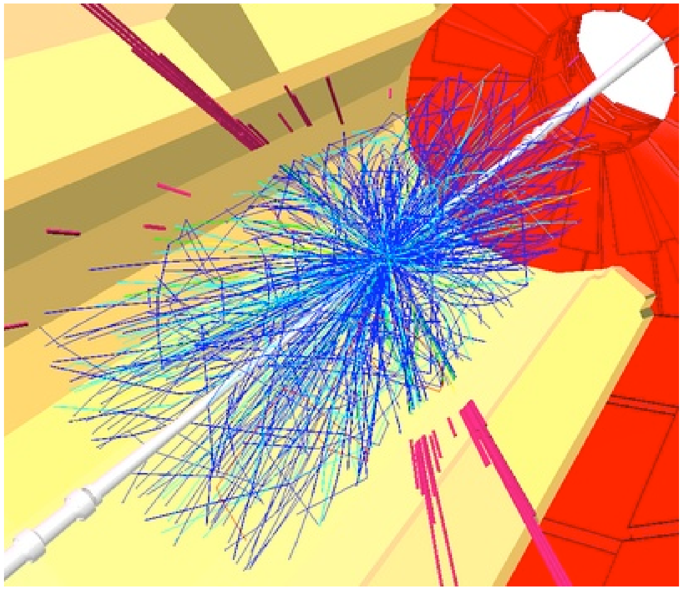
Missing energy with 100 pb-1



Joseph Lykken
Fermilab

with Jay Hubisz (FNAL/Argonne), Maurizio Pierini (CERN), Maria Spiropulu (CERN)

LHC New Physics Signatures Workshop, 5-11 Jan 2008

outline

- the LHC Inverse Problem in the 100 pb-1 era
- missing energy lookalikes
- discriminating SUSY from non-SUSY duals with 100 pb-1

the LHC inverse problem

J.L.Bourjaily, G.L.Kane, P.Kumar and T.T.Wang, arXiv:hep-ph/0504170.

A.Datta, G.L.Kane and M.Toharia, arXiv:hep-ph/0510204.

N.Arkani-Hamed, G.L.Kane, J.Thaler and L.T.Wang, arXiv:hep-ph/0512190.

- it is the end of 2009 and I have analyzed data from the first physics run
- I see a signal in one or more inclusive channels
- what is it? how do I map the signal back to theory space?
- we know this is a hard problem, because theory space is very large, and there are many “lookalikes”

playing twenty questions @LHC

- the theory space of possible BSM models is highly constrained and coarse-grained, so the number of possibilities, though large, is finite number N

- ANY approach to this LHC Inverse Problem boils down to designing a game of "twenty questions" that pinpoints the correct answer in O(log N) steps

- consider a real-life example: last week I played 3 games of twenty questions with my son, for which the answers were:

playing twenty questions @LHC

- 1) an anchovy 2) a pewter tankard 3) deadly nightshade
- in each case, 20 cleverly designed yes/no questions were more than enough to pinpoint the correct answer, starting from scratch
- note in general there are many possible sets of questions that will give the correct answer in O(log N) steps
- note that the design of the LATER questions depends on the answers to the EARLIER questions, since in reality we are moving up a decision tree

missing energy discovery scenario with ~100 pb-1

- we will assume that a >5 sigma excess is observed in an inclusive MET + X analysis @LHC with the first 100 pb-1 or less of understood data (~20% level)
- this should be the case if there is a BSM source of large missing energy + hard jets with a cross section of at least a few pb.
- we want to design one possible strategy to BEGIN playing the game of twenty questions, to find the BSM source of the MET signal
- we want to do this taking into account realistic uncertainties and capabilities of the LHC experiments during the 100 - 1000 pb-1 era

Table 4.2: The $E_{\mathrm{T}}^{\mathrm{miss}}$ + multi-jet SUSY search analysis path

Requirement	Remark
Level 1	Level-1 trigger eff. parameter.
HLT, $E_T^{miss} > 200\,\mathrm{GeV}$	trigger/signal signature
primary vertex ≥ 1	primary cleanup
$F_{em} \geq 0.175$, $F_{ch} \geq 0.1$	primary cleanup
$N_j \geq 3$,$\lvert\eta_d^{1j}\rvert < 1.7$	signal signature
$\delta\phi_{min}(E_T^{miss} - jet) \geq 0.3$ rad, $R1, R2 > 0.5$ rad, $\delta\phi(E_T^{miss} - j(2)) > 20^\circ$	QCD rejection
$Iso^{ltrk} = 0$	ILV (I) $W/Z/t\bar{t}$ rejection
$f_{em(j(1))},\ f_{em(j(2))} < 0.9$	ILV (II), $W/Z/t\bar{t}$ rejection
$E_{T,j(1)} > 180\,\mathrm{GeV}$,$E_{T,j(2)} > 110\,\mathrm{GeV}$	signal/background optimisation
$H_T > 500\,\mathrm{GeV}$	signal/background optimisation
SUSY LM1 signal efficiency 13%	

CMS Physics TDR Vol. II, CERN/LHCC 2006-021

- we will assume that the discovery is made with Maria's analysis
- the signature is large MET plus >= 3 jets; no leptons are required; in fact there is a partial lepton veto to suppress SM EW backgrounds
- this is a counting experiment based on the MET trigger + cleanup + hard cuts on MET and jet ET

Table 3. All-hadronic selected low mass SUSY and Standard Model background events for 1 fb^{-1} from CMS

Signal (LM1)	6319
$t\bar{t}$/single t	56.5
$Z(\rightarrow \nu\bar{\nu})$+ jets	48
$(W/Z, WW/ZZ/ZW)$ + jets	33
QCD	107

M. Spiropulu, arXiv:0801.0318[hep-ex]

- having assumed this analysis we can also use this estimate of the residual SM backgrounds after all cuts
- note that the background rejection in this analysis is highly efficient
- to be conservative we will double these backgrounds and assume a 50% background uncertainty

model template method

- simulate some model templates that represent qualitatively different regions of theory space
- develop experimental observables that robustly discriminate these models from lookalikes, in your actual data samples
- determine which regions of theory space are more likely
- iterate as you get more and better data

CMS has a set of model "benchmarks" based entirely on mSUGRA

Point	$M(\tilde{q})$	$M(\tilde{g})$	$\tilde{g}\tilde{g}$	$\tilde{g}\tilde{q}$	$\tilde{q}\bar{\tilde{q}}$	$\tilde{q}\tilde{q}$	Total
LM1	558.61	611.32	10.55 (6.489)	28.56 (24.18)	8.851 (6.369)	6.901 (6.238)	54.86 (43.28)
LM2	778.86	833.87	1.443 (0.829)	4.950 (3.980)	1.405 (1.013)	1.608 (1.447)	9.41 (7.27)
LM3	625.65	602.15	12.12 (7.098)	23.99 (19.42)	4.811 (3.583)	4.554 (4.098)	45.47 (34.20)
LM4	660.54	695.05	4.756 (2.839)	13.26 (10.91)	3.631 (2.598)	3.459 (3.082)	25.11 (19.43)
LM5	809.66	858.37	1.185 (0.675)	4.089 (3.264)	1.123 (0.809)	1.352 (1.213)	7.75 (5.96)
LM6	859.93	939.79	0.629 (0.352)	2.560 (2.031)	0.768 (0.559)	0.986 (0.896)	4.94 (3.84)
LM7	3004.3	677.65	6.749 (3.796)	0.042 (0.028)	0.000 (0.000)	0.000 (0.000)	6.79 (3.82)
LM8	820.46	745.14	3.241 (1.780)	6.530 (5.021)	1.030 (0.778)	1.385 (1.230)	12.19 (8.81)
LM9	1480.6	506.92	36.97 (21.44)	2.729 (1.762)	0.018 (0.015)	0.074 (0.063)	39.79 (23.28)
LM10	3132.8	1294.8	0.071 (0.037)	0.005 (0.004)	0.000 (0.000)	0.000 (0.000)	0.076 (0.041)
HM1	1721.4	1885.9	0.002 (0.001)	0.018 (0.016)	0.005 (0.005)	0.020 (0.021)	0.045 (0.043)
HM2	1655.8	1785.4	0.003 (0.002)	0.027 (0.024)	0.008 (0.007)	0.027 (0.028)	0.065 (0.061)
HM3	1762.1	1804.4	0.003 (0.002)	0.021 (0.018)	0.005 (0.004)	0.018 (0.019)	0.047 (0.043)

mSUGRA models as missing energy templates

- To be seen at startup, the new heavy particles must be strongly produced. So looking at squark-squark, squark-gluino, and gluino-gluino is a good start (different color charges and parton initial states)

- I care whether these heavy objects have two body decays or more complicated cascades; mSUGRA has both

- I care whether I make no leptons or some leptons, and how the leptons are related; mSUGRA covers most possibilities

what important templates are missing?

mSUGRA limitations come from fixed relations between masses of gluino, charginos and neutralinos; thus we miss things like:

- models with less missing energy, e.g. hidden valley models, SUSY with nonuniversal gaugino relations

- models which are more like the SM background, or where the source of missing energy is entirely from neutrinos (from extra tops, Ws, Zs,...)

- models with larger numbers of leptons, e.g. 6d UED

- non-SUSY cases, e.g. ADD, UED, Little Higgs, warped, un, etc for this iteration we use templates from three classes of models

- the CMS mSUGRA benchmarks generated by Isajet 7.69 + Pythia 6.4
- general low scale MSSM models generated by Suspect 2.3.4 + SusyHit 1.1 + Pythia 6.4
- Little Higgs with T parity implemented in MadGraph 4.2 + Bridge + Pythia 6.4

defining the lookalikes

Now that we have some reasonable templates, let's find some lookalikes of these models. We define a lookalike by first defining

- an inclusive signature or, more simply, a trigger sample
- a set of analysis cuts
- an integrated luminosity
- a > 5 sigma signal and the estimated background + systematics for this analysis. Two models that explain the same signal (within e.g. 2 sigma) are lookalikes
- a detector in which all this is happening

detector simulation

- eventually you need to perform this exercise using a full detector simulation tuned to the initial data

- for the first iteration we used a parametrized simulation tuned to reproduce the cut-by-cut signal efficiencies of the CMS full simulation ORCA (now replaced by CMSSW)

Results for analysis Jet Met with trigger MET

Efficiency of Cut 1 = 0.54	ORCA says 0.54
Efficiency of Cut 2 = 0.72	ORCA says 0.72
Efficiency of Cut 3 = 0.90	ORCA says 0.88
Efficiency of Cut 4 = 0.79	ORCA says 0.77
Efficiency of Cut 5 = 0.98	ORCA says 0.98
Efficiency of Cut 6 = 0.85	ORCA says 0.85
Efficiency of Cut 7 = 0.63	ORCA says 0.63
Efficiency of Cut 8 = 0.94	ORCA says 0.93
Total efficiency = 0.137	ORCA says 0.129

Jets are iterative cone 0.5 genjets with pT,eta dependent "corrections" to simulate the losses that occur in a real detector

ORCA numbers appear in M. Spiropulu, arXiv:0801.0318[hep-ex]

reconstructed objects

Lookalike studies designed for LHC after 10, 100, or 1000 fb-1 have the luxury of assuming that everything in an event is reconstructable. This will not be true in the 100 pb-1 era.

We make the very conservative assumption that the only well understood reconstructed objects at the time of the 5 sigma MET discovery are:

- MET (probably just in the range 200 GeV <~ MET <~ 600 GeV)
- jets with uncorrected ET>30 GeV (~= Et>50 GeV genjets)
- muons (not necessarily isolated but with pT > 20 GeV)

This is too conservative, since we will need electrons too. We are also considering “poor man’s” simple algorithms for a first pass at tau and b tagging

triggers and boxes

- the MET trigger + MET analysis cuts define a data set, which we call a “box”

- since other triggers will also be available in the 100 pb-1 era, we can define new boxes by Trigger X + MET analysis cuts

- since the MET analysis cut (MET > 200 GeV) is so hard, these new boxes are subsets of our original box (+- 1 event)

- thus we can compute all of our observables in any of several boxes

triggers as boxes

we defined three additional boxes:

- Dijet box: events that also would have passed a dijet trigger
- Trijet box: events that also would have passed a trijet trigger
- Muon20 box: events that also would have passed a muon trigger

for the Dijet and Trijet boxes, a naive rescaling of the SM backgrounds after cuts is very conservative

for the Muon20 box, the SM background is enhanced with respect to the original data set, but only by a factor ~<=2.

what are the discriminating observables?

For this study, two models are defined as lookalikes if they give the same count within 2 sigma total estimated errors after performing the MET analysis in our simulation

- **we want to identify experimental observables that the best and most robust discriminators between sets of lookalikes**

- **the answer depends upon the analysis we chose, the experimental and theoretical uncertainties, and which lookalike models we generated**

- **in our case the observables must only refer to MET, hard jets, muons, and possibly a few derived features (e.g. counting charged tracks with pT > some threshold)**

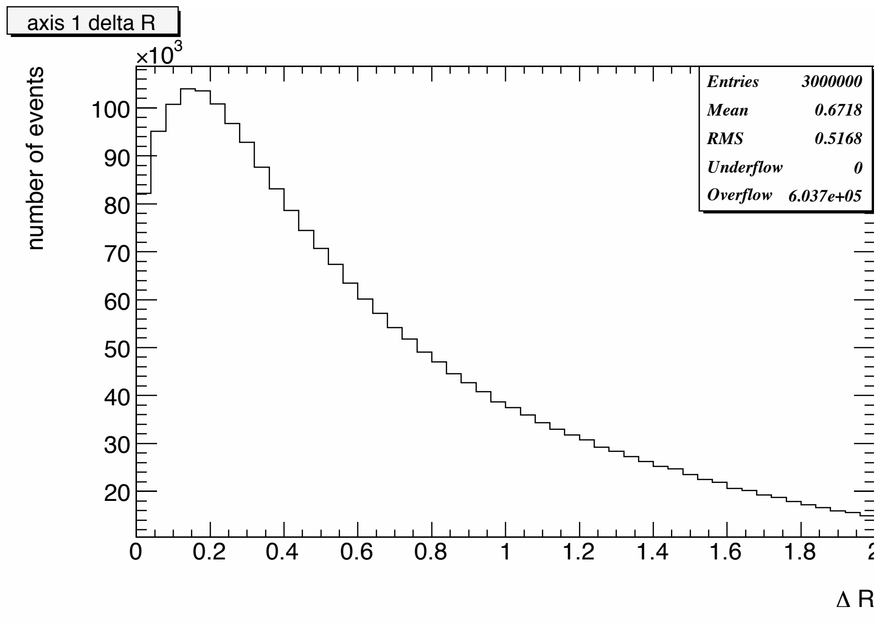
observables

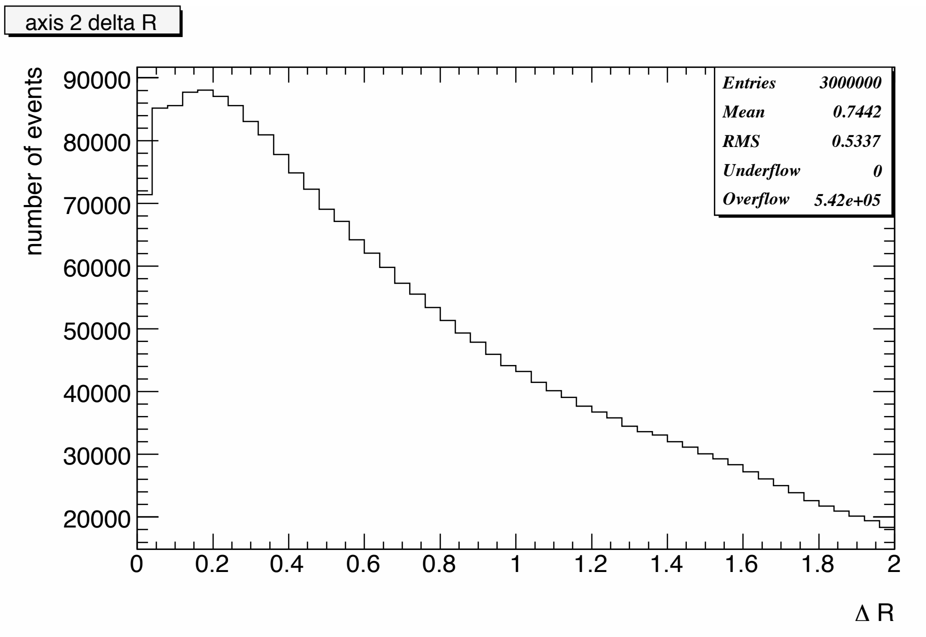
- N is the original signal count
- N_3j is the number of these events with >=3 jets
- N_hem_3 is the number of these events whose hemisphere counts differ by >= 3
- N_1p_m is the number of these events with a positively charged muon
- N_1tkjet and N_1softmu are coarse attempts at tau and b tagging
- obviously from these counts we form ratios, to reduce the errors

MODEL compsusy4d 14.5 pb

OBSERVABLE	COUNT
N	1975
N_3j	1975
N_4j	1412
N_5j	822
N_MET320	1398
N_hem_1	1519
N_hem_2	559
N_hem_3	152
Ht_500_800	1154
Ht_800_1100	632
Meff_800_1400	1444
Meff_1400_2000	364
N_1m_3j	371
N_2m_3j	47
N_1m_4j	279
N_2m_4j	35
N_SS_m	16
N_1p_m	40
N_1n_m	40
N_1tkjet	265
N_2tkjet	17
N_1softmu	109
N_2softmu	5

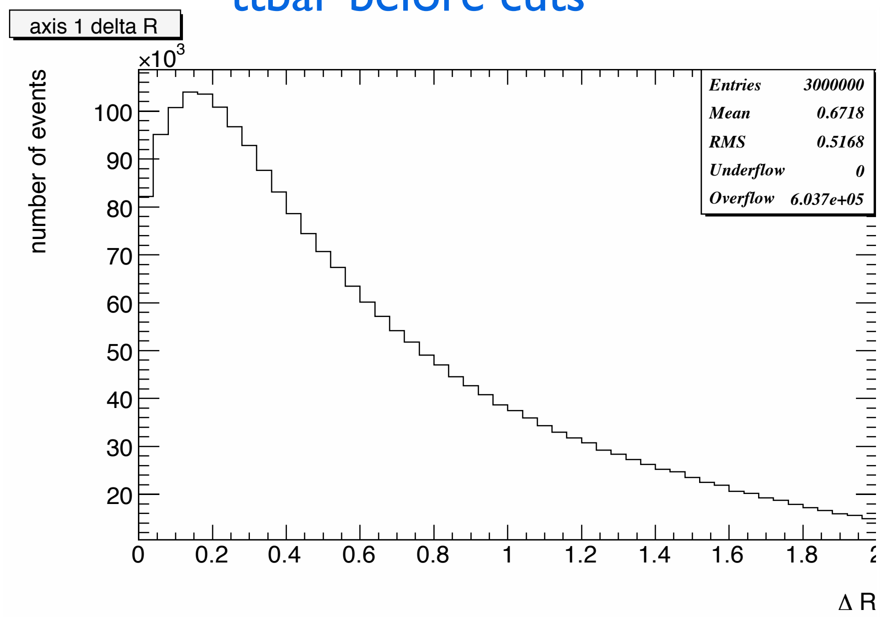
hemisphere separation

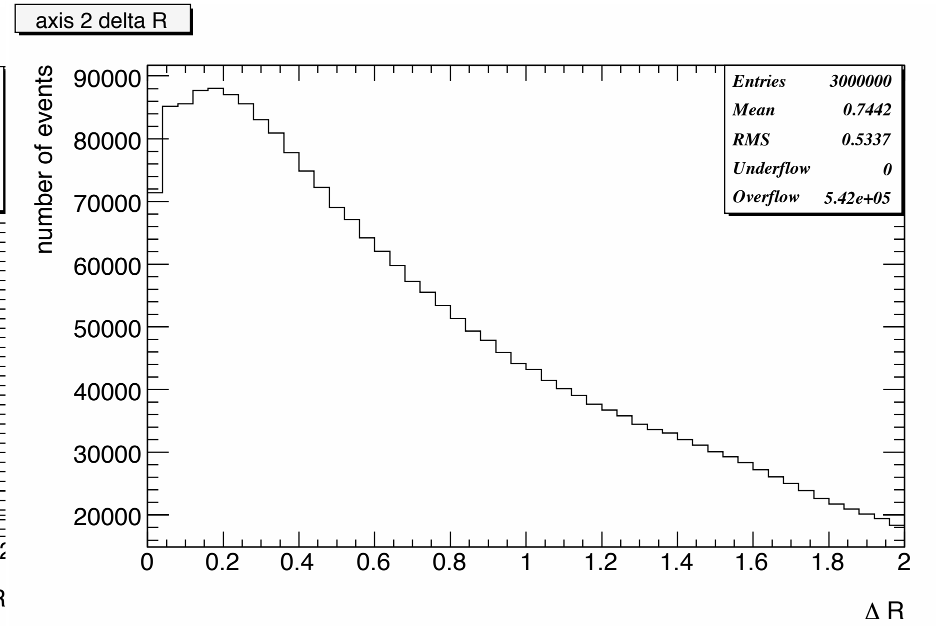




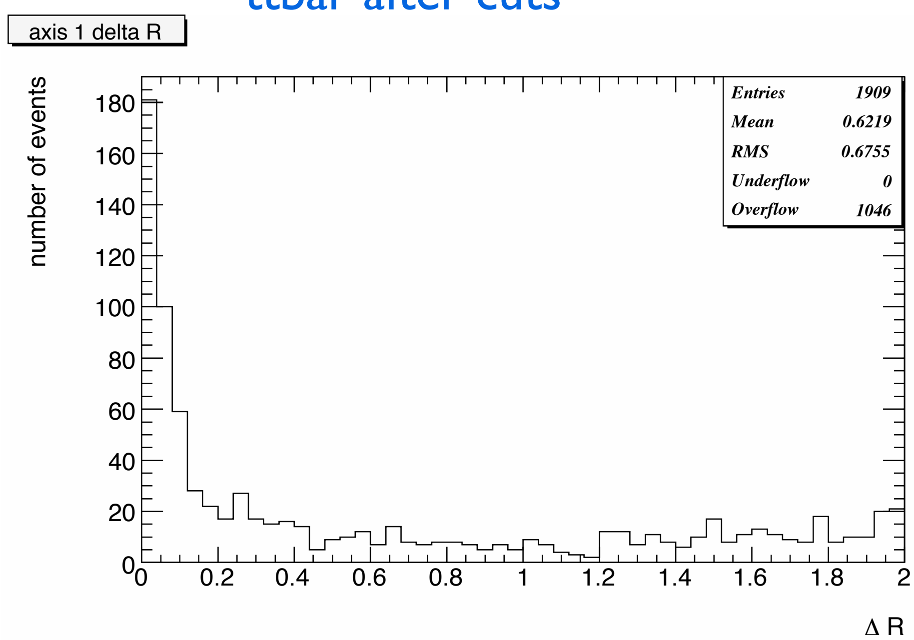
- We use the algorithm of Filip Moortgat and Luc Pape that attempts to separate the reconstructed objects into two hemispheres, corresponding to the two final state partons
- For unfiltered ttbar events this works pretty well

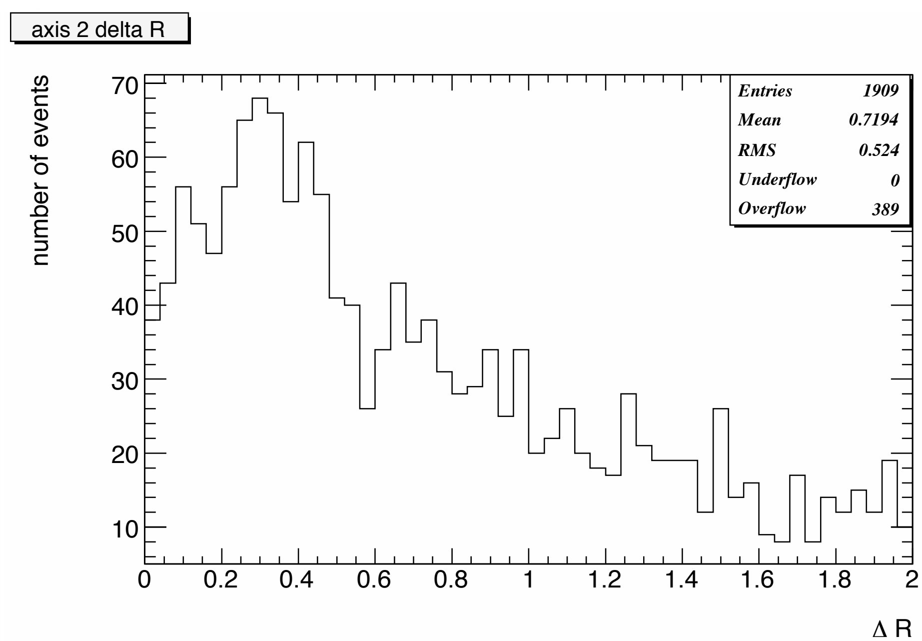
ttbar before cuts



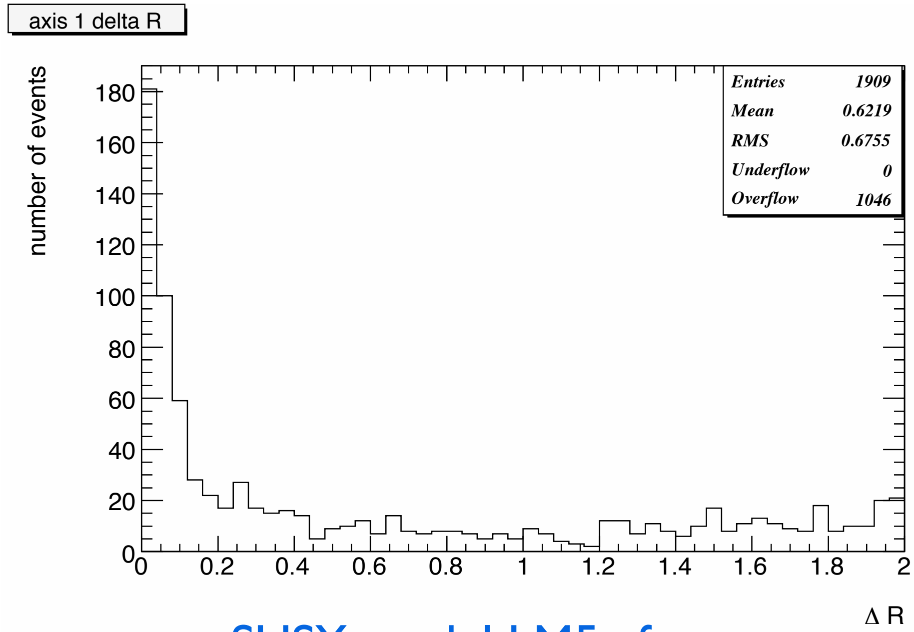


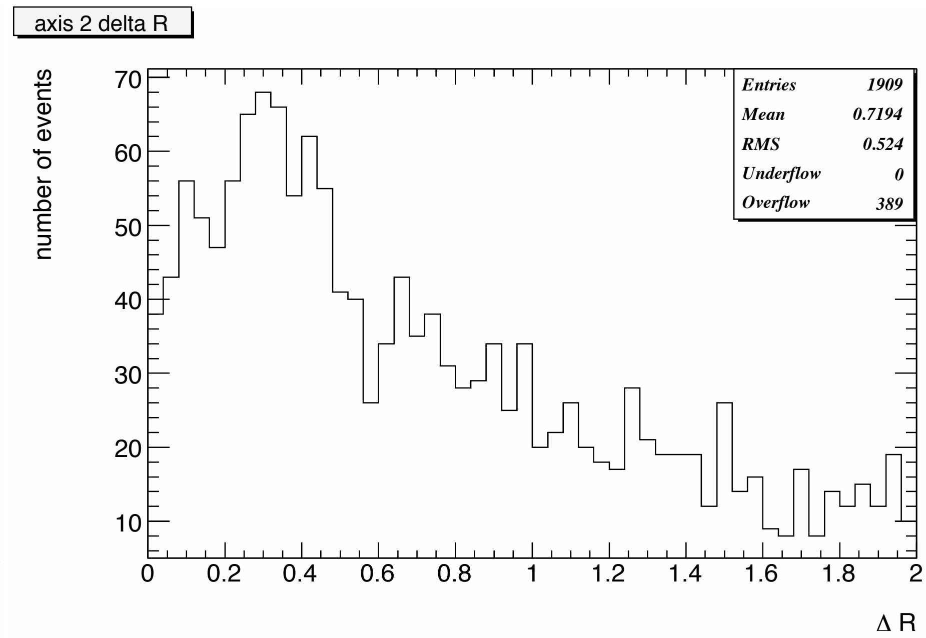
ttbar after cuts



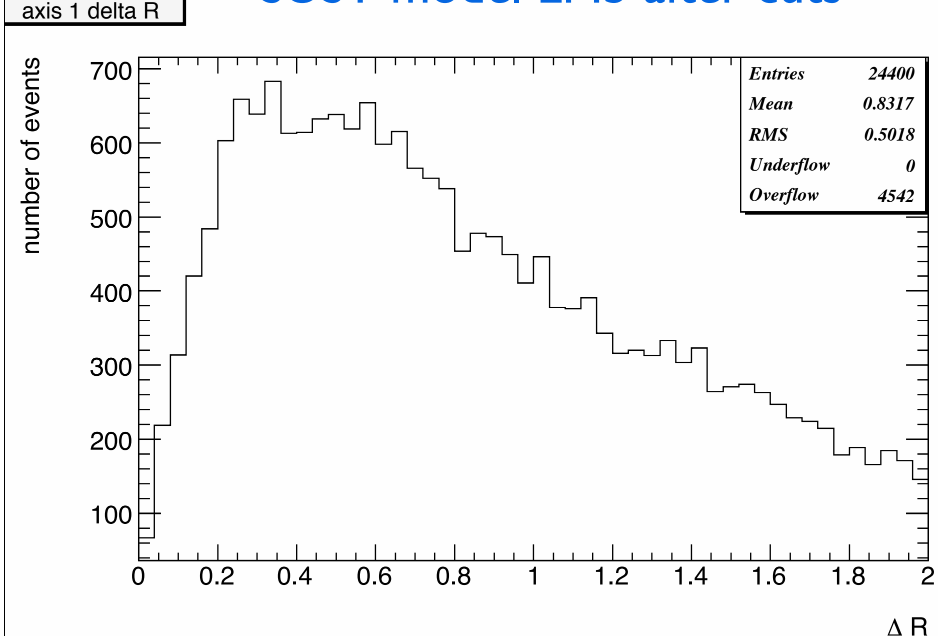


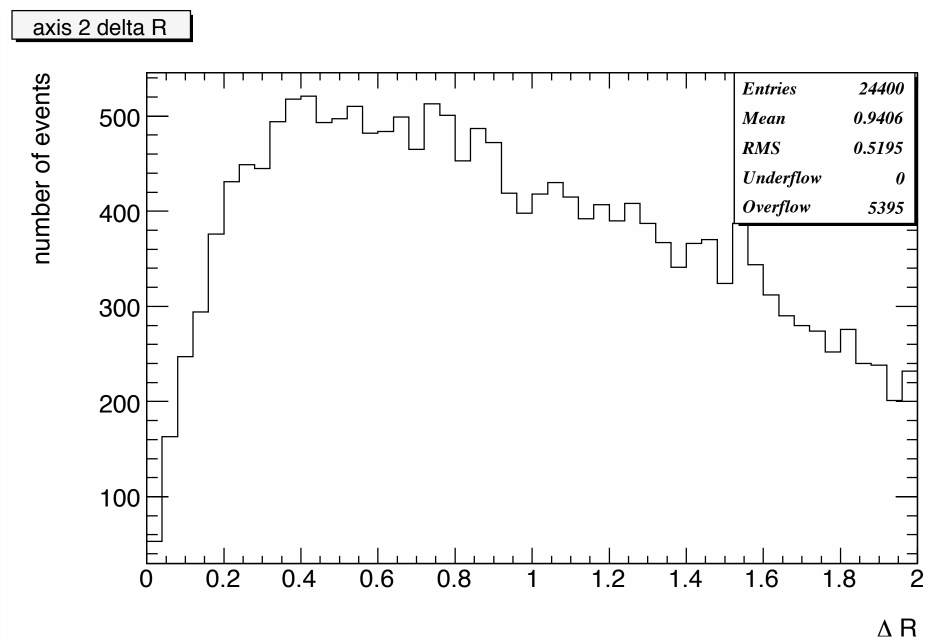
ttbar after cuts





SUSY model LM5 after cuts





theory model systematic uncertainties

- For each startup observable, there is a systematic uncertainty from our imperfect knowledge of the correct pdfs.

- To estimate this, we compute each observable using the average of 3 different pdfs: CTEQ56l1,   CTEQ6m and MRST2004nlo.

- As our estimate of the one-sigma systematic uncertainty, we use one-half of the maximum difference of these three numbers.

comparison of SUSY generators

	Isajet 7.69	Suspect 2.3 + SusyHit 1.1	SoftSusy 2.0.14
LM1:	57.6 pb	59.7 pb	60.7 pb
LM2:	9.9 pb	10.3 pb	10.8 pb
LM3:	46.2 pb	48.1 pb	47.7 pb
LM4:	26.2 pb	26.9 pb	27.2 pb
LM5:	8.1 pb	8.4 pb	8.4 pb
LM6:	5.4 pb	5.6 pb	5.5 pb
LM7:	18.7 pb	7.4 pb	10.4 pb
LM8:	12.7 pb	12.7 pb	13.0 pb
LM9:	55.0 pb	37.7 pb	47.8 pb

cross sections are NLO squark/gluino production taken from Prospino2 and
LO chargino/neutralino/slepton/associated production taken from Pythia 6.4

comparison of SUSY generators

	Isajet 7.69	Suspect 2.3 + SusyHit 1.1	SoftSusy 2.0.14
LM1:	7930	9025	8332
LM2:	2326	2595	2644
LM3:	5364	5759	5658
LM4:	4335	4934	4540
LM5:	1976	2187	2094
LM6:	1397	1475	1424
LM7:	393	397	584
LM8:	1936	1860	1971
LM9:	1634	1417	1629

number of events passing the MET analysis, for integrated luminosity 1 fb-1

theory model systematic uncertainties

- It does not seem reasonable to treat these discrepancies as part of our systematic errors
- Instead we will regard the name of the generator as one of the model input parameters
- This is what is also done with M_top, which otherwise can introduce a large uncertainty on the SUSY spectrum via the RGEs

3 of these benchmarks are lookalikes!

	Isajet 7.69	Suspect 2.3 + SusyHit 1.1	SoftSusy 2.0.14
LM1:	7930	9025	8332
➡ LM2:	2326	2595	2644
LM3:	5364	5759	5658
LM4:	4335	4934	4540
➡ LM5:	1976	2187	2094
LM6:	1397	1475	1424
LM7:	393	397	584
➡ LM8:	1936	1860	1971
LM9:	1634	1417	1629

number of events passing the MET analysis, for integrated luminosity 1 fb-1

theory-to-theory systematic uncertainties

- The additional theory systematics come from our imperfect implementation of radiative corrections to the signals.
- There is an overall systematic on the cross section which we take to be 5% (though it is actually larger for the LHwTP models). This is analogous to a luminosity uncertainty for data.
- There is an additional uncertainty for each observable from the missing higher order matrix elements. It is NOT included in the analysis shown here.
- It could be included crudely by running Pythia with different values of the ISR scale controlled by MSTP(68), similar to how we do the pdf uncertainties.
- A better way is to include the higher order matrix elements for the emission of extra hard jets

theory-to-”data” comparisons

- Since we don’t have data we use a theory model as mock data.
- Take Theory B to be your data; Theory A is to be tested.
- Generate high statistics MC samples for both A and B and run these events through our triggers and event selection.
- For the events that pass, compute all of the startup observables (counts and ratios).
- For each observable, compute both the theory uncertainties and the estimated experimental uncertainties.
- Determine which observables are the best discriminators

theory-to-”data” systematic uncertainties

- In addition to the statisical uncertainties and the theory systematics, the theory-to-data comparision has additional experimental uncertainties. The two largest are:

- Luminosity uncertainty: we take this to be 10%.

- Detector simulation uncertainty:

detector simulation uncertainty

- The signal and SM background events are produced by an imperfect simulation of the real detector.

- Right now this uncertainty is large. By the time of discovery, it will be much smaller. Although it will still be pretty large for the residual background (where you are cutting on tails of distributions), the net effect on a discovery signal is small since the residual background is small.

- Though in reality there will be variations depending on what observable you are considering, we will assume a flat 10% uncertainty.

- Combining in quadrature with the theory systematic, we use an overall estimate of 15% for the systematic uncertainty.

systematic uncertainties in ratios

- Most but not all of the systematic errors will cancel in the inclusive ratios. Examples:

- All of the luminosity and NLO cross section uncertainty cancels in the inclusive ratios.

- Part of the pdf uncertainty cancels (the part that makes events harder or softer ***independent*** of the dominant partonic subprocesses). In principle we are getting this right.

- Part of the detector simulation uncertainty cancels (the part that makes jets and muons harder or softer in a process ***independent*** way). We crudely assume that this part is close to 100% of the total detector simulation uncertainty for our models.

discriminating LHwTP from SUSY with 100 pb-1

- We have looked at a lot of lookalikes, but I will only present the example that most resembles Barack Obama
- Numbers are all preliminary, because our statistics expert Maurizio Pierini had a non-machine-readable passport
- In this example we see a 5 sigma signal from LHwTP with 100 pb-1, mistakenly call it SUSY, then immediately recover
- The scenario also works vice-versa, although the numbers change

Little Higgs with T parity model LH2

J.~Hubisz and P.~Meade, [arXiv:hep-ph/0411264].
J.~Hubisz, P.~Meade, A.~Noble and M.~Perelstein, [arXiv:hep-ph/0506042].
J.~Hubisz, S.~J.~Lee and G.~Paz, [arXiv:hep-ph/0512169].

---- 2000 GeV TP3,TM3 T even/odd top partners

---- 540 GeV U1,D1,U2,D2,U3,D3 T odd quark partners

---- 449 GeV WH, ZH T odd W, Z partners

---- 195 GeV L1,L2,L3,N1,N2,N3 T odd lepton partners

---- 103 GeV AH the stable LTP

Little Higgs with T parity model LH2

production and decays at LHC:

$$\mathbf{q\bar{q},\ gg \Longrightarrow U_i\bar{U}_i,\ D_i\bar{D}_i}$$

$$\begin{aligned} \mathbf{U} &\Longrightarrow \mathbf{q + W_H} \quad \mathbf{30\%} \\ & \quad\ \ \mathbf{q + Z_H} \quad \mathbf{15\%} \\ & \quad\ \ \mathbf{q + A_H} \quad \mathbf{55\%} \end{aligned}$$

$$\begin{aligned} \mathbf{D} &\Longrightarrow \mathbf{q + W_H} \quad \mathbf{50\%} \\ & \quad\ \ \mathbf{q + Z_H} \quad \mathbf{25\%} \\ & \quad\ \ \mathbf{q + A_H} \quad \mathbf{25\%} \end{aligned}$$

LO cross section 13.5 pb with CTEQ6l1

SUSY model NM1

(Suspect+SusyHit)

production and decays at LHC:

$$\mathbf{q\bar{q},\ gg \Longrightarrow U_i\bar{U}_i,\ D_i\bar{D}_i}$$

$$\mathbf{U \Longrightarrow q + W_H \quad 30\%}$$

$$\mathbf{q + Z_H \quad 15\%}$$

$$\mathbf{q + A_H \quad 55\%}$$

$$\mathbf{D \Longrightarrow q + W_H \quad 50\%}$$

$$\mathbf{q + Z_H \quad 25\%}$$

$$\mathbf{q + A_H \quad 25\%}$$

LO cross section 13.5 pb
with CTEQ6l1

$$\mathbf{q\bar{q},\ gg,\ qq \Longrightarrow \tilde{q}_i\tilde{q}_i}$$

$$\mathbf{\tilde{q}_L \Longrightarrow q + \tilde{\chi}_1^{\pm} \quad 60\%}$$

$$\mathbf{\Longrightarrow q + \tilde{\chi}_2^0 \quad 30\%}$$

$$\mathbf{\Longrightarrow q + \tilde{\chi}_1^0 \quad 10\%}$$

$$\mathbf{\tilde{q}_R \Longrightarrow q + \tilde{\chi}_1^0 \quad 100\%}$$

LO cross section 6.6 pb
with CTEQ6l1

LH2 versus NM1

The part of the spectra of these models most relevant to LHC in the 100pb-1 era is identical, with partners differing by spin

So what are the sources of possible differences in the phenomenology of these models?

- The cross sections differ by a factor of 2. This is a generic handle (in principle) for discriminating spin at LHC

A.Datta, G.L.Kane and M.Toharia, arXiv:hep-ph/0510204.

- The relative fraction of direct 2-body decays to the LSP/LTP is different, which could affect the signal efficiency

- Because the 2 TeV gluino is not completely decoupled, in the SUSY case we get 7.5% of events that pass coming from squark-gluino instead of squark-squark, and 26% of squark-squark events before cuts are from qq initial states.

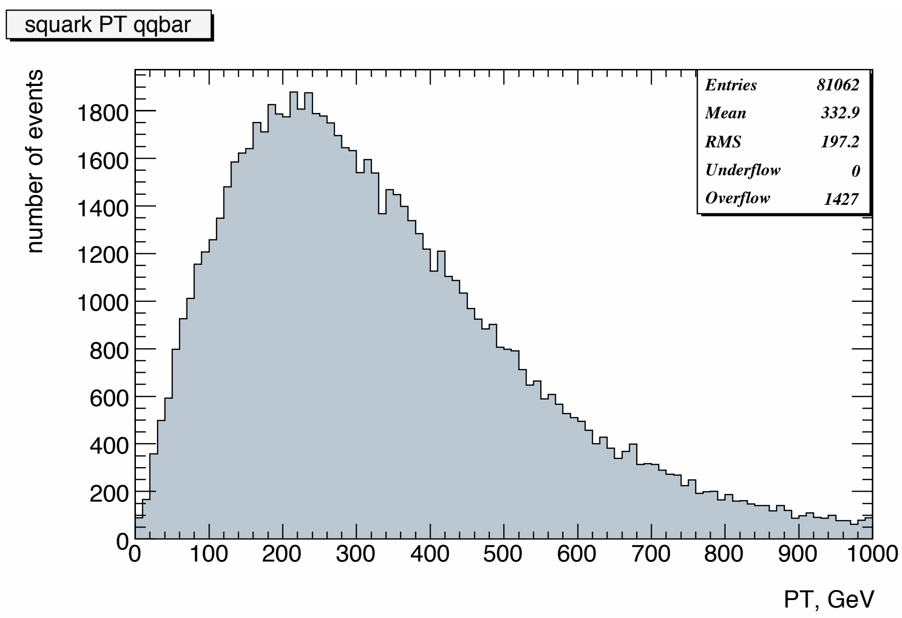
- The differential cross sections have a different detailed dependence on pT and $\eta_1 - \eta_2$

LH2 versus NM1

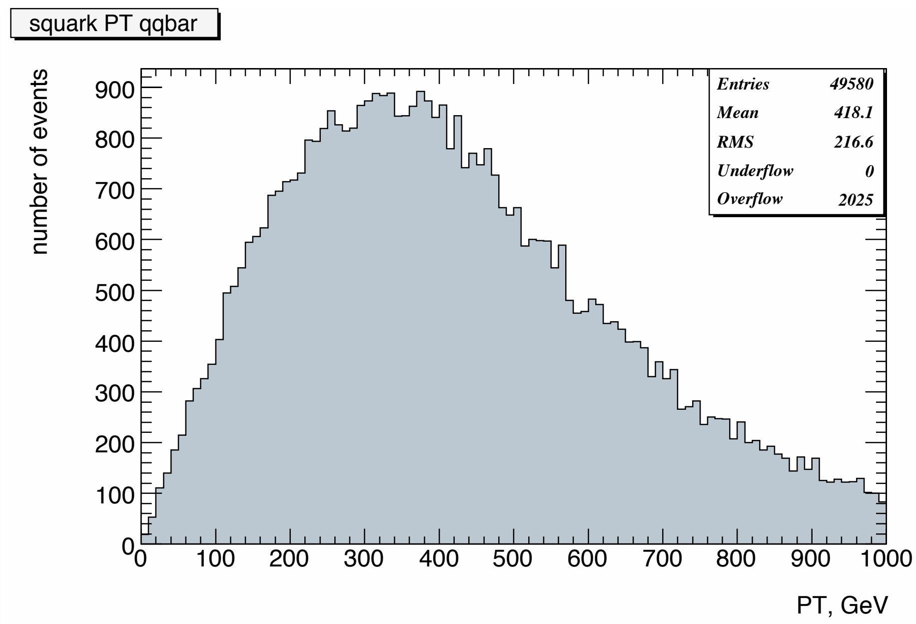
LO Cross sections:	LH2	13.5 pb	NM1	6.6 pb
Efficiencies in MET analysis:	LH2	7.4%	NM1	13.7%
Signal events for 100 pb-1:	LH2	99	NM1	90

- So these two models, that to first approximation differ only by spin, are in fact lookalikes, despite the factor of two difference in cross section
- part of this is the 2 TeV gluino fooling us (a realistic effect)
- part of this is other detailed spin-related differences that affect the signal efficiency to pass our hard cuts (a very good thing!)

pT distribution of squarks/Qs for $q\bar{q}$ initiated events before cuts



LH2 LHwTP model



NM1 SUSY model

LH2 versus NM1

LO Cross sections:	LH2	13.5 pb	NM1	6.6 pb
Efficiencies in MET analysis:	LH2	7.4%	NM1	13.7%
Signal events for 100 pb-1:	LH2	99	NM1	90

- So these LHwT/SUSY duals are indeed lookalikes in our 100 pb-1 discovery analysis
- Now we look at our ~30 conservative observables to find the best discriminators, treating LH2 as “the data”
- We reject cases where the counts are too small (< 10). But we redo the analysis again at 1 fb-1, where many more observables will come into play

LH2 versus NM1 versus compsusy7d

To make the comparison more fun, let's add another qualitatively different SUSY model, that is also a lookalike:

SUSY model compsusy7d

LO cross section 5.1 pb

signal events after all cuts with 100 pb-1: 96

92% of events that pass are gluino-gluino

LH2 versus NM1: best robust conservative discriminators for 100 pb-1

- best count: HT_500_800 in MET box: 2.4 sigma
- ratios:
  - N3j / N5j in MET box: 3 sigma
  - MET/TriJet: 6 sigma
  - inv_mass_700_1000 / inv_mass_400_700 in Muon20 box: 3 sigma

LH2 versus NM1: best robust conservative discriminators for 1fb-1

- counts:
    - N4j in TriJet box: 4.2 sigma
    - HT_500_800 in MET box: 3.1 sigma
- ratios:
    - N3j / N5j in MET box: >10 sigma
    - MET/TriJet: 7.5 sigma
    - inv_mass_700_1000 / inv_mass_400_700 in Muon20 box: 8.7 sigma

LH2 versus compsusy7d: best robust conservative discriminators for 100 pb-1

- best count: N5j in MET box: 3 sigma
- ratios:
    - N3j / N5j in MET box: 7 sigma
    - MET/TriJet: 8 sigma

LH2 versus compsusy7d: best robust conservative discriminators for 1 fb-1

- counts:
  - N5j in MET box: 4.1 sigma
  - N_1p_muon in Muon20: 6.7 sigma
- ratios:
  - N3j / N5j in MET box: >10 sigma
  - MET/TriJet: >10 sigma

statements about spin discrimination at LHC

- It will be impossible to discriminate BSM spin at LHC (not true!)
- Direct spin determination should be possible with large integrated luminosities and mature experiments (true!)
- Indirect spin discrimination should be possible even earlier, perhaps even during the 100 pb-1 era (obama!)
- However the devil is in the details, which are complicated (as usual)

some general results
from the full set of lookalike comparisons

- obviously the best discriminators vary a lot depending on the models

- for 100 pb-1, there is not always enough statistics to get a 3 sigma discrimination, even though we had more than enough statistics to get a 5 sigma discovery

- for 1 fb-1 many more discriminating observables open up. we are looking for suggestions (from you) of new discriminators that fit with our conservative assumptions about errors and physics objects at startup

the beginning of the beginning

- this is just a warmup of what really needs to be done in 2008 for this kind of study

- there are also lots of nasty details about systematics and simulation that I am leaving out

- but it will be a lot of fun