Teilchenphysik II (Higgs-Physik) (SS 2016)

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Exercises Sheet 12

http://www-ekp.physik.uni-karlsruhe.de/~quast/ Release: Thu, 17.06.2016

Exercise 34: Making Spin Visible (presence)

In the lecture we have discussed the decay of τ's as the only way to make a direct polarization measurement at LEP, which was operated with unpolarized beams. What makes this measurement possible is e.g. the $\tau^- \to \nu_\tau \pi^-$ two-body decay, which can make the spin of the τ accessible to an observation: the π^- has spin 0; the ν_τ is of spin 1/2 with a well defined helicity; neutrinos fly against the direction their spin, anti-neutrinos in the direction of their spin!

a) Draw the *Feynman* diagram of the decay $\tau^- \to \nu_\tau \pi^-$.

b) Draw the decay in the restframe of the τ. What is the flight direction of the π^- relative to the spin of the τ^-? Answer the same question for the charge conjugate decay.

c) Draw the decay $Z \to \tau^+\tau^-$ in the restfram of the Z, including the spins of the Z and the τ's. If you assume that the Z is produced at rest in the laboratory frame, how can you infer the residual polarization of the Z from the decay $Z \to \tau^+\tau^- \to \pi^+\pi^-$?

Exercise 35: Direct Higgs Boson Searches at LEP (presence)

After the strong hints on the Higgs boson mass from indirect constraints from LEP precision measurements and the confirmation of the employed methods by the exact prediction of the top quark mass there was a strong push to run the LEP collider as long as possible at the highest achievable center of mass energies for the direct search for the Higgs boson.

a) Draw the *Feynman* diagram of the dominant production mode for SM Higgs bosons at LEP. The published LEP fit from 2005 based only on the 14(+1) LEP (and SLD) high precision Z-pole observables discussed in the lecture had its best fit value at

$$\log(m_H/\mathrm{GeV}) = 2.05 \pm 0.385\,,$$

corresponding to a value of $m_H \approx 112$ GeV. First preliminary results, shown on conferences long before the actual publication where similar. What was the minimal center of mass energy to produce a Higgs boson with this mass in e^+e^- collisions?

b) LEP reached a maximal center of mass energy of 207 GeV at the end of running in 2000. What was the maximal reach of LEP in m_H?

Exercise 36: Direct Higgs Boson Searches at the Tevatron (presence)

Also at the Tevatron direct searches have been conducted for the SM Higgs boson. At the Tevatron protons were brought to collision head on with anti-protons at center of mass energies of 1.96 TeV. What was the reason to collide protons with anti-protons? What is the mean fractional momentum that was needed of both protons to create a real Higgs boson with $m_H = 125$ GeV?