# Layer 0 Grounding

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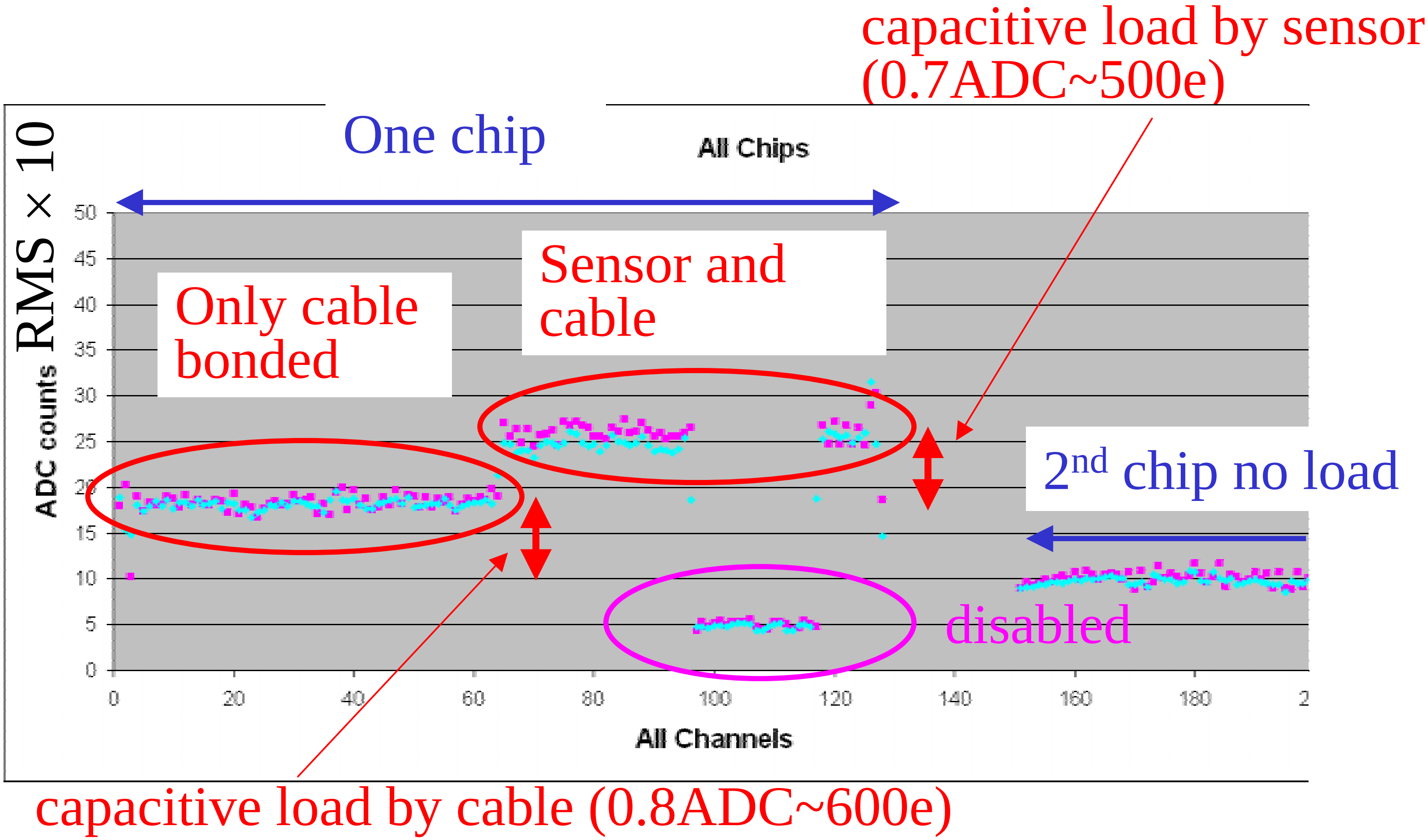
- Requirement in terms of noise performance
- Grounding/Shielding studies with L0 prototype
- Summary

# Best noise performance before installation



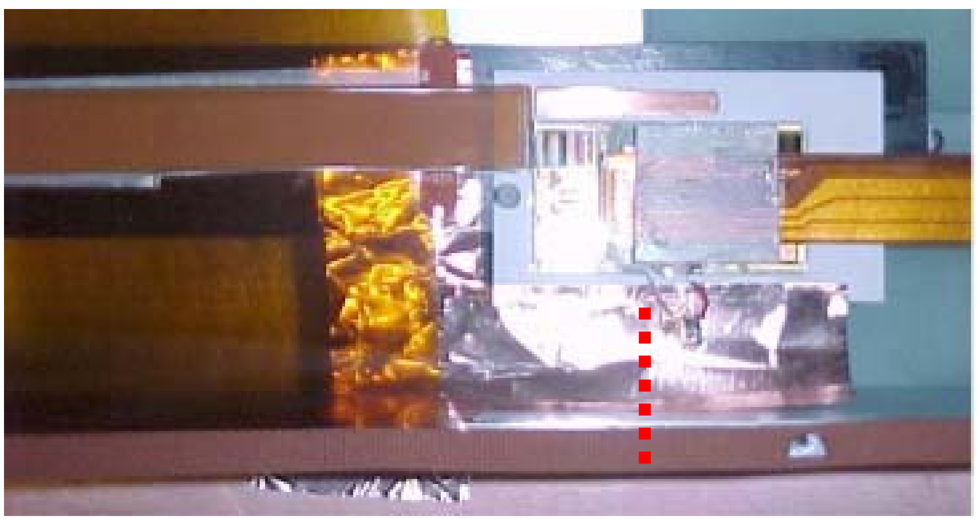

Total noise = 2.7ADC ~ 1900e.
Differential noise = 2.5ADC ~ 1800e.

# Signal to Noise ratio

- A MIP creates 22000e.
- The best noise = 1800~1900e.
- Noise increase by 300~400e is expected after 15fb$^{-1}$.
- The goal is to keep S/N better than 10.
- The current best noise performance before installing on the L0 support is already marginal.
  ➔ Any additional noise must be avoided.

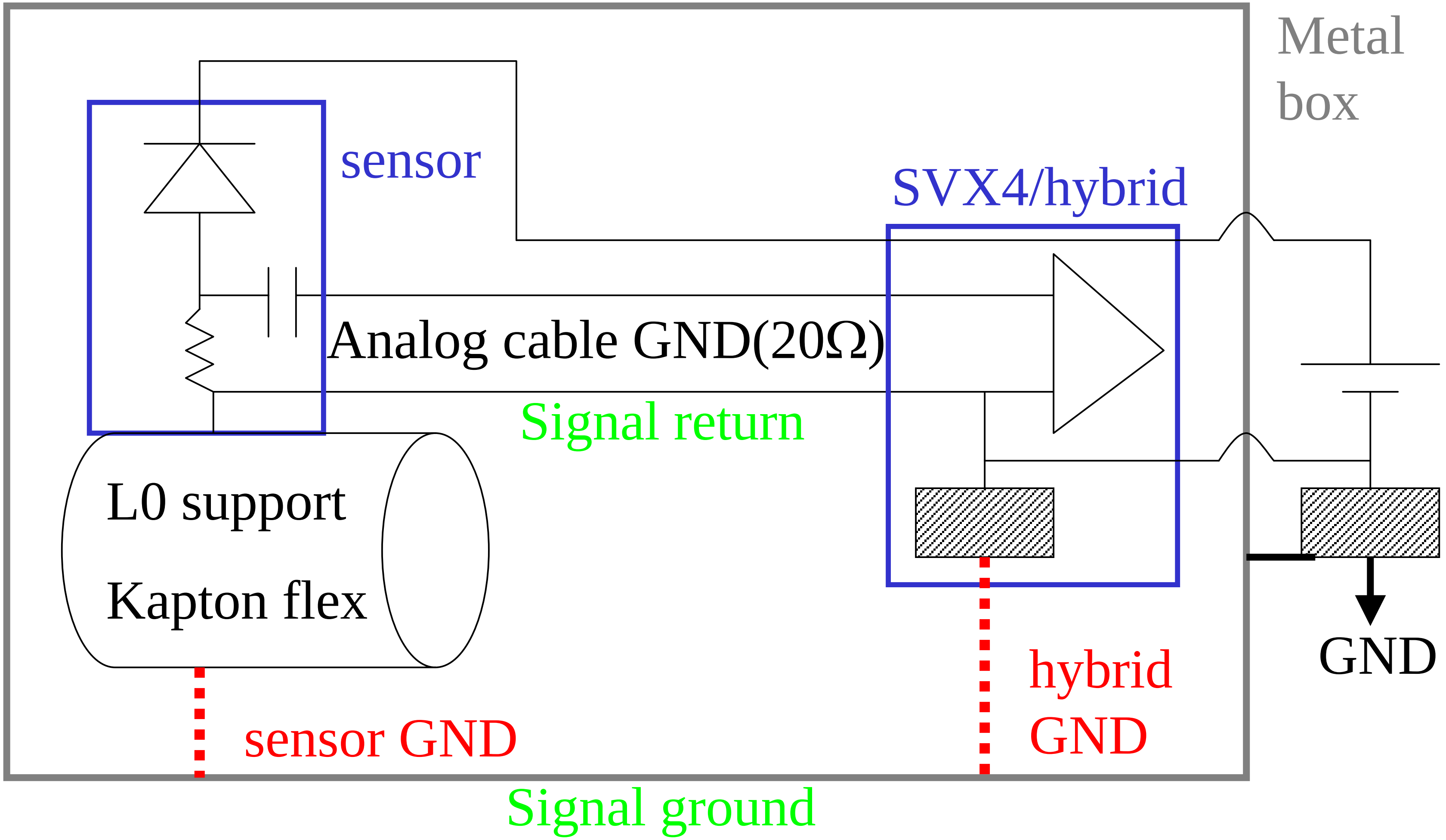
# L0 prototype module

sensor GND

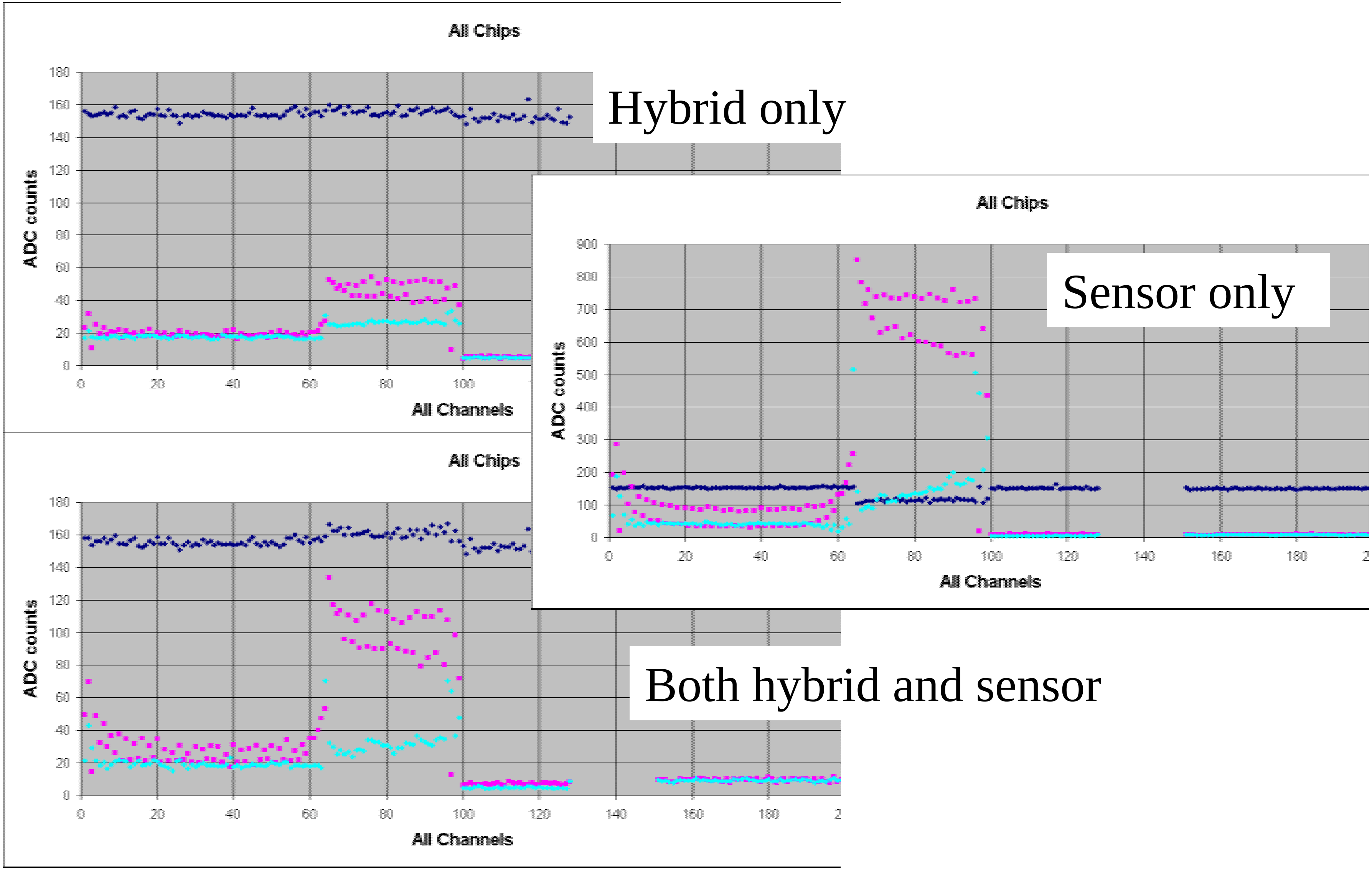


hybrid GND

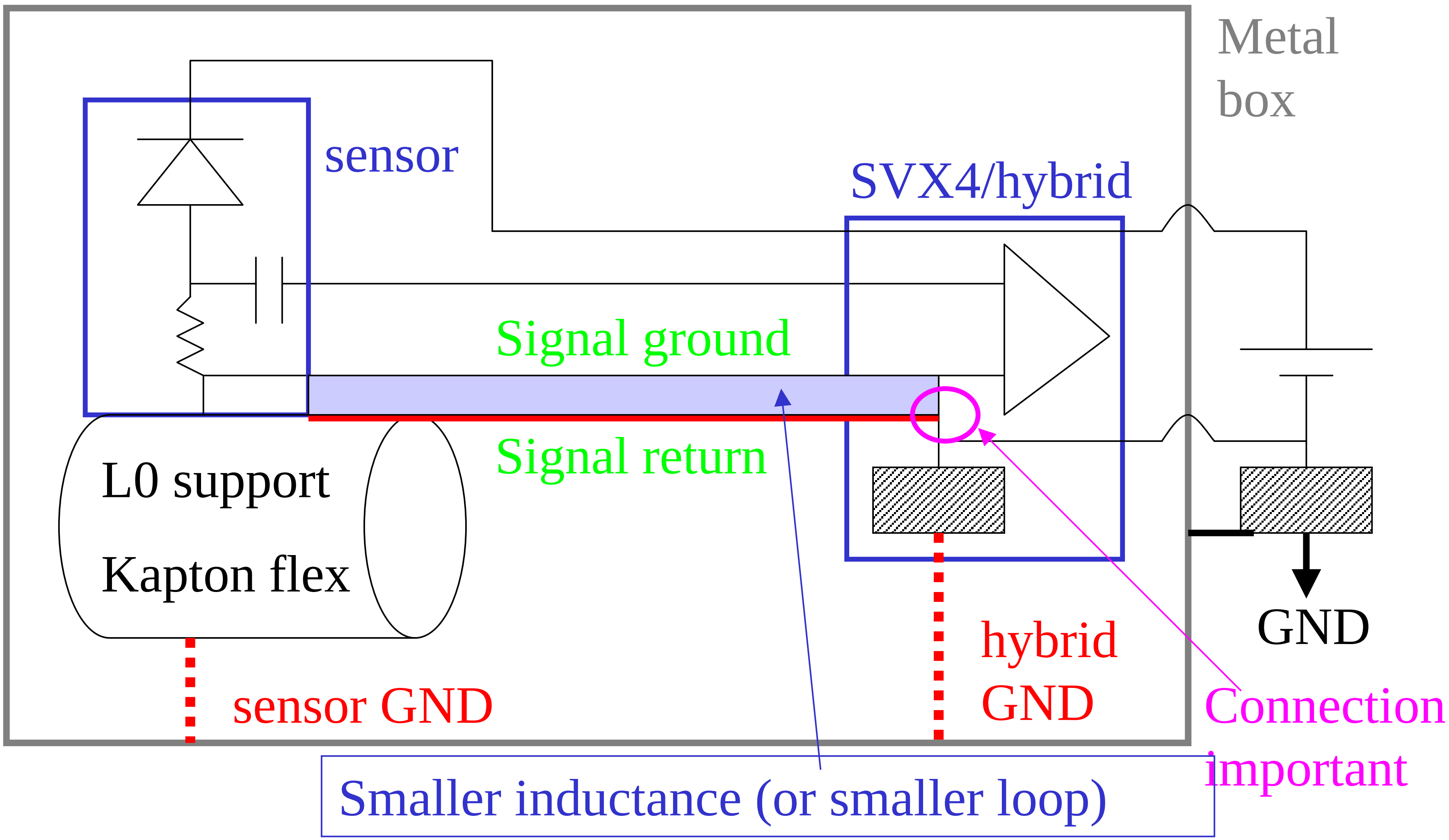
# Grounding Studies



# Noise level on the L0 support structure



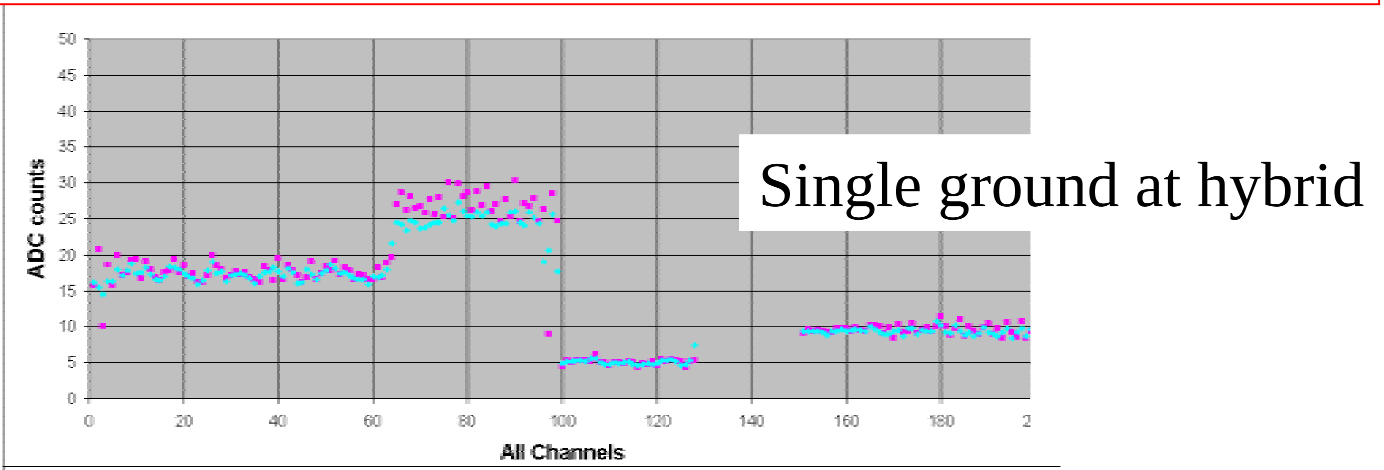
# Equivalent (?) circuit (cont'd)

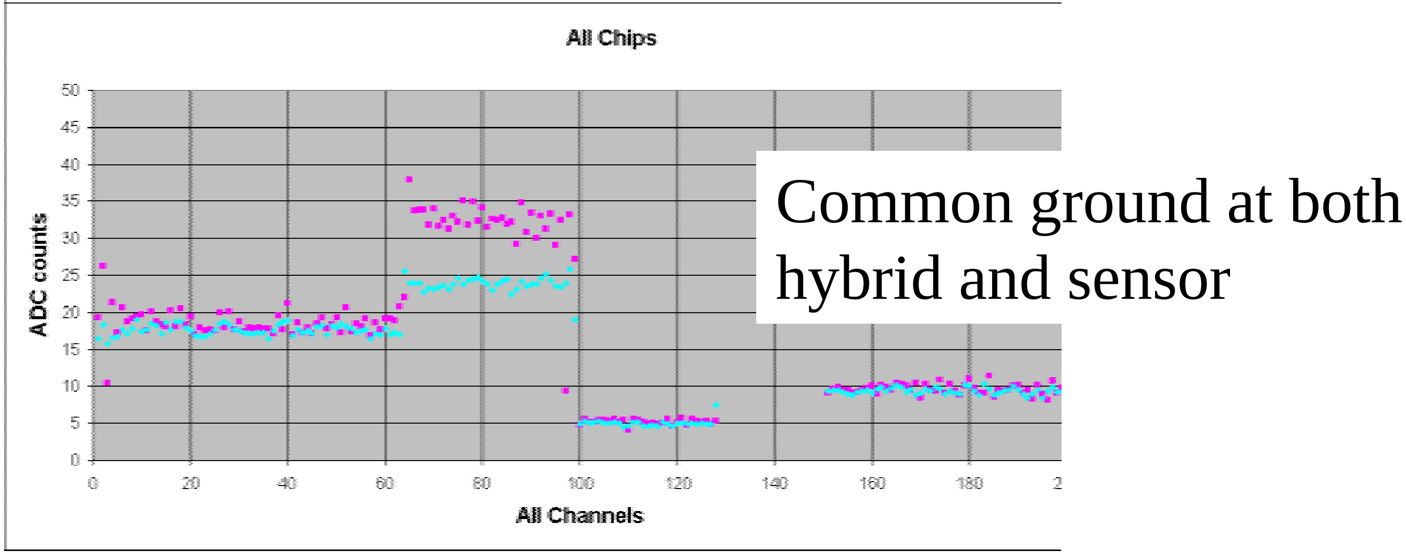



Least impedance = least inductance for high frequency (not resistance).

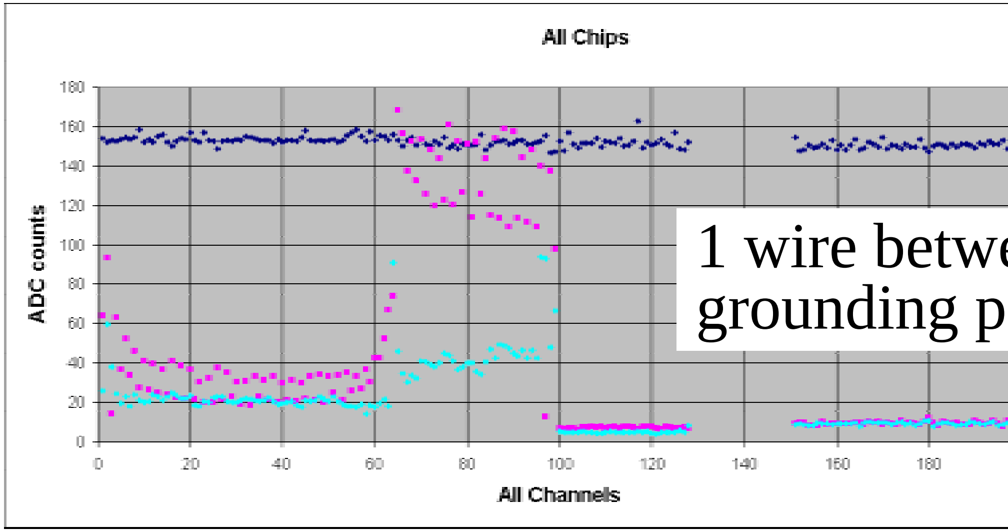
# After putting extra grounding plane

Note! Still the hybrid grounding is not perfect in terms of getting low inductance… but the effect of the extra grounding by kapton flex is so clear!!!



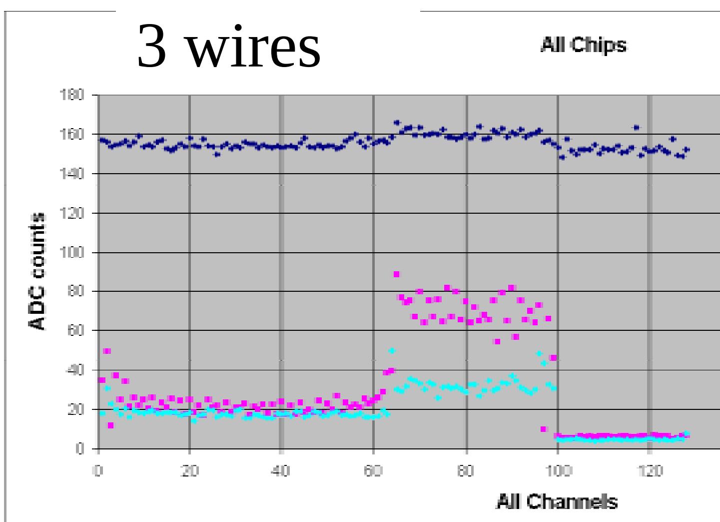



# Importance of low inductance connection

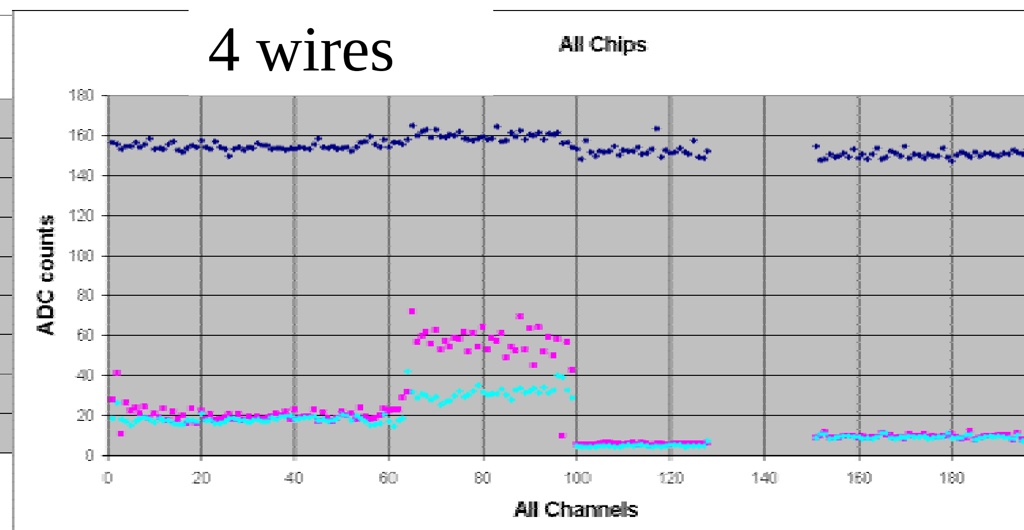



1 wire between hybrid and the extra grounding plane

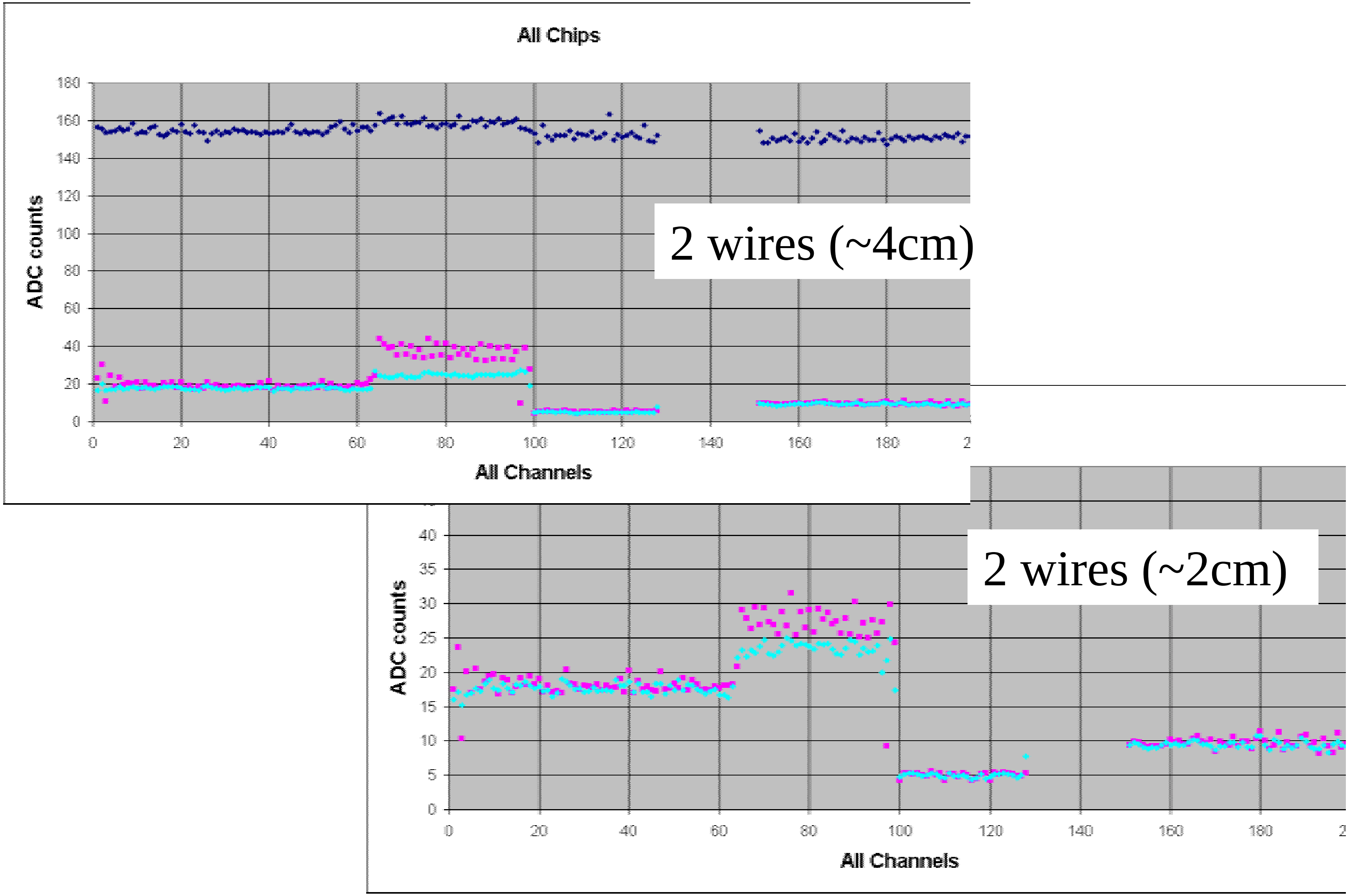
3 wires




4 wires

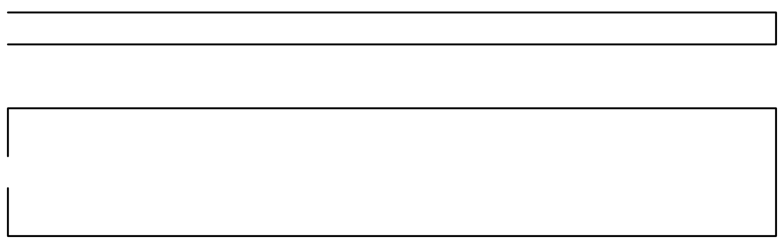


# Low inductance connection (cont'd)



# Reducing the inductance

- Having lower inductance connection to GND seems crucial.
- L ~ (wire) length/radius: $M=\mu l/2\pi[\log(2l/r)-1]$
- $L = \Psi/I$
- $\Psi$ ~ area of the closed circuit

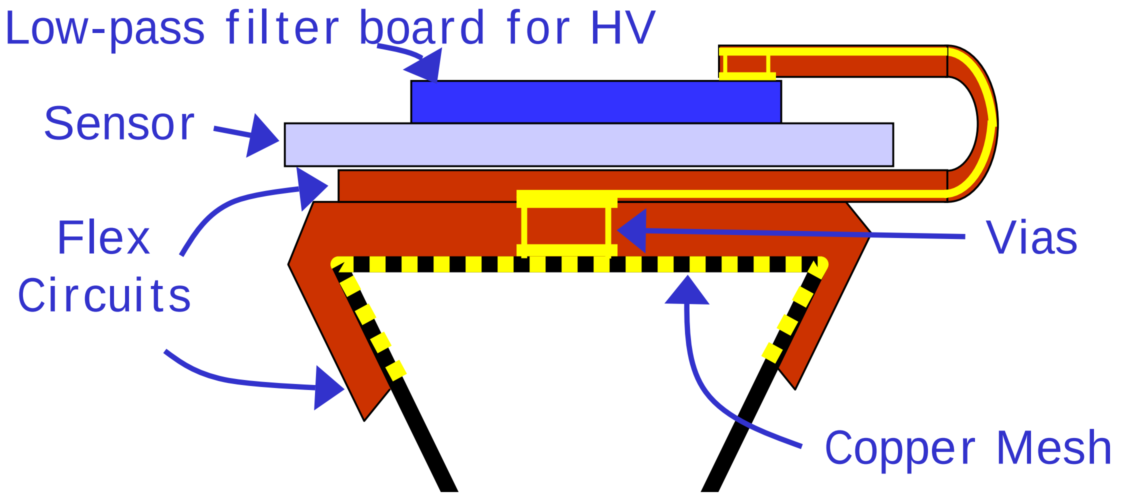


better

- People know these rules well, but sometimes forget to apply.
- But these rules are always critical for any grounding connections, both locally and generally.

# How do we achieve????????????

- Sensor grounding.

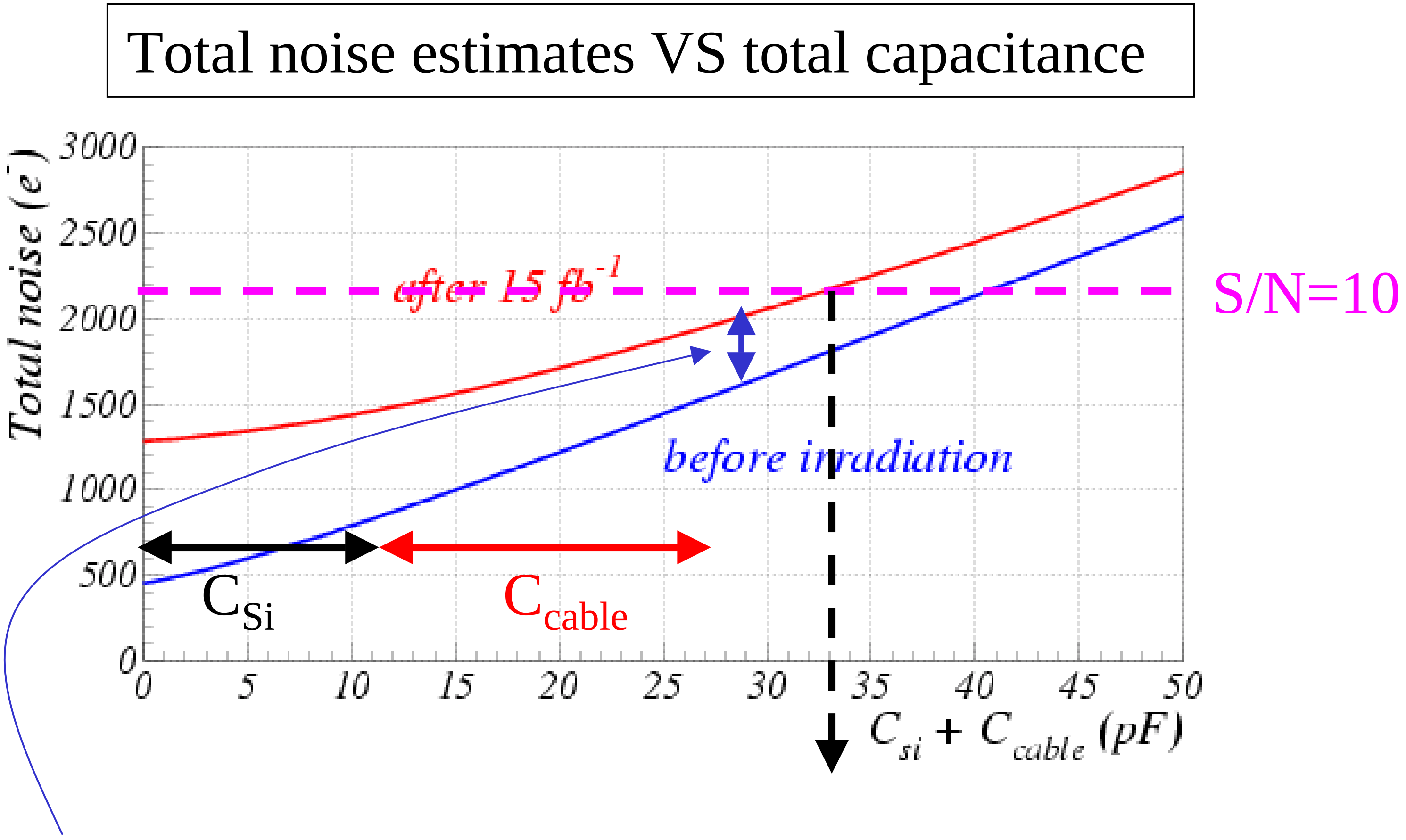



- The sensor and hybrid need to be connected through rigid ground plane. This should work also as a shielding.
  ← extension of kapton flex with copper mesh embedded.
- Hybrid side: proposal using the similar technique, but not yet decided.
- Need to decide; multi point ground vs single point ground.

# Summary

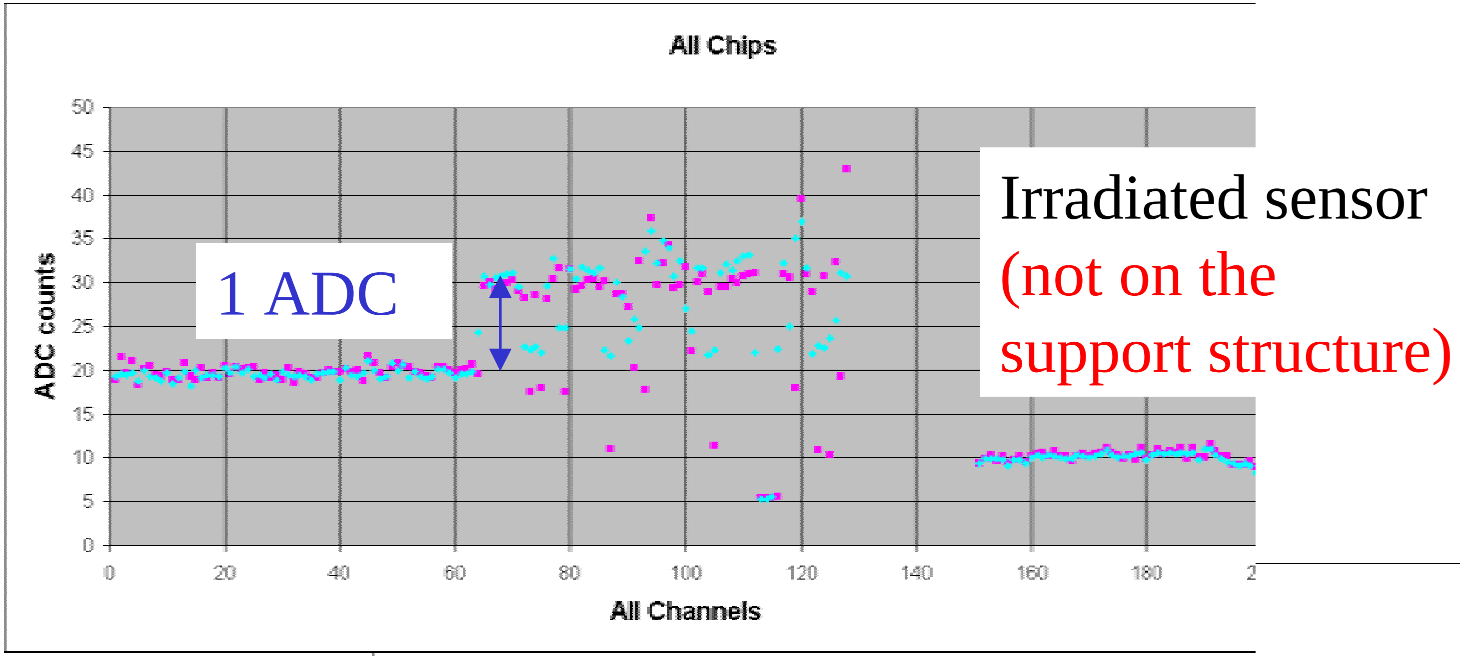
- No additional noise is allowed for L0.
- Low inductance ground connection is crucial, especially at the hybrid end.
- Grounding scheme at the hybrid must be fixed.
- Rigid grounding, or low inductance grounding path to the outside world must be maintained.

# Signal to Noise ratio

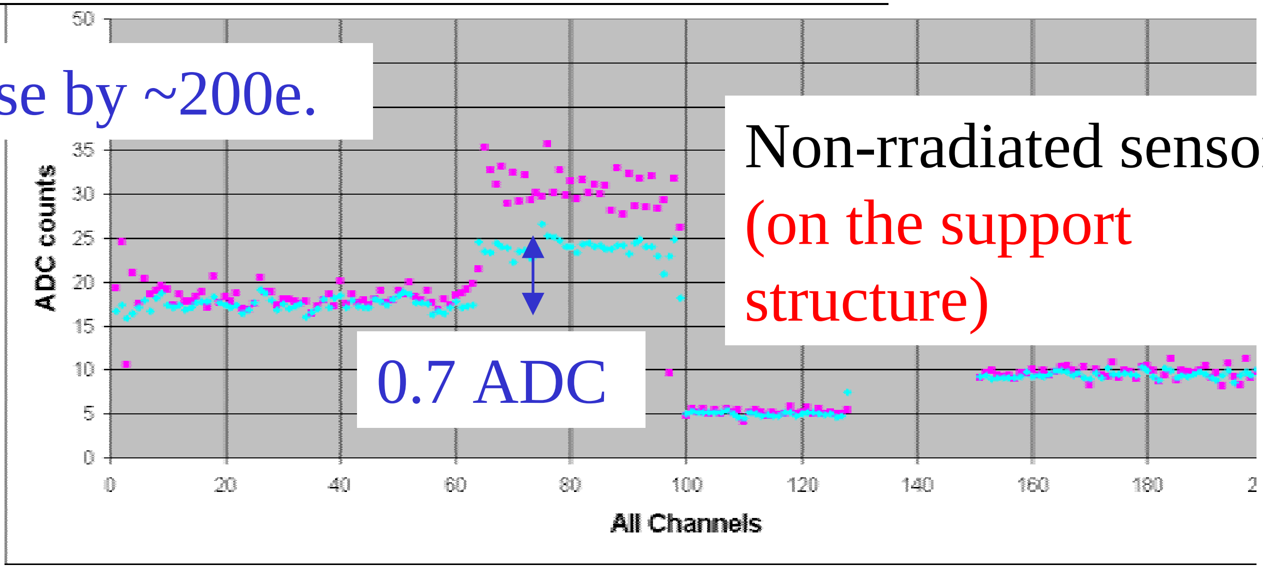



Noise increase by 300~400e is expected after the irradiation.

# Irradiated sensor




Noise increase by ~200e.

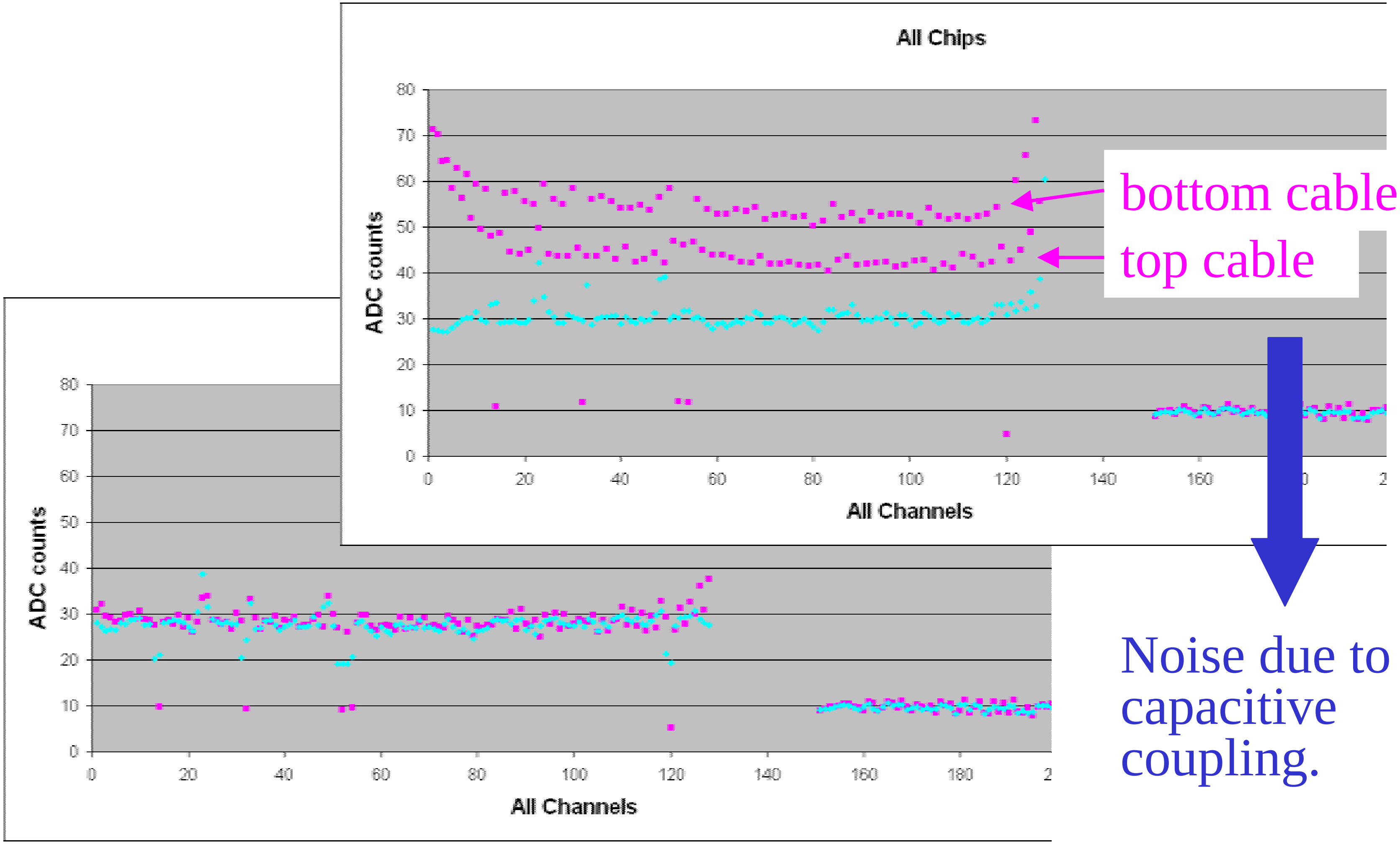


# Radiation length

| Min (2 cables) | | Max (12 cables) | |
|---|---|---|---|
| 100μm Kapton | 0.04% | 600μm Kapton | 0.21% |
| 3μm Cu (a) | 0.02% | 16μm Cu (a) | 0.11% |
| 300μm (b) polypropylene | 0.07% | 1300μm (b) polypropylene | 0.32% |
| 20μm Al (c) | 0.02% | 20μm Al (c) | 0.02% |
| Total | 0.15% | Total | 0.66% |

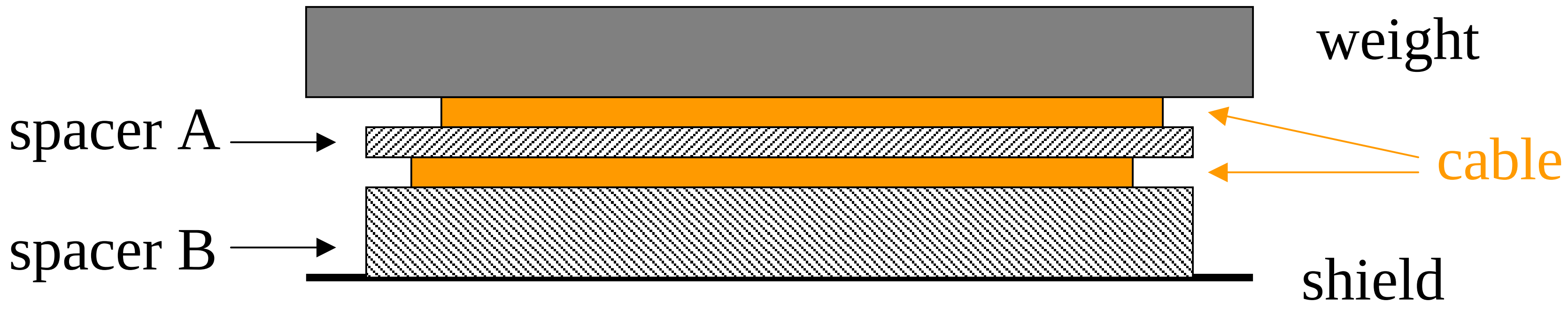
- (a) 16% of area occupancy is taken account.
- (b) 50% of volume occupancy assumed. May be possible to reduce.
- (c) heavy duty aluminum foil was measured to 20μm thick.

# Proximity to the grounding/shielding




- Only the difference is the weight on top of the cables.
  ➔ Proximity to the shielding material.

# Proximity to the Shielding (cont'd)



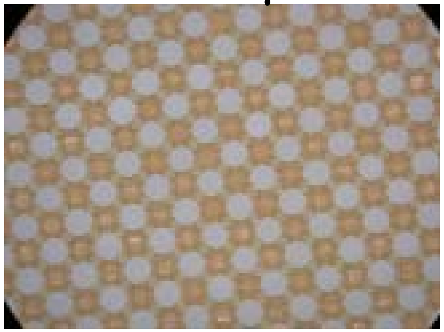

| A:nothing B: | top | bottom |
|---|---|---|
| 75μm Kapton (no weight) | 2.8 | 2.8 |
| 75μm Kapton + 400μm polypropylene mesh | 2.8 | 2.9 |
| 75μm Kapton + 200μm polypropylene mesh | 3.2 | 3.3 |
| 75μm Kapton | 4.3 | 5.3 |

- The study is still on going…

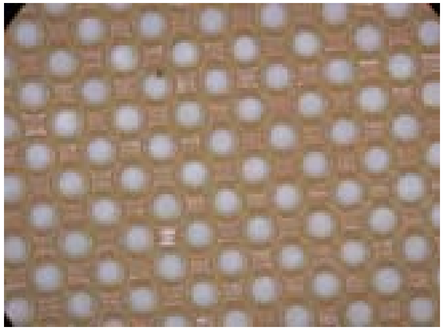
# Choice of spacer

- Dyconex has produced three different meshes with kapton sheet.
  - hole radius: 60 μm
  - hole-distance: 190, 210 and 230 μm
  - corresponding to $\varepsilon_r$ ~1.95, 2.2 and 2.45

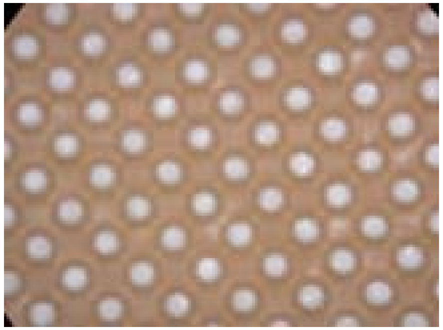
190 μm



210 μm



230 μm



- Polypropylene mesh sheet