Mass Degenerate Heavy Vector Mesons at Hadron Colliders

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Talk Outline

1. Introduction
2. A Rule of Thumb on Event Rates
3. Crash Course on Asymmetry Measure
4. Asymmetry at the LHC
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Introduction

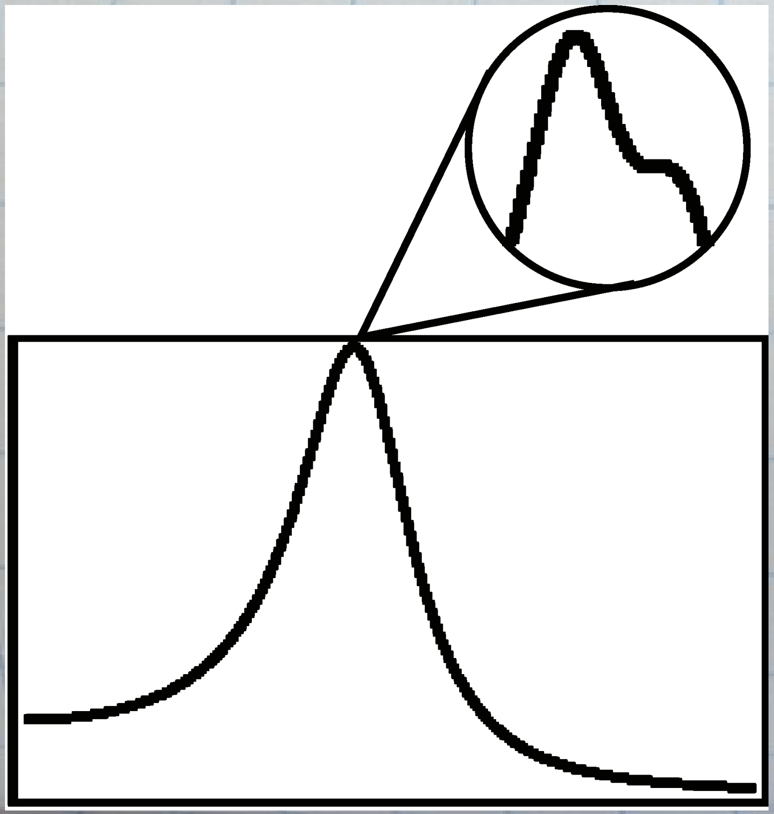
1. New resonances for the fun of it!
2. Many SM extensions e.g. Technicolor
3. LHC will push back current reach
4. Study ability to tell a Z-prime apart from a photon-prime.

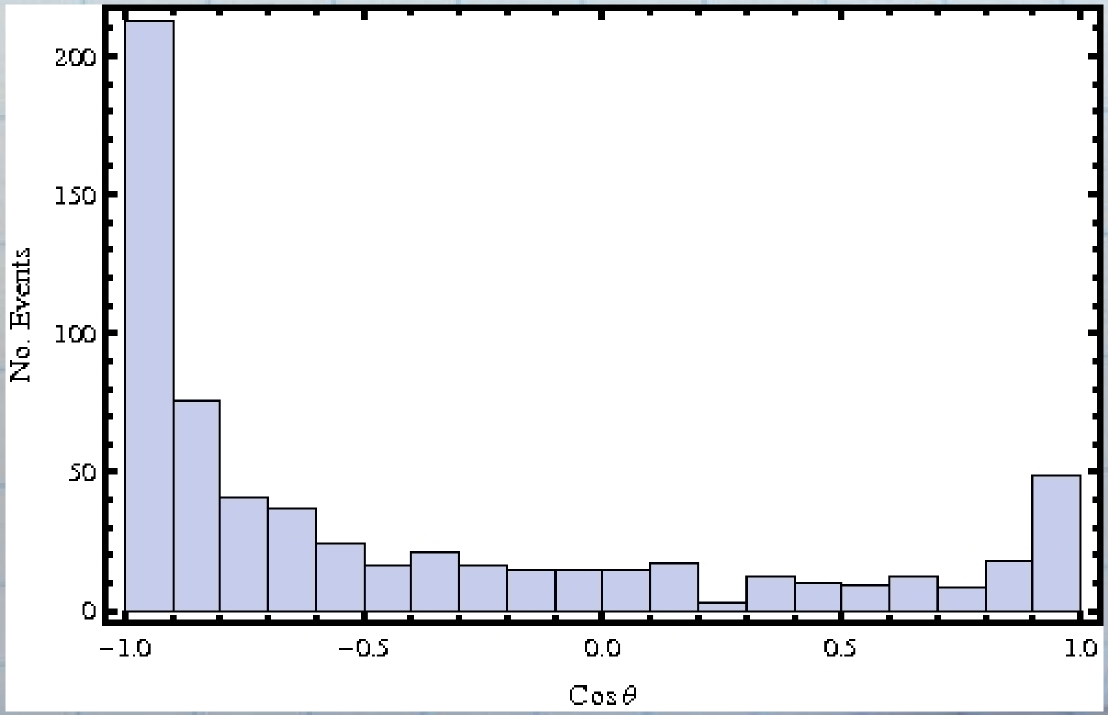
Introduction

1. We study the Drell-Yan process into muons where there is a low background
2. Assume "degenerate" masses so that Z-prime and photon-prime peaks overlap
3. Add a new set of SU(2)xU(1) fields to the SM Lagrangian and assume some mechanism breaks the symmetry down to EM giving a single "degenerate" TeV mass to the new fields and SM values to SM fields.

An Example Simulation

Below is a cartoon of what a new peak may look like and the possible hidden peak structure. This might be revealed by asymmetry plots (right).





A Rule of Thumb on Event Rates

We can all compute the amplitude of qqbar to muons in the SM. All we must do is take this amplitude and add to it the same again but with coupling Rg^2 and a photon-prime/Z-prime mass of m.

$$\mathcal{M}_\gamma + \mathcal{M}_Z + \mathcal{M}_{\gamma'} + \mathcal{M}_{Z'}$$

Now we can find the cross-section,

$$\frac{d\sigma_{q\bar{q}}}{d\hat{s}}$$

Rule of Thumb (cont.)

Now we turn qqbar into a pp collision with a set of parton distribution functions (PDFs). We can say that,

$$N = \int \sum_q \frac{d\sigma_{q\bar{q}}}{d\hat{s}} \mathscr{L}_q d\hat{s}$$

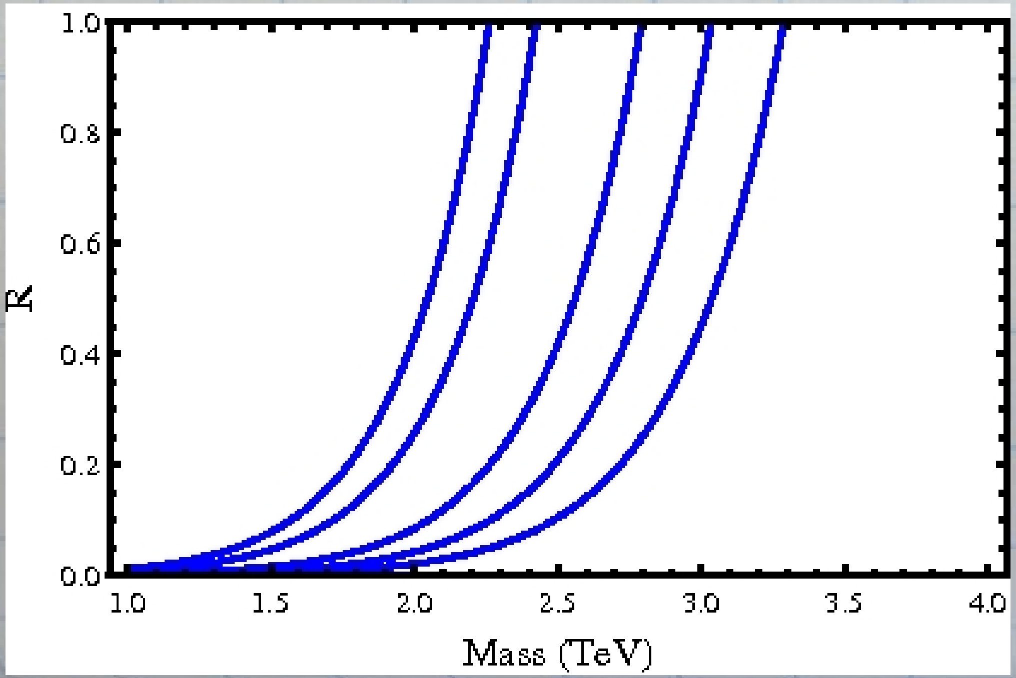
This can be approximated as (see paper for how!),

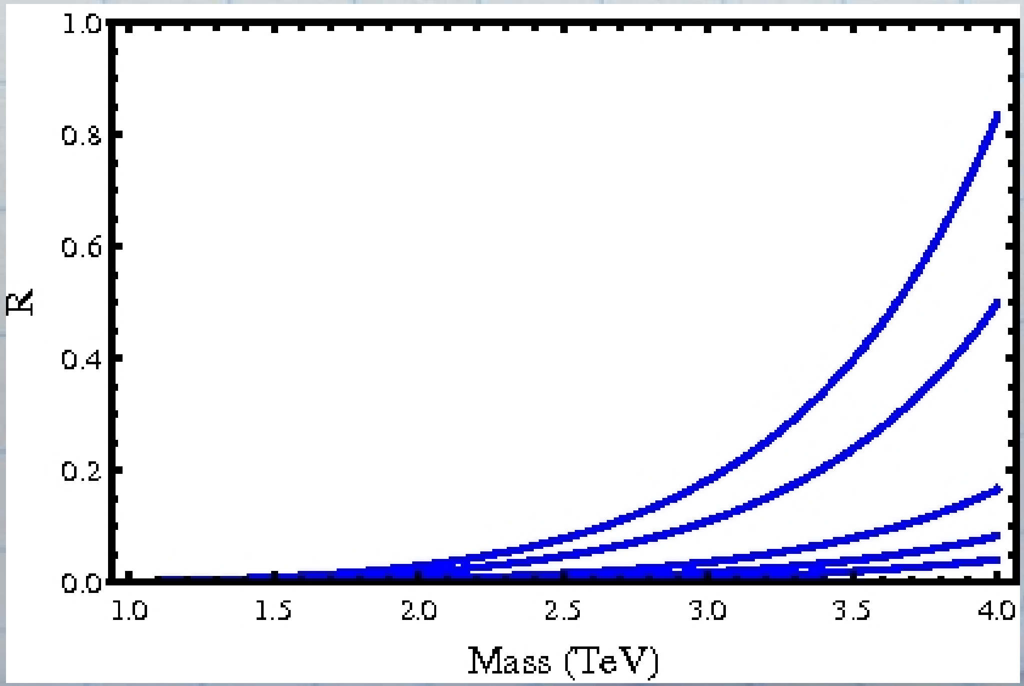
$$N = \kappa \frac{sLR}{m^4}$$

Example Plots

Using the Fermi02 PDF set (available through LHAPDF) we turn the handle.

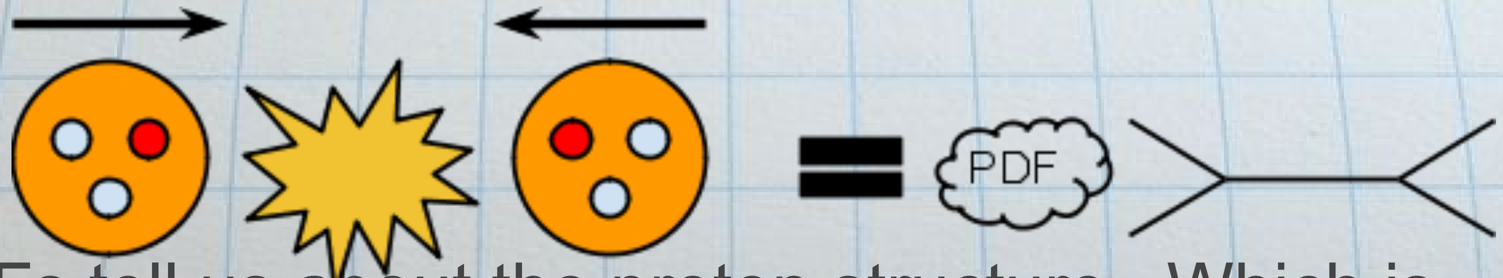
Here are 2 example plots of mass vs coupling at 10 (left), 24 (right) TeV for the event rate/luminosity of (from left to right) 5, 3, 1, 1/2, 1/4 fb.





A Crash Course on Asymmetry Measure

The new pole may be asymmetric in the forward-backward plane, but it's hard to know which way is forward in a hadron machine.



The PDFs tell us about the proton structure. Which is something like uud + a lot of glue. Consider the high rapidity collisions only. Then most of the energy is from one proton and it's a lot easier to get a high energy u(or d) than a ubar(dbar) by the proton make-up.

Beware of high fraction PDFs - the errors are very large.

Part II of the Crash

By cutting the data in an experiment for high rapidity only, we can (with some error) know the initial quark directions and extract an asymmetry.

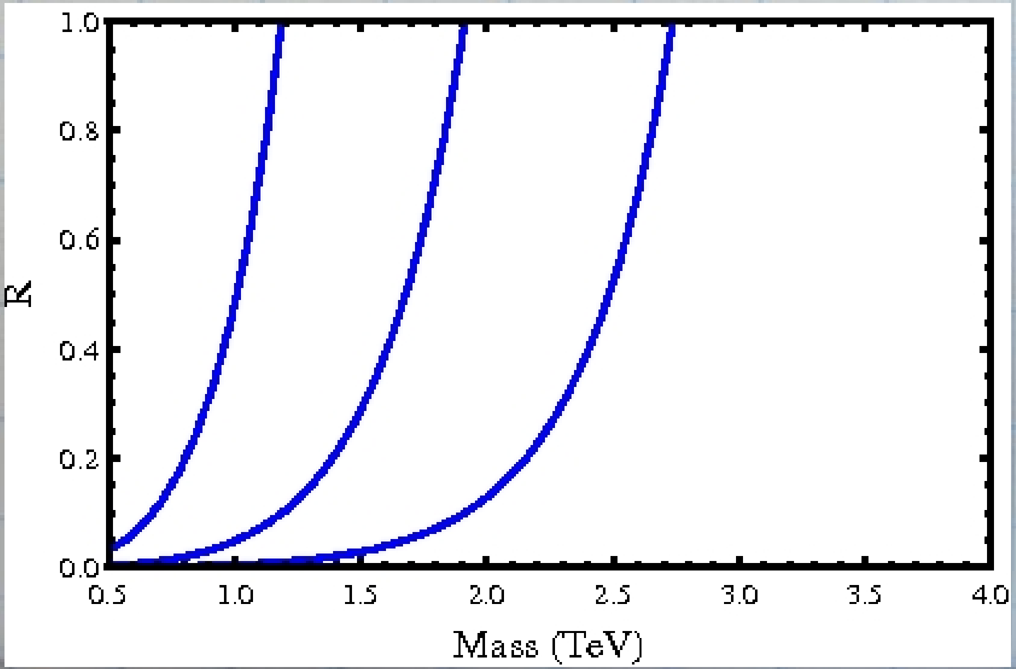
$$\langle\theta\rangle = \int_0^{\pi} \theta \left[\frac{3}{8}(1+\cos^2\theta) + A_{FB}\cos\theta\right] d\theta = \frac{\pi}{4}(2 - A_{FB})$$

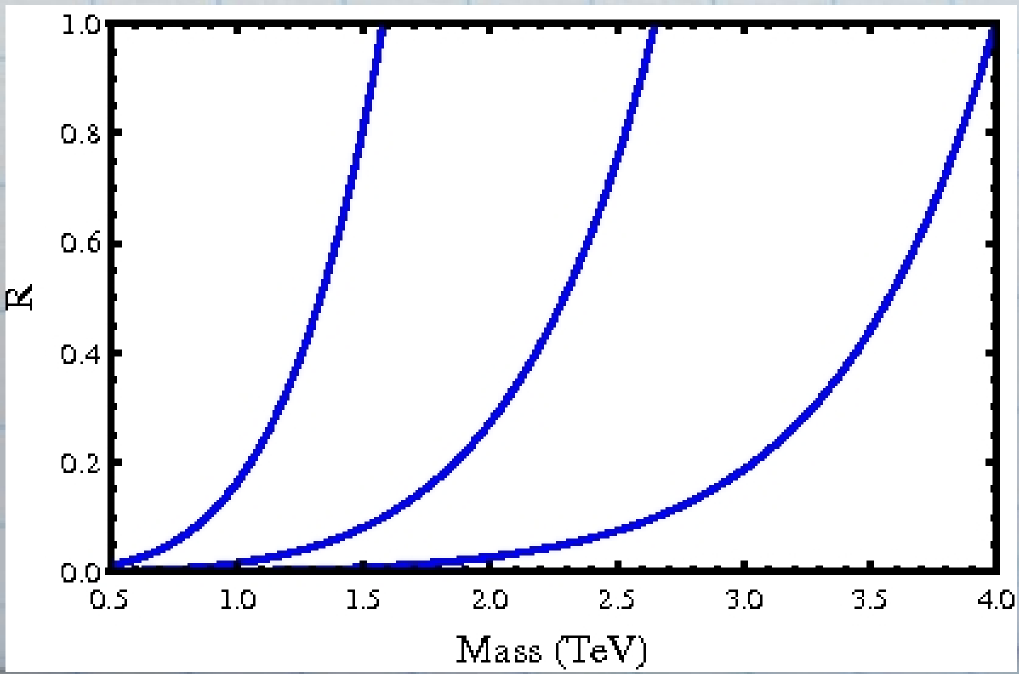
$$\Delta A_{FB} = 2p(Y_c) + \frac{4\sigma}{\pi\sqrt{n-1}}$$

Asymmetry at the LHC

$$N \geq \frac{1}{P}\left[\left(\frac{4\sigma}{\pi(\mathscr{E}-2p)}\right)^2+1\right]$$

For a 14 (left), 24 (right) TeV machine and at L =(from left to right) 1, 10, 100 fb^-1 a 3 sigma effect is observed in the m vs R plane as follows,





Summary

Our theoretical study of the potential reach of a hadron machine has shown the great improvement in going from 10/14 to 24 TeV.

We have seen a scenario where increasing the energy of a hadron collider would allow a precision measure in contrast to requiring more luminosity (which is generally the case).

This is a result of the PDF scaling behaviour - more events have high rapidity with higher energy.