

Correlated noise studies

Valencia

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IFIC-VALENCIA

Correlated noise

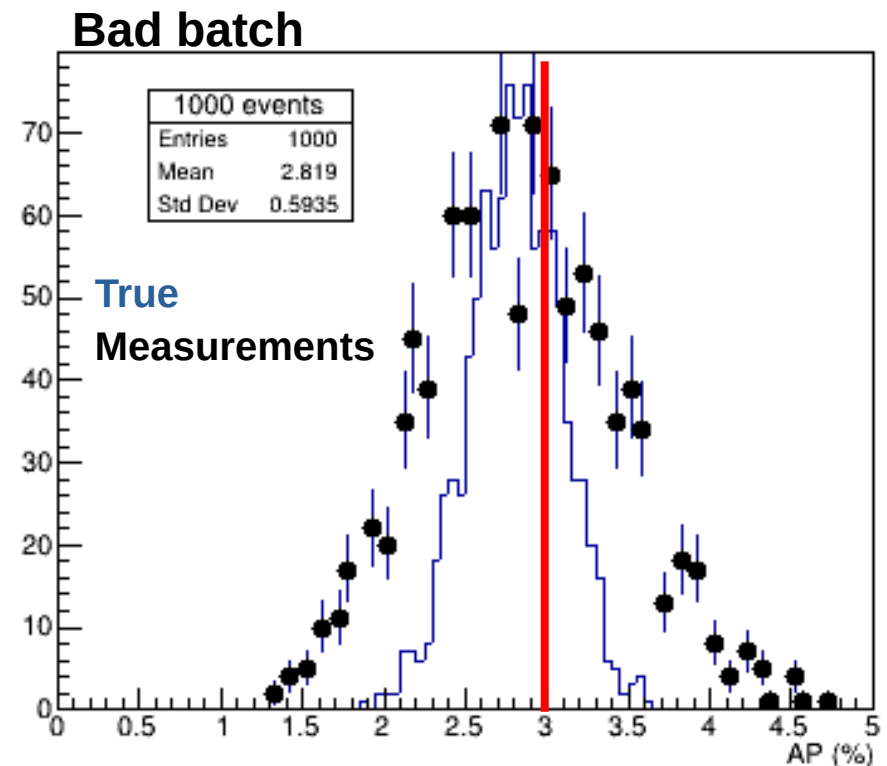
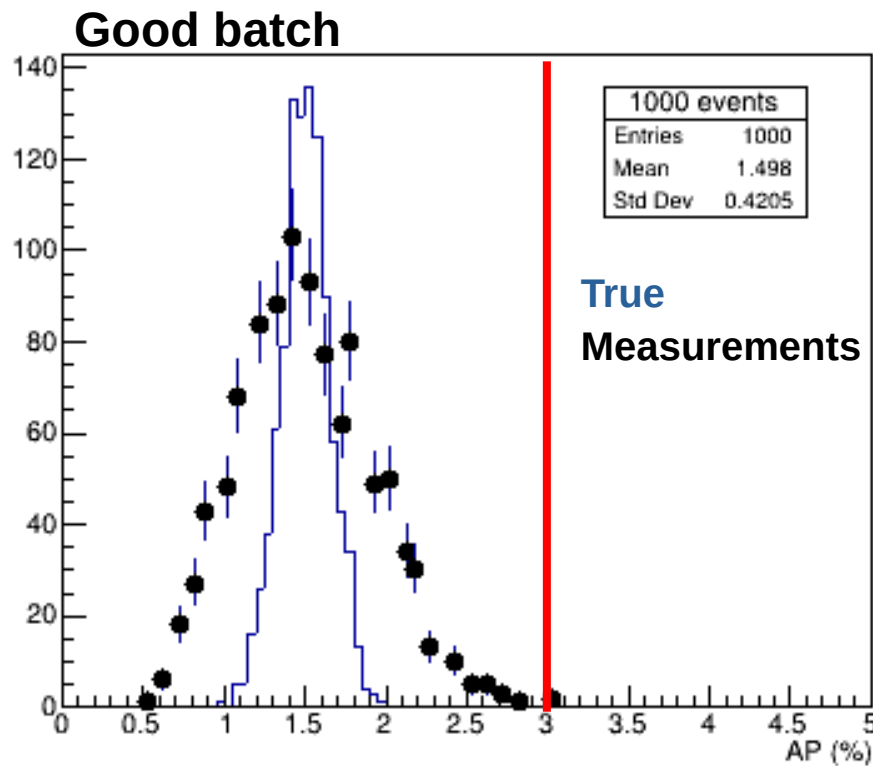
- ↗ Includes after pulse (AP) probability, cross talk (XT) probability, and dark count rate (DCR). All of them are computed from the same measurement.
- ↗ Until now, it was required to acquire waveforms for at least a 2000 s (~35 min).
- ↗ For the DUNE mass production, 5-10% of the SiPMs will be fully characterized. This means 15000-30000 SiPM.
- ↗ This will be very time consuming.

Mass production objective

- ↗ To reduce the correlated noise bottleneck it is important to understand which is the objective of the mass tests.
- ↗ Why are we measuring 5% of the SiPMs?
 - ↗ Will the taken data be used afterwards for DUNE analysis? If so, which precision do we need for the measurements?
 - ↗ Or are the SiPMs just being characterized to detect problematic batches? If so, how do we define a 'problematic' batch?
 - ↗ Additionally, how many OV will be tested and why?

Bad batch definition

A given fraction of the SiPMs (e.g. 5%) has a larger AP than a predefined maximum value (e.g. 3%), or a larger XT than (e.g.) 30% or a DCR without burst larger than (e.g.) 100 mHz/mm²



Each entry on the histogram is a simulated SiPM measurement

Potential Errors

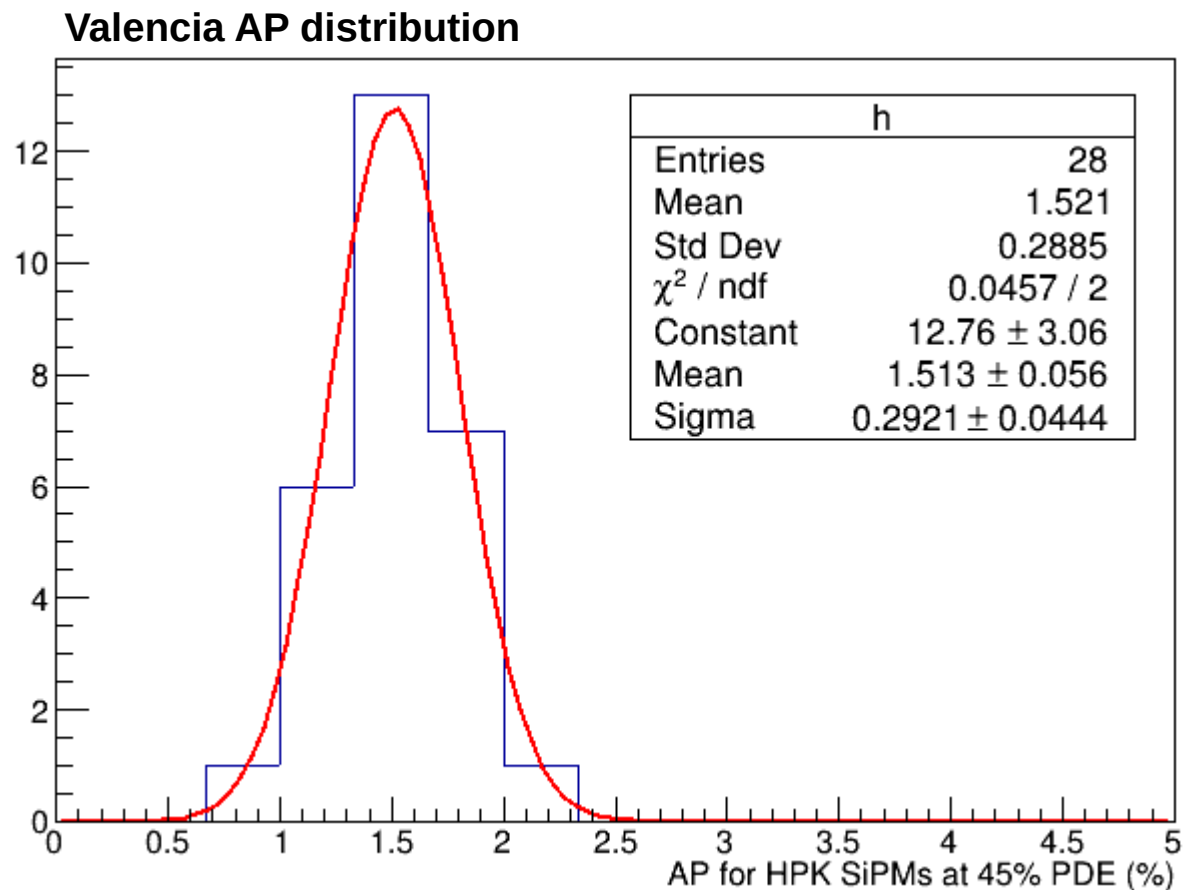
- ¬ A false negative would not be critical: a batch that is tagged as bad would be investigated, and soon recognized as good. We'll be just losing time.
- ¬ On the other hand, a false positive would be more dangerous, because a bad batch of SiPMs would be installed in DUNE.
- ¬ So the question is:
 - ¬ **how many SiPMs per batch do we need to measure and which precision is needed in the measurements in order to avoid a false positive?**

AP and XT

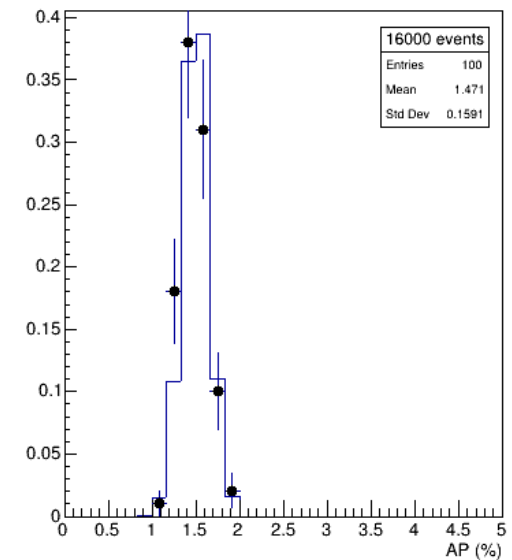
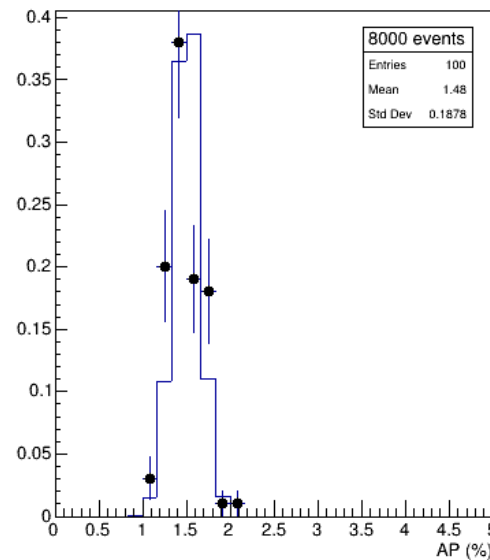
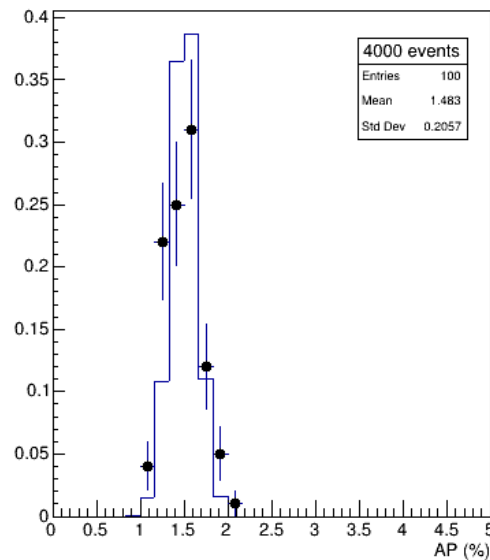
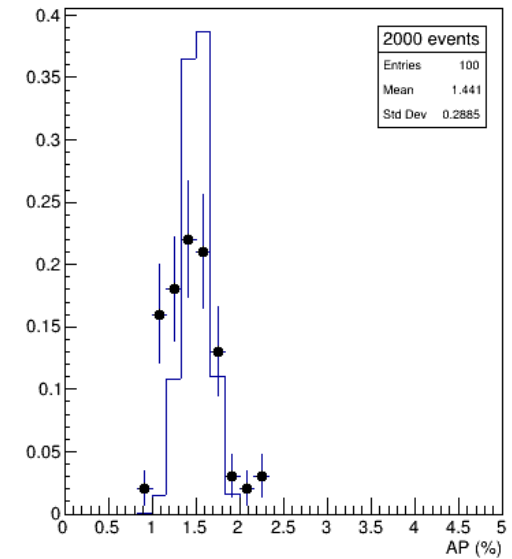
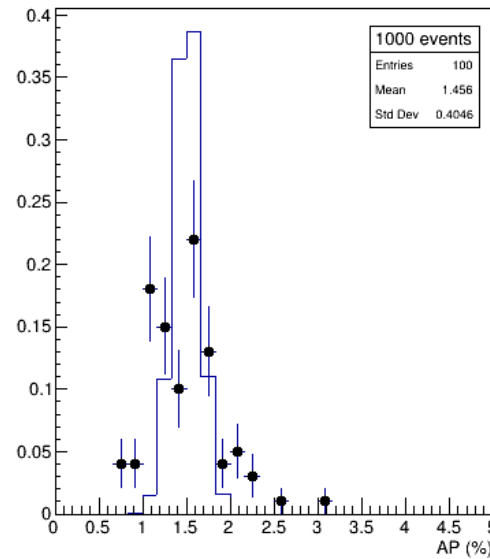
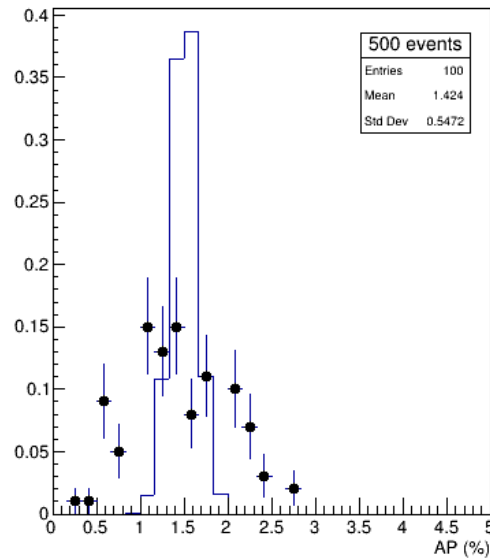
- └ AP and XT are similar magnitudes in a sense that we can simulate them as binomial effects. There is a primary event (a dark count) and afterwards a given probability of having AP or XT. We can simulate numerically how our knowledge about these magnitudes of a batch depends on the amount of SiPM measured and the precision dedicated to each measurement.
- └ As the AP is much smaller than the XT and thus the most constraining, in the following I will study only the AP measurement. The results will of course apply to XT.

The AP simulation

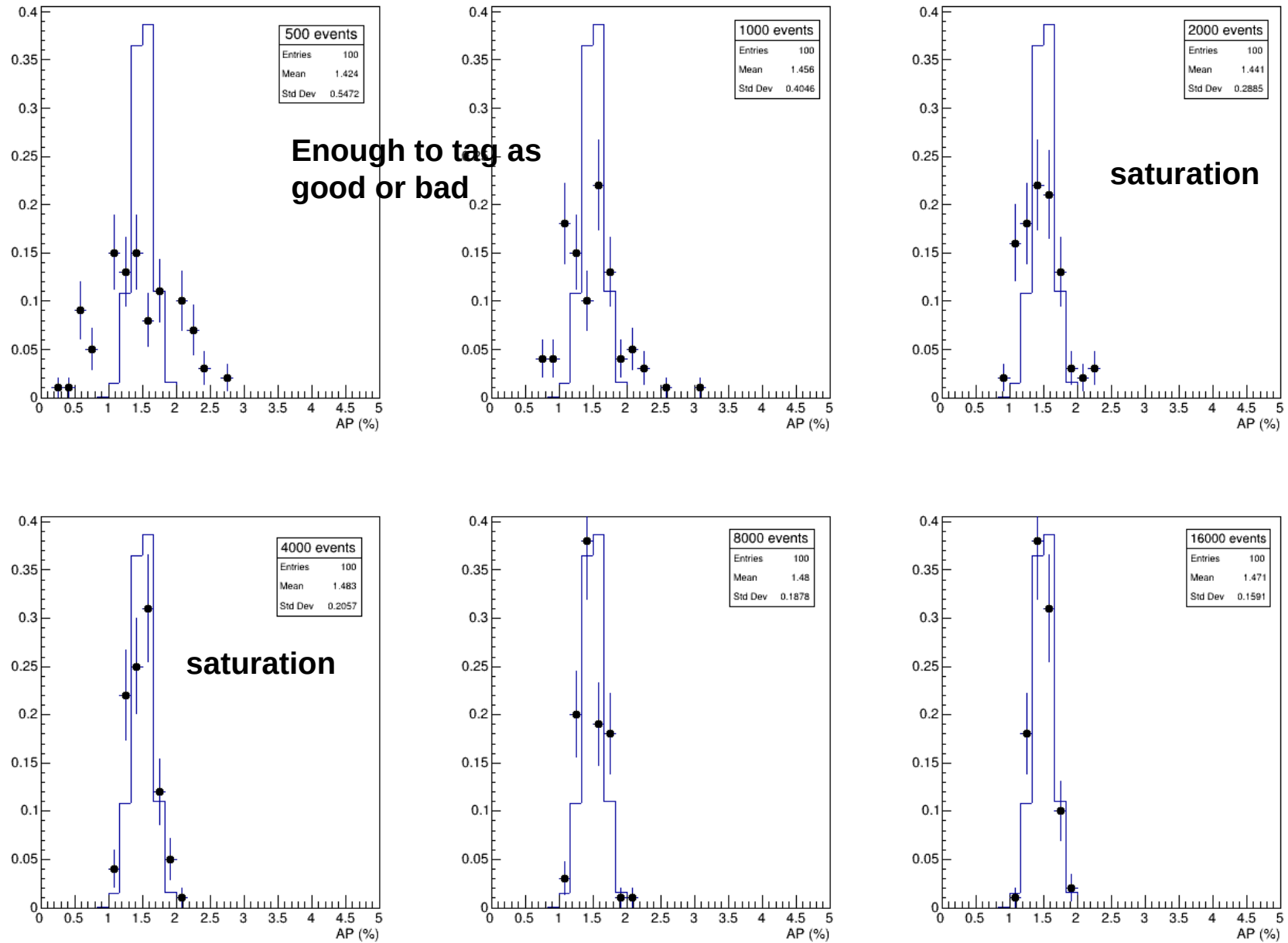
- A true AP distribution is generated for the batch (a gaussian centred in 1.5 with a sigma of 0.2, based on the data taken at Valencia during the 25-bath and the 250-batch tests).
- For each SiPM of the batch that is being tested, a true AP is randomly chosen from the distribution.
- Then, a different number of primary events (dark counts) is simulated and for each of them an AP event may (or may not) happen based on the true AP.
- Then the “measured” AP distribution of the SiPM is compared with the true AP distribution.



1000 SiPMs batch, measuring 10%

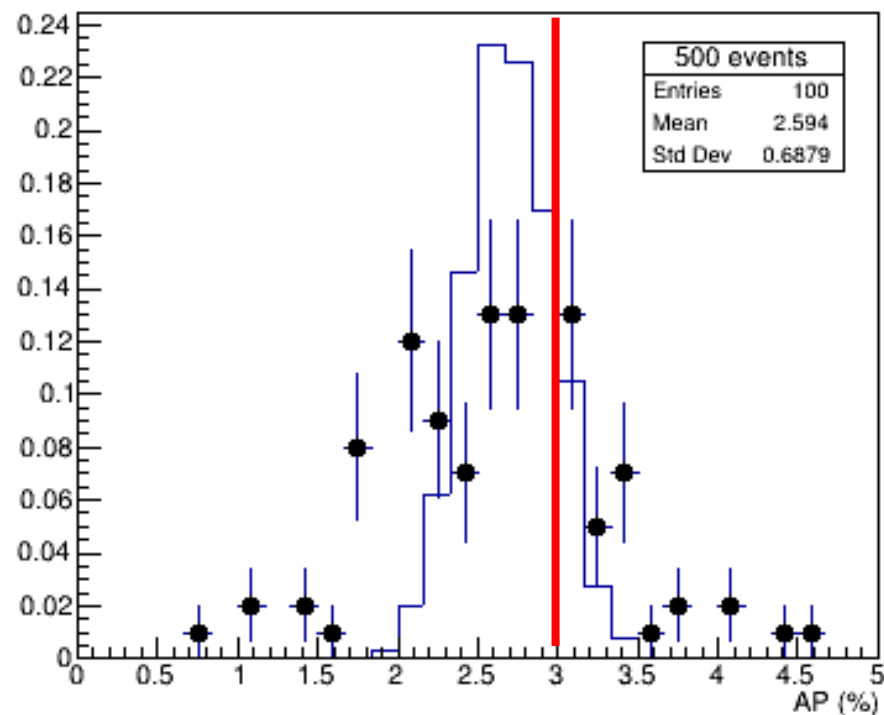
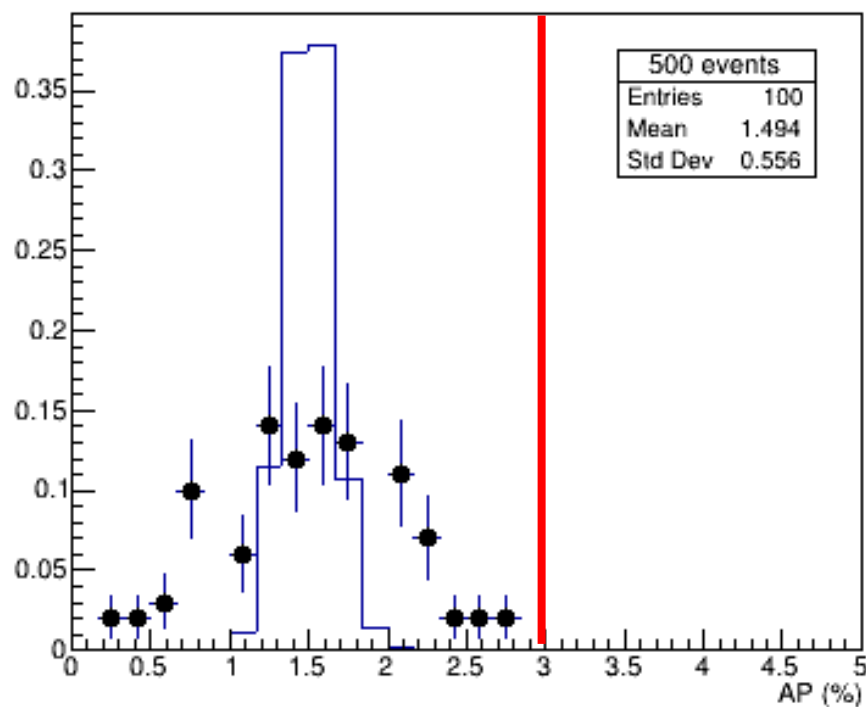


1000 SiPMs batch, measuring 10%

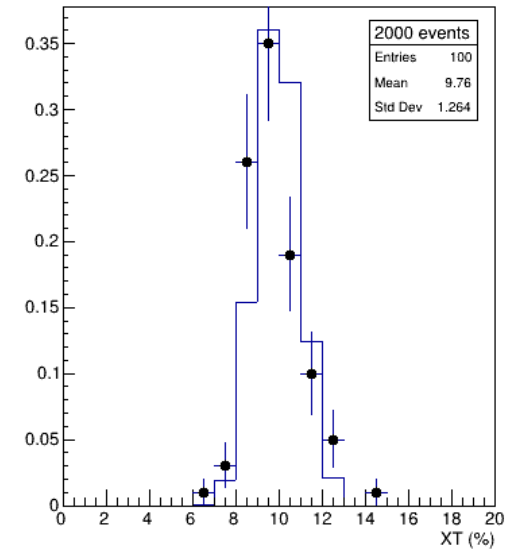
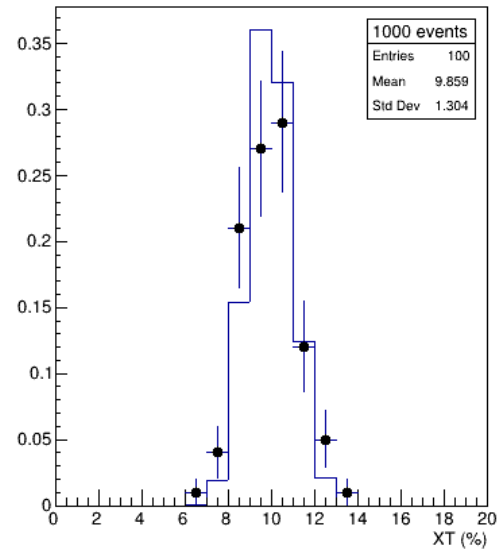
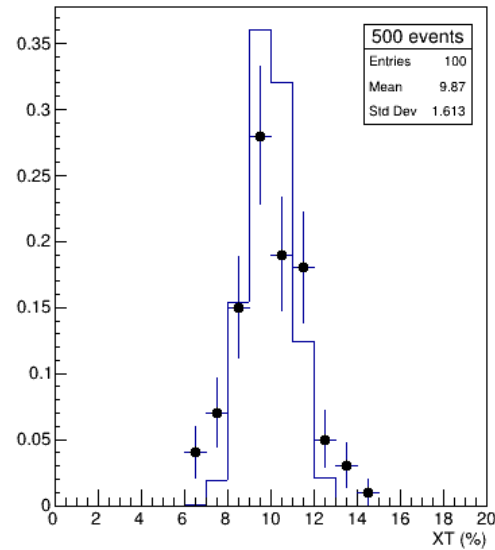


Good batch, bad batch

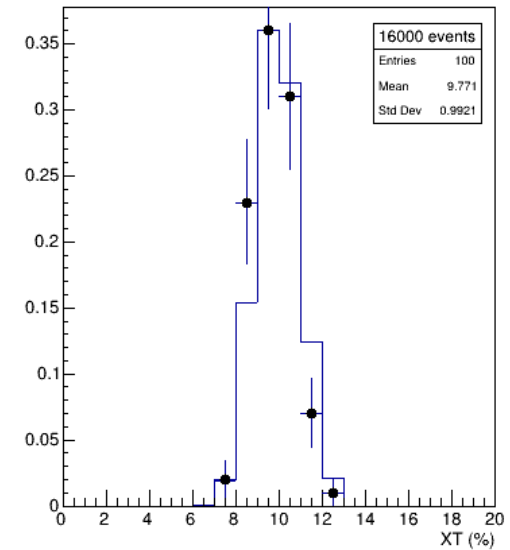
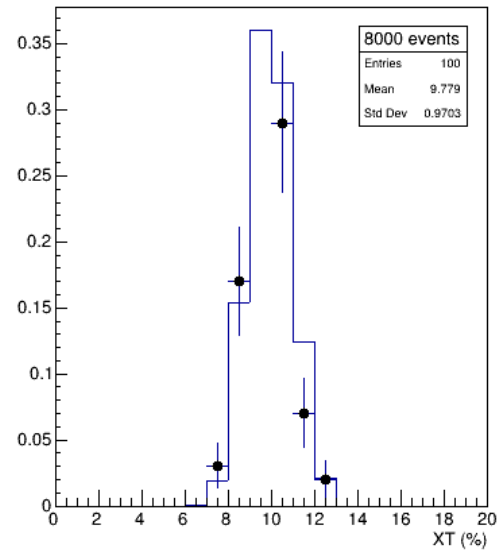
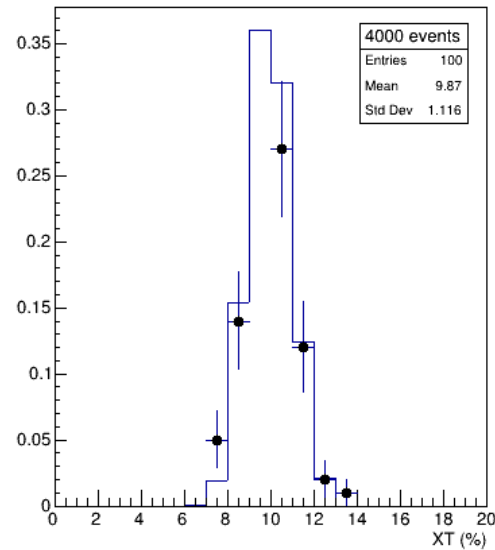
Making short measurements (500 events, 5-10 minutes) would be enough to tag a batch as problematic confidently enough.



XT simulation

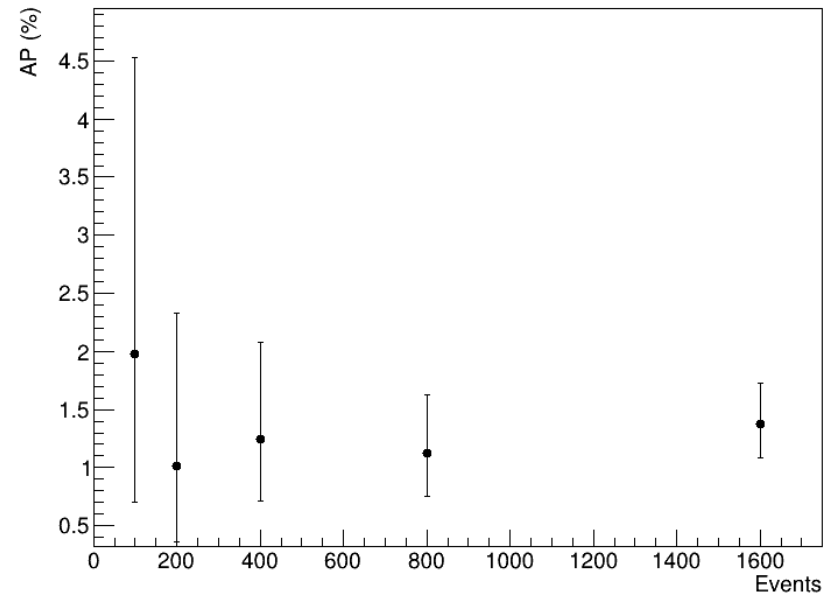
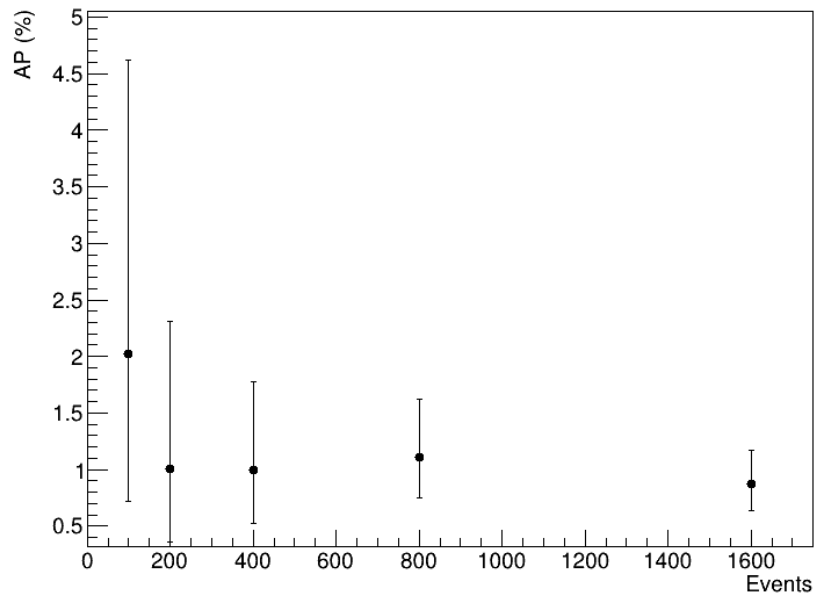
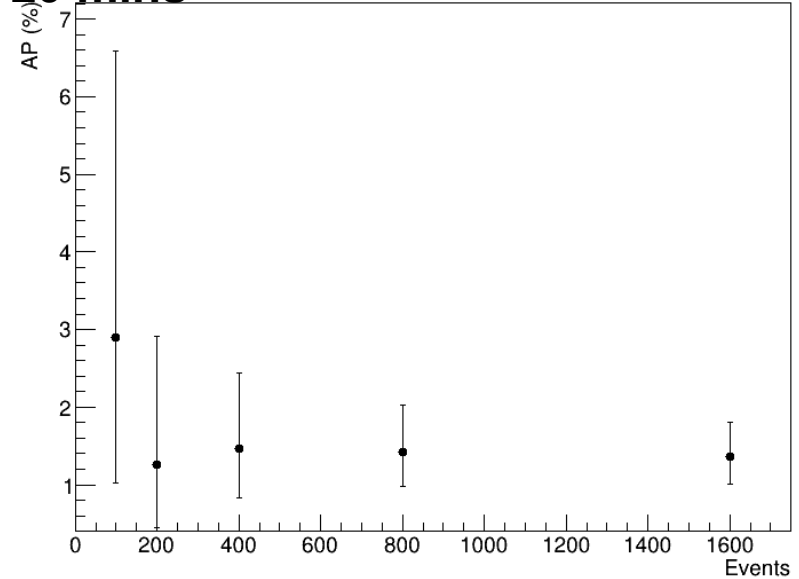
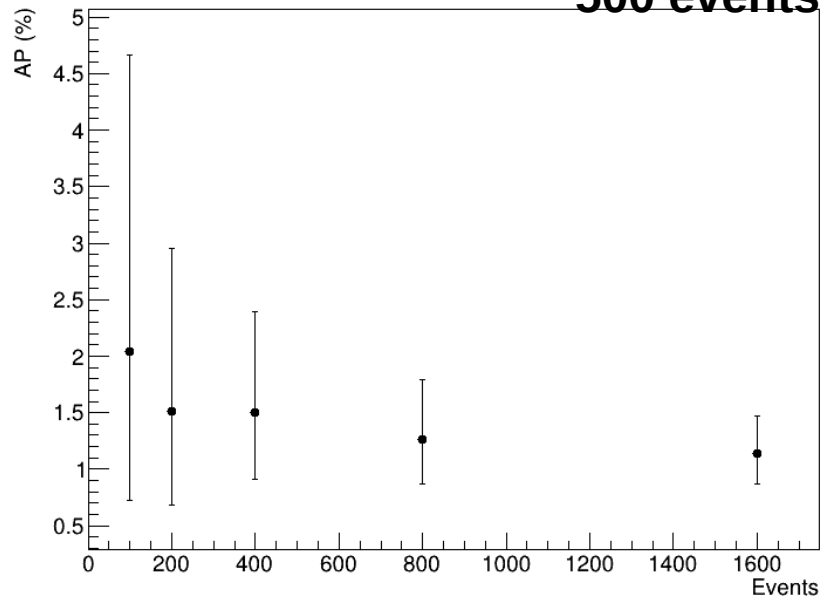


Since the XT probability is larger, the measurement quickly saturates.



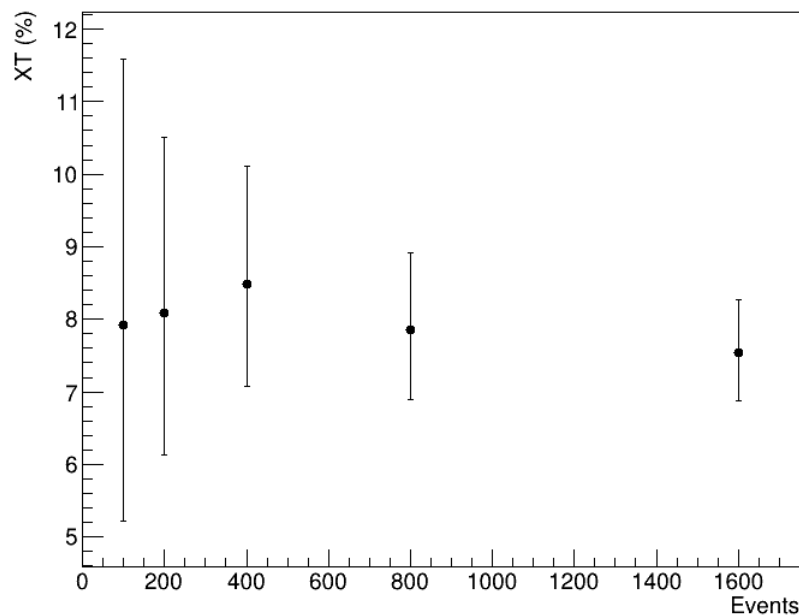
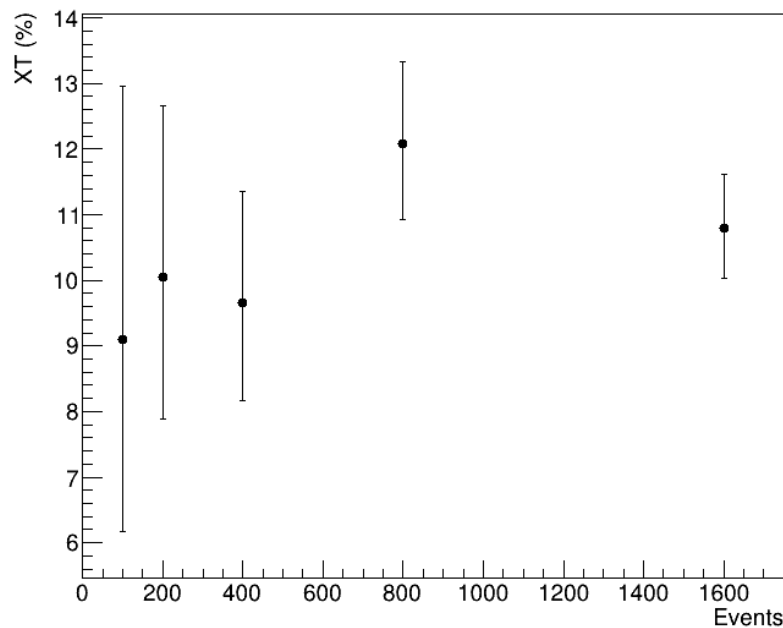
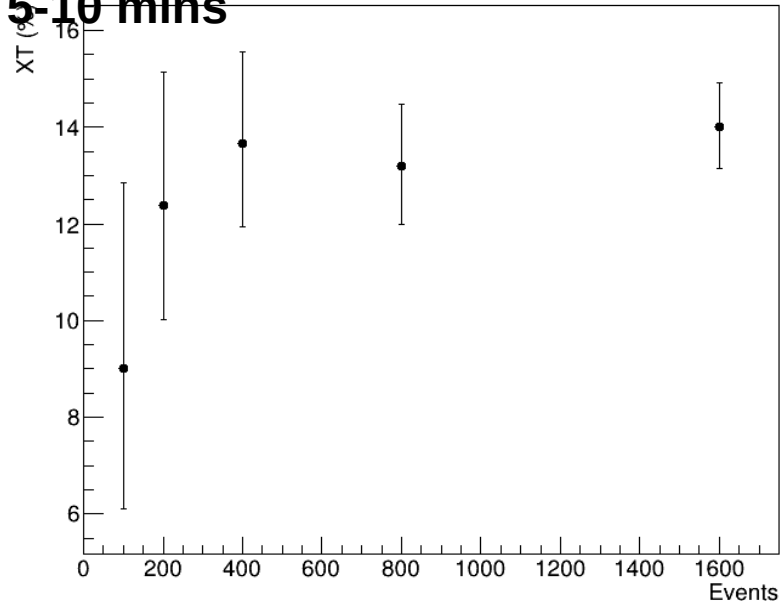
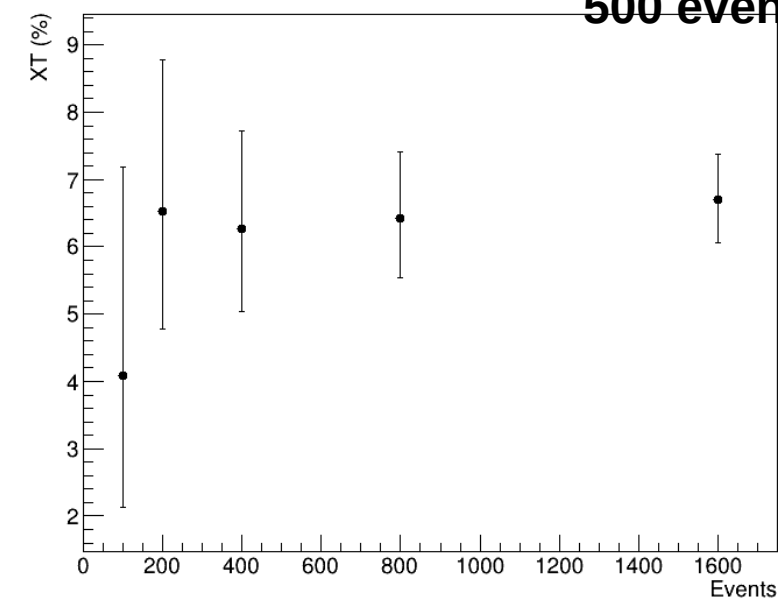
AP real examples

500 events ~ 5-10 mins



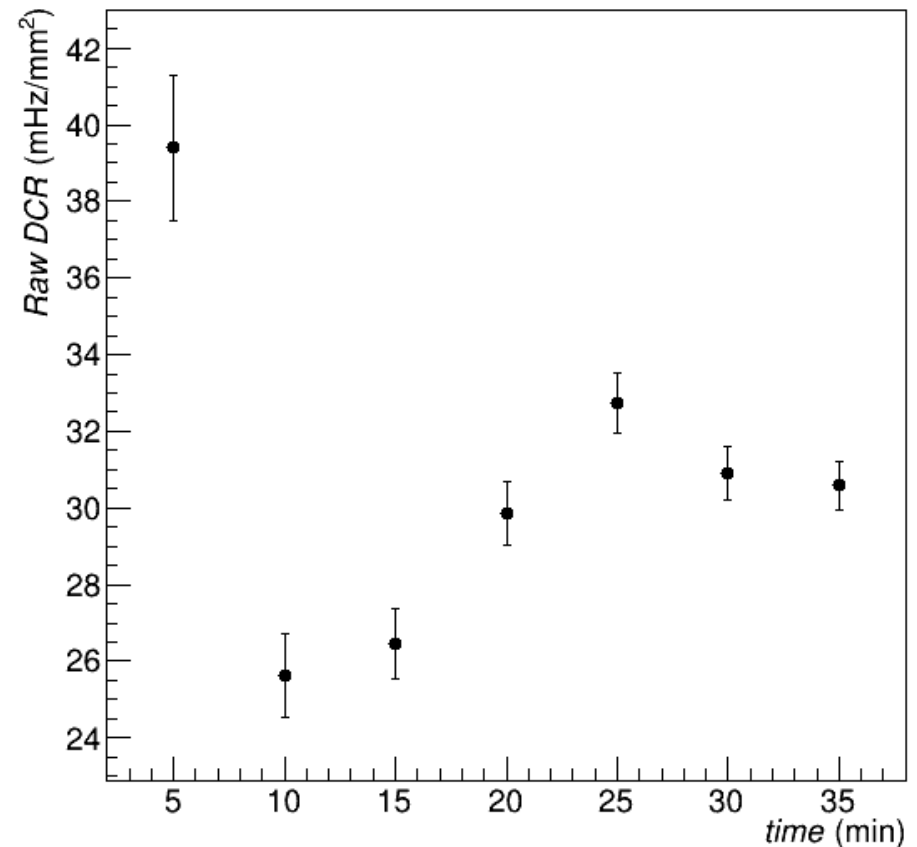
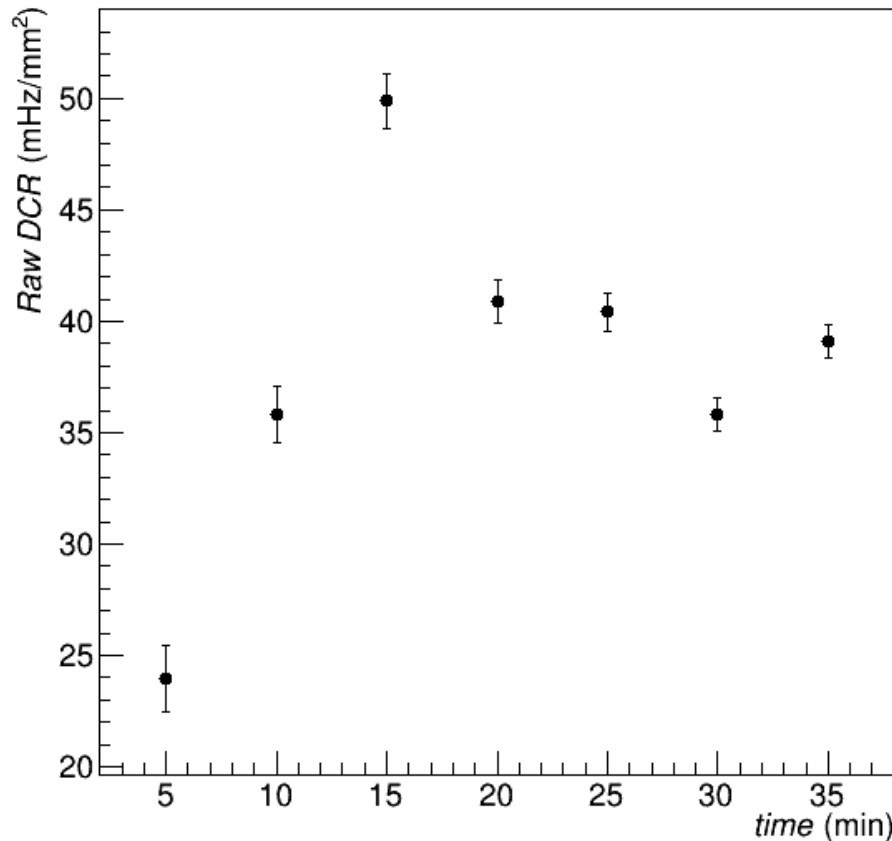
XT real examples

500 events ~ 5-10 mins



DCR with burst

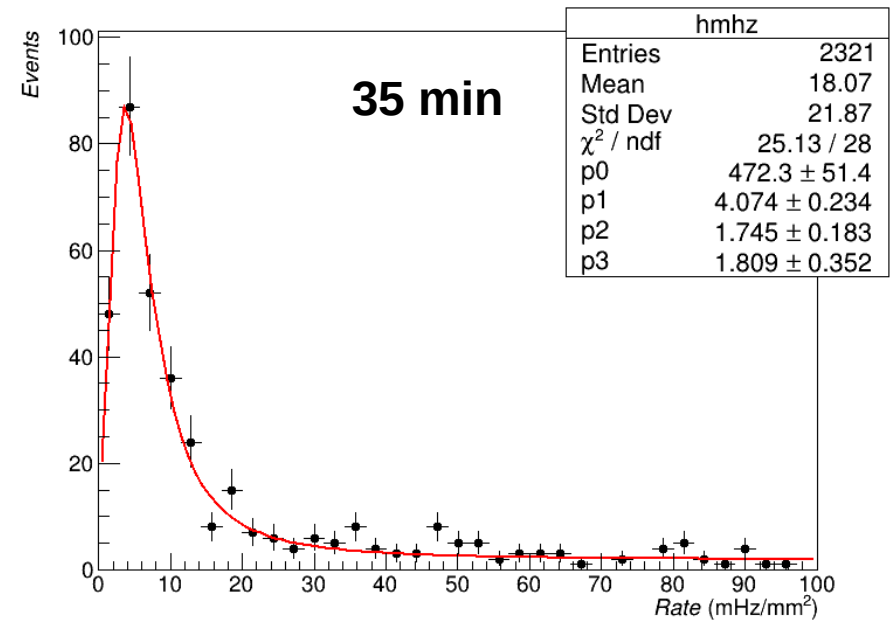
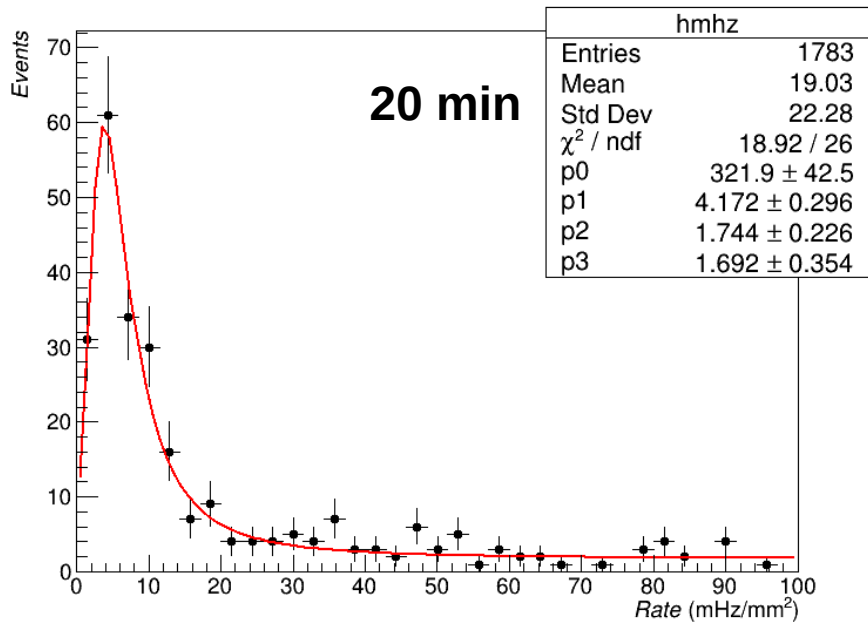
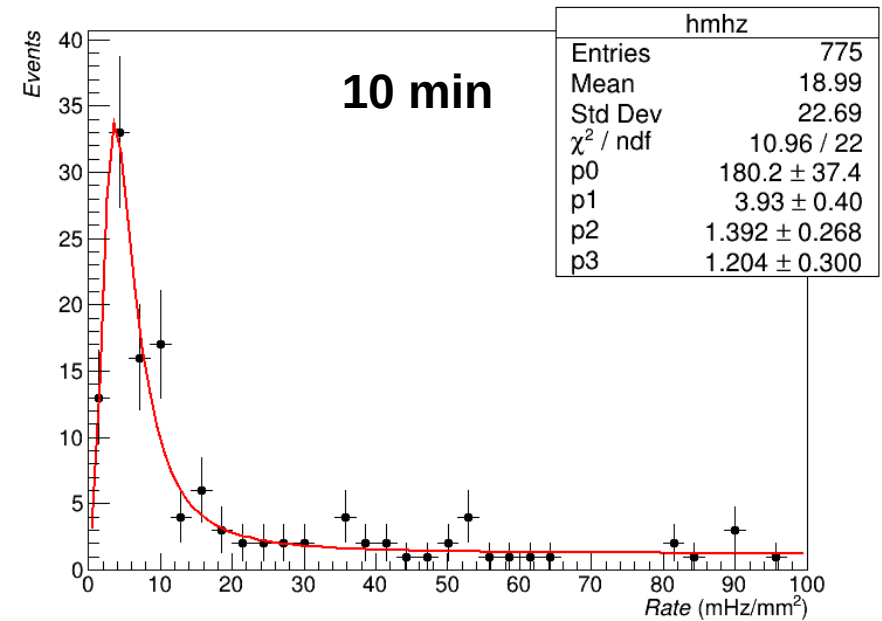
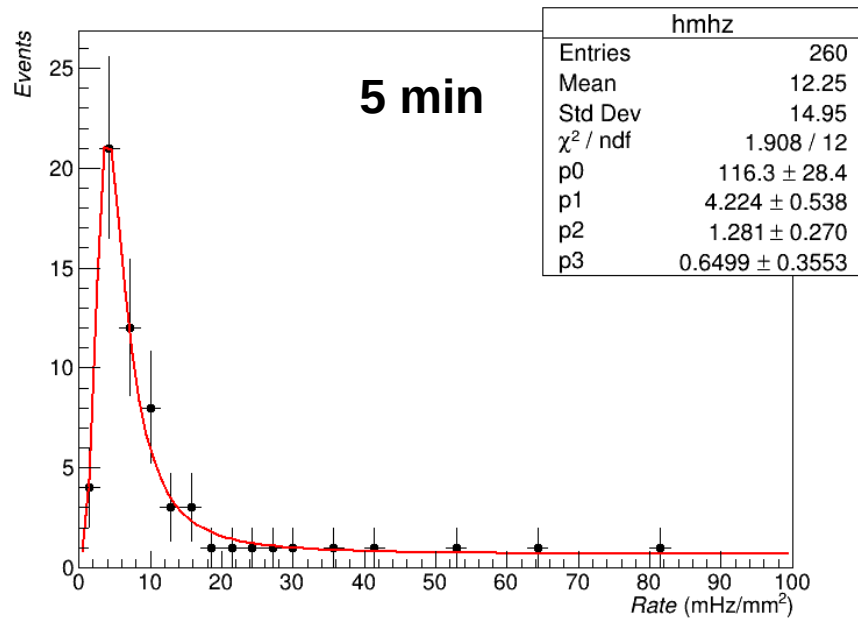
The case of the DCR is different due to the existence of the burst phenomena. It is a random phenomena that also contributes to the DCR and makes it to not converge at least in the timescale of measurements we've been using so far.



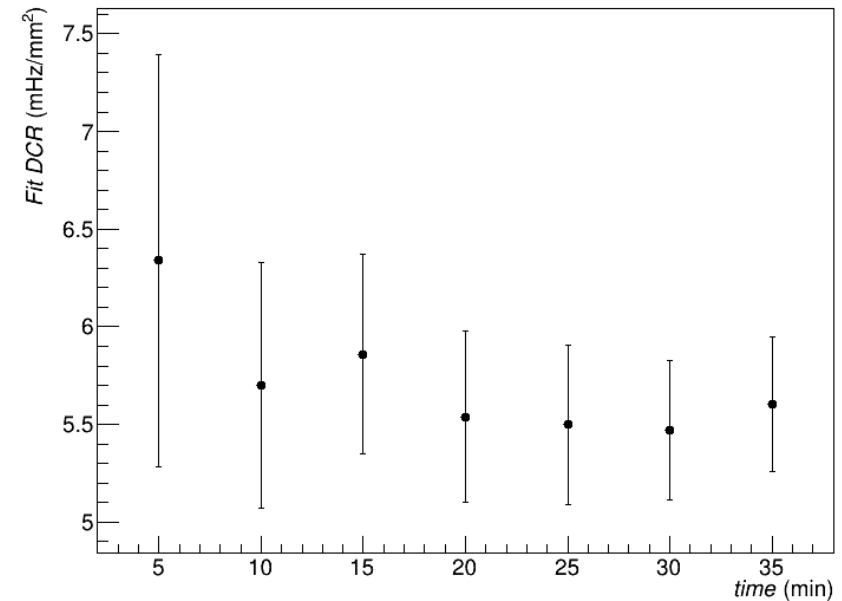
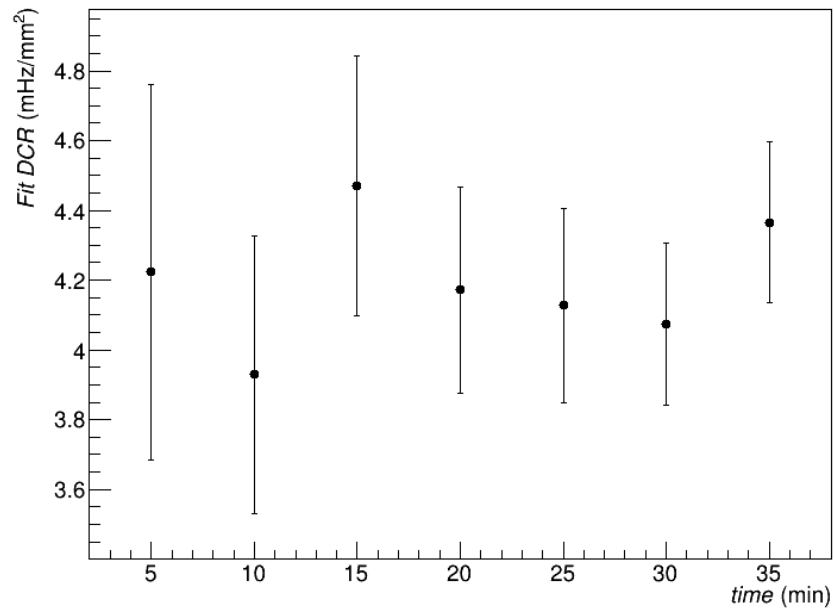
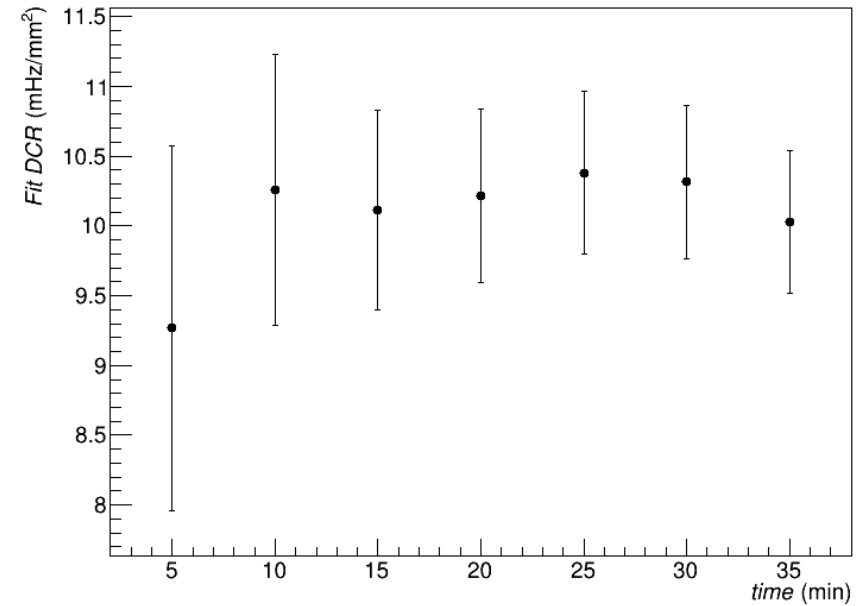
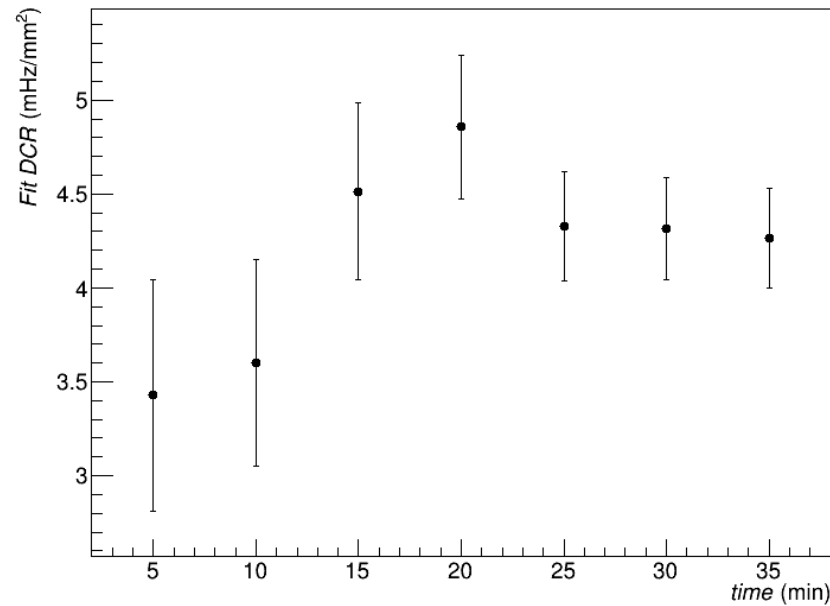
DCR without burst

In this case we cannot use the number of events as a guide to understand the evolution of the measurement because of the bursts, but the time can be used instead.

DCR without burst



DCR without burst



Conclusion

- ↗ The mass test will require a huge effort by all involved labs.
- ↗ The measurements should be optimized depending on the objective of the tests. A numerical simulation has been developed for this purpose.
- ↗ Once the different parameters are properly defined (number of SiPMs per batch, AP_{bad} , XT_{bad} , DCR_{bad} , number of OV) most realistic values could be provided.
- ↗ For the moment, results suggest that shorter measurements than we have been doing so far should be enough to confidently recognize problematic batches.

Backup

