ATLAS Policy on Grounding and Power Distribution

Introduction

As is well known from previous experiments, careful attention must be paid to the grounding and power distribution of each of the detector systems if they are to operate successfully at the low signal levels required. While this has been an important issue in previous experiments, it is an especially important issue for ATLAS given the large expense and time required to redo any system, and given the very large power in most systems. In this note, we outline the present ATLAS policy on grounding and power distribution. The primary content of this note is a set of proposed guidelines that have been arrived at via reasonably extensive consultation with each of the subsystems. The intent is that these guidelines must be followed unless specific approval for a deviation is granted by the Executive Board. Some discussion is also presented as to how the guidelines can be accomplished. It is expected that recommended implementations will become increasingly detailed after further discussion and thought and as experience in test beams and system tests provides additional information.

A Summary of ATLAS Policy

The primary guidelines are the following. First a summary list is presented and then comments are presented on each item.

- All Detector Systems will be electrically Isolated

  No Connection to Ground other than "Safety Network"
  No electrical connection between different detector systems

- Low Voltage Power Supplies Floating

  Power return either fully isolated from Gnd or connected by device which has high impedance for normal operation but low impedance during failure (e.g. saturable inductors or diodes)

- High Voltage Power Supplies Floating

  HV return likely isolated from detector by resistor

- Data, Clock, and Trigger Transmission

Optical or Shielded Twisted Pair

- Detector in Faraday Cage
- Monitor and Control Signals

Optical, Shielded Twisted Pair, or similar isolation

Comments on Individual Guidelines

All Detector Systems Electrically Isolated - The electrical isolation really has two different aspects: isolation from "Ground" and isolation of one detector system from each of the others. The first aspect is concerned primarily with the desire to eliminate, or at least minimize, ground loops. Each system will have to be connected to earth at some location for safety reasons, but the location and manner of this connection must be chosen carefully. In the last section of this document, the location and nature of the proposed safety connections to earth are summarized for each of the major subsystems. By designing the system so that it can in principle be "completely" isolated from earth (safety considerations aside), one has maximum control over how the connection to earth is finally made, and the best assurance that unintended connections are avoided.

Inadvertent or unintended connections between detector systems could well foil the intended noise immunity of a particular system and would certainly make debugging noise problems much more difficult. In the final installation, it could prove advantageous to connect some detector systems together, but any such connections should be carefully designed and implemented only optionally and with the agreement of all subsystems.

While parasitic AC "connections", either to ground or between detector systems, can never be completely avoided, an effort should be made to identify those that are likely to be problematic and to minimize them.

Low Voltage Power Supplies Floating - The focus here is on treatment of the power supply return, whether it is connected to earth and if so in what fashion. It is our present understanding of CERN safety policy that if the voltage is less than 50 volts it is acceptable to have the power returns completely isolated from earth at the power supply. For larger voltages, a "safety" connection of the power supply return may be required. In the event that a "safety ground" is required, for those sybsystems that do not intend to make their "primary" earth connection at the power supplies, it will be requested that this connection be made via circuit elements which provide a "high" impedance to earth during normal operating conditions but a very low impedance in the event of failure. Examples of such elements are "saturable isolation inductors" and diodes; a schematic of the power supply configurations, for voltages less than 50 volts and for larger voltages, is presented in Figure 1.

High Voltage Power supplies Floating - Again the focus is on treatment of the power supply return. Where truly high voltages are utilized (e.g. > 1000 volts, and distribution is via coaxial cables, it is likely that the shield of the cable must be connected to earth. In this case it is customary to break potential ground loops by connecting the HV shield to the detector via a resistor, ypically of order 1 kilohm. (In some cases a resistor may also be inserted in the HV supply conductor, to provide a more balanced system). In the initial plans, most subsystems in ATLAS plan on this traditional approach. It may also be considered whether safety connections that provide high impedance during normal operation, such as those discussed for low voltage power supplies, will be allowed. An alternative approach could also be to distribute the HV power and HV power return via two conductor cables with an outer shield. In this case, grounding the outer shield should be sufficient for safety purposes (this could also reduce noise conducted into the detector). .

Data Transmission, Clock and Control Distribution - Transmission of the data and clock and control is expected to be either via optical fiber or shielded twisted pair using low level differential signals. If the latter is utilized, it is expected that the shield of the cable will be connected directly to the local "detector ground" at the detector and via a capacitor to the local "ground" at the other end. This provides for maximum shielding and noise immunity at high frequencies while at least breaking any ground loops created at low frequencies. An example (certainly not unique) of a system which uses shielded twisted pair in this fashion and obtains very good noise immunity is NA48; a diagram of their signal and ground connections is presented in Figures 2 and 3.

Detector Located in Faraday Cage - The maximum protection against EMF noise is produced by locating the detector(s) in a carefully designed Faraday cage. Currently this is planned for the Liquid Argon, Tile Calorimeter, TRT and Muon Systems. The SCT and Pixel systems are less susceptible to pickup than some of the others, but some form of overall shielding may be necessary.

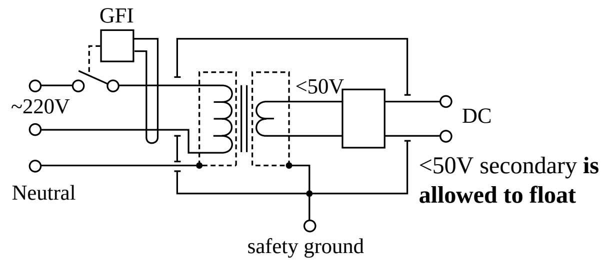
Plans for Implementation in each Subsystem

Each subsystem is required to provide a description how it intends to achieve the guidelines stated above. Key features of this note include:

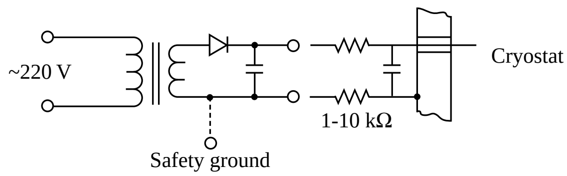
- Summary List of how electrical isolation is maintained for ALL mechanical and electrical interfaces to the subsystem
- Schematic diagram(s) indicating where, and in what manner, all connections to earth or safety grounds are made.
- Summary of primary outstanding issues, if any.
- Identification of an individual to serve as primary contact for information and meetings concerning grounding and power distribution.

Initial plans have been received for almost all of the subsystems, and also for the magnet systems. Most of these are available on the WEB via the Front End Electronics link from the ATLAS page. An example summary of the techniques used to achieve isolation is shown in Fig. 4 for the Liquid Argon System. Additional details of the plans for implementation will be provided during Fall 1998

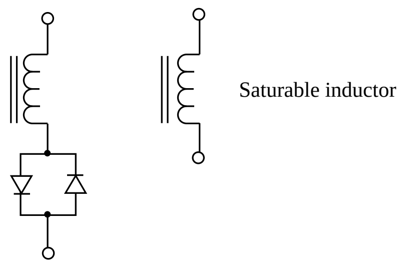
1. LV Supplies <50V



2. HV Supplies > 50V ⟶ ~kV Supplies, low current



3. Supplementary safety grounding:
high impedance at low voltage



Planned Connections to Earth - Safety Grounds

For reasons of safety all conducting objects of any size in a subsystem must be connected to earth. We note here that connections to earth will in practice be made via a small number of cables which travel from the cavern or USA15 or other halls to the surface building. Because of the poor conductivity of the rock surrounding the cavern, there is no "local" earth connection. As noted above, to eliminate ground loops there should be a "single point connection" for each piece of a subsystem that is electrically isolated from other subsystems and from other pieces of the same subsystem. (A "single point connection" could consist of a number of connections or conductors as long as the routing of the conductors and the location of the conductors does not allow significant loops.) Considerable discussion has been held amongst the subsystems to determine where this connection would be best made. The TRT, Liquid Argon Calorimeter, Tile Calorimeter, and Muon systems currently endorse the following plan

- The safety connection to earth will be made in USA15
- The connection should be made via a well-defined number of connections or cables, such that the quality of the connection and the current flowing can be easily monitored
- There will be NO connection of the detectors to earth, including large metallic objects such as the cryostat, in the cavern.
- A safety procedure should be established such that the safety connection in USA15 **cannot be removed** unless an alternate safety connection has been made.

We note that this approach is nearly identical to that of the NA48 experiment. Diagrams specifying the location and nature of connections to ground for the NA48 experiment have already been presented in Figures 2 and 3. In this case the primary connection to safety ground is made at the CPD crates which receive signals sent from the calorimeter. There are no additional connections to ground either at the cryostat or at the power supply return leads at the preamp supplies.

Common aspects of the TRT, Liquid Argon Calorimeter, Tile calorimeter, and Muon systems that argue for the above approach are (1) it is expected that the power supplies will be located in the cavern in a number of different locations and (2) there will be a significant number of signals sent over twisted pair to USA15. Thus making safety grounds at the power supplies would create ground loops (unless high impedance safety connections were utilized). There is also a strong argument to reduce any potential difference between the "local grounds" of the receiving electronics and the "local detector ground" at the electronics on the detector. Making the earth connection for the subsystems, at USA 15, accomplishes this since little or no DC current should be flowing in the ground connection between the detectors and USA 15.

For the SCT and Pixel systems a different approach is anticipated. In the case of these systems (1) it is planned to locate all power supplies either in USA15 or US15, (2) all transmission to USA15 is optical, (3) the detector systems are highly modular encompassing 4080 (2500) isolated modules. Each of these modules has an independent power supply. Thus it is planned that the safety connection will be made at the power supply for each module.

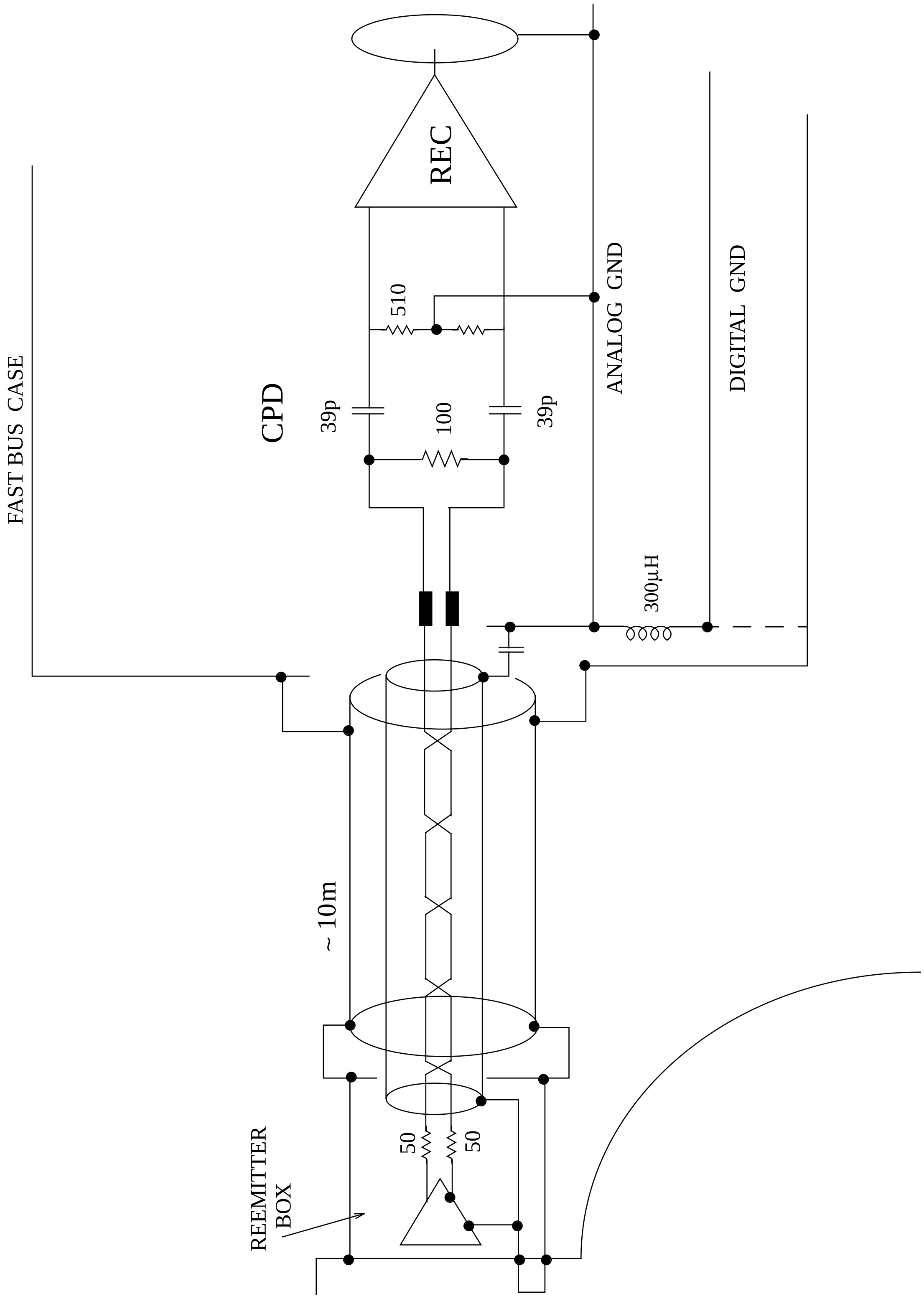

FAST BUS CASE
REC
CPD
510
39p
100
39p
ANALOG GND
DIGITAL GND
300µH
~ 10m
50
50
REEMITTER
BOX

Figure: 2

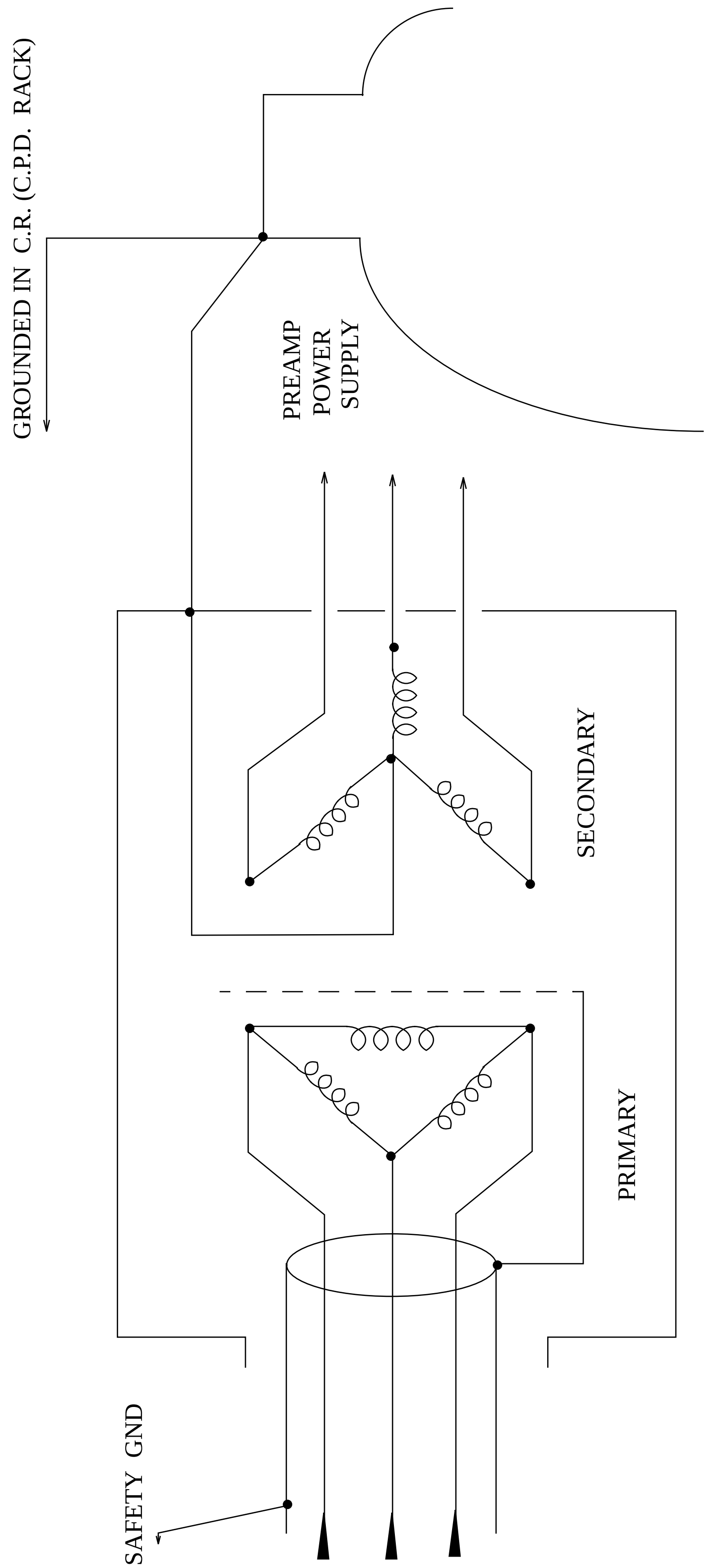
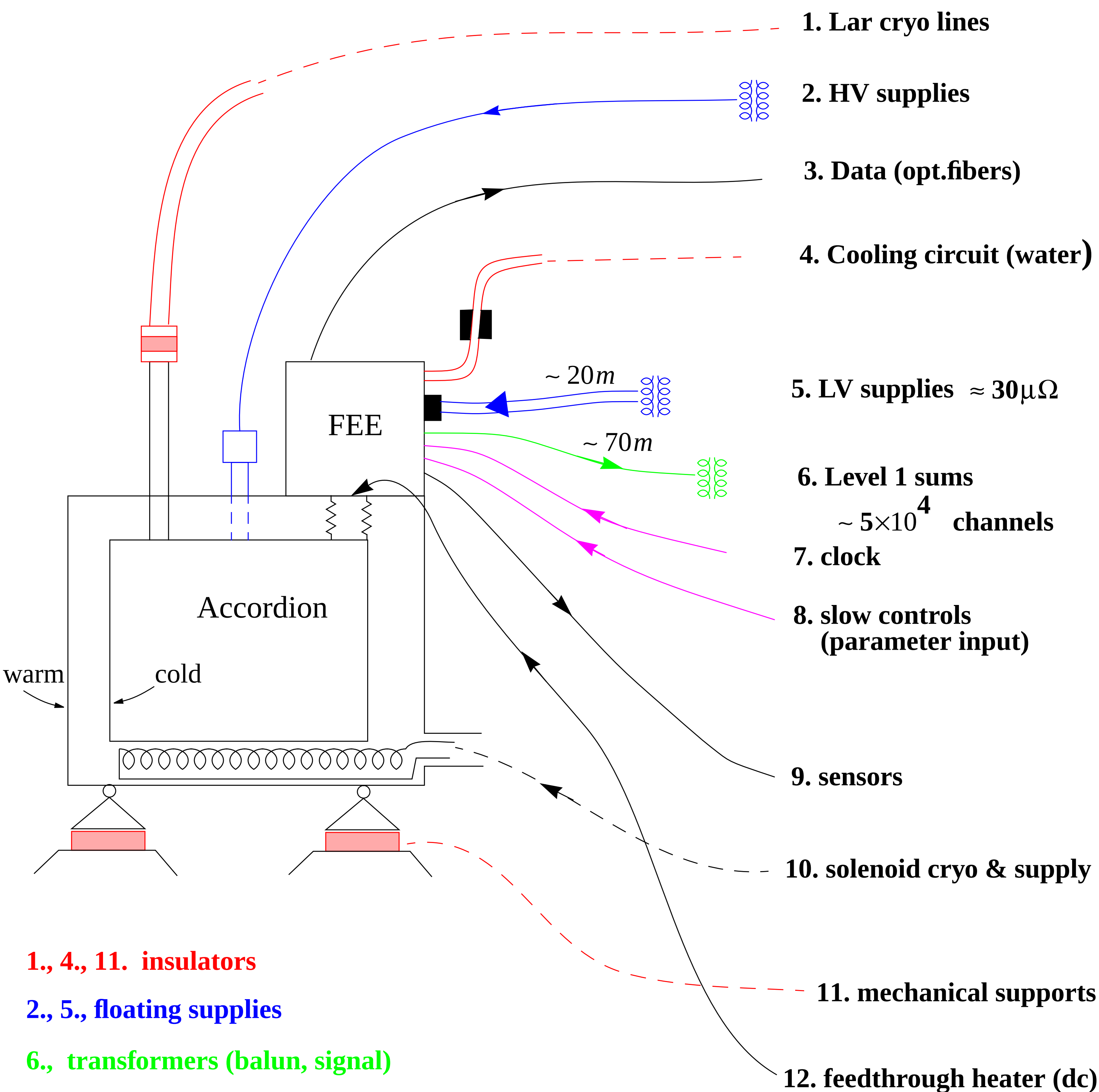

GROUNDED IN C.R. (C.P.D. RACK)
PREAMP
POWER
SUPPLY
SECONDARY
PRIMARY
SAFETY GND

Figure: 3

LAr Cal. Vital lines (i.e., Potential ground loops)



1., 4., 11. insulators

2., 5., floating supplies

6., transformers (balun, signal)

7., 8. opto-couplers (or transformers)

9. insulate sensors; different techniques at various receivers

10. solenoid line to be insulated, power supply floating

BUT .... a major effort required

12. heater insulated

Figure: 4