Comp Phys Z boson

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1 Question 1

This exercise focuses on muons that are detected with the CMS detector. How can you describe the behaviour and detection of muons in the CMS? The trajectories of charged particles are bent due to a strong magnetic field that allows the momentum to be calculated, and the energy of the muons is detected by measuring the amount of light produces in the ECAL.

2 Question 2

Let's practice the calculation of the invariant mass with the following task. Let's assume that for one muon pair the following values have been measured or determined:

1. $\rho_{T1} = 58,6914 GeV/c$
2. $\rho_{T2} = 45,7231 GeV/c$
3. $\eta_1 = -1,02102$
4. $\eta_2 = -0,37030$
5. $\phi_1 = 0,836256\text{rad}$
6. $\phi_2 = 2,741820\text{rad}$

Calculate the invariant mass value for this single pair of muons.

$$M = \sqrt{2p_{T1}p_{T2}(\cosh(\eta_1 - \eta_2) - \cos(\phi_1 - \phi_2))} \tag{1}$$

$$= 91.14 GeV \tag{2}$$

This calculated value matches very well with the published values of approximately $91.1876 GeV$

3 Quation 3

This histogram shows us in a very concise way the range of invriant masses recorded as well as the relative probabilities of the different masses.

4 Question 4

What can you say about the appearance of the Z boson based on the histogram and the fitted function? The appearance of the Z boson with a mass around 90 is most common which can help us calculate the expected mass of a Z boson.

Can you define the mass of the Z with the uncertainty? How? The mass would be the most likely value which calculated from the fit is $M = 90.798 + -0.0305$

5 Question 5

Calculate the lifetime τ of the Z boson with the uncertainty by using the fit.

$\tau = \frac{\hbar}{\Gamma} = \frac{\hbar}{3.924 \times 10^9} = 1.677 \times 10^{-25}$

Compare the calculated value to the known lifetime of the Z. What do you notice? What could possibly explain your observations? The recorded value for the lifetime of the Z boson is $3 \times 10^{-25} s$. Our calculated lifetime is shorter than the recorded value whic is possibly due to having a limited number of data points to use.

6 question 6

The Z boson was first detected on June 1 in 1984 according to CERN. According to CERN, physically the Z boson is the medium that carries the weak force which holds subatomic particles together.

7 Question 7

There wouldn't be just one peak because we aren't just detecting Z bosons when we analyze two muons that resulted from a reaction. They could have been the result of any possible reaction, so there wouldn't be just one peak in the graph.

8 Question 8

These two graphs are very similar to each other, but one of the main differences that I notice is the valley between 0.5 and $1.0 Gev$. In our histogram the valley is much deeper and more pronounced as there is a much larger bulge to the right of this valley.

9 Question 9

Having a small eta broadens the possible values for mass significantly and creates a much less defined peak on the histogram. This could be due to there being a much greater variation in the trajectories and thus momentums of the recorded muons. This variation would create a less defined and broader histogram.