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PHYS265

Lab 3- Atlas Data Analysis

I. Introduction

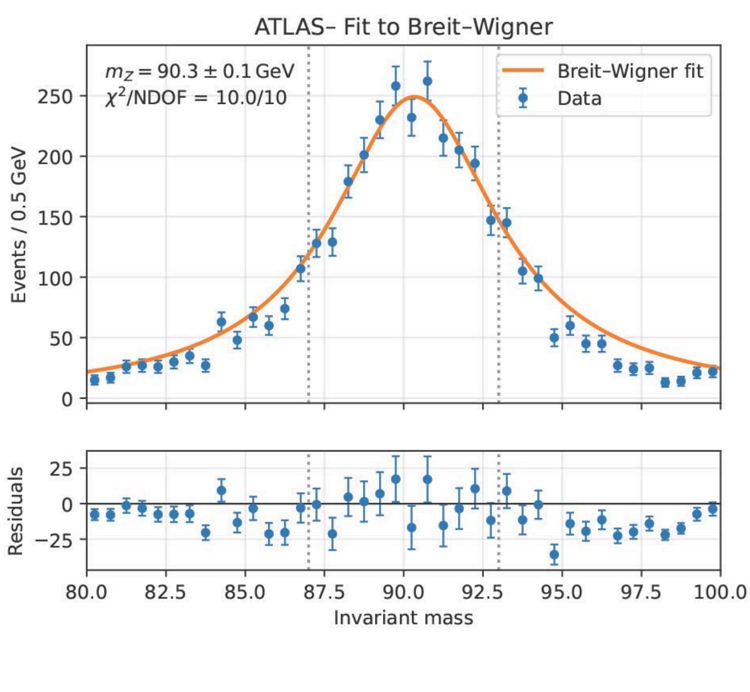
At Cern's large hadron collider or LHC, the ATLAS experiment investigates proton to proton collisions. This lab will investigate the Z0 boson. This weak force mediator will have leptonic decays, which will be examined by the lab. Using data from the experiment, we will find the invariant mass distribution, and perform a Breit-Wigner fit, while also visualizing the parameter space in a 2D analysis.

II. The Invariant Mass Distribution and Fit

Analyzing 5000 ATLAS events containing lepton pairs, the invariant mass was calculated using measured energies and momenta. Through the histogram, data was put between 80-100 GeV and in 41 bins. This represents the invariant mass spectrum. The Breit-Wigner distribution captures the behavior of the Z^0 decay.

- Fitted Z^0 mass: 90.3 GeV
- Mass uncertainty: 0.1 GeV
- Chi square: 10
- Degrees of freedom (NDOF): 10

Figure 1 demonstrates good fit quality, suggesting the Breit-Wigner model



accurately represents the measured data.

III. 2D Parameter Scan

a 2D x^2 scan was performed over the mass range of 89 to 91 GeV and width Γ from 5 to 8 GeV. This will visualize parameter uncertainties. We generated a Δx^2 contour plot, defining $\Delta x^2 = x^2 - x^2$ min. Also marked the best fit in the confidence regions.

- 1σ contour corresponds to $\Delta x^2 = 2.30$
- 3σ contour corresponds to $\Delta x^2 = 11.83$

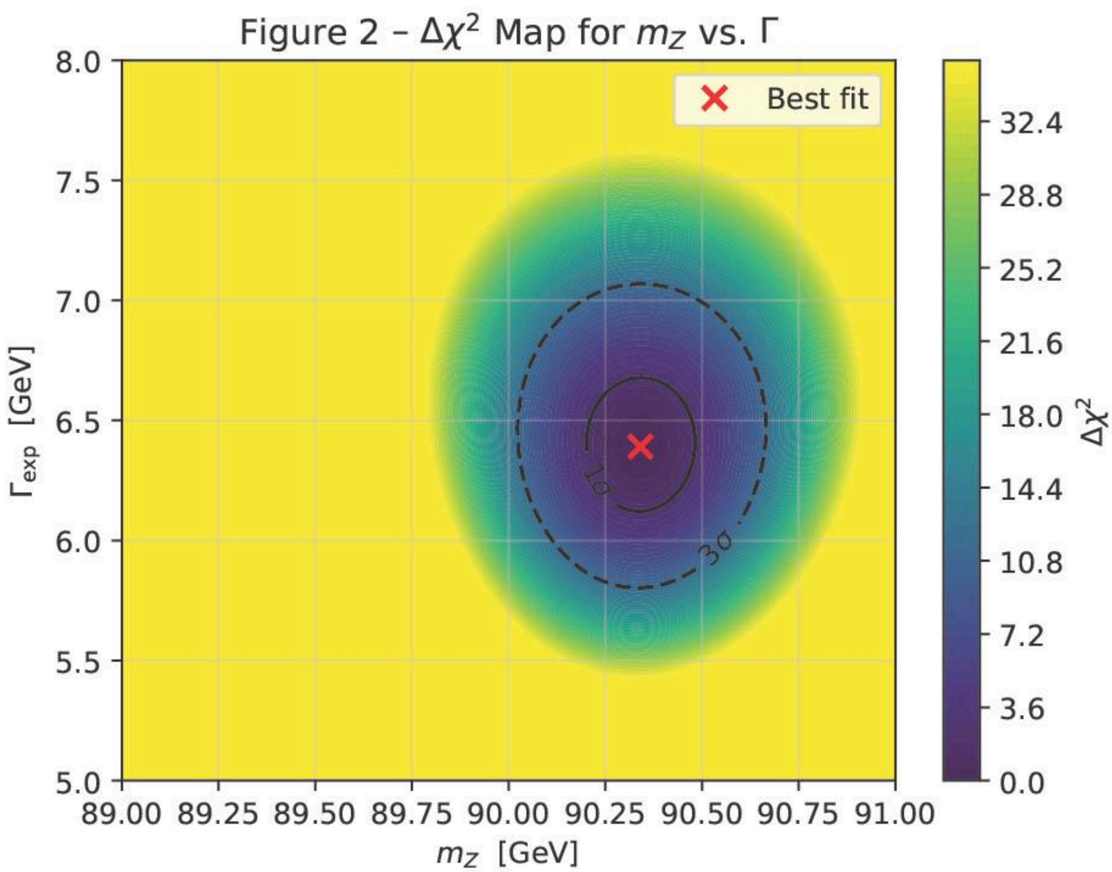


Figure 2 shows clearly marked confidence regions, and the best-fit parameters (mass and width) *are indicated by the central point.*

IV. Discussion and Future Work

In comparing the literature value with the measured mass, we find that our measured Z^0 mass, which is 90.3 ± 0.1 GeV, is slightly lower than the PDG literature value, which is 91.188 ± 0.002 GeV. The possible deviations and differences might have come from simplifications such as neglecting systematic uncertainties and detector resolution effects. Future analyses should include a detailed energy calibration, consider systematic uncertainties, and enhanced detector modeling for more realistic outcomes. Larger datasets and refined fitting techniques could improve precision, and the calculations will be closer to the literature value.