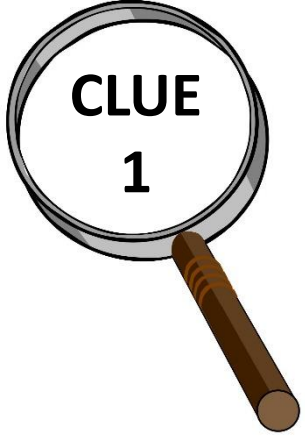
Stave Noise Hypothesis

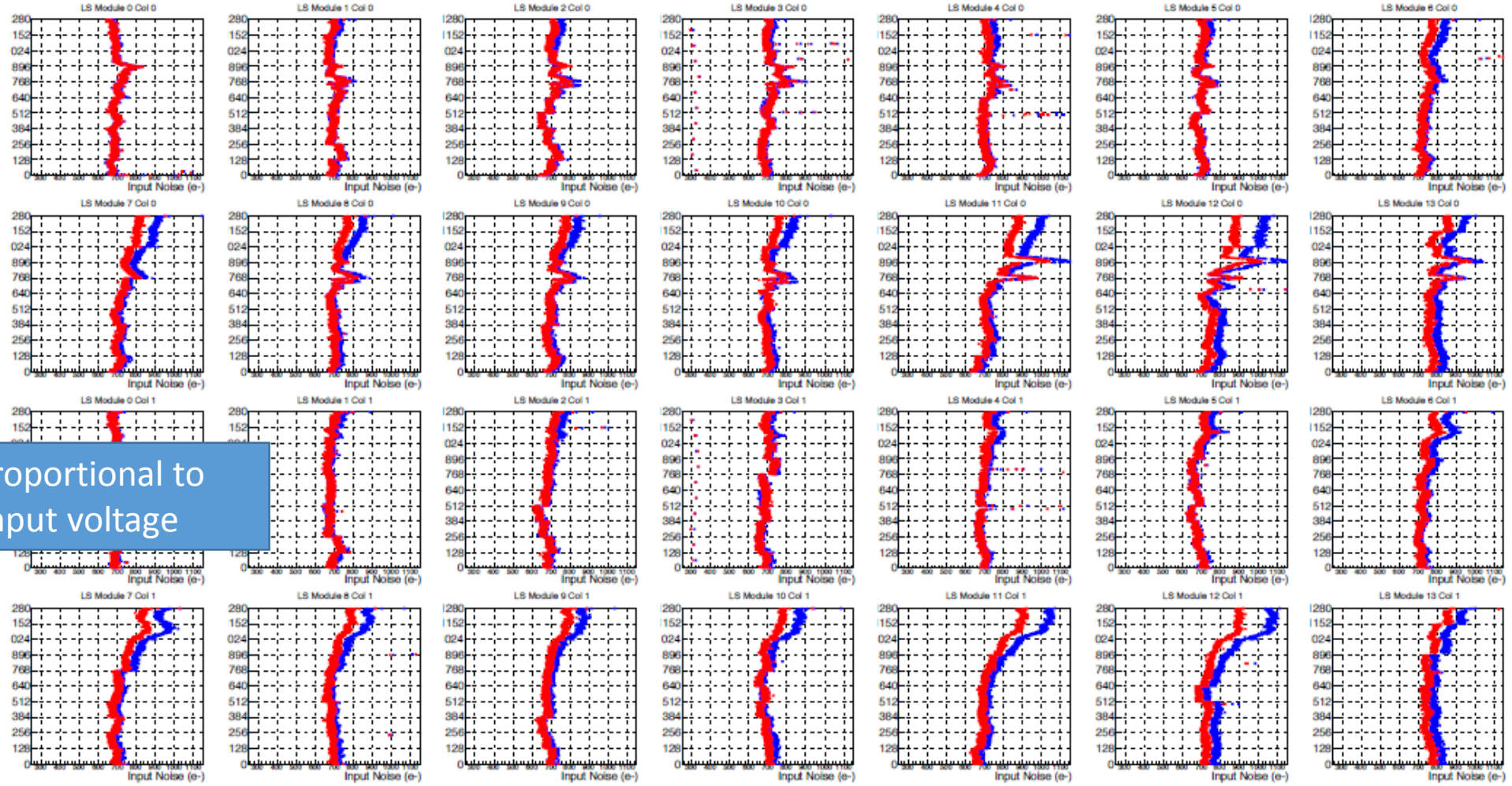
Work in Progress

PWP

20/02/2020



Dependence of noise on DC-DC input voltage



Effect is proportional to DC-DC input voltage

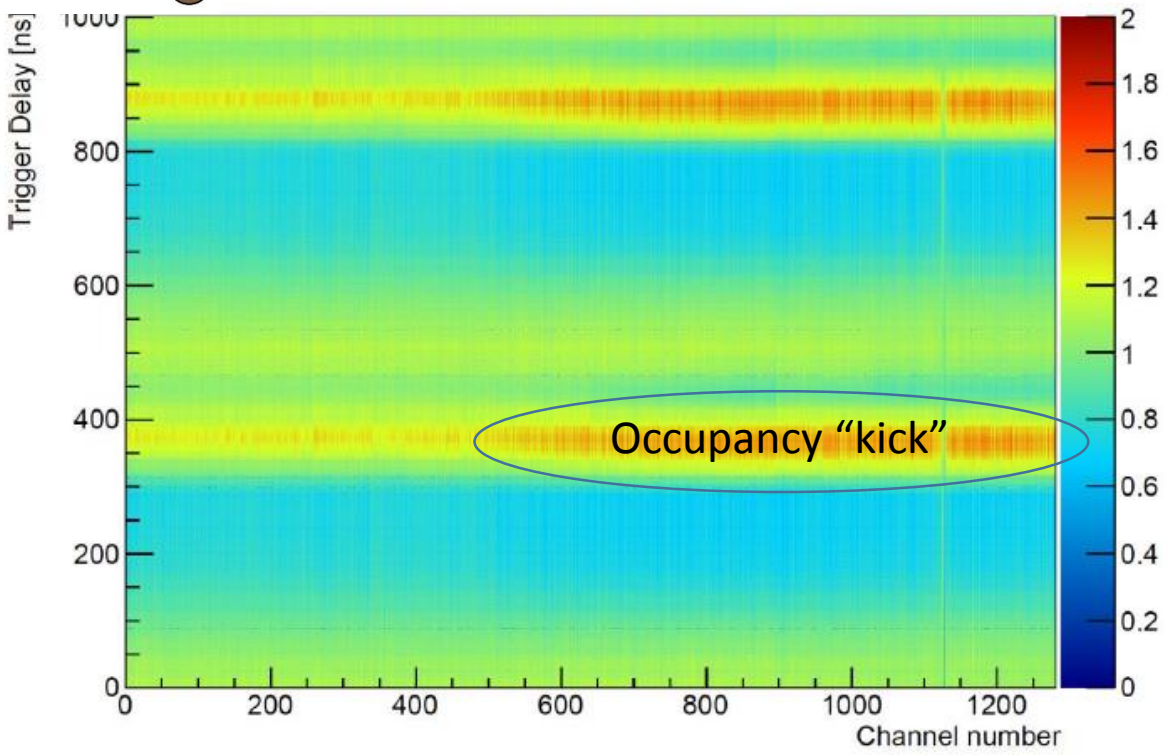
BLUE 11V
RED 10V

Magnetic Trigger Noise Test
ABCStar LS modules, outer columns

CLUE 2

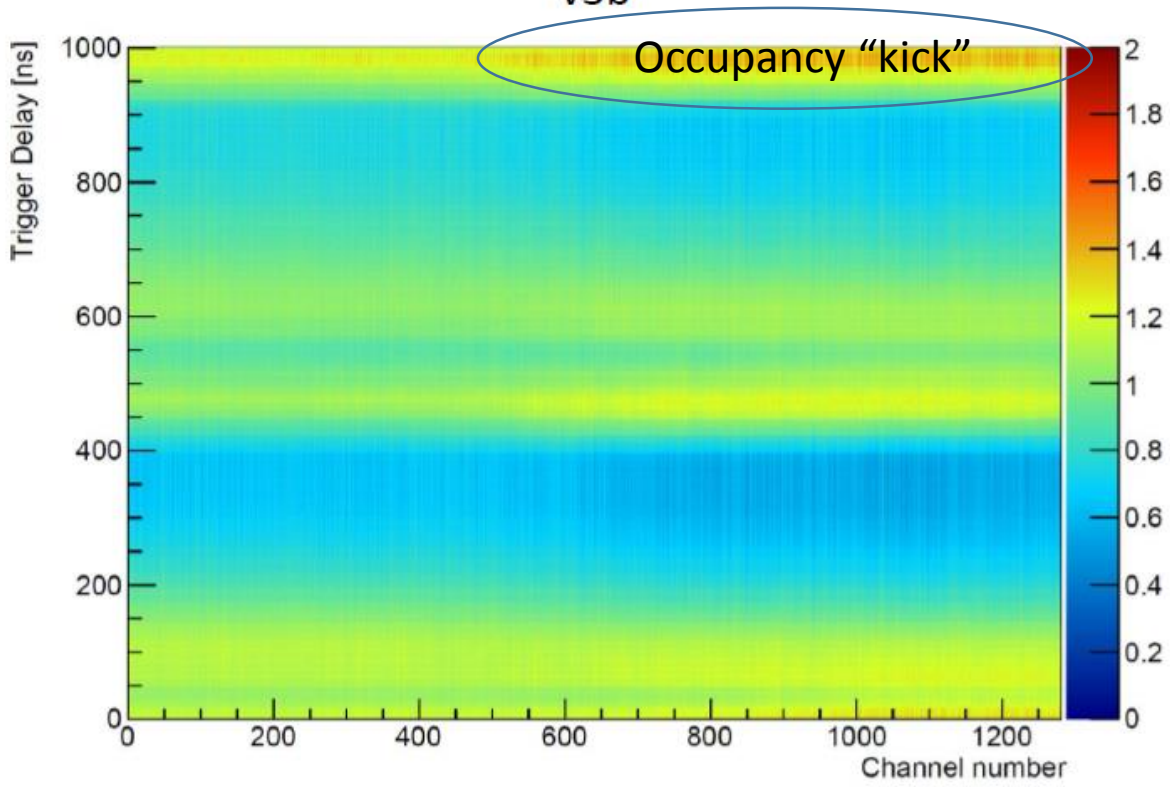
0.5 oz copper

v3a



1 oz copper

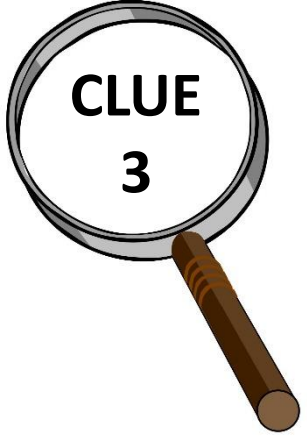
v3b



At a certain point in the DC-DC cycle, there is increased occupancy in all channels.
The dominant effect is a global movement of VT50 (pedestal), in the “upper half” of the hybrid x2.
In isolation this is considered as an acceptable, background effect.

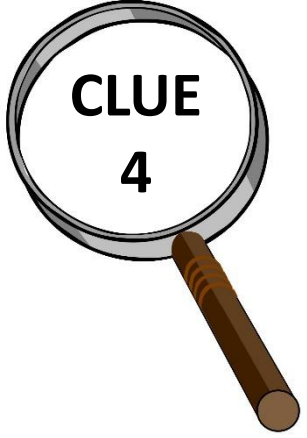
Science and Technology Facilities Council

ATLAS ITk



AC GND

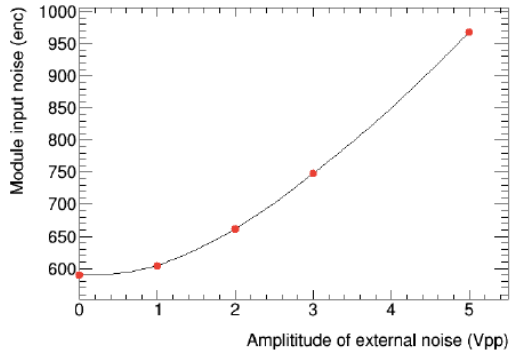
- The “Striping” effect shown on the previous slide was also seen for ABC130 modules but without the additional occupancy increase in the upper half of the hybrid.
  - The AC GND tie, located at the upper edge of the hybrid, is only supported in the ABCStar test frames (and on STAR and 130 staves). It was not included in the ABC130 test frame design.
  - Its inclusion gives a route for currents to flow in the 0V plane of the upper half of the hybrid which does not apply to the lower half.



Noise Injection through under-sensor structures

Amplitude of external noises Vs Module Noise

Amplitude of injected external noise from cooling pipe (chip 0) Frequency = 2Mhz	Average Input Module Noise (enc) Input noise 1.00fc
0 Vpp	590
1 Vpp	605
2 Vpp	662
3 Vpp	748
5 Vpp	968



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- Ash recalled a study made at B180, to see if a noise voltage applied to the cooling pipe would lead to localised pickup in the sensors
  - https://indico.cern.ch/event/309419/contributions/714147/attachments/591447/814153/B180_noisestudy1.pdf
- Spoiler: it did (although the signals here were large)
  - Sensor backplane is not an efficient shunt against dV underneath

Hypothesis

- During the “occupancy kick” generated by the DC-DC, the local module ground will move with respect to the AC signal ground
  - This will push current through the AC ground bonds and the upper part of the hybrid’s ground plane leading to the “slopey” part of the observed noise signal
  - In addition the potential difference between the (clean) signal ground which runs underneath the sensor and the module’s (dirty) local ground gives a mechanism for more “localised” charge injection.
- **IF** we can confirm that the “occupancy kick” is more pronounced at lower temperatures, due to changes in coil resistance and/or operation of the FEAST/BPOL12V chip, then the noise injection mechanism is understood.
  - Caveat: this only fully explains the stave observations for modules 0 through 12. module 13 does not fit the same pattern: still working on that.

Prediction: Removal of AC GND bonds

OFF STAVE

- A Magnetic Trigger Noise Occupancy test made after removal of the AC GND bonds should make the occupancy kick appear more uniformly across all channels.

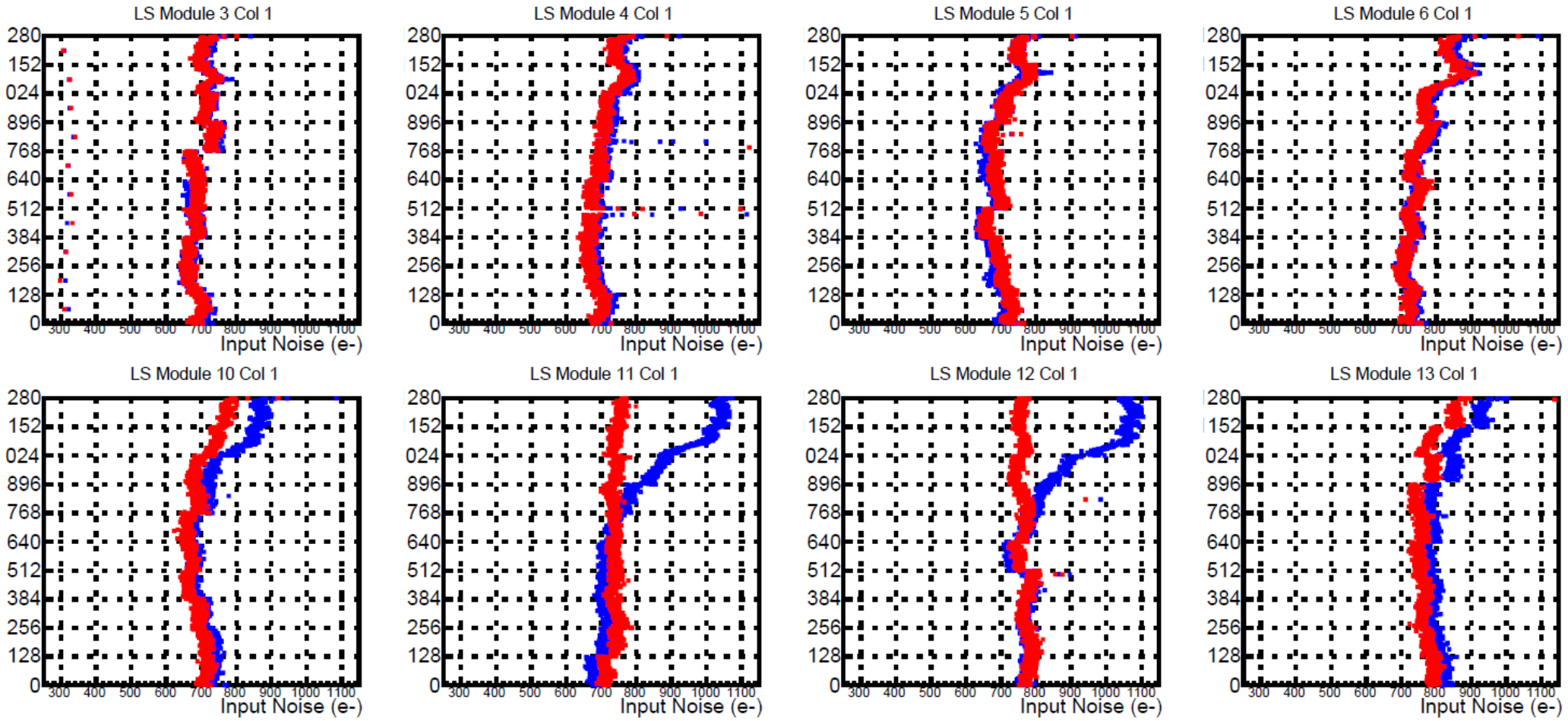
ON STAVE

- The “slopey” part of the noise increase across the upper portion of each hybrid should disappear BUT we should still see localised effects correlated with the signal ground traces. (Indeed these may become more obvious.)

NB this slide was written yesterday morning UK time, before the relevant test was made...

Result: Removal of AC GND bonds ON STAVE

Bonds removed from modules 11 and 12 only. Master side, coolant -50C



BONDS ON

BONDS OFF

The Origins of the Occupancy “Kick”?

- My understanding of the v3a and v3b PB designs is that, between the 11V input and the 1V5 output there are two 0V layers which both carry 11V return currents.
  - v3b planes 1oz copper, v3a planes 0.5 oz copper
- The final HV filter bypass capacitor connects to 0V near the 11V input and 0V is fed to the hybrids at the module centre.
  - There will be common impedance coupling between the 11V return current and the sensor return current (which flows into a virtual ground at AMAC)
  - AC currents in this common path can give the module a “kick”
- I believe there was a proposal for v3c such that only one 0V plane would carry currents, making the bottom layer a true shield
  - connected to the current carrying plane only at the module centre (under AMAC).
- One may also consider making the HV bypass capacitor’s 0V connection directly to the shield plane
  - In DC terms the CI coupling is still there in the other layer, but the AC bypass is moved to the “star” point
  - Optimum rejection of internally generated noise
- BUT this may lead to inferior rejection of externally generated noise
  - dV caused by dI in current carrying plane will increase due to use of a single 0V plane
  - sensor may “see” external structures which do not move with the local 0V potential more easily
- Swings and roundabouts...

Possible follow up tests

- [REQUIRED] Magnetic Trigger NO as f(T) OFF STAVE
  - will confirm or deny the supposition upon which this hypothesis is based
  - ideally with and without ACGND bonds
- [RECOMMENDED] Magnetic Trigger NO as f(LV) OFF STAVE
  - Has been done for ABC130 but withpout ACGND
  - May confirm reduction in striping
- [RECOMMENDED] Magnetic Trigger NO ON STAVE
  - as above, f(T) and f(V)
- [RECOMMENDED] eye diagrams with and without ACGND
  - ACGND was put there for reasons of signal integrity: does its removal effect BERT?

Possible follow up tests

- [OPTIONAL] One could lift the second HV filter cap on a PB and implement a current free referencing tie by wire tack
  - will be inductive – will we learn anything?
- [OPTIONAL] One could bricolage an AC ground tie which drops to 0V close to the module centre
  - will be similarly inductive, of questionable merit

Possible Additional Measures

1. Additional HV coupling capacitor at upper edge of hybrid
   - improves shielding efficiency of sensor backplane
2. Additional shielding layer connected to module local ground could be placed between the sensor and the data traces
   - shunts any “signal” into the module 0V reference potential BUT would also mess with trace impedances requiring a significant redesign of the bus tape☹
3. Substitution of the present lower layer of the bus tape by a solid (hatched) ground plane to unify signal ground and LVRET throughout
   - Relatively easy but still subject to effects due to dI/dV in the PB ground planes

Module 13 (slave side)

Special case: ACGND tie goes direct to LVRET, not clean signal ground!!