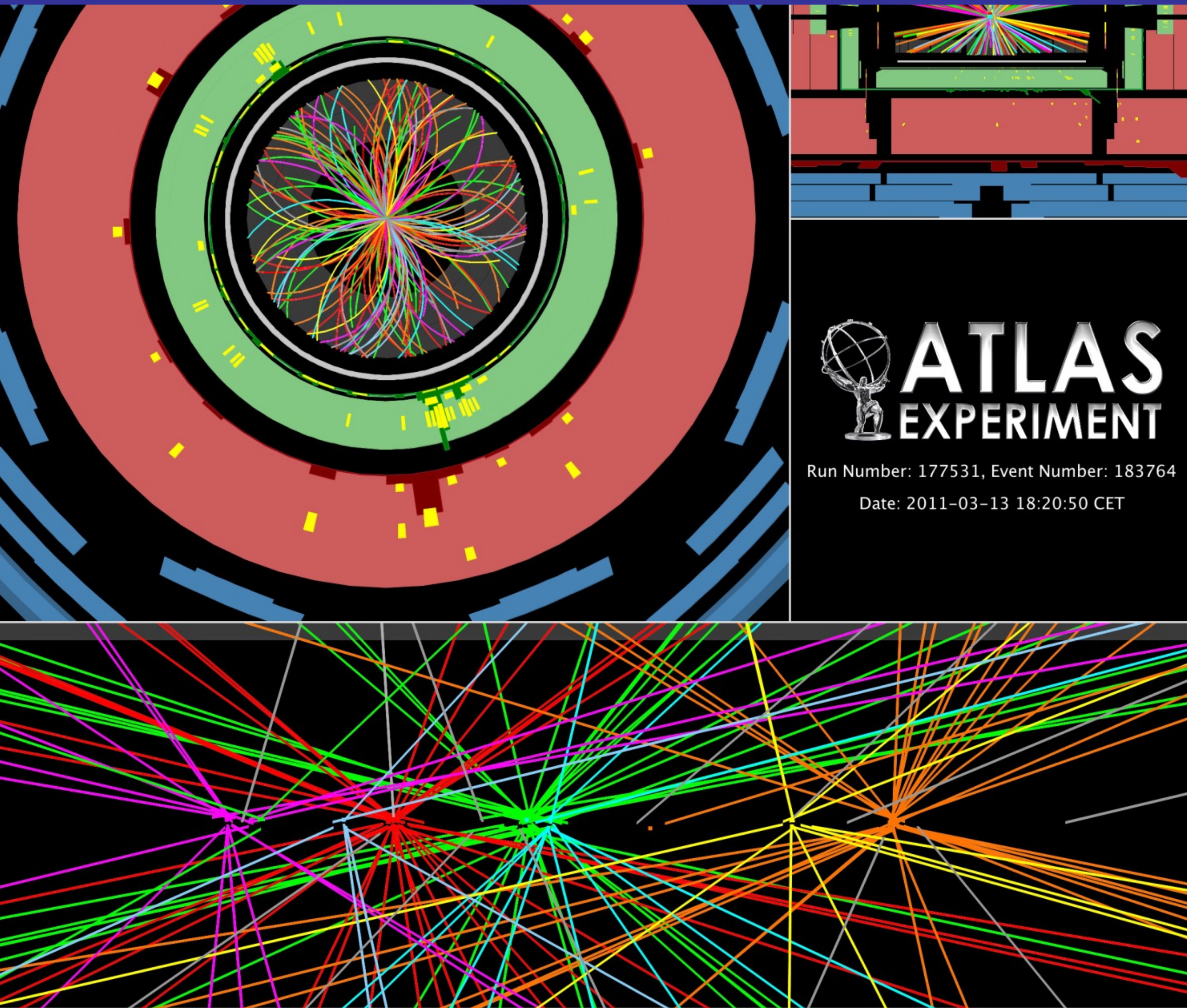
ATLAS Status Report



Cigdem Issever
University of Oxford

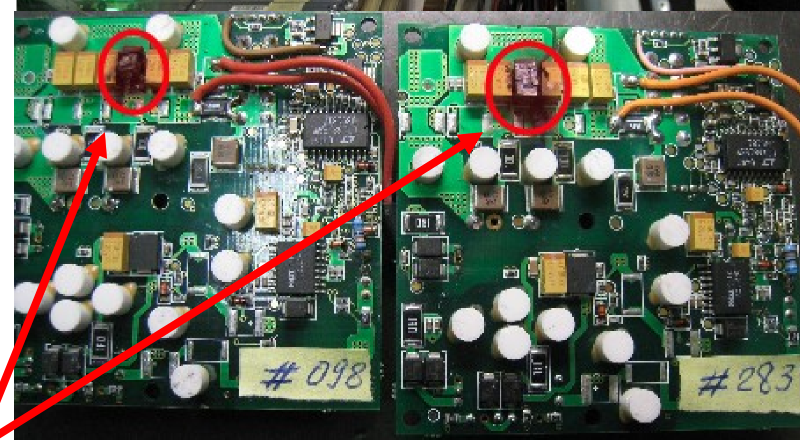
Open LHCC Session
23.03.2011

Activities during 2010/2011 Technical Stop

- End-cap calorimeters opened and closed → many repairs, including
  - liquid-argon EM calorimeter optical links
  - Tile calorimeter LVPS
  - Muon chambers specific repairs
    - ~3800 HV RPC connectors substituted, …
  - Magnets bus-bars
- Maintenance and consolidation
  - cooling, ventilation, cryogenics, magnets, UPS …
- Installation of Roman Pots (ALFA)

Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	80 M	97.2%
SCT Silicon Strips	6.3 M	99.2%
TRT Transition Radiation Tracker	350 k	97.5%
LAr EM Calorimeter	170 k	99.9%
Tile calorimeter	9800	98.8%
Hadronic endcap LAr calorimeter	5600	99.8%
Forward LAr calorimeter	3500	99.9%
LVL1 Calo trigger	7160	99.9%
LVL1 Muon RPC trigger	370 k	99.5%
LVL1 Muon TGC trigger	320 k	100%
MDT Muon Drift Tubes	350 k	99.8%
CSC Cathode Strip Chambers	31 k	98.5%
RPC Barrel Muon Chambers	370 k	97.0%
TGC Endcap Muon Chambers	320 k	99.1%

Access to the calorimeter front-end electronics

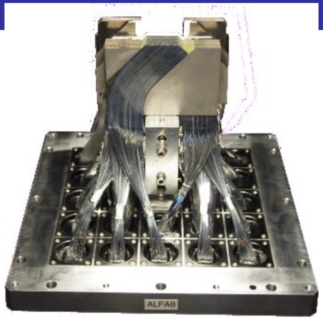


7 weeks of intense mechanical work
open and close the detector

3 weeks work on calorimeter electronics:

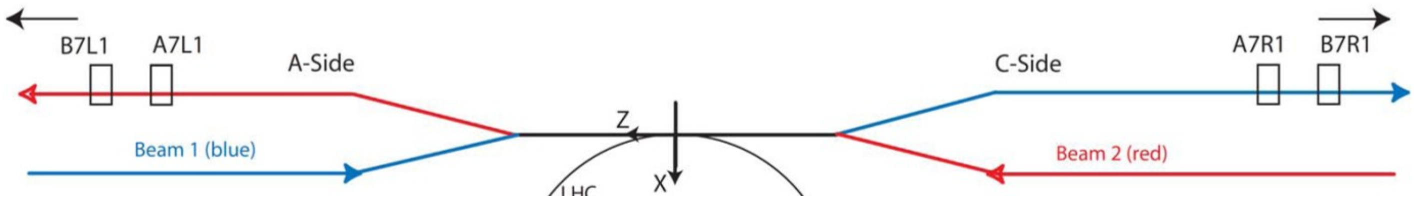
LAr front-end electronics : 54 OTXs exchanged, 11 electronics boards
repaired Tiles front-end : 23 LVPS repaired/exchanged, 16 drawers
repaired (3 drawers failed after closing)

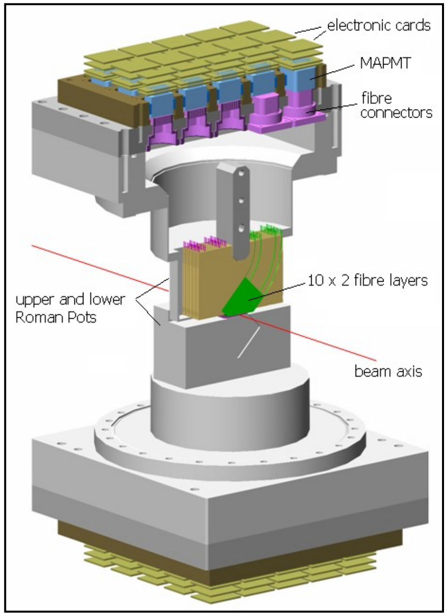
ALFA Roman Pots : Installation

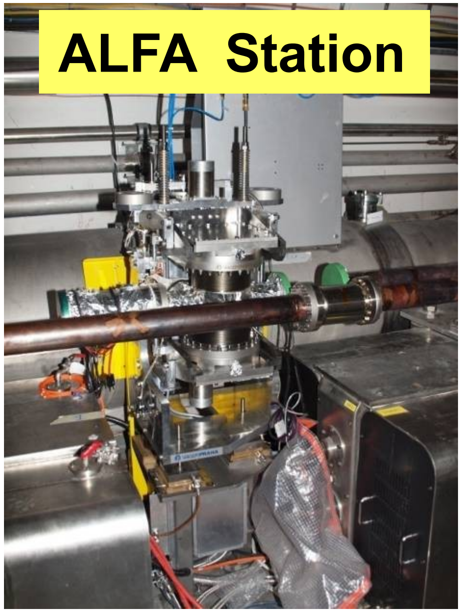


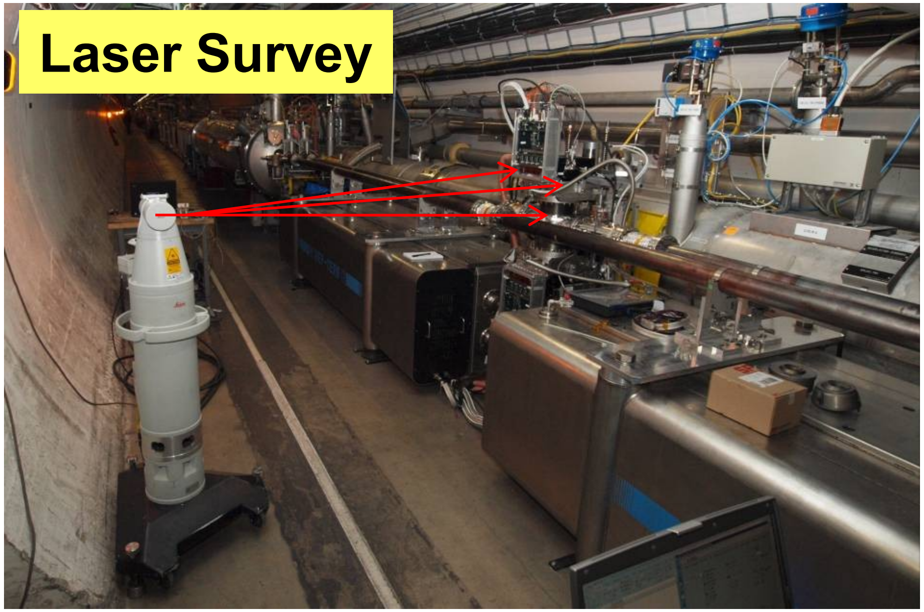
Fibre detector

ALFA:= 4 Roman Pot Stations for luminosity measurement
± 240 m from ATLAS IP







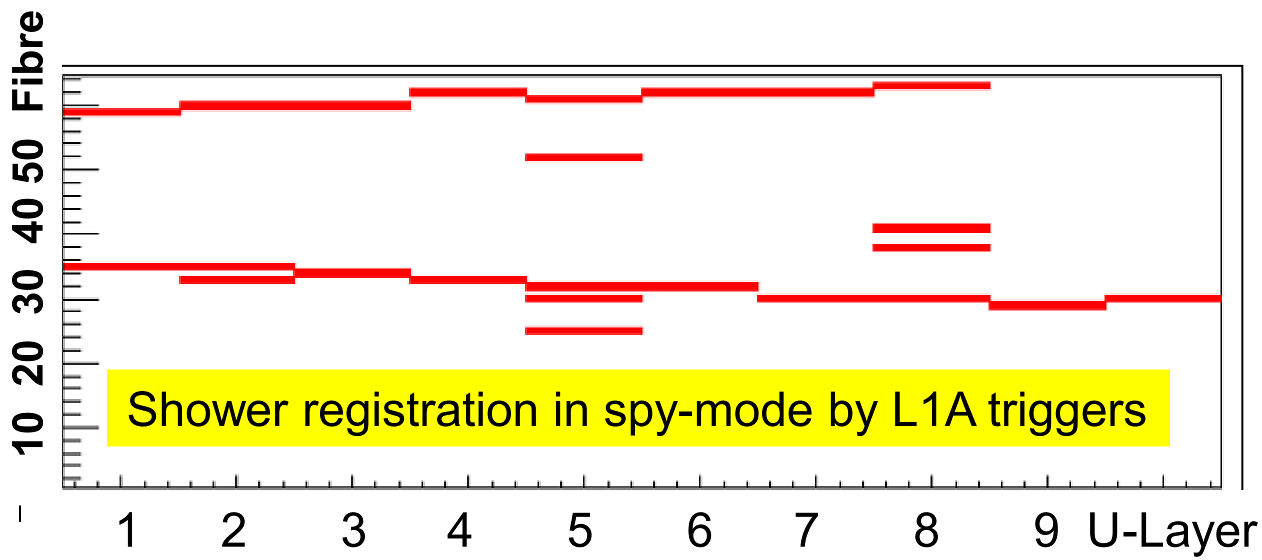


December: all 4 stations with Roman Pots installed and bake out finished
January : 8 fibre detectors, front-end electronics, cabling & infra-structure,
laser survey finished

ALFA Roman Pots: Commissioning & Planning

February, March Commissioning:

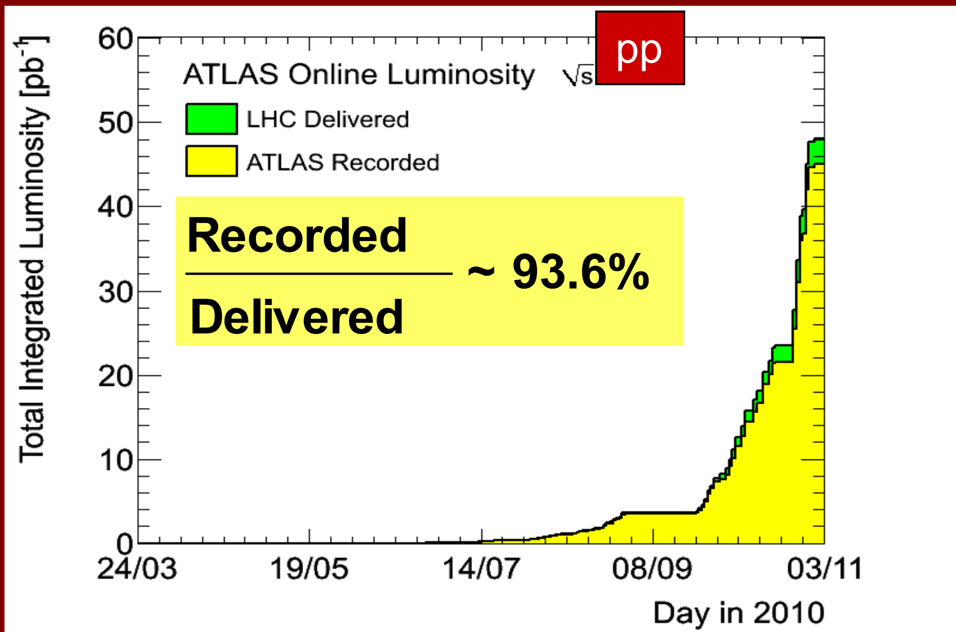
- readout and latencies with LEDs inside RPots
- DCS/TDAQ integrated into central ATLAS

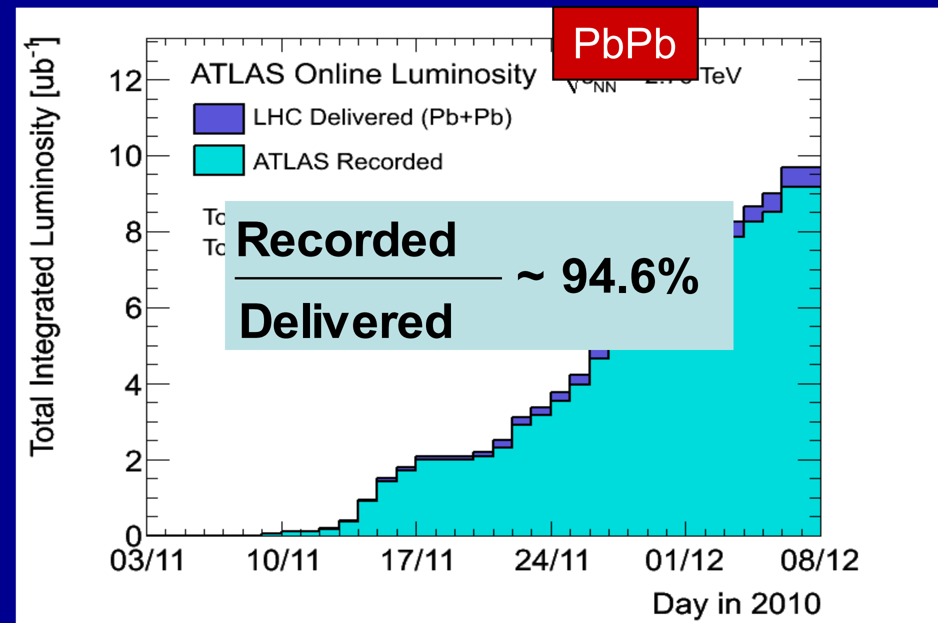


Plans 2011:

- scraping for alignment & positioning with beams
- implementations of ALFA triggers in menu
- move out of garage for detection of halo particles
- physics run close to beam with high β*

2010 Recorded Data





Inner Tracking Detectors			Calorimeters				Muon Detectors			
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	CSC	TGC
99.1	99.9	100	90.7	96.6	97.8	100	99.9	99.8	96.2	99.8

2010 pp run

Luminosity weighted relative detector uptime and good quality data delivery during 2010 stable beams in pp collisions at √s=7 TeV between March 30th and October 31st (in %). The inefficiencies in the LAr calorimeter will partially be recovered in the future.

Improved Luminosity Measurement

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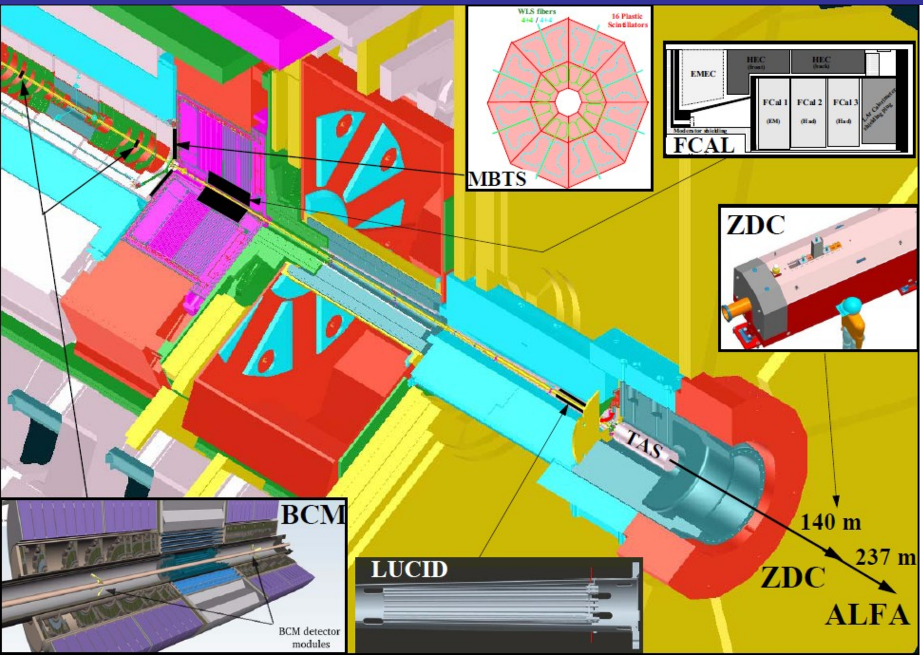
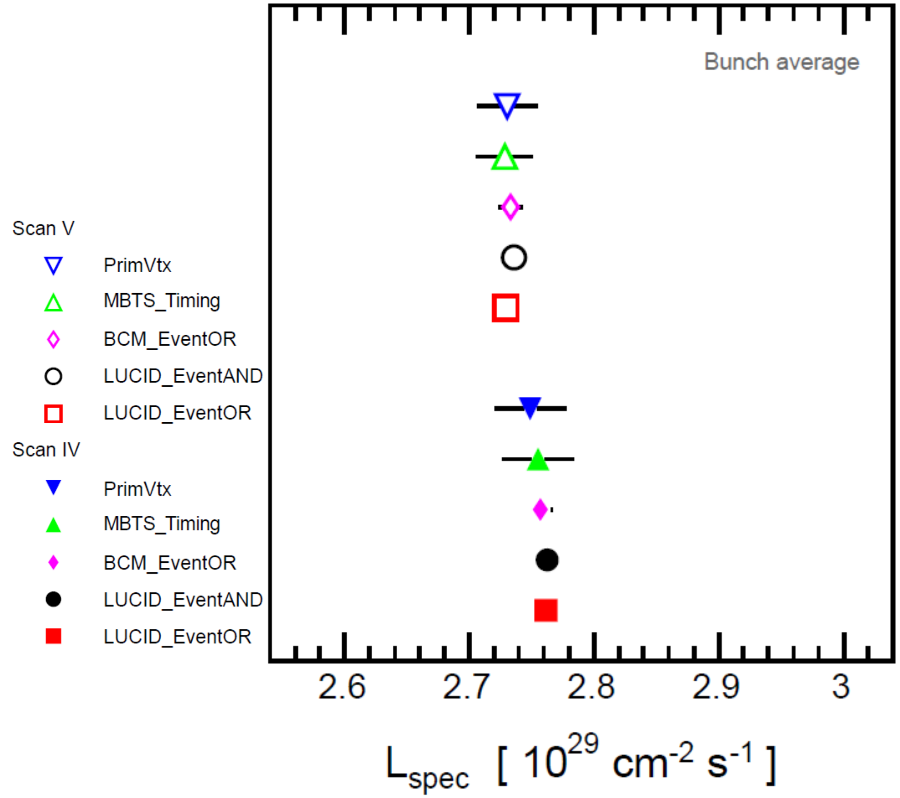


van der Meer Scans

5 lumi detectors and up to 5 algorithms

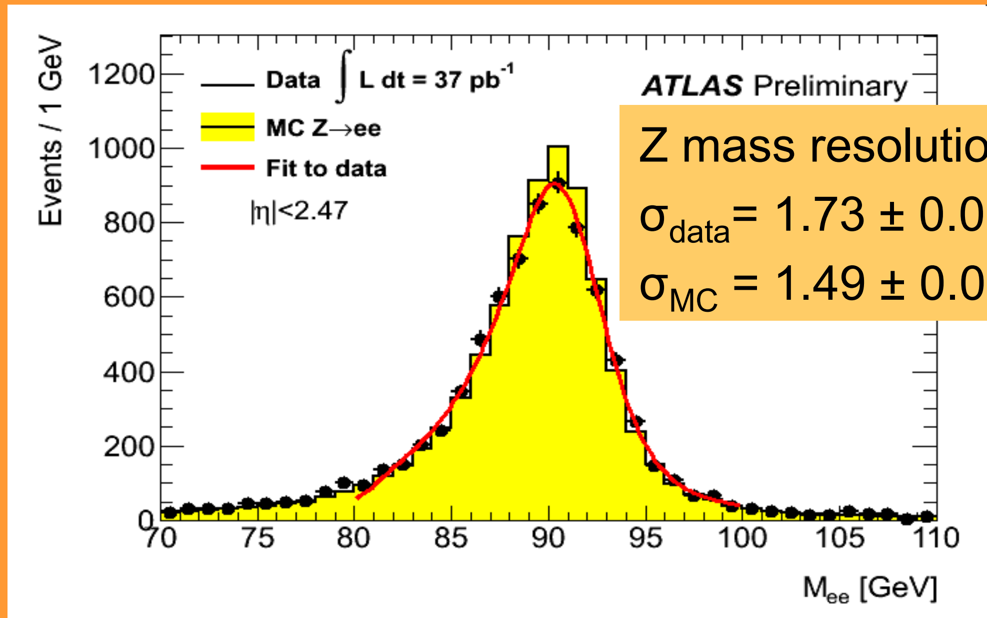


Thanks to LHC team and ATLAS efforts

- Improved determination
  - LHC bunch currents: 10% -> 2.9%
- ATLAS vdM scan analysis
  - length scale: 2%→0.3%
  - emittance growth: 3%→0.5%
  - mu dependence: 2%→0.5%
  - fit model: 1%→0.1%
  - beam centering: 2%→0.1%

Uncertainty reduced 11% → 3.4%

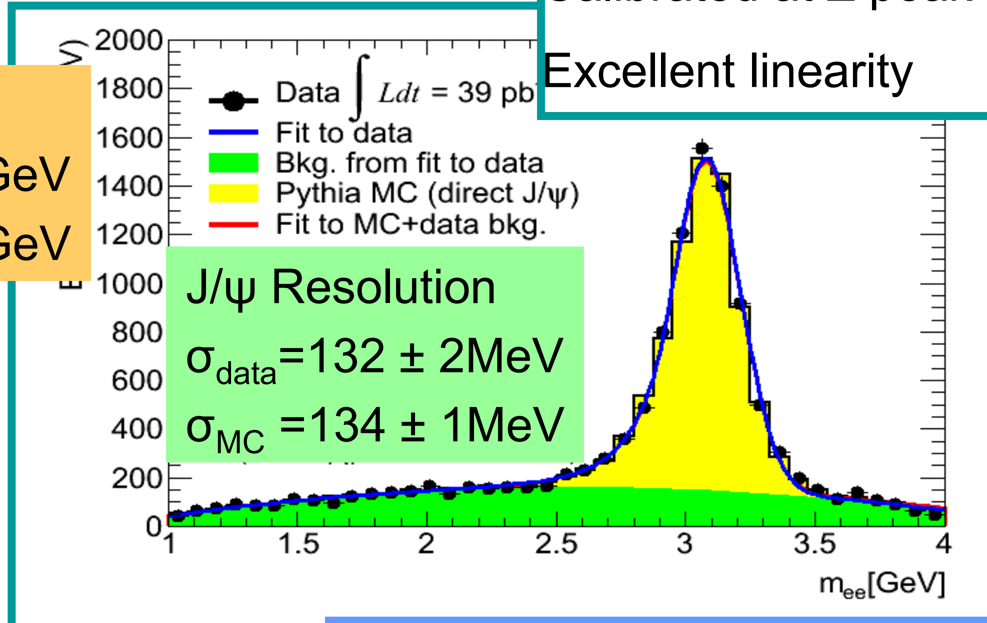
Electron Performance Results



Z mass resolution

σ_{data}= 1.73 ± 0.08 GeV

σ_{MC} = 1.49 ± 0.02 GeV



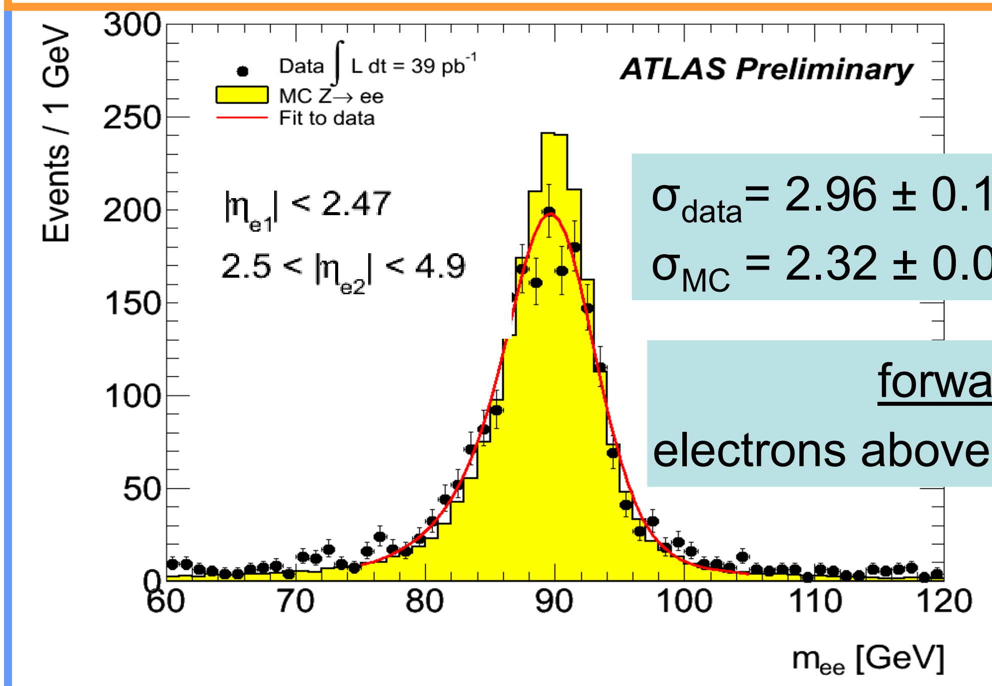
Calibrated at Z peak

Excellent linearity

J/ψ Resolution

σ_{data}=132 ± 2MeV

σ_{MC} =134 ± 1MeV

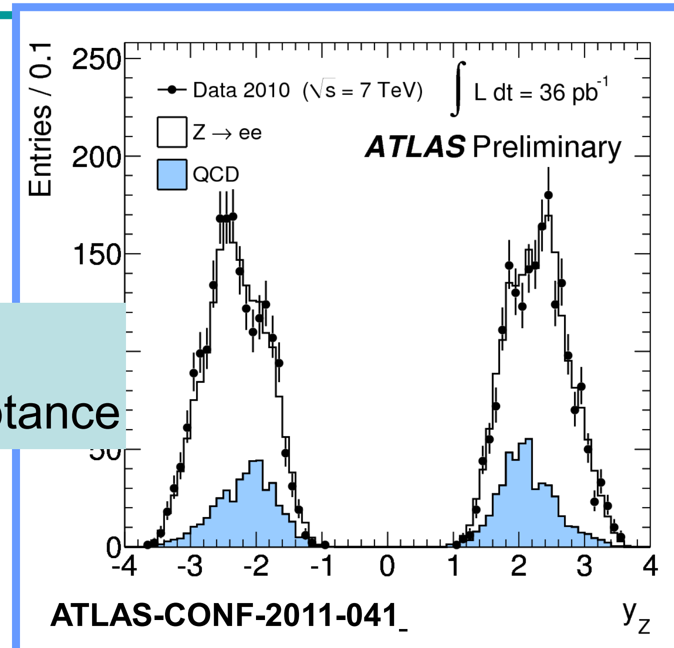


σ_{data}= 2.96 ± 0.1 GeV

σ_{MC} = 2.32 ± 0.03 GeV

<u>forward-central Zs</u>

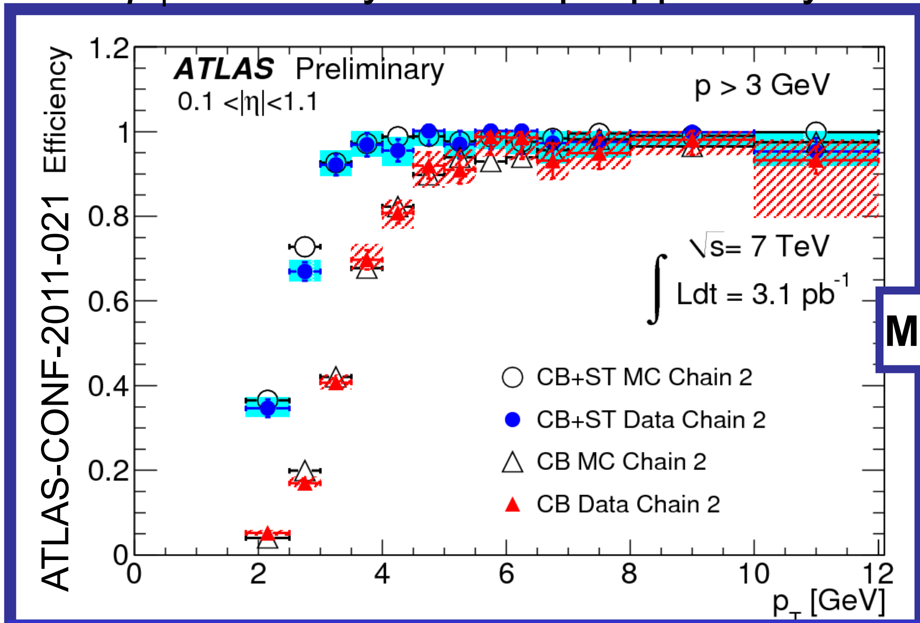
electrons above the tracker acceptance



ATLAS-CONF-2011-041

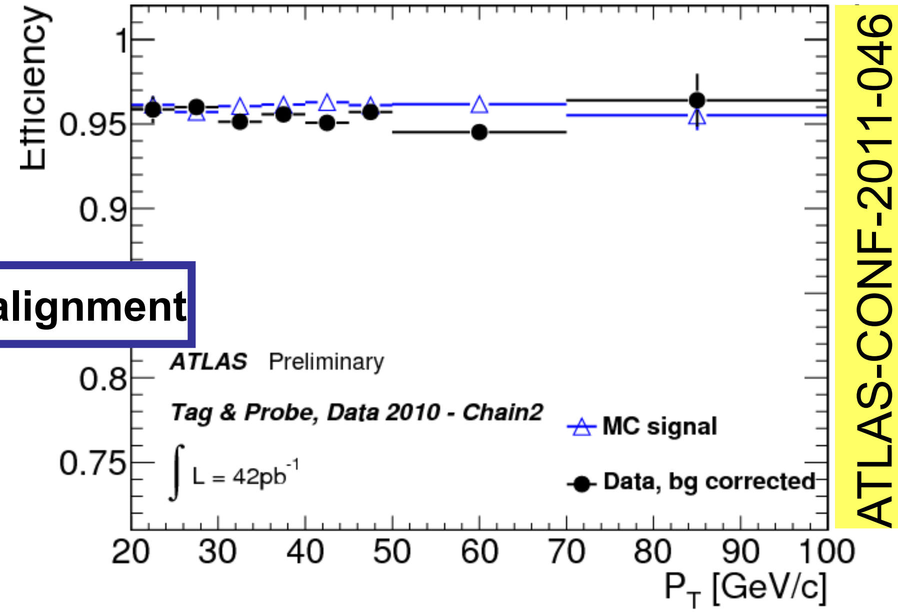
ID and Muon Combined Performance Results

Low p_T efficiency from $J/\psi \rightarrow \mu\mu$ decays

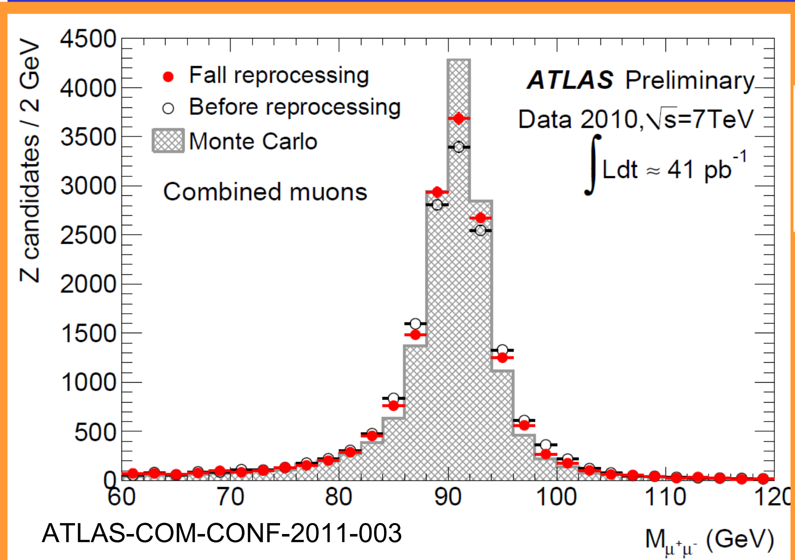


Efficiency understood down to very low p_T

High p_T efficiency from $Z \rightarrow \mu\mu$ decays



MC: perfect alignment



Present understanding of ID alignment

Detector type	coordinate	Barrel	End-caps
		c [μm]	
Pixel	local x	4	7
	local y	18	35
SCT	local x	10	11
TRT		0	0

Smear MC hit uncertainties

$$\sigma = a * \sigma \oplus c$$

$$a = 1$$

<u>Improved momentum scale and resolution</u>

muon scale uncertainty is < 1%

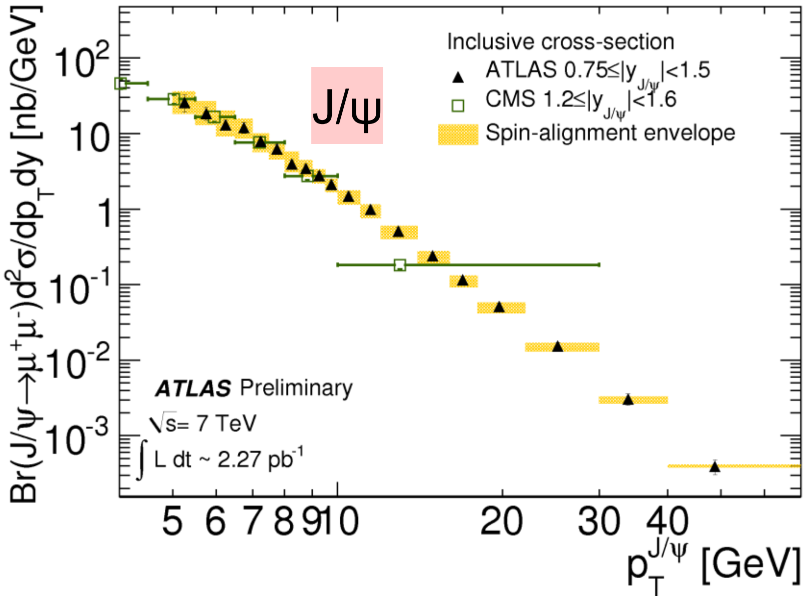
dimuon mass resolution 1.8% barrel and 3% end-cap

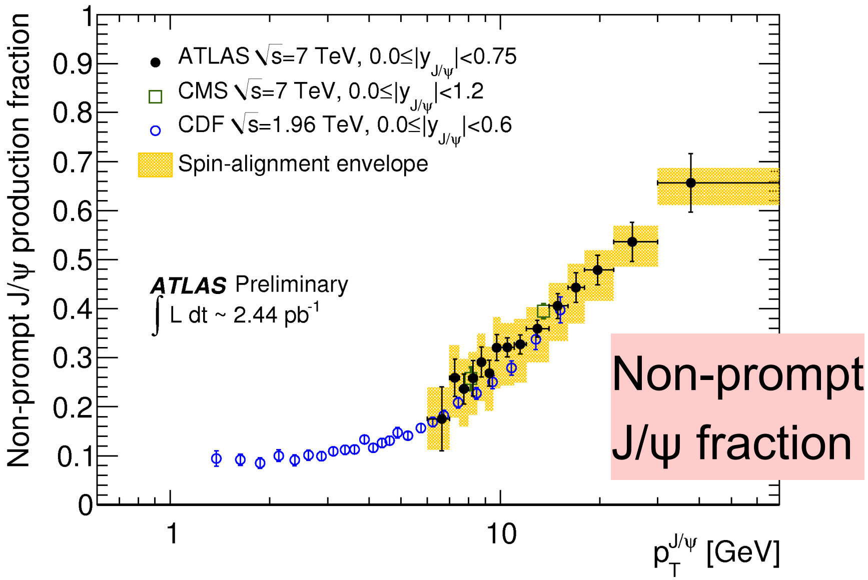
J/ψ and B± production

Measuring J/ψ and B production is an important test-bed for a variety of QCD models

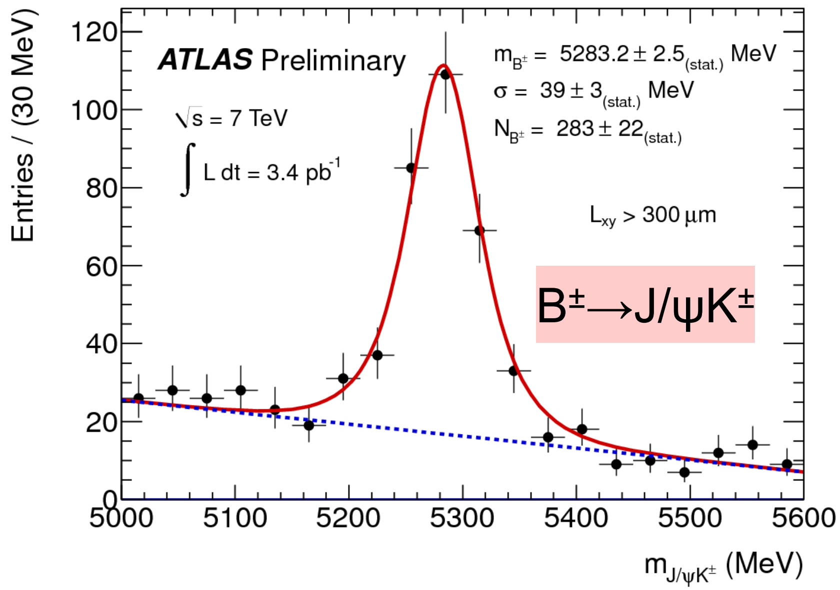
Measurements made in slices of J/ψ p_T from 1 to 70 GeV and in 4 rapidity slices from 0 to 2.4.

One rapidity slice shown here (0.75-1.5).

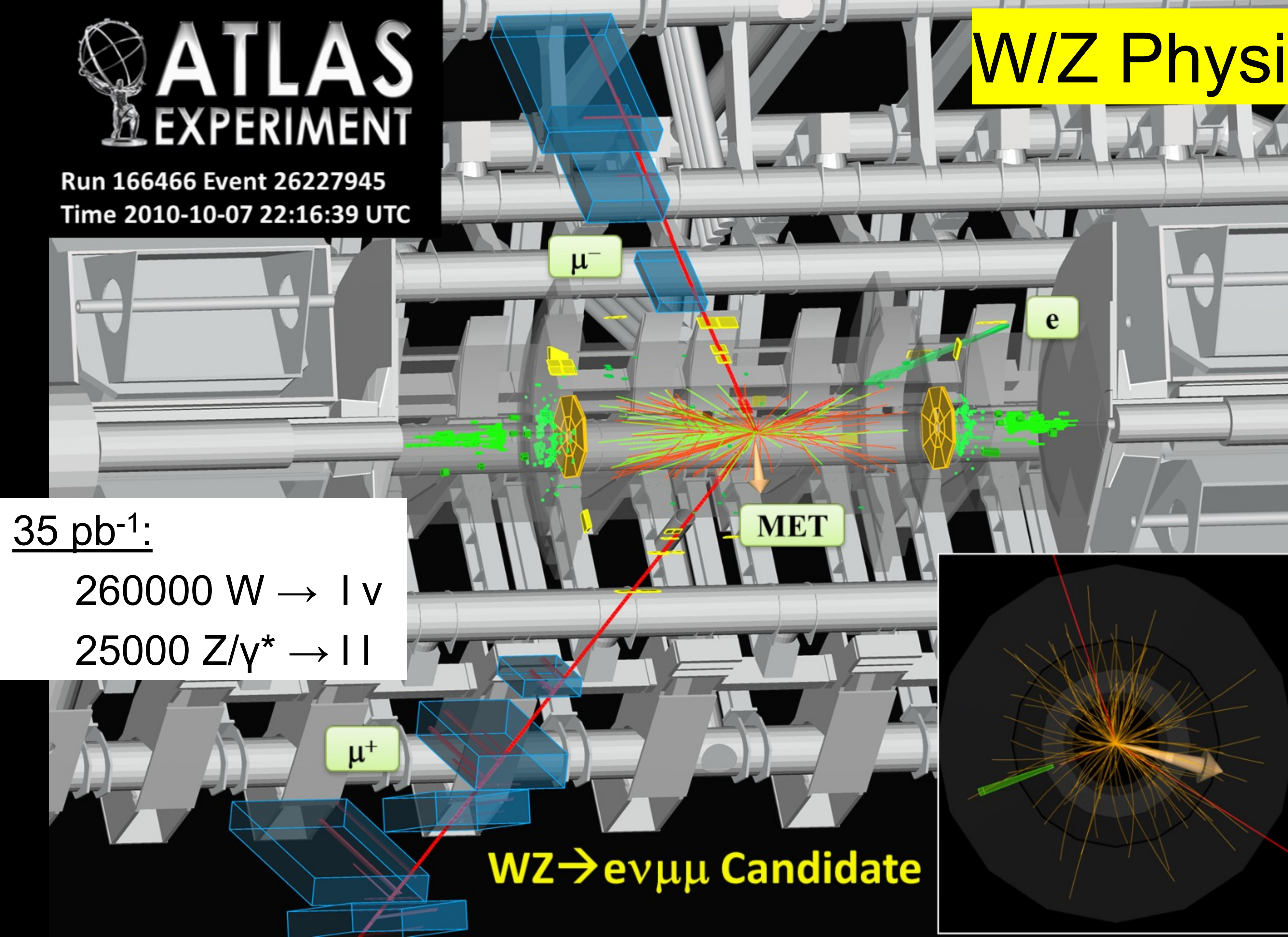




Reconstruction of an exclusive B decay mode



W/Z Physics



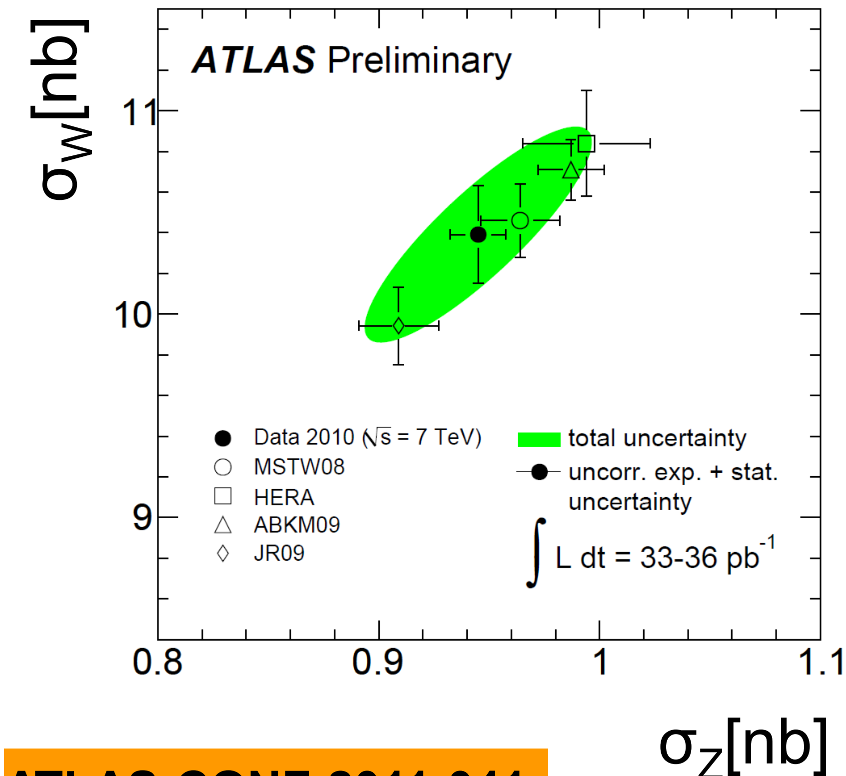
35 pb^{-1}:

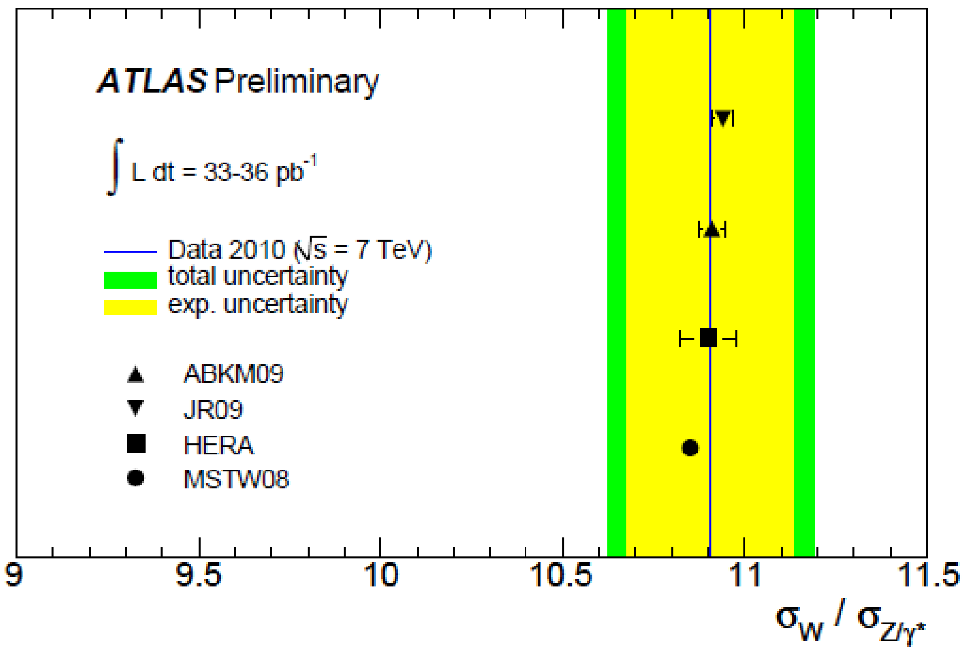
260000 $W \rightarrow l\nu$

25000 $Z/\gamma^* \rightarrow l\,l$

W and Z Inclusive Cross-Section – 33-36 pb^{-1}

- **Main improvements** wrt 0.3pb^{-1} measurement (JHEP, 12:060, 2010)
  - Systematic uncertainties diminished (/3): **σ(Z→ll) 1.2%, σ(W→lν) 2.4% + lumi**
  - experimental uncertainties smaller than theory uncertainties in fiducial regions
  - σ(Z→ee) extended up to |η|~4.9





NNLO predictions consistent with data
Remarkable success of pQCD and PDFs

ATLAS-CONF-2011-041_

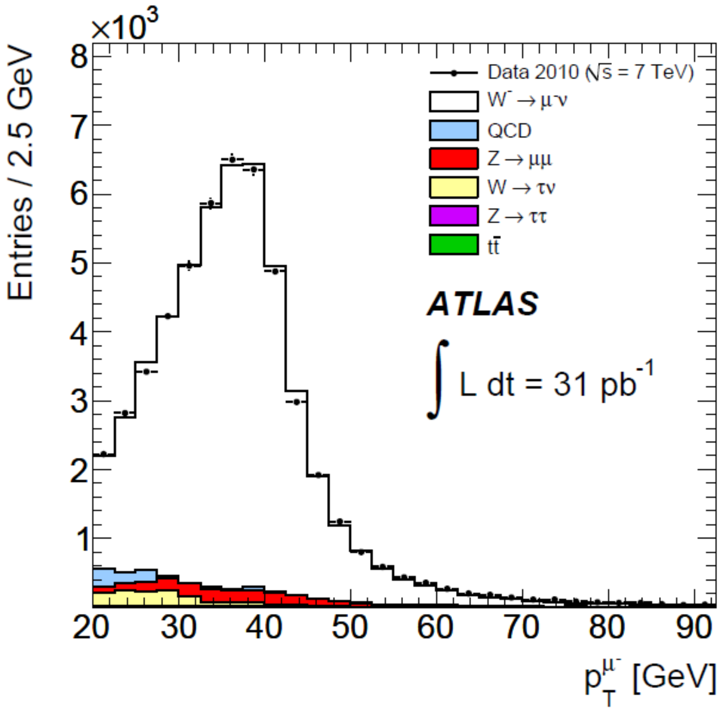
W Charge Asymmetry (muon channel)

$$A_\mu = \frac{d\sigma_{W\mu+}/d\eta_\mu - d\sigma_{W-}/d\eta_\mu}{d\sigma_{W\mu+}/d\eta_\mu + d\sigma_{W-}/d\eta_\mu} \approx \frac{d(x)}{u(x)}$$

http://arxiv.org/abs/1103.2929

submitted to PLB

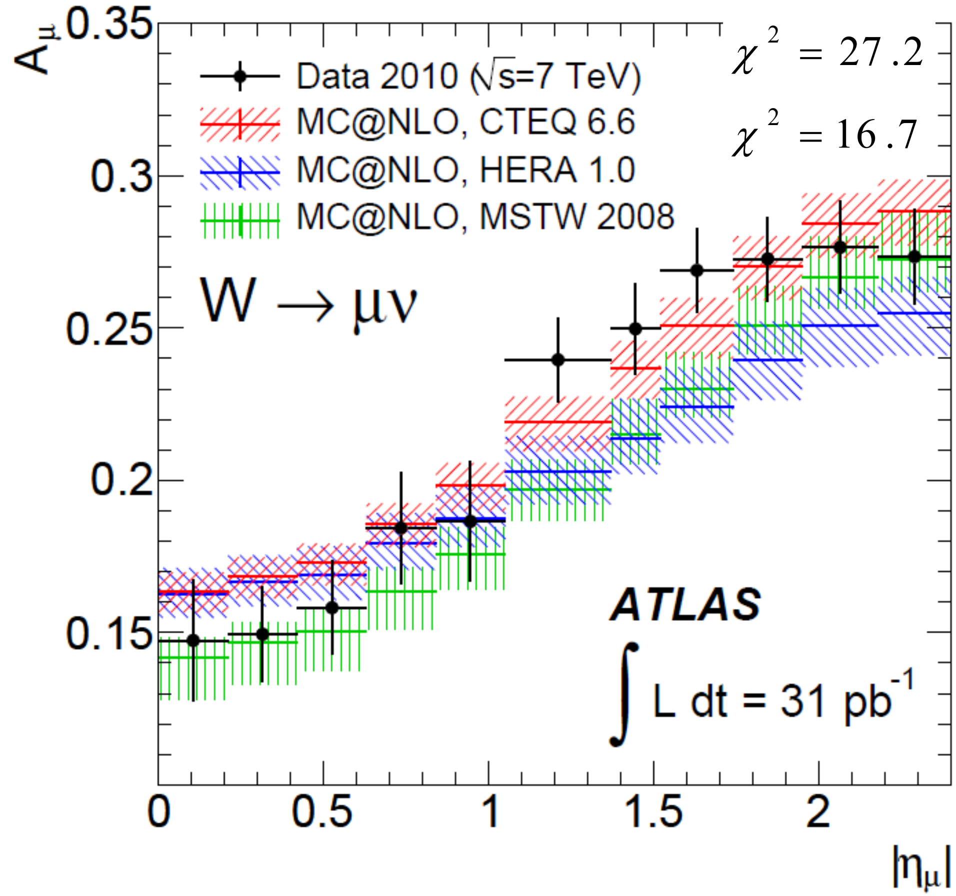
- Measurement constrains PDFs
  - $10^{-3} \leq x \leq 10^{-1}$

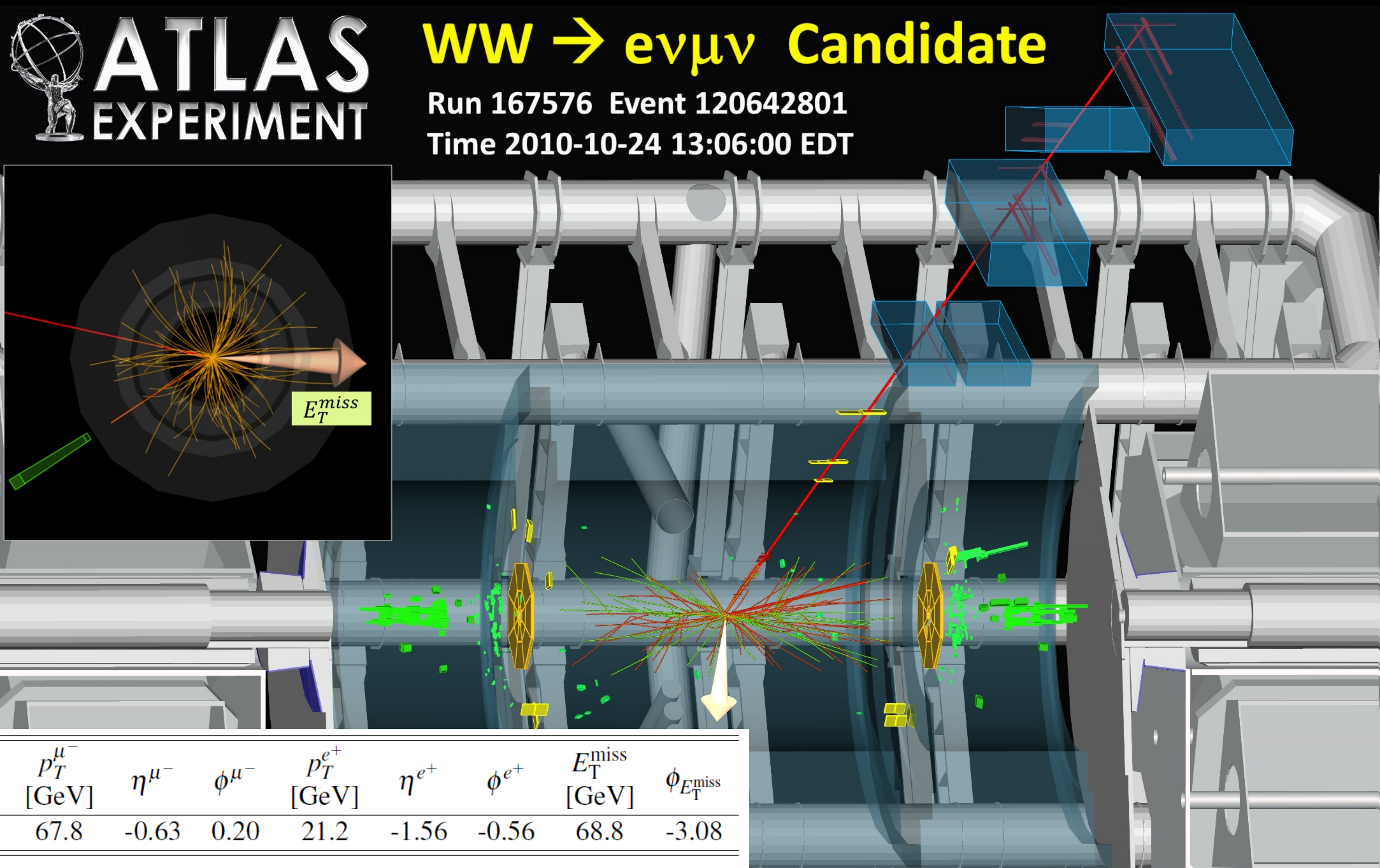


$\chi^2 = 8.8$

$\chi^2 = 27.2$

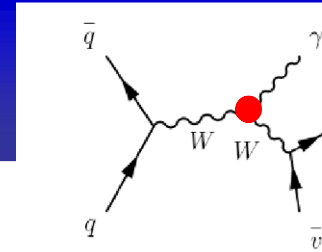
$\chi^2 = 16.7$

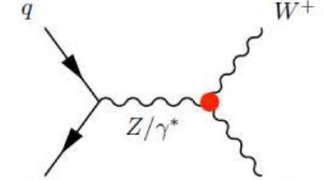




$p_T^{\mu^-}$ [GeV]	η^{μ^-}	ϕ^{μ^-}	$p_T^{e^+}$ [GeV]	η^{e^+}	ϕ^{e^+}	$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	$\phi_{E_{\mathrm{T}}^{\mathrm{miss}}}$
67.8	-0.63	0.20	21.2	-1.56	-0.56	68.8	-3.08

Diboson Production

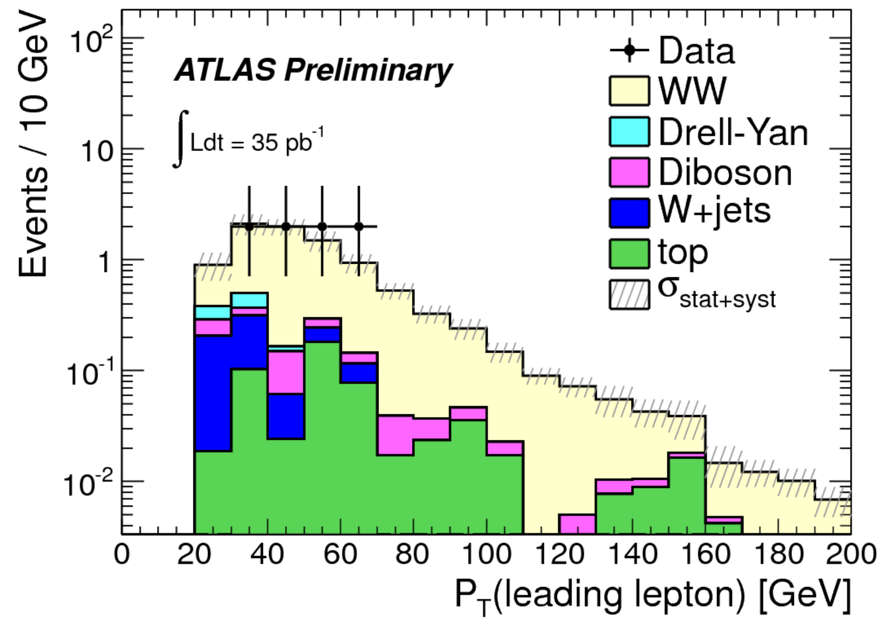




- WW Production **ATLAS-CONF-2011-015_**
  - Test non-abelian nature of EW sector
    - Sensitive to **Triple Gauge Couplings**
  - Main background to H → WW
  - NLO prediction: 46 ±3 pb
  - Results:

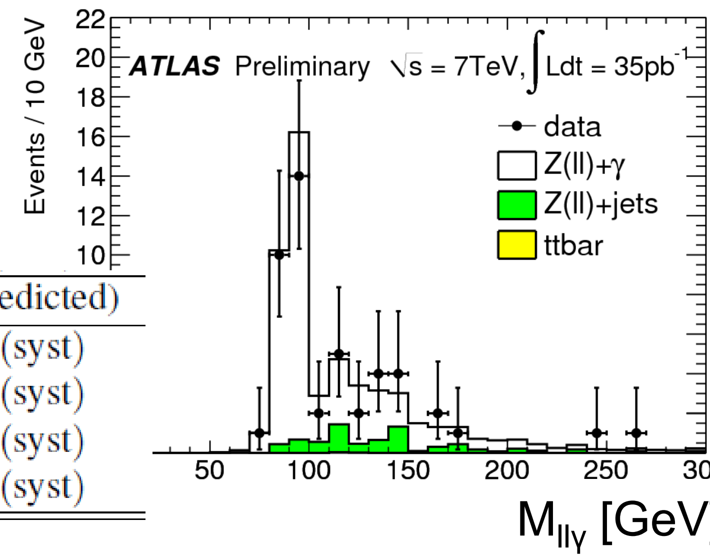
$$\sigma_{WW} = 40^{+20}_{-16}(stat) \pm 7(syst)\ pb$$

  - 8 events observed, 1.7 ± 0.6 bkg expected
  - Dominated by statistical uncertainty 44%



- W/Z+γ Production
  - Sensitive to Triple Gauge Couplings
  - Important test of SM

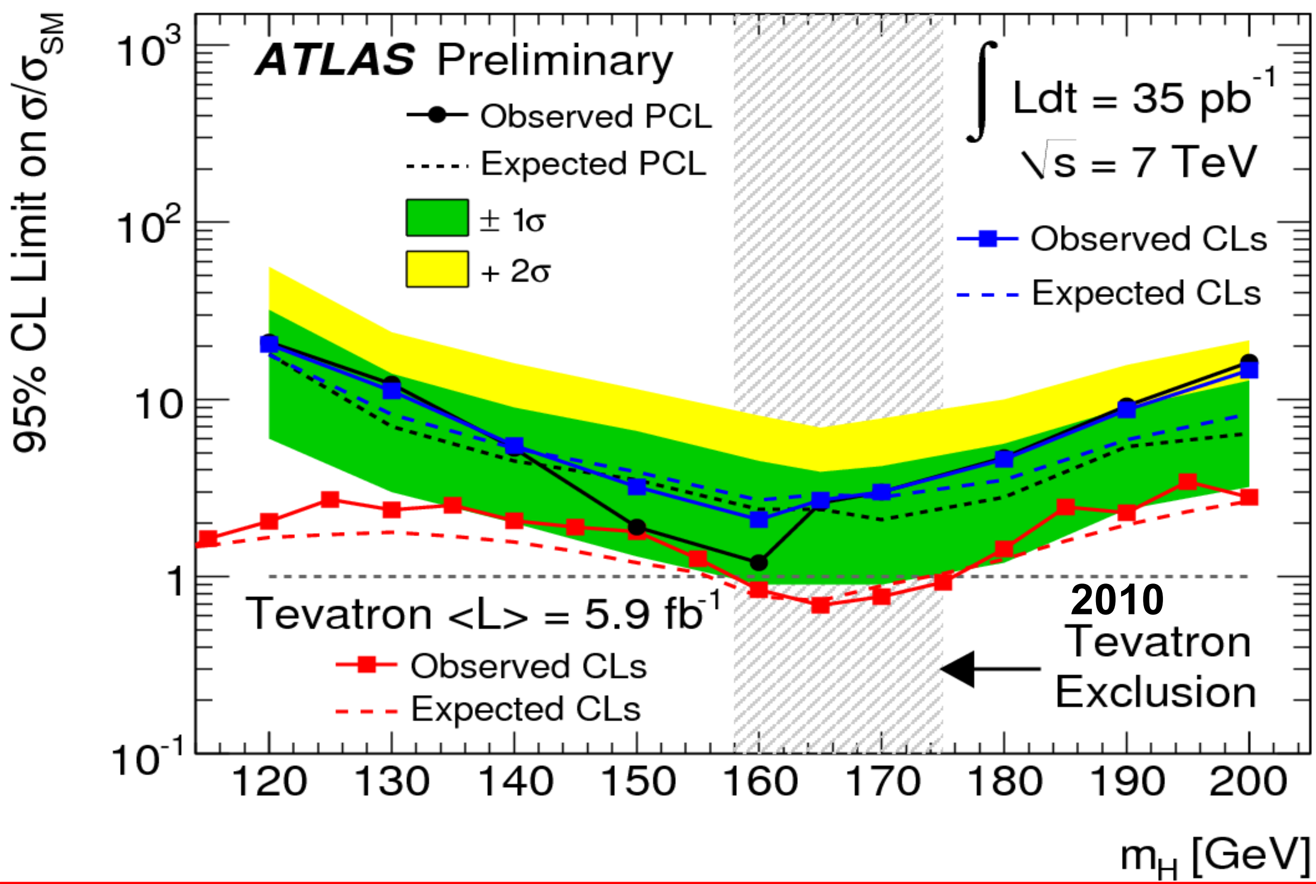
	$\sigma^{total}[pb]$(measured)	$\sigma^{total}[pb]$(predicted)
$pp \to e\nu\gamma$	$73.9 \pm 10.5(stat) \pm 14.6(syst) \pm 8.1(lumi)$	69.0 ± 4.6(syst)
$pp \to \mu\nu\gamma$	$58.6 \pm 8.2(stat) \pm 11.3(syst) \pm 6.4(lumi)$	69.0 ± 4.6(syst)
$pp \to e^+e^-\gamma$	$16.4 \pm 4.5(stat) \pm 4.3(syst) \pm 1.8(lumi)$	13.8 ± 0.9(syst)
$pp \to \mu^+\mu^-\gamma$	$10.6 \pm 2.6(stat) \pm 2.5(syst) \pm 1.2(lumi)$	13.8 ± 0.9(syst)

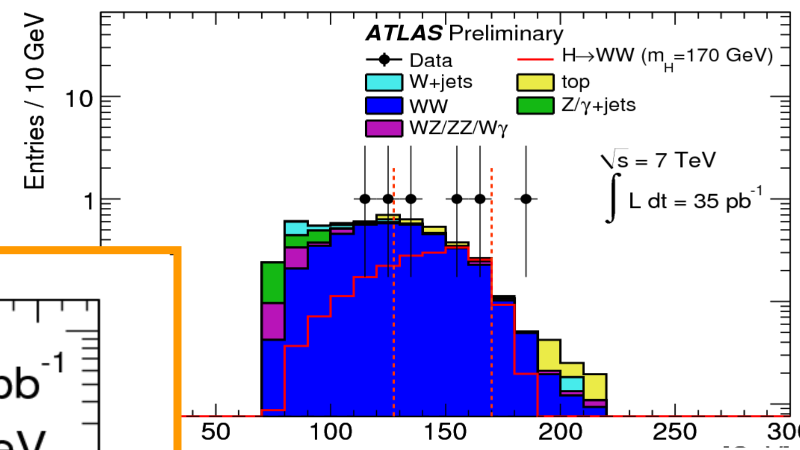


ATLAS-CONF-2011-013

SM Higgs →W W*→lν lν (l = e, μ)

- Strong sensitivity in 120 < $m(H_{SM})$ < 200 GeV
- Cut-based analysis
- Combining H + 0 jet, H + 1 jet and H + 2 jet





Transverse mass (H+0 jets)

Data-driven estimation WW, tt, W+jets, Z+jets backgrounds

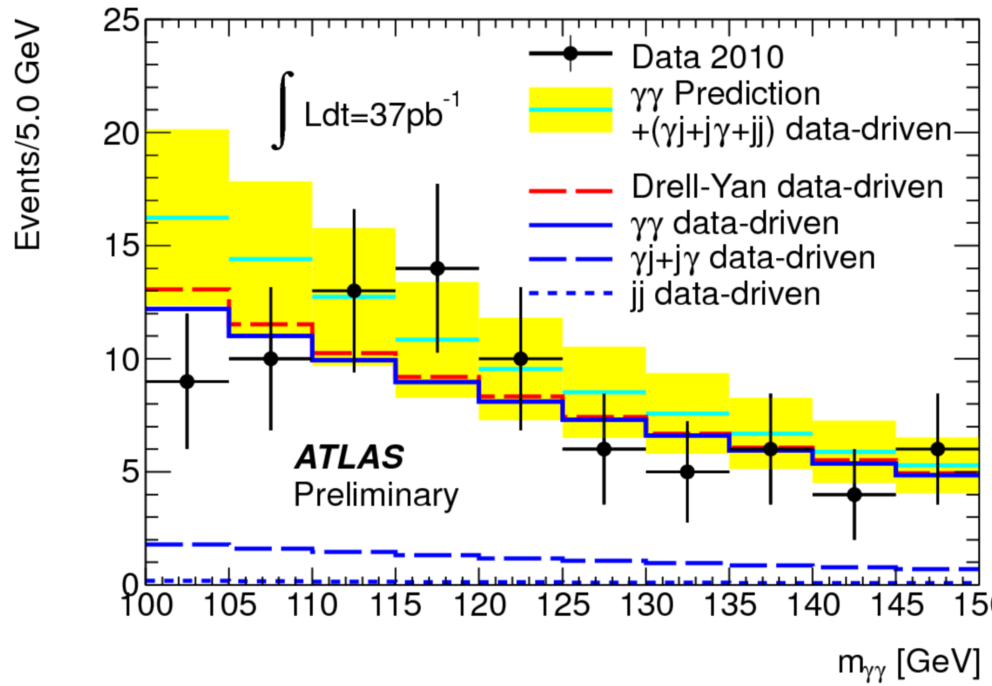
Upper limit on σxBR(H→WW*)
- m_H=120 GeV : 54 pb
- m_H=160 GeV : 11 pb
- m_H=200 GeV : 71 pb

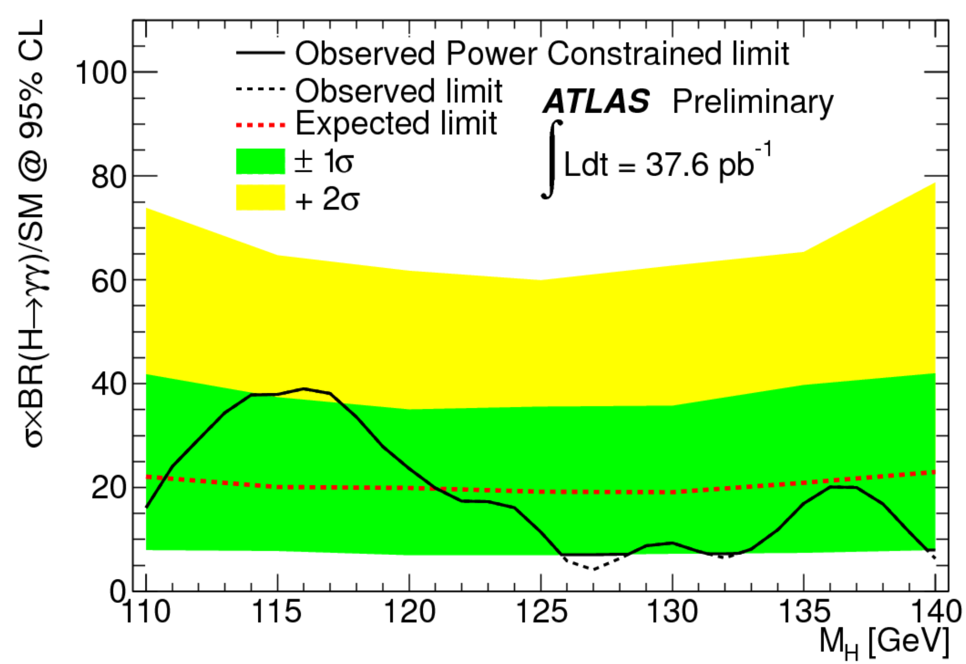
... will be catching up with the Tevatron very soon.

SM: H→γγ

ATLAS-CONF-2011-025

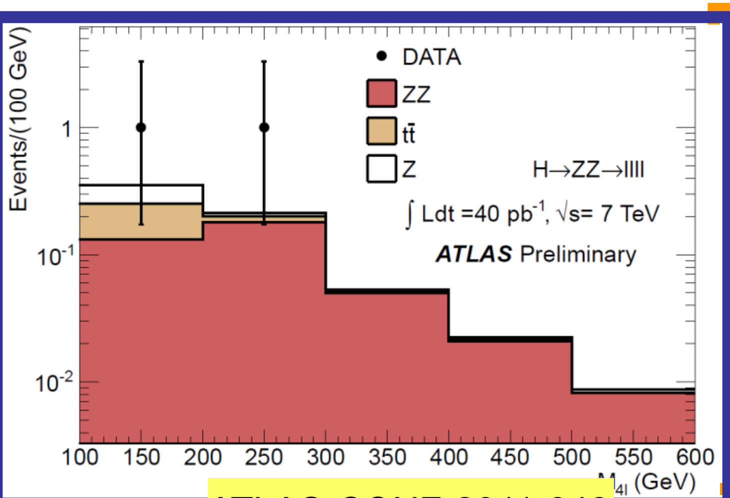
- Mass range: 110 GeV - 140 GeV
- Data-driven estimation of all background components
  - γγ, γj, jj
- Inclusive
  - only discriminant diphoton inv. mass

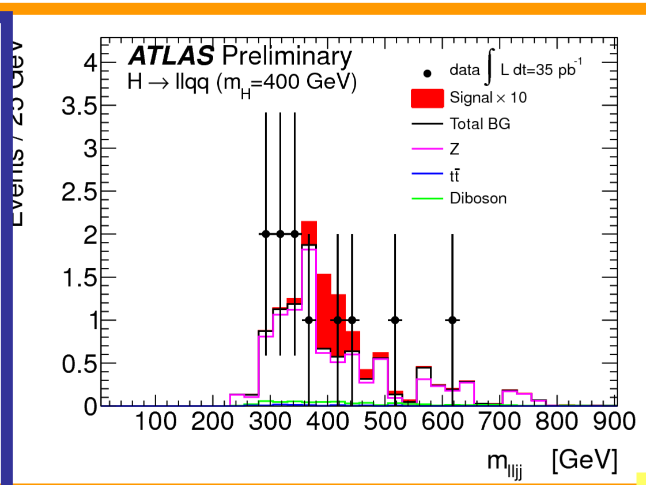


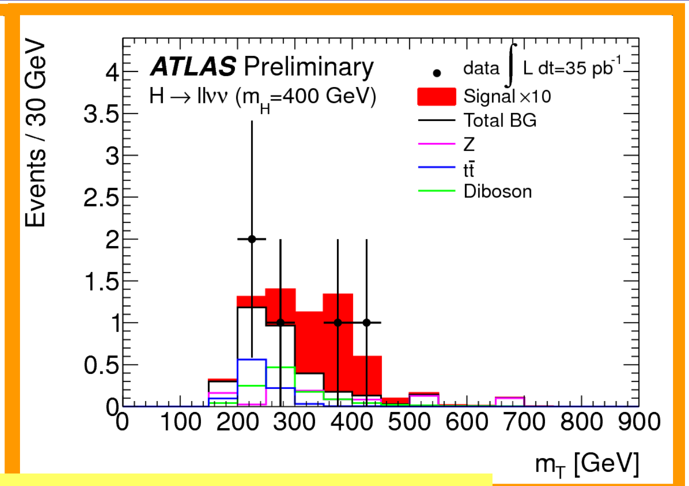


Sensitivity close to Tevatron

Exploring new mass reach! H → ZZ → llll, llqq, llνν







ATLAS-CONF-2011-048

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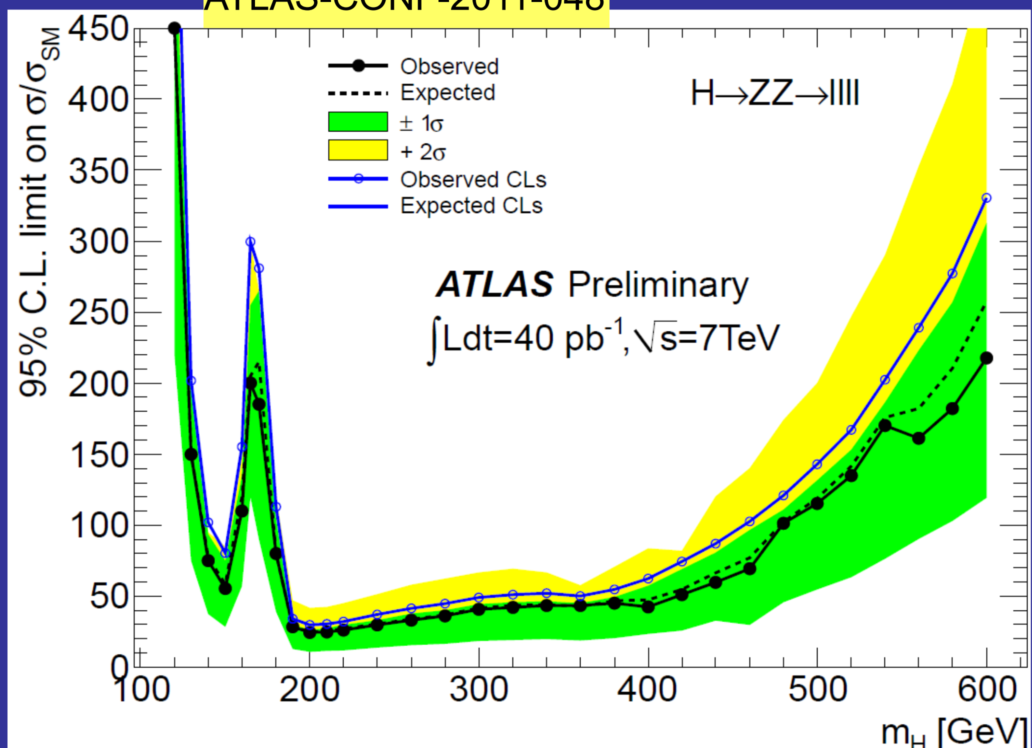
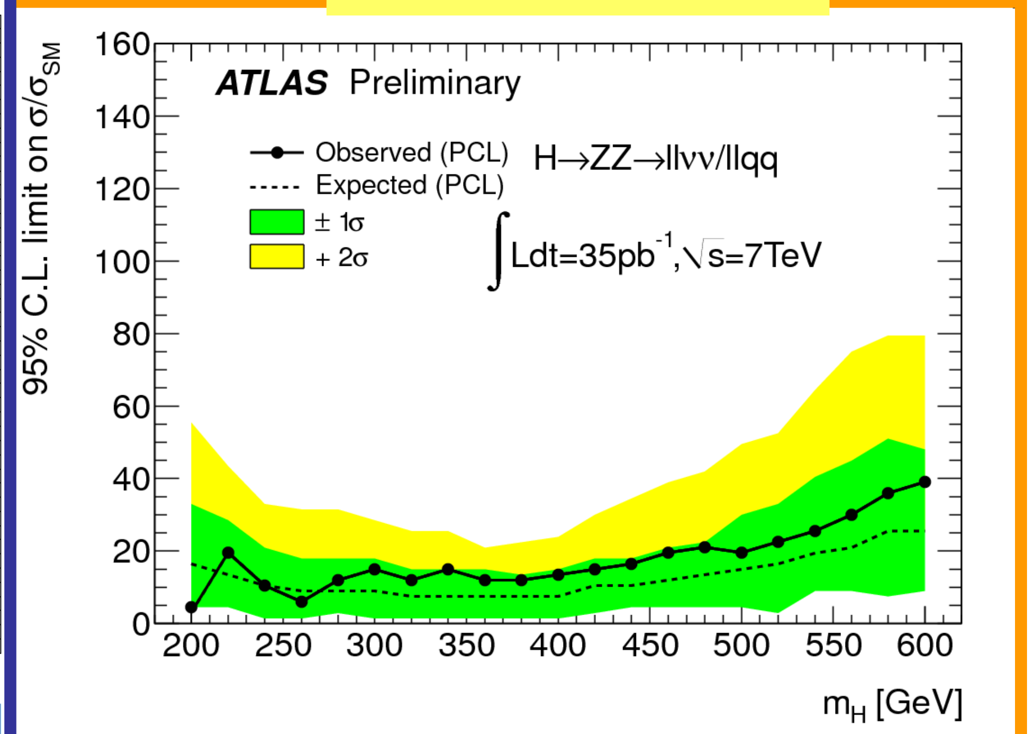
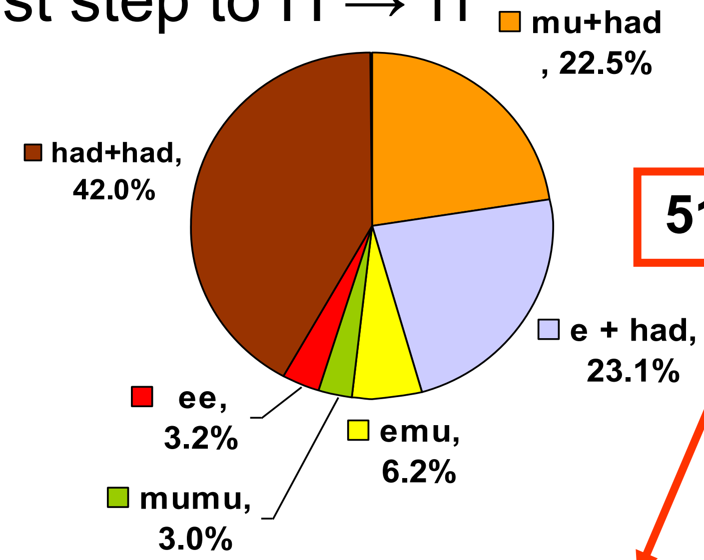




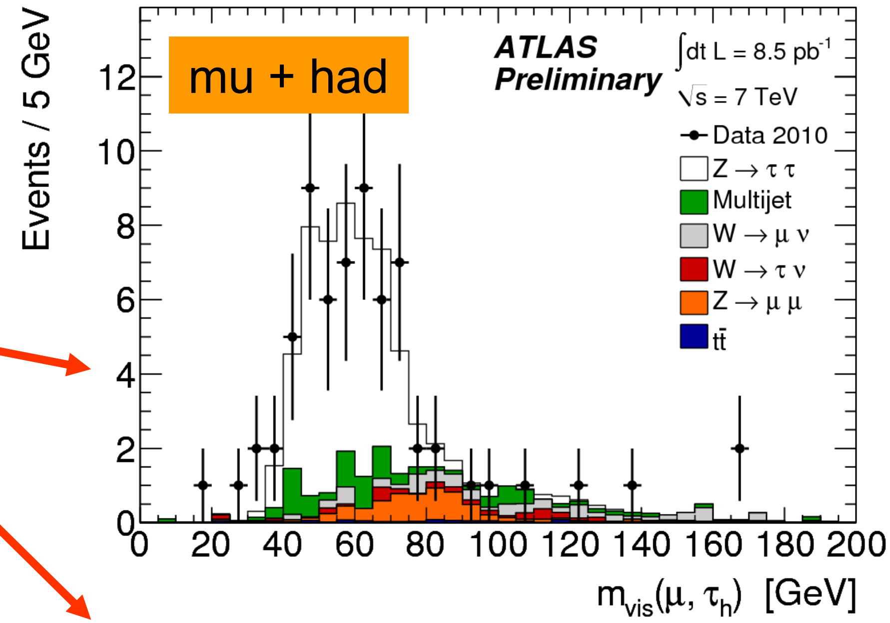
$Z \rightarrow \tau\tau$

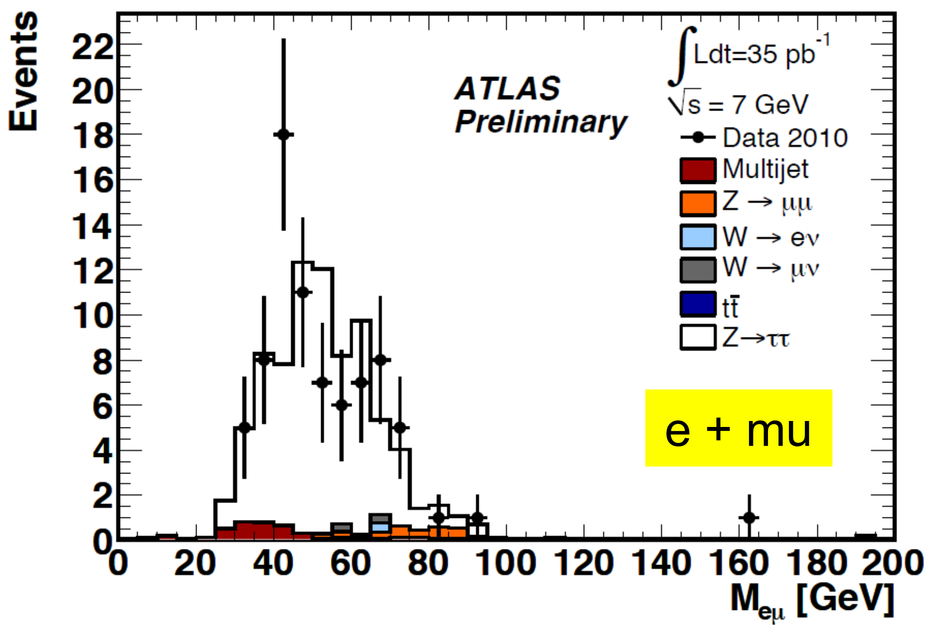
ATLAS-CONF-2011-010
ATLAS-CONF-2011-045

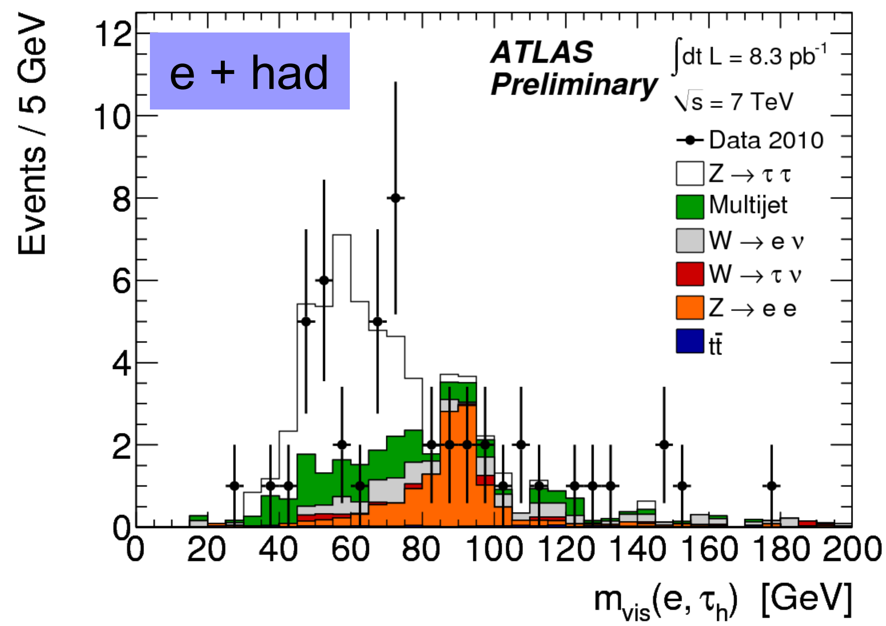
- First step to $H \rightarrow \tau\tau$



51.8%



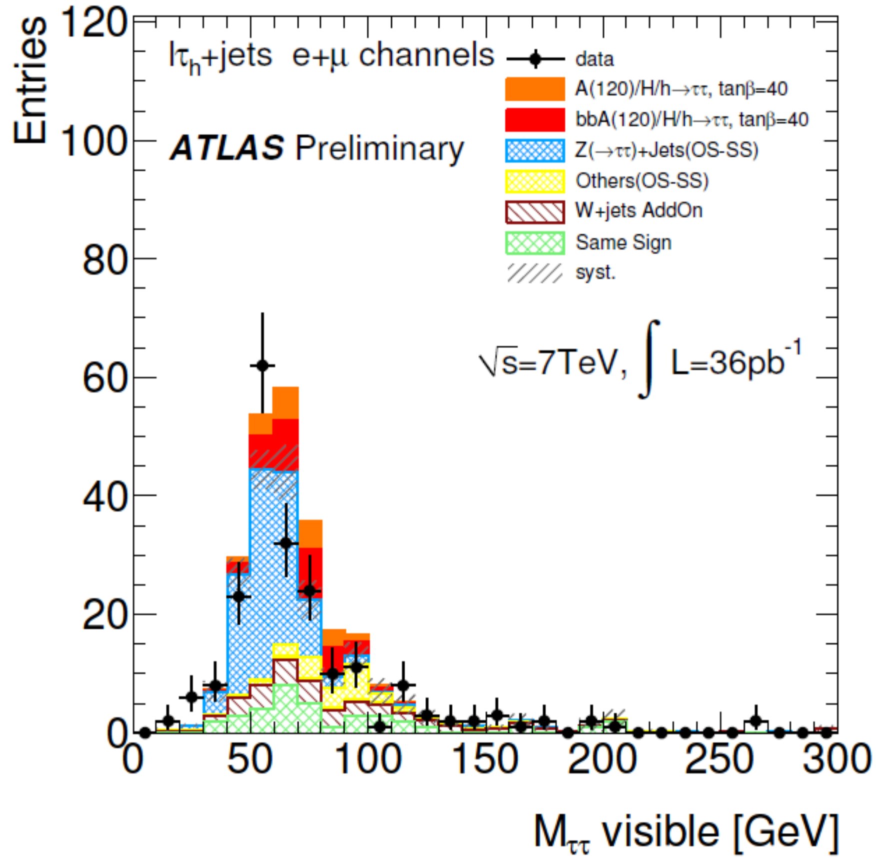


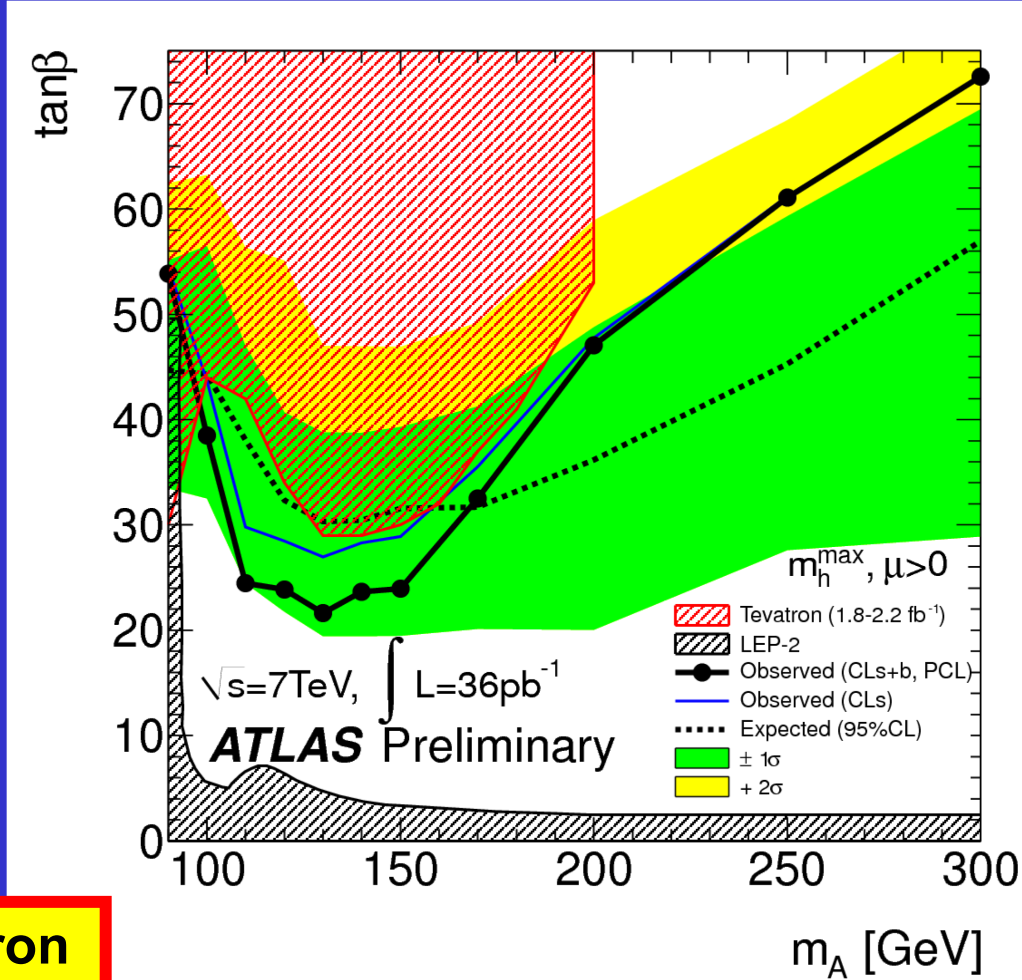


Neutral MSSM Higgs: A/H/h → $\tau_l\ \tau_h$

- **Inclusive cut based search** (semi-leptonic decay channel only)
  - no jet or b-jet multiplicities requirements
- Data-driven background estimation for Z+jets, QCD, W+jets

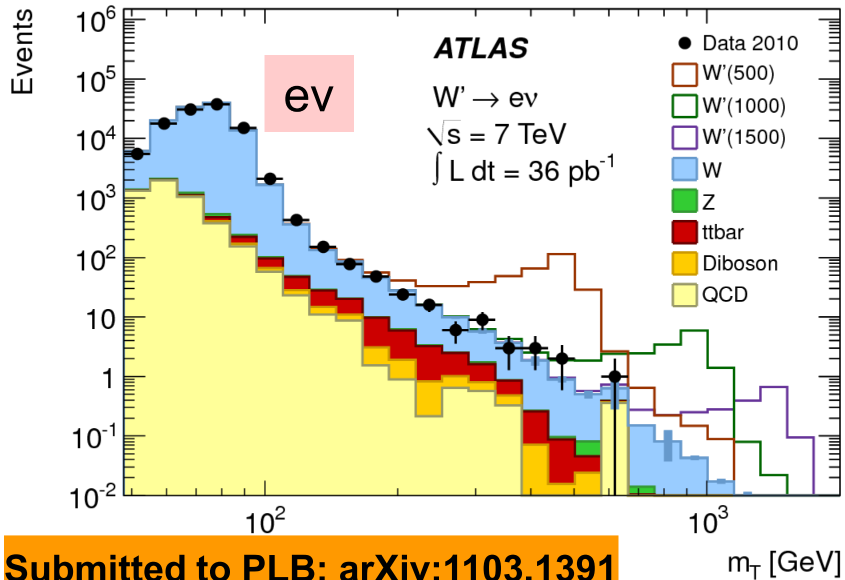
ATLAS-CONF-2011-024



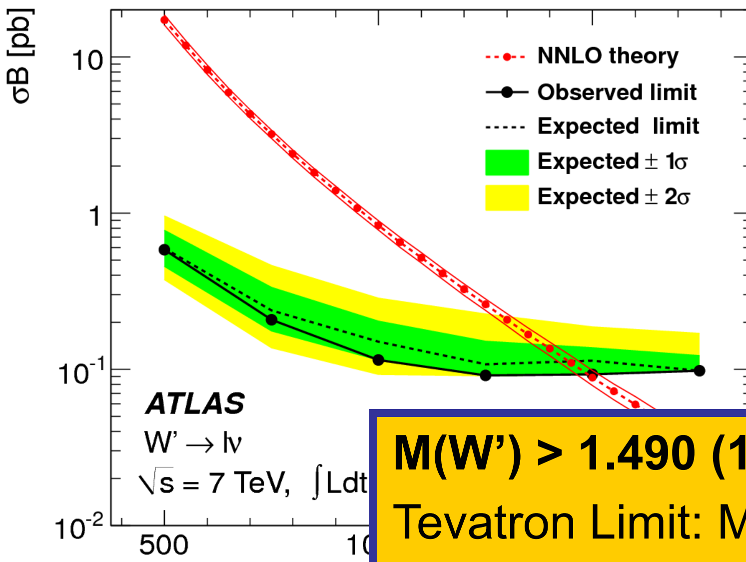


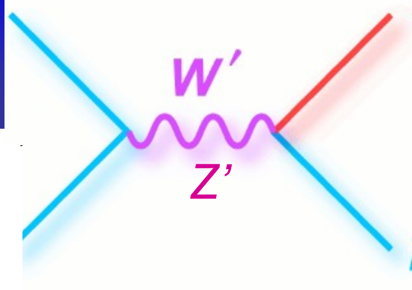
Exclusion reach better than at Tevatron

Extra Gauge Bosons (ll +lν)



Submitted to PLB; arXiv:1103.1391



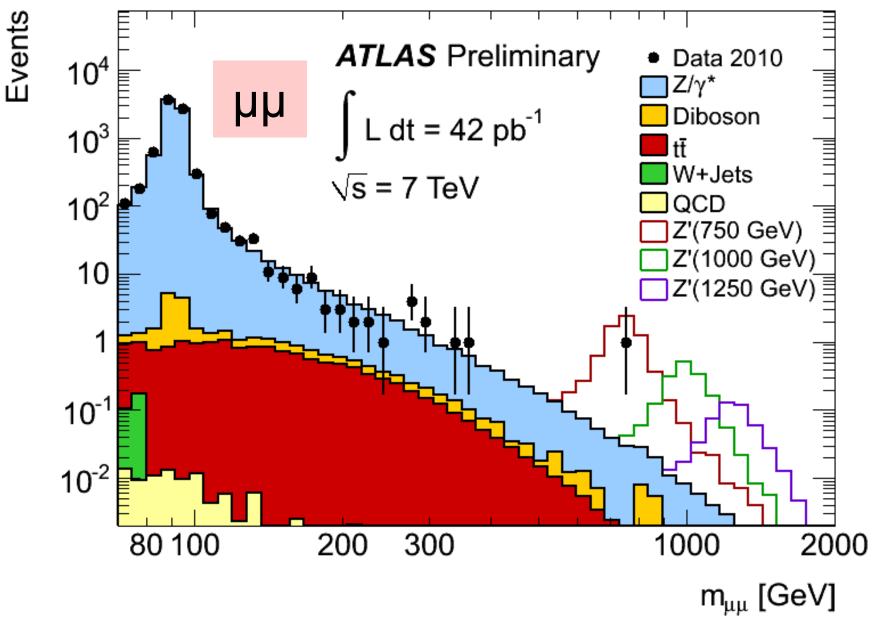


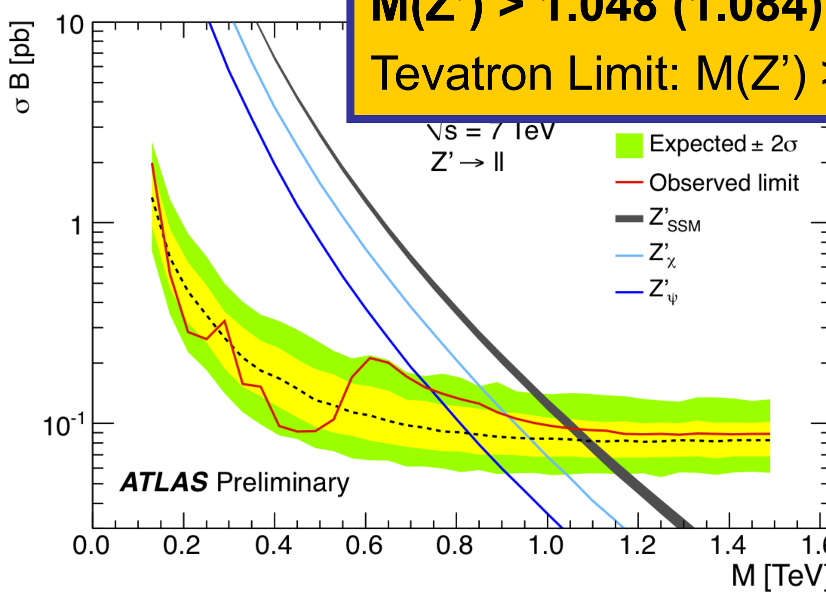
M(W') > 1.490 (1.450) TeV

Tevatron Limit: M(W') > 1.10 TeV

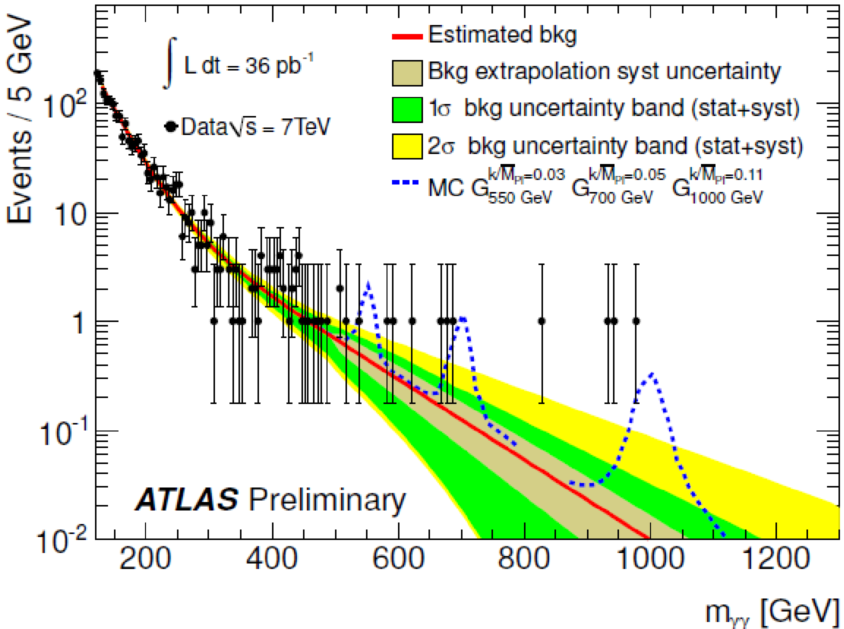
M(Z') > 1.048 (1.084) TeV

Tevatron Limit: M(Z') > 1.071 TeV





Searches with Di-Photons



NEW

Diphoton Resonance Search (36pb^{-1})

LIMITS 95% C.L:

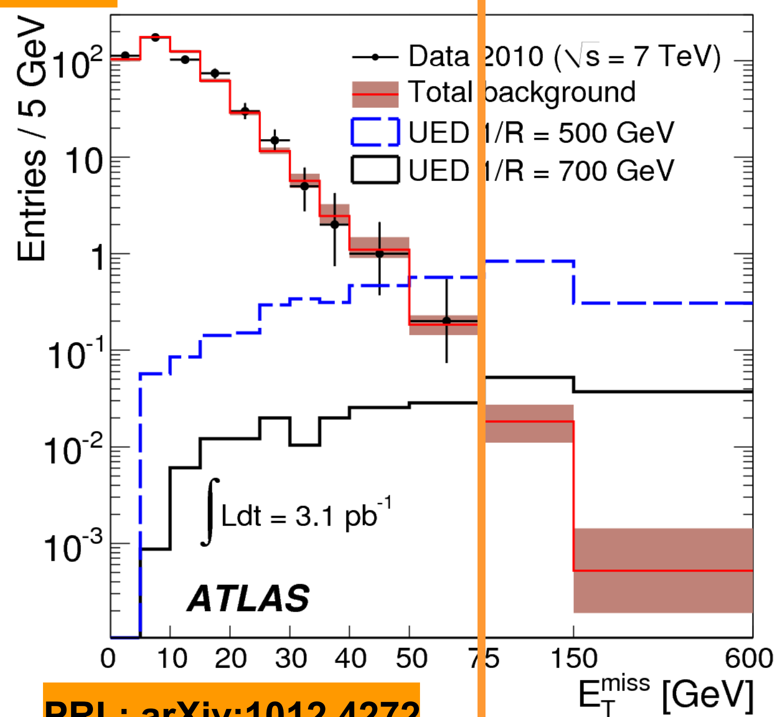
M(G) > 545 GeV (k/MPL = 0.02)

M(G) > 920 GeV (k/MPL = 0.1)

Previous Tevatron limit (D0):

M(G) > 1.050 GeV (k/MPL=0.1)

ATLAS-CONF-2011-044



Diphoton + Met Search (3 pb-1)

Universal Extra Dimension

- KK-g/q→γ* → γ + G (x2 per event)
  → observe: γγ + ETmiss (+ other SM)

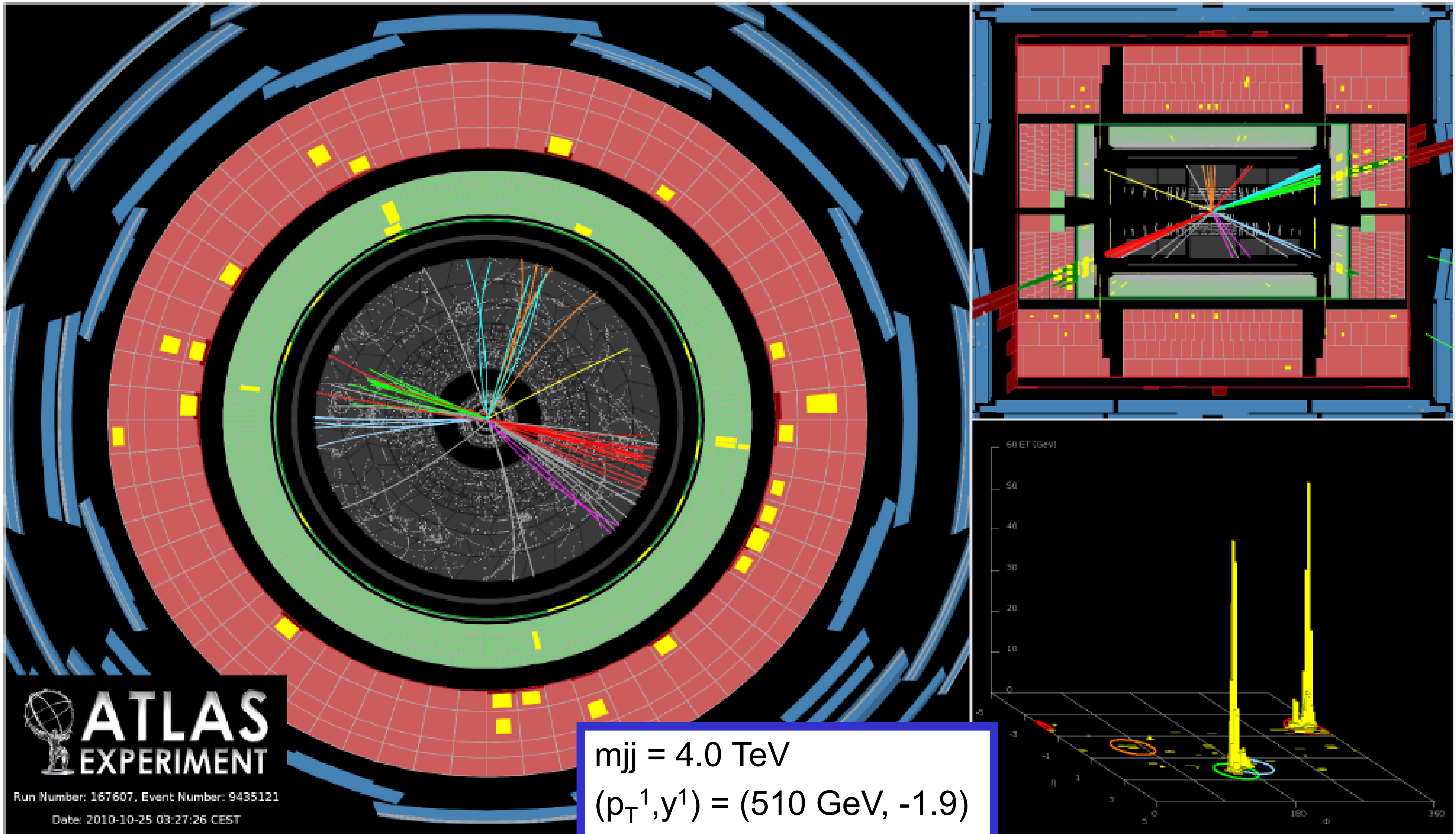
Limit: 1/R > 728 GeV (95% C.L.)

Previous Tevatron limit (D0): 1/R > 477 GeV

Most stringent limits to date

PRL; arXiv:1012.4272

Highest-mass dijet event recorded in 2010

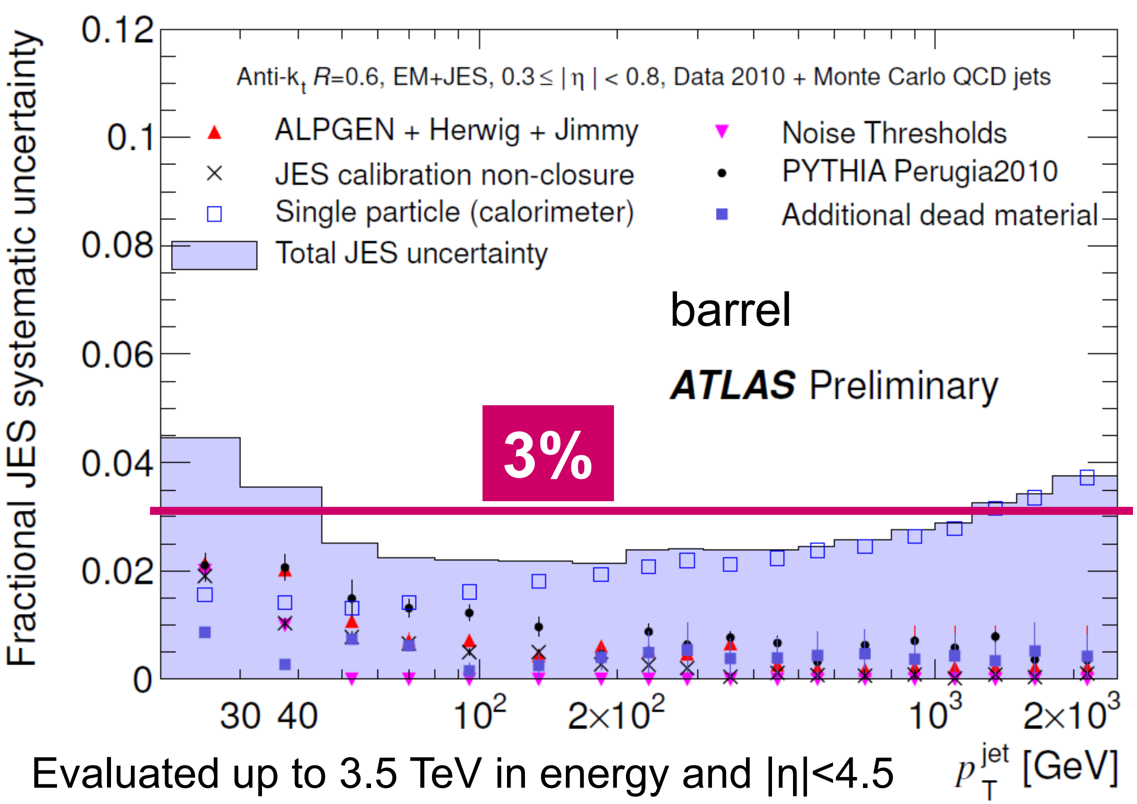


m_{jj} = 4.0 TeV

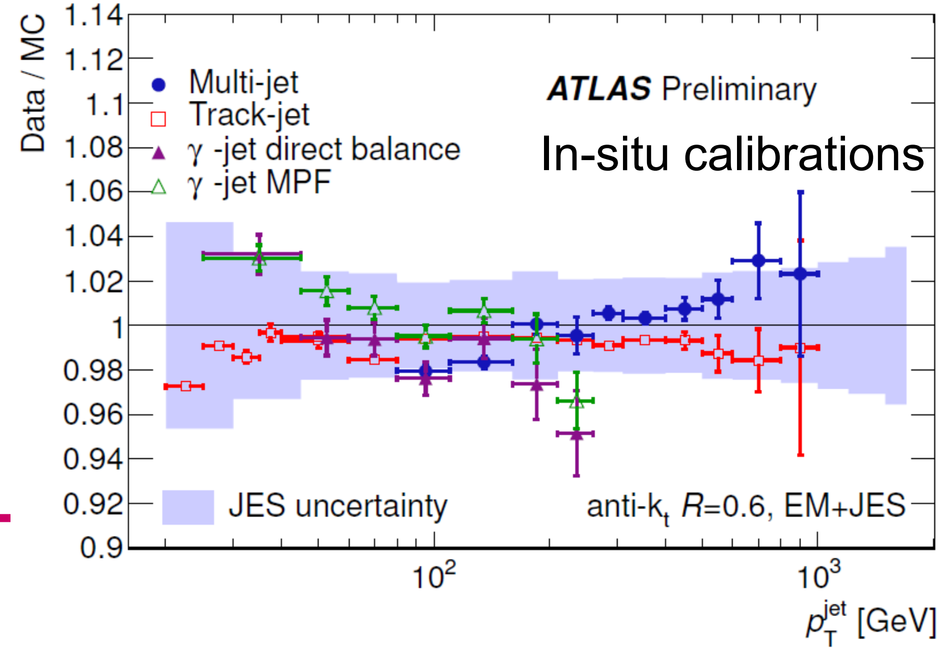
$(p_T^{\,1}, y^1)$ = (510 GeV, -1.9)

$(p_T^{\,2}, y^2)$ = (510 GeV, 2.2)

Jet Energy Scale



Evaluated up to 3.5 TeV in energy and |η|<4.5



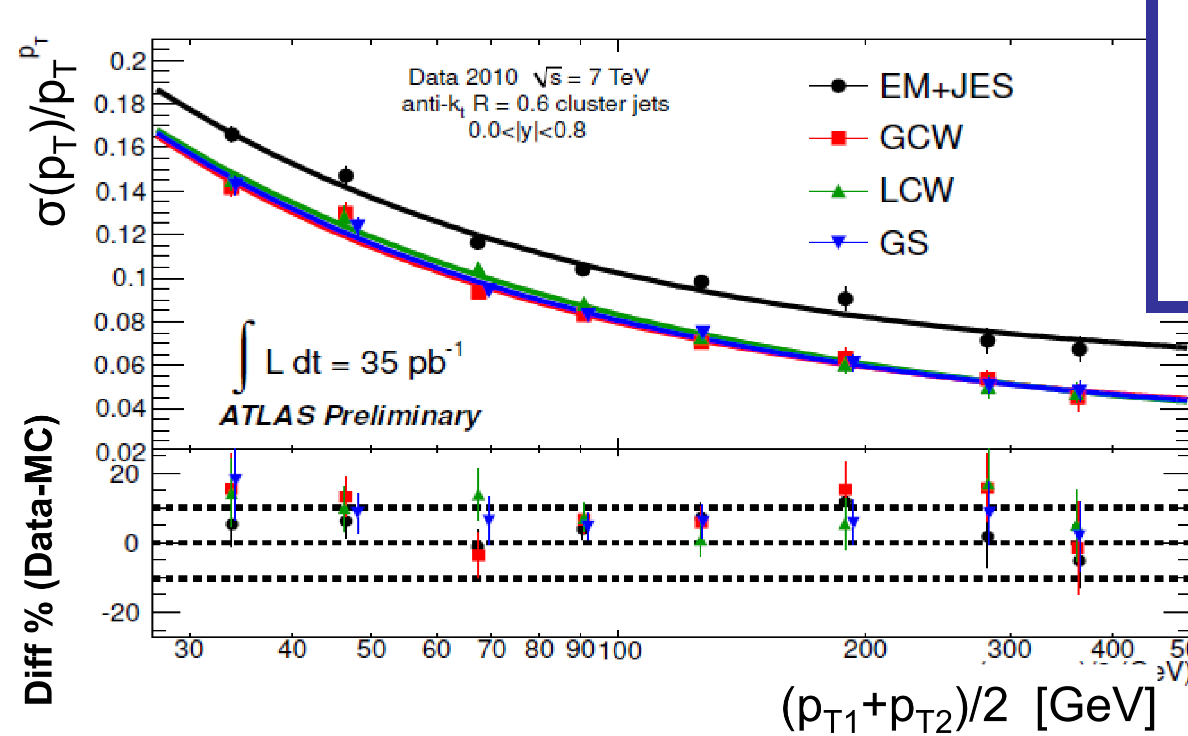
Improved by factor of 2

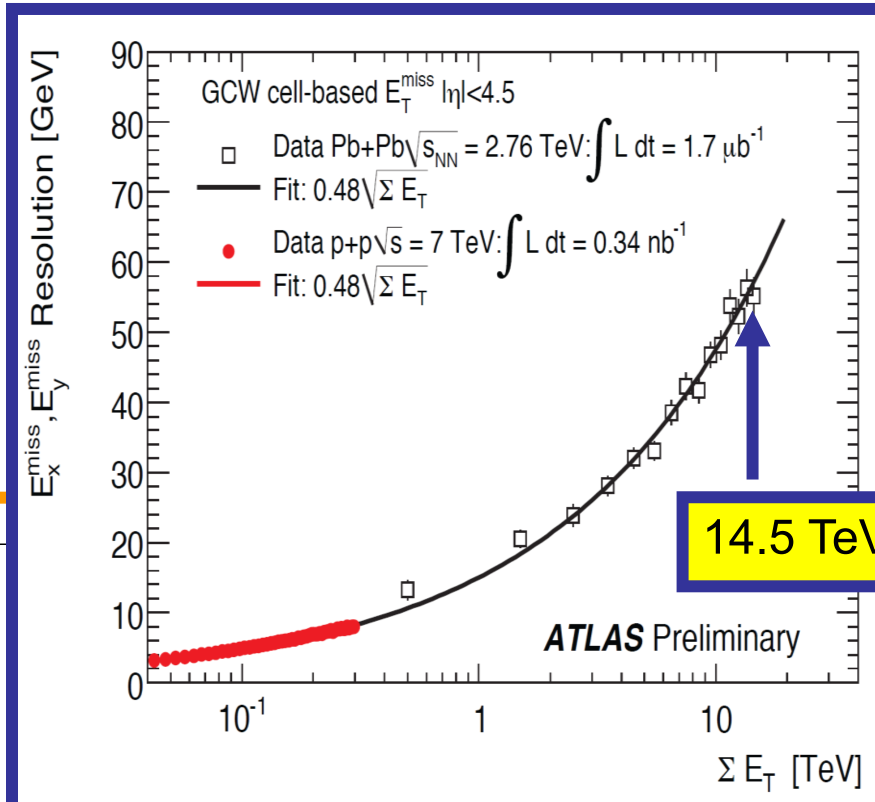
η region	Maximal relative JES uncertainty		
	P_T^{jet} = 20 GeV	P_T^{jet} = 200 GeV	P_T^{jet} = 1.5 TeV
|η|<0.3	4.6%	2.3%	3.1%
2.1<|η|<2.8	7.1%	2.5%	
3.6<|η|<4.5	12.6%	2.9%	

Jet Energy and Etmiss Resolutions

Advanced calibrations → improve resolution by 10-30%

Monte Carlo agrees with data within 10%

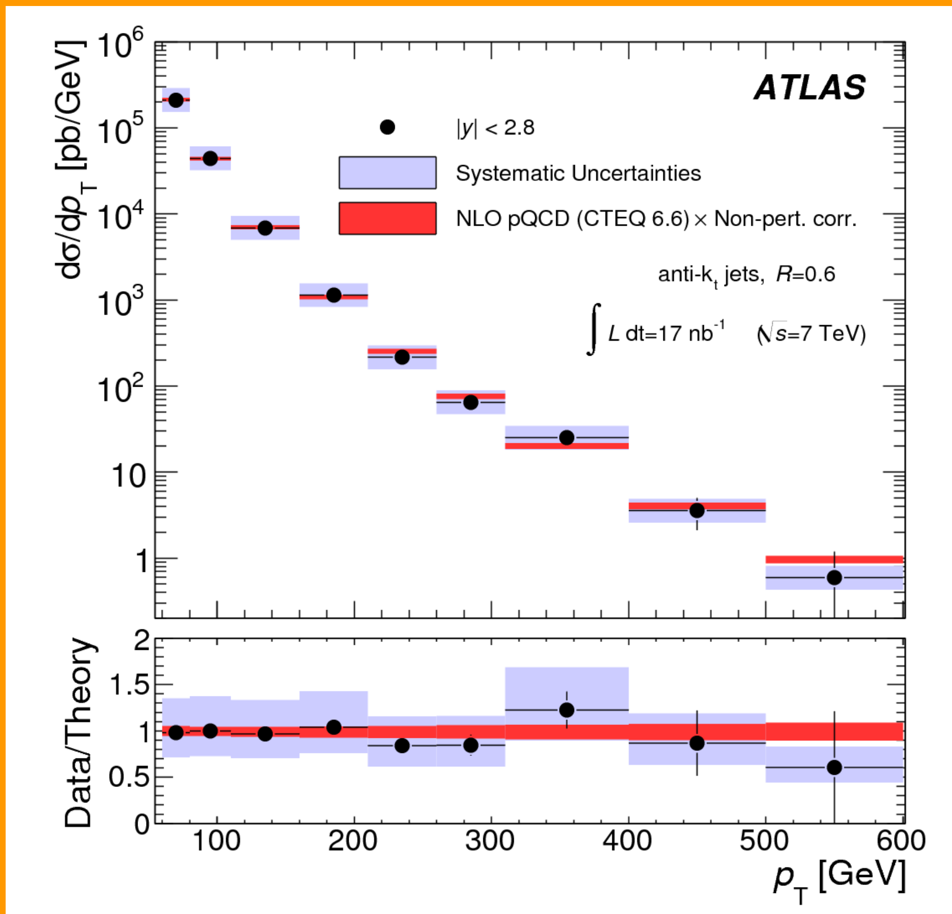


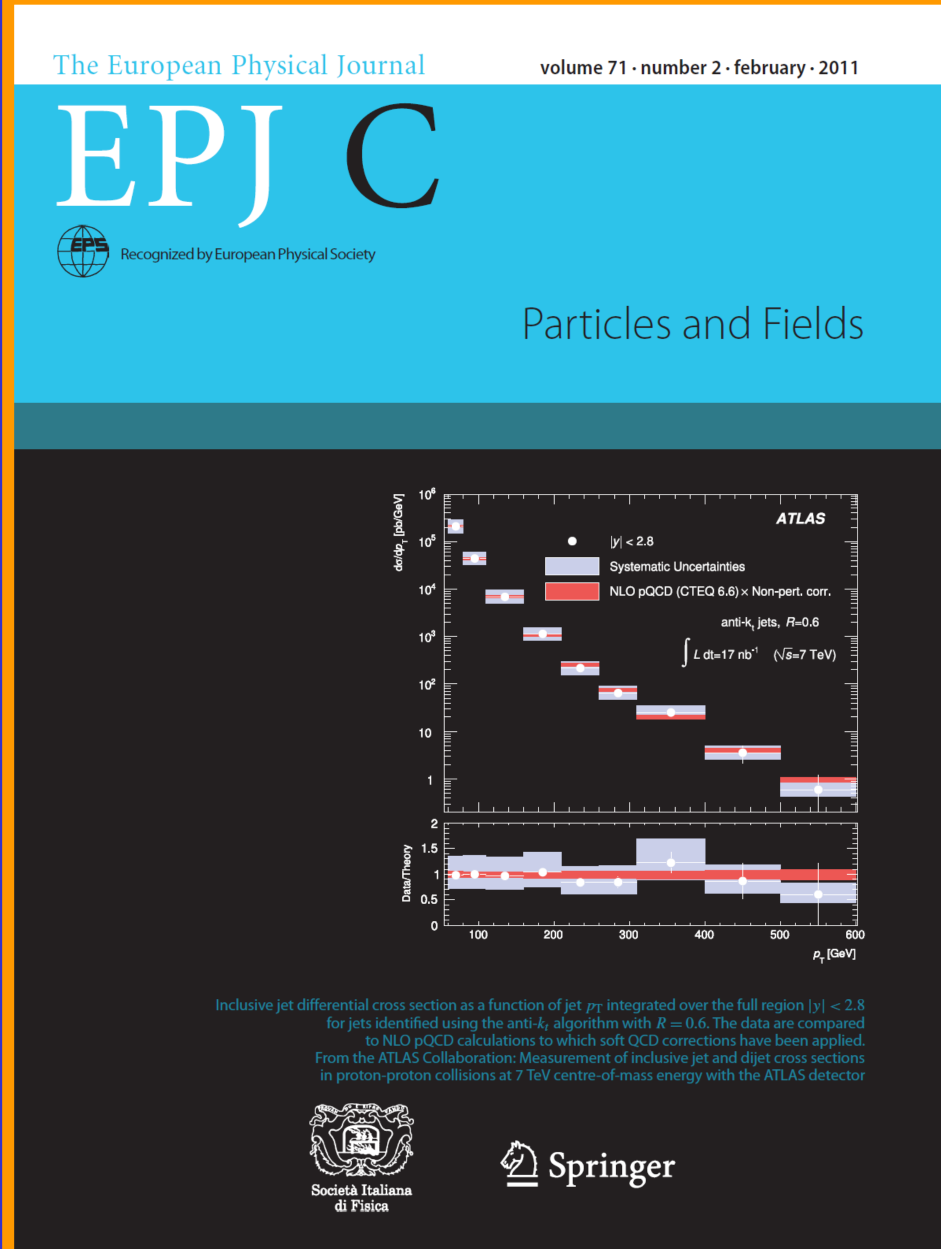


PbPb data only sample reaching this high in $\sum E_T$

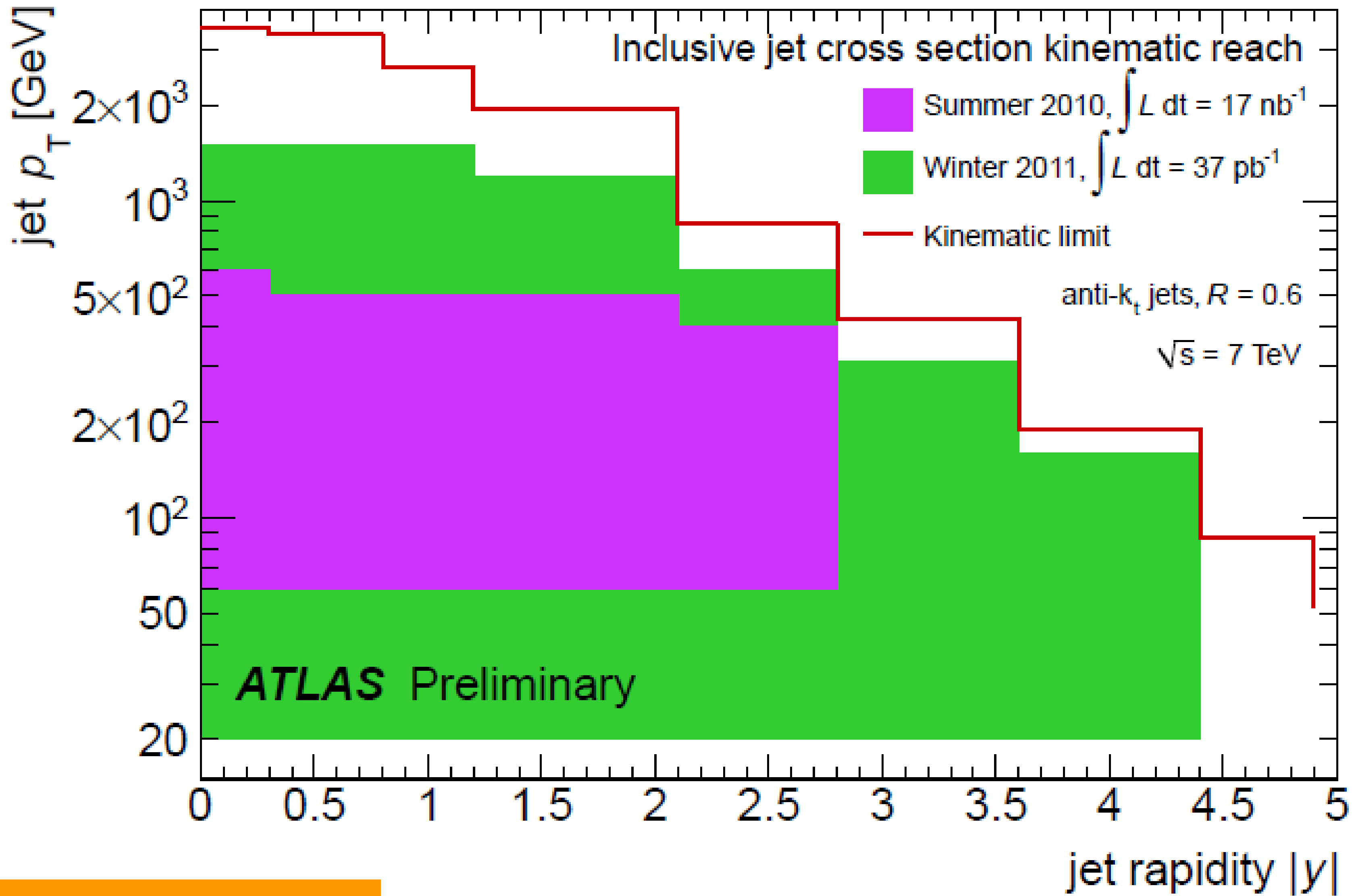
Inclusive Jet Differential Cross Sections

Our first measurement Sep 2010



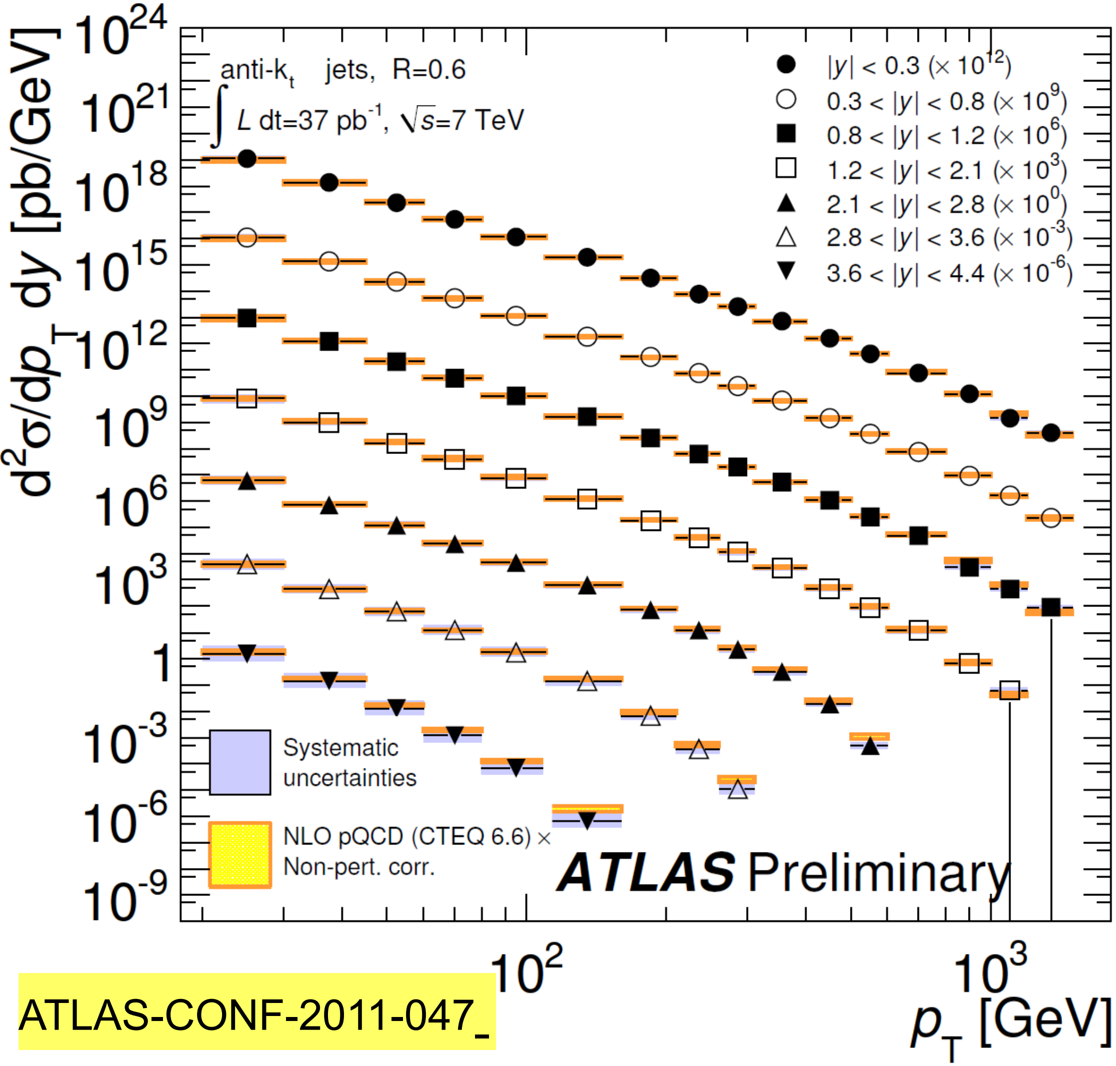


Inclusive Jet Cross Section Kinematic Reach



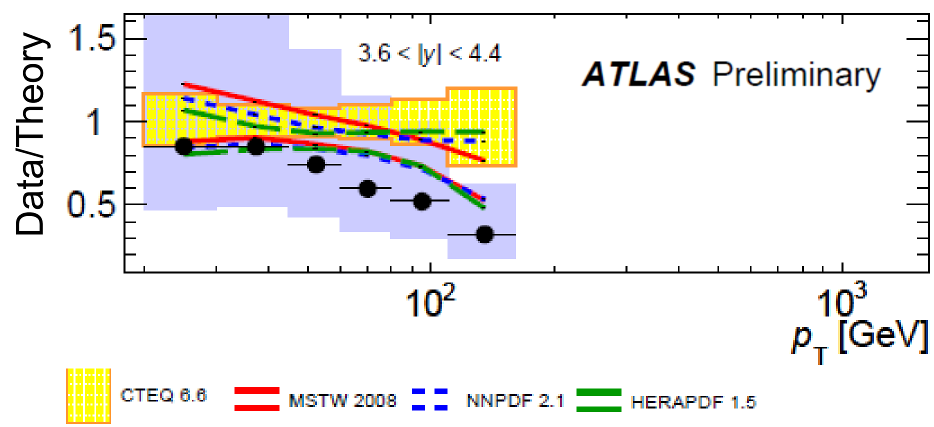
ATLAS-CONF-2011-047_

Inclusive Single Jet Double-Differential Cross Section



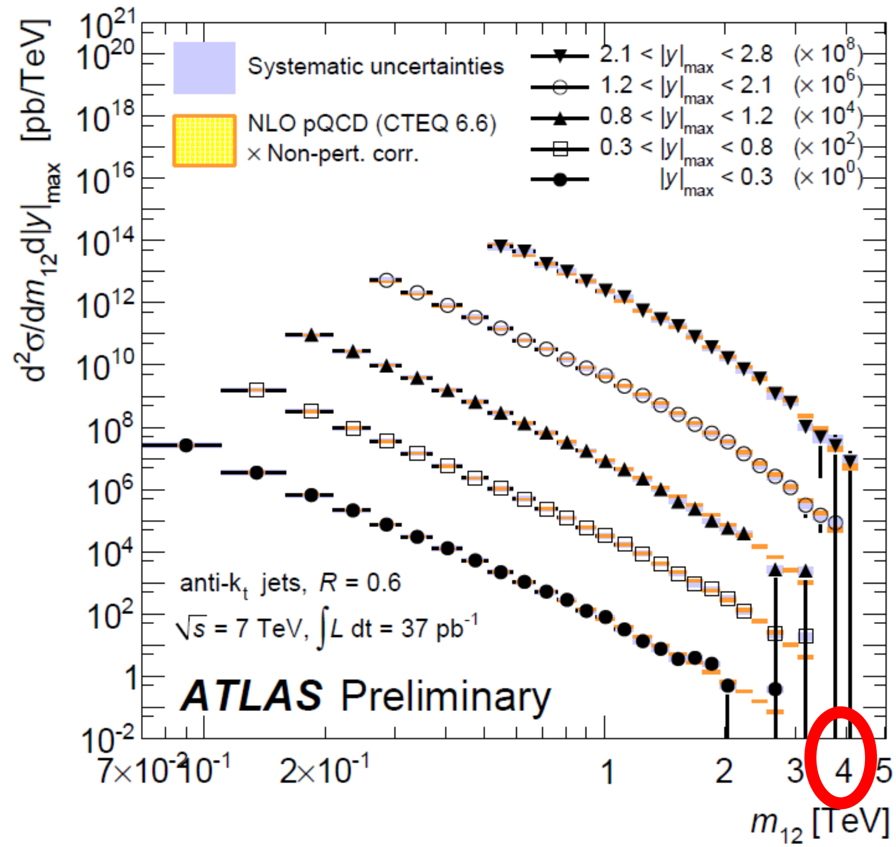
ATLAS-CONF-2011-047_

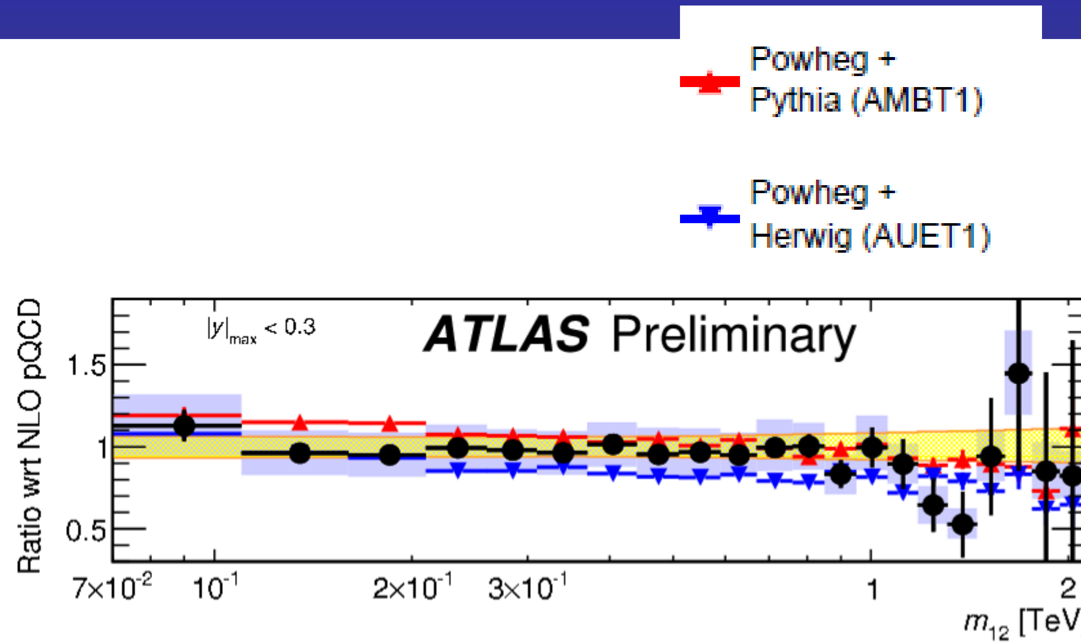
- Full 2010 data: 37 pb^{-1}
- 20 GeV < p_T < 1500 GeV
- 7 rapidity bins, |y|<4.4
- 10-12 orders of magnitude in cross section
- Total uncertainty 50-10%
  - Dominated by JES



Good agreement btw data and NLO pQCD with various PDFs

Inclusive Double-Differential Di-Jet Cross Section





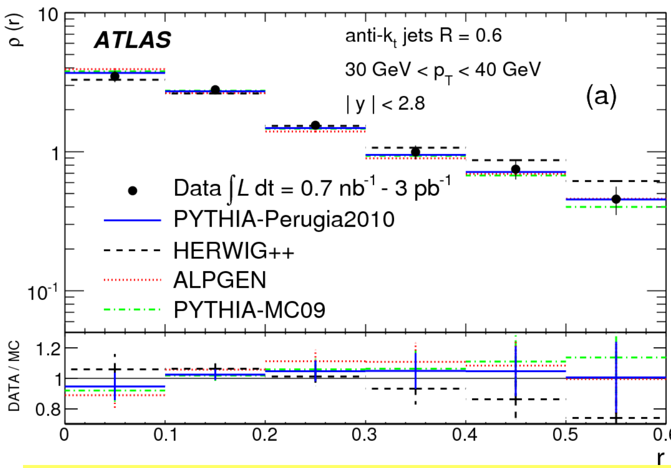
Inclusive Jet Cross Sections Summary

- Probing truly new, large kin. region
- Expanded to very forward region
  - |y| up to 4.4 (1st time at a hh collider)
- Uncertainty greatly reduced
  - 50% → 20% (central)
- Good agreement btw data and NLO pQCD with various PDFs

Breakthrough: POWHEG comparisons

ATLAS-CONF-2011-047

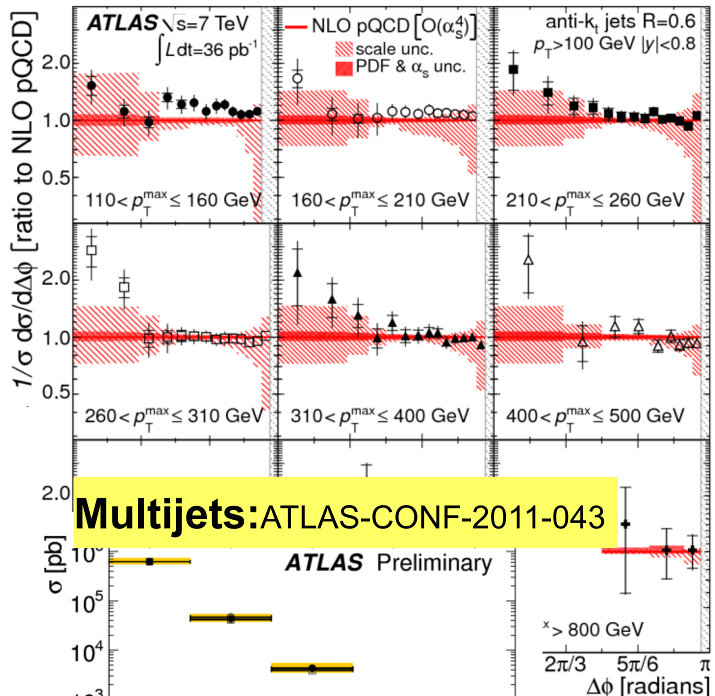
Many More SM Jet Results

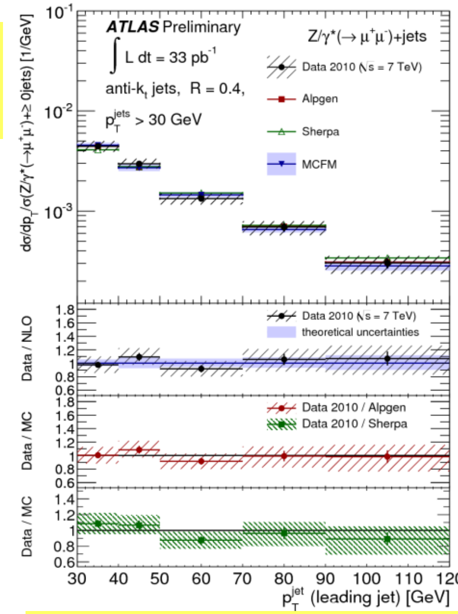


Jet Shapes: **Phys. Rev. D 83, 052003 (2**

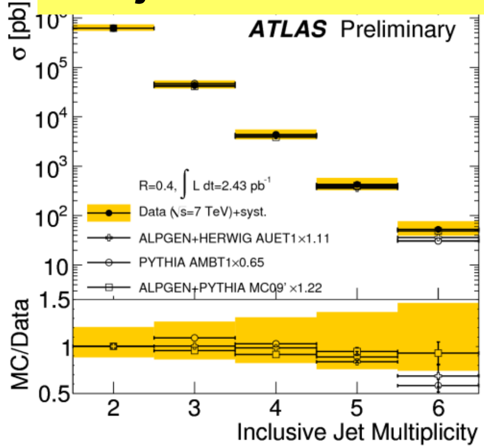
Dijet azimuthal decorrelations:

Accepted by PRL; arXiv:1102.2696 [hep-ex]



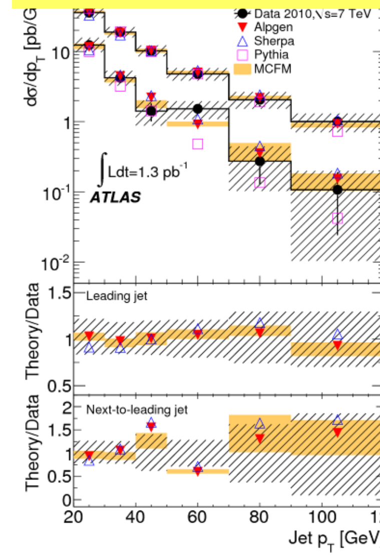


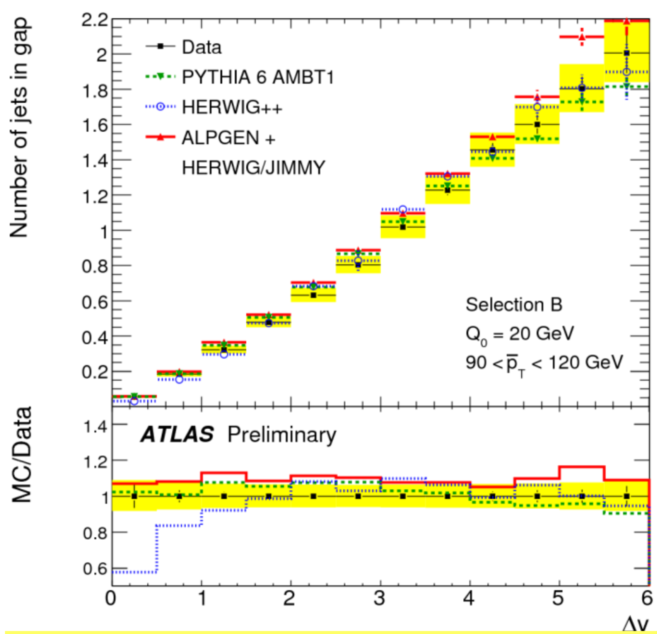
Multijets: ATLAS-CONF-2011-043



Z+jets: ATLAS-CONF-2011-042

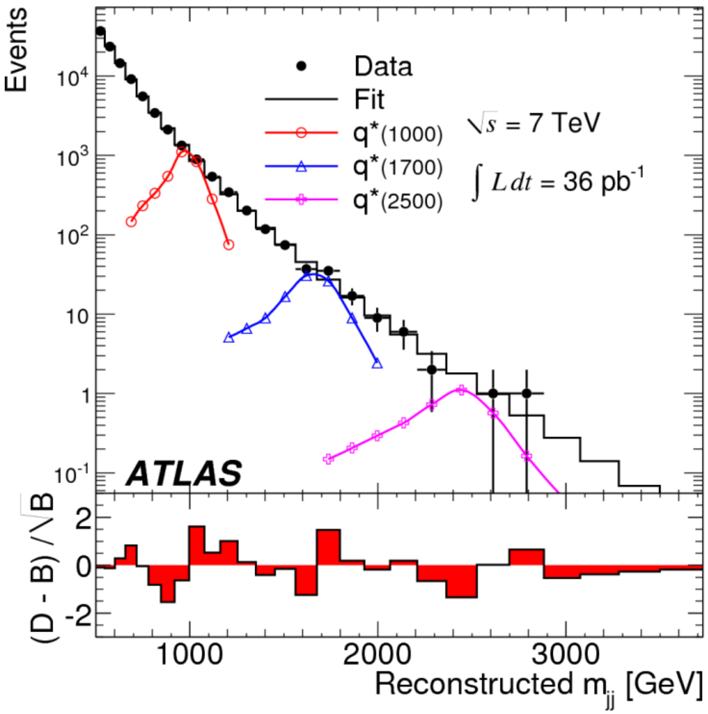
W+jets: Phys.Lett.B;1012.5382 [hep-ex]





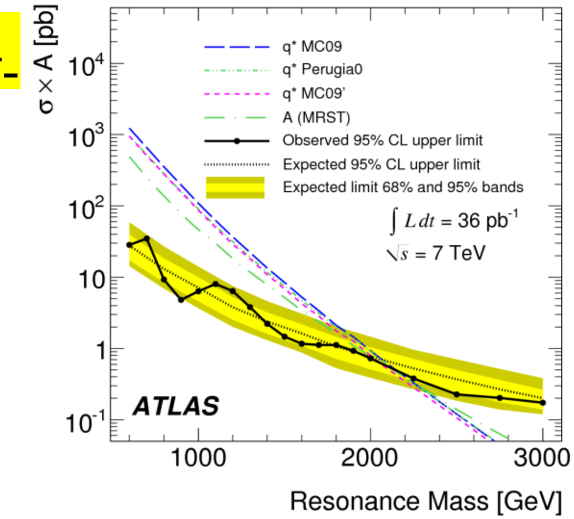
Dijet production with a jet veto: ATLAS-CONF-2011-038

Dijet Resonance Searches in ATLAS



Submitted to NJP; arXiv:1103.3864

Search for a BUMP
Nothing found
p-value = 0.39



95% C.L LIMITS Observed (Expected)

Excited quarks (q*): **M > 2.15 (2.07) TeV**

Quantum Black Holes: **M > 3.67 (3.64) TeV**

Axigluons: NEW **M > 2.10 (2.01) TeV**

Also 1st time more model Independent limits

	σ/m				
Mean m (GeV)	0.03	0.05	0.07	0.10	0.15
600	434	638	849	1300	1990
700	409	530	789	1092	945
800	173	194	198	218	231
900	88	103	123	162	311
1000	147	179	210	278	391
1100	143	169	204	263	342
1200	91	120	168	223	262
1300	65	80	101	120	122
1400	35	42	[illegible]	[illegible]	[illegible]
1500	24	27	[illegible]	[illegible]	[illegible]
1600	21	25	29	[illegible]	[illegible]

NEW

Lower limits on Nobs (95% C.L.)

Dijet Angular Distribution Searches

Submitted to NJP; arXiv:1103.3864

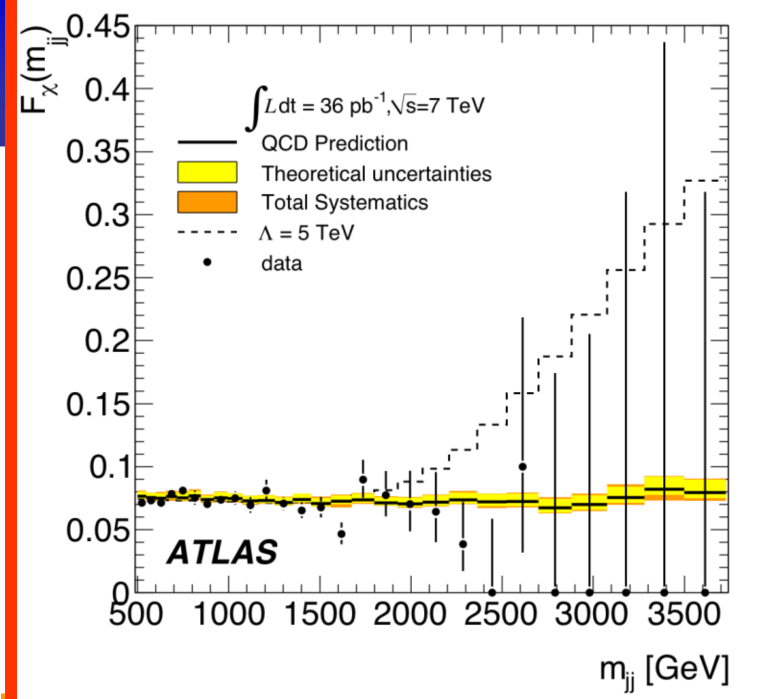
$$F_\chi(m_{jj}) = \frac{N_{events}(|y^*| < 0.6)}{N_{events}(|y^*| < 1.7)}$$

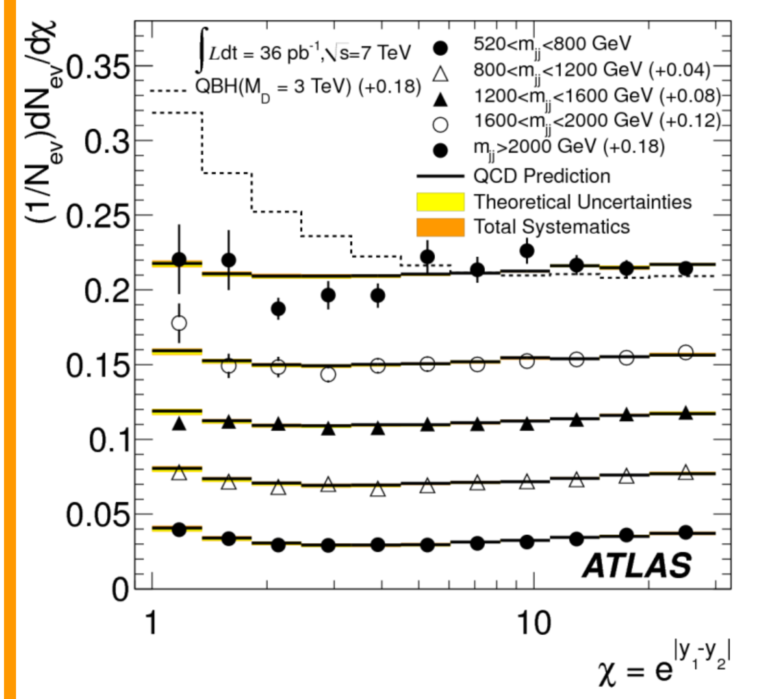
NEW

Summary of Dijet Search Reach (mass + angular)

Model and Analysis Strategy	95% C.L. Limits (TeV) Expected	Observed
Excited Quark q^*		
Resonance in m_{jj}	2.07	2.15
$F_\chi(m_{jj})$	**2.12**	**2.64**
Randall-Meade Quantum Black Hole for $n = 6$		
Resonance in m_{jj}	**3.64**	**3.67**
$F_\chi(m_{jj})$	3.49	3.78
θ_{np} Parameter for $m_{jj} > 2$ TeV	3.37	3.69
11-bin χ Distribution for $m_{jj} > 2$ TeV	3.36	3.49
Axigluon		
Resonance in m_{jj}	**2.01**	**2.10**
Contact Interaction Λ		
$F_\chi(m_{jj})$	**5.72**	**9.51**
F_χ for $m_{jj} > 2$ TeV	5.24	6.76
11-bin χ Distribution for $m_{jj} > 2$ TeV	5.40	6.58

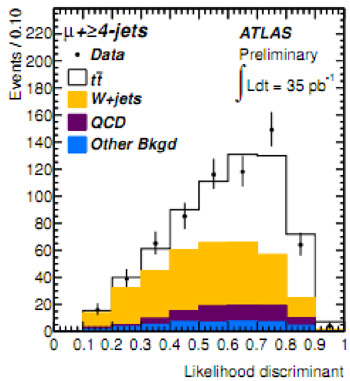
Most stringent limits to date



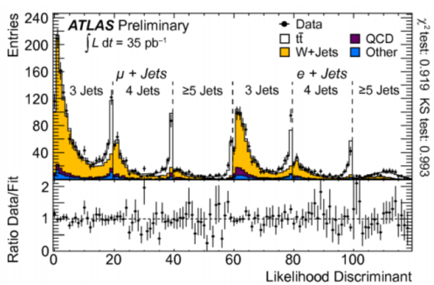


tt Production Cross Section with 35 pb^{-1}

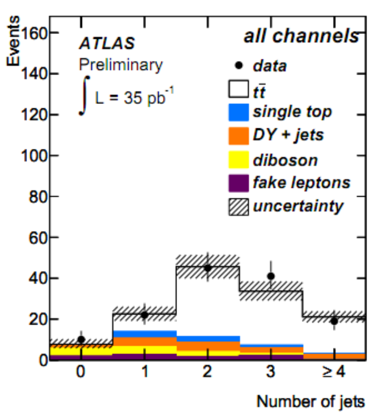
ATLAS-CONF-2011-023
ATLAS-CONF-2011-025
ATLAS-CONF-2011-034
ATLAS-CONF-2011-040



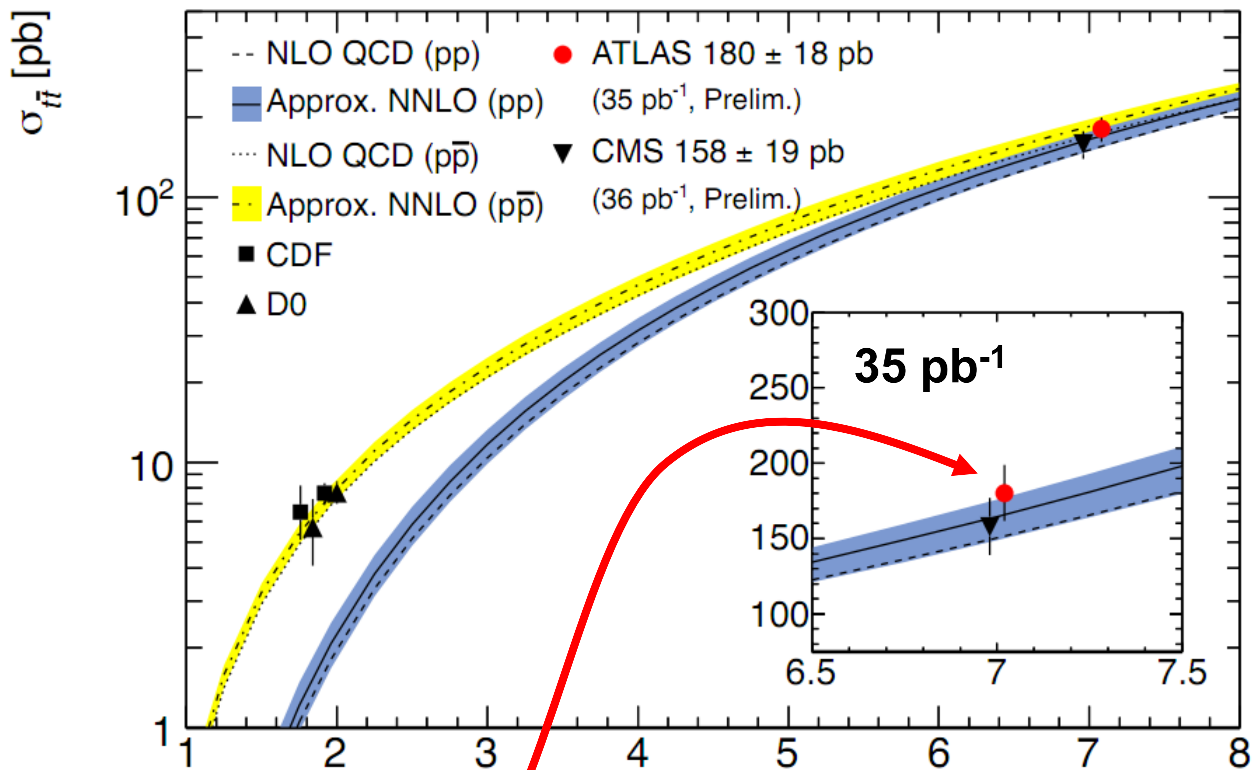
l+jets

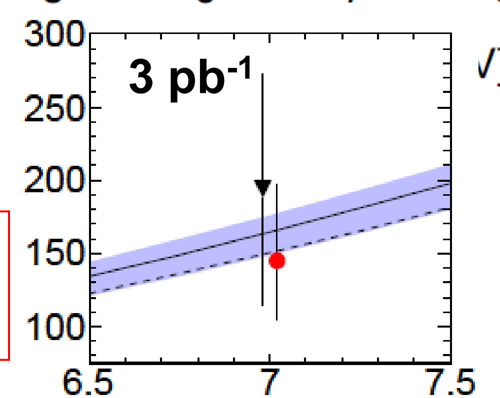


l+jets with b-tag



dilepton





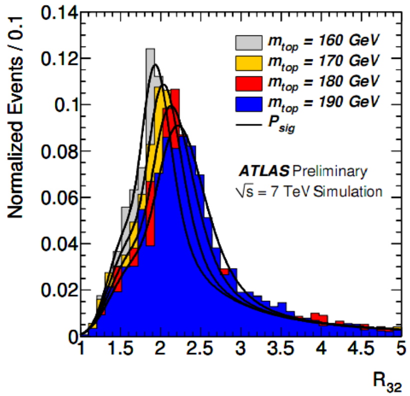
σ(tt) = 180 ± 9± 15 ± 6 pb
[10% total uncertainty]

Top Properties in 35 pb^{-1}

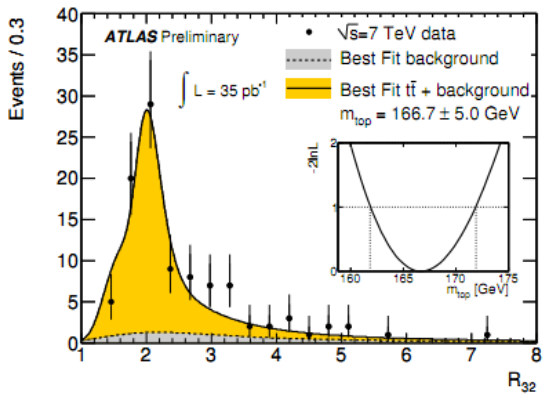
ATLAS-CONF-2011-033
ATLAS-CONF-2011-037

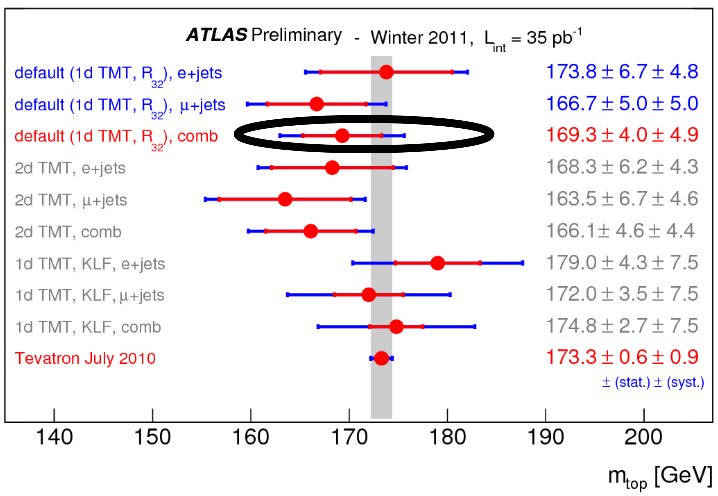
- Top Mass   **m(t) = 169.3 ± 4.0 ± 4.9 GeV**
  - Measured in lepton+jets channel
  - Dominant uncertainty due to JES
  - Uses ratio of reconstr. top to W mass

R_{32} - templates



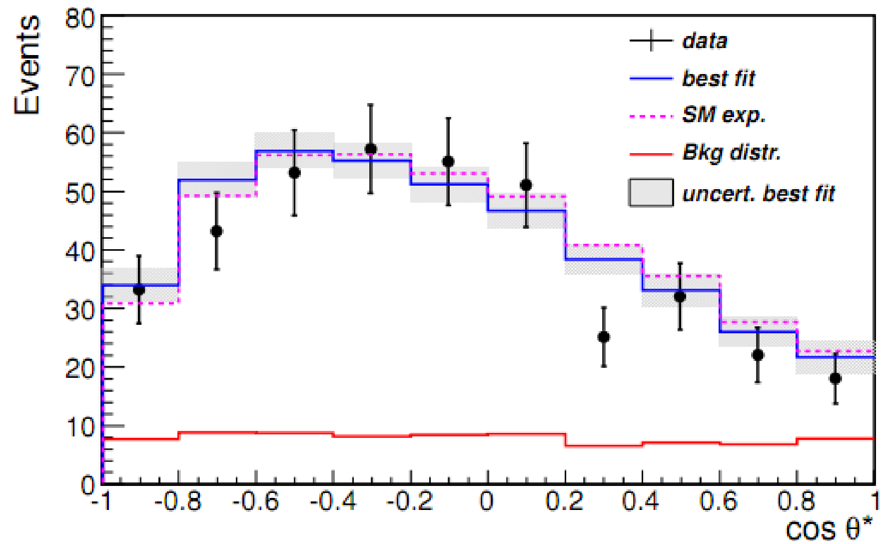
R_{32} - μ+jets channel





- W helicity in top decays
  - Sensitive to anomalous couplings
  - **F_L = 0.59 ± 0.12**
  - **F_0 = 0.41 ± 0.12**
  - Stat. limited, approaching Tevatron precision

cos(θ*) l+jets channel

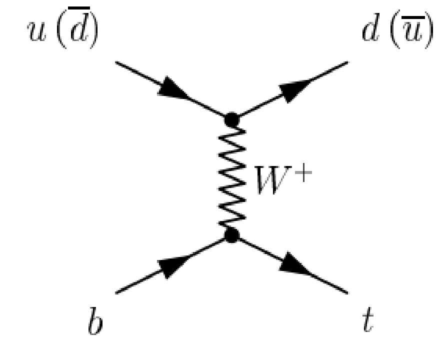


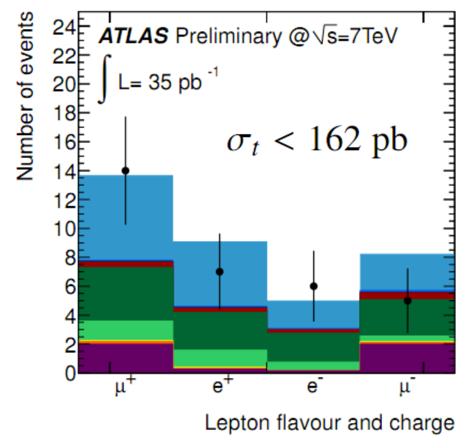
Top Physics with ATLAS

ATLAS-CONF-2011-027
ATLAS-CONF-2011-036

- **The era of top physics at the LHC has started**
- Pair-production cross-section
  - QCD
  - **Study different decay channels**
- Single top production
  - EWK
  - s-channel, **Wt-channel, t-channel**
- Properties:
  - **mass**, width, charge, spin
- Wtb vertex
  - **W helicity, anomalous coupling**
- Anomalous production
  - Resonances, **modified final state**

New Measurements at ATLAS





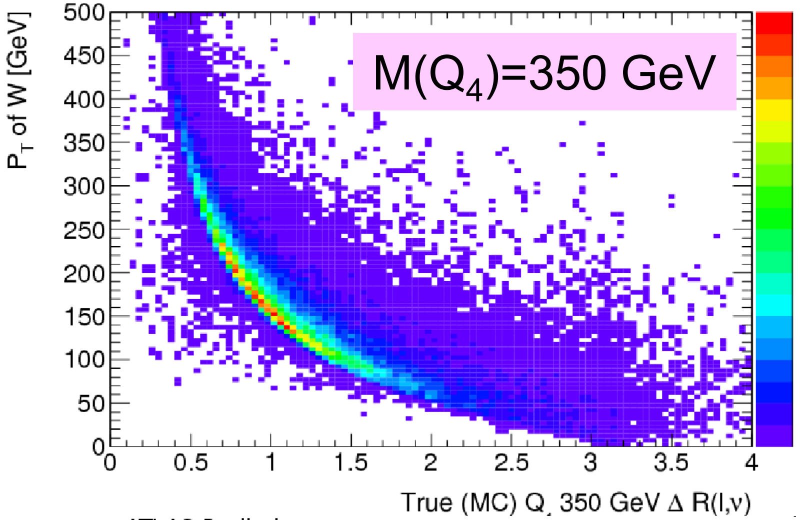
- **Statistics limited analysis will become attractive this year**
  2011: the year of precision top measurements at the LHC

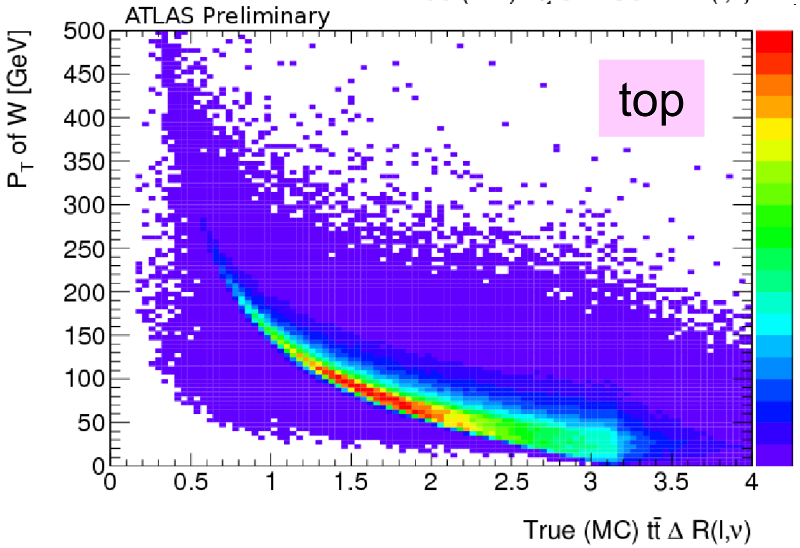
Searches for 4^{th} Generation Quarks in Dilepton Channel, 37 pb^{-1}

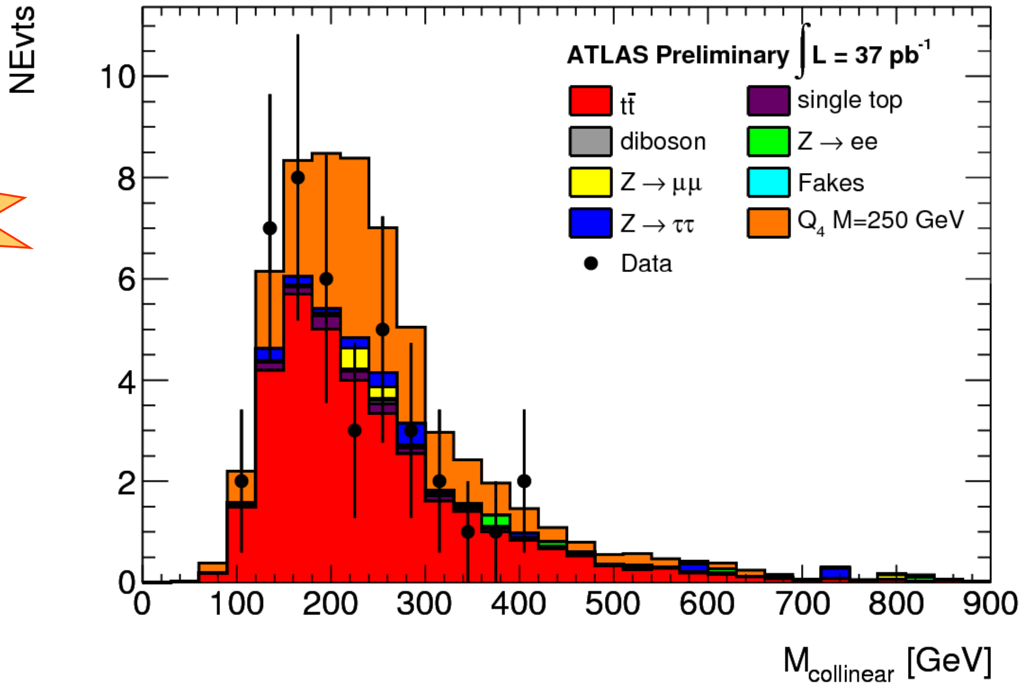
ATLAS-CONF-2011-022

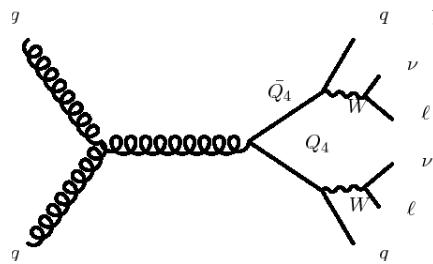
First dilepton u4 search!

NEW









LIMIT 95% C.L. Obs (Exp) :

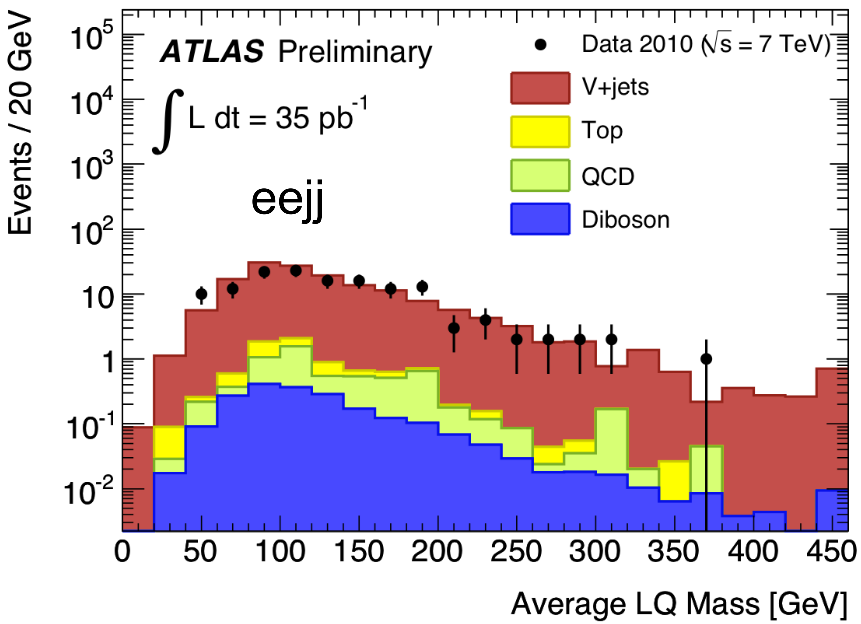
$M(Q_4) > 270$ (284) GeV

Limit with 5.6 fb-1 (CDF): $M(u_4) > 356$ GeV

Limit with 4.8 fb-1 (CDF): $M(d_4) > 372$ GeV

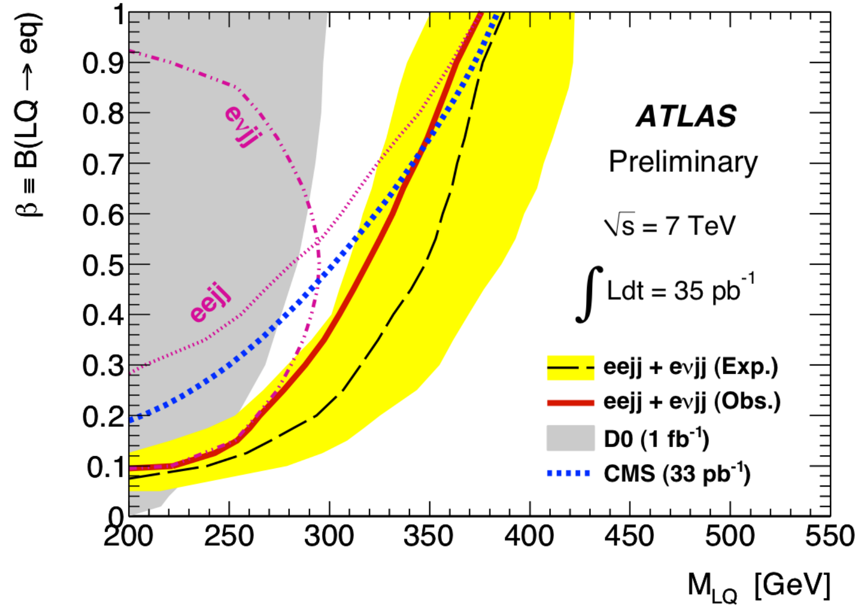
(CDFNote CDF/PUB/TOP/PUBLIC/10110, arXiv:1101.5728)

Search for 1st and 2nd gen Leptoquarks



llqq + lνqq

NEW



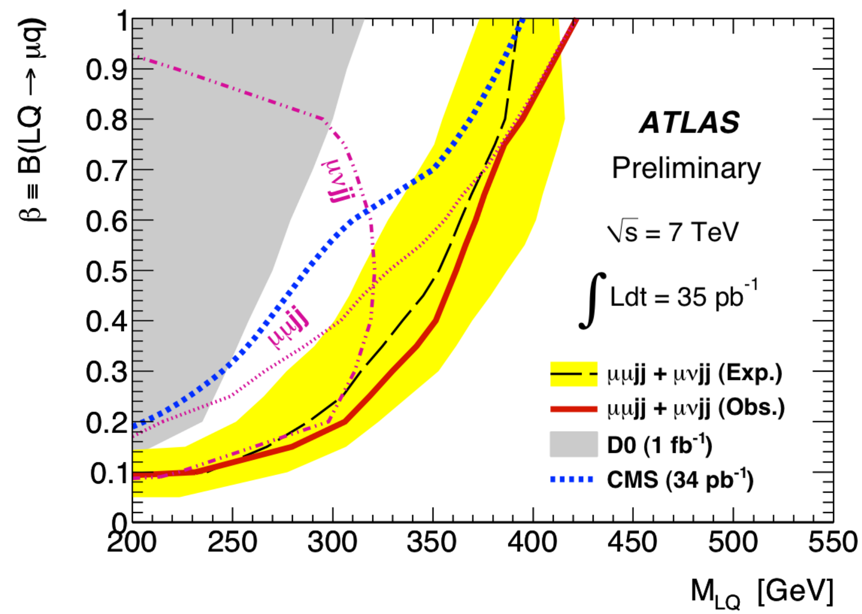
95% C.L. LIMITS Observed (Expected) [GeV]

1st Generation: M > 376 (387) GeV β=1

M > 319 (348) GeV β=0.5

2nd Generation: M > 422 (393) GeV β=1

M > 362 (353) GeV β=0.5

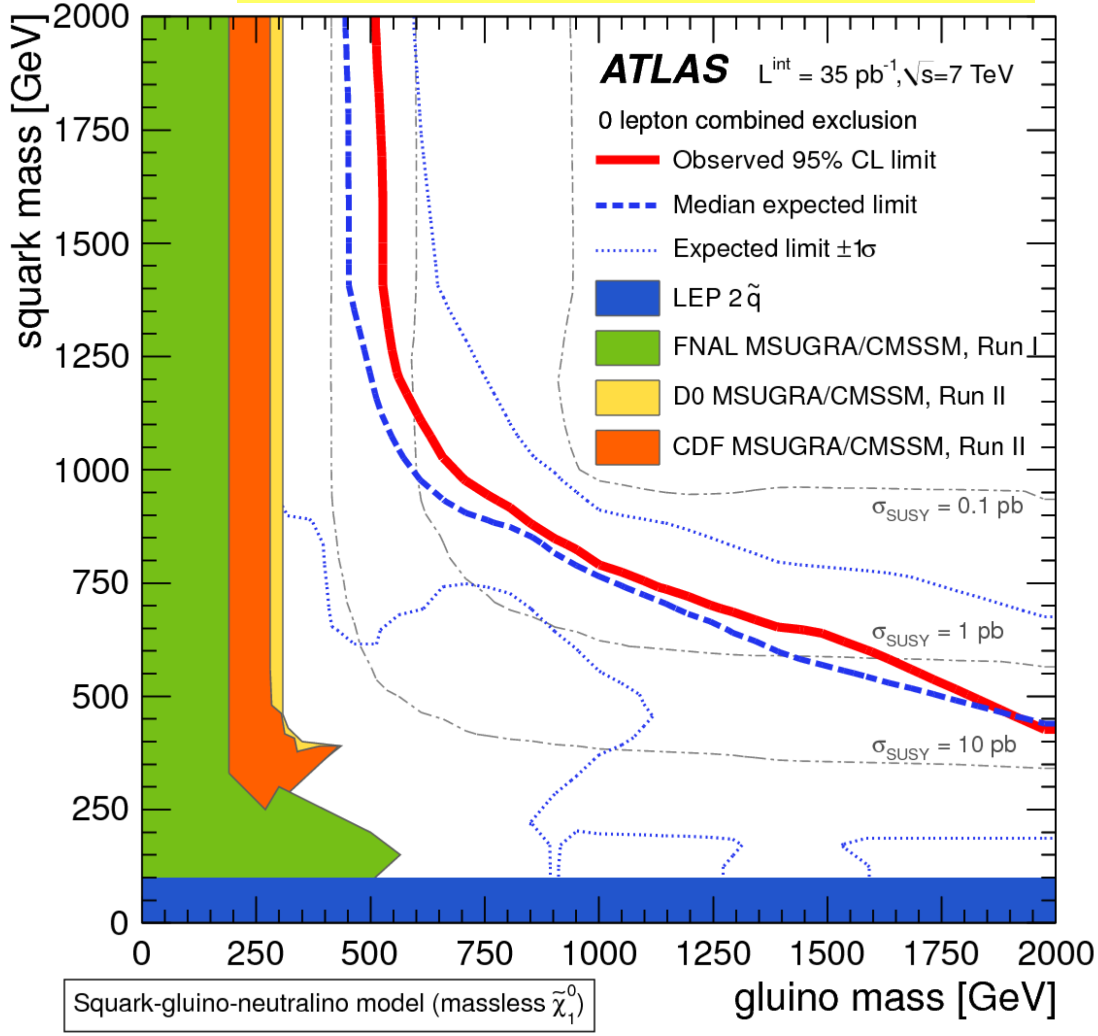


Significantly extending search reach

SUSY: 0 lepton + Etmiss + Jets

- Very sensitive to strong production of $\tilde{q}$ and $\tilde{g}$
  - SM background from W(lν)/Z(νν)+jets, QCD, top
  - 4 signal regions to cover maximum of the phase space
    - See no excess
- Interpret in Phenomenological simplified MSSM
  - If **m=m($\tilde{q}$)=m($\tilde{g}$)**,
    - exclude **m<870** GeV
  - Exclude **m($\tilde{g}$)<500** GeV

ArXiV:1102.5290, submitted to PLB

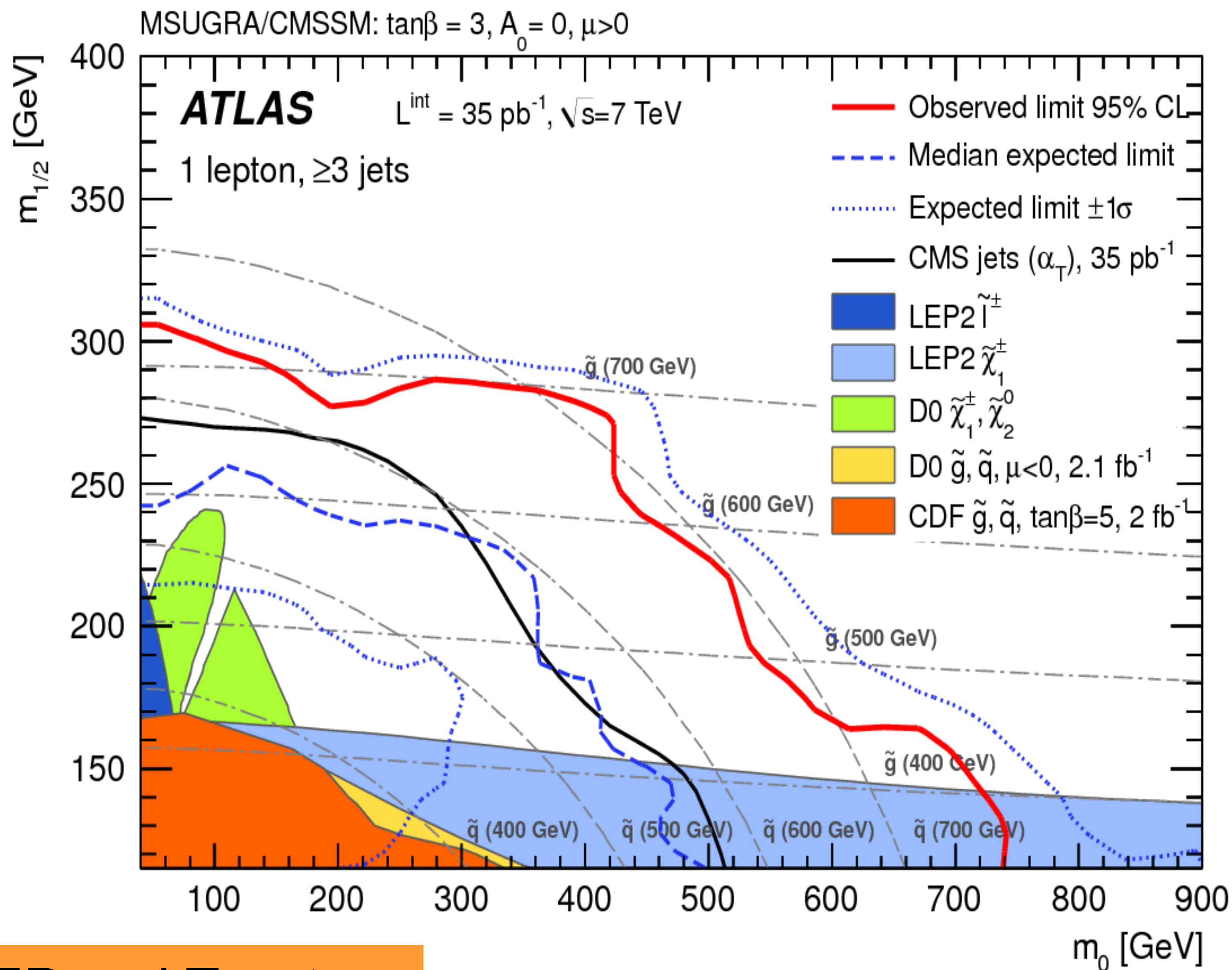


Most stringent limits to date

SUSY: 1 lepton + Etmiss + jets

ArXiV:1102.2357, accepted by PRL

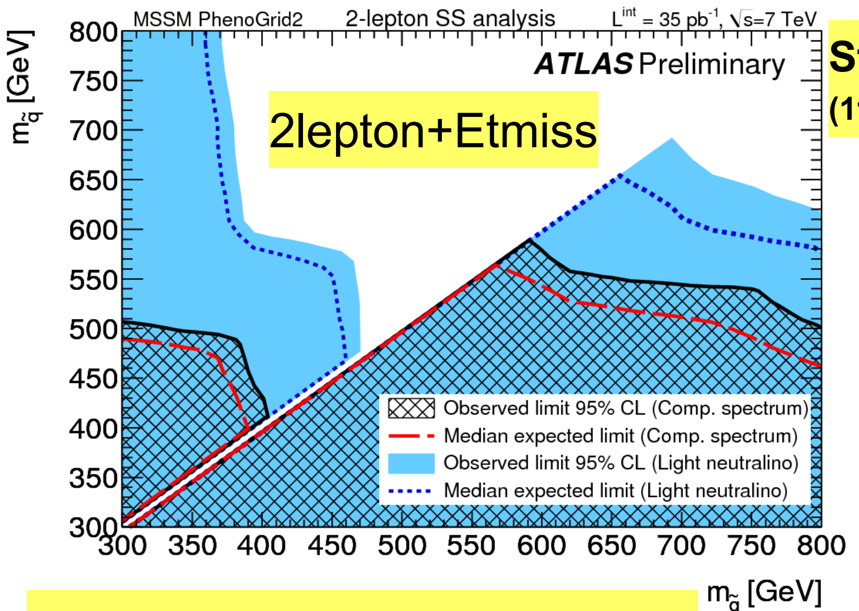
- Robust
- Isolated lepton ease triggering and QCD reduction
- Expect ~4 events and see 2 events
- Interpret in mSUGRA



Reach well beyond LEP and Tevatron

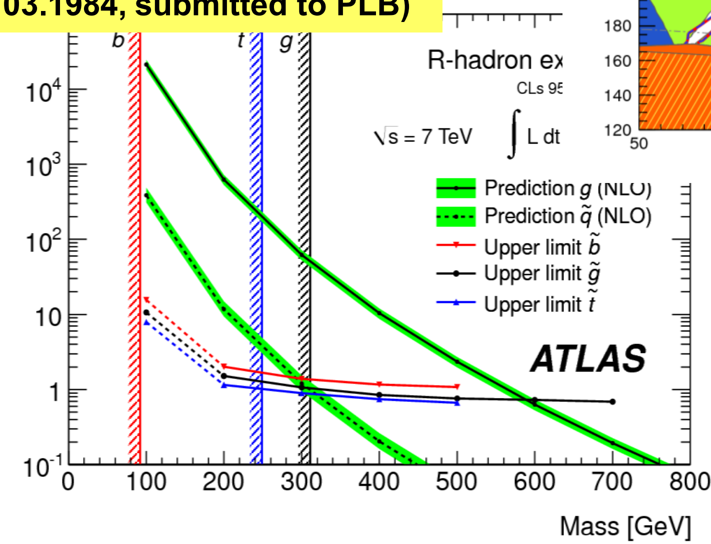
Many More SUSY Searches

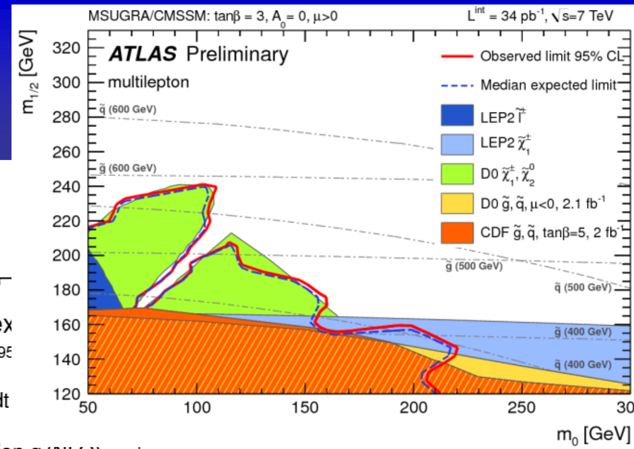
2lepton+Etmiss



Stable Massive Particle

(1103.1984, submitted to PLB)

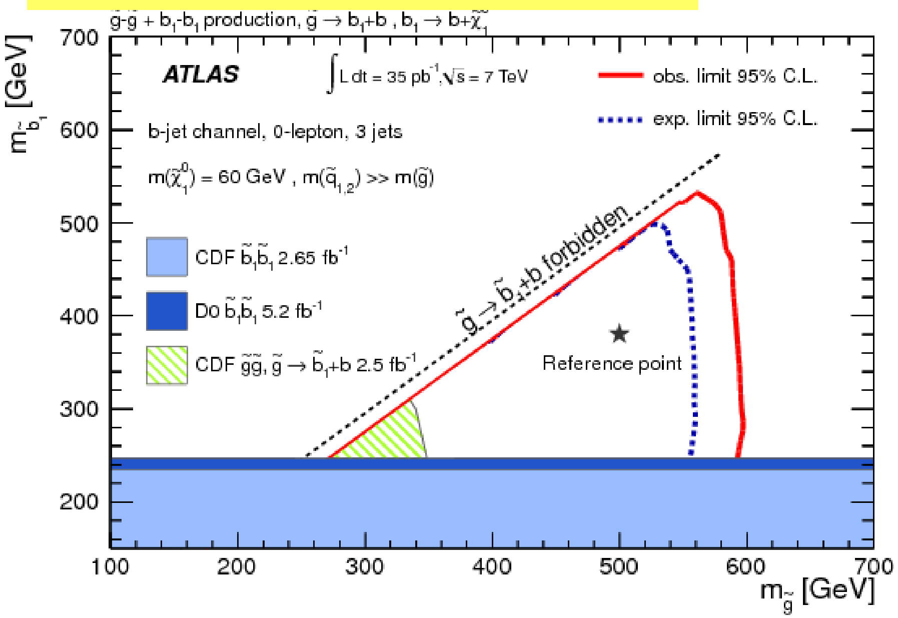




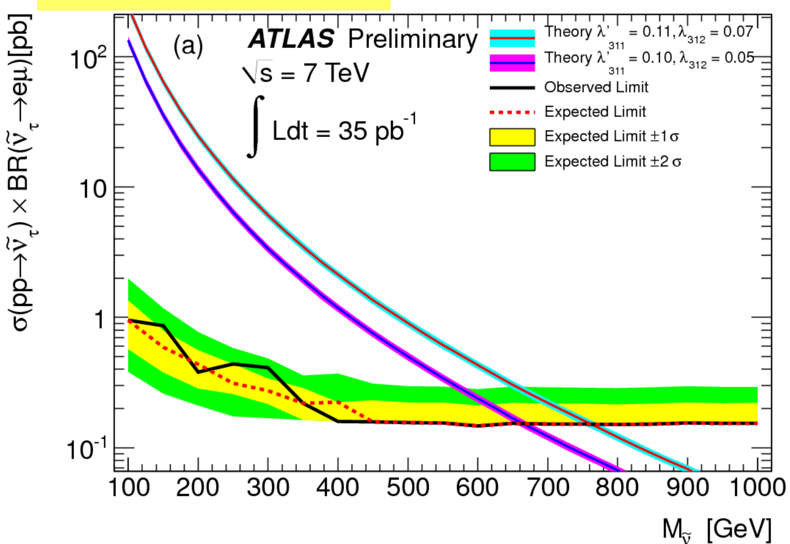
multi leptons;

ATLAS-CONF-2011-039

1bjet+Etmiss; submitted to PLB

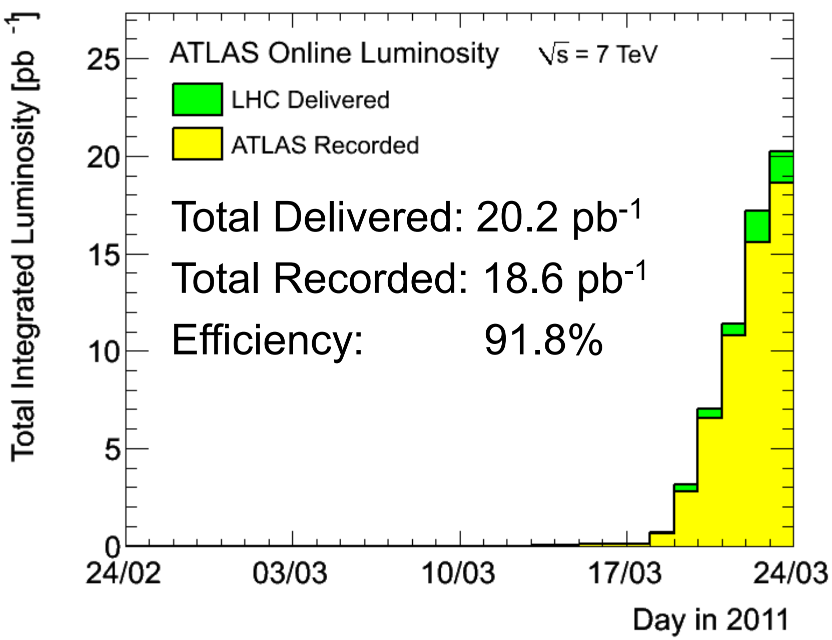


eμ resonances



Summary

- Detector performed beautifully
- 2010 work/results foundation for 2011
  - Rediscovered SM and pushing the “precision frontier”
  - Extended the reach in many channels beyond Tevatron
  - **25 papers submitted and 11 in the pipeline**
- Great Thank You to the LHC Machine Team



Notes for Winter Conferences	
Performance Groups	14
Data Preparation	1
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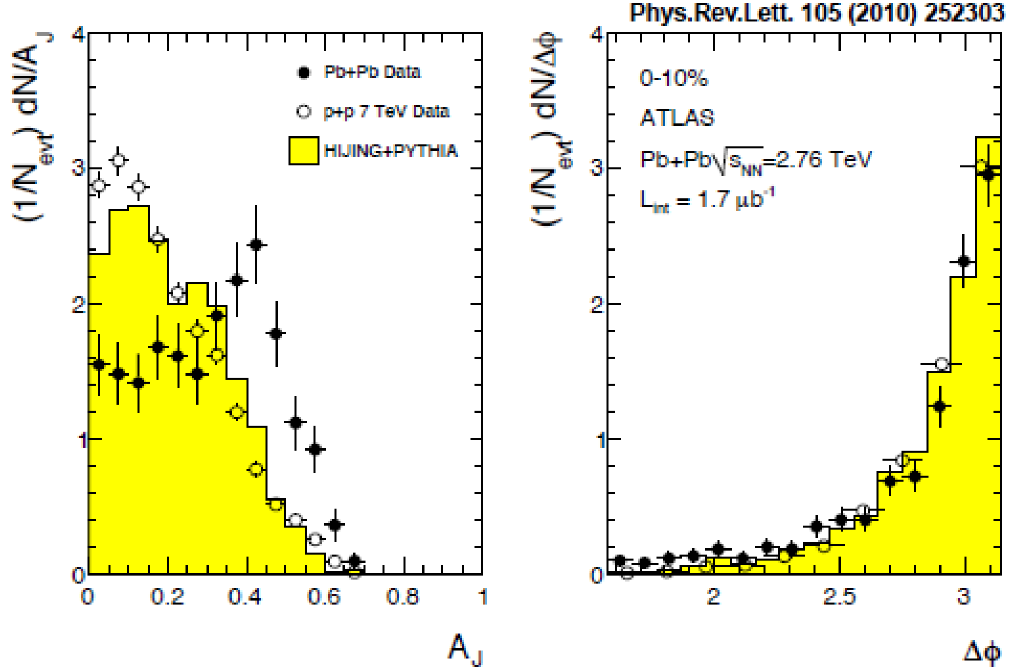
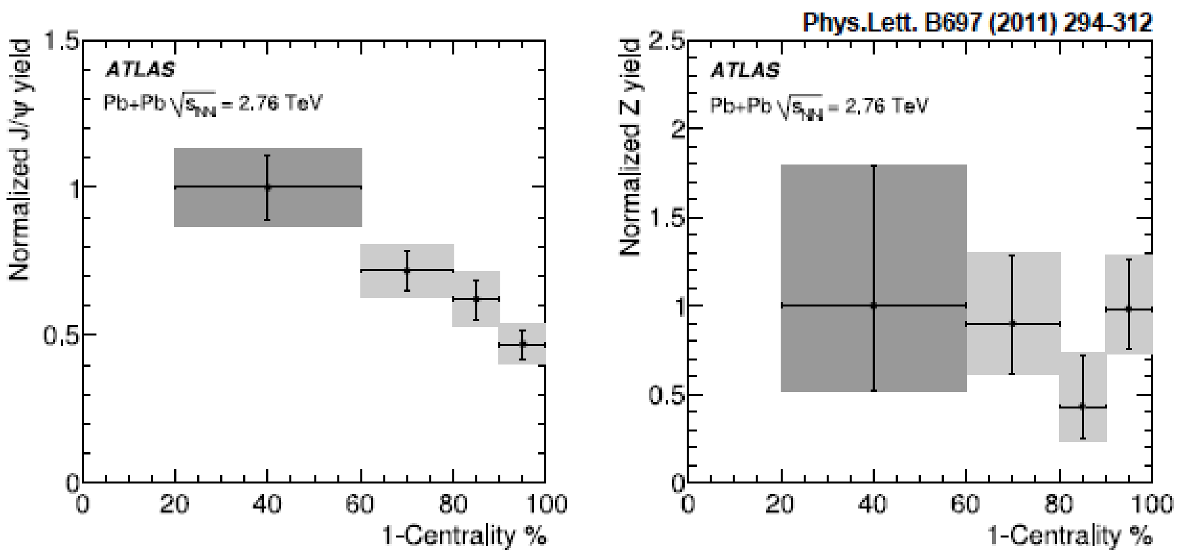
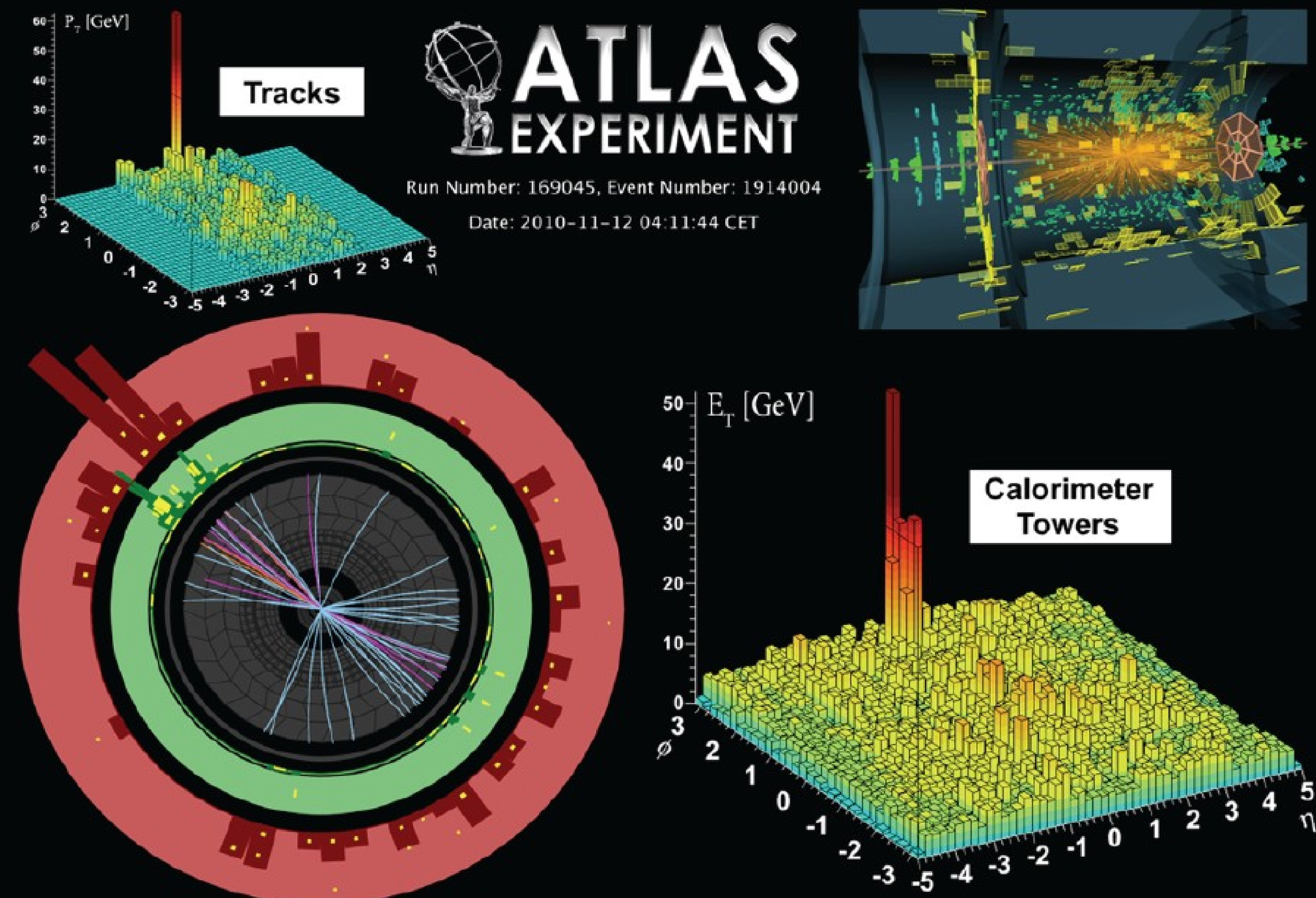
Backup Slides



First measurements of asymmetric dijets in lead-lead collisions at $\sqrt{s_{NN}}$=2.76 TeV

First measurements of J/ψ and Z yields in lead-lead collisions: systematic suppression of J/ψ, but insufficient statistics for any conclusion on the Z

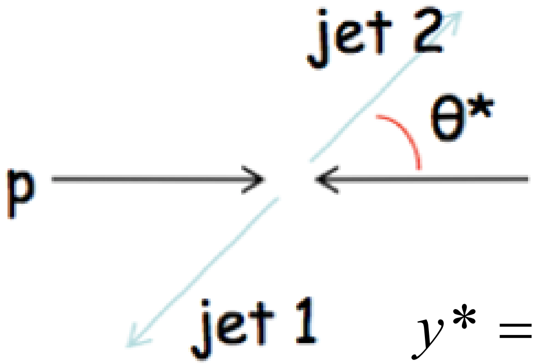




P_T [GeV]
Tracks
ATLAS
EXPERIMENT
Run Number: 169045, Event Number: 1914004
Date: 2010-11-12 04:11:44 CET
E_T [GeV]
Calorimeter
Towers
φ
η

Dijet Angular Distribution Searches

- Gain sensitivity by looking at rapidity



$$y^* = \frac{1}{2}\ln\left(\frac{1+|\cos\theta^*|}{1-|\cos\theta^*|}\right)$$

- Observarables

$$\boxed{\chi = \exp(|y1 - y2|) = \exp(2|y^*|)}$$

$$\boxed{F_\chi(m_{jj}) = \frac{N_{events}(|y^*| < 0.6)}{N_{events}(|y^*| < 1.7)}}$$

NEW