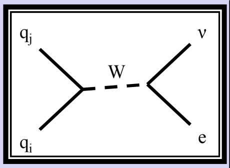
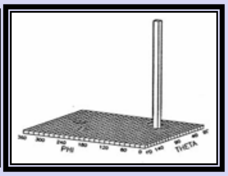
The UA2 Experiment

1981-1990

Berne-Cambridge-CERN-Heidelberg-Milan-Orsay(LAL)-Pavia-Perugia-Pisa-Saclay(CEN).

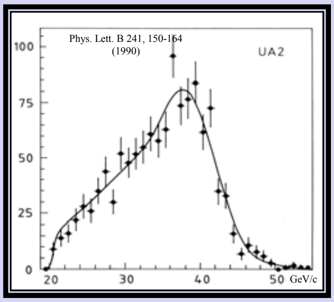
The W boson





A pattern of energy deposition seen in the UA2 calorimeter interpreted as the decay of a W boson into electron and neutrino.

The electron is stopped in the detector and deposits all of its energy in a small region. The neutrino is not detected and escapes.



This figure shows the distribution of the electron transverse momenta measured for many W decays (data points). The W mass is deduced by fitting the expected functional form to the data (solid line).

W and Z Boson Physics

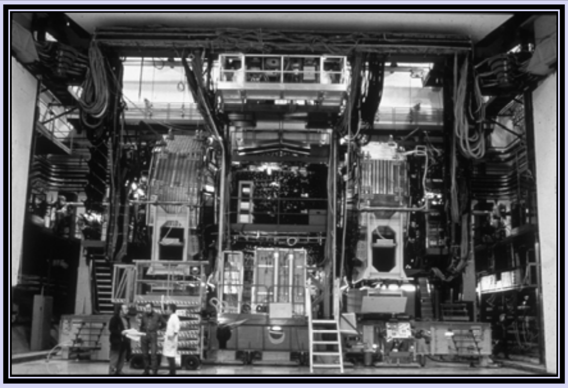
The Electroweak Standard Model of particle physics, developed by Glashow, Salam and Weinberg, unified the electromagnetic and weak nuclear forces into a single theory and predicted the existence of the previously unknown W and Z bosons. Together with the more familiar photon, these particles explain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

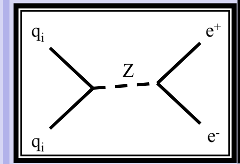
- W boson mass, $m_W = 80.84 \pm 0.22 \pm 0.17 \pm 0.81$ GeV/c^2;
- Z boson mass, $m_Z = 91.74 \pm 0.28 \pm 0.12 \pm 0.92$ GeV/c^2;
- W boson width, $\Gamma_W = 2.10 \pm 0.14 \pm 0.08$ GeV/c^2;
- $\sin^2\theta_W = 0.2234 \pm 0.0072$.

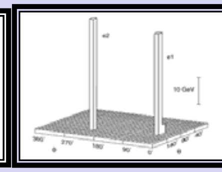
[1 GeV/c^2 is roughly equal to the mass of 1 proton]



The UA2 detector at the CERN proton-antiproton collider.

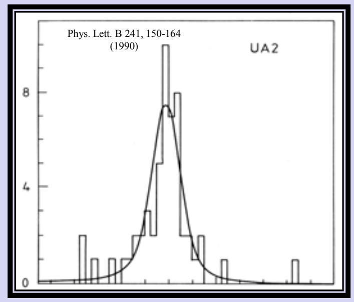
The Z boson





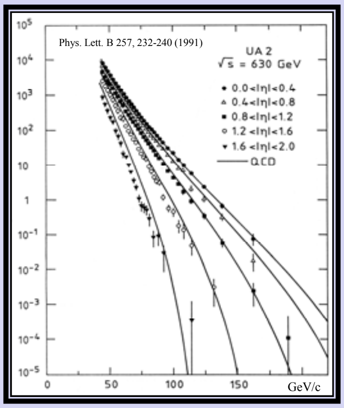
A pattern of energy deposition seen in the UA2 calorimeter interpreted as the decay of a Z boson into an electron and positron (anti-electron).

Both electron and positron deposit all of their energy in localised regions of the detector. The sum of energy deposited is roughly equal to the Z mass.

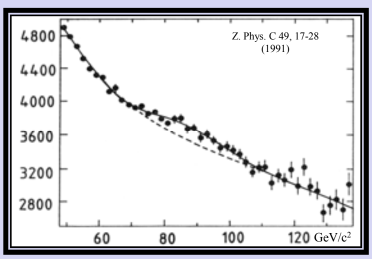


This figure shows the distribution of the invariant mass of electron-positron pairs measured for many Z decays (data points). The Z mass is deduced by fitting the expected functional form to the data (solid line).

Jets



Measurements of the inclusive jet cross-section in various pseudorapidity intervals. The data points are compared with the predictions of QCD (solid lines).



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.

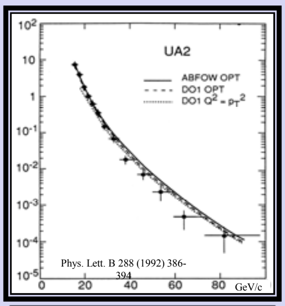
Other results

In addition to the properties of the W and Z bosons, the UA2 experiment made many other important measurements including:

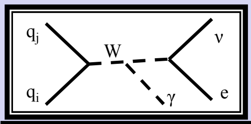
- the strong coupling constant, $\alpha_s(M_W^2) = 0.123 \pm 0.018 \pm 0.017$;
- jet cross-sections and angular distributions;
- the cross-section for single and double direct photon production;
- a limit on the top quark mass, $m_t \geq 69$ GeV/c^2;
- tests of electron-tau universality.

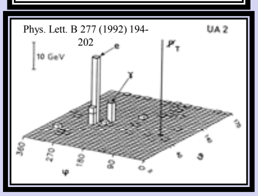
Several searches for new particles were also made allowing constraints to be placed on theories that predicted the existence of supersymmetry, quark compositeness, leptoquarks, additional vector bosons, excited quarks and a charged Higgs boson.

Photons



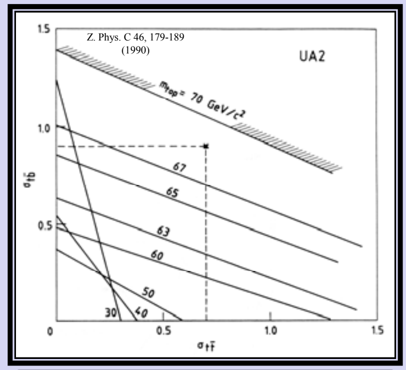
The study of photons in association with jets reveals information about the structure of the proton. The plot compares the observed photon production rate with contemporary theoretical predictions as a function of transverse momentum .



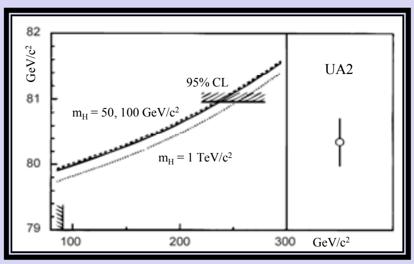


Photons, measured in association with an electron and neutrino, provide a test of the W-γ coupling in the Standard Model. The plot shows the measured distribution of energy in the UA2 calorimeter for a typical event.

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.



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±60 GeV/c^2 for a Higgs mass of 100 GeV/c^2.