

Particle Physics

FYS4560

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Project 2

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I. Di-lepton production in e^+e^- in the SM

1. Which (lowest order) SM processes contribute to di-lepton production in e^+e^- annihilations:

$$e^+e^- \rightarrow l^+l^-$$

1. Draw all possible Feynman graphs. Qualitative discussion. Consider the Higgs case.
 2. How do final states look like for various lepton cases?
 3. Make use of Feynman rules in QED to calculate the differential cross-section $d\sigma/d\cos\theta$, where θ is the scattering angle between μ^- and e^- , as well as the total cross-section, as function of the centre of mass energy.
 4. What is the expected rate (number of events) at $\sqrt{s} = 5, 50, 91$ and 125 GeV, assuming an integrated luminosity of 100 pb^{-1} and an overall detection efficiency of *50% for muons*?
 5. Compare (qualitatively) the following cases $e^+e^- \rightarrow e^+e^-, \mu^+\mu^-, \tau^+\tau^-$
2. Make use of Feynman rules (SM electroweak) to calculate the μ differential and integrated cross-sections, $d\sigma/d\cos\theta$ and $\sigma(\sqrt{s})$, as well as the forward-backward asymmetry, $A_{\text{FB}}(\cos\theta)$ and $A_{\text{FB}}(\sqrt{s})$
 3. Plot all results above (QED, electroweak, ...) and discuss qualitatively μ -pair production as energy increases (cross-section, angular distribution, electroweak asymmetry). Compare all your results to CompHEP.

II. Dilepton production beyond the SM

1. New weak gauge bosons, Z' , are predicted by various theories Beyond the SM. Assume similar Z' couplings to fermions as the SM Z .
 1. Discuss the processes involved and the physics behind (motivation for Z').
 2. Use CompHEP and include a new Z' gauge boson of mass 1 TeV.
 3. Plot the total cross section into $\mu^+\mu^-$ as well as the FB-asymmetry.
 4. What are the current limits set-up by ATLAS on such particles? How would Z' and W' be produced in pp collisions? What are the background processes in each case? How would you look for W' (learn about transverse mass)?
 5. Optional: add a W' of 1 TeV to CompHEP and plot transverse mass for W and W' .
2. Discuss a possible slepton pair production.
 1. Feynman graphs.
 2. What are the competing SM background processes?
 3. How would you separate signal and backgrounds?
 4. Optional: make use of CompHEP.

$$e^+e^- \rightarrow \tilde{l}^+\tilde{l}^-$$