/or change of printing position will be done if the "intensity pattern" permits, as indicated in the following table:

	Renormalization option					
Intensity pattern	1	2	3	4	5	6
All absolute	Yes	Yes	Yes	Yes	Yes	Yes
All relative	Yes	No	No	No	Yes	No
All relative + norm. absolute	Yes	Yes	Yes	Yes	Yes	Yes
Inconsistent	Yes	No	No	No	Yes*	No

*Either the absolute or relative intensities will be used if complete (from one level); the relative will be used if both relative and absolute are given for each transition from the level.

Rounding of renormalized intensities will be done in accordance with the rounding and uncertainty specifications described in sections V.K.1 and V.K.2. When any number that contains an uncertainty on input is renormalized and/or rounded, the resulting number will also contain an uncertainty (properly renormalized and/or rounded). Uncertainties generated by a general uncertainty specification (see section V.K.2) will be printed under the "A" options below, but not under the "B" options.

The renormalization specifications are:

RENORM OPTION=nA
RENORM OPTION=nB — where n is the renormalization option number (1 to 6)

The default option is

** RENORM OPTION=1A

(no renormalization, "normal" plotting positions; output uncertainties generated by a general uncertainty specification, as well as uncertainties input explicitly, will be printed).

Notes:

1) Renormalization and/or change of printing position (options 2 - 6) affect only the numbers printed on the plot; it does not alter the input data (which may subsequently be stored in its original form).

2) When an "all relative + normalizing absolute" set of intensities is renormalized to absolute, the uncertainty on the one absolute intensity will be added (quadratically) to the uncertainty in the relative intensities. If no input uncertainty was given, the general uncertainty specified by UNCERTA= ... (see section V.K.2) will be used. The uncertainty thus propogated to the derived (renormalized) absolute intensities (if non-zero) will be printed under either the A or B options.

3) If neither explicit nor general uncertainty is specified for a renormalized intensity (or the normalizing factor), the intensity will be printed to the same number of significant figures as input.

4) Whenever renormalization is to be done (i.e., for the absolute intensities derived, under options 2 - 6, from "all relative + normalizing absolute" input intensities, or for relative branching derived under options 5,6),

the rounding specification must be of the "n, nS, nX, or nSX type (see section V.K.1). If not specified, or of the nD type, the specification

ROUNDA=5
or ROUNDR=5

will be assumed.

5) The general uncertainty specifications

UNCERTR= ...
UNCERTA= ...

apply to the input intensities; that is, UNCERTR applies to intensities input as relative. Rounding specifications

ROUNDR= ...
ROUNDA= ...

apply to the output intensities (printed on the plot, whether in the normal position or not). Thus, rounding of absolute intensities under the renormalization options 2, 3, or 4 is governed by the ROUNDA= ... specification, regardless of whether the absolute intensities were input or were derived by renormalization.

6) See also note (e), section V.K.2.

V.M. Cutoff Options

These suppress printing or plotting of data above a specified level energy. For example,

NO GAMMAS>3.5

will suppress plotting of γ-rays from levels above 3.5 (input energy units). The level energy is a decimal number or integer. Omission of the > sign and energy results in total suppression, e.g.

NO GAMMAS results in a plot with all γ-rays omitted. The full set of options are:

NO LEVELS
NO LEVEL ENERGIES
NO GAMMAS
NO GAMMA LABELS
NO GAMMA ENERGIES
NO RELATIVE
NO ABSOLUTE
NO MULTIPOLARITIES
NO FEEDS
NO FEED INTENSITIES
NO FT
NO HF
NO SPINS

Notes:

(1) The NO LEVELS specification must be given with an energy limit.

(2) The default option is none of the cutoff specifications, and may be reset by specifying a large cutoff energy (or by the general RESET specification).

(3) The specification NO GAMMA LABELS removes all gamma energies, intensities, and multipolarities, and, if given without an energy limit, also compresses the X-scale by decreasing the separation between the γ-ray arrows by a factor 2/3. This may be useful for plotting schemes with very many gamma rays.

VI. STORAGE, RETRIEVAL, AND EDITING

VI.A. Storage and Retrieval is specified by an S-card ("Store") and an F-card ("Fetch"). The S-card may occur anywhere in the input deck, whereas the F-card is placed before the input deck, and separated from it by a 7-8-9 card (record separator) (see figure 3c).

The same format is used for both S and F-cards. The quantities are identifiers required by the chipstore routines WRITEMS and COPYMS:

Columns	Quantity
2 - 11	group name
12 - 21	owner
22 - 31	account
32 - 41	set name
42 - 51	subset name
52 - 80	ignored; may be a comment

Notes:

(1) Account is not required on an F-card, and is ignored if present.

(2) Set name must be preceeded by an asterisk on an S-card if and only if the set is a new one (does not yet exist on the chipstore).

(3) Re-storing data in the same set and subset replaces the previous data stored in that subset.

(4) Store only large decks; storage of small decks is unnecessary, and wastes space in the mass-storage system.

(5) Errors in the F- or S-card specifications will cause the retrieval or storage to be omitted or aborted. In the case of storage, processing of the data and plotting will continue.

VI.B. Editing

Editing is done by the system routine UPDATE. See the UPDATE manual for the full range of features. Only the most common operations are described below.

The first card of an editing deck is

*IDENT MOD1

MOD1 is an alphanumeric identifier ($\leq$ 5 characters). This card takes the place of the *DECK ... card for normal input decks. The modification identifier name (MOD1 in the above example) must be different from all DECK names in the original deck. If the deck has previously been edited and re-stored, the identifier name must also differ from previously used modification identifiers.

The most common editing directives are insertion and deletion directives, and have the form

```
*I  NAME.n
*D  NAME.n
*D  NAME.n,m
```

The first (*I) positions to the card NAME n, where, NAME must be a previously used deck name (or modification identifier). Cards following *I ... will be inserted after the card NAME n. (The card labels are those printed on the output from the level-scheme program).

*D NAME.n deletes card NAME n, and also positions to that card; following cards will be inserted in place of the deleted card. Similarly, *D NAME.n,m deletes cards NAME n through NAME m, and positions to the location of the deletion.

If more than one DECK was present in the original input (one or more additional *DECK ... cards), decks may be selectively processed by the directive

*C NAME1, NAME2, ... NAMEn

The editing specifications end when a 7-8-9 card is encountered.

Notes:

1) The S-card itself, which was part of the original input deck, will be part of the edited deck, and will cause re-storage of the edited data in the same set and subset. To avoid this, the S-card must be deleted.
2) All UPDATE edit directives begin with an asterisk in column 1.
3) If a partial set of the original input DECKS is specified by a *C ... directive, and the edited data is processed and includes an S-card, only the selected decks will be re-stored.
4) An error in the edit directives will terminate execution of the programs after the rest of the editing specifications have been checked.

VII. OUTPUT

The printed output includes:

A. Output from the FETCH program and COPYMS, if a fetch was requested via an F-card.

B. Output from UPDATE. If the deck structure is bad (bad editing directives, no *DECK card, or a directive other than a proper *DECK NAME card in a new deck), this output will explain the error. (Execution then terminates.)

C. Output from LVS. This includes

1) Standard data tables used by the program - element name list, a list of legal spin and multipolarity formats, and a listing of even-even α standards used to calculate hindrance factors for odd-mass and odd-odd α emitters. (See fig. 4.)

2) A direct listing of the input data (after editing if the data was retrieved and edited).

3) A listing of the input data as it is interpreted and processed by the program, including diagnostic notes on errors detected and radii used for α-hindrance factor calculations.

4) Following each completed level scheme, a summary of feeding and calculated FT,HF values and a table of level differences vs. γ-ray energies.

D. Output from WRITEMS, if storage was requested.

E. Output from the SCH program. This output is minimal. It will normally consist only of a listing of the plots processed. If rescaling of the energy scale is required, this will be noted. Any other output from SCH probably indicates something is awry.

VIII. COST AND TIME REQUIREMENTS

Processing of a typical level scheme of moderate to high complexity requires about 1 - 5 CUS for analysis (LVS) and about 5 - 30 CUS per plot for graphics (SCH). Accounting costs for each level scheme are printed by LVS; costs for each plot are printed by SCH. SCH will not begin a new plot unless $\geq$ 30 CUS are available to it. There is an additional overhead cost for retrieving and loading the programs, and for retrieving, indexing, editing

and storing input data, of ≈ 20 CUS; staging of the plot file will require ≈ 5 - 30 CUS per plot. An overall job limit of 100 CUS should be more than sufficient for a short job (1 - 2 plots).

At the present time, 1 CU ≈ 6¢.

IX. ERRORS AND BUGS

A. LVS is supposed to be able to process errors in the input data without failing. Serious errors may result in suppression of plots, as noted in the printout following the listing of Z-cards. SCH should plot all schemes thus checked by LVS.

The diagnostic messages from LVS begin with the comment ERROR, WARNING, or NOTE. ERROR represents a definite error. WARNING or NOTE diagnostics vary in severity from "very probable" errors (e.g. violation of parity conservation in γ decay) to "slightly possible" errors (e.g. minor violation of the legal spin-syntax forms). All such warning messages indicate that the input data should be checked for possible errors.

Note: this is not a substitute for proofreading!

The tables following each completed level scheme may be helpful for finding errors, such as misplaced transitions.

B. At the present time, the programs have undergone only a partial testing, and may fail for unexpected reasons. Control cards have been set up to provide adequate dumps for the diagnosis of the errors. If dumps occur, or if the plots or output contain apparent errors, please contact the author at 843-2740, ex. 5995, Bldg. 70A, Rm. 2255B. Supply him with the complete output, including film if any was produced.

Note: Because of peculiarities in the present 7600 system, short (1-page) dumps will unavoidably occur:

1) Before the COPYMS output, whenever a retrieval is specified.

2) Before the WRITEMS output, whenever a store is specified.

3) After SCH output, whenever 35-mm film was specified.

4) After the output from UPDATE, COPYMS, or WRITEMS, if the input to these routines contains errors.

Only in the last case (4) does this dump imply an error, whose meaning should be obvious from the preceeding printout.

Figure Captions

Fig. 1. Example of how to use LESAGE to produce a decay scheme

a) Input forms

b) Printout from program - analysis of the input

c) Plot produced by program

Fig. 2. Another example of the use of LESAGE - a reaction scheme. (See caption of fig. 1.)

Fig. 3. Input deck structure

a) Deck structure for creation of new level schemes

b) Example of how a number of level schemes can be grouped logically into one input deck

c) Deck structure for retrieval and editing of previously stored level-scheme input data

d) Structure of a single level scheme

Fig. 4. Standard output from LVS -

a) Legal ("non-questionable") spin and multipolarity formats

b) Standard (even-even) α data for calculation of hindrance factors.

PAGE: 1 ISOTOPE: 117-Sn REACTIONS: Decay

I		ISOTOPE		REACTION			ID
R		REFERENCES					
R	C	REFERENCES, CONTINUED					
P		PARENT	MODE	HALF-LIFE	SPIN	Q-VALUE	ID
Q		DAUGHTER	MODE	Q-VALUE	LEVELS [ENERGY Iπ]		
Q	C	LEVELS, CONTINUED					
C		COMMENT					
X		PLOT CONTROL					
1	2	3-21	22-31	32-41	42-61	62-79	80
I	1	117-SN	DECAY				
R	*	NUCL. *PHYS. *A158 (1970) 607					
K	E	V					
P	1	117-IN	B-	44.6 M	9/2+	1964+-9	A
P	1	117M-IN	B- 57	1.95 H	1/2-	1779+-9	B
P	1	117-SB	EC+B+	2.80 H	5/2+	1753+-40	C
C		*REL. INTENSITIES ARE PER 117-*SN DECAY→					
C		*SPINS OF THE 1004, 1020, 1179, AND 1446 KE*V LEVELS ARE					
C		TAKEN FROM REACTION STUDIES→					

PAGE: ISOTOPE: REACTIONS:

LEVELS							DECAY					
L 1	ENERGY 3-11	SPIN 13-41	HALF-LIFE 42-61	FEEDING 62	63-71	INT. 63-71	FT, HF 72-79	D 1	GAMMA 3-11	I ABS. 13-20 2,6	I REL. 21-30	MULTIP. 41-70	FINAL LEV. 71-80
L	0	1/2+		B		40							
L	158.6	3/2+	0.31 NS	B		17							
L				C	EC	97.5							
L				C	B+	2.5							
								D	158.6		3000+-500	M1	0
L	314.6	11/2-	14.0 D	A		0.17							
								D	156.0			M4	158.6
L	711.5	7/2+	1.0 NS	A		99.83							
L				C		0.066							
								D	396.6		W		314.6
								D	552.9		23+-3	E2	158.6
L	1004	3/2+	0.63 PS	B		0.0074							
L				C		0.27							
								D	846		15+-2	M1	158.6
								D	1004		78+-10		0
L	1020	5/2+	1.1 PS	B		0.023							
L				C		0.38							
								D	862		100	M1	158.6
								D	1020		33+-6		0
L	1179	(5/2+)		C		0.10							
								D	1021		36+-6		158.6
L	1446.4	5/2+		C		0.078							
								D	1287.6		9.2+-20	M1	158.6
								D	1446.4		18+-5		0
L	1498			C		0.009							
								D	1339		3+-1		158.6
L	1578.3			C		0.034							
								D	1420.1		5.7+-20		158.6
								D	1578.0		6.2+-20		0
X	FILM=35												
Z													

RL-6169—1/72

Fig. 1a

```
////////// BEGIN LEVEL SCHEME NO.  1 //////////

================================================================================
                REACTION IDENTIFICATION (I-CARDS, R-CARDS)

ISOTOPE=117-SN          ; RXN.=DECAY                    ; FEEDING ID=           ; IDENT= ; A117   2
REFERENCES=*NUCL. *PHYS. *A158 (1970) 607                                       ; A117   3
//////////////////////////////////////////////////////////////////////////////
***** CHANGE UNITS *****=KEV                                                     A117   4
//////////////////////////////////////////////////////////////////////////////

================================================================================

                DECAY-PARENT IDENTIFICATION (P-CARDS)

PARENT=117-IN           ; MODE=B-       ; T12=44.6 M    ; SPN=9/2+      ; Q=1464+-9     ; IDENT=A; A117   5
PARENT=117M-IN          ; MODE=B- 57    ; T12=1.95 H    ; SPN=1/2-      ; Q=1779+-9     ; IDENT=B; A117   6
PARENT=117-SB           ; MODE=EC=3P    ; T12=2.80 H    ; SPN=5/2+      ; Q=1753+-40    ; IDENT=C; A117   7
//////////////////////////////////////////////////////////////////////////////
***** COMPILERS COMMENTS *****=*REL. INTENSITIES ARE PER 117-*SB DECAY.          A117   8
//////////////////////////////////////////////////////////////////////////////
***** COMPILERS COMMENTS *****=*SPINS OF THE 1004, 1020, 1199 AND 1446 KEV LEVELS ARE TAKEN FROM REACTION  A117   9
//////////////////////////////////////////////////////////////////////////////
***** COMPILERS COMMENTS *****=STUDIES=                                          A117  10
//////////////////////////////////////////////////////////////////////////////

================================================================================

                LEVEL DATA (L-CARDS) AND DECAY(GAMMA) DATA (D-CARDS)

LEVEL NO.=--ENERGY--;=----------SPIN----------;=---T1/2---;= ;=--MODE---;=---INT.---;=--FT.HF--;
                                                            ^
                                                          PARENT

      =--GAMMA---;=---ABS.INT.----;=---REL.INT.----;=--------MULTIPOLARITY--------;  =FINAL LEV.;

   1. =0          ;=1/2+                          ;=          ;=B;=    ;=40     ;=      ;          A117  11
   2. =158.6      ;=3/2+                          ;=0.31 NS   ;=B;=    ;=17     ;=      ;          A117  12
   2. =           ;=                              ;=          ;=C;=EC  ;=97.5   ;=      ;          A117  13
   2. =           ;=                              ;=          ;=C;=B+  ;=2.5    ;=      ;          A117  14
      =158.6      ;=          ;=3000+-500         ;=M1                          ;=0     ;          A117  15
   3. =314.6I     ;=11/2-                         ;=14.0 D    ;=A;=    ;=0.17   ;=      ;          A117  16
      =156.0      ;=          ;=                  ;=M4                          ;=158.6 ;          A117  17
   4. =711.5      ;=7/2+                          ;=1.0 NS    ;=A;=    ;=99.83  ;=      ;          A117  18
   4. =           ;=                              ;=          ;=C;=    ;=0.066  ;=      ;          A117  19
********** NOTE, FEEDING MODE ASSUMED IDENTICAL TO THAT OF PARENT **********
      =396.6      ;=          ;=M                 ;=                            ;=314.6 ;          A117  20
      =552.9      ;=          ;=23+-3             ;=E2                          ;=158.6 ;          A117  21
```

Fig. 1b

5.	1004	3/2+	0.63 PS	B	0.0074			A117	22
5.				C	0.27			A117	23
********** NOTE. FEEDING MODE ASSUMED IDENTICAL TO THAT OF PARENT **********									
	846		15+-2	M1		58.6		A117	24
	1004		78+-10			0		A117	25
6.	1020	5/2+	1.1 PS	B	0.023			A117	26
6.				C	0.38			A117	27
********** NOTE. FEEDING MODE ASSUMED IDENTICAL TO THAT OF PARENT **********									
	862		100	M1		58.6		A117	28
	1020		33+-6			0		A117	29
7.	1179	(5/2+)		C	0.10			A117	30
********** NOTE. FEEDING MODE ASSUMED IDENTICAL TO THAT OF PARENT **********									
	1021		36+-4			58.6		A117	31
8.	1446.4	5/2+		C	0.078			A117	32
********** NOTE. FEEDING MODE ASSUMED IDENTICAL TO THAT OF PARENT **********									
	1287.6		9.2+-20	M1		58.6		A117	33
	1446.4		18+-5			0		A117	34
9.	1498			C	0.000			A117	35
********** NOTE. FEEDING MODE ASSUMED IDENTICAL TO THAT OF PARENT **********									
	1339		3+-1			58.6		A117	36
10.	1578.3			C	0.034			A117	37
********** NOTE. FEEDING MODE ASSUMED IDENTICAL TO THAT OF PARENT **********									
	1420.1		5.7+-20			58.6		A117	38
	1578.0		6.2+-20			0		A117	39
P_DT CONTROL, FILM=35								A117	40

Fig. 1b (continued)

LEVEL(S)		PARENT	MODE	FEEDING, PERCENT	CALC FT(HF)	INPUT FT(HF)	DIFF.	CALC. TOT.FEED.
3.	.31460	117 - IN	B-	1.700E-01	7.88	NO INPT	-----	
4.	.71150		B-	9.983E+01	4.44	NO INPT	-----	
TOTAL INPUT FEEDING FROM THIS PARENT 1.000E+02 PERCENT								
1.	0.00000	117M- IN	B-	4.000E+01	6.66	NO INPT	-----	
2.	.15860		B-	1.700E+01	6.87	NO INPT	-----	
5.	1.00400		B-	7.400E-03	9.03	NO INPT	-----	
6.	1.02000		B-	2.300E-02	8.85	NO INPT	-----	
TOTAL INPUT FEEDING FROM THIS PARENT 5.703E+01 PERCENT								
2.	.15860	117 - SB	EC	9.750E+01	4.86	NO INPT	-----	9.930E+01
2.	.15860		B+	2.500E+00	4.72	NO INPT	-----	1.382E+02
4.	.71150		EC+B+	6.600E-02	7.65	NO INPT	-----	
5.	1.00400		EC+B+	2.700E-01	6.75	NO INPT	-----	
6.	1.02000		EC+B+	3.800E-01	6.58	NO INPT	-----	
7.	1.17900		EC+B+	1.000E-01	6.94	NO INPT	-----	
8.	1.44640		EC+B+	7.800E-02	6.46	NO INPT	-----	
9.	1.49800		EC+B+	9.000E-03	7.23	NO INPT	-----	
10.	1.57830		EC+B+	3.400E-02	6.28	NO INPT	-----	
TOTAL INPUT FEEDING FROM THIS PARENT 1.009E+02 PERCENT								
********** WARNING. >100 PERCENT **********								

COMPARISON OF GAMMA ENERGIES WITH LEVEL DIFFERENCES

ENERGY, MEV	MISFIT, KEV	0.01	0.02	0.05	0.1	0.2	0.5	1	2	5	10	20	50	100	200	500	>500
		MISFIT LESS THAN (X) KEV															
.15860	0.000	X															
.15600	.000+	X															
.55290	0.000	X															
.39660	.300-						X										
1.00400	0.000	X															
.84600	.600+							X									
1.02000	0.000	X															
.86200	.600+							X									
1.02100	.600+							X									
1.44640	0.000	X															
1.28760	.200-					X											
1.33900	.400-						X										
1.57800	.300-						X										
1.42010	.400+						X										

GAMMA INTENSITY PATTERN ALL RELATIVE

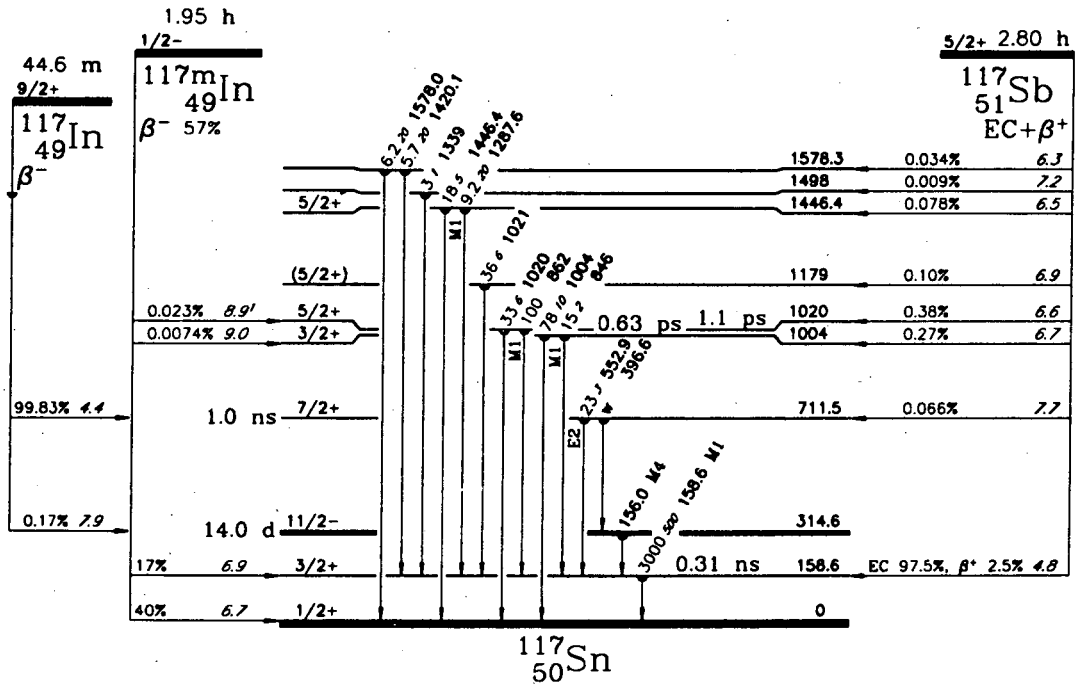
********** DO PLOT 2

A117 41

////////// PLOT NUMBER= 1. LEVEL SCHEME NO. 1 //////////

////////// END LEVEL SCHEME NO. 1. 1.586 CUS //////////

Fig. 1b (continued)



$^{117}_{50}Sn$ – REFERENCES

Nucl. Phys. A158 (1970) 607

$^{117}_{50}Sn$ – COMMENTS

1. Rel. intensities are per 117-Sb decay
2. Spins of the 1004, 1020, 1179, and 1446 keV levels are taken from reaction studies

XBL7311-4460

Fig. 1c

PAGE: 1 ISOTOPE: 117-Sn REACTIONS: (p,t) + ⇑ (a)

I	ISOTOPE	REACTION	FEEDING LABEL	ID
R	REFERENCES			
R	C REFERENCES, CONTINUED			
P	PARENT	MODE	HALF-LIFE	SPIN	Q-VALUE	ID
Q	DAUGHTER	MODE	Q-VALUE	LEVELS [ENERGY Iπ]		
Q	C LEVELS, CONTINUED					
C	COMMENT					
X	PLOT CONTROL					

1	2	3-21	22-31	32-41	42-61	62-79	80
I		117-SN	119-SN (P,T)				A
R	*	NUCL. *PHYS.	*A163 (1971) 401				
I		117-SN	COULOMB EXCITATION				B
R	*	NUCL. *PHYS.	*A123 (1969) 193				
M	=	V					
C	*	QUOTED L-VALUES ARE FOR THE (P,T) REACTION					
X		NO FAN					

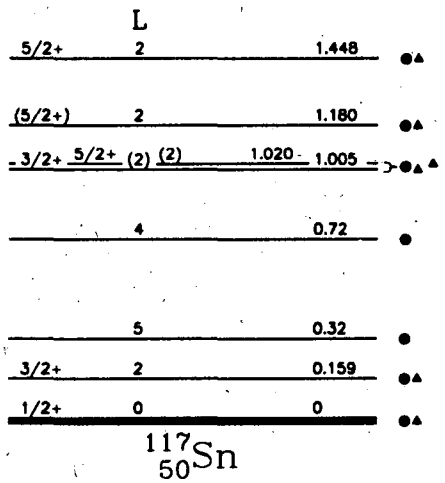
PAGE: 2 ISOTOPE: 117-Sn REACTIONS: (p,t) + ⇑

L 1	ENERGY 2-11	SPIN 12-41	HALF-LIFE 42-51	FEEDING 52	FEEDING 53-61	INTENSITY 62-71	FT, HF 72-80
L	0	1/2+ L0		A	B		
L	0.159	3/2+ L2		A	B		
L	0.32	L5		A			
L	0.72	L4		A			
L	1.005	3/2+ L(2)		B			
L	1.020	5/2+ L(2)		B			
L				A	S2		
L	1.180	(5/2+) L2		A	B		
L	1.448	5/2+ L2		A	B		
Z							

Fig. 2a

```
////////// BEGIN LEVEL SCHEME NO.  2 //////////

=============================================================================================================
                    REACTION IDENTIFICATION (I-CARDS, R-CARDS)

 ISOTOPE=117-SN              ; RXN.=117-SN(P,T)                    ; FEEDING ID=                ; IDENT=A;  A117   42
 REFERENCES=*NUCL. *PHYS. *A163 (1971) 401                                                                 A117   43
 ISOTOPE=117-SN              ; RXN.=COULOMB EXCITATION             ; FEEDING ID=                ; IDENT=B;  A117   44
 REFERENCES=*NUCL. *PHYS. *A123 (1969) 193                                                                 A117   45
//////////////////////////////////////////////////////////////////////////////////////////////////////////
 ***** CHANGE UNITS *****=MEV                                                                               A117   46
//////////////////////////////////////////////////////////////////////////////////////////////////////////
//////////////////////////////////////////////////////////////////////////////////////////////////////////
 ***** COMPILERS COMMENTS *****=QUOTED L-VALUES ARE FOR THE (P,T) REACTION                                   A117   47
//////////////////////////////////////////////////////////////////////////////////////////////////////////

=============================================================================================================

                    LEVEL DATA (L-CARDS) AND DECAY(GAMMA) DATA (D-CARDS)

 LEVEL NO.=---ENERGY---;=----------SPIN----------;=---T1/2---;=FEED-MODE-; =---INT.---;=--FT.HF--;
          =--GAMMA---;=---ABS.INT.----;=---REL.INT.----;=------MULTIPOLARITY-------; =FINAL LEV.;

      1. =0          ;=1/2+ L0          ;=          ;=AB     ; =          ;=          ;            A117   48
      2. =0.159      ;=3/2+ L2          ;=          ;=AB     ; =          ;=          ;            A117   49
      3. =0.32       ;=L5               ;=          ;=A      ; =          ;=          ;            A117   50
      4. =0.72       ;=L4               ;=          ;=A      ; =          ;=          ;            A117   51
      5. =1.005      ;=3/2+ L1(2)       ;=          ;=B      ; =          ;=          ;            A117   52
      6. =1.020      ;=5/2+ L1(2)       ;=          ;=B      ; =          ;=          ;            A117   53
      6. =           ;=                 ;=          ;=AS2    ; =          ;=          ;            A117   54
********** WARNING. SUM-FEED GIVEN WITH NO INTENSITY **********
      7. =1.180      ;=(5/2+) L2        ;=          ;=AB     ; =          ;=          ;            A117   55
      8. =1.448      ;=5/2+ L2          ;=          ;=AB     ; =          ;=          ;            A117   56
//////////////////////////////////////////////////////////////////////////////////////////////////////////
 PLOT CONTROL= NO FAN                                                                                      A117   57
//////////////////////////////////////////////////////////////////////////////////////////////////////////

=============================================================================================================

 GAMMA INTENSITY PATTERN=(NO INTENSITIES GIVEN)

 ********** DO PLOT=Z                                                                                      A117   58
 //////////  PLOT NUMBER=  2. LEVEL SCHEME NO.  2 //////////
 //////////    END LEVEL SCHEME NO.  2.    .648 CUS //////////
```

Fig. 2b



$^{117}_{50}Sn$ – LEGEND

● $^{119}Sn(p,t)$
▲ Coul. ex.

$^{117}_{50}Sn$ – REFERENCES

$^{119}Sn(p,t)$: Nucl. Phys. A163 (1971) 401
Coul. ex.: Nucl. Phys. A123 (1969) 193

$^{117}_{50}Sn$ – COMMENTS

1. Quoted l-values are for the (p,t) reaction

XBL 7311-4459

Fig. 2c

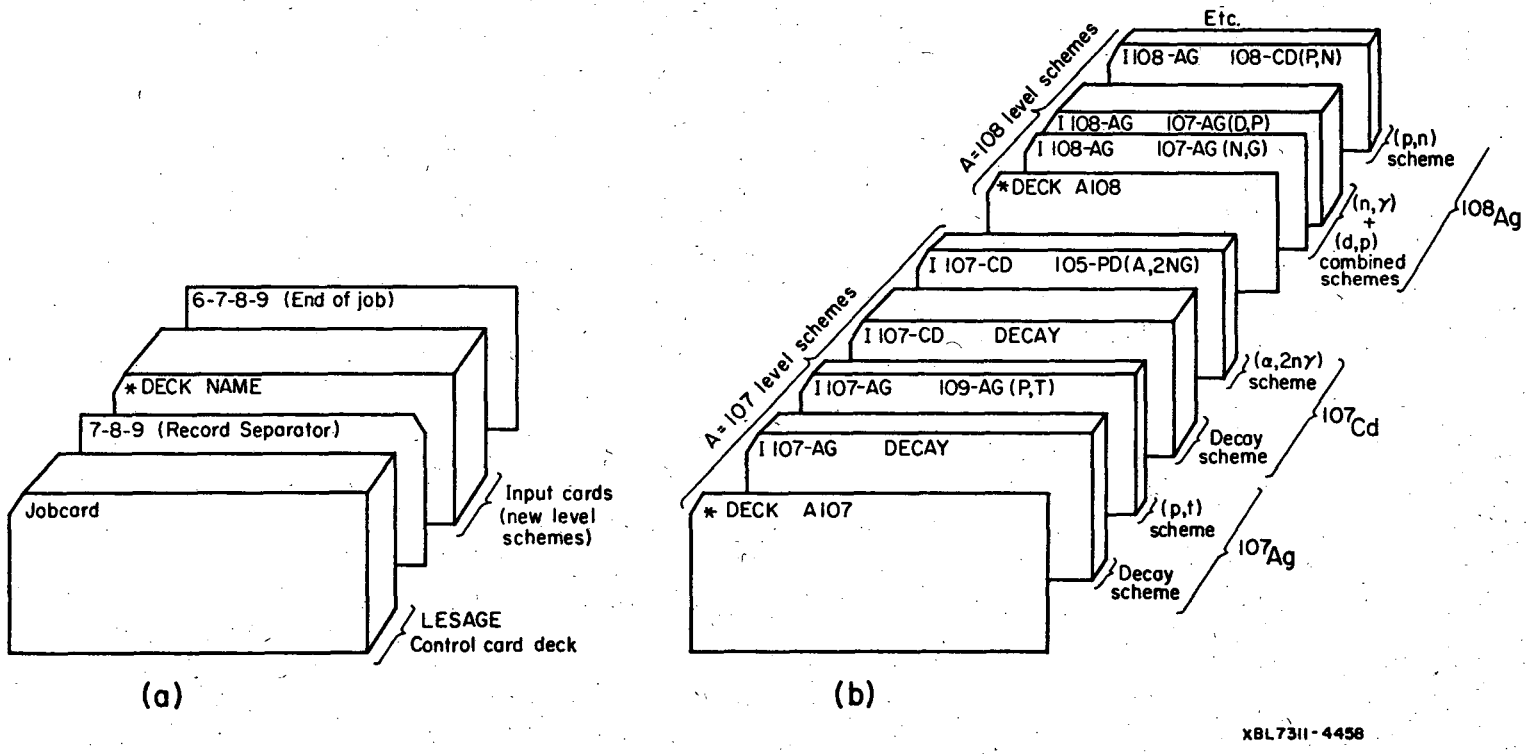

6-7-8-9 (End of job)
*DECK NAME
7-8-9 (Record Separator)
Jobcard
Input cards
(new level
schemes)
LESAGE
Control card deck
(a)
Etc.
A=108 level schemes
I 108-AG 108-CD(P,N)
I 108-AG 107-AG(D,P)
I 108-AG 107-AG (N,G)
*DECK A108
(p,n)
scheme
(n,γ)
+
(d,p)
combined
schemes
108Ag
A=107 level schemes
I 107-CD 105-PD(A,2NG)
I 107-CD DECAY
I 107-AG 109-AG (P,T)
I 107-AG DECAY
* DECK A107
(α,2nγ)
scheme
Decay
scheme
(p,t)
scheme
Decay
scheme
107Cd
107Ag
(b)
XBL7311-4458

Fig. 3a, b

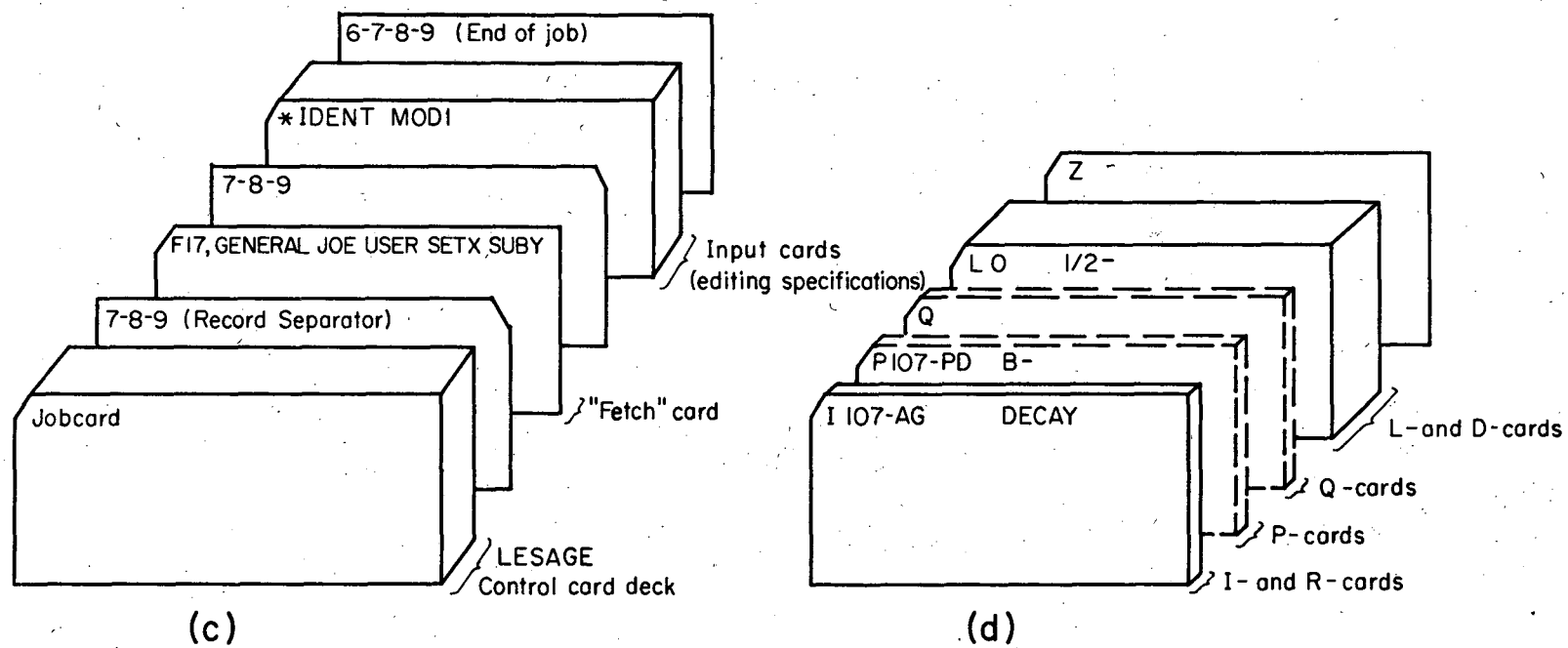

6-7-8-9 (End of job)
*IDENT MOD1
7-8-9
F17, GENERAL JOE USER SETX,SUBY
7-8-9 (Record Separator)
Jobcard
Input cards
(editing specifications)
"Fetch" card
LESAGE
Control card deck
(c)
Z -
L O 1/2-
Q
P107-PD B-
I 107-AG DECAY
L-and D-cards
Q-cards
P-cards
I- and R-cards
(d)
XBL7311-4457

Fig. 3c,d

LEGAL SPIN AND MULTIPOLARITY FORMATS

SPINS (≠ STANDS FOR +-)

1. S+
2. S-
3. (S+)
4. (S-)
5. S
6. (S)
7. (S)+
8. (S)-
9. S(+)
10. S(-)
11. +
12. -
13. (+)
14. (-)
15. [S+]
16. [S-]
17. S,S+
18. S,S-
19. S,S
20. (S,S)+
21. (S,S)-
22. (S,S)
23. (S,S+)
24. (S,S-)
25. S,S(+)
26. S,S(-)
27. S+,S-
28. S-,S+
29. (S+,S-)
30. (S-,S+)
31. S,(S)
32. S,(S)+
33. S,(S)-
34. S+,(S-)
35. S-,(S+)
36. S≠,S+
37. S≠,S-
38. S+,S≠
39. S-,S≠
40. S,S,S
41. S,S,S+
42. S,S,S-
43. S,S,S(+)
44. S,S,S(-)

L-VALUES

45. S
46. (S)
47. S,S
48. (S,S)
49. S(+S)
50. S+S

T-VALUES

51. S
52. (S)

MULTIPOLARITIES (≠ STANDS FOR NOT)

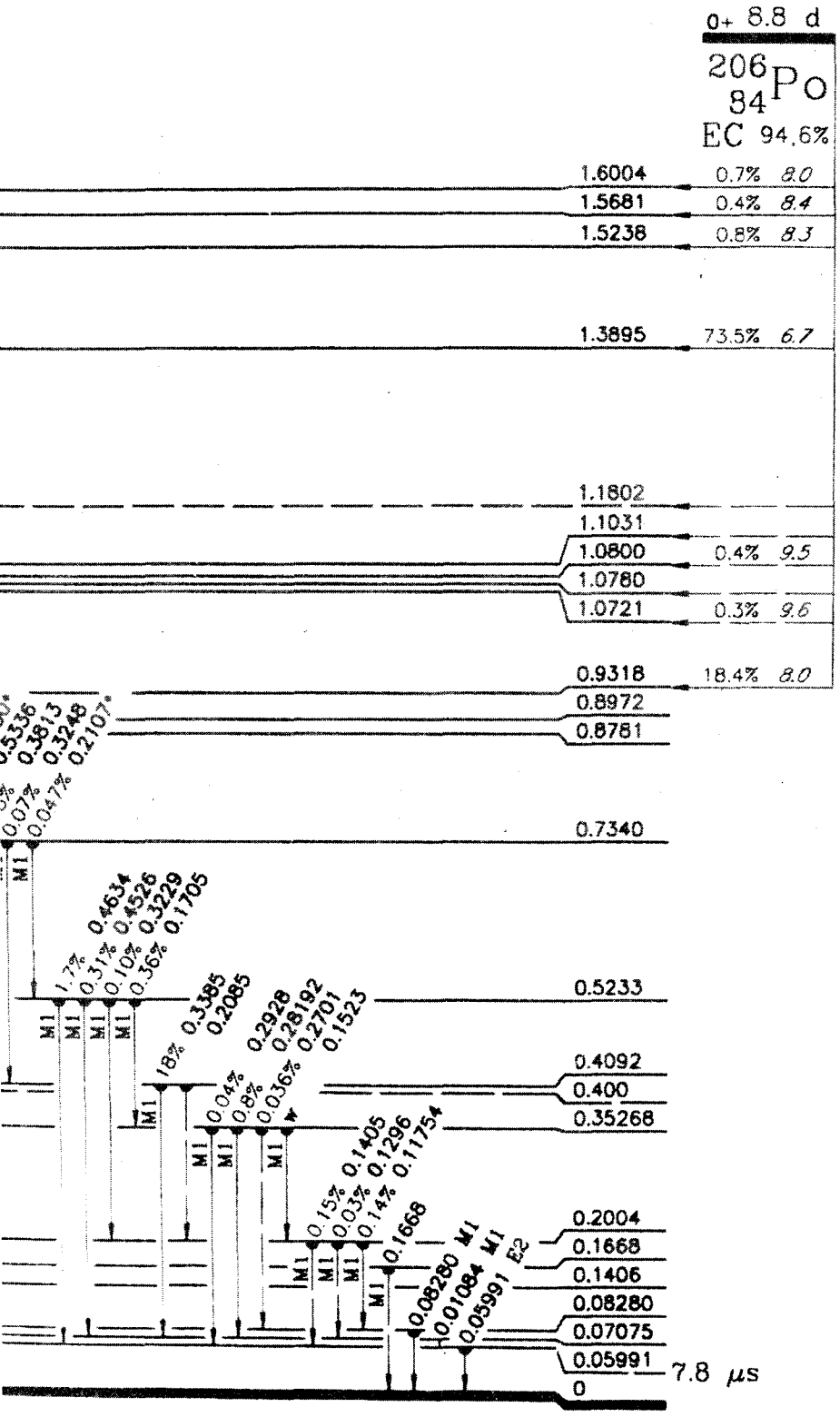
1. M
2. (M)
3. [M]
4. ≠M
5. (≠M)
6. M+M
7. M+NM
8. M(+M)
9. M(+NM)
10. (M+M)
11. (M+NM)
12. [M+M]
13. [M,M]
14. M,M
15. ≠M,M
16. M+M+M
17. M+NM+NM
18. M+M(+M)
19. M+(M,M)
20. M+NM(+M)
21. M,M,M

Fig. 4a

ALPHA STANDARDS

	ISOTOPE	E0	T1/2 + PRCNT ERROR		BRANCHING
1.	144-ND	1.8488+-28	2.4E15 Y	12.5	100
2.	146-SM	2.474+-17	1.026E8 Y	4.69	100
3.	148-SM	1.9203+-29	8E15 Y	25	100
4.	148-GD	3.184+-5	97.5 Y	6.7	100
5.	150-GD	2.719+-10	1.78E6 Y	4.5	100
6.	152-GD	2.143+-7	1.08E14 Y	7.4	100
7.	15 -DY	4.232+-5	7.4 M		18
8.	152-DY	3.627+-5	2.37 H	0.84	0.055+-10
9.	154-DY	2.870+-20	1E6 Y	50	100
10.	152-ER	4.80+-2	10.7 S	4.7	90+-20
11.	154-YB	5.330+-20	0.39 S	10.3	98
12.	174-HF	2.497+-30	2.0E15 Y	20	100
13.	176-PT	5.734+-9	6.0 S	8.3	42+-4
14.	178-PT	5.440+-10	21.2 S	3.8	7.2+-8
15.	18 -PT	5.14+-1	50 S	10	0.3
16.	182-PT	4.834+-17	3.0 M	6.7	0.02
17.	184-PT	4.490+-15	17 M	11.8	0.0015
18.	186-PT	4.23+-2	3.0 H	10	0.00014
19.	188-PT	3.93+-1	10.2 D		0.00003
20.	19 -PT	3.175+-20	6.9E11 Y	7.3	100
21.	182-HG	5.865+-15	11.3 S	4.4	9+-2
22.	184-HG	5.535+-15	32.5 S	3.1	1.25+-20
23.	186-HG	5.094+-15	1.42 M	7.0	0.016+-5
24.	21 -PB	3.792+-20	20.4 Y	1.47	0.0000017+-3
25.	194-PO	6.845+-7	0.6 S	33.3	100
26.	196-PO	6.520+-6	5.5 S	10	95
27.	198-PO	6.180+-3	1.76 M	1.70	70+-8
28.	200-PO	5.862+-2	11.5 M	.87	15+-2
29.	202-PO	5.588+-2	45.0 M	1.11	2.00+-15
30.	204-PO	5.377+-1	3.52 H	0.57	0.66+-1
31.	206-PO	5.2235+-16	8.8 D	1.14	5.45+-5
32.	208-PO	5.110+-5	2.8976 Y	0.055	99.998
33.	210-PO	5.30493+-60	138.3763 D	0.002	100
34.	212-PO	8.7843+-6	304 NS	1.32	100
35.	214-PO	7.687090+-56	163.7 US	0.12	100
36.	216-PO	6.7785+-5	145 MS	1.38	100
37.	218-PO	6.00255+-10	3.05 M		100
38.	20 -RN	6.909+-8	1.0 S	20	98
39.	202-RN	6.636+-3	9.85 S	2.03	100+-30
40.	204-RN	6.416+-3	1.24 M	2.4	72+-8
41.	206-RN	6.258+-3	5.47 M	3.0	68+-3
42.	208-RN	6.139+-3	24.35 M	1.54	52+-5
43.	21 -RN	6.037+-3	2.42 H	2.06	96+-1
44.	212-RN	6.262+-3	25.5 M	.39	99.995
45.	214-RN	9.035+-10	0.27 US	7.4	100
46.	216-RN	8.05+-1	45 US	11	100
47.	218-RN	7.127+-10	35 MS	2.9	100
48.	22 -RN	6.28829+-10	55.61 S	0.072	100
49.	222-RN	5.48966+-30	3.823 D	0.078	100
50.	206-RA	7.270+-5	0.4 S	50	100
51.	208-RA	7.131+-5	1.2 S	16.7	100
52.	21 -RA	7.018+-5	3.8 S	5.3	100
53.	212-RA	6.869+-5	13 S	15.4	100
54.	214-RA	7.136+-5	2.6 S	7.7	100
55.	218-RA	8.392+-8	14 US	14.3	100
56.	22 -RA	7.455+-1	23 MS	21.7	99
57.	222-RA	6.555+-10	37.5 S	5.3	96
58.	224-RA	5.68556+-20	3.66 D	0.55	94
59.	226-RA	4.78450+-25	1600 Y	1.0	94.5
60.	214-TH	7.680+-10	125 MS	20	100
61.	216-TH	7.921+-8	28 MS	7.1	100
62.	222-TH	7.980+-10	2.8 MS	10.7	100
63.	224-TH	7.174+-10	1.03 S	4.9	81+-3
64.	226-TH	6.334+-10	30.9 M		79
65.	228-TH	5.42333+-22	1.9131 Y	0.047	71
66.	23 -TH	4.6840+-1	8.0E4 Y	3.75	74
67.	232-TH	4.012+-5	1.41E10 Y	2.7	77
68.	228-U	6.684+-10	9.1 M	2.2	70+-4
69.	230-U	5.887+-3	20.8 D		67.5+-5
70.	232-U	5.32035+-4	71.7 Y	1.25	68.6+-6
71.	234-U	4.7743+-10	2.47E5 Y	1.21	72
72.	236-U	4.493+-3	2.391E7 Y	0.76	74
73.	238-U	4.195+-5	4.507E9 Y	0.20	77
74.	234-PU	6.203	9.2 H	5.6	4.1
75.	236-PU	5.767	2.851 Y	1.28	72.4
76.	238-PU	5.49921+-20	87.75 Y	0.057	71.1+-12
77.	24 -PU	5.1677+-7	6520 Y	0.61	75.5
78.	242-PU	4.9000+-12	3.869E5 Y	0.41	74
79.	244-PU	4.587+-1	8.28E7 Y	1.21	80.6
80.	24 -CM	6.289	28 D		71.1
81.	242-CM	6.112918+-82	163 D	0.61	74.2
82.	244-CM	5.804958+-50	18.099 Y	0.028	76.4
83.	246-CM	5.385+-3	4646 Y	0.48	79
84.	248-CM	5.078	3.52E5 Y	1.14	75.4
85.	244-CF	7.210	19.4 M	3.1	75
86.	246-CF	6.757	35.7 H	1.40	78
87.	248-CF	6.26+-3	350 D		82
88.	25 -CF	6.030+-5	13.08 Y	0.69	82.2
89.	252-CF	6.118+-5	2.646 Y	0.151	81.7
90.	254-CF	5.834+-5	60.5 D	0.33	0.26
91.	246-FM	8.24+-2	1.2 S	16.7	6.4
92.	248-FM	7.87+-2	38 S	10.5	90
93.	25 -FM	7.42+-3	30 M	10.0	80
94.	252-FM	7.04+-2	22.7 H	3.1	85
95.	254-FM	7.199+-5	3.24 H	0.62	84.5
96.	256-FM	6.925+-5	157 M	1.27	6.5
97.	252-NO	8.41+-2	2.3 S	13.0	56
98.	254-NO	8.10+-2	55 S	9.1	80
99.	256-NO	8.43+-2	3.2 S	6.3	90

Fig. 4b


0+ 8.8 d
206 84 Po
EC 94.6%
1.6004
0.7% 8.0
1.5681
0.4% 8.4
1.5238
0.8% 8.3
1.3895
73.5% 6.7
1.1802
1.1031
1.0800
0.4% 9.5
1.0780
1.0721
0.3% 9.6
0.9318
18.4% 8.0
0.8972
0.8781
0.7340
0.5233
0.4092
0.400
0.35268
0.2004
0.1668
0.1406
0.08280
0.07075
0.05991
0
7.8 μs
0.5336
0.3813
0.3248
0.2107*
0.07%
0.047%
M1
0.4634
0.4526
0.3229
0.1705
1.7%
0.31%
0.10%
0.36%
0.3385
0.2085
0.2928
0.28192
0.2701
0.1523
18%
0.04%
0.8%
0.0367%
0.1405
0.1296
0.11754
0.15%
0.03%
0.14%
0.1668
0.08280
0.01084
0.05991
M1
E2