Charge collection measurement on slim edge sensors with the ALiBaVa system

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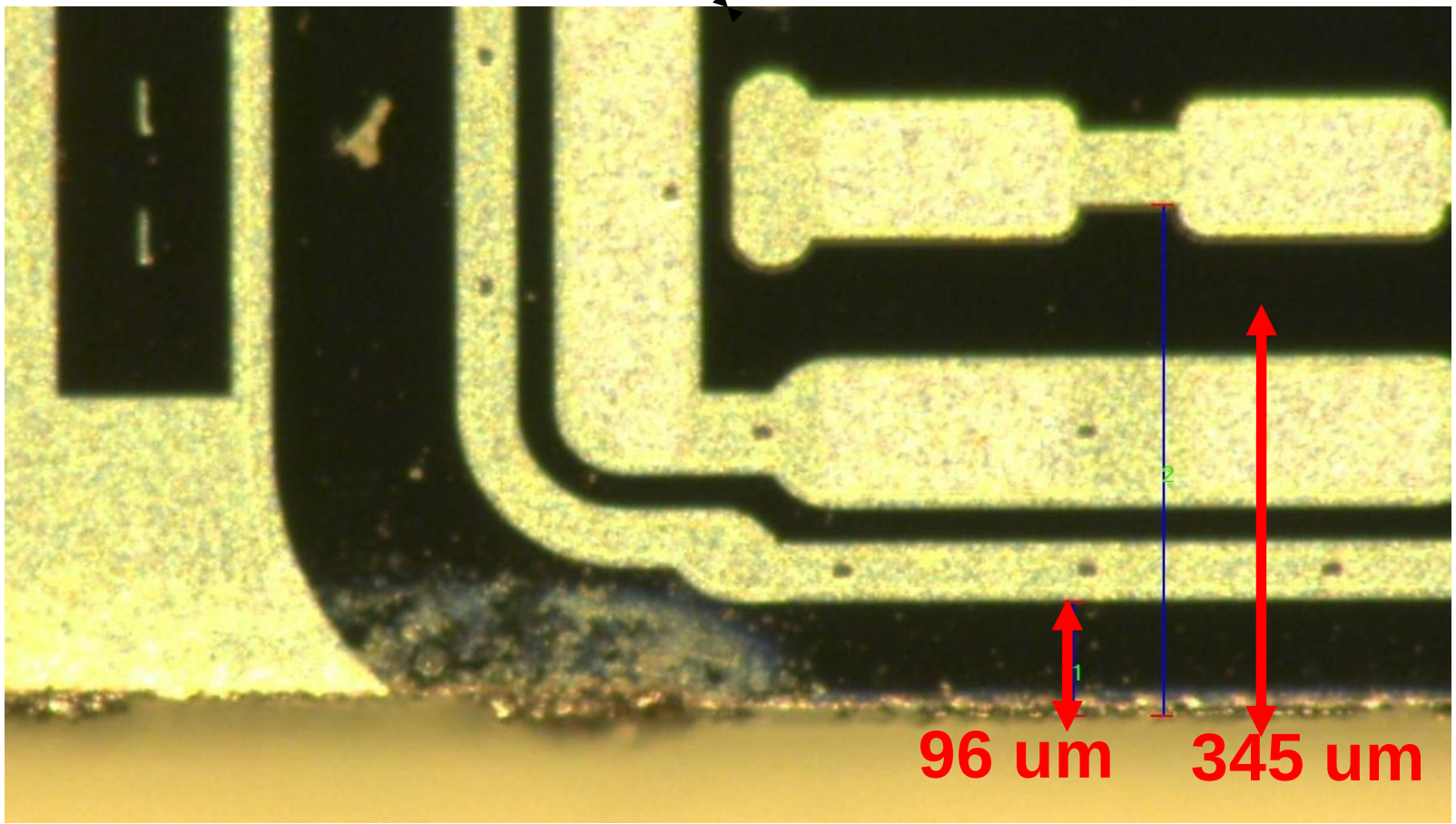
Introduction

- ALiBaVa[1] is a portable read-out system developed for test sensors in (s)LHC-like experiments. It provides a real-time GUI and data format for custom (ROOT) analysis.
- There is the interest on the SNR and the efficiency of detectors. In particular it is interesting to know the performances of slim edges (cut) detectors, compared to the uncut ones.
- It is interesting to study the relation between the occupancy and the efficiency of a detector by a threshold scan:
  - To vary the threshold mean to scale the occupancy by a factor proportional to the integral of the distribution[2].
- Our objectives are to study the signal distributions and to characterize slim edge sensors:
  - comparing cut and uncut detectors;
  - comparing inner strips with edge-strips (outer strips).

[1]Marco-Hernandez, IEEE TNS, 2009; [2] Spieler, Introduction to radiation detectors and electronics, 1998, ch. VIII.6.

Materials

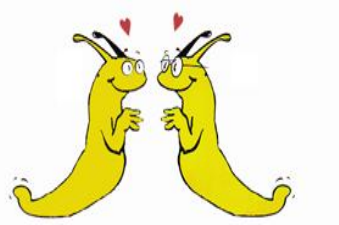
- **Sensors:**
  - (CMS, p-on-n, unirradiated, 128 strips.)
  - GLAST cut (Si oxide passivated, laser-scribed and cleaved), p-on-n, unirradiated, 8 strips. (Thanks to Bernard Phlips and Marc Christophersen!)
  - GLAST uncut, p-on-n, unirradiated, 8 strips.



Experimental set-up

- **Set-up:**
  - $^{90}Sr/^{90}Y$ (disintegration energies 0.5/2.3 MeV, half-life 29y/64h).
  - Scintillator + photomultiplier (PM) tube from UCSC.
  - ALiBaVa system from INFN Florence.
- **Settlings**:
  - Vbias=[1,10,20,50,100,150,200,500] V.
  - Beetle settlings: high gain, "Kazu" configuration.
  - Noise measurements: detector not in front of the source.

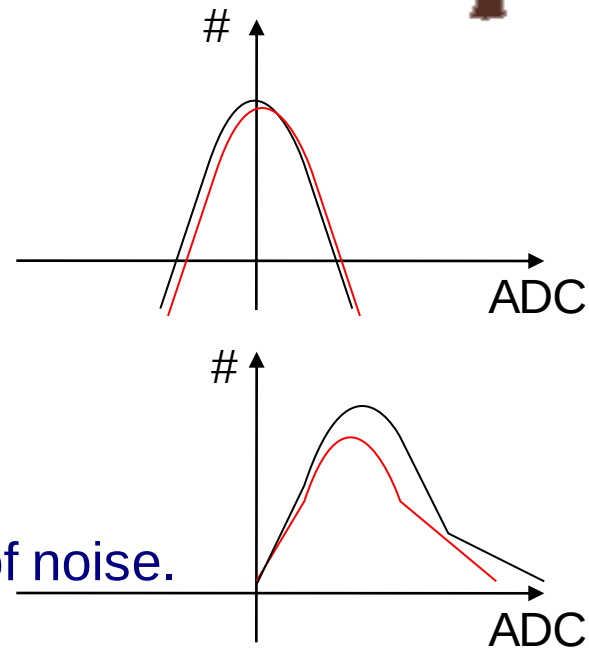
Analysis



- *Noise measurement analysis:*
  - Fit of the distribution to get the sigma.
  - Occupancy threshold scan and fits to cross-check.
- *Signal measurements analysis:*
  - Time cut.
  - Clustering: amplitude cut for seed and neighbours.
  - Fit of the distribution to get the MPV and a sigma of noise.

=> SNR=MPV/sigma (from noise distribution fit).

- *Analysis vs. bias voltage.*
- *Analysis vs. channel index:* look at the edges!



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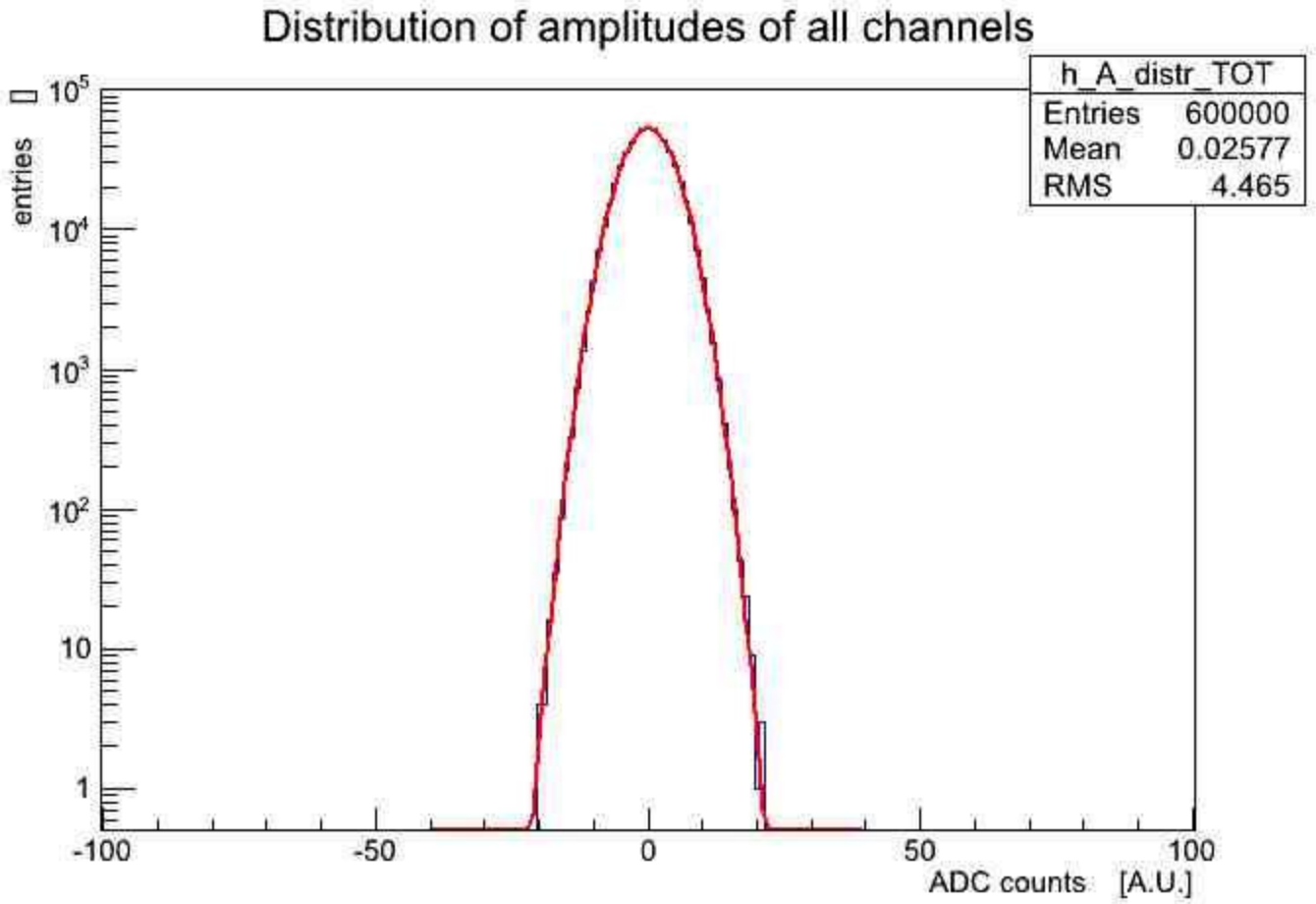
Experimental results

- GLAST cut (inner channels):
  - Noise: distribution

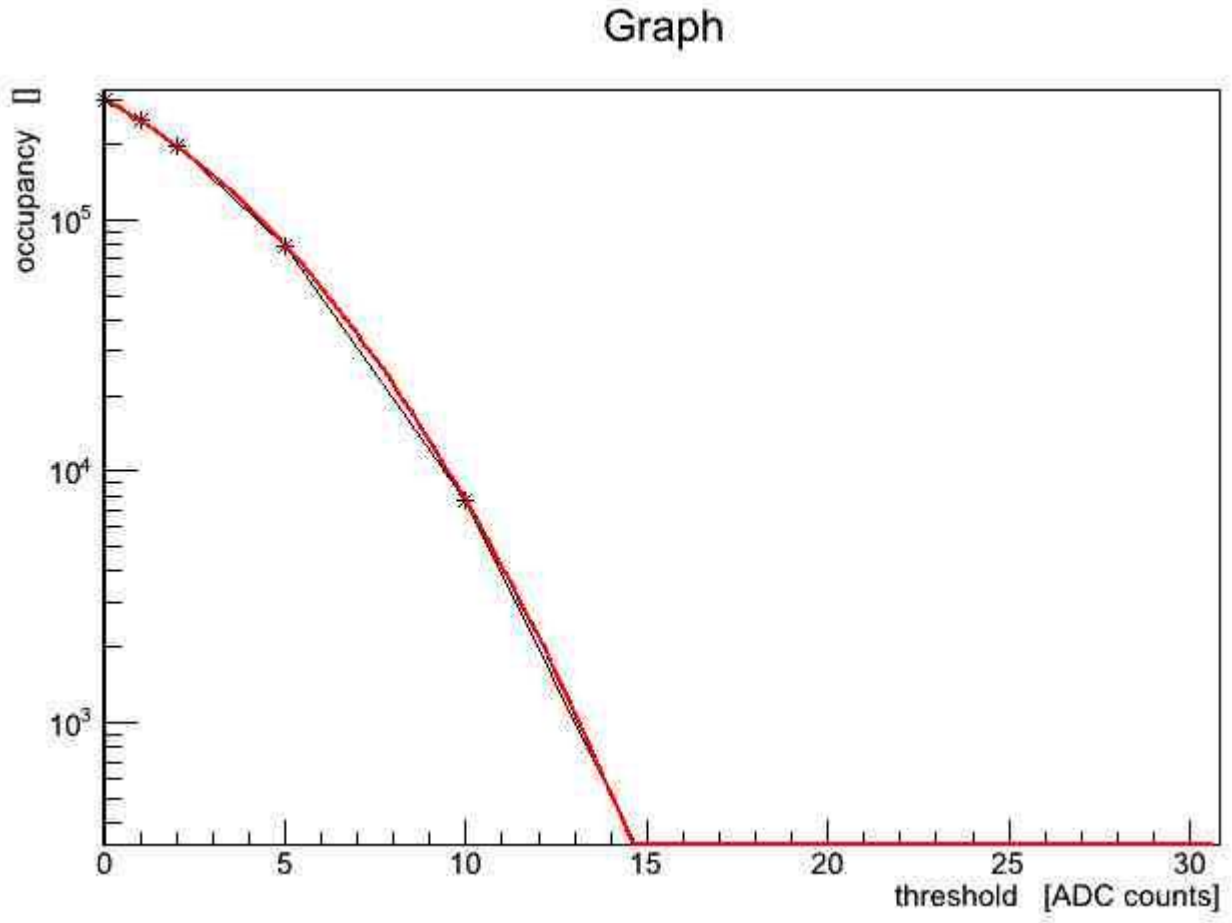
Vbias=200V



- Sigma=4.46 ADCs

Experimental results

- GLAST cut (inner channels):
  - Noise: occupancy threshold scan.

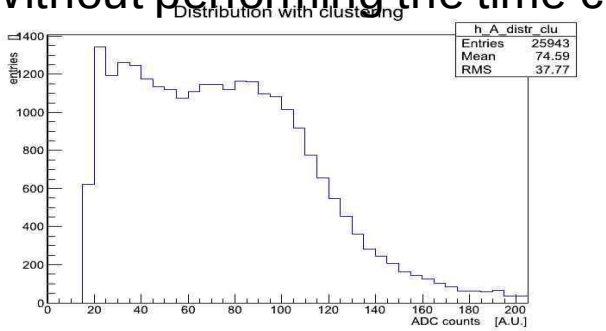


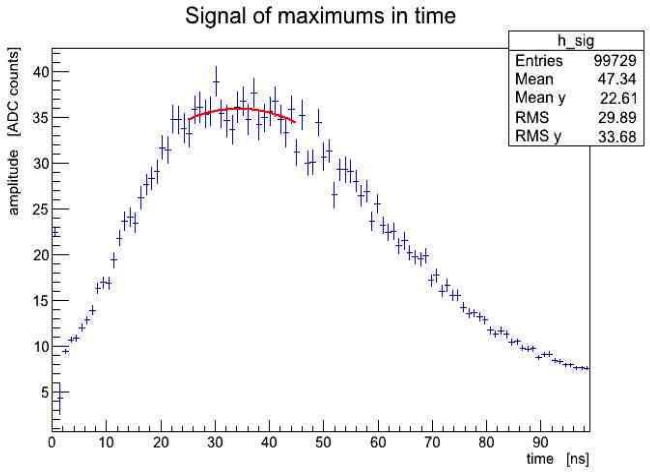
- Sigma=6.34 ADCs

Experimental results

- GLAST cut (inner channels):
  - Signal: in time and distributions

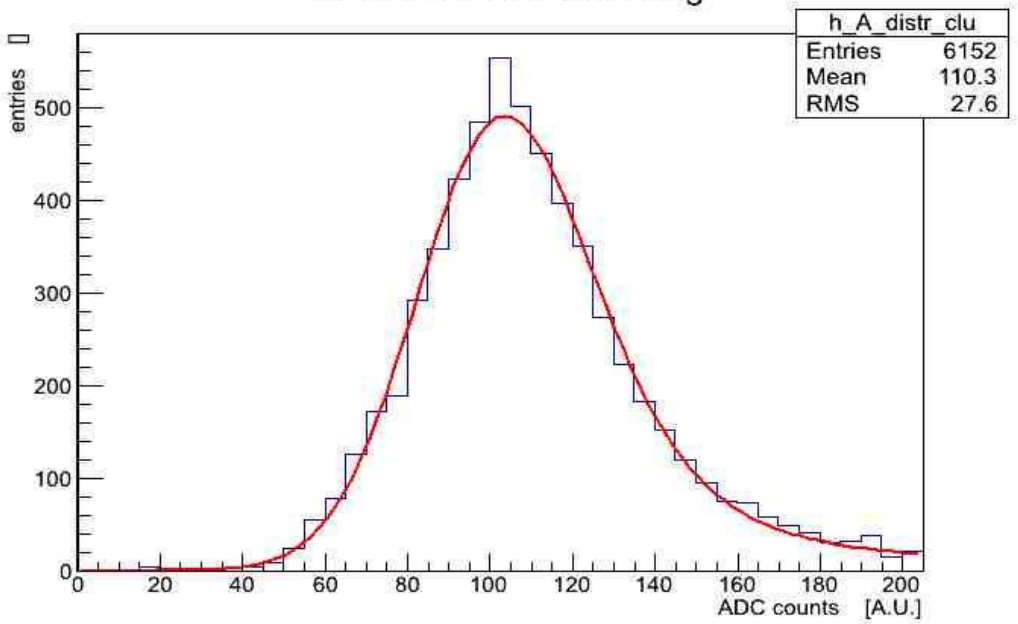
Without performing the time cut





- Time cut: [25,45]ns
- Correction factor: 1.013.

Distribution with clustering



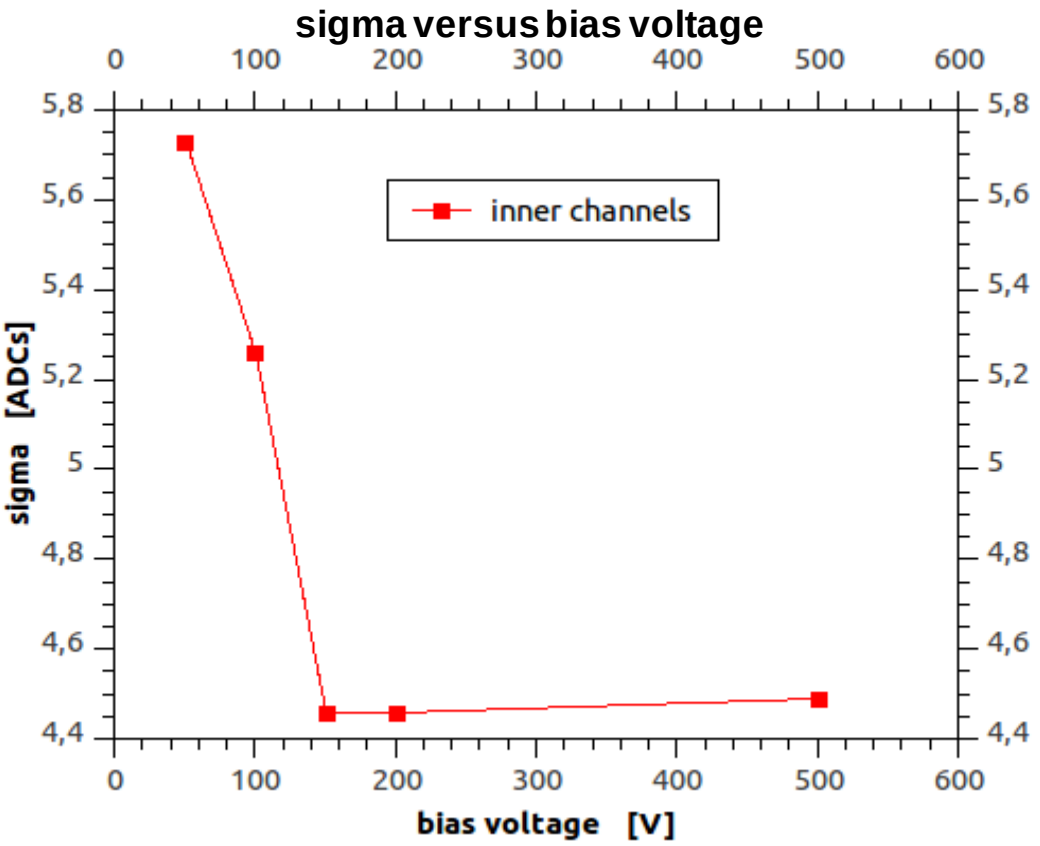
Vbias=200V

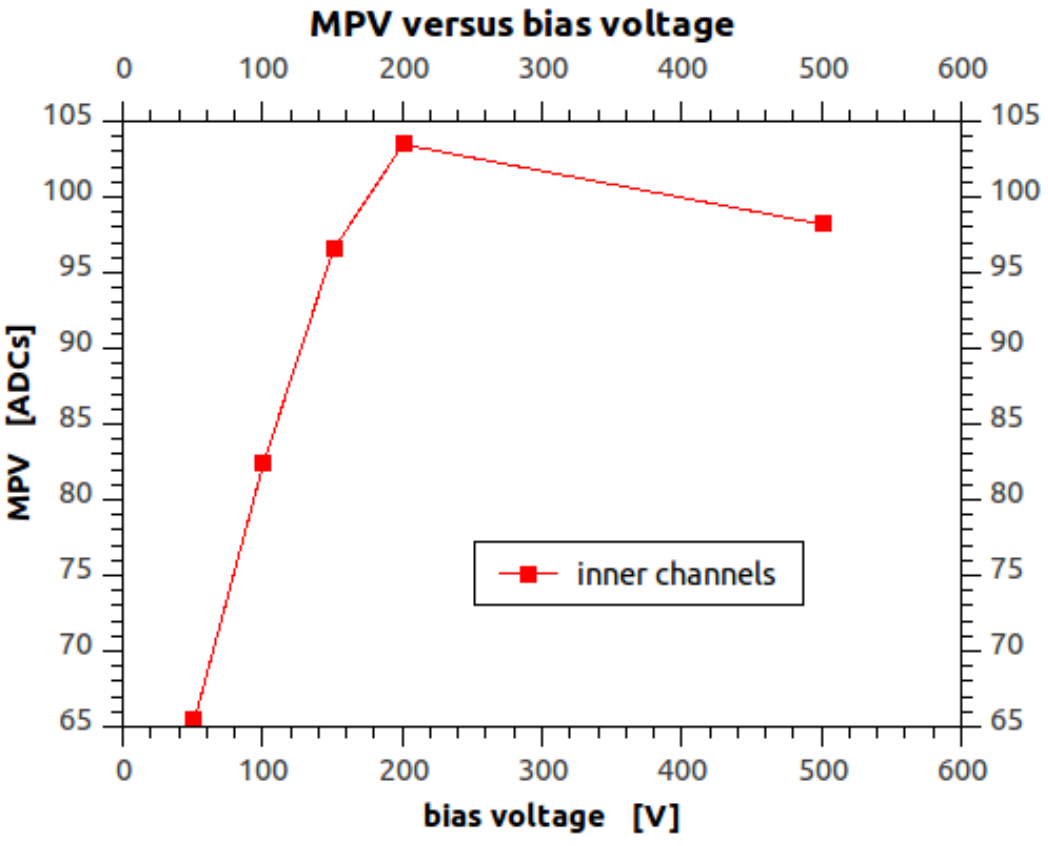
- MPV=103.62*1.013 ADCs (from the CMS, expected 107.33!).
- Sigma(Gaussian)=18.62 ADCs.

SNR=103.26*1.013/4.46=23.64

Experimental results

- GLAST cut (inner channels):
  - Results versus bias voltage

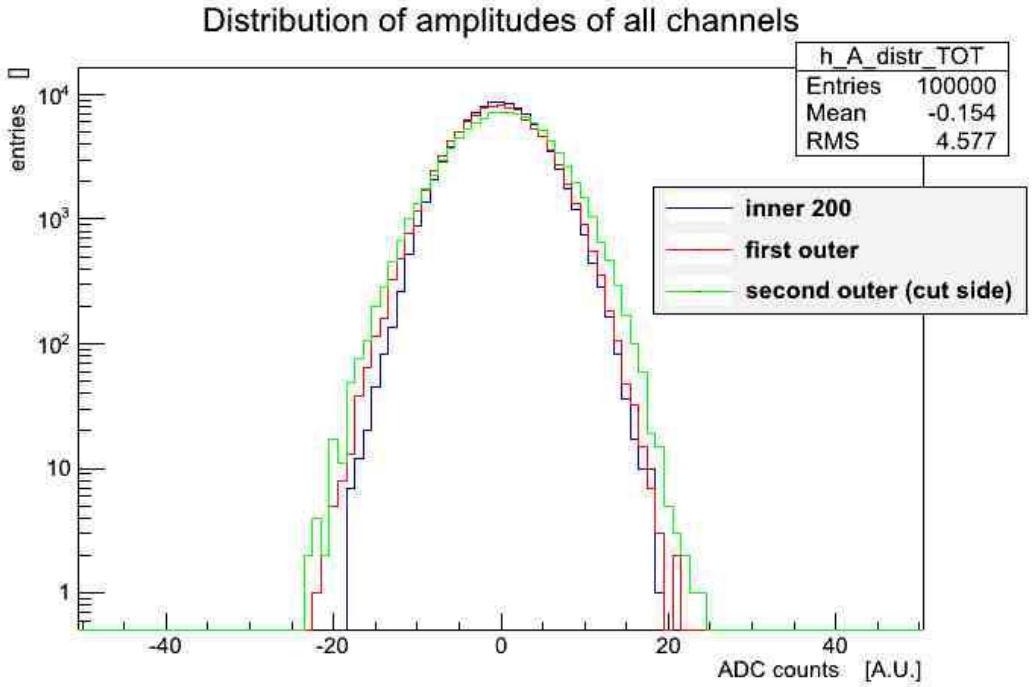




Experimental results

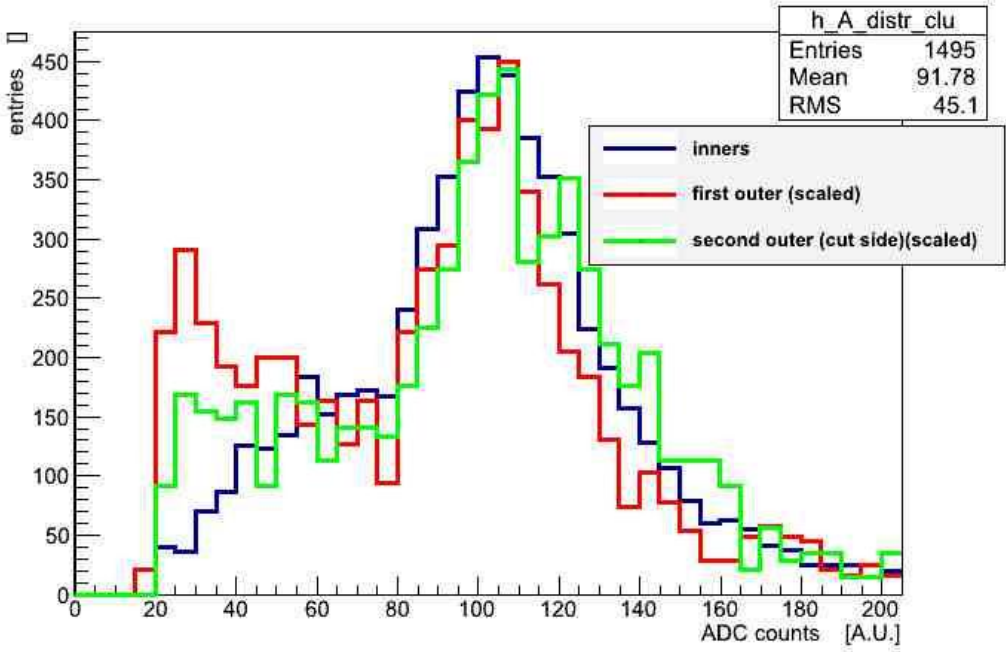
Comparison inner-outer channels: the anomaly of the outer channels

Noise distributions



Outer noise larger because of the interstrip capacitance.

Signal distributions

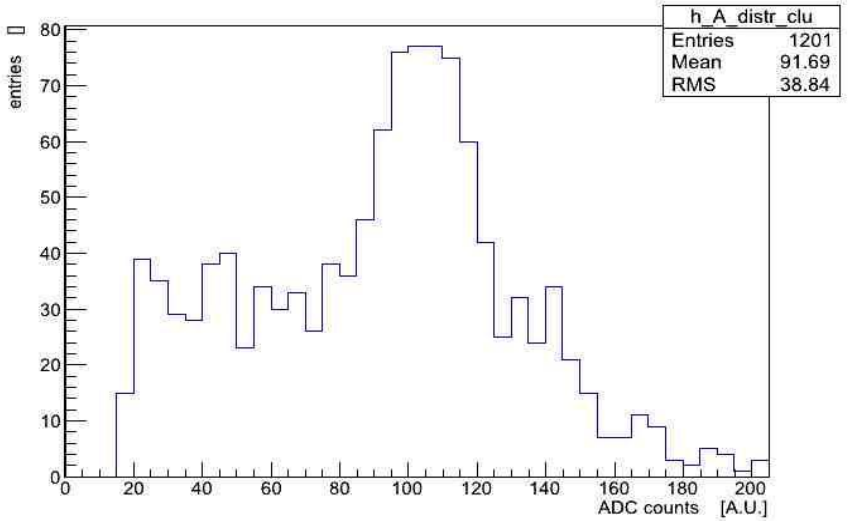


Outer signals have a tail!?!

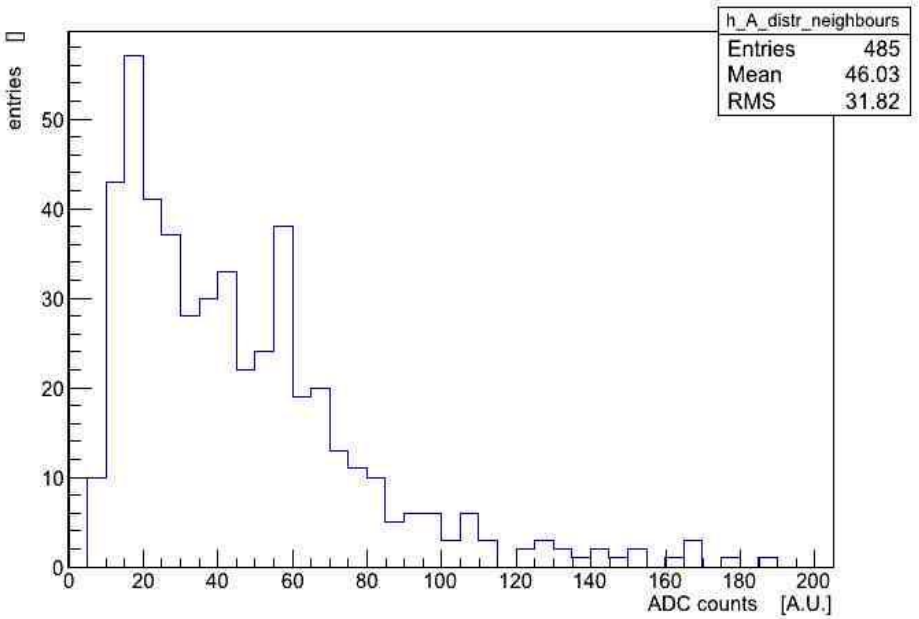
Experimental results

Comparison inner-outer channels: the anomaly of the outer channels

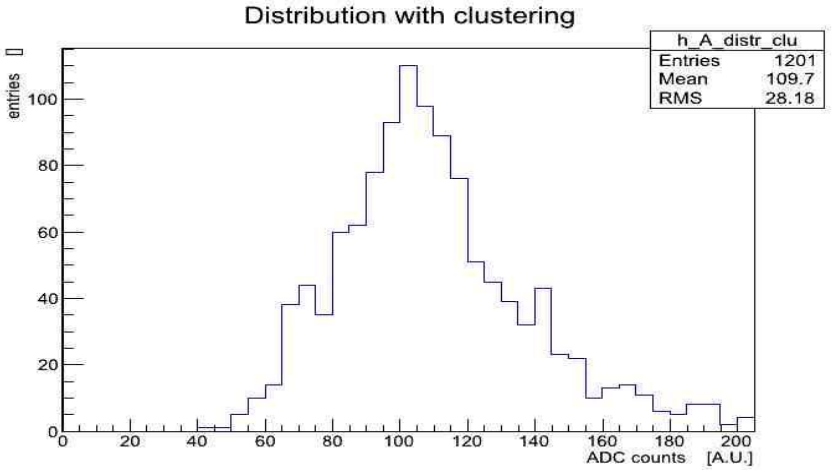
An inner channel without adding the neighbours...



The highest neighbours distribution: the tail!!!



Adding the neighbours...



The outer channels has the guard ring as neighbors, which is not read out.

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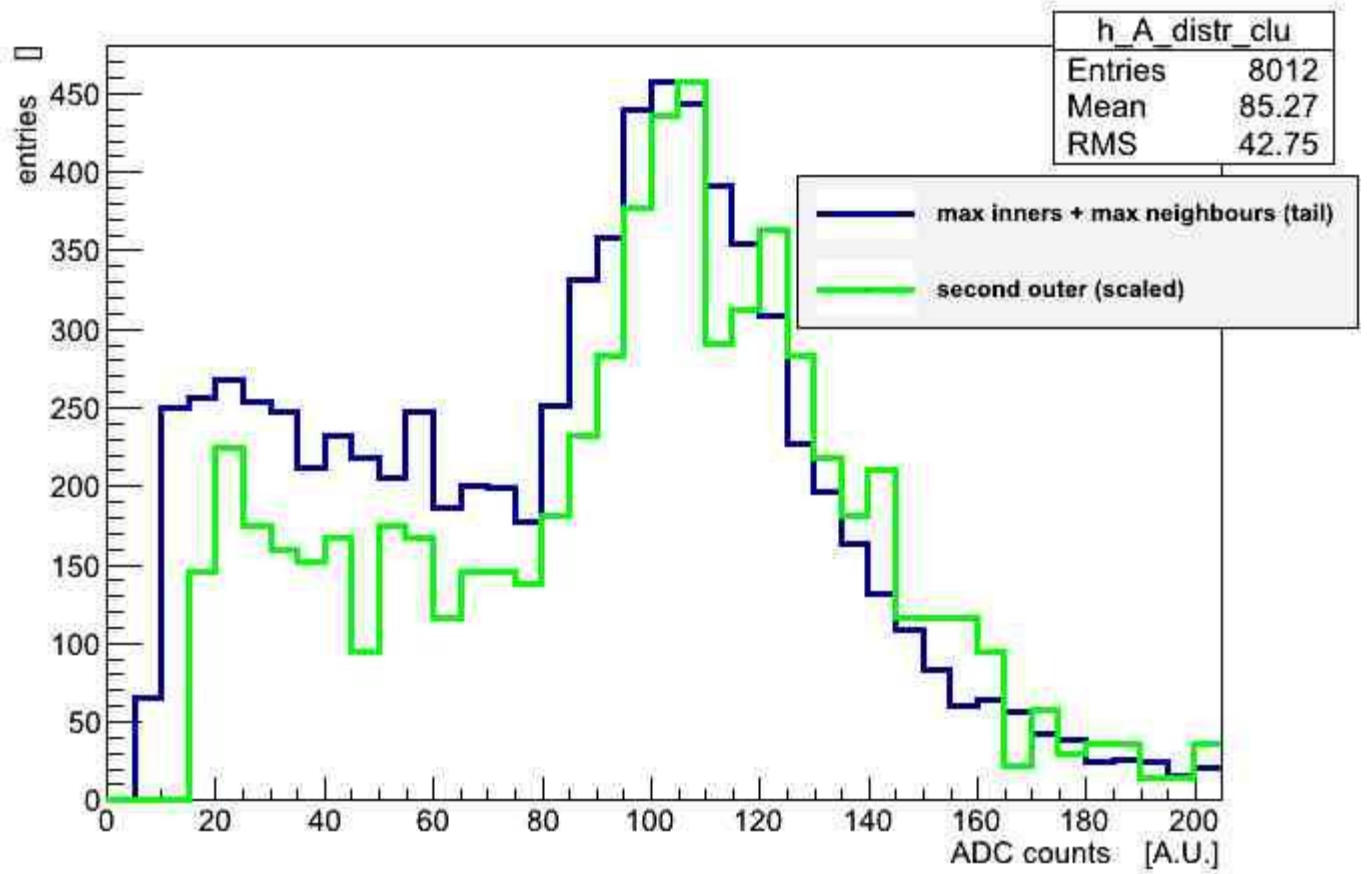
Experimental results

Comparison inner-outer channels: reconstructing the outer channels

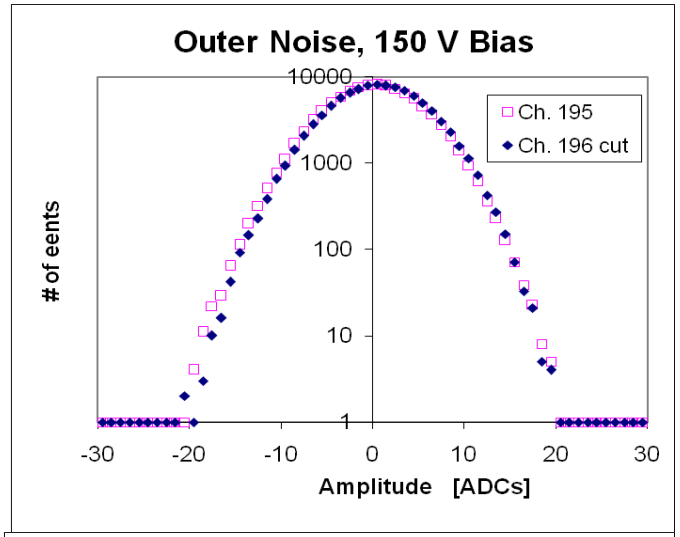


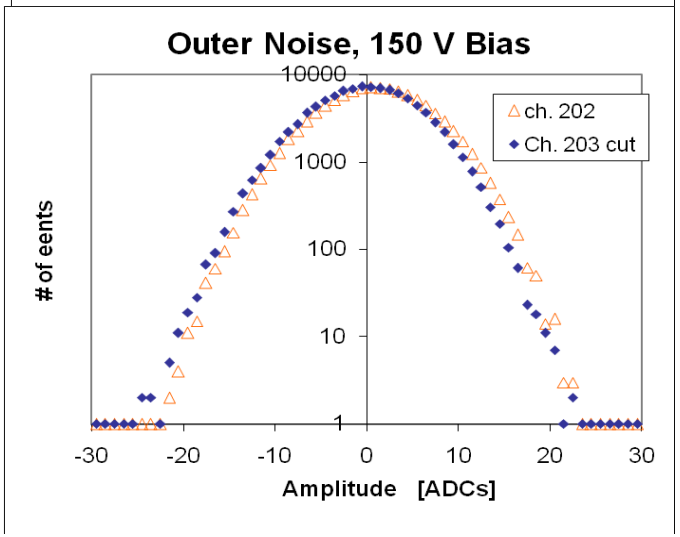
Experimental results

Comparison cut-uncut:

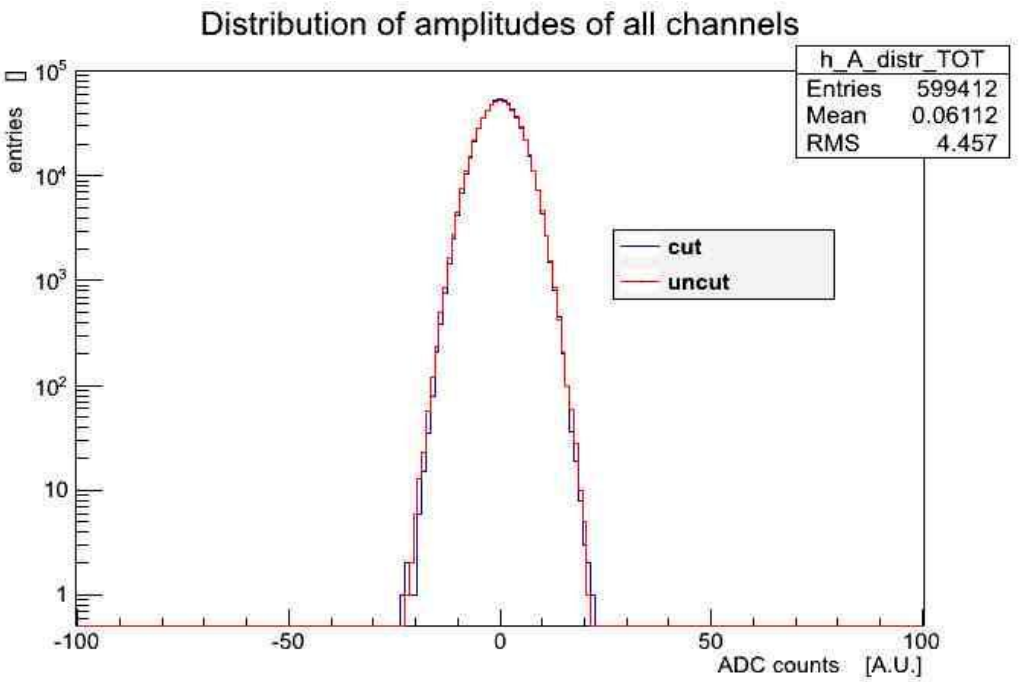
Vbias=150V

Noise:





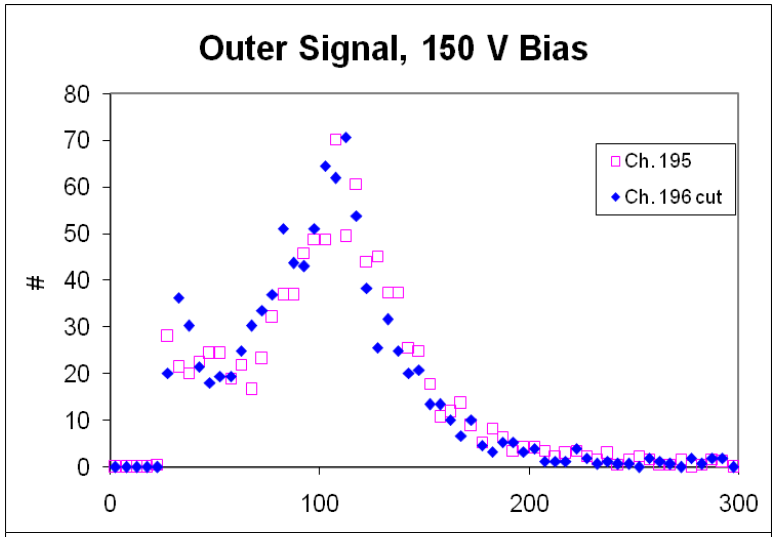
Inner noise

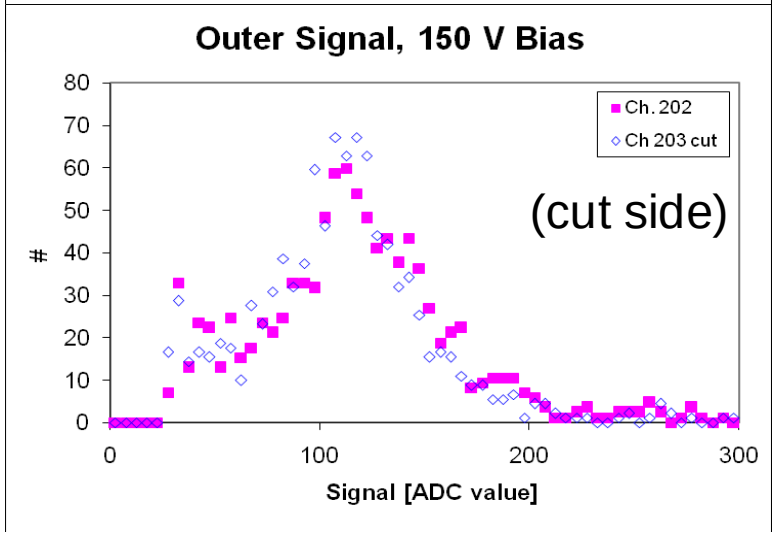


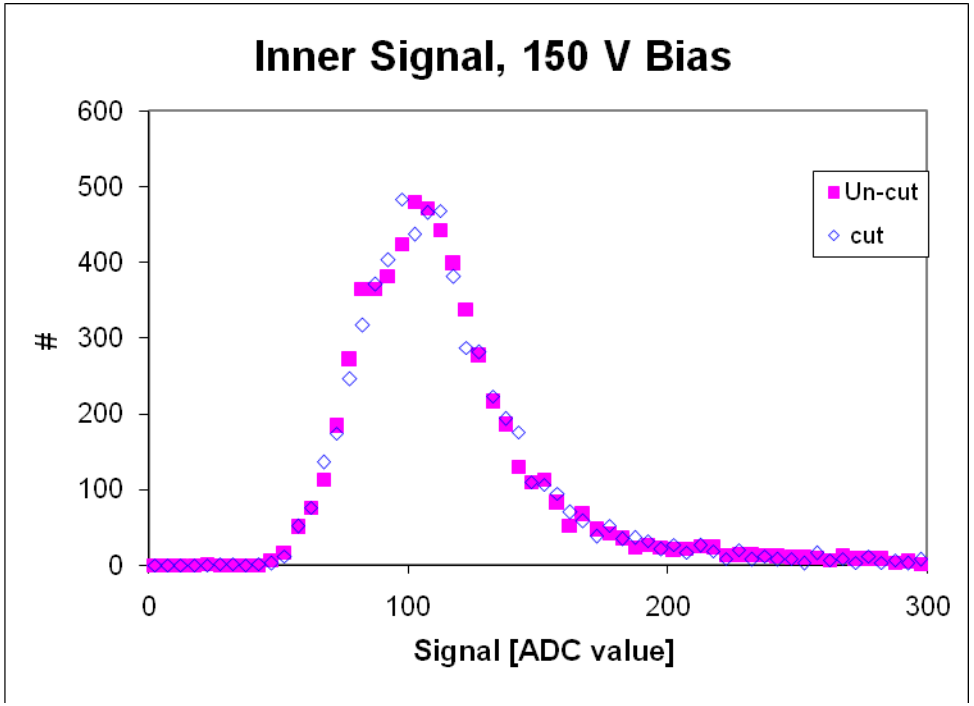
About the same sigma!

Experimental results

- Comparison cut-uncut:
  - Signal:







About the same pulse height!

Discussion

- **Limits:**
  - No calibration.
  - No separated pedestal run.
- **On the results:**
  - Width of the distribution:
    - Noise.
    - Dispersion of the path length.
    - Natural broadening of the Landau described by Meroli[4].
  - MPV decrease from 200V to 500V.
  - The border strips clearly have a tail due to the charge sharing with the bias ring, in general due to the contribution as a neighbours of channels unread-out.

[4]Meroli, http://meroli.web.cern.ch/meroli/Lectures_StragglingFunction.html

Conclusions

- **Work done:**
  - Tested ALiBaVa.
  - Tested detectors: SNR, efficiency.
  - Compared cut-uncut.
- **Results:**
  - The cut sensor is as good as the uncut one: about the same sigma and the same pulse height.
- **Future works:**
  - Calibration.
  - Test of other sensors (GLAST wonder baby, p-type).

Acknowledgements

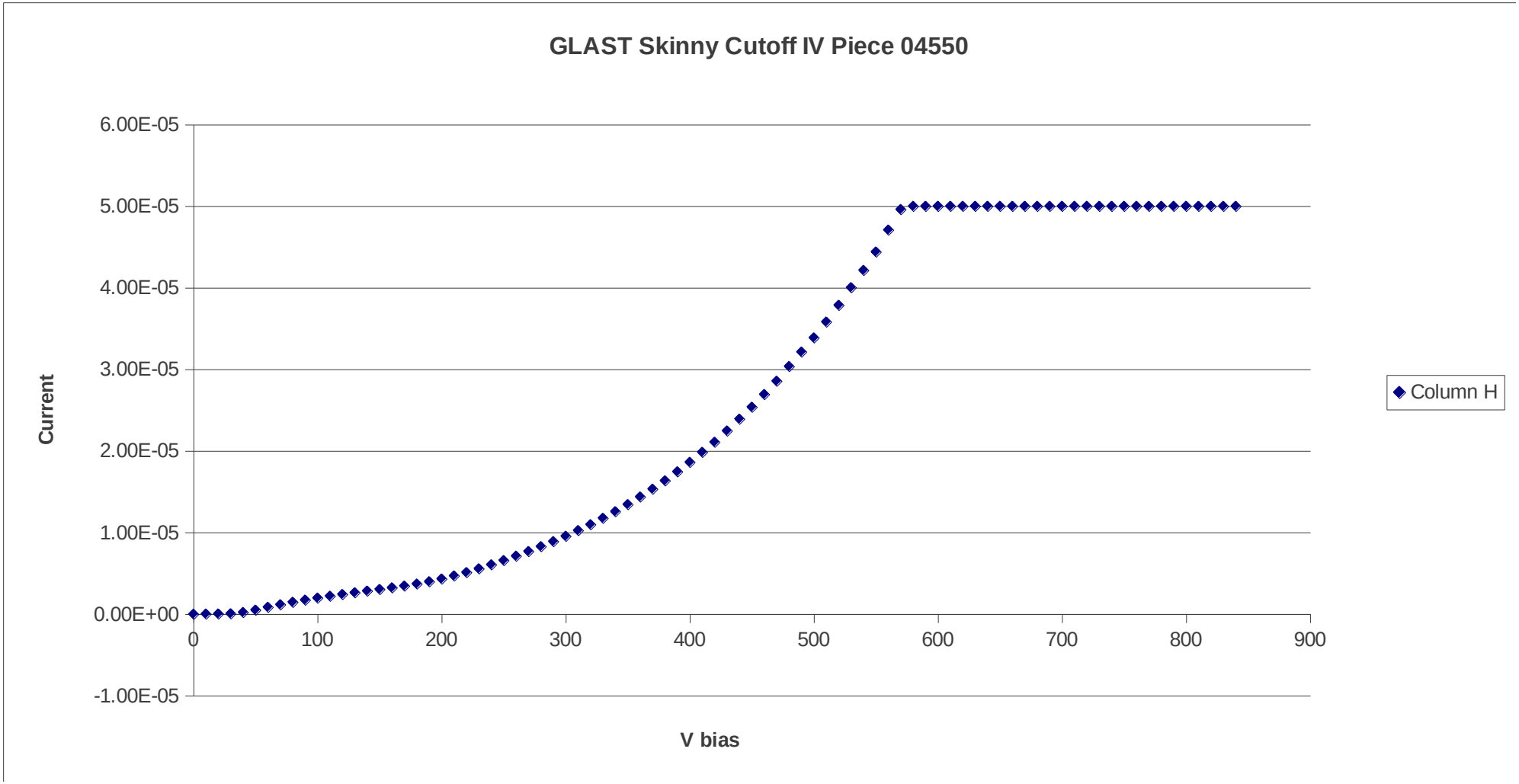
- In particular, to Nicola Pacifico.

Spares

- I-V cut sensor.
- CMS sensor results.
- GLAST uncut sensor results.
- Results vs. channel index.
- Dispersion of the path length.
- Warnings: “Teppo's effect”.
- Set-up.

Spares

I-V of sensors:



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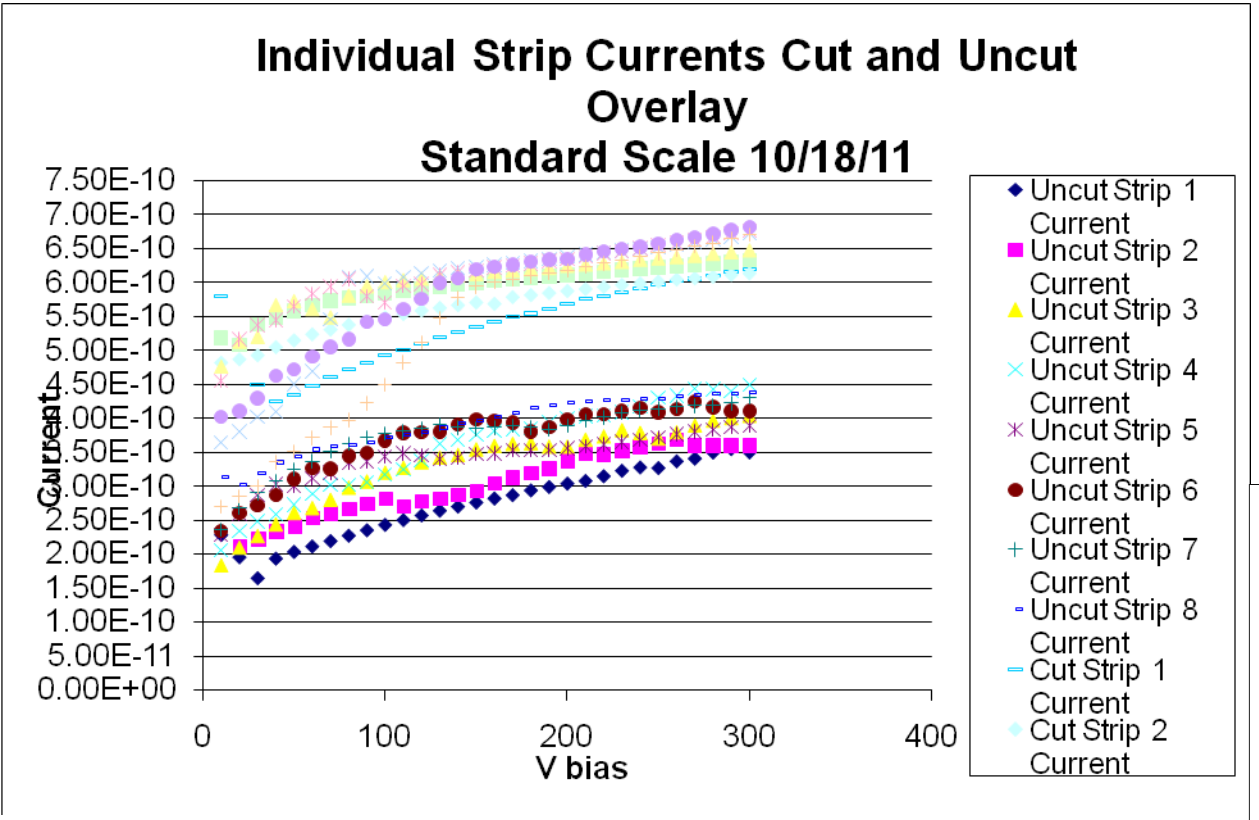
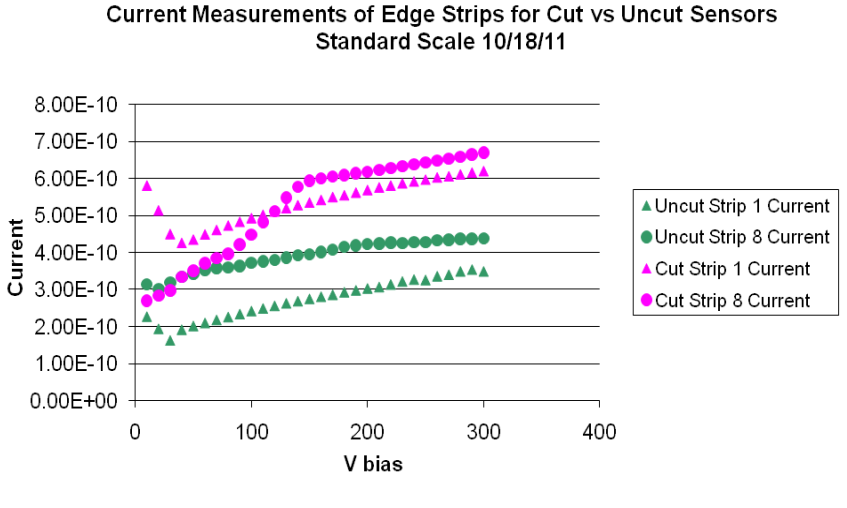
I-V of individual channels:





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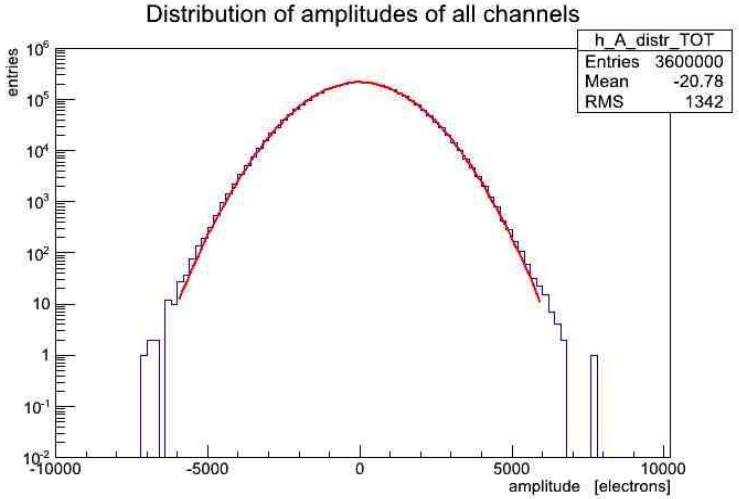
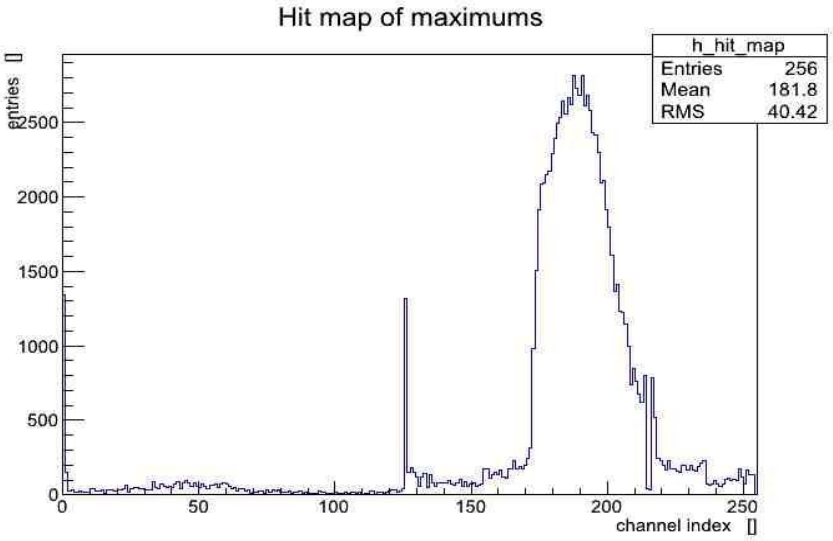
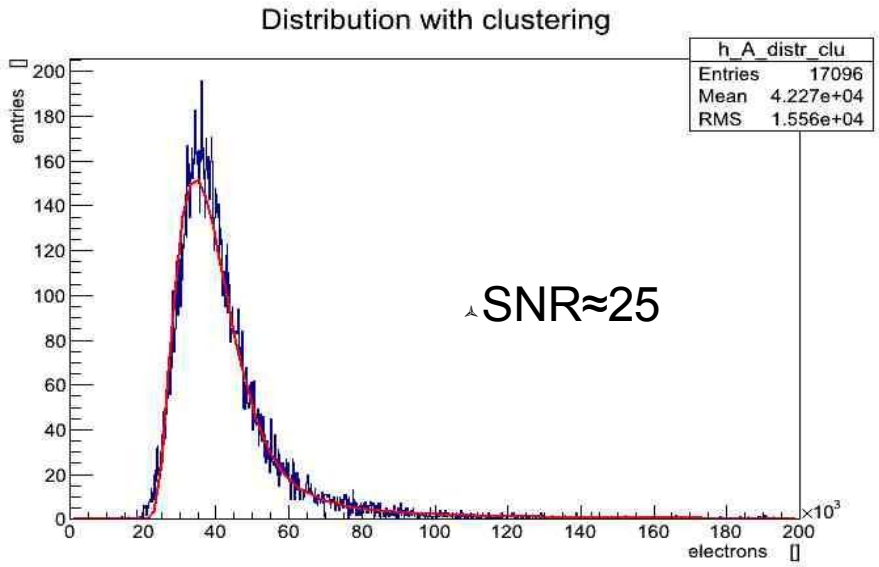
CMS sensor results:

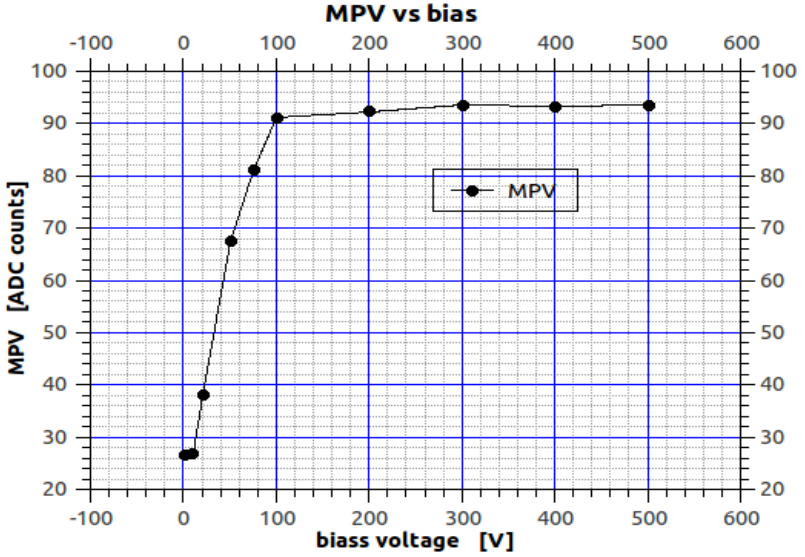




- sigma=3.3 ADCs



- SNR≈25



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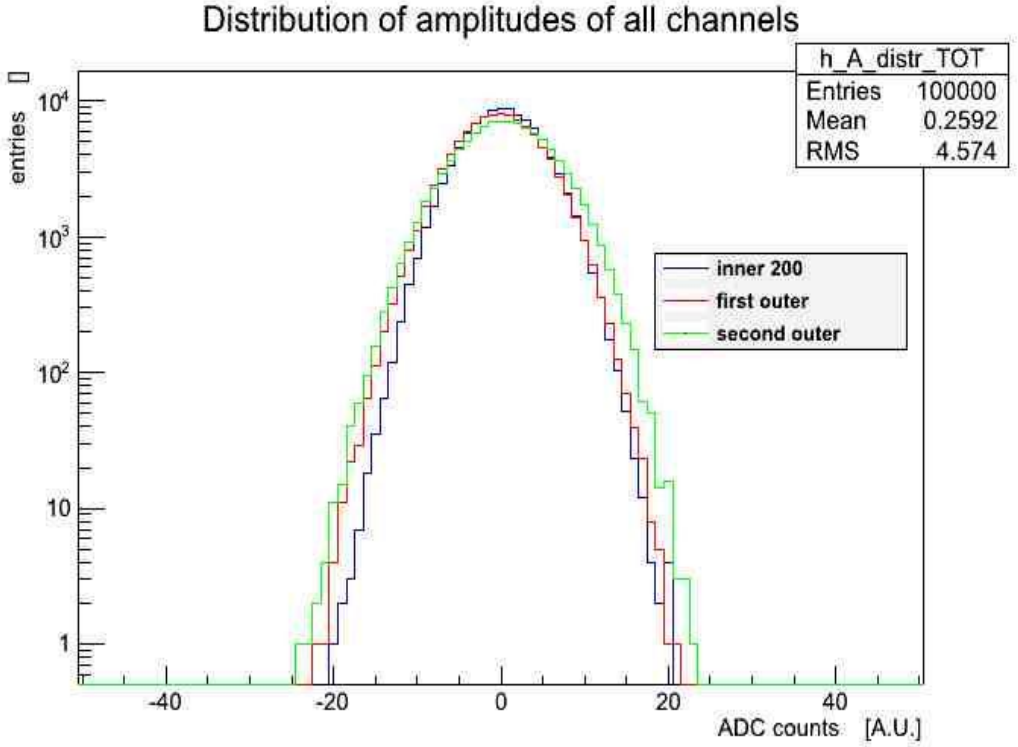
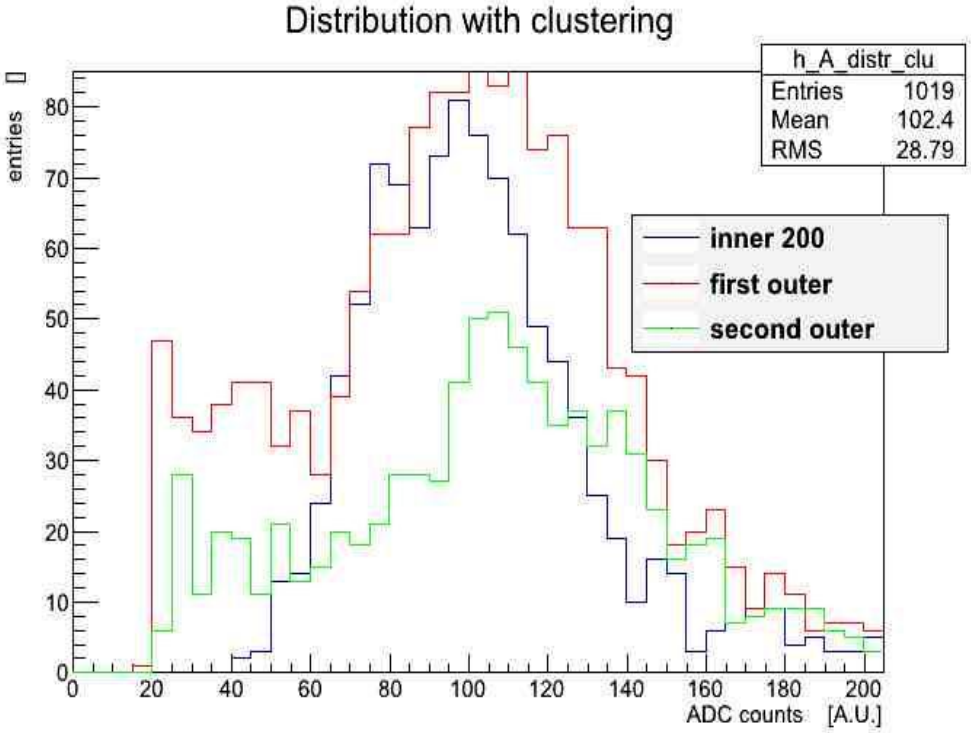
- GLAST uncut sensor results:





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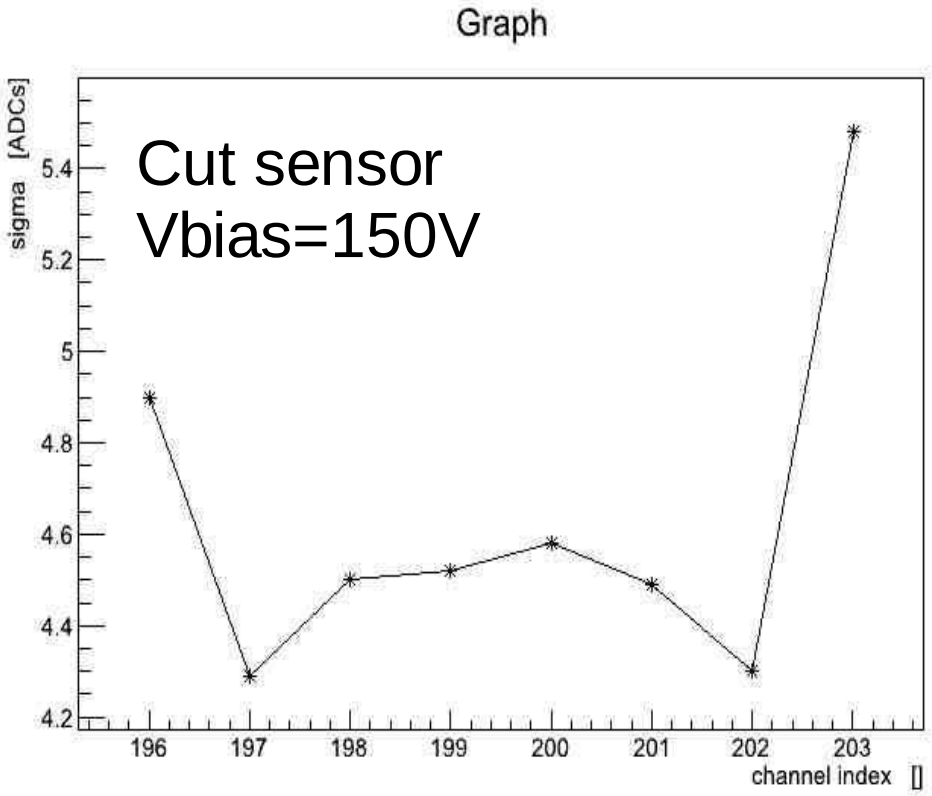
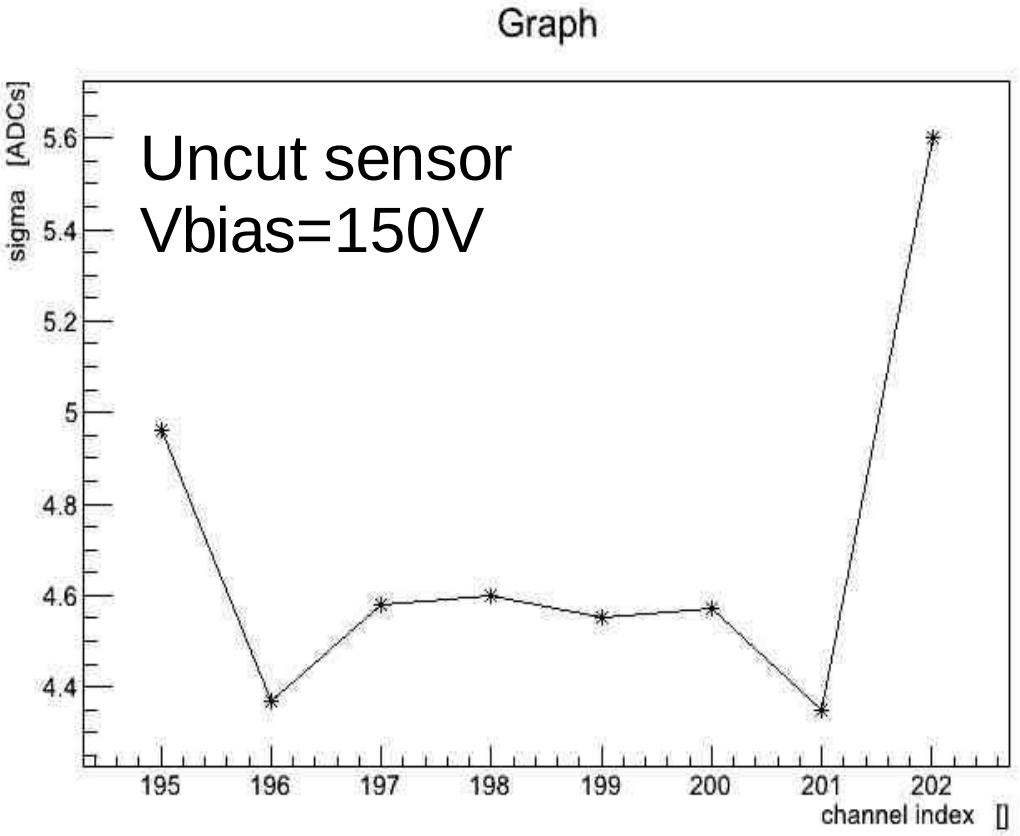
- Results vs. channel index (all channels):





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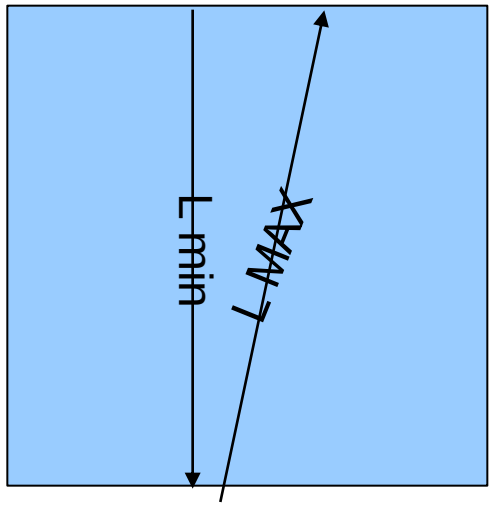
Dispersion of the path length:

L min=400um
L MAX=460.42um

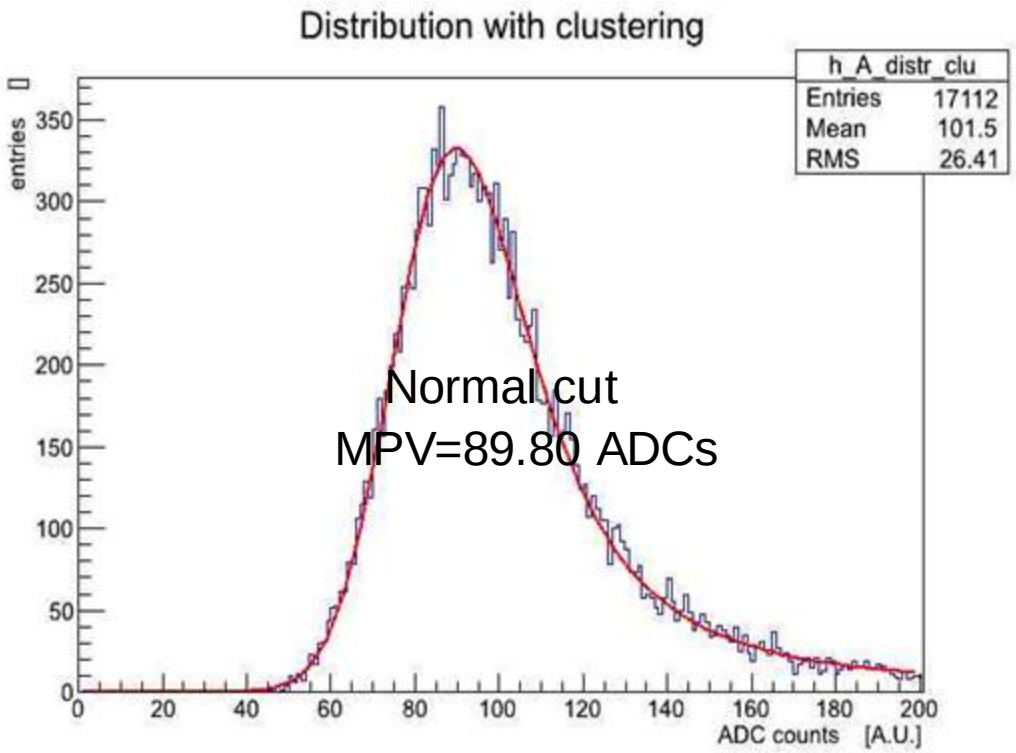
Assuming: MPV(L min)=100 ADCs
=>MPV(L MAX)=115.10 ADCs
=> Dispersion of 15.1 ADCs

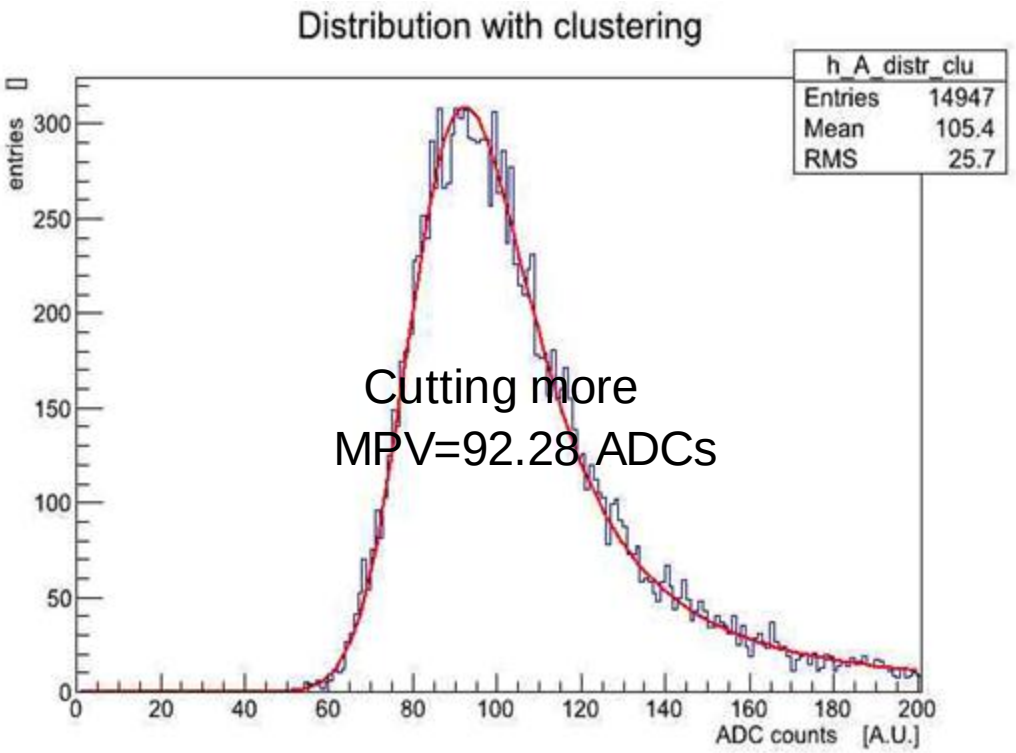


=>ENOUGH TO EXPLAIN!

Spares

- *Warnings:*
  - "Teppo's effect"[3]:
    - Be careful on the settling of the threshold: with a too high threshold, a Landau still appear and the MPV is biased (higher respect to the real).





[3] Maenpaa, Ph.D thesis, 2011.

Spares

- Set-up: