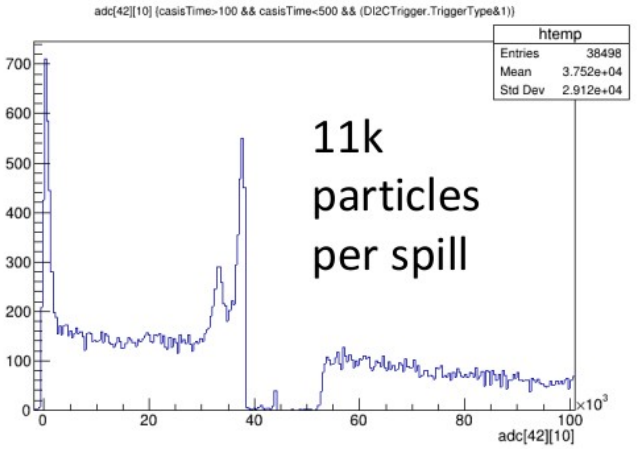
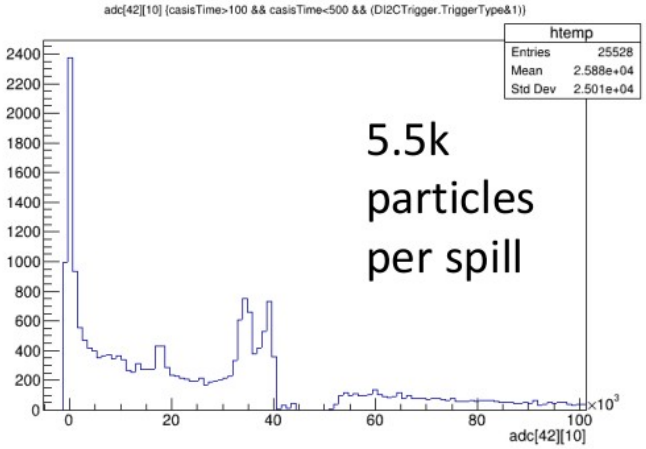
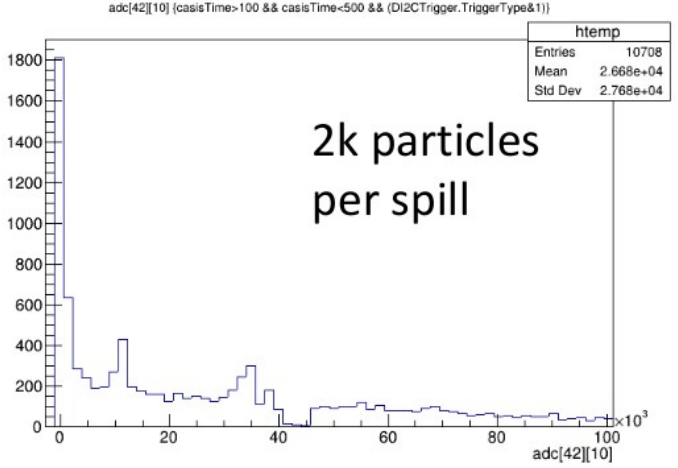
The “peak” on the HG-LG switching region: tests and solution.

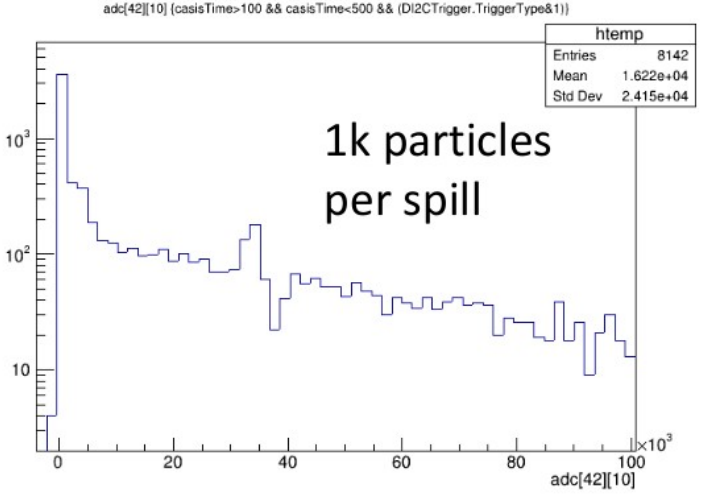
Lorenzo Pacini, 07/02/2024

Main goal: understand SPS2023 data









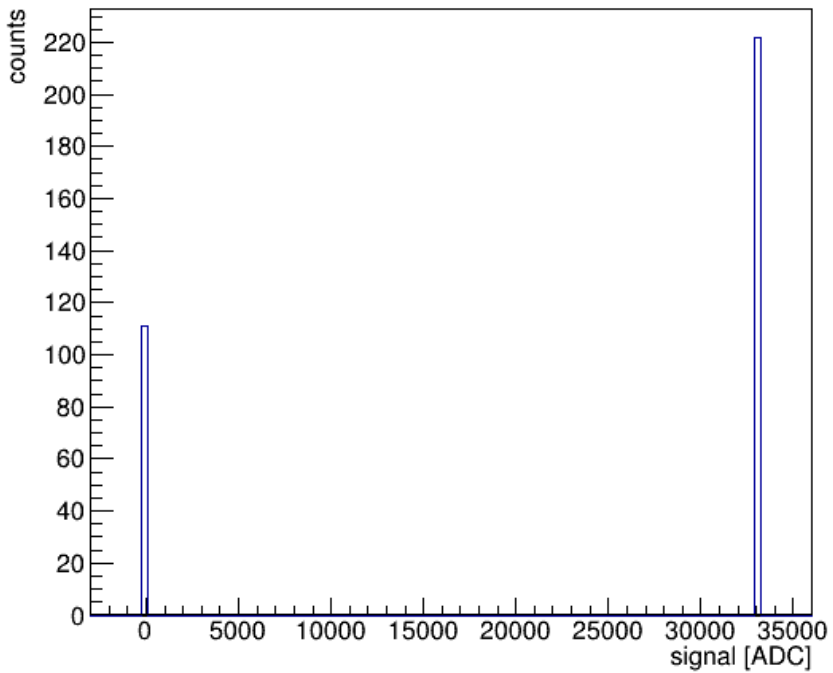
Testing with 2 LED pulses and 3 triggers

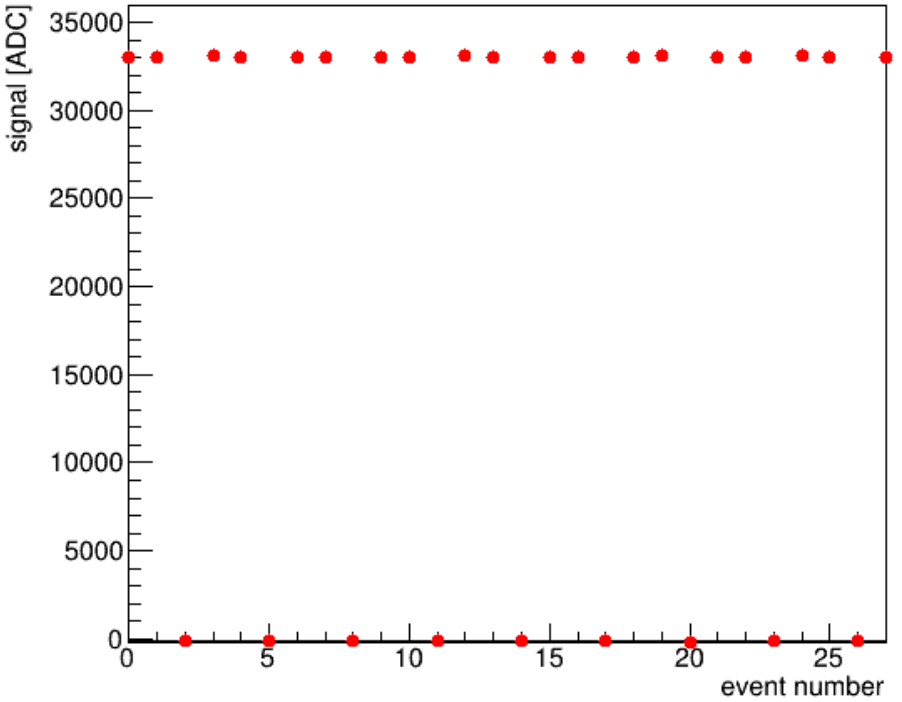
- After several tests with LED we guessed that the problem was due to a charge injection **after** the trigger and during the HOLD signal
- We implemented a signal sequence: trigger → LED pulse → trigger → LED pulse → trigger
- LED: pulse delay from 0 to 600 us, amplitude 5 V, pulse width 3 us
- An example (pulse delay 150 us): oscilloscope signals

Trigger
LED pulse
/HOLD

Hypothesis confirmation

- Channel 17, chip 8, LED delay 150 us:





- First and second triggers of each bunch are affected by the following LED pulses, the read-out signals are consistent with the peak observed in SPS2023 data.

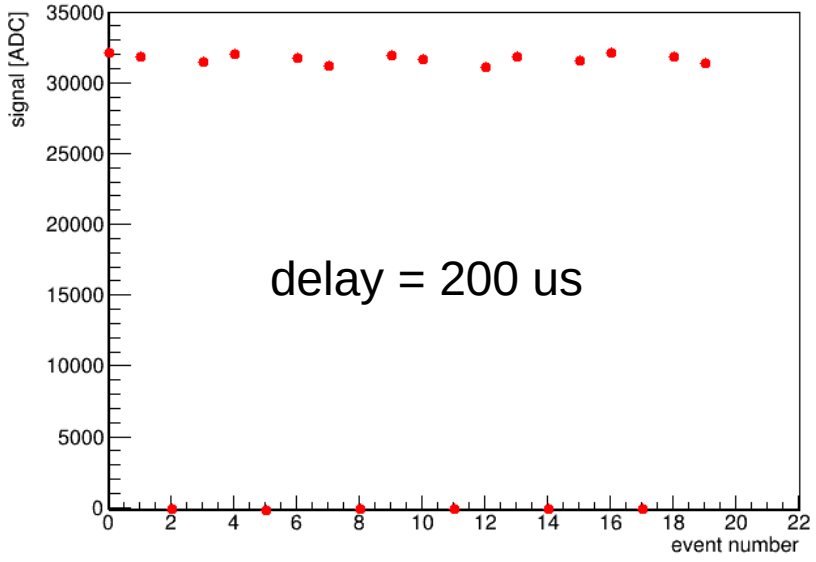
Checking the logic HIDRA signals

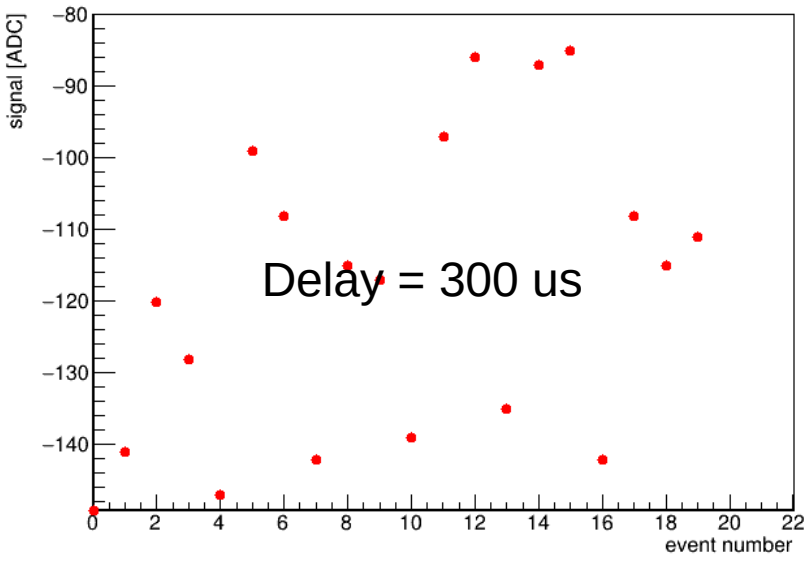
- We checked directly on the chip pins:
  - HOLD (both LVDS inputs)
  - GHOLD (both LVDS inputs)
  - CDS_R, CSA_RH, CSA_RS (both LVDS inputs)
  - CAL_EN and other CAL signals
- All the signals are consistent with the expected sequence, here few examples:

/CDS_R
/CSA_RH
/CSA_RS

Peak position vs LED delay

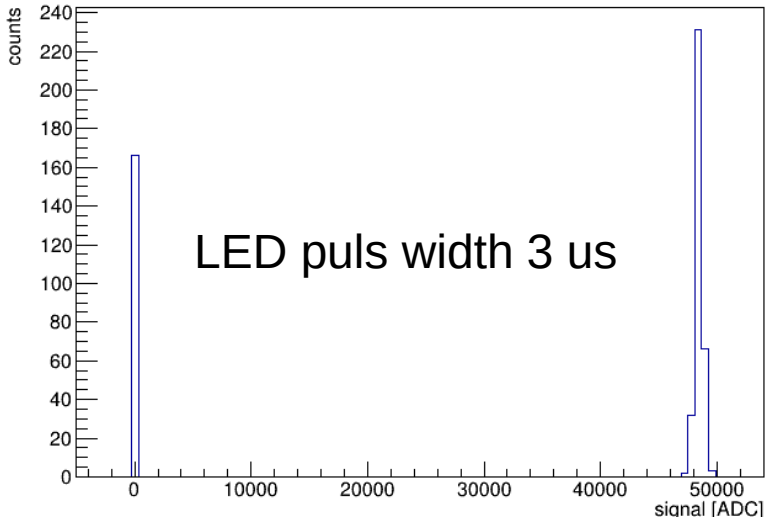
- We changed the LED delay (3 triggers 2 LED pulses configuration):
  - the peak values is almost the same for each delay up to a specific value (d_M).
  - If the delay > d_M the peak is not present.
  - d_M depends on the channel number, particularly in the channel conversion time.

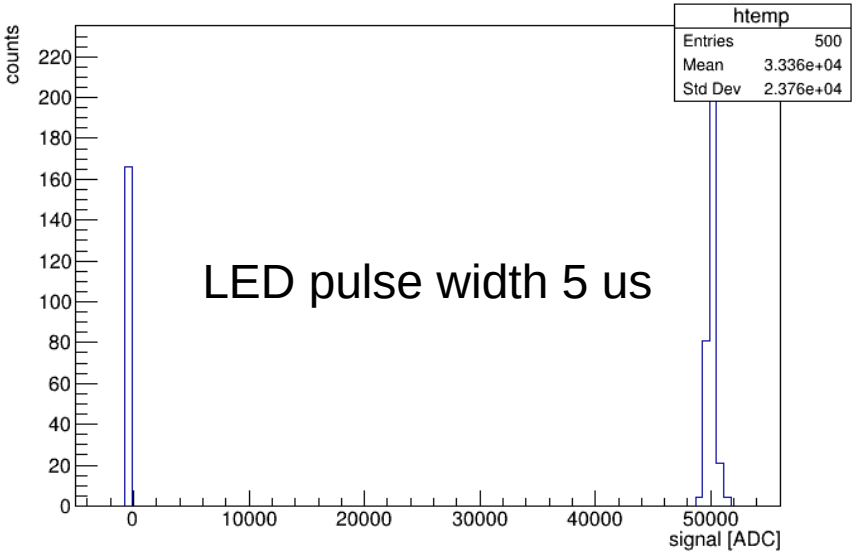




Removing GHOLD

- Removing the GHOLD could allow the chip to switch gain after the HOLD.

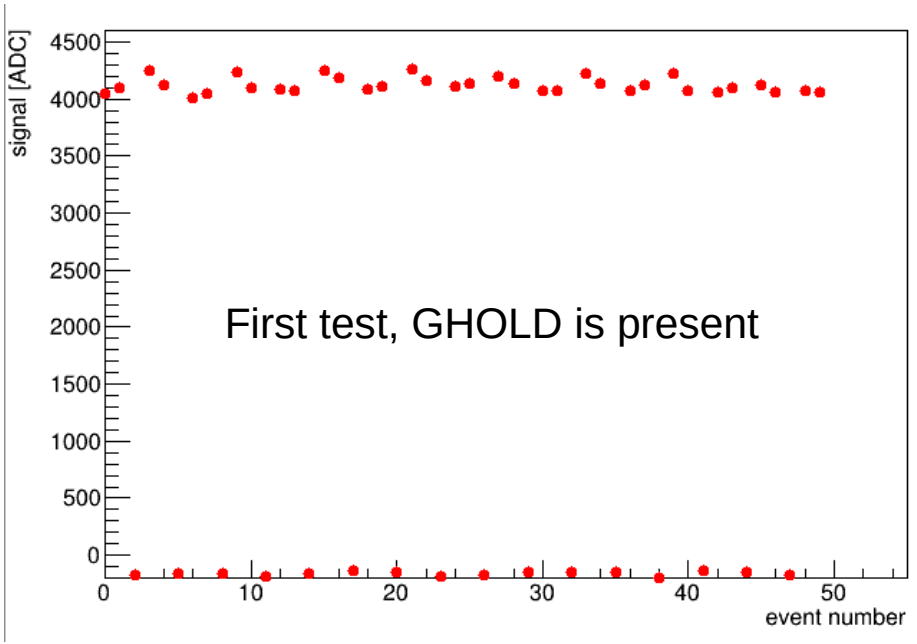


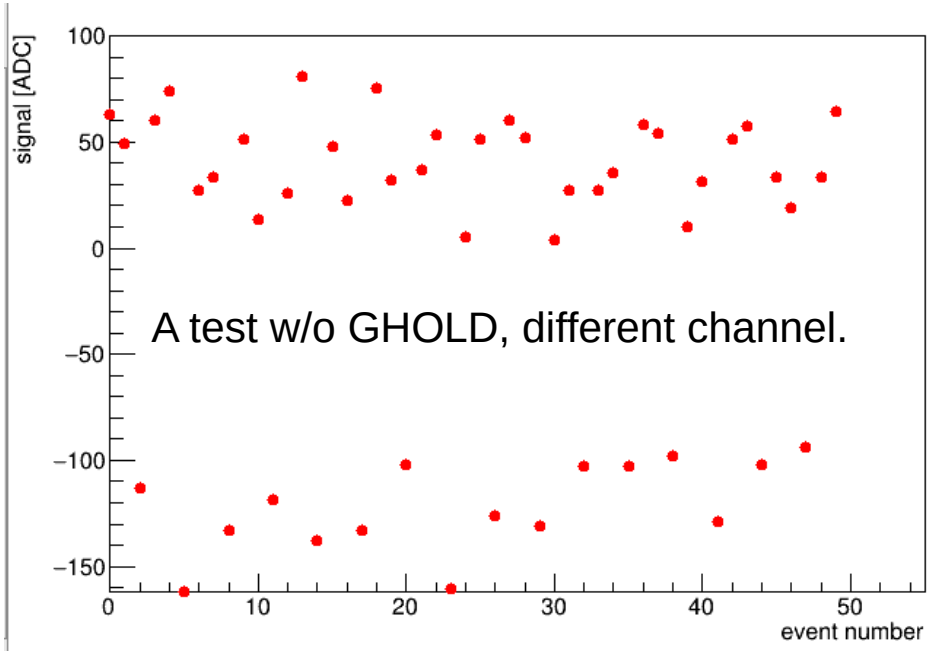


- The value of the signals increase (35k → 50k), these slightly depend on the injected charge values, d_M remains the same.
- The channel is in low gain! (by checking the low gain flag on the data).

LED signals in HG region

- We tested by injecting signals in HG (i.e. 1 us pulse width)

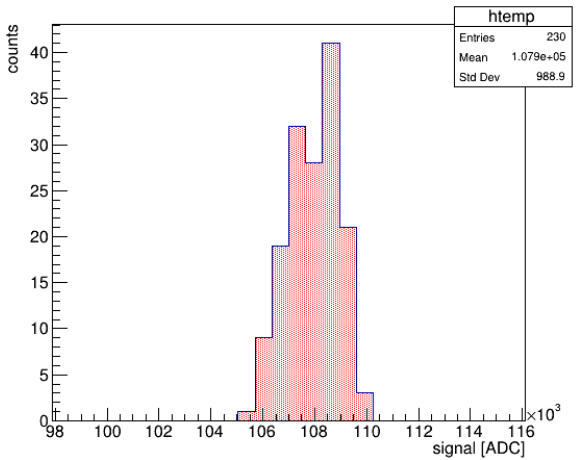




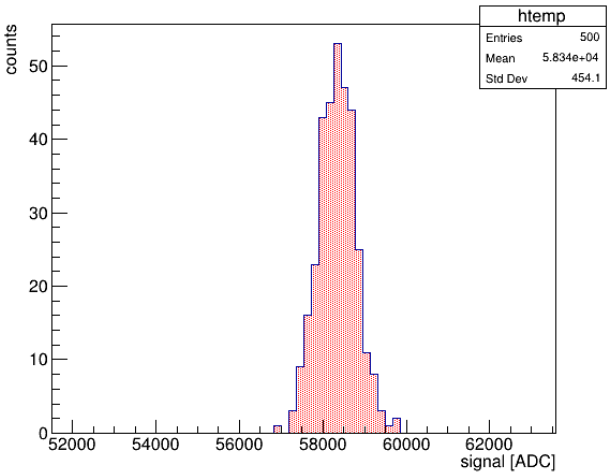
- A effect is present but the value is not consistent among different tests and channels.
- It is not clear if GHOLD affects the HG problem.

Test with two LED pulses

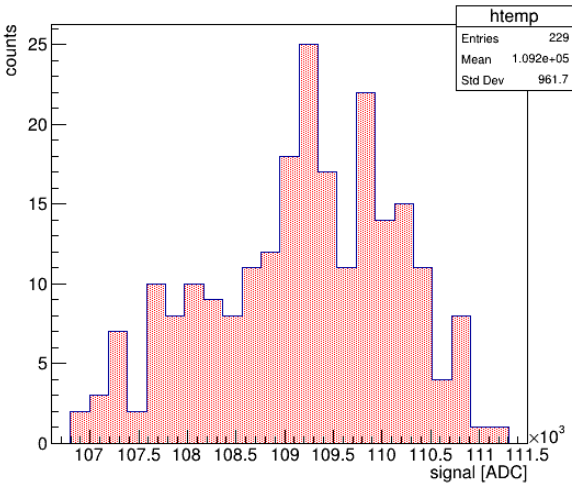
A LED pulse is sent with delay = 0, pulse width 3 us.



A LED pulse is sent with delay = 150 us, pulse width 3 us.



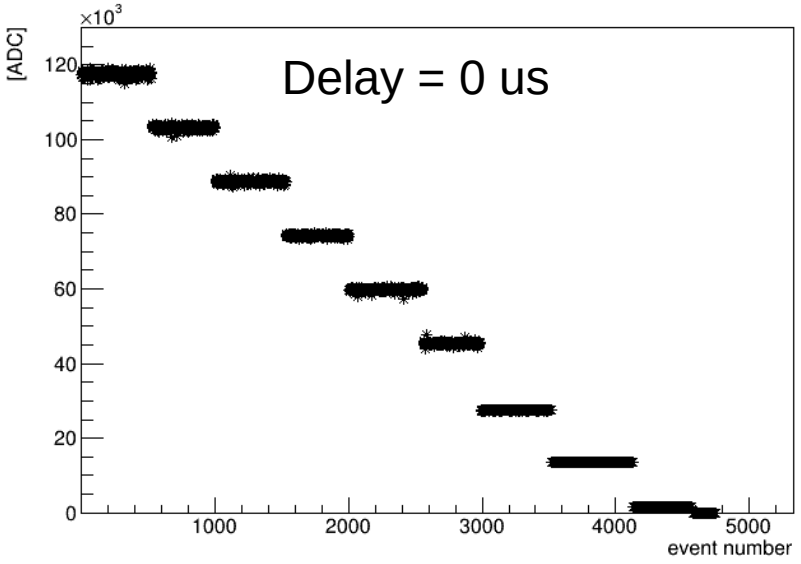
A LED pulse is sent with delay = 0, a second is sent with delay = 150 us, pulse width 3 us.

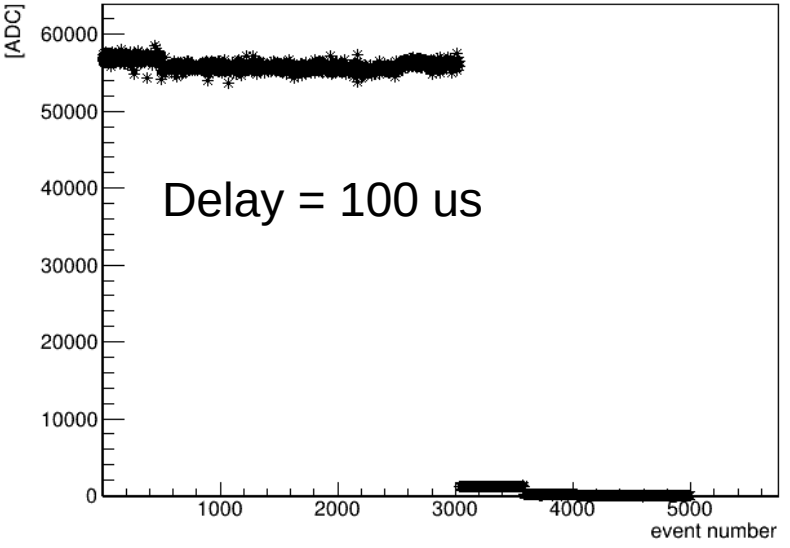


- Sending a delayed LED pulse after a standard LED pulse, the signal is the same of having a single LED pulse with delay = 0.

Check the linearity of this effect

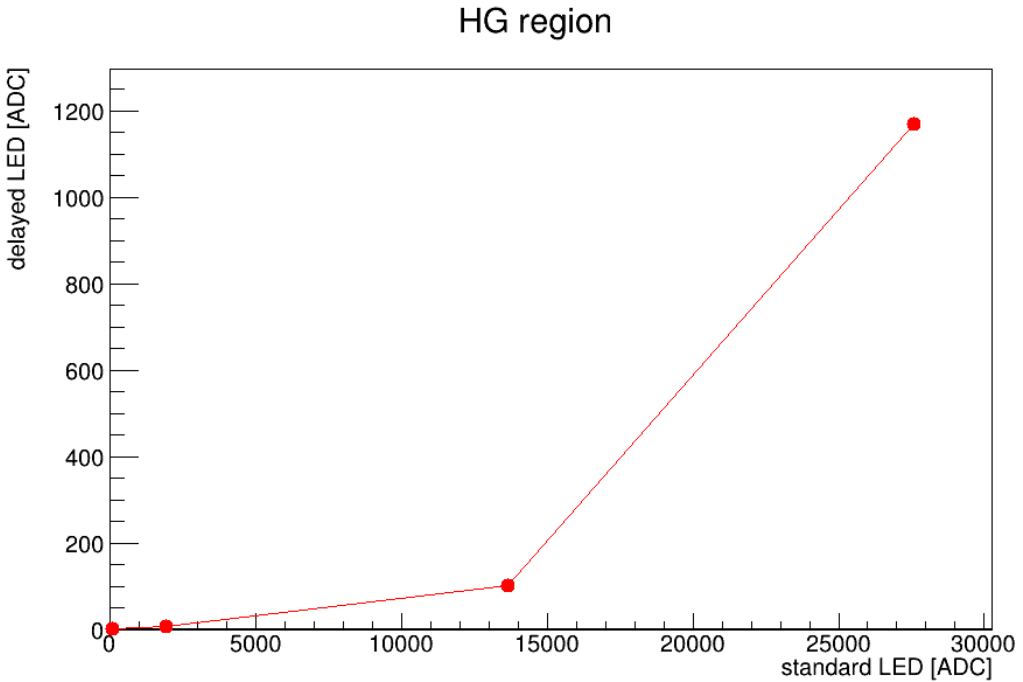
- Short LED pulses (~300 ns), at high frequency (2.5 MHz).
- The number of LED pulses is decreased for each ~500 events to scan a large range of signals
- The acquisition is done with delay = 0 (used for calibration) and delay = 100 us (the actual measurement).





Check the linearity of this effect (2)

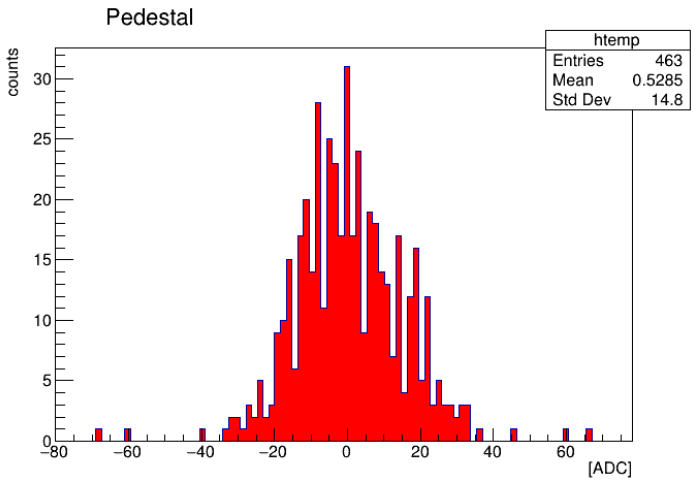
- In LG region: the signal due to delayed LED is clearly not proportional with the injected light.
- In HG region we check the correlation between delayed and standard LED pulse measurements

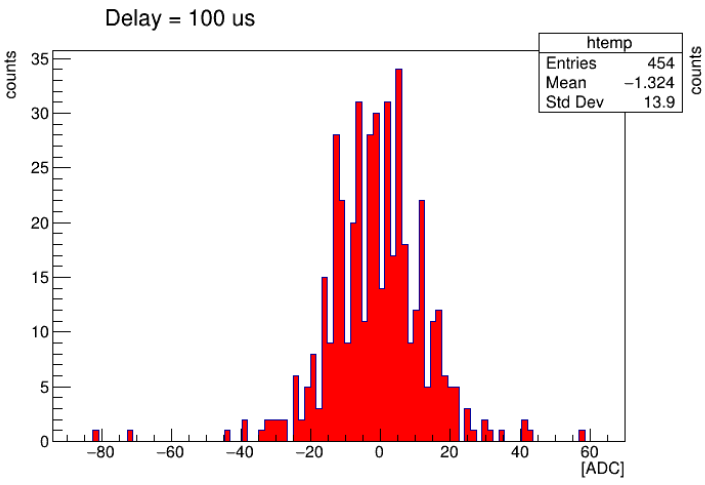


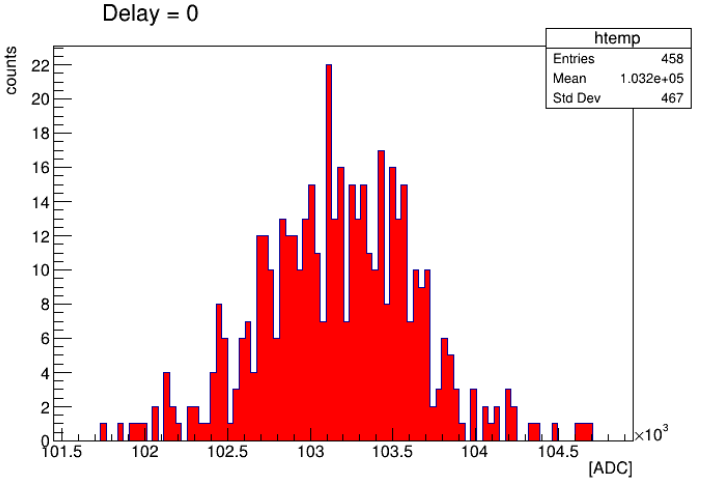
- Even in HG the delayed signal is not directly proportional with the injected charge.

Preliminary solution of the problem

- Solution suggested by Gianluigi and Nicola: to send the CSA rests during the HOLD
- Monica adjusted the firmware to send CSA_RST (H and S) after the HOLD rising edge (100 ns). The resets are high until the HOLD falling edge.
- Preliminary tests: the peak disappears, the noise is reasonable, the LED signal with delay = 0 is consistent with the expected one



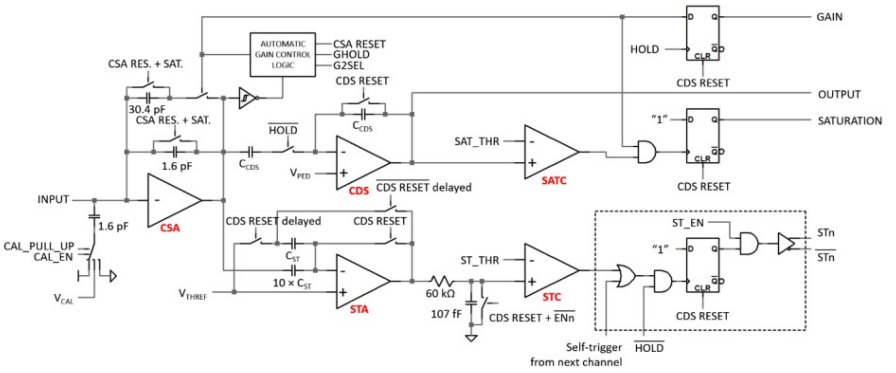




- Great results!

Summary of tests.

- The “peak” is due to charge injection (in LG range) during the HOLD.
- The rate and the delay of the charge injection does not strongly affect this feature.
- The feature is present if the charge injection delay is minor of the channel conversion time.
- By removing the GHOLD signal: the value of the signal increases and the channel is in low gain.
- Even if the injected signal is in HG range, some effect are present: the peak position is not proportional with the injected charge.
- The problem seems solved by sending the CSA_RST (H+S) during the HOLD.
- 2024 beam tests: we will use adjusted firmware.



Two questions:
2) which is the cause of the problem?
1) without GHOLD, it seems that the gain change when the HOLD is high, how is it possible?

Backup

Laboratory test set-up

- A blue LED injects light inside a LYSO cube coupled with PDs. LED parameters:
  - amplitude → 5 V
  - Pulse width → from 1 us to 6 us.
  - HG-LG threshold corresponds to 1.2 us pulse.
- The main goal of the test is to check the following hypothesis related to the peak around 35k:
  - The effect depends on the rate.
  - It is related to the base line shift.
  - It is related to the charge obtained from the previous events.
- Very long story short (see next slides for details):
  - this problem is present even with a single charge injection thus it is not related to previous charge injections and baseline shifts,
  - the peak is due to a charge injection after the trigger, even with a time distance of > 50 us.

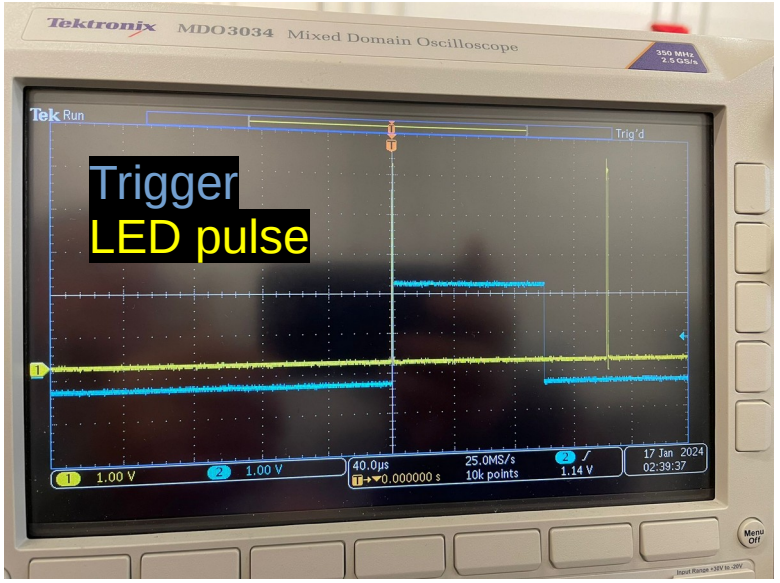
d_M value for different channels

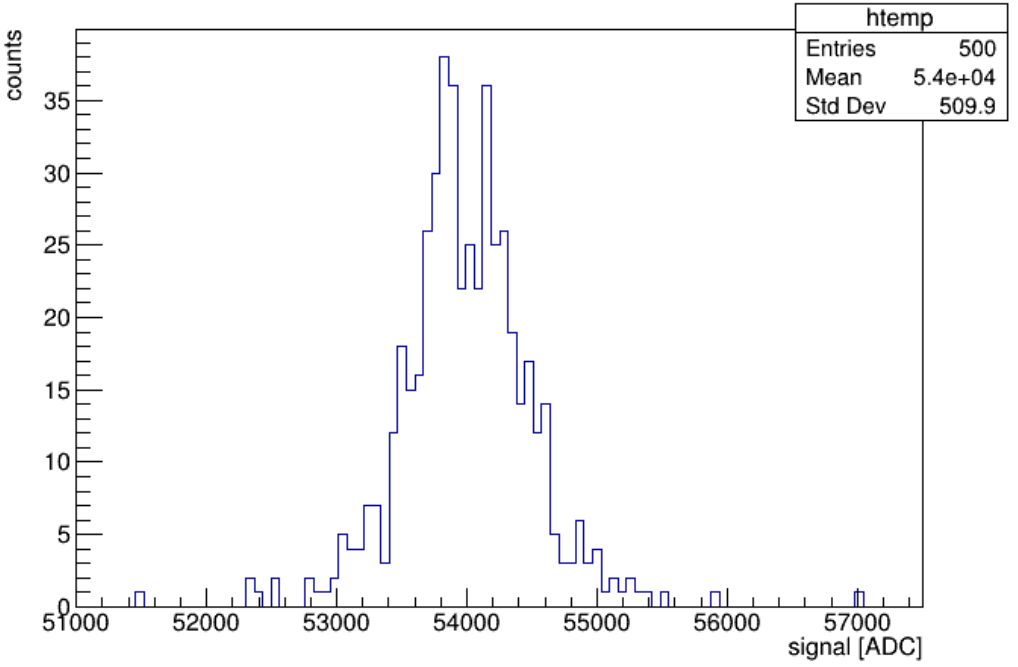
- Hypothesis: d_M is related to the (ADC) conversion time of the channel.
- Board config: 3 ADCs, 4 chips for each ADC, 14 channels for each chip.
- Conversion time for each channel ~ 7.2 us
- Chip 8 channel 17 → 1st chip of the 3rd ADC, 18th channel
  - Measured d_M ~ 120 us
  - Computed (17*7.2) d_M ~ 120 us
- Chip 9 channel 18 → 2nd chip of the 3rd ADC, 19th channel
  - Measured d_M ~ 320 us
  - Computed ((18+24)*7.2) d_M ~ 300

Trigger
LED pulse
Analog output

Test with single trigger and LED pulse

- Even with a single trigger followed by a single LED pulse the signals are in the same region.
- Channel 18, chip 9, pulse width = 3 us.





All events have gain flag = 1!