Higgs Physics

Exercise Sheet 3

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Exercise 1 [*Measurement of the W boson mass at LEP*]

Read the attached paper from the ALEPH Collaboration **Phys. Lett. B 422 Z1998. 384398**.

a) The technique used in this paper to measure the W boson mass employs the direct reconstruction of W boson decay products invariant mass.

- What are the advantages of using such a technique at a lepton collider with respect to an hadronic machine?
- How is the W mass extracted from the distribution of reconstructed invariant masses?

b) The paper considers events where two W bosons are produced in e^+e^-collisions and selects the fully hadronic and semi-leptonic decays of the W pairs.

- Which components of the ALEPH detectors are used to reconstruct electrons, muons and tau leptons?
- How are the hadronic final states reconstructed?
- Can the energy and momentum of the final state neutrinos be reconstructed?
- Why do you think that fully leptonic decays are not considered in this paper?

c) The requirements used to select fully hadronic and semi-leptonic final states are detailed in section 4.

- The efficiency of the fully hadronic event selection is more stringent than the semi-leptonic cases in which the muon or electron decay are selected. What is the reason?
- List advantages and disadvantages of the different final states used in the analysis.

d) The extraction of the decay products invariant masses and the W boson mass are described in section 5 and 6.

- What kind of information does the kinematic fit use to improve the measurement of the decay products energies and momenta? How does this improve the precision of the W boson mass measurement?

- The reconstructed invariant mass distributions in the selected decay channels are reported in Figures 1,2 and 3. Would you be able to estimate the uncertainty on the W mass measurement in each channel from these plots?
- How is the distribution of the decay products invariant masses at different m_W obtained and how is the best value of m_W chosen?

e) The systematic uncertainties on the measurement are reported in section 8.

- Which are the dominant sources of systematic uncertainties in the measurement?
- Classify the uncertainties into detector and theory driven ones.
- At which integrated luminosity would the precision be dominated by the systematic uncertainties?