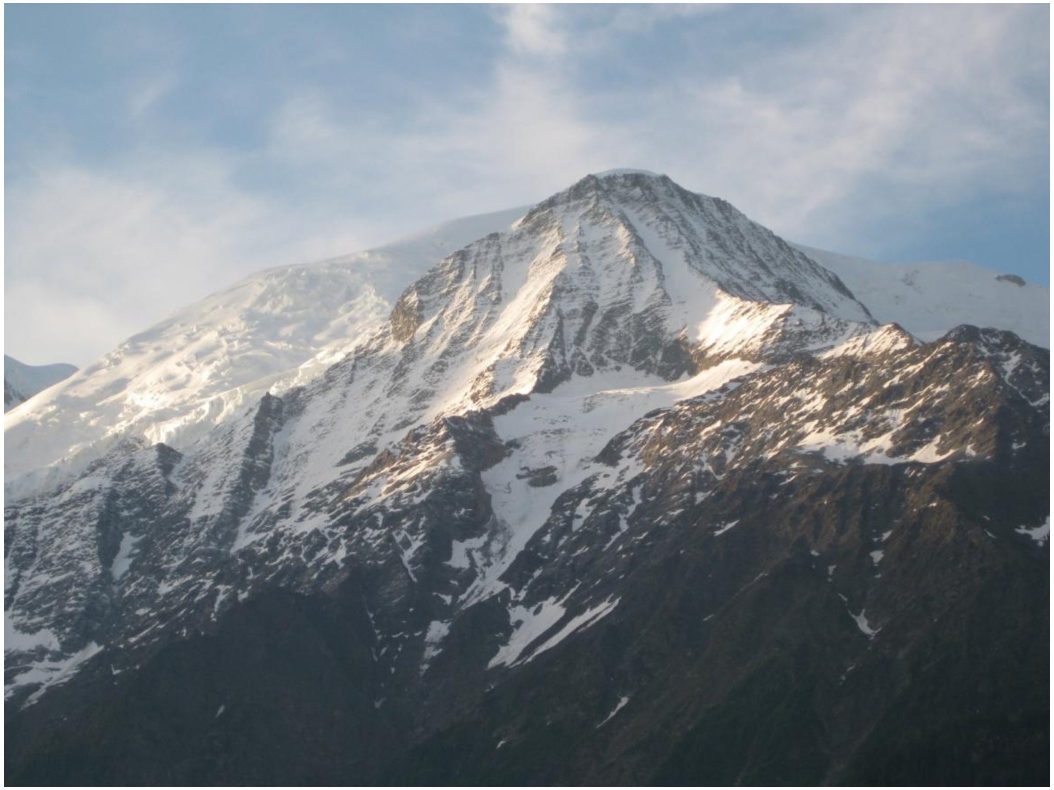
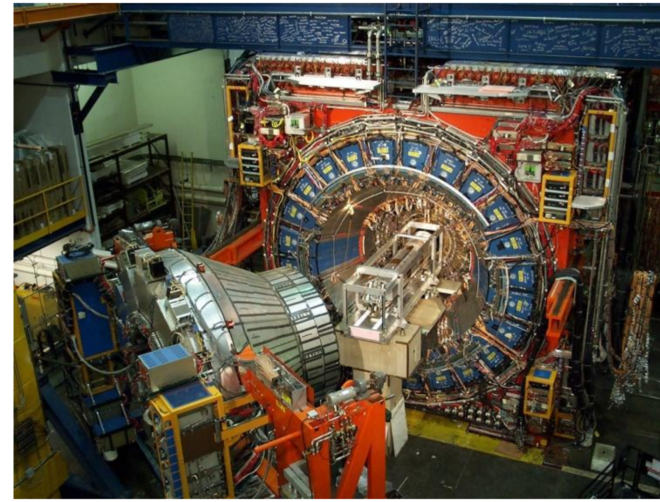
Leptophobic Z' Associated Production & Wjj





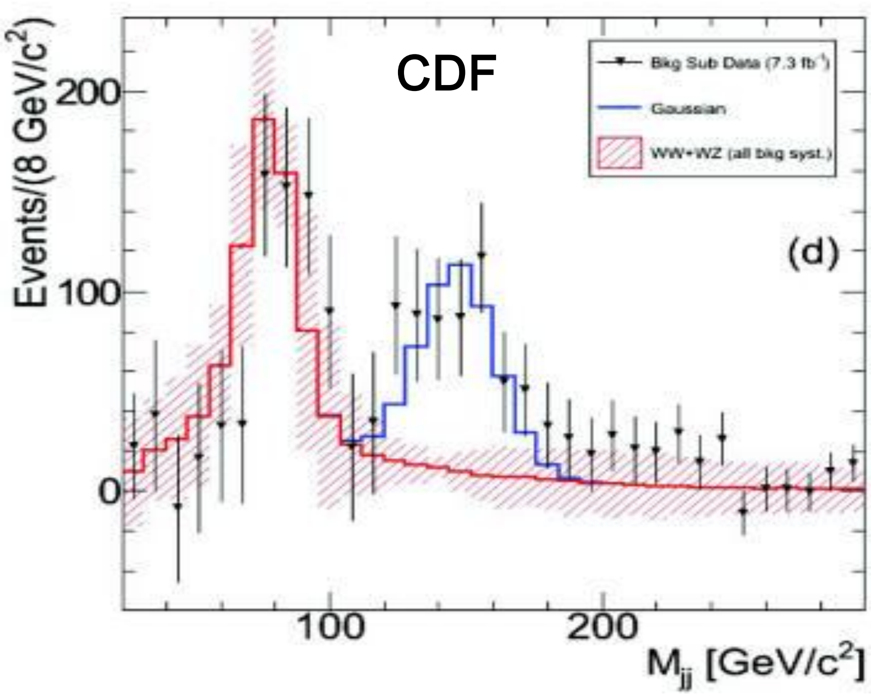
SLAC NATIONAL ACCELERATOR LABORATORY

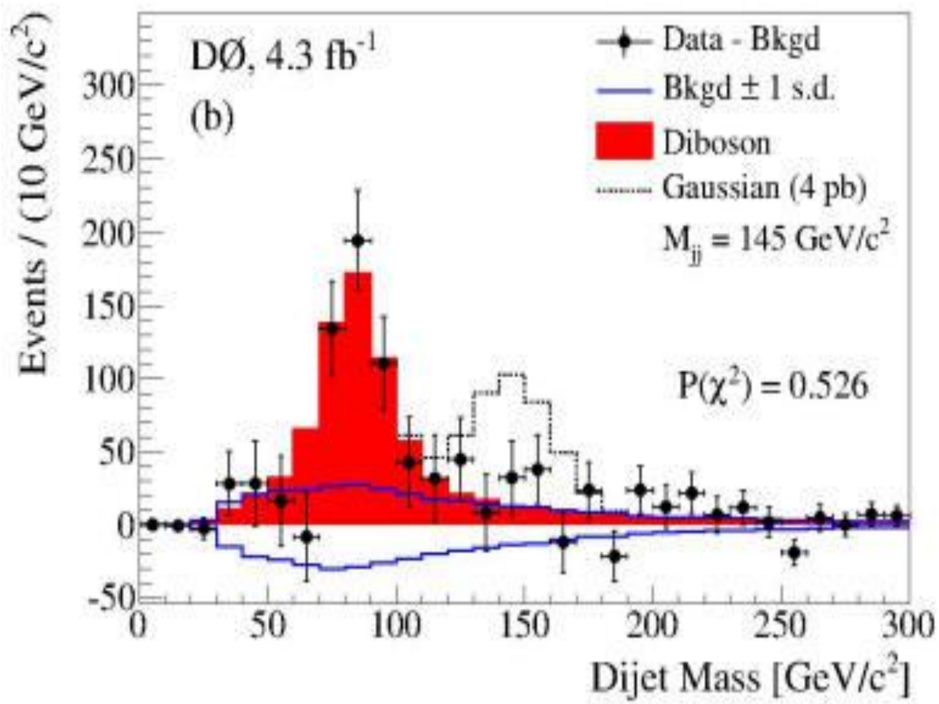
06/13/11

J. L. Hewett & TGR

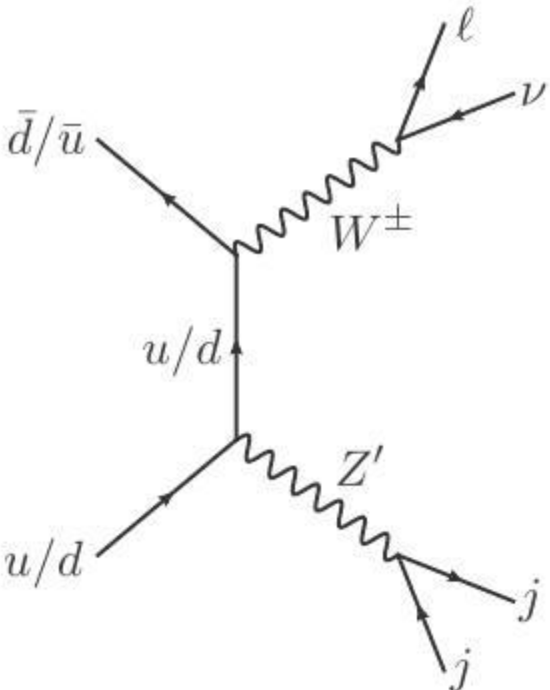
arXiv:1106.0294

?????





$\rightarrow$ M $\approx$ 147 GeV, $\Gamma <<$ σ_m =14.3 GeV, $\sigma \approx$ 1-4 pb



(+ t → u)

Leptophobic Z'

M. R. Buckley, D. Hooper, J. Kopp, E. Neil, [arXiv:1103.6035 [hep-ph]]; F. Yu, [arXiv:1104.0243 [hep-ph]]; P. Ko, Y. Omura, C. Yu, [arXiv:1104.4066 [hep-ph]]; D. - W. Jung, P. Ko, J. S. Lee, [arXiv:1104.4443 [hep-ph]]; Z. Liu, P. Nath, G. Peim, [arXiv:1105.4371 [hep-ph]].

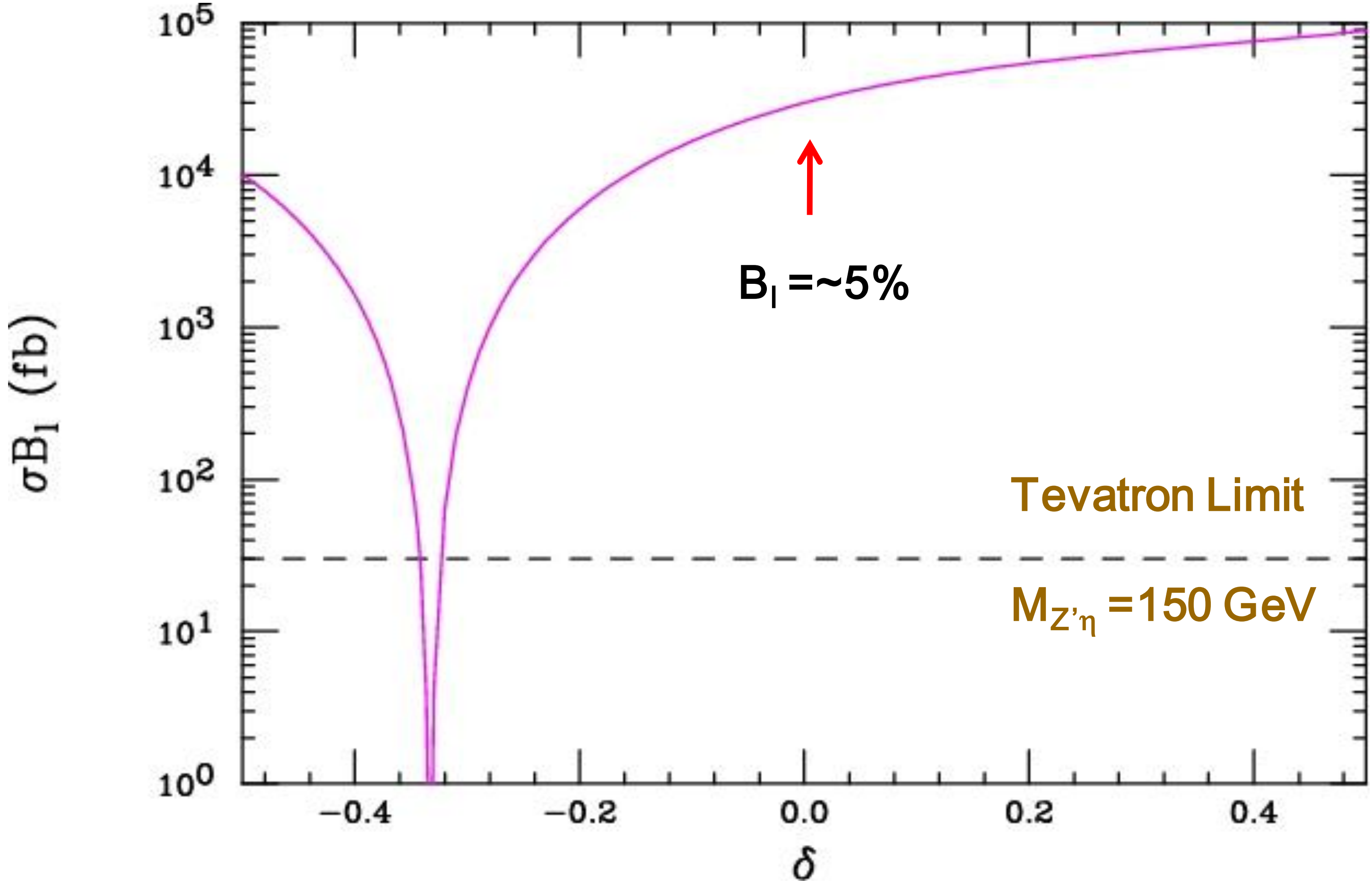
X. -P. Wang, Y. -K. Wang, B. Xiao, J. Xu, S. -h. Zhu, [arXiv:1104.1161 [hep-ph]]; K. Cheung, J. Song, [arXiv:1104.1375 [hep-ph]]; L. A. Anchordoqui, H. Goldberg, X. Huang, D. Lust, T. R. Taylor, [arXiv:1104.2302 [hep-ph]]; M. Buckley, P. Fileviez Perez, D. Hooper, E. Neil, [arXiv:1104.3145 [hep-ph]];

Not your typical animal !

→ Leptophobic? A ~150 GeV Z' must be leptophobic to avoid LEP2, Tevatron & LHC constraints on dilepton resonances

$B(Z' \to jj) = 1$ $(B \to l^+ l^- < \sim 10^{-4})$ →→

- To avoid FCNC issues we assume generation-independence otherwise we follow a model-independent approach



An example GUT-based model w/ a kinetic mixing parameter that allows it to become sufficiently leptophobic to evade both the Tevatron & the LHC Drell-Yan bounds.

EXTREMELY fine-tuned! The required suppression is > ~10^3

• Without PREJUDICE there are only 4 unknown parameters:
$u_{L,R}$, $d_{L,R}$ → What are their values ?

• However in WZ' production the W's LH nature projects out only $(u, d)_L$!

u → t non-symmetric

$$\frac{d\sigma}{dz} = K_W \frac{G_F^2 M_Z^4}{48\pi \hat{s}} (2c_W^2)\beta_W \left[(u_L - d_L)^2 X + \left[u_L^2 \frac{\hat{s}^2}{\hat{u}^2} + d_L^2 \frac{\hat{s}^2}{\hat{t}^2} \right] Y + 2u_L d_L (M_W^2 + M_{Z'}^2) \frac{\hat{s}}{\hat{u}\hat{t}} \right]$$

z=cos θ

$$X = \frac{1}{M_W^2 M_{Z'}^2} \left[\frac{1}{4}(\hat{u}\hat{t} - M_W^2 M_{Z'}^2) + \frac{1}{2}(M_W^2 + M_{Z'}^2)\hat{s} \right]$$

Brown & Mikaelian '79
Cvetic & Langacker '92

$$Y = (\hat{u}\hat{t} - M_W^2 M_{Z'}^2)/\hat{s}^2$$

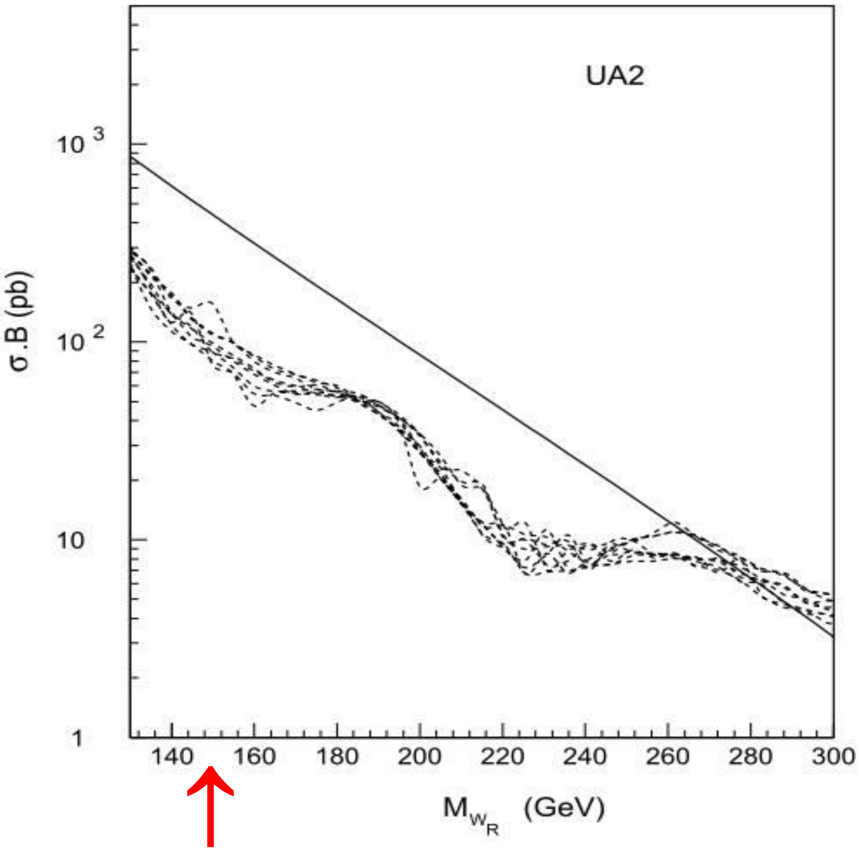
u → t
symmetric

→ Distributions will be coupling sensitive

→ $d\sigma \sim A\,(u_L^2 + d_L^2) + B\, u_L d_L$ (an ellipse for any fixed σ)

• However, the couplings can't be arbitrary as s-channel Z' production leads to a dijet resonance @ ~150 GeV

• For these masses the best limit on a spin-1 dijet resonance comes from UA2 (in '93 !) :

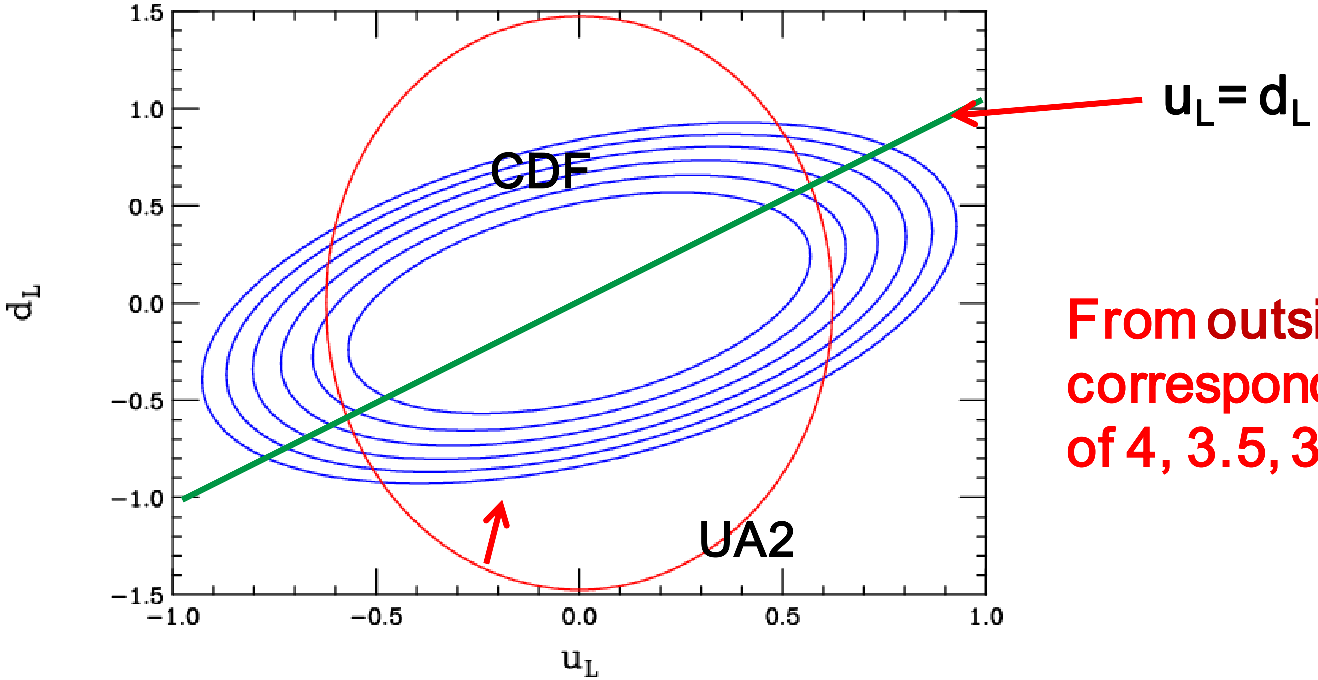


$\sigma_{jj} = A_j (u_L^2 + u_R^2) + B_j (u \rightarrow d)$

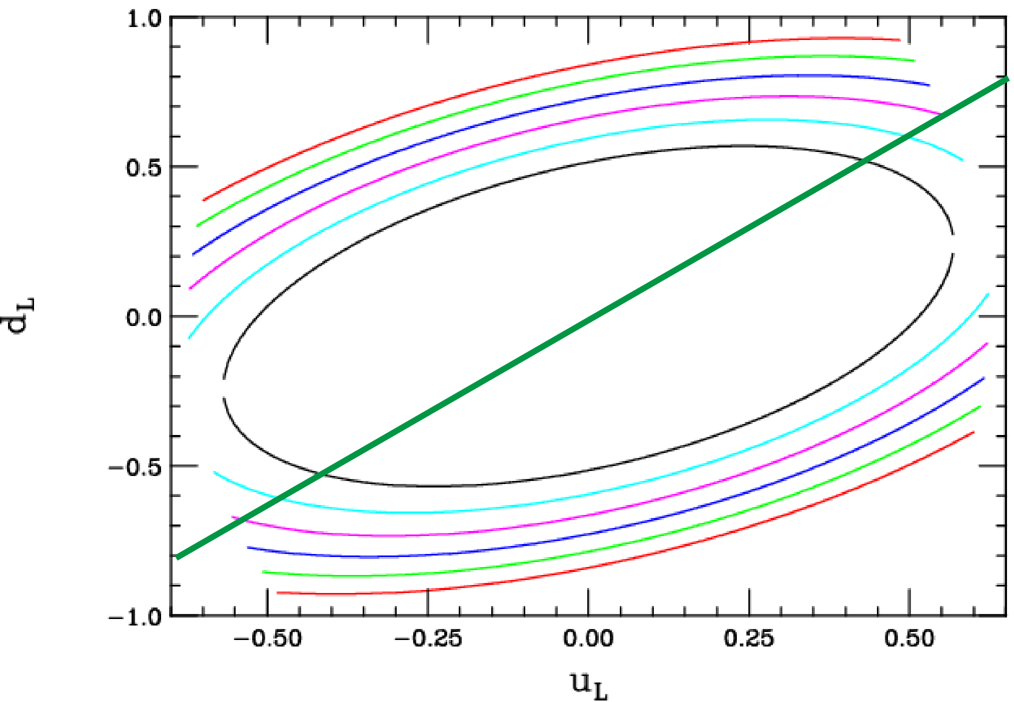
<~ 150 pb for M(Z') ~150 GeV

→ another ellipse in the $(u, d)_L$ plane we need to look at

So, at best, w/ $(u, d)_R = 0$ …



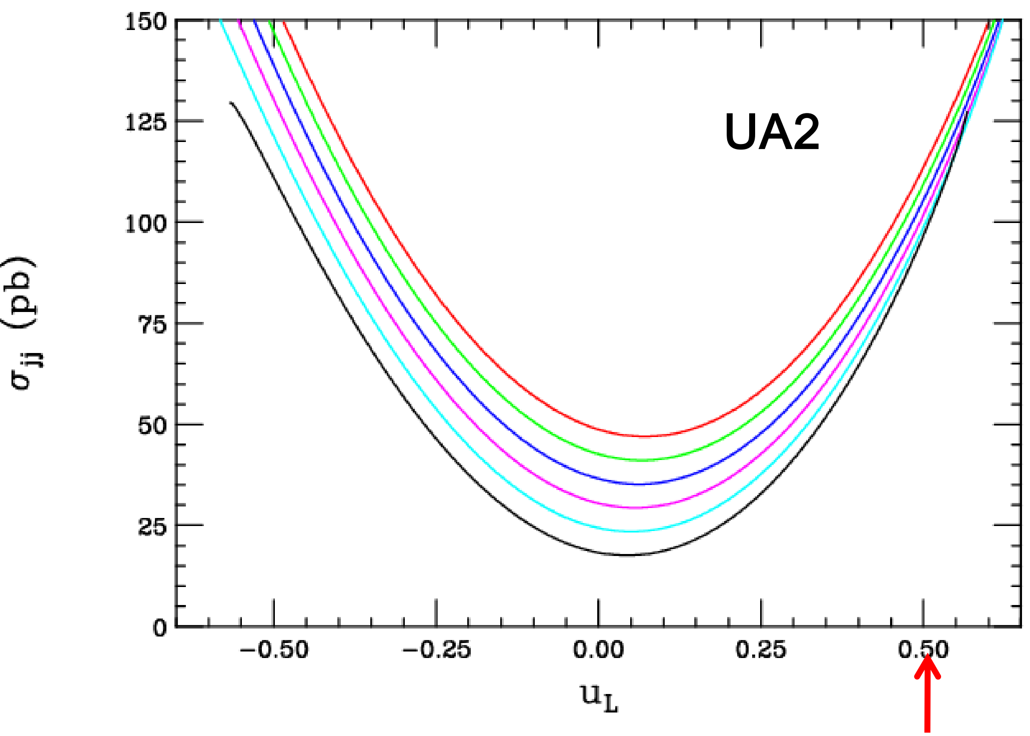
From outside in the blue ellipses correspond to WZ' cross sections of 4, 3.5, 3,…,1.5 pb



The truncated ellipses (arcs) will remain allowed in the least constrained case of $(u,d)_R = 0$

What are the values of σ_{jj} ?

('upper' solutions only)



For every point on these curves we can determine the set of values of $(u,d)_R$ which are allowed by the UA2 constraint & scan over them. ($5\cdot 10^9$ pts)

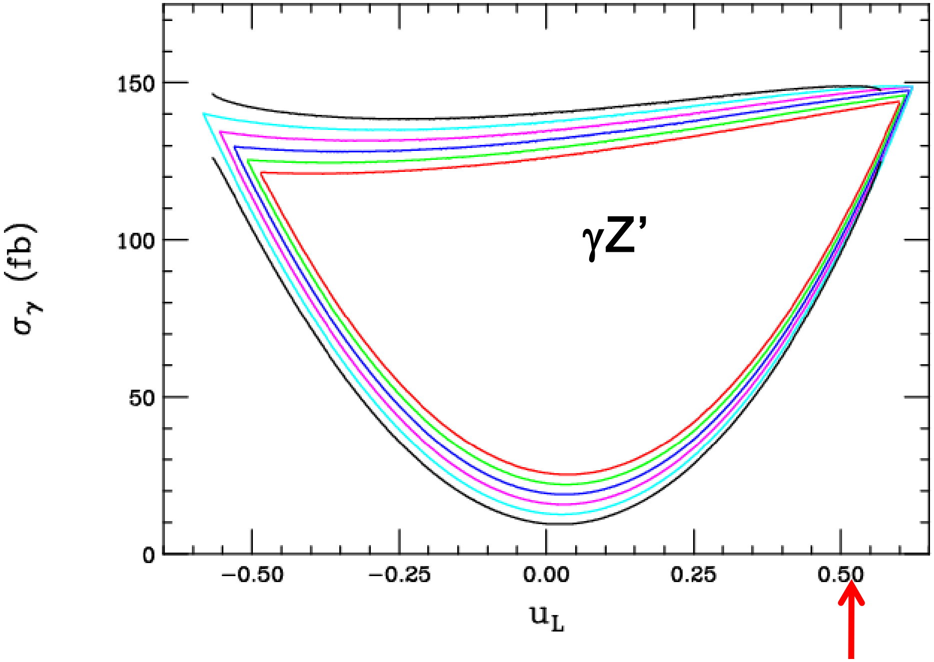
We can then use this info to calculate other quantities

$$\sigma_{\gamma Z'} = A_\gamma (u_L^2 + u_R^2) + B_\gamma (u \rightarrow d)$$

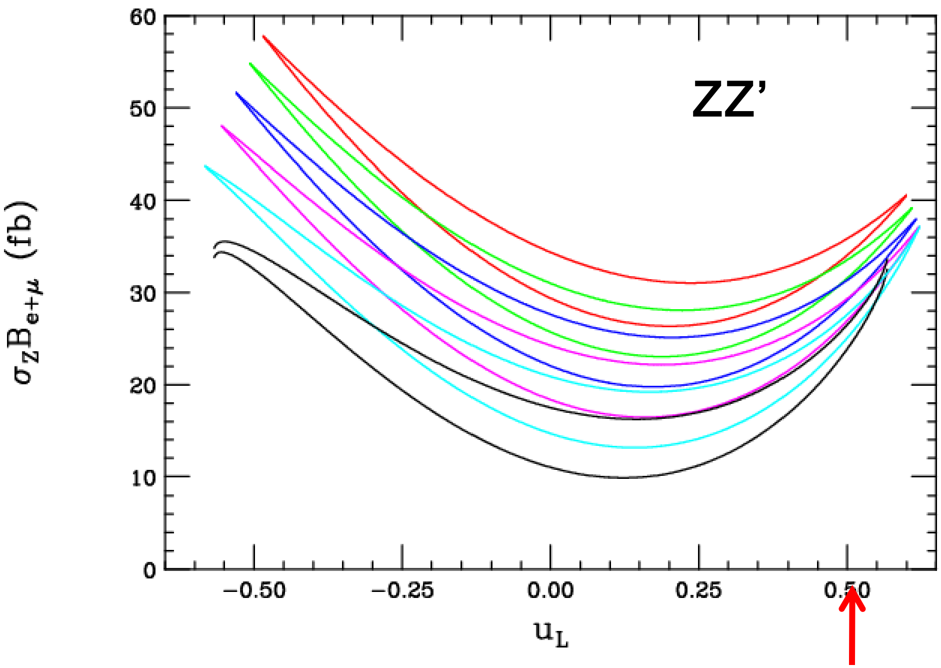
$|\eta_\gamma| < 1$ (2.5), $p_T^\gamma > 25(50)$ GeV for TeV (LHC)

$$\sigma_{ZZ'} = \alpha\, u_L^2 + \beta\, u_R^2 + \gamma\, d_L^2 + \delta\, d_R^2$$

→ Remember all the coefficients are fixed by the kinematics and the PDFs while the couplings are scanned over



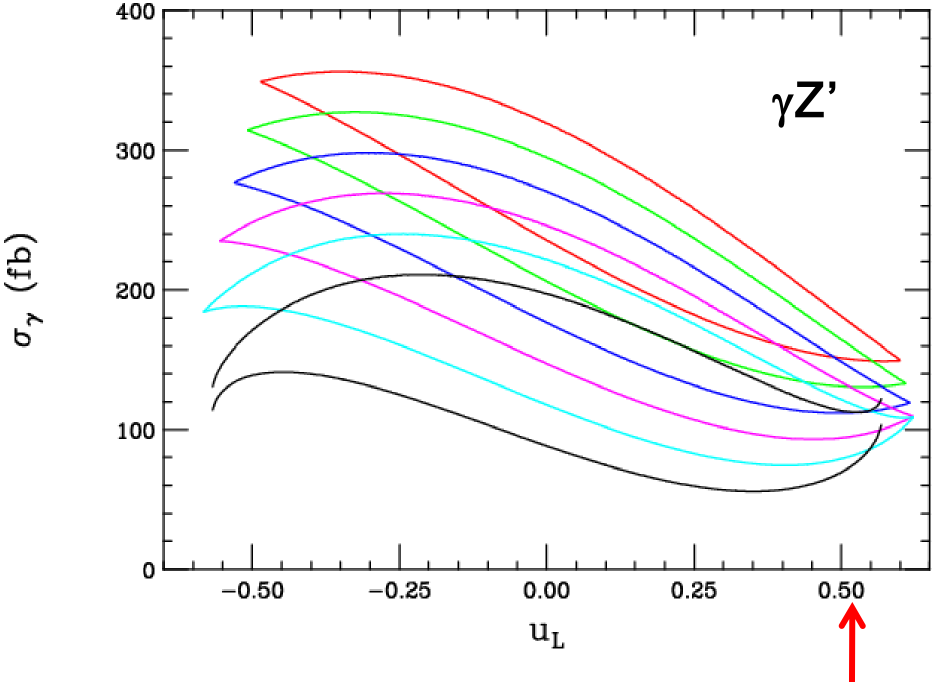
The predicted allowed regions lie inside the color-coded curves which correspond to a fixed value of the Tevatron WZ' cross section

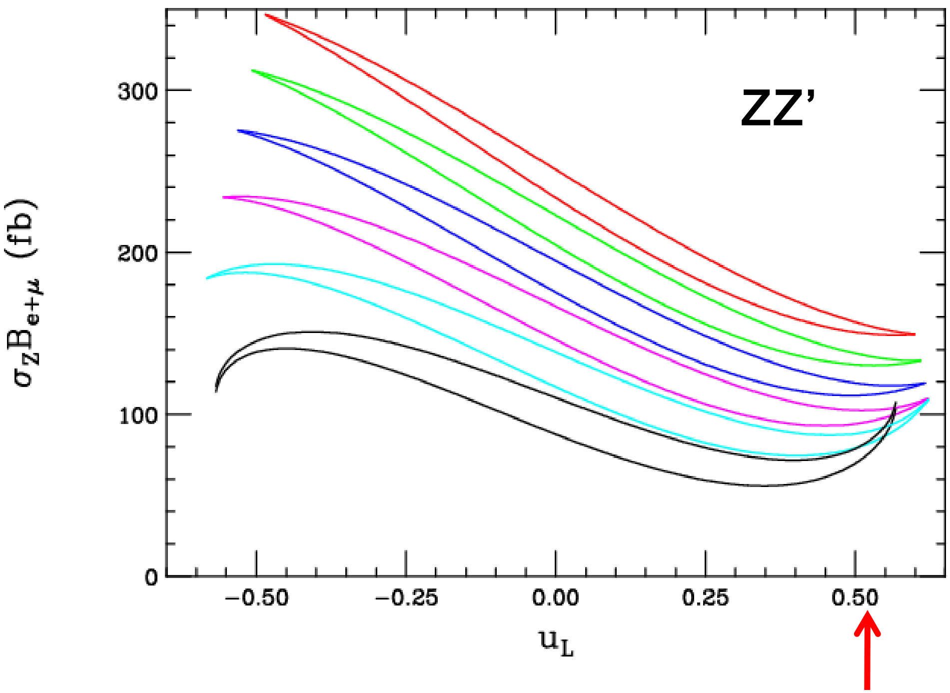


Note that these cross sections are both small & should not have been seen at the Tevatron

Observing such processes would provide additional constraints on the Z' couplings

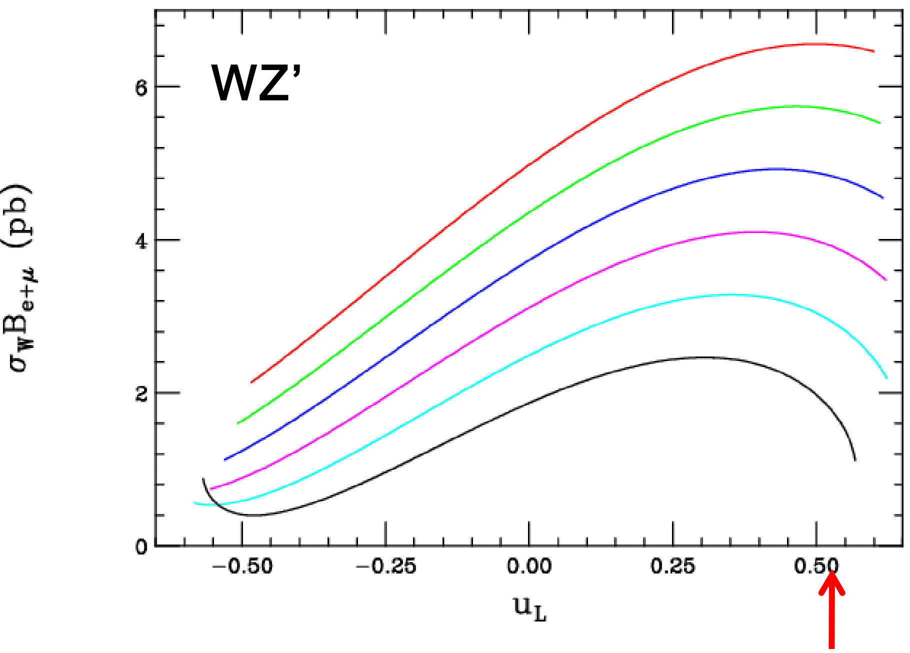
At the 7 TeV LHC…

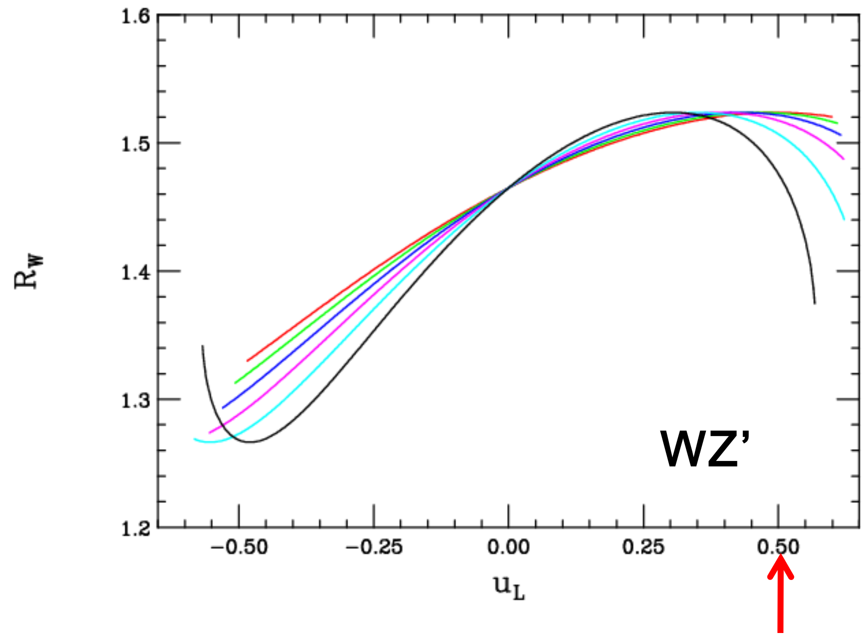




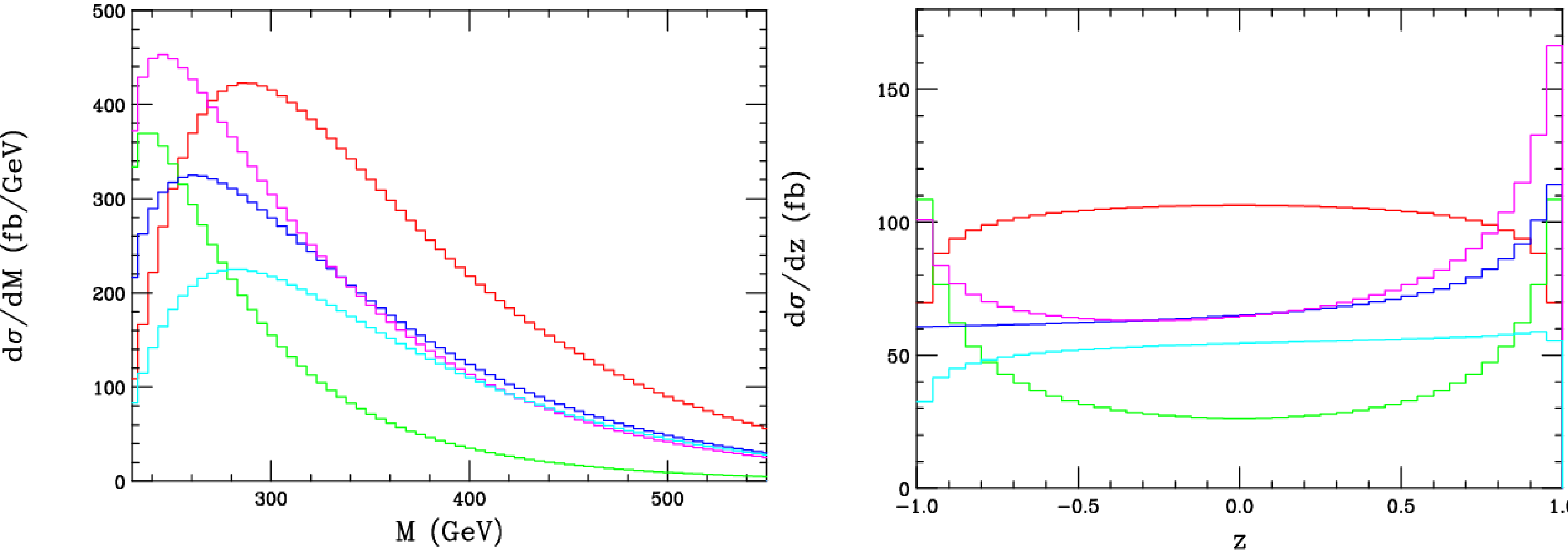
- For a given value of the WZ' cross section these rates are comparably small but are rather well-determined

At the 7 TeV LHC…



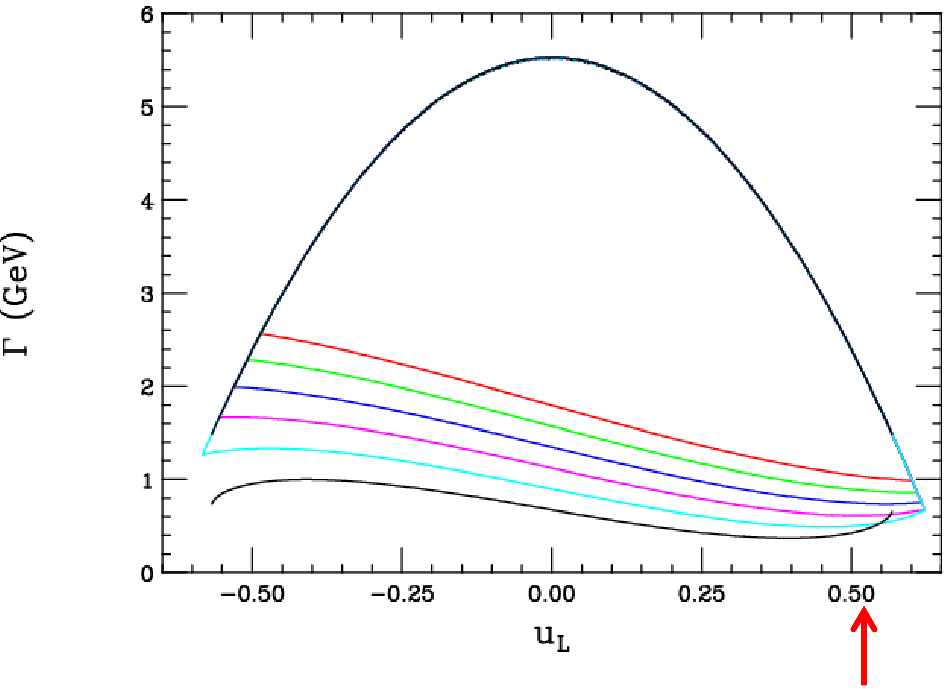


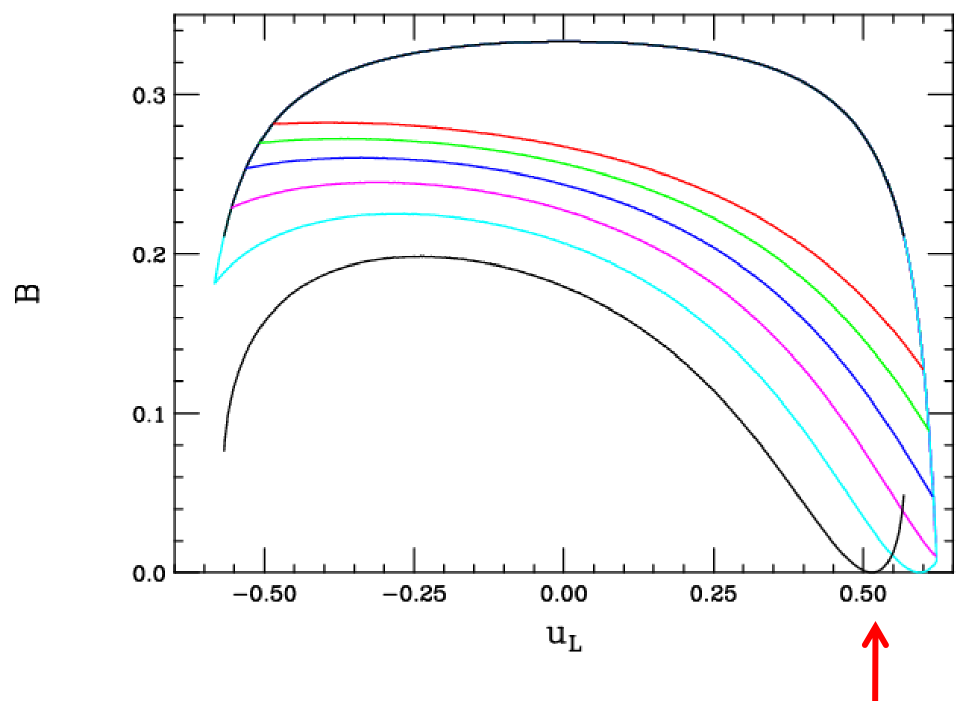
- The cross section is large & depends on the choice of the W charge assignment



(u_L, d_L) = (-0.5,0.5) (-0.5,-0.5) (0, 0.7) (-0.2,-0.8) (-0.2,0.5)

- Many of the WZ' kinematic distributions at the Tevatron are quite sensitive to the assumed values of the couplings. The W angular distribution is more problematic at the LHC since the initial q direction is not trivially identified.





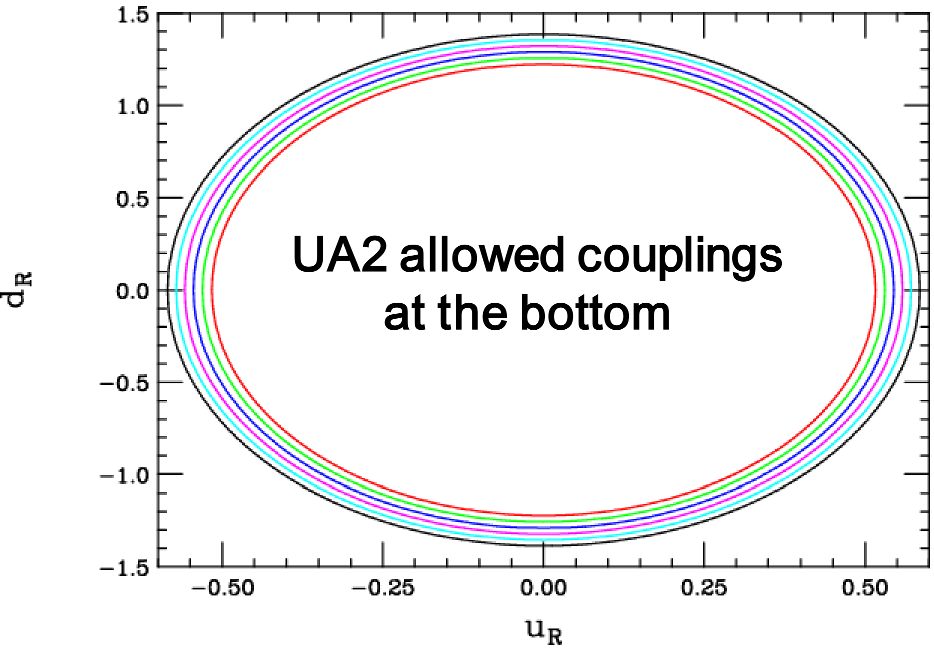
- The Z' is always rather narrow (as required by the CDF data) with $\Gamma/M < 0.035$. The values of B(Z'→ bb) are found to be rather restricted & are easily compatible w/ the CDF results

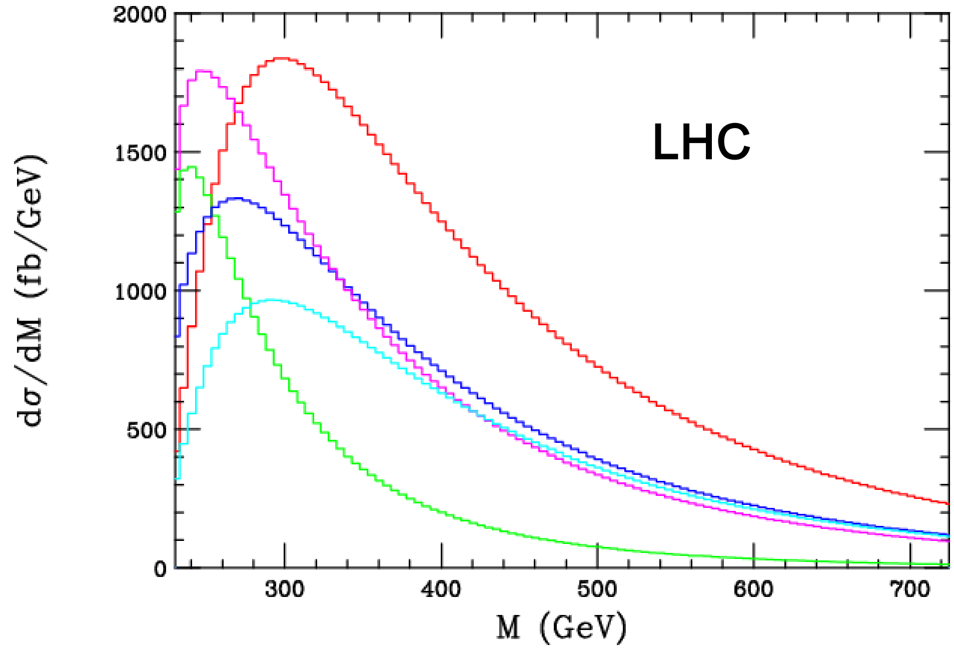
Summary & Conclusions

- The Z' hypothesis is rather general & can be easily made to satisfy all the existing constraints from other searches & flavor physics as well as the 'observed' production rate, total decay width & b-jet content requirements.

- If such a scenario is realized the determination of the Z' coupling constants will be necessary. Is it, e.g., gauged baryon number? To do this we need to look at both other associated processes as well as the various WZ' kinematic distributions

BACKUPS


UA2 allowed couplings
at the bottom
d_R
u_R


LHC
dσ/dM (fb/GeV)
M (GeV)