Walking Technicolor at Colliders

LHC and ILC

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4. Problem: no fermion masses. Extended Technicolor (ETC) needed at some higher scale. (Lane and Eichten 80)
   - ETC typically leads to flavor changing neutral currents (FCNC).
   - Tension between fermion masses and FCNC in QCD-like Technicolor.

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3. Better behavior of the S parameter relative to a running theory. (Appelquist and Sannino 98)
4. Problem: Walking dynamics with fermions in the fundamental representation is only achieved for a large number of flavors. $\rightarrow$ **Large contribution to the S parameter**.

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   - $N_c = 3,\ N_f = 2$ in the two index symmetric $\rightarrow$ Next to Minimal Walking Technicolor (NMWT)

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3. Examples:
   - $N_c = 2$, $N_f = 2$ in the fundamental and 2 adjoint Weyl fermions $\rightarrow$ Ultra Minimal Technicolor (UMT) $\rightarrow$ Gauge singlet DM candidate !

New Physics

- $\mathcal{L}_{\text{newphysics}} = -\frac{1}{4}F^a_{\mu\nu}F^{a\mu\nu} + i\bar{Q}_{\text{L}}\gamma_\mu D^\mu Q_{\text{L}} + i\bar{Q}_{\text{R}}\gamma_\mu D^\mu Q_{\text{R}}$

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  - Plus ETC interactions.

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3. Effective theory:
   - spin-0 and spin-1 objects filling out representations of the chiral symmetry group.
   - Higgs sector with a broken phase.

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4. Allow for a violation of the second WSR:
   - $F_{\rm V}^2 M_{\rm V}^2 - F_{\rm A}^2 M_{\rm A}^2 \neq 0$.

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   - + additional composite states in theories with chiral symmetry larger than $\mathrm{SU(2)_L \times SU(2)_R}$ (if not too heavy, due to ETC) + techni-omega and techni-eta.

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   - Compare unitary gauge and 't Hooft-Feynman gauge implementations.

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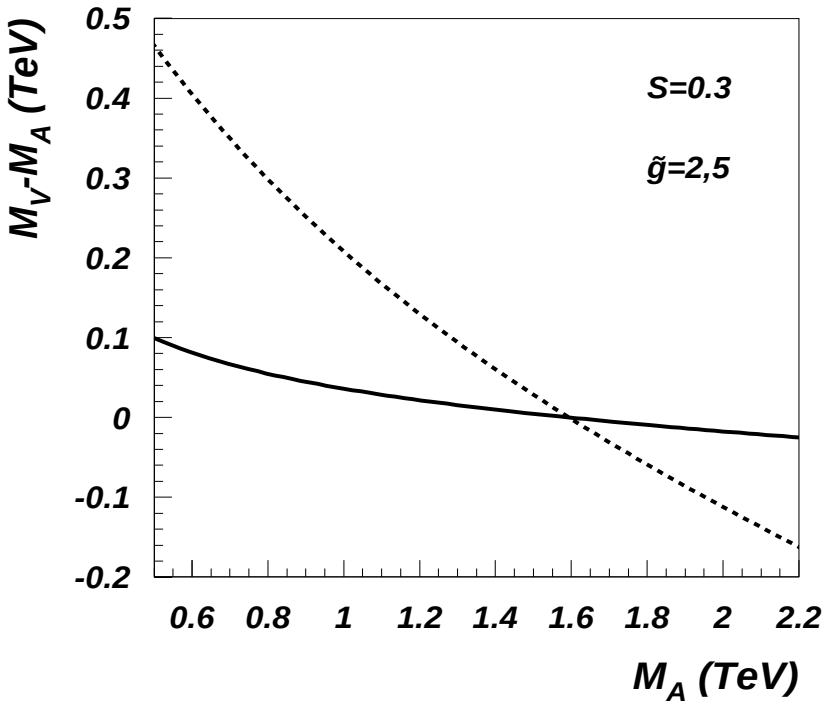
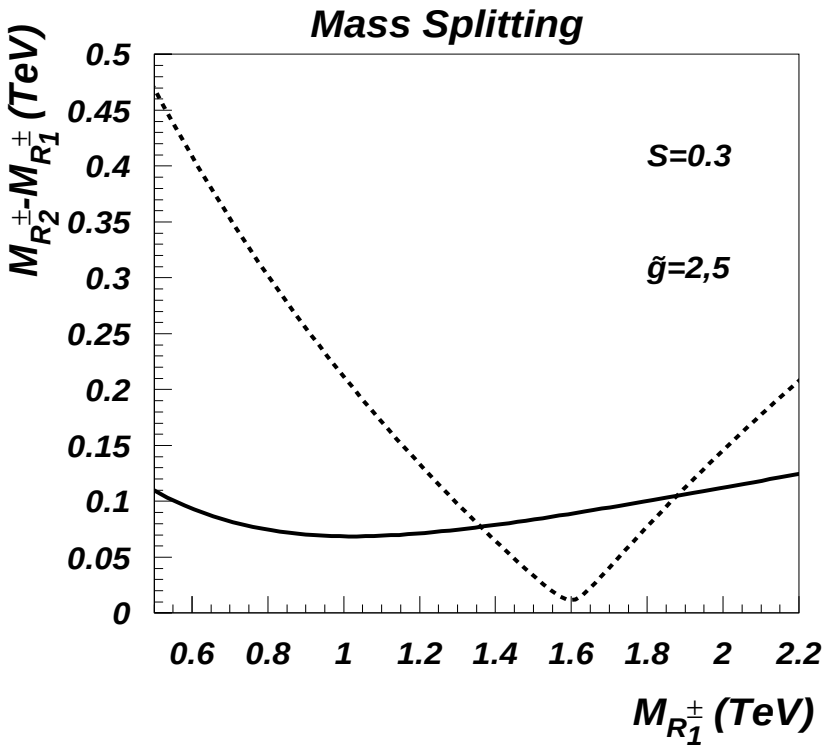
- Higgs production and decay (see next talk).

Vector-Axial Mass Splitting: $g,\ g' \to 0$



- "Vector" and "axial vector" useful labels only away from the degeneracy point.

Vector-Axial Mass Splitting: $g,\ g' \neq 0$



- $R_1^{\pm,0}$=lighter vector resonance, $R_2^{\pm,0}$= heavier vector resonance.
- Below and away from the degeneracy point $\rightarrow$ $R_1^{\pm,0} \simeq A^{\pm,0}$, $R_2^{\pm,0} \simeq V^{\pm,0}$.
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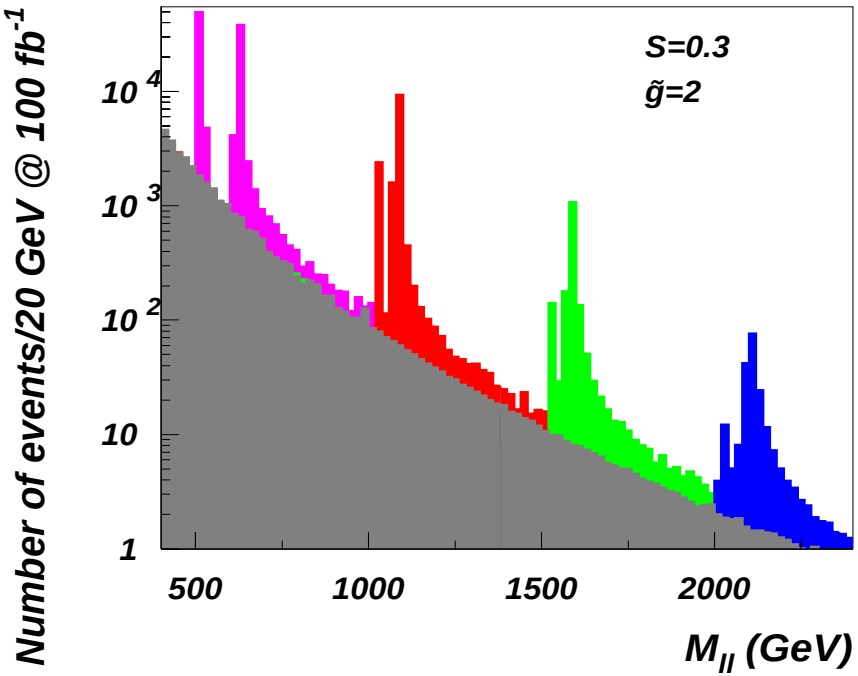
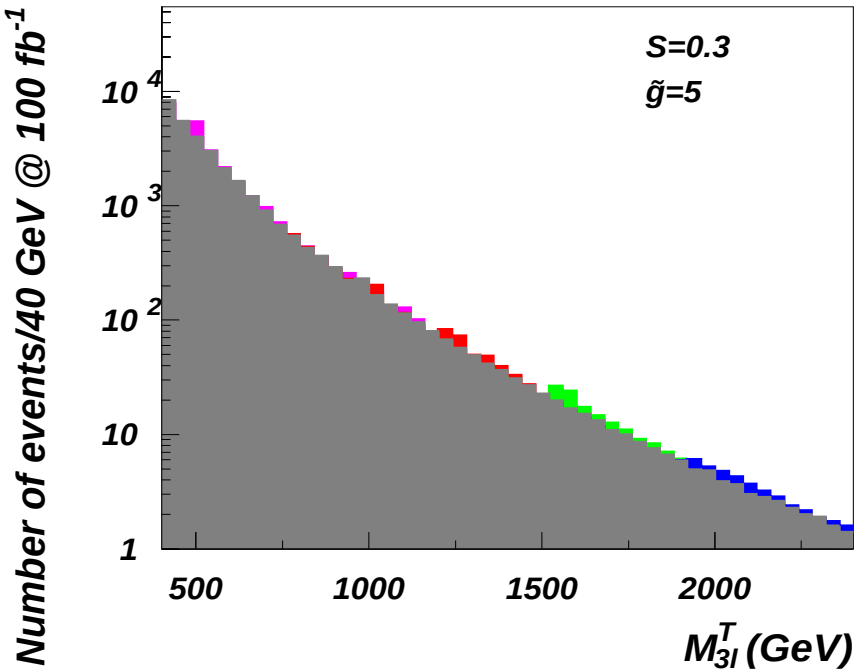
  3. $3\ell + \not{E}_T$ signature from $pp \rightarrow R^\pm_{1,2} \rightarrow ZW^\pm \rightarrow 3\ell\nu$

$\ell^+\ell^-$ signature from $pp \to R^0_{1,2} \to \ell^+\ell^-$





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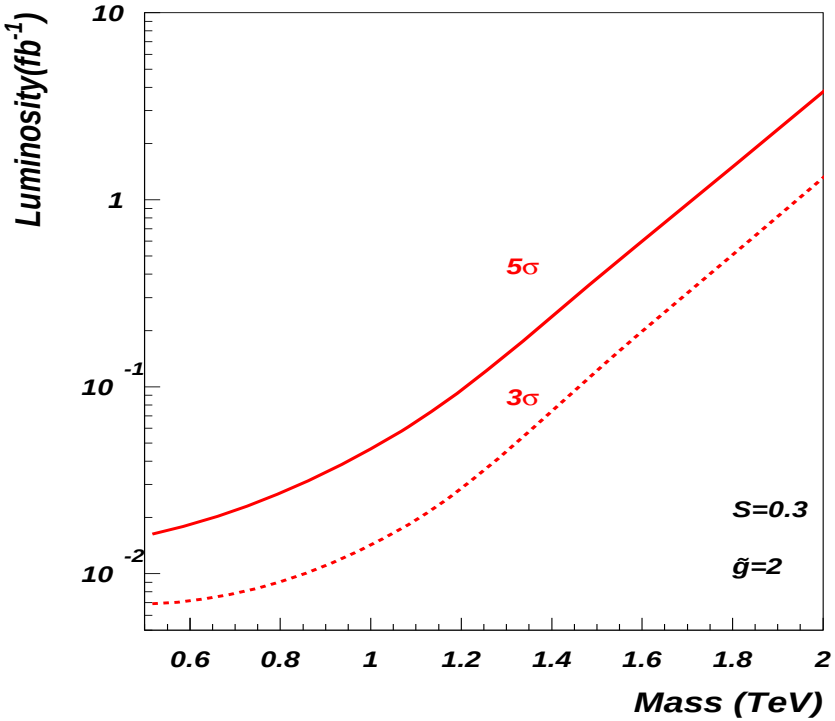
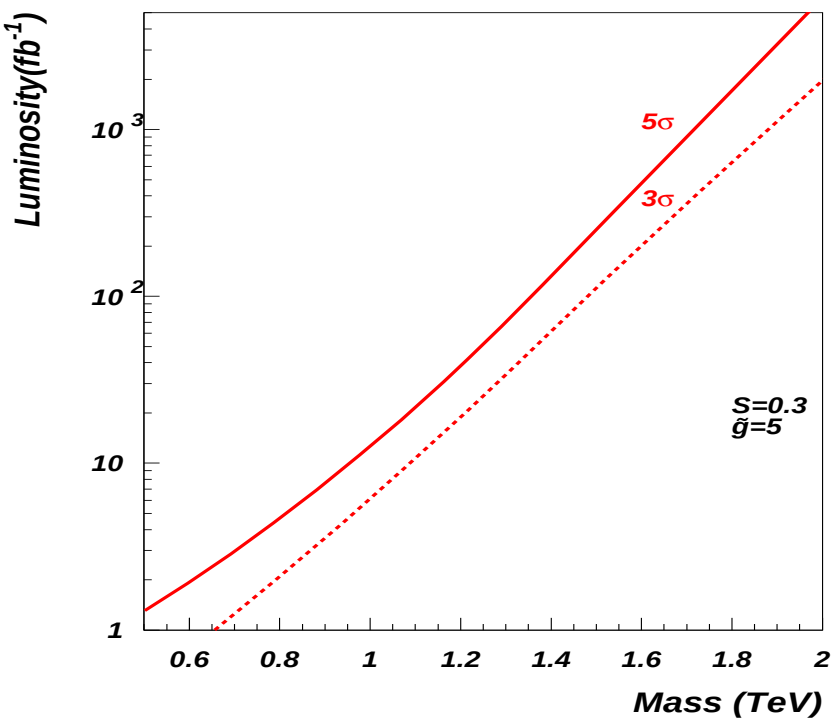
Required luminosity for 5σ and 3σ discovery





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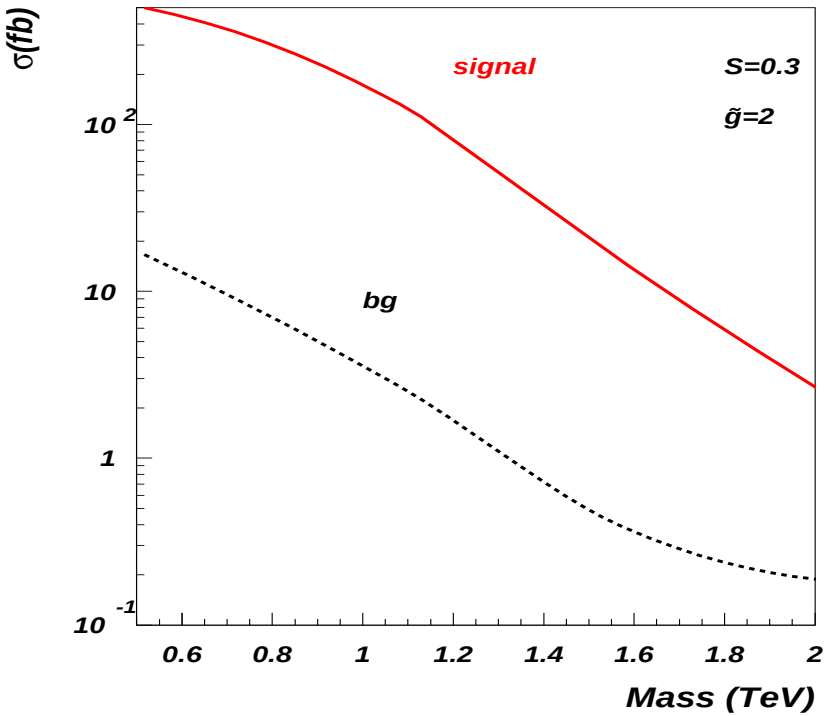
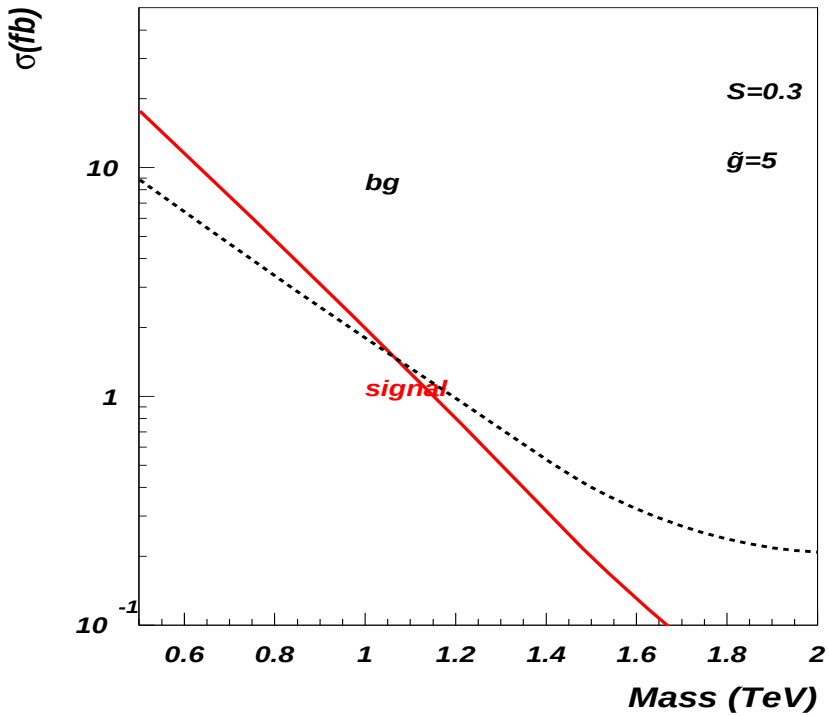
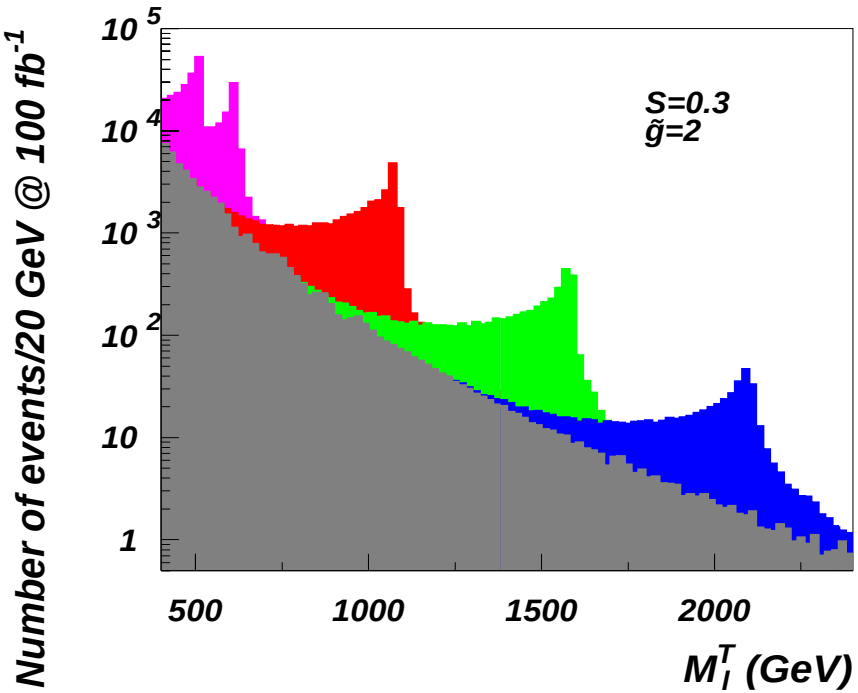
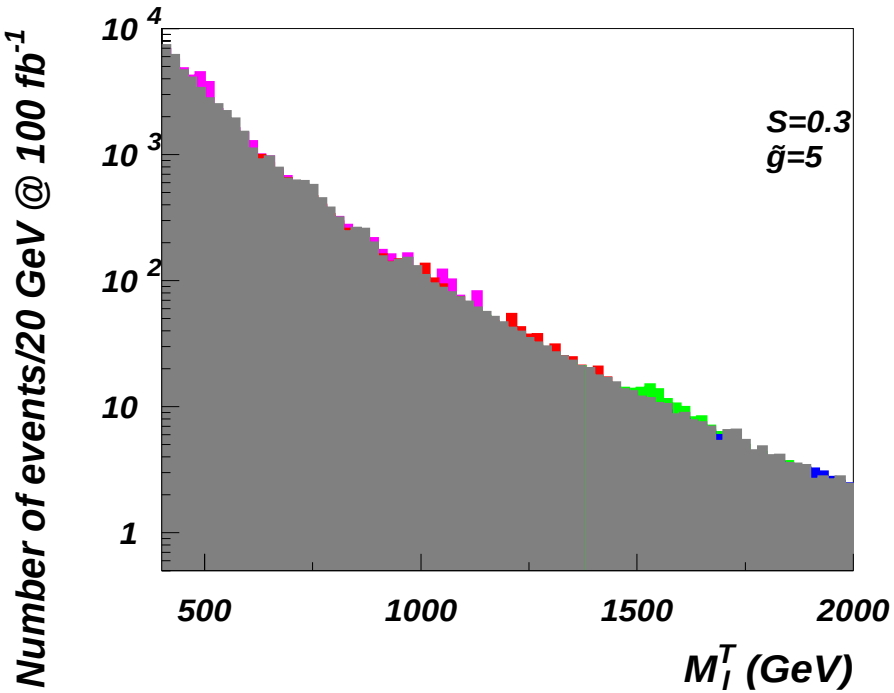
Signal





$\ell + \not{E}_T$ signature from $pp \to R^{\pm}_{1,2} \to \ell^{\pm}\nu$





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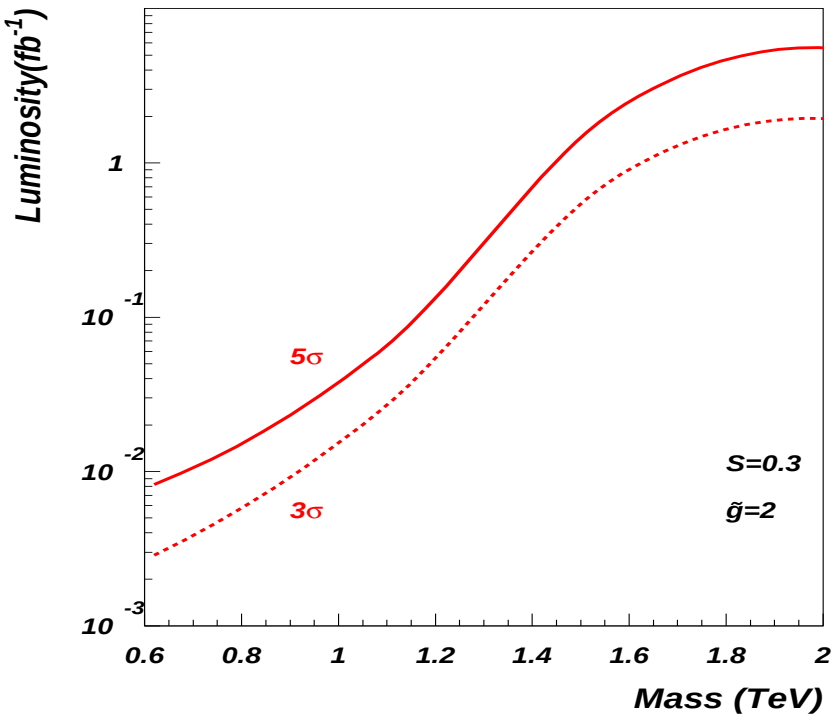

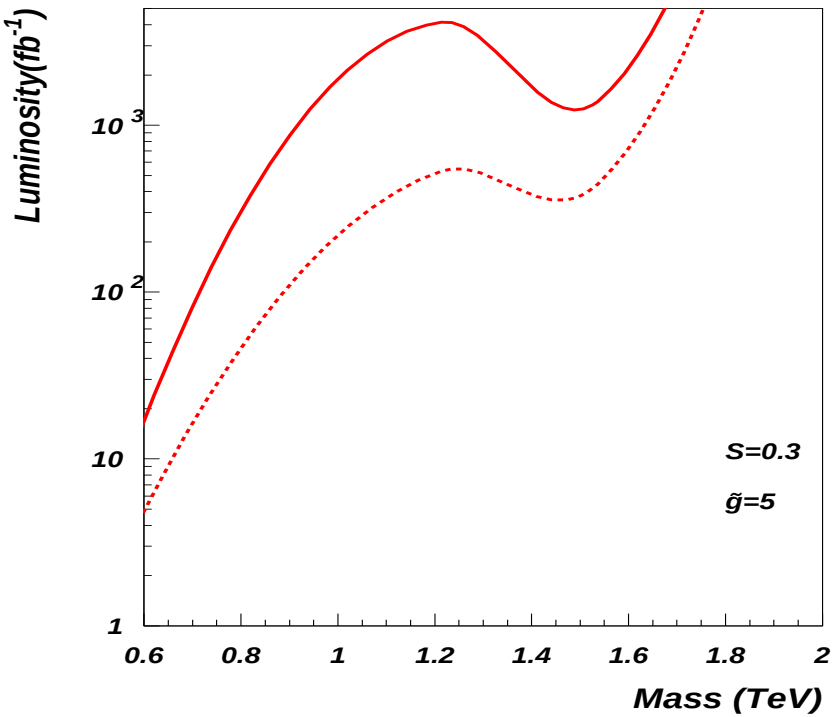

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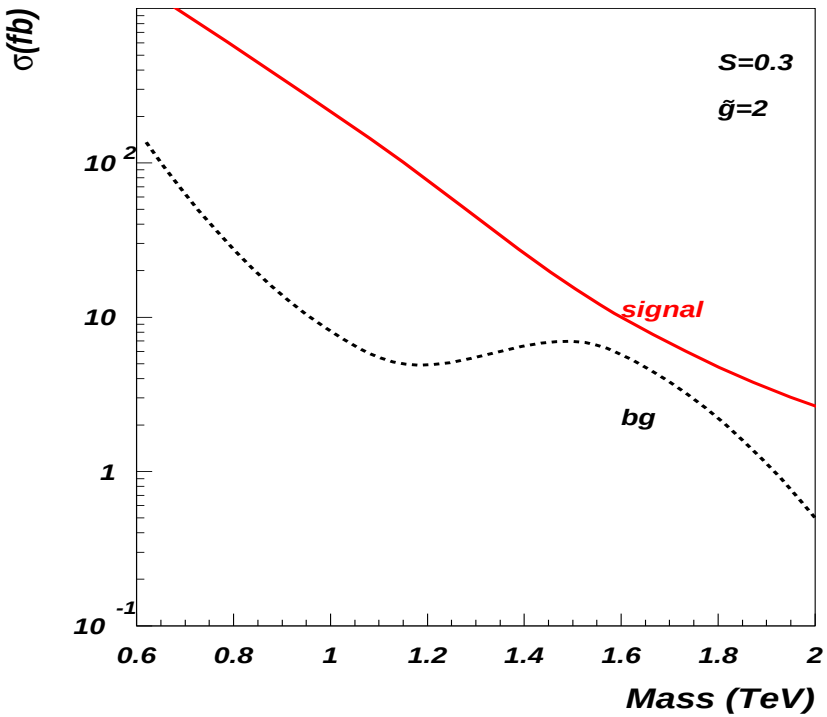
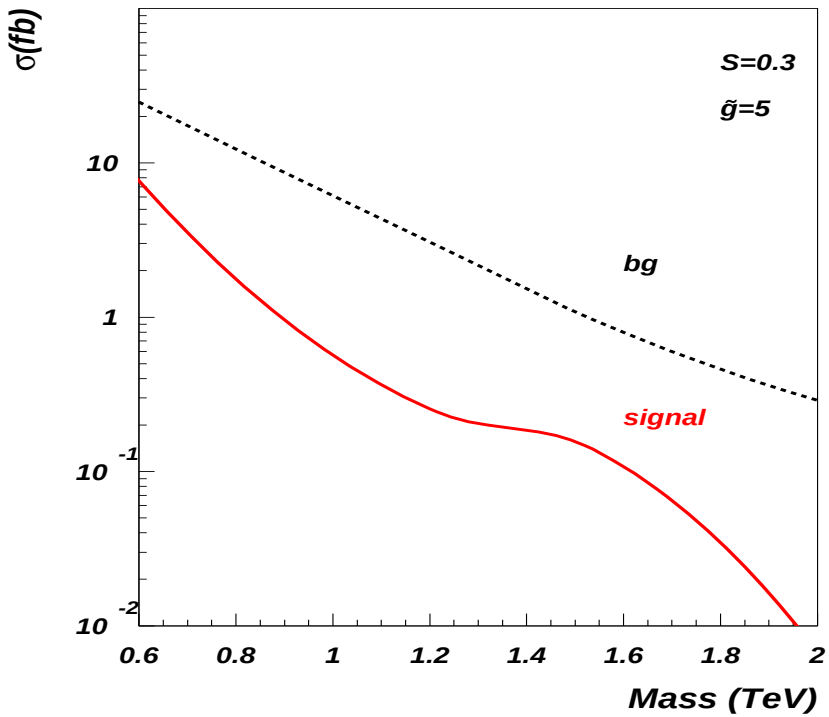
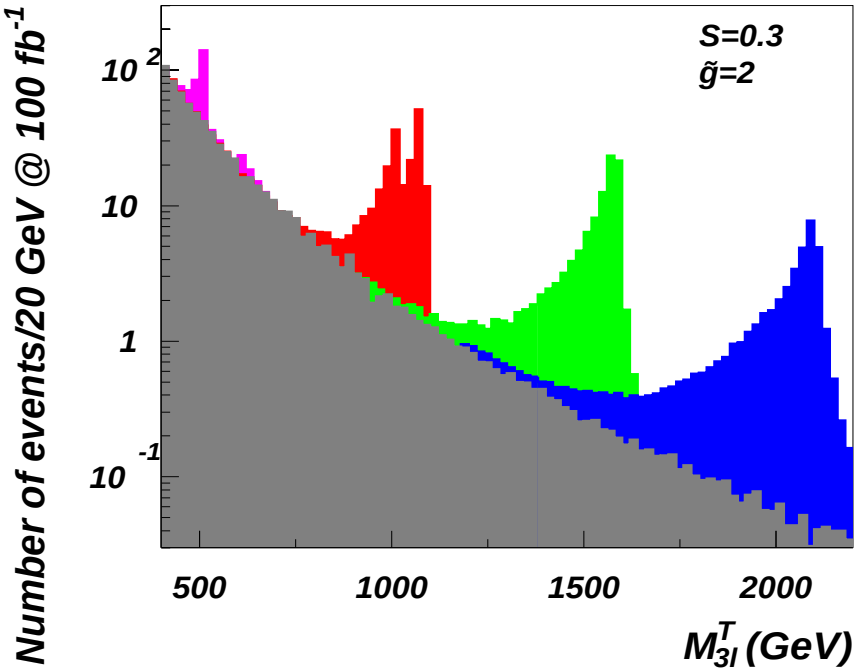
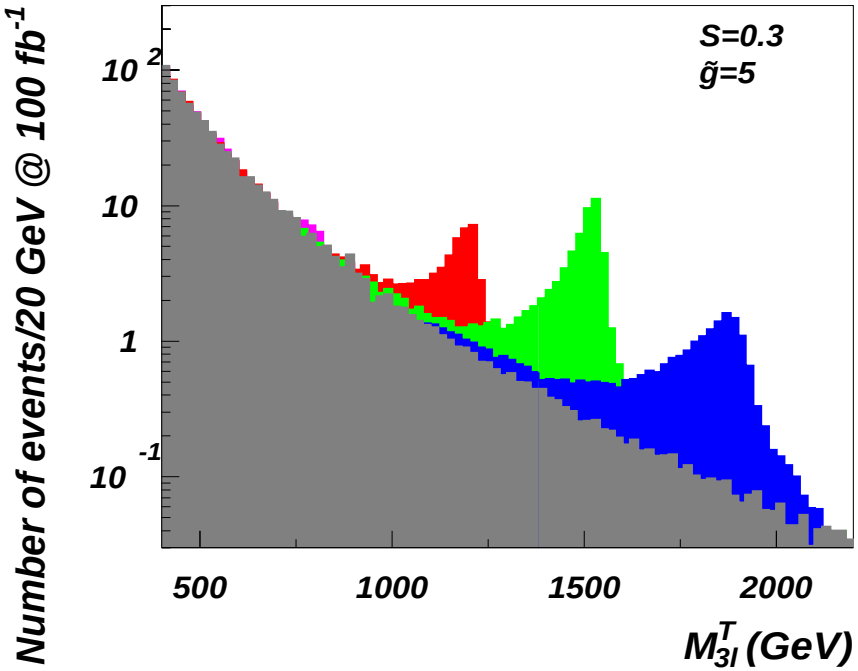




$3\ell + \not{E}_T$ signature from $pp \to R^{\pm}_{1,2} \to ZW^{\pm} \to 3\ell\nu$





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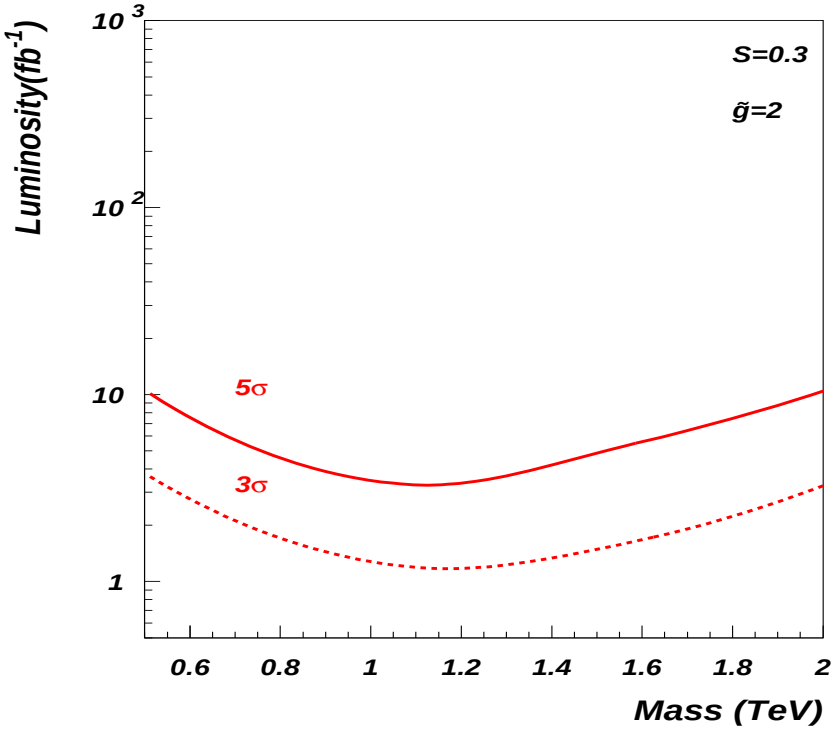

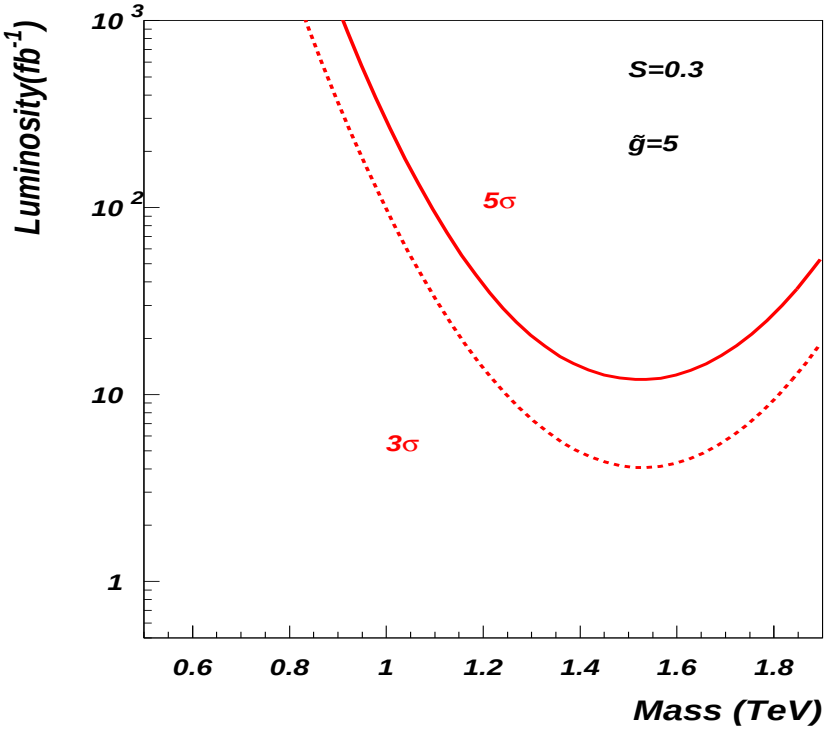

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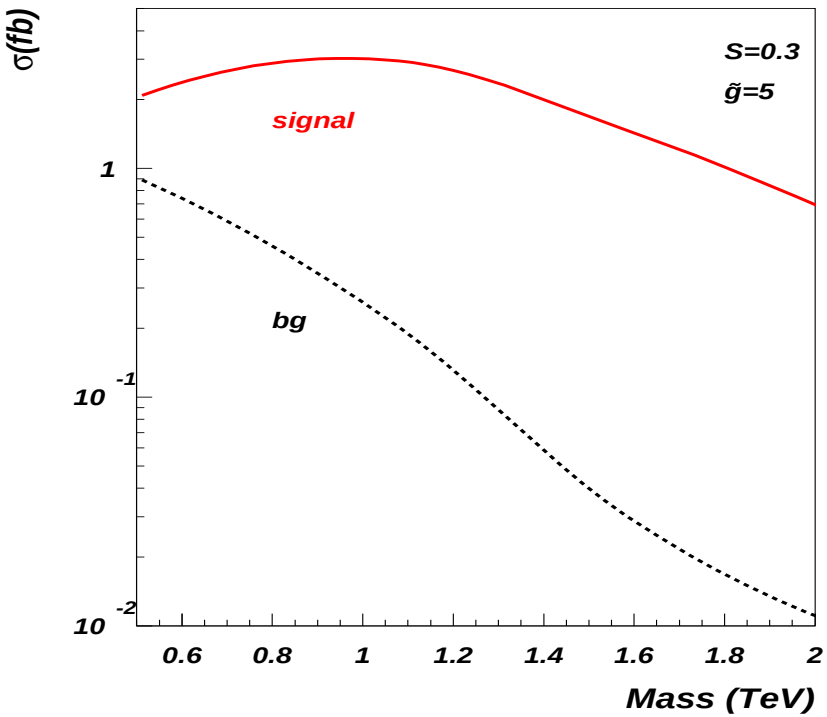
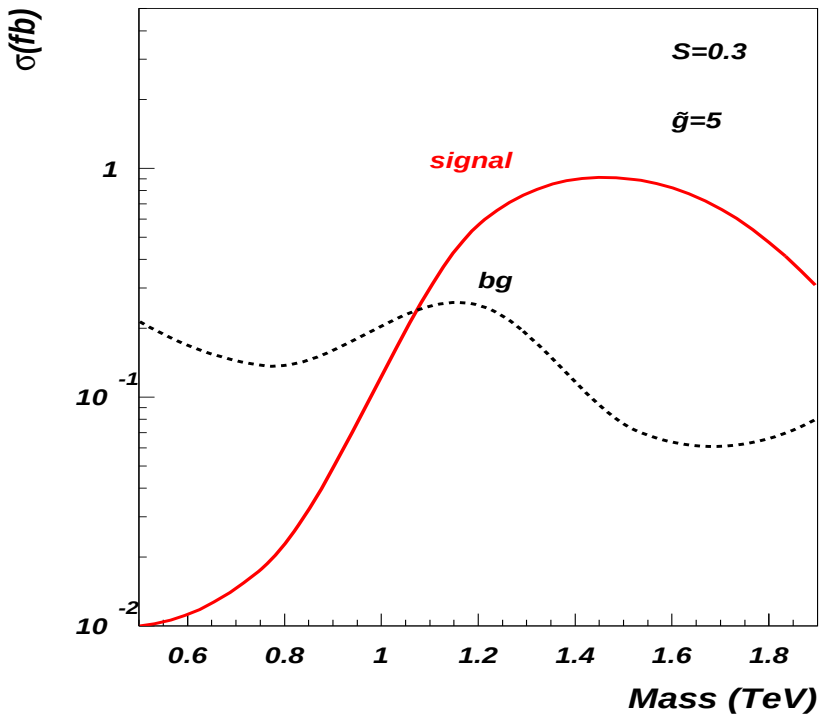
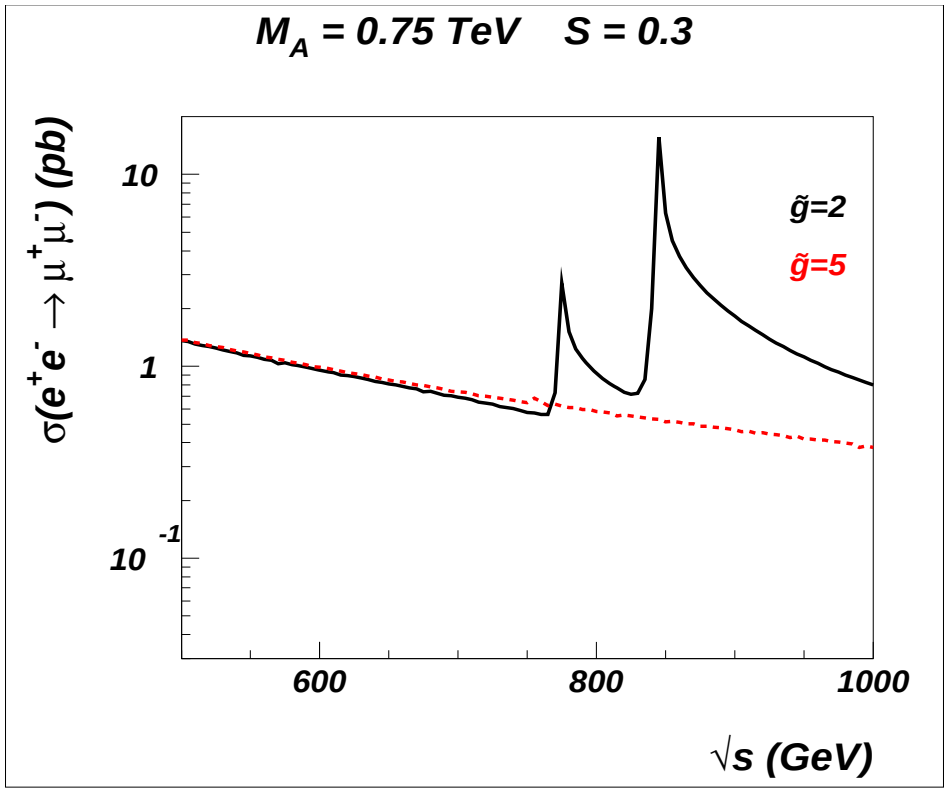




$$e^+e^- \longrightarrow \mu^+\mu^-$$



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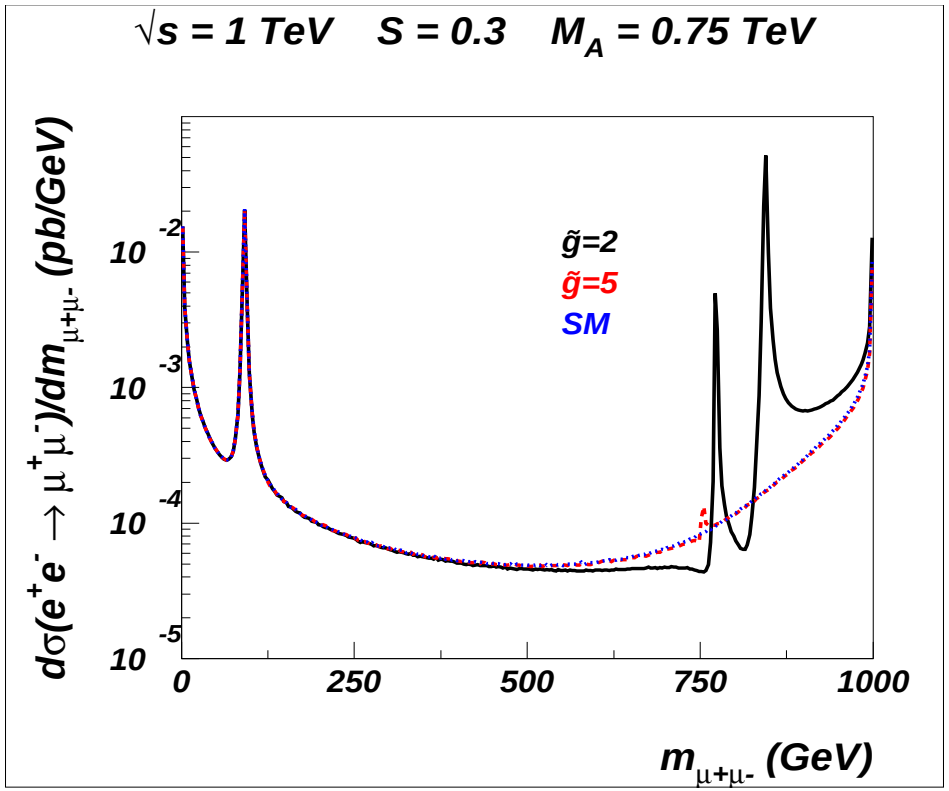

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- In minimal models of WT the S parameter is small: because of the small number of flavors and because of the near conformality. Additional negative contributions to S can arise from new leptons.

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- If not too heavy, the vector resonances of WT can be produced and observed at linear colliders.
- Key processes are $e^+e^- \to \mu^+\mu^-$, $e^+e^- \to ZZZ$, $e^+e^- \to ZH$ (work in progress !)