The MVD detector in PISA

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1 Turning it "on" in PISA

The MVD is controlled by the 'VER' command card in pisa.kumac which a set of commands to PISA. A typical use of this control card, which turns on the detector and causes the digitized hits to be saved is:

```
VER  'ON'  'FULL' 'P_ID' 'FULL' 'VCAL' 0.0  0.0 !  MVD on, hits stored
```

The 'VER ' command is followed by 5 character parameters whose meanings are defined in table 1. The last 4 of these parameters are stored in the variable CVOLU_OPT(1-4,1) in common GUPHNX in PISA.

Table 1: Parameters in VER command to PISA

parameter#	possible values	meanings
1	'ON' 'OFF'	MVD is "on" MVD is "off"
2	'FULL' 'VOLS'	Geant hit banks for MVD are defined MVD geometry set up, but no Geant hit banks
3	'P_ID'	if the Geant hit banks are "on" (controlled via the 4th parameter), then this must be 'P_ID'. It controls the numbers of elements in the Geant hits banks
4	'NONE' 'FULL'	stops hits information from being stored store hits – the normal condition
5	'VCAL' 'VMUL'	store standard output hits does the same thing as 'VCAL'

2 Geometry

2.1 Geometry Summary

The MVD geometry is defined in subroutine ver (cvs/pisa/src/ver/ver.f). The "barrel" part of the MVD is constructed from ladders, where a "ladder" consists of an inner and outer detector plane (Si) and a rohacell support structure which holds them together. The electronics and the associated cooling plenum (made of rohacell) is at the bottom of the detector. The pad detectors (endcaps) and the mounting plates which hold the foam cages in the barrel (aka foam cage adapter) are included. The enclosure for the detector is also included. The geometry parameters are read from a file (phnx.par). Default values of the parameters are defined in data statements in subroutine ver_pars. In the rest of this document, the names of variables which are read from phnx.par are CAPITALIZED. Other variable names are in lower case.

The overall position of the MVD in the 'HALL' reference frame is defined in the include file cvs/pisa/inc/gu_geom.inc. The variable pos_vert defines the position. The z position of the center of the MVD is passed as an arguement to subroutine ver and is saved in the zebra bank of MVD geometry parameters as z_mvd_cent.

A cross sectional view (looking down the beam line) of the MVD barrel geometry is shown in fig. 1. The inner and outer detector planes are represented by the two concentric hexagons. The electronics are collected on the bottom of the detector. The inner detector layer is VISLR cm from the beam line and the outer detector layer is VOSLR cm from the beam line – measured on a line perpendicular to both the beam line and to the detector planes. The measurement is to the inner surface of the detector plane. Fig. 2 shows a cross section through the MVD in the horizontal plane. The location of the pad detectors and the electronics motherboards associated with them is shown.

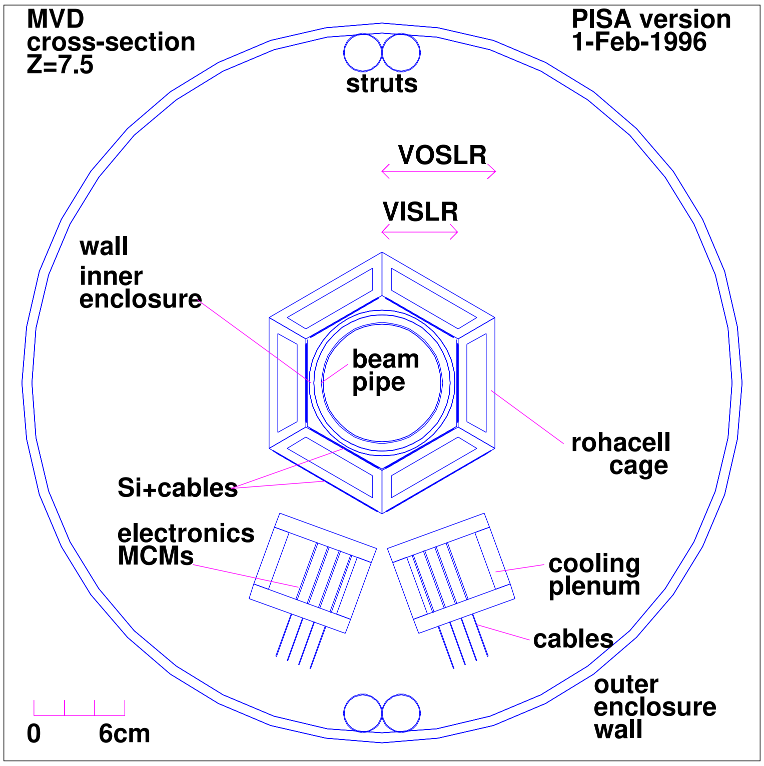

Figure 1: cross section through the MVD, perpendicular to beam axis.

The active parts of the endcap pad detectors are 12-sided polygons with holes through the middle for the beam pipe. The inner and outer "radii" of these polygons are R1_VER_PAD and R2_VER_PAD cm, respectively. The pads are mounted to "motherboards" which represent the electronics for the pad planes. These motherboards are ±Z_VER_PAD cm from the center of the MVD.

Tables 2 - 4 summarize the geometry parameters describing the MVD and where they are stored in the output Zebra bank. The position in the zebra bank is given using parameters which define offsets from the base address (IQ(LFV_PARA)) for the MVD geometry parameters. The size parameters usually follow the Geant convention in which the half-length is used rather than the full length. The parameters listed in table 2 are generally related to the sizes and positions of the active detector elements of the MVD, the parameters in table 3 are related to the geometry of the support structure, and the parameters in table 4 are generally related to the electronics, cables, and cooling plena. Table 5 gives the Geant tracking medium numbers used in the PISA definition

Table 2: Geometry parameters related to active detector elements in the MVD. See text for details.

Name	offset param name from IQ(LFV_PARA) in Zebra bank	typical value	Description
DVISL(1)	OFVA_DVISL	0.015cm	dx,dy,dz of volume VISL, the whole inner
(2)	OFVA_DVISL+1	2.5cm	Si layer in a ladder,
(3)	OFVA_DVISL+2	31.8cm	in its local coordinates
DVOSL(1)	OFVA_DVOSL	0.015cm	dx,dy,dz of volume VOSL, the whole outer
(2)	OFVA_DVOSL+1	4.0cm	Si layer in a adder,
(3)	OFVA_DVOSL+2	31.8cm	in its local coordinates
DVWR1(1)	OFVA_DVWR1	0.015cm	dx,dy,dz of volume VWR1 (inner detector
(2)	OFVA_DVWR1+1	2.5cm	wafer), elements (1) and (2) also define x,y
(3)	OFVA_DVWR1+2	2.65cm	dimensions of the active area of each wafer
DVWR2(1)	OFVA_DVWR2	0.015cm	dx,dy,dz of volume VWR2
(2)	OFVA_DVWR2+1	3.725cm	(one outer detector wafer)
(3)	OFVA_DVWR2+2	2.65cm	elements (1) and (2) also define the x,y dimensions of the active area of each wafer
NWHOLE	OFVA_NWHOLE	8	For segments 3-6 of the outer barrel, the number of missing detector wafers (and electronics MCM's) in the "hole"
NWPERP	OFVA_NWPERP	12	N detector wafers per ladder
PITCH	OFVA_PITCH	0.02cm	Read-out interval
NSTRIP	OFVA_NSTRIP	256	Number of strips per wafer, active area of the wafer is NSTRIP*PITCH
VISLR	OFVA_VISLR	4.985cm	perpendicular distance from beam line to inner surface of inner barrel.
VOSLR	OFVA_VOSLR	7.485cm	perpendicular distance from beam line to inner surface of outer barrel.
SV1PH	OFVA_SV1PH	-120.deg	azimuthal angle to the center of the first ladder, remaining ladders are spaced by ver_delphi=60deg from this one.
NPH_SEGS	OFVA_NPHSEG	6	number of ladders – if this is 2, the detectors are not in the angular coverage of the two arms, if it is 6, it is a full barrel
R1_VER_PAD	OFVA_R1_PAD	5.0cm	inner radius of pad detector, also inner radius of motherboard
R2_VER_PAD	OFVA_R2_PAD	12.0cm	outer radius of pad detector
z_ver_pad	OFVA_Z_PAD	34.975cm	z position of pad detector, calculated as Z_VER_PMB-(DZ_VER_PMB+DVISL(1))
z_mvd_cent	OFVA_Z_MVD	-8.0cm	offset of MVD center from z=0, defined in gu_geom.inc

of the MVD.

In addition to the parameters in tables 2 - 5, which are saved in a Zebra bank, the parameter COLOR_VER, with a typical value of 4, is read from the phnx.par file, but is not saved in the Zebra bank. COLOR_VER specifies the color number used when drawing the MVD in PISA.

2.2 Details of ladder geometry

The barrel portion of the MVD has NPH_SEGS ladders each covering approximately 60 degrees in azimuthal angle. The first of the ladders is at azimuthal angle SV1PH. Additional ladders (i=2,NPH_SEGS) appear at angles SV1PH + (i-1)*(60 degrees). The first two ladders have complete inner and outer layers of detectors. By default, these appear at the bottom of the detector in order to remain outside the electron arm acceptance. The next 4 arms of the MVD barrel have a "hole" in the center part of the outer layer – the silicon is left out of the central part of the outer layer. The size of the hole is controlled by NWHOLE, which should be from 0-12 and is 8 by default — corresponding to a ±21.2cm hole in the outer layer.

The detector wafers in each detector plane are placed inside a Geant 'BOX ' (see GEOM-050 in Geant manual) with a volume name VISL for the inner detector layer, VOSL for the outer detector layers (on the bottom of the MVD) with complete outer detector layers, and VOS2 in the outer detector layers with a "hole". These boxes contain "insensitive Si", or medium number MED_VER_INS. Only the sensitive part of the detector, which is placed inside this larger volume, is made of "sensitive" Si. The sizes of these boxes (one size for the inner layer and another, larger, size for the outer layer) are given by DVISL(3) for the inner detector layer and DVOSL(3) for the

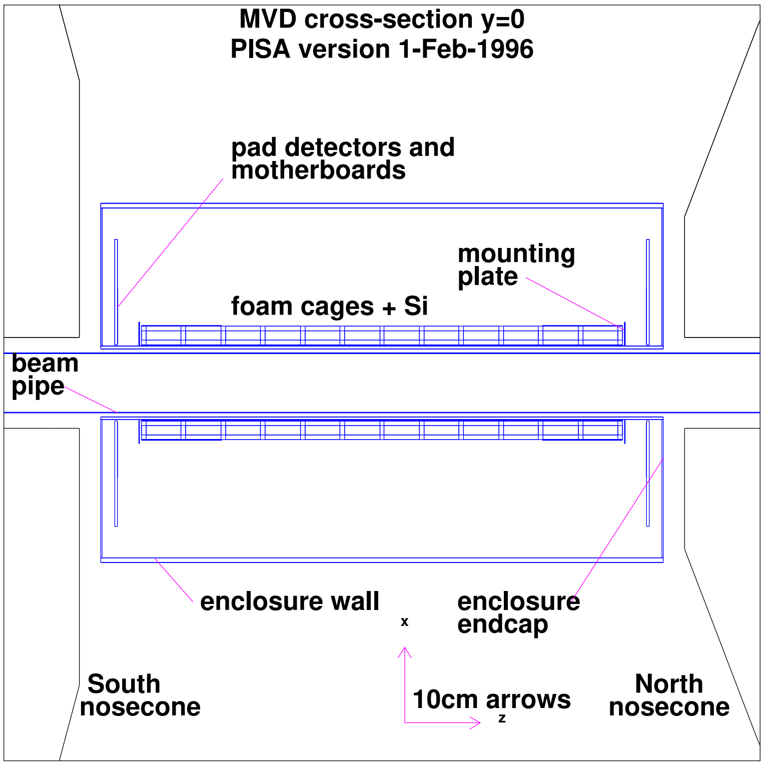

Figure 2: cross section through the MVD, in the horizontal plane.

outer detector layer. The sizes are given in terms of the half-lengths in x, y, z in cm. The local coordinate system used to define these sizes is shown in fig. 3.

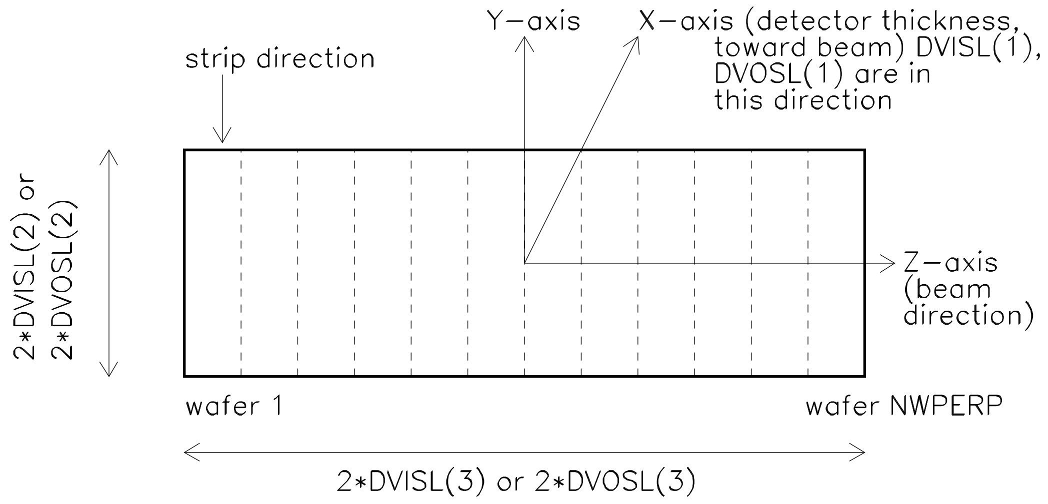

Figure 3: Diagram of layout of Si detector wafers in a ladder – not to scale

There is a further substructure inside each of these boxes. First, a series of NWPERP boxes, representing the individual detector wafers, are placed inside the volumes VISL and VOSL (the complete detector layers). Only NWPERP-NWHOLE wafers are placed inside the volume VOS2 – representing the outer detector layers with holes in them. The wafers (volume names VWR1 inside VISL, VWR2 inside VOSL, and VVW3 inside VOS2) are assumed to be made of "insensitive Si" (tracking medium MED_VER_INS) also. The x,y,z dimensions of these wafers are defined by DVWR1(3) for the inner layer and DVWR2(3) for the outer layer, where the coordinate system is oriented as in fig. 3. Inside each of these detector wafers, volumes (VSL1 in the inner layer and either VSL2 or VSL3 in the outer layers) representing the sensitive part of the wafer are defined. The sensitive part of each wafer (tracking medium MED_VER_SEN) has the same x,y dimensions as the whole wafer, but a z dimension defined by the pitch (PITCH) and number of strips per wafer (NSTRIP) – centered in the wafer. After each of these wafer types is defined, a series of NWPERP of them are placed in each detector ladder at z positions
DVWR1(3)+(i-1)*(2.0*DVWR1(3)) - DVISL(3) for wafer numbers i=1,NWPERP
in the inner layer and similarly (with DVWR2(3) and DVOSL(3)) in the outer layer. The geometry in the ladders with the hole in the outer layer is similar to the geometry for complete ladders except NWHOLE wafers are omitted in the center.

The geometry of the rohacell support cage is defined using Geant trapezoids ('TRD1') – see GEOM-050 in the Geant manual. This support cage will go between the inner and outer detector layers in each ladder. The volume it occupies will be mostly empty, with thin ribs. The thickness of the ribs is given by WDVROH. Each support ladder (there are NPH_SEGS of them) is initially defined as a trapezoidal volume, whose size is defined by the variable dvroh, filled with rohacell. After defining this volume, the holes in it (which contain most of the volume) are defined. There are 3 types of holes – the holes "perpendicular to the beam axis" which fill most of the volume, the "up holes", which are against the outer detector layers, and the "down" holes, which are near the inner detector layer. The number of holes in the rohacell support cage is defined by NHVROH, which should generally be set to the same value as NWPERP (the number of wafers). The rest of the dimensions of the rohacell support are calculated within subroutines ver_pars and ver_fram from the detector dimensions. This includes dvroh, which is included in the Zebra geometry bank for the MVD. A sketch of the support structure for one ladder is shown in fig. 4. Notice that the local coordinate system, which is used to specify the size of the support ladder, is different than for the detector planes.

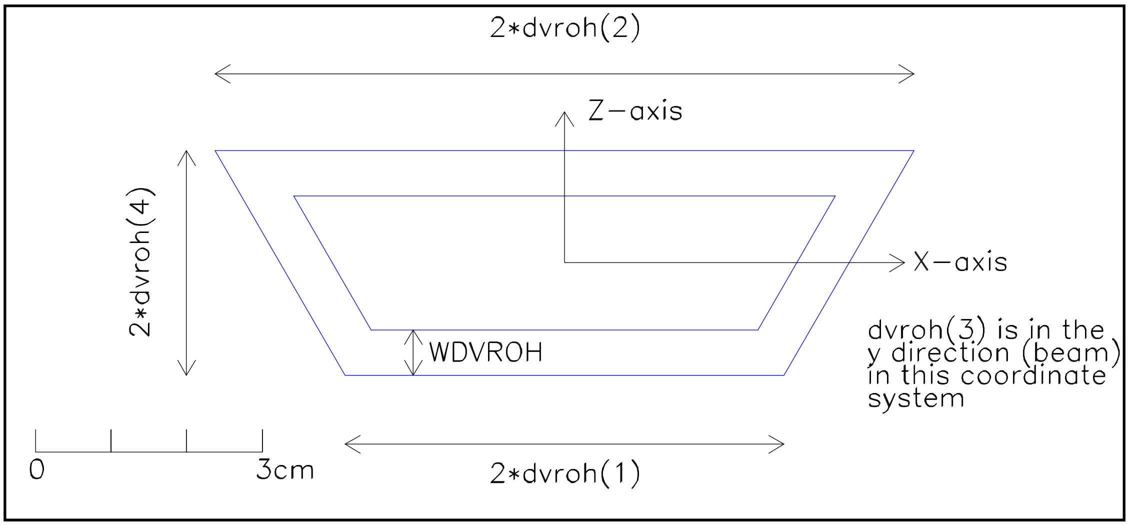

Figure 4: Cross section of the support structure for one ladder

Volumes names VCA1, VCA2, VCA3, and VCA4 are used to represent the kapton cables (with copper traces) which go from the Si detector wafers in the barrel to the MCM's. The portions of the cables which are on the surface of the Si detector wafers are included in the model. The small segments of cable from the bottom of the barrel to the MCM's inside the cooling plenum are not in the model.

2.3 Details of electronics geometry

There is one row of electronics MCM (multi-chip modules) for each plane of barrel detectors, or a total of NPH_SEGS*2 planes. The MCM's for the inner detector layer are all the same. For the outer detector planes, the first two planes are the similar to those for the inner detectors, the MCM's associated with the outer layers for segments 3-6 have nothing in the middle ± 21.2 cm (this is the default value when NWHOLE=8) – i.e. in the region in which there are no detector wafers. All of the MCM's is collected in two groups near the bottom of the detector. The MCM's are enclosed by a rectangular rohacell plenum, the plenum walls have volume names VXWL and VYWL. "Bus cables" (volume names VBU1 and VBU2) representing the cables and associated connectors which go from the MCM's to the outside world are at the bottom of the plenum.

The MCM's are represented by many individual "boxes" containing G10 (actually Geant tracking medium MED_VER_MCM, which by default = 107 = G10) which represent the MCM's for each individual detector wafer. The Geant volume name for each of these MCM's is VMCM. The inner details of their construction is ignored. The local coordinate system used to define the size of these MCM's is like that used for the detector wafers, but since the MCM's are oriented approximately

Table 3: Geometry parameters related to support structure for the MVD. See text for details.

Name	offset param name from IQ(LFV_PARA) in Zebra bank	typical value	Description
dvroh(1)	OFVA_DVROH	2.90cm	= TAND(30.)*(VISLR+2.*DVISL(1)
dvroh(2)	OFVA_DVROH+1	4.62cm	= TAND(30.)*VOSLR
dvroh(3)	OFVA_DVROH+2	31.8cm	= DVOSL(3)
dvroh(4)	OFVA_DVROH+3	1.485cm	= (VOSLR-VISLR)/2. - DVISL(1) defines trapezoid with DX1, DX2, DY, DZ containing rohacell support cage
WDVROH	OFVA_WDVROH	0.6cm	width of rohacell cage struts
NHVROH	OFVA_NHVROH	12	Number of holes on the side of the support cage – should normally be set = NWPERP
R1_VER_ENC	OFVA_R1_ENC	4.83cm	Radius, inside of inner wall of outer enclosure, also inner radius of enclosure's endcap
R2_VER_ENC	OFVA_R2_ENC	23.165cm	Radius, inside of outer wall of outer enclosure, also outer radius of enclosure's endcap
DR_VER_ENC1	OFVA_DR_ENC1	0.001cm	Thickness of aluminum skin for the MVD enclosure barrel – 4 layers total, inside/outside of inner/outer walls
DR_VER_ENC2	OFVA_DR_ENC2	0.64cm	Thickness of rohacell core for MVD enclosure barrel outer layer, inner layer is 1/2 this thickness
DZ_VER_ENC	OFVA_DZ_ENC	37.2cm	Length of enclosure barrel
R_VER_STRUT	OFVA_R_STRUT	1.22cm	Inner radius of struts
DR_VER_STRUT	OFVA_DR_STRUT	0.050cm	Wall thickness of struts
DZ_VER_ENDPL	OFVA_DZ_ENDPL	0.109cm	half-thickness of endplate of MVD enclosure
DZ_VER_MOPL	OFVA_DZ_MOPL	0.048cm	half-thickness (dz/2) of barrel mounting plate (aka foam cage adapter) – the actual geometry is like a wheel with spokes, this is an average thickness
R_VER_MOPL	OFVA_R_MOPL	8.0cm	outer radius of mounting plate
Z_VER_MOPL	OFVA_Z_MOPL	32.1cm	z of barrel mounting plates

Table 4: Geometry parameters related to electronics, cooling plenum, and cables. See text for details.

Name	offset param name from IQ(LFV_PARA) in Zebra bank	typical value	Description
DVOEL(1)	OFVA_DVOEL	2.00cm	dx,dy,dz of volume VOEL
(2)	OFVA_DVOEL+1	0.055cm	(electronics MCM for one
(3)	OFVA_DVOEL+2	2.40cm	detector wafer)
DZ_VER_PMB	OFVA_DZ_PMB	0.16cm	half-thickness, pad motherboard
Z_VER_PMB	OFVA_Z_PMB	35.15cm	$\pm$z position of the 2 pad motherboards
R_VER_PMB	OFVA_R_PMB	19.0cm	Outer radius of pad motherboard
VER_EL_SPACE	OFVA_EL_SPACE	0.8cm	spacing between MCM's
VER_TH_BUS_CABLE	OFVA_TH_BUS	0.043cm	thickness of bus cable from MCM to outside world
VER_W_BUS_CABLE	OFVA_W_BUS	3.0cm	width of bus cable
VER_PLNM_THWALL	OFVA_PLNM_THWALL	1.0cm	thickness of plenum walls
R_VER_PLENA	OFVA_R_PLENA	11.5cm	distance of closest wall of plenum to beam line
ANG_VER_PLENA	OFVA_ANG_PLENA	20.0deg	tilt angle of plenum
VER_TH_CABL	OFVA_TH_CABL	0.005cm	thickness of cable from Si to MCM

radially w.r.t. the beam (whereas the detectors are perpendicular to the beam), the thin dimension of the MCM called y in these coordinates. The size of this "box" is defined by the array DVOEL.

2.4 Summary of enclosure and barrel support geometry

The enclosure consists of two concentric thin-walled cylindrical shells, which are made of tracking medium number MED_VER_ENC2 (rohacell by default) covered inside and outside with thin layers of tracking medium number MED_VER_ENC1 (aluminum by default). The thickness of the 2 "rohacell" layers is given by DR_VER_ENC2 and the thickness of the 4 "aluminum" layers is DR_VER_ENC1. The outer radius of the inner shell is R1_VER_ENC (cm) and the inner radius of the outer shell is R2_VER_ENC (cm). The enclosure is completed by two endcaps, which are disk-shaped with a hole in the middle for the beam pipe. The inner radius of each endcap is R1_VER_ENC (cm), the outer radius is R2_VER_ENC (cm), and the thickness is DZ_VER_ENDPL. The endcaps are made of tracking medium number MED_VER_ENDPL (aluminum by default). Finally, the enclosure has 4 tube-shaped supporting struts. The these struts are made of tracking medium number MED_VER_STRUT (aluminum by default). The struts have inner radius R_VER_STRUT, wall thickness DR_VER_STRUT, and are dz_ver_strut (which is =DVISL(3) = the length of the detector ladders in the current version). As shown in fig. 1, two of the struts are at the top of the enclosure and two are at the bottom.

2.5 Details of the pad geometry

There are two approximately disk-shaped pad "detectors", one at each end of the the MVD barrel. The active elements of the detectors are defined as 12-sides polygons instead of disks, using the Geant shape called 'PGON' (see section GEOM-050 of Geant manual). Each disk has a hole in the middle for the beam pipe (that is, it is shaped something like a compact disk). The active part of the detector is made of material MED_VER_SEN (which is Si by default). The thickness of the pad detectors is assumed the same as the Si in the barrel (DVIEL(1)). The inner radius is R1_VER_PAD and the outer radius is R2_VER_PAD. It's position is ±z_ver_pad (which is calculated from the position of the "motherboard", which is an input parameter). Each pad detector also has a "motherboard" made of medium number MED_VER_PMB (G10 by default), which is also "compact disk shaped" with a thickness of DZ_VER_PMD, inner radius R1_VER_PAD, and outer radius R_VER_PMB. The motherboard has rounded edges – not 12-sided.

Table 5: Summary of materials (tracking medium numbers) in the PISA version of the MVD.

Name	offset param name from IQ(LFV_PARA) in Zebra bank	typical value	Description
MED_VER_SEN	OFVA_MED_SEN	105	Silicon (sensitive) – used for Si volumes which have "hits" structures.
MED_VER_INS	OFVA_MED_INS	101	Silicon (insensitive) – used for Si volumes without "hits"
MED_VER_ROH	OFVA_MED_ROH	102	Rohacell – used in support frame
MED_VER_PMB	OFVA_MED_PMB	107	G10 - pad motherboards
MED_VER_ENC1	OFVA_MED_ENC1	106	Aluminum – skin on enclosure walls
MED_VER_ENC2	OFVA_MED_ENC2	102	Rohacell – in enclosure walls
MED_VER_STRUT	OFVA_MED_STRUT	106	aluminum in enclosure struts
MED_VER_ENDPL	OFVA_MED_ENDPL	106	Aluminum for enclosure endplate
MED_VER_HE	OFVA_MED_HE	1	helium – in "empty" spaces
MED_VER_MOPL	OFVA_MED_MOPL	106	medium for barrel mounting plate
MED_VER_MCM	OFVA_MED_MCM	107	medium for MCM's (default=G10)
MED_VER_BUS_CABLE	OFVA_MED_BUS	108	cable from MCM to outside
MED_VER_CABL	OFVA_MED_CABL	108	cable from Si to MCM

2.6 Volumes Hierarchy in the MVD

The tube-shaped mother volume for the MVD is called 'VERT' and is defined in subroutine hall (cvs/pisa/src/phnxcore/hall.F). Subroutine ver places the rest of the volumes inside this larger volume. VSL1, VSL2, and VISL3, are the "sensitive" volumes in the barrel and VPAD is the "sensitive" volume in the pad detector. Volumes VISL, VOSL, VOS2 (related to the Silicon ladders) and all of their sub-volumes are box-shaped ('BOX '). Volume VROH and all of its sub-volumes (related to the rhoacell ladders) are trapezoidal shaped ('TRD1'), volume VPAD is a 12-sided polygon, and the remaining volumes are tube-shaped ('TUBE'). Fig. 5 shows the "tree" structure of the volumes. The size parameters, the material numbers, and a description of how the sizes are calculated from the input paramerters is given for each of the volumes in appendix A.

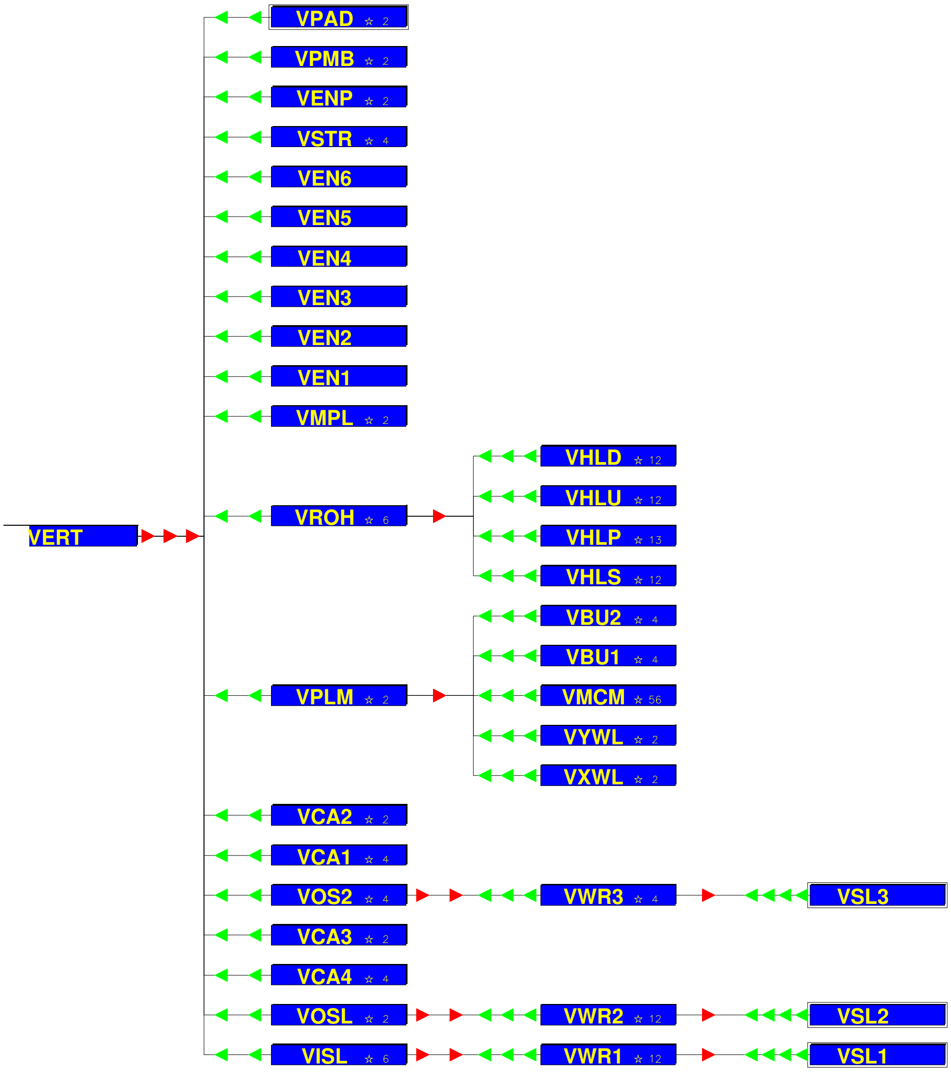

Figure 5: Geant volumes in the MVD

3 Digitization

The Geant hit banks are booked in subroutine ver when the geometry is being defined. The hit banks are only defined if CVOLU_OPT(1,1)='FULL'. This is the 2nd control variable on the input data card VER in gffgo.dat – the Geant input file. The volumes named 'VSL1', 'VSL2', 'VSL3' and 'VPAD' are considered sensitive, so they are the only volumes with hits banks associated with them. The data stored in Geant's hit banks are stored as positive integers with values IVAR = (VAR+VORIG)*VFACT, where VORIG and VFACT are given in table 6.

Table 6: The elements of each hit

name NAMESH	n bits per hit element NBITSH	offset VORIG	scale factor VFACT	notes
POSX	24	80.0	100000.0	0.1μm resolution
POSY	24	80.0	100000.0	0.1μm resolution
POSZ	24	80.0	100000.0	0.1μm resolution
DELE	20	0.0	1.0E+7	0.1 keV resolution
TOFL	16	0.0	100.0	10 psec timing
P_ID	8	0.0	1.	IDs are integers

Subroutine VER_DIGI (cvs/pisa/src/ver/ver_digi.f) uses these hit banks. This subroutine counts the hits on each wafer and stores them in Zebra banks which go to the output data file (default name phnx.dat). The Geant hit banks come in pairs – an entrance and exit hit. The information from each pait of Geant hits in combined into one entry in the output Zebra banks. In principle, the type of output is controlled by CVOLU_OPT(4,1), which is the 5th item in the list of commands of the VER control card in gffgo.dat. This option can be either 'VCAL' or VMAP'. Currently, there are different banks for the two cases (called 'VCAL' or 'VMAP'), but the same information is stored in both cases. In each sub-event, a maximum of MFV_ALLDETS (a parameter whose current value is 5000) hits are allowed. Either MFV_CAL or MFV_MAP (parameters whose current values are both 9) elements are stored for each strip hit. These parameters are:

1 Integer: overall wafer address. For detectors in the barrel this is 10000*n_type + n_ladder + n_wafer, where n_type is 1 for the inner detector layer and 2 for the outer detector layer, n_ladder is the ladders number (aka azimuthal section number) which runs from 1 - NPH_SEGS, and N_WAFER is the wafer number within the ladder – from 1 - NWPERP. For the pad endcaps, the address is 30000 for the endcap at +z and 40000 for the endcap at -z.

2 Real: the energy loss in GeV.

3 Integer: track number

4-6 x,y,z at entrance to detector in local coordinates

7-9 x,y,z at exit from detector in local coordinates

A large part of the digitization step takes place in subroutine VER_HITS, which is called by VER_DIGI. Subroutine VER_HITS calls GFHITS (a Geant routine) to retrieve the Geant hit banks. If there are too many hits in one sub-event, a message is written to logical unit number lver_out (currently=6) and the number of strips hit is truncated to 5000.

The MVD zebra banks are written to the output file by subroutine FV_PUT_DST (cvs/pisa/src/ver/fvputdst), which also writes the geometry parameters to the output file.

4 Summary of Subroutines

The subroutines related to the MVD are individual files in directory cvs/pisa/src/ver. The column "subdirec. name" lists the subdirectory name on cvs/pisa/src in which the file is stored. Table 7 gives a brief summary of the purpose of each of these routines.

Table 7: MVD-related subroutines in PISA

Subroutine name	subdirec. name	called by	subroutines called	purpose
VER	ver	GUGEOM	VER_PARS, GSVOLU, GSATT,GSPOS, GSROTM,GSDET, GSDETH,VER_FRAM, VER_ENCL, VER_PADS, VERMATDEF,VER_PLEN	Define MVD geometry
VER_PARS	ver	VER	MZFORM,MZBOOK	put geometry pars into a Zebra bank
VER_DIGI	ver	GUDIGI	VER_HITS, MZFORM,MZPUSH MZBOOK	"digitize" vertex detector hits, put in Zebra bank
VER_HITS	ver	VER_DIGI	GMTOD GFHITS,GMEDIA	find all strips hit in a sub-event
VER_FRAM	ver	VER	GSVOLU,GSATT, GSPOS,GSROTM	define "frame" geometry:rohacell cage+mounting plates
VER_ENCL	ver	VER	GSVOLU,GSATT, GSPOS	defines enclosure cylinder and endcaps
VER_PADS	ver	VER	GSVOLU,GSATT, GSPOS,GSDET, GSDETH	defines Si pad + its motherboard
VERMATDEF	ver	VER	GSTMED,GSMIXT, GSMATE, GSTPAR	define materials used in MVD code
VER_USER	ver	G_USER2	—	skeleton of an analysis code
VER_PLEN	ver	ver	GSVOLU, GSATT, GSPOS, GSROTM	define plenum, MCM's, and "bus" cables
FV_PUT_DST	phnxcore	E_PUT_DST	U_PUT_DST	Zebra bank output

A Details of geometry parameters

This section shows how the sizes of the Geant volumes related to the MVD are defined from the input parameters in phnx.par. In the list below, variable names which are CAPITALIZED are input from phnx.par – other variables are in lower case. The geometry tree associated with these volumes names is shown in fig. 5. Default values of the parameters input from phnx.par are given in tables 2 and 4. The names of the tracking medium number assumed for each material is given after the volume name.

The following Geant volumes are defined in cvs/pisa/src/ver/ver.f:

VISL (MED_VER_INS) is defined by array DVISL (input from phnx.par)

VOSL (MED_VER_INS) is defined by array DVOSL (input from phnx.par)

VOS2 (MED_VER_HE) is defined by array DVOSL (input from phnx.par)

VWR1 (MED_VER_INS) is defined by array DVWR1 (input from phnx.par)

VWR2 (MED_VER_INS) is defined by array DVWR2 (input from phnx.par)

VSL1 (MED_VER_SEN) is defined as follows:
dvsl1(1) = DVWR1(1), dvsl1(2) = DVWR1(2), dvsl1(3) = NSTRIP*PITCH/2

VSL2 (MED_VER_SEN) is defined as follows:
dvsl2(1) = DVWR2(1), dvsl2(2) = DVWR2(2), dvsl2(3) = NSTRIP*PITCH/2

VSL3 (MED_VER_SEN) is defined by array dvsl2 which is calculated as for volume VSL2.

The following Geant volumes are defined in cvs/pisa/src/ver/ver_plen.f:

VPLM (MED_VER_HE) is defined as follows:
vsiz_plena(1-3) = DVOEL(1) + VER_PLNM_THWALL + VER_W_BUS_CABLE/2., 3.*VER_EL_SPACE + VER_PLNM_THWALL, DVOSL(3)

VMCM (MED_VER_MCM) is defined by array DVOEL (input from phnx.par)

VYWL (MED_VER_ROH) is defined as follows:
vsiz_ywall(1-3) = DVOEL(1), VER_PLNM_THWALL/2., vsiz_plena(3)

VXWL (MED_VER_ROH) is defined as follows:
vsiz_xwall(1-3) = VER_PLNM_THWALL/2., vsiz_plena(2), vsiz_plena(3)

VBU1 (MED_VER_BUS_CABLE) is defined as follows:
vsiz_bus1_cable(1-3) = VER_W_BUS_CABLE/2., VER_TH_BUS_CABLE/2., vsiz_plena(3)

VBU2 (MED_VER_BUS_CABLE) is defined as follows:
vsiz_bus2_cable(1-3) = VER_W_BUS_CABLE/2., VER_TH_BUS_CABLE/2., float(nends)*DVWR2(3), where nends = (NWPERP-NWHOLE)/2.

VCA1 (MED_VER_CABL) is defined as follows:
ver_siz_cab1(1-3)= VER_TH_CABL/2., rcable*tand(ver_delphi/2.), ver_siz_cab4(3), where rcable = VOSLR + VER_TH_CABL + DVWR2(1)*4., and ver_delphi=60.

VCA2 (MED_VER_CABL) is defined as follows:
ver_siz_cab2(1-3) = VER_TH_CABL/2., rcable*tand(ver_delphi/2.), DVOSL(3),
where rcable = VISLR - VER_TH_CABL - 2.0*DVWR1(1)

VCA3 (MED_VER_CABL) is defined as follows:
ver_siz_cab3(1-3) = VER_TH_CABL, rcable*tand(ver_delphi/2.), DVOSL(3),
where rcable = VISLR - 2.0*VER_TH_CABL - 2.0*DVWR1(1)

VCA4 (MED_VER_CABL) is defined as follows:
ver_siz_cab4(1-3) = VER_TH_CABL, rcable*tand(ver_delphi/2.),
0.5*DVOSL(3)*FLOAT(NWPERP-NWHOLE)/FLOAT(NWPERP),
where rcable = VOSLR + 2.0*VER_TH_CABL + DVWR2(1)*4.

The following Geant volumes are defined in cvs/pisa/src/ver/ver_fram.f:

VROH (MED_VER_ROH) is defined as follows:
dvroh(1) = tand(30.)*(VISLR+2.*DVISL(1)), dvroh(2) = tand(30.)*VOSLR,
dvroh(3) = DVOSL(3), dvroh(4) = (VOSLR-VISLR)/2. - DVISL(1)

VHLS (MED_VER_HE) is defined as follows:
shole(1) = dvroh(1) + WDVROH*tand(30.), shole(2) = dvroh(2) - WDVROH*tand(30.),
shole(3) = (dvroh(3) - 0.5*float(NHVROH+1)*WDVROH)/float(NHVROH),
shole(4) = dvroh(4) - WDVROH

VHLP (MED_VER_HE) is defined as follows:
phole(1) = shole(1) - WDVROH/cosd(30.), phole(2) = shole(2) - WDVROH/cosd(30.),
phole(3) = WDVROH/2., phole(4) = dvroh(4) - WDVROH

VHLU (MED_VER_HE) is defined as follows:
uhole(1) = shole(2) - WDVROH/cosd(30.), uhole(2) = dvroh(2) - WDVROH/cosd(30.),
uhole(3) = shole(3), uhole(4) = WDVROH/2

VHLD (MED_VER_HE) is defined as follows:
dhole(1) = dvroh(1) - WDVROH/cosd(30.), dhole(2) = shole(1) - WDVROH/cosd(30.),
dhole(3) = shole(3), dhole(4) = WDVROH/2

VMPL (MED_VER_MOPL) is defined as follows:
par_vtmp(1-3) = VISLR, R_VER_MOPL, DZ_VER_MOPL

The following Geant volumes are defined in cvs/pisa/src/ver/ver_encl.f:

VEN1 (MED_VER_ENC1) is defined as follows:
par_vtmp(1-3) = R1_VER_ENC - (2*DR_VER_ENC1+DR_VER_ENC2),
R1_VER_ENC - (DR_VER_ENC1+DR_VER_ENC2), DZ_VER_ENC

VEN2 (MED_VER_ENC2) is defined as follows:
par_vtmp(1-3) = R1_VER_ENC-(DR_VER_ENC1+DR_VER_ENC2),
R1_VER_ENC - DR_VER_ENC1, DZ_VER_ENC

VEN3 (MED_VER_ENC1) is defined as follows:
par_vtmp(1-3) = R1_VER_ENC - DR_VER_ENC1, R1_VER_ENC, DZ_VER_ENC

VEN4 (MED_VER_ENC1) is defined as follows:
par_vtmp(1-3) = R2_VER_ENC, R2_VER_ENC+DR_VER_ENC1, DZ_VER_ENC

VEN5 (MED_VER_ENC2) is defined as follows:
par_vtmp(1-3) = R2_VER_ENC + DR_VER_ENC1, R2_VER_ENC + DR_VER_ENC1 + DR_VER_ENC2, DZ_VER_ENC

VEN6 (MED_VER_ENC1) is defined as follows:
par_vtmp(1-3) = R2_VER_ENC + DR_VER_ENC1 + DR_VER_ENC2, R2_VER_ENC+DR_VER_ENC1 + 2*DR_VER_ENC2, DZ_VER_ENC

VSTR (MED_VER_STRUT) is defined as follows:
par_vtmp(1-3) = R_VER_STRUT, R_VER_STRUT+DR_VER_STRUT, DZ_VER_STRUT

VENP (MED_VER_ENPL) is defined as follows:
par_vtmp(1-3) = R1_VER_ENC, R2_VER_ENC, DZ_VER_ENDPL

The following Geant volumes are defined in cvs/pisa/src/ver/ver_pads.f:

VPMB (MED_VER_PMB) is defined as follows:
par_vtmp(1-3) = R1_VER_PAD, R_VER_PMB, DZ_VER_PMB

VPAD (MED_VER_SEN) is defined as follows:
par_vtmp uses R1_VER_PAD, R2_VER_PAD, DZ_VER_PAD (10 pars) to define a 12-sided polygon