On the Possibility of Darkening Epoxy due to Radiation Damage in the STAR EPD

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Introduction

The STAR EPD (event plane detector) is a subsystem of the STAR experiment at the Relativistic Heavy Ion Collider (RHIC) whose purpose is to probe the geometry of a heavy ion collision by examining the distribution of forward-going charged particles exiting the collision. The EPD consists of two wheels of scintillators wound with wavelength shifting fibers, each composed of 12 supersectors which are themselves connected to a Silicon photomultiplier (SiPM) via an optical fiber connection (Figure 1). To hold the wavelength shifting fibers in their place within each supersector, Eljen EJ-500 optical epoxy was used. The goal of this study was to determine if this epoxy darkened appreciably throughout RHIC's operation from 2018 - 2021 due to radiation damage. Analysis was performed on measurements of output (ADC, Figure 2) vs. bias voltage to investigate this phenomenon.The obtained results are consistent with the hypothesis of no darkening during the period 2018-2021.

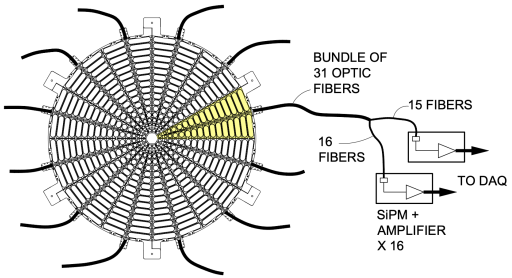

Figure 1: EPD wheel

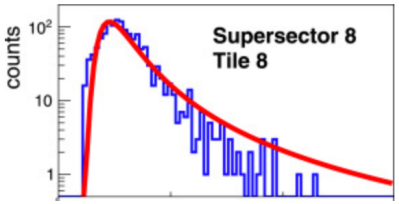

Figure 2: Spectra in ADC units from a cosmic ray test stand

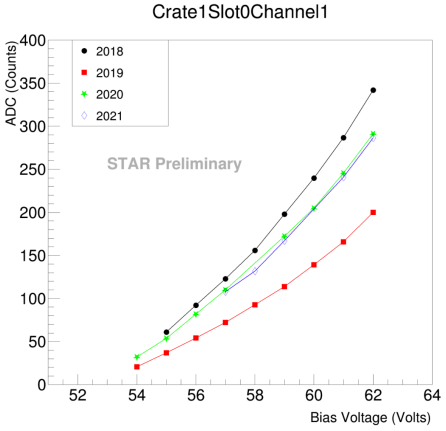

Figure 3: ADC vs. Bias Voltage plots for a sample tile

Methods

In order to investigate the darkening phenomenon, three steps were taken:

- For each tile, ADC was plotted against Bias Voltage for a four year period 2018 - 2021 (figure 3).
- The slopes of this graph for each year were computed in two different ways: Pol1 fit in root and slope computed between the first and last entries (figure 4).
- The ratio of the slope in 2021 to the slope in 2018 was computed for every tile and plotted (figure 5).

Results

- In figure 5, one notices that under both methods of slope computation the mean ratio of the slopes is compatible with one within one standard deviation.
- In figure 4, a typical tile, there is a marked decrease in slope between 2018 and 2019 and an increase in slope from 2019 to 2021.
- For such typical tiles, this pattern indicates that approximately the same bias voltage from 2018, when used in 2021, can produce approximately same ADC.

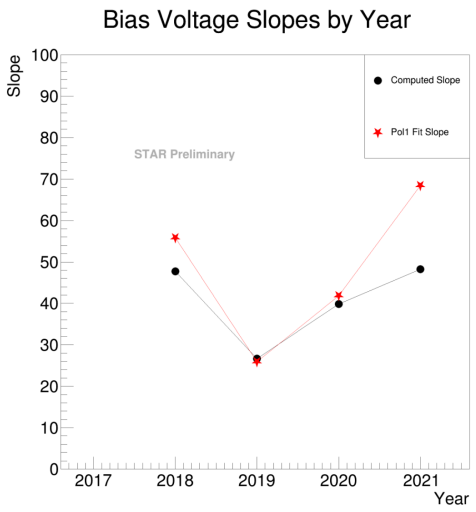

Figure 4: Sample of slopes computed in two different ways from 2018 - 2021 for a single tile plot

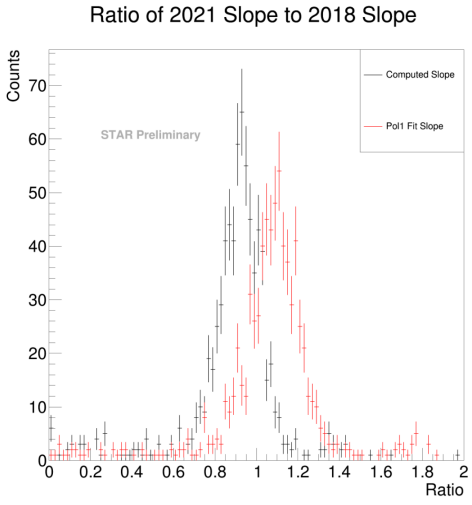

Figure 5: A histogram plotting the ratio of 2021 slope to 2018 slope for all tiles

Conclusion

- The fact that the mean ratio of 2021 ADC vs. bias voltage slope to 2018 ADC vs. bias voltage slope was compatible with one within one standard deviation corroborates the hypothesis that Epoxy darkening is not the mechanism responsible for the observed dip in tile performance from 2018 to 2019.
- If the tiles had darkened irreversibly and appreciably to cause this change, a majority of tiles would not be able to perform as well as they had in 2018 in 2021.
- Beyond darkening, a number of yet-unknown mechanisms could have contributed to the dip in performance observed from 2018 - 2019, as well as anomalous cases.
- In particular, work could be done to differentiate tiles closer to the beam pipe which would receive more radiation and tiles further away. If tiles closer to the beam pipe more frequently disobey the pattern in figure 4, one would have evidence in support of local darkening in that region.

References:

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