Atlas Data Analysis Report

By: Giancarlo Roach

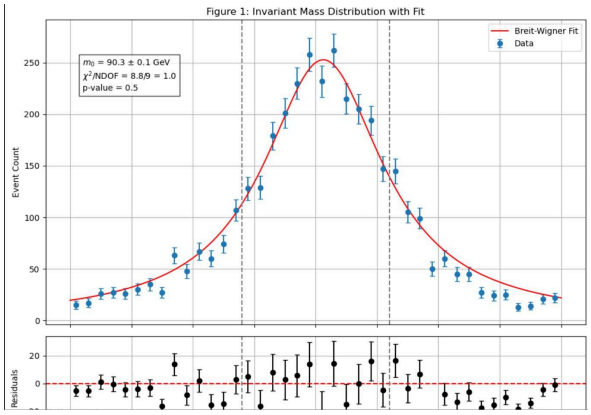
I. Introduction

Through this analysis, the invariant mass distribution of lepton pairs recorded by the ATLAS detector is studied with the aim of reconstructing the Z^0 boson mass and width, computing the invariant mass of all lepton pairs and fitting the resulting invariant mass distribution with a Breit-Wigner distribution based on principles of special relativity and conservation of four-momentum. The mass and error of the Z^0 as well as the chi-squared goodness-of-fit are derived from this fit. A two-dimensional scan of the mass-width plane lends an interpretation to the results, exposing correlations and confidence intervals of the fit.

II. The Invariant Mass Distribution and Its Fit

We have calculated the invariant mass. The components of the momentum vector were determined from transverse momentum pT, pseudorapidity , and azimuthal angle. The energy and momentum vectors of the two leptons were summed before invariant mass for the system was calculated.

A histogram of these invariant masses was produced with Poisson corresponding error bars, and fitting of the histogram between 87 and 93 GeV was done with a scaled Breit-Wigner distribution.



From the best-fit, the mass is 90.3 GeV with an error of ±0.1 GeV. The fit's estimated chi-square is 8.8 with 9 degrees of freedom, giving a p-value of 0.5. The result is shown in figure 1 which displays the overlay of the fit and histogram with residuals plot below. Therefore, the rejection of the model on the basis of goodness-of-fit through a reduced chi-square value close to unity and a p-value close to 0.5 confirms the validity of the model.

III. Two-dimensional Parameter Scan

A series of two-dimensional chi-square scans was performed to explore the two-dimensional probability space of the mass and width parameters for the interval range of 89"91 for the mass and 5"8 for the width. A total of 300 times 300 points were scanned thus allowing chi-square calculations among the mass-width combinations and mapping the minimum chi-square point along with that of Δχ2.

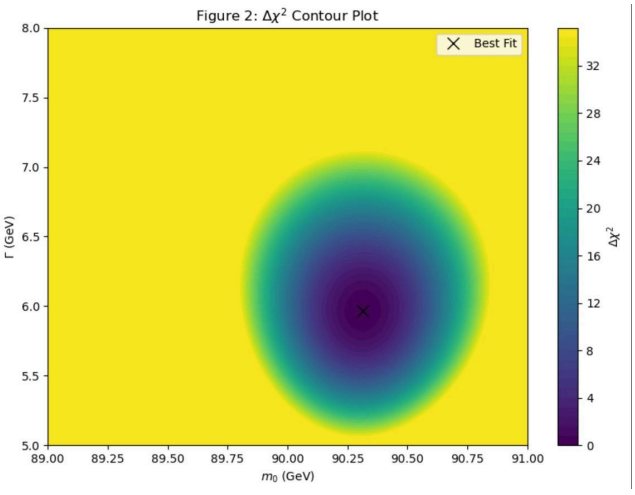


Figure 2 is a filled-contour plot of the map cut off at $\Delta\chi^2 = 35$ for clarity. The cross indicates the best fit point from Part II. This plot gives an idea about the precision and correlation between the mass and width.

IV. Discussion and Future Work

We measure the mass of the Z0 boson as 90.3 ± 0.1 GeV, very close to 0.9 GeV of the presently accepted Particle Data Group value 91.2 GeV. Since our model does not incorporate any systematic uncertainties or the effects due to the ATLAS detector resolution, this agreement seems reasonable.

There were many approximations in our analysis: We had assumed ideal detector resolution, ignored background contamination, and modeled errors to be totally statistical by using Poisson distributions. Our fit also ignored any smearing from energy mismeasurement - a realistic characteristic of any detector.

These shortcomings will be handled in the next set of analyses, including detector resolution through convolution with a Gaussian kernel, simulating and subtracting expected background contributions, and unbinned likelihood fitting for improved accuracy. In its entirety, this analysis demonstrates statistically significant reconstruction of the Z0 mass peak and, more importantly, provides a baseline framework for a more realistic simulation of particle physics.