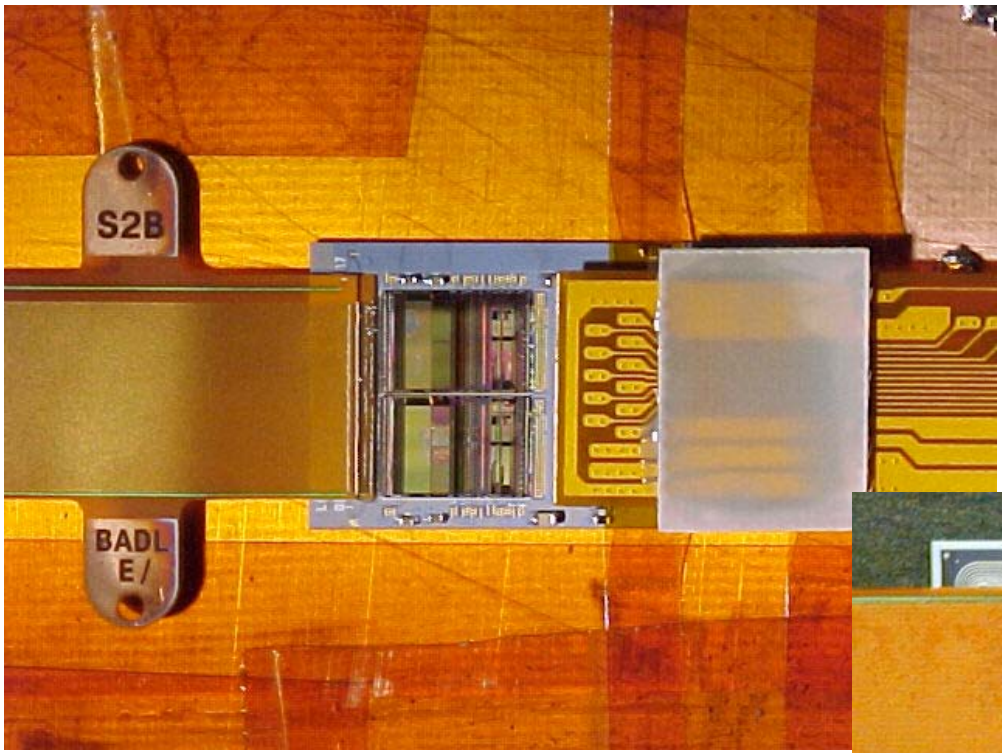
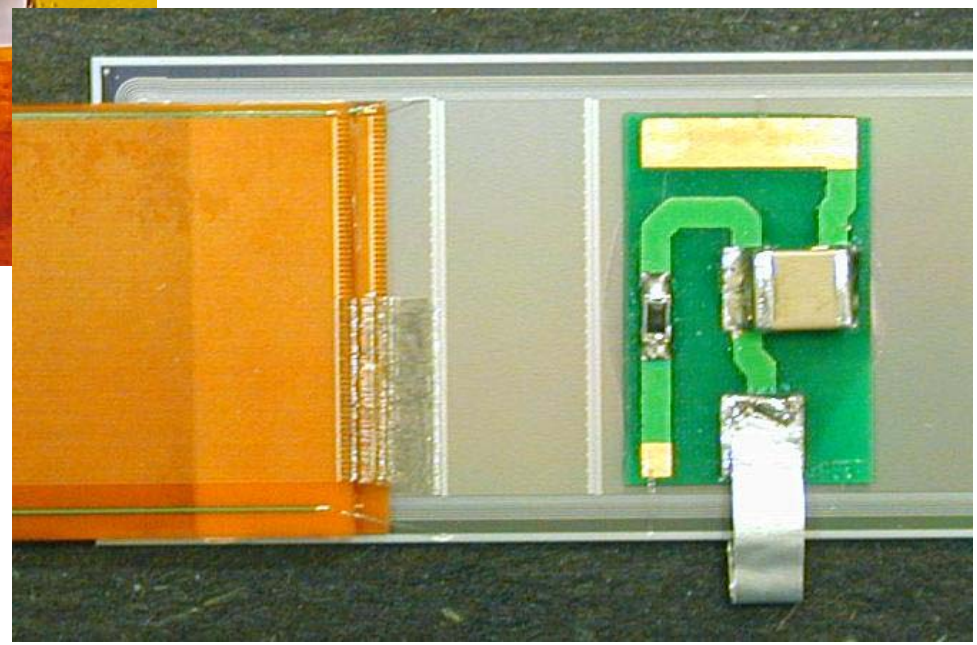
Summary of Grounding Studies

Kazu Hanagaki / Fermilab

- Noise level in a bare (before installing on to the support structure) module
- Study on the support strucutre
- Outcome from the study and the concept of grounding scheme
- Noise level on the prototype support strucuture
- Conclusion

Prototype module



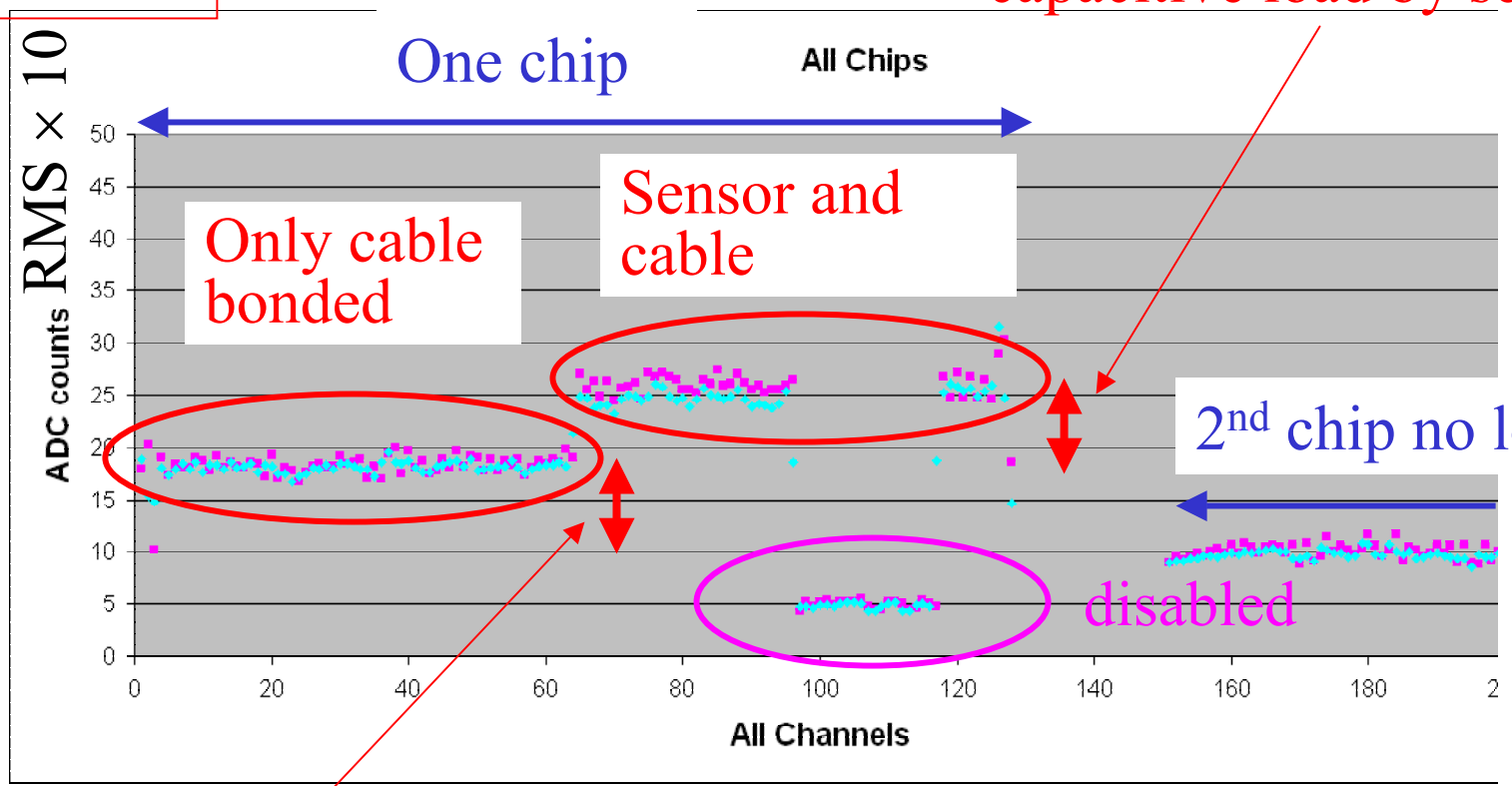


Noise Level before installation

Total noise
Diff. noise

for all plots

capacitive load by sensor

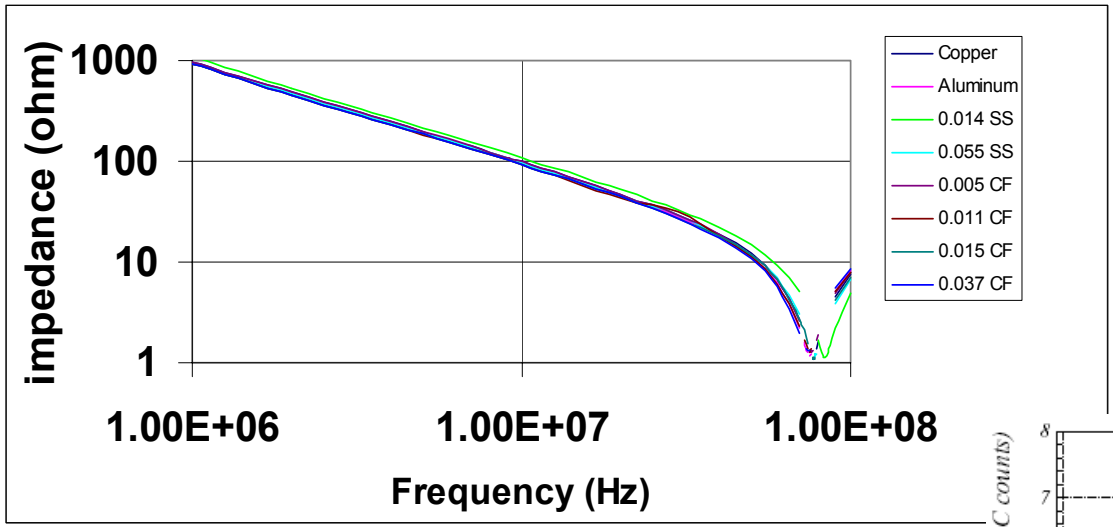


capacitive load by cable (0.8ADC~600e)

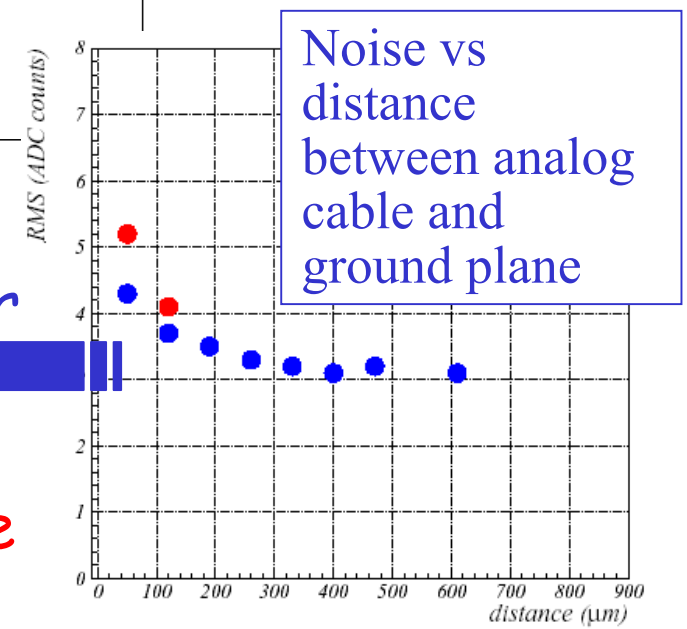
SVX4 ENC: const+41C ➔ 600e indicates C = 15pF for ~45cm

Application of Carbon Fiber

- Carbon fiber has high conductivity



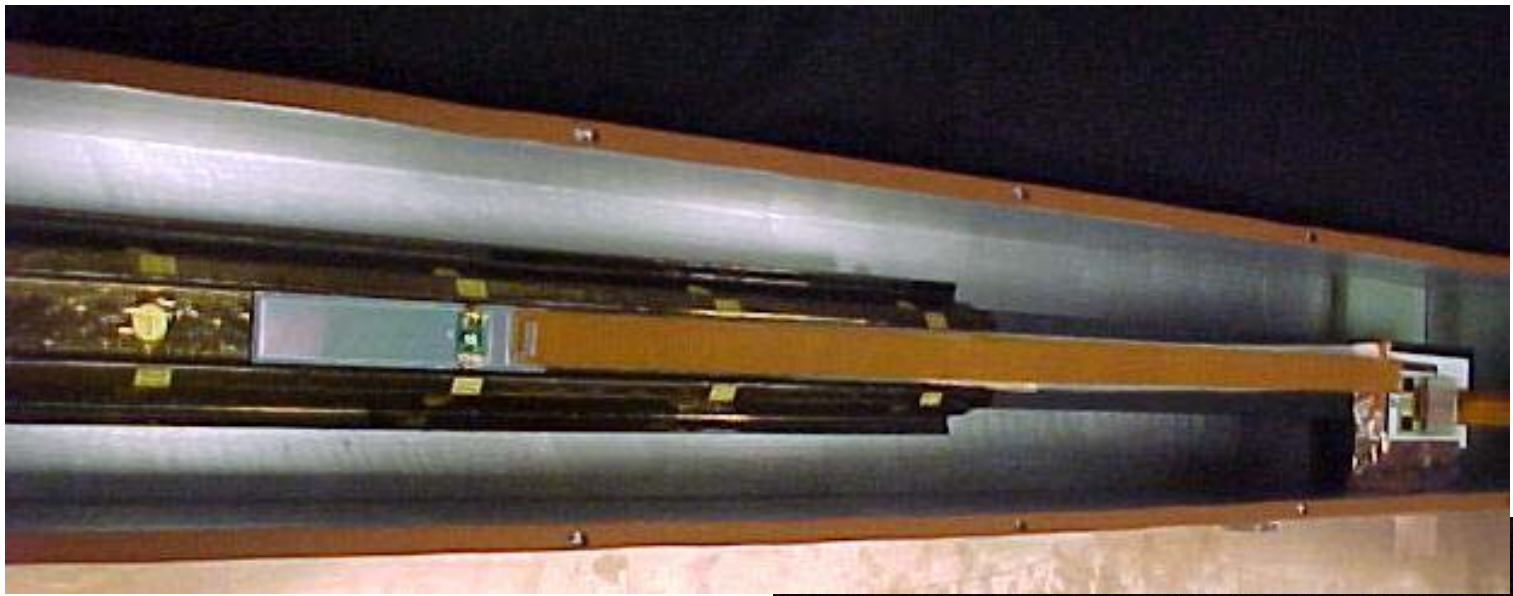
➔ Special caution needed in grounding scheme

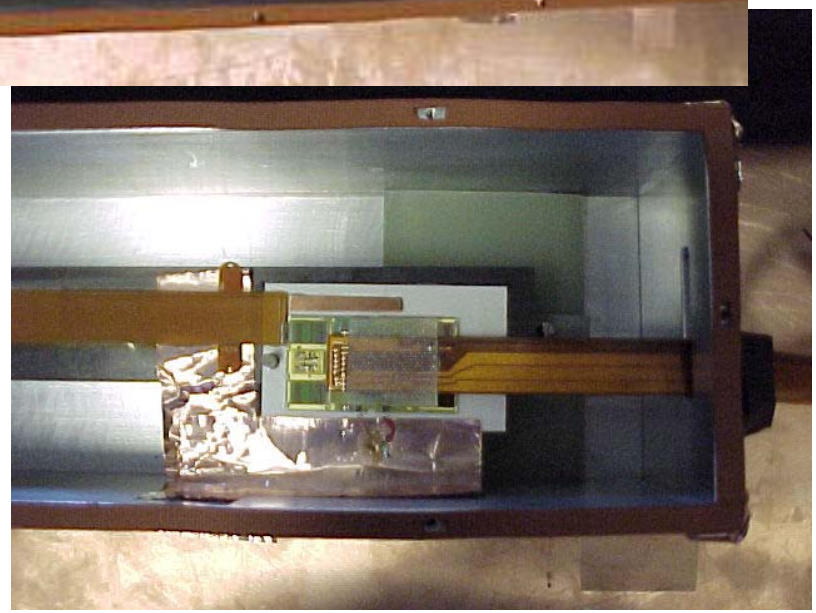


Noise vs distance between analog cable and ground plane

- Sensor/analog cable can be coupled to the support structur capacitively
- Controlling proximity between detector and support structure important

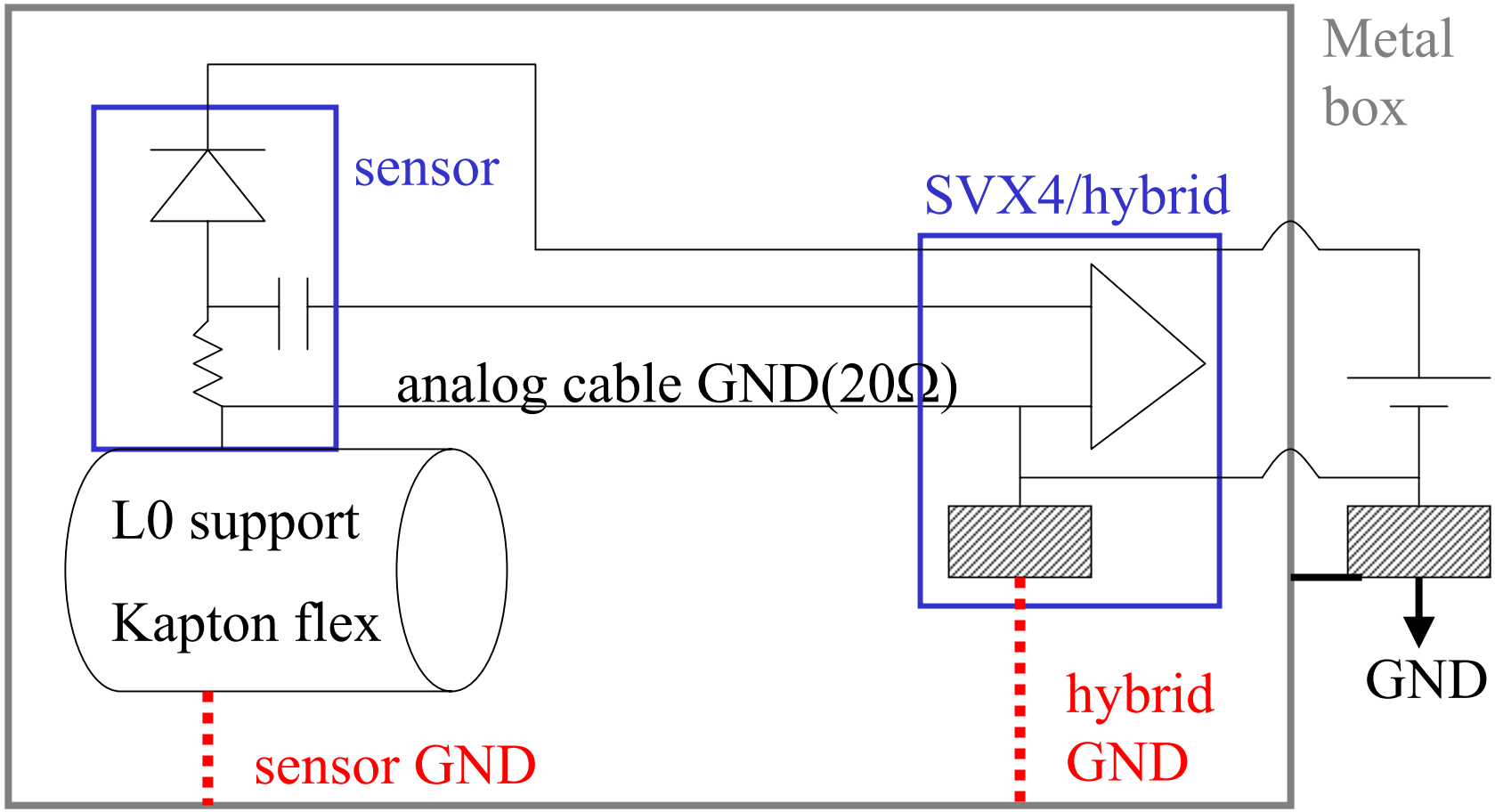
On the Support Structure





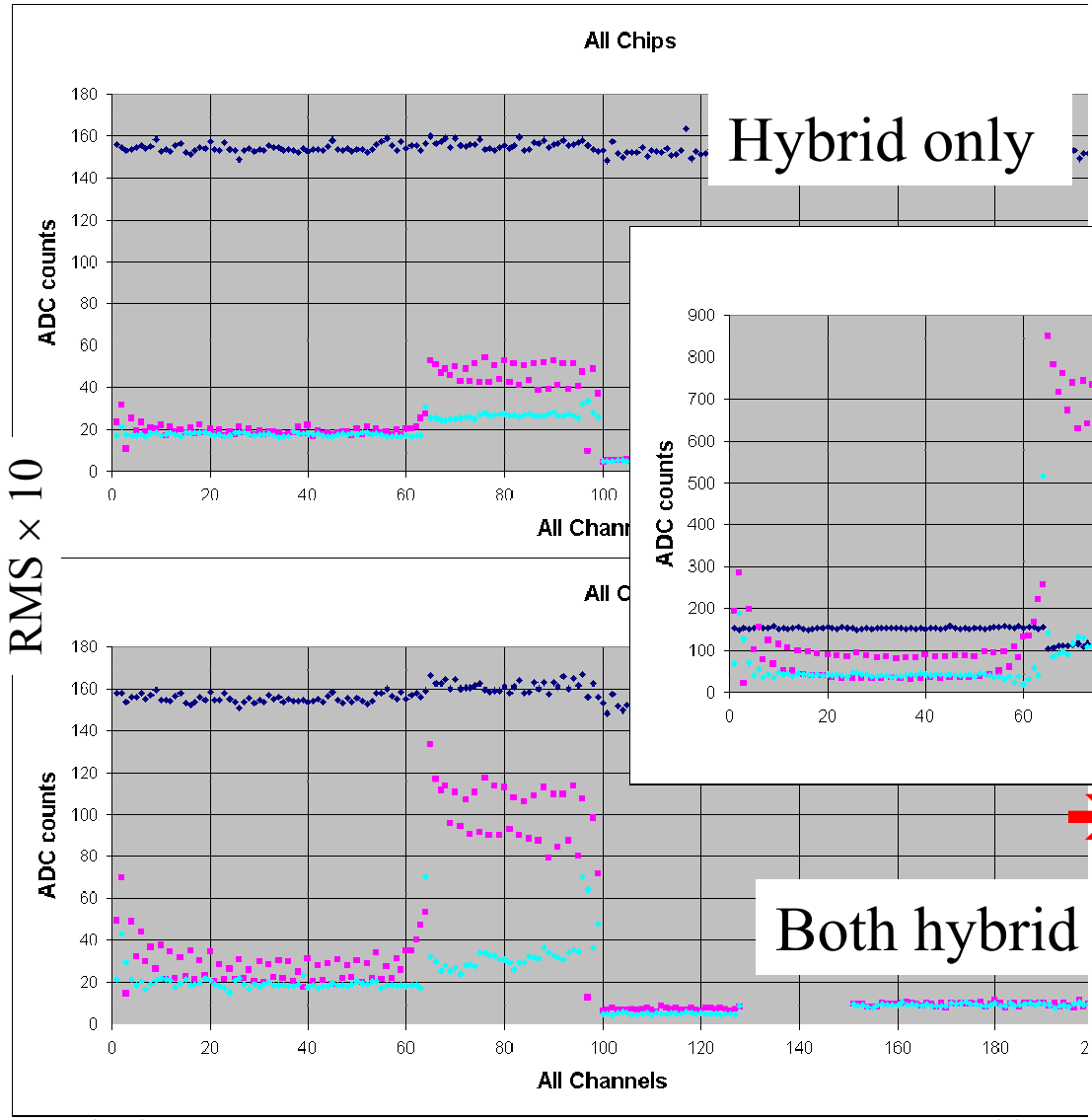
- Sensor directly mounted on carbon fiber structure
- Everything is inside Faraday cage for this study

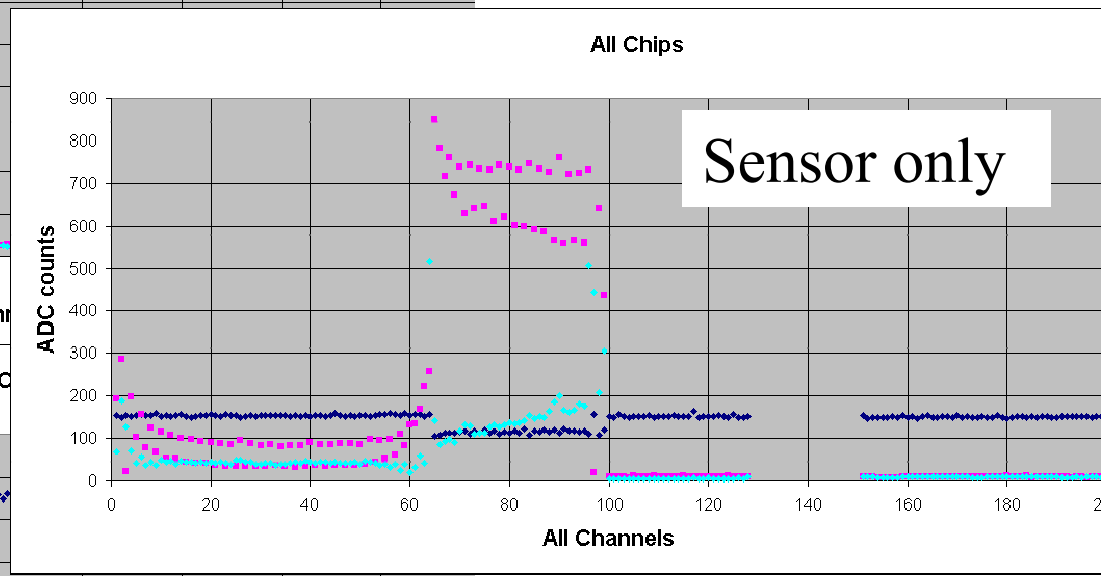
Grounding Study



Grounding Study – cont'd

Structure inside the aluminum box.



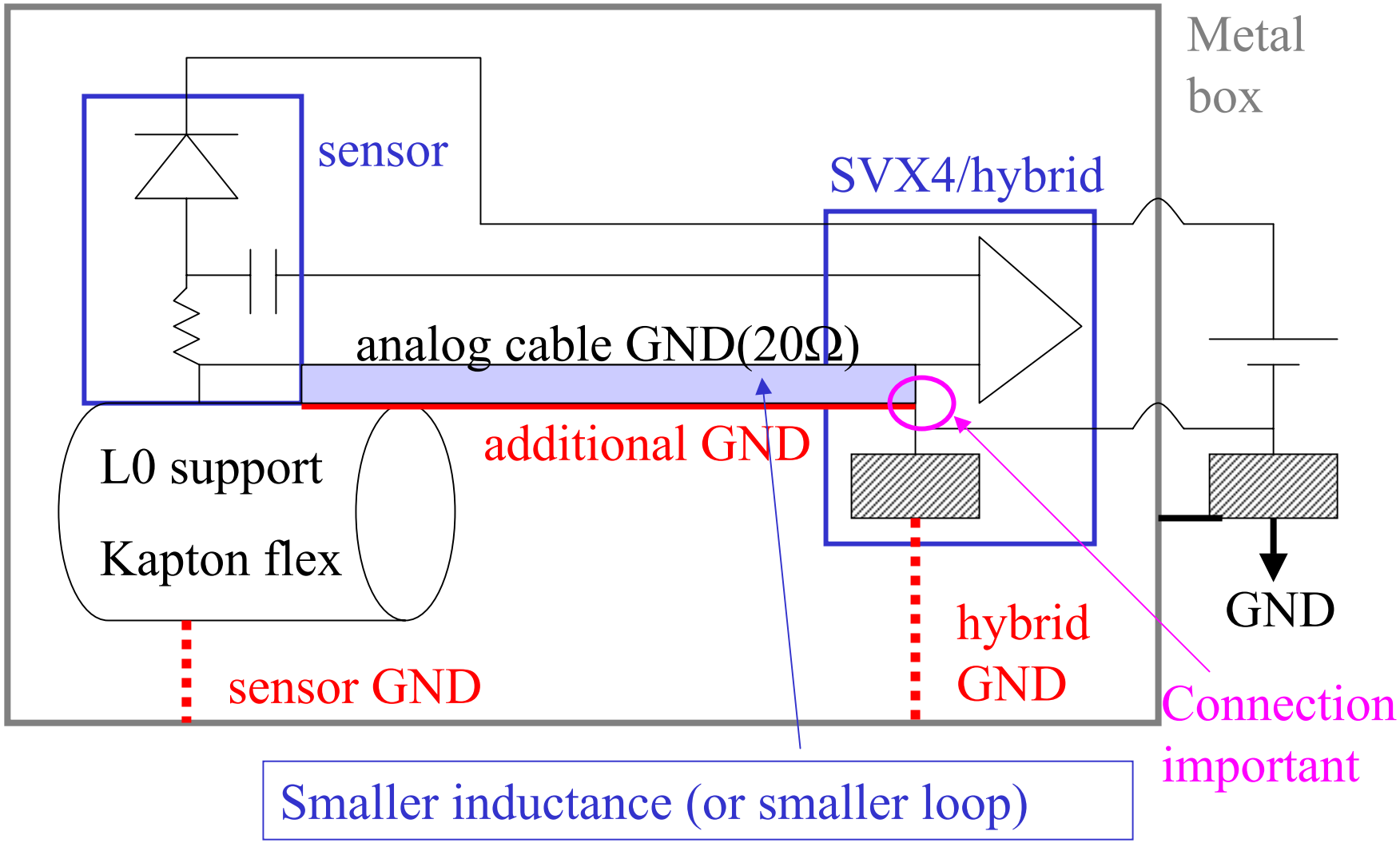


RMS × 10

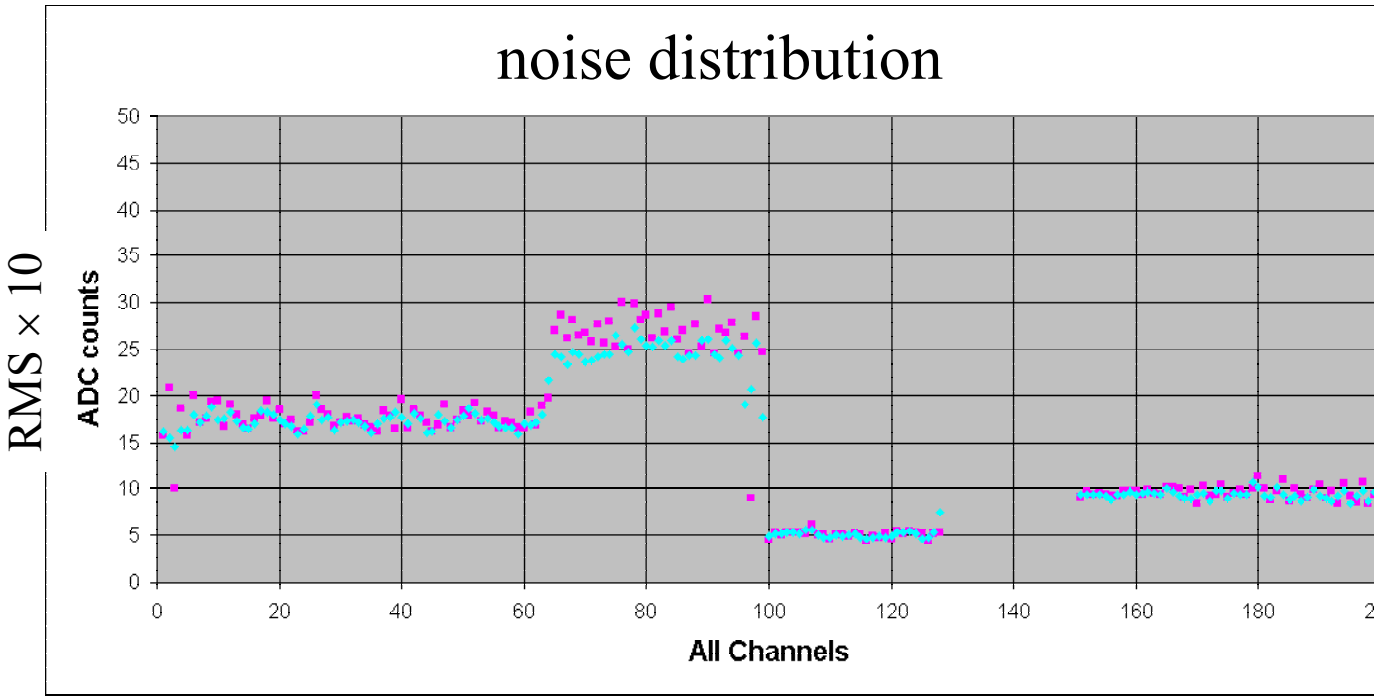
➔Large grounding loop

Both hybrid and sensor

Grounding Study – cont'd



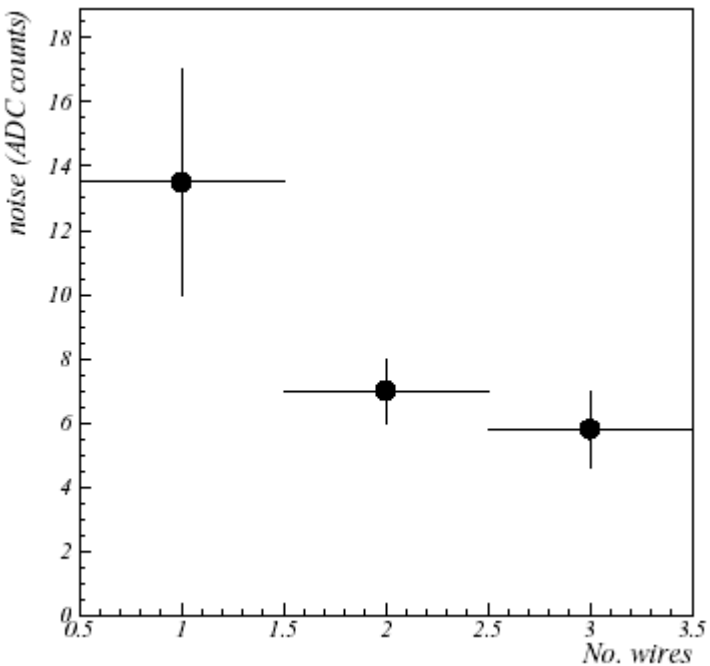
Grounding Study – cont'd

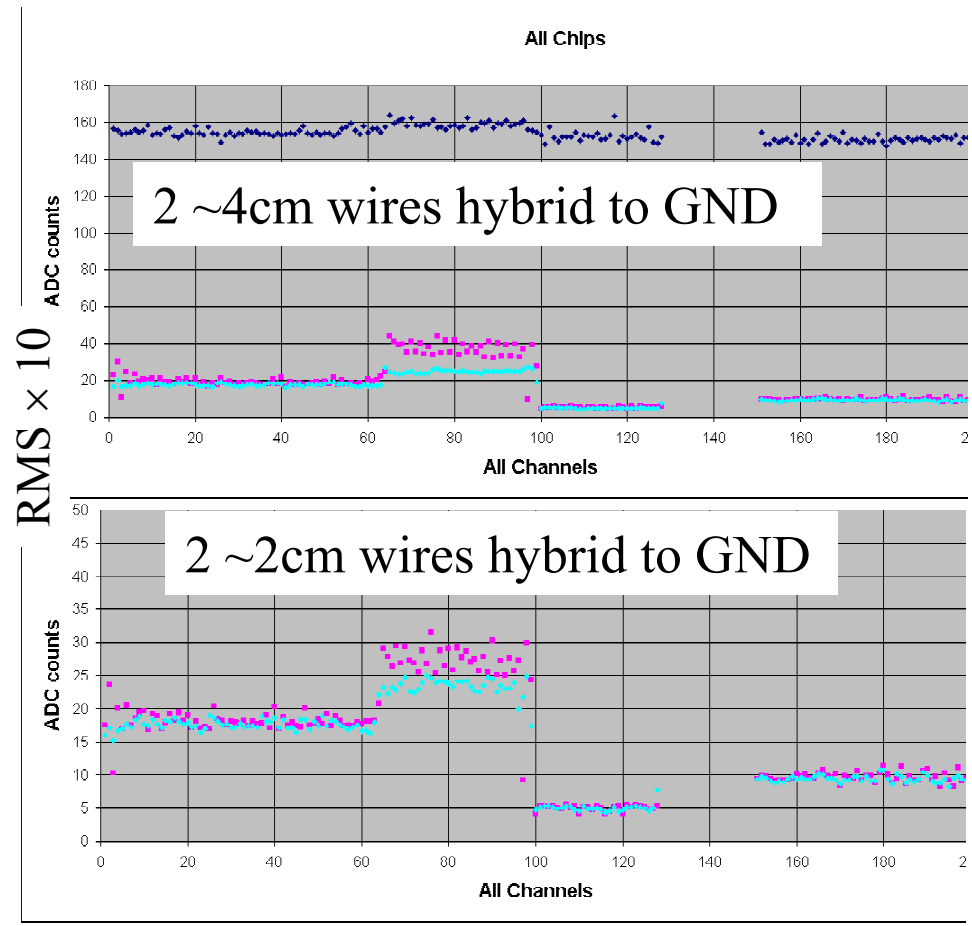


- After adding extra ground connection just below the analog cable (and achieving low inductance ground connection at hybrid ← see next slide), S/N maintained to be ~ 11

Importance of Low Inductance Connection

- In frequency range of our interests, low impedance connection is equivalent to low inductance connection



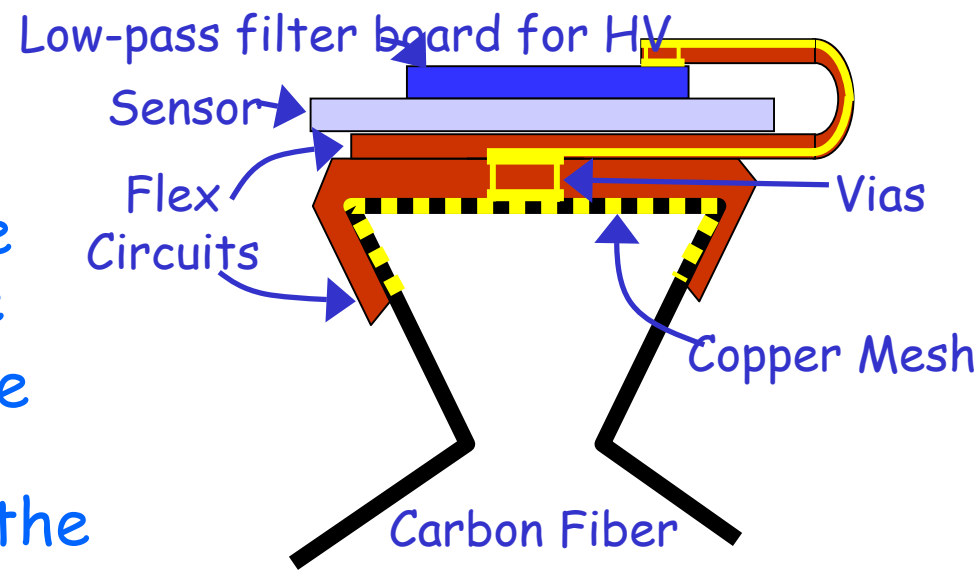


- Clearly indicates low inductance connection reduces noise

Outcome of the Studies

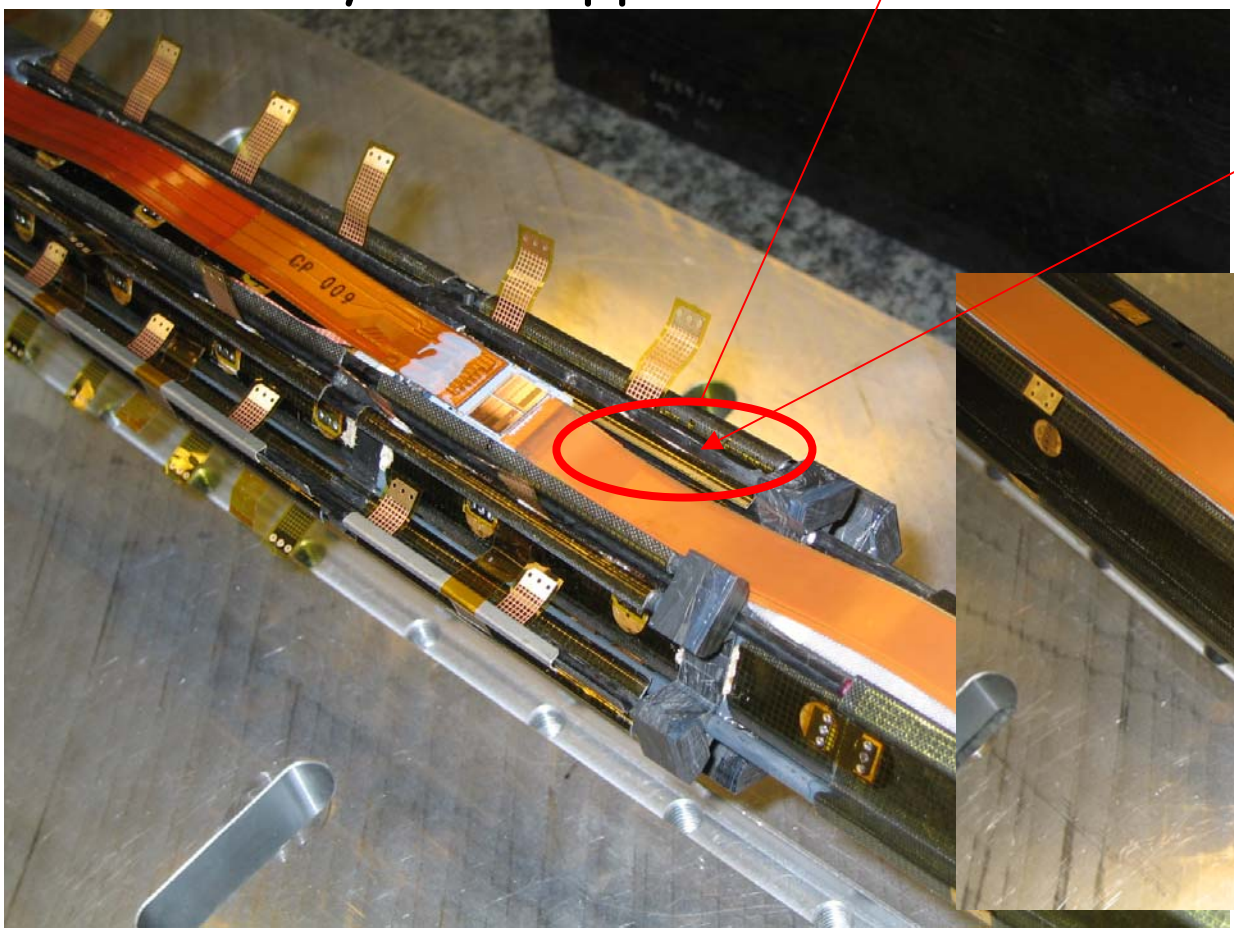
- Avoid grounding loop ➔ any conductor, i.e. carbon fiber support structure must be grounded with low inductance
- Particular importance of the ground connection at the hybrid

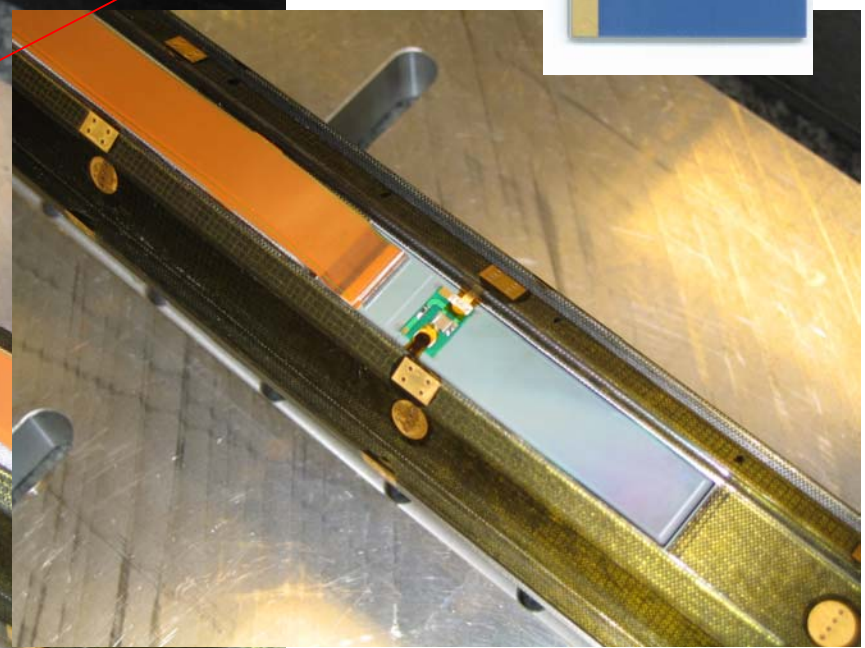
- Kapton flex with Cu mesh co-cured to the CF support structure
- Grounding pads at the backplane of hybrid allows connection to the co-cured Kapton flex



New Support Structure

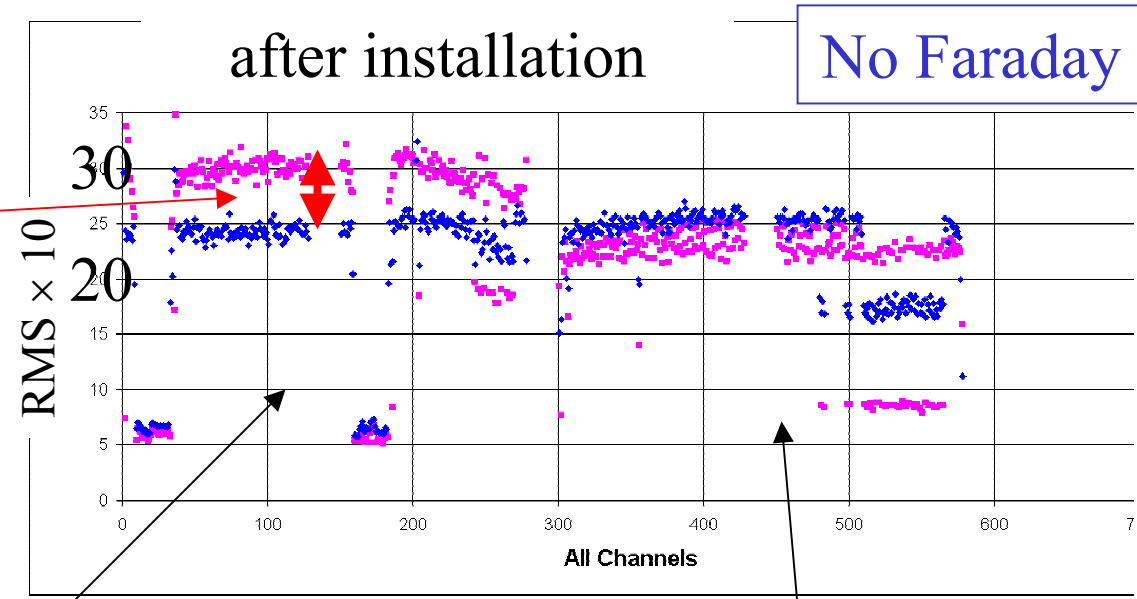
- Kapton flex with ground pads co-cured on hybrid support

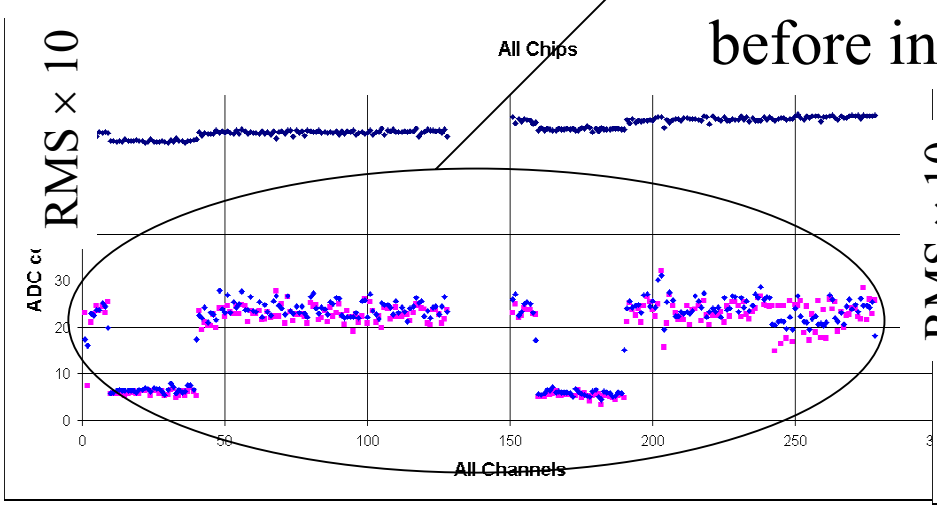




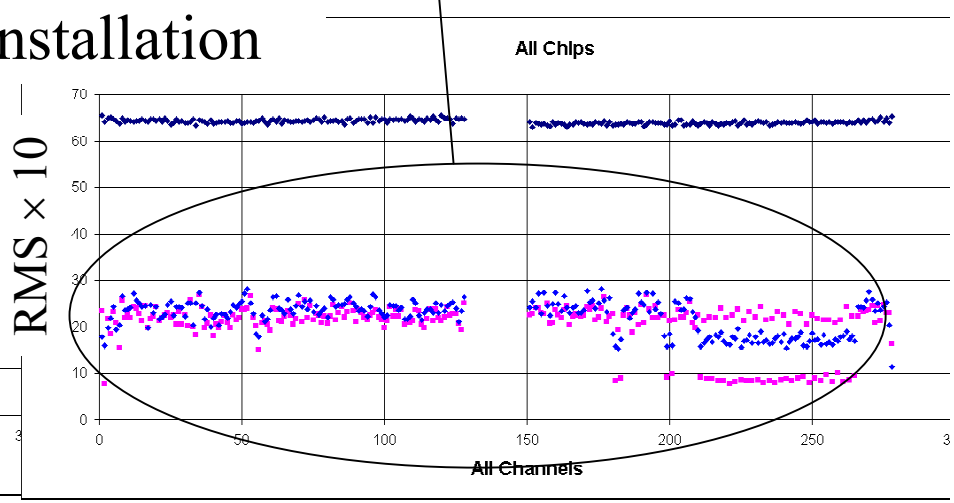
Noise Level (old hybrid)

Long cable between hybrid's GND and support structure's GND → large inductance





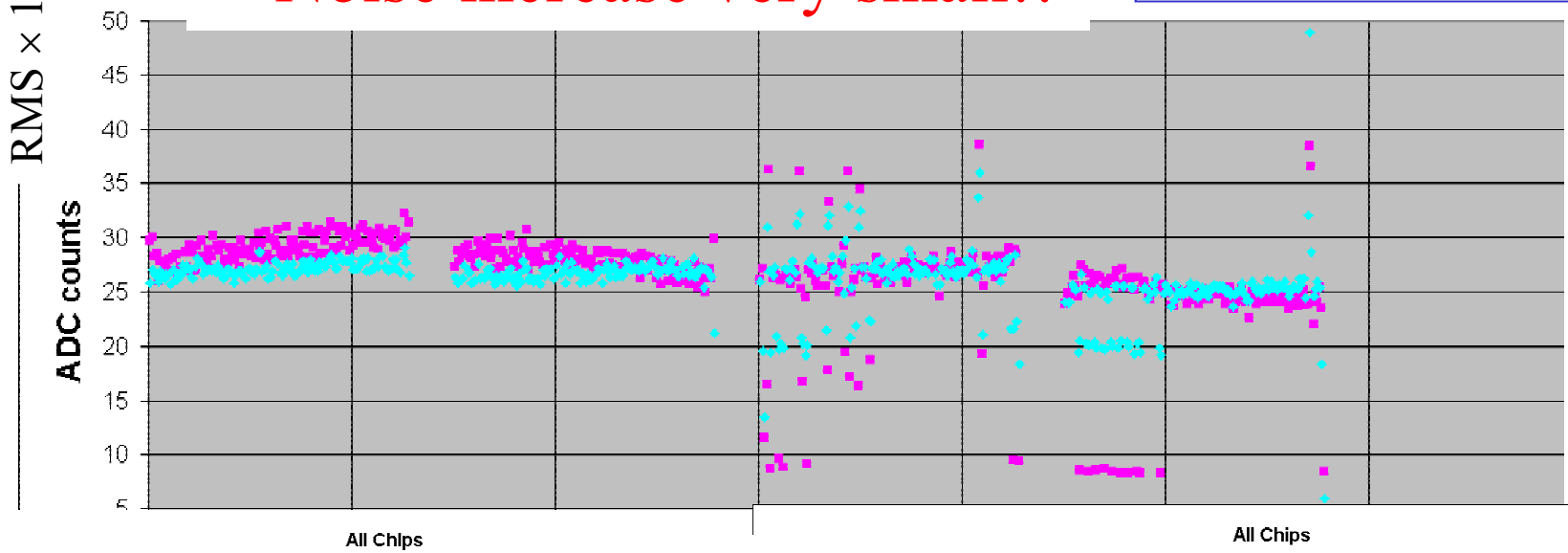
before installation



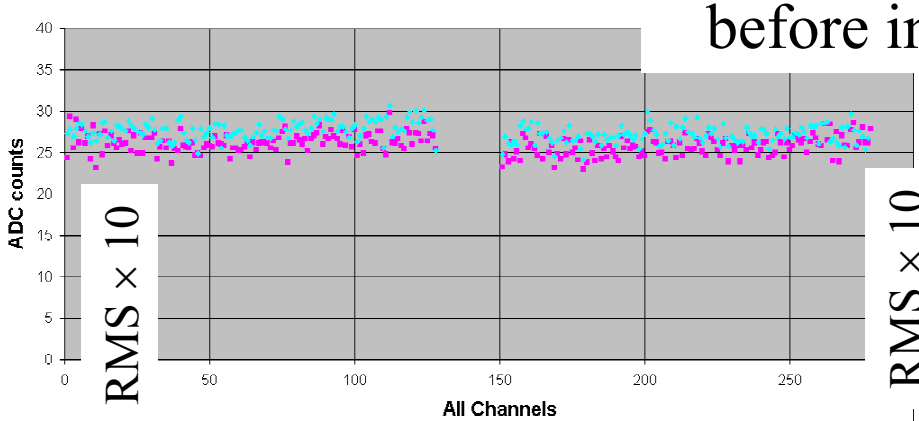
Noise Level (new hybrid w/GND pad)

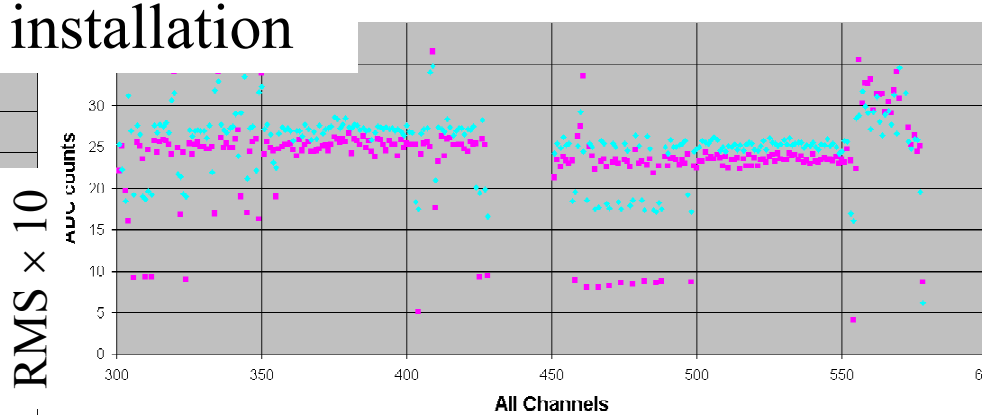
- Noise increase very small!!

No Faraday cage



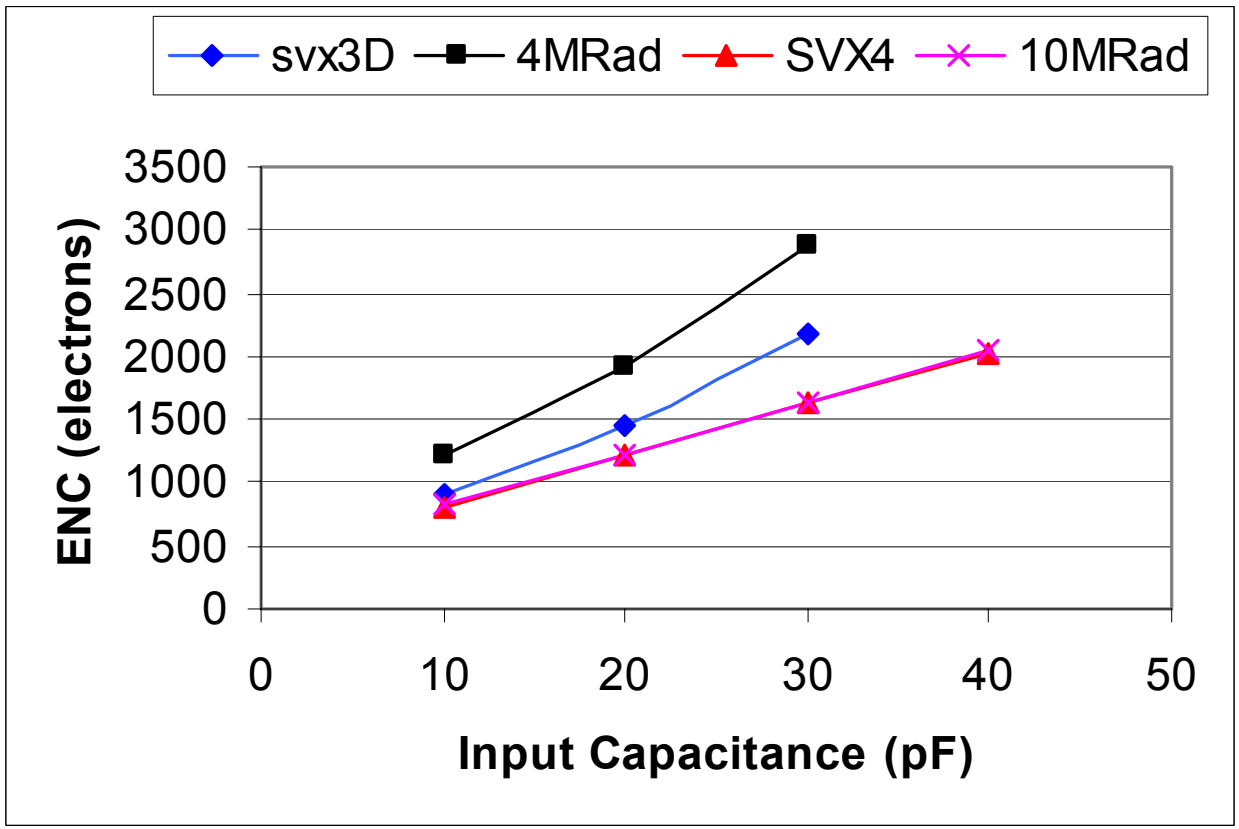
before installation





Conclusion

- Design to avoid any grounding loop ➔ any conductor, including carbon fiber support structure, must be grounded
- Particular importance of low inductance ground connection
- The performance with the prototype module and support structure proves the design principle

SVX4 Noise

- Noise
  - For fixed rise time (69ns): ENC ≅ 300 + 41C (2025e$^-$ @40pF)
  - Spec. < 2000e for 40pF @ 100ns rise time.
    ➔ very good noise performance.