Can an Aluminum Shield Stop High-Energy Muons?

Muon versus Aluminum:

Who will survive?

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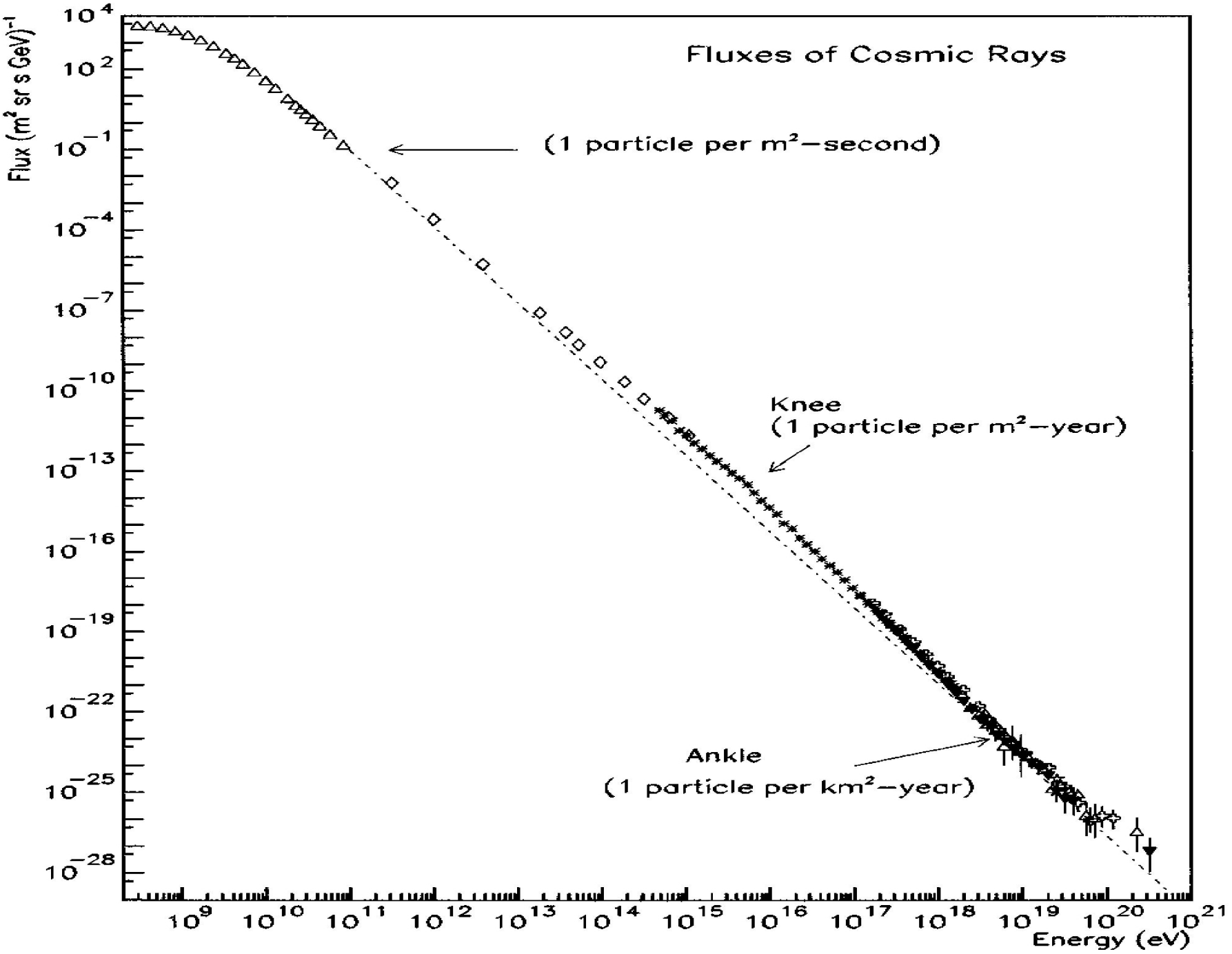
WALTA

- WAshington Large-scale Time coincidence Array
- Purpose: To look at the toe region of the cosmic ray spectrum and collect data.
- Procedure: Put cosmic ray detectors in local schools and use the Internet to gather data.

What are Cosmic Rays?

- Cosmic rays are charged particles from outer space
- Cosmic rays can range from gamma rays to iron nuclei
- Some Cosmic rays can have as much energy as a fastball


Fluxes of Cosmic Rays
Flux (m² sr s GeV)⁻¹
(1 particle per m²–second)
Knee
(1 particle per m²–year)
Ankle
(1 particle per km²–year)
Energy (eV)

Extensive Air Showers (EAS)

- Caused by a Cosmic Ray hitting the upper atmosphere.
- When the particle hits it causes a particle shower of secondary particles which in turn produce more particles.
- The higher the energy of the initial Cosmic Ray the bigger the air shower.

Muons

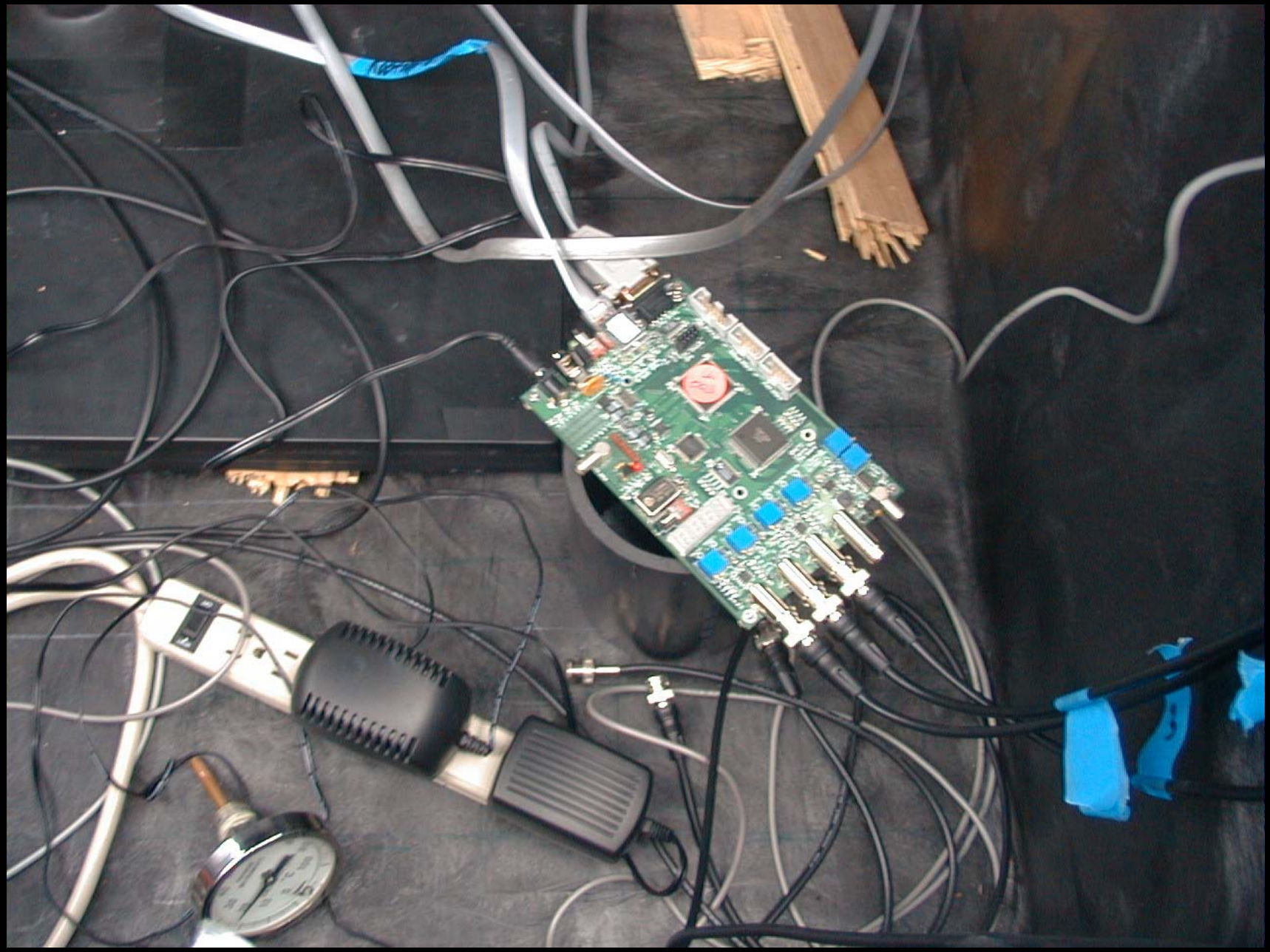
- Basically a heavy electron
  - Mass of an electron: .511 MeV
  - Mass of a muon: 106 MeV
- Typically produced by pion decay in EAS
- Highly Penetrating
- Mean-lifetime: 2.2×10^{-6} sec

Equipment

- Scintillator
  - Fluorescent Plastic which releases photons when impacted by a charged particle
- Photomultiplier Tubes (PMT)
  - Detects the photons and changes the light into an electrical signal
- Matter Slab (In this case Aluminum)
  - Used to select higher energy particles

Equipment (Continued)

- Data Acquisition Card (DAQ card)
  - Gather data from the detectors and change it into a format that is able to be read by the computer
- GPS Unit
  - Nanosecond timing
- Boxes
  - Protect the detectors from the weather



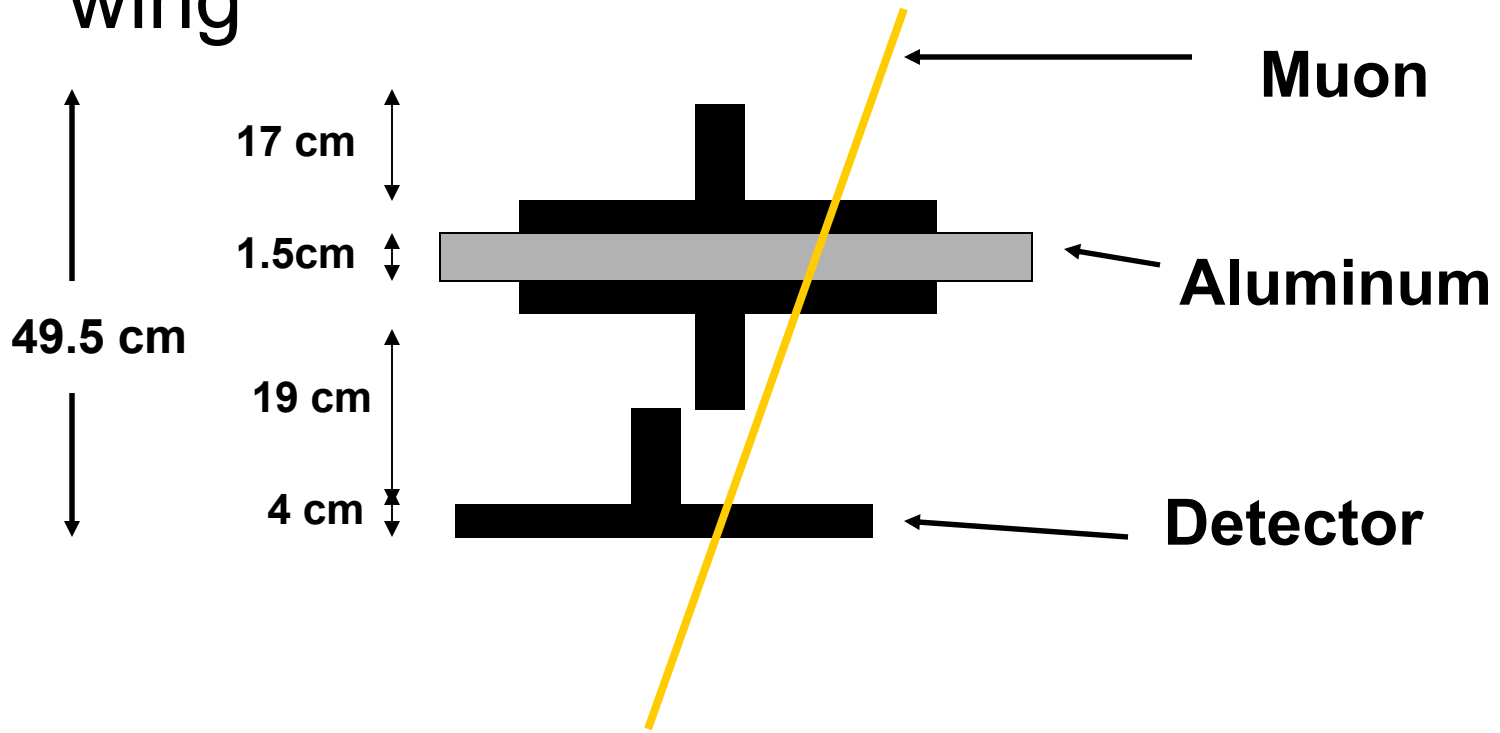
Boxes

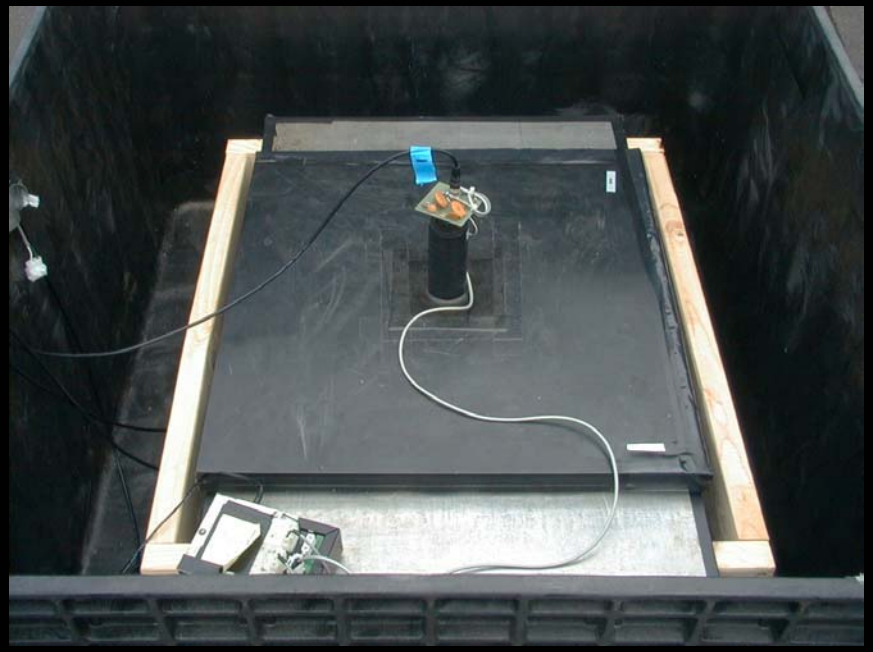
- Black Plastic Boxes
  - Dimensions (BWH):

    44 in. X 48 in. X 30.75 in.

Muon Telescope

- Location: Top of Physics Building B-wing



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Muon Momentum

- Energy Loss through materials
  - Scintillator: 2.89 MeV
  - Aluminum (1.5 cm): 6.54 MeV
  - Total Energy Loss through Entire Setup with atmosphere above: 37 MeV
- Minimum Muon Momentum: 95.85 MeV/c

Muon Energy Loss computed by RJ Wilkes

Muon Rate

- "Vertical" Muon Rate for .096 GeV/c ~ .0102 cm^{-2} sr^{-1} sec^{-1}
- Solid Angle of Rooftop Setup: 1.82 sr
- Rate if Muons are Uniform across sky ~ 66 Hz
- Rate if Muons follow $\cos^2$ (zenith angle) ~ .1 Hz

Vertical Muon Rate extrapolated from data given by the book Physics Data: Cosmic Rays on Earth by PKF Grieder
Solid Angle Calculated by RJW

Current Issues

- Figure out expected rate
- Compute actual rate with error
- Compare the two rates