CHARACTERIZATION OF LARGE-DIAMETER PHOTO-MULTIPLIER TUBES

DEREK BOYLAN
PHOTO-MULTIPLIER TUBES (PMTS)

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

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

Photo by Derek Boylan
HOW A PMT WORKS

• 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.
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
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
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