The OPAL Experiment at LEP

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1. Introduction

OPAL is one of the four large experiments at the e^+e^- collider LEP at CERN, the world's largest particle accelerator with a circumference of almost 27 km. A sketch of the OPAL detector is shown in fig.1.

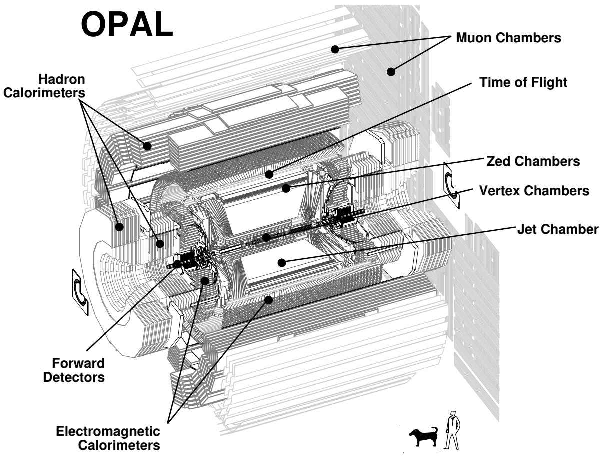

Fig. 1: The OPAL detector.

The layout follows the generic design of modern general-purpose detectors at high-energy colliders. The innermost layer is a small, high-precision silicon detector followed by a large jet-chamber, which reconstruct the trajectories of charged particles, resolve secondary vertices and measure the particle momenta from their curvature in the magnetic field. The outer layers are formed by the electromagnetic calorimeter consisting of lead glass blocks for the precise measurement of the energy of electrons nd photons, then the hadron calorimeter and finally the muon chambers.

2. Physics at LEP1

In the first phase (LEP1) from 1989 to 1995 LEP was operated at centre-of-mass energies close to the Z^0 resonance at 91 GeV. Owing to the large cross-section at this energy (fig.2) about 5 million Z^0 decays have been recorded. Using this high statistic data sample numerous novel analyses and measurements could be performed in the fields of electroweak and strong interactions and heavy quark properties, which provide precision tests of theoretical predictions and constrain fundamental parameters.

A main focus at LEP1 are precise measurements of the properties of the Z^0 boson, the mass and couplings to fermions [1]. The high precision of these measurements imposes stringent tests on the Standard Model (SM) of electroweak interactions, at the level level of quantum loop corrections. Through these corrections the measurements are sensitive to unknown or weakly constrained parameters of the SM, like the mass of the Higgs boson or the top quark (m_t). An impressive confirmation of the SM is the good agreement between the direct measurement of m_t at the Tevatron and its indirect determination from electroweak precision measurements [2].

The strong interaction is a further central topic at LEP1, namely the determination of the strong coupling constant α_s and the properties of quarks and gluons [3].

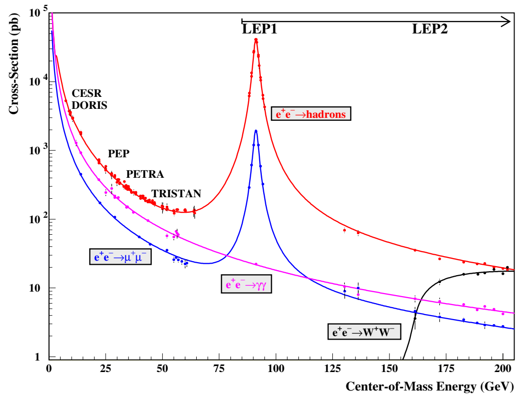

Fig. 2: The cross-section for several e^+e^- reactions as function of the centre-of-mass energy.

3. Physics at LEP2

The second phase (LEP2) began in 1996 with energies above the W^+W^- production threshold (fig.2) at 161 GeV and will eventually extend until 2000 and reach a centre-of-mass energy slightly above 200 GeV. The main goals at LEP2 are the detailed investigation of the W boson properties and the search for new particles.

W bosons are produced in pairs at LEP. Each W decays immediately either into two quarks (67 %) and subsequently into two hadronic jets or into a charged lepton and the corresponding neutrino (33 %). Besides the measurement of the production cross-section and the decay fractions the central issue is the precise measurement of the mass m_W. In the SM m_W can be expressed in terms of other well-measured parameters. But it is sensitive to a specific class of radiative corrections; therefore the comparison with the direct measurement is of particular interest. Each of the possible W^+W^- decay channels – purely hadronic, semileptonic and purely leptonic – has specific features which must be carefully studied to optimize the precision of the measurement [4].

An exciting field at LEP2 are searches for new particles. Year-by-year the centre-of-mass energy increases by several GeV, which extends the accessible mass range for such particles. Most 'wanted' is the Higgs boson, the only missing but crucial element of the SM. Equally important are searches for additional particles predicted in extensions of the SM [5]. These are motivated by several conceptual problems of the SM, which suggest that the SM is only a low energy approximation.

References

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