(B)SM Parameter Fitting in the Alliance

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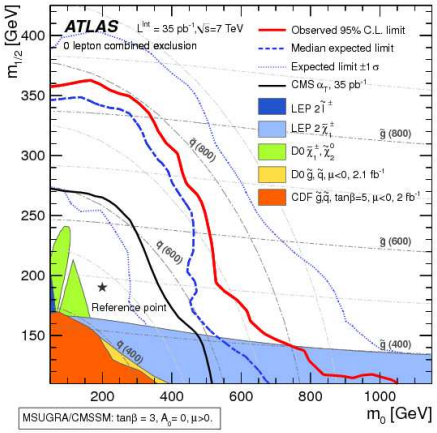
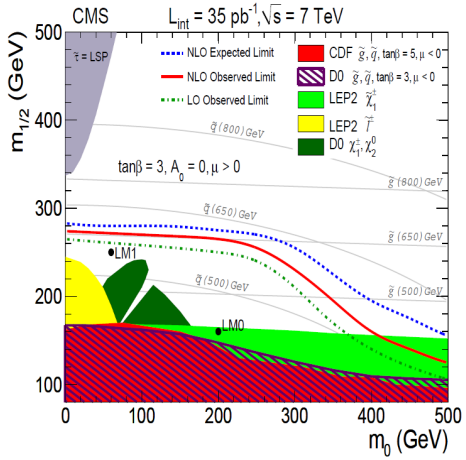
An Incomplete Overview of the Current Situation

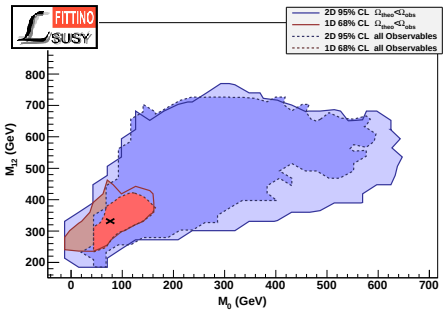
Old slide, but still almost up-to-date!

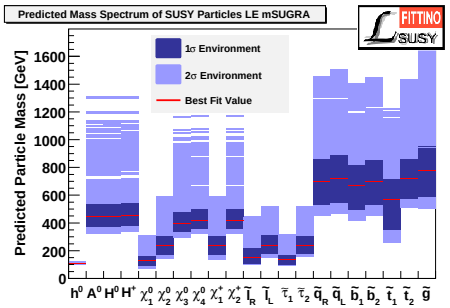


arXiv:1102.5290 [hep-ex]



arXiv:1101.1628 [hep-ex]





e.g. arXiv:0907.2589 [hep-ph]

- Does the non-observation of SUSY in the 2010 LHC searches agree with mSUGRA?
- If mSUGRA-like SUSY is realized, can we expect to discover SUSY in 2011/2012?
- If not, what are the implications for mSUGRA/SUSY and for Collider Physics?

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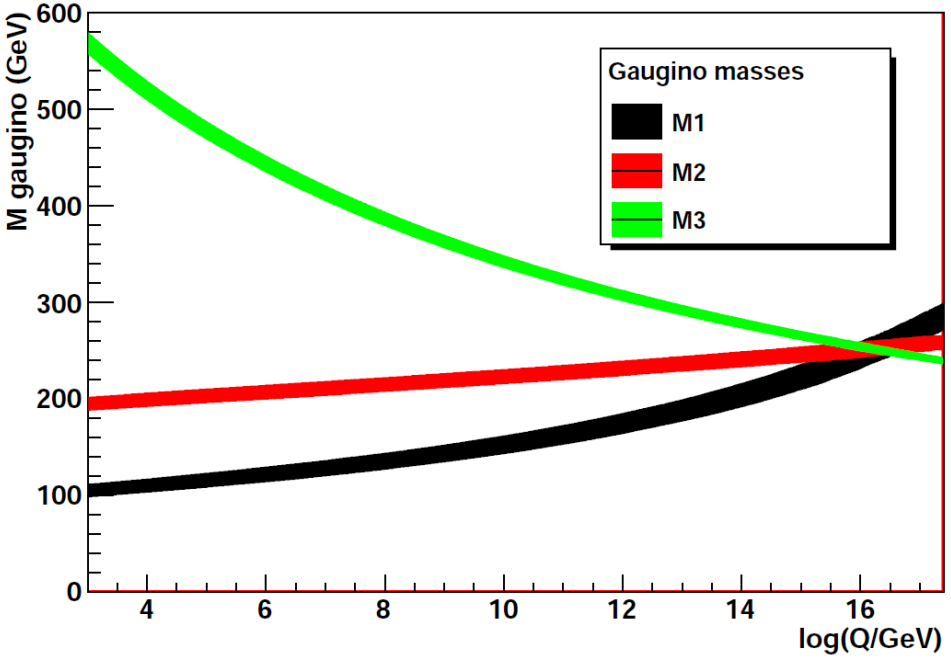
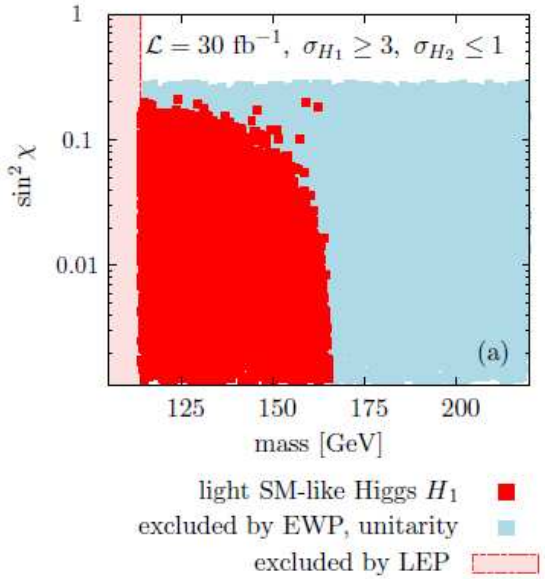
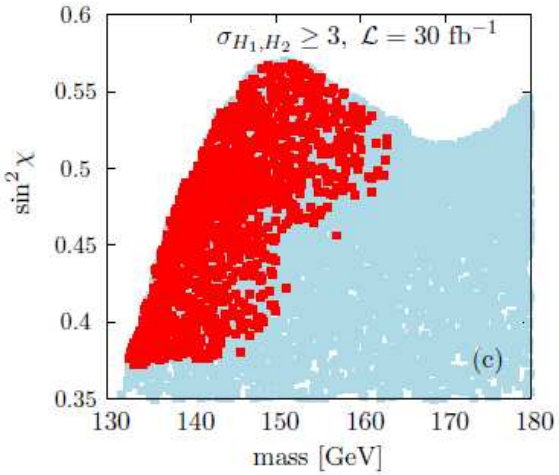
Strong existing projects in Germany

- e.g. SFitter (e.g. arXiv:1106.3097 [hep-ph])







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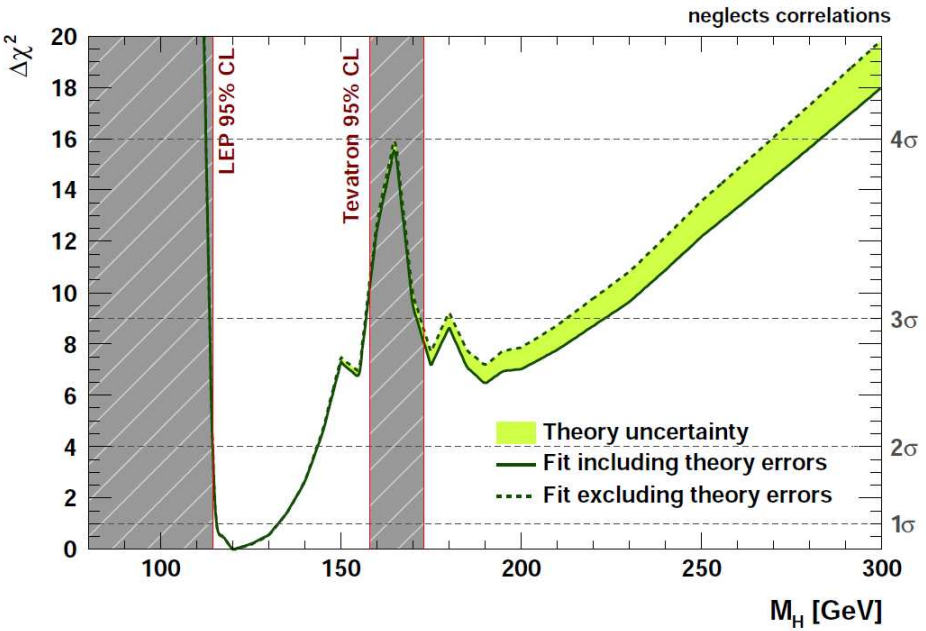
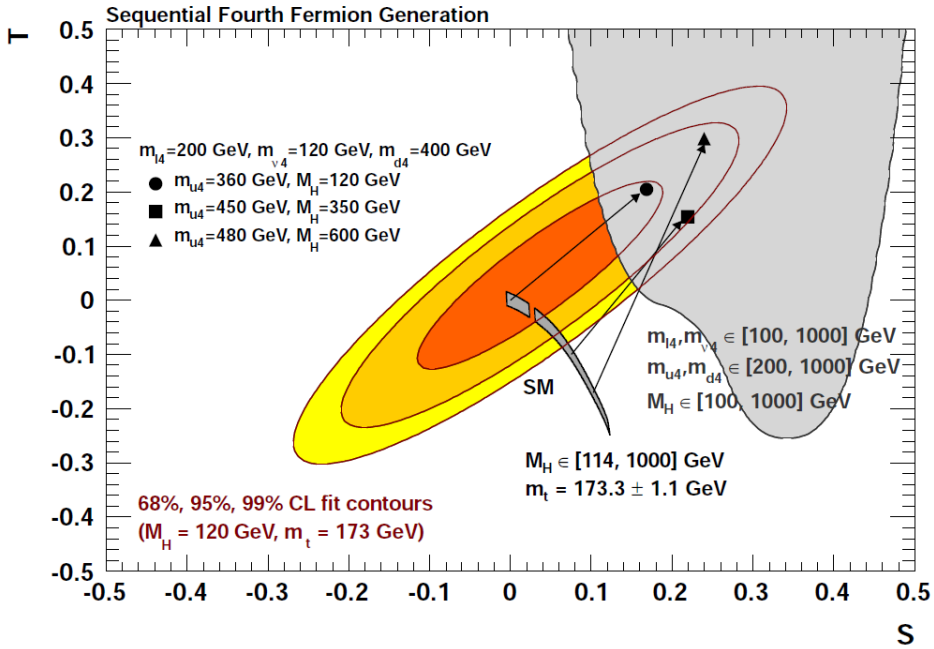
Strong existing projects in Germany

- e.g. GFitter (e.g. arXiv:1107.0975 [hep-ph])





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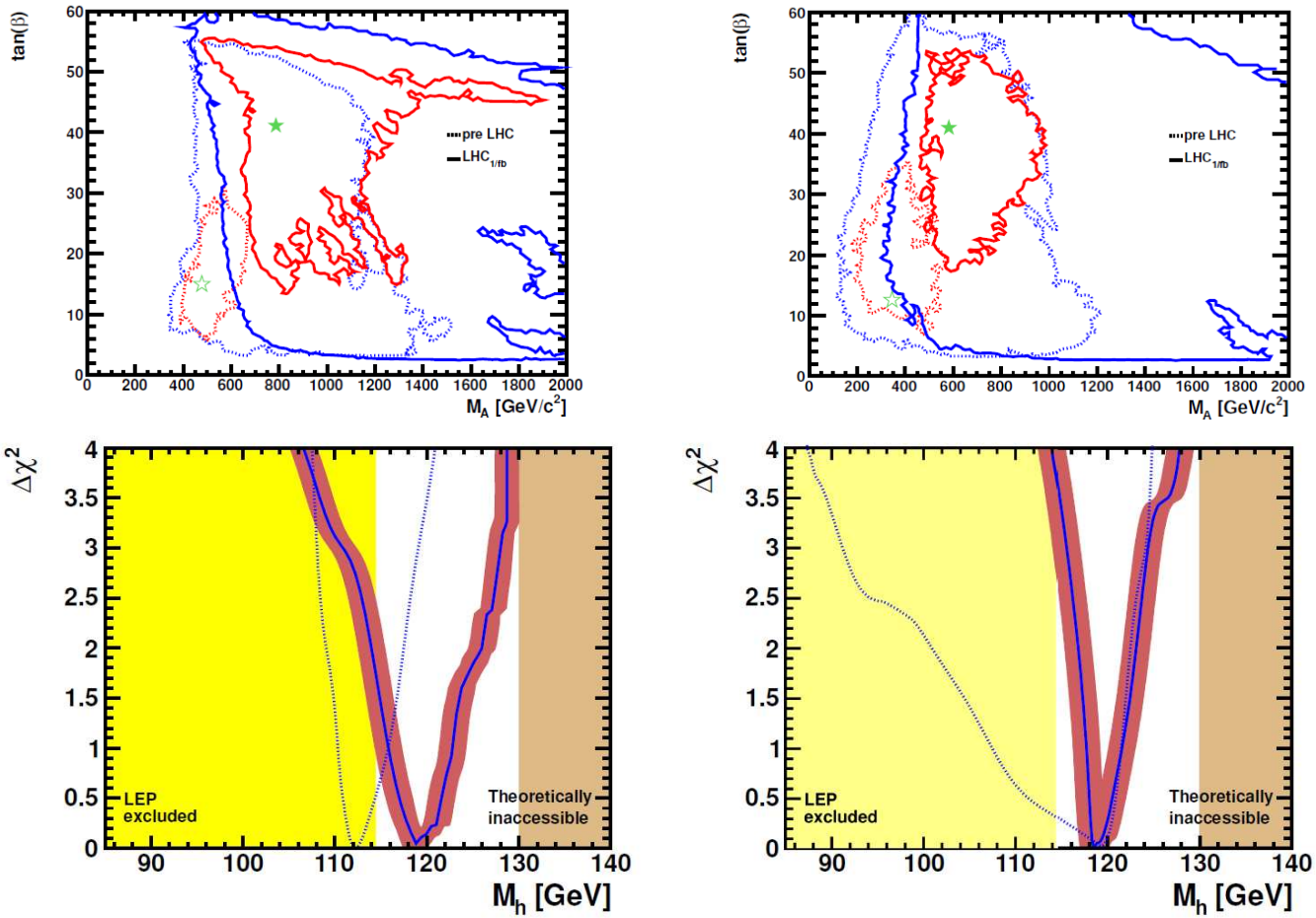
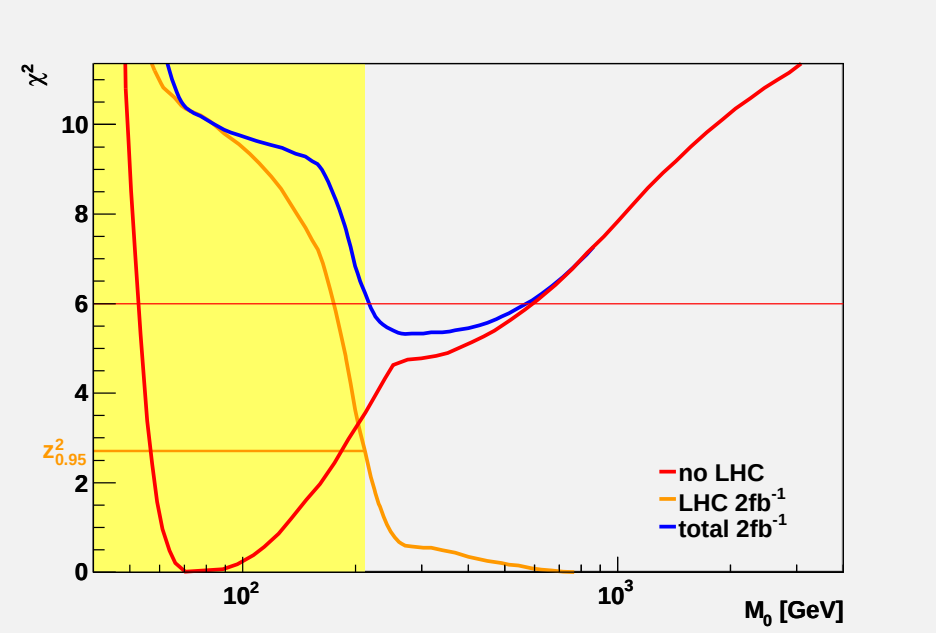
Strong existing projects in Germany

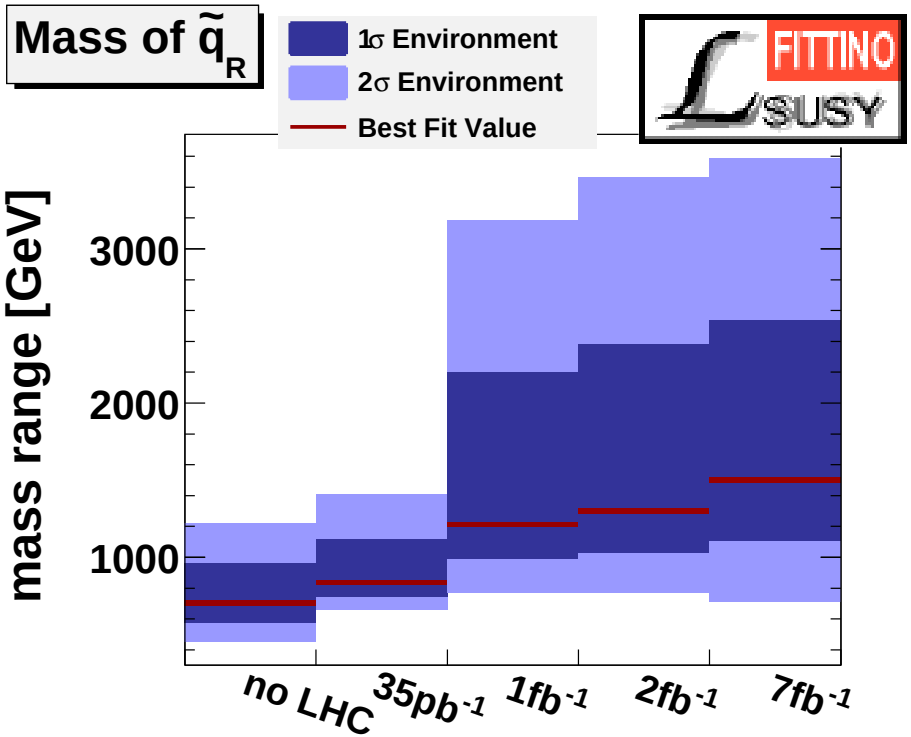
- e.g. Mastercode (e.g. `arXiv:1110.3568 [hep-ph]`)



Strong existing projects in Germany

- e.g. Fittino (e.g. arXiv:1102.4693 [hep-ph])





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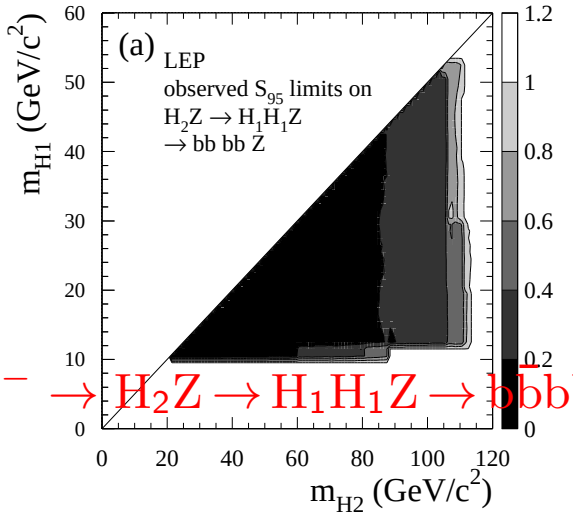
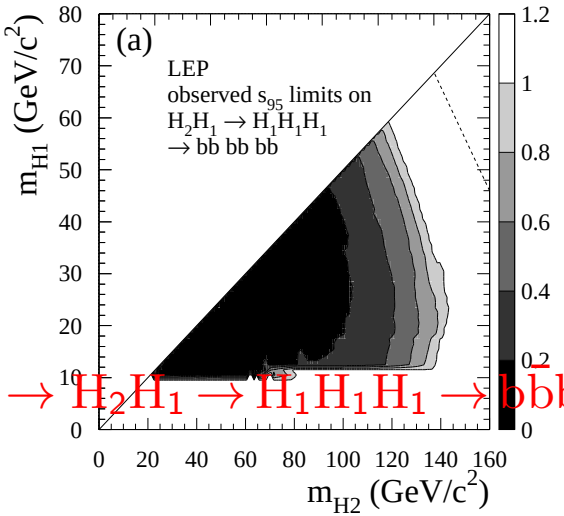
Strong existing projects in Germany

- Support, such as HiggsBounds (e.g. arXiv:1102.1898 [hep-ph]):



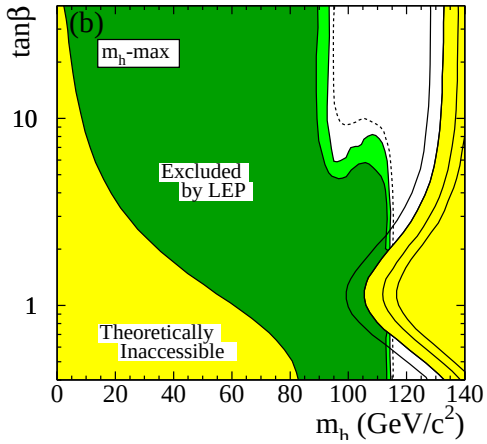
$e^+e^- \to H_2Z \to H_1H_1Z \to b\bar{b}b\bar{b}Z$

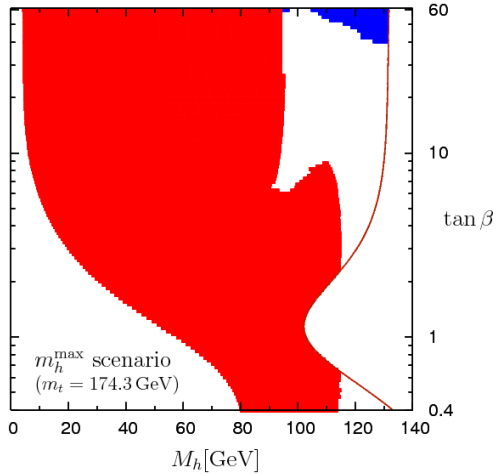


$e^+e^- \to H_2H_1 \to H_1H_1H_1 \to b\bar{b}b\bar{b}b\bar{b}$

Have to add a third dimension to these plots

Test using the MSSM:





Contribution of the Alliance

- Meetings between projects
- Work mainly on interfacing: Common plans to use workspaces (never fully implemented)
- Common work on maintaining up-to-date lists of all relevant variables

SUSY/BSM Parameter Fitting

site notice:

Following the discussion at the BSM/SUSY fit workshop (26-28 July 2010), are given here detailed references to experimental results.

- 'BF' = Branching fraction,
- 'deltaM' = Mass difference between the different mass eigenstates
- 'amu' = Relative magnetic moment of the muon (g-2)/2
- '_0' = For the LEP observables: measured at the Z peak
- 'Gamma_xx' = For the LEP observables: width of Z0->xx

For remarks or questions, please write to prudent[at]physik.tu-dresden.de

Contents
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B physics

Observable	Source	Value	Remark	Reference
deltaMs/deltaMd	Combination	0.0285 +- 0.0003	Ratio of oscillation frequencies for Bs and Bd	[1] page 46, Eqt 102
deltaMs	Combination of CDF & D0	(17.78 ± 0.12)/ps	Oscillation frequency of Bs	[1] page 46, Eqt 99
BF(Bd->l+l-)	Measurement by CDF	<1.5e-8	Measured in di-muon channel, lowest bound, other bounds given in reference	[2] page 176, Table 45
BF(b->sgamma)	Combination of BaBar & Belle & CLEO	(3.52 +- 0.23 +- 0.09)e-4		[1] page 166, Table 120
BF(Bs->mu+mu-)	Combination of CDF & D0	< 4.7e-8		[1] page 170, Table 127
BF(B->tau nu)	Combination of BaBar & Belle & CLEO	(1.41 +43 -42)e-4		[1] page 167, Table 122
BF(B->Xsl+l-)	Measurement by BaBar	(5.6 +- 1.5(stat) +- 0.6(syst) +- 1.1(mode))e-6	Sum of exclusive measurements, not the recoil method	[2] page 180, Eqt 294
BF(B->Xsl+l-)	Measurement by Belle	(4.1 +- 0.83(stat) +0.85 -0.81(syst))e-6	Sum of exclusive measurements, not the recoil method	[2] page 180, Eqt 294

New values from the 2010 update of HFAG:

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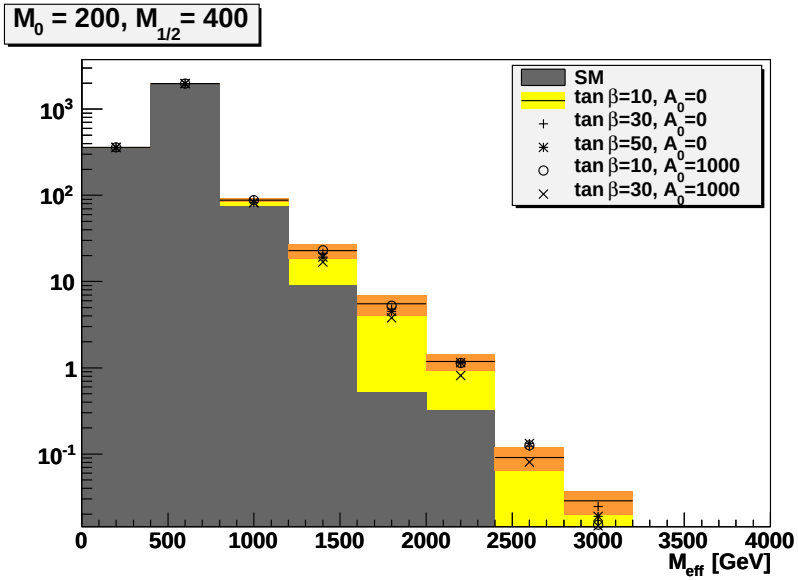
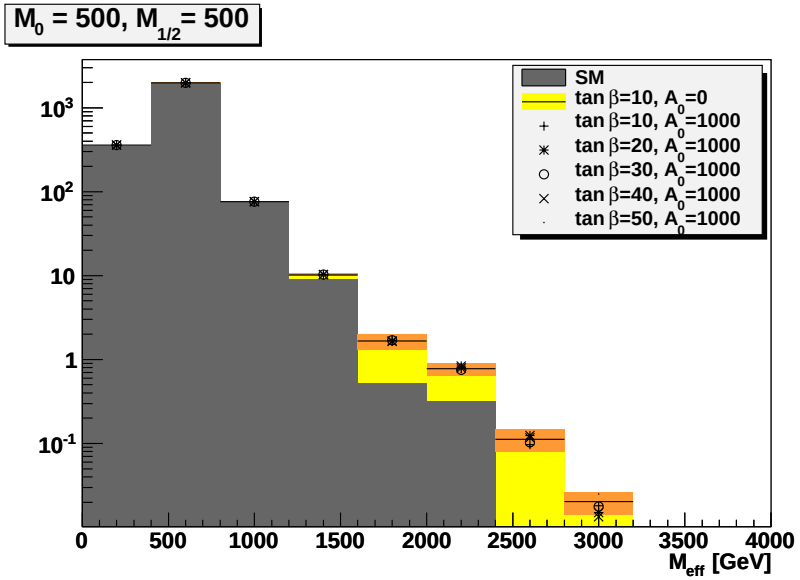
Systematic Check of the MSUGRA Parameter Grid





- Full re-implementation of the ATLAS search on free MC!
- Variations of the signal shape for different $\tan\beta$ and A_0 covered by systematic uncertainty
- This is specific for the 0ℓ search – more complicated grids would be necessary for other searches
- Based on the full M_{eff} distribution, calculate CL_{s+b} for the median background hypothesis
- Transfer CL_{s+b} into $\chi^2 = 2[\,\mathrm{erf}^{-1}(1 - 2\,CL_{s+b})]^2$

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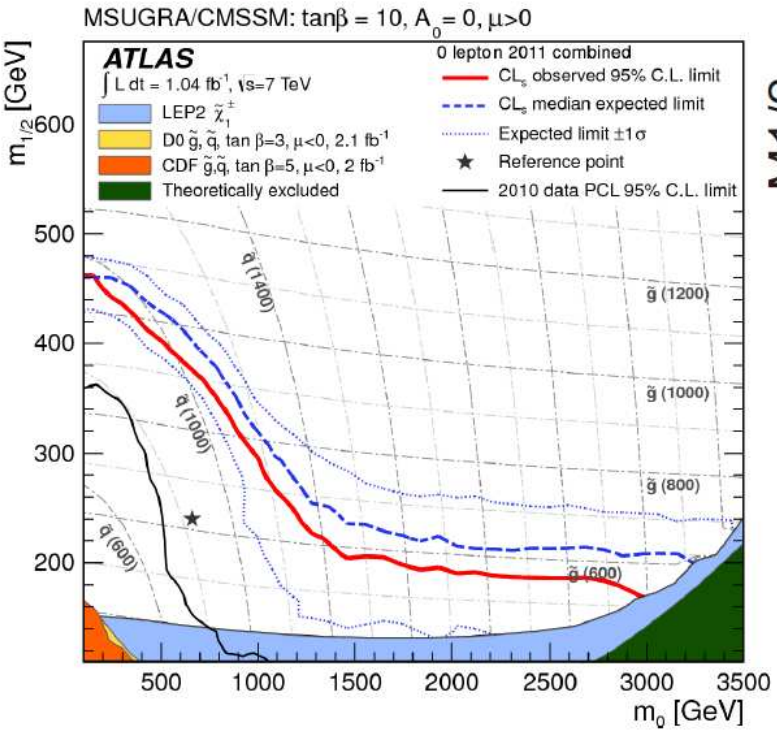
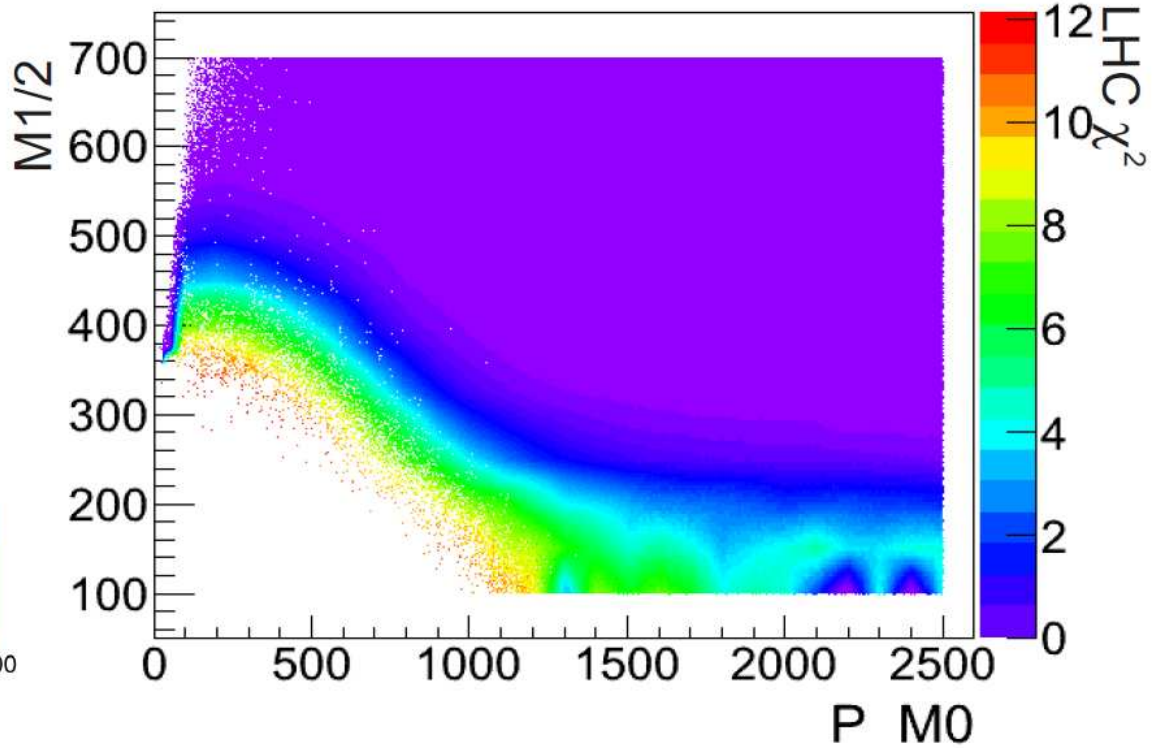
Full re-implementation of an LHC Search

ATLAS, 1.04/fb:



Fittino analysis emulation, 2/fb:



More crude Approximations also used

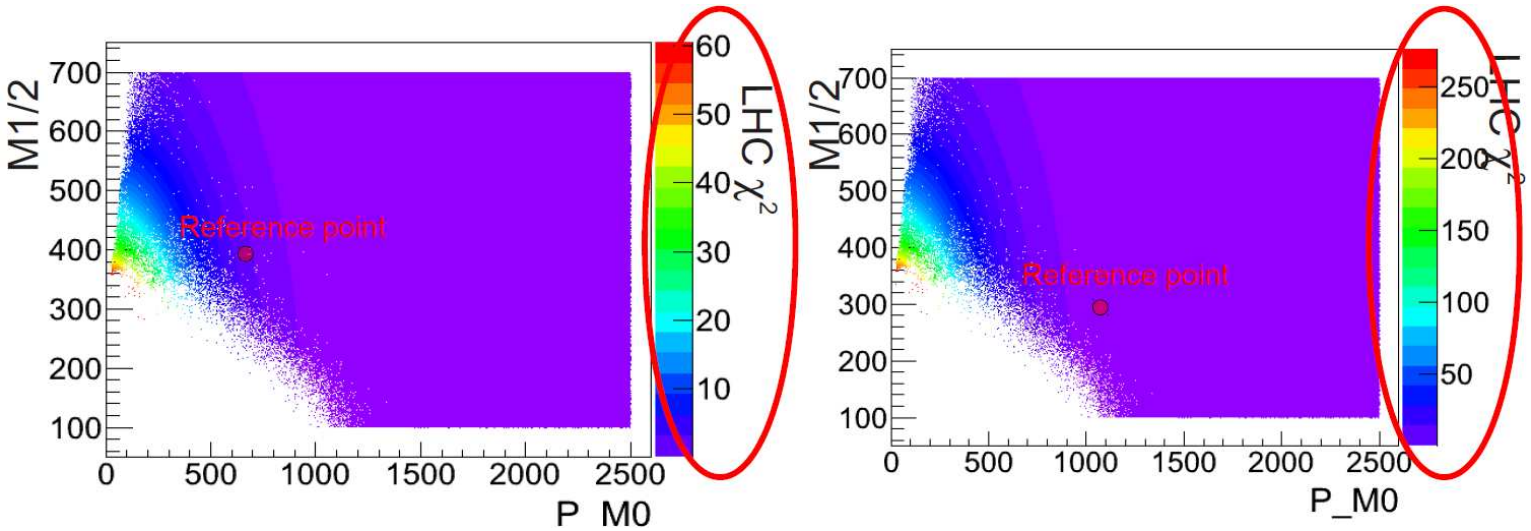
- Choose a point on the 95 % CL exclusion contour:

$$(M_0^{95\%\mathrm{CL}}, M_{1/2}^{95\%\mathrm{CL}})$$

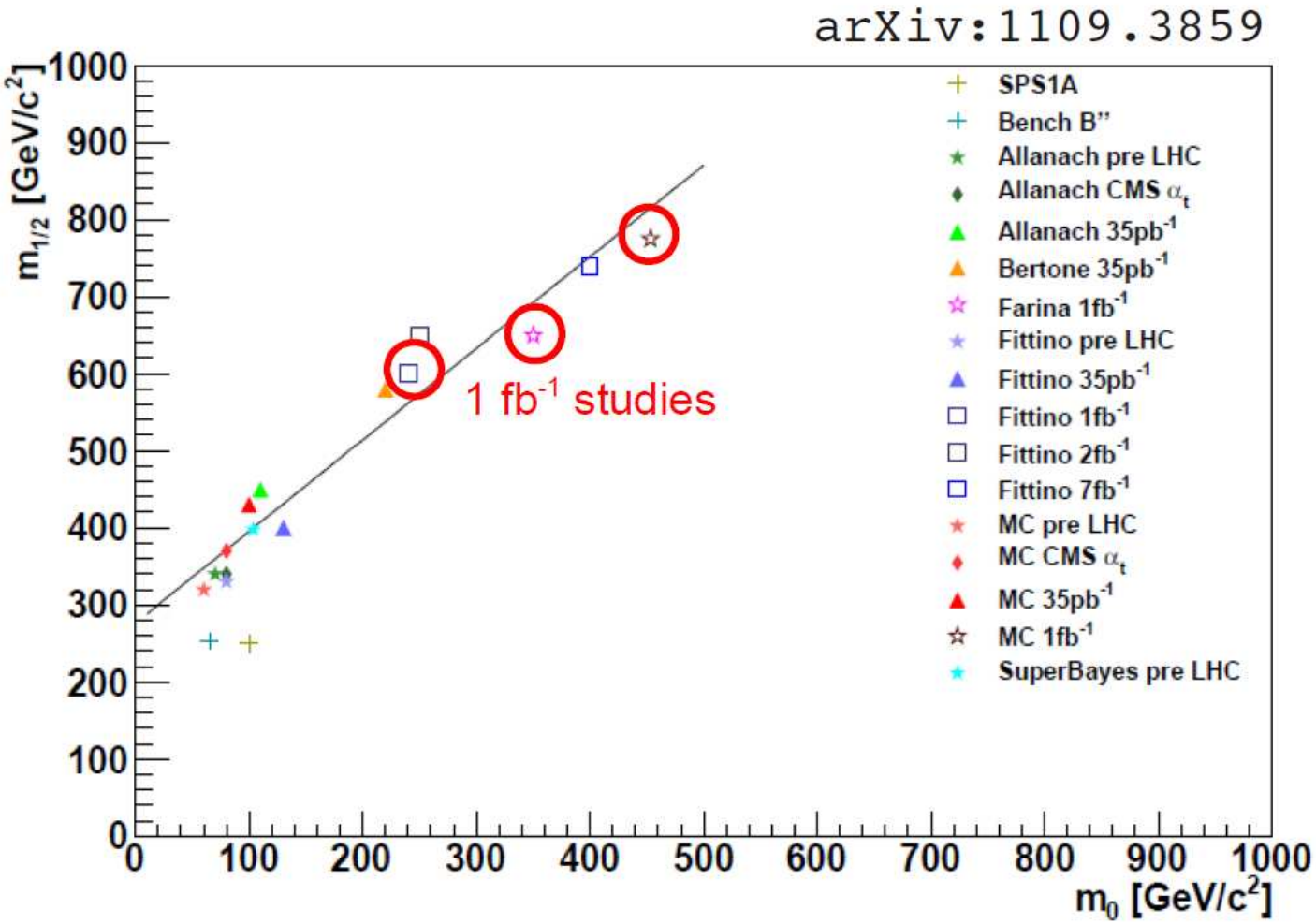
- Assume following χ^2 scaling:

$$\chi^2 = \chi^2_{95\%\mathrm{CL}} \left(\frac{R(M_0, M_{1/2})}{R(M_0^{95\%\mathrm{CL}}, M_{1/2}^{95\%\mathrm{CL}})} \right)^{-4}$$

with $$R(M_0, M_{1/2}) = \sqrt{M_0^2 + M_{1/2}^2}$$



Result of the different level of complexity



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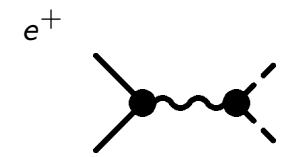
Why SUSY is different than e.g. the Higgs-Sector



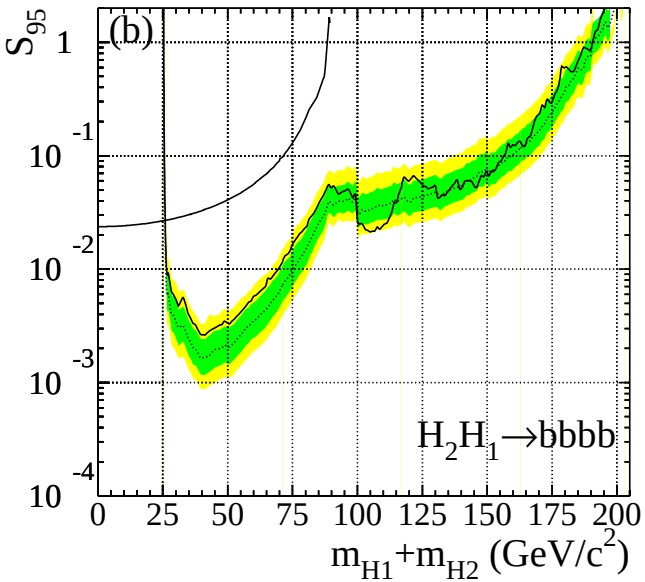
H_2

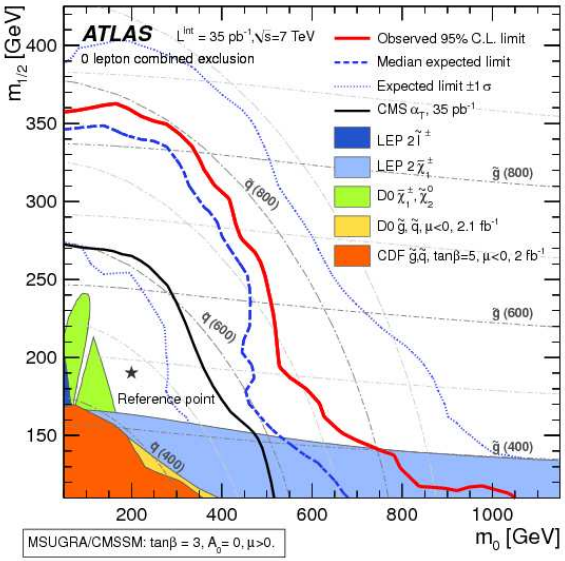
H_1

$S_{95} \equiv$

$\max(\cos^2(\beta - \alpha)$

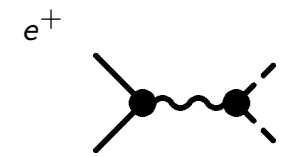
$\times \mathcal{B}(H_i \to b\bar{b}))$





- Higgs Searches (at least at LEP) could be presented in terms of S_{95} for each signature separately, because the signatures can be nicely isolated experimentally: $hZ \to b\bar{b}\ell\ell$, $hA \to b\bar{b}\,b\bar{b}\ldots$
- Higgs: Only very few parameters: $m_h, m_A, \cos^2(\beta - \alpha)$, model-independent comparison with all possible models e.g. in
  PB et al. arXiv:0811.4169 [hep-ph]
- SUSY: incredibly complicated signatures possible, many masses and relations of couplings

Why SUSY is different than e.g. the Higgs-Sector



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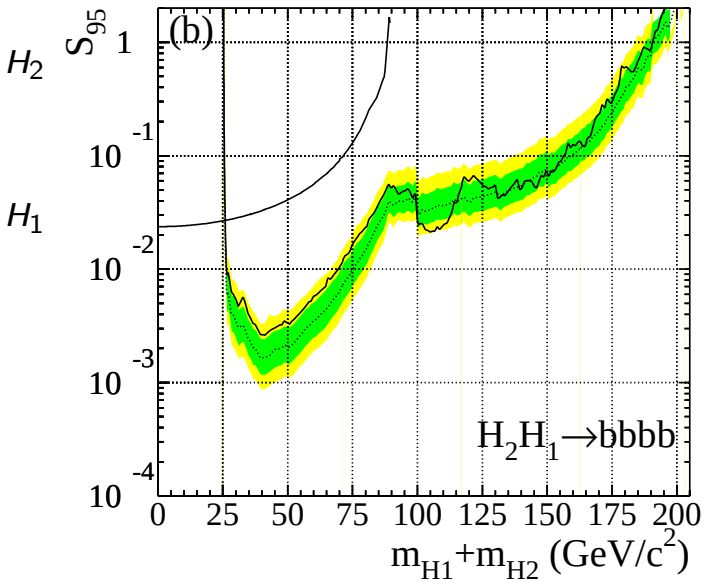

	Signal region A
QCD	$7\ ^{+8}_{-7}$[u+j]
W+jets	50 ± 11[u] $^{+14}_{-10}$[j] $\pm$ 5[$\mathcal{L}$]
Z+jets	52 ± 21[u] $^{+15}_{-11}$[j] $\pm$ 6[$\mathcal{L}$]
$t\bar{t}$ and t	$10 \pm$ 0[u] $^{+\ 3}_{-\ 2}$[j] $\pm$ 1[$\mathcal{L}$]
Total SM	118 ± 25[u] $^{+32}_{-23}$[j] $\pm$ 12[$\mathcal{L}$]
Data	87

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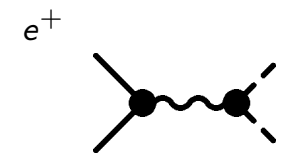

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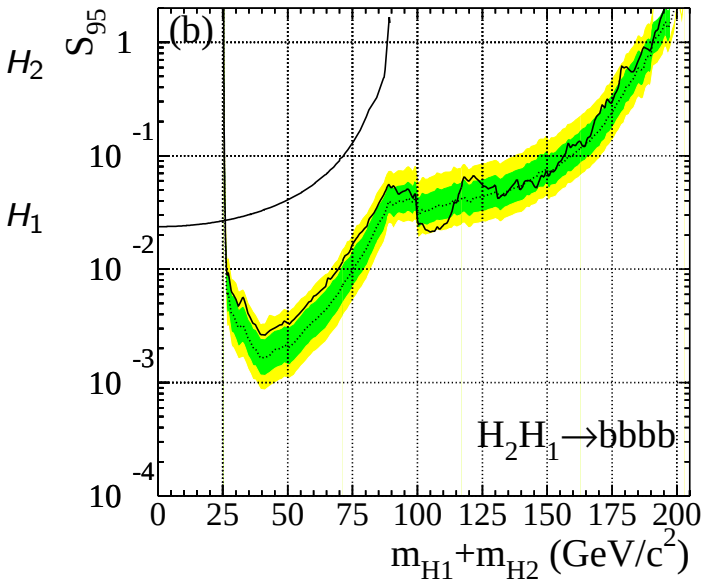

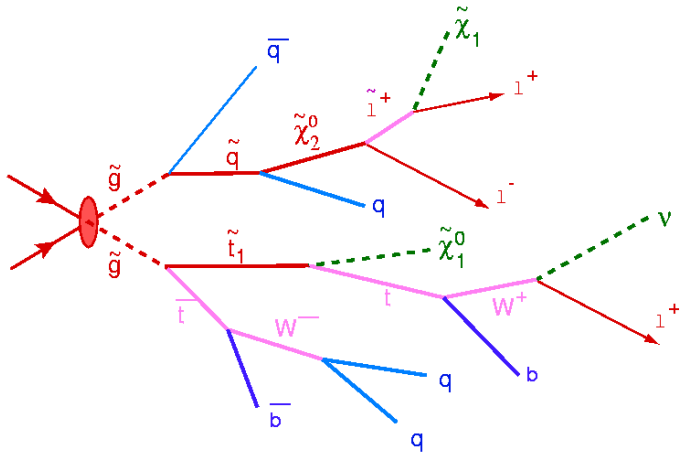

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Other Approaches to Parametrizations of Searches

- Obvious: For model independent results, everything has to be presented in terms of (pseudo)observables (e.g. M_{eff}, masses, couplings, ...)

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- Obvious: For model independent results, everything has to be presented in terms of (pseudo)observables (e.g. M_{eff}, masses, couplings, ...)
- 95 % CL Limit on $\sigma \times \prod_i \mathcal{B}_i$ for a given signature (For some reason specific signatures are sometimes called "simplified model")
  - 95 % CL not very useful for global fits $\rightarrow$ need full CL_{s+b} space
  - Very high dimensional binning is needed (many masses)
  - Much less sensitive for discovery or exclusion, since only a small part of the possible decay chains is probed at a time
- 95 % CL Limit on the number of events for a given selection
  - Simulation needed to determine number of events for any model prediction
- Distributions of b, d in discriminating variables corrected for detector effects, acceptances
  - Sounds nice, but probably impossible: Correction depends on many factors (many masses, couplings)

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Examples of possible Research Topics

- Interfacing fitting better with the experiments
  - More work in the experiments on RooStats workspaces, model independent parametrizations of search results, etc.
- More work on statistics: Mainly sampling can be improved!
- More work on precision predictions
  - m_h, reducing theoretical uncertainties for cosmological observables, etc.
- Direct Fitting of BSM – the only thing which can be precisely calculated: SUSY
  - Combining LHC Searches in the same fit
  - Making the use of more complex models than CMSSM/NUHM possible
- Fitting of Higgs observables
  - Looking into many more models than SUSY in the Higgs sector
- Complete SM Fit – separating SM fitting from BSM fitting doesn't make sense
  - Obvious, and with more observables than before once Higgs-like object is observed

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What would be possible with Great Personpower?

- German community already strong here, we can build on that and create something really very strong!
- Better interfacing with Analysis Center possible (previously not yet so strong, but definitely not the fault of the AC!)
- Many of the above can be continued somehow with existing funds, but . . .

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- Many of the above can be continued somehow with existing funds, but . . .
- Let's assume 3-4 positions from the alliance:
- Better integration between phenomenology and experiment – hiring a pheno postdoc in an experimental group?
- More fundamental work on optimal sampling – difficult because most experimentalists with background in statistics are highly "used" and bound in the experiments
- Much more work on interpreting many more direct searches for New Physics at the same time – in the moment we use only 1 out of many!
- Focussing a lot on getting everything out of a possible Higgs-like signal – ratios of $\mathcal{B}$, rates, etc.

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Main Messages

- Interpretations are the most complex link between theory and experiment
- It links the LHC to many other experiments, it links ATLAS and CMS, and it is one of the fields which can make the most early statements on the use of future colliders like the ILC!
- The german community has strong contributions in this field
- (B)SM Fitting is ideally suited for support from and to the Analysis Center
- Therefore, it is an ideal (also, and positively, "propaganda") part of the Alliance

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- (B)SM Fitting is ideally suited for support from and to the Analysis Center
- Therefore, it is an ideal (also, and positively, "propaganda") part of the Alliance
- It could be even stronger and better integrated in the future
- And there is still so much to do to understand EWSB!

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