How the discovery of Cold Noise delayed the production of ATLAS ITk strip tracker modules by a year

AKA FUN WITH LASERS

Andy Blue
ITk Strip Barrel Modules

Long-strip module

Strip

Powerboard

Hybrids

Short-strip module

Strip
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- Thicker glue layers under PB and hybrid(s) can reduce CN.
- Softer “glues” (Sylgard encapsulant, SE-4445 gel) remove CN.
  - Only diagnostic, not suitable for detector.
Finding the source of vibrations
Powerboard is instigator of Cold Noise
- Powerboard electrically bypassed - CN is removed

“Singing” capacitors known phenomenon when dielectric used in capacitor has piezoelectric effect
- Occurs with a oscillating voltage on capacitors
- Buck converter a potential candidate for singing capacitors
Propagating wave - Vibrometer

• Cant remove the source of vibration

• Need to understand how vibration is propagating

• **Use a Vibrometer**
  - Non-contact measurement
  - No mass loading
  - Laser spot 40 µm
  - Sensitive to MHz range

• Upgraded Vibrometer with 2D scanning
  - Single point measurements across module
  - Stitched together measurements in phase
    - Magnetic trigger on buck converter as reference

• Capacitor amplitude approx. 1 nm
  - Amplitude is dependent on power draw of powerboard

• Vibrations propagate across Silicon at same wavelength as calculated ~1.3 mm

• The wavelength on the PCB is ~400 µm

• **CN** connected to wavelength in **Silicon** so interested in scan of **back side of module**
Propagating Wave in Silicon Sensor

- Propagation across the silicon sensor
- Window cut in pcb readout board for module to scan the pack of the sensor
- Module powered in climate chamber at -60C
- Vibrometer scan through 9 pane window
Vibrometer scan of Silicon sensor from the back of module while in climate chamber at -60C
Propagating Wave in Silicon Sensor

- The glue gaps allow the waves to pass through.
- The glue under the hybrids dampens the vibrations.
- There is an interference pattern between the caps.
- The C2 cap has strong oscillations when at full power.
- The location of CN readout is not clearly correlated to the wave pattern.
• CERN’s bPOL (on ITk strip module) and FEAST DCDC power converters used in multiple experiments

• 0.5 nm vibrations seen on both versions

• FEAST has been running in CMS operationally for over a year

• These capacitor vibrations are the same as our module

• Source and scale of vibrations not unique to ATLAS ITk strip