Beyond the Higgs Boson:

LOOKING FOR SUPERSYMMETRY at the LHC

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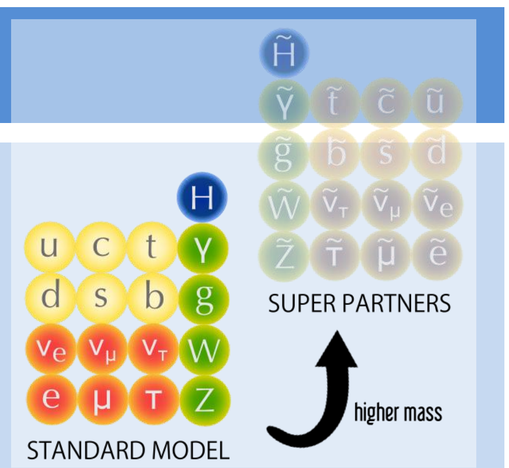
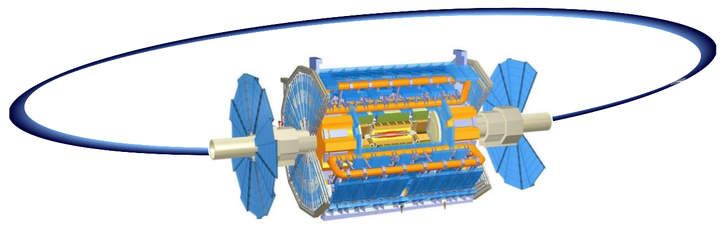
Introduction

- The Standard Model has been strengthened by the discovery of the Higgs boson.
- Many questions remain open:
  - → What is **dark matter**?
  - → Why is the **Higgs mass** ~125 GeV?
  - → How can we fit **gravity** into the global picture?
  - → Why are the fundamental interactions so different in **strength**?



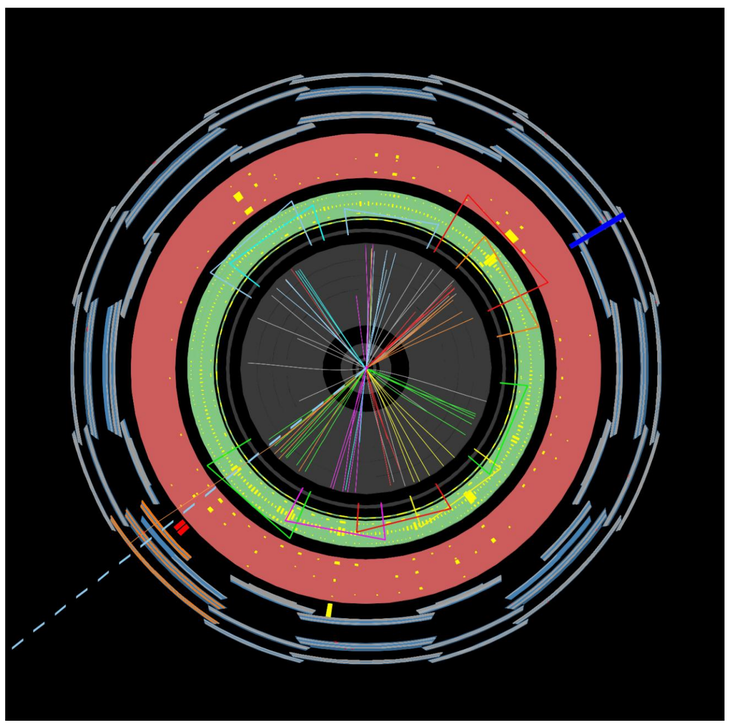
Supersymmetric models provide some answers to these questions.

The Large Hadron Collider



- Protons are accelerated in the 27 km ring until they reach 8 TeV of energy.
- Four collision points.
- Tens of *millions* of crossings per second.

- ATLAS is a cylindrical detector situated around one of the collision points.
- The energy released in the collision turns into new particles ($E=mc^2$), which are then detected by ATLAS. The high energy reached allows us to potentially produce particles in a very high and completely unexplored mass range.

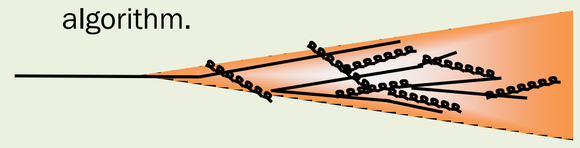


Event selection and reconstruction

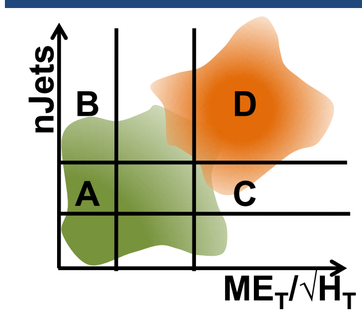
- Not all events can be recorded due to bandwith limitations. Focus on configurations of interest (*triggering* system).
- We define a search strategy to **maximise signal significance** over Standard Model backgrounds (QCD production, $t\bar{t}$, W, Z…).
- We select events with **large numbers of *jets,*** which may come from the **decay of very heavy particles**.
- The events are **classified** according to:
  1. Number of jets (>7, >8, >9).
  2. Number of jets originating from a *b*-hadron.
  3. Total mass of large-radius jets.
- 19 *signal regions* with different cuts on these variables are defined. We optimised each of them to be sensitive to a different type of new physics model.

What is a jet?

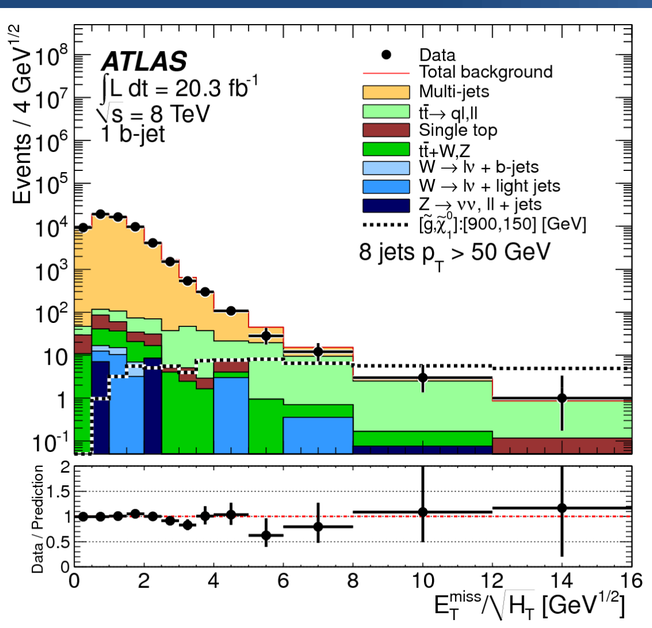
- A jet is a cone-shaped bundle of particles detected in the calorimeter.
- It generally contains a cascade of particles originating from a hadron, a photon or an electron.
- The cascades are classified as hadronic or electromagnetic.
- The size of jets can be fixed as a parameter of the reconstruction algorithm.

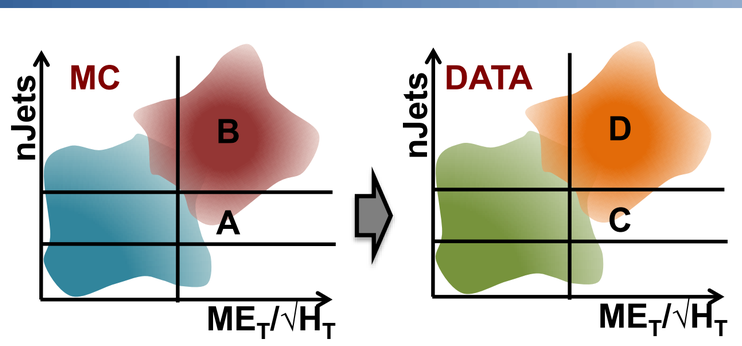


Background prediction

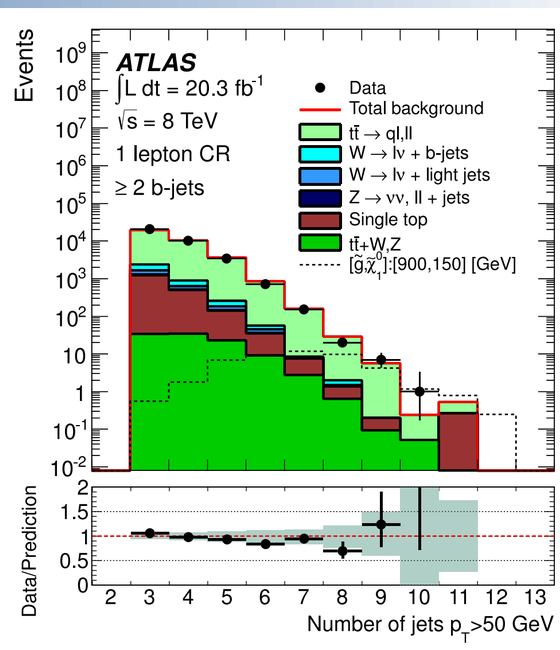


- We predict the multi-jet background from an orthogonal sample of data for each signal region.
- More accurate than numerical simulation.

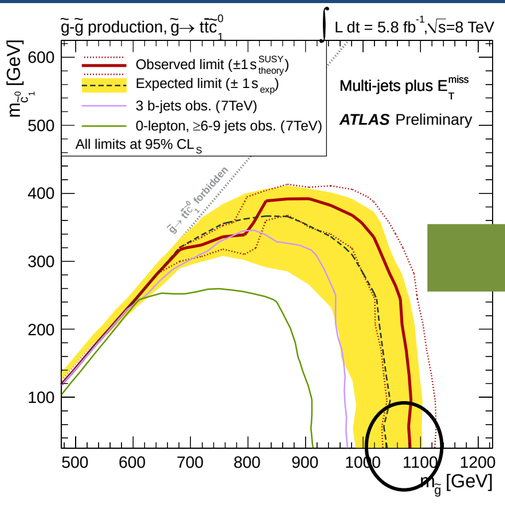


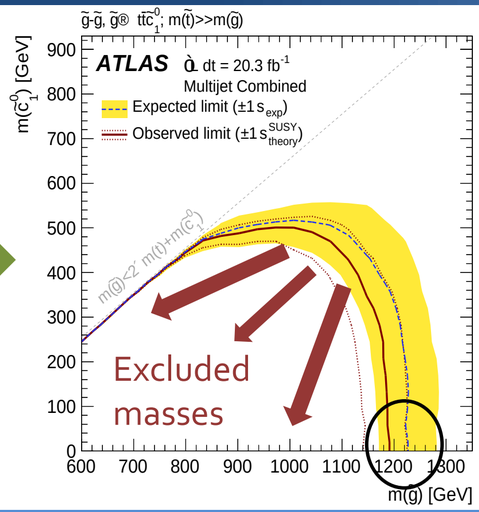


- The non-all-hadronic background is estimated from Monte Carlo simulations.
- Dominant processes ($t\bar{t}$, W+jets) are constrained in *control regions* where there is no significant contribution from signal.

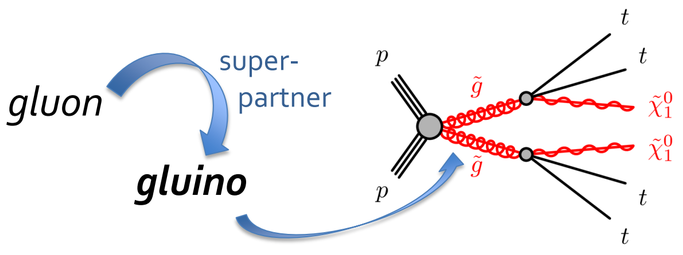


Discussion





- Most of the signal and control regions are combined into a global fit to get a better description of the data.
- After doing this, the **data agrees with the Standard Model prediction** within the statistical and systematic uncertainties.
- We set limits on some representative supersymmetric models. For example:



If gluinos are directly produced and decay into 2 tops and 1 light neutralino, then their mass must be higher than 1200 GeV.

(See the exclusion figures on the left)

Conclusions

- We have performed a search for new physics in events with very large jet multiplicities, different numbers of b-tagged jets and different values of the total jet mass. The full data set taken by the LHC in 2012 was analysed.
- No excess over the Standard Model prediction is found, so limits on supersymmetric models are extended beyond previous searches.
- This places important constraints on supersymmetry, which is now forced to live at higher mass ranges, if it is indeed present in Nature. The next LHC run, starting in 2015 at almost twice the center-of-mass energy (13 TeV) is expected to shed some light on the mysteries that for now remain unsolved.

REFERENCES: JHEP, 10 (2013) 130; CERN-PH-EP-2013-110 ; ATL-COM-PHYS-2012-1814

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