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Search for a New Vector  
Resonance in the  $pp \rightarrow WWtt+X$   
Channel at LHC

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# Motivation

An alternative to the SM Higgs boson:

Strong Electroweak Symmetry Breaking

A new strong vector resonance  $\rho$  as an isospin triplet ( $\rho^\pm, \rho^0$ )

# The Model

Modified BESS model --  $\rho$  the only non SM particle

Respects the symmetries of the SM Higgs sector:

$SU(2)_L \times U(1)_Y$  local,  $SU(2)_L \times SU(2)_R$  global

$$L = ig_\pi \frac{M_\rho}{v} (\pi^- \partial^\mu \pi^+ - \pi^+ \partial^\mu \pi^-) \rho_\mu^0 + g_1^t \bar{t} \gamma^\mu t \rho_\mu^0 + g_2^t \bar{t} \gamma^\mu \gamma^5 t \rho_\mu^0$$

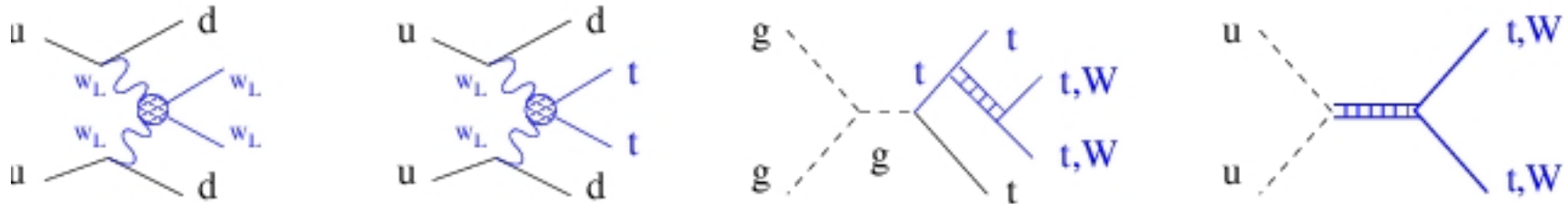
$$g_\pi = \frac{M_\rho}{2vg''} \quad g_1^t = g_2^t = \frac{g'' b_2}{4} + O\left(\frac{g^2}{g''^2}\right)$$

$g'', b_2$  ... coupling constants of the original BESS  $g'' \gtrsim 10 \quad b_2 \lesssim 0.1$

$g$  ...  $SU(2)_L$  coupling constant

$v \cong 246$  GeV ... electroweak scale

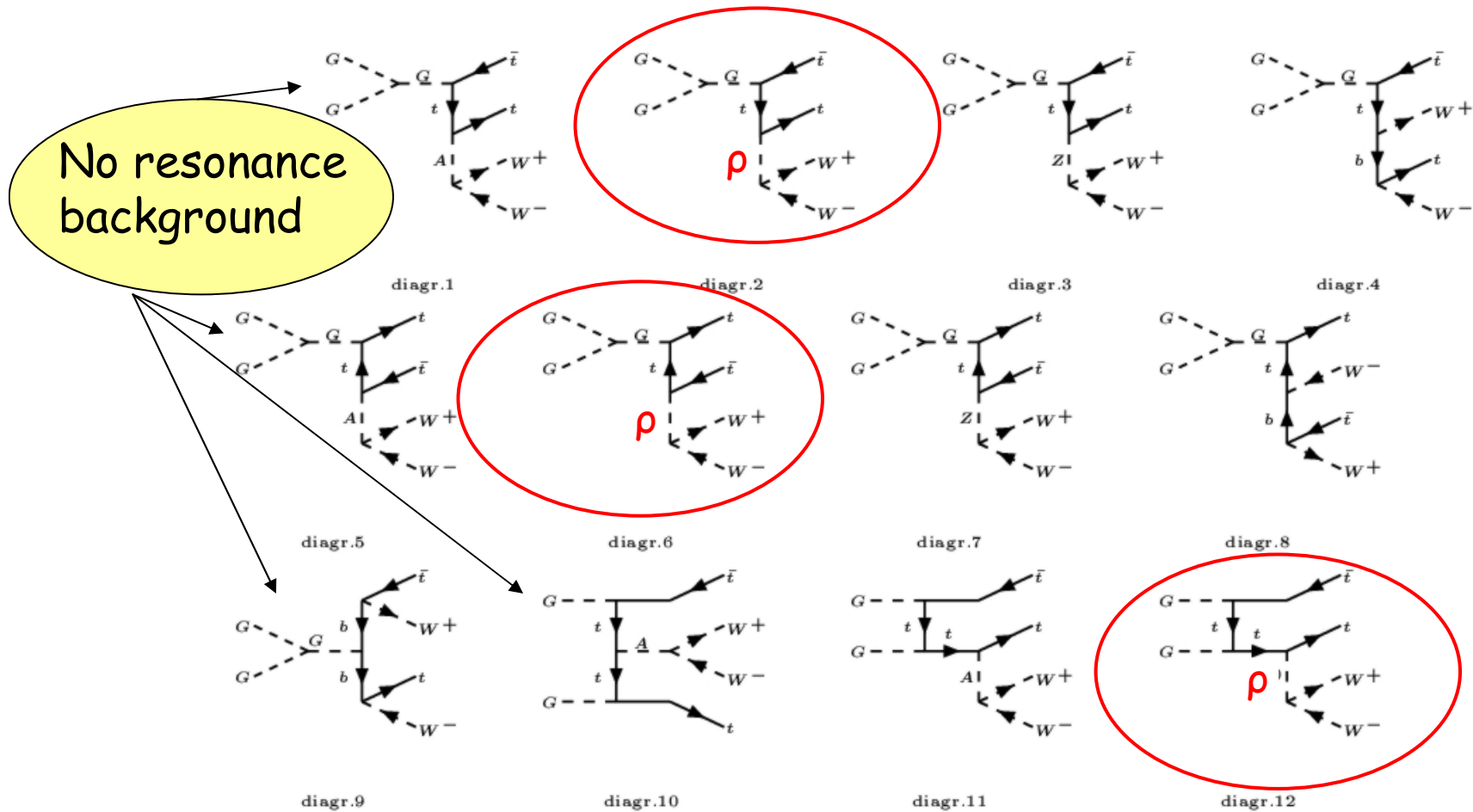
# Analysis of $pp \rightarrow W^+W^-t\bar{t} + X$



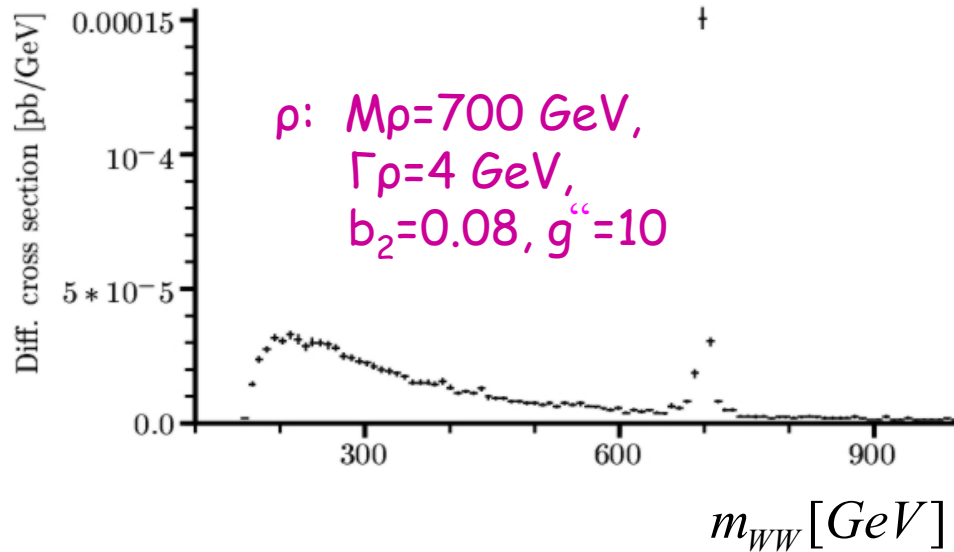
For the dominant  $gg$  channel:

- I.  $W^+W^-t\bar{t}$  cross-sections and statistical significance  
CompHEP
- II.  $lv_jjbjj\bar{b}jj$  reconstruction  
CompHEP – events generation  
Pythia – decay and hadronization  
Atfast – detector effects and reconstruction of the jets  
ROOT, C++ -- event reconstruction

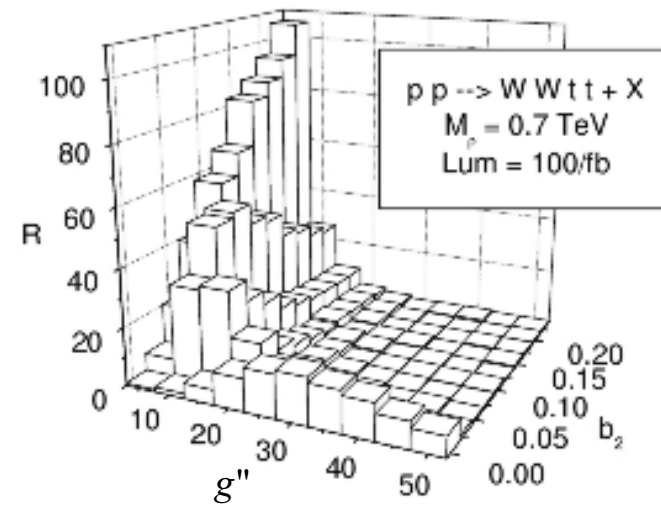
# 39(8) diagrams in the dominant gg channel



# CompHEP Results



$$R = \frac{|N(\rho) - N(\text{No } \rho)|}{\sqrt{N(\text{No } \rho)}}$$



Cuts:  $p_T(t), p_T(\bar{t}) > 100 \text{ GeV}$

$|Y(t), Y(\bar{t})| < 2$

$700 - 3\Gamma_\rho < m_{WW} < 700 + 3\Gamma_\rho$

$\sigma(gg)$ :

0.96 fb ...  $\rho$  39 diagrams

0.037 fb ... No  $\rho$  39 diagrams

R

$\approx 46$  ...  $\rho$  39 diagrams

# $1\nu_l jjbjbjj$ Reconstruction

One charged lepton channel: 40% of events

$$W^+W^-t\bar{t} \rightarrow W^+W^-bW^+\bar{b}W^- \rightarrow l\nu_l jjbjbj\bar{j}j$$

Cuts:  $p_T$  of electron > 30 GeV  
muon > 20 GeV  
jets > 25 GeV

mass of the W:  $m_W \pm 25$  GeV

b-tagging efficiency 50%

Reconstruction criterion

$$\chi^2 = (m_{j_1j_2} - m_W)^2 + (m_{j_3j_4} - m_W)^2 + (m_{j_5j_6} - m_W)^2 + (m_{W_1b_1} - m_t)^2 + (m_{W_2b_2} - m_t)^2$$

Invariant mass of the WW pair ...

$$m_{WW}^2 = E_{WW}^2 - \vec{p}_{WW}^2$$

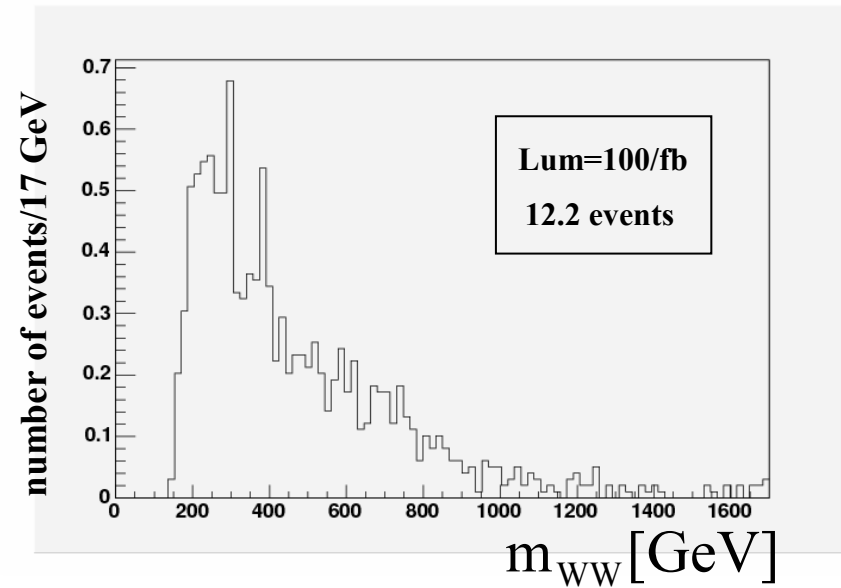
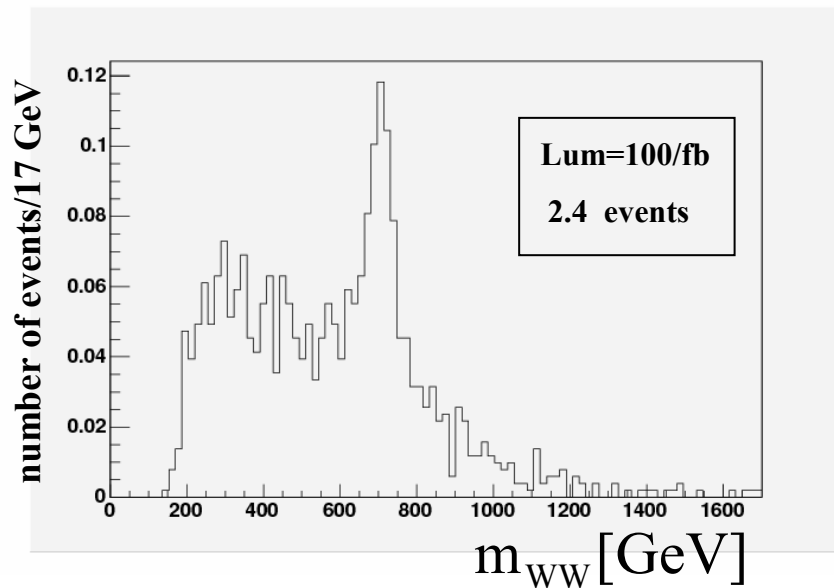
$$E_{WW} = E_{W_1} + E_{W_2}$$

$$p_{WW,x} = p_{W_1,x} + p_{W_2,x}$$

Mass of the  $\rho$ -resonance

8 diagrams

39 diagrams

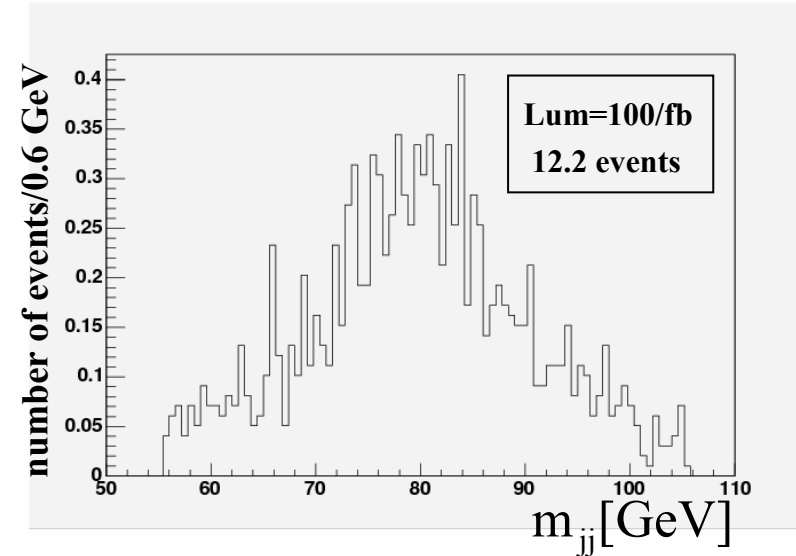
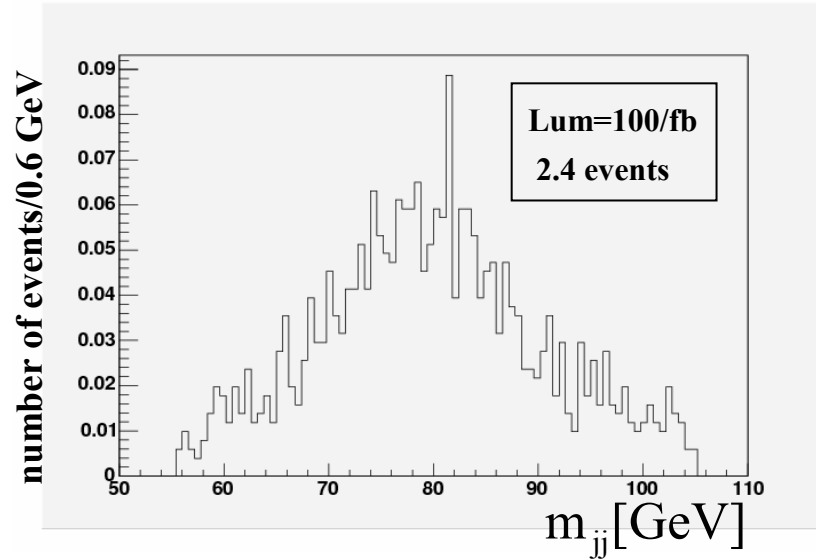




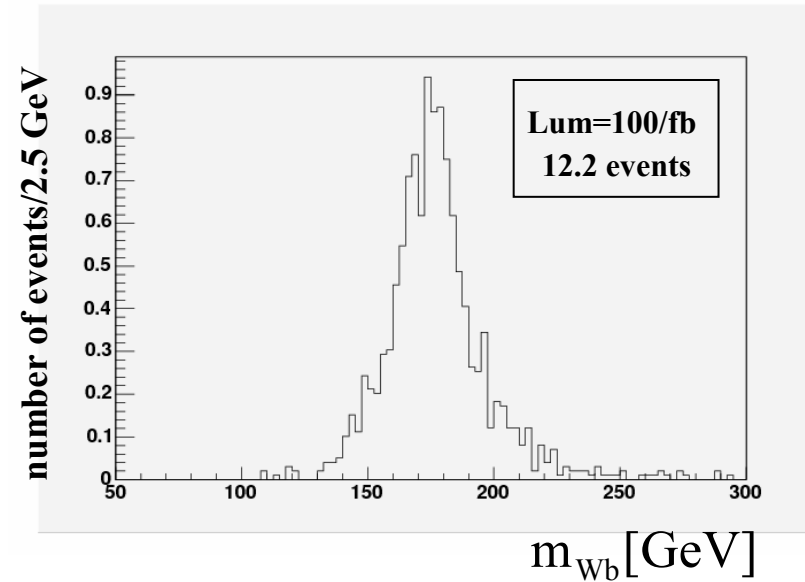
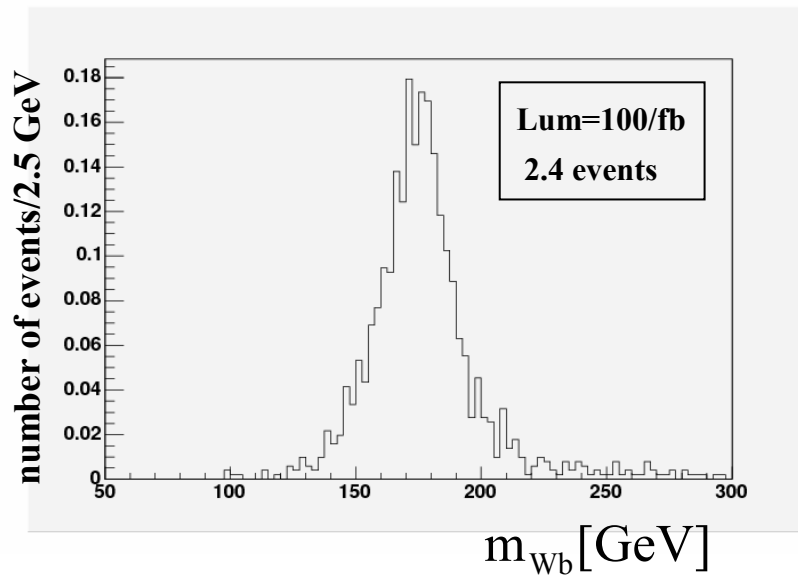
8 diagrams

39 diagrams

Mass of the W boson



Mass of the top quark



# Conclusions

For the resonance with  $M_\rho = 700$  GeV,  $g''=10$ ,  $b_2 = 0.08$ :

I.  $W^+W^-t\bar{t}$  in the final state – maximum values of R at around 100

II.  $lv_ljjb\bar{j}\bar{j}$  reconstruction

The top quark and the W reconstruction O.K.

The  $\rho$  reconstruction – 40% of events fall into the  $\rho$  peak  $\rightarrow$  need to improve the reconstruction algorithm

III. Future work --  $pp \rightarrow t\bar{t}t\bar{t}$  -- much larger cross-section compared to  $W^+W^-t\bar{t}$ , i.e. larger numbers of events

$t\bar{t}t\bar{t}$

versus

$W^+W^-t\bar{t}$

