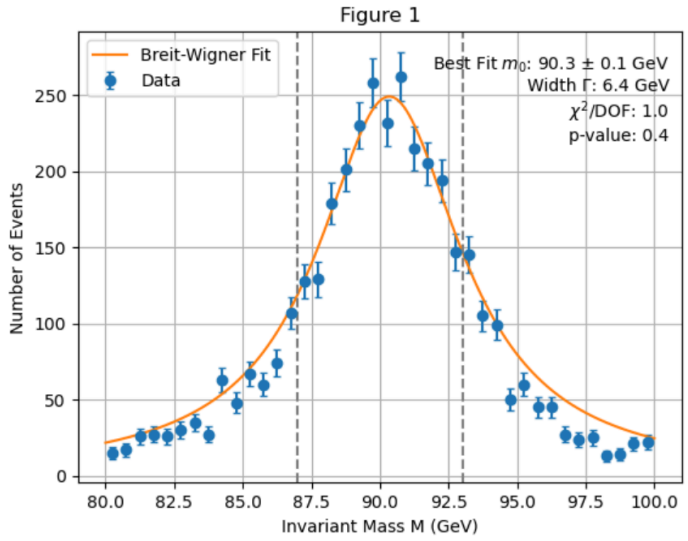
Lab 2 Report Chris Lipscomb

I. Introduction

Using data from the ATLAS experiments at CERN, we can use the four momentum of the Z0 boson's lepton decays to compute invariant masses and fit the distribution with a Breit-Wigner fit. This lets us find more information about the Z0 boson like the mass and decay width. This report will discuss the findings and quality of my data analysis by looking at the chi-squared value, p-value, and uncertainties.

II. The Invariant Mass Distribution

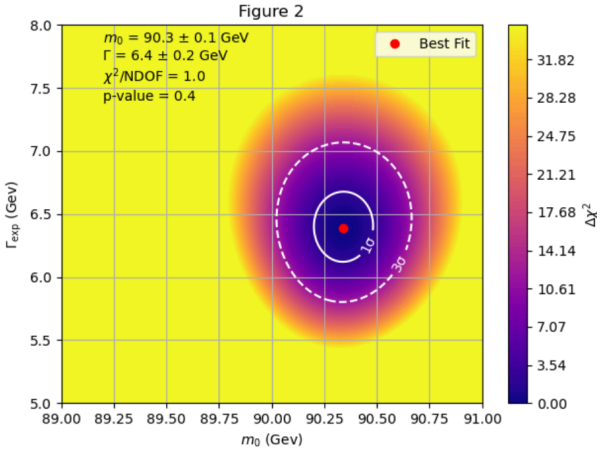
Figure 1



What you see in Figure 1 is a plot of the invariant masses calculated from the ATLAS data. These were found using the equation $M = \sqrt{E^2 - (p_x^2 + p_y^2 + p_z^2)}$ which uses the four momentum of the particles. The masses were plotted onto a histogram with 41 bins and includes errorbars. We have also plotted the Breit-Wigner peak to the data, which is the pattern that the distribution of decays should theoretical follow. It is calculated using $\mathcal{D}(m; m_0, \Gamma) = \frac{1}{\pi} \frac{\Gamma/2}{(m - m_0)^2 + (\Gamma/2)^2}$. This gives a fitted mass of 90.3 GeV with an uncertainty

of 0.1 GeV, chi-squared value of 9.98, 10 degrees of freedom, and a p-value of 0.4. This means there is a 40% chance the distribution will be greater than or equal to the observed data.

III. 2D Parameter Scan



In Figure 2, we performed a 2D scan from a mass range of 89 to 91 GeV and a width of 5 to 8 GeV. We made a map using delta chi-squared, calculated with $\Delta\chi^2 = \chi^2 - \chi^2_{min}$. Also the delta chi-squared values were clipped at 35 to make a more clear plot. The delta chi-squared values of 2.3 for 1 sigma and 11.83 for 3 sigma were chosen using a chi-squared distribution table for two degrees of freedom. 1 sigma has a confidence level of 68.3% and with two degrees of freedom corresponds to a delta chi-squared of 2.3, 3 sigma has confidence of 99.7% and corresponds to 11.83. The 1 sigma level is shown as a solid line, and 3 sigma is a dashed line. The red dot in the center of those sigma levels is the best fit location.

IV. Discussion and Future Work

In conclusion, the calculated Z0 boson mass of 90.8 +/- 0.2 GeV closely matches up with the PDG value of 91.2 +/- 0.0021 GeV, with a percent error of 0.44%. There were

numerous assumptions made that potentially caused lower accuracy in our findings. Such as a lack of systematic uncertainties, and approximating the energy resolution of the ATLAS detector. In the future, we could include the ATLAS's resolution to the fit calculation, and include systematic uncertainty bands.