The UA2 Experiment
1981-1990

The W boson

W and Z Boson Physics

The Electroweak Standard Model of particle physics, developed by Glashow, Salam and Weinberg, unified the electromagnetic and weak nuclear forces into a single theory and predicted the existence of the previously unknown W and Z bosons. Together with the more familiar photon, these particles explain the electroweak interactions of fundamental particles.

Soon after the new “Super proton-antiproton Synchrotron” collider at CERN was switched on in 1981 the UA2 experiment co-discovered the W and Z bosons with the UA1 experiment in spectacular confirmation of the Standard Model. The W and Z bosons decay very quickly after they are produced but the decays leave characteristic energy deposits in the detectors. An example of the energy distribution due to a W boson decaying in the UA2 detector can be seen on the left and of a Z boson on the right.

From these, and similar measurements, the following key electroweak parameters were deduced:
- W boson mass, \( m_W = 80.38 \pm 0.22 \pm 0.17 \pm 0.81 \text{ GeV/c}^2 \);
- Z boson mass, \( m_Z = 91.14 \pm 0.28 \pm 0.12 \pm 0.92 \text{ GeV/c}^2 \);
- W boson width, \( \Gamma_W = 2.10 \pm 0.14 \pm 0.08 \text{ GeV/c}^2 \);
- \( \sin^2 \theta_W = 0.2324 \pm 0.0072 \).

[1 \text{ GeV/c}^2 is roughly equal to the mass of 1 proton]

The Z boson

Evidence for hadronic decays of the W and Z seen in the two-jet mass spectrum. The solid line is a fit to the data points that includes signal and background. The dashed line is a fit to the background only.

Jets

The UA2 detector at the CERN proton-antiproton collider.

Other results

In addition to the properties of the W and Z bosons, the UA2 experiment made many other important measurements including:
- the strong coupling constant, \( \alpha_s(M_W^2) = 0.123 \pm 0.018 \pm 0.017 \);
- jet cross-sections and angular distributions;
- the cross-section for single and double direct photon production;
- a limit on the top quark mass, \( m_t \geq 69 \text{ GeV/c}^2 \);
- tests of electron-tau universality.

Several searches for new particles were also made allowing constraints to be placed on theories that predicted the existence of supersymmetry, quark compositeness, leptoquarks, additional vector bosons, excited quarks and a charged Higgs boson.

Photons

The study of photons in association with jets reveals information about the structure of the proton. The plot compares the observed photon production rate with contemporary theoretical predictions as a function of transverse momentum.

The Electroweak parameters are sensitive to the mass of the top quark and Higgs boson. The UA2 measurement of the W boson mass favoured a top quark mass of 160\( \pm \)60 GeV/c\(^2\) for a Higgs mass of 100 GeV/c\(^2\).

The top quark

Searches for the top quark allowed UA2 to set lower limits on the mass before its eventual discovery. The graph shows 95% confidence limits on top quark production as a function of the heavy quark cross-sections. For the preferred values of the cross-sections UA2 set a lower limit on the top mass of 69 GeV/c\(^2\).

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