Physics Beyond the Standard Model

Exercise 10

Exercise 1: Resolution of secondary vertices

A major component of the Higgs search at LEP was b-tagging. B-tagging is the possibility to distinguish Jets that contain b-quarks from other jets (in the mass range that was relevant for LEP the Higgs decays to $b\bar{b}$ in 37% of all cases). B-jets contain B-mesons that have a relatively long lifetime (e.g. $\tau(B^- = b\bar{u}) = 1.653ps$, $\tau(D^0 = c\bar{u}) = 0.4126ps$)

Assume that the detector has a DCA resolution (DCA = Distance of closest Approach, i.e. distance of a track from the primary vertex) of 35 μm.

We consider decays of B hadrons in two charged particles. We can reconstruct an intersection point from the two charged tracks. The resolution function is

$$\sigma = \frac{\sigma_{\mathrm{DCA}}}{\sqrt{1 - |\cos\alpha|}} \tag{1}$$

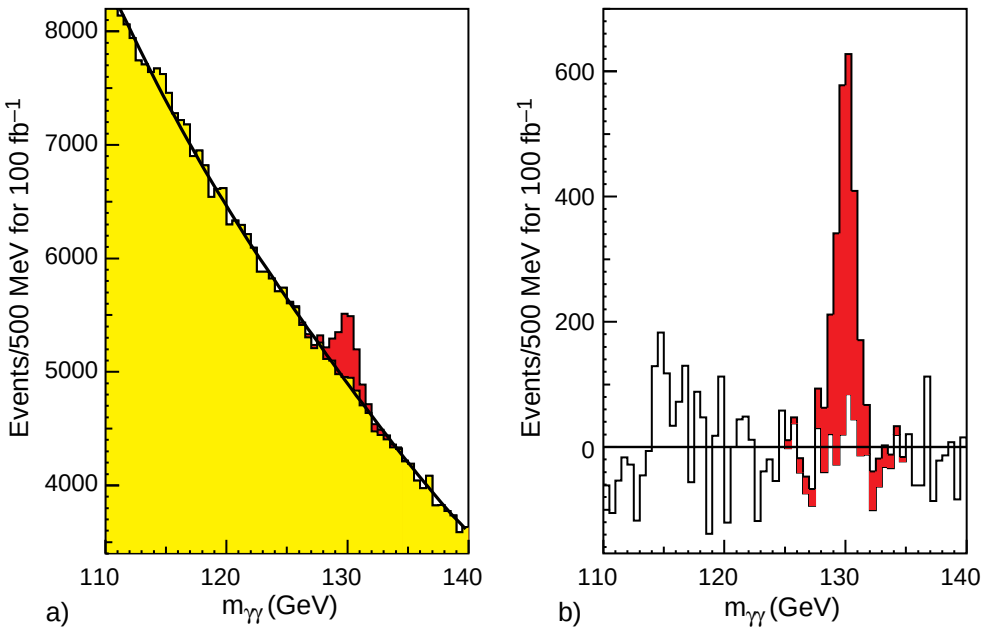
where α is the angle between both tracks. Assume that on average, the larges angle between all charged tracks of the decay products of the B hadrons is 26°.

a) How large is the distance between the primary and secondary vertex for which one can distinguish the secondary vertex from the interaction vertex at a 99.5% confidence level.

b) What is the fraction of B^- mesons that travel this distance under the assumption that the average transverse momentum is 31.7 GeV? ($m_{B^-} = 5.279$GeV)

Exercise 2: $H \to \gamma\gamma$ at the LHC for $m_H = 130$ GeV

a) Assume the depicted $\gamma\gamma$ invariant mass distribution has been observed. Estimate the significance of such a signature. How large is the cross-section after selection for signal and background (in fb or fb/GeV).



b) Assume that the true cross-sections are the ones shown above. Calculate the γ-resolution $\Delta E/E$ in the electromagnetic calorimeter (ECAL) that is required in order to observe the Higgs with a significance of 5σ in this channel for an integrated luminosity of $100 fb^{-1}$. Assume that the decay width for $H \to \gamma\gamma$ for $m_H = 130$ GeV is approximately 4 MeV and can thus be neglected.