Signals of new vector resonances at future colliders

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Outline

- Motivations
- A model with vector and axial vector particles degenerate in mass
- Signals and bounds from LHC
- Indirect effects at TESLA
- Studying the properties of the resonances at a multi-Tev collider
- Conclusions

- The SM of the electroweak interactions is confirmed with excellent accuracy by the existing experiments

- Therefore only extensions which smoothly modify the SM are still conceivable.

- The MSSM is the most favorite.
  In the "heavy" limit, when all susy-particles become heavy, for what concerns the electroweak tests,

$$MSSM \quad \rightarrow \quad SM \quad \textit{decoupling}$$

  with a light Higgs

- In this talk:
  An example of dynamical symmetry breaking (DSB) of the electroweak symmetry with decoupling property. The DSB model will be specified by a low energy effective Lagrangian with a chiral symmetry group G, the unbroken group H and the electroweak group G_W. The model has two new triplets of spin 1 gauge bosons with a discrete symmetry implying their mass degeneracy.

Is it possible to avoid the stringent bounds from LEP?

Deviations with respect to SM can be encoded in the S, T, U $(\epsilon_1, \epsilon_2, \epsilon_3)$ parameters. Peskin, Takeuchi (1990), Altarelli, Barbieri (1991)
Dispersive representation for ϵ_3:

$$\epsilon_3 = -\frac{g^2}{4\pi}\int_0^\infty \frac{ds}{s^2}\Big[\mathrm{Im}\Pi_{VV} - \mathrm{Im}\Pi_{AA}\Big]$$

Peskin, Takeuchi (1990)

where $\Pi_{VV(AA)} = \langle J_{V(A)} J_{V(A)} \rangle$

Assume vector meson dominance:

$$\mathrm{Im}\Pi_{VV(AA)}(s) = -\pi g^2_{V(A)}\delta(s - M^2_{V(A)})$$

$g_{V(A)}$ is the coupling of $V(A)$ to $J_{V(A)}$

$$\epsilon_3 = \frac{g^2}{4}\left[\frac{g_V^2}{M_V^4} - \frac{g_A^2}{M_A^4}\right]$$

In QCD-scaled TC models, using Weinberg sum rules $g_V = g_A$, $M_A^2 = 2M_V^2$ and KSFR $g_V^2 = 2v^2 M_V^2$, we get $\epsilon_3 \simeq 0.0008 N_{TC} N_d$ which is ruled out by the experiments.

$$\Downarrow$$

A possibility for $\epsilon_3 \to 0$ is $g_A = g_V$ $\quad M_A = M_V$ that is vector and axial-vector resonances degenerate in mass and couplings.
Meaningful ONLY if a further symmetry protects the degeneracy.

A model with vector and axial-vector resonances was formulated several years ago

Casalbuoni,De Curtis,D.,Feruglio,Gatto (1989)

The symmetry group is $G' = G \otimes H'_{local} \to H_D$ where

$G = SU(2)_L \otimes SU(2)_R$ $\qquad\qquad H_D = SU(2)_V$

$H'_{local} = SU(2)_L \otimes SU(2)_R$ with gauge fields $\mathbf{L}_\mu, \mathbf{R}_\mu$ (triplet-s)

SSB of $G' \to H_D$ gives $3 \times 4 - 3 = 9$ GB

- 6 are absorbed by $\mathbf{L}_\mu, \mathbf{R}_\mu$ which get mass
- 3 give mass to W and Z when part of G is promoted to local EW gauge symmetry

Taking the same gauge coupling constant g'' for $\mathbf{L}_\mu, \mathbf{R}_\mu$, we end with two more parameters

$$\boxed{M_V,\ M_A,\ g'', z}$$

with the vector and axial-vector resonances defined as $\mathbf{V}_\mu = (\mathbf{L}_\mu + \mathbf{R}_\mu)/2$, $\mathbf{A}_\mu = (\mathbf{R}_\mu - \mathbf{L}_\mu)/2$ and $z = g_V/g_A$.

Degenerate BESS model

Casalbuoni,Deandrea,De Curtis,D.,
Feruglio,Gatto,Grazzini (1995)

Choose the parameters in the BESS model Lagrangian in such a way that

$$M_V = M_A \qquad z = 1$$

the symmetry is enhanced to

$$[SU(2)_L \otimes SU(2)_R]^2_{\text{global}} \otimes [SU(2)_L \otimes SU(2)_R]_{\text{local}}$$

So this special case is protected by an additional custodial symmetry $SU(2)_{\text{cust}} \to SU(2)_{\text{cust}} \otimes [SU(2)_L \otimes SU(2)_R]$.
See also the parity doubling in Appelquist,Da Silva,Sannino (1999)

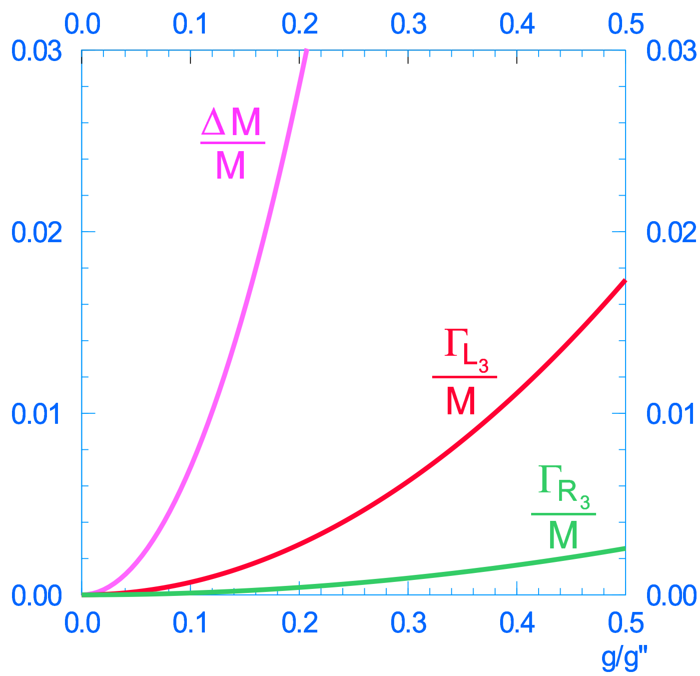
Features of the model

- $M_L = M_R = M$ (apart from EW corrections)
- DECOUPLING
  In the limit $M \to \infty$ one recovers the SM Lagrangian (for $M_H \to \infty$)
- $\mathbf{L}_\mu, \mathbf{R}_\mu$ are NOT coupled to $w^\pm, z$ (the GB eaten up by $W^\pm, Z$), in QCD dictionary $g_{\rho\pi\pi} = g_{\rho A\pi} = 0 \to$
  the $\mathbf{L}_\mu, \mathbf{R}_\mu$ decays in $W_L W_L$ are suppressed
  Unlike other schemes of SEWSB, the $W_L W_L$ final state is not enhanced

- Fermionic couplings of $\mathbf{L}_\mu$,$\mathbf{R}_\mu$ through mixing $\sim (g/g'')$ with $W^\pm, Z, \gamma \to$ very good signatures at future colliders in the di-lepton channel.
For ex. $Br(L_3(R_3) \to l^+l^-) \sim 4(12)\%$

- From decoupling: $\Gamma(f\bar{f}) \sim \Gamma(WW) \sim M M_W^4 (G_F/g'')^2$ $\to$ Very NARROW resonances. For $g/g'' \ll 1$):

$$\frac{\Gamma_{L_3}}{M} \sim 0.068 \left(\frac{g}{g''}\right)^2, \quad \frac{\Gamma_{R_3}}{M} \sim 0.01 \left(\frac{g}{g''}\right)^2, \quad \frac{\Gamma_{R_3}}{\Gamma_{L_3}} \sim 15\%$$



- The degeneracy between L_3 and R_3 is broken by weak corrections. The mass splitting is ($g/g'' \ll 1$):

$$\frac{\Delta M}{M} \sim (1 - \tan^2\theta_W) \left(\frac{g}{g''}\right)^2 \sim 0.70 \left(\frac{g}{g''}\right)^2$$

Bounds from the ϵ-parameters fit

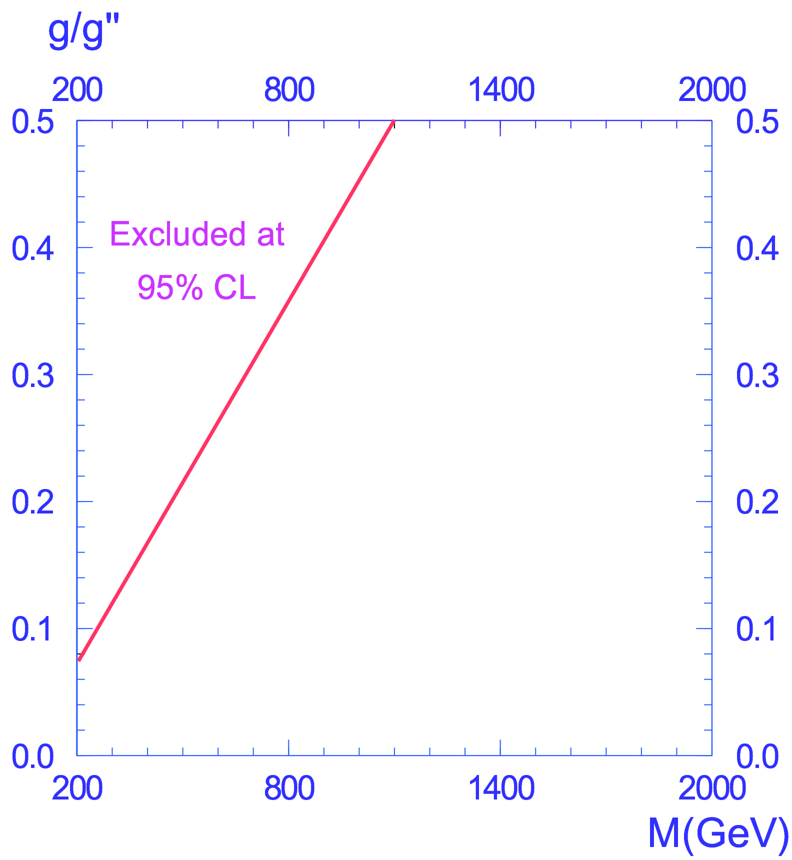
The D-BESS has very loose bounds from the existing experimental data: $\epsilon_i \to 0$ for $M \to \infty$
Calculation to the next-to-leading order:

$$\epsilon_1 = -\frac{c_\theta^4 + s_\theta^4}{c_\theta^2} X \qquad \epsilon_2 = -c_\theta^2 X \qquad \epsilon_3 = -X$$

$$X = 2\ (g/g'')^2 (M_Z/M)^2$$

double suppression factor

To compare to the experimental data consider for D-BESS the same radiative corrections of the SM with $m_H = \Lambda = 1\ TeV$ (neglect new physics loop corrections)



Experimental values from all High-Energy data fit:
$\epsilon_1 = (3.92 \pm 1.14) \times 10^{-3}$, $\epsilon_2 = (-9.27 \pm 1.49) \times 10^{-3}$, $\epsilon_3 = (4.19 \pm 1.00) \times 10^{-3}$ (Altarelli (1999))

- The Degenerate BESS is a non renormalizable model, described by an effective lagrangian.
  It is a non linear realization of the spontaneous symmetry breaking. Scalar particles are absent.

- A renormalizable realization The model contains in addition to the vector states scalar fields and it is renormalizable. This allows to discuss the decoupling also at the radiative corrections level.

Casalbuoni, De Curtis, D., Grazzini (1997)

Gauge symmetry

$$SU(2)_L \otimes U(1) \otimes SU(2)'_L \otimes SU(2)'_R$$
$$\downarrow u$$
$$SU(2)_{weak} \otimes U(1)_Y$$
$$\downarrow v$$
$$U(1)_{em}$$

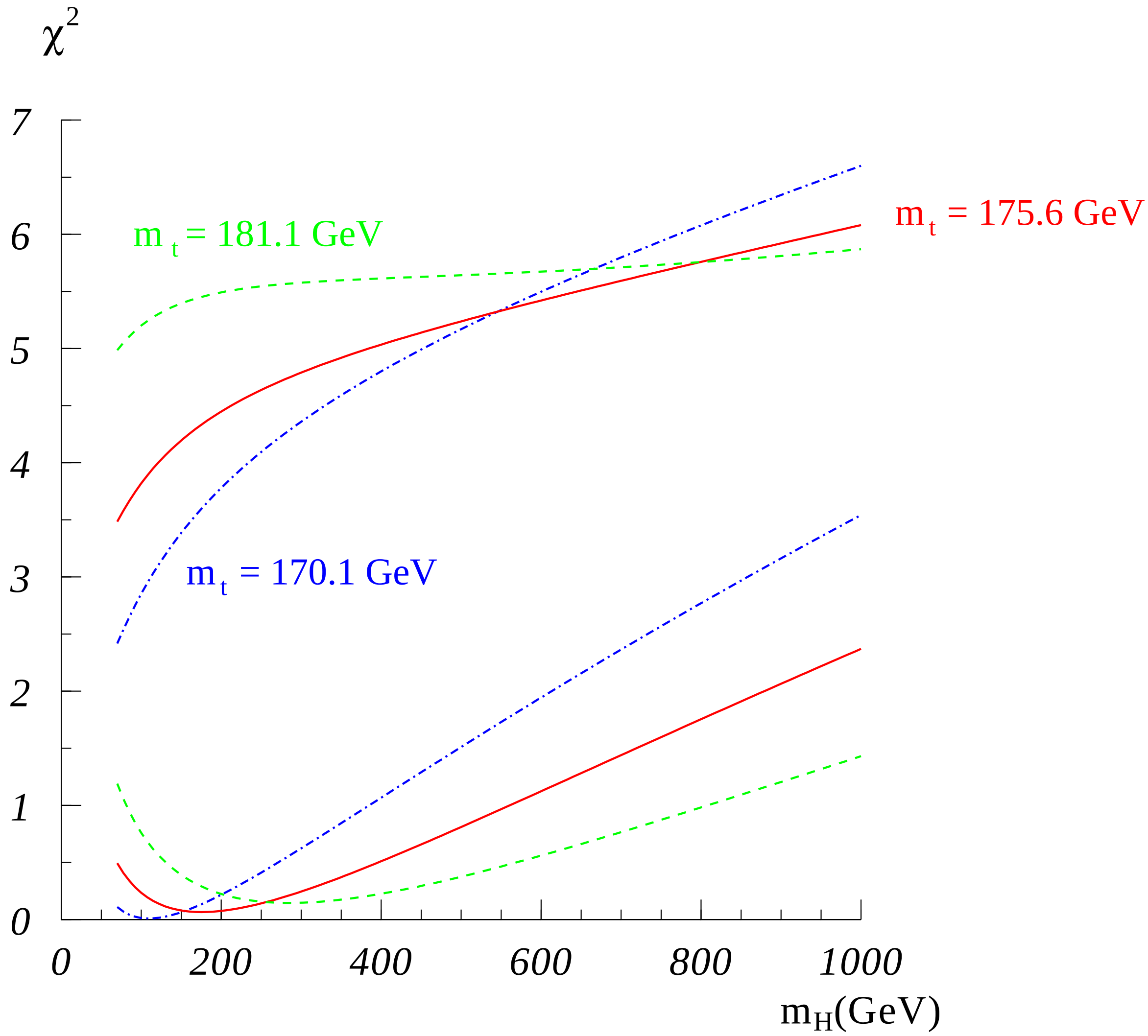
The scale $u =< \tilde{L} >=< \tilde{R} >= 2\sqrt{2}M/g''$.
For $u \to \infty$ one recover the SM.
ϵ parameters $\sim X \sim \mathcal{O}(v^2/u^2)$.

A best fit to the ϵ parameters gives

$$1.3 \times 10^{-3} \leq X \leq 2 \times 10^{-3}$$

for $170.1 \leq m_t(GeV) \leq 181.1$, $70 \leq m_H(GeV) \leq 1000$.
Remember

$$X = 2\frac{m_Z^2}{M^2}(\frac{g}{g''})^2$$



Casalbuoni,De Curtis,D.,Gatto,Grazzini (1998)

- Upper part: the SM χ^2.
  Lower part: the decoupling model χ^2 with X corresponding to the best fit.

- Correspondingly the 95% CL bound on m_H goes from ~ 200 GeV to ~ 1 TeV

Degenerate BESS at hadron colliders

Casalbuoni, Chiappetta, Deandrea, De Curtis, D., Gatto (1997)

Future hadron colliders will be able either to discover the new resonances or to constrain the physical region still available.

We have studied the signatures of the D-BESS resonances at the Tevatron Upgrade and at the LHC with the following configurations:

- $\sqrt{s} = 2\ TeV$ and $\mathcal{L} = 10^{33} cm^{-2} sec^{-1}$ for the so-called TEV-33 option

- $\sqrt{s} = 14\ TeV$ and $\mathcal{L} = 10^{34} cm^{-2} sec^{-1}$ for the LHC

Production of $L^\pm, L^3, R^3$ through quark annihilation and decay in the lepton channel:

$$q\bar{q}' \to L^\pm, W^\pm \to (e\nu_e)\mu\nu_\mu$$
$$q\bar{q} \to L_3, R_3, Z, \gamma \to (e^+e^-)\mu^+\mu^-$$

In the charged channel only $L^\pm$ are relevant because $R^\pm$ are completely decoupled (couplings to fermions are only through the mixing to SM gauge bosons)

Fusion process is negligible in D-BESS, the resonances are not strongly coupled to WW

Degenerate BESS at LHC

$\sqrt{s} = 14\ TeV \qquad \mathcal{L} = 10^{34} cm^{-2} sec^{-1} \qquad L = 100\ fb^{-1}$

Casalbuoni,De Curtis,Redi (2000)

Charged channel: $pp \to L^{\pm}, W^{\pm} \to e\nu_e(\mu\nu_\mu) + X$

Neutral channel: $pp \to L_3, R_3, Z, \gamma \to e^+e^-(\mu^+\mu^-) + X$

Events simulated using PYTHIA MonteCarlo (6.136) and analyzed with CMSJET package which performs a simulation of the energy smearing of the CMS detector

Observables transverse mass (charged channel) and invariant mass (neutral channel) distributions for several choices of D-BESS parameters (g'', M) taken inside the allowed region

BKGD Drell-Yan processes with SM gauge bosons exchange in the electron and muon channel (this is the relevant BKGD after isolation cuts on the outgoing leptons)

For each case cuts have been selected to maximize the statistical significance of the signal (cut on low p_T^l events, take m_T or $m_{l^+l^-}$ in a range containing the resonance)

The electron channel is experimentally much more convenient → the CMS detector has a better energy resolution (1%). The distributions are much more peaked around the resonances

The cleanest signature is in the neutral channel expecially IF it is possible to disentangle the two resonances but the production rate is less favorable

Degenerate BESS at LHC

$\sqrt{s} = 14\ TeV \qquad \mathcal{L} = 10^{34} cm^{-2} sec^{-1} \qquad L = 100\ fb^{-1}$

Charged channel: $pp \to L^{\pm}, W^{\pm} \to e\nu_e + X$

g/g''	M GeV	$\Gamma_{L^{\pm}}$ GeV	$\|p_T^e\|_c$ GeV	$\|m_T\|_c$ GeV	$\#B$	$\#S$	ss
0.10	1000	0.7	300	800	1468	2679	42
0.10	1500	1.0	500	1300	154	339	15
0.10	2000	1.4	700	1800	26	67	6.9

Neutral channel: $pp \to L_3, R_3, Z, \gamma \to e^+e^- + X$

g/g''	M GeV	Γ_{L_3} GeV	Γ_{R_3} GeV	$\|p_T^e\|_c$ GeV	$\|m_{e^+e^-}\|_c$ GeV	$\#B$	$\#S$	ss
0.10	1000	0.7	0.10	300	800	590	375	12
0.20	1000	2.8	0.40	300	800	590	1342	31
0.10	1500	1.0	0.15	500	1300	58	46	4.5
0.20	1500	4.0	0.6	500	1300	58	189	12
0.10	2000	1.4	0.20	700	1800	9	9	2.1
0.20	2000	5.6	0.8	700	1800	9	43	6.0

$ss = S/\sqrt{S+B}$

DISCOVERY LIMIT $M \leq 2\ TeV$ for $g/g'' = 0.1$

Degenerate BESS at LHC

$\sqrt{s} = 14\ TeV \qquad \mathcal{L} = 10^{34} cm^{-2} sec^{-1} \qquad L = 100\ fb^{-1}$

Charged channel: $pp \to L^{\pm}, W^{\pm} \to \mu\nu_\mu + X$

g/g''	M GeV	$\Gamma_{L^\pm}$ GeV	$\|p_T^\mu\|_c$ GeV	$\|m_T\|_c$ GeV	$\#B$	$\#S$	ss
0.10	1000	0.7	300	800	1529	2876	43
0.10	1500	1.0	500	1300	166	422	17
0.10	2000	1.4	700	1800	31	92	8.3

Neutral channel: $pp \to L_3, R_3, Z, \gamma \to \mu^+\mu^- + X$

g/g''	M GeV	Γ_{L_3} GeV	Γ_{R_3} GeV	$\|p_T^\mu\|_c$ GeV	$\|m_{\mu^+\mu^-}\|_c$ GeV	$\#B$	$\#S$	ss
0.10	1000	0.7	0.10	300	800	680	411	12
0.20	1000	2.8	0.40	300	800	680	1520	32
0.10	1500	1.0	0.15	500	1300	71	69	5.8
0.20	1500	4.0	0.6	500	1300	71	247	14
0.10	2000	1.4	0.20	700	1800	12	12	3.0
0.20	2000	5.6	0.8	700	1800	12	52	6.5

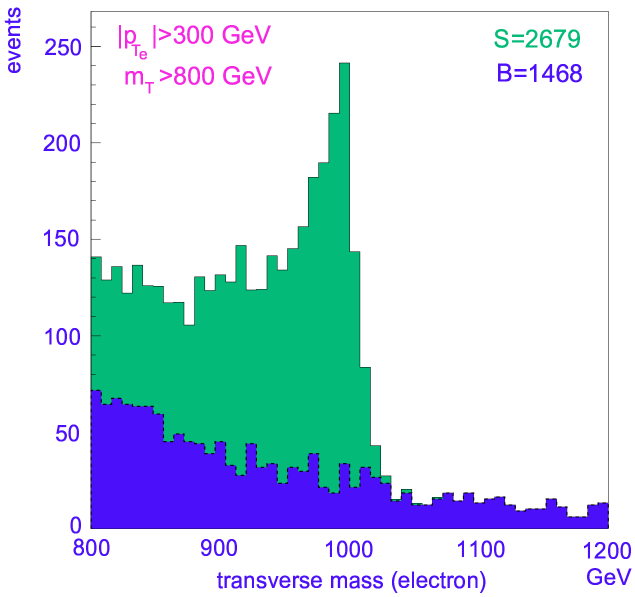
$ss = S/\sqrt{S+B}$

Signals of D-BESS at LHC

$\sqrt{s} = 14\ TeV \qquad L = 100\ fb^{-1}$

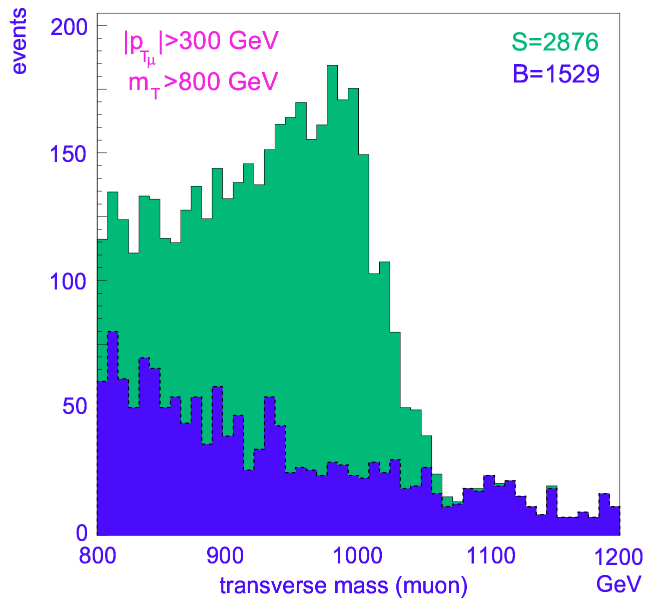
CHARGED CHANNEL

$pp \to L^{\pm}, W^{\pm} \to e\nu_e$



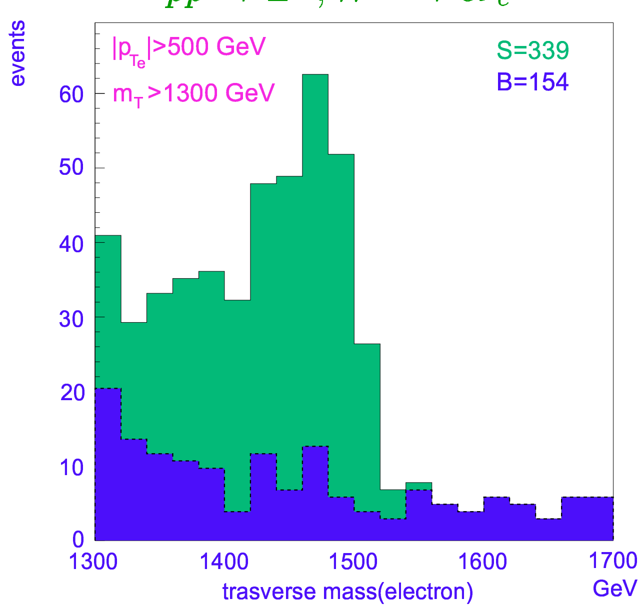
$M = 1000\ GeV \quad g/g'' = 0.1$

$pp \to L^{\pm}, W^{\pm} \to \mu\nu_\mu$



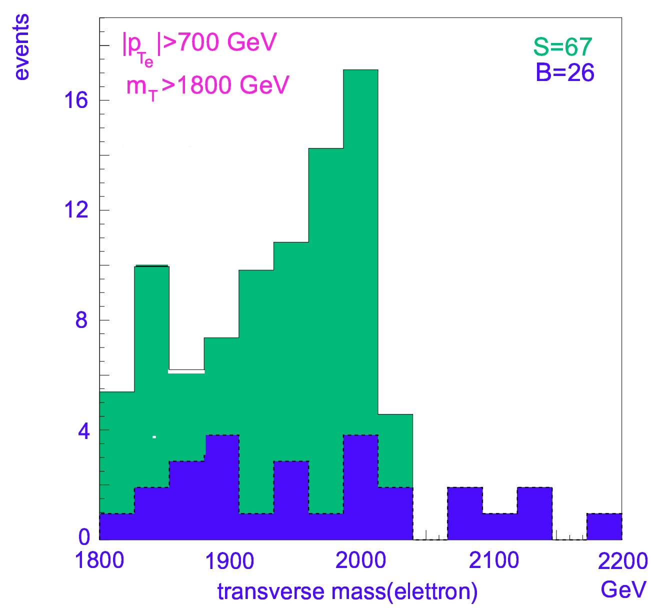
$M = 1000\ GeV \quad g/g'' = 0.1$

$pp \to L^{\pm}, W^{\pm} \to e\nu_e$



$M = 1500\ GeV \quad g/g'' = 0.1$

$pp \to L^{\pm}, W^{\pm} \to e\nu_e$

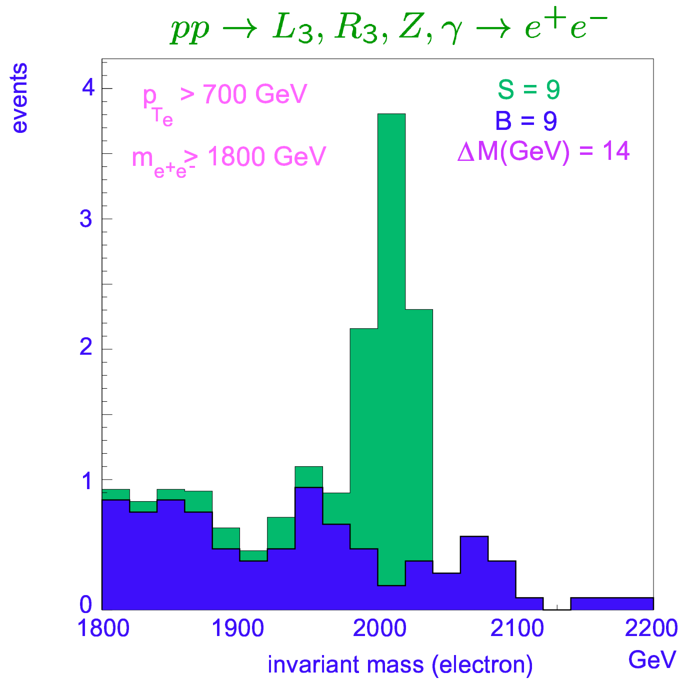


$M = 2000\ GeV \quad g/g'' = 0.1$

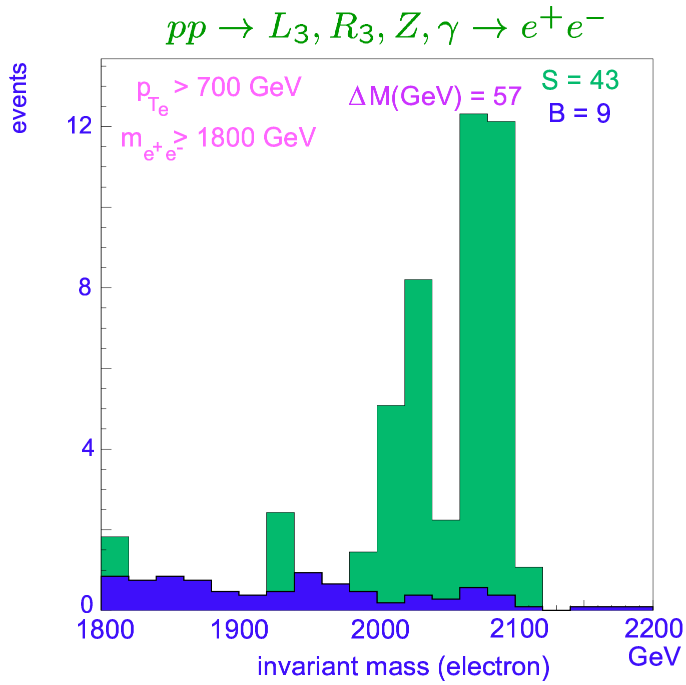
Signals of D-BESS at LHC

$\sqrt{s} = 14\ TeV \qquad L = 100\ fb^{-1}$

NEUTRAL CHANNEL



$M = 2000\ GeV, \quad g/g'' = 0.1$



$M = 2000\ GeV \quad g/g'' = 0.2$

The possibility to disentangle the double peak depends strongly on g/g'' and smoothly on the mass (as long as a good statistical significance is achieved)

By comparing $R = 1\%$ with $\Delta M/M \sim (1 - \tan^2\theta_W)(g/g'')^2$ we find a threshold value $\boxed{g/g'' > 0.15 \text{ for } M \leq 2\ TeV}$

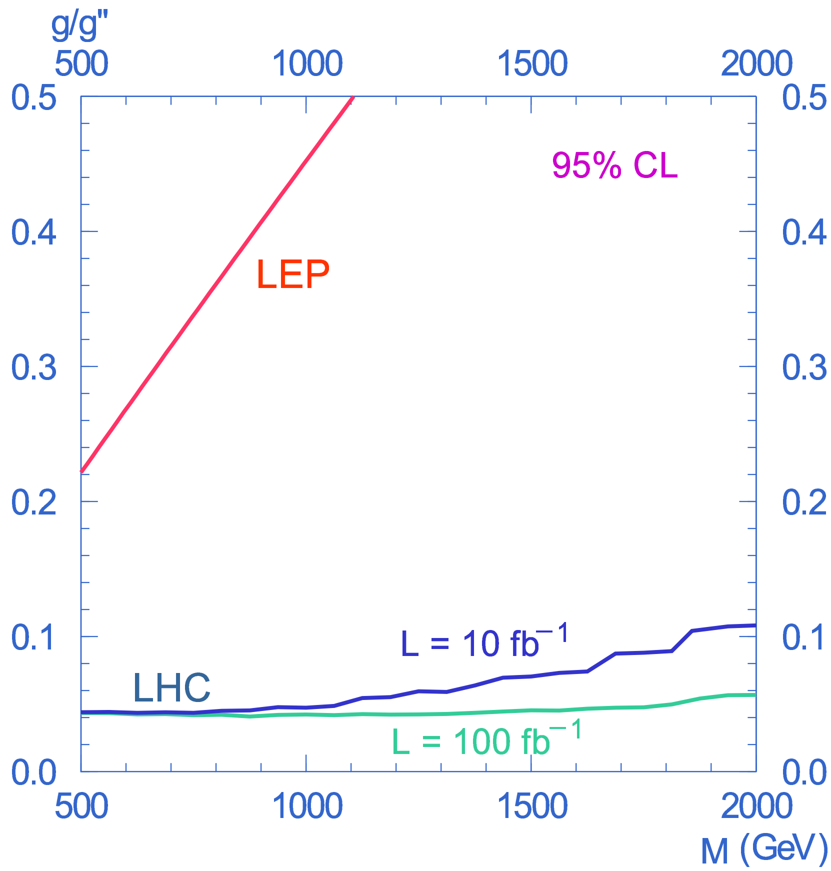
Bounds from LHC

Consider the total cross-section

$$\sigma(pp \to L^{\pm}, W^{\pm} \to \mu\nu_{\mu} + X)$$

and compare with the SM BKGD. A minimum of 10 events per year is required to claim the signal

IF NO DEVIATIONS are seen within the statistical error and a systematic 5% on the cross-section, we get the 95% CL bounds in figure



from a grid of 25×25 cross-section points in the parameter space of the model. Applied cut $|p_{T\mu}| > M/2 - 50GeV$

Also shown are the bounds from LEP/SLC/Tevatron

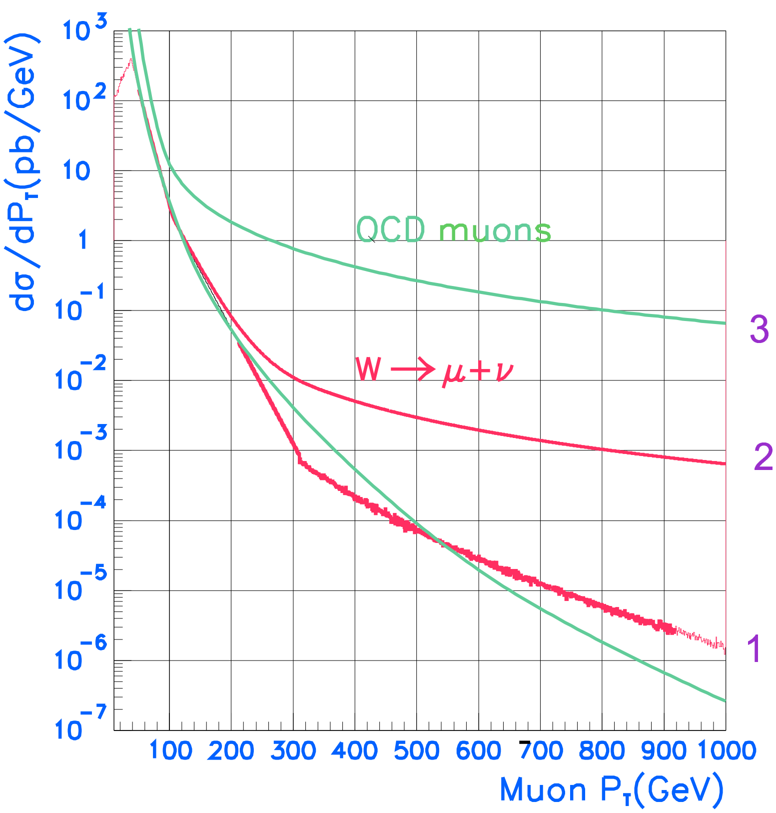
Muon reconstruction and BKGD suppression in CMS $pp \to L^{\pm}, W^{\pm} \to \mu\nu_\mu + X$

M.Spezziga thesis (2000)

Main BKGD's to $L^{\pm} \to \mu\nu_\mu$ are $W^{\pm} \to \mu\nu_\mu$ and QCD muons from $b\bar{b}$, $c\bar{c} \to \mu + X$, (typically not isolated, embedded in jets)

OPTIMISTIC SCENARIO good muon reconstruction for a wide p_T range; Gaussian smearing function $\to$ isolation cut can reduce the QCD BKGD to be three orders of magnitude lower than the irreducible $W^{\pm} \to \mu\nu_\mu$

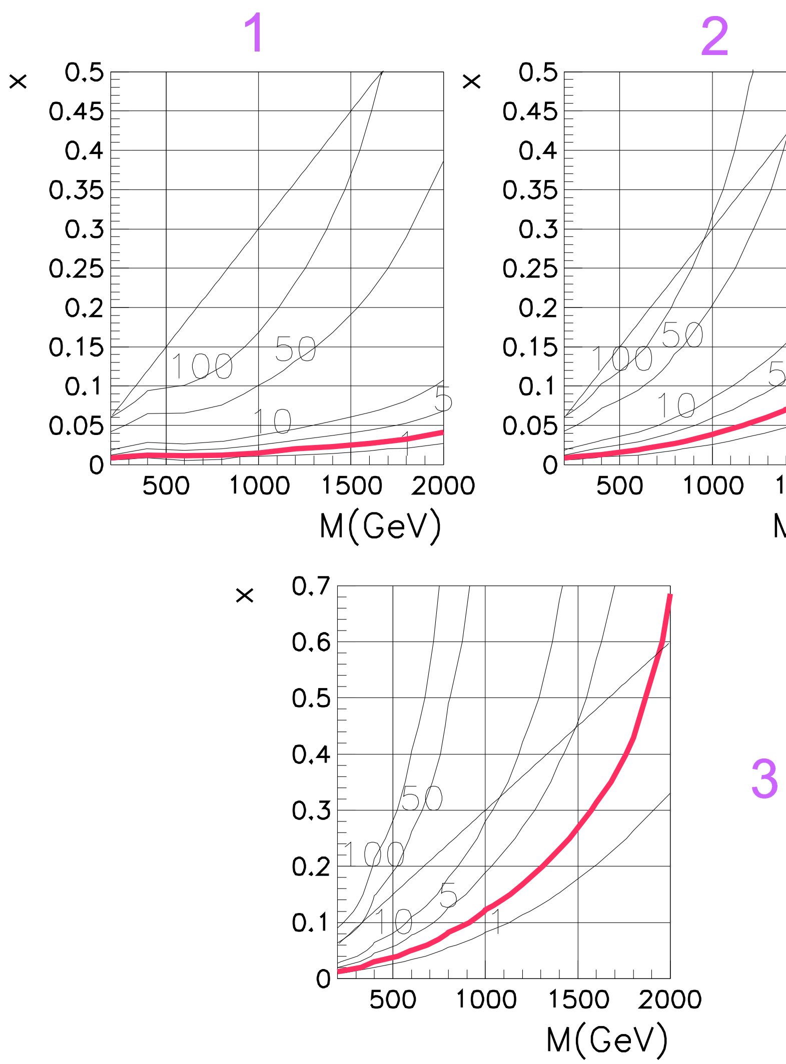
CONSERVATIVE SCENARIO the smearing function has larger tails in which the effect of badly reconstructed events is not negligible. The QCD BKGD rejection could be a problem



How do the limits on D-BESS change?

$\sqrt{s} = 14\ TeV \qquad L = 130\ fb^{-1}$

M.Spezziga thesis (2000)



Contour plots of $S/\sqrt{S+B}$. The red line corresponds to 90%CL ($S/\sqrt{S+B} = 2.15$)

1 - optimistic scenario → Gaussian smearing and QCD BKGD rejection

2 - conservative scenario → non Gaussian smearing and QCD BKGD rejection

3 - worst scenario → non Gaussian smearing and no QCD BKGD rejection

D-BESS at e^+e^- colliders

Casalbuoni, Deandrea, De Curtis, D., Gatto

In presence of new spin-one resonances the annihilation channel in $f\bar{f}$ and W^+W^- is much more efficient than the fusion channel.
In D-BESS, due to decoupling, L_3, R_3 are not strongly coupled to WW $\to$ the best channel for discovery is $f\bar{f}$

ASSUME a neutral resonance (hopefully two, nearly degenerate) with $M \leq 1\ TeV$ is seen at LHC $\to$ the first next generation of LC could measure widths and mass splitting depending on the beam energy spread (see later)

IF $M > 1\ TeV$ $\to$ wait for CLIC and study the indirect effects at TESLA in the cross-sections of

$$e^+e^- \to L_3, R_3, Z, \gamma \to f\bar{f}$$

Analysis based on the following observables:

$$\sigma^\mu, \quad \sigma^h$$

$$A_{FB}^{e^+e^-\to\mu^+\mu^-}, \quad A_{FB}^{e^+e^-\to\bar{b}b}$$

$$A_{LR}^{e^+e^-\to\mu^+\mu^-}, \quad A_{LR}^{e^+e^-\to\bar{b}b}, \quad A_{LR}^{e^+e^-\to had}$$

We have assumed for σ^h (σ^μ) a total error of 2% (1.3%). For the other observable quantities we assumed only statistical errors.

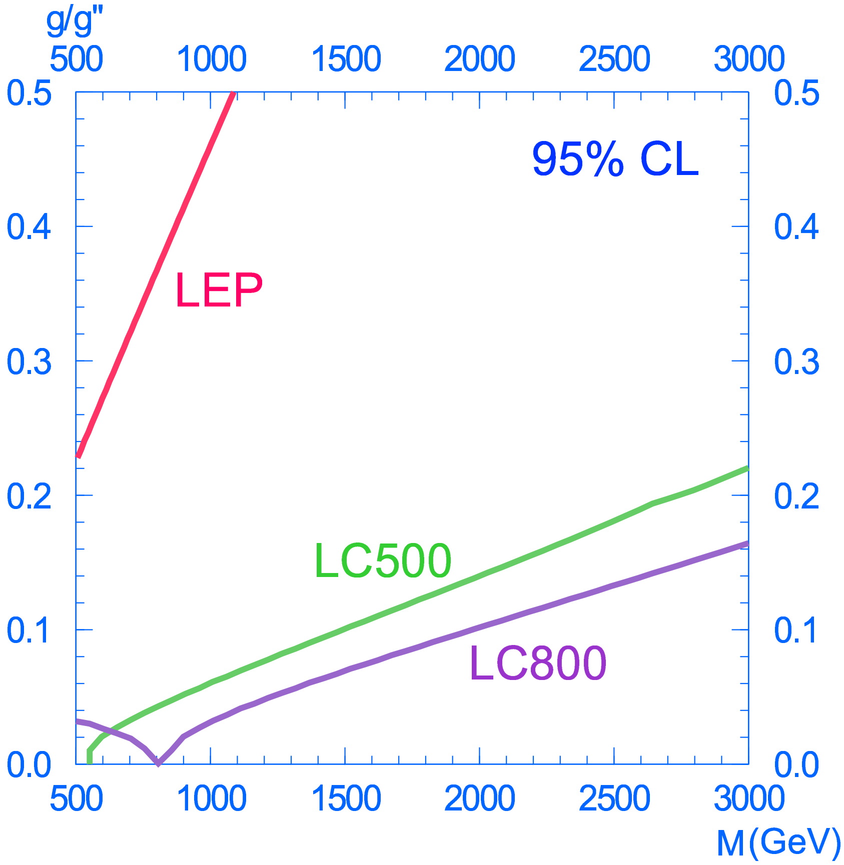
We have considered the following LC configurations:

LC500 : $\sqrt{s}(GeV) = 500$, $L(fb^{-1}) = 1000$

LC800 : $\sqrt{s}(GeV) = 800$, $L(fb^{-1}) = 1000$

with $P(e^-) = 80\%$

IF NO DEVIATIONS are seen within the statistical and systematic errors, a combined χ^2 analysis gives bounds on the parameter space of D-BESS



Compare with the bounds from LHC (only studied for $M \leq 2\ TeV$):

<u>optimistic scenario</u> $\rightarrow$ LHC is superior for any g/g'', a LC with higher c.o.m. energy is needed to compete

<u>conservative scenario</u>$\rightarrow$ LHC and LC800 are comparable

<u>worst scenario</u> $\rightarrow$ LC500 is superior to LHC for any g/g''

Analysis of Narrow s-channel Resonances at Lepton Colliders

Casalbuoni,Deandrea,De Curtis,D.,Gatto,Gunion (1999)

If a resonance has been seen at LHC, especially if heavy, very little informations can be derived about its properties (also difficult to distinguish if it is a single one or two nearly degenerate) $\longrightarrow$ it can be studied at a high-energy lepton collider.

Main issues

- the spread σ_E in the c.o.m. collision energy: intrinsic beam energy spread, ISR, beamstrahlung

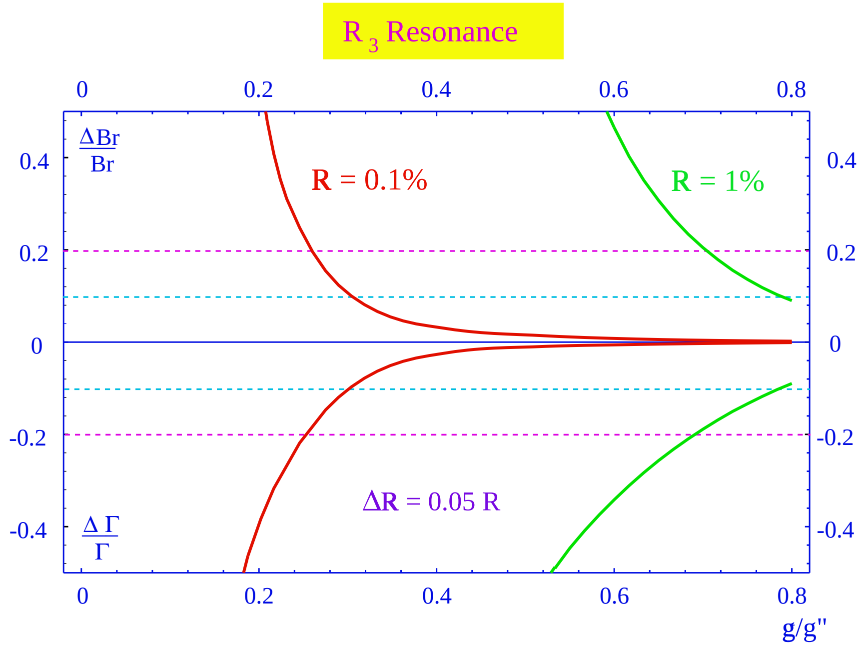
- the uncertainty $\Delta\sigma_E/\sigma_E$ which may induce relatively large errors in the determination of the parameters of a resonance with $\Gamma \sim \sigma_E$

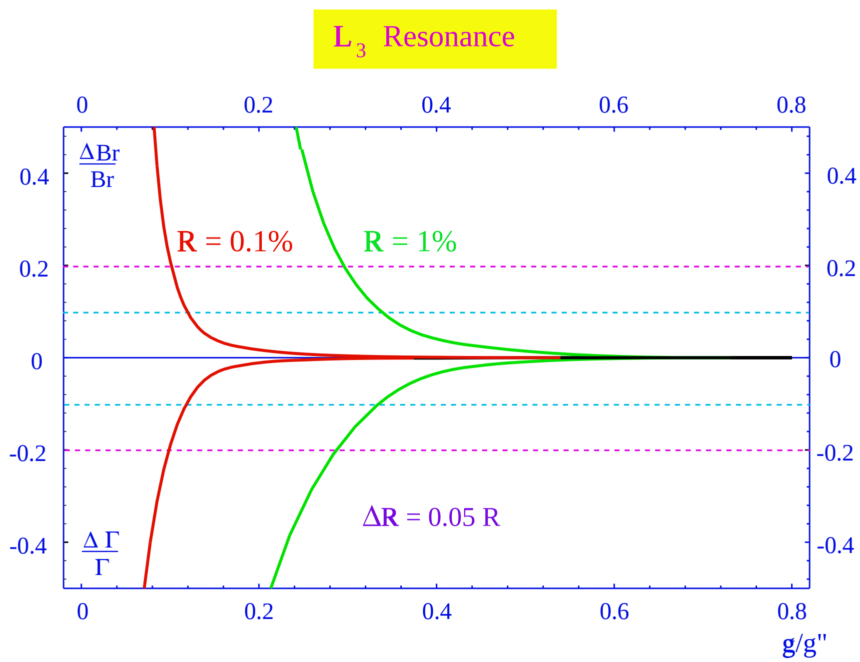
As a first step:
ASSUME to know exactly the beam energy
ASSUME a GAUSSIAN distribution energy peaked at the mass M of the resonance and characterized by

$$\sigma_M(GeV) = 0.007\ R(\%)\ M(GeV)$$

where R is the beam energy resolution
MAKE a convolution with a Breit-Wigner cross-section for the production of a vector resonance V
TAKE the narrow width limit
STUDY how an error on σ_M induces errors on Γ and $Br(V \to l^+l^-)$

Measuring Γ and Br with a given error leads to an observability region in the parameter space.
For example in D-BESS, for a given σ_M (for $\sigma_M \ll \Delta M$ the analysis can be applied for R_3 and L_3 separately) and for a given $\Delta\sigma_M/\sigma_M$ we get:





Ex: $\Delta R/R = 5\%$, $R = 1\%$ for L_3: $\Delta\Gamma/\Gamma < 20\%$ for $g/g'' > 0.3$ (from LEP bound: $M > 700\ GeV$)

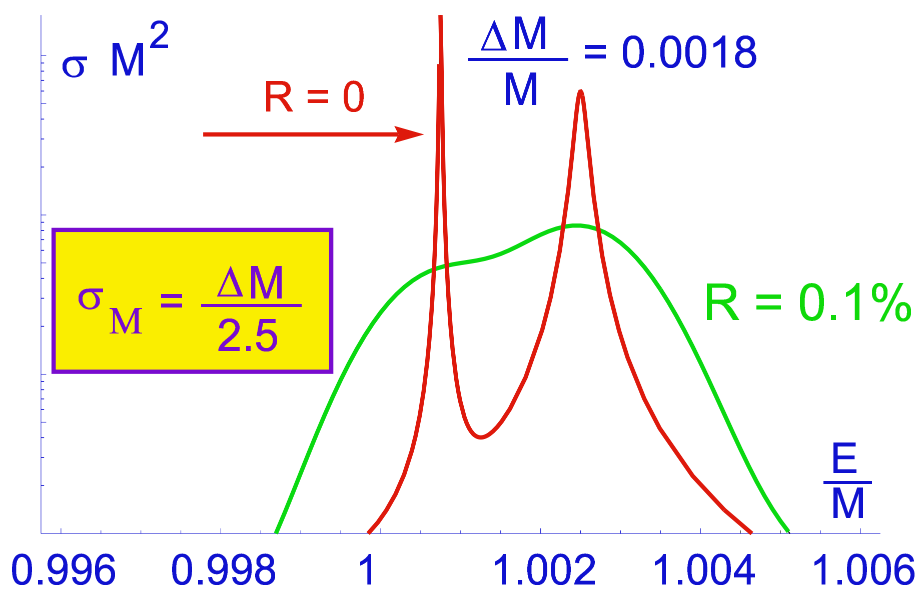
s-channel production of nearly degenerate resonances ($\sigma_M \approx \Delta M$)

To resolve two resonances one has to require that, from the convoluted cross section, one starts to detect the two peak structure .

In the narrow width limit ($\Gamma_1,\ \Gamma_2 \ll \Delta M,\ \sigma_M$) we get:

$$\sigma_M \le \frac{\Delta M}{2.5} \quad \text{or} \quad \frac{\Delta M}{M} \ge 0.0175\ R(\%)$$

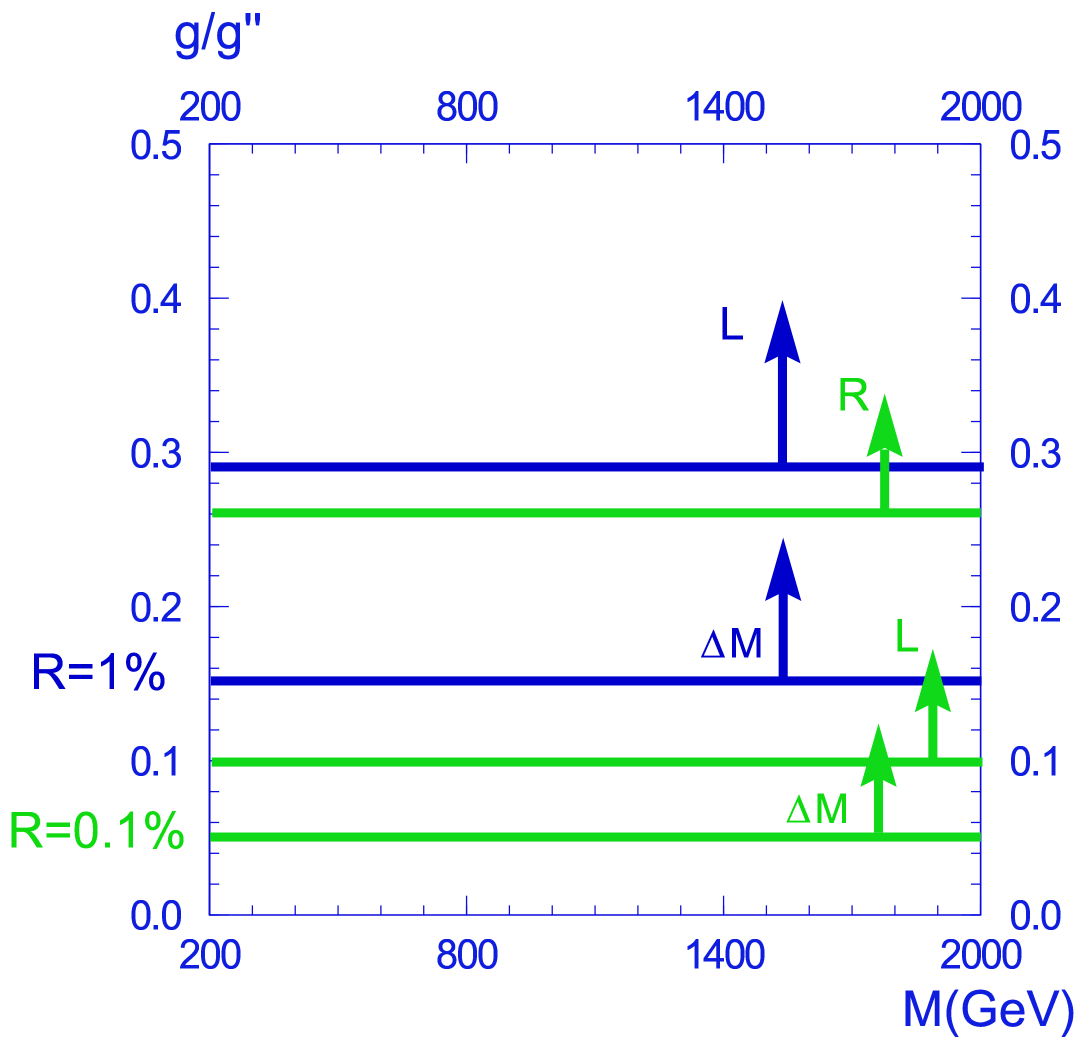
For example, in the D-BESS $\Gamma_{L_3},\ \Gamma_{R_3} \ll \Delta M$ is verified. Take $g/g'' = 0.05$ (corresponding to $\Delta M/M = 0.0018$). The R_3, L_3 resonances can be resolved for $R \le 0.1\%$



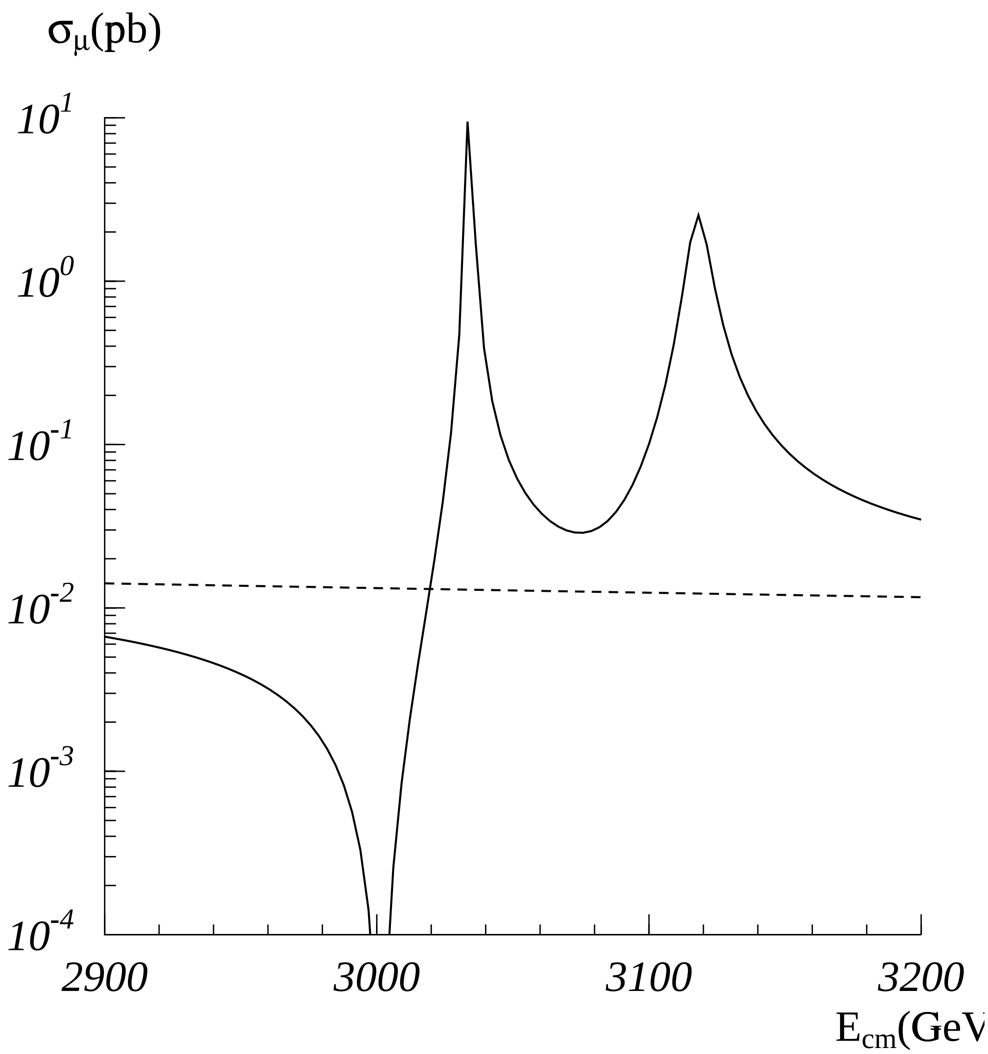
Bounds on the D-BESS parameter space

By requiring:

- $\Delta\Gamma_{L_3,R_3}/\Gamma_{L_3,R_3} \leq 20\%$ (induced by $\Delta\sigma_M/\sigma_M = 5\%$)
- $\Delta M/M \geq 0.0175\ R(\%)$ (to detect the two peaks)



D-BESS at CLIC



M(GeV) = 3000

g/g'' = 0.20

For inclusion of ISR, beam energy spread, beamstrahlung
M.Battaglia talk

A heavy Z' or a degenerate pair L_3, R_3?

(additional informations)

A high energy lepton collider (like CLIC), sitting on the resonance peak, could distinguish a single resonance from a nearly degenerate pair by the line shape analysis or by factorization tests among EW observables (T.Rizzo (1999))

From the Z-pole studies at SLC and LEP → important tree-level factorization result $\boxed{A_{LR}A_{FB}^{pol}(f) = A_{FB}^{f}}$

It comes from $A_{FB}^{pol}(f) = 3/4\ A_f$, $A_{FB}^{f} = 3/4\ A_e A_f$, $A_{LR} = A_e$ with $A_f = 2v_f a_f/(v_f^2 + a_f^2)$ and $v_f(a_f)$ the vector (axial-vector) coupling of the Z to fermions.

In general, these relations are no longer satisfied for two almost degenerate resonances (for ex. A_{LR} is flavor dependent). Define (Rizzo 1999)

$$T_2(f) = A_{LR}^{f}A_{FB}^{pol}/A_{FB}^{f}$$

For a single resonance $T_2 = 1$ at tree-level for any fermion channel

We have evaluated T_2 within the D-BESS model (in the small mixing limit the g/g'' dependence drops out)

$$\boxed{T_2(\mu) = 0.306, \quad T_2(b) = 0.127, \quad T_2(c) = 0.211}$$

The single resonance relations are numerically badly broken in the D-BESS model

Conclusions

- In spite of the impressive agreement of the present data with the SM predictions, the origin of EW symmetry breaking remains unknown

- The success of the SM poses strong limitations on the possible forms of new physics

- Decoupling models are particularly appealing since they show little deviations from the SM structure. The Degenerate BESS model is an example of dynamical EWSB scenario with decoupling

- D-BESS predicts new spin 1 resonances which could give well visible signals in the di-lepton channels at the LHC for $M \leq 2 \div 3\ TeV$

- The first next generation of linear e^+e^- colliders could put bounds on the parameter space of the model if the resonances are too heavy to be discovered

- If the mass of the resonances is in the multi-TeV range CLIC or a μC could perform a detailed study of their properties, in particular, disentangle the two very narrow nearly degenerate neutral resonances, the distinctive feature of D-BESS