Dijet Searches in ATLAS

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(U.Chicago)
on behalf of the **ATLAS** Collaboration

Nov. 3, 2010
GDR Terascale @ Brussels

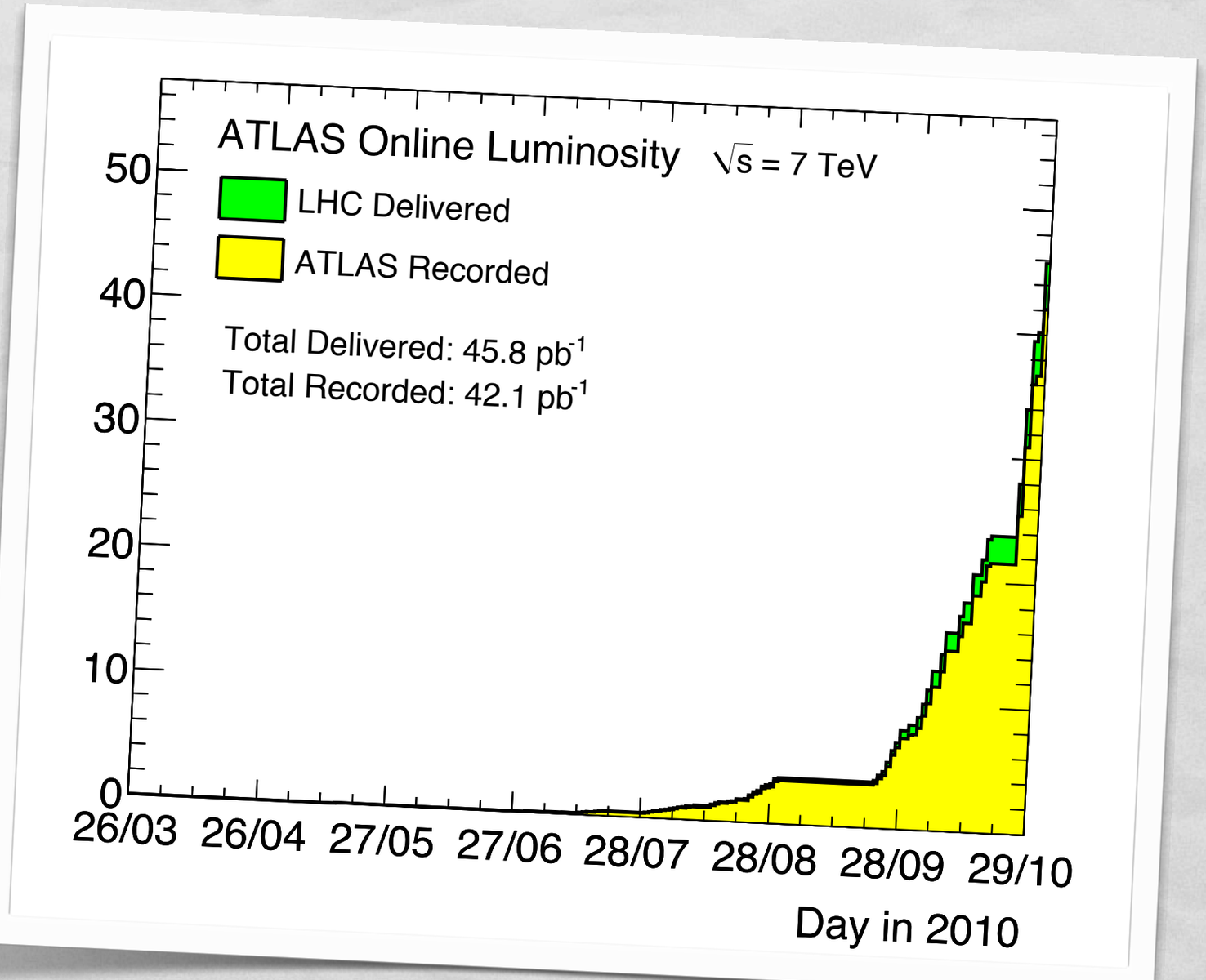
Overview

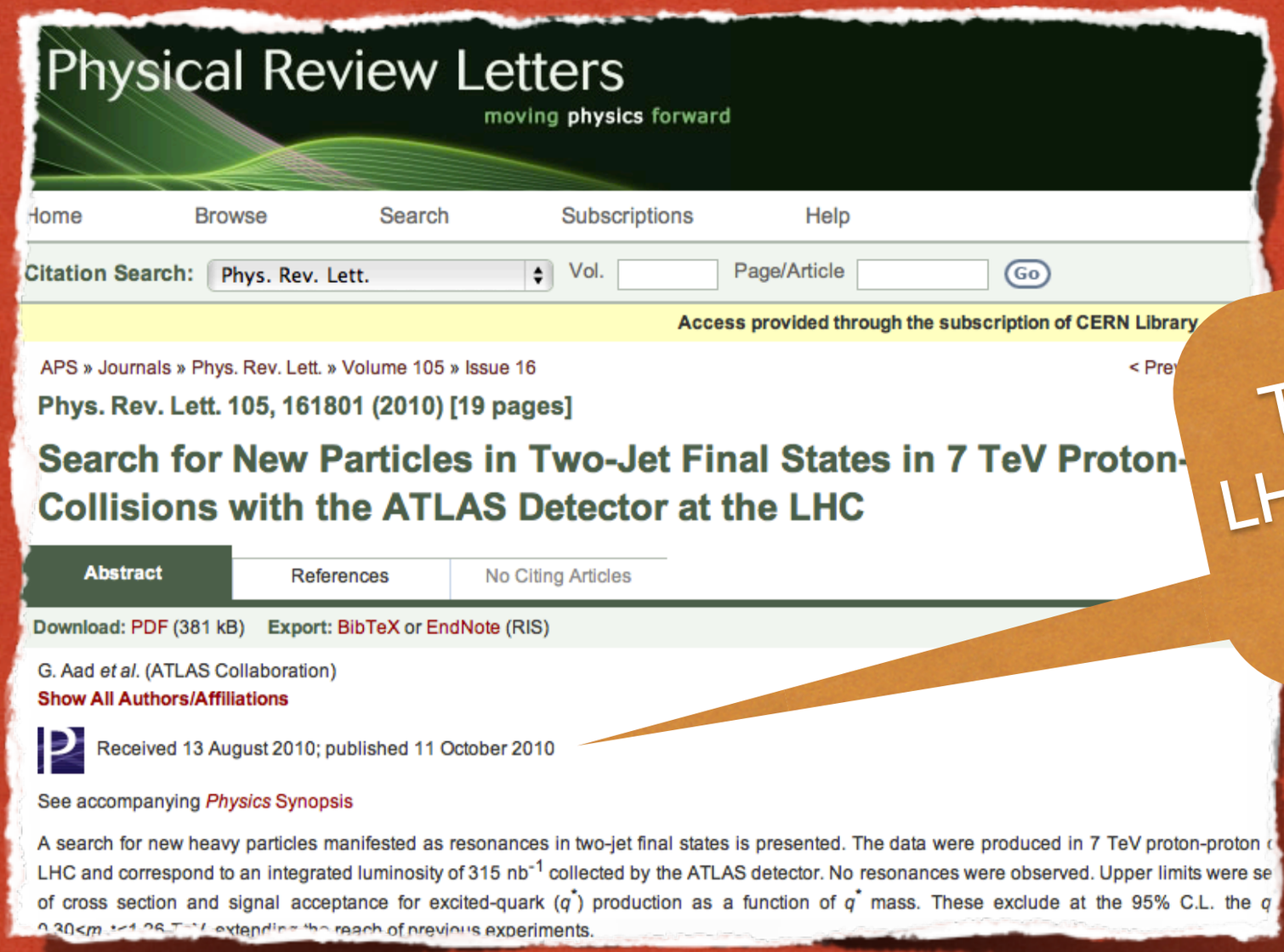
- Dijet resonance search
- Dijet search for contact interactions

The LHC

Rough schedule:

- pp collisions over.
- About 1 month of lead (Pb) collisions.
- Xmas break.
- Upgrade for a couple of months (?)
- More collisions to the end of 2011 (details uncertain).

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Phys. Rev. Lett. 105, 161801 (2010) [19 pages]
Search for New Particles in Two-Jet Final States in 7 TeV Proton-
Collisions with the ATLAS Detector at the LHC
Abstract References No Citing Articles
Download: PDF (381 kB) Export: BibTeX or EndNote (RIS)
G. Aad et al. (ATLAS Collaboration)
Show All Authors/Affiliations
Received 13 August 2010; published 11 October 2010
See accompanying Physics Synopsis
A search for new heavy particles manifested as resonances in two-jet final states is presented. The data were produced in 7 TeV proton-proton
LHC and correspond to an integrated luminosity of 315 nb^{-1} collected by the ATLAS detector. No resonances were observed. Upper limits were se
of cross section and signal acceptance for excited-quark (q^*) production as a function of q^* mass. These exclude at the 95% C.L. the q
$0.30<m_{q^*}<1.26$ TeV, extending the reach of previous experiments.

The first LHC exotics result

The dijet resonance search

Related articles from LHC

Collaboration	Reference	Integrated Luminosity
ATLAS	Phys. Rev. Lett. 105, 161801 (2010)	0.31 pb^{-1}
CMS	CMS-PAS-EXO-10-010	0.84 pb^{-1}
ATLAS	ATLAS-CONF-2010-093	3.1 pb^{-1}
CMS	arXiv:1010.0203v1 [hep-ex]	2.9 pb^{-1}

Overview of dijet resonance search

- Select inclusive dijet events, and plot dijet mass distribution:

$$m^{jj} = \sqrt{(E_{j1} + E_{j2})^2 - (\vec{p}_{j1} + \vec{p}_{j2})^2}$$

- The background is obtained by fitting a smooth function[☆]:

$$f(m) = p_1 \frac{(1 - \frac{m}{\sqrt{s}})^{p_2}}{\frac{m}{\sqrt{s}}(p_3 + p_4 \cdot \ln \frac{m}{\sqrt{s}})}$$

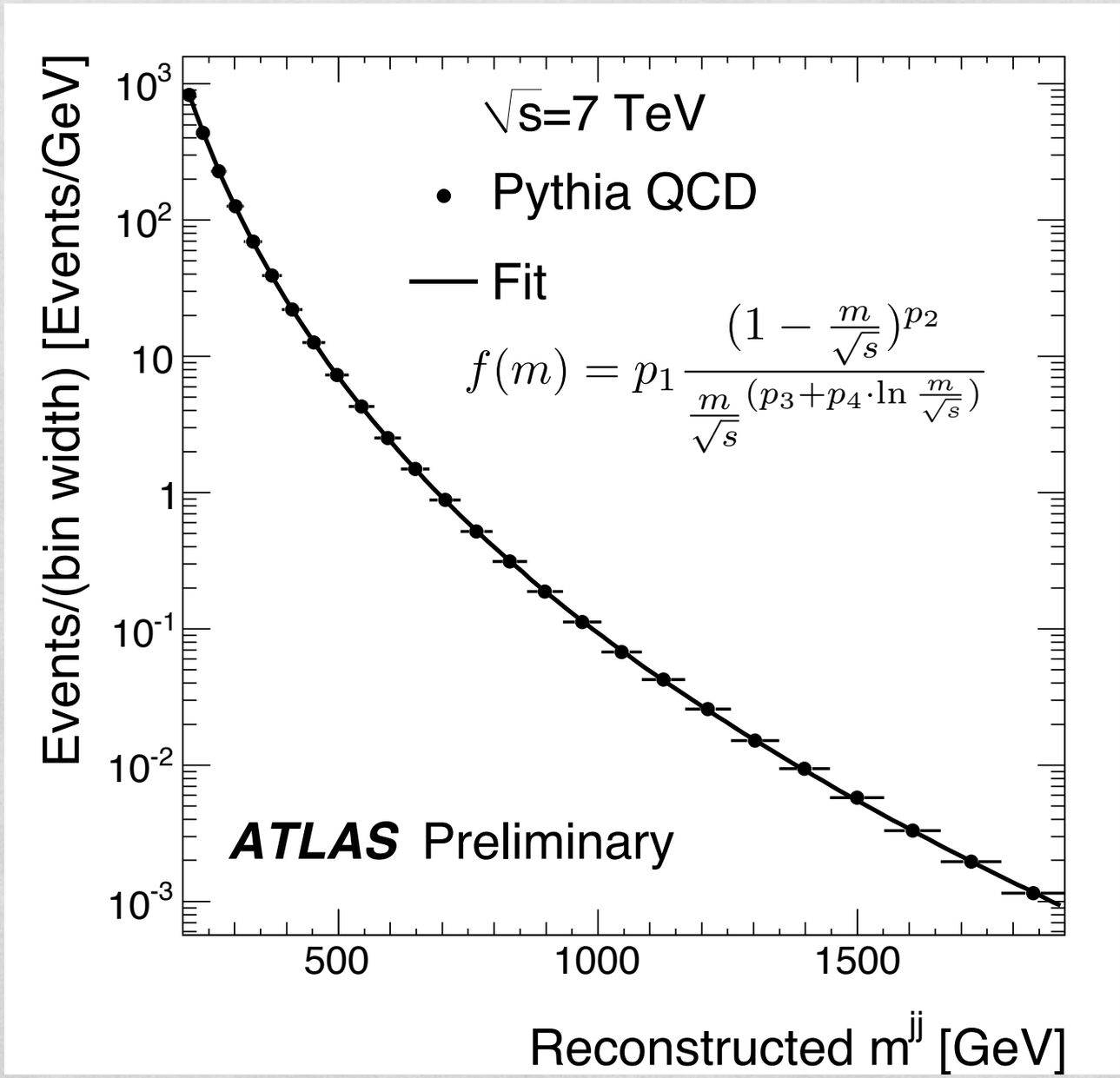
- Search for discrepancies between data and background.

- If no discrepancy found, set limits on benchmark model: q*

[☆]CDF, Phys.Rev.D79:112002,2009

Fit justification using Monte Carlo

- Excellent ability to fit SM QCD at $\sqrt{s}$ = 7 TeV.
- Same for PYTHIA, ALPGEN, NLOJET++, hadron-level, reco-level...
- Same for $\sqrt{s}$ =1.96 TeV, shown by CDF.
- By construction smooth, monotonic in the range used, and goes to 0 at m=$\sqrt{s}$.
- So, if it can't fit the data, something is going on.



Event Selection

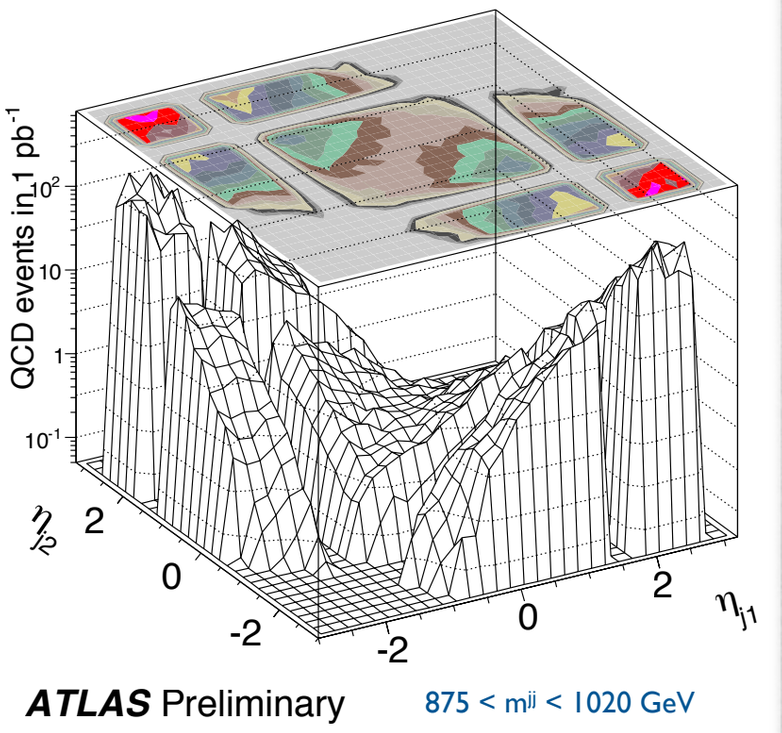
✓ Data quality

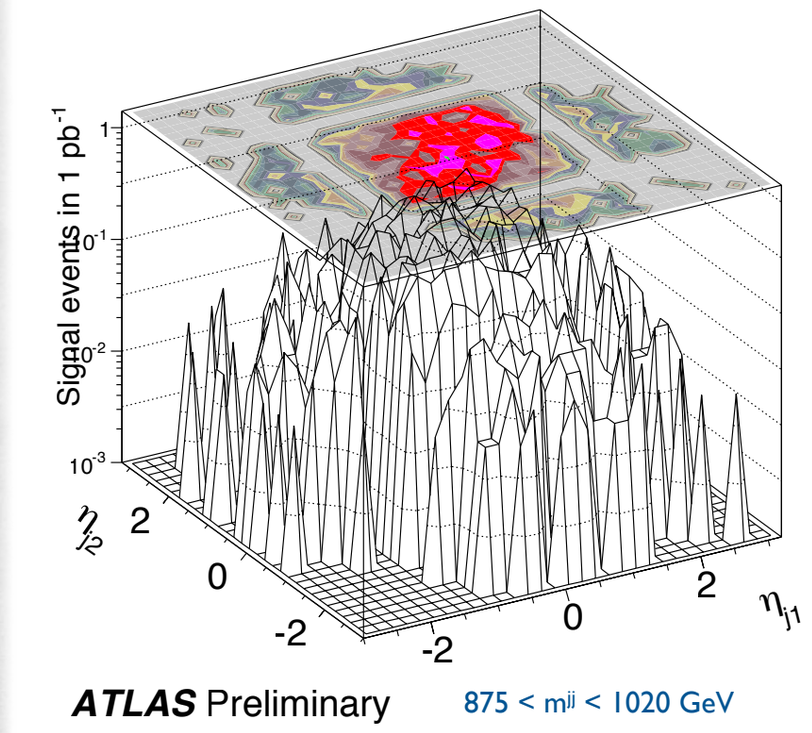
✓ p_T^{j1} > 80(150) GeV → trigger eff.
p_T^{j2} > 30 GeV → reconstruction eff.

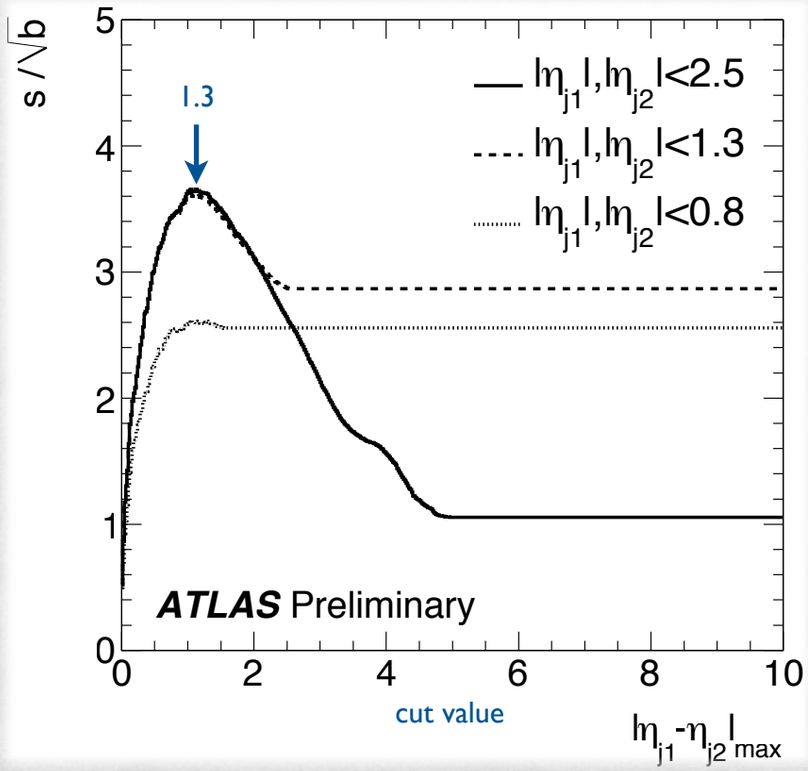
✓ m^{jj} > 200(350) GeV → no kin/tic bias

✓ Veto 0.1% of events, where there is a poorly measured jet of p_T>15 GeV
→ no p_T-ordering doubts

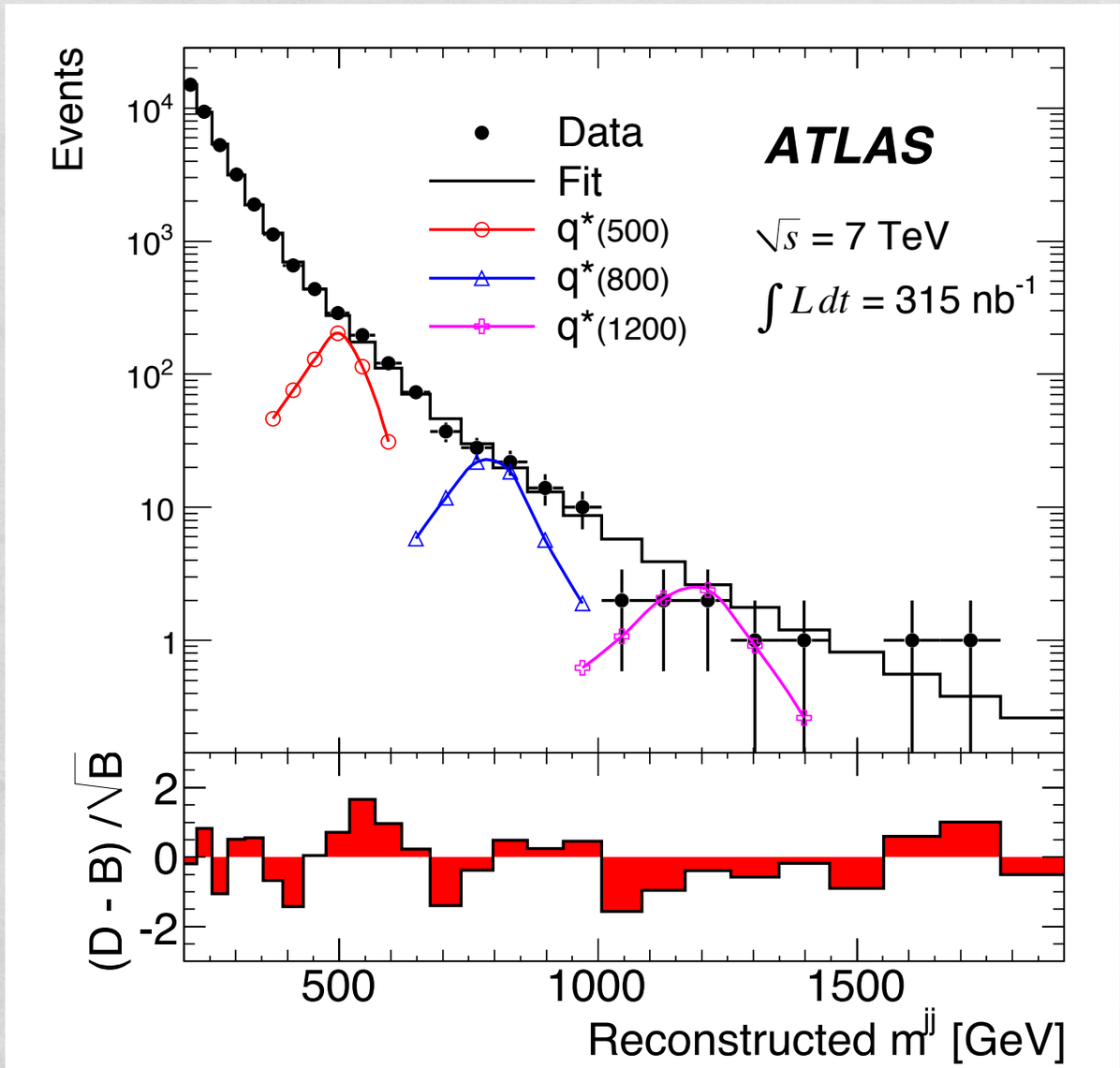
✓ $|\eta|$<2.5 and **$|\Delta\eta|$<1.3**



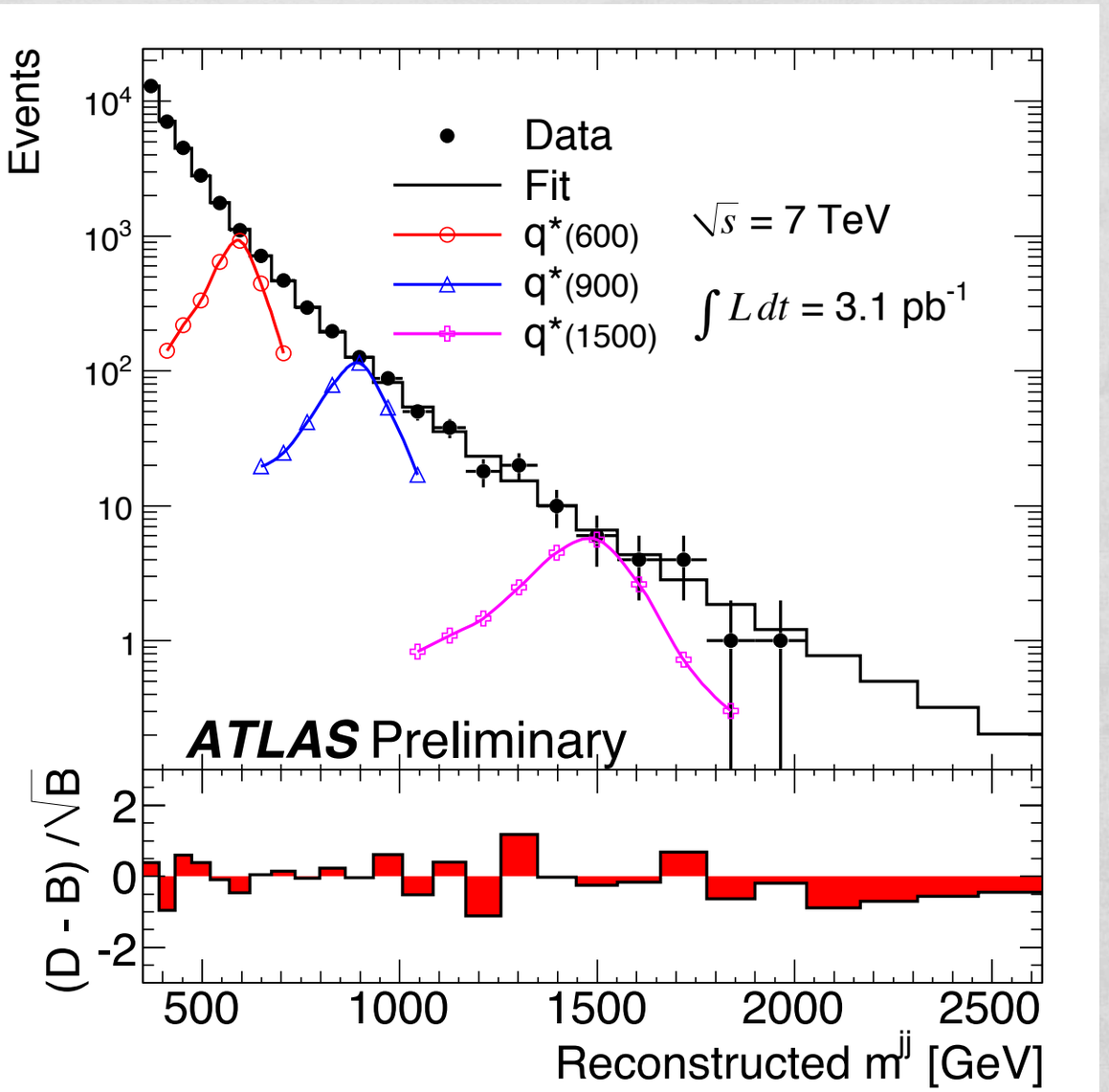




Data and background



0.31 pb^{-1}



3.1 pb^{-1}

Agreement

- Array of statistical tests, from traditional KS and χ^2 test, to more advanced ones, looking for resonances, tails, and overall shape discrepancy.

- All 6 tests indicated that the data are consistent with the background-only hypothesis.
  - In 0.31 pb^{-1}, all p-values were between 0.45 and 0.80.
    → *Perfectly consistent.*
  - In 3.1 pb-1, the data were so well-fitted that the p-values were about 99%.
    → Multiple tests confirm this is just a coincidence.

Nothing Found

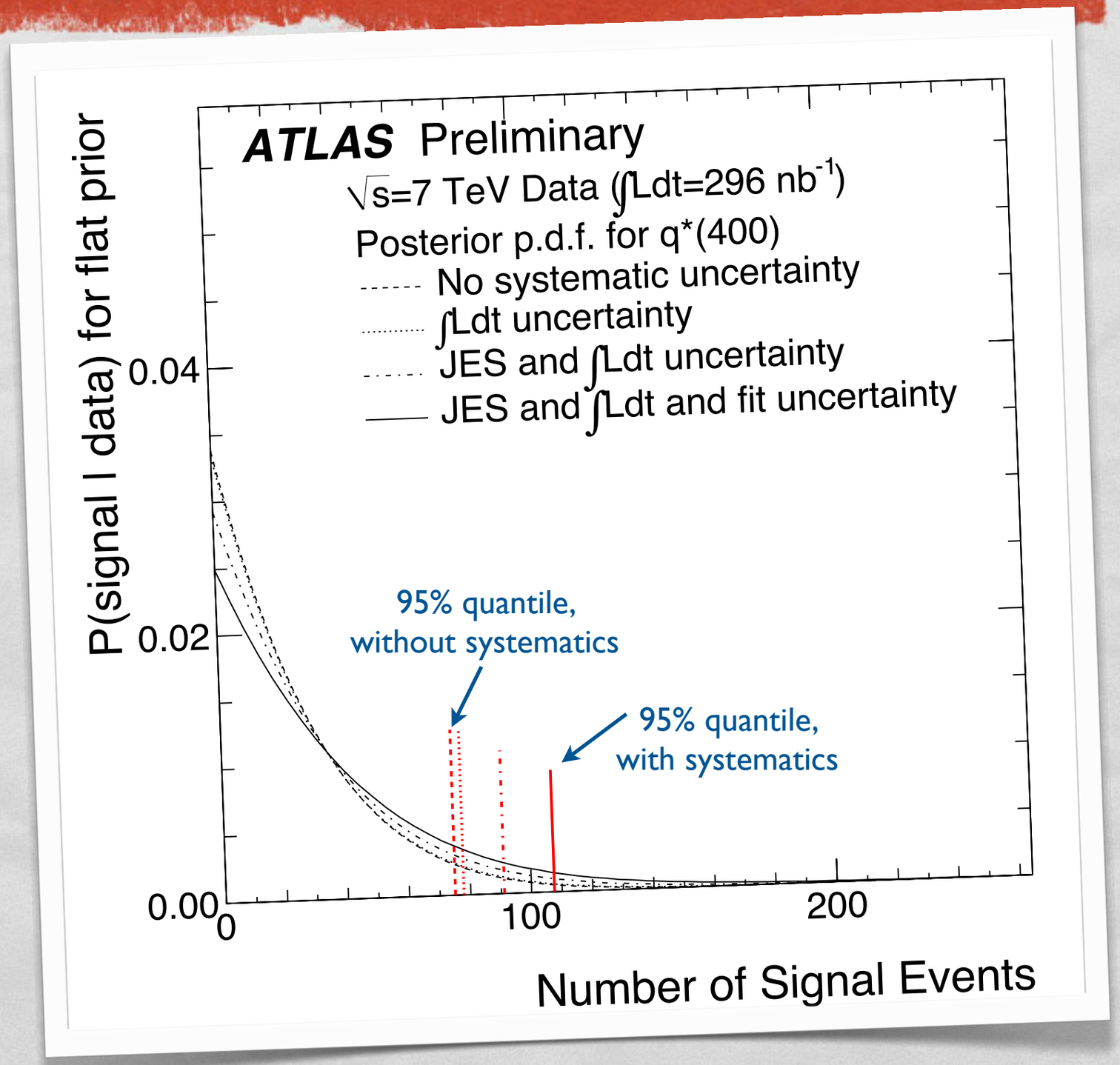
Back to setting limits...

Limit setting

Bayes's theorem

$$P(S|\bar{D}) = P(\bar{D}|S)\frac{P(S)}{P(\bar{D})}$$

const.

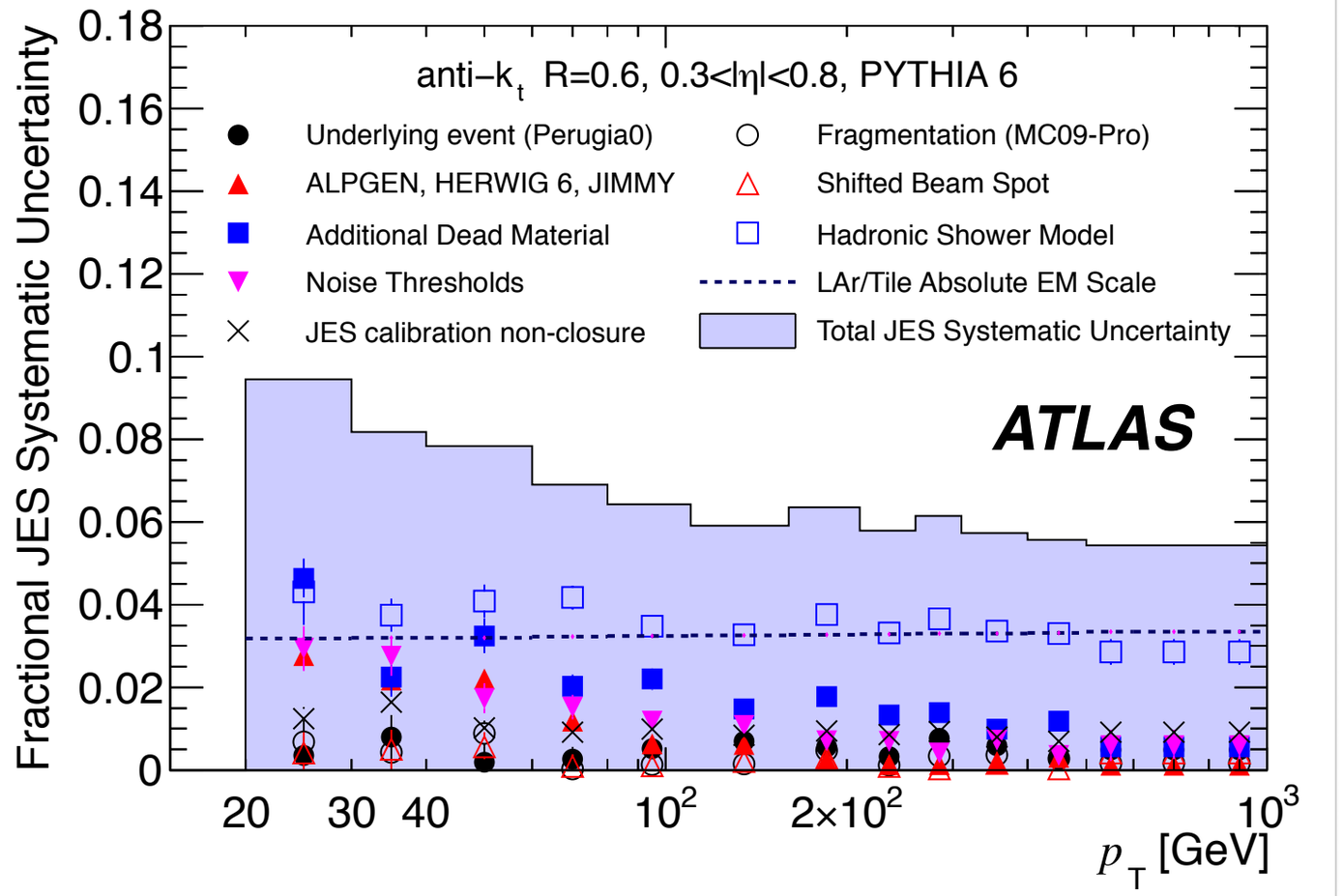


Systematic uncertainties

- Jet energy scale
- Jet energy resolution

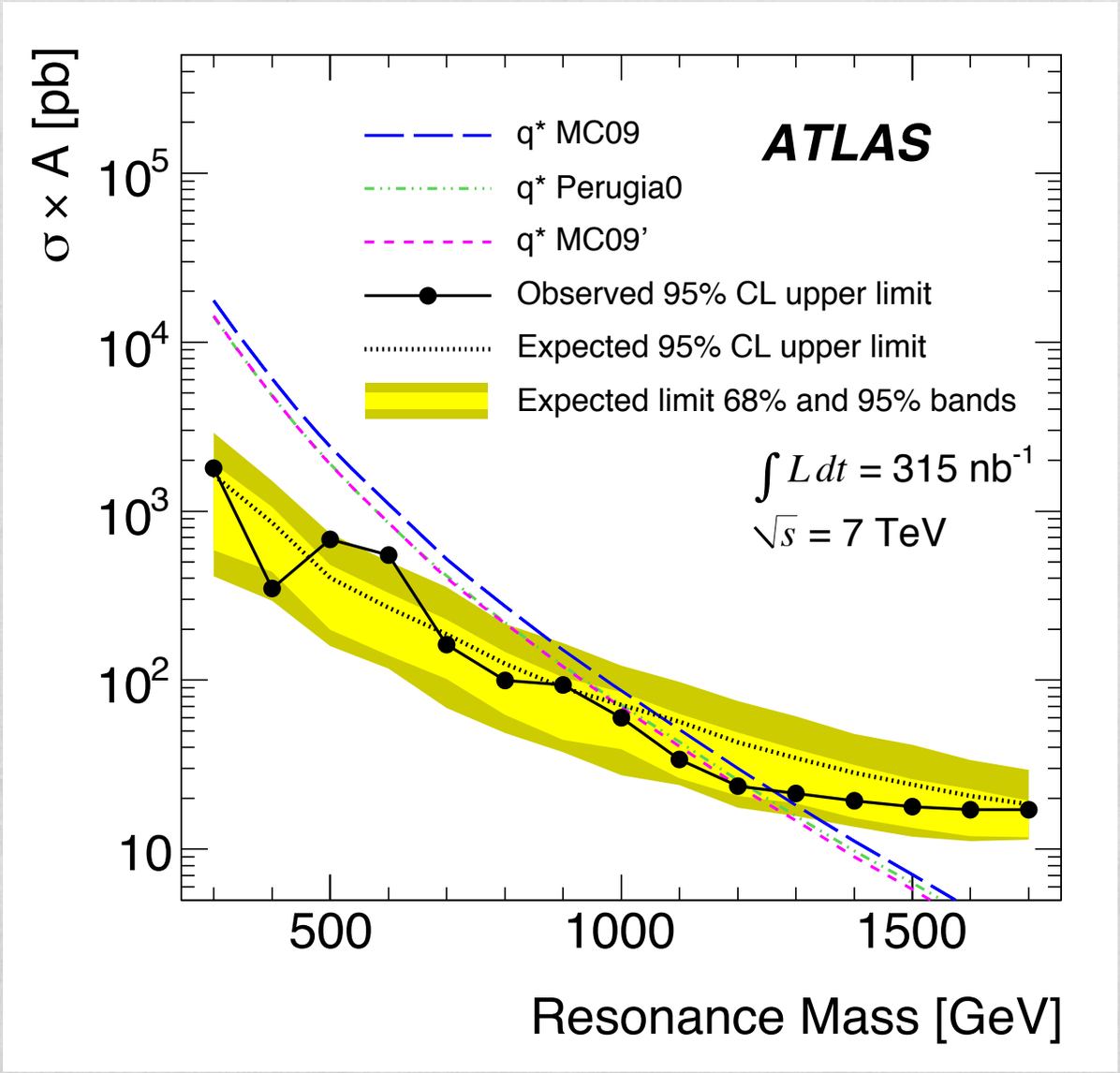
negligible

- Luminosity (11%)
- Fit parameters (3 to 30%, increasing with m^{jj})



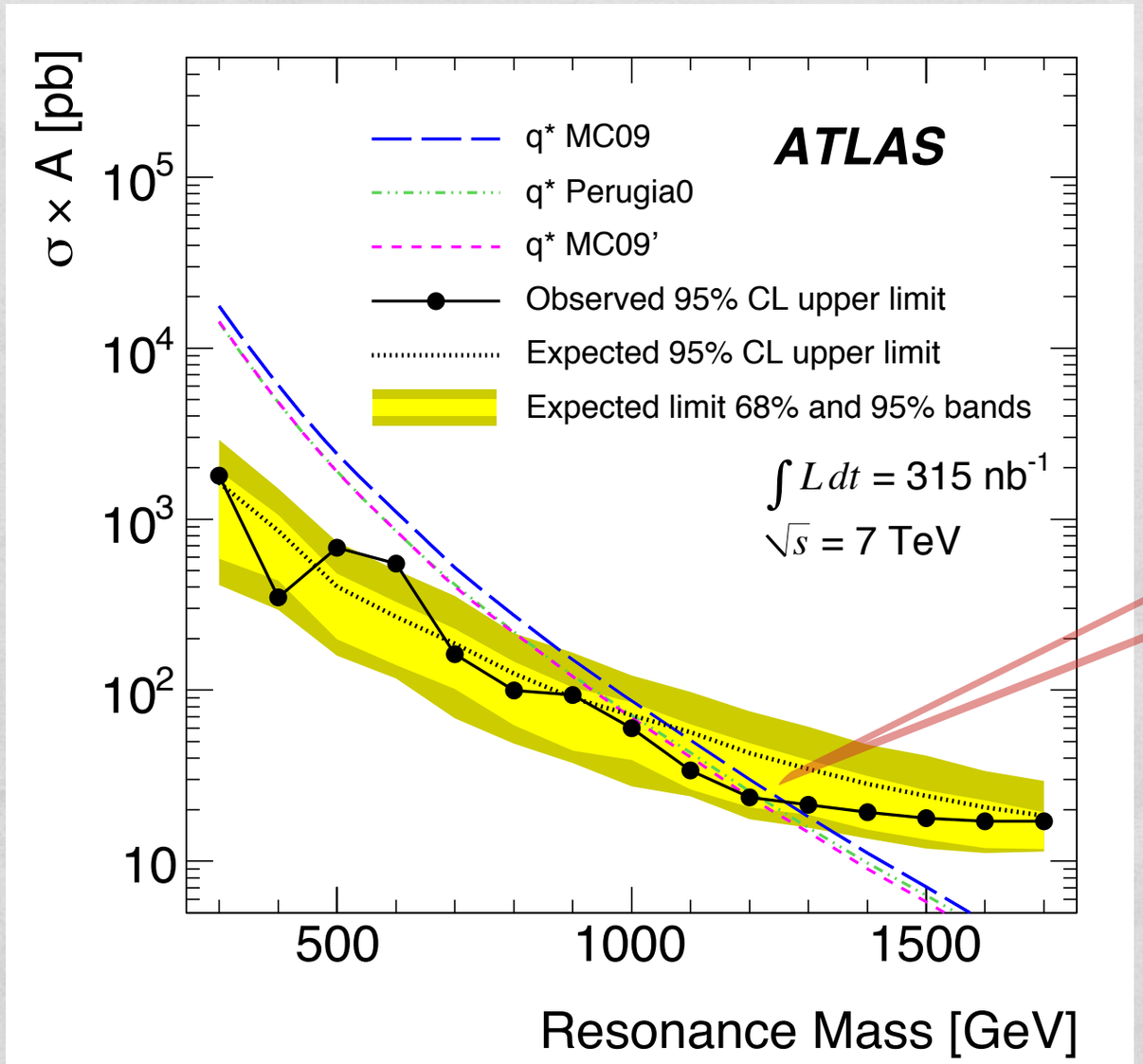
arXiv:1009.5908v2 [hep-ex]

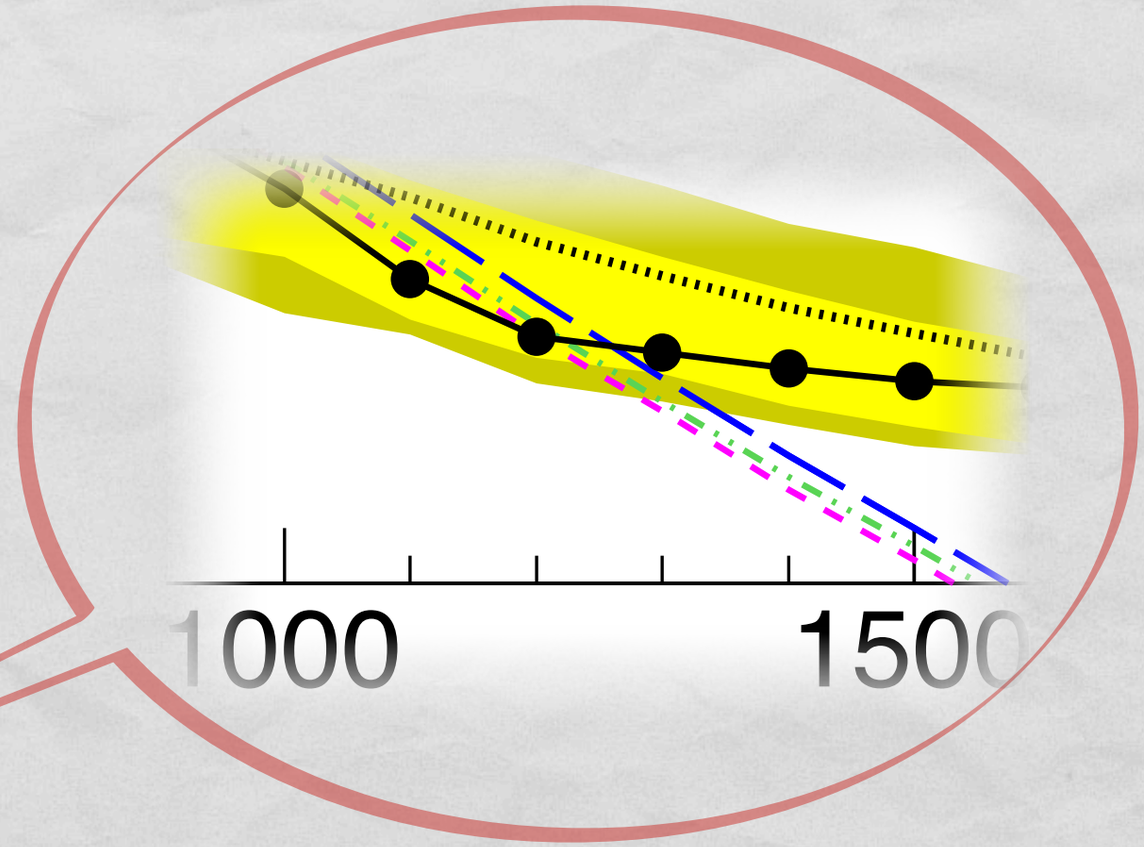
Limits on excited quark



0.31 pb^{-1}

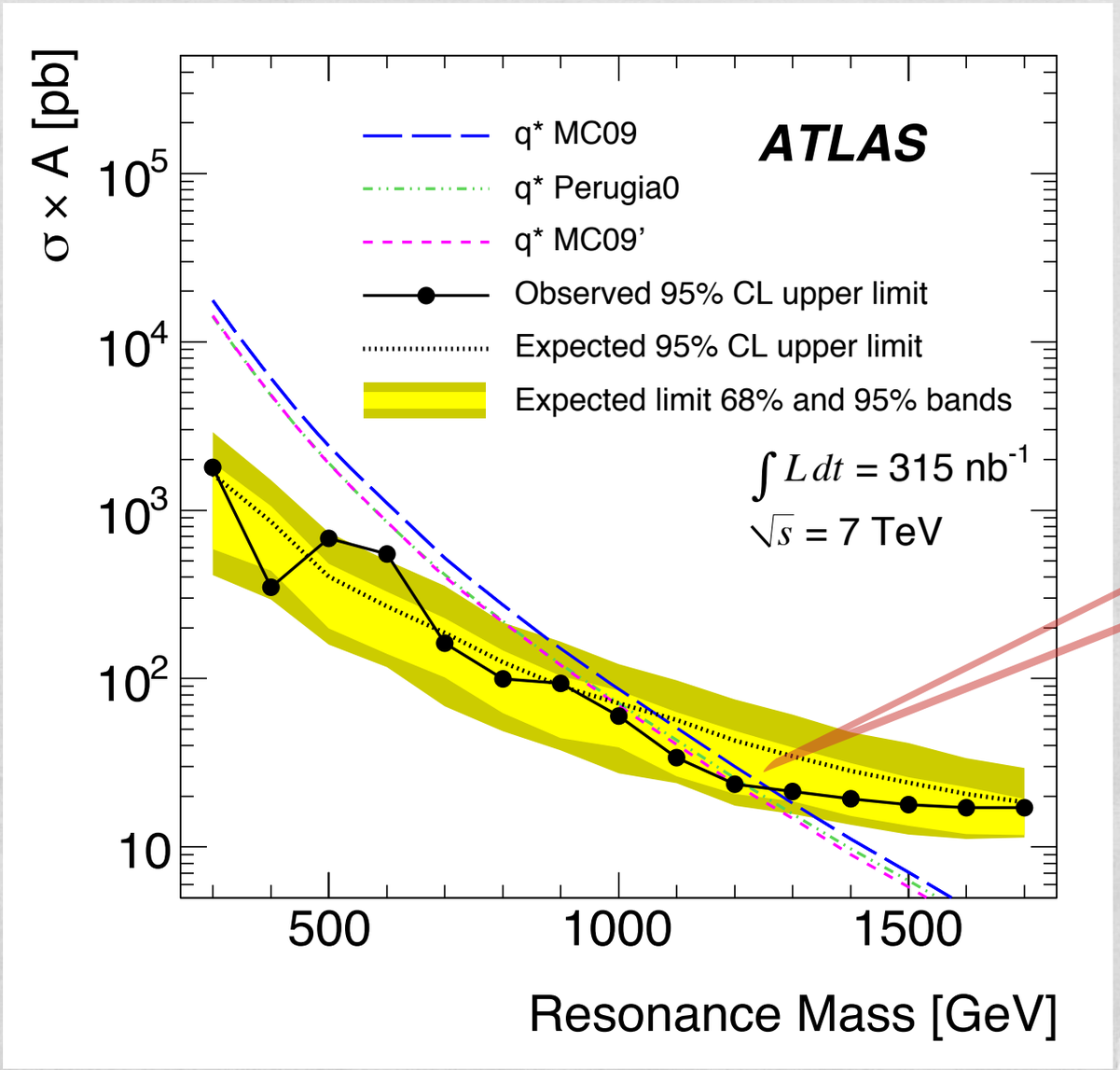
Limits on excited quark



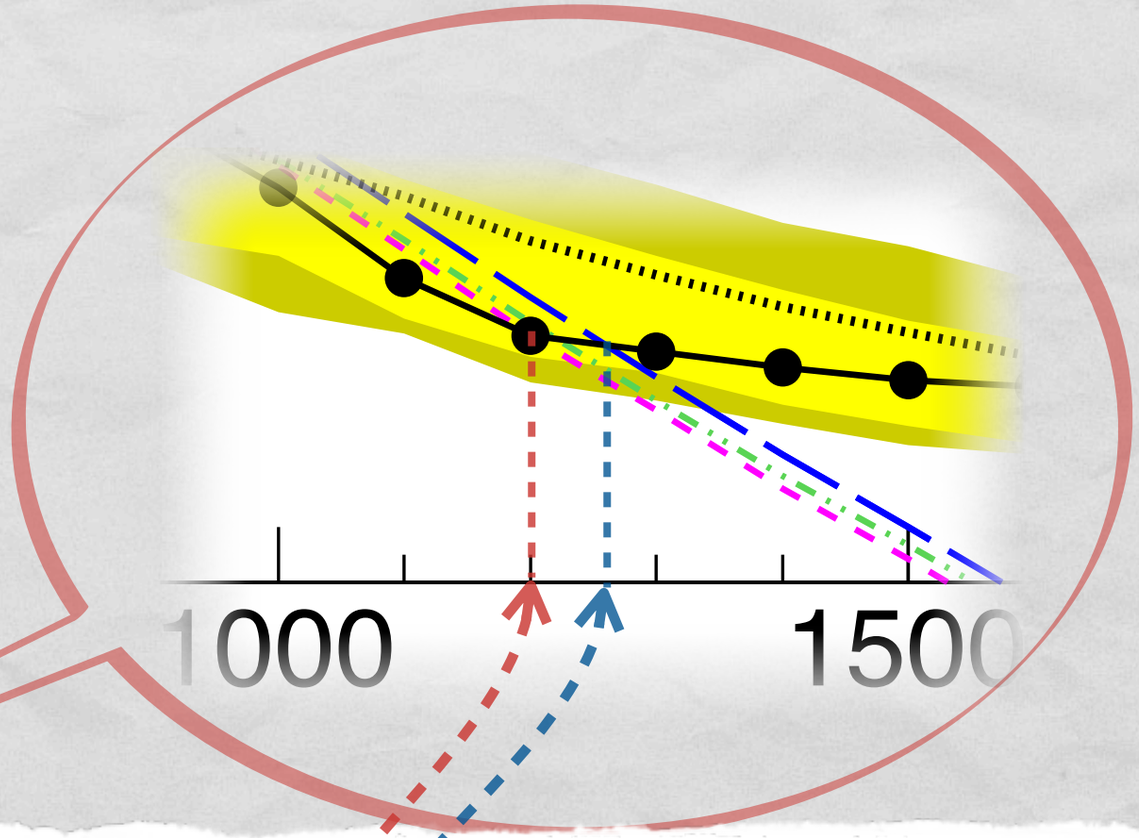


0.31 pb^{-1}

Limits on excited quark



0.31 pb^{-1}



(2010) PHYSICAL REVIEW LETTERS

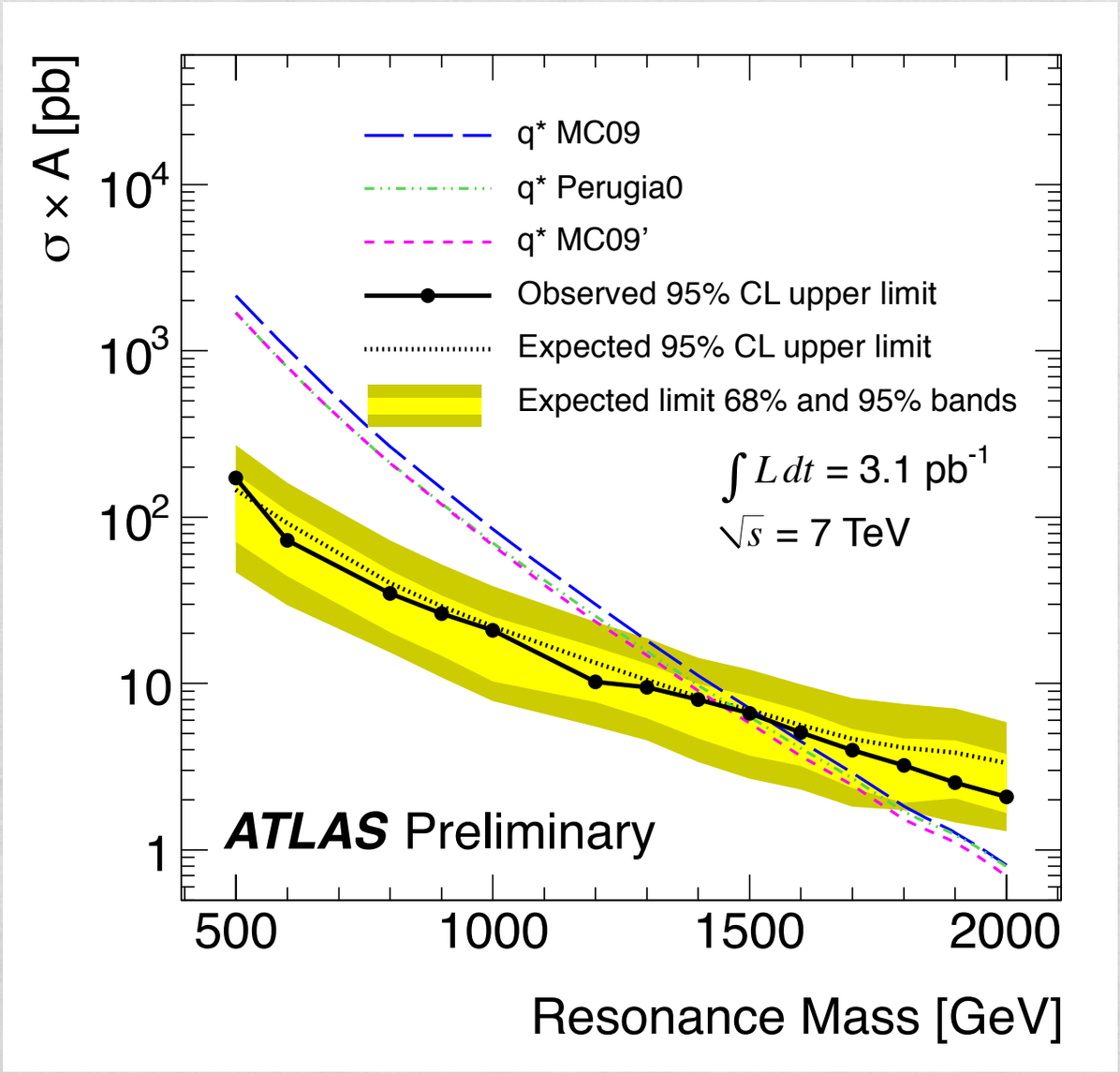
TABLE I. The 95% C.L. lower limits on the allowed q^* mass obtained by using different PD sets.

IC tune	PDF set	Observed mass limit [TeV] Stat. ⊕ Syst.	Observed mass limit [TeV] Stat. only	Expected mass limit [TeV Stat. ⊕ Syst.
MC09 [27]	MRST2007 [25]	1.26	1.28	1.06
MC09'[a]	CTEQ6L1 [37]	1.20	1.23	0.99
Perugia0 [38]	CTEQ5L [39]	1.22	1.25	1.00

[a]The MC09′ tune is identical to MC09 except for the PYTHIA [24] parameter PARP(82) = 2.1

Phys. Rev. Lett. 105, 161801 (2010)

Limits on excited quark



3.1 pb^{-1}

	Observed Limit	Expected Limit
MRST2007	1.53 TeV	1.51 TeV
CTEQ6L1	1.45 TeV	1.43 TeV

Observed ≈ Expected
neither lucky, nor unlucky

Table 1: The 95% CL lower limits on the allowed q^* mass obtained using different PDF sets.

		Observed Mass Limit [TeV]		Expected Mass Limit [TeV]
MC Tune	PDF Set	Stat. ⊕ Syst.	Stat. only	Stat. ⊕ Syst.
MC09 [3]	MRST2007 [4]	1.53	1.64	1.51
MC09′	CTEQ6L1 [5]	1.45	1.56	1.43
Perugia0 [6]	CTEQ5L [7]	1.49	1.60	1.46

ATLAS-CONF-2010-093

Summary of q* limits

	CDF using 1130 pb^{-1}	CMS using 2.9 pb-1	ATLAS* using 3.1 pb-1
Observed Limit	0.87 TeV	1.58 TeV	1.45 TeV
Expected Limit		1.32 TeV	1.43 TeV

* Listing result with CTEQ6L1, for easier comparison with CMS.

Agreement between ATLAS and CMS.

Search for contact interactions

Related articles from the LHC

ATLAS

Using 3.1 pb^{-1}

submitted to Phys.Lett.B on Sept. 26

arXiv:1009.5069 [hep-ex]

CMS

Using 2.9 pb^{-1}

submitted to Phys.Rev.Lett on Oct. 21

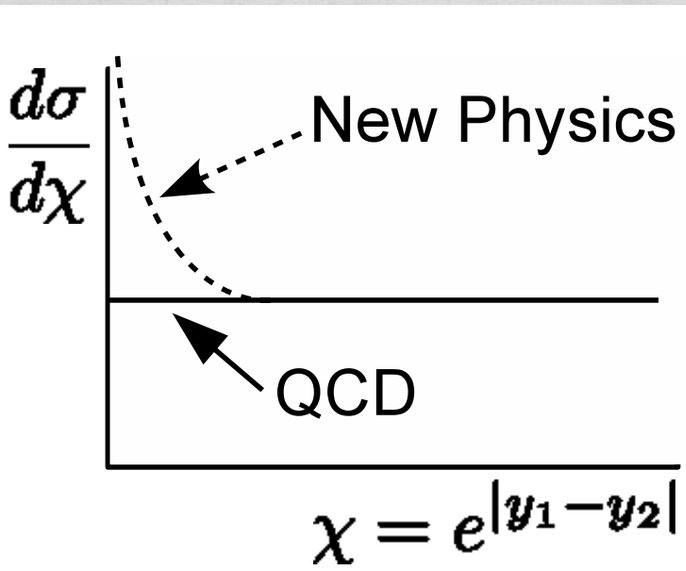
arXiv:1010.4439 [hep-ex]

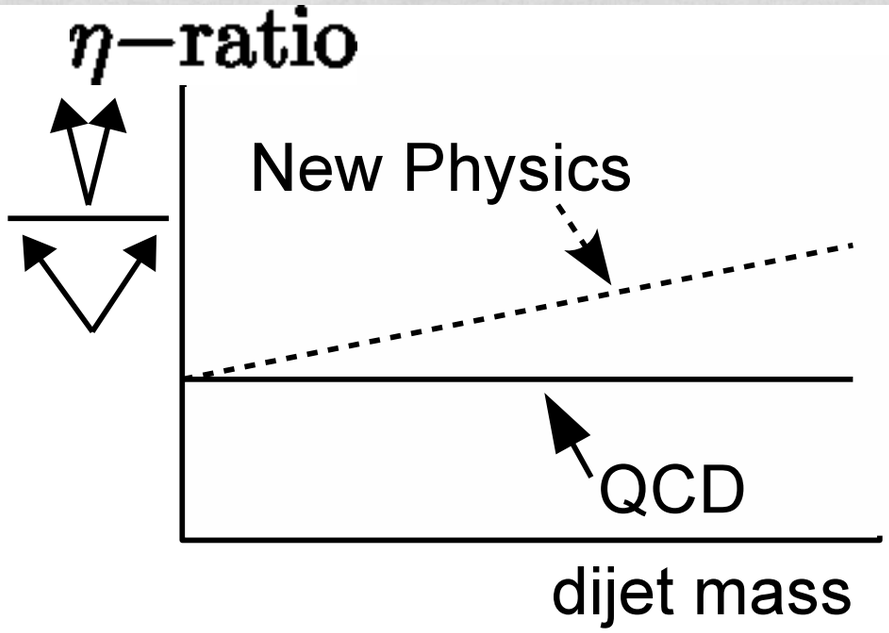
Overview of search for contact interactions

- Contact interaction: $\mathcal{L} = \frac{-2\pi}{\Lambda^2} \bar{\Psi}_q^L \gamma^\mu \Psi_q^L \bar{\Psi}^L \gamma_\mu \Psi_q^L$
- Two reco-level observables, analyzed separately:

$$\chi = e^{|y_1 - y_2|} \qquad R_C = \frac{N(|\eta_{1,2}| < 0.7)}{N(0.7 < |\eta_{1,2}| < 1.3)}$$

- Background = PYTHIA QCD with NLO correction.

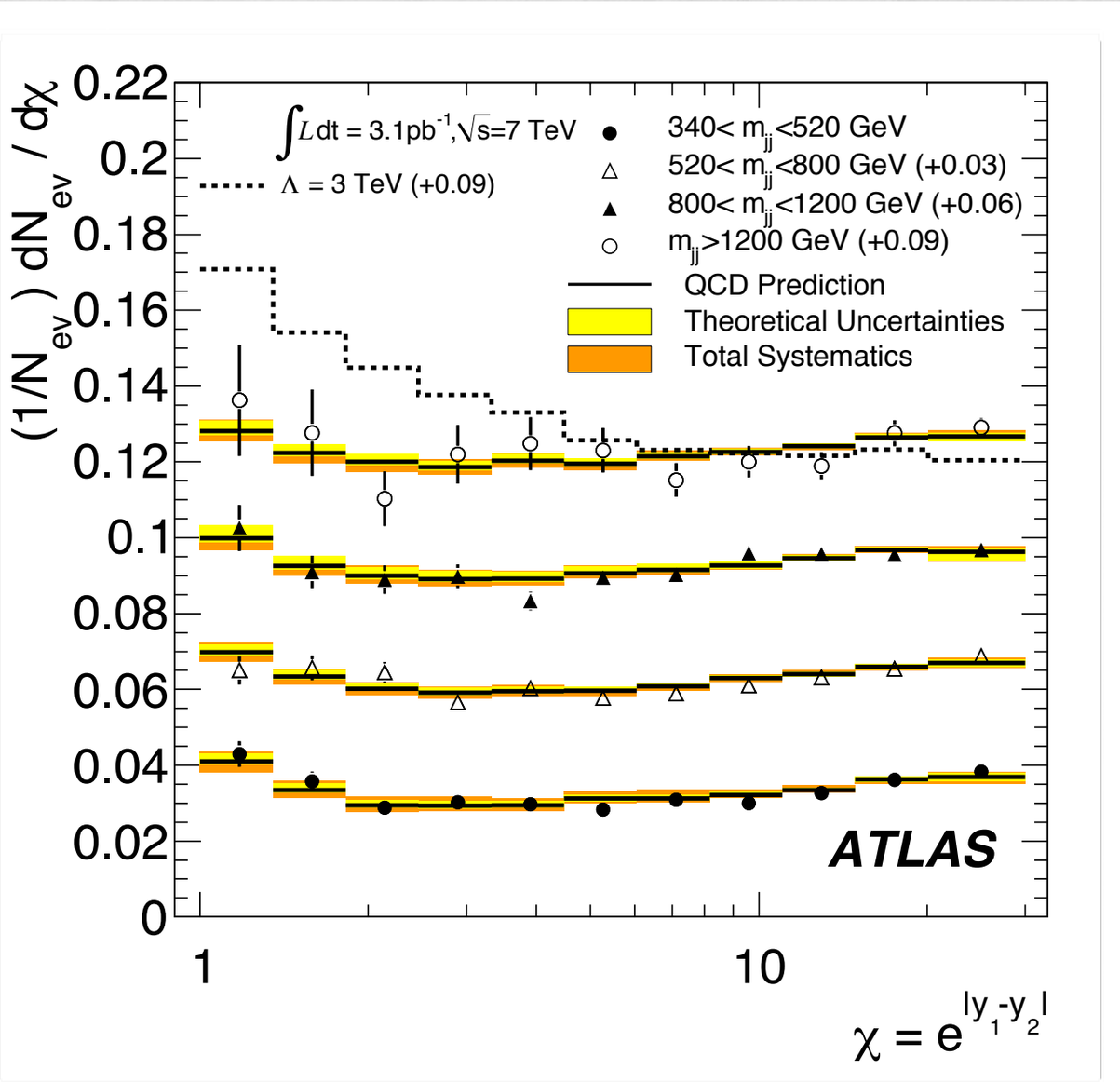




χ observable

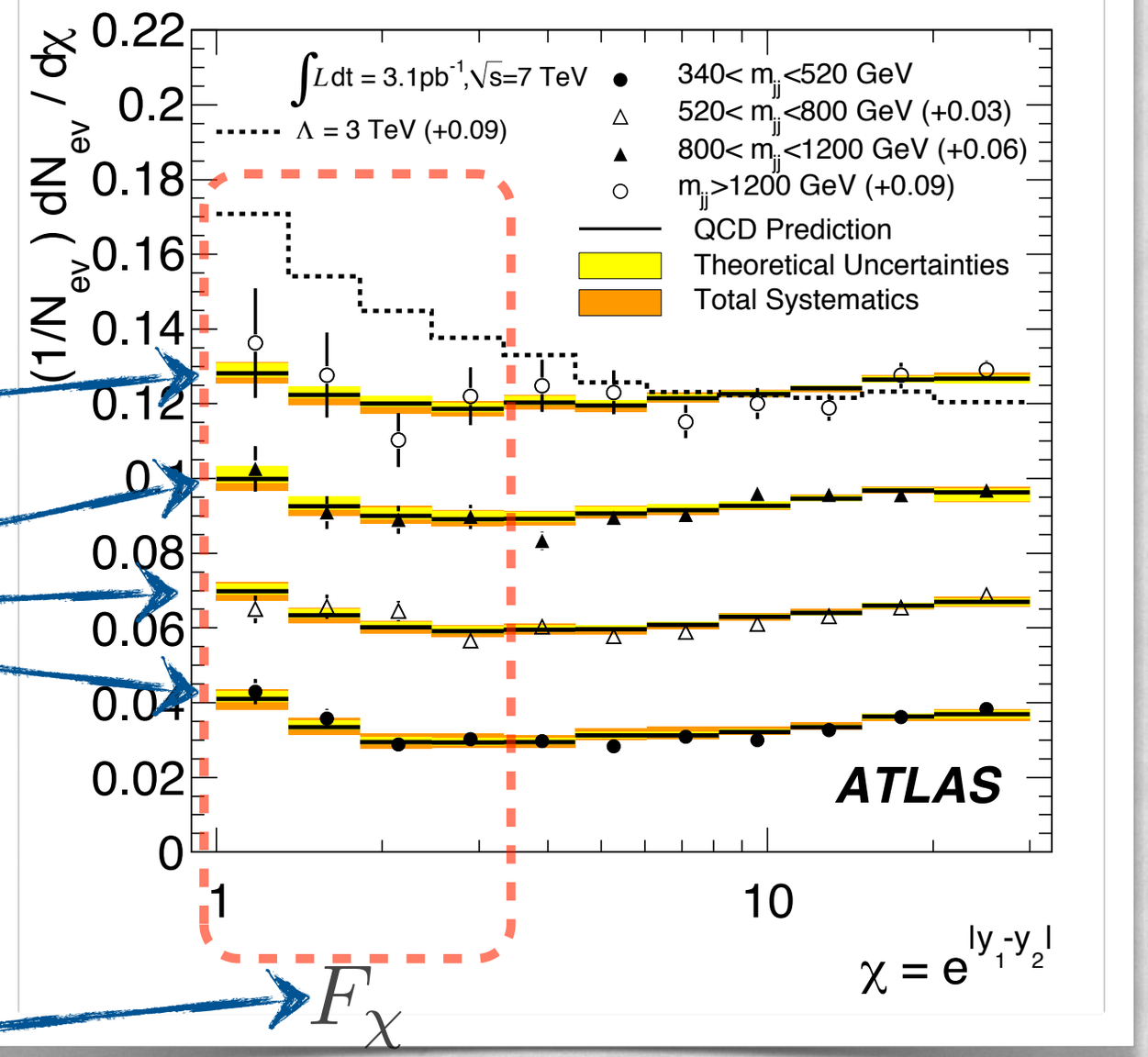
Systematics

1) JES →~6%
2) μ_R, μ_F → ~3%
3) CTEQ6.6 PDF → ~1%



χ observable

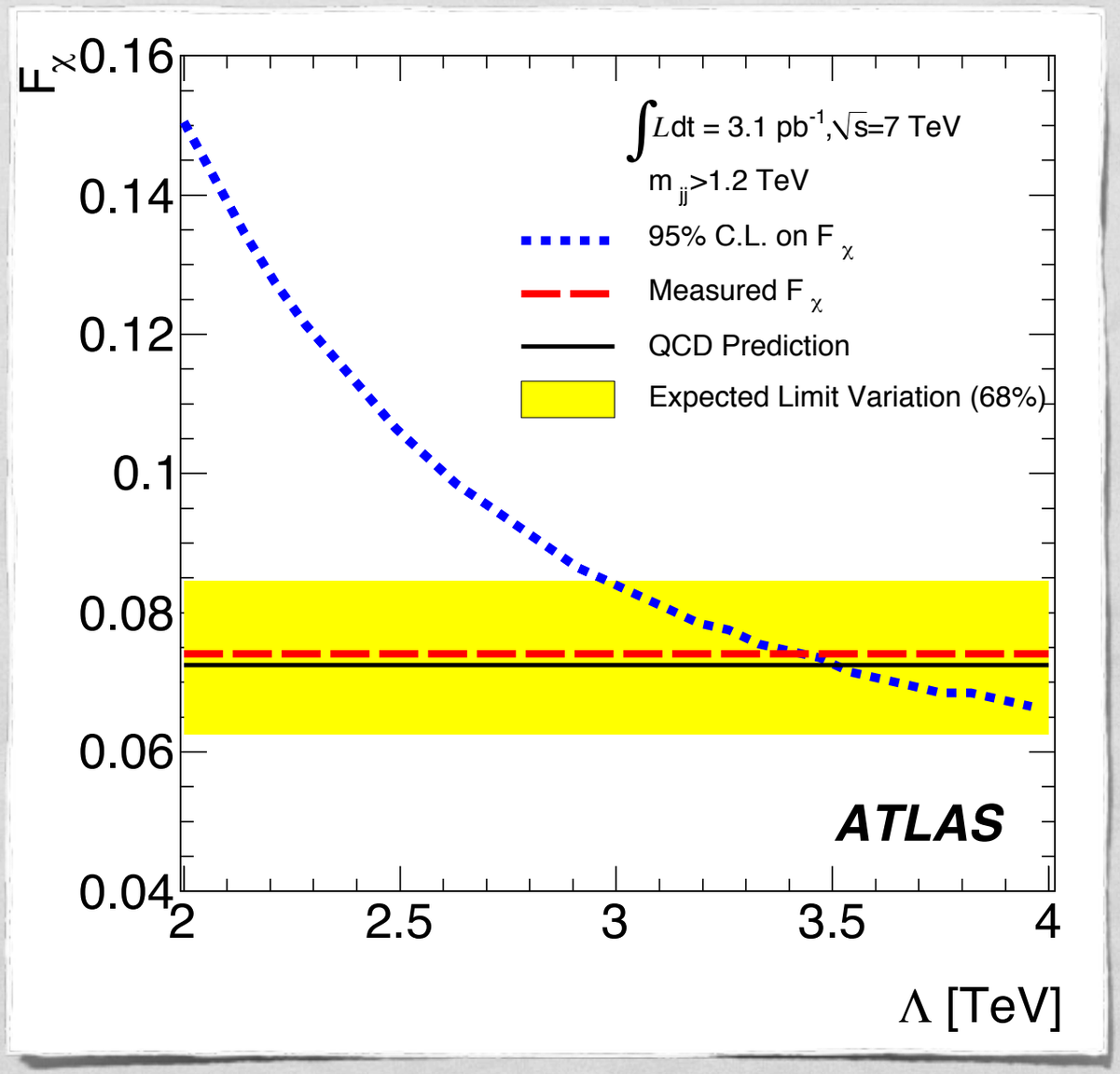
- Signal region
- Control region
- χ-Ratio used to set frequentist limit



Limit on Λ

- Frequentist limit
- Observed 95% CL limit:
  Λ > 3.4 TeV (expected 3.5 TeV)

  → De Broglie wavelength:
  ~6 x 10^{-20} m

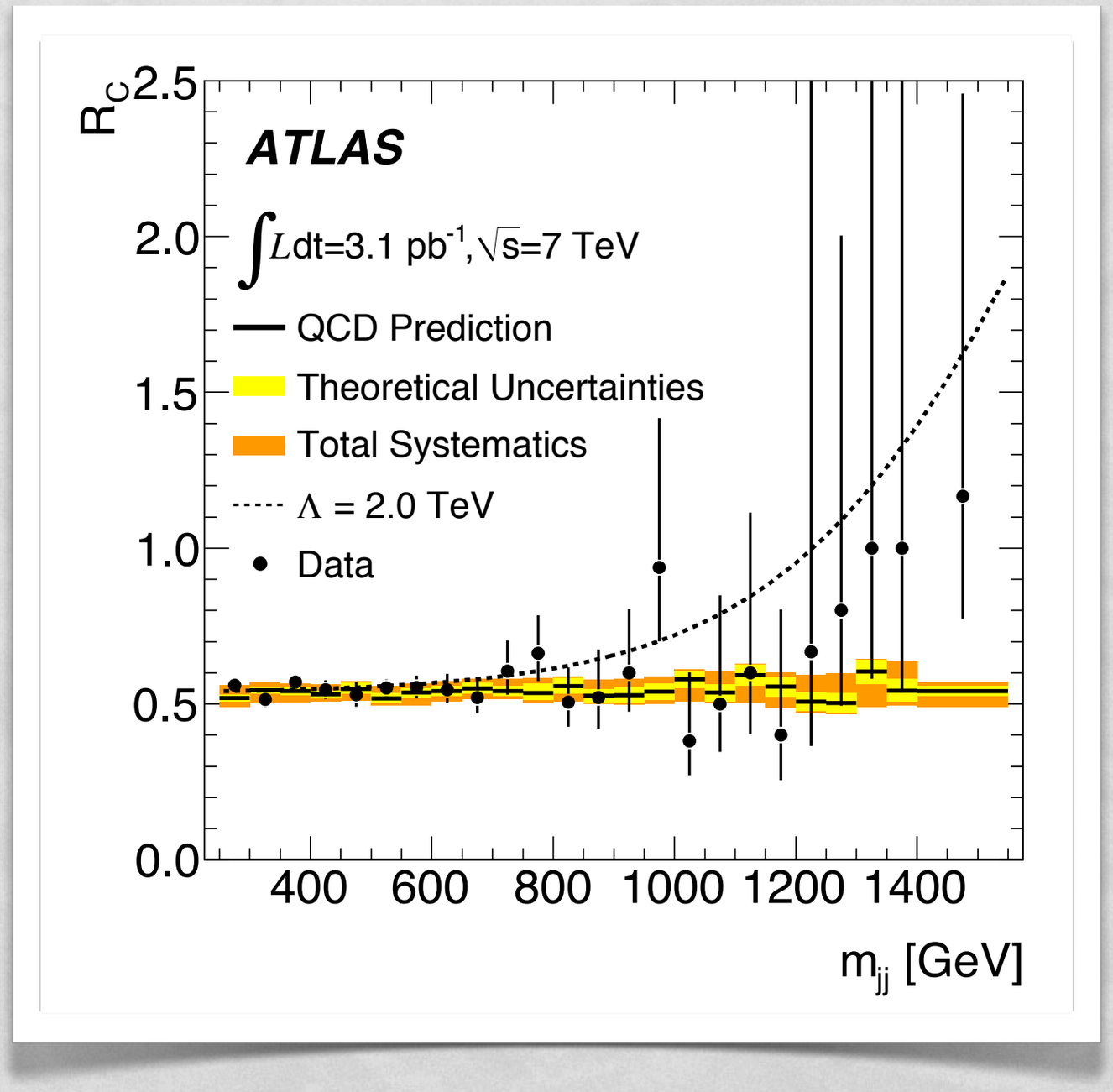


Tevatron limit was: 2.8 TeV

arXiv:0906.4819v1 [hep-ex]

Limit on Λ, using η-Ratio

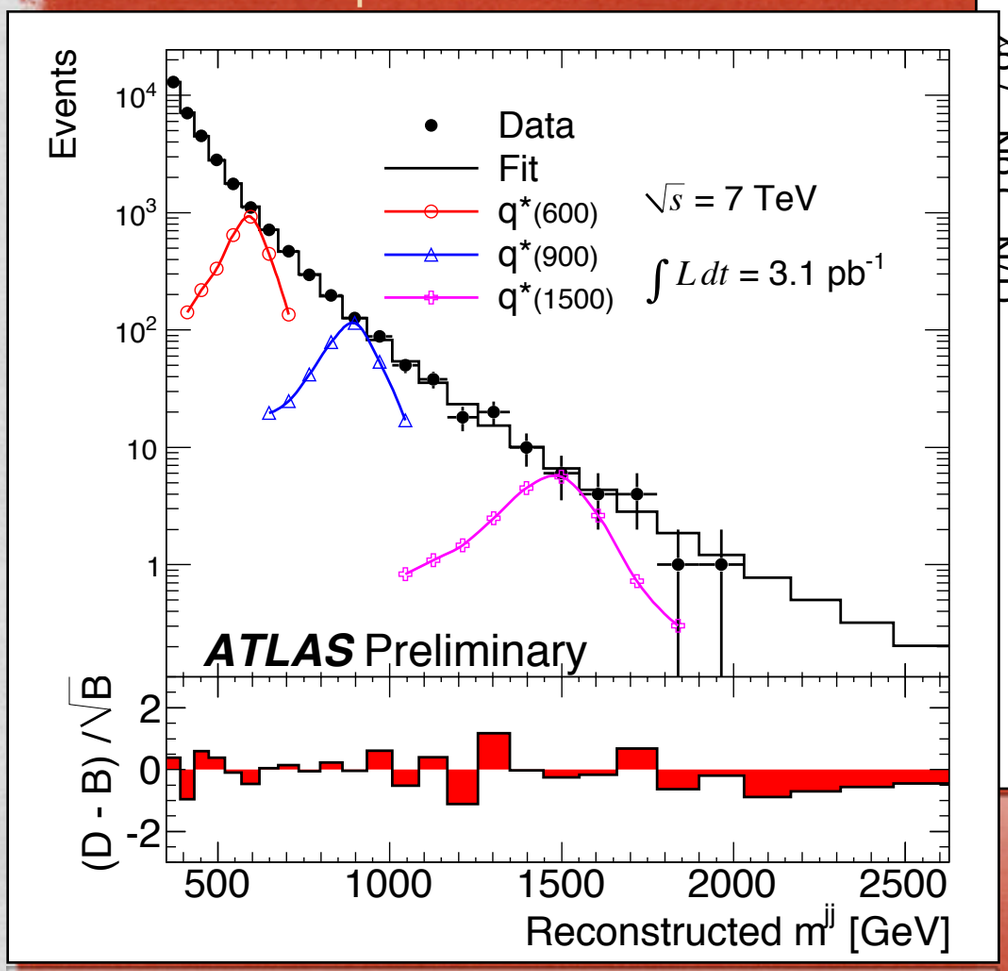
- Bayesian limit
  (flat prior in $\sigma \sim 1/\Lambda^4$ and $1/\Lambda^2$)
- Observed 95% CL limit:
  2.0 TeV (2.4 TeV expected).



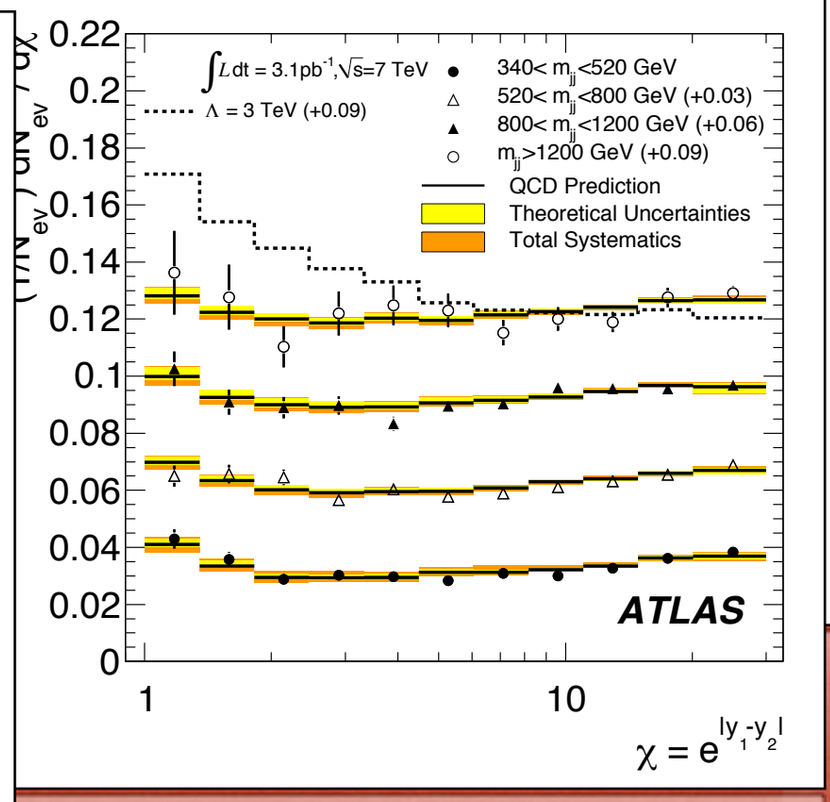
Summary

No hint of new physics in 3.1 pb^{-1}, at $\sqrt{s}$ = 7 TeV.
LHC sets world's best limits since only 0.31 pb^{-1}.

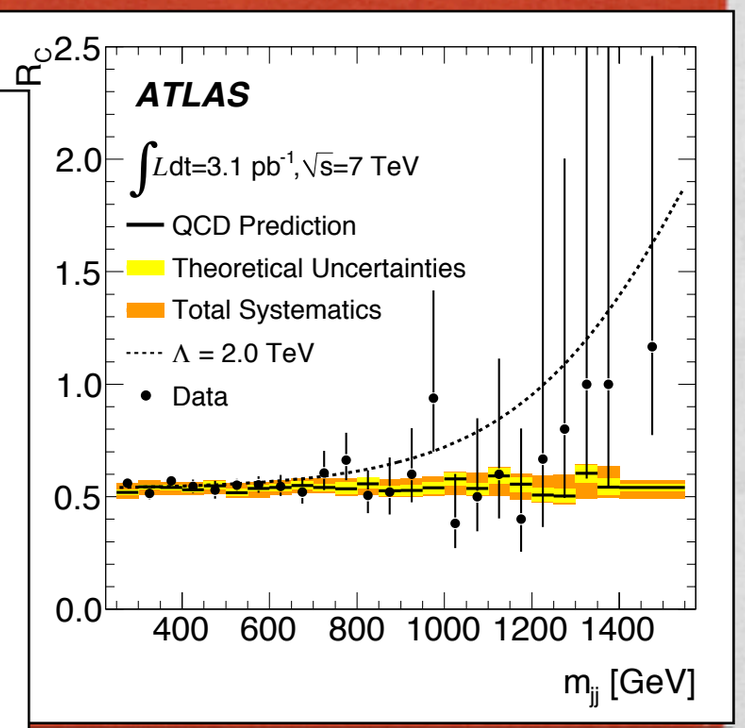
m_{q^*} > 1.53 TeV



Λ > 3.4 TeV

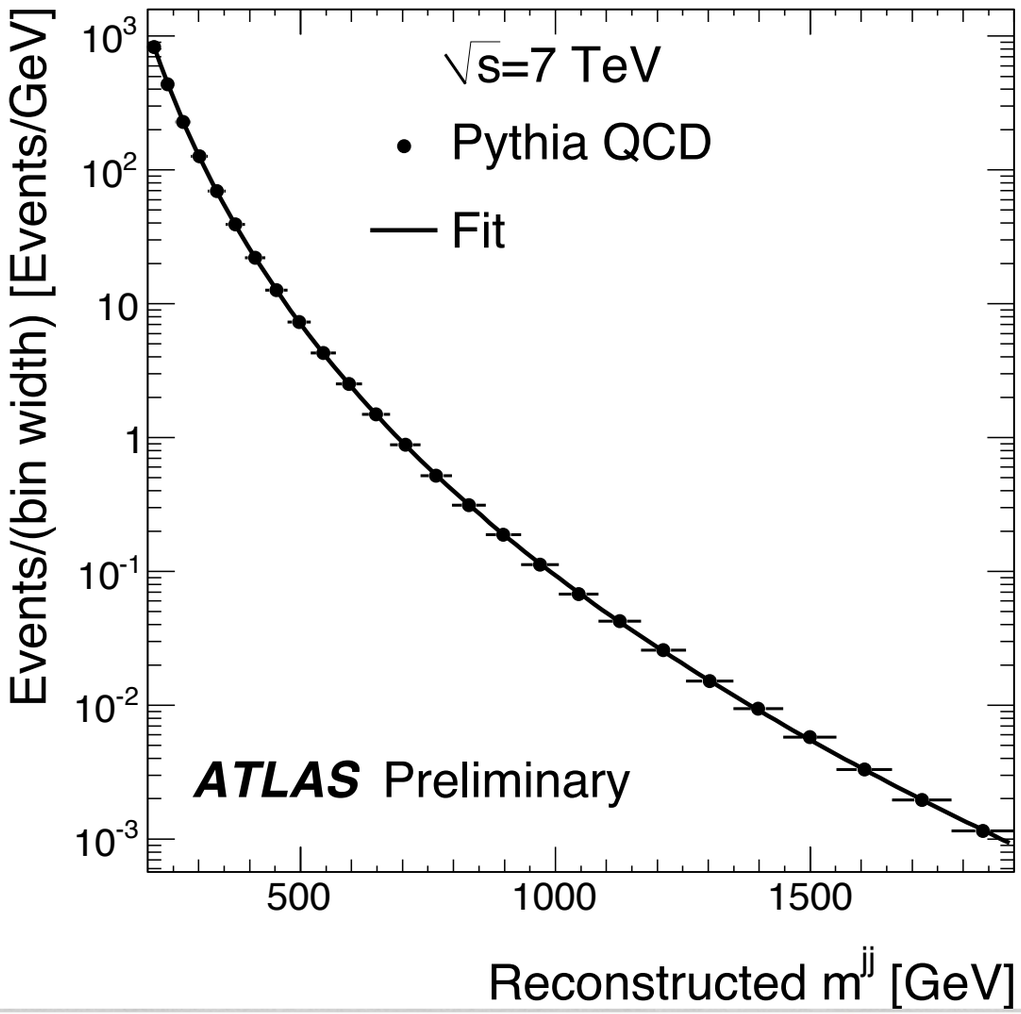


Λ > 2.0 TeV



The searches continue...
Over 40 pb^{-1} on tape.

Appendix


Events/(bin width) [Events/GeV]
10^3
10^2
10
1
10^{-1}
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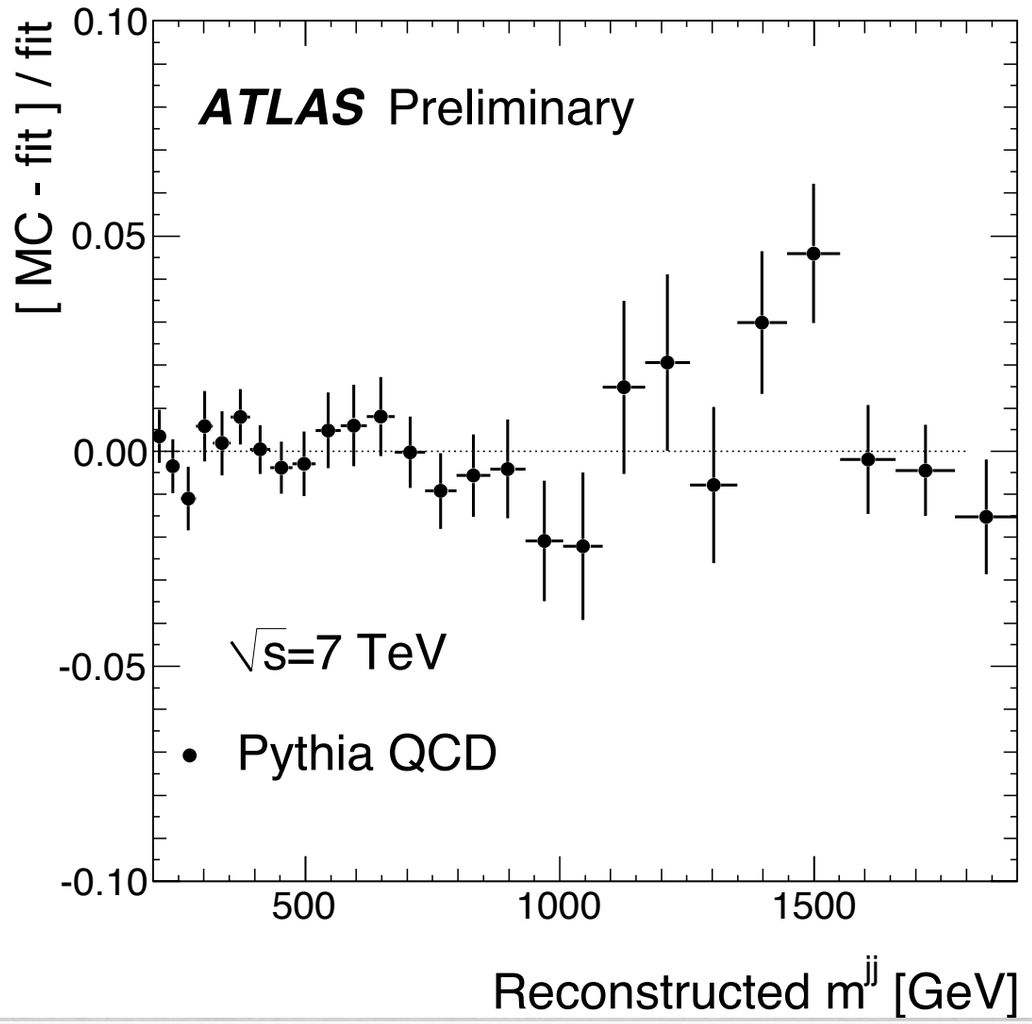
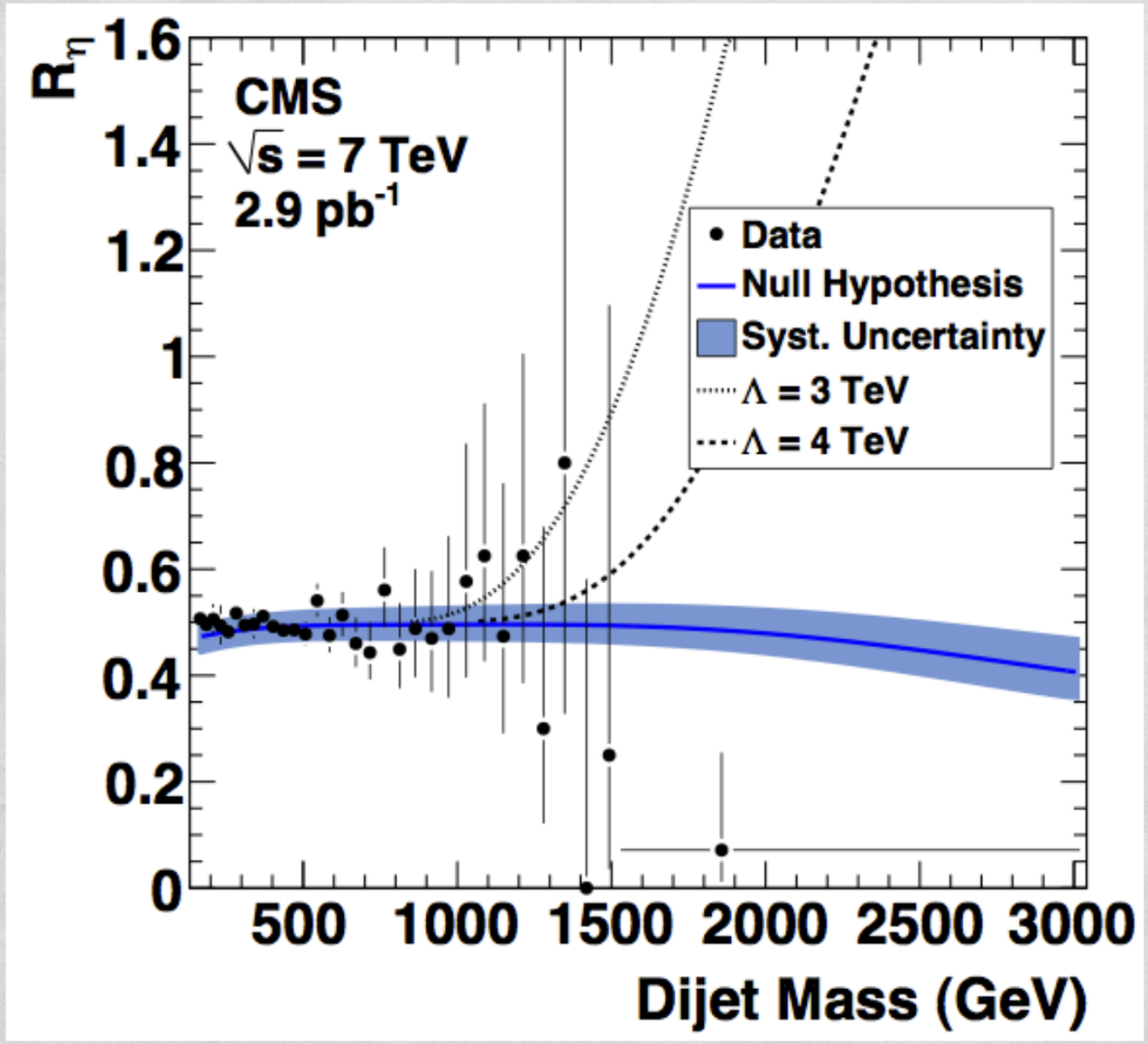
10^{-3}
$\sqrt{s}$=7 TeV
Pythia QCD
Fit
ATLAS Preliminary
500
1000
1500
Reconstructed m^{jj} [GeV]

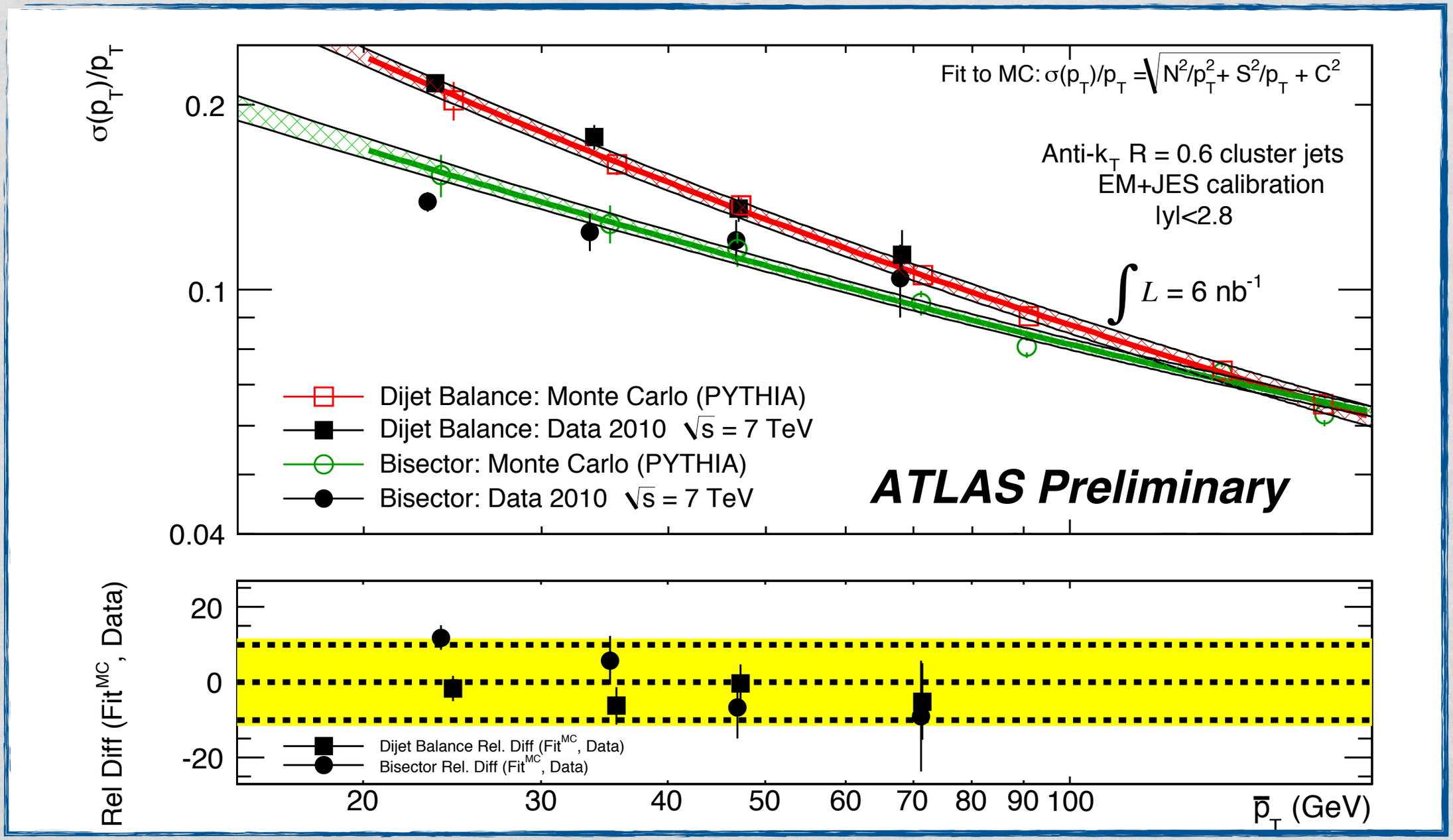

[MC - fit] / fit
0.10
0.05
0.00
-0.05
-0.10
ATLAS Preliminary
$\sqrt{s}$=7 TeV
Pythia QCD
500
1000
1500
Reconstructed m^{jj} [GeV]



Contact interactions at CMS

"because the observed value of the centrality ratio at high invariant mass is below the expectation, the observed limit is 4.0 TeV at the 95% confidence level."

arXiv:1010.4439 [hep-ex], submitted to PRL.



ATLAS-CONF-2010-054