Challenges for Supersymmetry in this Millennium

J. Bagger

SUSY 2000

FIND IT!

Rise of the SM

Before we look forward, we must first look back.

Not 1,000 years, but 25:

1974	Discovery of charm quark
1976	Discovery of tau lepton
1977	Discovery of bottom quark
1979	Discovery of gluon
1983	Discovery of W,Z
1994	Discovery of top quark

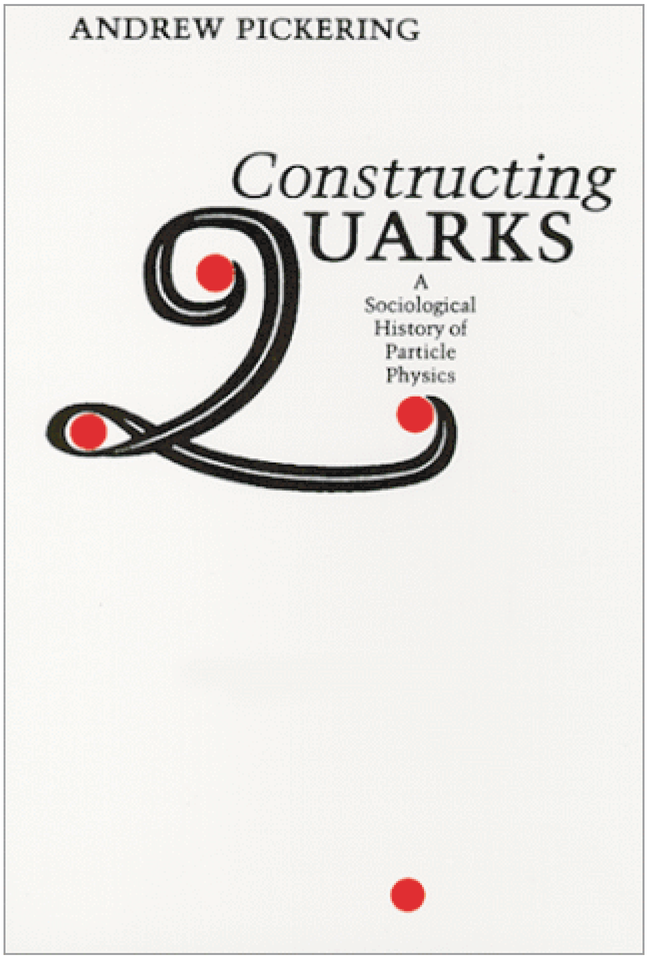
There is no question that this has been a remarkable era!

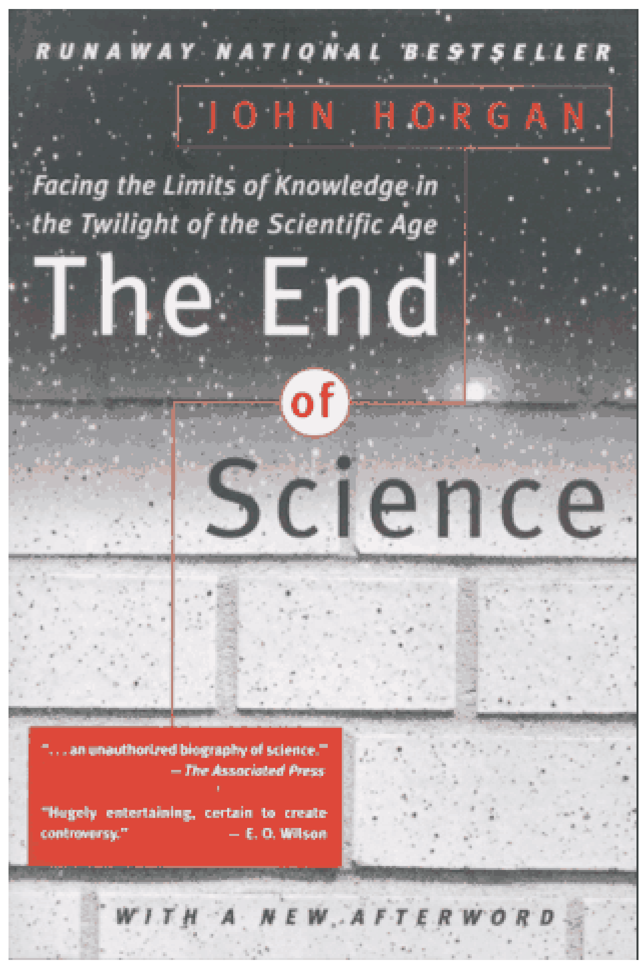
Postmodern Attack

Some say that the decreasing rate of discovery proves that the good times are over.

They argue that we are, in fact, reaching "The End of Science."

This postmodern view is reflected in the press, in politics, and in academia.


ANDREW PICKERING
Constructing
QUARKS
A
Sociological
History of
Particle
Physics


RUNAWAY NATIONAL BESTSELLER
JOHN HORGAN
Facing the Limits of Knowledge in
the Twilight of the Scientific Age
The End
of
Science
". . . an unauthorized biography of science."
— The Associated Press
"Hugely entertaining, certain to create
controversy." — E. O. Wilson
WITH A NEW AFTERWORD

Vith the Arts
\nd Entertainment

Science Times

The New York Times

315 Physicists Report Failure In Search for Supersymmetry

The negative result illustrates the risks of Big Science, and its often sparse pickings.

By MALCOLM W. BROWNE

THREE HUNDRED AND FIFTEEN physicists worked on the experiment.

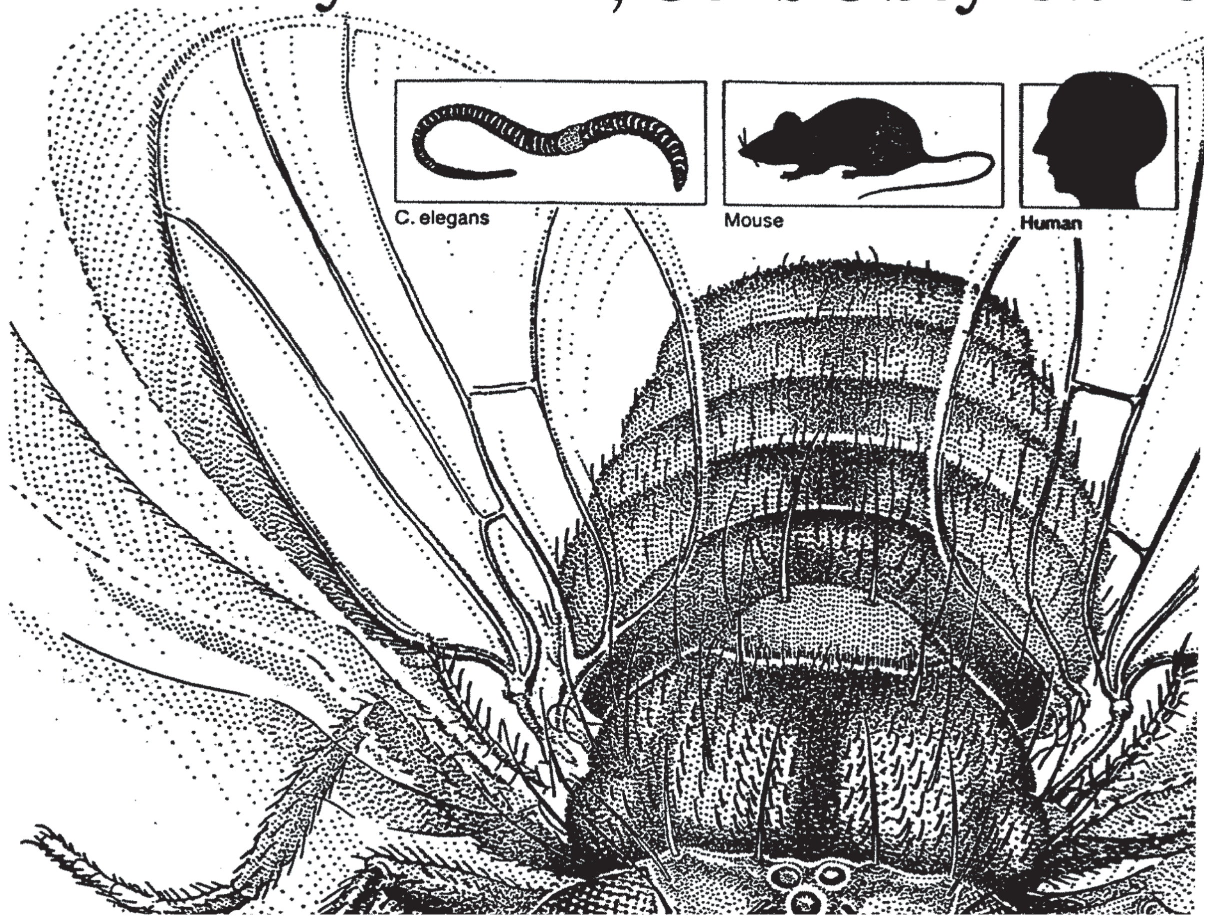
Their apparatus included the Tevatron, the world's most powerful particle accelerator, as well as a $65 million detector weighing as much as a warship, an advanced new computing system and a host of other innovative gadgets.

But despite this arsenal of brains and technological brawn assembled at the Fermilab accelerator laboratory, the participants have failed to find their quarry, a disagreeable reminder that as science gets harder, even Herculean efforts do not guarantee success.

In trying to ferret out ever deeper layers of nature's secrets, scientists are being forced to accept a markedly slower pace of discovery in many fields of research, and the consequent rising cost of experiments has prompted public and political criticism.

To some, the elaborate trappings and null result of the latest Fermilab experiment seem to typify both the lofty goals and the staggering difficulties of "Big Science," a term coined in 1961 by Dr. Alvin M. Weinberg of Oak Ridge National Laboratory. Some regard such fail-

From Fly to Man, Cells Obey Same



OK / NOT OK

Print, email, or fax this article for free.

Bruce Sterling's fissionary in/out list for the next 100 years.

Intellectually Sexy for 2000 and Beyond

Cruise missiles The ultimate billy club of the New World Order, the rich guy's truck bomb. Expect a rain of them anytime NATO loses its temper - especially in the Balkans, where it's not over by a long chalk. What to watch for: a cheapo Third World version, made of wooden kite framework and targeted via GPS.

Meteorological disasters In 1998 there were more weather-insurance payouts than during the entire 1980s. A harbinger of worse things to come: After the Hurricane Floyd floods, North Carolina drowned in pig excrement oozing from huge, centralized hog farms.

Antibiotic resistance The dark side of the biotech revolution is upon us. The microbial world is promiscuously switching packets of resistance data, crossing species lines to get each other up to speed in their war against penicillin. Prepare for a new septic age.

Peewee powers with big bangs Thanks, Pakistan, for the Islamic nuke and consequent coup d'état - nice to know the bomb is in unstable hands.

Stock ownership Equity, not salary! Stocktrader Nation! It really is a social revolution. More to the point, owning stock is the only way to get out of the new economy alive.

Fills Me With Inertia

Quarks Particle physics has been gut-shot ever since the spectacular failure of the Superconducting Super Collider. The next generation of physicists is going where the real money is - computer science. At the end of the 20th century, the only thing more pitifully dated than being an atom splitter is being a rocket scientist.

Voice-based telephone companies Living only on the iron lung of government regulation. They just can't buy a clue in Netland.

Network television The nets are the playthings of Disney and Viacom anyhow, so good riddance to them. Shovel 'em under, along with the news-anchor father figures the population "trusted."

NO!

These experimental discoveries have led us to develop a microscopic theory of matter.

The theory has been tested to incredible precision.

History will show this to be one of the most compelling successes of the 20^{th} century.

Moreover, the story is not complete:

There is every reason to expect that a threshold for new physics is close at hand.

How this plays out will be a central drama of the next 100 years!

Prophecies?

As a physicist, I believe that the post-modernists will be proved wrong.

In the end, I expect that science will prevail.

The conference organizers have asked me to look ahead and describe how the battle will be won.

However, I find it hard to look ahead 20 years, much less 50, 100 or 1000.

For that I urge you to consult Nostradamus.

This Talk

In this talk I will narrow my focus.

I will first describe the present, and then I will peek ahead 10 – 20 years.

I will argue that we are about to enter a second golden era for experimental particle physics!

And we theorists had better be ready ….

The Year 2000

In the year 2000, we have the Minimal Standard Model: the quarks, leptons and gauge bosons.

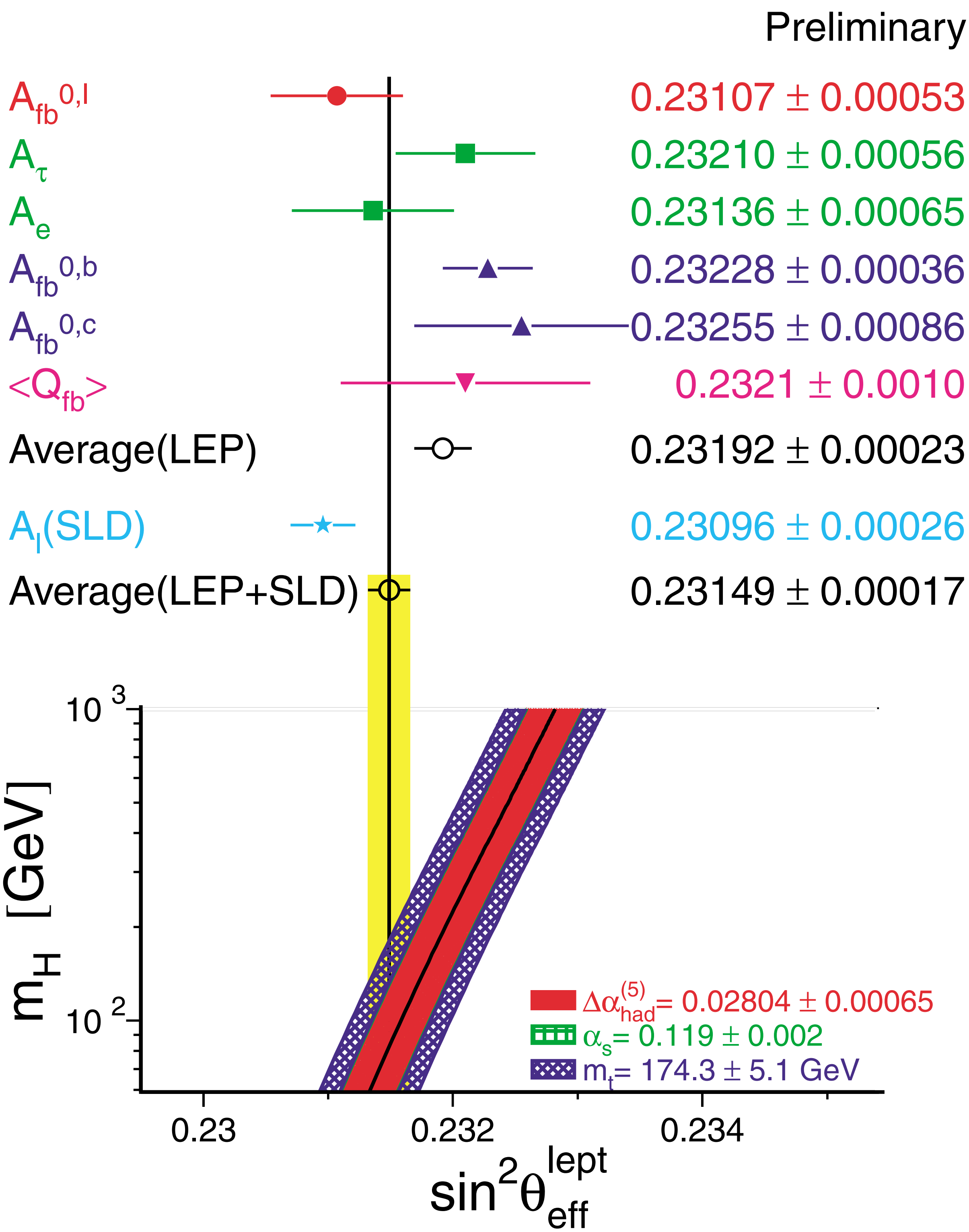
It is a nonrenormalizable effective field theory, which breaks down by 3 TeV.

It works beautifully at today's energies. All data to date are in accord with its predictions.

In fact, the data seem to indicate that Minimal Standard Model breaks down well before the TeV scale.

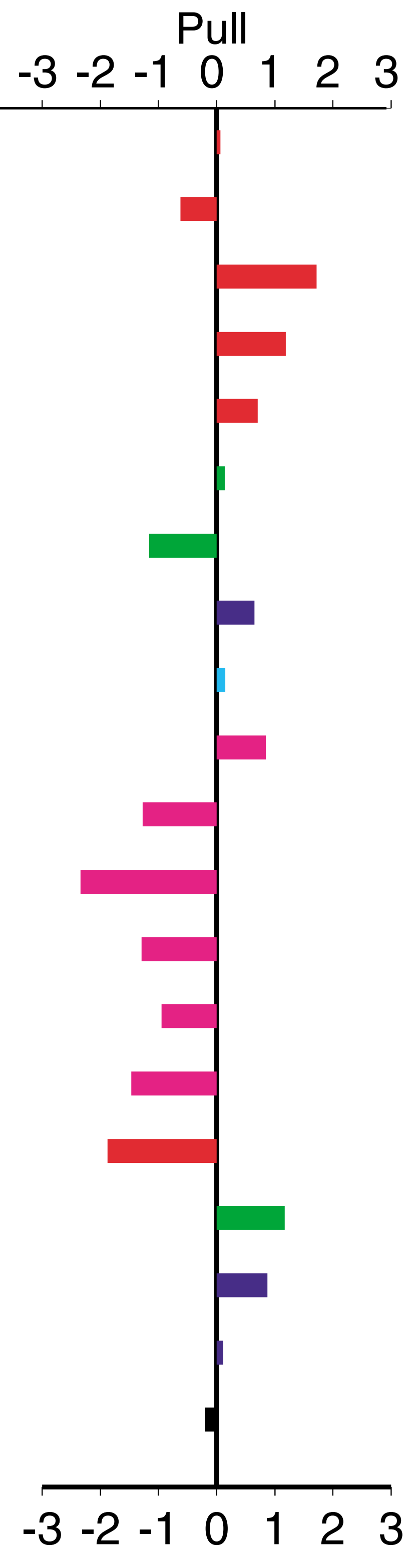
A new threshold is close at hand!

Weak Mixing Angle

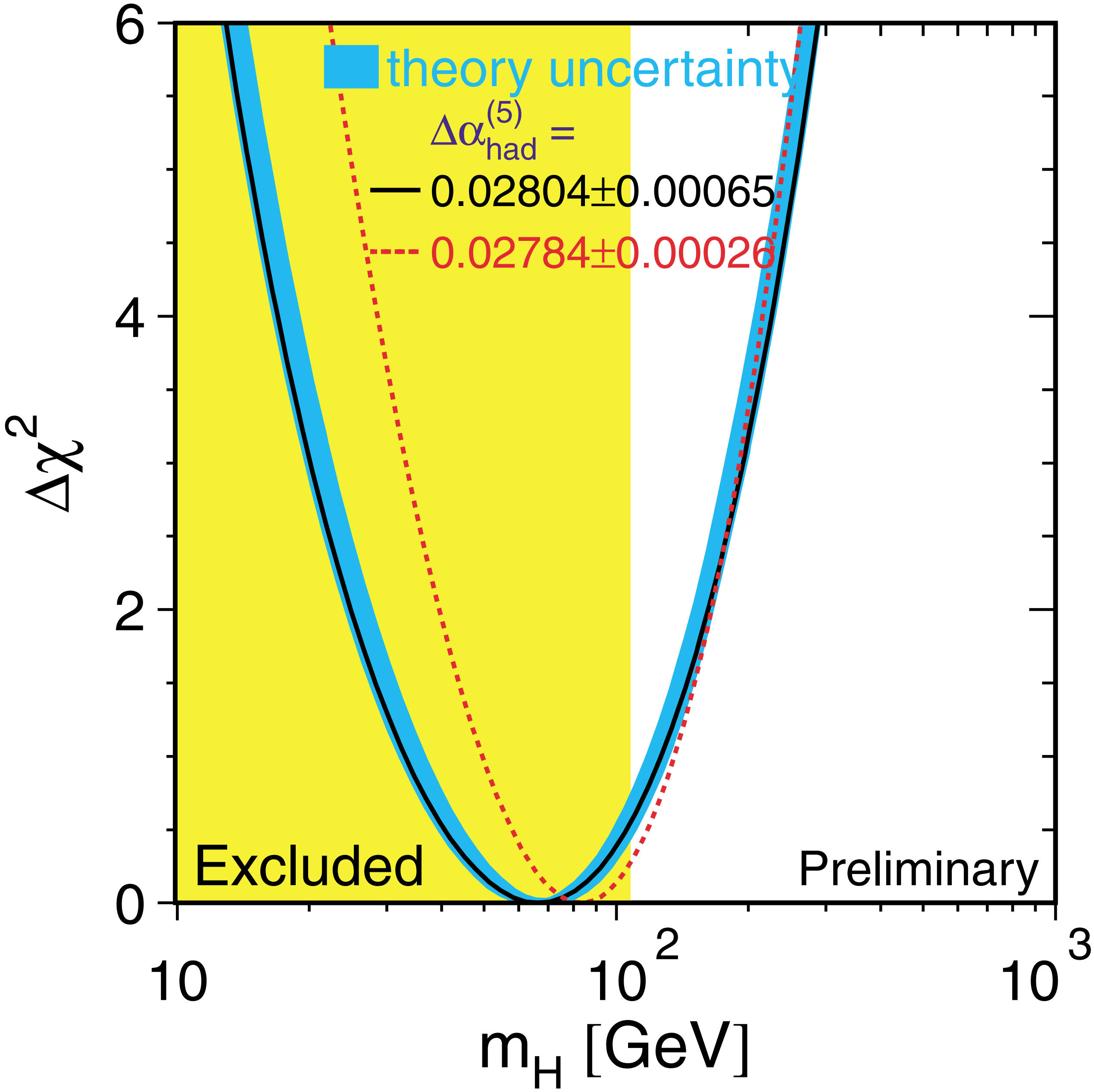


SM Fit

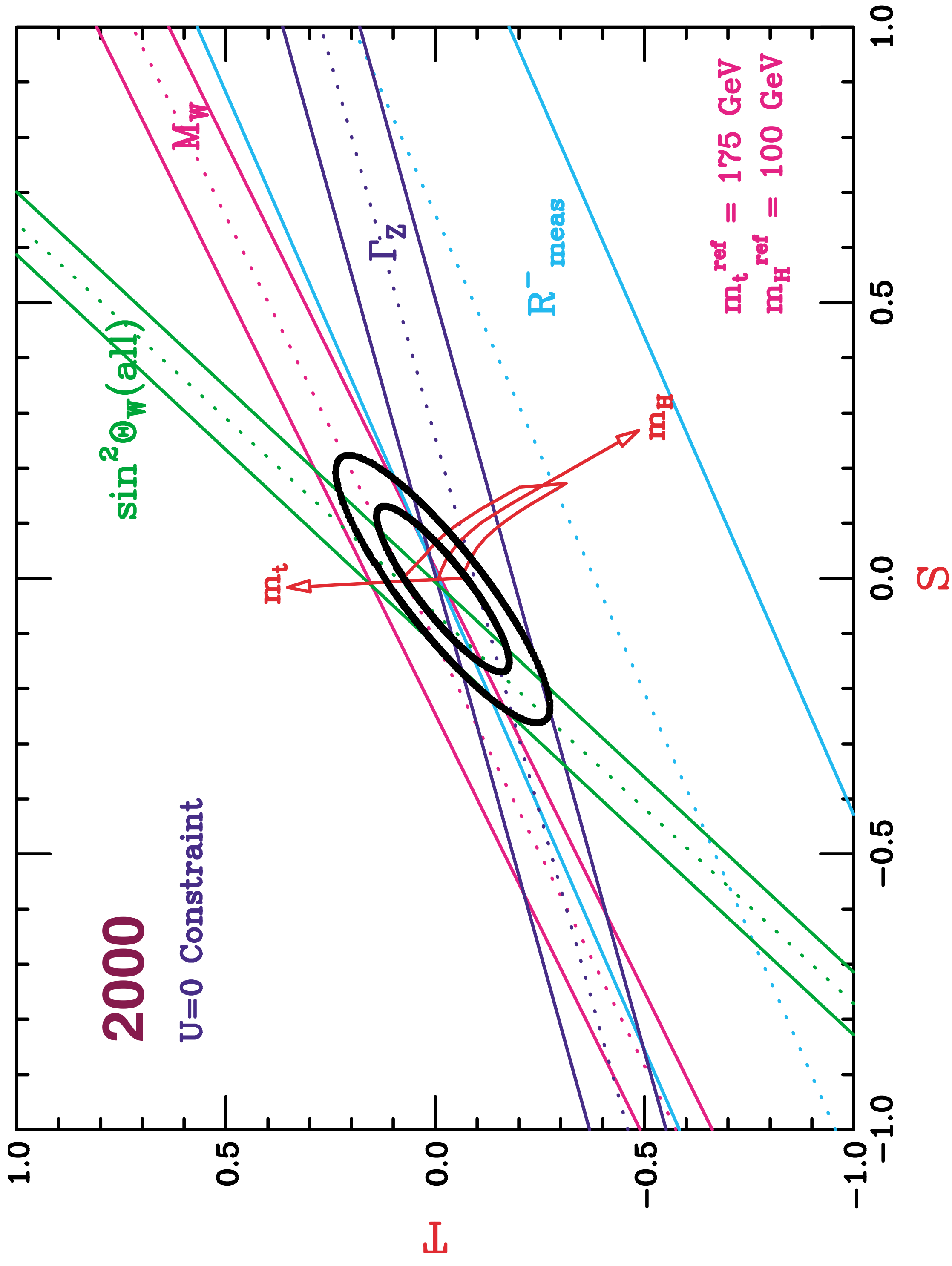
	Measurement	Pull
m_Z [GeV]	91.1871 ± 0.0021	.07
Γ_Z [GeV]	2.4944 ± 0.0024	-.62
σ^0_{hadr} [nb]	41.544 ± 0.037	1.72
R_e	20.768 ± 0.024	1.19
$A^{0,e}_{fb}$	0.01701 ± 0.00095	.70
A_e	0.1483 ± 0.0051	.13
A_τ	0.1425 ± 0.0044	-1.16
$\sin^2\theta^{lept}_{eff}$	0.2321 ± 0.0010	.65
m_W [GeV]	80.401 ± 0.048	.15
R_b	0.21642 ± 0.00073	.85
R_c	0.1674 ± 0.0038	-1.27
$A^{0,b}_{fb}$	0.0988 ± 0.0020	-2.34
$A^{0,c}_{fb}$	0.0692 ± 0.0037	-1.29
A_b	0.911 ± 0.025	-.95
A_c	0.630 ± 0.026	-1.47
$\sin^2\theta^{lept}_{eff}$	0.23096 ± 0.00026	-1.87
$\sin^2\theta_W$	0.2255 ± 0.0021	1.17
m_W [GeV]	80.448 ± 0.062	.88
m_t [GeV]	174.3 ± 5.1	.11
$\Delta\alpha^{(5)}_{had}(m_Z)$	0.02804 ± 0.00065	-.20



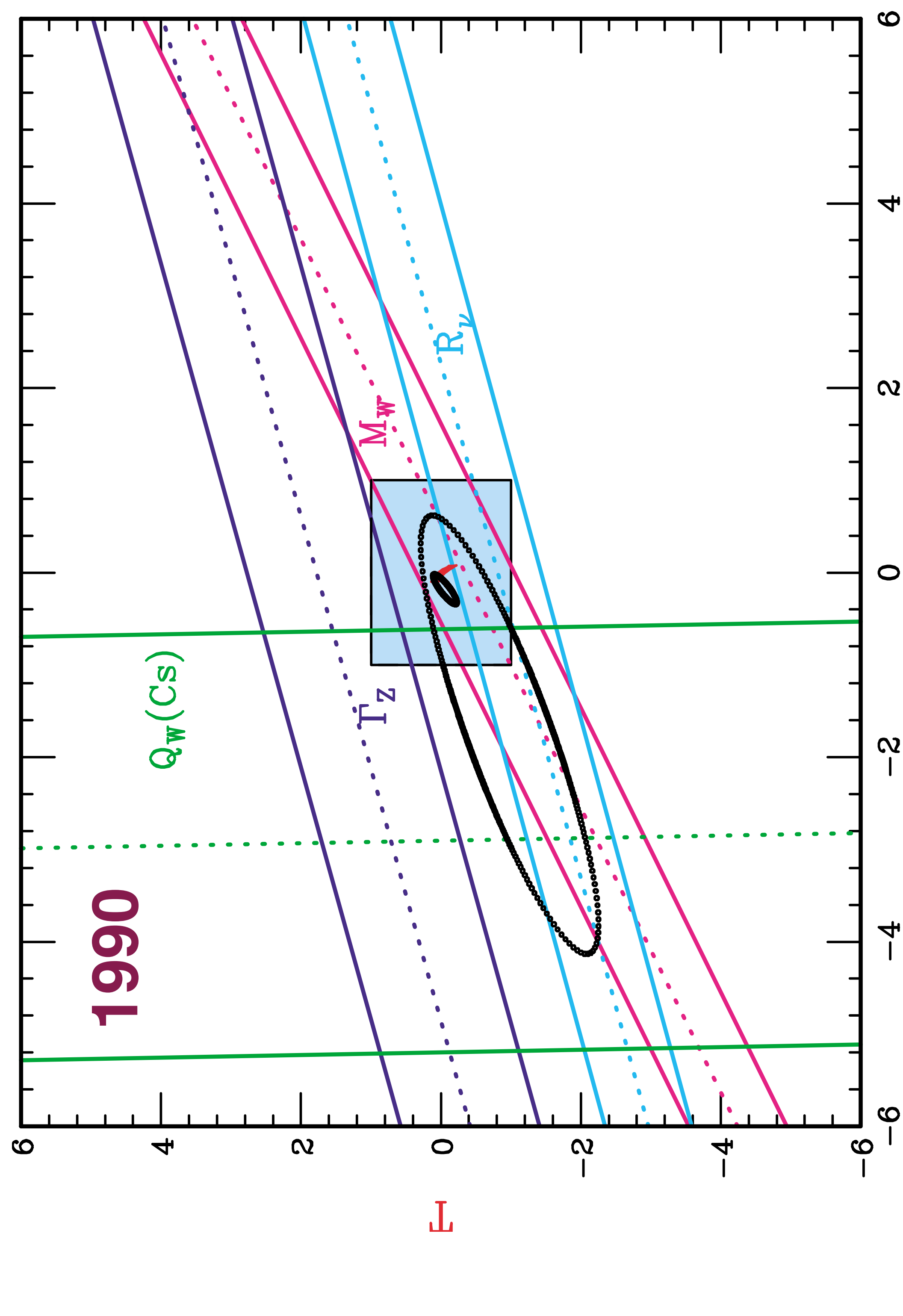
Higgs Mass



theory uncertainty
$\Delta\alpha^{(5)}_{had}$ =
0.02804±0.00065
0.02784±0.00026
Excluded
Preliminary
6
4
2
0
10
10^2
10^3
$\Delta\chi^2$
m_H [GeV]



2000
U=0 Constraint
sin²Θ_W(all)
M_W
Γ_Z
R⁻_meas
m_t^ref = 175 GeV
m_H^ref = 100 GeV
m_t
m_H
S
T


1990
$Q_W(Cs)$
Γ_Z
M_W
R_ν
S
T

The Year 2020

By 2020 we will have constructed the Supersymmetric Standard Model – and we will be wondering what lies beyond.

We will have developed a deeper understanding of space and time.

We will have found extra dimensions, either bosonic or fermionic.

We will have discovered at least two Higgs doublets and a large variety of superparticles.

We will be busy filling in the Sparticle Data Book.

The SPDG is an international collaboration that reviews Sparticle Physics and related areas of Astrophysics, and compiles/analyzes data on particle properties. SPDG products are distributed to 130,000 physicists, teachers, and other interested people. **The Review of Sparticle Physics** is the most cited publication in particle physics during the last twenty years. Plots of SPDG statistics are available.

Mirror sites: USA (LBNL) Brazil CERN Italy (Genova) Japan (KEK) Russia (Novosibirsk) Russia (Protvino) UK (Durham)

Review of Sparticle Physics Charts, Educational materials, Sparticle Adventure Information and Databases
US-HEPFOLK Sparticle Physics: Twenty Years of Discoveries Home Pages of major HEP labs

The Review of Sparticle Physics

C. Caso *et al*, The European Physical Journal **C103** (2018) 1 (2018 Authors)

- 2019 **2019 Web update of Reviews, Tables, Plots** **New November 2, 2019**
- 2019 **2019 Web update of Sparticle Listings** **New July 6, 2019**

- 2018 **2018 Summary Tables and Conservation Laws**
- **2018 Reviews, Tables, Plots (incl. Intro. Text)** **Superseded by 2019 Web Version**
- **2018 Sparticle Listings (published version)** **Superseded by 2019 Web Version**

- **Errata** (last changed January 18, 2020)
- Archived WWW editions: 2017 2016 2015
- Descriptions of the Summary Tables, Reviews, Listings, etc.
- **Ordering information** and list of products
- **2018 Authors** and **Directory of Sparticle Data Group Authors, Associates, and Advisors**
- Computer-readable files -- masses, widths, cross-sections, etc., including Palm Pilot XXII files.
- Encoder tools (for SPDG collaborators)

Why?

- Supersymmetry protects the electro-weak hierarchy from destabilizing divergences.

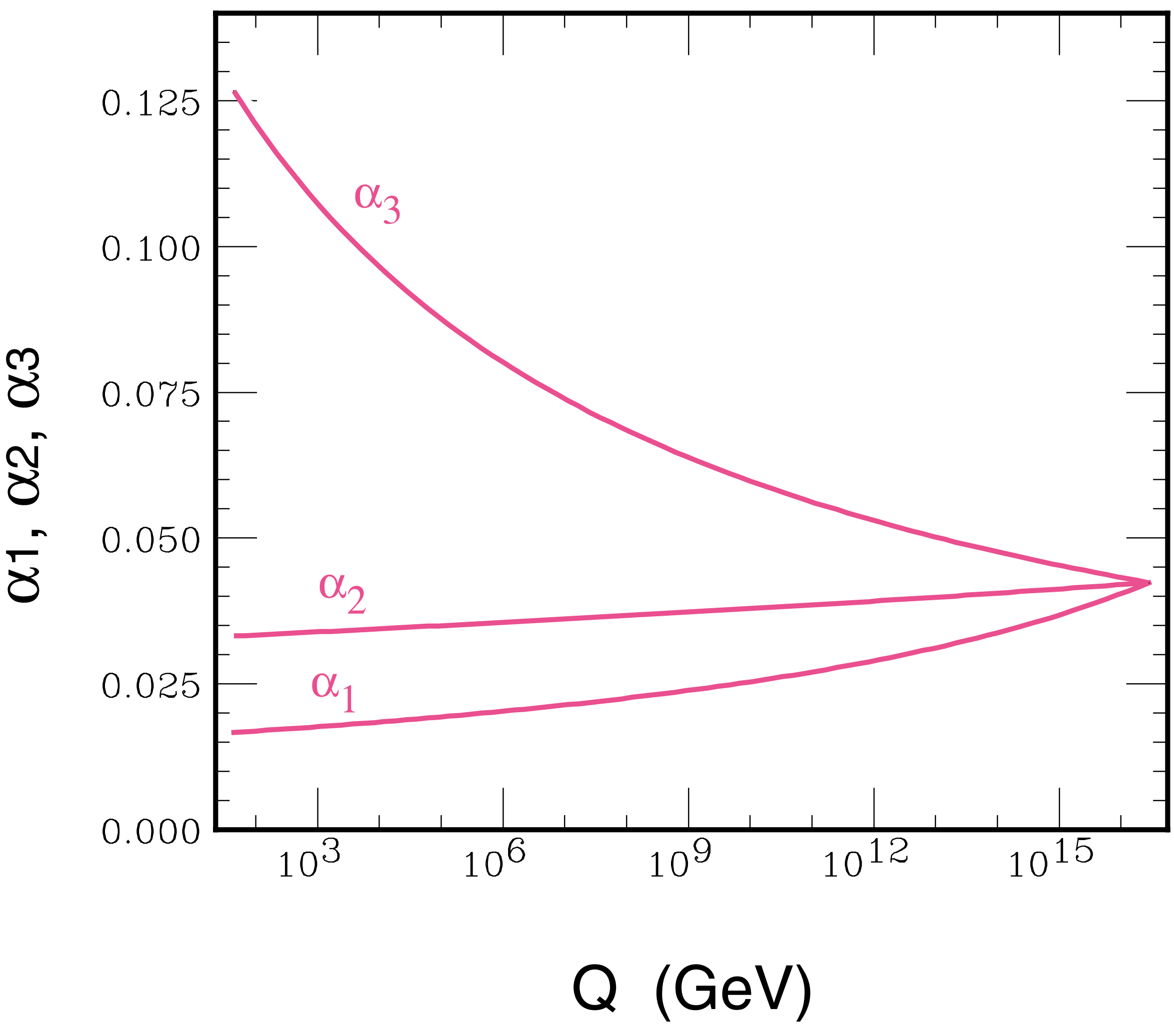
- Supersymmetry leads to the unification of gauge couplings.

- Supersymmetry decouples from precision measurements.

- Supersymmetry accommodates a large top quark mass.

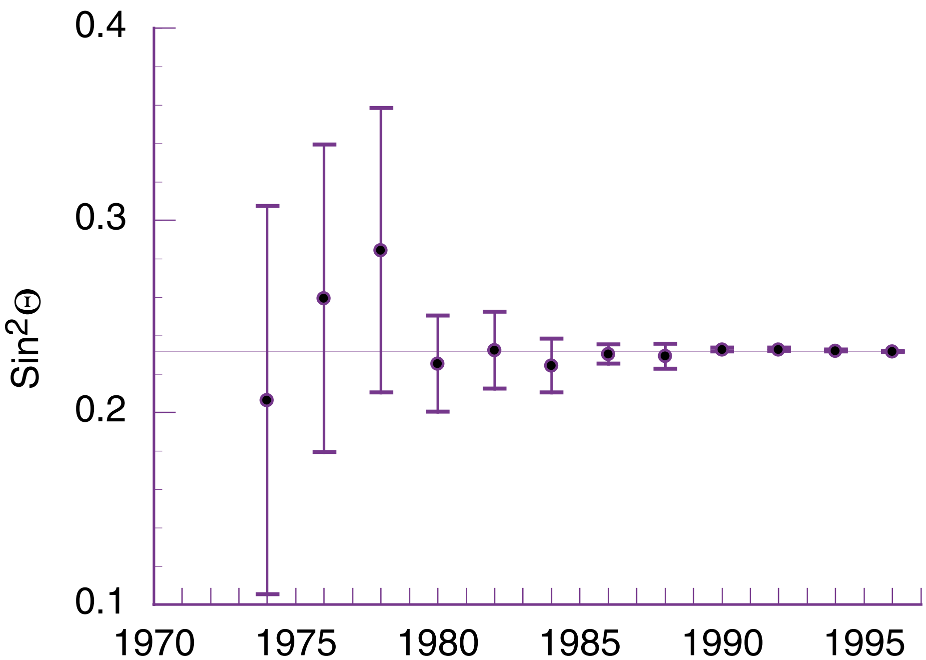
- Supersymmetry can provide a natural candidate for dark matter.

Gauge Unification

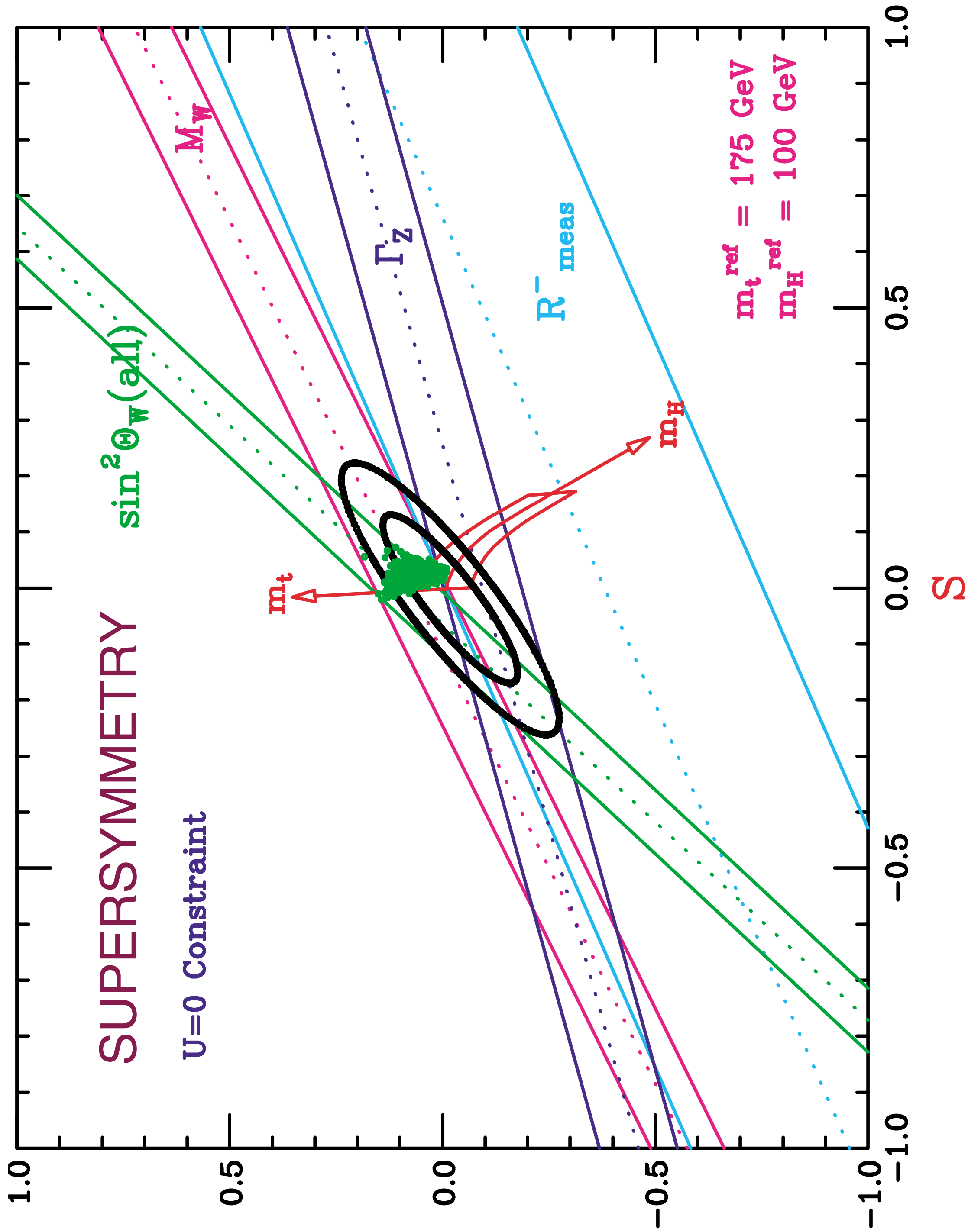


Dimopoulos, Raby, Wilczek

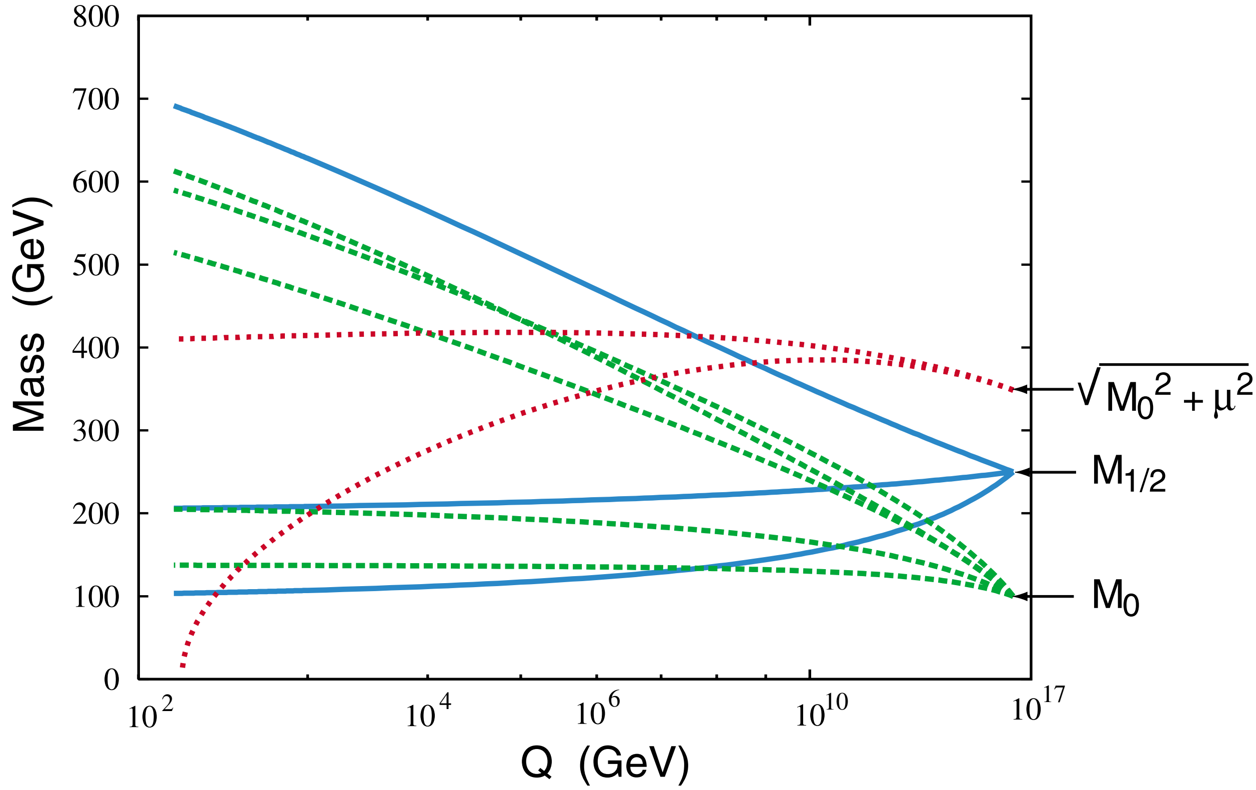
Time Series



It took 20 years to get this right!


SUPERSYMMETRY
U=0 Constraint
$\sin^2\Theta_W$(all)
M_W
Γ_Z
R^-_{meas}
m_t^{ref} = 175 GeV
m_H^{ref} = 100 GeV
m_t
m_H
S
T
−1.0
−0.5
0.0
0.5
1.0

Top Quark



The Higgs mass is driven negative by the large top quark Yukawa.

Experiment

Experiments are finally beginning push into a significant region of super-symmetry parameter space.

By 2010, we will finally know whether weak-scale supersymmetry is right or wrong.

If it is right, we can expect a huge change in our field. Because, after all, this is an experimentally driven subject.

(Can you imagine coming up with SU(3) x SU(2) x U(1) on the basis of aesthetics alone?)

It will be like the 1950's and 1960's, when each new accelerator revealed a bewildering array of new particles!


WIDESCREEN SPECIAL EDITION
ROSANNA ARQUETTE
AIDAN QUINN
AND MADONNA
AS SUSAN
DESPERATELY SEEKING SUSY

Since 1985!

Theory

On the theory side, we are witnessing a flowering of creative activity.

Already the tempo is quickening:

1981	MSSM
1983	Gravity mediation
1995	Gauge mediation
1998	Anomaly mediation
1999	Gaugino mediation

The tyranny of mSUGRA is over!

New Ideas

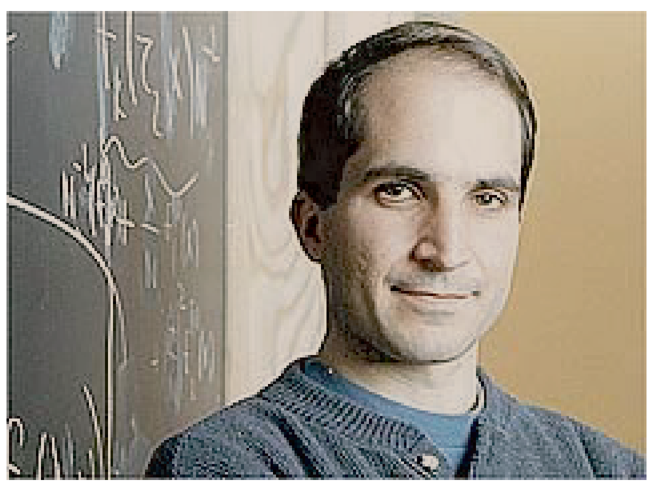
Moreover, a variety of new ideas are germinating:

1994	Duality
1995	D-Branes/ M-theory
1996	Weak scale strings
1997	AdS/CFT relation
1998	Microscopic and macroscopic extra dimensions
1999	Infinitely large extra dimensions

June 20, 2000

New Generation of Physicists Sustains a Permanent Revolution

By GEORGE JOHNSON



With the stern visage of Leon Trotsky glaring from a huge screen behind the lectern, Dr. Joseph Lykken, a particle physicist at the Fermi National Accelerator Laboratory in Batavia, Ill., launched into his best parody of a coffeehouse radical railing against the counterrevolutionary tendencies of the old guard.

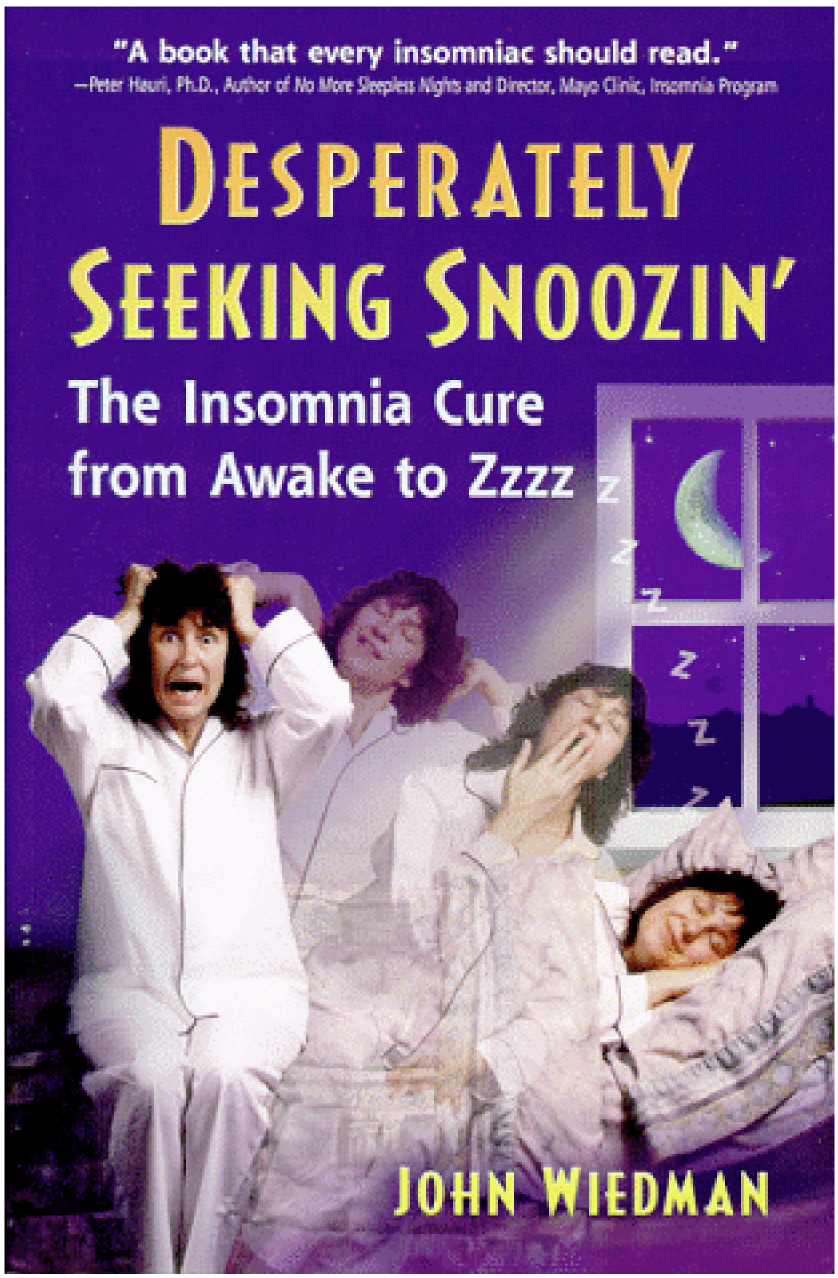
"Among the many crimes of the bourgeois overlords of HEP and their running dog lackeys is to have allowed the misapprehension among students (and the public) that particle physics is almost done," he declared in a manifesto delivered near the end of an international conference on particle physics last August at Stanford.

"HEP," in the jargon, is high-energy physics, the attempt to use powerful particle accelerators to study the tiniest pieces of matter. Dr. Lykken was tired of hearing some of his own colleagues lament that this centuries-long pursuit had run out of intellectual steam and was coming to an end.

"Trotsky was right," Dr. Lykken proclaimed as the image of the dour Bolshevik and advocate

Gravity Mediation

The theory of gravity mediation has merged from a decade of slumber.



We now know that that multi-TeV scalars can be natural.

- One idea is to break universality and exploit the existence of a RG fixed point.

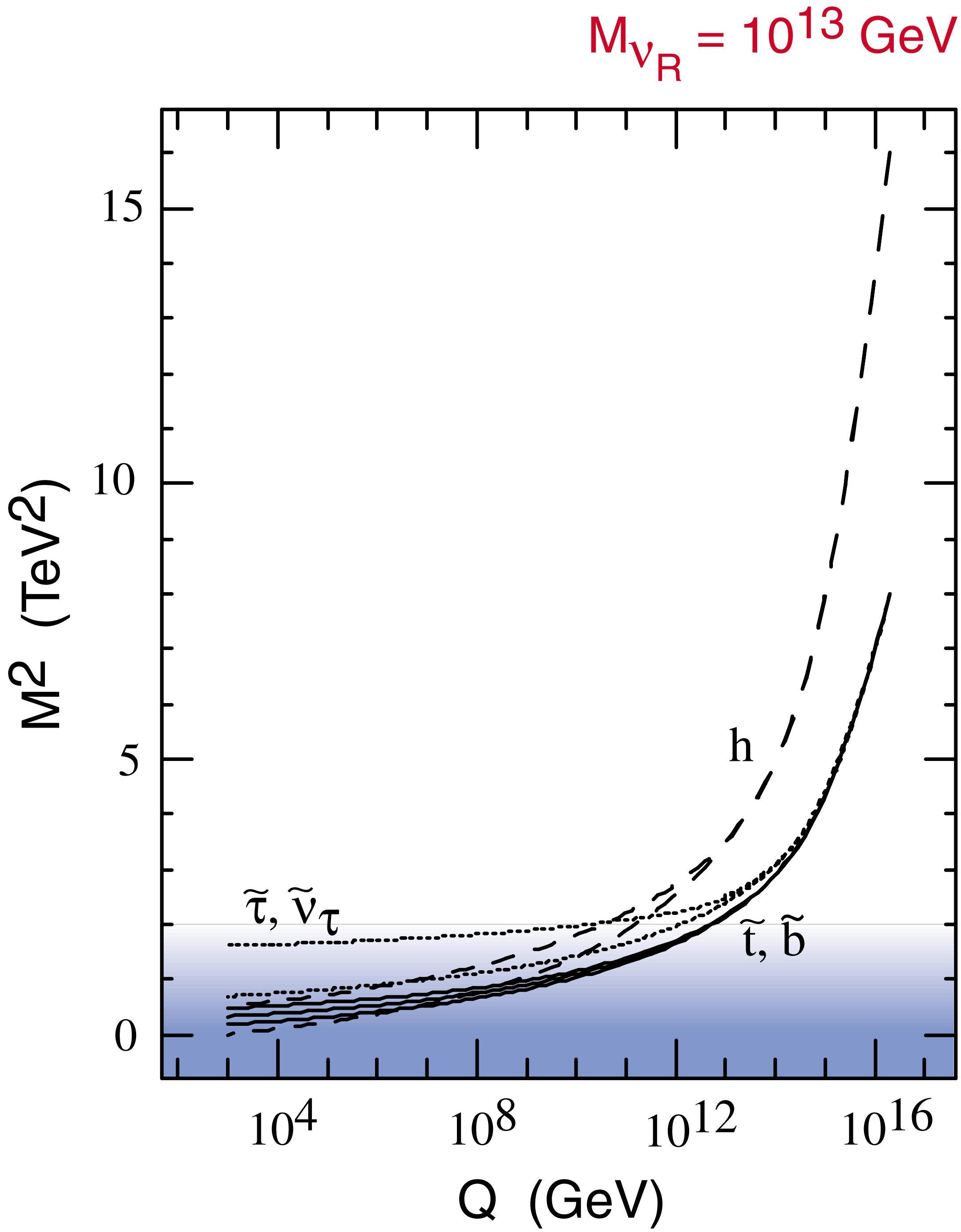
- Another possibility is to keep universality and exploit a RG focus point.

In either case, all scalars are heavy at the GUT scale. The third generation scalars are driven light, but the first and second generation scalars stay heavy.

This suppresses FCNC, the bane of the MSSM.

It also may be necessary to make proton decay agree with experiment.

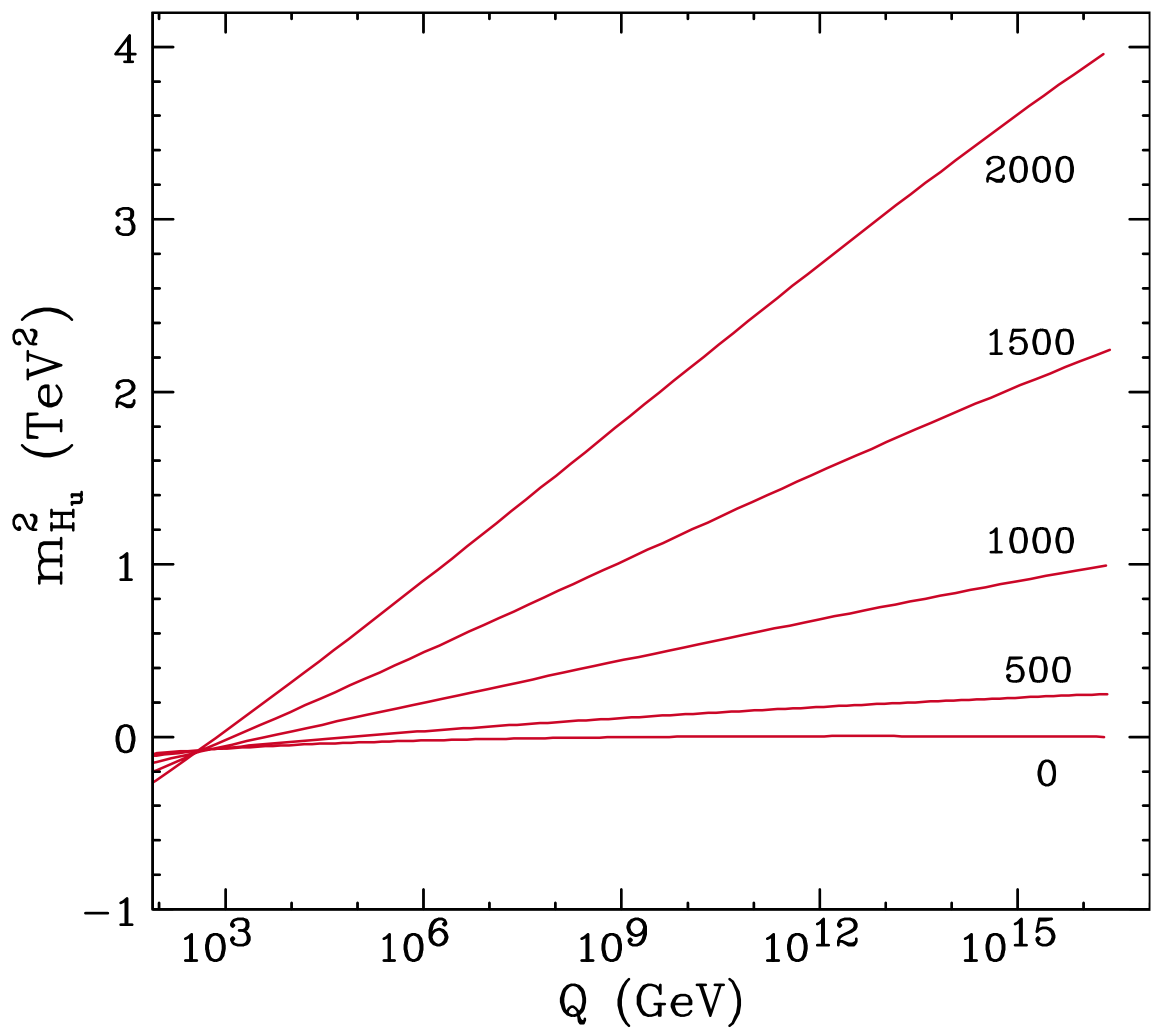
Fixed Point



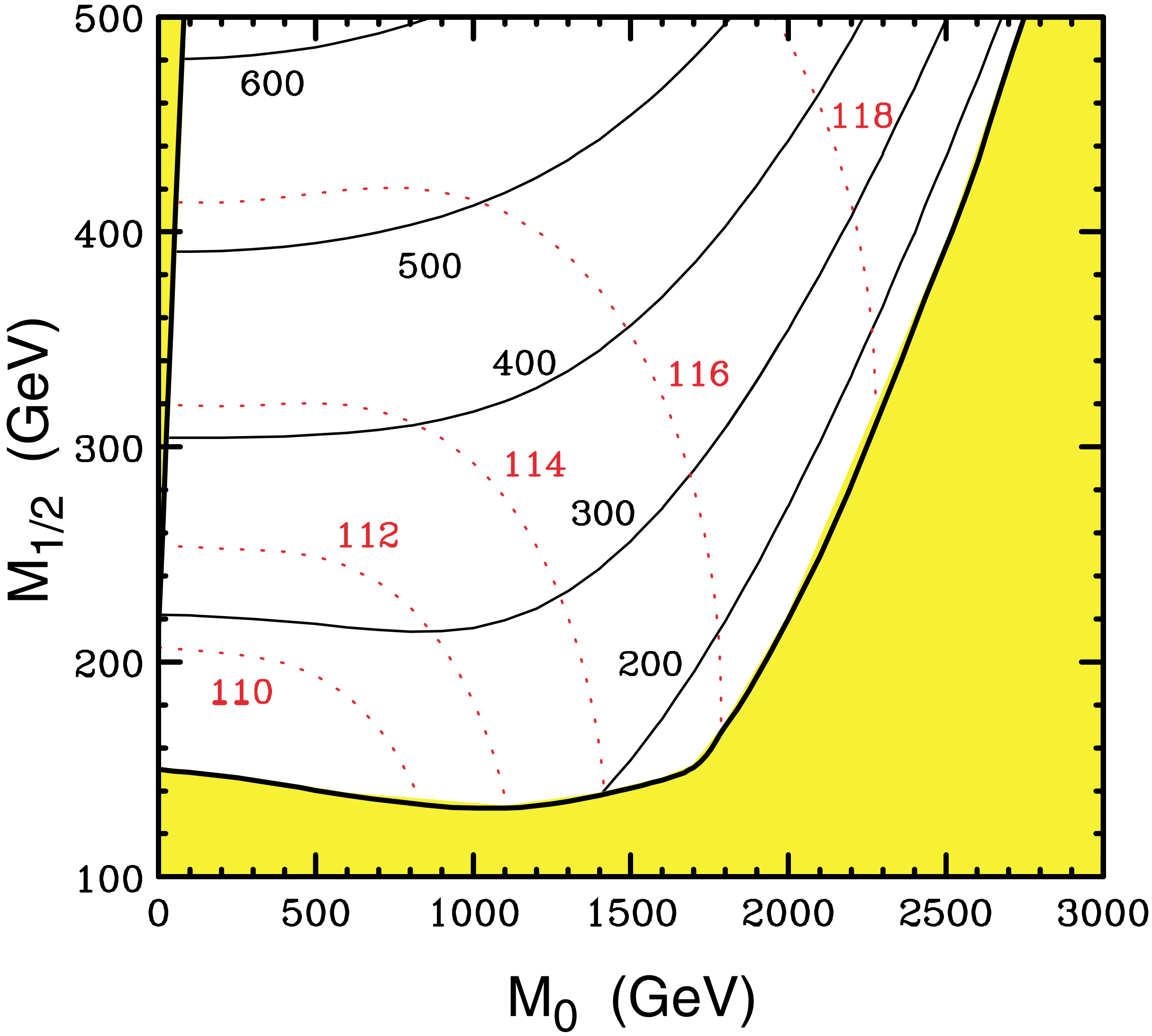
$$m_U^2 = m_Q^2 = m_D^2 = m_L^2 = m_E^2 = m_N^2 = \frac{1}{2}m_{H_u}^2 = \frac{1}{2}m_{H_d}^2$$

Bagger, Feng, Polonsky

Focus Point



Feng, Matchev, Moroi



μ (solid)

M_h (dotted)

Feng, Matchev, Moroi

Gauge Mediation

Gauge mediation provides a beautiful solution to the SUSY flavor problem.

But the simplest version has trouble with the Higgs sector.

By now there are variants with almost any particle as the NLSP:

$\tilde{B}$	$\gamma + \tilde{G}$
$\tilde{H}$	$Z,\ h + \tilde{G}$
$\tilde{\tau}$	$\tau + \tilde{G}$
$\tilde{\ell}$	$\ell + \tilde{G}$
$\tilde{q}$	$q + \tilde{G};\quad q' W + \tilde{G}$
$\tilde{g}$	$g + \tilde{G}$

These NLSP decays can give rise to dramatic signatures!

Anomaly Mediation

Anomalies induce gaugino masses in any model with gravity mediation.

$$M_{1/2} = \frac{g^2 b_0}{16\pi^2} M_{3/2}$$

Are they dominant?

In general, the gaugino masses are affected by high energy physics, such as anomaly-canceling GS terms in superstring theories.

In some models, they are indeed the leading contributions. Wino LSP!

Unfortunately, in the simplest examples, the two-loop slepton masses are tachyonic.

Gaugino Mediation

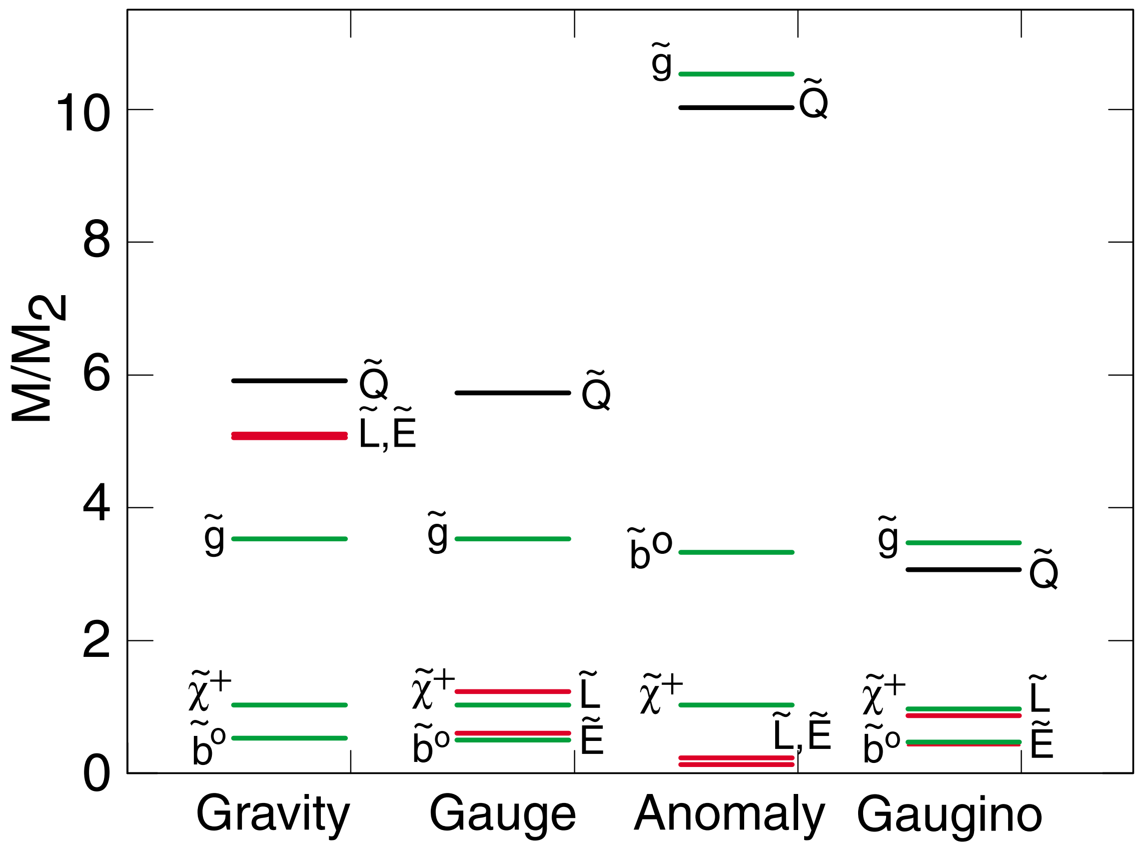
Gaugino mediation is a new approach that combines many of these ideas.

In gauge mediation, the MSSM matter fields live on one brane, while SUSY is broken on another.

Standard-Model gauge fields live in the bulk, and carry the supersymmetry breaking from brane to brane.

The resulting MSSM spectrum looks like pure no-scale supergravity.

Sparticle Spectra



Sparticle spectra for various mediation mechanisms.

Extra Dimensions

The subject of extra dimensions is still in its infancy.

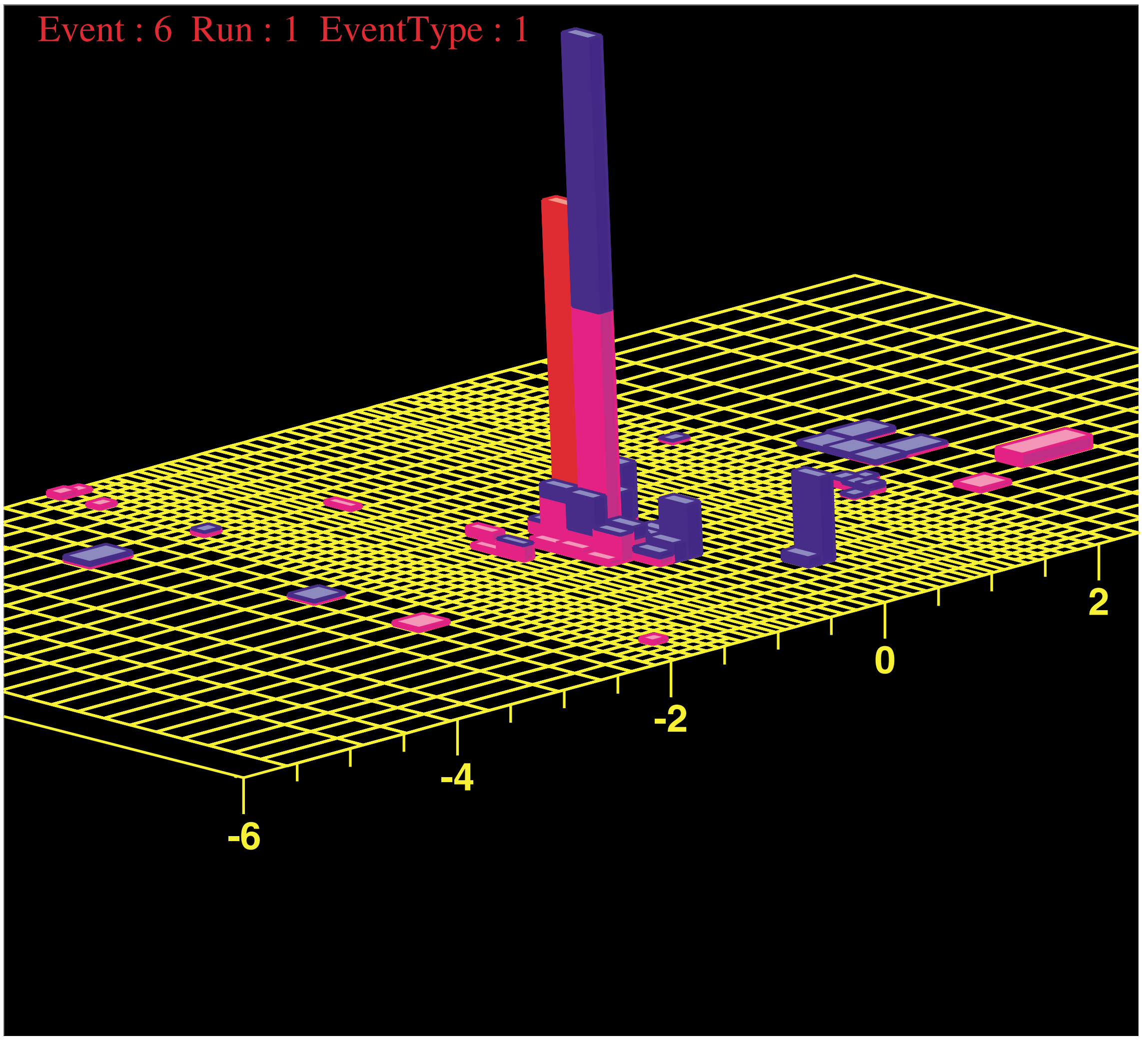
It allows us to reformulate the hierarchy problem, and perhaps explain the cosmological constant.

But it opens many questions:

- How many are there, and what is their size? How are they stabilized?
- What is the string scale?
- Where is supersymmetry broken – in the bulk or on the brane?
- How can we tell?

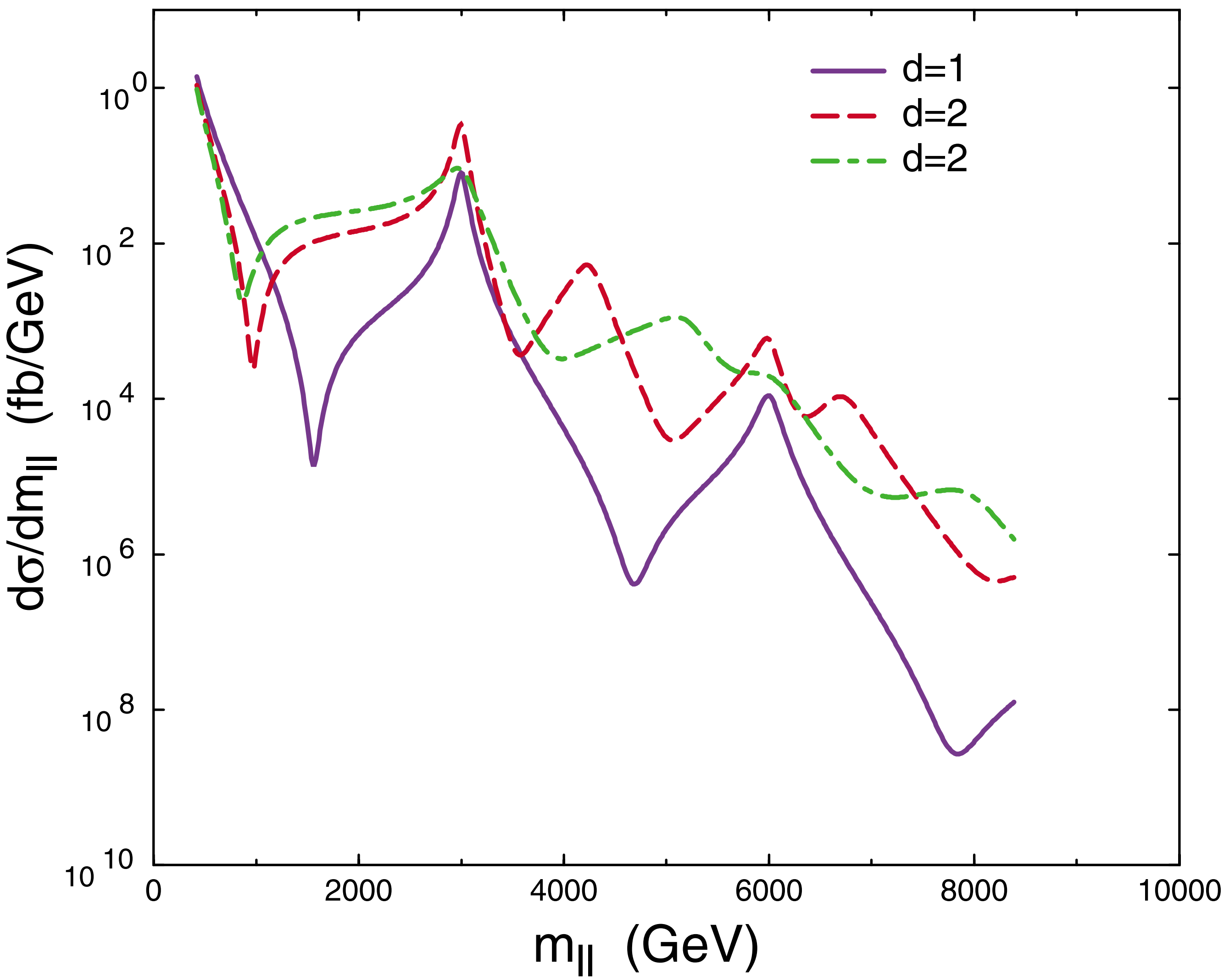
SUSY 2000 $\Rightarrow$ DIM 2010

Monojets!



CDF monojet recoiling against
an extra-dimensional graviton

Kaluza Klein



Dilepton spectra at LHC from Kaluza-Klein excitations of the photon and Z

Cullen and Perelstein

Higgs & SUSY

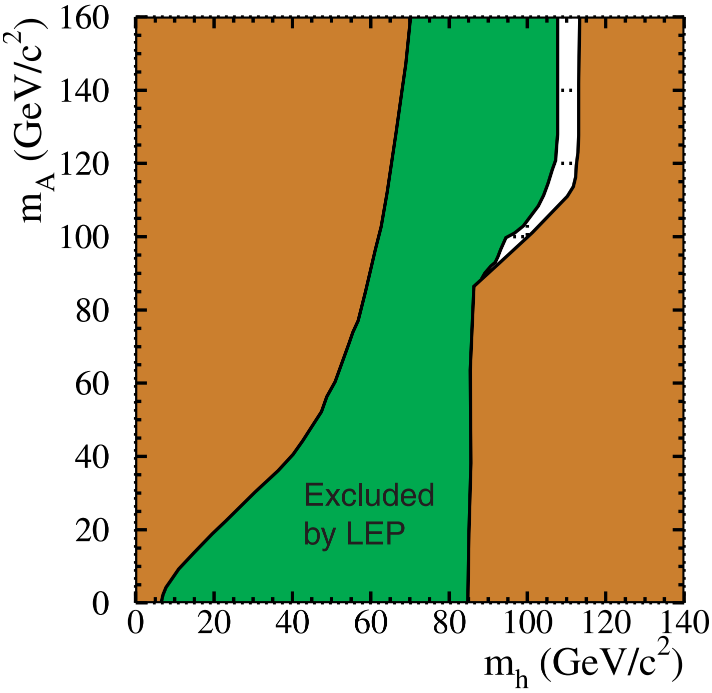
To date, experiments have confirmed the Minimal Standard Model and set the stage for supersymmetry.

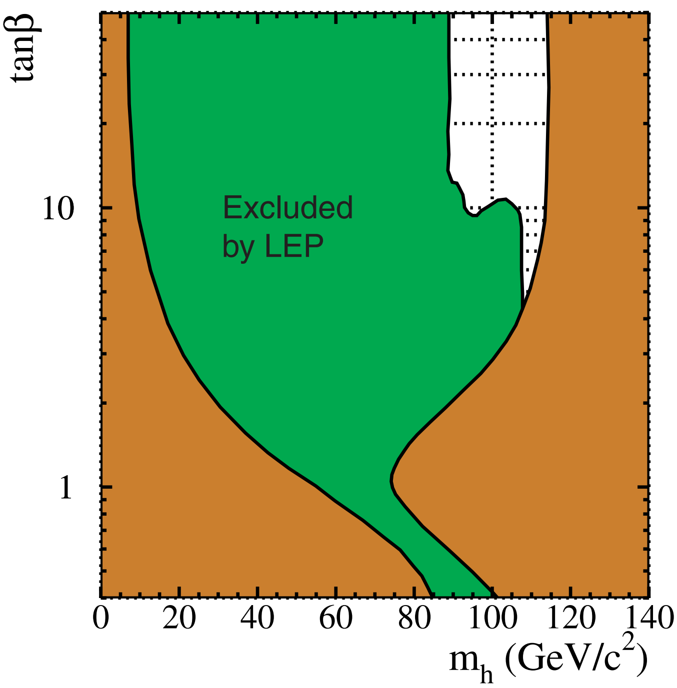
LEP I and LEP II, the Tevatron and SLC, have placed serious limits on the Higgs mass, but they have not really constrained the rest of the super-symmetry parameter space.

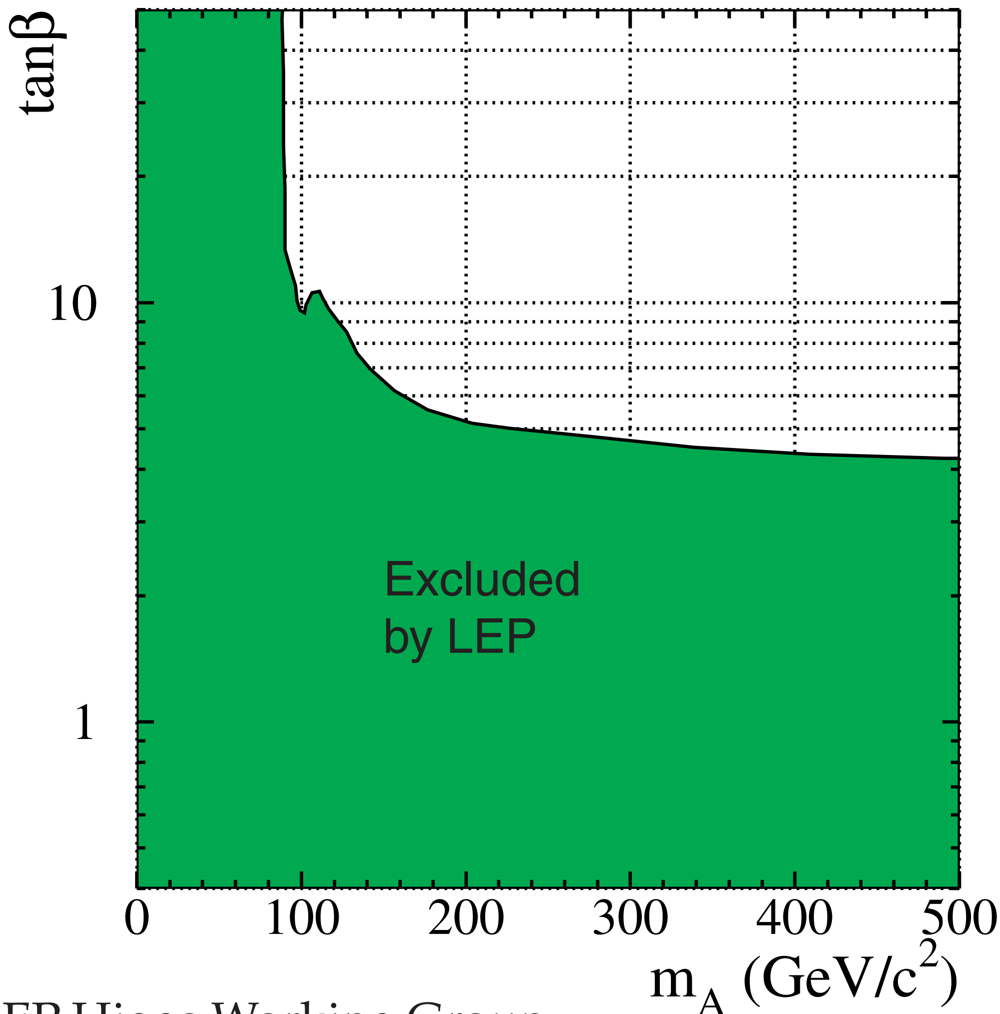
As we have heard at the conference, the present Higgs limits are beginning to pinch the MSSM, but there is still plenty of room.

And in nonminimal supersymmetry, the MSSM Higgs limits do not apply.

LEP Higgs



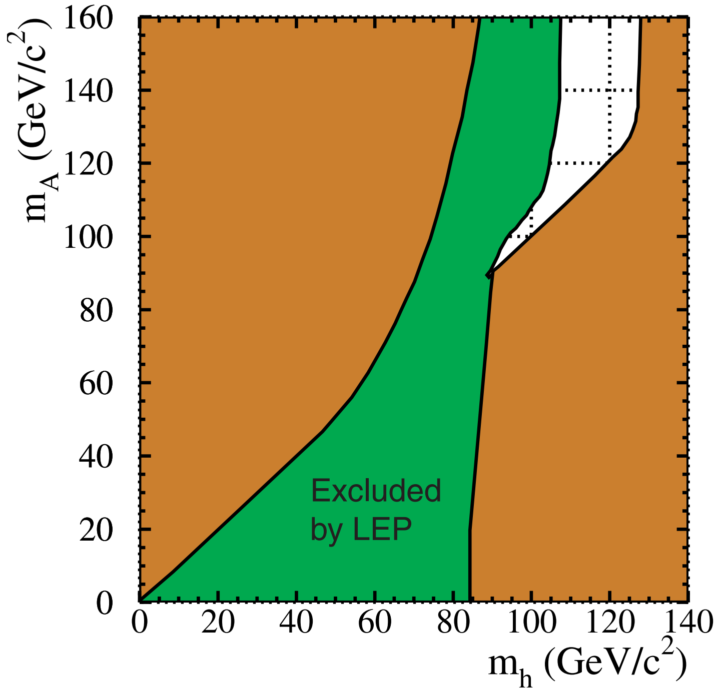


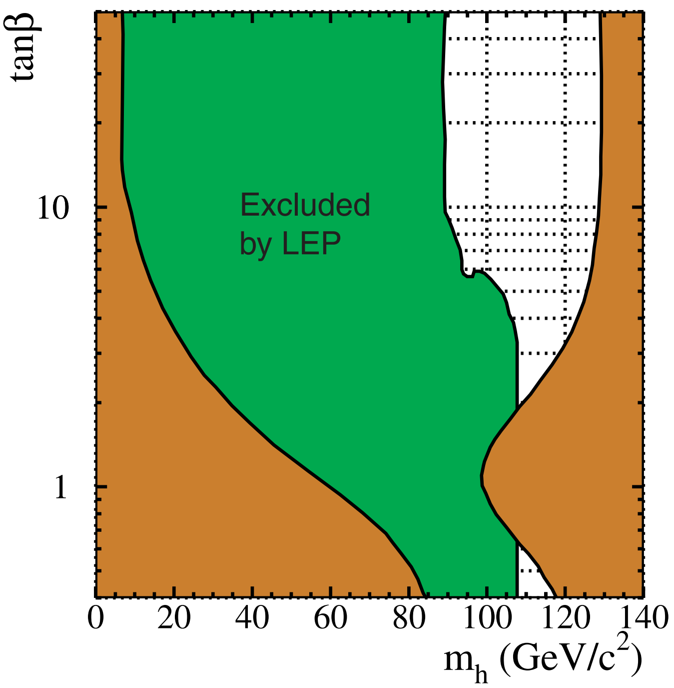


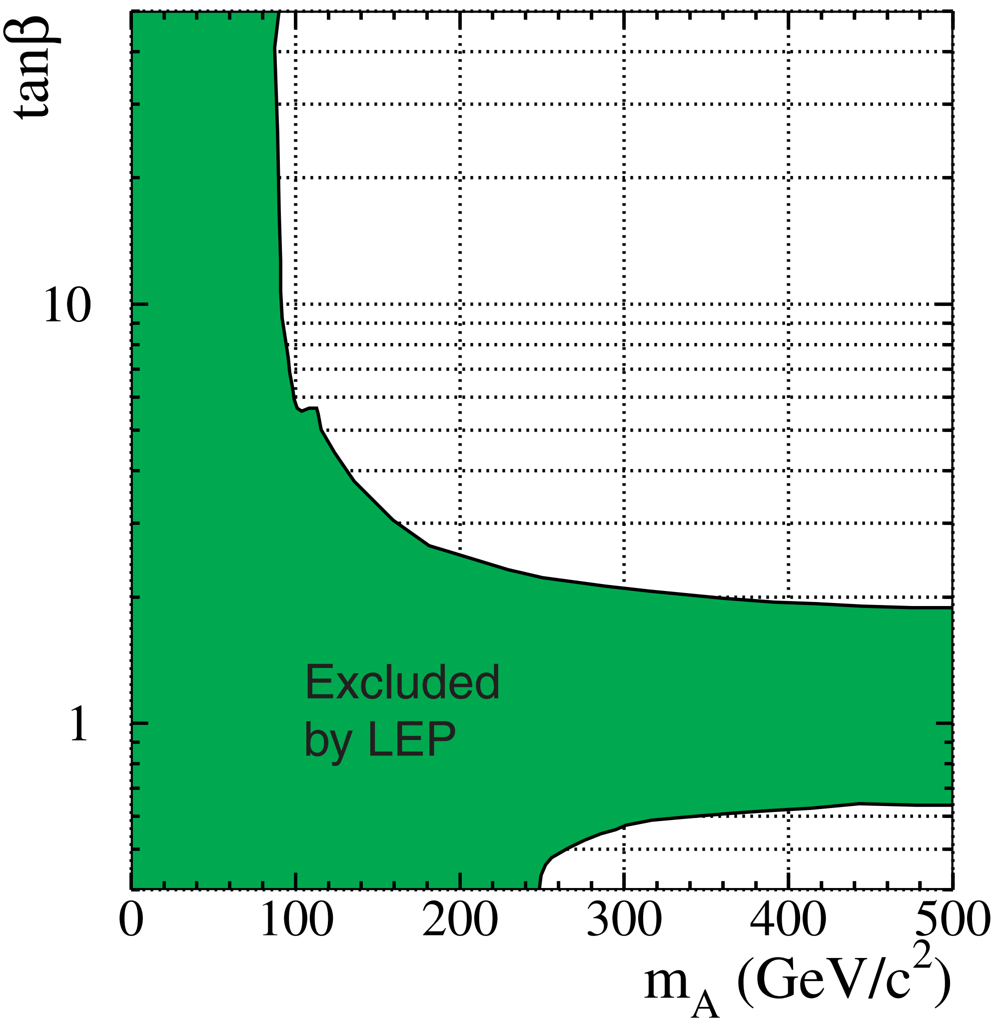
No mixing

LEP Higgs Working Group

LEP Higgs







Full mixing

LEP Higgs Working Group

This Decade

During this decade, we can expect great experimental activity:

2000	LEP II
2001 – 2006	Tevatron Run II
2006 –	LHC

LEP II will cover much of the MSSM Higgs parameter space.

The Tevatron will soon gather 10 times its accumulated luminosity, and perhaps another factor of 10 before LHC, a total of about 20 fb^{-1}.

The Tevatron has a good chance to find the Higgs and a surprisingly large super-symmetry reach.

Of course, the LHC will be a SUSY factory if SUSY is relevant to the weak scale.

Tevatron SM Higgs

During Run II, the Tevatron will be able to exclude the Standard Model Higgs over most of the remaining parameter space.

The discovery reach depends crucially on the luminosity. With 30 fb^{-1}, we can expect 3-5 σ discovery for $M_h < 185$ GeV.

$M_h < 135$ GeV

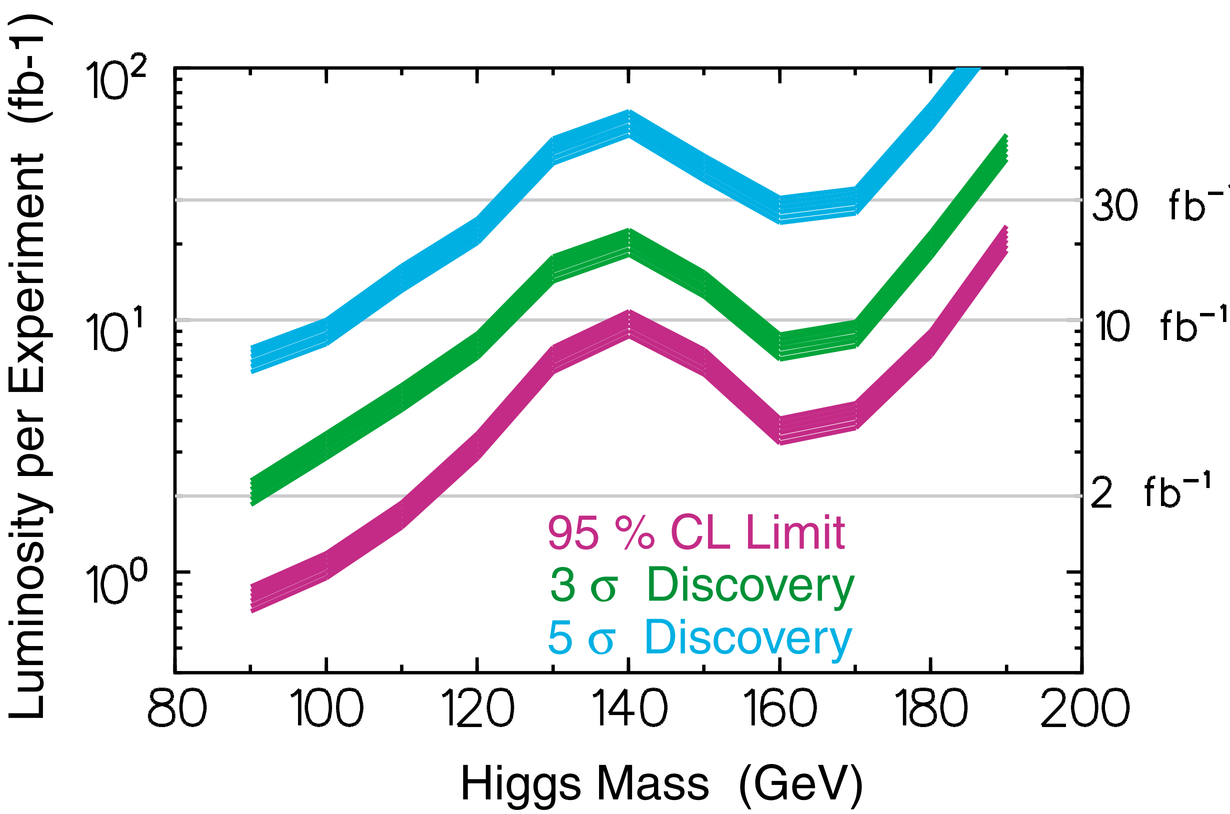
$$q\,\bar{q} \;\rightarrow\; V\;h \;\rightarrow\; \ell\,\bar{\ell}\,b\,\bar{b} \qquad V \;=\; W,Z$$

$M_h > 135$ GeV

$$q\,\bar{q} \;\rightarrow\; V\;h \;\rightarrow\; V\;\;V'\,\bar{V}' \;\rightarrow\; \ell^{\pm}\,\ell^{\pm} + jj$$

$$\ell^{+}\,\ell^{-} + E_T^{\mathrm{MISS}}$$

$$g\,g \rightarrow\; h \;\rightarrow\; V\bar{V} \;\rightarrow\; \ell^{+}\,\ell^{-} + E_T^{\mathrm{MISS}}$$



Combined CDF / DØ analysis

Tevatron SUSY Higgs

During Run II, the Tevatron will be able to exclude the MSSM Higgs over most of the parameter space.

As before, the discovery reach depends crucially on the luminosity. With 30 fb^{-1}, the discovery potential is large.

Higgs particles: h, H, A, $H^{\pm}$

Parameters:

Tree level: $\tan\beta, \quad M_A$

Loop level: $M_{\text{SUSY}}, \quad M_{\tilde{t}}, \quad X_{\tilde{t}}$

Decoupling region:

$M_A > 200$ GeV

Processes:

$M_h < 130$ GeV

$$g\,g \;\longrightarrow\; h\,b\,\bar{b} \;\longrightarrow b\,\bar{b}\,b\,\bar{b}$$

$$q\,\bar{q} \;\longrightarrow\; V\,\phi \;\longrightarrow\; \ell\,\bar{\ell}\,b\,\bar{b}$$

$$V \;=\; W, Z;\; \phi \;=\; h, H$$

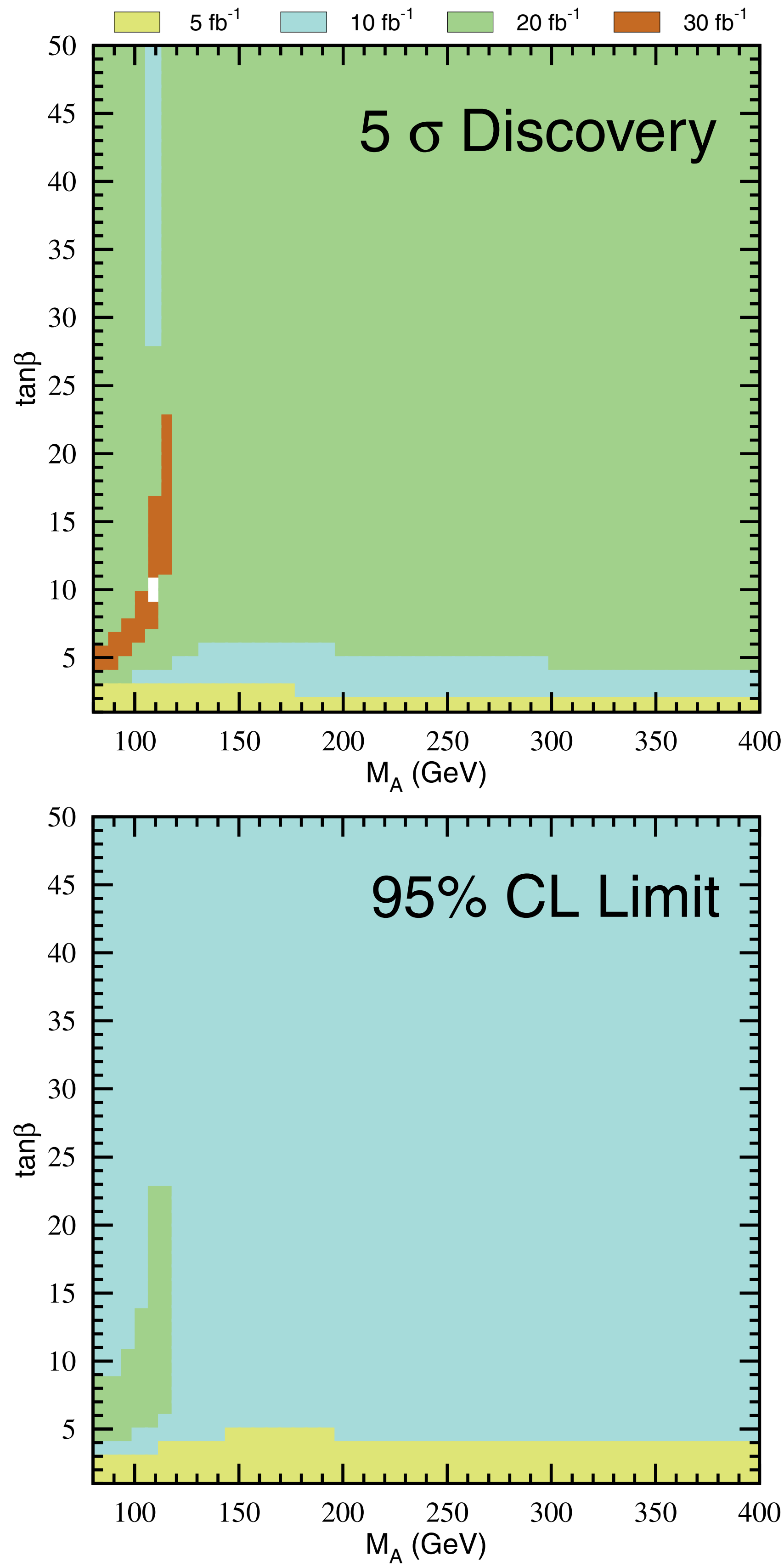
Exploit complementarity!

$$g_{VVh} \;\sim\; \sin(\alpha - \beta)$$

$$g_{VVH} \;\sim\; \cos(\alpha - \beta)$$

(The plots assume an average stop mass of 1 TeV.)

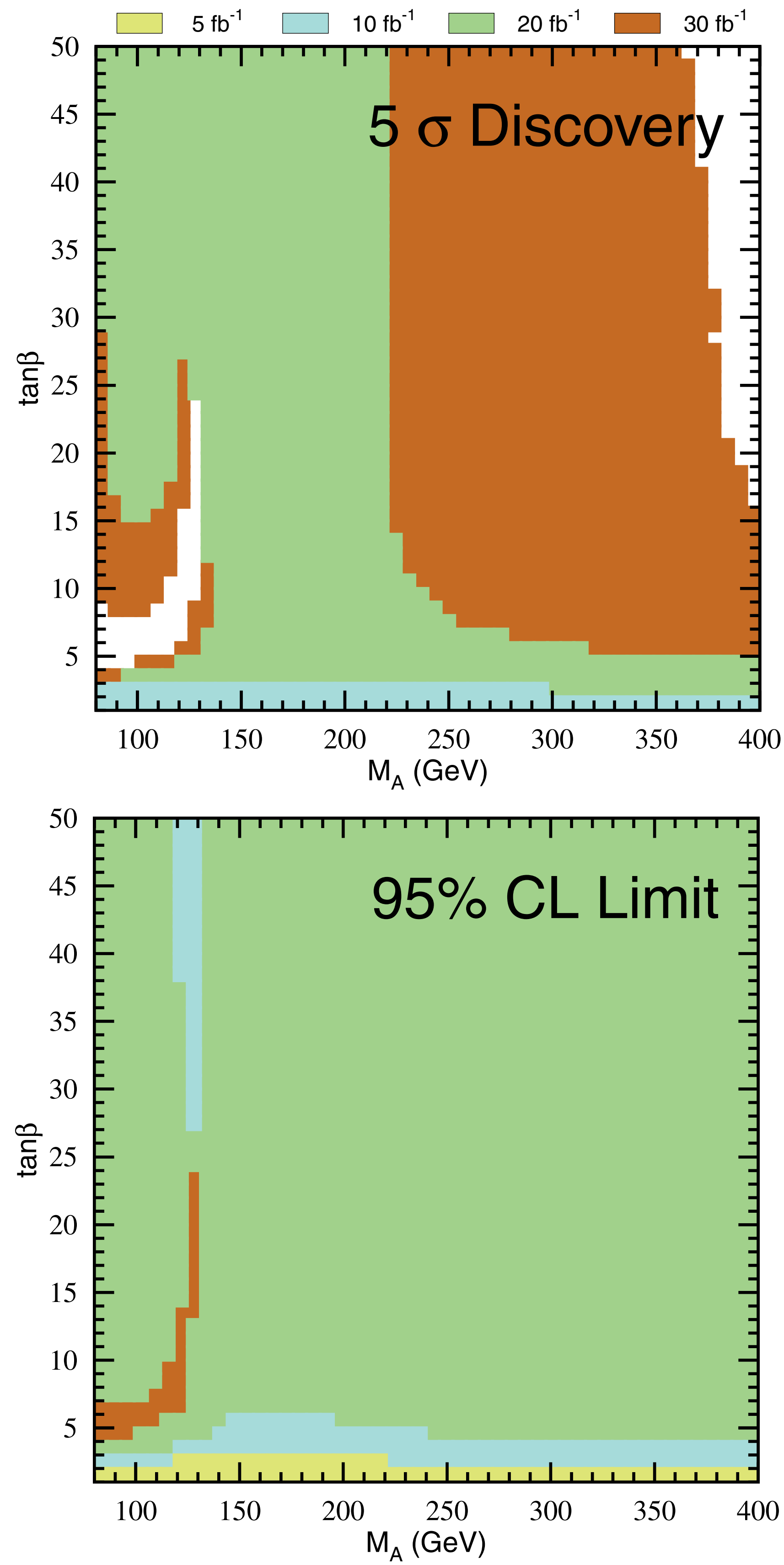
Tevatron SUSY Higgs – No Mixing



Preliminary

Mrenna – Run II SHWG

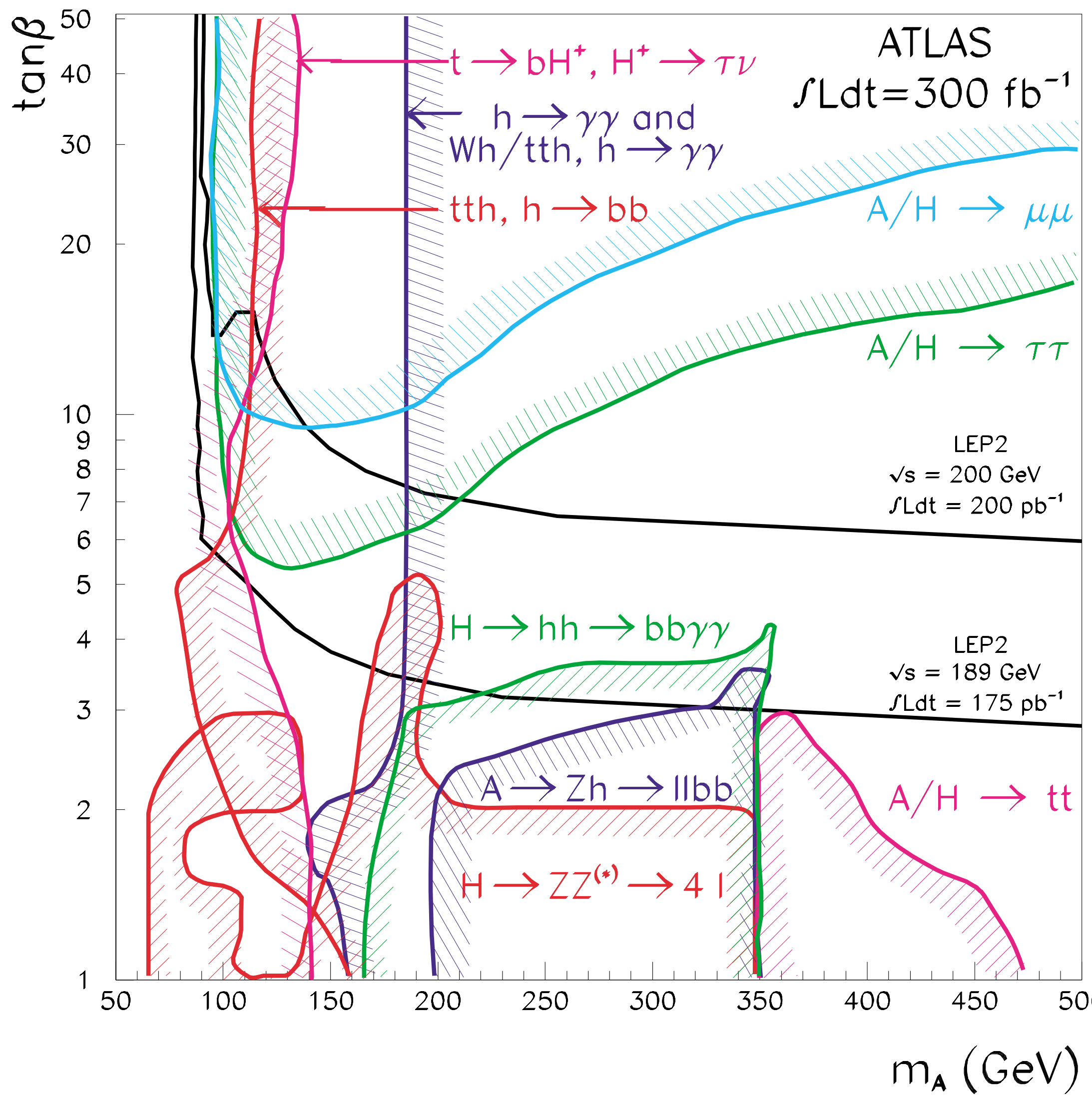
Tevatron SUSY Higgs – Full Mixing



Preliminary

Mrenna – Run II SHWG

LHC Higgs



Enough said!

Experimental SUSY

With all the SUSY models, it is best for experimentalists to keep an open mind.

- We know the sparticles and their couplings.

- We don't know their masses and mixings.

So it's safe to assume SM production, and cascade decay to the (N)LSP.

The (N)LSP can be any of the spartners.

The (N)LSP might or might not decay –

Either into SM particles, as in theories with R parity violation, or into the gravitino, as in gauge mediation.

SUSY Scales

The mass of the gravitino is essentially

$$\frac{M^2_{\rm SUSY}}{M_{\rm P}}$$

The masses of the superpartners are

$$\frac{M^2_{\rm SUSY}}{M} \sim M_W$$

where M is not necessarily M_P.

If M << M_P, as in gauge mediation, the gravitino the lightest sparticle.

The scale M determines the scale of supersymmetry breaking.

M_{SUSY} can range between 1 TeV and 10^{10} GeV.

NLSP Decays

The NLSP decay is governed by the Sgoldberger-Treiman relation:

$$c\tau(\tilde{X} \to X\tilde{G}) = \left(\frac{100\ \mu\text{m}}{\kappa}\right)\left(\frac{100\ \text{GeV}}{M_{\tilde{X}}}\right)^5 \left(\frac{M_{\text{SUSY}}}{100\ \text{TeV}}\right)^4 \left(1 - \frac{M_X^2}{M_{\tilde{X}}^2}\right)^{-4}$$

For M_{SUSY} > 1000 TeV, the NLSP decays outside the detector. It is essentially stable.

Otherwise, the decay can be prompt, which gives rise to two hard partons and missing energy.

For a range of parameters, the NLSP decays inside the detector, which leads to displaced tracks.

All possibilities are open!

Tevatron SUSY

The Tevatron Run II SUSY Higgs Working Group found:

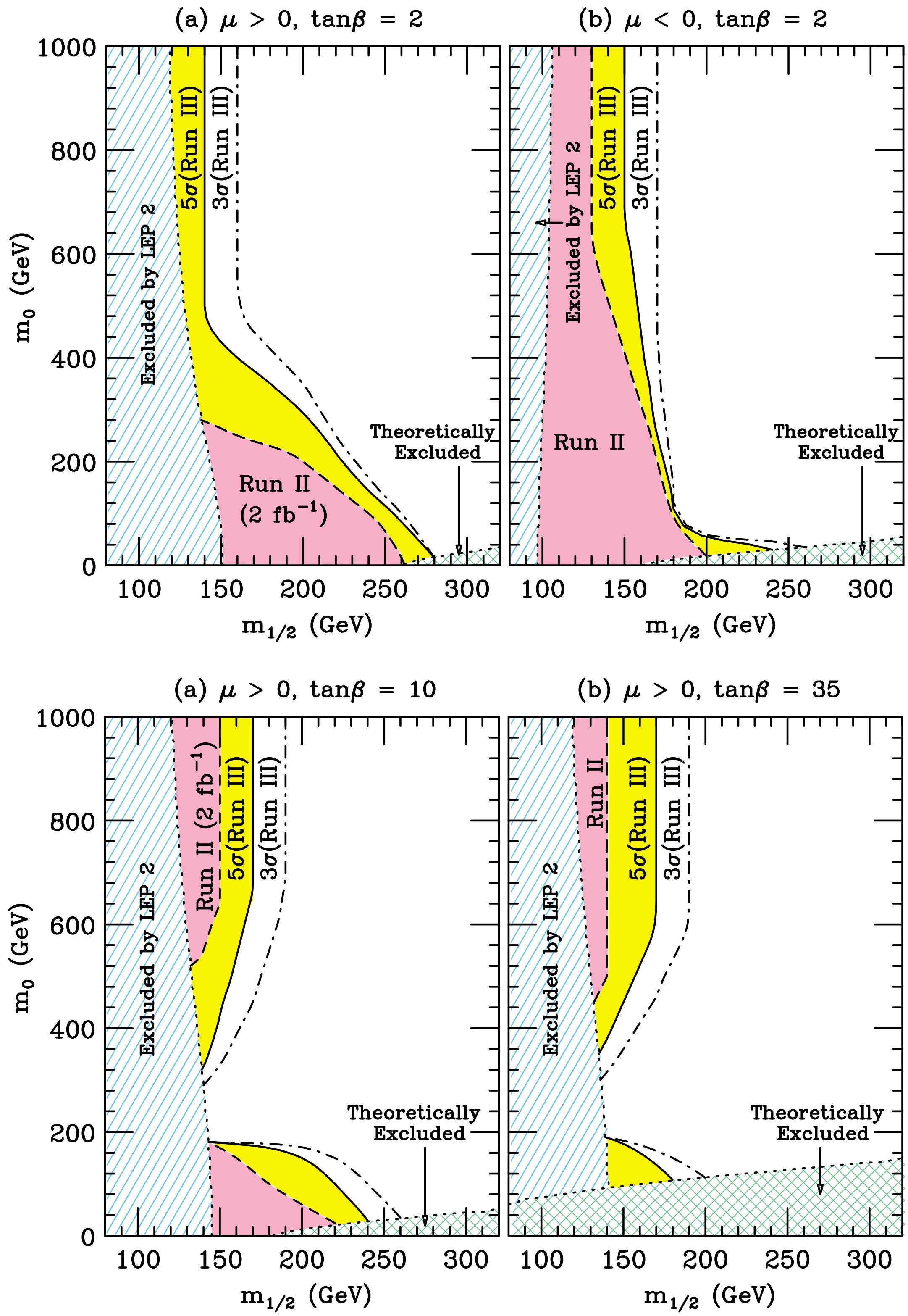
• Reasonable reach for supersymmetry with a stable (N)LSP using the trilepton channel.

$$\chi_1^{\pm}\,\chi_2^0 \;\rightarrow\; \ell^{\pm}\,\ell\,\bar{\ell}$$

• Substantial reach for models with low-scale supersymmetry breaking.

In that case the chargino reach is about 350 GeV, which in gauge mediation, corresponds to a 1 TeV gluino!

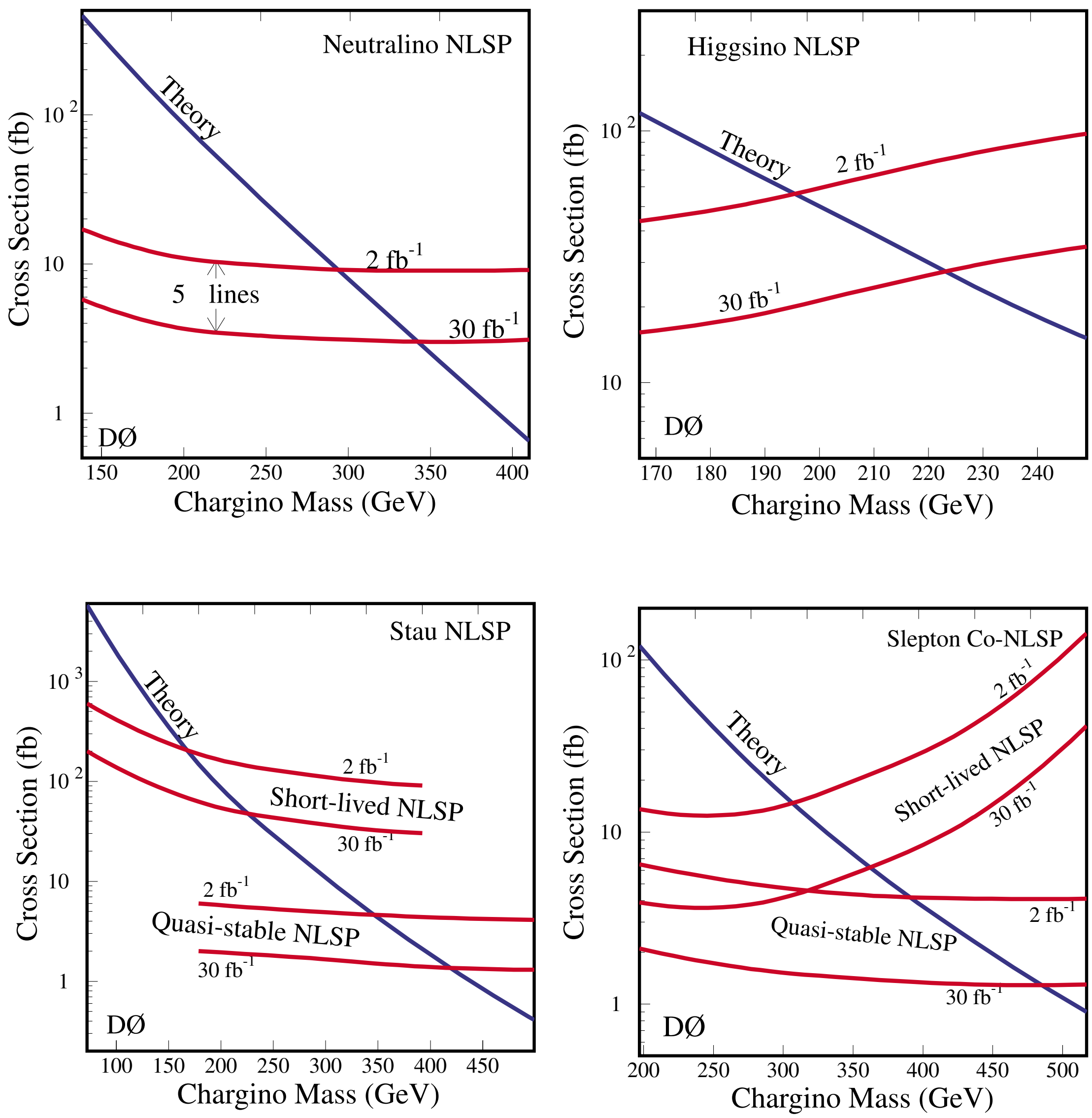
Tevatron Trilepton Reach



Run III = 30 fb^{-1}

Run II SHWG

Tevatron GMSB Reach



LHC SUSY

LHC will certainly see SUSY, if it is relevant to the weak scale.

Indeed, at LHC the background to SUSY is SUSY!

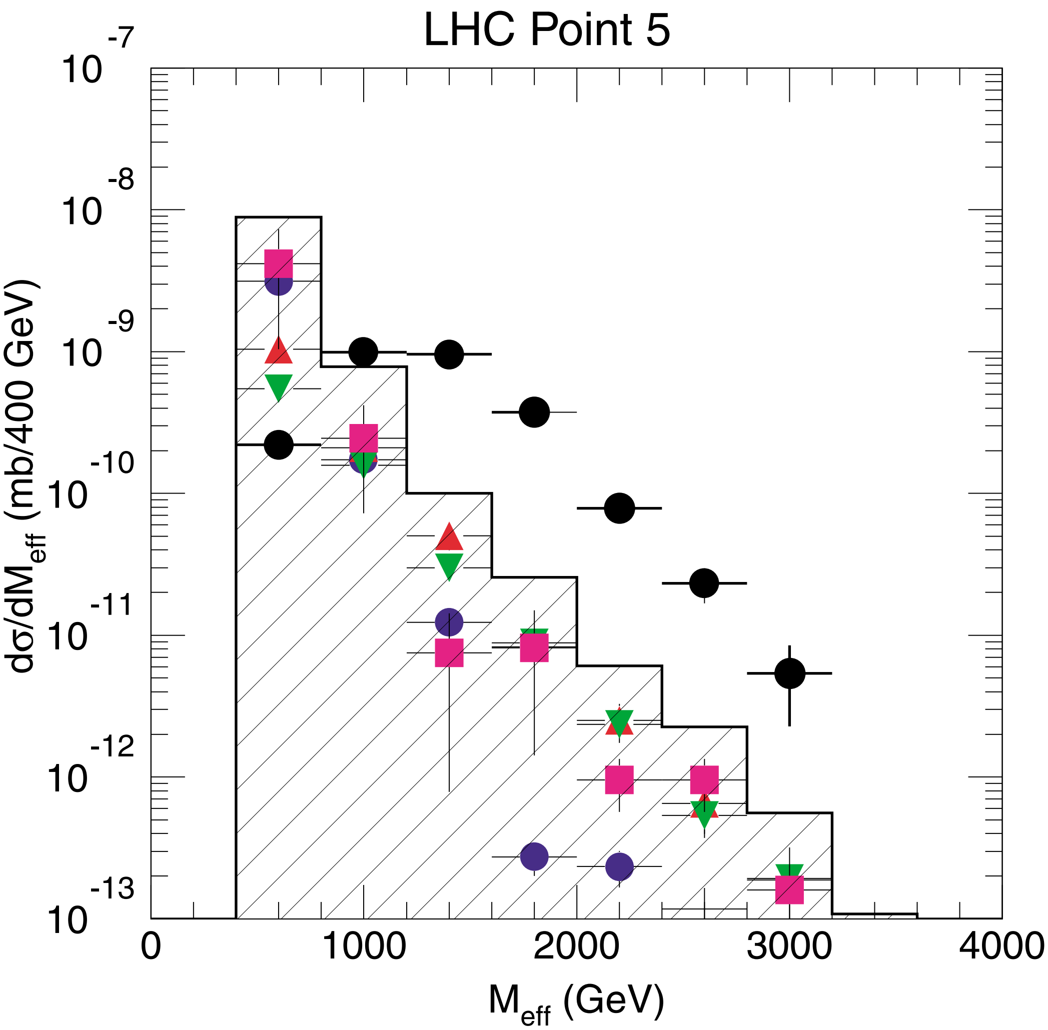
One early indication will be excess effective mass.

$$M_{\text{eff}} = E_T^{\text{MISS}} + p_{T1} + \dots + p_{T4}$$

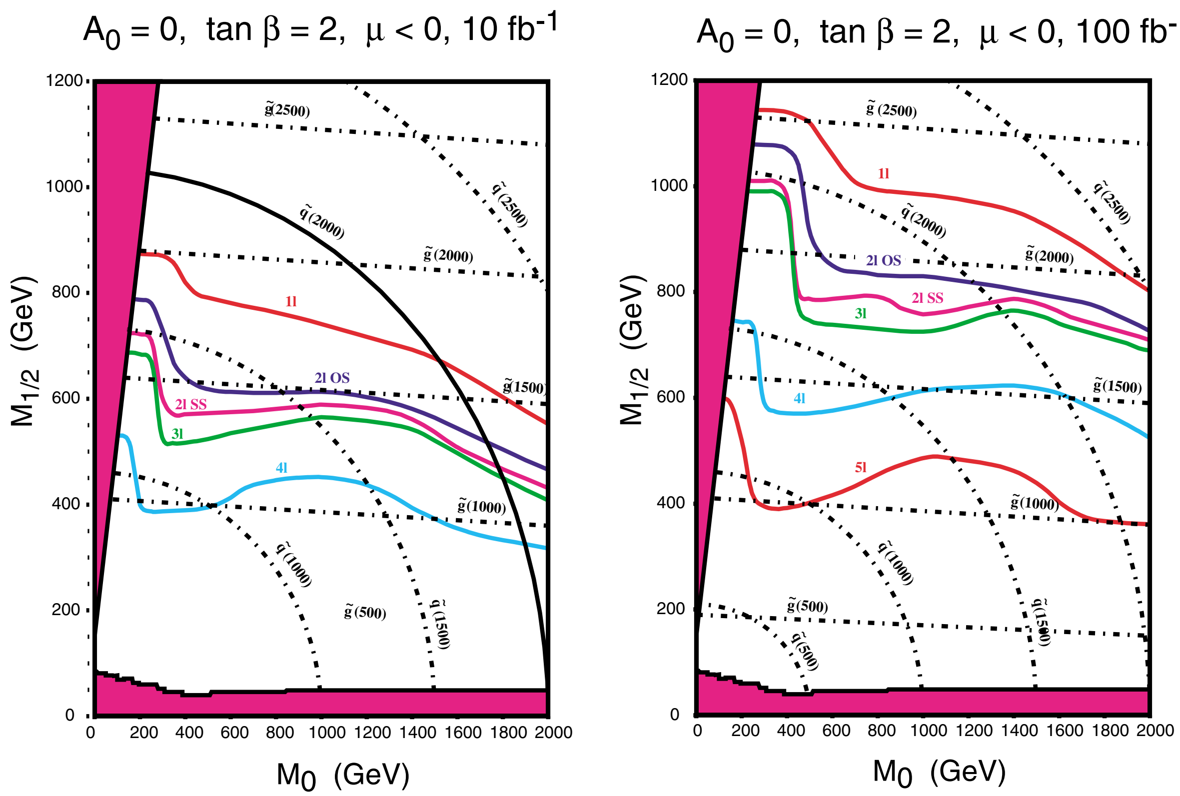
Sorting out the details will be a challenge. Environment "busy."

But experimentalists with data are clever and motivated!

LHC Effective Mass



LHC Reach



The LHC reach is huge.

CMS Note 98-006

LHC Dileptons

Exclusive measurements can be made by looking at features of decay chains.

Kinematic edges in dilepton distributions can arise from neutralino decay.

$$\chi_2^0 \rightarrow \tilde{\ell}^{\pm}\ell^{\mp} \rightarrow \chi_1^0 \ell^+ \ell^-$$

$$\chi_2^0 \rightarrow \chi_1^0 \ell^+ \ell^-$$

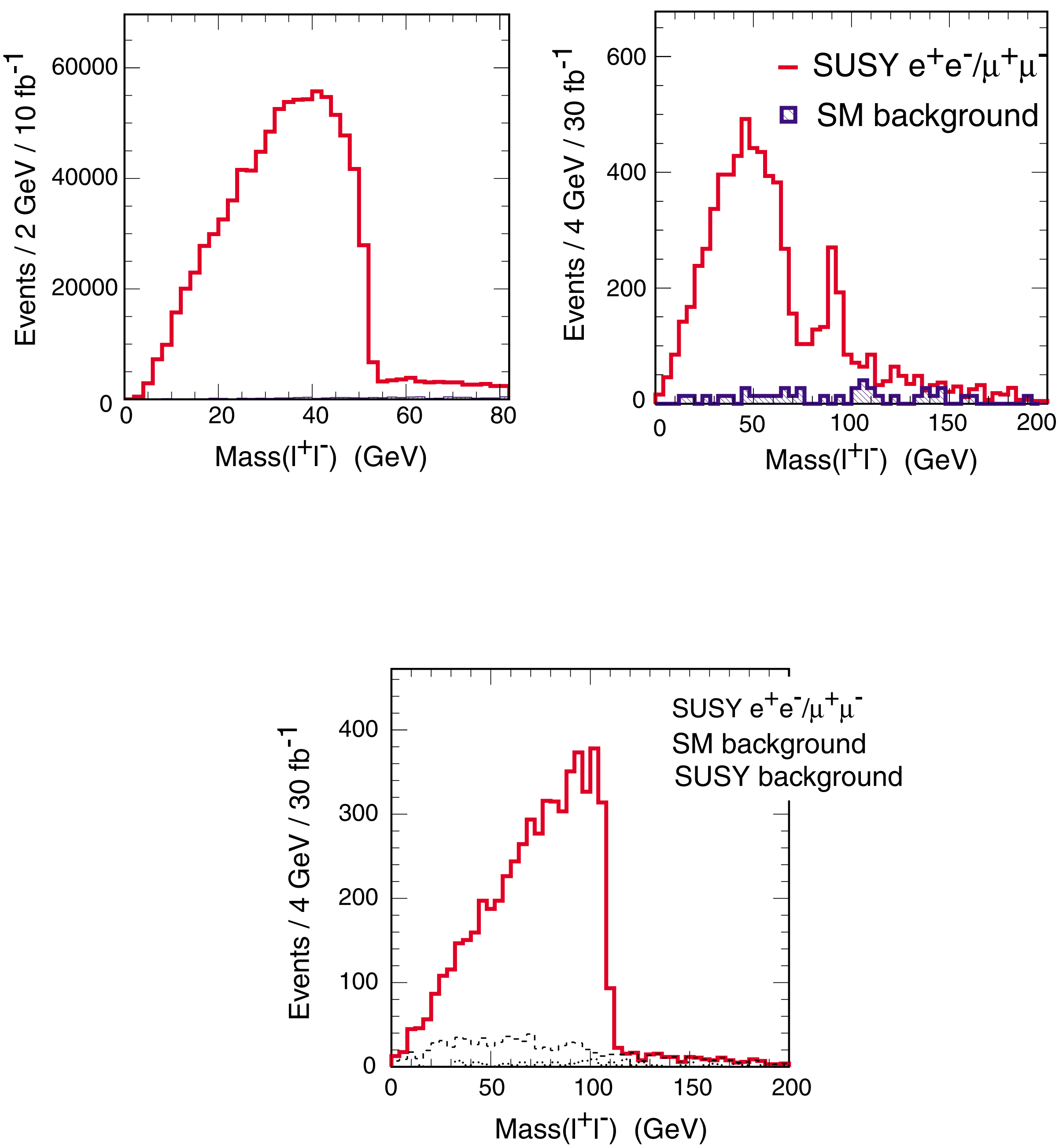
They determine mass differences, such as

$$M_{\chi_2^0} - M_{\chi_1^0}$$

and

$$M_{\ell\ell}^{\mathrm{MAX}} = M_{\chi_2^0} \sqrt{1 - \frac{M_{\tilde{\ell}}^2}{M_{\chi_2^0}^2}} \sqrt{1 - \frac{M_{\chi_1^0}^1}{M_{\tilde{\ell}}^2}}$$

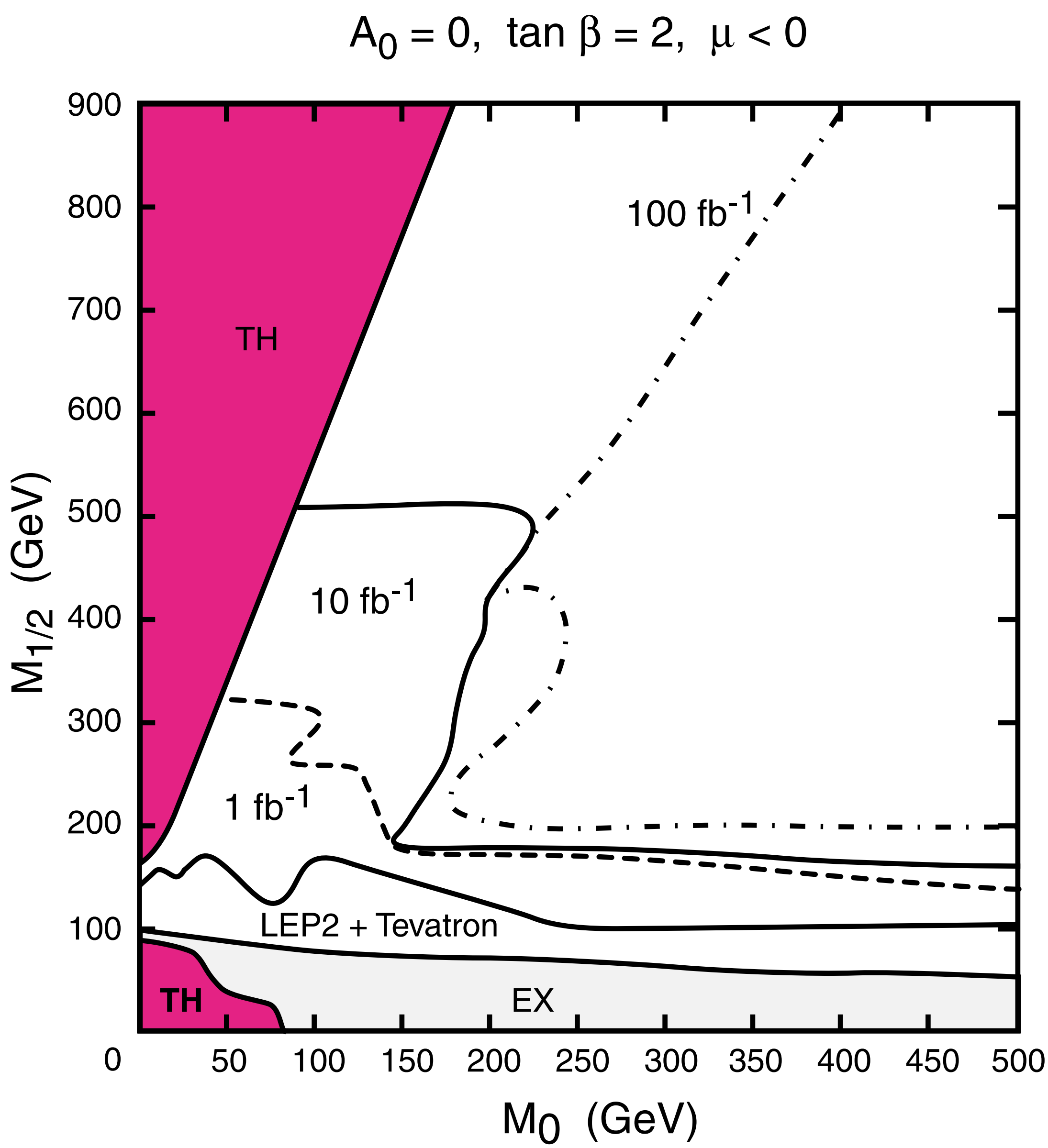
However, the region is limited.



Sample dilepton mass distributions

Atlas TDR

LHC Dilepton Reach



Soft Parameters?

The LHC will make many detailed measurements.

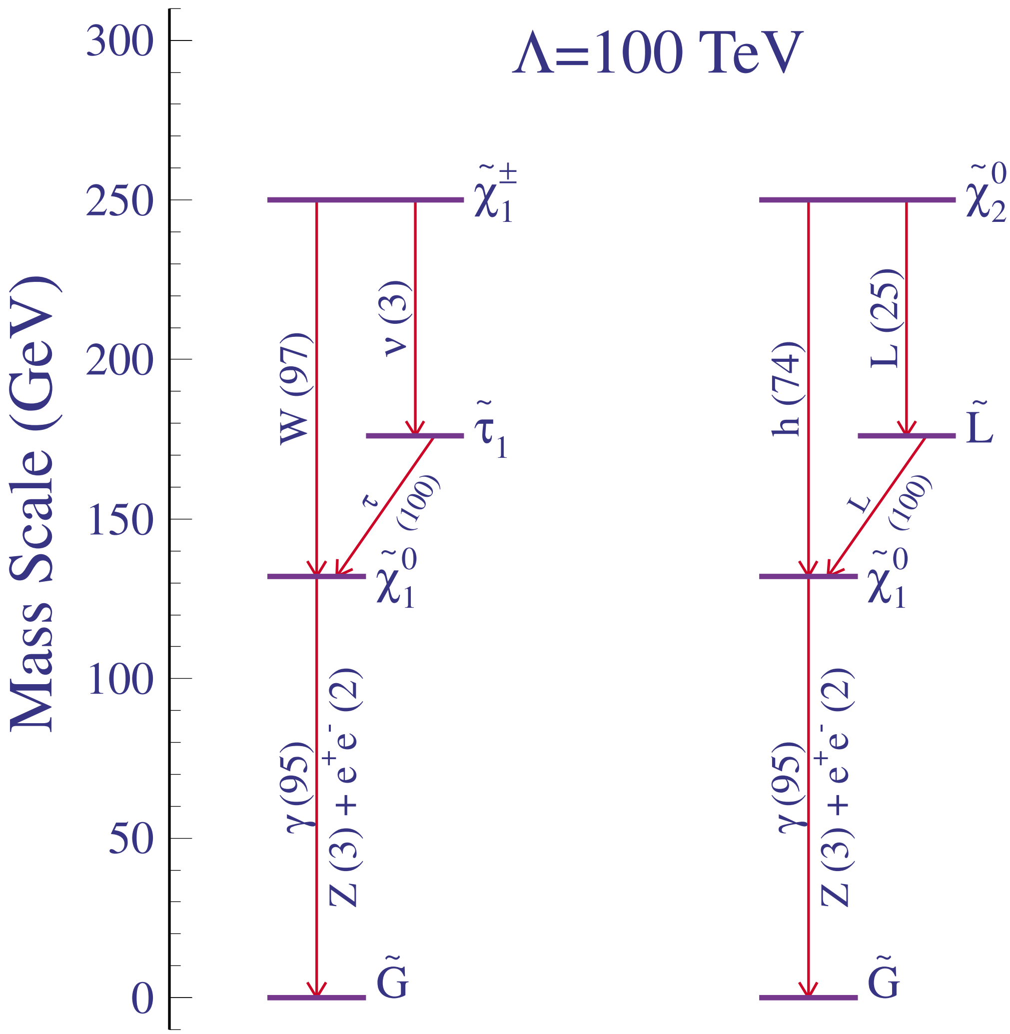
Extracting the underlying parameters will require considerable ingenuity.

Model fits can help in simple scenarios. But what if the models are wrong?

We would like to be able to determine the full sparticle spectroscopy.

We need many measurements to construct a complete theory of the over 100 soft SUSY breaking parameters.

Sparticle Spectroscopy



Run II SHWG

Linear Collider

An e+e- collider is an excellent tool to sort out the details. It can

- determine the spins and quantum numbers of new particles

- measure cross sections and branching rates

- determine masses and mixing angles.

At an e+e- collider, the desired signals have large production rates and favorable S/B ratios.

The variable collider energy provides a sharp movable threshold that can be used to untangle the signals.

LC Example

Smuon production:

$$e^+ e^- \;\rightarrow\; \tilde{\mu}^+ \tilde{\mu}^-$$

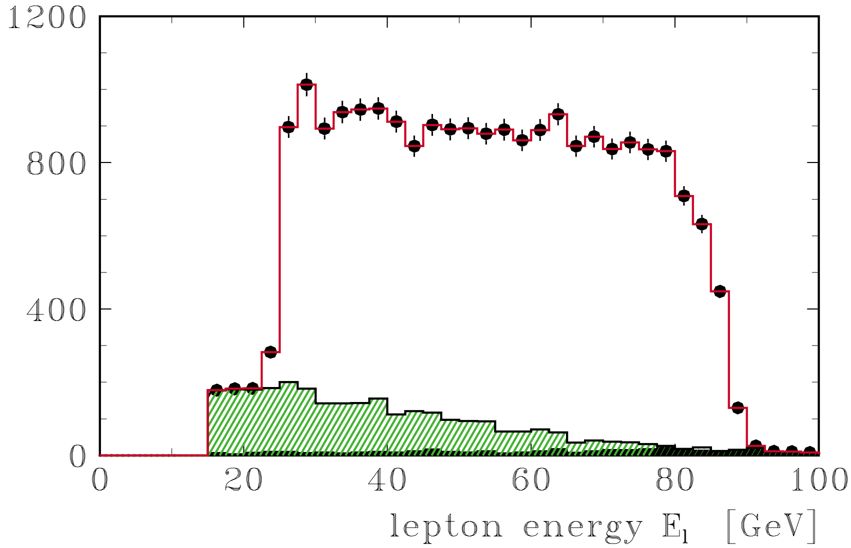
Decay:

$$\tilde{\mu}_R^+ \tilde{\mu}_R^- \;\rightarrow\; \mu^+ \mu^- + E_T^{\mathrm{MISS}}$$

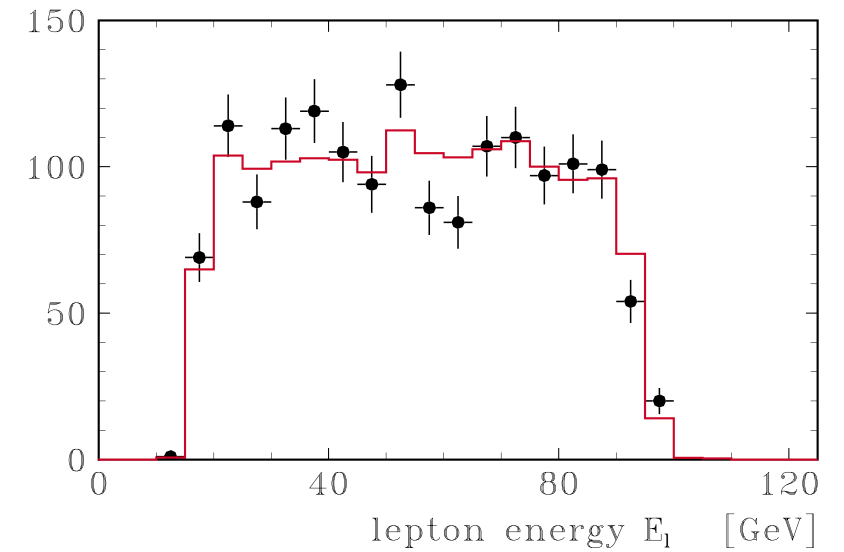
$$\begin{aligned} \tilde{\mu}_L^+ \tilde{\mu}_L^- &\rightarrow \mu^+ \mu^- \tilde{\chi}_2^0 \tilde{\chi}_2^0 + E_T^{\mathrm{MISS}} \\ &\rightarrow \mu^+ \mu^- \ell^+ \ell^- \ell'^+ \ell'^- + E_T^{\mathrm{MISS}} \end{aligned}$$

The muon energy distributions can determine masses to high accuracy.

Lepton Energy



$\tilde{\mu}_R,\ \tilde{\chi}_1^0$



$\tilde{\mu}_L,\ \tilde{\chi}_2^0$

Sociology or Science?

- What is the scale of supersymmetry breaking? Is it high or low?

- Is there a hidden sector? If so, what communicates the supersymmetry breaking to the standard model fields?

- Are there extra dimensions? If so, how large are they? Is supersymmetry broken in the bulk or on a brane?

- Why is the cosmological constant so small?

- What is the LSP? Is it stable? What is its mass?

- Is there a GUT? Does the proton decay? Why are FCNC suppressed?

Data Rules!

We cannot settle these questions without data. But data is on the way:

- LEP II, Tevatron, LHC

- Searches for nonstandard gravity, dark matter, proton decay

- Precision measurements of cosmological parameters

Will they be enough?

If supersymmetry is correct, the answer is NO.

We need to look beyond LHC, to the next big collider.

SUSY 2000 Manifesto

If supersymmetry is right, there is no doubt that this next machine should be a high luminosity e+e- linear collider.

For supersymmeters, it's a slam dunk proposition.

But – the world doesn't need many small machines. We need one linear collider with enough energy to do the job.

CERN shows that European cooperation works well. We physicists should take the lead and show that cooperation can work on a larger scale.

Where are the Rabi, Amaldi, and Auger of today?

I hope they are right here, in this audience!

In Conclusion ….

Our community needs to be ready to exploit the first hint of new physics.

And I believe that hint may be coming very soon!

As a first step, we need to pull together.

To that end, I urge you to come to the Snowmass Workshop next July.

Make your voice heard!

We need YOU to define the future of our field!