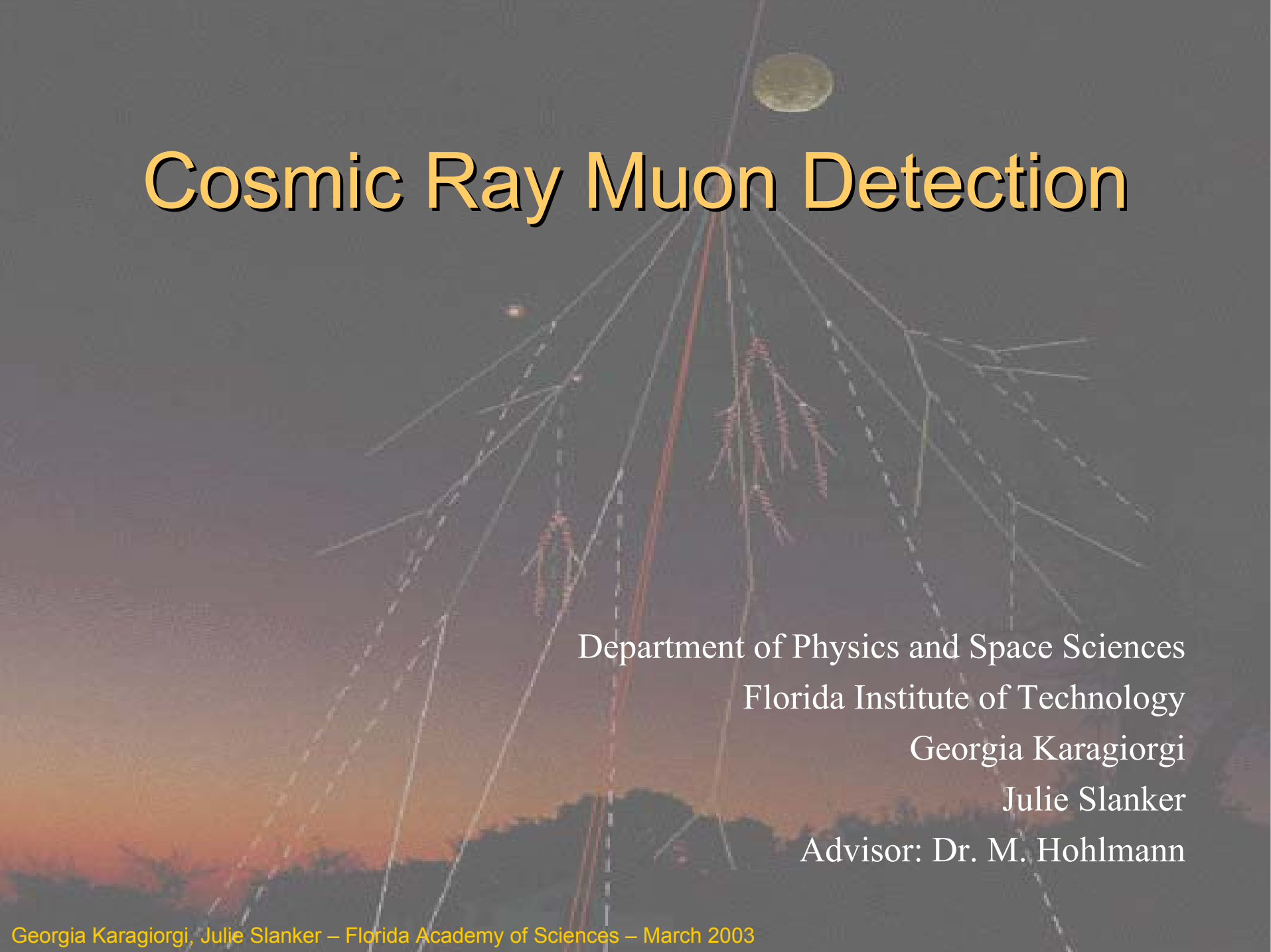
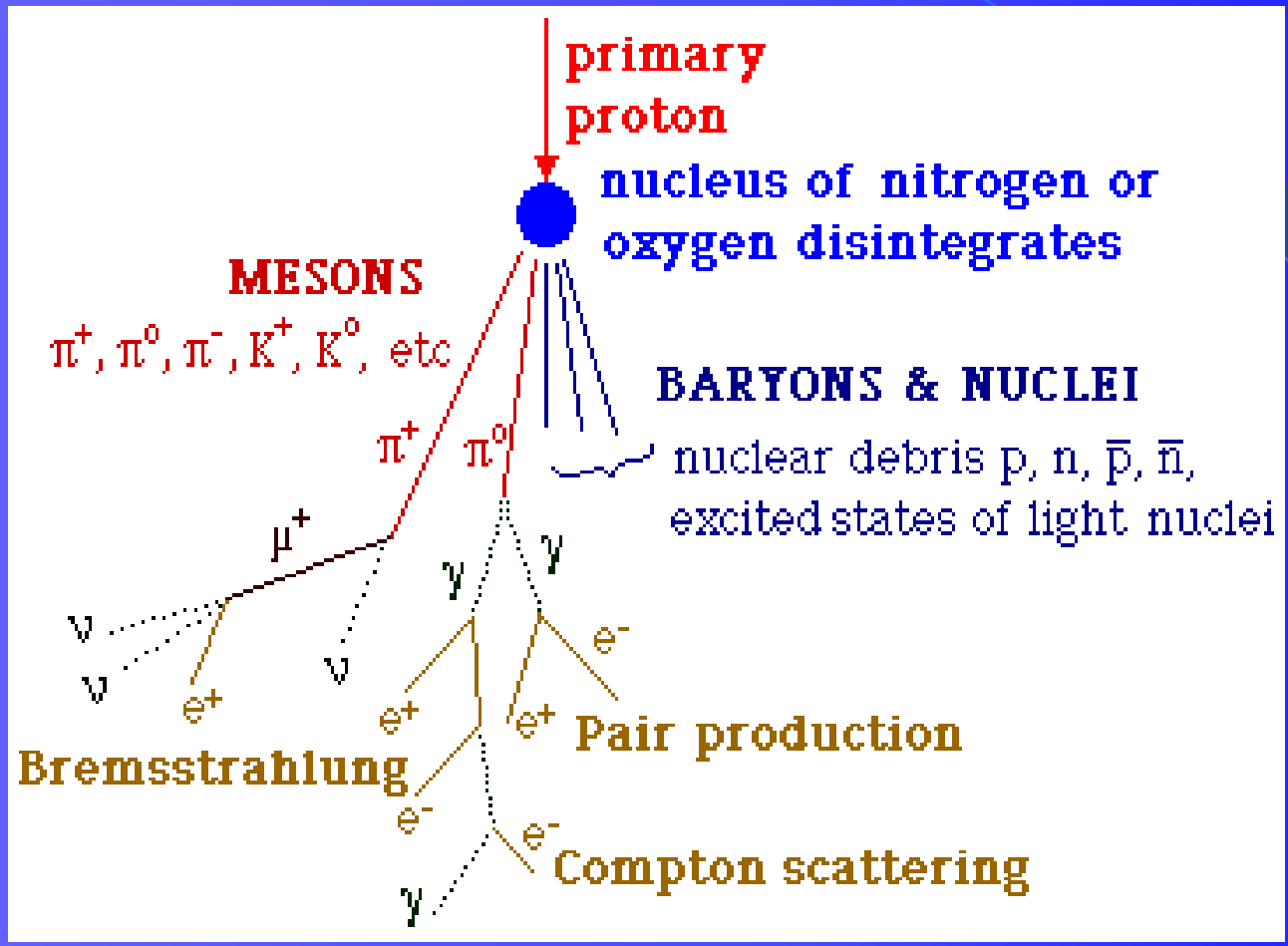


Cosmic Ray Muon Detection

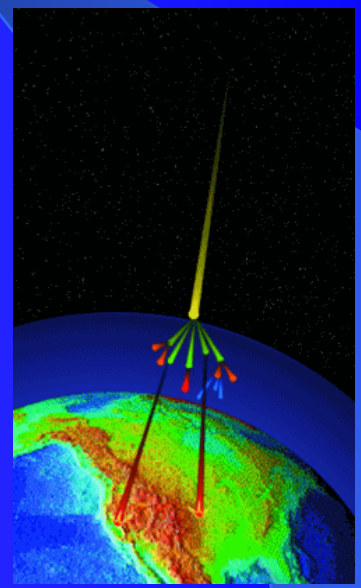
Department of Physics and Space Sciences
Florida Institute of Technology
Georgia Karagiorgi
Julie Slanker
Advisor: Dr. M. Hohlmann

Cosmic Ray Muons



$\pi^+ \rightarrow \mu^+ + \nu_\mu$

$\pi^- \rightarrow \mu^- + \bar{\nu}_\mu$



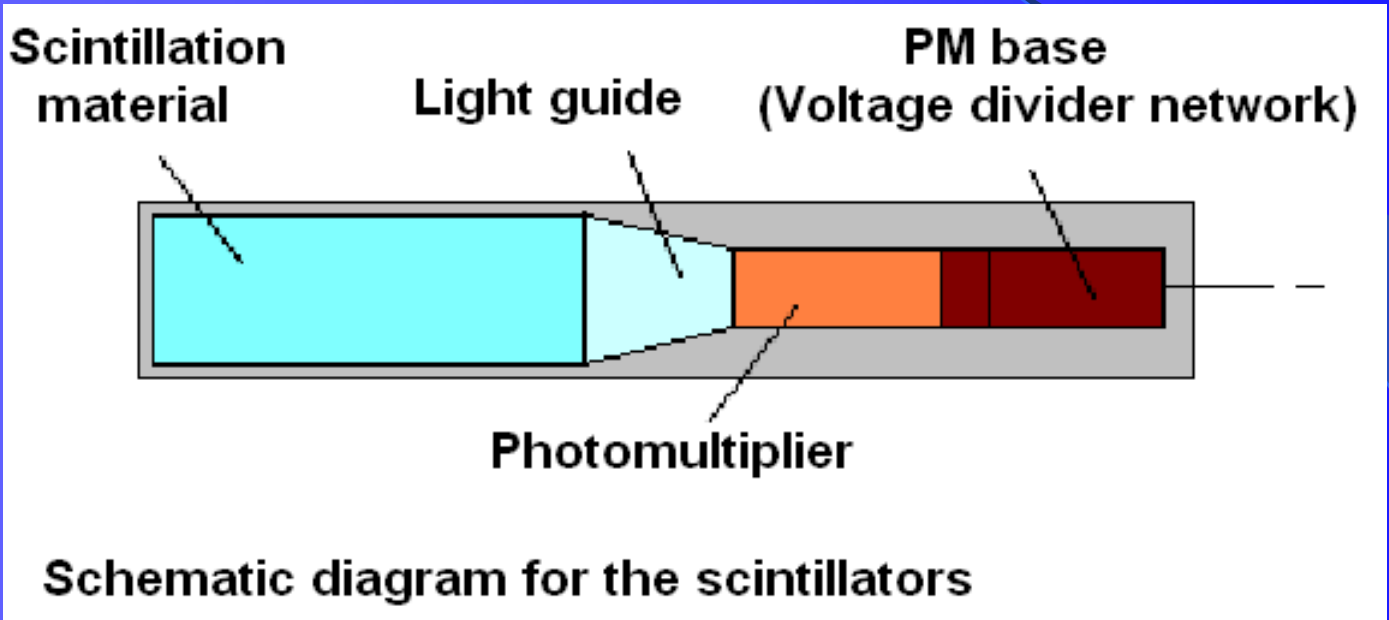
Main goals

- Set up equipment
- Flux measurement
- Investigate count rate/flux variation with
  - Overlap area
  - Orientation angle with respect to the horizon

Equipment

- 2 scintillation detectors developed at Fermilab
- 2 PMT tubes
- amplifiers, discriminators, fast coincidence unit, counter

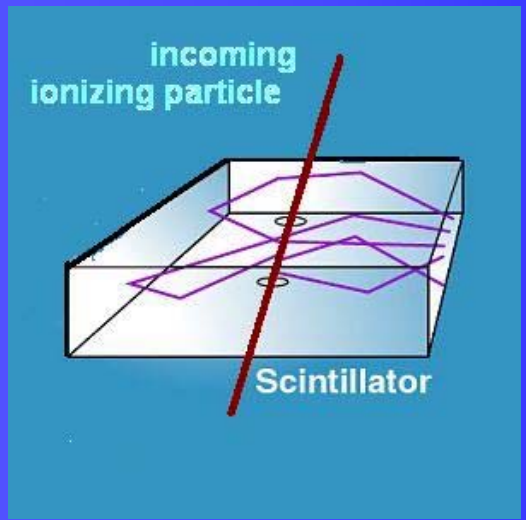
Scintillation Detectors

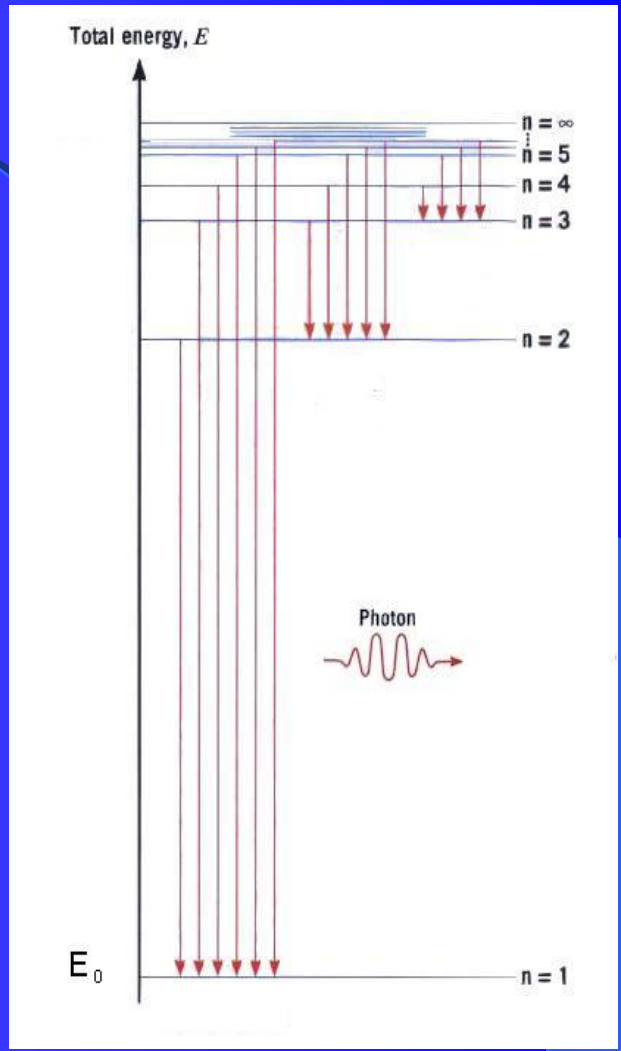


Schematic diagram for the scintillators

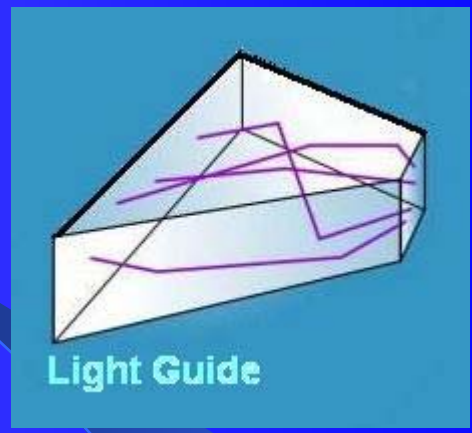
A scintillation detector has the property to emit a small flash of light (i.e. a scintillation) when it is struck by ionizing radiation.

When a particle passes through the scintillation material it collides with atomic electrons, exciting them to higher energy levels. After a very short period of time the electrons fall back to their natural levels, causing emission of light.



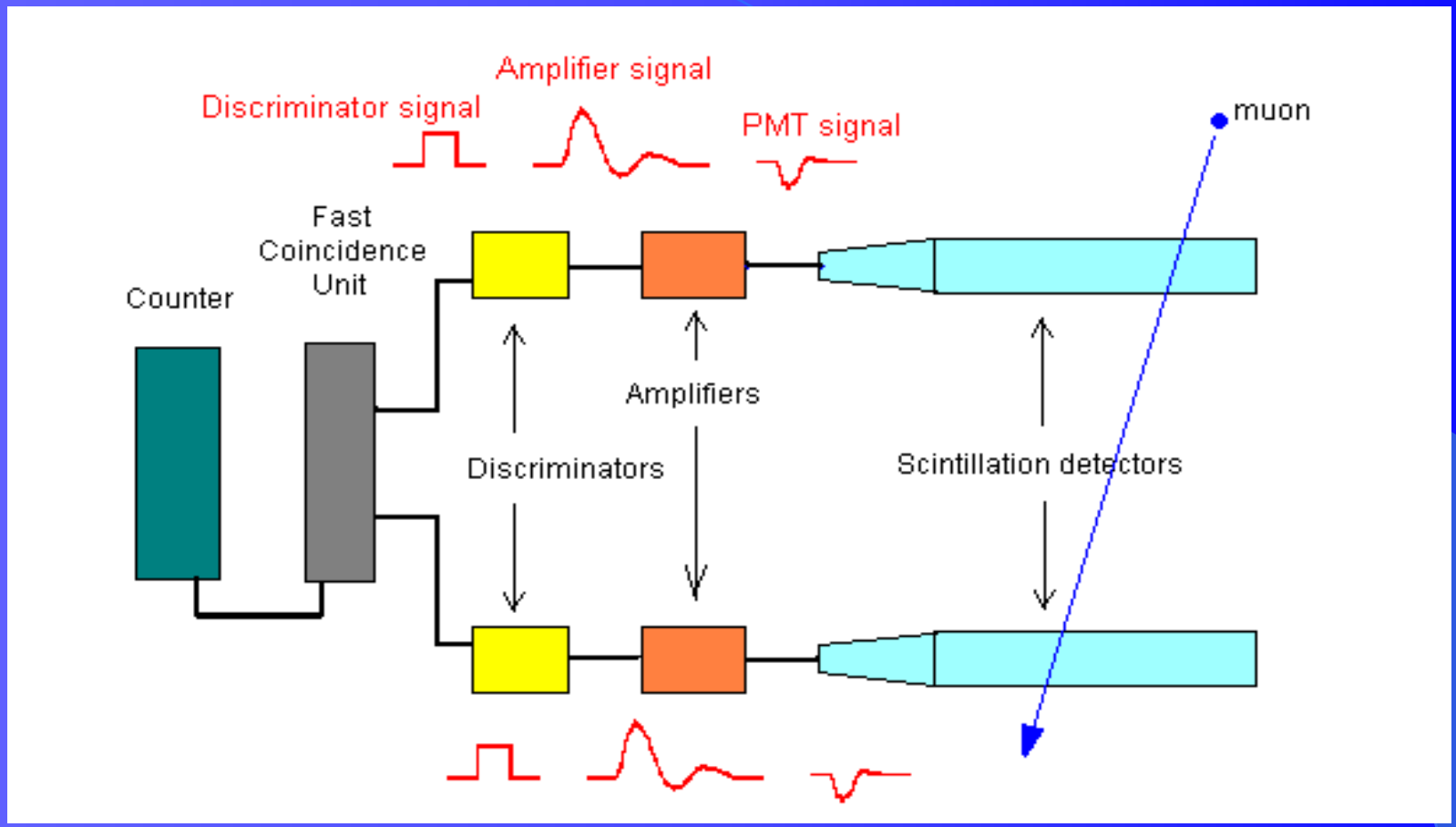


The scintillator is optically coupled to a photomultiplier through a light guide



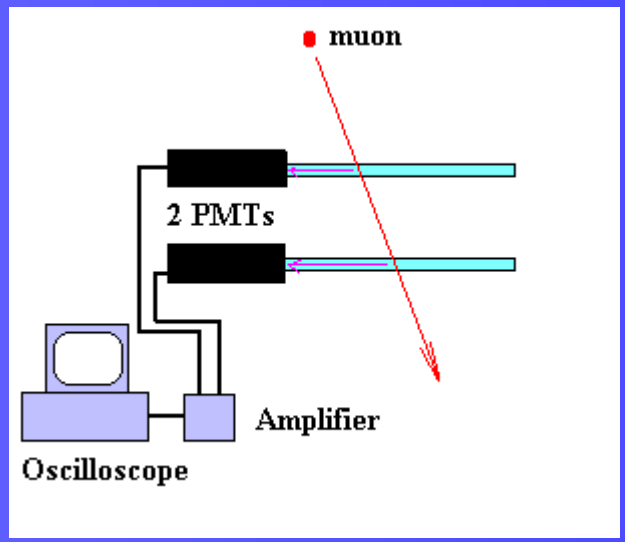
The photomultiplier converts the received light to a current of photoelectrons and sends it to an electronic system to be analyzed

Setup



The equipment is set so that the counter is counting "coincidences", i.e. signals received from both discriminators at the same time

We recognize a coincidence when the two signals are received by the fast coincidence unit within 100ns



This technique

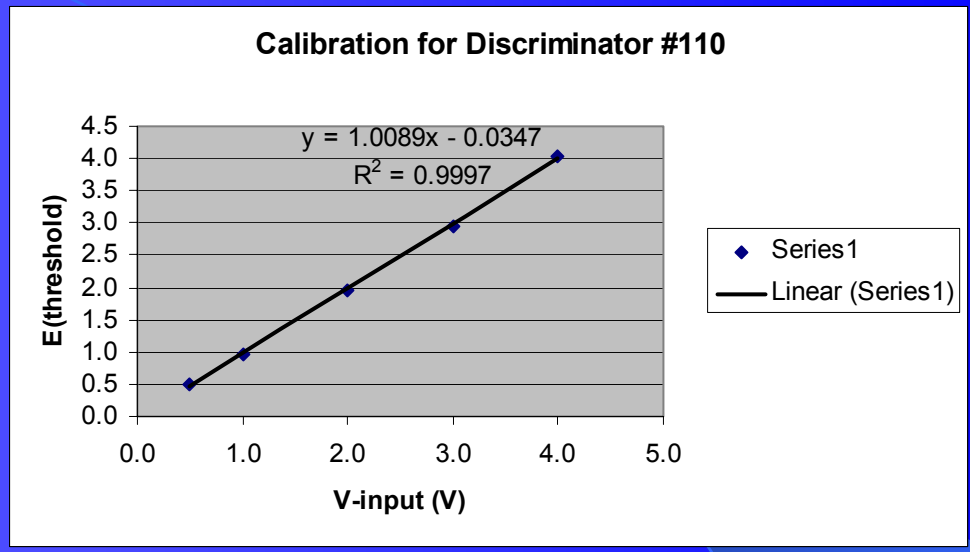
- results in **elimination of background noise** (from the PMT's, amplifiers, etc)
- offers a great number of possible experiments

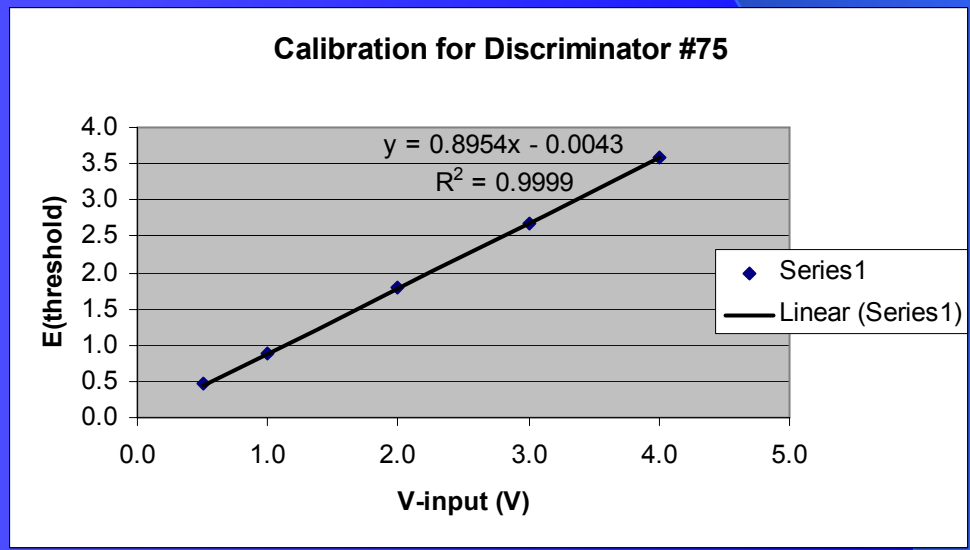
I. Setting up equipment

- Calibration of the discriminators

Method:

Used a signal generator, and looked at discriminator output signal on the oscilloscope





I. Setting up equipment

- Plateau Measurements for PMT's

(Procedure for finding *working voltage*)

Example of a plateau curve:

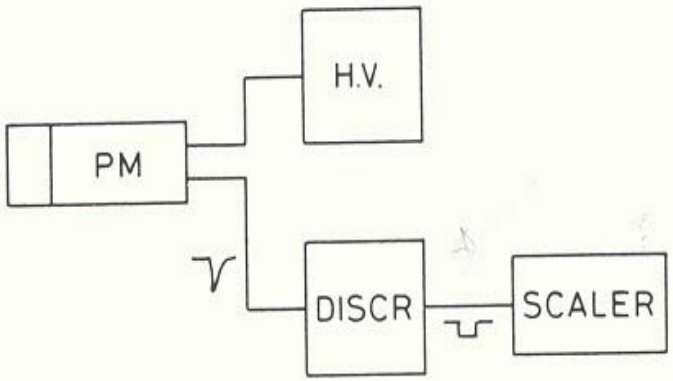


Fig. 9.17. Set-up for counter plateau measurement

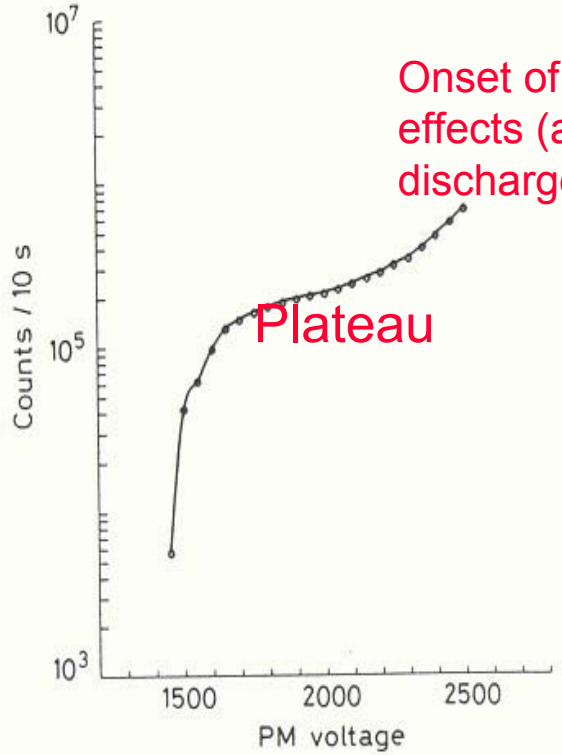
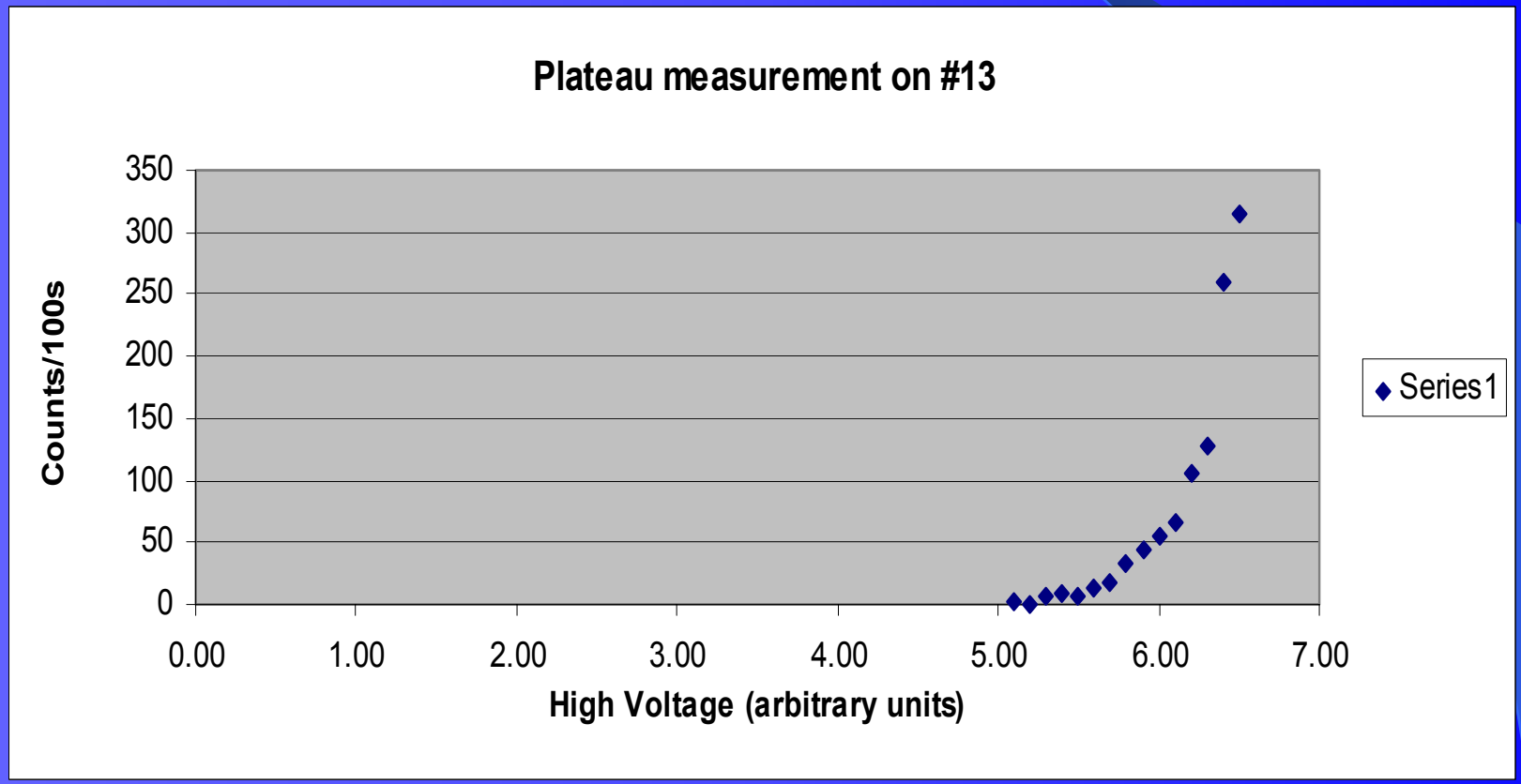


Fig. 9.18. Measured plateau curve for plastic scintillator detector shown in Fig. 9.16 using a ^{207}Bi source ►

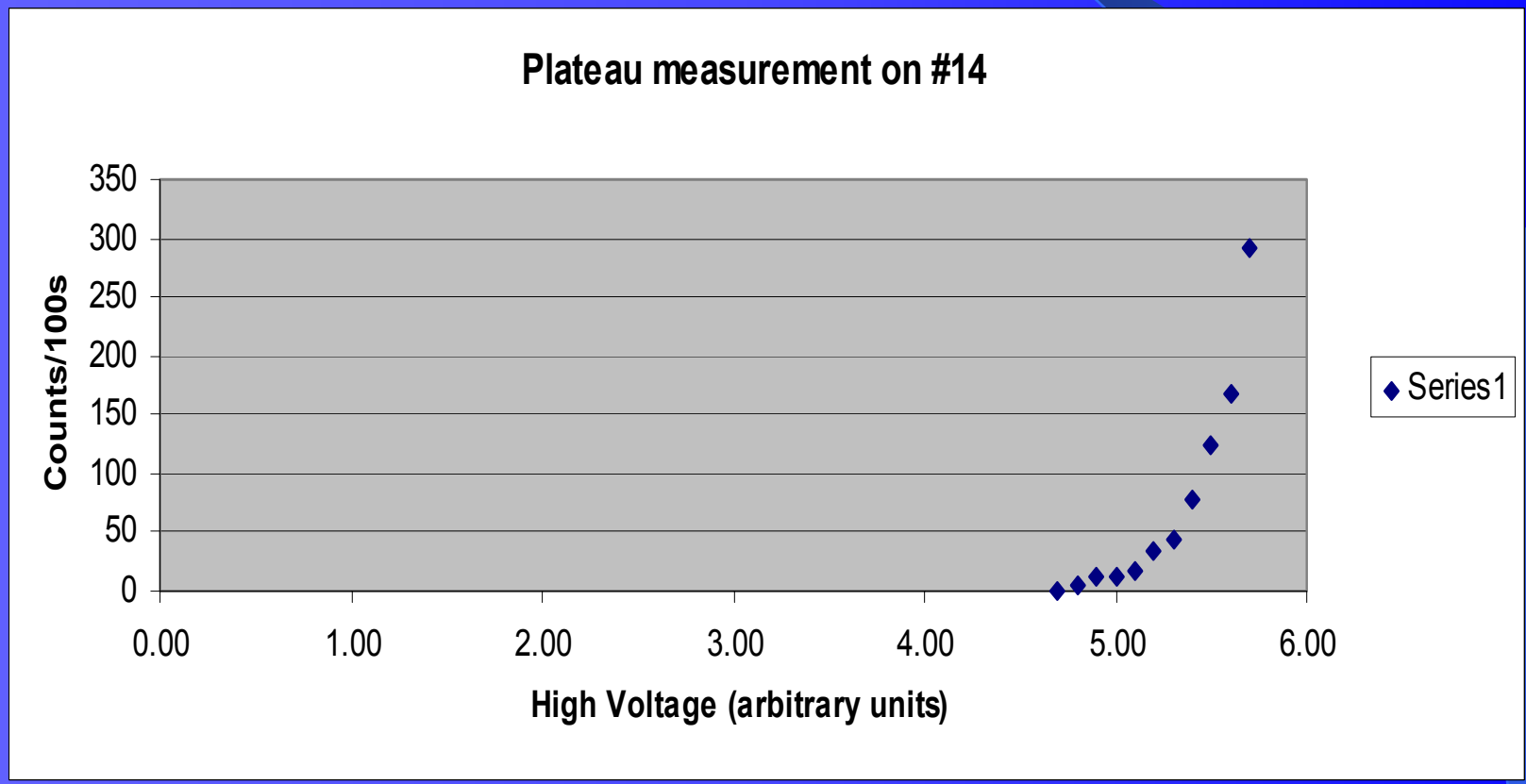
Plateau Measurements

Plan A… (without noise discrimination)



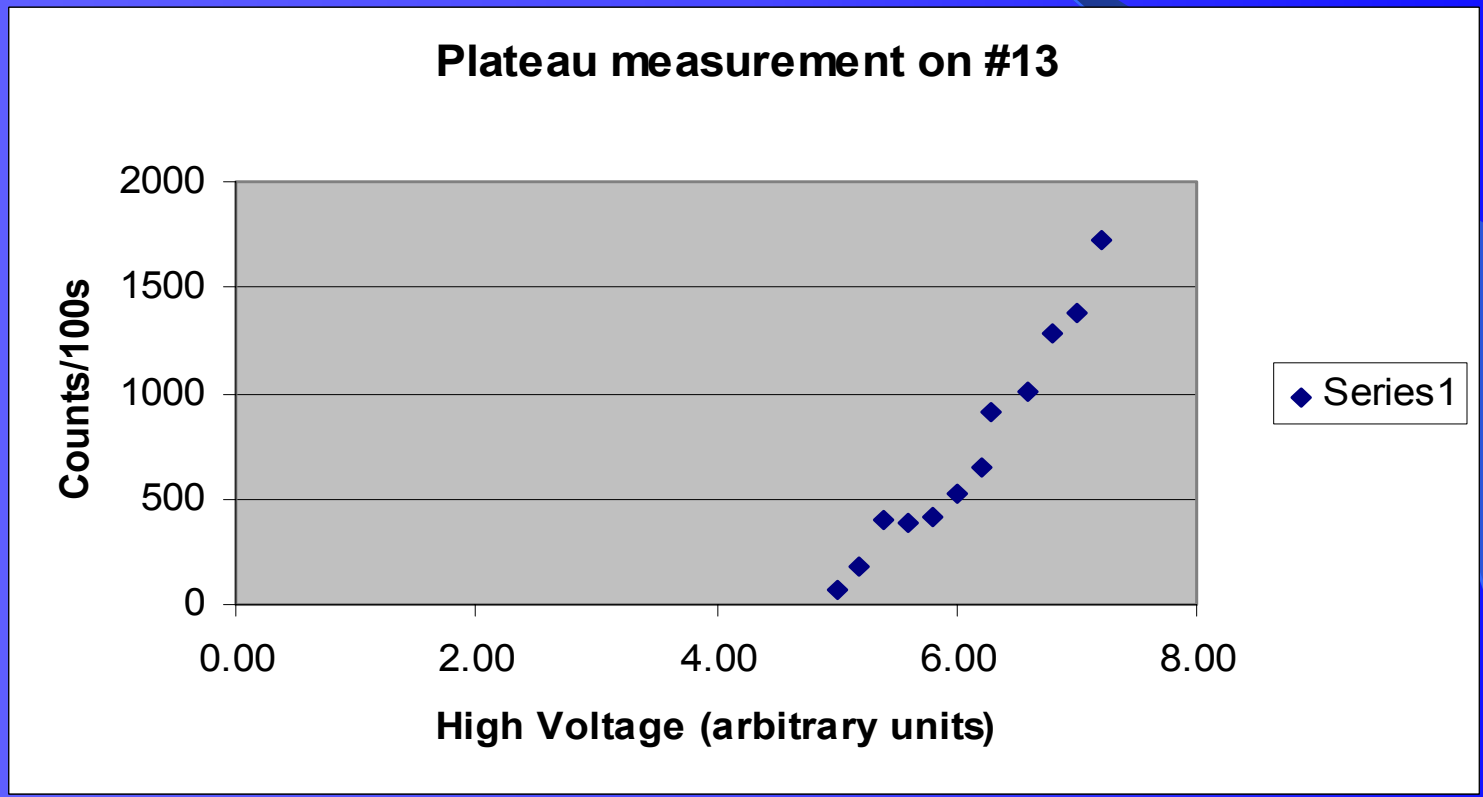
Plateau Measurements

Plan A… (without noise discrimination)



Plateau measurements

Plan B… (using partial noise discrimination, and operating at higher amplification)

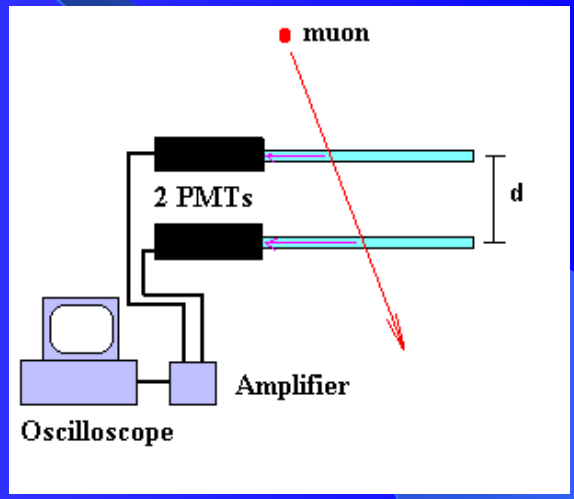


…On progress for #14

II. Flux

Muons reach the surface of the Earth with typically constant flux Fμ.

$$F\mu = \frac{(\text{count rate})d^2}{(\text{area of top panel})(\text{area of bottom panel})}$$



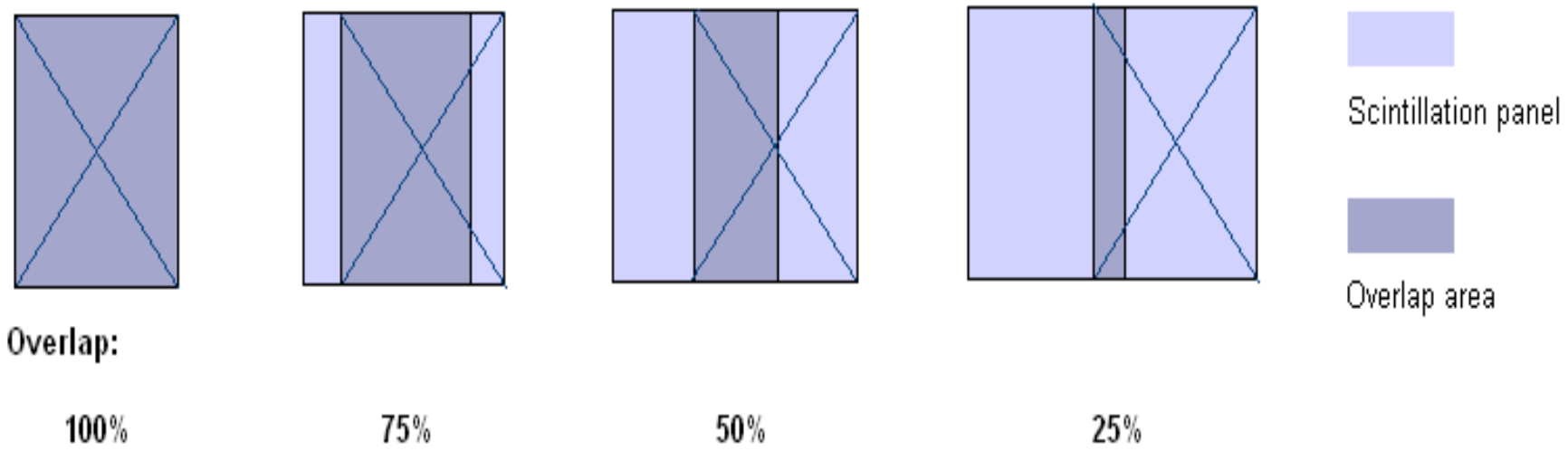
$F\mu = 70 m^{-2} s^{-1} sr^{-1}$ $(\sim 1 cm^{-2} min^{-1})$ (independent of detector)

Goal: verify this value

III. Investigation of count rate variation

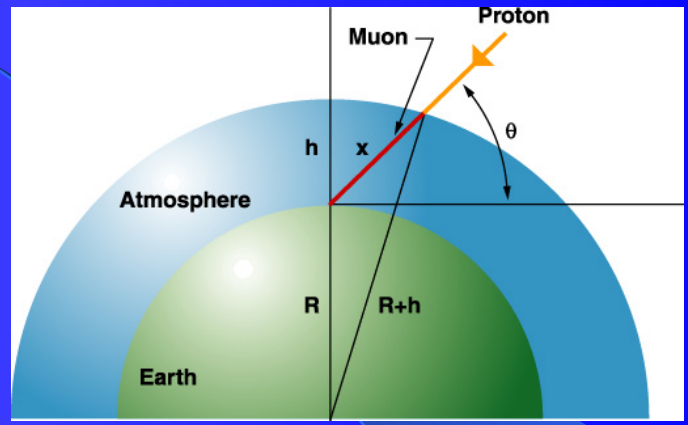
With overlap area

(Currently in the process of taking data)

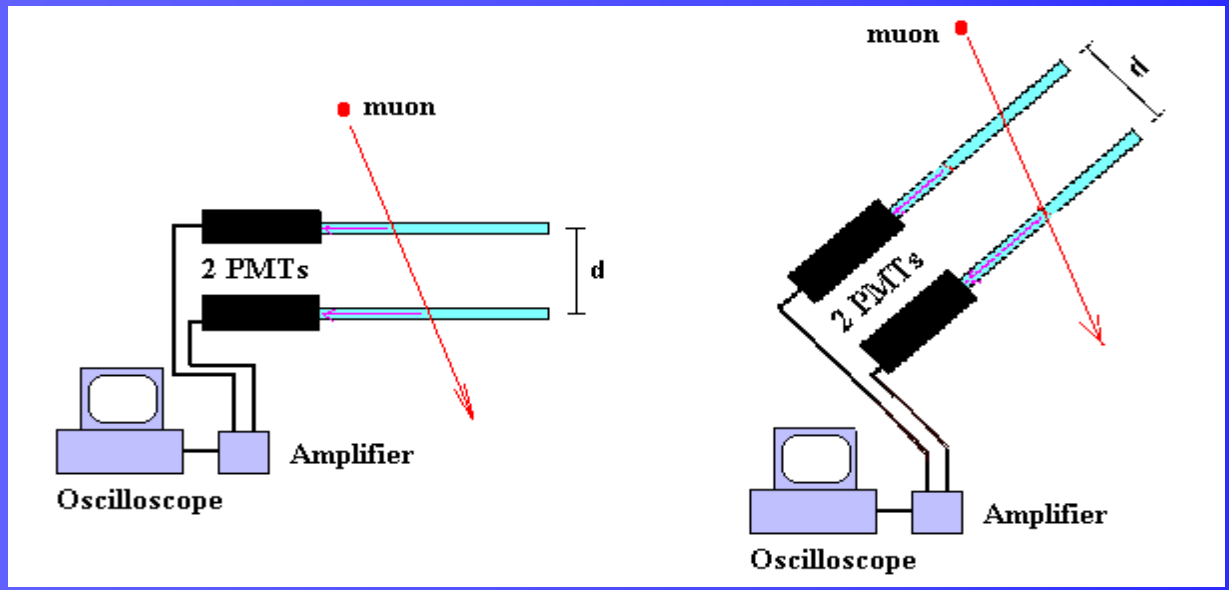


Investigation of flux variation

With angle θ with respect to the horizon



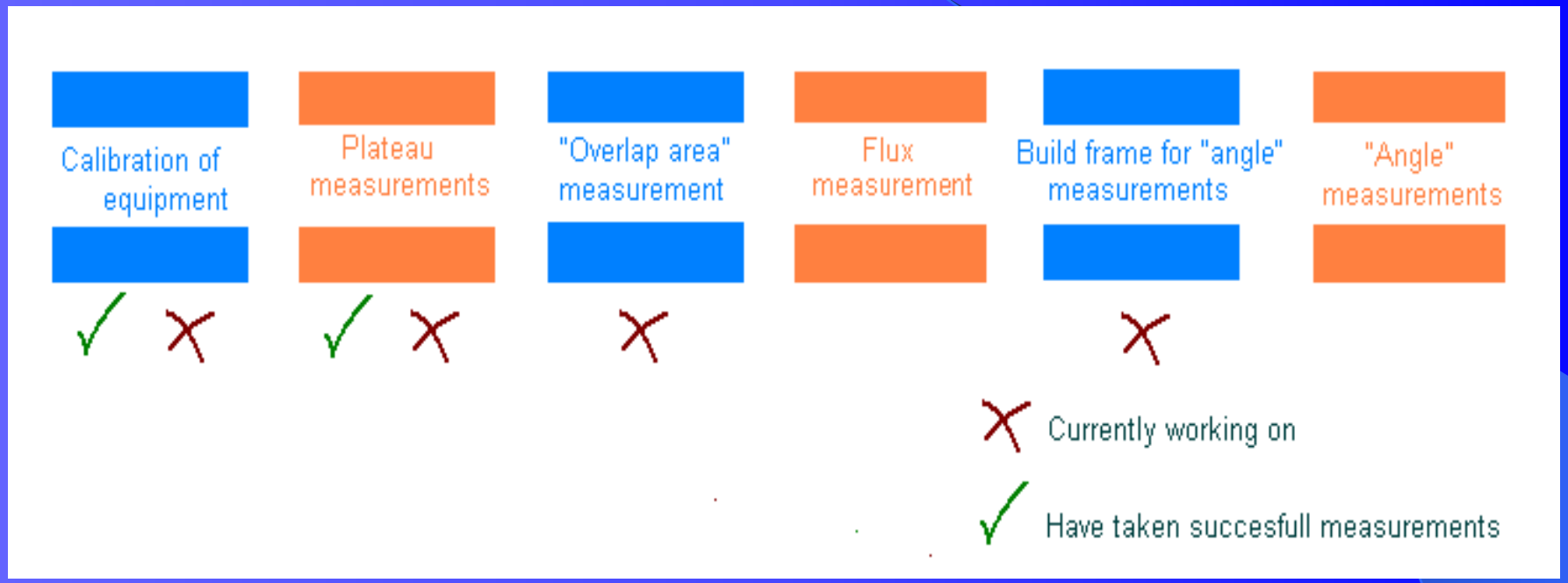
$$F_\mu \sim \cos^2 \theta$$



Problems we are facing

- We are dealing with old equipment
- We need to calibrate many pieces of our equipment
- We need to re-mask detectors on a frequent basis in order to avoid light leaks

Status


Calibration of equipment
Plateau measurements
"Overlap area" measurement
Flux measurement
Build frame for "angle" measurements
"Angle" measurements
Currently working on
Have taken succesfull measurements

References

- http://pdg.lbl.gov/2002/cosmicrayrpp.pdf
- http://www2.slac.stanford.edu/vvc/cosmicrays/crdetour.html
- http://hermes.physics.adelaide.edu.au/astrophysics/muon/