Engineering Note

ATLAS Inner Detector Grounding and Shielding, Engineering Implementation

This document attempts to identify how the proposed grounding and shielding scheme for the ATLAS ID can be practically implemented

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Distribution List

ATLAS ID TC

History of Changes

Rev. No.	*Date*	*Pages*	*Description of changes*
0	15.12.2003		First draft, TRT internal grounding scheme need to be updated, localisation of IDGND hast to be decided
1	29.01.2004		Changes in isolation techniques of cable trays, updated TRT grounding scheme.
2	29.06.2004		Changes in isolation techniques of cable trays, more details about TRT and Pixel grounding schemes. Definition of the connection of the IDGND to the overall ATLAS ground system. Grounding of the ID end plates.
3	14.07.2004		Suplemented with sections 2.5.1 & 3.5
4	9.02.2005		Add comments from reviewers, updated Fig. 4.1
5	7.04.2005		Add comments from reviewers, changes the IDGNDPA & IDGNDPC locations
6	28.02.2006		New location of the IDGNDPA in Z0, below the tiles

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1 Scope

This document aims to describe the proposed implementation of the grounding and shielding scheme for the ATLAS Inner Detector system. It should also provide guidelines for the integration of the grounding and shielding systems of the ID sub-detectors and common items like cooling systems, support structures, etc.

It uses the general concept of shielding and grounding for the ATLAS detector, providing compatibility between the detailed schemes implemented in each sub-detector. The detailed schemes of the subsystems might be found in following notes: ATL-IS-EN-0014 (SCT end cap), ATL-IS-ES-0056 (SCT barrel), ATL-IC-ES-0007 (heaters), ATL-IC-EN-0004 (old document for Pixel and SCT), and ATL-IT-EN-0050 (TRT).

This document summarises the grounding and shielding schemes of following items:

- Sub-detectors grounding and shielding
  - Pixel detector
  - SCT
  - TRT
- Common items
  - ID Cooling system
  - ID Mechanical support (trays for pipes and cables)
  - Heaters
  - DCS sensors

A summary of the ATLAS policy on grounding and power distribution is the following:

- All sub-detectors are electrically isolated (only safety ground connections are common)
- Low voltage power supplies floating (but they are referenced to signal ground with respect to High Voltage i.e. Low Voltages are referenced to the safety ground as well).
- High Voltage power supply floating (but referenced to the safety ground)

In order to present more clearly the grounding scheme of the Inner Detector, we introduce term "Inner Detector Ground" (IDGND).

IDGND will be a star connection of all safety grounding cables for ID system sub-detectors (Pixel, SCT, and TRT) and common items (support structure, pipes for cooling and gas, heaters, and DCS sensors). The IDGND star connection will be connected to the ATLAS ground distribution system between the Tile calorimeter and the first level of Muon chambers. (See Figure 4.1.)

In order to provide reasonable isolation of the sub-detectors and at the same time to complete the requirements for the safety grounding, all connections to the IDGND from any sub-detector should be done from its electromagnetic (EM) shield using a single point connection. The floating power supplies will be referenced in most cases on the detector modules (analogue and digital grounds) and on PP1 (connection of detector module grounds to the EM shields).

2 Grounding and shielding of sub-detectors – local schemes

2.1 Grounding and shielding of the Pixel detector

The overall grounding and shielding philosophy is similar to the SCT solution
(See: https://edms.cern.ch/file/108383/1/sct_pixel_gnd_shield.pdf).

Individual detector modules are supplied separately from the voltage regulators placed on PP2. All grounding /commoning takes place inside the detector volume. (The bulk power supplies are in floating configurations.) The EMI shield (50µm Al foil) formed at the outer radius of the PST (Pixel Support Tube) is used for referencing all internal detector module grounds and will be connected with a single link (8AWG cable, cross section10mm^2) to the IDGND. The referencing of the analogue and digital ground and the detector bias return is done on the detector modules. The second reference point is the connection of the digital grounds at the PP0 patch panels. The ground of the PP0 is connected to the EM shield (PST shield) at PP1. PP1 serves to close the Faraday Cage around the Pixel detector by connecting the outer EM shield to the Al foil shield around the insulated outer wall of the beam pipe (beryllium beam pipe shield - 50µm Al foil wrapped around thermal insulation) as well as being the overall commoning point. Shields of Type 2 cables (from PP1 outwards) are connected together at the PP1 commoning point in a star topology. The simplified grounding scheme for the pixel detector is shown in Figure 2.1.1.

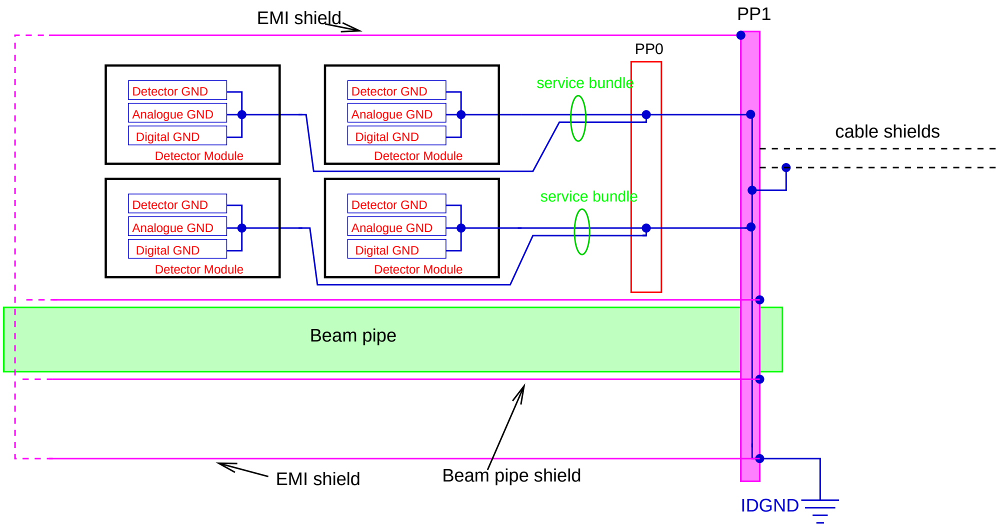


Figure 2.1.1: Simplified grounding scheme for ATLAS Pixel detector.

The routing of the 8AWG cable connecting the commoning point on the PST EM shield (PP1) is shown in Figure 2.1.2. The cable will be routed through sector 13A and tile finger 51A to the IDGND without any break.

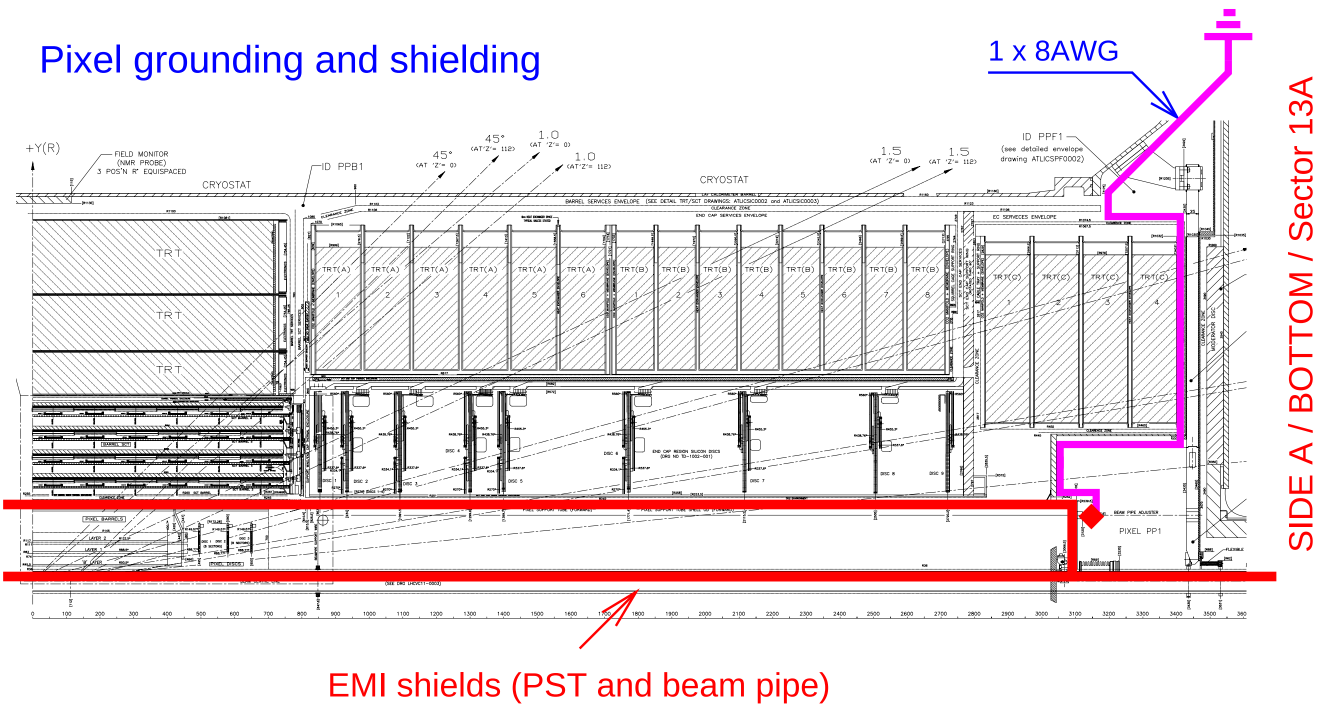


Figure 2.1.2: Location of the ground connections for PST EM shield in the ID volume.

2.2 Grounding and shielding of the SCT

The connections in-between the module supply lines and different types of cables are done on the patch panels PP1-PP3. Each of 4088 SCT detector modules has its own, separate connection to the High Voltage/Low Voltage power supply channel. The connection from the power supply located in the control room to the detector module is done via 100m cable type IV connected on PP3 (platform tray) to 25m cable type III joined with type II at PP2 (located in muon area) and finally using low mass Al tape (PP1 located in bore).

The PP1s for barrel (PPB1) are located along the cryostat bore (176 per side, one serves 6 modules (halve-stave), staggered in 2 positions. The PPF1s for the end cap (EC) modules are located at the cryostat bore-flange corner.

In the SCT there are three electrically independent sections of the detector: barrel and two end cap wheels (A and C) surrounded by three independent EM shields. Each of these shields is electrically connected (DC) to the base plate of appropriate PPB1 or PPF1.

The shields of the conventional cables type II, III and IV and the shield of LM tapes are connected together and tied to the main shield at PPB1. The cooling pipes for barrel and end cap subsystems (inside the EM shields) are electrically connected to the relevant main shields. The cooling block (electrically connected to the cooling pipe) is isolated from the module with the shunt shield, electrically connected to the module (local) analogue ground. The schematic drawings of the power and ground distributions for the SCT including decoupling circuit implemented on PP3 is shown in Figure 2.2.1.

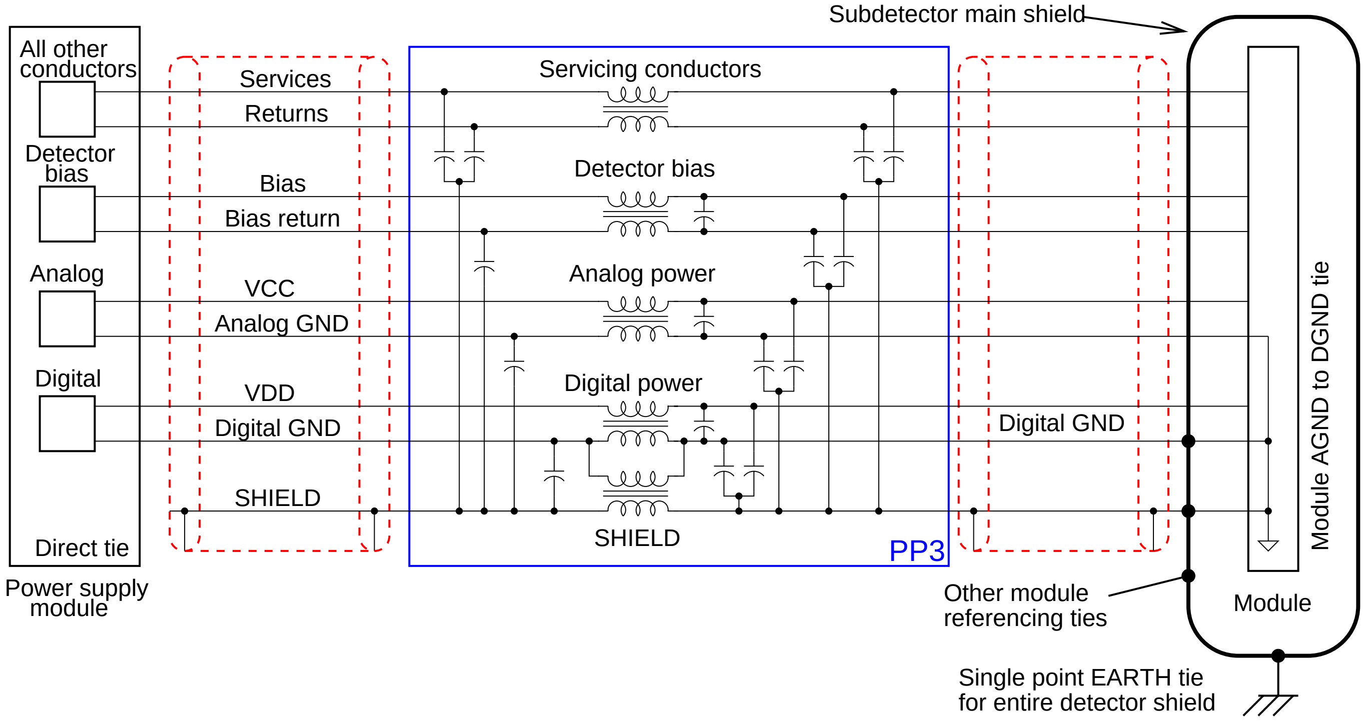


Figure 2.2.1: Simplified power supply distribution scheme for barrel and end cap SCT.

For each detector module the digital ground link is tied to the shield at PPB1. This connection is referencing each module ground to the common ground provided by relevant EM shield (the low impedance connection between detector, analogue and digital grounds is already provided on each detector module).

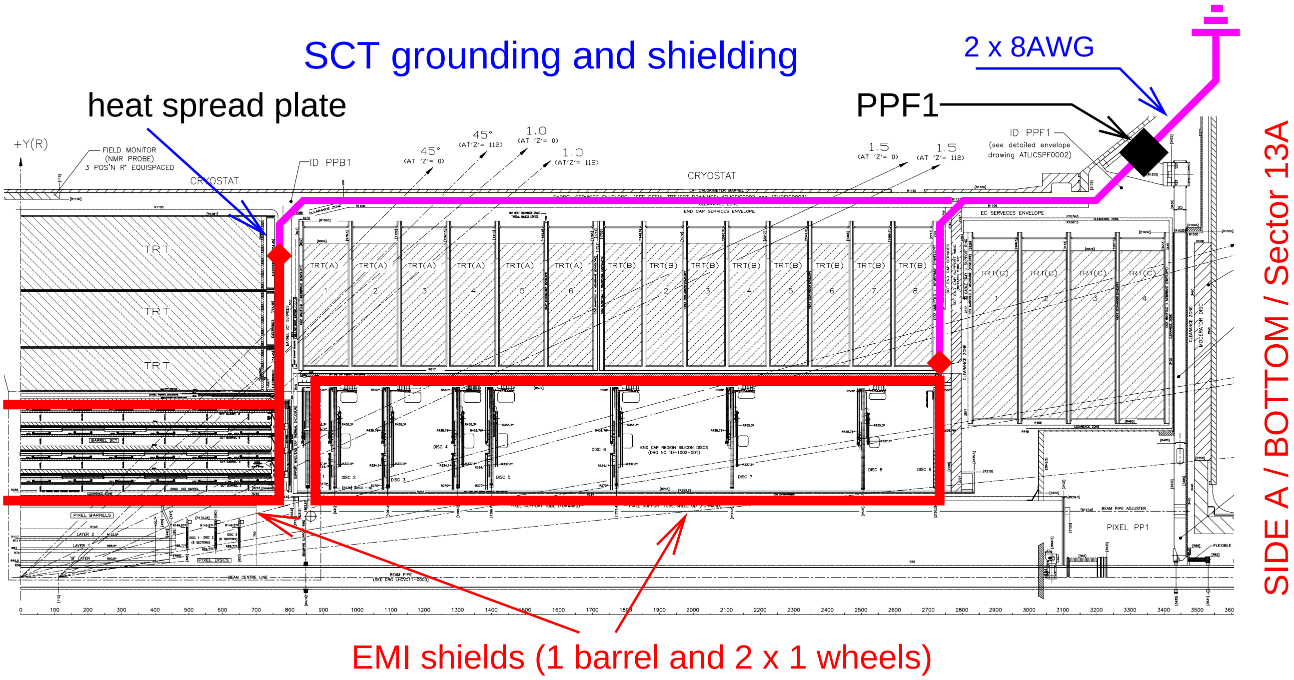


Figure 2.2.2: Location of the ground connections for barrel and one of the end cap SCT EM shields in the ID volume.

The single point connection between a given SCT EM shield and IDGND is done by a single 8AWG (cross section10 mm^2) copper cable. The cable routing for the A side of the detector is shown in Figure 2.2.2. For the end caps A and C the cables will be routed on each of their outer sides of the detector through tile finger 51A and 51C respectively. In case of the barrel, there are two reserved connections on the heat spreader plates, sector 13A and 13C. The heat spreader plate is connected electrically to the EM shield. Only one connection will be completed and the cable will be routed on side A or C through tile finger gap 51A or 51C, respectively (in fact all reserved cables will be in place, some of them will be simply not used).

2.3 Grounding and shielding of the TRT

The grounding scheme of TRT detector is described in document ATL-IT-EN-0050. The detailed connection between different grounds in the TRT barrel module is shown in Figure 2.3.1. The detector and analogue grounds are connected together on the detector module. The digital ground (DTMROC chip) is connected to the analogue ground through a resistor. (In the case of the end cap module they are short circuited directly.)

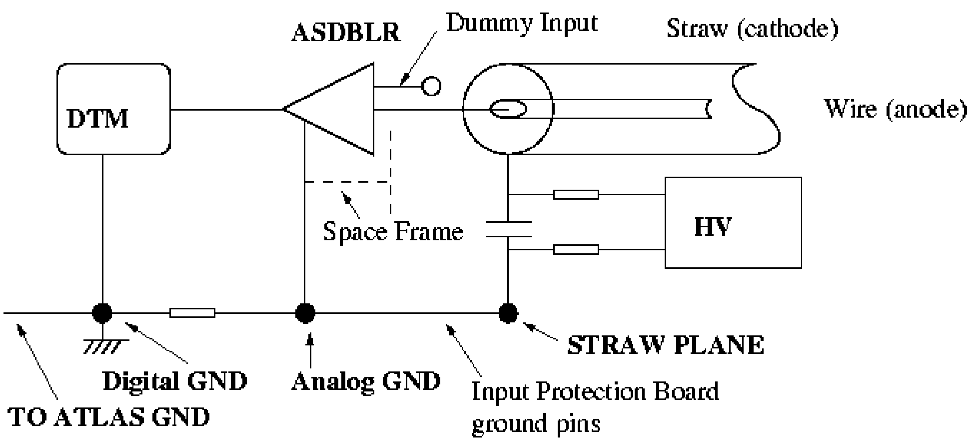
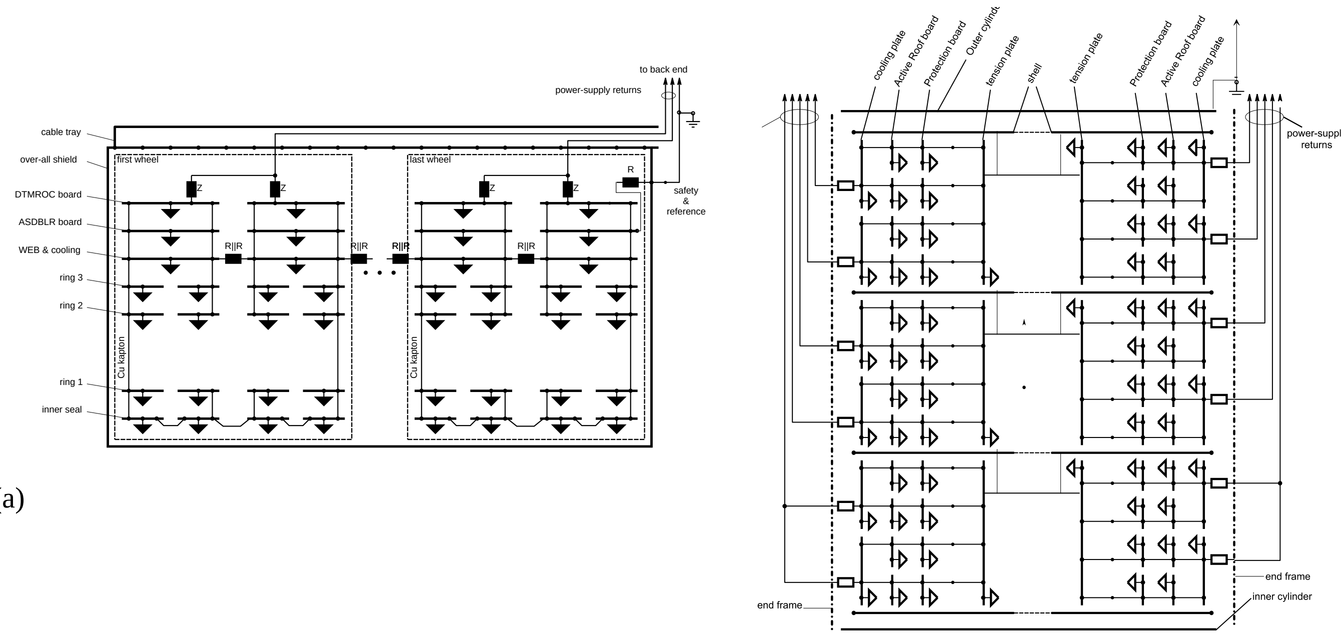


Figure 2.3.1: Detailed connection diagram for grounding in the barrel TRT module. (In the case of the end cap module the Digital GND and Analogue GND are short circuited without resistor.)

The internal grounding scheme of the TRT detector for barrel and for end cap parts is shown in Figure 2.3.2 (a) and (b), respectively. For the TRT end cap a controlled current approach has been chosen. The smallest unit of the end cap is 1/32 of one half of a wheel served by one front-end board with ASDBLR chips. The analogue board ground (plane) and digital board ground with DTMROC chips (plane) are interconnected with multiple ground pins. The modularity of the power supply is 1/32 of a complete wheel (impedance Z is a part of the power supply filter decoupling two halves of the wheel). In the azimuthal direction the grounds of the front-end boards (analogue and digital) are interconnected with the cooling and gas pipes (labelled in Figure 2.3.2 as web & cooling). The segmentation of the ground systems is done in the axial direction, i.e. the wheels are separated and shielded with the capton foil connected to the web & cooling ground. The wheel grounds are interconnected using a low value resistance R (three per 1/96 of a wheel). The last wheel ground is referenced to the overall shield (end cap cable trays a part of the overall shield structure) with a single resistance R. The shields of the four end cap wheels are connected to IDGND using single, 8AWG conductors (one link per shield).



(a) (b)

Figure 2.3.2: Grounding schemes for end cap (a) and barrel (b) sections of TRT detector.

Due to limited space, a different approach is used for the barrel TRT. The front-end electronics boards cover both ends of the detector. The overall shield is built with the copper layer developed on the outer and inner modules walls interconnected at board roofs. The idea is to have the lowest impedance between any two points of the internal ground mesh (return currents can flow through the overall shield).

The single point connection between given EM shield and IDGND is done by single 8AWG (cross section 10 mm^2, outer diameter ~6.5 mm) copper cable. The cable routing for the A side of the detector is shown in Figure 2.3.3. The EM shield of the barrel is connected at one side, A or C; however, as for barrel SCT there are two possible connections reserved. For the cables to the end cap wheels connectors near PPF1 are provided for installation reasons.

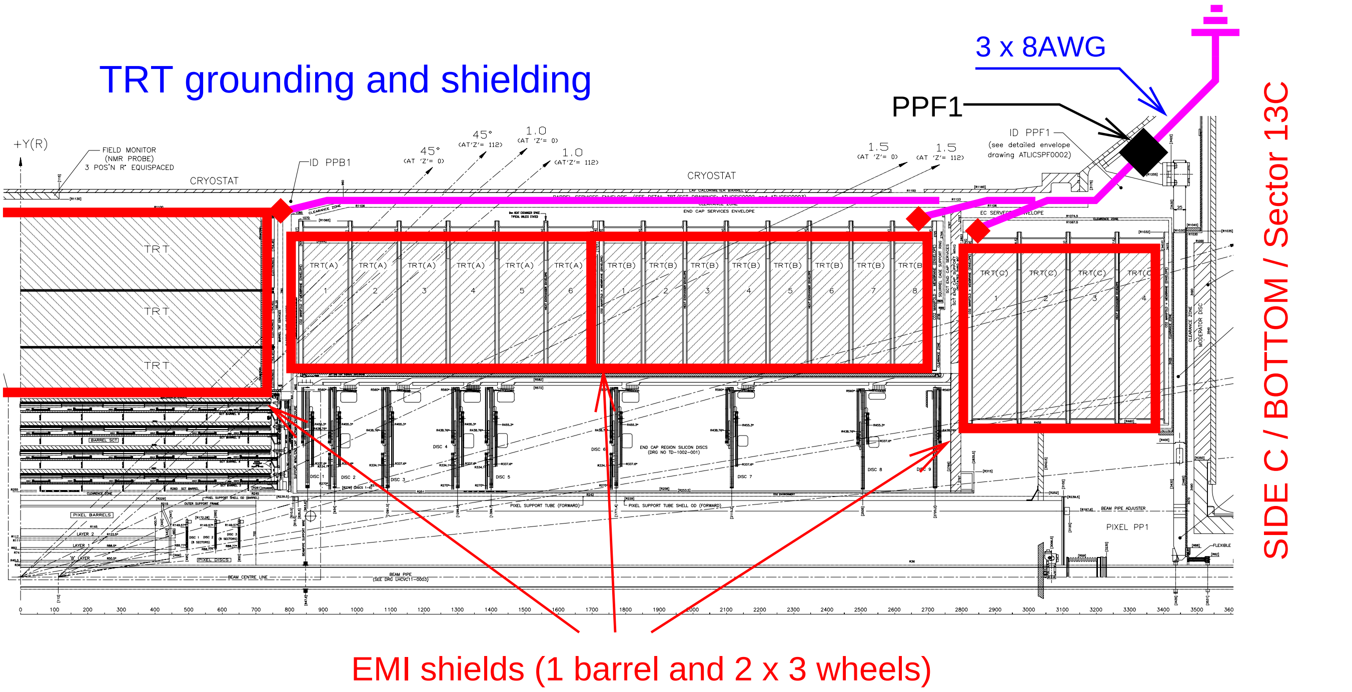


Figure 2.3.3: Location of the ground connections for barrel and end cap TRT EM shields in the ID volume.

2.4 Detailed grounding scheme of the Pixel services

2.5 Detailed grounding scheme of the SCT services

2.5.1 Grounding and shielding of the EC services

The engineering implementation of the SCT EC grounding and shielding is described in detail in ATL-IS-EN-0014. Some details extracted from that note follow.

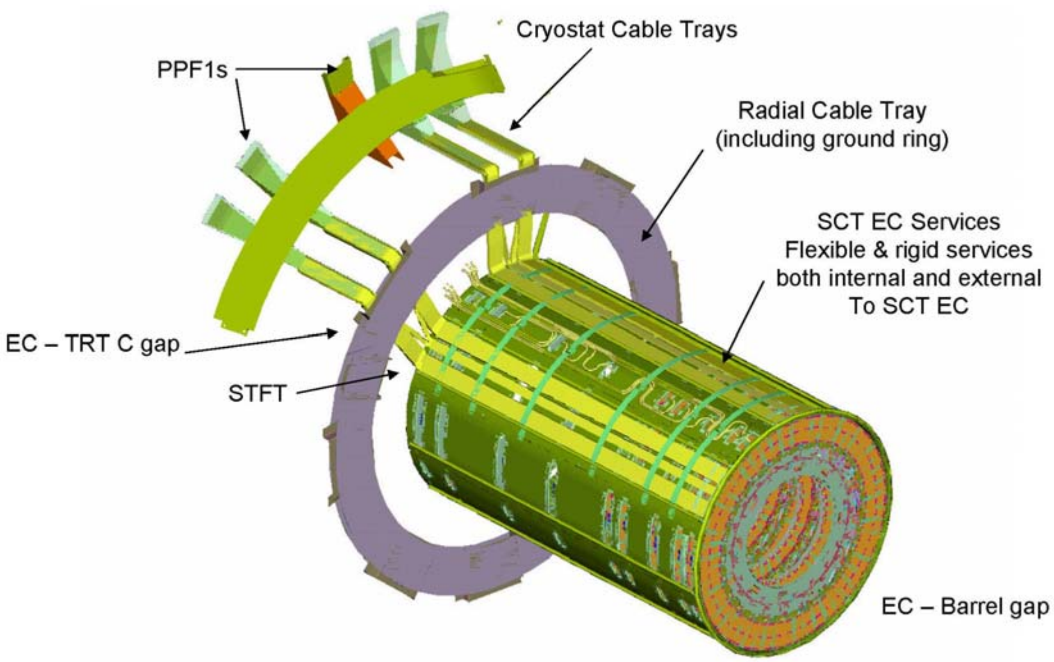


Figure 2.5.1: General view of the SCT EC showing location of the Master Ground Ring (Radial Cable Tray).

The EMI shield for the SCT EC is created by the 100μm Al foil laid on the outer surface of the thermal enclosure (OTE). The OTE will be connected to the Master Ground Ring (Radial Cable Tray on Figure 2.5.1), which is a commoning ring for following components:

- The aluminium screening layer associated with LMTs (Low Mass Tapes) on the cylinder (including Cryostat Cable Trays on Figure 2.5.1 and PPF1 back-plate)
- The Al foil on the outside of the of the rear wing thermal enclosure
- The Al wraps of the LMT bundles going to PPF1 (screening of the LMT)
- The cooling pipes (after the electrical breaks)
- 8AWG single (per one EC) link connection to IDGND (safety ground/ATLAS GND)

The cooling pipes have electrical breaks after passing through the thermal feed-throughs (in proximity of the Master Ground Ring). The pipes (after the electrical breaks) are shorted to the Master Ground Ring. The grounding of the pipes outside the electrical breaks relies on their electrical conductivity up to the distribution racks and their ground connection to the ATLAS GND (platform tray). Except for the single point connections to the Master Ground Ring, the pipes are isolated from the EC cable trays and other conductive parts connected to the EMI shield (to avoid ground loops).

The grounding of the type II cable shields is done at PPF1. The details of the clamping connection of the cable shields are shown on Figure 2.5.2. The type II cable is held in place by the tin-plated cable clamp. Two ferrules glued onto the outer cable sheath capture the clamp saddle. The type II cable drain wire is inserted into a hole in the cable clamp and compressed with a grub screw. Litz wire is crimped to groups of the foil shields and the litz wire is clamped with the drain wires. The back-plate (Alochromed or Ni plated) with clamp is connected to LMT cable trays and finally to the Master Ground Ring. The Digital Ground wires (digital ground of detector module) are shorted to the shield via the PPF1 PCB. This provides required referencing of grounds of all detector modules to the ground of the patch panels (and finally to IDGND/ATLAS ground).

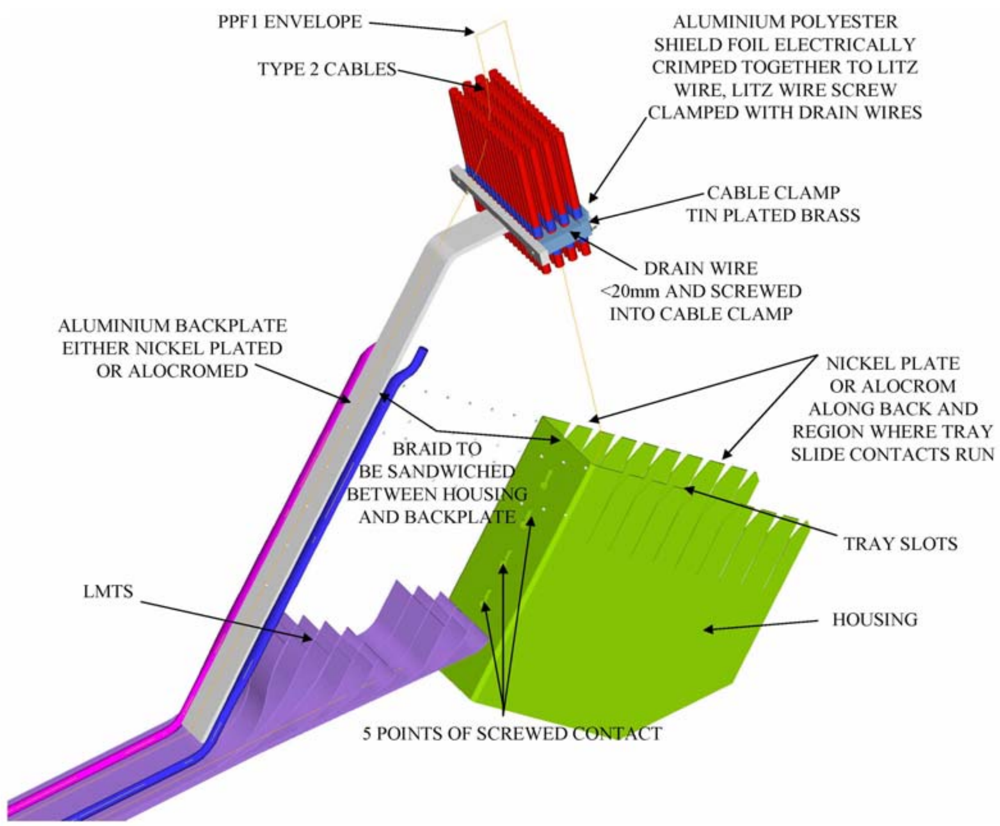


Figure 2.5.2: Details of PPF1 showing grounding of the type II cable shield.

All foil-to-foil connections will be made by first converting the aluminium foil surface to Alochrome (Class 3).

2.5.2 Grounding and shielding barrel SCT services

The Ni plated Aluminium base plate of the PPB1 is used as a ground reference for the cable shields. The details of the cable clamp (nickel-plated Al) connected to the PPB1 base-plate are shown in Figure 2.5.4. The base-plate is connected to the aluminium heat spreader plate (which provides cooling of the low mass tapes). The thermal enclosure (EMI shield) is electrically connected to the spreader plate. The connection to IDGND (one, 8 AWG single link for the whole barrel) is done at the spreader plate (1 mm thick aluminium) close to the connection with TE.

For the case of the module cooling tubes there is no electrical break at the thermal enclosure. The pipes are electrically bonded to the spreader plate, which is connected to the ground reference (thermal enclosure bulkhead). The electrically insulating joints are located immediately outside of PPB1. LMT cooling tubes and dry N2 delivery tubes are treated as above. For the case of type two cable cooling tubes, which make a U-turn loop at the end of the cable tray before they reach PPB1, there is no need for an isolating joint.

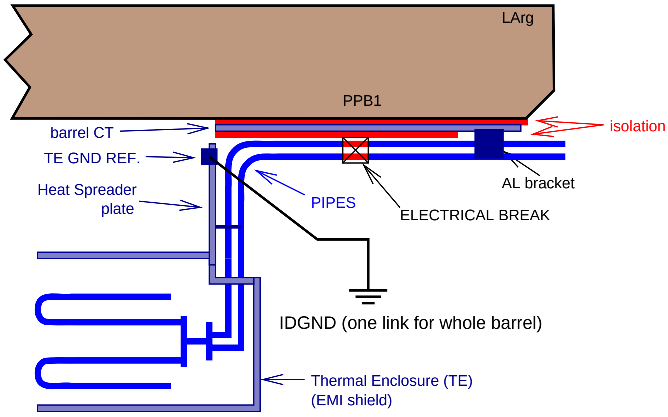


Figure 2.5.3: Details of PPB1 showing grounding of the pipes, location of the electrical break, and the reference point.

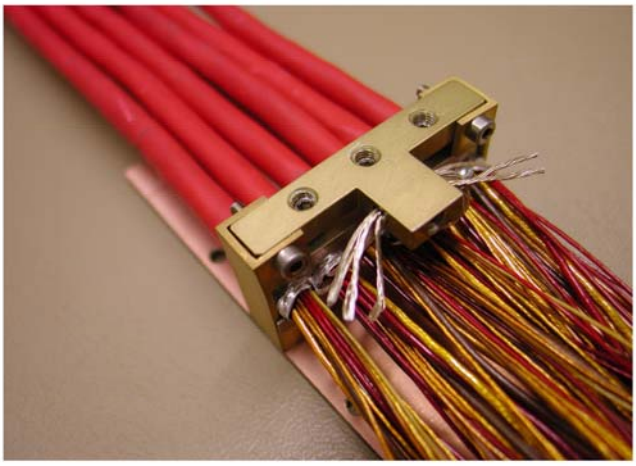
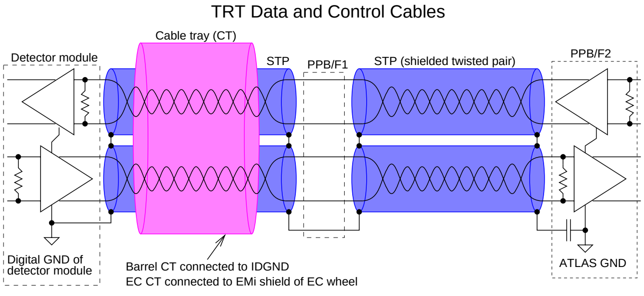
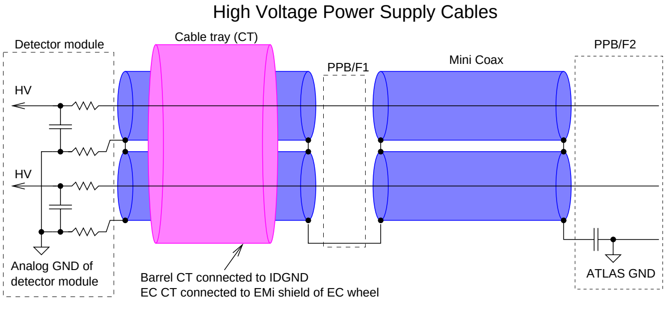


Figure 2.5.4: Cable ground clamp. Bracket is made with tin coated brass.

2.6 Detailed grounding scheme of the TRT services

In general one has to provide the isolation of all TRT services (cables and pipes for both barrel and ECs) with respect to the LAr cryostat and to the EMI shield of the sub-detectors (including cable trays of the EC's) as well as barrel cable trays being connected to IDGND.





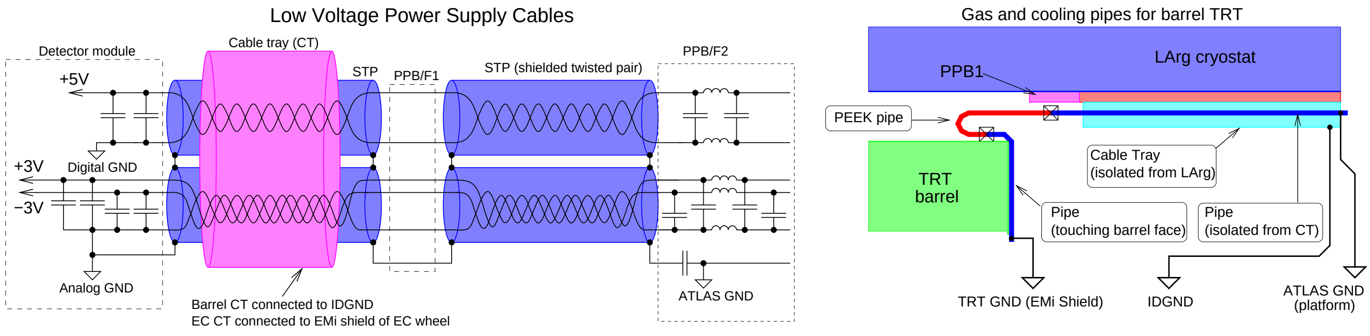


Figure 2.6.1: Detailed grounding scheme of the TRT services.

2.6.1 Grounding of the cable shields

The shields of all cables (Data, LV and HV) are connected to the ground of the detector modules (EMI shield of the sub-detector). In the region of PP1, the shields of the cables are FLOATING, however, they are connected together inside cable bundle. (See Figure 2.6.1.) The continuity of the cable shields is provided up to PP2 where the shields are AC coupled to the ATLAS GND.

Since the shields of the data and control cables are done with the aluminized Mylar foil wrapped around the cable, the electrical isolation of this type shield is not reliable. In order to reinforce the electrical isolation of the data cable shield and to isolate all metallic parts of the pipes (barrel part mostly) with respect to the mechanical support structures (cable trays, pockets in the region of PPB1), layers of Kapton sheets are used in the relevant places. (See isolation techniques for the cable trays; section 3.2.)

2.6.2 Ground connection and isolation requirements for PPB1

The arc plates supporting PPB1 are in electrical contact with LAr cryostat. Although the HV cables are insulated with kapton, the connectors used in the region of PPB1 are metallic with the case connected to the cable shield. Therefore, the support for HV connectors has to be isolated from the arc plates (insulating brackets or Kapton wrapping).

The metallic parts of the fittings, pipes and data cable shields must be isolated from the pockets (Kapton layers).

All pipes must electrically bond to the barrel face, which is part of the TRT Faraday shield. (See Figure 2.6.1.)

2.6.3 Barrel cable trays inside cryostat bore

The barrel cable trays are insulated from the cryostat bore. (See section 3.2 and drawing ATLICSPB0069.) The LV and HV cables are insulated with Kapton. The inside surface of the barrel cable trays is insulated with Kapton (due to bad isolation of data cable shield). The metallic parts of the pipes are wrapped with Kapton sheets in order not to short them to data cable shields (in that case the data cable shield will touch the platform ground causing a ground loop). (See drawing ATLICSPB0202.) The barrel cable tray is connected (cable link) at the end to the common IDGND ring. (See Figure 3.1.1 and drawing ATLICSPB0069.)

2.6.4 Barrel services exiting the bore in the PPF1 region

All the surfaces of the conical plate (electrically connected to LAr) and the IDGND ring have to be insulated (until the cryostat flange) to avoid contact with the barrel services passing through (see drawing ATLICSPF0035). The electrical insulation has to be provided between the IDGND ring plate and the TRT PPF1 base plate for the barrel steel pipes.

2.6.5 End cap services

All pipes inside cable trays are made of peek (no need of extra insulation). Cable trays have to be insulated inside with epoxy paint and treated with Alodine on the outer surface. The EC cable trays are the part of the EMI shield of the EC. The connection of the EMI shield to the IDGND is made by one single conductor (8AWG) and the cable is attached to the EMI shield. Pipes, and HV connectors have to be insulated at PPF1 from the base plate; data cables might be left in contact. LV cable shields have to be connected all together to the TRT PPF1 base plates, which have to be left floating with only the LV shield connected (driven by the simplicity of the design – in principle all cable shields should be floated in the PP1 regions – here the LV cable shields are connected to the PPF1 base plate but the base plate is isolated with respect to the rest of the mechanical structure).

3 Grounding of ID services

3.1 Grounding of cooling pipes and cable trays

As already mentioned each sub-detector (Pixel, SCT barrel, SCT ECs (end caps), TRT barrel, TRT wheels) will be placed in the Faraday cages formed by EM shields referenced by single point connections to IDGND. In order to provide effectiveness of the shielding scheme one has to break the electrical continuity of the cooling and gas pipes at the entrance to the volume defined by the given EM shield. This feature is provided by each sub-detector internal grounding and shielding scheme.

In case of the Pixel detector the electrical breaks are located at patch panel PP1. For EC TRT the isolation is done either before the entrance to the module (active gas pipe) or by the section of the PEEK pipe running along the cryostat bore in the cable tray (cooling pipe). For the EC SCT the electrical breaks of the pipes are placed at the thermal enclosure of the EC. The cable trays for both the TRT EC and SCT EC, which are inside of their respective PPF1s, are connected to the EM shields of the relevant sub-detectors. **Isolation of the SCT cooling tubes from the trays inside of SCT PPF1 must be provided** because the tubes are referenced to the platform ground but the trays are referenced to the SCT EM shield in this location. Likewise, **isolation of the TRT cooling tubes from the trays inside of TRT PPF1 must be provided** because the tubes are referenced to the platform ground but the trays are referenced to the TRT EM Shield in this location. The techniques of isolation of the pipes and cables from the cable trays are described later.

The barrel cable trays sitting directly on the cryostat bore are electrically isolated from it by the fibreglass layer. Since they are not a part of the EM shields of the barrel SCT and TRT, they are referenced to IDGND in the following way. All barrel cable trays are connected together using at least 2mm thick and 1.5cm wide Al strap forming the ring at the end of the CT. This ring is connected to the sector plate structure at least at 3 locations per quadrant using at least 0.5mm thick and 2-3cm wide Al strap. All sector plates are connected together at the outer radius by the Al sealing structure (Al parts minimum 2cm thick). Sector plates are bonded to the ATLAS ground and IDGND directly through the Tile support structure (Figure 3.2.1).

All tubes running inside the PPB1 i.e. inside the electrical break (see Figure 2.5.3) should be referenced to SCT base plate i.e. SCT barrel EM shield.

Another mechanical structure which has to be referenced to the IDGND is a segmented ring (IDGND ring) at both ends of the ID. Since the segmentation of the IDGND ring follows the segmentation of the barrel cable trays, it is necessary to interconnect the separated sections by washers. (See Figure 3.1.2.) Two IDGND rings installed on side A and C of the detector are electrically separated. Connection to the IDGND is provided by two single links of 8AWG, attached to each of the IDGND ring in sector 13A and 13C, and routed through tile finger gaps 51A and 51C which provide safety ground connection for the barrel CT structure. (See Figure 3.1.3.)

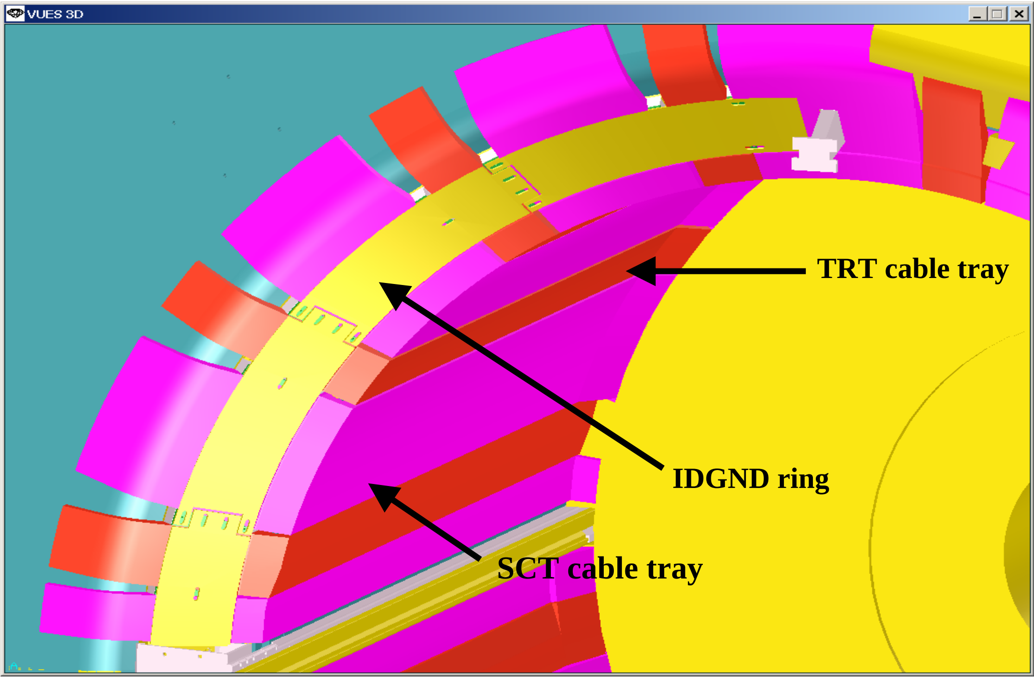


Figure 3.1.1: 3D view of the IDGND ring (2nd layer of the conical plate) and barrel services envelopes.

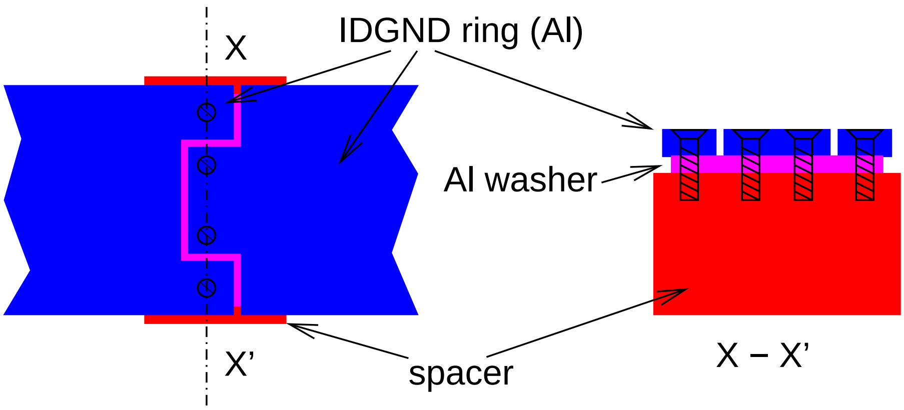


Figure 3.1.2: Interconnection method for IDGND ring (second layer of the conical plate). **All aluminum** part treated with **Alodine** process.

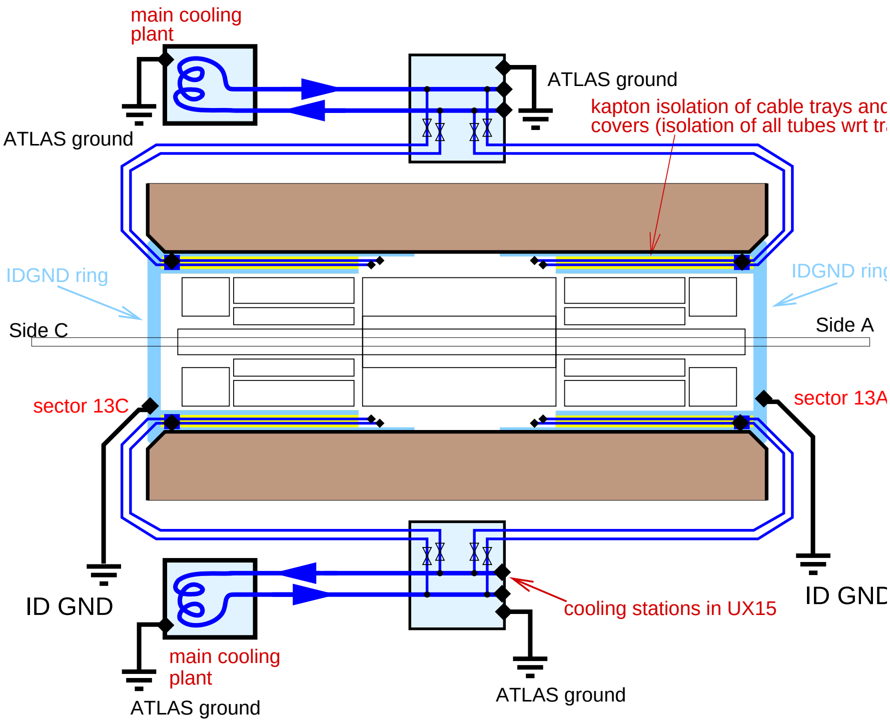


Figure 3.1.3: Grounding connection of the barrel cable trays and IDGND ring. The grounding of the pipes outside the sub-detector volumes (outwards electrical breaks before EM shields) is provided by direct connection of distribution racks on the platform.

The barrel section of the cable trays connected to the sector plates form an extra Faraday cage connected to IDGND and ATLAS GND, which shields the ID from the LAr cryostat.

All gas and cooling tubes outside the electrical breaks will be connected electrically to the distribution racks sitting on the platform, i.e. they will be connected to the platform ground (ATLAS ground) and they will be in electrical contact (screwed) with the sector plates (IDGND). All service support trays located on the LAr calorimeter must be electrically isolated from it. The ground connection will be provided by the electrical continuity of the tubes connected to the platform ground and support structure (Tile and ATLAS feet). Therefore, one should improve quality connection of the support structure to the pipes outside PP1. At the same moment one has to provide electrical isolation of those supports from the data cable shields for TRT (data cables with weak insulation of shield). The isolation techniques are described in the next paragraph.

3.2 Grounding of the ID end plate

The ATLAS Inner Detector (ID) volume inside the LAr cryostat bore is closed at the two ends by two end plates (IDEP). The IDEP is physically separated into two major parts with different geometry and requirements:

- The internal part extending from the beam pipe to the cryostat chamfer area (end plate)
- The external part extending from the cryostat chamfer area to the outer edge of the cryostat flange (sector plate)

The engineering drawings can be found on EDMS; ATLICSIA0018. The IDEP will have to be electrically insulated from the cryostat, the PST, the beam pipe and some ID services (some TRT cables having insufficient isolation around the cable screen). The IDEP, ID sector plates and IDEP cover plates are electrically connected to the Tile structure which is bonded to the ATLAS GND.

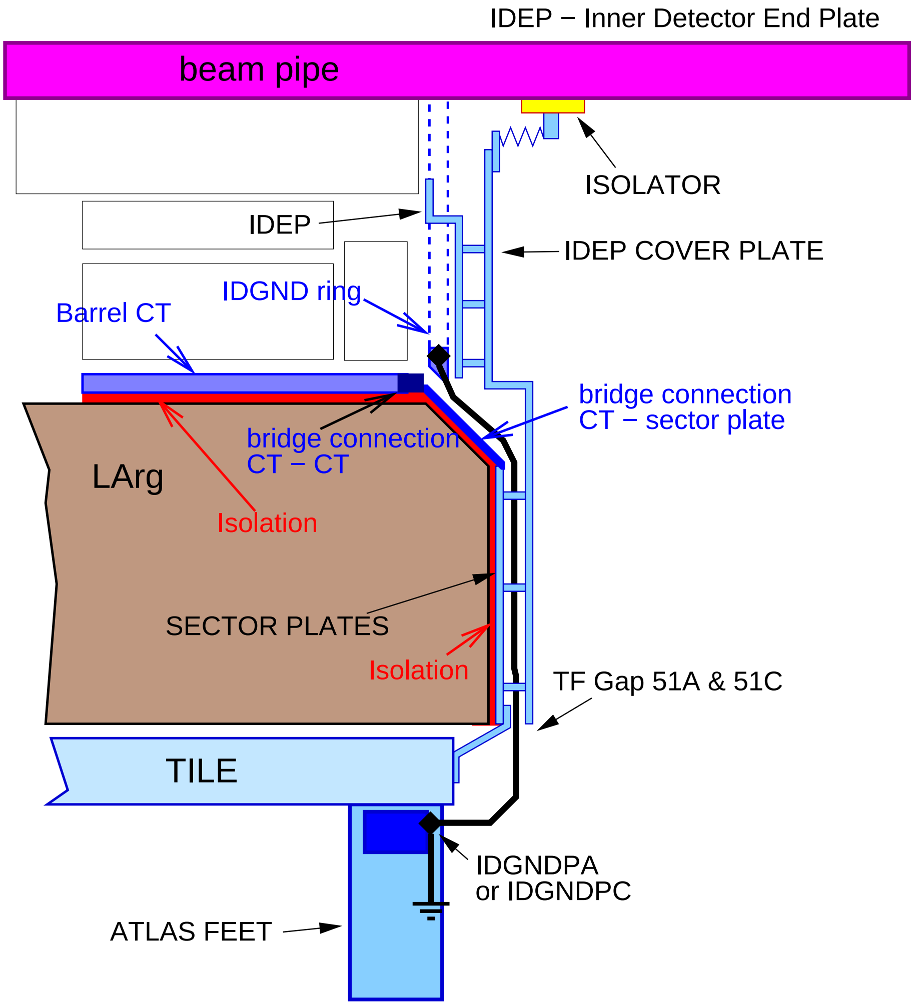


Figure 3.2.1: Grounding connection of the barrel cable trays, IDGND ring, ID sector plate and ID end plate for one side of the detector. The connection between CT and IDGND ring is done for every tray. The ID sector plate, ID end plate and IDEP cover plate is electrically connected to Tile structure which is bonded to the ATLAS ground. The IDGND ring (on one detector side) is connected to IDGND by one single 8AWG link (sector 13A and 13C, Tile Finger Gap 51 A and 51C for side A and C respectively) in point IDGNDPA or IDGNDPC for side A or C respectively.

3.3 Techniques used for isolation of the pipes and cables inside cable trays

Figure 3.3.1 shows the techniques used for isolation of the tubes and TRT cable shields for end cap and barrel cable trays inside the ID volume. The isolation of the barrel SCT and TRT cable trays from the LAr cryostat is provided using fibre glass fabric, 200µm thick 90-90°. The isolation of the cable trays from each other is provided by Kapton sheets. As was mentioned the shield of the TRT data and control cables has an outer coating done with Mylar foil, i.e. it does not provide reliable electrical isolation. In order to isolate them from TRT cable trays the inner side of the trays will be layered with Kapton sheets. To prevent a short in between the metallic tubes and cable shield, the metallic tubes will be coated with Kapton sheets. For SCT, since all cables have outer isolation, one has to take care only about the isolation between cable trays and pipes. For the barrel SCT trays, the electrical isolation will be provided naturally by the thermal isolation of cooling pipes. For the EC SCT, due to limited space, the tubes will be coated with a Kapton layer. In both cases of TRT and SCT EC trays, the outer side of the cable trays will be covered with Kapton sheets in places where they could touch the metallic parts since these will be at different reference potentials (not IDGND).

In some cases, peek tubes are going to be used, which will provide natural electrical isolation (TRT cooling and gas in EC trays).

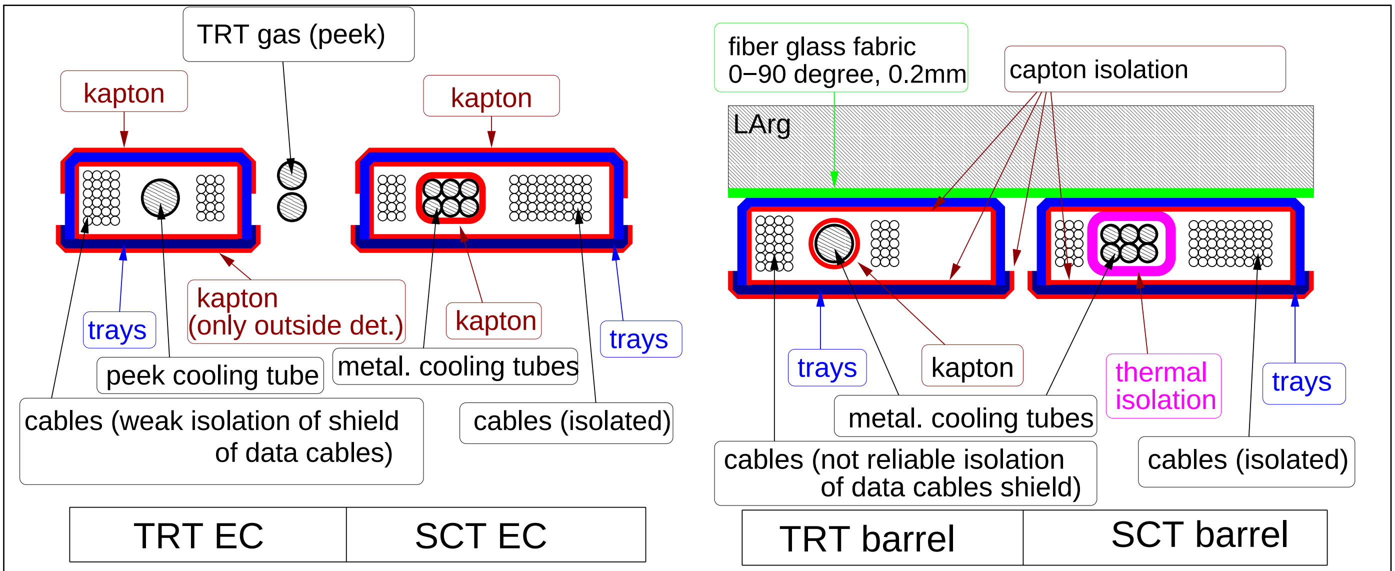


Figure 3.3.1: Techniques used for isolation of the tubes and TRT cable shields for end cap and barrel cable trays inside ID volume

3.4 Grounding scheme of 48V and 110V heaters

In ID heaters are employed in:

- evaporative cooling exhaust pipes for pixel and SCT (110V DC)
- thermal barrier of pixel and SCT (48V DC)
- ID end plates (48V DC)
- service feed-throughs at outer radius of ID end plate (48V DC)

There are 16 Power groups for the 48V heaters distributed over the PST shield and the thermal enclosure of the SCT (EM shield) for two caverns (US15 and USA15):

- barrel TE forward
- barrel TE rear
- end-cap forward
- end-cap rear
- Pixel forward
- Pixel rear
- ID endplate forward
- ID endplate rear

The thermal screens of the SCT and Pixel are to follow the general grounding and shielding principles of the SCT. All the power supplies are fully floating, referenced at the heater PP1. Figures 3.4.1 and 3.4.2 detail the PP1 grounding connections of the thermal shield heater for the SCT heater type. The cable and PP1 are simplified: only one of four power triples is illustrated and only one of eight sensor pairs. The heater cable shields are DC tied to the sub-detector earth through the heater PP1 and patch panel base plate (base plate is connected to the EM shield of a given subdetector SCT or TRT in case of TRT TE heaters). **Therefore the referencing conductor for a power supply group uses particular sub-detector EM shield, which has a single conductor to IDGND.** The sub-detector shielding must have a direct path between the PP1 heater modules in a power group. It should be a 10 AWG copper wire or a foil equivalent in conductive cross-section to 10 AWG copper wire. Care must be taken to provide minimum impedance for good shield continuity at cable connectors and splice joints.

The return of the power pack groups will be remotely referenced, so the conductors are not considered SELV. The rear rack door requires an interlock if there are any exposed remote referenced conductors. Also, a provision for tying the return to local earth will simplify maintenance and debugging.

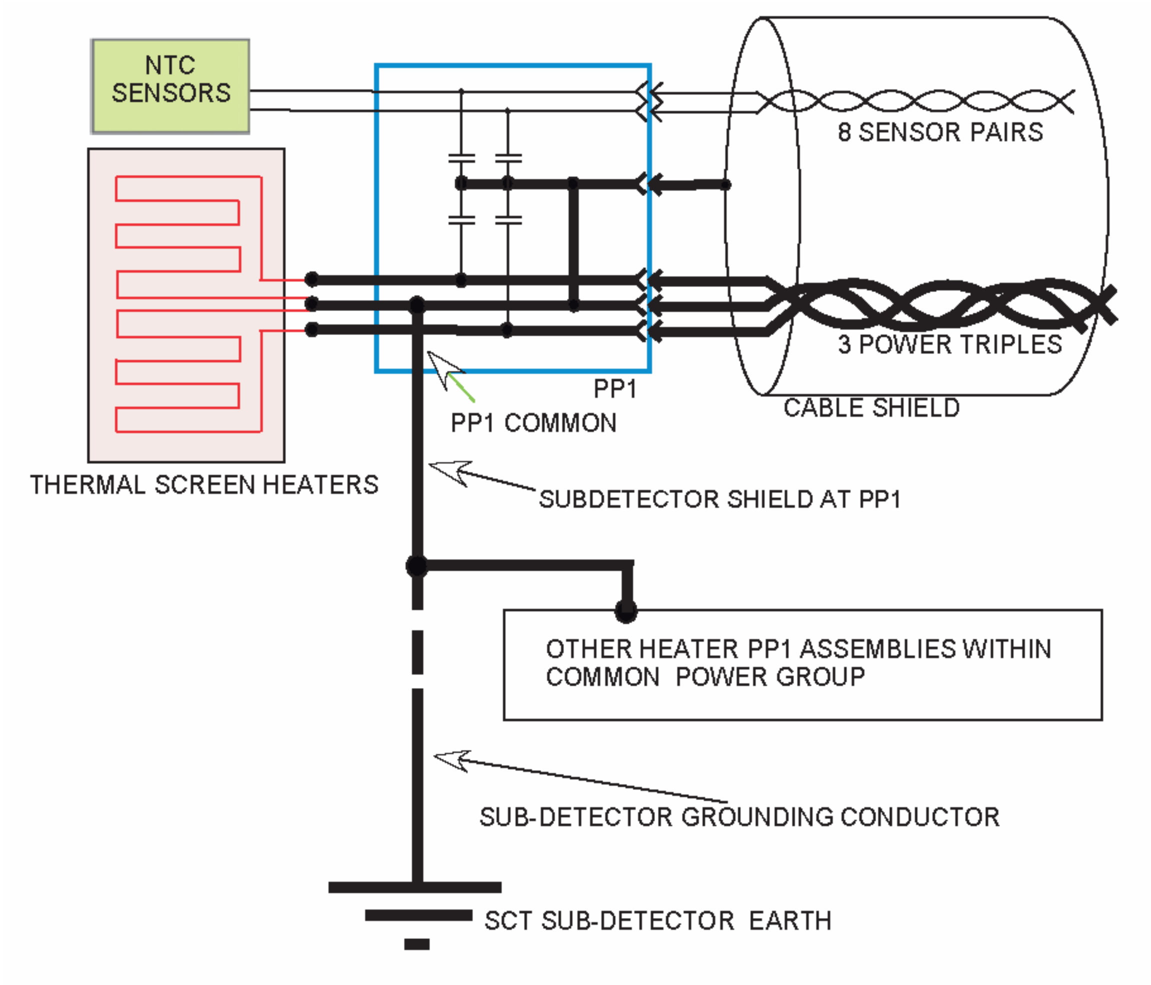


Figure 3.4.1: Thermal enclosure heater grounding.

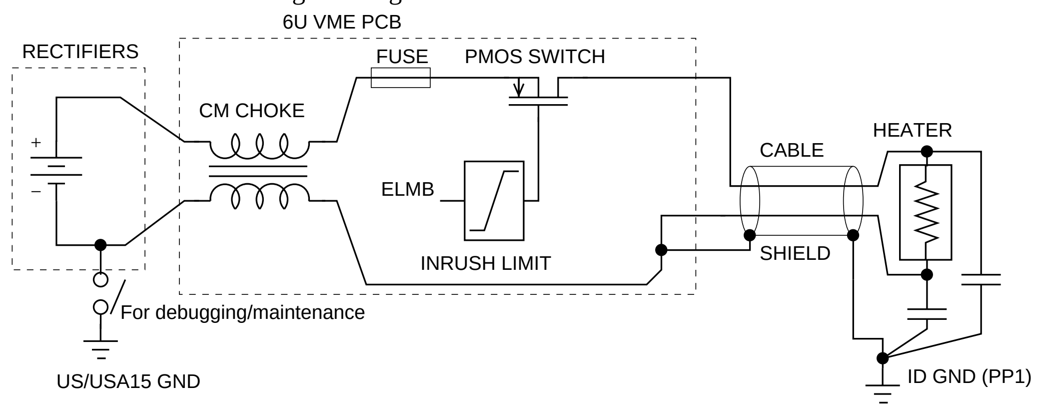


Figure 3.4.2: Output stage of the 48V heater switch showing the power supply distribution, earthing and fuse location.

For the 110V heaters the conductor pair will consist of +55 V and -55 V conductors. The ±55 Volt supplies are referenced to the ATLAS GND (near the power racks in US/USA15). The shield of the power cable (one shielded twisted pair per single heater – exact specification in the ATL-IC-EC-0007) is connected on one side to the exhaust tube (ATLAS GND in UX15), on the other side to the rack ground (ATLAS GND in US/USA15). Each heater load will be fused on power and return line of the single channel (see Figure 3.4.3) – 16A. The fuse locations will be on the 6U VME PCB holding also the MOS switches. Additional fuses cutting the supply for the whole switch card (3 channels – 30A) will be located on the DIN rail in the rack between the power packs and switch crate. The control signals from PLC and interlock card will be optically isolated.

All power connectors for the heaters on the heater side are LEMO series B (IP50 isolation level). Detailed specifications of those connectors are following:

- Power cable type DII; twisted pair, shielded, 2x AWG14, OD=5.5mm
  - Plug: **FGG.1B.302.CYCD62**
  - Receptacle: **PHG.1B.302.CYMD62**
- Power cable type CII; twisted pair, shielded, 2x AWG18, OD=4,3mm
  - Plug: **FGG.0B.302.CYCD52**
  - Receptacle: **PHG.0B.302.CYMD52**

The general schematic and detailed implementation of the power and ground connections are shown in Figures 3.4.3.

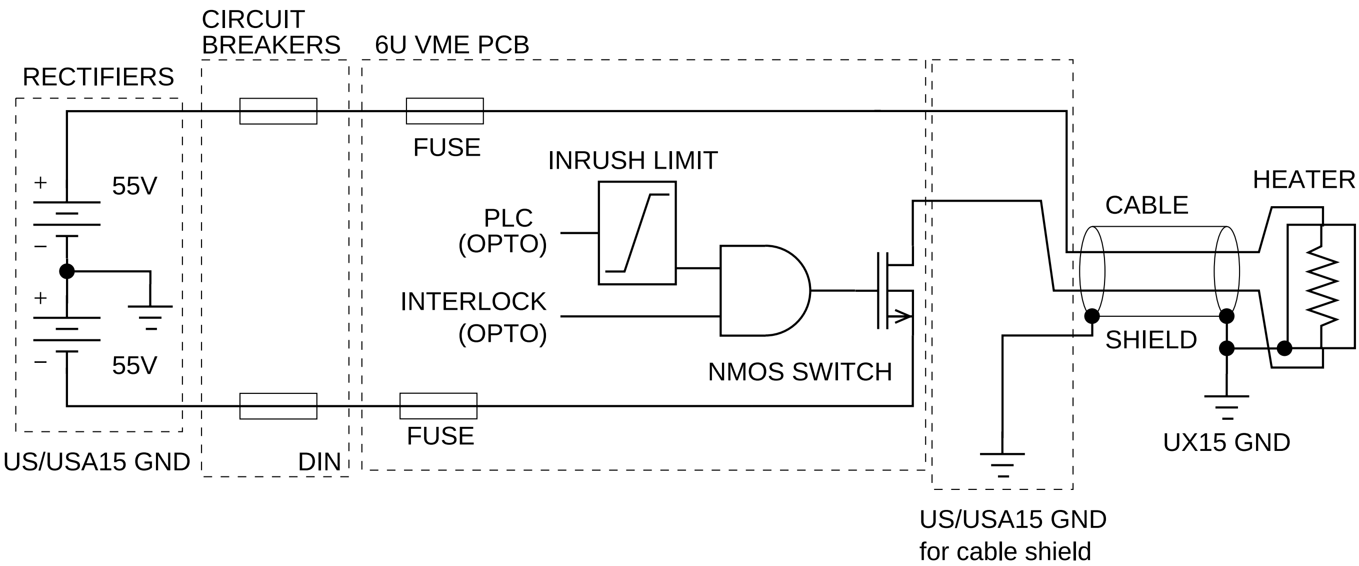


Figure 3.4.3: General schematic of power distribution and grounding showing also location of the fuses.

3.5 Grounding of DCS sensors

All DCS sensors (SCT and common ID DCS sensors) will be readout by ELMB boards. The ADC implemented on the ELMB provides separate floating ground reference for the analogue inputs. The shield of the cables is connected to the PP1 ground (referenced to the EMI shield of a given sub-detector – SCT EC or SCT barrel). The decoupling of the signal wires is done as well on the PP1 boards to the local ground referenced to the given sub-detector ground.

That scheme requires use of separate ELMB card for DCS components used in different sub-detectors (in order not to short the grounds of different sub-detectors on one ELMB board). The schematic diagram of the grounding and shielding of the DCS items is shown in Figure 3.5.1.

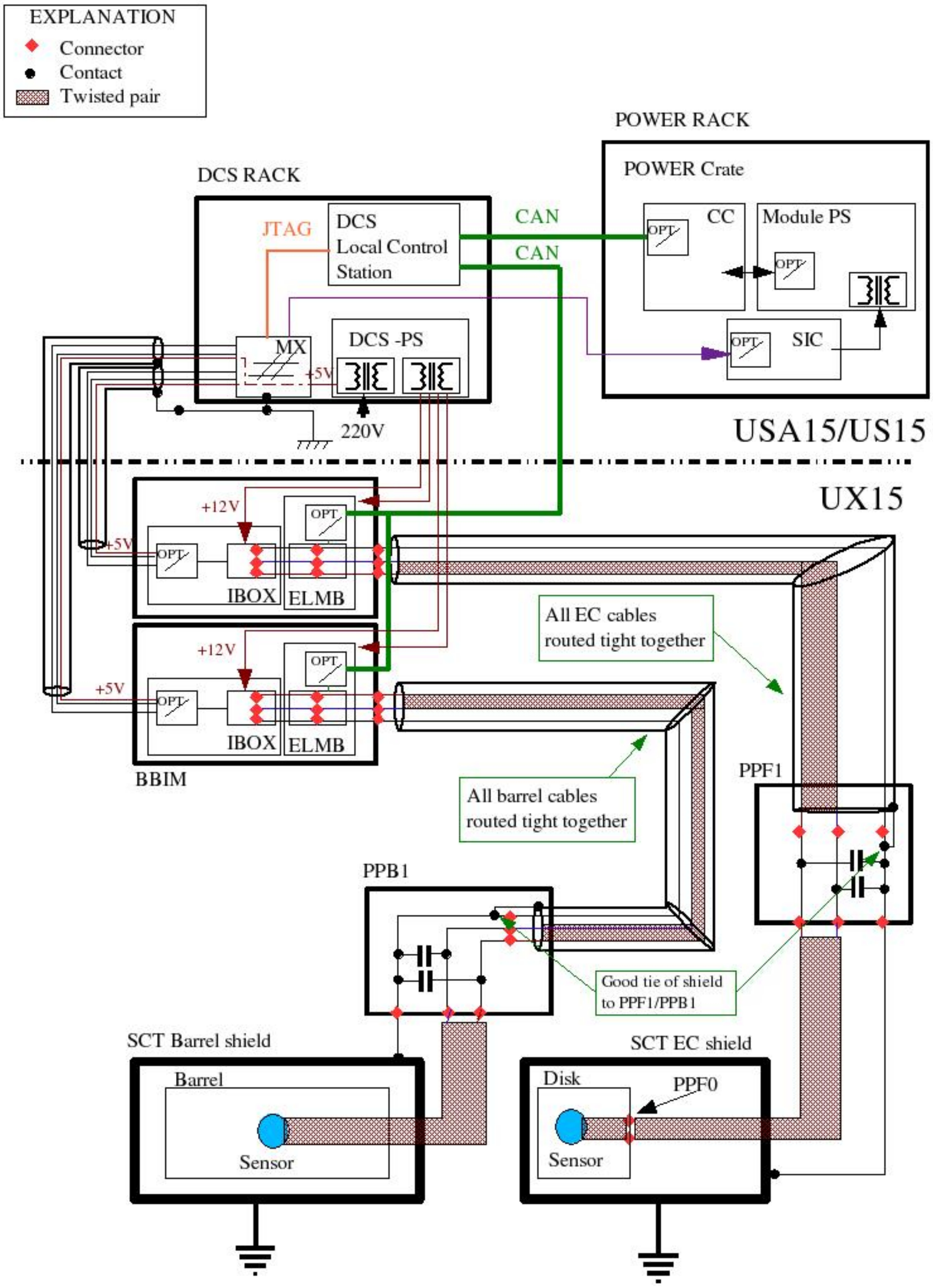


Figure 3.5.1: Grounding and shielding of the DCS sensors.

4 IDGND cable routing (default)

The routing of cables connecting ID sub-detectors and barrel trays to IDGND and further to the overall ATLAS ground system is shown in Figure 4.1. For all 13 cables referencing EM shields of all sub-detectors and barrel trays, the tile finger gap number 51A and 51C have been reserved. This will allow relatively short connections to the IDGND commoning point, which is electrically bonded to the ATLAS support structure (point IDGNDPA) and overall ATLAS ground system (Figures 4.2 and 4.3).

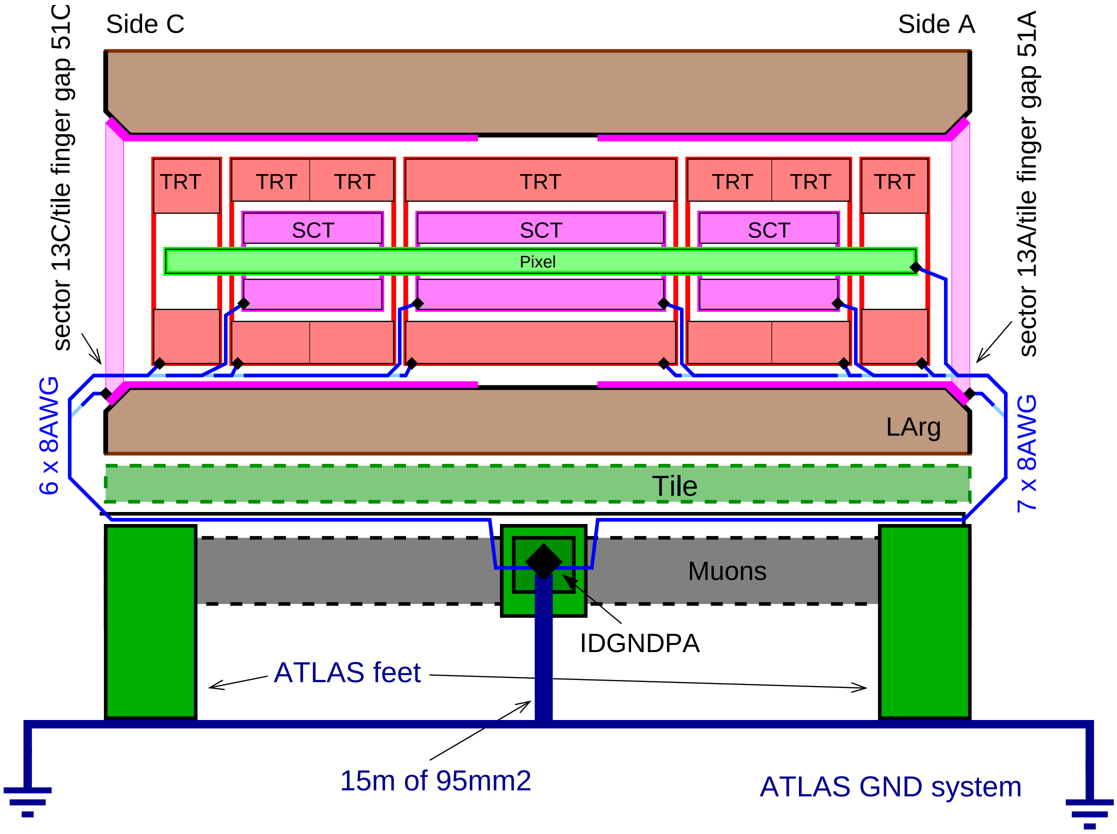


Figure 4.1: Routing of the cables for IDGND connections of ID subsystems.

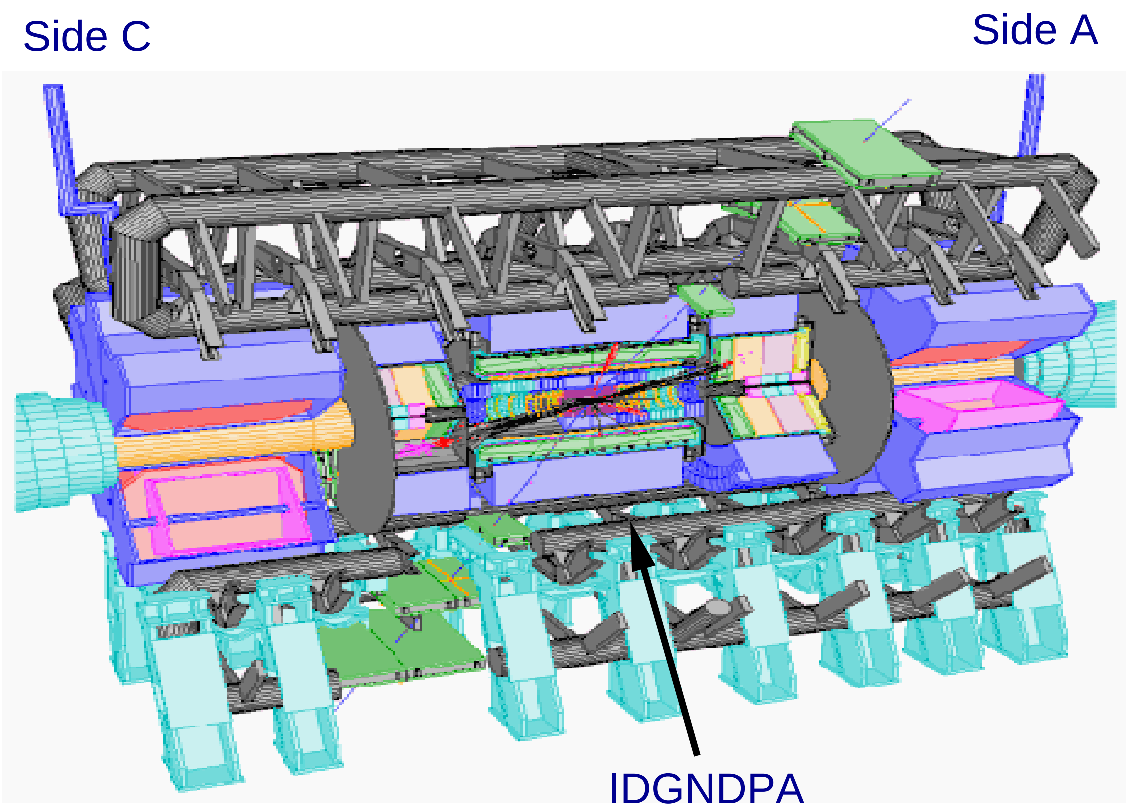


Figure 4.2: Location of the IDGND connection points to ATLAS GND (IDGNDPA).

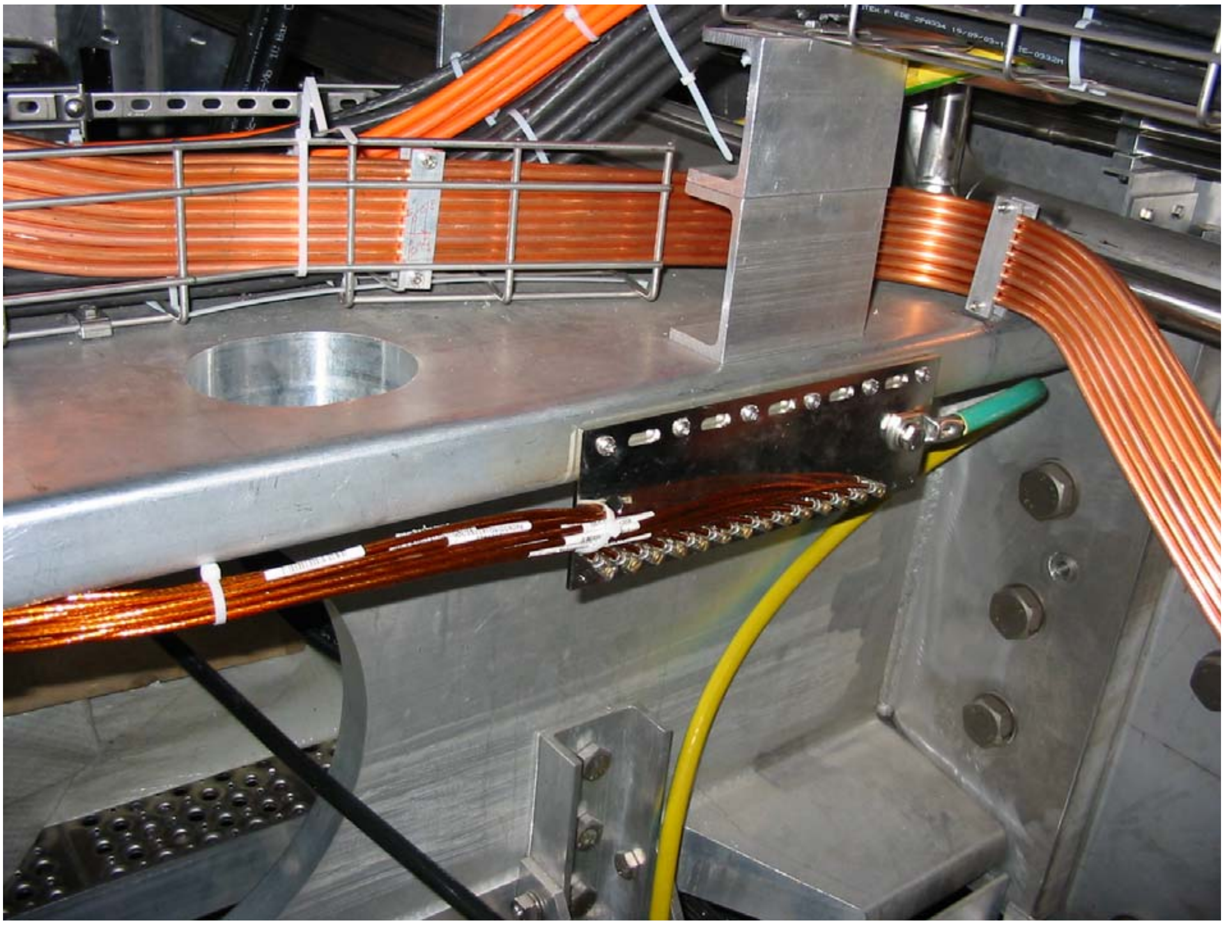


Figure 4.2: Location of the IDGNDPA grounding plate.

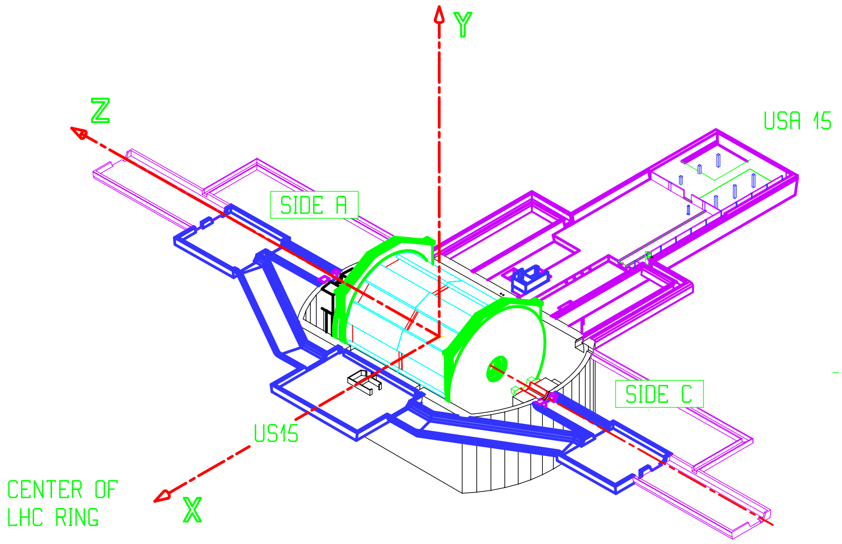


Figure4.4: Configuration of the ATLAS detector in the experimental hall – naming conventions.

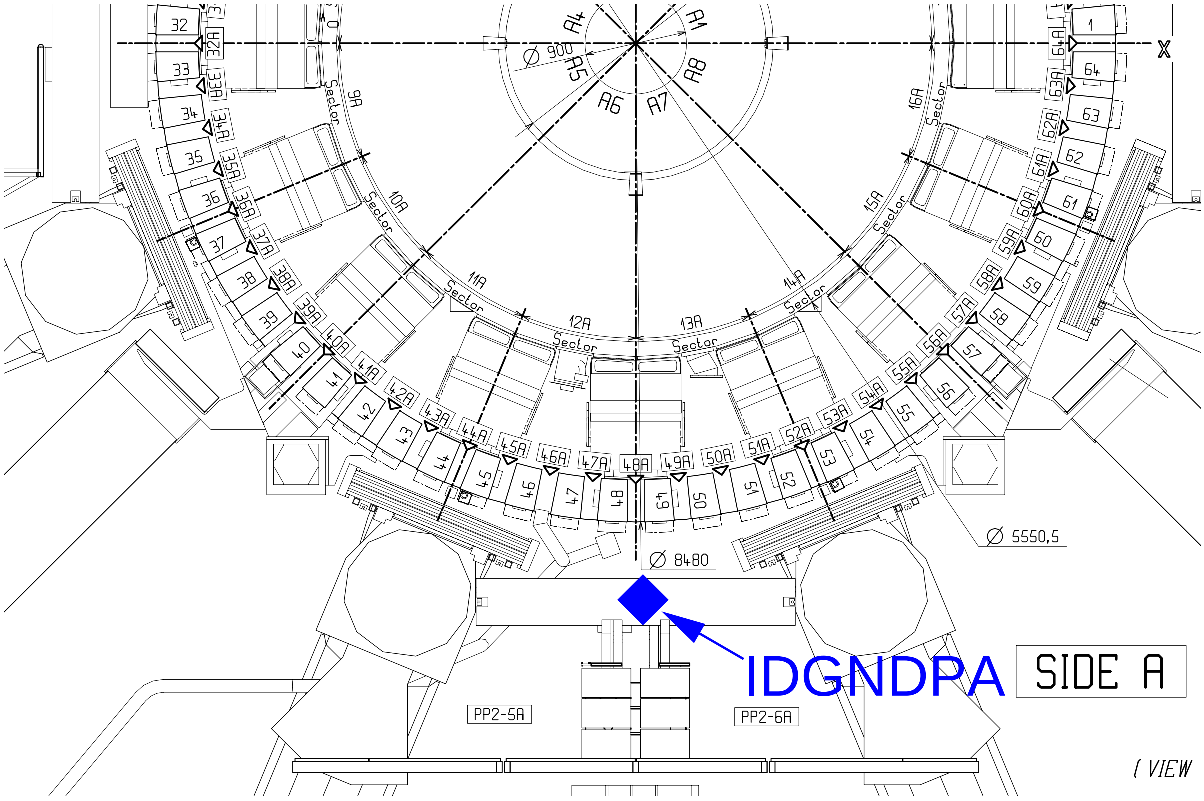


Figure 4.5: Naming of the tile finger gaps and gaps between LAr boxes, location of IDGNDPA.

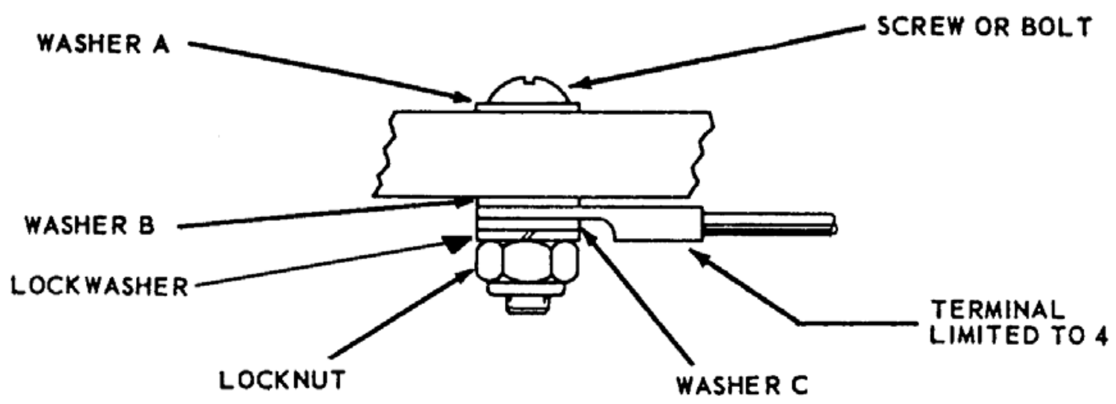
4.1 Reliable aluminium-copper connection, grounding cable

Direct simple connection of the aluminium and copper parts leads to the creation of a mini-cell effect. For reliable bonding and grounding connections of the aluminium parts we follow the specification AC43.13-1B document by Federal Aviation Administration about grounding in the aircrafts. Some details follows. In some cases where the space for the connections is limited one can omit WASHER A and WASHER B (this concerns some connections of the barrel cable trays where the space is very limited).

Extracted from AC 43.13-1B document (could be found on

http://atlas-id-grounding.web.cern.ch/ATLAS-ID-Grounding/)

TABLE 11-16. Bolt and nut bonding or grounding to flat surface.



Tinned Copper Terminal and Jumper					
	Screw or bolt				

Structure	***and nut plate***	***Lock-nut***	***Washer A***	***Washer B***	***Washer C***
Aluminum Alloy	*Cadmium Plated Stainless Steel*	*Cadmium Plated Stainless Steel*	*Cadmium Plated Stainless Steel*	*Aluminum[1] Alloy*	*Cadmium Plated Stainless Steel*
Stainless Steel	*Stainless Steel or Cadmium Plated Stainless Steel*	*Cadmium Plated Stainless Steel*	*Stainless Steel*	*None*	*Cadmium Plated Stainless Steel*
[1.] Use washers having a conductive finished treated to prevent corrosion (Alodine)					

The grounding cable used for all grounding connection in the ID volume is a single core AWG 8 119/0.30mm NPCW Kapton/polyimide enamel insulated 600v rms OD 4.6mm(+/-.2mm) (supplier: CDT-Raydex, qualified for 10MRad). For availability please contact Jan Kaplon or Marco Olcese.