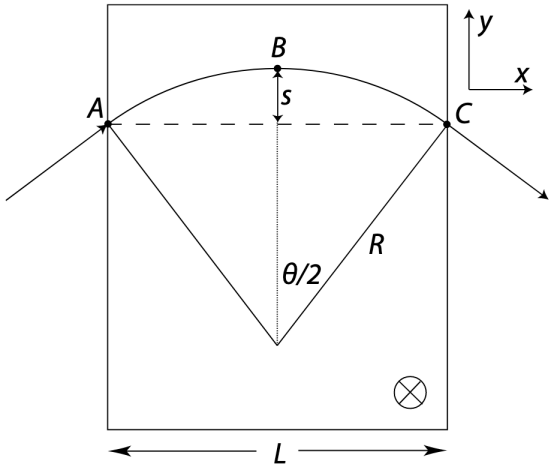
Homework #9

- In the Particle Data Book (http://pdglive.lbl.gov/) the mass of the W boson is given as 80.379±0.012 GeV while that of the Z boson as 91.1876±0.0021 GeV. Why the precision on the W mass is about a factor of 5 worse?
- The mean ionisation energy in Silicon is w = 3.6 eV and the mean energy loss of a MIP is dE/dx = 3.9 MeV/cm. Calculate how many electron-hole pairs are created by a MIP in a d=300 μm thick pixel detector module, and compare it to the number of thermal e-h pairs at T=300 K (where the intrinsic charge carrier density is $n_i(T) = 1.45 \cdot 10^{10}$ cm^{-3}) if the module area is A = 1 cm^2. How do we remove the thermal e-h pairs in semi-conductor detectors?
- The LEP collider collided electron and positron beams at 91 GeV (at the Z resonance peak) in the early 90s. What processes the following event displays on the next page show? Draw the relevant Feynman diagrams. The cyan lines correspond to charged particle tracks in the inner tracking detector, the yellow (magenta) boxes indicate energy deposits in the electromagnetic (hadronic) calorimeters and the cyan arrows indicate a muon that is observed in the outer muon chambers.
- Cosmic rays can be used to help the initial calibration of particle detectors, for example to measure the position of the different detector modules (position alignment). How would a typical cosmic ray event look in an LHC detector? How would you select such an event sample?
- The momentum of charged particles is measured in a solenoidal magnetic field B at a collider.
  (a) Calculate the radius R of the curvature for a particle with transverse momentum p_T. Express the sagitta s of the curved track with radius R and a length L (see figure) for a small deflection θ (i.e. $L/R \ll 1$) as a function of R.
  (b) The trajectory is measured in three equidistant points A, B, C with equal resolution σ_y in the y direction. From these the sagitta can be determined taking point B as one of its endpoints and the other endpoint derived from points A and C. Assuming that the measurements are uncorrelated, calculate the relative transverse momentum resolution $\sigma(p_T)/p$. Derive the general formula. What does it give for p_T = 10 GeV, L = 1 m, B = 2 T and σ_y= 20 μm?



LEP OPAL events