top-BESS Model

and

its Phenomenology

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IEAP CTU Prague, Sep 20, 2011

Outline

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Electroweak Symmetry

Gauge Principle

$SU(2)_L \times U(1)_Y \quad \Rightarrow \quad$ EW interactions: $\mathcal{L}_{EW,m=0}$

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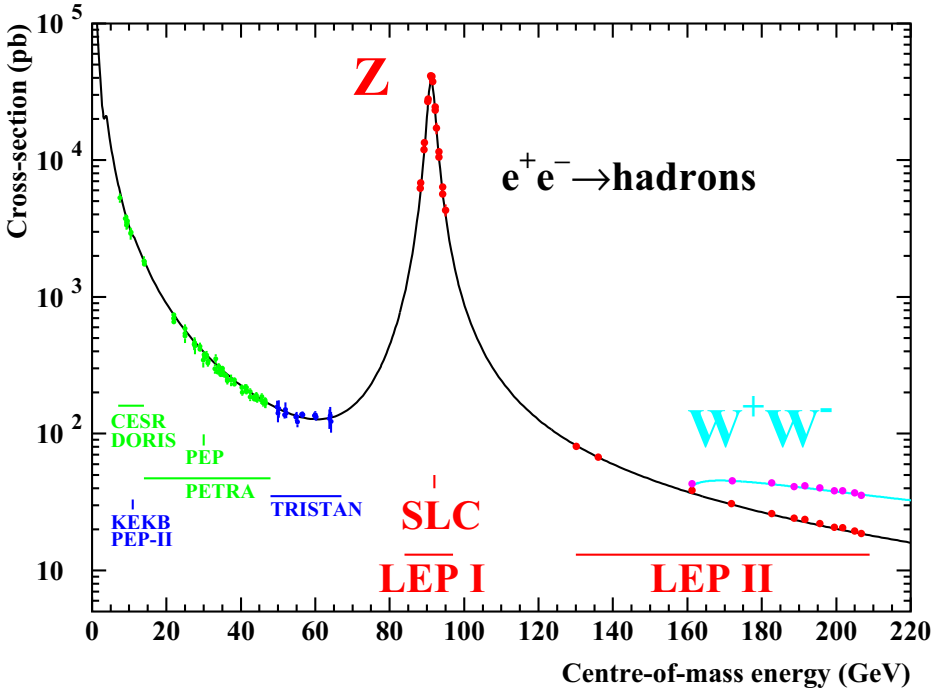

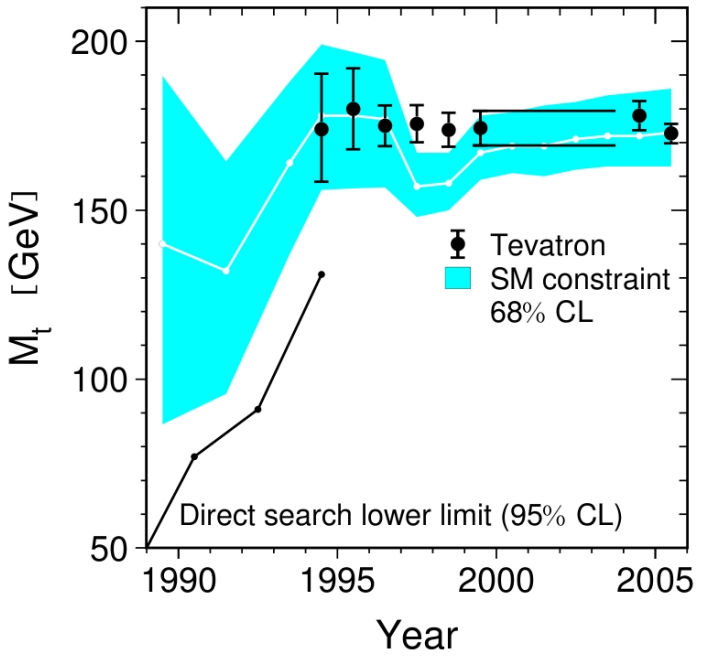

EW symmetry broken!

masses **break** EW symmetry

- fermions:

$$m_t \gg m_b, \quad \ldots \quad m_e \gg m_{\nu_e}$$

- weak gauge bosons:

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$$\text{symm}(vacuum) < \text{symm}(Lagr)$$

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BENCHMARK HYPOTHESIS $\rightarrow$ SM HIGGS

- $SU(2)_L$ complex scalar doublet Φ
- $v = \langle 0|\Phi|0\rangle$

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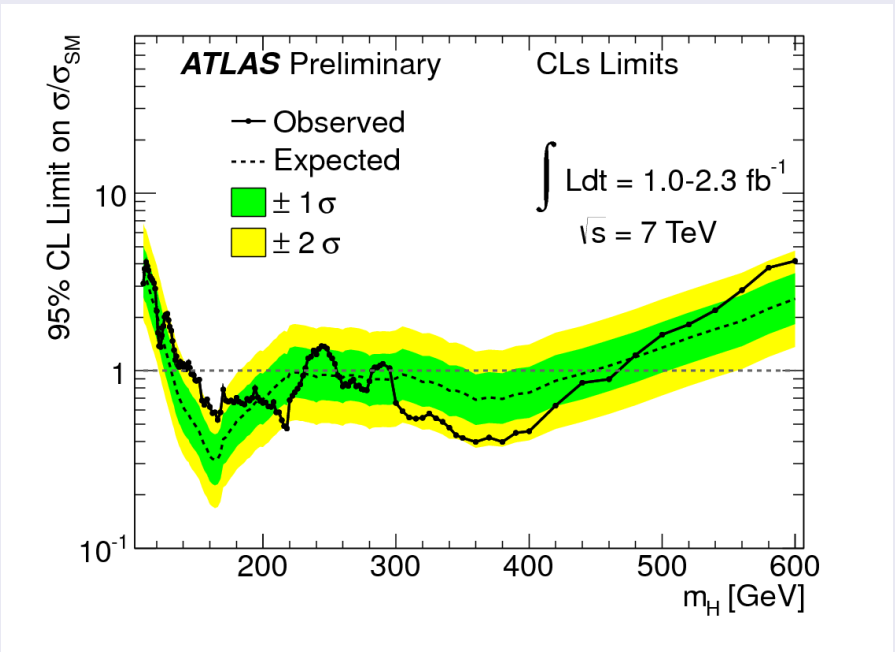

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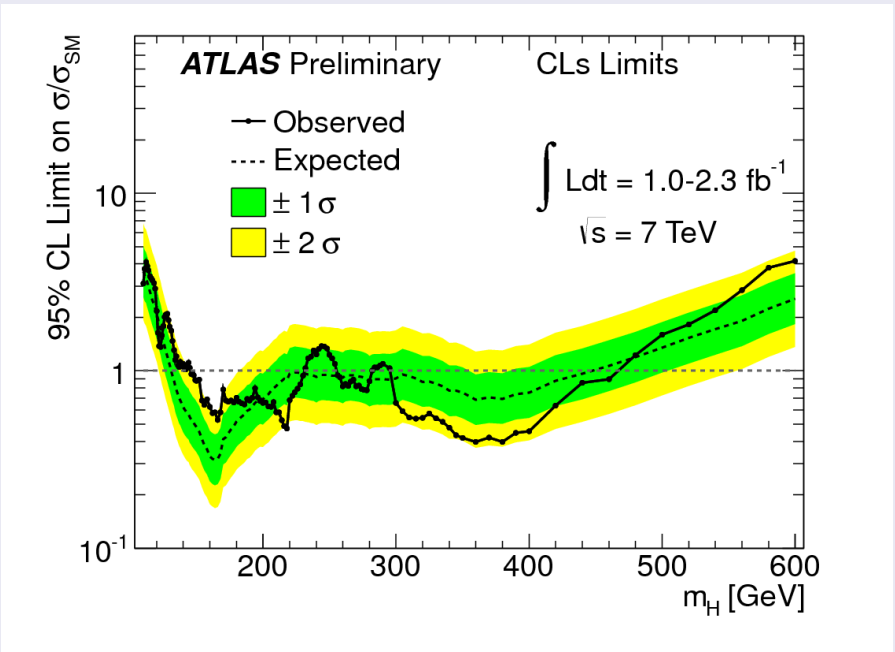

theoretical pathologies

↓

just a parameterization of ESB?

Higgs boson alternatives

weakly interacting:

- new forces and particles
- *perturbative*
- more Higgses, SUSY

strongly interacting:

- new forces and particles
- *non-perturbative* $\rightarrow$ *bound states*
- TC and its extensions

extra-dimensions:

4D *strongly* interacting $\longleftrightarrow$ 5D *weakly* interacting

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New particles WANTED!

- Model InDependent Reason

  heavy/no Higgs violates unitarity $\approx$ 1 TeV

- Model Dependent Reason
  - SUSY: ... superpartners, Higgs-like scalars
  - TC: ... bound states
  - extra-dim: ... KK towers

Outstanding Top Quark

$m_t \approx v/\sqrt{2}$ → special role in ESB?

new physics behind m_t

↙ ESB related

Extended TC, ...

↘ ESB *un*related

Topcolor Assisted TC, ...

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Effective description of Strong ESB

- $SU(2)_L \times U(1)_Y$ broken *dynamically*
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- LHC $\rightarrow$ the *lightest* BSM resonances
- *chiral effective* Lagrangian for Goldstone bosons

  nonlinear sigma model
- ... + resonances

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$$W^{\pm}, Z \quad A \quad V^{\pm}, V^0 \qquad \text{...mixing}$$

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Phys. Rev. **D84**, 035013 (2011)

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top $\rightarrow$ ESB?

- $\diamond$ 3^{rd} quark generation only ... b_L, b_R
- $\diamond$ $bottom_R$ vs. top_R ... p
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NEW RESONANCE MASSES

- mass of the vector resonance:

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- EW gauge bosons $\rightarrow$ mixing $\rightarrow$ mass splitting

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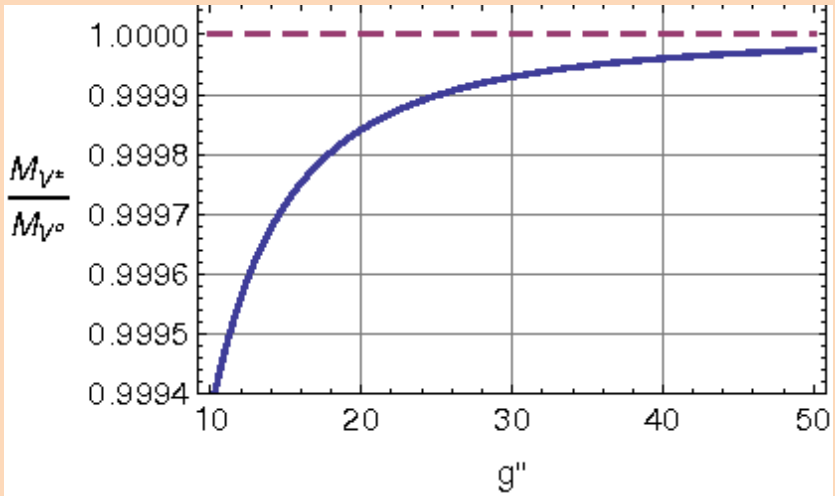
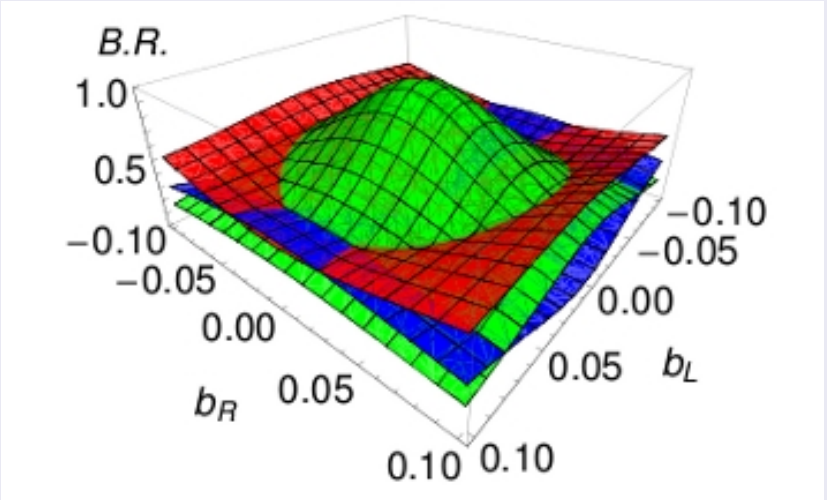


Decay Widths

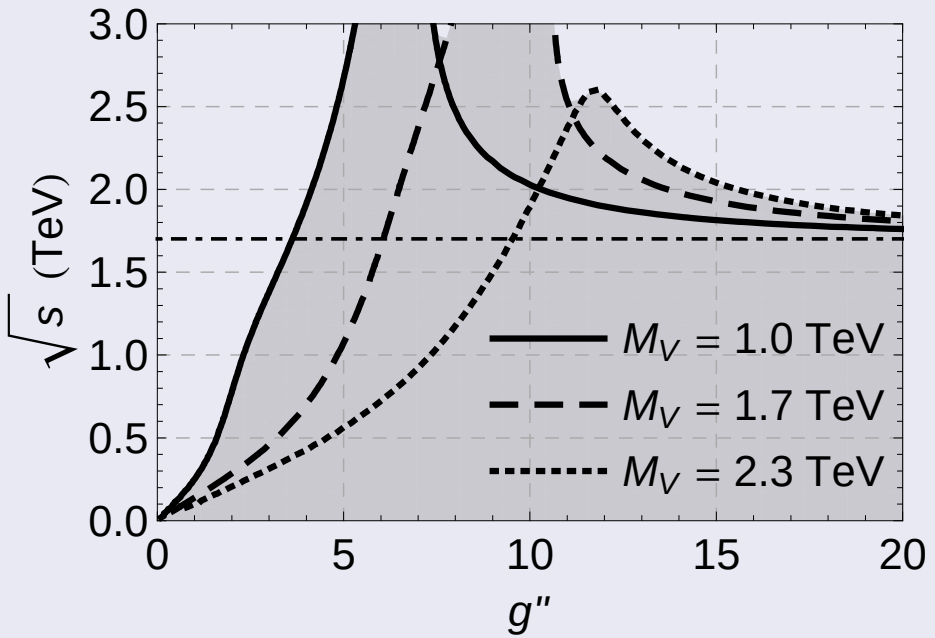
- $V^0 \rightarrow W^+W^- + t\bar{t} + b\bar{b} + \ldots$
- $V^+ \rightarrow W^+Z + t\bar{b} + \ldots$
- $\Gamma \sim 10 - 100$ GeV



WW, *tt*,*bb*

Unitarity constraints

- GB scatterings:
  $W_L^+ W_L^-$, $Z_L Z_L$,
  $W_L^\pm Z_L$, $W_L^\pm W_L^\pm$
- tree level
- Equivalence Theorem



Low-energy limits

experiment: LEP + SLC + Tevatron

EWPD ϵ-analysis: ϵ_1, ϵ_2, ϵ_3, ϵ_b, $\Gamma(Z \to b\bar{b})$, $B \to X_s\gamma$, $p\bar{p} \to WZX$

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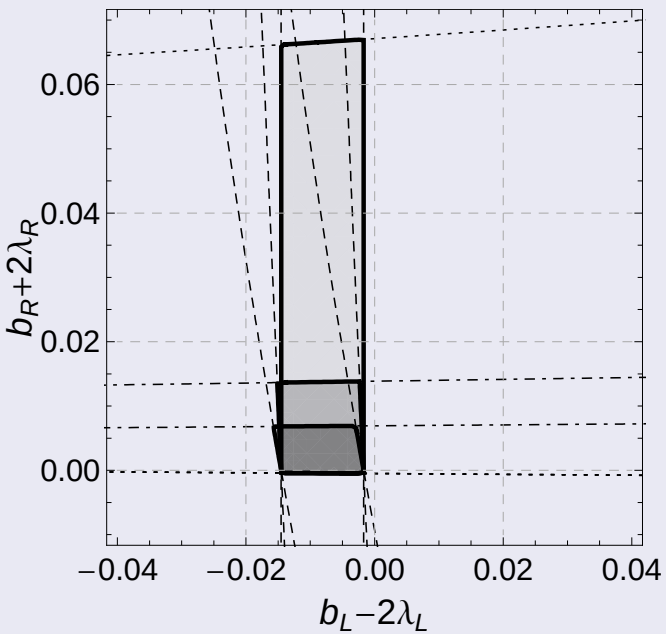

Intersections of 90% C.L. allowed regions.

$M_V = 1$ TeV
$g'' = 10$

The Death Valley

direct + indirect *cplgs* $\Rightarrow$ DV

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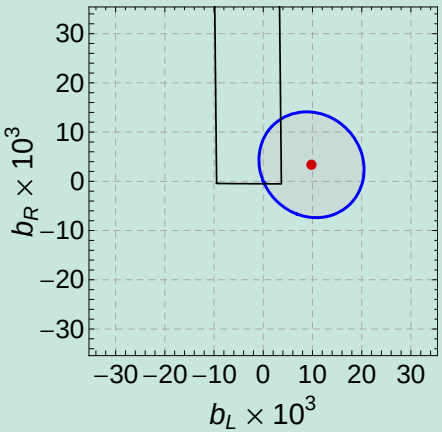
$V^0 \to t\bar{t}$



$g'' = 10,\ \lambda_L = \lambda_R = 0$

The Death Valley regions of the $V \to t\bar{t}/b\bar{b}/tb$ *decays.*

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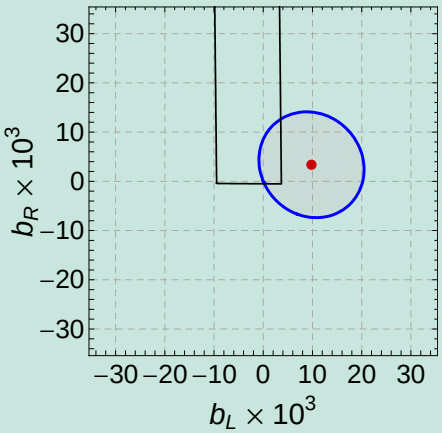

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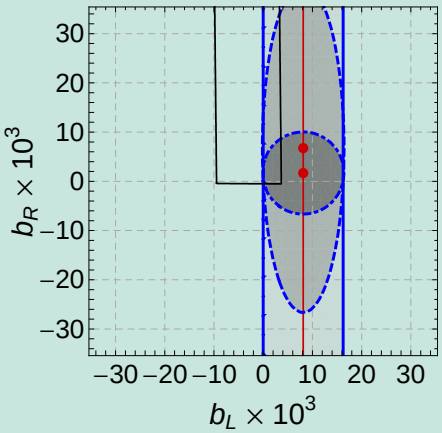

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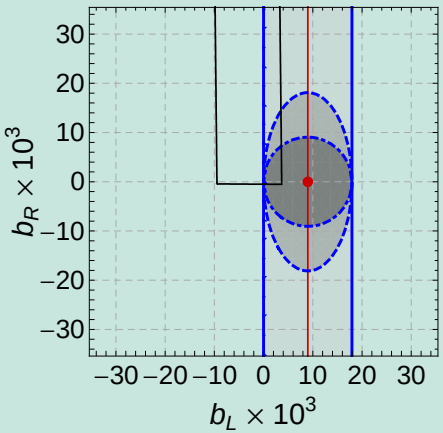

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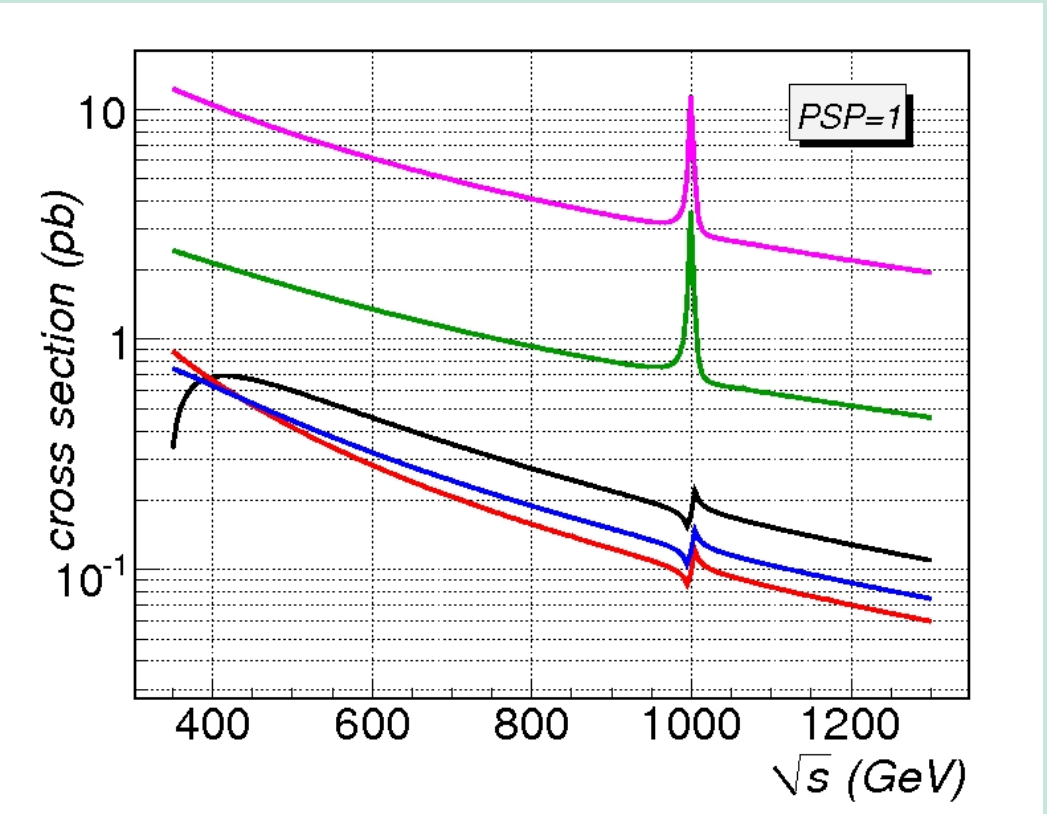

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- **outside the DV**
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- **$t\bar{b}$ & $b\bar{b}$ in the DV**
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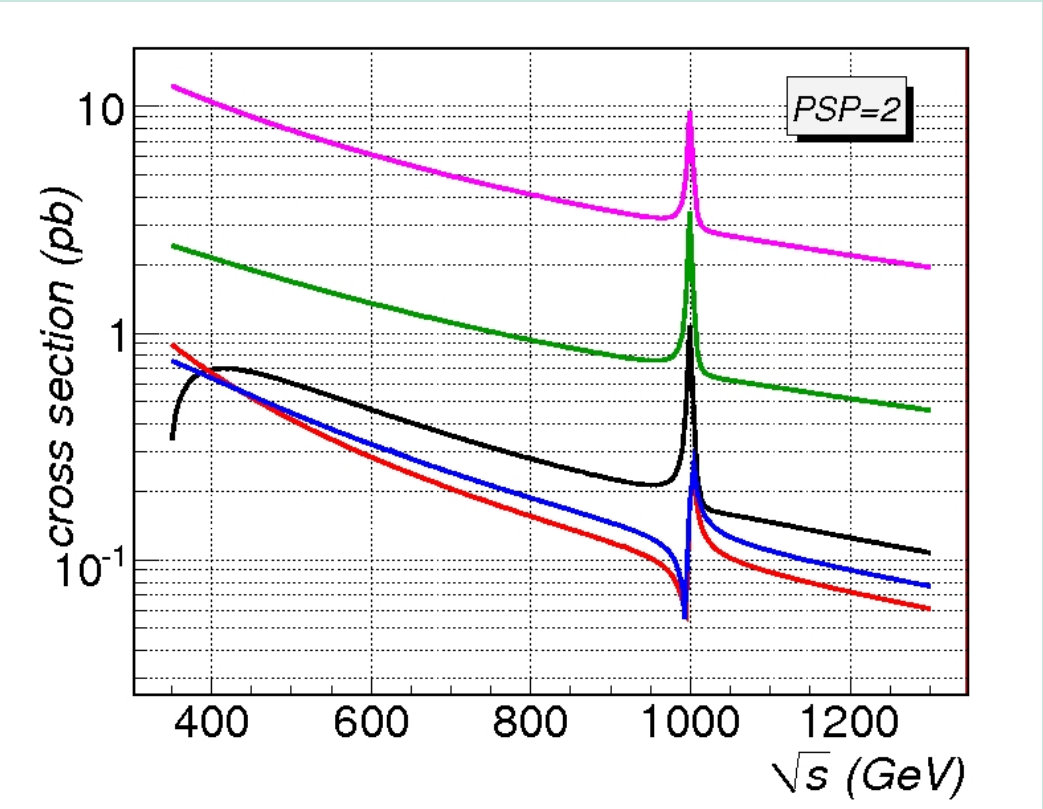

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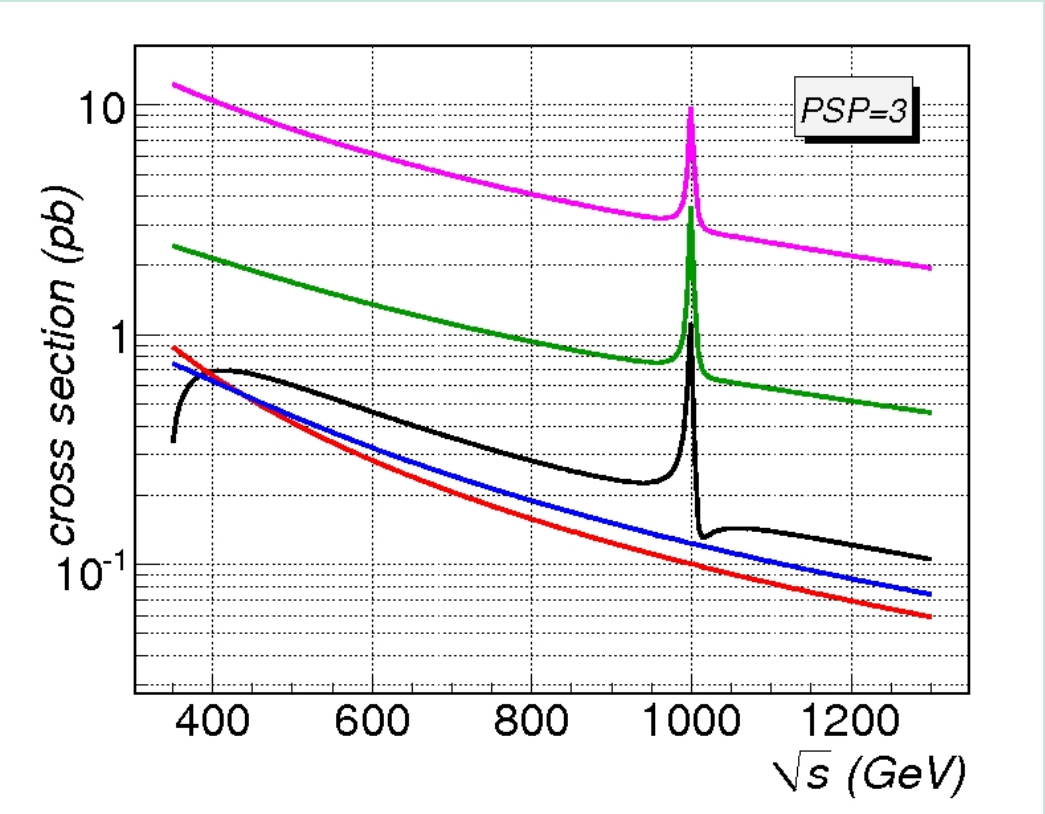

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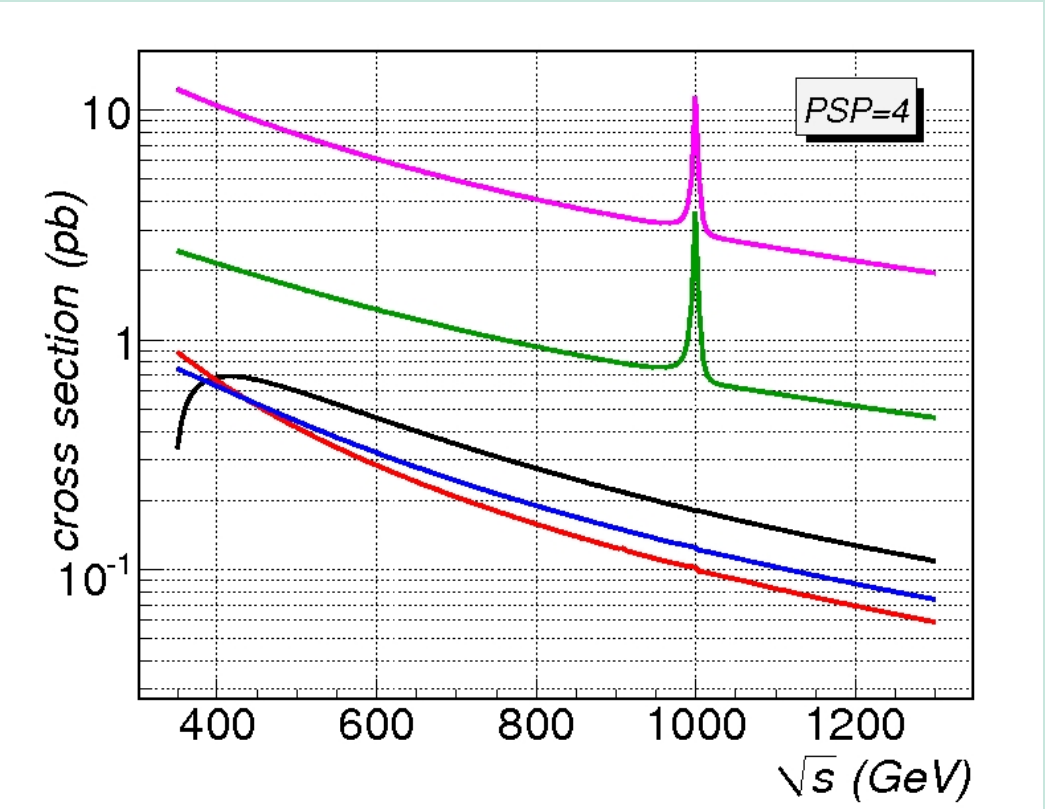

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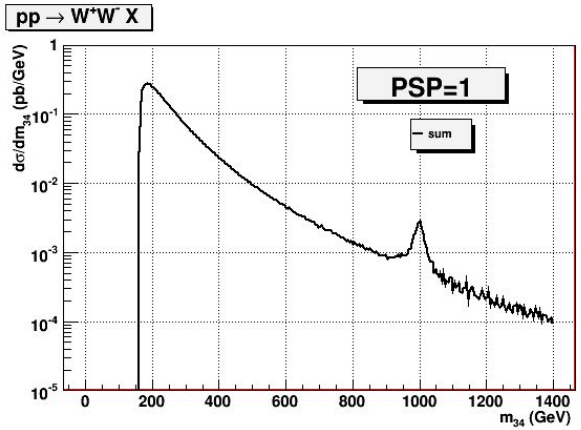
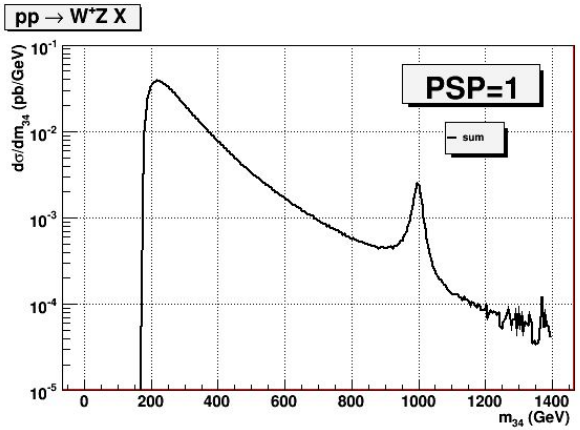
What's next?

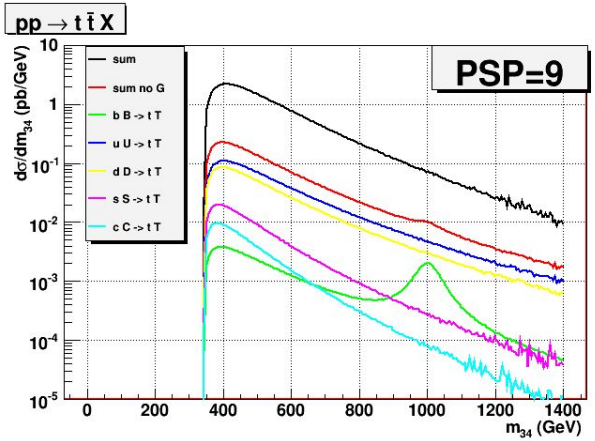
- theoretical development
  - low-energy limits
  - scrutinizing the parameter space
  - relation to existing theories
  - ...
- probing tBESS at LHC and ILC
  - Drell-Yan processes at LHC
  - ...

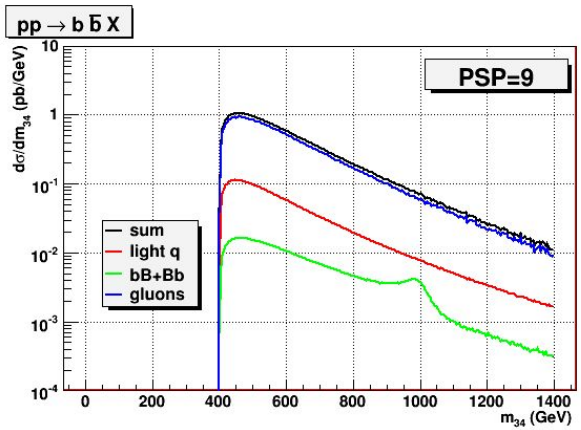
Drell-Yan at LHC

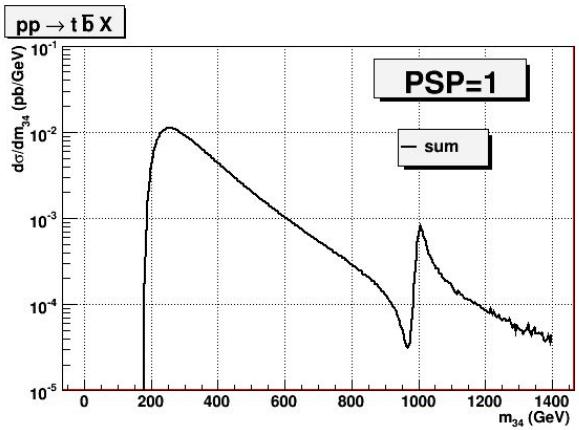
... peeking











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Conclusions

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- top-BESS — modification of BESS, special role of top quark
  - *new SU(2) resonance triplet*
  - *direct coupling to top and bottom*
  - *λ-terms*
- low-E limits on the fermion parameters relaxed
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