Search for New Phenomena in Dijet Mass and Angular Distributions at ATLAS

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PRISMA

FSP 101 ATLAS

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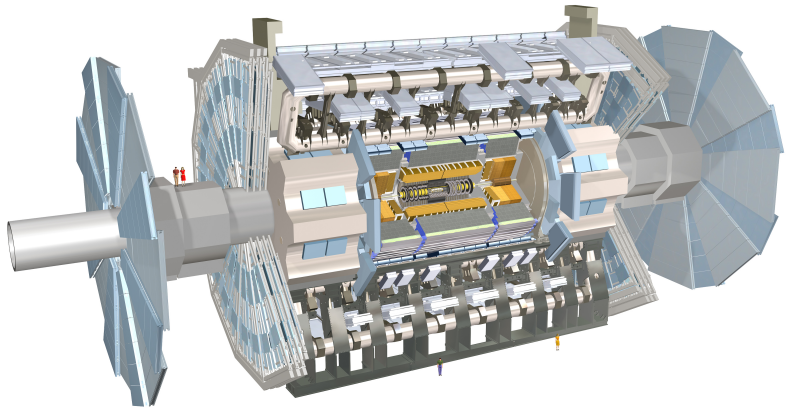
arXiv:1210.1718 (2011 paper submitted to JHEP)
ATLAS-CONF-2012-148 (2012 conference note)

Motivation

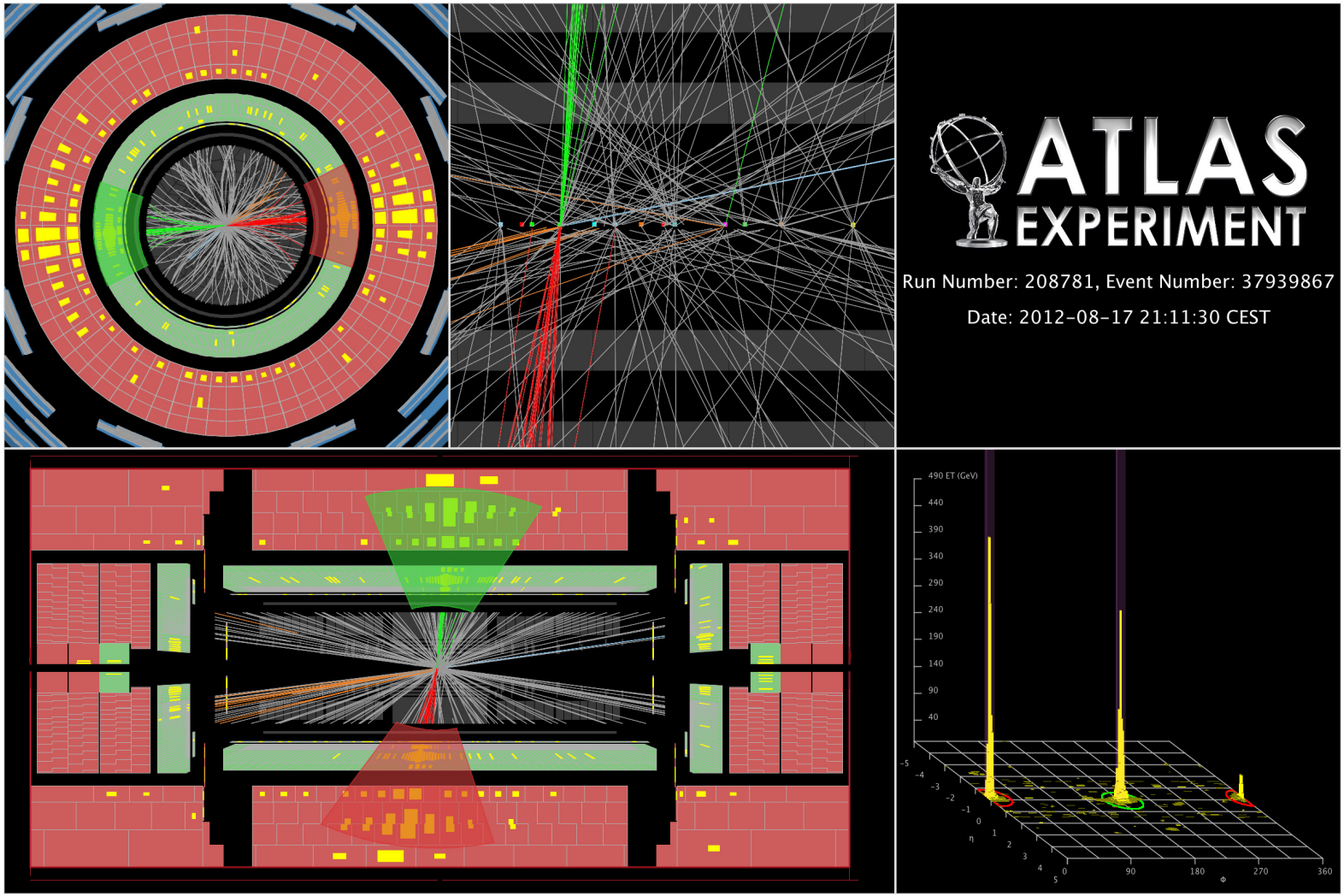
Highest energies at LHC make it possible to look for New Phenomena:

- new particles
  - excited quark q^*
  - heavy gauge boson W'
  - string resonances SR
  - quantum black holes QBH
  - color scalar octet S8
- new interactions
  - Contact interaction



Eventdisplay ($pp \rightarrow jj + x$)

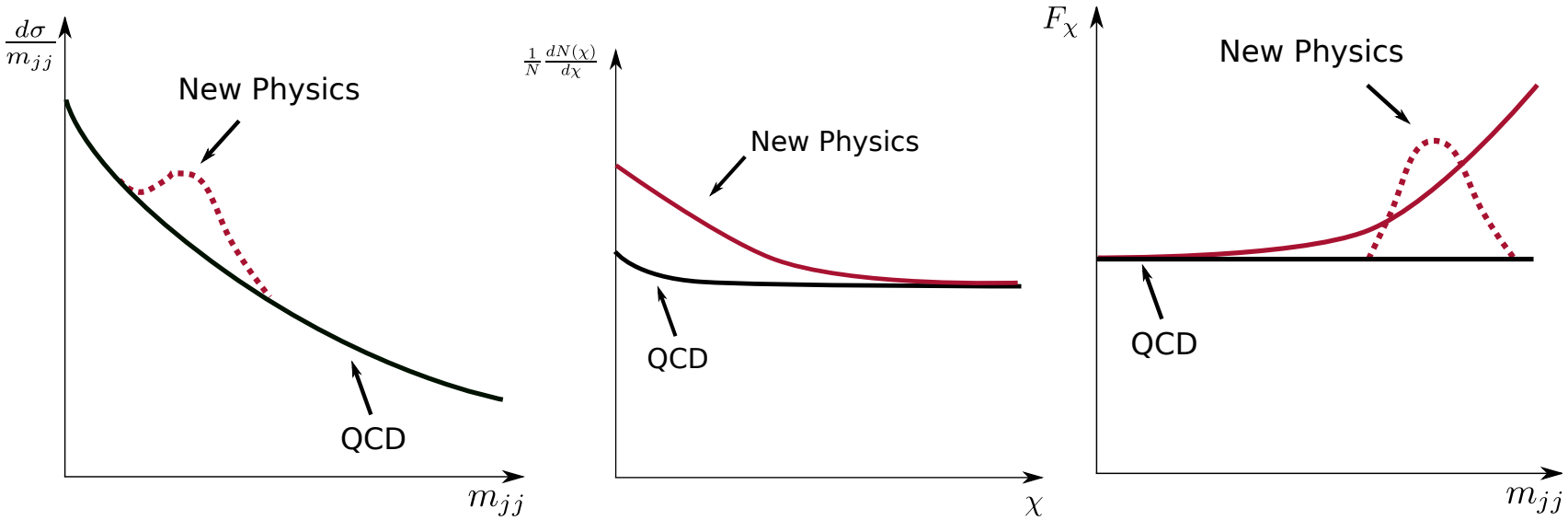
Highest jet p_t event: p_t = 2.34 TeV and 2.10 TeV



Motivation

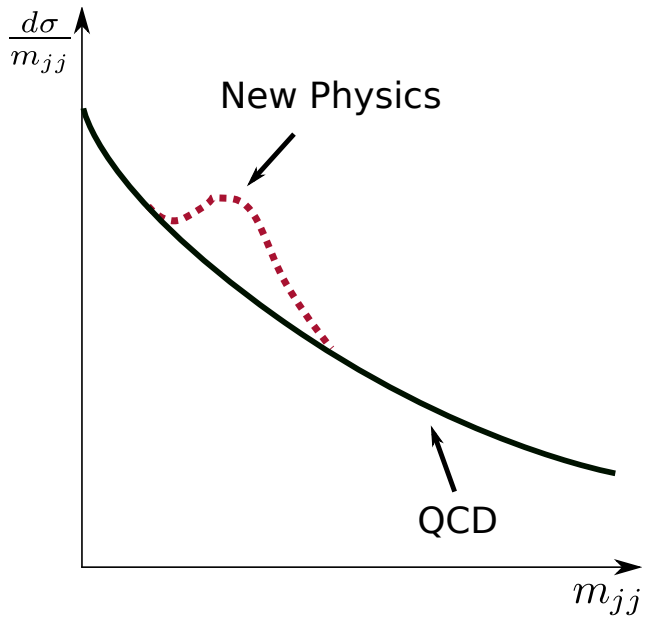
Search for deviations from the SM in 3 spectra:

- Dijet mass (QCD: smoothly falling)
- $\chi = exp(|y_1 - y_2|)$ in bins of m_{jj} (QCD: approx. flat)
- $F_\chi(m_{jj}) = \frac{N(|y^*|<0.6)}{N(|y^*|<1.7)}$ with $y^* = 0.5 \cdot (y_1 - y_2)$ (QCD: flat)



Analysis Strategy Dijet Mass

1. Search for narrow width resonances
   - Event + Jet Selection
   - Fit QCD background from data
   - Search for significant excesses
2. Set limits on New Phenomena
   - Determine systematic uncertainties
   - Calculate limits on mass of hypothetical NP particles
   - Calculate limit on $\sigma \cdot \mathcal{A}$ for Gaussian shaped signal



QCD Background Fit

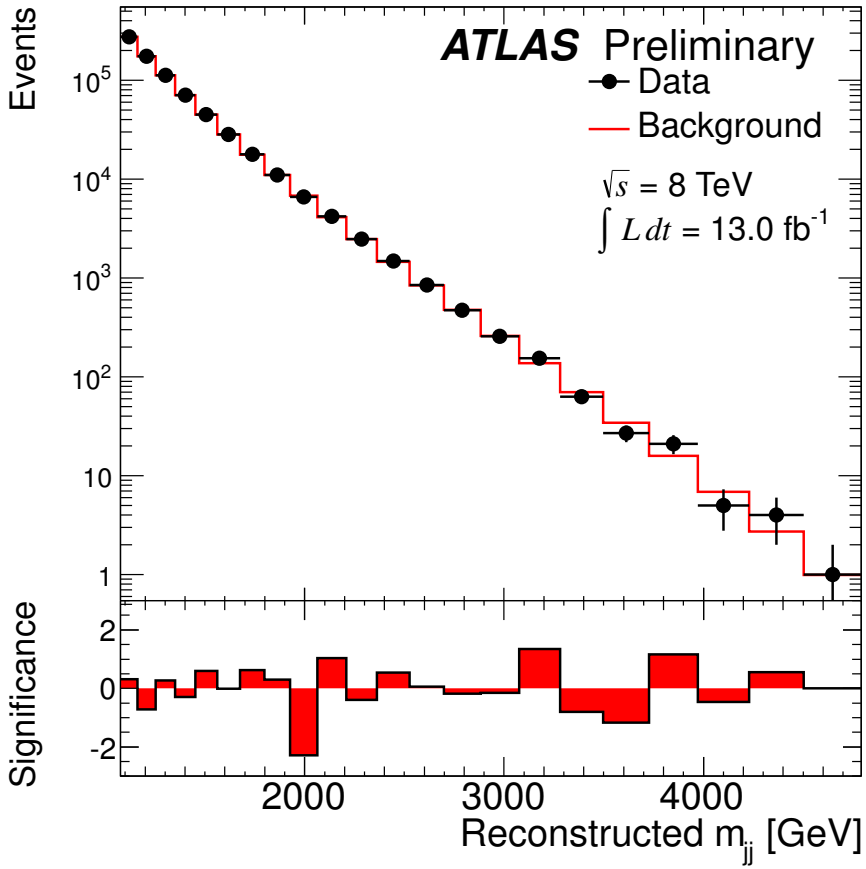
Fit function for QCD background:

$$f(x) = p_1 \cdot (1-x)^{p_2} \cdot x^{p3+p4 \cdot ln(x)}$$

with $x = m_{jj}/\sqrt{s}$

Smoothly falling function

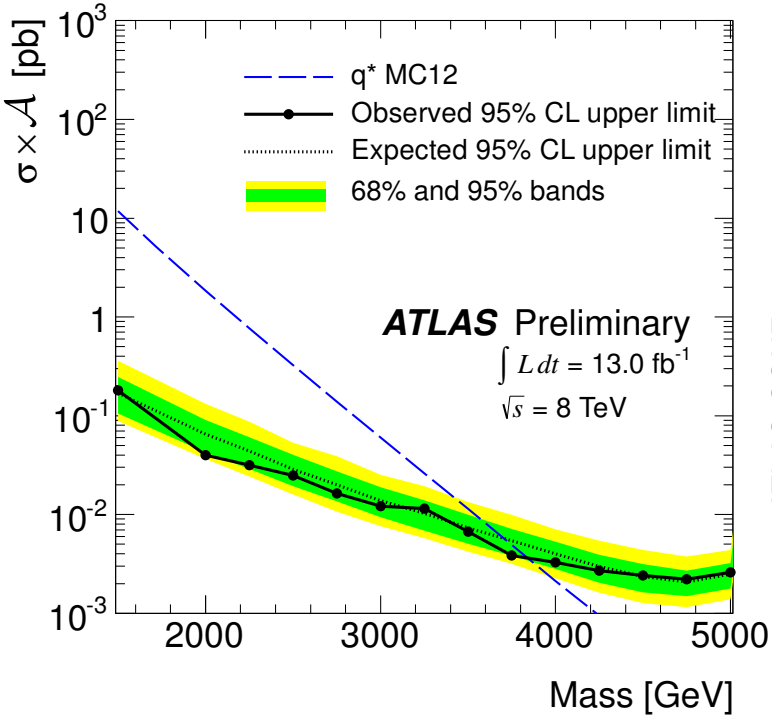
Not flexible enough to hide narrow resonances
p-Value for null hypothesis: 0.98

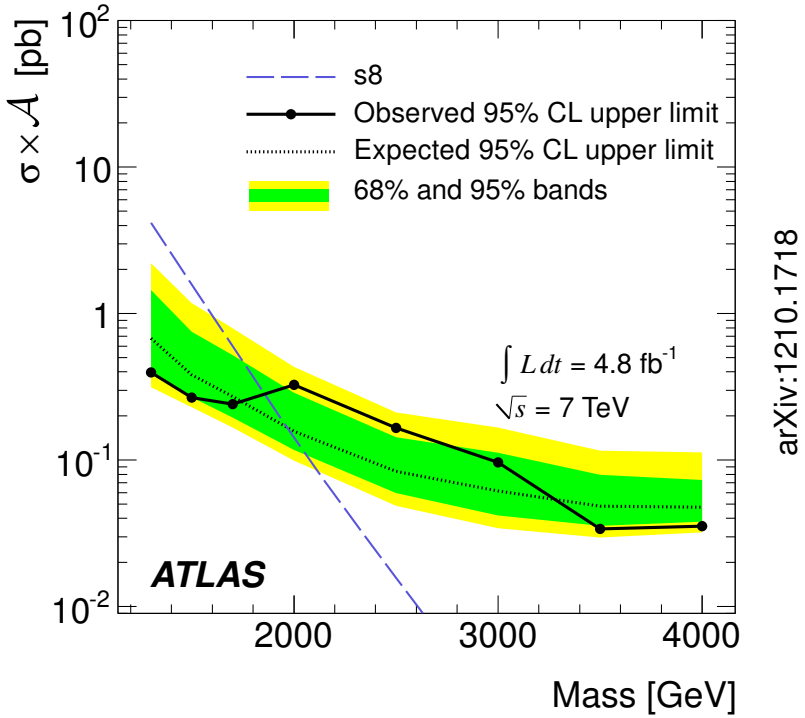


Systematic uncertainties

1. Jet energy scale (JES) uncertainty:
   - Gaussian limits: use conservative value of 4% for shifting peak
   - Bayesian limit setting: use signal templates with jets shifted by 2012 JES (propagated via grid convolution)
2. Jet energy resolution uncertainty:
   - Negligible wrt JES uncertainty
3. Acceptance uncertainty:
   - Uncertainty derived by using changes in acceptance due to JES
4. Luminosity uncertainty:
   - Using preliminary 2012 value of 3.6%
5. Fit uncertainty
   - Derived by fitting to pseudo-data

Limit Setting



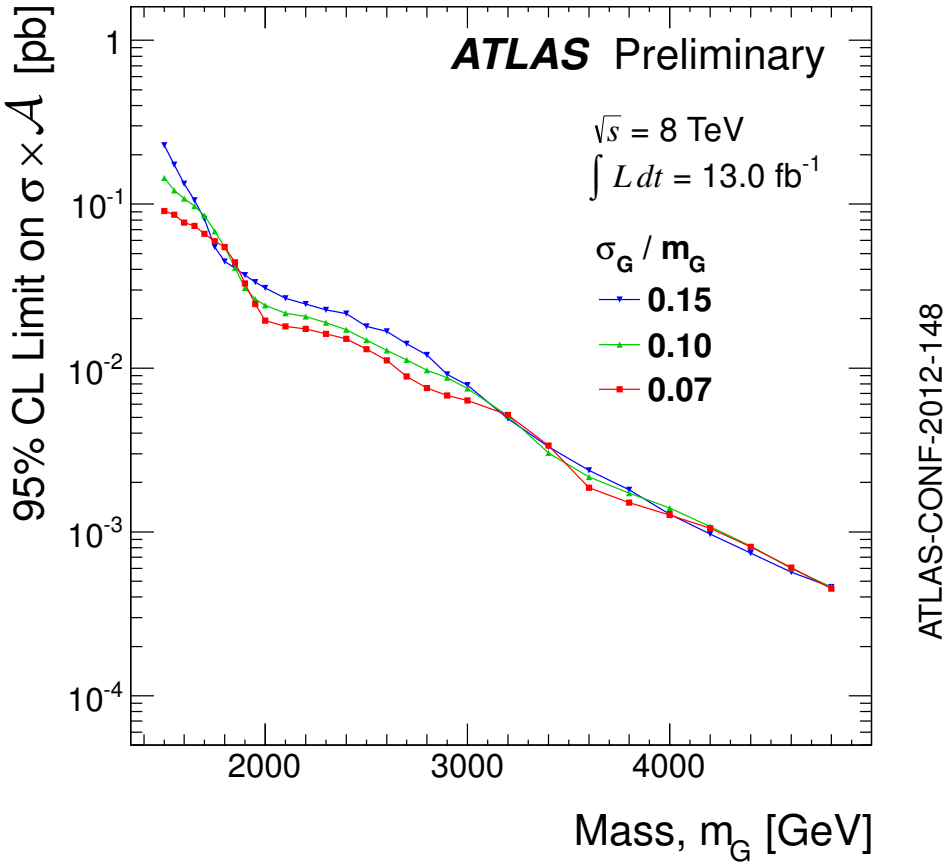


q^*(2012) S8(2011)

Models	q^*(2012)	S8	SR	W'
expected Limit [TeV]	3.70	1.97	3.47	1.74
observed Limit [TeV]	3.84	1.86	3.61	1.68

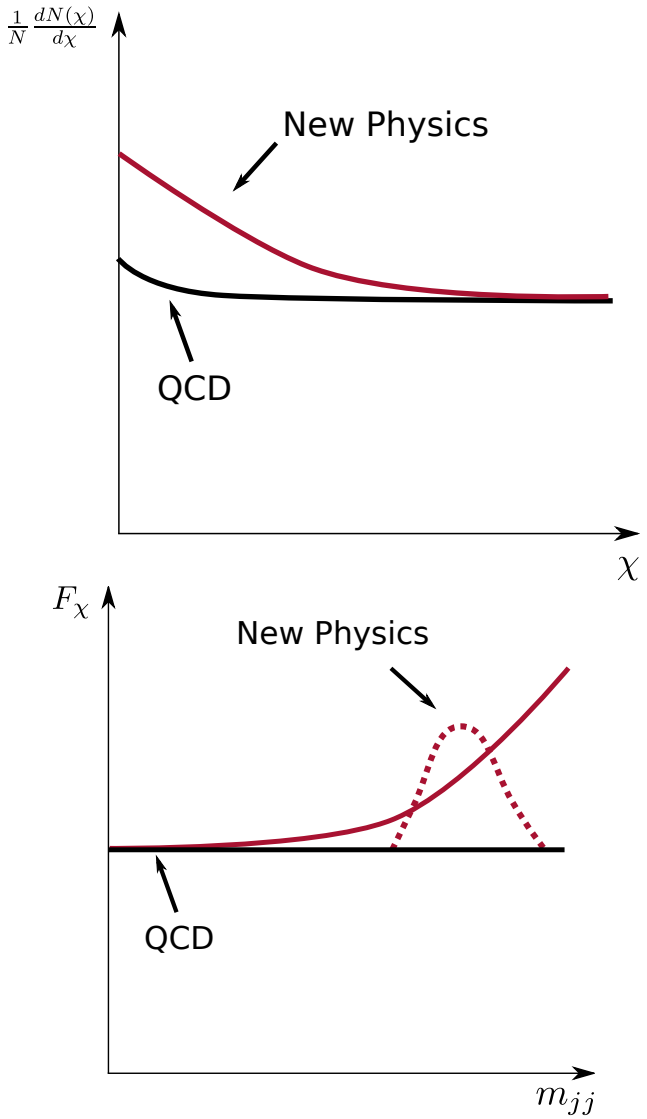
Limit Setting II

Limits for Gaussian shaped signals



Analysis Strategy Angular Distributions

1. Search for deviations from QCD
   - Event + Jet Selection
   - QCD background from LO MC + bin-by-bin k-factors
   - Determine systematic uncertainties
   - Statistical tests of null hypothesis
2. Set limits on New Phenomena
   - Determine systematic uncertainties
   - Calculate limits on contact interactions and QBH (χ)
   - Calculate limits on q^*, contact interactions and QBH ($F_\chi(m_{jj})$)



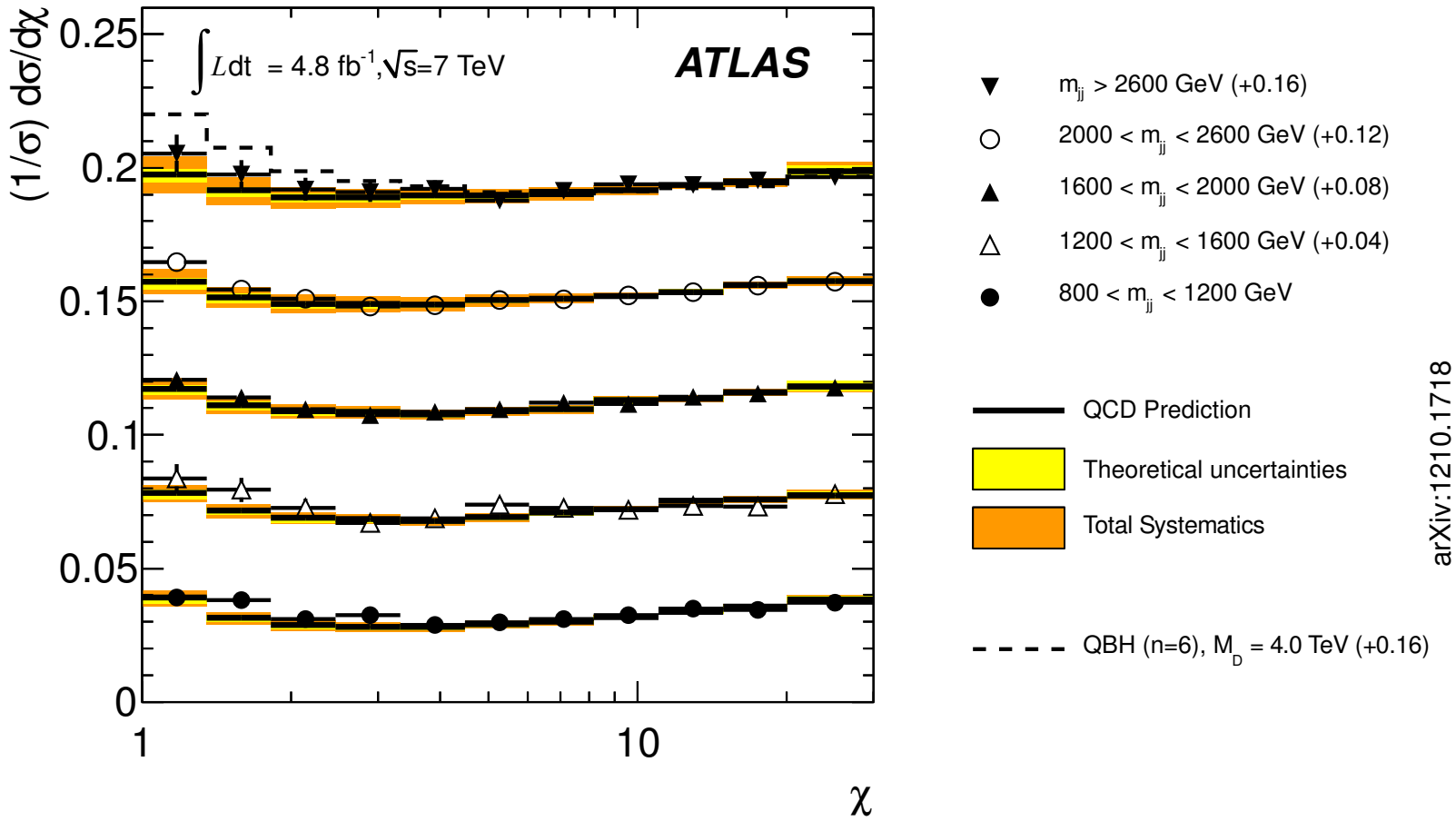
Systematic uncertainties

Search phase + Limit setting:

1. JES uncertainty: 5% - 15%
   - 14 nuisance parameters
2. Renormalisation/Factorisation scale: $\approx 8\,\%$
   - QCD scales varied independently by a factor of two
3. PDFs: $\approx 1\,\%$
   - Using CT10 NLO PDF error sets

Search Phase I

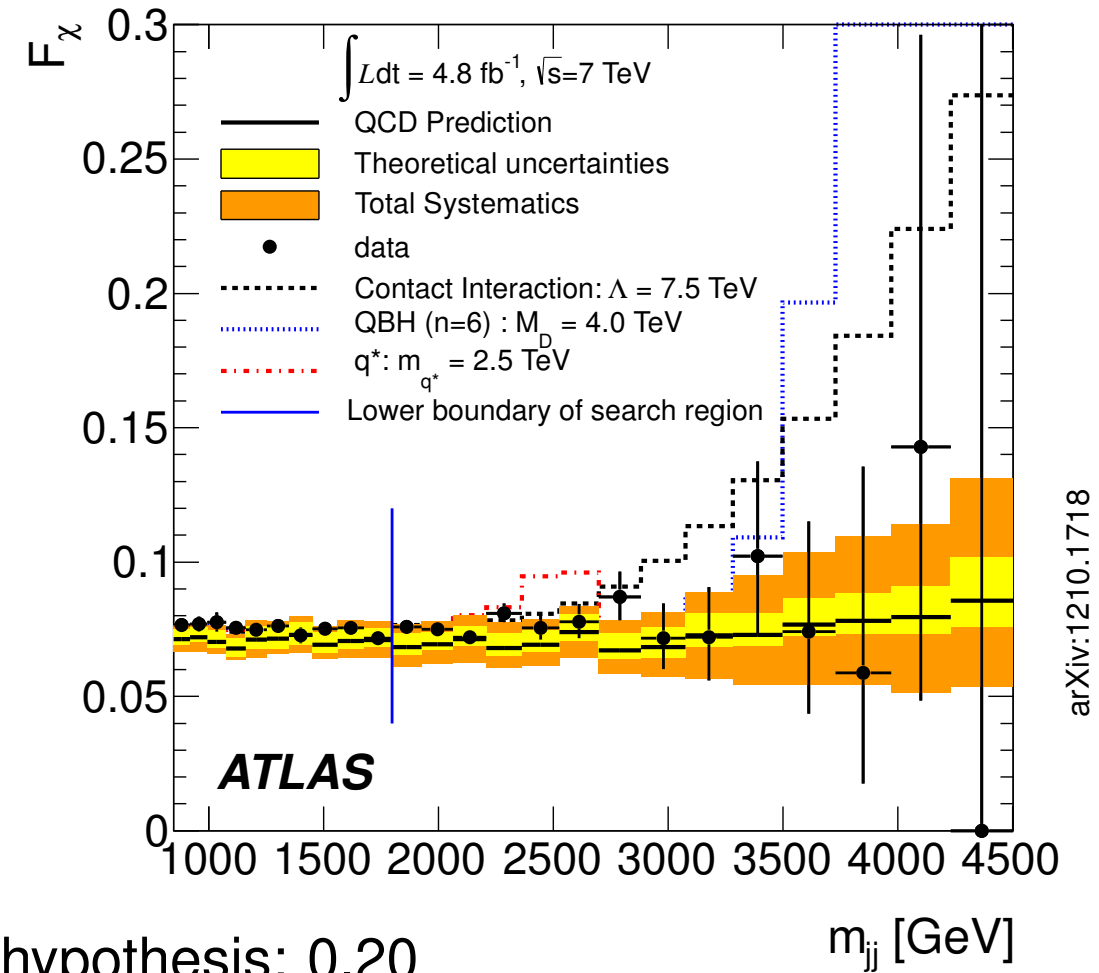
χ spectrum with QBH superimposed



p-Value for null hypothesis: 0.17 - 0.38

Search Phase II

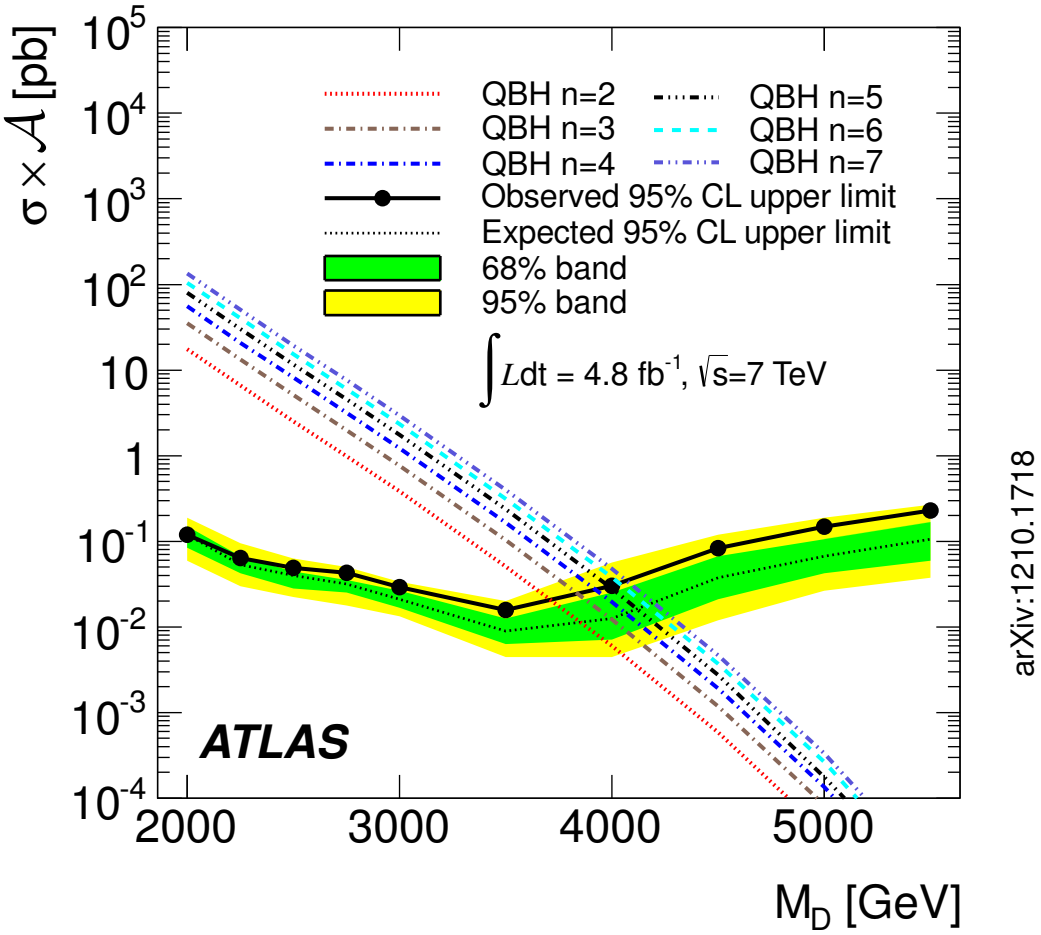
$F_\chi(m_{jj})$ spectrum with signals superimposed



p-Value for null hypothesis: 0.20

Limit Setting

Limits for QBH from F_χ



For n=6 Expected limit: 4.16 TeV Observed limit: 4.03 TeV

Summary

Search for New Physics with dijets produced in pp collisions at $\sqrt{s}$= 7/8 TeV using $\int \mathcal{L} dt = 4.8/13.0\,\text{fb}^{-1}$ in three spectra:

- Dijet mass
- Two angular distributions

With data from 2011 and 2012 no new physics was found.
Previous limits on New Phenomena have been improved.

Thanks for your attention!

Model overview

- Excited quark
  - Same couplings as quark
- Heavy gauge boson W'
  - V-A SM couplings
  - No interference with W considered
- String resonances
  - Fundamental string mass scale $\mathcal{O}(1\,\text{TeV})$
  - Open strings ending on D-branes
- Quantum black holes
  - Produced by black hole generator Blackmax
  - Different values for the reduced Planck scale M_d
- Color scalar octet
  - Example for exotic coloured resonance decaying to gluons
  - Predicted by different models: GUT, SUSY, Leptoquark, ...
- Contact interactions
  - Models quark compositness
  - Only destructive interference taken into account