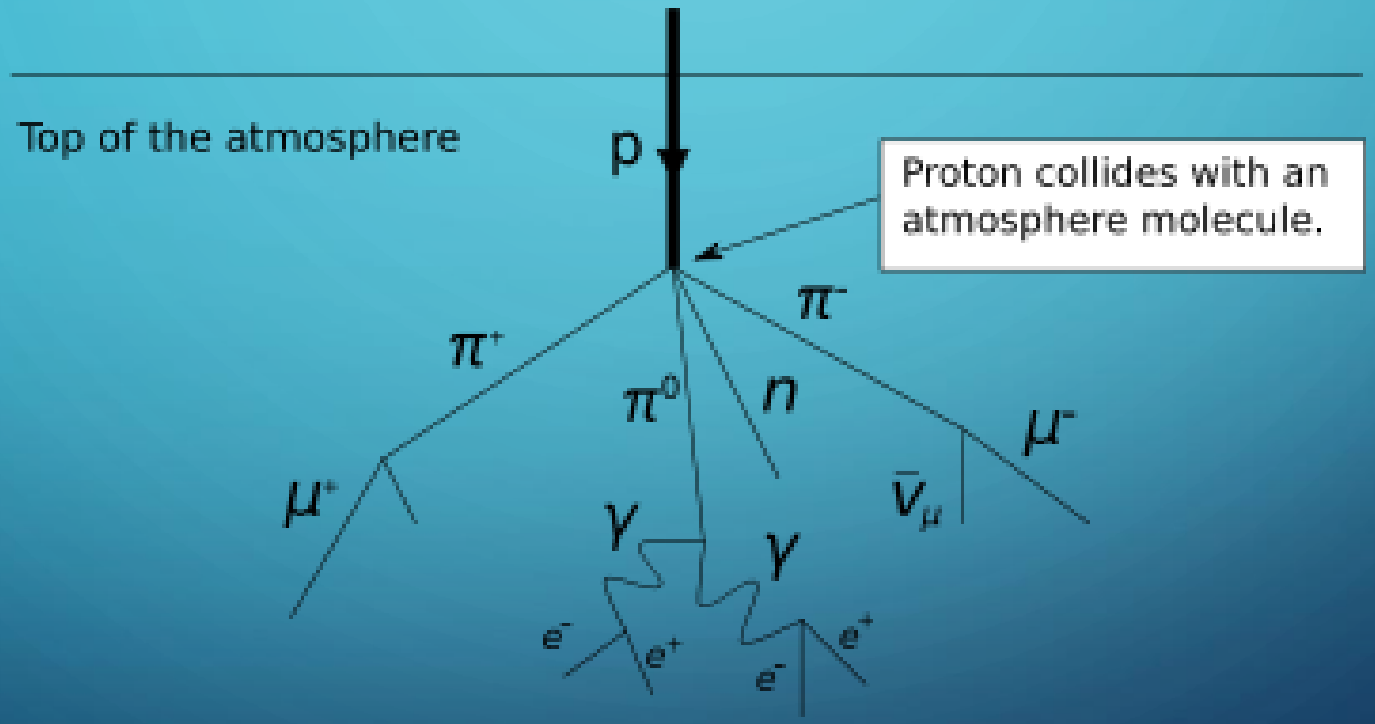
COSMIC RAYS AND PHOTOMULTIPLIER TUBE TESTING

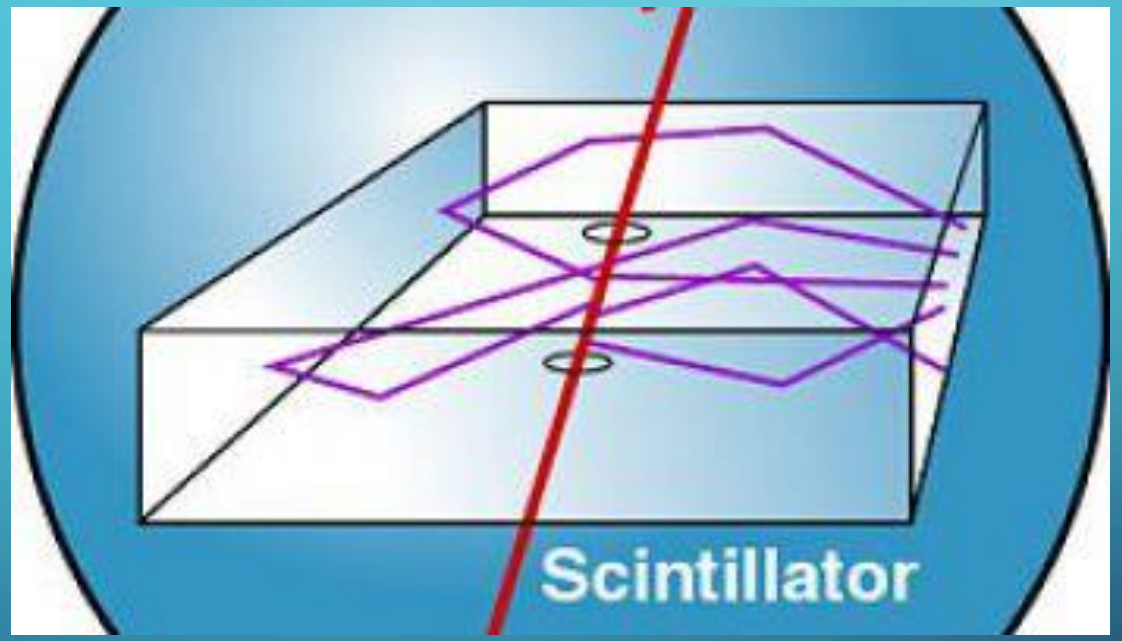
GARRETT STODDARD

MENTOR: RAUL ARMENDARIZ

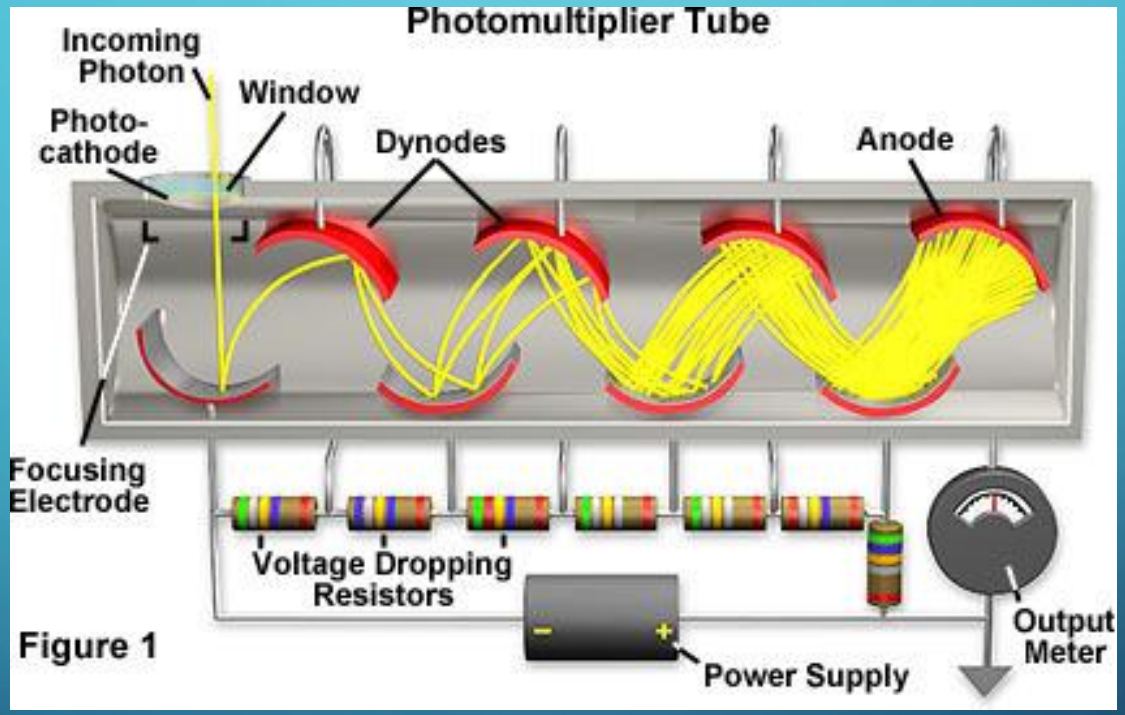
WHAT ARE COSMIC RAYS



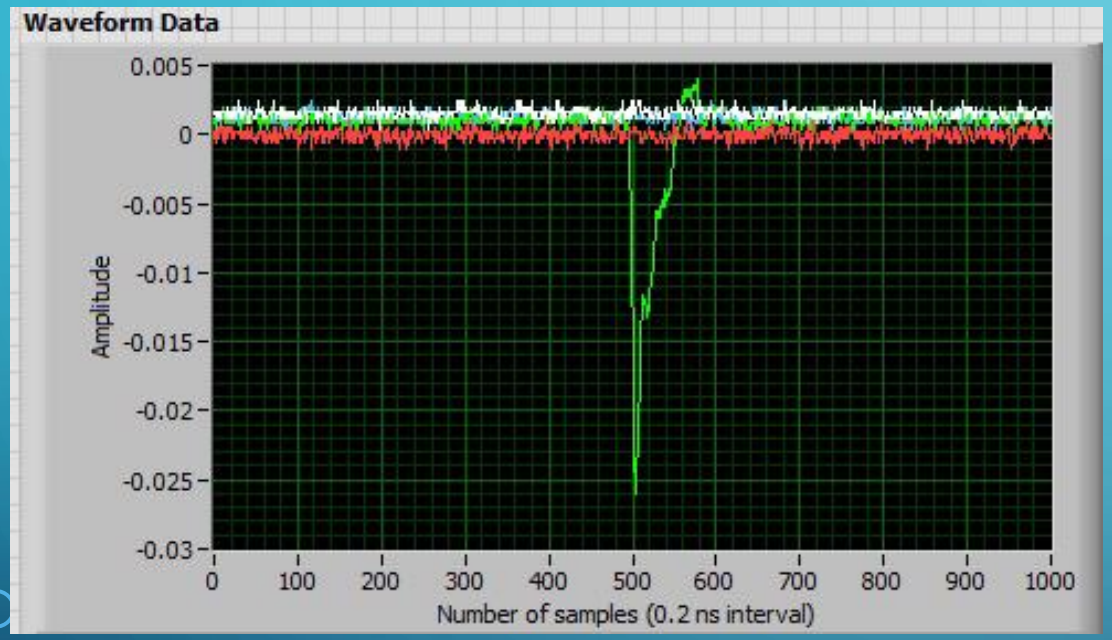
HOW DO WE DETECT THEM



PHOTOMULTIPLIER TUBES



SINGLE PHOTON DETECTION



$$V_{\text{peak}} = IR = \frac{\Sigma \Delta Q_i}{\Delta t} R = \frac{R}{\Delta t} \Sigma (N_{pe} ge) = R \frac{ge}{\Delta t};$$

$$V_{\text{peak}} = \frac{ge}{\Delta t} R = \frac{(2.5x10^{6})(1.6x10^{-19}\text{C})}{10x10^{-9}\text{s}} 50\Omega = .002 \textbf{ Volts}$$

N_γ = Number of photons incident on photocathode

N_{pe} = Number of photoelectrons emitted by photocathode

N_e = Number of electrons emitted by anode

$g = N_e/N_{pe}$ = Gain of PMT

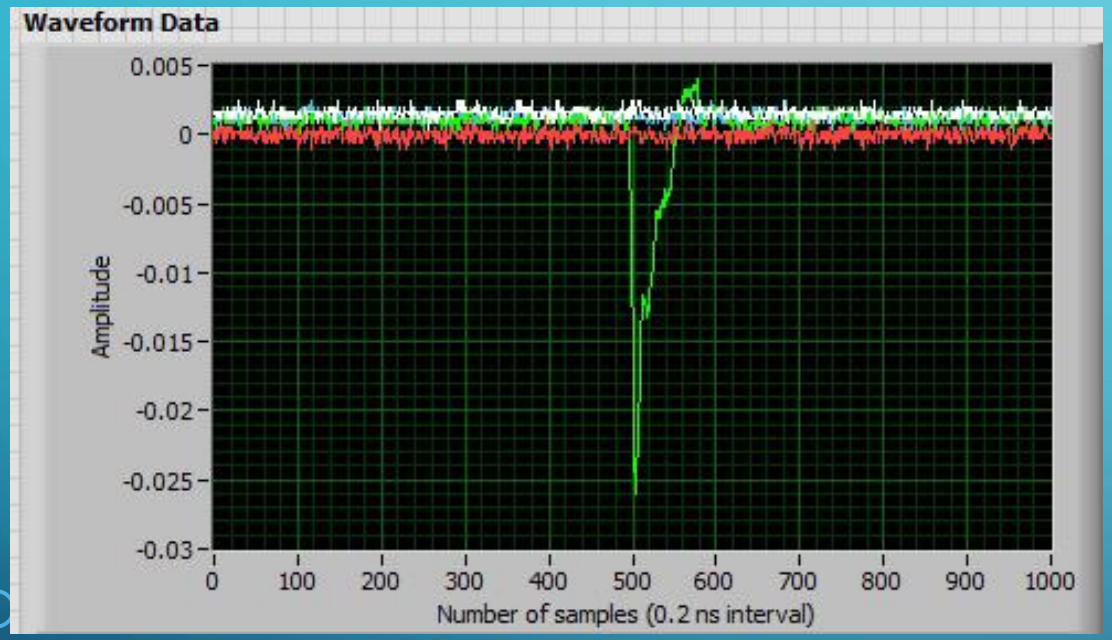
$e = 1.6x10^{-19}$C Electron charge

$Q = N_e e$ Charge emitted by anode

$I = \frac{\Delta Q}{\Delta t}$ Photocurrent emitted by anode

I_D Dark Current emitted by anode

SINGLE PHOTON DETECTION



$$V_i = IR = \frac{\Delta Q_i}{\Delta t} R,$$
$$\Delta Q_i = \frac{1}{R} V_i \Delta t,$$
$$Q_{\text{Total}} = \Sigma \Delta Q_i = \frac{\Delta t}{R} \Sigma V_i;$$

N_γ = Number of photons incident on photocathode

N_{pe} = Number of photoelectrons emitted by photocathode

N_e = Number of electrons emitted by anode

$g = N_e/N_{pe}$ = Gain of PMT

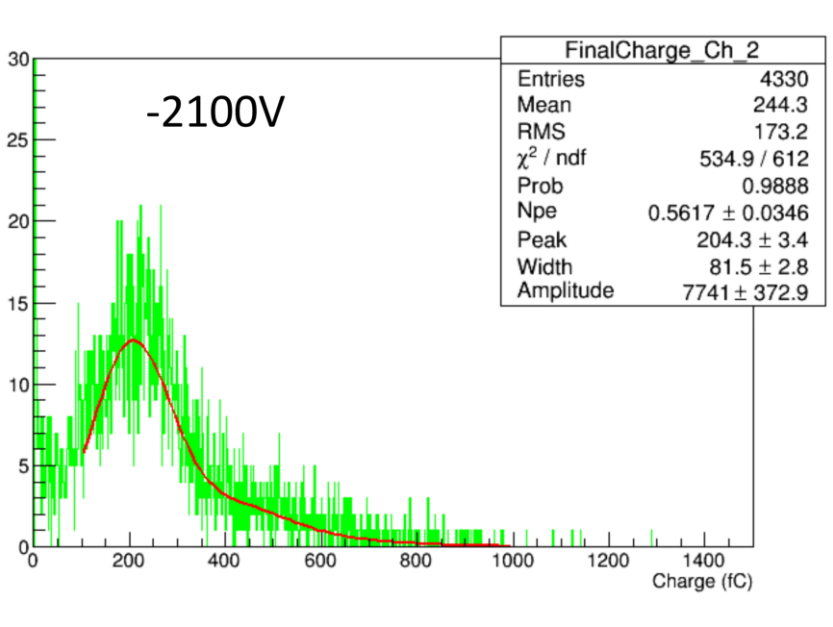
$e = 1.6 \times 10^{-19} C$ Electron charge

$Q = N_e e$ Charge emitted by anode

$I = \frac{\Delta Q}{\Delta t}$ Photocurrent emitted by anode

I_D Dark Current emitted by anode

SINGLE PHOTON DETECTION



$$V_i = IR = \frac{\Delta Q_i}{\Delta t} R,$$

$$\Delta Q_i = \frac{1}{R} V_i \Delta t,$$

$$Q_{\text{Total}} = \Sigma \Delta Q_i = \frac{\Delta t}{R} \Sigma V_i;$$

Table Legend (Applies to the Fit Curve)

Entries – # of Waveforms

Mean – Average Charge of all Waveforms

RMS – Root mean Squared

X^2/ndf –

Prob – ?

Npe – ?

Peak – Charge value at the peak of the fit

Width – ?

Amplitude – ?

N_γ = Number of photons incident on photocathode

N_{pe} = Number of photoelectrons emitted by photocathode

N_e = Number of electrons emitted by anode

$g = N_e/N_{pe}$ = Gain of PMT

$e = 1.6 \times 10^{-19} C$ Electron charge

$Q = N_e e$ Charge emitted by anode

$I = \frac{\Delta Q}{\Delta t}$ Photocurrent emitted by anode

I_D Dark Current emitted by anode

SINGLE PHOTON DETECTION

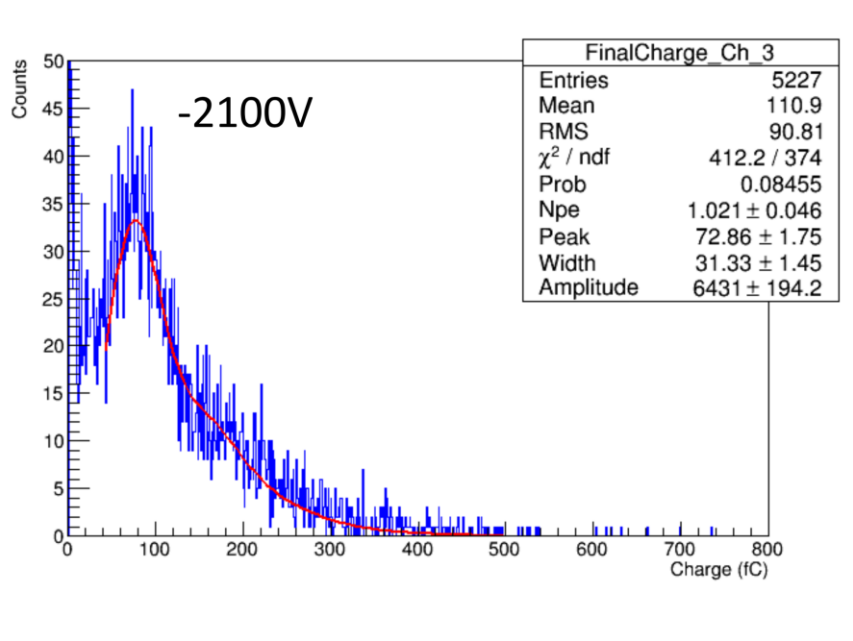


Table Legend (Applies to the Fit Curve)

Entries – # of Waveforms

Mean – Average Charge of all Waveforms

RMS – Root mean Squared

X^2/ndf –

Prob – ?

Npe – ?

Peak – Charge value at the peak of the fit

Width – ?

Amplitude – ?

N_γ = Number of photons incident on photocathode

N_{pe} = Number of photoelectrons emitted by photocathode

N_e = Number of electrons emitted by anode

$g = N_e/N_{pe}$ = Gain of PMT

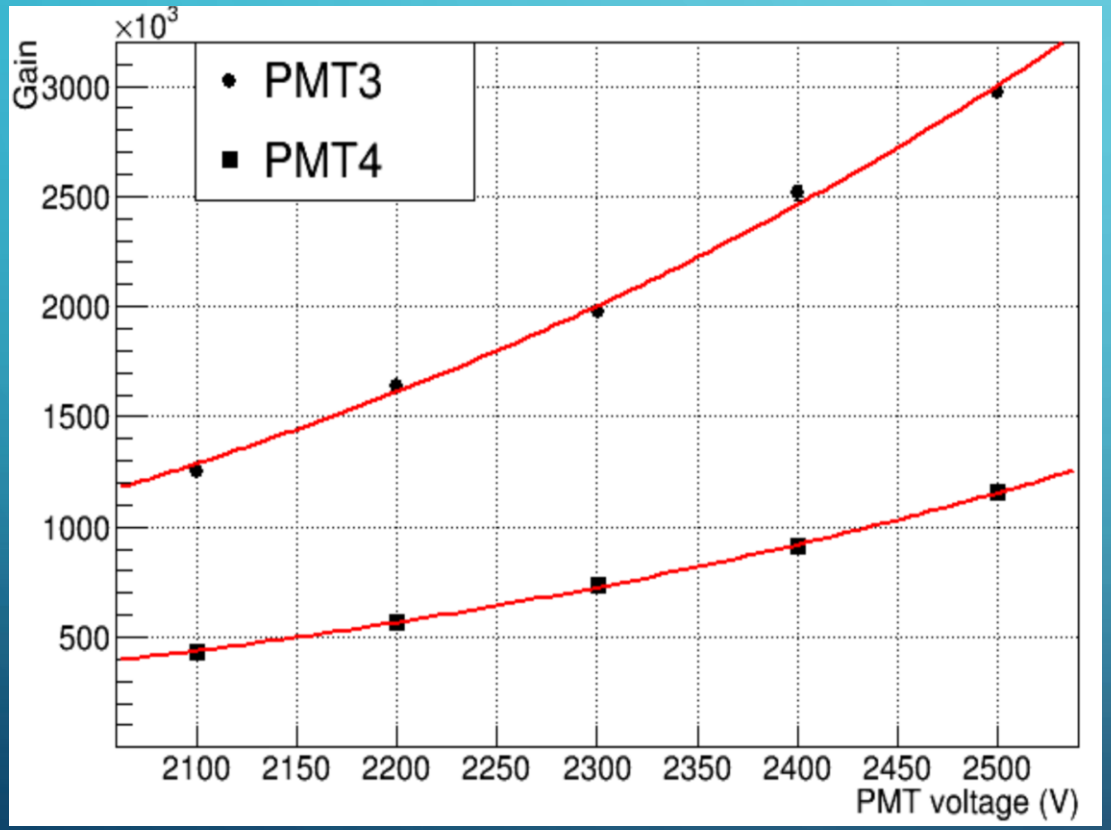
$e = 1.6x10^{-19}C$ Electron charge

$Q = N_e e$ Charge emitted by anode

$I = \frac{\Delta Q}{\Delta t}$ Photocurrent emitted by anode

I_D Dark Current emitted by anode

GAIN


×10^3
Gain
3000
2500
2000
1500
1000
500
PMT3
PMT4
2100
2150
2200
2250
2300
2350
2400
2450
2500
PMT voltage (V)

Text