System Overview of Grounding and Shielding

Jason Andrews, Brian Hamilton,
Hassan Jawahery, **Tom O'Bannon**, Will Parker,
and Jack Wimberley

University of Maryland
May 18, 2016

Agenda

- PEPI to service bay
  - Description of connections
  - Some Cabling requirements compared with electrical requirements
- Review of PEPI and hybrid ground approach
- Shields vs power grounds
- Discussion

Connection Categories

- PEPI to Service Bay
  - Power wire pairs for 4-ASIC loads
  - PEPI ground reference braid for SMCU
  - Ganged regulator lines for PEPI backplane power groups
  - Optical fibers
  - System control and sense cable
    - Local environmental failsafe sensors for SMCU use
    - Secondary elink control interface for GBT-SCAs
- Chassis, structural items, and shield grounds
  - Detector items (eg cooling tubes, carbon foam, frame, …)
  - PEPI Chassis
- Single point safety ground

Some Requirements

- Hybrid circuit ground management
  - Ground sense wires in staves
    - 1 physical wire per 4 ASIC group
  - Use series diode clamps to limit the maximum voltage excursion of resistive-summed hybrid grounds relative to facility safety grounds
    - Clamps to be incorporated in the regulator boards
- Cable shields
  - RF connections to chassis at both ends of cables
  - System power grounds are managed independent of all shield connections
  - No shielded bundle can contain signals from multiple maraton channel outputs
  - SALT ASIC power bundles to have dedicated shields independent of PEPI backplane power groups
  - 2 options for regulator sense lines
    - Can be bundled together, but SALT ASIC remains separate from PEPI backplane power group sense lines
    - Can be bundled with their respective voltage rails

Single Service Bay Power Cable Bundles

Rail	$I_{\max}$ per Grp	Grps per SBC	MARATON channels per SBC	target ΔV_{src}	target ΔV_{ret}	Max spec ΔV_{rt}	Possible cabling ($\ell \approx 9\ m$)	#of shielded bundles
1.5V (PEPI)	15.4 A	33	16	250mV	150mV	480mV	$10mm^2$ $+16mm^2$	20*
2.5V (PEPI)	2.22 A	33	2	250mV	150mV	480mV	$1.5mm^2$ $+2.5mm^2$	6
PEPI SENSE		66						
1.2V (SALT)	2.13 A	262	16	250mV	100mV	420mV	$1.5mm^2$ $+4.0mm^2$	48**
SALT SENSE		262						

* 1 per MARATON channel except for the two devoted to master control circuits, which go one per backplane

** 1 per backplane per MARATON channel

48 SALT bundles are:

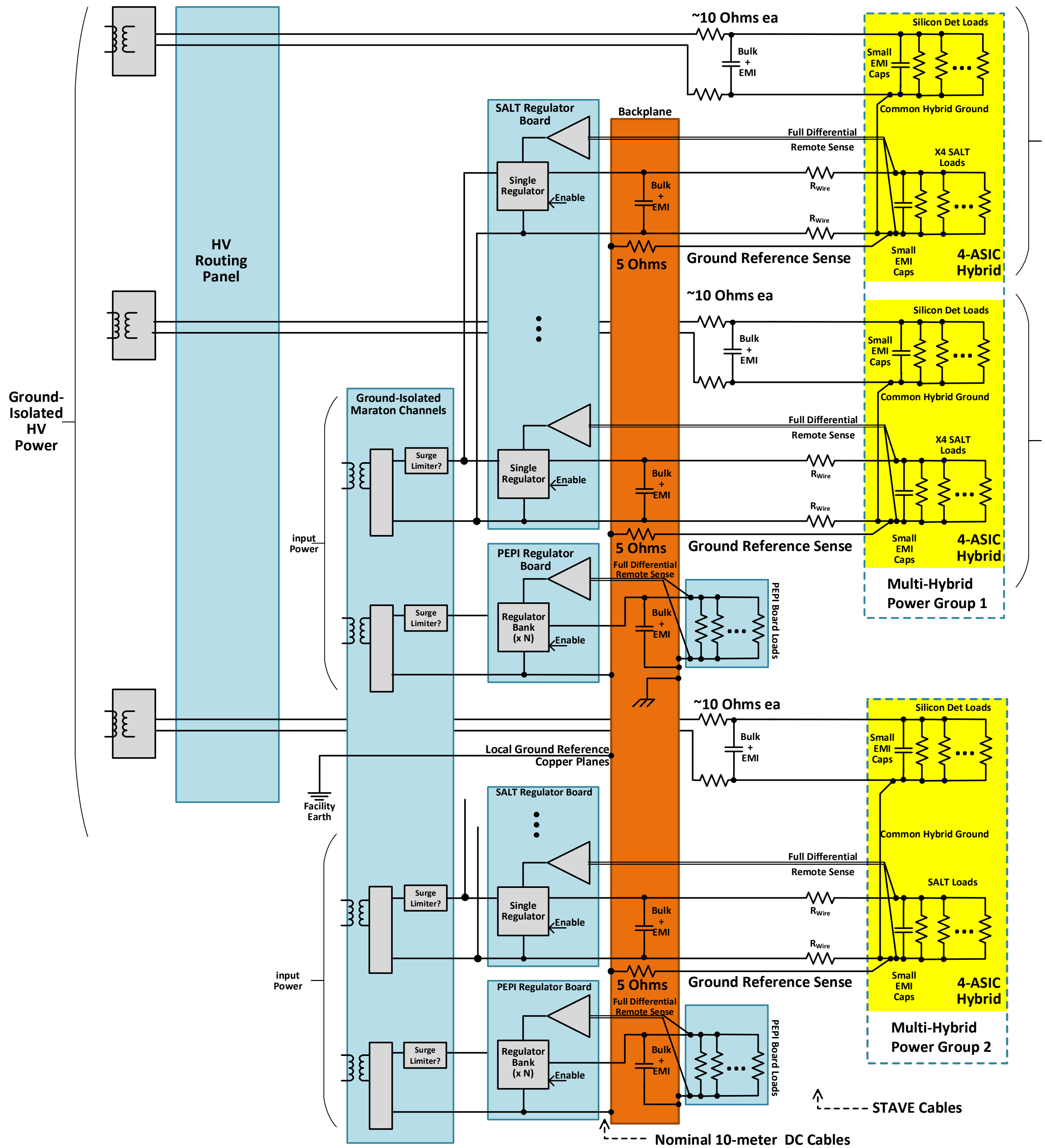
- 4 bundles of 11 pairs (2 “a”, 2 “b”)
- 26 bundles of 6 pairs (10 “a”, 16 “b”)
- 10 bundles of 4 pairs (8 “a”, 2 “b”)
- 6 bundles of 3 pairs (2 “a”, 4 “b”)
- 2 bundles of 2 pairs (2 “a”, 0 ”b”)

Existing TT Cable Tray Volume Assessment

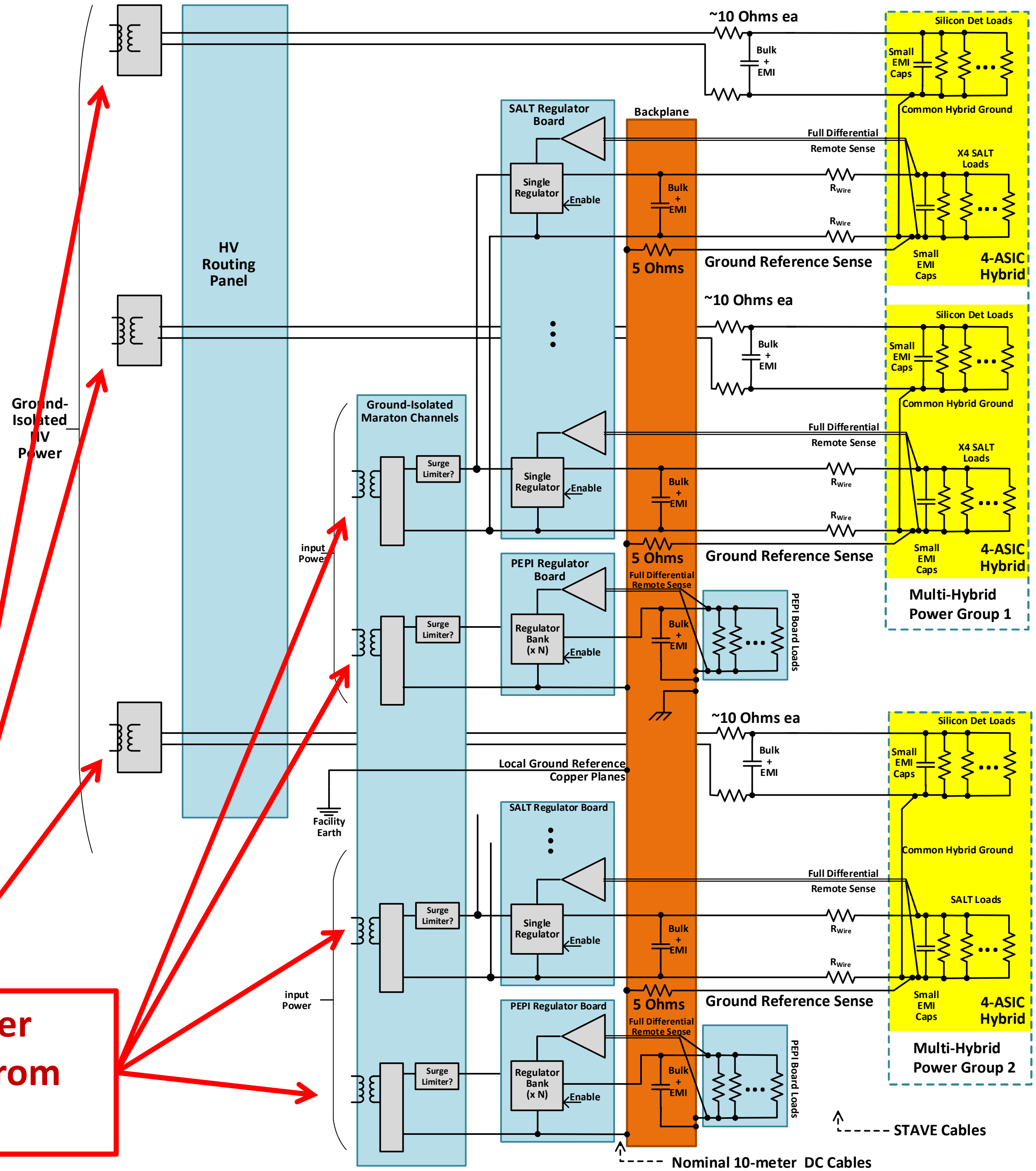
- First-pass estimate of cable tray volume was made
  - Assuming off-the-shelf EPDM insulated conductors (SCEM 0.4.08.61.xxx) and copper areas listed previously
- Power conductors require 9,840 out of 11,600 mm^2
- Sense lines estimate assumed 9 twisted pairs in a common insulation (O.D. 7.2mm per group of 9 pairs) which adds another 1,650 mm^2
- Will need a more refined selection of insulated wires to ultimately accommodate both power system wire and optical fiber bundles

Note: 4mm2 SALT load return cable from this category of the CERN store has a cross section of 14.5mm2 with insulation which alone account for like 40% of the space quoted

System Ground Partial Block Diagram

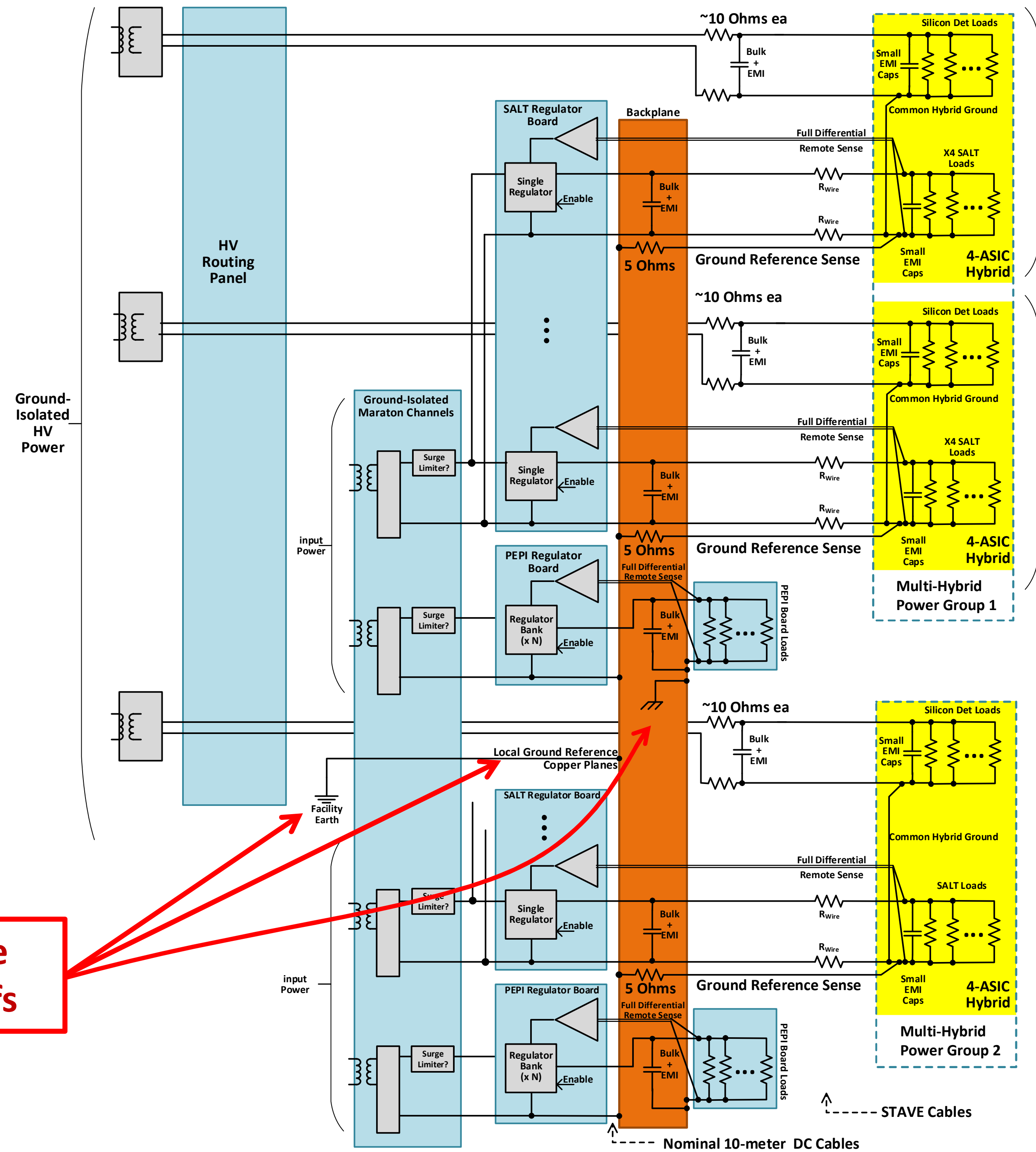


System Ground Partial Block Diagram



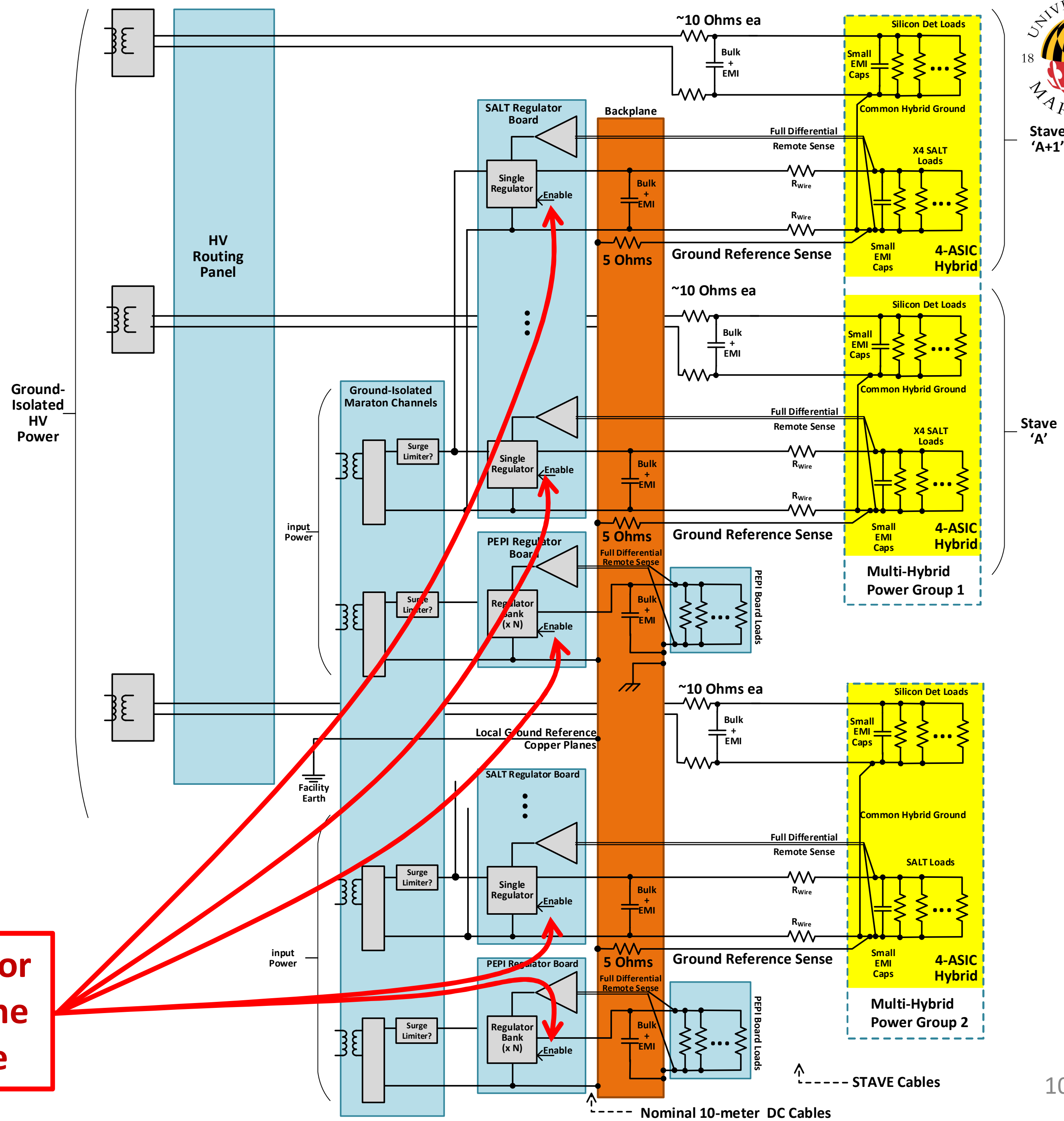
Each Source Power Channel Isolated From Ground

System Ground Partial Block Diagram



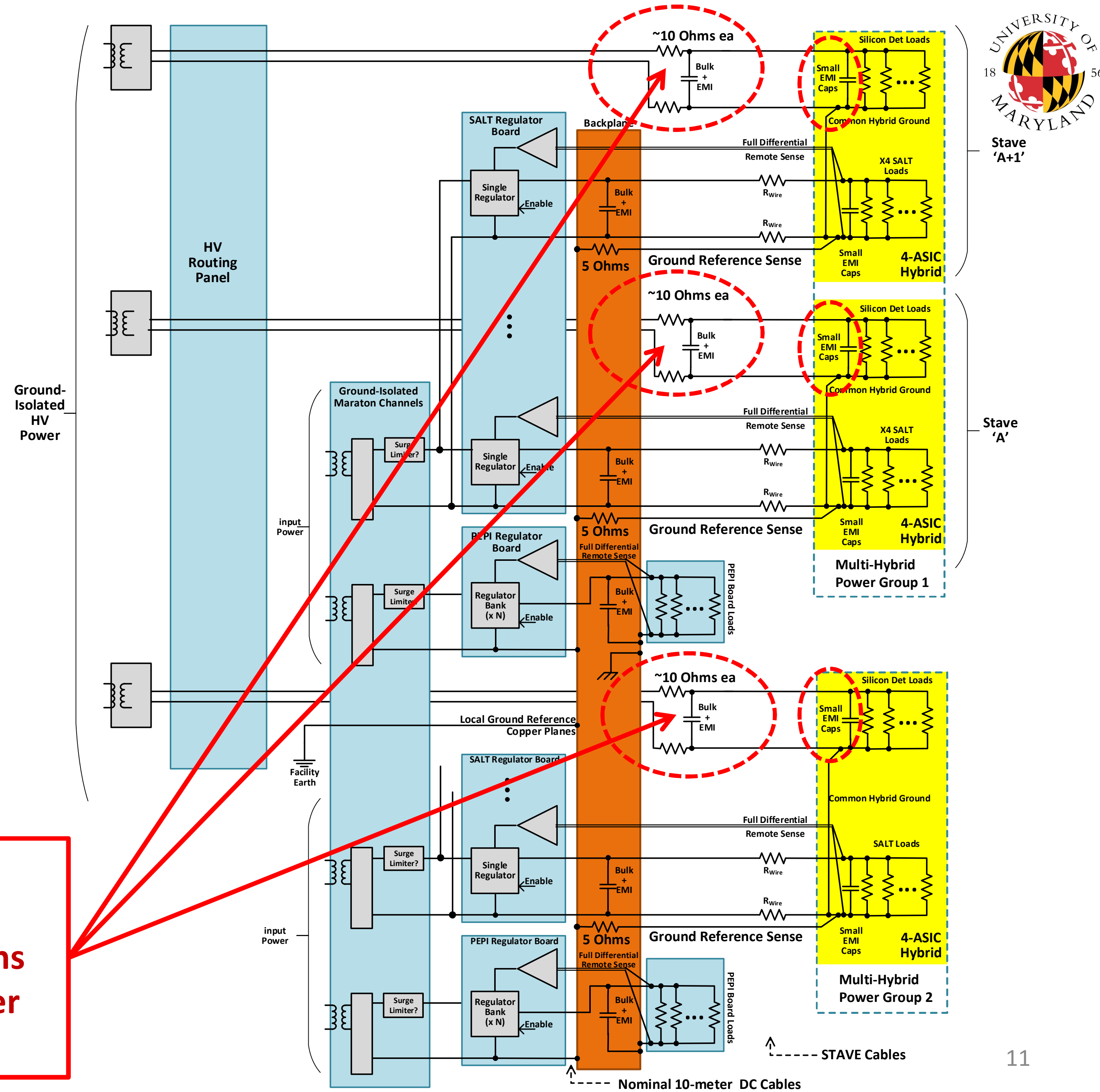
Backplanes are the System Ground Refs

System Ground Partial Block Diagram



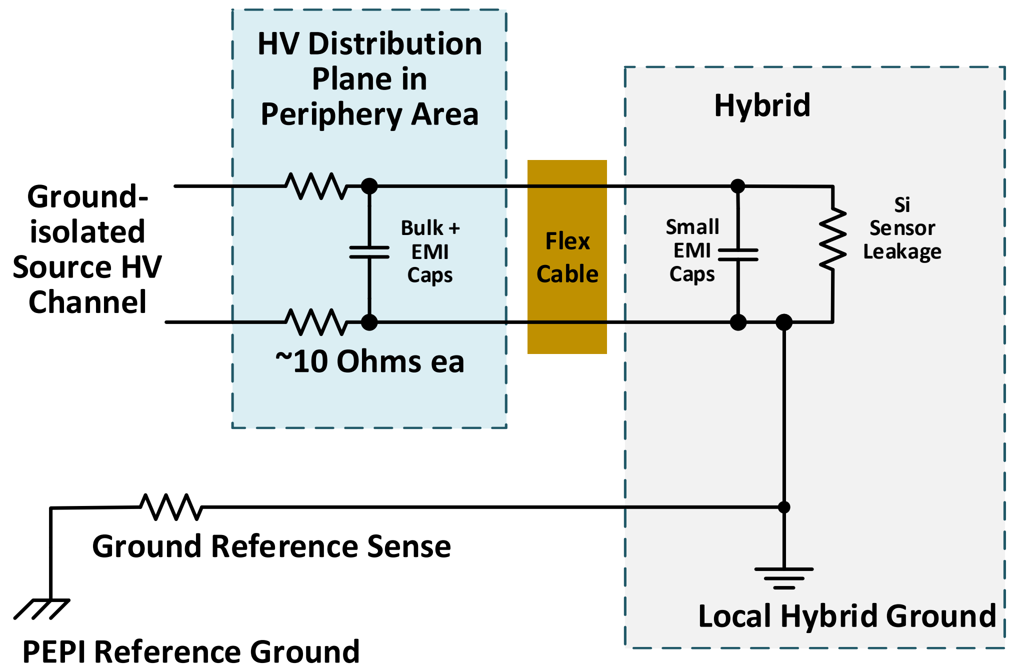
Control of Regulator 'Enables' determine On/Off Sequence

System Ground Partial Block Diagram



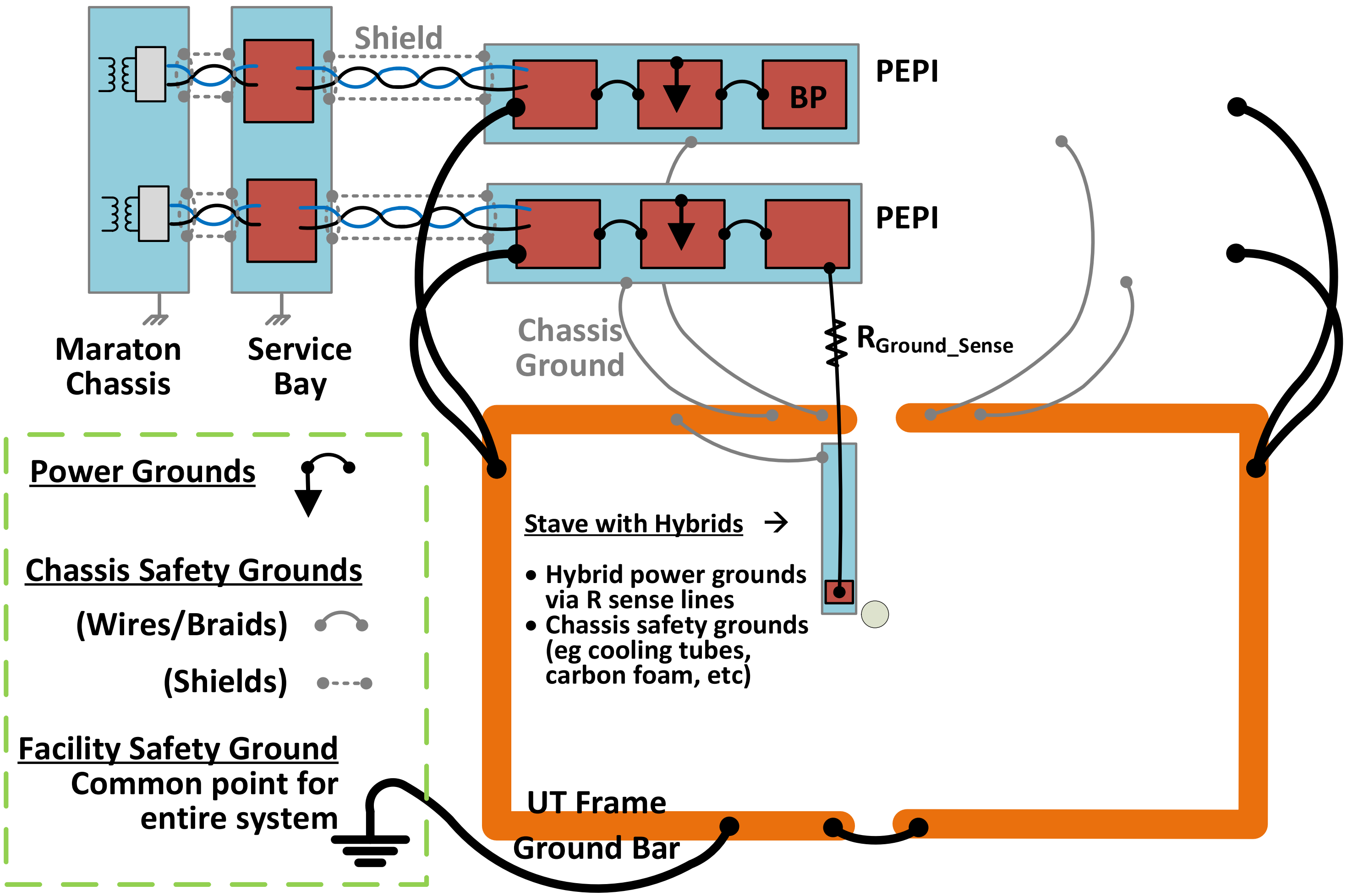
HV Distribution Networks Need Dedicated Locations to Decouple Longer Cable Runs

HV Grounds



- HV Grounds established thru the ground reference sense lines
- Bulk decoupling can be placed in the periphery area to minimize mass placed in detector planes

Power Versus Shield Grounds



ALL power grounds remain isolated from chassis safety grounds <u>EXCEPT</u> for the ONE connection coming from each PEPI chassis

Remaining Power Subsystem test Plans

- Multiple Power Group Test
  - Measure resulting common mode excursions for various power on sequences
    - Simultaneous horizontal power group on/off
    - Vertical stave (ie slices of multiple power groups) on/off
  - Common mode measurements are a validation input for study of effects on PEPI-hybrid communications
    - SE i2C and diff elinks
- Full scale ganged regulator test
- Results feed into power subsystem PRR scheduled for Sept 23, 2016
  - But, SALT128 pre and post radiation electrical current requirements must be fully characterized to make informed approval
    - Eg: GBTx post-radiation power consumptions increases by 333% for digital circuit sections
      - Peaks at ~ 600 kRad
    - Present config nominally has 1 regulator driving 4 SALT ASICs
      - 4 * 533 ma = 2.132 Amps, BUT 80% derated limit is 2.4 Amps!

Discussions

HI Tom

There is a big grounding issue here that we need to thoroughly discuss. You have your Pepi ground that eventually runs along the dataflex cables. The dataflex are separated from each other by ~3mm of space and two Carbon fiber sheets (CF) thats have dc resistances of ~0.03 Ohms/cm. The CF is grounded to the Aluminum endblocks of the staves..

It is planned to then ground the endblocks to the frames in the box that are in turn grounded to the Faraday cage in the box. Of course the cage can be grounded to your Pepi ground.

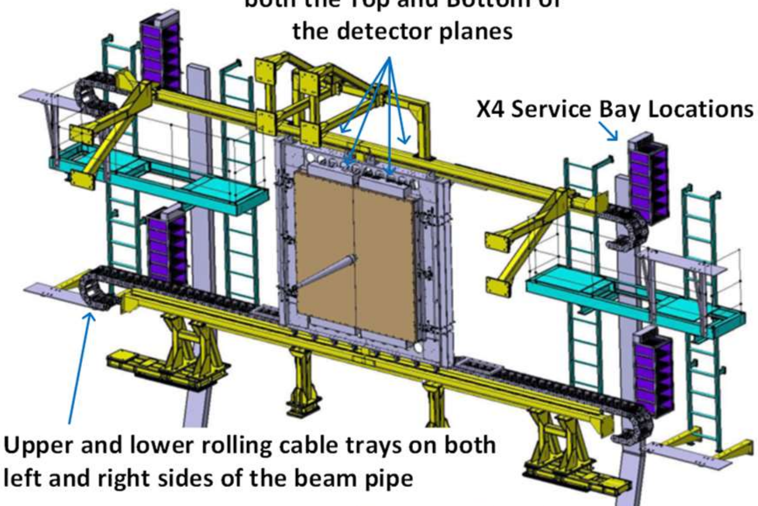
Another consideration is that the Titanium tubes are grounded to the CF and also are electrically connected to the CO2 feed lines running out in the hall.

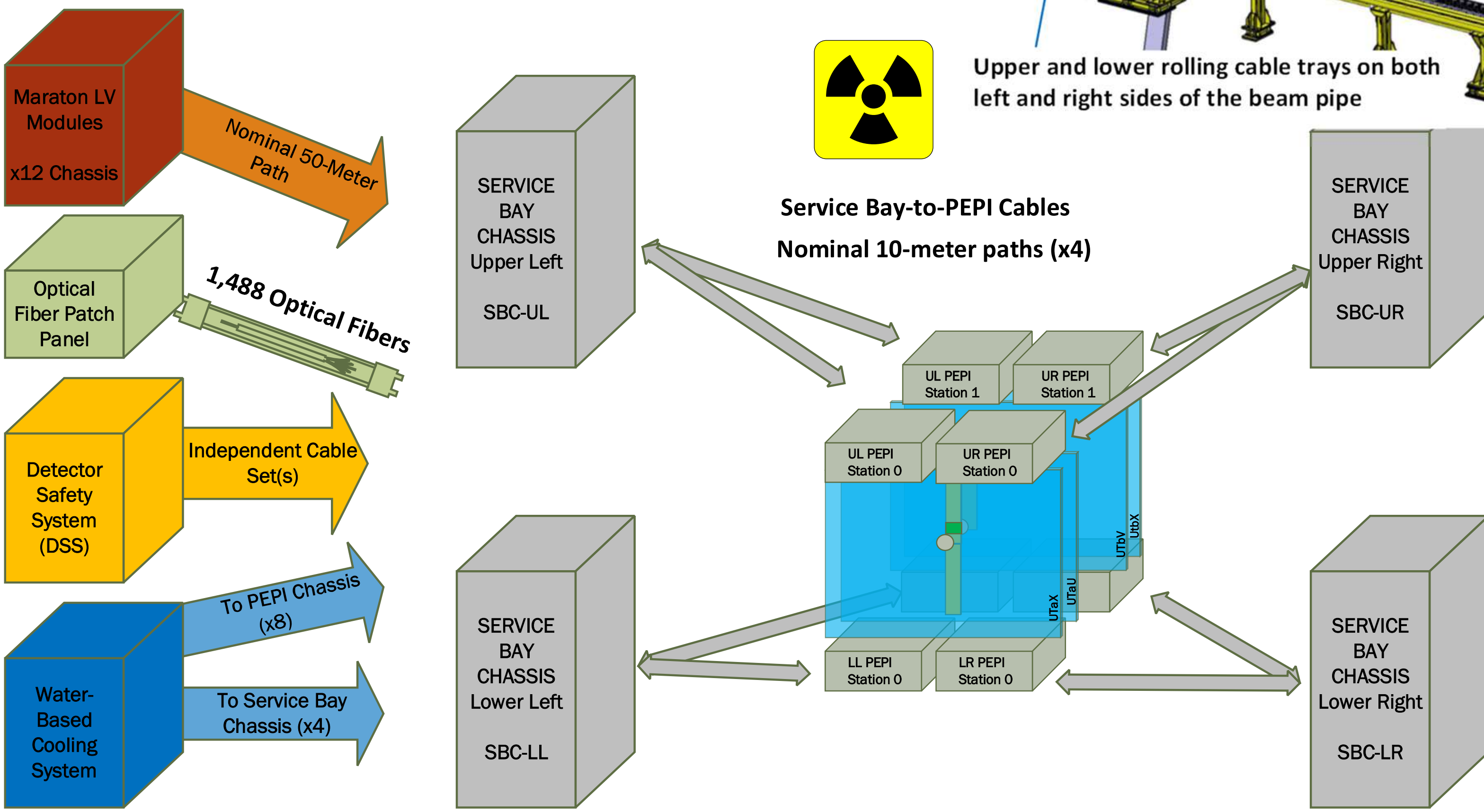
Subject to discussion is whether or not this is the best scheme? Are there ways of testing it?

sincerely
sheldon

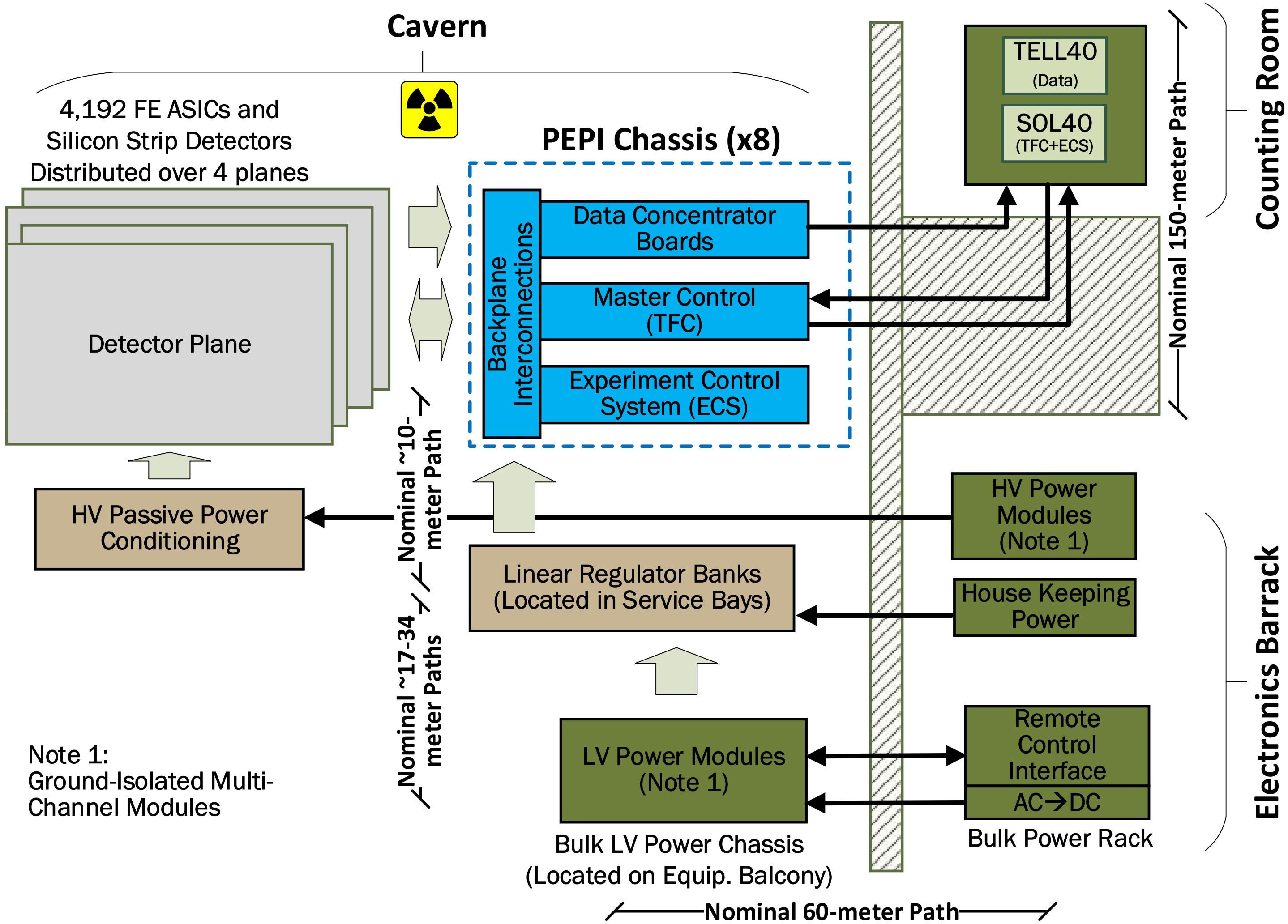
BACKUP

Cavern Electronics and Support Subsystems





UT Electronics Block Diagram



Baseline Assumptions: *Stave Flex Voltage and Sense Connections*

- Stave interface will provide **single set of DC power traces for each 4-ASIC group**
  - 1.2V at the hybrid SALT ASIC inputs
    - *1.5V for SALT LDO not part of present baseline, but still easily accommodated by the power architecture if eventually needed*
  - V Sense positive and negative
  - Ground sense wire
    - *OK to use common ground plane in 8-ASIC hybrids, but using one per 4-ASICs provides similar redundancy as the regulator circuit assignments*
  - Round trip voltage drop system allocation on flex cable is 0.5V max
- HV distribution:
  - Deploy **local distribution planes** near end of staves, but outside of PEPI chassis
    - Provide interface connectors for external HV power supply cables
    - Provides means to employ isolation networks near end of staves to account for long HV cable runs
      - **Reduces amount of capacitance needed near sensor areas**
  - **Separate interconnect approach used for HV connections to the Stave Flex cable (ie not part of MegArray connections)**

Loss Model from LV EDR