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I. Introduction

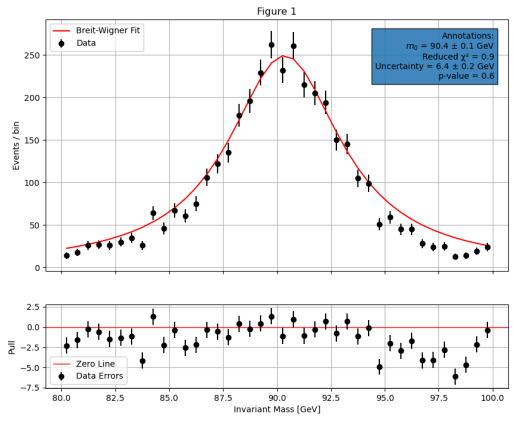
The following report analyzes the data from the ATLAS detector at the CERN Large Hadron Collider in Geneva to identify and measure the mass of the Z^0 boson. This is done by using the provided data and several calculations specified below.

II. The Invariant Mass Distribution and its Fit

Using the provided data file, the following values were calculated:

- Fitted mass of Z^0 boson: 90.4 GeV
- Fitted uncertainty of Z^0 boson: 0.1 GeV
- X^2: 8.6
- Degrees of freedom: 10
- P-Value: 0.6

These values were calculated by taking the given Pt, η, ϕ, and Energy values and using the $p_x = pt \cos(\varphi)$, $p_y = pt \sin(\varphi)$, $p_z = pt \sinh(\eta)$ functions to find the respective momentums, adding the total from the 2 data sets, and using those values to find the mass with the formula $M = \sqrt{(E^2 - (p^2_x + p^2_y + p^2_z))}$. The decay function $D(m; m0, \Gamma) = (1/\pi) * ((\Gamma/2)/((m - m_0)^2 + (\Gamma/2)^2)$ was later used to find the distribution of decays.

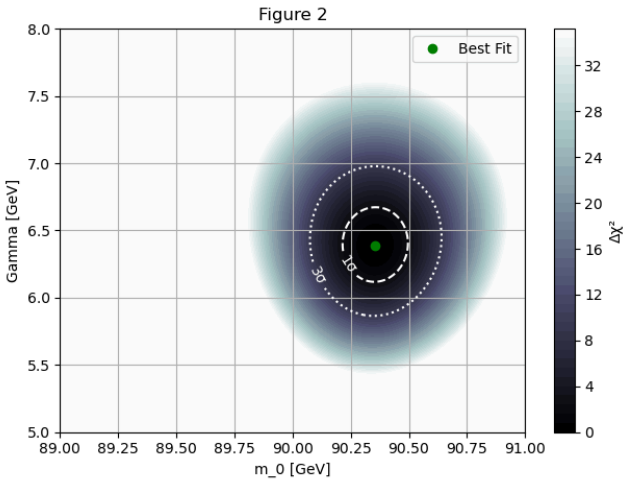


After this, the data was fitted with the Breit-Wigner function and the normalization was halved to create a peak. This resulted in the top part of Figure 1. The lines in each data point are the uncertainty value (how far the true value could deviate from the calculated one). The bottom graph is the distribution of how far each mass is from the normal curve, or in other words, the uncertainty. The rest of the values including chi squared were found using simple statistical formulas and are also noted in the graph.

The best fit mass and uncertainty were found using a covariance matrix which resulted in the top value of the graph, 90.4.

III. 2D Parameter Scan

In order to better visualize the joint probability space, a 2D parameter scan was used using a contour plot as shown in figure 2 with a width from 5 to 8. You can see how the ∆χ2 value is 0 at the best fit location but slowly increases the farther away you get. The graph contains masses from 89, to 91, with ∆χ2 being clipped at 35 for an easier visualization. The 1σ and 3σ confidence levels have also been included in order to demonstrate how accurate the data is. The best fit location is at 90.4 GeV and 6.4 GeV.



IV. Discussion and Future Work

The fitted mass of the Z^0 boson agrees well enough with the accepted PDG value. Unfortunately the fit does not include any systematic uncertainties, or the energy resolution of the ATLAS detector which could explain why the value is not perfect. In order to make everything more accurate in the future, some ideas could be to have more data values, account for the energy resolution of the ATLAS, or use different types of data to compare the values.

V. Conclusion

I believe that the data is accurate and that everything went well. Thanks for listening to my TedTalk