The AMDB Documentation

Contents

1 The AMDB Detector Description **3**
1.1 Introduction . . . 3
1.2 The layout of the ATLAS Muon Spectrometer . . . 3
1.3 The AMDB structure . . . 3

2 The AMDB Axis Systems **4**
2.1 The Global Axis Systems XYZ . . . 4
2.2 The Rotating frame SZT . . . 5
2.3 The Local Station frame szt (or xyz) . . . 5

3 Positioning of Stations **8**
3.1 General scheme . . . 8
3.2 Symmetries and conventions . . . 9
3.2.1 Mirror symmetry with respect to the Z=0 plane . . . 9
3.2.2 Cylindrical sectorisation . . . 10
3.2.3 Barrel versus EndCap positionings . . . 10

4 Alignment of Stations **11**

5 Definition of Stations **12**
5.1 General scheme . . . 12
5.2 Basic shapes . . . 12
5.3 Position in the station . . . 12
5.4 Dimensions of objects in the station . . . 15
5.5 Technology-specific fields in the D entries . . . 15
5.6 Naming of stations . . . 15
5.7 Complex shapes . . . 16

6 Grand Final Positioning of Chambers **17**

7 Definition of Inner Structures **22**
7.1 MDT . . . 22
7.2 RPC . . . 22
7.3 CSC . . . 22
7.4 TGC . . . 23
7.4.1 Layers of materials . . . 24
7.4.2 Strips layout . . . 24
7.4.3 Wire gangs . . . 25
7.4.4 Wire supports . . . 28
7.4.5 Button supports . . . 28
7.5 SPA, SUP, DED, LB, CRO, CMI, CHV . . . 29
7.5.1 The MDT Spacer : Cross Plates CRO, CMI, CHV and Longbeams LB . . . 29
7.5.2 The RPC Support : SUP . . . 30

8 Cutouts Description **31**

9 Deformation parameters **33**
9.1 Torsion tw 36
9.2 Cross plate sags so,sv 38
9.3 Cross plate elongations eo,ev 39
9.4 Longbeam sags sy,sz 41
9.5 Trapezoidal effect tr 41
9.6 Temperature global expansion T 41

10 Definition of Dead Matter elements **42**
10.1 The AGDD-XML Description 42
10.2 Implementation in AMDB 42

1 The AMDB Detector Description

1.1 Introduction

The ATLAS Muon Detector Description Database (AMDB) is an object-oriented description used in the simulation and reconstruction of events in the ATLAS Muon Spectrometer. The numbers are provided in a flat file organized in entries reproducing the detector description sheme. This organization reproduces the symmetries inherent to the Spectrometer so as to simplify and compactify as greatly as possible its description.

The AMDB file is coupled to the *Amdbsimrec/Amdcsimrec* software packages which build the geometry taking into account the symmetries and conventions described in this document. The detector description sheme is also tightly coupled to the offline identifier scheme used to describe the muon events.

The AMDB Detector Description is organized in two independent branches : the description of active elements (detectors) and the description of passive elements (dead matter such as magnets and support structures).

The description of active elements is object-oriented. The objects are implemented in a geometry tree. At the top level are found the Stations. These objects are built from a collection of objects characterized by a pointer to their technology and to their Inner Structures. Technologies are attributed with basic shapes. Cutouts in objects in the Station are implemented as well as the deformations. Copies of the Stations are positioned and aligned in the AMDB axis systems.

The description of passive elements is based on the AGDD-XML meta-language. It relies on a set of geometrical elements defining basic volumes. The description of complex and composite objects is achieved through volume operations and compositions.

1.2 The layout of the ATLAS Muon Spectrometer

Barrel vs EndCap, Mirror symmetry z+/z-, coaxial layout, cylindrical sectorisation, octagonal layout, Small vs Large sectors, Feet sectors, Magnetic field, three-points measurement, precision vs 2nd coordinate, Trigger coincidence planes, projectivity, Alignment systems, ...

1.3 The AMDB structure

W,D,P,H,M,E,N,V,A,B,C,R,X,* entries

2 The AMDB Axis Systems

The AMDB Detector Description relies on three axis systems schematically represented in Figure 1 and defined as follow.

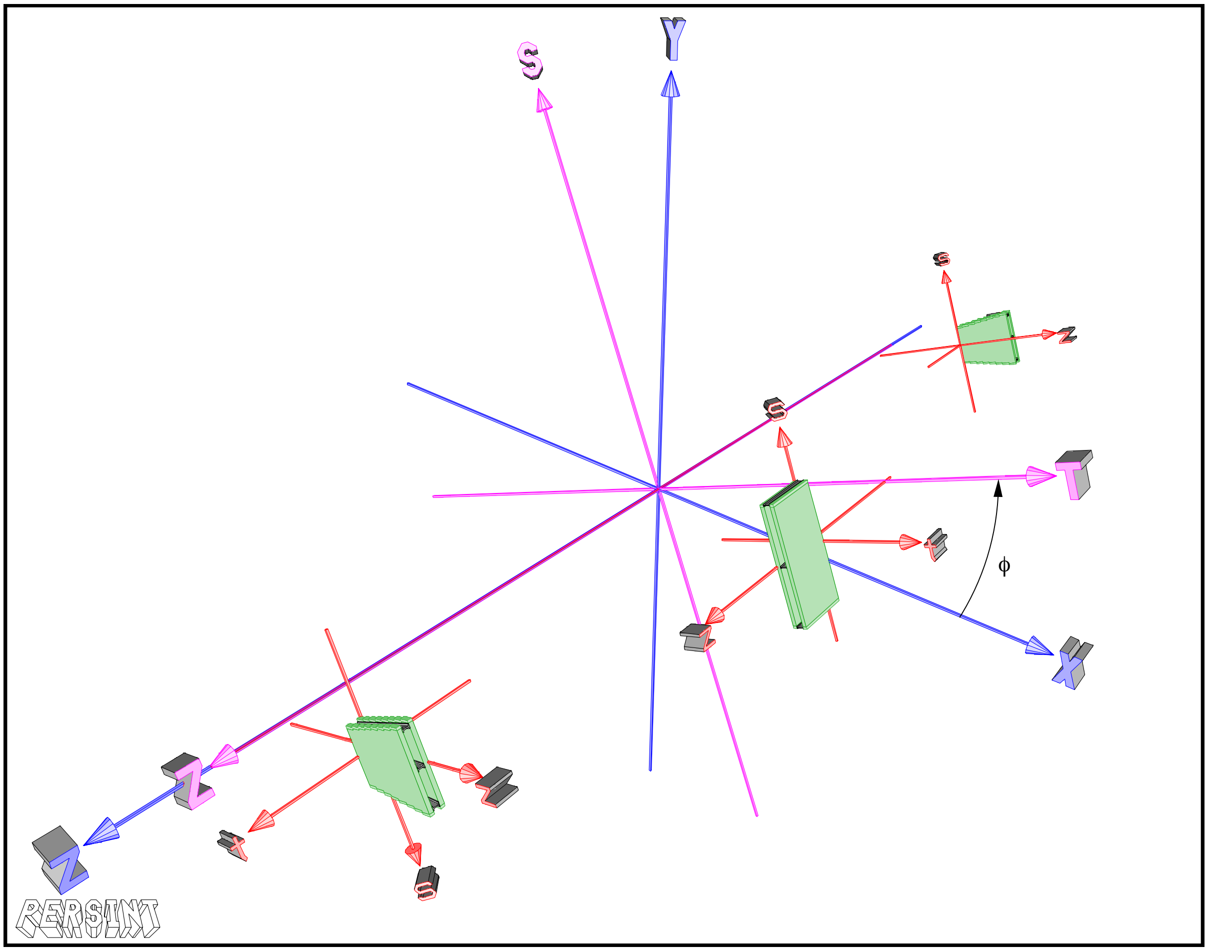


Figure 1: Definition of the three AMDB axis systems

2.1 The Global Axis Systems XYZ

The Global AMDB XYZ system is the official Global ATLAS reference frame defined in [1]. The origin is the interaction point. The X-axis is horizontal, and points from the interaction point towards the centre of the LHC ring. The Y-axis is perpendicular to the X-axis and to the mean local beam direction, and points upwards; it is inclined by 0.704 deg with respect to the local vertical. The Z-axis is aligned with the mean beam direction, so as to create a right handed Cartesian coordinate system.

The side of Z-axis positive, on the left when looking from inside the LHC ring, is conventionaly called side A, while at the opposite, the Z-axis negative, at the right, is called side C [1].

The detector is installed coaxial with the Z axis, so that its description benefits from the use of the cylindrical coordinate ϕ as shown in Figure 1. The angle ϕ is measured around the Z-axis, originating on the X-axis, positive values being in an anticlockwise direction.

2.2 The Rotating frame SZT

The AMDB frame SZT is a rotating frame around the Z axis with (see Figures 1, 2 and 3) :

- the axis Z is always equal to the Global Z axis of ATLAS (i.e. along the beam axis)
- the axis T is always equal to the radial outgoing axis corresponding to the ϕ_0 of the current (Small or Large) sector. For $\phi_0 = 0$, T = X and more generally :

  T = $cos(\phi_0)\times$ X + $sin(\phi_0)\times$ Y
- the axis S is always equal to the third axis forming a right-handed system i.e. the ortho-radial axis always pointing to the positive ϕ. For $\phi_0 = 0$, S = Y and more generally :

  S = - $sin(\phi_0)\times$ X + $cos(\phi_0)\times$ Y
- the origin of this frame is the same as the global one (X=Y=Z=0).

The Rotating frame SZT is thus characterized by the ϕ_0 rotation around the Z axis common with the Global frame.

2.3 The Local Station frame szt (or xyz)

The Local Station frame szt (or xyz with x=s, y=z, z=t) has different definitions in the Barrel, EndCap Side A, and EndCap Side C (see Figures 1, 2 and 3) :

- in the Barrel, the local frame szt reproduces exactly the local rotating frame SZT but for its origin. The origin of this frame is arbitray and, up to now, it has been in general taken at the lower Z and lower of T the station, with S=0. In the specific context of track measurements in the Barrel system, t measures the transverse position while z and s measures the precision and second coordinates.
- in the EndCap A-side (Z>0), the physical meaning of s,z,t is preserved, so that z=T, t=Z, s= - S. The direction given to the s-axis ensures the right-handedness of this system. The origin has been chosen up to now at the lower Z and lower of T the station, with S=0.
- in the EndCap C-side (Z<0), the physical meaning of s,z,t is again preserved, so that z=T, t= - Z, s=S. The direction given to the t-axis ensures the right-handedness of this system. The definition of the origin is different from the EndCap A-side : the origin has been chosen up to now at the lower |Z| and lower of T the station, with S=0.

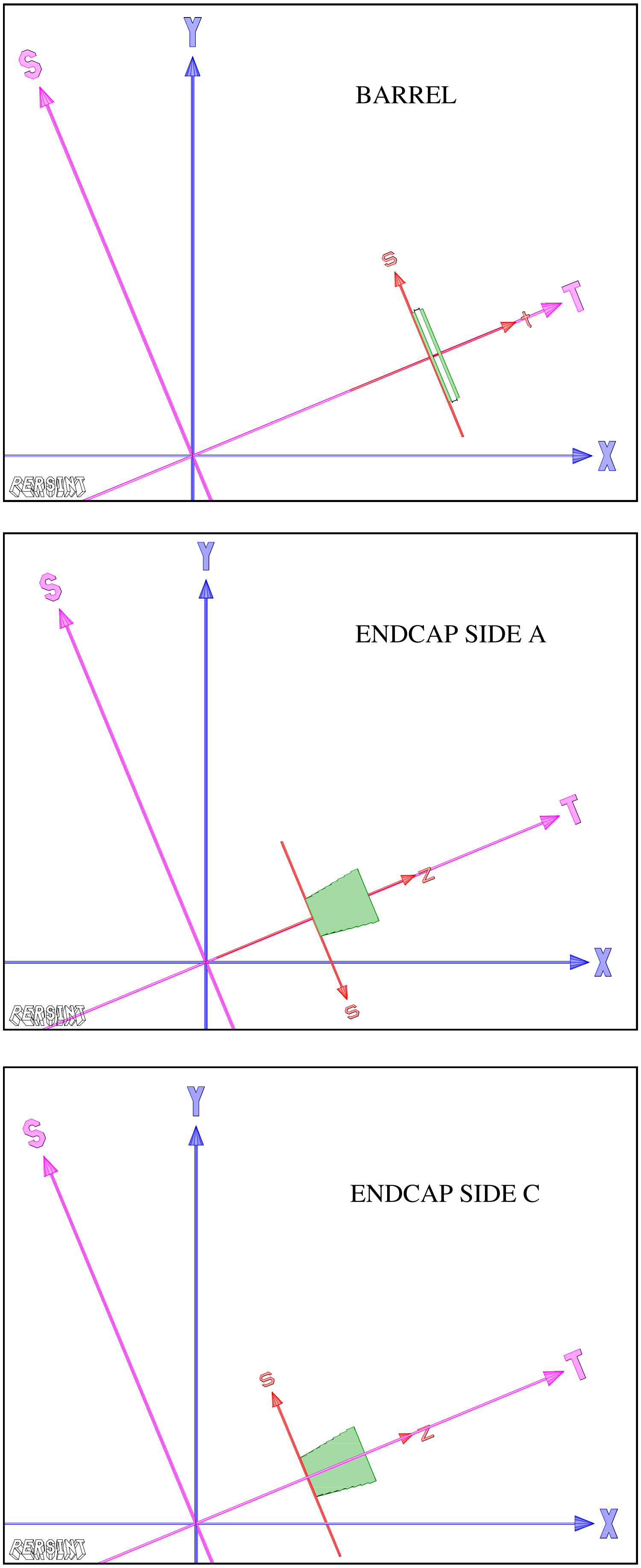


Figure 2: The AMDB axis systems in Barrel, EndCap Side A, and EndCap Side C (Z-projection)

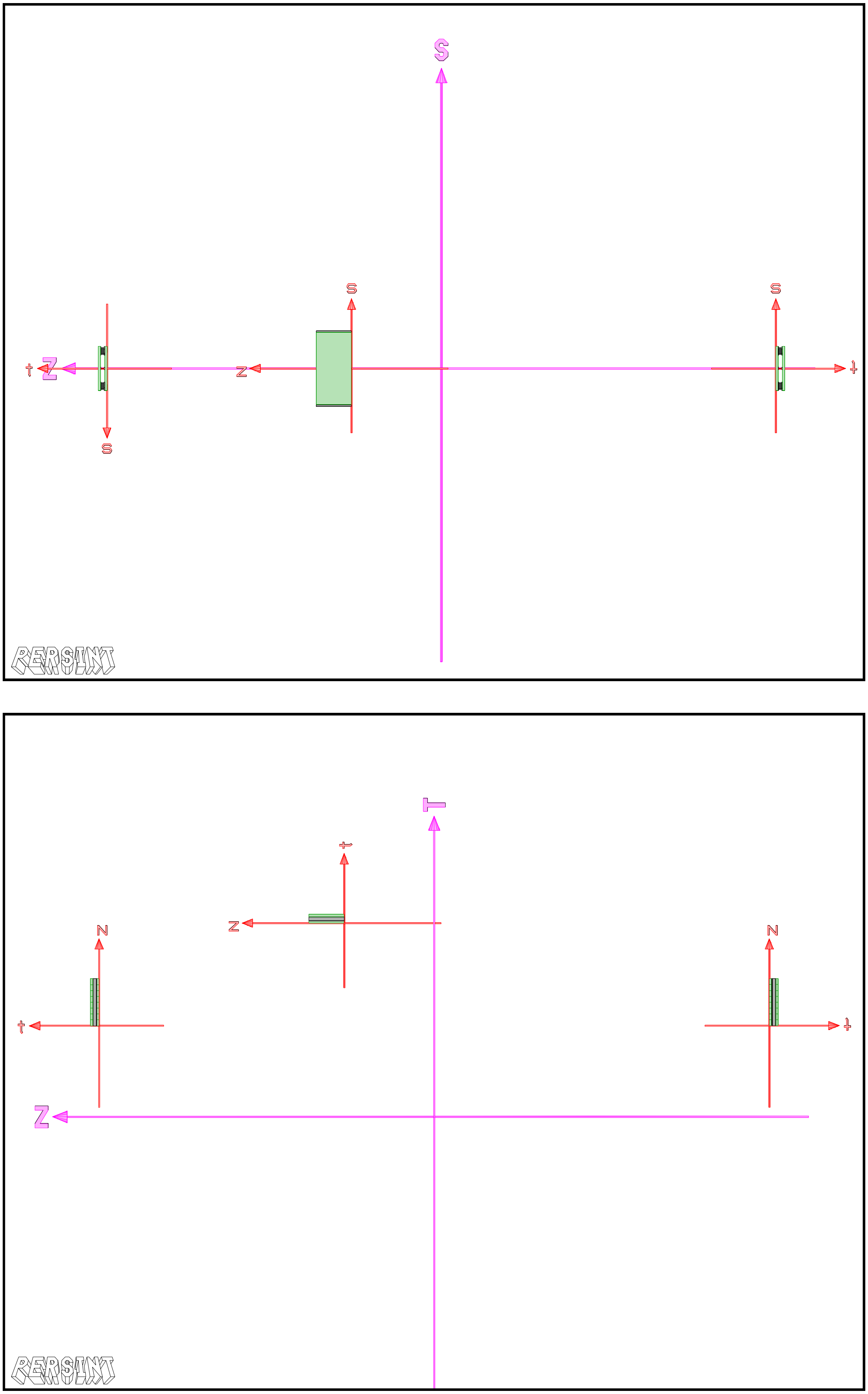


Figure 3: The AMDB axis systems (upper T-projection, lower S-projection)

3 Positioning of Stations

The positioning of Stations refers to the nominal positions. The deviation with respect to the nominal positions, as measured by means of surveys and alignment corrections, are dealt with in the Alignment of Stations (section 4). The actual position of a chamber depends on its positioning within the station (section 5). The full sequence of chamber positioning is summarized in section 6.

3.1 General scheme

The positioning of Stations is defined by the P entries. Copies of a given station, e.g. BIL 2, can be positioned at different locations in the global set up. Each location has a ϕ-index (called Jff or *StationPhi*) and a Z (or η) index (called Jzz or *StationEta*). The syntax of the "P" entries is the following:

```
*-- Positioning of BIL stations ------------------------------------------------
*    Jgeo   Iphi     <-------- Translation (mm) ------->-<--- Rotation (Deg) --->
* Typ |Jcut    |     Jzz   dPhi       Z         T       S      Alpha   Beta    Gamma
*  |   | |     |      |      |        |         |       |       /t      /z      /s
*  |   | | --------   |      |        |         |       |       |       |       |
P BIL 2   11200000  1      0.      330.    4740.96    0.       0.      0.      0.
```

This entry connects the identification of the stations and their physical position and orientation in space. Stations are identified by their type (a name and an index Jgeo as explained in section 5), the map Iphi of the ϕ-octants they occupy and the Z (or η) index Jzz. The Jff and Jzz indexes are built up following the rules and conventions described in section 3.2 below. This identification ensures an unambiguous mapping with the offline geometry identifiers established to comply with the AMDB scheme [2]. Finally, an additional field Jcut is reserved to identify stations with cuts as explained in section 8.

The positioning parameters are illustrated in Figure 4 (in which S=0, as in Figure 1). The parameters Z, T, S given in mm are defined in the Rotating frame SZT with its ϕ angle defined as ϕ = (Jff-1)$\times\pi/4 + d\phi$, $d\phi$ corresponding to dPhi given in deg. The use of the S parameter is necessary to describe a number of stations which have an offset with respect to a perfect coaxial layout.

The parameters S, Z, T given here define in the Rotating frame SZT, the origin of the Local Station frame szt.

Once the station is positioned in the Rotating frame SZT, rotations are applied in the Local Station frame szt according to the following scheme (see Figure 4) :

- α around t
- β around z
- γ around s
- the order of the transformations is α, β, γ

More generally in AMDB, rotations are always applied in the order t, z, s.

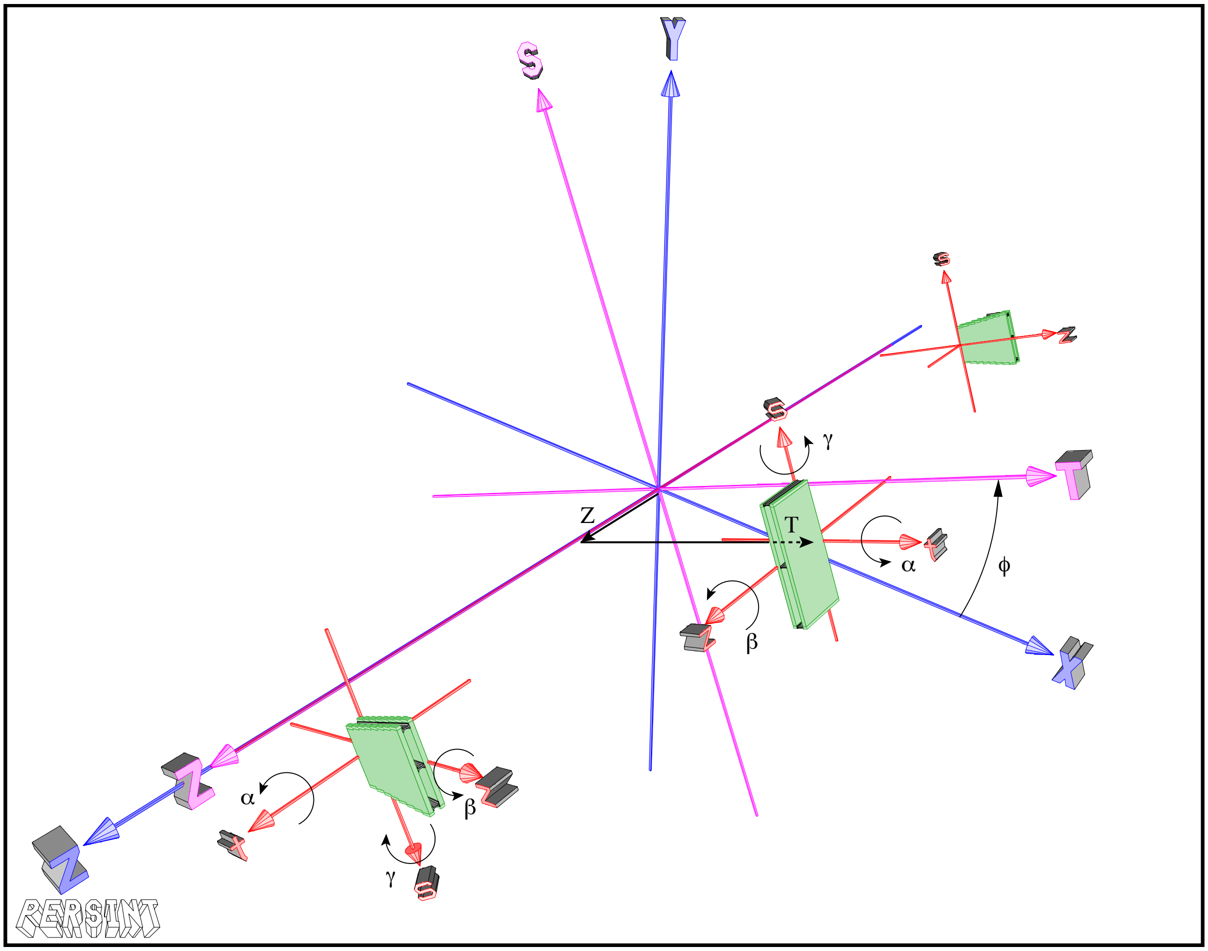


Figure 4: Positions and orientations of stations

3.2 Symmetries and conventions

The AMDB scheme is designed to benefit as much as possible from the symmetries inherent to the Spectrometer. The two main symmetries are the Mirror symmetry with respect to the Z=0 plane and the cylindrical sectorisation of the spectrometer layout resulting in an octagonal organization of the stations, an octant being itself an association of a Large and a Small sector. The use of these symmetries, and the description of the possible cases where these symmetries are broken, need to be based on conventions.

3.2.1 Mirror symmetry with respect to the Z=0 plane

The following conventions are used to perform or not the Mirror symmetry with respect to the Z=0 plane :

- all stations described with Jzz>0 are positioned to their Z-position, which defines the Local Station frame origin. Such a station is associated to the offline identifiers Jzz.
- by default, all these stations are duplicated by mirror symmetry with respect to the Z=0 plane, and corresponds to the offline identifiers -Jzz. For Barrel stations, the Local Station frame origin is positioned as (refer to section 5 for definition of Length_of_Station) Pos_Z(Type,Jff,-Jzz) = - Pos_Z(Type,Jff,Jzz) - Length_of_Station, so that the origin is at

the most negative Z edge of the station. For EndCap stations, the Local Station frame origin is positioned as Pos_Z(Type,Jff,-Jzz) = - Pos_Z(Type,Jff,Jzz).

- if a station is positioned with Jzz=0, then no Mirror symmetry is performed.
- if a station is positioned with Jzz<0, then no mirror-symmetric copy is created, and no mirror symmetry is performed on the station with corresponding Jzz'=-Jzz>0 (if it exists). This does not depend on the sign of Z.
- if the Iphi mapping of the octant positionings gives 2 for the associated Jff octant, then no Mirror symmetry is performed, whatever the sign of Jzz.

It has to be noted that a new geometrical type (i.e. a new Jgeo, see section 5) is created for stations created by the Mirror symmetry.

All the description of the Station is subject to the mirror symmetry, as well as the internal structures of objects forming the Station, including :

- Stacking of objects versus their positions in the Local Station frame szt
- Cutouts
- Tube staggering

For station with Jzz < 0 explicitly positioned (i.e. not obtained by the mirror symmetry), the internal structure (tube staggering) is built as in stations with Jzz > 0 with subsequent mirror symmetrisation. The cutouts and the stacking of objects versus their positions in the Local Station frame szt is done explicitely with no mirror symmetrisation.

3.2.2 Cylindrical sectorisation

Copies of stations are created in the different octants following the rules of the Iphi mapping of generic form $I_1I_2I_3I_4I_5I_6I_7I_8$:

- if $I_n = 0$ no station is created at Jff=n.
- if $I_n = 1$ a copy of the station is created at Jff=n, and another copy can be created by Mirror symmetry following the conventions described above (i.e. when Jzz > 0 and no explicit positioning of -Jzz station exists).
- if $I_n = 2$ a copy of the station is created at Jff=n, and no copy whatsoever is created by Mirror symmetry, as already mentioned above.

3.2.3 Barrel versus EndCap positionings

The definition of the Local Station frame szt being clearly established for the Barrel, EndCap side A, and EndCap side C, it has to be understood how the Stations are attributed with one of these three different conventions. By default, all stations with type name begining by B are considered as Barrel stations. The other are considered as EndCap stations.

This convention can be supplanted if the P entry explicitely forces the station to be positioned following the Barrel or the EndCap convention. This is achieved using the Pb or Pe positionings, with the following convention :

- stations positioned with Pb are placed following the Barrel local frame convention

- stations positioned with Pe are placed following the EndCap local frame convention

An example of EndCap station positioned as a Barrel station is given below.

```
*-- Positioning of stations -------------------------------------------------
*    Jgeo   Iphi     <-------- Translation (mm) -------><--- Rotation (Deg) --->
* Typ |Jcut   |     Jzz   dPhi       Z        T       S     Alpha   Beta    Gamma
*  |  | |      |     |      |        |        |       |      /t      /z      /s
*  |  | | --------  |      |        |        |       |       |       |       |
PbEIL 1   20000000  1     0.00    511.99 39851.99 -858.89   14.    180.    165.
```

The sign of the Jzz offline identifier indicates if the station is to be placed following the EndCap side A (Jzz >0) or EndCap side C (Jzz <0) convention.

4 Alignment of Stations

The Alignment of Stations is meant to describe the deviation with respect to the nominal positions, as measured by means of surveys and optical alignment corrections. Surveys and alignment corrections are merged in a unique set of parameters provided by alignment reconstruction programs. These alignment corrections are given in the A entries, an example of which is given below.

```
*-- Adjustment of  szt  position of Stations -----------------------------
*     Jff   Job  <---- Translation (mm) --->  <----- Rotation (Rad) ----->
* Typ  | Jzz |      s         z         t        /s        /z        /t
*  |   |  |  |      |         |         |         |         |         |
A BIL  3  1  0     0.395     1.612    -1.013  0.000876 -0.000468 -0.000336
```

This entry connects the identification of a station or an object of the station and its alignment. The identification relies on the Station Type, the Jff index, the Jzz index, and the Job object identifier. By convention, if Job=0, the alignment is performed identically on all the objects of the station. If Job is equal to the value of one of the Io indexes of the objects of the station, as described in section 5, then the alignment is performed in this object with Io=Job.

The alignment is given by the three translations and the three rotations given in the Local Station frame szt, defined in section 2.3. The translations are given in mm, while the rotations are given in rad, the order in which they are applied being t, s, z, i.e the same order as the α, β, γ rotations. Rotations are to be applied **before** the translations in such a way that the translations are not affected by the rotations.

5 Definition of Stations

5.1 General scheme

Stations are built by the stacking of objects in the D entries of AMDB. Each object in the stack is positioned in the Local Station frame szt (or xyz) and is characterized by a pointer to a technology and an inner structure (see section 7), and by the dimensions given to this object. An example is given below.

```
*-- Definition of stations ----------------------------------------------------------
* Typ I  No
*   s     z      t    Io Tec i    sh  W_xS    W_xL     L_y      Ex     D1      D2      D3
*
D BIL 1   7
   0.     0.     0.    1 MDT 1       2671.5  2671.5 1081.261   0.    55.      0.      0.
-1280.    0.   123.03 2 CHV 1          6.0     6.0 1081.261   0.     0.      0.      0.
   0.     0.   123.03 3 CMI 1          6.0     6.0 1081.261   0.     0.      0.      0.
1280.     0.   123.03 4 CRO 1          6.0     6.0 1081.261   0.     0.      0.      0.
   0.   240.   208.03 5 LB  1       2620.0  2620.0    50.     0.     0.      0.      0.
   0.   840.   208.03 6 LB  1       2620.0  2620.0    50.     0.     0.      0.      0.
   0.     0.   293.03 7 MDT 2       2671.5  2671.5 1081.261   0.    55.      0.      0.
```

The D entry contains a header giving the station identification and the number of objects in the station. The station identification is made of the station type (a name of three characters) and the Jgeo=I index. The Jgeo index serves first in the instantiation of stations of same type but with different composition of objects. The header is followed by the stack of objects.

Each object has an entry giving its position in the station (3 parameters s,z,t also called previously dx,dy,dz), its sequential number Io, a pointer to a general technology (three characters MDT, RPC, ...) plus a pointer to a specific implementation of this technology Jsta=i, its global dimensions in the sz (xy) plane (4 parameters W_xS, W_xL, L_y, Ex), and additional technology-specific fields (sh and D1,D2,D3).

5.2 Basic shapes

Objects in the stack with technology MDT, RPC, TGC, DED, SPA have the shape of the extrusion along the t (z) axis of an asymmetric trapezoid defined in the sz (xy) plane. An example of the most general volume is shown in Figure 5.

An object with technology CSC is an extrusion along the t (z) axis of a symmetric "coffin shape" defined in the sz (xy) plane, see Figure 6.

More complex, ad-hoc shapes are available to describe specific elements, as explained in section 5.7.

5.3 Position in the station

The position of the object in the station is given in the Local Station frame szt (or xyz).

By convention the position along the s (x) axis corresponds to the center of the object. The positions along the z (y) axis corresponds to the edge with lower z (y) of the object. The positions along the t (z) axis corresponds to the edge with lower t (z) of the object.

This is illustrated in Figure 7 for the BIL 1 station described above. It shows how the CRO 1 object (Io=4) is positioned along the s (x) axis, as well as the MDT 2 object (Io=7) is positioned along the t (z) axis.

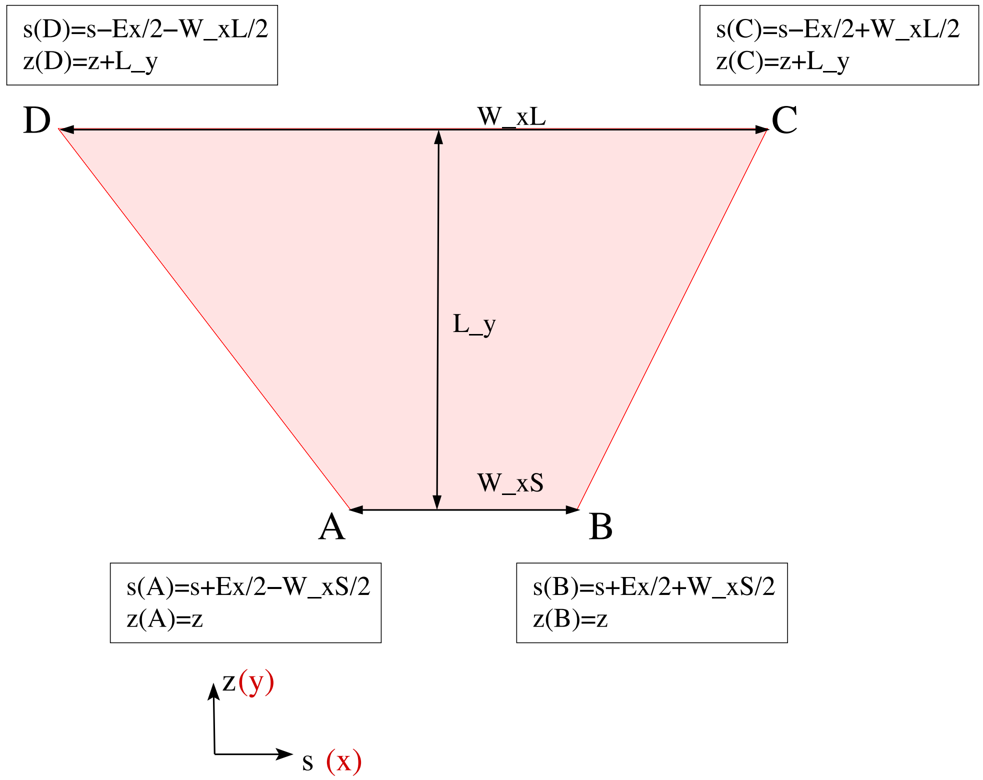


Figure 5: Basic shape of object with technology MDT, RPC, TGC, SUP, SPA ("asymmetric trapezoid") in the sz plane of the Local Station frame szt (or xyz). The positions are given in the sz plane for the 4 corners of the chambers, taking into account the local positioning in the station. The asymmetry is parameterized by Ex.

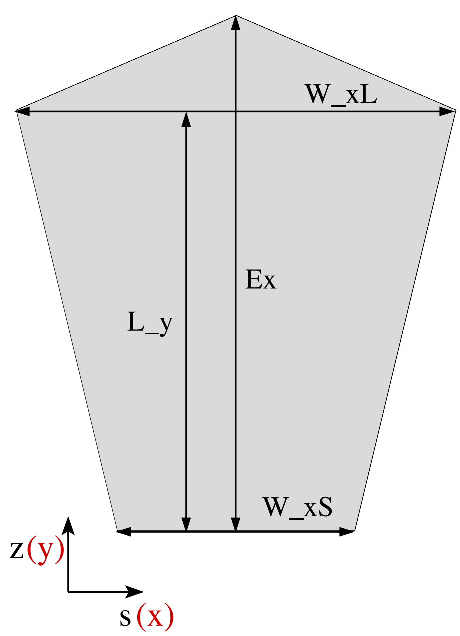


Figure 6: Basic shape of object with technology CSC ("coffin shape"). The full extension along z is given by Ex.

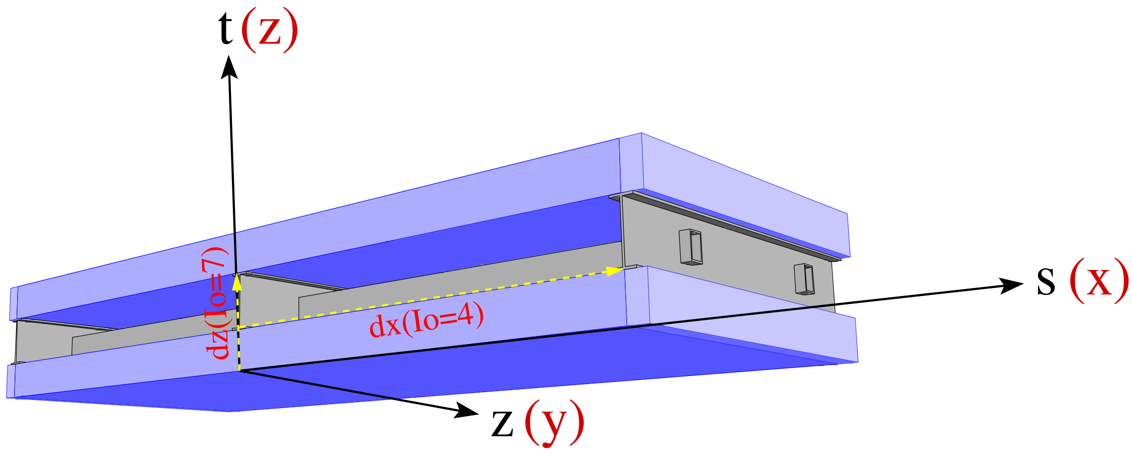


Figure 7: Definition of the positions of objects in a station.

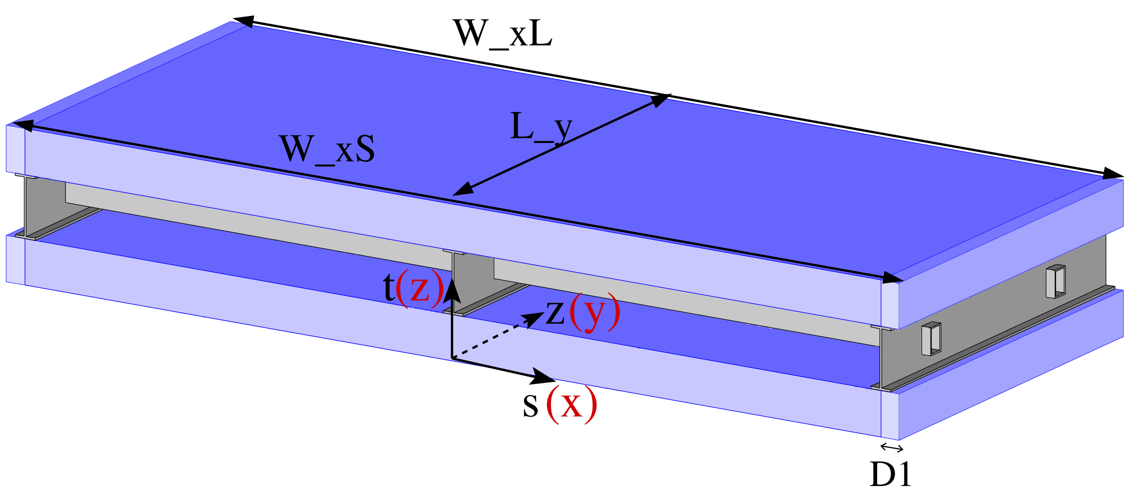


Figure 8: Definition of station parameters (dimensions).

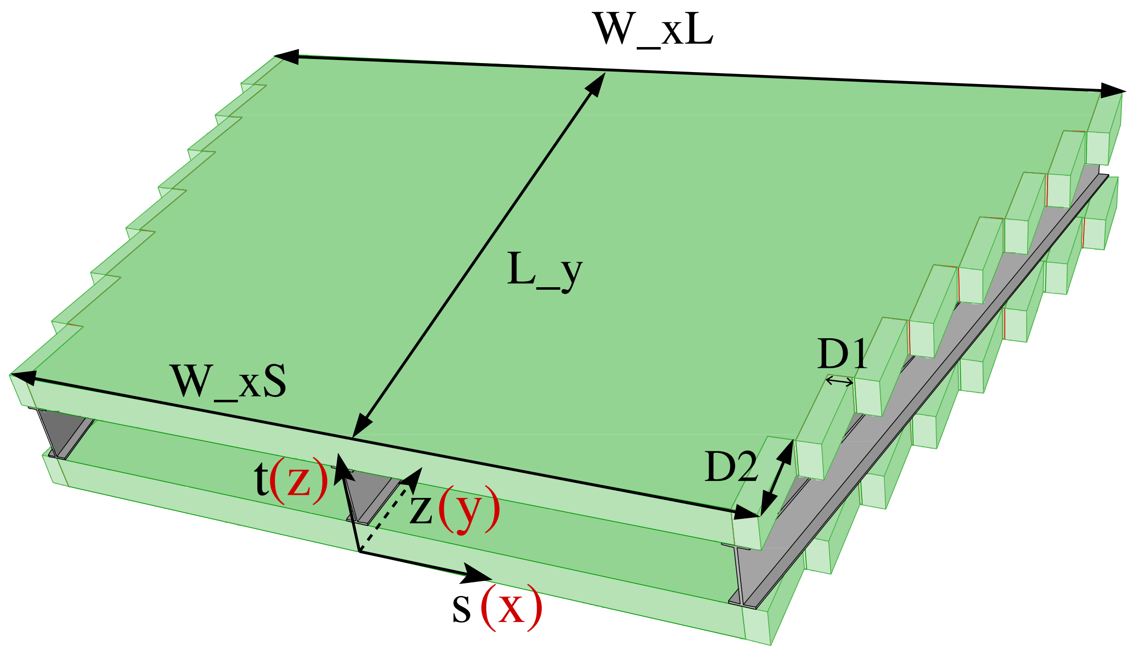


Figure 9: Definition of station parameters (dimensions).

The illustration of the positioning of an object is also illustrated in Figure 5, where the positions of the chamber corners are given as a function of s and z.

5.4 Dimensions of objects in the station

An object with technology MDT, RPC, TGC, SUP, SPA has the shape of the extrusion along the t (z) axis of an asymmetric trapezoid defined in the sz (xy) plane. The extension of the volume along the extrusion axis (thickness) is defined by the technology (internal structure, see section 7). The most general object of this shape is shown in Figure 5 where the dimensions are indicated. More complex shapes can be obtained through the use of cutouts (see section 8).

Most usually, the volumes described in AMDB are simpler than non-symmetric trapezoid. The most common cases are rectangular shape (W_xS = W_xL, Ex=0) such as Barrel chambers, see Figure 8, or symmetric trapezoids (W_xS ≠ W_xL, Ex=0), such as EndCap chambers, see Figure 9.

Object with technology CSC is an extrusion along the t (z) axis of a symmetric diamond shape defined in the sz (xy) plane. The parameterization of this volume is given in Figure 6.

5.5 Technology-specific fields in the D entries

Additional fields are reserved for the description of technology-specific features, as given in Table 1.

5.6 Naming of stations

The name reproduces in general the official naming of the stations, with the generic form $X_1X_2X_3$. With the exception of the Barrel or EndCap default positioning described in section 3.2.3, the naming has no direct role to play in the detector description appart from the

Technology	sh	D1	D2	D3
MDT		dead region at tube extremity (endplug)		extension of stair casing along z (y)
RPC	-1 flip internal structure along t (z)	board spacer ?	elx box ?	
TGC				
CSC	1 diamond shape 2 coffin shape			

Table 1: Technology-specific fields in the D entries

identification of the stations. However it is interesting to explain how the naming is established, as it is associated to the sub-region of the spectrometer in which stations are installed.

- X_1=B stands for Barrel stations.
- X_1=E,T,C stands for EndCap MDT, TGC, and CSC stations, respectively
- X_2=I,M,O stands for Inner, Middle, and Outer layer of the spectrometer
- X_3=S,L stands for Small and Large sectors, respectively
- some special cases are used : feet Barrel chambers have X_3=R,M,F,G,H though being in a Small sector. Extra stations are added to the three layer organization X_2=E. The following cases X_2=S,1,2,3,4 is used for stations relying on CSC and TGC technologies. Finally X_3=E,F allows to identify TGC stations in the Forward region.

5.7 Complex shapes

The objects described here have the shape of asymmetric trapezoid in the sz plane but are not obtained by an extrusion along the t axis. The exact shape in the ts and zt plane is conventional, parametrized in the W structures.

The parametrization of LB, CRO, CMI, CHV can be found in section 7.5.1. The parametrization of SUP can be found in section 7.5.2.

6 Grand Final Positioning of Chambers

In this section is illustrated the actual positioning of chambers. The positioning of a chamber in the Global Axis Systems XYZ results from the three sequential steps needing a total of 16 parameters :

- Positioning of the chamber elements in the station.
  - 3 parameters s,z,t given in the local szt frame.
- Positioning of the station, based on the nominal positions.
  - 1 parameter ϕ to define the rotating SZT frame. w.r.t global frame XYZ
  - 3 translation parameters SZT defined in the rotating SZT frame.
  - 3 rotation parameters α, β, γ defined in the local szt frame.
- Alignment of the station, based on the deviations with respect to the nominal positions.
  - 6 parameters : 3 translations and 3 rotations defined in the local szt frame.

An example of geometry is laid out p. 18, where an MDT chamber is subject to the full positioning sequence. This sequence is illustrated in Figure 10 through 15.

```
*-- Name of this AMDB file -------------------------------------------------------------
N Amdb_Test_1
* ****************
*
*-- AMDB version Number ----------------------------------------------------------------
V     7
* *****
*
*-- Definition of stations -------------------------------------------------------------
* Typ I  No
*   s      z       t  Io Tec i    sh  W_xS    W_xL     L_y     Ex     D1     D2     D3
D EML 1   5
   0.     0.     0.   1 MDT 1       2000.0  3000.0 1922.241   0.    55.     0.   240.28
 -630.    0.    97.02 2 CHV 1          6.0     6.0 1922.241 500.     0.     0.
   0.     0.    97.02 3 CMI 1          6.0     6.0 1922.241   0.     0.     0.
1130.     0.    97.02 4 CRO 1          6.0     6.0 1922.241-500.     0.     0.
 250.   240.28 267.02 5 MDT 2       1500.0  2250.0 1441.681   0.    55.     0.   240.28
*
*-- Positioning of stations ------------------------------------------------------------
*    Jgeo   Iphi     <-------- Translation (mm) -------><--- Rotation (Deg) --->
* Typ |Jcut   |    Jzz   dPhi       Z        T        S     Alpha   Beta    Gamma
*  |  | |     |     |      |        |        |        |      /t      /z      /s
*  |  | | --------  |      |        |        |        |       |       |       |
PbEML 1   00200000  1    22.50  1000.00  3000.00  500.00    0.      0.    -10.
*
*-- Adjustment of SZT position of Stations ---------------------------------------------
*     Jff   Job  <---- Translation (mm) ---><------ Rotation (Rad) ------>
* Typ  | Jzz |      s         z         t        /s        /z        /t
*  |   |  |  |      |         |         |         |         |         |
A EML  3  1  0     0.000     0.000    55.000  0.000000  0.000000  0.250000
*
*-- Inner structures of MDT's ----------------------------------------------------------
* note : all MDTs have 15mm protective foam layer
*        this is included in Thickness and Ytubepos
*     Iw X0 Nlayer Pitch   Rtube   Thickness DeadLengthInTubes
*                  Ytubepos(1:Nlayer)
*                  Xtubepos(1:Nlayer),TubeWallThickness
*
W MDT 1 .080   3 30.0350 14.6000 97.0571 70.0000
                 30.0175 56.0286 82.0396
                 15.0175 30.0350 15.0175  0.4000
W MDT 2 .080   3 30.0350 14.6000 97.0571 70.0000
                 15.0175 41.0286 67.0396
                 15.0175 30.0350 15.0175  0.4000
*
*-- Inner structures of Crossplates ----------------------------------------------------
*  +-----------------------------------> Type_id
*  |  +--------------------------------> Type number
*  |  |        +-----------------------> Number of objects (must be /=0 !!!)
*  |  |        |    +------------------> Height
*  |  |        |    |       +----------> T-shape largeness
*  |  |        |    |       |       +--> T-shape thickness
*  |  |        |    |       |       |
W CHV 1        1  170.     60.      6.
W CMI 1        1  170.     60.      6.
W CRO 1        1  170.     60.      6.
*
End
```

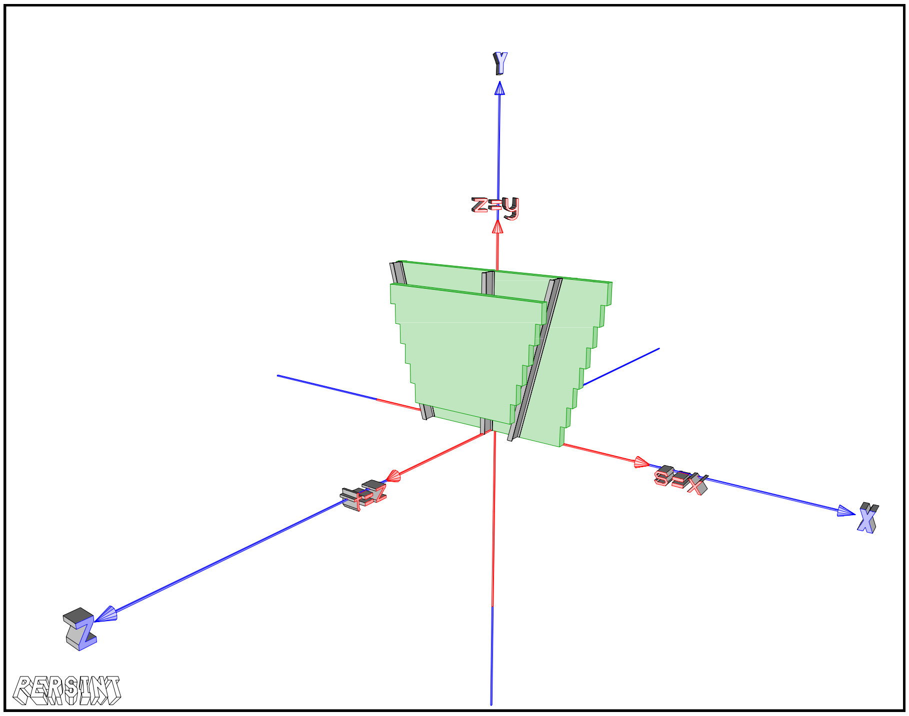


Figure 10: Definition of the station. The elements in the station are positioned in the Local Station frame szt.

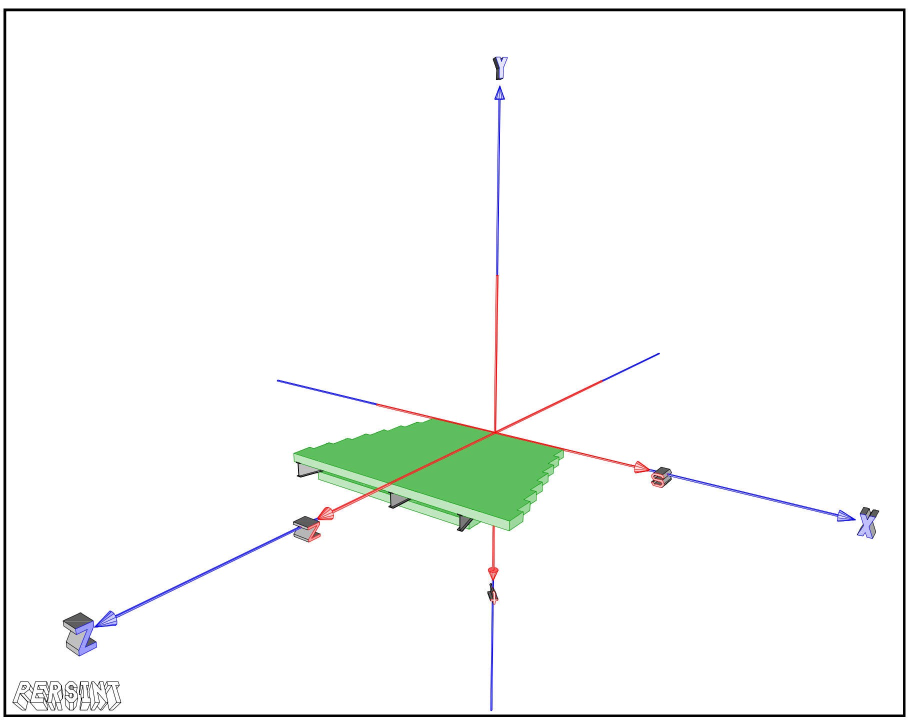


Figure 11: The station is considered as a Barrel station (Pb positioner).

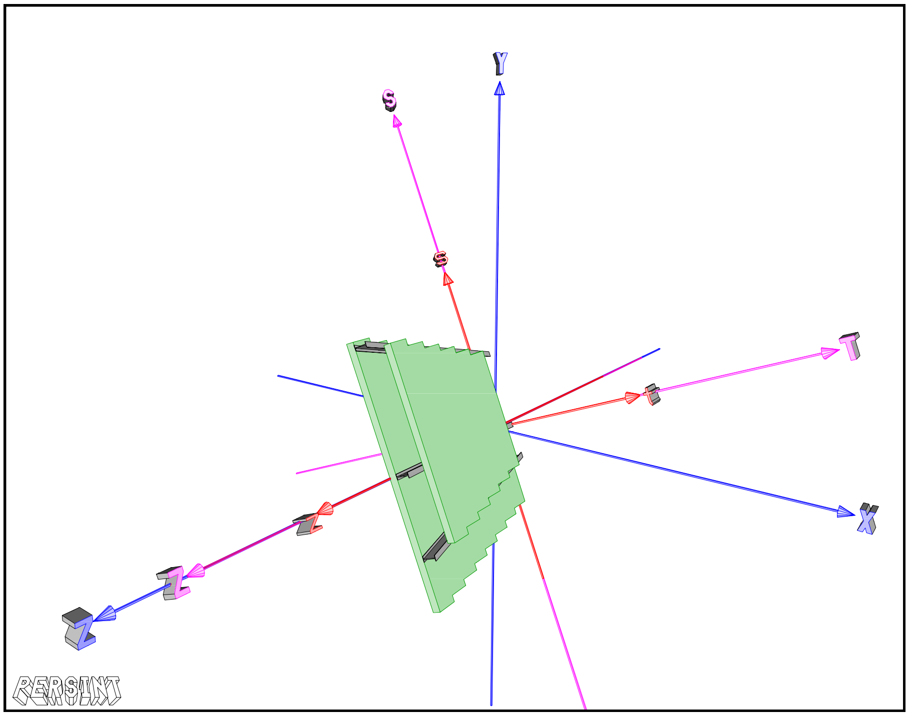


Figure 12: Implementation of the rotating frame SZT with dPhi=22.5^o.

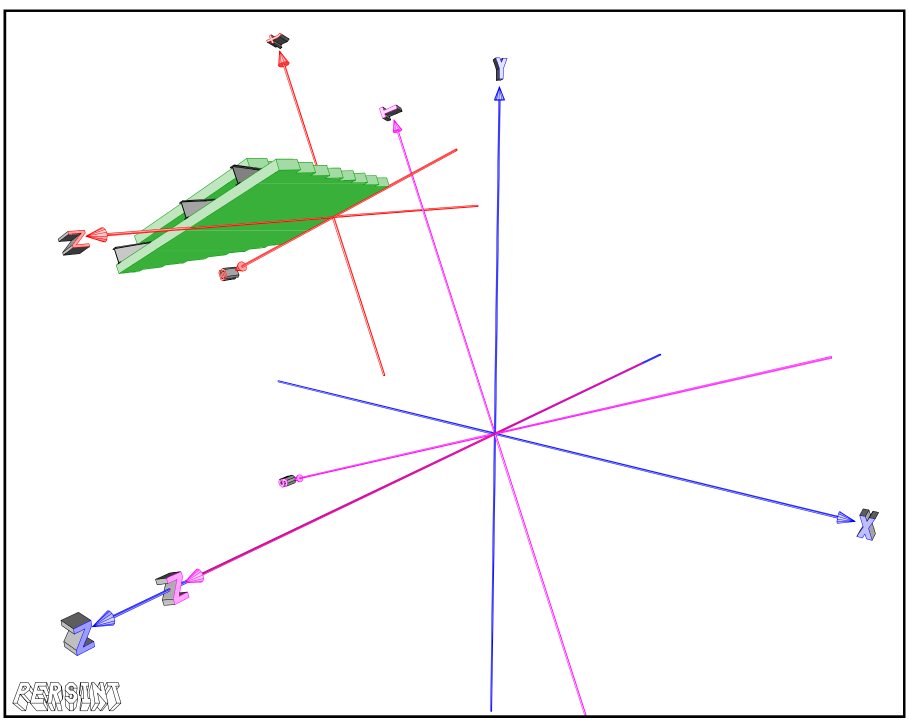


Figure 13: Implementation of the rotating frame SZT in octant Jff=3 and dPhi=22.5^o. The station (or rather the origin of its Local Station frame szt) is positioned at Z=1000, T=3000, S=500 mm in this rotating frame. The station is not duplicated in the Z<0 side (Iphi=00200000).

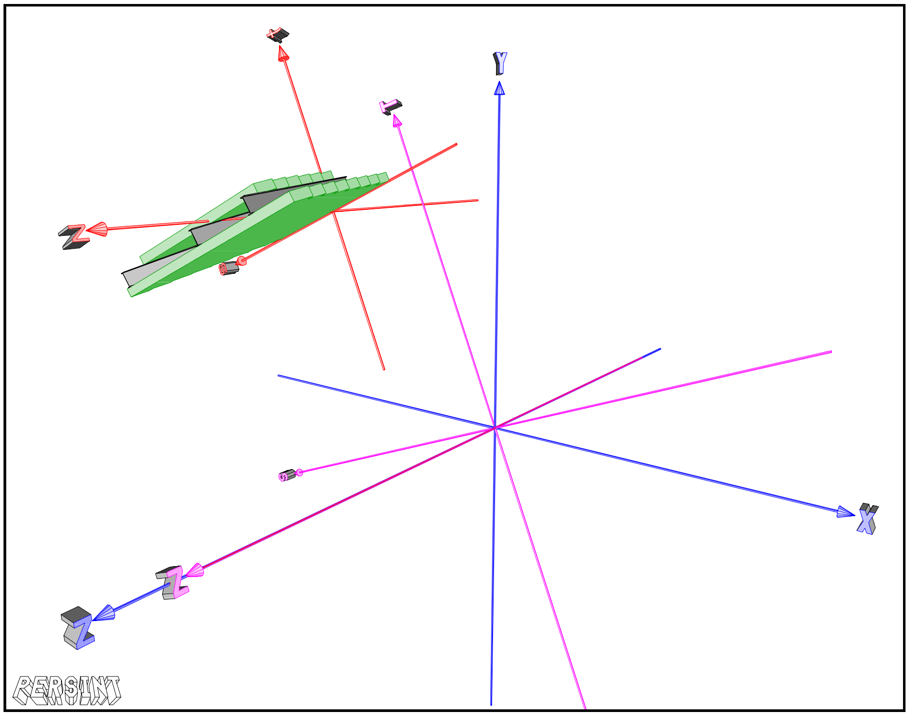


Figure 14: Rotation of the station in the Local Station frame szt : Gamma=-10^o (around s-axis). The station is now in its nominal position.

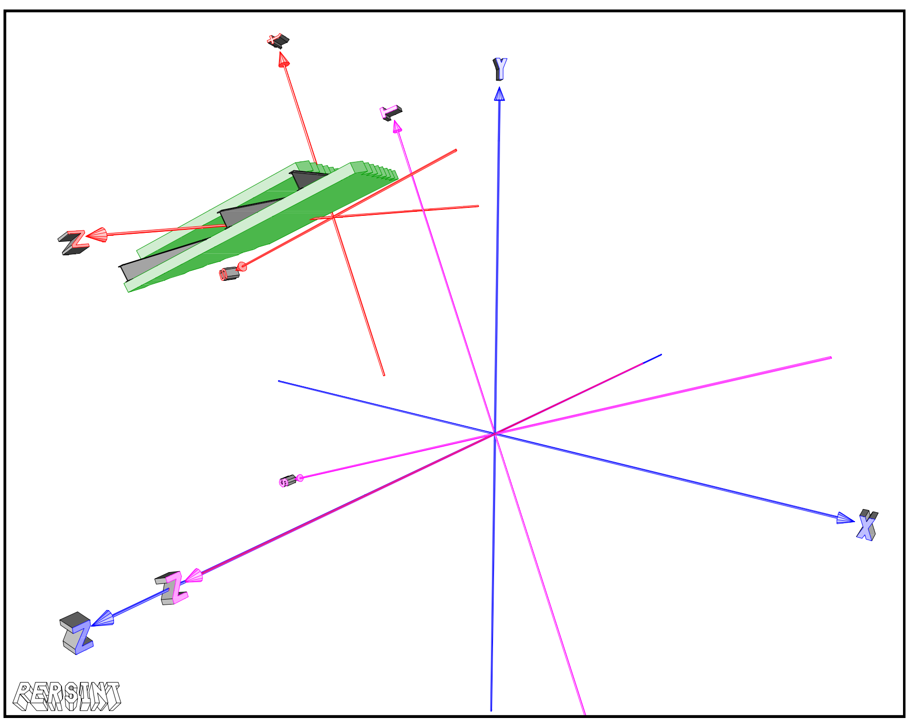


Figure 15: Alignment with 0.25 rad rotation around t-axis, then 55 mm translation along t-axis.

7 Definition of Inner Structures

The inner structures of station objects are given in the W entries of AMDB.

7.1 MDT

7.2 RPC

7.3 CSC

7.4 TGC

The TGC inner structure is described in terms of its layers of materials, the wire gangs (groups of wire readout together) giving the 1st coordinate, the strips giving the 2nd coordinate, the wire supports, and the button supports.

An example is given below where both the Definition of station composed of a single TGC chamber and the Inner Structure of this chamber are given. Note that we keep the A, B, H dimensions for comparison with the set of parameters used in the TGC Master database [3].

Each components of the inner structure are described in the following subsections.

```
*   s      z       t    Io Tec i     sh  W_xS     W_xL      L_y      Ex      D1      D2      D3
*
*dphi      hmin     dz Io    Tec      I       B        A        H     b        a
*
D T1E 1    1
  0.000 6054.5    0.0   1 TGC 3      0  918.0  1215.1  2266.5     0.0    0.0
*
********* Inner structures of TGC's  + Digitization Parameters (wire ganging) **************
*
* Typ I NbXO Nlay  dZ   R-frame width
*                            |   P-frame width
*                            |       |
*  n mat   Zi      dZi       |       |
*         1=Gas Gap          |       |
*         2=G10              |       |
*         3=Honeycomb        |       |
*         4=Copper           |       |
*                          *****   *****
W TGC 2 .130  15   70.00   20.00   24.00
   1  2   0.000   0.100
   2  3   0.100   5.000
   3  2   5.100   1.600
   4  1   6.700   2.800
   5  2   9.500   0.500
   6  3  10.000  20.000
   7  2  30.000   0.500
   8  1  30.500   2.800
   9  2  33.300   1.600
  10  3  34.900  20.000
  11  2  54.900   0.500
  12  1  55.400   2.800
  13  2  58.200   1.600
  14  3  59.800   5.000
  15  2  64.800   0.100
--------------------------------------------! WIRE GANGING + STRIP POSITION
                       92      91      91    ! NWGS   = Nb of groups of wires (gang) per chamber in each layer
                       32       1      32    ! NSPS   = Nb of strips per chamber in each layer (1=>0)
                        0       0       0    ! ROFFST = offset of wire group Address 1
                    18.00                    ! Physical distance of strips w.r.t. bases (mm)
                     1.80    0.09            ! Wire spacing, Strip thickness (mm)
  7.0     30.0                               ! Wire Support : width, width Of Gas Channel
227.0     43.0     0.    -43.0      0.       ! Wire Support : separation, offset of Wire Support (layer 1,2,3), tilt angle (deg)
  3.5     26.0   240.0     1.875             ! Button Support : radius, separation, pitch, tilt angle in trapezoid regions (deg)
--------------------------------------------!
   9  11  10  11  11  11  11  11  11  11     ! IWGS1 = wire ganging (1232+2 Wires + 2*margin= 2261.2 mm)
  12  11  12  12  12  12  12  12  13  12
  13  13  13  13  13  13  13  14  14  13
  14  14  14  14  15  14  15  14  15  15
  15  15  15  15  15  15  15  15  15  15
  14  15  15  15  14  15  15  14  15  14
  15  15  14  14  15  14  15  14  14  14
  14  15  14  14  13  14  14  14  14  13
  14  13  14  13  14  13  14  13  13  13
  14   4
--------------------------------------------!
  10  11  10  11  11  10  11  12  11  11     ! IWGS2 = wire ganging  (1232+2 Wires + 2*margin= 2261.2 mm)
  12  11  12  12  12  12  12  12  12  13
  13  12  13  13  13  14  13  13  14  14
  14  13  15  14  14  14  15  15  14  15
  15  15  15  16  15  15  15  14  15  15
  15  15  15  14  15  15  15  14  15  15
  14  15  14  15  14  15  14  14  15  14
  14  14  14  14  14  14  14  14  14  13
  14  13  14  14  13  13  14  13  13  14
  15
--------------------------------------------!
  11  11  10  11  10  11  11  11  11  12     ! IWGS3 = wire ganging  (1232+2 Wires + 2*margin= 2261.2 mm)
  11  12  11  12  12  12  12  13  12  13
  12  13  13  13  13  13  13  14  13  14
  14  14  14  14  14  15  14  15  15  15
  15  15  15  15  15  15  15  15  15  15
  15  15  15  14  15  15  15  14  15  15
  14  15  14  15  14  15  14  15  14  14
  15  14  14  14  14  14  14  14  13  14
  14  14  13  14  13  14  13  13  14  13
  13
------------------------------------------------! STRIPS LAYOUT Type T3
  -438.01  -404.78  -377.27  -349.77  -322.28   ! Start of Strip on large base 1st plane (mm wrt center of chamber)
```

```
  -294.81  -267.35  -239.90  -212.46  -185.03
  -157.60  -130.18  -102.77   -75.36   -47.96
   -20.55     6.85    34.25    61.66    89.07
   116.48   143.89   171.31   198.74   226.18
   253.62   281.08   308.54   336.02   363.51
   391.02   418.54   438.01
------------------------------------------------!
  -292.21  -257.71  -240.19  -222.68  -205.19   ! Start of Strip on small base 1st plane (mm wrt center of chamber)
  -187.69  -170.21  -152.74  -135.26  -117.80
  -100.34   -82.88   -65.43   -47.98   -30.53
   -13.08     4.36    21.81    39.26    56.71
    74.16    91.61   109.07   126.53   144.00
   161.47   178.95   196.44   213.93   231.44
   248.95   266.47   292.21
*
*
```

7.4.1 Layers of materials

A TGC chamber is built as an assembly of layers. It is parametrized in the header of the corresponding W entry as follows :

- Nlay is the number of layers
- dZ is the total thickness

The list of layers is given with

- a layer ID
- a reference to a material (1=Gas Gap, 2=G10, 3=Honeycomb, 4=Copper)
- zi position
- dzi extension

7.4.2 Strips layout

The strips are laid out on one side of the gas gaps described in the "Layers of materials" section. The NSPS array is used to give the total number of strips per gas gap. A value of 1 means that no strips are readout. The strip panel is always laid on the outer side of the gas gap.

The layout of strips in the chamber main plane is illustrated in Figure 16. It is defined in the (x,y) frame contained in the chamber main plane and tied to the chamber with origin in the middle of the small base. The x axis is defined as follow in the AMDB reference systems (see section 2 and Figure 1 for reference) :

- The x axis points as the s axis of the local station frame szt in the A-side (Z-axis positive of the Global XYZ system)
- The x axis points as -s in the C-side (Z-axis negative of the Global XYZ system)
- This amounts to x pointing as $\phi-$ in both A and C sides (to be confirmed)

The strips are defined in the xy plane as follows :

- The strips extend along y from y1=(Physical distance of strip w.r.t. bases) to y2=H $-$ (Physical distance of strip w.r.t. bases).
- The extension of the strips along the x axis is defined at the level of y1 by the "Start of Strip on small base" array (NSPS+1 variables).

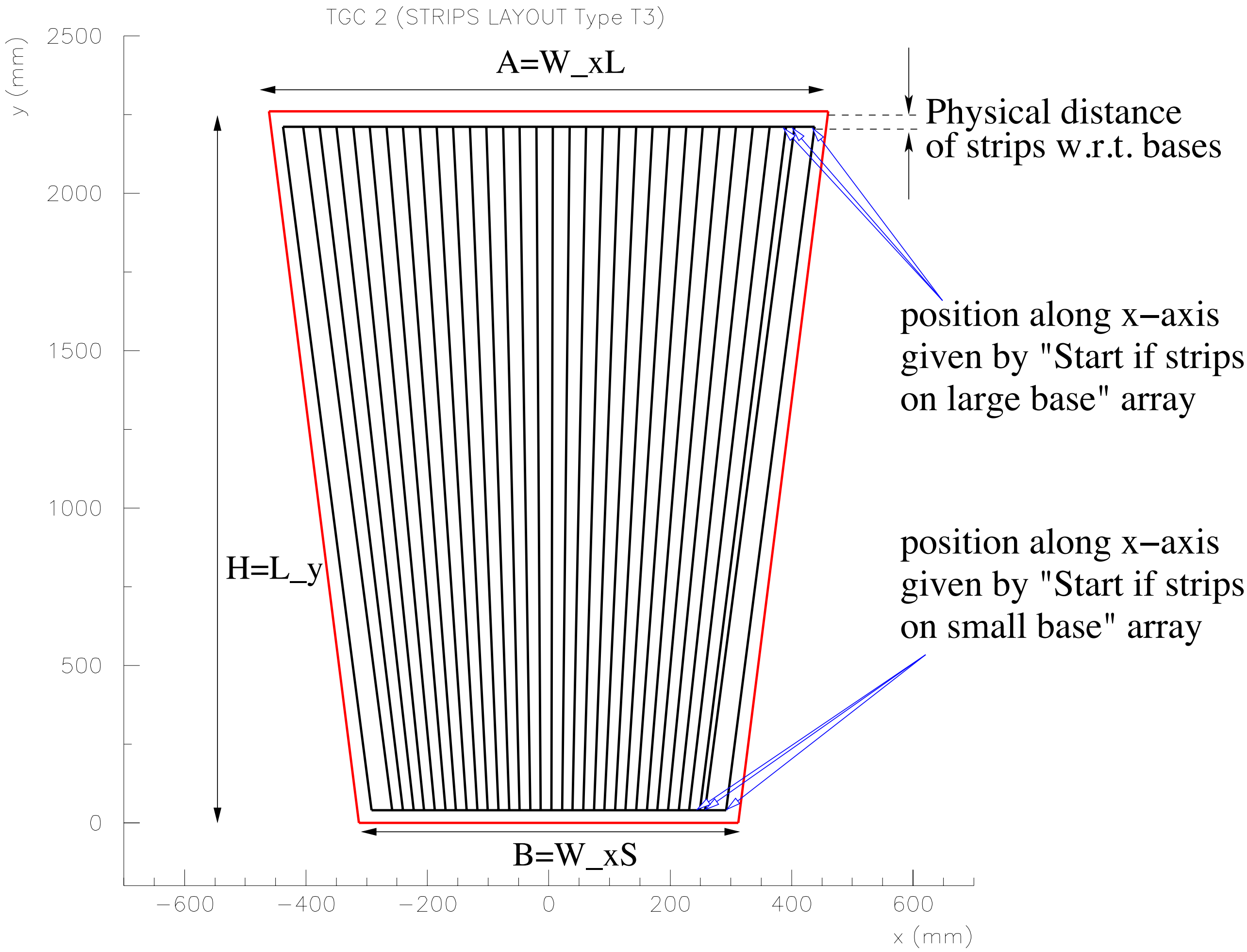


Figure 16: Description of TGC strips.

- The extension of the strips along the x axis is defined at the level of y2 by the "Start of Strip on large base" array (NSPS+1 variables).

The definition above is valid for the first plane of strips. The layout of strips on the second plane is obtained by mirror symmetry with respect to the x=0 plane.

7.4.3 Wire gangs

The wires are laid out in the middle of the gas gaps described in the "Layers of materials" section. They are grouped in "wire groups" or "wire gangs" readout altogether as single channels. The NWGS array gives the total number of wire gangs per gas gap. The number of wires in each gang is given by the IWGS arrays.

The layout of wire gangs in the chamber main plane is illustrated in Figure 17. It is defined in the (x,y) frame defined in the previous section. It has to be taken into account that a single wire is always present close to the large base and never readout. The gang closest to the large base is hence defined starting from the 2nd wire, see Figure 18. The gangs are described in the xy plane as follows :

- the last gang I=NWGS extends from

  y2(I)=H − ((R-frame width)+(Wire spacing)/2)

  down to y1(I) = y2(I) − IWGS(I)∗(Wire spacing)

- each successive gang is obtained by iteration, so that it extends from

  y2(I)=y1(I+1) to y1(I)=y2(I) − IWGS(I)∗(Wire spacing)

- wires cover the full extension of the chamber along x minus the P-frame width on each sides.

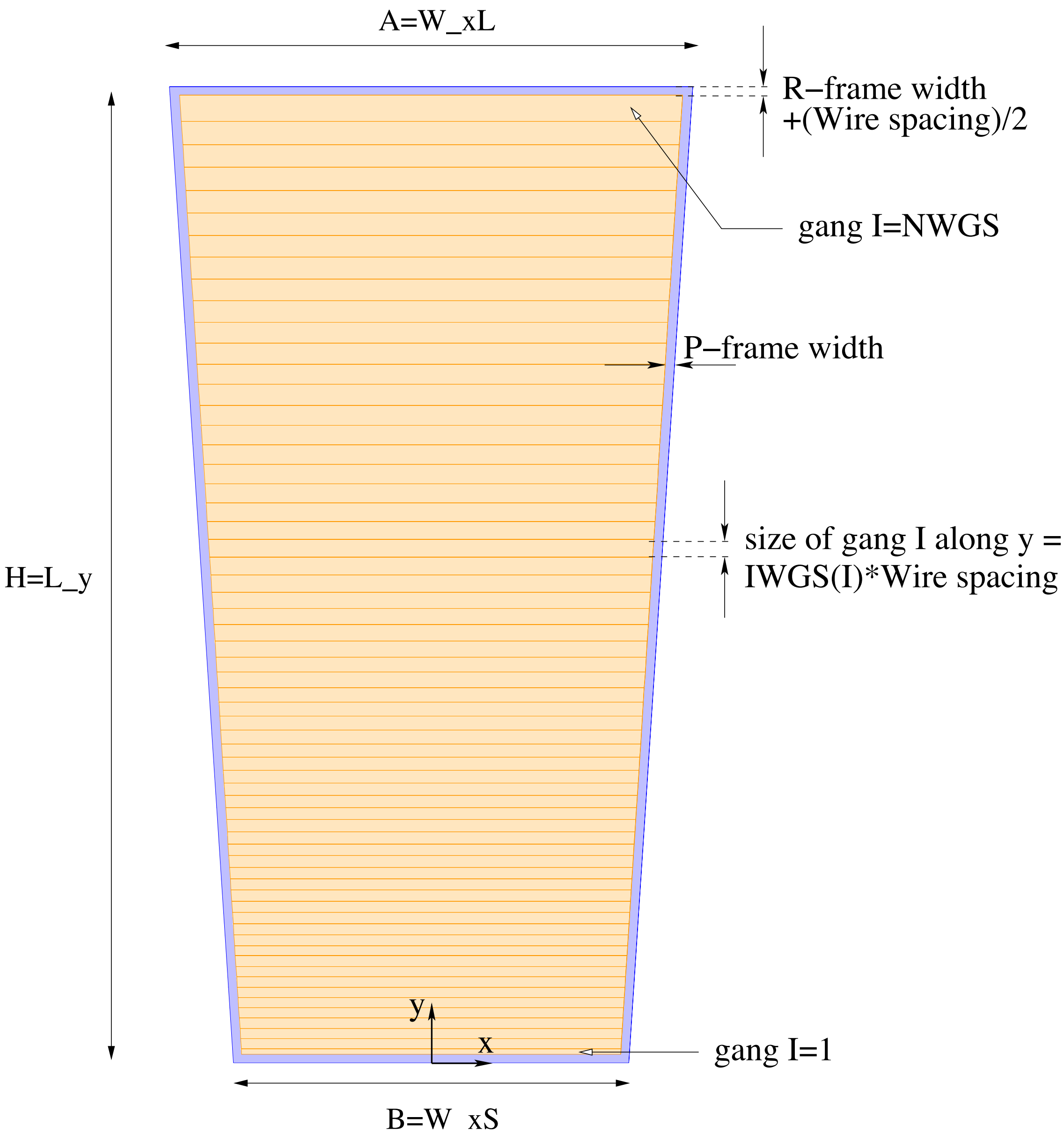


Figure 17: Description of TGC wire gangs.

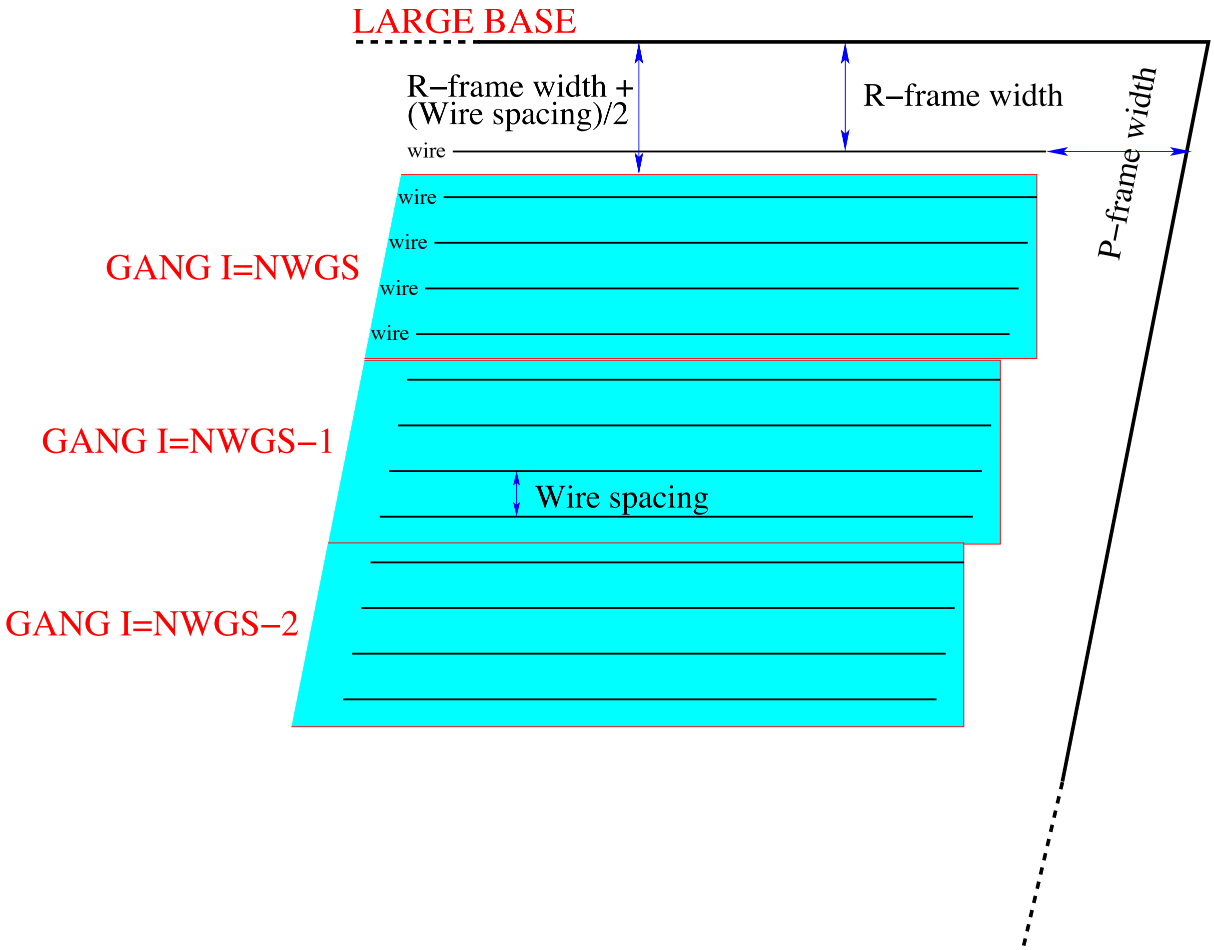


Figure 18: Details of TGC wire gangs.

7.4.4 Wire supports

7.4.5 Button supports

7.5 SPA, SUP, DED, LB, CRO, CMI, CHV

7.5.1 The MDT Spacer : Cross Plates CRO, CMI, CHV and Longbeams LB

The MDT spacer elements are defined by the D entries for what concerns their spatial extension and positions within the station and by their W entries for what concerns their specific design. They have the shapes of an asymmetric trapezoid in the sz plane but are not obtained by an extrusion along the t axis. The exact shape in the ts and zt plane is conventional, parametrized in the W structures.

An example of AMDB description is given below. The parametrization of Cross Plates CRO, CMI, CHV is illustrated in Figure 19. Note that the Ex parameter can be used to obtain cross plates extending along s, see Figure 5. This is used for the description of cross plates in trapezoidal chambers (see e.g. Figure 9).

```
*-- Definition of stations ----------------------------------------------------------
* Typ I  No
*   s     z      t    Io Tec i    sh  W_xS    W_xL     L_y     Ex     D1     D2     D3
*
D BIL 1   7
   0.     0.     0.   1 MDT 1       2671.5  2671.5 1081.261   0.    55.     0.     0.
-1280.    0.   123.03 2 CHV 1          6.0     6.0 1081.261   0.     0.     0.     0.
   0.     0.   123.03 3 CMI 1          6.0     6.0 1081.261   0.     0.     0.     0.
1280.     0.   123.03 4 CRO 1          6.0     6.0 1081.261   0.     0.     0.     0.
   0.   215.   208.03 5 LB  1       2620.0  2620.0    50.     0.     0.     0.     0.
   0.   815.   208.03 6 LB  1       2620.0  2620.0    50.     0.     0.     0.     0.
   0.     0.   293.03 7 MDT 2       2671.5  2671.5 1081.261   0.    55.     0.     0.
*
********* Inner structures of Spacers ********************************************
********* Crossplates *************************************************************
*
*  +-----------------------------------> Type_id
*  |  +--------------------------------> Type number
*  |  |        +-----------------------> Number of objects (must be /=0 !!!)
*  |  |        |    +------------------> Height
*  |  |        |    |       +----------> T-shape largeness
*  |  |        |    |       |       +--> T-shape thickness
*  |  |        |    |       |       |
W CHV 1        1  170.     60.      6.
W CMI 1        1  170.     60.      6.
W CRO 1        1  170.     60.      6.
*
********* LongBeams ***************************************************************
*
*  +-----------------------------------> Type_id
*  |  +--------------------------------> Type number
*  |  |        +-----------------------> Number of objects (must be /=0 !!!)
*  |  |        |    +------------------> Height
*  |  |        |    |       +----------> Wall thickness
W LB  1        1   75.      4.
**
**********************************************************************************
*
```

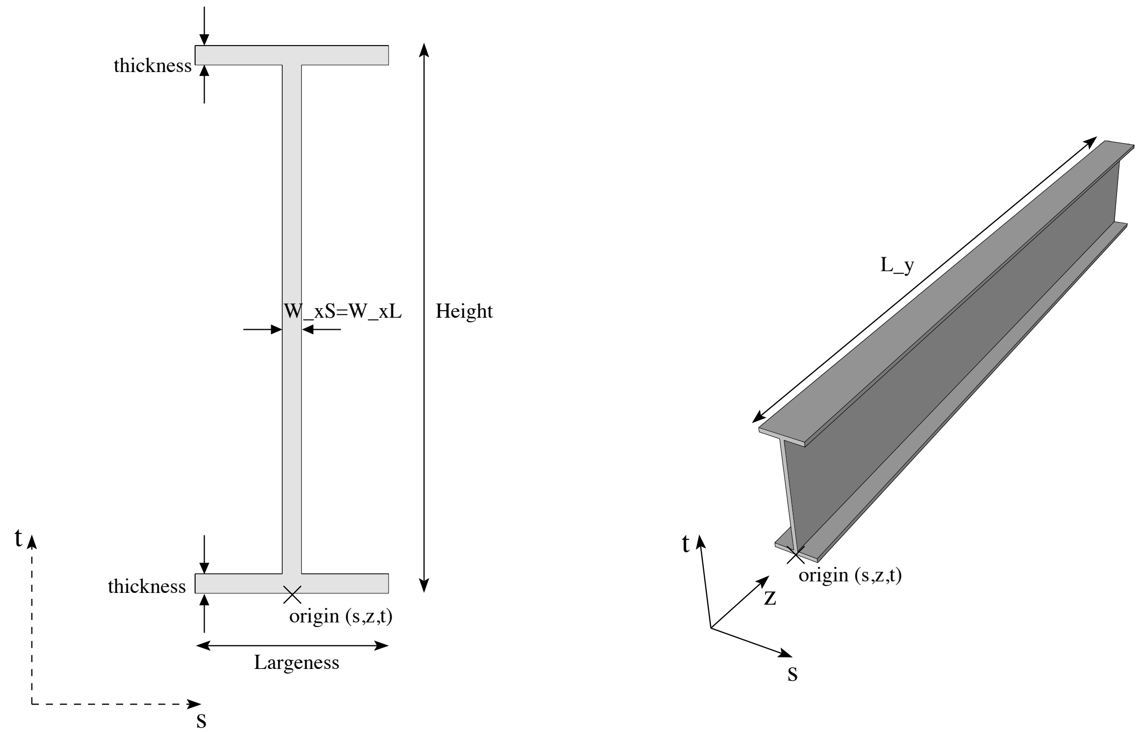


Figure 19: Parametrization of Cross plates CRO, CMI, CHV. The origin of the object in the szt reference system is marked.

7.5.2 The RPC Support : SUP

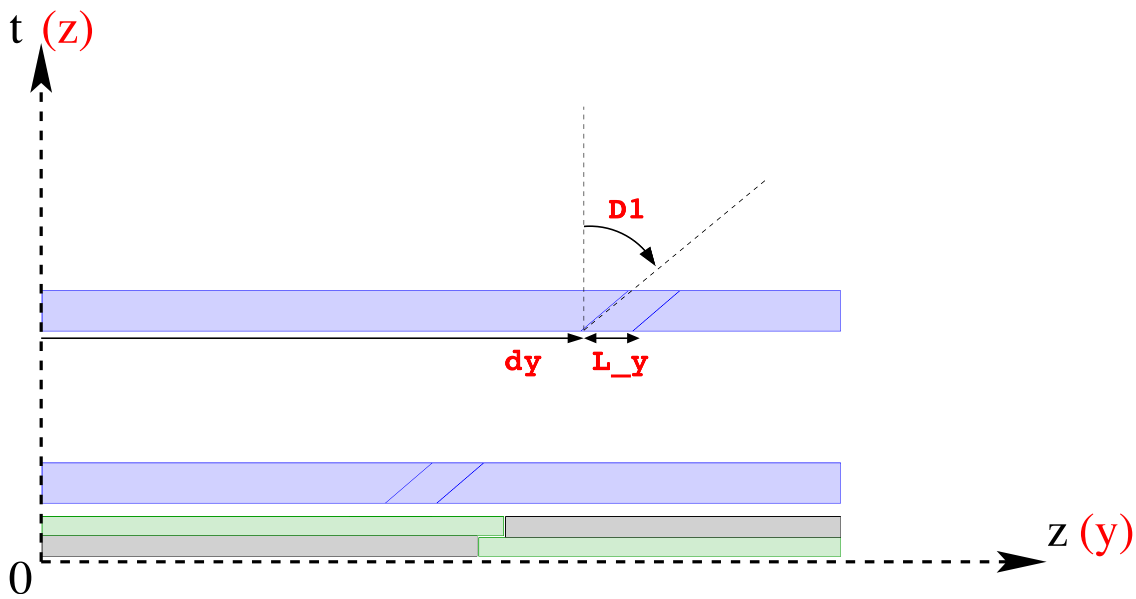
8 Cutouts Description

The cutouts are defined by the H entries. The H entry contains a header giving the station type to which it is associated (e.g. BOS 1), an index Jcut, and the total number of cutouts in the station. An example is given below for a typical station for which chambers have alignment holes.

```
*-- Definition of BOS stations -----------------------------------------------
* Typ I  No
*  dx     dy     dz  Io Tec i x y s  W_xS    W_xL     L_y     Ex     D1     D2
* ...
D BOS 1  10
   0.     0.     7.00 1 SUP 1       3660.   3660.      0.     0.     0.     0.
   0.     0.     7.00 2 DED 1       3660.   3660.   1046.     0.     0.     0.
   0.  1050.     7.00 3 RPC15       3660.   3660.    870.     0.     8.   120.
   0.  1046.     7.00 4 SUP 3       3660.   3660.      0.     0.     0.     0.
   0.     0.    57.00 5 RPC13    -1 3660.   3660.   1110.     0.     8.   120.
   0.  1114.    53.00 6 DED 1       3660.   3660.    806.     0.     0.     0.
   0.  1920.     7.00 7 SUP 2       3660.   3660.      0.     0.     0.     0.
   0.     0.   135.00 8 MDT 1       3773.3  3773.3  1920.     0.    55.     0.
   0.     0.   232.02 9 SPA 4       3773.3  3773.3  1920.     0.     0.     0.
   0.     0.   549.0210 MDT 2       3773.3  3773.3  1920.     0.    55.     0.
H BOS 1 1 4
1045.   630.         2               140.0   140.0   200.00   0.    49.7
1045.   684.2        5               140.0   140.0   200.00   0.    49.7
1451.7  824.3        8               870.0   870.0   123.75   0.    49.7
1451.7 1295.3       10               870.0   870.0   123.75   0.    49.7
*
*-- Positioning of BOS stations ----------------------------------------------
*    Jgeo   Iphi     <-------- Translation (mm) -------><--- Rotation (Deg) --->
* Typ |Jcut   |     Jzz   dPhi       Z        T       S      Alpha   Beta    Gamma
*  |  | |     |      |      |        |        |       |       /t      /z      /s
*  |  | | --------  |      |        |        |       |       |       |       |
P BOS 1 1 11111001  6    22.5  10910.   10153.48    0.      0.      0.      0.
*
```

In the H entry, each cutout is described by a line with format similar to the D entry, but with different parameters meaning. Each line has an object identifier Io used as a pointer to the station objects. The geometrical parameters are expressed in the Local Station frame szt (or xyz) and defined as shown in Figure 20. Units are mm and degree. Several cutouts can be defined for a single station object

The station with cutouts are positioned using the P entries where the Jcut index is specified, as shown above. It is thus possible to position stations of the same type with and without cutouts, with multiple cutouts definitions.



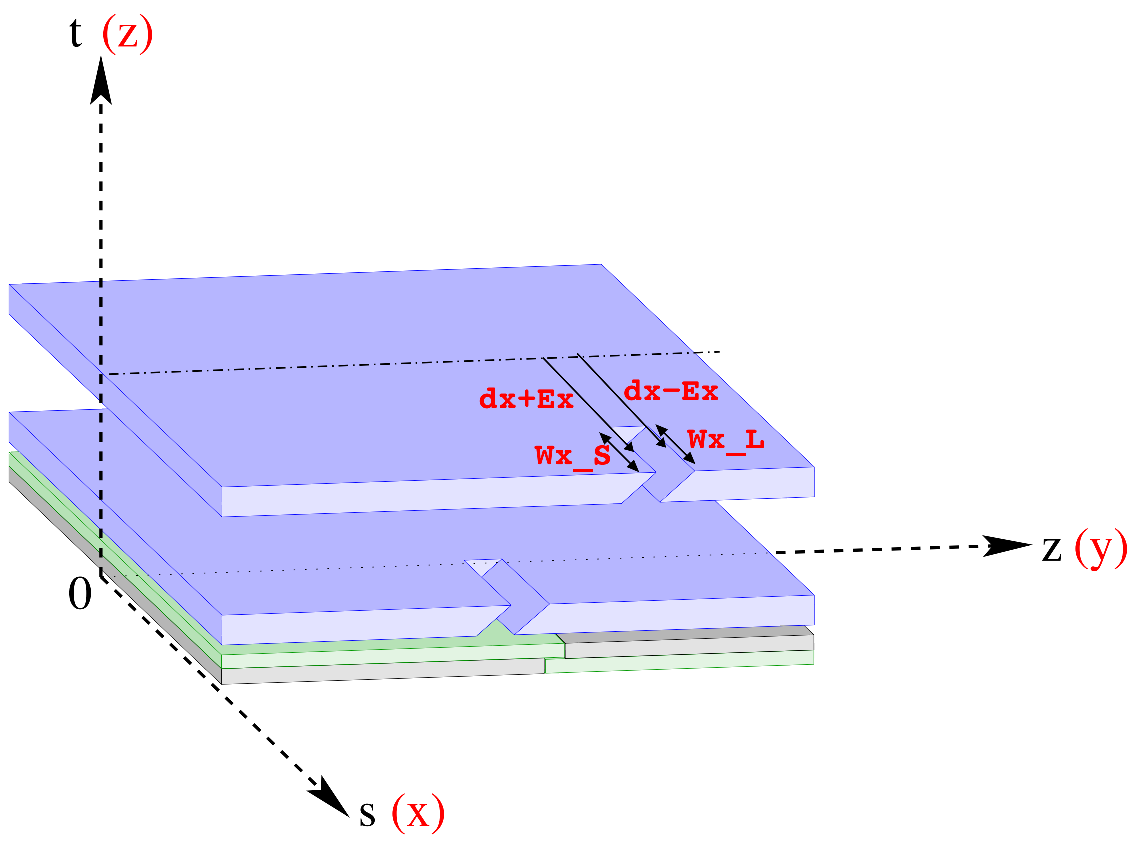


Figure 20: Definition of cutout parameters.

9 Deformation parameters

The deformations of MDT chambers are modelized by the eight parameters presented in Figure 21. In addition, the temperature T is used for global expansion. In Figure 22 is shown the current AMDB implementation.

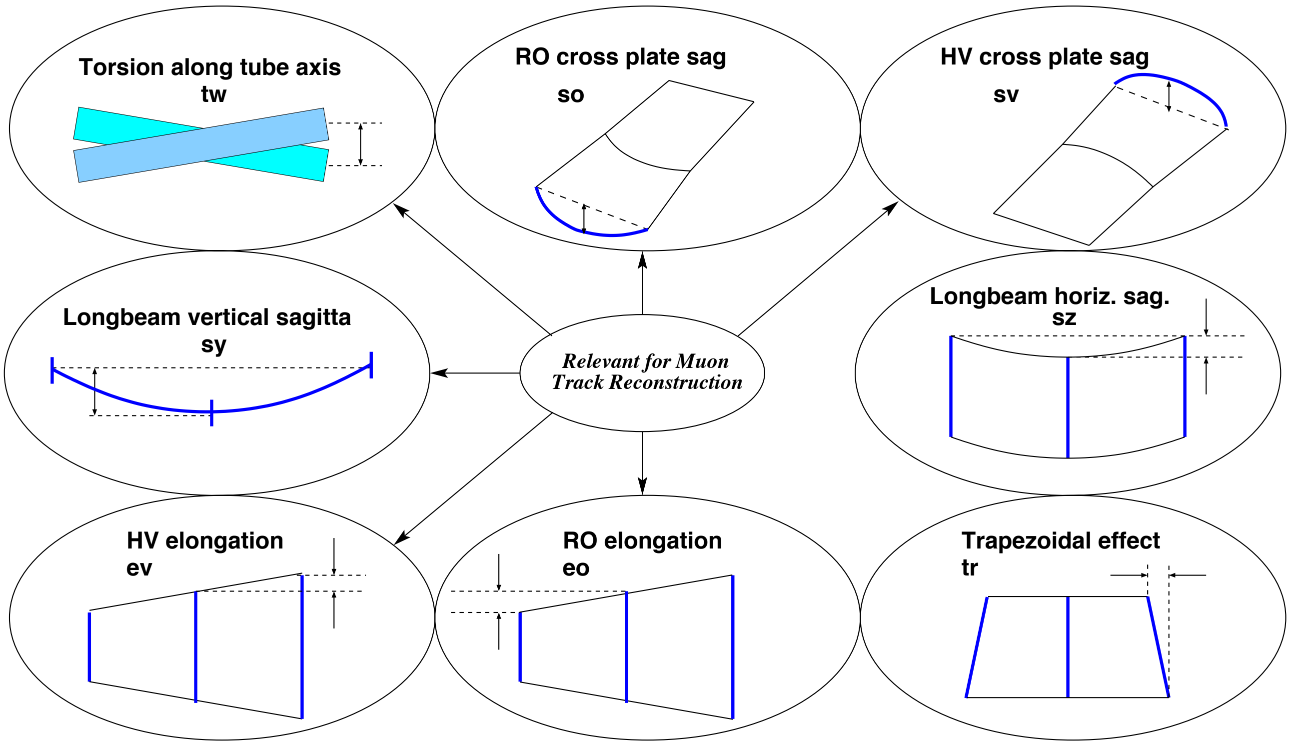


Figure 21: Definition of deformation parameters (Claude Guyot model).

The deformation parameters are given in the B entries. An example is given below for an MDT EML chamber with a torsion.

```
*
*-- Deformation in SZT of stations ------------------------------------------
*
* TypJffJzzJob   tw     so     sv     eo     ev     sy     sz     tr      T
*
B EML  1  2  0 90.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  20.00
*
```

The parameters are expressed in mm in the szt local reference frame defined in Figure 23. Deformations result primarily in the modification of the wire layout. This is illustrated in the following sections.

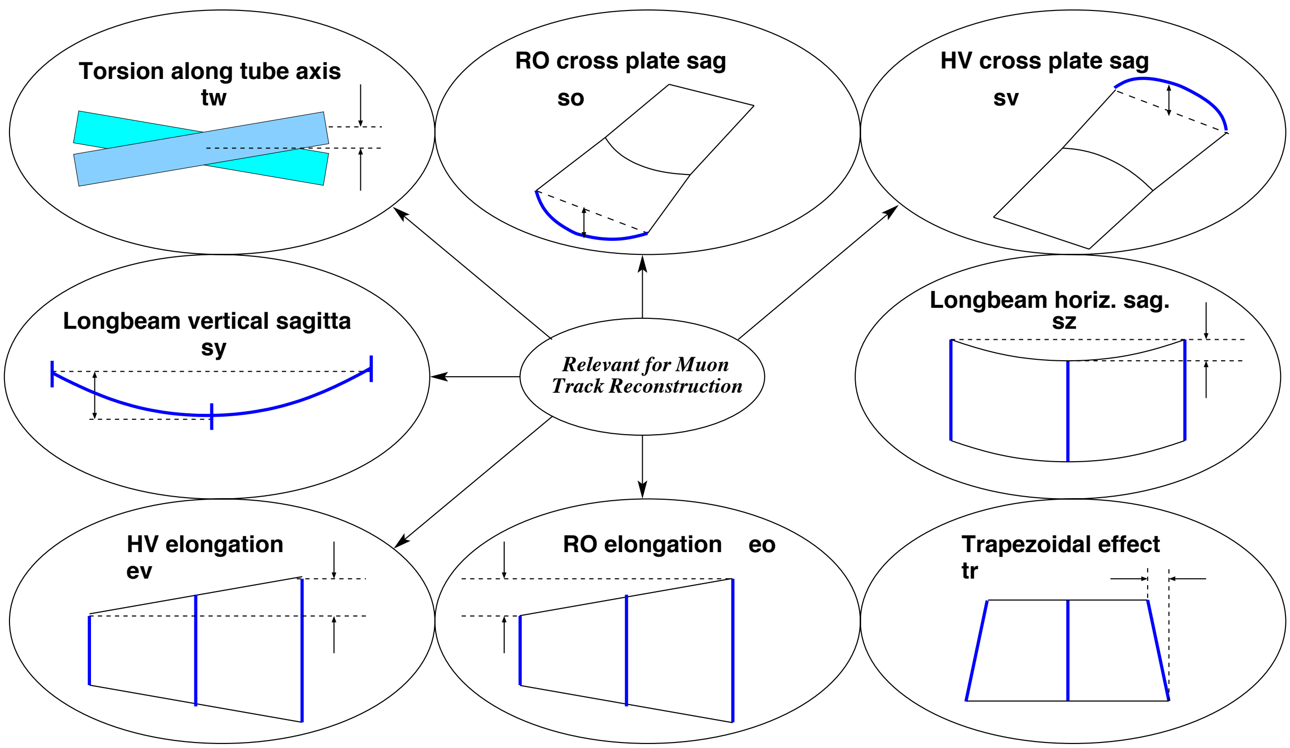


Figure 22: Definition of deformation parameters (Current AMDB implementation).

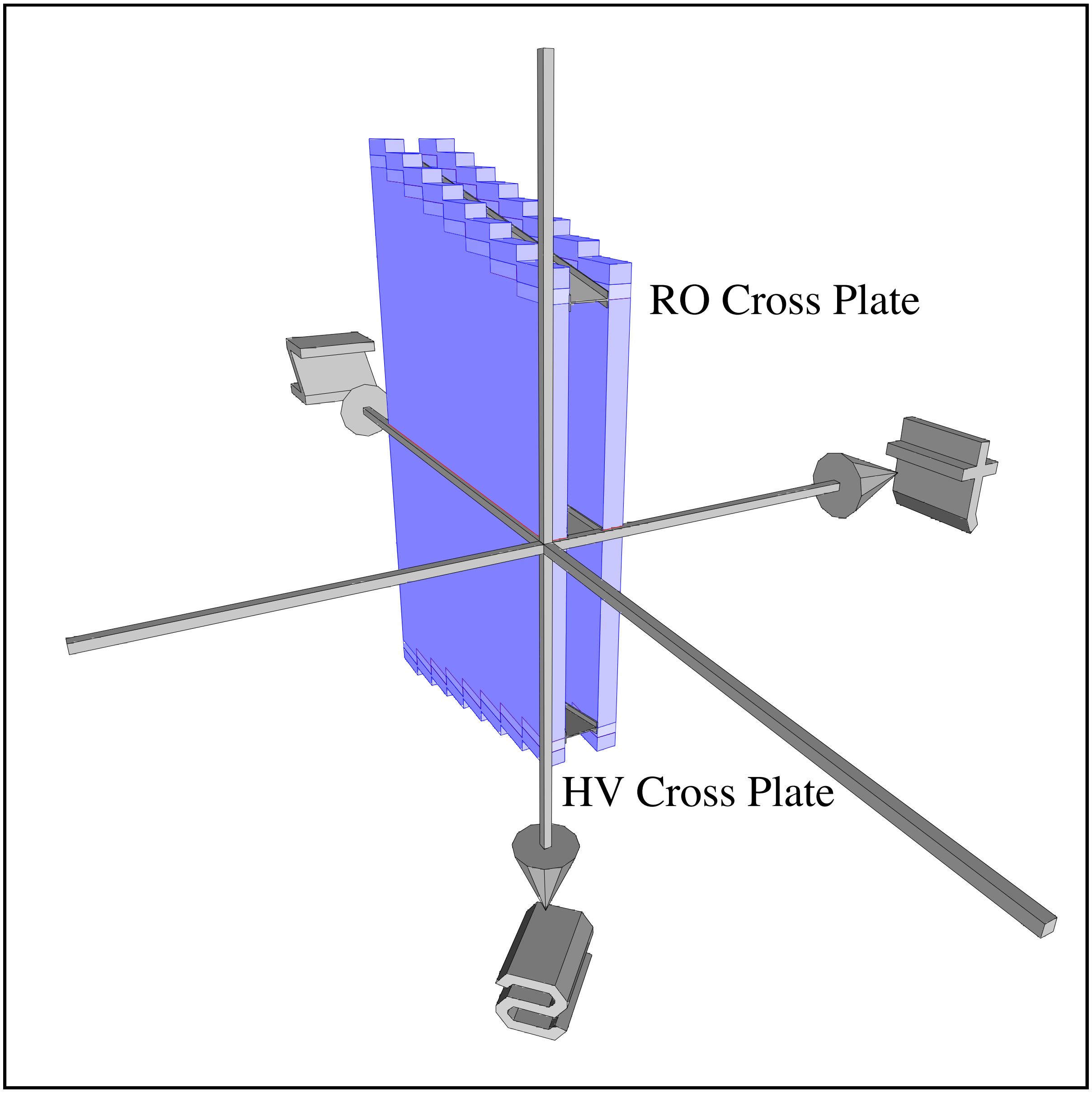


Figure 23: MDT chamber with local reference frame szt.

9.1 Torsion tw

The torsion is understood as a relative rotation of the HV crossplate with respect to the RO crossplate around the s-axis. It is expressed as the deviation of the extremity of the first wire along t. The effect on the tube layout of a positive 90 mm torsion is illustrated in Figure 24. Projections in the ts and tz planes are given in Figure 25

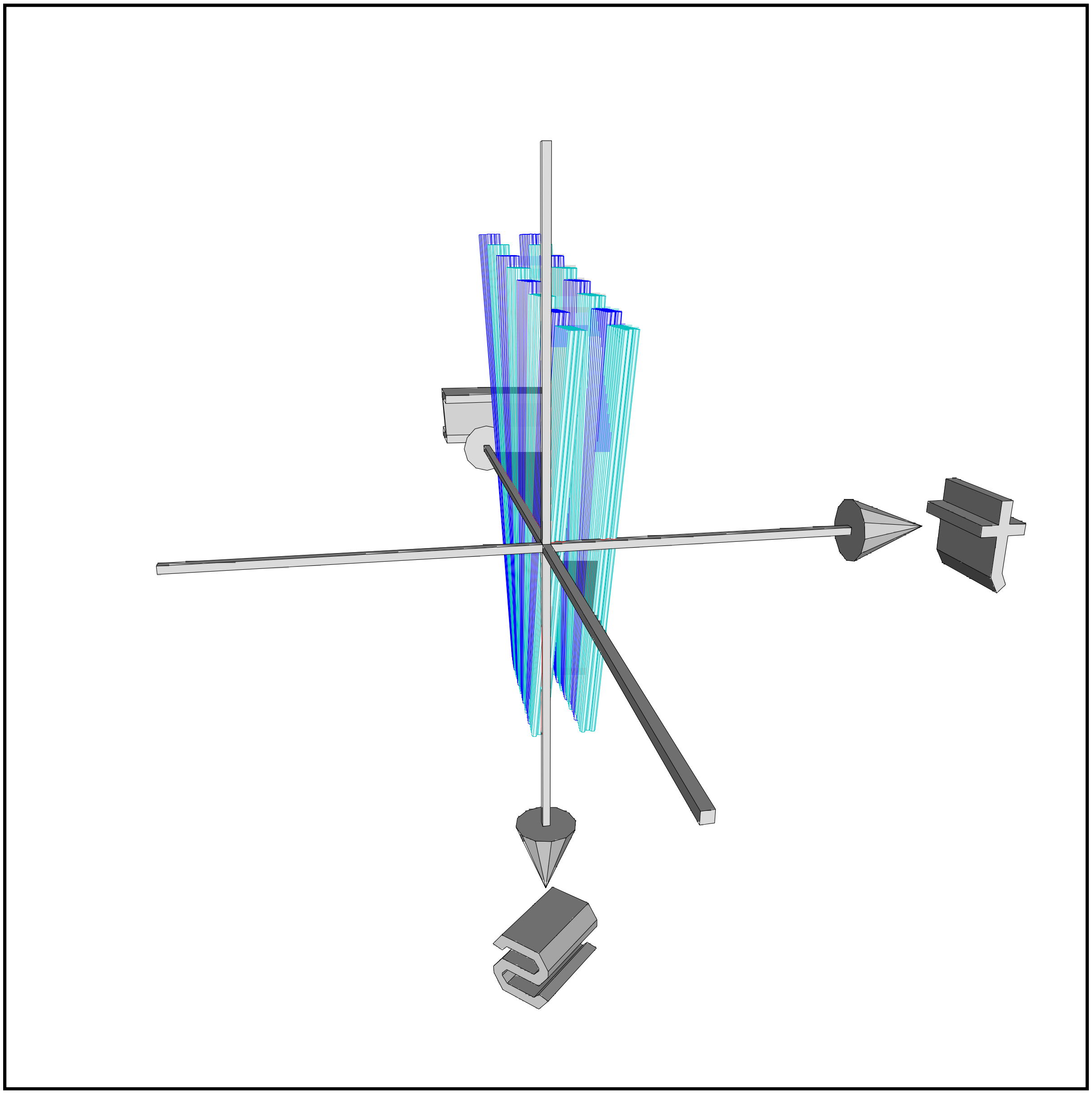


Figure 24: Effect of torsion tw=+90mm.

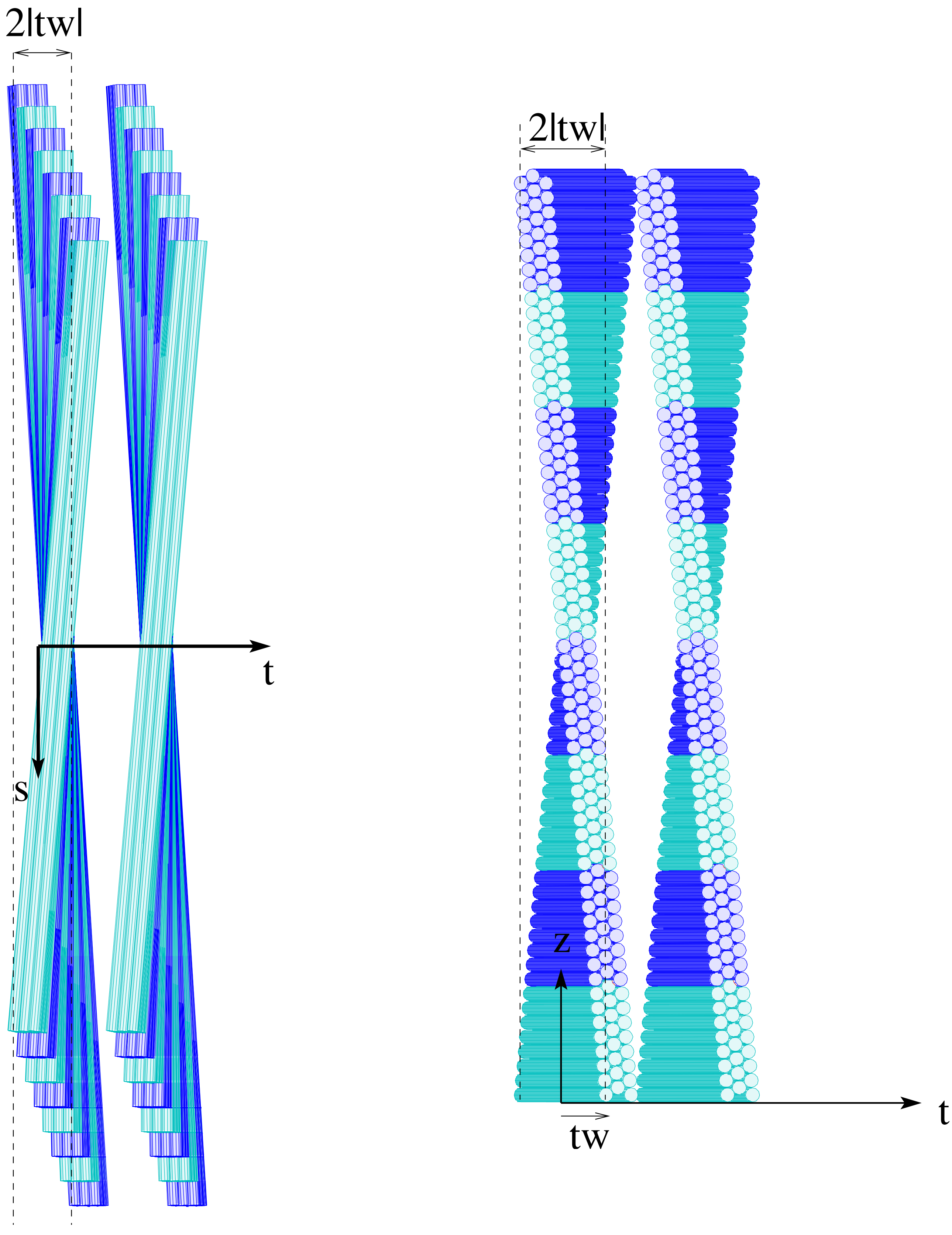


Figure 25: Effect of torsion tw=+90mm observed in ts and tz projections.

9.2 Cross plate sags so,sv

The Cross plate sags so and sv are associated to the s<0 and s>0 chamber extremities, respectively. Hence it may be not assocatied to the actual RO and HV sides. The Cross plate sag so is illustrated in Figure 26. The so parameter is the sagitta of the arc associated to the wire positions, pointing toward t<0, i.e. always toward the center of the detector in the case of the ATLAS layout. Same definition applies to sv.

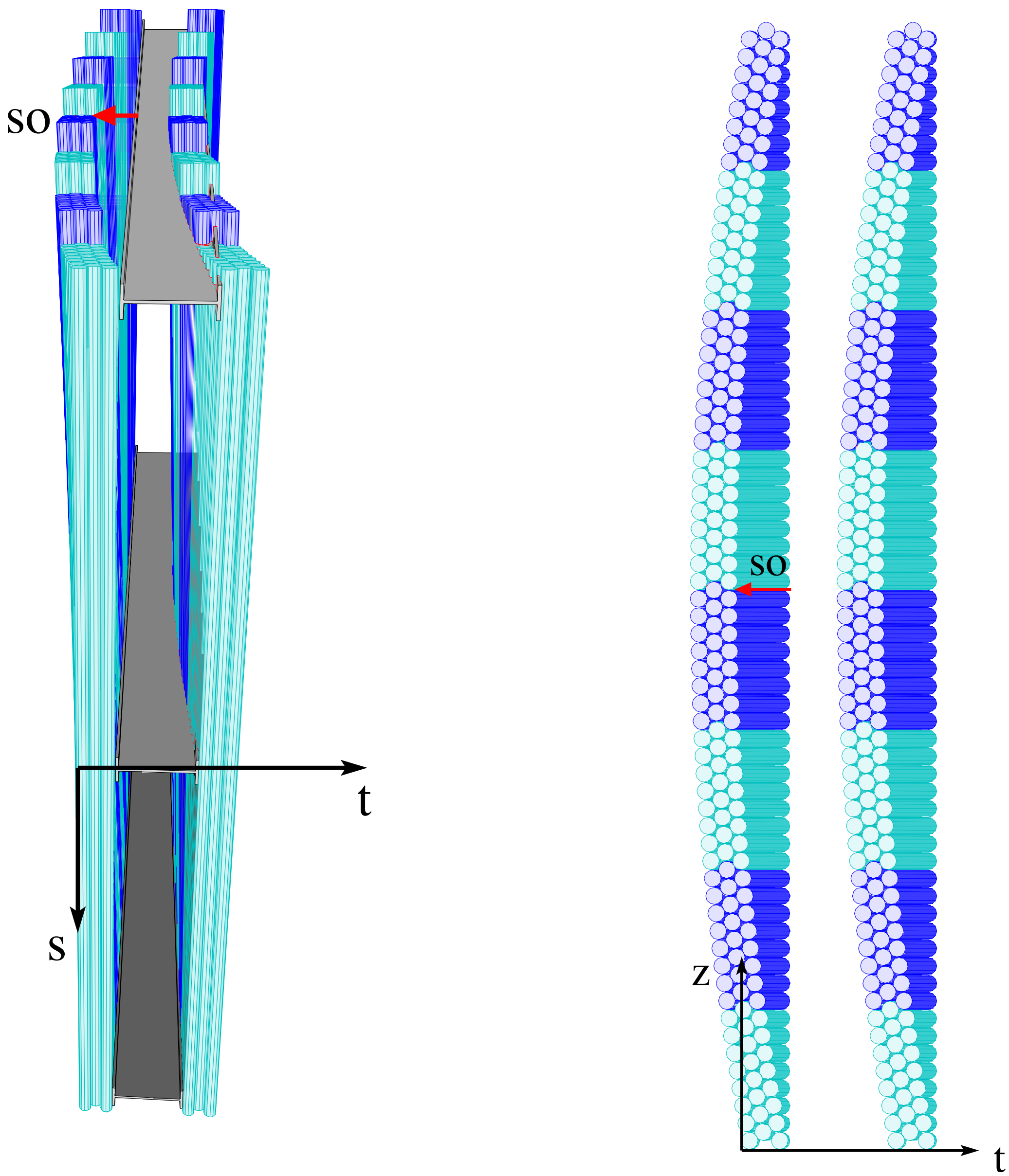


Figure 26: Effect of Cross plate sag so=+90mm. On the left-hand side illustration the non-deformed crossplates are shown superimposed for reference.

9.3 Cross plate elongations eo,ev

The Cross plate elongations eo and ev are associated to the s<0 and s>0 chamber extremities, respectively. Hence it may be not assocatied to the actual RO and HV sides. The Cross plate elongation eo is illustrated in Figure 27 and 28 in terms of the tube/wire layout. The eo/ev parameters describe an elongation of the corresponding value on both z-extemities of the chamber, outward when positive, inward when negative.

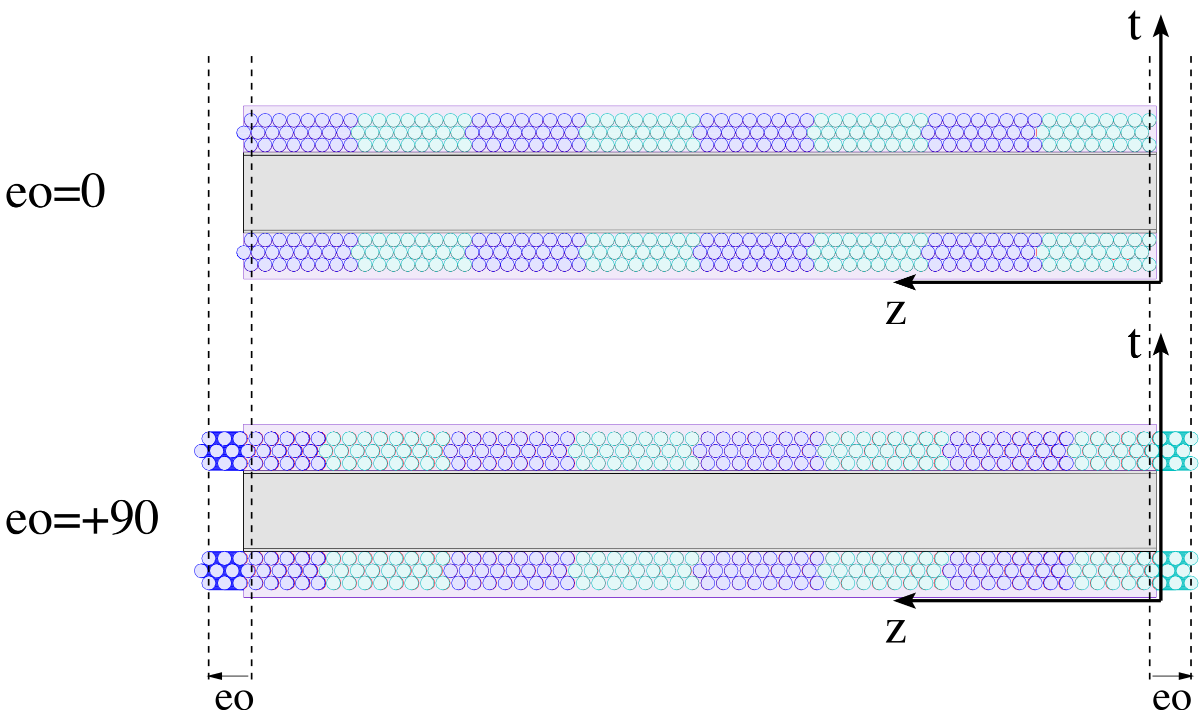


Figure 27: Effect of Cross plate elongation eo=+90mm in the tz plane. The non-deformed crossplates are shown superimposed for reference.

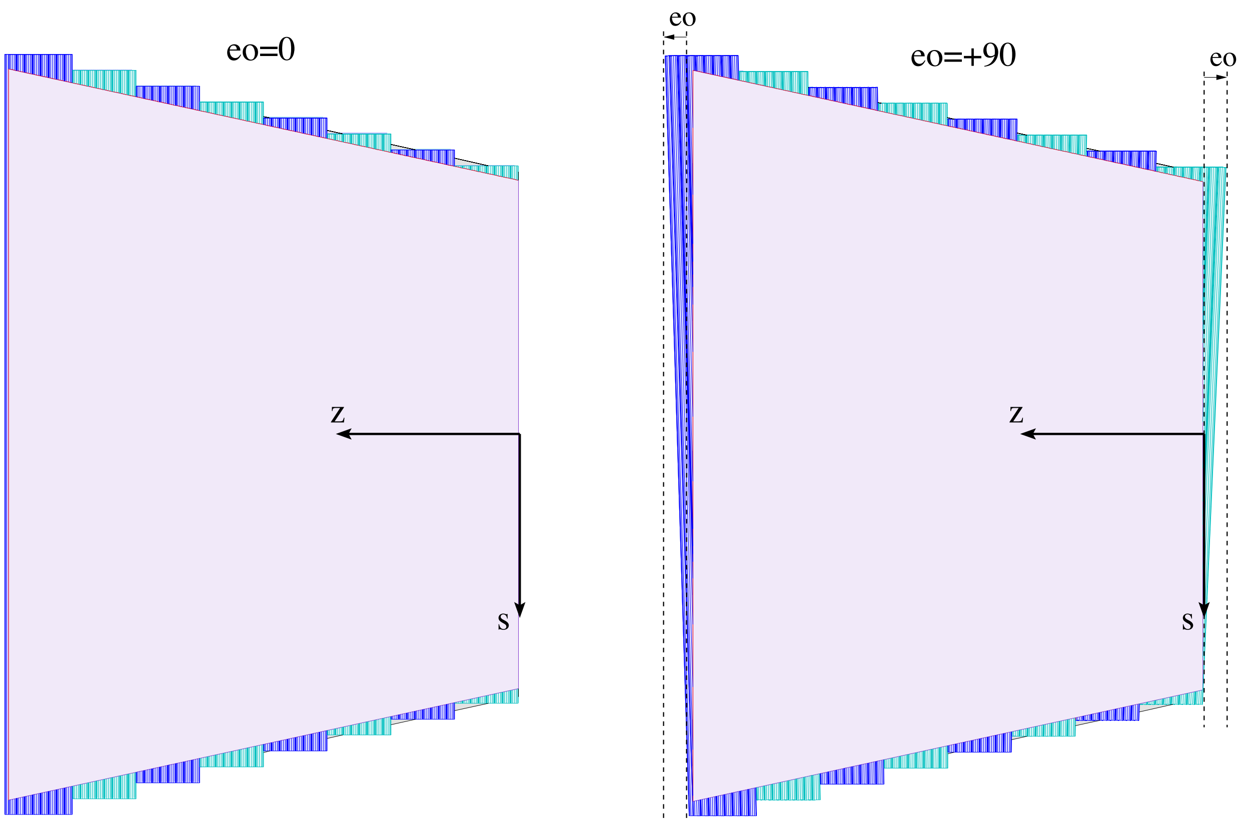


Figure 28: Effect of Cross plate elongation eo=+90mm in the sz plane.

9.4 Longbeam sags sy,sz

The sy parameter describes the sag along the t-axis. It is positive when the sagitta point to the center of the detector, i.e. opposite to t.

The sz parameter describes the sag along the z-axis. It has its sign going with z (???).

9.5 Trapezoidal effect tr

tr positive corresponds to a trapezoid with large base on high-t side ???

9.6 Temperature global expansion T

The expansion is expressed with respect to the reference temperature T=20^{o}C.

10 Definition of Dead Matter elements

10.1 The AGDD-XML Description

10.2 Implementation in AMDB

References

[1] G. Bachy, Atlas Project Document ATL-GE-CERN-QAP-024.01 (1996).

[2] K. Assamagan, et al., Atlas Communication ATL-COM-MUON-2002-0019 (2002).

[3] http://atlas.web.cern.ch/Atlas/project/TGC/www/design/tgc.xls