Summary and Outlook

SM and BSM: What has LHC taught us so far?

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1 State of play in HEP

2 Experimental reasons and Theoretical motivations for going beyond the SM (BSM).

3 Two ways of being BSM:SUSY and Extra Dimensions

4 **What does the current information (Tevatron and LHC) tell us?** Subtle is the Nature! Is it Malicious ? We dont know yet!

5 Interplay between Higgs, top, B-physics and Search for BSM!.

Combination of my view and those presented at the meeting!

The field of High Energy Physics (HEP) had been in a strange situation.

The usual road through which Science progresses:

Existing Theory and Unexplained Phenomena ⇒ New Theoretical developments ⇒ Predictions ⇒ Testing in Experiments.

State in HEP for the past decade or so

Existing Theory **No Unexplained Phenomena!**, demands made by the Community on the properties of a theory ⇒ New Theoretical Developments ⇒ Predictions ⇒ Testing in Experiments.

We have had strong theoretical reasons to believe that there is new physics at $\sim$ TeV scale, Did not have *any strong* experimental evidence indicating its need AT THE TEV SCALE.

The track record of particle physicists has been pretty good so far and theoretical developments based on demands of aesthetics alone have been fruitful at getting at the root of fundamental questions.

BUT

The gap between theory and experiment had never been so large!

When we say we expect new physics at the TeV scale are we theorists sure of prefactor before the TeV. How big or small can it be?.

We expected the world from LHC: (a multi TeV collider) would help unravel the mystery.

Paris Sphicas explained to us why our expectations were so high!

Data from LHC have started coming, time of reckoning has arrived!

Generalities:

The SM Lagrangian consists of 'proved' gauge sector and **yet to be proved scalar** sector:

$$\mathcal{L} = -\frac{1}{4}F^a_{\mu\nu}F^{a\,\mu\nu} + i\bar{\psi}\not{D}\psi + \psi^T\lambda\psi h + h.c. + |D_\mu h|^2 - V(h)$$

Gauge sector in good shape.

The beginning of the spell of the gauge principle cast by QED is made much stronger with Non Abelian Gauge Field Theories with Spontaneous Symmetry Breaking and without symmetry breaking

But no direct evidence yet exists for the last piece of the Gauge Paradigm : the scalar sector! What is the experimental information on it?

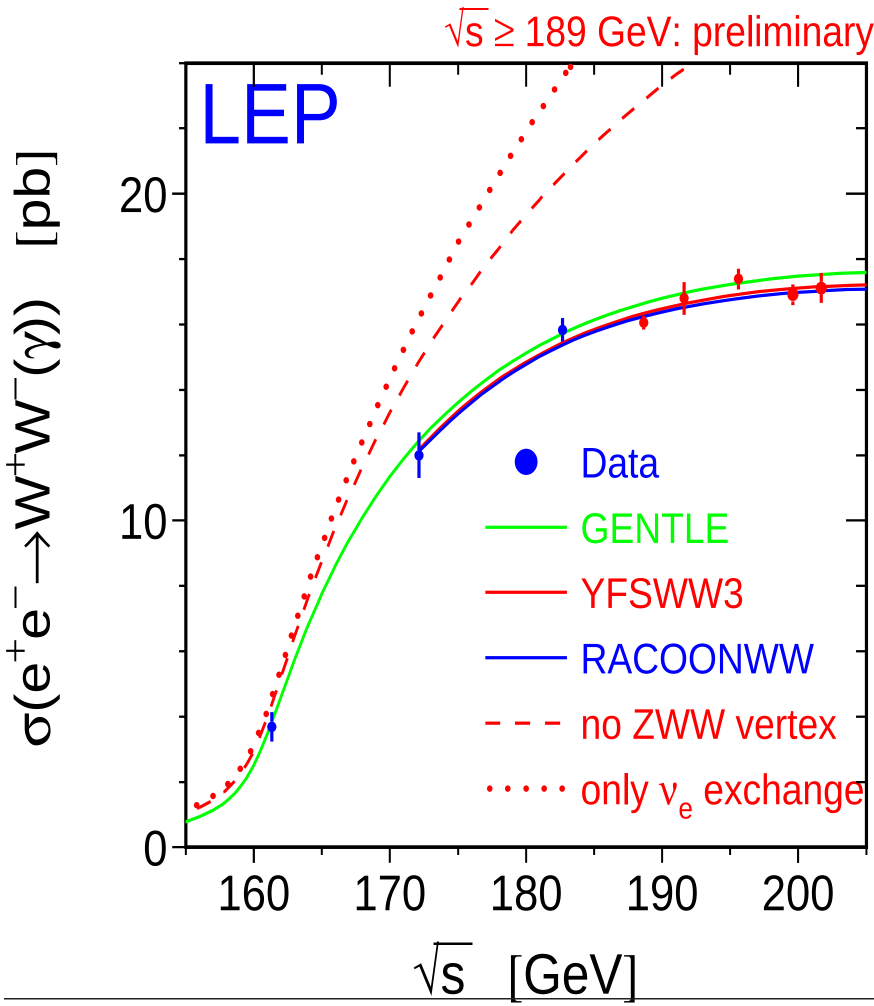
Unitarity:

The existence of the Higgs boson with precisely the same interactions as predicted in the SM can also be inferred by simply demanding that the scattering amplitudes for $W^+W^- \to W^+W^-$ etc. satisfy unitarity. (Tiktopoulos, Cornwall; Joglekar..)

The arguments simply tell that there should be a 'S-wave' contribution to the scattering amplitude which will tame the bad high energy behaviour and hence restore unitarity. Only a rough idea on the scale of this high energy ULTRA-violet 'completion' of the theory.

We had discussions of these and some more (where the unitarisation comes from spin one object) here by Frederica Bazzochi, Nicolas Berger, Sannino.

Direct 'Proof' of Symmetry and Symmetry breaking!!

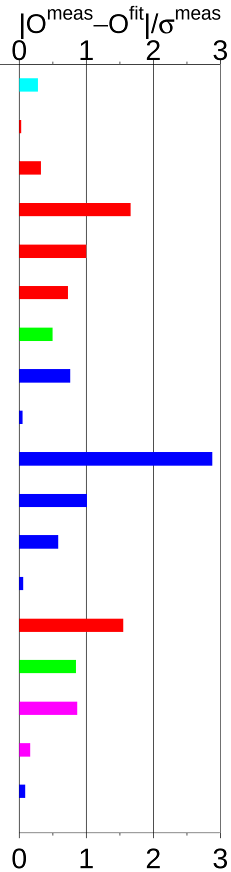


Proof that electroweak symmetry exists and that it is broken.

The triple gauge boson ZWW coupling tames the bad high energy behaviour of the cross-section caused by the t-channel diagram. Direct proof for the ZWW coupling.

This and precision testing, confirm basics of the SM

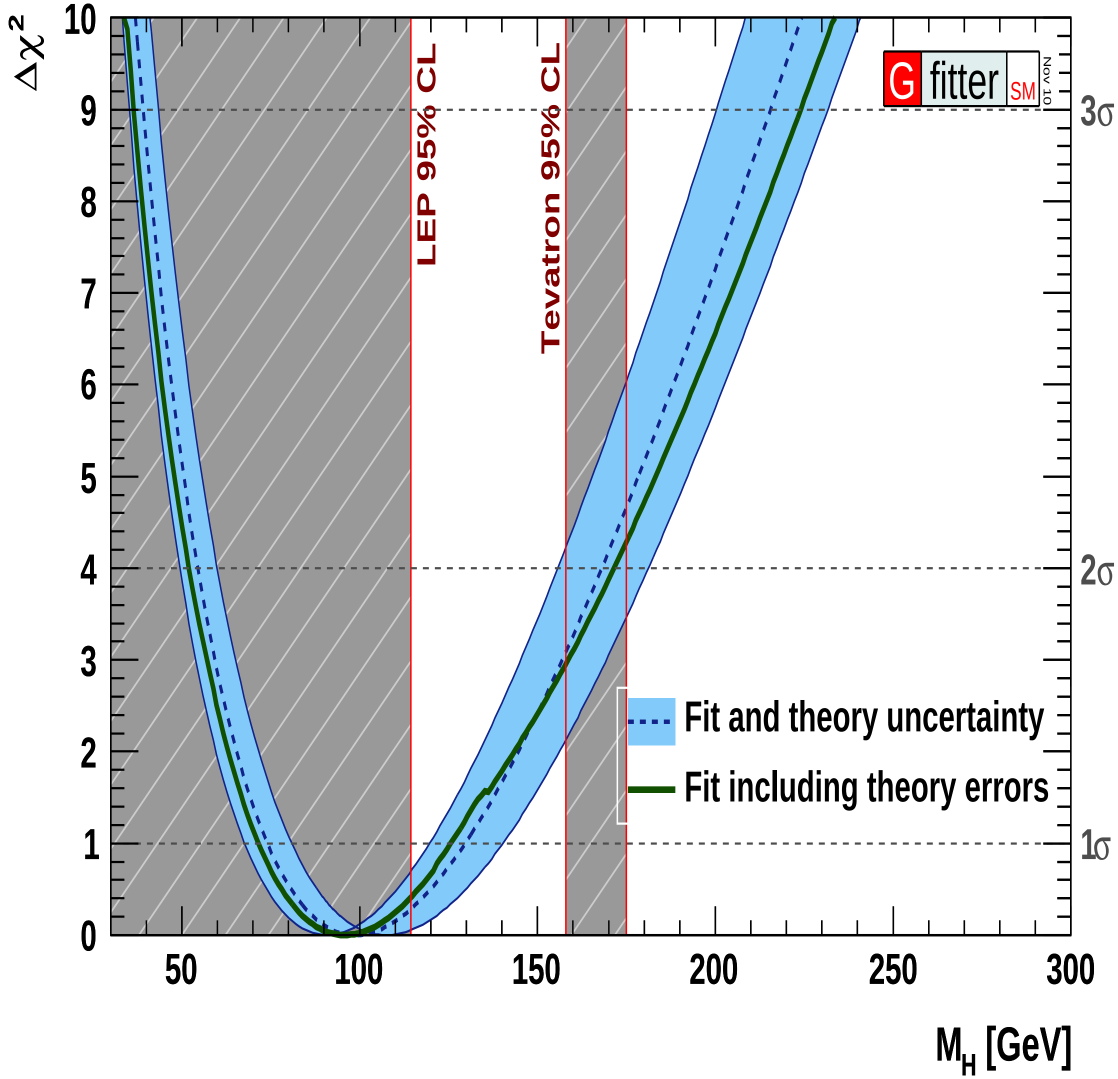
	Measurement	Fit
$\Delta\alpha^{(5)}_{had}(m_Z)$	0.02758 ± 0.00035	0.02768
m_Z [GeV]	91.1875 ± 0.0021	91.1874
Γ_Z [GeV]	2.4952 ± 0.0023	2.4959
σ^0_{had} [nb]	41.540 ± 0.037	41.479
R_l	20.767 ± 0.025	20.742
$A^{0,l}_{fb}$	0.01714 ± 0.00095	0.01645
$A_l(P_\tau)$	0.1465 ± 0.0032	0.1481
R_b	0.21629 ± 0.00066	0.21579
R_c	0.1721 ± 0.0030	0.1723
$A^{0,b}_{fb}$	0.0992 ± 0.0016	0.1038
$A^{0,c}_{fb}$	0.0707 ± 0.0035	0.0742
A_b	0.923 ± 0.020	0.935
A_c	0.670 ± 0.027	0.668
A_l(SLD)	0.1513 ± 0.0021	0.1481
$\sin^2\theta^{lept}_{eff}(Q_{fb})$	0.2324 ± 0.0012	0.2314
m_W [GeV]	80.399 ± 0.023	80.379
Γ_W [GeV]	2.085 ± 0.042	2.092
m_t [GeV]	173.3 ± 1.1	173.4



July 2010

- All the current experiments have tested the perturbative predictions of the Standard Model (SM) to an **unprecedented** accuracy.
- **May be holds also some clues of Physics beyond the SM**

see http://lepewwg.web.cern.ch



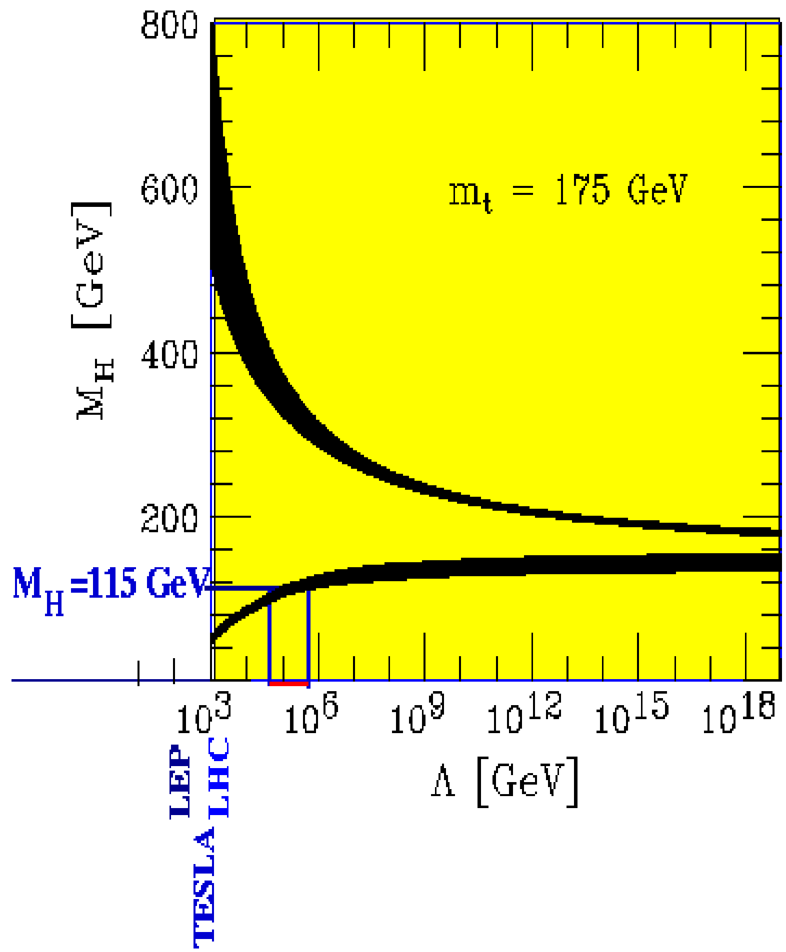
What does it mean for the Higgs? If all the current information is put together the Higgs mass should be less than 150 GeV. (**indirect experimental limit!**) Michael Kraemer reminded us about these things.

Does the SM have anything to say about what the Higgs mass should be?

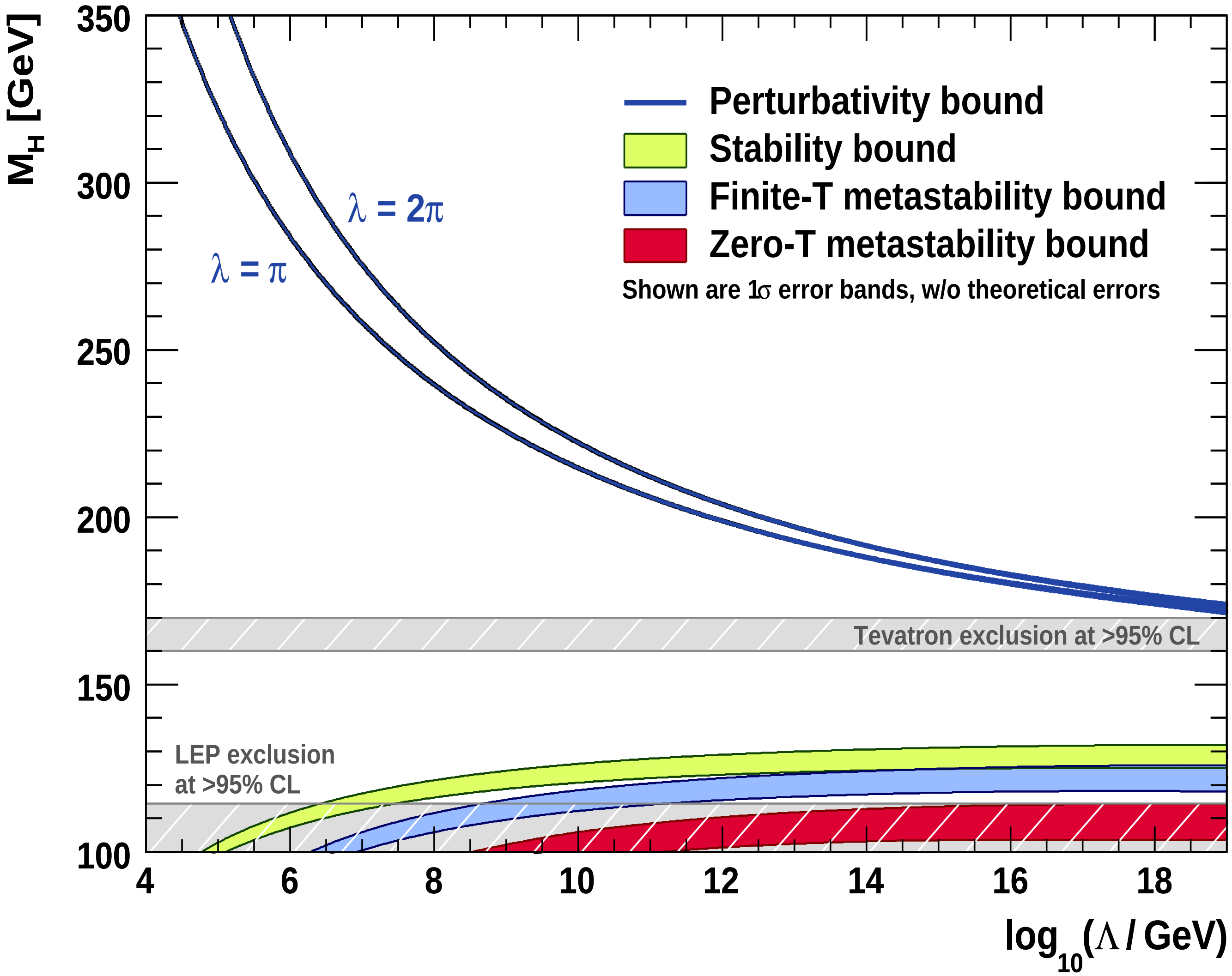
Theory predicts the interactions of the Higgs boson, BUT is *completely* silent about its mass.

Note : Just the mass of the Higgs when observed can give nontrivial indication on the BSM physics!

A heavy Higgs ($\gtrsim$ 300 GeV) would have meant new physics around a few TeV.



Riessleman and Hambye



J. Ellis, G. Giudice et al.

Lessons:

- The EW precision data like a light higgs.

- ANY discussion of alternate scenarios of symmetry breaking MUST always pass the **precision** test.

LHC mission is to understand the mechanism of the EWSB.

Various BSM ideas have been suggested to address what we think are esthetically nonpleasing issues.

Direct searches for this BSM physics have been on.

The properties of Higgs sector can get affected by the BSM physics.

May be the clues to BSM physics are to be had more subtly (indirectly) than through direct searches?

After all recall flavour physics K-meson mixing or B-meson mixing (reminded here to us by Niels Tuning) gave clues of higher scale physics!

Last decade great progress in the flavour sector:

The correctness of CKM picture, Excellent results from B-factories now augmented with LHCb, ν oscillations...

SM needs to be augmented by

$$\mathcal{L}' = \frac{1}{M} L_i \lambda^{\nu}_{ij} L_j h^2 \text{ and/or } L_i \lambda^{\nu}_{ij} N_j h + h.c. \tag{1}$$

Neutrinos are special in that they are neutral and many new physics ideas have implications for neutrino mass generation which can *in principle* be different from other fermions. (Beyond standard model..)

1] Neutrinos have nonzero masses *and* the fermion masses have a huge hierarchy

SM has bearing on issues cosmological and needs BSM physics as well.

2]. The contents of our periodic table seem to account for ONLY 4% of the matter in the Universe! Astrophysical evidence pretty convincing. Dark Matter: exptal information indicates a BSM particle

3] **A** *qualitative* **explanation of the Baryon-Antibaryion asymmetry in the Universe, in terms of** *known* **CP violation in the SM,** *measured in laboratory*, **is possible.** A quantitative explanation indicates need of BSM physics.

(Sebastian Jager gave a very clear reivew of some of these issues)

Then there are esthetic/theoretical reasons motivated by the experimental information on the Higgs mass!

The fact that SM works so well means

1) a Higgs OR a look alike must exist and data tell us it must be light!

2) We should also understand why it is light!! Loop corrections will always push it to the maximum mass in the theory.

This is one reason for expecting physics beyond the Standard Model!!

The hierarchy problem:

The EW theory has been tested at 1-loop level. The Higgs mass which is a free parameter in the SM, receives large quantum corrections and the mass will approach the cutoff scale of the theory.

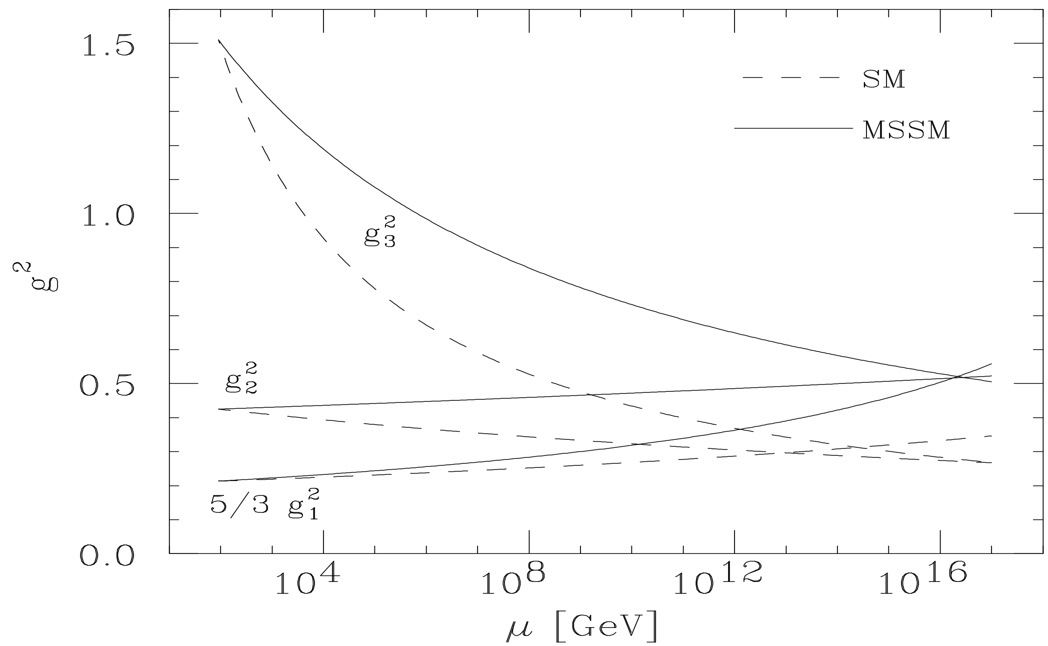
If, $m_{\mathsf{h}}^2 = m_{\mathsf{bare}}^2 + \delta m_{\mathsf{h}}^2$ the top loop (e.g.) gives

$$\delta m^2_{\mathsf{h}|\mathsf{top}} \sim -\frac{3G_{\mathsf{F}}}{2\sqrt{2}\pi^2} m_t^2 \Lambda^2 \sim -(0.2\Lambda)^2.$$

The light higgs is 'natural' then only if $\Lambda \sim$ TeV.

A little more 'experimentally' motivated hint for BSM?:

- Do strengths of all the interactions unify at some high energy?
- with Supersymmetry (still to be discussed) there is some evidence that they might.
- Models to explain observed mass patterns, all like unified models.



Is that the whole truth? Is this a time for a paradigm shift?

Are Quantum Field Theories sort of a ’low energy’ paradigm?. Can we combine gravity somewhere in the picture?

- Dark Matter makes up 23% of the Universe.!
- Direct evidence for the nonzero ν masses
- Quantitative explanation of the Baryon Asymmetry in the Universe!

- **Instability of the EW scale under radiative corrections.**
- Need to get a basic understanding of the flavour Issue
- Unification of couplings
- Inclusion of Gravity in the picture?

We know at present two ways to keep the Higgs 'naturally' light:

1] Introduce a symmetry:

Supersymmetry : cancel the large top loop contribution by contributions from scalars. There exist host of new particles which we should see at the colliders, *around* TeV scale.

OR

Little Higgs models: The Higgs mass is small because its mass is protected as it is a pseudo goldstone boson. There exist many additional fermions, gauge bosons in the theory at the TeV scale.

2] The cutoff is lowered to TeV:composite models and brane-worlds. Brane Worlds postulate behaviour of the space and time different from what we understand, such as additional compactified dimensions! new developments: String theories havegs begun to make some statements about such models!

3]Higgsless models/Light composite Higgs?

Little Higgs or Higgsless models can have problem passing the acid test of LEP precision measurements and one has to work hard. Issues of ultraviolet completions are sometimes solved by reintroducing a high scale (much above a TeV scale) Supersymmetry.

1)Introduce a symmetry: supersymmetry

Theoretically extremely elegant and attractive: Spacetime symmetry, finite ultraviolet behaviour.

However:

It is *clearly* broken. ALL the experiments have so far only given NEGATIVE results, giving LOWER limits on sparticle masses.

The symmetry is beautiful, the ideas of how to break it are mostly not!

Keeps the Higgs light 'naturally'! But sparticle should not be too heavy. What is 'too heavy'? When should we be worried?

Predictive: Higgs mass limits, quite robust with respect to SUSY breaking parameters.

WIMP miracle happens easily. Ready made DM candidate. But in CMSSM again it is now under great scrutiny. Good point: predictive in a given model. (we heard here from Decowski and Milstead)

Baryogenesis works. Requires NMSSM and/or additional CP violation.

Can address ν masses, but requires R-parity violaton.

Flavour physics: SUSY has no neat solution. B physics measurements put it under strain in fact.

Local supersymmetry : Supergravity contains automatically Einstein Gravity.

String theory requires Supersymmetry, BUT REMEMBER NOT TEV scale Supersymmetry.

Question:

1)Should we be worried now with the newer exclusions from CMS/ATLAS?

Is it still 'natural'? In T. Huxley's words will SUSY be a great tragedy of science: 'A beautiful theory slain by an ugly fact?'

2) Synergy between the DM experiments and LHC experiments?

3) What are the best ways of proving/disproving the idea given the current CMS/ATLAS results?

a How many extra dimensions?

b What is the size of the Xtra dimensions? What is the 'size' of the bulk? ('large' extra dimesions, TeV^{-1} dimensions)

c What is the geometry of the additional dimensions? (warped or otherwise?) (Randall Sundrum and many variations thereof)

d Which particles propagate into the bulk?

e Symmetries that the KK spectrum has (Universal Extra Dimension: UED)

f Interesting flavour physics model building possible in RS picture.

• Extra dimensions are an exciting idea. Very interesting that it is compatible with the data. Provide an intimate link with structure of spacetime and technical problems in particle physics

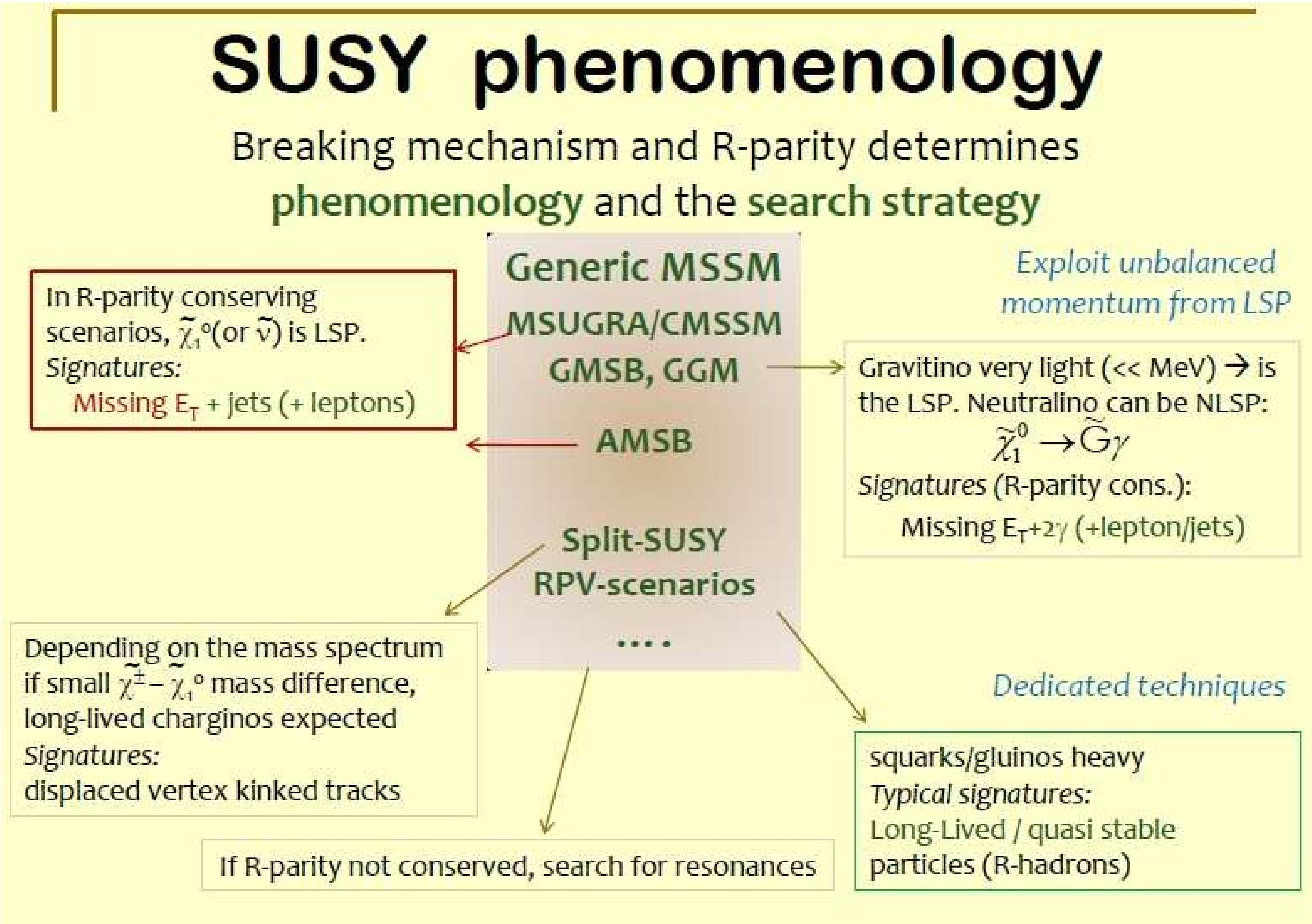
• None of the models is completely free from fine-tuning. RS the best and hence the template of almost all the ED phenomenology these days.

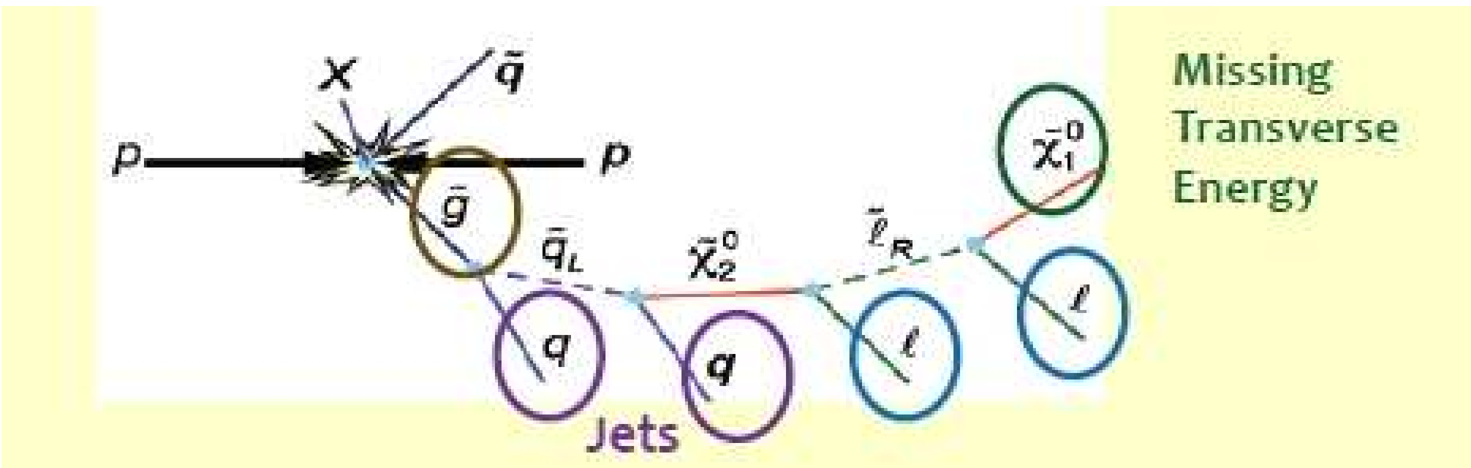
• Phenomenology is highly model- dependent: only spin-2 graviton is unique, if it (the spin) can be determined.

• Predictions for collider signals in some cases depend on the Ultra-violet completion of the theories. Counterpart of uncertainties about SUSY breaking (to some extent). In general less predictive than SUSY.

- EWPT not always easy.
- KK parity gives DM candidate.
- Does not address the different reasons for BSM as well as SUSY.

Currently we only have limits on sparticle masses (for given SUSY breaking scenarios) or on the scale Λ of the extra dimensional theories.


SUSY phenomenology
Breaking mechanism and R-parity determines
phenomenology and the search strategy
Generic MSSM
MSUGRA/CMSSM
GMSB, GGM
AMSB
Split-SUSY
RPV-scenarios
....
In R-parity conserving scenarios, $\tilde{\chi}_1^o$(or $\tilde{\nu}$) is LSP.
Signatures:
Missing E_T + jets (+ leptons)
Exploit unbalanced momentum from LSP
Gravitino very light (<< MeV) → is the LSP. Neutralino can be NLSP:
$\tilde{\chi}_1^0 \rightarrow \tilde{G}\gamma$
Signatures (R-parity cons.):
Missing E_T+2γ (+lepton/jets)
Depending on the mass spectrum if small $\tilde{\chi}^{\pm}-\tilde{\chi}_1^o$ mass difference, long-lived charginos expected
Signatures:
displaced vertex kinked tracks
Dedicated techniques
squarks/gluinos heavy
Typical signatures:
Long-Lived / quasi stable particles (R-hadrons)
If R-parity not conserved, search for resonances


X
$\tilde{q}$
p
p
$\tilde{g}$
$\tilde{q}_L$
$\tilde{\chi}_2^0$
$\tilde{\ell}_R$
$\tilde{\chi}_1^0$
Missing Transverse Energy
q
q
ℓ
ℓ
Jets

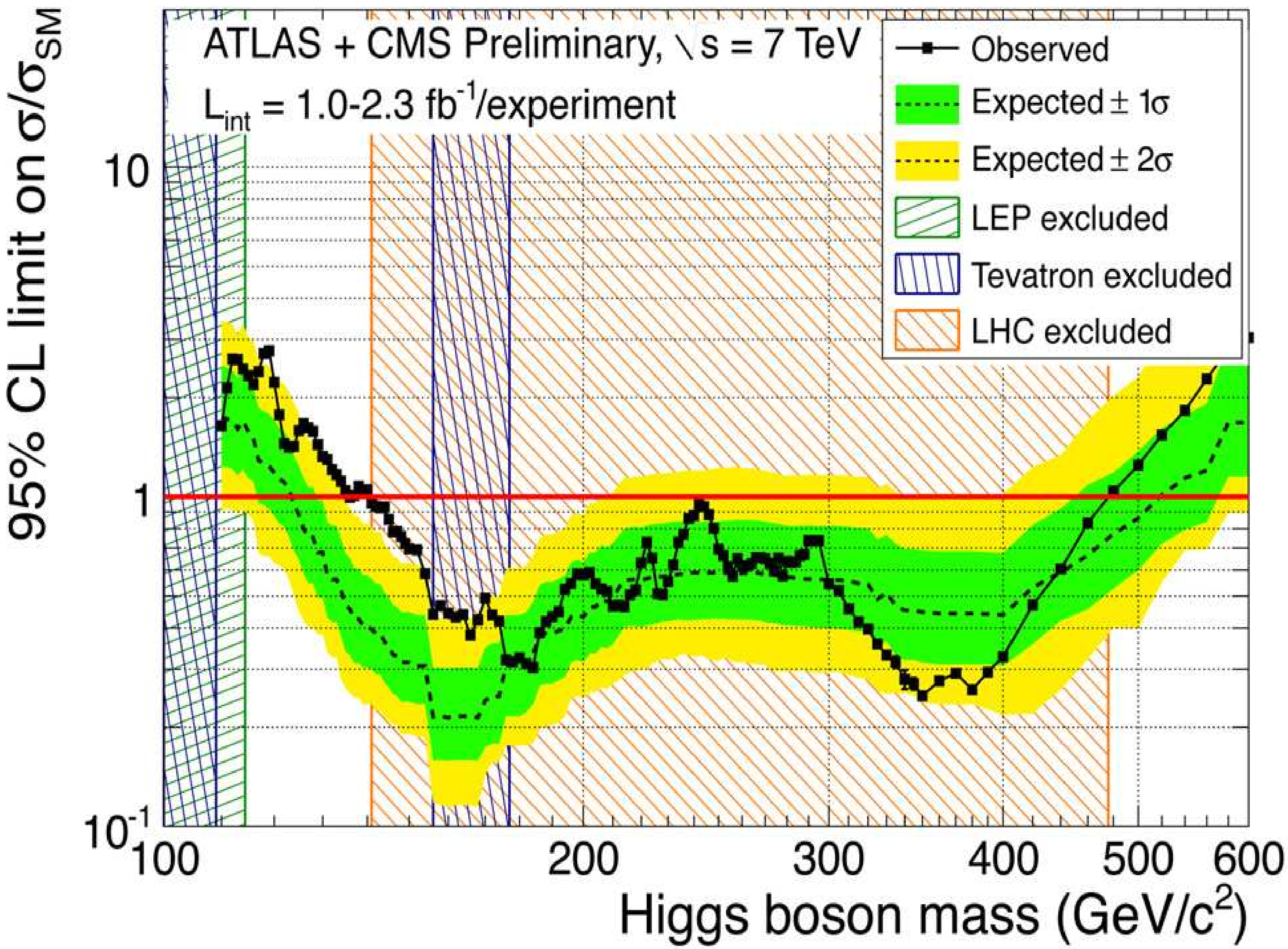
A lot of work over the past decades done by a lot of people:

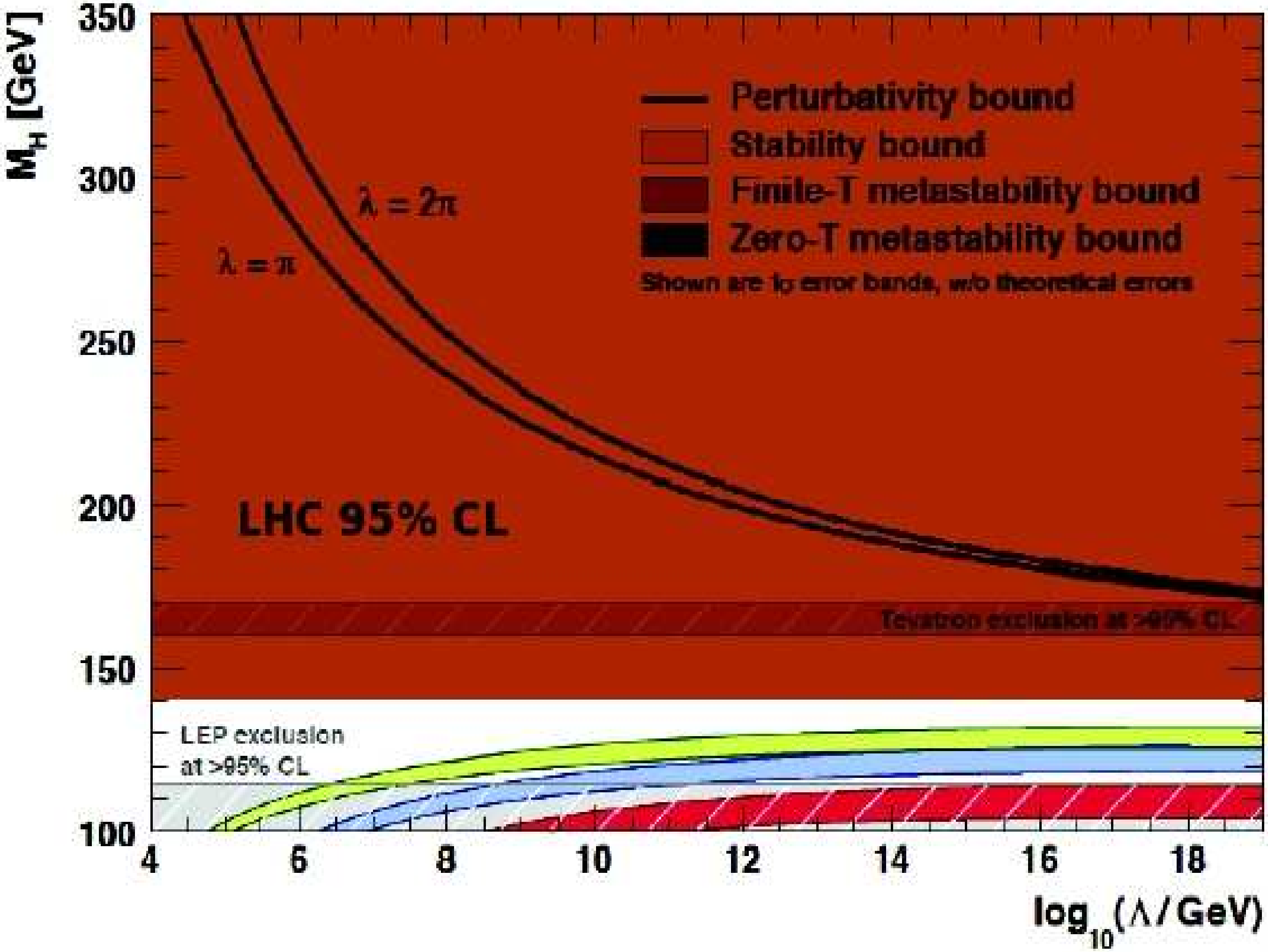
1) Hpw to predict reliably what the detectors should see (Stefano Frixione, Stefan Kluth, Achilleas Lazopoulos,Maria Ubiali) and make sure we dont calibrate away the signal!

1)How to compute the expected particle spectra for a given SUSY breaking scenario

2) How to compute expected cross-sections for sparticle production (Irene Niessen told us here about these)

3)What are 'tell tale' final states and signatures for different SUSY models. That needs to be used once the experimentalists tell us if they have seen any events above the background.


ATLAS + CMS Preliminary, \s = 7 TeV
L_int = 1.0-2.3 fb^-1/experiment
Observed
Expected ± 1σ
Expected ± 2σ
LEP excluded
Tevatron excluded
LHC excluded
95% CL limit on σ/σ_SM
10
1
10^-1
100
200
300
400
500
600
Higgs boson mass (GeV/c^2)



M_H [GeV]
350
300
250
200
150
100
4
6
8
10
12
14
16
18
log10(Λ/GeV)
Perturbativity bound
Stability bound
Finite-T metastability bound
Zero-T metastability bound
Shown are 1σ error bands, w/o theoretical errors
λ = 2π
λ = π
LHC 95% CL
Tevatron exclusion at >95% CL
LEP exclusion
at >95% CL

1)Higgs heavier than 500 GeV: In conflict with implications of EWPT.

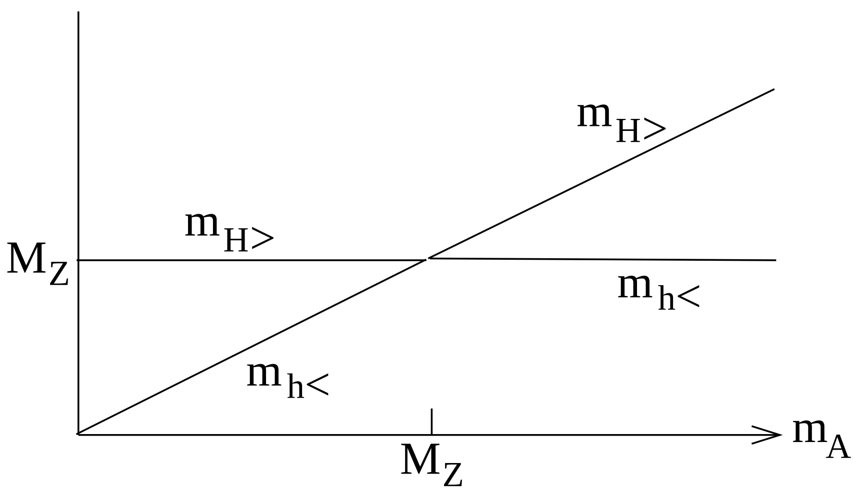
2)Light Higgs : can we already take this to be 'indication' for BSM?

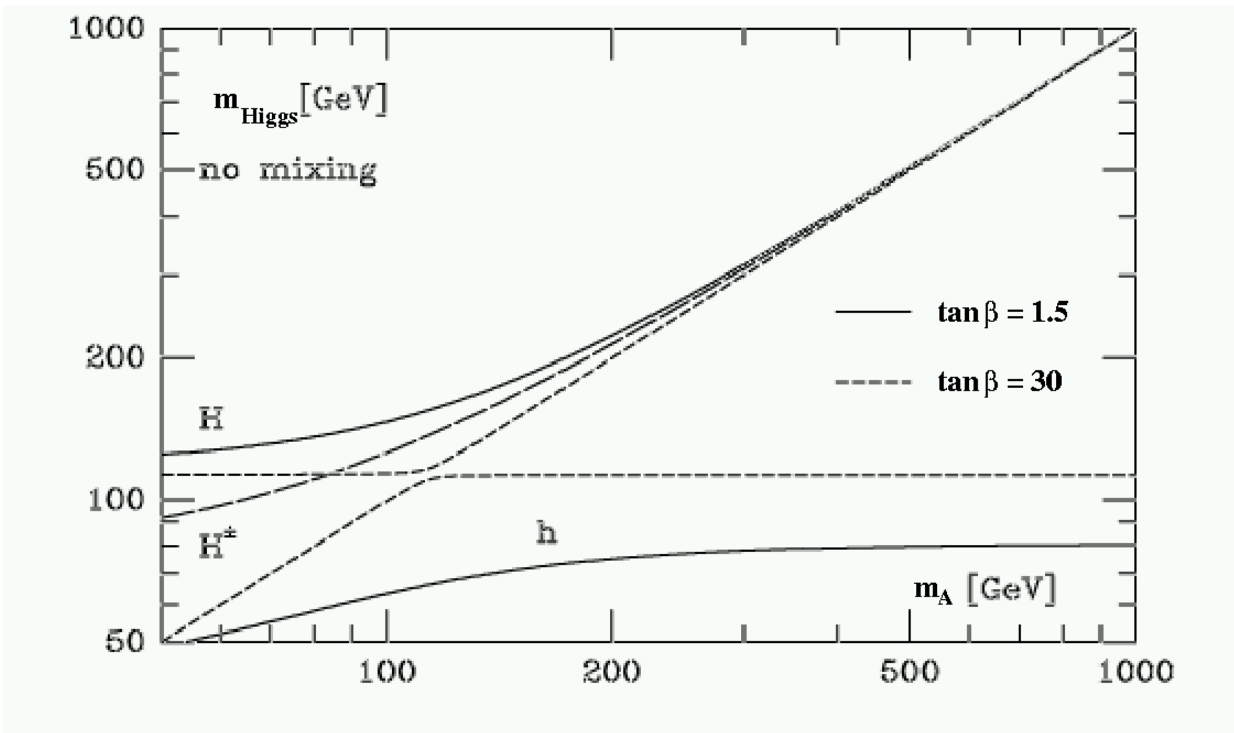
3)If the upper bound should be lowered below 135 GeV or so, with the newer data it could indicate BSM.

4)What is the effect of this BSM on Higgs production and decay? Can one probe the BSM through the 'Higgs' portal?

A very exhaustive discussion of the connection between DM and BSM through the Higgs portal, by Yan Mambrini. I will discuss example of SUSY, which he did not talk about.

Higgs mass in MSSM is bounded, bound increasing due to radiative corrections mainly coming from top. (Is there anything else that can rleax this bound: NMSSM, BMSSM?)

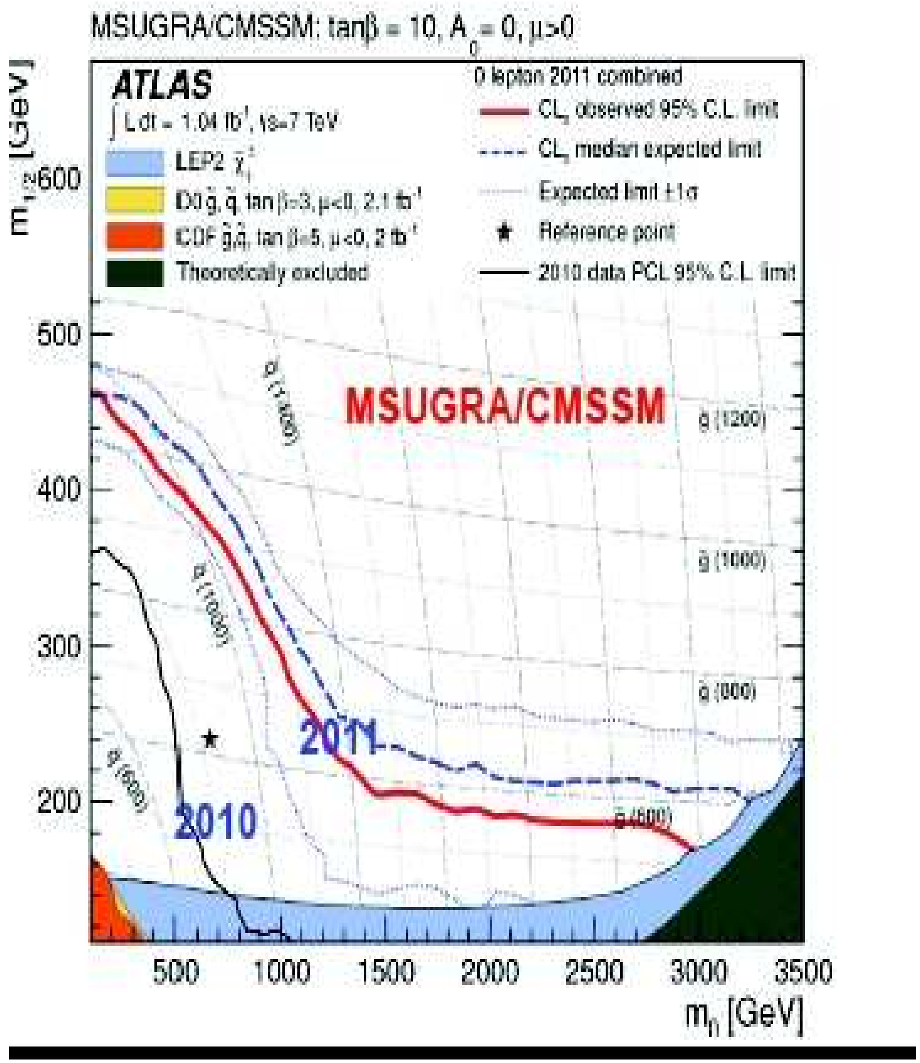


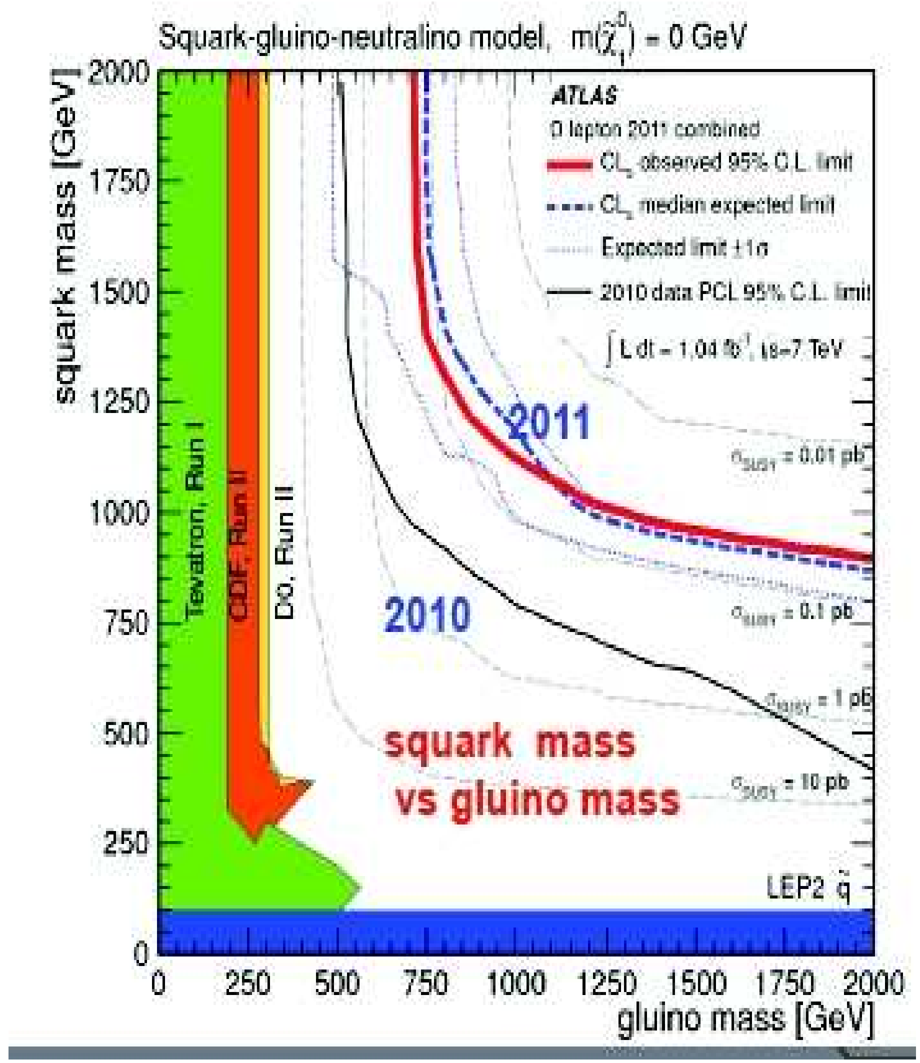


m_{Higgs}[GeV]
no mixing
H
$H^{\pm}$
h
$\tan\beta = 1.5$
$\tan\beta = 30$
m_A [GeV]
1000
500
200
100
50
100
200
500
1000

So really if the Higgs searches should rule out Existence of a light Higgs below 125 GeV or so we would have ruled out a large number of simple implementations of SUSY and SUSY breaking!

But if they rule out a Higgs with mass between ~ 130 and 141 GeV this could imply BSM!





From the talk by Paul de Jong.

Theorists have

i) Analysed the effect of these data for the best fit to a variety of all the other data such as $(g-2)_\mu, B \to s\gamma$, requiring that SUSY gives the right amount of DM and analysed what region gives the best fit to define the 'corner' arund which SUSY is hiding once again. (Michael's talk & 1109.3859v2, S. Sekmen et al: 1109.5119, A. Fowlie et al: 1111.6098)

Will not discuss details of this.

ii) Discussed how much worse the fine tuning problem has become Strumia: 1101.2195v1, Ellwanger et al.arXiv: 1107.2471

How significant is this? Will discuss later.

iii) What are 'natural' sparticle mass spectra in light of new LHC exclusion? Since the $\tilde{t}_1\bar{\tilde{t}}_1$ x.section is much smaller than the first two generation squarks, constraints are indeed weaker. (Discussed by paris Sphicas)

Lighter third generation squarks, lighter EWinos, 1.5 TeV $\tilde{g}$. Indeed the 'corner' where one should look for SUSY has changed. After all 'naturalness' requires only the third generation squarks to be light and 'EW'inos to be light. (light means $\sim<$ 1 TeV), a few hundred GeV. Barbieri: talk at HCP, L. Hall

http://indico.cern.ch/getFile.py/access?contribId=7
&sessionId=2&resId=0&materialId=slides&confId=157244

For this particular spectra multi top final states can be a signal. Incidentally such a scenario had meritted a page in 'good' textbooks on sparticles (☺), So this is clearly not 'desperation days'

My take: if one is very agnostic, take a view that SUSY spectra has only those features which we require to 'address' the observational issues.

Check whether we have

1)a light neutralino, (one needs a chargino along with it), and 2)one light stop state.

Handles the matter-antimatter asymmetry, as well as DM.

Is not sooo inconsistent with 'naturalness' and keeps the Higgs light without too much fine tuning, if the stop less than few hundred GeV.

With current data and that of 2012 (perhaps with 8 TeV, quoting Paris Sphicas) may be possible to answer such questions as well.

iv) Effects of SUSY on Higgs searches:

Different production and decay modes get affected differently. As one goes away from cMSSM the effects of SUSY on Higgs phenomenology can be varied.

Obvious question: How will these effects change the strength of 'Higgs' signal and what would be associated sparticle phenomenology?

Utilise the correlation between 'diect' searches and this 'indirect' effect on Higgs sector to either rule out SUSY or find it !

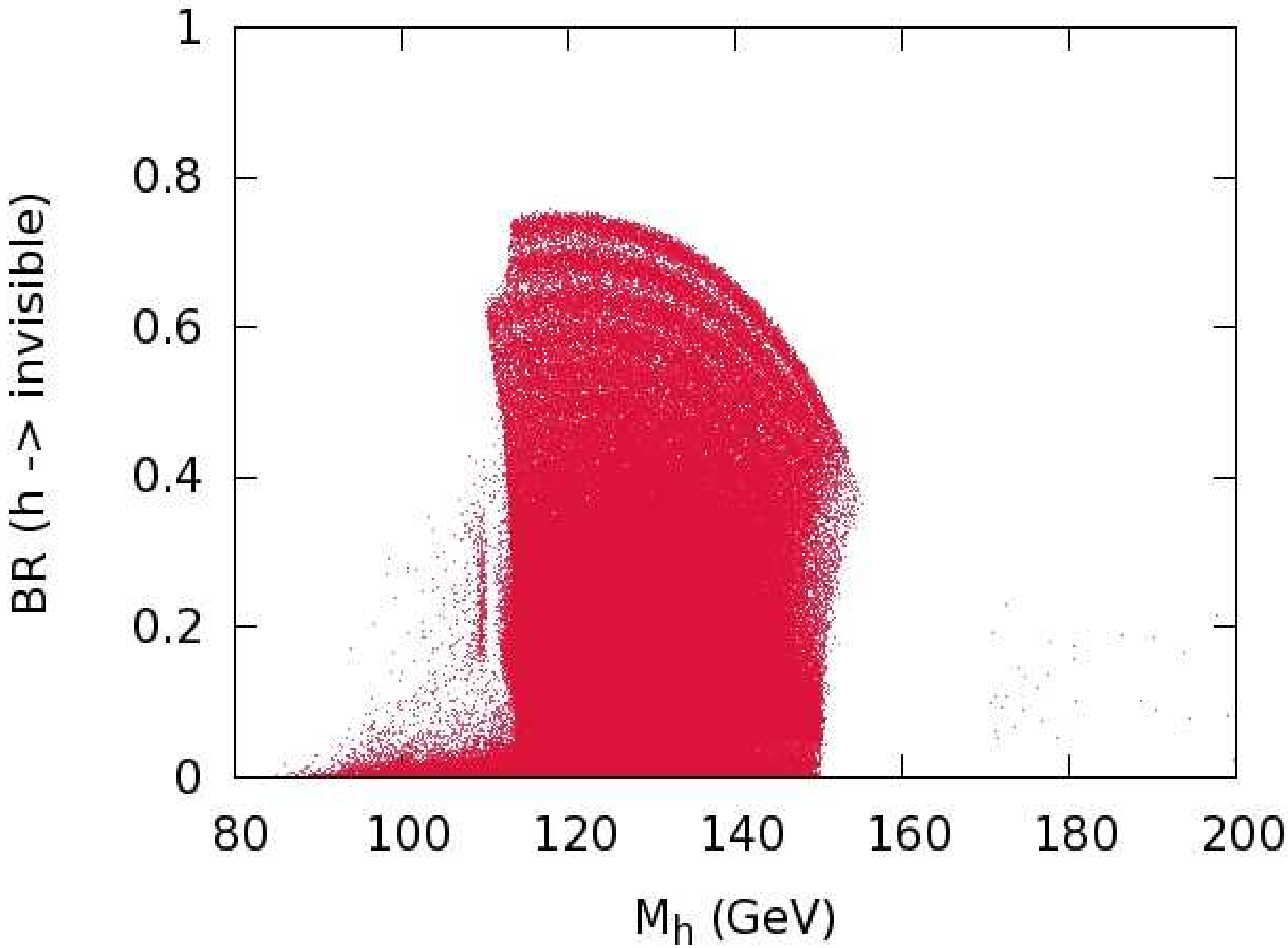
The new heavy supersymmetric spectra means that perhaps one should consider an effective theory where these sparticles have been integrated out. The higher order operators will improve fine tuning.

So essentially additional contribution to the Lagrangian. A special case will be for example, NMSSM.

(Carena et al: Phys. Rev. 82, 1111.2049, Boudjema, G. Drieu la Rochelle: in preparation.)

Upper limit on the light higgs is relaxed from 131 GeV. Analysis where the constraints from EWPT, experimental searches at Teavtron and LHC, allow for light Higgs mass upto 150 GeV, for some points in the scan going upto 180-200 GeV.

There can be regions with large 'invisible' branching ratio for the Higgs.



F. Boudjema and G. Drieu la Rochelle.

Albornoz Vasquez, Belanger, R.G.: (Update of R.G., G. Belanger, F. Boudjema et al: NPB 581, 2000, 3)

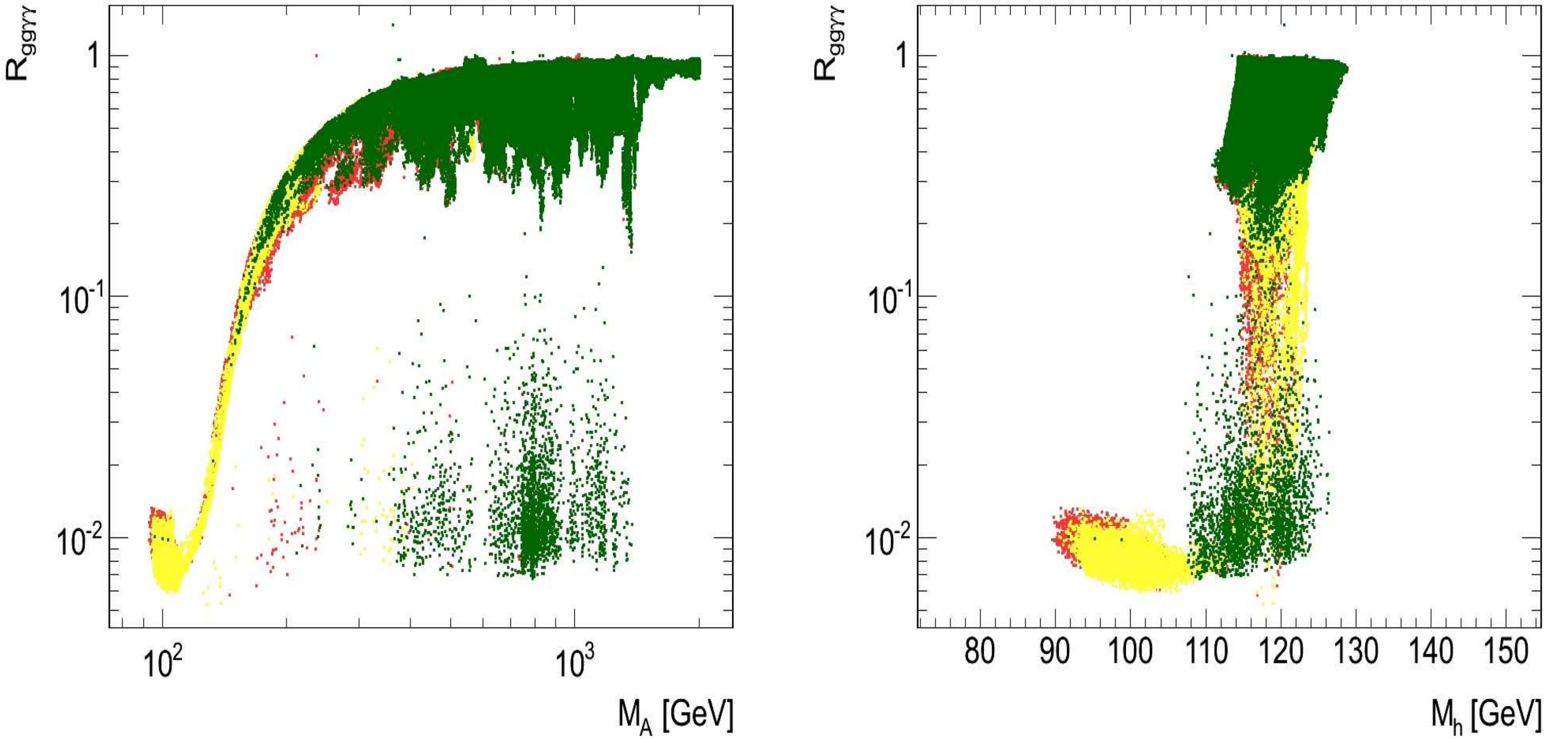
Looked effects in MSSM, with reduced parameters.

$M_i, i = 1, 3, \mu, \tan\beta, M_A, M_{\tilde{l}_R}, M_{\tilde{l}_L}, M_{\tilde{q}_{1,2}}, M_{\tilde{q}_3}$ and A_t.

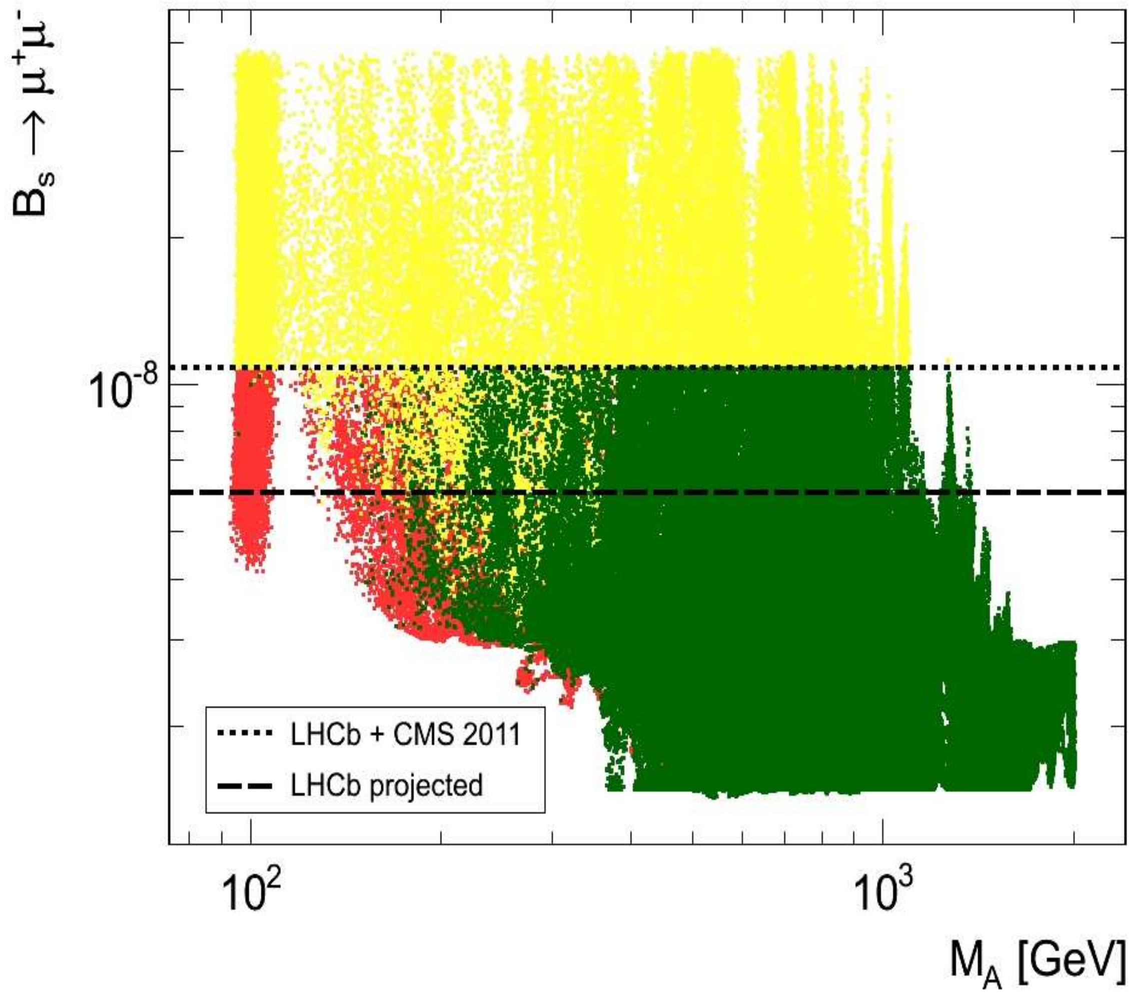
Characterised by light neutralino Dark Matter.

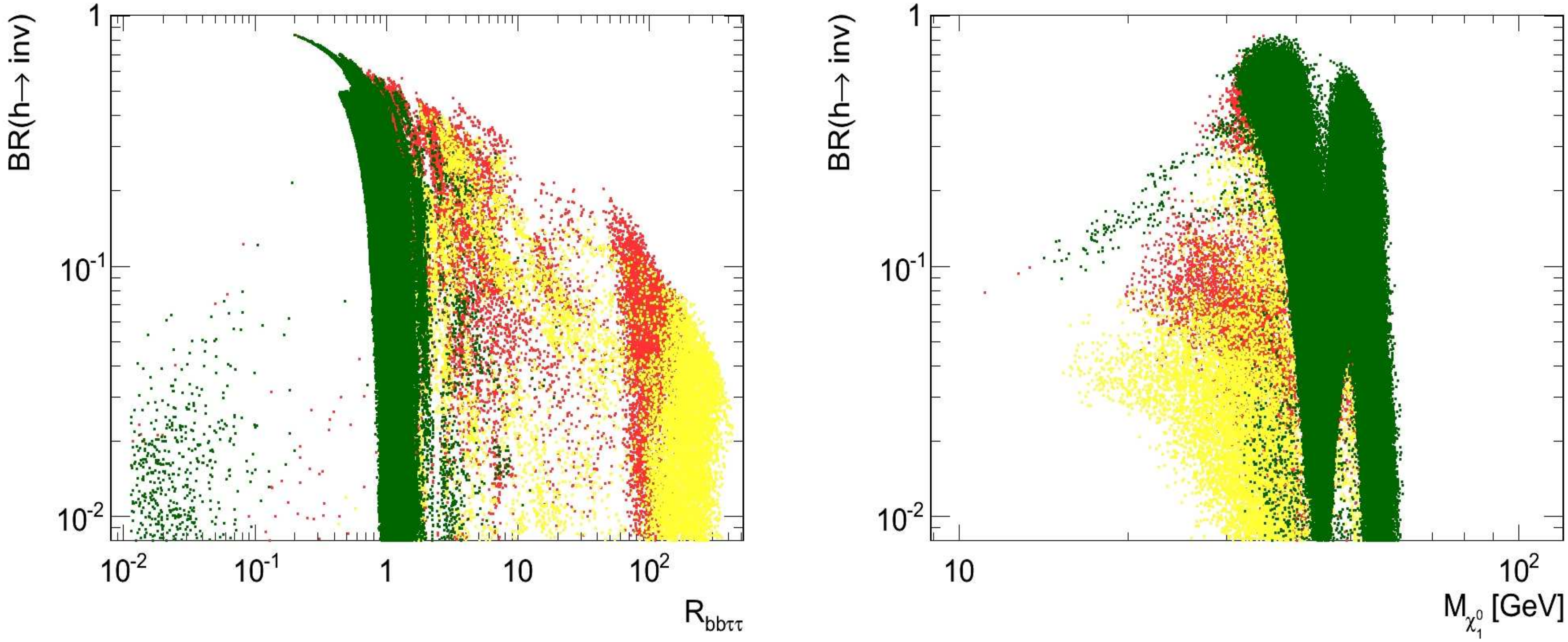
Light M_A and light neurtalino can affect the B.R. $(h \to \gamma\gamma)$ and gg fusion rate.

Loop couplings changed by sparticle loops.



The effect on production in gg fusion and decay into $\gamma\gamma$ channel, relative to the SM.

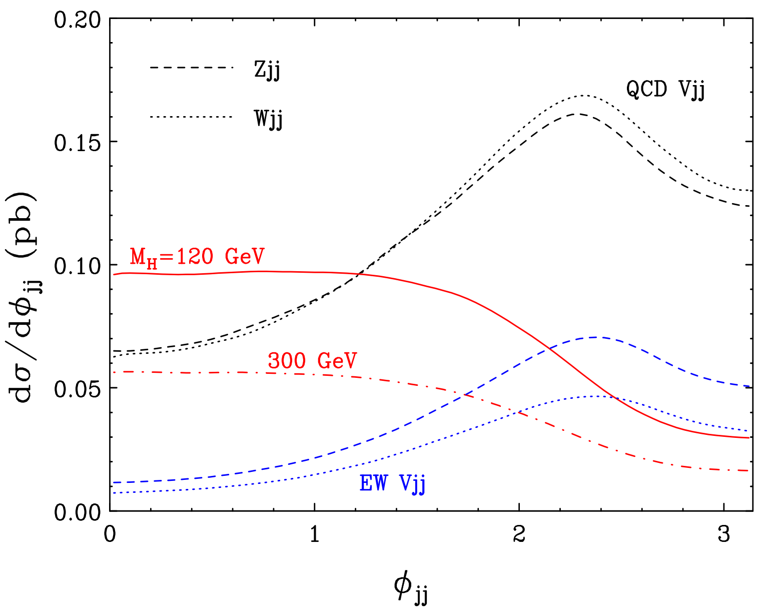

$B_s \to \mu^+\mu^-$
10^{-8}
10^2
10^3
M_A [GeV]
LHCb + CMS 2011
LHCb projected

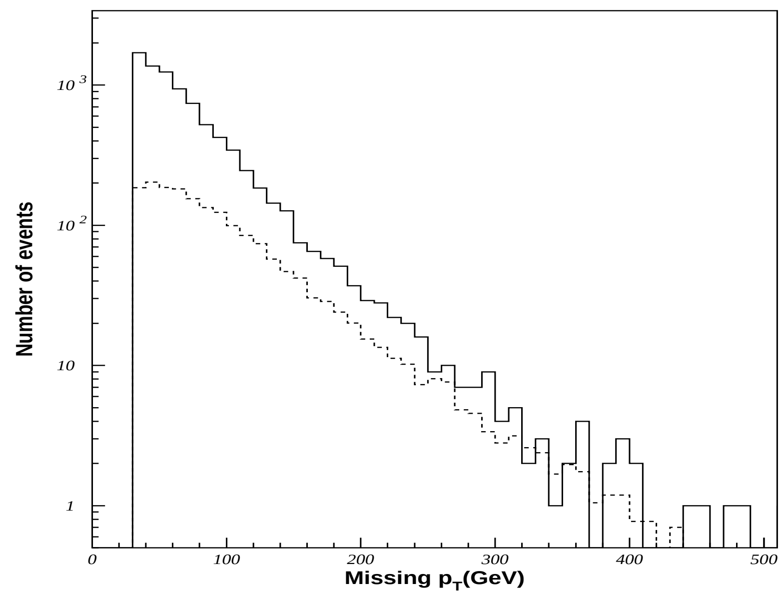


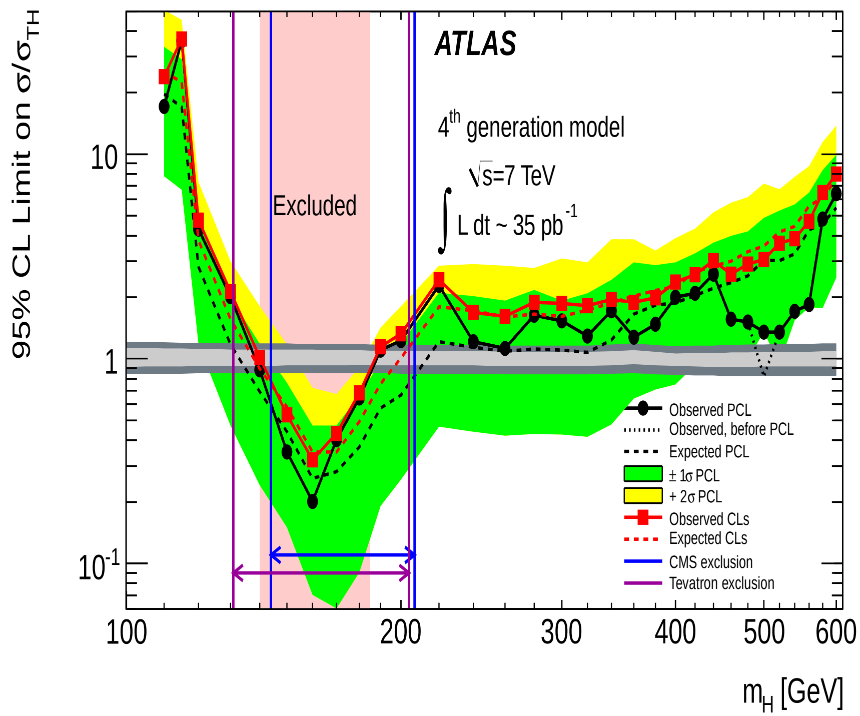
Recall Yan Mambrini's different DM models also predicted an invisible Higgs.

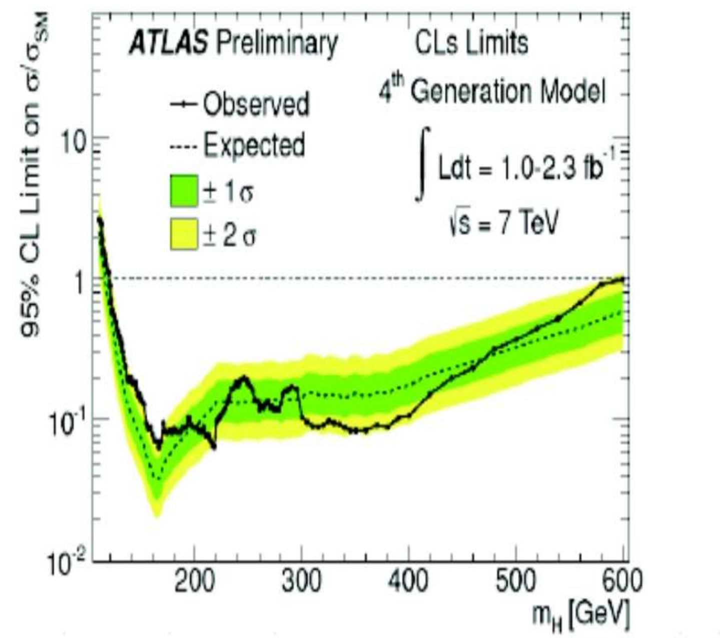
VBF (discussed here by B. jaeger).
For invisible Higgs: O. Eboli and D. Zeppenfeld, PLB 495 (2000) 147. Works with 30 fb^{-1}, at 14 TeV.

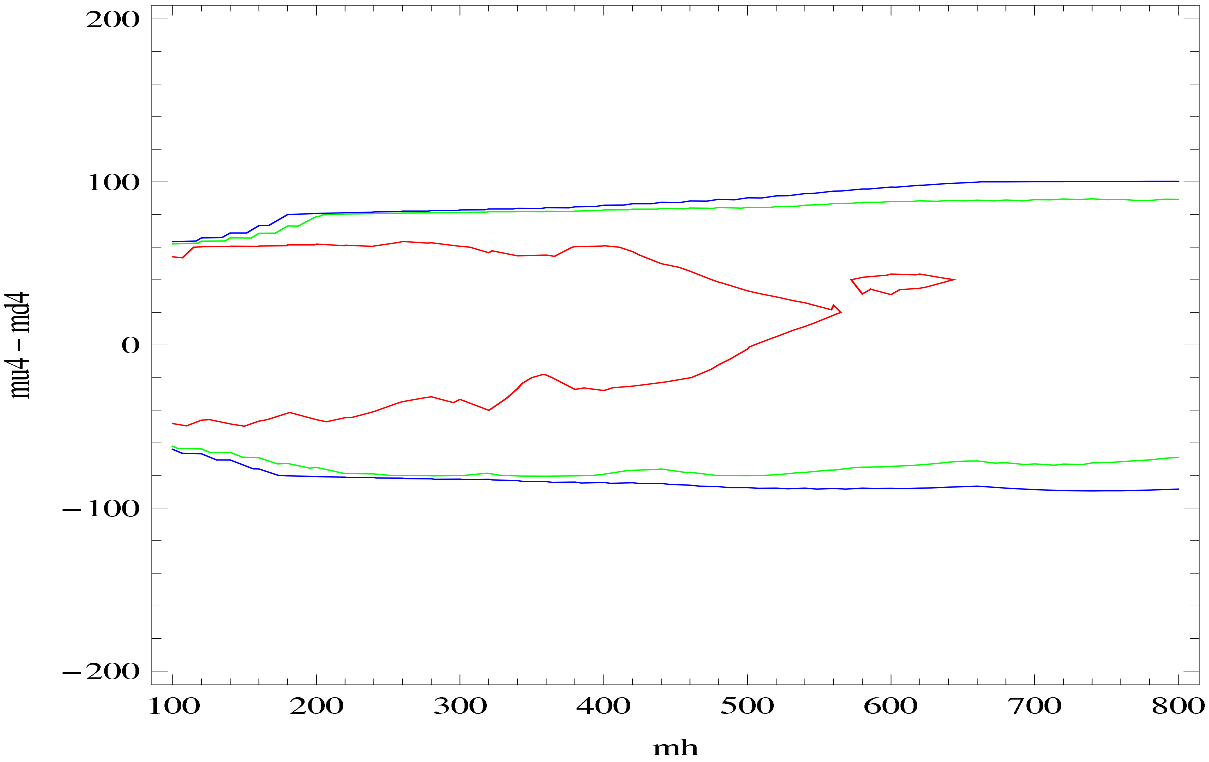
R.G., Guchait et al.PLB 571 (2003) 184 Works for a light Higgs upto invisible branching ratio 0.3, with 30 fb^{-1}, at 14 TeV.






ATLAS
4th generation model
√s=7 TeV
∫ L dt ~ 35 pb⁻¹
Excluded
Observed PCL
Observed, before PCL
Expected PCL
± 1σ PCL
+ 2σ PCL
Observed CLs
Expected CLs
CMS exclusion
Tevatron exclusion
95% CL Limit on σ/σTH
mH [GeV]

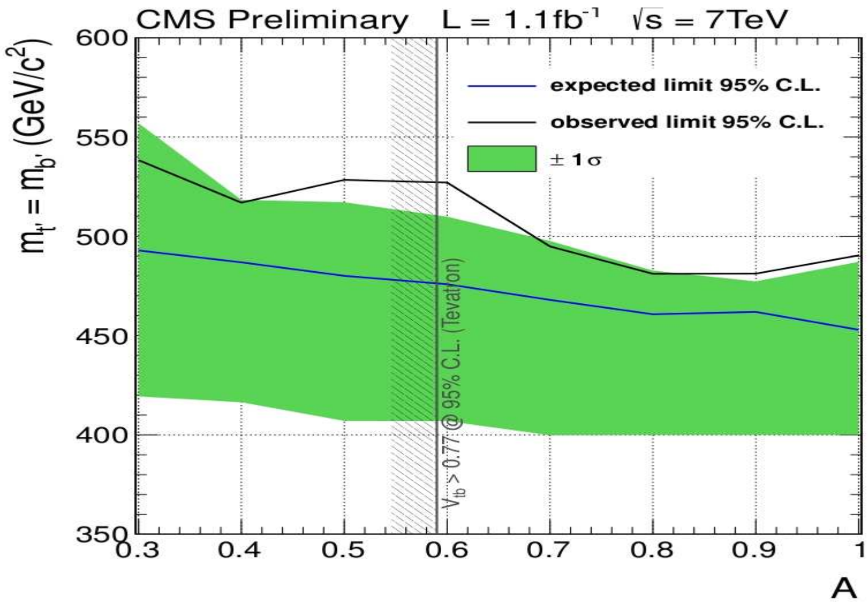

ATLAS Preliminary
CLs Limits
4th Generation Model
Observed
Expected
± 1σ
± 2σ
∫ Ldt = 1.0-2.3 fb⁻¹
√s = 7 TeV
95% CL Limit on σ/σSM
mH [GeV]



$M_{t'} - M_{b'} > m_W$ allowed for M_H.

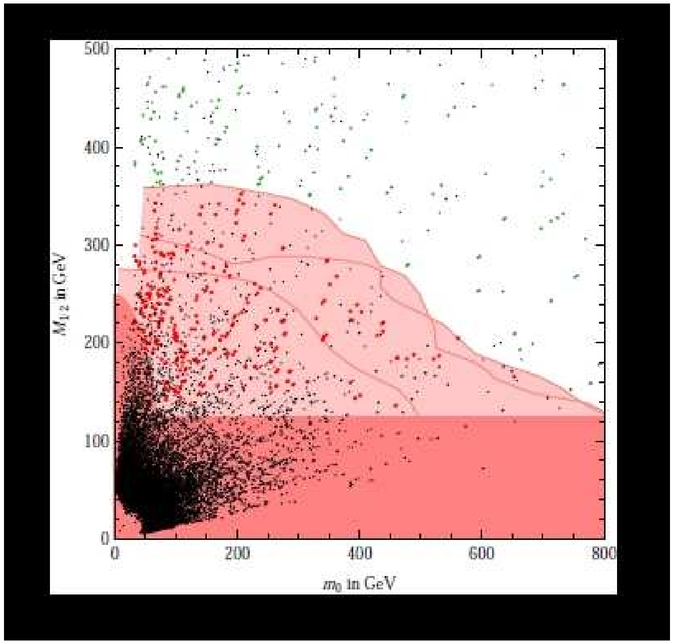
(Amold Dighe, RG, V. Arunprasath, Diptimoy Ghosh)

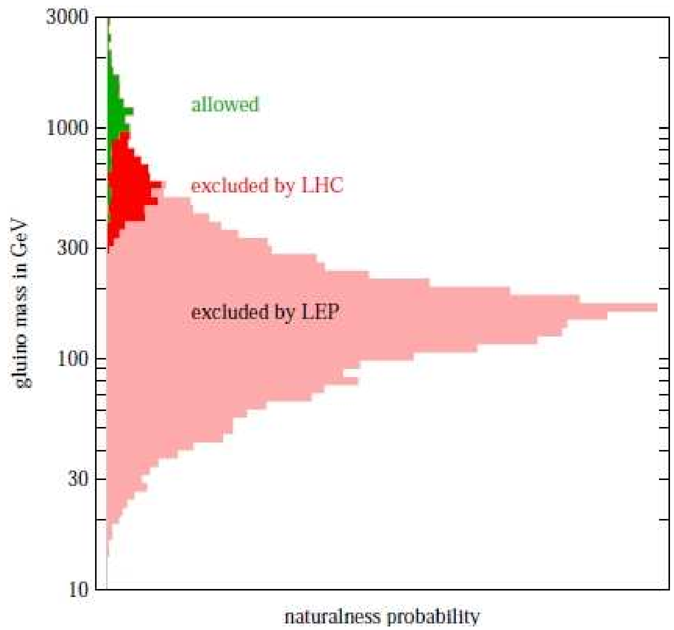
Why is this important?



Searches at present use a final state $t' \to bW$ as the channel $t' \to b'W$ was not expected to be open. So the search strategies might have to be revisited! Nontrivial interplay between different search groups!

Also between theory and experimentalists!





In CMSSM:

$$M_Z^2 \simeq 0.2 m_0^2 + 0.7 M_3^2 - 2\mu^2$$

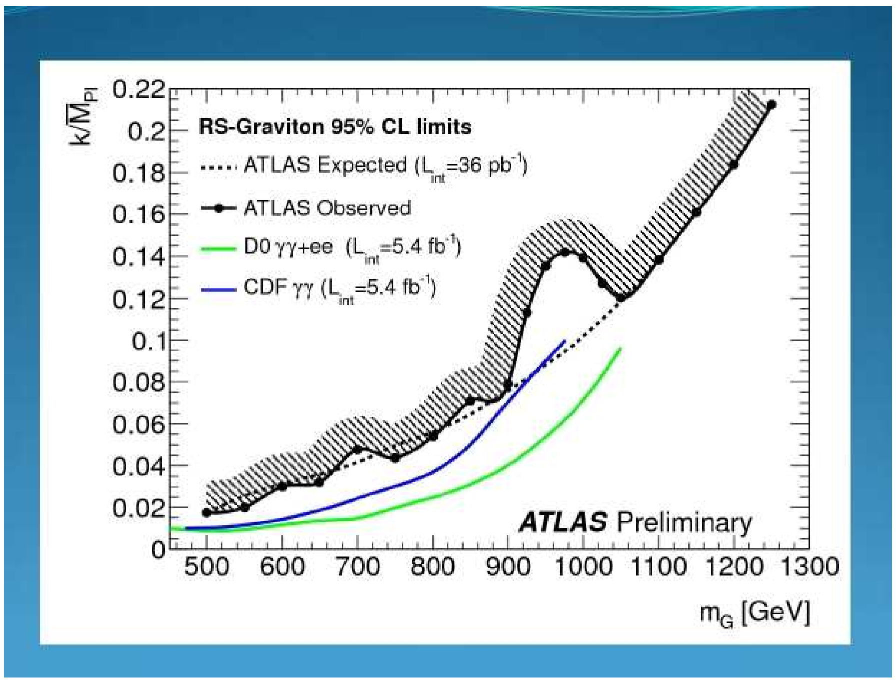
One can define fine tuning measures depending on the level of cancellation required to get the correct mass M_Z.

For CMSSM for $M_3 > 650$ GeV it is about 1 part in 35.

Green points correspond to allowed regions accroding to fine tuning criterion.

Plotted in the second graph is the naturalness probability. In the allowed regions fine tuning is about one part in 100.

In RS models one has resonances which would decay into $\gamma\gamma$ and/or $\mu^+\mu^-$. Already surpassing Tevatron constraints.



Implications for, for example, $t\bar{t}$ physics.

Here one has a effective low energy theory and one can make predictions using semiclasscial approximations.

These contribute to the two jet, dimuon and diphoton cross-sections due to tree level or loop graviton exchange and give rise to higher dimensional operators. Experimentalists prefer first to use dimuon and diphoton. jj final state would be the best channel from the point of view of rates.

There are two types of operators:

Dimension 8: $\mathcal{L}_{int} = c_{\mathcal{T}} \mathcal{T} = \frac{4}{M_T^4}\left(T_{\mu\nu}T^{\mu\nu} - \frac{T_\mu^\mu T_\nu^\nu}{\delta+2}\right)$

$T_{\mu\nu}$ is the SM energy momentum tensor.

Dimension 6: $\mathcal{L}_{int} = C_6 \Upsilon = C_6 \Sigma_f (\bar{f}\gamma_\mu\gamma_5 f)\Sigma_f(\bar{f}\gamma^\mu\gamma^5 f)$

C_6 depends on D-dimensional Planck mass M_D and cutoff parameter Λ in a nontrivial way.

The conversion of the limits on observed signals to parameter M_T which parameterises the large extra dimension really does depend on the ultraviolet completion. Dijets at large invariant mass and large rapidity separations are less suceptible to issues of ultraviolet completion.

Giudice et al do this in arXiv: 1101.4919

For dimension 8 operartor:

For one extra dimension: LHC bounds are comparable to the earlier bounds

For higher number of extra dimensions LHC due to larger energy is already probing new regions of the parameter space for these theories.

Caveats: jj data. Uncertainties in theoretical predictions and experimental analyses?

Again watch the space is the message.

Many extensions of the SM (discussed by Mambrini) have a neutral, stable particle with all the properties needed for it to be an ideal candidate for the dark matter.

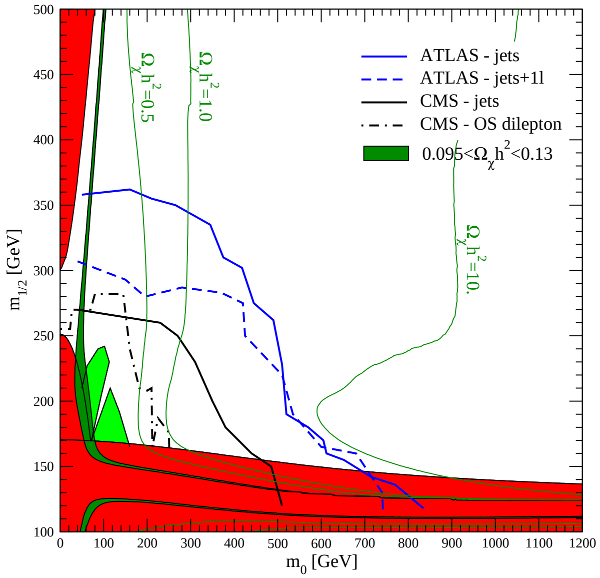
The suggested solutions to cosmological questions can be tested in HEP experiments and Physics Beyond the SM can be constrained by Cosmological connections.

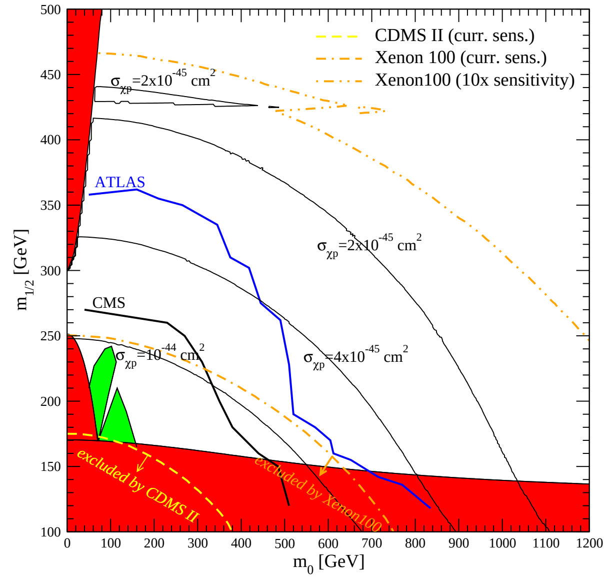
(Talks by Mambrini, Milstead,Ruchaskiy)

Does the DM need to be coming from TeV scale BSM: not necessarily!

LHC and Direct detection making inroads into answering this question.

Ruchaskiy painted a picture where LHC will have not much to say. Answers to the riddles may not be provided by LHC at all !





(As an example Profumo: 1105.5162)

LHC has cornered TeV scale BSM through direct searches and both the SM and BSM, through the Higgs and data from LHC_b.

For TeV scale Supersymmetry the year 2012 will be critical. The small hierarchy problem (that is a fine tuning to about a one part in 10-100 for the Higgs mass) has got accentuated. Higgs sector can provide nontrivial cross-checks.

For theories with extra dimension new paramter regions begin to be explored.

Is there TeV scale BSM? . At least it has not been realised in the most obvious ways. Nature is may be 'subtle'

1) 2011-2012 is the crucial year for SUSY. Not just direct searches but Higgs physics (just its mass), results from LHCb as well as direct/indirect DM detection from XENON, CoGent putting SUSY under a scanner.

2)Extra dimensions: ideas interesting..but not predicitve enough to be pushed to wall. In principle these ideas do not necessarily address the different observational facts which indicate BSM.

3) What if we have only strongly interacting WW sector? No elementary Higgs? Need 14 TeV, 100 fb^{-1}. But difficult. (talk by Nicolas) (Classic: Butterworth, Foreshaw: Nucl. Phys. B). Discription depends on the unitarisation scheme. The typical scale estimated to unitarise the WW amplitude is rather high (seen in talk by F. Sannino)

4)A recent analysis: Addition of a spin 1 resonance in a controlled fashion, to extend the validity of perturbative analysis. Estimate the onset of strong dynamics, which is lower than the earlier one and investigate LHC phenomenology. (Falkowski et al,arXiv:1108.1183.)

5)We should be in fact be prepared that we are completely wrong and none of the ideas are right!

6)Let us hope that nature is 'kind' even though it may not be 'natural'!

Exciting Times ahead for sure!