# Little Higgs with T-parity in MadGraph

Jay Hubisz
Fermilab

3/21/06

# Little Higgs vs. SUSY

- There are models of BSM physics that can mimic the collider signatures of supersymmetry
- Universal Extra Dimensions (UED)
- Little Higgs with T-parity
- Cascade decays down to a missing energy signature – (WIMP dark matter)
  - have to look closer

# Little Higgs model

- Higgs is light because it is a pseudo-Goldstone boson of spontaneously broken global symmetries
  - Collective symmetry breaking mechanism
- New particles cancel SM 1-loop quadratic divergences in Higgs mass
- “Partners” have same statistics

# with T-parity

- $Z_2$ symmetry that forbids mixing with SM particles
  - alleviates tree level EWP constraints
- Most new particles are 'odd' under T-parity
- Provides weak scale dark matter candidate
- Heavy particles cascade decay down to LPOP
  - many particle final states
  - potential for “faking” supersymmetry at the LHC

# BSM Particle Content

## Spin 1

New partners of SM gauge fields $W_H^{\pm},\ Z_H,\ A_H$

## Spin 1/2

Vector like colored $SU(2)_L$ singlets $T_+,\ T_-$

Vector-like partners of quark and lepton SU(2)_L doublets

'mirror fermions' $Q_L^{(-)},\ L_L^{(-)}$

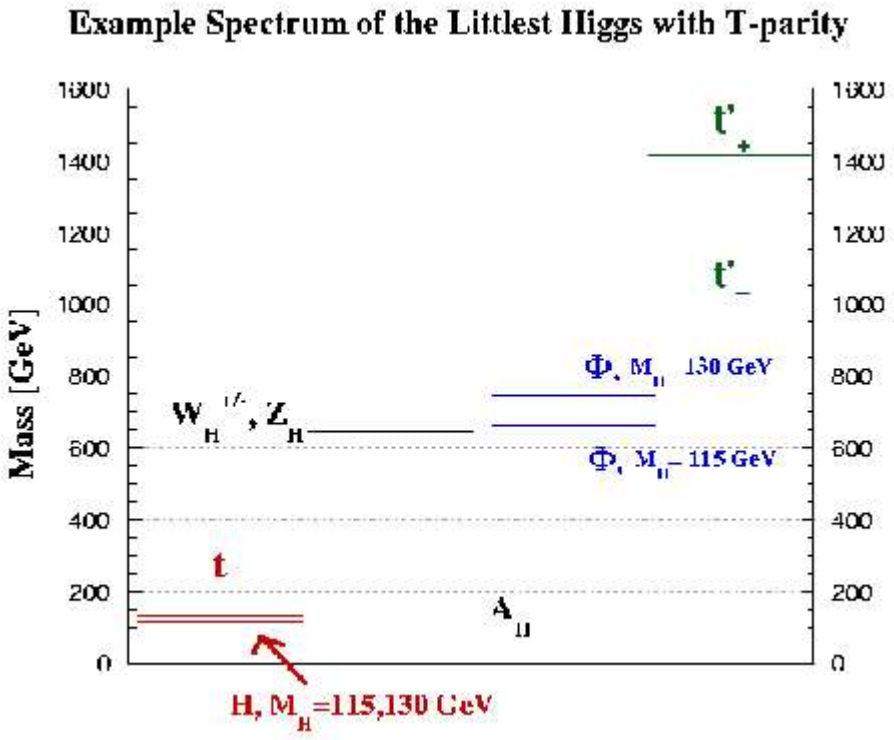
## Spin 0

Scalar SU(2)_L triplet $\Phi : \phi^{\pm\pm}, \phi^{\pm}, \phi^0, \phi^P$

# Spectrum

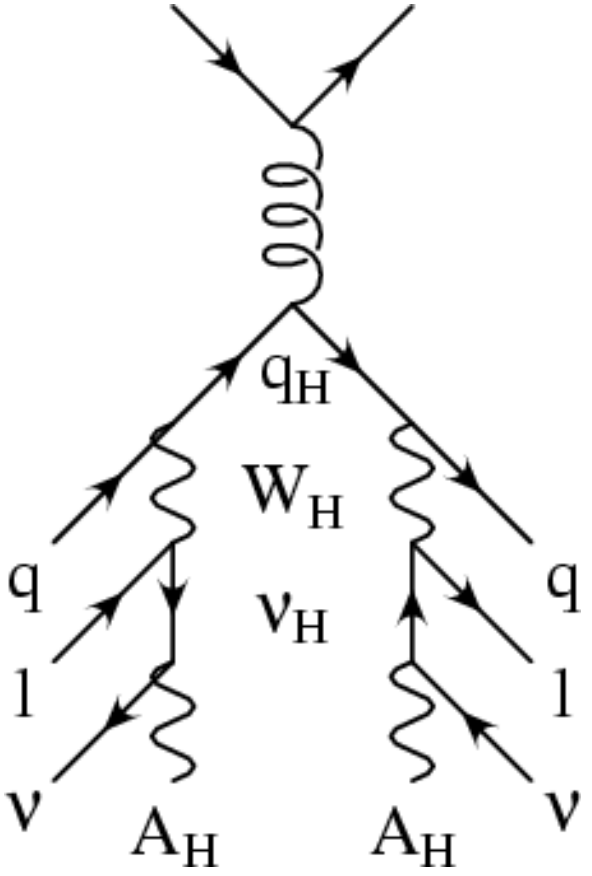
Parts of spectrum fixed by symmetry

T-odd fermion doublets can be anywhere

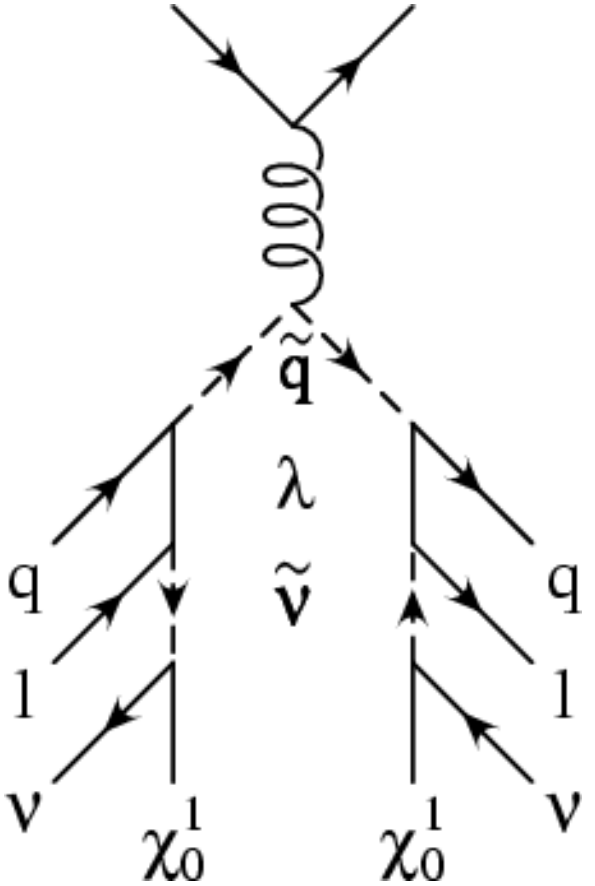


# Cascade Decays

Little Higgs




MSSM



# SUSY LHwTP dictionary

| | | |
|---|---|---|
| squarks, sleptons | ⟷ | mirror fermions |
| gauginos | ⟷ | heavy gauge bosons |
| 2 Higgs | ⟷ | scalar triplet |
| gluino | ⟷ | NONE |
| NONE | ⟷ | Singlet quarks |

# MadGraph

- Calculates arbitrary tree level helicity amplitudes using HELAS subroutines – retains spin correlations!
  - efficient for N > 4
- Creates MadEvent – a stand-alone event generator
- Contains SM by default - “easily” extended to include BSM physics
- SMadGraph – implementation of SUSY in MadGraph

# How to Input BSM into MadGraph

- Particles and interactions go into data files that come with installation
  - interactions.dat - particles.dat
- Couplings and widths defined in fortran code that is compiled into MadEvent
- New particle:
  - Name – Spin – Mass – Width – Color

# BSM into MadGraph

- Specify new BSM interactions - interactions.dat
- new variables into common blocks (masses, widths, couplings)
- Set values of input parameters – calculate all couplings – couplings.f
- Use most recent version of MadGraph!

# BSM MadGraph and Widths

- Need new particle widths to regulate on-shell poles in matrix elements
- MadGraph does not do this for you
- For SUSY – programs exist (e.g. Sdecay)
  - Can modify MadGraph to read Sdecay output
  - Not the case for arbitrary BSM physics

# MadGraph – CalcHEP Interface

- Can define BSM physics relevant to decay amplitudes in CalcHEP
- I have written scripts which run CalcHEP through all new particles, calculating widths (2 body decays only)
  - Input: Particles to decay – Values for free parameters
  - Output: Widths and branching fractions
- Modify MadGraph to read in values of free parameters
- Works in general for ANY BSM models

# Distinguishing Models

- Generic missing energy signal – cascade decays
- Distinguishing characteristics – spins and couplings
- MadGraph offers an accurate comparison of different BSM physics – spin information is preserved
- Pipeline:  BSM Theory – Matrix Element Generator – Parton shower MC – Detector Sim.

# The Pipeline