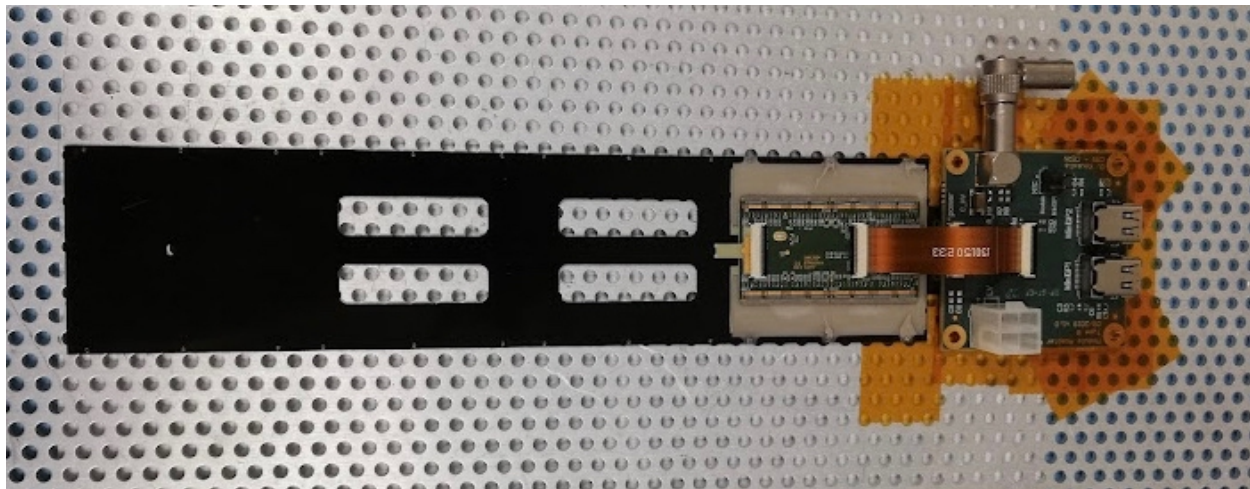


RD53A QUAD module mechanical and electrical properties after thermal cycling

R.Dell'Orso, A.Messineo, A.Starodumov

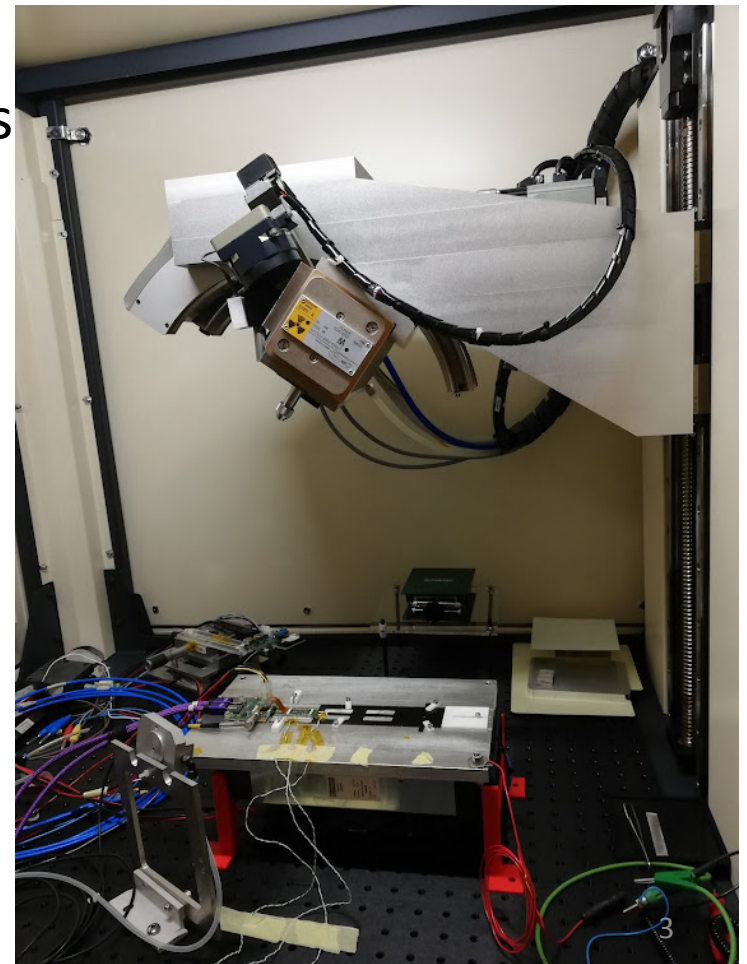
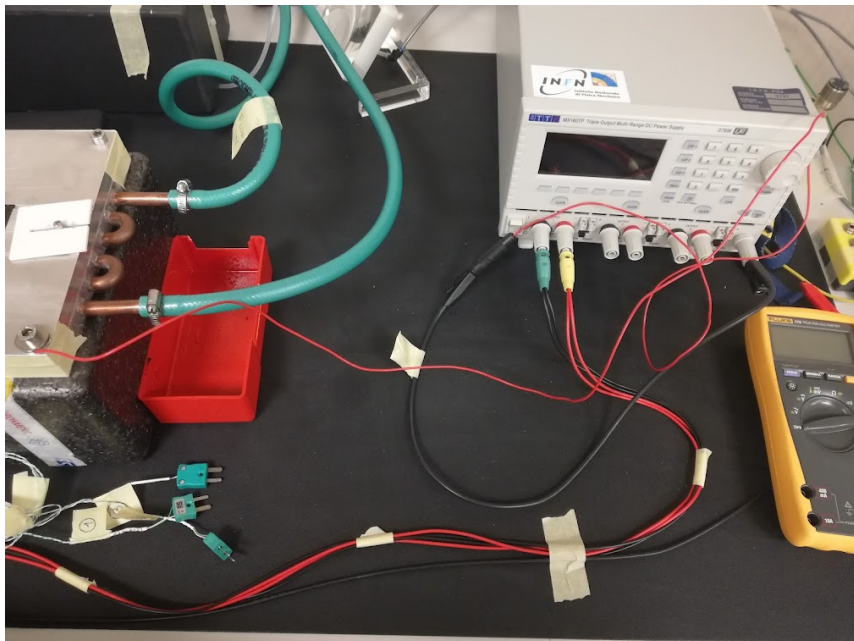
Goal of the study

- Goal of this study: investigate influence of T-cycling on mechanical and electrical properties of pixel module
- T-cycling done with with climatic chamber in CERN DSF QART lab
- Inspection of modules can be with new Nikon X-ray/CT machine installed recently in DSF clean room
- In May: learned how to operate climatic chamber with module inside and what can be do with Xray/CT machine
- Next week: another measurements at DSF

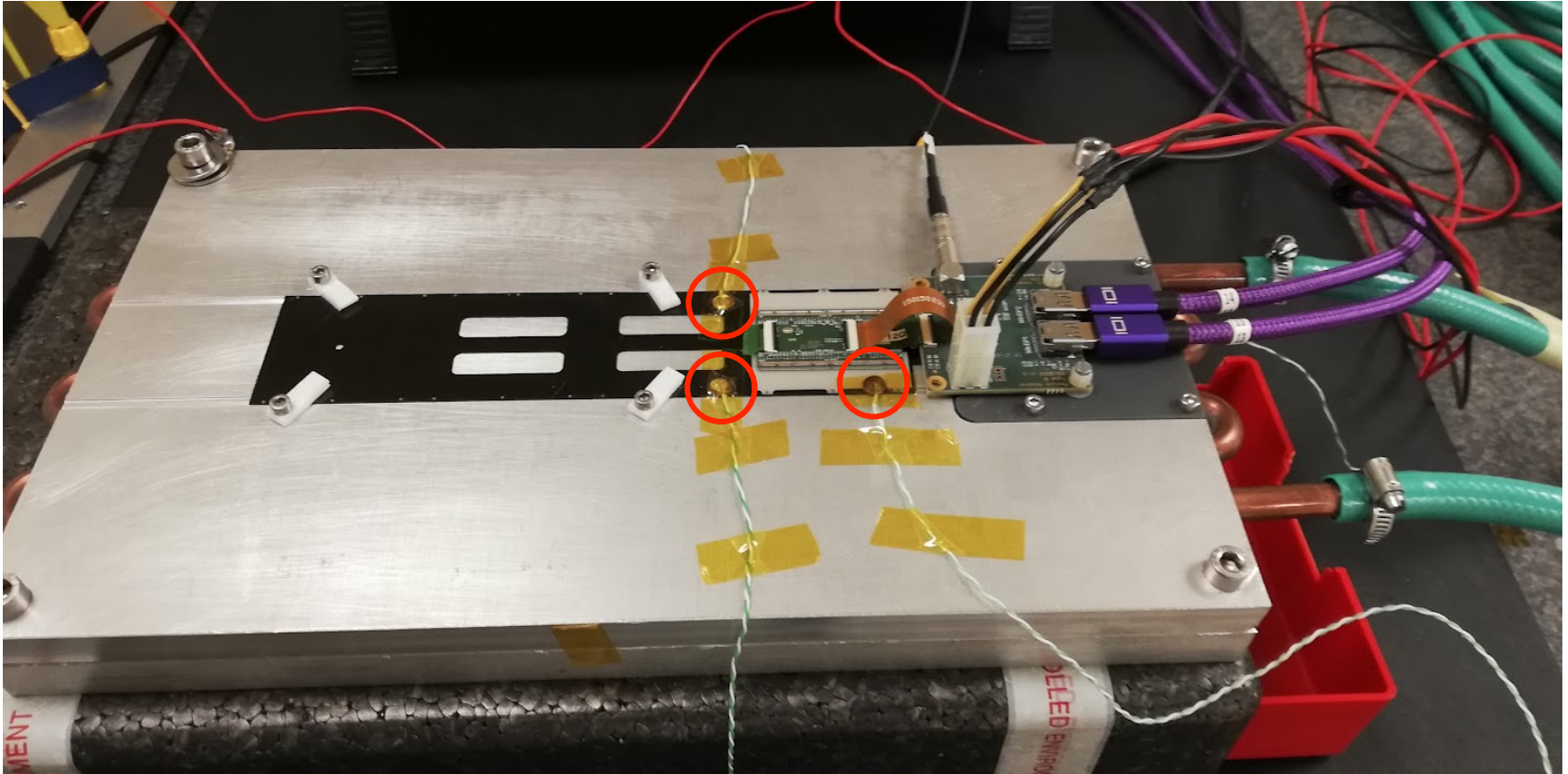


Thermal study in Pisa

- RD53A modules used in the study were built in Florence and tested/ studied in Pisa
- To test modules cooling setups has been build: cooled by 1) chiller and 2) air cooled Peltier
- Peltier setup uses the same top Al plates as one with chiller and operated inside Xray box



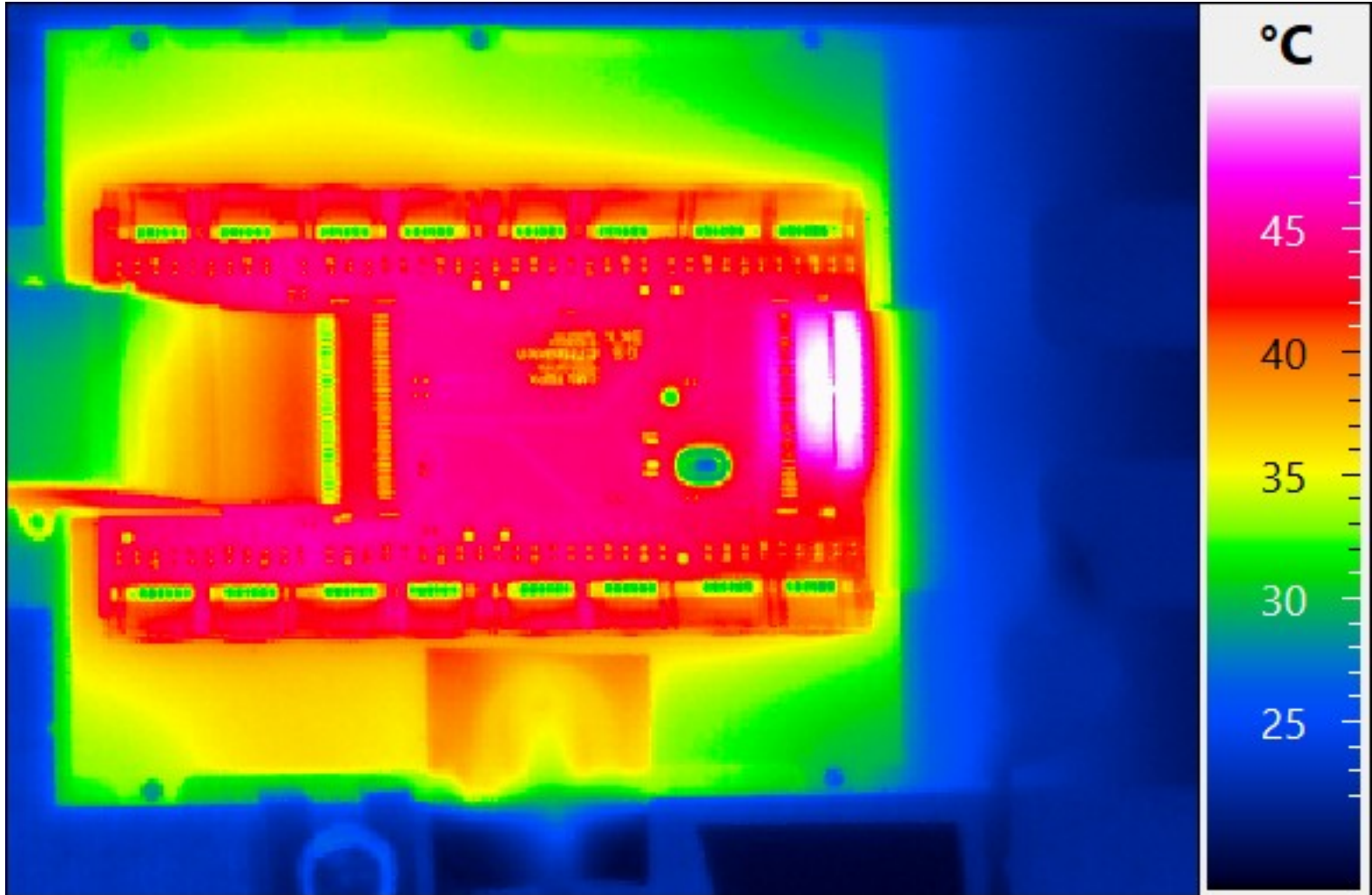
Thermal study in Pisa



- Chiller set to +15C, Al cooling plate +16C, Air +20C
- Carbon Fiber support structure +23C
- Module rails +36C
- Chip measurements: +70C
- HDI (thermal camera measurements): +45C

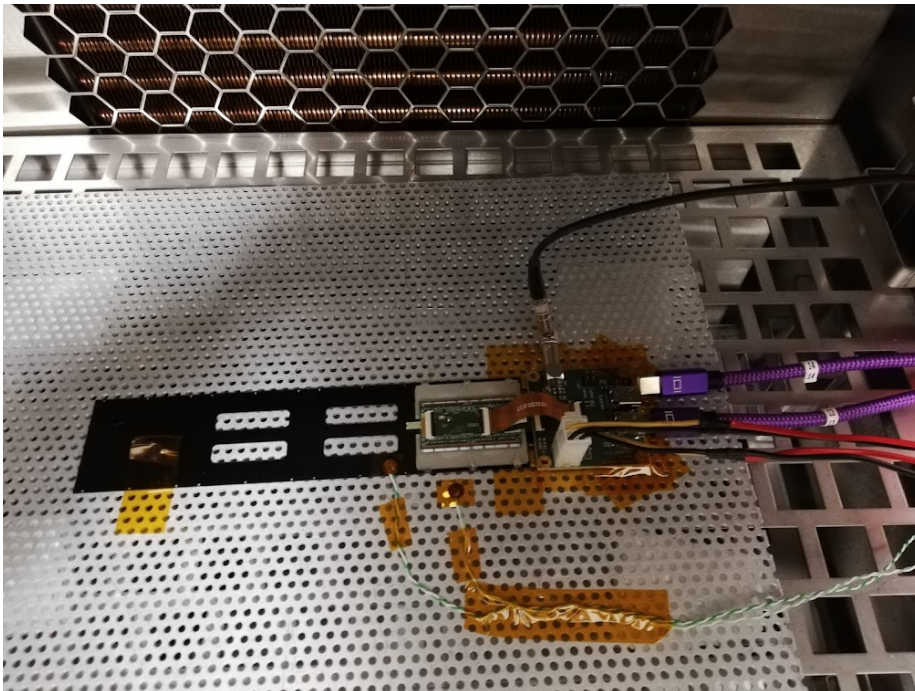
ΔT (CF-plate) = 7C
 ΔT (rails-CF) = 13C
 ΔT (chips-rails) = 34C
 ΔT (chips-CF) = 47C

Thermal camera image



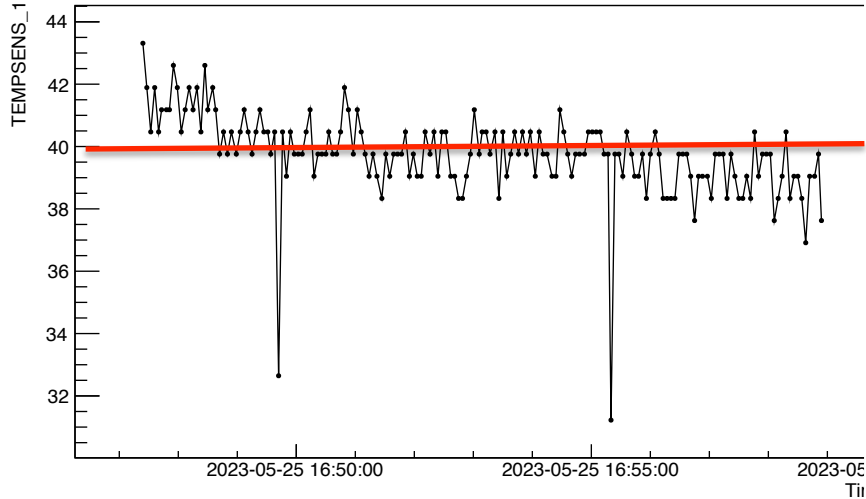
Thermal study at QART lab

- Substitute heavy Al cooling plate with a light Al mesh to avoid condensation during T ramp up
- Two T sensors: T1 – CF ladder, T2 – Al plate. Measurement with digital thermometer
- Thermal cycles between Tair of +5C and -20C
 - At air T = -20C: T1 = -7C, T2 = -16C
 - test module at -20C after a few cycles
 - LV power ON, HV power OFF

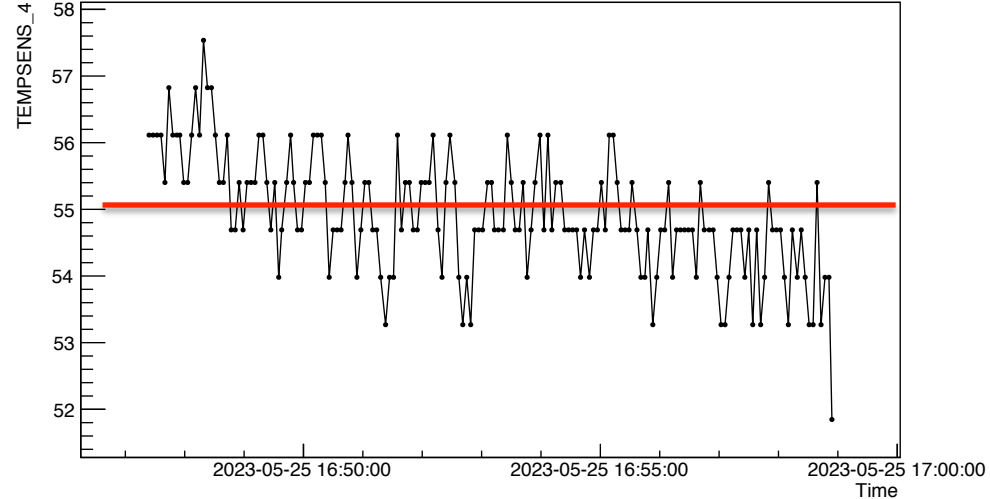


Thermal study at QART lab

D_B(0)_O(0)_H(2)_DQM_TEMPESENS_1_Chip(7)



D_B(0)_O(0)_H(2)_DQM_TEMPESENS_4_Chip(7)



Two T sensors place on T1 CF and T2 on Al mesh

Air T = -20C

T1 = -7C, T2 = -16C

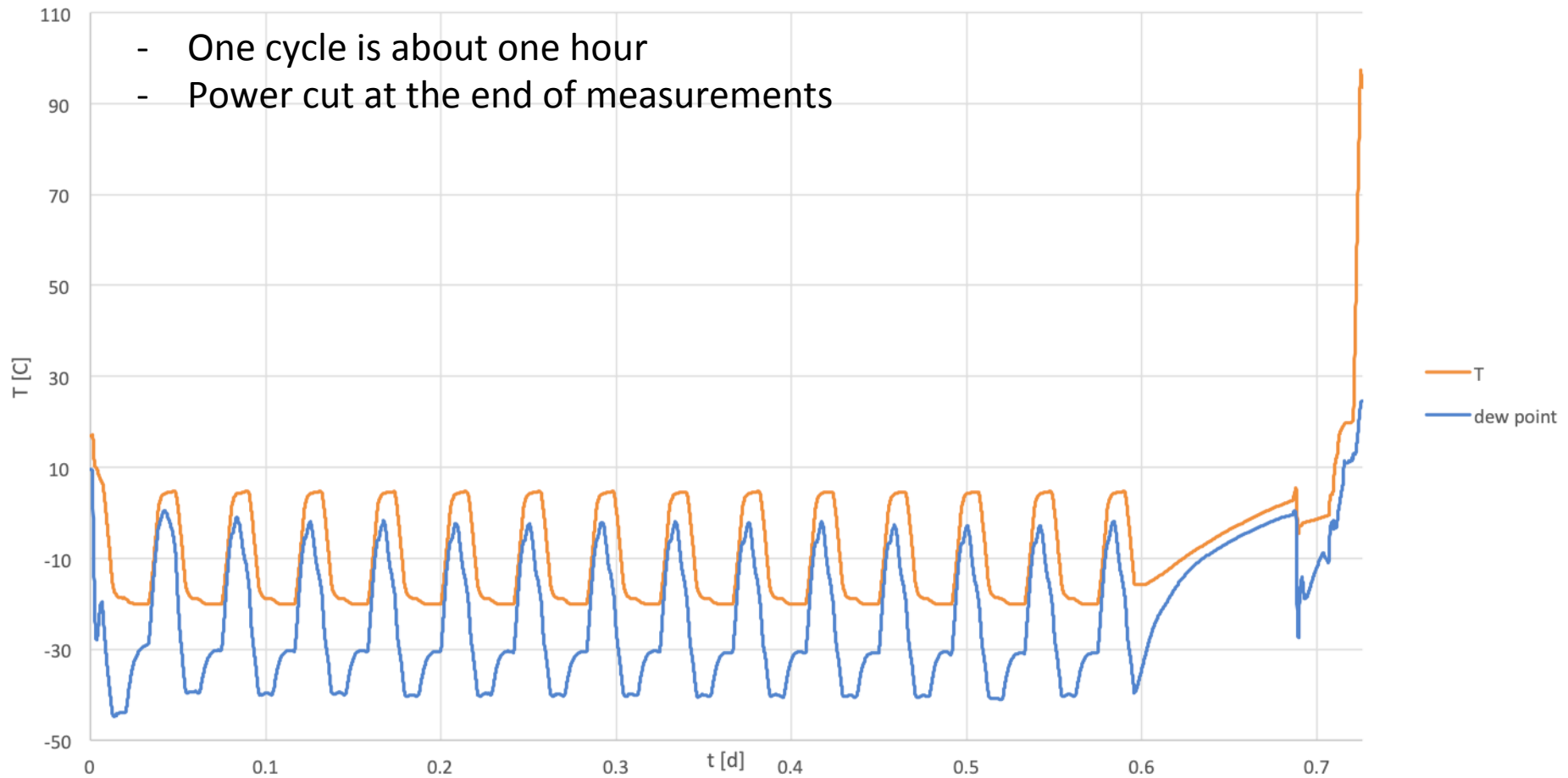
Measurements on chips: **+48C**

$\Delta T(\text{chips-CF}) = 55C$

Air T = +5C

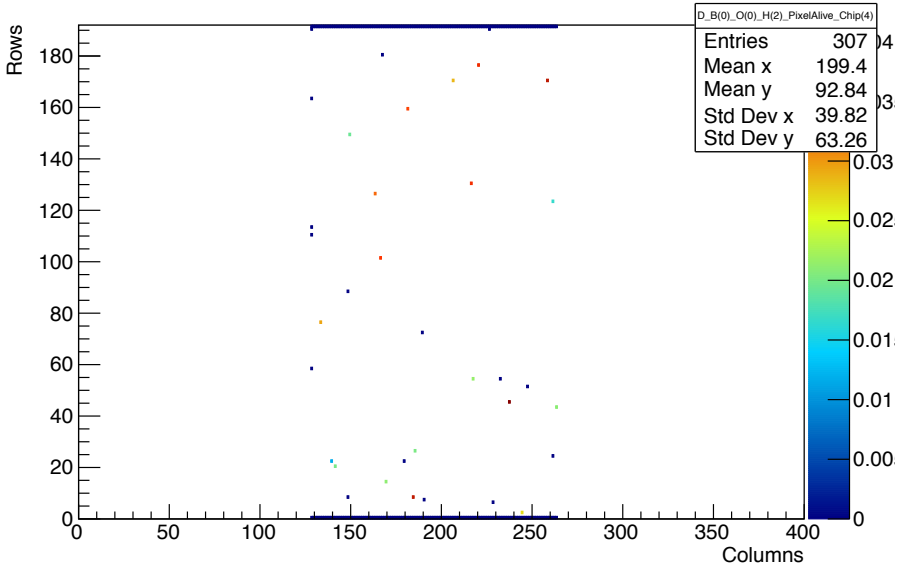
Measurements on chips: **+75C**

T vs time in QART lab, T-cycling

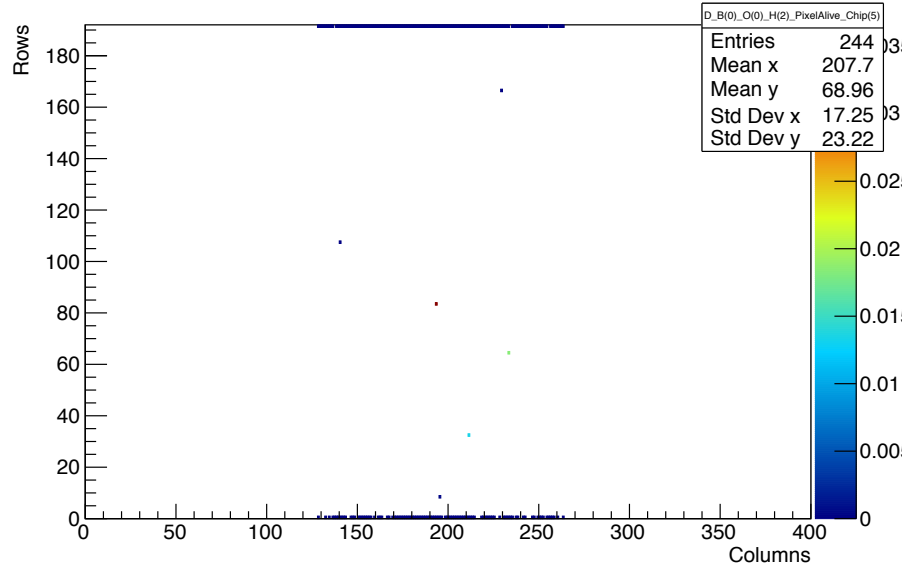


Noise issues after T-cycling, HV OFF

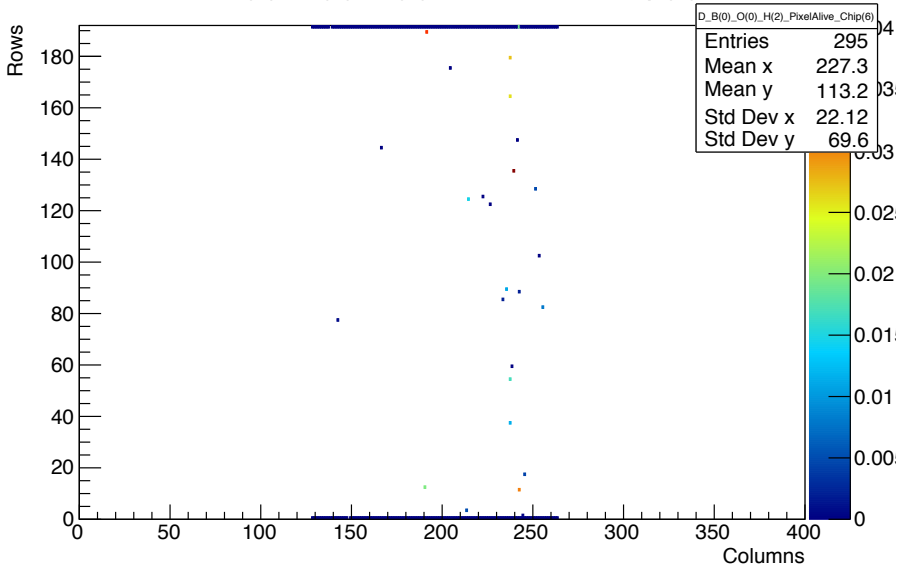
D_B(0)_O(0)_H(2)_Pixel Alive_Chip(4)



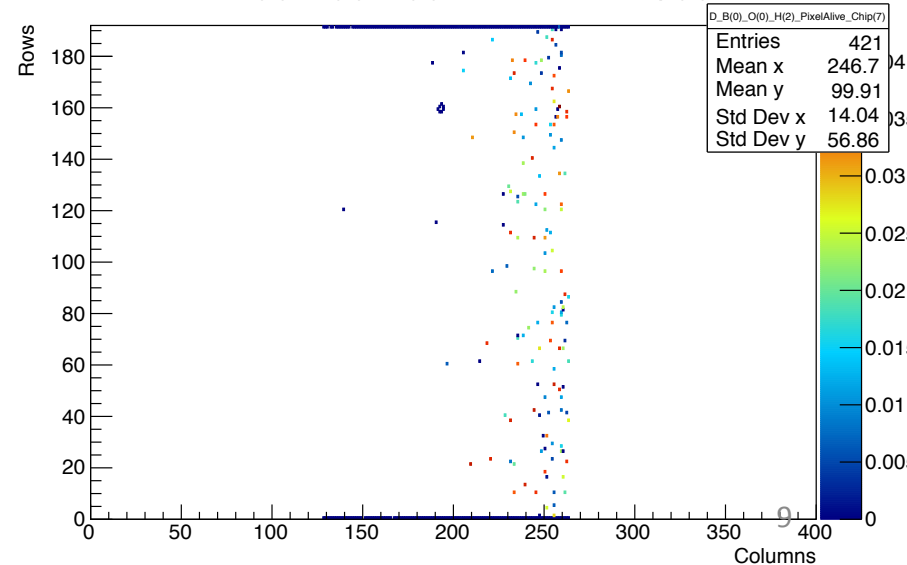
D_B(0)_O(0)_H(2)_Pixel Alive_Chip(5)



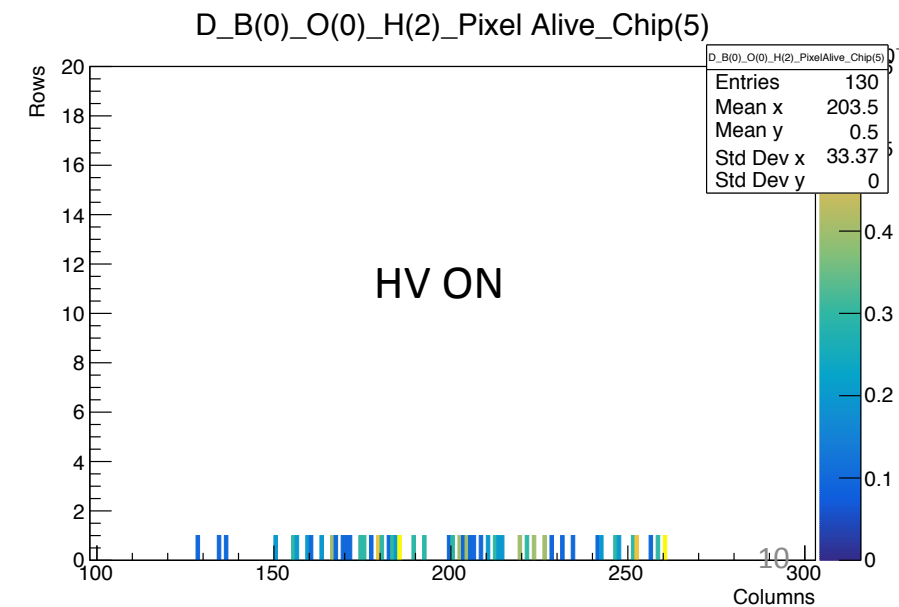
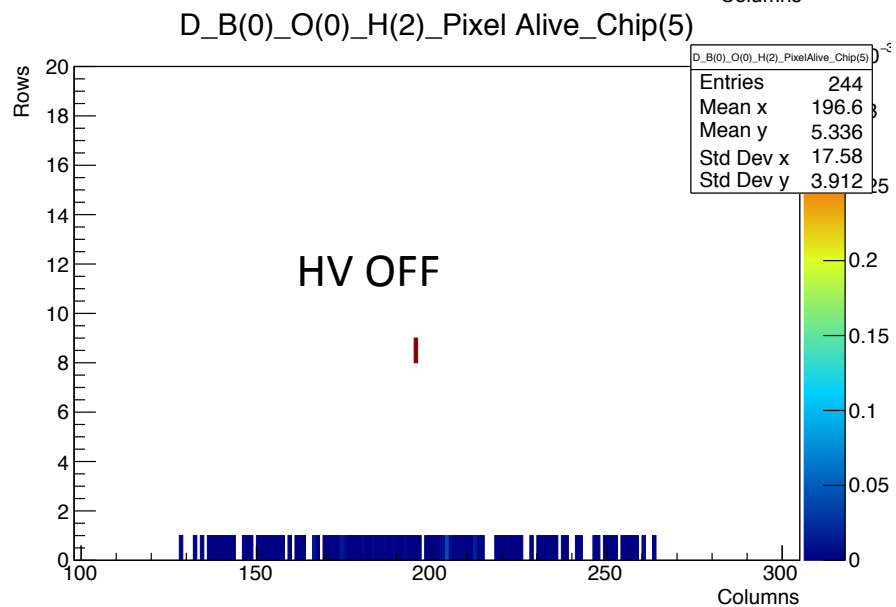
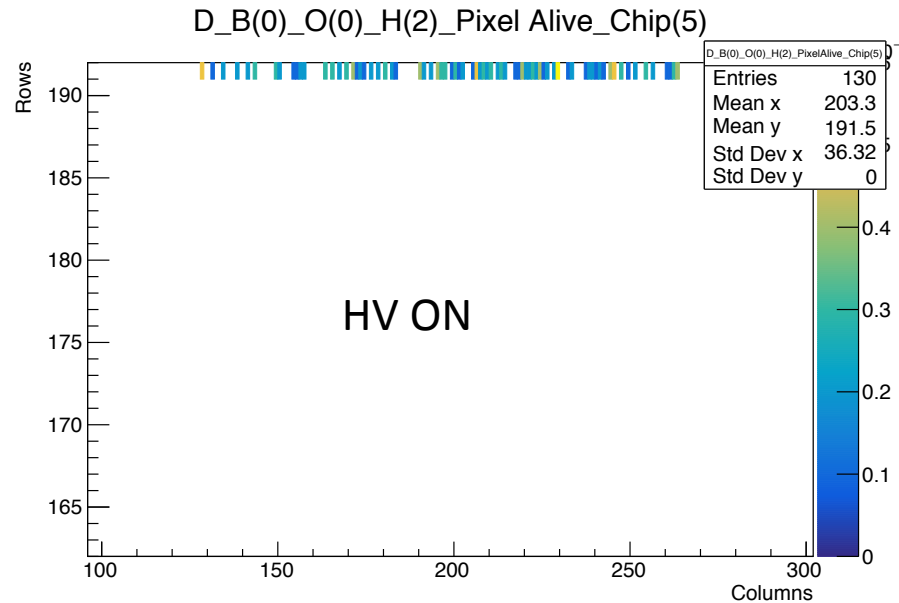
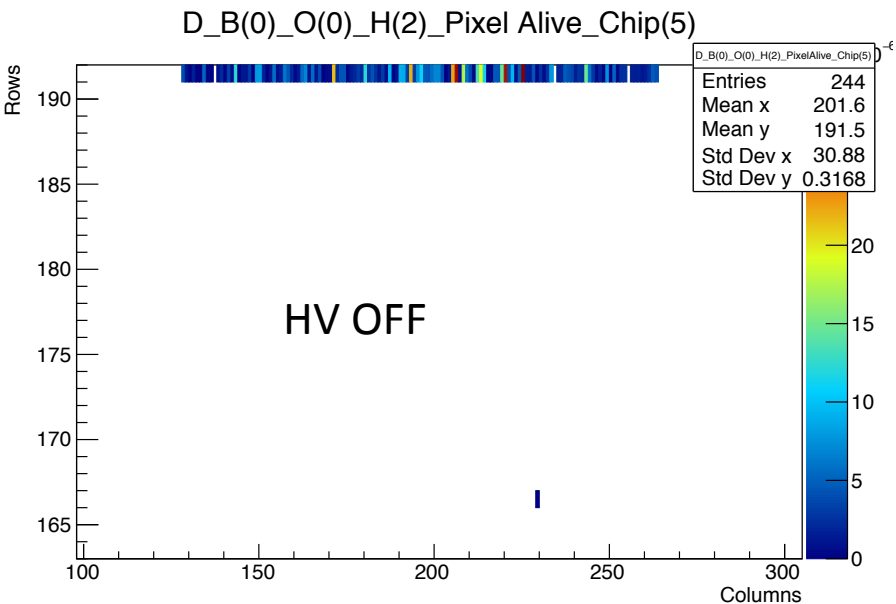
D_B(0)_O(0)_H(2)_Pixel Alive_Chip(6)



D_B(0)_O(0)_H(2)_Pixel Alive_Chip(7)

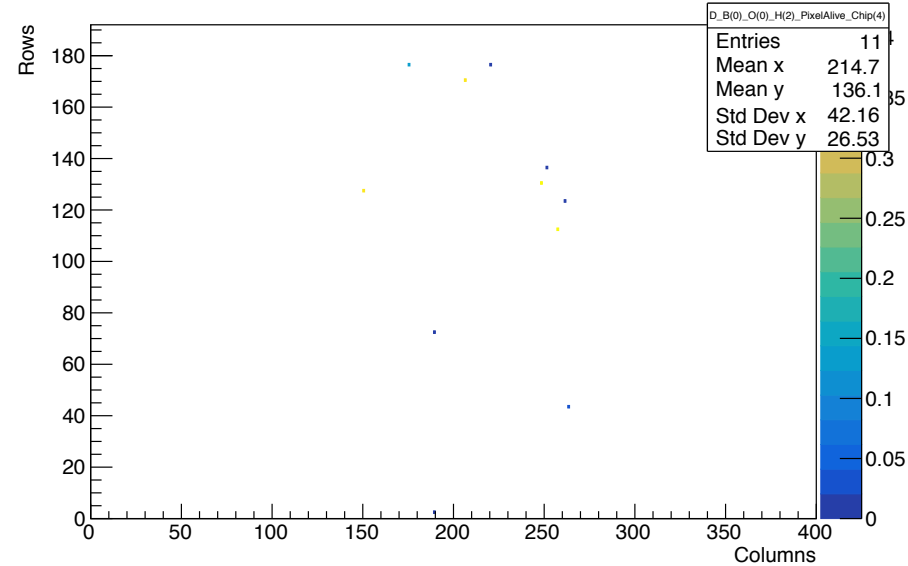


Noise issues: HV OFF/ON

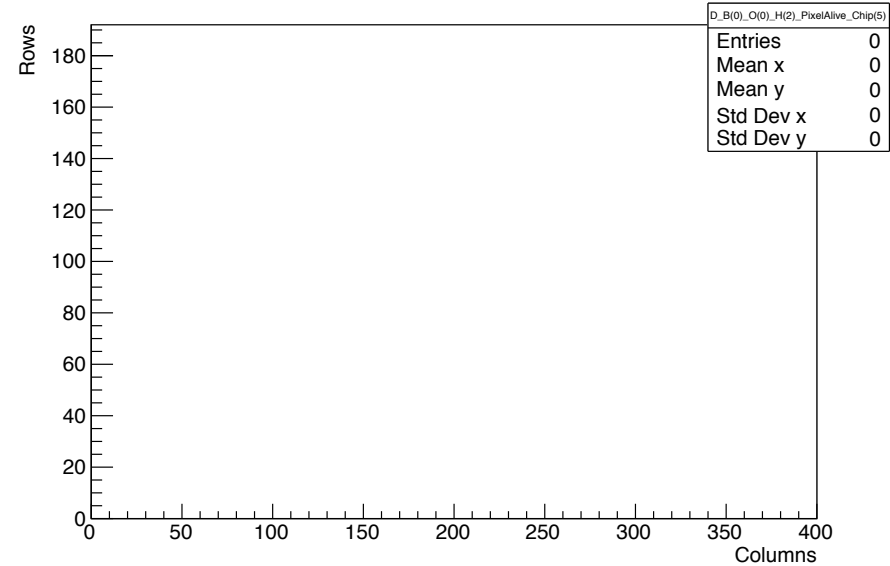


No issues before T-cycling, HV OFF

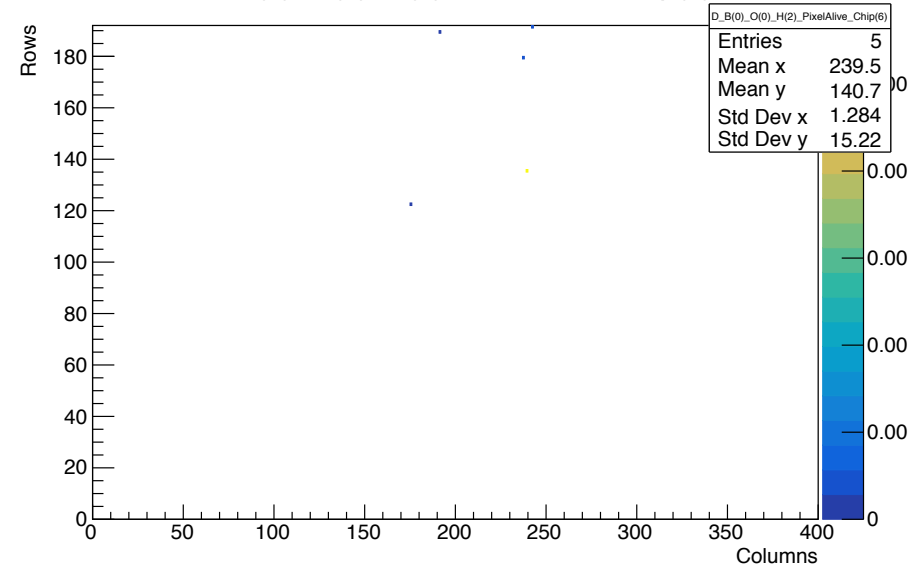
D_B(0)_O(0)_H(2)_Pixel Alive_Chip(4)



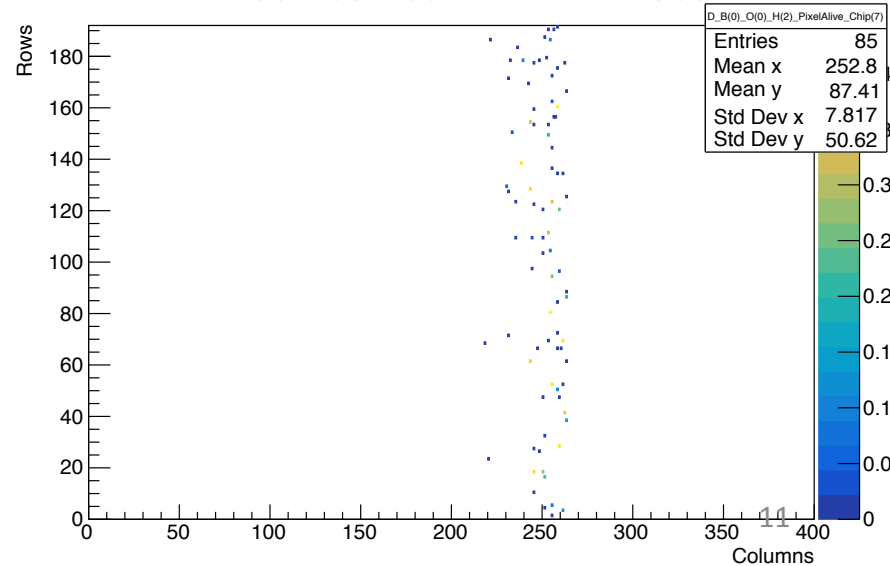
D_B(0)_O(0)_H(2)_Pixel Alive_Chip(5)



D_B(0)_O(0)_H(2)_Pixel Alive_Chip(6)



D_B(0)_O(0)_H(2)_Pixel Alive_Chip(7)



Observations

- After T-cycling down to -20C (about 20 cycles)
 - A lot of noisy pixels appear in the first and last raw
- Questions:
 - can one trust ΔT (chips-CF) = 50C in climatic chamber?
 - how much one can trust on chip T sensors without calibration?
 - need to use module with calibrated T sensors (ADC) on chips
- Next steps:
 - simulate the module and cooling setup to verify observed large ΔT
 - repeat study in climatic chamber: keep LV and HV OFF during T-cycling and turn on LV periodically to emulate T during power accidents ($\Delta T = 60-70C$)
 - repeat study with **CROC module and final module design/components**