ITk Pixel – Outer Barrel Naming Convention

Abstract

The present document outlines the naming scheme devised to identify the components and sub-assemblies comprising the Pixel Outer Barrel.

Prepared by:	Checked by:	Approved by:
Diego Alvarez Feito (CERN) **Sebastien Michal (UniGe)**	**Sergio Gonzalez Sevilla (UniGe)** **Matthias Hamer (Bonn)** **Susanne Kuehn (CERN)**	

Distribution List:	*EDMS Approval by:*

Revision History			
Rev. No.	1.0	Initial Version	Diego Alvarez Feito
	1.1	Corrected version with comments from S. Gonzalez and S. Kuehn	Diego Alvarez Feito
	2.0	Updates in the Type-1 section, with a more comprehensive naming scheme for the bundles, including their grouping at PP1 and the termination boards at the opto-end.	Diego Alvarez Feito
	2.1	Minor modifications for the name of the IU data bundles	Diego Alvarez Feito

5

Contents

1. Introduction: General Outer Barrel Naming Scheme

A unique naming convention has been developed to identify unequivocally all the elements in the Outer Barrel detector. It is to be used in all the areas of the design, including the connectivity maps for the electrical and cooling services at the Patch Panel 1 (PP1) and at the opto-boxes. The Outer Barrel naming convention follows the scheme below[1], which is described in more detail in the next sections:

Table 1. Scheme used in the Outer Barrel naming convention. Items in brackets are optional (i.e. only required in certain cases).

Coordinate System Identifier	-	**Sub-System Identifier**	-	**Component or Sub-assembly Identifier**	-	**(Detector Side)**	-	**(Item Identifier)**

2. Coordinate System Identifier

The first letter in the OB naming denotes the coordinate system used to identify the component or sub-assembly. Two different options are considered, as shown in Table 2.

Table 2. Identifier for the coordinate system used in the name of an OB component or sub-assembly.

	Identifier	**Meaning**
Coordinate System	**G**	**Global**
	L	**Local**

The "Global" Outer Barrel naming scheme relies on the official ATLAS detector coordinate system. In this framework, the phi-positions of angular sectors or components in the detector are numbered starting from the positive x-axis and increase with the azimuth angle (Φ) regardless of the detector side or point of view (see Figure 1).

[1] *A similar naming convention following an equivalent scheme has been adapted for the Endcap and Inner System.*

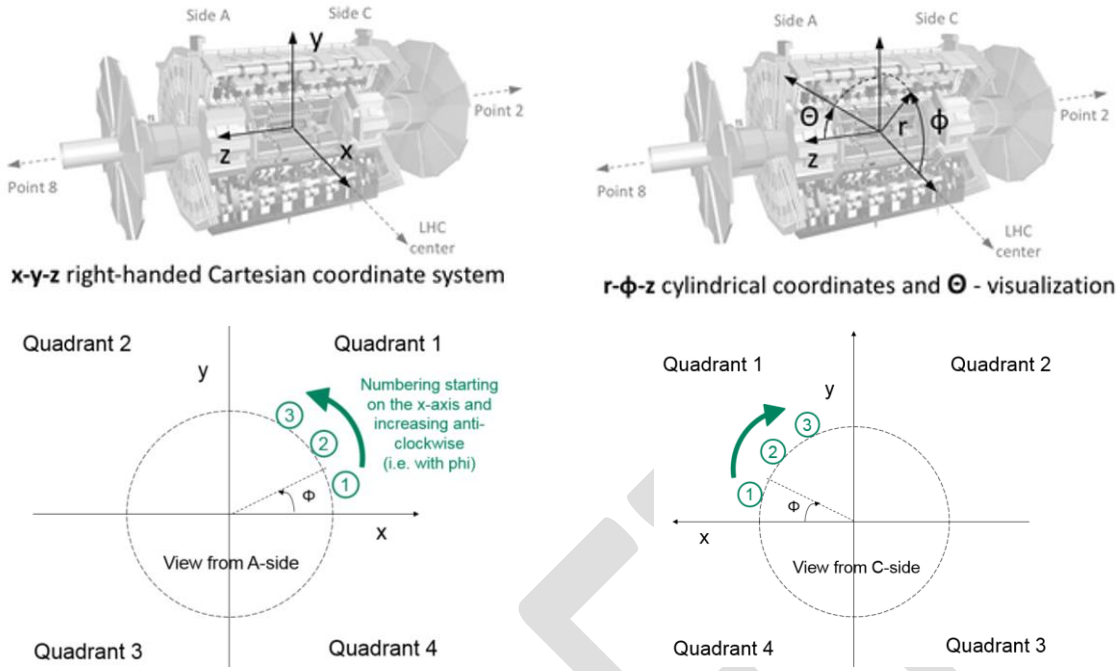


Figure 1. Top: ATLAS Detector axis used to define the Global coordinate system (G) for the Outer Barrel naming convention. Bottom: Corresponding numbering scheme for the phi-positions in the A (left) and C (right) sides of the detector.

The use of a "Local" coordinate system is also contemplated, as it offers significant advantages during the design and construction phases of the project. In particular, a "local" naming convention is very convenient when multiple copies of the same sub-assembly are used in different positions within the detector. In those situations, if the final position of a sub-assembly cannot be defined when it is first put together, a "local" naming scheme is required to identify its components until sufficient information is available to designate them according to the global coordinate system (i.e. until the final position of the sub-assembly is determined). This is the certainly the case for the Outer Barrel local supports. For example, all the inclined half rings (IHR) in a given layer are identical and therefore interchangeable[2]. As such, their assignment to a specific inclined unit and their position in Z are not defined neither by design nor when the half rings are first assembled. Instead, their final position in the detector will be chosen considering the integration needs and the performance measured in the QC tests. Taking this into account, the local coordinate systems showed in Figure 2 and Figure 3 can also be used to refer to the components in the longerons and the inclined half rings respectively.

[2] *Similarly, the longerons in a given layer can be classified in one of two categories depending on the orientation of the cooling pipe, which is set to be connected to either the A or the C side of the detector.*

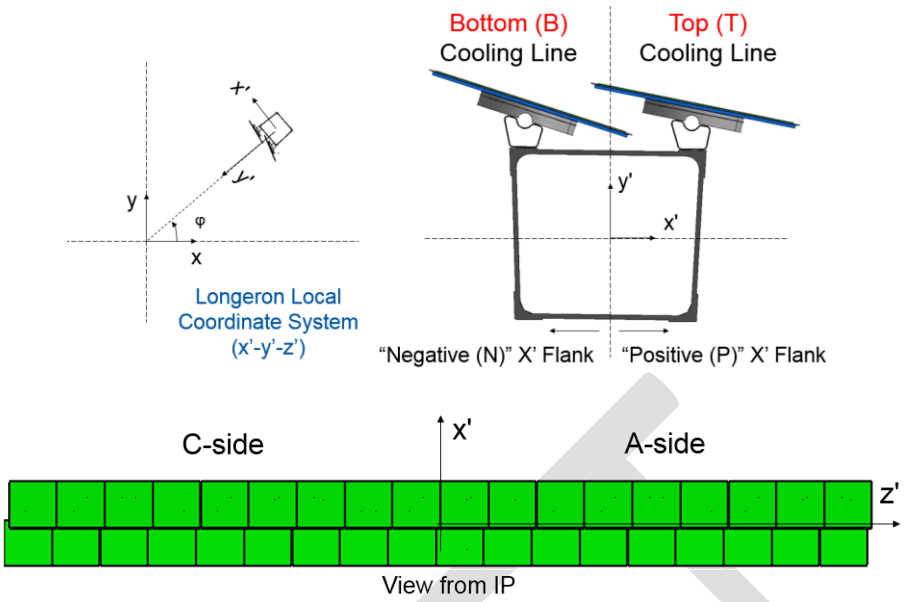


Figure 2. Local coordinate system (x'-y'-z') used for the Outer Barrel Longerons.

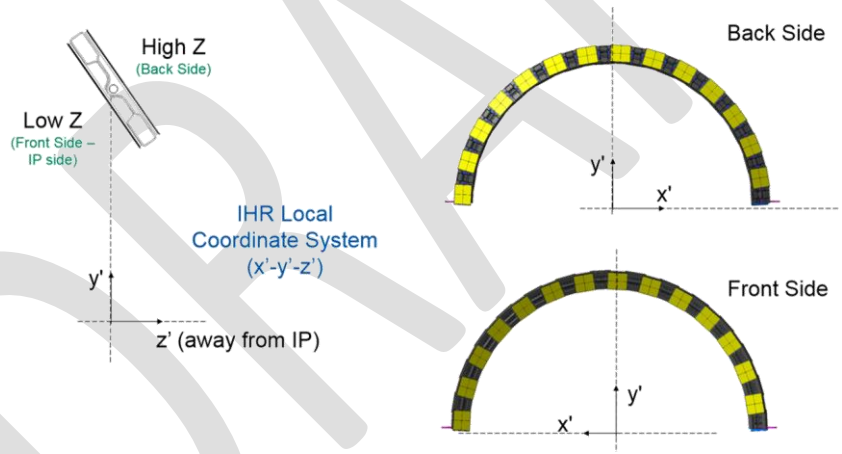


Figure 3. Local coordinate system (x'-y'-z') used for the Outer Barrel Inclined Half Rings (IHR).

3. Sub-system Identifier

In order to identify components from the three Pixel sub-detectors, the general naming convention includes a two-letter sub-system identifier after the coordinate system label (see Table 3).

Table 3. Identifiers for the three Pixel Sub-systems.

Sub-System	Identifier	Meaning
	OB	Outer Barrel
	EC	Outer Endcap
	IS	Inner System

4. Component or Sub-assembly Identifier

4.1 Outer Barrel Halves

For integration reasons, the Outer Barrel is built in two halves, one at each side of the horizontal plane x-z. As shown in Figure 4, the top and bottom halves are referred to as Outer Barrel Half 1 and 2 respectively. In the global naming scheme these assemblies are identified as G-OB-H1 and G-OB-H2 respectively. However, for simplicity they are often referred to as OBH1 and OBH2. It should be noted that all the Outer Barrel components (i.e. modules, support structures, cooling pipes, electrical services) are part of one of these two assemblies.

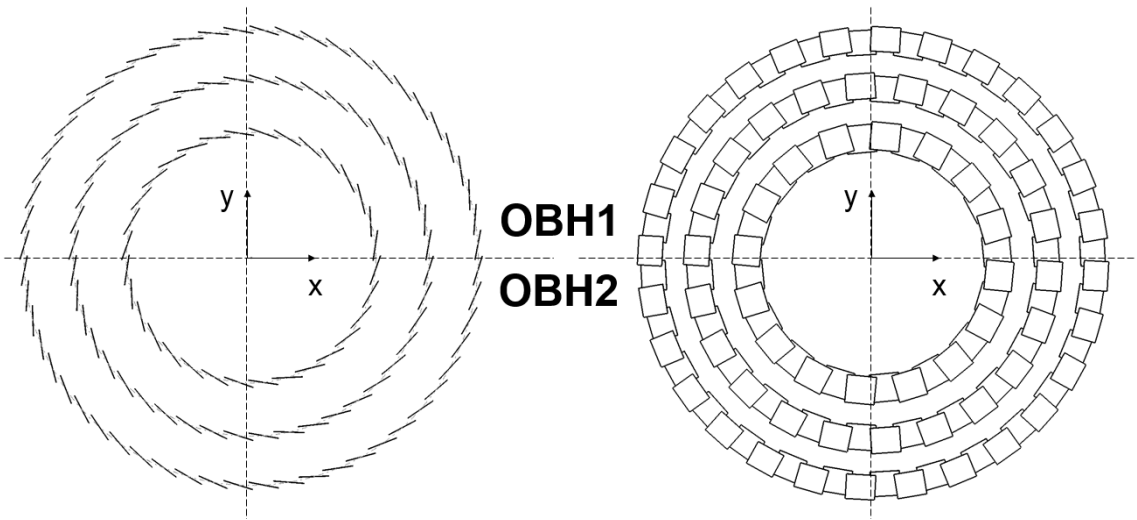


Figure 4. Front view of the flat (left) and inclined (right) sections of the Outer Barrel layout illustrating the split in the Outer Barrel halves 1 and 2 (OBH1 and OBH2 respectively).

4.2 Outer Barrel Half Layers: Barrel Halves and Inclined Units

An Outer Barrel half contains three half layers (HL), each comprising a barrel half (BH) in the centre and two inclined units (IU), one at either side of the longerons. Table 4 summarises the names used to identify these assemblies in the global coordinate system.

Table 4. Name used to identify the individual half layers, barrel halves and inclined units in the Outer Barrel in the global coordinate system.

OB Half	Half Layer	Barrel Half	Inclined Units	
G-OB-H1	G-OB-H1-HL2	G-OB-H1-BH2	G-OB-H1-IU2-A	G-OB-H1-IU2-C
	G-OB-H1-HL3	G-OB-H1-BH3	G-OB-H1-IU3-A	G-OB-H1-IU3-C
	G-OB-H1-HL4	G-OB-H1-BH4	G-OB-H1-IU4-A	G-OB-H1-IU4-C
G-OB-H2	G-OB-H2-HL2	G-OB-H2-BH2	G-OB-H2-IU2-A	G-OB-H2-IU2-C
	G-OB-H2-HL3	G-OB-H2-BH3	G-OB-H2-IU3-A	G-OB-H2-IU3-C
	G-OB-H2-HL4	G-OB-H2-BH4	G-OB-H2-IU4-A	G-OB-H2-IU4-C

4.3 Local Supports

In the global coordinate system, the OB local supports are designated according to their position in the detector following the scheme summarised in Table 5. The name begins with the detector layer, which is indicated by a label "L" followed by the layer number (i.e. 2, 3 or 4). The type of local support and its position within the layer are described in more detail in the next sections.

Table 5. General naming structure for the Outer Barrel local supports.

Detector Layer - Local Support Type - Position within Layer

4.3.1 Outer Barrel Flat Region: Longerons

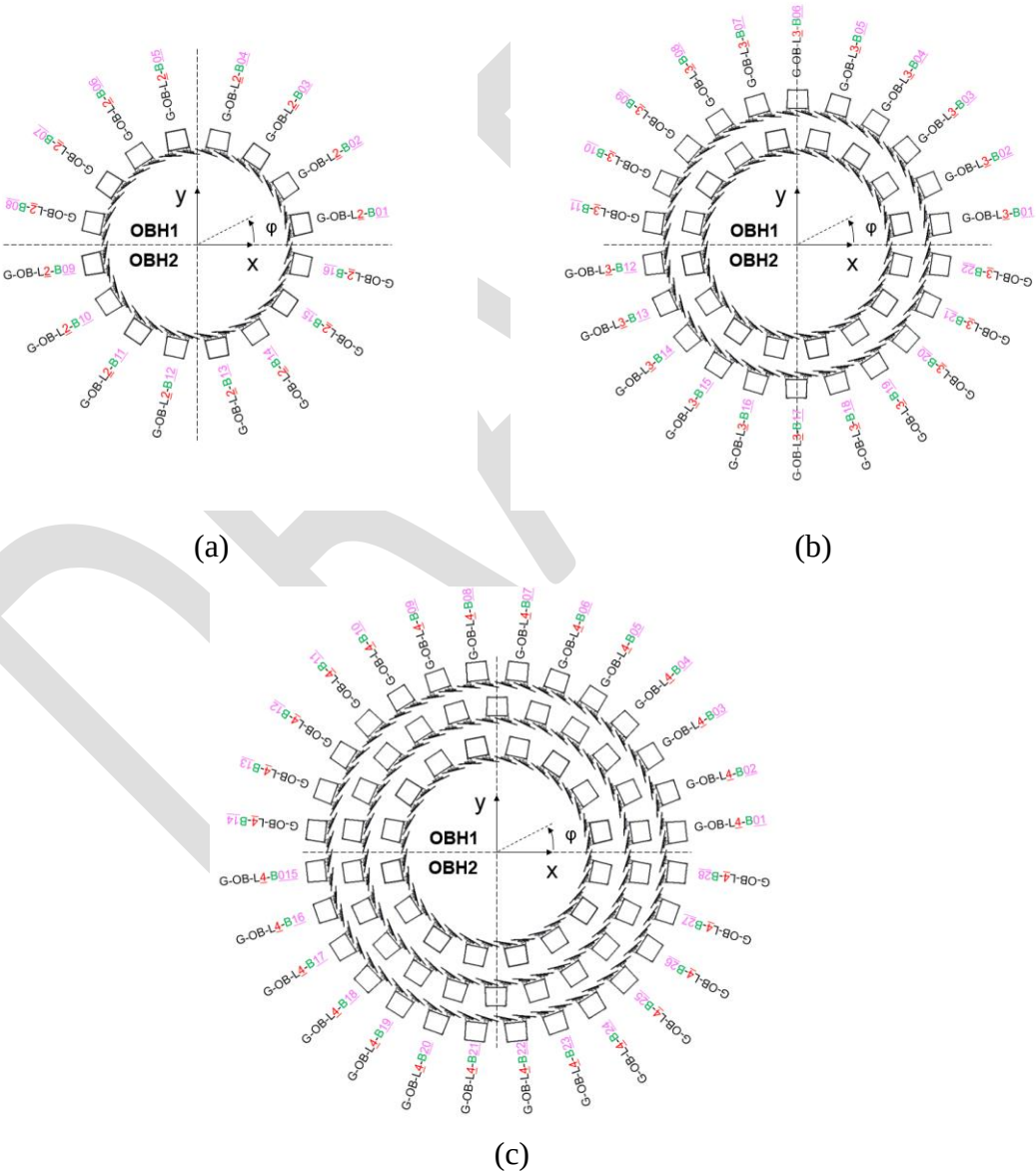
4.3.1.1 Name and Detector Position

In the flat section, the longerons are named with the letter "B" followed by a two-digit number which refers to their phi-position. As stated in section 2, in the global coordinate system the

130 phi-positions are numbered starting from the positive x-axis with the increasing azimuth angle. The resulting names of the OB longerons are shown in Figure 5.

Table 6. Naming scheme for the Outer Barrel Longerons. The letter "L" denotes the layer, while the two-digit number following the barrel (B) label refers to the azimuthal position in the
135 *layer.*

Coordinate System Identifier	**-**	**OB**	**-**	**L#**	**-**	**B##**



(a) (b)

(c)

Figure 5. Name of the Outer Barrel Longerons in layers (a) 2, (b) 3 and (c) 4 in the global coordinate system.

4.3.1.2 Longeron Items

The components within an Outer Barrel Longeron are named according to the scheme below.

Table 7. Naming scheme for the components in the Outer Barrel Longerons. Items in brackets are optional (i.e. only required in certain cases).

(Detector Side)	**-**	**Item Identifier**	**-**	**(Longeron "Flank")**	**-**	**(Item Number)**

An Outer Barrel longeron comprises two rows of modules, each placed at either side of the local y'-axis defined in Figure 2. In this local coordinate system, the two sides of the longeron are designated as the "positive" (P) and "negative" (N) flanks in reference to the corresponding sides of the local x'-axis. On the other hand, in the global coordinate system the two sides are denoted as "top" (T) and "bottom" (B), alluding to the relative position of the corresponding modules (the modules in the "top" side are above those in the "bottom" in the overlap region)[3].

4.3.1.2.1 Longeron Modules, Cells, Cooling Blocks, Graphite Tiles and Base Blocks

The item identifiers for the modules, the cells, the cooling blocks, the graphite tiles and the base blocks are summarised in Table 8. As for their numbering, it starts at the origin of the coordinate system[4] and increases with the distance to the interaction point (see Figure 6). As an example, the complete name of all the modules in longeron G-OB-L4-04 is summarised in Table 9.

[3] This distinction is necessary to prevent any confusion arising from the mismatch between the global x-axis and the local x'-axis. The local terminology is easier to use for the design of the longeron, whilst the global naming is better suited for the cell integration process, where the "top" and "bottom" sides can be easily identified visually.

[4] It should be noted that the position along the beam pipe is the same for the origins of both the global and local coordinate system for the longerons (i.e. the interaction point is both at z=0 and z'=0).

Table 8. Identifiers for the modules, the cells, the cooling blocks, the graphite tiles and the base blocks.

Component or Sub-assembly	Identifier
Module	M
Cell	CE
Cooling Block	CB
Graphite Tile	GT
Base Block	BB

160

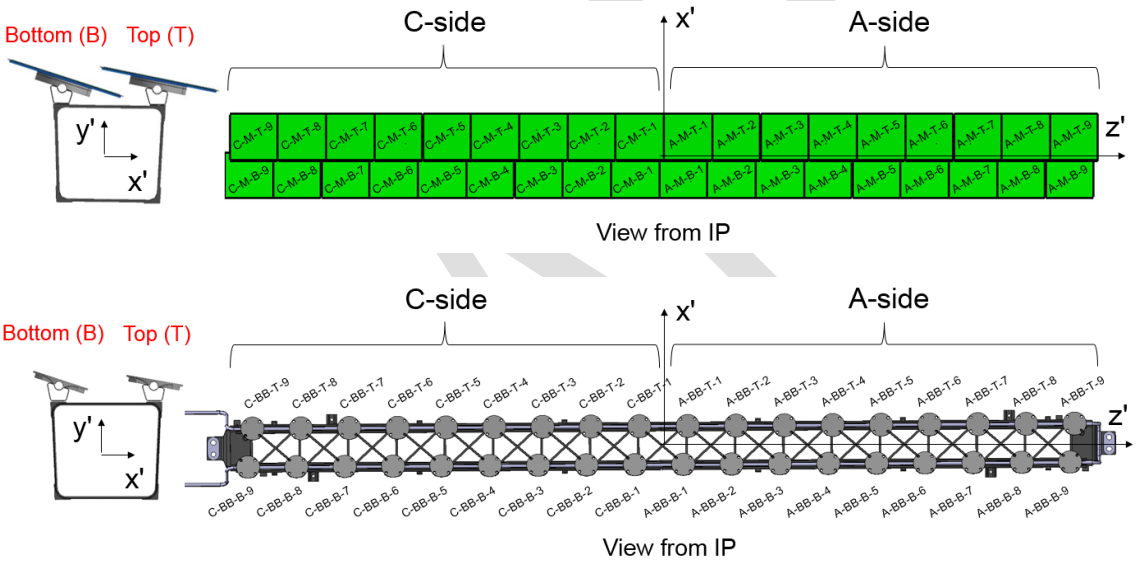


Figure 6. Example of the naming of the modules (top) and the base blocks (bottom) in an Outer Barrel longeron in the global coordinate system.

Table 9. Complete name of all the modules in longeron G-OB-L4-04 in the global coordinate system.

Detector Side	Longeron Flank	Modules								
A	"Top"	G-OB-L4-B04-A-M-T-1	G-OB-L4-B04-A-M-T-2	G-OB-L4-B04-A-M-T-3	G-OB-L4-B04-A-M-T-4	G-OB-L4-B04-A-M-T-5	G-OB-L4-B04-A-M-T-6	G-OB-L4-B04-A-M-T-7	G-OB-L4-B04-A-M-T-8	G-OB-L4-B04-A-M-T-9
	"Bottom"	G-OB-L4-B04-A-M-B-1	G-OB-L4-B04-A-M-B-2	G-OB-L4-B04-A-M-B-3	G-OB-L4-B04-A-M-B-4	G-OB-L4-B04-A-M-B-5	G-OB-L4-B04-A-M-B-6	G-OB-L4-B04-A-M-B-7	G-OB-L4-B04-A-M-B-8	G-OB-L4-B04-A-M-B-9
C	"Top"	G-OB-L4-B04-C-M-T-1	G-OB-L4-B04-C-M-T-2	G-OB-L4-B04-C-M-T-3	G-OB-L4-B04-C-M-T-4	G-OB-L4-B04-C-M-T-5	G-OB-L4-B04-C-M-T-6	G-OB-L4-B04-C-M-T-7	G-OB-L4-B04-C-M-T-8	G-OB-L4-B04-C-M-T-9
	"Bottom"	G-OB-L4-B04-C-M-B-1	G-OB-L4-B04-C-M-B-2	G-OB-L4-B04-C-M-B-3	G-OB-L4-B04-C-M-B-4	G-OB-L4-B04-C-M-B-5	G-OB-L4-B04-C-M-B-6	G-OB-L4-B04-C-M-B-7	G-OB-L4-B04-C-M-B-8	G-OB-L4-B04-C-M-B-9

4.3.1.2.2 Longeron Serial Powering Chains and Type-0 Services

The modules in a Longeron are divided into four serial powering chains (i.e. SP-chains), two per detector side. Modules of the two sides of the cooling loop (i.e. from the positive and negative x' flanks of the Longeron) are grouped in the same SP-chain, following a so-called "tree" arrangement. Two short chains with six modules each are used in the central part of the longeron, while twelve modules are grouped together in a longer chain at either side. The distributed PP0 for each of the four SP-chains in a longeron is implemented in a separate rigid-flex (comprising one or two rigid boards) placed on top of the truss, which includes a series of connectors to interface with the data and power (and DCS) Type-1 bundles[5]. Along the length of the longeron, short flexible circuits also known as "wings" protrude beyond the footprint of the rigid boards. Each wing has a connector to interface with a pixel module through a separate flexible printed circuit referred to as "pigtail". The identifiers used to refer to these elements are summarised in Table 10.

The numbering scheme for these components is equivalent to that used for the modules in the global coordinate system, i.e. starting at the origin of the global coordinate system and increasing with the distance to the interaction point (see Figure 7). As an example, the complete name of all the pigtails in longeron G-OB-L4-04 is summarised in Table 11.

[5]*The number of Type-1 data connectors in the distributed PP0 for the Longerons varies with the layer according to the required number of uplinks.*

185 *Table 10. Identifiers for the serial powering chains and the Type-0 services (including their components, i.e. rigid boards, wings, connectors and pigtails).*

Item	**Identifier**
Serial Powering Chain	SP
Rigid Flex	RF
Rigid Board	RB
Wing	WN
Pigtail	PG
Module connector (pigtail-wing interface)	MC
Type-1 Data connector	DC
Type-1 Power & DCS connector	PC

Table 11. Complete name of all the module pigtails in longeron G-OB-L4-04 in the global coordinate system.

Detector Side	**Longeron Flank**	**Module Pigtails**								
A	"Top"	G-OB-L4-B04-A-PG-T-1	G-OB-L4-B04-A-PG-T-2	G-OB-L4-B04-A-PG-T-3	G-OB-L4-B04-A-PG-T-4	G-OB-L4-B04-A-PG-T-5	G-OB-L4-B04-A-PG-T-6	G-OB-L4-B04-A-PG-T-7	G-OB-L4-B04-A-PG-T-8	G-OB-L4-B04-A-PG-T-9
	"Bottom"	G-OB-L4-B04-A-PG-B-1	G-OB-L4-B04-A-PG-B-2	G-OB-L4-B04-A-PG-B-3	G-OB-L4-B04-A-PG-B-4	G-OB-L4-B04-A-PG-B-5	G-OB-L4-B04-A-PG-B-6	G-OB-L4-B04-A-PG-B-7	G-OB-L4-B04-A-PG-B-8	G-OB-L4-B04-A-PG-B-9
C	"Top"	G-OB-L4-B04-C-PG-T-1	G-OB-L4-B04-C-PG-T-2	G-OB-L4-B04-C-PG-T-3	G-OB-L4-B04-C-PG-T-4	G-OB-L4-B04-C-PG-T-5	G-OB-L4-B04-C-PG-T-6	G-OB-L4-B04-C-PG-T-7	G-OB-L4-B04-C-PG-T-8	G-OB-L4-B04-C-PG-T-9
	"Bottom"	G-OB-L4-B04-C-PG-B-1	G-OB-L4-B04-C-PG-B-2	G-OB-L4-B04-C-PG-B-3	G-OB-L4-B04-C-PG-B-4	G-OB-L4-B04-C-PG-B-5	G-OB-L4-B04-C-PG-B-6	G-OB-L4-B04-C-PG-B-7	G-OB-L4-B04-C-PG-B-8	G-OB-L4-B04-C-PG-B-9

190

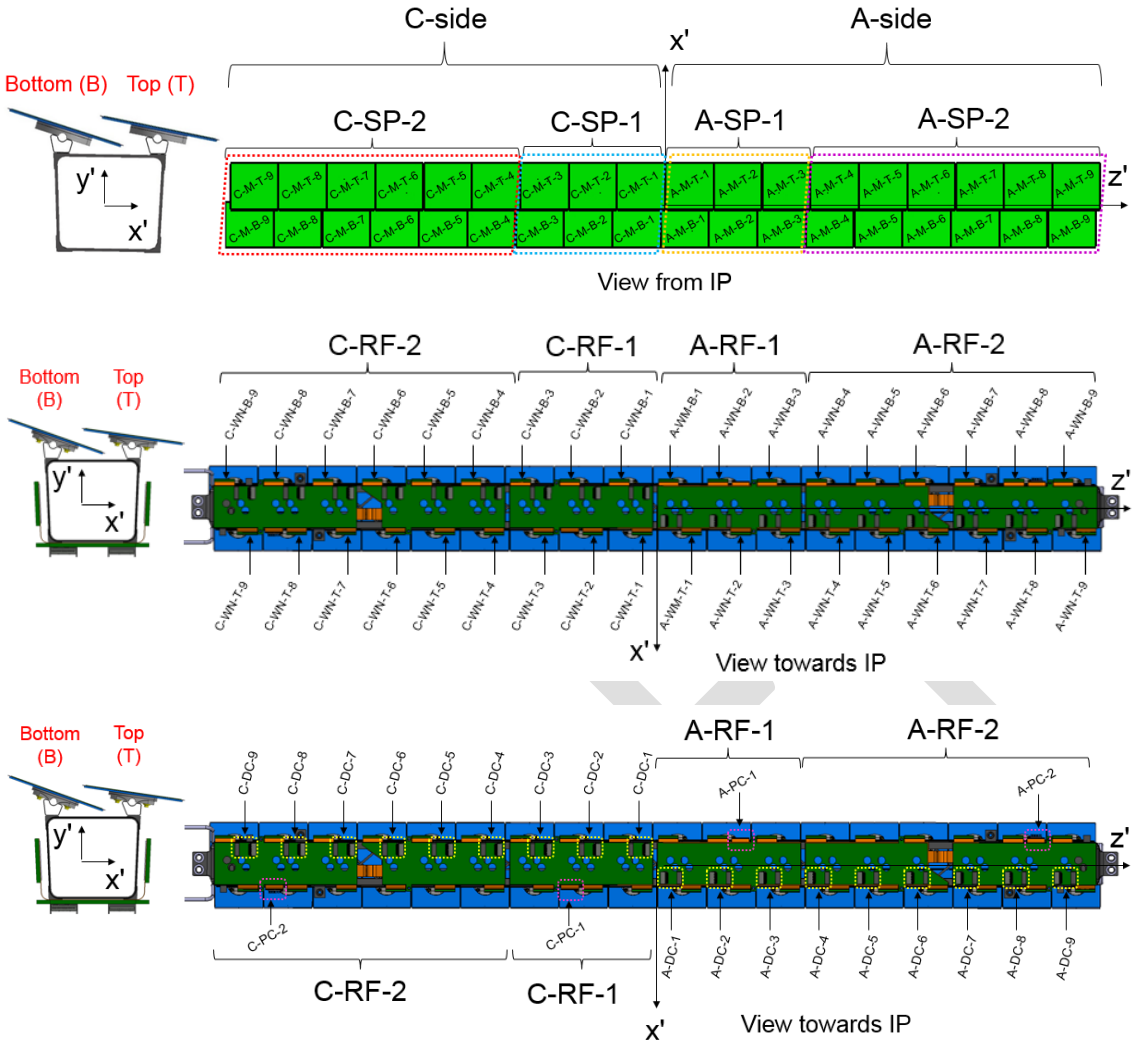


Figure 7. Example of the naming for the serial powering chains (top), the rigid-flexes and their wings (middle) and the Type-1 data and power connectors (bottom) in an Outer Barrel longeron in the global coordinate system. The number and position of data connectors showed in the pictures represents the maximum which can be fitted in the Outer Barrel volume, but does not correspond to any specific layer since the reduction of the trigger rate in layer 4 from 4MHz to 1MHz.

4.3.1.2.3 Longeron Evaporator

The two cooling lines of a longeron run parallel to the beam pipe, one on each flank. They are connected in series though the U-turn to create a single evaporator, which is identified with the letters "EV". If needed, the longeron flank ("T/B" or "P/N" in the global and local coordinate systems respectively) can be added to the name to identify the individual branches of a given evaporator. It should be noted that, while it is not strictly needed to identify a longeron evaporator, the detector side label (i.e. A or C) is added to its name in the global coordinate

system in order to indicate the patch panel 1 to which it is connected fluidically (see section 4.5 for more details). As an example, the names of the evaporators for the longerons in layer 2 are included in Table 12.

Table 12. Name in the global coordinate system used to identify the evaporators of the longerons from layer 2. The detector side label denotes the patch panel 1 from which a given evaporator is fed with CO_2 coolant.

Barrel Half	**PP1 Side**	**Longeron Evaporator**			
G-OB-H1-BH2	A	G-OB-L2-B02-A-EV	G-OB-L2-B04-A-EV	G-OB-L2-B06-A-EV	G-OB-L2-B08-A-EV
	C	G-OB-L2-B01-C-EV	G-OB-L2-B03-C-EV	G-OB-L2-B05-C-EV	G-OB-L2-B07-C-EV
G-OB-H2-BH2	A	G-OB-L2-B10-A-EV	G-OB-L2-B12-A-EV	G-OB-L2-B14-A-EV	G-OB-L2-B16-A-EV
	C	G-OB-L2-B09-C-EV	G-OB-L2-B11-C-EV	G-OB-L2-B13-C-EV	G-OB-L2-B15-C-EV

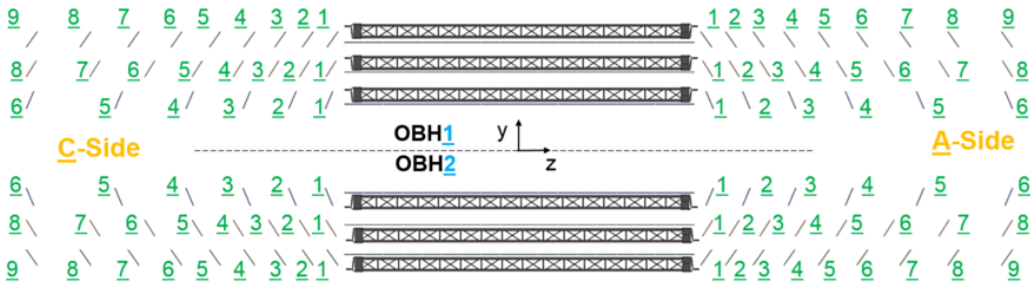
4.3.2 Outer Barrel Inclined Region: Inclined Half Rings

4.3.2.1 Name and detector Position

In the inclined regions, the half rings are named with the letter "R" followed by a two-digit number which refers to their z-position. As illustrated in Figure 8, in the global coordinate system the z-positions are numbered starting at the closest inclined half ring to the longerons and increase with the distance to the interaction point (IP). Next, the labels "T" and "B" are used to distinguish between half rings installed in the top and bottom halves of the Outer Barrel (i.e. OBH1 and OBH2 respectively). Finally, the letters "A" or "C" are used to indicate whether the ring is placed on the positive or negative end of z-axis (i.e. in the A or C-sides of the detector respectively). The resulting structure is summarised in Table 13, while the names of the OB inclined half rings in the global coordinate system are shown in Figure 9.

Table 13. Naming scheme for the Outer Barrel Inclined Half Rings. The letter "L" denotes the layer, while the two-digit number (##) following the ring (R) label refers to the z-position in the layer. The letters "T" and "B" denote whether the half rings are installed in the top or bottom half of the Outer Barrel, while "A" or "C" are used to indicate the detector side.

Coordinate System Identifier	**-**	**OB**	**-**	**L#**	**-**	**R##**	**-**	**OBH1 or OBH2 (T/B)**	**-**	**Detector Side (A/C)**



230 *Figure 8. Numbering scheme adopted to indicate the z-position of the inclined half rings in the global coordinate system.*

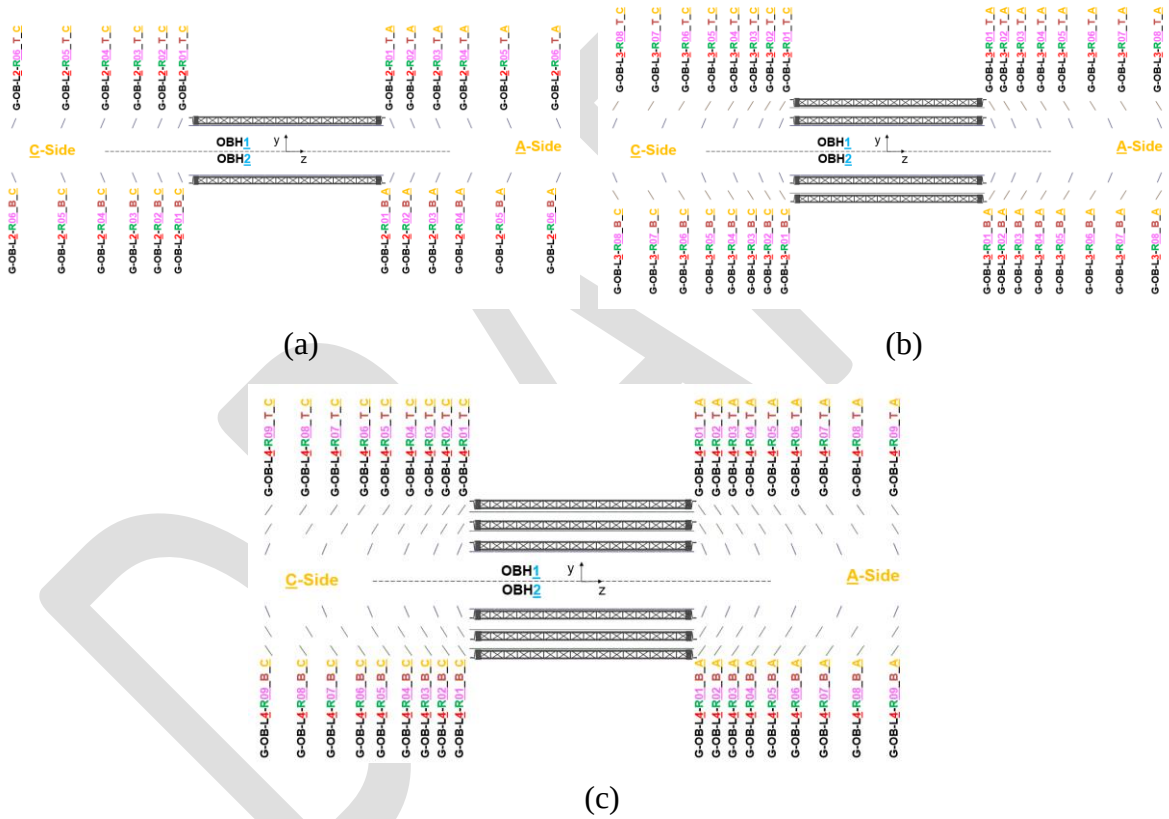


Figure 9. Name of the Outer Barrel Inclined Half Rings in layers (a) 2, (b) 3 and (c) 4 in the global coordinate system.

235 ### *4.3.2.2 Inclined Half Ring Items*

The components within an Outer Barrel inclined half ring are named according to the scheme shown in Table 14. Because of their conical nature, the two sides of the Outer Barrel inclined

half rings are somewhat different. The side facing the interaction point is referred to as the "front" (F) of the ring, with the other side being referred to as "back" (B) side [6] (see Figure 3).

Table 14. Naming scheme for the components in the Outer Barrel IHRs. Items in brackets are optional (i.e. only required in certain cases). Unlike in the longerons, the detector side label is included in the IHR name, so it is not needed to identify the individual components.

Item Identifier	**-**	**(IHR "Side")**	**-**	**(Item Number)**

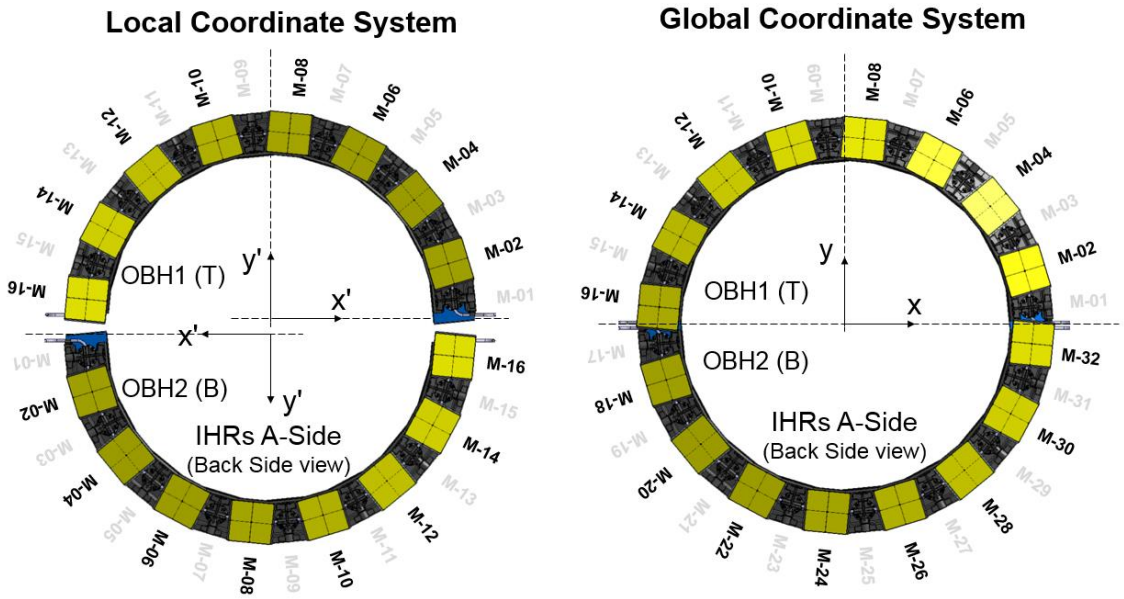
4.3.2.2.1 IHR Modules, Cells, Cooling Blocks, Graphite Tiles and Base Blocks

The item identifiers for the modules, the cells, the cooling blocks, the graphite tiles and the base blocks for the inclined half rings are the same than those used in the longerons (see Table 8). As for their phi-position, the numbering starts from the positive x-axis of the relevant coordinate system and increases with the azimuth angle. This results in two different numbering schemes in the local and global coordinate system, as the local coordinate system (x'-y'-z') rotates with the IHR when it is installed in OBH2 (see Figure 10). It should be noted that, due to the design of the OB layout and local supports, the odd numbers correspond to the front of the half ring while the even numbers refer to the back side regardless of the coordinate system. As an example, the complete names for the modules in two IHRs, G-OB-L2-R04-T-A and G-OB-L2-R04-B-A, are summarised in Table 15.

Table 15. Name of all the modules in the IHRs G-OB-L2-R04-T-A and G-OB-L2-R04-B-A in the global coordinate system.

IHR	**Modules**							
G-OB-L2-R04-T-A	G-OB-L2-R04-T-A-M-01	G-OB-L2-R04-T-A-M-03	G-OB-L2-R04-T-A-M-05	G-OB-L2-R04-T-A-M-07	G-OB-L2-R04-T-A-M-09	G-OB-L2-R04-T-A-M-11	G-OB-L2-R04-T-A-M-13	G-OB-L2-R04-T-A-M-15
	G-OB-L2-R04-T-A-M-02	G-OB-L2-R04-T-A-M-04	G-OB-L2-R04-T-A-M-06	G-OB-L2-R04-T-A-M-08	G-OB-L2-R04-T-A-M-10	G-OB-L2-R04-T-A-M-12	G-OB-L2-R04-T-A-M-14	G-OB-L2-R04-T-A-M-16
G-OB-L2-R04-B-A	G-OB-L2-R04-B-A-M-17	G-OB-L2-R04-B-A-M-19	G-OB-L2-R04-B-A-M-21	G-OB-L2-R04-B-A-M-23	G-OB-L2-R04-B-A-M-25	G-OB-L2-R04-B-A-M-27	G-OB-L2-R04-B-A-M-29	G-OB-L2-R04-B-A-M-31
	G-OB-L2-R04-B-A-M-18	G-OB-L2-R04-B-A-M-20	G-OB-L2-R04-B-A-M-22	G-OB-L2-R04-B-A-M-24	G-OB-L2-R04-B-A-M-26	G-OB-L2-R04-B-A-M-28	G-OB-L2-R04-B-A-M-30	G-OB-L2-R04-B-A-M-32

[6] *The "front" and "back" sides of an inclined half ring are also referred to as "low-z" and "high-z" sides respectively, alluding to their position with respect to the local z'-axis shown in Figure 3.*



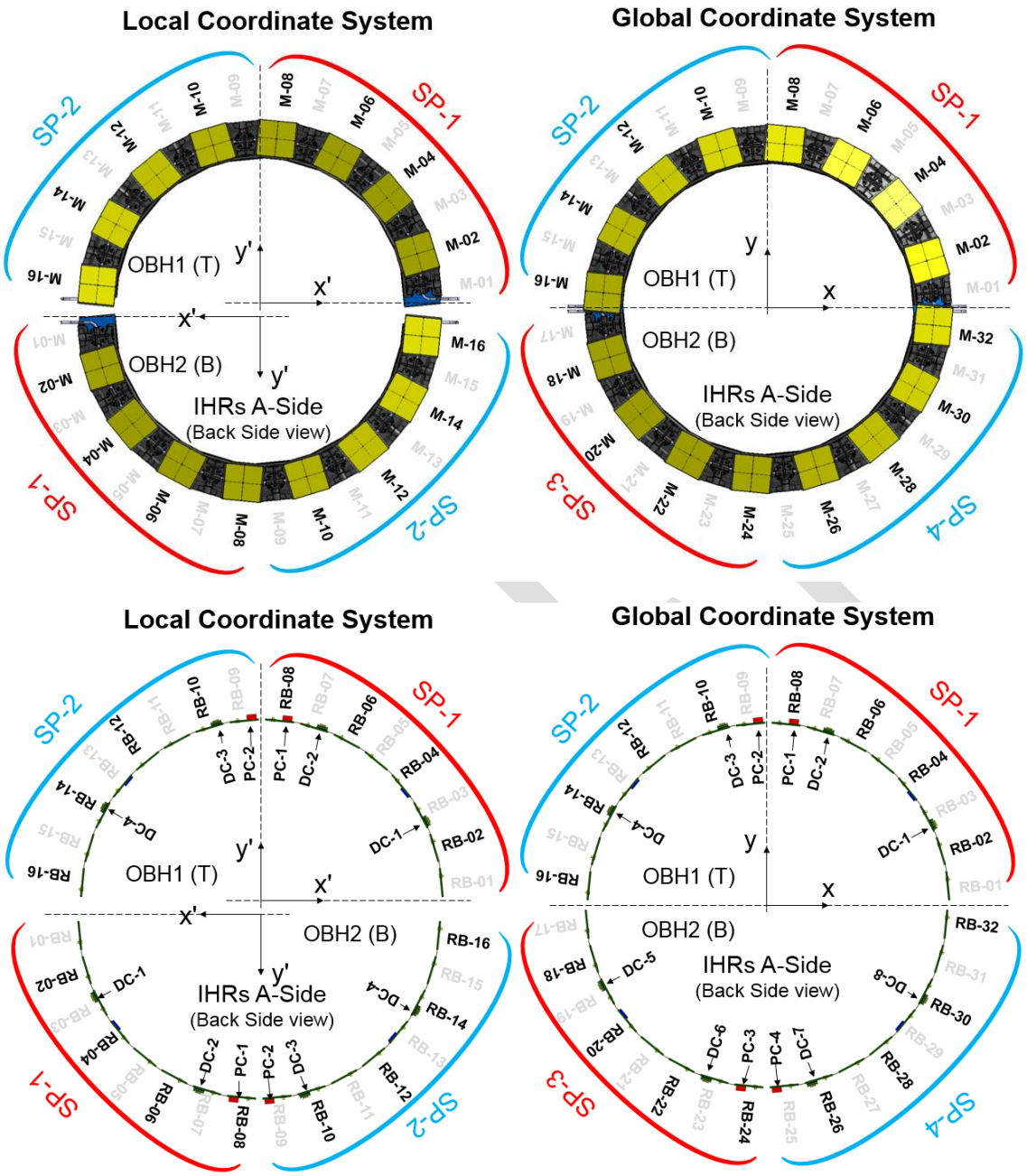
260 *Figure 10. Example of the numbering scheme for the modules in two inclined half rings located in the A-side of layer 2 according to the local (left) and the global (right) coordinate systems. The odd numbers (in grey) correspond to modules on the front of the half ring (i.e. not visible in the pictures), while the even numbers (in black) refer to modules on the back side.*

265

4.3.2.2.2 Inclined Half Ring Serial Powering Chains and Type-0 Services

The modules of an Inclined Half Ring are split in two serial-powering chains at the centre of the ring. Modules from the front and back sides are grouped together following a "tree" scheme equivalent to that used in the longerons. The length of the SP-chains varies with the Outer
270 Barrel layer: eight, eleven and fourteen modules are grouped together in the rings of layers 2, 3 and 4 respectively. Each SP-chain is implemented using a series of rigid boards (RB) connected to one another permanently though a continuous embedded flexible circuit, resulting in a supple construction that can be curved to follow the outer radius of the corresponding half ring. The rigid boards house the connectors to interface with Type-1 services[7] and the modules
275 through the pigtails. The identifiers for these items are the same than those used in the longerons (see Table 10). As for the numbering scheme for these components in the local and global coordinate systems, it is equivalent to that described for the modules in section 4.3.2.2.1 (see Figure 11).

[7] *The number of Type-1 data connectors in the distributed PP0 for the Inclined Half Rings varies with the layer according to the required number of uplinks.*



280 *Figure 11. Example of the naming for the serial powering chains (top), the rigid boards and the Type-1 data and power connectors (bottom) in two inclined half rings from layer 2 according to the local (left) and the global (right) coordinate systems.*

4.3.2.2.3 Inclined Half Ring Evaporator

285 Each inclined half ring contains a single, semi-annular cooling pipe to circulate boiling CO_2. As in the longerons, this evaporator is identified with the letters "EV". As an example, the

names of the evaporators for the inclined half rings in the inclined units "G-OB-H1-IU2-A" and "G-OB-H1-IU2-A" are included in Table 16.

Table 16. Names used to identify the evaporators of the IHRs in the inclined units "G-OB-H1-IU2-A" and "G-OB-H1-IU2-A" in the global coordinate system.

Barrel Half	**IHR Evaporator**		
G-OB-H1-IU2-A	G-OB-L2-R01-T-A-EV	G-OB-L2-R02-T-A-EV	G-OB-L2-R03-T-A-EV
	G-OB-L2-R04-T-A-EV	G-OB-L2-R05-T-A-EV	G-OB-L2-R06-T-A-EV
G-OB-H2-IU2-A	G-OB-L2-R01-B-A-EV	G-OB-L2-R02-B-A-EV	G-OB-L2-R03-B-A-EV
	G-OB-L2-R04-B-A-EV	G-OB-L2-R05-B-A-EV	G-OB-L2-R06-B-A-EV

4.4 Type-1 Services

The Type-1 services for the Outer Barrel are arranged in two types of bundles, namely: (i) power & DCS and (ii) data.

(i) For a given SP-chain, a single power and DCS bundle contains all the conductors used to route the low voltage, high voltage, low power mode, temperature interlock, CAN and VCAN signals up to PP1. On the PP0/Type-0 side, these cables terminate on the corresponding power connector. At PP1, up to four power & DCS bundles from different SP-chains are merged in the same connector.

(ii) The data bundles contain shielded Twinax cables used to route data, clock and command signals up to the opto-boxes. At the PP0 end, groups of up to twelve Twinax cables are terminated in a single PCB, which is inserted in one of the data connectors. These data bundles will be partially ribbonized to improve the packing. Whenever possible, the bundles exiting the individual data connector are grouped together in a larger bundle to ease the routing within the detector volume.

Each Outer Barrel Type-1 bundle connected to an OB PP0 is identified with a unique name which follows the structure outlined in Table 17. For simplicity, the proposed scheme starts with the full name of the corresponding SP chain, adding a specific label to distinguish between power and data bundles (i.e. PB and DB respectively). If needed, the group of Twinax cables exiting a specific PP0 data connector can be identified by adding the identifier and number of said connector (see sections 4.3.1.2.2 and 4.3.2.2.2). Conversely, if the data connector identifier and label are omitted, the bundle name refers to all the Twinax cables for the corresponding serial powering chain. In addition, if the serial powering chain identifier (i.e. SP) and number are omitted, the resulting bundle name can be used to designate the group of data or power bundles connected to a detector side for the corresponding local support. As an example, the

names of the Type-1 bundles for a longeron and an inclined half ring from layer 3 are included in Table 18. A schematic representation of the naming scheme for the bundles connected to the PP0s of the OB local support in layer 3 is shown in Figure 12.

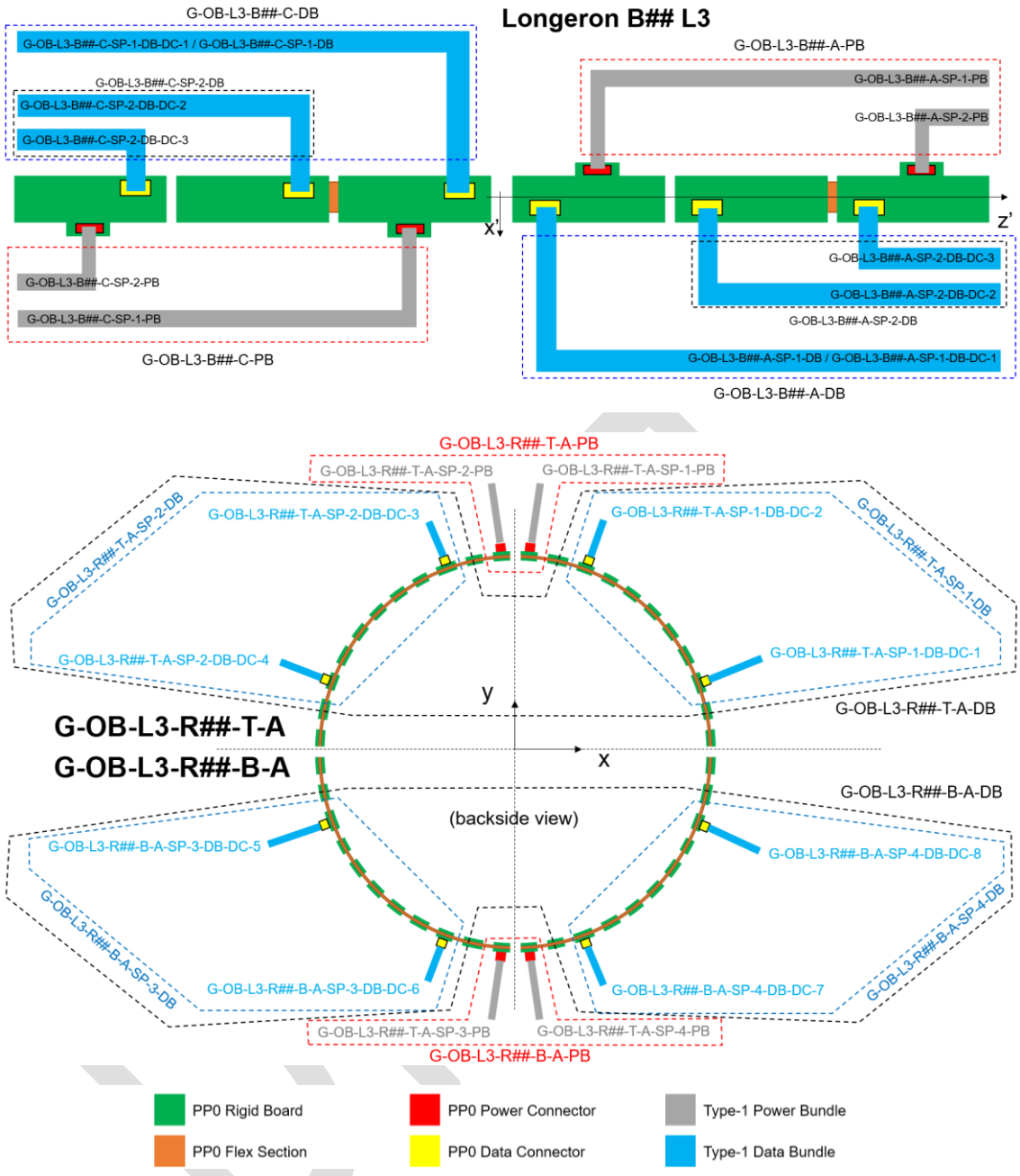
320

Table 17. Naming scheme for the Outer Barrel Type-1 bundles. If present, the items in brackets are used to denote the Twinax bundle exiting a specific data connector from a given SP-chain. Otherwise, the bundle name refers to all the Twinax cables for the corresponding chain.

SP Chain Full Name	-	**Bundle Type Identifier (PB=Power; DB=Data)**	-	**(Data Connector Identifier)**	-	**(Data Connector Number)**

325 *Table 18. Name of the power and data bundles connected to the PP0s of a longeron and an inclined half ring from layer 3 ("G-OB-L3-B02" and "G-OB-L3-R02-B-A" respectively) in the global coordinate system. The name of both the full data bundles for each SP-chain and those of the Twinax bundles exiting the individual PP0 data connectors are included.*

Local Support	**SP Chain**	**Power Bundle**		**Data Bundle**		
				Complete SP Bundle	**Conector Bundle**	**Local Support Bundle**
G-OB-L3-B02	A-SP-1	G-OB-L3-B02-A-SP-1-PB	G-OB-L3-B02-A-PB	G-OB-L3-B02-A-SP-1-DB	G-OB-L3-B02-A-SP-1-DB-DC-1	G-OB-L3-B02-A-DB
	A-SP-2	G-OB-L3-B02-A-SP-2-PB		G-OB-L3-B02-A-SP-2-DB	G-OB-L3-B02-A-SP-2-DB-DC-2	
					G-OB-L3-B02-A-SP-2-DB-DC-3	
	C-SP-1	G-OB-L3-B02-C-SP-1-PB	G-OB-L3-B02-C-PB	G-OB-L3-B02-C-SP-1-DB	G-OB-L3-B02-C-SP-1-DB-DC-1	G-OB-L3-B02-C-DB
	C-SP-2	G-OB-L3-B02-C-SP-2-PB		G-OB-L3-B02-C-SP-2-DB	G-OB-L3-B02-C-SP-2-DB-DC-2	
					G-OB-L3-B02-C-SP-2-DB-DC-3	
G-OB-L3-R02-B-A	SP-3	G-OB-L3-R02-B-A-SP-3-PB	G-OB-L3-R02-B-A-PB	G-OB-L3-R02-B-A-SP-3-DB	G-OB-L3-R02-B-A-SP-3-DB-DC-5	G-OB-L3-R02-B-A-DB
					G-OB-L3-R02-B-A-SP-3-DB-DC-6	
	SP-4	G-OB-L3-R02-B-A-SP-4-PB		G-OB-L3-R02-B-A-SP-4-DB	G-OB-L3-R02-B-A-SP-4-DB-DC-7	
					G-OB-L3-R02-B-A-SP-4-DB-DC-8	



330 *Figure 12. Example of the naming for the type-1 power and data bundles for a longeron (top) and an inclined half ring (bottom) of layer 3 according to the global coordinate system.*

4.4.1 Grouping of OB Type-1 Power Bundles: OB Power "Super-Bundles"

The power bundles of up to four serial powering chains are combined in a single connector at
335 the patch panel 1 (PP1). These groups of power bundles, hereinafter referred to as "power super-bundles", are identified with the label PW.

4.4.1.1 OB Longeron Power Super-Bundles

In the flat section of the Outer Barrel, each power super-bundle is identified with a unique name which follows the structure outlined in Table 19. The proposed scheme starts with the full name of the corresponding barrel half and the detector side, followed by the letters PW and a two-digit number which refers to the phi-position of the longerons. As stated in section 2, in the global coordinate system the phi-positions are numbered starting from the positive x-axis with the increasing azimuth angle (see Figure 13). As an example, the names of the power super-bundles for the layer 2 longerons connected to the A-side PP1 are included in Table 20.

Table 19. Naming scheme for the Outer Barrel Type-1 Power Super-bundles in the flat section.

Barrel Half Full Name	-	Detector Side (A or C)	-	Power Super-bundle Identifier (PW)	-	Super-Bundle Number

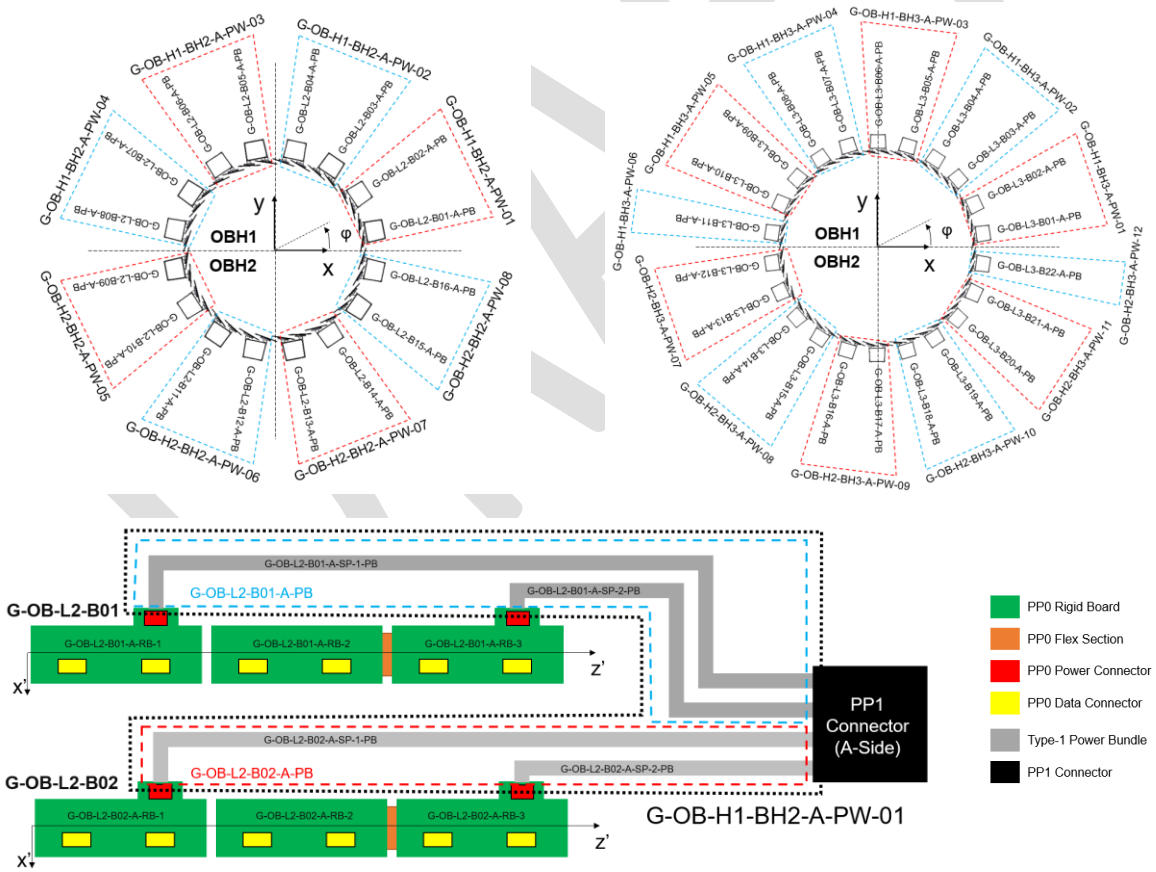


Figure 13. Top: Names of the type-1 power super-bundles of the longerons in layers 2 (top left) and 3 (top right) connected to the A-side PP1 according to the global coordinate system. Bottom: Schematic representation of the power super-bundle G-OB-H1-BH2-A-PW-01.

Table 20. Name in the global coordinate system used to identify the power super-bundles of the longerons in layer 2 connected to the A-side PP1.

Barrel Half	PP1 Side	Longeron	SP Chain Power Bundle	Power Super-Bundle
G-OB-H1-BH2	A	G-OB-L2-B01-A	G-OB-L2-B01-A-SP-1-PB	G-OB-H1-BH2-A-PW-01
			G-OB-L2-B01-A-SP-2-PB	
		G-OB-L2-B02-A	G-OB-L2-B02-A-SP-1-PB	
			G-OB-L2-B02-A-SP-2-PB	
		G-OB-L2-B03-A	G-OB-L2-B03-A-SP-1-PB	G-OB-H1-BH2-A-PW-02
			G-OB-L2-B03-A-SP-2-PB	
		G-OB-L2-B04-A	G-OB-L2-B04-A-SP-1-PB	
			G-OB-L2-B04-A-SP-2-PB	
		G-OB-L2-B05-A	G-OB-L2-B05-A-SP-1-PB	G-OB-H1-BH2-A-PW-03
			G-OB-L2-B05-A-SP-2-PB	
		G-OB-L2-B06-A	G-OB-L2-B06-A-SP-1-PB	
			G-OB-L2-B06-A-SP-2-PB	
		G-OB-L2-B07-A	G-OB-L2-B07-A-SP-1-PB	G-OB-H1-BH2-A-PW-04
			G-OB-L2-B07-A-SP-2-PB	
		G-OB-L2-B08-A	G-OB-L2-B08-A-SP-1-PB	
			G-OB-L2-B08-A-SP-2-PB	
G-OB-H2-BH2	A	G-OB-L2-B09-A	G-OB-L2-B09-A-SP-1-PB	G-OB-H2-BH2-A-PW-05
			G-OB-L2-B09-A-SP-2-PB	
		G-OB-L2-B10-A	G-OB-L2-B10-A-SP-1-PB	
			G-OB-L2-B10-A-SP-2-PB	
		G-OB-L2-B11-A	G-OB-L2-B11-A-SP-1-PB	G-OB-H2-BH2-A-PW-06
			G-OB-L2-B11-A-SP-2-PB	
		G-OB-L2-B12-A	G-OB-L2-B12-A-SP-1-PB	
			G-OB-L2-B12-A-SP-2-PB	
		G-OB-L2-B13-A	G-OB-L2-B13-A-SP-1-PB	G-OB-H2-BH2-A-PW-07
			G-OB-L2-B13-A-SP-2-PB	
		G-OB-L2-B14-A	G-OB-L2-B14-A-SP-1-PB	
			G-OB-L2-B14-A-SP-2-PB	
		G-OB-L2-B15-A	G-OB-L2-B15-A-SP-1-PB	G-OB-H2-BH2-A-PW-08
			G-OB-L2-B15-A-SP-2-PB	
		G-OB-L2-B16-A	G-OB-L2-B16-A-SP-1-PB	
			G-OB-L2-B16-A-SP-2-PB	

4.4.1.2 OB IHR Power Super-Bundles

In the inclined regions, each power super-bundle is identified with the full name of the corresponding inclined unit followed by the letters PW and a two-digit number which refers to the Z position of the relevant half rings (see Table 21). The z-positions of the super-bundles are numbered starting at group of rings closest to the flat region and increases with the distance to the interaction point (see Figure 14). If the number is omitted, the bundle name can be used to refer to all the power super-bundles of the inclined unit. As an example, the names of the power super-bundles for the half rings of the inclined units of layer 3, A-side are included in Table 22.

Table 21. Naming scheme for the Outer Barrel Type-1 power super-bundles of the inclined section.

Inclined Unit Full Name	-	**Power Super-bundle Identifier "PW"**	-	**(Super-Bundle Number)**

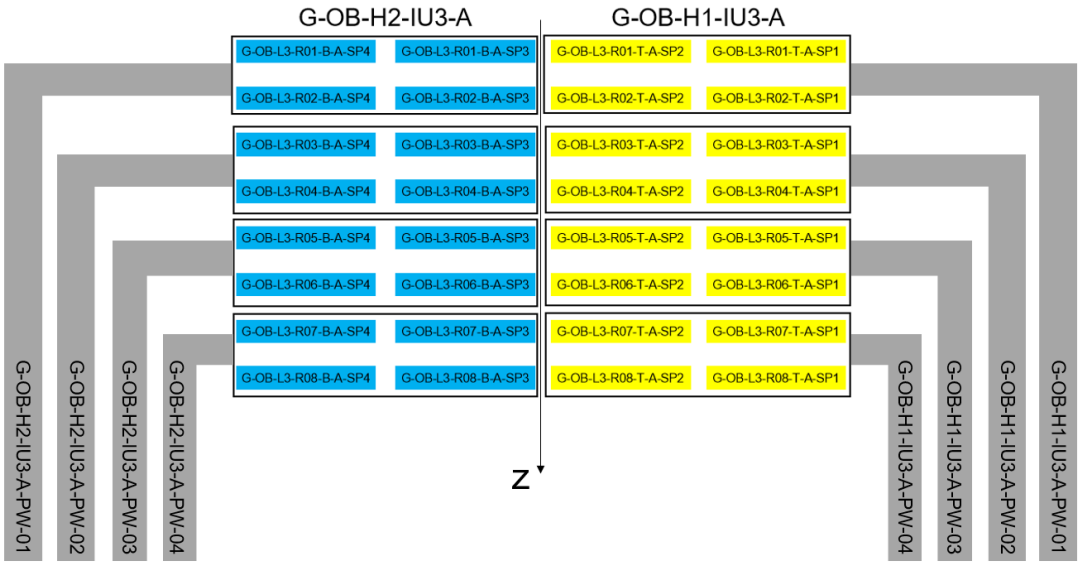


Figure 14. Example of the naming for the type-1 power super-bundles of the inclined half rings in layer 3 connected to the A-side PP1 according to the global coordinate system.

370 *Table 22. Name in the global coordinate system used to identify the power super-bundles of the inclined half rings in layer 3 connected to the A-side PP1.*

Inclined Unit	PP1 Side	Inclined Half Ring	SP Chain Power Bundle	Power Super-Bundle	IU Power Bundles
G-OB-H1-IU3-A	A	G-OB-L3-R01-T-A	G-OB-L3-R01-T-A-SP-1-PB	G-OB-H1-IU3-A-PW-1	G-OB-H1-IU3-A-PW
			G-OB-L3-R01-T-A-SP-2-PB		
		G-OB-L3-R02-T-A	G-OB-L3-R02-T-A-SP-1-PB		
			G-OB-L3-R02-T-A-SP-2-PB		
		G-OB-L3-R03-T-A	G-OB-L3-R03-T-A-SP-1-PB	G-OB-H1-IU3-A-PW-2	
			G-OB-L3-R03-T-A-SP-2-PB		
		G-OB-L3-R04-T-A	G-OB-L3-R04-T-A-SP-1-PB		
			G-OB-L3-R04-T-A-SP-2-PB		
		G-OB-L3-R05-T-A	G-OB-L3-R05-T-A-SP-1-PB	G-OB-H1-IU3-A-PW-3	
			G-OB-L3-R05-T-A-SP-2-PB		
		G-OB-L3-R06-T-A	G-OB-L3-R06-T-A-SP-1-PB		
			G-OB-L3-R06-T-A-SP-2-PB		
		G-OB-L3-R07-T-A	G-OB-L3-R07-T-A-SP-1-PB	G-OB-H1-IU3-A-PW-4	
			G-OB-L3-R07-T-A-SP-2-PB		
		G-OB-L3-R08-T-A	G-OB-L3-R08-T-A-SP-1-PB		
			G-OB-L3-R08-T-A-SP-2-PB		
G-OB-H2-IU3-A	A	G-OB-L3-R01-B-A	G-OB-L3-R01-B-A-SP-3-PB	G-OB-H2-IU3-A-PW-1	G-OB-H2-IU3-A-PW
			G-OB-L3-R01-B-A-SP-4-PB		
		G-OB-L3-R02-B-A	G-OB-L3-R02-B-A-SP-3-PB		
			G-OB-L3-R02-B-A-SP-4-PB		
		G-OB-L3-R03-B-A	G-OB-L3-R03-B-A-SP-3-PB	G-OB-H2-IU3-A-PW-2	
			G-OB-L3-R03-B-A-SP-4-PB		
		G-OB-L3-R04-B-A	G-OB-L3-R04-B-A-SP-3-PB		
			G-OB-L3-R04-B-A-SP-4-PB		
		G-OB-L3-R05-B-A	G-OB-L3-R05-B-A-SP-3-PB	G-OB-H2-IU3-A-PW-3	
			G-OB-L3-R05-B-A-SP-4-PB		
		G-OB-L3-R06-B-A	G-OB-L3-R06-B-A-SP-3-PB		
			G-OB-L3-R06-B-A-SP-4-PB		
		G-OB-L3-R07-B-A	G-OB-L3-R07-B-A-SP-3-PB	G-OB-H2-IU3-A-PW-4	
			G-OB-L3-R07-B-A-SP-4-PB		
		G-OB-L3-R08-B-A	G-OB-L3-R08-B-A-SP-3-PB		
			G-OB-L3-R08-B-A-SP-4-PB		

4.4.2 Grouping of OB Type-1 Data Bundles: OB Data "Super-Bundles"

At the opto-end, the Twinax bundles are soldered to custom-made termination boards equipped with a Samtec ERF8 connector. These termination PCBs interface directly with the Opto-boards. Due to constraints in electrical architecture of the Pixel detector, in some OB SP-chains the data bundles from different PP0 data connectors are soldered to the same termination board at the opto-end, thus sharing the same ERF8 connector. The term "data super-bundle" is used to refer to a group of Twinax bundles soldered to a single termination PCB at the opto-end (and thus sharing the same ERF8 connector).

Each Outer Barrel data super-bundle is identified with a unique name which follows the structure outlined in Table 23. The proposed scheme starts with the full name of the corresponding SP-chain, followed by the identifier OP ("opto") and a single-digit number which refers to the position of the super-bundle in the local support. In the longerons, the numbering alludes to the z-positions of the PP0 data connectors linked to the super-bundle, while in the inclined half rings it refers to their phi-position (see Figure 15 and Figure 16). As an example, the names of the data super-bundles connected to the A-side opto-panels for a longeron from layer 2 and an inclined half ring from layer 4 are included in Table 24.

Table 23. Naming scheme for the Outer Barrel Type-1 data super-bundles for both the flat and inclined regions.

SP Chain Full Name	**-**	**Data Super-Bundle Identifier (OP=Opto)**	**-**	**Super-Bundle Number**

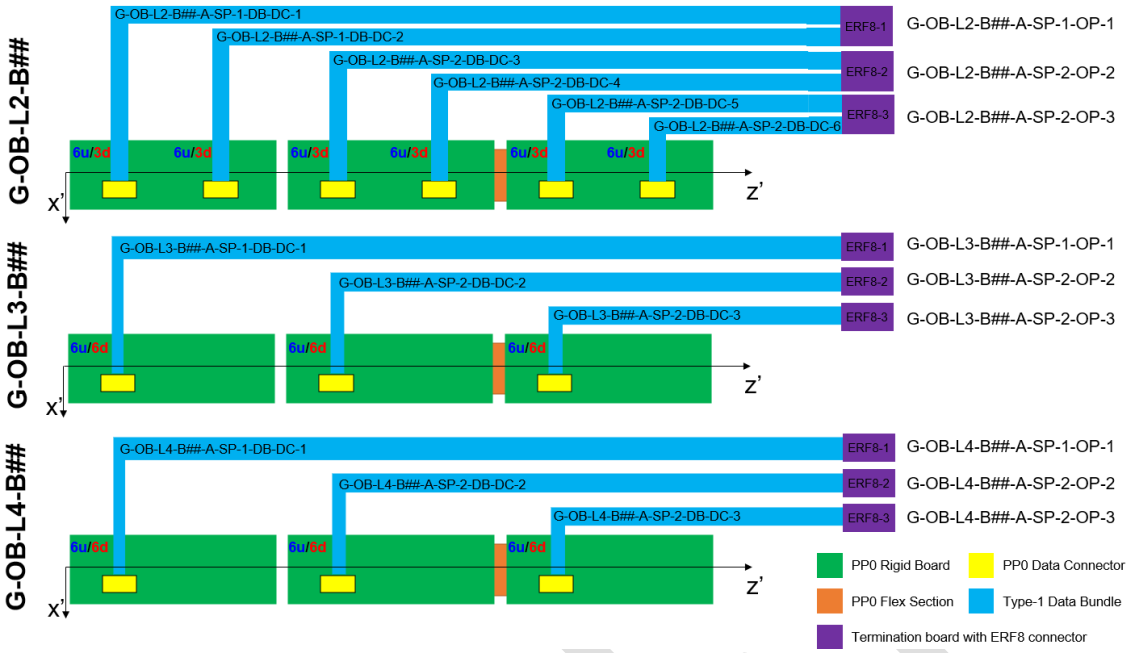


Figure 15. Schematic representation and naming (in the global coordinate system) of the type-1 data super-bundles connected to the A-side opto-panels from the longerons of the three OB layers. For each bundle, the numbers in blue and red indicate the number of uplinks ("u") and downlinks ("d") respectively.

Table 24. Name of the data bundles and super-bundles connected to the A-side opto-panels for a longeron from layer 2 ("G-OB-L2-B02") and an inclined half ring from layer 4 ("G-OB-L4-R02-B-A") in the global coordinate system.

Local Support	SP Chain	PP0 Data Bundle		Data Super-Bundle
G-OB-L2-B02	A-SP-1	DC-1	G-OB-L2-B02-A-SP-1-DB-DC-1	G-OB-L2-B02-A-SP-1-OP-1
		DC-2	G-OB-L2-B02-A-SP-1-DB-DC-2	
	A-SP-2	DC-3	G-OB-L2-B02-A-SP-2-DB-DC-3	G-OB-L2-B02-A-SP-2-OP-2
		DC-4	G-OB-L2-B02-A-SP-2-DB-DC-4	
		DC-5	G-OB-L2-B02-A-SP-2-DB-DC-5	G-OB-L2-B02-A-SP-2-OP-3
		DC-6	G-OB-L2-B02-A-SP-2-DB-DC-6	
G-OB-L4-R02-B-A	SP-3	DC-7	G-OB-L4-R02-B-A-SP-3-DB-DC-7	G-OB-L4-R02-B-A-SP-3-OP-5
		DC-8	G-OB-L4-R02-B-A-SP-3-DB-DC-8	G-OB-L4-R02-B-A-SP-3-OP-6
		DC-9	G-OB-L4-R02-B-A-SP-3-DB-DC-9	
	SP-4	DC-10	G-OB-L4-R02-B-A-SP-4-DB-DC-10	G-OB-L4-R02-B-A-SP-4-OP-7
		DC-11	G-OB-L4-R02-B-A-SP-4-DB-DC-11	
		DC-12	G-OB-L4-R02-B-A-SP-4-DB-DC-12	G-OB-L4-R02-B-A-SP-4-OP-8

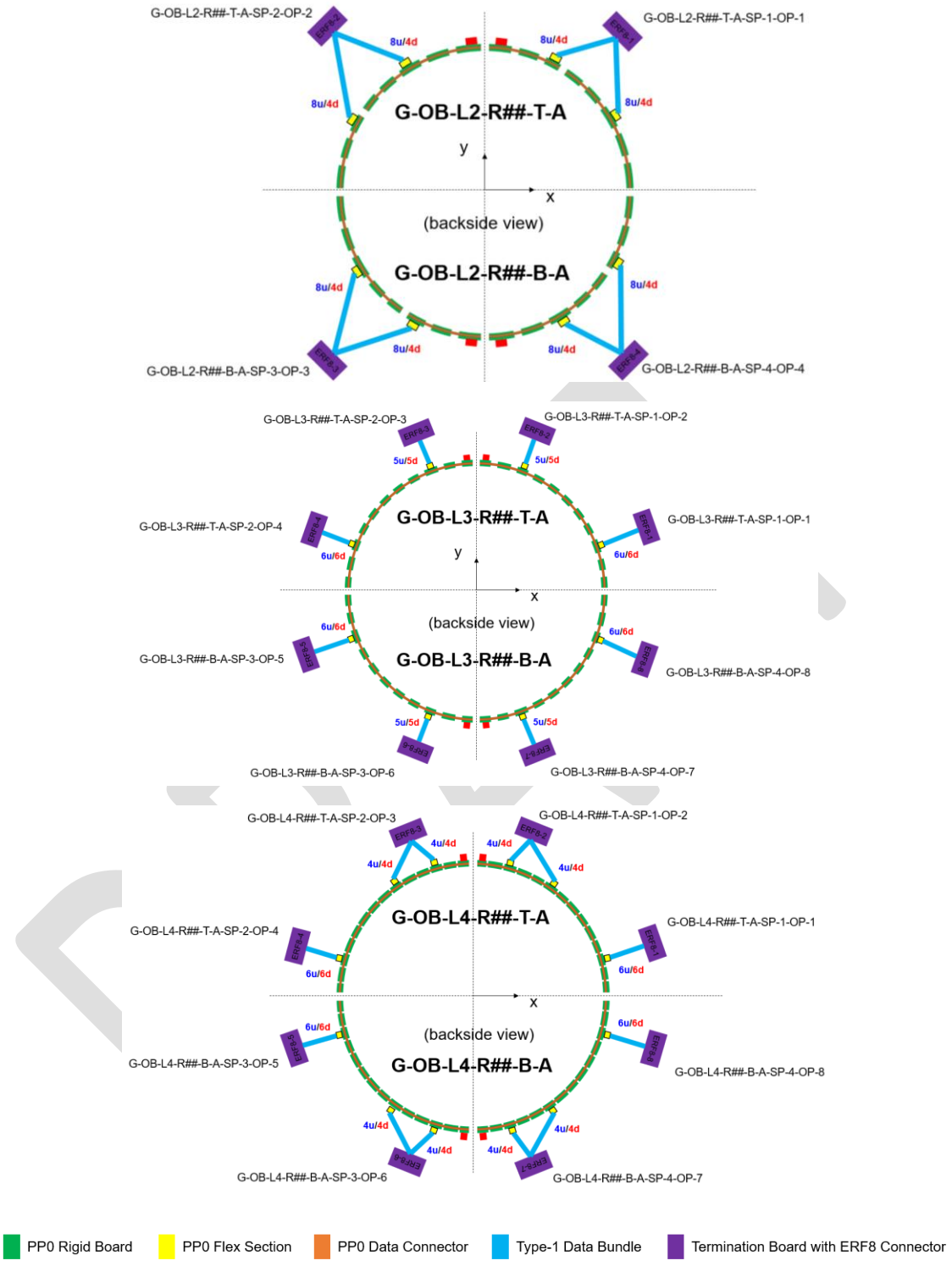


Figure 16. Schematic representation and naming (in the global coordinate system) of the type-1 data super-bundles connected to the A-side opto-panels from the inclined half rings of the three OB layers. For each bundle, the numbers in blue and red indicate the number of uplinks ("u") and downlinks ("d") respectively.

405

4.4.3 Grouping of IHR Data Bundles for Service Routing

In the inclined units, the data bundles of the individual half rings are grouped together to ease the routing within the detector volume. In particular, the Twinax bundles for all the half rings connected to the PP0s at the same phi-position are gathered in larger bundles, which are then routed atop the corresponding half layer shell and the then along the service support shells up to PP1. Even though the so-called "inclined unit data bundles" are not significant from the electrical standpoint, they can be identified with a unique name which follows the structure outlined in Table 25. The proposed name scheme starts with the full name of the inclined unit, followed by data bundle identifier (DB) and a two-digit number which refers to the phi-position of the PP0 data connector. If the number of the data connector is omitted, the resulting name can be used to identify all the data bundles for the inclined unit (e.g. "G-OB-H#-IU#-A/C-DB"). In that case, the serial powering chain identifier and number (SP-#) can be inserted before "DB" to designate the sub-group of bundles connected that SP chain for all the rings in the inclined unit (e.g. "G-OB-H#-IU#-A/C-SP-#-DB"). An example for the inclined unit "G-OB-H2-IU2-A" is shown in Table 26.

Table 25. Naming scheme used to refer to the inclined unit data bundles. The items in brackets can be added or removed to identify different groups and sub-groups of data bundles in the inclined unit for the purpose of service routing or CAD modelling.

Inclined Unit Full Name	**-**	**(SP Chain Identifier & SP Chain Number)**	**-**	**Data Bundle Identifier (DB=Data)**	**-**	**(Data Connector Number)**

Table 26. Name of the groups of data bundles in an inclined unit of layer 2 used for routing purposes.

Inclined Unit	SP Chain	Data Connector	Data Bundle				
			Local Support	Conector Bundle	IU Data Bundle		
G-OB-H2-IU2-A	SP-3	DC-5	G-OB-L2-R01-B-A	G-OB-L2-R01-B-A-SP-3-DB-DC-5	G-OB-H2-IU2-A-DB-05	G- OB-H2-IU2-A-SP-3-DB	G-OB-H2-IU2-A-DB
			G-OB-L2-R02-B-A	G-OB-L2-R02-B-A-SP-3-DB-DC-5			
			G-OB-L2-R03-B-A	G-OB-L2-R03-B-A-SP-3-DB-DC-5			
			G-OB-L2-R04-B-A	G-OB-L2-R04-B-A-SP-3-DB-DC-5			
			G-OB-L2-R05-B-A	G-OB-L2-R05-B-A-SP-3-DB-DC-5			
			G-OB-L2-R06-B-A	G-OB-L2-R06-B-A-SP-3-DB-DC-5			
		DC-6	G-OB-L2-R01-B-A	G-OB-L2-R01-B-A-SP-3-DB-DC-6	G-OB-H2-IU2-A-DB-06		
			G-OB-L2-R02-B-A	G-OB-L2-R02-B-A-SP-3-DB-DC-6			
			G-OB-L2-R03-B-A	G-OB-L2-R03-B-A-SP-3-DB-DC-6			
			G-OB-L2-R04-B-A	G-OB-L2-R04-B-A-SP-3-DB-DC-6			
			G-OB-L2-R05-B-A	G-OB-L2-R05-B-A-SP-3-DB-DC-6			
			G-OB-L2-R06-B-A	G-OB-L2-R06-B-A-SP-3-DB-DC-6			
	SP-4	DC-7	G-OB-L2-R01-B-A	G-OB-L2-R01-B-A-SP-4-DB-DC-7	G-OB-H2-IU2-A-DB-07	G-OB-H2-IU2-A-SP-4-DB	
			G-OB-L2-R02-B-A	G-OB-L2-R02-B-A-SP-4-DB-DC-7			
			G-OB-L2-R03-B-A	G-OB-L2-R03-B-A-SP-4-DB-DC-7			
			G-OB-L2-R04-B-A	G-OB-L2-R04-B-A-SP-4-DB-DC-7			
			G-OB-L2-R05-B-A	G-OB-L2-R05-B-A-SP-4-DB-DC-7			
			G-OB-L2-R06-B-A	G-OB-L2-R06-B-A-SP-4-DB-DC-7			
		DC-8	G-OB-L2-R01-B-A	G-OB-L2-R01-B-A-SP-4-DB-DC-8	G-OB-H2-IU2-A-DB-08		
			G-OB-L2-R02-B-A	G-OB-L2-R02-B-A-SP-4-DB-DC-8			
			G-OB-L2-R03-B-A	G-OB-L2-R03-B-A-SP-4-DB-DC-8			
			G-OB-L2-R04-B-A	G-OB-L2-R04-B-A-SP-4-DB-DC-8			
			G-OB-L2-R05-B-A	G-OB-L2-R05-B-A-SP-4-DB-DC-8			
			G-OB-L2-R06-B-A	G-OB-L2-R06-B-A-SP-4-DB-DC-8			

4.5 Cooling Pipes

A network of welded titanium pipes connects the evaporators of both longerons and inclined half rings with the flex lines supplying CO_2 at each of the cooling feedthroughs in PP1[8]. For construction reasons, in the Outer Barrel this pipe network is split in two sections, namely: (i) the cooling pipe extensions and (ii) the PP1 manifolds. In their simplest form, the so-called "cooling pipe extensions" are a prolongation of a local support evaporator which stretch up to the end of the service support shells. In that region, the extensions from several local supports are joined together in a common PP1 manifold so that they can be connected to the corresponding flex line. Together with the evaporators, these elements are designed to ensure that the fluid reaches the entrance of the local supports in the correct thermo-dynamic state.

4.5.1 Cooling Pipe Extensions

4.5.1.1 Longerons

Each longeron has two separate cooling pipe extensions reaching the PP1 region, namely: (i) an inlet capillary and (ii) a larger-diameter cooling exhaust. The identifiers "CPI" ("cooling pipe inlet") and "CPE" ("cooling pipe exhaust") are added at the end of the name for the corresponding longeron to identify these two elements (see Table 27). As an example, the names of the cooling pipe extensions for the Outer Barrel longerons in layer 2 are included in Table 28. As stated in section 4.3.1.2.3, the detector side label (i.e. A or C) indicates the detector side from which a specific longeron is fed with coolant.

Table 27. Naming scheme for the inlet and exhaust cooling pipe extensions of the Outer Barrel Longerons.

Longeron Inlet Pipe Extension	**G - OB - L# - B## - Detector Side (A/C) - CPI**
Longeron Exhaust pipe Extension	**G - OB - L# - B## - Detector Side (A/C) - CPE**

[8] *In the Pixel Outer System, the on-detector piping network finishes at the interface with the warm nose heat exchanges, the design of which is under the responsibility of the ITk Cooling working group.*

Table 28. Name used to identify the cooling pipe extensions of the longerons in layer 2 in the global coordinate system.

Barrel Half	PP1 Side	Longeron	Cooling Pipe Extensions	
			Inlet Capillary	Cooling Exhaust
G-OB-H1-BH2	A	G-OB-L2-B02-A	G-OB-L2-B02-A-CPI	G-OB-L2-B02-A-CPE
		G-OB-L2-B04-A	G-OB-L2-B04-A-CPI	G-OB-L2-B04-A-CPE
		G-OB-L2-B06-A	G-OB-L2-B06-A-CPI	G-OB-L2-B06-A-CPE
		G-OB-L2-B08-A	G-OB-L2-B08-A-CPI	G-OB-L2-B08-A-CPE
	C	G-OB-L2-B01-C	G-OB-L2-B01-C-CPI	G-OB-L2-B01-C-CPE
		G-OB-L2-B03-C	G-OB-L2-B03-C-CPI	G-OB-L2-B03-C-CPE
		G-OB-L2-B05-C	G-OB-L2-B05-C-CPI	G-OB-L2-B05-C-CPE
		G-OB-L2-B07-C	G-OB-L2-B07-C-CPI	G-OB-L2-B07-C-CPE
G-OB-H2-BH2	A	G-OB-L2-B10-A	G-OB-L2-B10-A-CPI	G-OB-L2-B10-A-CPE
		G-OB-L2-B12-A	G-OB-L2-B12-A-CPI	G-OB-L2-B12-A-CPE
		G-OB-L2-B14-A	G-OB-L2-B14-A-CPI	G-OB-L2-B14-A-CPE
		G-OB-L2-B16-A	G-OB-L2-B16-A-CPI	G-OB-L2-B16-A-CPE
	C	G-OB-L2-B09-C	G-OB-L2-B09-C-CPI	G-OB-L2-B09-C-CPE
		G-OB-L2-B11-C	G-OB-L2-B11-C-CPI	G-OB-L2-B11-C-CPE
		G-OB-L2-B13-C	G-OB-L2-B13-C-CPI	G-OB-L2-B13-C-CPE
		G-OB-L2-B15-C	G-OB-L2-B15-C-CPI	G-OB-L2-B15-C-CPE

4.5.1.2 Inclined Units

In an inclined unit, each inclined half ring features and individual inlet capillary of approximately the same length. However, all the half rings in the inclined unit share a common exhaust pipe which runs along the length of the corresponding half layer shell and then up to the PP1 region. The label "CPI" ("cooling pipe inlet") is added at the end of the name for the IHRs to identify the capillaries. The "CPE" label is used for the exhaust, substituting the two-digit number usually used to identify the z-position of an individual ring by the letters "IU" to signify that this element is common to all the IHRs in the same inclined unit (see Table 29). As an example, the names of the cooling pipe extensions for the inclined half rings in two

inclined units from layer 2 ("G-OB-H1-IU2-A" and "G-OB-H2-IU2-A") are included in Table 30.

Table 29. Naming scheme adopted for the individual inlet pipe extension and the common exhaust for the half rings in a given inclined unit.

IHR Inlet Pipe Extension	**G - OB - L# - R## - OBH1 or OBH2 (T/B) - Detector Side (A/C) - CPI**
Inclined Unit Common Exhaust pipe Extension	**G - OB - L# - RIU - OBH1 or OBH2 (T/B) - Detector Side (A/C) - CPE**

Table 30. Name used to identify the cooling pipe extensions of the inclined half rings in the inclined units "G-OB-H1-IU2-A" and "G-OB-H2-IU2-A" in the global coordinate system.

Inclined Unit	**IHR**	**Cooling Pipe Extensions**	
		Inlet Capillary	**Cooling Exhaust**
G-OB-H1-IU2-A	G-OB-L2-R01-T-A	G-OB-L2-R01-T-A-CPI	G-OB-L2-RIU-T-A-CPE
	G-OB-L2-R02-T-A	G-OB-L2-R02-T-A-CPI	
	G-OB-L2-R03-T-A	G-OB-L2-R03-T-A-CPI	
	G-OB-L2-R04-T-A	G-OB-L2-R04-T-A-CPI	
	G-OB-L2-R05-T-A	G-OB-L2-R05-T-A-CPI	
	G-OB-L2-R06-T-A	G-OB-L2-R06-T-A-CPI	
G-OB-H2-IU2-A	G-OB-L2-R01-B-A	G-OB-L2-R01-B-A-CPI	G-OB-L2-RIU-B-A-CPE
	G-OB-L2-R02-B-A	G-OB-L2-R02-B-A-CPI	
	G-OB-L2-R03-B-A	G-OB-L2-R03-B-A-CPI	
	G-OB-L2-R04-B-A	G-OB-L2-R04-B-A-CPI	
	G-OB-L2-R05-B-A	G-OB-L2-R05-B-A-CPI	
	G-OB-L2-R06-B-A	G-OB-L2-R06-B-A-CPI	

4.5.2 OB Cooling Manifolds at PP1

Sixteen cooling feedthroughs at PP1, i.e. eight per detector side, are allocated to the Outer Barrel. The local supports are divided into the so-called "cooling groups", each assigned to a single feedthrough served by a flex line with a nominal power of 5kW. The inlet and exhaust pipe extensions from the local supports in a given group are merged together in a PP1 manifold so that they can be connected to the corresponding flex line.

The manifold scheme for the Outer Barrel is designed to avoid mixing local supports from different half layers in the same feedthrough. The number of cooling feedthroughs assigned to each Outer Barrel layer is summarised in Table 31. As for the grouping of the local support, four longerons and the half rings in an inclined unit share a single flex line in layer 2. Similarly, in layer 3 up to 6 longerons and eight half rings are connected to the same feedthrough. On the other hand, longerons and inclined half rings from layer 4 are not mixed on the same feedthrough to respect the maximum power per flex line.

Table 31. Number of cooling feedthroughs (i.e. flex lines) at PP1 assigned to each layer of the Outer Barrel for the A and C sides of the detector.

Outer Barrel Layer	Allocated Cooling Feedthoughs at PP1	
	A-side	C-Side
2	2	2
3	2	2
4	4	4

The number and types of local support assigned to each cooling groups is summarised in Table 32. Each cooling group is referred to with the identifier "CG" followed by a number from 1 to 8 and a letter (A or C) to denote the detector side to which it is connected fluidically[9]. A detailed list of the local supports included in each cooling group is included in Appendix B: Outer Barrel Cooling Groups. For each cooling group, the inlet and exhaust manifolds at PP1 are designated with the "MI" and "ME" identifiers followed by the corresponding cooling group number and detector side (see Table 32). It should be noted that the final assignment of the different Outer Barrel cooling groups to specific cooling feedthroughs has not be finalised yet.

[9] *The total number of "cooling groups" is sixteen, i.e. eight for each detector side, as each group is connected to a single feedthrough at PP1*

Table 32. Number and type of local support assigned to each Outer Barrel cooling group, and name for the corresponding inlet and exhaust manifolds at PP1.

OB Half Layer	Cooling Group (CG)	Number of Local Supports in Cooling Group		PP1 Manifold Name	
		Longerons	Inclined Half Rings	Inlet	Exhaust
G-OB-H1-HL2	1-A	4	6	OB-MI-1-A	OB-ME-1-A
	1-C	4	6	OB-MI-1-C	OB-ME-1-C
G-OB-H1-HL3	3-A	5	8	OB-MI-3-A	OB-ME-3-A
	3-C	6	8	OB-MI-3-C	OB-ME-3-C
G-OB-H1-HL4	5-A	0	9	OB-MI-5-A	OB-ME-5-A
	6-A	7	0	OB-MI-6-A	OB-ME-6-A
	5-C	0.	9	OB-MI-5-C	OB-ME-5-C
	6-C	7	0	OB-MI-6-C	OB-ME-6-C
G-OB-H2-HL2	2-A	4	6	OB-MI-2-A	OB-ME-2-A
	2-C	4	6	OB-MI-2-C	OB-ME-2-C
G-OB-H2-HL3	4-A	6	8	OB-MI-4-A	OB-ME-4-A
	4-C	5	8	OB-MI-4-C	OB-ME-4-C
G-OB-H2-HL4	7-A	0	9	OB-MI-7-A	OB-ME-7-A
	8-A	7	0	OB-MI-8-A	OB-ME-8-A
	7-C	0	9	OB-MI-7-C	OB-ME-7-C
	8-C	7	0	OB-MI-8-C	OB-ME-8-C

4.6 Half Layer Shells and Intermediate Supports

In an Inclined Unit, the Outer Barrel half rings are mounted on the inner side of a carbon composite semi-cylindrical shell known as the “Half Layer Shell” (HLS). For each detector side, the inclined units of two adjacent layers (i.e. 2-3 and 3-4) are connected mechanically at their two extremities through the so-called Intermediate Supports (SI). Table 33 and Figure 17 summarise the names used to identify these components in the global coordinate system.

Table 33. Name used to identify the Outer Barrel half layer shells and intermediate supports in the global coordinate system.

OB Half	A-side			C-side		
	Half Layer Shell	Intermediate Support		Half Layer Shell	Intermediate Support	
		Low Z	High Z		Low Z	High Z
G-OB-H1	G-OB-H1-HLS2-A	G-OB-H1-SI23-A-1	G-OB-H1-SI23-A-2	G-OB-H1-HLS2-C	G-OB-H1-SI23-C-1	G-OB-H1-SI23-C-2
	G-OB-H1-HLS3-A			G-OB-H1-HLS3-C		
	G-OB-H1-HLS4-A	G-OB-H1-SI34-A-1	G-OB-H1-SI34-A-2	G-OB-H1-HLS4-C	G-OB-H1-SI34-C-1	G-OB-H1-SI34-C-2
G-OB-H2	G-OB-H2-HLS2-A	G-OB-H2-SI23-A-1	G-OB-H2-SI23-A-2	G-OB-H2-HLS2-C	G-OB-H2-SI23-C-1	G-OB-H2-SI23-C-2
	G-OB-H2-HLS3-A			G-OB-H2-HLS3-C		
	G-OB-H2-HLS4-A	G-OB-H2-SI34-A-1	G-OB-H2-SI34-A-2	G-OB-H2-HLS4-C	G-OB-H2-SI34-C-1	G-OB-H2-SI34-C-2

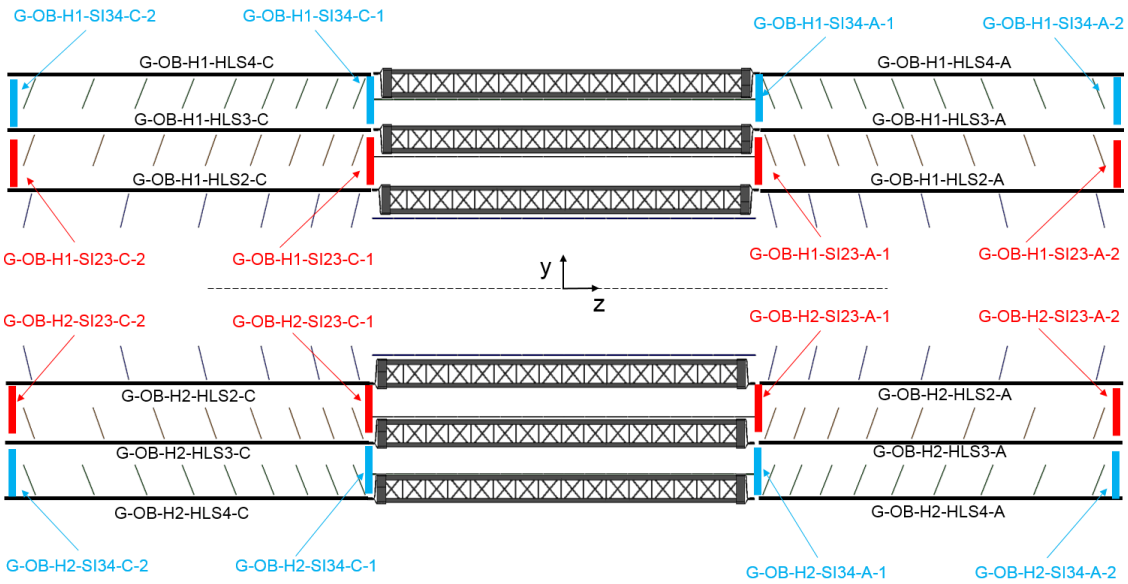


Figure 17. Names for the Outer Barrel half layer shells and the intermediate supports in the global coordinate system.

4.7 Outer Barrel Service Support Shells

515 In each OB half, six service support shells (three for each detector side) are used to route the Type-1 bundles and cooling pipe extensions along the service gap between the inner bore of the PST and the outermost shell of the Endcaps (see Figure 18). The names used to identify each of these assemblies are included Table 34.

520 *Table 34. Name used to identify the individual half layers, barrel halves and inclined units in the Outer Barrel in the global coordinate system.*

OB Half	**Service Support Shells**		
G-OB-H1	G-OB-H1-SS-A-1	G-OB-H1-SS-A-2	G-OB-H1-SS-A-3
	G-OB-H1-SS-C-1	G-OB-H1-SS-C-2	G-OB-H1-SS-C-3
G-OB-H2	G-OB-H2-SS-A-4	G-OB-H2-SS-A-5	G-OB-H2-SS-A-6
	G-OB-H2-SS-C-4	G-OB-H2-SS-C-5	G-OB-H2-SS-C-6

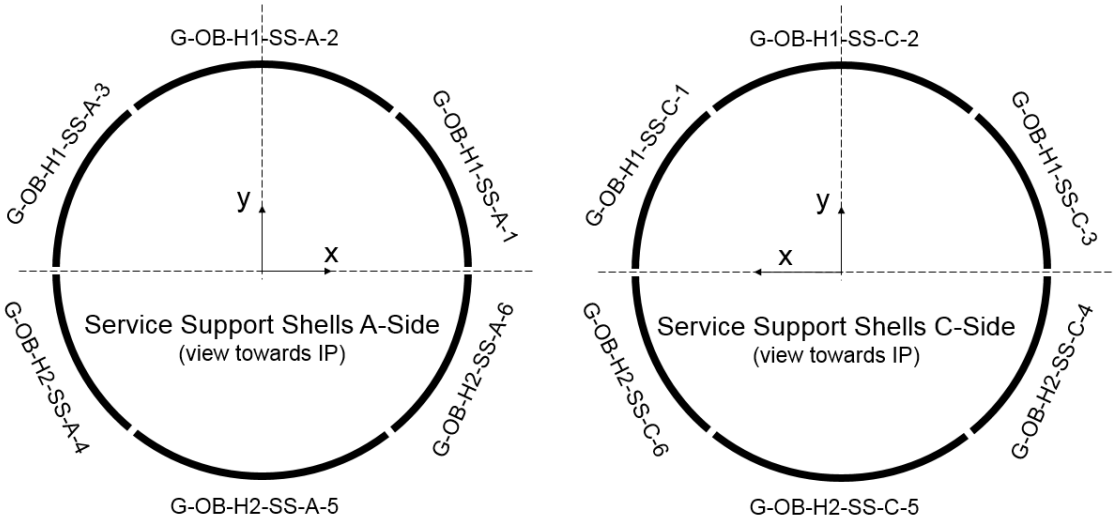


Figure 18. Schematic view of the service support shells for the A (left) and C (right) sides of the Outer Barrel, including their corresponding names in the global coordinate system.

4.8 Outer Barrel Support Points

In its final configuration inside the inner bore of the PST, the Outer Barrel rests on eight support points (PS) along two rails. The name for these elements comprises (i) the "PS" identifier, (ii) the detector side (A or C), (iii) a label to indicate the location with respect to the vertical y-z plane (i.e. "P" and "N" for the points on the positive and negative sides of the x-axis) and (iv) a number to denote the position along the beam axis (see Figure 19).

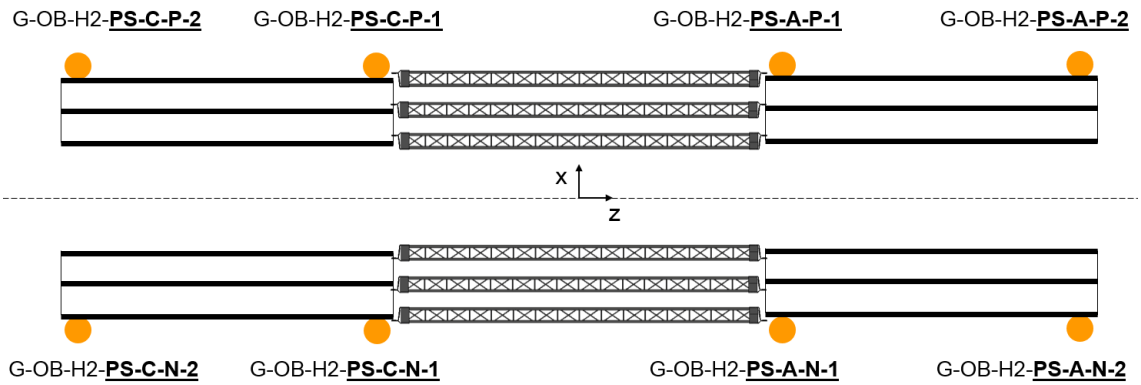


Figure 19. Names for the Outer Barrel support points in the global coordinate system.

5. Appendix A: List of Outer Barrel Identifiers

Identifier	Component or Sub-Assembly	Identifier	Component or Sub-Assembly
A	Detector A-side	**L**	- Local Coordinate system - Layer
B	- Barrel (ref. to longeron) - Bottom (ref. to longeron bottom flank or IHR installed in OBH2)	**M**	Module
BB	Base Block	**MC**	Module connector (pigtail-wing interface)
BH	Barrel Half	**ME**	Manifold Exhaust
C	Detector C-side	**MI**	Manifold Inlet
CB	Cooling Block	**N**	Negative (reference to longeron negative flank)
CE	Cell	**OB**	Global
CG	Cooling Group	**OP**	Data Super-bundle (from “opto” end)
CP	Cooling Pipe	**P**	Positive (reference to longeron positive flank)
CPE	Cooling Pipe Exhaust	**PB**	Power Bundle
CPI	Cooling Pipe inlet capillary	**PC**	Type-1 Power & DCS connector
DB	Data Bundle	**PG**	Module Pigtail
DC	Type-1 Data connector	**PS**	Support Point
EC	Endcap	**PW**	Power Super-bundle
EV	Evaporator	**R**	Ring (reference to inclined half ring)
G	Global coordinate system	**RB**	Type-0/PP0 Rigid Board
GT	Graphite Tile	**RF**	Type-0/PP0 Rigid Flex
H	Outer Barrel Half	**SI**	Support Intermediate
HL	Half Layer	**SP**	Serial Powering Chain
HLS	Half Layer Shell	**SS**	Service Support Shell
IS	Inner System	**T**	Top (reference to longeron top flank or IHR installed in OBH1)
IU	Inclined Unit	**WN**	Type-0 Wing

6. Appendix B: Outer Barrel Cooling Groups

The allocation of the individual local supports to the Outer Barrel cooling groups is summarised in the tables below.

Table 35. Cooling group allocation for the Outer Barrel local supports from layer 2.

	Local Support	Cooling Group		Local Support	Cooling Group
G-OB-H1-HL2	G-OB-L2-R01-T-A	1A	G-OB-H2-HL2	G-OB-L2-R01-B-A	2A
	G-OB-L2-R02-T-A	1A		G-OB-L2-R02-B-A	2A
	G-OB-L2-R03-T-A	1A		G-OB-L2-R03-B-A	2A
	G-OB-L2-R04-T-A	1A		G-OB-L2-R04-B-A	2A
	G-OB-L2-R05-T-A	1A		G-OB-L2-R05-B-A	2A
	G-OB-L2-R06-T-A	1A		G-OB-L2-R06-B-A	2A
	G-OB-L2-B01	1C		G-OB-L2-B09	2C
	G-OB-L2-B02	1A		G-OB-L2-B10	2A
	G-OB-L2-B03	1C		G-OB-L2-B11	2C
	G-OB-L2-B04	1A		G-OB-L2-B12	2A
	G-OB-L2-B05	1C		G-OB-L2-B13	2C
	G-OB-L2-B06	1A		G-OB-L2-B14	2A
	G-OB-L2-B07	1C		G-OB-L2-B15	2C
	G-OB-L2-B08	1A		G-OB-L2-B16	2A
	G-OB-L2-R01-T-C	1C		G-OB-L2-R01-B-C	2C
	G-OB-L2-R02-T-C	1C		G-OB-L2-R02-B-C	2C
	G-OB-L2-R03-T-C	1C		G-OB-L2-R03-B-C	2C
	G-OB-L2-R04-T-C	1C		G-OB-L2-R04-B-C	2C
	G-OB-L2-R05-T-C	1C		G-OB-L2-R05-B-C	2C
	G-OB-L2-R06-T-C	1C		G-OB-L2-R06-B-C	2C

Table 36. Cooling group allocation for the Outer Barrel local supports from layer 3.

	Local Support	Cooling Group		Local Support	Cooling Group
G-OB-H1-HL3	G-OB-L3-R01-T-A	3A	G-OB-H2-HL3	G-OB-L3-R01-B-A	4A
	G-OB-L3-R02-T-A	3A		G-OB-L3-R02-B-A	4A
	G-OB-L3-R03-T-A	3A		G-OB-L3-R03-B-A	4A
	G-OB-L3-R04-T-A	3A		G-OB-L3-R04-B-A	4A
	G-OB-L3-R05-T-A	3A		G-OB-L3-R05-B-A	4A
	G-OB-L3-R06-T-A	3A		G-OB-L3-R06-B-A	4A
	G-OB-L3-R07-T-A	3A		G-OB-L3-R07-B-A	4A
	G-OB-L3-R08-T-A	3A		G-OB-L3-R08-B-A	4A
	G-OB-L3-B01	3C		G-OB-L3-B12	4A
	G-OB-L3-B02	3A		G-OB-L3-B13	4C
	G-OB-L3-B03	3C		G-OB-L3-B14	4A
	G-OB-L3-B04	3A		G-OB-L3-B15	4C
	G-OB-L3-B05	3C		G-OB-L3-B16	4A
	G-OB-L3-B06	3A		G-OB-L3-B17	4C
	G-OB-L3-B07	3C		G-OB-L3-B18	4A
	G-OB-L3-B08	3A		G-OB-L3-B19	4C
	G-OB-L3-B09	3C		G-OB-L3-B20	4A
	G-OB-L3-B10	3A		G-OB-L3-B21	4C
	G-OB-L3-B11	3C		G-OB-L3-B22	4A
	G-OB-L3-R01-T-C	3C		G-OB-L3-R01-B-C	4C
	G-OB-L3-R02-T-C	3C		G-OB-L3-R02-B-C	4C
	G-OB-L3-R03-T-C	3C		G-OB-L3-R03-B-C	4C
	G-OB-L3-R04-T-C	3C		G-OB-L3-R04-B-C	4C
	G-OB-L3-R05-T-C	3C		G-OB-L3-R05-B-C	4C
	G-OB-L3-R06-T-C	3C		G-OB-L3-R06-B-C	4C
	G-OB-L3-R07-T-C	3C		G-OB-L3-R07-B-C	4C
	G-OB-L3-R08-T-C	3C		G-OB-L3-R08-B-C	4C

545 *Table 37. Cooling group allocation for the Outer Barrel local supports from layer 4.*

	Local Support	Cooling Group		Local Support	Cooling Group
G-OB-H1-HL4	G-OB-L4-R01-T-A	5A	G-OB-H2-HL4	G-OB-L4-R01-B-A	7A
	G-OB-L4-R02-T-A	5A		G-OB-L4-R02-B-A	7A
	G-OB-L4-R03-T-A	5A		G-OB-L4-R03-B-A	7A
	G-OB-L4-R04-T-A	5A		G-OB-L4-R04-B-A	7A
	G-OB-L4-R05-T-A	5A		G-OB-L4-R05-B-A	7A
	G-OB-L4-R06-T-A	5A		G-OB-L4-R06-B-A	7A
	G-OB-L4-R07-T-A	5A		G-OB-L4-R07-B-A	7A
	G-OB-L4-R08-T-A	5A		G-OB-L4-R08-B-A	7A
	G-OB-L4-R09-T-A	5A		G-OB-L4-R09-B-A	7A
	G-OB-L4-B01	6A		G-OB-L4-B15	8A
	G-OB-L4-B2	6C		G-OB-L4-B16	8C
	G-OB-L4-B03	6A		G-OB-L4-B17	8A
	G-OB-L4-B04	6C		G-OB-L4-B18	8C
	G-OB-L4-B05	6A		G-OB-L4-B19	8A
	G-OB-L4-B06	6C		G-OB-L4-B20	8C
	G-OB-L4-B07	6A		G-OB-L4-B21	8A
	G-OB-L4-B08	6C		G-OB-L4-B22	8C
	G-OB-L4-B09	6A		G-OB-L4-B23	8A
	G-OB-L4-B10	6C		G-OB-L4-B24	8C
	G-OB-L4-B11	6A		G-OB-L4-B25	8A
	G-OB-L4-B12	6C		G-OB-L4-B26	8C
	G-OB-L4-B13	6A		G-OB-L4-B27	8A
	G-OB-L4-B14	6C		G-OB-L4-B28	8C
	G-OB-L4-R01-T-C	5C		G-OB-L4-R01-B-C	7C
	G-OB-L4-R02-T-C	5C		G-OB-L4-R02-B-C	7C
	G-OB-L4-R03-T-C	5C		G-OB-L4-R03-B-C	7C
	G-OB-L4-R04-T-C	5C		G-OB-L4-R04-B-C	7C
	G-OB-L4-R05-T-C	5C		G-OB-L4-R05-B-C	7C
	G-OB-L4-R06-T-C	5C		G-OB-L4-R06-B-C	7C
	G-OB-L4-R07-T-C	5C		G-OB-L4-R07-B-C	7C
	G-OB-L4-R08-T-C	5C		G-OB-L4-R08-B-C	7C
	G-OB-L4-R09-T-C	5C		G-OB-L4-R09-B-C	7C