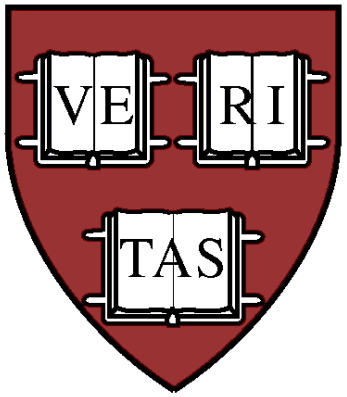
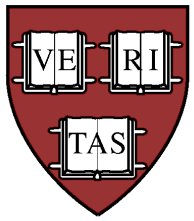



# ATLAS Recent Results Standard Model

A. Belloni

Harvard University

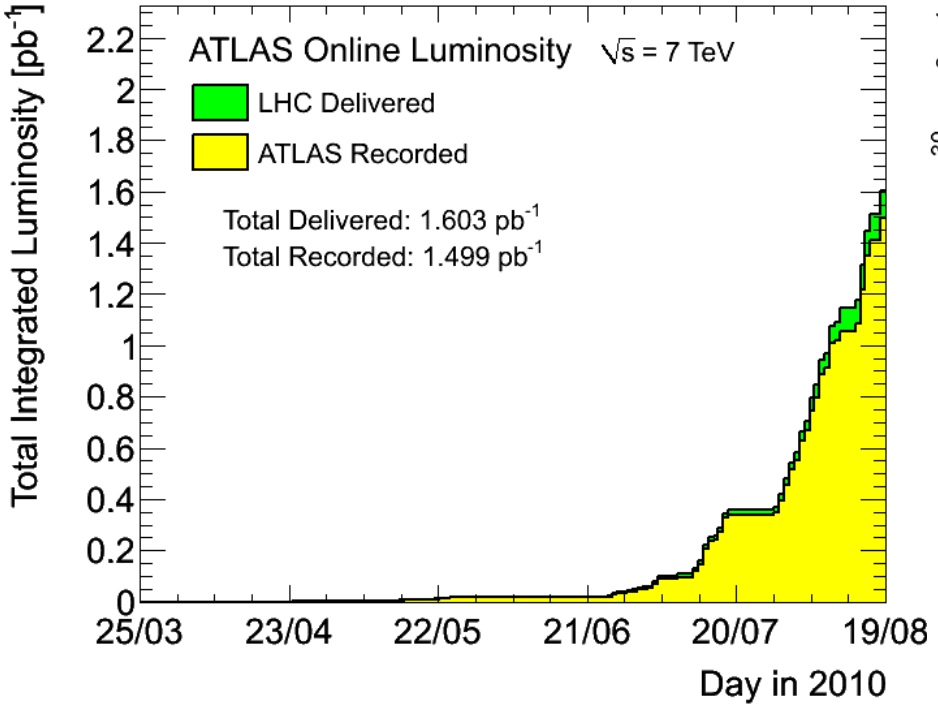
On behalf of the ATLAS Collaboration

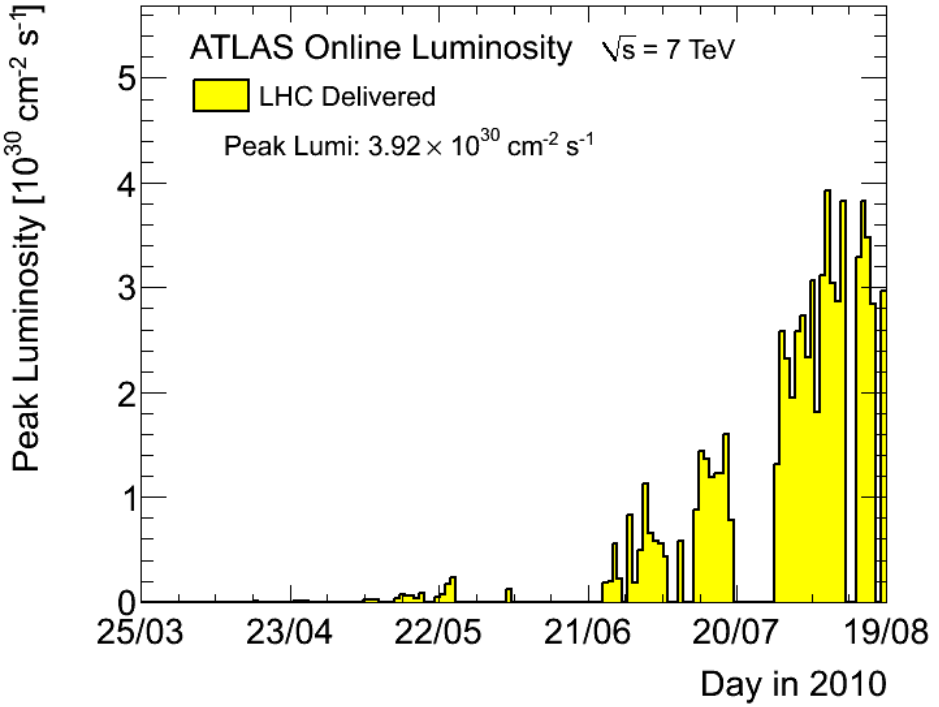



# Synopsis

- The ATLAS Detector & data samples
- Performance and Physics Results
  - Tracking, Calorimetry, Muons
  - Jets, MET, photons, leptons
  - Electroweak Physics, Top
- Summary

# Data Samples at 7 TeV



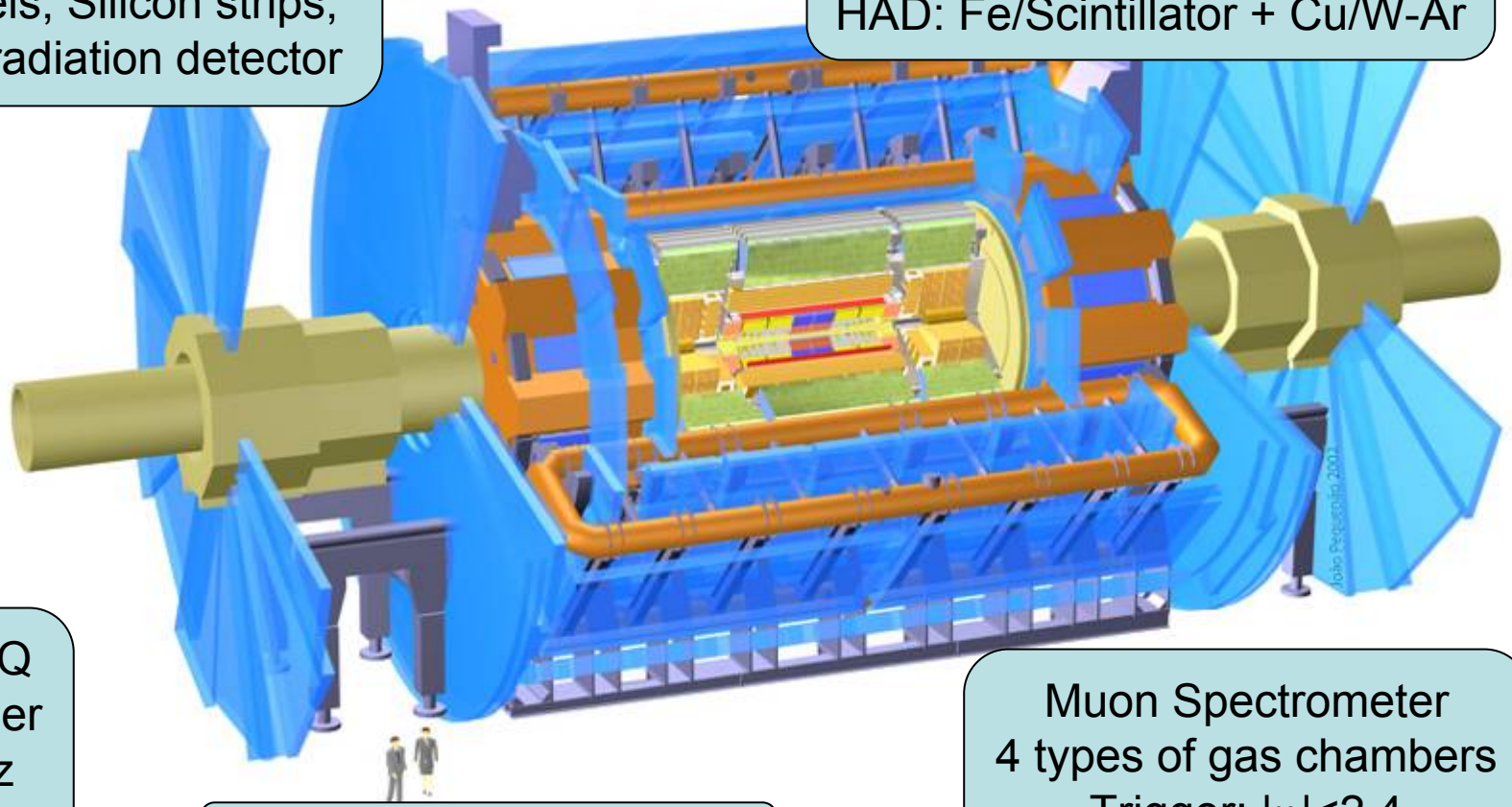




- First pb$^{-1}$ integrated on Sunday 8$^{th}$
  - Instantaneous luminosity steadily increasing
  - Luminosity systematic uncertainty: 11%
- Data collection efficiency ~94%

# The ATLAS Detector

Inner Detector
$|\eta|<2.5$, in solenoidal 2T field
Silicon pixels, Silicon strips,
Transition radiation detector

Calorimeters, $|\eta|<5$
EM: Pb-LAr accordion
HAD: Fe/Scintillator + Cu/W-Ar



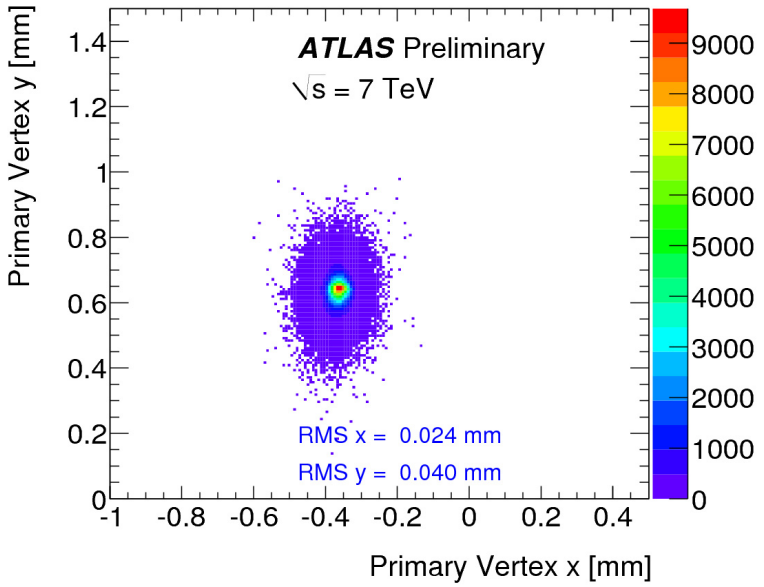
Trigger/DAQ
3-level trigger
In: 40 MHz
Out: 200 Hz

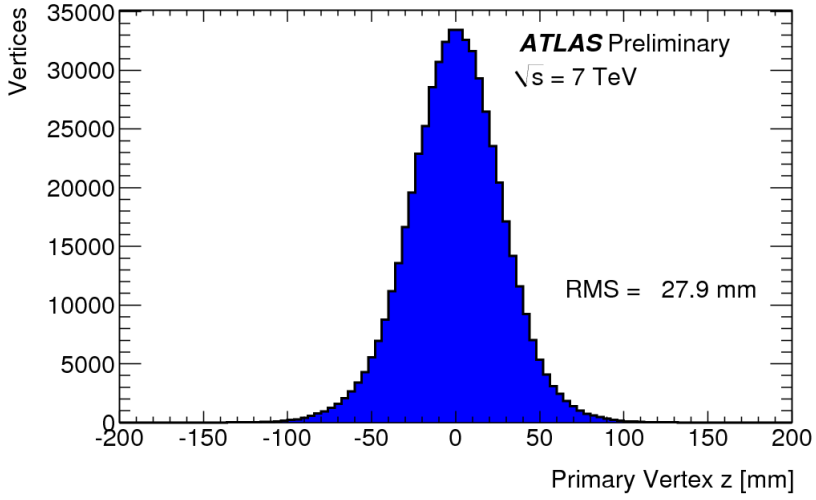
Toroidal Air-core Magnets

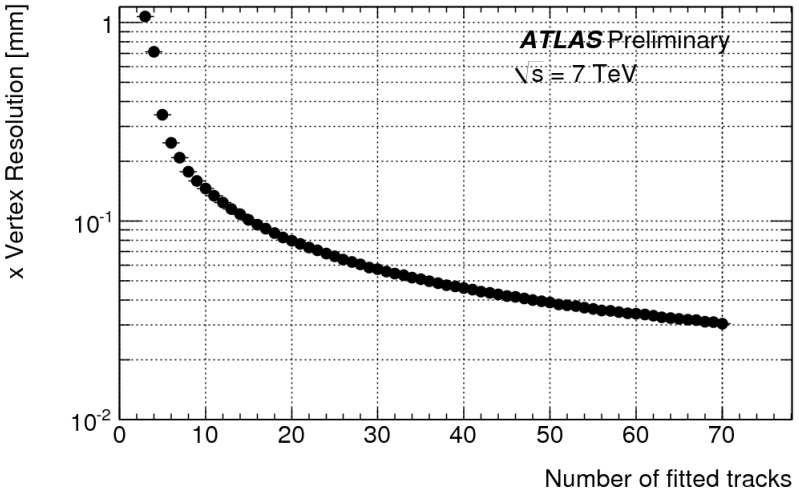
Muon Spectrometer
4 types of gas chambers
Trigger: $|\eta|<2.4$
Reconstruction: $|\eta|<2.7$

# Tracking Performance

- First measurement of resolution of ATLAS Primary Vertex Finder
  - Fundamental starting point for most physics measurements
  - Minimum Bias data; 6 $nb^{-1}$ enough to fully characterize algorithm
- Recursive algorithm
  - Tracks incompatible with current vertex used as seeds for new one
- Resolution in transverse/longitudinal plane
  - 30/50 μm for events with >70 tracks or $\sqrt{\Sigma(p_T^2)} > 8$ GeV

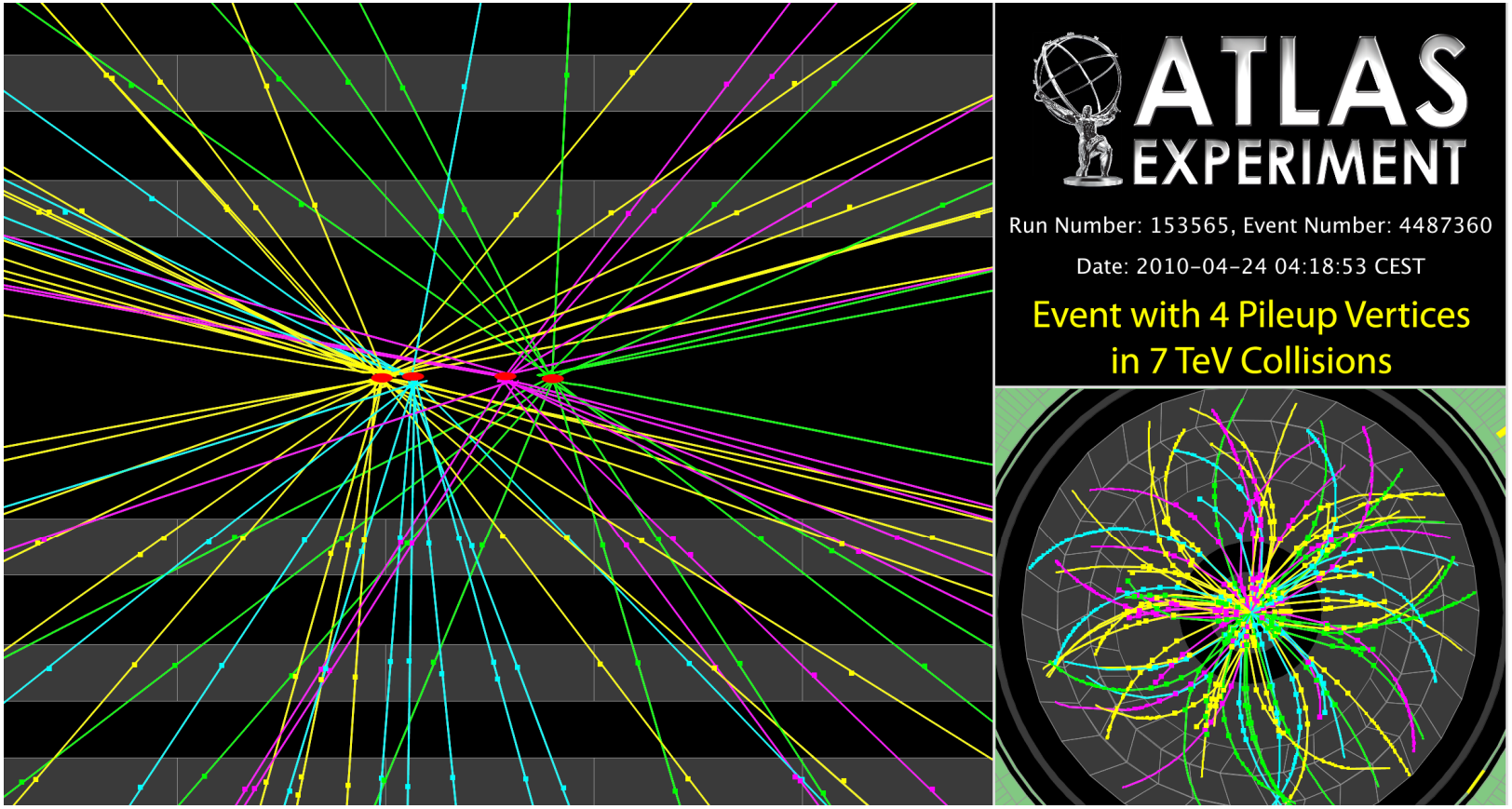


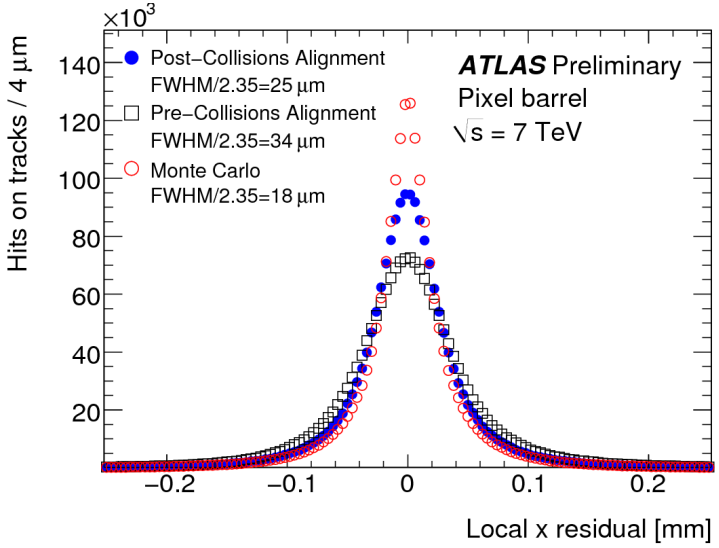



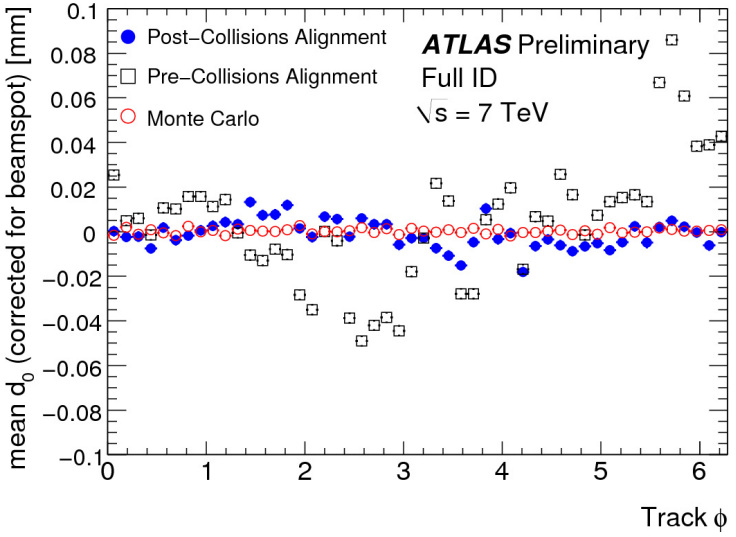
# Challenging Environment

- Analyses becoming more and more complex
  - Already 40% of events with >1 primary interaction per crossing
    - ~10-45 tracks with $p_T$ > 150 MeV per vertex

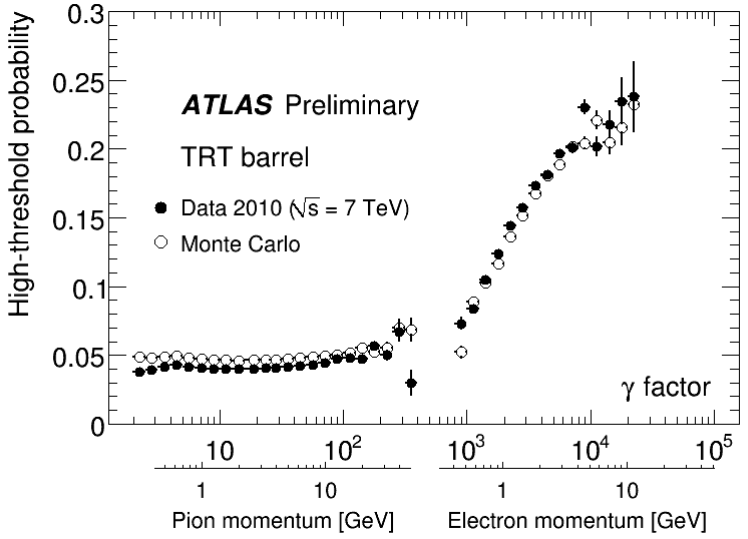


# Inner Detector



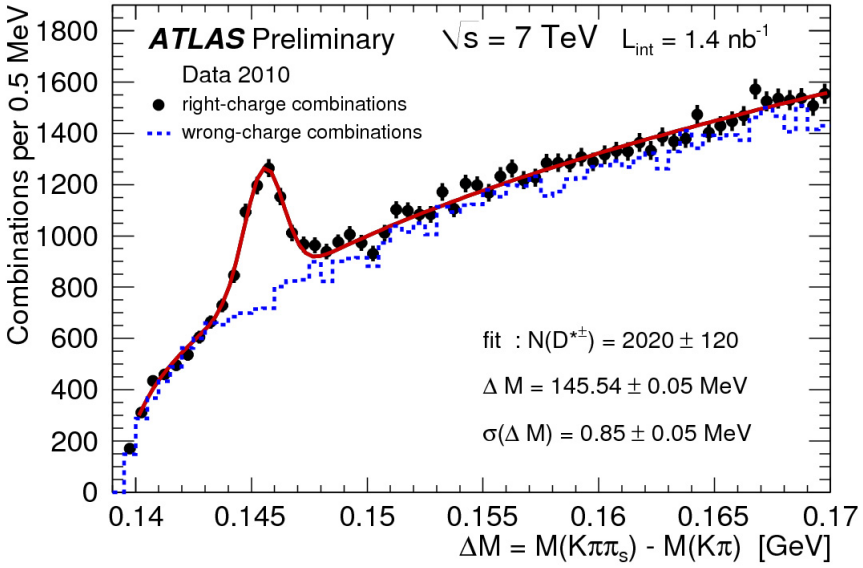



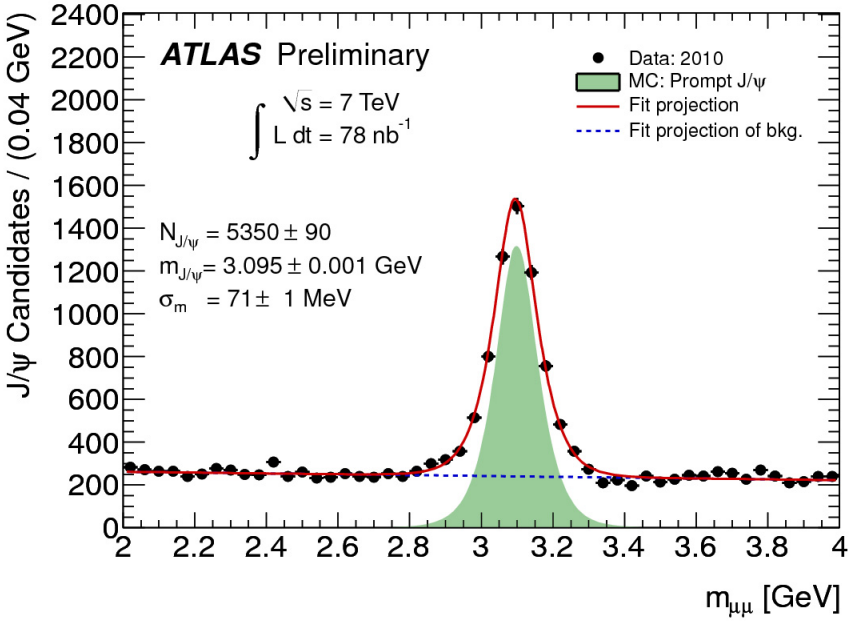

- Tracking detectors performing close to design
  - First collision data provided alignment corrections
  - Hit resolution Pixel/SCT/TRT: 25 μm, 42 μm, 141 μm
    - Expected resolutions at probed low momentum range
- First result of particle identification with Transition Radiation Tracker
  - High-γ: electrons from conversions
  - Low-γ: all tracks assumed to be pions



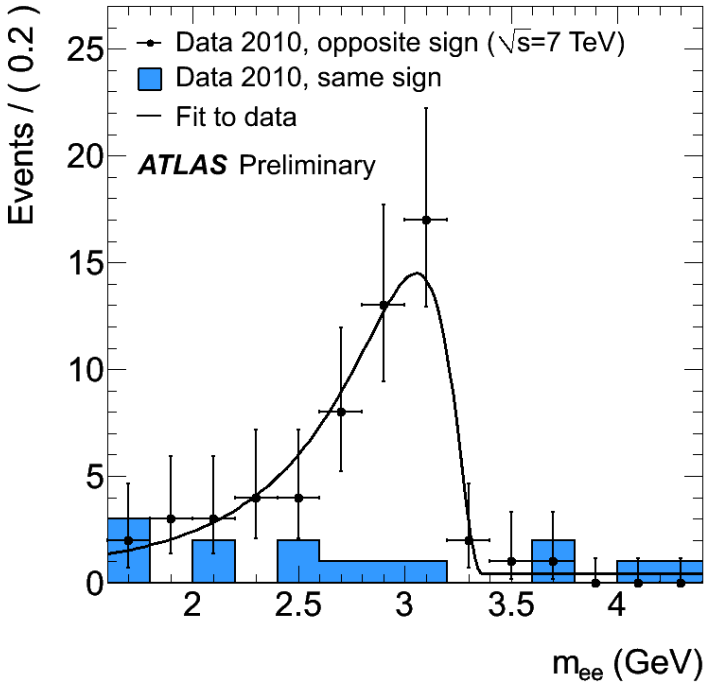
# Measurements with Resonances

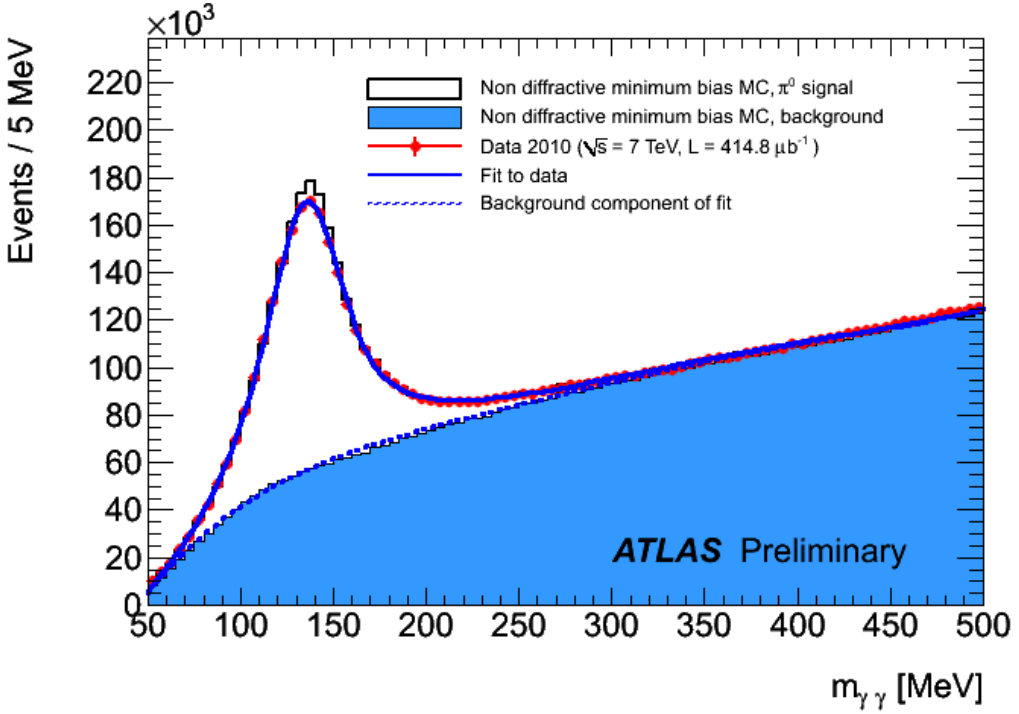
- Observed all classic resonances
  - $K_s$, $K^*$, $\Lambda$, $\Omega$, $\Xi$, D, $D^*$
    - Some mass plots in backup
- Moving on to precision measurements
  - J/$\psi$ mass studies constrain ID momentum scale
    - Max deviation (0.2±0.1)% of reconstructed mass from PDG value



# EM Calorimetry



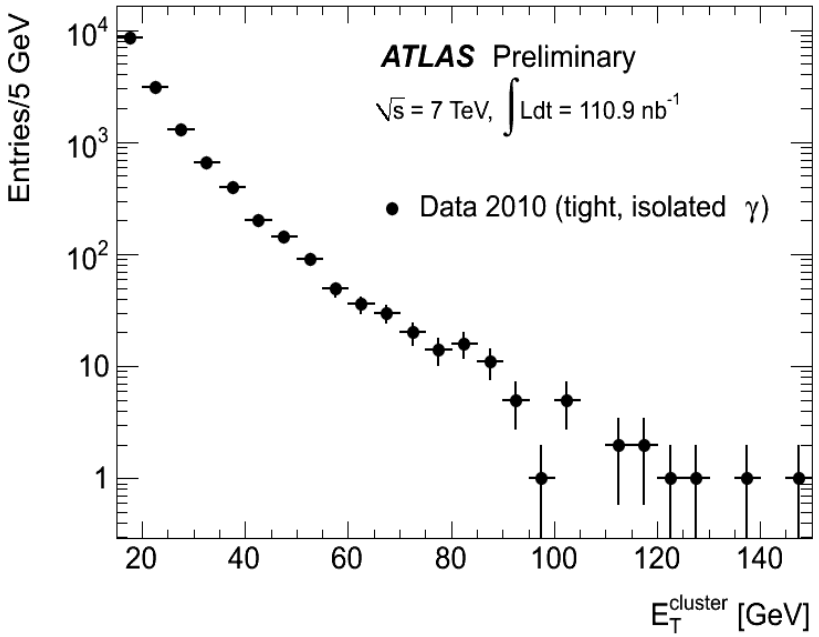



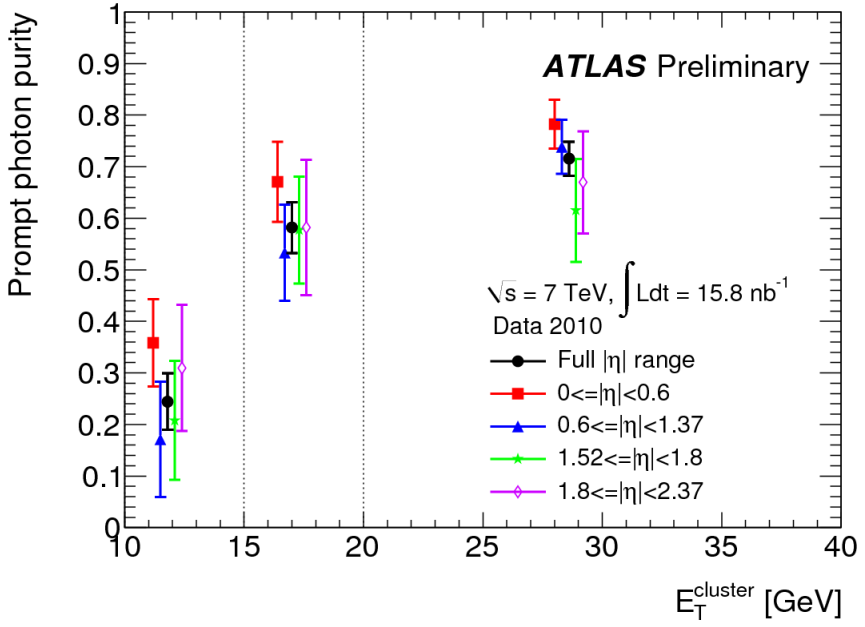

- $J/\psi \rightarrow ee$
  - Shower shape, quality cuts, particle-ID cuts applied
  - Mass calculated from tracks, no correction for bremsstrahlung

- Neutral pions provide handle for measuring EM energy scale and response uniformity in $\phi$
  - ~2% in $\eta$, < 0.7% in $\phi$
  - Mass: 135.04±0.04 MeV
    - PDG: 134.98 MeV

# Photon Identification

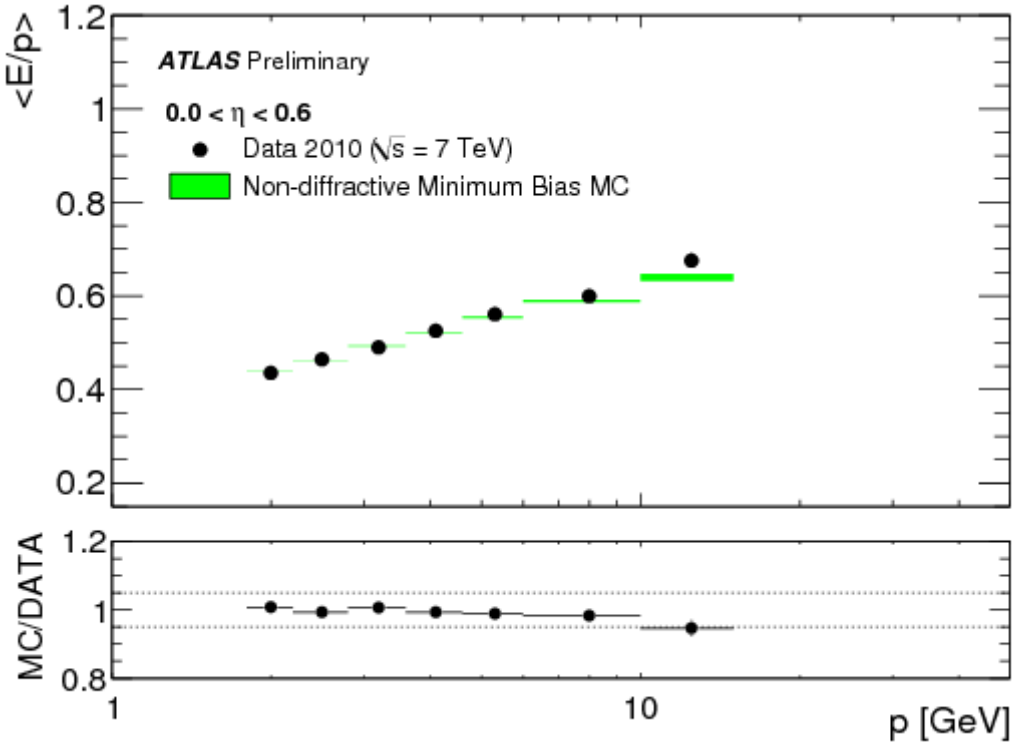
- Test perturbative QCD, constrain parton distribution function, preparation towards $H \rightarrow \gamma\gamma$
  - Fine granularity and longitudinal segmentation of EM calorimeters permits rejection of $\pi^0$ candidates
  - Inner detector allows for reconstruction of conversions
- Evidence for prompt, isolated photons
  - Data-driven estimate of fake rates (isolation vs shower shape)
  - Observe ~40 prompt $\gamma$ ($E_T$ > 20 GeV) per nb; purity ~70%



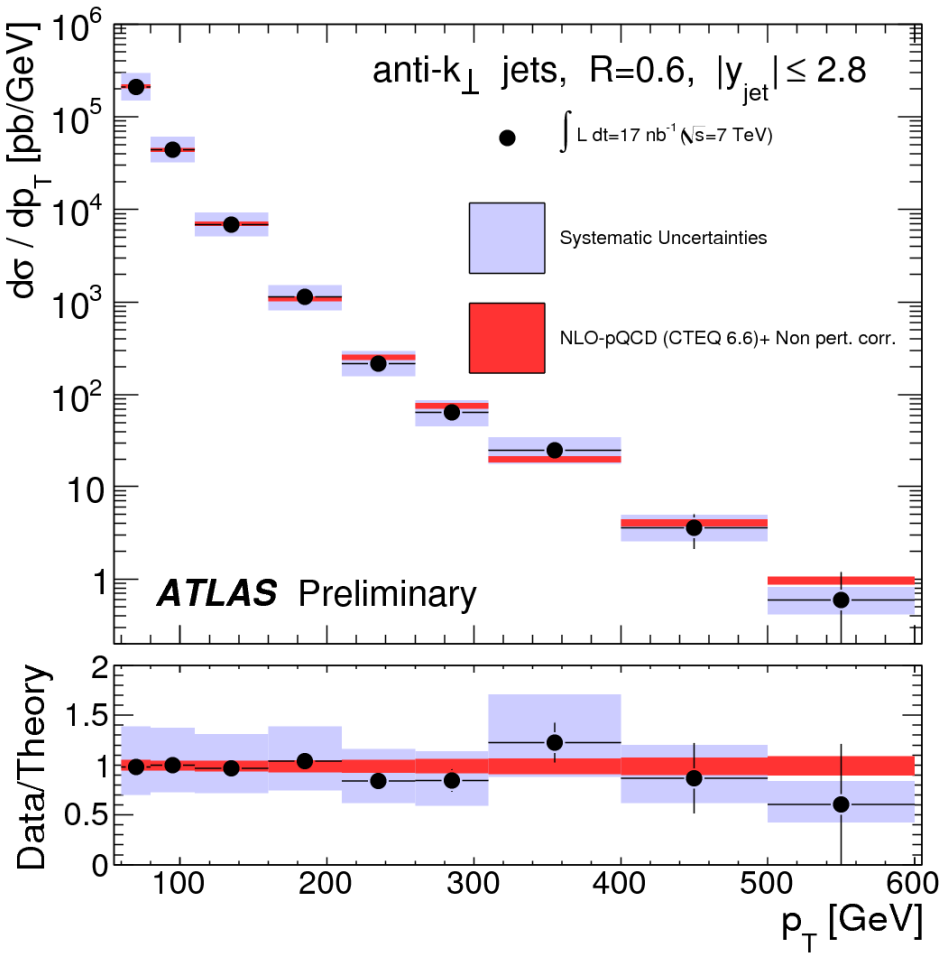
# Jet Energy Scale

- ATLAS Jet Algorithm: anti-$K_T$, jet radius R=0.6, 0.4
- Determine Jet Energy Scale with single-particle response
  - Use isolated tracks, determine calorimeter response for single particles
  - Propagate single-particle measurement with MC to determine JES and JES uncertainty
    - Calorimeter uncertainty on JES ~3-4% for $|\eta| < 0.8$ and $20\ \text{GeV} < p_T < 1\ \text{TeV}$



# Jet Production at 7 TeV

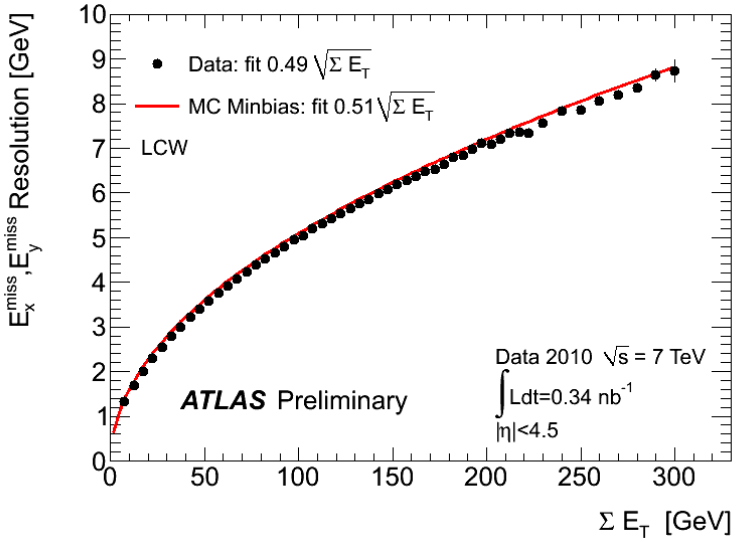
- Inclusive jet cross-section (~Tevatron x 100)
  - Restricted to 17 $nb^{-1}$ (no pile-up contamination); $p_T > 60$ GeV and $|y| < 2.8$
- Measured jets corrected to particle level using parton-shower MC
  - Experimental uncertainties dominated by JES
    - 9% in $p_T$ and y ranges considered
    - 11% from Luminosity not included
- Good data-MC agreement over 5 orders of magnitude!

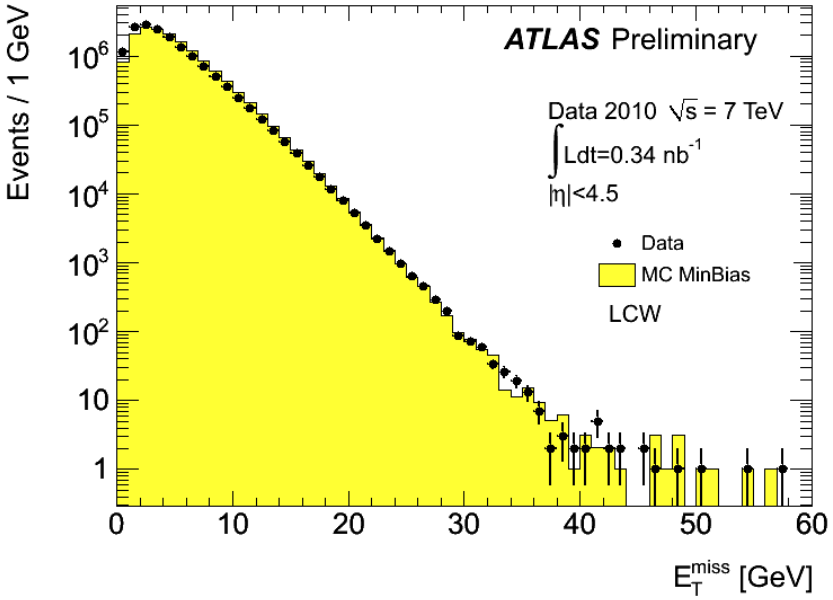


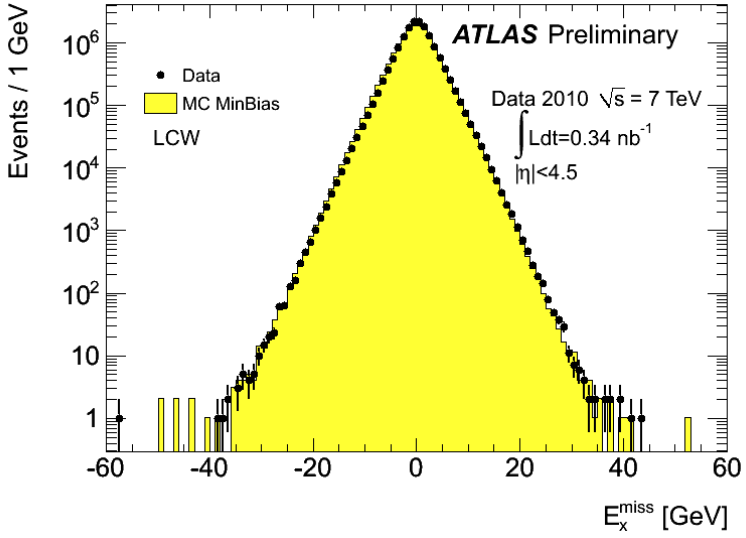

Other results in backup: di-jet cross-section

# Missing Transverse Energy

- Good model of MET resolution
  - Early Minimum-Bias measurement
  - Resolution measured over full calorimeter coverage
    - $|\eta| < 4.5$, ~200k cells
- No MET tails after calibration
  - Of utmost important for searches

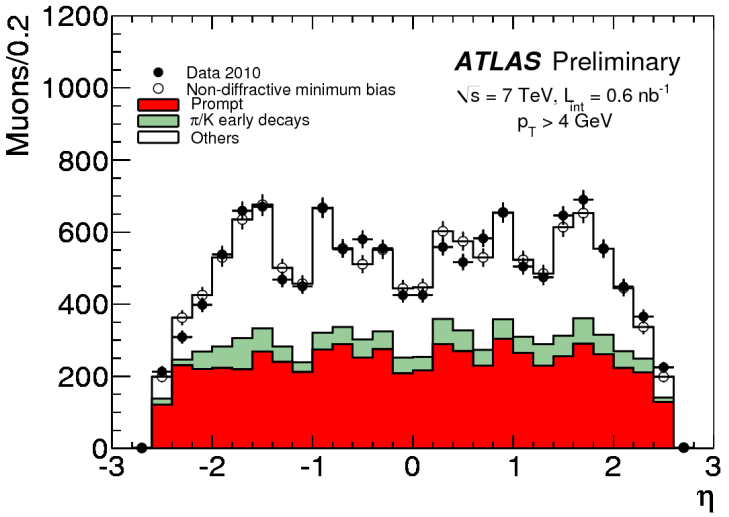


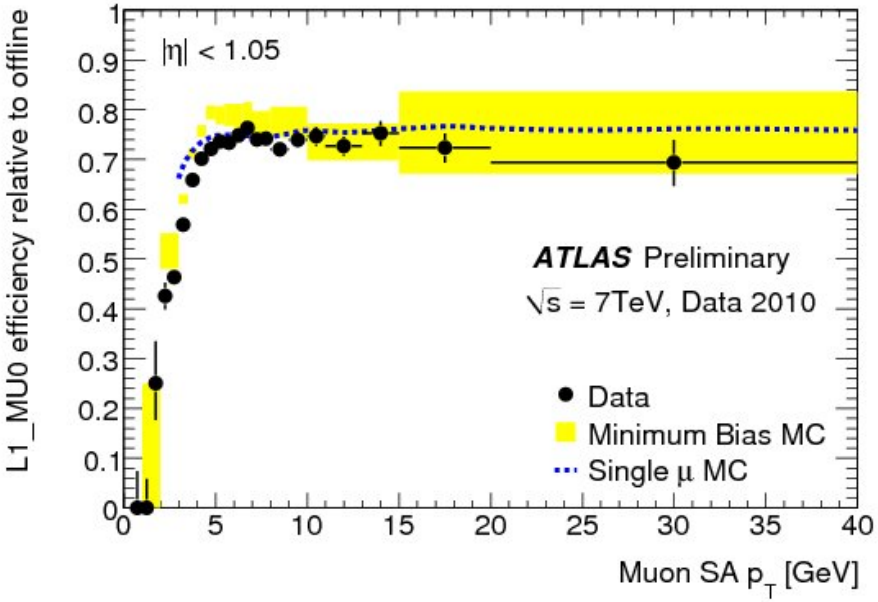



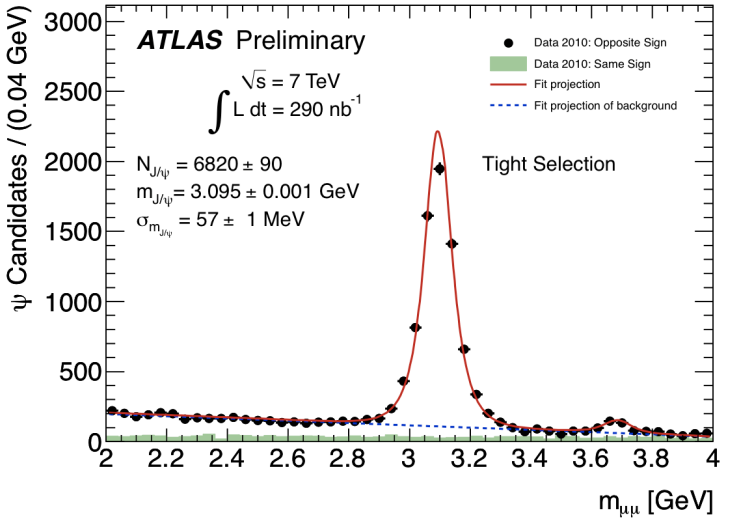



# Muon Performance

- Good performance of combined ID-MS reconstruction
  - MC reproduces well results
- J/ψ and Z samples allow for first tag & probe measurements
  - Shown: boot-strap trigger efficiency, to be compared with tag & probe

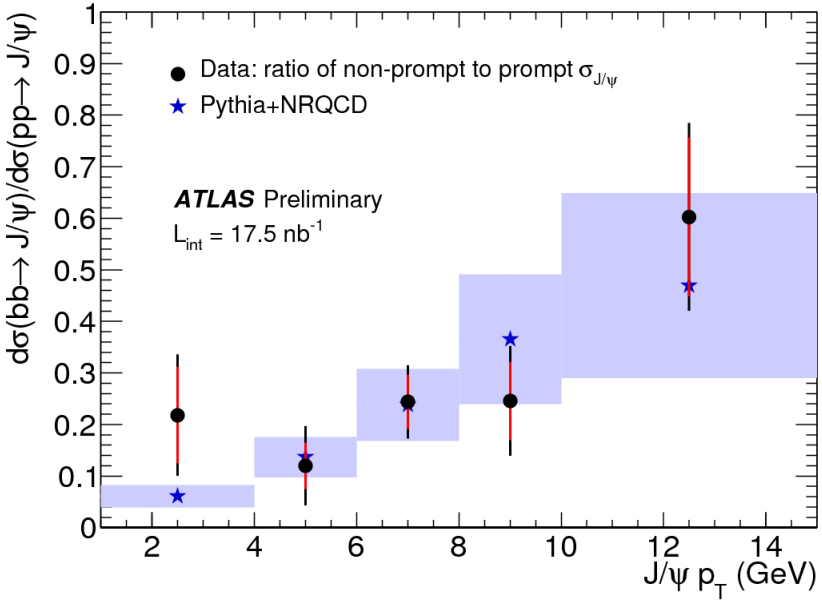


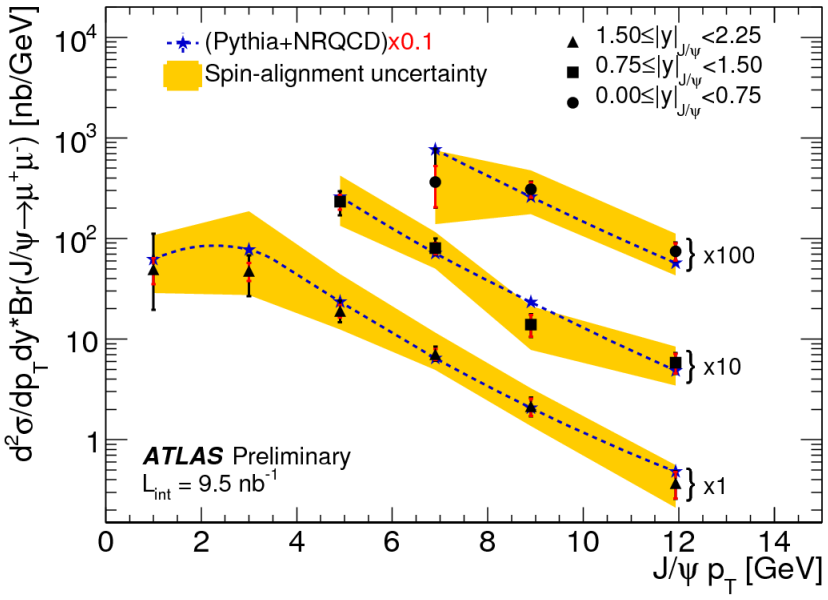



# Initial J/ψ Physics

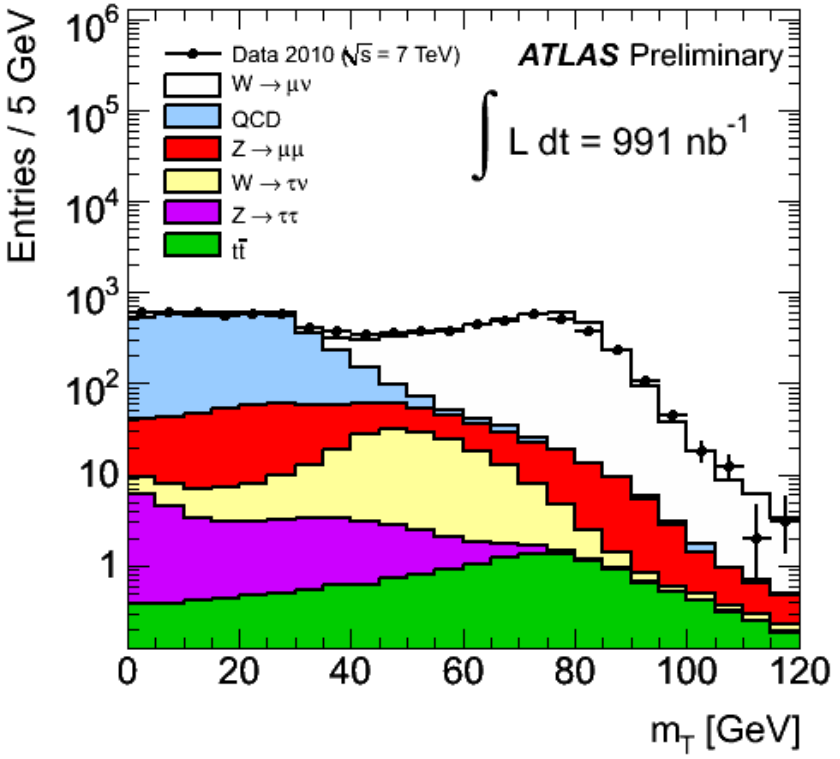
- First look into J/ψ production mechanism
  - Measure prompt vs non-prompt fraction
    - Template fits of proper time distribution
- Doubly-Differential production cross-section
  - Good data-MC agreement in shape



# W and Z Physics

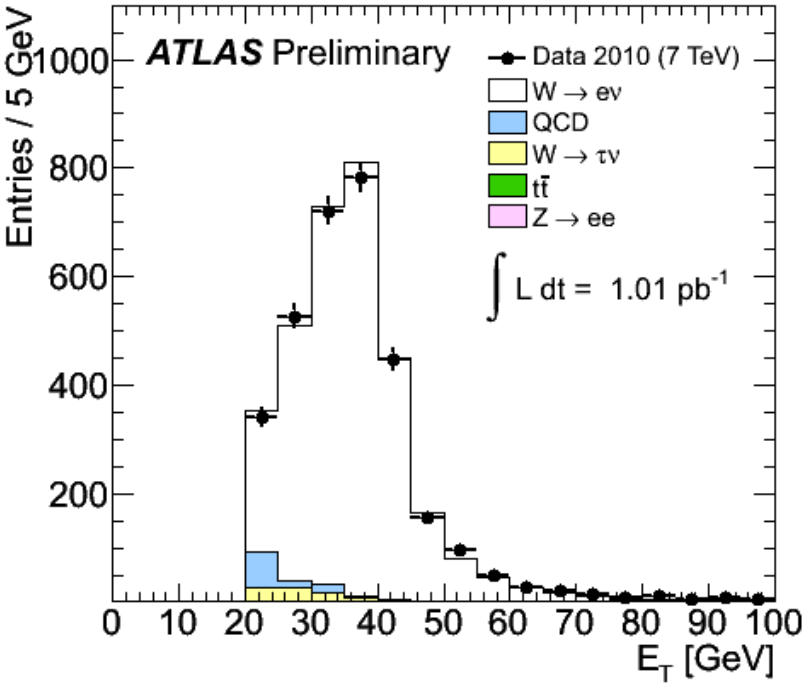
- Important milestone in re-discovery of SM
  - W's provide powerful constraints on PDF
  - Dominant source of background for BSM signatures
  - Provide great source of high-$p_T$ leptons for calibrations
- Physics analyses quickly follow data-taking
  - Preliminary Z cross-section with L~230 $nb^{-1}$, 1 $pb^{-1}$ distributions
  - W distributions with L=991 $nb^{-1}$
    - W cross-section with L=17 $nb^{-1}$
- Good data-MC agreement in shape at all stages of analyses

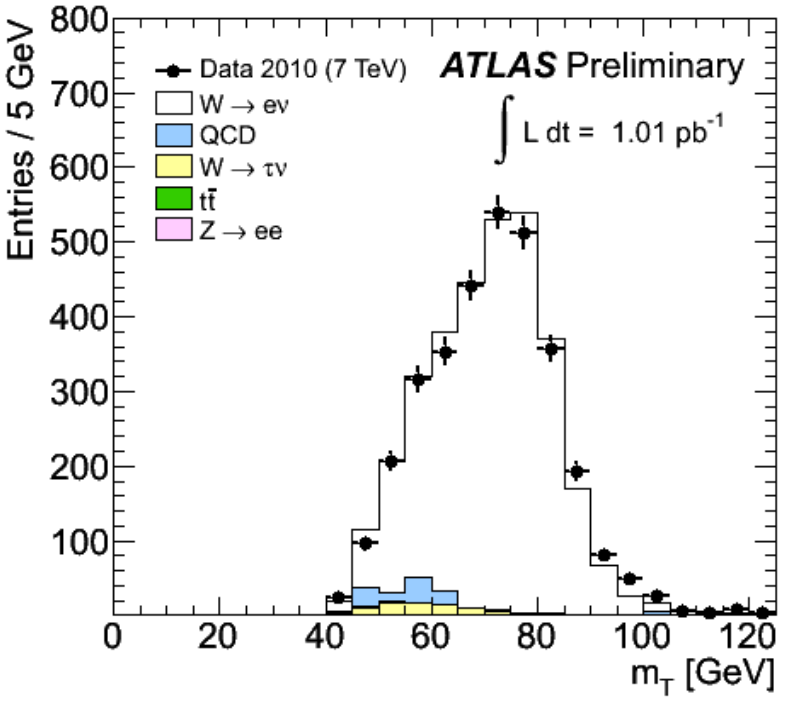



**W→μν candidate before $E_T^{miss}$ cut**

# W(eν) Production

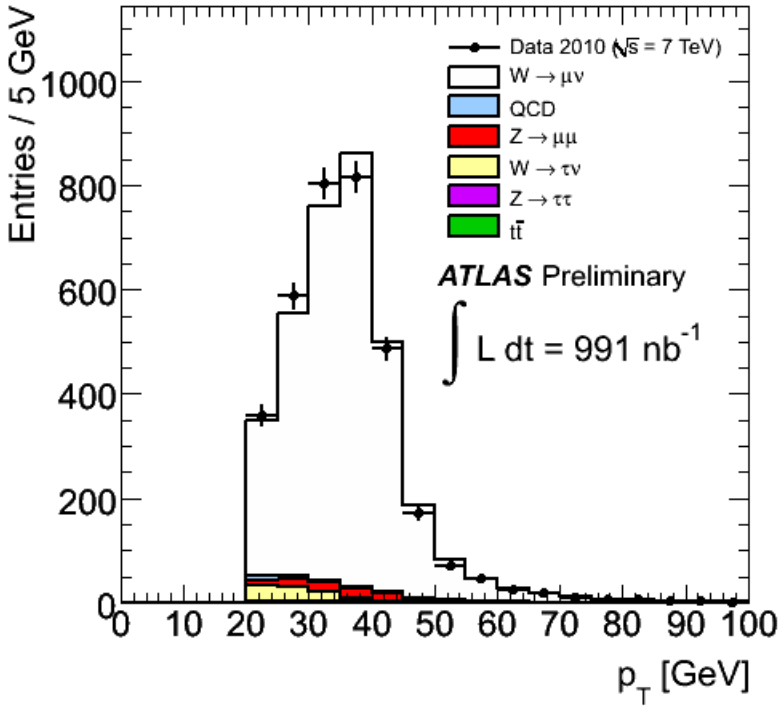
- Shape of all distributions well modeled by MC
- 46 W→eν candidates in 17 $nb^{-1}$
  - Very good S/B ratio: expect ~2.6 background events

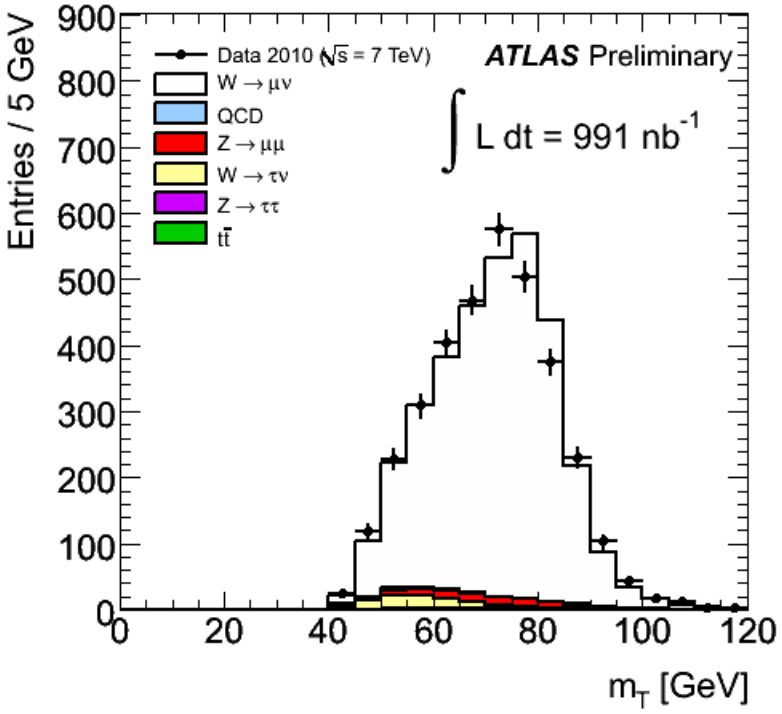


# W(μν) Production

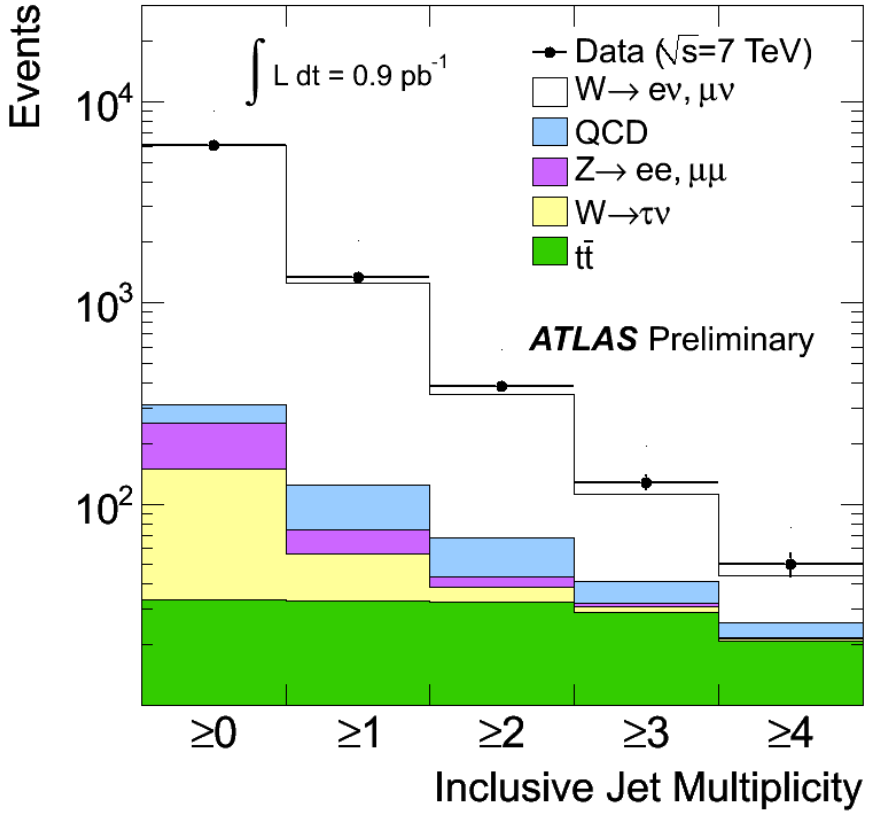
- Muon analysis adopts track-based isolation cut
  - Great rejection power on QCD background, small but least manageable
- 72 W→μν candidates in 17 $nb^{-1}$
  - Data-driven methods to estimate backgrounds

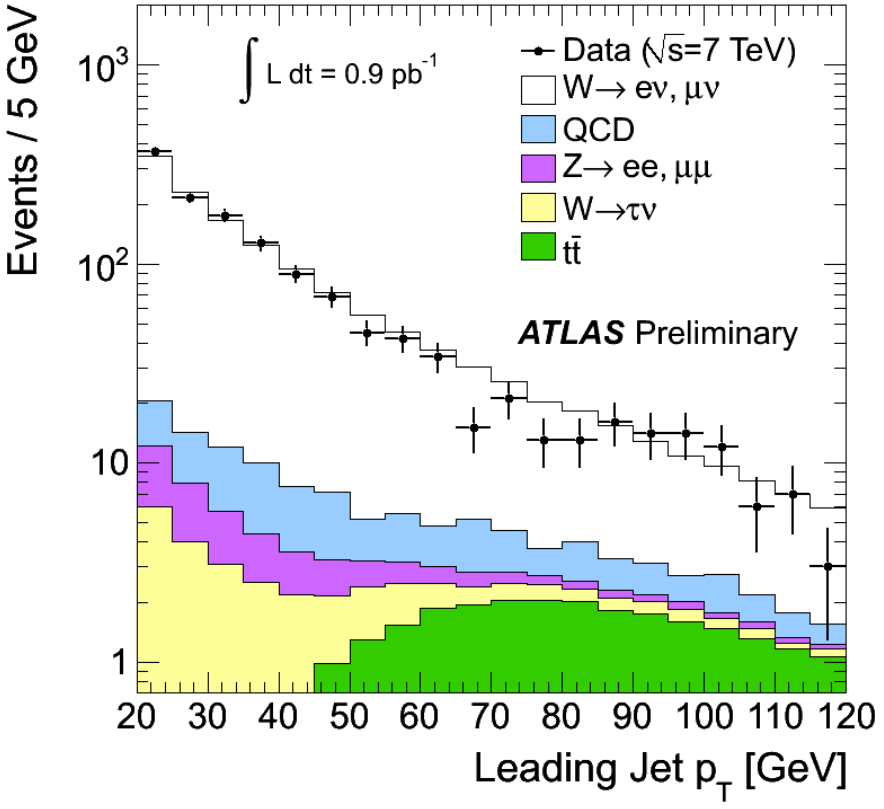


# W + Jets

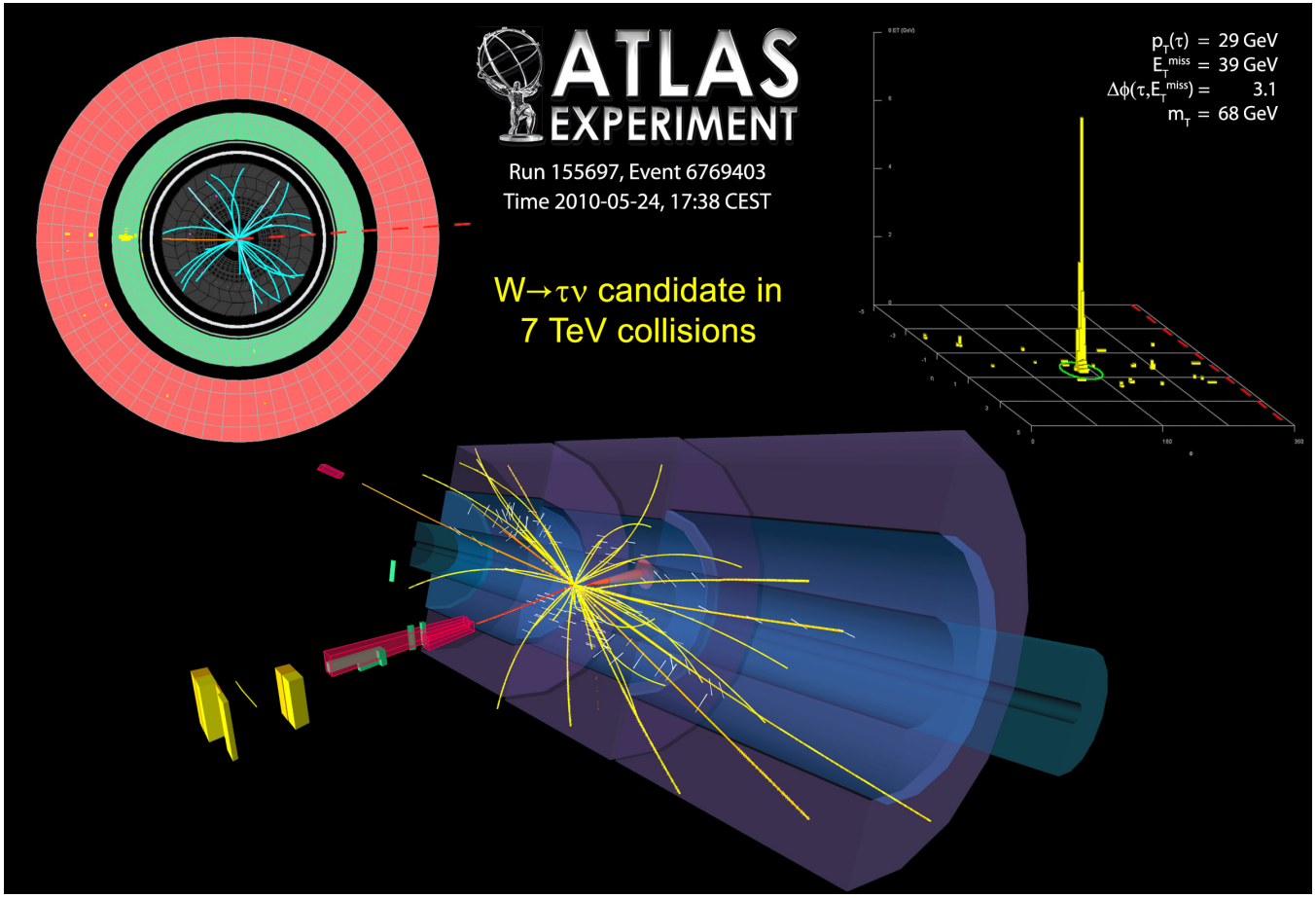
- Select anti-$K_T$ jets with radius 0.4, |y|<2.8, full W selection
  - Alpgen used to produce signal template



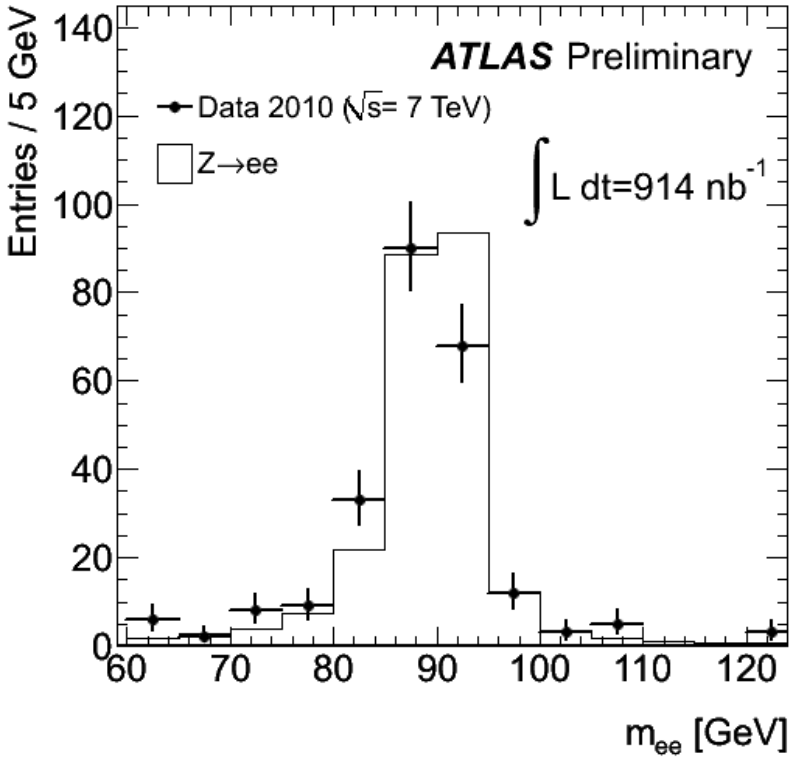
# Tau Physics

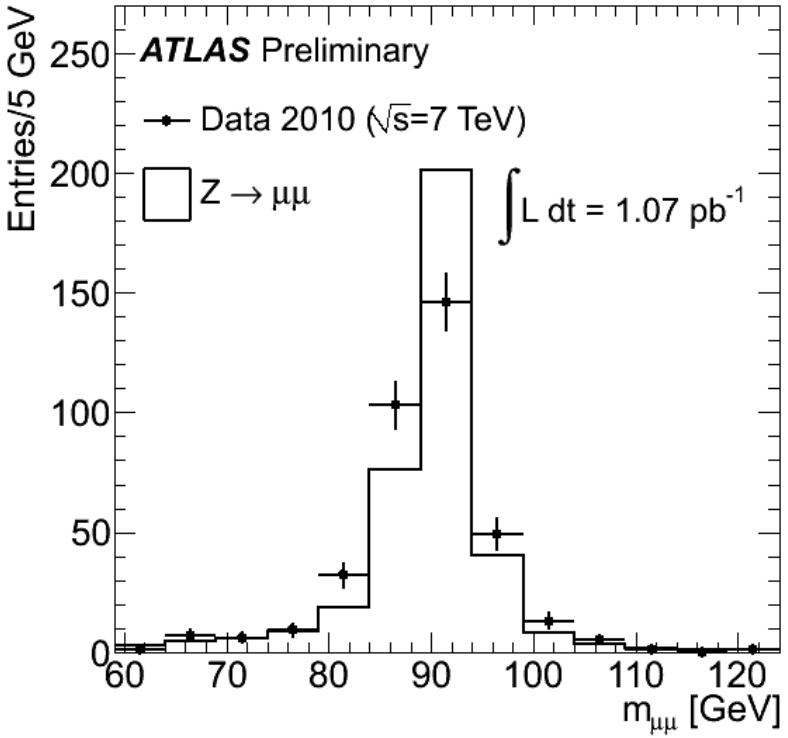
- First W→τν candidate
  - 1-prong τ candidate; second hardest track: $p_T$ ~ 3 GeV



# Z Production

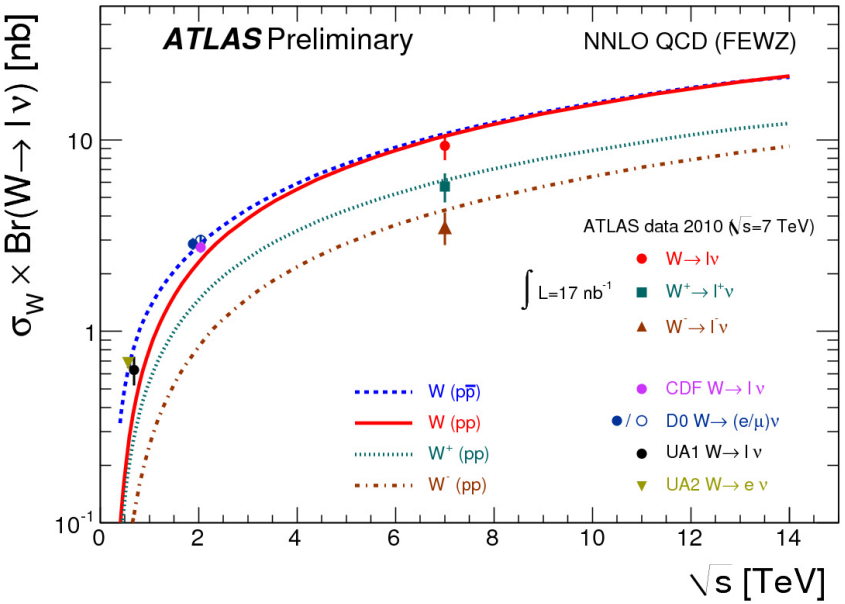
- 125 Z→*ll* candidates, extremely low background expected
  - 46 Z→*ee* in L=219 nb$^{-1}$, 79 Z→μμ candidates in L=229 nb$^{-1}$, <1 background event per channel
    - Electron: 88.7±0.8 GeV, σ = 3.6±0.8 GeV
    - Muon: 89.3±0.8 GeV, σ = 4.2±0.8 GeV

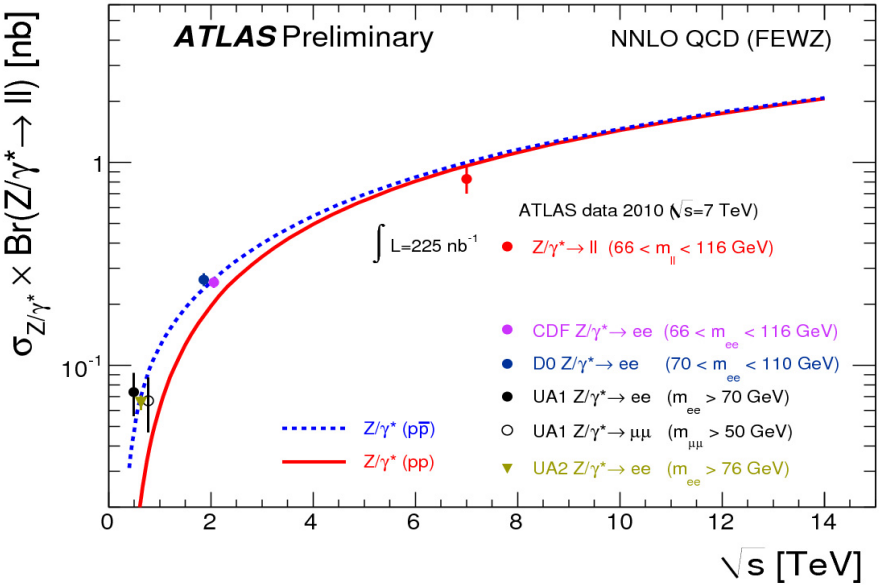


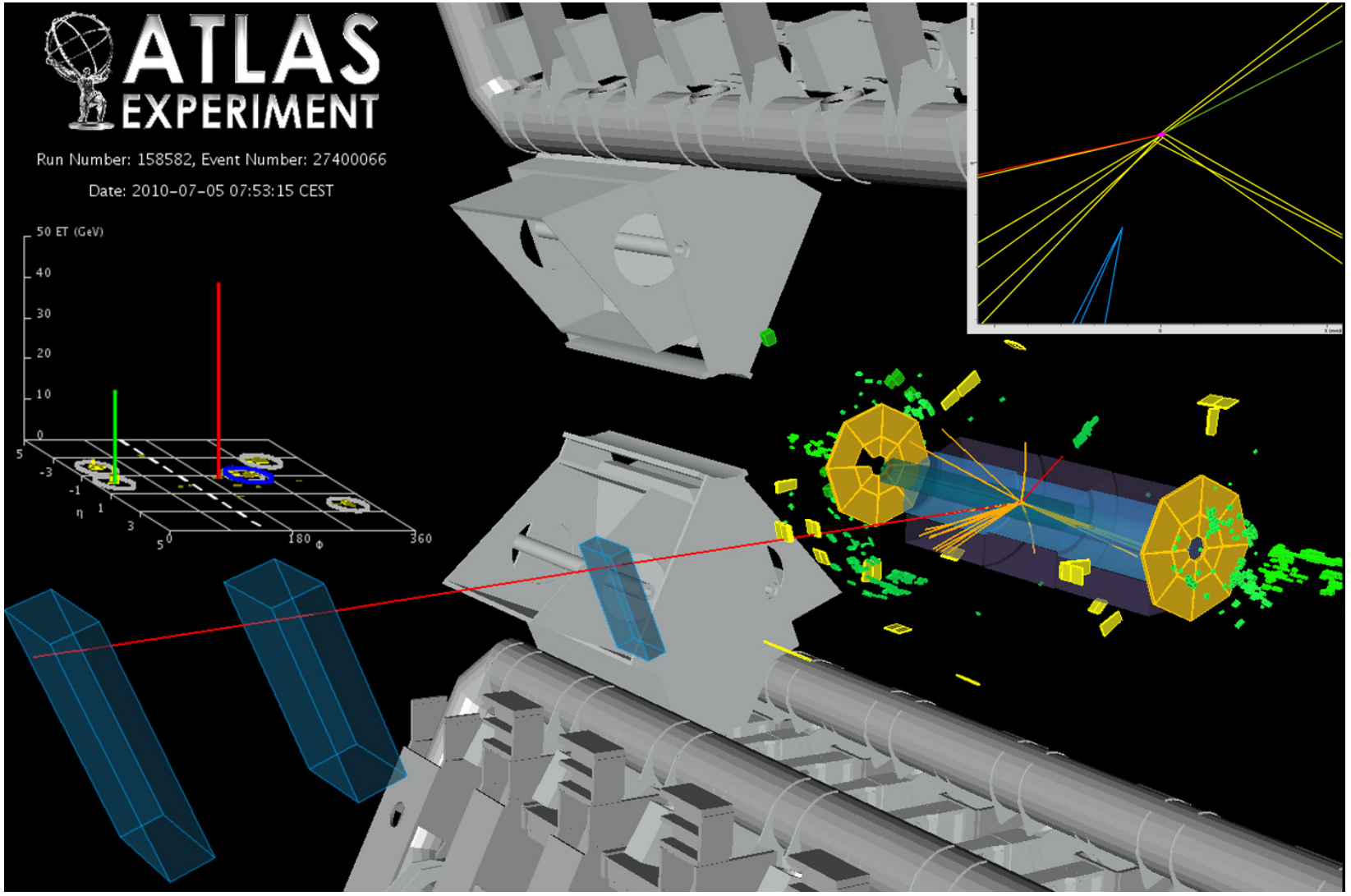
# Z/W Cross Section

- Performed measurements with L~225 $nb^{-1}$ (Z) and L~17 $nb^{-1}$ (W)
  - $\sigma(Z/\gamma^* \rightarrow ee) = 0.72 \pm 0.11(stat) \pm 0.10(syst) \pm 0.08(lumi)$ nb
  - $\sigma(Z/\gamma^* \rightarrow \mu\mu) = 0.89 \pm 0.10(stat) \pm 0.07(syst) \pm 0.10(lumi)$ nb
    - Z mass window: 66 GeV < $m_{ll}$ < 116 GeV; SM expectation: 0.99±0.04 nb
  - $\sigma(W \rightarrow e\nu) = 8.5 \pm 1.3(stat) \pm 0.7(syst) \pm 0.9(lumi)$ nb
  - $\sigma(W \rightarrow \mu\nu) = 10.3 \pm 1.3(stat) \pm 0.8(syst) \pm 1.1(lumi)$ nb
    - SM expectation: 10.5±0.4 nb



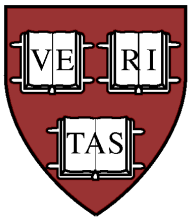
# Top Quark – eμ Candidate




Talk by S. Strandberg

# Summary

- Excellent performance of ATLAS detector
  - Subsystems operating according to design specifications
  - High data-collection efficiency
  - Monte Carlo simulation in good agreement with data
- Interesting physics results start to appear
  - Jet cross-section, studies of inelastic pp events
    - Inelastic pp events studied at 0.9 TeV and 2.36 TeV too
  - Measurement of W, Z cross sections
  - First signs of Top candidates
- Re-establishing Standard Model fundamental step before looking for new physics
  - Shall not underestimate effective first look at 7 TeV QCD



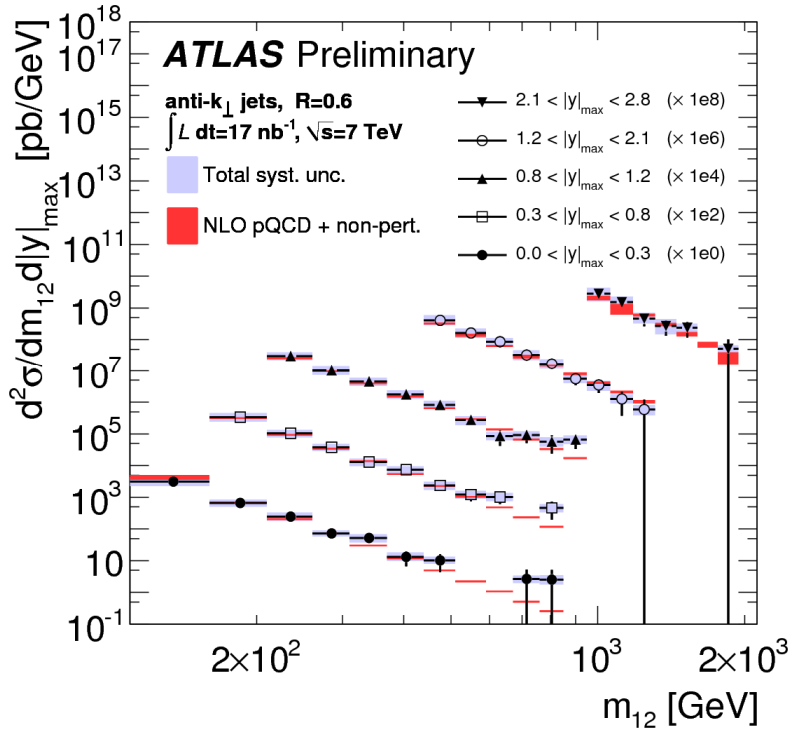

# Backup

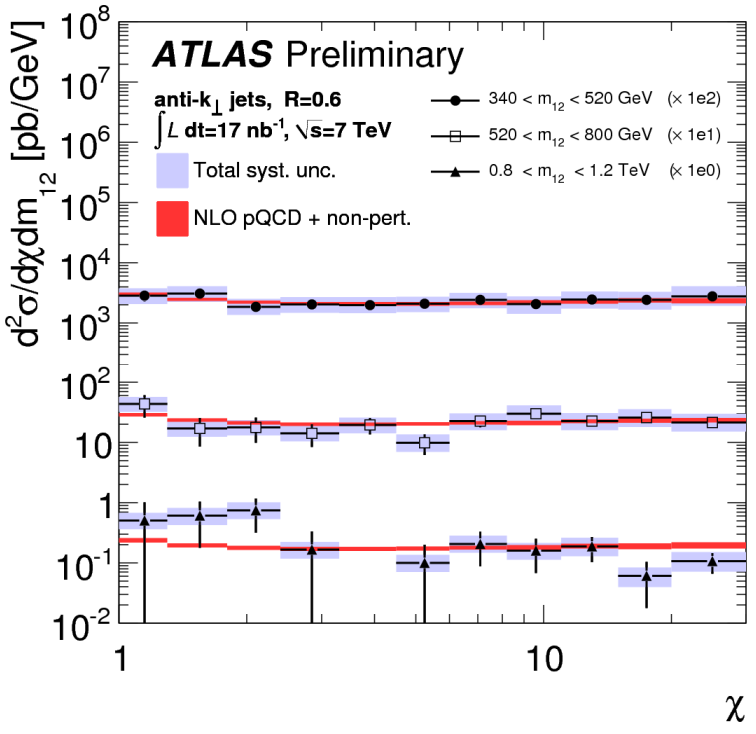
# Public Documentation

- Tracking Performance
  - Primary Vertices: ATLAS-CONF-2010-069
  - Inner Detector Alignment: ATLAS-CONF-2010-067
  - J/ψ Performance: ATLAS-CONF-2010-078
- Calorimeters and QCD Physics
  - Evidence for Prompt Photons: ATLAS-CONF-2010-077
  - Charged Particles Multiplicities: ATLAS-CONF-2010-046
  - Jet Production: ATLAS-CONF-2010-050
- Muon Performance and Physics
  - J/ψ cross-section and Prompt Fraction: ATLAS-CONF-2010-062
  - Prompt Muon Fraction: ATLAS-CONF-2010-75
- Electro-weak and Top Physics
  - W cross-section: ATLAS-CONF-2010-051
  - Z cross-section: ATLAS-CONF-2010-076

# Di-jet Production

- Doubly-differential di-jet cross-section measurements
  - Leading jet: $p_T$ > 60 GeV; sub-leading jet: $p_T$ > 30 GeV
- Great data-MC agreement in all rapidity and mass regions



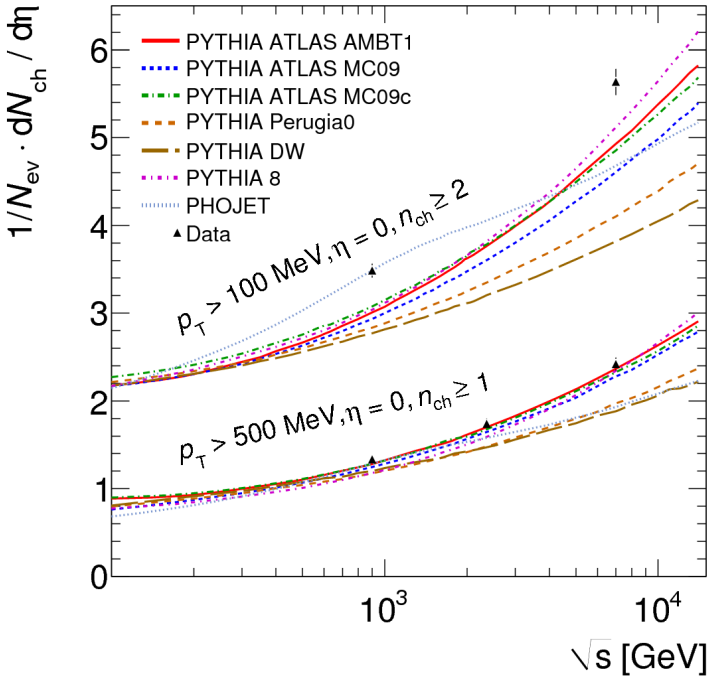



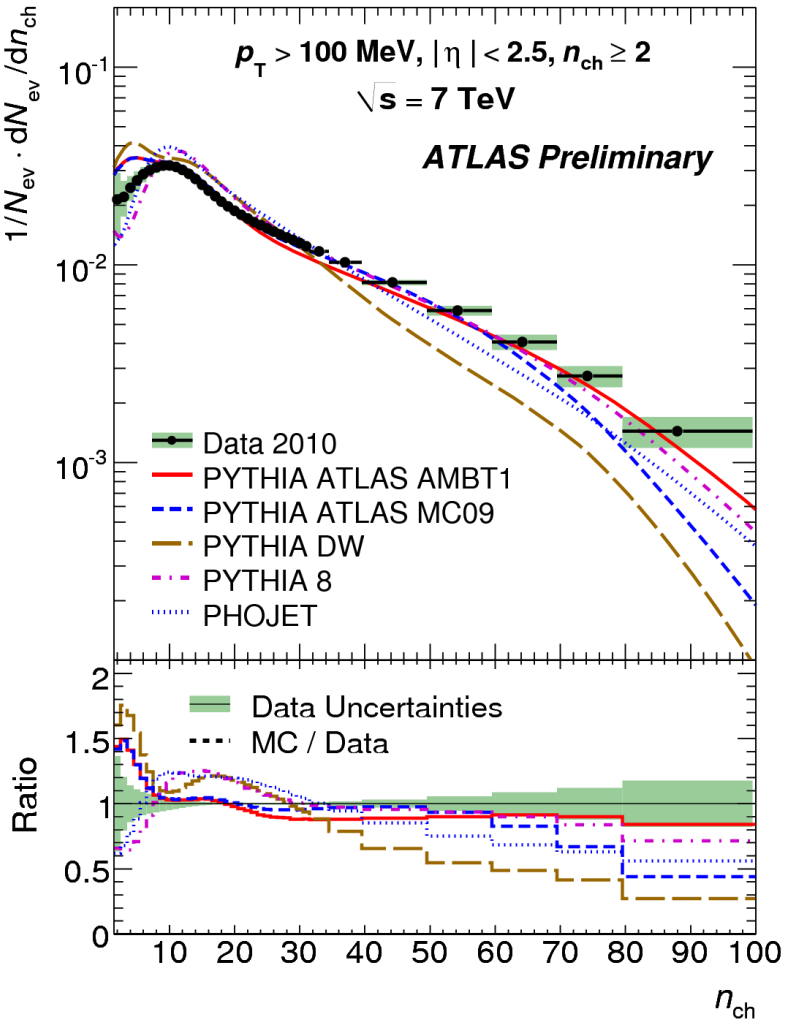

Search for NP in di-jet: talk by J. Haller

$\chi = \exp(|y_1-y_2|) \sim (1+\cos\theta^*)/(1-\cos\theta^*)$

# First Physics: Minimum-Bias

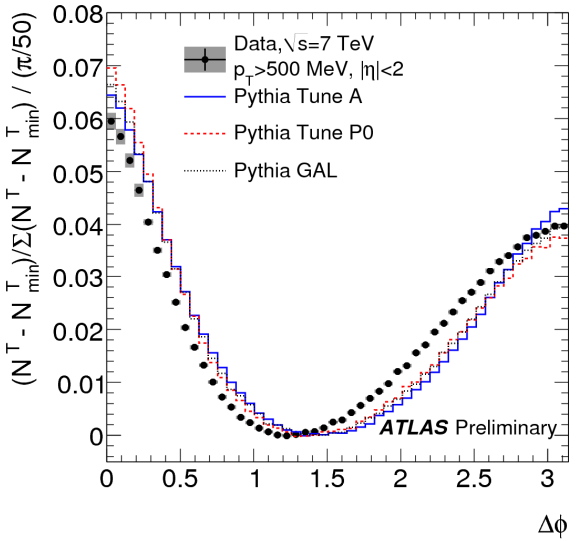
- Charged-particle multiplicities
  - $|\eta|<2.5$, $p_T>100$ ($n_{ch}\geq 2$) and 500 MeV ($n_{ch}\geq 1$)
- First tuning of PYTHIA6 to LHC data at 900 GeV and 7 TeV
  - Data fully corrected to hadron level
  - Avoided model-dependent corrections
    - i.e., diffractive contributions not subtracted

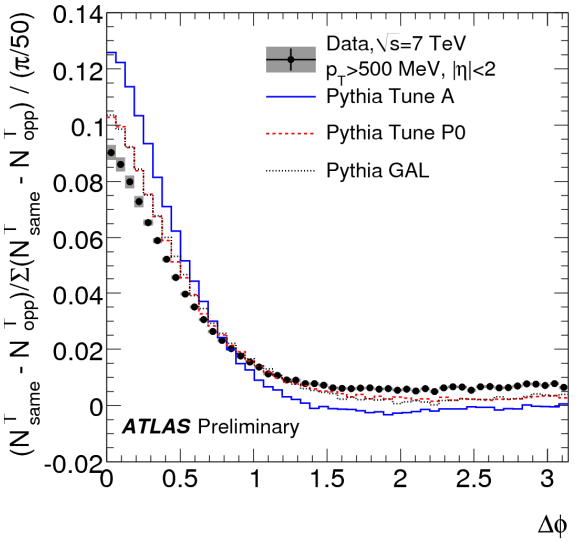


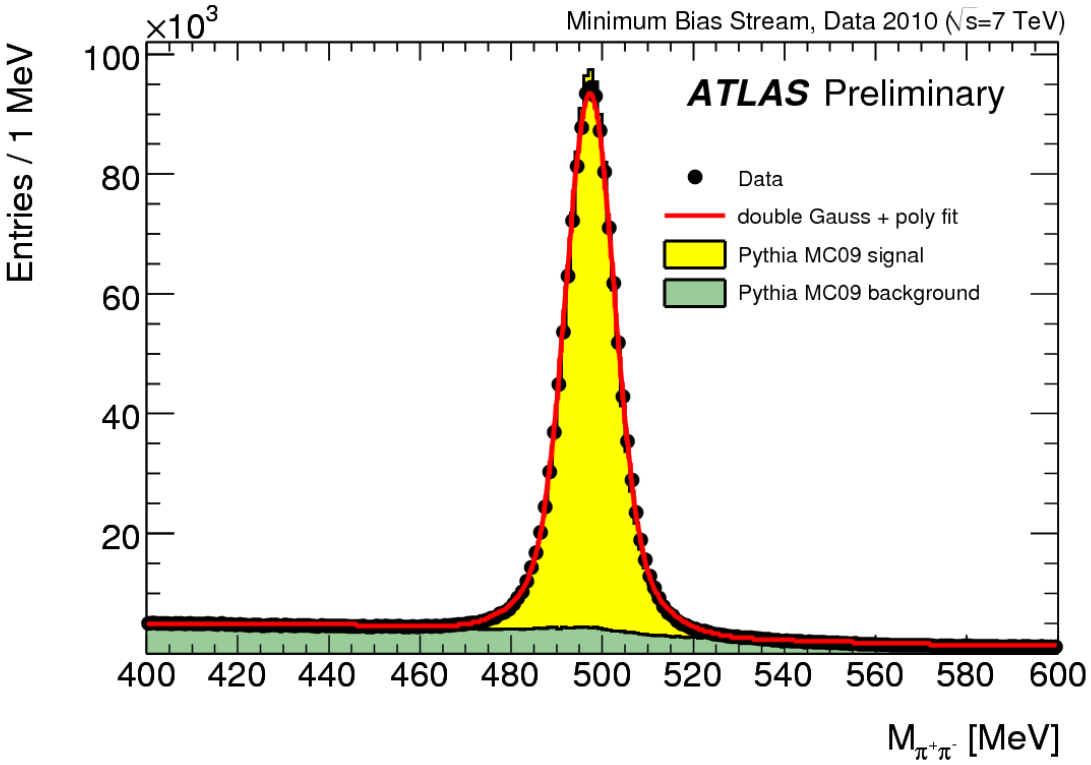
# QCD Angular Correlations

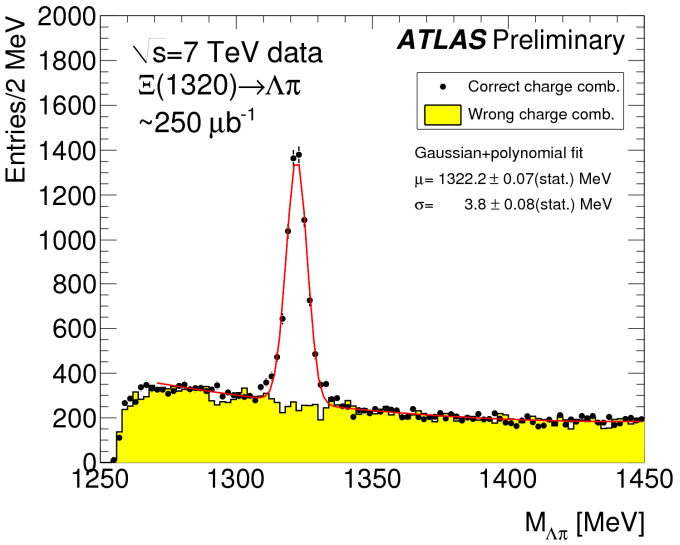
- Angular difference in transverse plane between highest-$p_T$ track in event and other tracks
  - Very robust shape
  - Allow for generator tuning
- Study $\delta\phi$ crest shape and same-opposite $\eta$ tracks
  - Subtract minimum number of tracks in $\delta\phi$ bin, then normalize to unity
    - Observable is $\delta\phi$ crest shape
  - In each $\delta\phi$ bin, subtract N tracks in opposite $\eta$ side of leading track from N tracks in same $\eta$ side

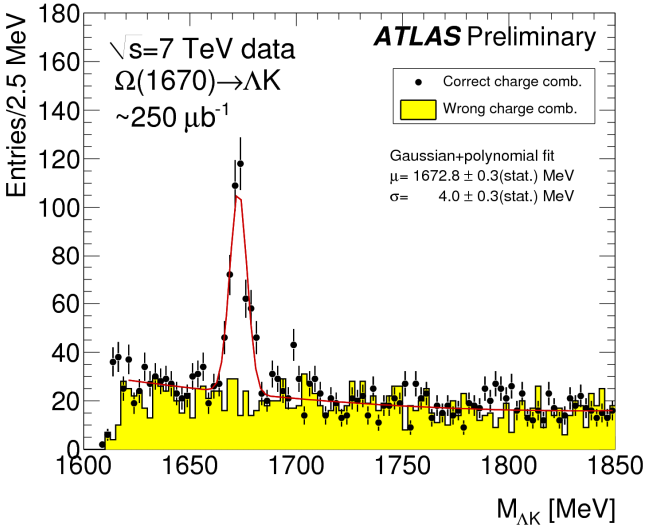


# Resonances

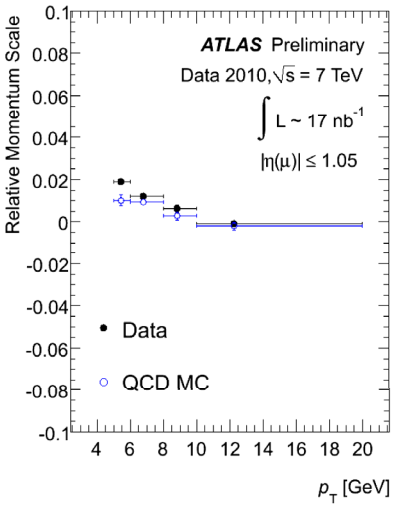

×10³
Minimum Bias Stream, Data 2010 (√s=7 TeV)
ATLAS Preliminary
Data
double Gauss + poly fit
Pythia MC09 signal
Pythia MC09 background
Entries / 1 MeV
M_π⁺π⁻ [MeV]

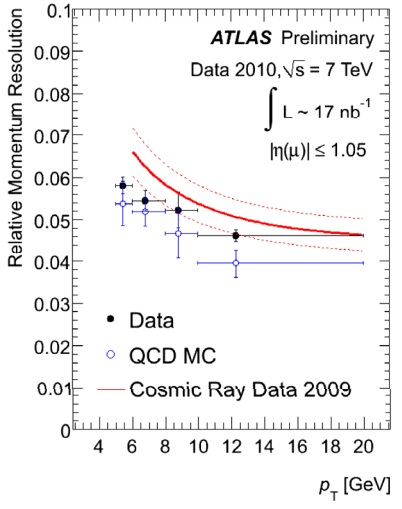

√s=7 TeV data
Ξ(1320)→Λπ
~250 μb⁻¹
ATLAS Preliminary
Correct charge comb.
Wrong charge comb.
Gaussian+polynomial fit
μ= 1322.2 ± 0.07(stat.) MeV
σ= 3.8 ± 0.08(stat.) MeV
Entries/2 MeV
M_Λπ [MeV]

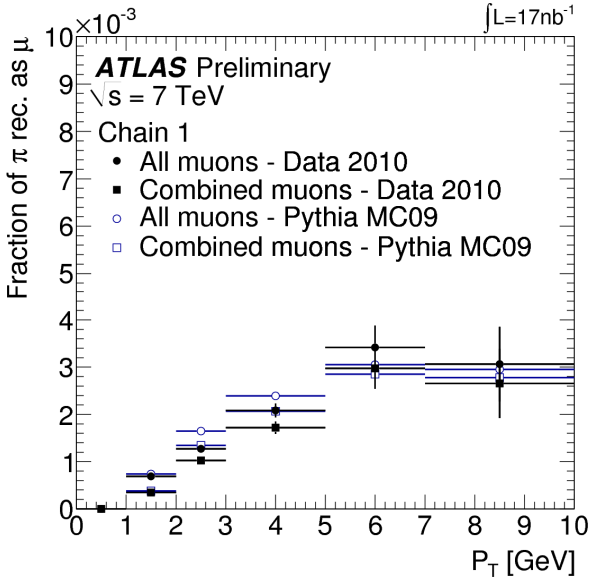

√s=7 TeV data
Ω(1670)→ΛK
~250 μb⁻¹
ATLAS Preliminary
Correct charge comb.
Wrong charge comb.
Gaussian+polynomial fit
μ= 1672.8 ± 0.3(stat.) MeV
σ= 4.0 ± 0.3(stat.) MeV
Entries/2.5 MeV
M_ΛK [MeV]

# Muon Performance (cnt.)

- Comparison between ID and MS allows for measurement of MS momentum scale and resolution
  - At low transverse momentum, ID dominates
  - Data-MC in agreement, no significant scale effect
- Start measuring fake rates in data
  - Pions from $K_s$
  - ~0.3% @ 10 GeV, probing low momenta

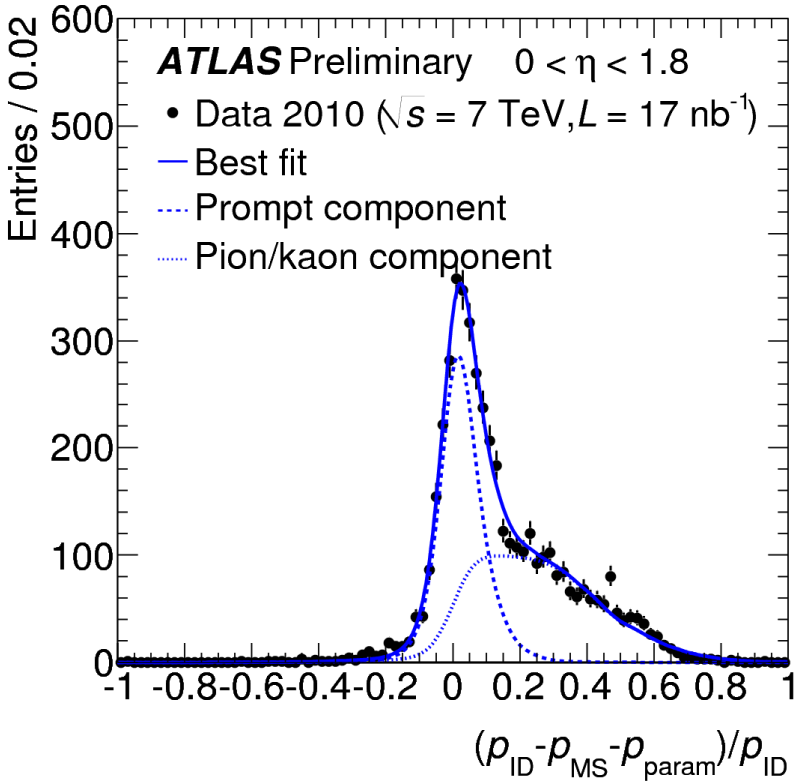


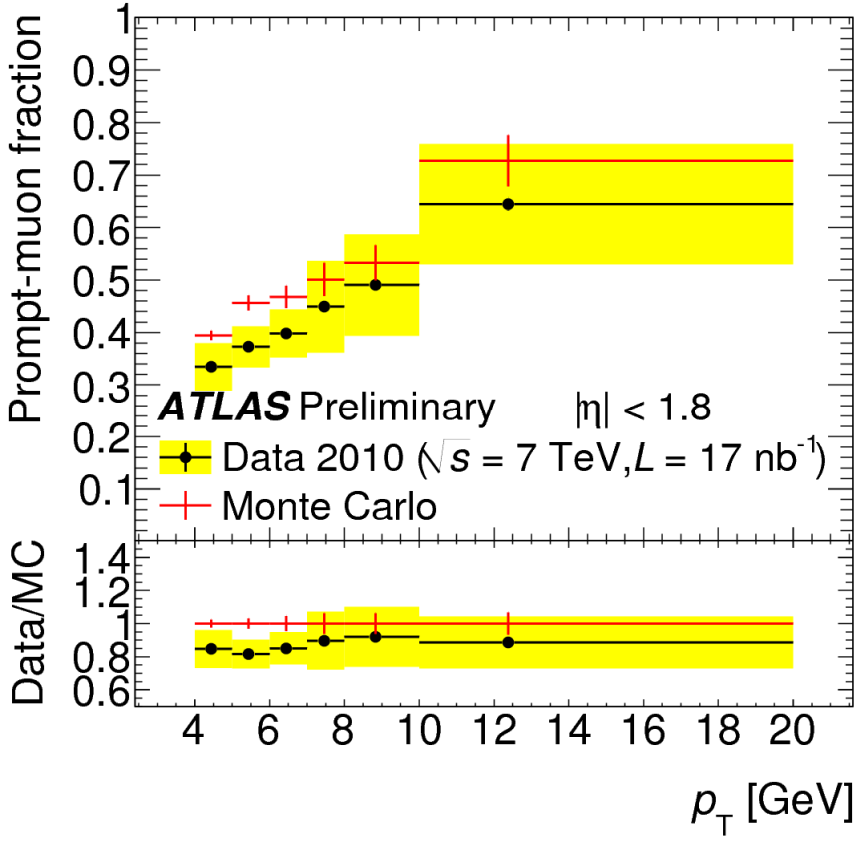



# Muons in ATLAS

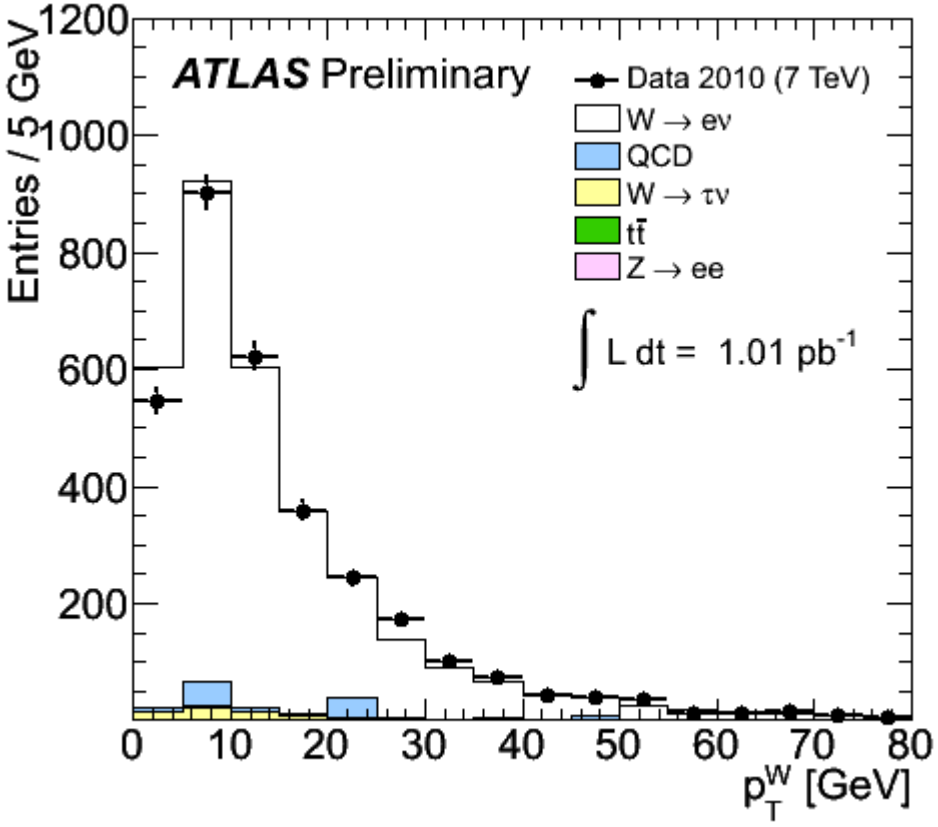
- Template fits to determine fraction of prompt muons
  - Tails in MS-ID momentum imbalance separate prompt muons from pions and kaons decayed in flight

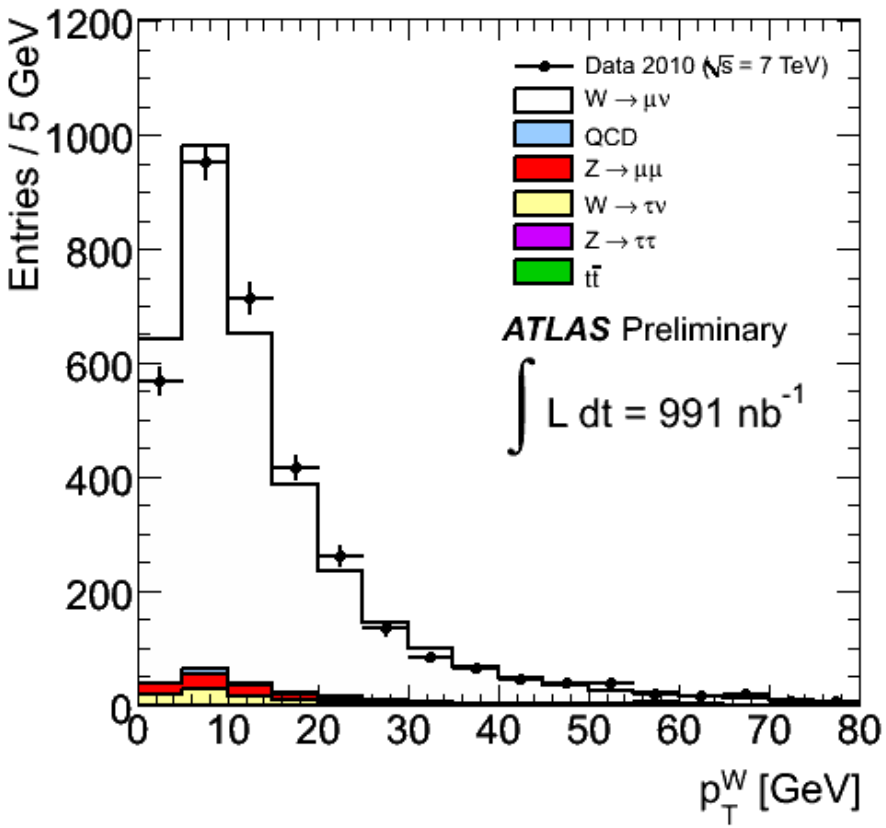


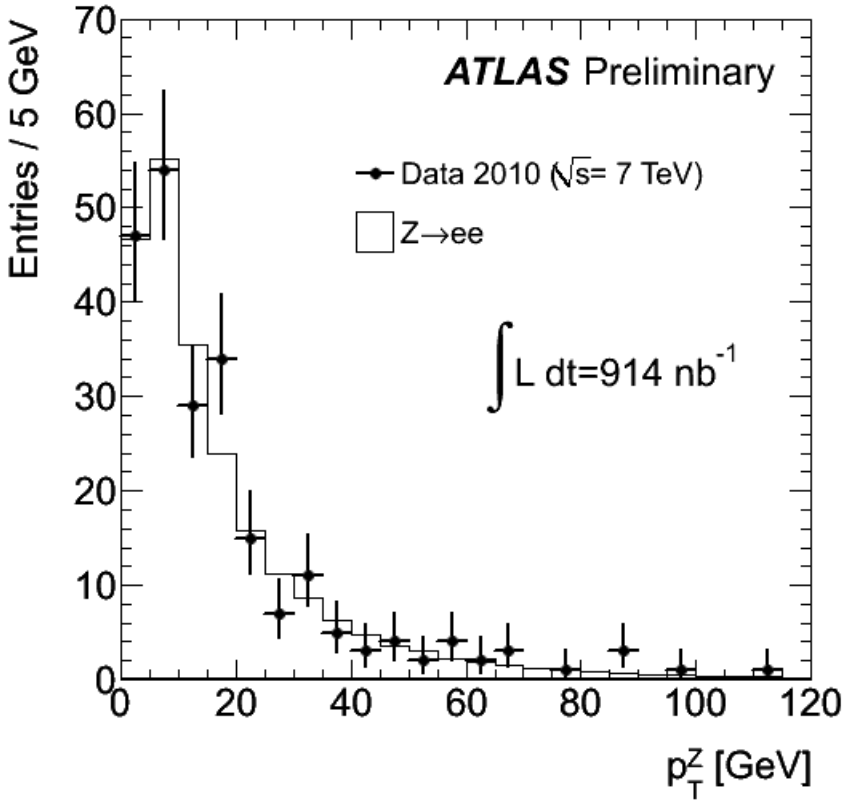
# W Physics

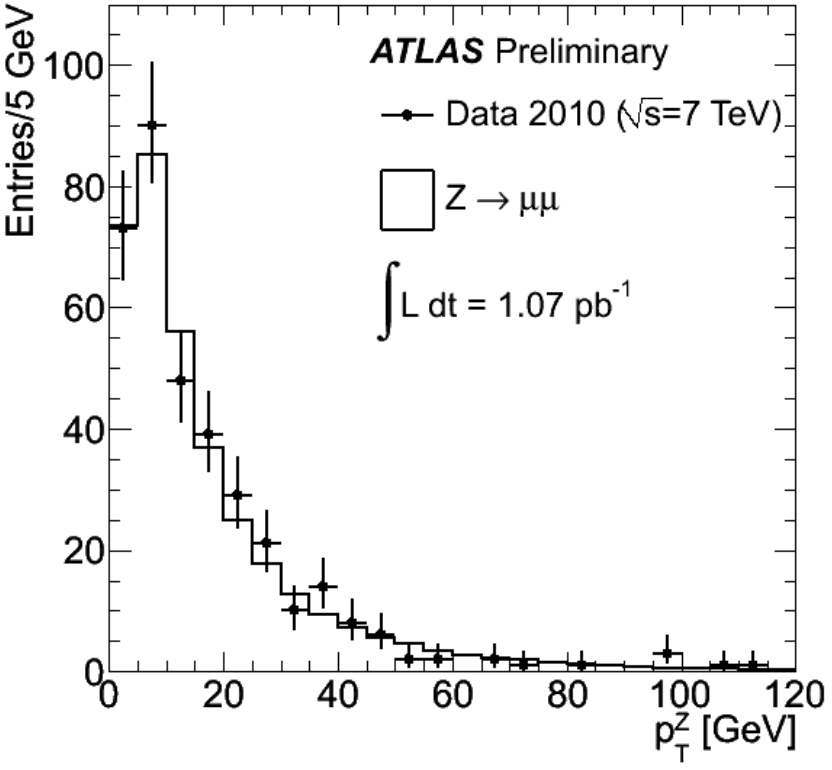
- 7 TeV environment rich in jets
  - Studies of W transverse momentum ongoing



# Z Candidate $p_T$




**All Z selection cuts applied**