

# 2x2 PMT Optical Cross Talk

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# X-talk



- I don't know the full history of PMT x-talk, but from doc-db the problems started early.
  - There are a many documents in doc-db on pmt x-talk
- In PMT x-talk in the data was found by Jeremy fairly early in the MINERvA and was studied fairly early & a bunch of tubes were replaced.
- For the 2d testbeam, Steve Hahn and I looked at these tubes.
- The test was to illuminate 4 non edge pixels and sum the 4 edge pixels to the pixel being illuminated and form  $(\text{edge sum})/(\text{illuminated pixel})$ .
- From what I remember the light of the illuminated pixels was  $\sim 500$  counts.
- The cut for the tube was  $\sim 0.08$ .
- In order to get enough tubes we along with Roberto and Janina start to repair test PMT boxes.
  - Some of the PMTs were not quite aligned in the boxes
  - some had bad tubes.
  - Debbie bought new tubes for the test beam
  - Adam Para showed that some of the our
- Although we finally got enough tubes for the test beam, but I did not understand what created this problem with the tubes.



# X-talk



- Although we finally got enough tubes for the test beam, but I did not understand what created this problem with the tubes.
- The claim was Rutgers, who tested the PMTs, did not find cross talk.
- I found a talk which stated 216 tubes had no cross talk from the Rutgers test stand. The average x-talks was 4.7% with the 4 pixel sum.
- My speculation of what caused the cross talk was the PMT boxes were handled roughly during their shipment to FNAL, but there was no direct evidence to back this up.
  - There were some badly damaged boxes that arrived, so it is clear the shipper was not gentle. The PMT boxes were not in any kind of padding during shipment.
  - During the assembly of 2x2 we did of one incident of some PMT boxes being jarred.
- The goal of this talk is to see if any high cross talk tubes are on the 2x2.
  - We might replace tubes with high x-talk relative to the rest.
- I am doing this with beam, it's not clear the final numbers have the correct normalization, but the ratios PMT box to PMT box should be OK.



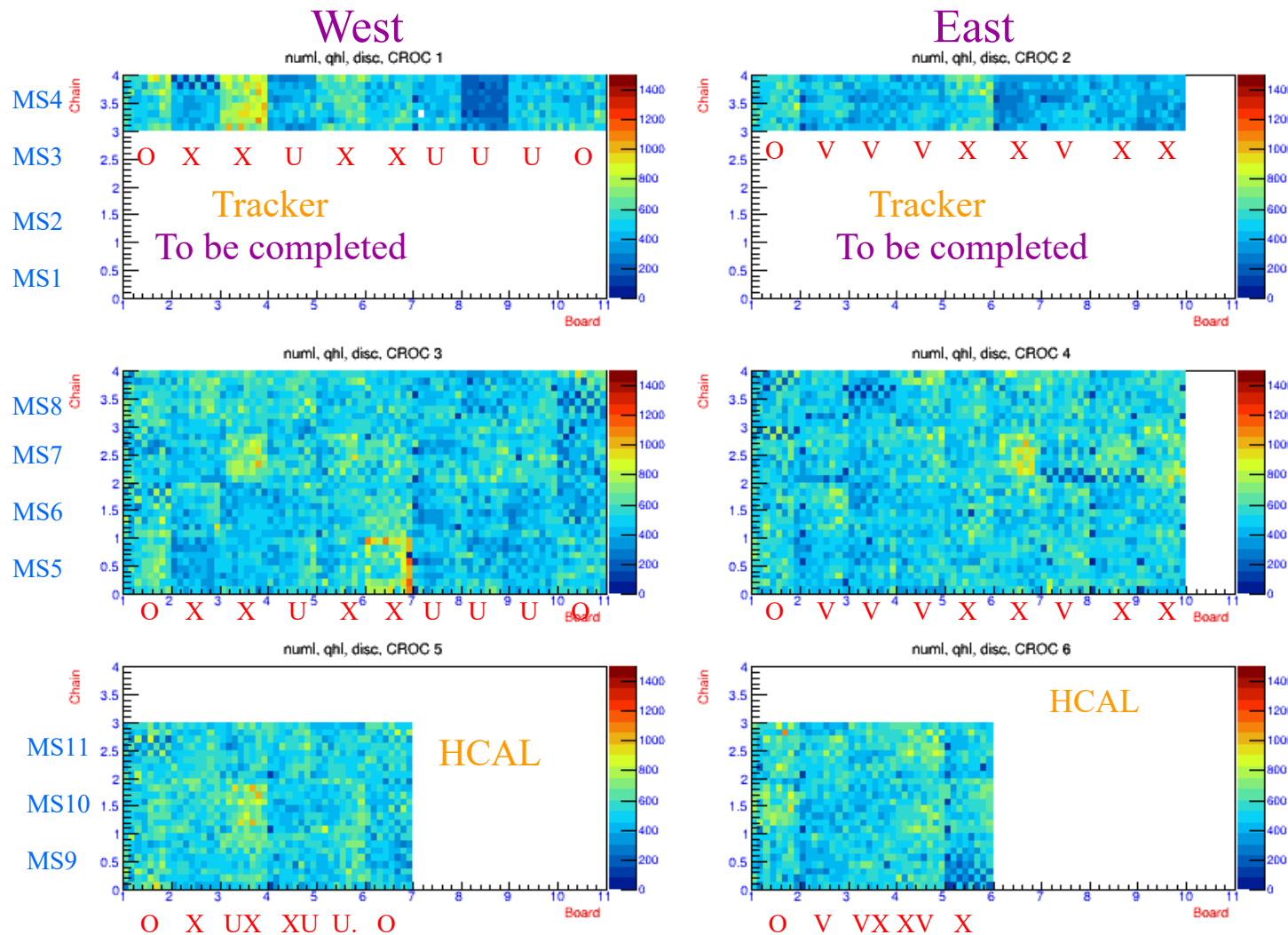
# X-talk



- For each non edge pixel, central pixel, we sum the pulse height of the 4 adjacent edge pixels
  - This is what was done for the 4.7% x talk measurement with the Rutgers test stand
- The summed pixels and the central pixel have the same timing to within 50 ns (5 clock counts.)
- We average this for each non edge pixel for a NUMI beam run, 36 pixels
- Since our action is to replace problematic PMT boxes, we average the 36 pixels to find a PMT average.
- To show what the plots show I will show an old croc-chain-board-pixel plot before the assembly was finished.



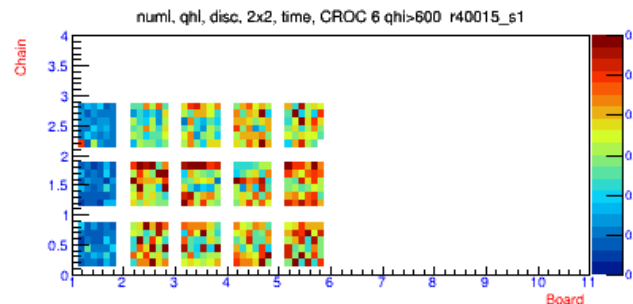
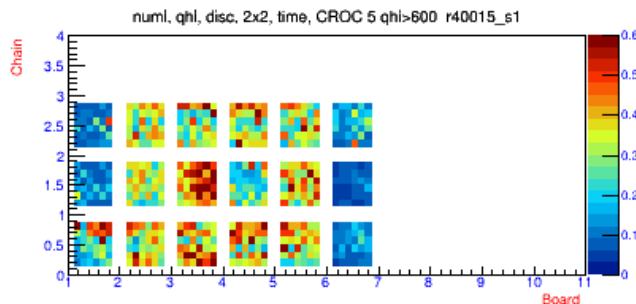
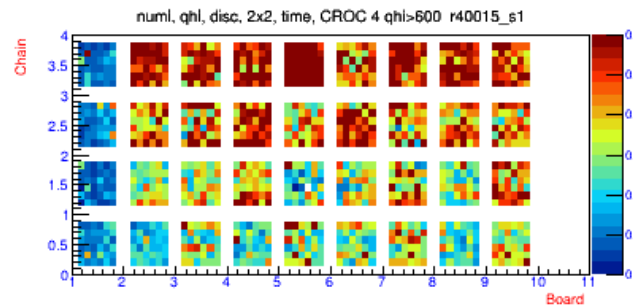
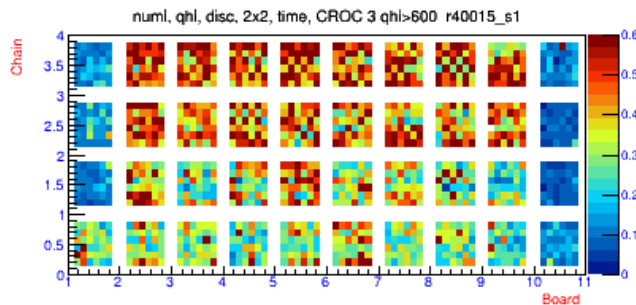
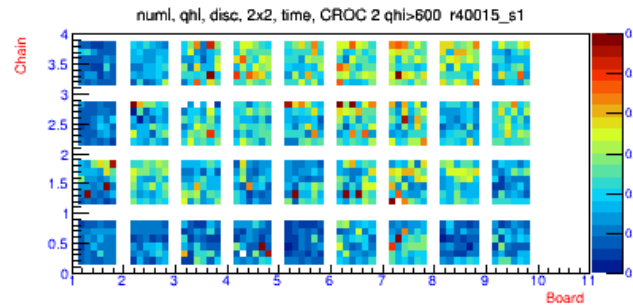
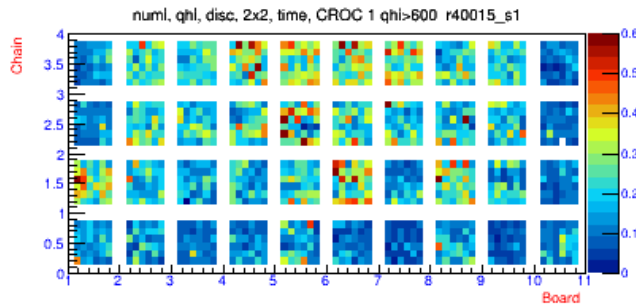
# Ave Qhi for Pixel



- qhi for pixels, vs CROC, board & chain
- MS 1- 6 ½ tracker
- Cryo gap between MS 3 & 4.
- MS 6 ½-8 ECAL
- MS9-11 HCAL
- O outer calorimeter
- X x plane
- U u plane
- V v plane



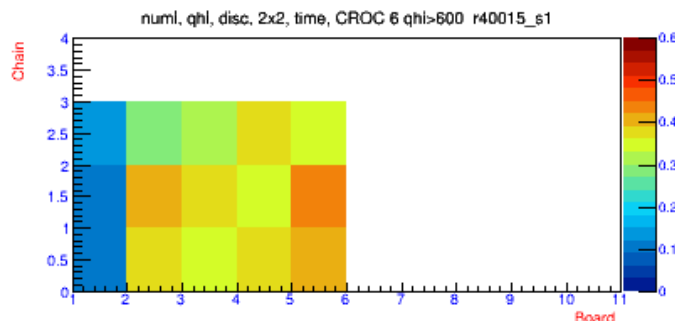
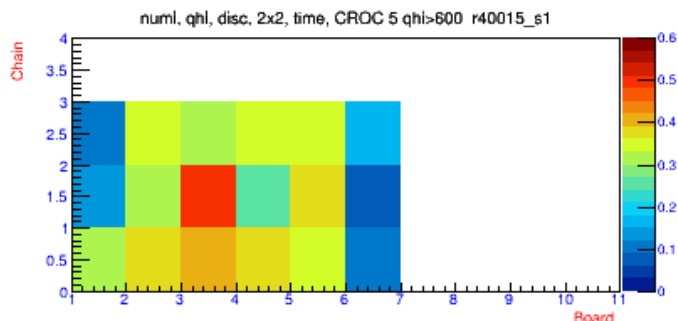
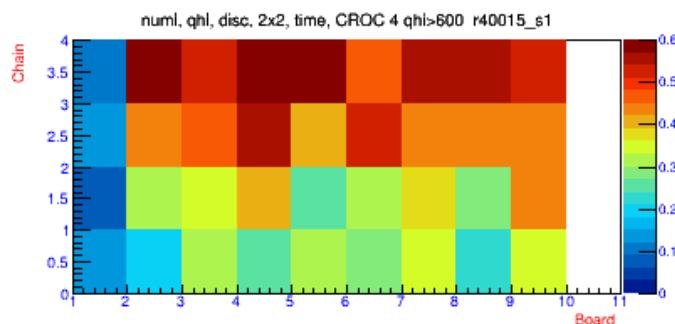
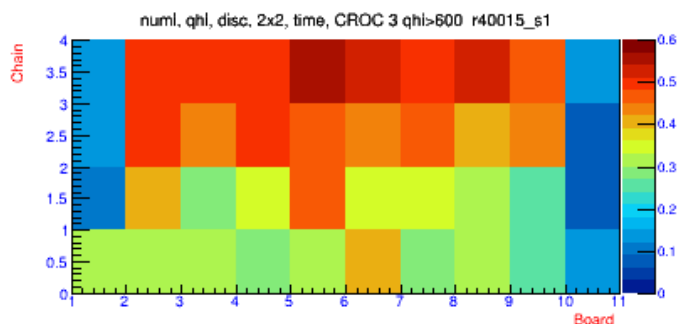
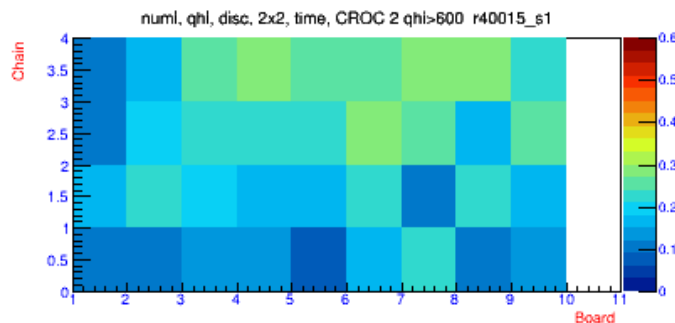
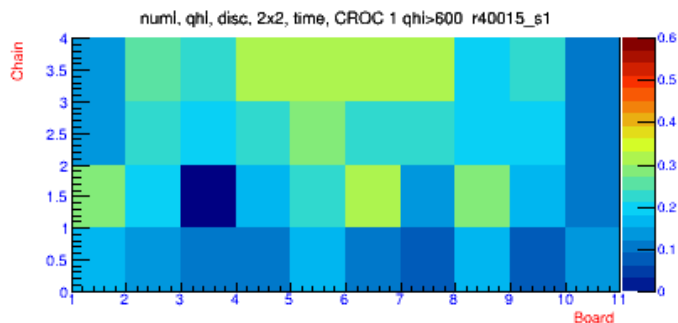
# Pixel X- talks



- The Z axis goes up to 0.6
- This x-talk seem fairly high, especially the test setup hardware cut was 0.08, Rutgers setup of gave a 0.047 ave.
- Most of what we are measuring are shower pulse height where the width is larger than couple of pixels
- We see the program measures the highest "x-talk" in ECAL
- Board 4-3-5 seems to have especially high x-talk.



# X-talk average over boards



- Z limit is 0.6
- We are interested so see if any boards need to be replaced
- So, we average over the boards.
- Again we see small x-talks in the OD and in MS 1.
  - These not dominated by showers



# Optical X-talk

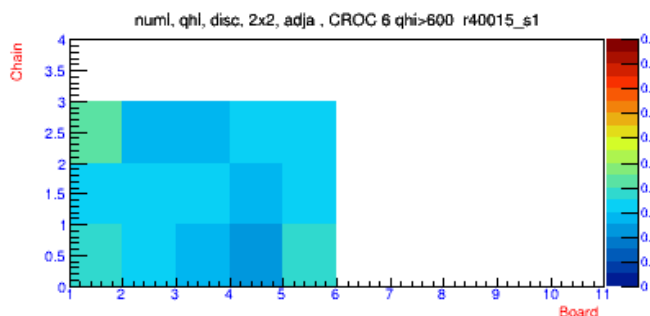
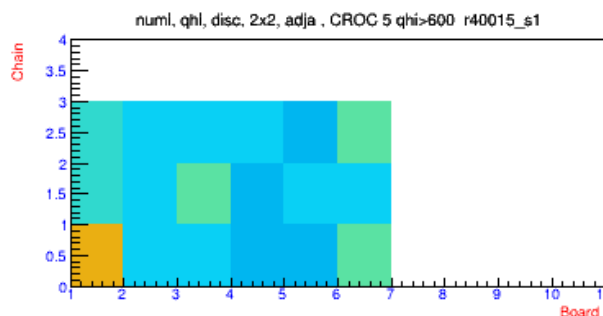
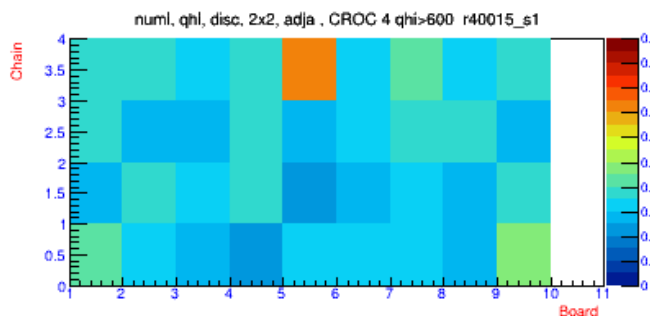
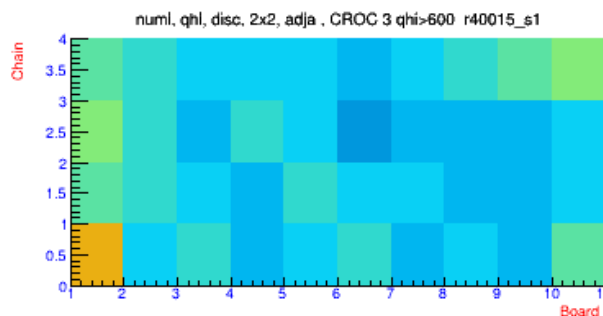
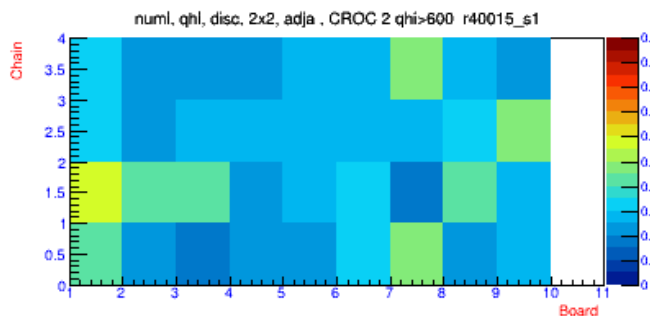
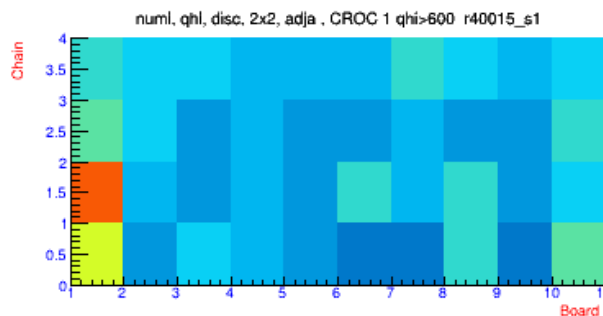


- We are interested in whether a tube has high optical X talk, without our measurement being confused by showers.
- We impose 2 cuts
  - We determine the 2 pixels which are associated with the adjacent strip to the central pixel. We make 5% cut on one of the 2 pixels both using the Tufts and the Rutgers weave.
    - I didn't feel like typing for all 185 tubes which had the Tufts weave or Rutgers weave, so I cut on both weaves.
  - I require  $(\text{sum of 4 edge pixels}) / \text{central pixel} < 0.5$ 
    - We are not measuring x-talk if the  $> 0.5$
  - Cuts could be tighter





# Optical x-talk



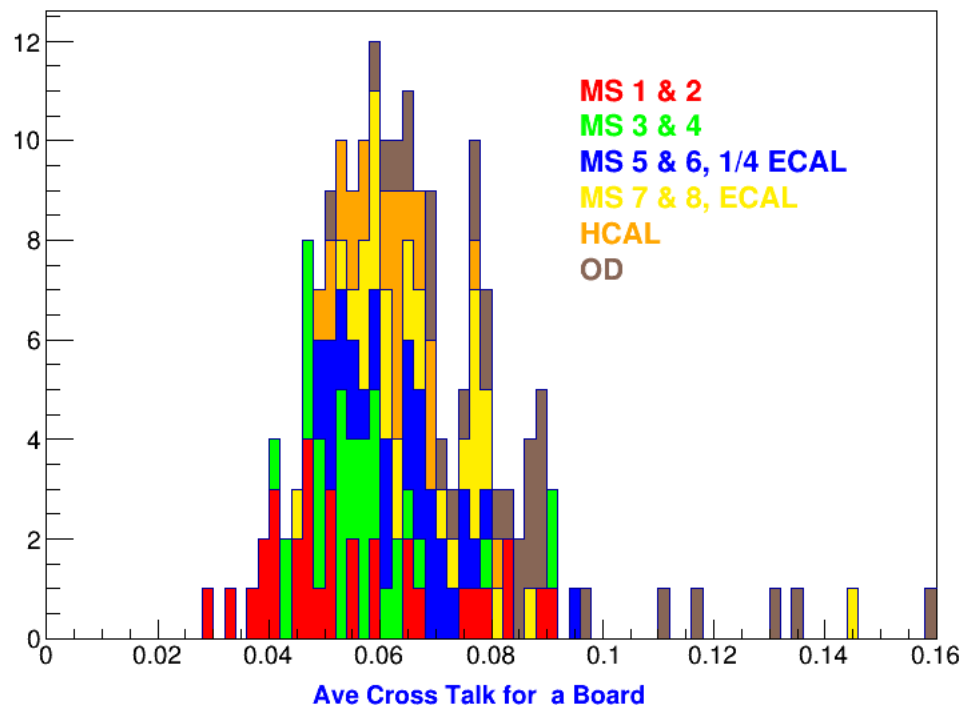
- The z limit is now 0.2 instead of 0.6
- The x-talk distribution is now more even across the detector.
- The x-talks of the ID and OD look similar so we are probably looking more at optical x talk than showers.
- To look at tails we want to look at a 1d hist.



# Optical x-talk



numi, 2x2, adja, qhi>600 r40015\_s1



- 1d histogram of the x-talk, color coded to show the different regions.
- MS 1 & 2 have ~ 5-6% x-talk, so this about what we might expect from just optical cross talk.
- The OD seem to have slightly bigger x-talk than the ID, so we are probably getting close the measuring optical x-talk.
- As we move down stream the numbers go up a bit. Optical cross talk in HCAL is same as tracker
- There are only 4 tails, which is what we are looking for
  - 5-0-1 in OD, 0.131
  - 3-0-1 in OD 0.134
  - 1-1-1 in OD, 0.158
  - 4-3-5 in ECAL, 0.144, also high in our original plot
    - ~2 times higher than others in MS 7 & 8



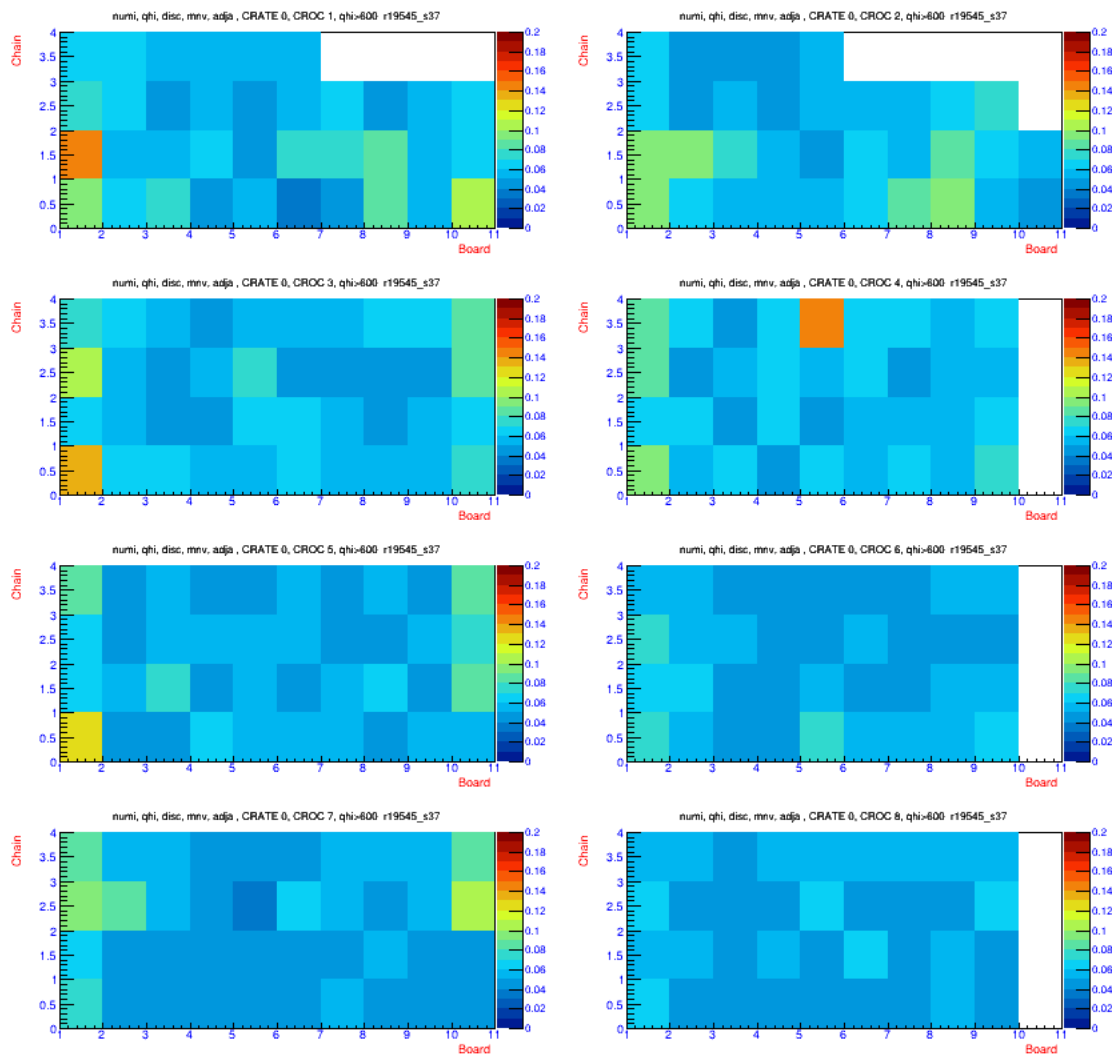
# Optical x-talk



- ~ 5 OD tubes have high cross talk in the tails
  - OD tubes seem to have higher cross talk than ID. It might be because the lower cross talk tubes were put on ID. I was not involved in this so I'm not sure this was done.
  - As OD tubes, they probably do not need to be replaced.
  - They tube 1 on west side, so they are on the west edge. They might not be too hard to replace.
- 4-3-5 x-talk ~ 2 times larger than the average of its neighbors, so it might be worth replacing. This is the location we did a practice replacement, so it's possible. Jack and I looked at it & it might be possible without lying flat on the lift. If we are going to replace this, I would like to do this before the NUMI beam stops so we can check the results.
  - I can run the code on a MINERvA DST to find PMTs with low optical x-talk, so it's not crucial we do it before beam ends



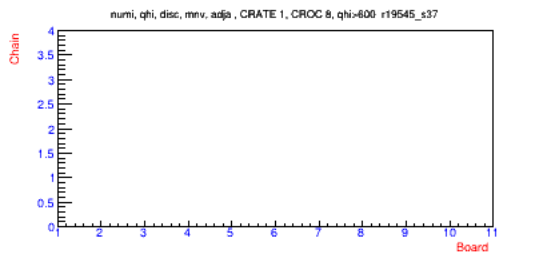
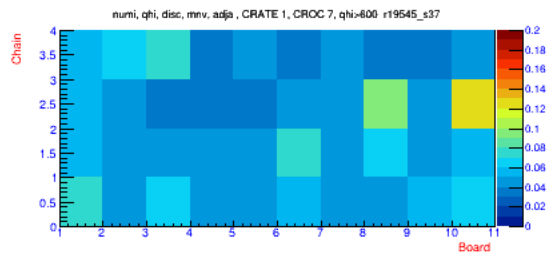
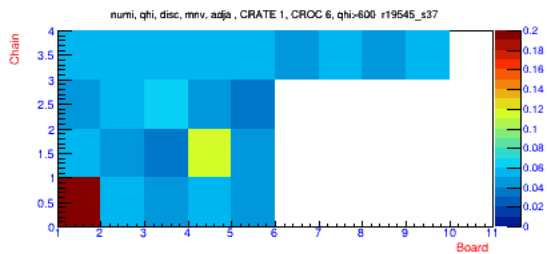
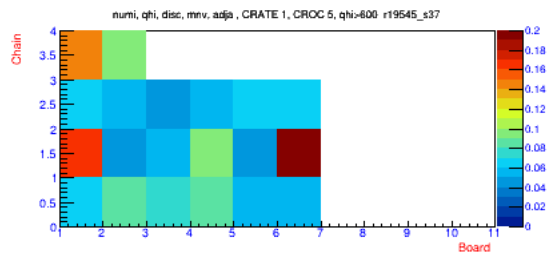
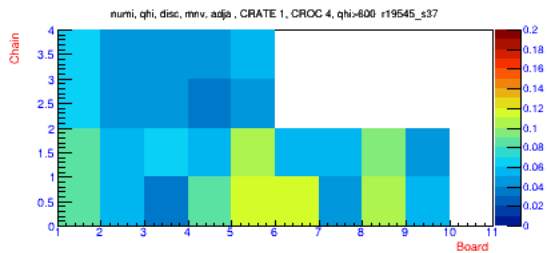
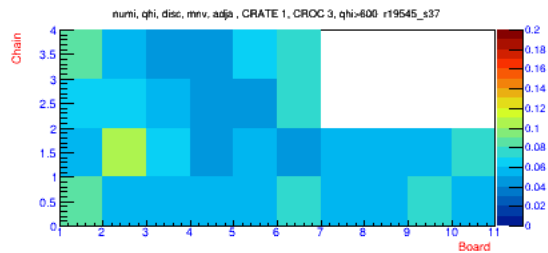
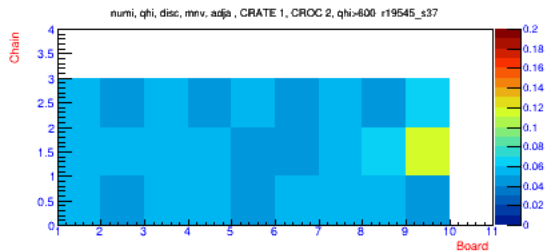
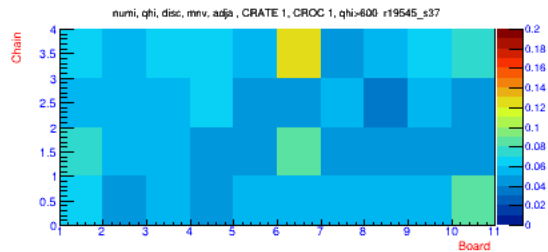
# MINERvA x-talk



- Crate 0 for MINERvA
- We notice the same tubes were noisy in MINERvA 2x2 were noisy in MINERvA.
- Hence, the long storage of the tubes did not effect the x-talk.
- Again we are seeing noisier tubes in the outer calorimeter so I assume that was done on purpose



# MINERvA Crate 1



- X-talk x-crate 1
- Same cuts as for MINERvA 2x2



# Further checks



- Pixel to pixel variation in x-talks might be statistics
- There is a further check that might be done. I have been unable to do the HV check because of the DAQ problem. We would run the DAQ over a long period of time. This check can be done using ped, LI or NUMI beam.
- Also note that our check of the optical cables yielded ~ 10 which according to the data looked like they were not quite plugged in, but the investigation could not find a problem.