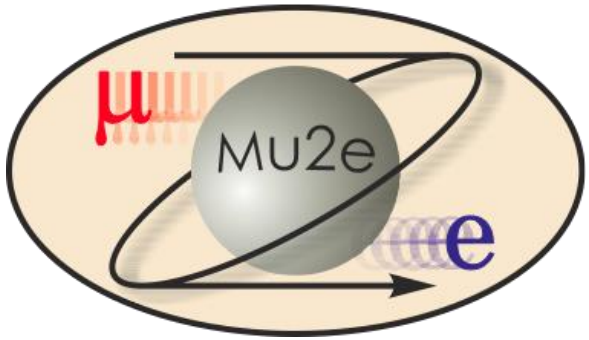
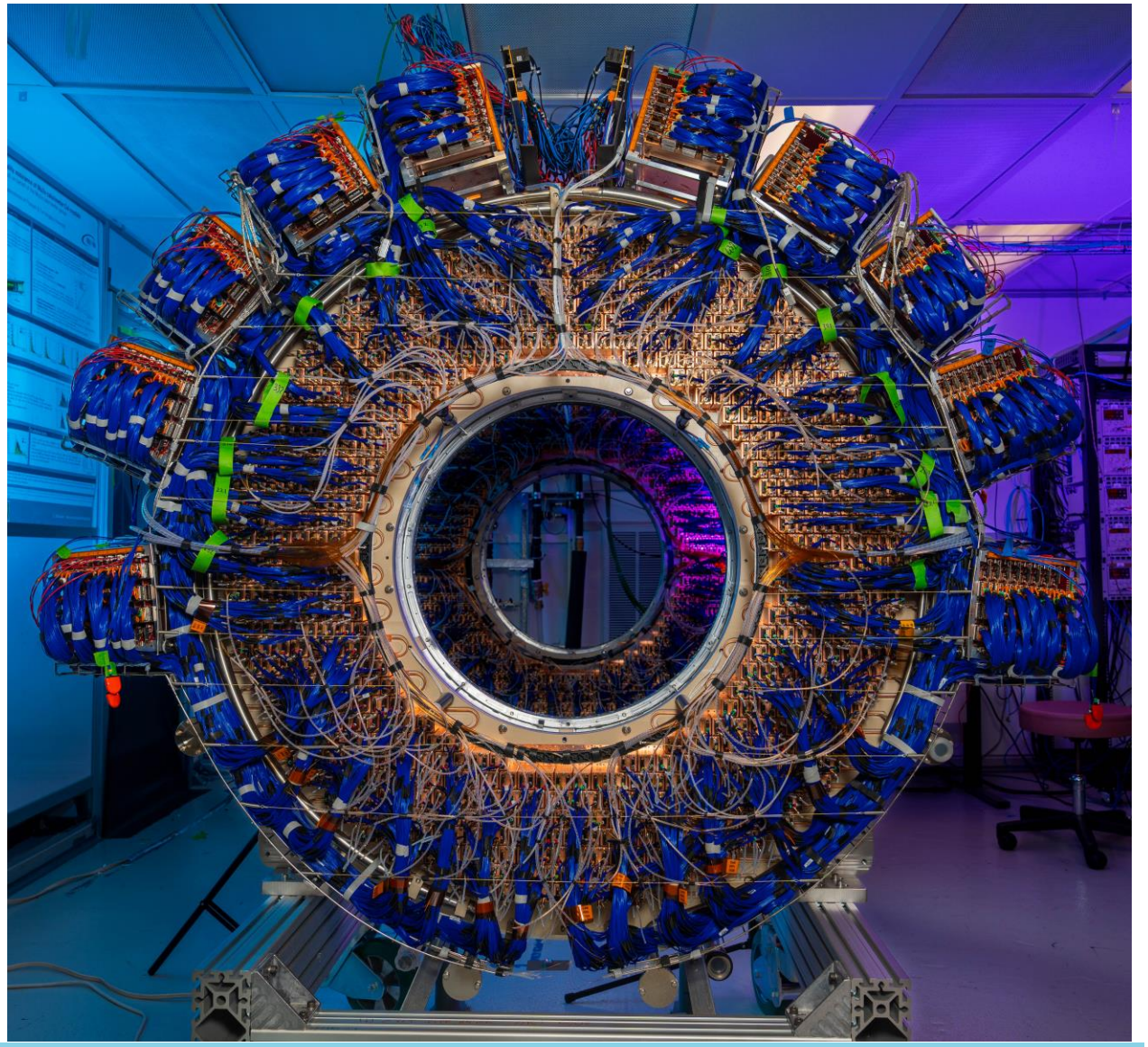


Report on Calorimeter Comissioning run

Mu2e Collaboration meeting, calo session
June 9th, 2025

L. Crescimbeni on behalf of the Calorimeter group

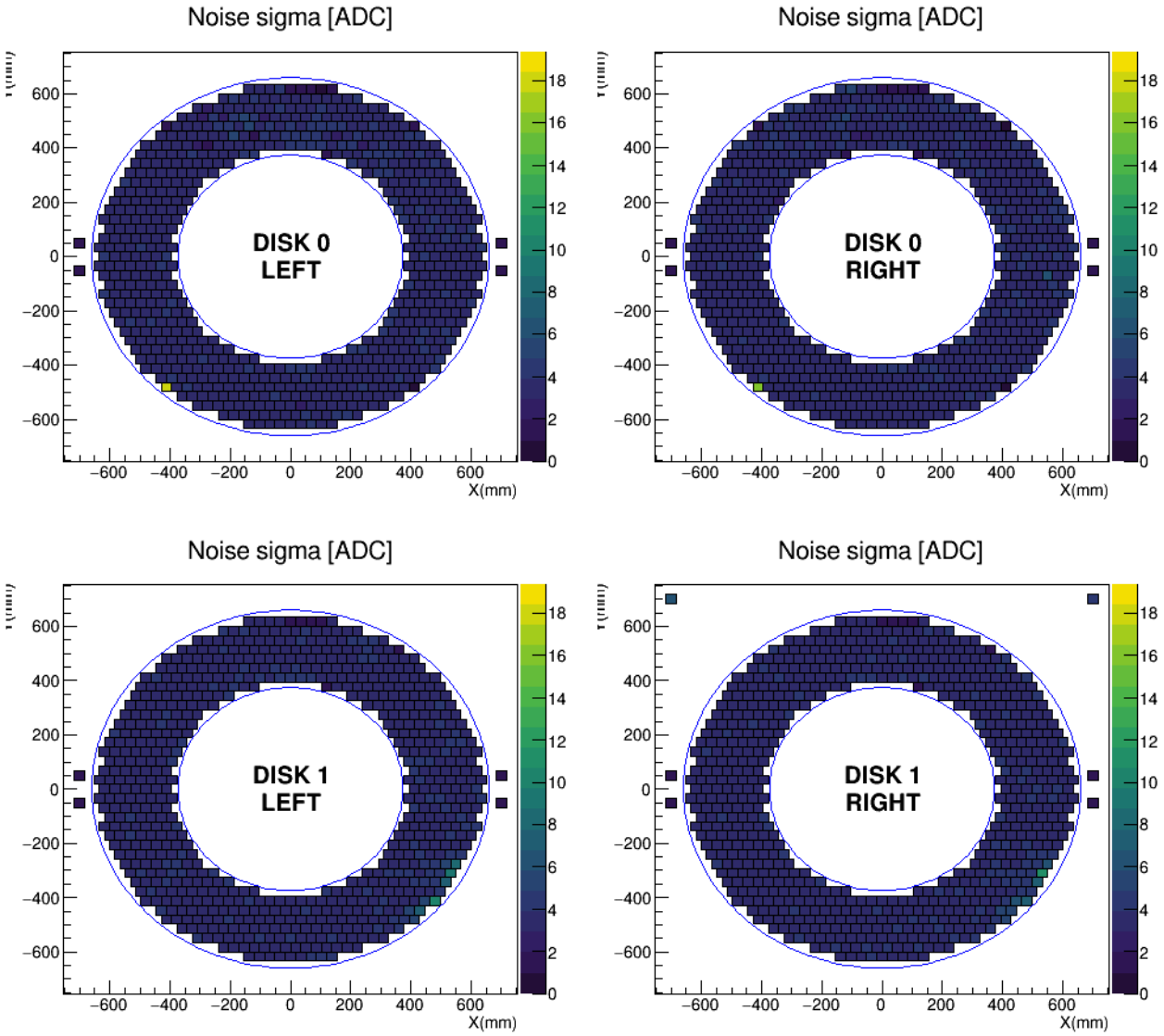
Mu2e calorimeter, up to date



Mu2e calorimeter – Commissioning run

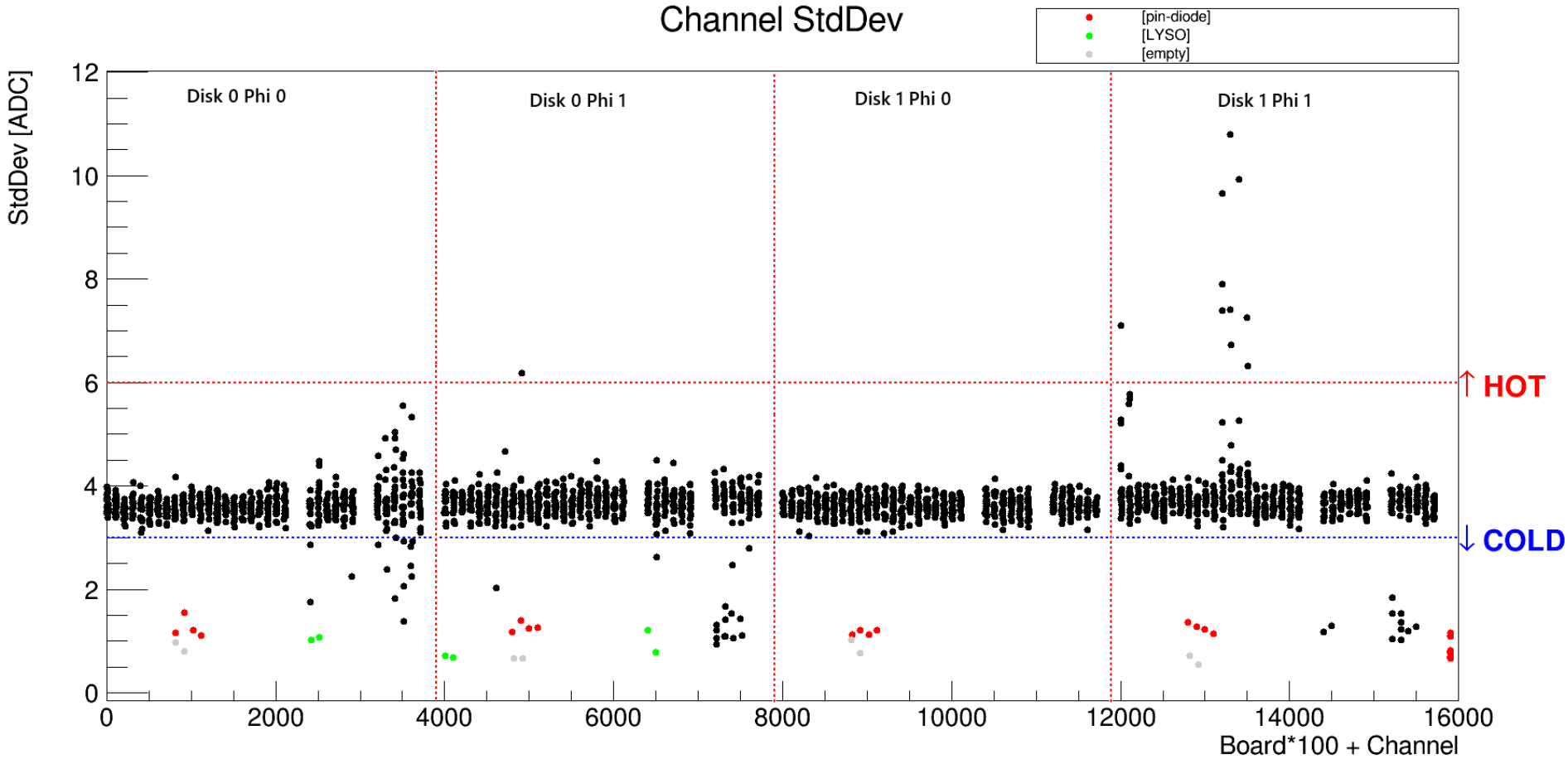
- The Mu2e calorimeter team has performed a commissioning run of the two calorimeter disks, now that the hardware is finalized, with the following plan:
  - Verify noise behavior and light infiltration in both disk
  - Use the laser system to verify the correct functionality of all channels
  - With the laser data try a first equalization routine (wait for Sabrina Salamino and Vittoria Ciccarella presentations for more information)
  - Cosmics acquisitions to improve MIP statistics and verify correct functionality of all the channels
  - Test the DAQ system as in operations, trying to smooth out some hard edges with experts
  - Test of the DQM (see Mark Vakulenko presentation)
  - Test of ARTDAQ acquisition with Disk 0

Noise acquisition lightoff

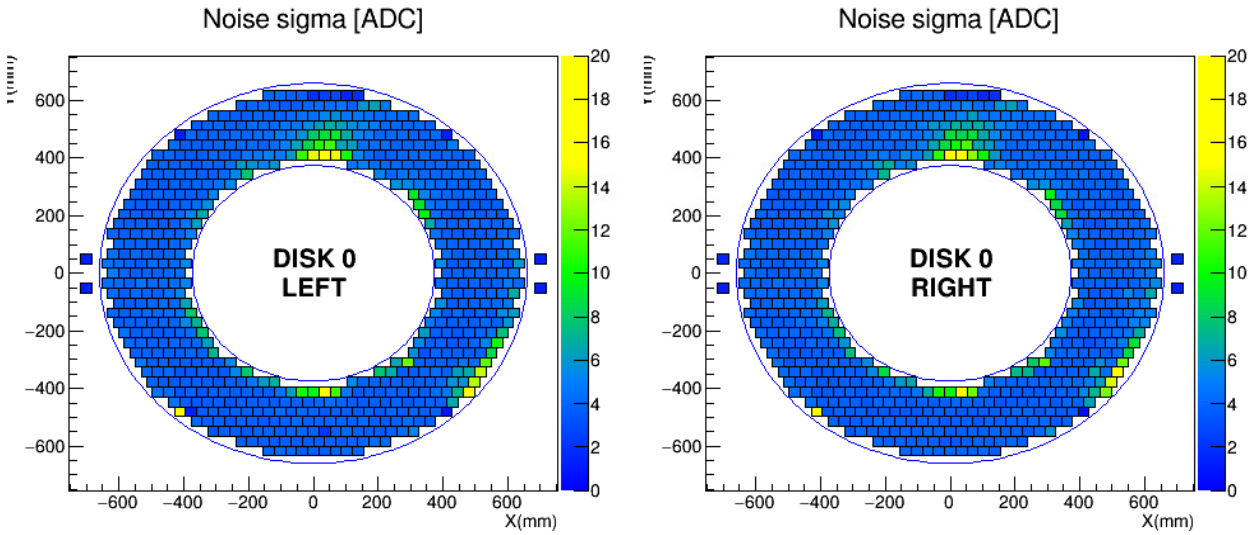


Noise acquisition lightoff

- There are no "dead channels" or with extremely high noise. Still some infiltrations of lights, that lift the baseline value of some channels
- The few FEE units with the corrected Sipm voltage regulator shows a much lower standard deviation, as expected



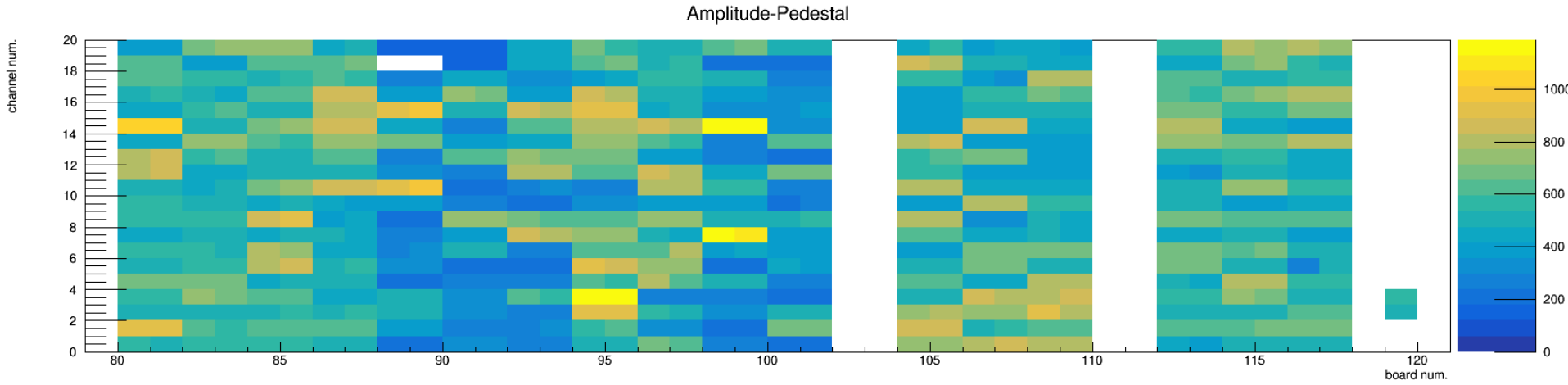
Noise acquisition lighton



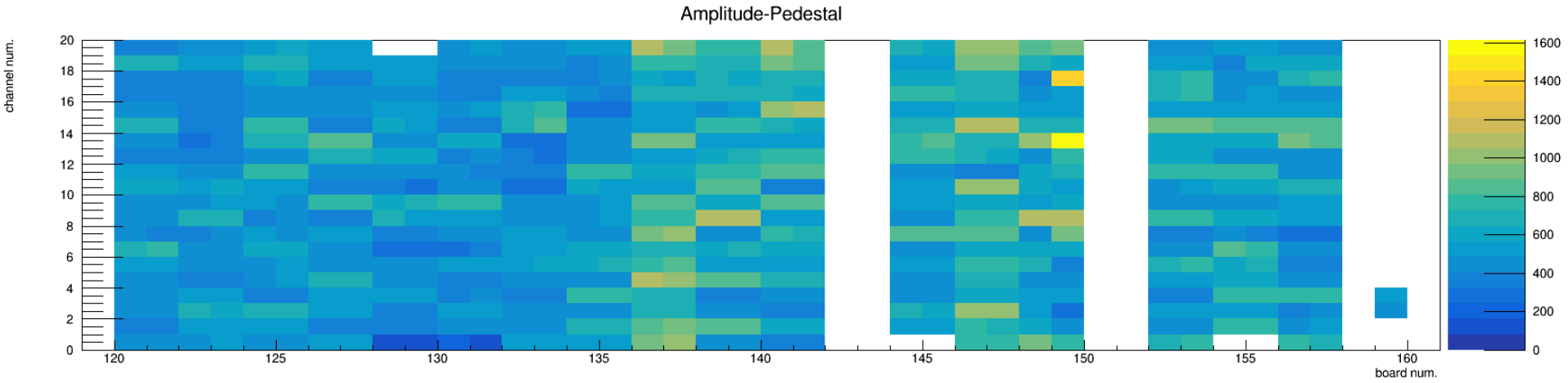
- Still some work to be done to solve the issues of light infiltrations in the disks
- The vacuum wax applied to the holes on the side of the disks was an improvement but some opening between the backplane and the tubing of the radiative source are still an issue. Same for some spots of connection at the edges

Laser Disk 1

DISK 1 PHI 0

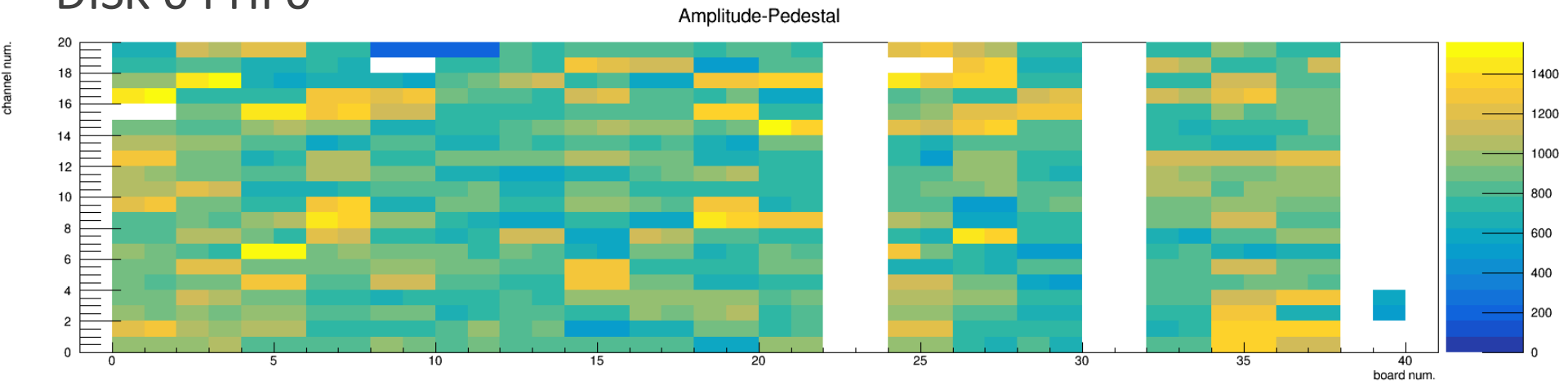


DISK 1 PHI 1

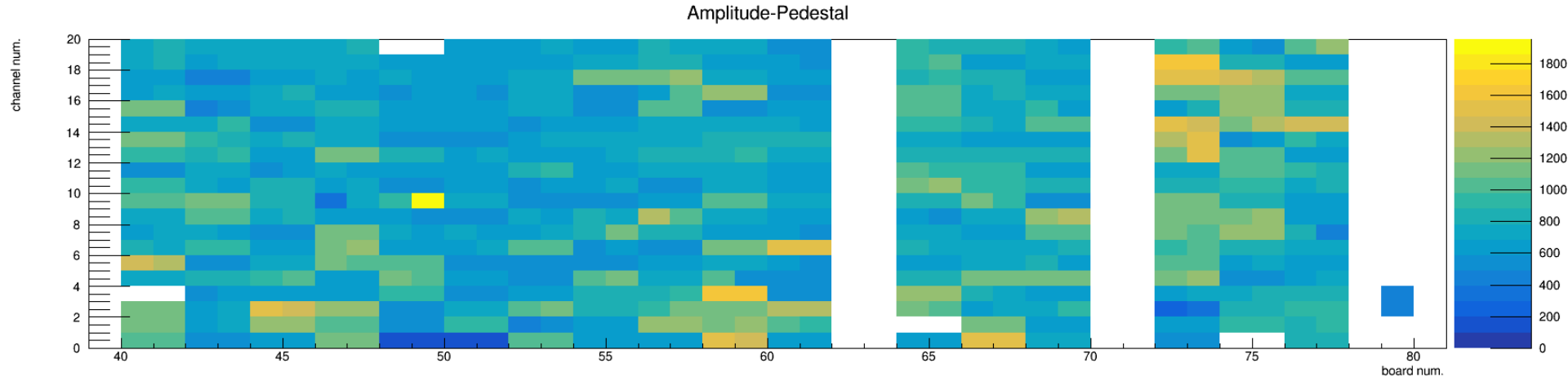


Laser Disk 0

DISK 0 PHI 0

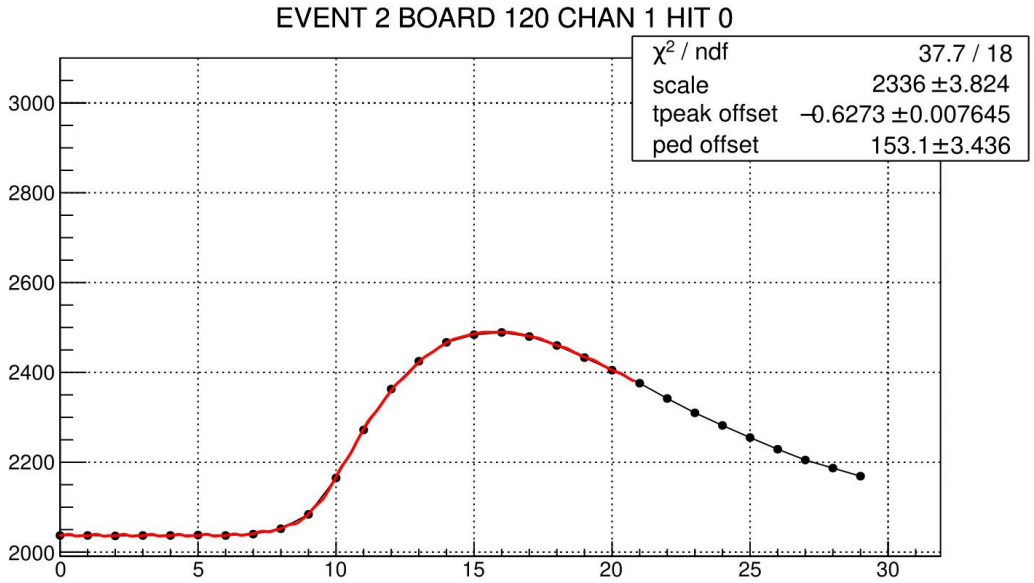


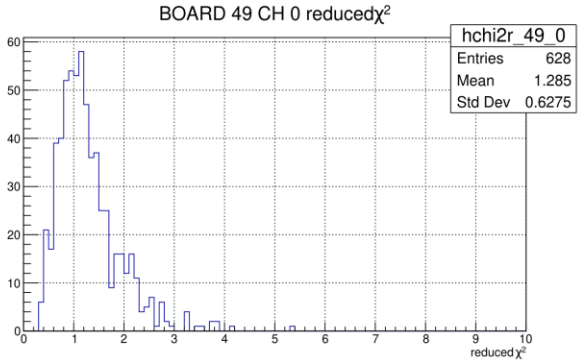
DISK 0 PHI 1

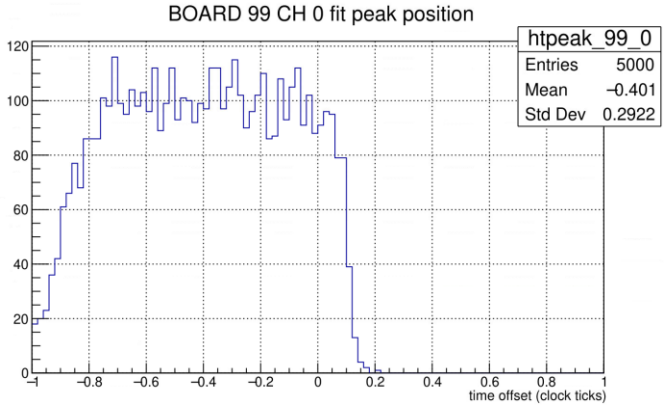


Template for time resolution

- During the first commissioning run we have also finalized a first version of the template fit for the full calorimeter, that we have applied on laser runs to extract the time resolution of the calorimeter and eventual timing issue between the boards (for more information see a detailed analysis of previus test in my docdb presentation about global run 4 Mu2e docdb 51682-v1 and 51820-v4)
- A template is build using a laser reference run for each half disk, then used to fit all data collected with that disk section

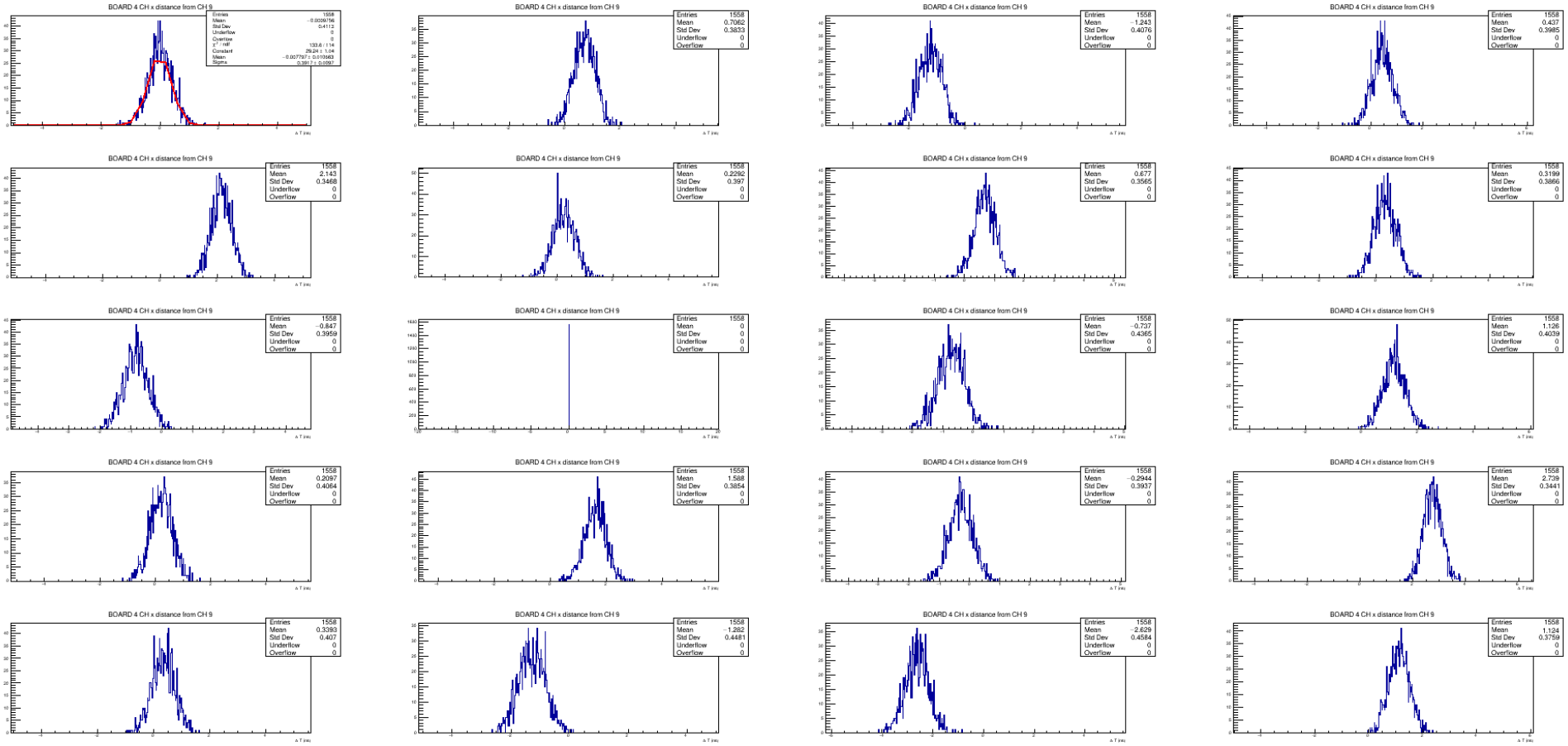




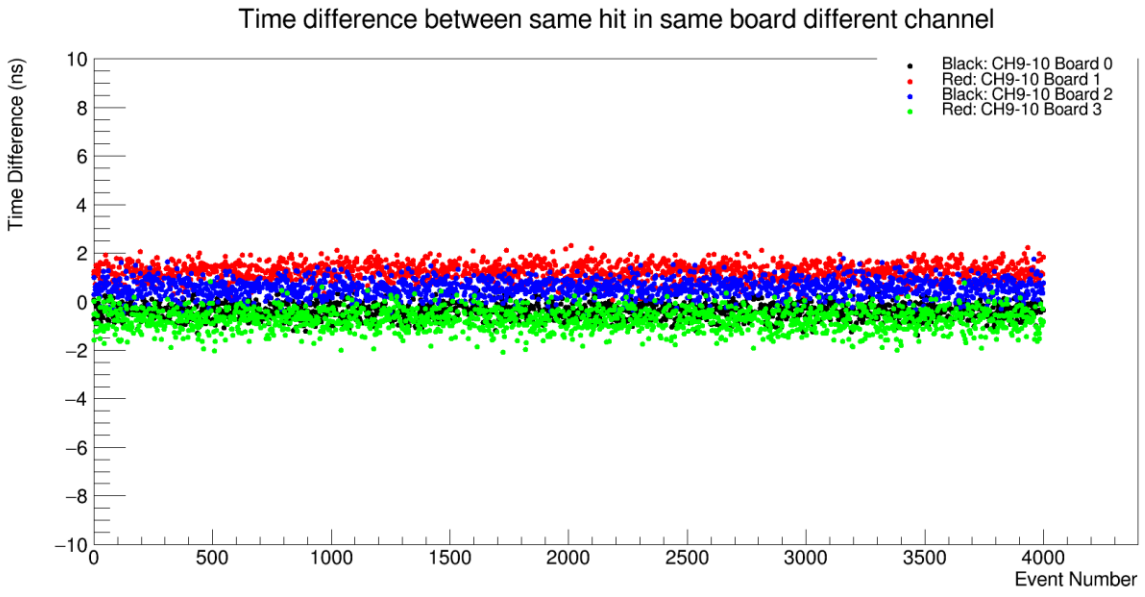


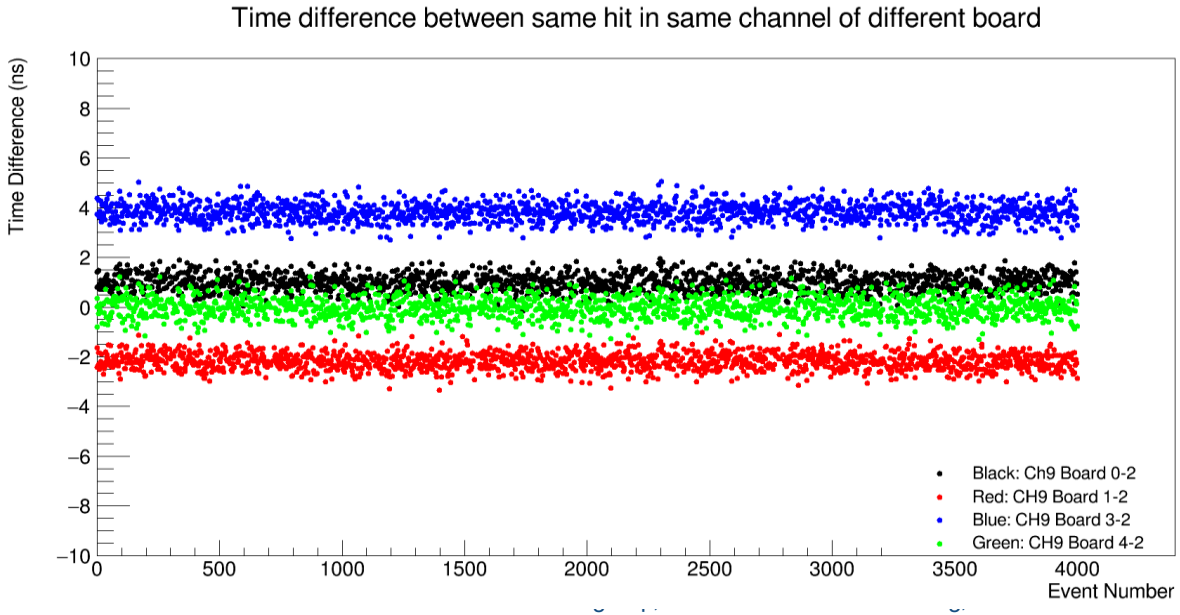
Time difference between channel in a board

Example: Board 4 time difference between all channel and the reference channel (10).



Stable with event in acquisitions





- The time difference inside the board and between different board stays the same along the full acquisition
- There are still jumps of 5 ns between boards when a reset happens, that are under investigations
- There are also discrete jumps of multiples of 250 ps between channels in the same board when the boards are power cycled, caused by arbitrary lock of the jitter cleaner phase at the start, a solution to this issue has been developed in this last few days, and is undergoing test in Pisa, with promising result, but still preliminary
- Further information on time synchronization will be hopefully provided in the next meetings

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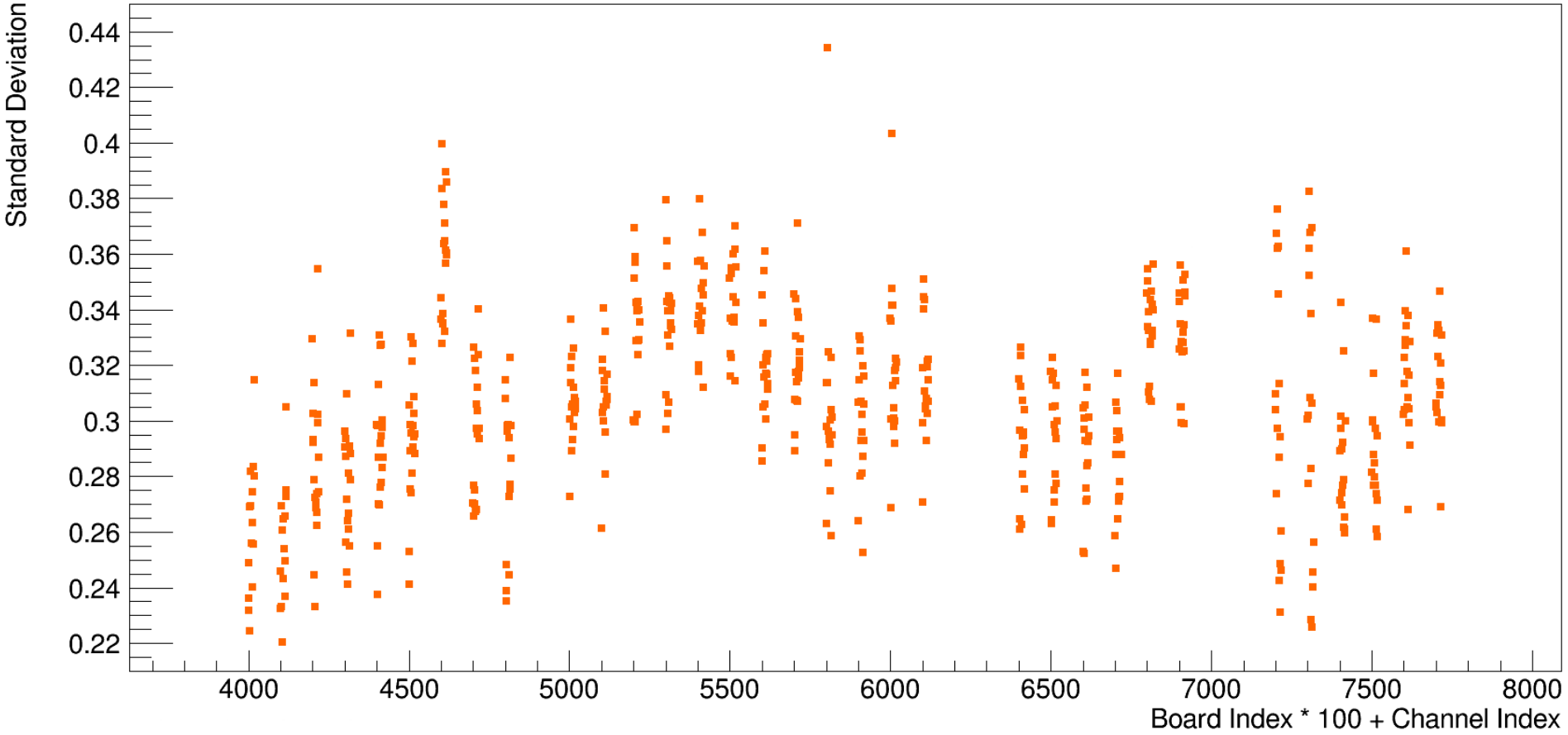
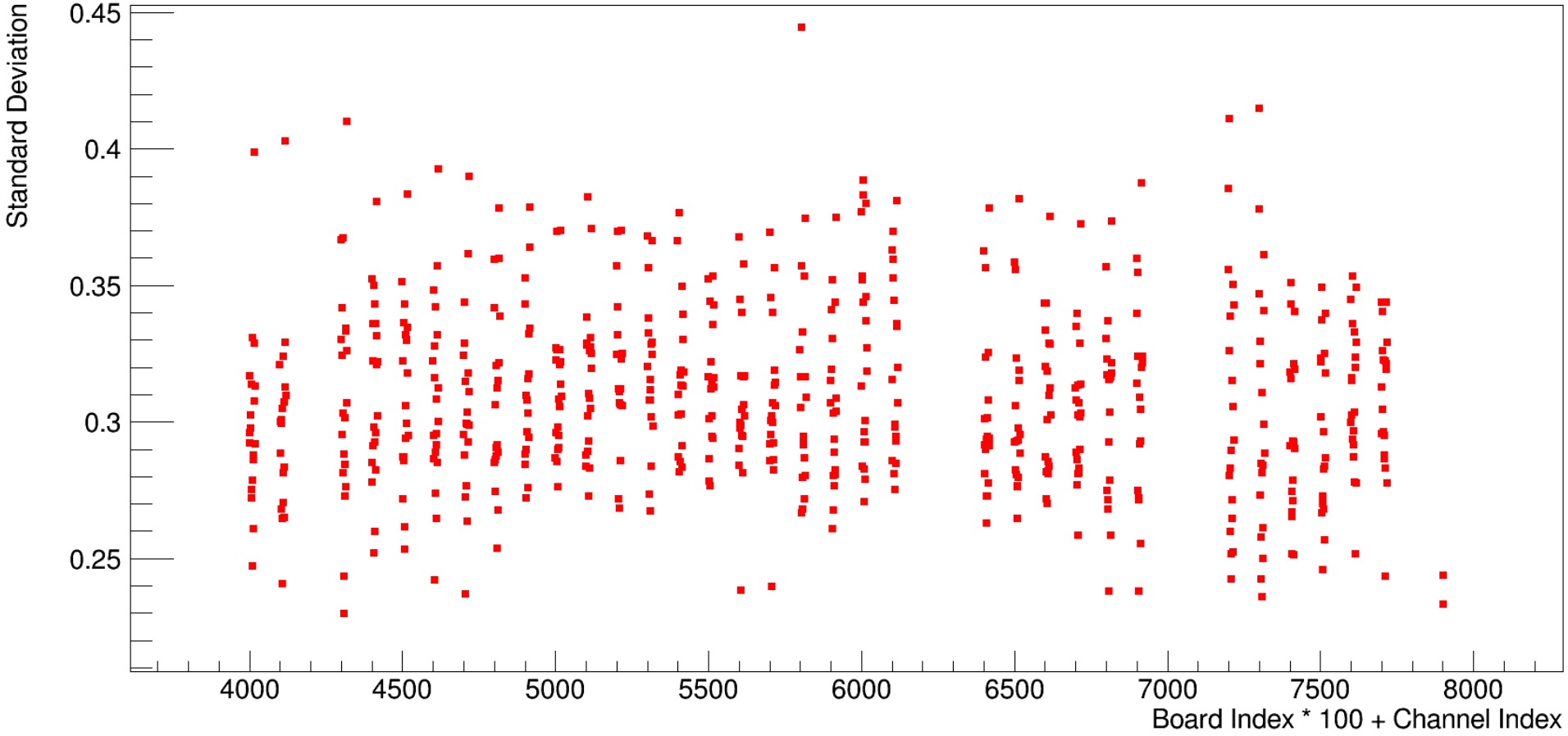
Standard deviation: channel in same board

The standard deviation of all the channels in same board is around 300 ps, and this is consistent in all the 4 sections of the calorimeter



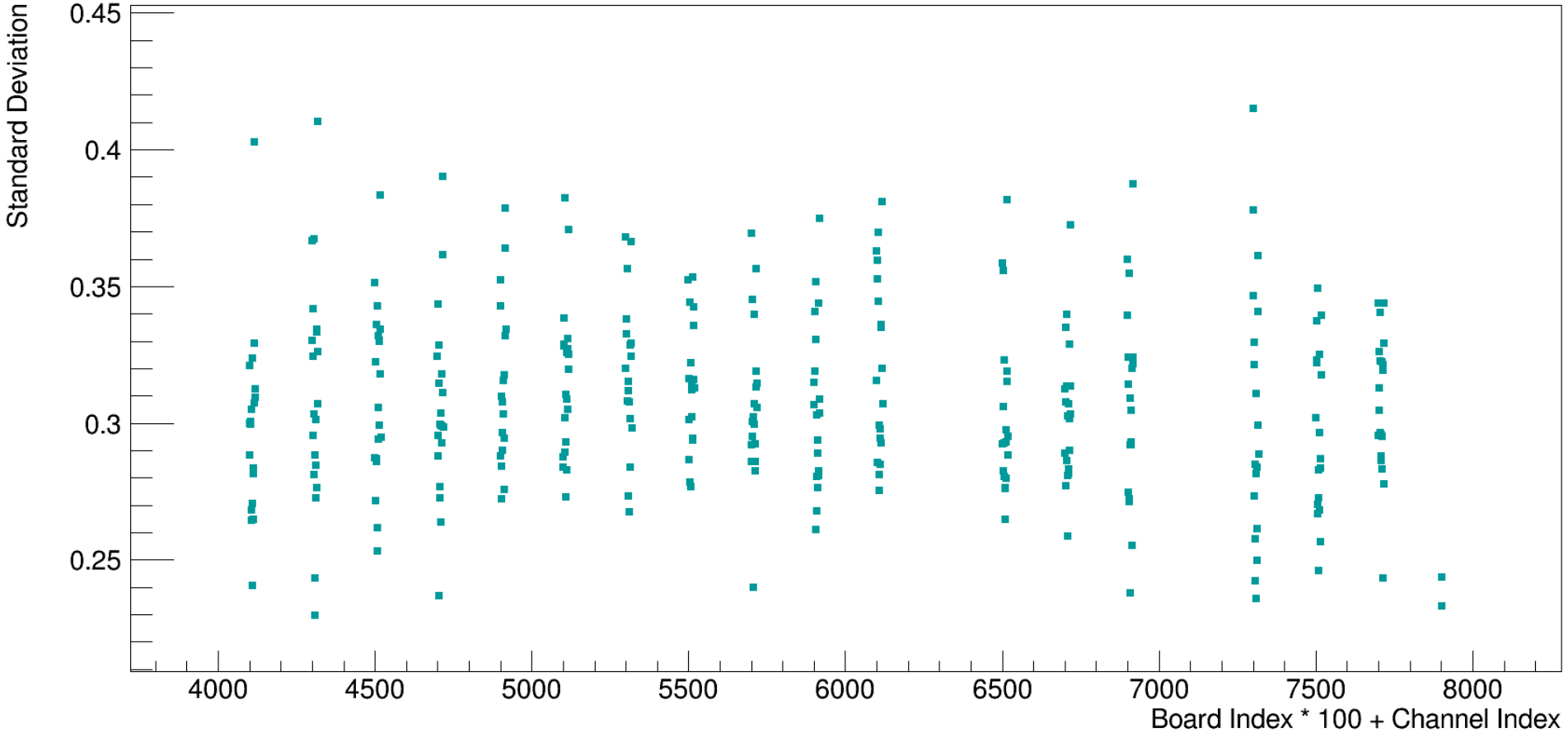
Standard deviation: different boards

The standard deviation of the time difference between all boards and a reference one is also around 350 ps, again consistent everywhere



Standard deviation: Sipms on same crystal

Same is true for the two Sipms on each crystal, around 300 ps and consistent for all the 4 section of the calorimeter



Timing analysis with template

- This system for time analysis is still in development and is currently being optimized.
- It needs to be automatized to detect possible changes of timing due to reset and power cycle that may have slipped during the global run or in the test bench that we are using to investigate the performance of firmware modifications in Pisa
- However, we have a first estimation of the time resolution of the full calorimeter, that raise no alarm flags on the correct functionality of the detector
- If someone is interested in more details on this timing analysis feel free to ask, for timing reason I limited the amount of information that I was able to shown
- Next step is to finalize the template procedure on the cosmics data sets, to have a prototype version of a timing analysis for the detector

Last step: cosmics

- As Sabrina will show in the following, we have collected approximately 60-80k of cosmics for each quarter of the calorimeter, allowing a first estimation of the MIP distribution to perform channel equalization
- A first test of the equalization procedure has been performed and checked using laser, as will show Vittoria in the following, it was successful but there is still a lot of space left for optimization
- In any case, the cosmics acquisition have revealed no issues in the calorimeter
- During the acquisition we have used the last update version of OTS-DAQ with really a minimum amount of downtimes, ensuring a successful commissioning run
- Furthermore, we were able to operate using ART-DAQ acquisition for Disk 1 (as in the past) and for Disk 0, without any sensible issue and with a quite smooth operation
- Also a first running version of the DQM has been tested, with relative success (Mark will probably tell you more)

Still some issues to be solved

- We have talked about successful points, we still have also some issues, starting on the DAQ side:
  - We faced several times an issue with the dispatcher of the trigger machine stopping working when the acquisition is halted, in particular if the acquisition has been stopped by release of incomplete event, forcing every time an hard reset of OTS to be able to start again an acquisition. Thanks to the work of the DAQ experts the downtime of the system when the runs are correctly closed has been strongly reduced, but there is probably still space for improvements
  - It's still missing an online database to log all the configuration of High Voltages and thresholds, in progress (more information in Anna Driutti presentation)
- On the Calorimeter side:
  - Issues with the MZB firmware that arises when the Busy signal of the MZB is raised. The mzb are then stuck in a state in which they are unable to communicate with the DIRAC (for example no slow control reading) that can be solved with a reset of the boards (powercycle). Further investigations are ongoing
  - Issues with Dirac firmware, like time offsets, that are under investigations at the moment

Commissioning run summary

- In the week between the 26th of May and the 1th of June the calorimeter team has performed a commissioning run collecting noise, laser and cosmics data with all 4 sections of the calorimeter with the hardware side (cabling and electronics) finalized
- All sections of the calorimeter are working correctly, with no dead channels or broken cables
- First test of a normalization routine for all the channels, analysis ongoing
- Ongoing timing analysis using laser acquisition for all the calorimeter channels
- Data have been collected using binary and with ART-DAQ for all the calorimeter, with minimum downtime. Some issues are already been solved, some are in progress, like the online database
- First working prototype of the DQM tested
- To conclude, the calorimeter is finalized and ready to be moved to the experimental hall!

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Thanks a lot for your attention!

If you have any question, feel free!

Mu2e