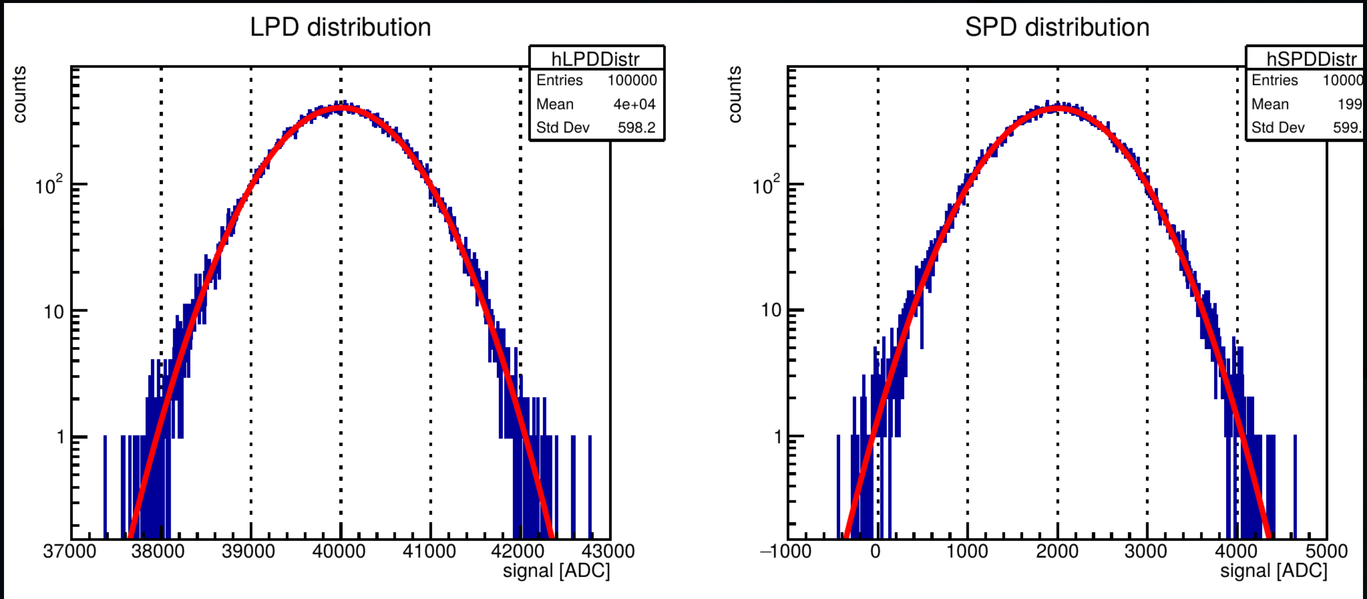
How to measure the PD ratio with LABEC data: simple toy MC approach

How to compute the PD ratio

- It seems a trivial question but, having LPD and SPD signals, what is the best method for computing the "true" PD ratio?
- Several solutions:
  - For each events we compute LPD/SPD, we obtain a distribution, then we use the peak or mean of the latter.
    - It works only if the noise is $<<$ than the signals (see next slide)
  - We fit the 2D plot which represents the LPD-SPD correlation:
    - It works only if the signal range is $>>$ than the noise.
  - We compute the mean or peak of LPD and SPD distributions:
    - It works well when the signal (here the beam) is stable.

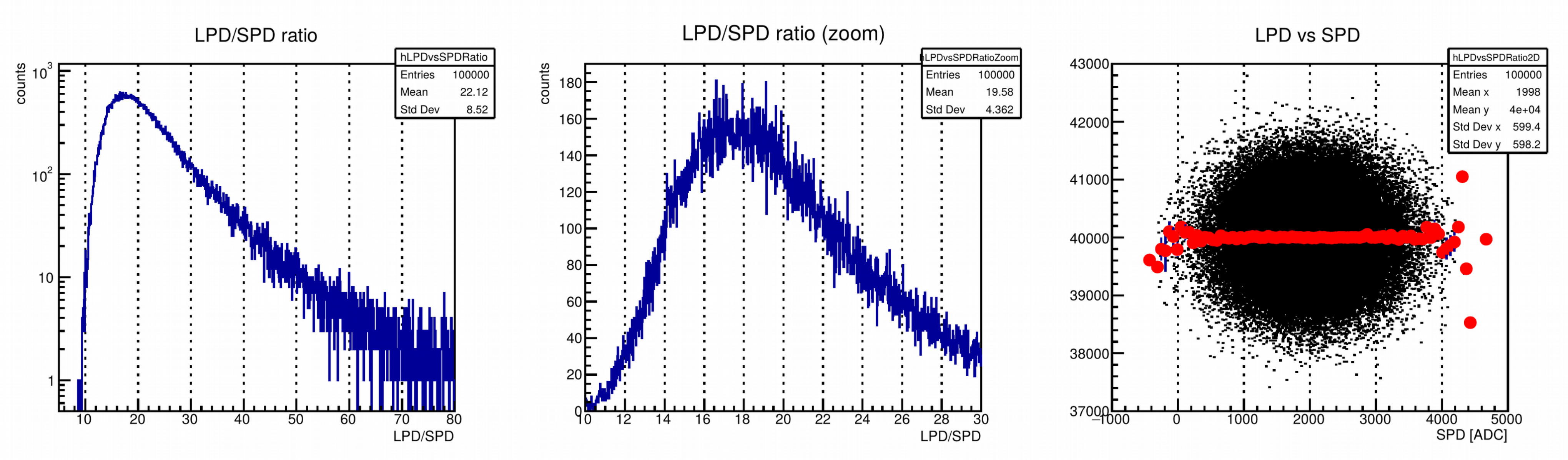
First toy MC test.

- Simulating a constant signal, Gaussian noise on LPD and SPD. Parameters
  - LPD mean signal: 40k ADC
  - LPD noise = SPD noise = 600 ADC (correlation between LPD and SPD is not included)
  - LPD/SPD true ratio = 20



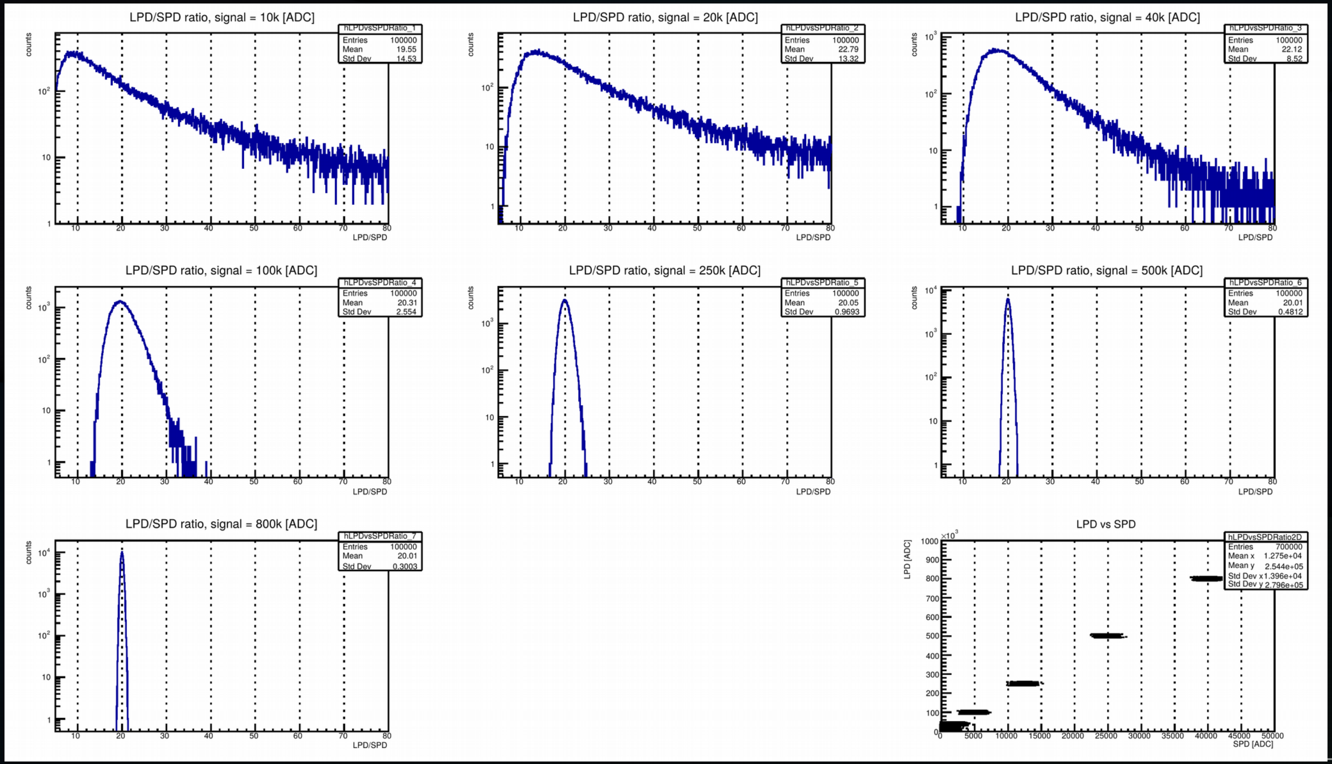
Ratio distribution

- The distribution obtained by event by event ratio is not a gaussian, it is a Cauchy distribution:
  - The peak and the mean are not equal true ratio: the ratio distribution is a distribution which has not the mean defined. The median is ~ 20 but it is not a proper statistical estimator.
  - The correlation plot does not work for "monochromatic signal".



Try with different LPD signals

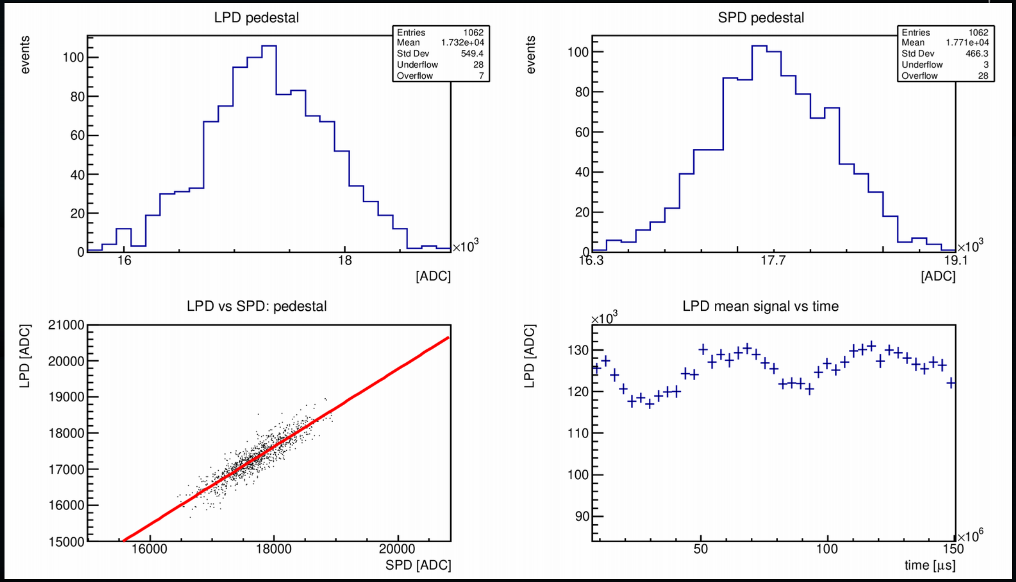
- Same calculation with different LPD signals.
- We can use the ratio distribution only for LPD $>=$ 100k ADC (LABEC configuration).



Improved MC

- MC is improved using LABEC data (by Pietro):
  - We selected a “good” BT data set.
  - LPD and SPD noise value and correlation,
  - beam stability measured with LPD.
- Physics signal is not simulated, it is obtained from the beam stability graph.
- Noise is replicated with this procedure:
  - Measure the proper noise of LPD: NpL^2 = NtL^2 – (C*NtS)^2
  - SPD: random number according a Gaus with RMS = to NtS
  - LPD: random number according the NpL + SPD signal * C

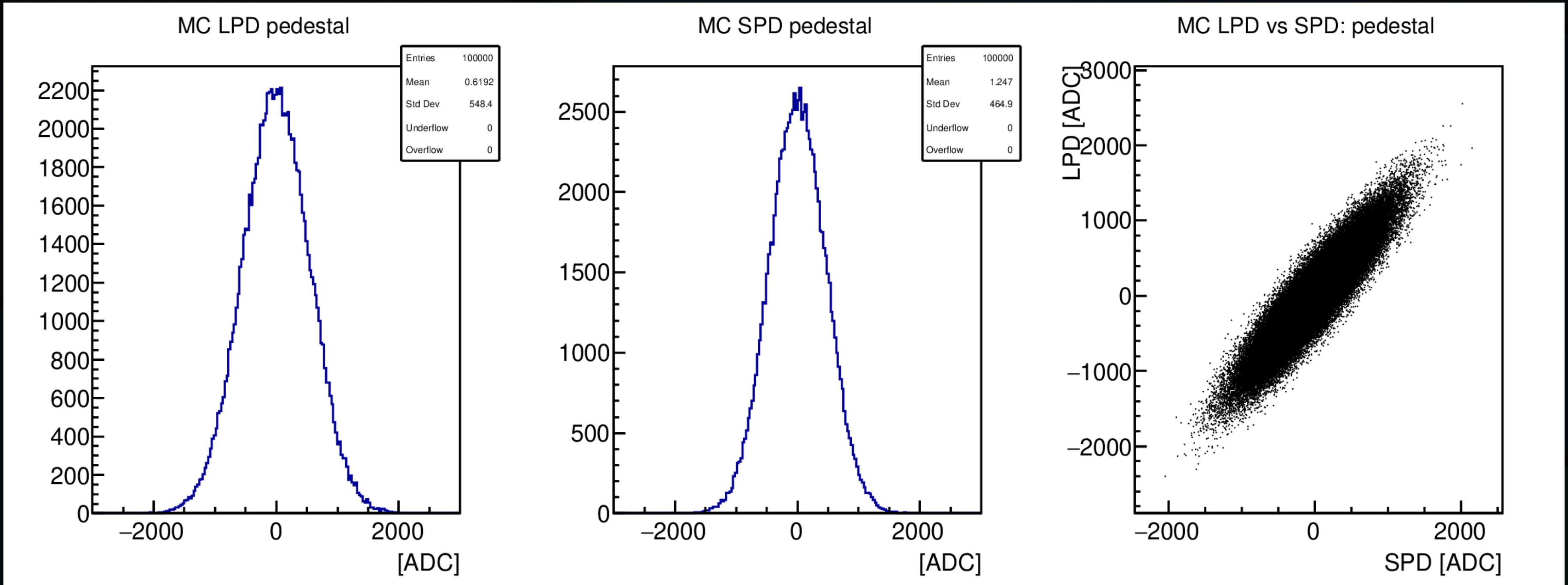
Beam test data



NpL (NpS): proper noise of LPD (SPD)
NtL (NtS): total noise of LPD (SPD)
C: correlation coeff. (LPD vs SPD)

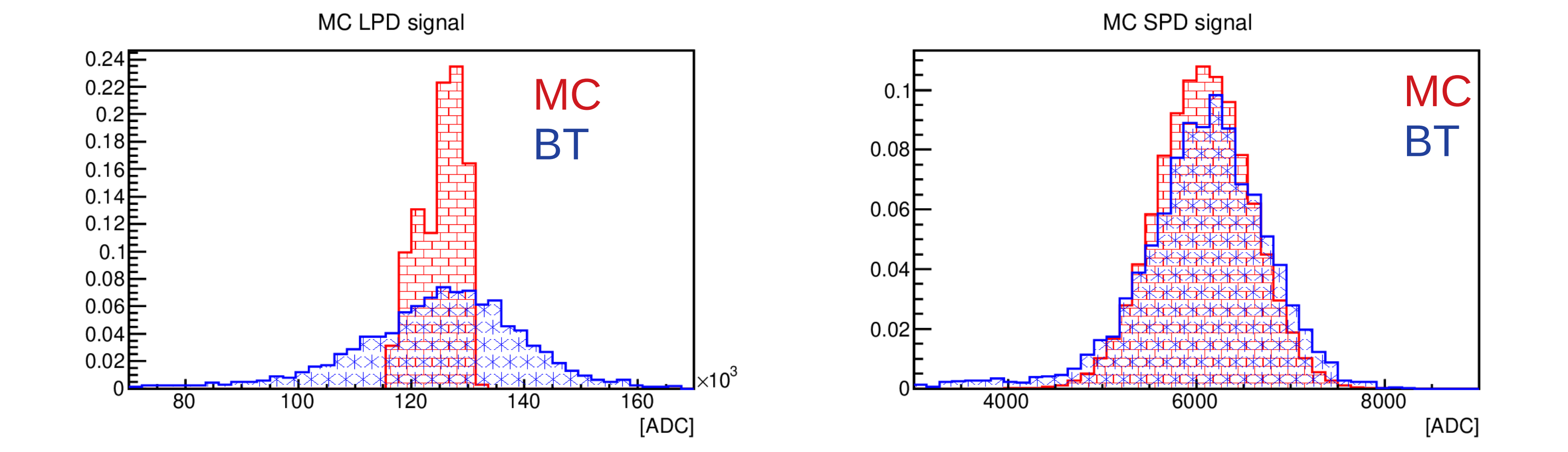
Simulated pedestal events

- The procedure almost reproduces the pedestal distributions:
  - True data RMS: 549 (LPD), 466 (SPD), C ~ 10.8, NpL ~ 223 ADC



Physics events: MC vs data

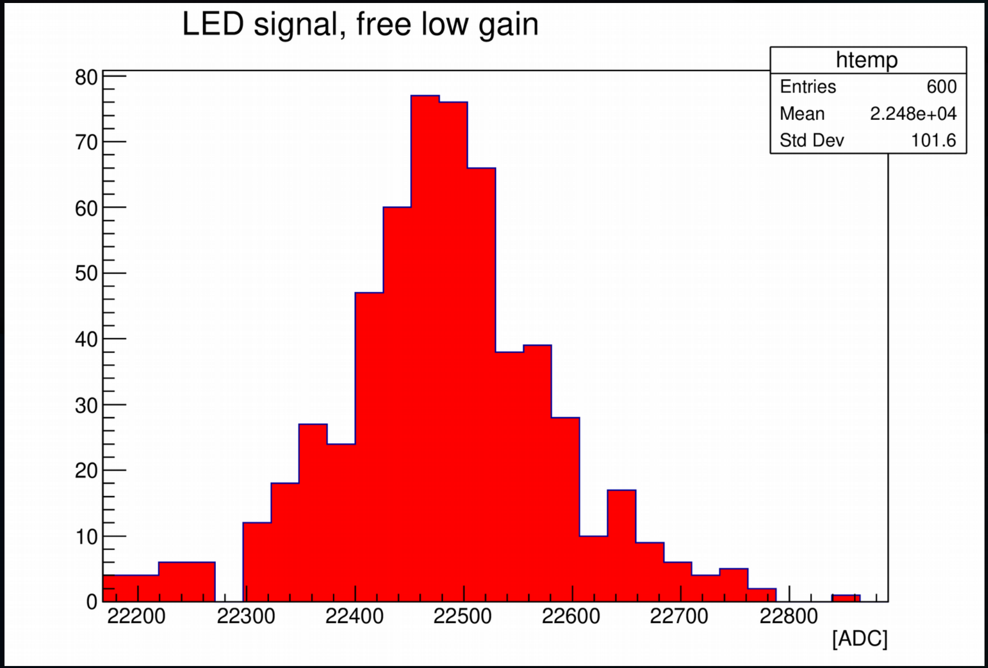
- SPD: reasonable agreement
- LPD: large discrpeancy

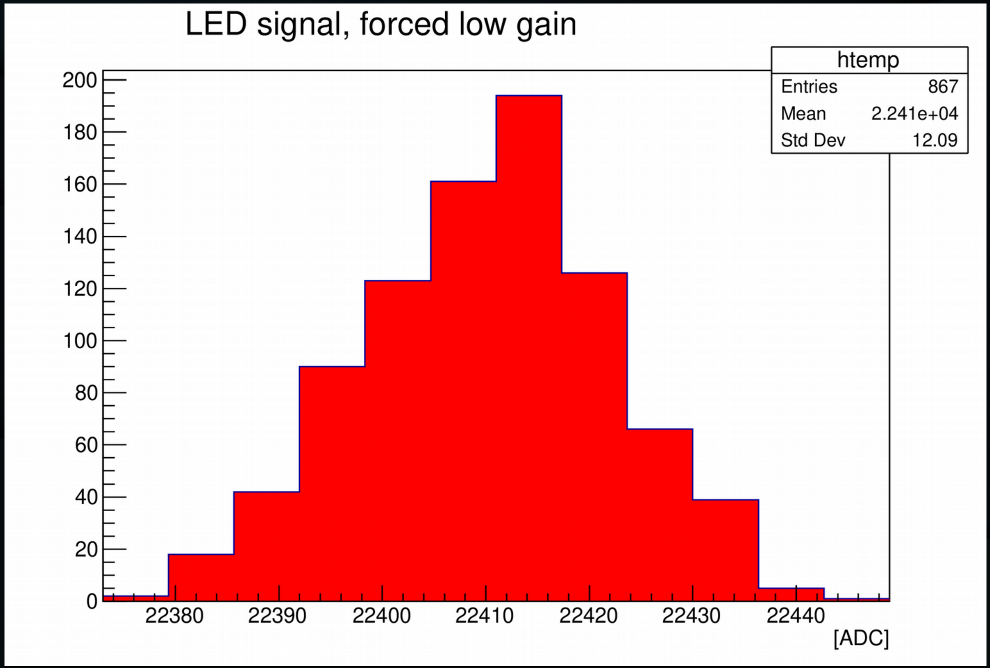


- The SPD is in high gain while the LPD is in low gain, so using the pedestal noise (which are in high gain) for LPD is not reasonable.

Noise in low gain: forced vs free

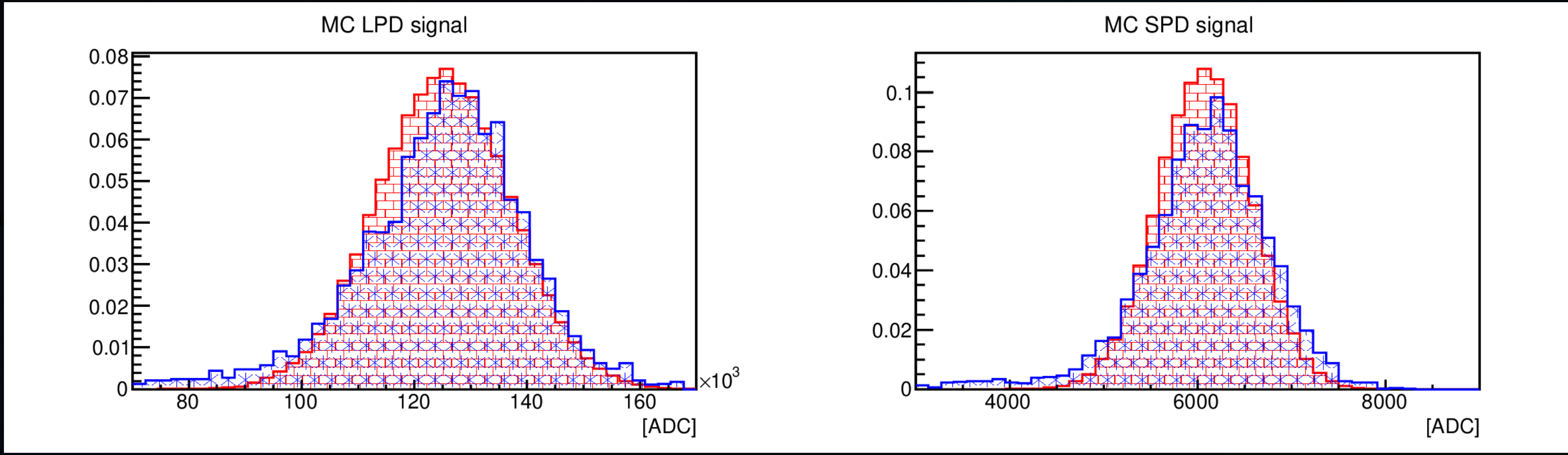
- We can not use the pedestal used in forced low gain since the noise of forced gain is very different with respect to the one obtained in free gain.





MC vs BT data: noise*gain

- Since at LABEC the interference strongly dominates the noise we tried to use the noise in high gain multiplied by the gain (~20) to approximate the noise in low gain. (In typical lab configuration this is not true!!)



- We can replicate the data, so we will use this approximation.

LPD/SPD measurement summary

- We can not use event by event ratio (as shown by previous toy MC)
- We can not use correlation plots (signal range < noise)
- Using the mean of the distribution by MC:

20.5986 +-0.00875601 (true gain = 20.6012)

- Using a Gaussian to fit the peak of SPD and LPD by MC:

20.603 +- ?? (very preliminary, to be refined)

- Next steps:
  - Implement Gaussian fit in MC to replicate the procedure done by Pietro with BT data.
  - Finally decide if we will use the Gaussian peak or the mean for SPD/LPD.
  - Try with different LABEC data sets.
  - Ask Trieste about the noise in free low gain: how can we measure it??