MDT Electronics

Mezzanine PCB

Requirements

- **Mixed signal design with ASDs and TDCs**
- **Maintain low noise levels (< 1fc)**
- **Low Crosstalk from adjacent channels (< 1%)**
- **Low digital−to−analog feedthrough (few % above noise)**
- **Robust ESD / discharge protection**
- **Need about 15k boards in several flavors:**

  Endcap vs Barrel
  3−Layer vs 4−Layer
  Top vs Bottom Superlayer
  ⇒ 8 Mezzanine Types

Design Characteristics

- **6 layer PCBs**
- **Split analog/digital planes**
- **All LVDS I/O**

Status

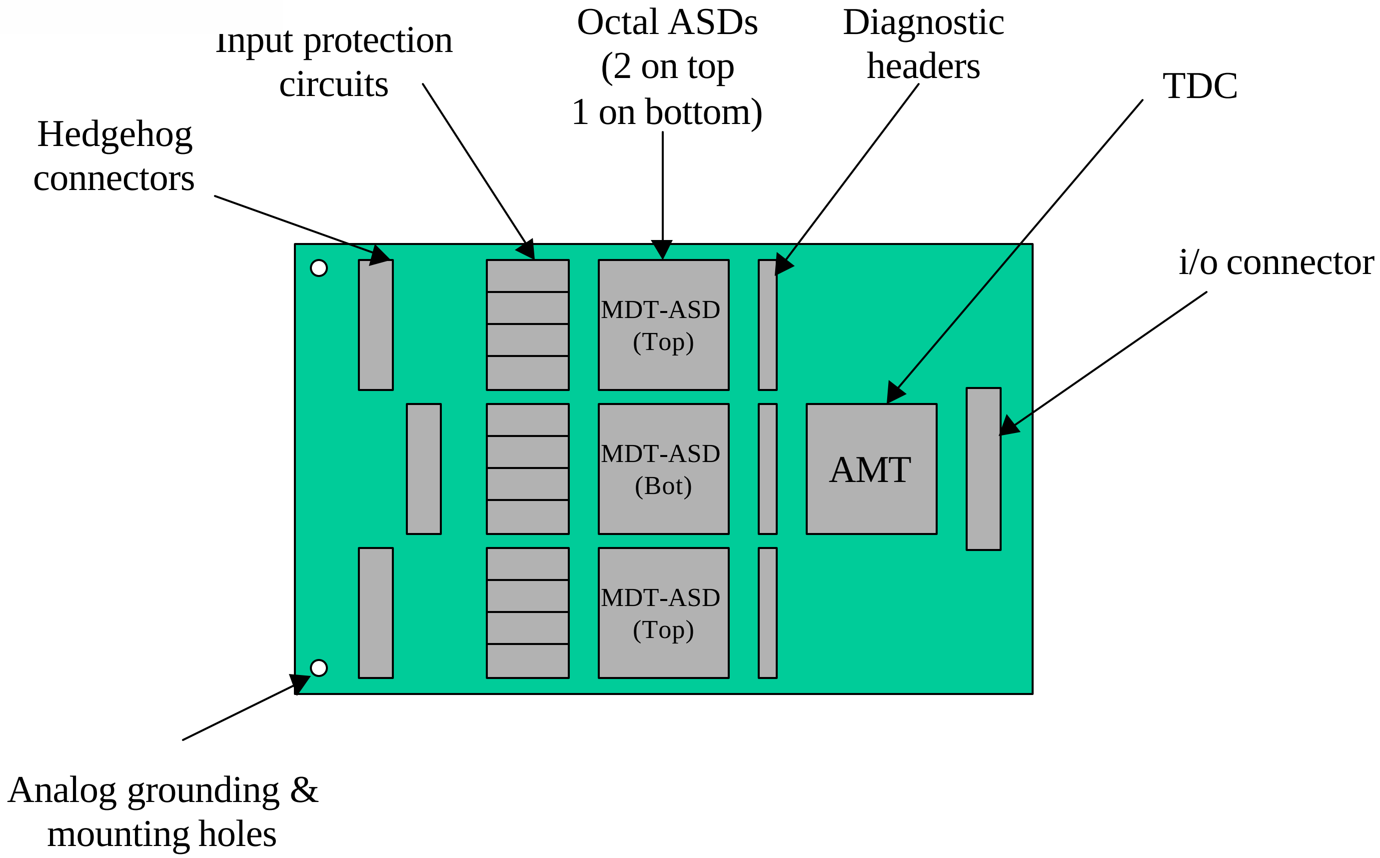
- **2400 channels "Mezz Lite" produced (10k underway)**

  Use for testing during chamber production

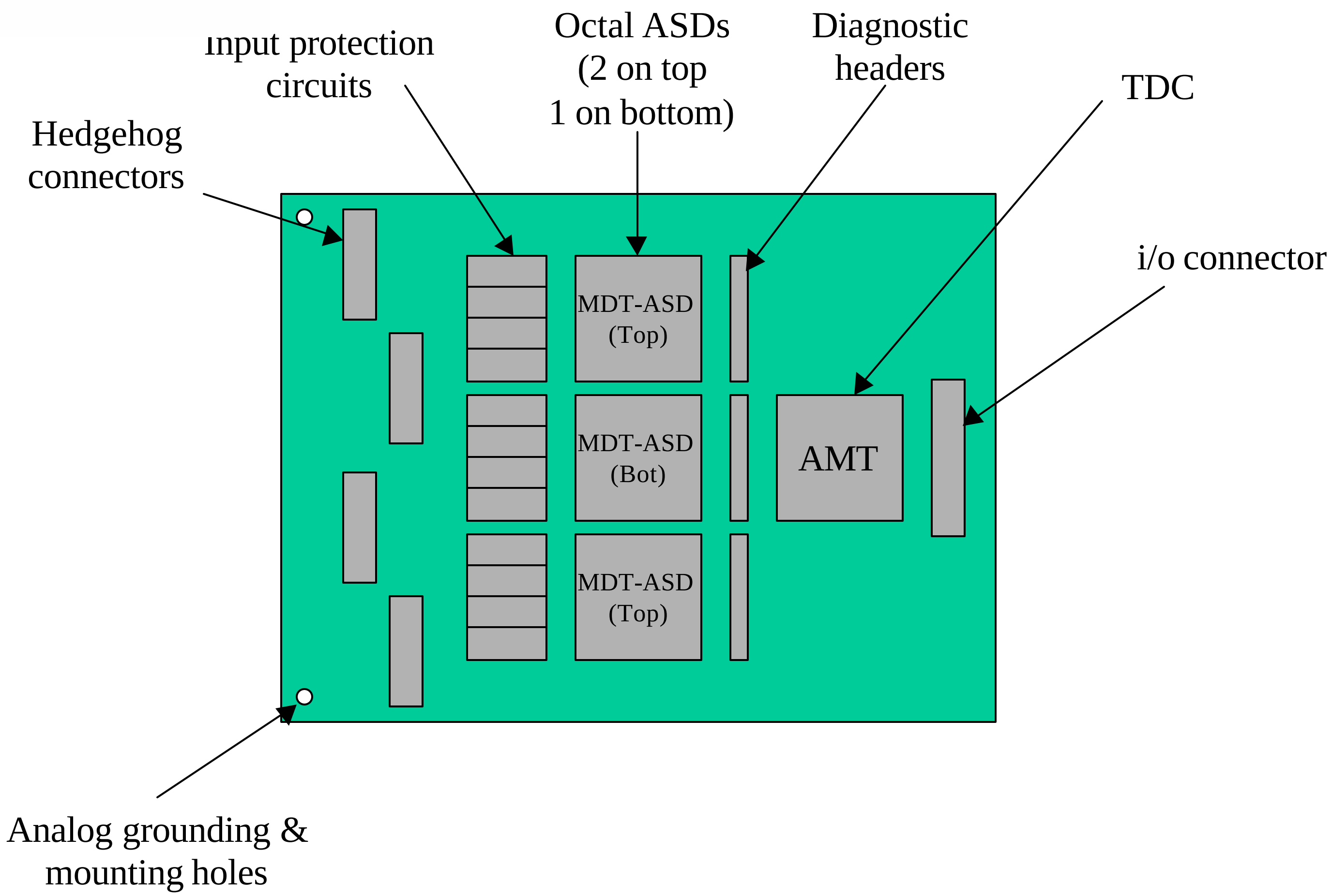
- **Final design underway**

ATLAS
Muon Spectrometer

MDT3xx : 3 layer mezz card

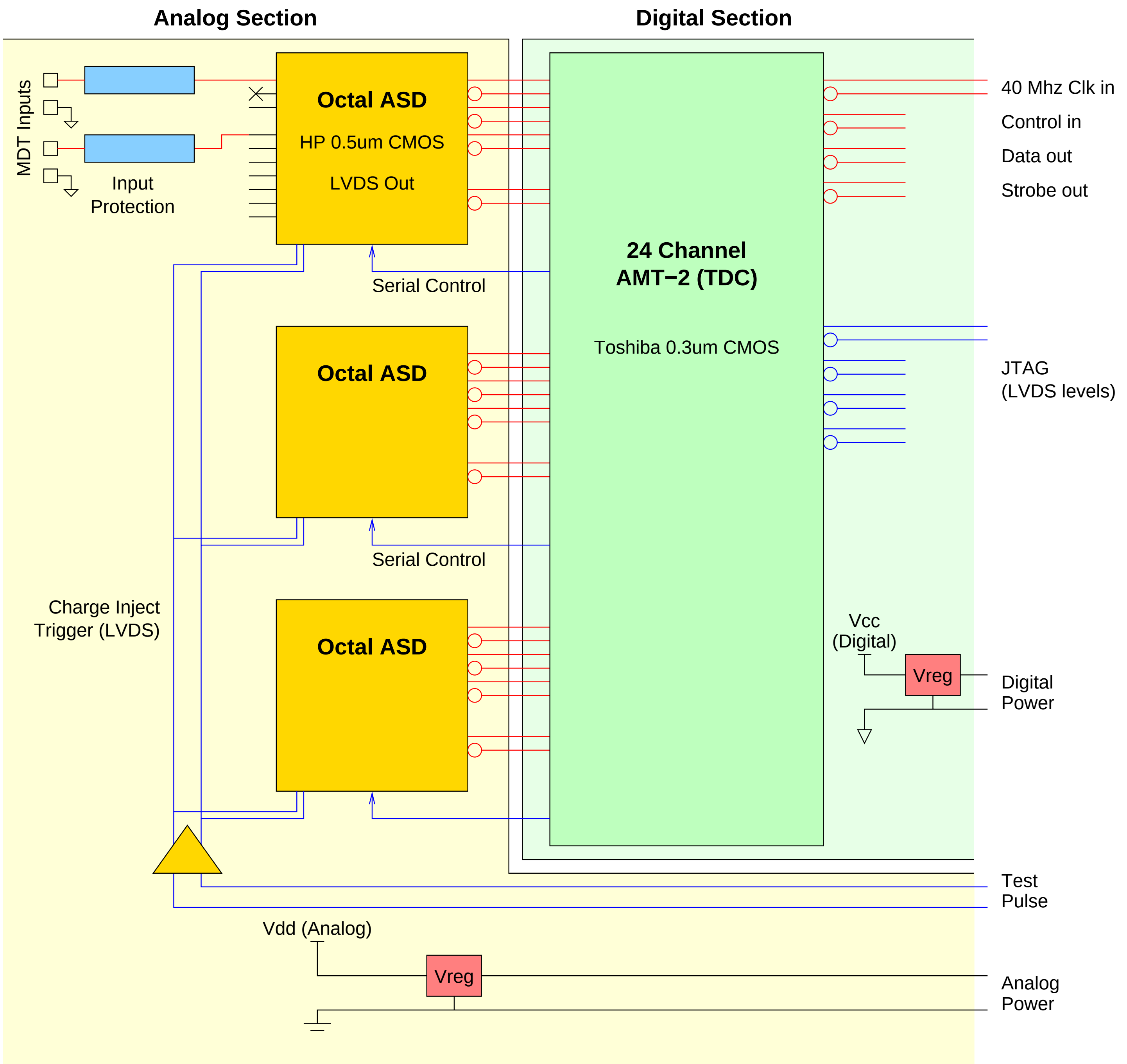


MDT4xx : 4 layer mezz card

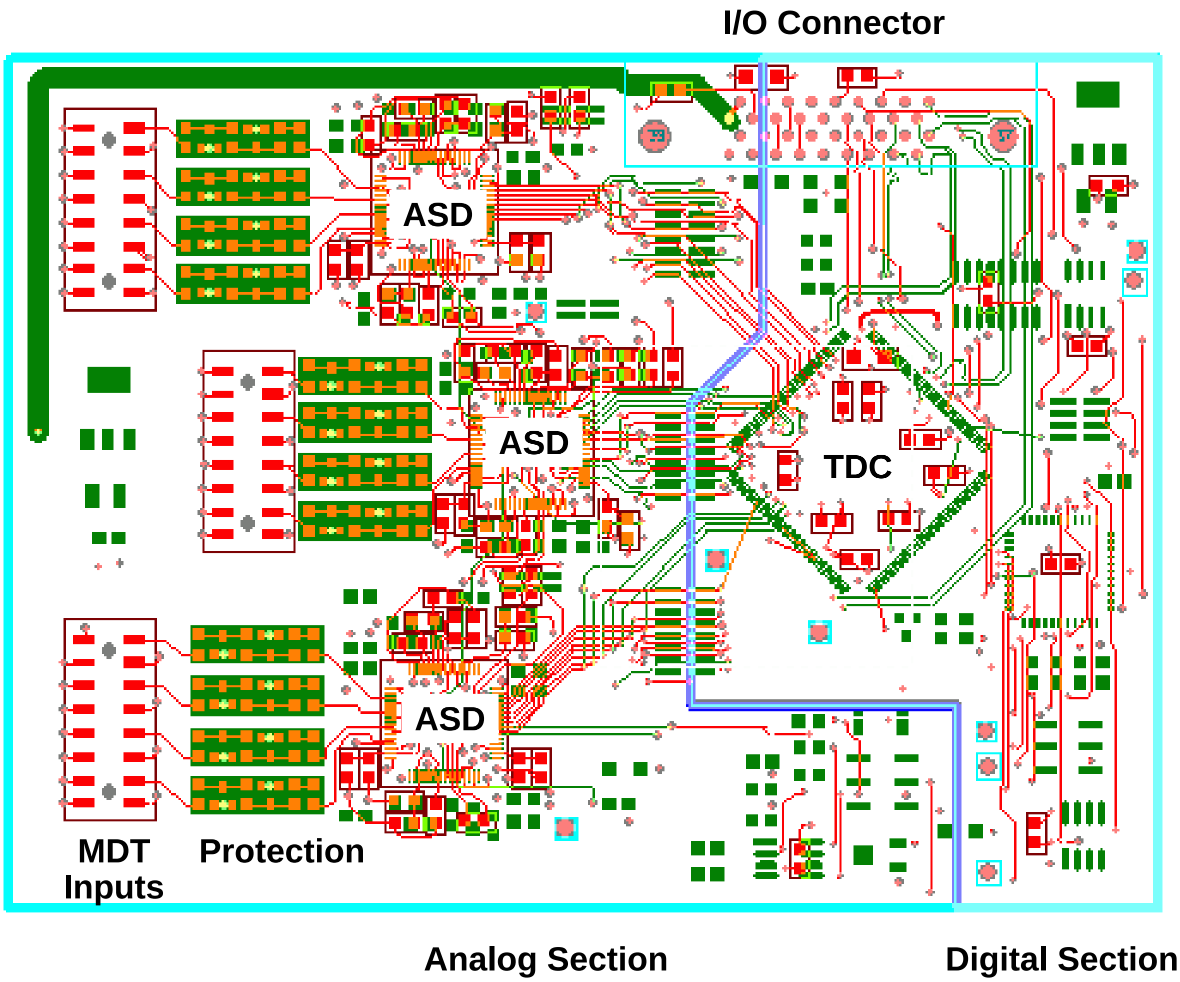


Mezzanine PCB

Production PCB Block Diagram



Mezzanine PCB
"Mezz Lite" Prototype Layout



	Analog	Digital
1	Signal (top)	Signal (top)
2	AGND	Shield (DGND)
3	AVdd	DGND
4	Signal (inner)	Signal / DVdd
5	AGND	Shield (DGND)
6	Signal (bottom)	Signal (bottom)

Layer Stacking

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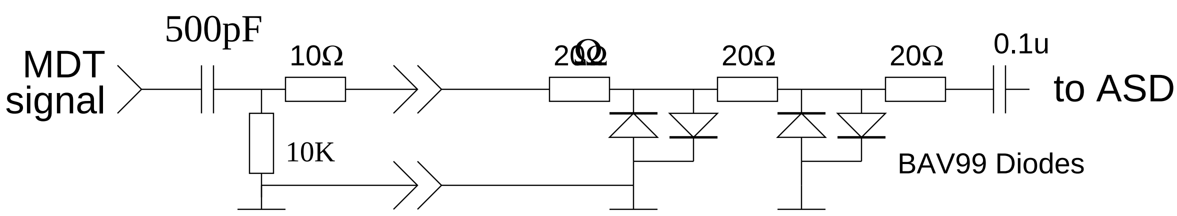
ESD / Spark Protection

Requirements

- **survive occasional HV discharge without damage**
- **survive continuous HV discharges without damage to neighboring channels**
- **minimal impact on performance**

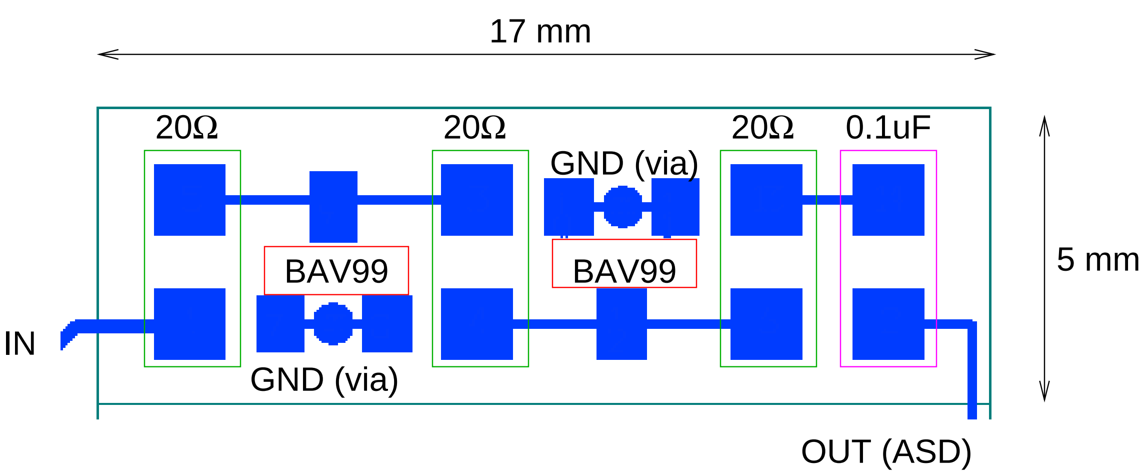
Protection Circuit Schematic

- **multi−stage resistor/diode combination**
- **long pcb traces on hedgehog help: higher L on inputs**



Protection Circuit Layout

- **Compact layout −> low inductance (good protection)**
  low capacitance (small noise increase)



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Mezzanine PCB − Summary

Requirements met by Mezz Lite:

- **Low noise, Crosstalk.**
- **Stable operations, robust against discharges**

Design Changes for Production:

- **Mostly omitting components (Xilinx, DAC, Op−amp etc)**
- **ASD Lite −> Octal ASD**
- **AMT−1 −> AMT−2 (includes JTAG control)**
- **Addition of test pulse injection**
- **Various geometries for chamber types (Endcap I/II, Barrel I/II)**

Open Issues:

- **LVDS I/O on TDC vs discrete ICs (if discrete ICs, rad tolerance?)**
- **Final I/O connector choice**
- **Final conclusion on exact mechanics**

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On−Chamber Architecture − Introduction

System Requirements

Architecture Overview

Electronics Topology − Details

Special Cases

Summary and Status

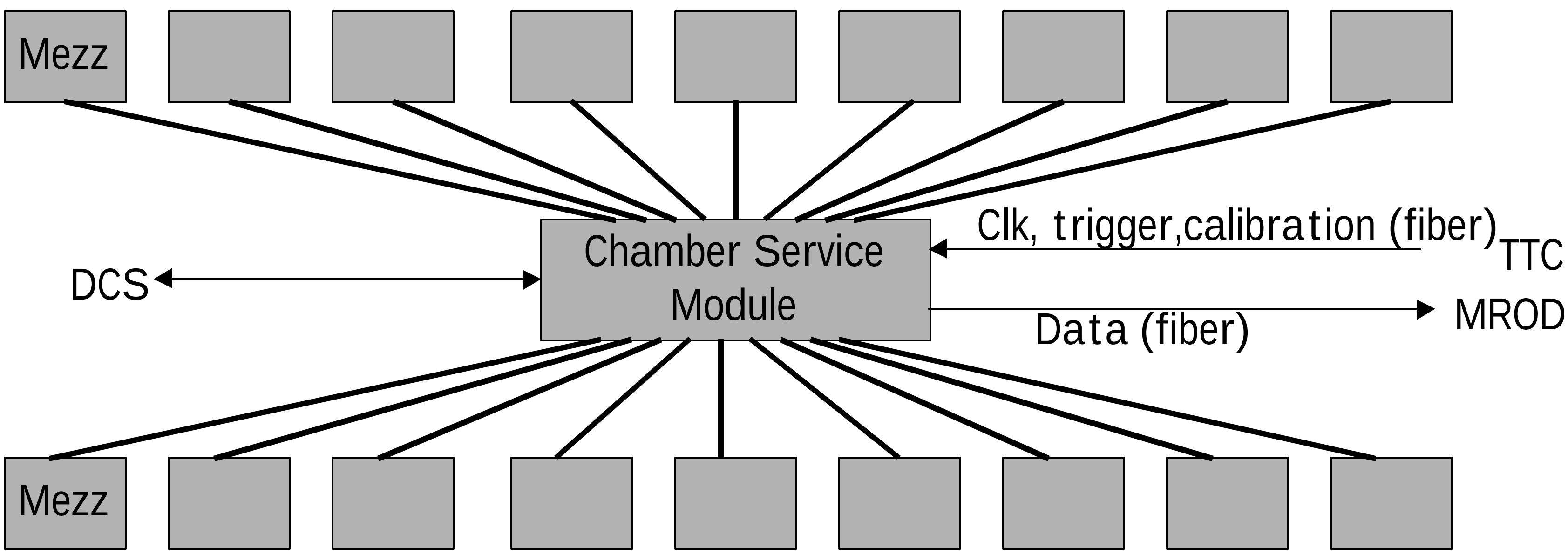
System Requirements

- **Good Performance in potentially noisy environment**
- **Compliance with ATLAS policies:**
  - Grounding
  - EMC
  - Radiation Tolerance
- **Long−term reliability**
- **Within budget**

ATLAS
Muon Spectrometer

Finished MDT Chamber

- Connections to CSM -



40 conductor twisted pair ribbons carry :

- Power, Gnd
- Data
- Clk
- Timing calibration
- V,T monitoring

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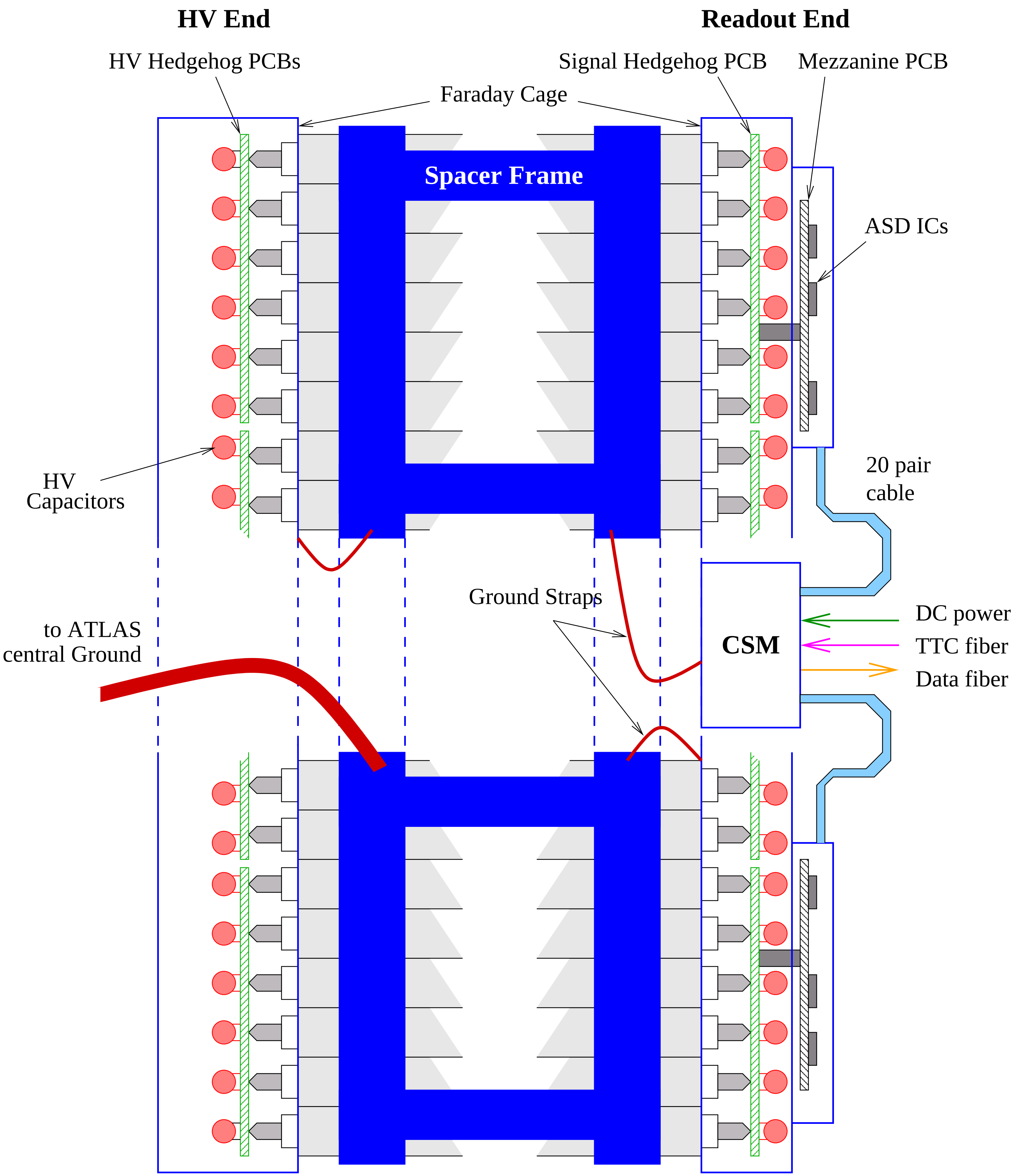
On−Chamber Electronics Topology



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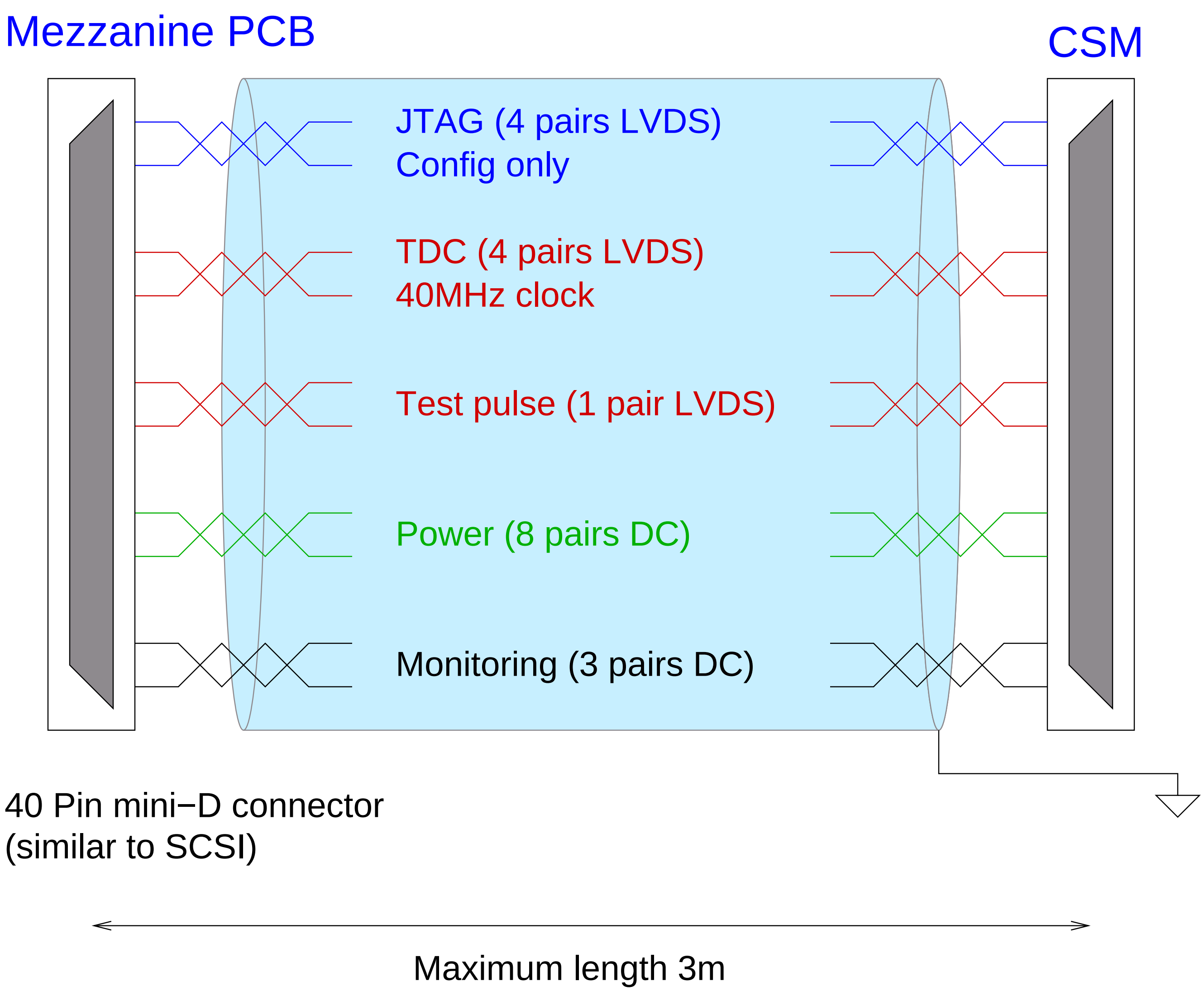
Mezz PCB to CSM Cabling

20 pair .025 in micro twist/flat cable
Overall copper mesh shield
(zero halogen type)



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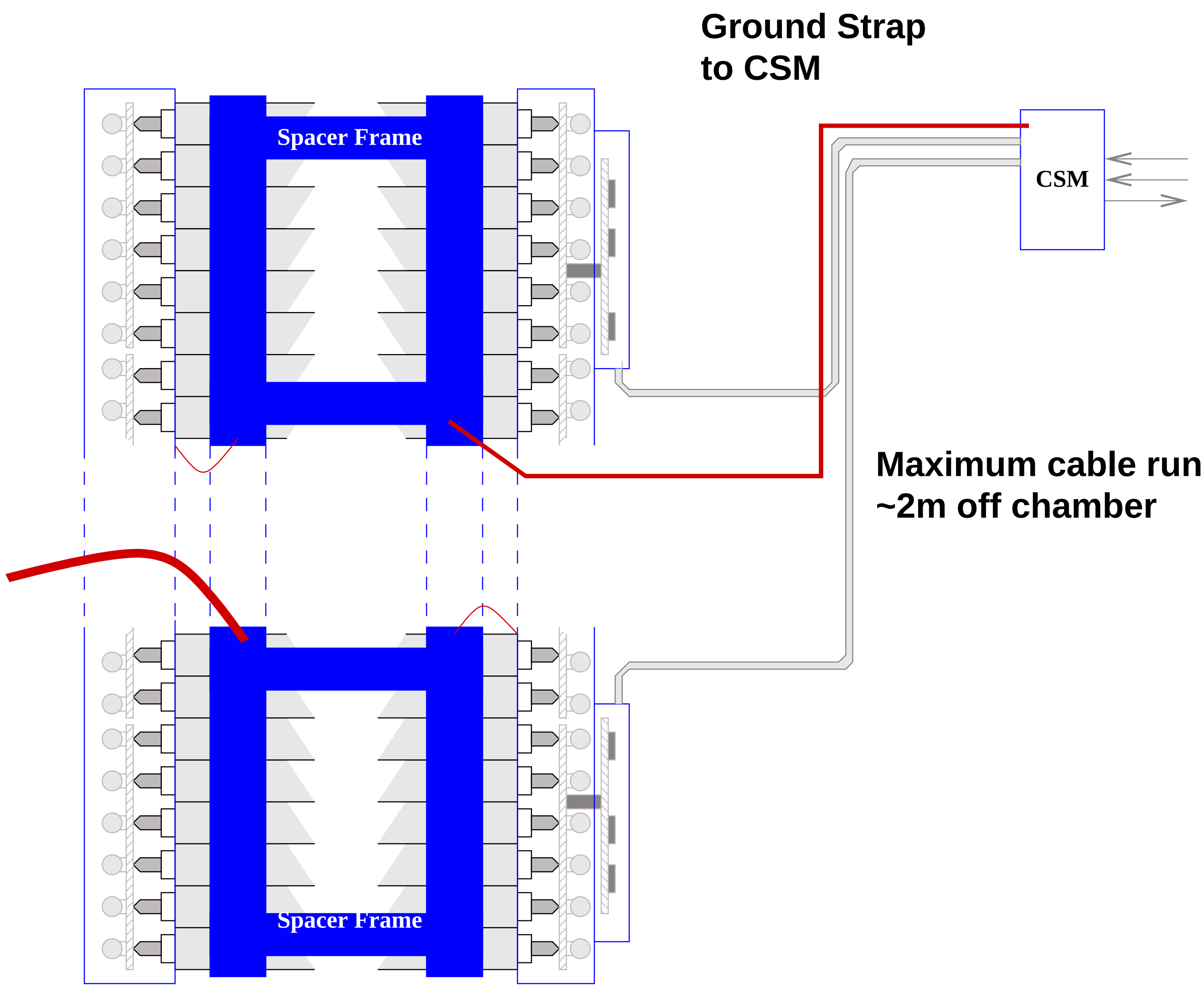
Special Cases

A few MDT chambers require remote CSM



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MDT Electronics
On−Chamber Architecture Summary

Design Features

- o Single point external ground per ATLAS policy
- o Only DC power in (floating supply) and Optical Fibre I/O
- o Hermetic Faraday Cage surrounds electronics
- o Only LVDS communication between elements
- o Robust ESD / discharge protection
- o Single point−to−point cable from each Mezz card to CSM

Measured Performance

- o Noise consistent with thermal (5000e)
- o Essentially zero spurious discriminator firings at nominal operating threshold

Open Issues

- o Final choice of cable from Mezz cards to CSM
- o Final design of Mezz PCB and CSM yet to come!

Status

- o Basic performance proven with Mezz Lite boards
- o No fundamental problems − design work continues

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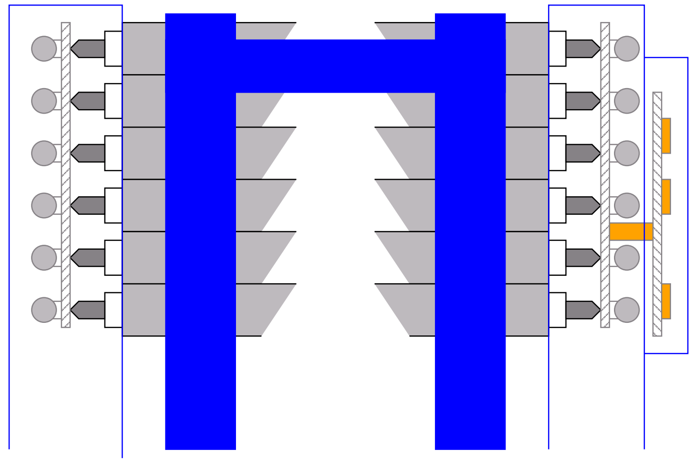
Faraday Cage / Grounding − Introduction



Requirements

- Shield front−end electronics from coupled signals
- Keep signal and noise currents separate
- Comply with Grounding Policy

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Ideal Faraday Cage Principles

Openings in Shield

Minimize size of physical opening. Attenuation for an aperture is:

$$A_{ap} = 20 \log \frac{\lambda}{2L} \text{ [dB]}$$

where L is longest aperture dimension
λ λ is the wavelength

So, at high frequencies (>10MHz or so), shielding effectiveness is limited by the apertures in the shield.

MDT Faraday Cages have maximum apertures of 10cm (narrow slits)

Penetrations for Cables, Plumbing

All cables should be shielded, with shield connected to cage at entrance
All cables shielded. Shield connections optimized individually

No signal currents should flow in Shields (including Faraday shield)
Generally true BUT MDT tubes themselves form part of shield!

Differential or Optical couplings are preferred for all AC signals
True for all MDT signal connections

Plumbing and Mechanical connections must be isolated to avoid ground loops

This is the baseline design.

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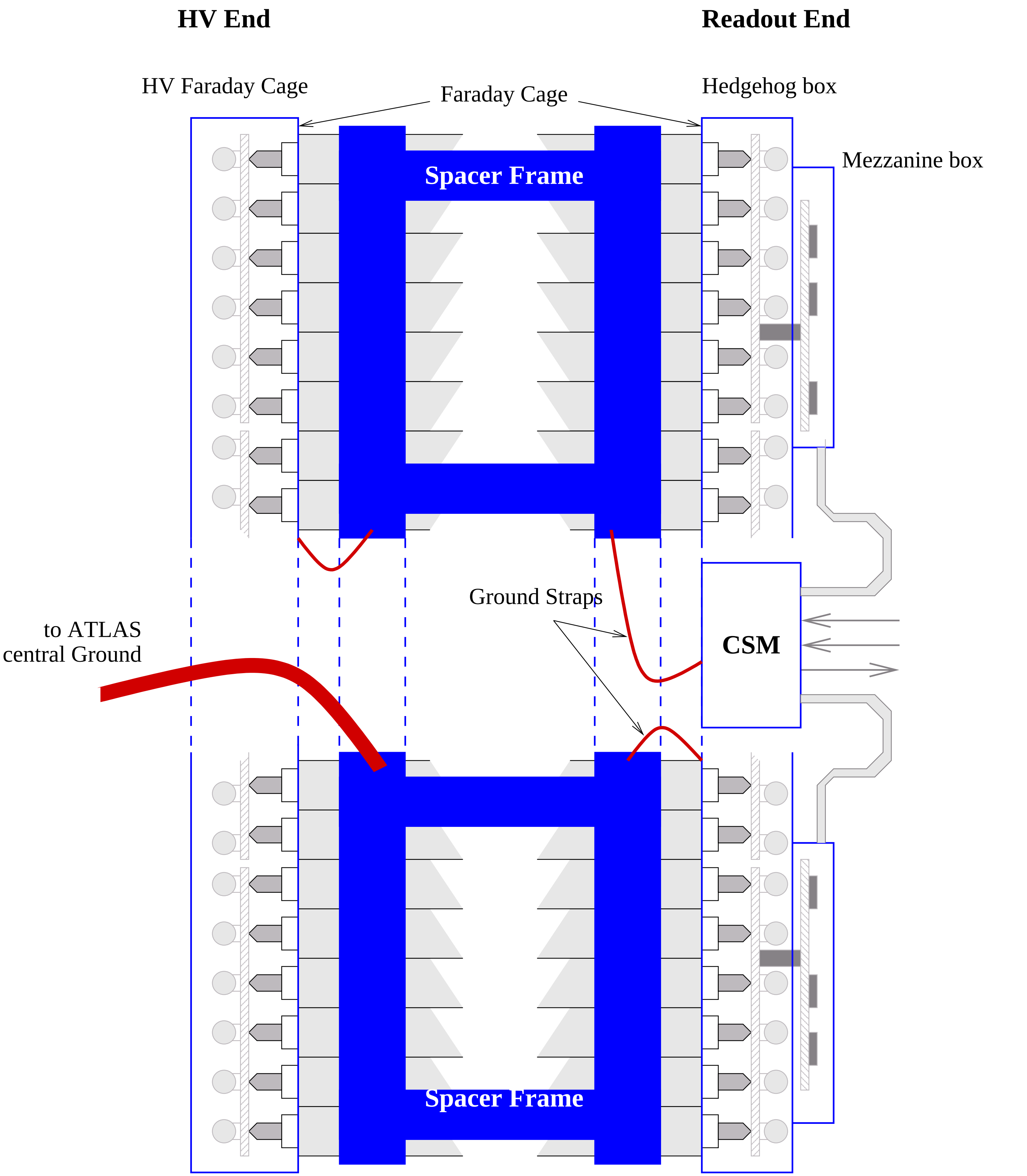
Faraday Cage



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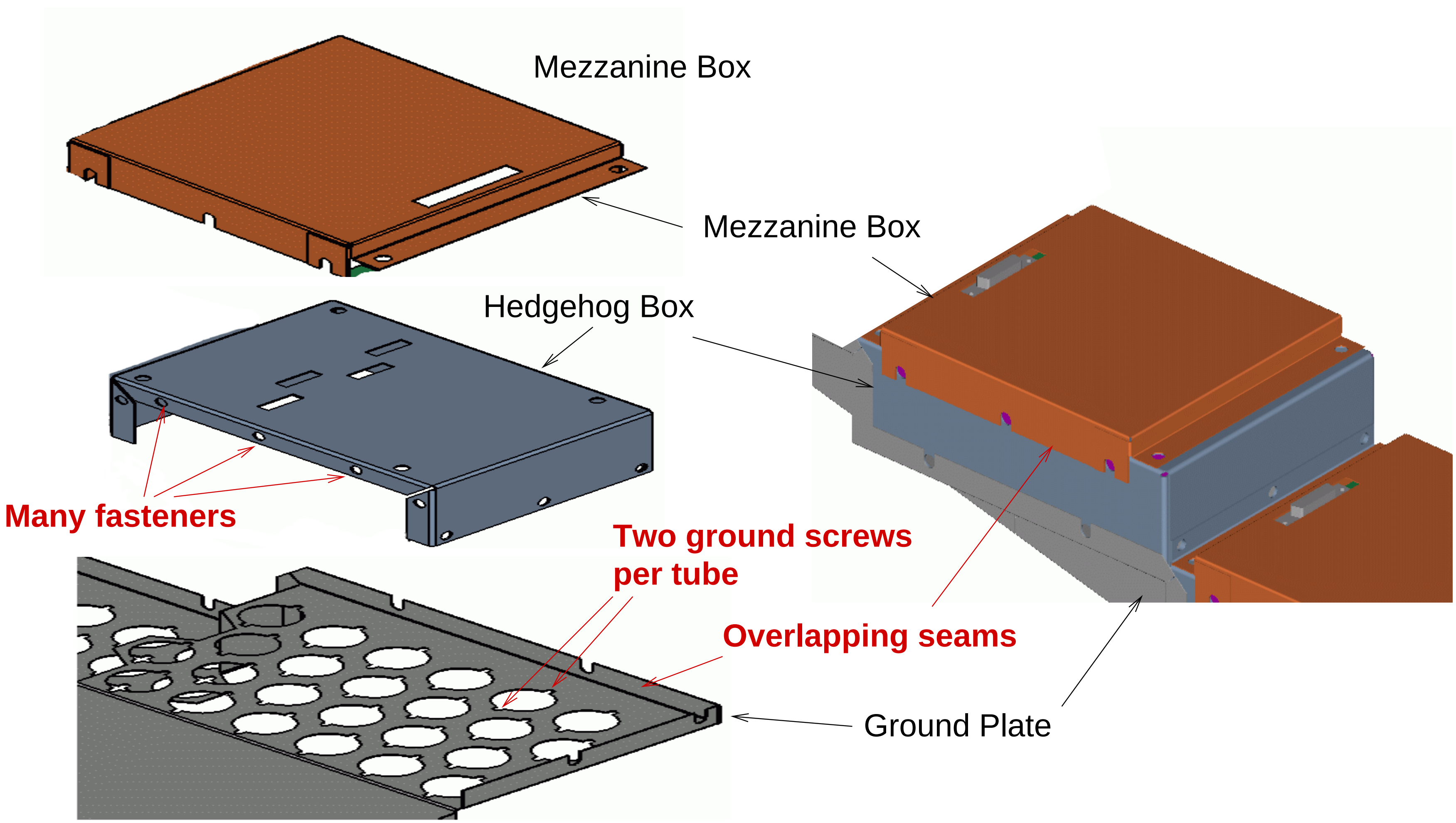
Endcap Chamber Faraday Cage

Key features to ensure hermeticity

Conductive Chromate coating ("Iridite/Alodine")
No gaps > few mm



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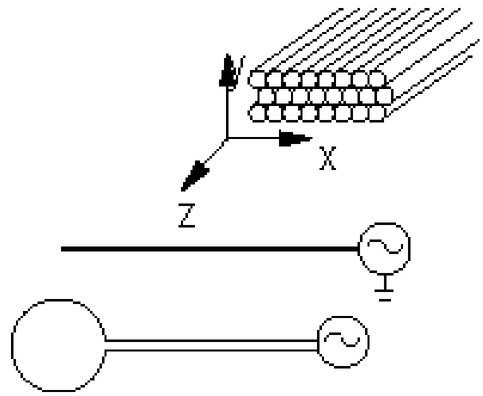
Faraday Cage Shielding Effectiveness

Extensive testing was done on a model faraday cage with prototype electronics (details published)

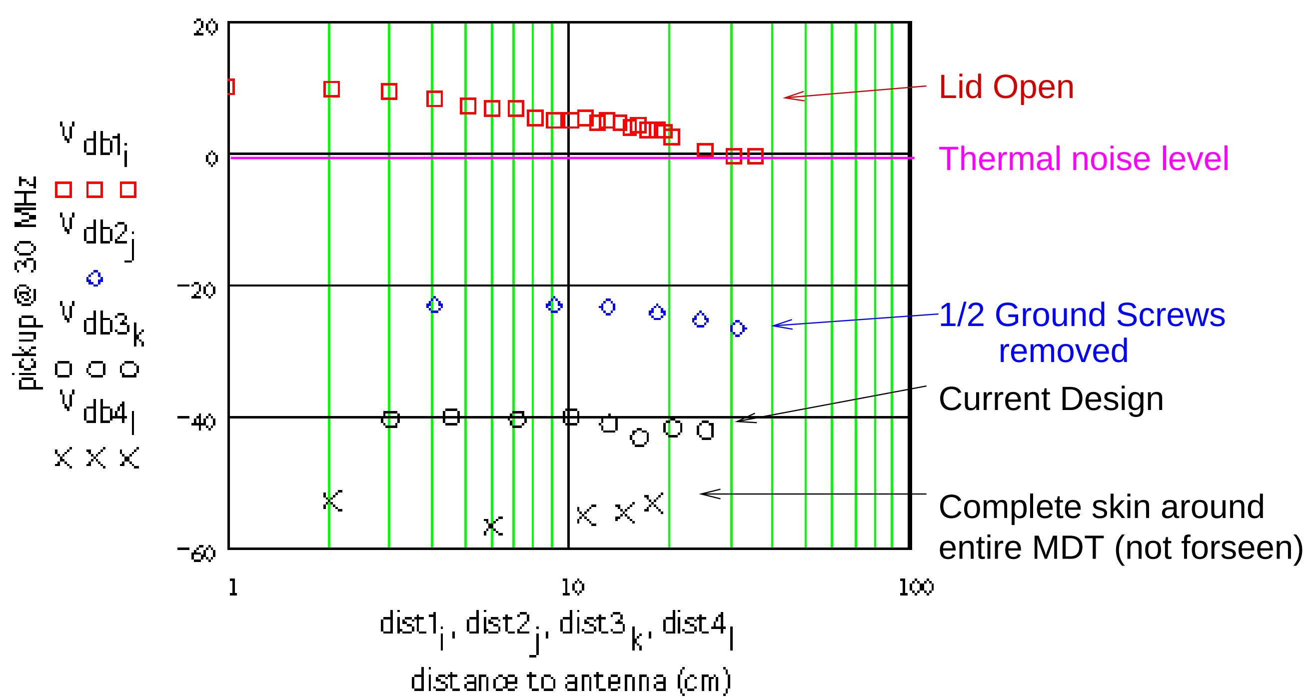
Typical results shown below for vertical 1m line antenna (LVDS level SE signal)

Conclusions:

- o Faraday cage shield is required
- o Good contact from bottom plate to tube ground rings is important
- o Current design without complete "skin" provides adequate shielding



a) Box open, b) 1 screw, c) 2 screws, d) skin



b) Line antenna in y direction (vertical) as a function of distance

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Faraday Cage / Grounding − Summary

Summary

- o Requirements met for performance
- o Grounding Policy Complied with
- o Some variation from "ideal shielding"

Status

- o Detailed design exists for some chambers
- o Complete test with (close to) final design underway on EIL module−0 chamber at Boston
- o Final test cannot occur until CSM exists!