Particle Physics Phenomenology II

FS 11, Series 10

Due date: 09.05.2011, 1 pm

Exercise 1

Consider the 3 sigma excess recently found by the CDF collaboration at TeVatron in the W+jj invariant mass distribution (http://arxiv.org/abs/1104.0699). One possibility to explain the bump is to postulate a new particle (spin 0 or spin 1) with a mass around 140GeV, which strongly couples to quarks. In order to evade the electroweak precision tests, which put very strong constraints on new particles charged under the electroweak symmetry group, we could hypothesize that this new state is a heavy spin 1 particle charged only (as far as we know) under SU(3) color. Assume that this particle G couples to quarks exactly like the gluon but with a coupling xg_s where $0 < x < 1$. Further more you may assume that it has transverse and longitudinal polarisations.

i) Show that the spin summed and averaged squared amplitude for the process $q\bar{q'} \to WG$ is given by

$$\sum |M|^2 = x^2 \pi \alpha_s \sqrt{2} G_F M_w^2 |V_{qq'}|^2 \frac{32}{9} \left[\frac{u}{t} + \frac{t}{u} + 2(M_W^2 + M_G^2)\frac{s}{ut} - M_W^2 M_G^2 \left(\frac{1}{u^2} + \frac{1}{t^2} \right) \right]$$

where s, t and u are the usual Mandelstam variables and satisfy $s + u + t = M_W^2 + M_G^2$.

ii) Given that for $x = 1$ the total cross section for $p\bar{p} \to WG$ at the TeVatron would be 32pb, that Tevatron has collected 4.3fb^{-1} of data and that they the bump contains about 50 events find the value of x which reproduces the bump.

iii) In which other signatures would you expect to see traces of this particle? Do you expect it to be ruled out by any existing data?