Baryonic Z' Explanation for the CDF Wjj Excess

The year 2011 is perhaps the last year of running for the Tevatron, which is subject to a severe budget cut. It has been giving insights and challenges to the high energy community.



Fig. 1 The Tevatron, Fermi National Accelerator Laboratory, near Batavia, Illinois, USA. The photo shows the Main Ring and Main Injector as seen from the air. (From http://www.fnal.gov/pub/inquiring/physics/accelerators /index.html)

Nevertheless, the Tevatron would not end with fading colors, but full of surprises. The latest surprise was announced in April 2011. An excess was observed by the CDF collaboration in the invariant-mass window of 120 -160 GeV in the dijet system of the associated production of a W boson with 2 jets [1].



Fig. 2 The dijet invariant mass distribution found in the new Tevatron experiment. The sum of electron and muon events is plotted. In the left plot, CDF show the fits for known processes with the addition of a hypothetical Gaussian component (c). On the right plot CDF show, by subtraction, only the resonant contribution to M_{ij} including WW and WZ production and the hypothesized narrow Gaussian contribution (d). (from CDF [1], reprinted with permission of APS and the authors)

This suggests new physics beyond the standard model of particle physics. If this is a real discovery, it will be among the greatest discoveries of recent decades. Kingman Cheung of <u>National Tsing Hua University</u>, Hsinchu, Taiwan and Jeonghyeon Song of <u>Konkuk University</u>, Seoul [2] recently provided a concise, critical, and very interesting explanation to the excess. They suggested that a new force of nature, mediated by a baryonic Z' proposed 15 years ago, can explain this excess. This baryonic Z' boson is very different from the usual Z boson as it only couples to quarks that carry baryon numbers. Amazingly, with this special property, the baryonic Z' boson can overcome all other constraints imposed on Z' bosons and exactly explain the excess. Cheung and Song [2], which appeared in the May 2011 issue of the Physical Review Letters, rapidly caught eyes of particle physicists world-wide. The paper was cited more than 30 times in the first month after its appearance. Further tests for the Z' boson include looking for excess in similar channels such as photon + 2 jets and Z+2 jets. The expected cross sections are shown in Fig. 3. The other cross sections are only a factor of 2-3 smaller than that of WZ', so that they could also be observable when more data are accumulated. The prospect at the Tevatron looks promising. This baryonic Z' can come from some specific versions of the grand unified theory (GUT) or some entirely new type of models. If this observation is real and a baryonic Z' is confirmed with more data, it will possibly lead to the final theory of particle physics.



Fig. 3: Production cross sections for $WZ', ZZ', \gamma Z', Z'Z'$ versus $M_{Z'}$ at the Tevatron ($\sqrt{s} = 1.96$ TeV). (from Cheung and Song [2], reprinted with permission of APS and the authors)

If the associated production of a baryonic Z' boson with the W boson accounted for the excess in *Wjj* production observed by the CDF at the Tevatron, Cheung and Song went ahead and analyzed other possible channels of this Z' at the Tevatron and at the LHC, including $\gamma Z'$ and Z Z' with the $Z' \rightarrow jj$. They showed that the chances of confirming this baryonic Z' is better at the Tevatron than at the LHC because of the faster growing backgrounds at the LHC. Unfortunately, the current systematic uncertainties of the order of 10% cannot yield any significant excess in both $\gamma Z'$ and ZZ'

channels at the Tevatron and also at the LHC. Nevertheless the search using the $b\bar{b}$ decay mode of Z' is much more feasible at the LHC, provided that the branching ratio $B(Z' \rightarrow b\overline{b}) > 0.1$. In particular. the $WZ' \rightarrow l\nu b\bar{b}$ mode has a signal-to-background ratio larger than 1. Even with 1 fb⁻¹ luminosity at the LHC it can lead to a high significance level. The $WZ' \rightarrow lvb\bar{b}$ and $\gamma Z' \rightarrow \gamma b\bar{b}$ are also highly observable at the Tevatron. More details can be found in the follow-up paper by Cheung and Song [3], which will appear in Physical Review D.

References:

[1] CDF Collaboration (T. Aaltonen *et al.*), Invariant Mass Distribution of Jet Pairs Produced in Association with a W boson in $p\overline{p}$ Collisions at $\sqrt{s} = 1.96$ TeV, Phys. Rev. Lett. 106 (2011) 171801.

[2] Kingman Cheung and Jeonghyeon Song, Baryonic Z' Explanation for the CDF Wjj Excess, Phys. Rev. Lett. 106 (2011) 211803.

[3] Kingman Cheung and Jeonghyeon Song, *The* Golden Mode for a Baryonic Z' Boson at Hadronic Colliders: $pp/pp \rightarrow WZ' \rightarrow lvb\bar{b}$, arXiv:1106.6141 [hep-ph], to appear in Phys. Rev. D.