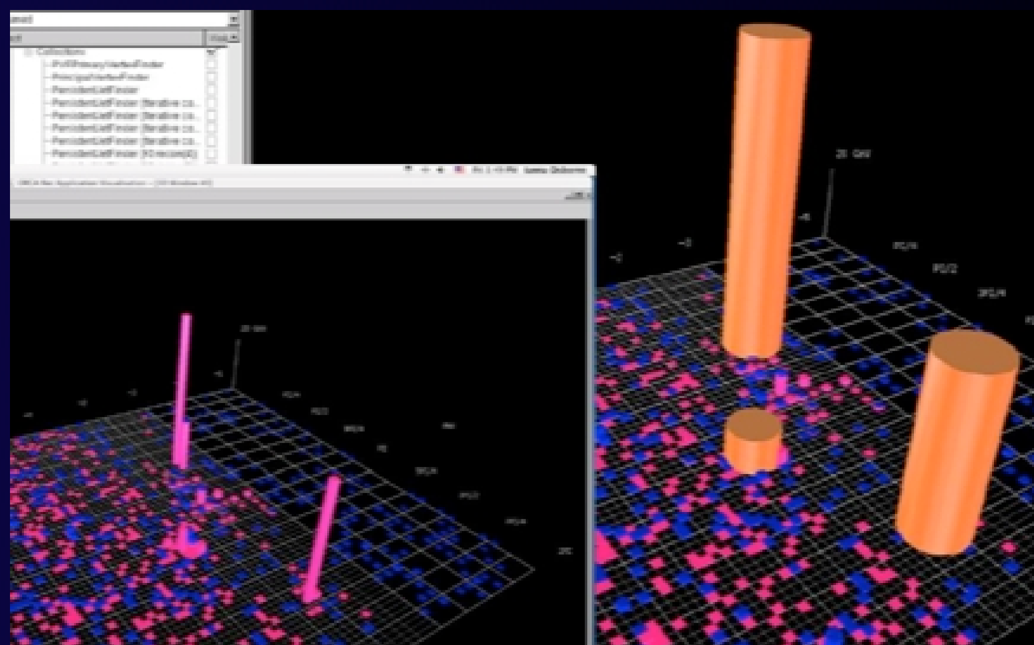
is particle physics ready for the LHC?



Joseph Lykken
Fermi National Accelerator Laboratory

Hinchliffe's theorem:

when a title is in the form of a question,
the answer is always "no"

outline

- accelerator, detector challenges
- is it new physics?
    - "clean" signatures
    - inclusive SUSY channels
    - missing energy
- what kind of new physics?
    - is it SUSY, or is it deconstructed little Higgs +T parity?
    - hidden SUSY
    - is that bump a Z', or is it M-theory?
- is Princeton ready for the LHC?

accelerator challenges

- the LHC accelerator design (to compete with the SSC!) pushes the envelope in several areas:
- 30,000 tons of 8.4 Tesla dipoles cooled to 1.9 degrees K by 90 tons of liquid helium
- 2808 proton bunches (each direction), with 100 billion 7 TeV protons per bunch
- Beam energy of 300 Megajoules = 120 Kg TNT, enough to melt ~ a ton of copper

beam safety is a critical issue

What CDF was surprised by and reacted to

- Very Serious (CDF)
  - Fast beam loss (risk was known - but reinforced by experience)
  - Damage to silicon from low doses (100's of rads) at high rate (100 nsec) [particular failure mode not reproduced in tests]
  - (note: CDF shields D0 from proton halo)
- Serious (CDF and D0)
  - Damage to various electronics in collision hall due to SEB (single event burnout) or similar single events ← abnormally high losses
- Annoying (CDF)
  - Example: Beam induced background in missing E_T trigger ← halo scraping upstream of CDF

what is the message to theorists?

- LHC startup will be slow and gradual
- the discoveries announced in 2009-2010 will be made from data sets with $<\sim \mathbf{10}\ \mathrm{fb}^{-1}$ not the $\mathbf{30-100}\ \mathrm{fb}^{-1}$ that you see in all the studies

The LHC Start-Up

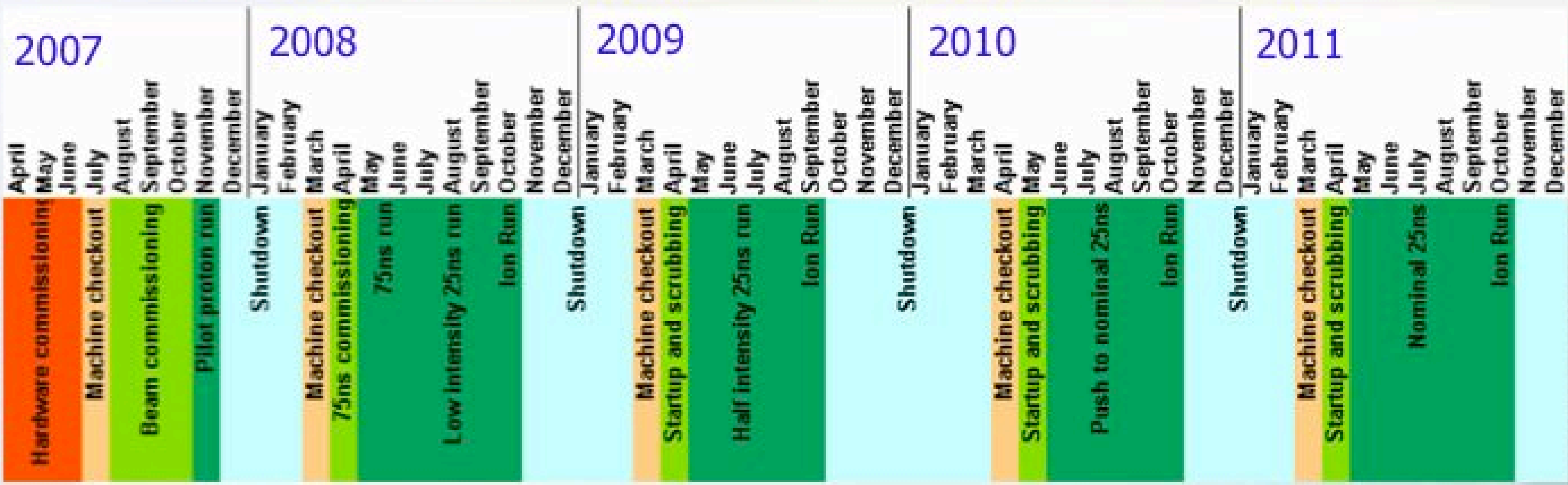
- Physics running: 140 days/year
- ATLAS/CMS running: ~100 days/year
- Typical efficiency for physics: 40%
- Effective ATLAS/CMS running time/year: ~1000 hours ~ 4×10^{6} s ~ 4×10^{38} cm^{-2} = 4×10^{14} b^{-1} = 400 pb^{-1} @ 10^{32}cm^{-2}s^{-1}
- Note that the schedule below [R. Bailey, LHCAC, 6/5/05] is "all goes well" scenario

Pilot run, 75ns
L~5×10^{30} cm^{-2}s^{-1}
$\int Ldt$ ~ 20 pb^{-1}

2008, 75/25ns
L~3×10^{32} cm^{-2}s^{-1}
$\int Ldt$ ~ 1.2 fb^{-1}

2009, 25ns
L~1×10^{33} cm^{-2}s^{-1}
$\int Ldt$ ~ 4 fb^{-1}

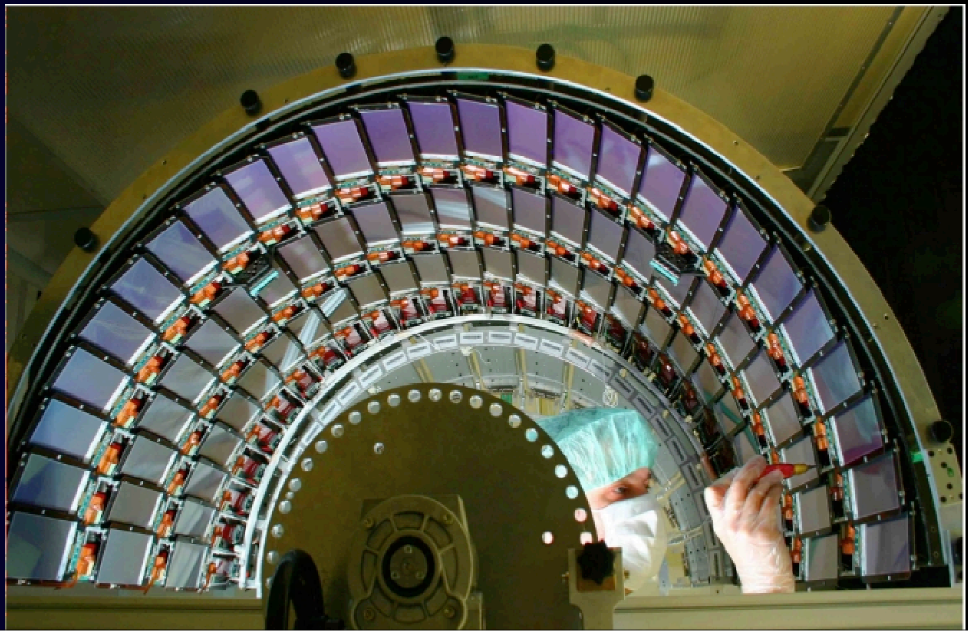
2010, 25ns
L~1×10^{34} cm^{-2}s^{-1}
$\int Ldt$ ~ 40 fb^{-1}



detector challenges

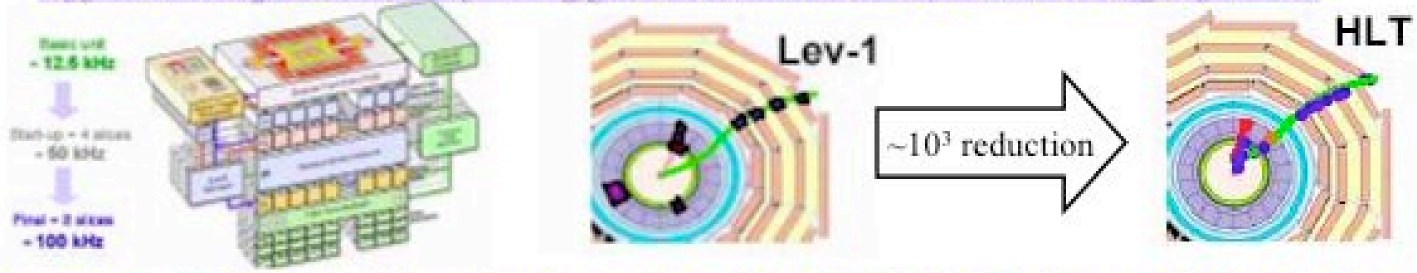
detector challenges

- new detectors with new technologies
- new environment: higher energy + luminosity
- calibration, alignment, and integration of many big subsystems

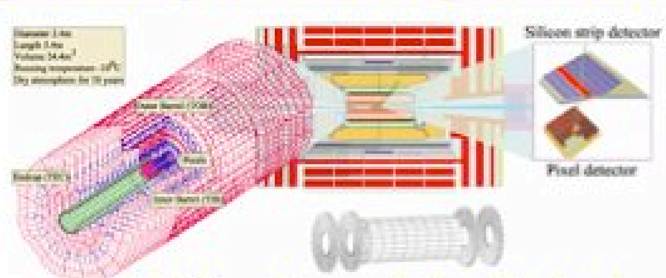


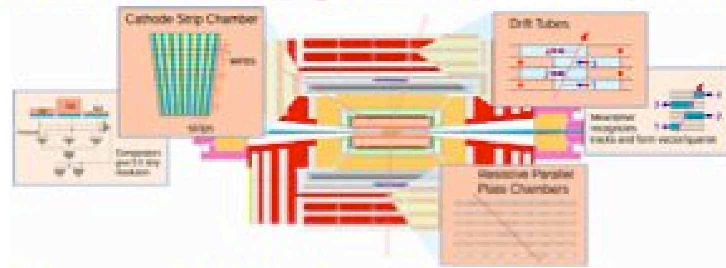
Major Commissioning Challenges

Efficient operation of Trigger (Level1/HLT) and DAQ System

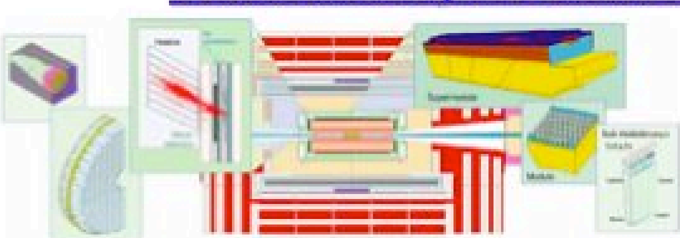


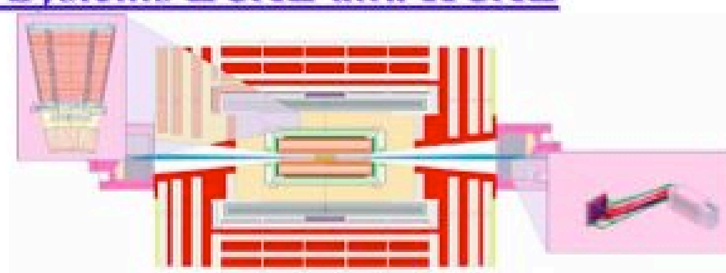
Alignment of the tracking devices Tracker(PIXEL,Strip) and Muon System





Calibration of the Calorimeter Systems ECAL and HCAL





→form the base for the "commissioning of physics tools" like b and τ tagging, jets, missing E_T …

trigger and reconstruction challenges

- 40 MHZ collision rate = 1 Terabyte/sec raw data
- 5 events out of a billion will be a light Higgs
- all the reconstructed physics objects are new kinds of beasts: e.g. for a CMS electron with PT=35 GeV, 44% of its energy is in bremsstrahlung
- a CMS jet is not the same as a CDF jet, and CMS SUSY multijets are not the same as CMS Higgs -> bbar dijets

what is the message to theorists?

- initial LHC discoveries will come from simple inclusive signatures

is it new physics?

Standard Model cross sections at LHC are huge:

- total inelastic: ~ 0.1 barns
- inclusive bbar: ~ 500 microbarns
- inclusive W and Z: ~ 100 nanobarns
- inclusive top: 0.89 nanobarns
- Z + 2 jets, with Z decaying to neutrinos: ~ 200 pb
- compare this to 1 TeV inclusive SUSY: ~ 3 pb

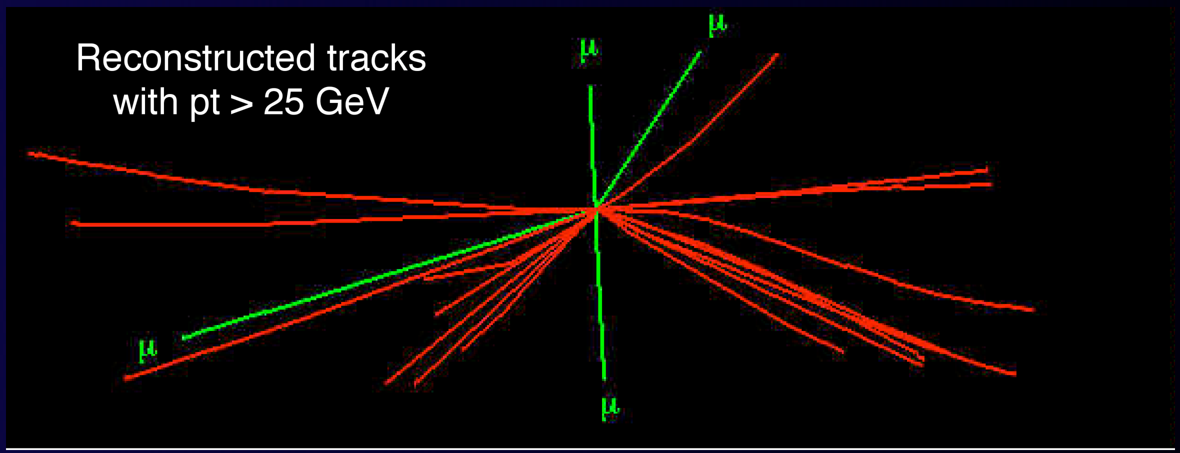
is it new physics?

unavoidable tension between using simple inclusive samples for understanding SM backgrounds+detector issues ***versus*** making initial discoveries:

- want to use dijets and W+jets for determination of pdfs, but there is probably new physics in these channels!
- want to use inclusive top, W+jets, Z+jets for energy scale calibration and to study jet algorithms, but there is probably new physics in these channels!

“clean” signatures at LHC

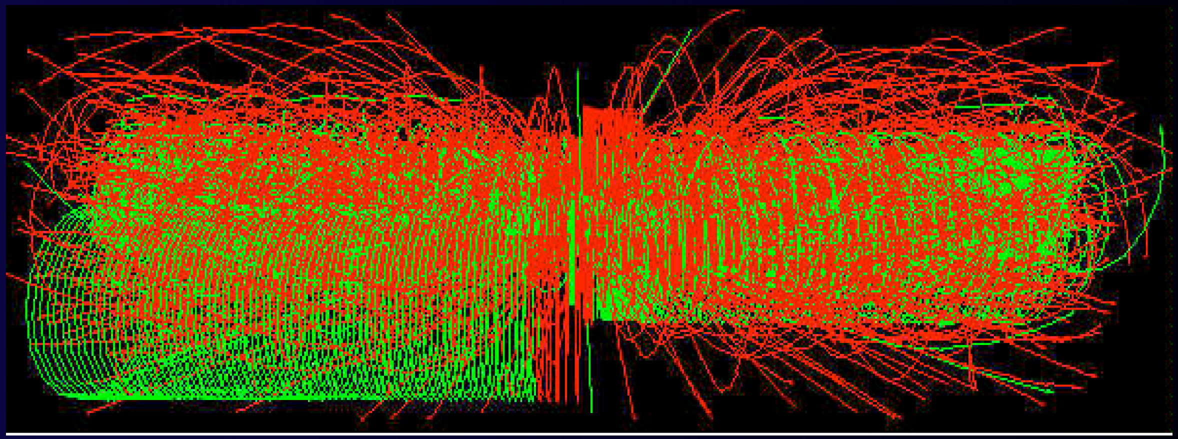
- every new physics event, no matter how clean, will have 20 - 50 additional min bias events laid on top of it, plus an underlying event from the pp remnants



golden event: $\mathrm{gg} \rightarrow \mathrm{h} \rightarrow \mathbf{ZZ} \rightarrow \mu^+\mu^-\mu^+\mu^-$

“clean” signatures at LHC

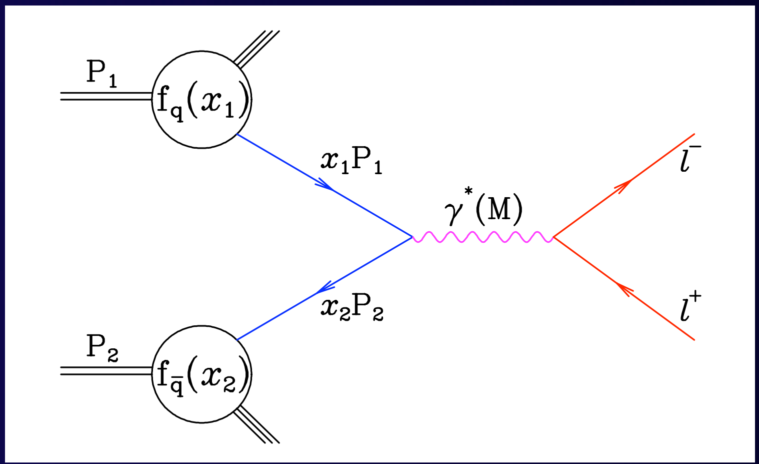
- the extra junk is soft, but adds a total of about 1 TeV to the event

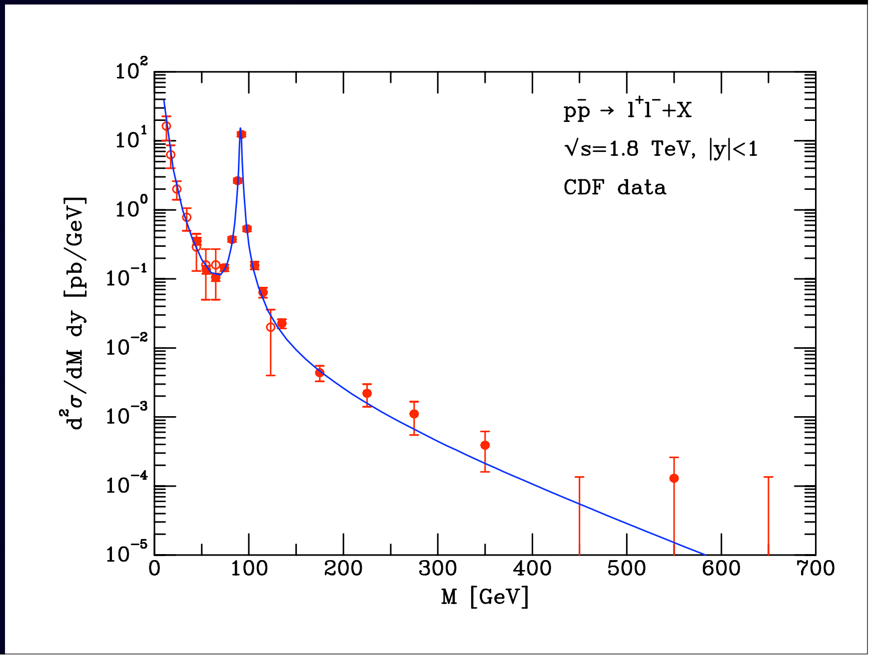


golden event: $\mathrm{gg} \rightarrow \mathbf{h} \rightarrow \mathbf{ZZ} \rightarrow \mu^+\mu^-\mu^+\mu^-$

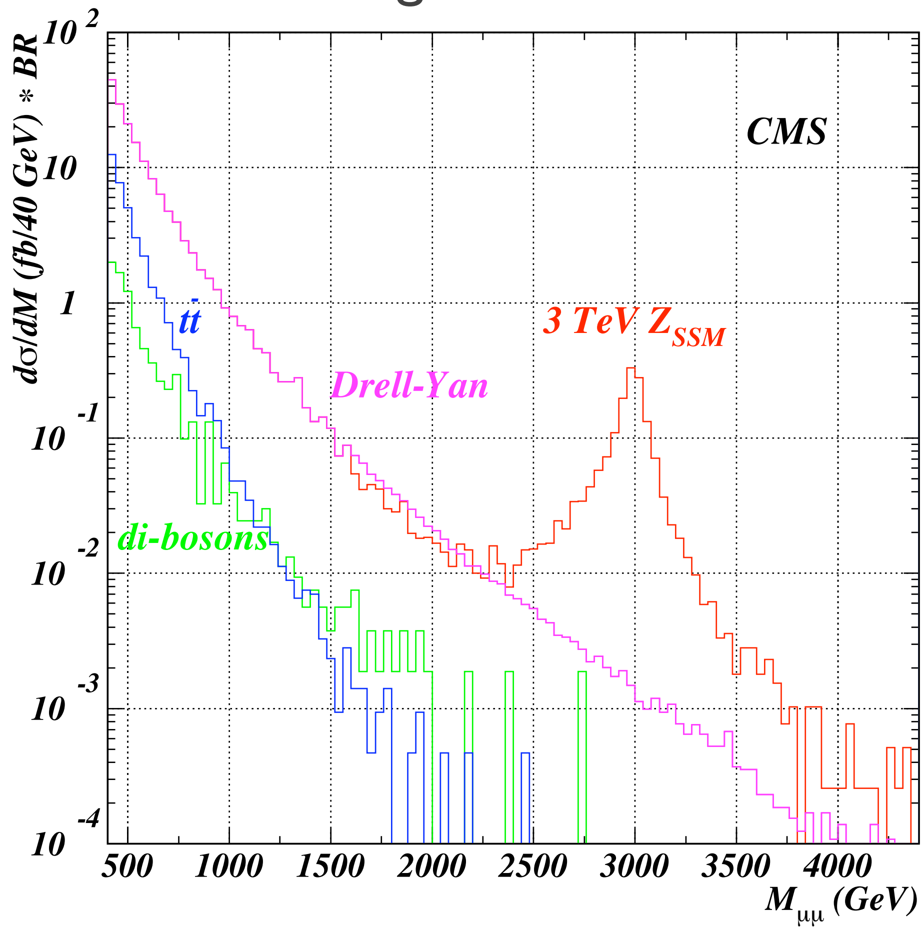
clean signatures: Drell-Yan

- Drell-Yan is well-understood theoretically and computed at NNLO
- theory and data agree very well





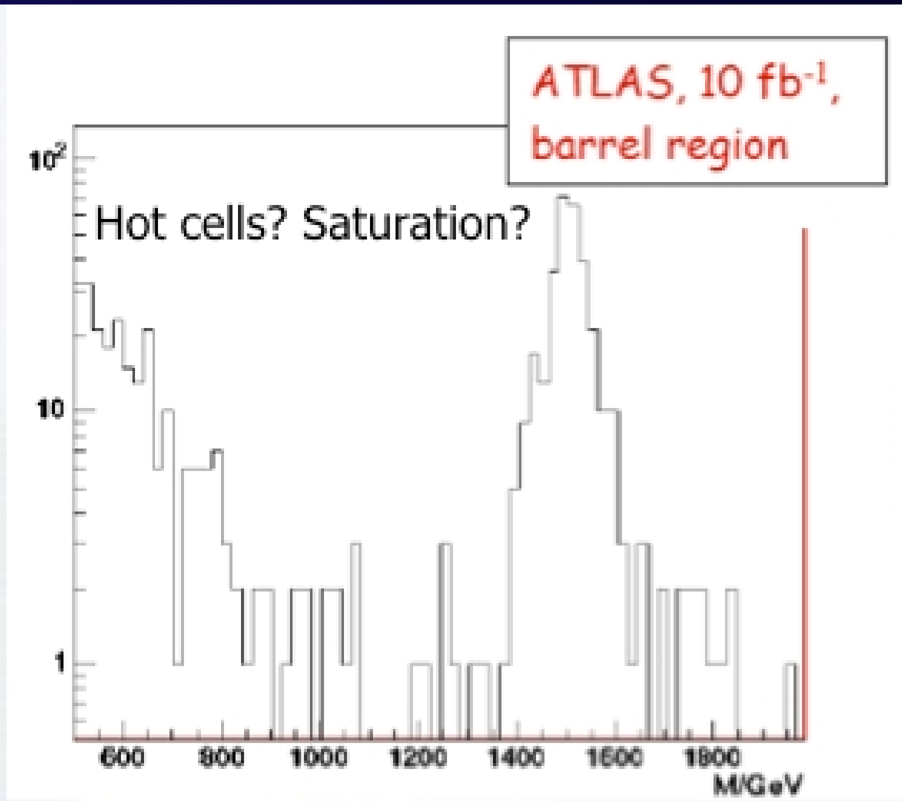
look for new resonances in ee or mumu with large invariant mass

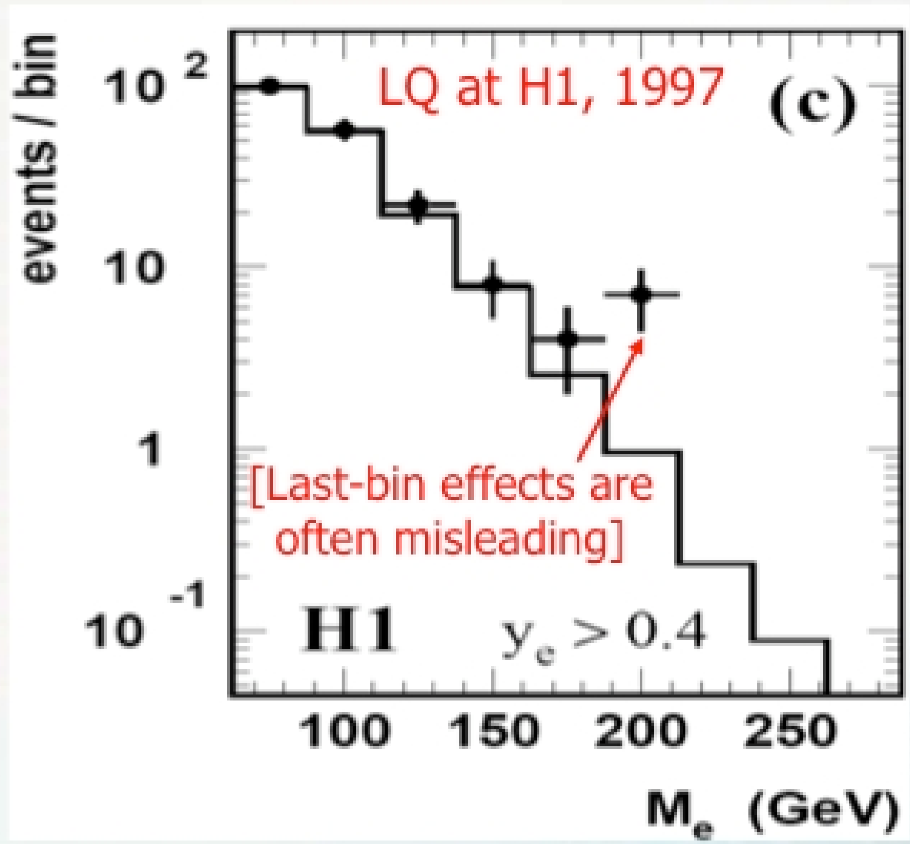


for a 1.5 TeV Z' with SM-like couplings, produce ~30 events per fb-1 after cuts

- this is one of the best-case scenarios for early discoveries at LHC, but even here there are challenges:
- as Samir Ferrag pointed out at Les Houches 05, no one has tried to estimate the total theoretical uncertainty (scale+pdfs+?)
- this will be needed as input to estimating the total experimental uncertainty in the real data

- especially with limited data, the signal may not be a nice peak; it could be a rise or a dip in the tail





Aspen 2005 Workshop   Greg Landsberg, The First Three Years: Before the Champagne?

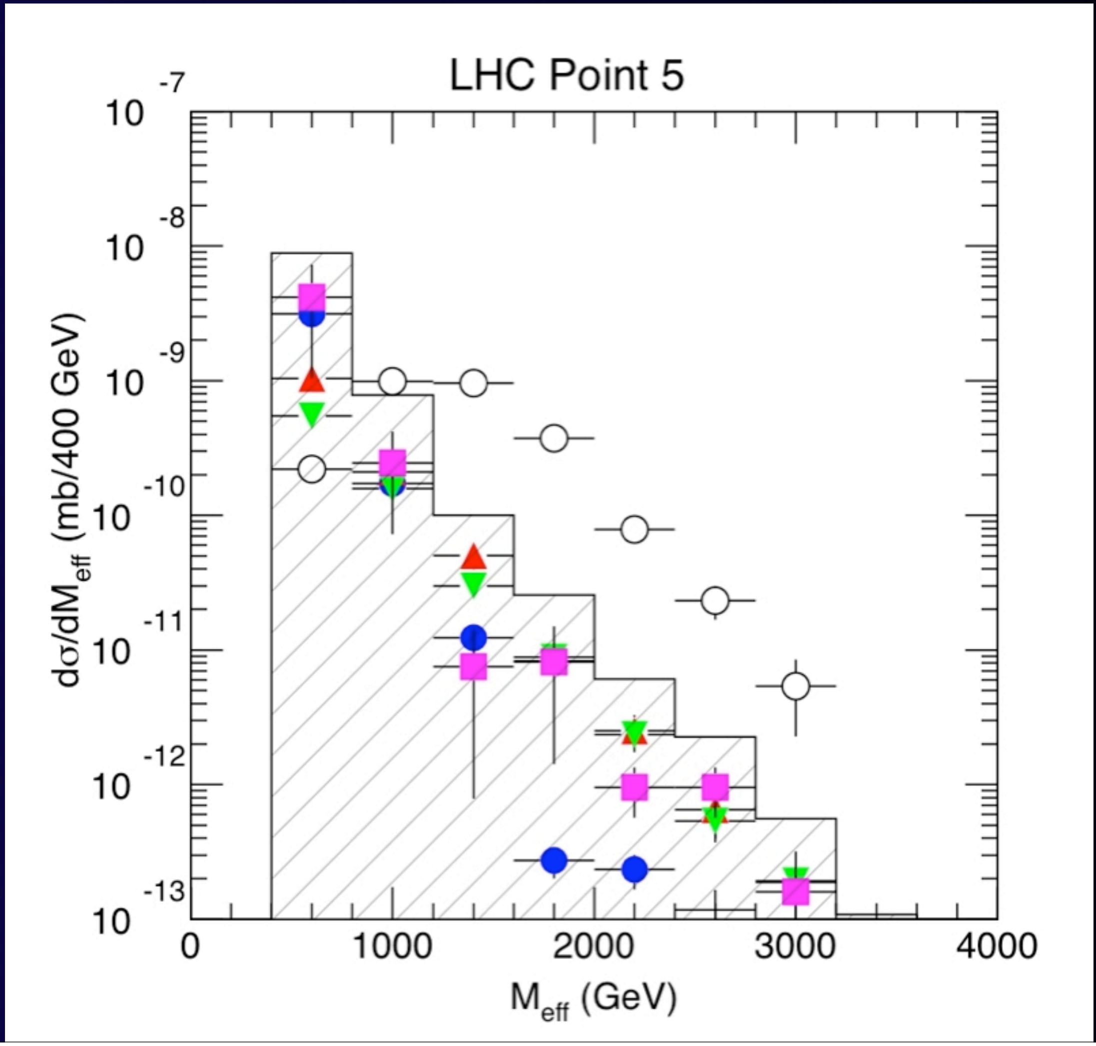
inclusive supersymmetry

- the dominant production of superparticles at LHC is through pairs of gluinos and squarks
- their cascade decays produce high PT jets and large missing energy
- a simple discriminant for inclusive SUSY searches is the effective mass defined as

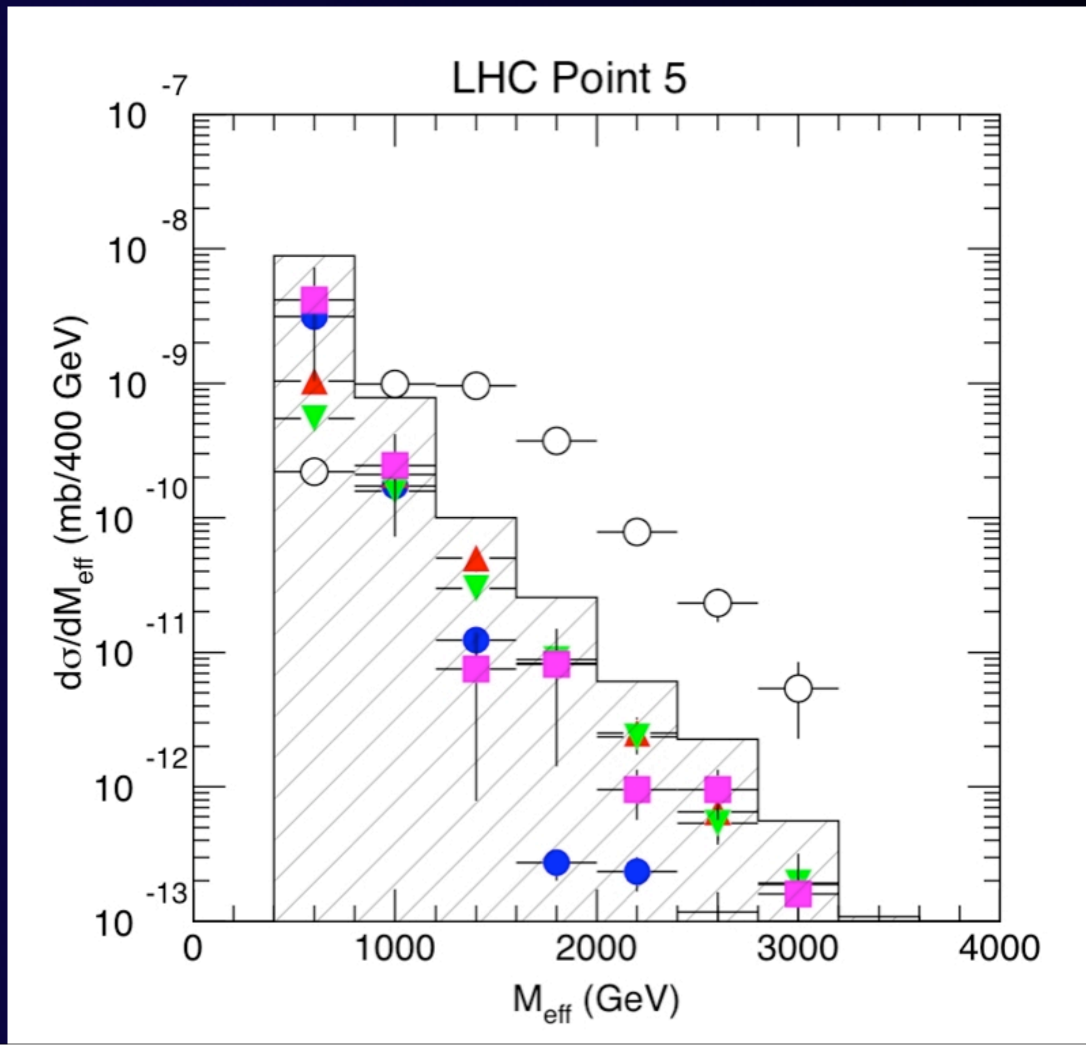
$$\mathrm{M_{eff}} = \mathrm{E_T^{miss}} + \sum_{i=1}^{4} \mathrm{P_T^{jet}}$$

- an excess of events with large $\mathrm{M_{eff}}$ could be the initial discovery of supersymmetry

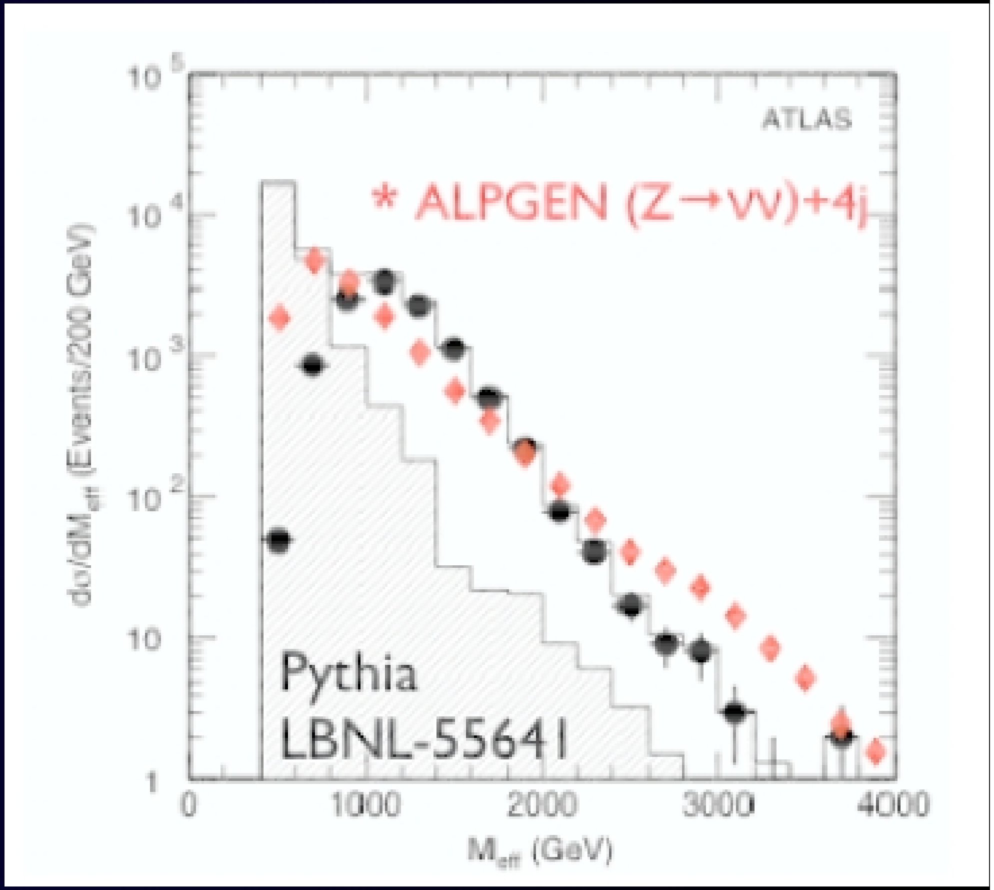
- this strategy is backed up by this famous plot from the ATLAS TDR
- for 8 years, was used to make the case that LHC can discover SUSY after "a few weeks of running"



the only problem is:
this plot is completely wrong

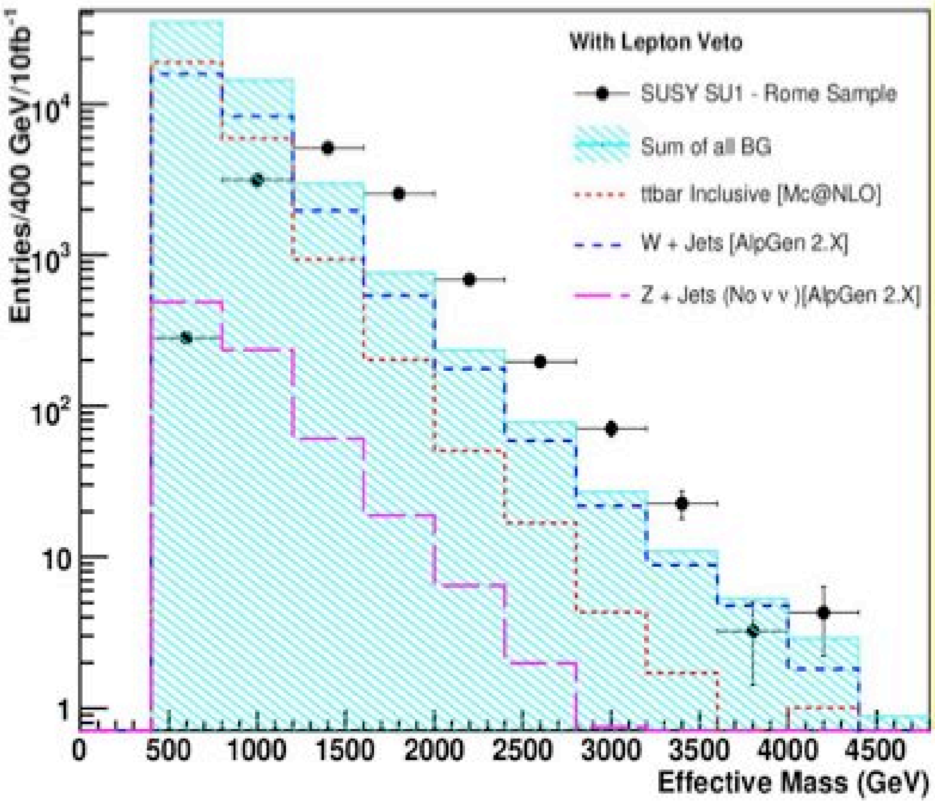


- at LHC, inclusive SUSY channels have large SM backgrounds from top, Z+jets, and W+jets
- showering Monte Carlos like Isajet and Pythia underestimate these backgrounds by up to a factor of ten in the SUSY signal region
- this was suspected but forgotten until recently, when better theory tools became available

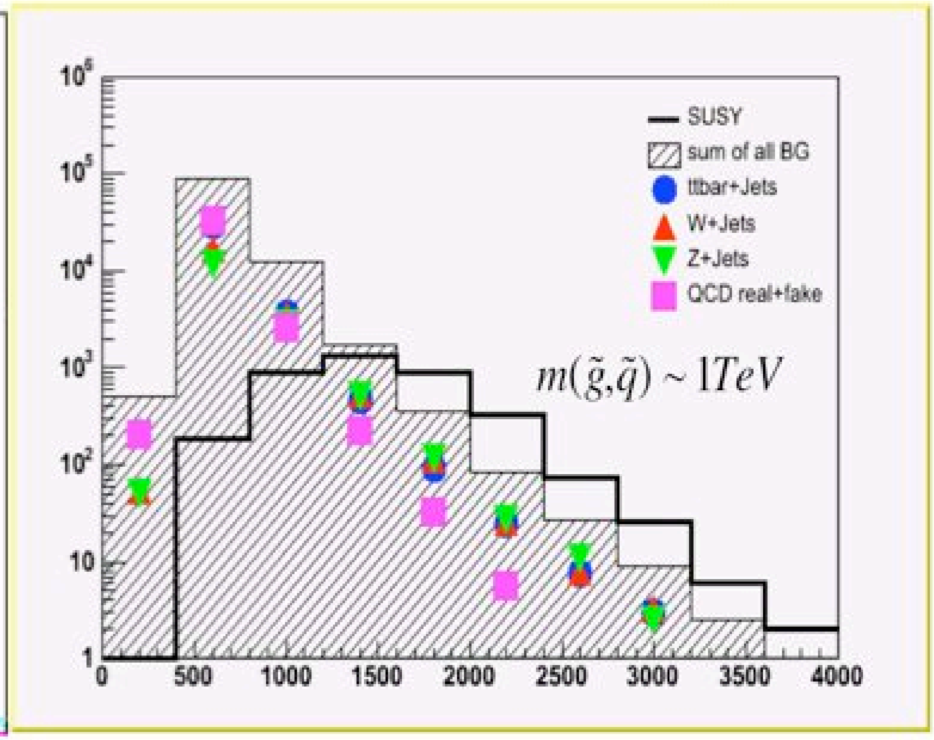


Comparisons with Other studies [0 lepton mode]

this study



S. Asai et. al.



Differences in Generator Version (AlpGen)

ME + PS matching prescriptions

Selection cuts and Scale choice

Matching presciption, Matching at Pt ~ 20 GeV Vs 40 GeV ??

now what?

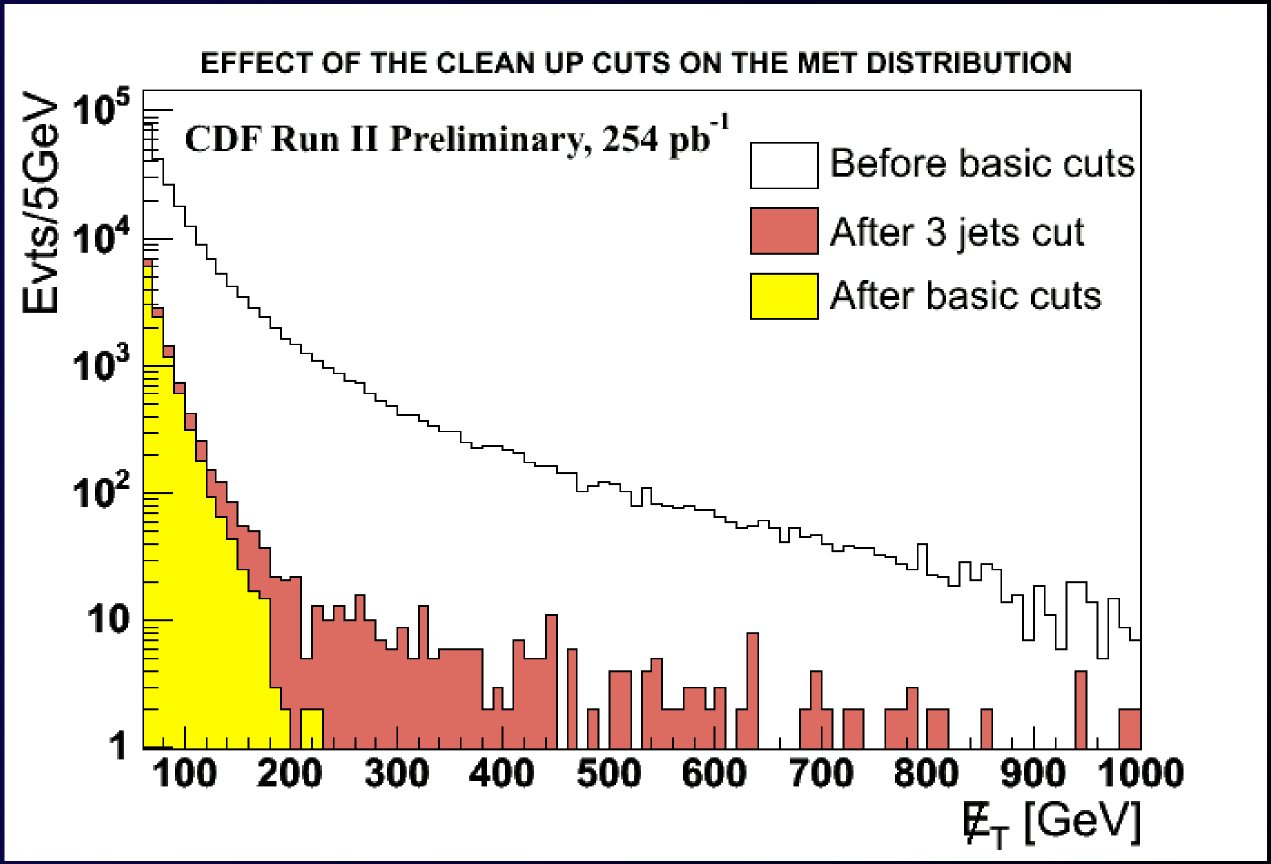
- can enhance the SUSY signal by requiring leptons (one lepton? two leptons?)
- but now we have to understand a lot: multijets, missing energy, leptons, jets faking leptons, ...
- note missing energy, the best discriminator between SUSY and SM, is also one of the most challenging physics objects

missing energy signatures

- ANY beyond the Standard Model theory which incorporates weakly interacting stable dark matter will have missing energy signatures
- so does ADD large extra dimensions and some varieties of warped extra dimensions models

see e.g. JL hep-ph/0503148,
JL and Randall, hep-th/9908076

not for amateurs



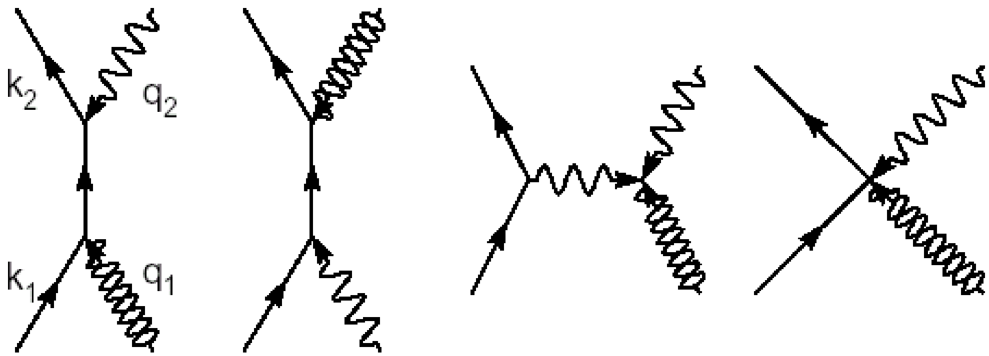
- missing energy + multijets among the most challenging searches at Tevatron Runs I and II

Background Estimation

- Aim to use techniques developed at CDF/D0 + some new ones
- W/Z + n jets
  - $Z \rightarrow \nu\nu$ + n jets, $W \rightarrow l\nu$ + n jets, $W \rightarrow \tau\nu$ + (n-1) jets (τ fakes jet)
  - Estimate from $Z \rightarrow l^+l^-$ + n jets (e or μ)
  - Tag leptonic Z and use to validate MC / estimate E_T^{miss} from $p_T(Z)$ & $p_T(l)$
- QCD / fake E_T^{miss} (from gaps in acceptance, dead/hot cells, non-gaussian tails etc.)
  - Much harder : simulations require detailed understanding of detector performance (not easy with little data).
  - Strategy (learn from Tevatron):
    1) Initially choose channels which minimise contribution until well understood
    2) Reject events where fake E_T^{miss} likely: beam-gas and machine background, bad primary vertex, hot cells, CR muons, E_T^{miss} vector pointing in (opposite) direction of (to) jets (jet fluctuations), jets pointing at regions of poor response, large Missing E_T Significance
    3) Choose hard cuts which minimise contribution to background.
    4) Estimate background using data and/or calibrated fast MC: need to estimate jet resolution functions using e.g. E_T^{miss} projection

"beware the monojet, my son"

- monojet searches are even more difficult
- at the Tevatron, the *Run I* monojet analyses were not completed until 2003/2004
- but monojet searches are essential for probing extra dimensions



KK graviton production (monojets)

(HLZ): Han, JL, and Zhang, hep-ph/9811350
(GRW): Giudice, Rattazzi, Wells, hep-ph/9811291

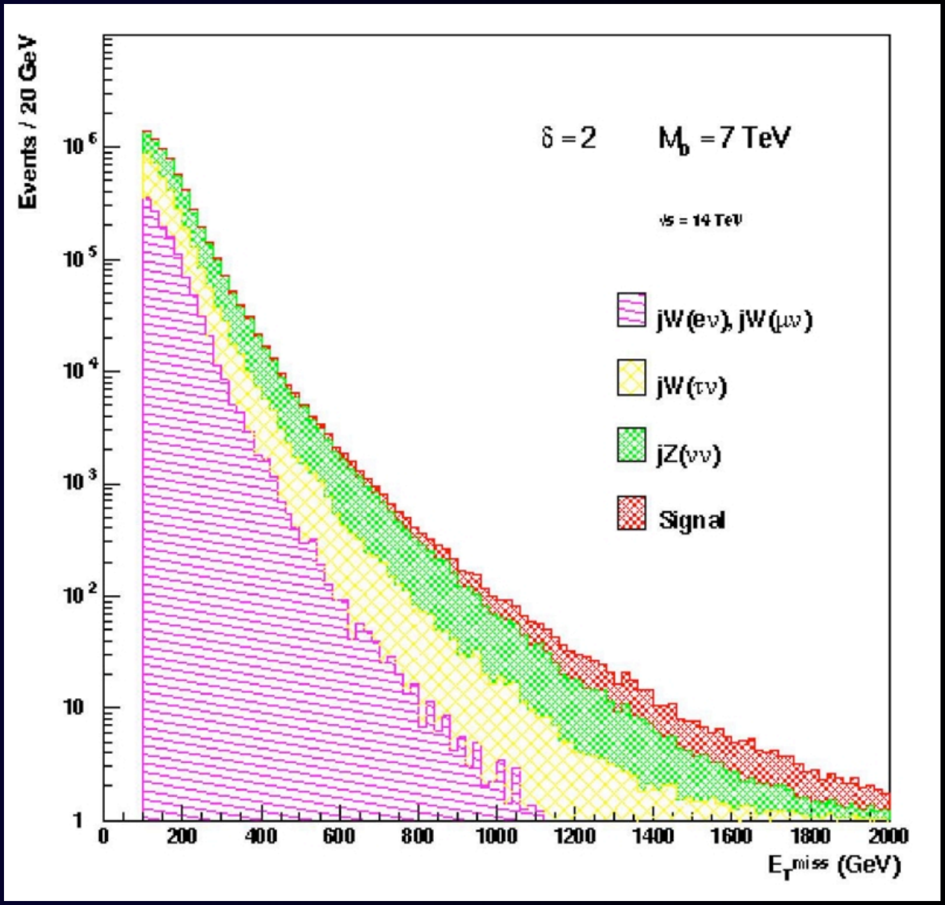
$$\sigma(\mathbf{q\bar{q}} \to \mathbf{KK + g})$$

$$= \frac{2\pi\alpha_s}{9M^2_{\rm Planck}} \int \mathbf{dx_1 dx_2 dm d\hat{t}\, f_1(x_1) f_2(x_2)}\, \rho_n(\mathbf{m})\, \frac{\mathbf{1}}{\hat{\mathbf{s}}} \mathbf{F_1}(\frac{\hat{\mathbf{t}}}{\hat{\mathbf{s}}}, \frac{\mathbf{m^2}}{\hat{\mathbf{s}}})$$

$$F_1(x,y) = \frac{1}{x(y-1-x)}\left[-4x(1+x)(1+2x+2x^2)+ y(1+6x+18x^2+16x^3)-6y^2x(1+2x)+y^3(1+4x)\right],$$

signals in ADD or LR scenarios are smooth excesses over SM backgrounds, e.g.

on-shell production of single KK gravitons produces a smooth MET distribution after convolving closely spaced KK spectrum with pdfs

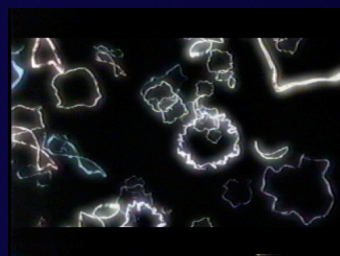


Hinchliffe and Vacavant, hep-ex/0005033

what kind of new physics?

- I just showed you an example where a smooth excess over significant SM backgrounds constitutes the discovery of extra dimensions of space
- or does it?
- experimenters can write neutral papers with titles like “observation of excess events in channel X”
- but there will be great urgency to put a label on the new physics

the big picture (we think)

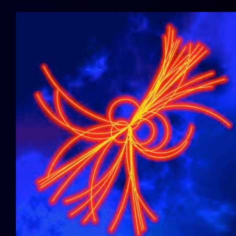


string unification

supersymmetry — broken → *new TeV scale physics*

extra dimensions — hidden → *new TeV scale physics*

new TeV scale physics



+ *neutrinos, cosmology, rare processes, astrophysics, etc*

all BSM models look alike

- when theorists first started thinking about LHC physics, there were only two competing BSM paradigms: supergravity SUSY, and technicolor
- their experimental predictions were wildly different
- then everything changed, prompted by
  - reality of dark matter
  - electroweak precision data

all BSM models look alike

- the undeniable existence of dark matter, plus the cosmological assumption that it is a thermal relic, implies TeV scale stable WIMPS
- the electroweak precision data implies that the new heavy particles associated with electroweak symmetry breaking are either
  - multi-TeV
  - conspiratorial
  - pair-produced (implying a conserved charge or parity)

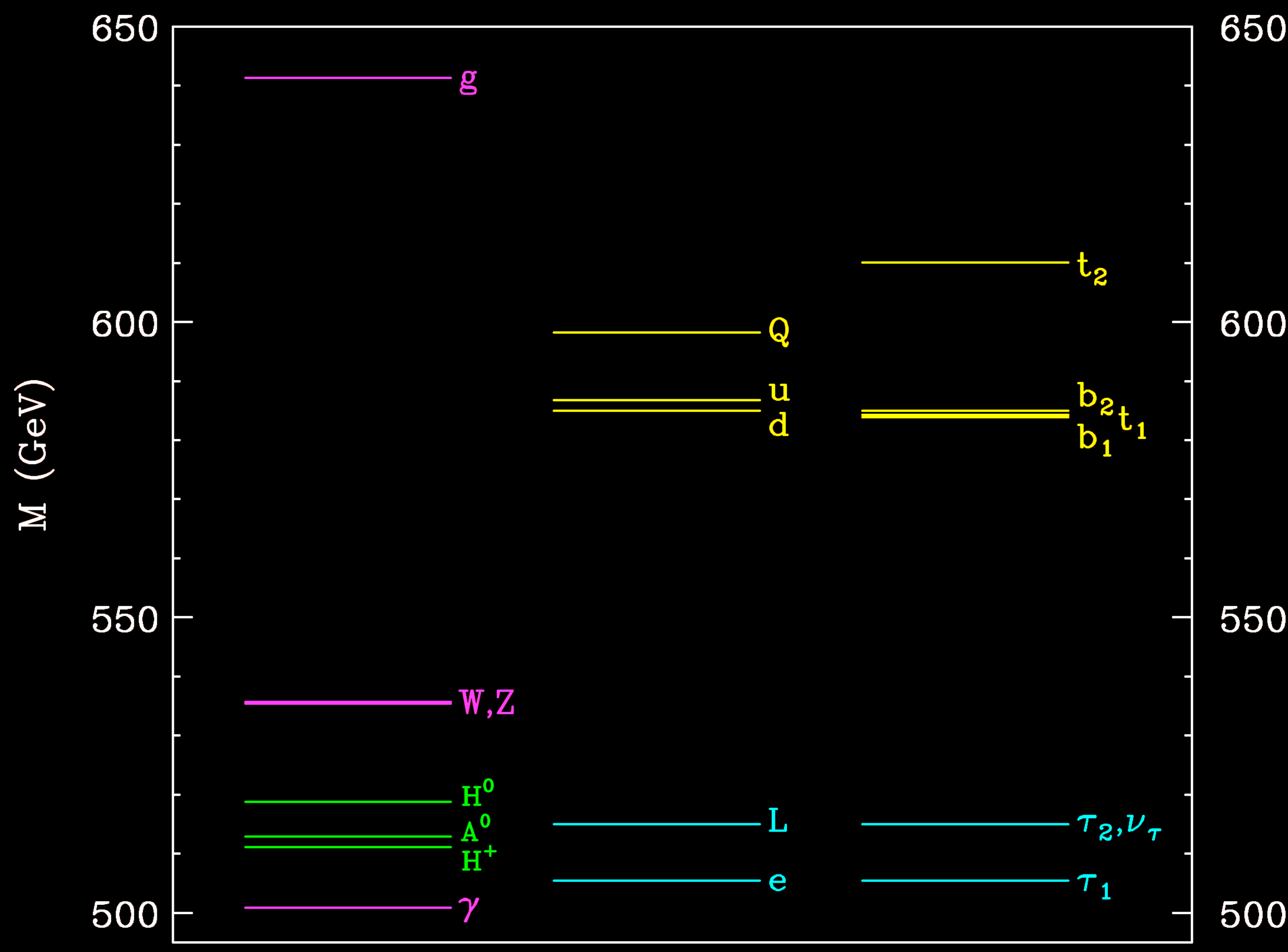
all BSM models look alike

- so nowadays several BSM models have LHC signatures which are similar to SUSY
- the non-SUSY-like models need to make most of the new particles multi-TeV, reducing the number of distinct signals accessible at the LHC
- the many varieties of SUSY models also present look-alike problems in their LHC phenomenology

“confusion scenarios”

- Michael Peskin’s name for different kinds of new heavy particles whose decay chains result in the same final state
- For example, in many SUSY models the squarks are heavier than the second-lightest neutralino, which is heavy than the sleptons, which are heavier than the LSP
- The same pattern occurs in UED (Universal Extra Dimensions), where relative masses of the lightest Kaluza-Klein partners are determined by SM radiative corrections

lowest KK modes of UED look like SUSY!



Cheng, Matchev, Schmaltz, hep-ph/0205314

confusion scenarios

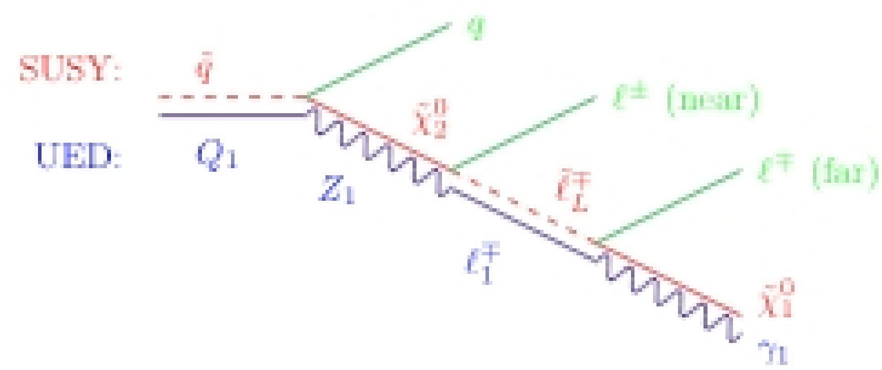


FIG. 10: Twin diagrams in SUSY and UED. The upper (red) line corresponds to the cascade decay $\tilde{q} \to q\tilde{\chi}_2^0 \to q\ell^\pm\tilde{\ell}_L^\mp \to q\ell^+\ell^-\tilde{\chi}_1^0$ in SUSY. The lower (blue) line corresponds to the cascade decay $Q_1 \to qZ_1 \to q\ell^\pm\ell_1^\mp \to q\ell^+\ell^-\gamma_1$ in UED. In either case the observable final state is the same: $q\ell^+\ell^- \not{E}_T$.

Datta, Kong, Matchev, hep-ph/0509246

- the LHC signature is jets + leptons + missing energy

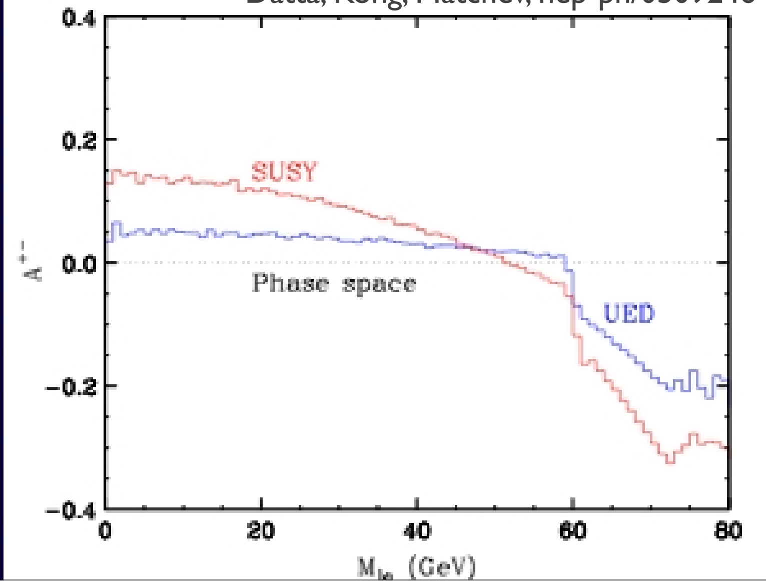
is it SUSY, or is it the 5th dimension?

- how do we tell these scenarios apart?
- the UED partners have a very specific mass pattern, but this may be an artifact of insufficiently creative model-building
- there are only two robust ways of discriminating:
  - superpartners and KK partners differ in spin
  - there is a 2nd, 3rd, ... set of KK partners lurking up at higher masses

is it SUSY, or is it the 5th dimension?

- the most recent study by Matchev et al indicates that the second set of UED Kaluza-Klein modes could be discovered at LHC in early (10 fb-1) running, if 1/R <= 750 GeV
- but discriminating the spins looks hopeless, even with 100 fb-1

Datta, Kong, Matchev, hep-ph/0509246



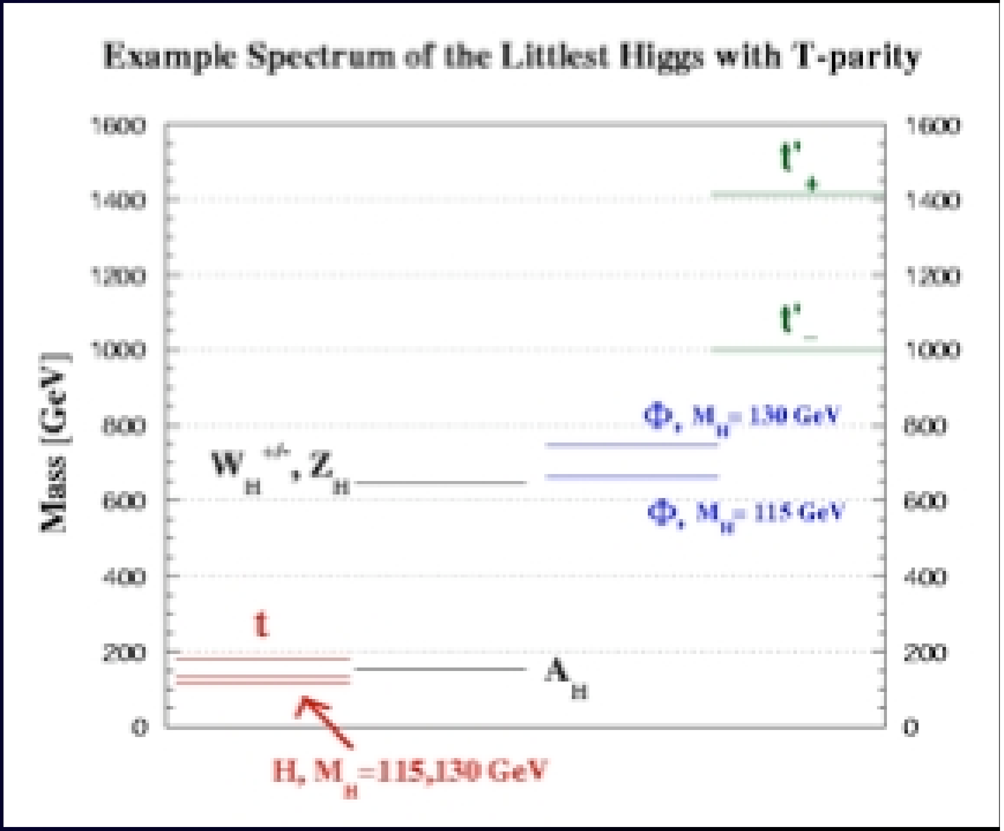
is it SUSY, or is it little Higgs with conserved T-parity?

- in the little Higgs models, heavy partners of the W, Z, Higgs, and top provide new loop diagrams that keep the Higgs light, without SUSY and with all the other new physics pushed up to 10 TeV
- little Higgs models have problems with the EW precision data, unless we invoke a conserved "T-parity"
- then the partners have to be pair-produced, and the lightest one (a neutral pseudoscalar) is a good dark matter candidate

Cheng and Low, hep-ph/0308199

is it SUSY, or is it little Higgs with conserved T-parity?

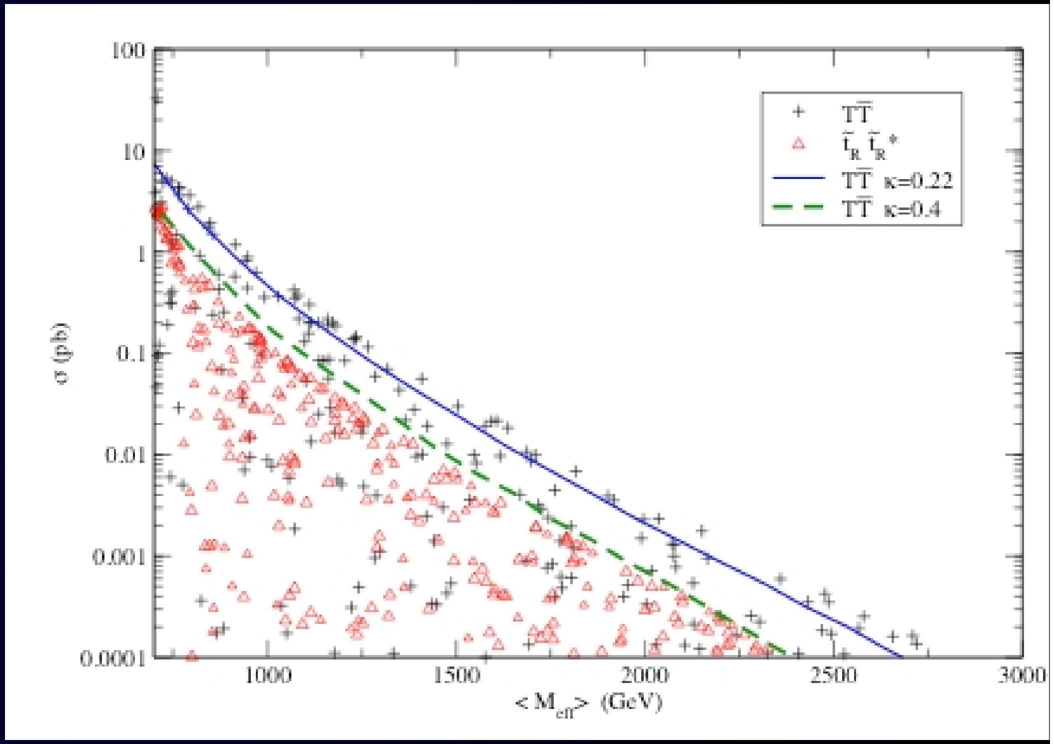
- the heavy partners of top will be strongly pair-produced at LHC
- they will cascade to W's, Higgs, and the LTP, which shows up as MET
- looks like heavy stops in SUSY, except for the spin



Hubisz and Meade, hep-ph/0411264

is it SUSY, or is it little Higgs with conserved T-parity?

- all other things being equal, having spin 1/2 versus spin 0 buys you about a factor of 8 in the production cross section
- but all other things are not necessarily equal



Cheng, Low and Wang, hep-ph/0510225

hidden SUSY

- another likely scenario is that there is TeV scale SUSY, but important parts of the superpartner spectrum are hard to see at LHC
- at Les Houches 05 we did a case study...

focus on BSM areas which are both underdeveloped ***and*** robust

CP violation in Higgs/SUSY

probably there!

effects on Higgs

effects on SUSY cascades

baryogenesis

“friends of top”

Nima Arkani-Hamed: top loop is biggest rad. corr. to Higgs, so light Higgs -> top has “friends”

could be extra vectorlike t_R, e.g. little Higgs models

could be stops

lights stops

JL talk at Les Houches 05

baryogenesis and stops

- electroweak baryogenesis requires a new source of CP violation, and new particles coupled to Higgs to make the phase transition more first order
- also want to get right amount of dark matter
- SUSY does all this naturally provided:
- lightest stop mass <~ 170 GeV
- moderate tan beta, 1st-2nd generation squarks very heavy
- stop-LSP mass difference 20-30 GeV

Balazs, Carena, Menon, Morrissey, Wagner, hep-ph/0412264

light stops at LHC?

$$\mathbf{m_{\tilde{t}_1} < 165}\ \mathrm{GeV},\ \mathbf{m_{\tilde{t}_1} - m_{\tilde{\chi}^0_1} \sim 30GeV},\ \tan\beta \sim \mathbf{5},$$

$$\mathbf{300 < m_{\tilde{g}} < 1000}\ \mathrm{GeV},\ \mathbf{m_{sq}},\ \mathbf{m_{sl} > 1}\ \mathrm{TeV}$$

production: $\mathbf{pp \rightarrow \tilde{t}_1\tilde{t}_1}$

$$\mathbf{pp \rightarrow \tilde{g}\tilde{g} \rightarrow tt\tilde{t}_1\tilde{t}_1}$$

decay: one-loop competes with 4-body!

$$\mathbf{\tilde{t}_1 \rightarrow c\tilde{\chi}^0_1}$$

$$\mathbf{\tilde{t}_1 \rightarrow bW^*\tilde{\chi}^0_1}$$

light stops signatures

$$\mathbf{pp} \to \tilde{\mathbf{t}}_1\tilde{\mathbf{t}}_1 \to \mathbf{cc}\tilde{\chi}_1^0\tilde{\chi}_1^0$$ (impossible)

$$\mathbf{pp} \to \tilde{\mathbf{t}}_1\tilde{\mathbf{t}}_1 \to \mathbf{bbW^*W^*}\tilde{\chi}_1^0\tilde{\chi}_1^0$$

$$\mathbf{pp} \to \tilde{\mathbf{g}}\tilde{\mathbf{g}} \to \mathbf{tt}\tilde{\mathbf{t}}_1\tilde{\mathbf{t}}_1 \to \mathbf{ttcc}\tilde{\chi}_1^0\tilde{\chi}_1^0$$

$$\mathbf{pp} \to \tilde{\mathbf{g}}\tilde{\mathbf{g}} \to \mathbf{tt}\tilde{\mathbf{t}}_1\tilde{\mathbf{t}}_1 \to \mathbf{ttbbW^*W^*}\tilde{\chi}_1^0\tilde{\chi}_1^0$$

$$\mathbf{pp} \to \tilde{\mathbf{g}}\tilde{\mathbf{g}} \to \mathbf{tt}\tilde{\mathbf{t}}_1\tilde{\mathbf{t}}_1 \to \mathbf{ttbcW^*}\tilde{\chi}_1^0\tilde{\chi}_1^0$$

Same-sign top pairs?

G.L. Kane and S. Mrenna, hep-ph/9605351

R. Demina, J. Lykken, K. Matchev, A. Nomerotski hep-ph/9910275

"Among the remaining SUSY particles, gluinos have the largest production cross section, and they can decay to stop pairs.

Since the stops are invisible, the signature is similar to the leptonic channels of top pair production. The crucial difference from $t\bar{t}$ production is that because of the Majorana nature of the gluino, half of the time the top quarks will have the same sign."

Cross sections, event numbers: SM processes

	tb	tqb	$\bar{t}b$	$\bar{t}qb$	ZZ	ZW	WW	$t\bar{t}$	$Zb\bar{b}$	All
σ, pb	0.212*	5.17*	0.129*	3.03*	18(NLO)	26.2	70.2	886(NLO)	232(NLO)*	
N1	2,120	51,700	1,290	30,300	180,000	262,000	702,000	8,860,000	2,320,000	
N2	112	1,798	71	1,067	256	727	39.7	142,691	12,924	160,000

main contribution into background

- Other process
  - generated with CompHEP

	WWW	ZWW	ZZW	ZZZ	$WWWW$	$ZWWW$	$ZZWW$	$ZZZW$	$ZZZZ$
σ, pb	0.129	0.0979	0.0305	0.00994	0.000574	0.000706	0.000442	0.000572	0.0000161
N1	1,290	979	305	99.4					
N2	<15	<10	<3	<1					

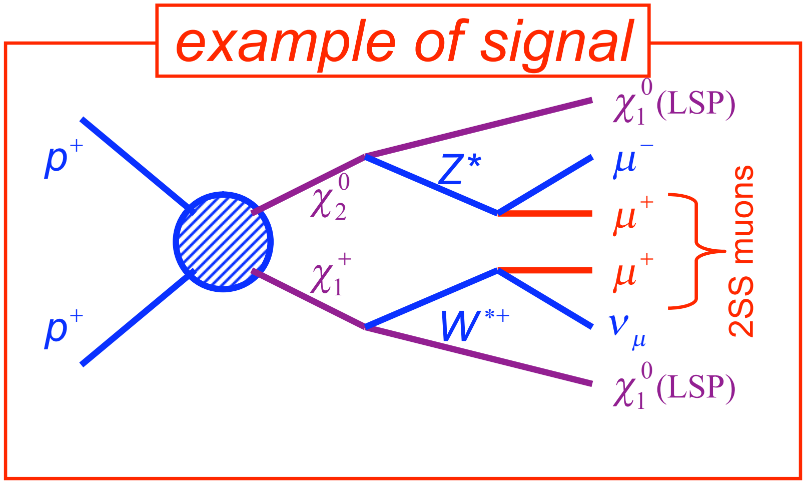
	$t\bar{t}W$	$t\bar{t}Z$	$t\bar{t}WW$	$t\bar{t}ZW$	$t\bar{t}ZZ$
σ, pb	0.556	0.65	neg.	neg.	neg.
N1	5,560	6,500			
N2	<200	<200			

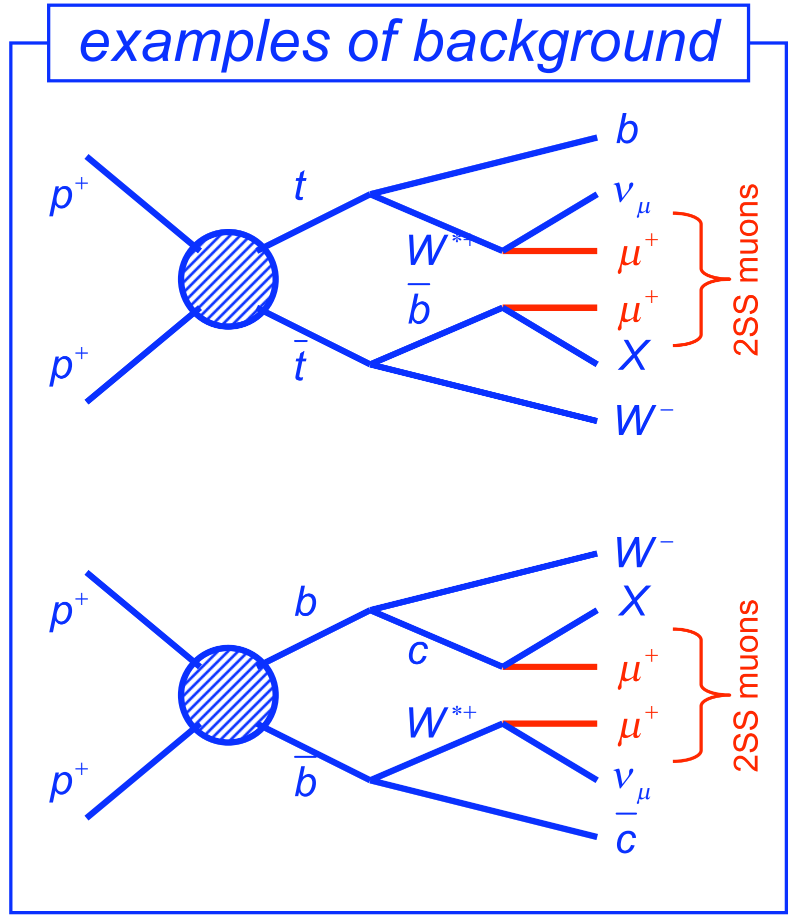
[grey] - negligible contribution

all but $t\bar{t}W$, $t\bar{t}Z$ are negligible

- Notations:
  - N1 – total number of expected events for integral luminosity of $10fb^{-1}$
  - N2 – number of events after pre-selection (two same sign muons, P_T>10 GeV)

Same-sign dimuons signal + backgrounds





- Handles for separation:
  - dimuons with same signs
  - isolation
  - cut on vertices
  - $\not{E}_t$
  - number of jets
- CDF and DØ successfully killed considered backgrounds

generator-level muons, pt >10 GeV, letal < 2.4
from Pythia t-tbar production
numbers = LHC 10 fb-1= 8,860,000 t-tbar pairs

single muon	OS dimuons	SS dimuons	tri-muons	4 muons
2,339,000	228,400	117,300	24,900	500

117300+24900+500 = 142,700, compare to 142,691 in the CMS study

generator-level muons, pt >10 GeV, |eta| < 2.4
from Pythia t-tbar production
numbers = LHC 10 fb-1= 8,860,000 t-tbar pairs

single muon	OS dimuons	SS dimuons	tri-muons	4 muons
2,339,000	228,400	117,300	24,900	500

require muon pt > 15 GeV:

2,028,900	155,300	68,100	11,500	100

apply isolation cut: remove muons within 30 degs of any >15 GeV “jet object”

single muon	OS dimuons	SS dimuons	tri-muons	4 muons
955,100	38,100	900	~100	~0

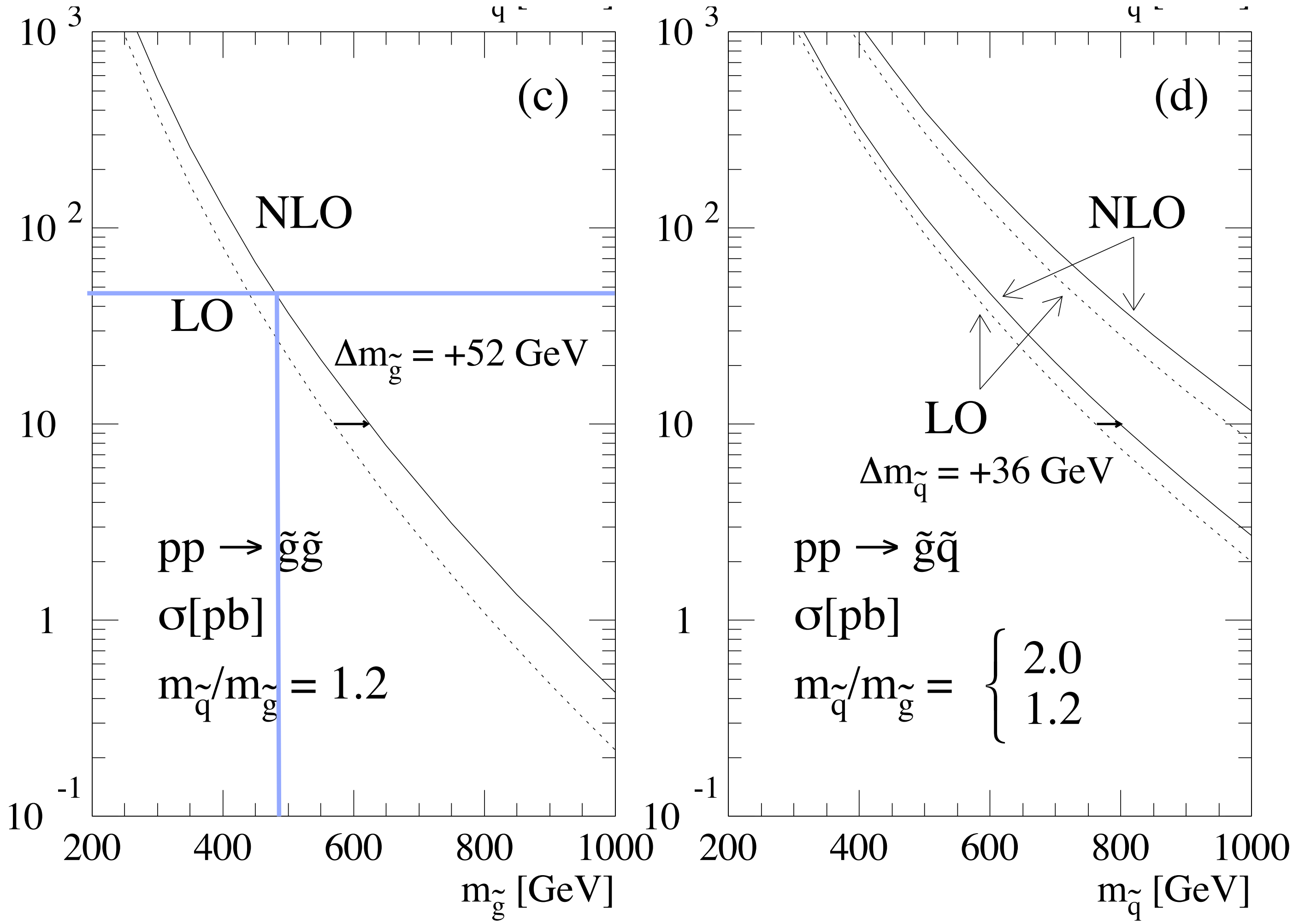


Figure 22: The total cross-section for the LHC ($\sqrt{S} = 14$ TeV). NLO (solid) compared with LO (dotted). Parton densities: GRV94, with scale $Q = m$.

W. Beenakker[1*], R. Höpker[2], M. Spira[3] and P. M. Zerwas[2]

hep-ph/9610490

Fermilab

Fermilab theory resources for LHC physics

The following is an evolving partial list of LHC-related physics topics that Fermilab theorists are (i) working on, (ii) would like to work on, or (iii) have worked on in the past and are still interested to discuss. Initials attached to each topic correspond to theorists named at the end of this page.

I. Beyond the Standard Model (including Higgs):

I.a. SUSY related

- Inclusive BSM searches (especially SUSY), focused on strategies for the first 1 to 10 fb-1. Techniques for model discrimination using only low integrated luminosity samples. (MC,BD,JL)
- SUSY+jets. Understanding extra radiation in SUSY events. To what extent does this extra radiation impact the reconstruction of cascade decays? (PS)
- Stops, search strategies, especially light stops relevant to baryogenesis and dark matter. (MC,JL)
- Diphoton+jets signatures for GMSB (Gauge-mediated SUSY breaking) models. (MC)
- R-parity violating SUSY. (PS)
- SUSY decays with taus. (JL)
- B_s -> mu+mu-. (MC)

I.b. Higgs

- MSSM Higgs benchmarks. (MC)
- CP violating Higgs. (MC)
- Higgs to gamma gamma, e.g. NMSSM H1 -> AA -> photons. (BD)
- VBF (Vector Boson Fusion) Higgs production, especially production of heavy Higgs in CP violating or NMSSM models, with decays H2-> H1+H1 -> bb+tautau. (MC)
- Inclusive heavy Higgs production with decay to ditaus. (MC)
- Charged Higgs production in association with top. (MC)

I.c. Extra Dimensions

- Phenomenology of ADD large extra dimensions models, especially monojets, gamma+MET, Z+MET. (JL)
- Phenomenology of UED (Universal Extra Dimensions) models. (BD,JL)
- Dijet and multijet signatures of extra dimensions. (JL)
- Deconstruction, topology and extra dimensions. (CH)

I.d. Other BSM topics

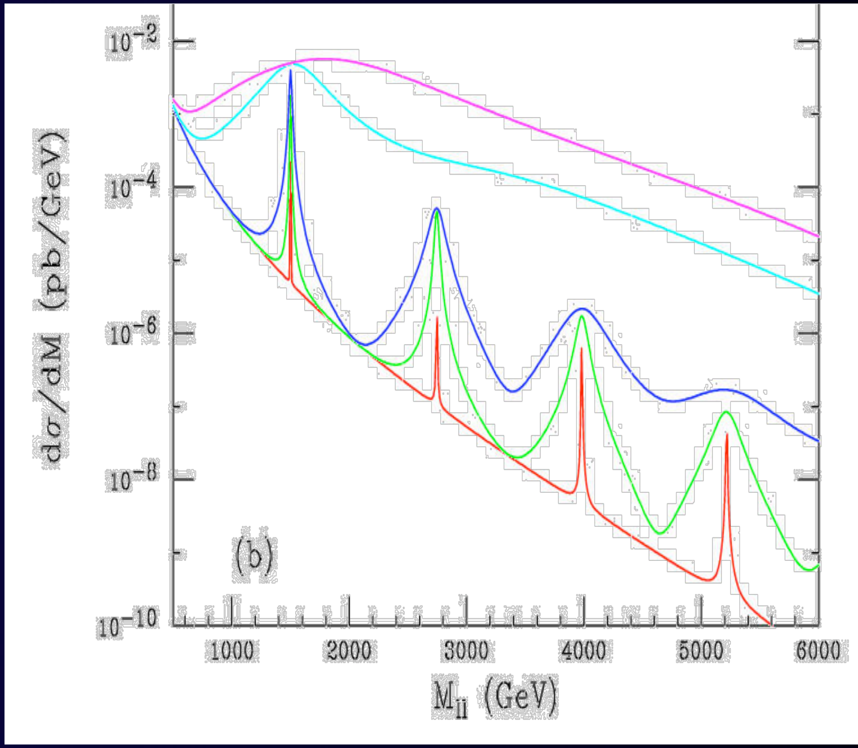
- Phenomenology of Little Higgs models with conserved T parity, especially missing energy signatures. (CH,JH,JL)
- Discriminating between BSM sources of high mass resonances (e.g. Z's, extra dimensions, Little Higgs

is it a Z', or is it M-theory?

- discovery of a heavy dilepton resonance will be interpreted as a Z'.
- discovery of more than one resonance in the same channel will be interpreted as extra dimensions
- are they spin one, or are they spin two gravitons?
- if they are gravitons $\longrightarrow$ warped extra dimensions
- what kind of warped extra dimensions?

- the smoking gun is the mass ratios
- if they are 1, 1.83, 2.66, 3.48, this is locally AdS(5), as you would get from D3 branes of 10d Type IIB strings
- if they are 1, 1.64, 2.26, 2.88, this is what you would get from M5 branes of 11d M-theory

Bao and JL, hep-ph/0509137



Davoudiasl, Hewett, Rizzo

is Princeton ready for the LHC?

is Princeton ready for the LHC?

titles of Princeton High Energy Theory Seminars, 10/31 - 11/11 2005:

- "Black Holes and Topological String"
- "The Open Topological String and 2-Dimensional Yang-Mills Theory"
- "Exploring the M-theory derivative expansion"
- "Strings as vacuum defects of lattice Yang-Mills theories"

LHC Olympics @ CERN

http://wwwth.cern.ch/lhcOlympics/lhcolympicsII.html

LHC- CERN - 9/10 February 2006

Information Letter

We are all eagerly awaiting the moment when the LHC experiment will announce its first data, which no doubt will open up exciting opportunities to explore and expand the frontier of high energy physics as we know it today. The anticipated new discoveries will reveal how the electroweak symmetry is broken, and hopefully provide striking signals of new physics beyond the Standard Model.

Once there is a discovery there will be celebrations and champagne. Then what? How well are we prepared for the unique challenge of disentangling and interpreting the new phenomena uncovered by LHC? For many years, theorists have explored numerous scenarios of physics beyond the Standard Model, driven mostly by intellect and imagination. In bridging the gap with experiment, one needs efficient tools to decode the theoretical models and exhibit their experimentally observable consequences, as well as proficiency to unravel experimental data into concrete clues about the underlying theory.

The ATLAS and CMS collaborations are engaged in the effort to meet the challenge before them. Theorists should be equally prepared. Some groups have been working on the very important studies of the SM signals that will be needed to ascertain a discovery, and have studied some new-physics signals. But many theorists, who are eager to have data pointing to how the SM will be extended, have not yet actively participated in the process of analysing new-physics signals and have not yet familiarized themselves with the necessary tools. We feel that now is the right time for theorists, especially those who have been so far mostly interested in model building or more abstract theoretical questions, to get involved in LHC-related issues.

What is the LHC Olympics?

The idea of the LHC Olympics is to serve as a forum for theorists of all stripes to prepare for the advent of LHC data, and to facilitate communication with experimentalists. This is done via three interrelated activities.

- Via a web page and links , we aim to provide user-friendly instructions on how to use existing collider event simulation tools. LHCO participants are invited to learn to use these tools and generate semi-realistic data sets starting from their own favorite theoretical models. Standard scenarios such as mSUGRA models have been well studied. There is however still a lot of work to do exploring less standard scenarios, and adapting existing Monte Carlo tools for this purpose. We have set up this wiki on which participants can post comments and results, or ask questions.
- To help stimulate and focus the discussion, a data challenge has been set up, in the form of three "black boxes". These are data sets generated with specified programs from theoretical models, unknown to LHCO participants. The black box data, with explanations on how they have been generated, are found here. Participants are challenged to look at and interpret the LHC new physics blackbox signals, or even to disentangle the data themselves.
- To favour communication and exchange of ideas, we are organizing a series of workshop meetings. The second LHCO workshop will take place at CERN on February 9 and 10, 2006. As with the first workshop, the list of participants will include leading experimenters, experts on Monte Carlo tools, and theorists with widely varying levels of expertise in collider physics. The program will consist of instructive talks by experts, discussions between theorists and experimenters, and reports by participants on their progress in deciphering the "black box" data sets.

Some links

- Pythia webpage
- Pythia lectures
- PGS webpage
- "LHCO Primer"
- hep-ph/0508097
- hep-ph/0504221

contact: Herman Verlinde