CHARACTERIZATION OF LARGE-DIAMETER PHOTO-MULTIPLIER TUBES

DEREK BOYLAN

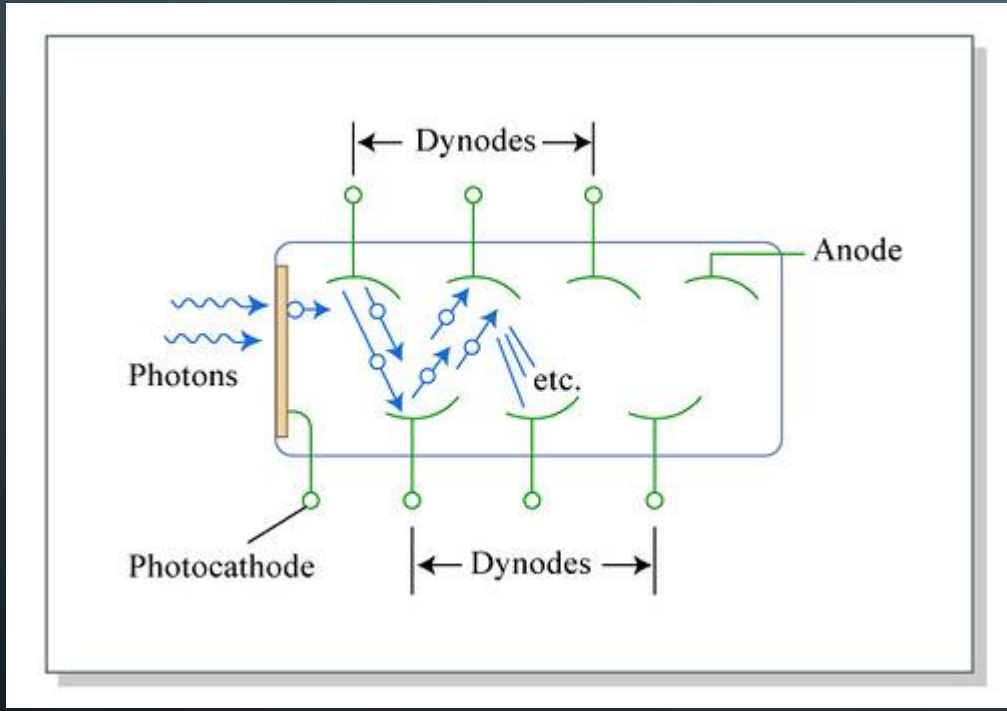
PHOTO-MULTIPLIER TUBES (PMTS)

XP4500/B PMT, used in detectors like Cherenkov detector at JLab

Photo by Derek Boylan

- Photomultipler tubes are vacuum-tight light detectors
- Can detect single photons
- Useful in particle detectors like those in Jefferson Laboratories and CERN

HOW A PMT WORKS

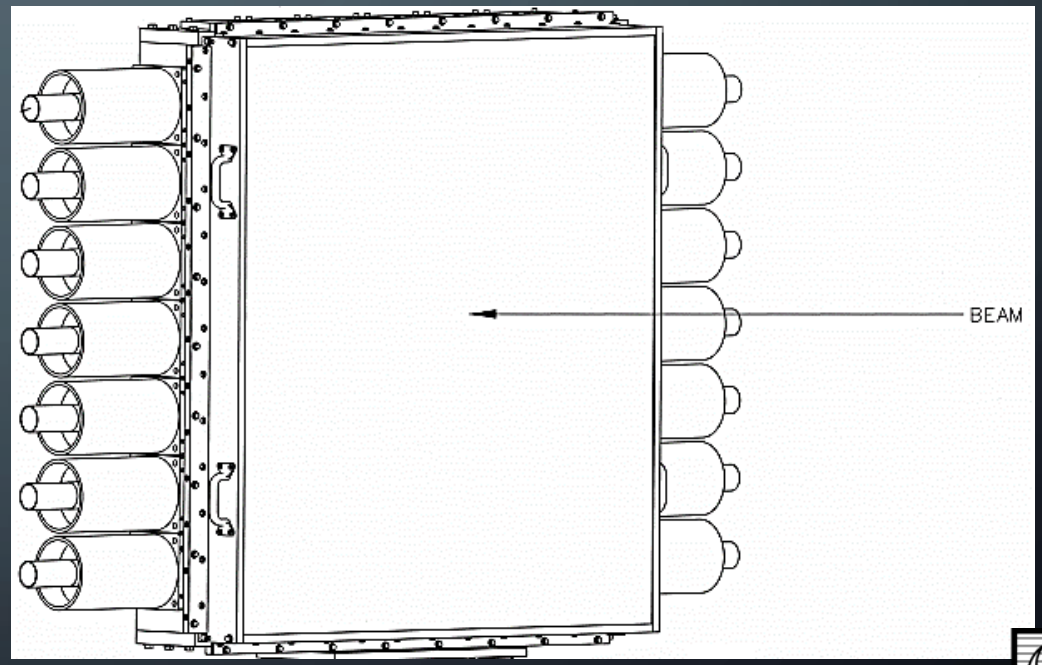


https://c2.staticflickr.com/4/3653/3681701585_8545d2d15a.jpg

- The front-facing photo-cathode in the PMTs at Catholic University creates a flow of electrons when struck by light due to the low work function of the face
- This current is then amplified through a series of dynodes which create a cascade of electrons
- The anode collects the current, which can be transferred to a computer through an analog to digital convertor

CHERENKOV RADIATION DETECTOR

- PMts used in Cherenkov radiation detectors.
- Hadronic particles that pass through detectors at Jefferson lab are categorized based on the angle at which Cherenkov radiation is refracted
- PMTs help determine whether particles are Pions, Kaons, or Protons



Picture by Bert Metzger (from CUA wiki)

PURPOSE OF CHERNKOV DETECTOR

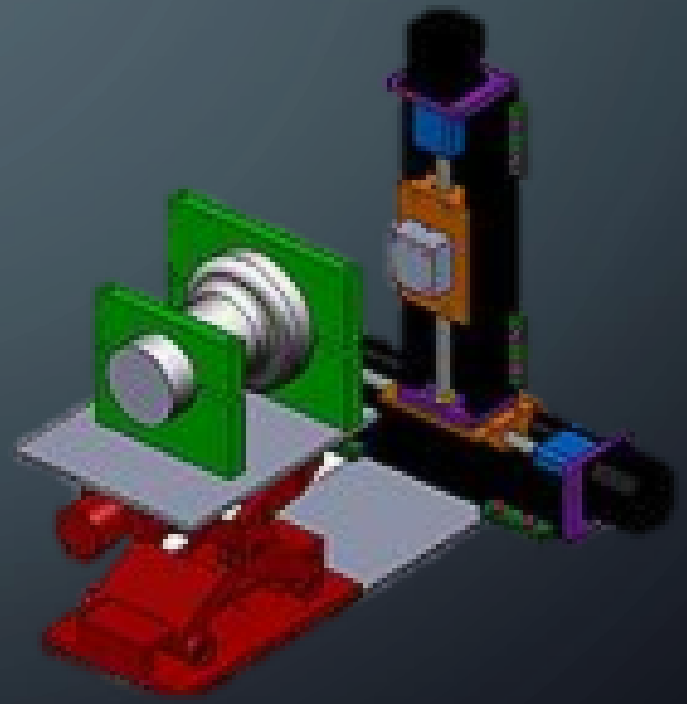
- With 12 GeV at Jefferson Laboratories, new insight can be gained about hadronic structure through kaon production.
- Hadronic degrees of freedom is an area of interest that Cherenkov detectors can help unearth

PURPOSE OF CHARACTERIZING PMTS

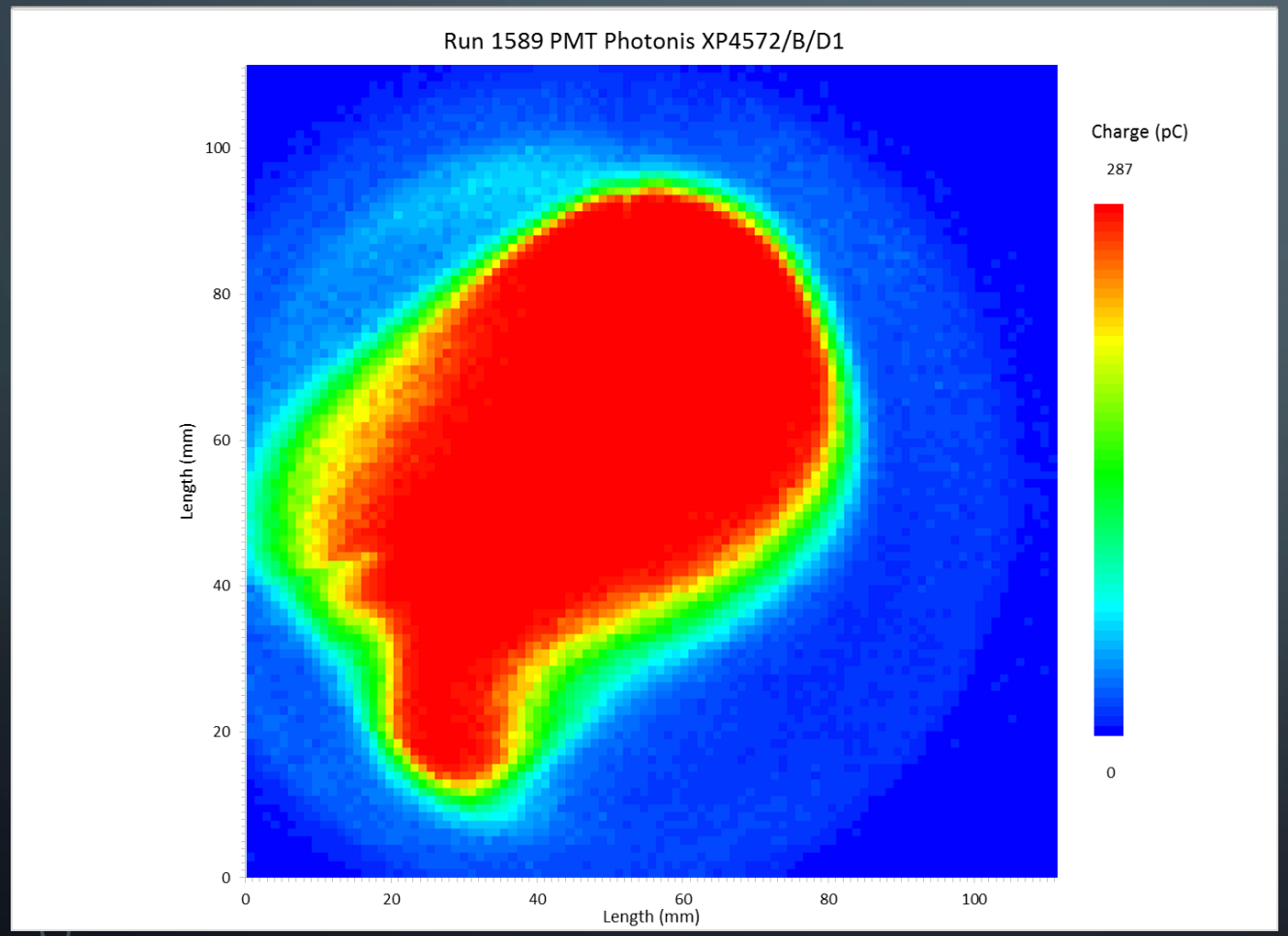
- One important characteristic of PMTs is their uniformity
- Without a uniform lens, some Cherenkov Radiation that made contact with a lens may not appear the same throughout
- The more uniform a PMT, the more accurate the data collected at Jefferson Laboratories becomes

PMT SCANNING

- Uniformity test using a collimated blinking LED, a two axis motor, and a PMT
- This test allows one to graphically depict the number of photoelectrons the lens of the PMT receives



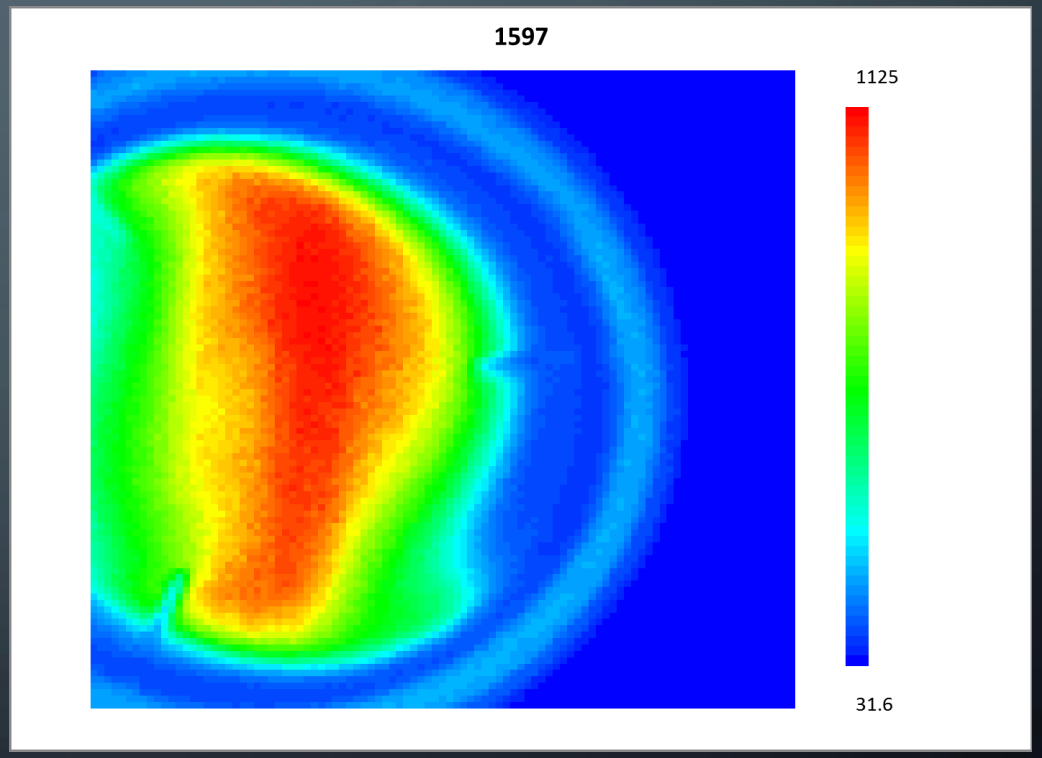
PRELIMINARY SCANNING OF XP4500



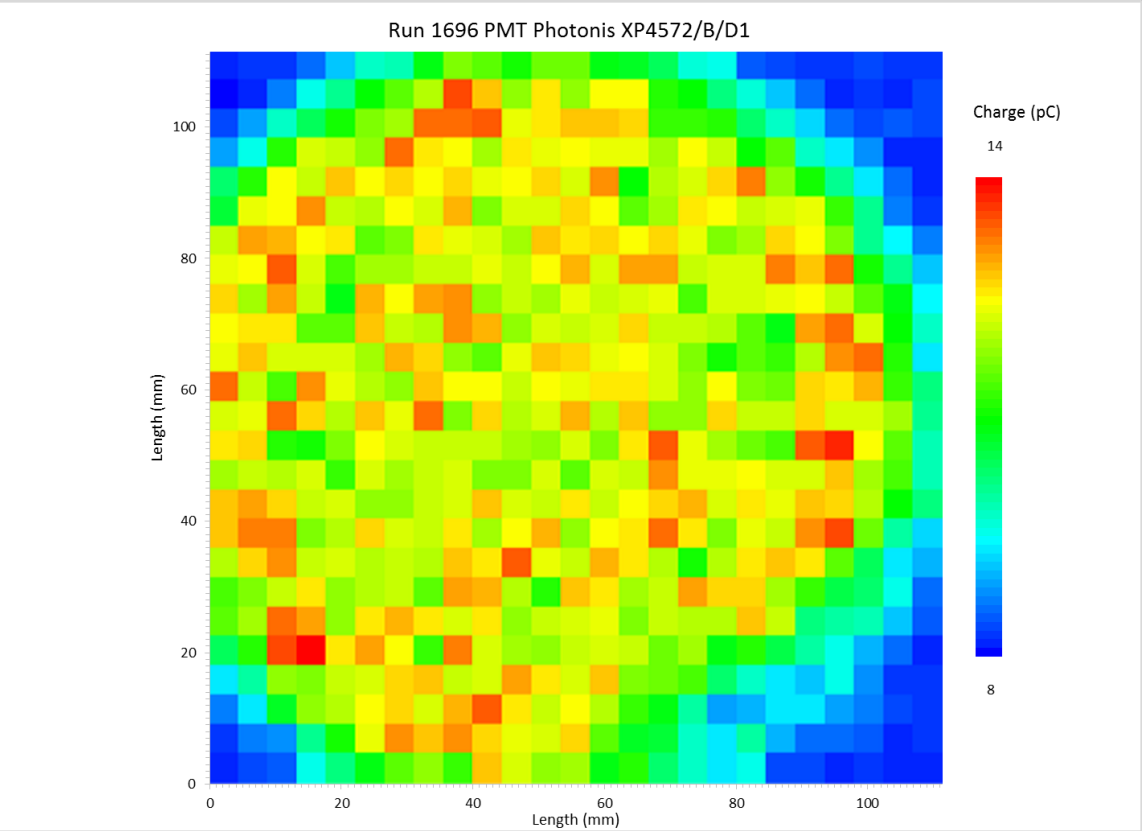
- Poor results, irregular patterns of lens, poor gain in certain areas
- Diagnosis was that something was wrong with the scanning method, or some part of the PMT was faulty

FURTHER TROUBLESHOOTING

- Tested the XP4572 PMT with similarly poor results
- Tested only 5 months ago and worked fine, therefore, concluded that something was wrong with the experimental setup and not the PMT itself



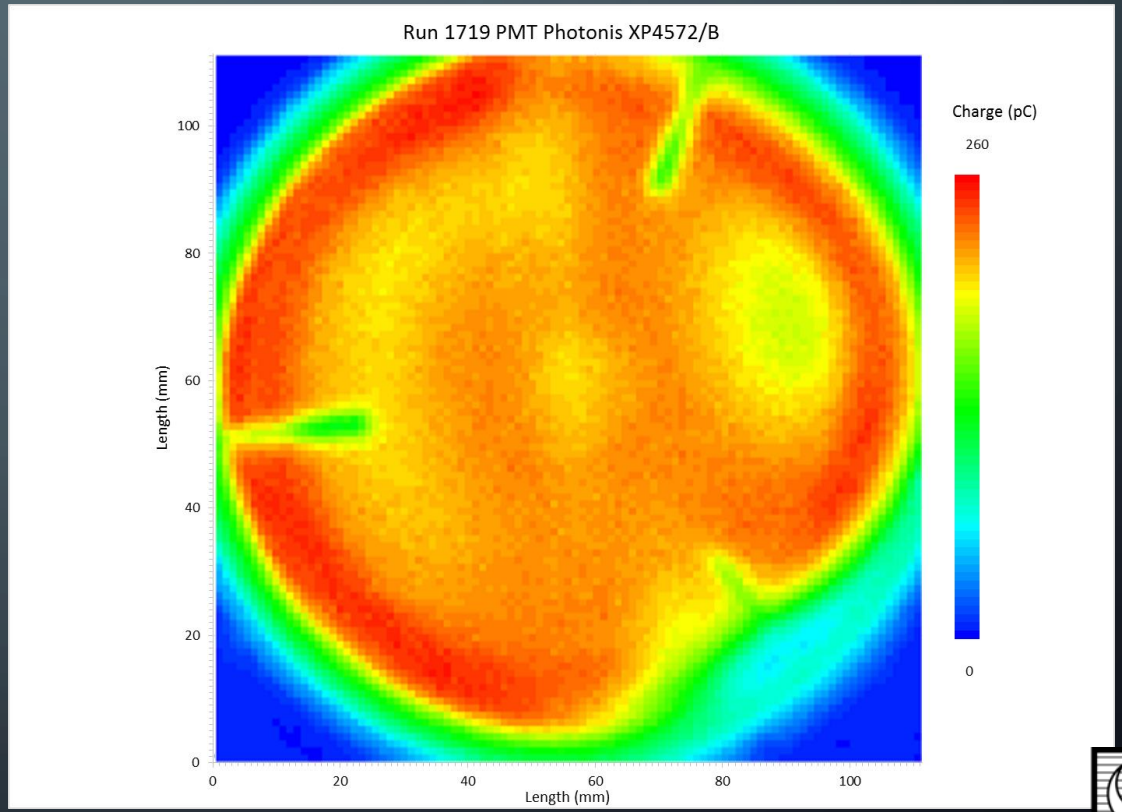
SWITCHED BASES



- After switching bases, the pictures resumed their original clarity
- Setup amended, scanning could continue
- Possible cause: base was not distributing high voltage to every component

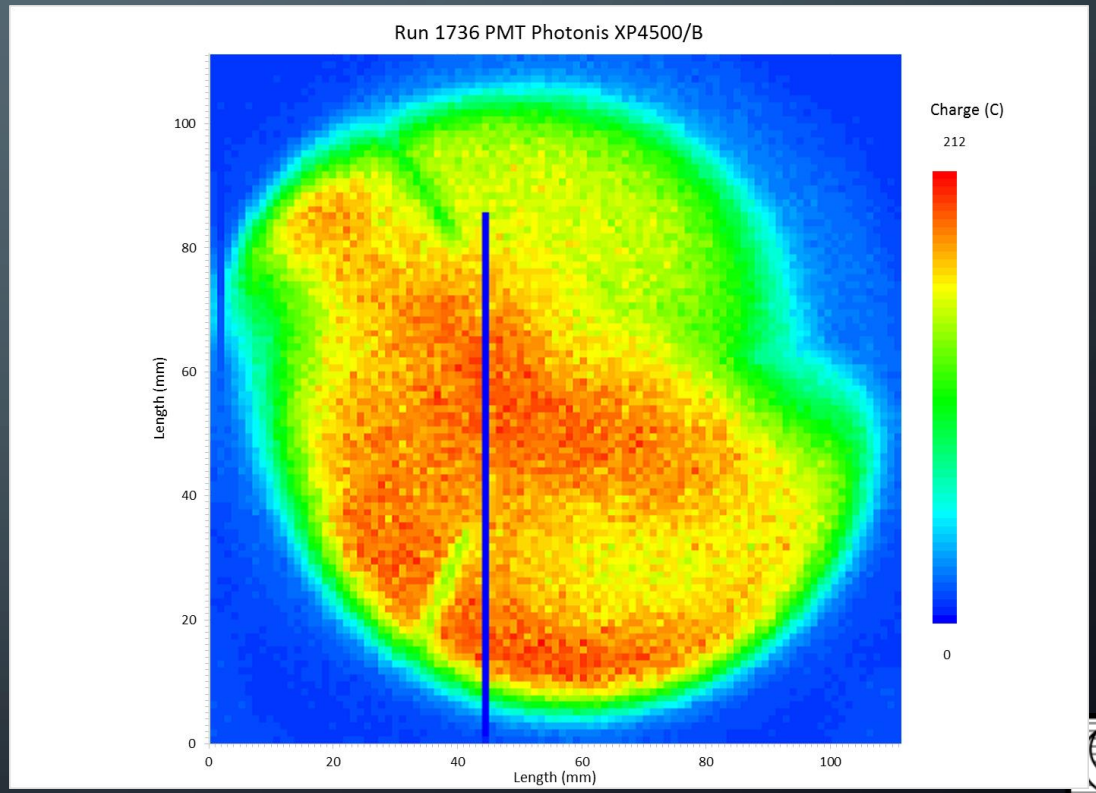
PHOTONIS XP4572/B

- PMT used to troubleshoot the scanning setup as the very same PMT had been scanned before in February of this year



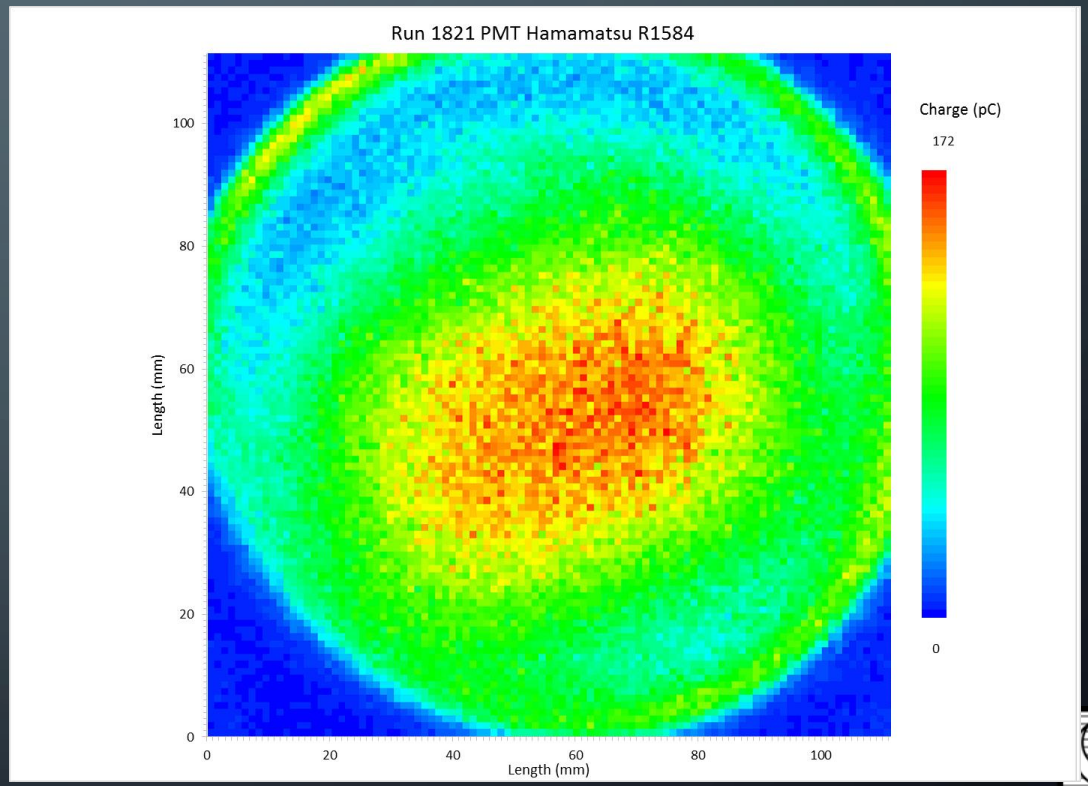
PHOTONIS XP4500/B/D1

- PMT currently used in Cherenkov detector at Jlabs
- Mainly uniform surface, some areas of low gain where there is a lining on the photo cathode face

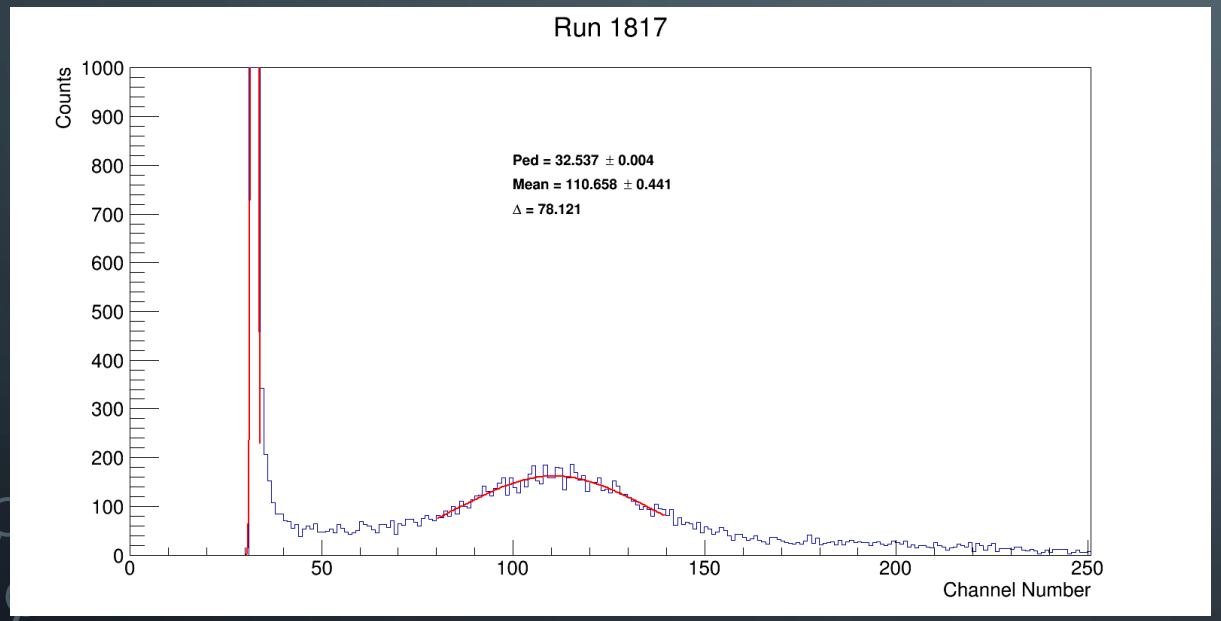


HAMAMATSU R1584

- More costly PMT that can detect lower wavelengths of light than the Photonis XP 4500
- If more uniform, could be a better suited PMT for the Cherenkov detectors at JLab



GAIN TESTING OF HAMAMATSU R1584



- In order to measure the gain of a PMT, the minimum amount of light was exposed to the PMT so that only single electrons were being displaced
- By measuring this data, the pedestal (background noise) and single electron peak, as well as the difference between those values, was measured

HAMAMATSU ANALYSIS

- Similar results to previous PMTs that had irregular patterns on their surfaces
- Could be another case of a base not distributing charge correctly

ANALYSIS OF R1584

- Nonuniform face
- Could be a result of a bad base – not distributing charge
- Current results demonstrate that there is no need to upgrade to this PMT due to nonuniformity of R1584

FUTURE WORK

- Gain testing of XP4500 to compare the photoelectron count of both (has been done in the past, but variables could have changed
- More testing of Hamamatsu with different base and higher intensity of light (causing more photoelectrons to be displaced)
- More testing of XP4500 to verify previous results
- Modeling of experiment and calorimeter

ACKNOWLEDGEMENTS

I would like to thank Dr. Tanja Horn, Marco Carmignotto, Indra Sapkota, Bijay Nepal, and Joel for their help and guidance as I conducted research. Additionally, I would like to thank my fellow interns, Stephanie Durham, Alex Dittman, Will Lash, and Buffy Parvatam for their help. Finally, I would like to thank Catholic University of America for allowing me to conduct research here over the summer.