SUSY Without Prejudice: Part I

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Part I : Motivation, Philosophy & Experimental Constraints

Non-SUSY exotics spotted so far….

The simplest SUSY model, the MSSM with R-parity conservation, has many nice features that we all know about : helps with the fine-tuning & hierarchy problems, dark matter candidates, possible coupling unification, etc.

However, the MSSM is very difficult to study in any detailed, model-independent manner due to the very large number of soft SUSY breaking parameters (~ 120) that one would have to deal with in a complete analysis…

To circumvent this issue, authors generally limit their analyses to a specific SUSY breaking scenario(s) such as mSUGRA, GMSB, AMSB,… with new ones coming along all the time. This choice then determines the sparticle masses, couplings & signatures in terms of only a few parameters.

But how well do any or all of these reflect the true breadth of the MSSM?? Do we really know the MSSM as well as we think??

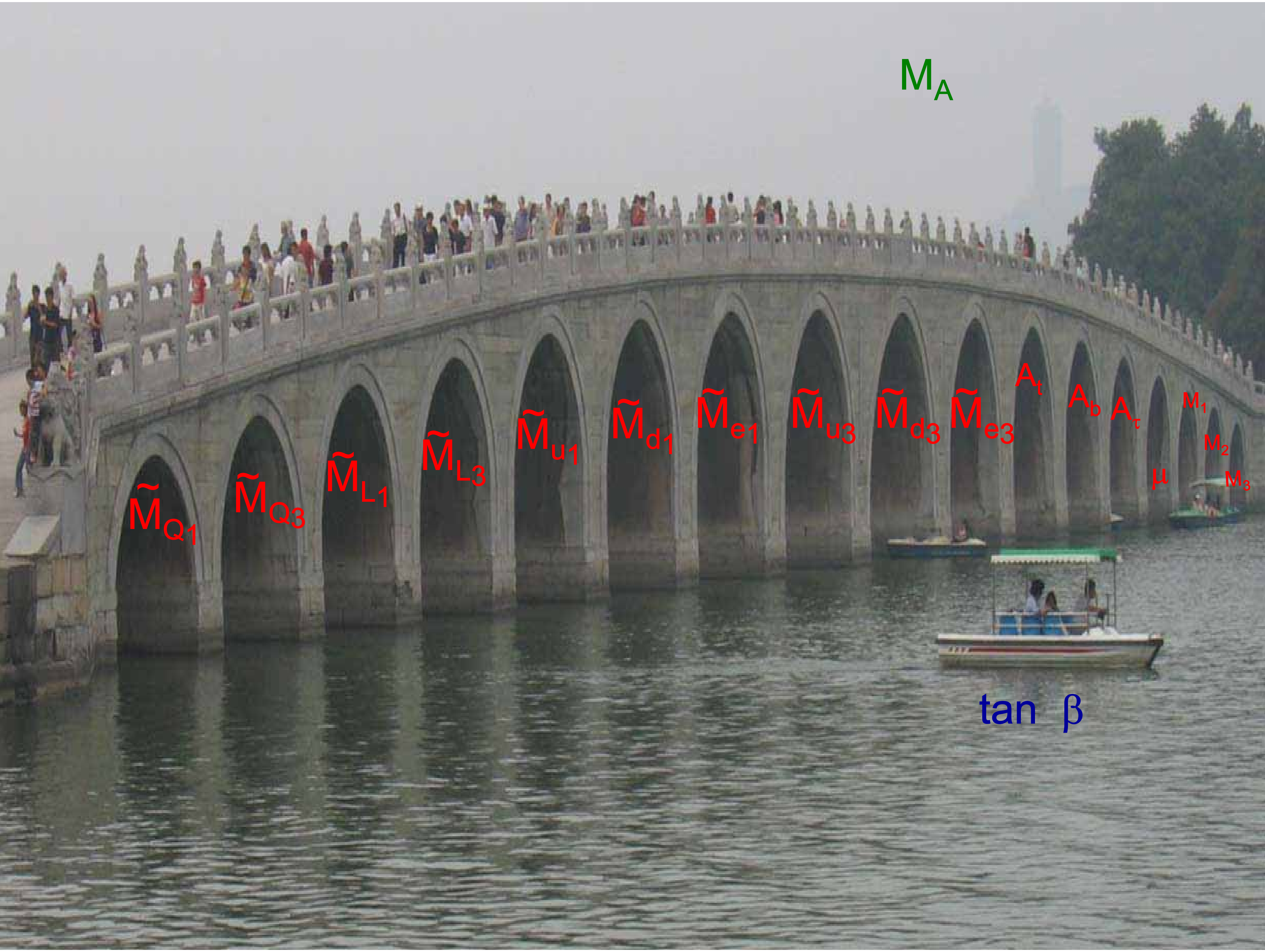
Is there another way to approach this problem & yet remain *more general* than what happens when we choose any specific SUSY breaking scenario? It's clear that *some* set of assumptions are obviously necessary to make any such study practical. But what?

Here we will study the most general, CP-conserving MSSM assuming MFV and that the lightest neutralino is the LSP. We will further assume that the first two sfermion generations are degenerate (which helps with strong meson/anti-meson mixing constraints) and that they have negligible Yukawa's.

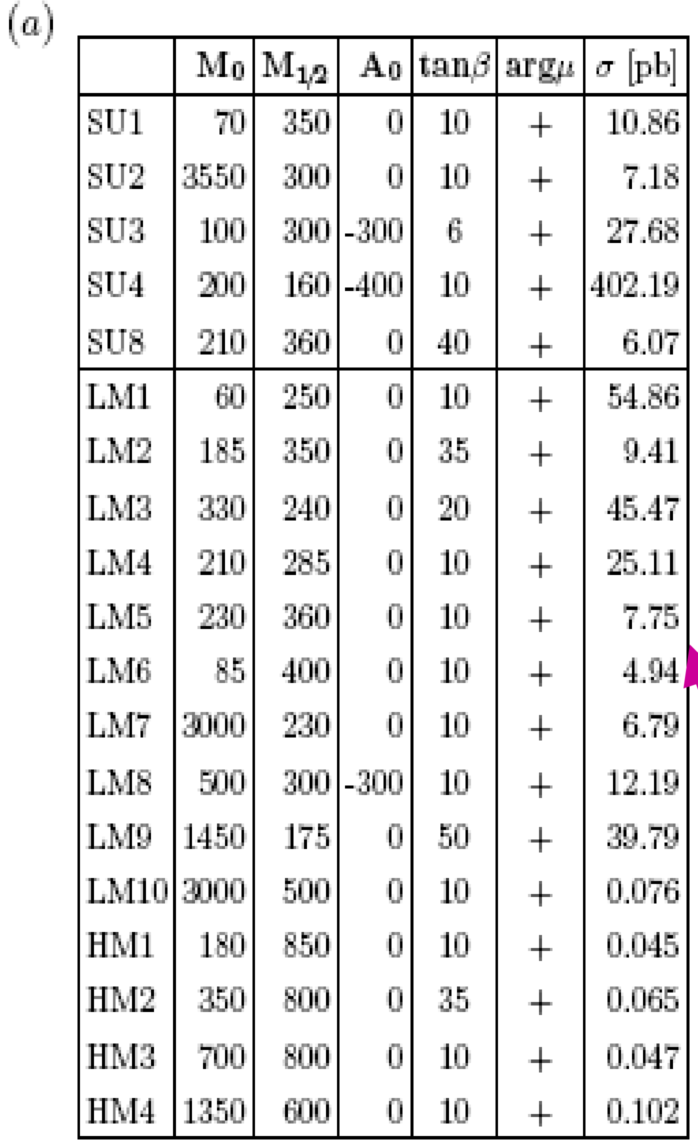
This leaves us with the pMSSM:

→ the MSSM with 19 real, weak-scale parameters…

What are they??

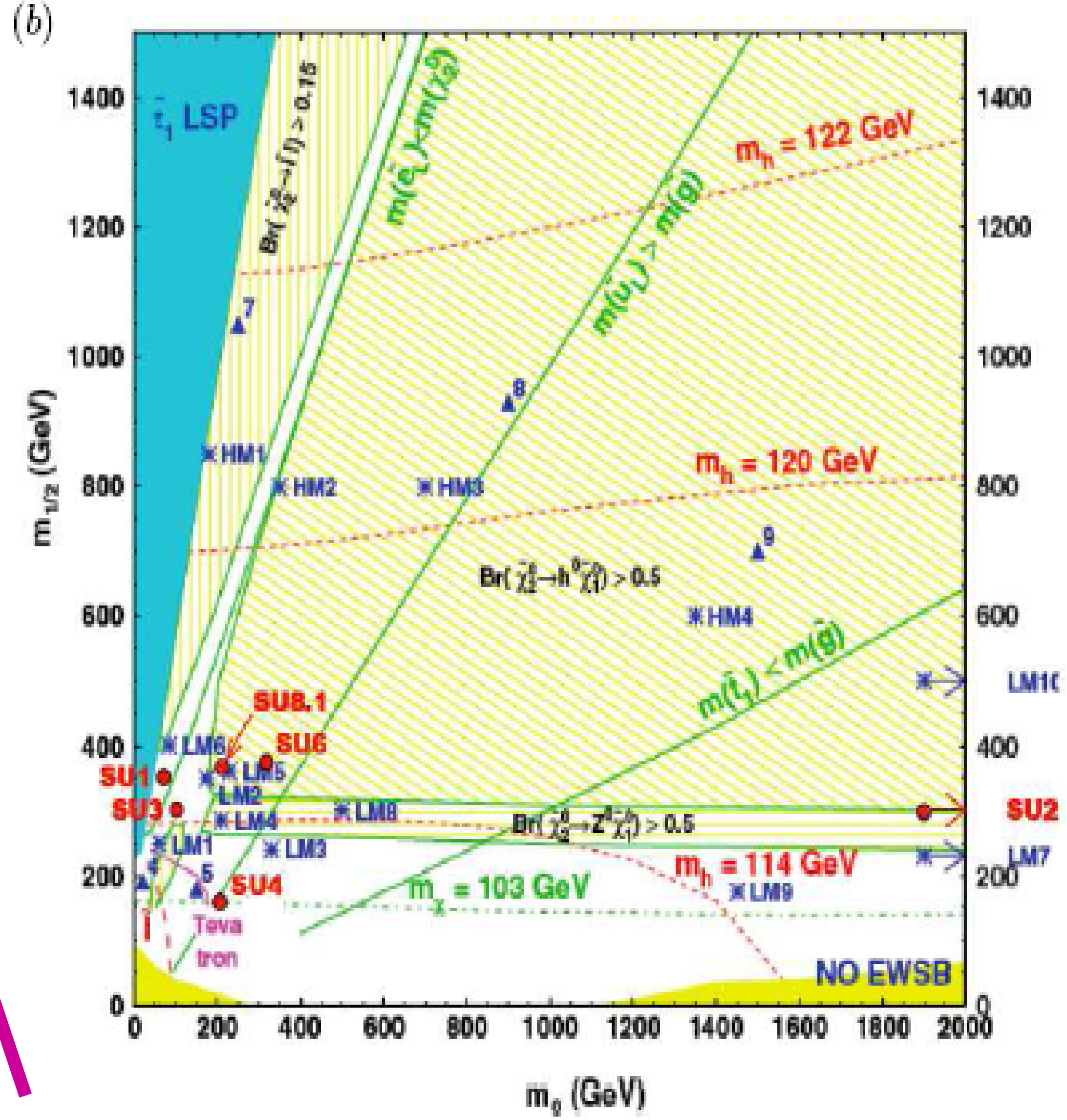

M_A
$\tilde{M}_{Q1}$
$\tilde{M}_{Q3}$
$\tilde{M}_{L1}$
$\tilde{M}_{L3}$
$\tilde{M}_{u1}$
$\tilde{M}_{d1}$
$\tilde{M}_{e1}$
$\tilde{M}_{u3}$
$\tilde{M}_{d3}$
$\tilde{M}_{e3}$
A_t
A_b
A_τ
μ
M_1
M_2
M_3
$\tan\beta$

Why perform such a general analysis? There are many VERY good reasons but perhaps the best is that the LHC is coming on in earnest soon & detailed SUSY searches are critical there.



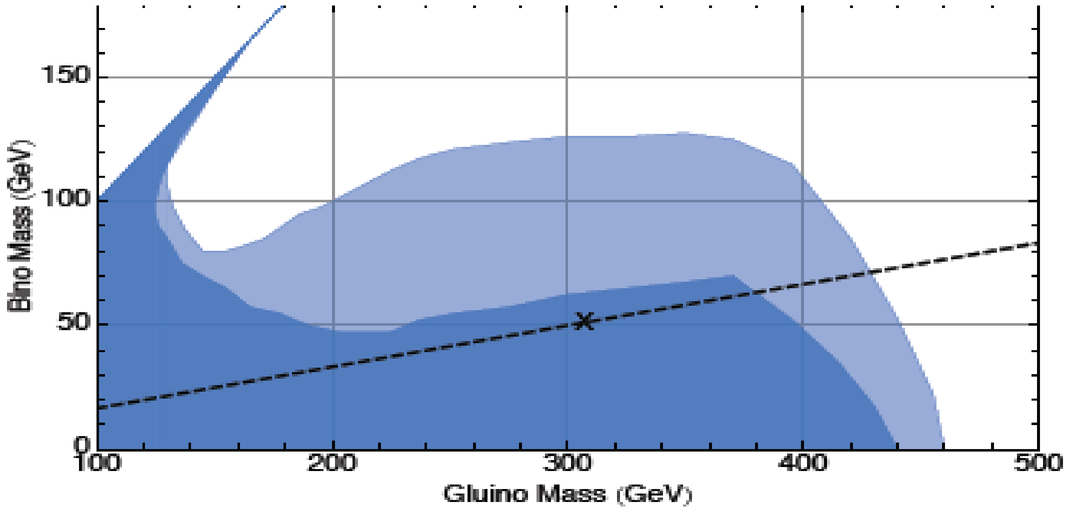
(a)

	M_0	$M_{1/2}$	A_0	$\tan\beta$	$\arg\mu$	σ [pb]
SU1	70	350	0	10	+	10.86
SU2	3550	300	0	10	+	7.18
SU3	100	300	-300	6	+	27.68
SU4	200	160	-400	10	+	402.19
SU8	210	360	0	40	+	6.07
LM1	60	250	0	10	+	54.86
LM2	185	350	0	35	+	9.41
LM3	330	240	0	20	+	45.47
LM4	210	285	0	10	+	25.11
LM5	230	360	0	10	+	7.75
LM6	85	400	0	10	+	4.94
LM7	3000	230	0	10	+	6.79
LM8	500	300	-300	10	+	12.19
LM9	1450	175	0	50	+	39.79
LM10	3000	500	0	10	+	0.076
HM1	180	850	0	10	+	0.045
HM2	350	800	0	35	+	0.065
HM3	700	800	0	10	+	0.047
HM4	1350	600	0	10	+	0.102



We'll come back to these guys later

While both ATLAS & CMS may have done a ‘good job’ trying to cover, e.g., mSUGRA or GMSB parameter space, it is more than likely that *general* MSSM parameter points may look *very different* than any of the traditional symmetry breaking scenarios. In fact, it is quite possible that light SUSY particles, e.g., light gluinos, may already have been missed by searches at the Tevatron due to failure to pass jet energy and/or MET requirements.



See J. Alwall’s talk…

FIG. 4: The 95% exclusion region for DØ at 4 fb^{-1} assuming 50% systematic error on background. The exclusion region for a directly decaying gluino is shown in light blue; the worst case scenario for the cascade decay is shown in dark blue. The dashed line represents the CMSSM points and the “X” is the current DØ exclusion limit at 2 fb^{-1}.

What are the Goals of this Study???

- Prepare a large sample, ~50k, of MSSM models (= parameter space points) satisfying 'all' of the experimental constraints. A large sample is necessary to get a good feeling for the variety of possibilities.

- Examine the properties of the models that survive. Do they look like the model points that have been studied up to now???? What are the differences? ←

- Do physics analyses with these models for LHC, GLAST, PAMELA, ILC/CLIC, etc. etc. – all your favorites!

Other benefits??

Also, such a general analysis allows us to study the MSSM at the electroweak/TeV scale without any reference to the nature of the UV completion: GUTs? New intermediate mass scales? Messenger scales?

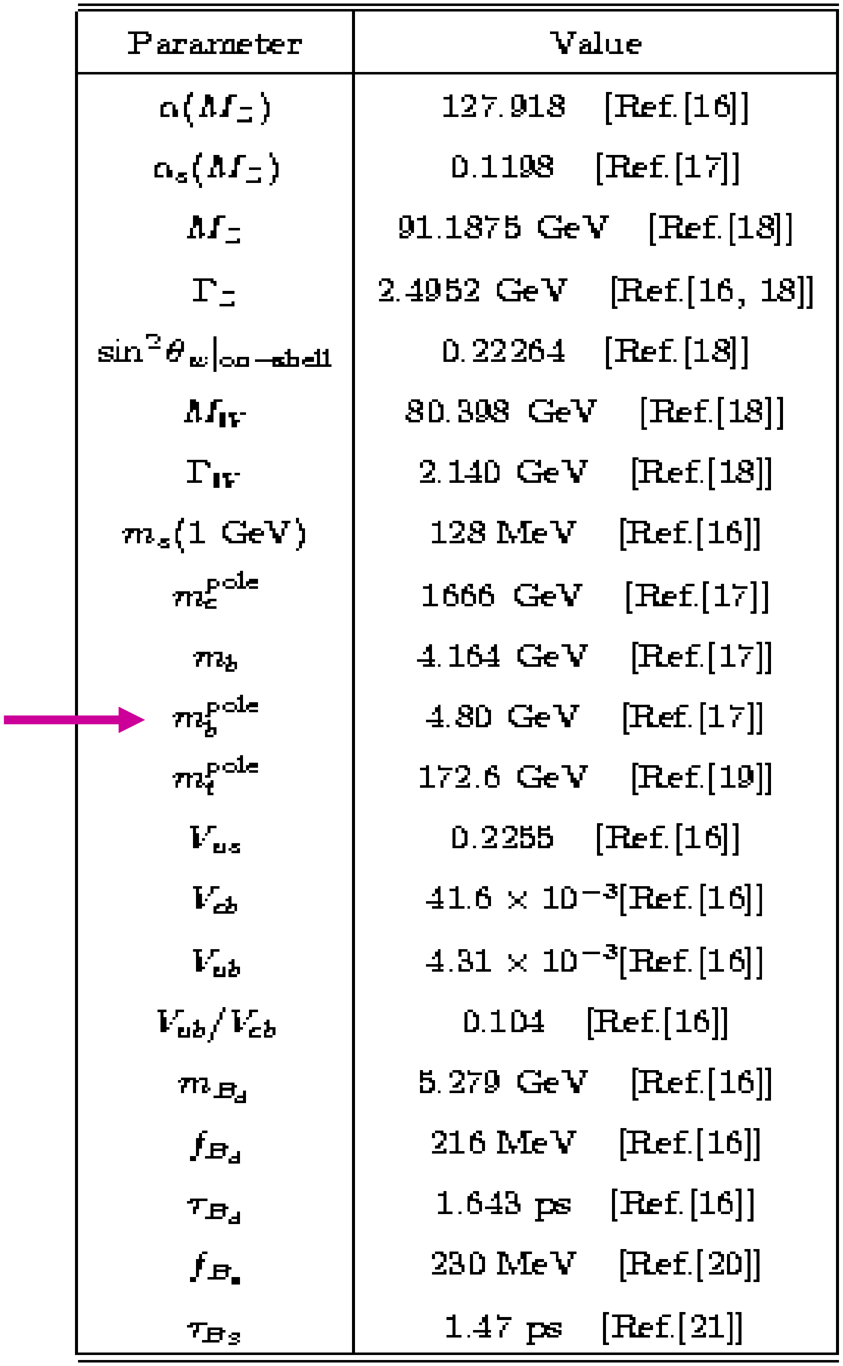
Questions:

- How should we perform our scans?
- What ranges of the soft SUSY breaking parameters should we choose?
- What values of the SM input parameters should we employ?
- What experimental constraints do we use?

There are no a priori unique or best answers to *some* of these questions and to some extent any reasonable answers will suffice.

What do we do in our analysis?

Some Answers



Parameter	Value
$\alpha(M_Z)$	127.918 [Ref.[16]]
$\alpha_s(M_Z)$	0.1198 [Ref.[17]]
M_Z	91.1875 GeV [Ref.[18]]
Γ_Z	2.4952 GeV [Ref.[16, 18]]
$\sin^2\theta_w\vert_{\text{on-shell}}$	0.22264 [Ref.[18]]
M_W	80.398 GeV [Ref.[18]]
Γ_W	2.140 GeV [Ref.[18]]
$m_s(1\text{ GeV})$	128 MeV [Ref.[16]]
m_c^{pole}	1666 GeV [Ref.[17]]
m_b	4.164 GeV [Ref.[17]]
m_b^{pole}	4.80 GeV [Ref.[17]]
m_t^{pole}	172.6 GeV [Ref.[19]]
V_{us}	0.2255 [Ref.[16]]
V_{cb}	41.6×10^{-3}[Ref.[16]]
V_{ub}	4.31×10^{-3}[Ref.[16]]
V_{ub}/V_{cb}	0.104 [Ref.[16]]
m_{B_d}	5.279 GeV [Ref.[16]]
f_{B_d}	216 MeV [Ref.[16]]
τ_{B_d}	1.643 ps [Ref.[16]]
f_{B_s}	230 MeV [Ref.[20]]
τ_{B_s}	1.47 ps [Ref.[21]]

Table 1: Values of the SM input parameters used in our analysis.

SM input parameters employed in our analysis from the PDG, LEPEWWG, ICHEP08, etc.

Some results are somewhat sensitive to these choices which we use mostly without any associated errors.

These errors can be reflected in the ‘allowed ranges’ we use for some experimental results.

How? Since we are not looking for any ‘particular’ or ‘best’ parameter regions (or performing any fits) a conventional scan is adequate & there is no need for Markov-chain MC’s.

We perform 2 large scans (& two smaller scans) :

i) 10^7 points with flat priors for masses:

- $100\ \text{GeV} \leq \tilde{M}_{\text{sfermions}} \leq 1\ \text{TeV}$
- $50\ \text{GeV} \leq |M_1, M_2, \mu| \leq 1\ \text{TeV}$, $100\ \text{GeV} \leq M_3 \leq 1\ \text{TeV}$
- $\sim 0.5\ M_Z \leq M_A \leq 1\ \text{TeV}$, $1 \leq \tan\beta \leq 50$
- $|A_{t\,b\,\tau}| \leq 1\ \text{TeV}$

These are Lagrangian parameters evaluated at the SUSY scale. Absolute value signs account for possible ‘phases’ (i.e., signs) : only Arg $(M_i\,\mu)$ and Arg $(A_f\,\mu)$ are physical…we take $M_3 > 0$

ii) 2 x10^6 points with log priors for masses:

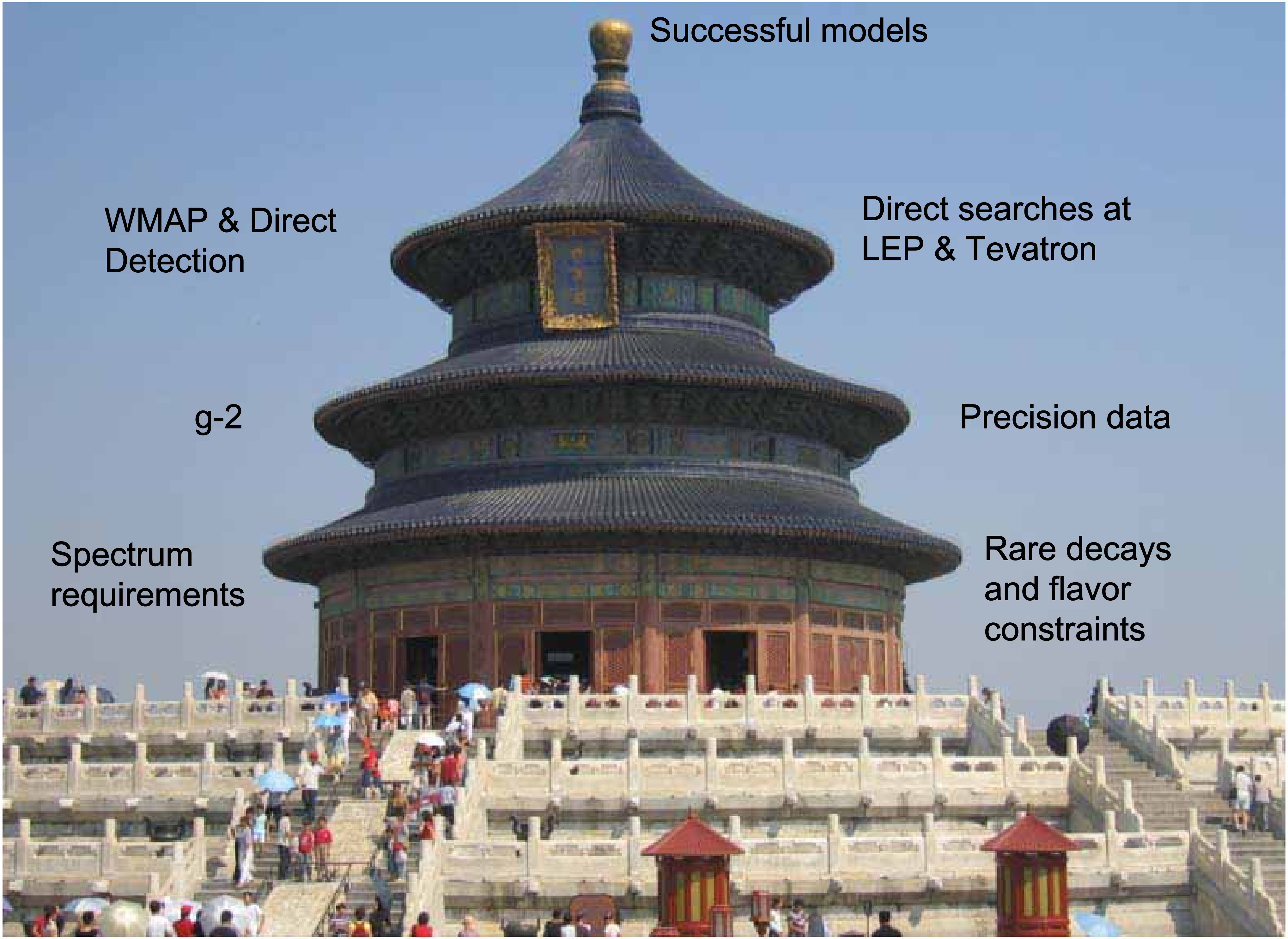
- 100 GeV $\leq \tilde{M}_{\text{sfermions}} \leq$ 3 TeV
- 10 GeV $\leq | M_1, M_2, \mu | \leq$ 3 TeV, 100 GeV $\leq M_3 \leq$ 3 TeV
- 0.5 $M_Z \leq M_A \leq$ 3 TeV , $1 \leq \tan\beta \leq 60$
- 10 GeV $\leq | A_{t\, b\, \tau} | \leq$ 3 TeV

While scan (i) emphasizes sparticles with moderate masses, scan (ii) emphasizes light sparticles BUT also extends to higher masses simultaneously

Comparison of these two scans will show the prior sensitivity

This analysis required ~ 1 processor-century of CPU time

What constraints and experimental data do we employ?



Successful models

WMAP & Direct Detection

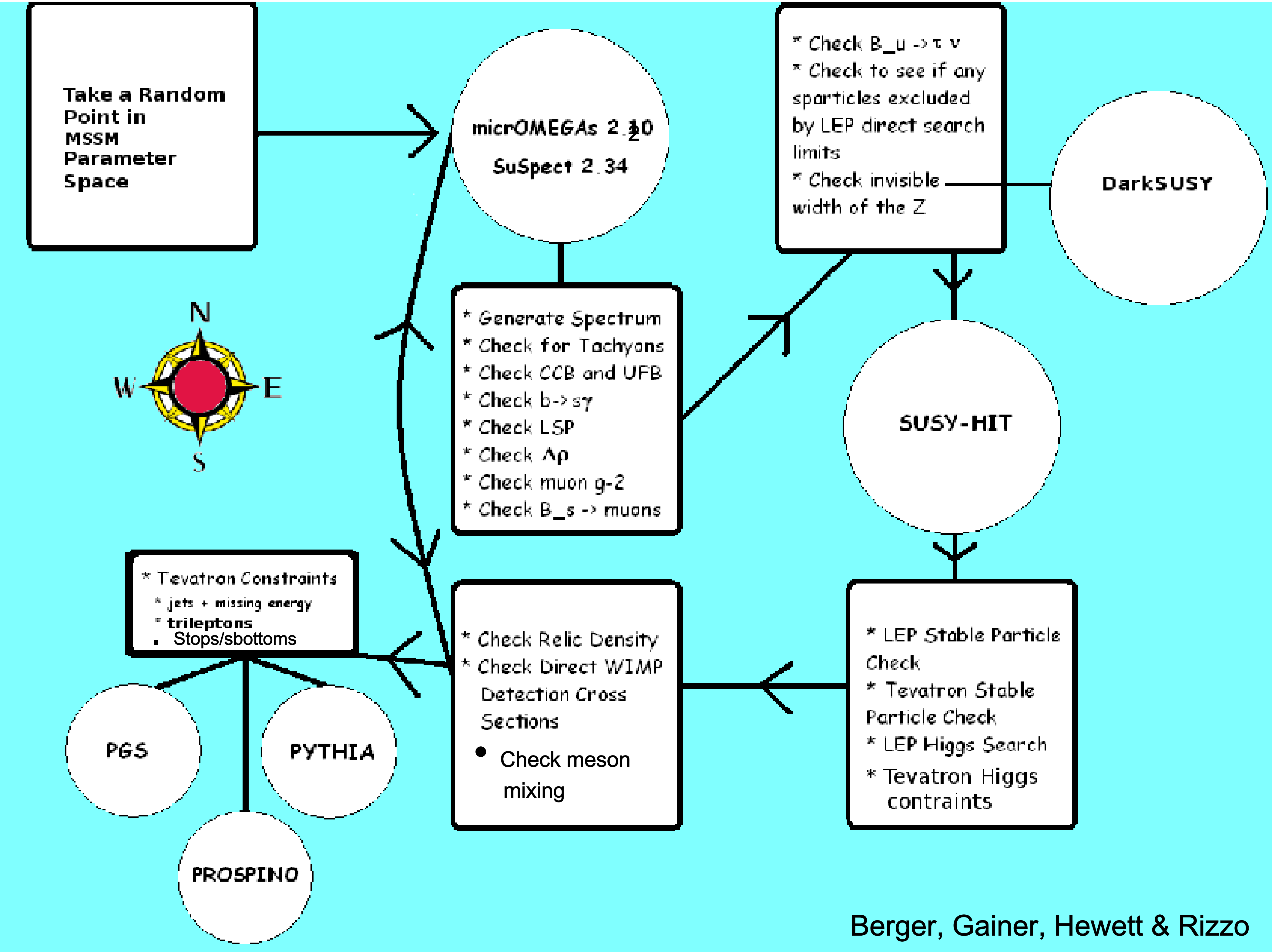
Direct searches at LEP & Tevatron

g-2

Precision data

Spectrum requirements

Rare decays and flavor constraints



Take a Random Point in MSSM Parameter Space

micrOMEGAs 2.10

SuSpect 2.34

- Generate Spectrum
- Check for Tachyons
- Check CCB and UFB
- Check b->sγ
- Check LSP
- Check Δρ
- Check muon g-2
- Check B_s -> muons

- Check B_u -> τ ν
- Check to see if any sparticles excluded by LEP direct search limits
- Check invisible width of the Z

DarkSUSY

SUSY-HIT

- LEP Stable Particle Check
- Tevatron Stable Particle Check
- LEP Higgs Search
- Tevatron Higgs contraints

- Check Relic Density
- Check Direct WIMP Detection Cross Sections
- Check meson mixing

- Tevatron Constraints
  - jets + missing energy
  - **trileptons**
  - Stops/sbottoms

PGS

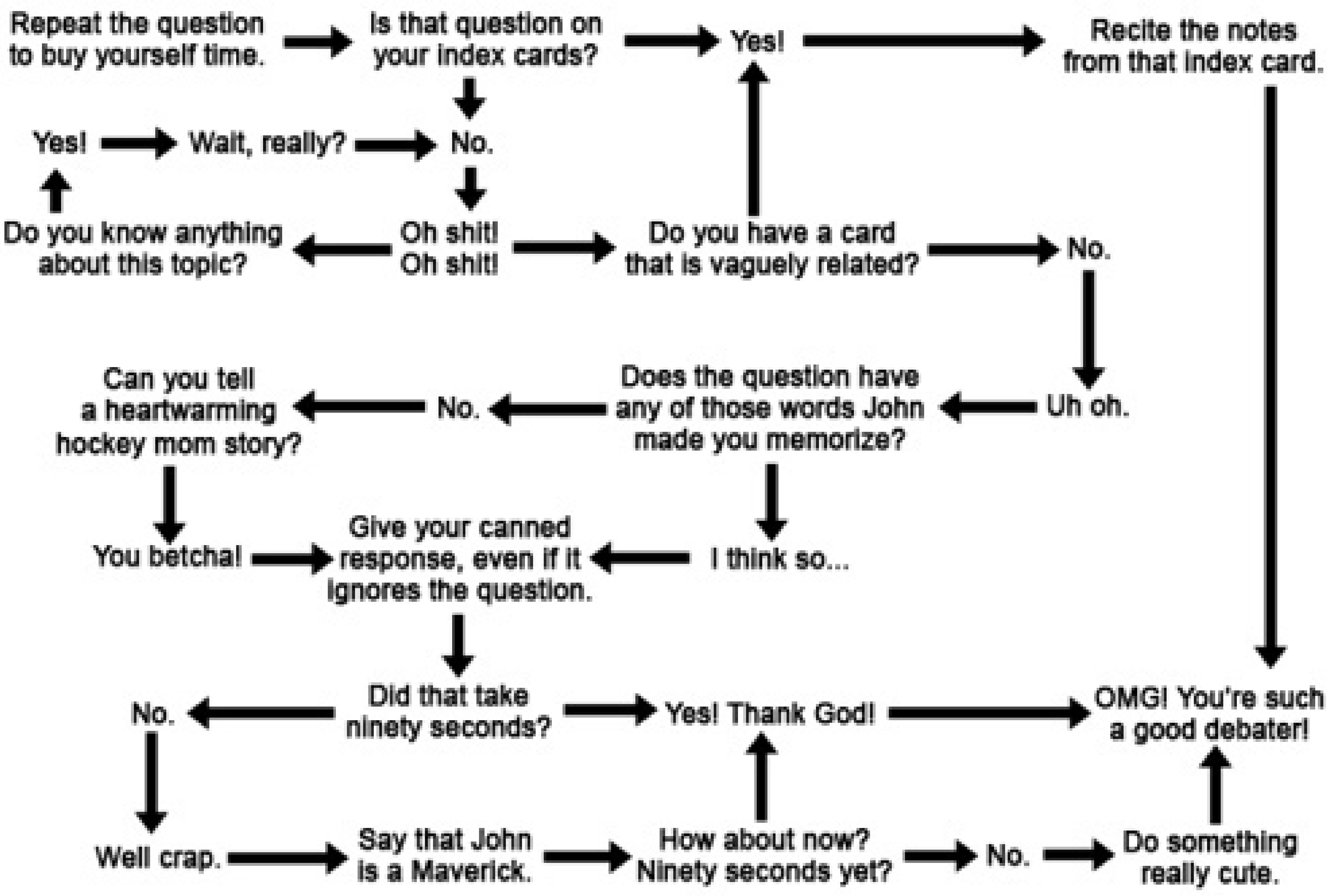
PYTHIA

PROSPINO

Berger, Gainer, Hewett & Rizzo

Sarah Palin Debate Flow Chart

www.adennak.com



Constraints (cont.)

- $-0.0007 < \Delta\rho < 0.0026$ (PDG'08)
- $b \to s\,\gamma$: $B = (2.5 - 4.1) \times 10^{-4}$; (HFAG) + Misiak etal. & Becher & Neubert
- $\Delta(g\text{-}2)_\mu$??? $(30.2 \pm 8.8) \times 10^{-10}$ (0809.4062)
  $(29.5 \pm 7.9) \times 10^{-10}$ (0809.3085)
  $[\sim 14.0 \pm 8.4] \times 10^{-10}$ [Davier/BaBar-Tau08]

→ $(-10 \text{ to } 40) \times 10^{-10}$ to be conservative..

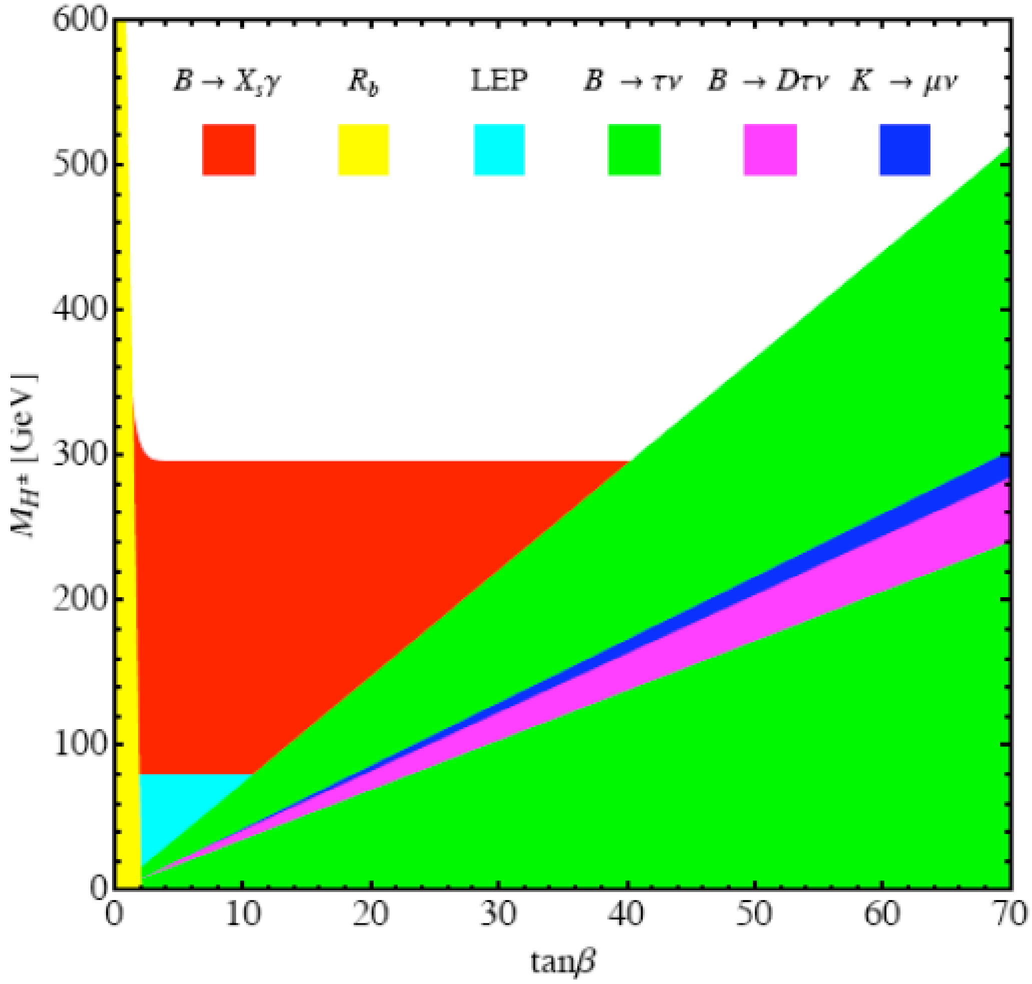
- $\Gamma(Z \to \text{invisible}) < 2.0$ MeV (LEPEWWG)
  This removes Z decays to LSPs w/ large Higgsino content
- Meson-Antimeson Mixing : Constrains 1st/3rd sfermion mass ratios to be < 5 in MFV context

$B \to \tau\nu$

Isidori & Paradisi, hep-ph/0605012 &
Erikson etal., 0808.3551 for loop corrections

Bounds on NP by rare decays: example of Two-Higgs-Doublet Model

Haisch,arXiv:0805.2141



New data from Babar and Belle

talks by Baracchini, Hara

* New bounds: $B \to K\nu\bar{\nu}, B \to \mu\nu$

* New HFAG for $B \to \tau\nu$

$BR(B \to \tau\nu) = (1.51 \pm 0.33)\, 10^{-4}$

SM: $\propto |V_{ub}|^2\ f_B^2$

$BR(B \to \tau\nu) = (0.80 \pm 0.12)\, 10^{-4}$

UTfit,2008

tan β suppression expected
in THDM/MSSM

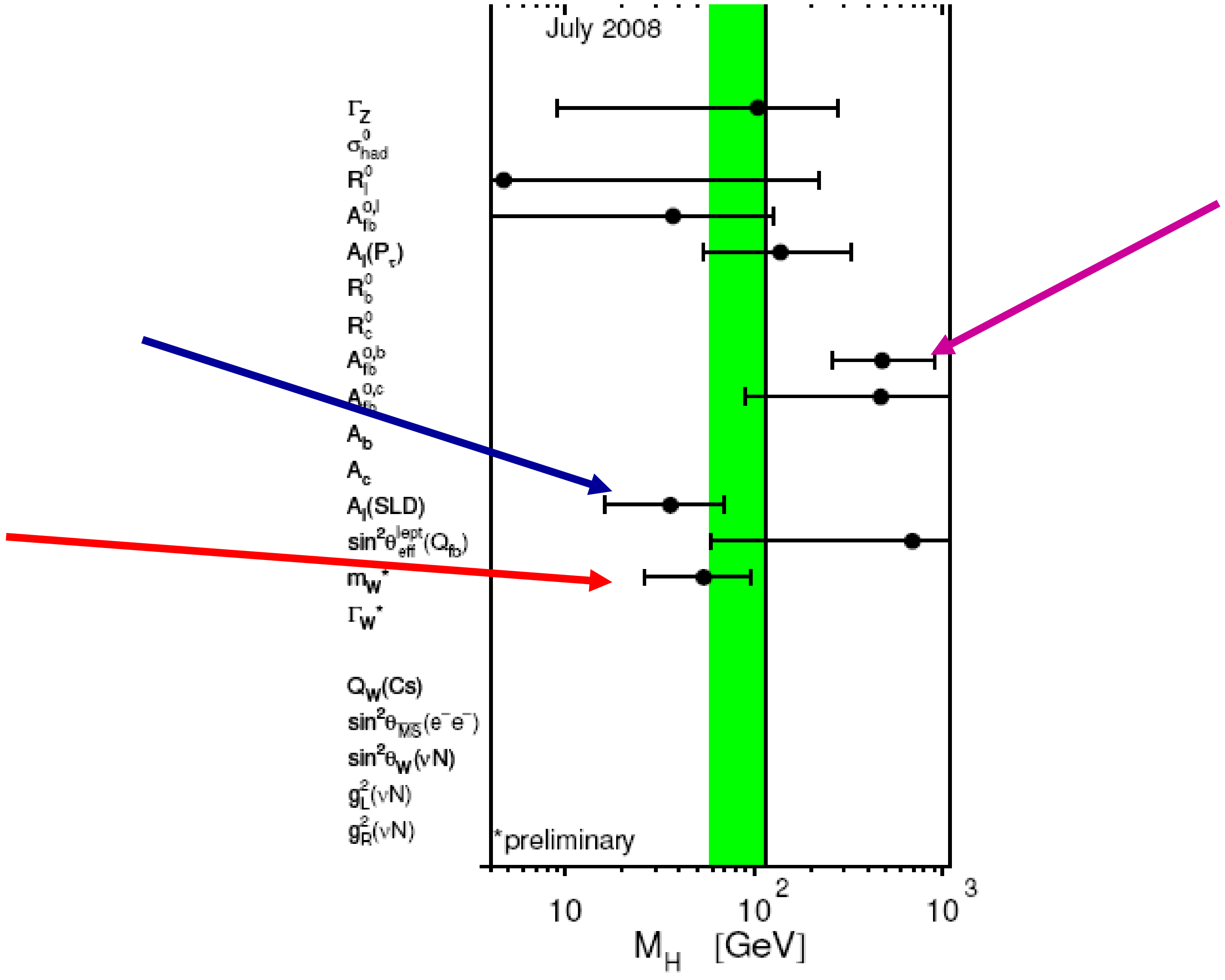
Super-B ($\succeq 50 ab^{-1}$) sensitivity

$3 - 4\%$ Stocchi et al.,arXiv:0710.3799

Heavy Flavour Theory, Tobias Hurth (CERN,SLAC)

→ $B = (55 \text{ to } 227) \times 10^{-6}$

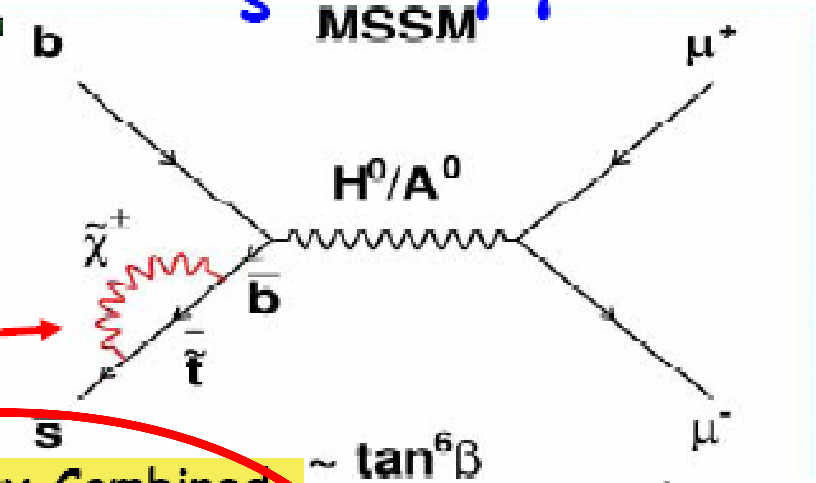
NOTE: We do not include R_b as a constraint in our analysis as the $Zb\bar{b}$ coupling occupies a controversial place in SM fits to precision measurements. This is something we plan to look at later.



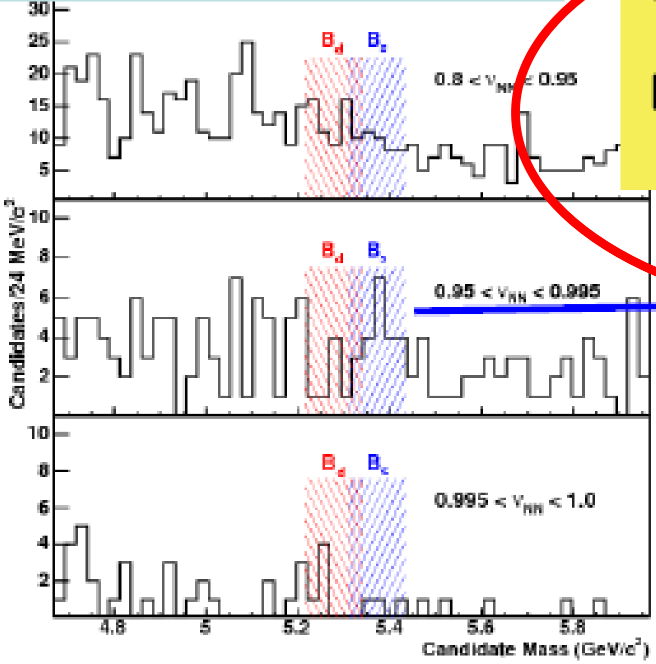
Indirect Search: $B_s \rightarrow \mu\mu$

The search for $B_s \rightarrow \mu\mu$ is perhaps the most sensitive to SUSY since sparticles show up in loops

Especially sensitive at high $\tan\beta$ ($\propto \tan\beta^6$)



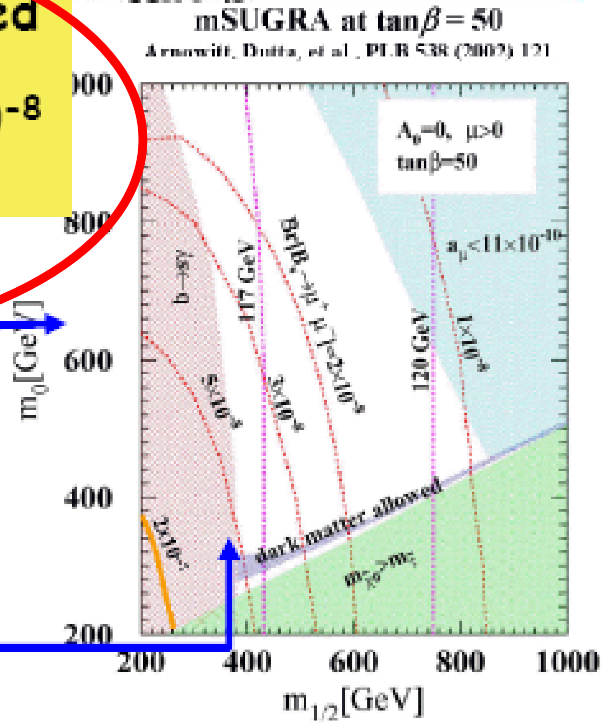
CDF, PRL 100, 101802 (2008)



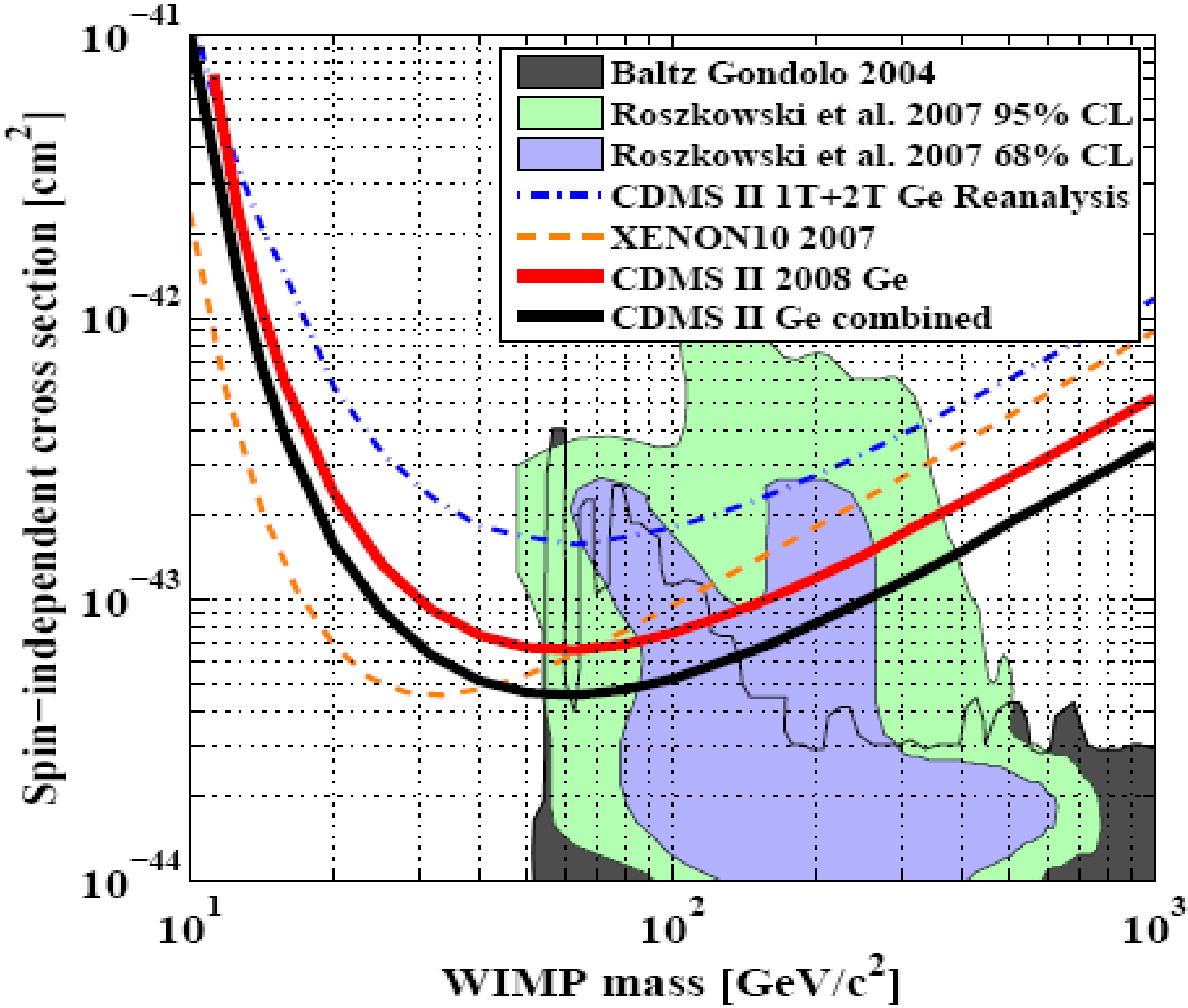
Preliminary Combined CDF/DØ

$BR(B_s \rightarrow \mu\mu) < 4.5\times10^{-8}$ @95%

$BR_{SM} = 3.5\times10^{-9}$

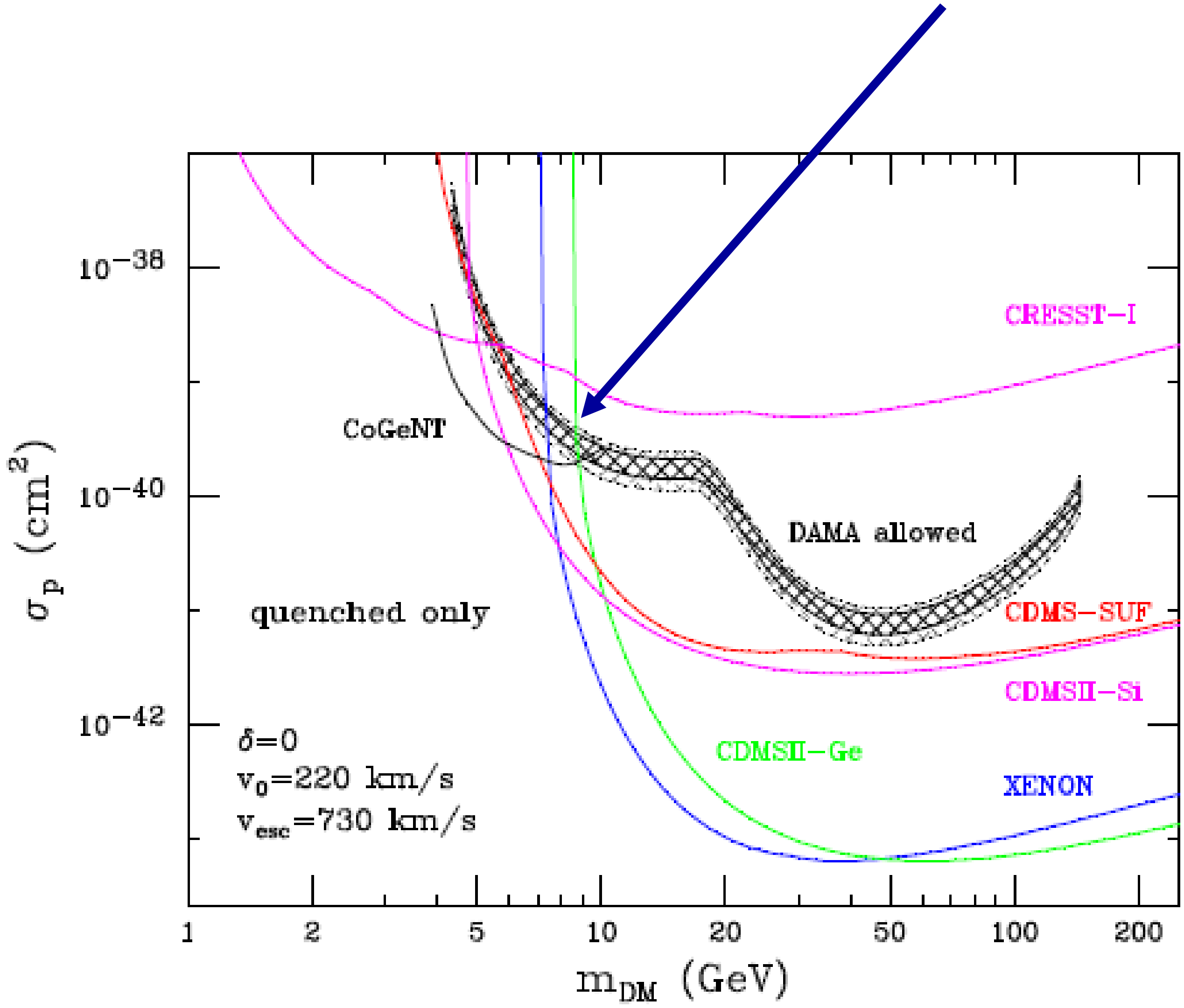


Dark Matter: Direct Searches for WIMPs



Another View….

Petriello & Zurek



complex region

Figure 2: Similar to Fig. (1), but if DAMA observed only quenched events. The presence of un-quenched (channeled) events is necessary to reconcile DAMA with null experiments.

- CDMS, XENON10, DAMA, CRESST-I,… → We find a factor of ~ 4 uncertainty in the nuclear matrix elements. This factor was obtained from studying several benchmark points in detail & so we allow cross sections 4x larger than the usually quoted limits. Spin-independent limits are completely dominant here.

- Dark Matter density: $\Omega h^2 < 0.1210$ → 5yr WMAP data + We treat this only as an upper bound on the LSP DM density to allow for multi-component DM, e.g., axions, etc. Recall the lightest neutralino is the LSP here

- LEP and Tevatron Direct Higgs & SUSY searches : there are *many* of these searches but they are very complicated with many caveats…. CAREFUL!

Zh, h-> bb, ττ

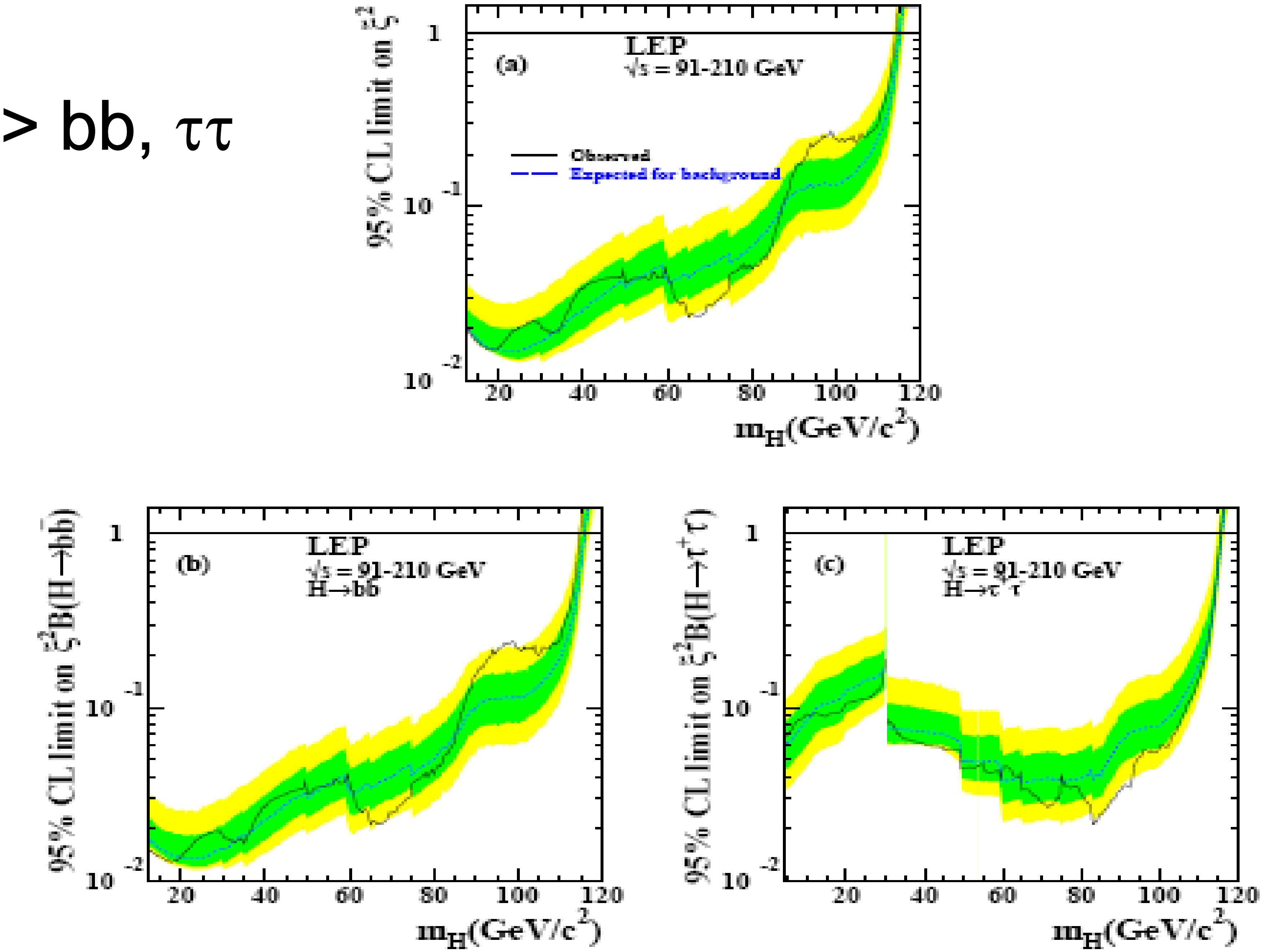


Figure 1: *The 95% c.l. upper bound on the coupling ratio* $\xi^2 = (g_{HZZ}/g_{HZZ}^{SM})^2$ *(see text). The dark (green) and light (yellow) shaded bands around the median expected line correspond to the 68% and 95% probability bands. The horizontal lines correspond to the Standard Model coupling. (a): For Higgs boson decays predicted by the Standard Model; (b): for the Higgs boson decaying exclusively into* $b\bar{b}$ *and (c): into* $\tau^+\tau^-$ *pairs.*

LEP II: Associated Higgs Production

Z→ hA →**4b,2b2τ,4τ**

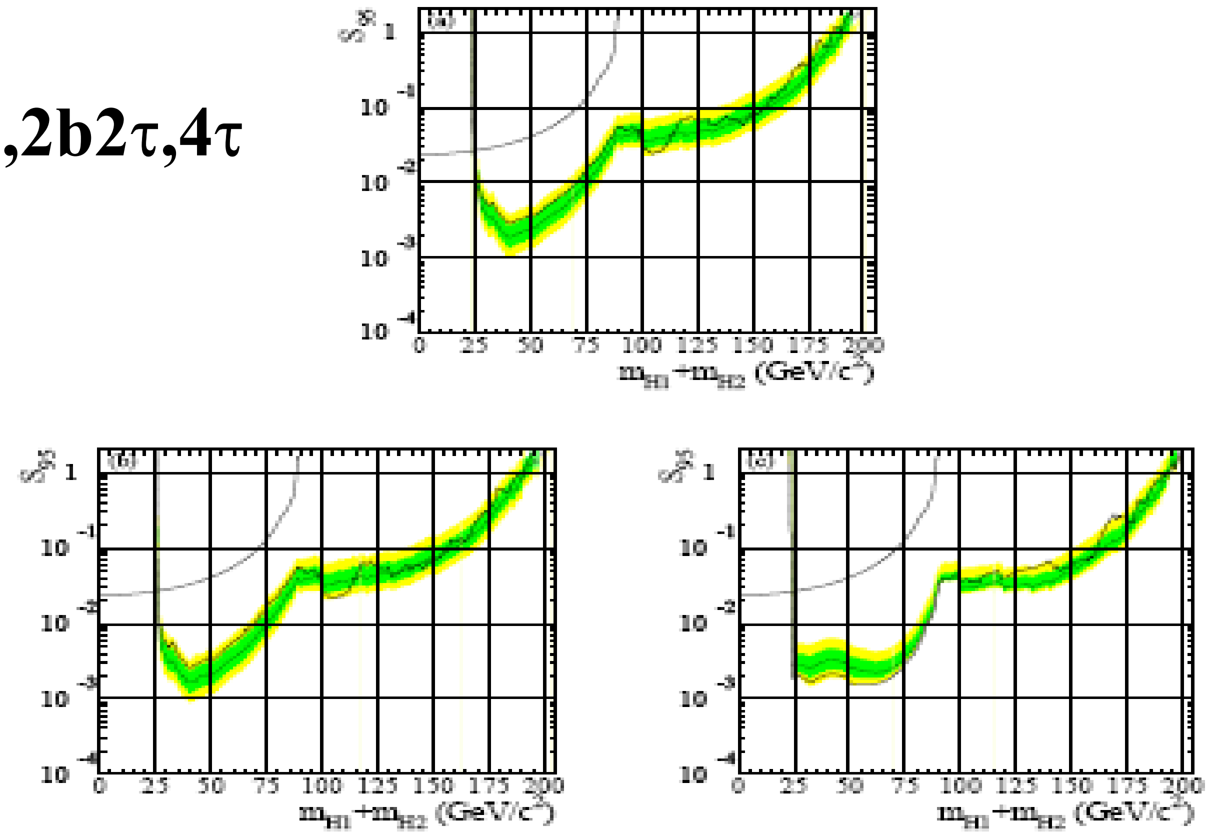
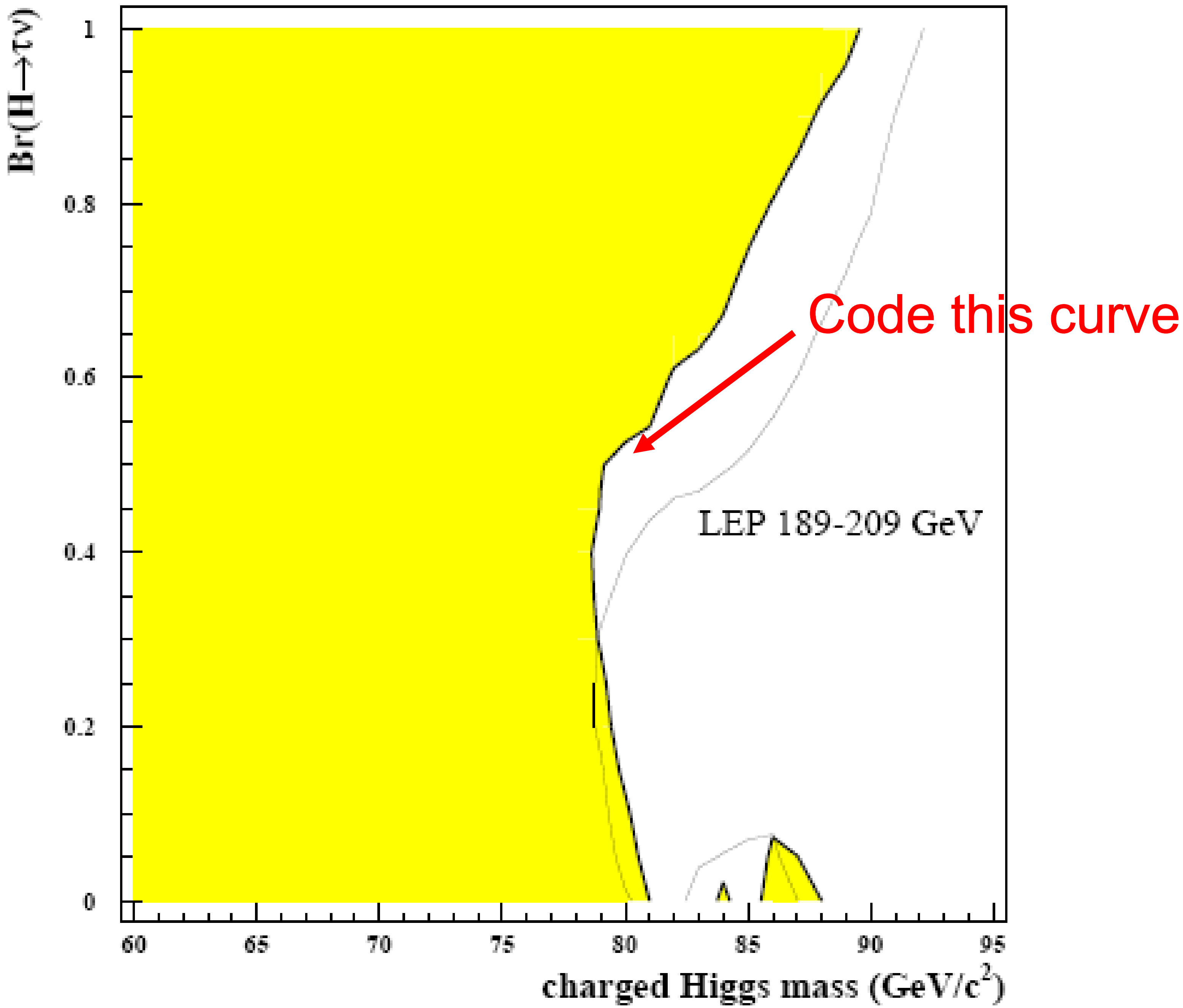


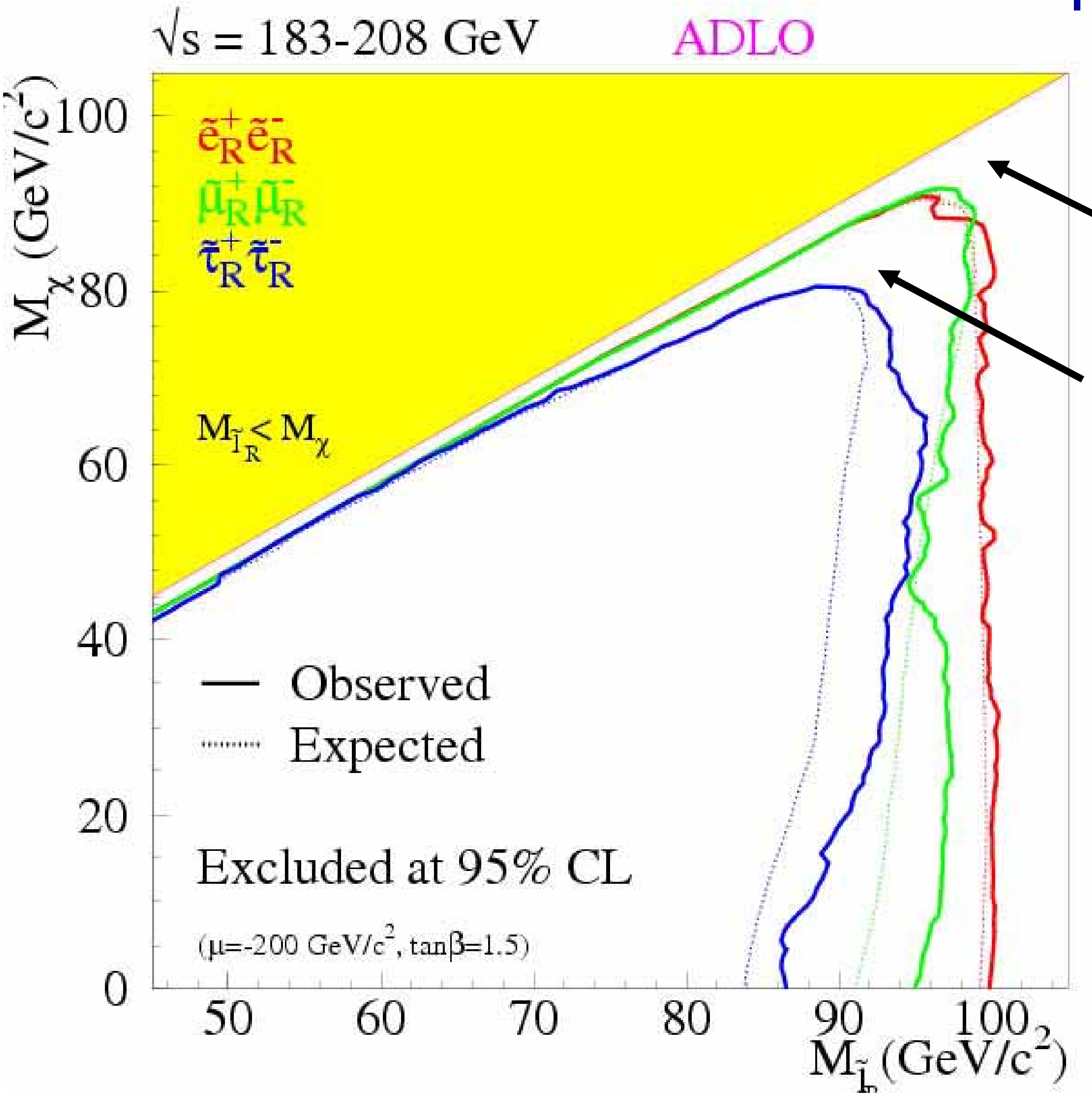
Figure 3: Model-independent 95% c.l. upper bounds, S_{95}, for various topological cross sections motivated by the pair-production process $e^+e^- \to \mathcal{H}_2\mathcal{H}_1$, for the particular case where $m_{\mathcal{H}_1}$ and $m_{\mathcal{H}_2}$ are approximately equal. Such is the case, for example, in the CP-conserving MSSM scenarios for tan β greater than 10. The abscissa represents the sum of the two Higgs boson masses. The full line represents the observed limit. The dark (green) and light (yellow) shaded bands around the median expectation (dashed line) correspond to the 68% and 95% probability bands. The curves which complete the exclusion at low masses are obtained using the constraint from the measured decay width of the Z boson, see Section 3.2. Upper plot: the Higgs boson decay branching ratios correspond to the m_h-max benchmark scenario with tan β=10, namely 94% $\mathcal{H}_1 \to b\bar{b}$, 6% $\mathcal{H}_1 \to \tau^+\tau^-$, 92% $\mathcal{H}_2 \to b\bar{b}$ and 8% $\mathcal{H}_2 \to \tau^+\tau^-$; lower left: both Higgs bosons are assumed to decay exclusively to $b\bar{b}$; lower right: the Higgs bosons are assumed to decay, one into $b\bar{b}$ only and the other one into $\tau^+\tau^-$ only. For the case where both Higgs bosons decay to $\tau^+\tau^-$, the corresponding upper bound can be found in Ref. [31], Figure 15.

CHARGED HIGGS - PRELIMINARY



Code this curve

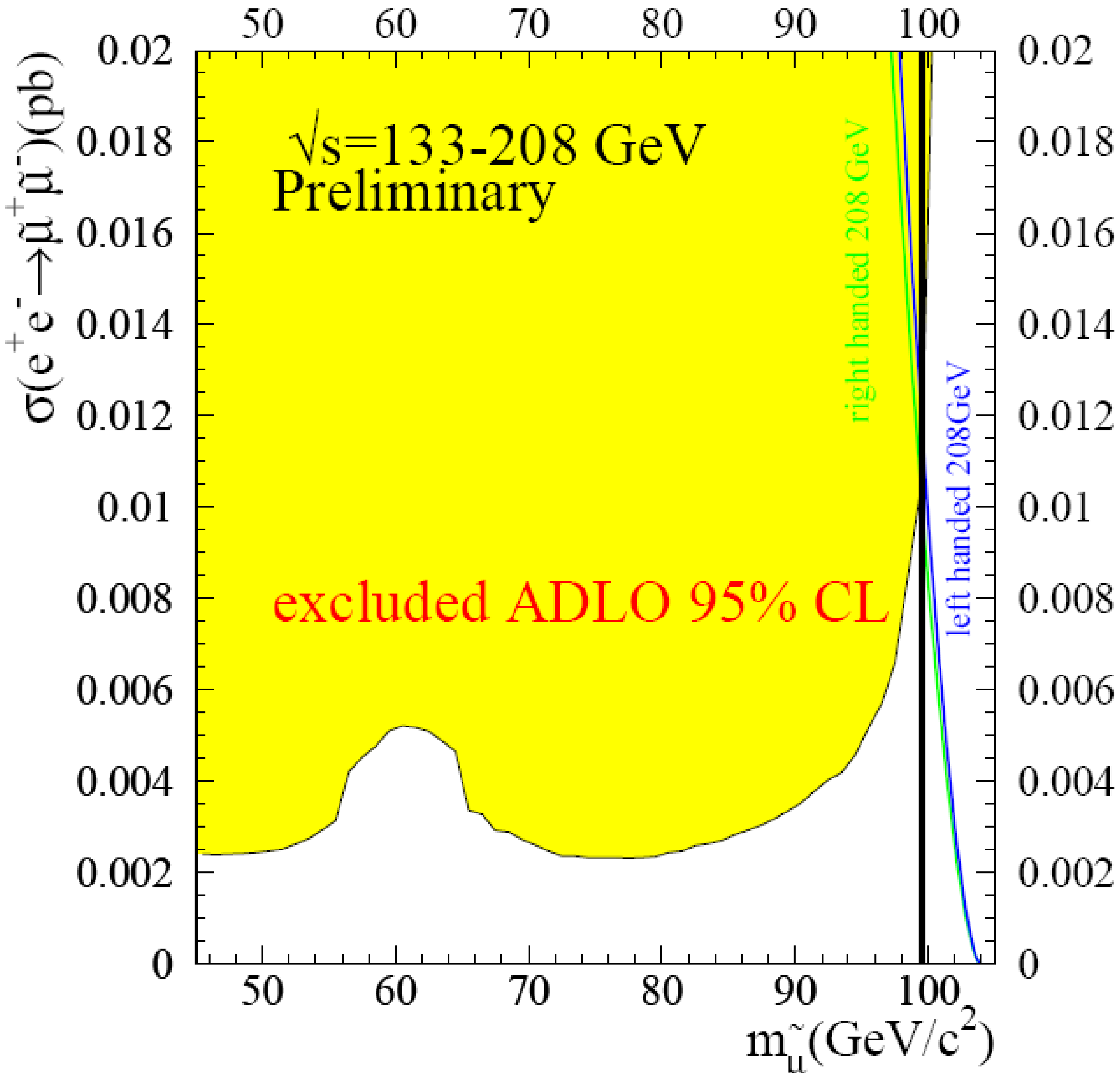
RH Sleptons



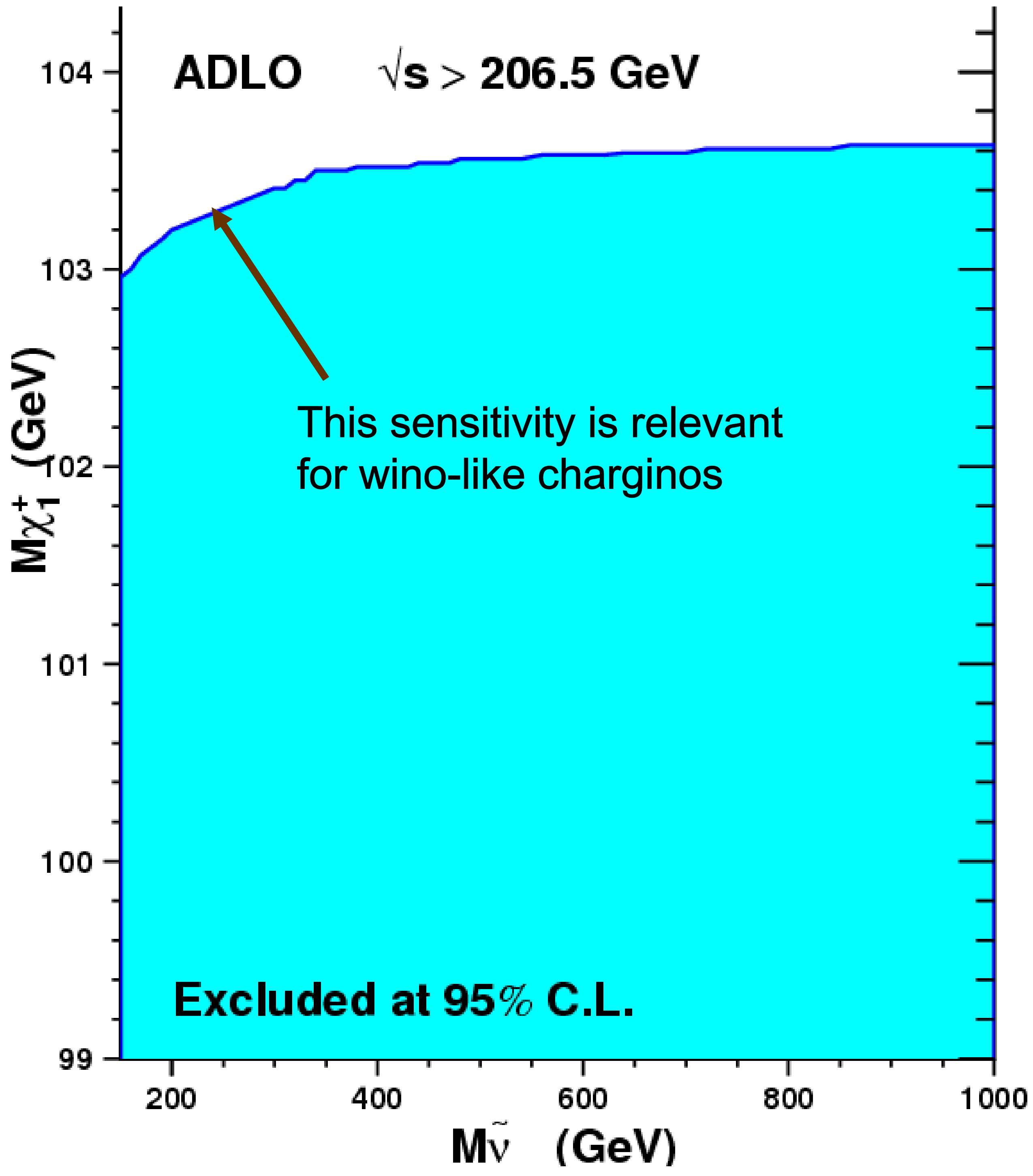
Note the holes where the leptons are too soft…

We need to allow for a mass gap w/ the LSP & also in the squark case when soft jets are possible..light guys may slip through

The left- & right-slepton reaches are similar



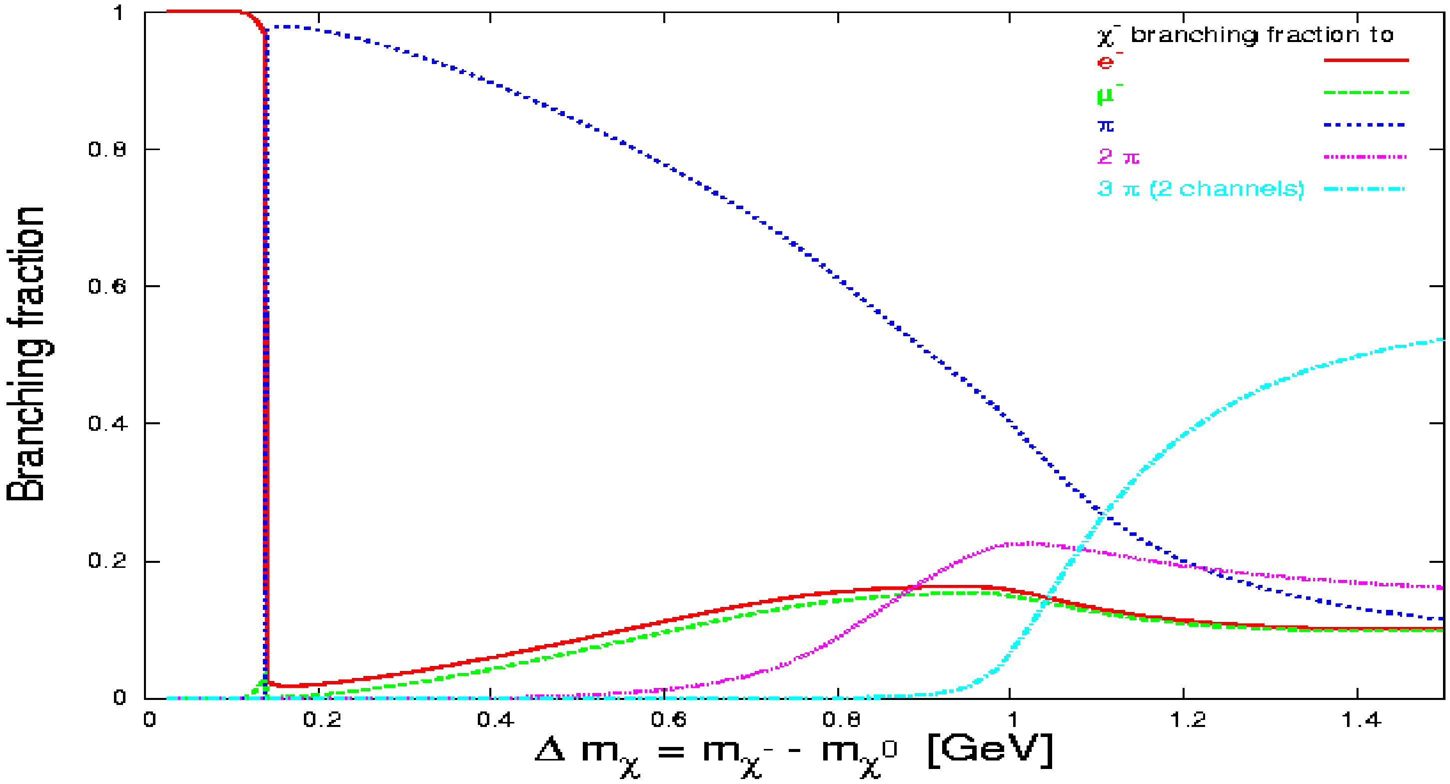
Large mass gap chargino search

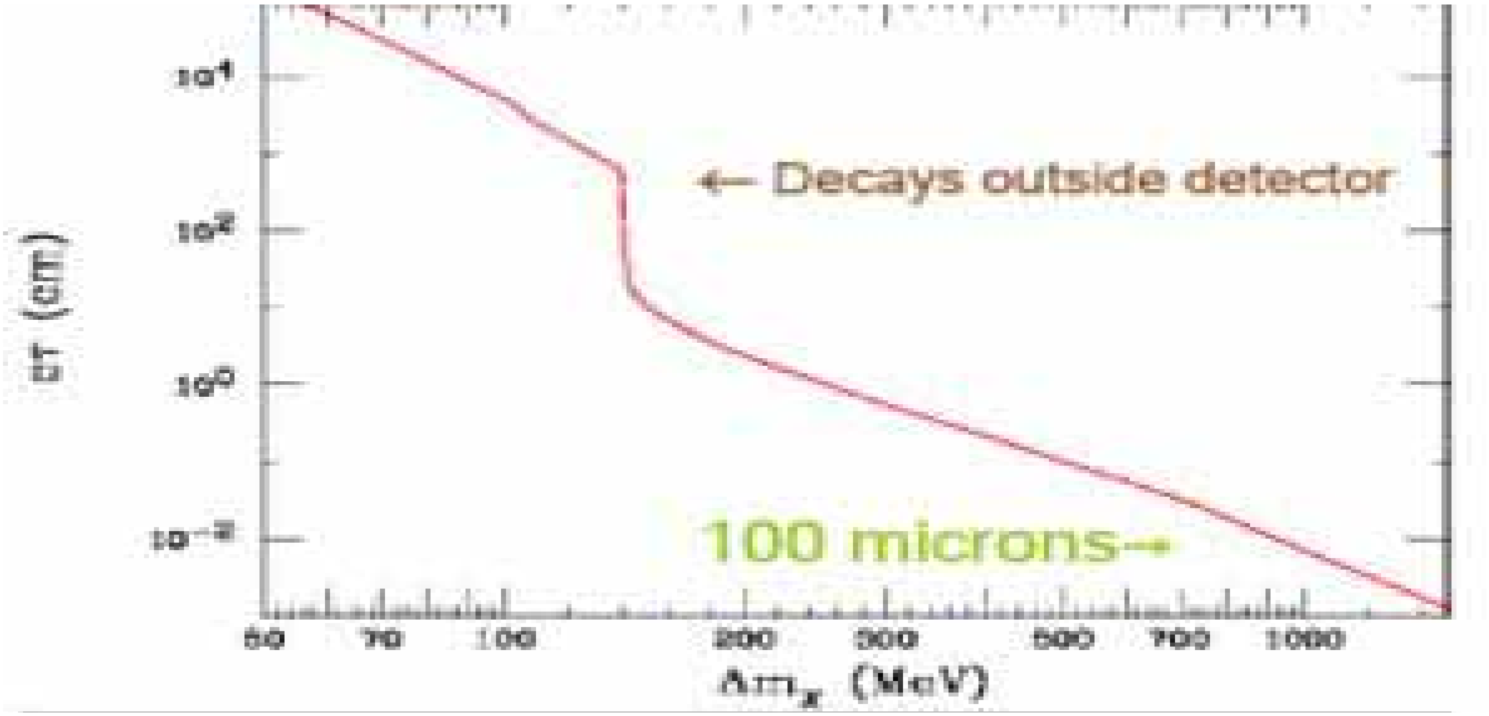


This sensitivity is relevant for wino-like charginos

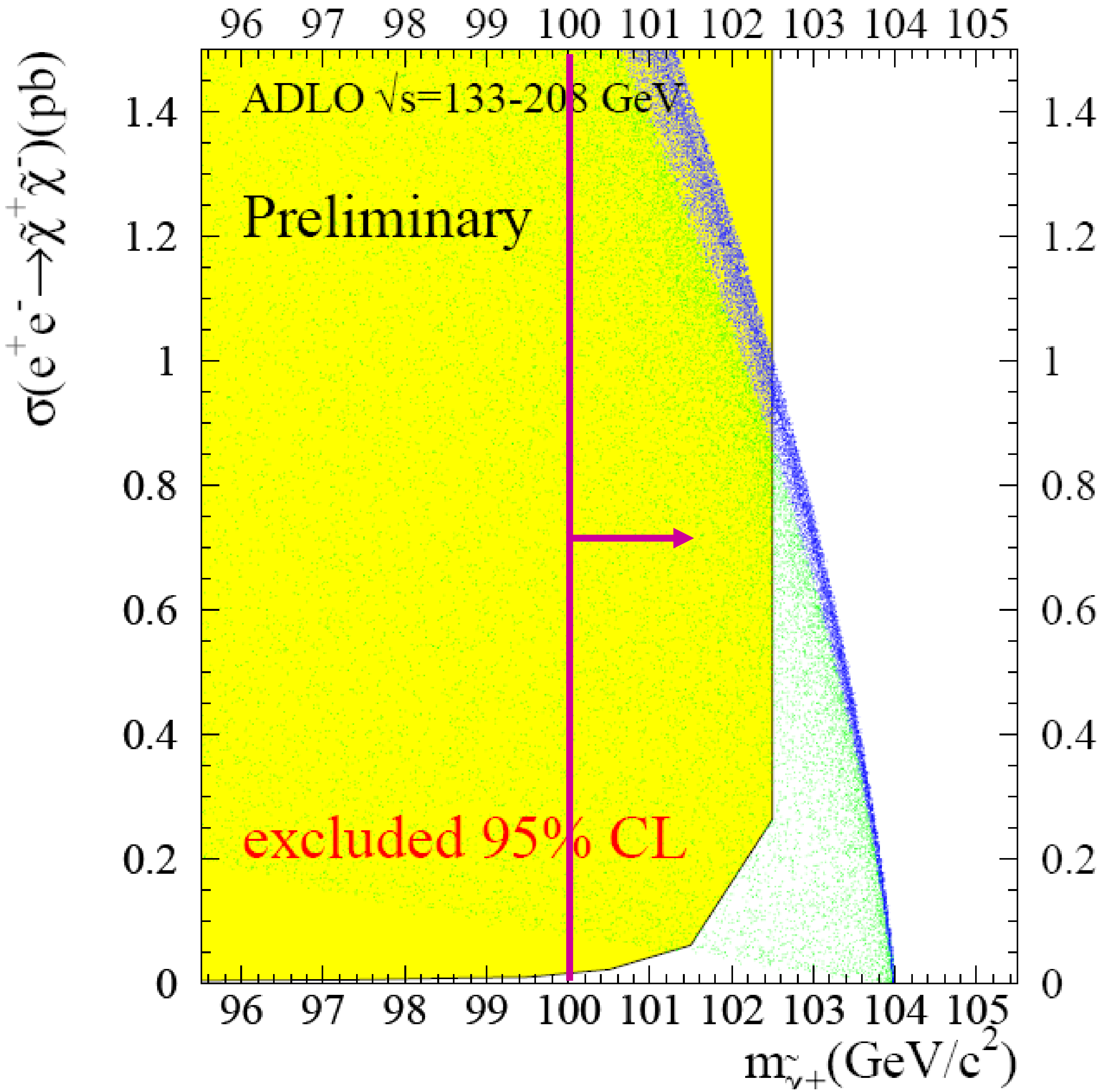
Depends on the sneutrino mass in the t-channel if less than ~ 160 GeV due to interference if large wino content

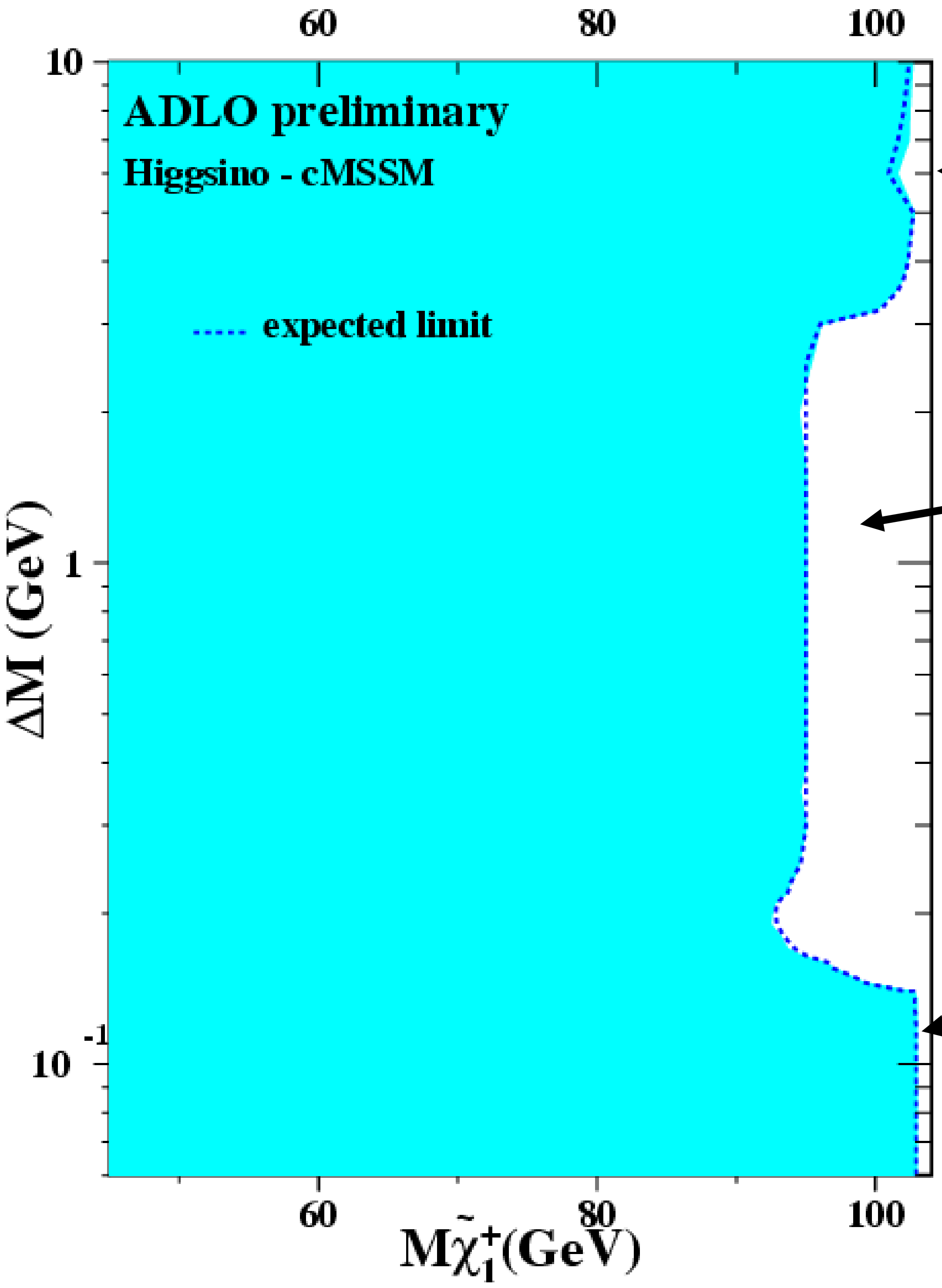
Some ‘light’ charginos may slip through as search reach is degraded


Branching fraction
1
0.8
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
$\Delta m_\chi = m_{\chi^-} - m_{\chi^0}$ [GeV]
χ^- branching fraction to
e^-
μ^-
π
2π
3π (2 channels)


cτ (cm)
10^4
10^2
10^0
10^{-2}
← Decays outside detector
100 microns→
50
70
100
200
300
500
700
1000
Δm_χ (MeV)

LEP Stable Particle Search





‘conventional’ search

Soft final state particles

Stable particle search

Tevatron Constraints : I Squark & Gluino Search

- 2,3,4 Jets + Missing Energy (D0)

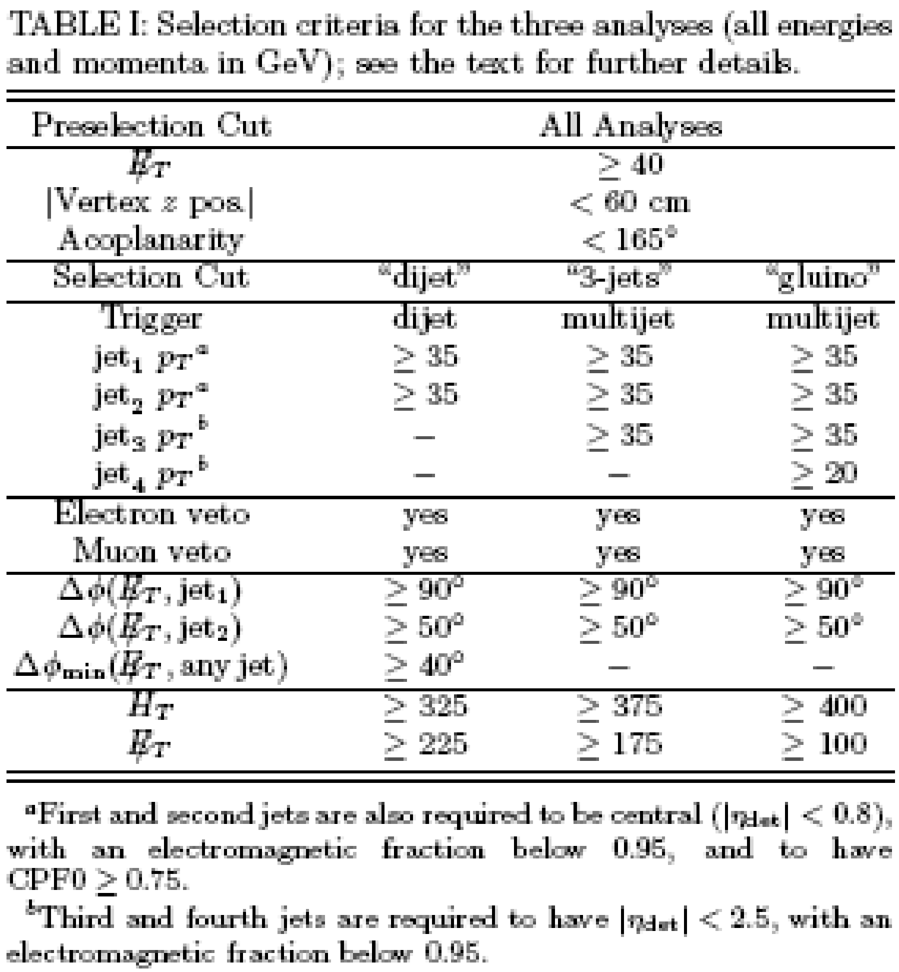


TABLE I: Selection criteria for the three analyses (all energies and momenta in GeV); see the text for further details.

Preselection Cut	All Analyses		
$\not\!\!E_T$	≥ 40		
|Vertex z pos.|	< 60 cm		
Acoplanarity	$< 165°$		
Selection Cut	“dijet”	“3-jets”	“gluino”
Trigger	dijet	multijet	multijet
$\text{jet}_1\ p_T$ [a]	≥ 35	≥ 35	≥ 35
$\text{jet}_2\ p_T$ [a]	≥ 35	≥ 35	≥ 35
$\text{jet}_3\ p_T$ [b]	–	≥ 35	≥ 35
$\text{jet}_4\ p_T$ [b]	–	–	≥ 20
Electron veto	yes	yes	yes
Muon veto	yes	yes	yes
$\Delta\phi(\not\!\!E_T, \text{jet}_1)$	$\geq 90°$	$\geq 90°$	$\geq 90°$
$\Delta\phi(\not\!\!E_T, \text{jet}_2)$	$\geq 50°$	$\geq 50°$	$\geq 50°$
$\Delta\phi_{\text{min}}(\not\!\!E_T, \text{any jet})$	$\geq 40°$	–	–
H_T	≥ 325	≥ 375	≥ 400
$\not\!\!E_T$	≥ 225	≥ 175	≥ 100

[a] First and second jets are also required to be central ($|\eta_{\text{det}}| < 0.8$), with an electromagnetic fraction below 0.95, and to have CPF0 ≥ 0.75.

[b] Third and fourth jets are required to have $|\eta_{\text{det}}| < 2.5$, with an electromagnetic fraction below 0.95.

Multiple analyses keyed to look for:

Squarks-> jet +MET

Gluinos -> 2 j + MET

The search is based on mSUGRA type sparticle spectrum assumptions which can be VERY far from our model points

D0 benchmarks

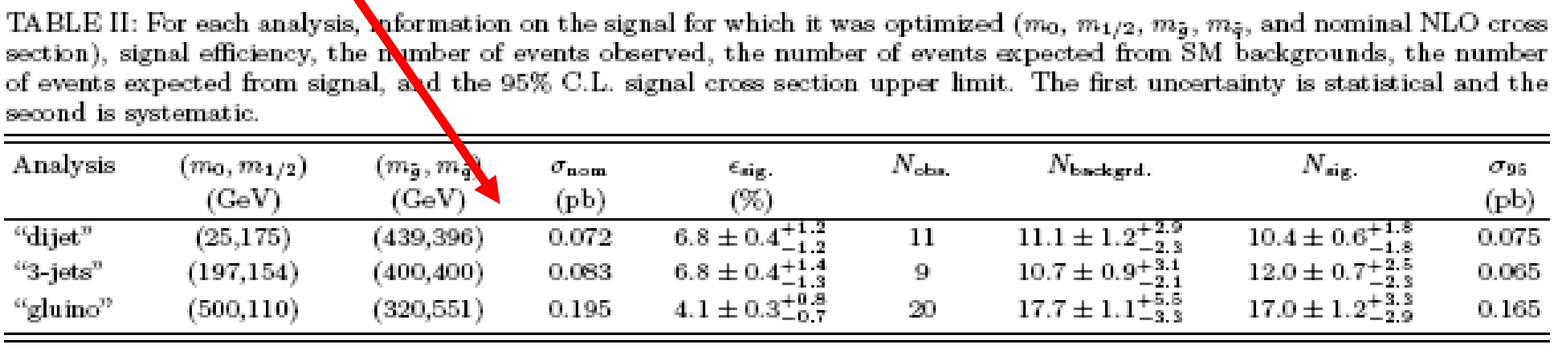


TABLE II: For each analysis, information on the signal for which it was optimized (m_0, $m_{1/2}$, $m_{\tilde{g}}$, $m_{\tilde{q}}$, and nominal NLO cross section), signal efficiency, the number of events observed, the number of events expected from SM backgrounds, the number of events expected from signal, and the 95% C.L. signal cross section upper limit. The first uncertainty is statistical and the second is systematic.

Analysis	$(m_0, m_{1/2})$ (GeV)	$(m_{\tilde{g}}, m_{\tilde{q}})$ (GeV)	σ_{nom} (pb)	$\epsilon_{\mathrm{sig.}}$ (%)	$N_{\mathrm{obs.}}$	$N_{\mathrm{backgrd.}}$	$N_{\mathrm{sig.}}$	σ_{95} (pb)
"dijet"	(25,175)	(439,396)	0.072	$6.8 \pm 0.4^{+1.2}_{-1.2}$	11	$11.1 \pm 1.2^{+2.9}_{-2.3}$	$10.4 \pm 0.6^{+1.8}_{-1.8}$	0.075
"3-jets"	(197,154)	(400,400)	0.083	$6.8 \pm 0.4^{+1.4}_{-1.3}$	9	$10.7 \pm 0.9^{+3.1}_{-2.1}$	$12.0 \pm 0.7^{+2.5}_{-2.3}$	0.065
"gluino"	(500,110)	(320,551)	0.195	$4.1 \pm 0.3^{+0.8}_{-0.7}$	20	$17.7 \pm 1.1^{+5.5}_{-3.3}$	$17.0 \pm 1.2^{+3.3}_{-2.9}$	0.165

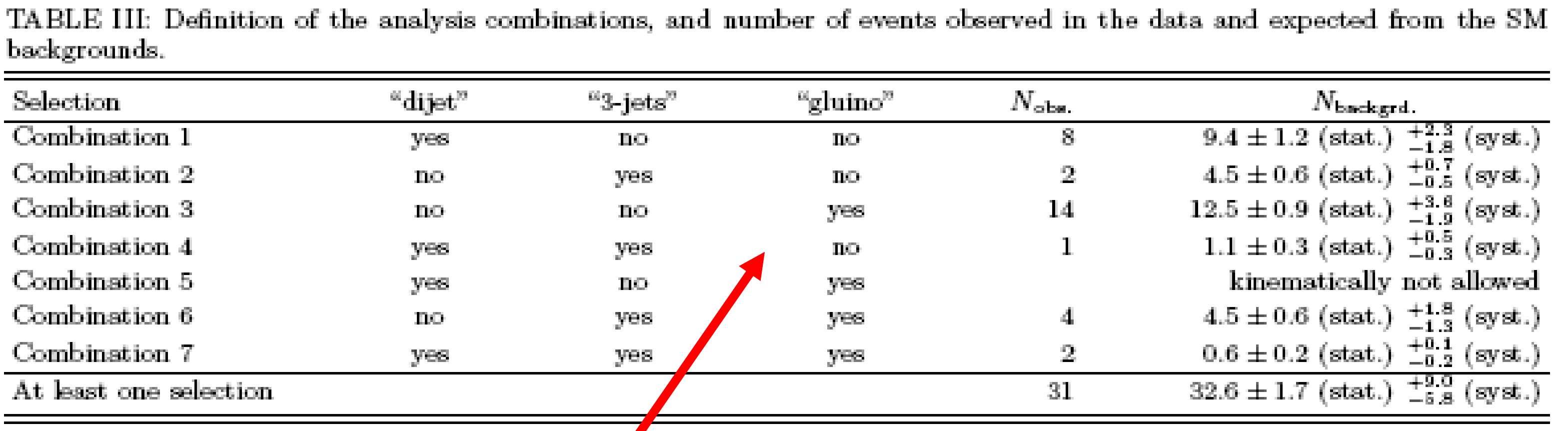


TABLE III: Definition of the analysis combinations, and number of events observed in the data and expected from the SM backgrounds.

Selection	"dijet"	"3-jets"	"gluino"	$N_{\mathrm{obs.}}$	$N_{\mathrm{backgrd.}}$
Combination 1	yes	no	no	8	9.4 ± 1.2 (stat.) $^{+2.3}_{-1.8}$ (syst.)
Combination 2	no	yes	no	2	4.5 ± 0.6 (stat.) $^{+0.7}_{-0.5}$ (syst.)
Combination 3	no	no	yes	14	12.5 ± 0.9 (stat.) $^{+3.6}_{-1.9}$ (syst.)
Combination 4	yes	yes	no	1	1.1 ± 0.3 (stat.) $^{+0.5}_{-0.3}$ (syst.)
Combination 5	yes	no	yes		kinematically not allowed
Combination 6	no	yes	yes	4	4.5 ± 0.6 (stat.) $^{+1.8}_{-1.3}$ (syst.)
Combination 7	yes	yes	yes	2	0.6 ± 0.2 (stat.) $^{+0.1}_{-0.2}$ (syst.)
At least one selection				31	32.6 ± 1.7 (stat.) $^{+9.0}_{-5.8}$ (syst.)

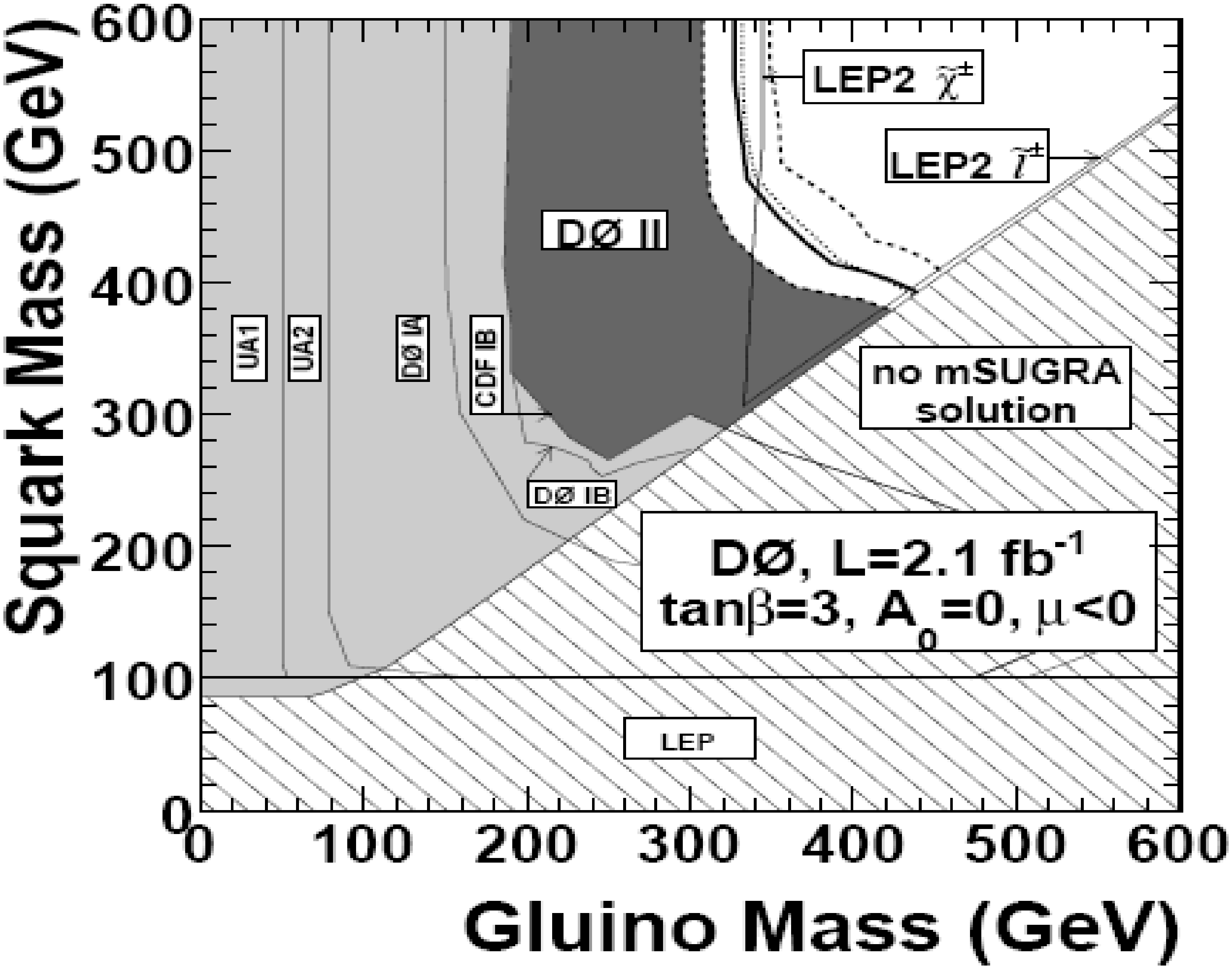
Combos of the 3 analyses

→ Feldman-Cousins 95% CL Signal limit: 8.34 events

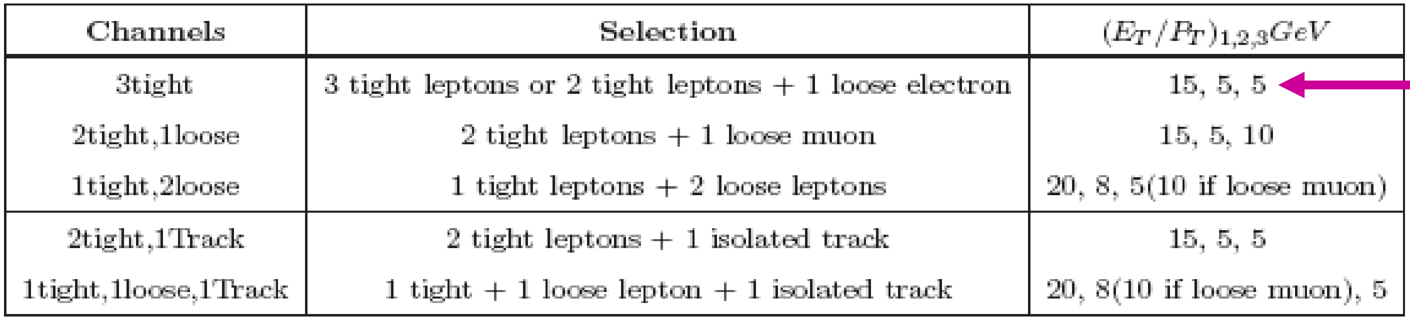
SuSpect -> SUSY-Hit -> PROSPINO -> PYTHIA -> D0-tuned PGS4 fast simulation (to reproduce the benchmark points)…

redo this analysis ~ 10^5 times !

This D0 search provides strong constraints in mSUGRA.. squarks & gluinos > 330-400 GeV…our limits can be *much weaker* on both these sparticles as we'll see !!



Tevatron II: CDF Tri-lepton Analysis



Channels	Selection	$(E_T/P_T)_{1,2,3} GeV$
3tight	3 tight leptons or 2 tight leptons + 1 loose electron	15, 5, 5
2tight,1loose	2 tight leptons + 1 loose muon	15, 5, 10
1tight,2loose	1 tight leptons + 2 loose leptons	20, 8, 5(10 if loose muon)
2tight,1Track	2 tight leptons + 1 isolated track	15, 5, 5
1tight,1loose,1Track	1 tight + 1 loose lepton + 1 isolated track	20, 8(10 if loose muon), 5

Table 1: The exclusive analysis channels. A 'tight' selection for leptons is a restrictive selection, for a 'loose' lepton the selection os made a little less restrictive to increase acceptance.

We perform this analysis using CDF-tuned PGS4, PYTHIA LO plus a PROSPINO K-factor

CDF benchmark

The benchmark mSUGRA point we consider has following parameters:

$$m_0 = 60 \text{ GeV}, m_{1/2} = 190 \text{ GeV}, \tan(\beta) = 3, A_0 = 0, \text{ and } \mu > 0 \quad (1)$$

The corresponding masses of interest are: $M_{\tilde{\chi}_1^\pm} = 119.6$ GeV, $M_{\tilde{\chi}_2^0} = 122$ GeV, and $M_{\tilde{\chi}_1^0} = 67$ GeV. and the corresponding $\tilde{\chi}_1^\pm \tilde{\chi}_2^0$ production cross section is 0.5 pb [7].

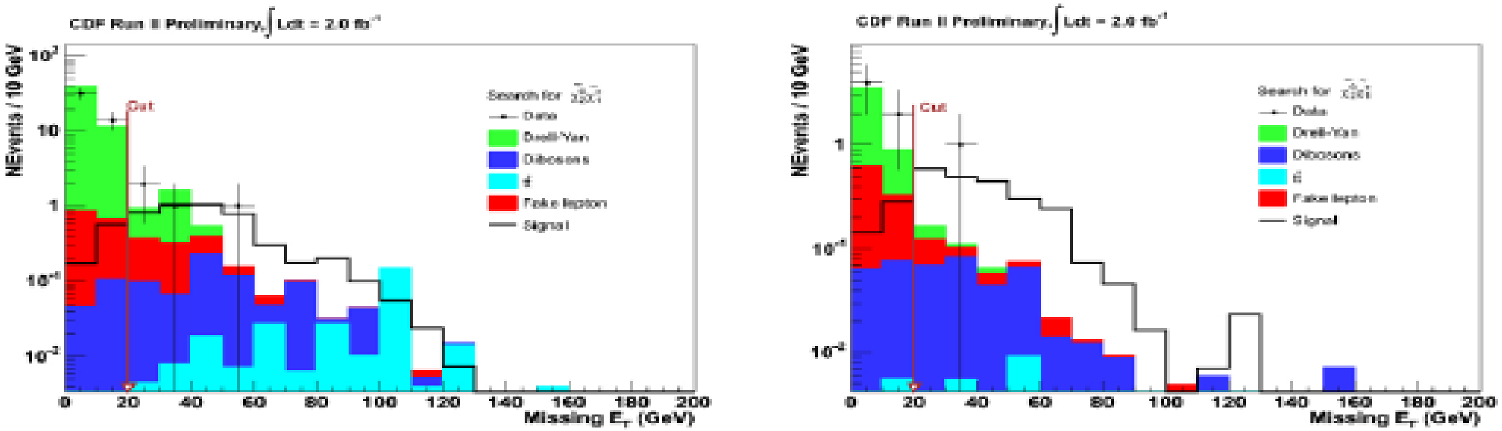
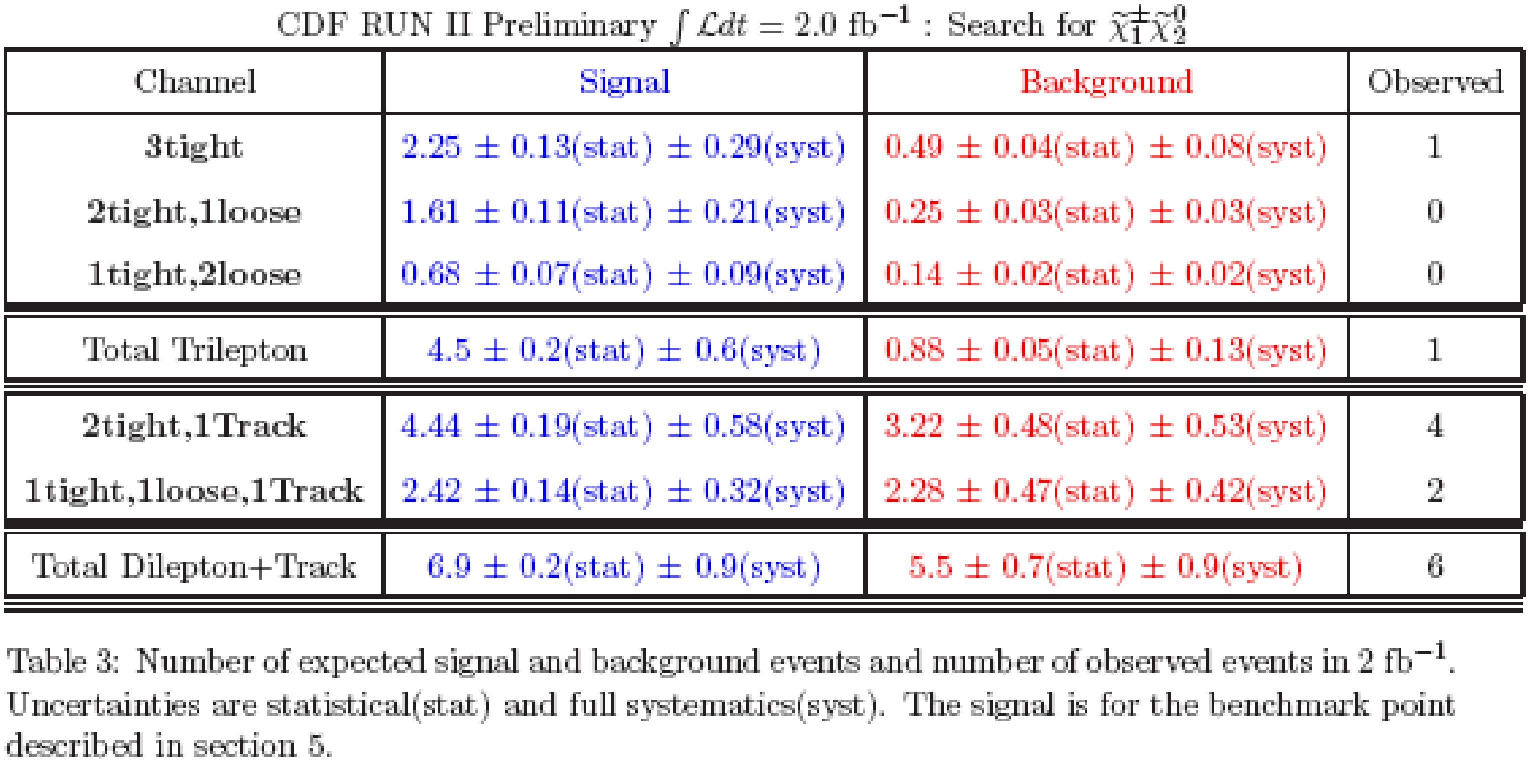


Figure 4: On the left is the $\not{E}_T$distribution for the dilepton+track channel (2tight,1Track) after all selections, on the right is the same for the trilepton channel (3tight). We keep events with $\not{E}_T > 20$ GeV.



CDF RUN II Preliminary $\int \mathcal{L}dt = 2.0\ \text{fb}^{-1}$: Search for $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^{0}$

Channel	Signal	Background	Observed
3tight	2.25 ± 0.13(stat) ± 0.29(syst)	0.49 ± 0.04(stat) ± 0.08(syst)	1
2tight,1loose	1.61 ± 0.11(stat) ± 0.21(syst)	0.25 ± 0.03(stat) ± 0.03(syst)	0
1tight,2loose	0.68 ± 0.07(stat) ± 0.09(syst)	0.14 ± 0.02(stat) ± 0.02(syst)	0
Total Trilepton	4.5 ± 0.2(stat) ± 0.6(syst)	0.88 ± 0.05(stat) ± 0.13(syst)	1
2tight,1Track	4.44 ± 0.19(stat) ± 0.58(syst)	3.22 ± 0.48(stat) ± 0.53(syst)	4
1tight,1loose,1Track	2.42 ± 0.14(stat) ± 0.32(syst)	2.28 ± 0.47(stat) ± 0.42(syst)	2
Total Dilepton+Track	6.9 ± 0.2(stat) ± 0.9(syst)	5.5 ± 0.7(stat) ± 0.9(syst)	6

Table 3: Number of expected signal and background events and number of observed events in 2 fb^{-1}. Uncertainties are statistical(stat) and full systematics(syst). The signal is for the benchmark point described in section 5.

We need to perform the 3 tight lepton analysis ~ 10^5 times

→ Feldman-Cousins 95% CL Signal limit: 4.65 events

The non-‘3-tight’ analyses are not reproducible w/o a better detector simulation

Tevatron III: D0 Stable Particle (= Chargino) Search

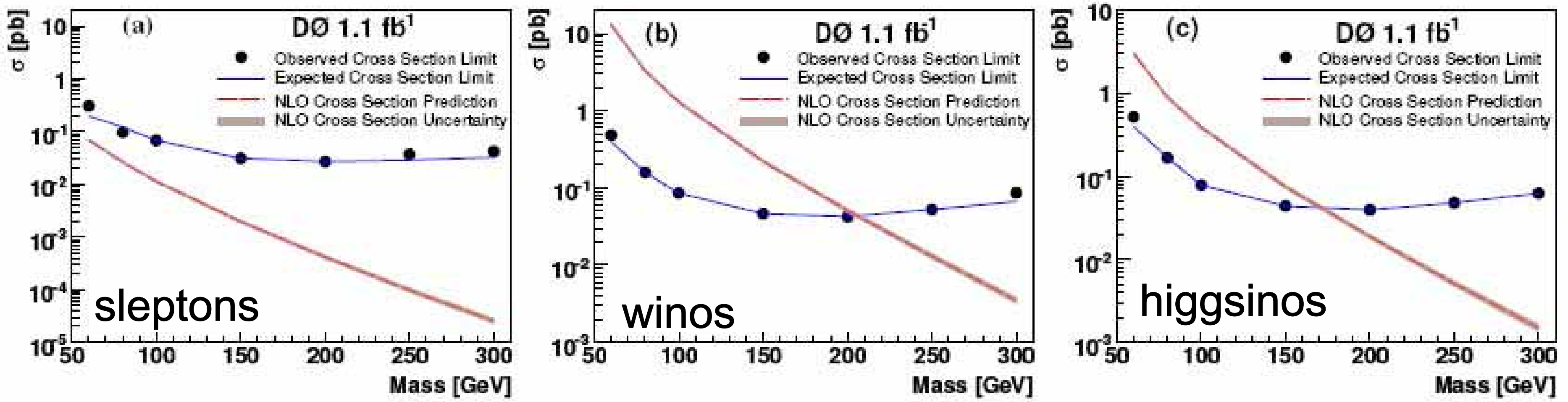
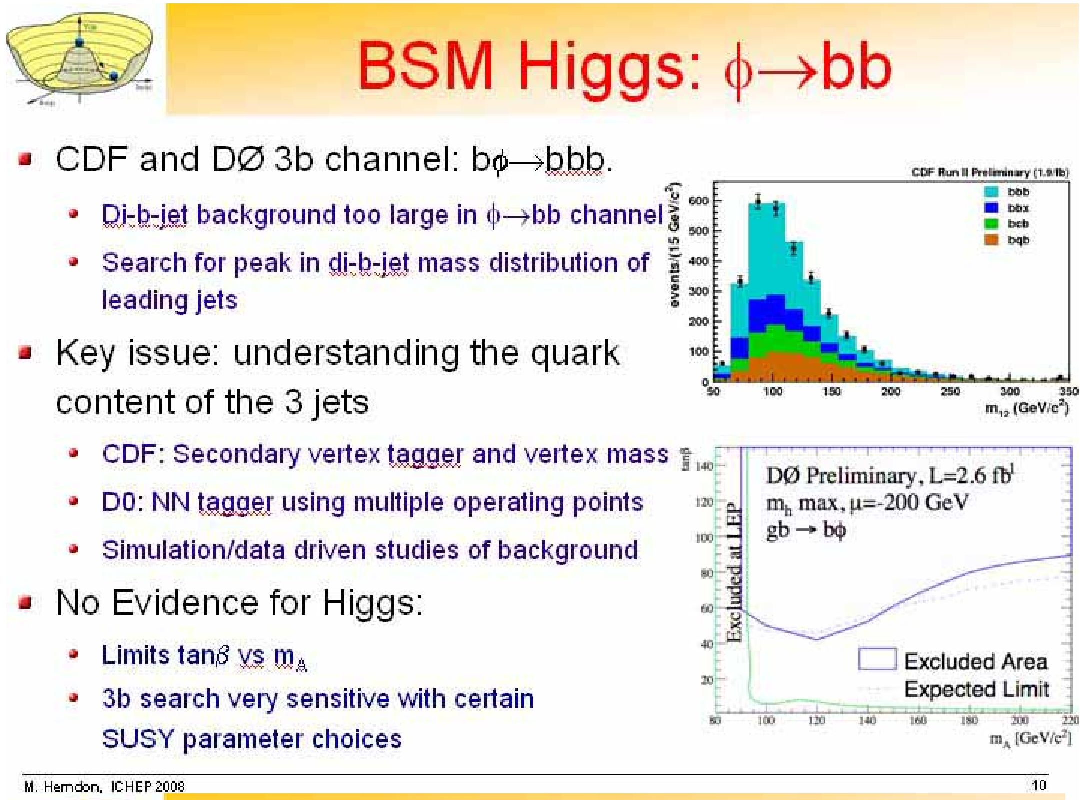


FIG. 2: The observed (dots) and expected (solid line) 95% cross section limits, the NLO production cross section (dashed line), and NLO cross section uncertainty (barely visible shaded band) as a function of (a) stau mass for stau pair production, (b) chargino mass for pair produced gaugino-like charginos, and (c) chargino mass for pair produced higgsino-like charginos.

Interpolation: $M_\chi > 206\,|U_{1w}|^2 + 171\,|U_{1h}|^2$ GeV

This is an *incredibly* powerful constraint on our model set as we will have many close mass chargino-neutralino pairs. This search cuts out a huge parameter region as you will see later. No applicable bounds on charged sleptons..the cross sections are too small.



BSM Higgs: $\phi \rightarrow bb$

- CDF and DØ 3b channel: $b\phi \rightarrow bbb$.
  - Di-b-jet background too large in $\phi \rightarrow bb$ channel
  - Search for peak in di-b-jet mass distribution of leading jets
- Key issue: understanding the quark content of the 3 jets
  - CDF: Secondary vertex tagger and vertex mass
  - D0: NN tagger using multiple operating points
  - Simulation/data driven studies of background
- No Evidence for Higgs:
  - Limits $\tan\beta$ vs m_A
  - 3b search very sensitive with certain SUSY parameter choices

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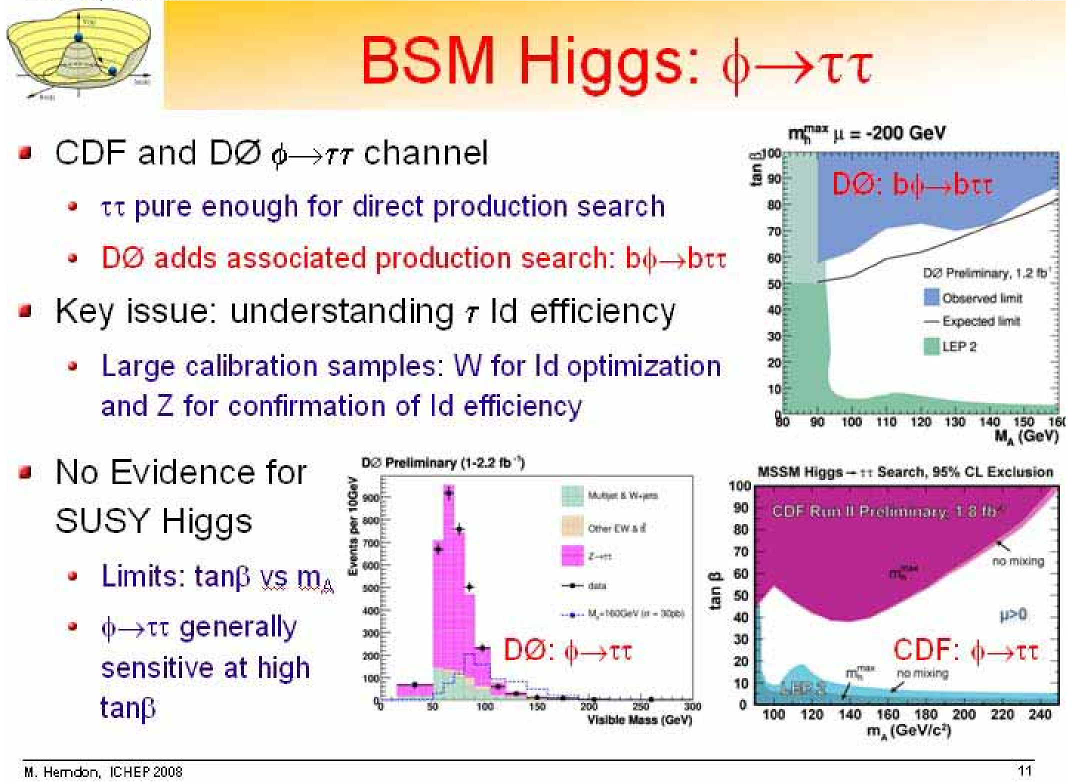

BSM Higgs: $\phi \rightarrow \tau\tau$

- CDF and DØ $\phi \rightarrow \tau\tau$ channel
  - $\tau\tau$ pure enough for direct production search
  - DØ adds associated production search: $b\phi \rightarrow b\tau\tau$
- Key issue: understanding τ Id efficiency
  - Large calibration samples: W for Id optimization and Z for confirmation of Id efficiency
- No Evidence for SUSY Higgs
  - Limits: $\tan\beta$ vs m_A
  - $\phi \rightarrow \tau\tau$ generally sensitive at high $\tan\beta$

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Tevatron IV :

We also incorporate the results of some null BSM Higgs searches at the Tevatron to round things out. These do not play a large role given our assumed parameter ranges in our scans.

$\tan\beta > 1.2\, M_A - 70$

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ATLAS	SU1	OK
	SU2	killed by LEP
	SU3	killed by Ωh^2
	SU4	killed by $b \to s\gamma$
	SU8	killed by g-2
CMS	LM1	killed by Higgs
	LM2	killed by g-2
	LM3	killed by $b \to s\gamma$
	LM4	killed by Ωh^2
	LM5	killed by Ωh^2
	LM6	OK
	LM7	killed by LEP
	LM8	killed by Ωh^2
	LM9	killed by LEP
	LM10	OK
	HM2	killed by Ωh^2
	HM3	killed by Ωh^2
	HM4	killed by Ωh^2

For the curious:

Most well-studied models do not survive confrontation with the latest data.

For many models this is not the unique source of failure

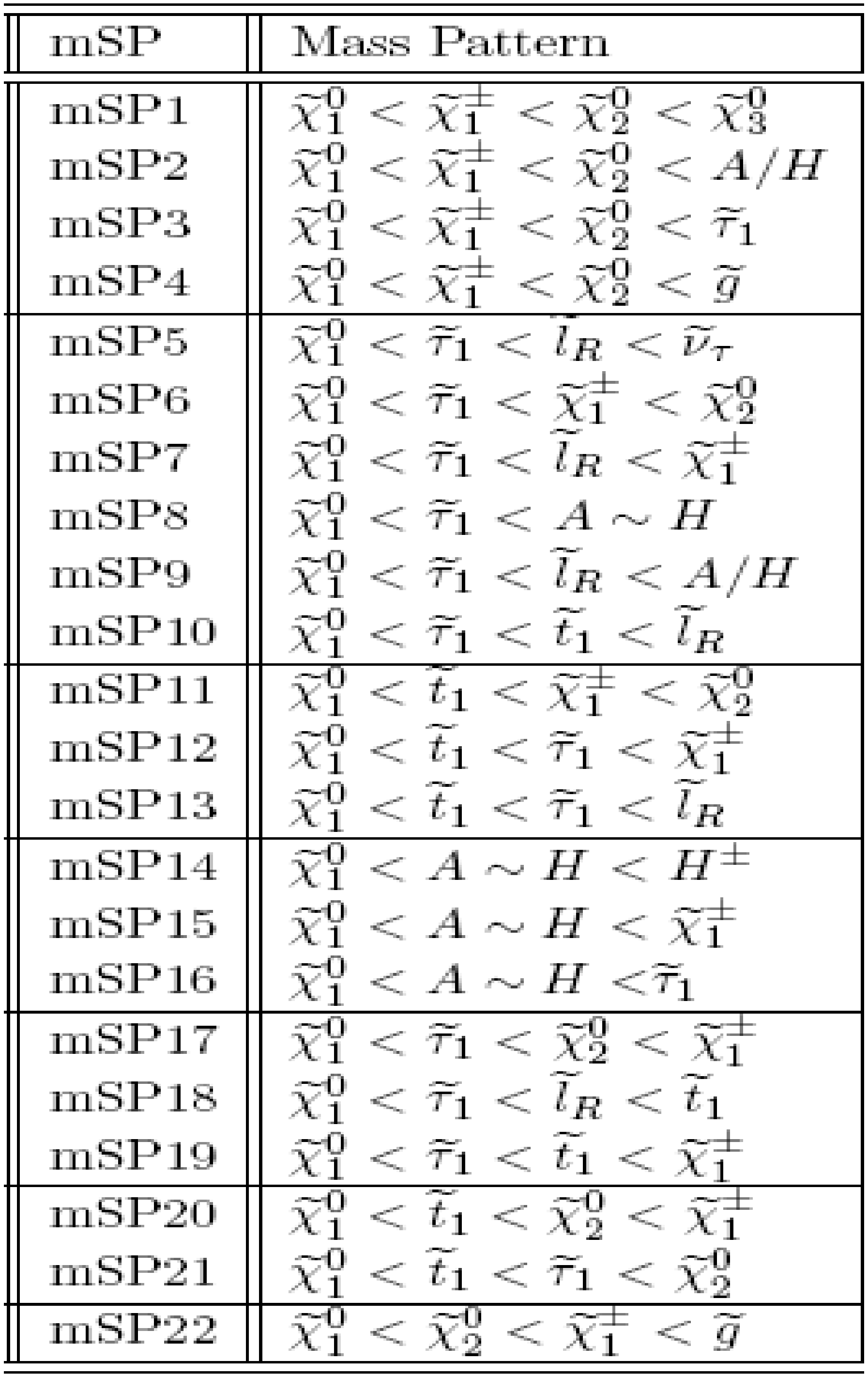
Similarly for the SPS Points

SPS1a	killed by $b \rightarrow s\gamma$
SPS1a’	OK
SPS1b	killed by $b \rightarrow s\gamma$
SPS2	killed by Ωh^2 (GUT) / OK(low)
SPS3	killed by Ωh^2 (low) / OK(GUT)
SPS4	killed by g-2
SPS5	killed by Ωh^2
SPS6	OK
SPS9	killed by Tevatron stable chargino

Results?????

Time to ‘spread the wealth around’

See JoAnne’s talk next up



mSP	Mass Pattern	Linear	Log
mSP1	$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{\chi}_3^0$	9.81	18.49
mSP2	$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < A/H$	2.07	0.67
mSP3	$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{\tau}_1$	5.31	6.60
mSP4	$\tilde{\chi}_1^0 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0 < \tilde{g}$	2.96	3.70
mSP5	$\tilde{\chi}_1^0 < \tilde{\tau}_1 < \tilde{l}_R < \tilde{\nu}_\tau$	0.02	0.13
mSP6	$\tilde{\chi}_1^0 < \tilde{\tau}_1 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0$	0.46	1.21
mSP7	$\tilde{\chi}_1^0 < \tilde{\tau}_1 < \tilde{l}_R < \tilde{\chi}_1^\pm$	0.02	0.03
mSP8	$\tilde{\chi}_1^0 < \tilde{\tau}_1 < A \sim H$	0.06	0.00
mSP9	$\tilde{\chi}_1^0 < \tilde{\tau}_1 < \tilde{l}_R < A/H$	0.01	0.00
mSP10	$\tilde{\chi}_1^0 < \tilde{\tau}_1 < \tilde{t}_1 < \tilde{l}_R$	0.00	0.00 ←
mSP11	$\tilde{\chi}_1^0 < \tilde{t}_1 < \tilde{\chi}_1^\pm < \tilde{\chi}_2^0$	0.09	0.00
mSP12	$\tilde{\chi}_1^0 < \tilde{t}_1 < \tilde{\tau}_1 < \tilde{\chi}_1^\pm$	0.01	0.00
mSP13	$\tilde{\chi}_1^0 < \tilde{t}_1 < \tilde{\tau}_1 < \tilde{l}_R$	0.01	0.00
mSP14	$\tilde{\chi}_1^0 < A \sim H < H^\pm$	0.35	0.10
mSP15	$\tilde{\chi}_1^0 < A \sim H < \tilde{\chi}_1^\pm$	0.01	0.03
mSP16	$\tilde{\chi}_1^0 < A \sim H < \tilde{\tau}_1$	0.08	0.00
mSP17	$\tilde{\chi}_1^0 < \tilde{\tau}_1 < \tilde{\chi}_2^0 < \tilde{\chi}_1^\pm$	0.18	0.40
mSP18	$\tilde{\chi}_1^0 < \tilde{\tau}_1 < \tilde{l}_R < \tilde{t}_1$	0.01	0.00
mSP19	$\tilde{\chi}_1^0 < \tilde{\tau}_1 < \tilde{t}_1 < \tilde{\chi}_1^\pm$	0.00	0.00
mSP20	$\tilde{\chi}_1^0 < \tilde{t}_1 < \tilde{\chi}_2^0 < \tilde{\chi}_1^\pm$	0.06	0.00
mSP21	$\tilde{\chi}_1^0 < \tilde{t}_1 < \tilde{\tau}_1 < \tilde{\chi}_2^0$	0.01	0.00
mSP22	$\tilde{\chi}_1^0 < \tilde{\chi}_2^0 < \tilde{\chi}_1^\pm < \tilde{g}$	0.27	0.51