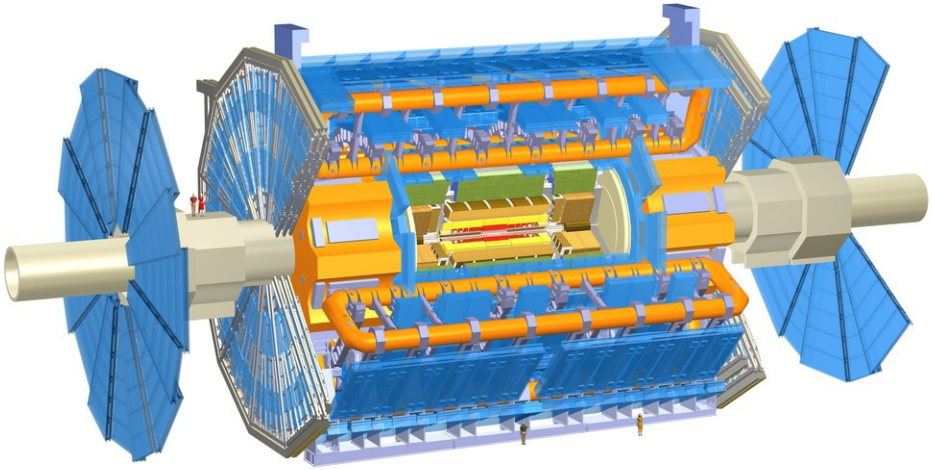
Search for new physics in dijet events at ATLAS



HASCO 2012

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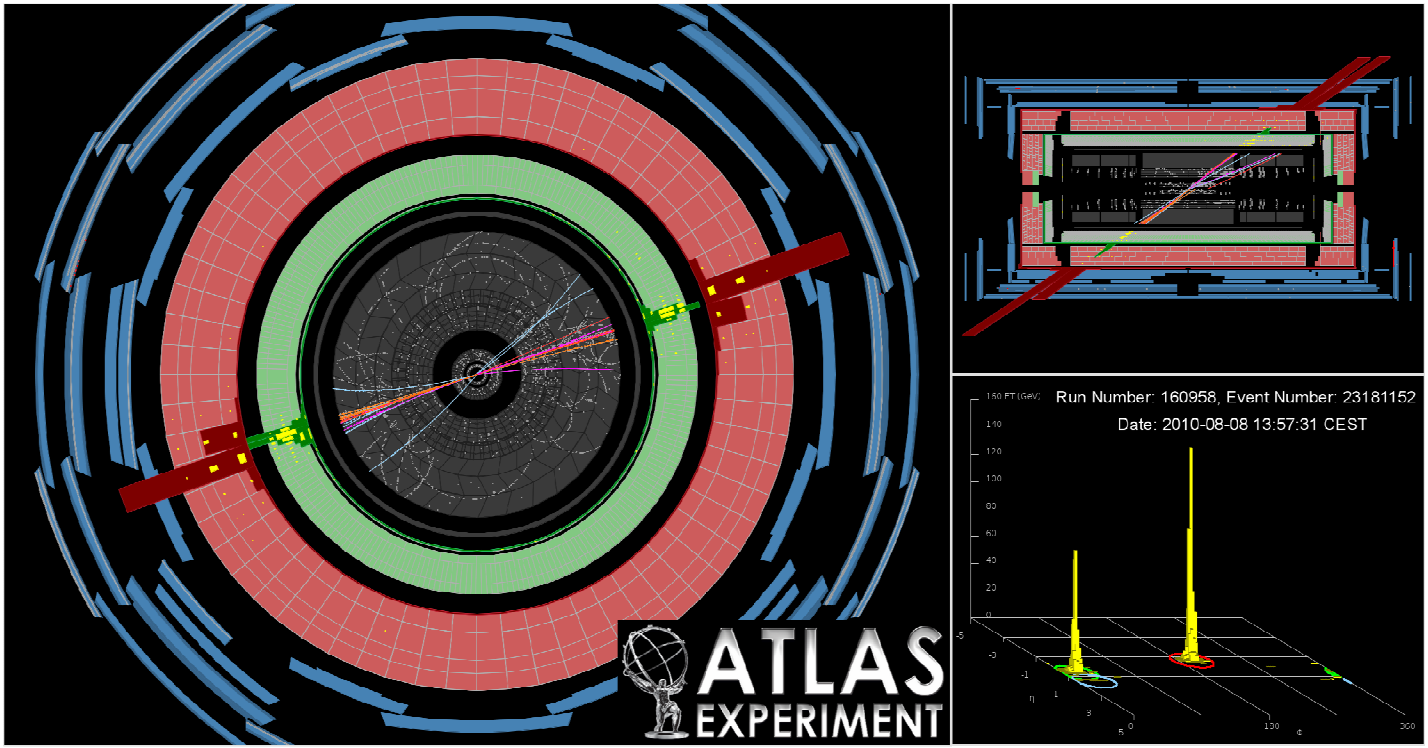
Introduction

Search for new Physics in Dijet events recorded in 2011

- 1 fb^{-1} of pp Collision Data at $\sqrt{s}$ = 7 TeV
- Search for peaks in mass spectrum
- 3 models tested:
  - Excited quarks
  - Axigluons
  - Colour octet scalar
- Paper published soon after 2011 data collected
  - Look for new physics as soon as data collected

Introduction

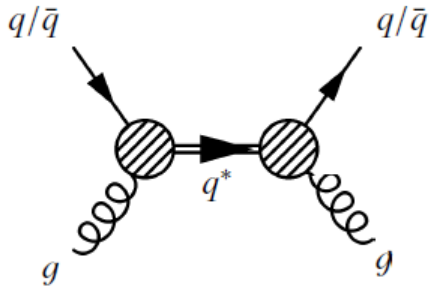
- Dijet events:
  - 2 → 2 scattering of a pair of partons
  - Parton showers hadronize to form jets
  - Energy spectrum predicted by QCD

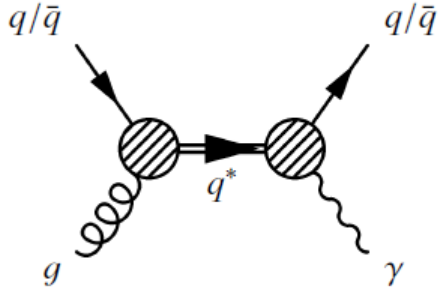


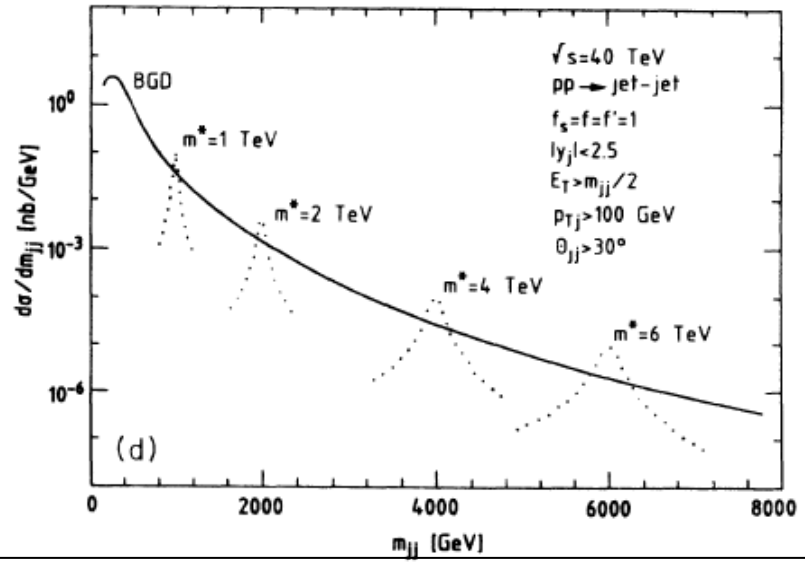
Excited quarks model

- If quarks have internal structure...
- Excited quark decays, producing excess in QCD background

Some possible excited quark decays







Theoretical predictions for excited quarks

Easy to see bumps above background!

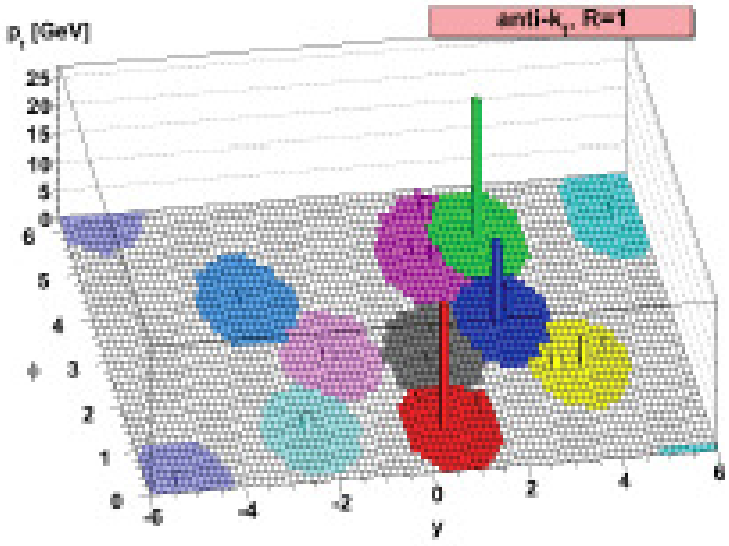
Jet reconstruction

- Jets are reconstructed from calorimeter energy deposits
  - Add 4 momentum P_i of cells to form P of energy deposit
  - Anti-k_t jet finding algorithm, R=0.6

- Jet 4 momenta corrected (calibrated) for effects such as
  - Hadronic shower response
  - Detector material distribution

  using Monte Carlo full detector simulation

- M_{jj} reconstructed from two leading jets



[Cacciari, Salam, Soyez JHEP 0804:063,2008]

Analysis Cuts

Several levels of selection applied to data:

- At least one large E_T deposition
- Primary collision vertex has at least 5 charged particle tracks
- Poorly measured jets vetoed, to reject:
  - Random noise
  - Jet found in bad area of detector
  - Cosmic rays
  - Beam background
- Only keep events with m_{jj} greater than 717 GeV

Analysis Cuts

Further kinematic cuts:

- $|\eta| < 2.8$ for both jets

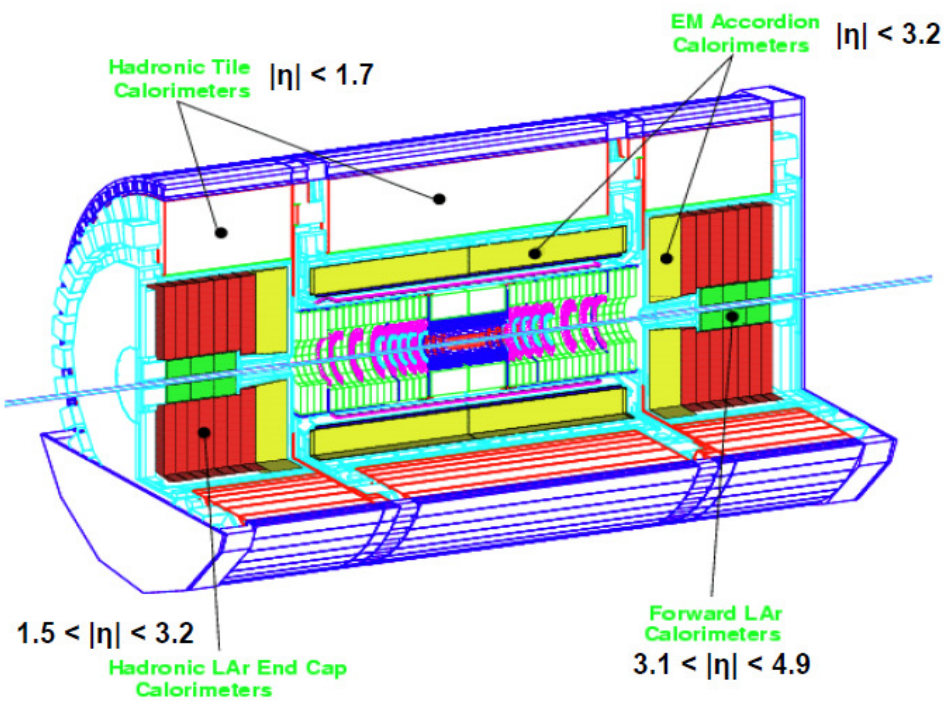
$$\eta = -\ln(\tan(\theta/2))$$

- $|y^*| < 0.6$

$$y = \frac{1}{2}\ln\frac{E + p_T}{E - p_T}$$

$$y^* = \frac{1}{2}\,|\, y_1 - y_2 \,|$$

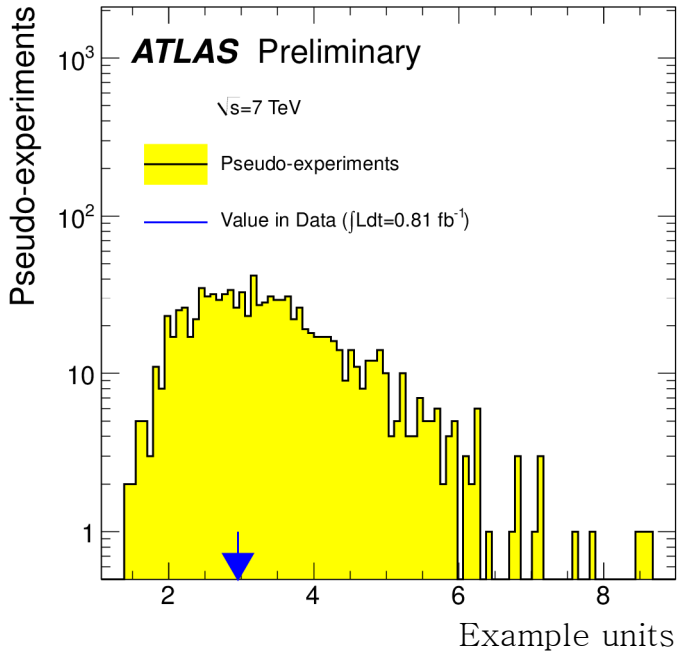
- Favour central collisions
- Optimise analysis sensitivity
- Section of calorimeter between $-0.1 < \eta < 1.5$ and $-0.9 < \Phi < -0.5$ discarded due to read out problems



Explanation of p- and z-value

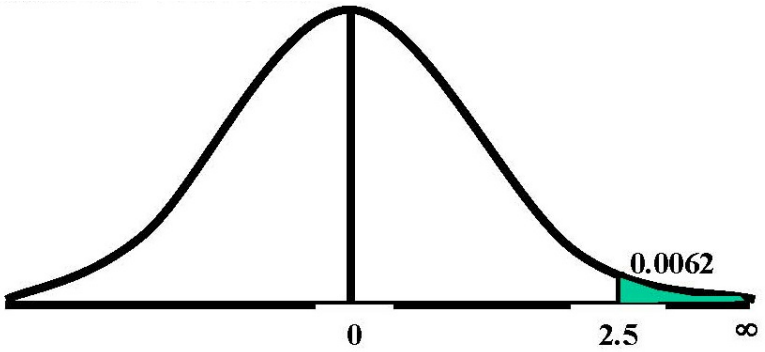
- Observable distribution generated using pseudo experiments, assuming H_0

- Assuming the null hypothesis is true, the p value tells us the probability of getting a result at least as extreme as the one we observe



- p value translated to z value
  - Position needed to give an equivalent area under a gaussian

$$p-value = \int_{z-value}^{\infty} \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} dx$$



Results

- Data compared to background fit

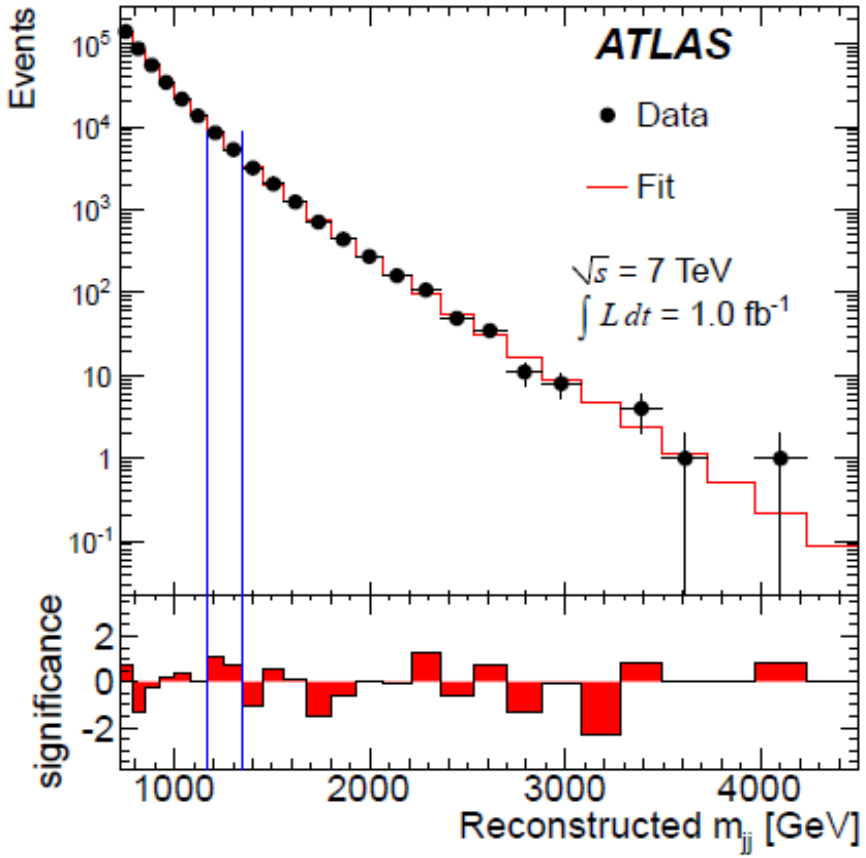
- Expect QCD to be described by a smooth function

- Empirical fit function

$$f(x) = p_1(1-x)^{p_2}\, x^{p_3 + p_4 \ln x}$$

x = $m_{jj}/\sqrt{s}$, p_i fit parameters

- Compare χ^2 for the data and pseudo experiments
→ p-value of 0.96

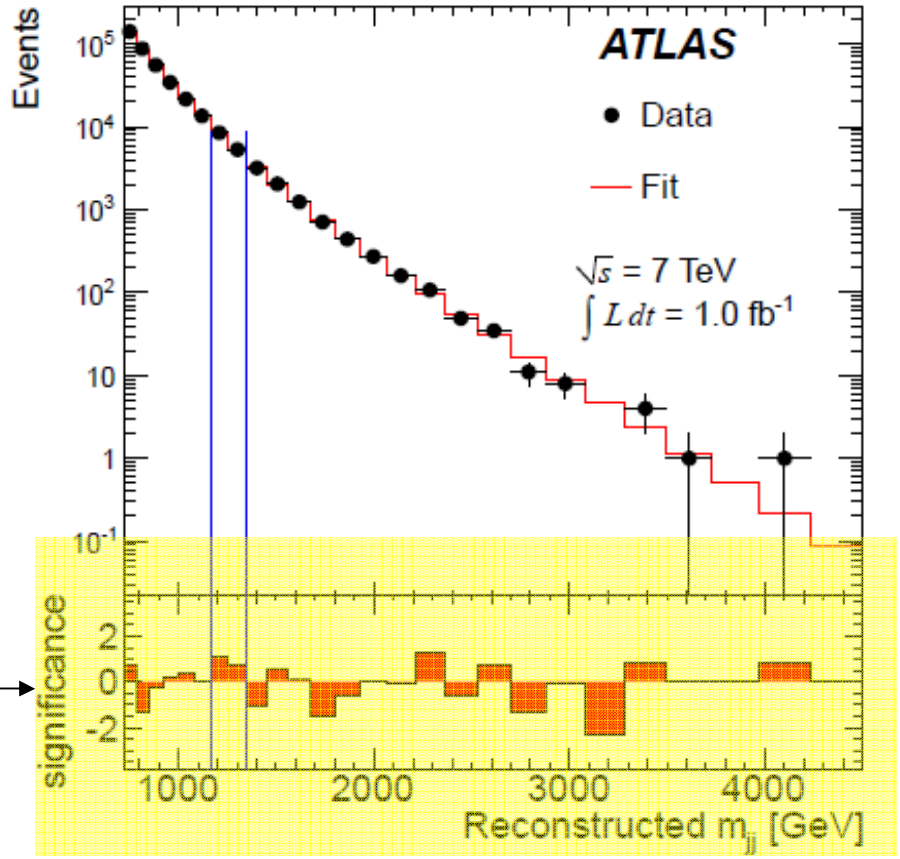


Results

- Significances shown are z values for each bin

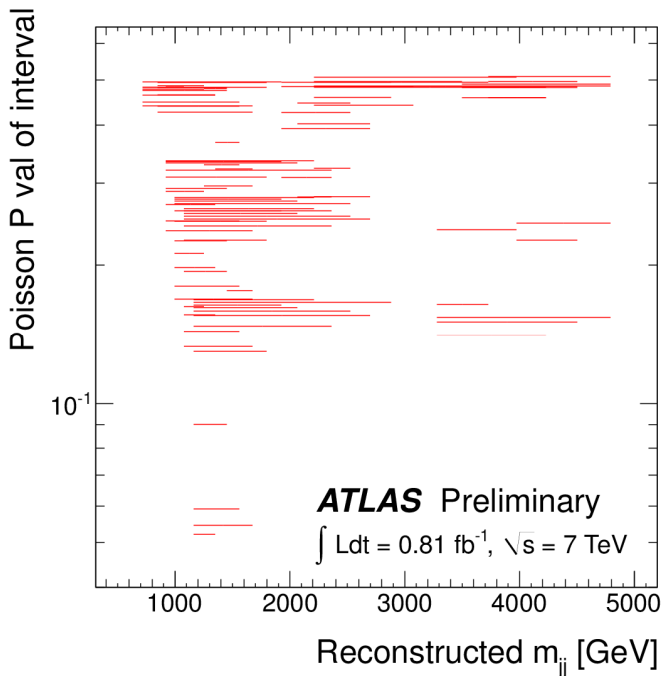
- Excesses of data indicated positive, deficits negative

Full explanation can be found in http://arxiv.org/abs/1111.2062



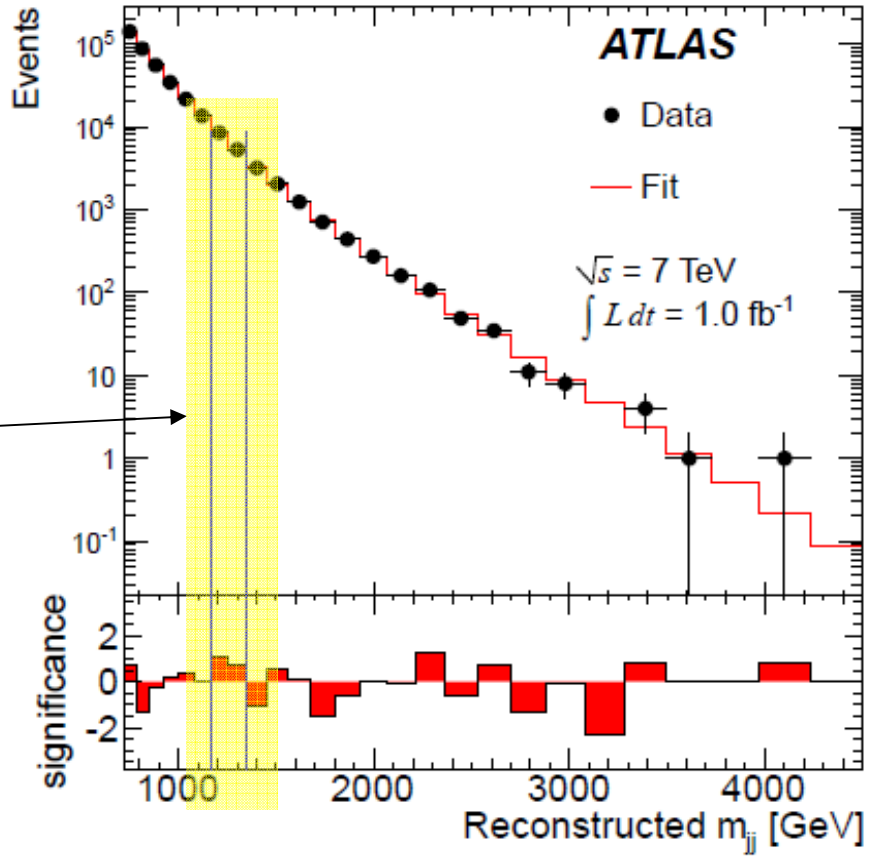
BumpHunter

- Scans spectrum with sliding window of various bin widths
- Sidebands on both sides of the central window
- Likelihood computed in central window and both bands
- Criteria:
  - Central window has an excess over background
  - Both sidebands have better agreement with background than central window
- Algorithm finds most significant bump in any of the binnings



BumpHunter

- q* width from MC simulations used for bin width
- Bin width set to half the width of q* resonance to maximise algorithm performance
- Most significant excess are marked 2 bins
- p-value of this excess is 0.82
  → not significant



Summary

- Dijet events from 2011 recorded, using 1 fb^{-1} of data at 7 TeV
- Several cuts applied to data to produce m_{jj} distribution
- Data fit to empirical curve
- Mass spectra analysed for excesses, using BumpHunter algorithm

NO EVIDENCE FOR NEW PHYSICS FOUND

References

- Original Paper
  Search for New Physics in the Dijet Mass Distribution using 1 fb^{-1} of pp Collision Data at $\sqrt{s}$ = 7 TeV collected by the ATLAS Detector
  http://arxiv.org/abs/1108.6311

- Excited quarks
  Excited-quark and -lepton production at hadron colliders
  http://prd.aps.org/abstract/PRD/v42/i3/p815_1

- Significance
  Plotting the Differences Between Data and Expectation
  http://arxiv.org/abs/1111.2062

- BumpHunter
  On hypothesis testing, trials factor, hypertests and the BumpHunter
  http://arxiv.org/abs/1101.0390