Recent ATLAS Results using 2010 pp Data

IOP Half Day
"Challenging the Standard Model at the High Energy Frontier"
Liverpool, January 12th, 2011

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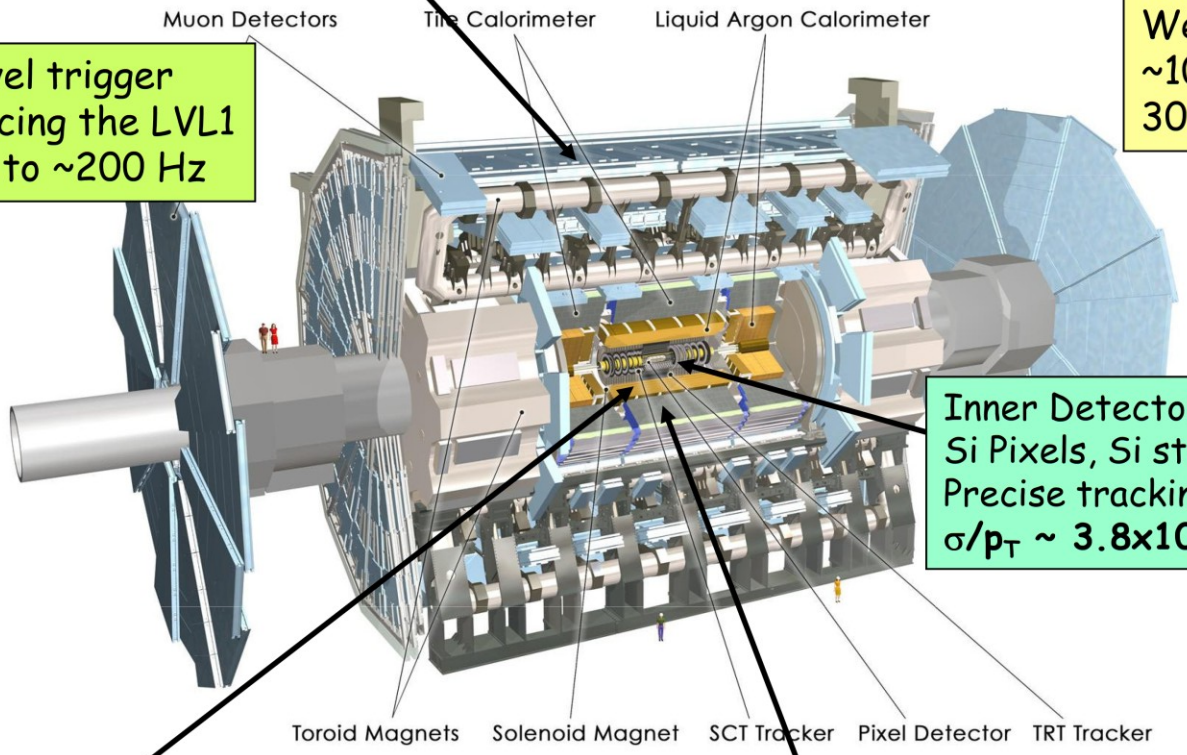
The collaboration …
3000 physicists including 1000 students from more than 174 institutions and 38 nations …

The ATLAS Detector

Muon Spectrometer ($|\eta|<2.7$) : air-core toroids with gas-based muon chambers
Muon trigger and measurement with momentum resolution < **10% up to E_μ ~ 1 TeV**

Length : ~ 46 m
Radius : ~ 12 m
Weight : ~ 7000 tons
~10^8 electronic channels
3000 km of cables

3-level trigger reducing the LVL1 rate to ~200 Hz

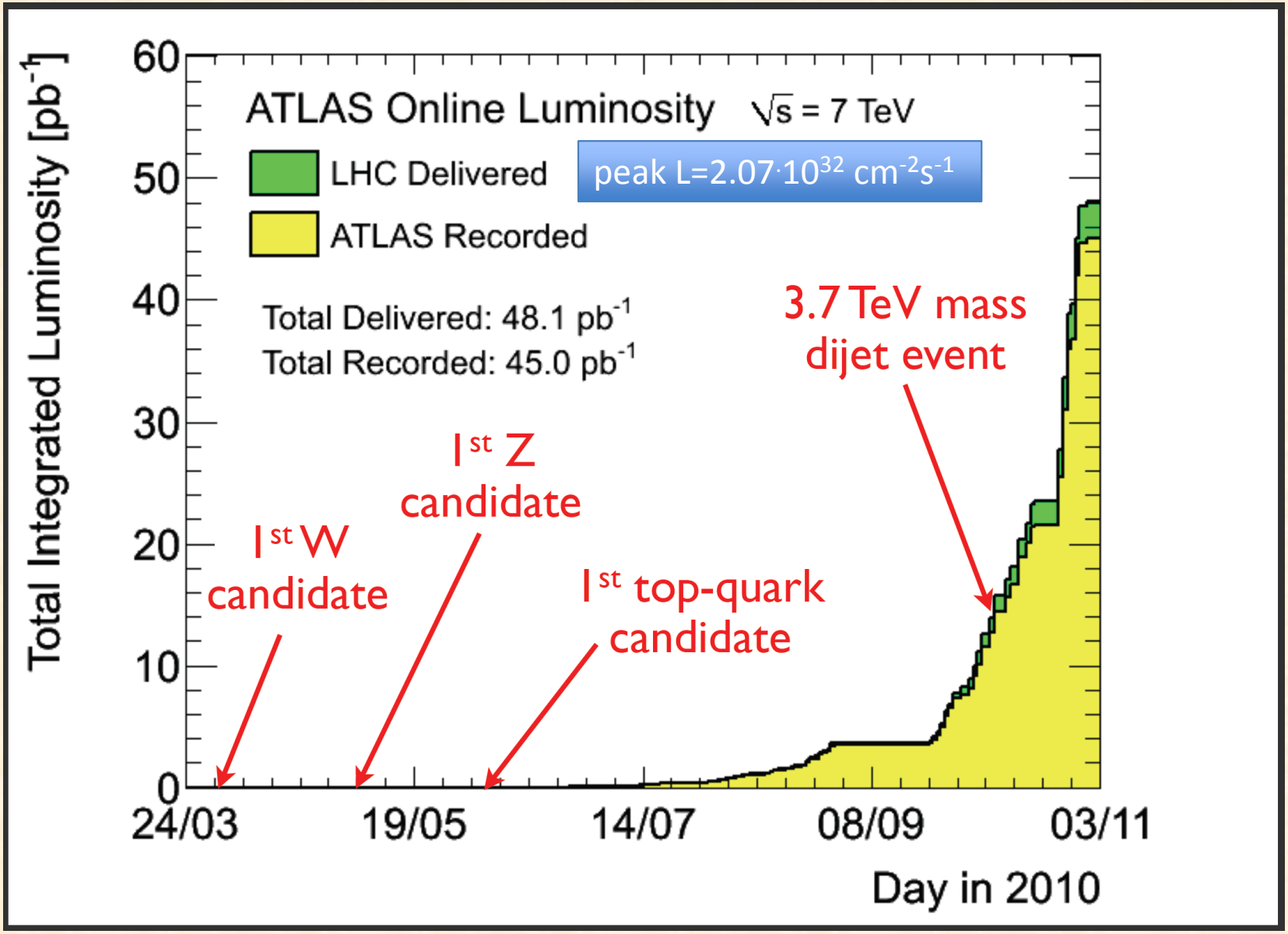


Inner Detector ($|\eta|<2.5$, B=2T):
Si Pixels, Si strips, TRT
Precise tracking and vertexing,
σ/p_T ~ 3.8×10^{-4} p_T (GeV) $\oplus$ 0.015

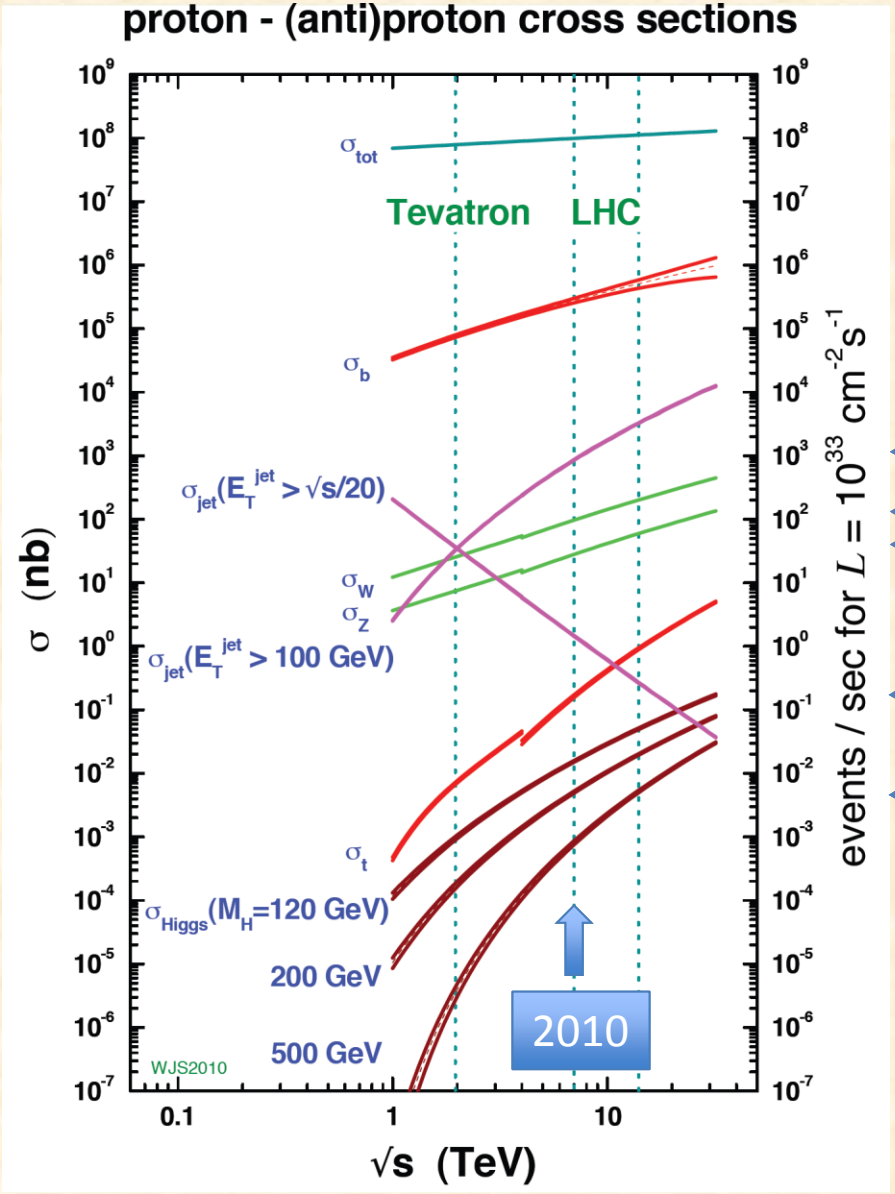
EM calorimeter: Pb-LAr Accordion
e/γ trigger, identification and measurement
E-resolution: **σ/E ~ 10%/$\sqrt{E}$ $\oplus$ 0.007**
granularity :.025 x .025 $\oplus$ strips

HAD calorimetry ($|\eta|<3$): segmentation **0.1 x 0.1**
Fe/scintillator Tiles (central), Cu/W-LAr (fwd)
E-resolution: **σ/E ~ 50%/$\sqrt{E}$** $\oplus$ 0.03
FWD calorimetry:W/LAr **σ/E ~ 90%/$\sqrt{E}$** $\oplus$ 0.07

Data 2010


ATLAS Online Luminosity √s = 7 TeV
LHC Delivered
ATLAS Recorded
peak L=2.07·10^32 cm^-2s^-1
Total Delivered: 48.1 pb^-1
Total Recorded: 45.0 pb^-1
Total Integrated Luminosity [pb^-1]
60
50
40
30
20
10
0
24/03
19/05
14/07
08/09
03/11
Day in 2010
1st W candidate
1st Z candidate
1st top-quark candidate
3.7 TeV mass dijet event

Standard Model Cross Sections



√s = 7 TeV

- high p_T jets
- W
- Z
- top pairs
- Higgs (?)

ATLAS Publications 2010

https://twiki.cern.ch/twiki/bin/view/AtlasPublic/WebHome#Publications_of_the_ATLAS_collab

Drift Time Measurement in the ATLAS Liquid Argon Electromagnetic Calorimeter using Cosmic Muons	Inspire record	EPJC 70 (2010) 755 (22 Feb 2010)
Charged-particle multiplicities in pp interactions at $\sqrt{s}$ = 900 GeV measured with the ATLAS detector at the LHC	Inspire record, Plots, Data points	Phys Lett B 688, 1, 21 (15 March 2010)
The ATLAS Inner Detector commissioning and calibration	Inspire record, Plots	EPJC 70 (2010) 787 (26 Apr 2010)
The ATLAS Simulation Infrastructure	Inspire record	EPJC 70 (2010) 823 (20 May 2010)
Performance of the ATLAS Detector using First Collision Data	Inspire record	JHEP 1009:056,2010 (28 May 2010)
Commissioning of the ATLAS Muon Spectrometer with Cosmic Rays	Inspire record	EPJC 70 (2010) 875 (18 Jun 2010)
Readiness of the ATLAS tile calorimeter for LHC collisions	Inspire record	EPJC 70 (2010) 1193 (30 Jul 2010)
Search for New Particles in Two-Jet Final States in 7 TeV Proton-Proton Collisions with the ATLAS Detector at the LHC	Inspire record, Plots	Phys. Rev. Lett. 105, 161801 (14 Aug 2010)
Search for Quark Contact Interactions in Dijet Angular Distributions in 7 TeV Proton-Proton Collisions with the ATLAS Detector at the LHC	Inspire record, Plots	Phys. Lett. B694 (2011) 327-345 (26 Sep 2010)
Measurement of inclusive jet and dijet cross sections in proton-proton collisions at 7 TeV centre-of-mass energy with the ATLAS detector	Inspire record, Plots, Data points	accepted by EPJC (submitted 30 Sep 2010)
Measurement of the W -> lnu and Z/gamma* -> ll production cross sections in proton-proton collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector	Inspire record, Plots	accepted by JHEP (submitted 11 Oct. 2010)
Observation of a centrality-dependent dijet asymmetry in lead-lead collisions at $\sqrt{s_{NN}}$ = 2.76 TeV with the ATLAS detector at the LHC	Inspire record, Plots	Phys. Rev. Lett. 105, 252303 (25 Nov 2010)
Studies of the performance of the ATLAS detector using cosmic-ray muons	Inspire record	submitted to EPJC (1 Dec 2010)
Measurement of underlying event characteristics using charged particles in pp collisions at $\sqrt{s}$ = 900 GeV and 7 TeV with the ATLAS detector	Inspire record, Plots	submitted to PRD (3 Dec 2010)
Measurement of the top quark-pair production cross section with ATLAS in pp collisions at $\sqrt{s}$=7 TeV	Inspire record, Plots	submitted to EPJC (8 Dec 2010)
NEW Search for Diphoton Events with Large Missing Transverse Energy in 7 TeV Proton-Proton Collisions with the ATLAS Detector	Inspire record, Plots	Submitted to PRL (20 Dec. 2010)
NEW Measurement of the inclusive isolated prompt photon cross section in pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector	Inspire record, Plots	Submitted to Phys Rev D (20 Dec. 2010)
NEW Charged-particle multiplicities in pp interactions measured with the ATLAS detector at the LHC	Inspire record, Plots	Submitted to New J Phys (22 Dec 2010)
NEW Measurement of the production cross section for W-bosons in association with jets in pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector	Inspire record, Plots	Submitted to Phys Lett. B (23 Dec 2010)
NEW Measurement of the centrality dependence of J/Psi yields and observation of Z production in lead-lead collisions with the ATLAS detector at the LHC	Inspire record	Submitted to Phys Lett. B (24 Dec 2010)
NEW Study of Jet Shapes in Inclusive Jet Production in pp Collisions at $\sqrt{s}$ = 7 TeV using the ATLAS Detector	Inspire record, Plots	Submitted to Phys Rev. D (30 Dec 2010)

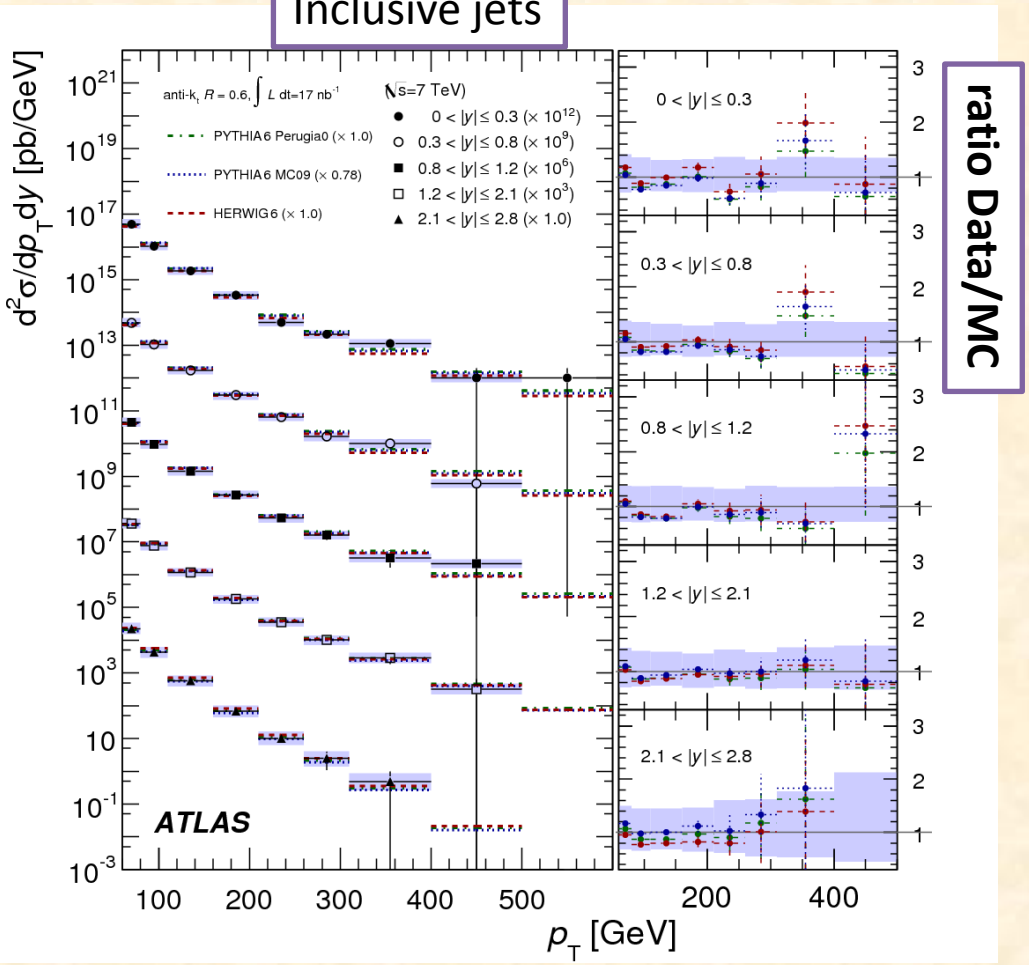
Talk uses material from the publications, preliminary results are extra indicated.

17 nb^{-1}

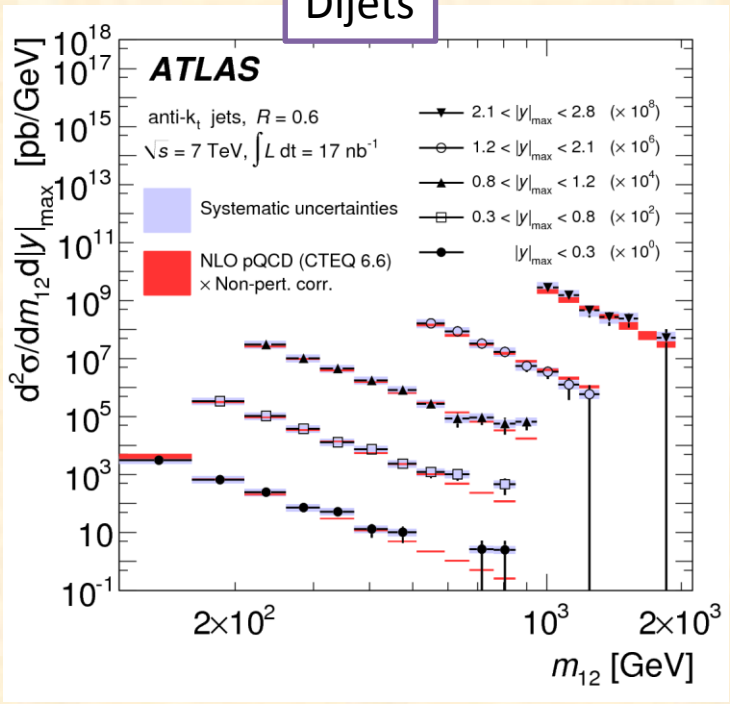
Inclusive Jet and Dijet Cross Sections

Double differential in p_T and y for anti-kt jets with R=0.6, similar results for R=0.4.

Inclusive jets



Dijets



arXiv:1009.5908

Data and theory are in good agreement over wide rapidity, p_T and M_{jj} ranges.

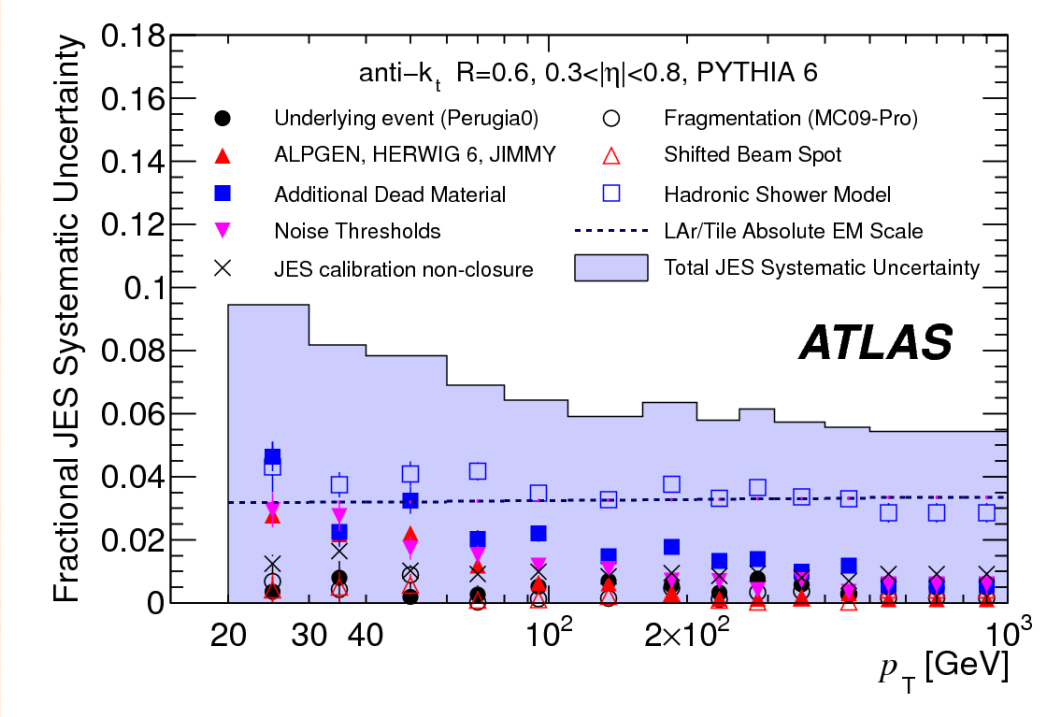
Fractional Jet Energy Scale Uncertainty

Based on:

- beam tests
- MC simulation
- in situ calibration
- done for R=0.6 and 0.4 anti-kt jets

→ dominated by the hadronic shower model and dead material description

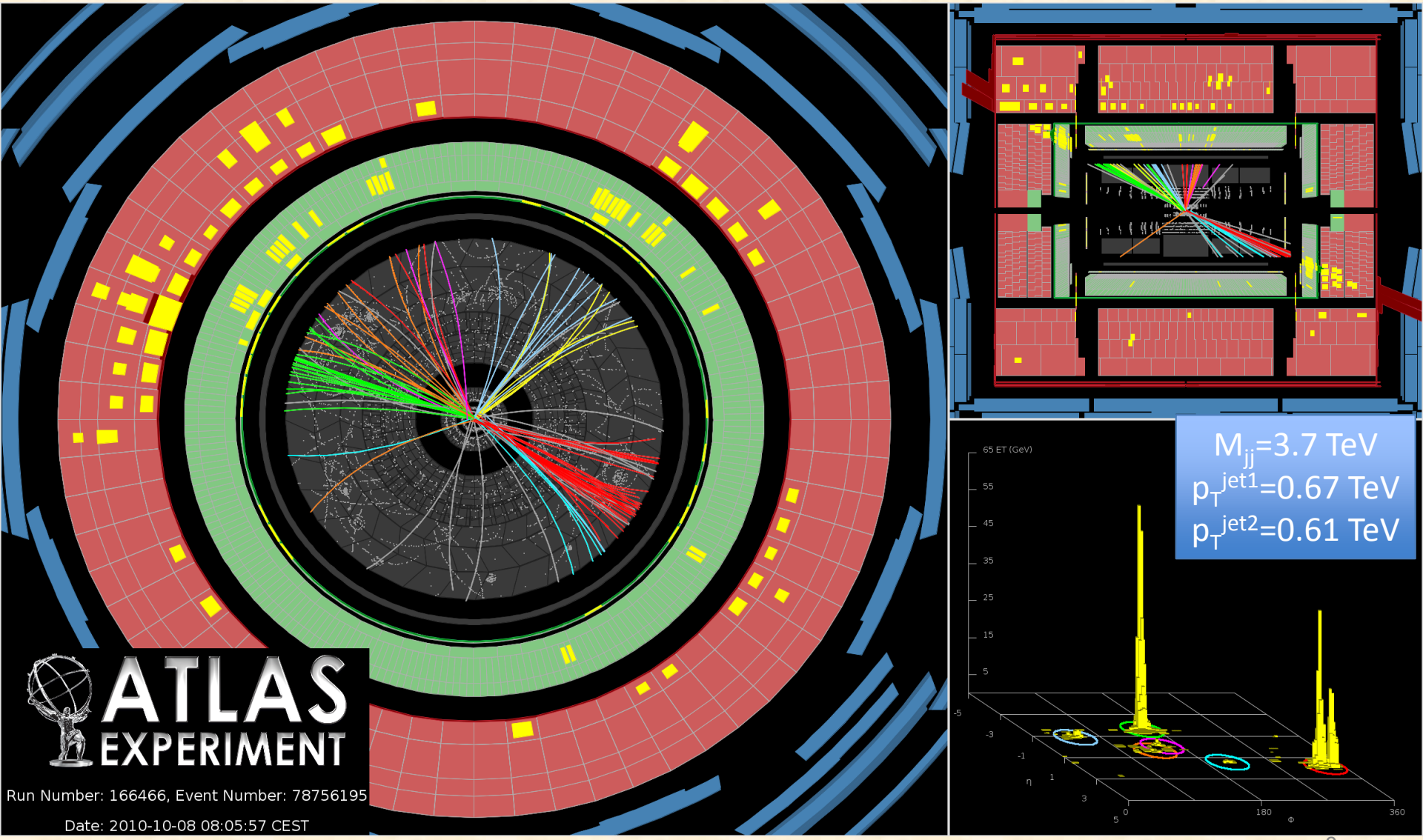
→ ***effect on cross sections is ~40%*** while luminosity uncertainty of 2010 data is 11%



arXiv:1009.5908

The total systematic uncertainty is shown as the solid light blue area. The individual sources are also shown, with statistical errors if applicable.

ATLAS high Dijet Mass Event



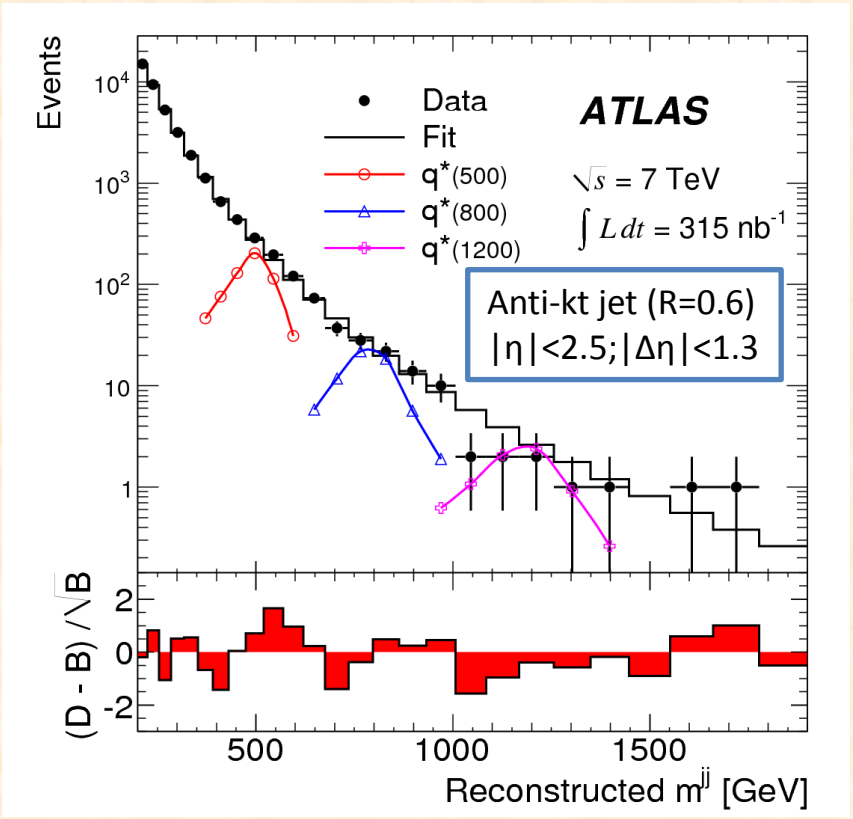
315 nb^{-1}

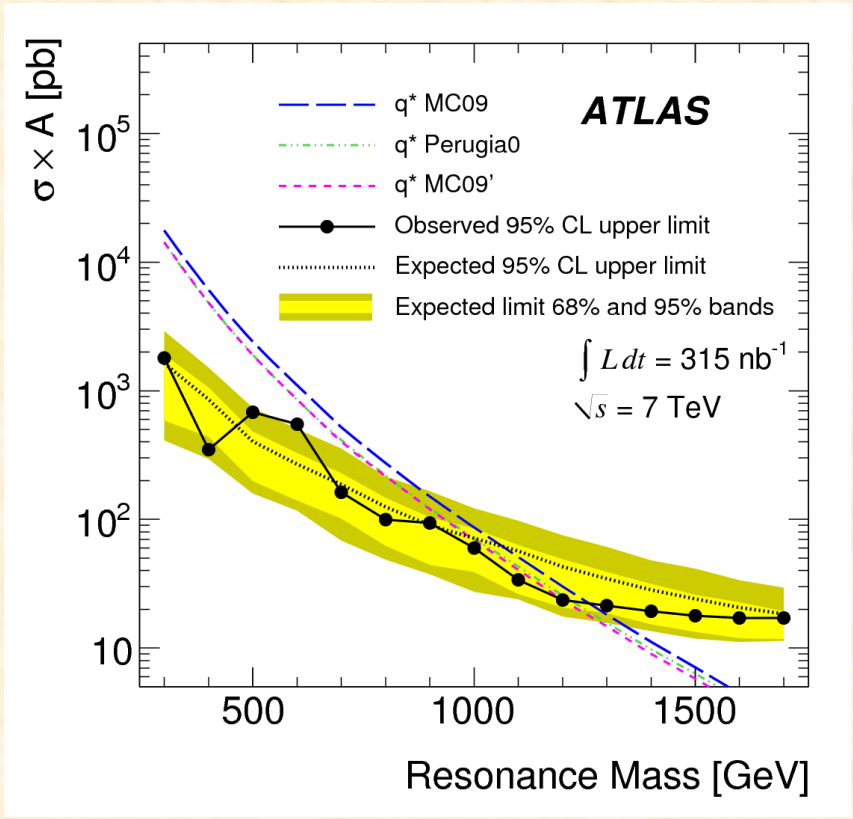
Standard Model vs New Physics

- Explore *invariant dijet mass* for new resonant states!
- New 95% C.L. exclusion limits on excited-quark (q*) production as a function of q* mass

$0.30 < m_{q^*} < 1.26$ TeV

[Tevatron $m_{q^*} < 0.87$ TeV using 1.13 fb^{-1}]





PRL 105, 161801 (2010)

$p_T^{j_1} > 80$ GeV
$p_T^{j_2} > 30$ GeV

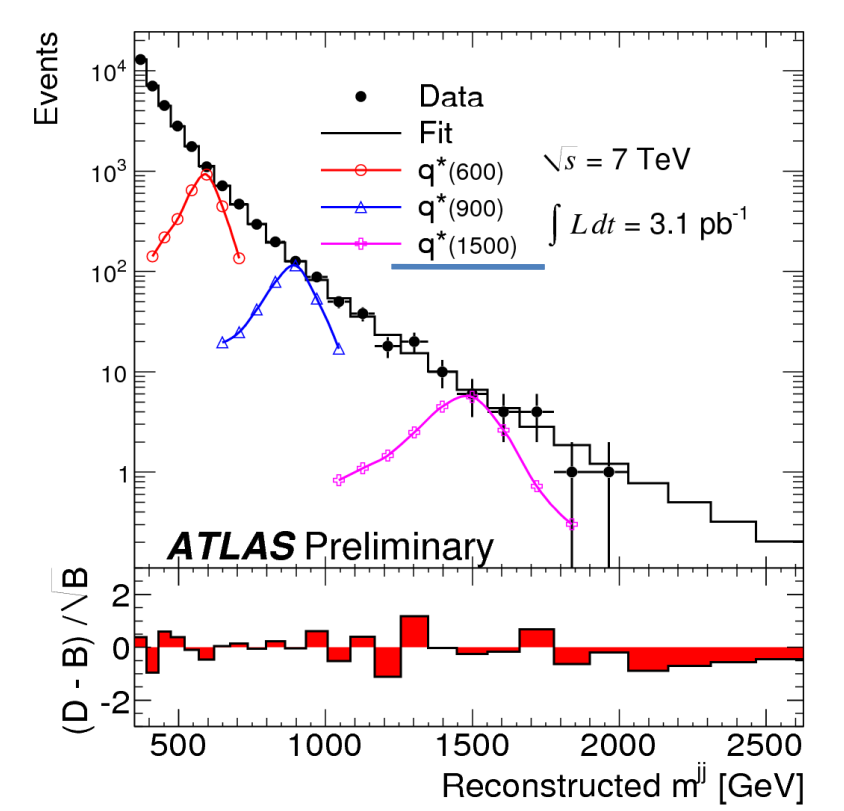
$$\sqrt{(E^{j_1} + E^{j_2})^2 - (\vec{p}^{j_1} + \vec{p}^{j_2})^2}$$

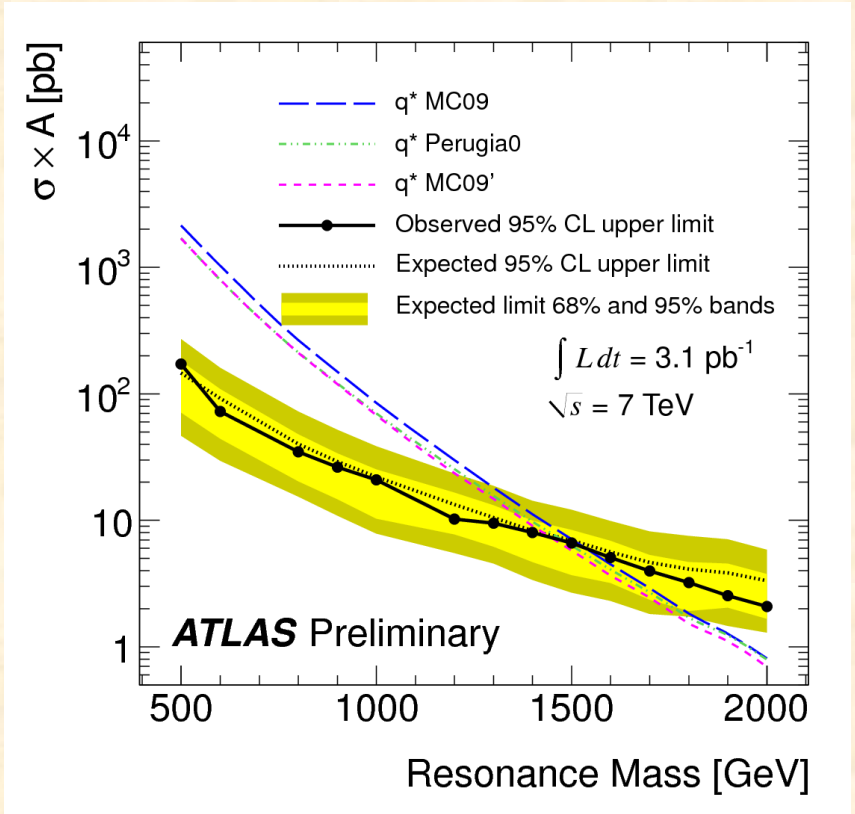
MC predictions are using different PDF sets

3.1 pb^{-1}

… Updated

$0.50 < m_{q^*} < 1.53$ TeV





ATLAS-CONF-2010-093

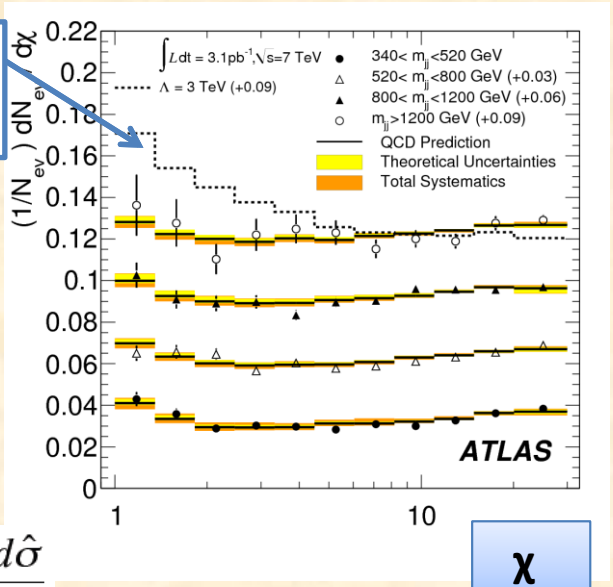
➔ Data well described by a steady fit function

Quark Contact Interactions?

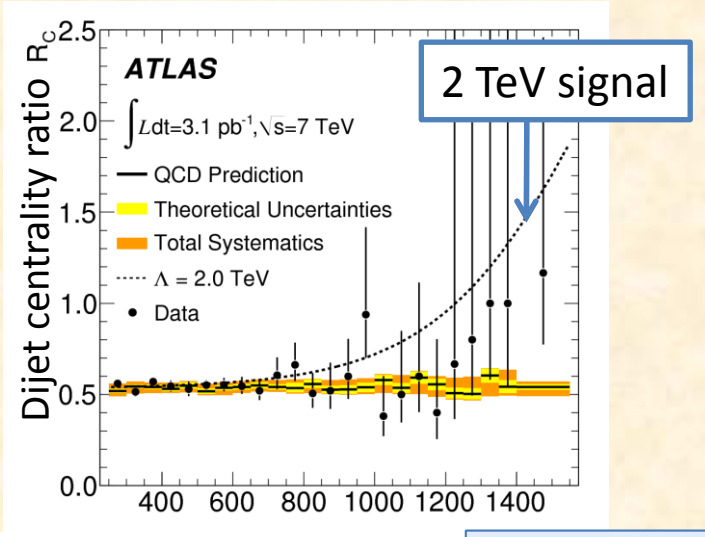
- Search for quark compositeness in *dijet angular distributions*
- In QCD, spin-1 gluon exchange : $dN/d\cos\theta^* \propto 1/\sin^4(\theta^*/2)$
- New processes are more isotropic → excess of events at low χ expected, $\chi = \exp(|y_1 - y_2|) = \exp(2|y^*|)$ and $y^* = \frac{1}{2}\ln(\frac{1+|\cos\theta^*|}{1-|\cos\theta^*|})$
- Quark contact interactions with scales Λ<3.4 TeV at 95% C.L. excluded

test distance scales of ~6·10^{-5} fm

3 TeV signal



$\frac{d\hat{\sigma}}{d\chi}$



2 TeV signal

$R_c = \frac{N(|\eta_{1,2}| < 0.7)}{N(0.7 < |\eta_{1,2}| < 1.3)}$

Phys. Lett. B694 (2011) 327

3.1 pb^{-1}

Diphotons at high $E_{T,miss}$

- Select two isolated photons with E_T>25 GeV and |η|<1.81 (exclude crack 1.37<|η|<1.52)
- 'Total background' is the sum of expected Standard Model cross sections, mainly

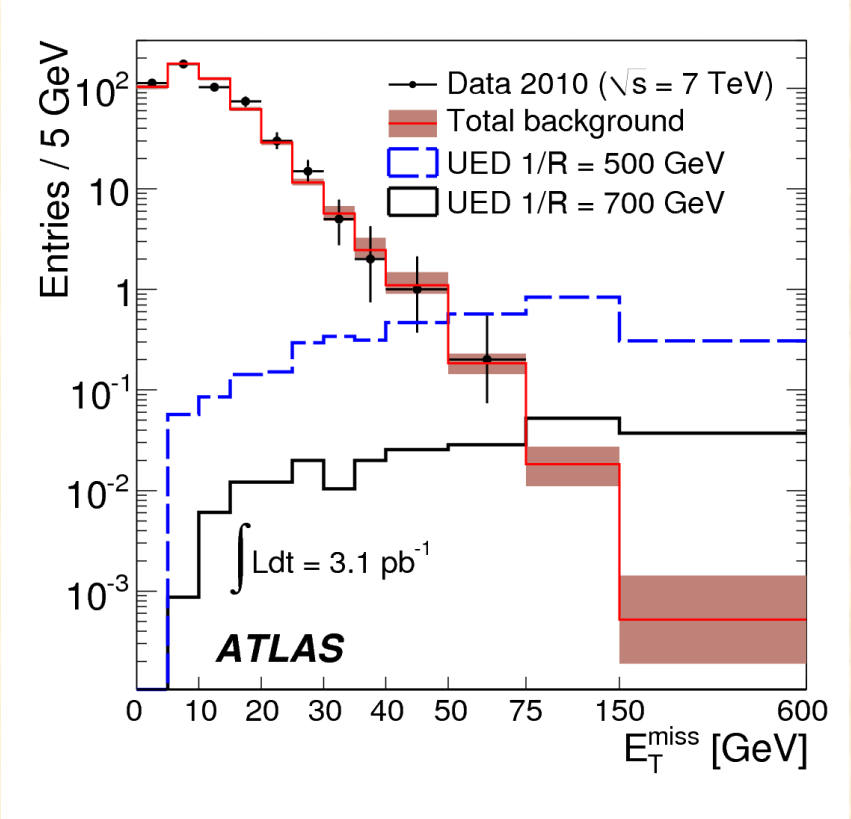
  W/Z+γγ (σ~fb)

→ Good agreement with 'BG prediction'

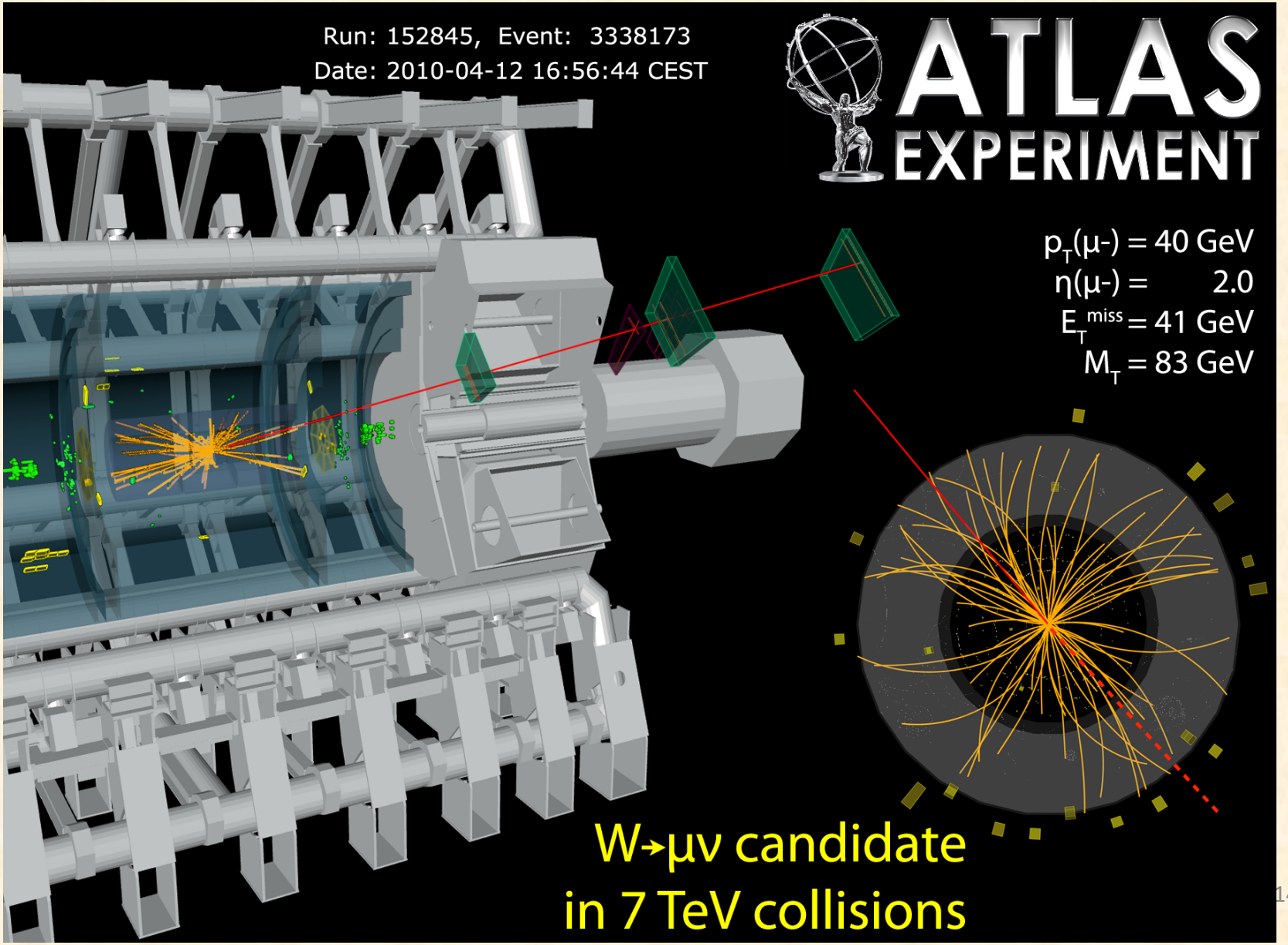
→ New exclusion limits for Universal Extra Dimensions in terms of a compactification radius:

1/R < 728 GeV

[Tevatron 1/R<477 GeV]



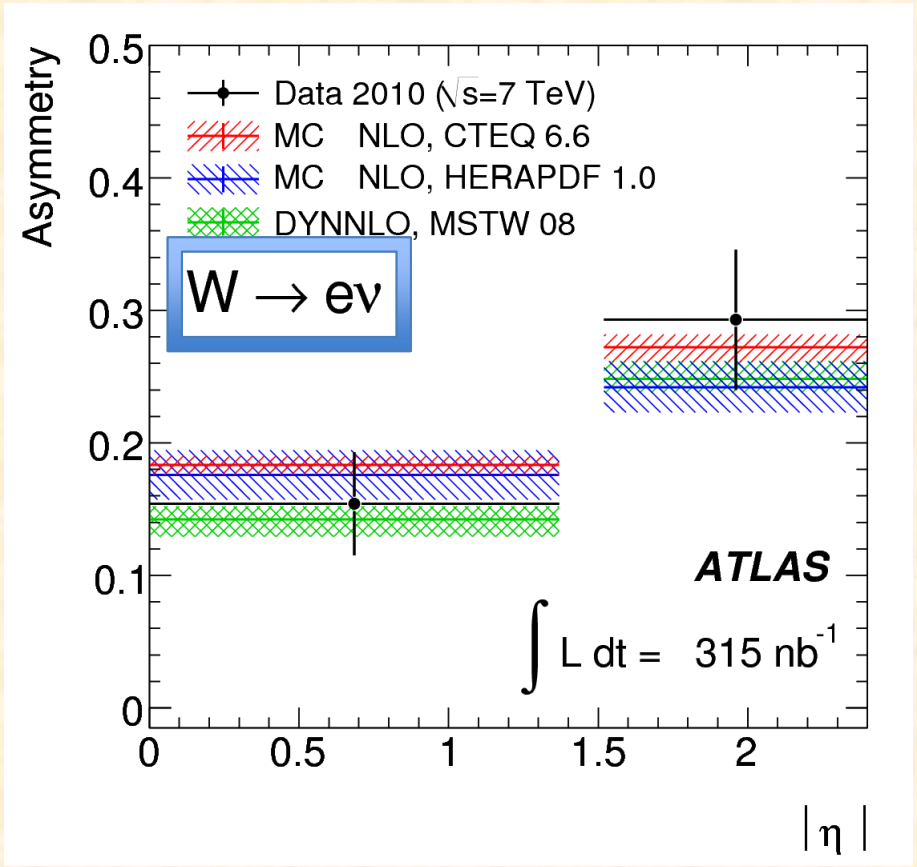
W→ μν Candidate

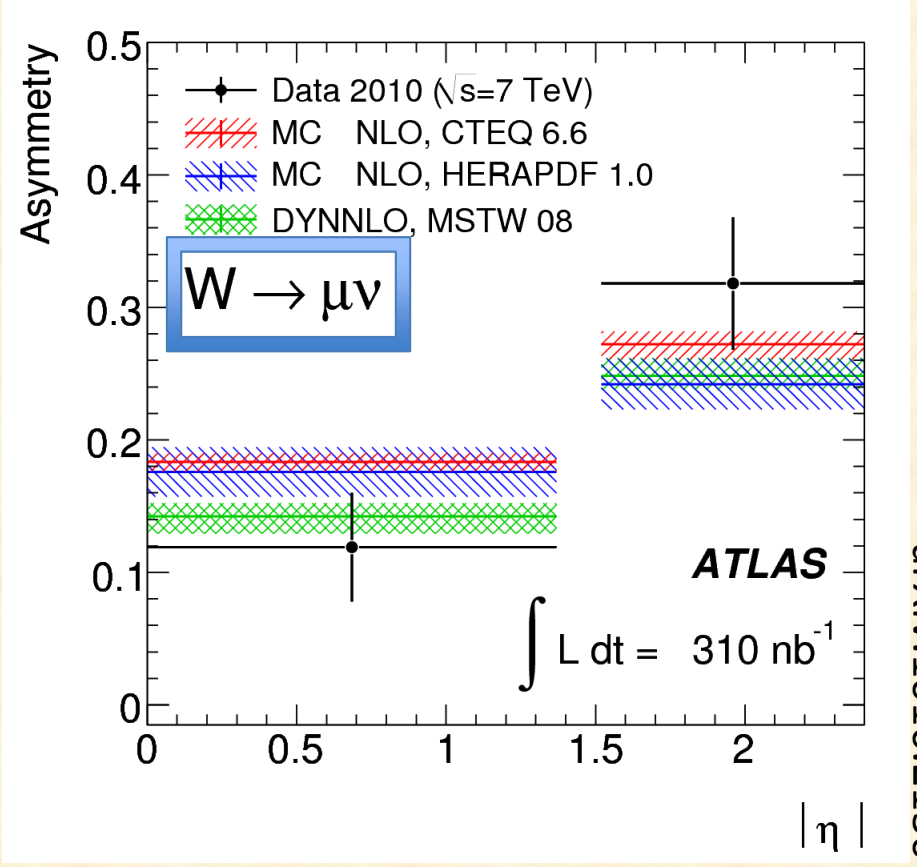


315 nb^{-1}

W Charge Asymmetry

- Select high p_T>20 GeV leptons within $|\eta^{\mu}|$<2.4, $|\eta^{e}|$<1.37 and 1.52<$|\eta^{e}|$<2.47 , $E_{T,miss}$>25 GeV and m_T>40 GeV
- Luminosity uncertainty cancels.
- Sensitive to PDFs.
- Results for fiducial cuts.



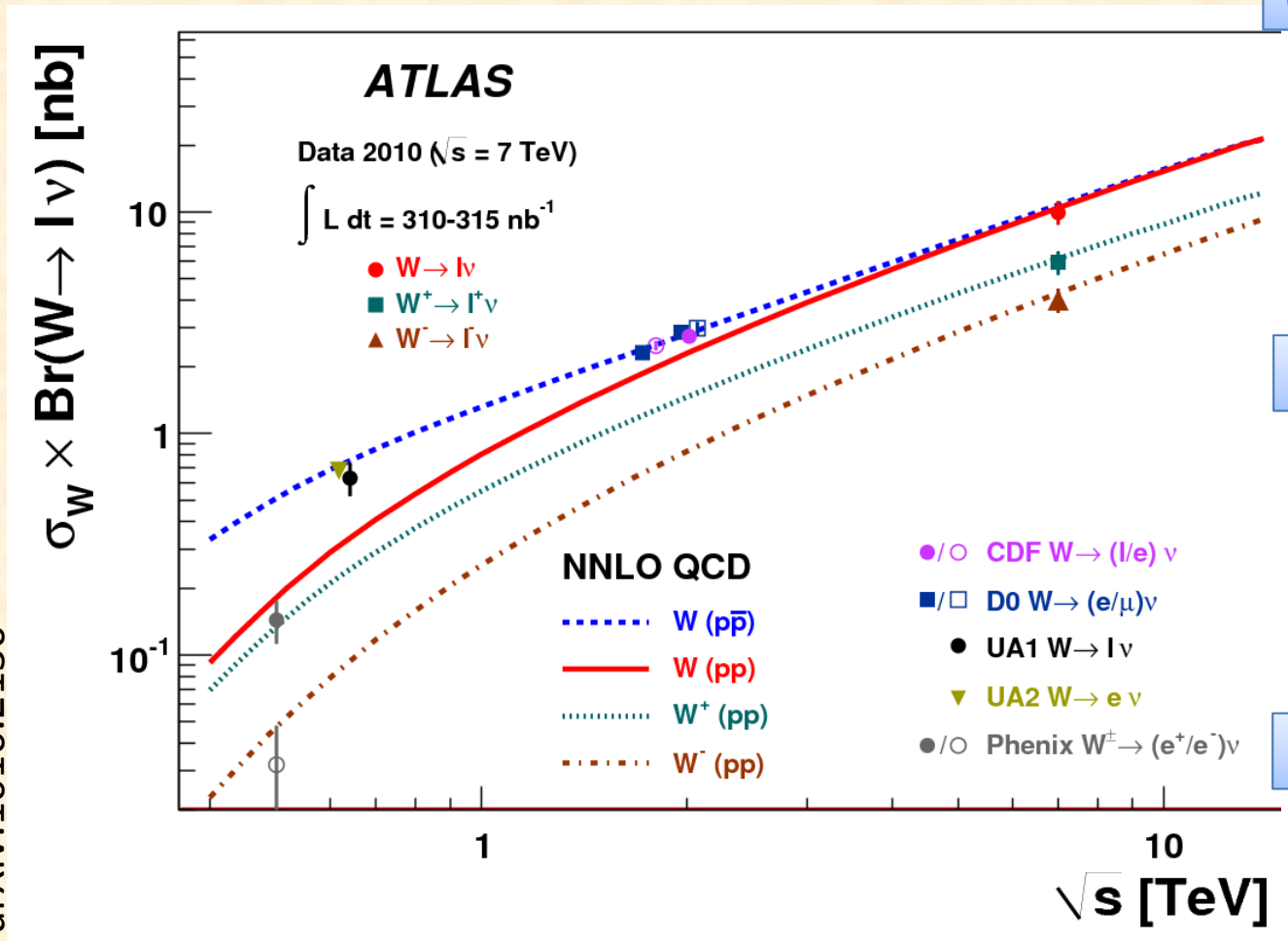


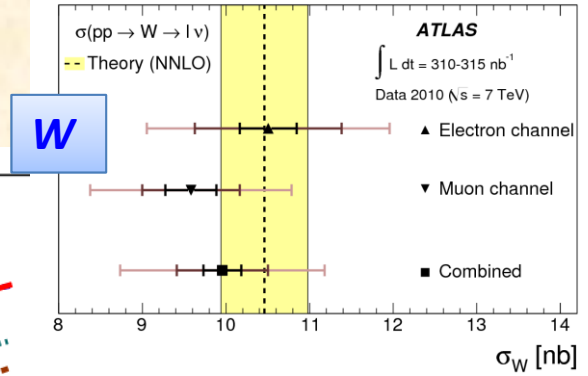
arXiv:1010.2130

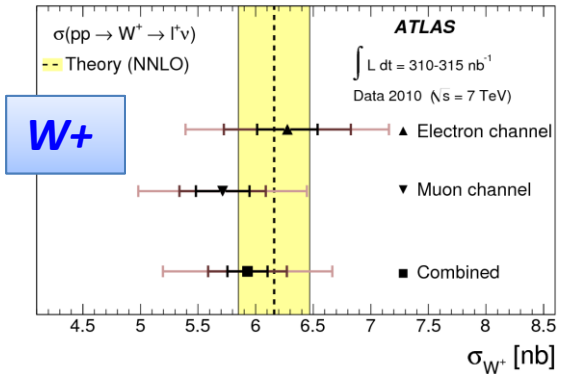
310-315 nb^{-1}

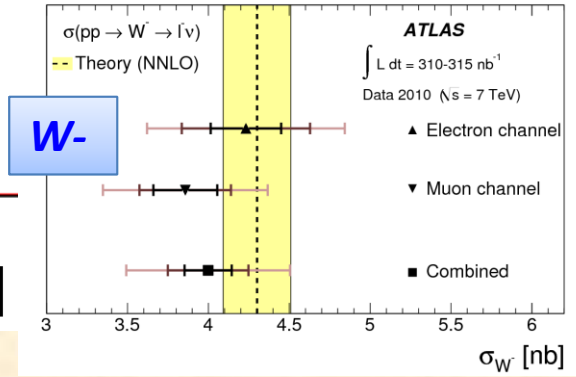
W Boson Production

Total cross section results.







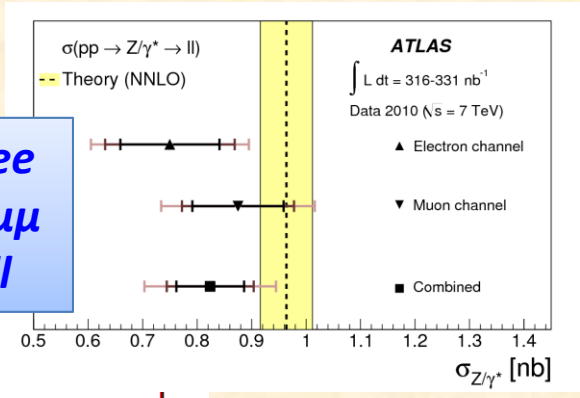


arXiv:1010.2130

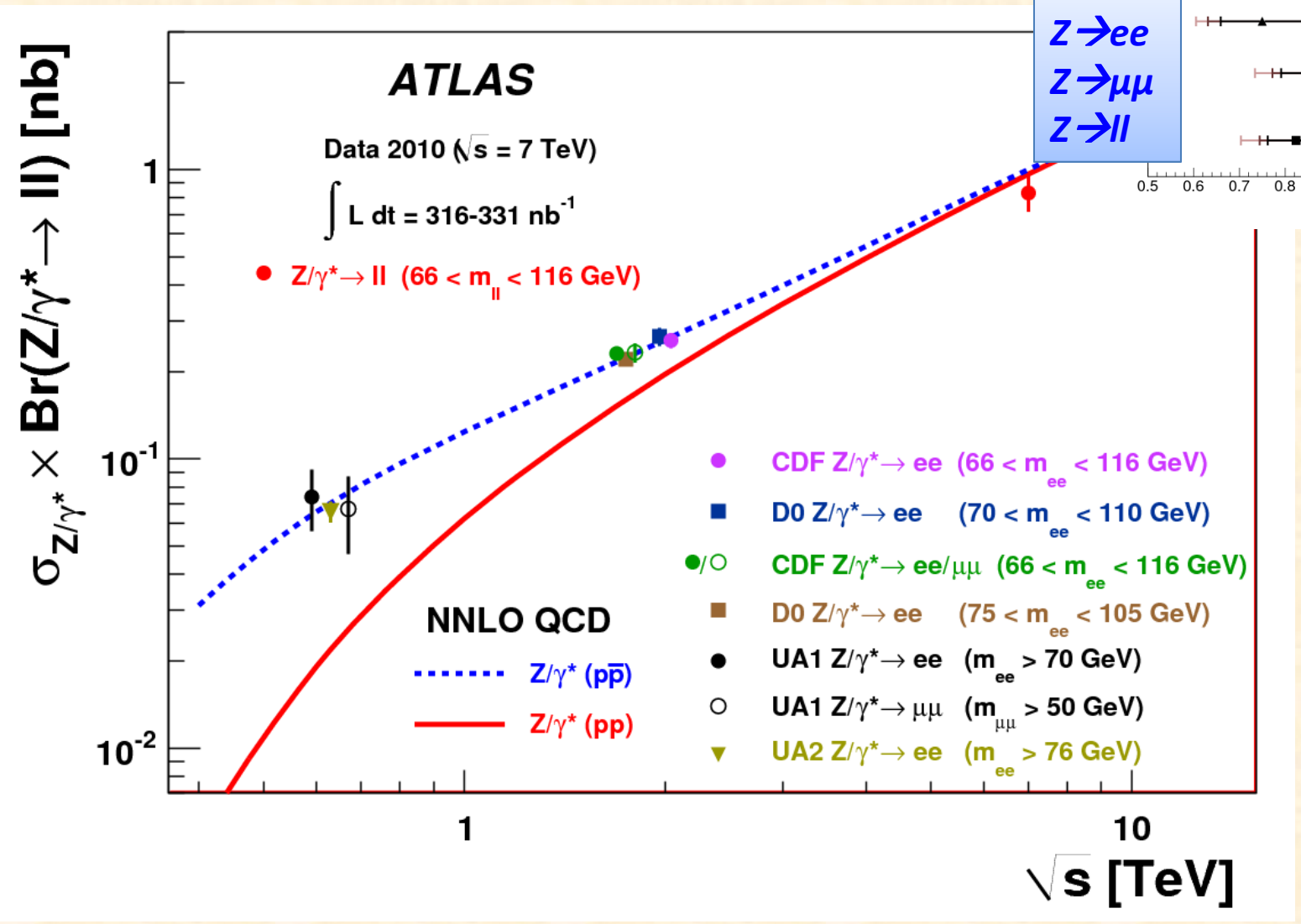
316-331 nb^{-1}

Z/γ* Production $66<M_{ll}<116$ GeV

Total cross section results.



Z→ee
Z→μμ
Z→ll



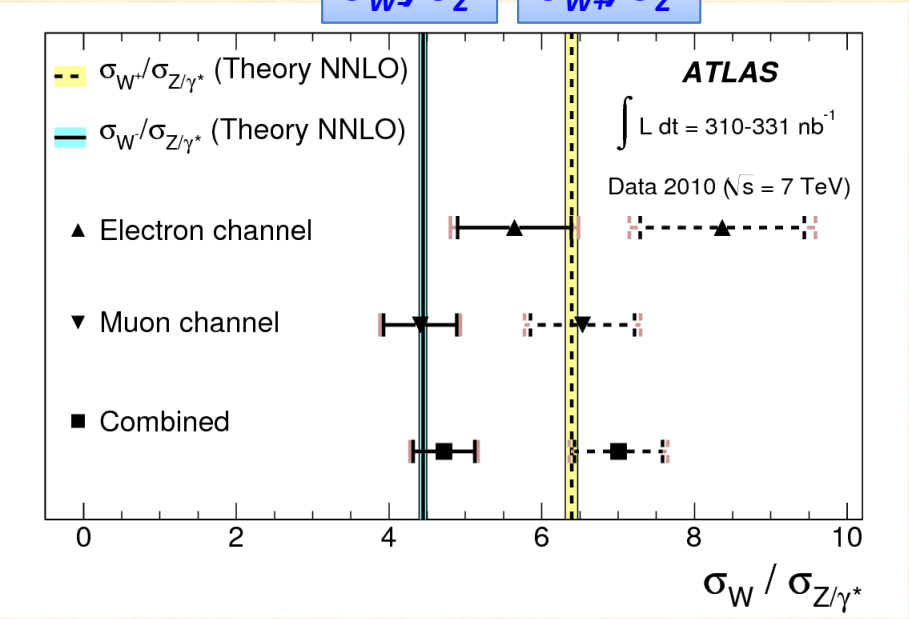
arXiv:1010.2130

316-331 nb^{-1}

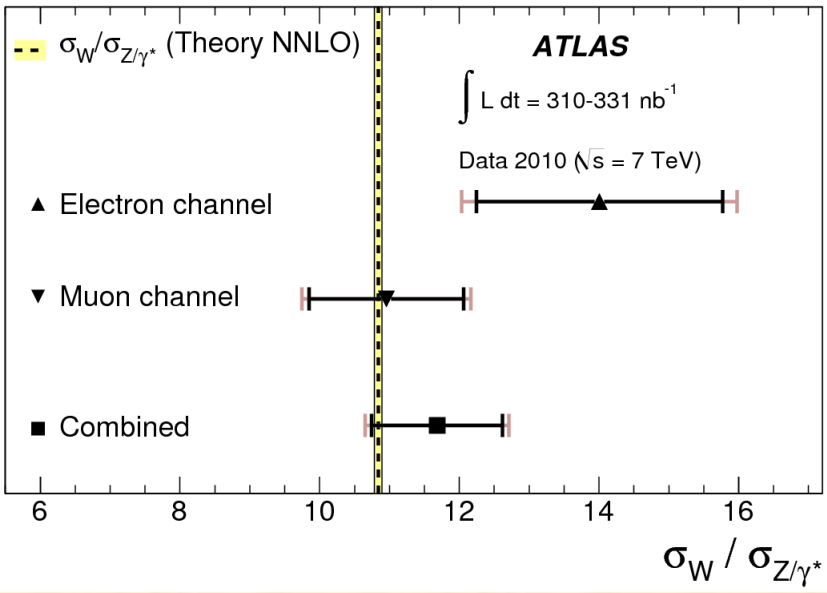
W and Z and their Ratios

Based on total cross section results.

σ_{W^-}/σ_Z σ_{W^+}/σ_Z



σ_W/σ_Z



arXiv:1010.2130

Good agreement with NNLO predictions for W and Z boson production cross sections and their ratios.

Published data can not distinguish yet between different PDF sets.

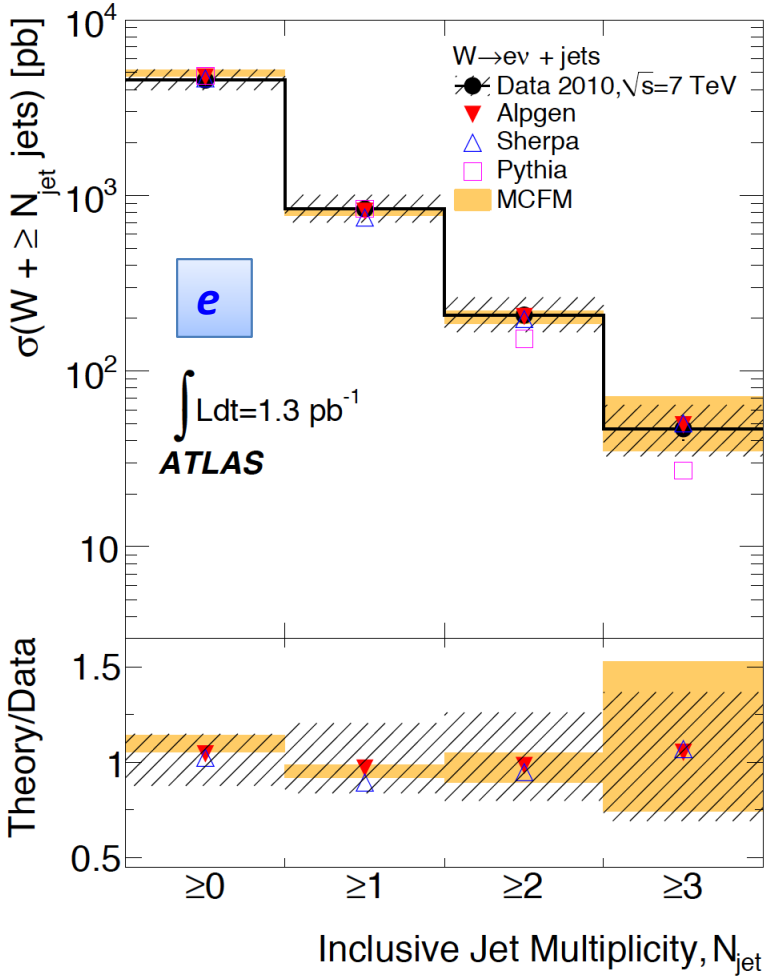
1.3 pb^{-1}

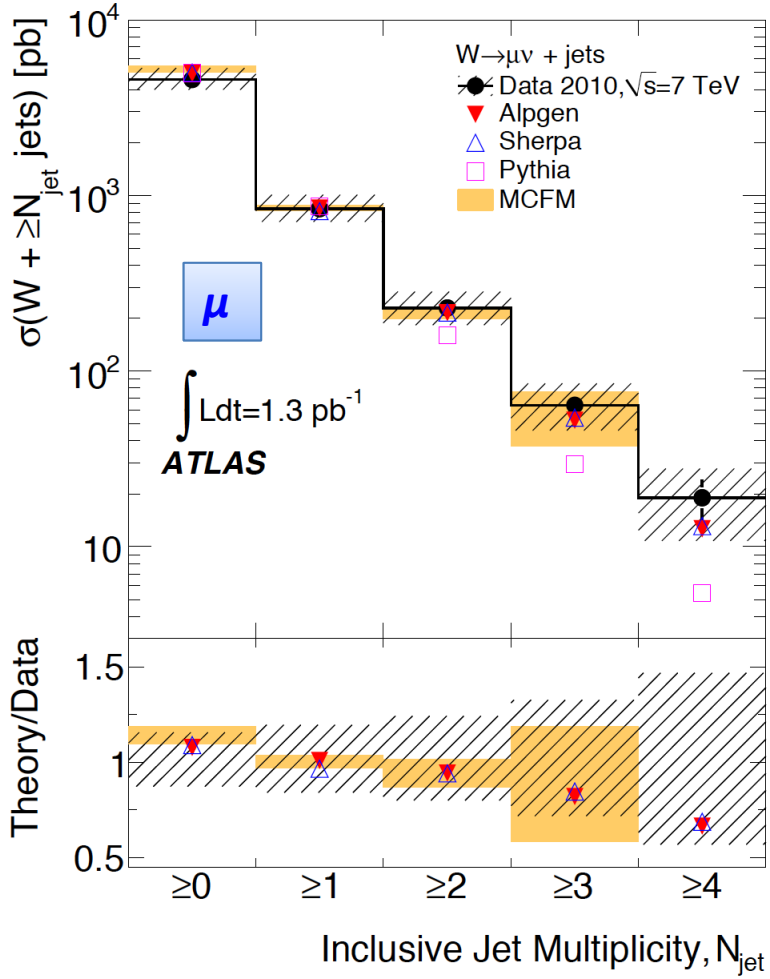
W+Jets

$$\sigma(W+ \geq n)/\sigma(W+ \geq n-1)$$

for inclusive jet multiplicities $n = 1$–4

- electron or muon selection as in W/Z boson paper





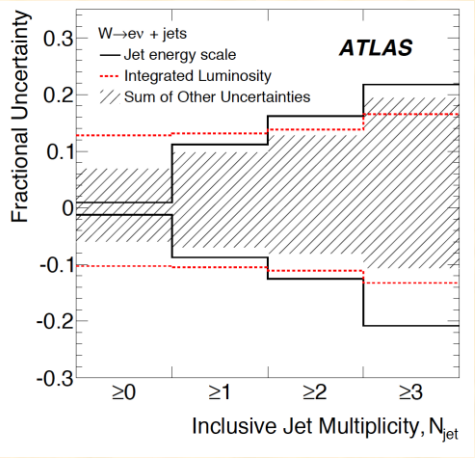
arXiv:1012.5382

W+Jets

Cross section times branching fraction

Jet multiplicity	$W \to e\nu$ (nb)	MCFM $W \to e\nu$ (nb)	$W \to \mu\nu$ (nb)	MCFM $W \to \mu\nu$ (nb)
≥ 0	$4.53 \pm 0.07\ ^{+0.35}_{-0.30}\ ^{+0.58}_{-0.47}$	$5.08^{+0.11}_{-0.30}$	$4.58 \pm 0.07\ ^{+0.38}_{-0.32}\ ^{+0.61}_{-0.48}$	$5.27^{+0.11}_{-0.32}$
≥ 1	$0.84 \pm 0.03^{+0.13}_{-0.10}\ ^{+0.11}_{-0.09}$	$0.81^{+0.02}_{-0.04}$	$0.84 \pm 0.03\ ^{+0.11}_{-0.09}\ ^{+0.11}_{-0.09}$	$0.84^{+0.02}_{-0.04}$
≥ 2	$0.21 \pm 0.01\ ^{+0.04}_{-0.03}\ ^{+0.03}_{-0.02}$	$0.21^{+0.01}_{-0.02}$	$0.23 \pm 0.02\ ^{+0.04}_{-0.03}\ ^{+0.03}_{-0.02}$	$0.21^{+0.01}_{-0.02}$
≥ 3	$0.047 \pm 0.007^{+0.014}_{-0.011}\ ^{+0.008}_{-0.006}$	0.05 ± 0.02	$0.064 \pm 0.008\ ^{+0.016}_{-0.014}\ ^{+0.010}_{-0.008}$	0.05 ± 0.02
≥ 4	-	-	$0.019 \pm 0.005 \pm 0.006\ ^{+0.004}_{-0.003}$	-

systematic uncertainty



arXiv:1012.5382

Cross section ratios

Jet multiplicity	$W \to e\nu$	MCFM $W \to e\nu$	$W \to \mu\nu$	MCFM $W \to \mu\nu$
$\geq 1/\geq 0$	$0.185 \pm 0.007^{+0.025}_{-0.019}$	$0.159^{+0.006}_{-0.005}$	$0.183 \pm 0.007^{+0.023}_{-0.020}$	$0.160^{+0.006}_{-0.005}$
$\geq 2/\geq 1$	$0.250 \pm 0.019^{+0.019}_{-0.010}$	$0.255^{+0.017}_{-0.022}$	$0.274 \pm 0.020^{+0.018}_{-0.011}$	$0.255^{+0.017}_{-0.021}$
$\geq 3/\geq 2$	$0.224 \pm 0.037 \pm 0.022$	$0.241^{+0.108}_{-0.061}$	$0.278 \pm 0.041^{+0.024}_{-0.020}$	$0.242^{+0.104}_{-0.061}$
$\geq 4/\geq 3$	-	-	$0.297 \pm 0.088^{+0.037}_{-0.026}$	-

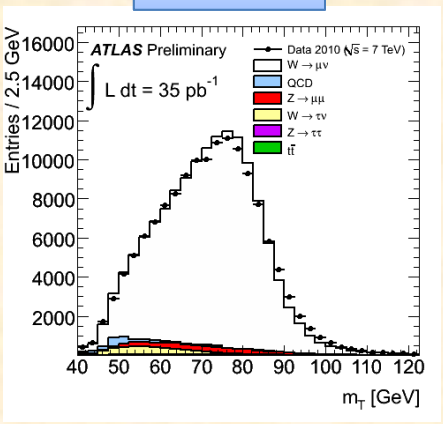
MCFM: NLO for $N_{jet} \leq 2$ and LO for $N_{jet}=3$

➔ good agreement with theory

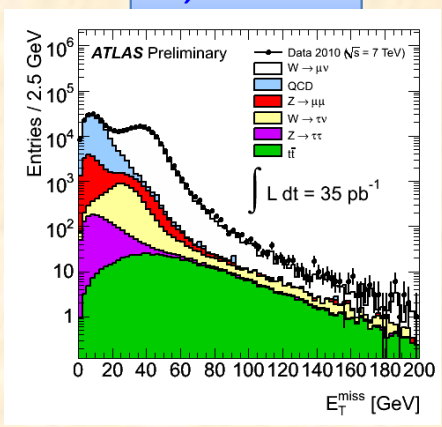
35-42 pb^{-1}

… More Precise Results Under Way

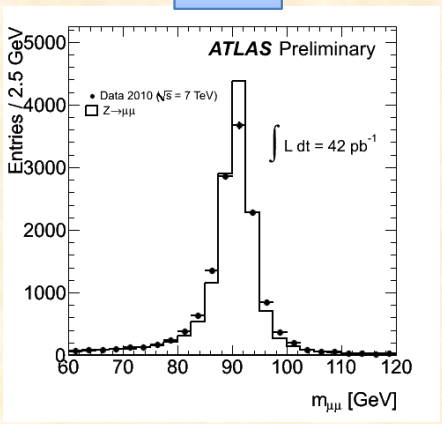
$M_T(W)$



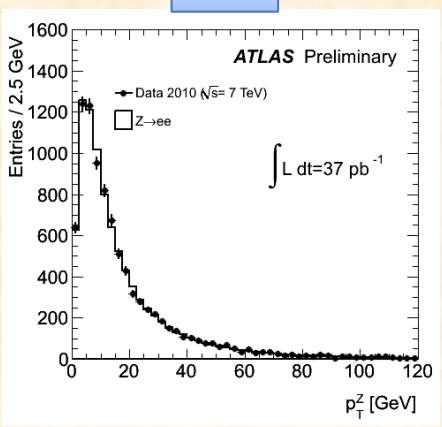
$E_{T,miss}(W)$



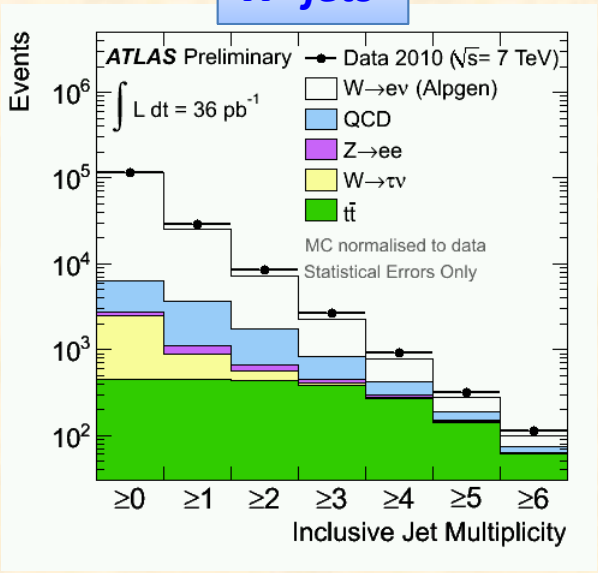
M_{ll}



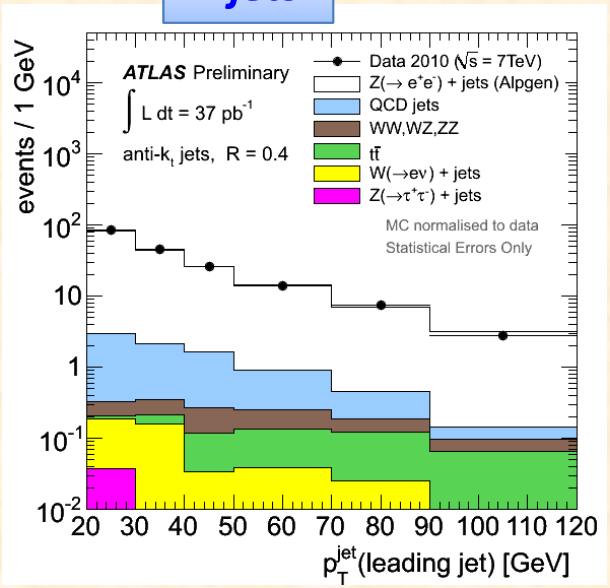
p_T^{ll}



W+jets



Z+jets

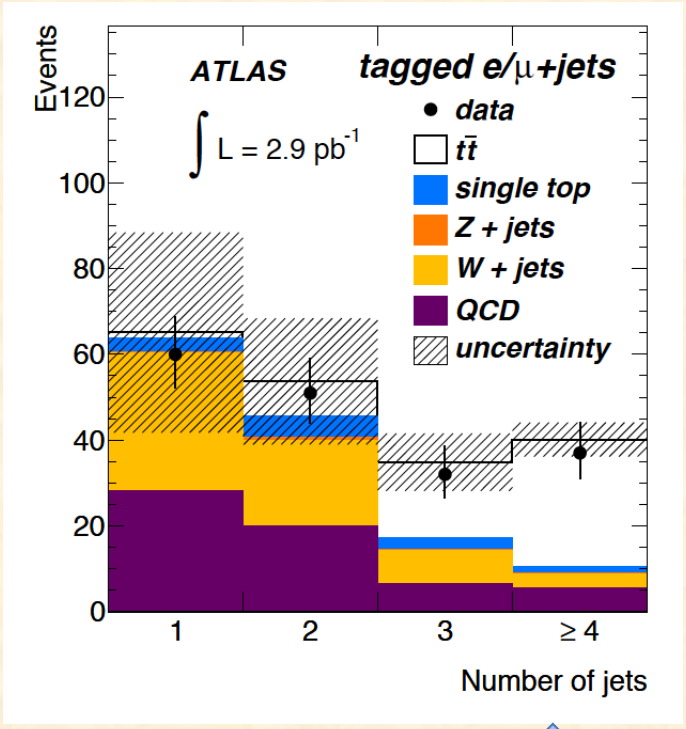


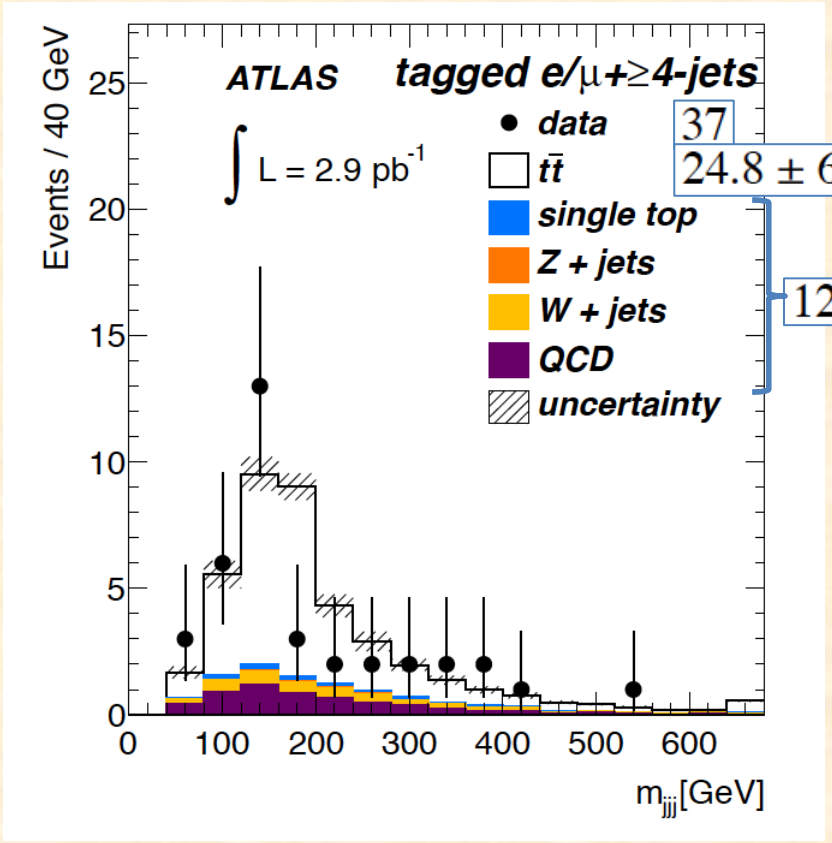
https://twiki.cern.ch/twiki/bin/view/AtlasPublic/StandardModelPublicCollisionPlots

Top Candidates

- select jets with $p_T > 25$ GeV and $|\eta| < 2.5$ and b-tag for either 1,2,3 or at least 4 jets and a *single high pT>20 GeV lepton e/μ* and

$$E_{\mathrm{T}}^{\mathrm{miss}} > 20 \text{ GeV and } E_{\mathrm{T}}^{\mathrm{miss}} + m_T(W) > 60 \text{ GeV}$$



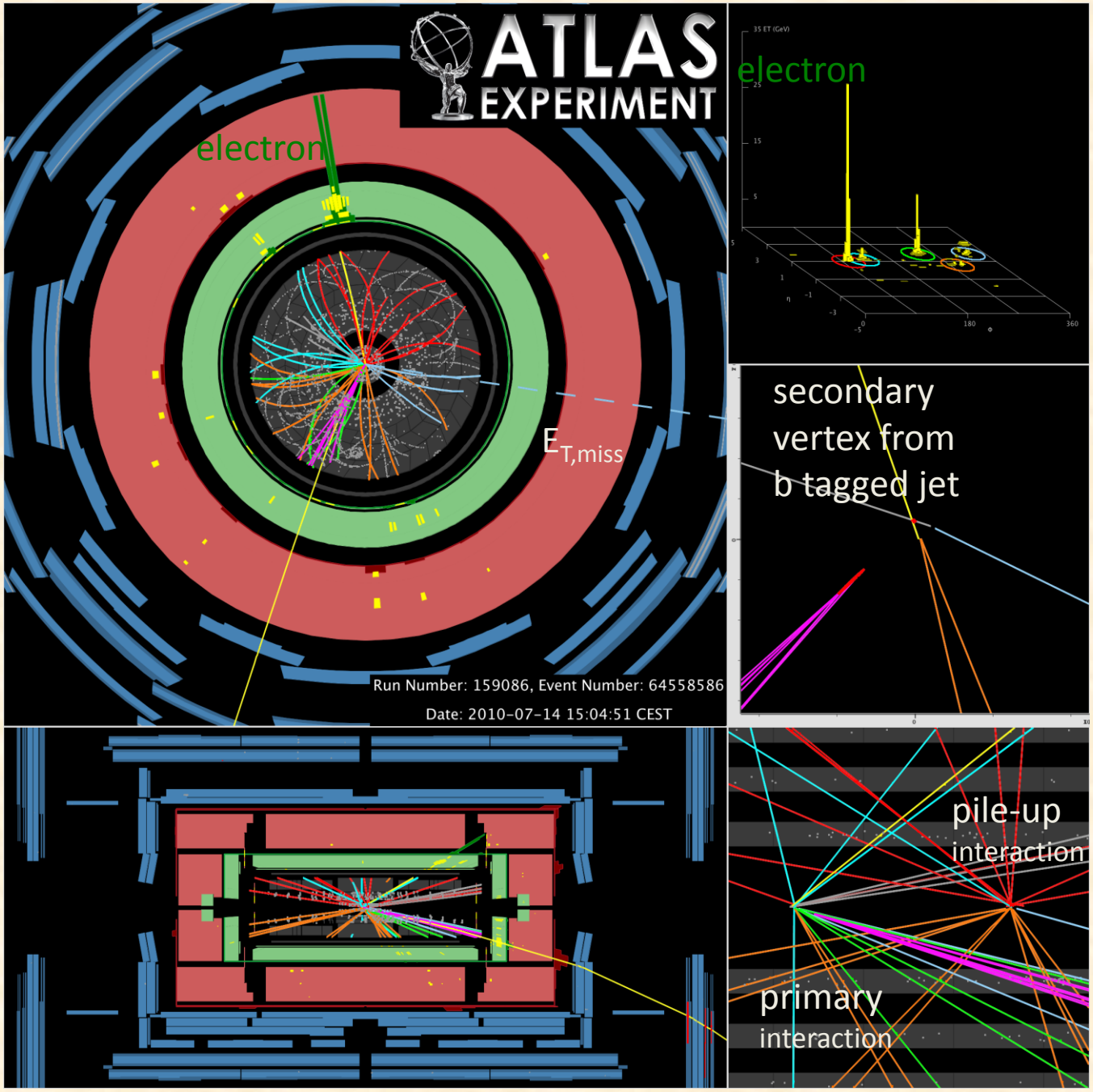


arXiv:1012.1792

Signal region: Acceptance*Branching fraction about 3%

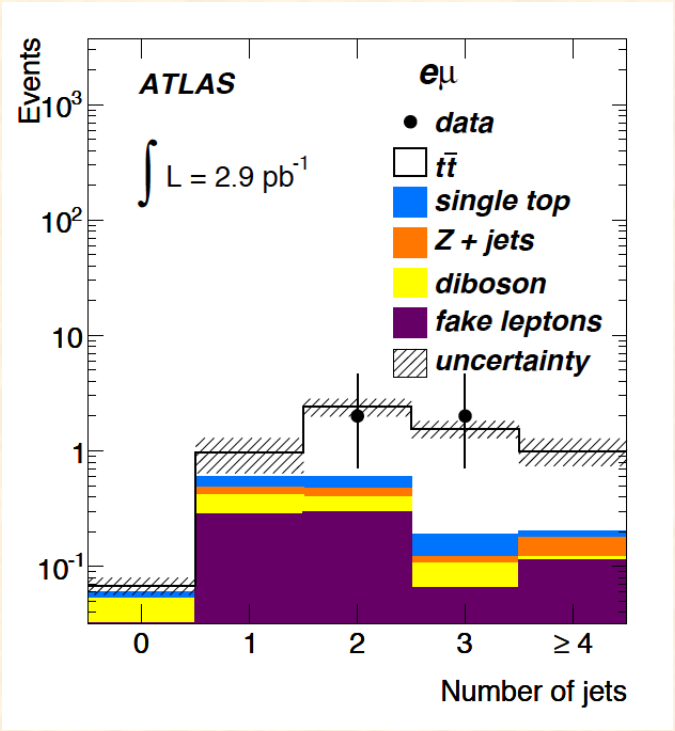
Electron + Jets Top Candidate

- JES uncertainty 6-10% in dependence of p_T(jet) and η
- JER 14%
- b-tagging efficiency (from data) rises from 40% to 60% for $25<p_T(\text{jet})<85$ GeV while mistag fraction increases from 0.2% to 1%



Top in the Dilepton Channel

- select jets with $p_T > 25$ GeV and $|\eta| < 2.5$ and b-tag for two jets *and two high p_T>20 GeV leptons ee/μμ/eμ* and $E_{T,miss}$>40 GeV



arXiv:1012.1792

Observed data and expected tt signal and background in the dilepton channel

	ee	*μμ*	*eμ*
Z+jets (DD)	0.25 ± 0.18	0.67 ± 0.38	-
$Z(\rightarrow \tau\tau)$+jets (MC)	0.07 ± 0.04	0.14 ± 0.07	0.13 ± 0.06
Non-Z leptons (DD)	0.16 ± 0.18	-0.08 ± 0.07	0.47 ± 0.28
Single top (MC)	0.08 ± 0.02	0.07 ± 0.03	0.22 ± 0.04
Dibosons (MC)	0.04 ± 0.02	0.07 ± 0.03	0.15 ± 0.05
Total (non $t\bar{t}$)	0.60 ± 0.27	0.88 ± 0.40	0.97 ± 0.30
$t\bar{t}$(MC)	1.19 ± 0.19	1.87 ± 0.26	3.85 ± 0.51
Total expected	1.79 ± 0.38	2.75 ± 0.55	4.82 ± 0.65
Observed	2	3	4

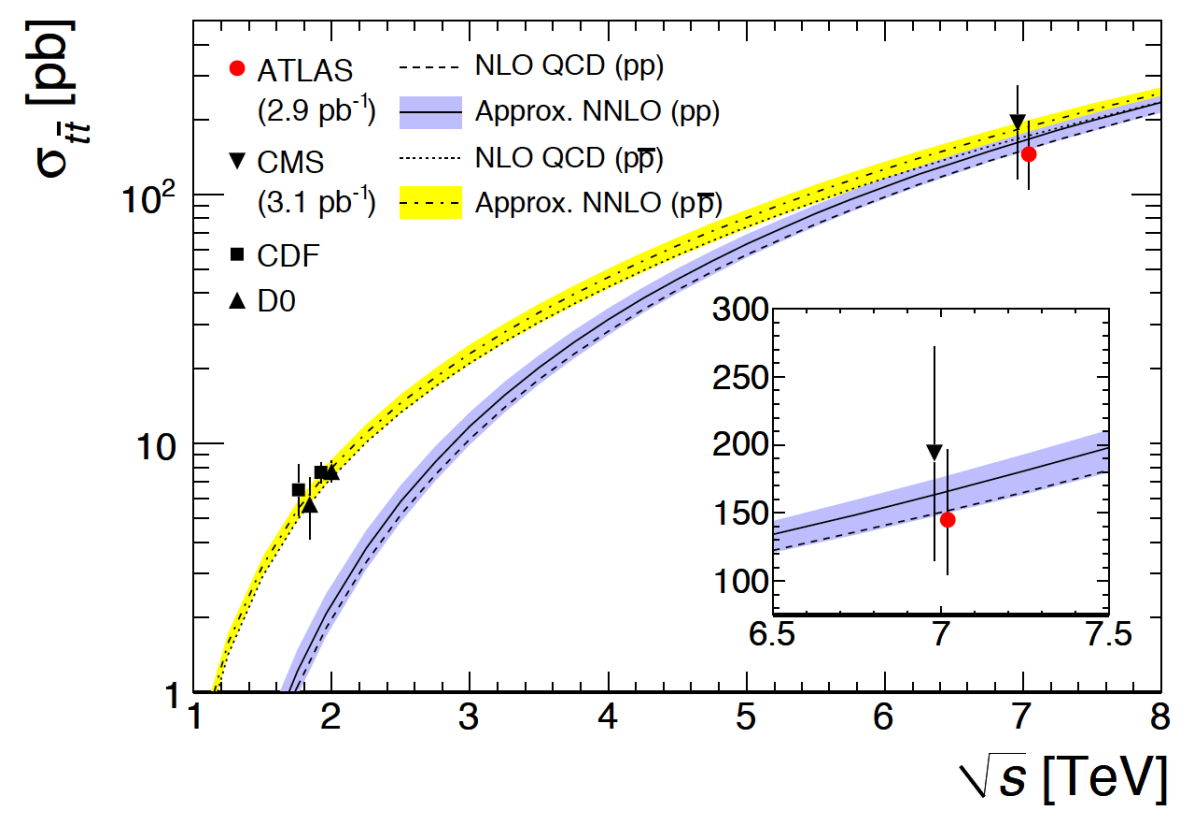
DD/MC : data driven/MC background estimates
Systematic uncertainties included

Signal region: Acceptance*Branching fraction about 0.24% (ee), 0.38% (μμ), 0.81% (eμ)

Top Pair Cross Section at 7 TeV

	Cross-section [pb]	Signal significance [σ]
Single lepton channels	$142 \pm 34\ ^{+50}_{-31}$	4.0
Dilepton channels	$151\ ^{+78}_{-62}\ ^{+37}_{-24}$	2.8
All channels	$145 \pm 31\ ^{+42}_{-27}$	4.8

Theory predictions using CTEQ6.6 PDFs and top mass of 172.5 GeV

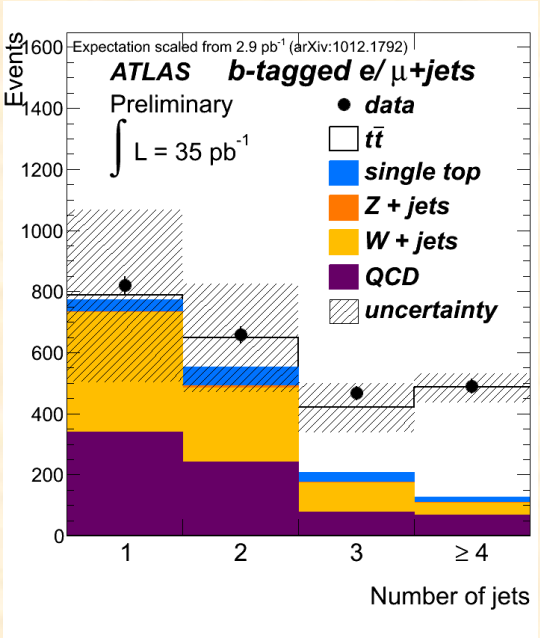


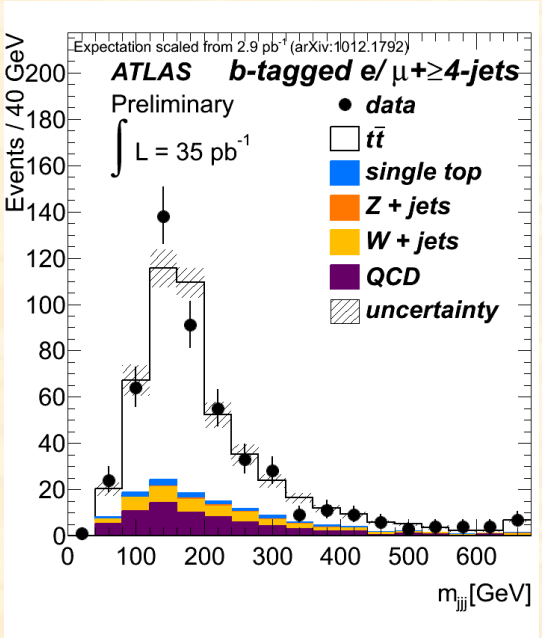
35 pb^{-1}

… Top from all 2010 pp Data

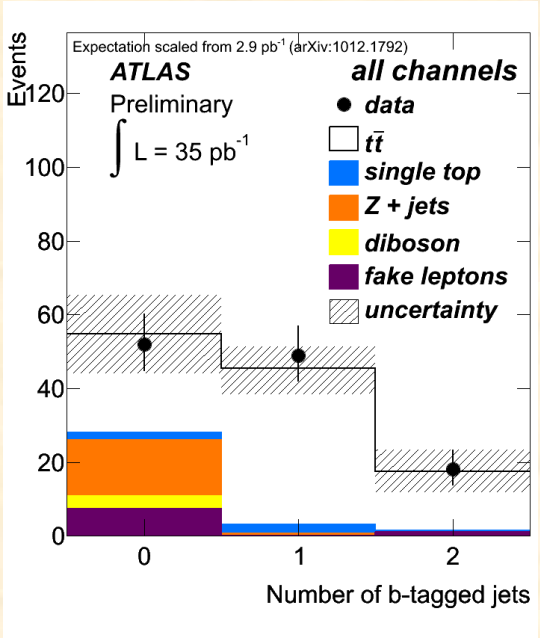
https://twiki.cern.ch/twiki/bin/view/AtlasPublic/TopCollisionPlots

Single lepton channel





Dilepton channel



➔preliminary results for single and dilepton channels are very encouraging

➔uncertainties on the background estimates are expected to be reduced for the full analyses

Summary and Outlook

- ATLAS performed excellently in its first physics year regarding the detector performance for complex particle final states.

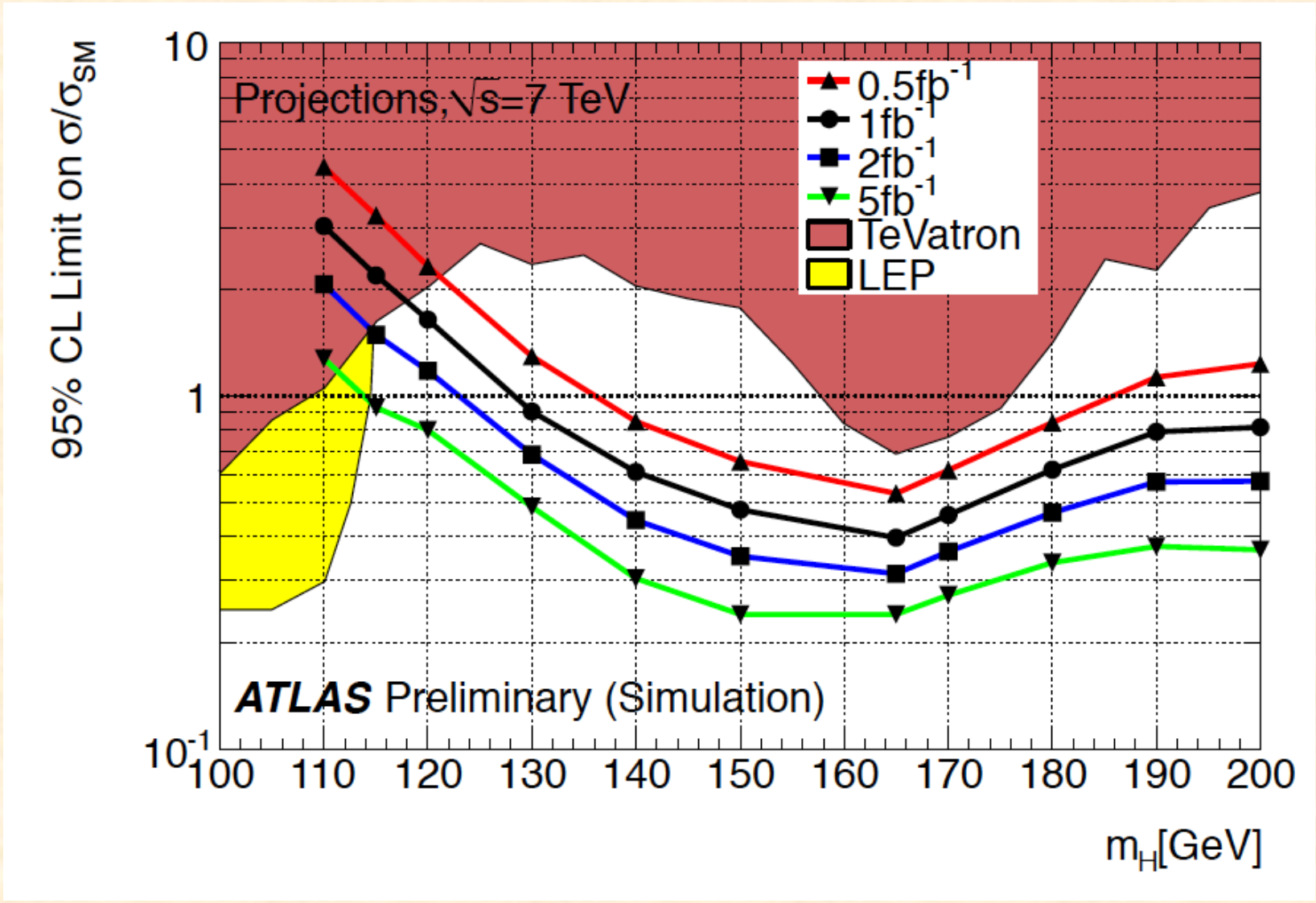
- ATLAS is exploring the Standard Model at uncharted high energies and ***expanding so far the validity range of the Standard Model***

→ ***good descriptions of key observables like high p_T of jets and leptons and high $E_{T,miss}$ by Monte Carlo.***

- **The ultimate goal remains to hunt for the SM Higgs *and for deviations from the Standard Model.***

We are eagerly awaiting the 2011 data!

ATLAS Higgs Prospects



ATL-PHYS-PUB-2010-015

BackUp

LHC Peak Performance in 2010

Peak stable luminosity delivered	$2.07 \times 10^{32}\ cm^{-2}s^{-1}$
Maximum luminosity delivered in one fill	$6304.61\ nb^{-1}$
Maximum luminosity delivered in one day	$5983.78\ nb^{-1}$
Maximum luminosity delivered in 7 days	$24637\ nb^{-1}$
Maximum colliding bunches	348
Maximum average events per bunch crossing	3.78
Longest time in Stable Beams for one fill	30.3 hours
Longest time in Stable Beams for one day	22.8 hours (94.9%)
Longest time in Stable Beams for 7 days	69.9 hours (41.6%)
Fastest turnaround to Stable Beams	3.66 hours (protons)

W+1Jet Cross Section Systematic

e channel		
Effect	Range	Cross Section Uncertainty (%)
Jet energy scale and $E_{\mathrm{T}}^{\mathrm{miss}}$	$\pm 10\%$ (dependent on jet η and p_{T}) $\oplus$ 5%	+11, -9
Jet energy resolution	14% on each jet	± 1.0
Electron trigger	$\pm 0.5\%$	∓ 0.7
Electron identification	$\pm 5.2\%$	∓ 5.5
Electron energy scale	$\pm 3\%$	+3.9, -4.7
Pile–up removal cut	$4-7\%$ in lowest jet p_{T} bin	± 1.9
Residual pile-up effects	from simulation	± 2.2
QCD background shape	from template variation	-1.5, +5.2
Luminosity	$\pm 11\%$	-10, +13

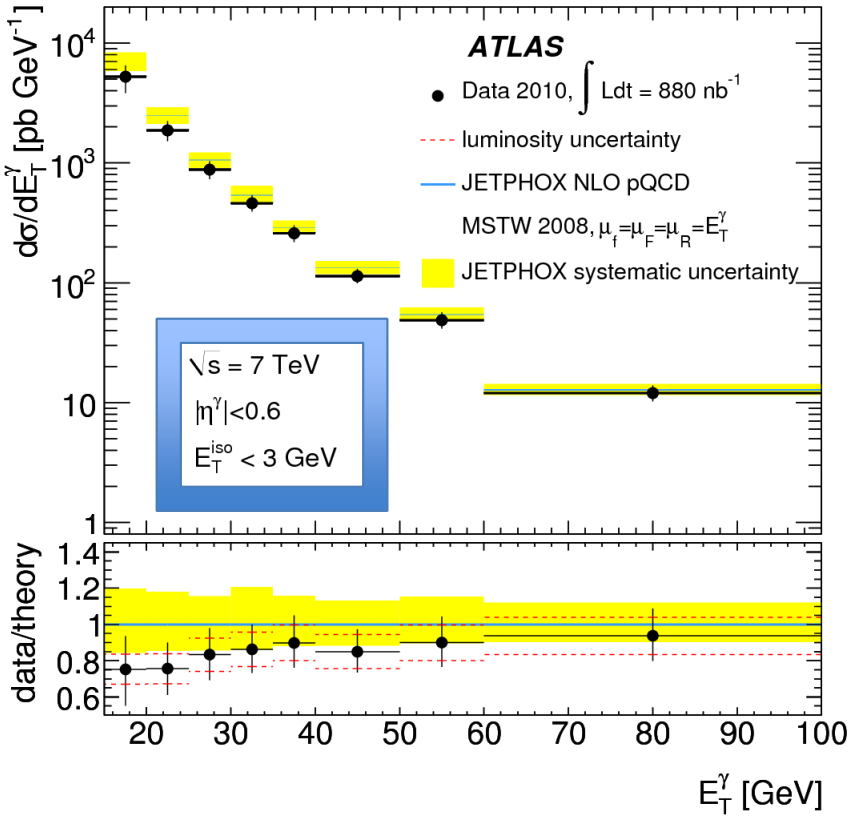
μ channel		
Effect	Range	Cross Section Uncertainty (%)
Jet energy scale and $E_{\mathrm{T}}^{\mathrm{miss}}$	$\pm 10\%$ (dependent on jet η and p_{T}) $\oplus$ 5%	+11, -9
Jet energy resolution	14% on each jet	± 1.8
Muon trigger	$\pm 2.5\%$ in barrel, $\pm 2.0\%$ in endcap	∓ 1.6
Muon reconstruction	$\pm 5.6\%$	-5.4, +5.9
Muon momentum scale	$\pm 1\%$	+2, -0.9
Muon momentum resolution	$\pm 5\%$ in barrel, $\pm 9\%$ in endcap	± 1.4
Pile–up removal cut	$4-7\%$ in lowest jet p_{T} bin	± 1.7
Residual pile-up effects	from simulation	± 1.4
Luminosity	$\pm 11\%$	-11, +13

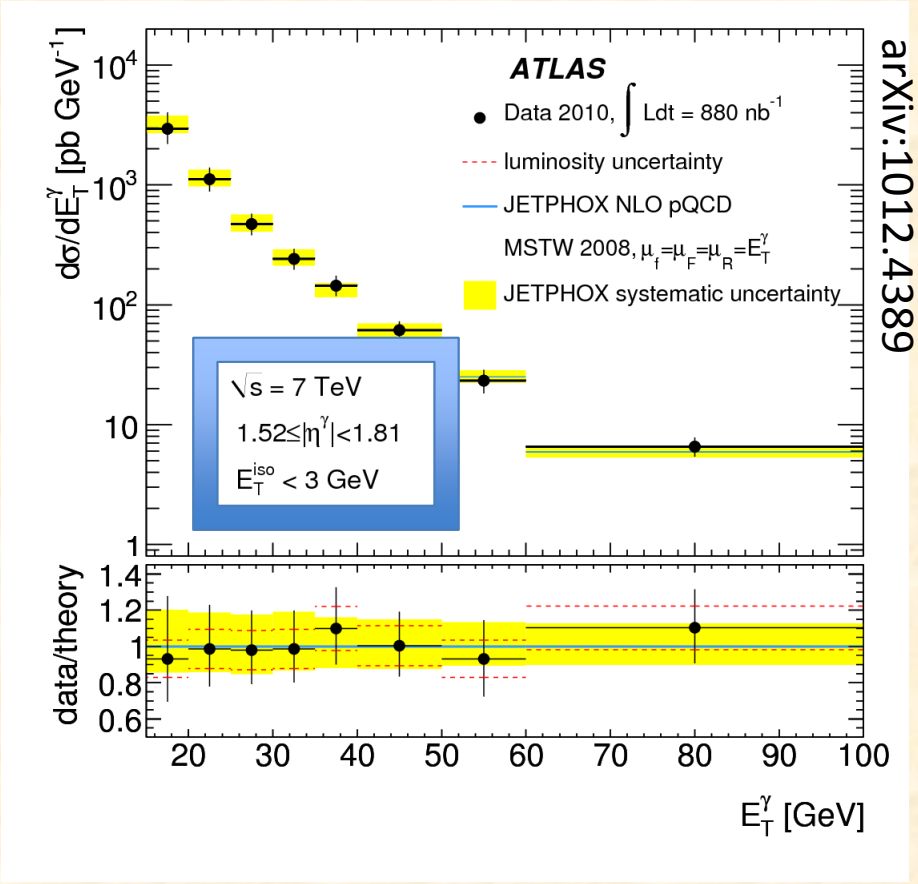
arXiv:1012.5382

880 nb^{-1}

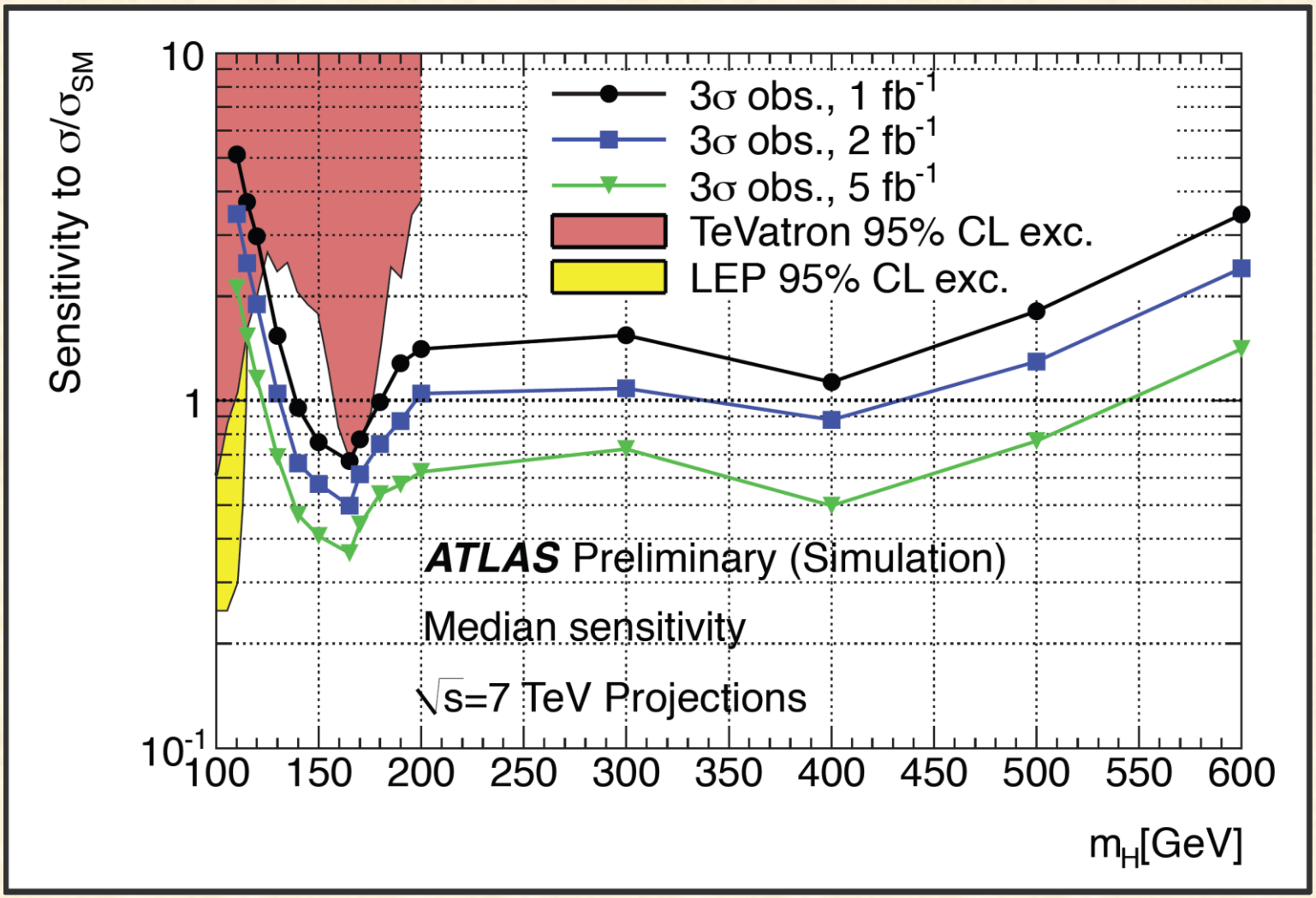
Inclusive Prompt Photons

- select isolated photons with E_T>15 GeV
- cross section measured in 3 different η ranges within $|\eta^\gamma|$<1.81





Higgs Observation Prospects



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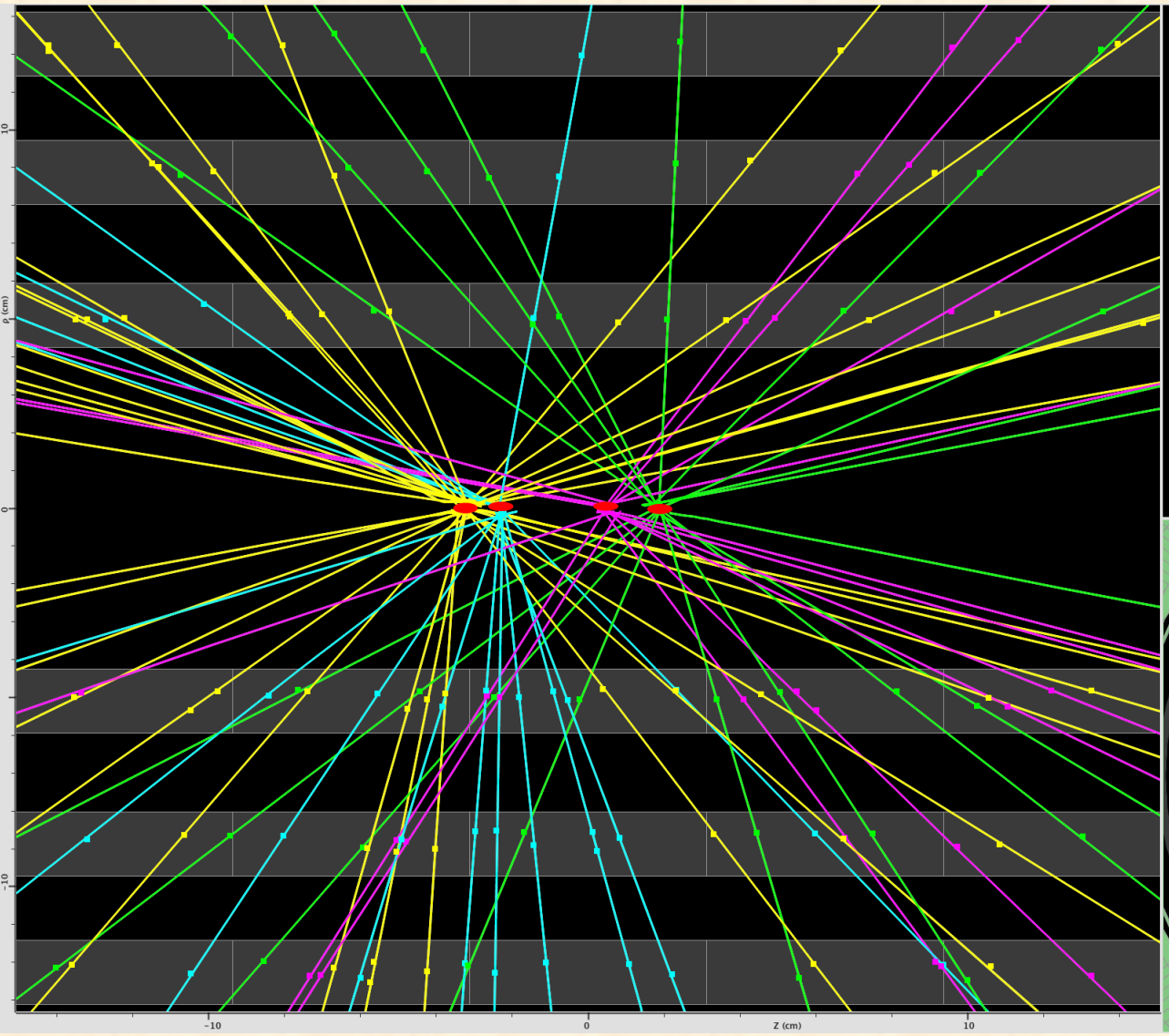
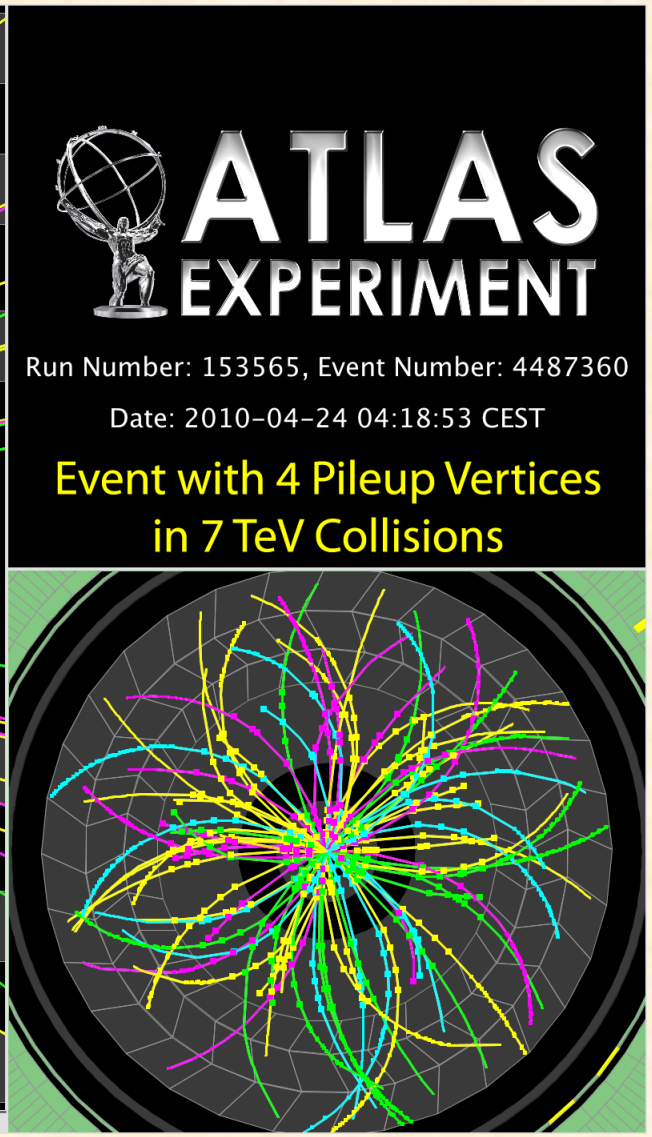
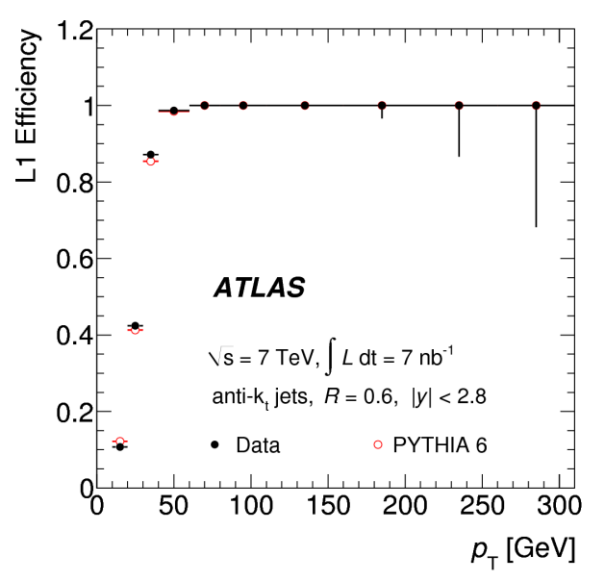
Pileup Event with 4 Vertices



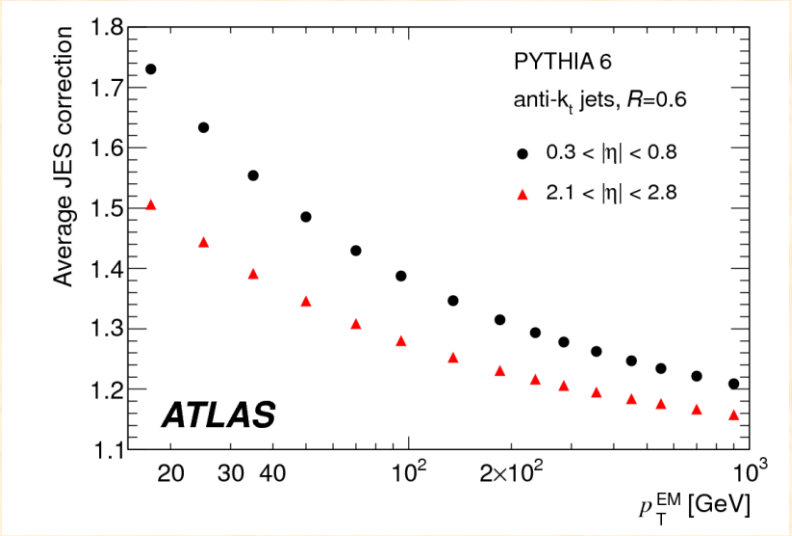


Jet Performance

L1 trigger

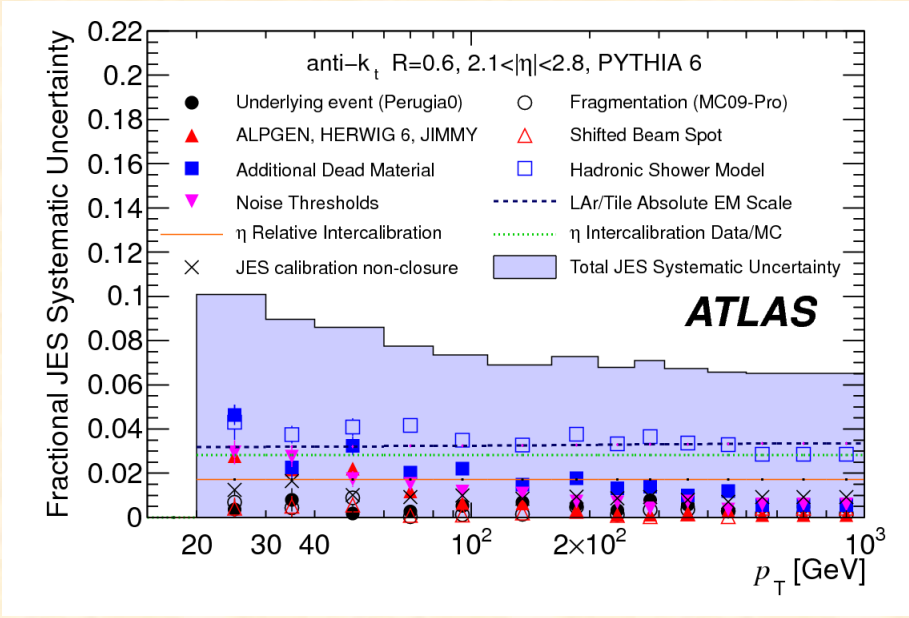


Average JES correction



arXiv:1009.5908

JES scale uncertainty in the end-cap region



Anti-Kt Jet algorithm

- For each input object (Topological Clusters), d_{ij} and d_{iB} are defined as

$$d_{ij} = \min\left(p_{Ti}^{-2}, p_{Tj}^{-2}\right)\frac{\Delta R_{ij}^2}{R^2}$$

$$d_{iB} = p_{Ti}^{-2}$$

$$\Delta R_{ij}^2 = \left(y_i - y_j\right)^2 + \left(\varphi_i - \varphi_j\right)^2$$

- A list of d_{ij} and d_{iB} are formed;
  - If d_{ij} is the smallest entry; objects i and j are combined and the list remade
  - If d_{iB} is smallest, it is a jet by itself
- Anti-Kt algorithm:
- is infra-red and collinear safe
- produces geometrically well-defined (cone-like) jets

Courtesy of C.Gwelan