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Beyond the Standard Model: Results with the 7 TeV LHC Collision Data

19 - 23 September 2011

Search for Dijet Resonances at ATLAS

Georgios Choudalakis
University of Chicago
U.S.A.

Dijet searches in ATLAS

Georgios Choudalakis*
on behalf of the
ATLAS Collaboration

*University of Chicago

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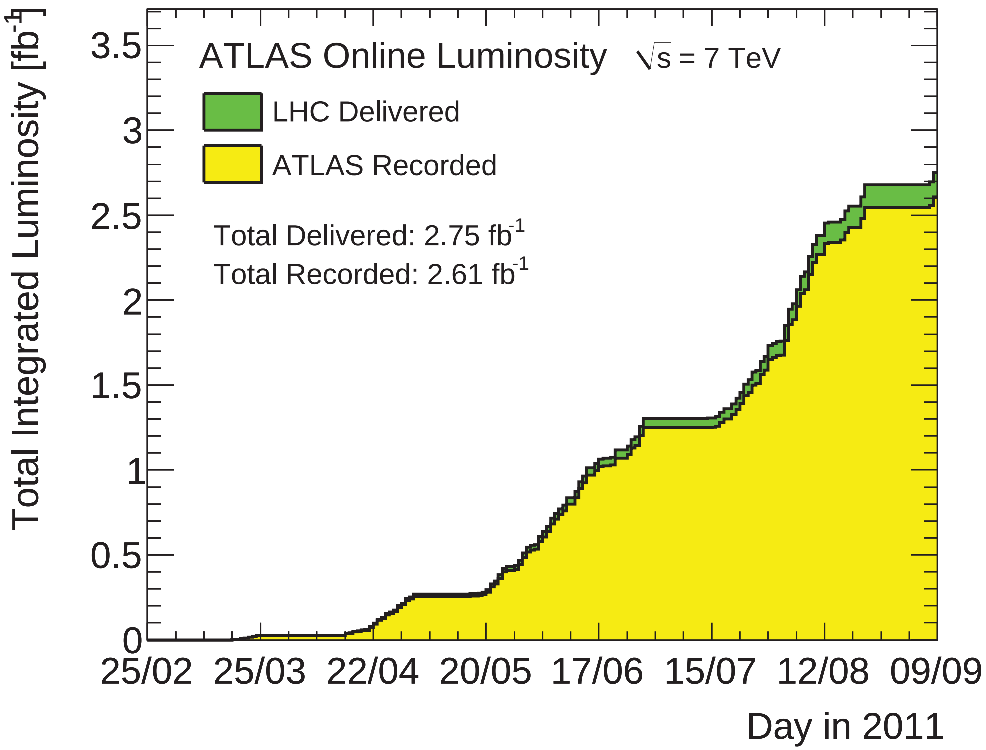
Overview

Two complementary ways of analyzing dijet events:

- Dijet resonance search in m_{jj}.
- Dijet angular distribution analysis.

In this presentation:

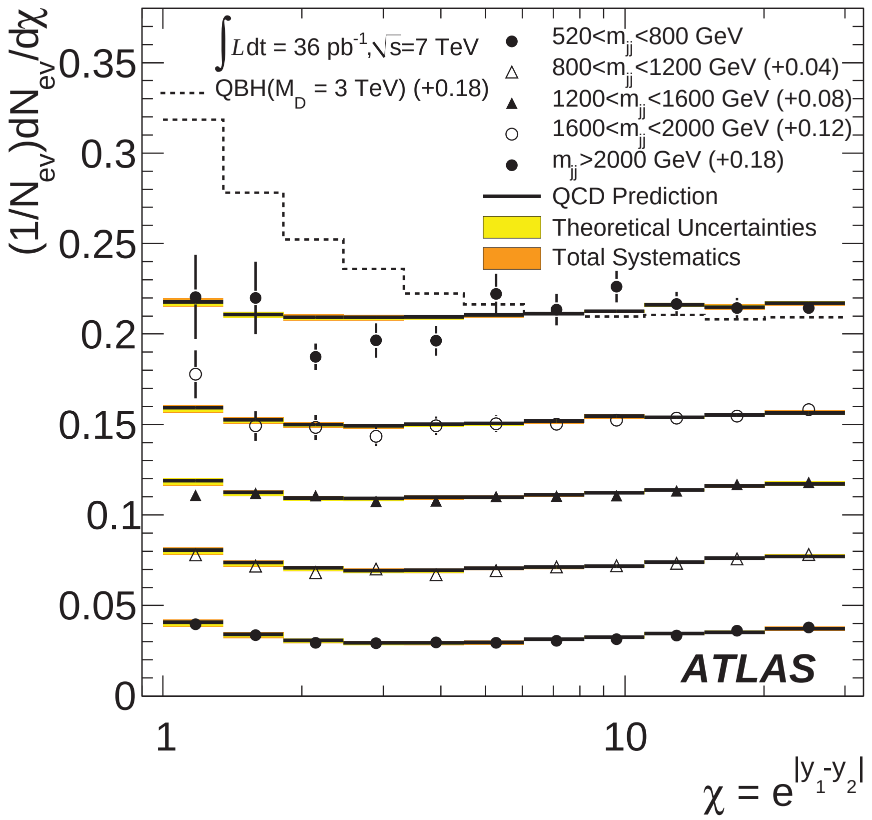
- Flashback of 2010 results
- Dijet resonance search in m_{jj} with 1.0 fb^{-1}.
- Model-independent search
- Limits to benchmark models
- Model-independent limits

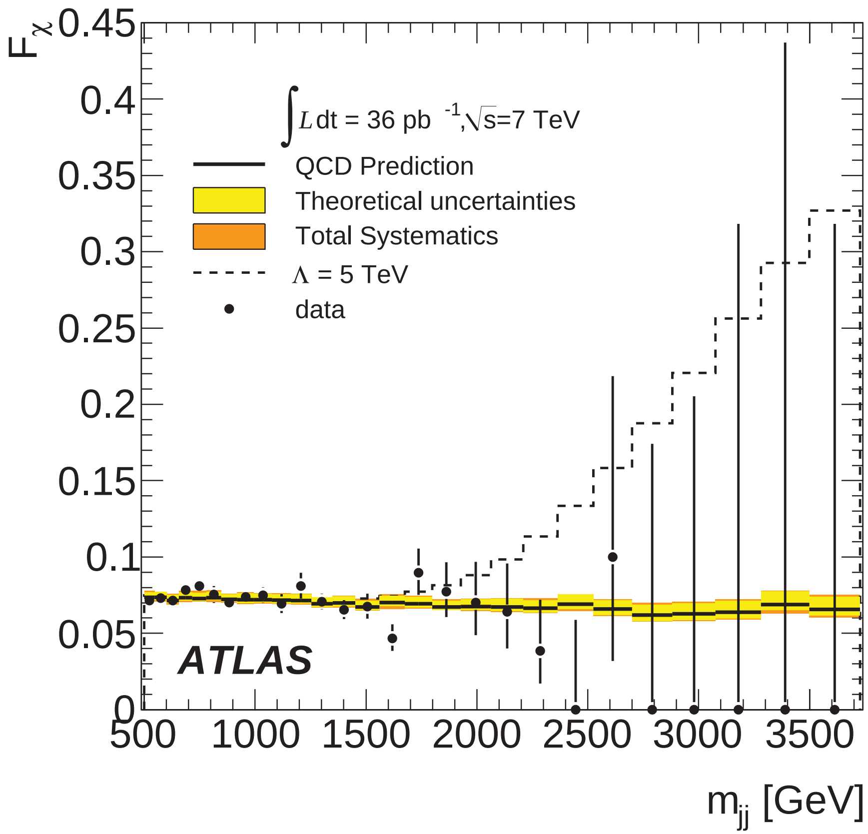


Flashback of 2010 results, with 36 pb^{-1}.

New J. Phys. 13 (2011) 053044

The observables of the angular analysis





The signal is expected in $|y_1 - y_2| < 1.2$, namely $\chi < 3.32$.

F_χ = fraction of events in $|y_1 - y_2| < 1.2$.

Background: PYTHIA QCD $\times$ k-factor from NLOJET++.

Systematics: Jet Energy Scale, μ_R and μ_F , PDF.

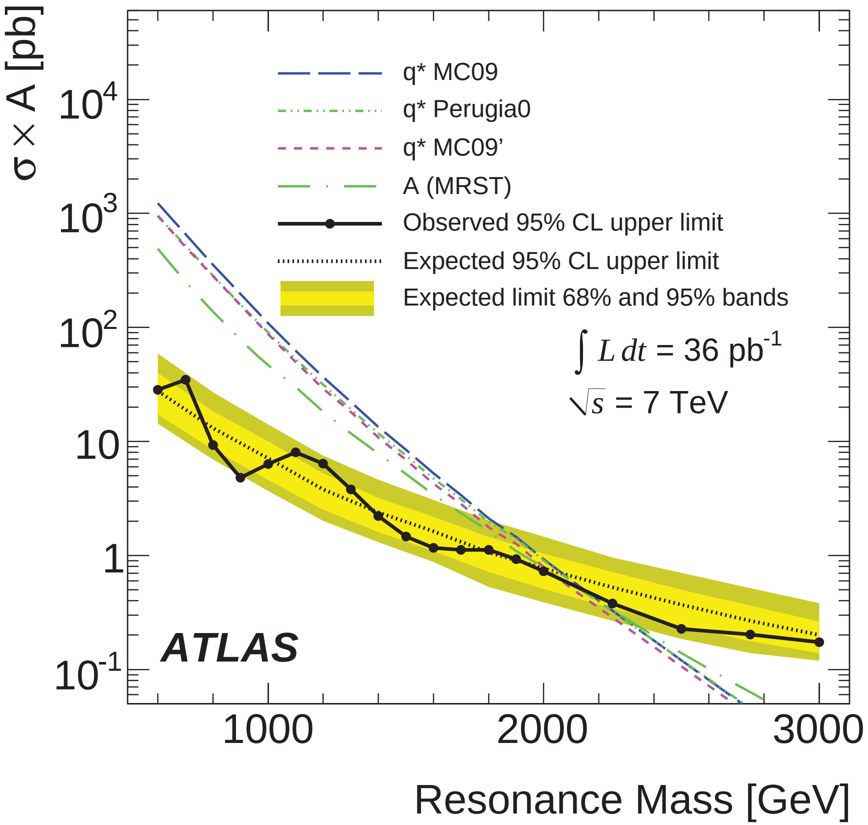
Summary of results with 36 pb^{-1}

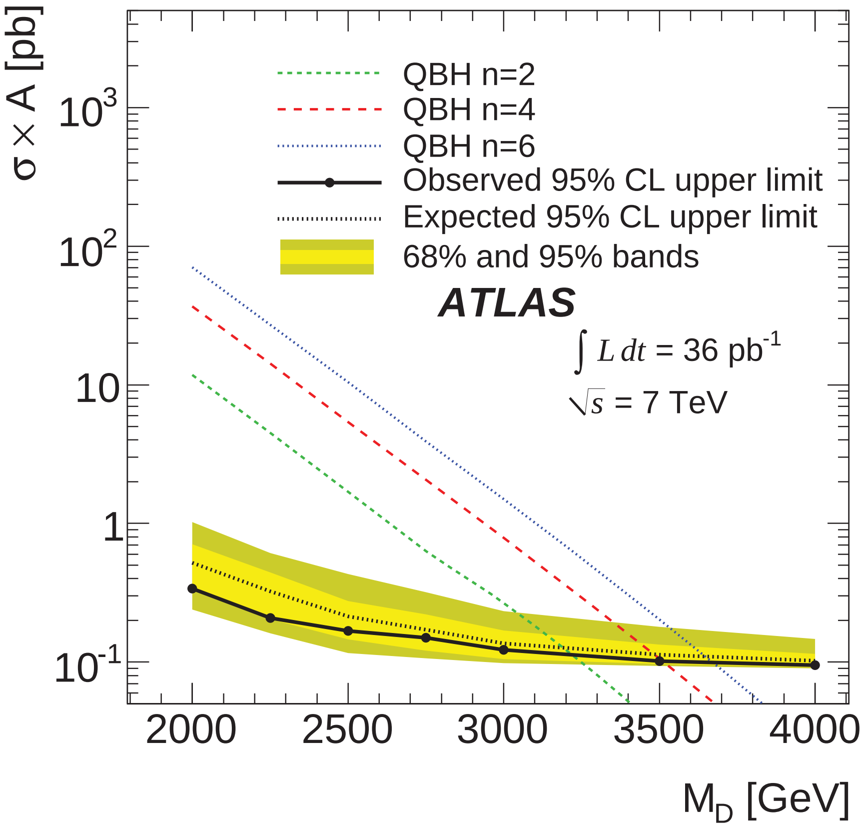
Analysis / observable	95% C.L. Limits (TeV) Expected	Observed
Excited Quark q^*		
Resonance in m_{jj} [Bayesian]	2.07	2.15
$F_\chi(m_{jj})$ [Frequentist]	2.12	2.64
Randall-Meade Quantum Black Hole for $n = 6$		
Resonance in m_{jj} [Bayes.]	3.64	3.67
$F_\chi(m_{jj})$ [Freq.]	3.49	3.78
F_χ for $m_{jj} > 2$ TeV [Freq.]	3.37	3.69
$\frac{dN}{d\chi}$ for $m_{jj} > 2$ TeV [Freq.]	3.46	3.49
Axigluon		
Resonance in m_{jj} [Bayes.]	2.01	2.10
Contact Interaction Λ		
$F_\chi(m_{jj})$ [Freq.]	5.7	9.5
$F_\chi(m_{jj})$ [Bayes.]	5.7	6.7
F_χ for $m_{jj} > 2$ TeV [Freq.]	5.2	6.8
$\frac{dN}{d\chi}$ for $m_{jj} > 2$ TeV [Freq.]	5.4	6.7

Three observables used in the angular analysis:

1. Whole $F_\chi(m_{jj})$ spectrum
2. F_χ for $m_{jj} > 2 TeV$
3. $\frac{dN}{d\chi}$ in 11 χ bins, for $m_{jj} > 2$ TeV

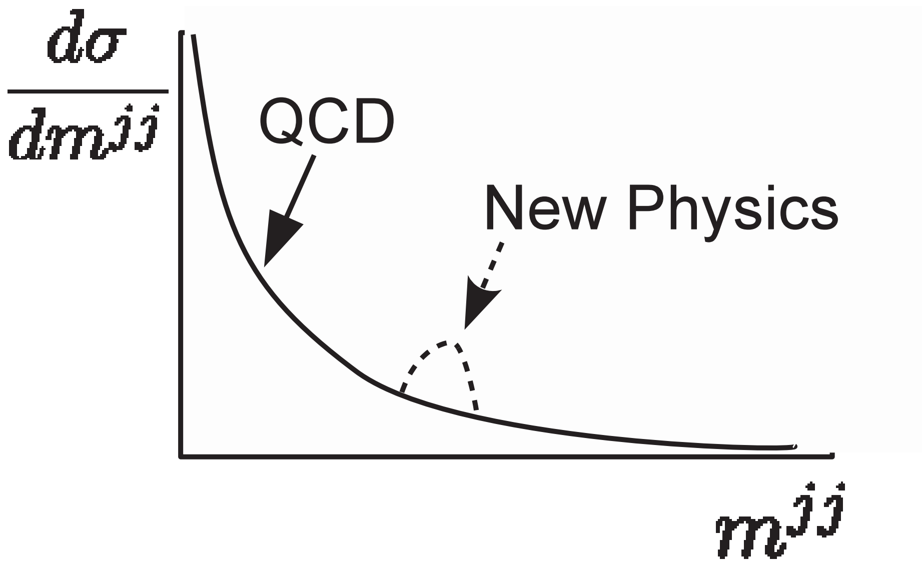
Dijet m_{jj} limits with 36 pb^{-1}





New results, from the dijet resonance search in m_{jj}.

Resonance search in dijet mass

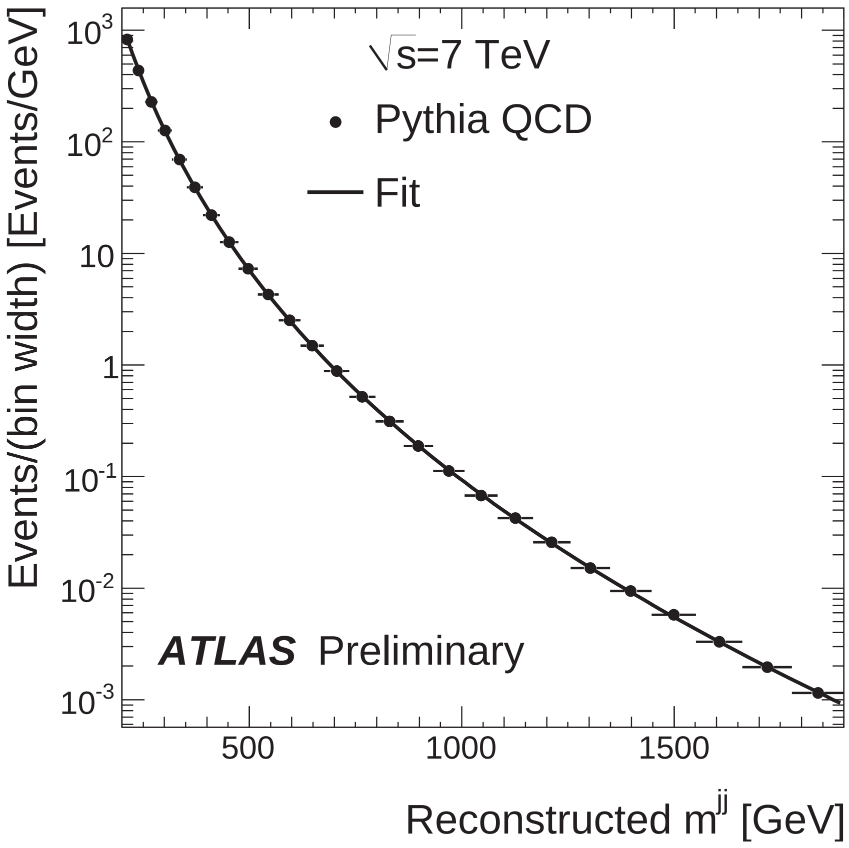


Background determined by (smart) fitting

$$f(x) = p_0 \frac{(1-x)^{p_1}}{x^{p_2+p_3 \ln x}}, \quad x \equiv \frac{m_{jj}}{\sqrt{s}}.$$

About the function $f(x) = p_0 \frac{(1-x)^{p_1}}{x^{p_2+p_3 \ln x}}, \quad x \equiv \frac{m_{jj}}{\sqrt{s}}$

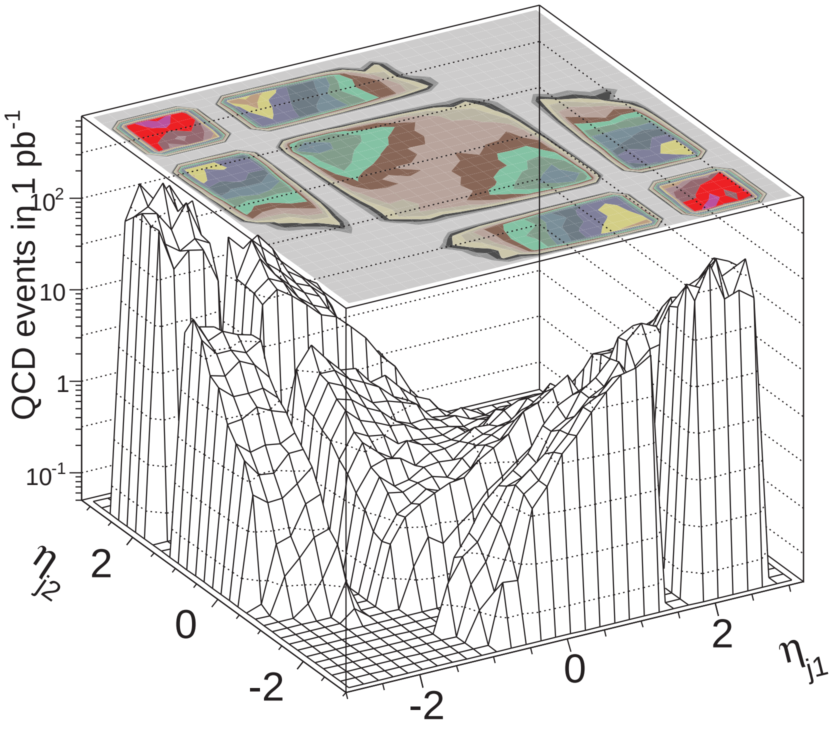
- Able to fit wonderfully Pythia QCD, Alpgen, Herwig, NLOJET++.
- No inflection points. [Unable to fit big bumps.]
- $f(m=\sqrt{s}) = 0$. [A physical property.]
- It is a parabola in log-log scale, except for the numerator which is added to make it go to 0 at $\sqrt{s}$.
- Known, and used several times before. [e.g., CDF, Phys.Rev.D 79 (2009) 112002].

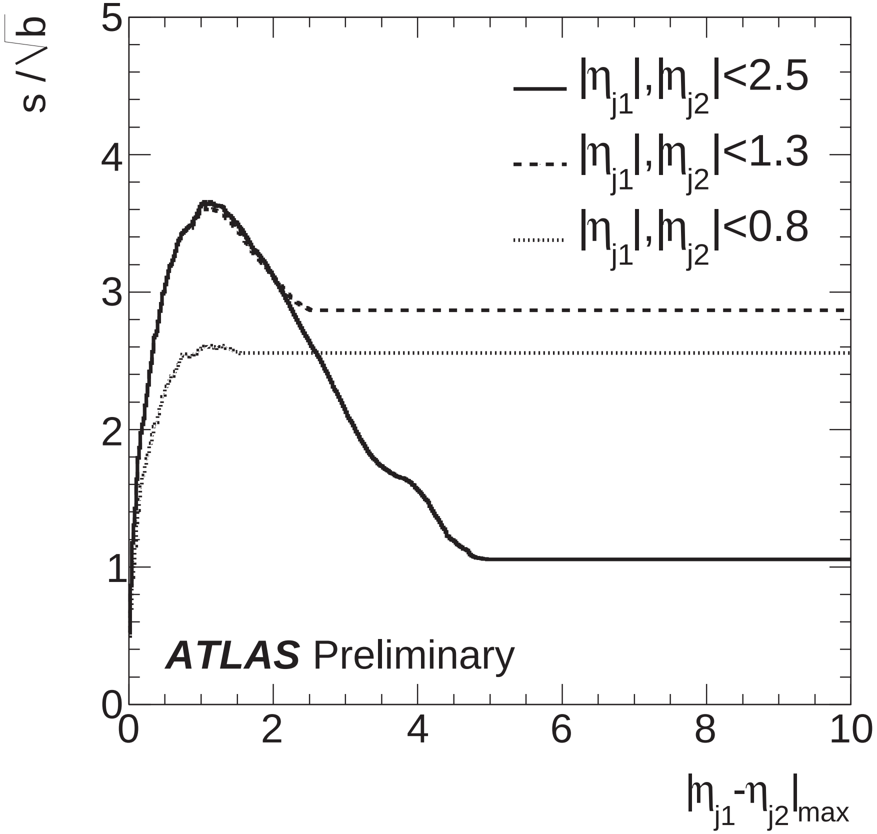


Event selection

- The obvious: Stable beams, good detector conditions, good vertex, etc.
- m_{jj} in trigger plateau.
- Two leading jets be of good quality.
- No other jet of poor quality that has $p_T > 0.3 p_T^{j2}$.
- $|\Delta y| < 1.2$

Suppression of QCD background

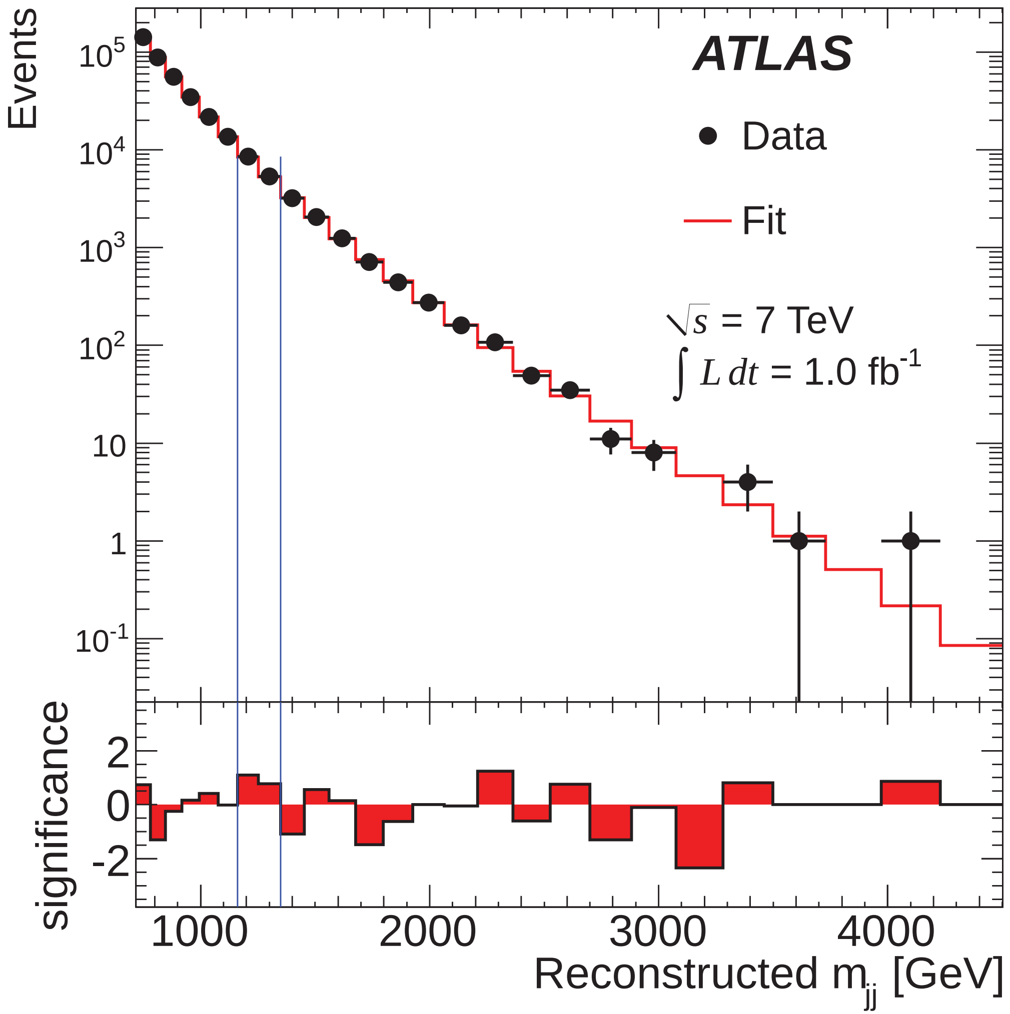




Great sensitivity boost, by selecting central events.

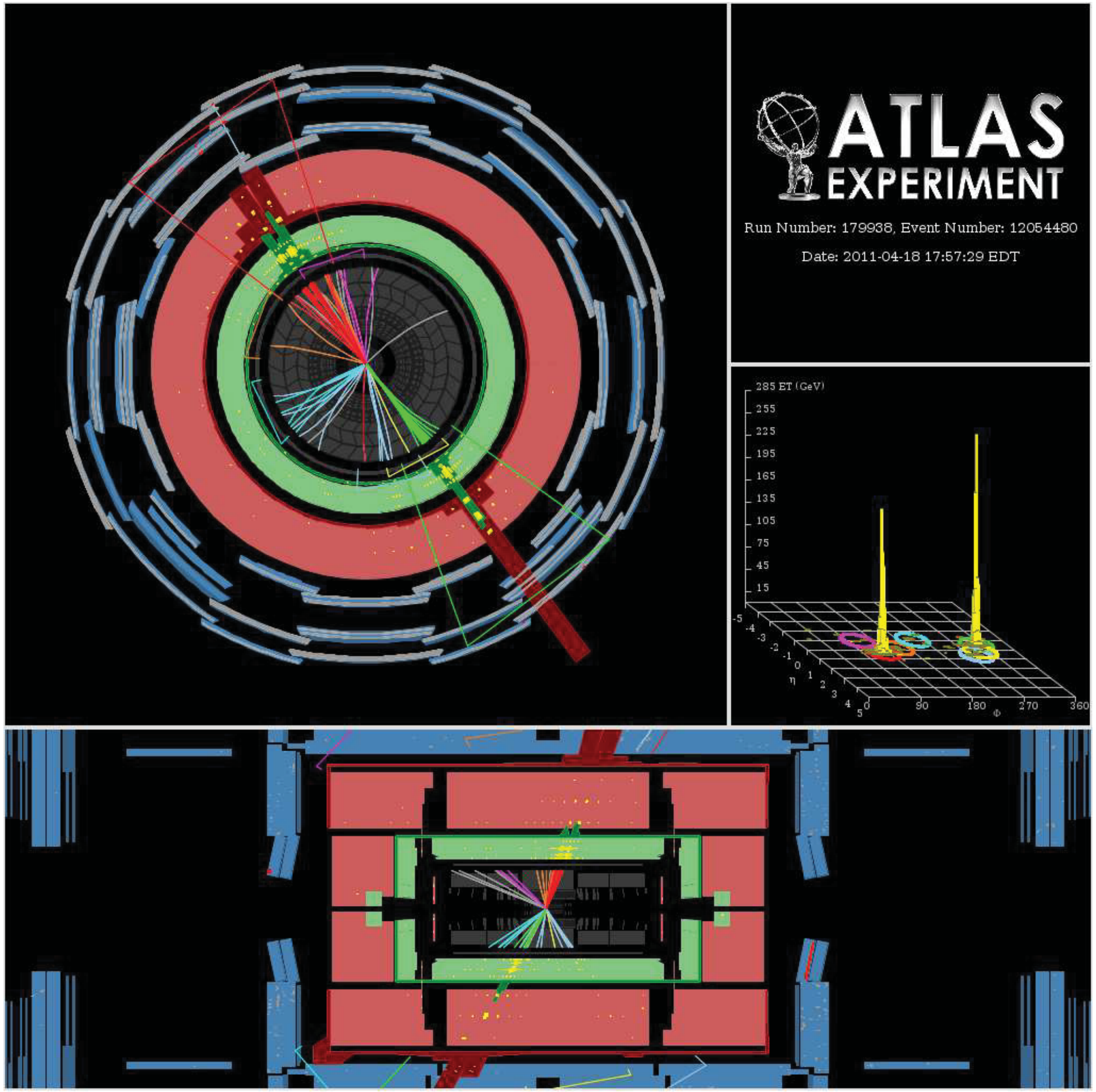
[This coheres with dijet angular analysis, where F_χ is, practically, the fraction of events passing this cut.].

The data



The fit, overall, is fantastic: The p-value of the $(-\log L)$ statistic is about 28%.

Event at $m_{jj} = 4$ TeV



Both jets at $p_T \simeq 1.8$ TeV.

The BumpHunter hypertest is used to look for excesses

Hypertests, and the BH in specific, are explained in arXiv:1101.0390 [physics.data-an].

What does it do?

- It counts events in all intervals, and computes Poisson p-values.
- It keeps the smallest Poisson p-value it finds. ⇒ BH's test statistic.
- It generates several 0-signal pseudo-experiments and scans them too.
- It counts how often a pseudo-spectrum would have any interval that is more significantly discrepant than the one observed in the data. ⇒ BH's p-value.

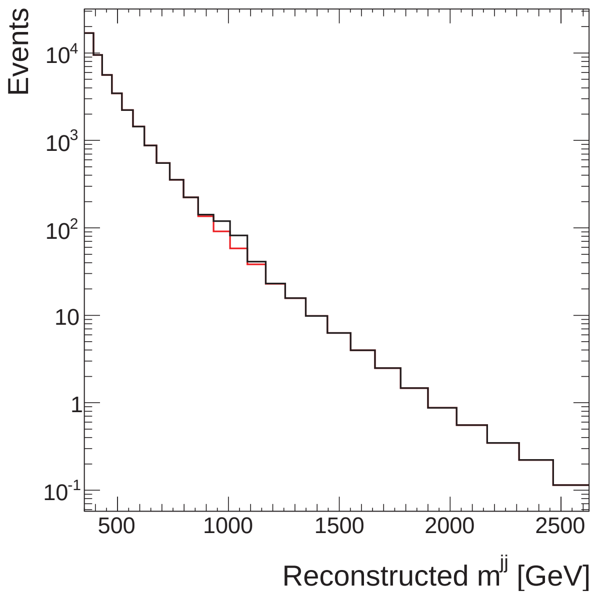
What is the point of this?

- Hypertests account for the trials factor.
- Sensitive to excesses, without presuming their shape or location.

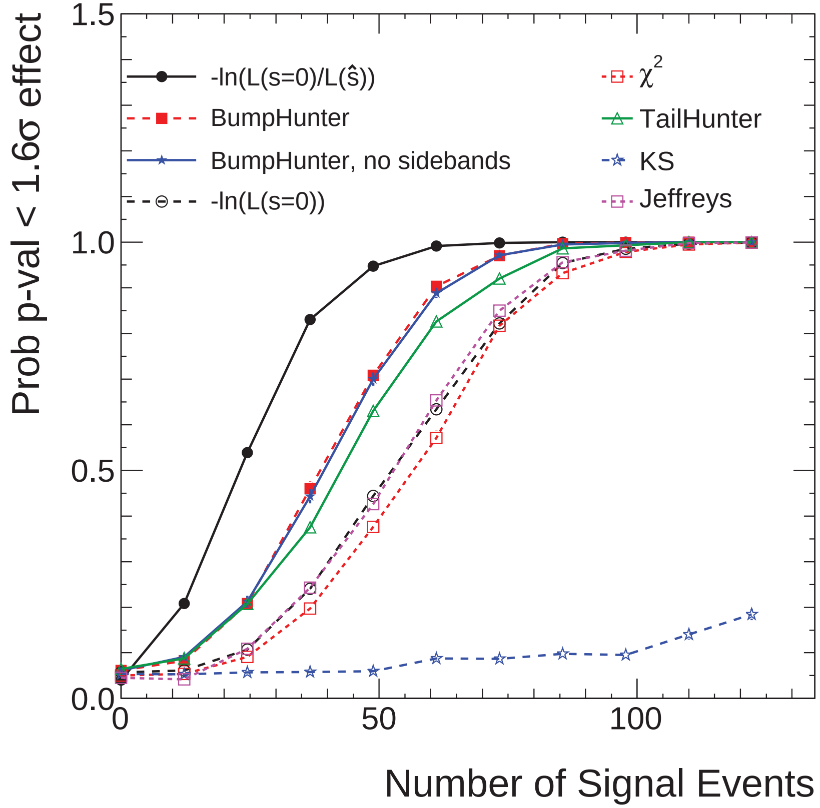
A demo of sensitivity

Toy MC used; no ATLAS data involved.

Gassian signal is injected, as shown here [At 1000±50 GeV]:

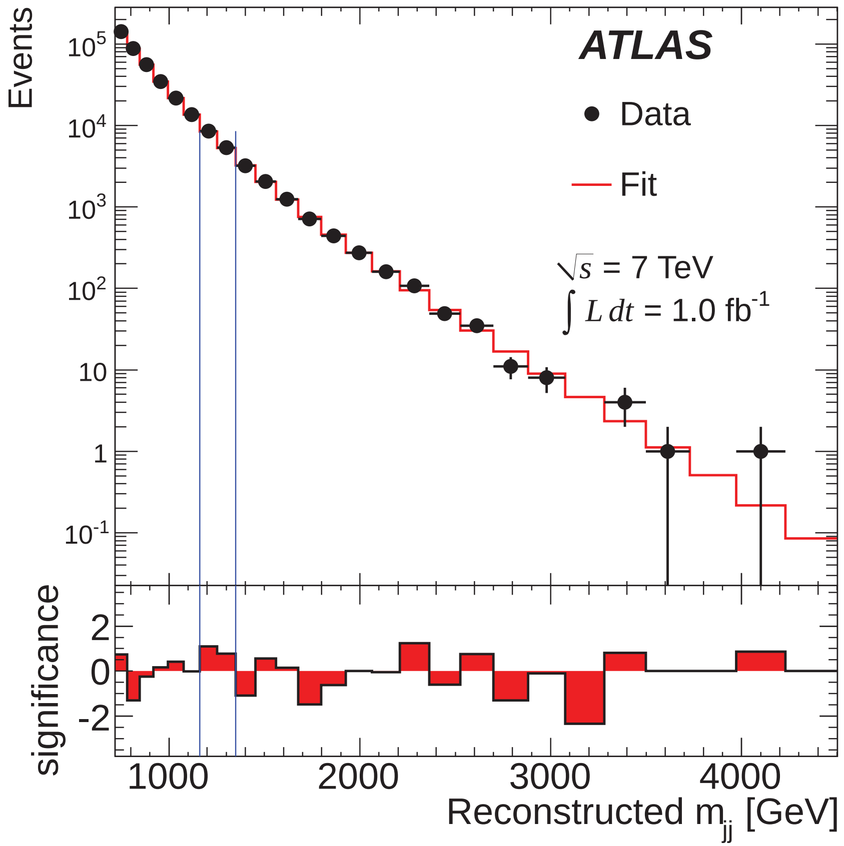


We find the probability of making a claim, as a function of expected signal.



The BUMPHUNTER is the most sensitive model-independent test.
The absolute "winner" (black) knows a-priori the signal shape and location.

The search phase of the analysis



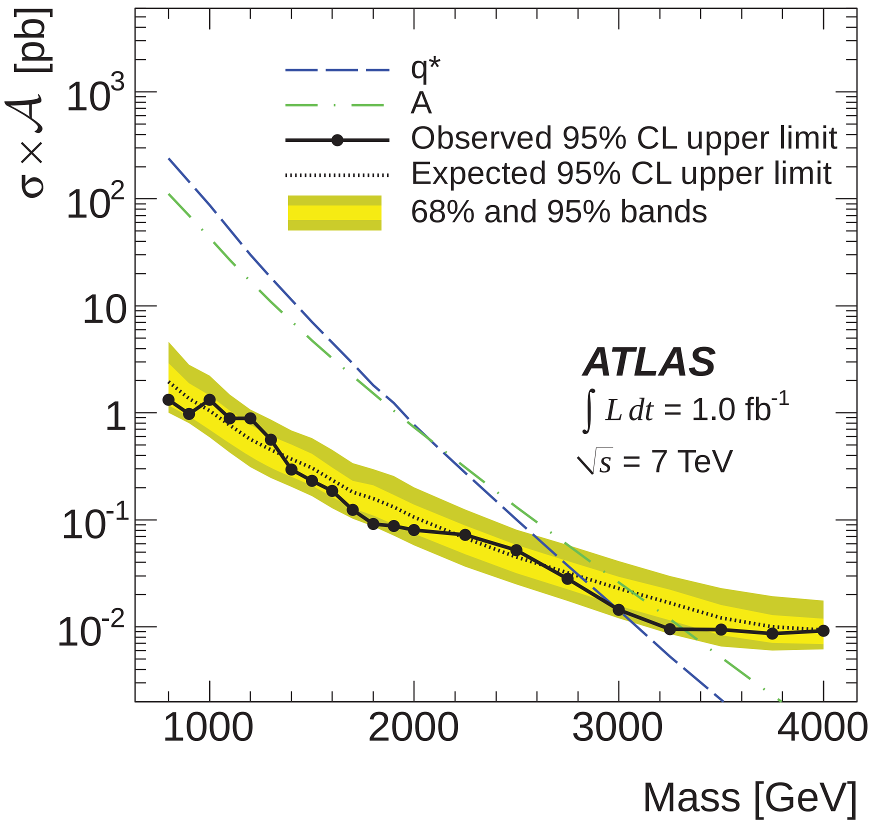
The p-value of the BumpHunter statistic is **82%**.

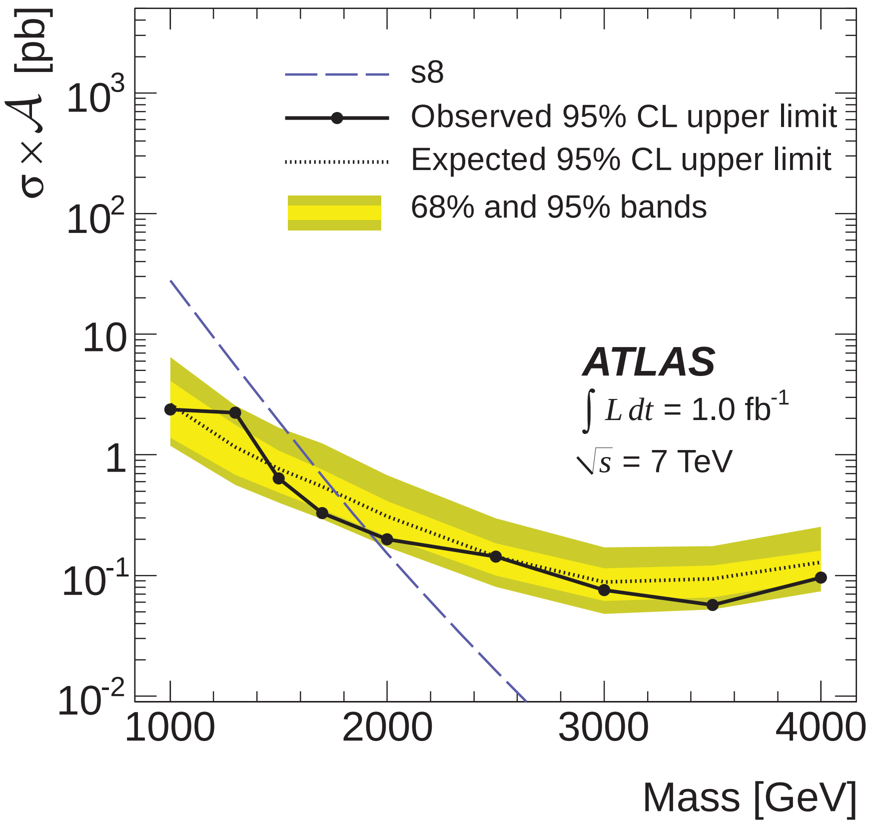
Totally insignificant.

Systematic uncertainties

- Jet Energy Scale: From 2 to 4% at p_T above 100 GeV.
- Jet Energy Resolution: Negligible.
- Fit uncertainty: Ranges from $< 1\%$ at 1 TeV, to $\sim 20\%$ at 4 TeV.
- Luminosity uncertainty: 3.7%

Limits to specific models





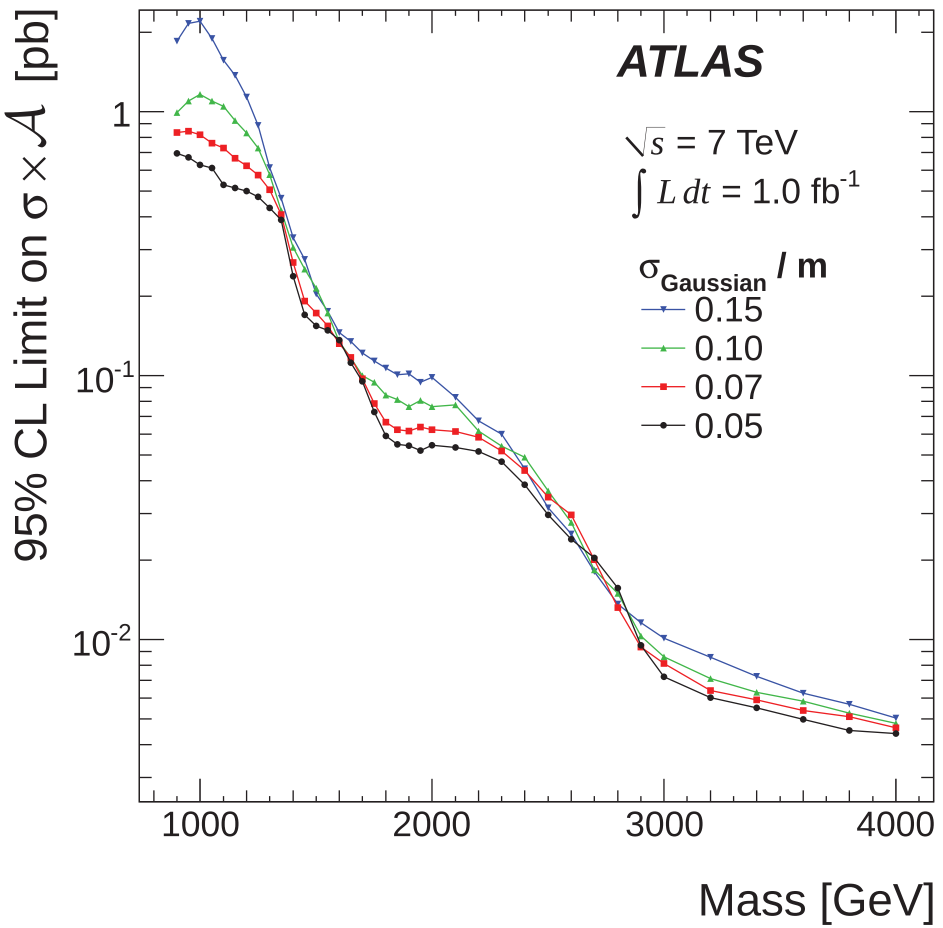
At 95% credibility level, with constant priors:

$m_{q^*} > 2.99$ TeV. [expected 2.81]

$m_A > 3.32$ TeV. [expected 3.07]

$m_{s8} > 1.92$ TeV. [expected 1.77]

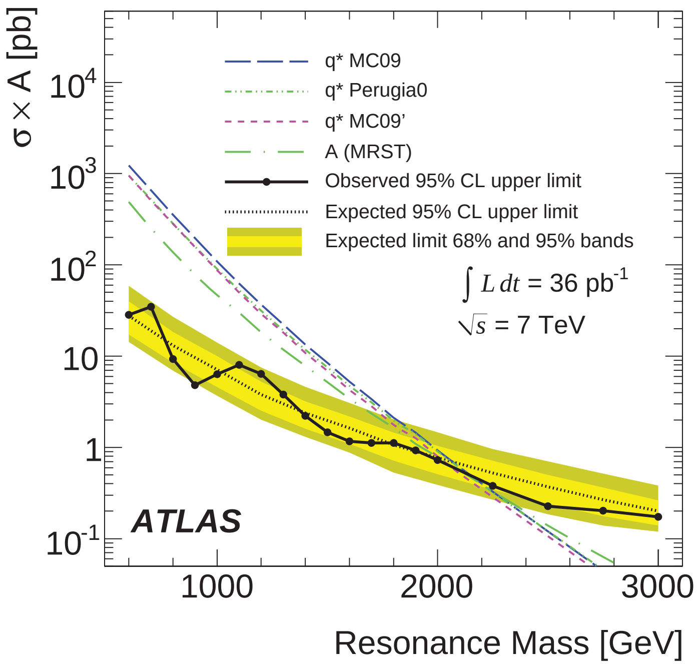
Limits to Gaussian signal templates



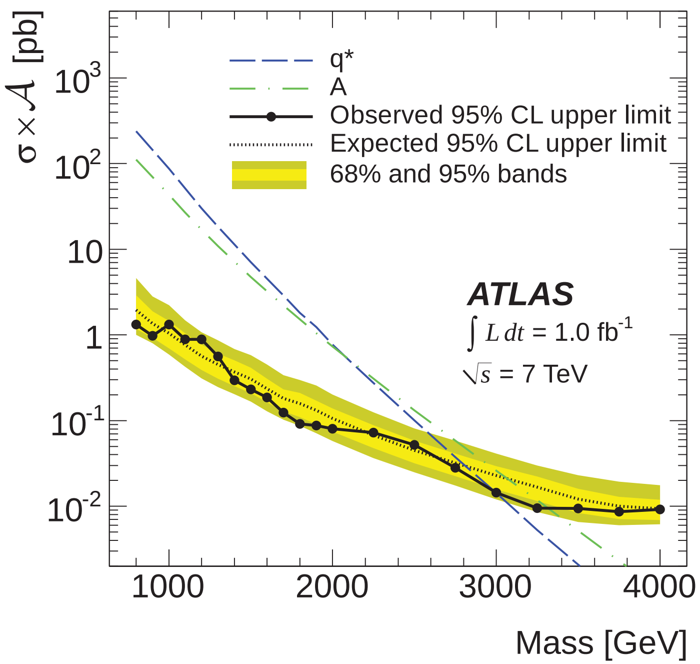
- Gaussian signals, of various means and widths.
- Approximation to virtually any resonance.
- Systematic uncertainties included, just like for specific models.

Summary

- Reviewed the results from 36 pb^{-1} of 2010.
- Updated the dijet resonance search in m_{jj} with 1.0 fb^{-1} of data.
- Model-independent search (BUMPHUNTER) found no significant discrepancy.
- Updated limits to benchmark models, like q^*. (2.99 TeV)
- Added scalar octet to the repertoire.
- Updated model-independent limits.



$\Rightarrow$



Our reach extended by about 1 TeV.

Backup

Signal examples