Extended Duration Studies of Energetic Particles in the Stratosphere

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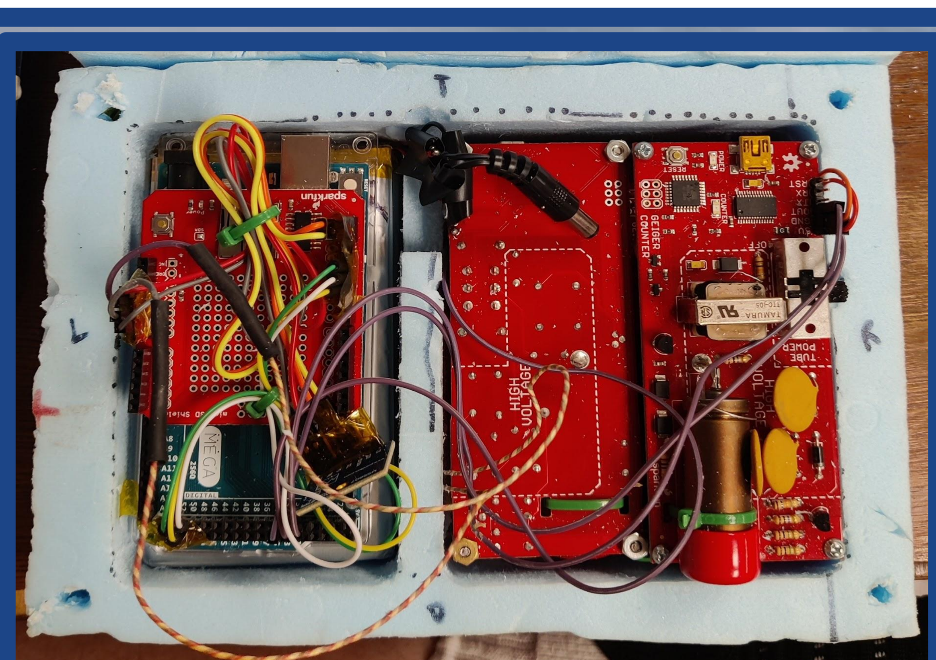
Abstract

The Balloon Assisted Stratospheric Experiments (BASE) program aims to measure atmospheric muon concentration at the Pfotzer Maximum with Geiger Counters carried by weather balloons. The most intense radiation is found at the Pfotzer Maximum 18 - 22 km (11 - 13 mi) above ground level. During this summer, seven flights were conducted to attain maximum time in the Pfotzer Maximum using different strategies like underfilling and multiple balloon systems.

Background

The Earth's atmosphere is bombarded by cosmic rays which are high-energy subatomic particles (mostly protons ~ 94%), originating from supernova explosions, quasar activity, black holes, and solar radiation. Cosmic rays interact with atmospheric atoms producing showers of secondary energetic particles. These meson showers are a mixture of energetic kaons and pions. These two mesons have a very short lifespan. Charged kaons live for 12 nanoseconds, charged pions live for 26 nanoseconds, and neutral pions live for 10 -7 nanoseconds. When Mesons decay, they form muons. Muons are the object of this study because their longer lifespan of 2.2 microseconds results in their presence dominating over the mesons.

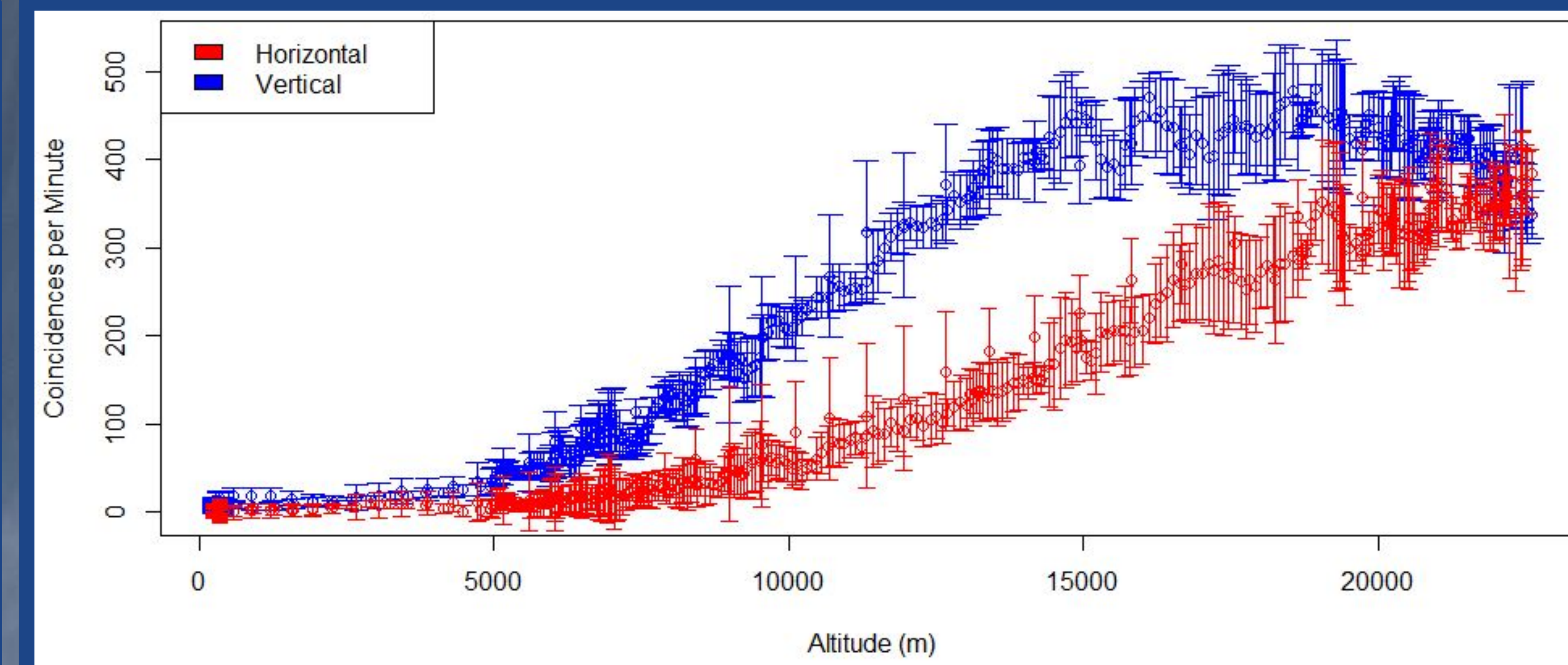


The picture above shows three geiger counters in their step geometry.

Equipment

- Geiger Counter
  - 3 Sparkfun geiger counter boards are arranged in a step geometry to detect muons. While any energetic particle can trigger each geiger counter individually, a muon has enough relativistic energy to travel through two geiger tubes and register as a coincidence. Vertical coincidences trigger the middle and top geiger counters while horizontal coincidences trigger the middle and side geiger counters. The dual axis system is informative of cascade showers and how their particles are traveling at different altitudes.
- Radios
  - The radios transmit on 2m wavelength and the 144.39MHz band. They transit using APRS (Automatic Packet Reporting System). It records the flight string's altitude, speed, direction, and coordinates. These radios and S3Research's flight predictions track the balloon's path.
- Arduino Mega and SD Card Shield
  - The Arduino board is the brains of the sensor array. It constantly tracks the number of counts and coincidences per minute. Once a minute, the data is formatted and written to a microSD card
- HAB Bounder and Doongara
  - These cutaway devices sit at the top of the flight string and connect our instruments to the balloon's line. Depending on the flight's parameters, the device is programmed to trigger with time or altitude.
- MS5607 Pressure sensor
  - This sensor collects auxiliary pressure information used to track the package's progress.

Flight	Brief Flight Summary
1st	• Radio flight; Doongara test failure
2nd	• Flew geiger counter and pressure sensor for first time • Classic flight with single filled balloon
3rd	• 2 balloon system, designed to cut a balloon away just under the Pfotzer maximum • Failed, auxiliary balloon burst early. Had a very slow ascent
4th	• Second attempt of 2 balloon method • Similar results, early burst and early descent on balloon • Theorized that new rough kevlar line was too abrasive on the balloon latex in collisions
5th	• No balloon burst! Softer dacron cord averted abrasion • HAB Bounder failure. Rapid climb
6th	• HAB Bounder test with radios; sucsessful
7th	• Landed in tree, data pending



This graph above shows the horizontal and vertical coincidences during flight 3. The vertical coincidences rise and fall off first because muons have a shorter straight line path when traveling toward Earth. The horizontal coincidences rise slower because they have a longer curving path, more likely to decay before reaching lower altitudes. The decrease in vertical coincidences at high altitudes shows the decrease in atmospheric density. With less air above, cosmic ray collisions become less common. With enough altitude, the horizontal coincidences would show a similar drop as diminishing atmosphere results in less muon production.

Results

While none of our flights perfectly sampled the Pfotzer maximum, every flight contributed to the depth of engineering and technological knowledge for future flights. Future projects will include perfecting the use of cutaway devices and multi-balloon systems.

Acknowledgements

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