Beyond the SM Physics at the Tevatron and LHC

"A (brief and not unweighted) random walk through the theory landscape"

M. Perelstein, Cornell

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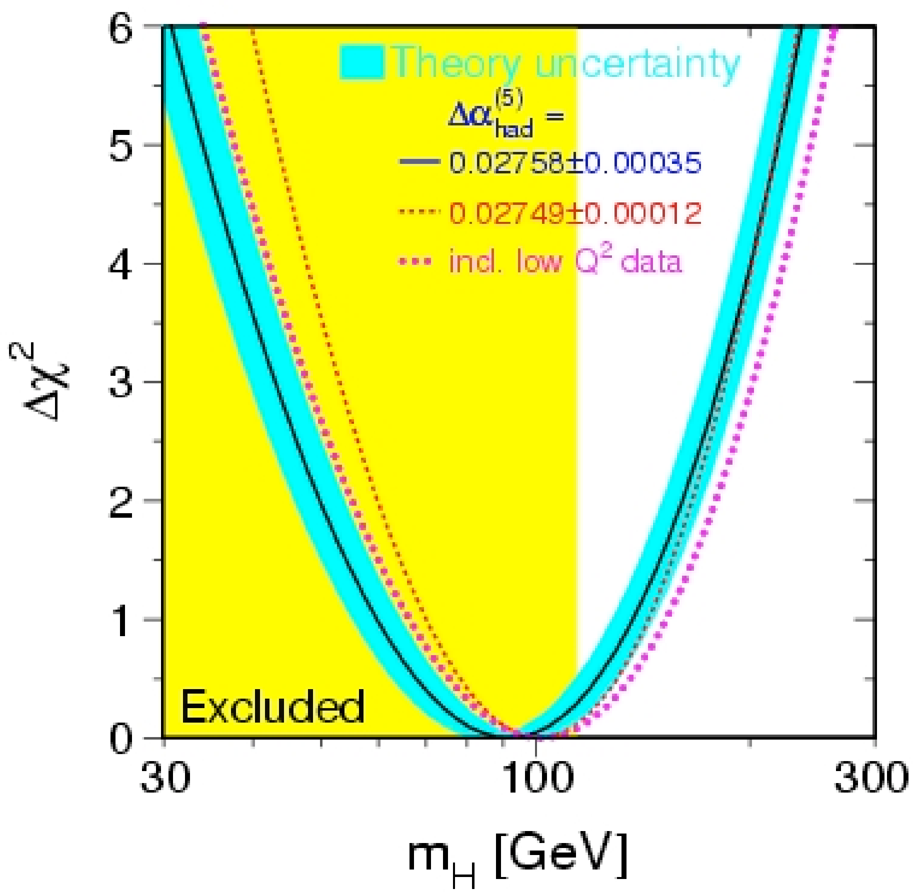
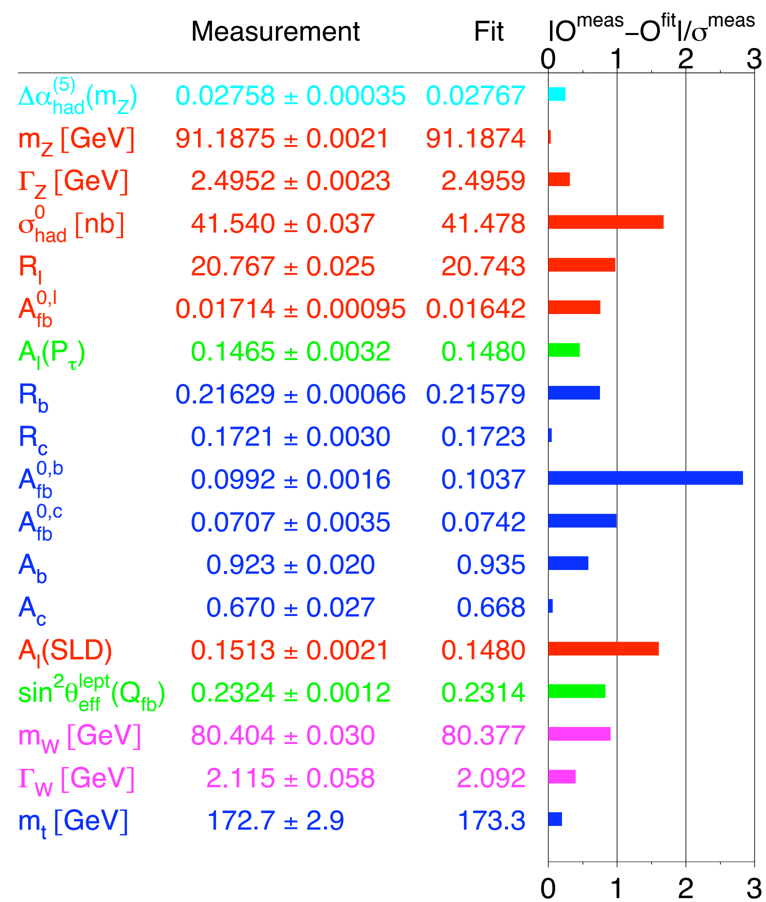
Introduction

- Standard Model: Electroweak gauge symmetry SU(2)xU(1) is fundamental, but spontaneously broken at low energies down to e&m U(1)
- Uncovering the mechanism of electroweak symmetry breaking (EWSB) is the central question for the LHC
- The Standard Model explanation of EWSB: Higgs phenomenon
- Postulate a new particle - the Higgs boson - of spin 0
- Vacuum is filled with Higgs condensate, which breaks the symmetry

Is the Higgs Really There?



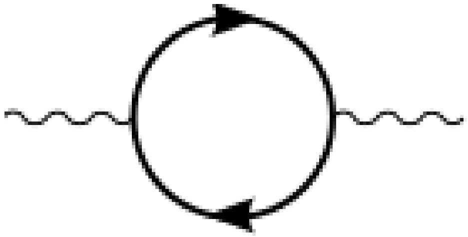


- Standard Model with a light Higgs provides a good fit to all data, indirect determination of H mass:

$$M_H < 186\ \mathrm{GeV} \quad (95\%\ \mathrm{c.l.})$$

Radiative Corrections

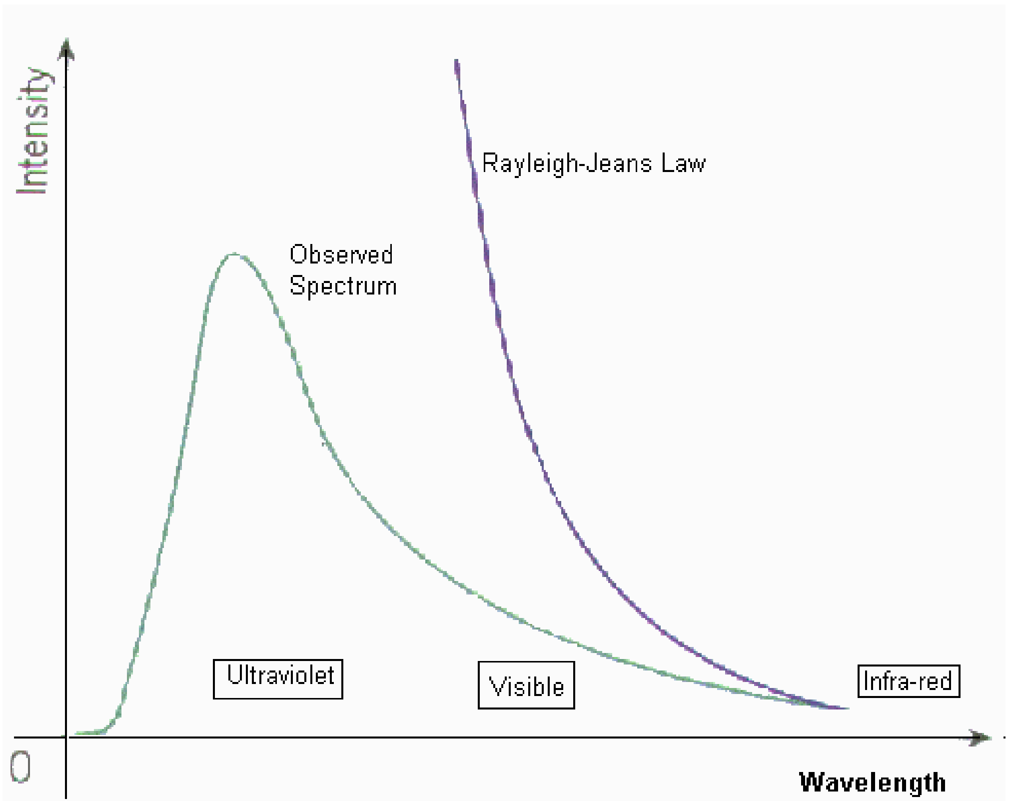
- Quantum mechanics allows for energy non-conservation for short periods of time: $\Delta E \Delta t \sim \hbar$
- A particle-antiparticle pair may spontaneously appear from the vacuum, and then disappear after $\Delta t < 1/M$
- The vacuum is full of such "virtual" pairs!
- The virtual pairs can interact with particles: this is described by Feynman diagrams with loops ("radiative corrections")



- Computing radiative corrections involves integration over the lifetime of the virtual pair, in principle down to t=0 (or equivalently energy up to infinity)

Beyond the SM

- Computing radiative corrections in most quantum field theories (including the SM) involves integrals which diverge at high virtual energies
- Mathematically, this can be dealt with by renormalization
- Physically, divergences mean that we're applying the theory in a regime where it is no longer valid!



Expect a deeper layer of structure beneath the SM!

Light Higgs ➡ NP at TeV!

- No elementary spin-0 particles are known to exist: scalar mass is unstable with respect to radiative corrections

- In SM, $V(H) = -\mu^2 H^\dagger H + \lambda (H^\dagger H)^2$

$$v^2 = \frac{\mu^2}{\lambda}, \quad m_h^2 = 2\mu^2$$

- Renormalization:

$$\mu^2(M_{\rm ew}) = \mu^2(\Lambda) + c_1 \frac{1}{16\pi^2}\Lambda^2 + c_2 \frac{1}{16\pi^2} \log\left(\frac{\Lambda}{M_{\rm ew}}\right) + \text{finite}$$

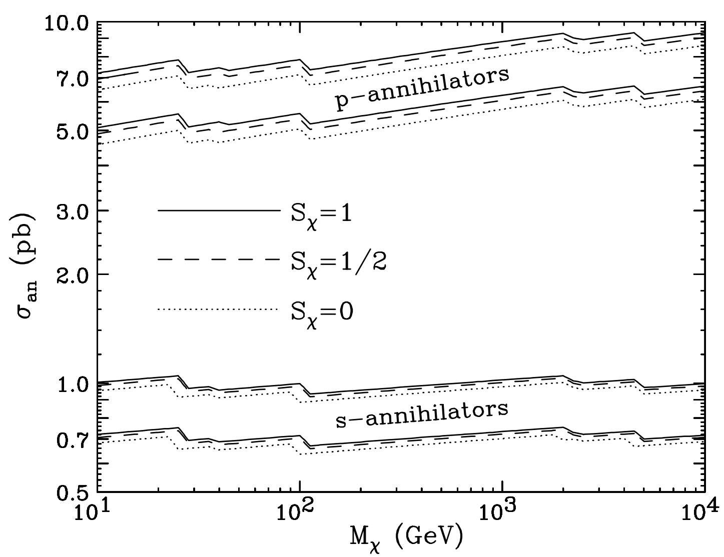
with $c_1 \sim 1$ and Λ is the scale where loop integrals are cut off by new physics

- Expect $\mu \sim \Lambda/(4\pi)$ ➡ $\Lambda \sim 1\ \text{TeV}$ (naturalness)

[But NB: $\Lambda \sim 10\ \text{TeV}$ if 1% fine-tuning is allowed!]

Thermal Dark Matter

- Dark matter (non-luminous, non-baryonic, non-relativistic matter) well-established by a variety of independent astro observations, ~20% of the universe
- None of the SM particles can be dark matter
- Assume new particle, in thermal equilibrium with the cosmic plasma in the early universe
- Measured DM density ⇨ interaction cross section DM-SM



$$\sigma \approx 1 \text{ pb} \sim \frac{\alpha}{(\text{TeV})^2}$$

independent hint for new physics at the TeV scale!

[figure: Birkedal, Matchev, MP, hep-ph/0403004]

Options for New Physics @ TeV

- Models with light Higgs, addressing naturalness:
  - New particles, related to SM by symmetry, cut off loops (ex. SUSY, Little Higgs, gauge-higgs unification)
  - Higgs not elementary, bound state resolved at ~TeV (ex. warped [Randall-Sundrum] extra dimensions)
  - Point-like SM particles resolved as TeV-scale strings (ex. large extra dimensions)
- Models without light Higgs, necessarily strongly-coupled at the TeV scale (ex.: Technicolor, Higgsless)
- Models that do not improve naturalness, but have other interesting features or unusual signatures (ex. hidden valley, unparticles, split SUSY)

Supersymmetry

- In supersymmetric theories scalar masses do not receive quadratic divergences
- SUSY not symmetry of nature ⇒ must be broken
- "Soft" breaking at the TeV scale ⇒ loops cut off at the TeV scale, naturalness restored
- "Minimal" supersymmetric SM (MSSM): superpartner for each SM d.o.f., plus 2nd Higgs doublet and its superpartners

Names	Spin	P_R	Gauge Eigenstates	Mass Eigenstates
Higgs bosons	0	+1	$H_u^0\ H_d^0\ H_u^+\ H_d^-$	$h^0\ H^0\ A^0\ H^\pm$
squarks	0	−1	$\widetilde{u}_L\ \widetilde{u}_R\ \widetilde{d}_L\ \widetilde{d}_R$	(same)
			$\widetilde{s}_L\ \widetilde{s}_R\ \widetilde{c}_L\ \widetilde{c}_R$	(same)
			$\widetilde{t}_L\ \widetilde{t}_R\ \widetilde{b}_L\ \widetilde{b}_R$	$\widetilde{t}_1\ \widetilde{t}_2\ \widetilde{b}_1\ \widetilde{b}_2$
sleptons	0	−1	$\widetilde{e}_L\ \widetilde{e}_R\ \widetilde{\nu}_e$	(same)
			$\widetilde{\mu}_L\ \widetilde{\mu}_R\ \widetilde{\nu}_\mu$	(same)
			$\widetilde{\tau}_L\ \widetilde{\tau}_R\ \widetilde{\nu}_\tau$	$\widetilde{\tau}_1\ \widetilde{\tau}_2\ \widetilde{\nu}_\tau$
neutralinos	1/2	−1	$\widetilde{B}^0\ \widetilde{W}^0\ \widetilde{H}_u^0\ \widetilde{H}_d^0$	$\widetilde{N}_1\ \widetilde{N}_2\ \widetilde{N}_3\ \widetilde{N}_4$
charginos	1/2	−1	$\widetilde{W}^\pm\ \widetilde{H}_u^+\ \widetilde{H}_d^-$	$\widetilde{C}_1^\pm\ \widetilde{C}_2^\pm$
gluino	1/2	−1	$\widetilde{g}$	(same)
goldstino (gravitino)	1/2 (3/2)	−1	$\widetilde{G}$	(same)

Table 7.1: The undiscovered particles in the Minimal Supersymmetric Standard Model (with sfermion mixing for the first two families assumed to be negligible).

34 new particles waiting to be discovered!

[table: S. Martin, hep-ph/9709356]

SUSY as an Extra (Fermionic) Dimension

- Grassmann (anticommuting) numbers:

  $\theta : \ \{\theta_1, \theta_2\} = 0$ $\Rightarrow$ $\theta^2 = 0$ cf normal numbers: $x : \ [x, y] = 0$

- In quantum field theory, fields of fermions (e.g. electrons) are Grassmann-valued - Pauli exclusion principle built in!

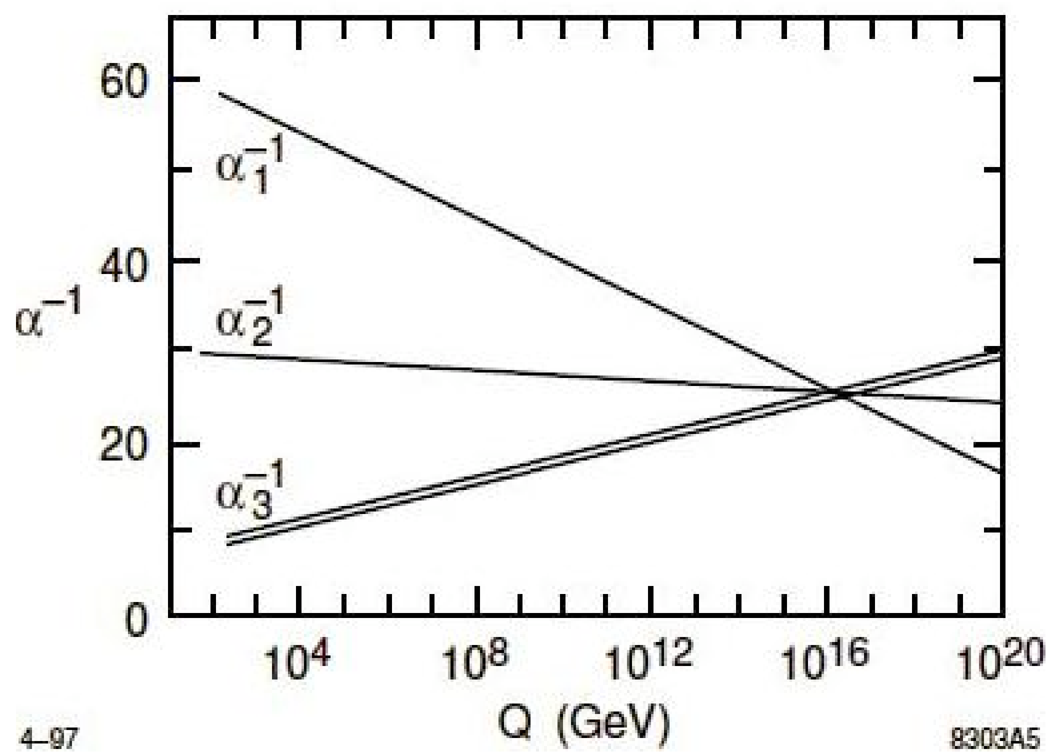
- Imagine a space with 1 or more G-valued coordinates, in addition to the usual 4: superspace

- "Superfield" lives in this superspace: $\Phi(x^\mu, \theta)$

- Taylor expand to obtain usual 4D fields: $\Phi(x^\mu, \theta) = \phi(x) + \theta\psi(x)$

- Supersymmetry is the generalization of Poincare group (rotations, translations, boosts) to this new superspace

Gauge Coupling Unification: a Hint for Supersymmetry?



- The three lines do not meet in the SM (but, considering the extrapolation range, come close!)
- There is at least one example of non-SUSY model where unification occurs with roughly same precision

MSSM and Its 100 Parameters

- Arbitrary soft terms ⇨ O(100) free parameters, affecting spectrum, branching ratios, etc.

$$
\begin{aligned}
\mathcal{L}_{\rm soft}^{\rm MSSM} \;=\; & -\frac{1}{2}\left(M_3\widetilde{g}\widetilde{g} + M_2\widetilde{W}\widetilde{W} + M_1\widetilde{B}\widetilde{B} + {\rm c.c.}\right) \\
& - \left(\widetilde{\overline{u}}\,\mathbf{a_u}\,\widetilde{Q}H_u - \widetilde{\overline{d}}\,\mathbf{a_d}\,\widetilde{Q}H_d - \widetilde{\overline{e}}\,\mathbf{a_e}\,\widetilde{L}H_d + {\rm c.c.}\right) \\
& - \widetilde{Q}^\dagger\,\mathbf{m_Q^2}\,\widetilde{Q} - \widetilde{L}^\dagger\,\mathbf{m_L^2}\,\widetilde{L} - \widetilde{\overline{u}}\,\mathbf{m_{\overline{u}}^2}\,\widetilde{\overline{u}}^\dagger - \widetilde{\overline{d}}\,\mathbf{m_{\overline{d}}^2}\,\widetilde{\overline{d}}^\dagger - \widetilde{\overline{e}}\,\mathbf{m_{\overline{e}}^2}\,\widetilde{\overline{e}}^\dagger \\
& - m_{H_u}^2 H_u^* H_u - m_{H_d}^2 H_d^* H_d - (bH_uH_d + {\rm c.c.})\,.
\end{aligned}
$$

- Models of SUSY breaking "predict" some parameters (or relations among them), reduce the freedom
- But: Many such models (e.g. gravity mediation, gauge mediation, anomaly mediation, etc.), each has strengths and weaknesses, no clear "winner" emerged over ~25 years of model-building ⇨ NEED DATA!!!
- Search strategies must be designed with this in mind - "cover" the 120-dimensional parameter space as well as experimental limitations allow

SUSY: Generic Predictions

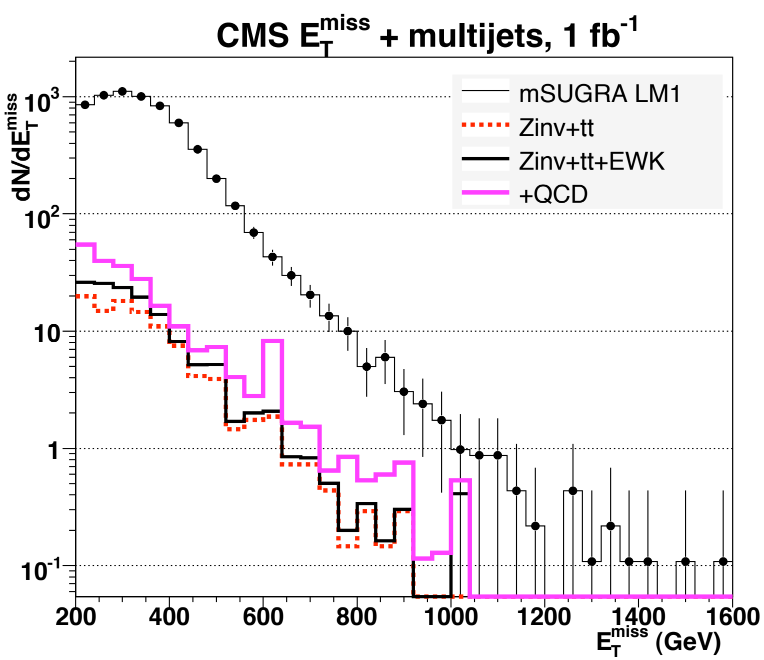
- Extra discrete symmetry - R parity - imposed to avoid rapid proton decay (may be relaxed, but very artificial)
- All SM states R-even, superpartners R-odd ⇒ lightest superpartner (LSP) stable
- Strong limits on colored/charged relics in the universe ⇒ prefer neutral LSP (also a WIMP dark matter candidate!)
- Generic signature: missing energy in every event with superpartner production
- Inclusive search for stable (neutral or not) objects plus high-pT jets and/or leptons is the best mod.-ind. strategy
- Production cross sections for strongly interacting superpartners - gluinos and squarks - are usually the largest (typically 1 - 10 pb ⇒ $10^4 - 10^5$ events/year at the LHC)

- Direct decays ("guaranteed"): $\tilde{q} \to q + \chi_1^0 \quad , \tilde{g} \to q\bar{q}\chi_1^0$
- Cascade decays (spectrum-dependent): for example

$$\tilde{q} \to q + \chi_2^0, \quad \chi_2^0 \to \mu^+ + \tilde{\mu}^-, \quad \tilde{\mu}^- \to \mu^- + \chi_1^0$$

iff $\quad M(\tilde{q}) > M(\chi_2^0) > M(\tilde{\mu}) > M(\chi_1^0)$

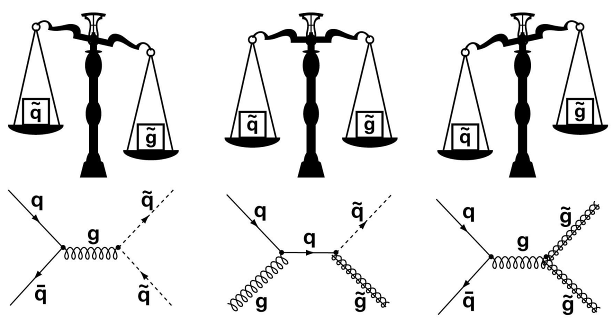
- Hard leptons are not guaranteed; ability to select and interpret events with jets+missing Et may be very important!



SM: Etmiss from neutrinos, especially $Z \to \nu\bar{\nu}$

"Reality": Etmiss from detector malfunctioning, jet energy mismeasurements, etc.

SUSY: Some Tevatron Searches



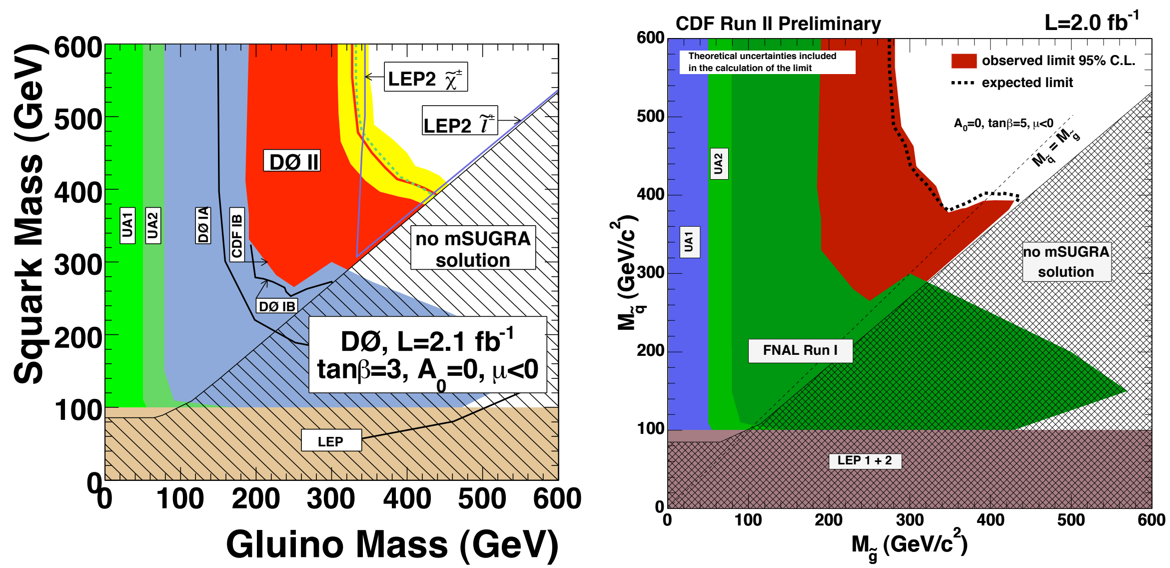


Figure 2: Limits on the squark and gluino masses from DØ (left) and CDF (right).

"trilepton"

$$p\bar{p} \rightarrow \tilde{\chi}_2^0 \tilde{\chi}_1^\pm$$

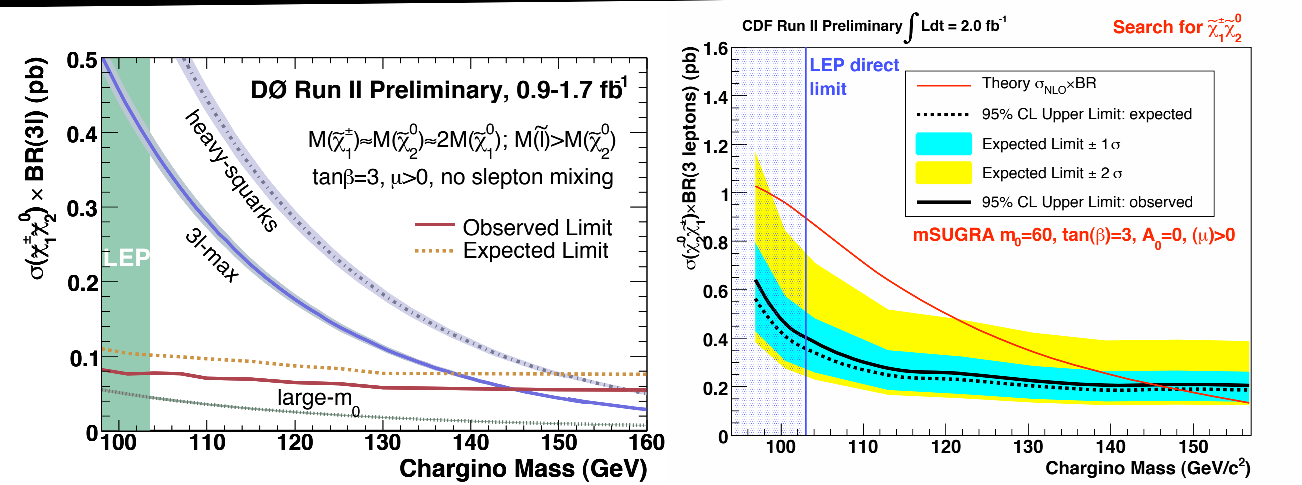


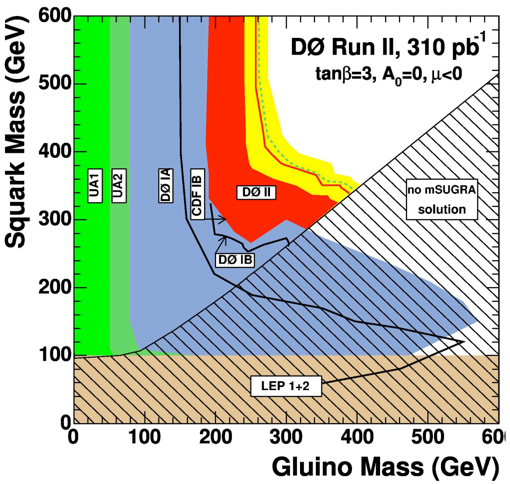
Figure 7: Limits on the cross section times branching ratio from the trilepton analyses of DØ (left) and CDF (right).

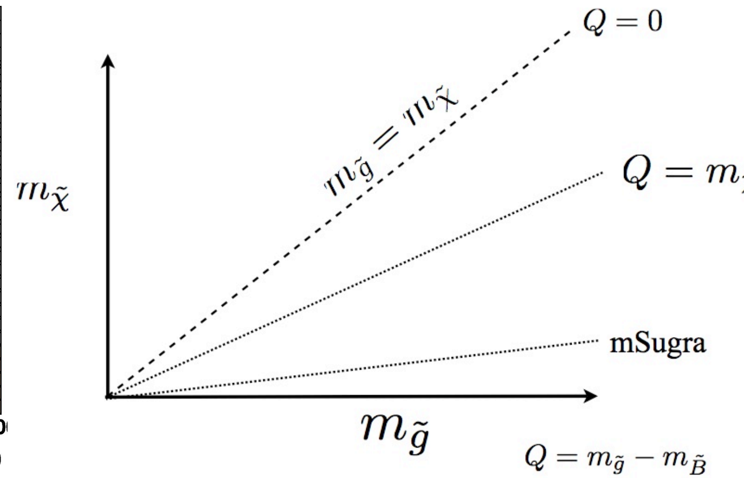
[figure credit: T. Adams, arXiv:0808.0728]

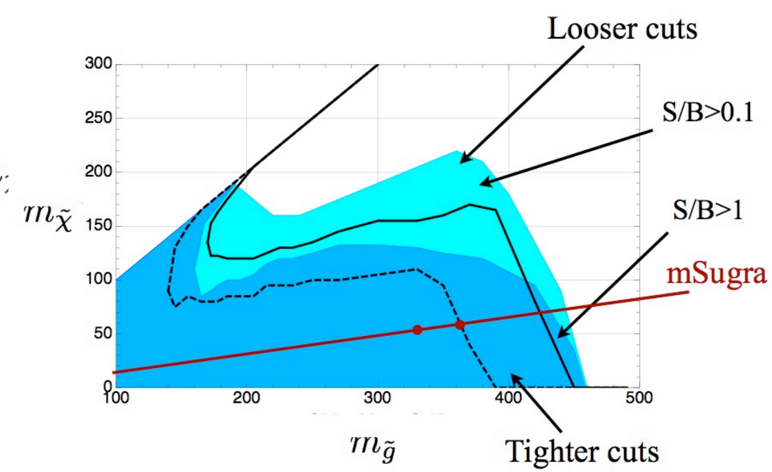
The Importance of Inclusiveness

- Experiments like to present results of searches as limits on model parameters
- 100+ par. framework impractical - choose a set of assumptions (mSUGRA most popular) to reduce to “a few”
- Advantage: Easy vocabulary to compare between experiments, both high-pT and others (g-2, EDMs, etc.)
- Disadvantage: Cuts optimized to maximize bounds in this framework, may miss a signal!!!

[Ex.: D0 squark/gluino search (Alwall et. al., 0803.0019)]







MSSM and Naturalness

- Non-observation of the Higgs at LEP2 presents a significant problem for the MSSM
- At tree level, a firm upper bound (ind. of 120 parameters) on the mass of the lighter CP-even Higgs boson: $m(h^0) < M_Z$
- Experimentally, $m(h^0) > 114 \text{ GeV}$ (except corners)
- Loop corrections to $m(h^0)$ must be large (25%)
- Same loops induce large corrections to Higgs vevs, which need to be canceled precisely - fine-tuning of O(1%)

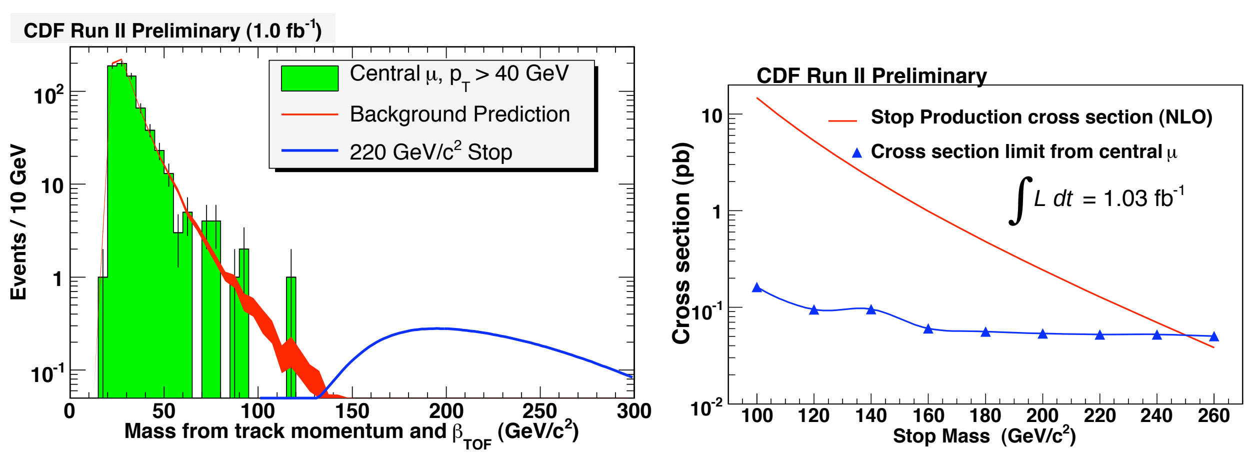
[possible way out: Choi et al, hep-ph/0508029; Kitano, Nomura, hep-ph/0509039]

- If SUSY is realized, it may well be a non-minimal version (e.g. extra scalars coupled to the Higgs sector, non-standard Higgs phenomenology)

MSSM Pheno: Some Caveats

- Caveat 1: R-parity may be broken (e.g. either L or B would be sufficient to ensure proton stability)

- Caveat 2: next-to-lightest SUSY particle (nLSP) may be long-lived enough to decay outside of the detector (10^{10} yrs $> \tau_{\mathrm{nLSP}} > 10^{-8}$ sec) ➡ no missing energy, a massive charged-particle (CHAMP) track or a decay of a particle stopped inside the detector instead



[figure credit: T. Adams, arXiv: 0808.0728]

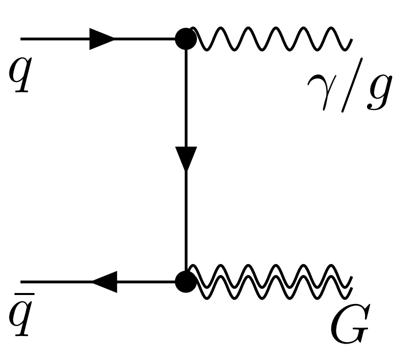
Figure 11: Spectrum of the mass calculated from the momentum and time of flight for CDF muon candidates (left). CDF limits on the production cross section versus stop mass of long-lived stop particles (right).

Quantum Gravity at TeV

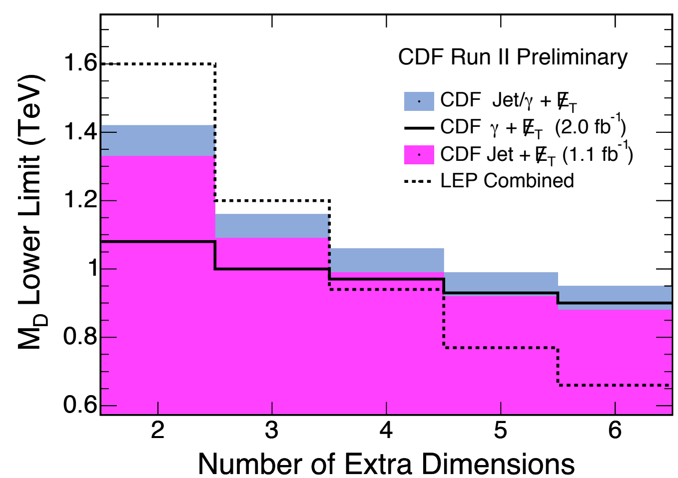
- In string theory, all divergent integrals cut off at M_S : Higgs and other particles turn into finite-size strings!
- If $M_S \sim 1\ \mathrm{TeV}$, there is no hierarchy problem! But $M_S \sim M_{\mathrm{Pl}}$
- ADD model: SM on a 4D brane inside higher-D space, with extra dimensions compactified with

$$R \sim M_{\mathrm{Pl}}^{-1} \left(\frac{M_{\mathrm{Pl},4}}{M_{\mathrm{Pl}}}\right)^{2/n} \gg M_{\mathrm{Pl}}^{-1}$$

- At $E < M_{\mathrm{Pl}}$, missing energy signature due to graviton emission into the extra dimensions

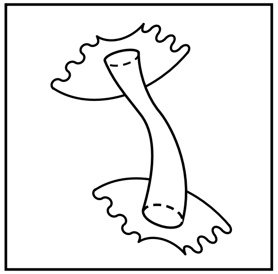


[Mirabelli, MP, Peskin, hep-ph/9811337, PRL82:2236]



Black Holes & Strings at LHC?

- If two partons collide at super-plankian energies $E \gg M_{\rm Pl}$, a black hole must form
- Given existing constraints on $M_{\rm Pl}$, it seems pretty unlikely that the LHC will probe the region $E \gg M_{\rm Pl}$ [Meade, Randall, 0708:3017]
- In any (weakly coupled) string theory, Regge excitations of SM particles lie below Planck scale $M_n = \sqrt{n} M_S, \quad M_S < M_{\rm Pl}$
- Reggeons appear as s-channel resonances in SM scattering processes: Easy to see, more realistic target than BHs
  [Cullen, MP, Peskin, hep-ph/0001166, PRD62:055012]



- Distinguish from Zprimes etc.: spin (e.g. first "Regge gluon" is spin-2!)
- Excited Reggeons have spin > 2, at present not handled by general-purpose MC generators!

QCD Redux: Composite Higgs, Technicolor, and Their Cousins

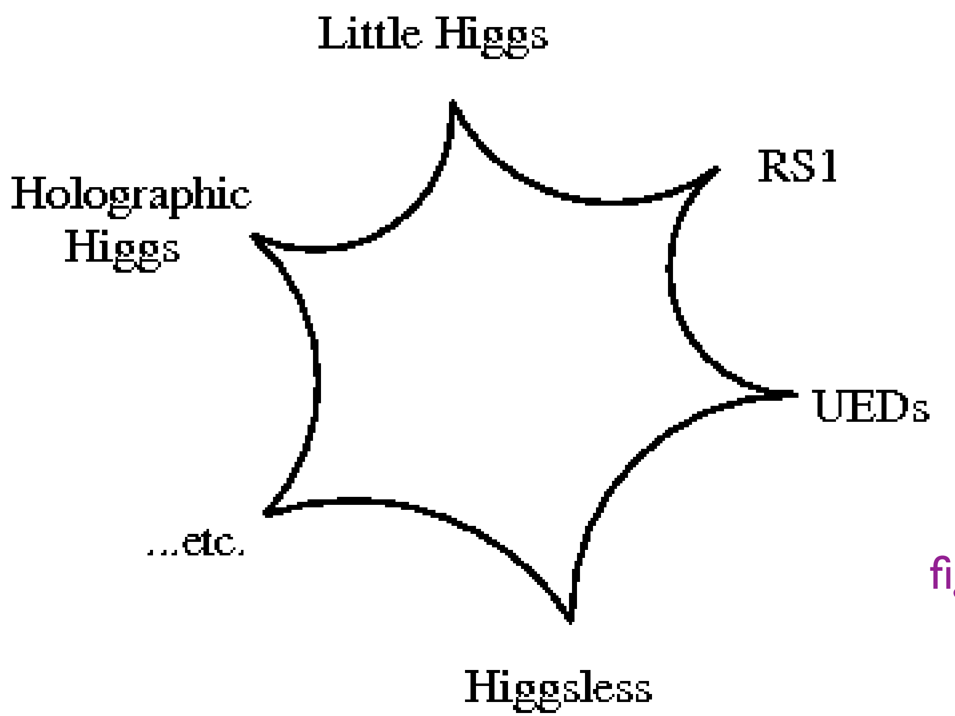


figure credit: Ian Low

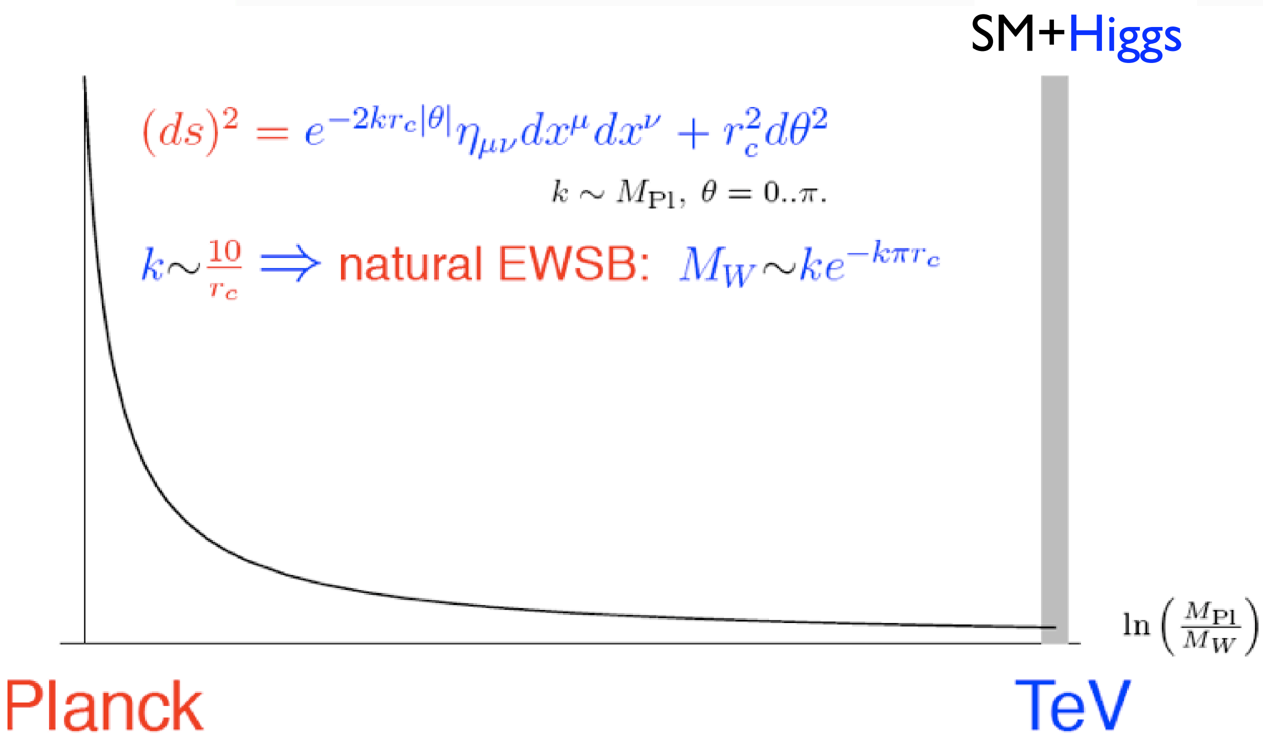
- All these models involve new strong dynamics at TeV (or 10 TeV), a la QCD confinement at GeV, but with interesting new twists!

Composite Higgs

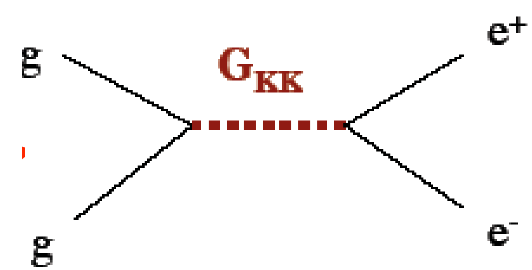
- Many spin-0 particles exist in nature - mesons
- They are composite, made of spin-1/2 quarks, bound by QCD strong force
- Above the QCD confinement scale, the good degrees of freedom are quarks ⇒ no hierarchy problem!
- Can the Higgs be a meson bound by a new strong force?
- Old idea, but difficult to build models - non-perturbative physics!
- New insight: AdS/CFT duality ⇒ some strongly coupled 4D models are "dual" to weakly coupled, calculable models with an extra dimension!
- Setup: Randall-Sundrum (RS) 5D model

Warped (RS) Extra Dimension

- Original model had the SM on the TeV brane, solves the hierarchy problem

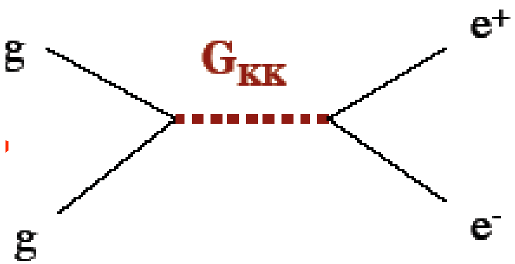


- New states: KK gravitons at the TeV scale



- Couplings: $\mathcal{L} \sim \dfrac{1}{(\mathrm{TeV})^2} T_{\mu\nu} G^{\mu\nu}_{\rm KK}$

RS: Some Tevatron Searches



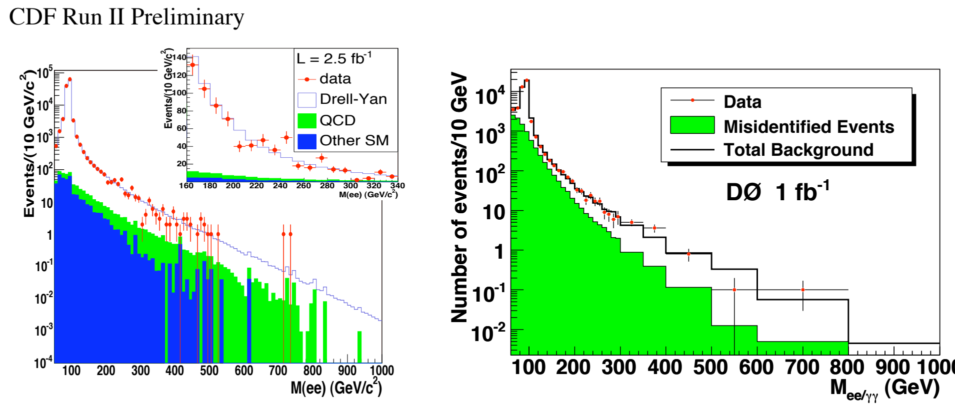


Figure 6: Search for high-mass ee, $\gamma\gamma$ resonances: the M_{ee} spectrum from CDF (left) and $M_{ee,\gamma\gamma}$ spectrum from D0 (right), observed (markers) and background prediction (filled histograms). The CDF data have a 3.8 σ excess for the mass window $228 < M_{ee} < 250$ GeV$/c^2$.

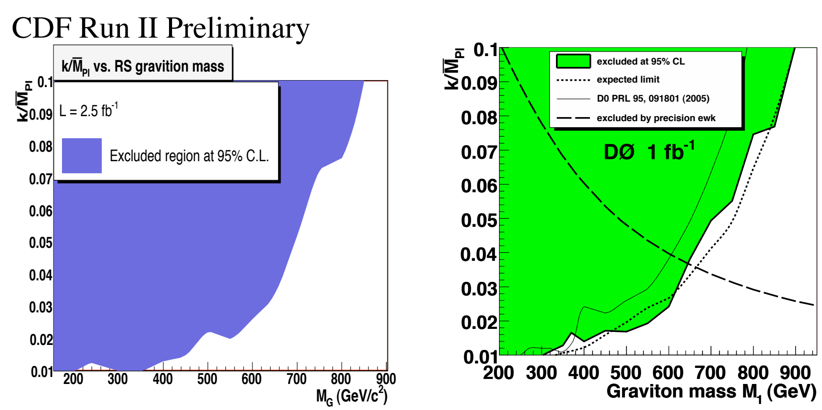
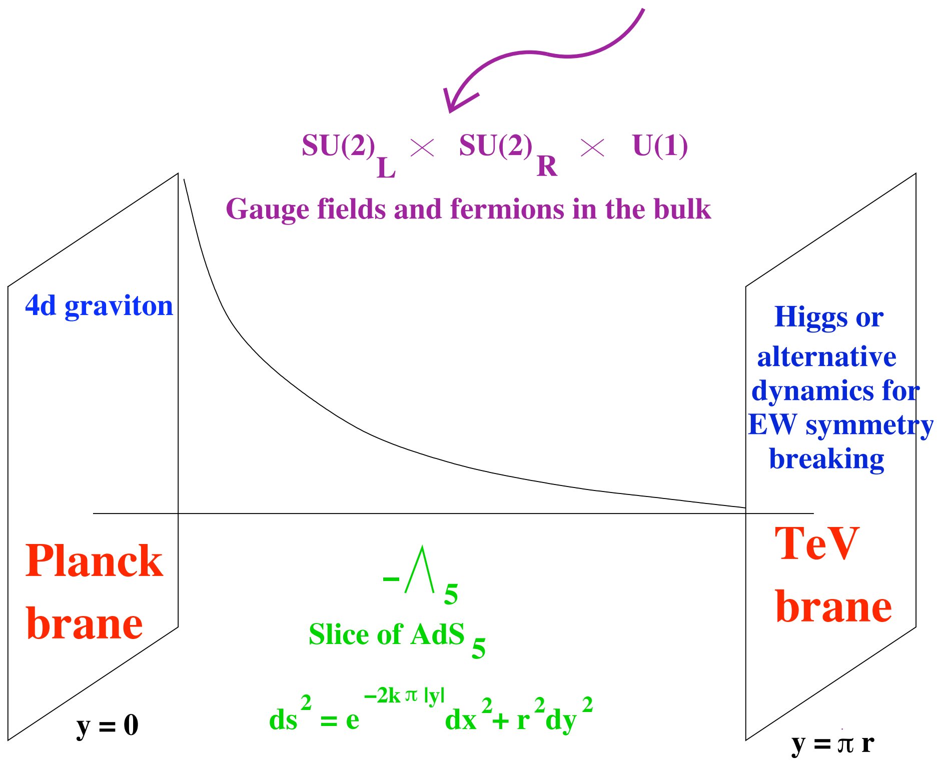


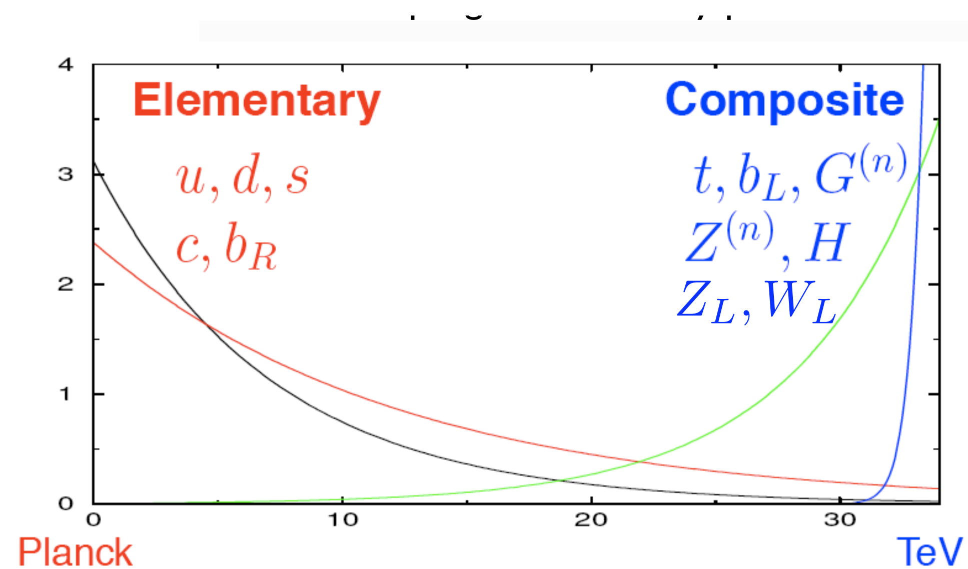
Figure 7: The excluded regions of RS graviton mass with respect to $k/\bar{M}_{Pl}$ from CDF (left) and D0 (right).

[figure credit: S.-S. Yu, arXiv:0807.3523]

RS with Bulk Matter

- It was subsequently realized that models with SM gauge fields and fermions in the "bulk" are more interesting:



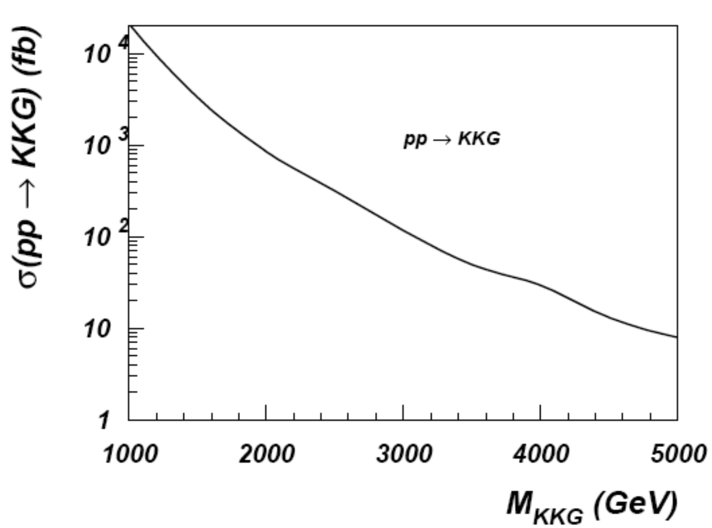


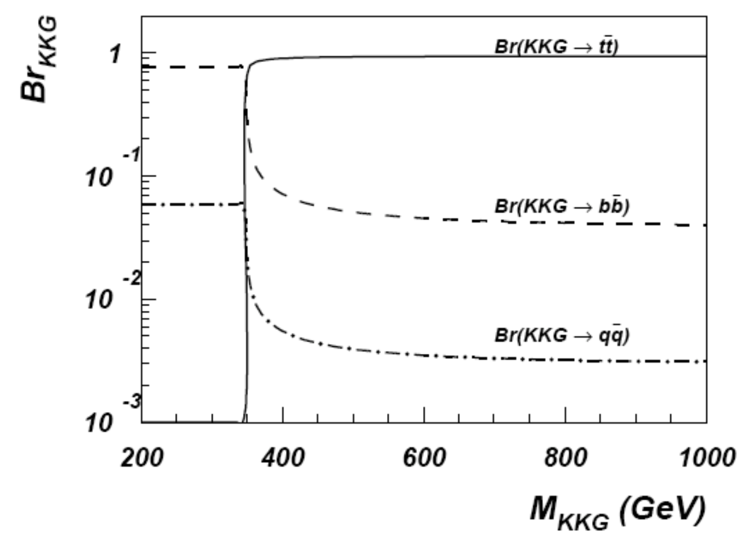
- natural solution to fermion mass hierarchy problem
- natural suppression of flavor-changing neutral currents
- possibility of gauge coupling unification, as in the MSSM

figure credits: G. Perez, G. Servant

RS with Bulk Matter: Pheno

- Good: all SM states now have KK modes!
- Bad: the KKs do not couple to light quarks and leptons much...
- Worse: PEW constraints force KK masses > 3 TeV or so
- KK gluon is probably the easiest target at the LHC



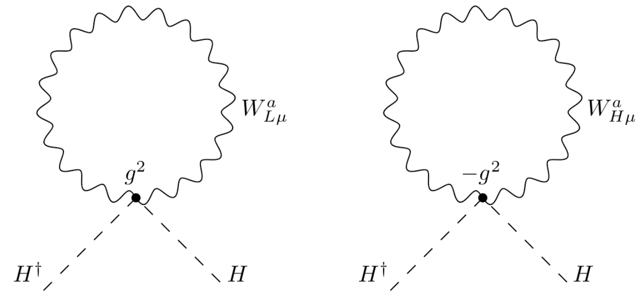


Agashe et. al., hep-ph/0612015; Lillie et.al., hep-ph/0701166

Final state: A pair of highly-boosted tops ("top jets"?)

Gauge-Higgs Unification

- A zero-mass photon does not require fine-tuning - mass is protected by gauge symmetry
- In a 5D theory, the gauge field $A_M(x) \to A_\mu(x), A_5(x)$
- If the 5th dimension is infinite, A_5 is naturally massless!
- After compactification, $m(A_5) \sim 1/R$ ⇨ good if $1/R \sim M_W \sim M(W')$
- Higgs mass quadratic divergences are canceled by KK modes:

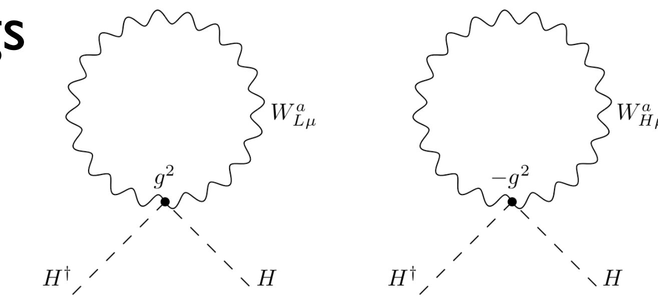


- A realistic GHU implementation, using a warped extra dimension, predicts $m_h < 140 \text{ GeV}$ and KK states at 2 TeV

[Agashe, Contino, Pomarol, hep-ph/0412089]

Little Higgs

- Quadratic divergence cancellation by same-spin states can also occur in a purely 4D theory - Little Higgs



[LH ⟺ effective theory of the first two KK modes in GHU!]

- In LH, Higgs is a Goldstone boson arising from a global symmetry breaking [a la pions in QCD]

- If the global symmetry is exact, $m_h = 0$ naturally!

- Goldstones only interact derivatively ⟹ need to break the global symmetry explicitly by gauge and Yukawa interactions

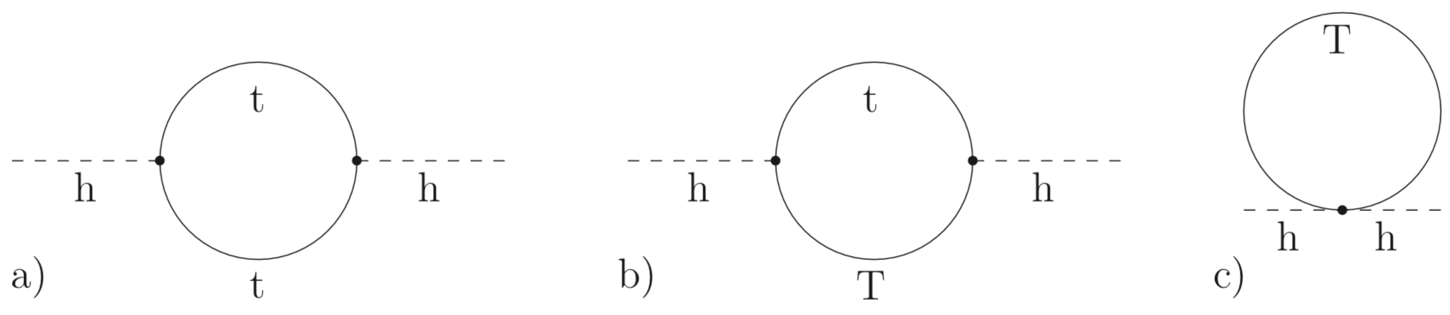
- Generically explicit breaking reintroduces quadratic divergences

- "Collective" breaking pattern in LH avoids quad. div. at one loop

[Arkani-Hamed, Cohen, Georgi, 2002]

EWSB in Littlest Higgs Model

- Higgs mass is dominated by top and Top loops:



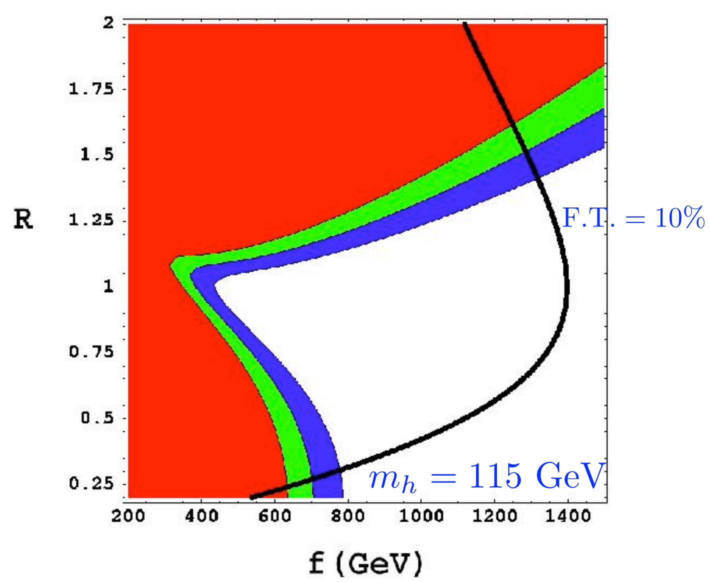
- This contribution is log-divergent and negative:

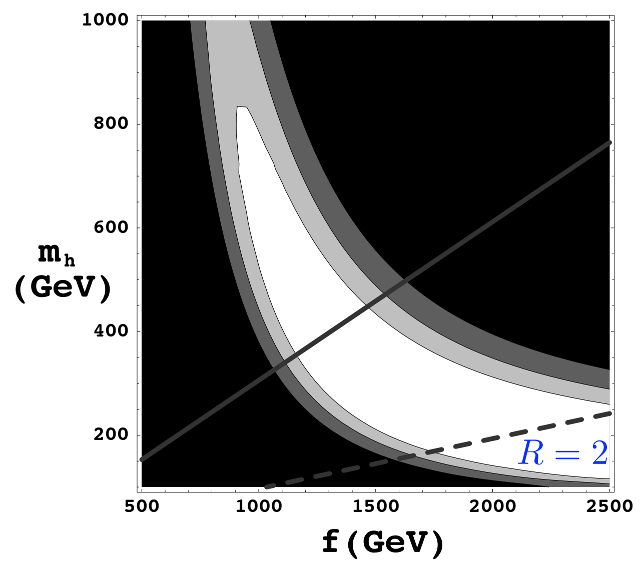
$$m_t^2(H) = -\frac{3\lambda_t^2 M_T^2}{8\pi^2} \log \frac{\Lambda^2}{M_T^2} \ .$$

- All other contributions are generically subdominant
- EWSB is triggered radiatively - simple mechanism!
- Similar to the MSSM but with no tree-level potential at all - e.g. no μ problem!

Little Higgs and T Parity

- LH models are weakly coupled at the TeV scale, predictive!
- The "first-generation" LH models strongly disfavored by precision electroweak data
- Best solution: introduce "T Parity": new TeV-scale particles T-odd and only appear in loops in PEWO [a la R parity of the MSSM]
- Littlest Higgs with T Parity (LHT) passes PEW tests without significant fine-tuning

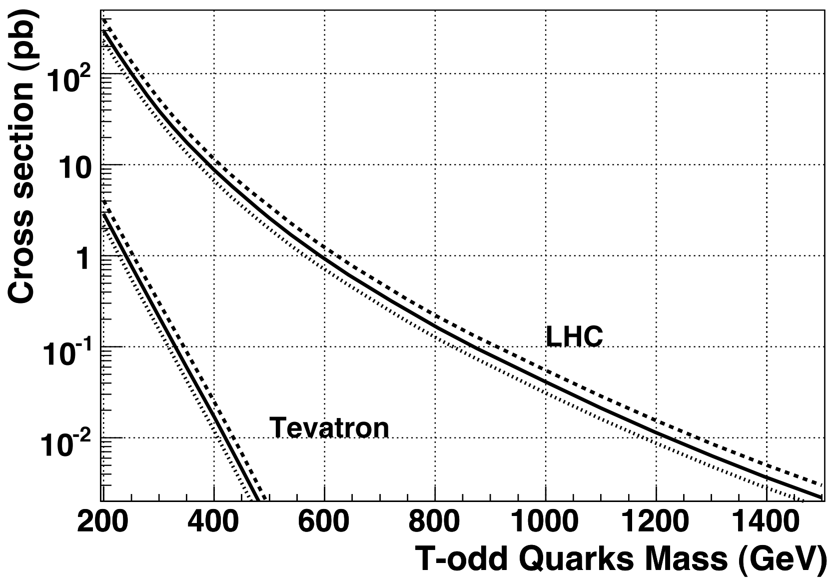


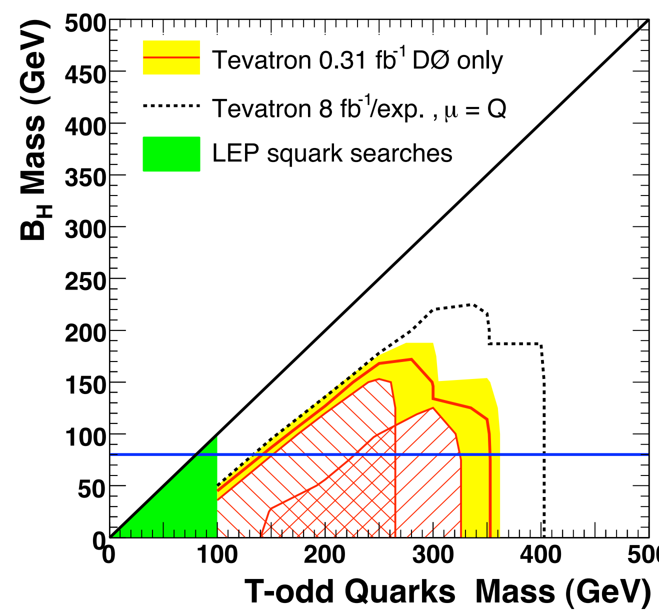


[Hubisz, Meade, Noble, MP, hep-ph/0506042]

LHT Collider Phenomenology

- The Lightest T-Odd Particle (LTP) is stable, typically the neutral, spin-1 "heavy photon" - WIMP DM candidate
- Symmetry structure forces introduction of T-odd partners for each SM (weak doublet) fermion - "T-quarks" and "T-leptons"
- Hadron collider signature: T-quark production, decays to LTP+jets





[Carena, Hubisz, MP, Verdier, hep-ph/0610156]

Another "SUSY look-alike" candidate!

LHT or SUSY?

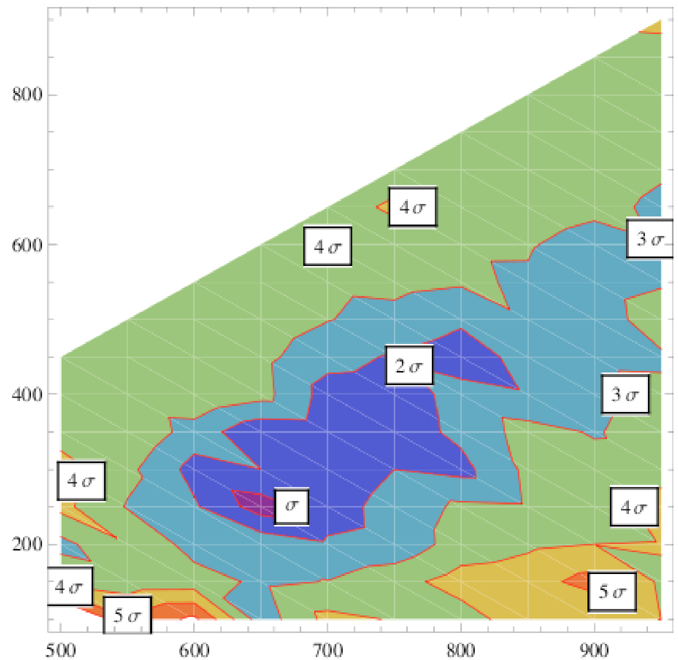
[Hallenbeck, MP, Spethmann, Thom, Vaughn, arXiv:0812.3135]

- Only looked at one channel, generic in both models

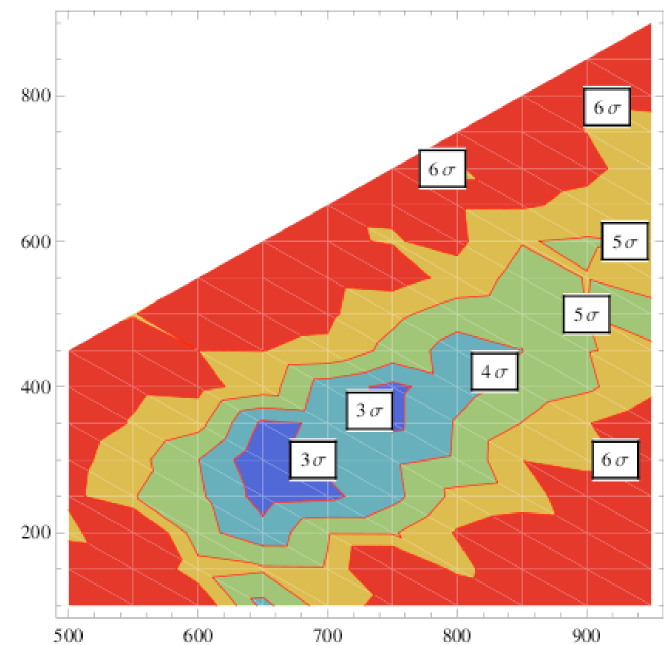
$$pp \rightarrow Q'\bar{Q}', Q' \rightarrow qB' \quad \Rightarrow \quad 2j + \mathrm{MET}$$

- Simulated SUSY+SM sample = "data", try to fit with LHT+SM, varying LHT parameters (T-quark and LTP masses)

- Fit to 10 observables: $\langle p_T \rangle, \langle H_T \rangle$, moments, asymmetries



200 pb-1



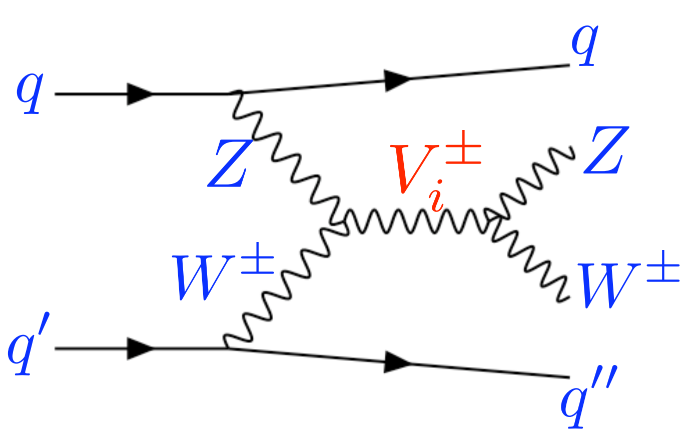
1 fb-1

What if There is No Higgs?

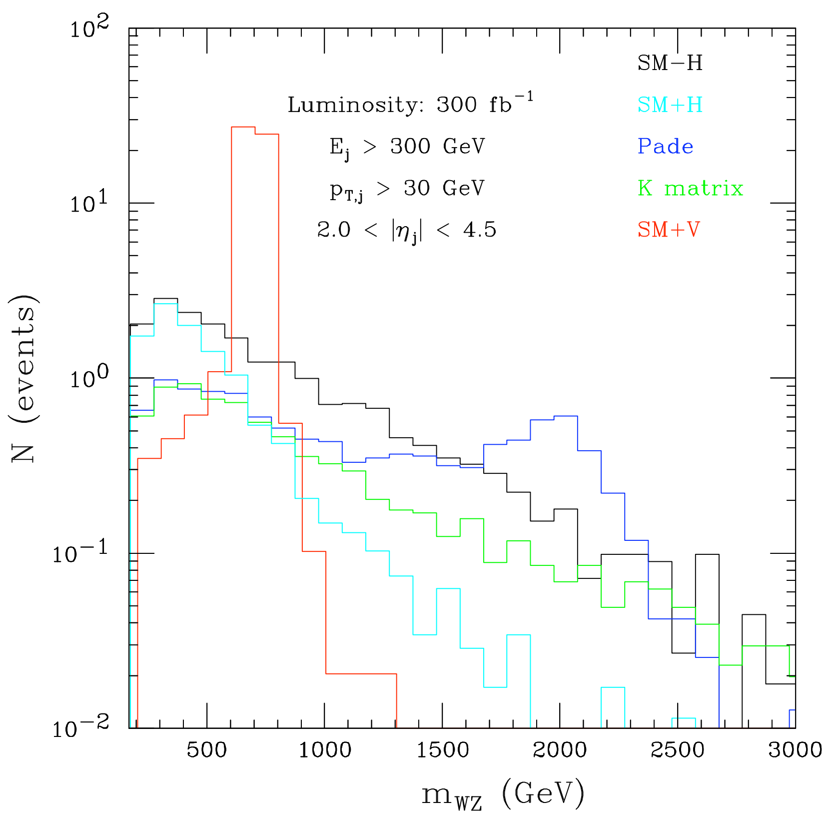
- If physics at TeV scale is strongly coupled, a symmetry-breaking condensate can exist without a physical Higgs boson in the theory - technicolor!
- TC with QCD-like dynamics at TeV is strongly disfavored by precision electroweak data
- Difficult to explore model space due to strong coupling
- New insight: AdS/CFT duality ⇒ some strongly coupled 4D models are "dual" to weakly coupled, calculable models with an extra dimension!
- 5D "Higgsless" models have been constructed, with EWSB by boundary conditions in RS-like setup, passes precision electroweak tests with ~1% fine-tuning
- Fermion masses can be straightforwardly incorporated

Higgsless Phenomenology

- Best place to search for all higgsless models is W/Z scattering
- Unitarity must be restored, typically resonances appear
- 5D Higgsless model predicts narrow, light (sub-TeV) resonances



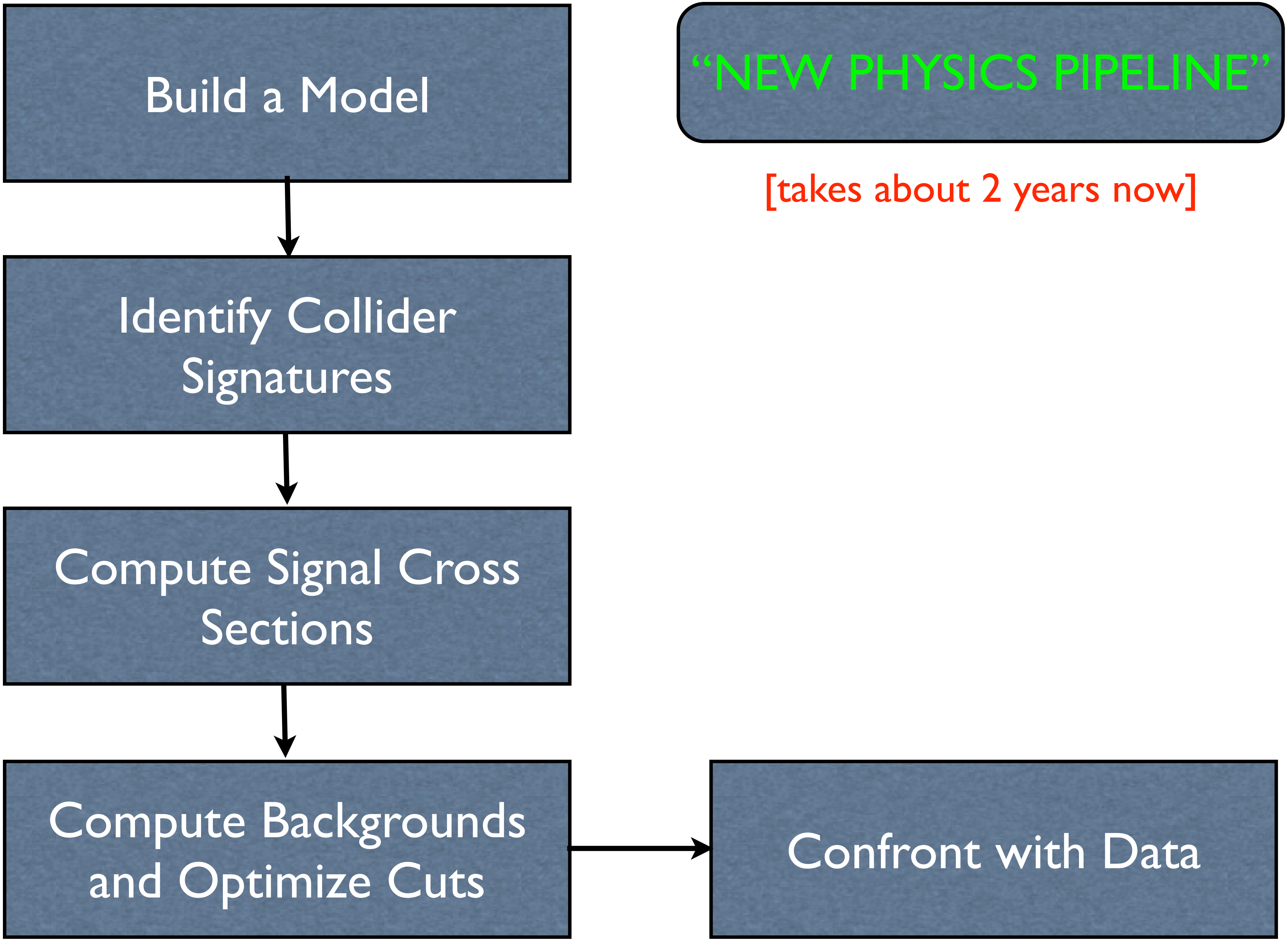
[Birkedal, Matchev, MP, hep-ph/0412278]

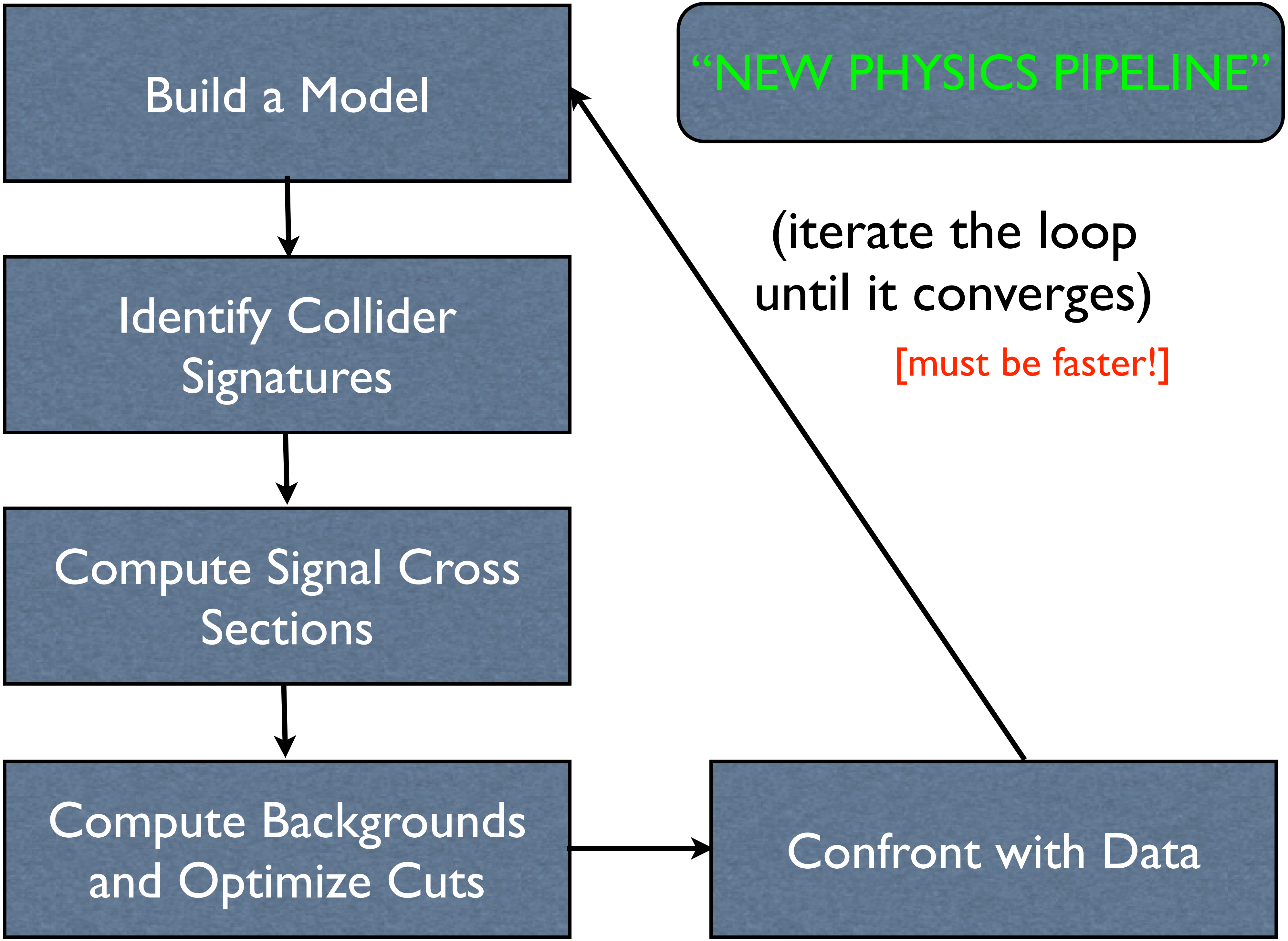


Gold-Plated Channel: 2j+3l+Et_miss

Closing Remarks

- Since the SM became accepted (~30 years), theorists have been able to provide very precise guidance for new physics searches at the energy frontier (e.g. W, Z, top)
- This is NOT the case in the BSM physics hunt:
  - Number of "ideas" is finite (SUSY, xdim, TC, ...)
  - Number of "implementations" is essentially infinite
  - Number of "free parameters" in each implementation is typically large
- Inclusive (signature-based whenever possible) searches are the best bet
- "Model space" will evolve very quickly once there is evidence for BSM in the data!

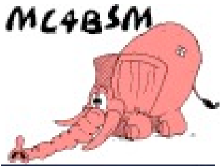

Build a Model
Identify Collider Signatures
Compute Signal Cross Sections
Compute Backgrounds and Optimize Cuts
Confront with Data
"NEW PHYSICS PIPELINE"
[takes about 2 years now]

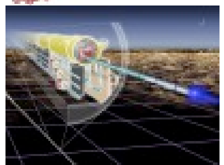


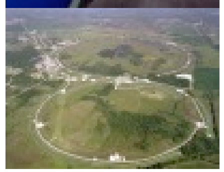
Build a Model
"NEW PHYSICS PIPELINE"
(iterate the loop
until it converges)
[must be faster!]
Identify Collider
Signatures
Compute Signal Cross
Sections
Compute Backgrounds
and Optimize Cuts
Confront with Data

Monte Carlo Tools for BSM

- Monte Carlo predictions from models are essential for theory/experiment connection (see G. Brooijmans's talk yesterday)
- Old model: MC developers implement models in general-purpose generators, users use these tools (slow!)
- New model:
  - users implement models in parton-level matrix element generators (e.g. Madgraph), output Les Houches Accord-compatible files
  - LHA files are passed on to the rest of the simulation chain (same as SM, except if long-lived BSM states)







[theory.fnal.gov/mc4bsm/]

Monte Carlo Tools for Beyond the Standard Model Physics

ORGANIZERS:
mc4bsm.AT.phys.ufl.edu

RESOURCES:

- BSM tool repository
- Video Lectures on Monte Carlo for the LHC
- Summary of MC4BSM-1 Discussion sessions

4th workshop: APRIL 3-4, 2009 (UC DAVIS)

Note: Organized in conjunction with HEFTI Workshop on Missing Energy Signals at the LHC. Full duration (both meetings): **Apr 1-4**

Organizing committee: Hsin-Chia Cheng, Christophe Grojean, Konstantin Matchev, Steven Mrenna, Maxim Perelstein, Peter Skands.

3rd workshop: MARCH 10-11, 2008 (CERN)

Organizing committee: Georges Azuelos, Christophe Grojean, Jay Hubisz, Borut Kersevan, Joe Lykken, Fabio Maltoni, Konstantin Matchev, Filip Moortgat, Steven Mrenna, Maxim Perelstein, Peter Skands, James Wells : mc4bsm.AT.phys.ufl.edu

2nd workshop: MARCH 21-24, 2007 (PRINCETON)

Organizing committee: Jay Hubisz, Konstantin Matchev, Steven Mrenna, Maxim Perelstein, Peter Skands.

1st workshop: MARCH 20-21, 2006 (FERMILAB)

Conclusions

- The mechanism which breaks electroweak symmetry remains a fundamental, unsolved mystery
- All natural models of EWSB predict new physics at the TeV scale
- Tevatron is at the frontier, discovery possible every day
- LHC is on its way!
- Lots of interesting possibilities - exciting physics ahead!
- Widely open theory space brings challenges as well:
  - Making sure no new physics is missed (triggers, cuts)
  - Experiment-theory communication issues