The Berkeley Lab Cosmic Ray Detector

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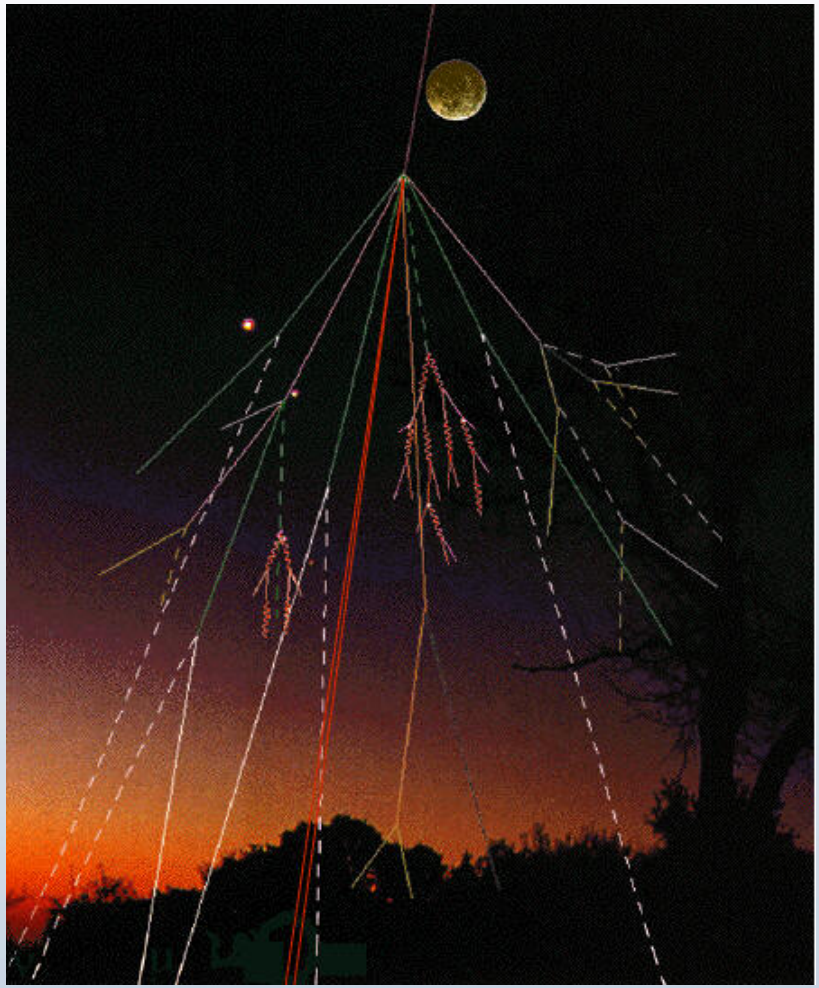
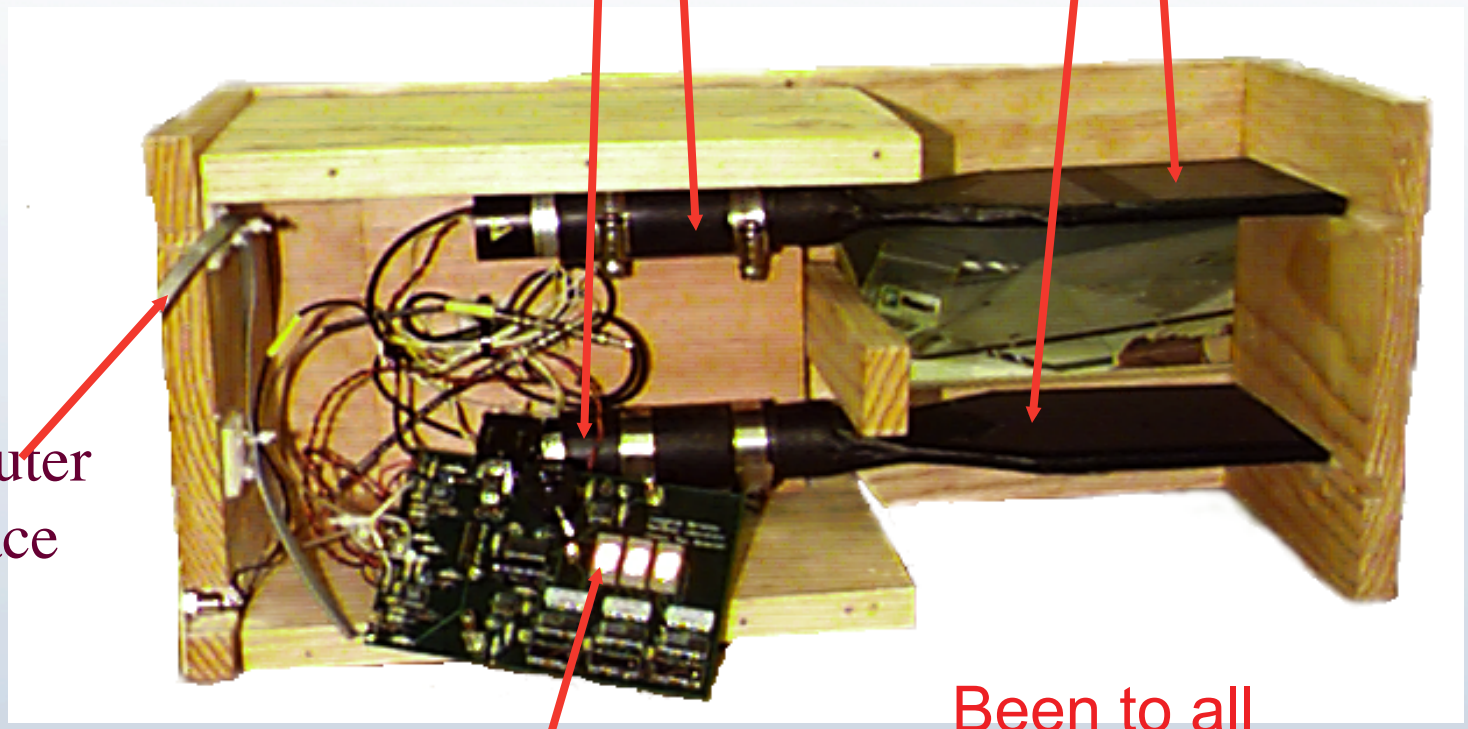
What are Cosmic Rays?

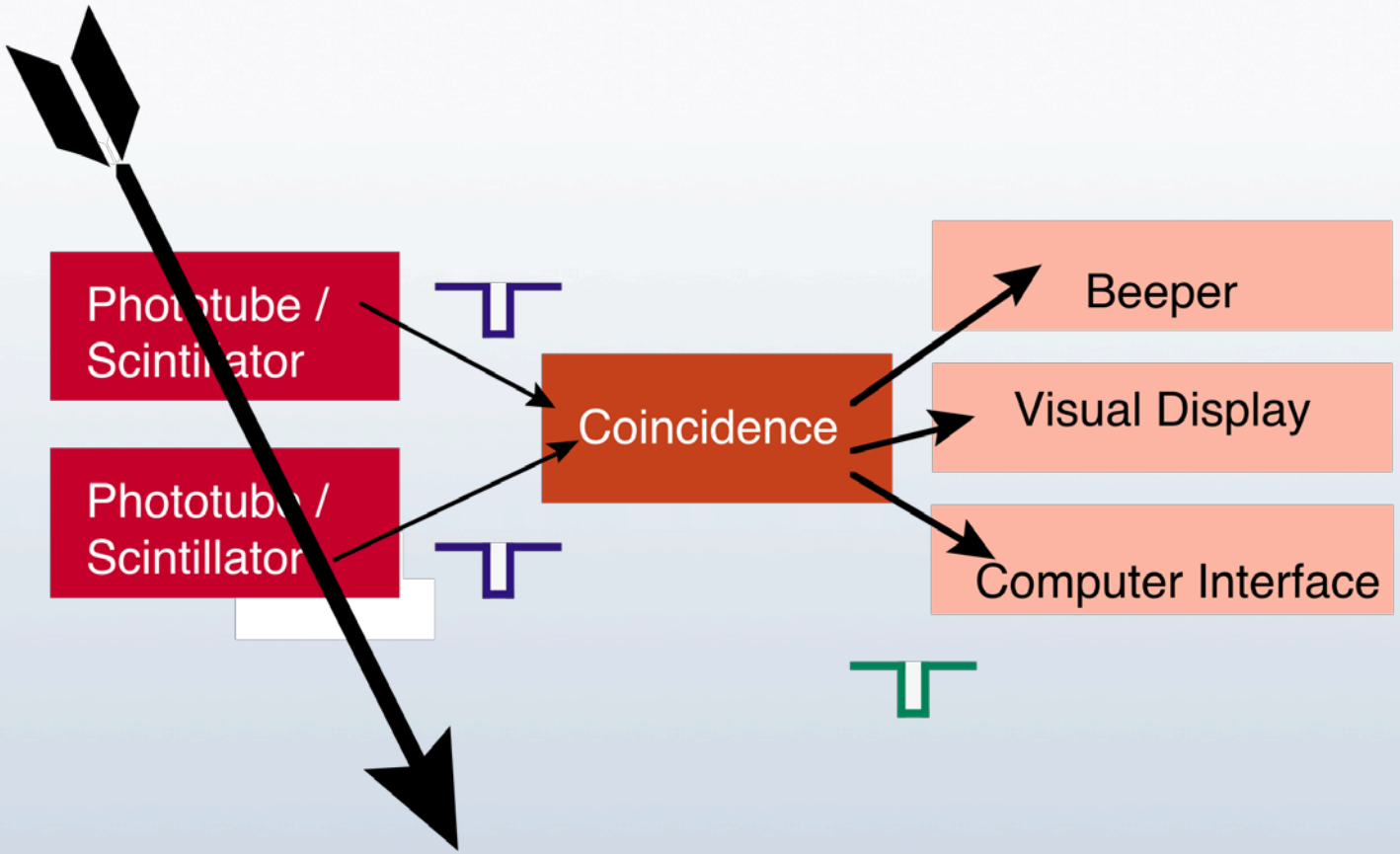
- Charged particles from the cosmos (star dust)
  - Protons, alpha-particles, heavier nuclei
  - Energies can go up to 10^{20} eV (energy of 50 mph baseball)
  - At 10^{10} eV - 1000 per m^2/s
  - At 10^{19} eV - 1 per km/s
  - (energy of old style tv ~10^3 eV)
- Origins: sun, other stars, supernovae, other catastrophic astrophysical events



Berkeley Lab Detector

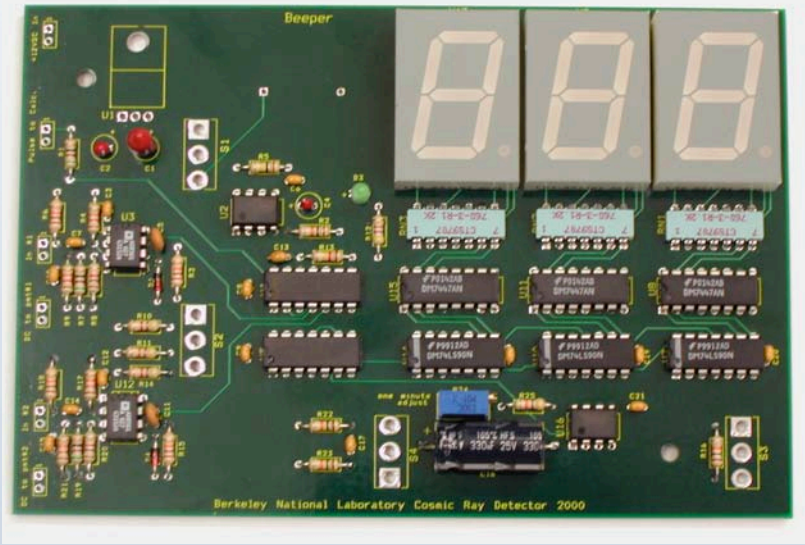


How it Works


Phototube / Scintillator
Phototube / Scintillator
Coincidence
Beeper
Visual Display
Computer Interface

How to Build

- Full instructions manuals on cosmic.lbl.gov
- Need
  - Two pair of scintillators
    - Can buy precut
  - Two photomultipliers
    - Prefer commercial with phototube base
  - Assemble Circuit Board
  - Build Structure
    - Most people use their own design
  - Assemble

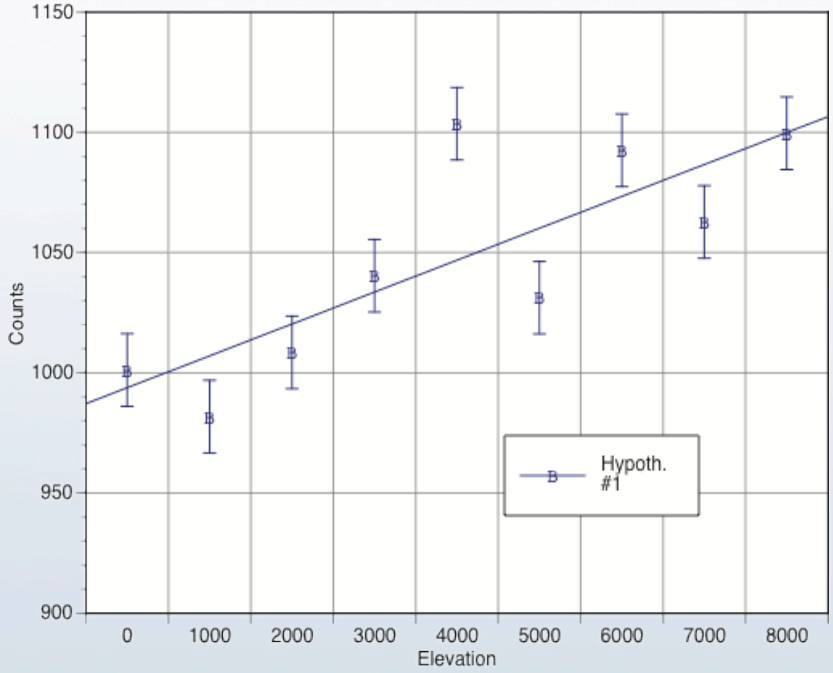


Measurements

- Cosmic Rays
  - Flux and direction of cosmic ray
  - Rough energy analysis (use absorbers)
  - Elevation studies
  - Measure attenuation of cosmic rays in a building
- Singles Mode
  - Measure radioactivity
- Mathematics
  - Measurement of a random phenomena
  - Describe statistical significance of a measurement
- How to take data efficiently

Use to teach how much data to take

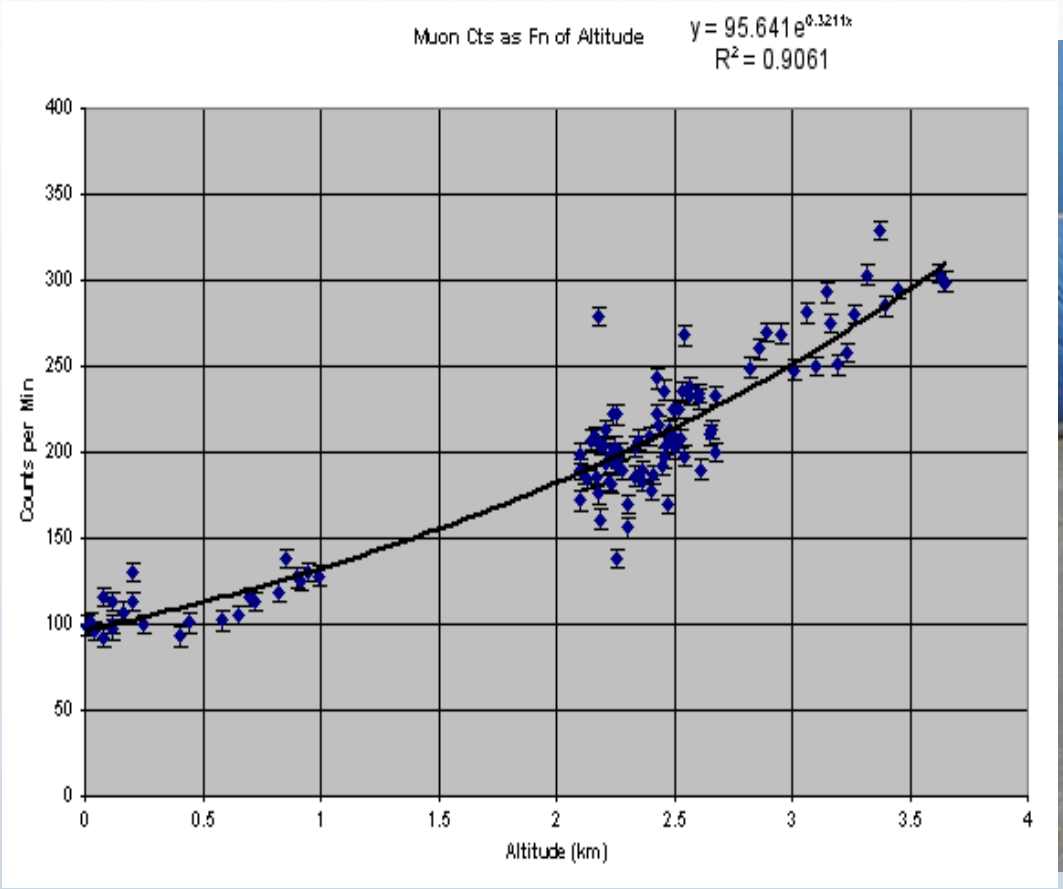
- First must estimate the effect
- Decide dynamic range of measurement
- Determine how long to count
- How many data points



Cosmic Connection Movie

- Shows how to use the detector
- Available from website or
  - http://tinyurl.com/CosmicConnectionMovie
- Talks about Cosmic Rays
- Shows that cosmic rays can be seen underground, at sea level and on a mountain
- Talks about radiation

Measure rate on earth and air



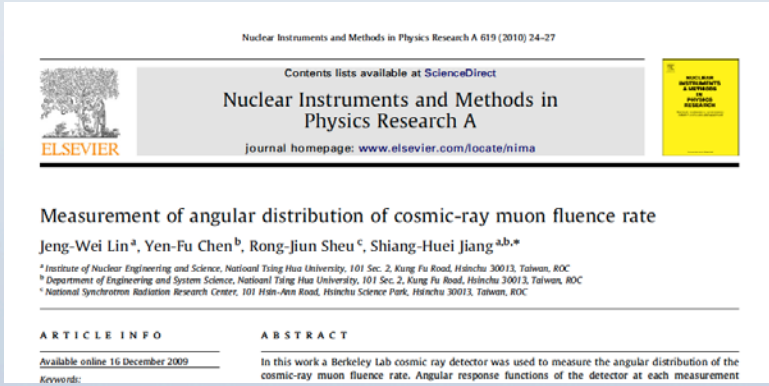
Computer Interface

- Using LabQuest mini
- Can handle two different detectors
- USB interface for PCs or Macs
- Has a GPS module for elevations studies
- Also can measure barometric pressure and/or temperature

Uses

- Science Fair
- Senior Project
- Board Uses
  - Portable Neutron Detector
  - Balloon Flights
  - Measured cosmic radiation on a train trip
- Museum Exhibits
- More than 100 detectors built

Greg Poe who flew this in an airplane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Measurement of angular distribution of cosmic-ray muon fluence rate

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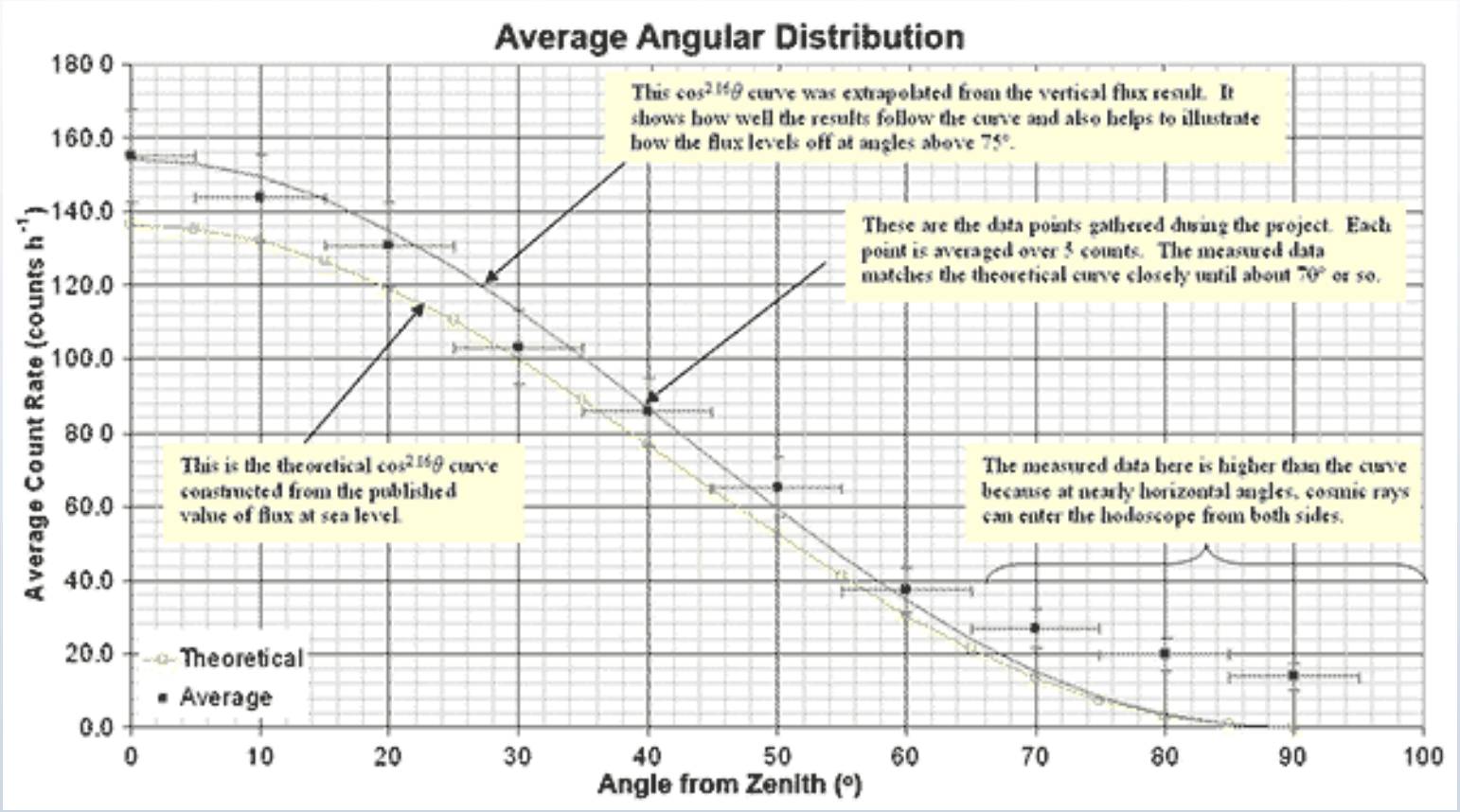
ABSTRACT

In this work a Berkeley Lab cosmic ray detector was used to measure the angular distribution of the cosmic-ray muon fluence rate. Angular response functions of the detector at each measurement

Angular Measurement made by Holly Batchelor (a fifth-year pupil from Edinburgh)



F. Barradas-Solas (Spain) +3 high school teachers

Figure 4. *Muon chambers for CMS being tested with cosmic rays at CIEMAT. On the lower part you can see two scintillation detectors used as part of the trigger system.*

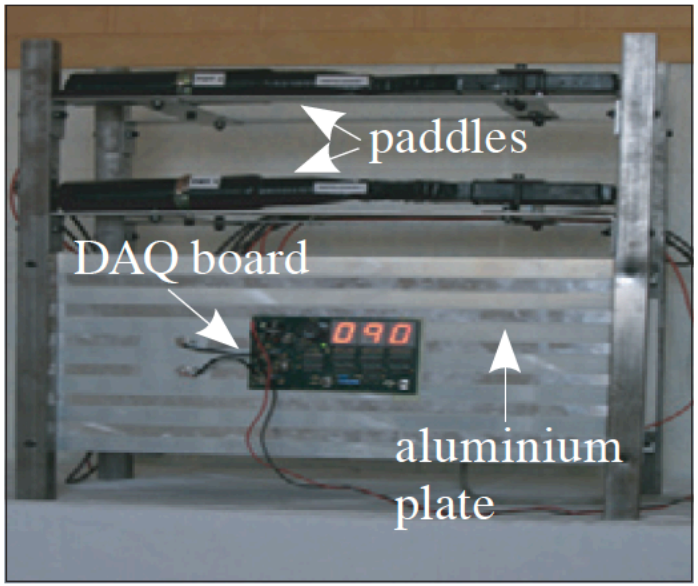
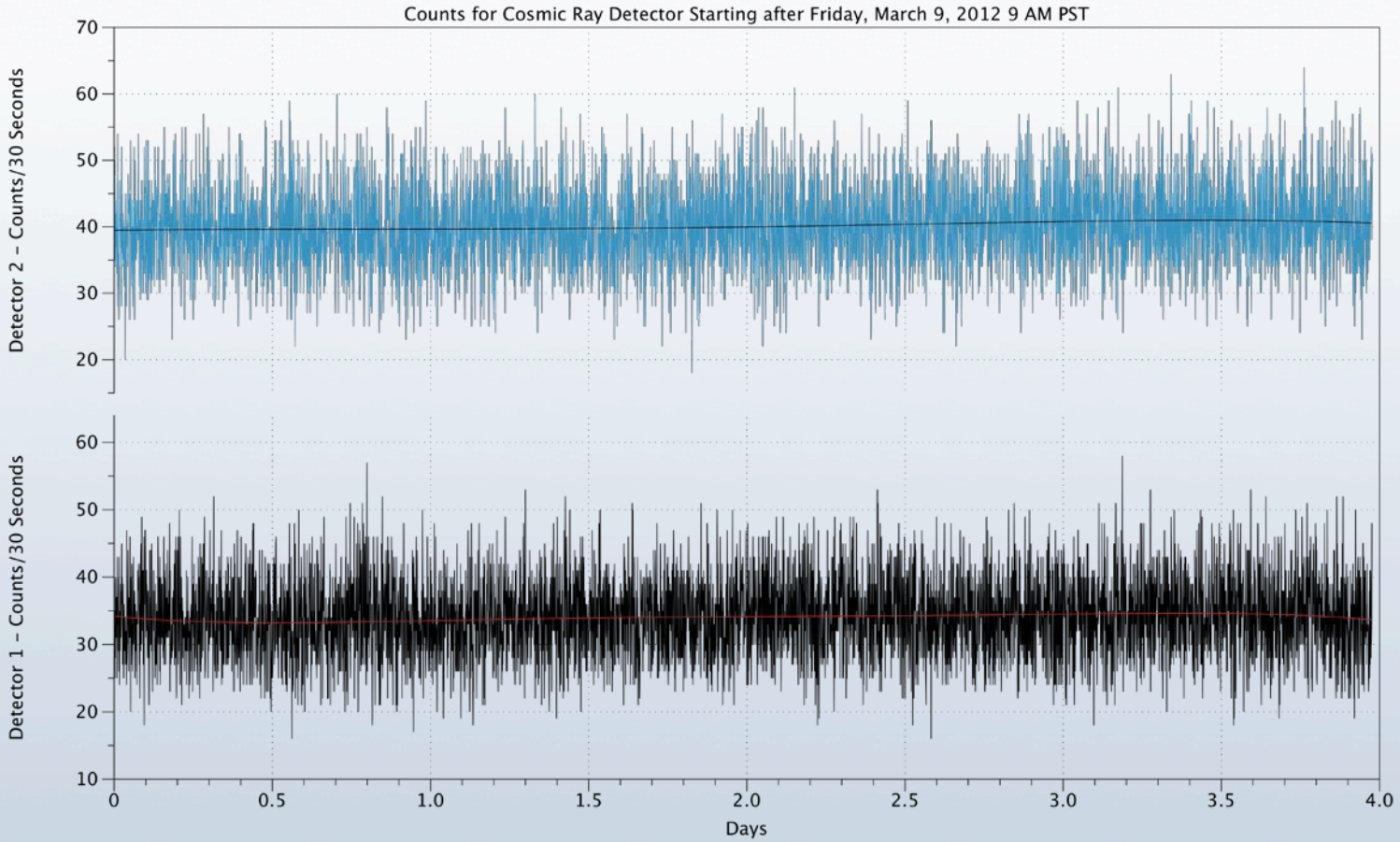


Figure 5. *Frontal view of the detector.*

March 9 – Solar Flare



Summary

- This detector can be easily built with full instructions
- Used widely – used in all of the continents of the world
  - Even went to the South Pole
- Excellent teaching tool – cosmic.lbl.gov
- Portable
- Excellent tool that students can do particle physics in the classroom
  - An adventure in serious science

Meet