Current Projects

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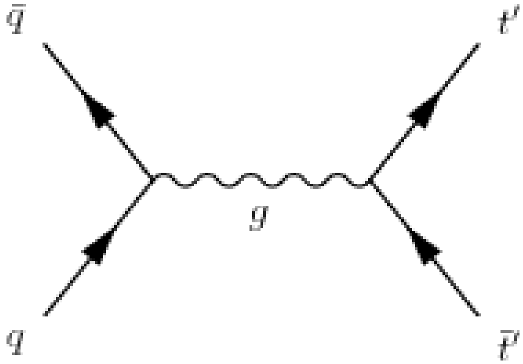
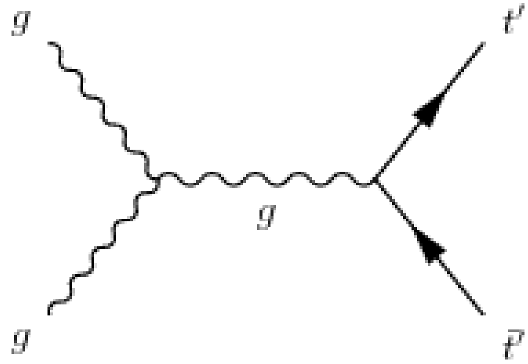
- **Mass determination with missing particles at the LHC** (*with Witek Skiba*).
- **Gauge-Higgs unification without tadpoles** (*with Yang Bai*) .

Mass determination with missing particles

- Missing particles bring difficulties in event reconstruction and mass determination.
- Example: t' pair production, assuming $t' \rightarrow t + A'$. A' : neutral missing particle.





Finding the proper variables

- Variables sensitive to the mass difference $M_{t'} - M_{A'}$, but not the absolute scale of the masses: average values of missing transverse momentum, total transverse momentum, etc. (*Cheng, Low & Wang; Meade & Reece*)

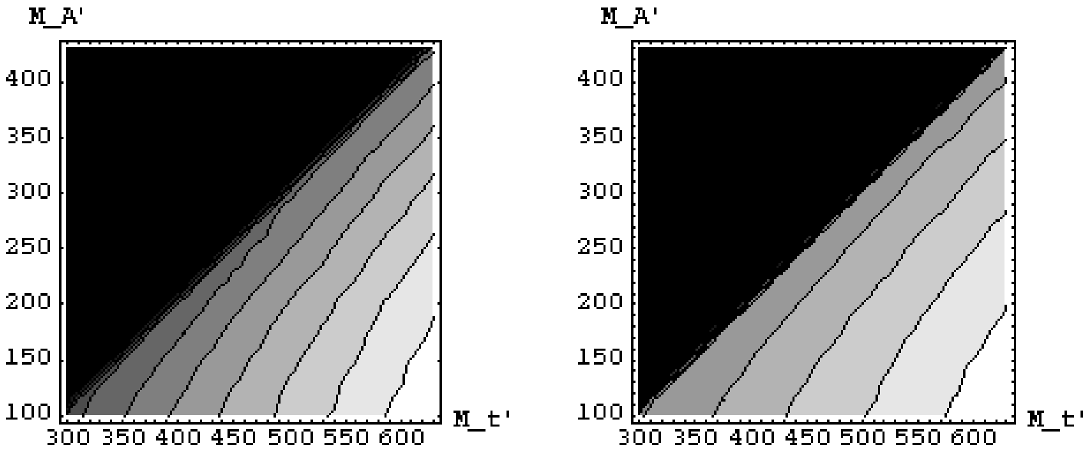


Figure 1: Contour plots for $\langle \not{P}_t \rangle$ and $\langle H_t \rangle$

- If found a variable with a different dependence on $M_{t'}$ and $M_{A'} \Longrightarrow$ masses determined.

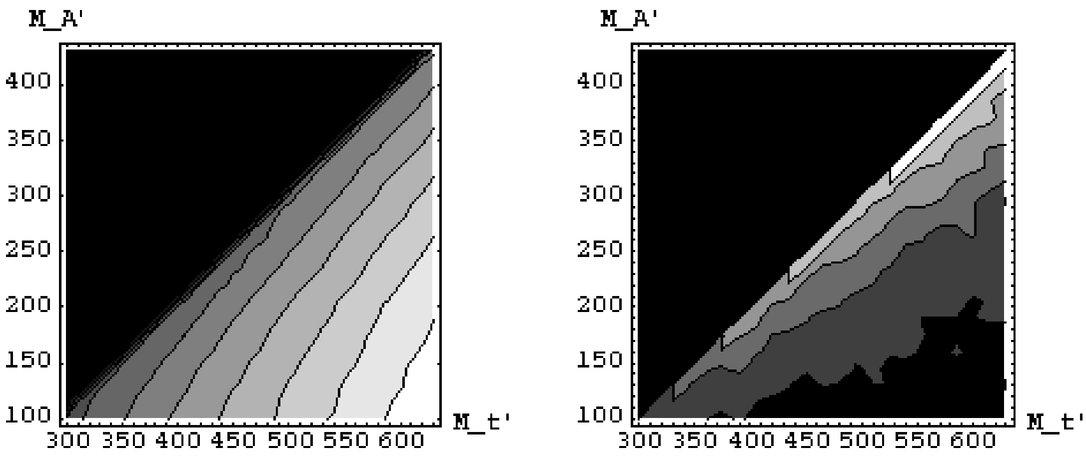


Figure 2: Contour plot for $\langle \not{P}_t \rangle$, and the correlation between $\langle \not{P}_t \rangle$ and $\langle H_t \rangle$.

Goals and Methods

- Generate events: signal+SM background, PYTHIA+ATLFAST
- Optimize the cuts to keep signal events and reduce background events.
- Looking for the best variable: stable and yields significant difference to raise the degeneracy.
- Estimate how well we could measure the masses at LHC.

Gauge-Higgs unification

- An alternative solution to the hierarchy problem –gauge symmetry in extra-dimensions protects the Higgs mass.
- Gauge components in extra-dimensions A_5, A_6 behave as scalar fields in 4-dimensions–candidates for the Higgs.
- Orbifold symmetry breaking–larger group broken to $SU(2) \times U(1)$ by boundary conditions and yields Higgs doublets

$$\text{e.x. } SU(3) \rightarrow SU(2) \times U(1) : 8 \rightarrow 3 + 2 + 2 + 1.$$

- Higgs mass proportional to the symmetry breaking scale ($M_h^2 \sim \frac{1}{16\pi^2 R^2}$), protected by gauge symmetry beyond that.

Tadpole problem in 6-dimensions

- There exist fixed points with symmetry broken to the SM $SU(2) \times U(1)$.
- In $SU(3)$ theory, F^8_{yz} is gauge invariant on the fixed points and contains a Higgs mass term.

$$\Longrightarrow M_h^2 \sim \Lambda^2/16\pi^2. \ \ \Lambda : cutoff.$$

Reintroduce the hierarchy problem.

- The tadpole problem is generic in gauge-Higgs unification in 6 dimensions, if the unbroken gauge symmetry contains a $U(1)$ factor.

The solution–collective symmetry breaking

- E.x. $G_2 \rightarrow SU(3)$ on one fixed points, $G_2 \rightarrow SU(2) \times SU(2)$ on another fixed points. The common subgroup of $SU(3)$ and $SU(2) \times SU(2)$ is $SU(2) \times U(1)$.
- The symmetry is broken to $SU(2) \times U(1)$ globally, but at each fixed points, the symmetry is larger than $SU(2) \times U(1)$.

$\Longrightarrow$ No tadpoles can be added.

- The goal: construct a realistic model– choices of orbifold, gauge group, fermion representations, Yukawa interactions. . .

Summary

Get ready for LHC: models and tools.

. . . but keep others in mind. . .