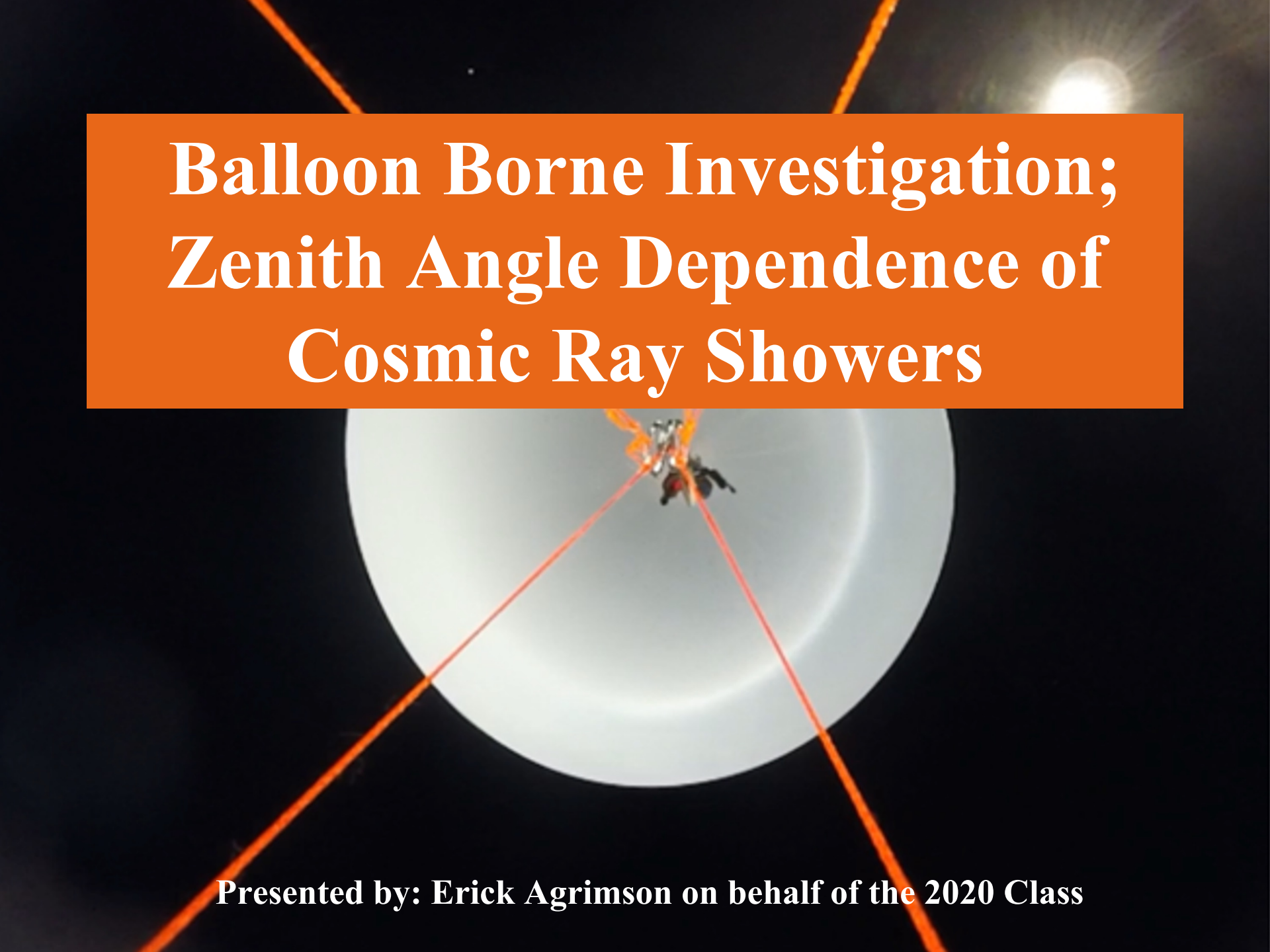


Balloon Borne Investigation; Zenith Angle Dependence of Cosmic Ray Showers

Presented by: Erick Agrimson on behalf of the 2020 Class

Outline

- Abstract
- Background
  - Regener-Pfotzer Maximum
  - Vertical and Horizontal Coincidences
- Quad Box
  - Setup of the box
- Experiments
- Results
- Conclusion
- Acknowledgements

Abstract

Galactic Cosmic Rays are high-energy particles from stars or remnants of a supernova. These particles impinge upon the Earth's atmosphere, in the form of positively charged particles, protons. Protons interact with atmospheric nuclei to produce a cascade of high energy secondary particles known as a Galactic Cosmic Ray Shower. This post-collision secondary shower depends on altitude, latitude, solar activity, and air pressure. The Regener-Pfotzer (R-P) maximum, which is between 15-25 km, is the altitude where the maximum number of detections is measured with a Geiger Müller detector. In order to quantify particle collisions, a payload was flown containing four Geiger counters in a cross configuration comparing and measuring vertical, horizontal, and omnidirectional coincidences. Analyzed data showed an R-P maximum occurring at different altitudes depending on the direction of the coincidences, consistent with previous research.

Background

- Galactic Cosmic Rays (GCRs) are constantly impinging Earth's atmosphere typically in the form of protons.
- This interaction ionizes the nitrogen and oxygen found in the atmosphere where the protons interact with atmospheric nuclei and then produces a cascade of high energy secondary particles called a Galactic Cosmic Ray Shower (GCRS).
- GCRs are the result of distant sources, such as stars or remnants of a supernova.

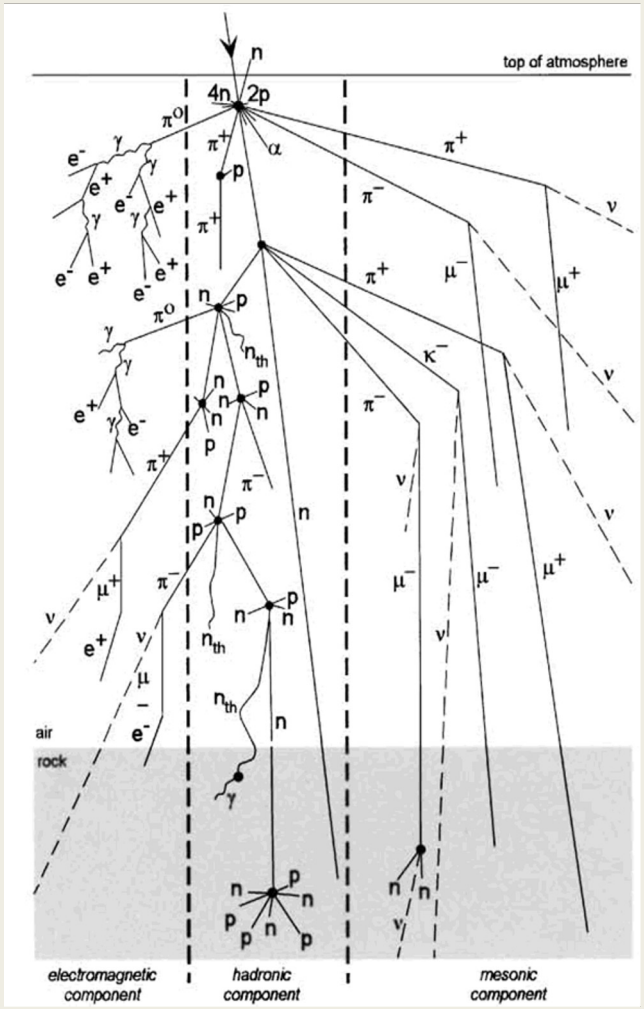


Figure 1. Cosmic Ray Shower.

Continued Background

- Post collision secondary particles are a shower of protons, neutrons, electrons, and muons. This secondary shower depends on altitude, latitude, solar activity, and air pressure.

- In order to detect the most diverse range of particles, readings must be taken in situ. GCR's can be classified into three main components: the electromagnetic (mostly photon- electron components) drive by neutral pion decay, the hadronic component (which constitutes the core portion of the showers) and the mesonic component driven mainly by decay of pions into muons.

The Regener-Pfotzer (R-P) Maximum

- The R-P max. is the altitude at which the maximum number of counts can be measured with a Geiger Müller (GM) detector.
  - *Each count is the detection of a single high-energy particle.*
- Between 15 and 25 km in altitude lies the R-P maximum.

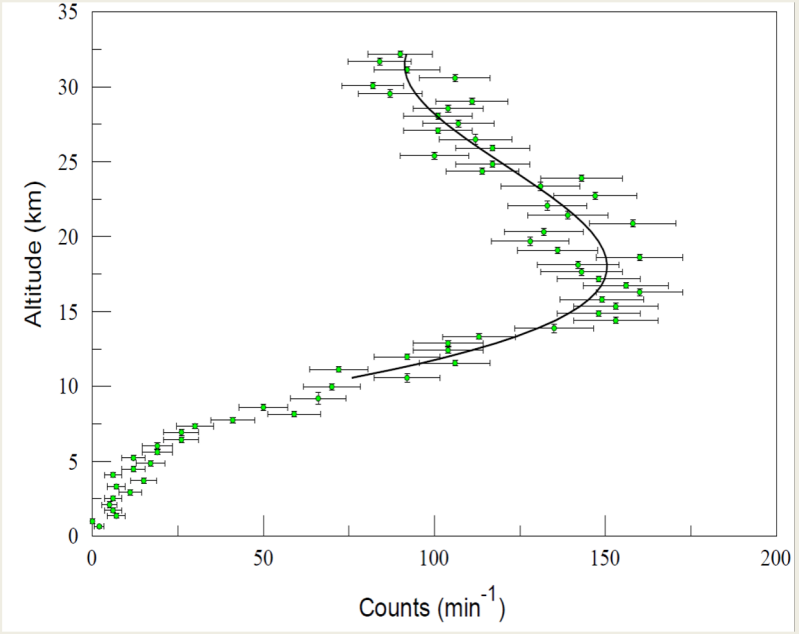


Figure 2. Altitude versus horizontal coincidence, R-P maximum at 18.1 km ± 1.0 km.

R-P Maximum comments

- Secondary particles in GCR's undergo decays and energy loss through interactions as they travel through the atmosphere. The changing profiles of these particles and energies are generated, and these profiles have peak intensities at the R-P maxima.

- The omnidirectional (360˚ view), vertical, and horizontal coincidence maxima do not occur at the same altitude.

Coincidence

Each detector has a field of view represented by the solid angle.

Figure 3 shows the solid angle of detector 2 superimposed on the solid angle of detector 1. The solid angle of the vertical coincidence is the intersection of detector 1 and 2.

This does not guarantee the direction of the particle.

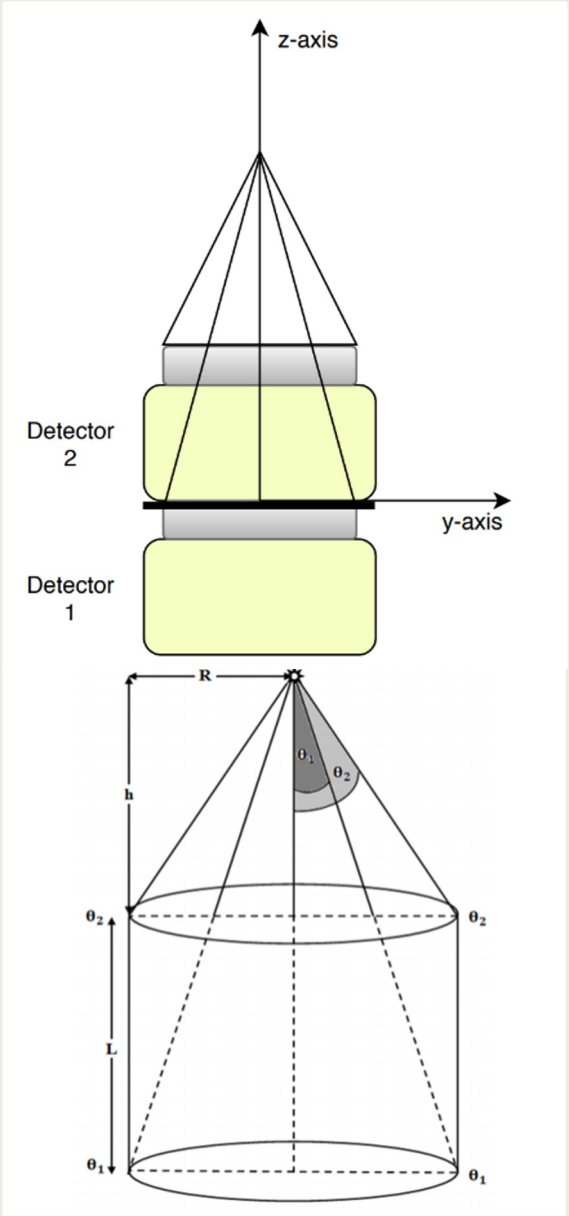


Figure 3. An axial point source with Cylindrical Detector.

Vertical Coincidence

Vertical coincidence occurs when two detectors are aligned vertically as in the figure. The detection of a particle both detectors simultaneously is vertical coincidence. This gives insight into the direction of the particle's movement.

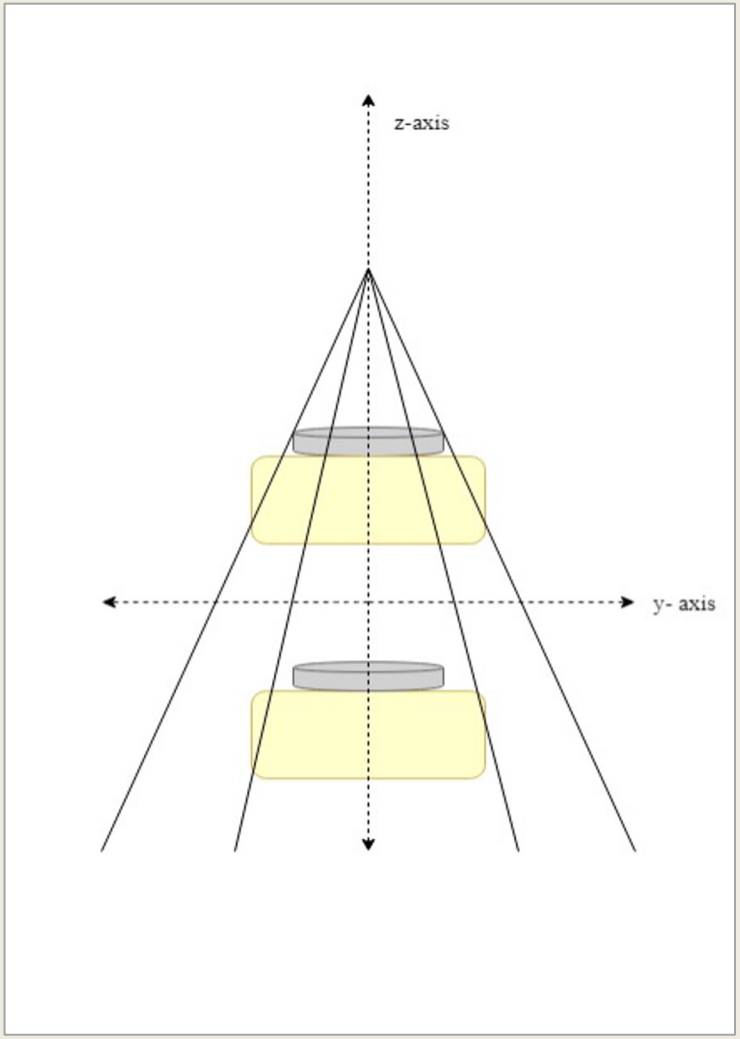


Figure 4. Vertical coincidence represented using two separated RM-80 Geiger counters

Horizontal Coincidence

Horizontal coincidence occurs similarly to vertical coincidence; however, the two RM-80 Geiger's are aligned and rotated -90 degrees.

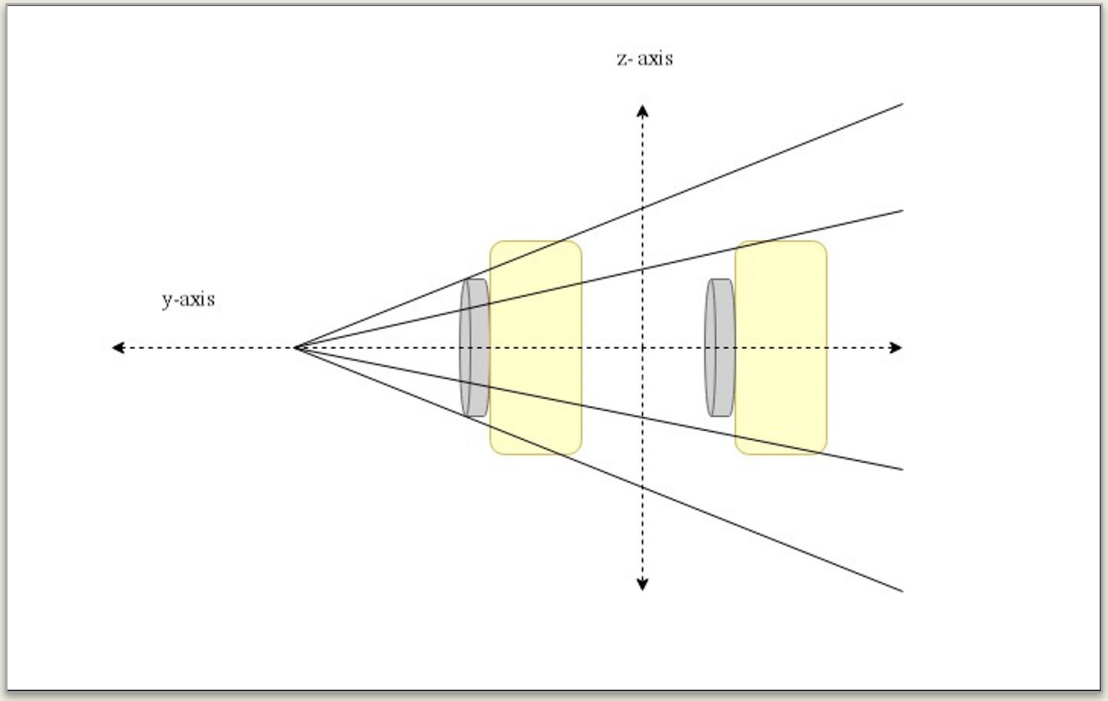


Figure 5. Horizontal coincidence represented using two separated RM-80 Geiger counters

Quad Box Design

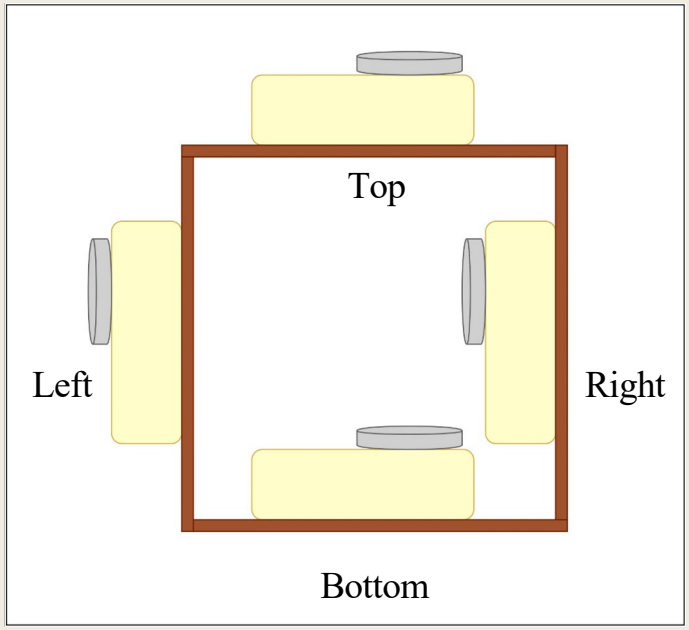


Figure 6. Design of Quad Box.

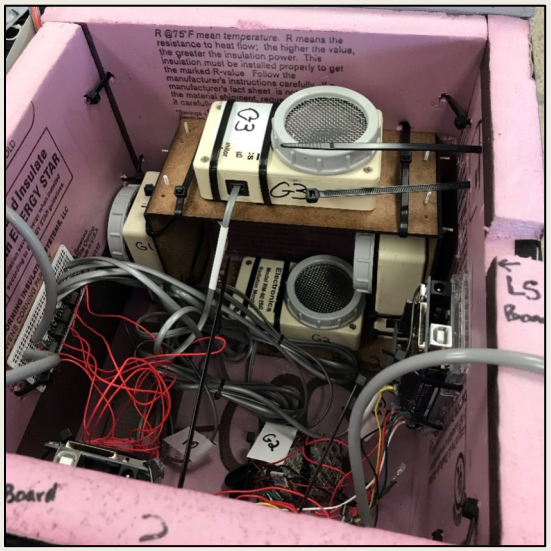


Figure 7. Oblique view of Quad Box.

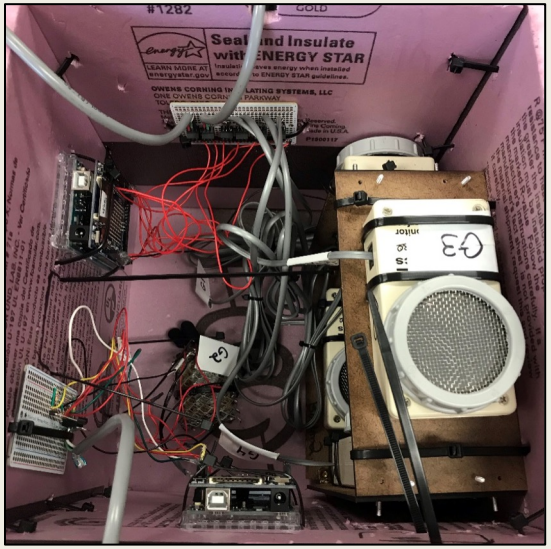


Figure 8. Top view of Quad Box.

Experiments

First Flight 6/7/19 (α)	Launch at 11:31 am CDT Burst at 1:29pm CDT Duration: 2 hrs. 13 mins.
Second Flight 6/13/19 (β)	Launch at 11:53 am CDT Burst at 1:27pm CDT Duration: 2 hrs. 4 mins.
Third Flight 7/27/19 (γ)	Launch at 11:55 am CDT Burst at 1:29 pm CDT Duration: 2hrs. 2 mins.

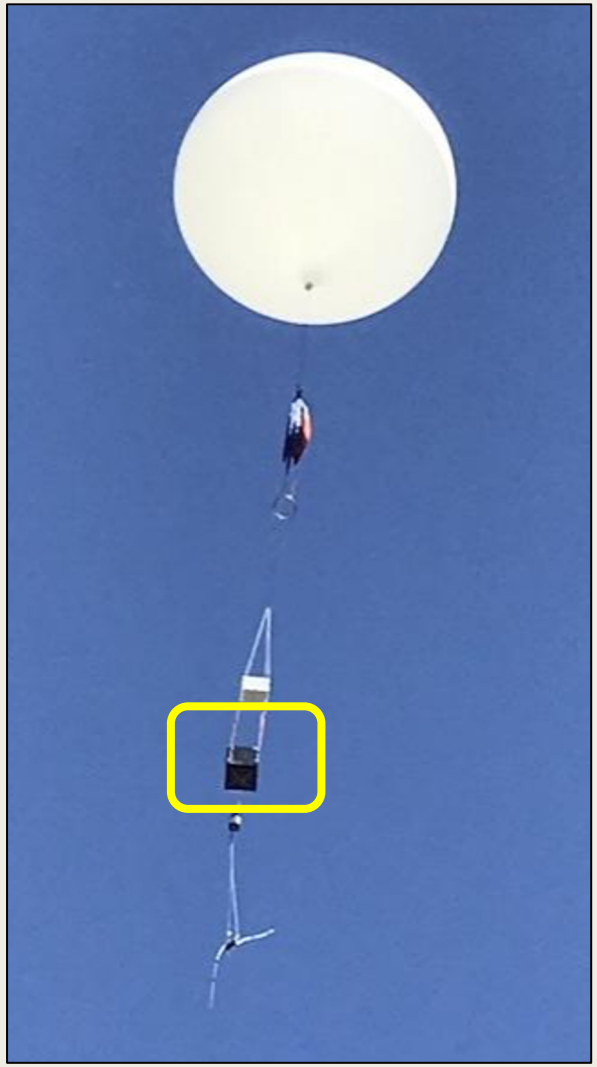
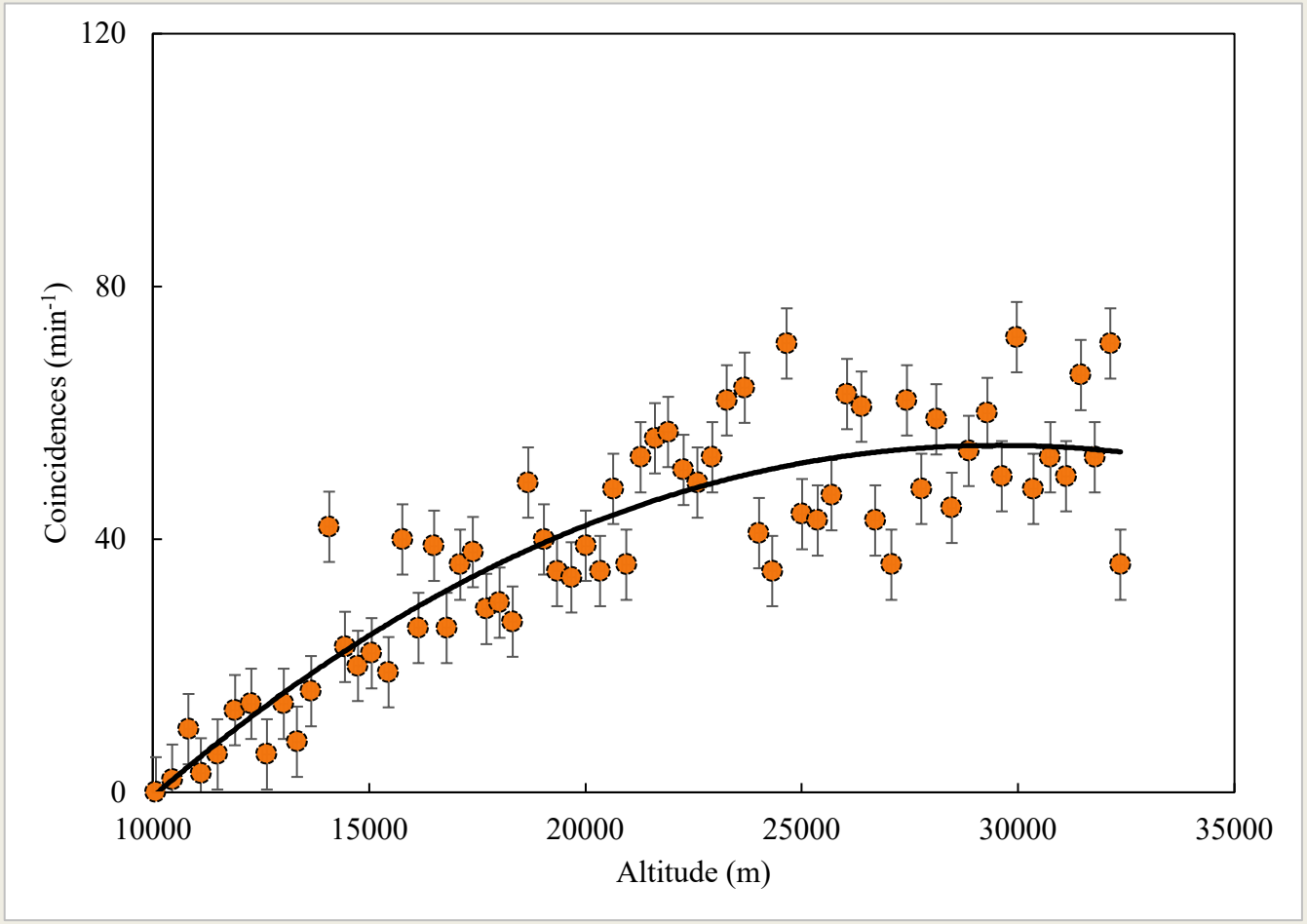
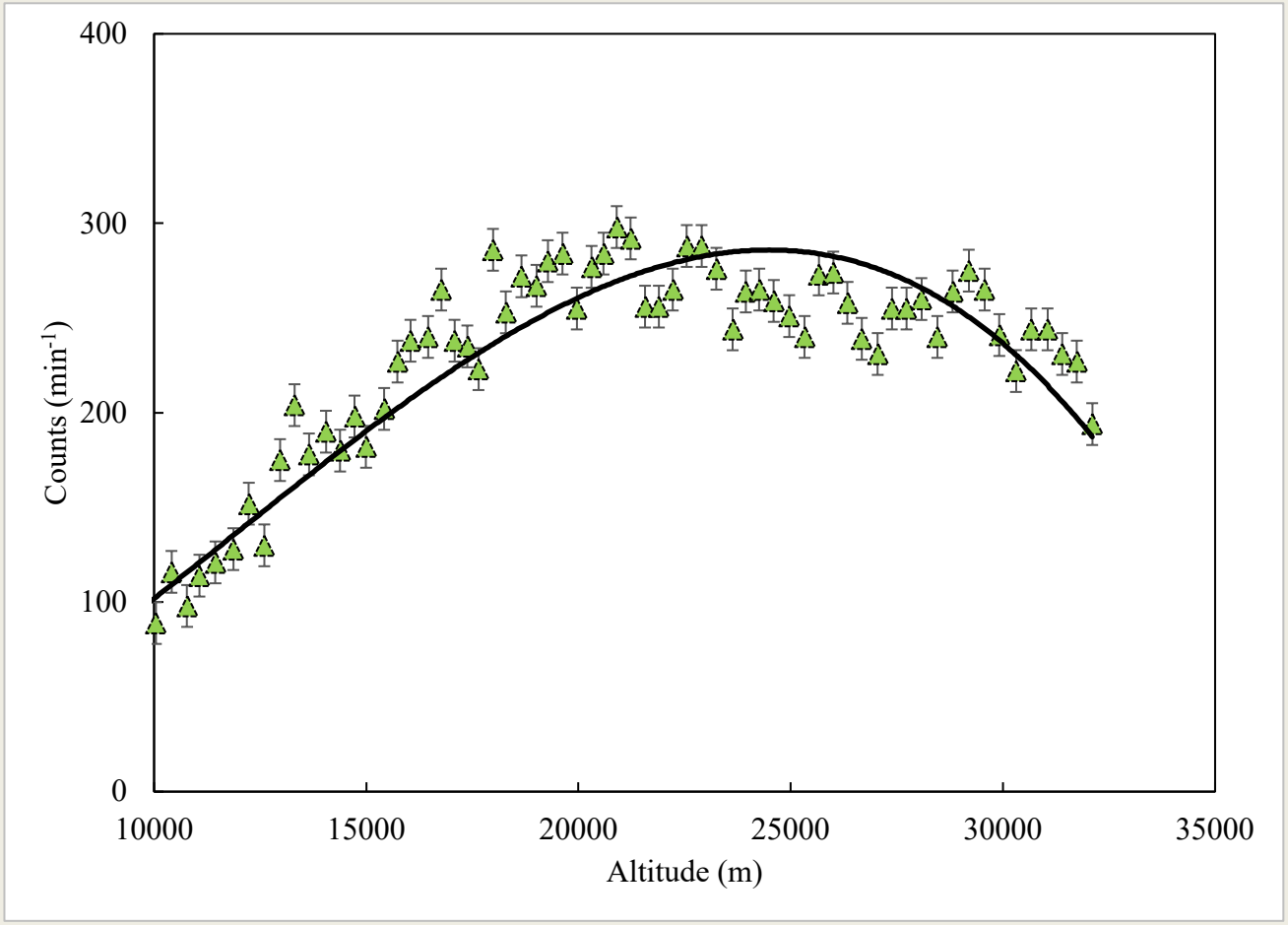


Figure 9. Stack set-up from flight 6/13/19 (β).

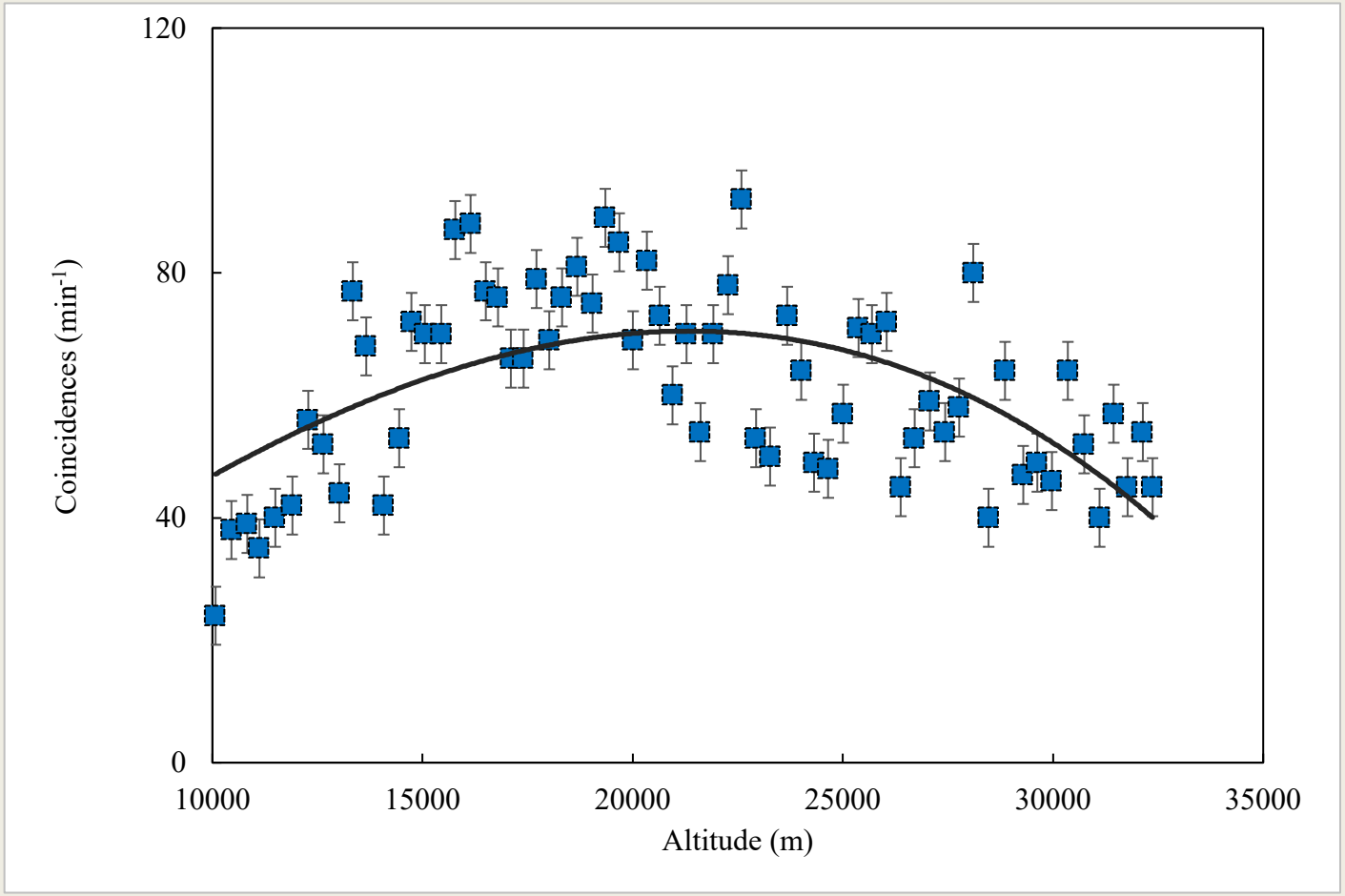
Plot of horizontal coincidences versus altitude of flight (β).



Plot of omnidirectional counts vs Altitude of flight (β).



Plot of vertical coincidences versus altitude of flight (β).

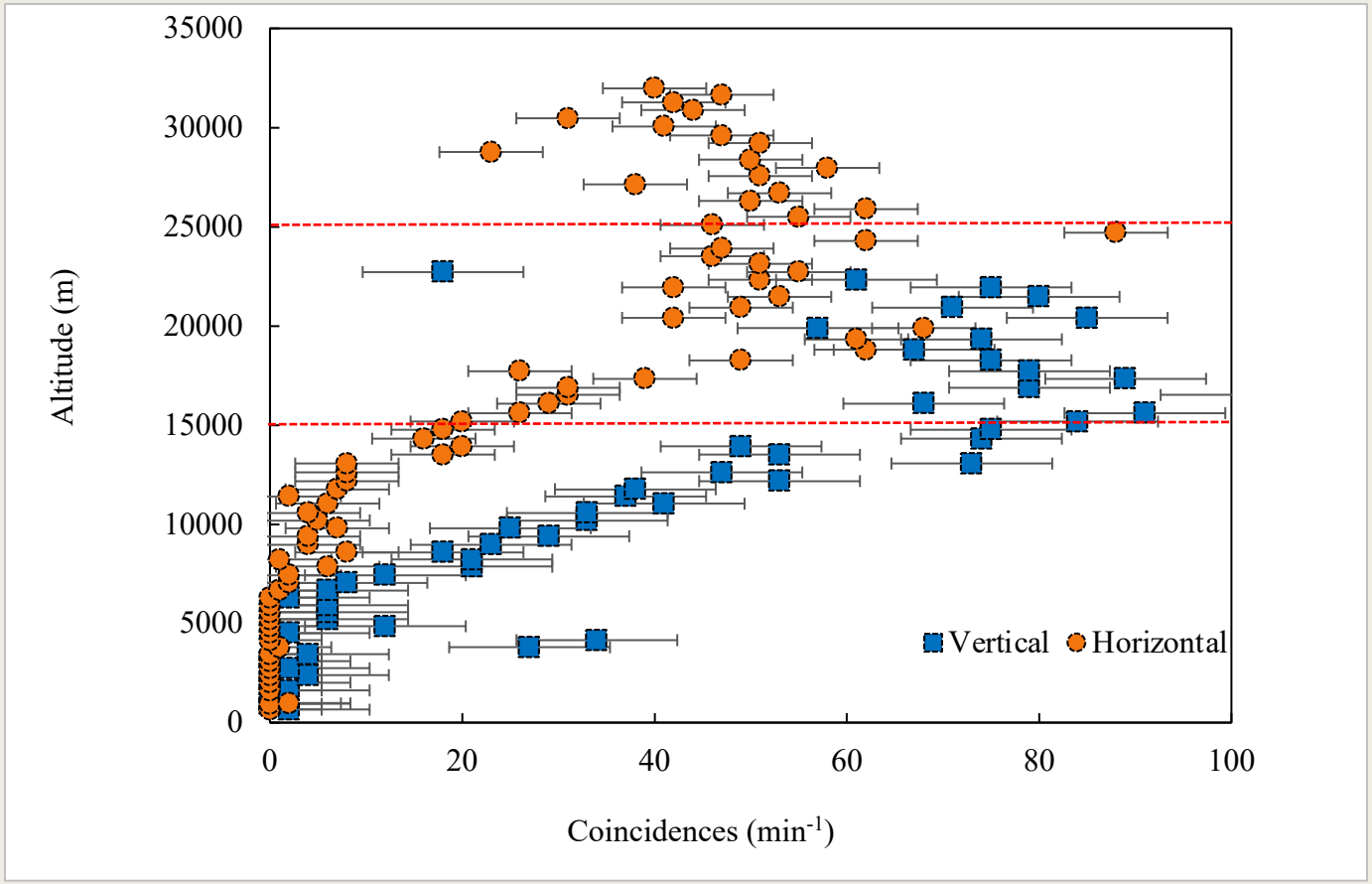


Data Summary

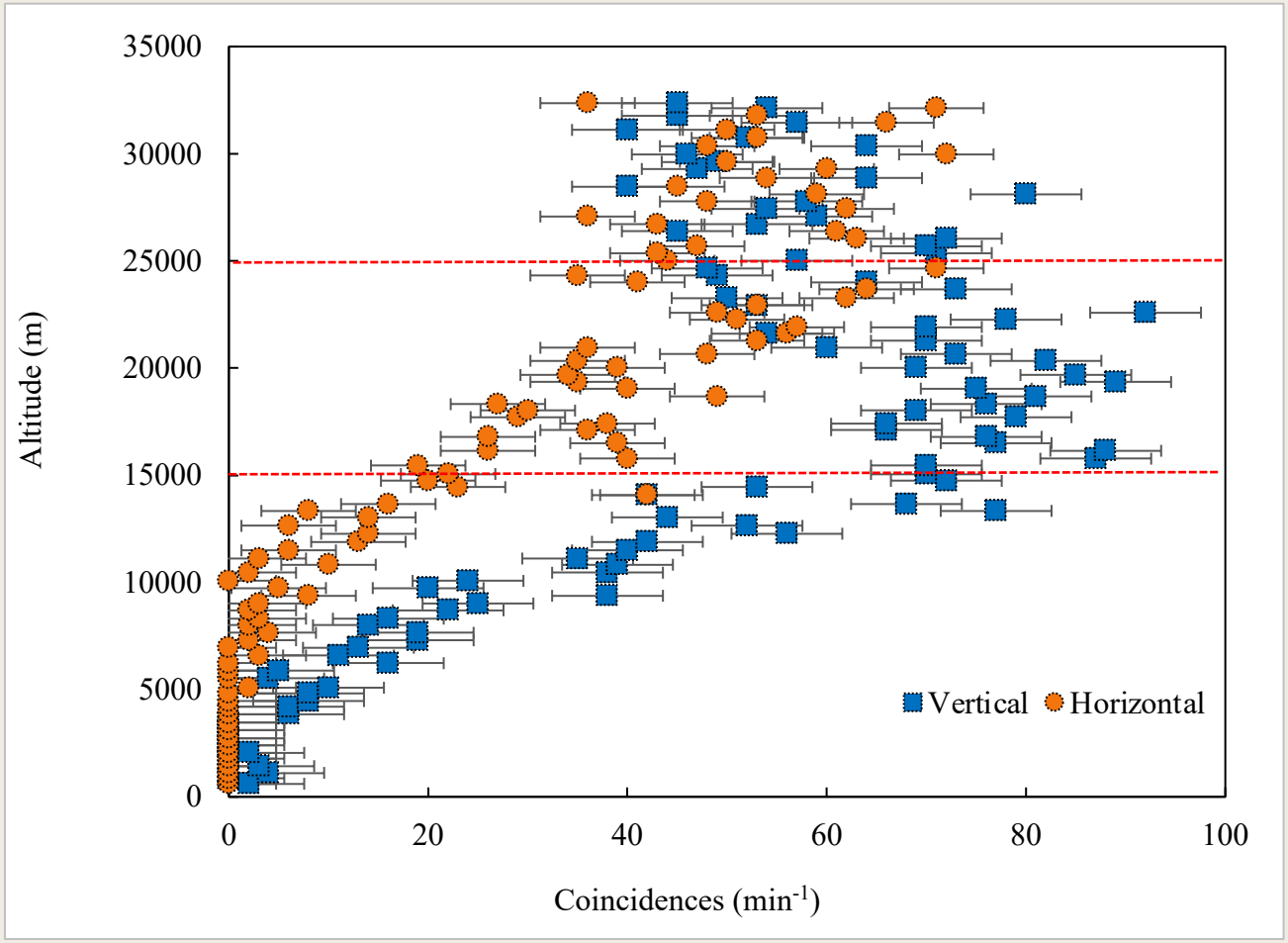
Table 1: Zenith angle R-P maximum determination

R-P Max	*Flight α, (3rd order poly fit) km*	*Flight β, (3rd order poly fit) km*	*Flight γ, (3rd order poly fit) km*
Horizontal	25.3	29.5	26.6
Omnidirectional	24.5	24.5	21.4
Vertical	X	21.3	23.0

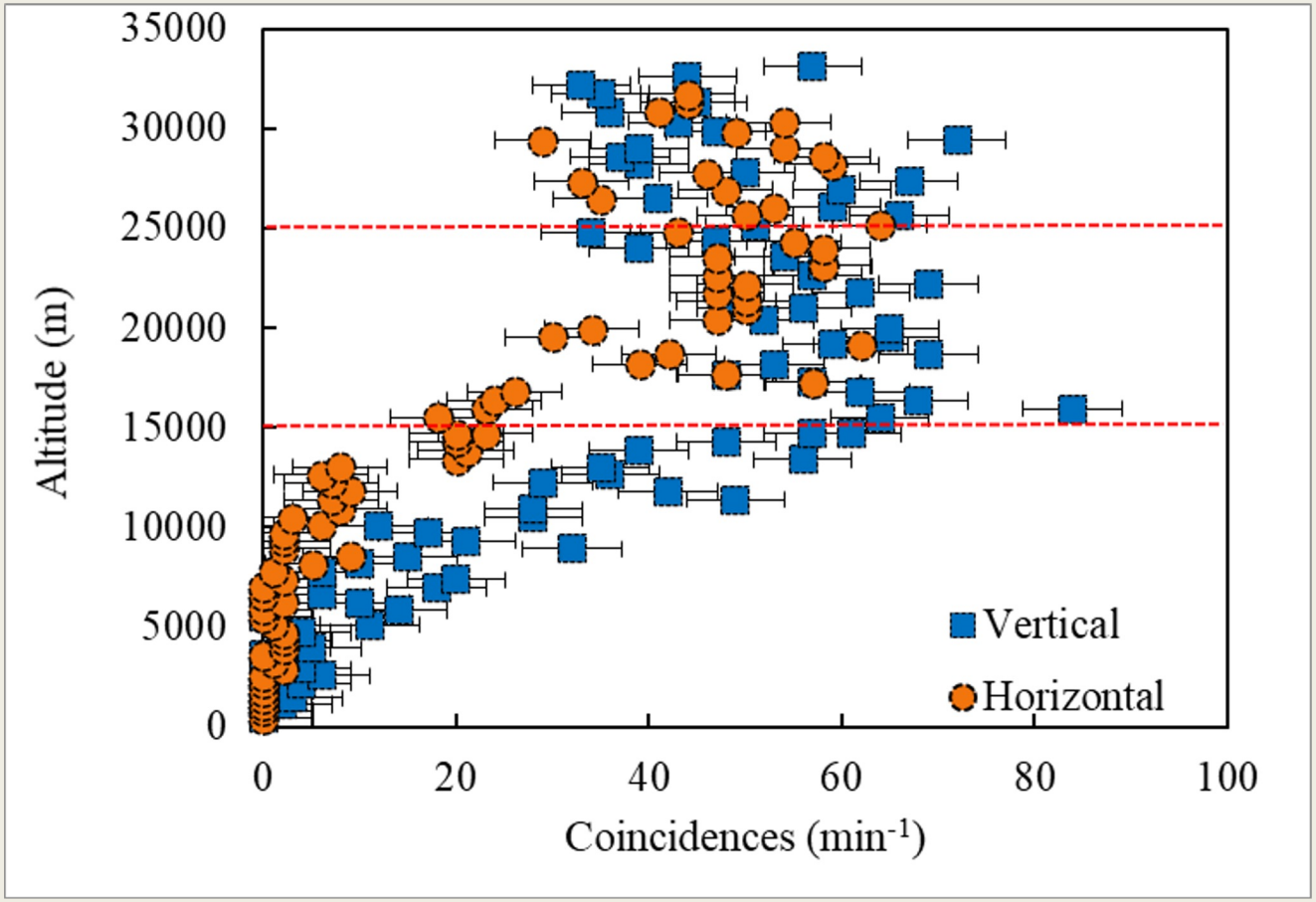
Plot of altitude versus vertical (blue) and horizontal (orange) coincidences for flight (α).



Plot of altitude vs vertical (blue) and horizontal (orange) coincidences versus altitude for flight (β).



Plot of altitude vs vertical (blue) and horizontal (orange) coincidences versus altitude for flight (γ).



Summary of results

- R-P Max for vertically oriented particles is always at a lower altitude as compared to the horizontal.
- Vertical orientated GM tubes also pick up coincidence readings at ground level whereas horizonal pick up none or very few.
- The omnidirectional count maxima is always at lower altitude compared to horizontal readings.

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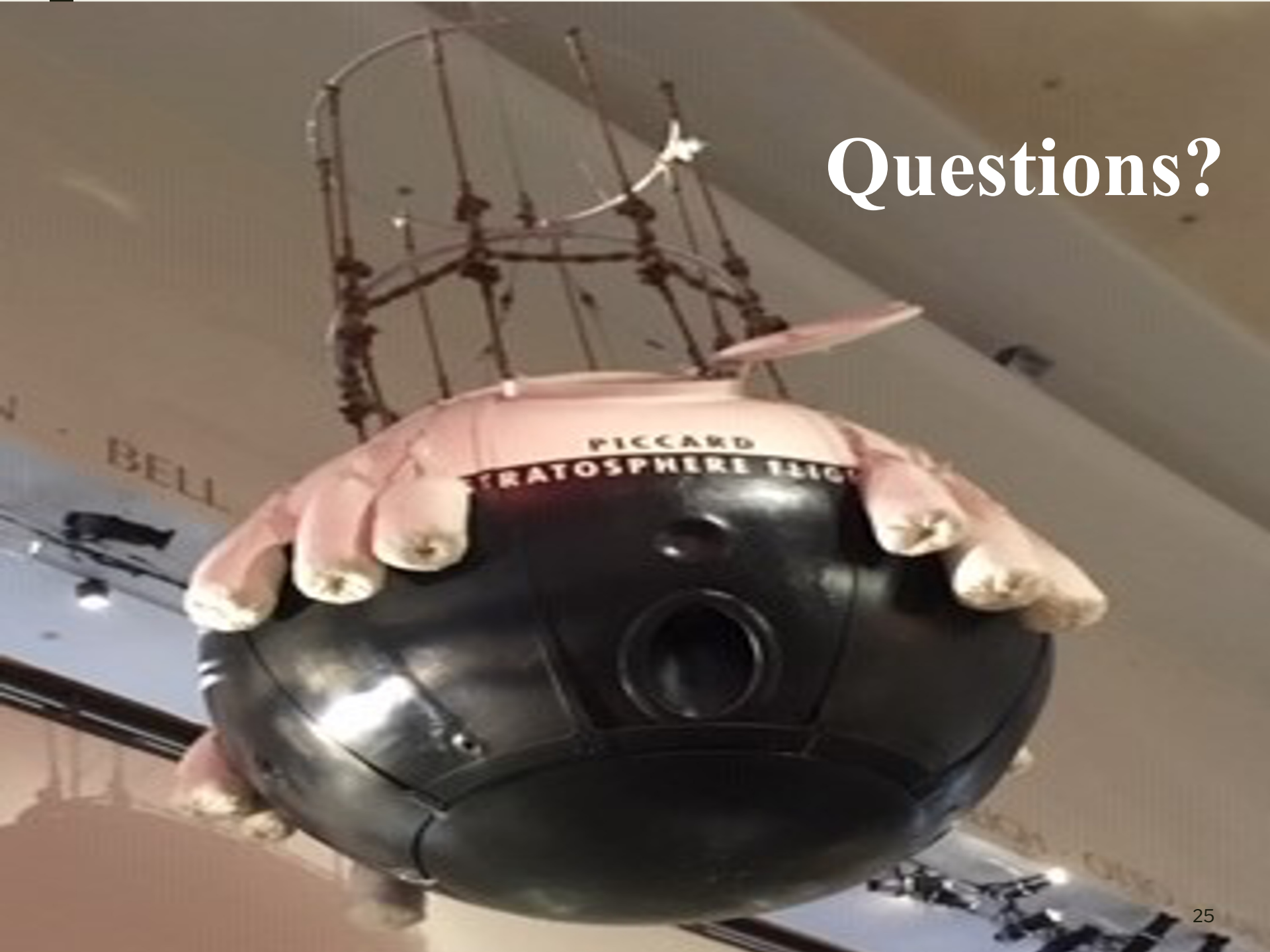
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