



Cosmic Rays in Flight

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- Jesse Chvojka – Grad. Student
- Briana Wood – Teacher
- Joe d'Arpino – Pilot
- Frank Wolfs – Co-Pilot/Professor

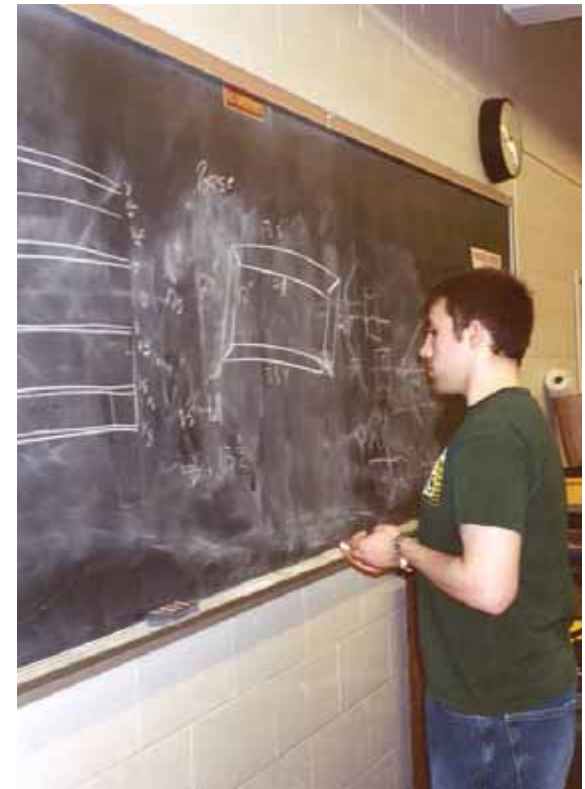
STUDENTS

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- Kate McCormick
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- Daniel Balonek
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- 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: 3×10^8 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 w/ 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

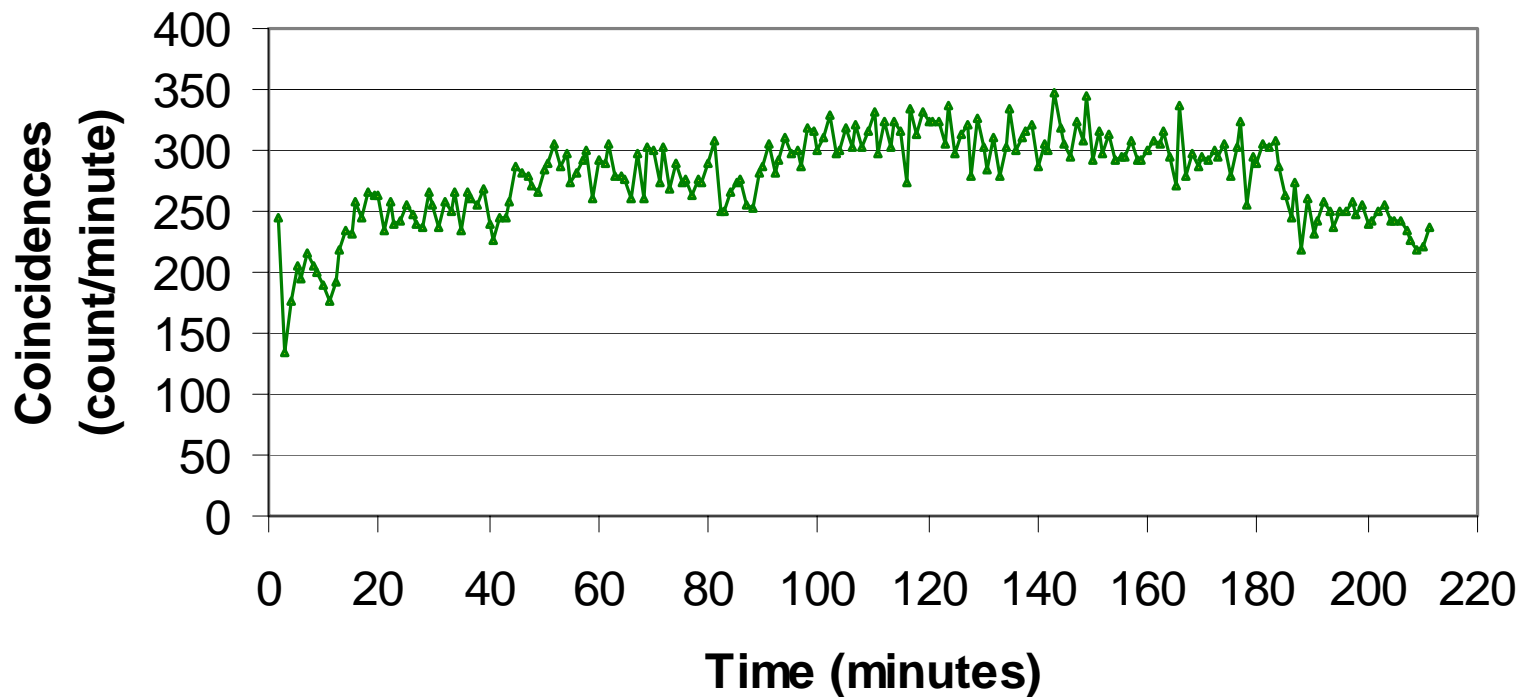
9000 ft

12000 ft

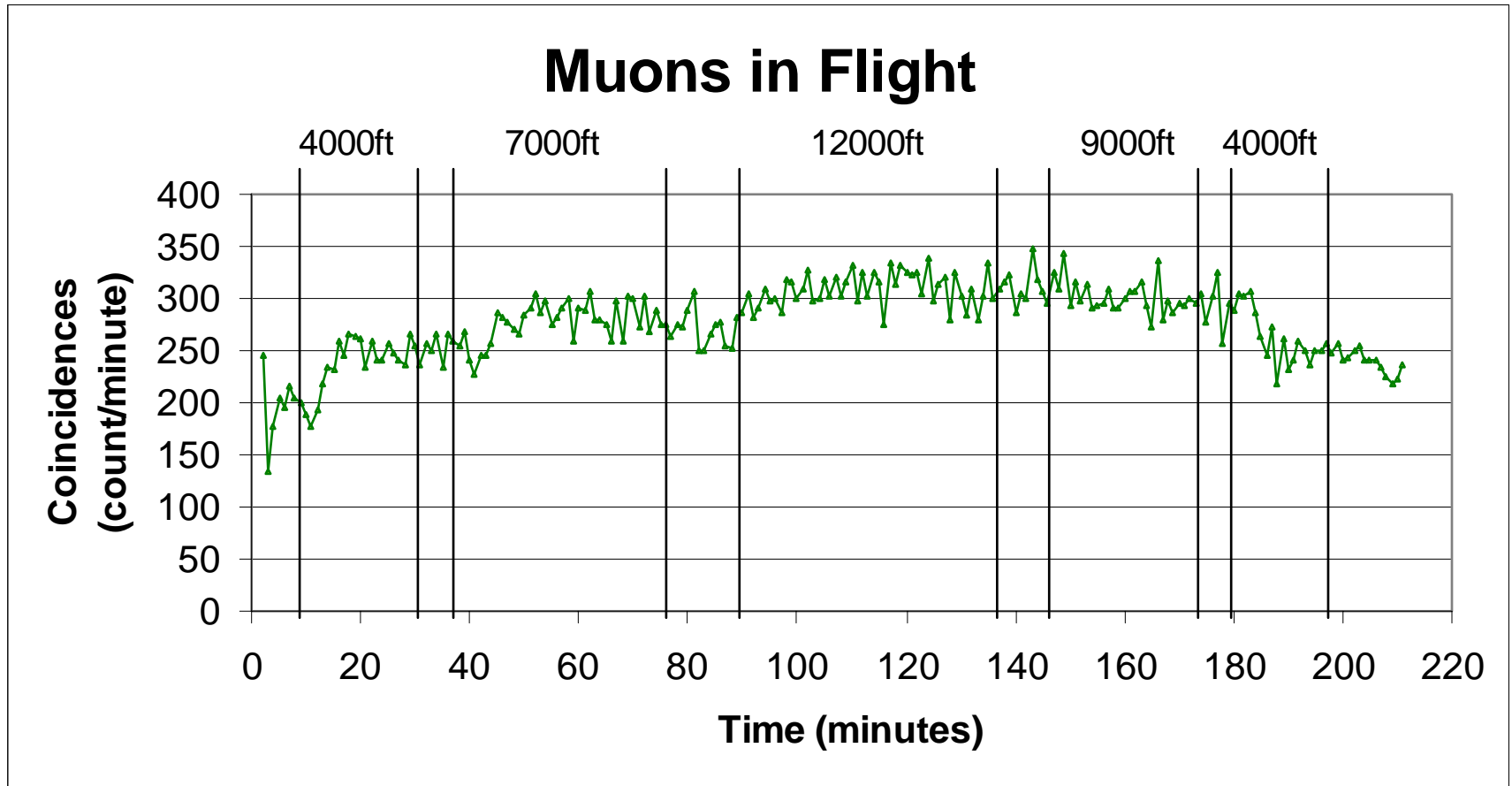


Data

Muons in Flight



Data





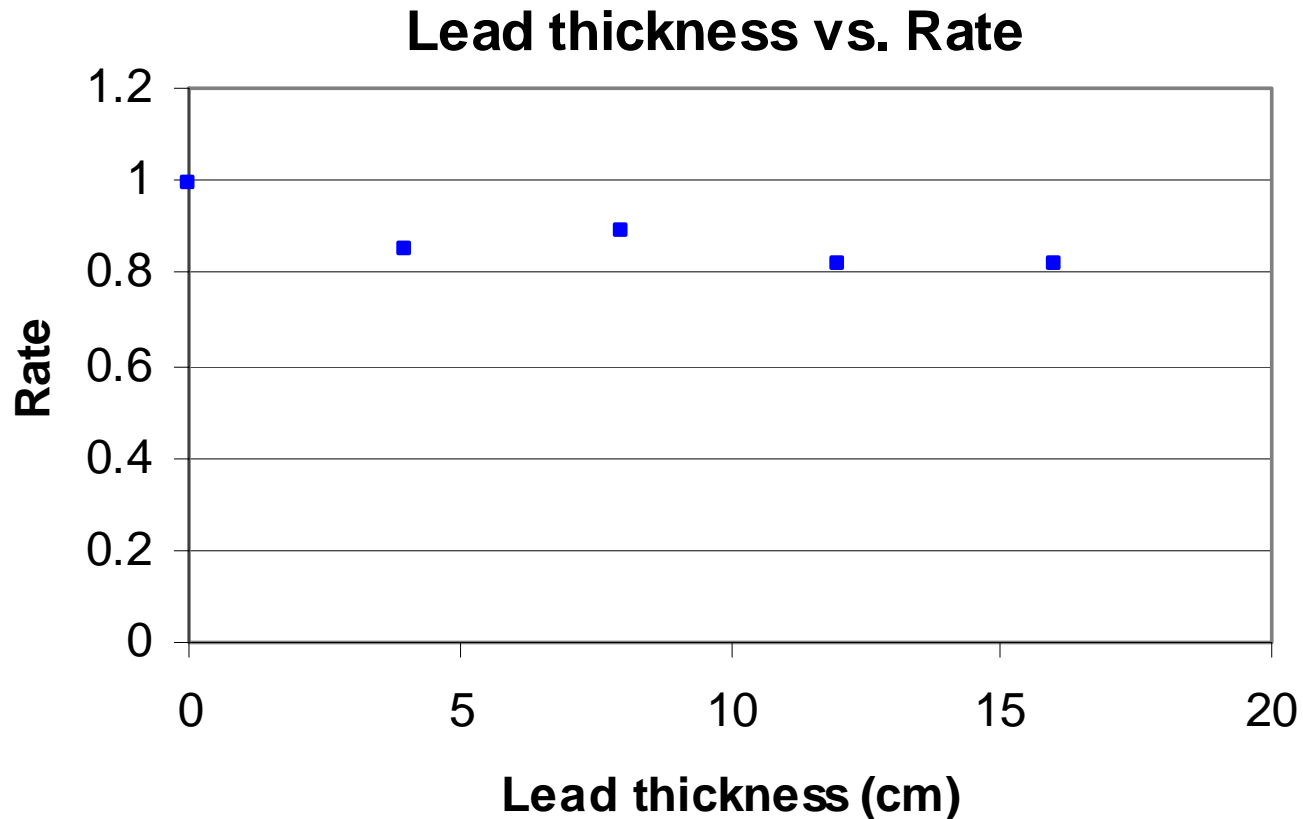
Data Summary

Altitude (ft)	Rate (#/min)
500	224.4
4000	249.1
7000	277.8
9000	300.3
12000	302.79

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

Altitude (ft)	Rate (#/min)	Rescaled Rate (#/min)
500	224.4	224.4
4000	249.1	225.4
7000	277.8	233.2
9000	300.3	240.9
12000	302.79	228.5



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

$\ln 2 = .69315$

t = time since particle is created



Data Comparison

Altitude (ft)	Rescaled Rate (#/min)	Predicted Rate (#/min)
500	224.4	15.7
4000	225.4	48.4
7000	233.2	126.7
9000	240.9	240.9



Relativity

- Frame of Reference
- Speed of Light (constant)
- Muon speed

$$T = T' \sqrt{1 - v^2/c^2}$$

- Effect on Lifetime



Data

Altitude (ft)	Rescaled Rate (#/min)	Predicted Rate (#/min)	Predicted Rate with Time Dilation (#/min)
500	224.4	15.7	224
4000	225.4	48.4	231
7000	233.2	126.7	236
9000	240.9	240.9	240.9



Time Dilation

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