Studies on noisy strips

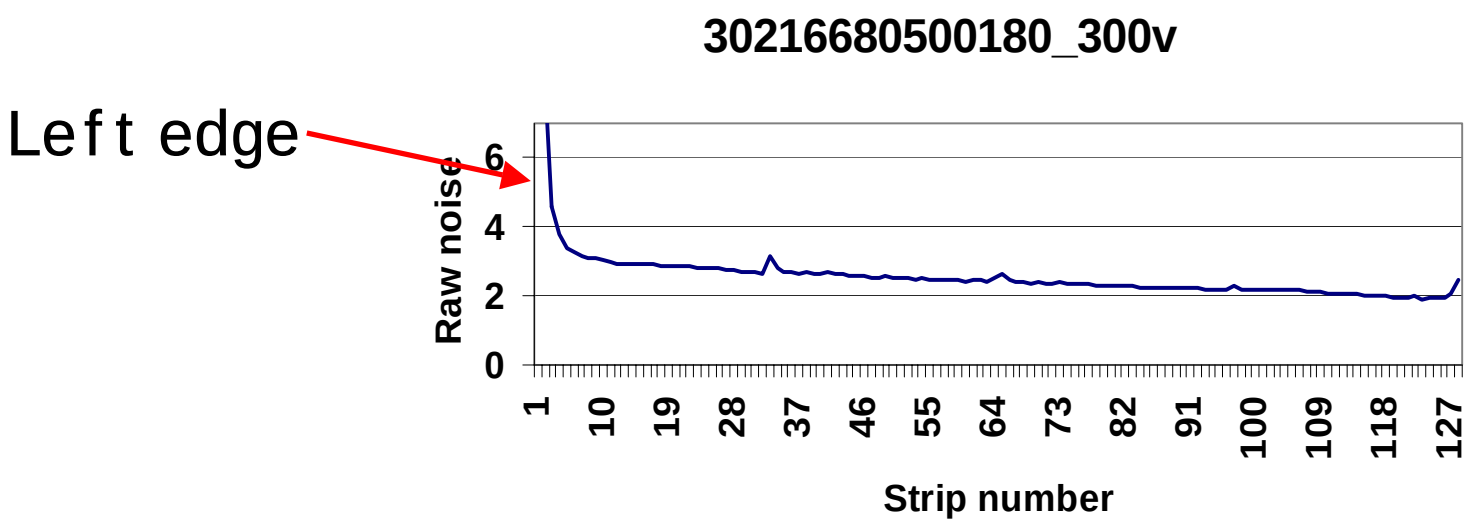
- Edge strip problem on TIB modules
- FED output data rate
- Inter-strip noise correlation

Carlo Civinini

INFN-Firenze

Edge strip problem

- At least 3 strips per side are 'unusable' because of abnormal noise level (~1% of total number of strips); this could compromise the module overlap .



TIB 302166805000177 HV 300V on ARC Peak-Inverter on

First and last strip σ ~12 ADC counts

Settings:

Events= 1000

CalculationMethod= n

RMSmin= 0.0

RMSmax= 5.0

TBad= 5.0

TSkip= 4.0

PSkip= 0.5

APVMode= Peak

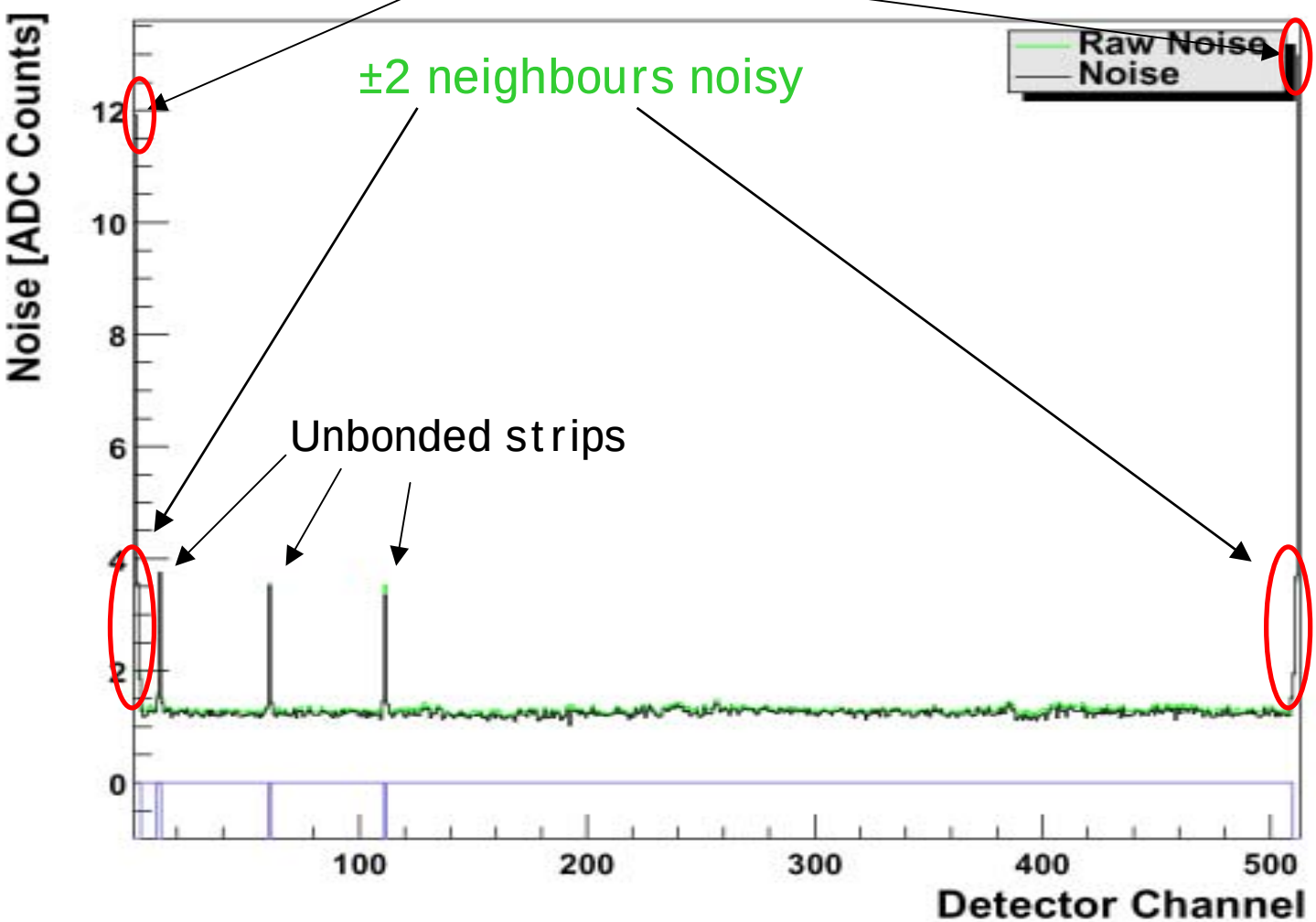
Inverter= Ion

Bad Channel:

1 2 3 11

12 60 111 510

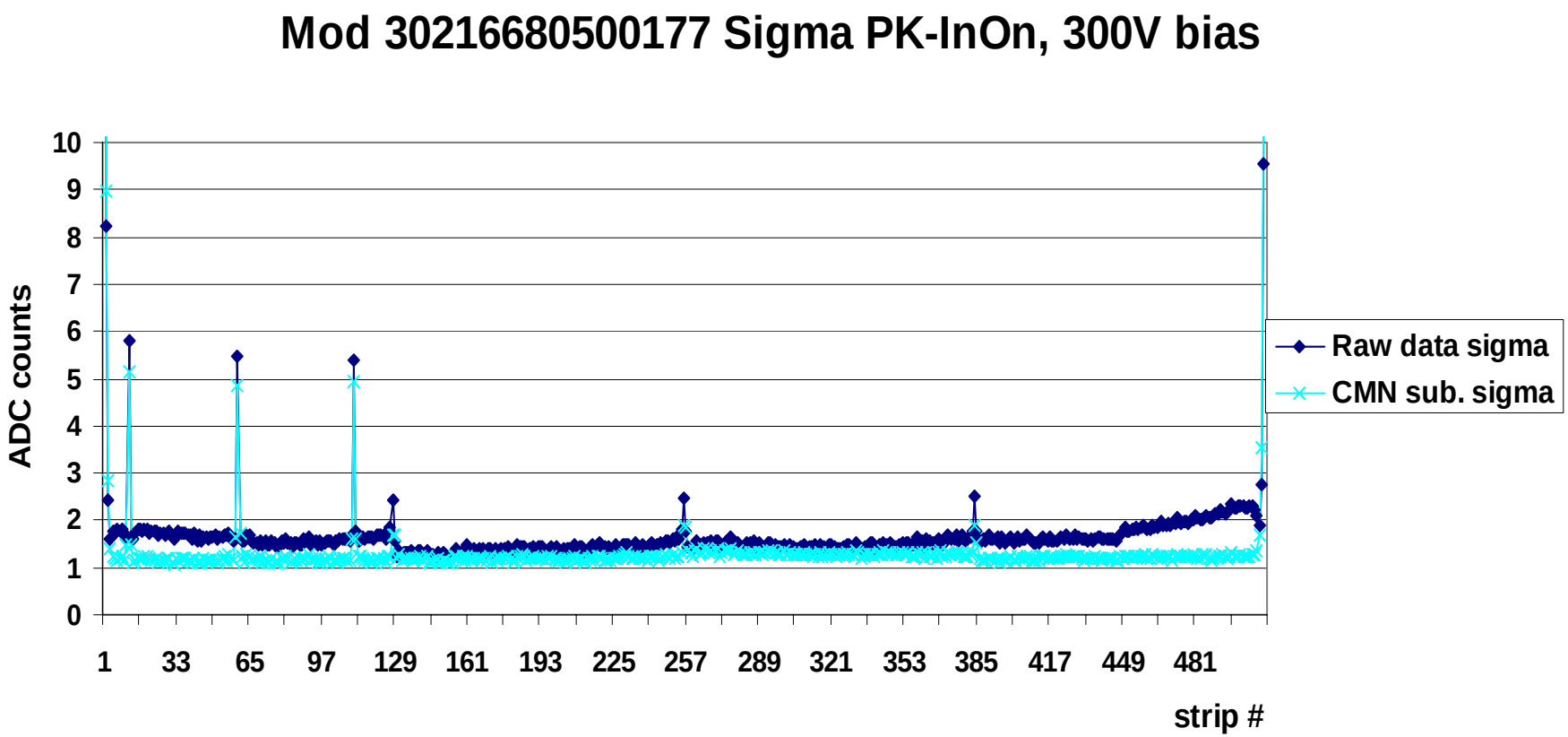
511 512



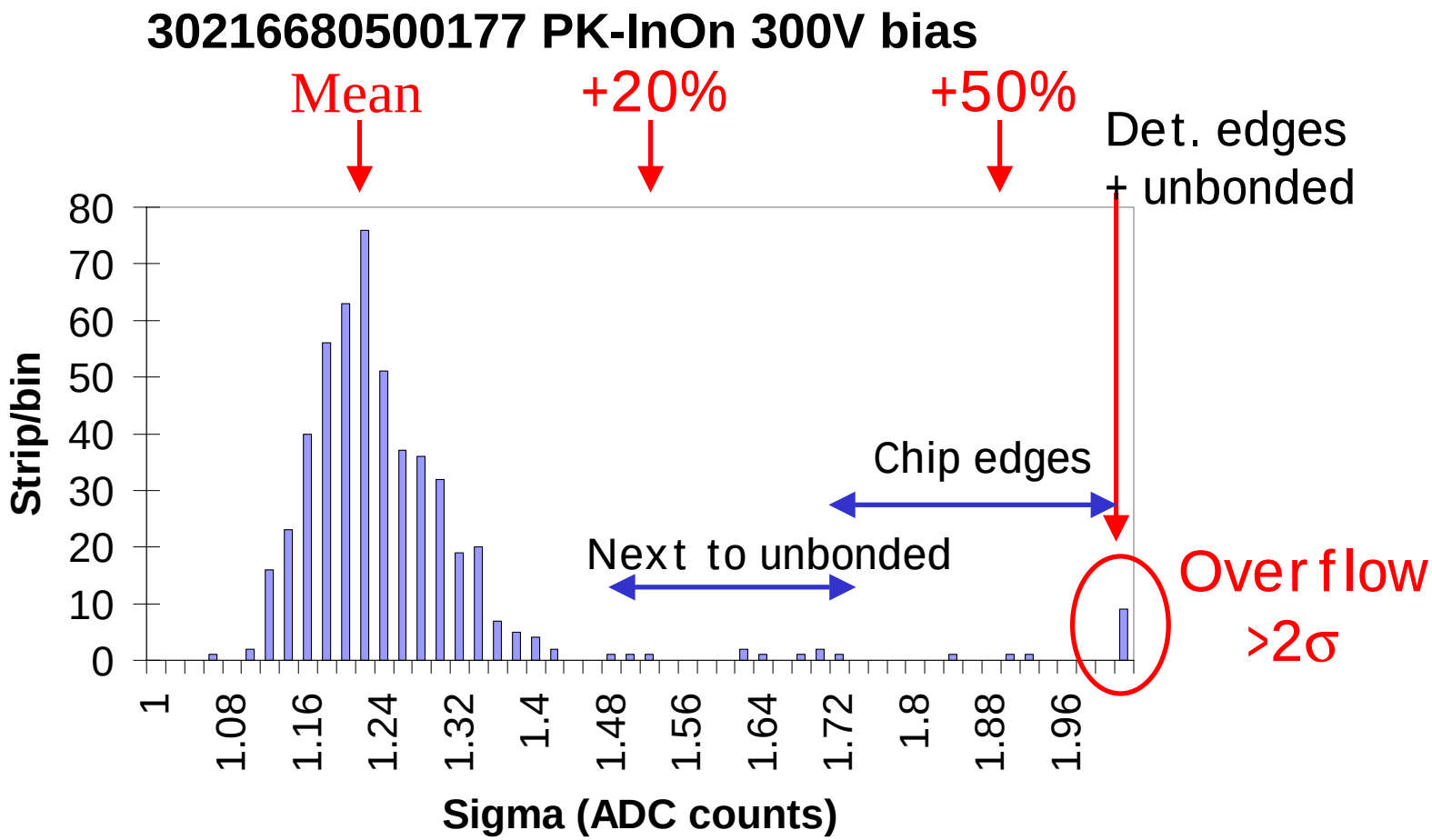
Noise study

- ARC system→ ascii file containing raw data for each strip (+header): very useful !
- My off-line analysis (pedestals, CMN, clustering);
- Cross-check with ARC built-in analysis results to validate my algorithms.

Noise using the off-line analysis (an example)



Noise distribution



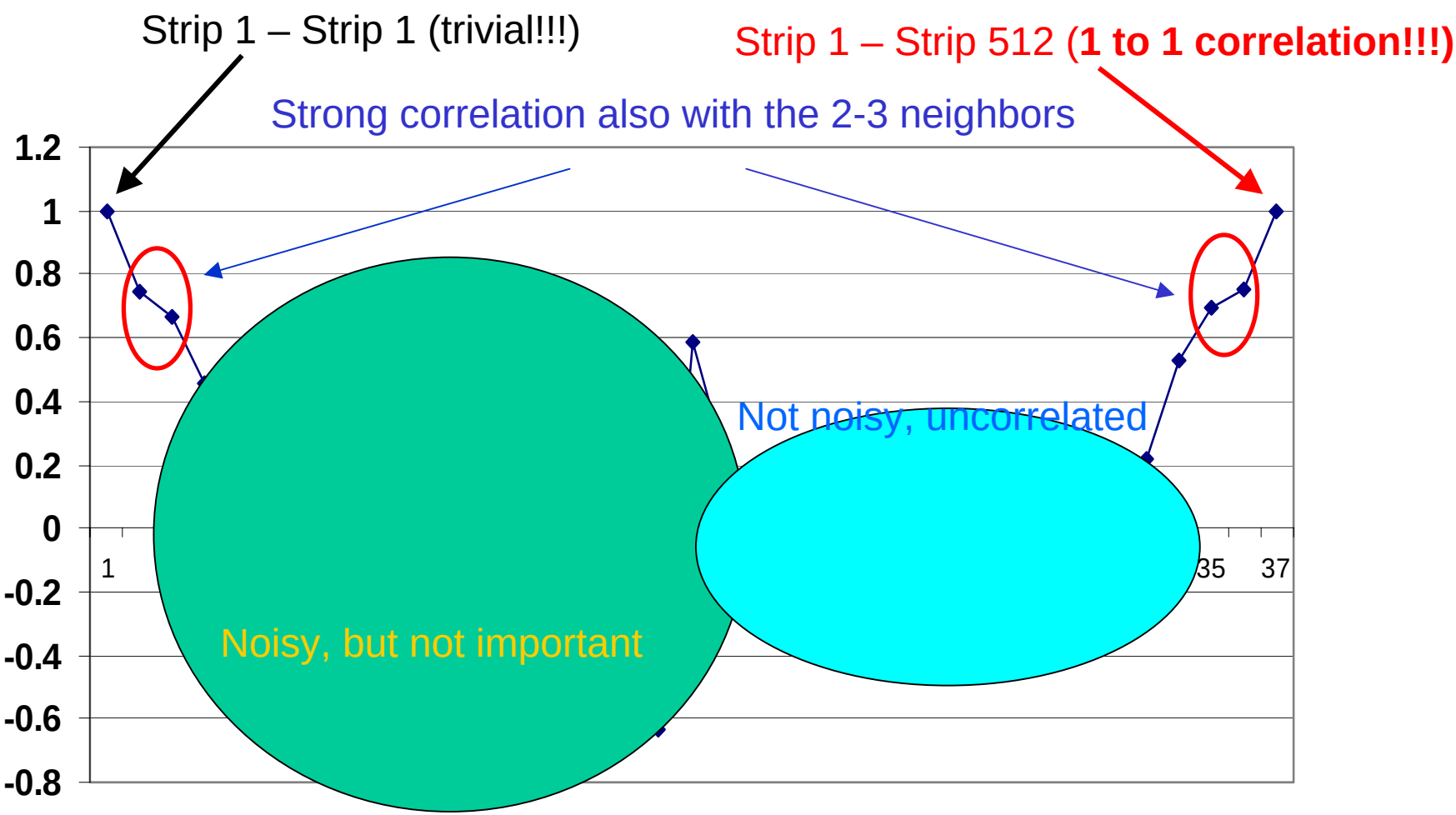
Edge strips behaviour

- The detector edge strips noise is visible even simply looking at the ARC event display...
- Reducing the monitor display frequency is evident, at first glance, that strip number 1 fluctuations are somewhat correlated with the ones of strip number 512
- Using a bit more formal language…

$$\rho_{xy} = E[(x-\mu_x)(y-\mu_y)]/\sigma_x\sigma_y$$

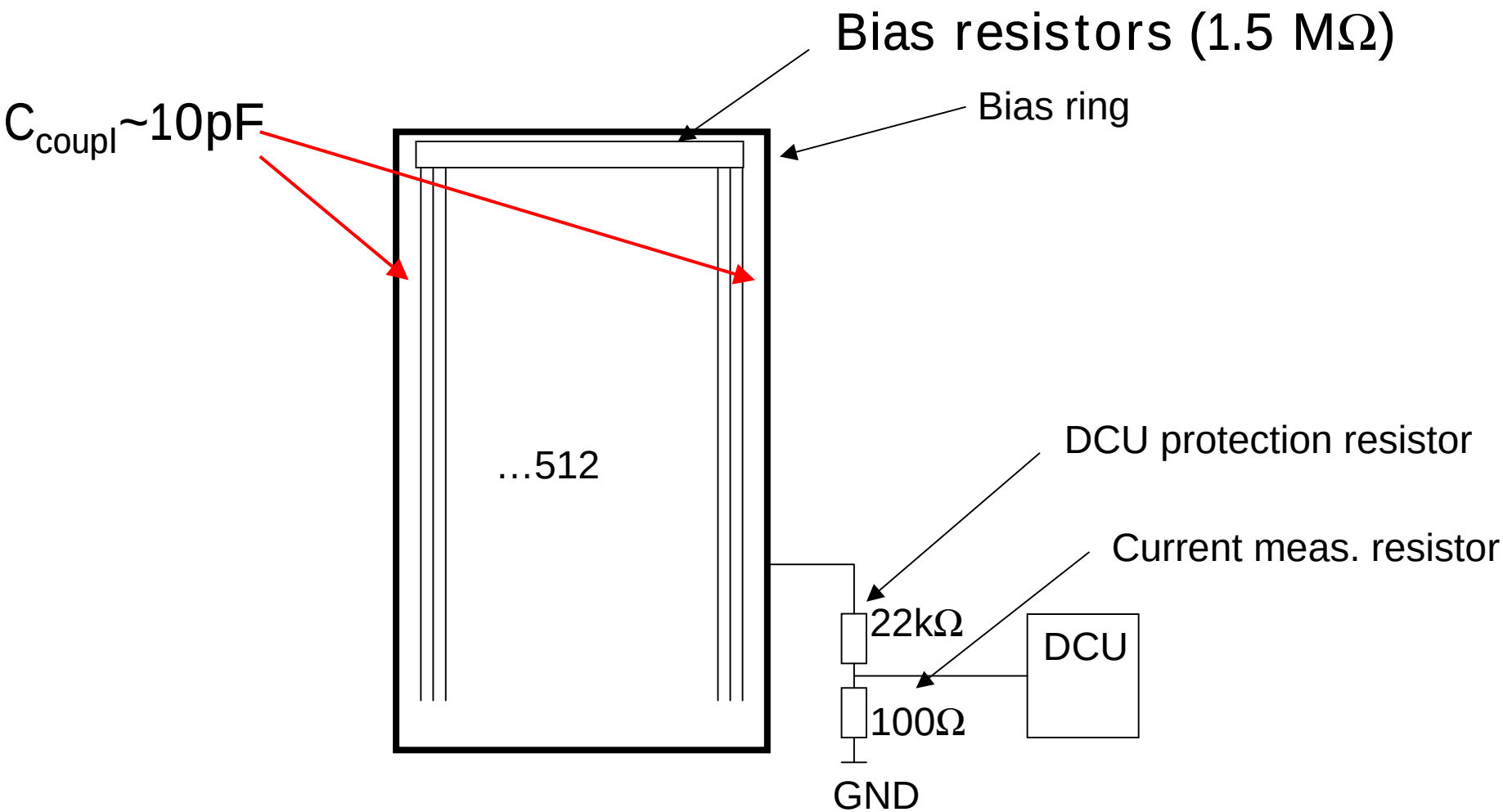
- …and plotting the correlation of the first strip with the others →

Strip #1 correlation with some other strips (mod 177)

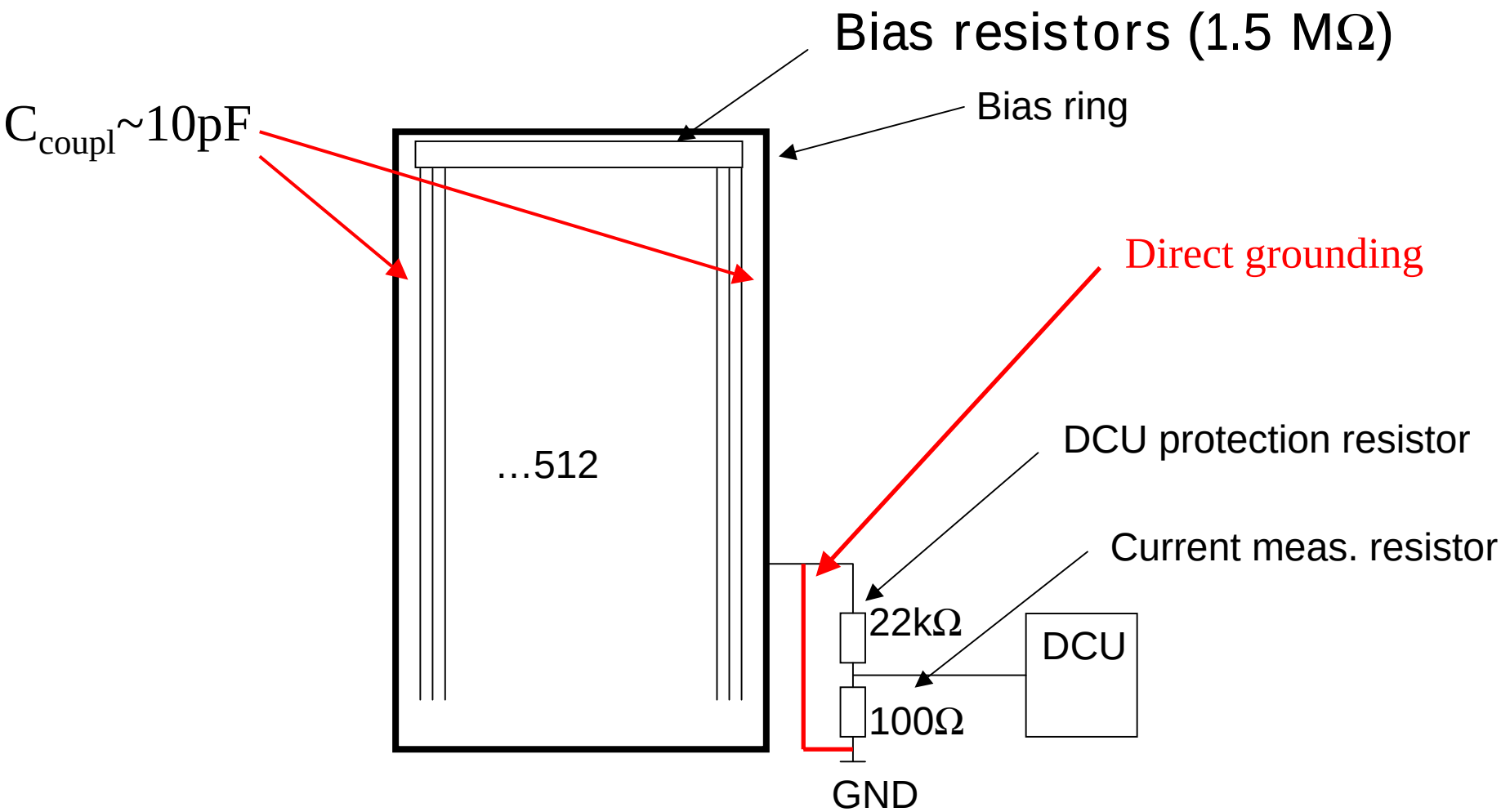


- The edge strips move together…
- A possible explanation is that they are forced to move by the coupling to the bias ring (61μm distance between the strip and the bias ring x116.8mm length) - TIB02-HPK
- $Z_{coupl} = 1/(j\omega C) \rightarrow |Z_{coupl}| \sim 10^4\Omega$ @ 1 MHz → order of 100 times less than R_{bias}
- In the present configuration the bias ring is grounded at the hybrid level through a 22KΩ resistor (2.2KΩ + 680Ω in the final design)

TIB Electrical configuration

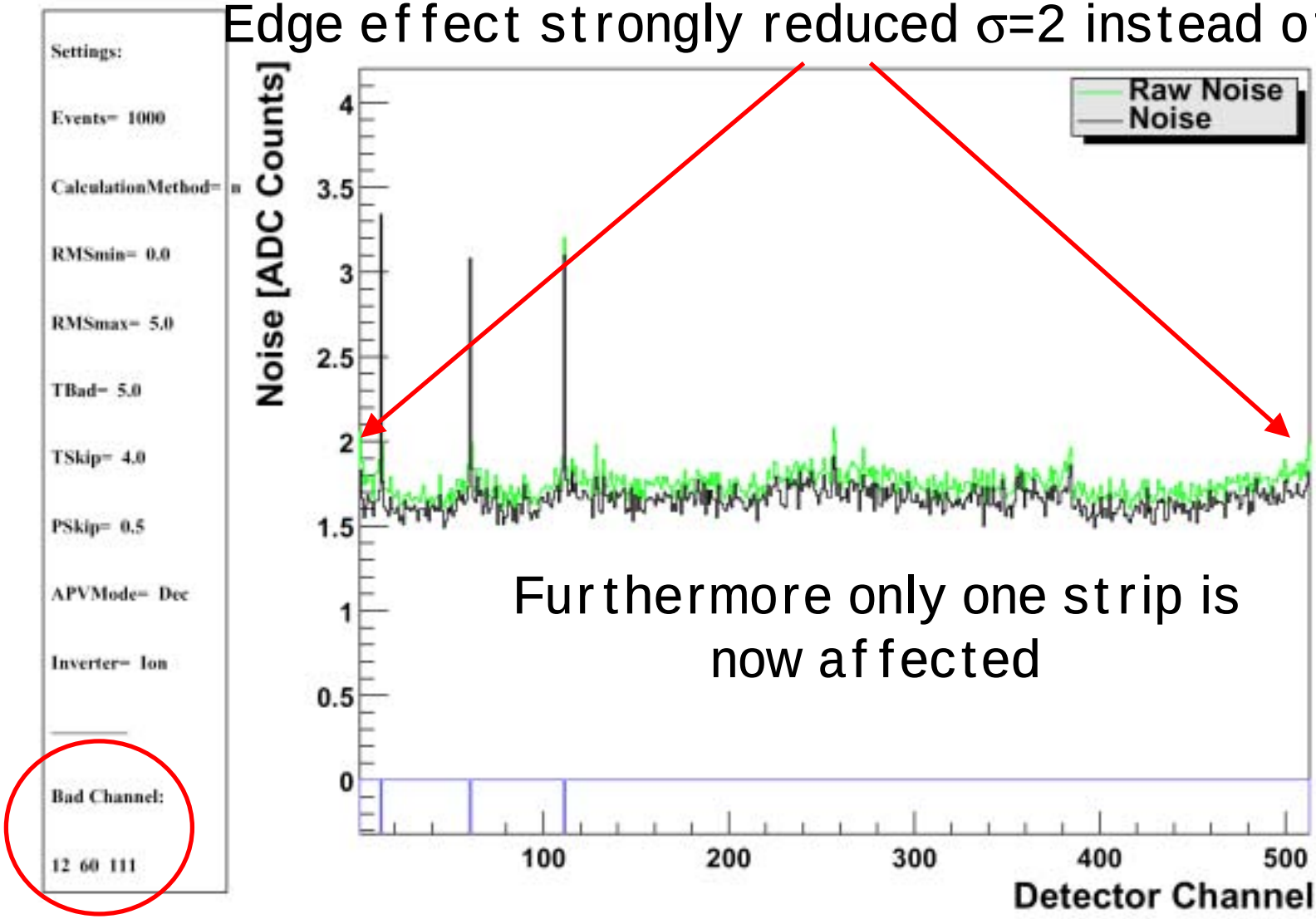


First test


Bias resistors (1.5 MΩ)
Bias ring
C_{coupl}~10pF
Direct grounding
…512
DCU protection resistor
Current meas. resistor
22kΩ
DCU
100Ω
GND

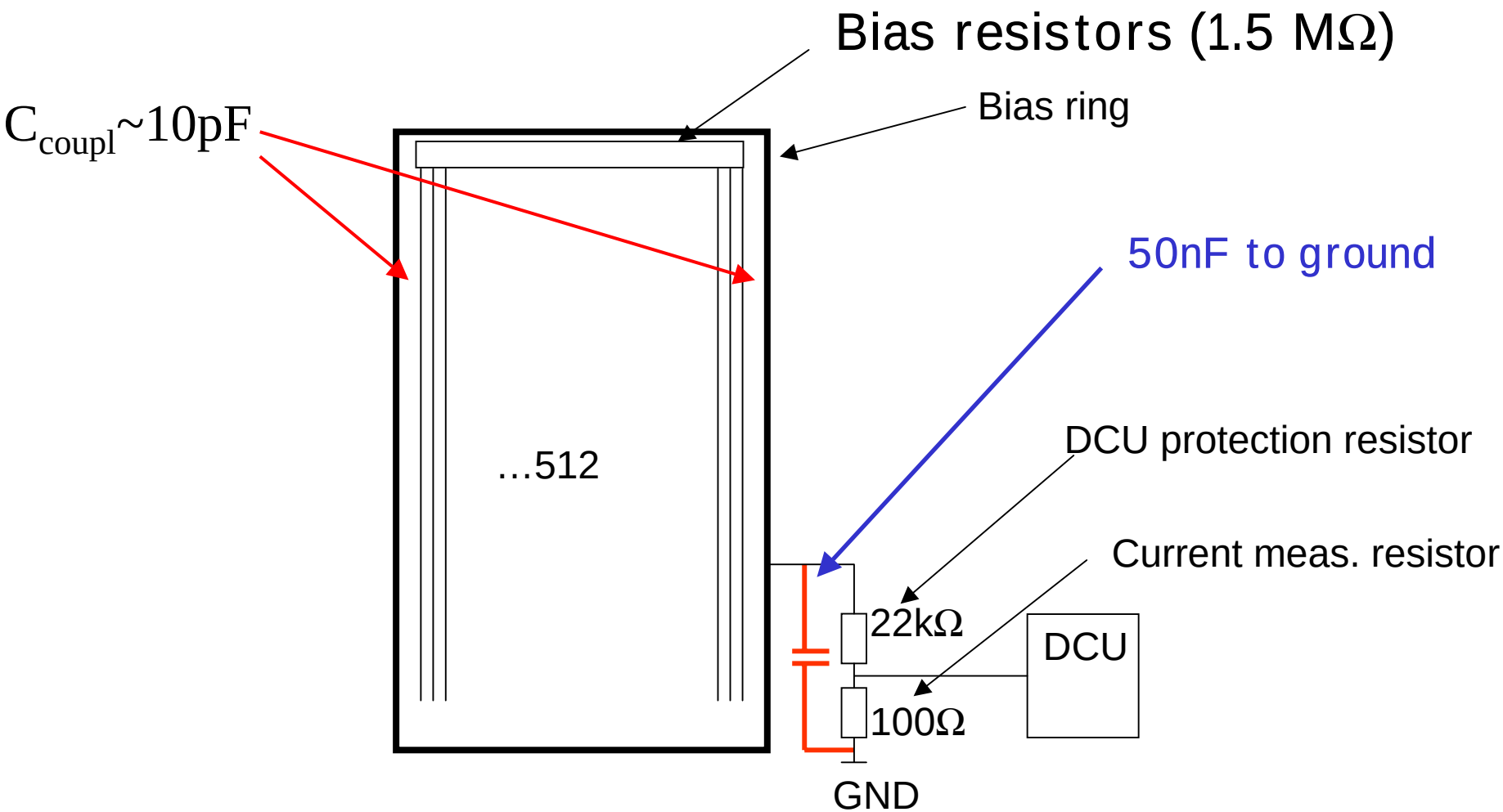
Same module as before but with direct connection to ground

Edge effect strongly reduced σ=2 instead of σ=12

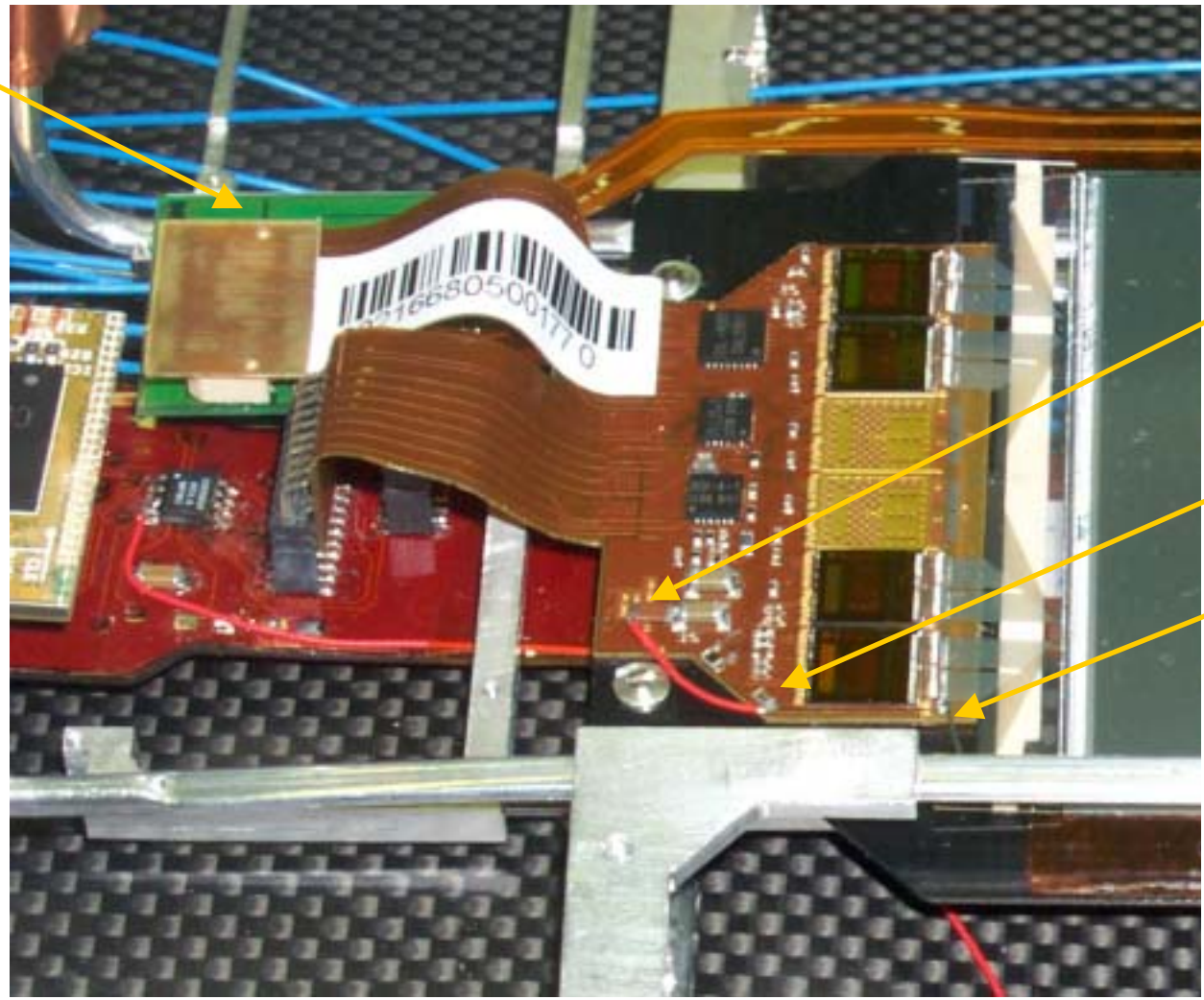


More realistic scenario

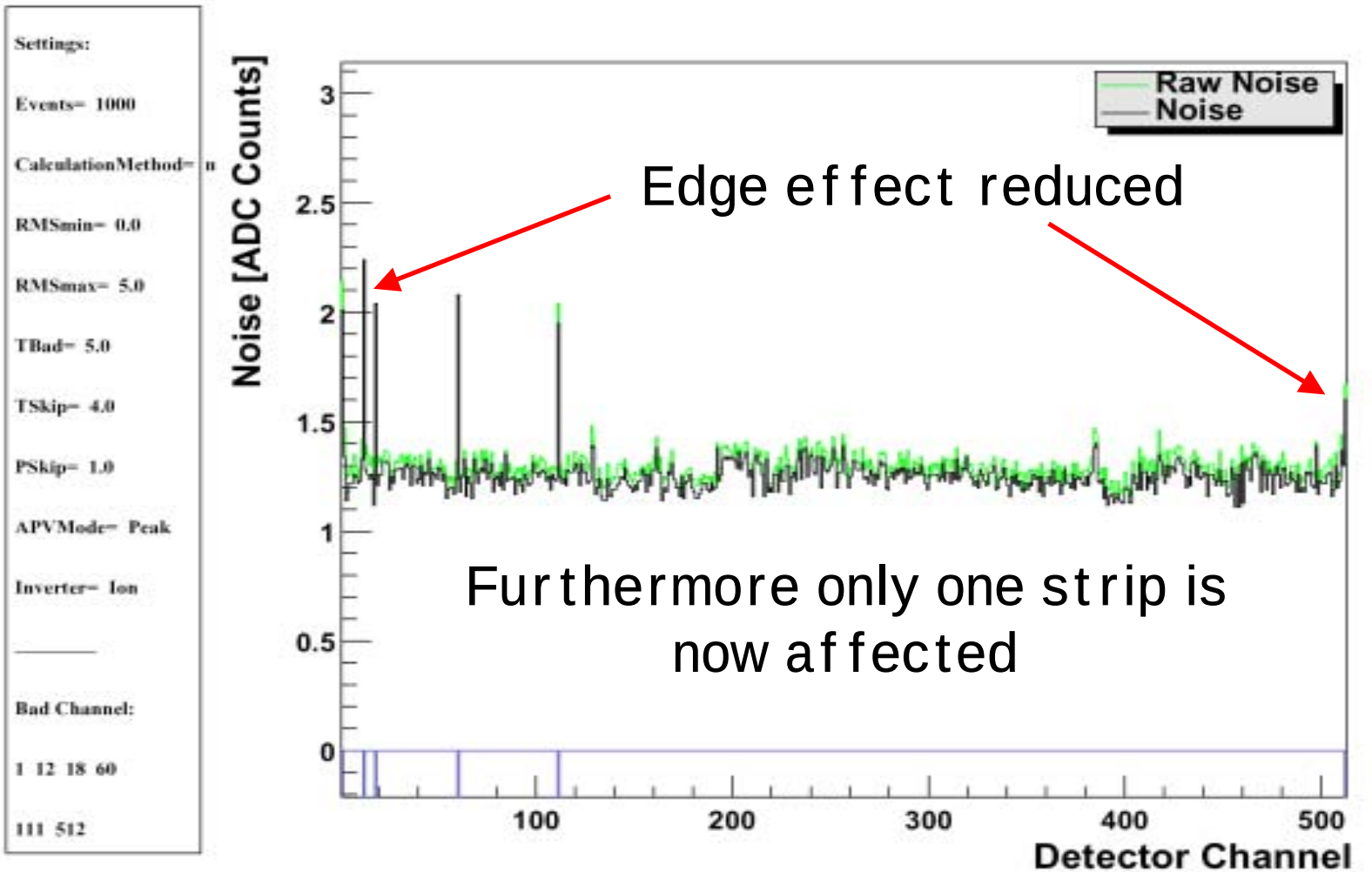
(~proposal for better HV filtering on TIB modules)



Picture from TIB System test in Florence

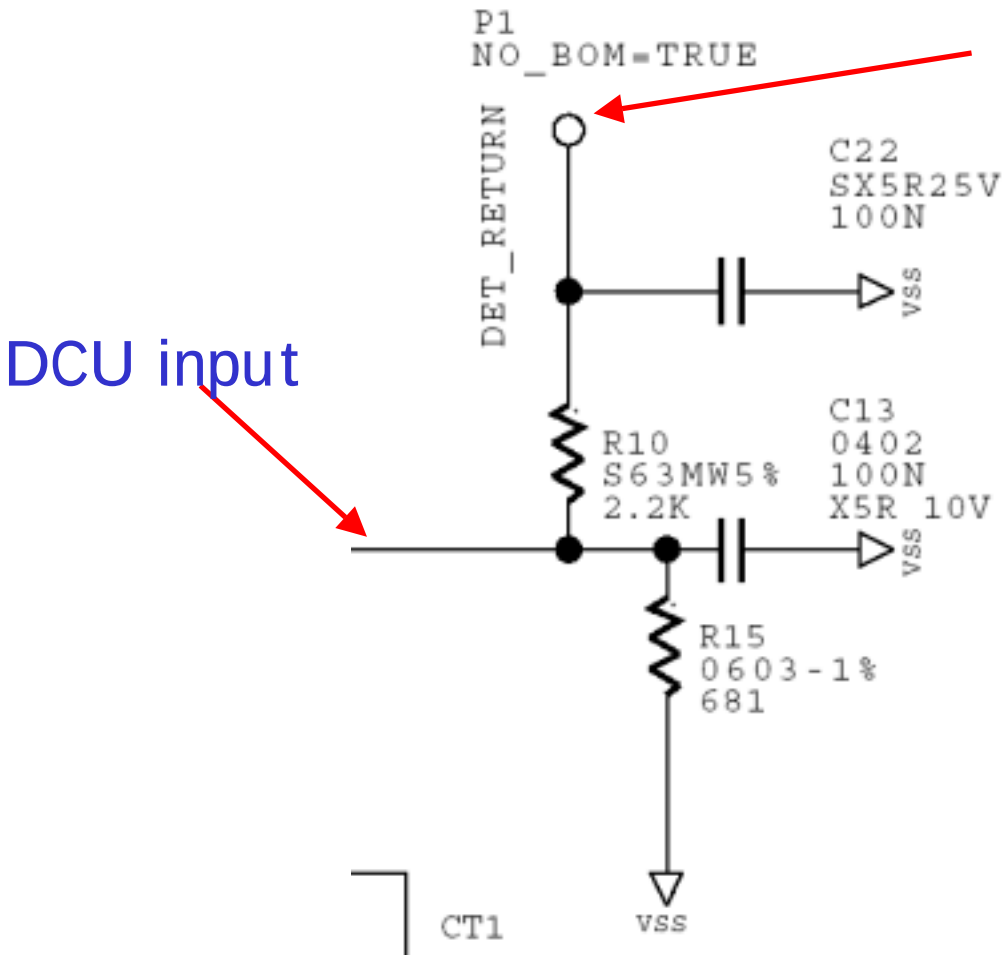


Same module as before but with 50nF capacitor to ground



...also the common mode is (slightly) reduced

New TIB hybrid layout (Dec. 2002 v11)

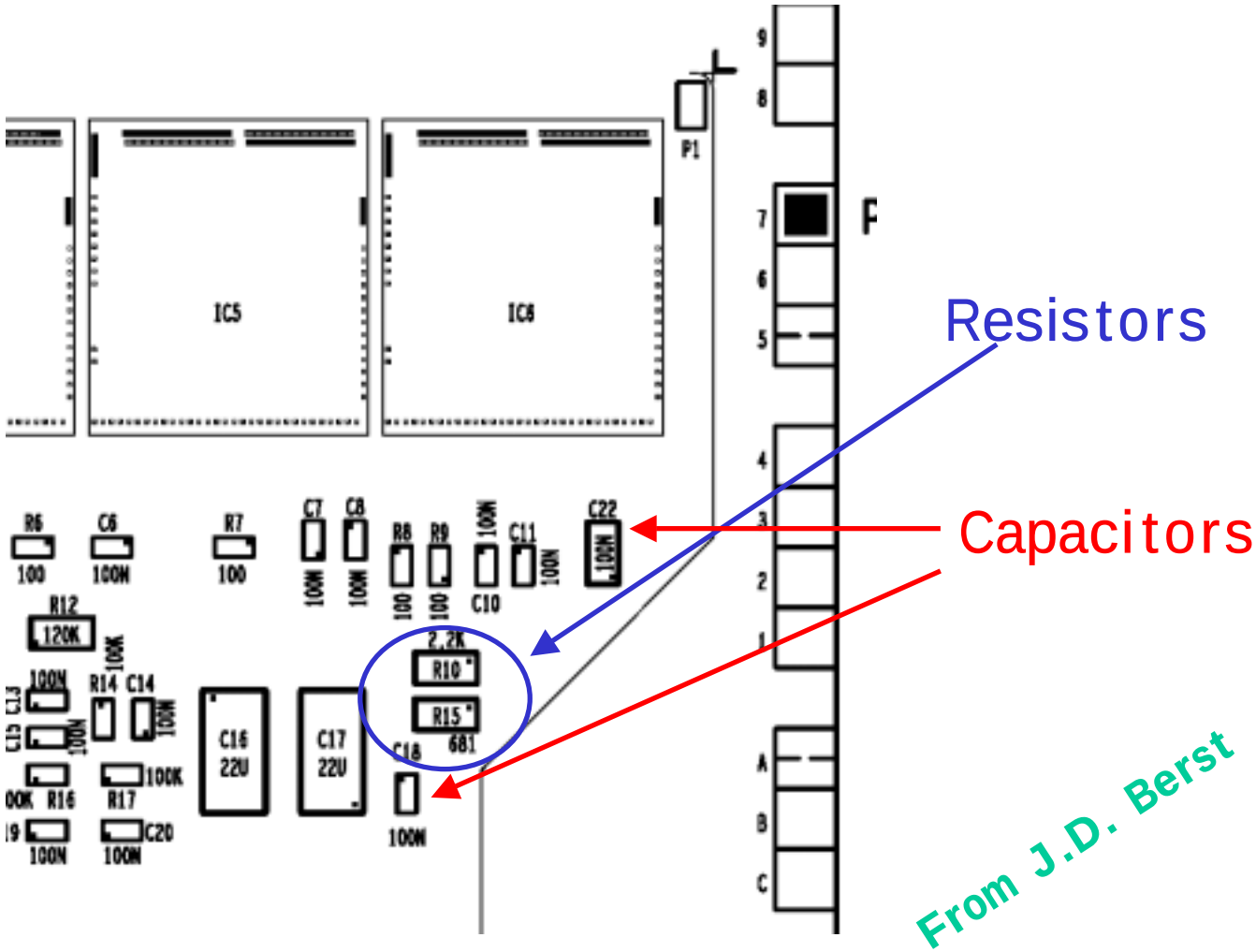


Bias ring

DCU input

From J.D. Berst

TIB hybrid layout (Dec. 2002 v11)

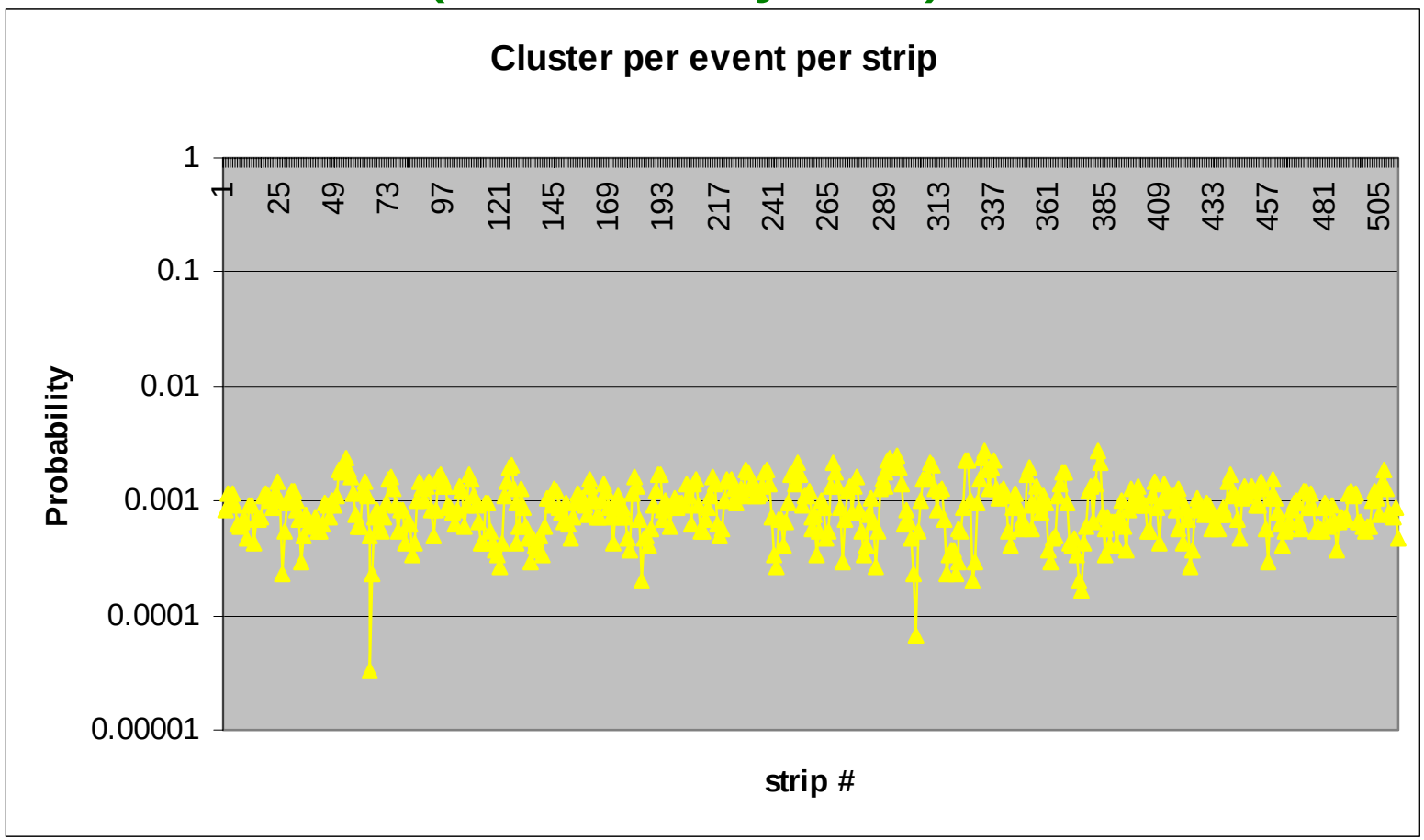


Studies on strip noise…

FED output data rate

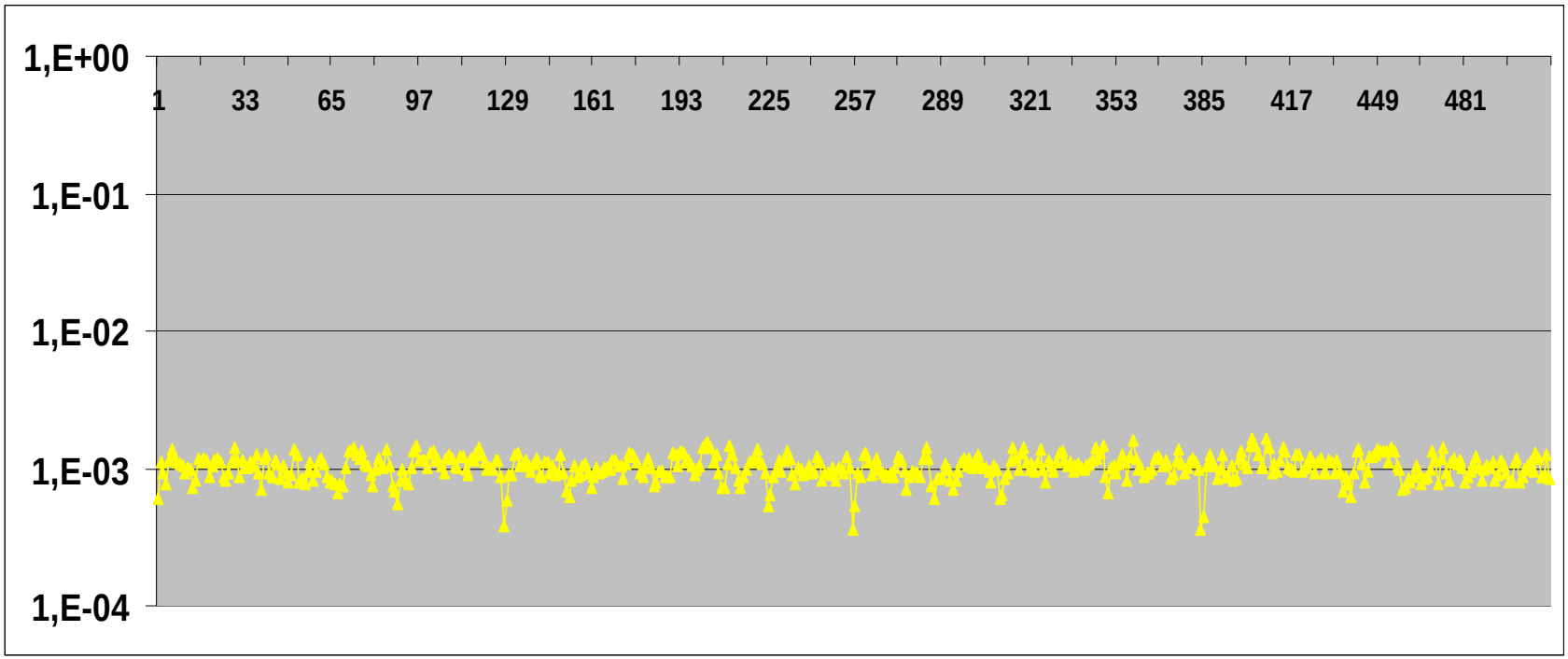
- Clustering algorithm FED02 taken from Ian's note (CMS-IN 2001/025)
  - Single strip if signal > 5σ
  - If $2\sigma < \text{signal}_n < 5\sigma$ taken in cluster only if $\text{signal}_{n+1} > 2\sigma$
- Comparison data/MC to check the algorithm consistency
- From pure gaussian uncorrelated strip noise distribution the cluster probability is 10^{-3} per strip per event

Cluster per strip per event (ceramic hybrid)



Hybrid only (no detector, no pitch adapter)
30216670300163

Cluster per strip per event (toy-MC)

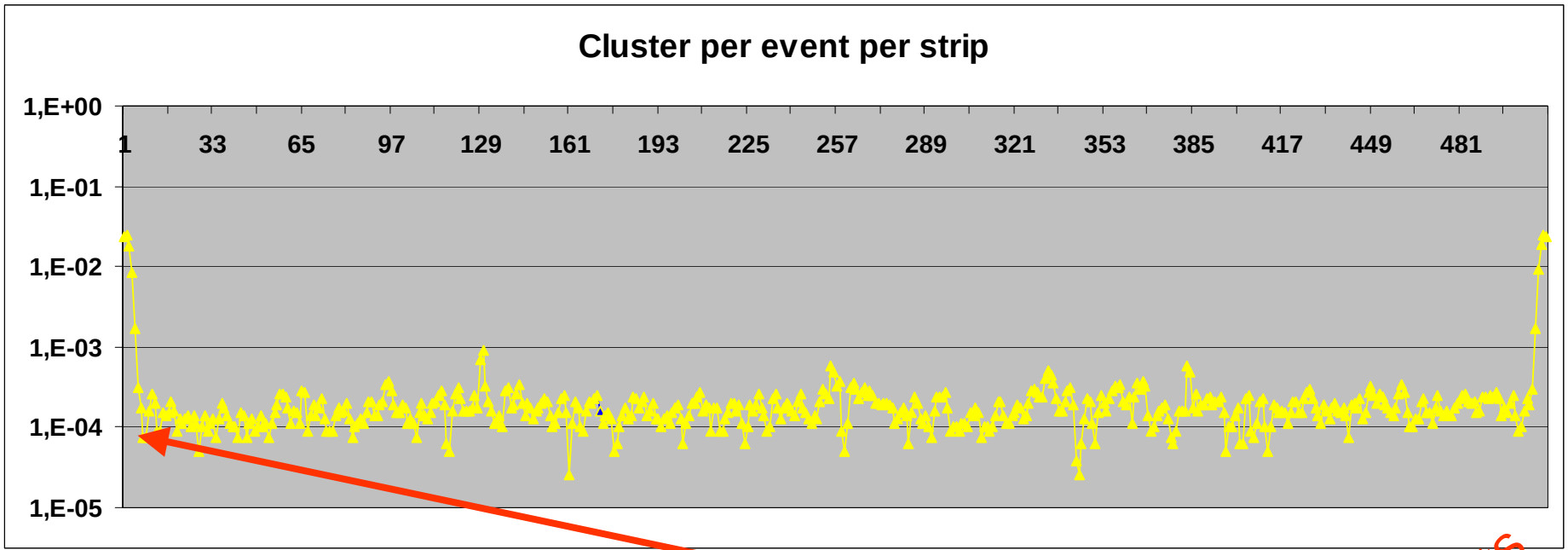


Using uncorrelated gaussian noise

…but, looking at complete module data →

Cluster per strip per event (data)

Mod. 30216680500180 PK inverter on HV=300V

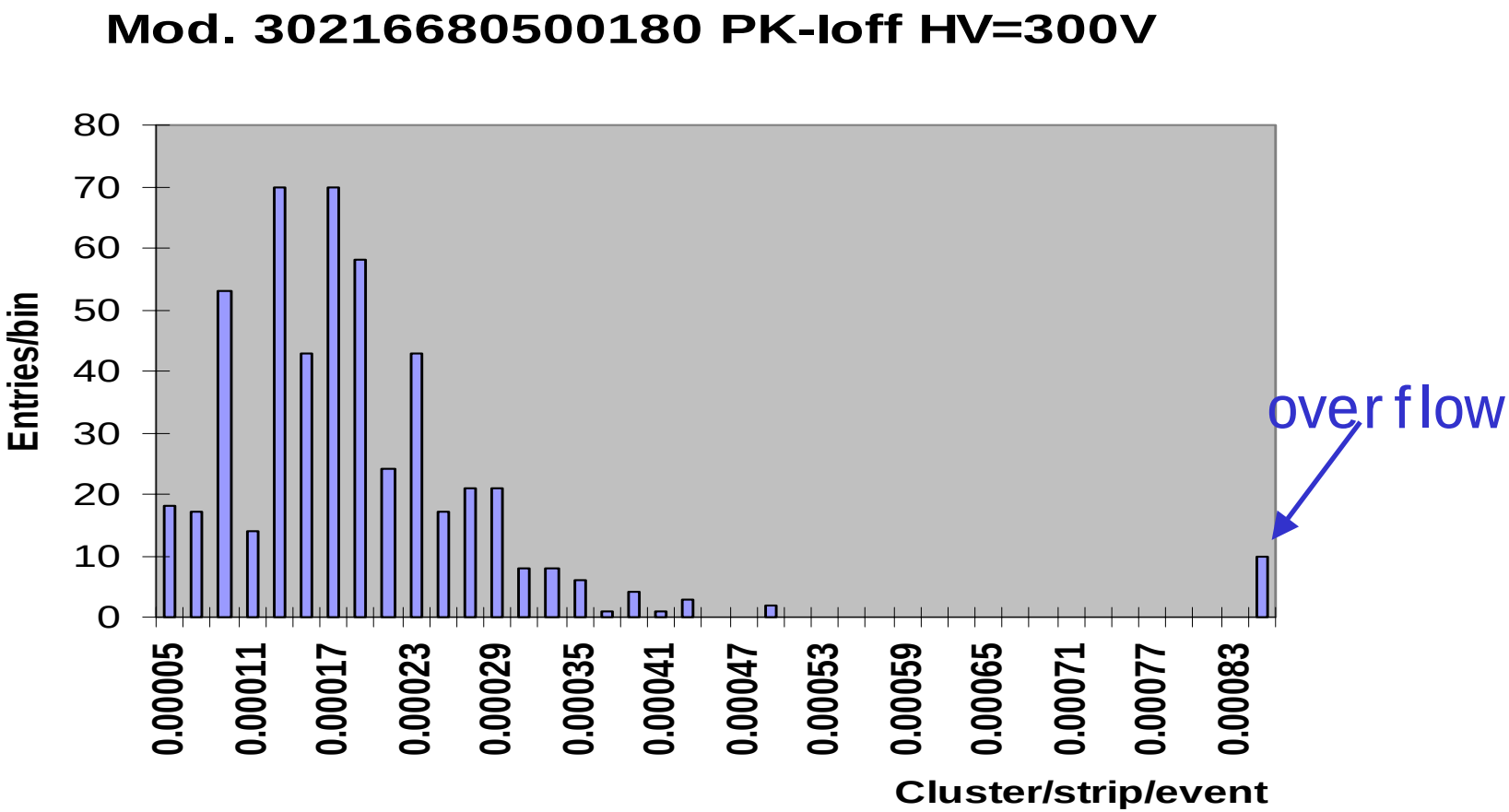


FED2

Cluster → strip n>2σ only if the strip n+1 >2σ

Probability = P(>2σ)*P(>2σ)*2 ~10^-3

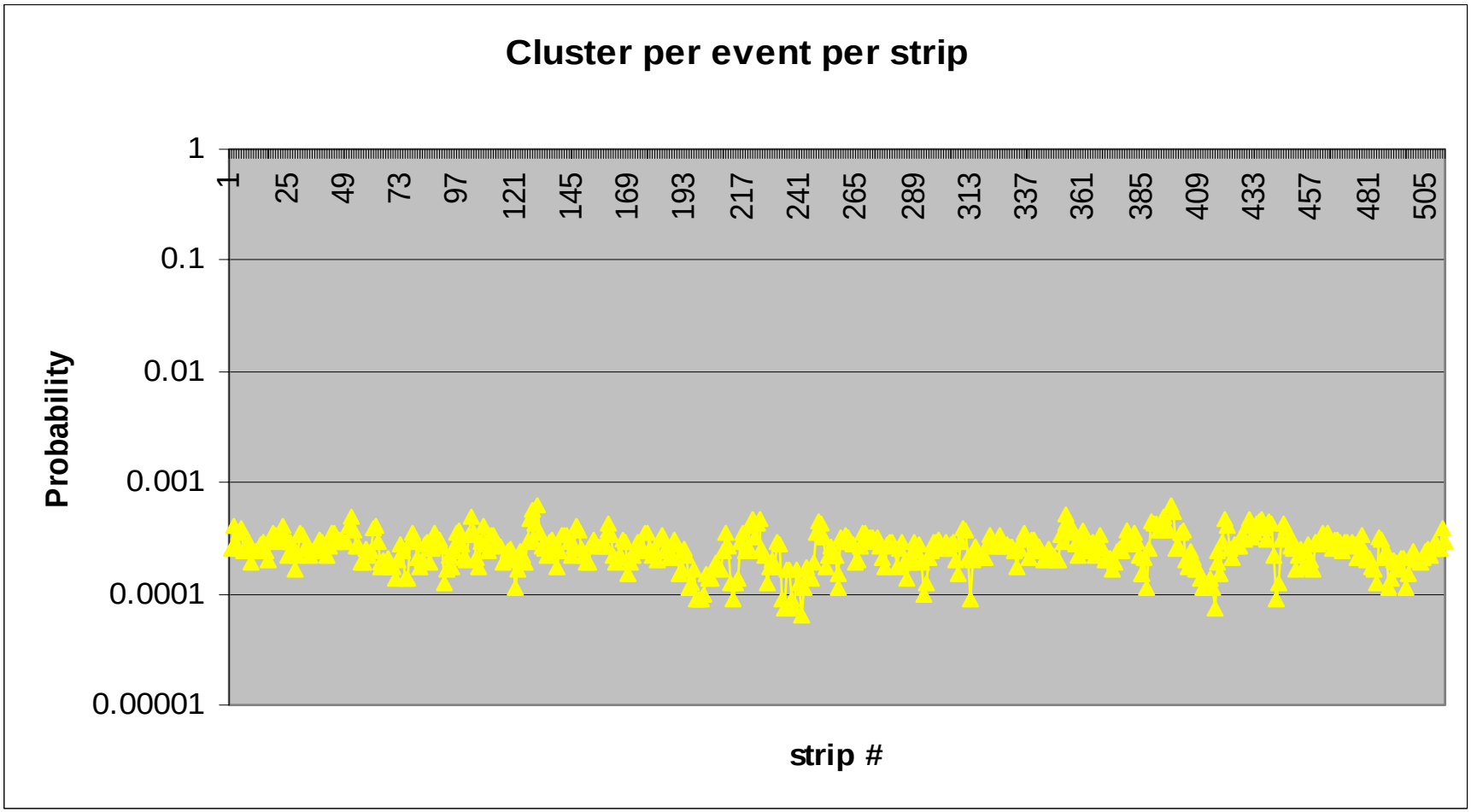
Cluster probability distribution



Mean value (edge channels excluded) = 1.8×10^{-4}

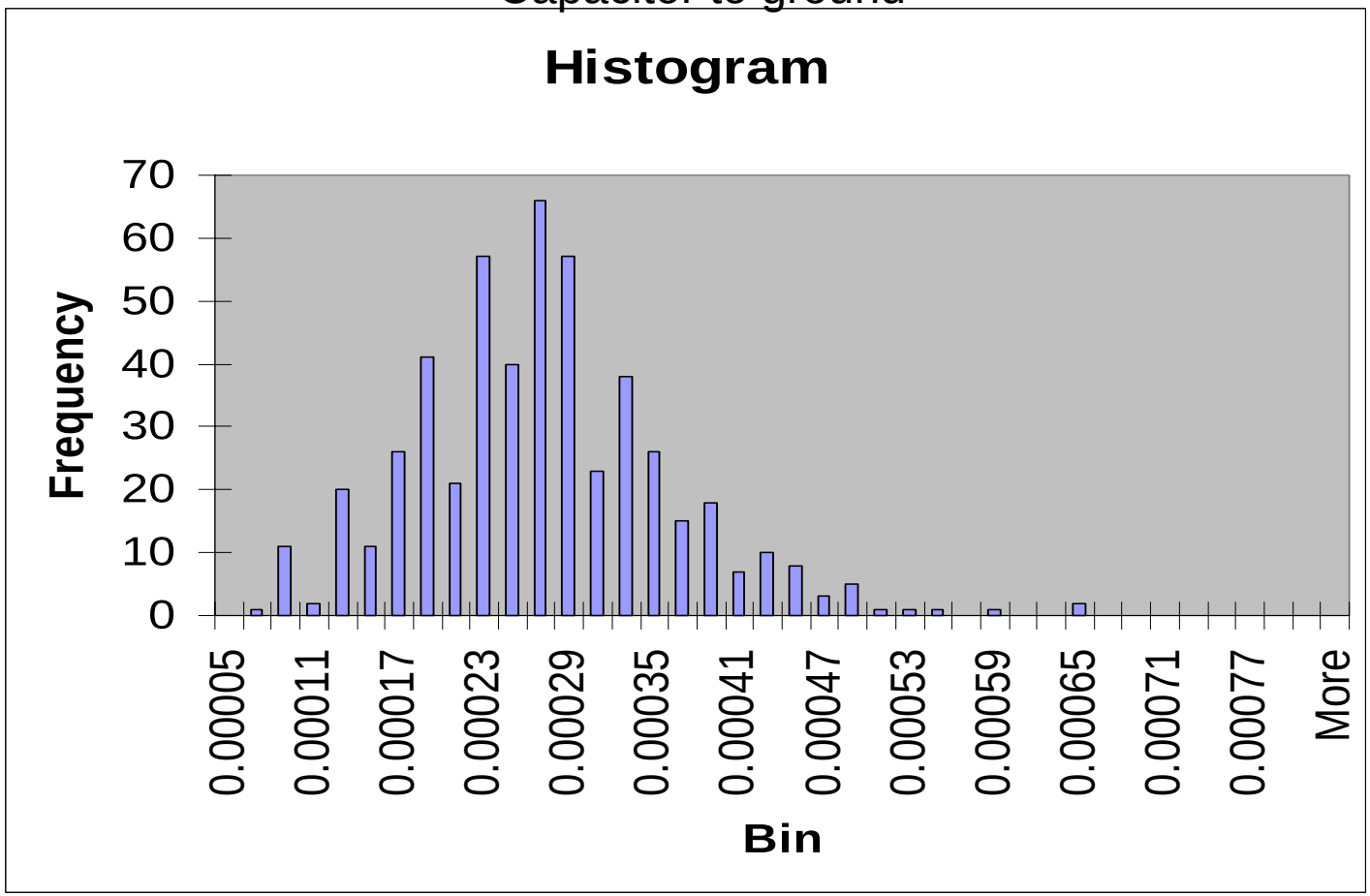
Cluster per strip per event (data)

Mod. 30216680500177 Dec. inverter on HV=300V
Capacitor to ground



Cluster probability distribution

Mod. 30216680500177 Dec. inverter on HV=300V
Capacitor to ground

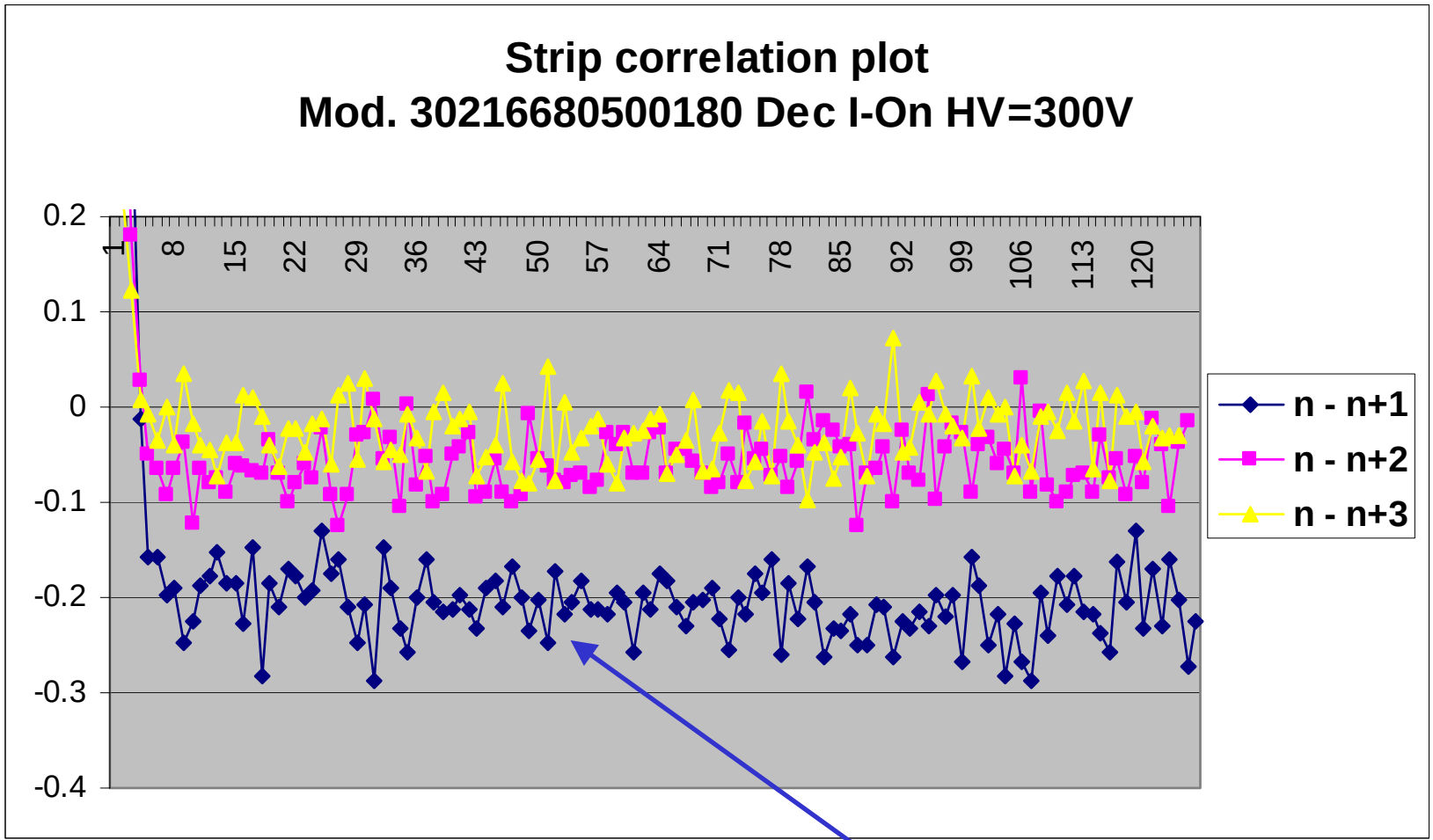


Mean value (edge channels excluded) = 2.6×10^{-4}

(Anti-)correlated noise

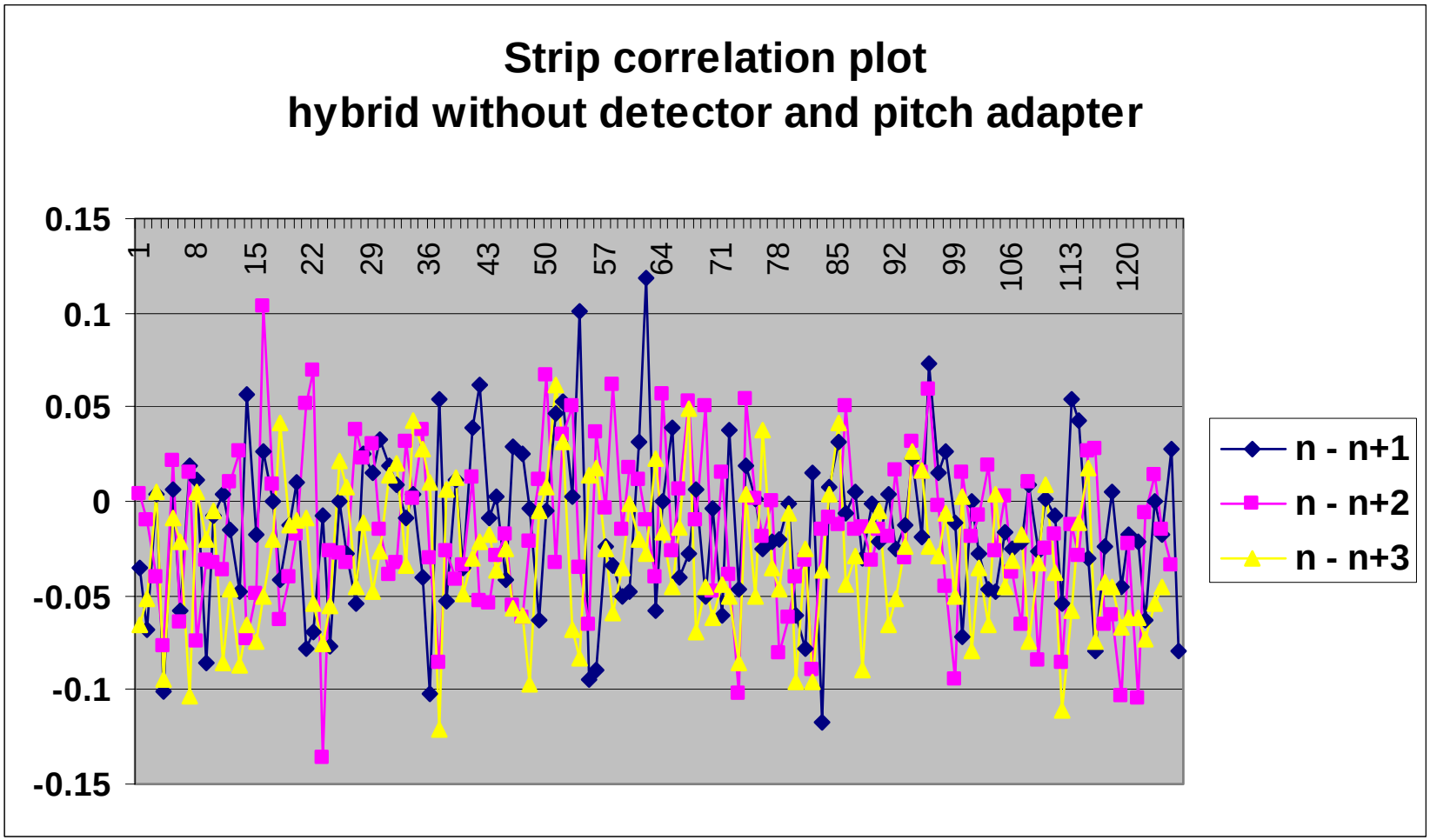
- The cluster noise probability in data sample from real detectors is a factor 5 lower than the simple calculation (assuming uncorrelated gaussian noise)
- This discrepancy mainly comes from the double strip clusters that, in the data, are strongly suppressed with respect to the expectation.
- The reason comes from the anti-correlation of the strip noise (channel n ←→ channel n±1).

(Anti-)correlated noise



First neighbour
Correlation ~ -20%

Correlation on a naked hybrid



First, and other, neighbours are uncorrelated…

Noise correlation

- The noise on each strip is anti-correlated with respect to the one of the neighbour (-20%); this effect strongly reduces the fake cluster identified by the proposed FED algorithm (FED2 from Ian's note).
- This 'cross-talk' seems to be related to the detector and not directly to the front-end electronics; in fact it is not present on a naked hybrid and do not depends on the chip working mode (pk, dec, inv on/off).
- More studies are needed to confirm it and possibly to measure this effect as function of the detector parameters (pitch, thickness, strip length, TIB, TEC, TOB)

Consideration on FED data rate

- 1 FED (96 channel) → 192 APV ~ $2.4*10^4$ strips
- Noise (from this work):
  - <noise> ~ $2*10^{-4}$ cluster/strip/event → 5 clusters/FED/event
  - @ 10^5 Hz (max. first level trigger) and 2 Bytes/cluster →
  - 1 Mbyte/s noise output rate
- Physics (2% occupancy):
  - <physics> ~ $2*10^{-2}$ cluster/strip/event → 100 Mbyte/s
- The safety margin has increased; part of this can be used to read-out strips 'marginally noisy', or, in other words, move the percentage cut above the 20% that is now used as default value on ARC systems and Lino's macros.

Conclusions

- The TIB modules edge noise has been traced out to an instability of the bias ring ground.
- A capacitor between bias ring and ground reduces the noise; this capacitor is included in the new TIB hybrid layout.

- The strip noise is anti-correlated with the one of the first neighbours.
- Due to this effect the noisy cluster data rate on FED is factor 5 less than what was expected.
- From the data acquisition point of view we have margin to include in the read-out strips that are only marginally noisy.