Search for heavy resonances in the dimuon channel with the D0 detector
van den Berg, P.J.

Citation for published version (APA):
van den Berg, P. J. (2009). Search for heavy resonances in the dimuon channel with the D0 detector.

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Chapter 7

Conclusion & Outlook

We have used 1 fb\(^{-1}\) of high-\(p_T\) dimuon data taken by the D∅ detector to look for a new heavy mass resonance. Since no significant excess over the Standard Model background was found, upper limits on the production cross-section times the branching ratio to muons were calculated for several models of new physics.

We set a lower 95% credibility limit on the mass of a hypothetical Standard Model-like \(Z'\) decaying to muons of 838\(^{+5}_{-8}\) GeV/c\(^2\). These cross section limits were interpreted as limits on the mass and couplings for generic models with an extra gauge boson; the limits on the mass of the \(Z_\psi\), \(Z_\eta\) and \(Z_\chi\) bosons that arise in various \(E_6\) grand unified theories were constrained to be 665 GeV/c\(^2\), 654 GeV/c\(^2\) and 790 GeV/c\(^2\) respectively.

We also set a limit for a spin-2 resonance predicted by the Randall-Sundrum model. The mass of the lightest massive graviton in the Randall-Sundrum model was constrained to be \(M_{G[1]} > 693\) GeV/c\(^2\) for \(k/M_P = 0.1\) at a 95% CL. These are the most stringent limits on \(\sigma(p\bar{p} \rightarrow Z' + X) \times BR(Z' \rightarrow \mu^+\mu^-)\) and \(\sigma(p\bar{p} \rightarrow G[1] + X) \times BR(G[1] \rightarrow \mu^+\mu^-)\) from direct searches to date.

As can be inferred from figures 6.4 and 6.6, the results are limited by statistics. Assuming the systematic uncertainties are unchanged\(^1\), the (mean) expected limit on the mass of a hypothetical SM-like \(Z'\) (assuming no new physics) would be 907 GeV/c\(^2\) with 4 fb\(^{-1}\) of data, which is about the amount of data on tape by the time of writing, or 955 GeV/c\(^2\) with 8 fb\(^{-1}\) of data, which the Tevatron is expected to have delivered by the end of 2010.

After that time the limits set by the LHC experiments might be much better, due to the larger energy range and luminosity available; a Standard Model-like \(Z'\) with a mass up to 2.5 TeV/c\(^2\) could be excluded with 1 fb\(^{-1}\) of LHC data and one with a mass up to 5 TeV/c\(^2\) with about 200 fb\(^{-1}\) of LHC data [87, 88].

Similar direct searches have been done in dielectron and dielectron plus diphoton data at D∅ and CDF [32, 33, 48] (see table 2.3). For models with generation-independent fermion couplings, these analyses resulted in more stringent limits on the presence of

\(^1\)The largest experimental systematic uncertainty comes from the uncertainty on the track resolution, which would be reduced by at most \(\sim 30\%\) with increased statistics (see table 5.3).
heavy resonances, or similar limits with less data, because of the higher acceptance
and better mass resolution that can be achieved for these channels. In addition, the
search for RS gravitons in the $e^+e^- + \gamma\gamma$ channel has the advantage of the double
branching ratio of the (spin-2) gravitons to photons.

Apart from the accumulation of more data, the inclusion of additional channels, and
the combination with CDF searches, one possible way of improving this analysis
would be to use the dimuon decay angle in addition to the dimuon invariant mass as
a discriminating variable; this would however introduce additional model dependence
to the limits.