Muon Experiment

Zewen Wu
Cooperator：Weizhen Wang
Data Supplyer：Shuo Wang

- Lifetime Measurement
- Time Dilation Effect Of Special Relativity

- Principle
- Measurement and Analysis
- Conclusion

Principle

15km N_0 (Production) $N(t) = N_0 * e^{-t/\tau}$

$$\begin{cases} H_1 & N_1 = N_0 * e^{-t_1/\tau} \\ & \xrightarrow{t=t_2-t_1} N_2 = N_1 * e^{-t/\tau} \\ H_2 & N_2 = N_0 * e^{-t_2/\tau} \end{cases}$$

Principle

Correction For Stopping Rate: correction factor 1.5 ± 0.2 —— R_0

H_1

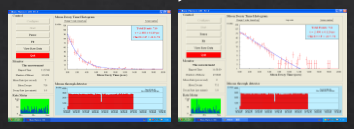
160MeV $\Longrightarrow \begin{cases} N_1 & N_1' \\ N_2' & N_2 \end{cases} \Longrightarrow \begin{cases} N_1' = R_0 * N_1 \\ N_2 = R_0^{-1} N_2' \end{cases}$

H_2

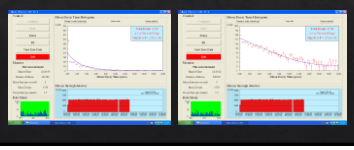
Measurement and Analysis

Taishan Mountain

H_1



H_2



Measurement and Analysis

Exponential Fitting $\Delta H = H_1 - H_2 = 1391m$

Height	Threshold/mV	Time/s	Muon Number	Muon Rate $/second^{-1}$	Decay Number	Decay Rate $/minute^{-1}$	τ /s
H_1	202	11:57:48	231454	7	710	1	2.488±0.119
H_2	200	22:26:59	340180	3	1739	1.3	2.766±0.073

160MeV $\Rightarrow \begin{cases} N_1 = 231454 \\ N_2' = 340180 \end{cases} \Rightarrow \begin{cases} N_1 = 231454 \\ N_2 = R_0^{-1} N_2' = 226786 \end{cases} Or \begin{cases} N_1' = R_0 * N_1 = 347181 \\ N_2' = 340180 \end{cases}$

Principle

15km N_0 **(Production)** $N(t) = N_0 * e^{-t/\tau}$

$$\begin{cases} H_1 & N_1 = N_0 * e^{-t_1/\tau} \\ H_2 & N_2 = N_0 * e^{-t_2/\tau} \end{cases} \xrightarrow{t=t_2-t_1} N_2 = N_1 * e^{-t/\tau}$$

Measurement and Analysis

$N_2 = N_1 * e^{-t/\tau}$ $\tau = 2.2\mu s$

$t = \Delta H / c \approx 2.1\tau$

$$\begin{cases} N_1 = 231454 \Rightarrow N_2 = N_1 * e^{-\frac{t}{\tau}} \approx 28343 \approx 0.1 * 226786 \\ N_2 = R_0^{-1} N_2' = 226786 \end{cases}$$

$$\begin{cases} N_1' = R_0 * N_1 = 347181 \Rightarrow N_2' = N_1' * e^{-\frac{t}{\tau}} \approx 42514 \approx 0.12 * 340180 \\ N_2' = 340180 \end{cases}$$

Measurement and Analysis

$N(t) = N_0 * e^{-t/\tau}$

Special Relativity $t = \frac{t'}{\sqrt{1 - (\frac{v}{c})^2}}$

For Muons $\tau = 2.2\mu s$

$v \approx 0.99c \Rightarrow t \approx 10t' \Rightarrow t' = 2.1\tau * 0.1 = 0.21\tau$

$$\begin{cases} N_1 = 231454 \Rightarrow N_2 = N_1 * e^{-\frac{t'}{\tau}} \approx 187613 \approx 0.83 * 226786 \\ N_2 = R_0^{-1} N_2' = 226786 \end{cases}$$

$$\begin{cases} N_1' = R_0 * N_1 = 347181 \Rightarrow N_2' = N_1' * e^{-\frac{t'}{\tau}} \approx 281419 \approx 0.83 * 340180 \\ N_2' = 340180 \end{cases}$$

Measurement and Analysis

0.83?

$v \approx 0.9999c \Rightarrow t \approx 100t' \Rightarrow t' = 2.1\tau * 0.01 = 0.021\tau$

$$\begin{cases} N_1 = 231454 \Rightarrow N_2 = N_1 * e^{-\frac{t'}{\tau}} \approx 226644 \approx 226786 \\ N_2 = R_0^{-1} N_2' = 226786 \end{cases}$$

$$\begin{cases} N_1' = R_0 * N_1 = 347181 \Rightarrow N_2' = N_1' * e^{-\frac{t'}{\tau}} \approx 339966 \approx 340180 \\ N_2' = 340180 \end{cases}$$

Measurement and Analysis

0.83?

$v \approx 0.999999c \Rightarrow t \approx 1000t' \Rightarrow t' = 2.1\tau * 0.001 = 0.0021\tau$

$$\begin{cases} N_1 = 231454 \Rightarrow N_2 = N_1 * e^{-\frac{t'}{\tau}} \approx 230968 > 226786 \\ N_2 = R_0^{-1} N_2' = 226786 \end{cases}$$

$$\begin{cases} N_1' = R_0 * N_1 = 347181 \Rightarrow N_2' = N_1' * e^{-\frac{t'}{\tau}} \approx 346452 > 340180 \\ N_2' = 340180 \end{cases}$$

Measurement and Analysis

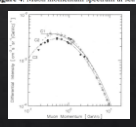
>?

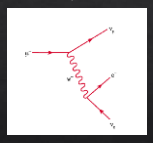
$v \approx 0.9999c$

τ

StatisticalDistribution

Figure 4. Muon momentum spectrum at sea level.





$\mu^- + p \rightarrow n + \nu_\mu$

Peak = 500 MeV/c p = 120 MeV/c – 790 MeV/c

Measurement and Analysis

Height	Threshold/mV	Time/s	Muon Number	Muon Rate $/second^{-1}$	Decay Number	Decay Rate $/minute^{-1}$	τ /s
H_1	202	11:57:48	231454	7	710	1	2.488±0.119
H_2	200	22:26:59	340180	3	1739	1.3	2.766±0.073

Conclusion

- Time Dilation Effect
- Decay: $\mu^- + p \rightarrow n + \nu_\mu$

Thank you

Measurement and Analysis