UCMARS - A User Code with a Multiple-Array System using Combinatorial Geometry for EGS4

- Linux version -

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Abstract - A user code for EGS4 was developed for modeling a complex geometry with repeated structure. The user code incorporates the MARS geometry package developed by ORNL. It allows the users to model many rectangular arrays containing a geometry modeled by a combinatorial geometry with unlimited array nesting. A sample user code is presented to describe how to use MARS package in the subroutine HOWFAR .

INTRODUCTION

Since the electromagnetic cascade code EGS4[1] requires users to make a user code for their own purpose, it therefore has flexibility for the specifications of geometry modeling, detectors, and other calculation conditions. The user code includes a subroutine representing a geometry for calculations, called HOWFAR.   In HOWFAR, it must be calculated at a distance from the present point to the point at which the particle track will cross a boundary between different materials, although it is difficult to model a complex geometry, such as a combination of spheres, cylinders and rectangules, with a simple algorism.   For modeling a complex geometry, combinatorial geometry (CG) package obtained from MORSE[2] Monte Carlo code have been used for EGS4, and a sample user code was shown as UCSAMPCG in SLAC-265[1]. The combinatorial geometry allows a description of the physical structures by combining certain basic geometric shapes (bodies), such as rectangular parallelepipeds, right circular cylinders, and a Boolean combination of them. The MARS[3] geometry system has been developed to allow one to model the complex lattice geometry of CG efficiently and quickly with a minimum of geometric approximations and a minimum of computer memory requirements.   By using MARS with EGS4, it allows one to simulate an electromagnetic cascade in a complex repeated structure, such as a realistic modeling of a calorie meter.

MARS GEOMETRY SYSTEM

Features of MARS

MARS (Multiple Array System) is a geometry system based on combinatorial geometry (CG) package, which was developed by Oakridge National Laboratory (ORNL) for the SCALE[4] computer code system designed for safety analyses of nuclear fuel facilities. The MARS system is a versatile system meeting the most rigid modeling requirements in a flexible and general manner. The features that the MARS system offers are as follows: [3]

1. Many arrays may be modeled - each being unique.

2. Array may contain other arrays embedded in their lattice positions. The user may nest arrays inside arrays with no program limitation.

3. Arrays may be repeated by simple reference.

4. Arrays may have vacant lattice positions to model irregular array shapes. A particle may enter or exit an array from any cell in an array.

5. Geometry may be optionally modeled around an array and repeated with the array.

6. Arrays may be arbitrarily oriented. An array may be rotated as well as translated when it is repeated.

7. User geometry is modeled in simple coordinate systems called "universes," which are separate and independent from other parts of a geometry model.

8. Array input is verified for logical consistency and fit during input.

9. Geometry models may be quickly verified numerically and visually with three-dimensional graphics code JUNEBUG or PICTURE[5].

10. Basic geometry modeling uses combinatorial geometry for ease of input and flexibility. No restrictions are placed on the shape or complexity of individual cell content provided the outer shape of the cell is rectangular.

Additionally, MARS employs a free-form input system for user convenience. MARS was originally developed with IBM main frame computers; we then converted it so as to be used on a Sun work station. The original source program of MARS system is available as a part of the SCALE system from Radiation Shielding Information Center (RSIC) of ORNL.

Geometry description of MARS

Detailed instructions for the geometry inputs of MARS are described in its manual.[3] The basic geometry shapes (bodies) that can be used in MARS and CG are as follows:

RPP   -   Rectangular Parallelepiped

SPH   - Sphere

RCC - Right Circular Cylinder

REC   - Right Elliptical Cylinder

TRC   - Truncated Right Angle Cone

ELL   -   Ellipsoid

WED   -   Right Angle Wedge

BOX   -   Box polyhedron which specify the vertex and one of the corner

ARB   - Arbitrary Polyhedron.

We added the following three bodies for modeling of an anthropomorphic human body phantom based on Yamaguchi's data.[6]

TOR - Torus

GEL   - General Ellipsoid

QUA - Truncated Right Elliptical Cone

The coordinate systems for above bodies are shown in Fig.1. Each material zone is described by Boolean (AND, OR) operations of these bodies.

Universe and "Array in Array"

In MARS, the separate unique geometry model described by CG is labeled "universe". Universes are used to describe nested structures and array system. A universe is a separate independent dimension in space defined by a collection of input zones bounded by a special boundary media. Every input zone resides in a universe. Every input zone must include a universe number containing the zone. The contents of a universe are arbitrary, and a universe may contain an array in one or more of its input zones. The coordinate in a universe is independent to those in other universes. The most global universe in a model is Universe 0 (absolute universe). All universes with the exception of the absolute universe must be surrounded by a special boundary media, Media -1000. The former CG description corresponds to the MARS description in which all zones are in Universe 0.

MARS allows the users the ability to describe rectangular cells of arbitrary content and to combine these cells to form unique arrays.   These arrays may subsequently be referenced for inclusion in a geometry model. The array could be referenced in an input zone in a geometry model. The arrays could be referenced in an input zone in a universe, or they could be referenced in lattice cell positions in a larger array. Thus, there is a nested array capability in the MARS system.

UCMARS - SAMPLE USER CODE USING MARS

A sample user code using the MARS geometry system is shown in Fig.2. This user code calculates the energy depositions in each medium, and simulates the electron-magnetic cascade in a MARS geometry irradiated by a pencil photon beam with an energy of 10MeV. The cross section data for a specified number (NREG-1) of materials are "hatched" by the subroutine HATCH. The NREG'th material represents an internal or external void. In the subroutine HOWFAR, the subroutine CALI of the MARS system is called and returns IRPRIM; the present zone number,

and the subroutine PILOT are called to obtain S1, the distance from the present points (XA) to a point at which tracks (direction DC) will cross the zone or the universe boundary. The subroutine RESETP and RESETZ are used to clear the array containing the data of universe. The FORTRAN function MEDNO returns a media number corresponding to the MARS zone number.

Input specifications of sample user code are as follows.

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Card 1   NREG,NHIST   (List indicated free format)
    NREG   : No. of regions including outer world
    NHIST : No. of histories to be executed

Cards 2 (repeat NREG-1 times)   II,(MEDIA(J,II),J=1,24)
                                   FORMAT(I5,5X,24A1)
    II   : Region No.
   MEDIA: Material name in cross section file produced fromPEGS4

Cards 3-   MARS geometry data described in Appendix.

Sample input data for this user code are shown in Fig.3.   This input data represents the human body phantom (Fig.4) used for correcting the efficiency of a whole body counter (human counter) at Tokyo University.[7]   The phantom comprises 13 acrylic boxes filled by water. Four plastic scintillators are placed below the phantom. The room wall is iron and is covered by an acrylic inner liner. A NaI scintillator was placed above the phantom as a monitor. The parts of the phantom are grouped into eleven universes and are aligned by using two nested arrays for a convenience to change the phantom geometry.

CONCLUDING REMARKS

A sample user code for EGS4 with the MARS geometry system is presented. With this system, an electromagnetic cascade simulation with EGS4 can be easily performed in complex and reciprocal geometries.

REFERENCES

(1) W.R.Nelson, H.Hirayama, and W.O.Rogers : THE EGS-4 CODE SYSTEM, SLAC-265(1985)

(2) M.B.Emmett, "The MORSE Monte Carlo Radiation Transport Code System," ORNL-4972(1975)

(3) J.T.West and M.B.Emmett," MARS: A Multiple Array System Using Combinatorial Geometry," NUREG/CR-0200, Vol.3,sect.M9, (1980)

(4) "SCALE-3 A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation," RSIC CCC-466,(1981)

(5) M.B.Emmett, "PICTURE: A Printer Plot Package for Making 2-D Pictures of MARS Geometries,"NUREG/CR-0200, Vol.3,sect.M13, (1980)

(6) Y.Yamaguchi, DEEP Code to Calculate Dose Equivalents in Human Phantom for External Photon Exposure by Monte Carlo,JAERI-M 90-235(1990)

(7) M.Togo, *private communication*.

Table A.1.   Input Required for Each Body Type (1/2)

| Body Type	ITYPE	LALP	Real Data Defining Particular Body					
Box	BOX	LALPos assigned by the user or	Vx	Vy	Vz	H1x	H1y	H1z
			H2x	H2y	H2z	H3x	H3y	H3z
Right Parallelepiped	RPP	by the code if left blank.	Xmin	Xmax	Ymin	Ymax	Zmin	Zmax
Sphere	SPH		Vx	Vy	Vz	R	--	--
Right Circular	RCC		Vx	Vy	Vz	Hx	Hy	Hz
Cylinder			R	--	--	--	--	--
Right Elliptical	REC		Vx	Vy	Vz	Hx	Hy	Hz
Cylinder			R1x	R1y	R1z	R2x	R2y	R2z
Ellipsoid	ELL		V1x	V1y	V1z	V2x	V2y	V2z
			R	---	---	---	---	---
Truncated Right Cone	TRC		Vx	Vy	Vz	Hx	Hy	Hz
			R1	R2	--	--	--	--
Right Angle Wedge	WED or RAW		Vx	Vy	Vz	Hx	Hy	Hz
			H2x	H2y	H2z	H3x	H3y	H3z
Arbitrary Polyhedron	ARB		V1x	V1y	V1z	V2x	V2y	V2z
			V3x	V3y	V3z	V4x	V4y	V4z
			V5x	V5y	V5z	V6x	V6y	V6z
			V7x	V7y	V7z	V8x	V8y	V8z
			Face Descriptions (See note below)					

NOTE: The arbitrary polyhedron input contains a four-digit number for each the six faces of an ARB body.

Table A 1.   Input Required for Each Body Type (2/2)

Body Type	ITYPE	LALP	Real Data Defining Particular Body					
Alternate Body Descriptions	BPP		Xmin	Xmax	Ymin	Ymax	Zmin	Zmax
	VPP		Xmin	Xmax	Ymin	Ymax	Zmin	Zmax
Torus	TOR		X0 $\,$ FXYZ	Y0	Z0	R	a	b
General Ellipsoid	GEL		V_x $\,$ R_{2x}	V_y $\,$ R_{2y}	V_z $\,$ R_{2z}	R_{1x} $\,$ R_{3x}	R_{1y} $\,$ R_{3y}	R_{1z} $\,$ R_{3z}
Truncated right elliptical cone	QUA		a $\,$ g	b $\,$ h	c $\,$ z_1	d $\,$ z_2	e	f
Termination of Body Input Data	END							

NOTE: The arbitrary polyhedron input contains a four-digit number for each the six faces
     of an ARB body.
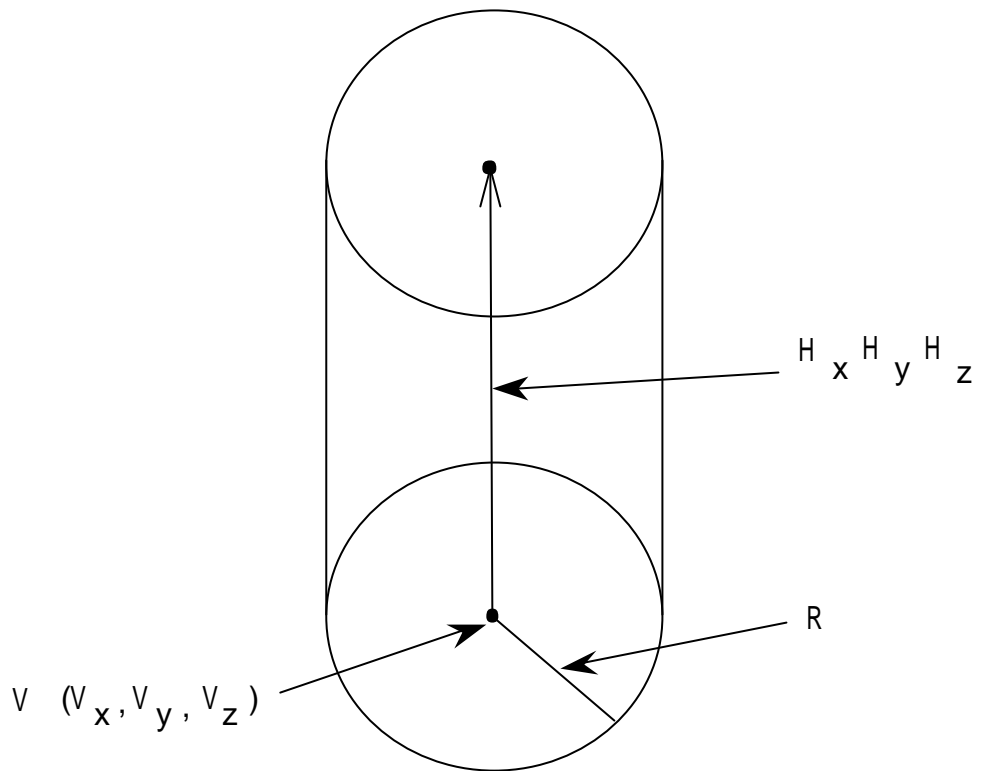
1. Rectangular Parallelepiped (RPP)
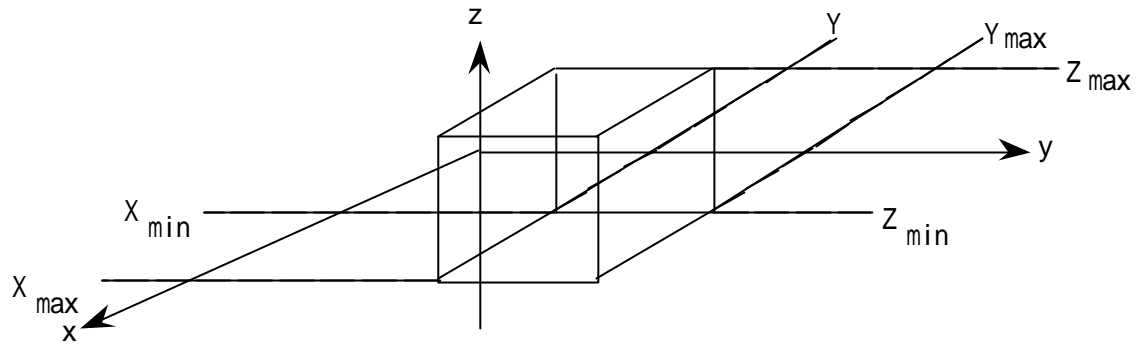
2. Sphere (SPH)
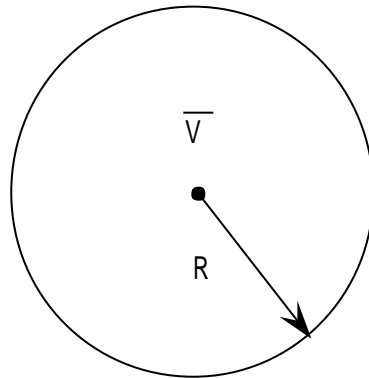
Fig. 1 Available bodies in a modified MARS geometry (1/7)

3. Right Circular Cylinder (RCC)

$H_x H_y H_z$

R

V (V_x, V_y, V_z)

4. Right Elliptical Cylinder (REC)

$\underline{H}$

$\underline{R_2}$

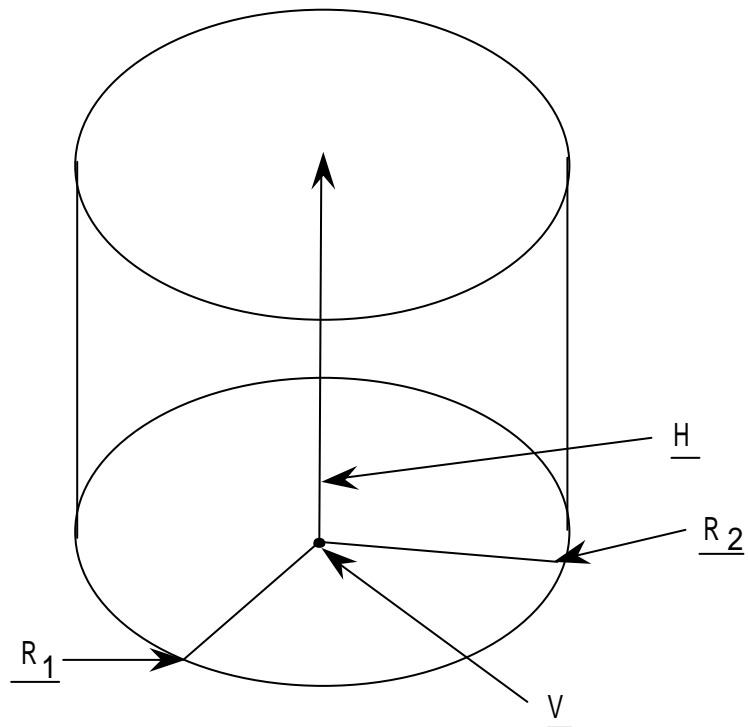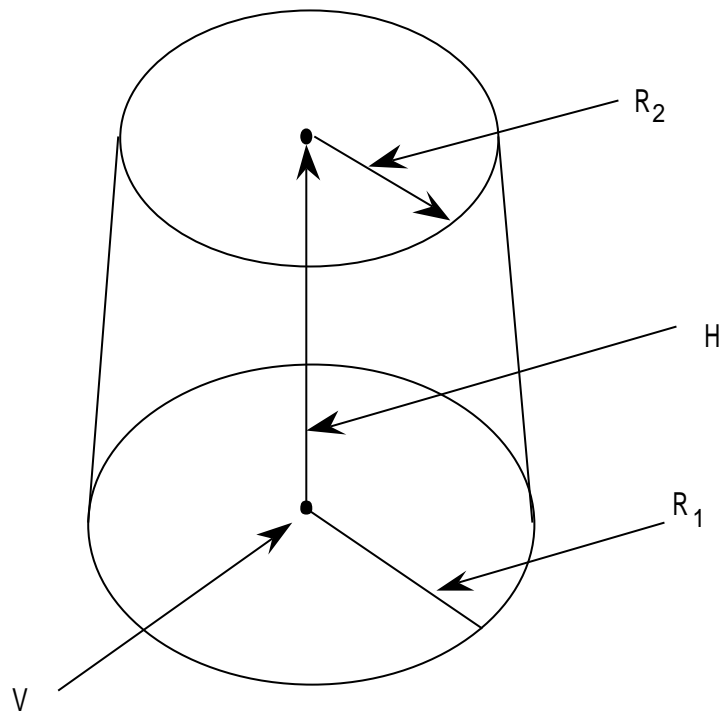$\underline{R_1}$

$\underline{V}$

Fig. 1 Available bodies in a modified MARS geometry (1/7)

5. Truncated Right Angle Cone (TRC)

R₂

H

R₁

V

6. Ellipsoid (ELL)

V₂

V₁

R

Fig. 1 Available bodies in a modified MARS geometry (3/7)

3
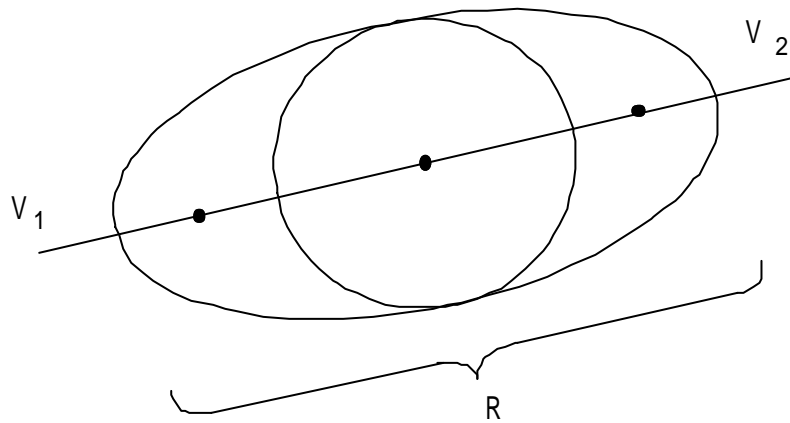
7. Right Angle Wedge (WED)

$\underline{a_1}$

$\underline{a_3}$

$\underline{a_2}$

$\underline{V}$

8. Box (BOX)
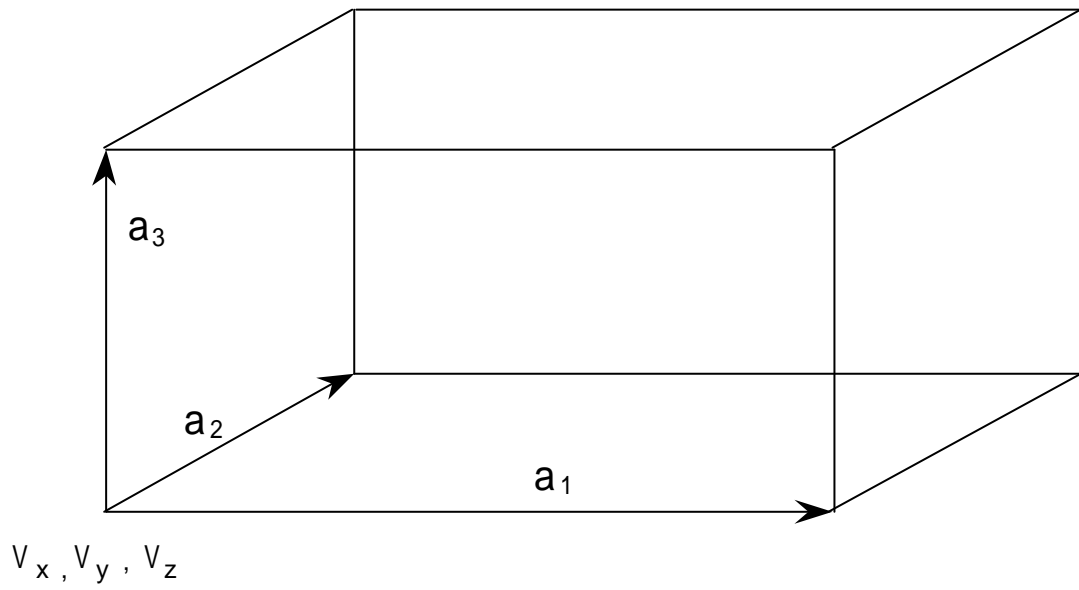

a_3

a_2

a_1
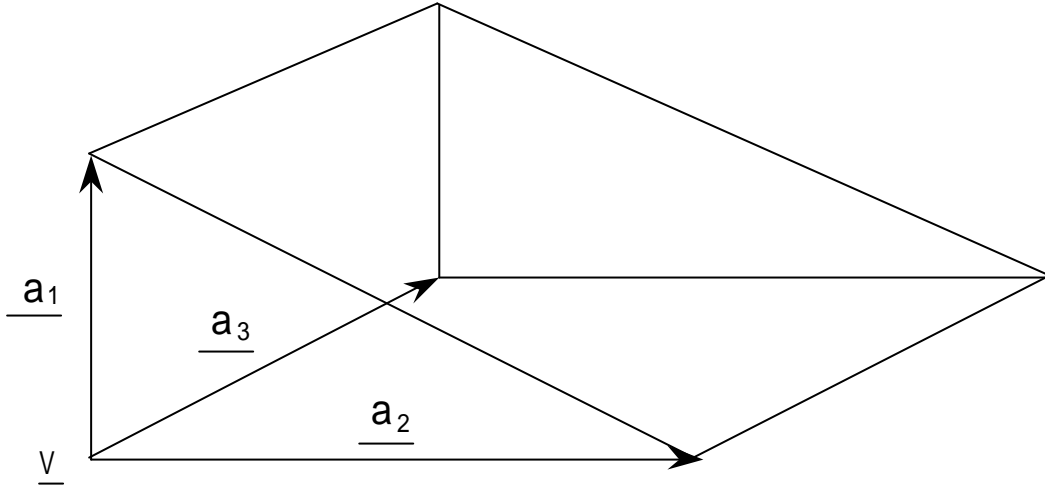
V_x, V_y, V_z

Fig. 1 Available bodies in a modified MARS geometry (4/7)
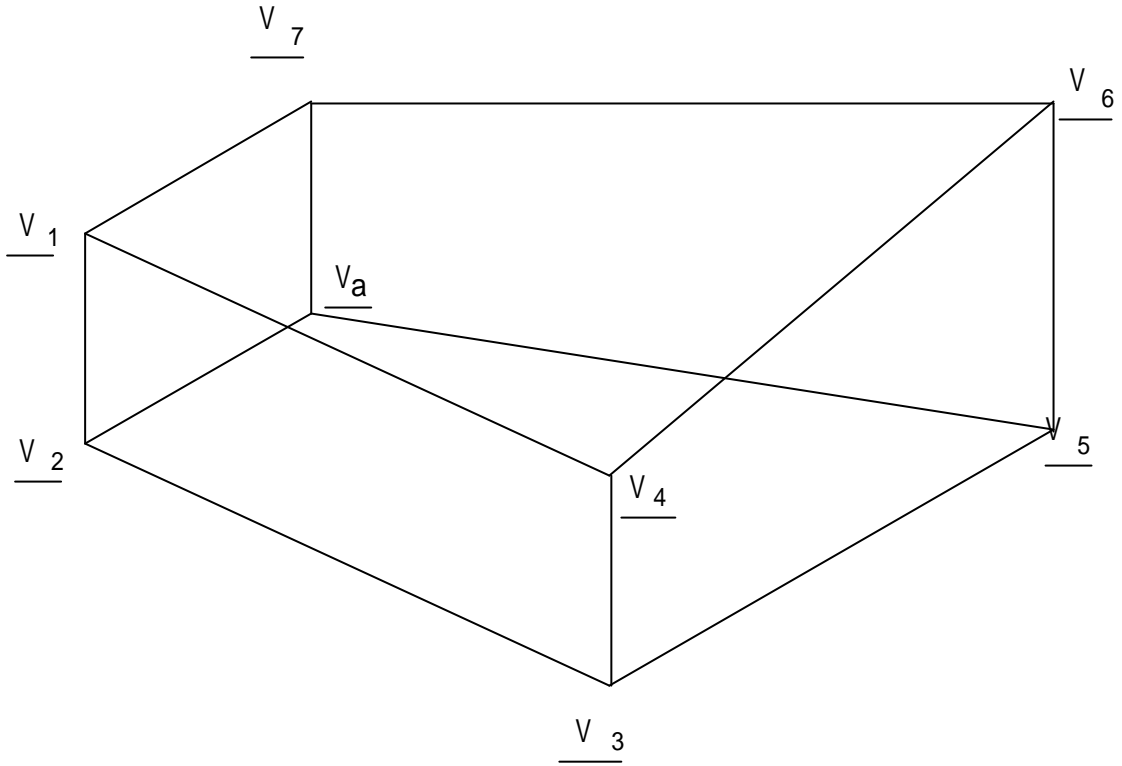
4

9. Arbitrary Polyhedron (ARB)

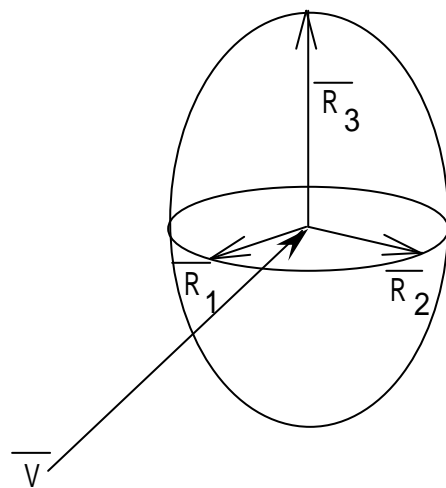Fig. 1 Available bodies in a modified MARS geometry (5/7)

10. Torus (TOR)

FXYZ=1

(y_0, z_0)

FXYZ=2

(z_0, x_0)

FXYZ=3

(x_0, y_0)

(x_0, y_0, z_0)

(x_0, y_0, z_0)

R   b   a
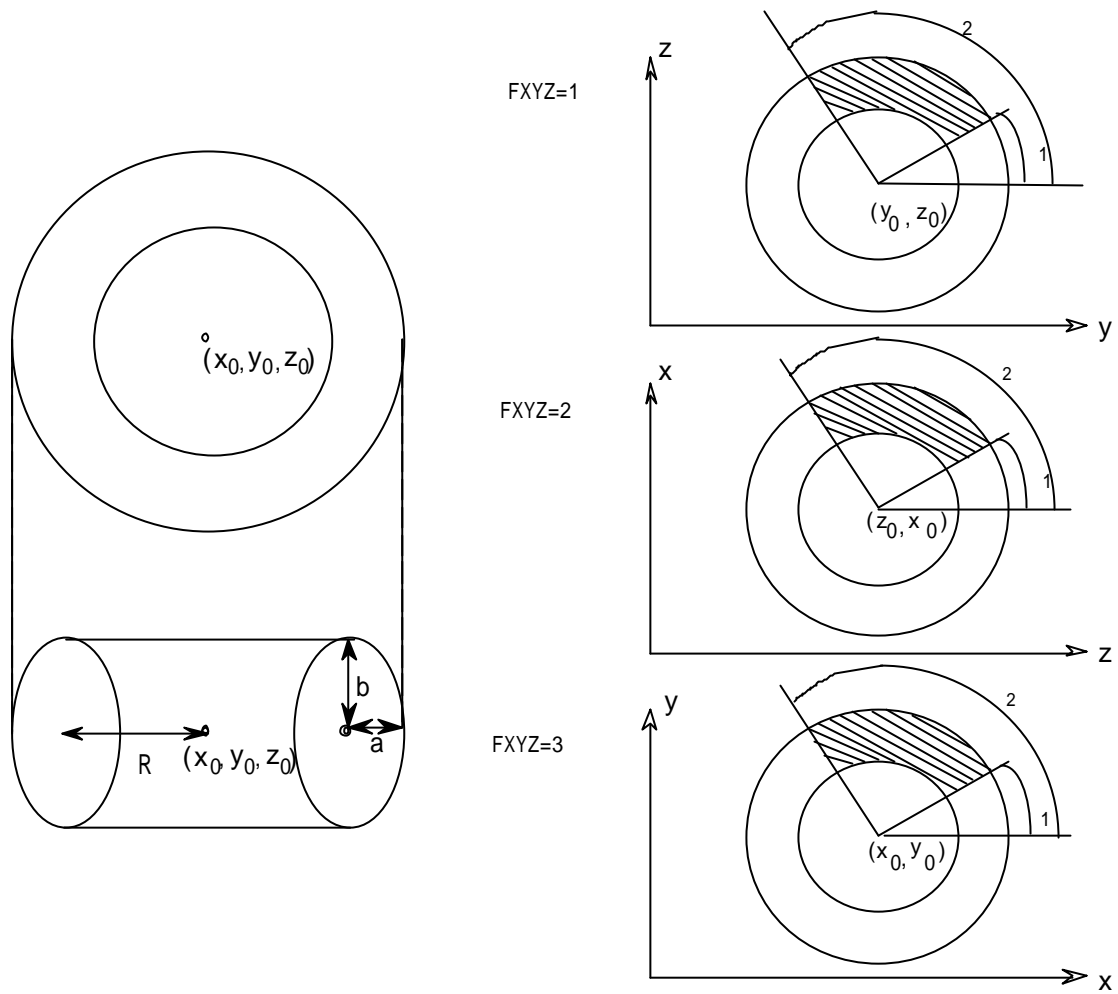
11. General Ellipsoid (GEL)

$\overline{R_3}$

$\overline{R_1}$ $\overline{R_2}$

$\overline{V}$

$\overline{V} \ = \ (V_x, \ V_y, \ V_z)$

$\overline{R}_1 = \ (\ R_{1x}, \ R_{1y}, \ R_{1z})$

$\overline{R}_2 = \ (\ R_{2x}, \ R_{2y}, \ R_{2z})$

$\overline{R}_3 = \ (\ R_{3x}, \ R_{3y}, \ R_{3z})$

Fig. 1 Available bodies in a modified MARS geometry (6/7)

12. Truncated right elliptical cone (QUA)
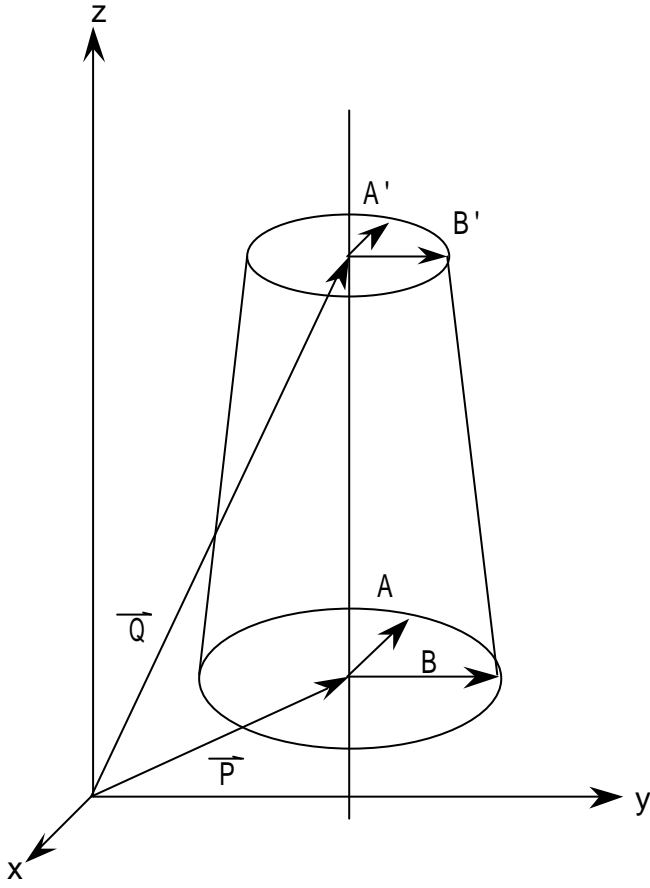
$$(ax + bx + c)^2 + (dx + ez + f)^2 = (gz + h)^2$$

or

$$\left\{ \frac{x + (bz + C)/a}{(gz + h)/a} \right\}^2 + \left\{ \frac{y + (ez + f)/d}{(gz + h)/d} \right\}^2 = 1$$

$$\vec{P} = \left(-\frac{bZ_1 + h}{a}, -\frac{eZ_1 + f}{d}, Z_1 \right)$$

$$\vec{Q} = \left(-\frac{bZ_2 + h}{a}, -\frac{eZ_2 + f}{d}, Z_2 \right)$$

$$(A, B) = \left(\frac{gZ_1 + h}{a}, \frac{gZ_1 + h}{d} \right)$$

$$(A', B') = \left(\frac{gZ_2 + h}{a}, \frac{gZ_2 + h}{d} \right)$$

Fig. 1 Available bodies in a modified MARS geometry (7/7)
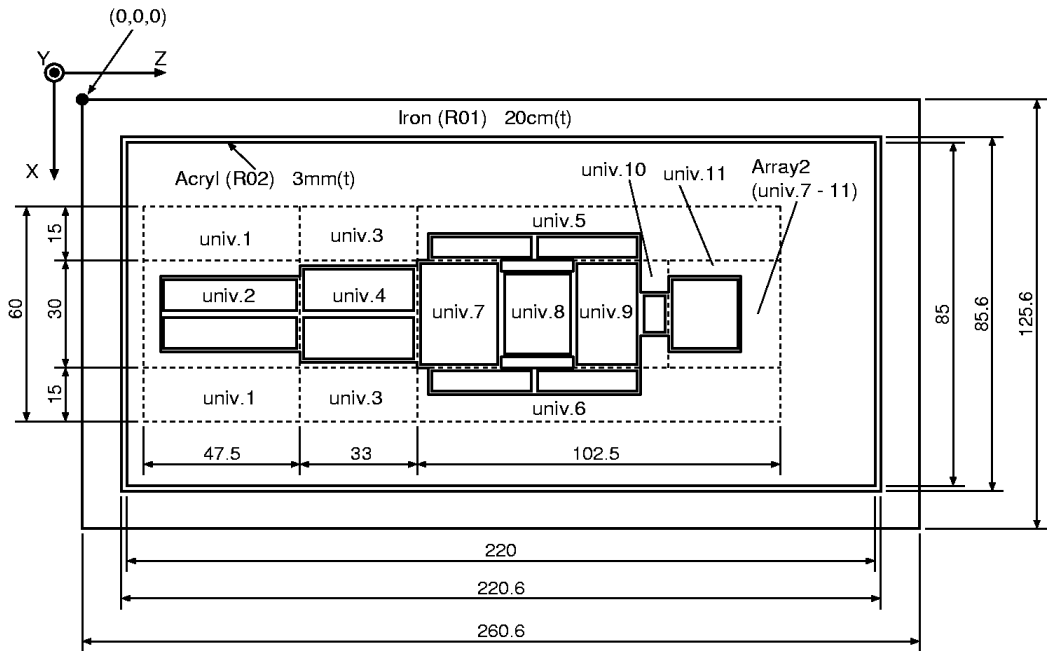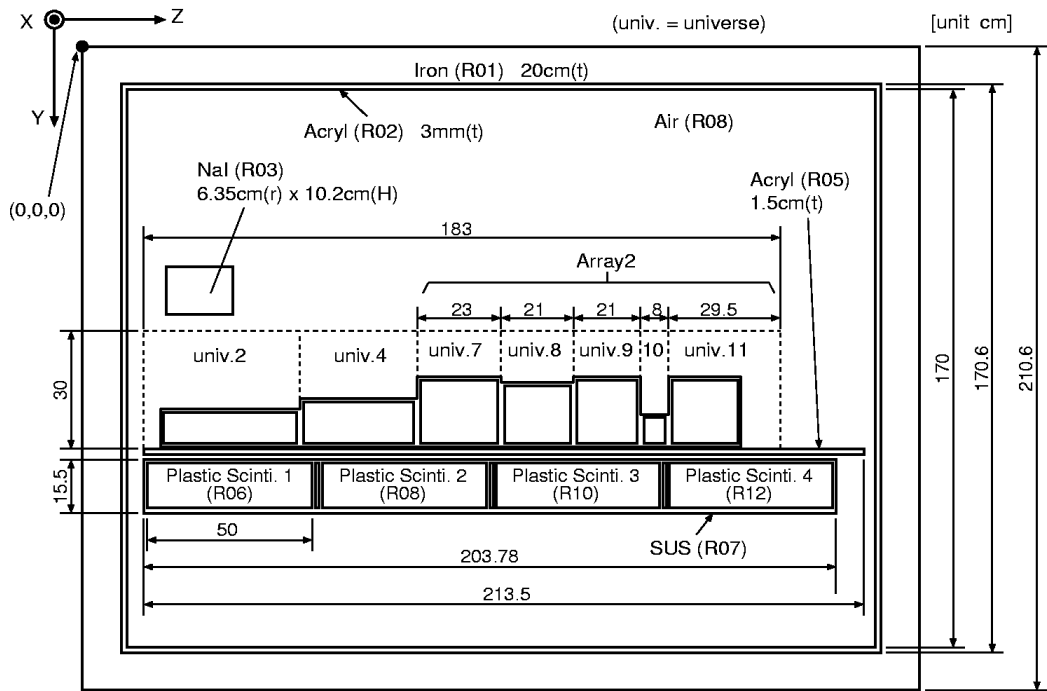
Fig.2 Geometry for sample input data : human.inp
(Water-filled phantom on scintilator)

```
   8    100            NREG : No. of material regions including void
                       NHST: No. of histories
   1      FE                                          Material No.s and names (MEDIA in EGS4)
   2      ACRYL
   3      NAI
   4      AIR AT NTP
   5      PLASTIC
   6      SUS
   7      WATER
HUMAN COUNTER (CASE 1)                               MARS card 1: Title card
   0   0   1    100                                  MARS card 2: Option card
   RPP    1    0.    125.6    0.    210.6    0.    260.6    MARS cards3: Body definition card
   RPP    2    20.   105.6    20.   190.6    20.   240.6
   RPP    3    20.3  105.3    20.3  190.3    20.3  240.3
   RPP    4    32.8   92.8    130.  131.5    22.8  236.3
   RPP    5    37.77  87.83   133.5 149.0    22.8  226.58
   RPP    6    37.80  87.80   133.53 148.53   22.83  72.83
   RPP    7    37.80  87.80   133.53 148.53   72.86  74.04
   RPP    8    37.80  87.80   133.53 148.53   74.07 124.07
   RPP    9    37.80  87.80   133.53 148.53  124.10 125.28
   RPP   10    37.80  87.80   133.53 148.53  125.31 175.31
   RPP   11    37.80  87.80   133.53 148.53  175.34 176.52
   RPP   12    37.80  87.80   133.53 148.53  176.55 226.55
   RPP   13    32.80  92.80    99.90 129.90   22.8  205.80
   RPP   14    0.     15.     0.     30.     0.     47.5
   RPP   15    0.     15.     0.     30.     0.     33.
   RPP   16    0.     15.     0.     30.     0.    102.5
   RPP   17    7.5    15.     22.5   30.     3.     65.
   RPP   18    8.     14.5    23.    29.5    3.5    33.5
   RPP   19    8.     14.5    23.    29.5    34.5   64.5
   RPP   20    0.     30.     0.     30.     0.     47.5
   RPP   21    5.5    24.5    20.5   30.     3.5    47.5
   RPP   22    6.     14.5    21.    29.5    4.     47.0
   RPP   23    15.5   24.0    21.    29.5    4.     47.0
   RPP   24    0.     30.     0.     30.     0.     33.
   RPP   25    1.5    28.5    16.5   30.     0.     33.
   RPP   26    2.     14.5    17.    29.5    0.5    32.5
   RPP   27    15.5   28.     17.    29.5    0.5    32.5
   RPP   28    0.     30.     0.     30.     0.     23.
   RPP   29    0.     30.     9.     30.     0.     23.
   RPP   30    0.5    29.5    9.5    29.5    0.5    22.5
   RPP   31    0.     30.     0.     30.     0.     21.
   RPP   32    2.     28.     11.    30.     0.     21.
   RPP   33    2.5    27.5    11.5   29.5    0.5    20.5
   RPP   34    0.     30.     0.     30.     0.     21.
   RPP   35    0.     30.     9.     30.     0.     21.
   RPP   36    0.5    29.5    9.5    29.5    0.5    20.5
   RPP   37    0.     30.     0.     30.     0.     8.
   RPP   38    10.    20.     21.    30.     0.     8.
   RPP   39    10.5   19.5    21.5   29.5    0.5    7.5
   RPP   40    0.     30.     0.     30.     0.     29.5
   RPP   41    7.5    22.5    9.5    30.     0.     20.
```

Fig.3 Sample input of the UCMARS user code for a human counter (1/3)

```
RPP    42   8.       22.      10.      29.5     0.5      19.5
RPP    43   0.       15.      0.       30.      0.       102.5
RPP    44   0.       7.5      22.5     30.      3.       65.
RPP    45   0.5      7.       23       29.5     3.5      33.5
RPP    46   0.5      7.       23       29.5     34.5     64.5
RPP    47   -1.0D+08  1.0D+08  -1.0D+08  1.0D+08  -1.0D+08  1.0D+08
RPP    48   -1.0D+09  1.0D+09  -1.0D+09  1.0D+09  -1.0D+09  1.0D+09
RCC    49   30.3     97.5     44.7     0.       -10.2    0.       6.35
END                                          MARS cards4: Input zone description cards
R01   +1 -2                                  Iron wall
R02   +2 -3                                  Acryl inner liner of wall
R03   +49                                    NaI scintillator
R04   +13                                    Boundary of ARRAY 1
R05   +4                                     Acryl plate below phantom
R06   +6                                     Plastic scintillator 1
R18   +8                                     Plastic scintillator 2
R10   +10                                    Plastic scintillator 3
R12   +12                                    Plastic scintillator 4
R17   +7                                     Air between scinti. 1 and 2
R19   +9                                     Air between scinti. 2 and 3
R11   +11                                    Air between scinti. 3 and 4
R07   +5 -6 -7 -8 -9 -10 -11 -12             SS wall of scintillator
R08   +3 -49 -13 -4 -5                       Air in room
R09   +48 -1                                 External void
A14   +14                                    Outer boundary of universe 1
U01   +47 -14                                External media (-1000) of univ.1
A20   +20 -21                                Outer boundary of universe 2
P21   +21 -22 -23
W22   +22
W23   +23
U02   +47 -20                                External media (-1000) of univ.2
A15   +15                                    Outer boundary of universe 3
U03   +47 -15                                External media (-1000) of univ.3
A24   +24 -25                                Outer boundary of universe 4
P25   +25 -26 -27
W26   +26
W27   +27
U04   +47 -24                                External media (-1000) of univ.4
A16   +16 -17                                Outer boundary of universe 5
P17   +17 -18 -19
W18   +18
W19   +19
U05   +47 -16                                External media (-1000) of univ.5
A43   +43 -44                                Outer boundary of universe 6
P44   +44 -45 -46
W45   +45
W46   +46
U06   +47 -43                                External media (-1000) of univ.6
A28   +28 -29                                Outer boundary of universe 7
P29   +29 -30
W30   +30
```

Fig.3 Sample input of the UCMARS user code for a human counter (2/3)

```
U07   +47 -28                                    External media (-1000) of univ. 7
A31   +31 -32                                    **Outer boundary of universe 8**
P32   +32 -33
W33   +33
U08   +47 -31                                    External media (-1000) of univ. 8
A34   +34 -35                                    **Outer boundary of universe 9**
P35   +35 -36
W36   +36
U09   +47 -34                                    External media (-1000) of univ. 9
A37   +37 -38                                    **Outer boundary of universe 10**
P38   +38 -39
W39   +39
U10   +47 -37                                    External    media    (-1000)    of
univ. 10
A38   +40 -41                                    **Outer boundary of universe 11**
P39   +41 -42
W40   +42
U11   +47 -40                                    External    media    (-1000)    of
univ. 11
END
59*1                                             **MARS card 5 : Region card (not used)**
15*0 2*1 5*2 2*3 5*4 5*5 5*6 4*7 4*8 4*9 4*10 4*11 **MARS card 6 : Universe card**
 1   2   3  -1   2       5   5   5   5   4   4   4   6   4   0**MARS cards7 : Media card**
 4   -1000                                       media for universe 1
 4   2   7   7   -1000                            media for universe 2
 4   -1000                                       media for universe 3
 4   2   7   7   -1000                            media for universe 4
 4   2   7   7   -1000                            media for universe 5
 4   2   7   7   -1000                            media for universe 6
 4   2   7   -1000                               media for universe 7
 4   2   7   -1000                               media for universe 8
 4   2   7   -1000                               media for universe 9
 4   2   7   -1000                               media for universe 10
 4   2   7   -1000                               media for universe 11
 3   1   3   1   1   5   0   2                    **MARS card 8 :** Array size specifications
input
                                                 (Array 1 : 3x1x3 as XxYxZ)
                                                 (Array 2 : 1x1x5 as XxYxZ)
 101$$ 1   2   1   3   4   3   5  -2   6          **MARS card 9 :** Array content description (1)
 102$$ 7   8   9   10   11   T                    **MARS card 9 :** Array content description (2)
 11*0                                            **MARS   card10   :   Universe   type(all**
combinatorial)
```

Fig.3 Sample input of the UCMARS user code for a human counter (3/3)

APPENDIX : FREE-FORM COMBINATORIAL MARS INPUT INSTRUCTIONS

(This instructions are re-typed from NUREG/CR-0200, section M9)

A.1   TITLE* CARD

FORMAT (15A4)

A.2   OPTIONS CARD (four entries required)

IVOPT- Volume option not implemented - enter 0.

IDBG - Debug print option if positive; otherwise, enter 0.

IBOD - Body numbers are assigned by the user if IBOD is greater than zero; otherwise, enter 0.

NAZ   - Number of zones to be added to the data storage for next zone of entry memory table. Enter any large number if extra storage is required. Default value allows for five zones to be entered from any single code zone. This option is normally not required; enter 0.

A.3   BODY DEFINITION CARDS

Each new body must start on a new card. The allowable body types are given In Table A.1 along with the required input variables to describe each body. An END card must be used to signify the end of the body definition cards. For each body, the following input is required:

ITYPE- Specifies the alphanumeric body type or END to terminate reading of body data (for example, BOX, RPP, ARB, RCC, etc.)

IALP   - Body number assigned by the user if IBOD is greater than zero; otherwise, it is not entered.

FPD(I)- Real data required for the given body as show in Table A.1. This data must be in cm.

A.4   INPUT ZONE DESCRIPTION CARDS

Each new zone must start on a new card. A three-character title should be given for each new input zone (not necessarily unique) which must start with an alpha-type character. An END card must be used to signify the end of the input zone description cards. For each input zone, the data needed is the title and zone data. Input zone numbers are assigned sequentially.

IALP   - The three-character title for the zone where the first character is a letter.

IIBIAS(I) - Specify the "OR" operator if required for the JTY(I) body.

JTY(I)   - Body number with the (+) or (-) sign as required for the zone description.

Example:

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PEL  +1
CLD  +2  -1
H2O  +3  -2
 END
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A.5   REGION CARD

One entry is required for each input zone. This specifies the importance region each input zone is inside. This determines which set of weights for splitting, Russian roulette, and path length stretching to use in each zone during tracking.

A.6   UNIVERSE CARD

This array specifies which universe each input zone is inside. One entry is required for each input zone. The entry must be either a zero or a positive integer. A negative entry is not valid. Each universe, with the exception of the absolute universe, must contain one and only one zone with a -1000 media. The absolute universe cannot contain any -1000 media zone.

A.7   MEDIA CARD

This array specifies the media contained in each input zone. One entries required for each input zone. If the entry is positive, it references a valid cross section mixture or a reflected boundary, MEDALB. If the entry is negative, it references a valid array number as the absolute value of the entry. If the entry is -1000, it references a universe external boundary media. If the entry is 1000, it references an internal void. If the entry is 0, it references an external void.

A.8   ARRAY SIZE SPECIFICATIONS INPUT

An array is a regular rectangular lattice composed of rectangular cells of arbitrary content. The size of each array should be entered as NXMAX, NYMAX, by NZMAX. Arrays are sequentially named as they are entered, starting with 1. The array size entered should include any vacant cells in the array, if any are present. After the size of the last array has been entered, a zero should be entered to terminate the entries. Zero is an illegal entry for an array size. After the zero terminator has been entered, a single integer parameter is entered to determine the means of entering the array specification list. If no array is to be described, only the zero terminator is required.

NXMAX   - The number of cells along the x-axis of array i
NYMAX   - The number of cells along the y-axis of array i
NZMAX   - The number of cells along the z-axis of array i

followed by a "0 terminator"

LOP   - array specification input option (required)
       = 0   Free-Form Input, FFREAD, type specification
      = 1   Standard KENO Mixed Cell (BOX) Orientation Cards
      = 2   Standard FIDO Integer Array Input Specification

Example: 15   15   1   6   5   2   7   7   1   0   0

This example describes three arrays. Array 1 will be a 15 by 15 by 1 array. Array 2 will be a 6 by 5 by 2 array. Array 3 will be a 7 by 7 by 1 array. Zero terminates the array size entries. The last zero entered selects the free-form input specification method of describing the array contents.

--End of Geometry Input if No Arrays are Modeled--

A.9   ARRAY CONTENT DESCRIPTION

The contents of each cell of each array must be defined. All contents of Array 1 are defined, then Array 2, etc. The method of entering this data is determined by IOP in Sect. A.8 input. There are three possibilities for each cell entry. These are distinguished by either a positive, zero, or negative entry. A positive entry is a universe number. The universe must fit slightly in the lattice cell position it is referenced inside. The contents of universe are completely arbitrary. A negative entry is an array entry. The absolute value of the entry is the array being referenced. It must completely fill the lattice position in which it is referenced. It cannot contain any vacancies in its lattice cell positions. Repeating a subarray in a larger array in this manner dose not require any additional input. The array must, however, fit snugly in the lattice cell position. The means of entering this data is selected by the user to give flexibility in describing his arrays. The options are:

1.   IOP = 0 - Free-Form Input Option

Free-form input is entered using the FFREAD notation. This allows an " " repeat feature. Data is entered as:

      DO 10 M = 1, NAR (NAR is the number of arrays entered)
      DO 10 K = 1, NZMAX
      DO 10 J = 1, NYMAX
      DO 10 I = 1, NXMAX
      ...enter the contents of the i , j , and z   cell location for array m...
       10 CONTINUE

All entries must be separated by a blank and data may be entered in all columns 1 through 80. Entries of the form, "L N," means enter the value N into the input L times. This could also be done with the "R" option by entering "LRN." In both cases blanks between entries are not allowed.

Example: 2 1 2 2 1 2 2 1 2

This could be the description of a 3 by 3 array of the form,

2 1 2
2 1 2
2 1 2

2. IOP = 1 - Mixed-Cell Orientation Cards

The first field contains the entry followed by three sets of three fields that are treated like FORTRAN.DO loops, followed by a field that indicates whether another set of data is to be read. The arrangement of lattice cells may be considered as consisting of a three-dimensional matrix of numbers, with the cell position increasing in the positive X, Y, and Z directions, respectively. Each set of orientation data consists of the following parameters, separated by one or more blanks.

LTYPE   The cell entry. LTYPE may be negative (array #), zero (empty cell), or positive (universe #).

IX1   The starting point in the X direction. IX1 must be at least 1 and less than or equal to NXMAX.

IX2   The ending point in the X direction. IX2 must be at least 1 and less than or equal to NXMAX.

INCX   The number of cells by which increments are made in the positive X direction. INCX must be greater than zero and less than or equal to NXMAX.

IY1   The starting point in the Y direction. IY1 must be at least 1 and less than or equal to NYMAX.

IY2   The ending point in the Y direction. IY2 must be at least 1 and less than or equal to NYMAX.

INCY   The number of cells by which increments are made in the positive Y direction. INCY must be greater than zero and less than or equal to NYMAX.

IZ1   The starting point in the Z direction. IZ1 must be at least 1 and less than or equal to NZMAX.

IZ2   The ending point in the Z direction. IZ2 must be at least 1 and less than or equal to NZMAX.

INCZ   The number of cells by which increments are made in the positive Z direction. INCZ must be greater than zero and less than or equal to NZMAX.

ISTP   = 0, read another set of data,

= 0, do not read any more mixed-cell orientation data.

An important feature of this type of data description is that, if any portion of an array is defined in a conflicting manner, the last card to define that portion will be the one that determines the array's cell type configuration. To utilize this feature, one can fill an entire array with the most prevalent cell type and then superimpose the other cell type in their proper places to accurately describe the array. the last set of mixed-cell orientation data must have a non zero entry in the last field.

3.   IOP = 2 - Standard FIDO Array Input

The array being entered is integer; therefore, it is a "S" or "SS" array. The array may be entered in the standard free-form FIDO format. The description for each lattice array is entered as a single array block with FIDO. The FIDO integer array number entered is the array number being described plus 100. The data is entered and each array description is terminated with a "T." All standard FIDO repeat options are available for entering the data. Array 1 would be entered as the "101$$" FIDAS array terminated with a "T." The process would continue until all array descriptions have been entered. The format for the data entry is the same as the description for free-form input. All x entries for the first y row and first z level are entered, then all x entries for the second y row and first z level are entered. This process continues until the entire first z level has been described. Then the geometry array description or given array is terminated with a "T."

A.10   UNIVERSE TYPE

One entry is required for each universe modeled in the combinatorial geometry, starting with Universe 1. The entries should be either a zero or a 1: a zero if the universe is "combinatorial" and a 1 if the universe is "simple." A "simple" universe is a universe composed of concentric zones, where every zone completely surrounds the zone inside of it. Furthermore, input zone in a simple universe may be only one code zone and may be described by only one or two bodies. Tracking through "simple" universes is aboat 30% or more faster than through regular combinatorial geometry tracking, although the modeling capability is limited. Simple universes maybe combined with regular combinatorial universes in arrays without any problems.