An Epic Tale: ICARUS Ground Short Search

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Technical Working Group Meeting

June 26, 2020

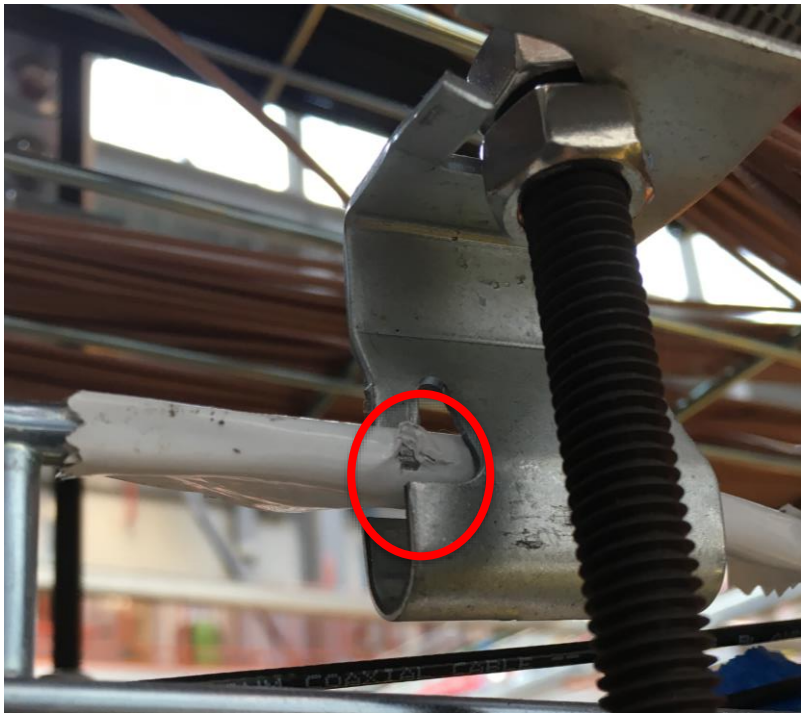
In collaboration with:

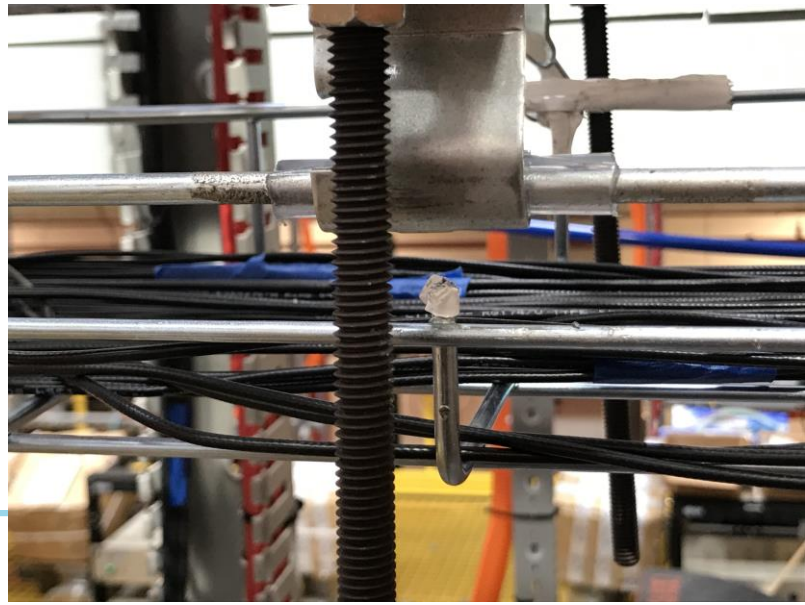
A little history---

- First started monitoring the ground ‘isolation’ February 9, 2019.
- The first ground short appeared April 17, 2019.
- Numerous shorts have been found and eliminated since then, with new ones developing along the way.
- On May 26, 2020 we began looking again.
- On June 19, we identified and resolved the last short.
- And this is our epic (25 step) tale……

Successes in ‘AC mode’

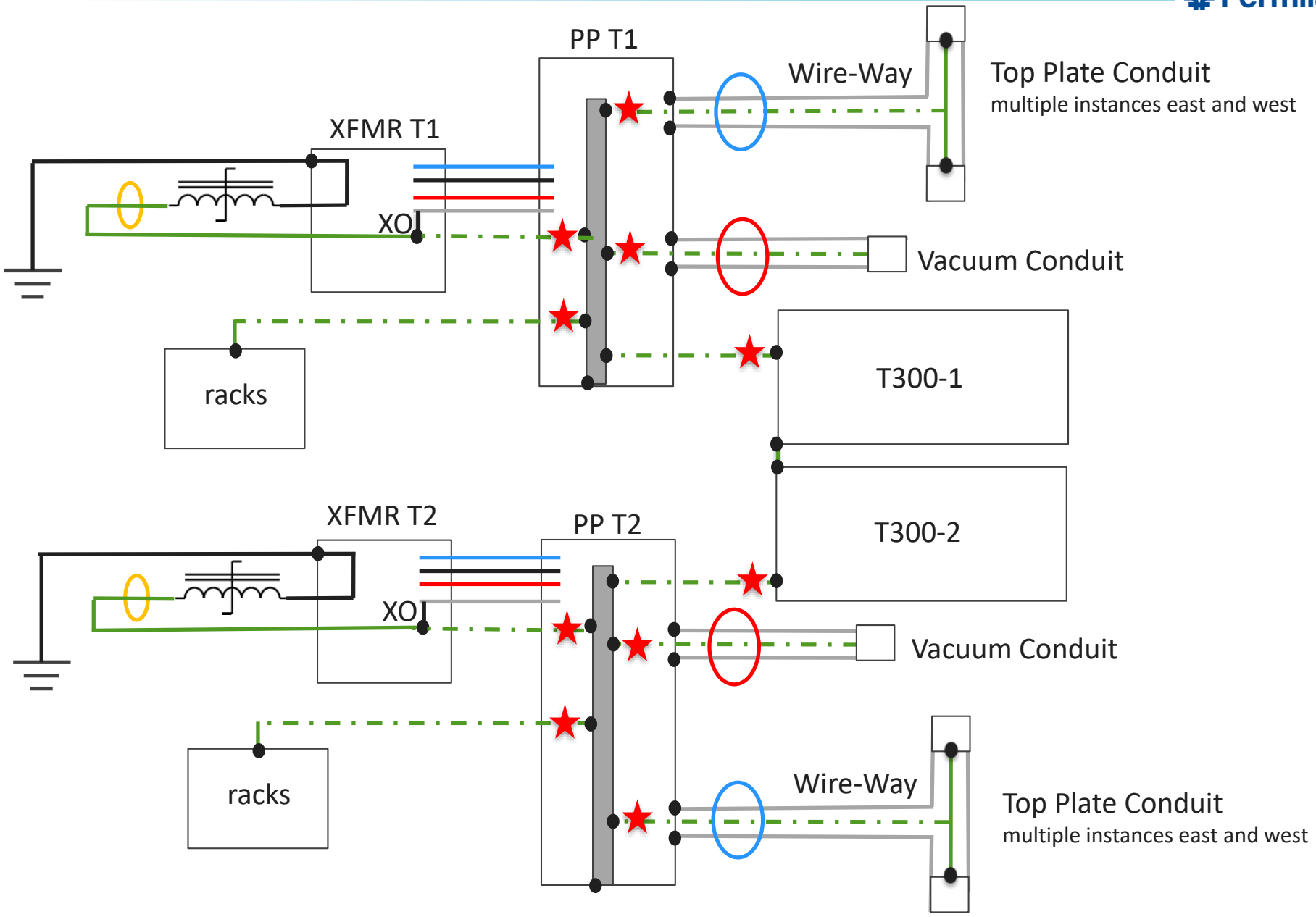
- With Z-mon active (AC search)
  - Clean off all unnecessary top plate equipment.
  - Perform visual inspection of experiment for mechanical short.
    - 4 cryo pipe mounting brackets
    - L-bracket mounted from building unistrut wedged between two detector referenced bits.
  - Verify cable trays are floating.
    - North to south cable trays indicated intermittent connections to building unistrut--eliminated shorts by isolating trays with tygon tubing so now trays can be grounded to the detector.





Successes in ‘DC mode’

- With Detector AC power locked out
  - Install 10K resistor between cryostats and building.
  - Remove T-300 ground connections.
  - Disconnect all safety ground wires to top plate outlet boxes in the power panels
  - Vacuum system: open at ‘break point’
  - Wire way: open at ‘dog leg’
  - Unplug and secure all AC power cords.
- Allowed us to clear all mounting hardware of the power distribution system on the top plate.
  - Numerous intermittent shorts were resolved by replacing metal screws with non-conductive screws on the wire ways.
- Once the top plate infrastructure was cleared
  - Allowed the investigation of power panel to the Laser, Mezz racks, Strain gauge, and HV drift conduits.
  - Shorts resolved by added additional insulation material between conduits and floor grating.


PP T1
Wire-Way
Top Plate Conduit
multiple instances east and west
XFMR T1
XO
Vacuum Conduit
racks
T300-1
T300-2
XFMR T2
PP T2
XO
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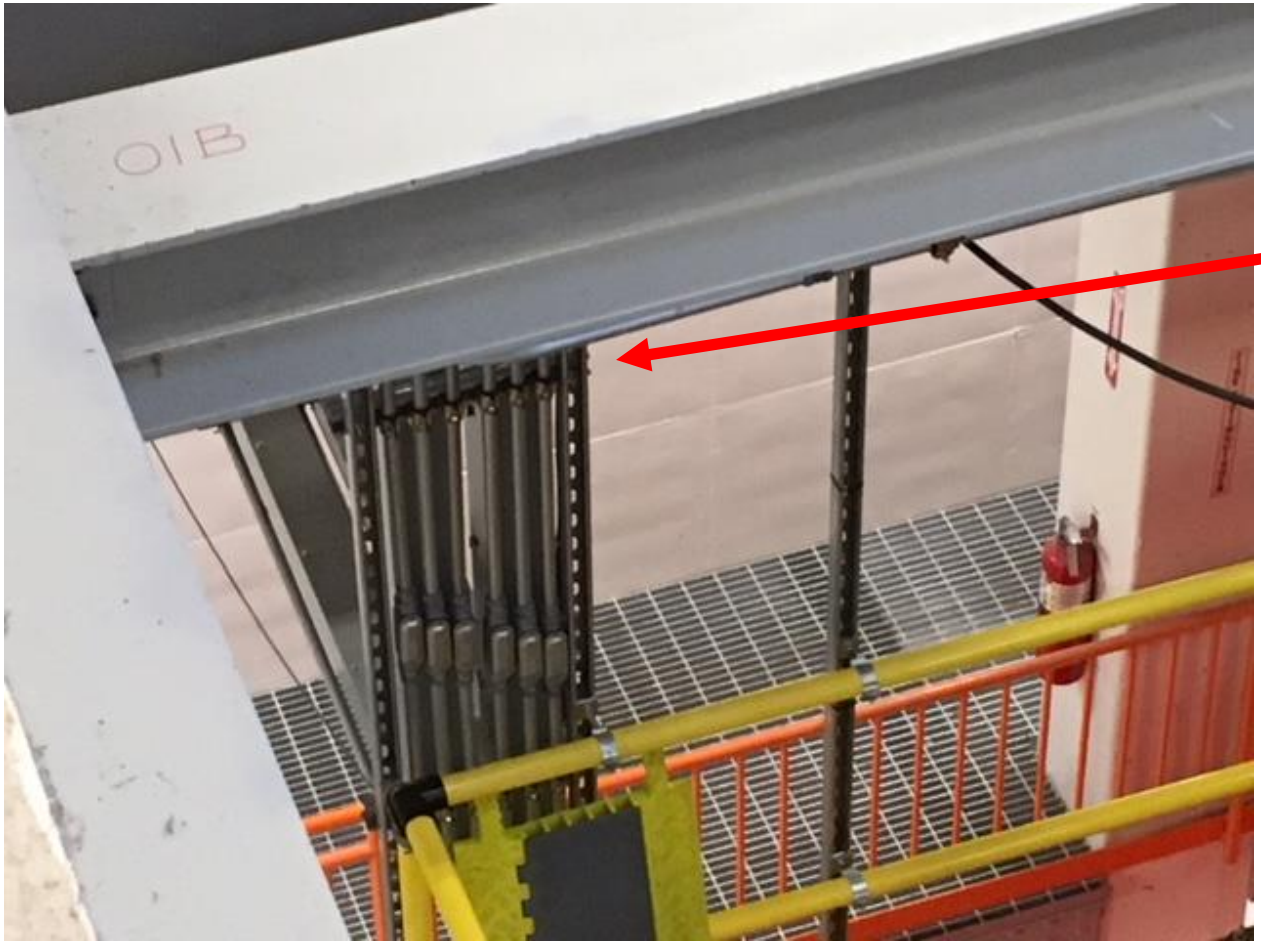
Vacuum Conduit



‘break point’

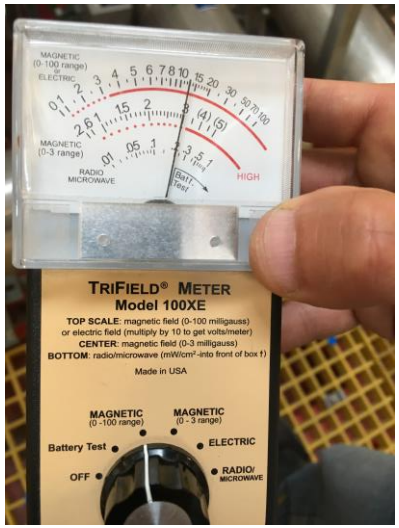
Wire Way

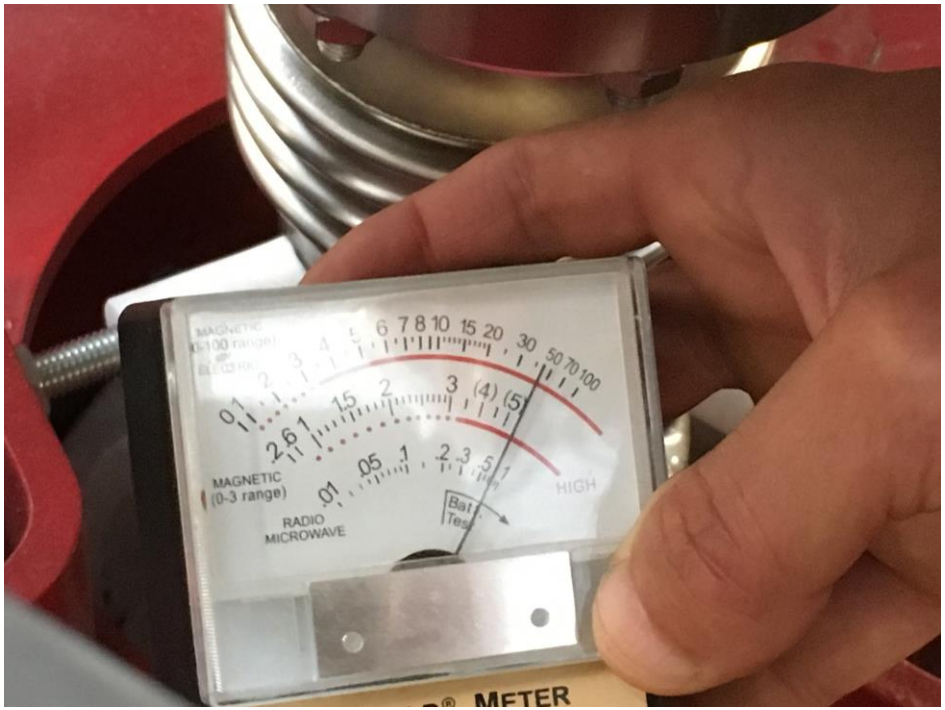
And there's more….

- Once all of the Detector AC power infrastructure was cleared, we still had a 1 Ω short between the cryostat and the building.
- The area to focus on was all locations where a cryostat structure was close to a building structure.
  - Flanges with dielectric breaks are one such spot.
- Tools:
  - DMM: Measuring resistance or voltage (with an external stimulus signal connected) across the breaks and chimney locations led to the same measurement everywhere—no help.
  - Also tried increasing the measurement resolution by using the Impedance monitor readback and moving the stimulus to different areas of the experiment—still no help.
- And then came a blessing----it began with an earlier observation that the bolts on the SE condenser didn't have visible sleeves.

Magnetic Pick-Up technique

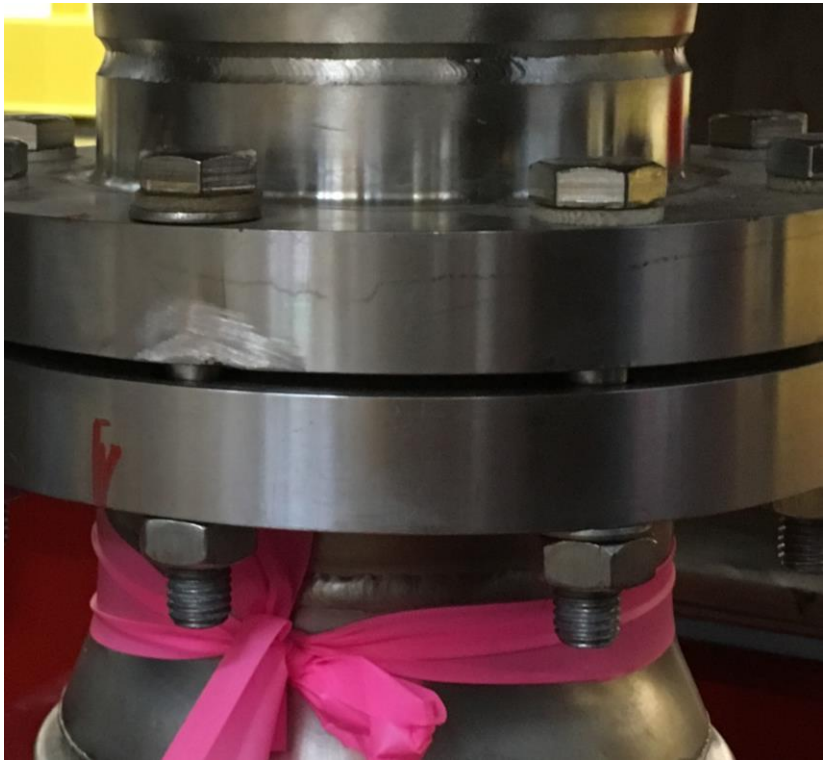
- Applied a 10kHz stimulus signal across the experiment, south end.
- Spectrum analyzer and hand held magnetic pick-up probe scan--nothing.
- Moved source to north end, and performed another scan with analyzer and a new tool from Joe Harris' arsenal--pointing to the SE condenser flange area.





Magnetic Pick-Up technique

- Using the analyzer and some keen eye balls, the magnetic field generated by the stimulus signal is measurable across 2 bolts. Hardware stack is different.



Smoking gun????

- Verified there was a sleeve—it's just long enough to cover the flange thickness.
- The external stimulus application changed the resistance from 1Ω to .5Ω so we knew we did something……

Short cleared--

- By cleaning the carbon off of the washer and reordering the stack, the detector to building ground resistance increased from .5Ω to 11kΩ.
- First glance at Impedance Monitor NOT displaying 5Ω.

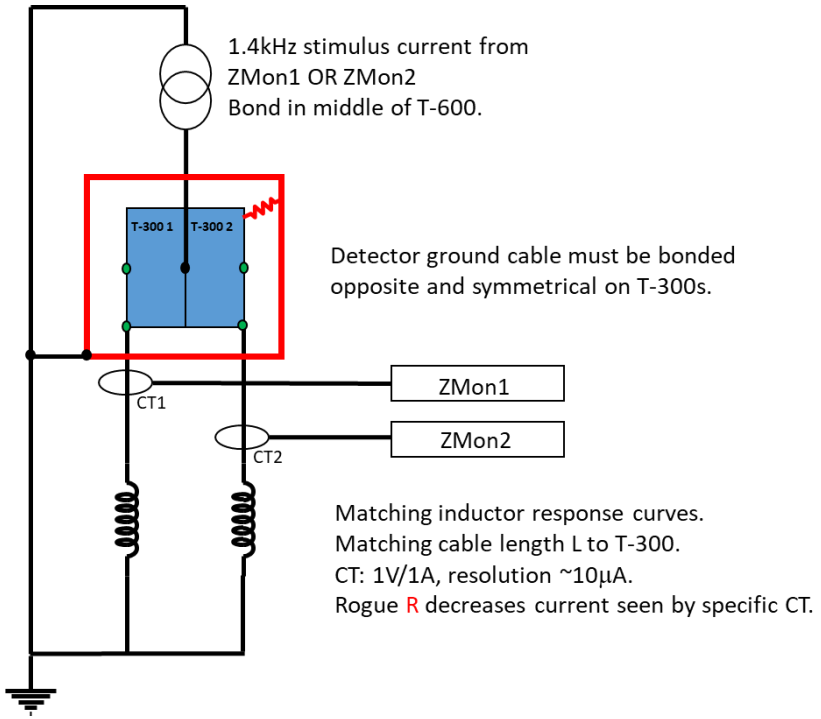
Short Gallery

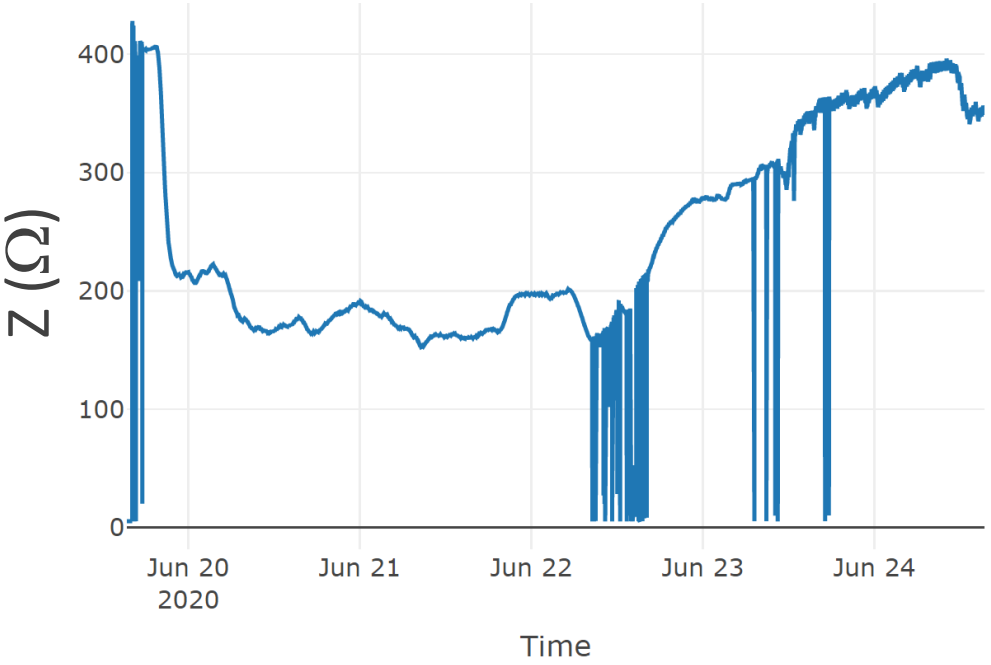
Lesson's Learned

- Use robust isolation materials: G-10, Teflon, fiberglass unistrut, and Tygon tubing are our friends.
- Design detector AC distribution systems that are easily divisible to clear large areas at a time.
- Pay careful attention to hardware stacks on dielectric breaks.
  - An aside: Check torque on all dielectric break flange bolts after cool-down.
- Magnetic field pick-up tools are powerful.
- Do not underestimate the importance of a casual observation.

But what does it mean….

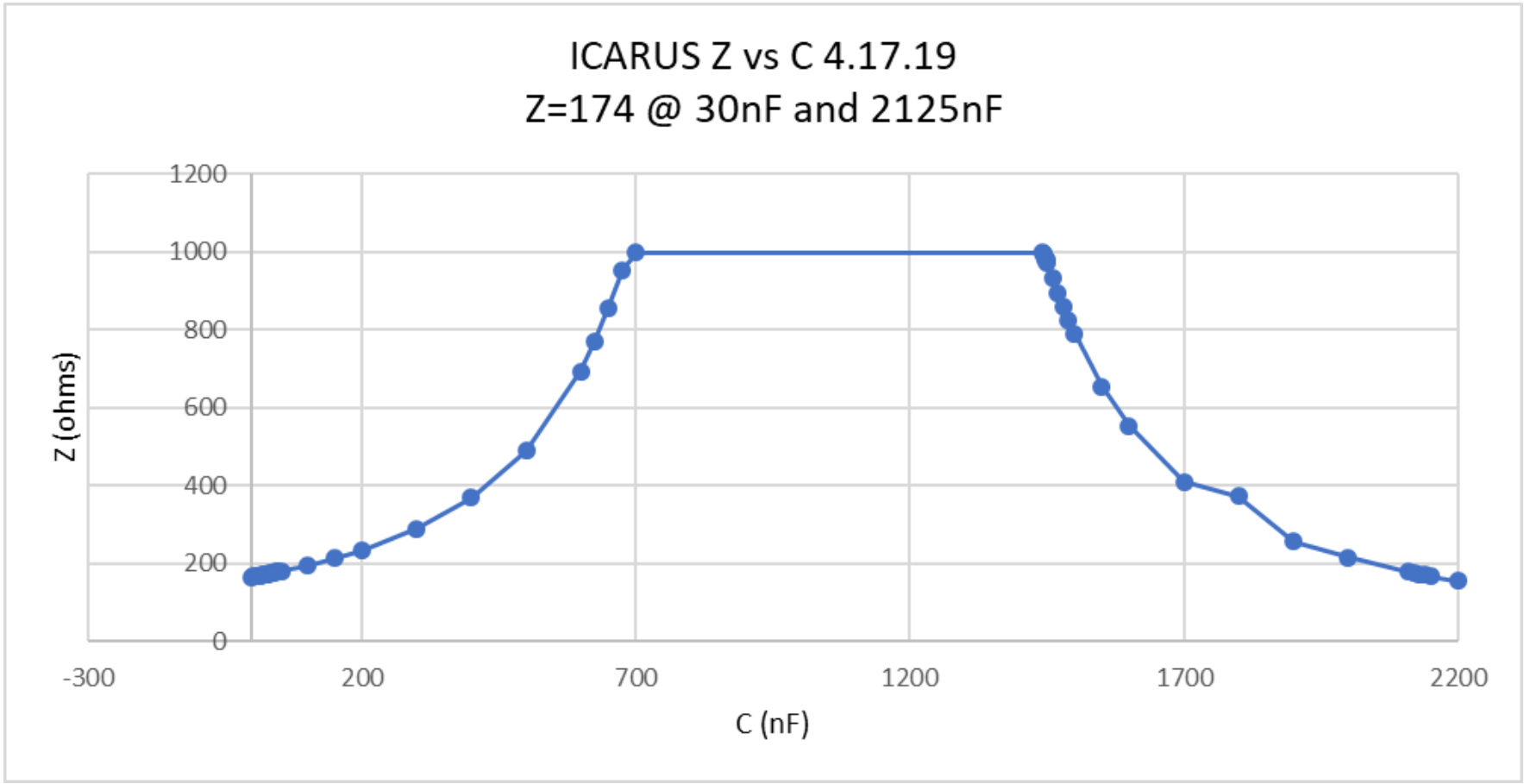
- Here's a plot from one of the monitors since last Friday.
- The vertical axis is Z (Impedance) of a 1.47kHz stimulus signal applied between the cryostat and the building grounds.
- The shorts shown were due to intermittent wire way connections and testing the system.
- We are working on correlating the fluctuations with building utilities, environmental changes, and cryo sensors.
- One thing for sure—we do not have a resistive short between the grounds.





Looking at the curve

June 20: Z = ~190Ω, +C decreased Z, C_d: ~2uF



It's a new day: T0

- To maintain the 'isolation', we must be diligent and proactive.
- Everyone working on the experiment must pay attention to the alarm system.
- Installation Rules:
  - Supervisor over new installations is responsible for maintaining the 'isolation'.
  - The work plan should include the intended cable/equipment plant—includes electrical, mechanical, and cryogenic disciplines.
  - When the alarm sounds and lights blink, **immediately stop** what is being done and resolve the source of the short.
    - The system updates every 3 seconds so there is a slight delay in response.
  - Work as a collective—know where other people are working to help.
  - If the short can not be resolved easily, contact management.

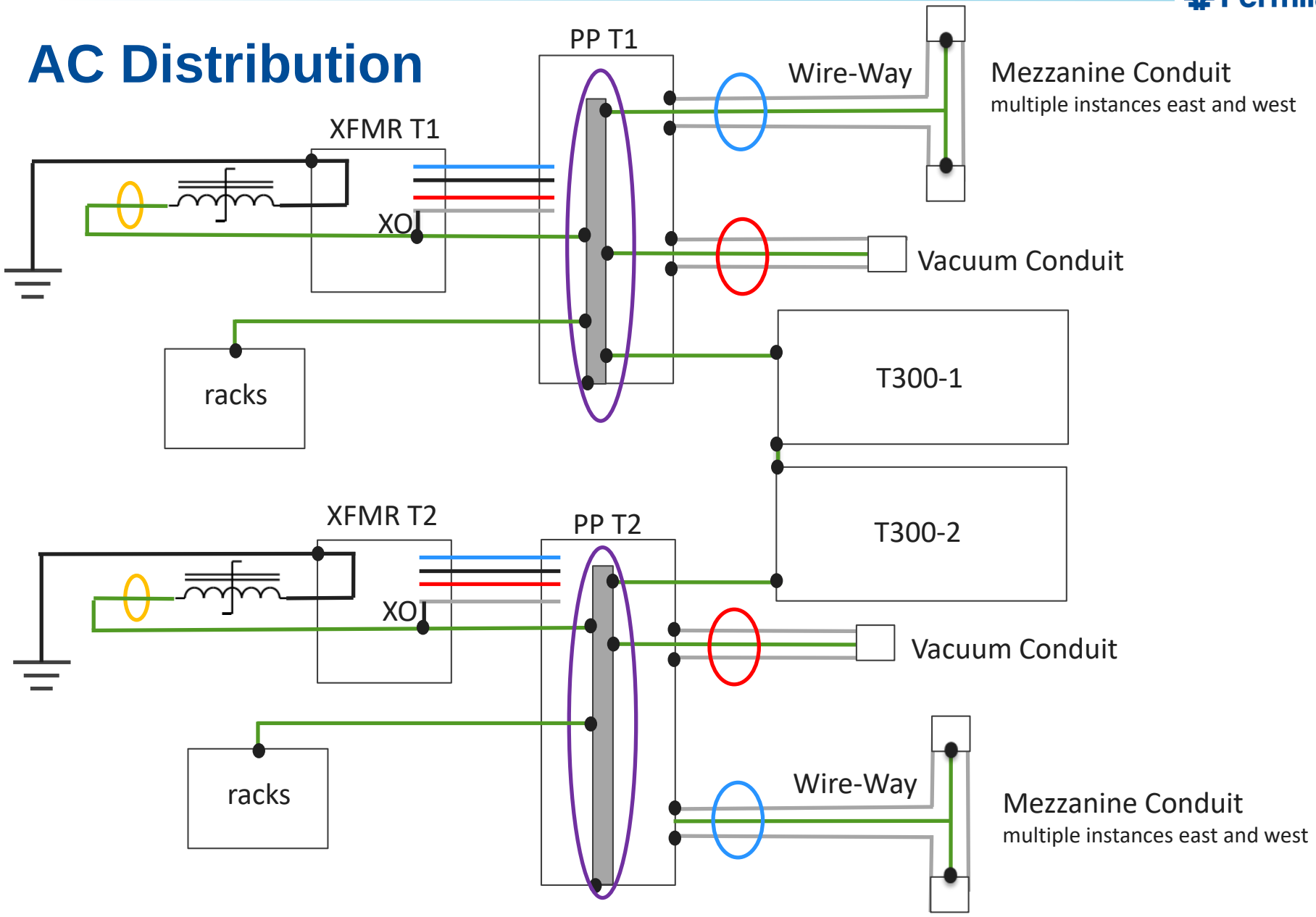
Thank you to everyone for helping

- Joe Brown (Skip)
- Mike Geynisman
- Kelly Hardin
- Joe Harris
- Claudio Montanari
- Trevor Nichols
- Donatella Torretta
- Peter Wilson

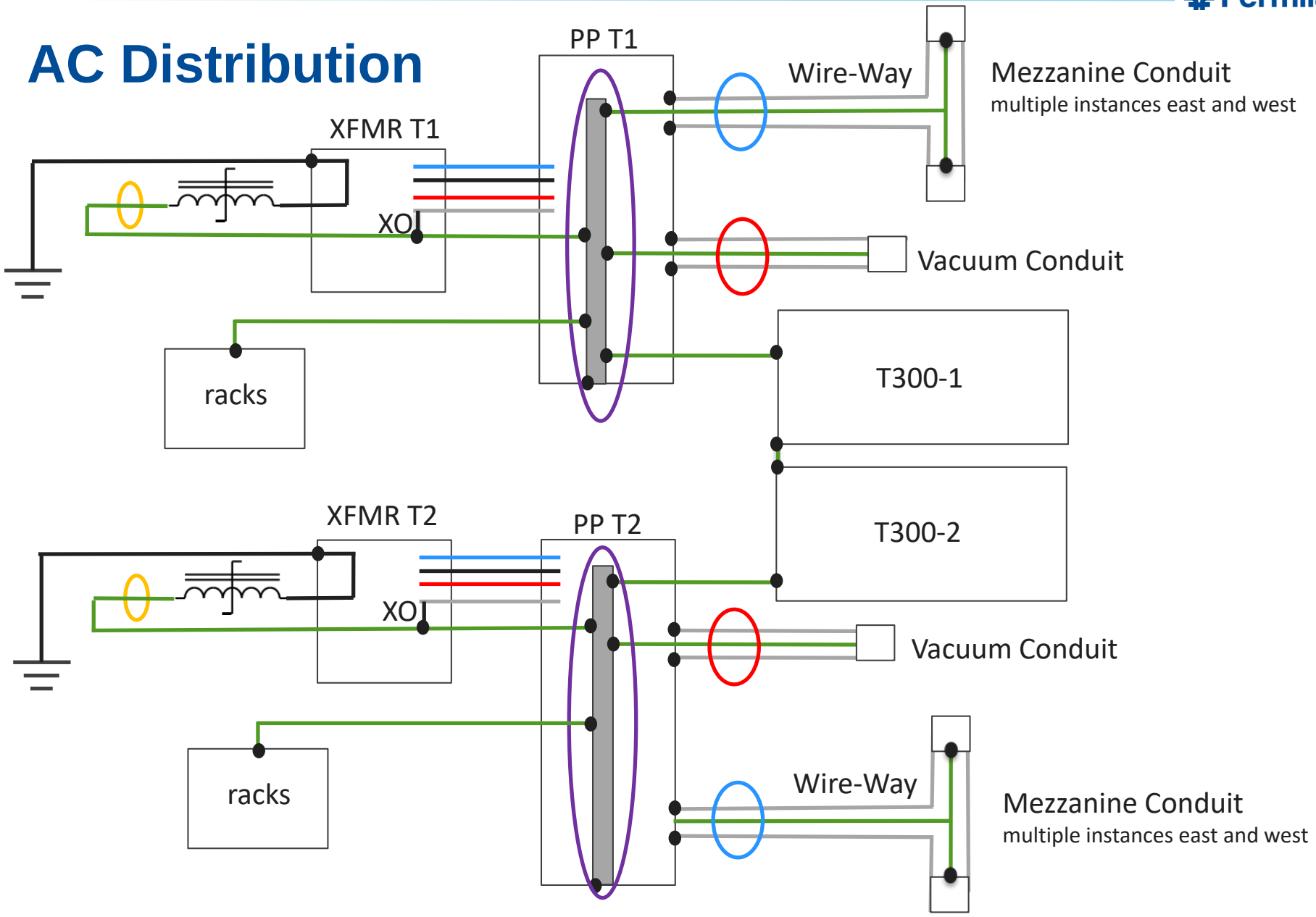
A demonstration

Extras

AC Distribution



AC Distribution



AC Distribution