PH3520 (Particle Physics)
Problem sheet 3
To be turned in by 10:00 a.m., Thursday, 20 October, 2011.

1: A charged pion passing through argon gas with a speed $\beta = 0.96$ is minimum ionising, having an energy loss per unit path length of $dE/dx = 1.5$ keV/cm. What would the dE/dx be for the following cases:

(a) Assume the particle is a proton moving with $\beta = 0.96$.

(b) Assume the particle is a charged pion moving with a speed $\beta = 0.48$. (For this, you can neglect the β dependence of the term in square brackets in equation (5.5); i.e., treat the part in brackets as a constant.)

(c) Assume the particle is an alpha particle moving with $\beta = 0.96$.

2: (a) Suppose the momentum measurement accuracy of the drift chamber is 0.4% for 1 GeV electrons. Using the relation for momentum resolution discussed in the lecture, find the measurement accuracy for 10 GeV electrons.

(b) Suppose the energy measurement accuracy of the electromagnetic calorimeter is 15% for 1 GeV electrons. What will the accuracy be for 10 GeV electrons?

3: Consider a particle detector for use at an electron-positron collider consisting of a cylindrical drift chamber in a magnetic field surrounded by an electromagnetic calorimeter, a hadron calorimeter, and muon detectors, as indicated in Fig. 1.

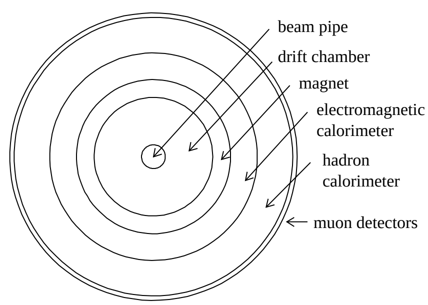


Figure 1: Schematic diagram of a particle detector viewed along the beam line.

Using the drawings on the next page, sketch where in the detector one would find signals from the events below. Draw a "blob" to indicate a deposition of energy, a solid line for the track of a charged particle, and a dashed line for the trajectory of a particle that does not leave a track.

(a) $\mathrm{e^+e^-} \to \mu^+\mu^-\mathrm{e^+e^-}$

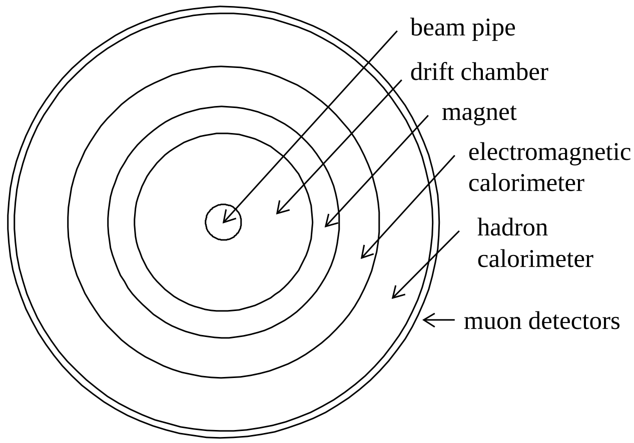
(b) $\mathrm{e^+e^-} \to \gamma\gamma$

(c) $\mathrm{e^+e^-} \to \nu\overline{\nu}\gamma$

(d) $\mathrm{e^+e^-} \to \tau^+\tau^-$, where the τ leptons decay $\tau^- \to \nu_\tau \mu^- \overline{\nu}_\mu$ and $\tau^+ \to \overline{\nu}_\tau K^+ \pi^0$.

(e) $\mathrm{e^+e^-} \to \pi^+\mathrm{n}\overline{\mathrm{p}}\pi^0\mathrm{K^+K^-}$

(f) $\mathrm{e^+e^-} \to q\overline{q}gg$, where the quarks and gluons result in 'jets' of at least several hadrons each (e.g., neutral pions, kaons, etc.).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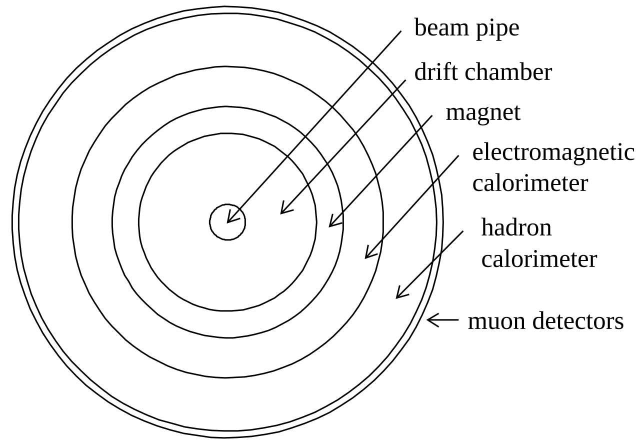
magnet
electromagnetic calorimeter
hadron calorimeter
muon detectors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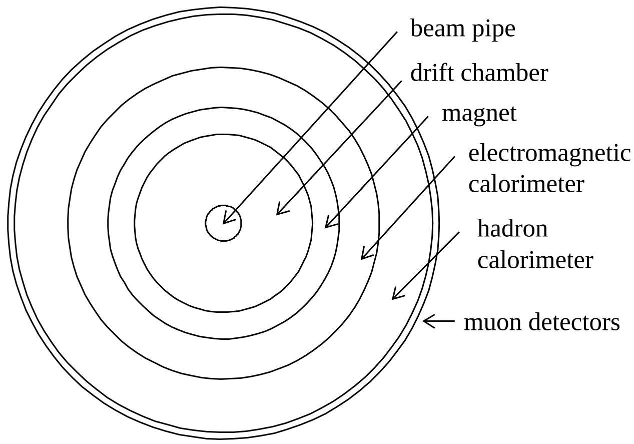
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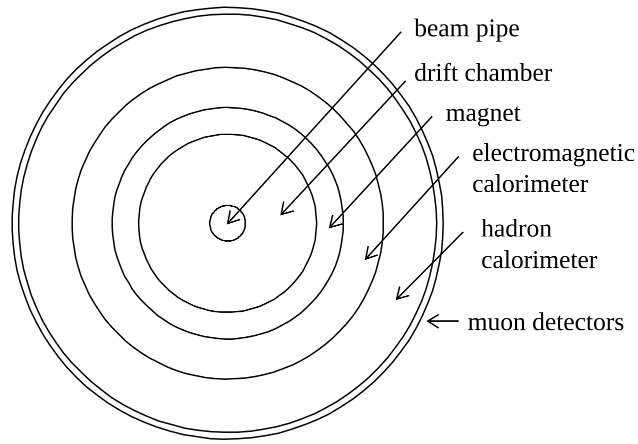
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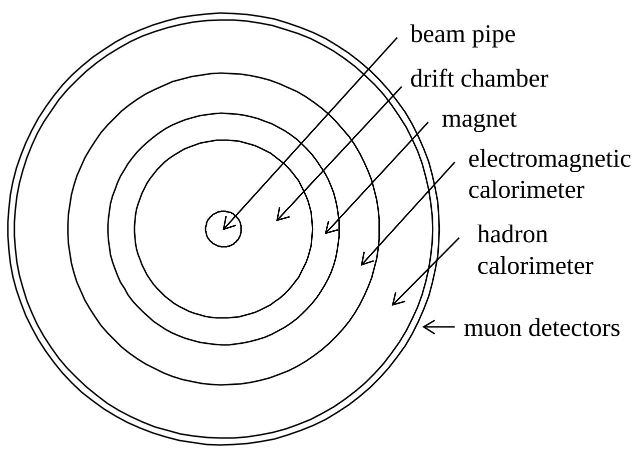
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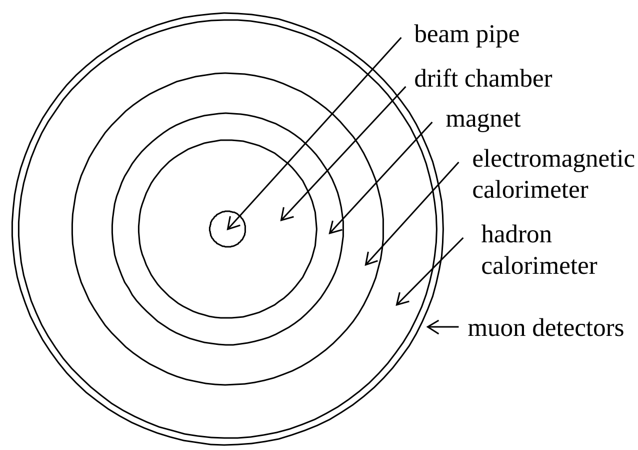
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