BESS MODEL RESONANCE AT FUTURE e+e- COLLIDERS

M. Gintner, J. Juráň, I. Melo, B. Trpišová

Department of Physics, University of Žilina, Žilina
Institute of Experimental and Applied Physics, Czech Technical University, Prague

Bratislava, September 2009

Electroweak Symmetry Breaking (ESB)

Mechanism of ESB – still unknown.

Benchmark hypothesis – the SM Higgs.

One of the alternatives to the SM Higgs – strong ESB – to this class of models belongs also BESS – Breaking EW Symmetry Strongly

BESS introduces instead of the Higgs bozon a new vector particle – the ρ resonance – which couples directly to the quarks of all genera -- tions. In technicolour theories the ρ resonance is a bound state, i.e. it is composed of particles called techniquarks that interact via new strong physics.

The Model Lagrangian

Our model – modified BESS model – ρ couples directly only to the top and bottom quarks.

Motivation – the extraordinary large mass of the top compared to the rest of the fermions is close to the ESB scale ⟹ the top quark may play a special role in the mechanism of ESB.

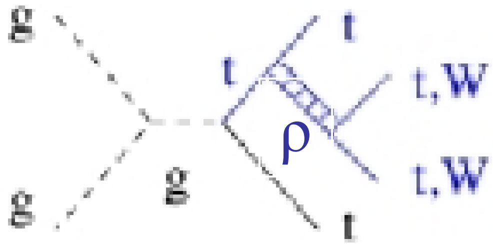
$$L_{\rho}^{(t,b)_L} = \frac{b_1}{1+b_1} g \overline{\psi}_L \gamma^{\mu} W_{\mu}^{a} \tau^{a} \psi_L + \frac{b_1}{1+b_1} g_V \overline{\psi}_L \gamma^{\mu} \rho_{\mu}^{a} \tau^{a} \psi_L$$

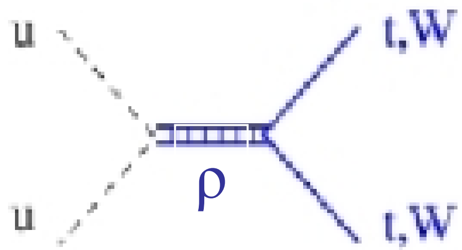
$$L_{\rho}^{(t,b)_R} = \frac{b_2}{1+b_2} g' (\overline{\psi}_R P_0) \gamma^{\mu} B_{\mu} \tau^{3} (P_0 \psi_R) + \frac{b_2}{1+b_2} g_V (\overline{\psi}_R P_0) \gamma^{\mu} \rho_{\mu}^{3} \tau^{3} (P_0 \psi_R)$$

$$\psi = \begin{pmatrix} t \\ b \end{pmatrix}$$

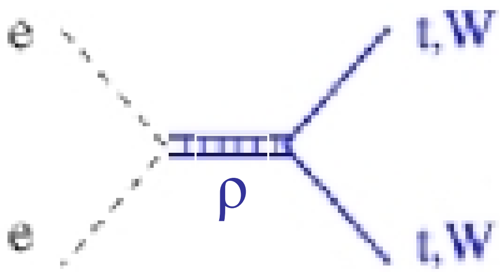
LHC versus e^+e^- colliders

LHC – also search for ρ
– large backgrounds





e^+e^- colliders – precise measurements of the parameters



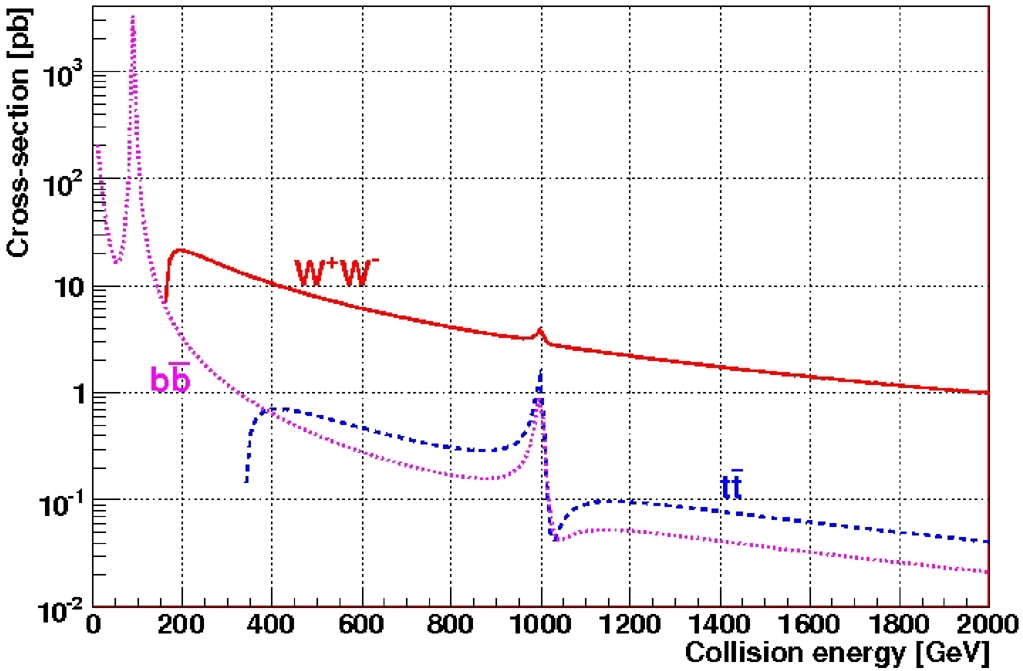
e^+e^- processes with 2 particles in the final state

$$e^+e^- \to W^+W^-$$ $$e^+e^- \to t\bar{t}$$ $$e^+e^- \to b\bar{b}$$

Low energy limits:

$$g_V \gtrsim 10 \qquad |b_1 - \lambda_1| \lesssim 0.01 \qquad -0.03 \lesssim b_2 - \lambda_2 \lesssim 0.04$$

CompHEP:



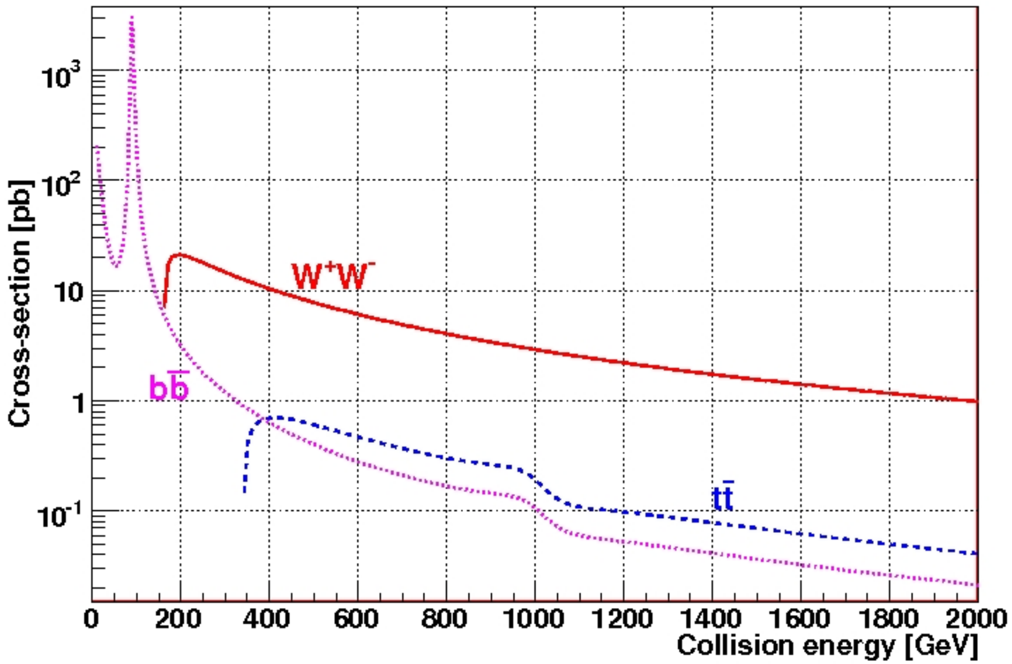
$$M_{\rho^0} = 1000 \text{ GeV}$$

$$\Gamma_{\rho^0} = 16.9 \text{ GeV}$$

$$b_1 = 0.08$$

$$b_2 = 0.04$$

$$g_V = 10$$



$M_{\rho^0} = 1000$ GeV

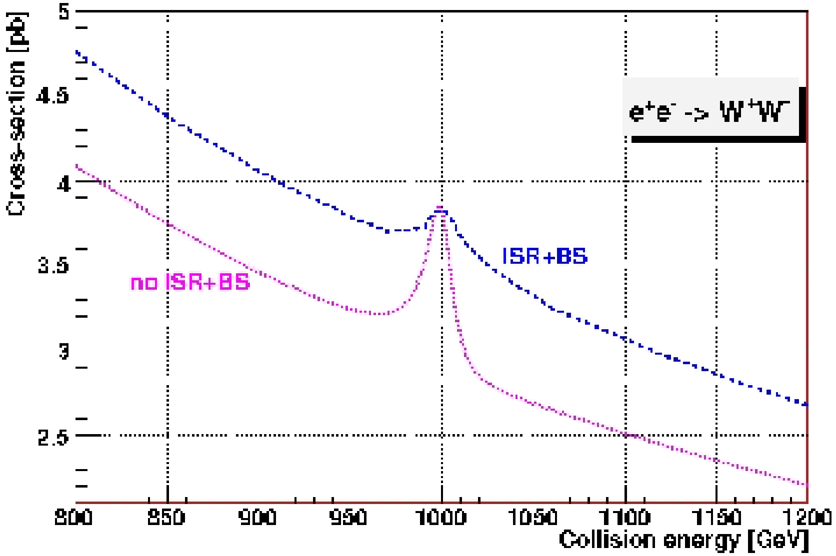
$\Gamma_{\rho^0} = 149.8$ GeV

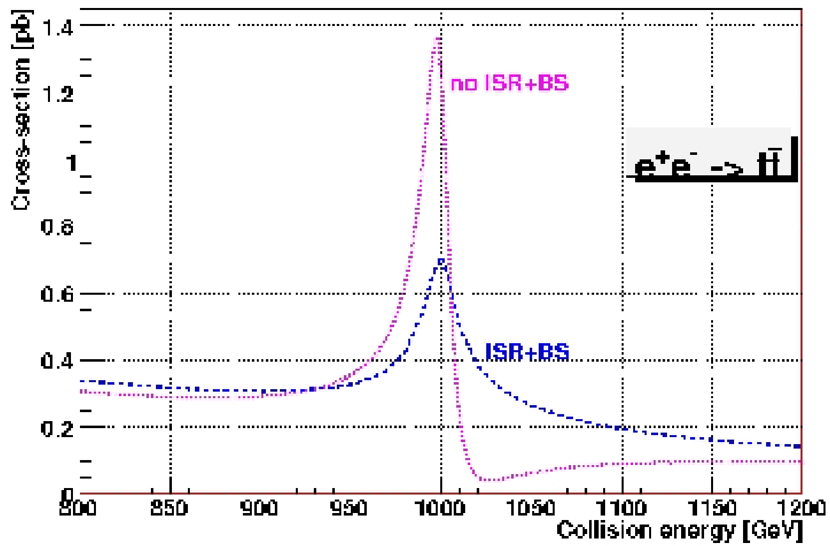
$b_1 = 0.08$

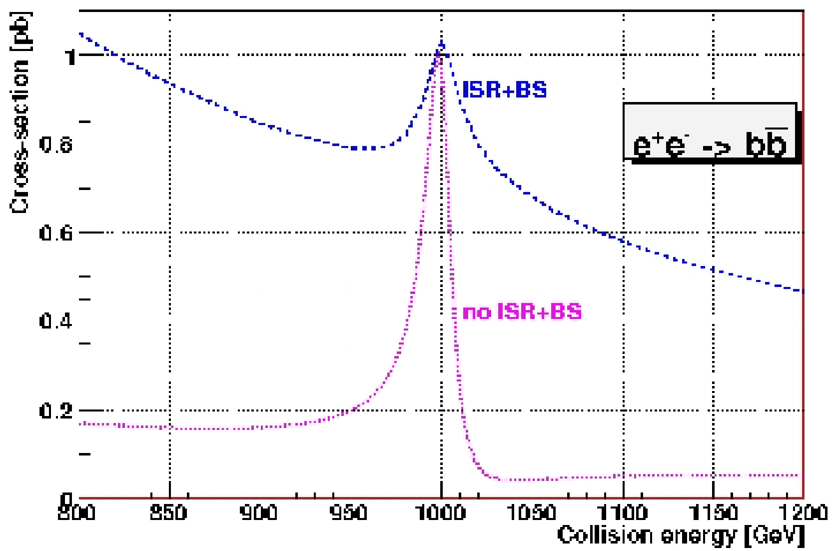
$b_2 = 0.04$

$g_V = 35$

Initial State Radiation (ISR) and beamstrahlung (BS)

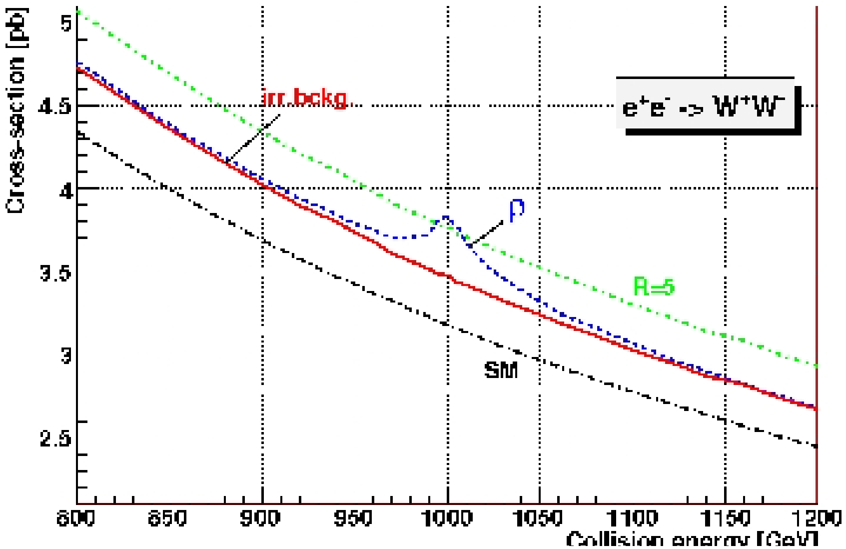


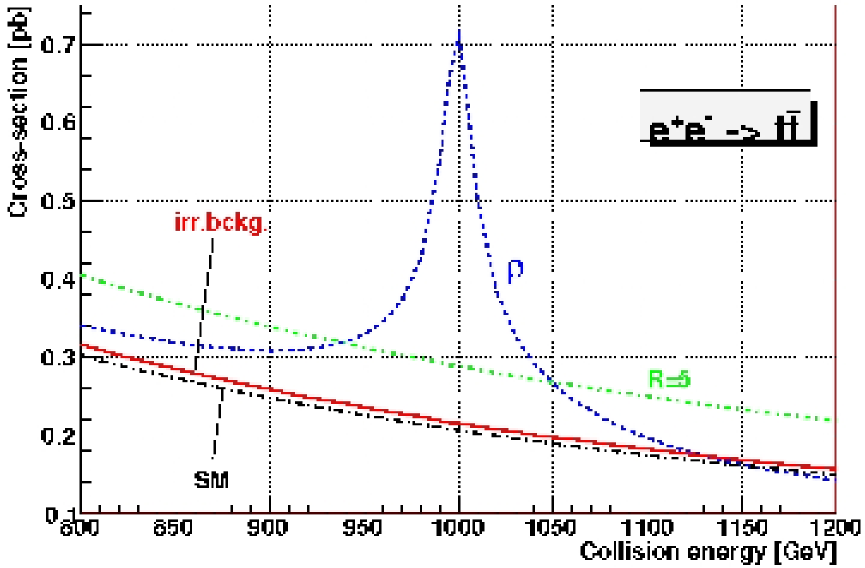


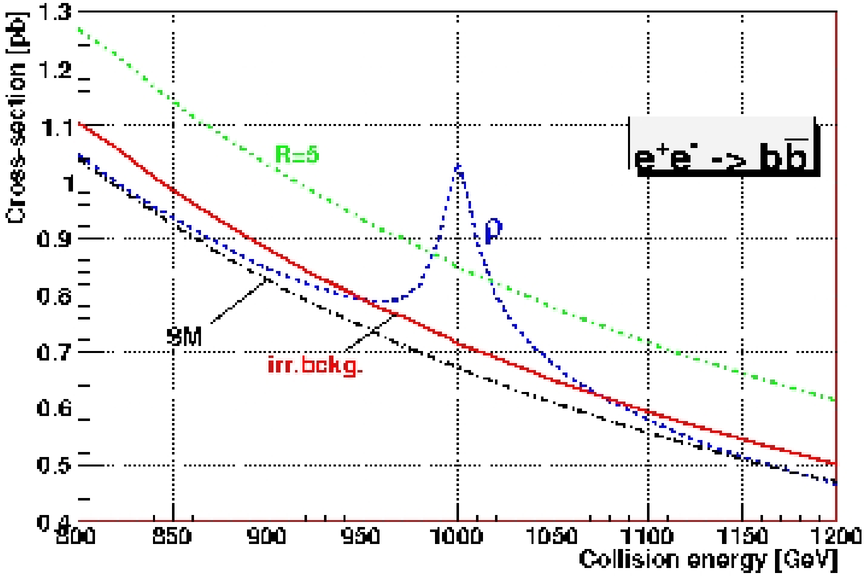


Irreducible Background, Standard Model

ISR and BS included







Statistical significance

$$R = \frac{N_S - N_B}{\sqrt{N_B}}$$

Comparison of the SM and our model – the χ^2 test

signal process	final state	r	$\tilde{\chi}_o^2$	P [%]
W^+W^-	$l_1^+\nu_{l_1}l_2^-\nu_{l_2}$	0.0121	0.837	55.6
	$l^+\nu_l jj$	0.0704	4.870	0.0
	$jjjj$	0.4096	28.332	0.0
$t\bar{t}$	$l_1^+\nu_{l_1}l_2^-\nu_{l_2}b\bar{b}$	0.003025	1.089	36.7
	$l^+\nu_l jjb\bar{b}$	0.0176	6.336	0.0
	$jjjjb\bar{b}$	0.1024	36.863	0.0
$b\bar{b}$	$b\bar{b}$	0.25	13.738	0.0

Reduced chi-squared

$$\tilde{\chi}_o^2 = \frac{1}{n}\sum_{k=1}^{n}\frac{(O_k - E_k)^2}{E_k}$$

O_k … ρ

E_k … SM

$n = 7$ points chosen in the range of energies 950 – 1050 GeV.
Integrated luminosity $L = 1\,fb^{-1}$.

$P = \mathrm{Prob}(\chi^2 \geq \tilde{\chi}_o^2)$ -- probability that we would get χ^2 as large as or larger than $\tilde{\chi}_o^2$ if our data O_k were distributed according to the expected distribution E_k .

Reducible background

$$e^+e^- \to W^+W^-$$

$$e^+e^- \to e^+e^-W^+W^-$$

$$e^+e^- \to e^+e^-ZZ$$

$$e^+e^- \to e^\pm \nu W^\mp Z$$

$$e^+e^- \to \nu\bar{\nu}W^+W^-$$

$$e^+e^- \to t\bar{t}$$

$$e^+e^- \to e^+e^-t\bar{t}$$

$$e^+e^- \to \nu\bar{\nu}t\bar{t}$$

$$e^+e^- \to \gamma t\bar{t}$$

Conclusions

* The calculated R and $\tilde{\chi}_o^2$ suggest that studying the e^+e^- processes may be a promising way in searching for ρ.

* Deeper analysis is necessary that would include reducible back-grounds and detector reconstruction efficiencies.

* In case of the e^+e^- processes with two particles in the final state the detector has to be able to scan the whole interval of possible ρ masses to find the ρ peak.