UNIVERSITY OF LIVERPOOL

DESY test beam 24-27 Feb 2014 report

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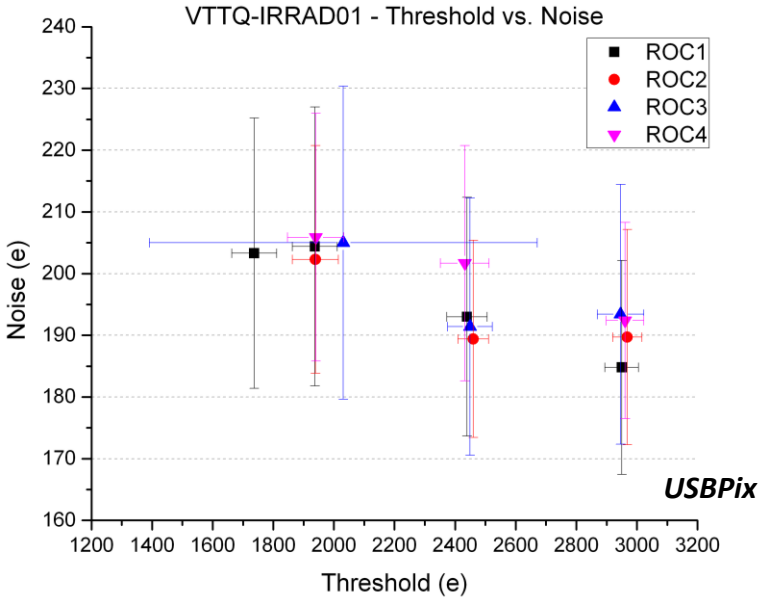
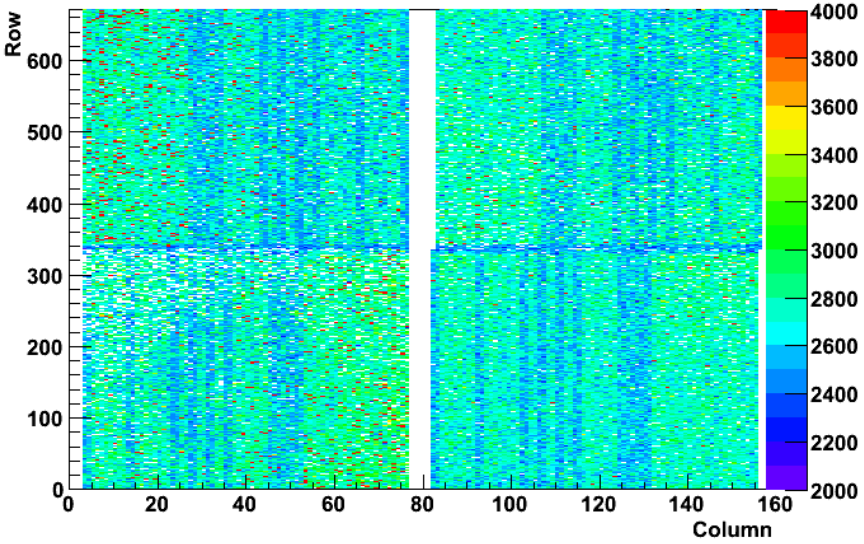
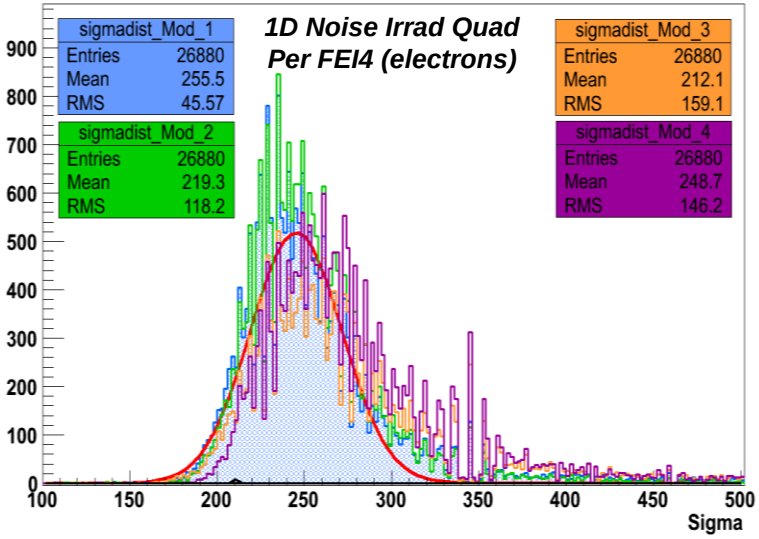
The irradiated quad results before the TB

- The irradiated quad showed very good results in terms of noise per FEI4A IBL ASIC; it is possible to bias it up to more than 1000V with proper cooling and can go down to 2000e threshold.



Threshold occupancy @3000e, 800V bias



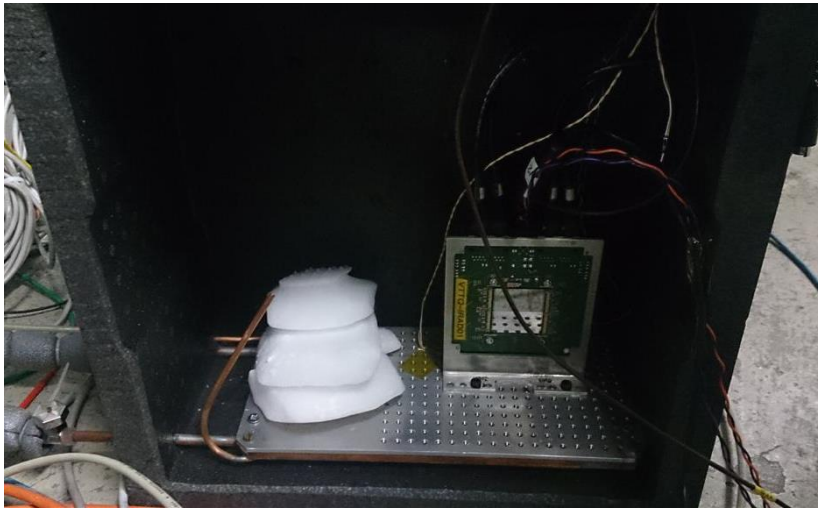


Test beam plans/DUTs

- The plan included following both non-irradiated and irradiated devices (by priority):
  - Quad (Quad5 and VTTQ-IRRAD01)
  - Sinlge (geometries):
    - 500x25um
    - 125x100um
    - 250x25um
    - 167x125um (spare, in case there is time)
- The plan was to test the non-irradiated quad at two thresholds (3000e and 2500e) at 10ToTs@16ke (tuned using IBL recommended primlist), looking at the centre and at the interface(s)/ganged pixels.
- Irradiated devices were all to be tuned to 2000e threshold, 8ToTs@15ke and tested at different voltages (at least two)
- It was planned to record ca.2 million trigger events for each given DUT voltage/threshold, and 3-4 million for the irradiated quad.
- Since the irradiated quad had noise issues with the RCE, it was suggested to use the USBPix for data taking.
- Tests with dry ice to see if it can be used as an additional coolant for the quad.

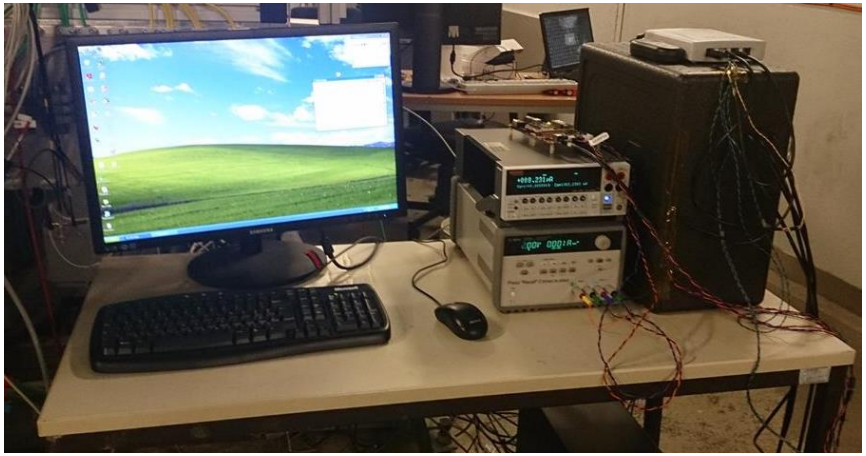
Test beam preparations

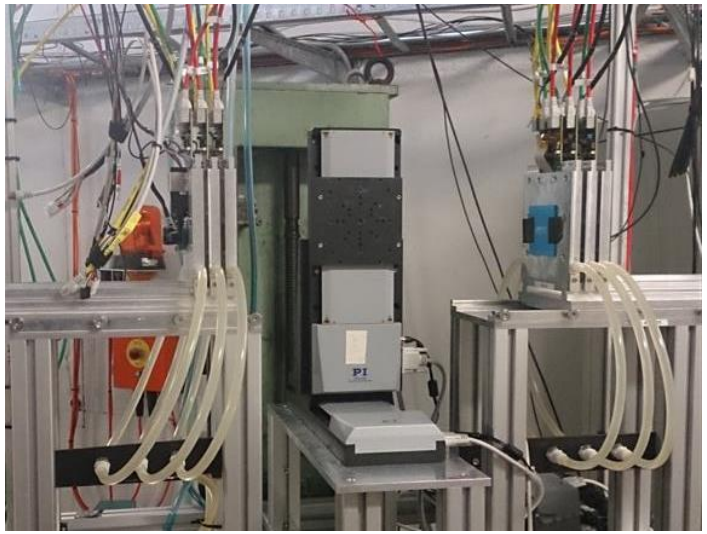
- During the weekend, tests were done with dry ice to check if it can be used for additional cooling power.
- The irradiated quad was put to the test and tuning at 2000e (400V bias) was attempted with USBPix.
- From the results we could conclude that as soon as the DUT reaches temperatures lower than ca. -40-45^{o}C, it would malfunction (in our case, the tuning was unsuccessful).
- This is because the **dew point inside the box varies from -60^{o}C, to -45^{o}C** during the measurements, even with the nitrogen supply that we took from TB22. In case of quad, it gets even higher than this during operation, due to large temperature differences.



Test beam preparations

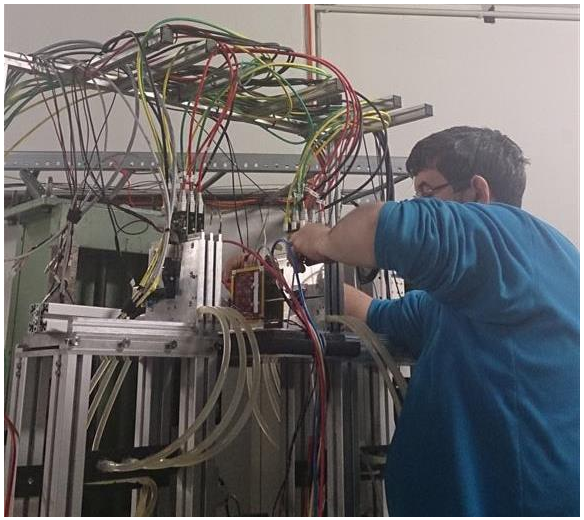
- The next day, dry ice cooling was tested again, but this time with the help of a chiller, which was used to stabilize the temperature, so it would not go below -35^{o}C.
- The tests came out successful, and we were able to tune one of the quad chips with USBPix to 2000e at 200V and 400V bias.
- In the meantime, we made a plan to put the non-irradiated in the test-beam on Monday morning, since it didn't require cooling.
- There were also some issues with the test beam equipment; the RCE computer lacked a network card, so Martin and Marco had to go and buy another one on Monday morning, while Igor was trying to set up the network, since the computers couldn't talk to each other even upon our arrival.

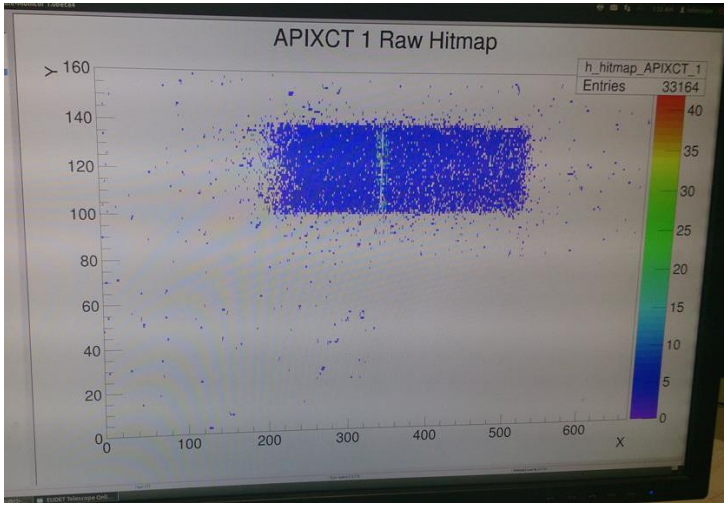




Test beam - Monday

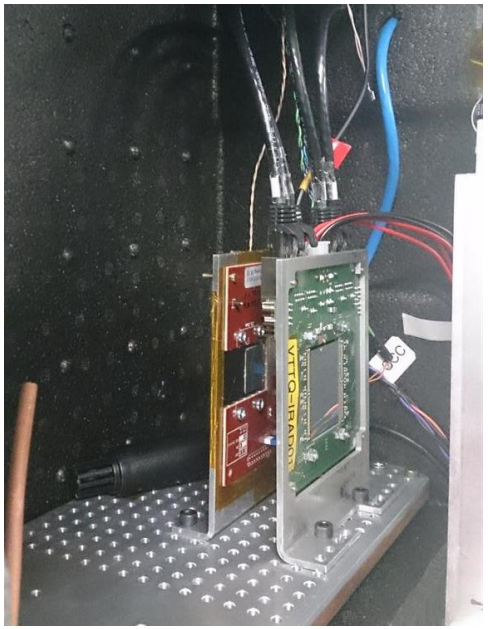
- While trying to recover the network and the RCE, the non-irradiated quad was mounted inside the old DOBOX, together with the 250x50 um reference DUT.
- Meanwhile, together with Martin, we were experimenting with different tuning primlists for the irradiated FEI4A quad, since the RCE had noise issues with it and adapted it with additional parameters to successfully tune one of the chips at 2000e.
- Data was taken with the Quad5, chips 1,2&3 (FEI4A) at 3000 and 2500e threshold, 10ToTs@16k (IBL recommended). However, due to ToT overflow (since these are 280um sensors), it was corrected to 10ToTs@20k and redone.
- Chip1&3 interface was looked at, as well as the centre of the quad.





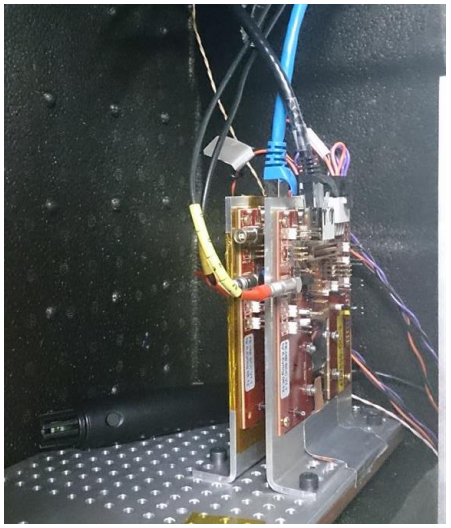
Test beam - Tuesday

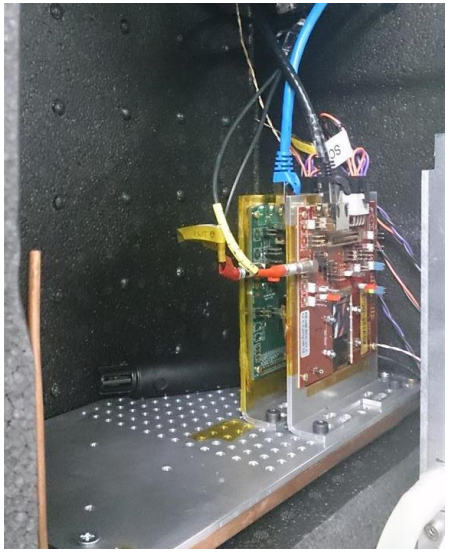
- The new ColdBox was mounted and the irradiated quad was tested with the RCE, using dry ice and chiller for temperature control.
- When running all 4 chips with the RCE, the convective heat transfer was insufficient (thermal runaway occurred even at 100V), and therefore we carried on with irradiated single chips and tried to find a solution in the meantime for cooling the quad.
- Data was taken first with the irradiated 500x25 using the same geometry non-irr. DUT as reference.

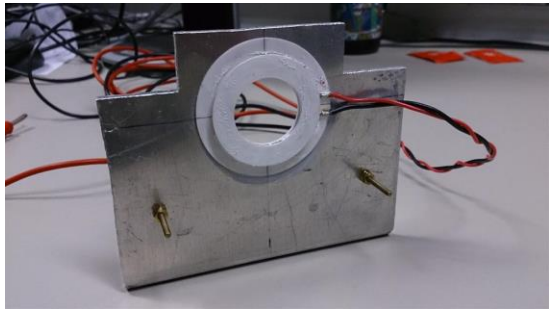


Test beam – Tuesday (continued)

- ADV500-DC-3 allowed biasing only up to 145V, when it went to breakdown and could not be recovered. However, data at 2000e, 9ToTs@15ke, 100V bias was taken.
- This device was critical before; added coating didn't help.
- The irradiated ADV125-DC-3 (square) device was put next and data at 2000e, 9ToTs@15ke, bias scan 100-500V in 100V was taken. There were no issues with this device.
- Since each measurement/tuning took roughly an hour, in order to go to higher voltages (400 and 500V), more dry ice was needed since one batch of 3-4 blocks lasts 3-4h.
- In the meantime, a cooling solution for the irradiated quad, using a round Peltier was tested and proved successful.

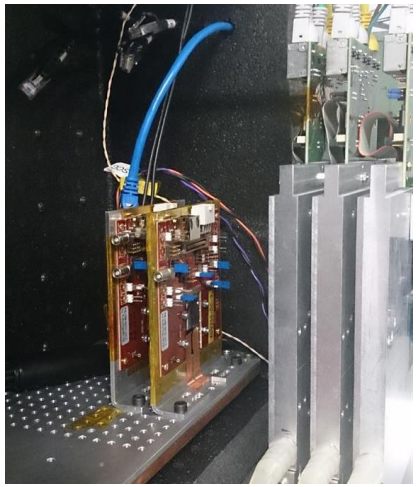


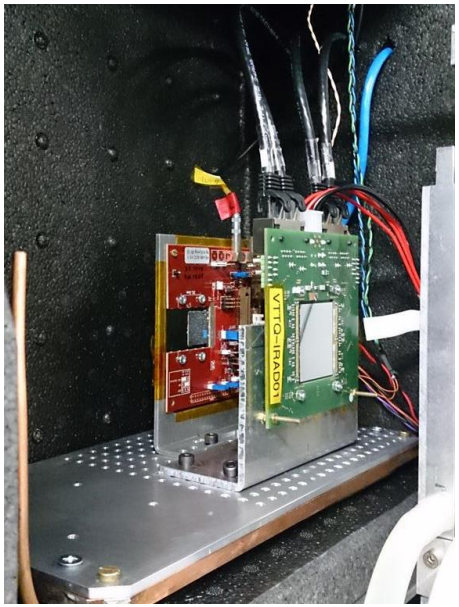




Test beam – Wednesday

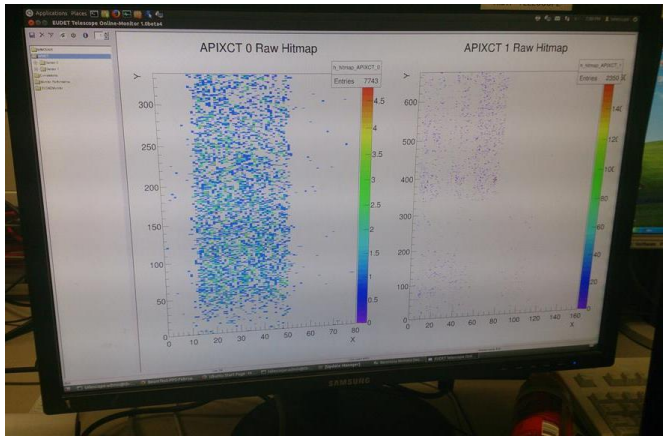
- ADV250-DC-3 irradiated device, with the same geometry non-irr. DUT as reference was tested next, and a bias scan also from 100 to 500V at 2000e threshold, 9ToTs@15ke was taken.
- There were no problems.
- The irradiated quad (VTTQ-IRRAD01) was then mounted, together with the round Peltier and Al support.
- We found that when tuning all 4 chips at the same time (not just one), the noise would again be an issue with the RCE. Therefore some time was spent in finding an optimal primlist with Martin (only the slow one gave satisfactory results).
- After ca. 4h, the dew point inside the box rose to above -30°C, and therefore another cycle of heating up and cooling down had to be done to prevent damage/malfunction with the quad.

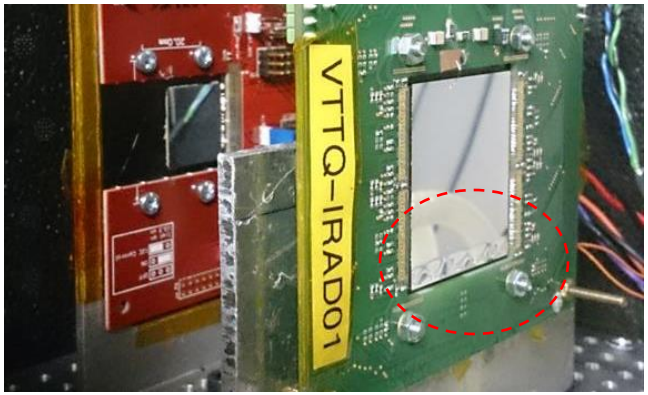


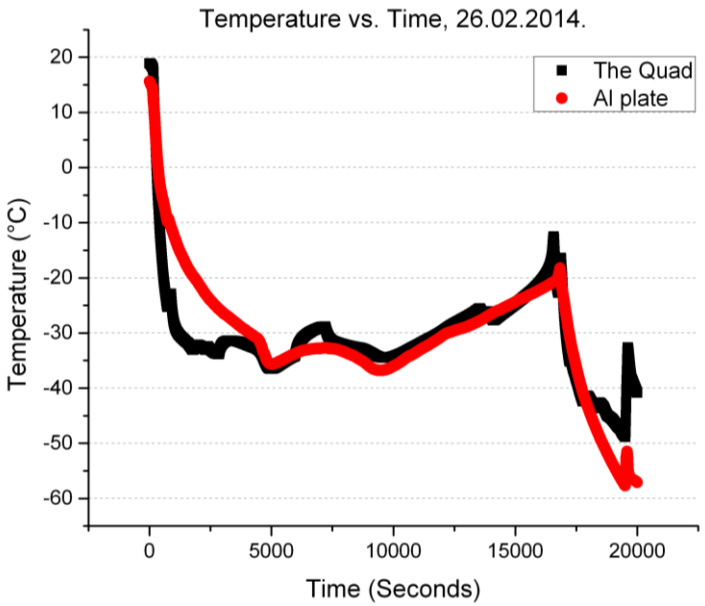


Test beam – Wednesday (continued)

- Afterwards, after aligning and minor issues with the eudet conf file we started taking data with the irradiated quad at 500V (2000e threshold, 9ToTs@10ke), using the same geometry non-irr. DUT (250x50) as reference.
- No additional quad positioning available, only the center of the quad could be looked at.
- During data taking, the temperature was not well controlled and it went down to ca.-50°C, which caused condensation to occur and chips 2&4 (at the bottom) malfunctioned.







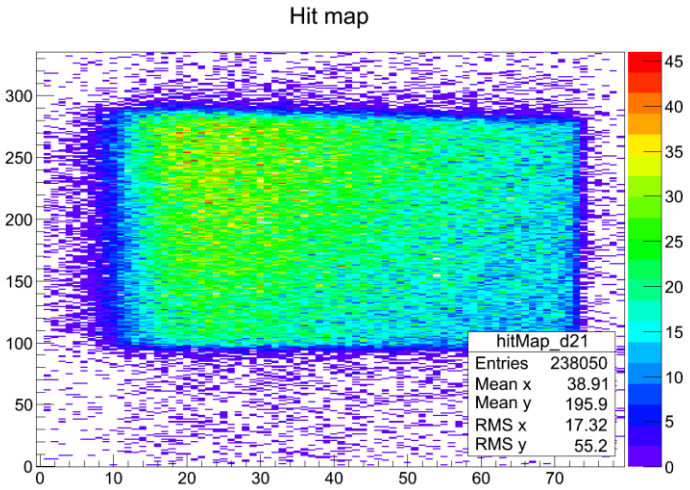
Test beam – Thursday (until 8am)

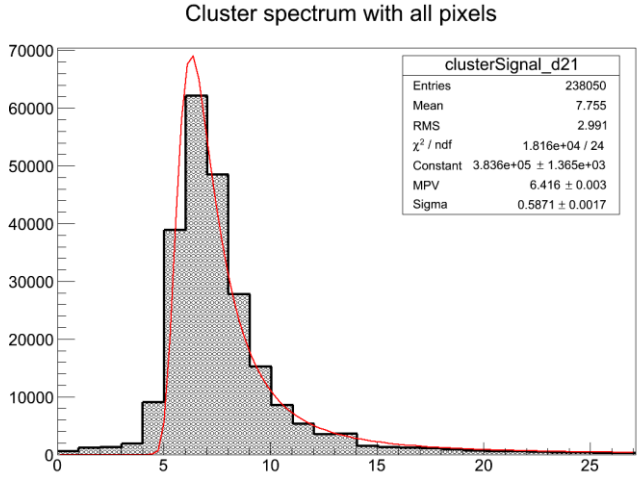
- The box/quad was heated up to remove all the condensation and try to revive the chips 2 and 4, however unsuccessful.
- Cooled back down and continued taking data at 700V and 300V with only chips 1&3 (chip 3 was known to be the noisiest); saw no correlations between the DUTs but thought it was due to a known software issue. However, only later found out that the reference DUT was not biased (front panel was on by default, instead of the rear) due to a lack of attention/concentration.
- The spare irradiated device, ADV167-DC-3 was not tested due to other priorities/lack of time.
- For each given DUT voltage/threshold, 2 million trigger events were recorded, except for the irradiated quad (3-4 million).

- The quad had a couple of wire bonds disconnected, however repaired and currently being tested.
- Reconstruction under way; the easiest (hit map) for irradiated singles extracted to show quality of data.

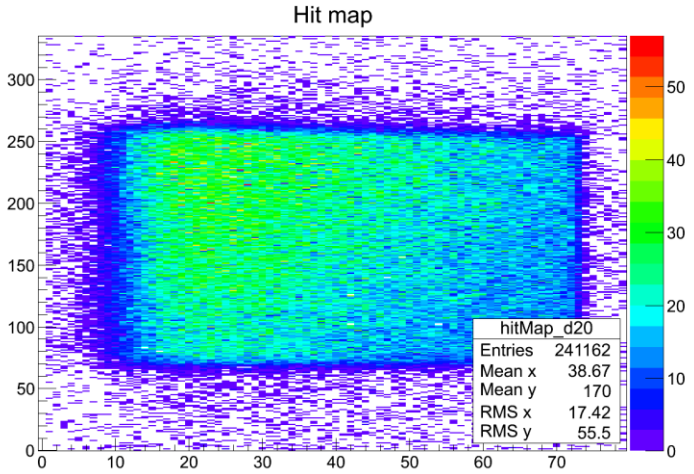
Test beam – reconstruction 250x50

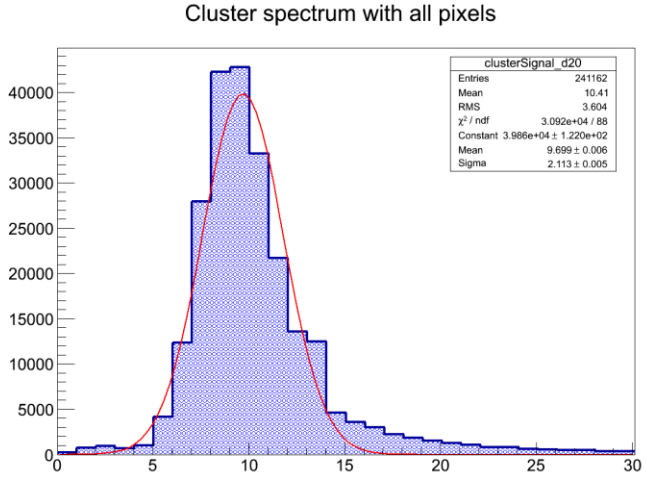
UN-IRRADIATED (100V)





IRRADIATED @ 1e^{15} n_{eq}cm^{-2} (500V)

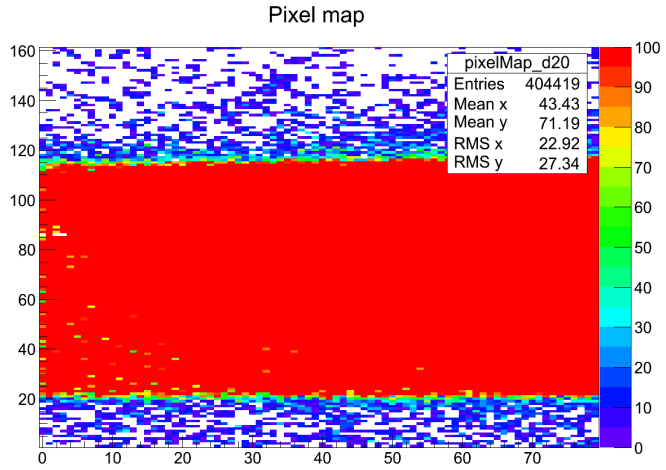


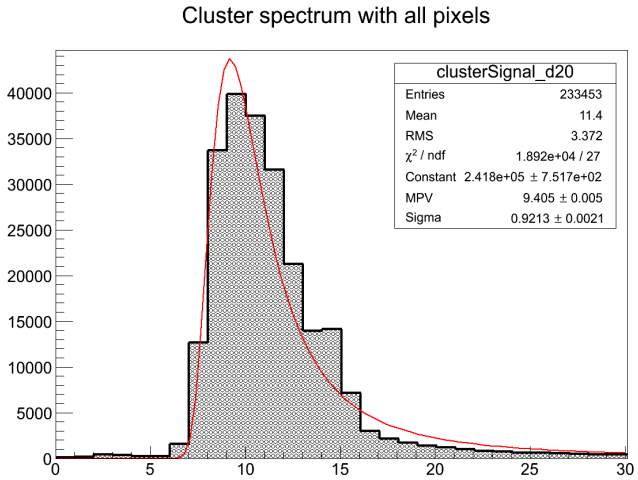


Promptly reconstructed by Dean Forshaw

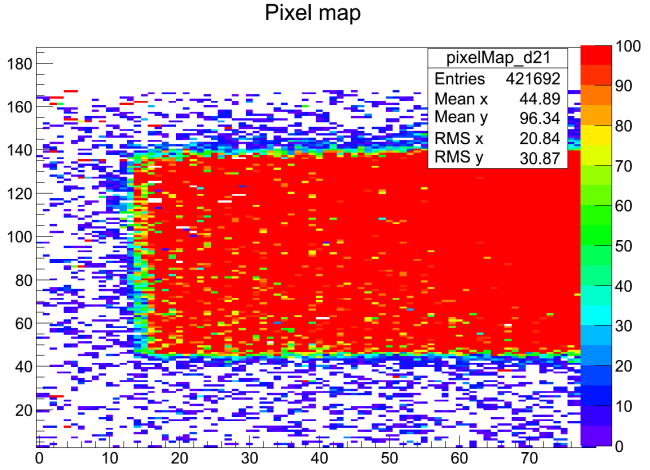
Test beam – reconstruction 125x100

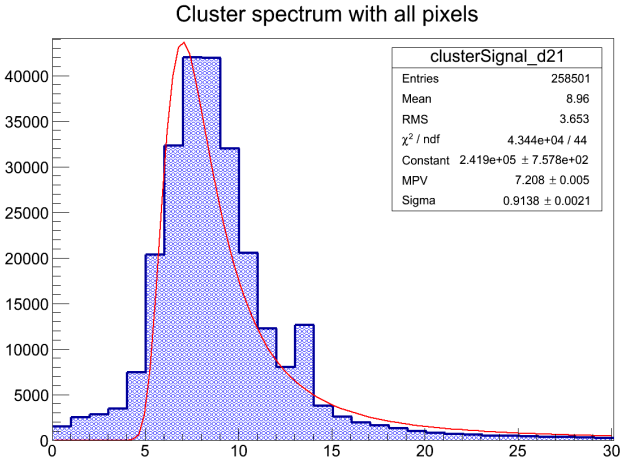
UN-IRRADIATED (100V)





IRRADIATED @ 1e^{15} n_{eq}cm^{-2} (500V)





Promptly reconstructed by Dean Forshaw

Conclusions

- Dry ice gives additional cooling power, but also adds in temperature instability – can be managed with the use of a chiller. However, still not enough to cool down the irradiated quad (5e15n_{eq}/cm^{-2}) due to insufficient convective heat transfer.
- The DUTs are NOT to be operated below the dew point found inside the box (-35^{o}C) – need a Peltier Module temperature controller and an online humidity/dew point monitoring device.
- A new solution for cooling down the quad, using two Peltiers in a row around the quad/SC, mounted on an extended carbon fiber and coupled on the other side of the Peltiers to the cooling plate is already being devised.
- The new solution should decrease preparation time from 2h to 30min.
- Need to find an optimal RCE primlist for tuning the irradiated DUTs (FEI4A).
- IBL recommended settings apply to 200um sensors => therefore 16k expected charge. For irradiated devices, should be adjusted depending on equivalent fluence and applied voltage/expected charge from the depleted portion of the sensor.

Backup slides