electromagnetic current: $\sqrt{s} < 2m_c \sim 3\,\mathrm{GeV}$

$$J_\mu^{\mathrm{em}} = \frac{2}{3}\bar{u}\gamma_\mu u - \frac{1}{3}\bar{d}\gamma_\mu d - \frac{1}{3}\bar{s}\gamma_\mu s = J_\mu^\rho + J_\mu^\omega + J_\mu^\phi$$

$$J_\mu^\rho = \frac{1}{2}(\bar{u}\gamma_\mu u - \bar{d}\gamma_\mu d)$$

$$J_\mu^\omega = \frac{1}{6}(\bar{u}\gamma_\mu u + \bar{d}\gamma_\mu d)$$

$$J_\mu^\phi = -\frac{1}{3}(\bar{s}\gamma_\mu s)$$

quark gas at finite temperature:

$$\frac{dR}{dM^2} = R^q \frac{\alpha^2}{6\pi^2} MTK_1(M/T)$$

$$R^q = N_c \sum_f e_f^2 = 3(\tfrac{4}{9} + \tfrac{1}{9} + \tfrac{1}{9})$$

resonance gas at finite temperature:

$$\frac{dR}{dM^2} = R^{\mathrm{exp}} \frac{\alpha^2}{6\pi^2} MTK_1(M/T)$$

$$R^{\mathrm{exp}} = \frac{\sigma(e^+e^- \to \mathrm{hadrons})}{\sigma(e^+e^- \to \mu^+\mu^-)}$$