Total Solar Eclipse Effects on Cosmic Ray Showers

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Introduction

We sought to discover the effects that a total solar eclipse (April 24, 2024) had on cosmic ray shower energy. Six cosmic ray detectors were set up in equilateral triangle nested arrays. Each detector array was concentric with different side lengths, except one, with a single control detector in a stack (See blue detector in *Figure 1*). The size of the detector triangle corresponded to an energy range of sensitivity, with larger triangles probing higher energies. We began collecting data two weeks prior to the eclipse and completed data collection 90 minutes after totality. Although a previous lunar shadow experiment provides evidence that the flux does not change as a result of the Moon's passing in the sky†, this experiment measured cosmic ray shower energy changes during a total solar eclipse.

Motivation

To investigate any changes in cosmic ray shower energies during a total solar eclipse.

Methodology

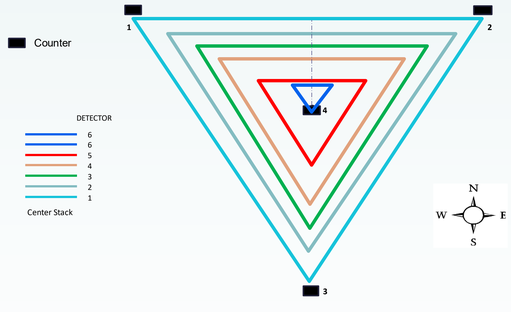

Figure 1. Layout diagram of counters for each of the six detectors.

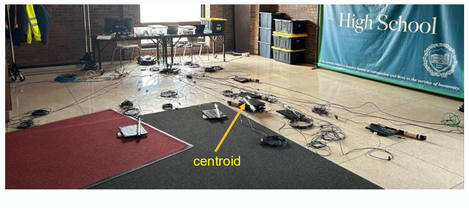

Figure 2. Partial triangle layout during feasibility study at New Trier High School.

Figure 3. View looking east at the detector array in Westport, IN. The stack of Counter 4 (⊕) from each detector is at the centroid of the respective triangles. The top vertices are Counter 2 of each detector.

The configuration employed six nested equilateral triangles of counters with a common centroid, except for the 0.6m side where the apex had two counters. One counter from each detector was placed at each vertex with the fourth counter at the common centroid. The side lengths of the equilateral triangles were 0.6m, 1m, 3m, 4m, 5m, 6m. We used equilateral triangles because the distance between vertices would be equal, simplifying the analysis. The fourth counter was placed at the centroid of the triangles to facilitate comparison among the different detectors. Count rates from each equilateral triangle were compared for results.

Results

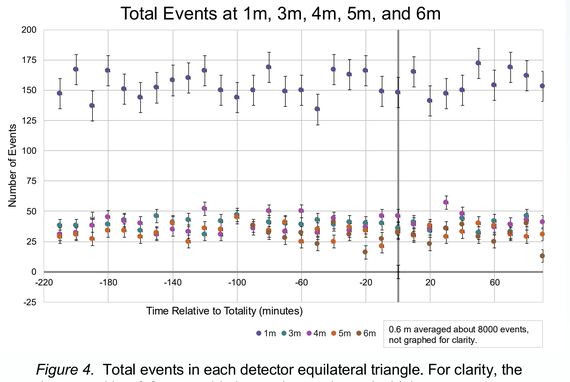

Figure 4. Total events in each detector equilateral triangle. For clarity, the detector with a 0.6 meter side is not shown, due to its high count rate.

Results (continued)

Beginning with the period of 200 minutes prior to the eclipse, and for 90 minutes after totality, the total number of events recorded by each detector during 10-minute bins remained constant (See *Figure 4*) . This was consistent with the two weeks of measurements prior to the eclipse.

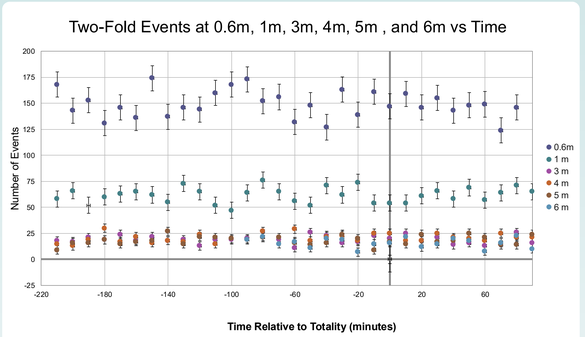

Figure 5. Two-fold events in the different equilateral triangles.

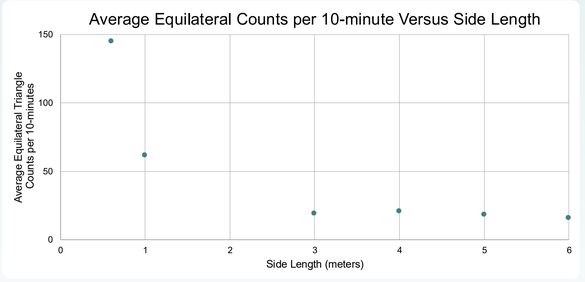

Figure 6. Average counts per 10-minute bin in each equilateral triangle.

Following this trend, the number of only double coincidence events per 10-minute bin throughout this same time period also remained constant (See *Figure 5)*. Double coincidence counts were used to reduce error due to a larger number of events. In calculating error ($1/\sqrt{n}$), no significant change was found for any of the detectors during the eclipse (See *Figures 4 and 5*). Additionally, it was found that as the side length of the triangular arrays decreased, the number of events detected increased (See *Figure 6*).

Conclusion

This experiment investigated the impact of the total solar eclipse on the energy of cosmic ray showers. Our data revealed no significant change in the count rates of cosmic ray showers detected by any of the arrays throughout the eclipse period. The observed trend showed an increase in the number of detected events as the side lengths of the triangular arrays decreased, which correlates to the increased number of lower energy cosmic ray showers in smaller triangles. These findings indicate that the solar eclipse did not change the distribution of the energies of cosmic ray showers, consistent with a previous total solar eclipse experiment which showed no change in flux due to the Moon's transit‡.

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Figure 7. Group photo at the Glover Farm High Energy Physics Laboratory, April 24, 2024.

Citations

† Mosen-Harzandi, Aitak, Garrett Chong, et. al., "Baseline: Looking for the Cosmic Ray Moon Shadow," American Association of Physics Teachers Winter Meeting, 6.January.2024, New Orleans, LA.

‡Dallal, Tamar A., et.al., "Solar Eclipse and Cosmic Ray Flux," *The Physics Teacher*, Feb 2022.

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