Cosmic Rays in Flight

- Kevin McFarland – Advisor/Professor
- Jesse Chvojka – Grad. Student
- Briana Wood – Teacher
- Joe d’Arpino – Pilot
- Frank Wolfs – Co-Pilot/Professor

STUDENTS

- Bobbi Nelson
- Kate McCormick
- Greg Balonek
- Robert Balonek
- Daniel Balonek
- Rian Morgan
- Robbie Fuller

Funding from the New York chapter of the American Physical Society
Plan of Action

- Performed individual experiments
  (angles, lead, separation)
- Build container for the detector
- Plane (setting up)
- Data Analysis
  (relativity and time dilation)
Muons

- Mass: 105.7 MeV
- Speed: close to the speed of light
- Speed of light: $3 \times 10^8$ m/s
- Charge: -1
- Origin
- Lifetime: 2.19 microseconds
Building the Box
Set-Up

- Three shelves with the paddles secured on each level
- Parallel and vertically aligned
- Enclosed with laptop on the top
Loading…
Experimental Setup

- Time for each trial (~30 min)
- Three Paddles (Data from top 2)
- Plane’s instruments (Check for interference)
Air Borne

- Heights
  - 500 ft (ground level)
  - 4000 ft
  - 7000 ft
  - 9000 ft
  - 12000 ft
Data

Muons in Flight

Time (minutes)

Coincidences (count/minute)
Data

Muons in Flight

Coincidences (count/minute)

Time (minutes)
Data Summary

<table>
<thead>
<tr>
<th>Altitude (ft)</th>
<th>Rate (#/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>224.4</td>
</tr>
<tr>
<td>4000</td>
<td>249.1</td>
</tr>
<tr>
<td>7000</td>
<td>277.8</td>
</tr>
<tr>
<td>9000</td>
<td>300.3</td>
</tr>
<tr>
<td>12000</td>
<td>302.79</td>
</tr>
</tbody>
</table>

Data needs to be rescaled to eliminate the effects of the air between different altitudes.
Effects of Lead on Muons

1 cm of lead decreases muon flux by .006%
### Rescaled Data

<table>
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<th>Altitude (ft)</th>
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<td>240.9</td>
</tr>
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<td>228.5</td>
</tr>
</tbody>
</table>
Muon Decay

\[ N = N_0 e^{-\ln 2 t/T} \]

- \( T \) = muon life time
- \( N_0 \) = initial number of muons (9000 ft.)
- \( N \) = number at x altitude
- \( \ln 2 \) = 0.69315
- \( t \) = time since particle is created
## Data Comparison

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<th>Predicted Rate (#/min)</th>
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<tr>
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<td>15.7</td>
</tr>
<tr>
<td>4000</td>
<td>225.4</td>
<td>48.4</td>
</tr>
<tr>
<td>7000</td>
<td>233.2</td>
<td>126.7</td>
</tr>
<tr>
<td>9000</td>
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</table>
Relativity

- Frame of Reference
- Speed of Light (constant)
- Muon speed
  \[ T = T' \sqrt{1-v^2/c^2} \]
- Effect on Lifetime
<table>
<thead>
<tr>
<th>Altitude (ft)</th>
<th>Rescaled Rate (#/min)</th>
<th>Predicted Rate (#/min)</th>
<th>Predicted Rate with Time Dilation (#/min)</th>
</tr>
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Time Dilation

- Muon lifetime with time dilation = 84.3 microseconds
- 50 microseconds to reach ground from 15 km
- Data supports theory