

Longing for SUSY at LHC...

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37 years ago, SUSY was young and beautiful,
and we were all in love with her . . .

- Only possible extension of symmetry beyond Lie Symmetries (Coleman–Mandula Theorem).
- Correct Unification of Gauge couplings at M_{GUT} .
- Solution of the Hierarchy Problem, low-energy SUSY.
- “Natural” Mechanism of Electroweak Symmetry Breaking, Radiative Symmetry Breaking.
- Necessary ingredient in String Theory. Local Supersymmetry \Leftrightarrow Supergravity.
- Dark matter candidate for free.
- New CP phases and interactions for baryogenesis.

CMSSM

- Minimal and simple realization of the MSSM.
- Similar sparticle masses in a general MSSM.
- Any generic MSSM must include CMSSM physics.
- Representative MSSM example for collider phenomenology.

Minimal number of new parameters at M_{GUT}

m_0^2	→	Universal scalar mass.	$M_{1/2}$	→	Common gaugino mass.
A_0	→	Universal trilinear.	B	→	Soft Higgs mass.
μ	→	Susy Higgs mass.	$\tan\beta$	→	Ratio of Higgs vevs.

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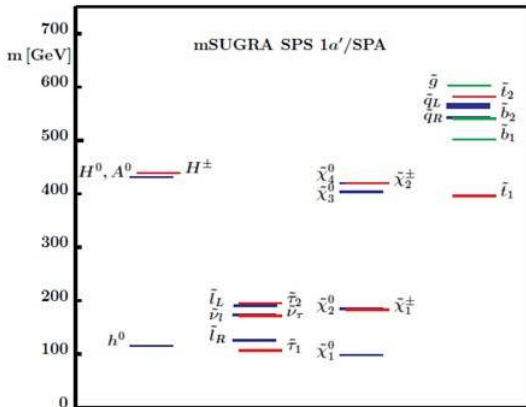
Reduced to 4 (plus one sign) by **Radiative Symmetry Breaking**:

$$m_0^2 \sim \mathcal{O}(v^2), M_{1/2} \sim \mathcal{O}(v), A_0 \sim \mathcal{O}(v), \tan\beta$$

In these conditions ...

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$$m_0^2 = 70 \text{ GeV}, M_{1/2} = 250 \text{ GeV}, A_0 = -300 \text{ GeV}, \tan \beta = 10$$



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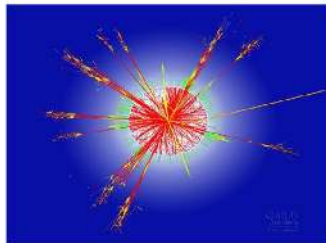
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**30/03/2010 BREAKING NEWS:
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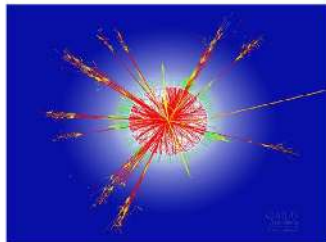
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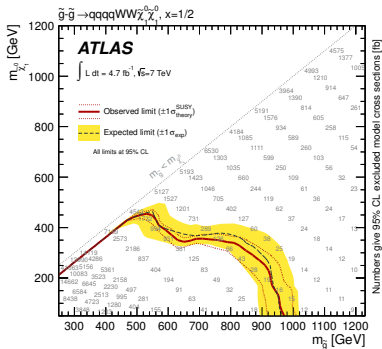
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But ...

Supersymmetry at LHC . . .

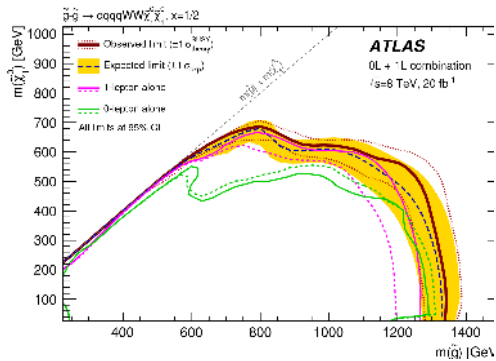
Supersymmetry at LHC . . .

After **LHC-7** no sign of New Physics. . . , **SUSY** strongly constrained.



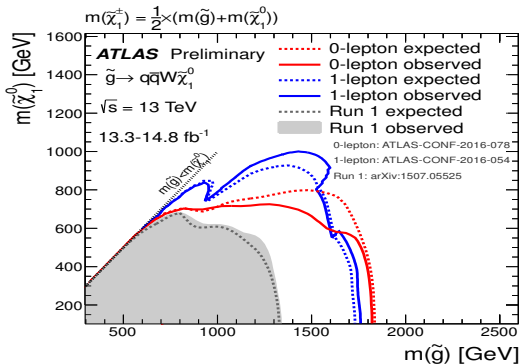
Supersymmetry at LHC . . .

After LHC-8 . . . , SUSY strongly constrained.



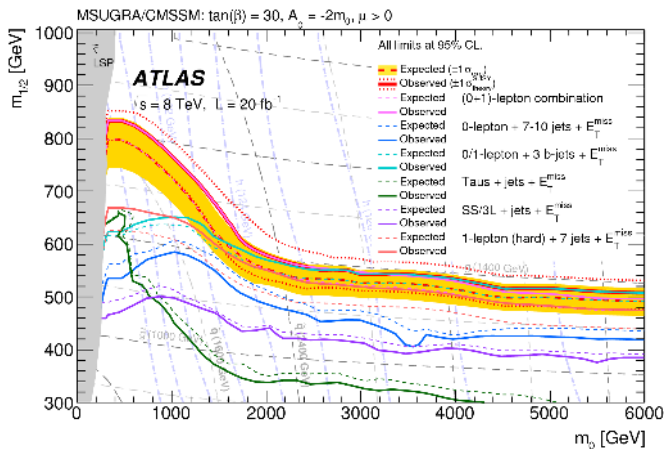
Supersymmetry at LHC ...

At LHC-13 ..., SUSY strongly constrained.

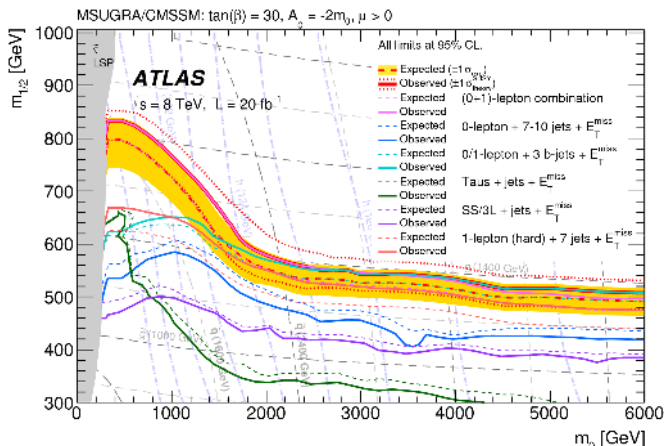


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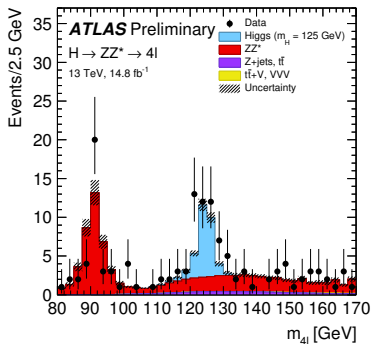
In terms of CMSSM parameters:



Still, other SM extensions equally challenged, **MSSM** remains best SM extension at EW scale

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$$m_H = 125.09 \pm 0.24 \text{ GeV}$$



$$m_h^2 \gtrsim M_Z^2 \cos^2 2\beta + \frac{3G_F m_t^4}{\sqrt{2}\pi^2} \log \frac{m_{\tilde{t}}^2}{m_t^2} + \mathcal{O}(X_t)$$

$$\Rightarrow m_{\tilde{t}} \gtrsim \mathcal{O}(\text{TeV}) \dots$$

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Flavour discrepancies in $b \rightarrow s l^+ l^-$ at LHCb

Therefore, how is SUSY doing??

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- Correct Unification of Gauge couplings at M_{GUT} . ?
- Solution of the Hierarchy Problem, ?
- “Natural” Mechanism of Electroweak Symmetry Breaking, ✓
- Necessary ingredient in String Theory. ✓
- Dark matter candidate for free. ?
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Therefore, how is SUSY doing??

- Only possible extension of symmetry beyond Lie Symmetries ✓
- Correct Unification of Gauge couplings at M_{GUT} . ✓
- Problems with Little Hierarchy, ✗
- “Natural” Mechanism of Electroweak Symmetry Breaking, ✓
- Necessary ingredient in String Theory. ✓
- Dark matter candidate for free. ✓
- New CP phases and interactions for baryogenesis. ✓



Multi-TeV SUSY ...

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- Correct Unification of Gauge couplings at M_{GUT} . ✓
- Solution of the Hierarchy Problem, ✓
- “Natural” Mechanism of Electroweak Symmetry Breaking, ✓
- Necessary ingredient in String Theory. ✓
- No Dark matter candidate. ✗
- New CP phases and interactions for baryogenesis. ✓



R-parity violating SUSY ...

Therefore, how is SUSY doing??

- Only possible extension of symmetry beyond Lie Symmetries ✓
- No Gaugino and sfermion mass Unification. ✗
- Solution of the Hierarchy Problem, ✓
- “Natural” Mechanism of Electroweak Symmetry Breaking, ✓
- Necessary ingredient in String Theory. ✓
- Dark matter candidate for free. ✓
- New CP phases and interactions for baryogenesis. ✓



Compressed, PMSSM or Natural SUSY ...

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- Parameter space of SUSY (and all SM extensions) getting narrow.
- But still SUSY maintains her charm.
- And, for us, she is . . . Still the one
- So, please keep searching, she may be just behind the corner.