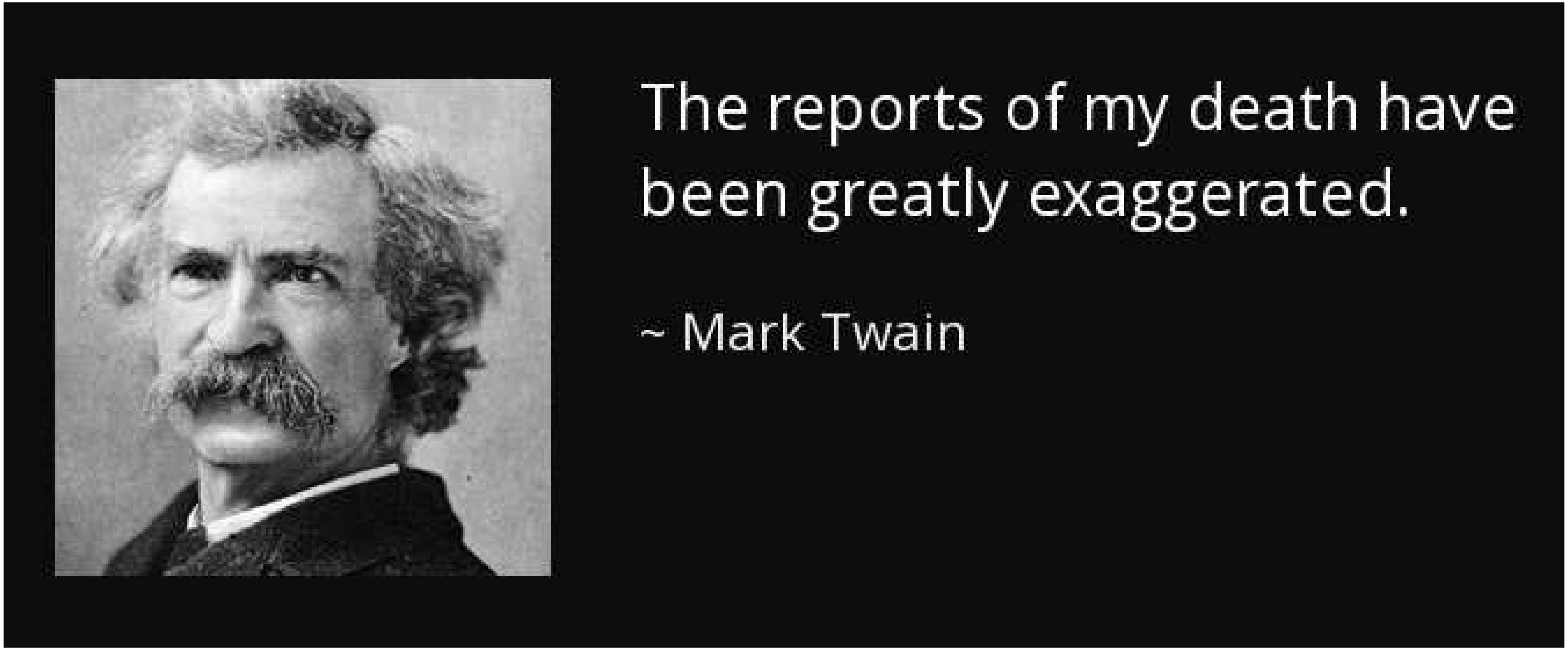
Round Table on “Supersymmetry”

Sven Heinemeyer, IFT/IFCA (CSIC, Madrid/Santander)

Madrid, 05/2018



Fact:

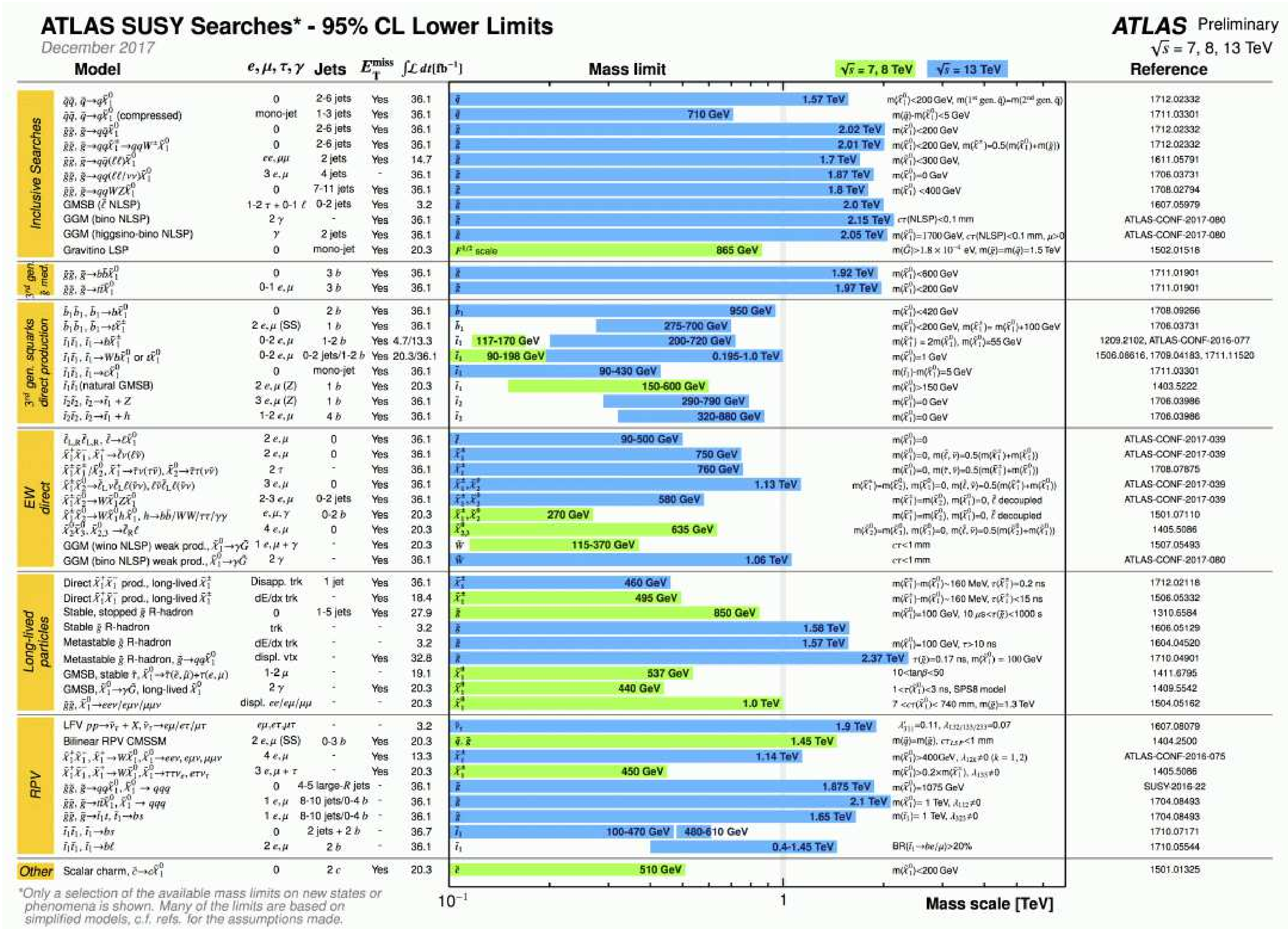
The SM cannot be the ultimate theory!

1. gravity is not included
2. the hierarchy problem
3. Dark Matter is not included
4. neutrino masses are not included
5. anomalous magnetic moment of the muon shows a $\sim 4\,\sigma$ discrepancy
6. . . .

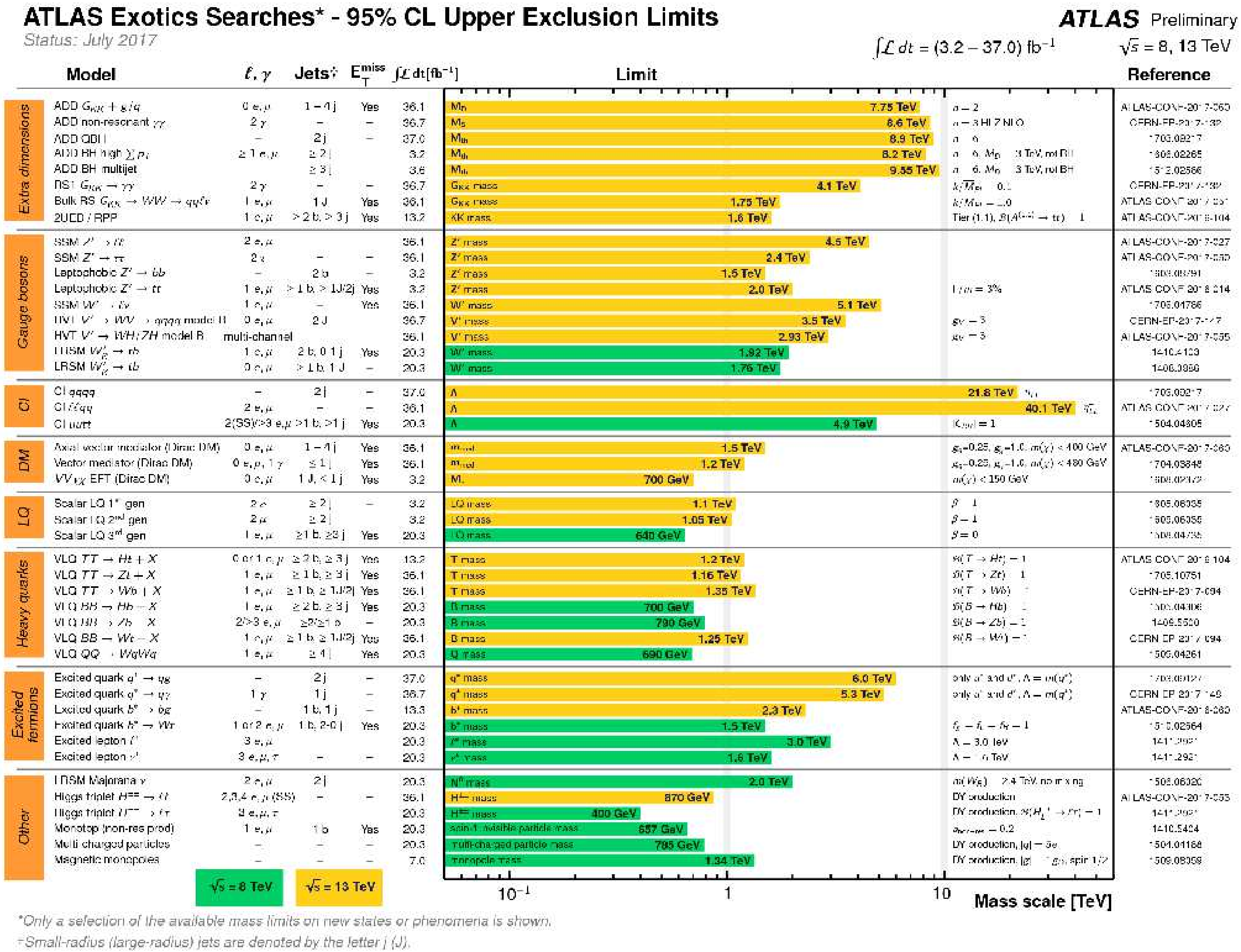
$\Rightarrow$ low-energy SUSY provides the solution(s) (or paves the way)!

$\Rightarrow$ But what about experimental results?

Is SUSY dead?   When will I give up on SUSY?



SUSY is as dead (or alive) as ANY OTHER BSM theory



SUSY is as dead (or alive) as ANY OTHER BSM theory

SUSY is as dead (or alive) as ANY OTHER BSM theory

$\Rightarrow$ **focus on the theoretically most appealing theory!**

SUSY is as dead (or alive) as ANY OTHER BSM theory

⇒ **focus on the theoretically most appealing theory!**

– It is nearly inconceivable that there is no symmetry between bosons and fermions (at low or high energy?)

– SUSY is the only non-trivial extension of (the SM) gauge symmetries

– SUSY gives you coupling constant unification

– SUSY predicted correctly the top quark mass

– SUSY predicted correctly the Higgs boson mass

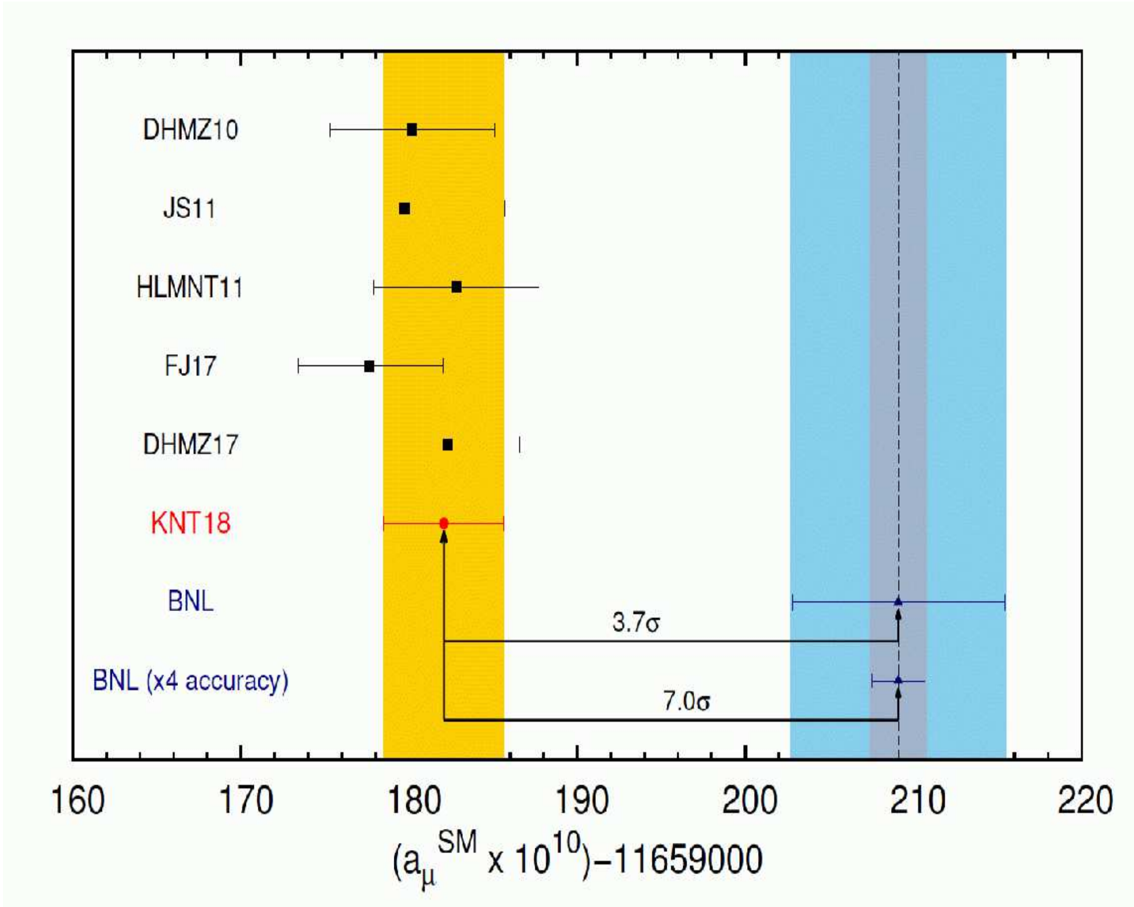
– SUSY predicted correctly an SM-like Higgs boson

– SUSY predicted correctly DM properties

The anomalous magnetic moment of the muon

$$a_\mu \equiv (g-2)_\mu/2$$

Overview about the current experimental and SM (theory) result:
[A. Keshavarzia, D. Nomura, T. Teubner '18]



$$a_\mu^{\rm exp} - a_\mu^{\rm theo,SM} \approx (27.05 \pm 7.26) \times 10^{-10} \quad : \; 3.7\,\sigma$$

SUSY can easily explain the deviation:

Feynman diagrams for MSSM 1L corrections:

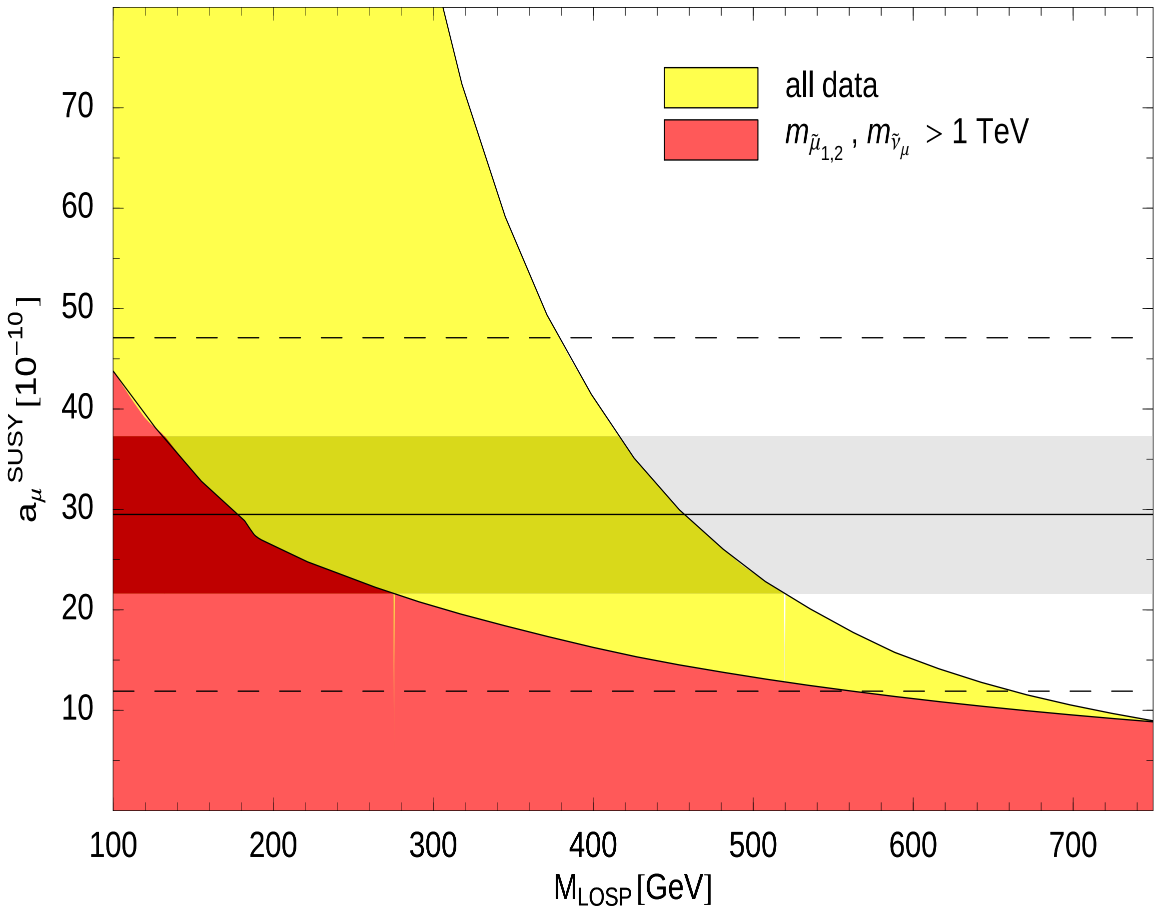
– Diagrams with chargino/sneutrino exchange

– Diagrams with neutralino/smuon exchange

If SUSY exists: it sould explain $(g-2)_\mu$

$\Rightarrow$ there should be (relatively) light EW SUSY particles!

Example: Scan over SUSY parameter space



Scan over

$\mu,\ M_2,\ m_{\tilde{\mu}},\ A_\mu$

LOSP = lightest observable SUSY particle

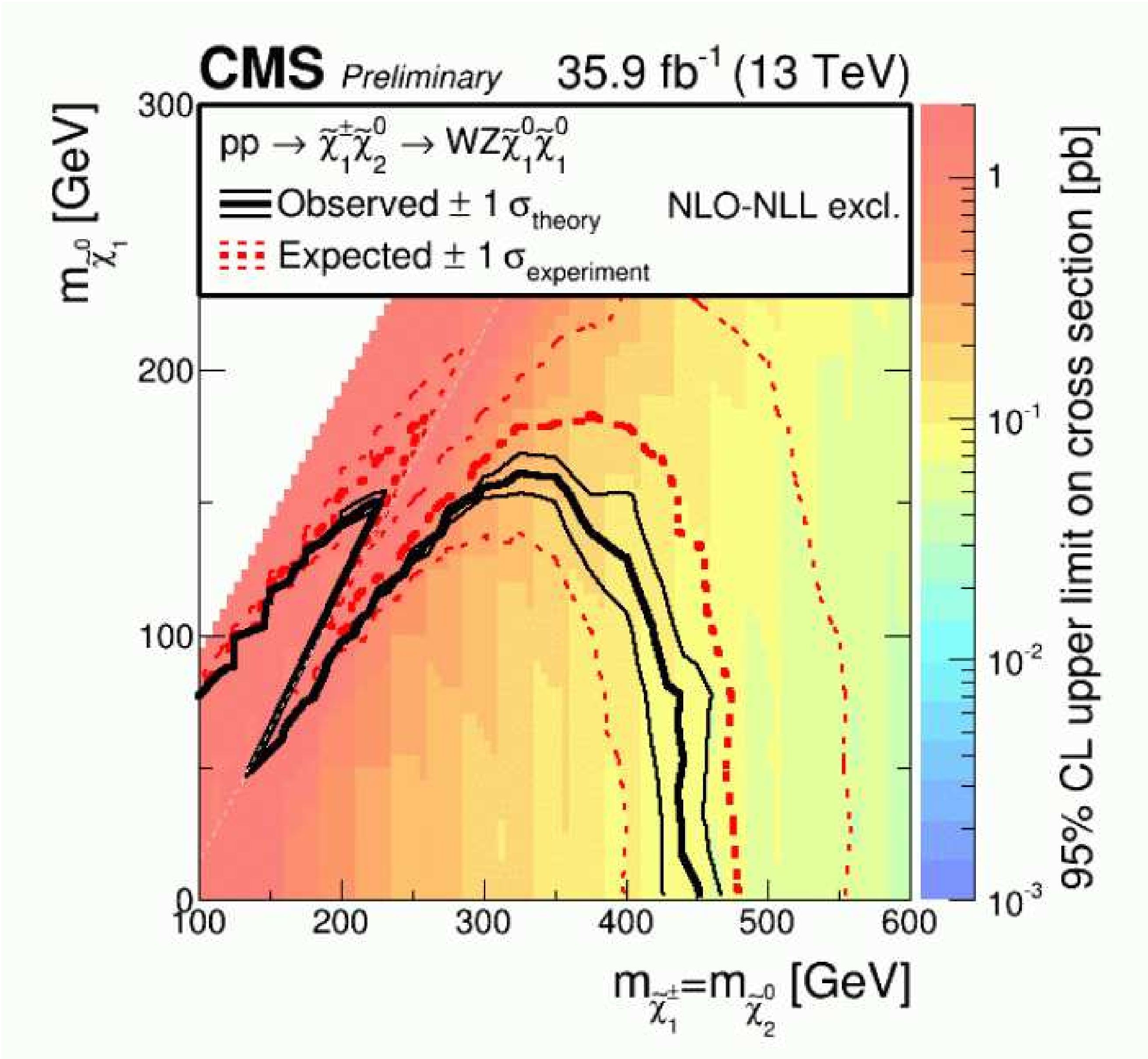
LOSP = $\tilde{\mu}$ or $\tilde{\chi}$

[D. Stöckinger '06]

SUSY could easily explain discrepancy

$\Rightarrow$ upper bound on EW SUSY particles!

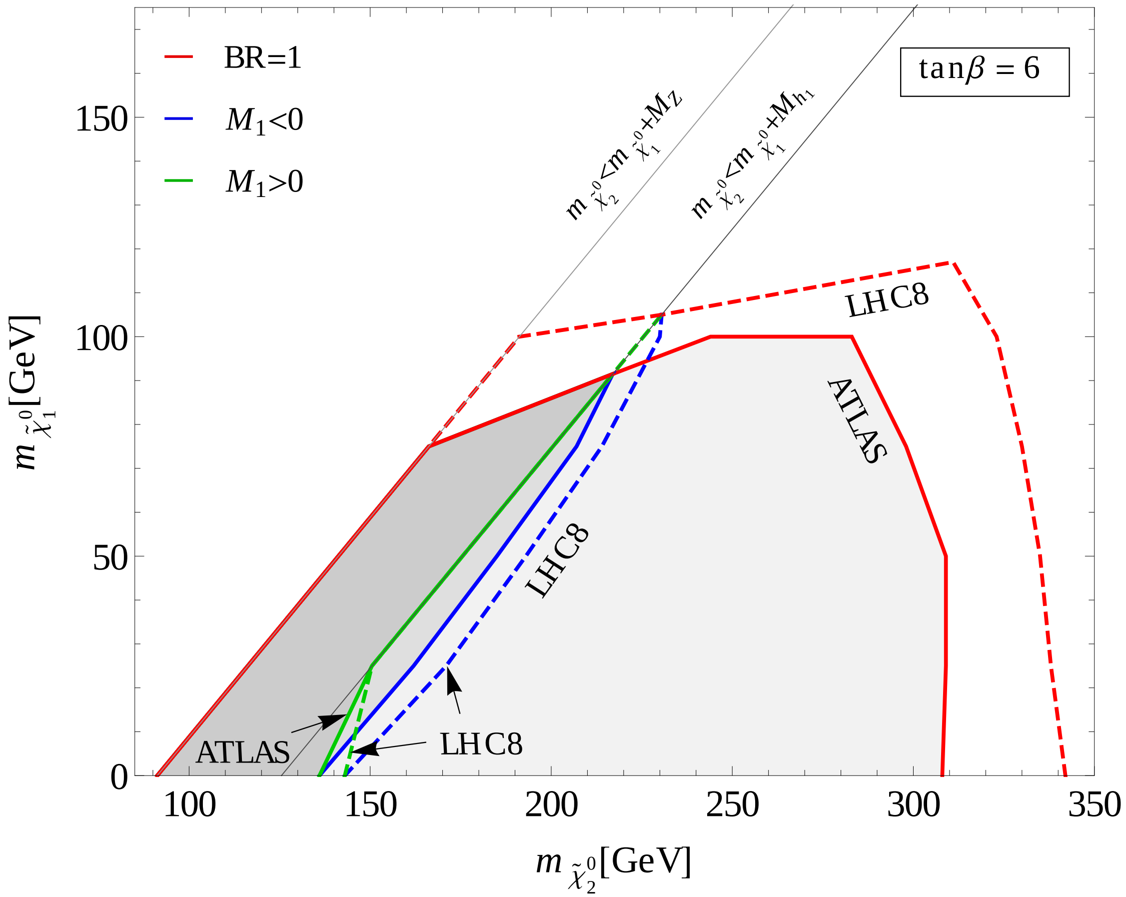
Electroweak searches:



LHC is looking for $pp \to \tilde{\chi}_1^\pm \tilde{\chi}_2^0 \to W^\pm \tilde{\chi}_1^0 Z \tilde{\chi}_1^0$

Reality: BR$(\tilde{\chi}_2^0 \to Z\tilde{\chi}_1^0) = 1$ is NEVER correct because $\tilde{\chi}_2^0 \to h\tilde{\chi}_1^0$ is possible

[A. Bharucha, S.H., F. v.d. Pahlen '13]

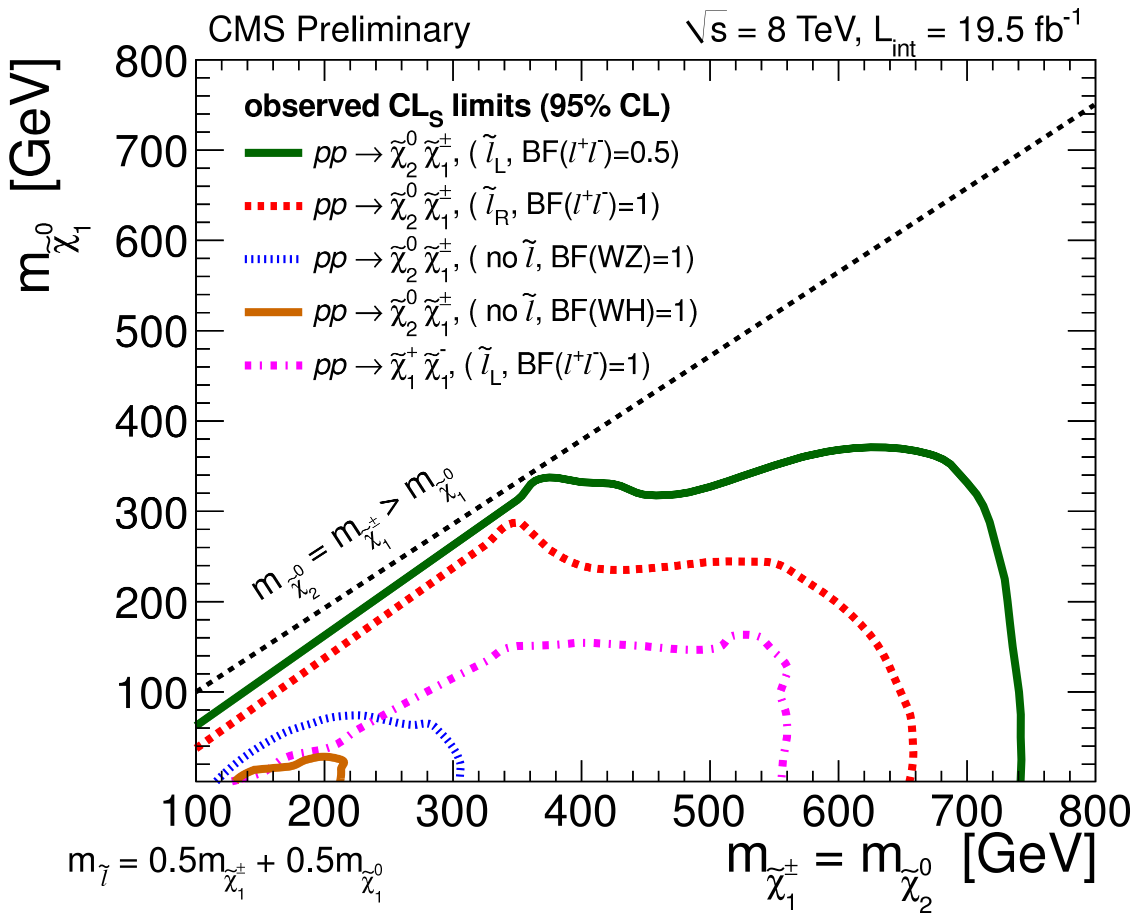


$\Rightarrow$ huge reduction of exclusion region (where $\tilde{\chi}_2^0 \to \tilde{\chi}_1^0 h$ allowed)

More recently:

ATLAS and CMS are now also searching for

$$pp \to \tilde{\chi}_1^\pm \, \tilde{\chi}_2^0 \to W^\pm \tilde{\chi}_1^0 \, \tilde{\chi}_2^0 \to W^\pm \tilde{\chi}_1^0 \, h \tilde{\chi}_1^0 \to W^\pm \tilde{\chi}_1^0 \, b\bar{b} \tilde{\chi}_1^0$$



⇒ strongly reduced bounds! ⇒ **THIS is where to look!**