Name(s) : Group:

due: 01.12.2011

Particle Physics – Exercise Sheet 7– WS 2011/12

7.1 3-jet cross section (40P)

In electron-positron collisions at PETRA (DESY) jet events are observed from the hadronisation of quarks from the process: $e^+e^- \to q\bar{q}$. From energy-momentum conservation it follows that the two jets have to be back-to-back. However, also events as shown in Fig. 1 were observed.

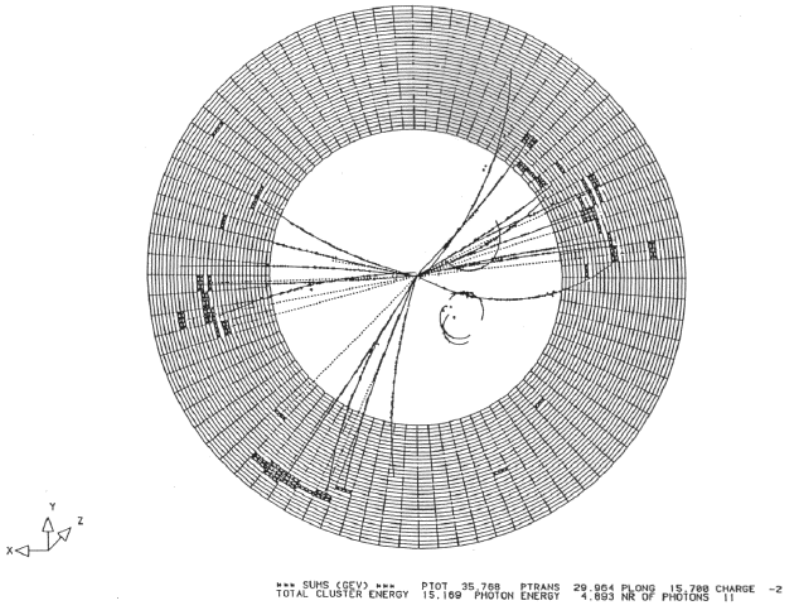

Figure 1: Particle trajectories in the transverse plane from $e^+e^- \to$ hadrons observed with the JADE detector at $\sqrt{s} = 31\,\text{GeV}$.

a) Draw the leading order Feynman diagram to explain this observation.

b) Estimate the theoretical cross section for the 3-Jet events at an energy of $\sqrt{s} = 31\,\text{GeV}$.
How big is α_s at this energy?
How many 3 Jet events were produced at PETRA running at a luminosity of $10^{30} s^{-1} cm^{-2}$ for one month (30 days) with a duty cycle of 70% ?

c) What is the experimental difficulty in the measurement of the $e^+e^- \to q\bar{q}g$ cross section?

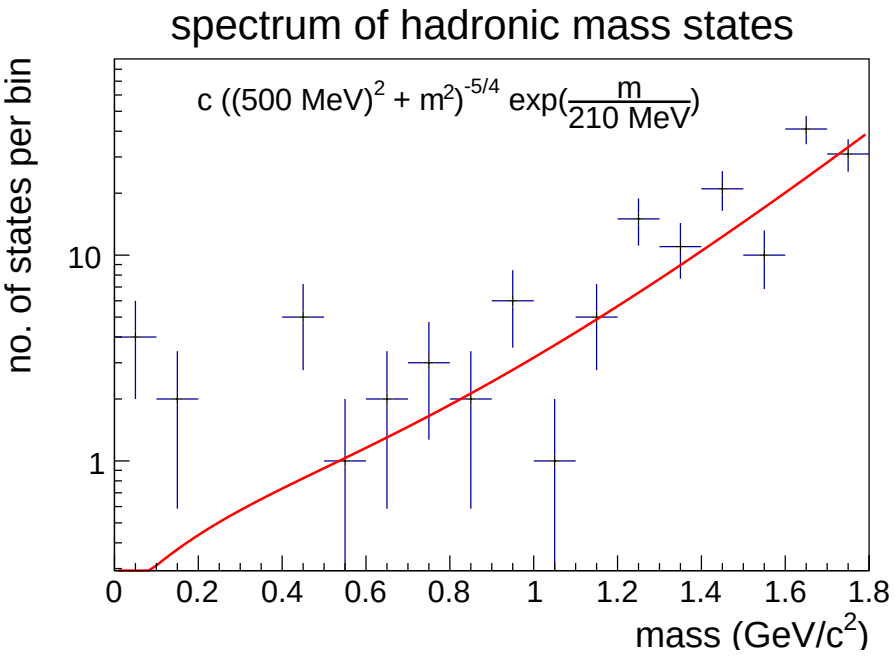

Figure 2: spectrum of hadronic states

7.2 Leptonic decays of vector mesons (30P)

Vector mesons have spin - parity quantum numbers $J^{PC} = 1^{--}$ and can decay into pairs of leptons. The lowest lying states for the different flavour quantum numbers are $\rho, \omega, \phi, J/\psi$ andΥ.

a) Draw the Feynman diagram for this process.

b) Neglecting phase space effects calculate the expected ratio of leptonic decay widths for the states listed above.

c) Compare your expectations to the experimental findings (http://www-pdg.lbl.gov/). What can you conclude?

7.3 Hagedorn's problem (30P)

The number of hadronic states per mass interval can be described by:

$$c(m_0^2 + m^2)^{-\frac{5}{4}} \exp\left(\frac{m}{b}\right). \tag{1}$$

The corresponding fit is shown in Figure 2.

a) Assume that the hadron mass spectrum continues according to Eq. 1. Write down the canonical partition sum assuming that the hadronic states are the only degrees of freedom. What is the implication if hadronic matter in thermal equilibrium is continuously heated?

b) In PbPb collisions at the LHC very high energy densities and temperatures are achieved. What is the way out of the dilemma described in (1).