

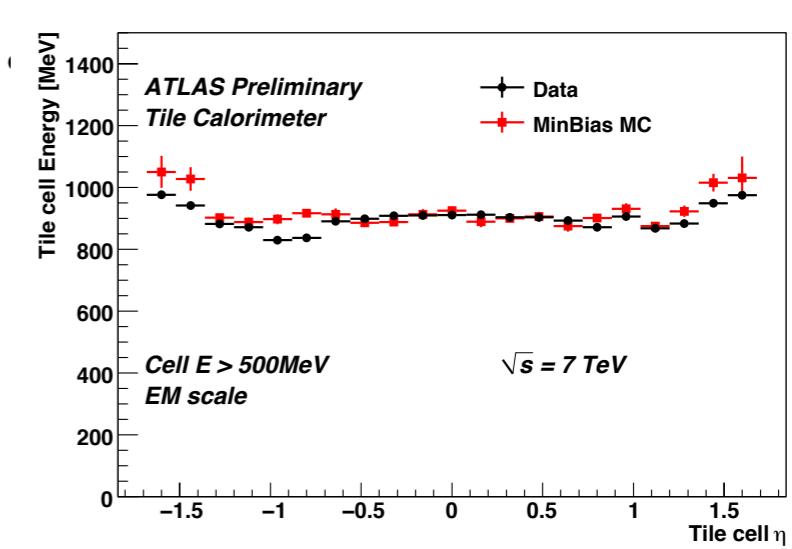
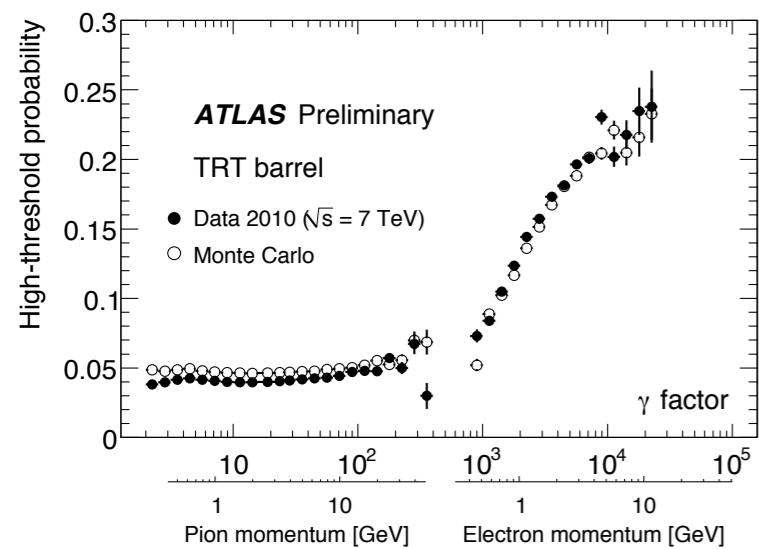
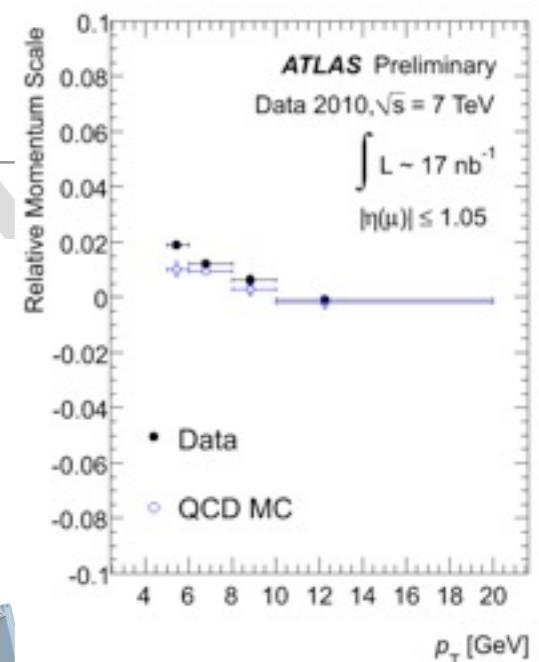
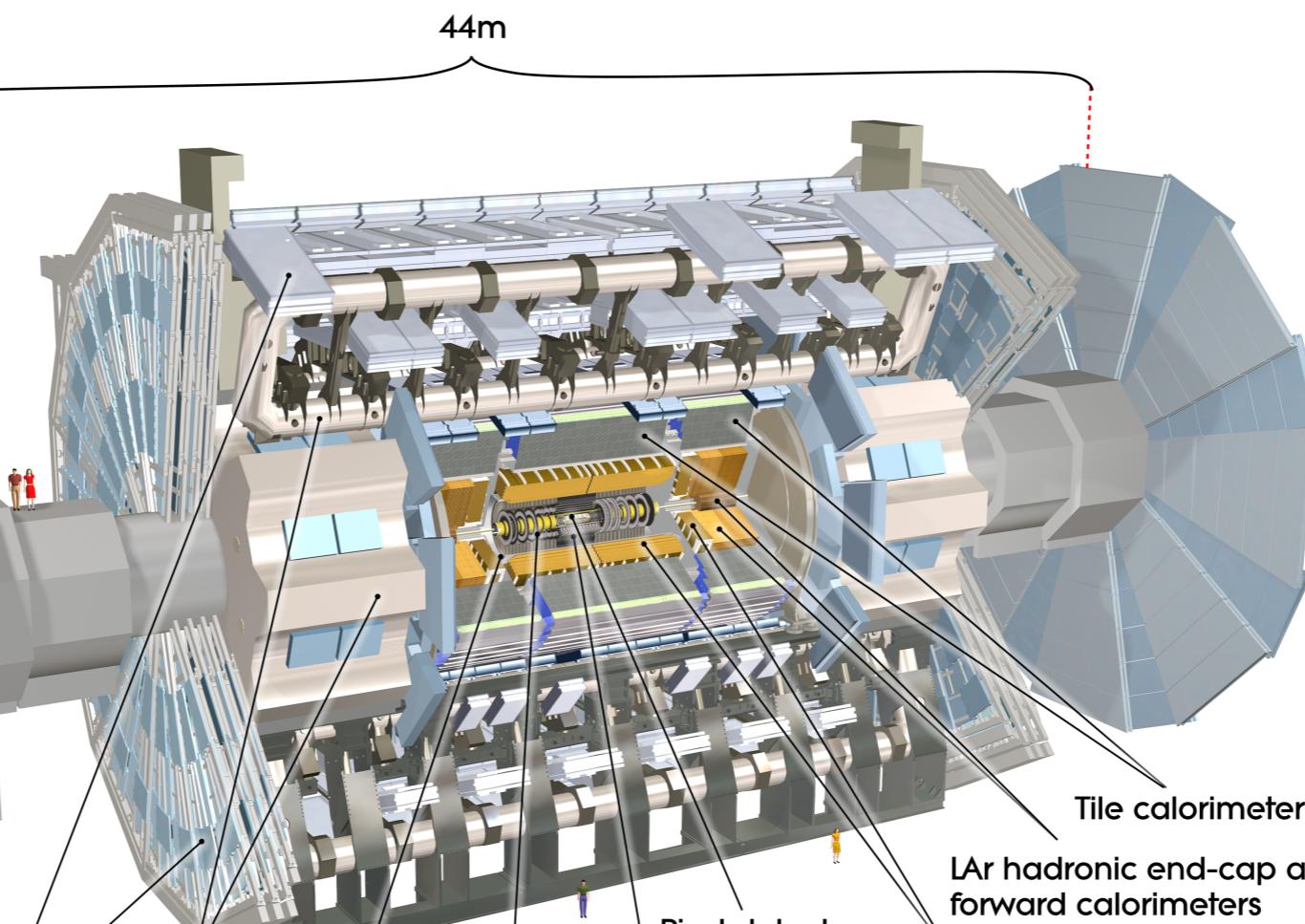
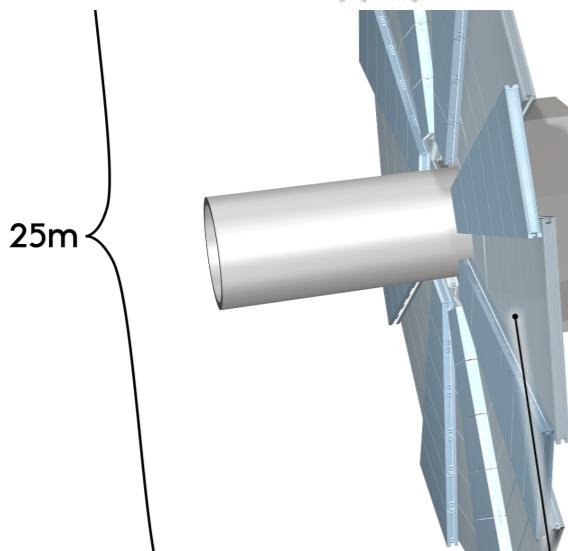
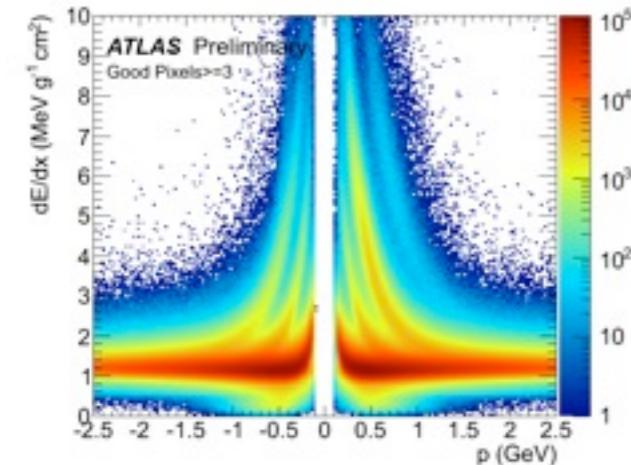
First Results from ATLAS and Perspectives for the HI Run

Heather M. Gray, Caltech/Columbia
on behalf of the ATLAS Collaboration

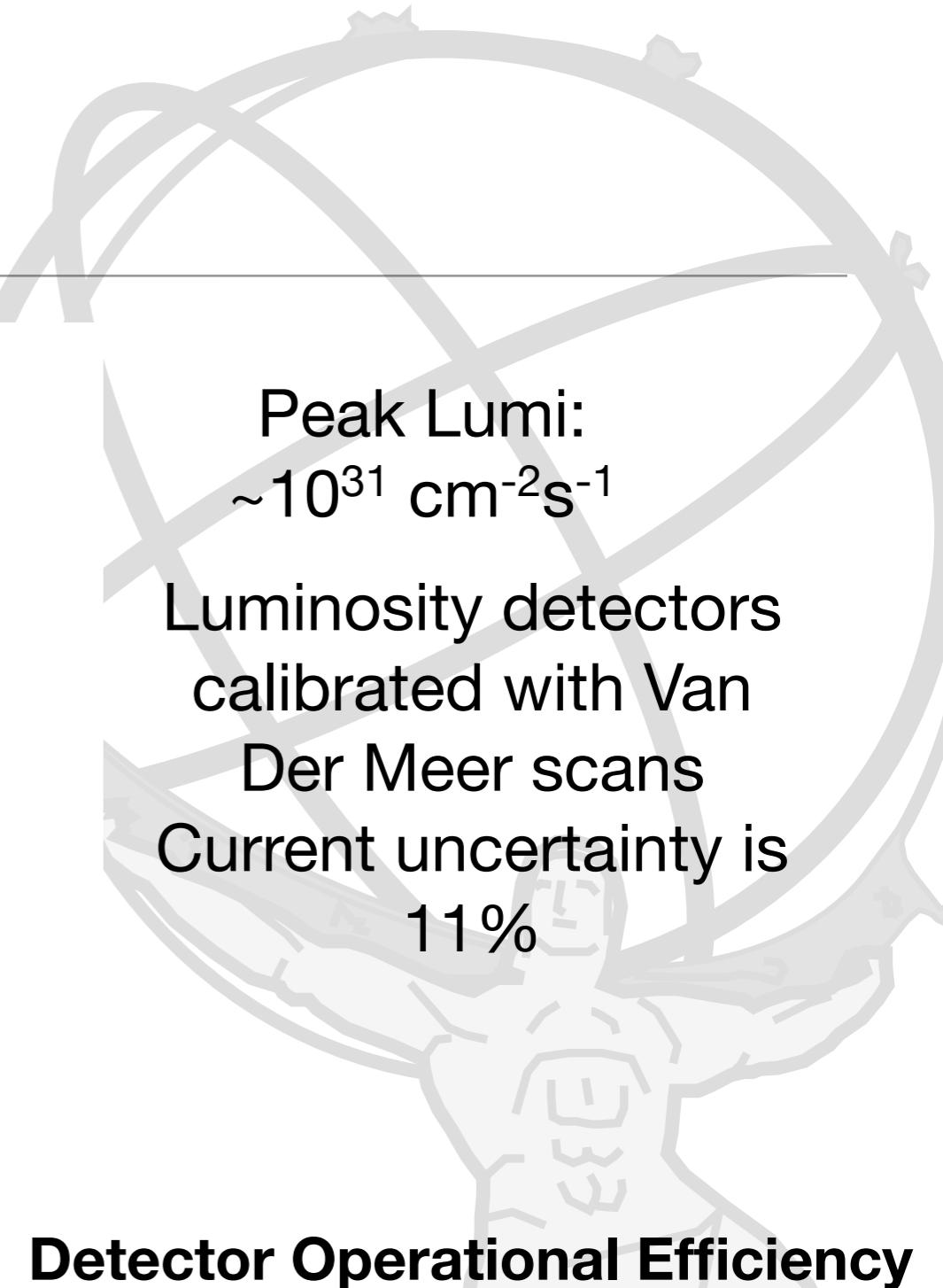
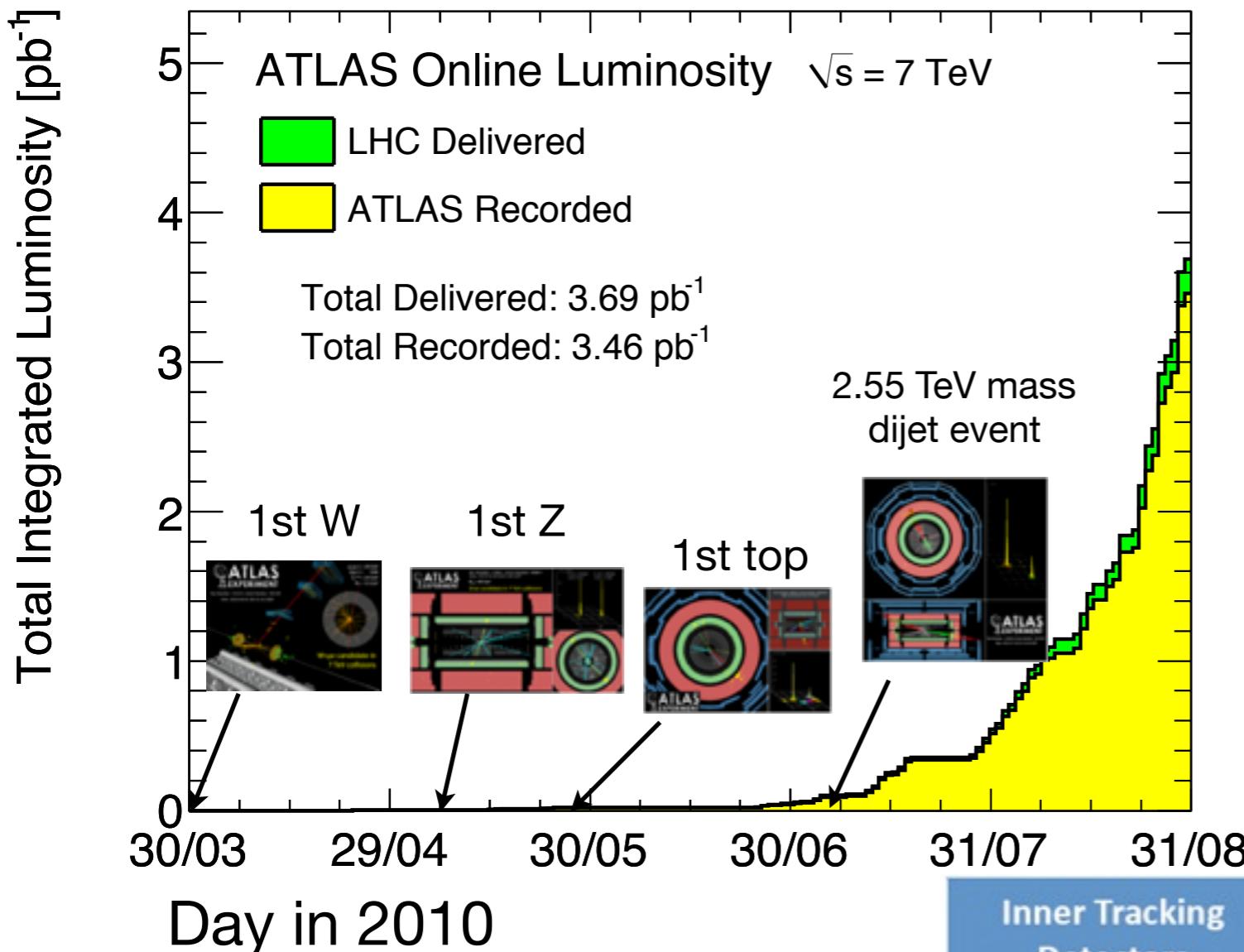
HIC2010, 3 September 2010



The ATLAS Detector



Luminosity



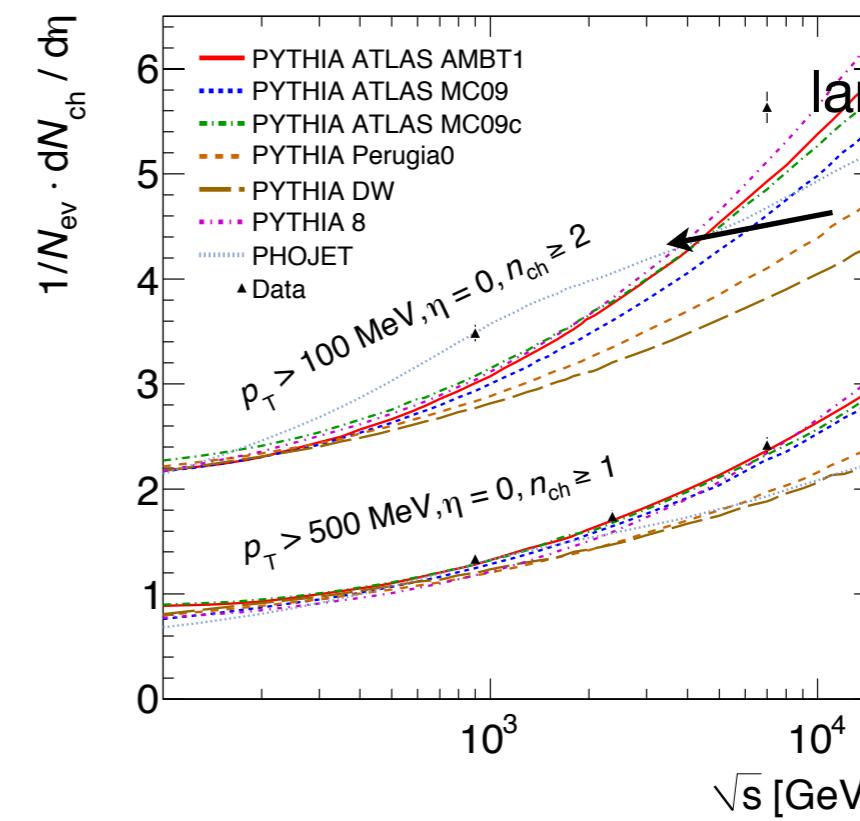
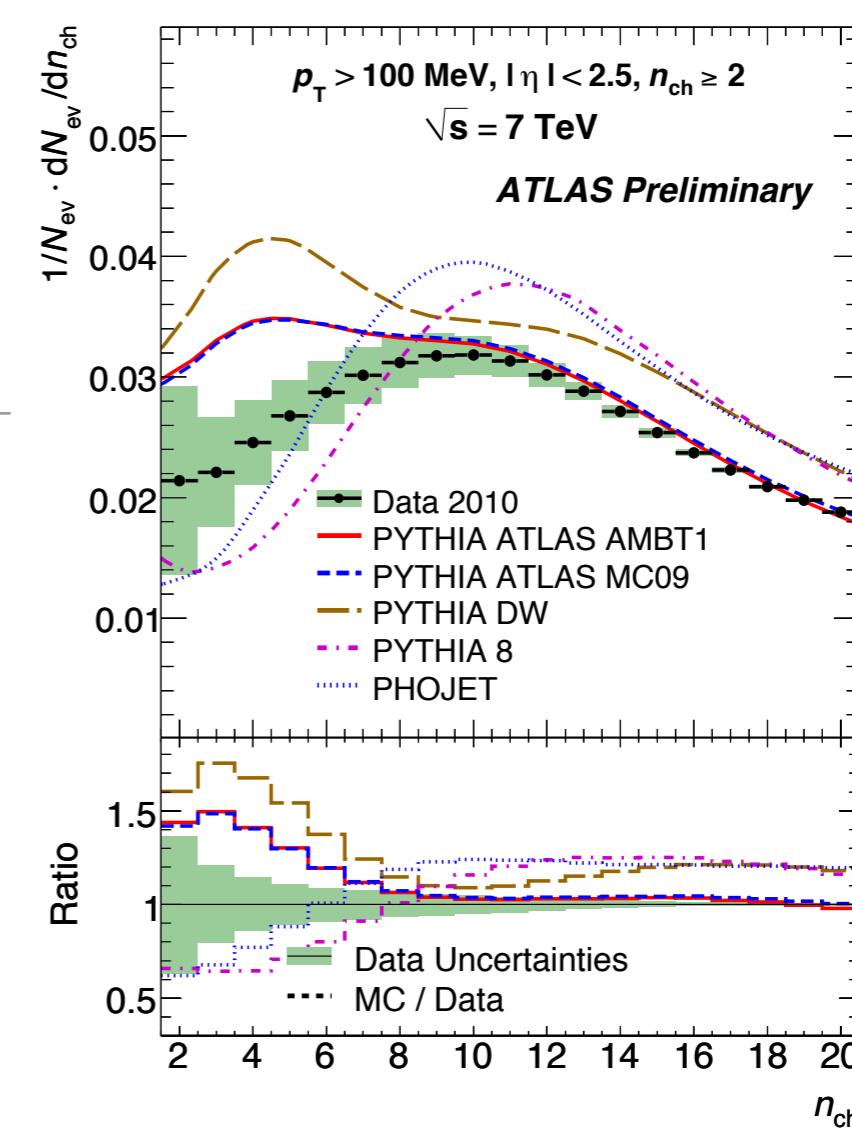
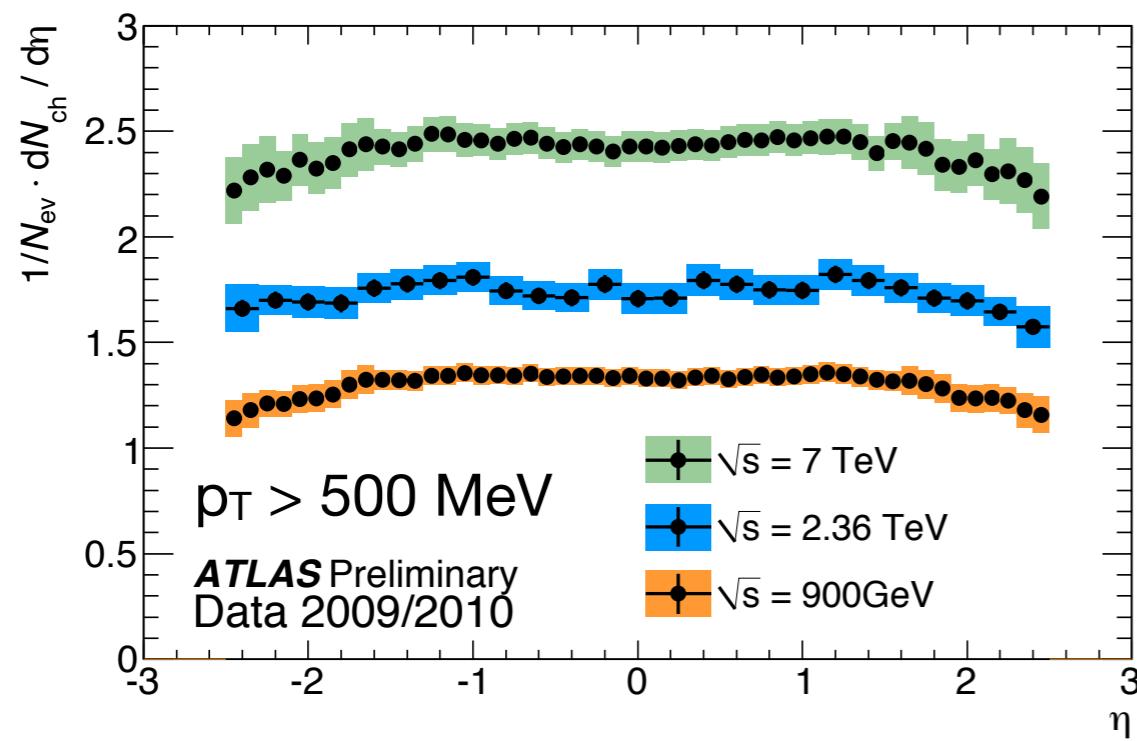
Detector Operational Efficiency

Inner Tracking Detectors			Calorimeters			Muon Detectors				
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	TGC	CSC
97.7	96.4	100	94.4	98.7	99.3	99.2	98.5	98.3	98.6	98.3

Luminosity weighted relative detector uptime and good quality data delivery during 2010 stable beams at $\sqrt{s}=7 \text{ TeV}$ between March 30th and August 14th (in %)

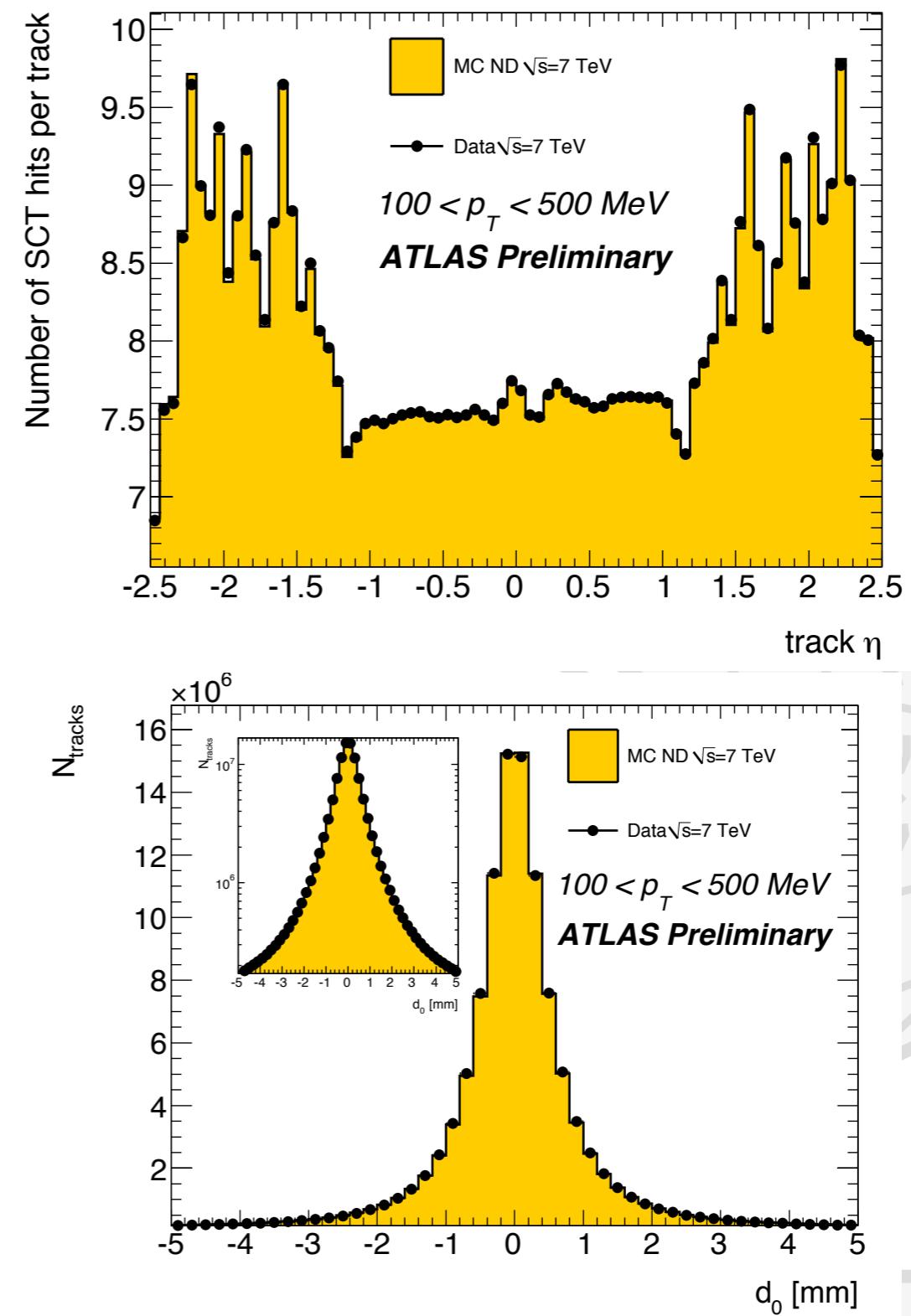
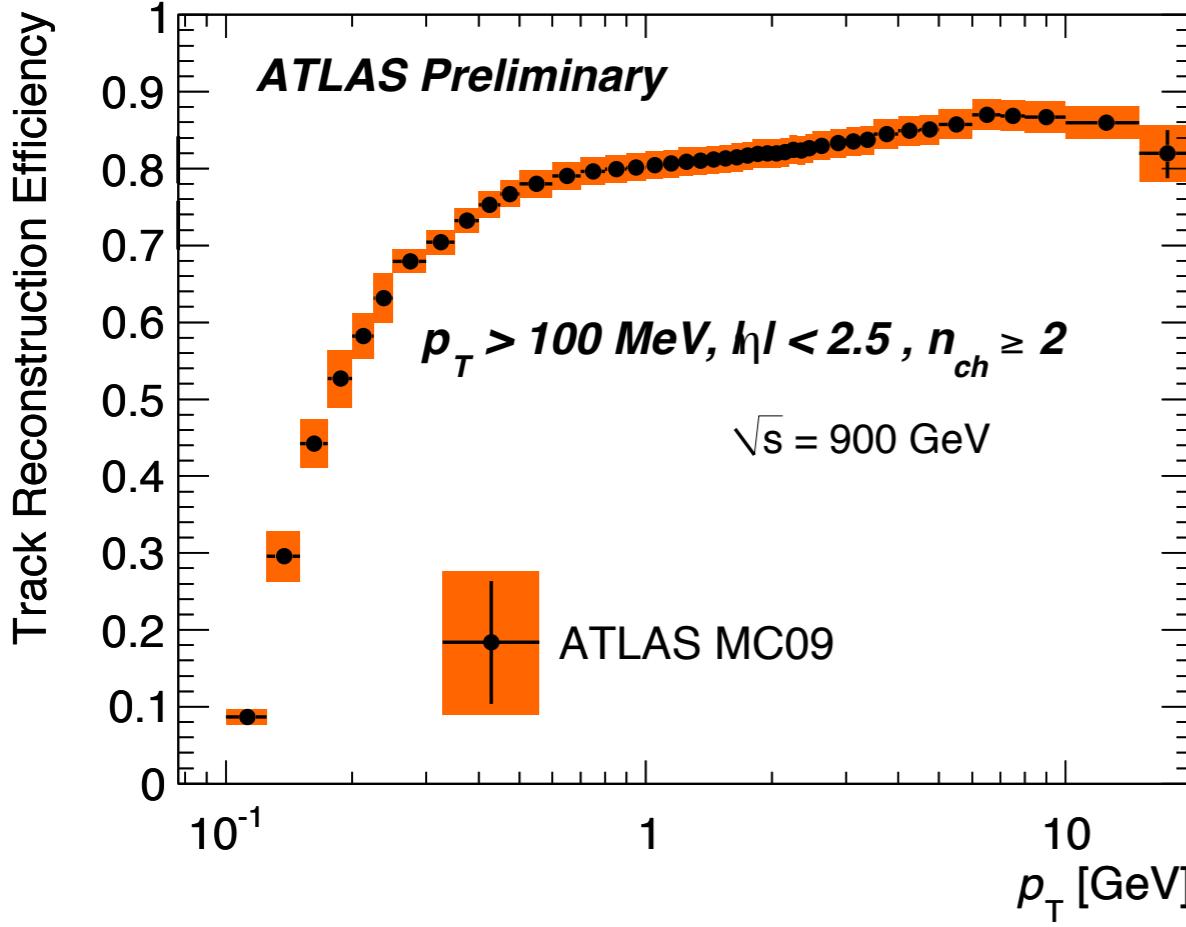
Soft QCD

- Study of particle multiplicities and spectra in pp minimum bias events
- Measured at 900 GeV, 2.36 TeV and 7 TeV
- Inclusive measurement: no correction to remove diffractive component
- Measured in 3 well-defined phase phases:
 $p_T > 100 \text{ MeV}$, $p_T > 500 \text{ MeV}$, $n_{\text{ch}} \geq 6$
- Strong constraints on MC models



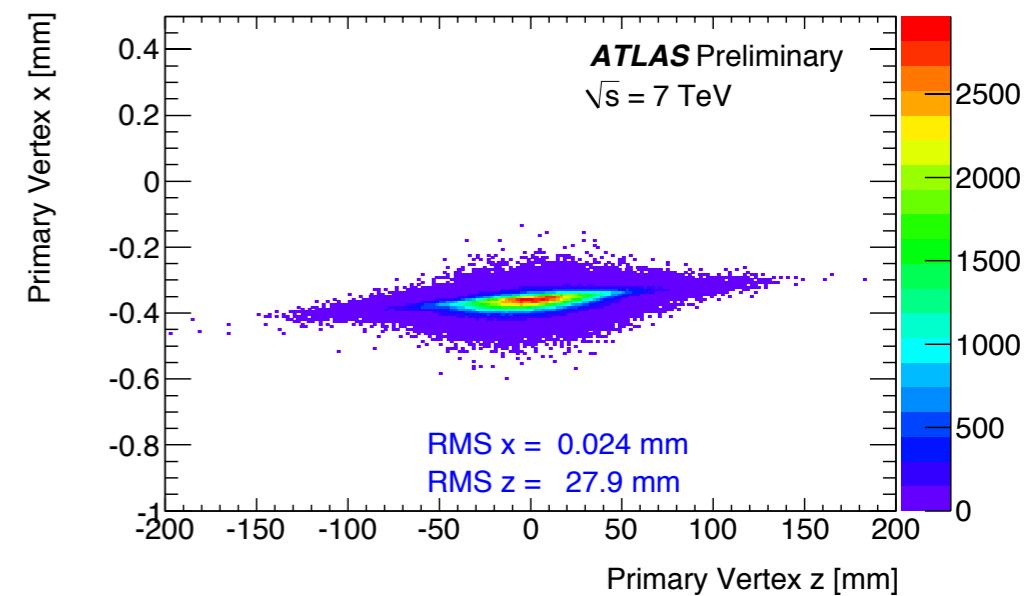
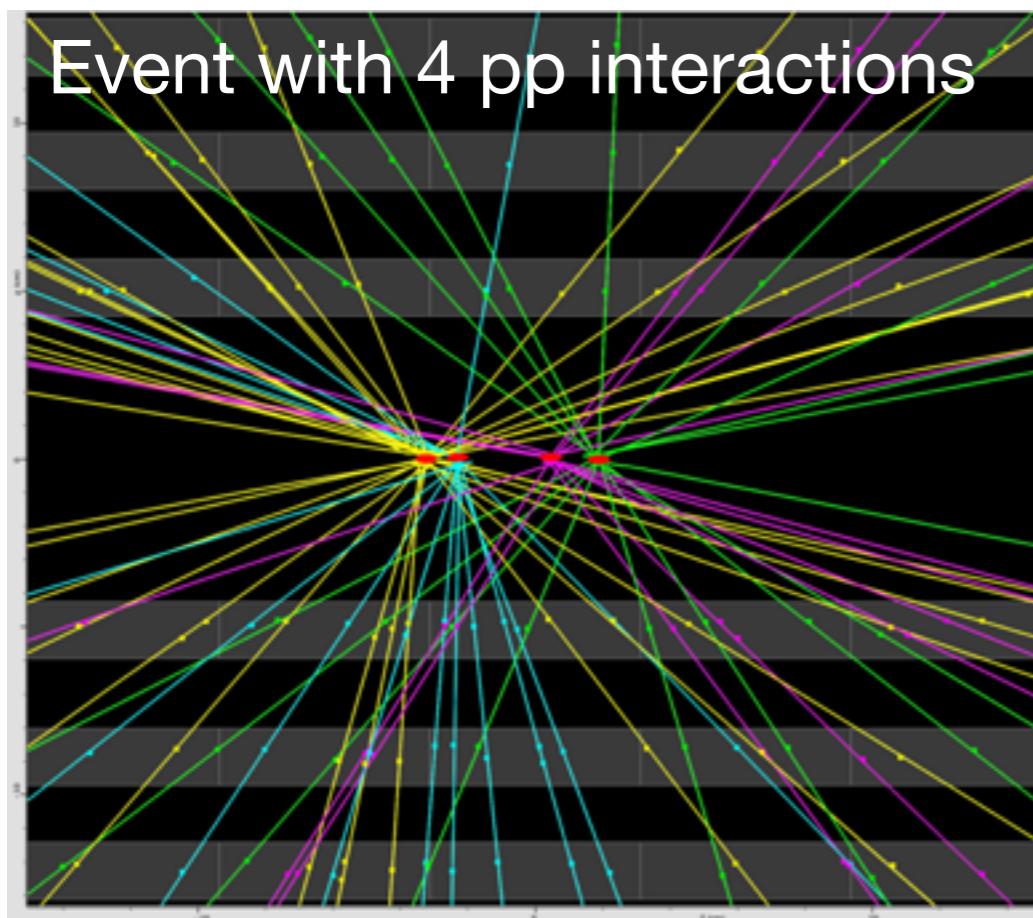
Low p_T Tracking Performance

- Track reconstruction efficiency in the ID is understood to few % level for charged particles with $p_T > 100$ MeV
- Excellent agreement between data and simulation

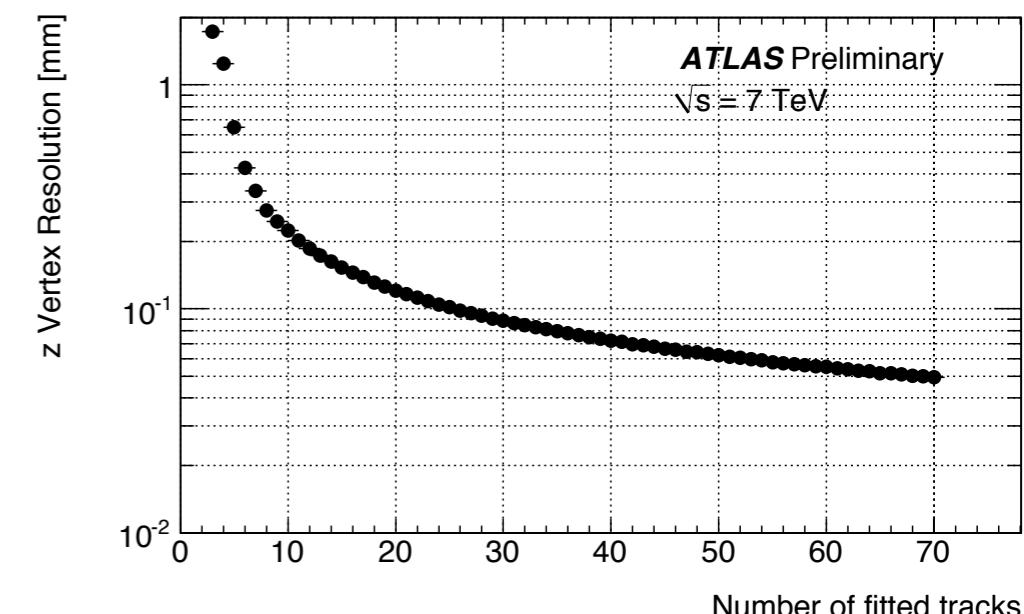


Vertex Reconstruction

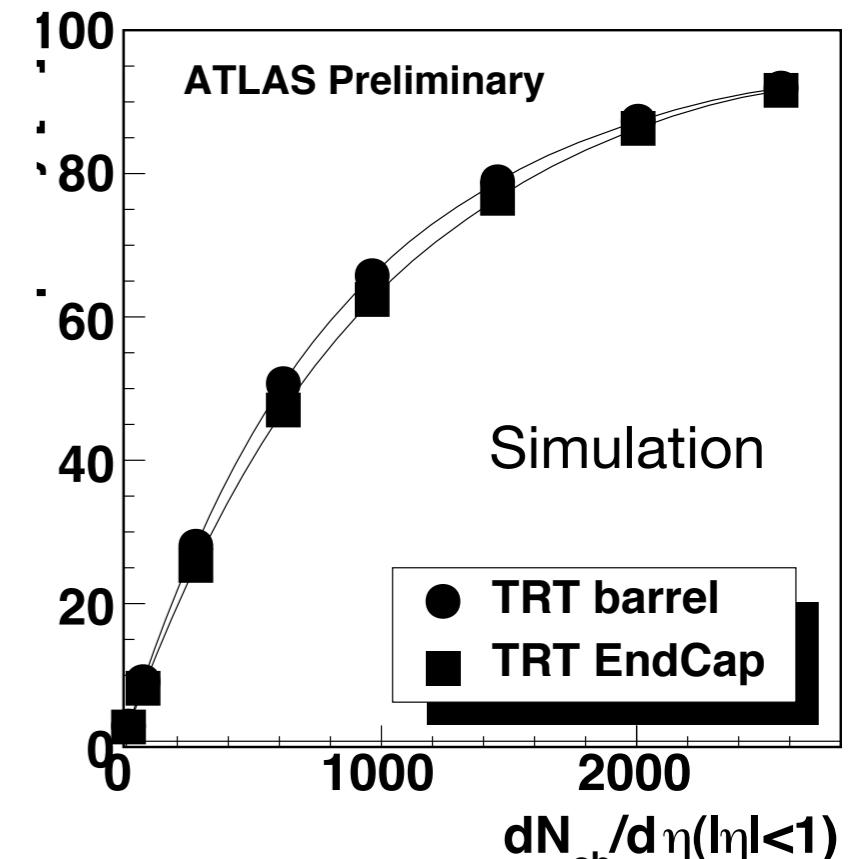
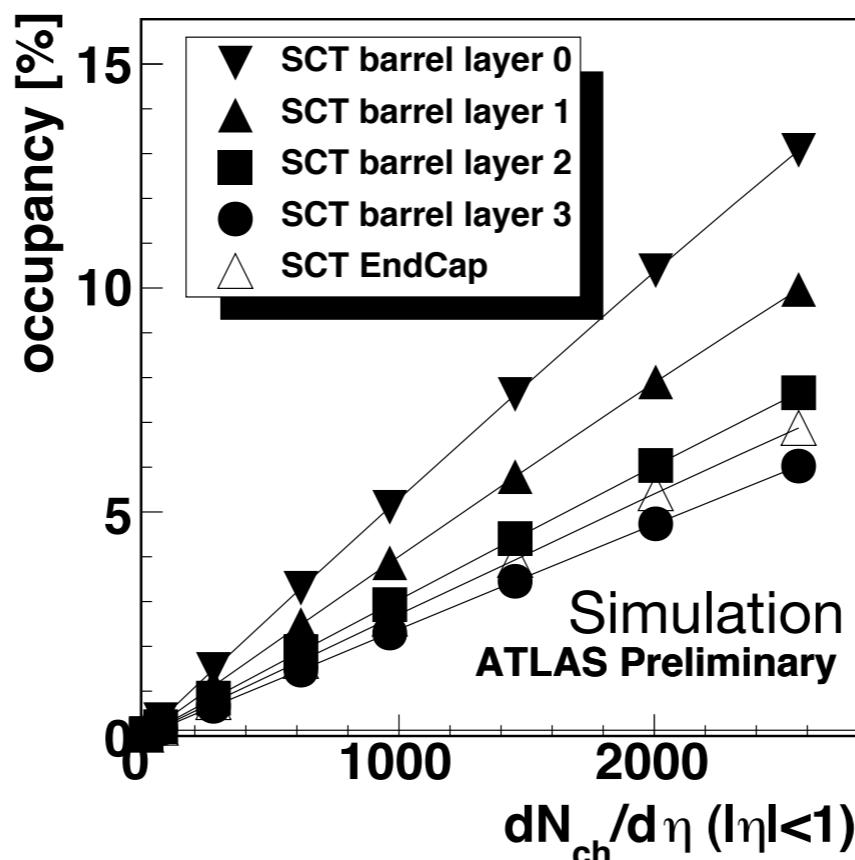
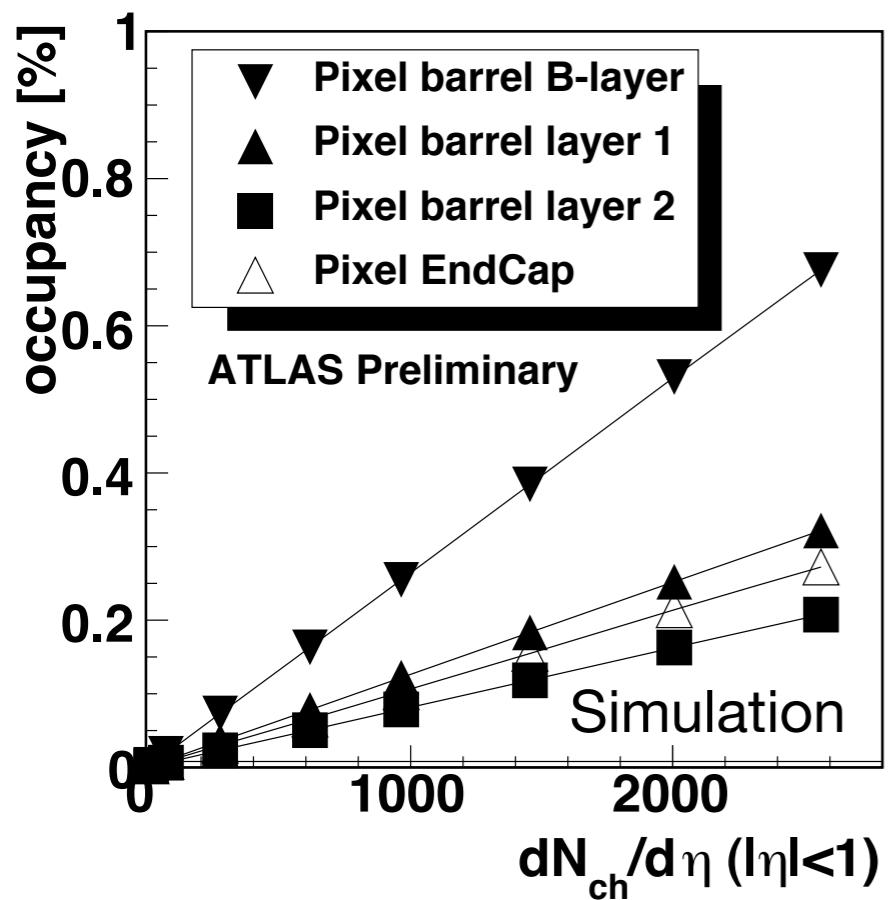
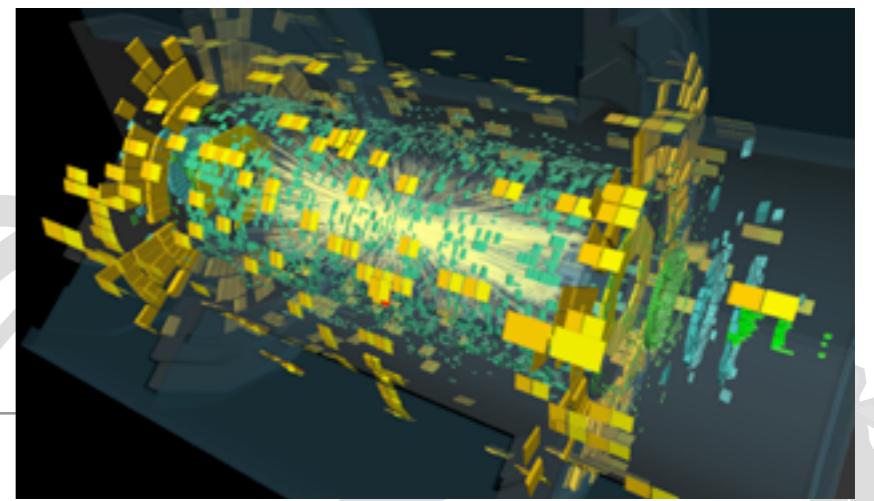
At peak luminosity:
~1.3 pp interactions per beam crossing
~40% of events with multiple pp interactions



Vertex resolution typically better than 100 microns



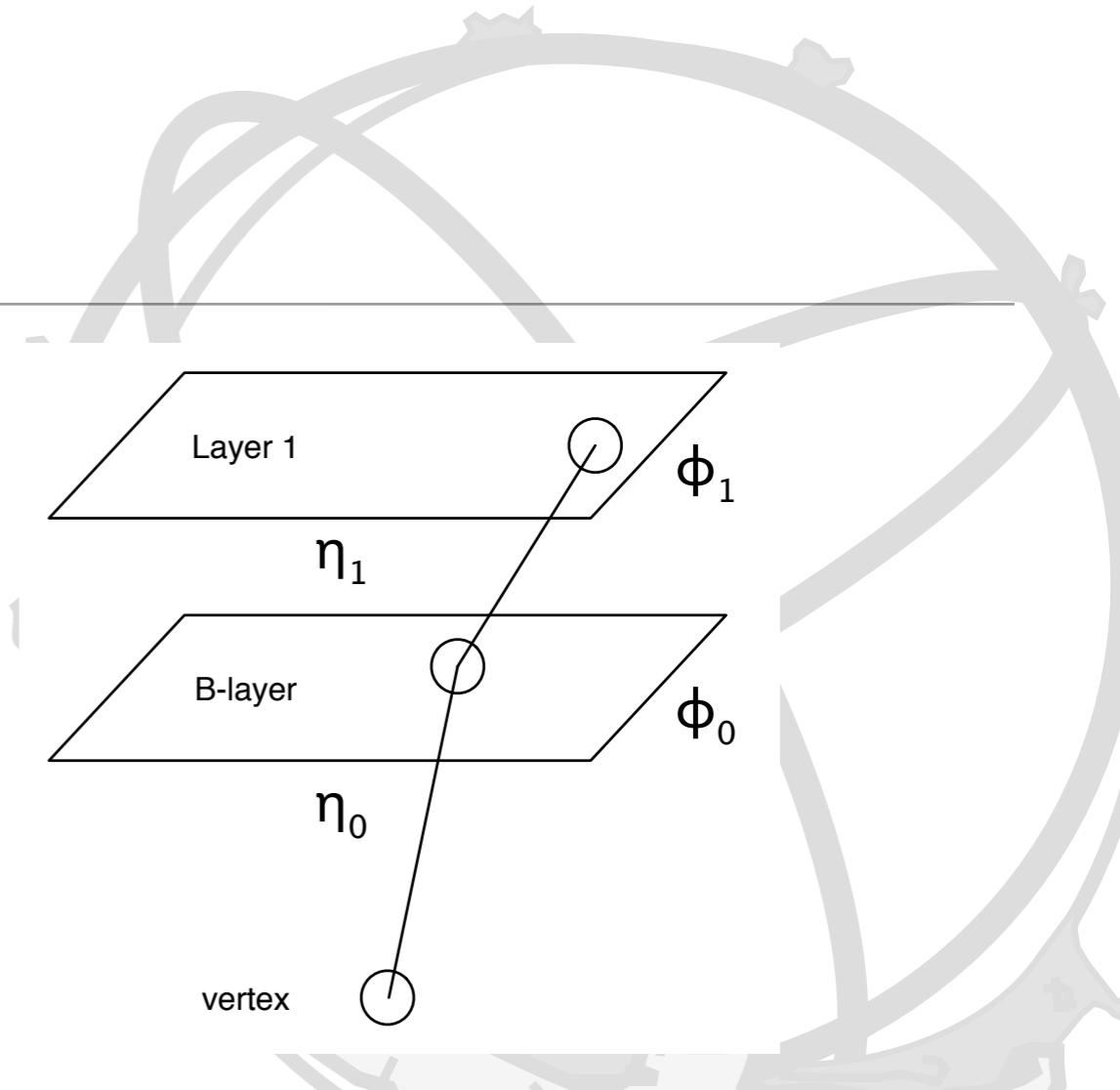
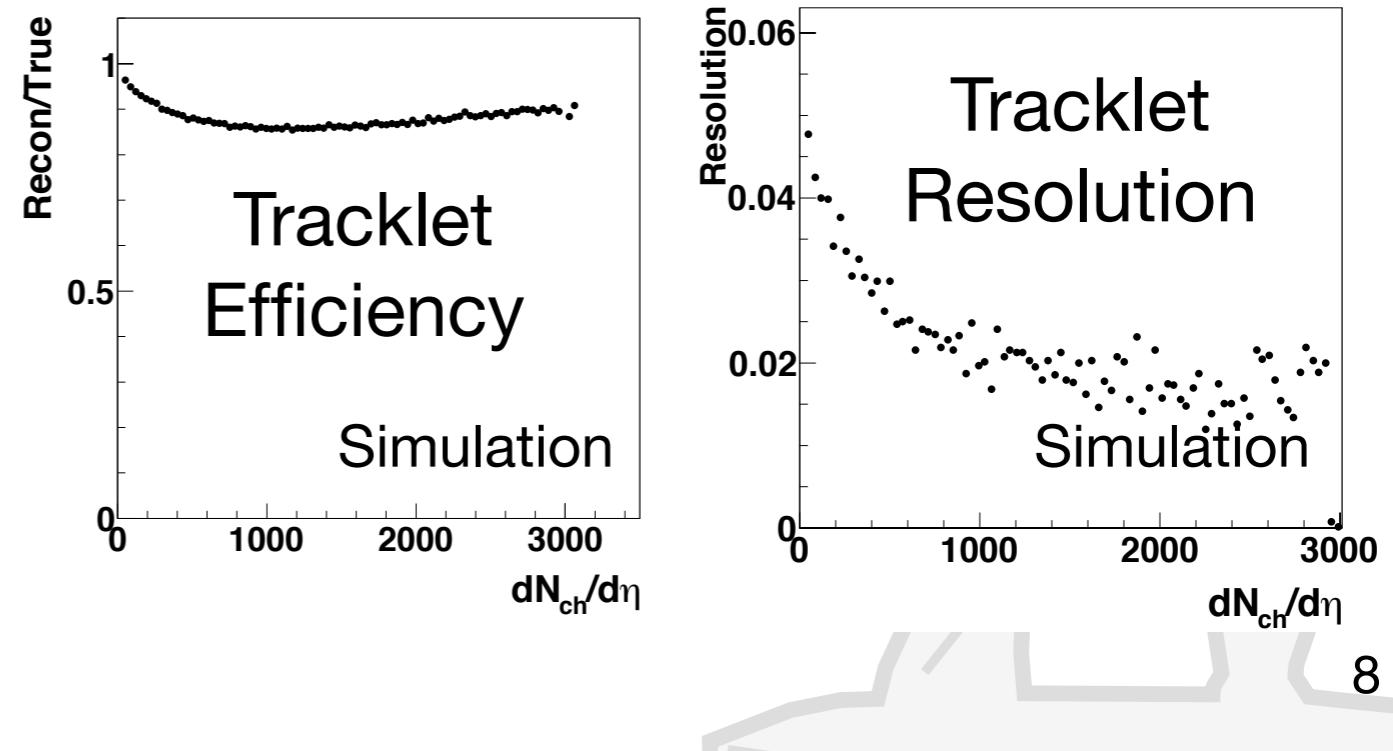
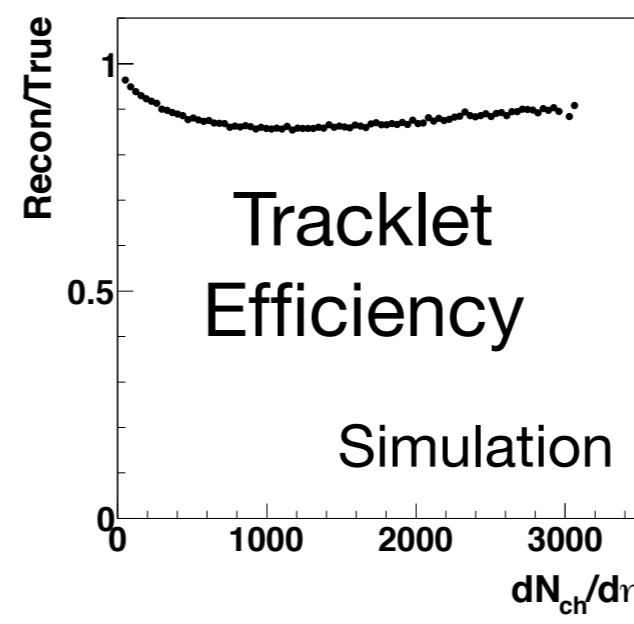
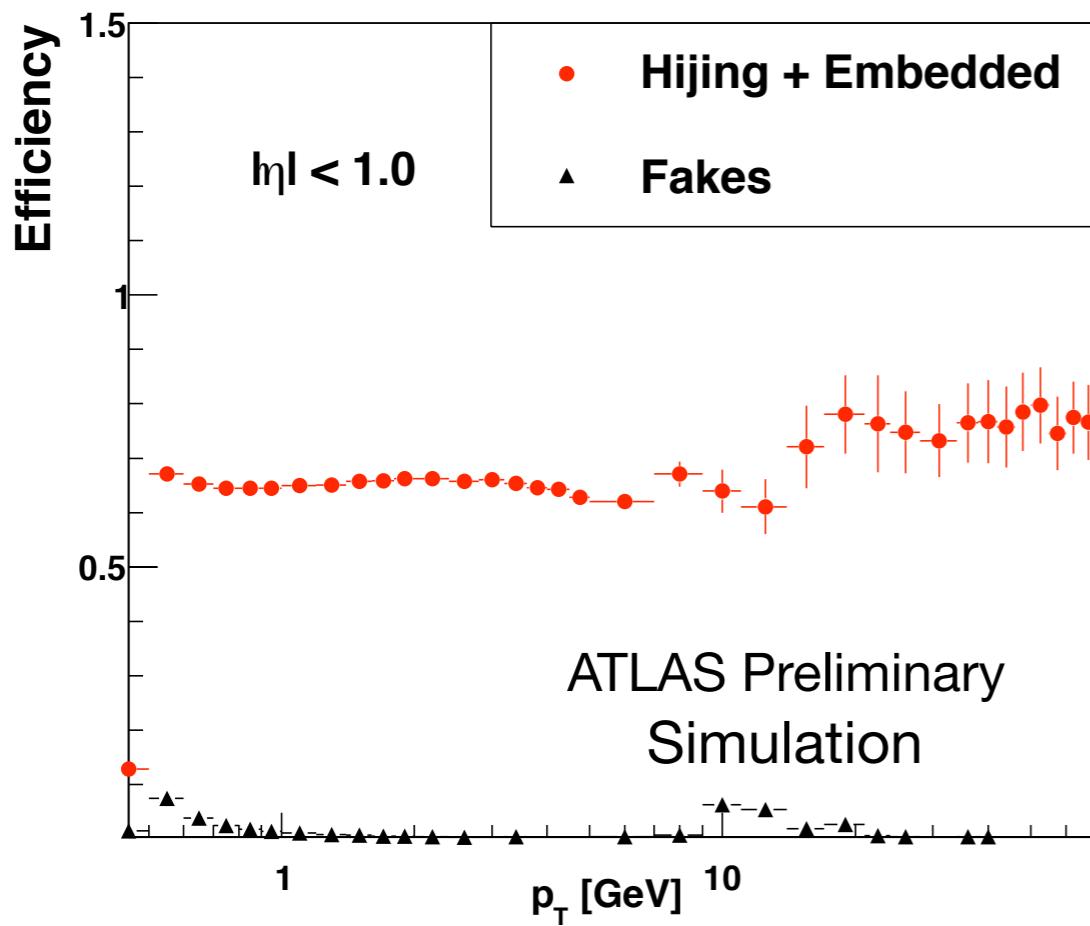
ID Occupancies in HI collisions



Inner Detector occupancies in HI collisions are expected to be quite comfortable, particularly in early data (reaching $dN_{ch}/d\eta \sim 2000$ in HIJING @ $\sqrt{s}_{NN}=2.76$ TeV)

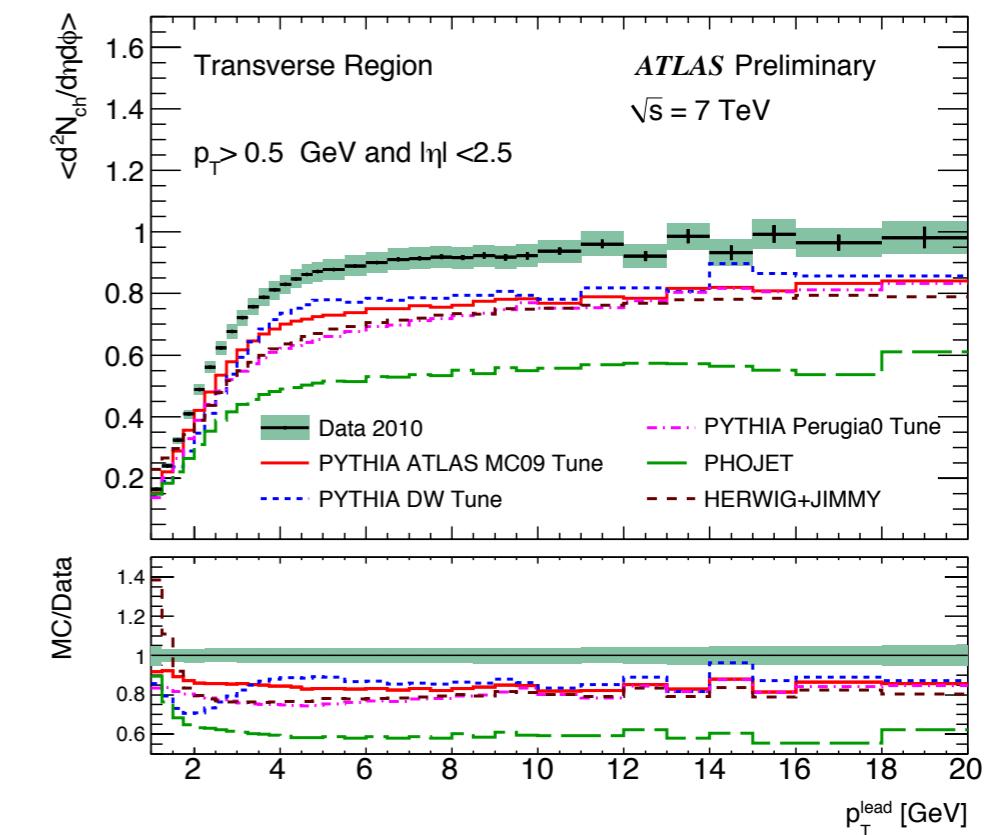
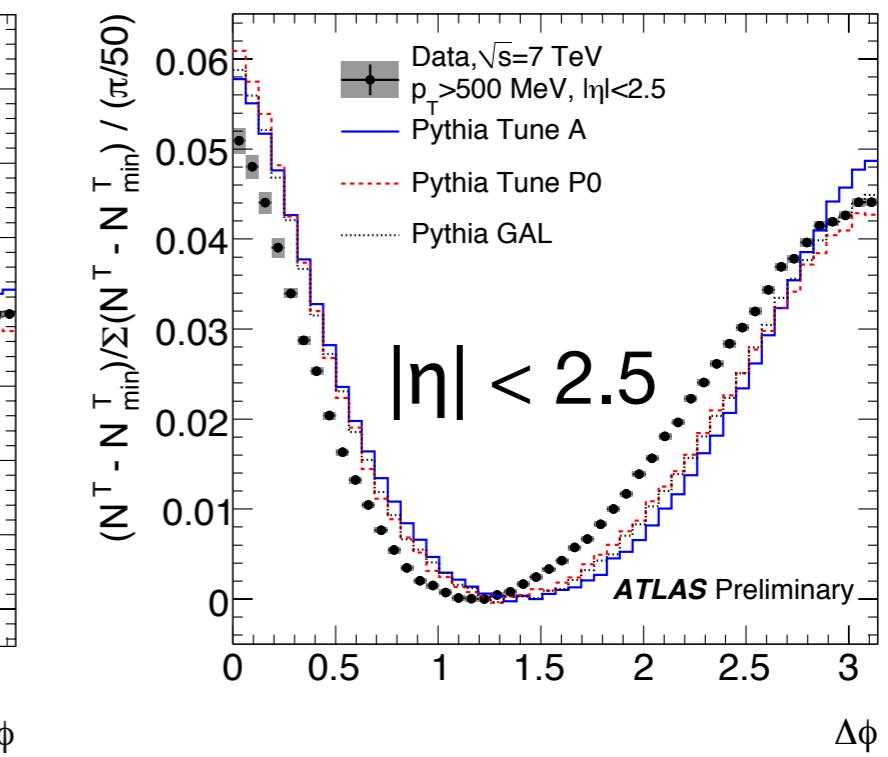
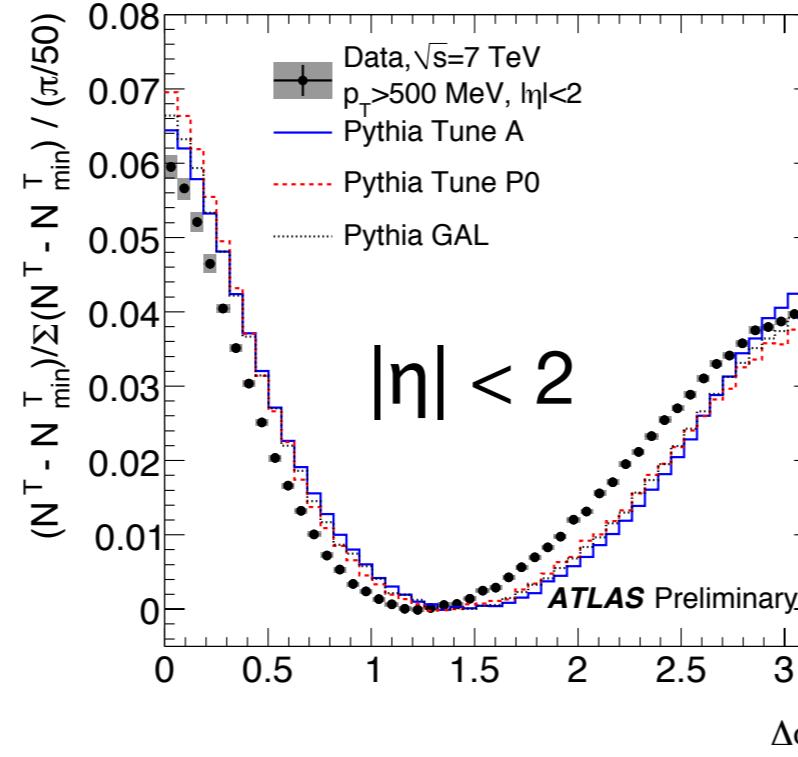
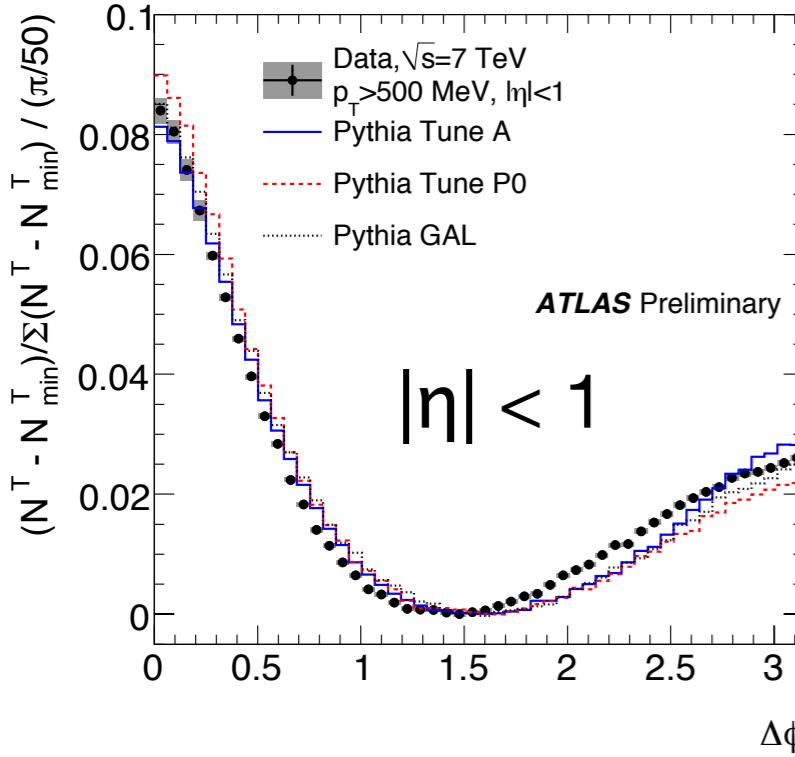
Tracking in Heavy Ion Events

- Standard Tracking Algorithms: Tracks seeded in pixel, extended into SCT, Kalman filter & track fit
- At high p_T , use calo association to obtain good efficiency/fake rate up to 100 GeV
- Study particle multiplicity using tracklets by combining two pixel clusters

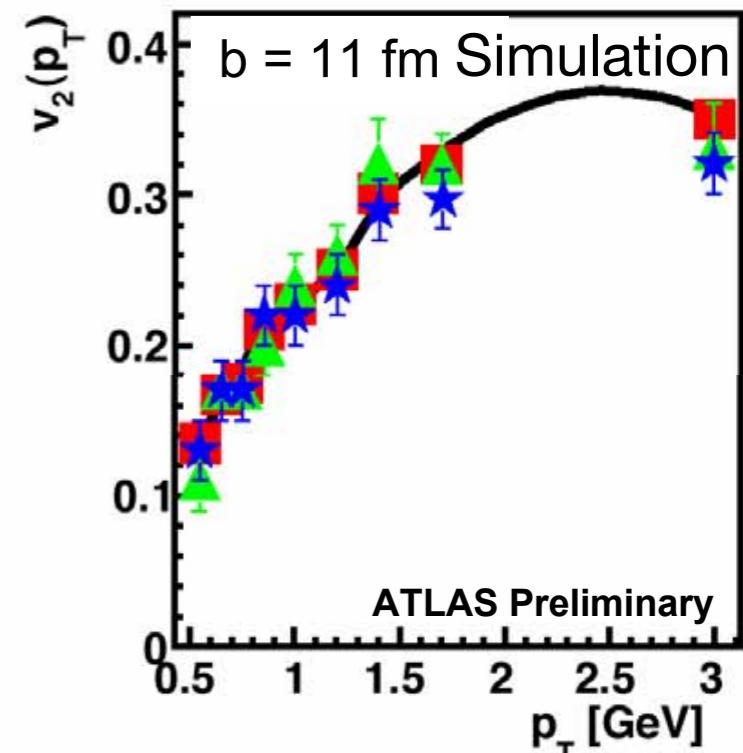
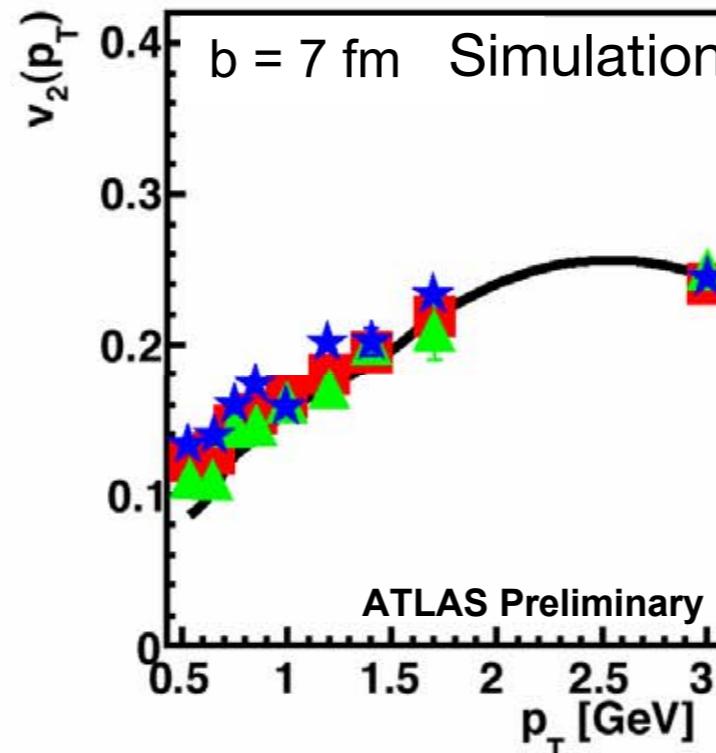
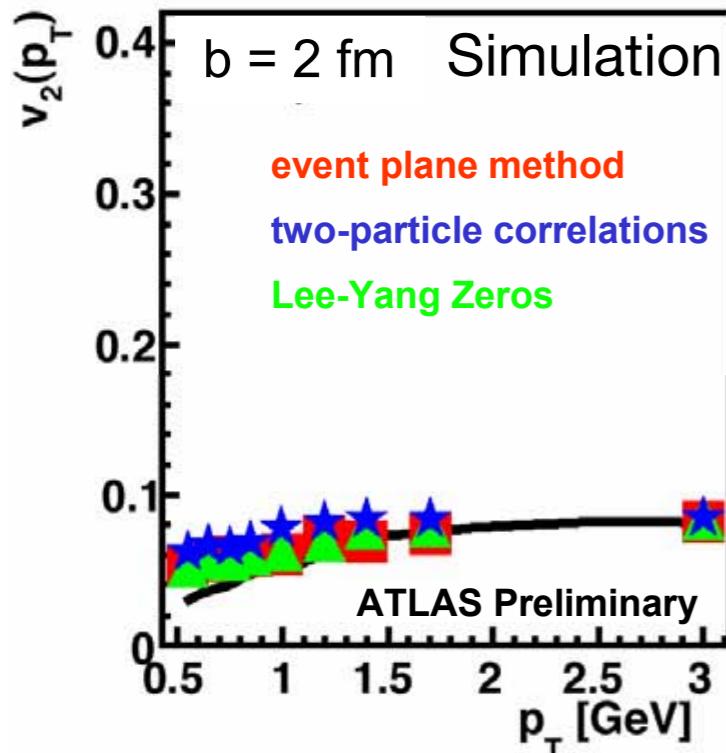


Particle Correlations

- Study distributions wrt to the reference system defined by the leading jet/track direction
- Study shape of the peak itself ($\Delta\phi$ correlations) or the transverse region (underlying event)
- Using similar variables to heavy-ion studies of the p_T -triggered correlations and elliptic flow measurements.

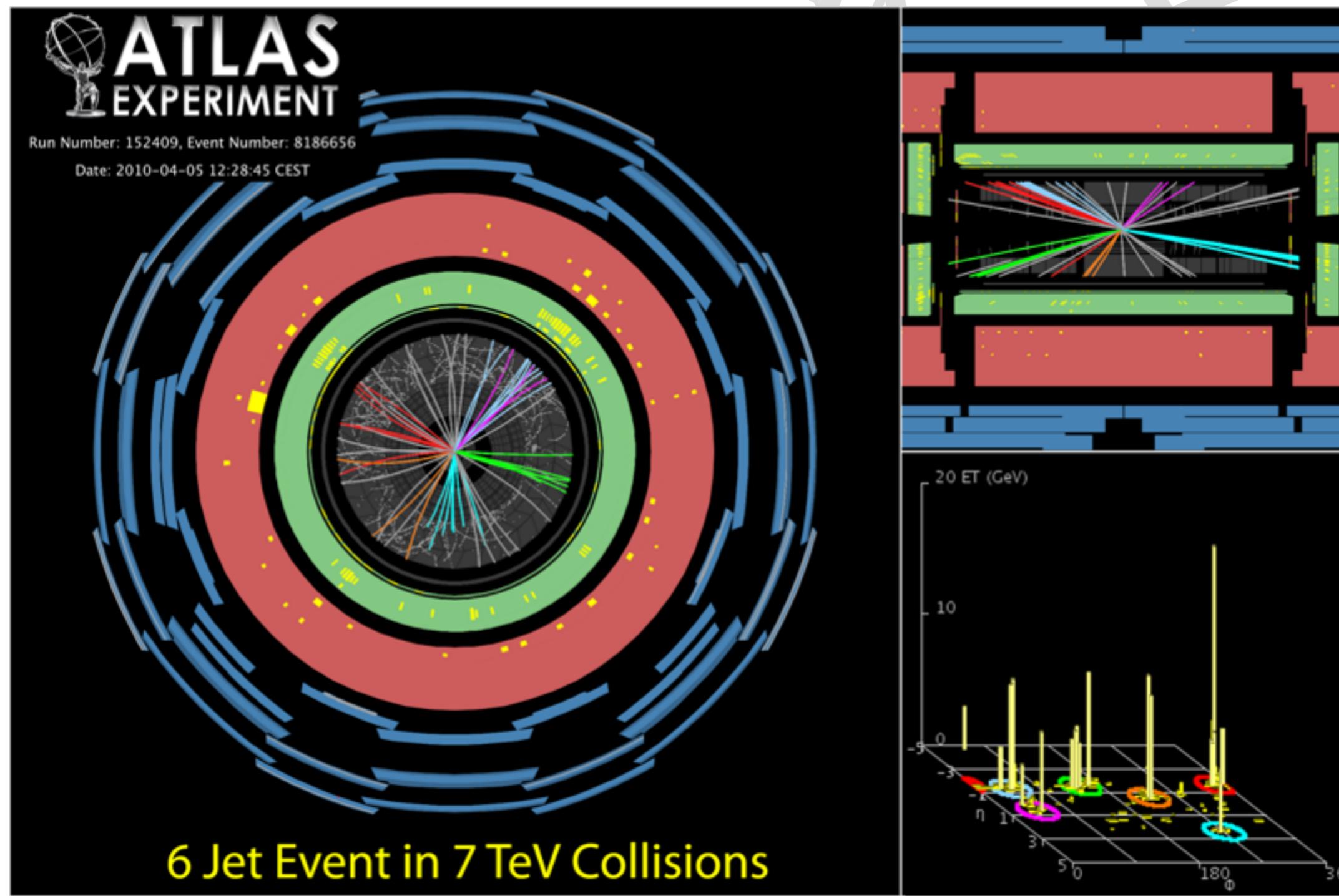


Global Correlations: Elliptic Flow



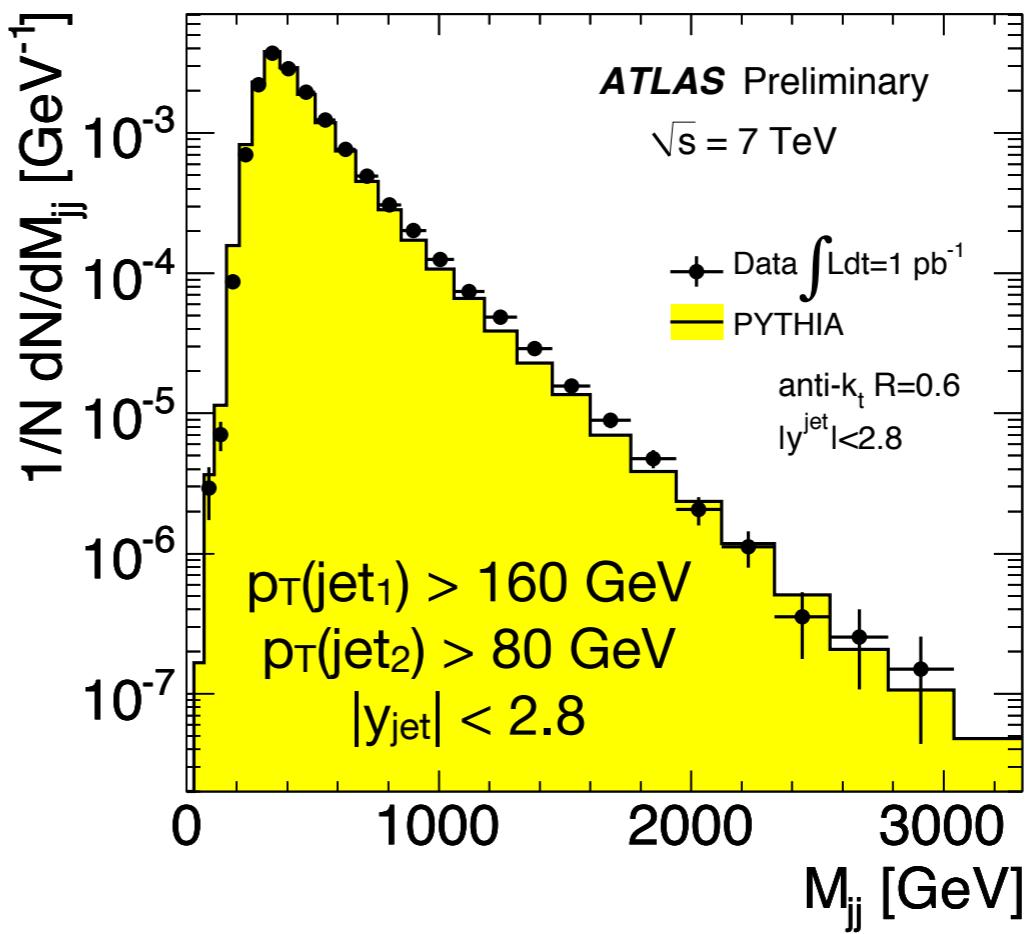
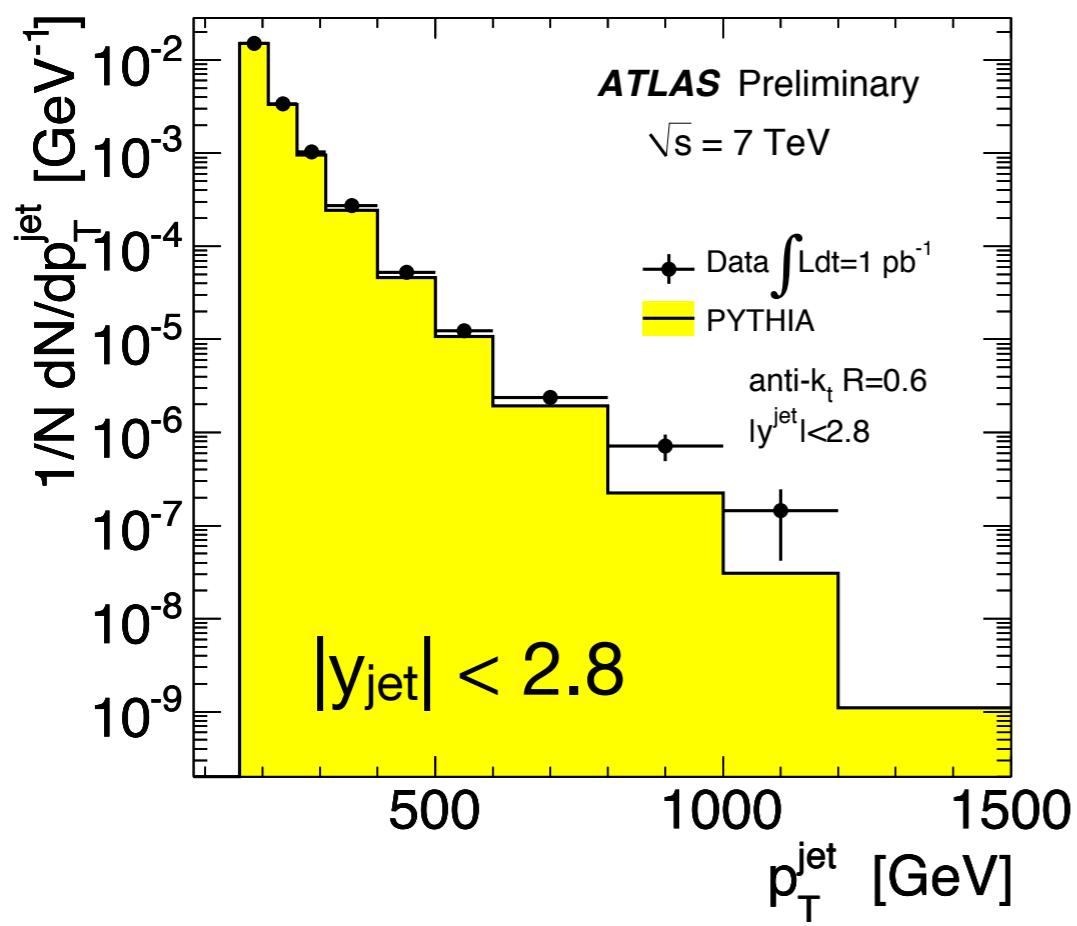
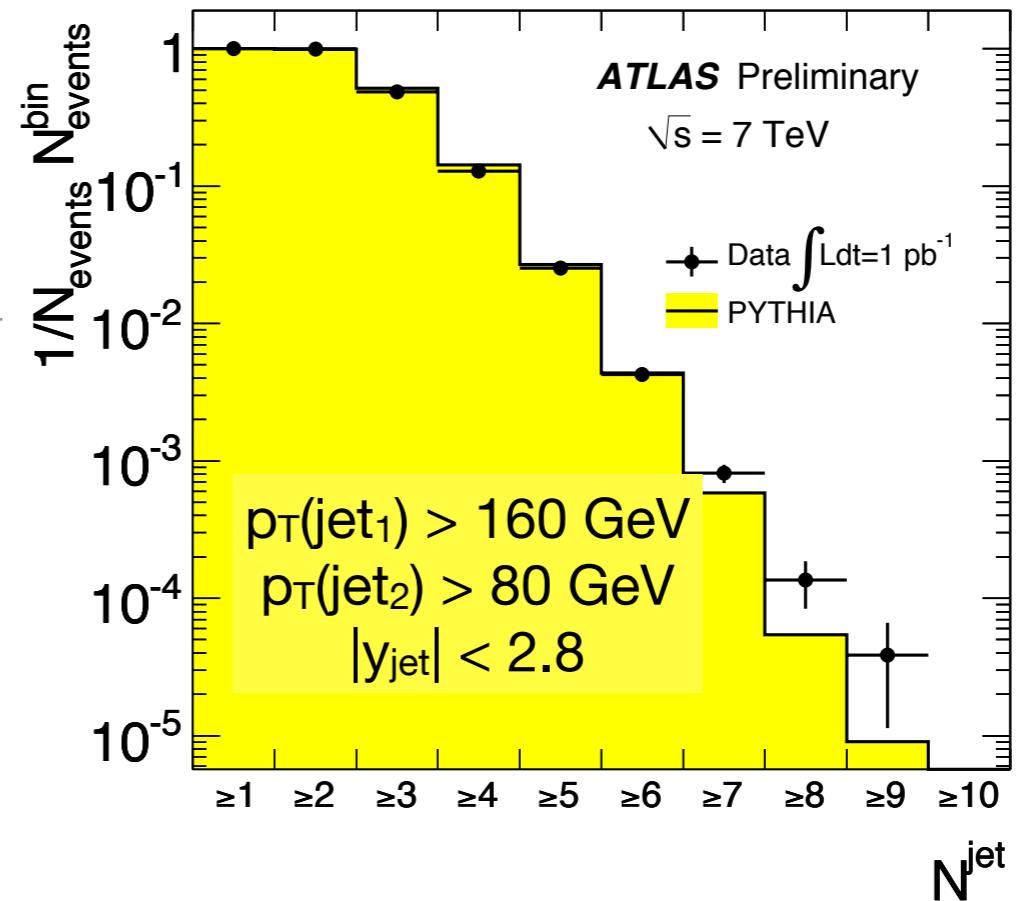
- Reaction plane can be reconstructed by a variety of subdetectors
 - Inner Detector (tracks > 1 GeV), FCAL, LAr
 - Elliptic flow calculated using
 - Event plane
 - 2 particle correlations
 - Lee-Yang Zeros method
- }
- Excellent agreement except at lower p_T

6 Jet Event



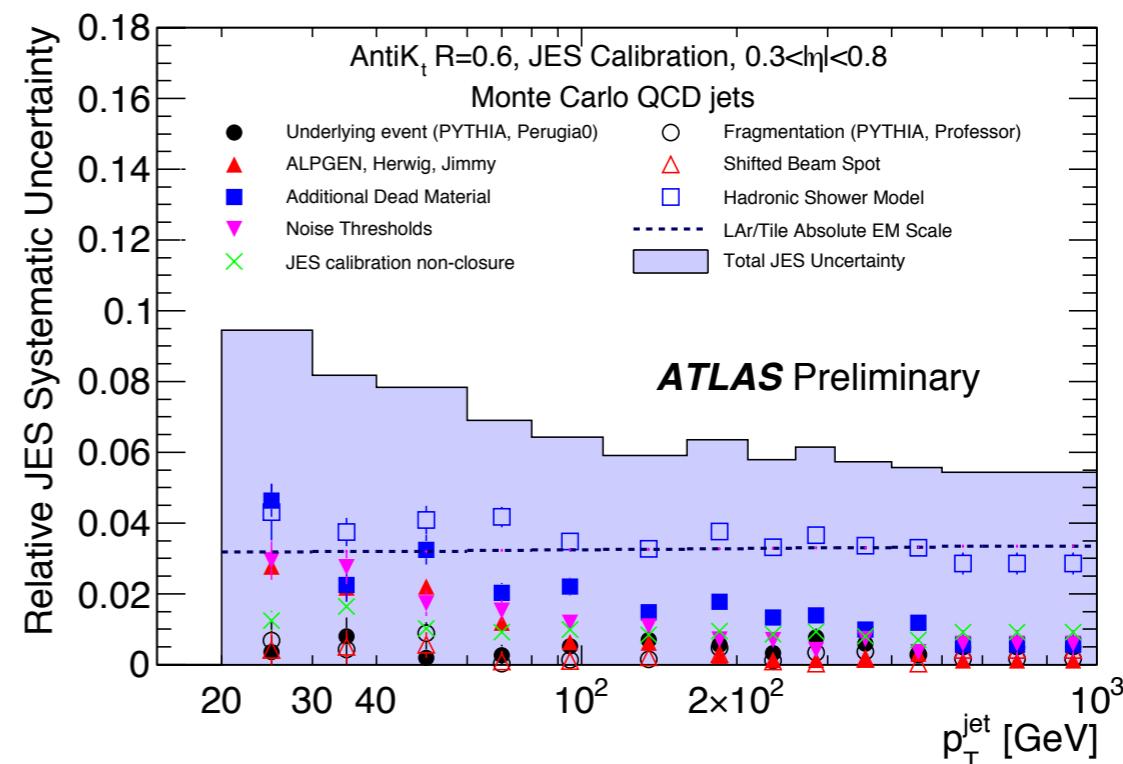
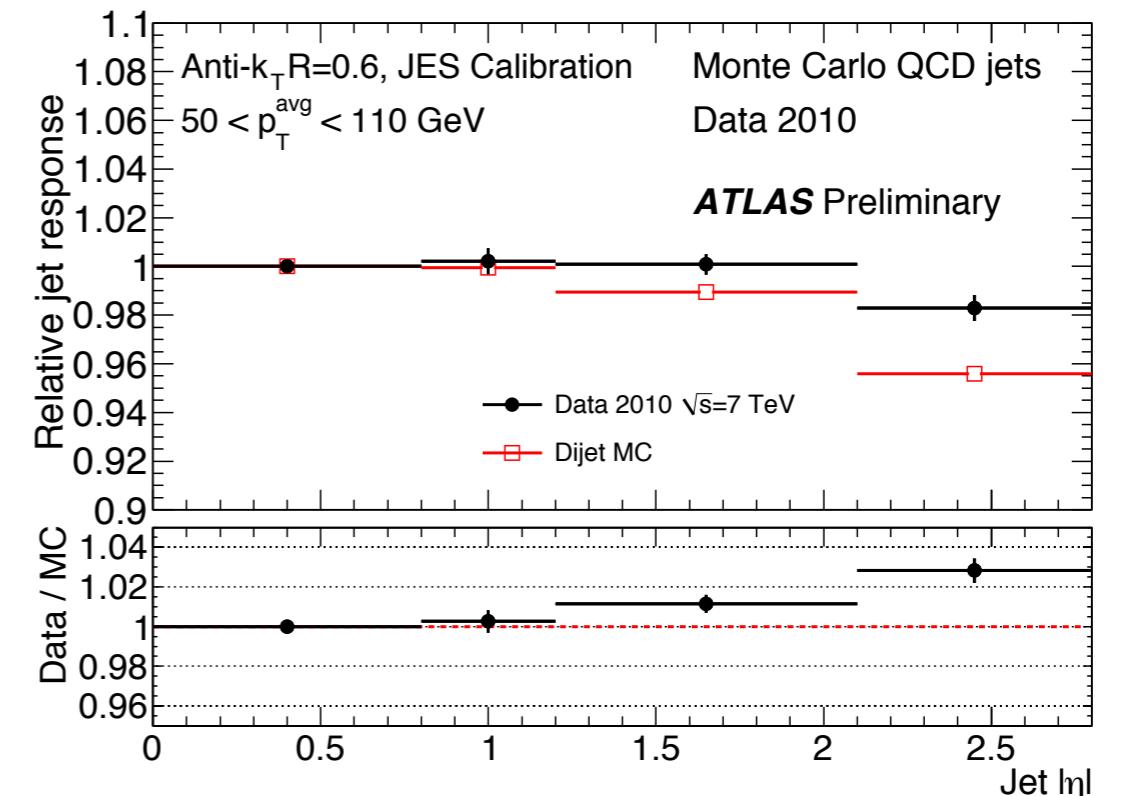
Jet Physics

Compare basic shapes
between data and simulation
Distributions normalised to
unity



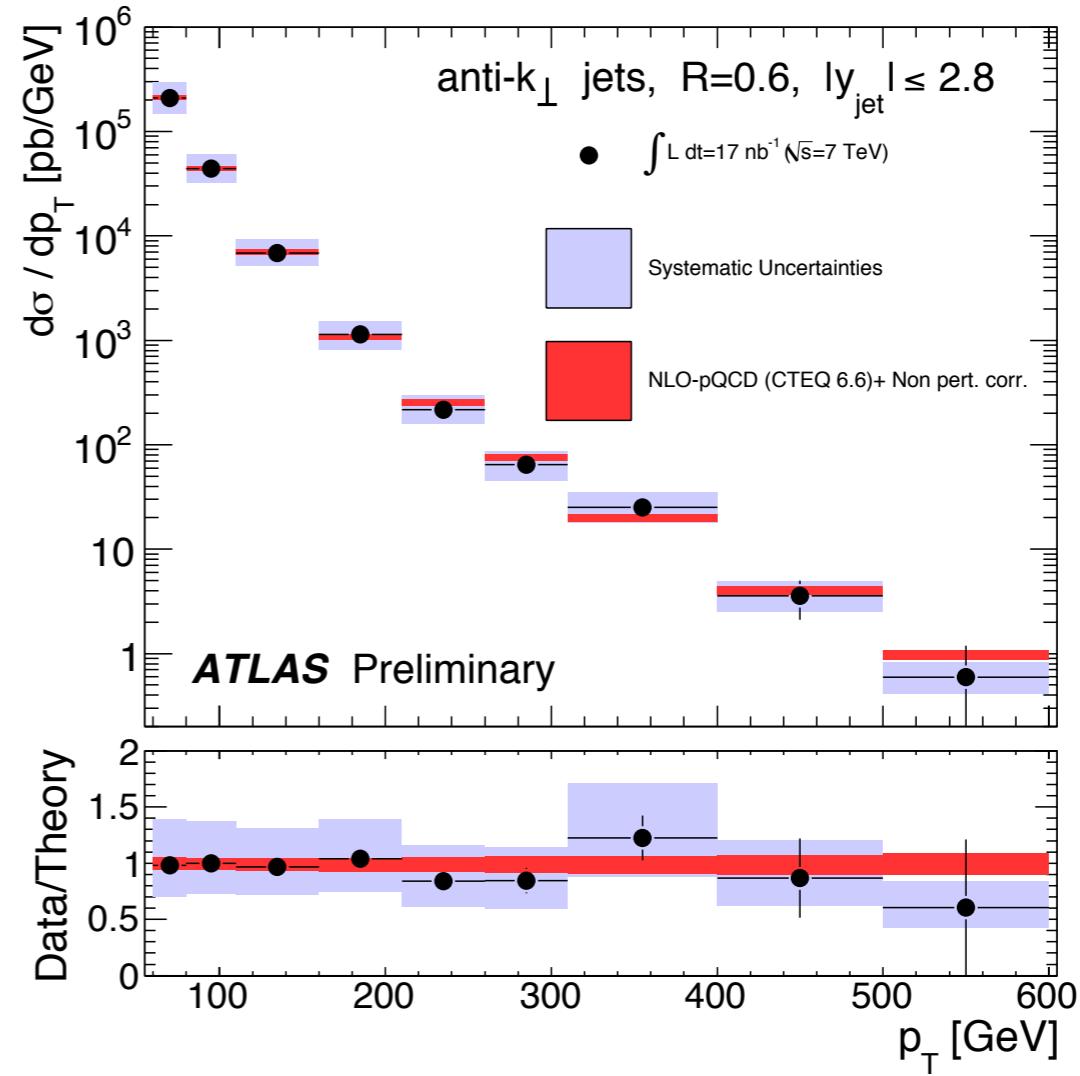
Jet Energy Scale Uncertainty

- Dominant uncertainty on jet cross-section measurements
- Jet momenta are corrected for effects including non-compensation in the calorimeter, material, etc. using η/p_T dependent MC correction factors
- Builds on detailed studies to understand data/MC agreement, used to determine systematic uncertainties
- The intercalibration of the forward and central regions has been checked using jet balance for $|\eta| < 2.8$
- Today JES is known to 7%: ultimate goal is 1%



Inclusive Jet Cross-section

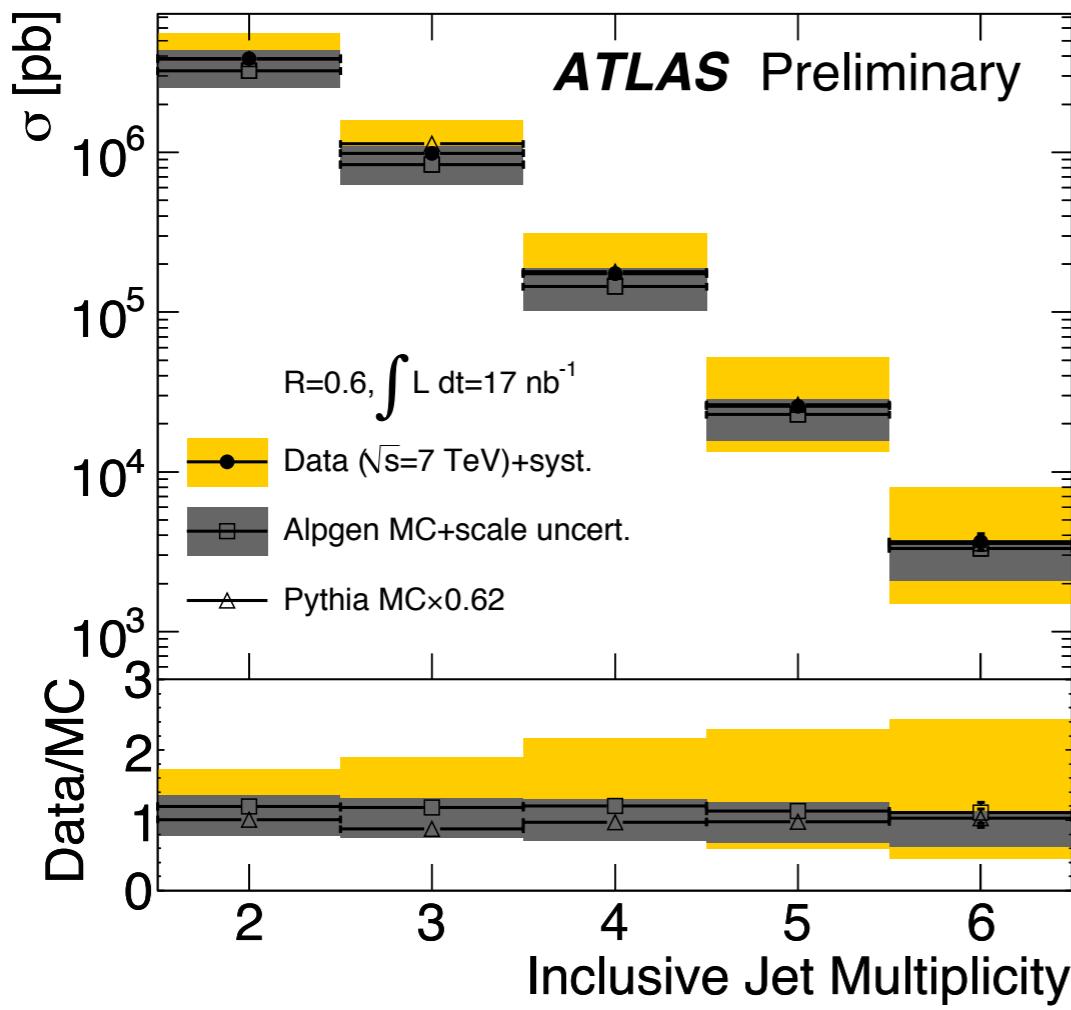
- Measured jets have been corrected to the particle-level using parton-shower MC
- Results are compared to NLO QCD predictions after applying corrections for hadronisation and underlying event
- Theoretical uncertainty is ~20%: variations of PDFs, α_s , renormalisation & factorisation scales
- Experimental uncertainty is ~30-40%: dominated by the jet energy scale (7%), luminosity uncertainty (11%) not shown



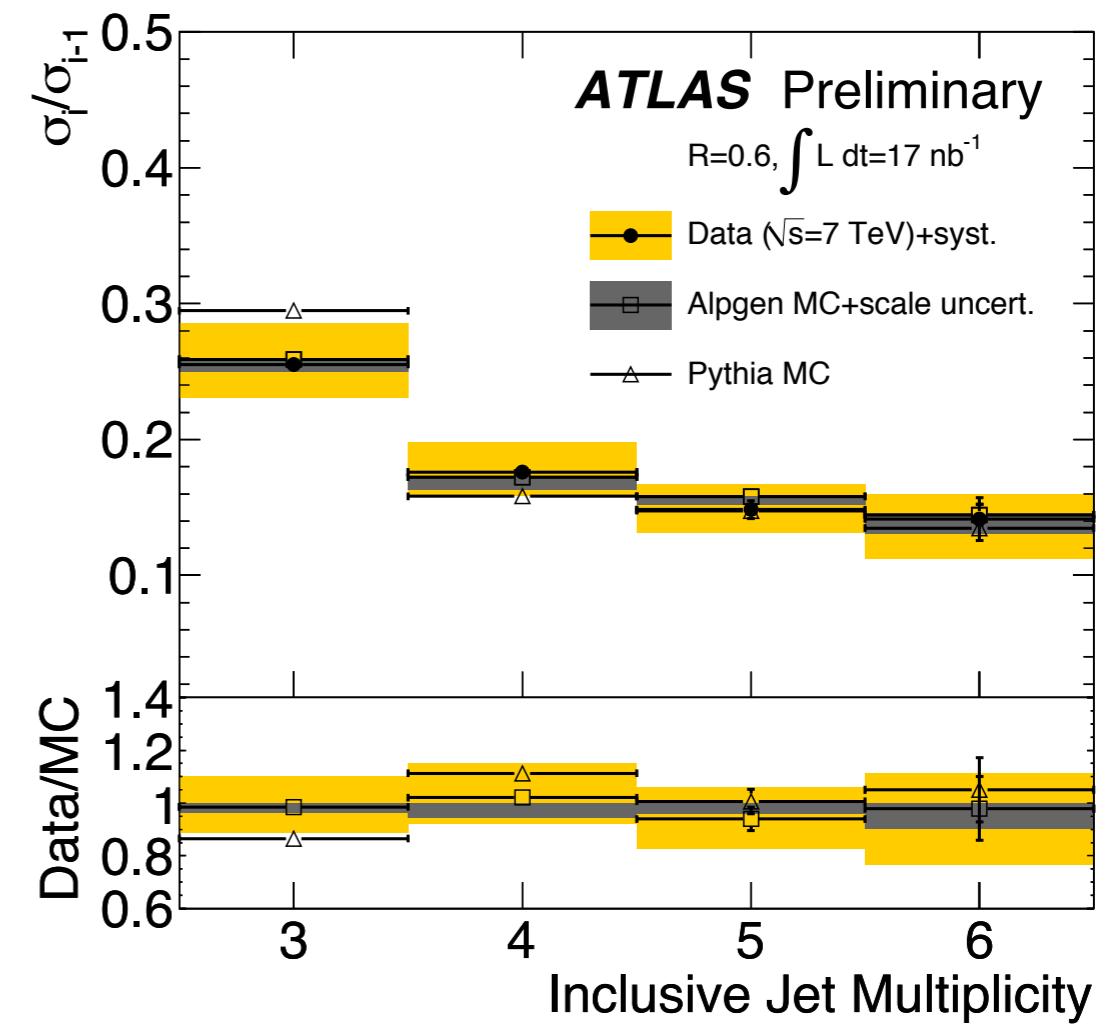
Good agreement between data/MC over 5 orders of magnitude

Multijet Cross-section

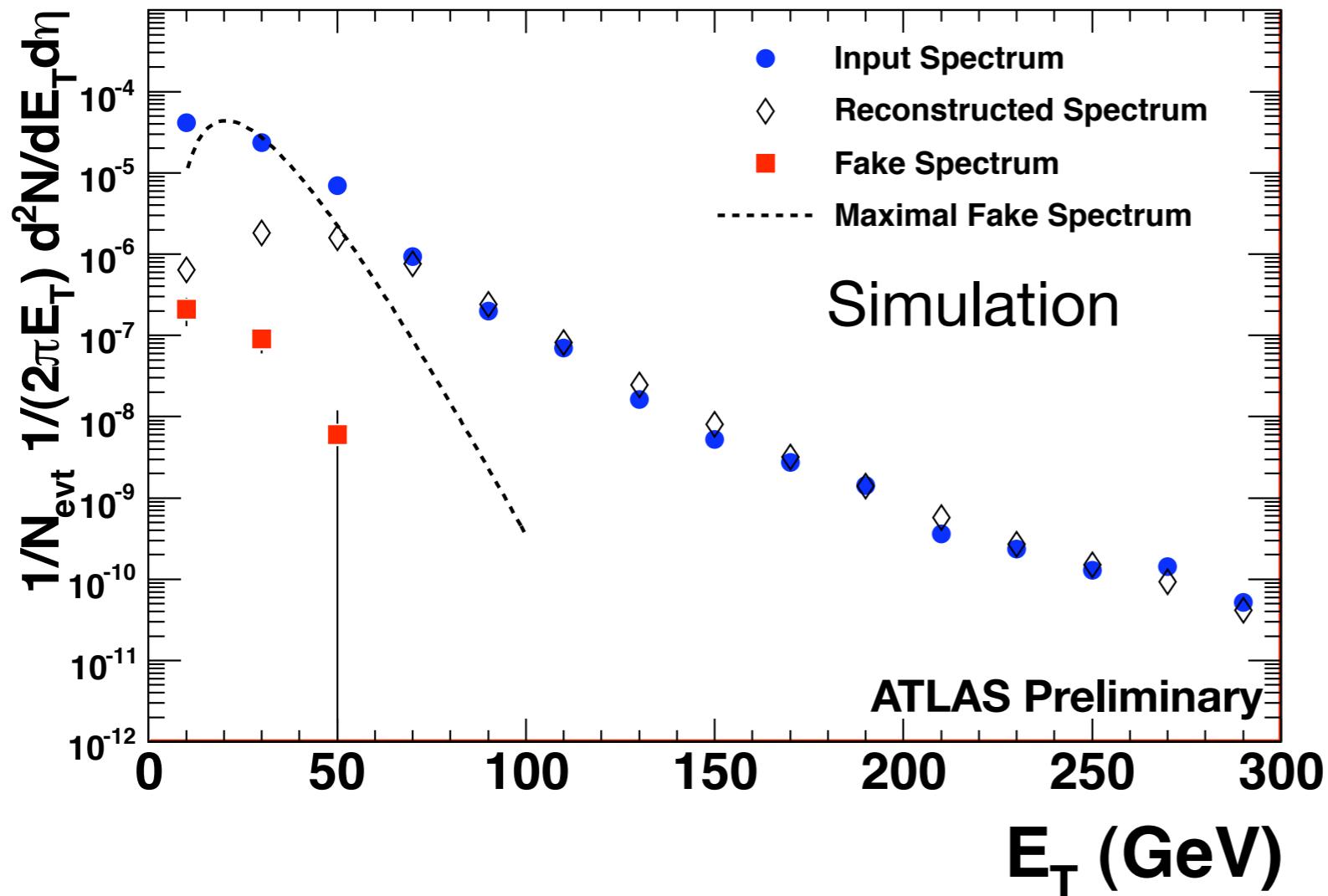
- Higher order processes have been studied directly
- $p_T(\text{jet}_1) > 60 \text{ GeV}$, $p_T(\text{jet}_{N>1}) > 30 \text{ GeV}$, $|y_{\text{jet}}| < 2.8$



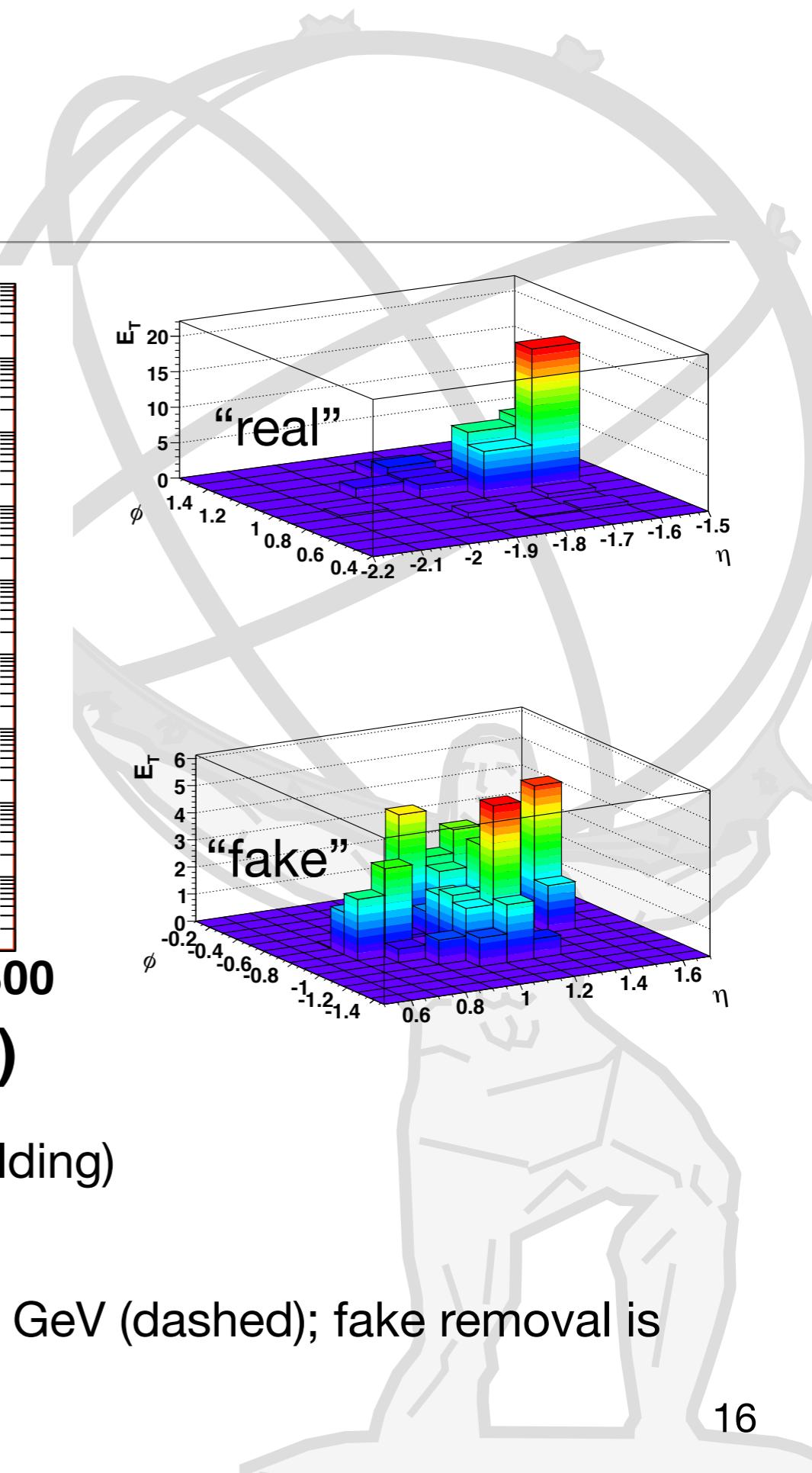
- Also measured as a function of $p_T(\text{jet})$ and $\sum p_T(\text{jet})$
- Alpgen provides a good description of the data



Jet Reconstruction in PbPb

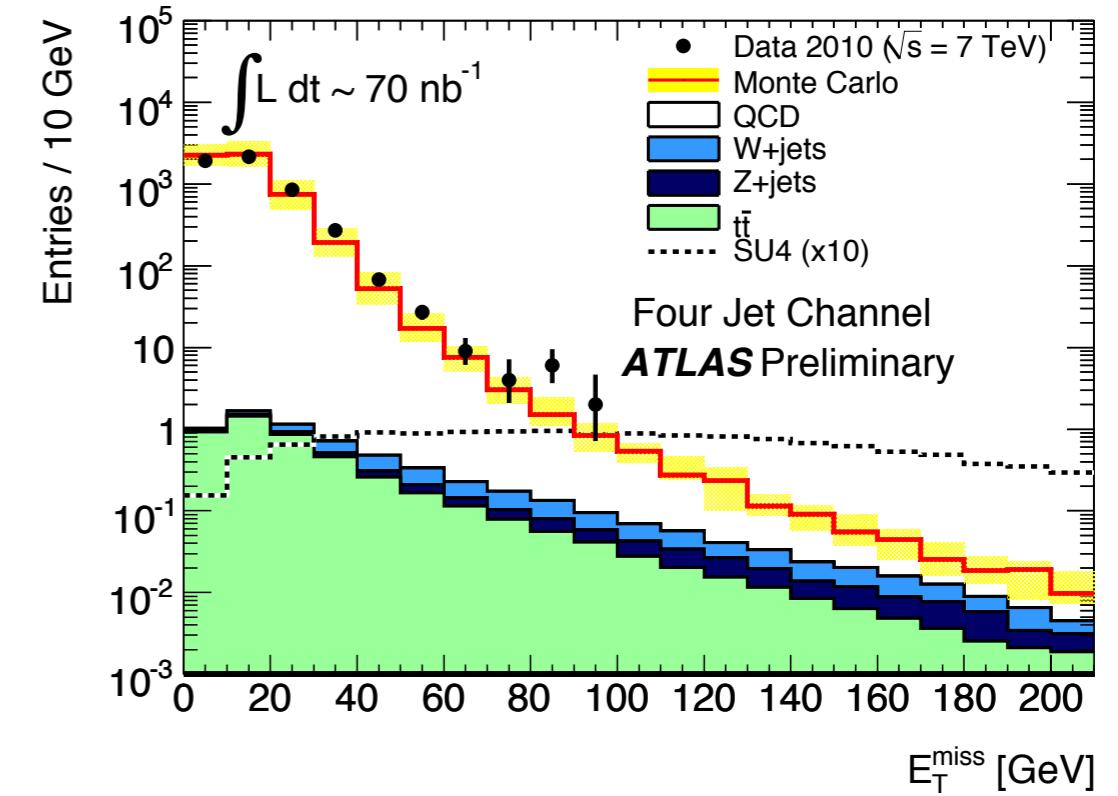
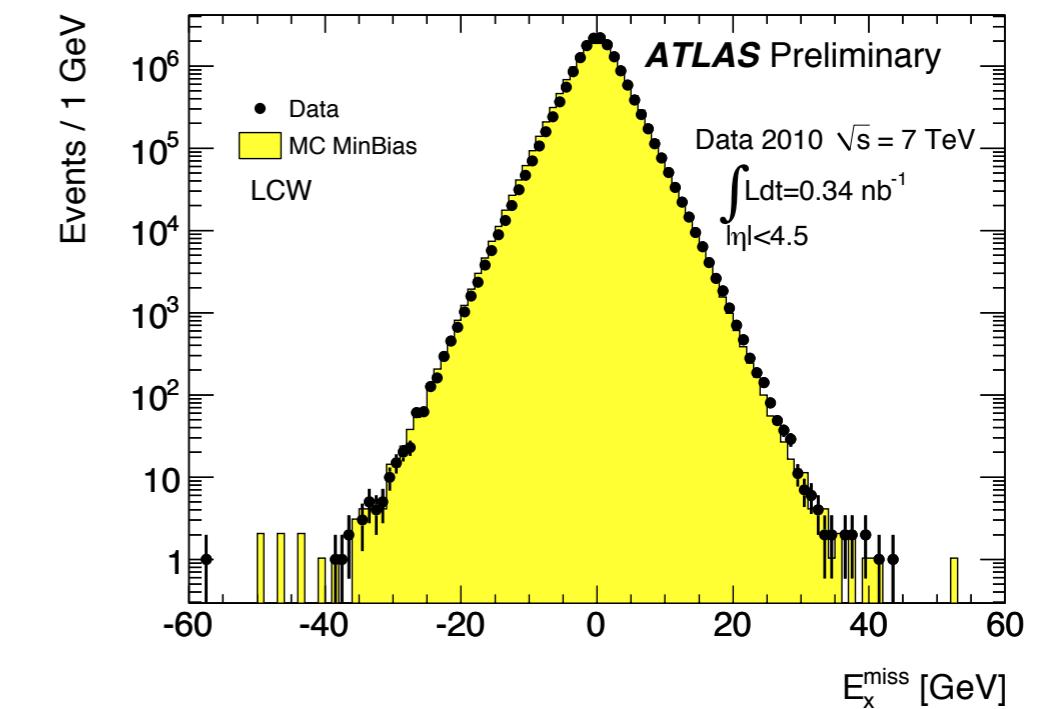
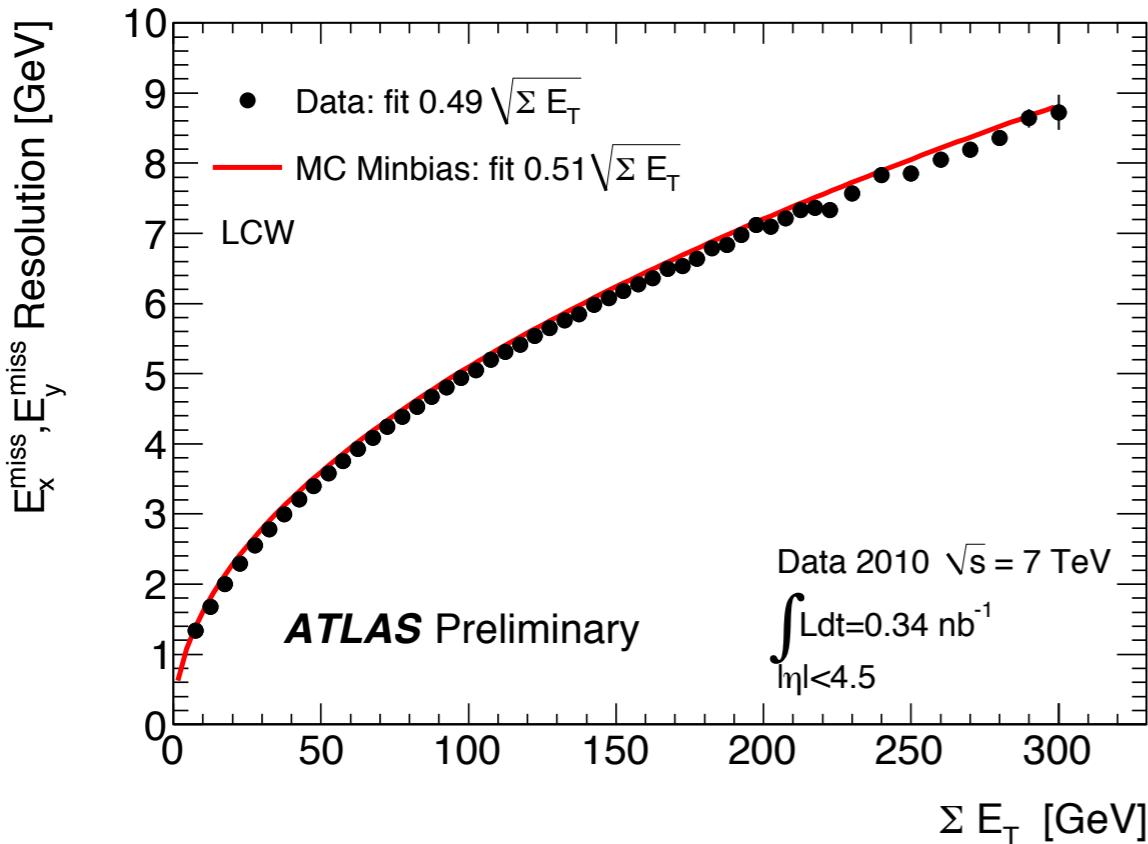


- Reconstruction of jet energy spectrum (before unfolding)
- Low efficiency for $E_T < 80$ GeV
- Fake jets (in HIJING) are significant until $E_T \approx 80-100$ GeV (dashed); fake removal is efficient (cf. red squares)



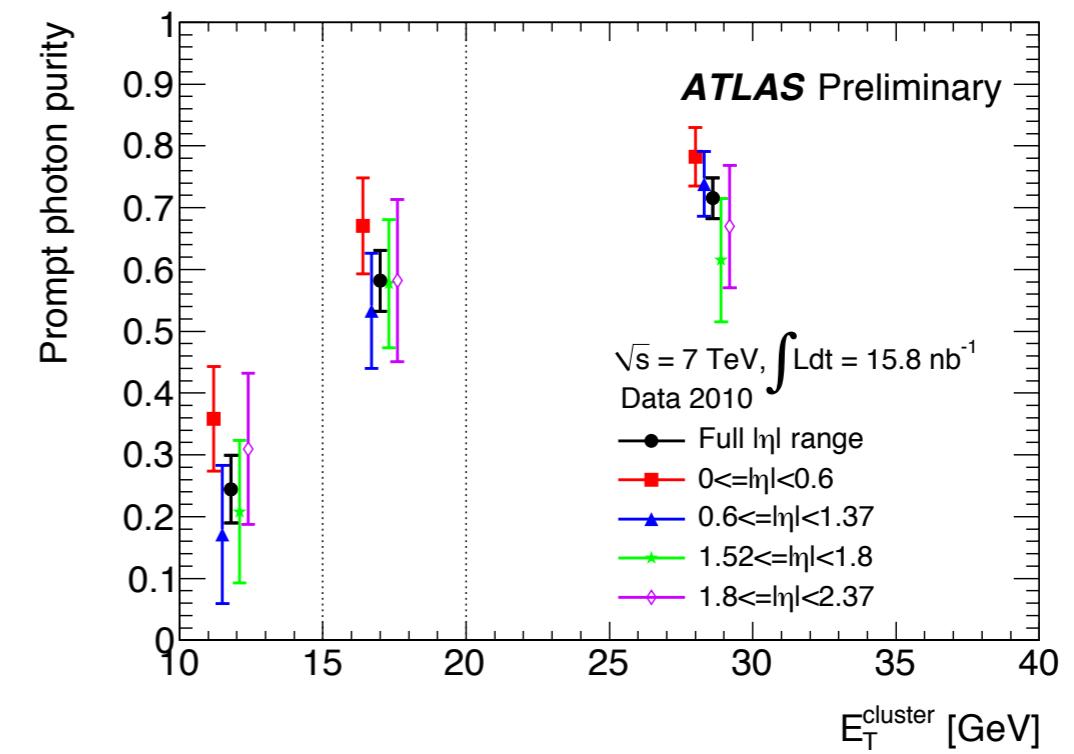
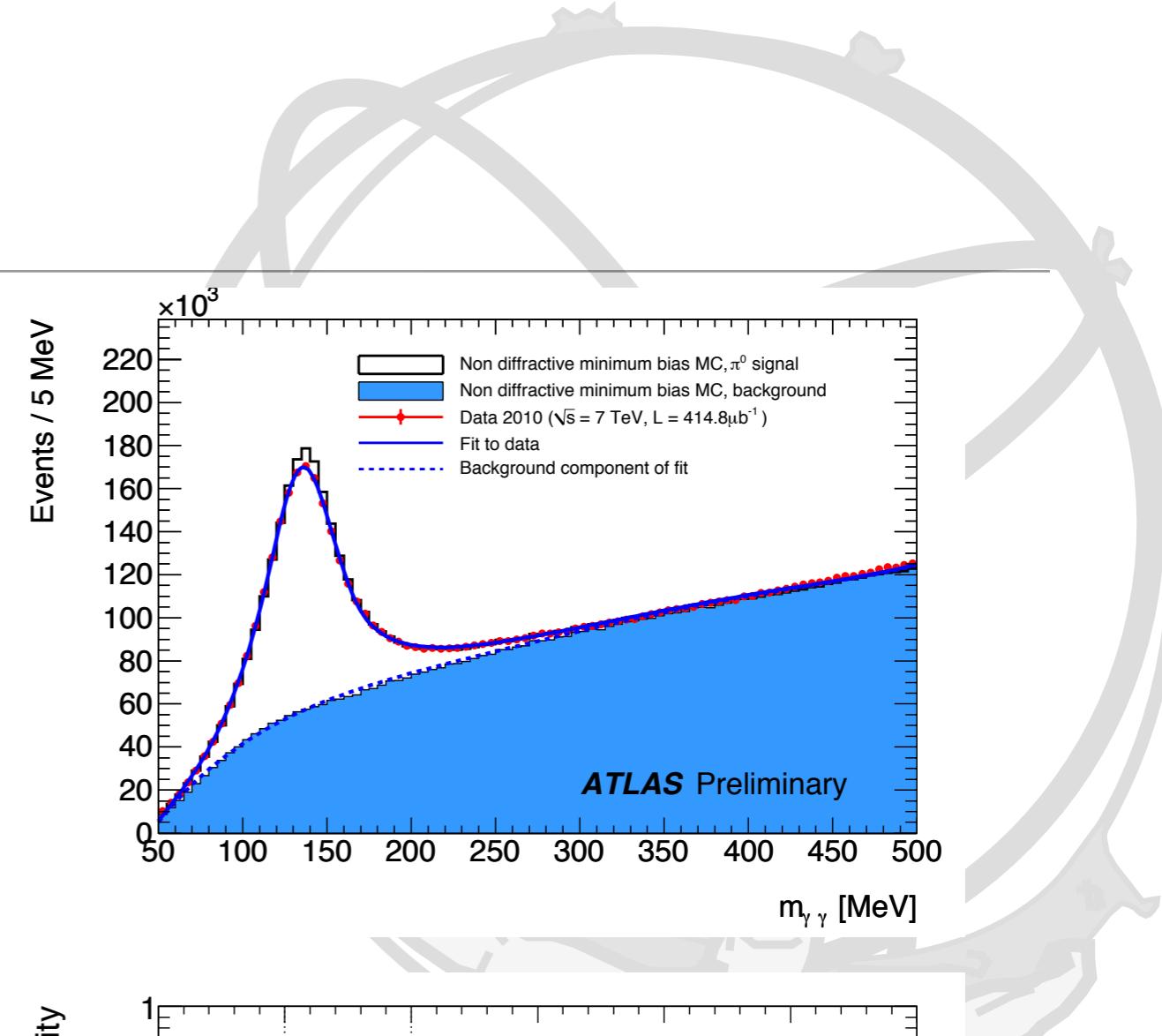
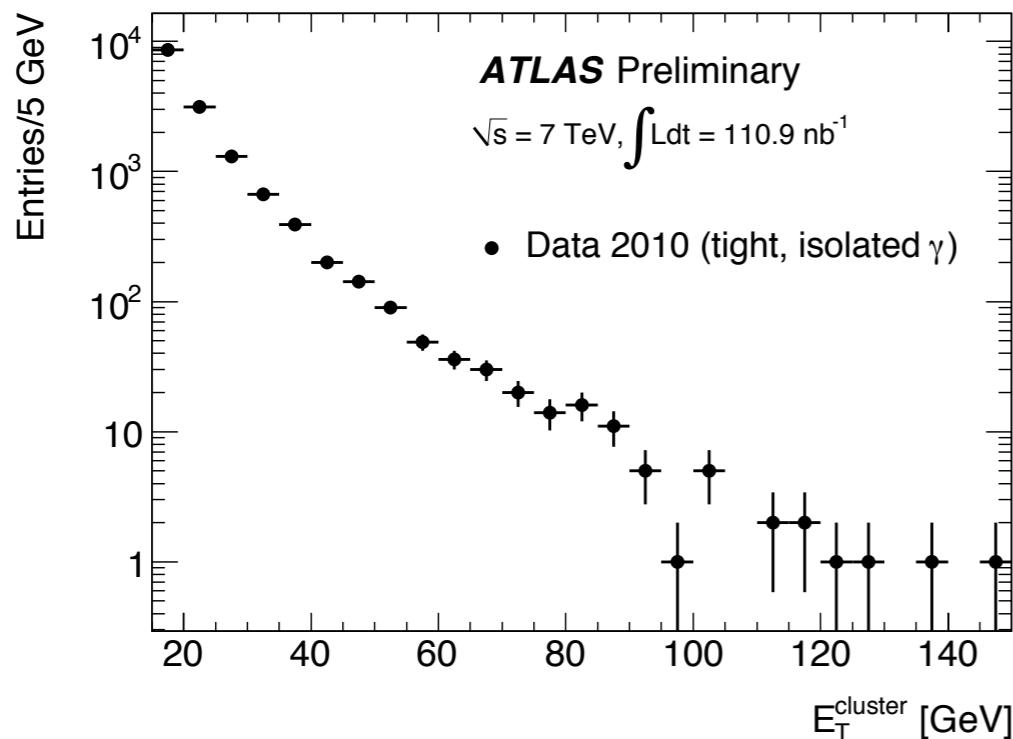
Missing Transverse Energy

- Sensitive measure of calorimeter performance
 - noise, dead cells, cracks, mis-calibration
 - cosmic and beam background
- E_T^{miss} calibrated using min bias events
- Example SUSY search (4 jets $p_T(j_1) > 70 \text{ GeV}$, $p_T(j_{>1}) > 30 \text{ GeV}$)

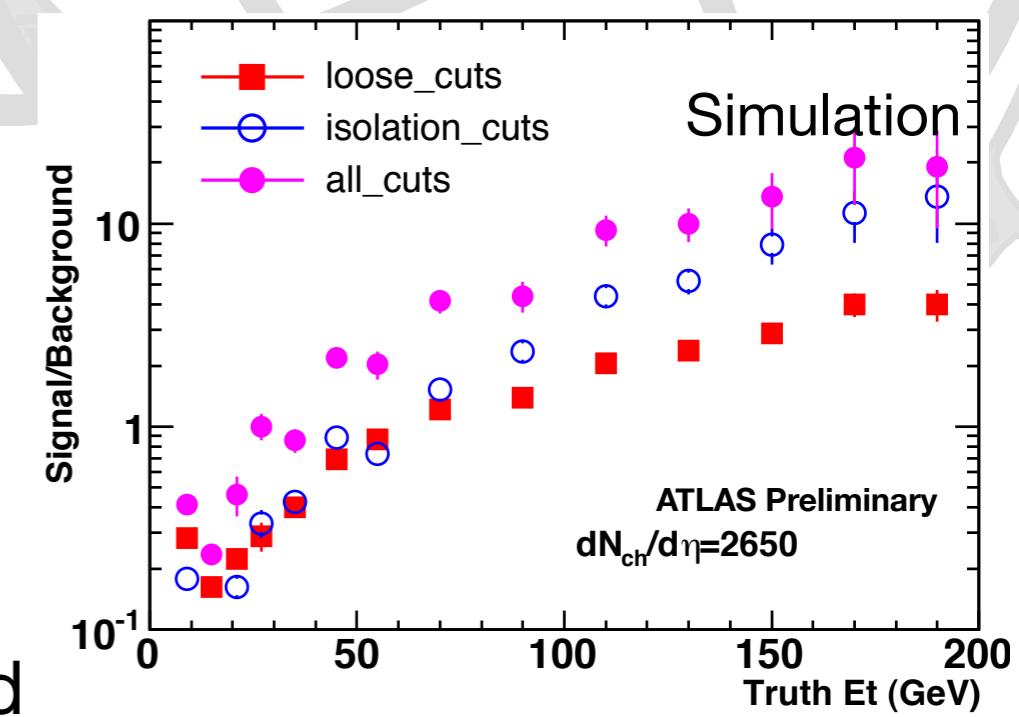
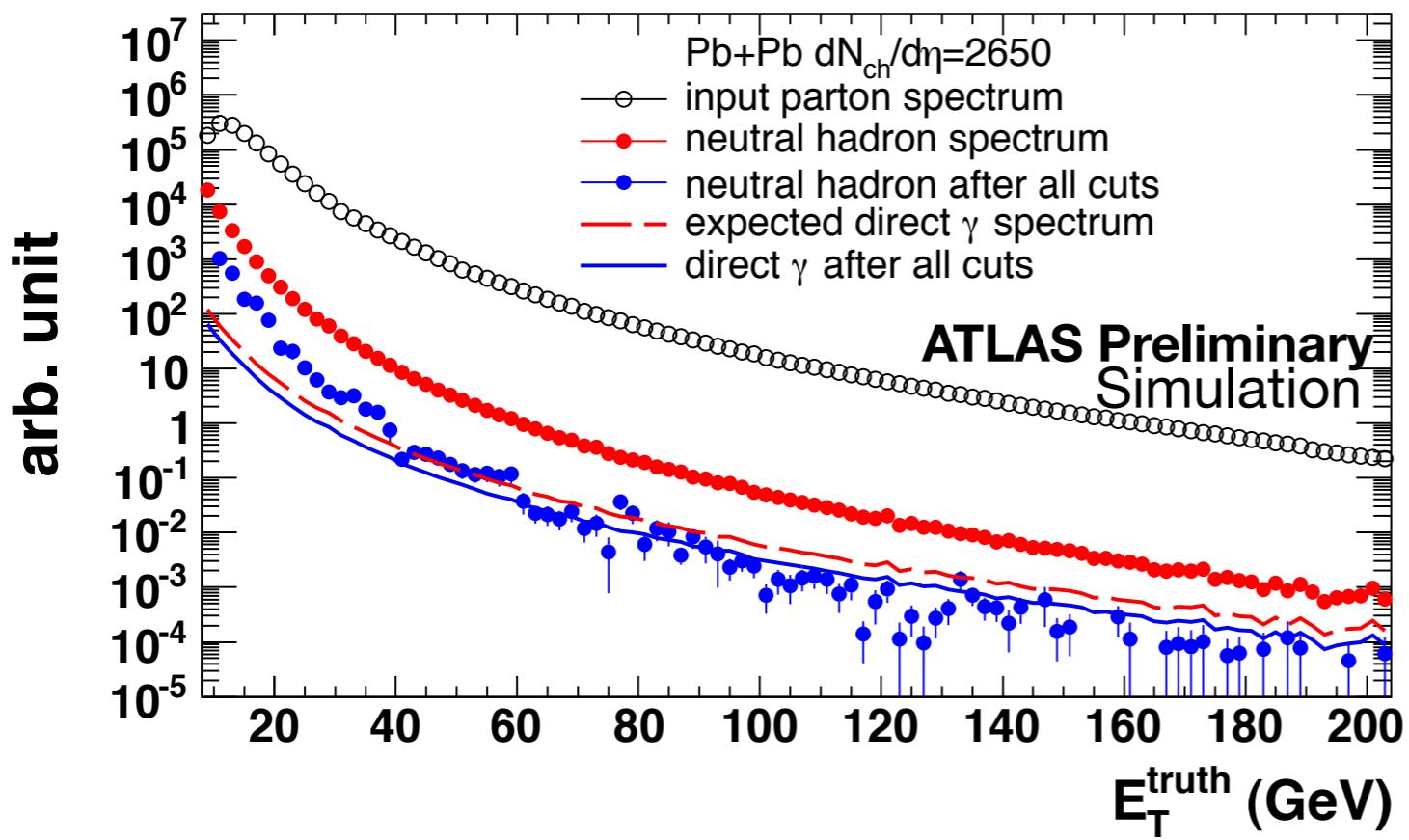


Photon Identification

- In pp collisions, use photons to test pQCD, pdfs, prepare for $H \rightarrow \gamma\gamma$
- Use fine calorimeter granularity to provide γ/π^0 discrimination
- Evidence for prompt isolated photons
 - Data-driven fake rate estimate
 - 40 prompt γ/nb ; ~70% purity



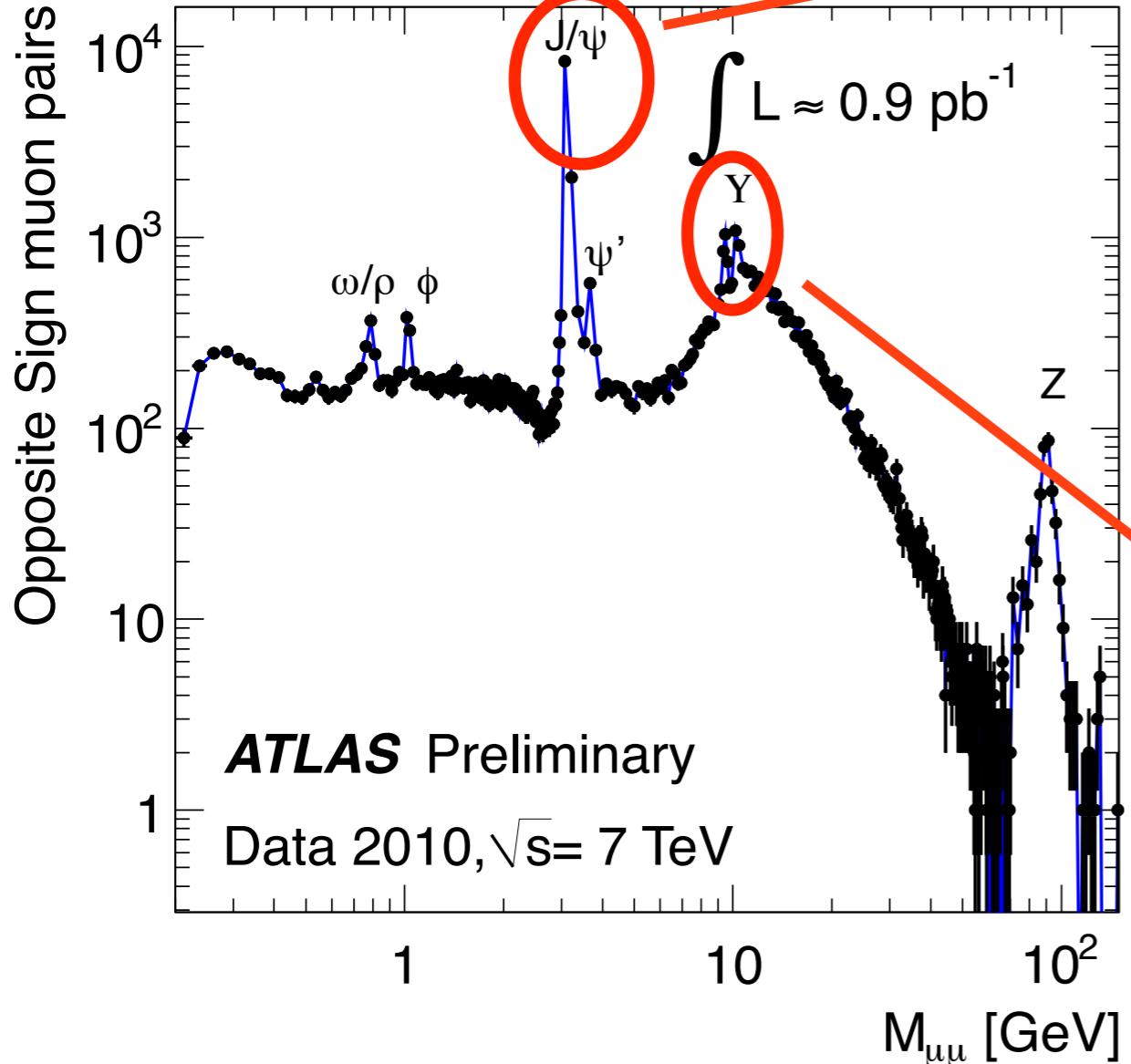
Direct Photon Spectrum in PbPb



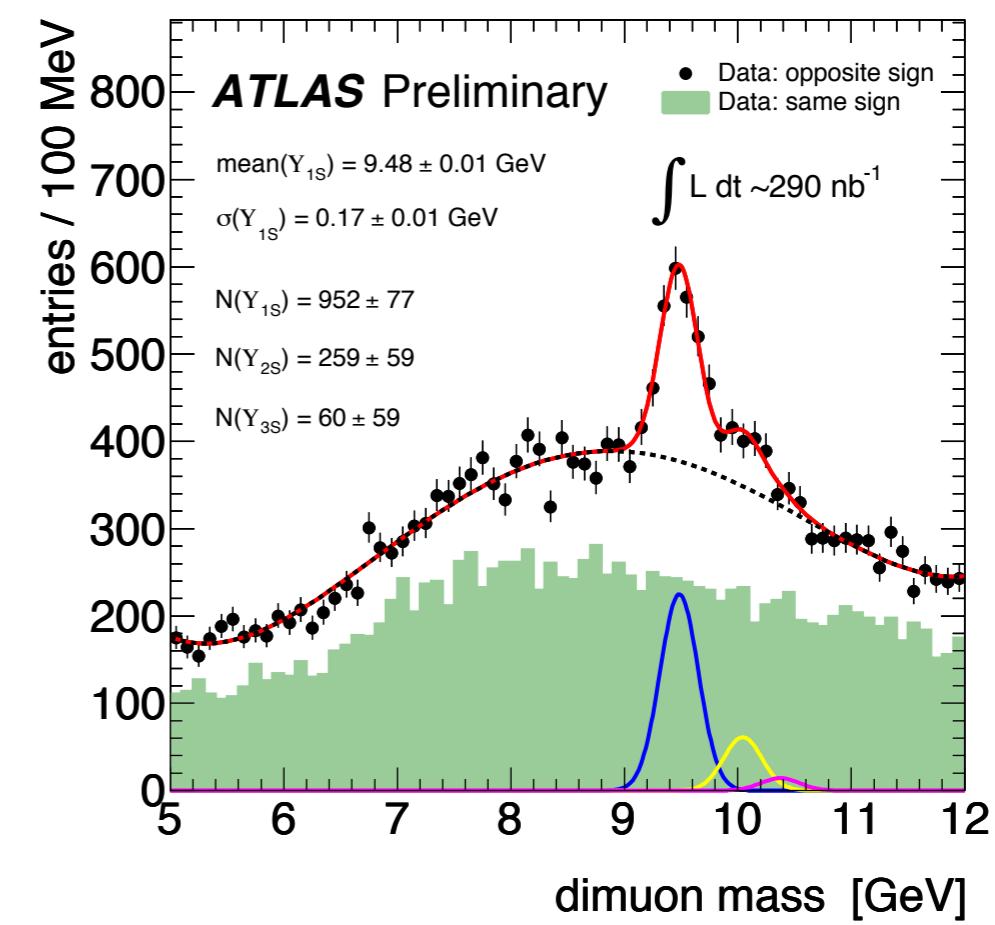
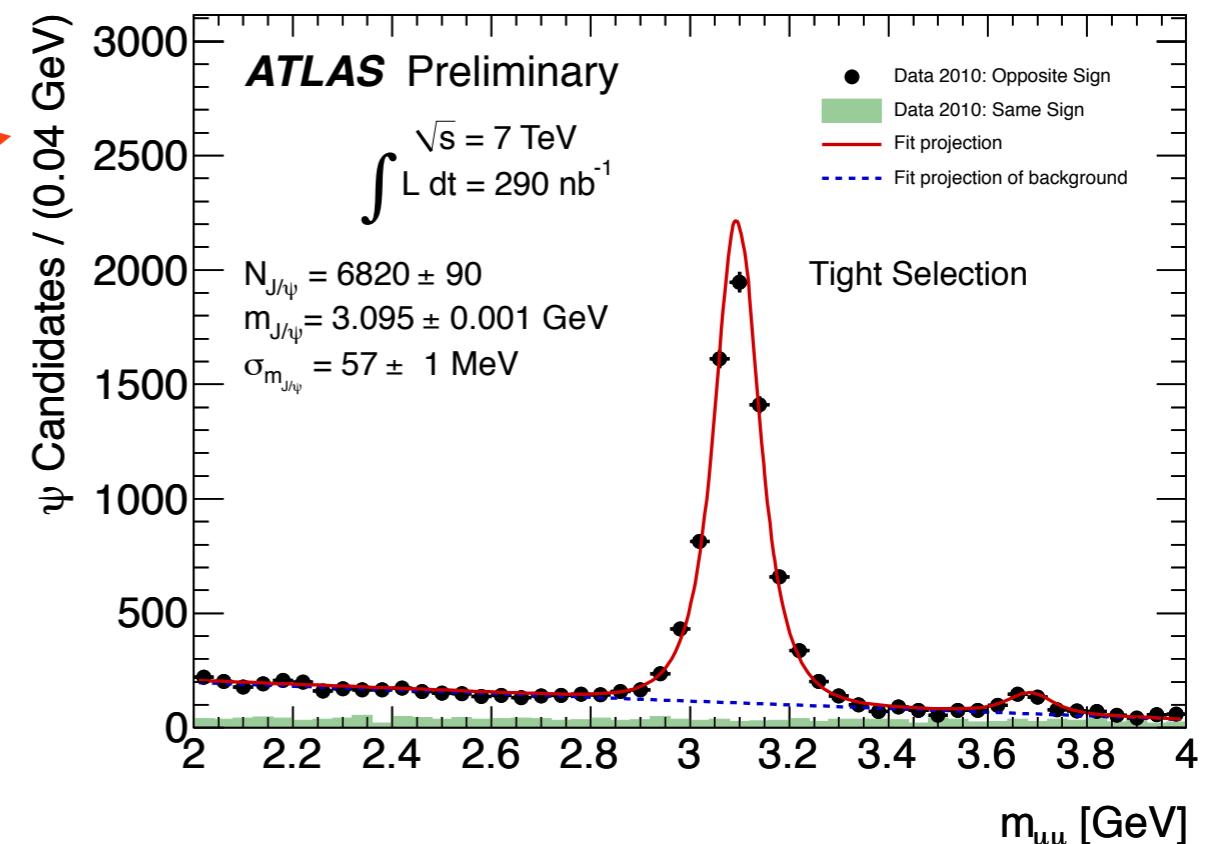
Detailed study performed on shower shape and isolation cuts to optimize ϵ & purity

With $R_{AA}=1/5$ (i.e. RHIC value), expect S/B~1 around 30 GeV

Low mass dimuon resonances

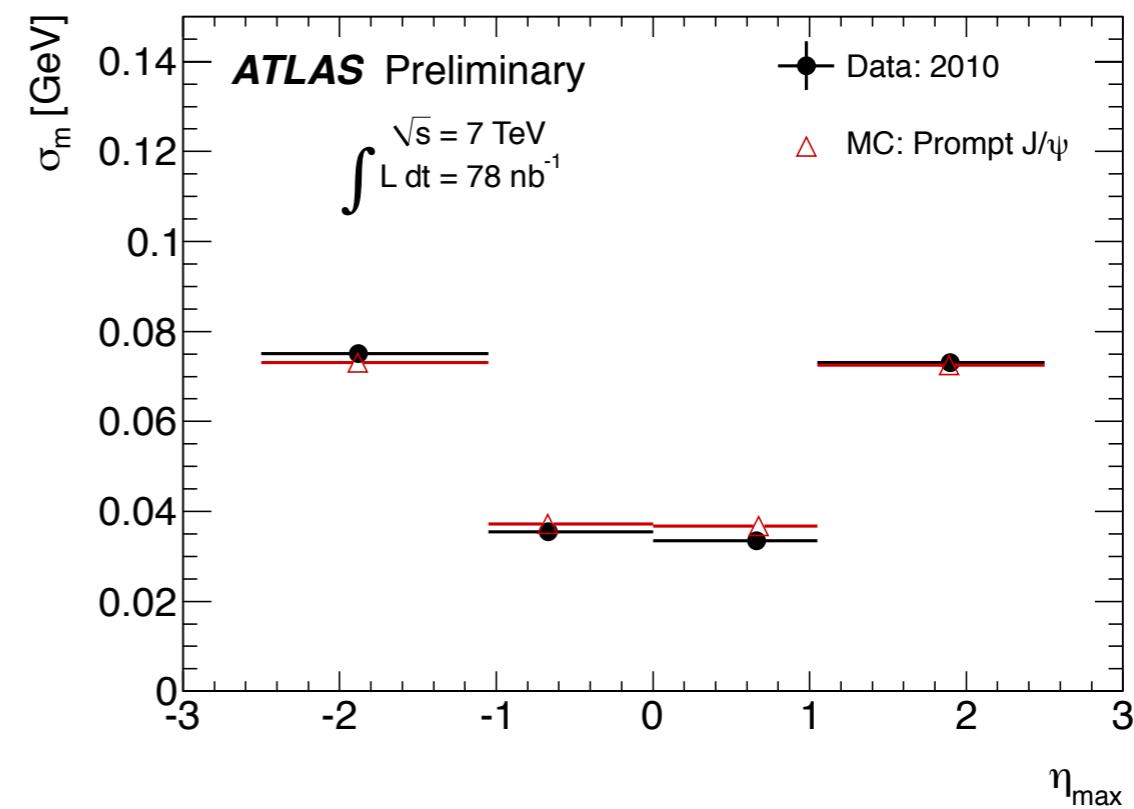
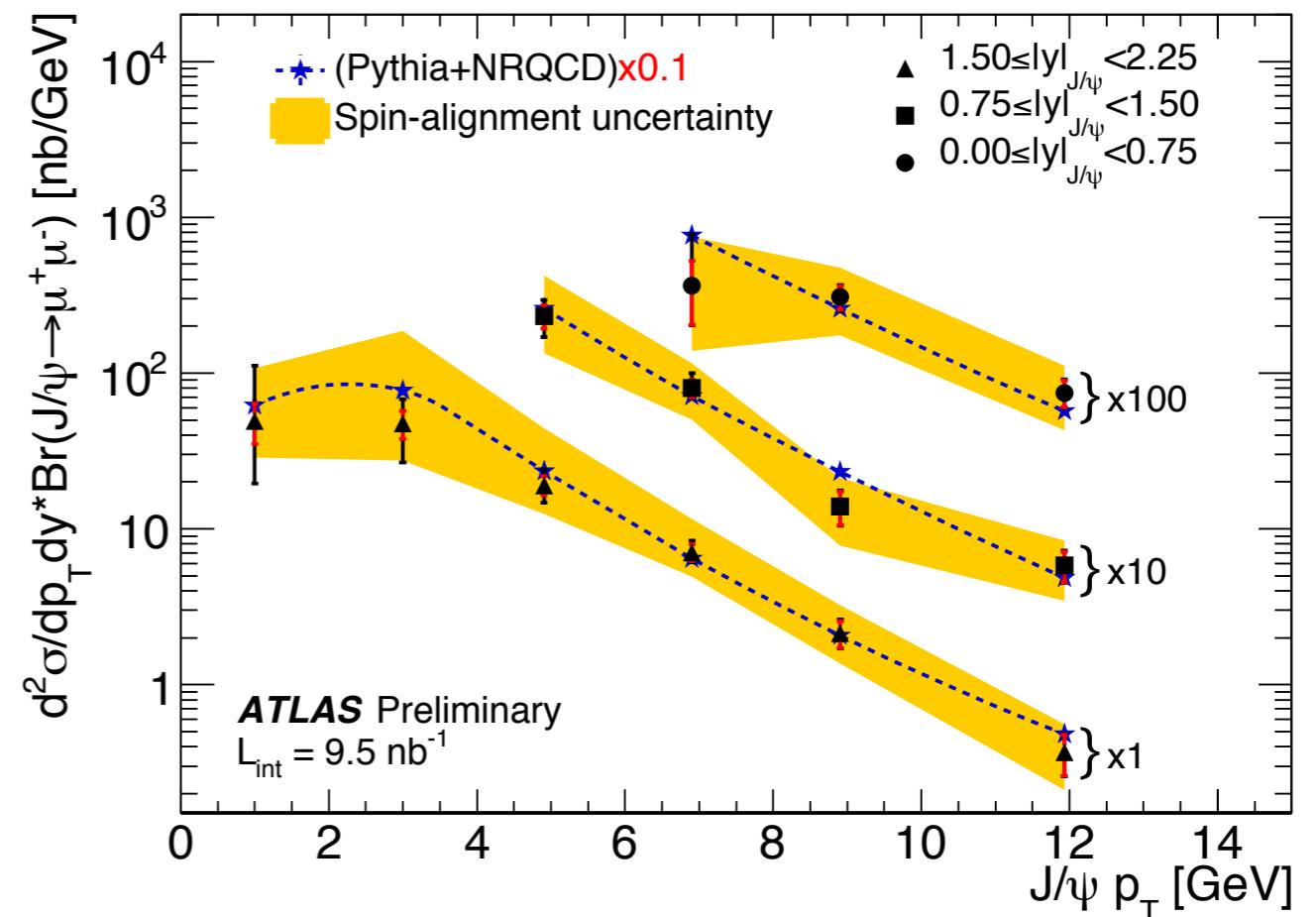
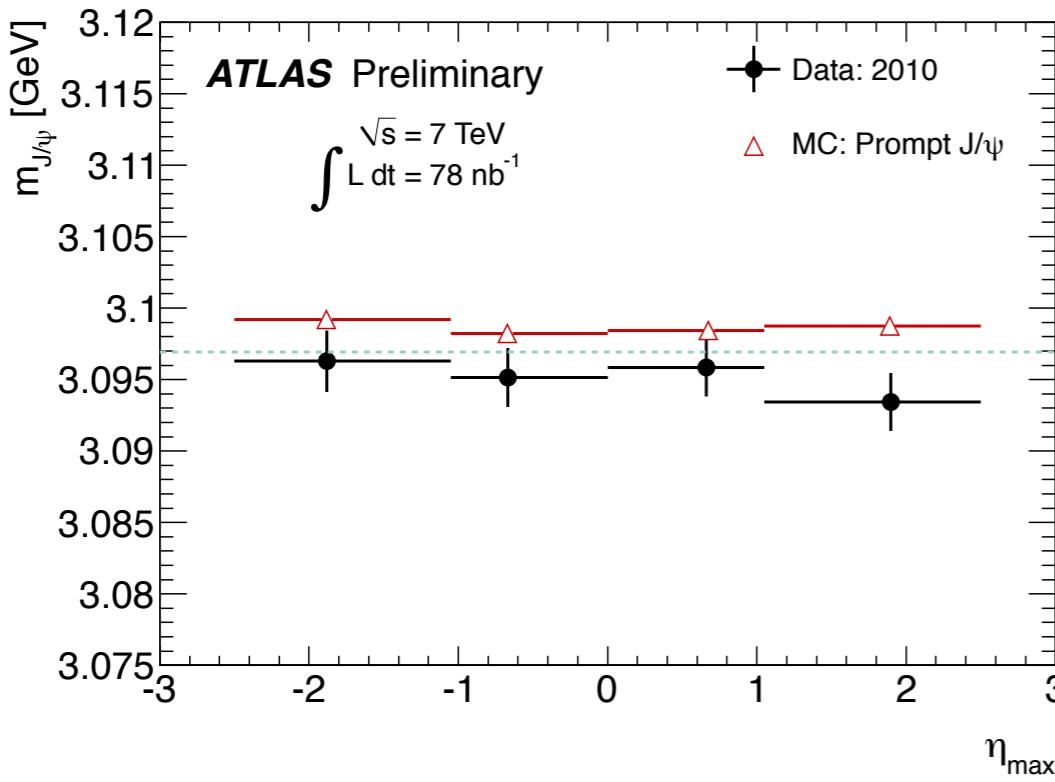


LV1 Muon trigger with $p_T > 6 \text{ GeV}$
 2 opposite signed muons reconstructed
 by combining ID and MS
 $p_T(\mu_1) > 4 \text{ GeV}; p_T(\mu_2) > 2.5 \text{ GeV}$

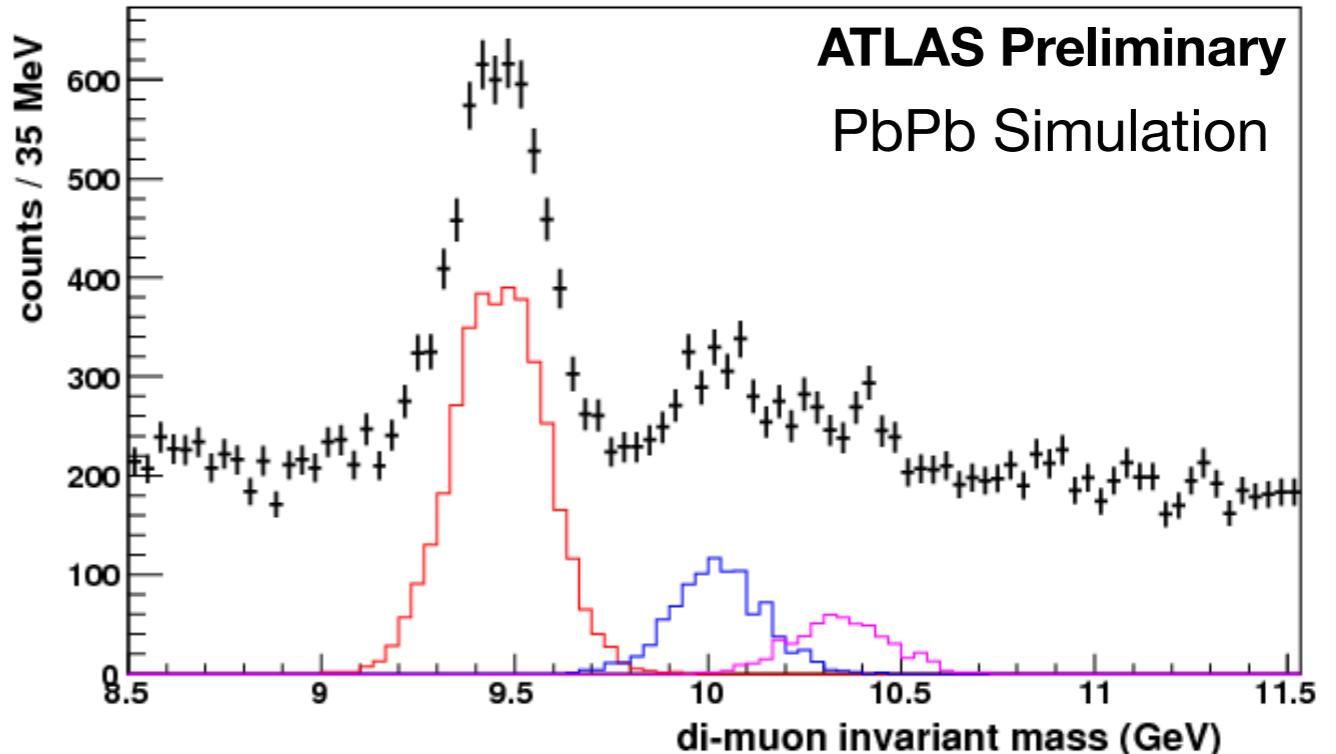
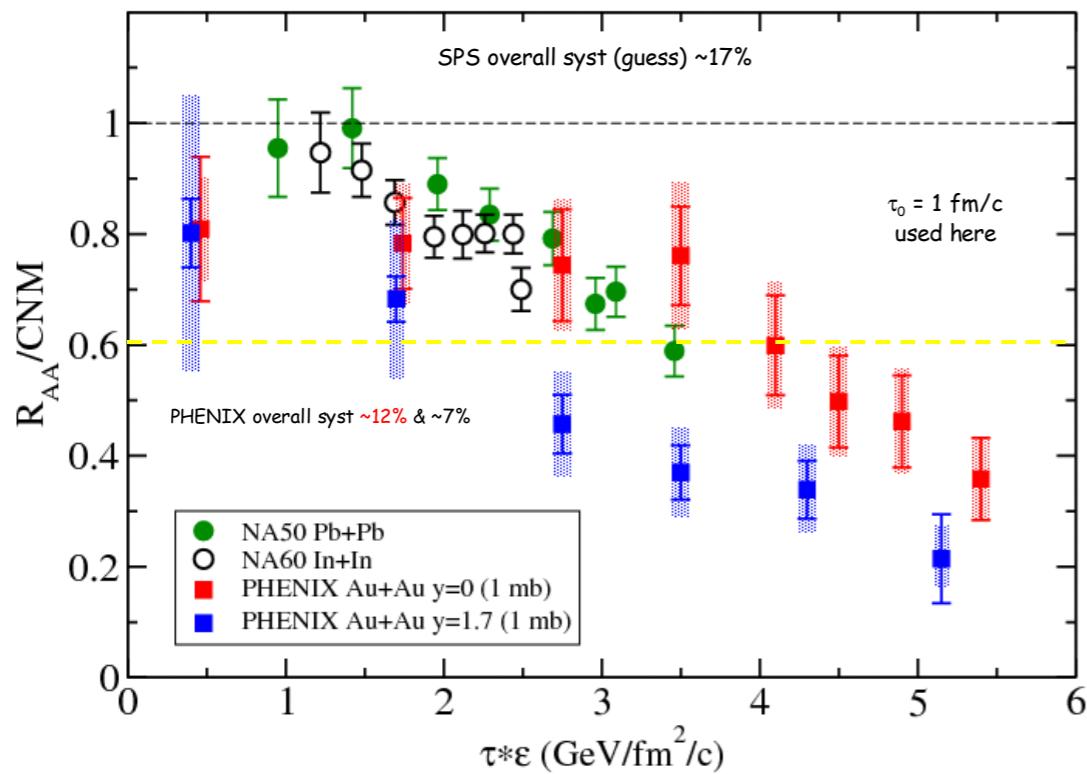


$J/\Psi \rightarrow \mu\mu$

- Cross-section significantly overestimated by Pythia; shape well-described
- One of the first standard candles for detector performance and commissioning
- Use J/Ψ mass and width to determine p_T resolution of the ID to 0.2% in few GeV range



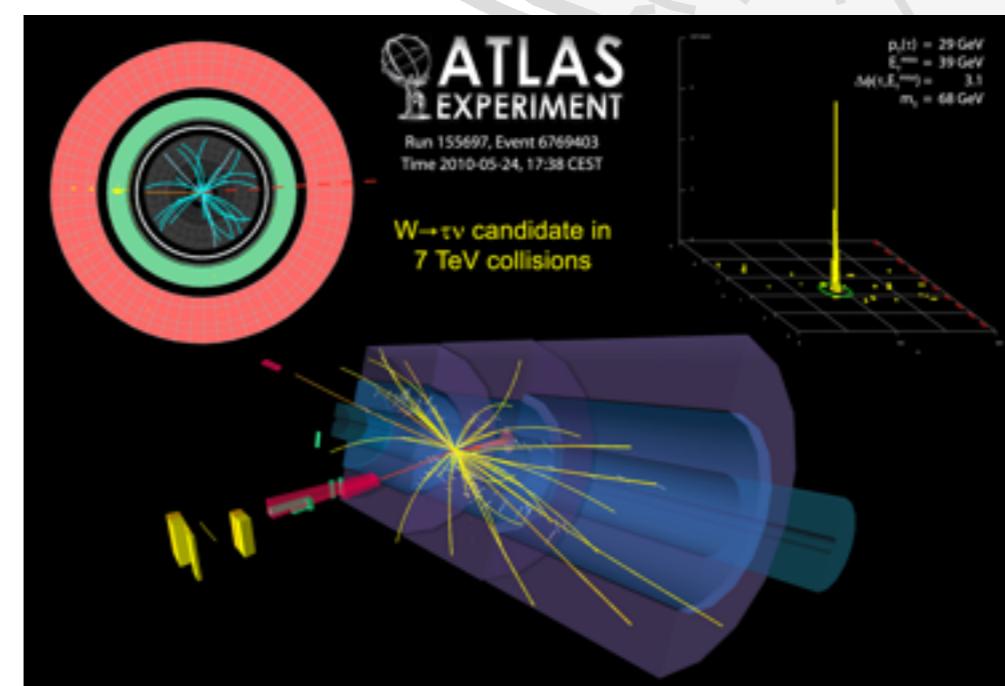
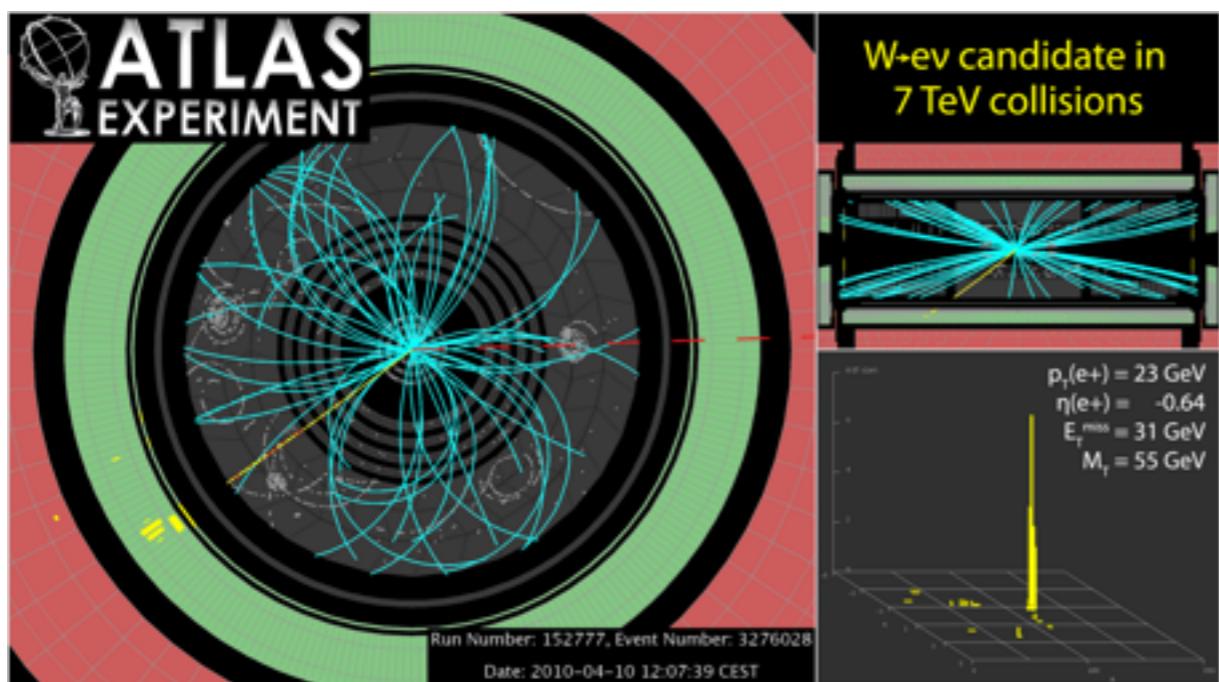
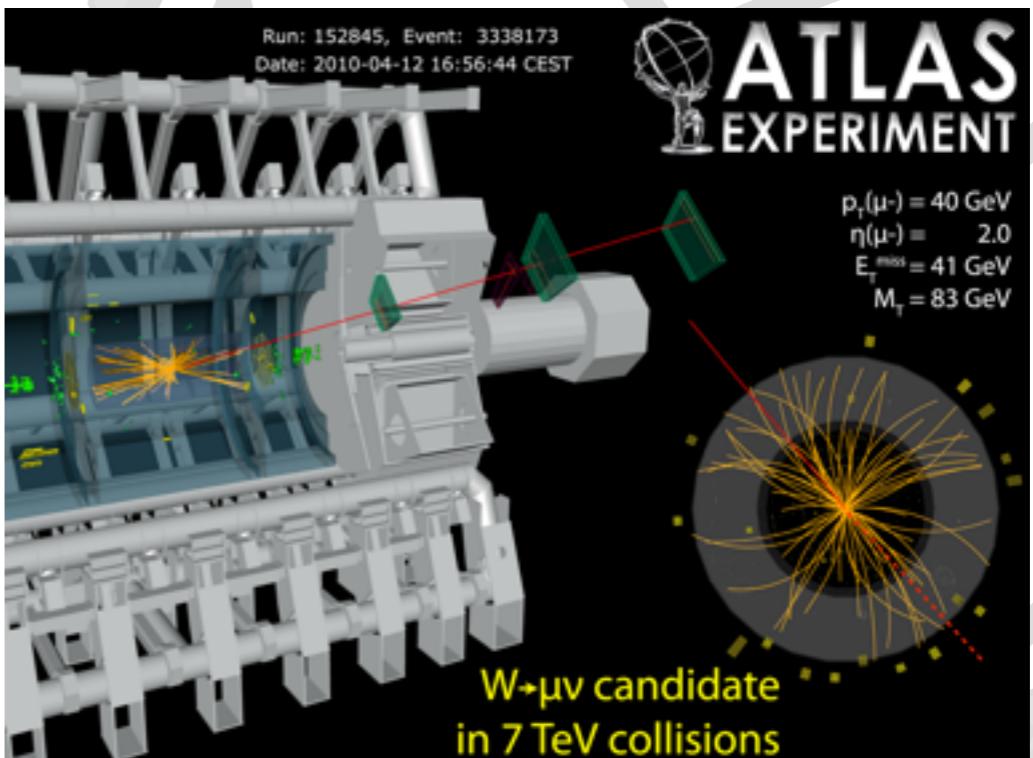
Quarkonia Production in PbPb



- Major outstanding mystery of RHIC is the similar suppression pattern of J/ψ at RHIC and SPS
 - Can be studied at the LHC using Υ
- In one month at nominal luminosity & energy, expect to measure all three Υ states
 - resolving $\Upsilon(1S)$ from $\Upsilon(2S/3S)$ with $\sigma \sim 120$ MeV

W and Z Physics

- Important milestones in the rediscovery of the Standard Model
 - W's provide powerful constraints on PDF
 - W/Z+jets are dominant background for top and many BSM signatures
- Excellent source of pure, high- p_T leptons
 - Essential component in detector calibration to obtain ultimate performance



W and Z Selection

Electron Selection

$E_T > 20 \text{ GeV}$, $|\eta| < 2.47$
tight (W)/medium (Z) ID
criteria

W Selection

$E_T^{\text{miss}} > 25 \text{ GeV}$
 $M_T > 40 \text{ GeV}$
 $S/B \sim 20$

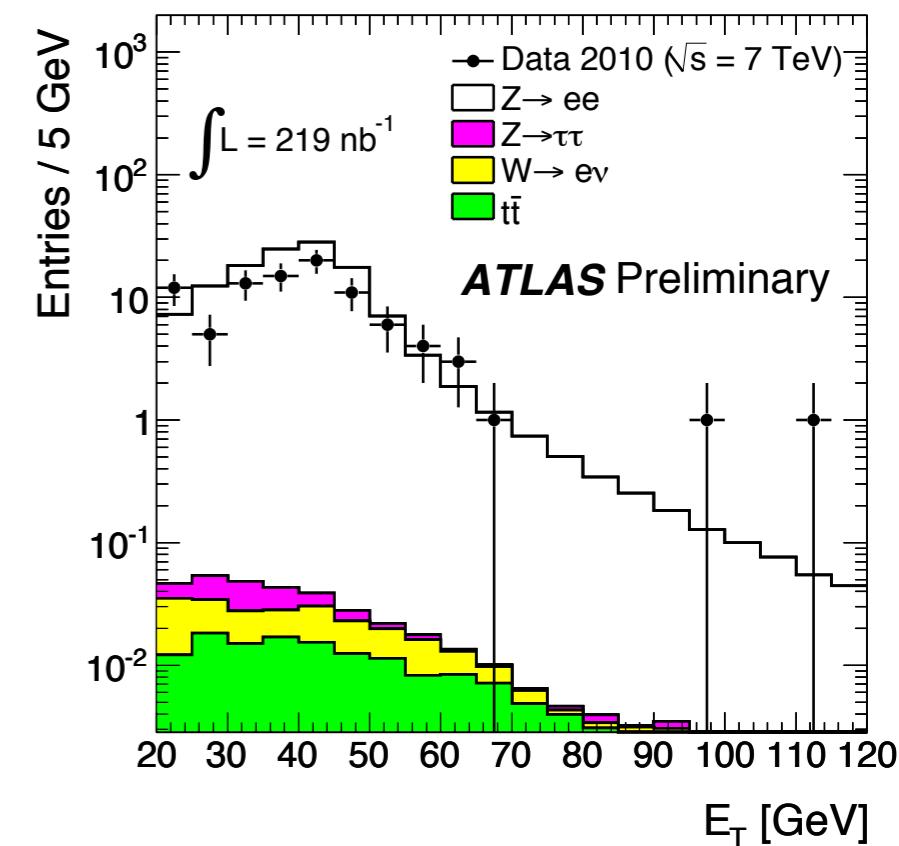
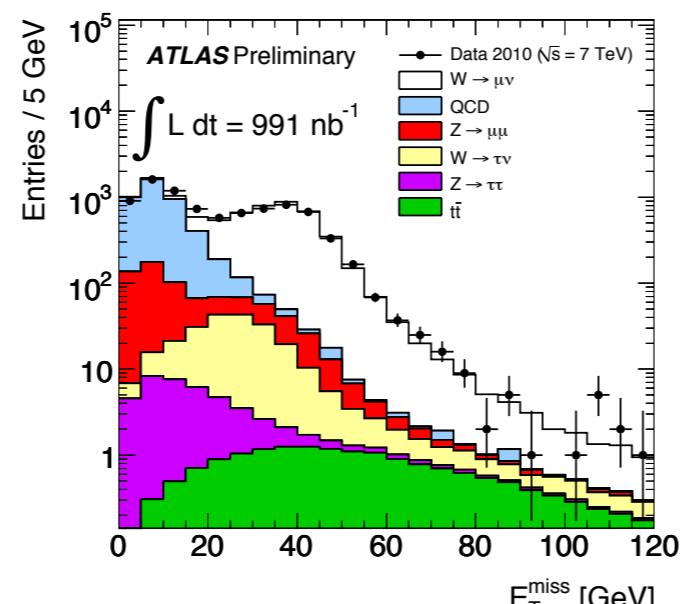
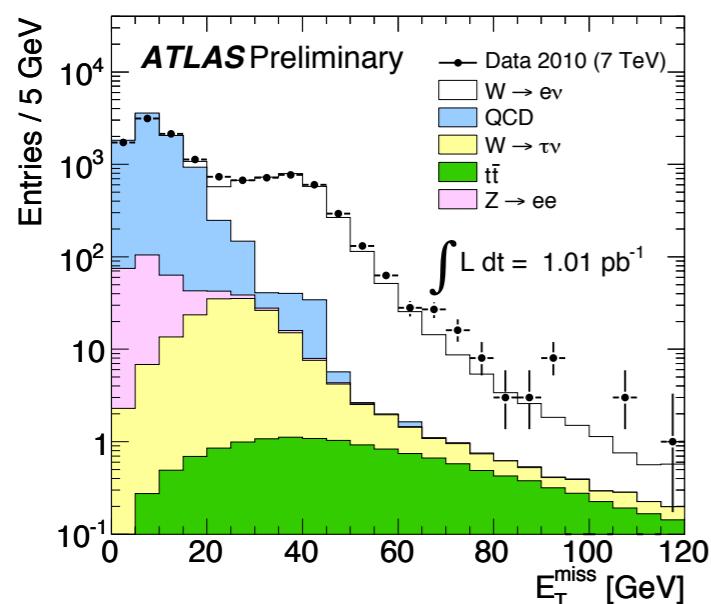
Acceptance x
efficiency:
Electrons: ~30%
Muons: ~40%

Muon Selection

$p_T > 20 \text{ GeV}$, $|\eta| < 2.4$
W: isolated, $|Z_\mu - Z_{\text{vtx}}| < 1\text{cm}$
Z: $|\Delta p_T(\text{ID-MS})| < 15 \text{ GeV}$

Z Selection

2 opposite sign
leptons
 $|M_{||} - M_Z| < 25$
GeV
 $S/B \sim 100$



W and Z Cross-sections

$$\sigma(W \rightarrow l\nu) = 9.3 \pm 0.9 \text{ (stat)} \pm 0.6 \text{ (syst)} \pm 1.0 \text{ (lumi)} \text{ nb}$$

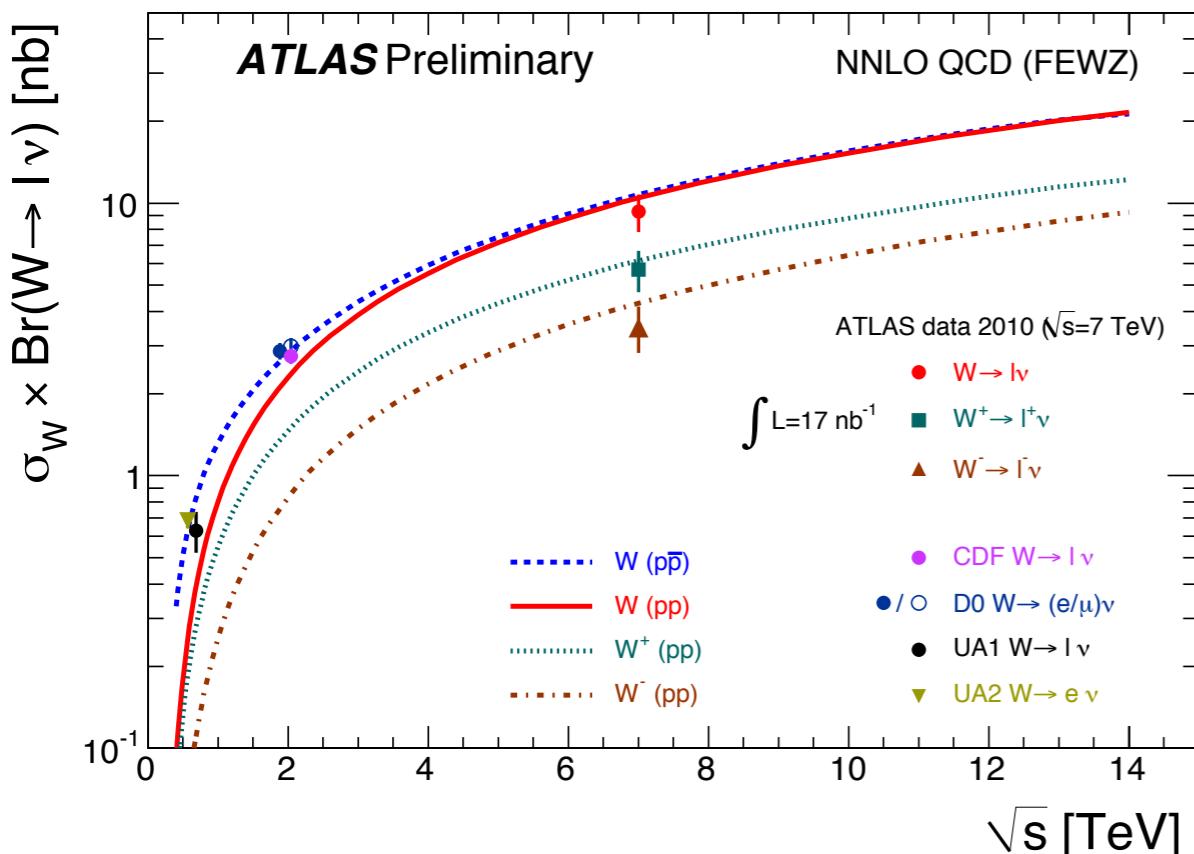
$$\sigma(Z \rightarrow ll) = 0.83 \pm 0.07 \text{ (stat)} \pm 0.06 \text{ (syst)} \pm 0.09 \text{ (lumi)} \text{ nb}$$

Dominant experimental uncertainties

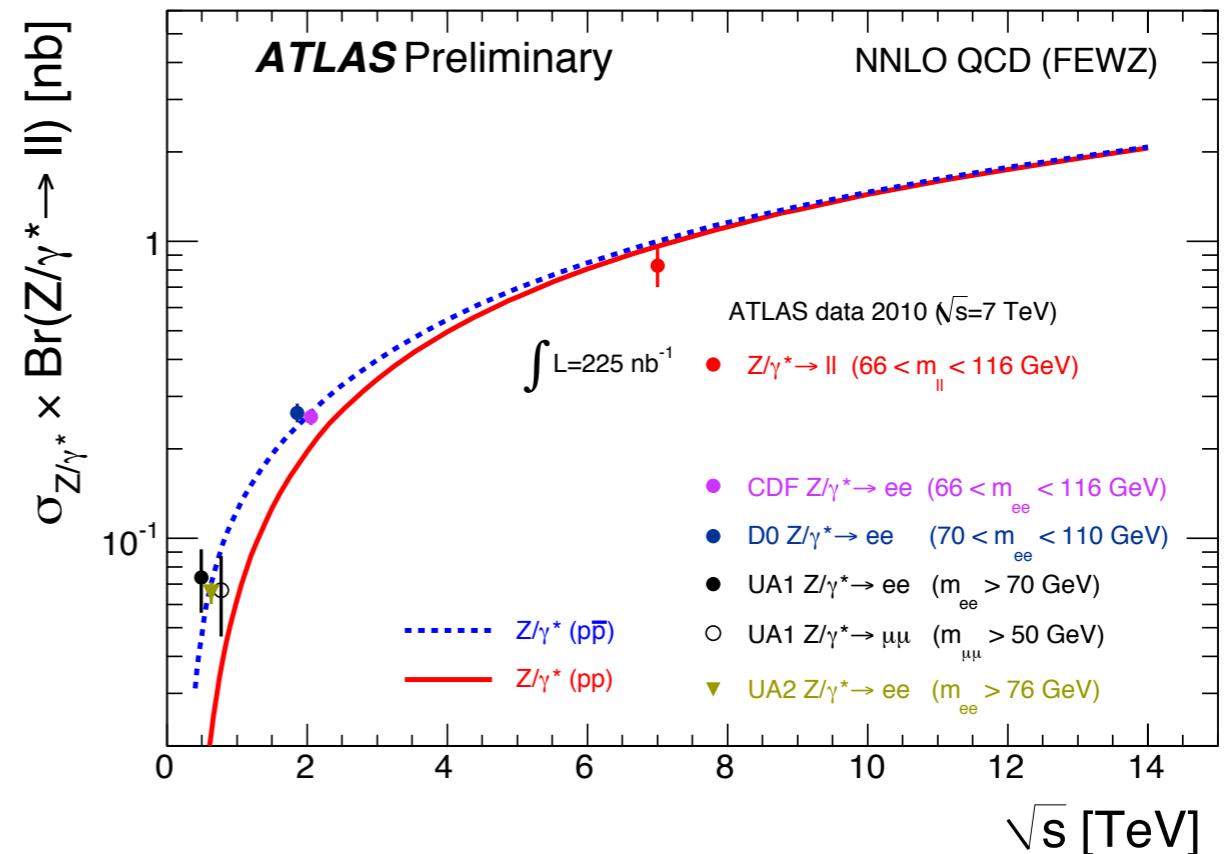
e: ID efficiency

μ : trigger and reco efficiency

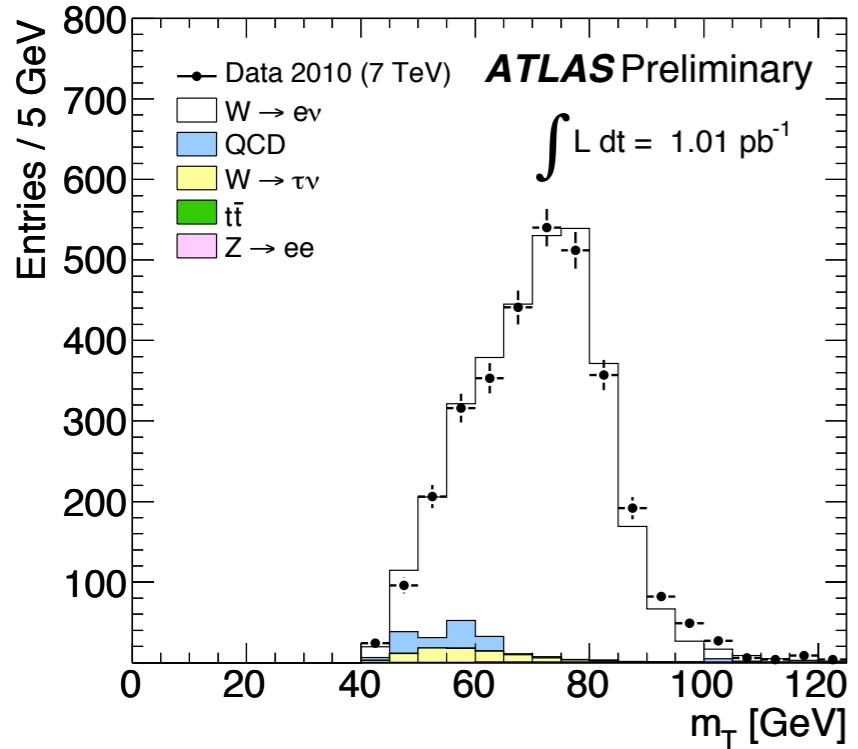
W Cross-section



Z Cross-section

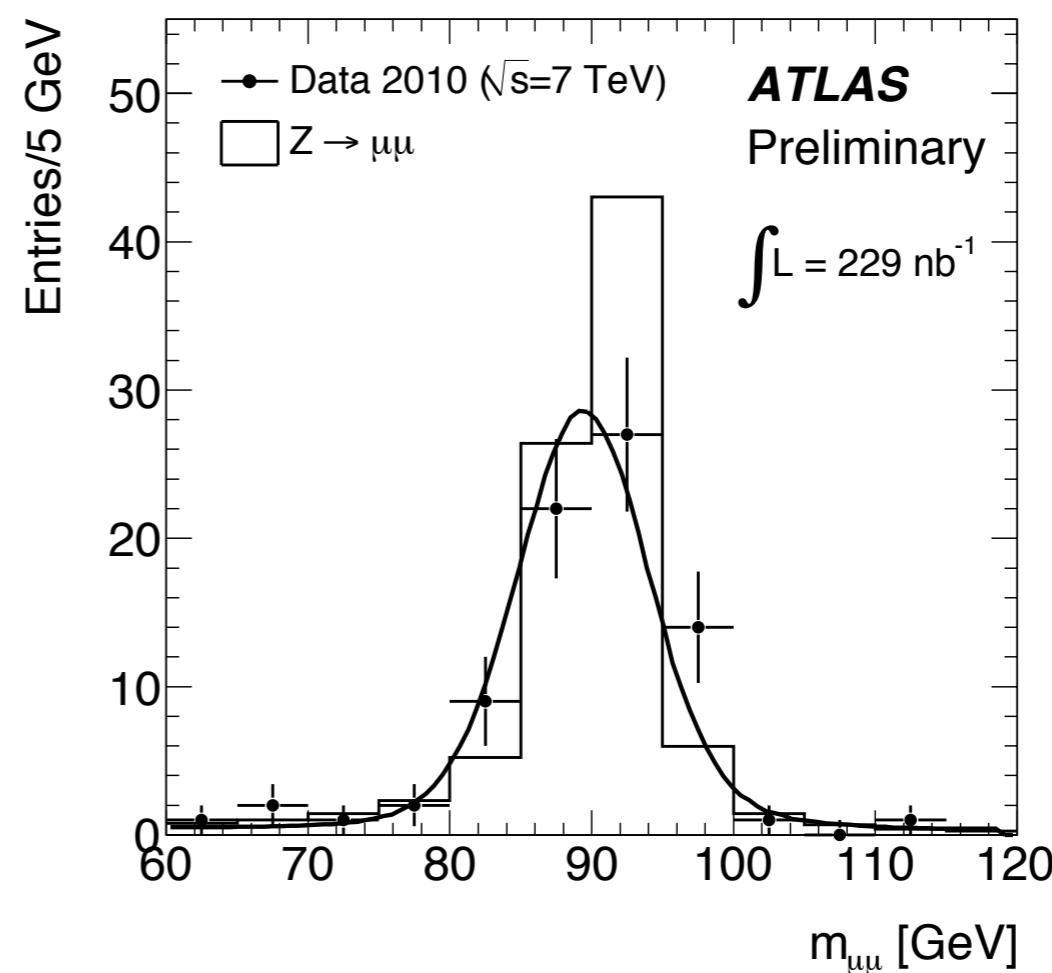
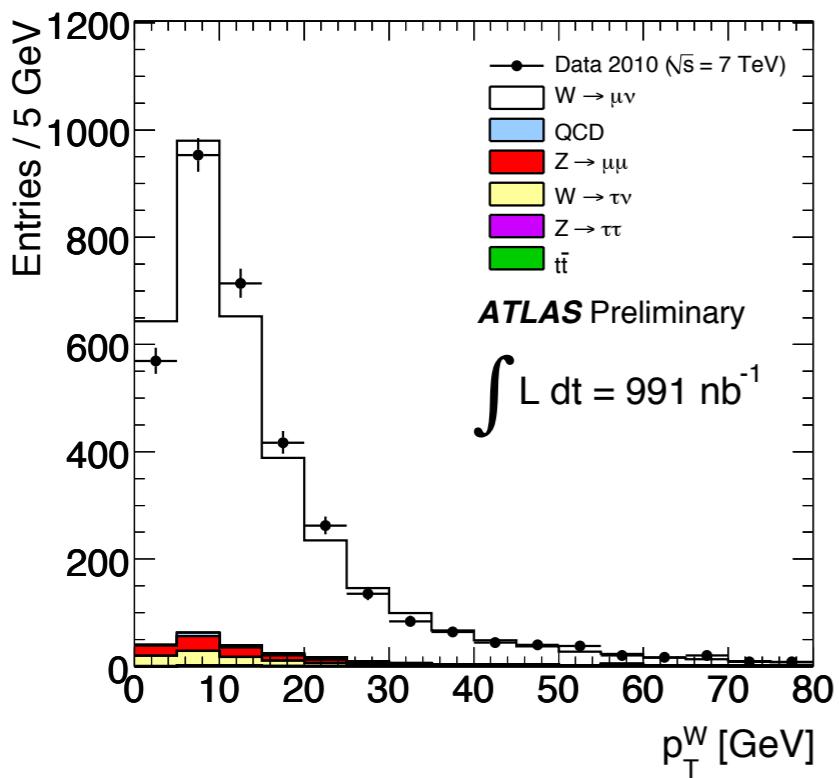


Vector Boson Properties



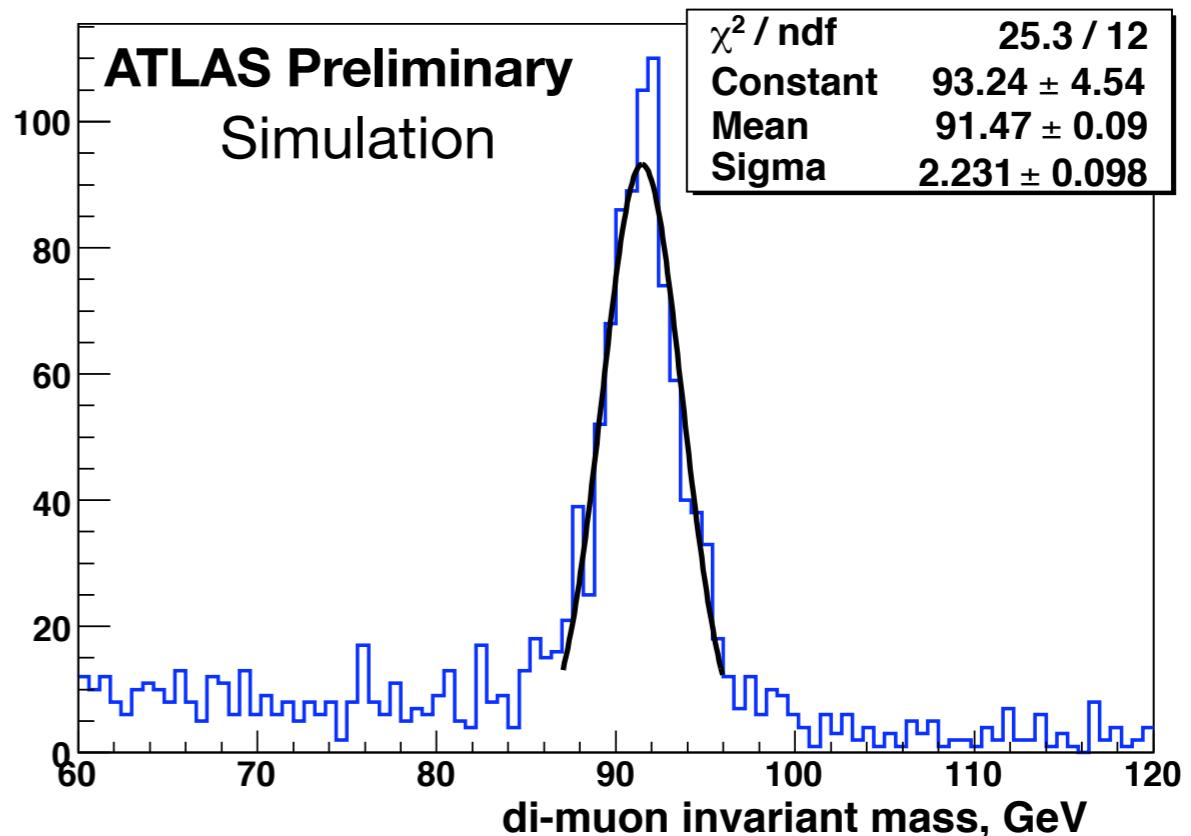
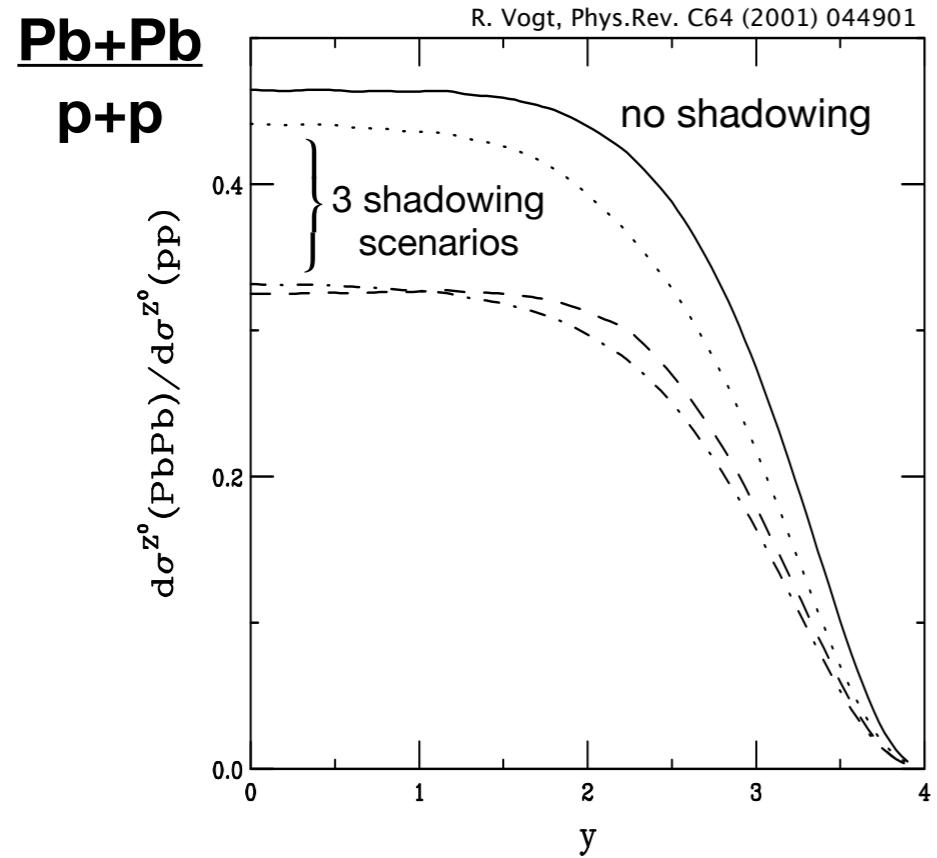
Z Boson Mass

	ee [GeV]	$\mu\mu$ [GeV]
Peak	88.7 ± 0.8	90.3 ± 0.8
Width	3.6 ± 0.8	42.8 ± 0.8



Improve ID and forward MS alignment and calorimeter intercalibration to achieve expected resolution

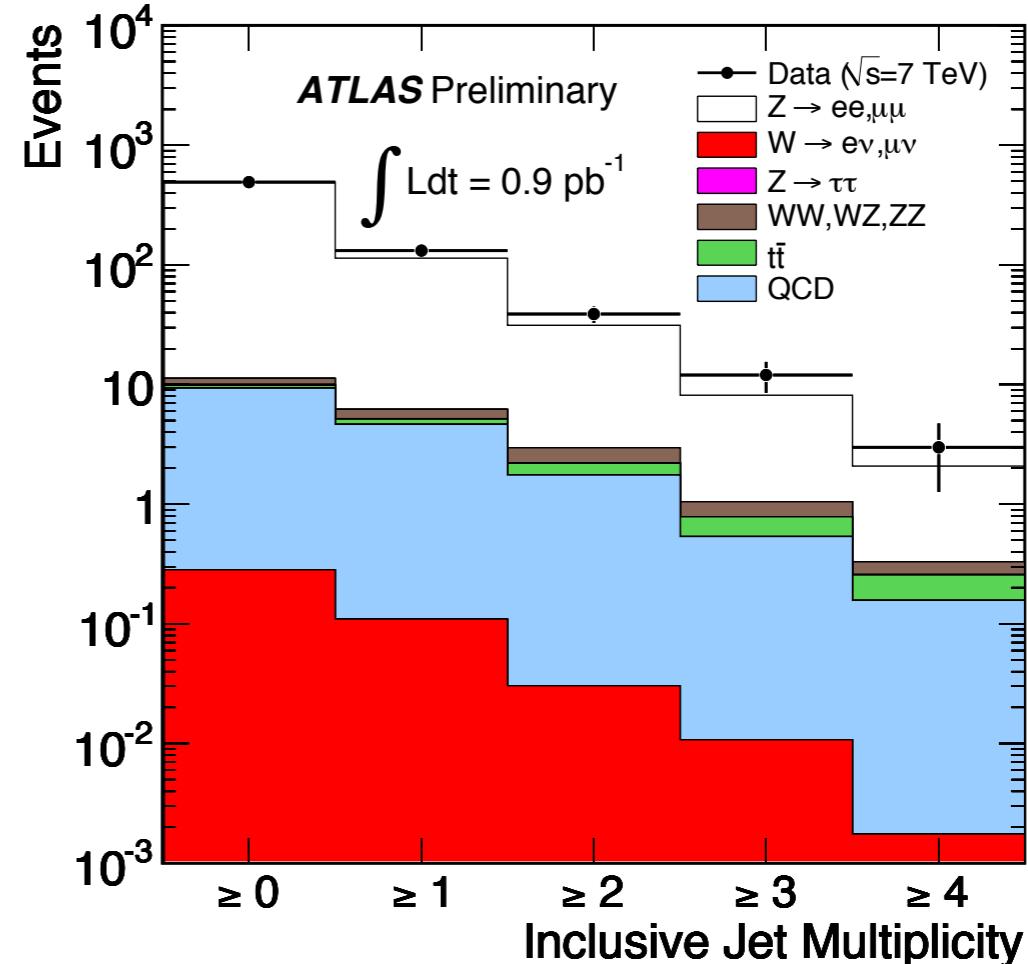
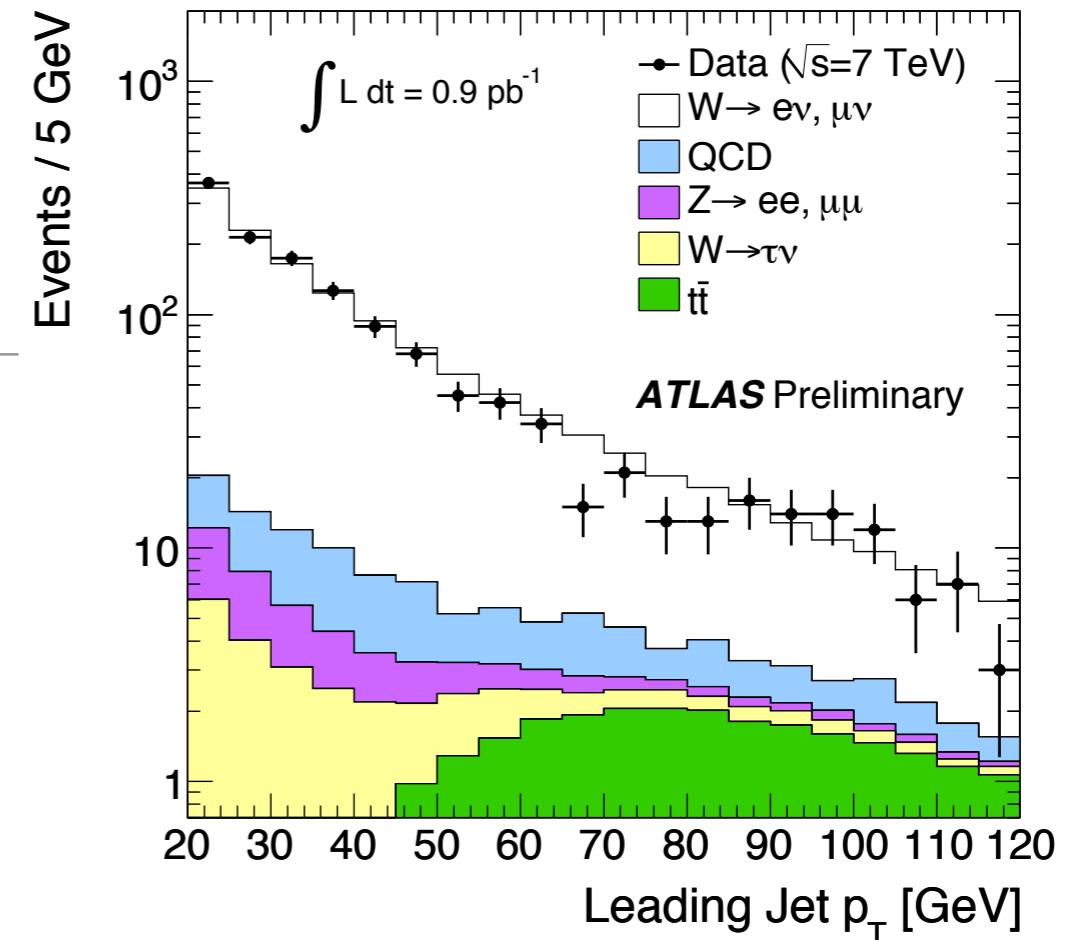
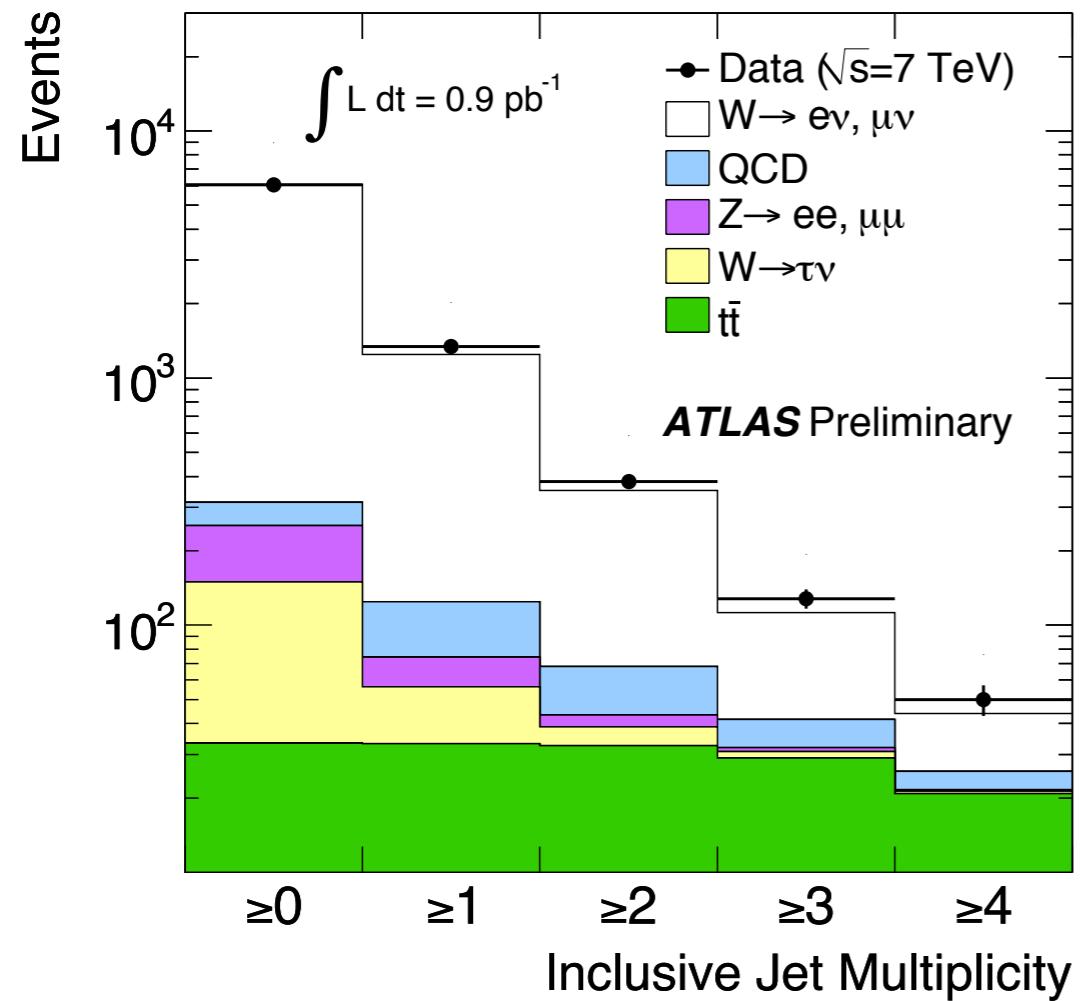
Z Reconstruction in PbPb



- Z bosons provide a nearly background-free measurement of nuclear PDFs
 - can be used to study nuclear shadowing
- Mass resolution of reconstructed Zs similar to pp
 - Minimal effect from embedding into HIJING background
- Expect ~8k Z's in 0.5nb^{-1} at $\sqrt{s_{\text{NN}}}=5.5 \text{ TeV}$

W/Z+Jets

- Anti- k_T jets $r=0.4$, $|\eta| < 2.8$, W/Z selection
- Signal templates produced using ALPGEN
- Major background to top/BSM signals



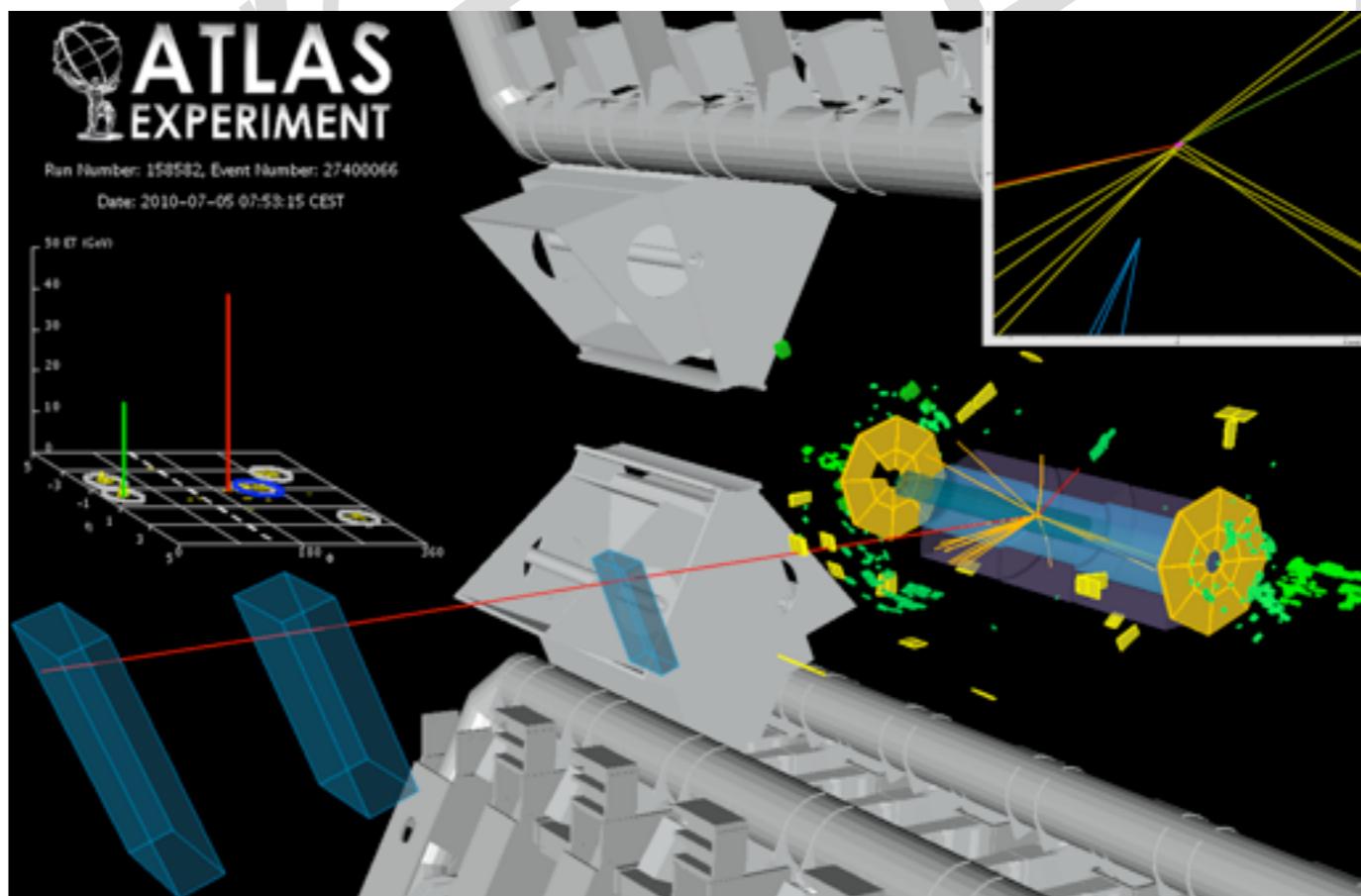
Top Quark Candidates

Lepton+Jets

- 1 iso lepton, $p_T > 20$ GeV
- $E_T^{\text{miss}} > 20$ GeV
- ≥ 4 jets, $p_T > 20$ GeV
- ≥ 1 b-tag jet
- Acc x Eff $\sim 30\%$

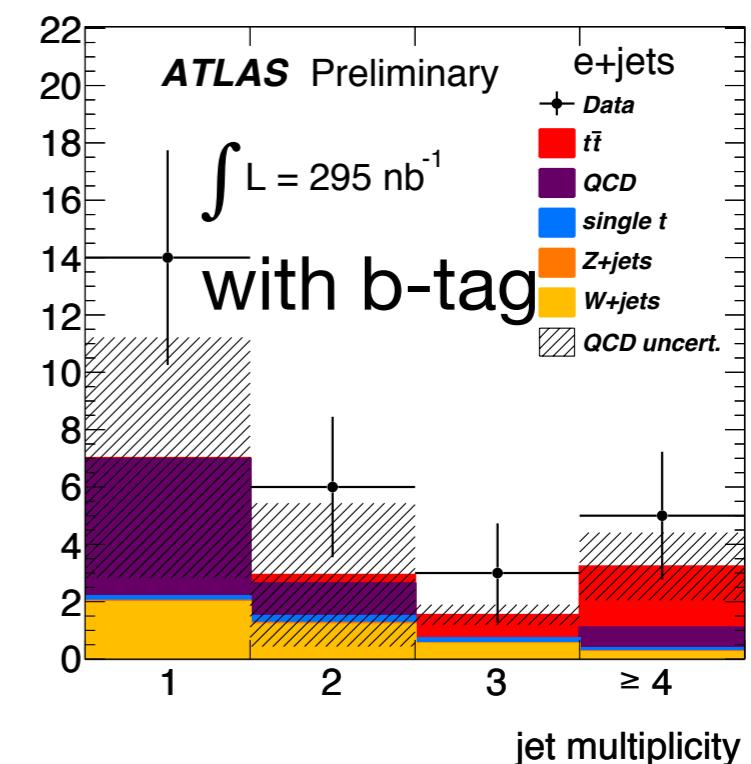
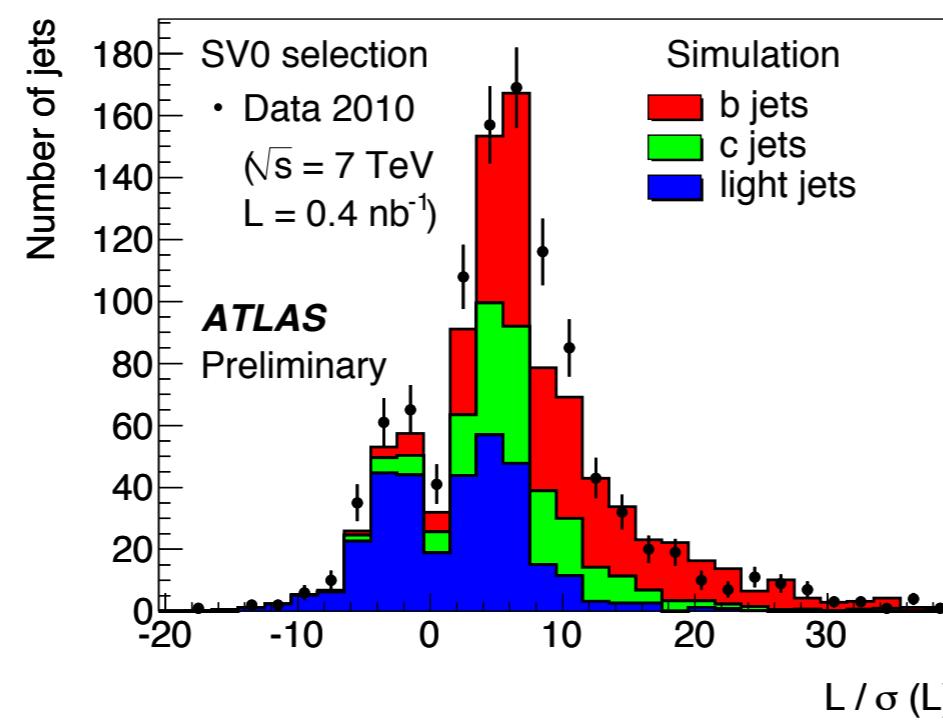
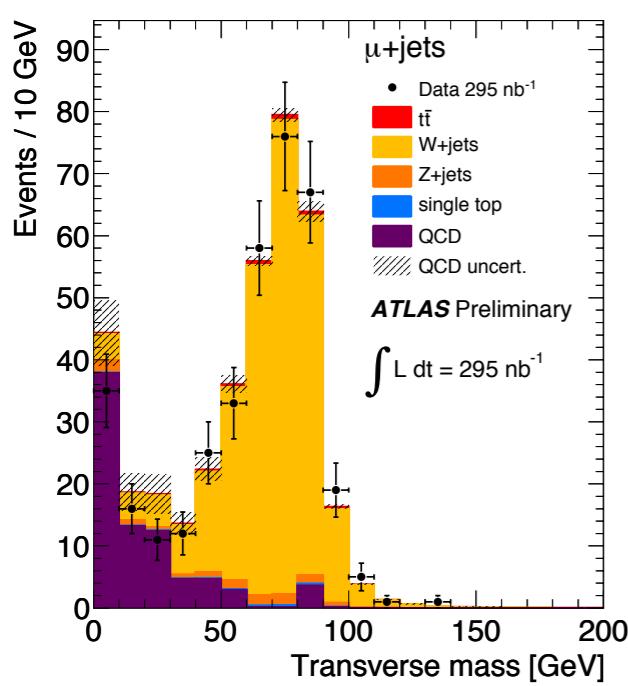
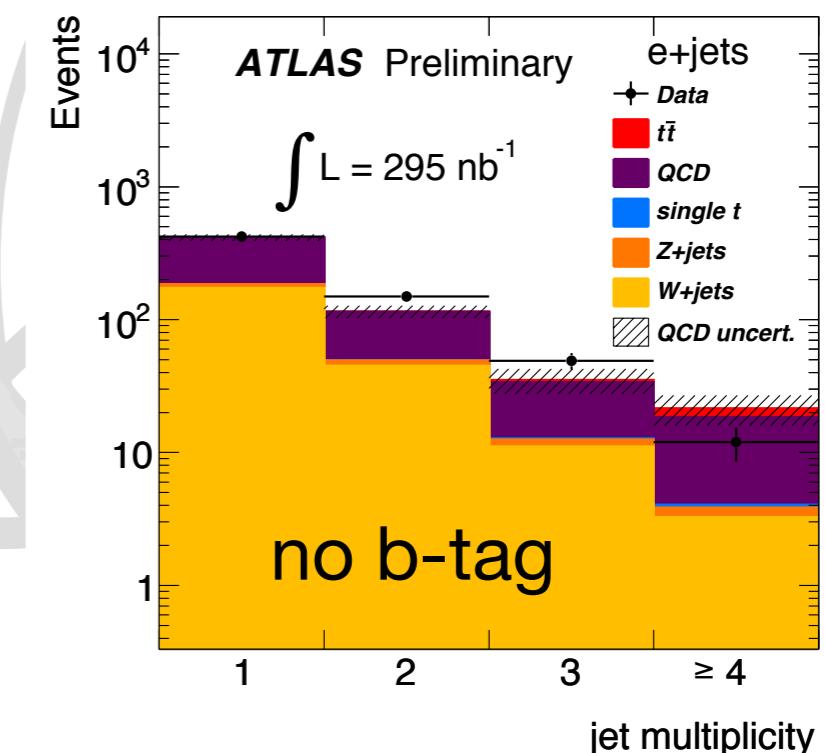
Dilepton

- 2 opp sign leptons, $p_T > 20$ GeV
- ≥ 2 jets, $p_T > 20$ GeV
- ee: $E_T^{\text{miss}} > 40$ GeV, $|M_{ee} - M_Z| < 5$ GeV
- $\mu\mu$: $E_T^{\text{miss}} > 30$ GeV, $|M_{\mu\mu} - M_Z| < 10$ GeV
- $e\mu$: $H_T > 150$ GeV
- Acc x Eff $\sim 25\%$



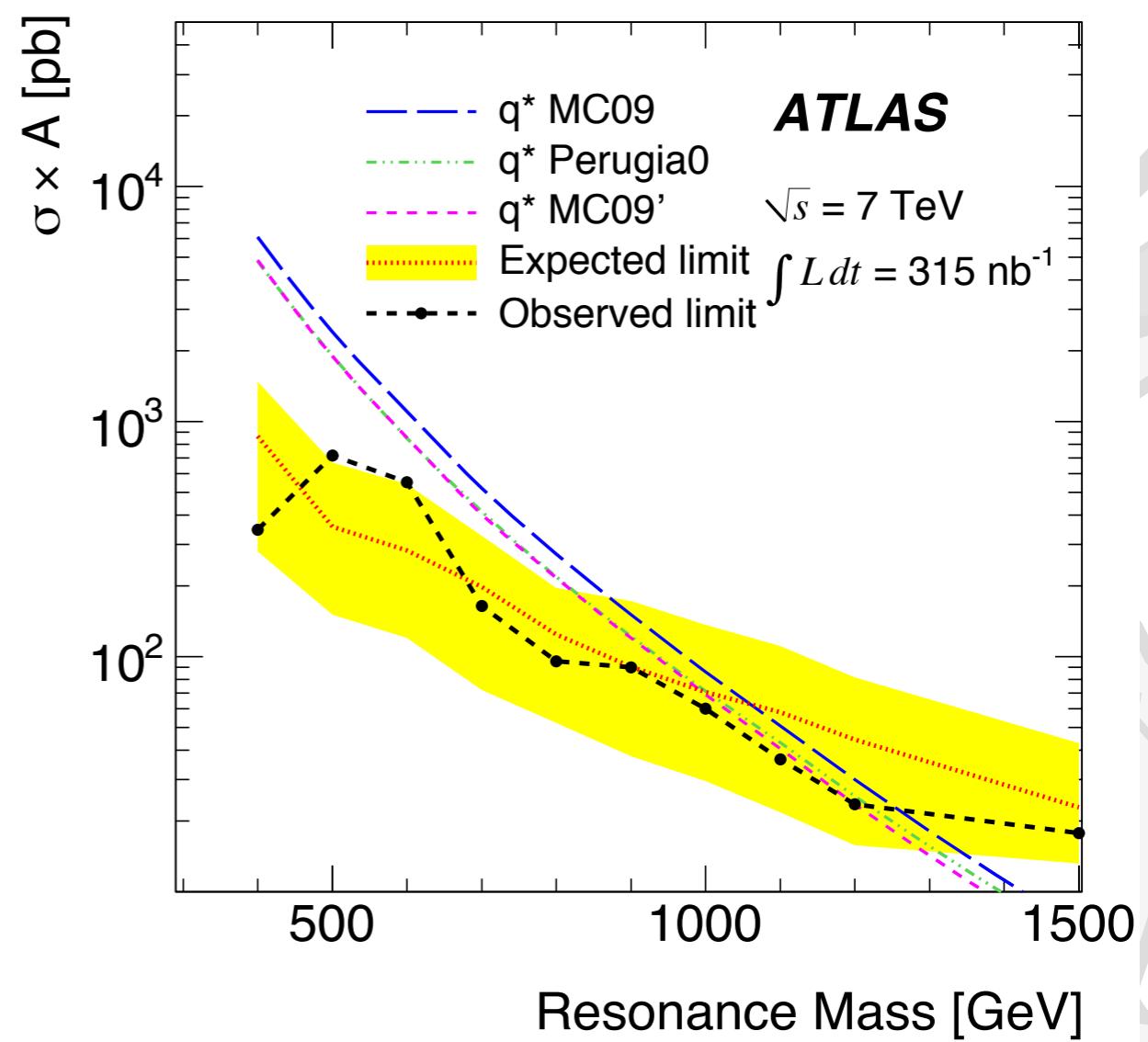
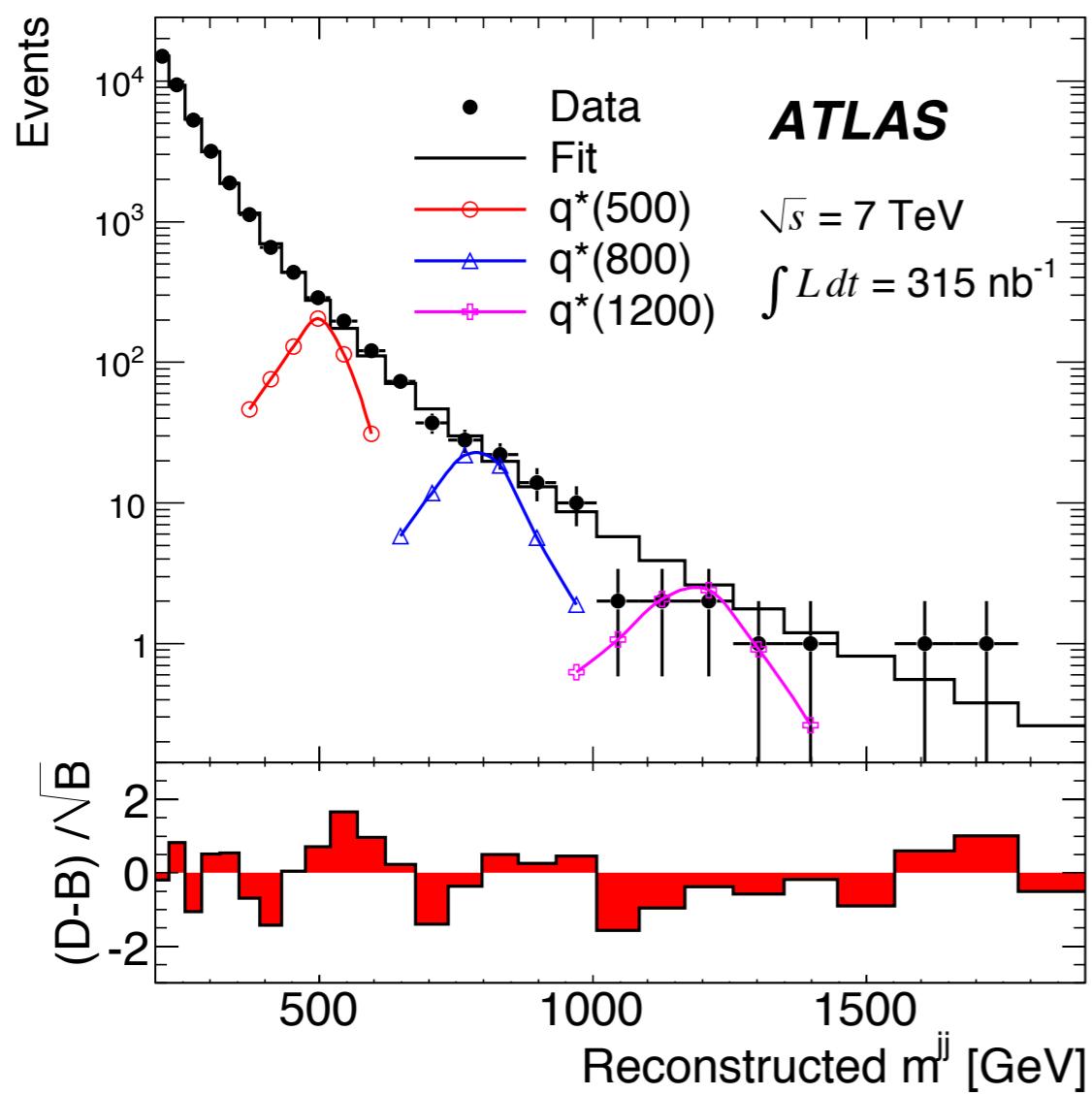
Towards Top Rediscovery

- Requires good understanding of the full detector performance
- Studies to obtain backgrounds from data are well underway
- QCD background estimated from data using loose lepton selection
- 7 lepton+jets, 2 dilepton candidates in 295 nb^{-1}



Searches for Excited Quarks

- Search for di-jet resonance in the $M(jj)$ distribution
 - Compatible with smooth monotonic function: no bumps
 - $0.4 < M(q^*) < 1.29$ TeV excluded at 95% CL (CDF publ: $260 < M(q^*) < 870$ GeV)

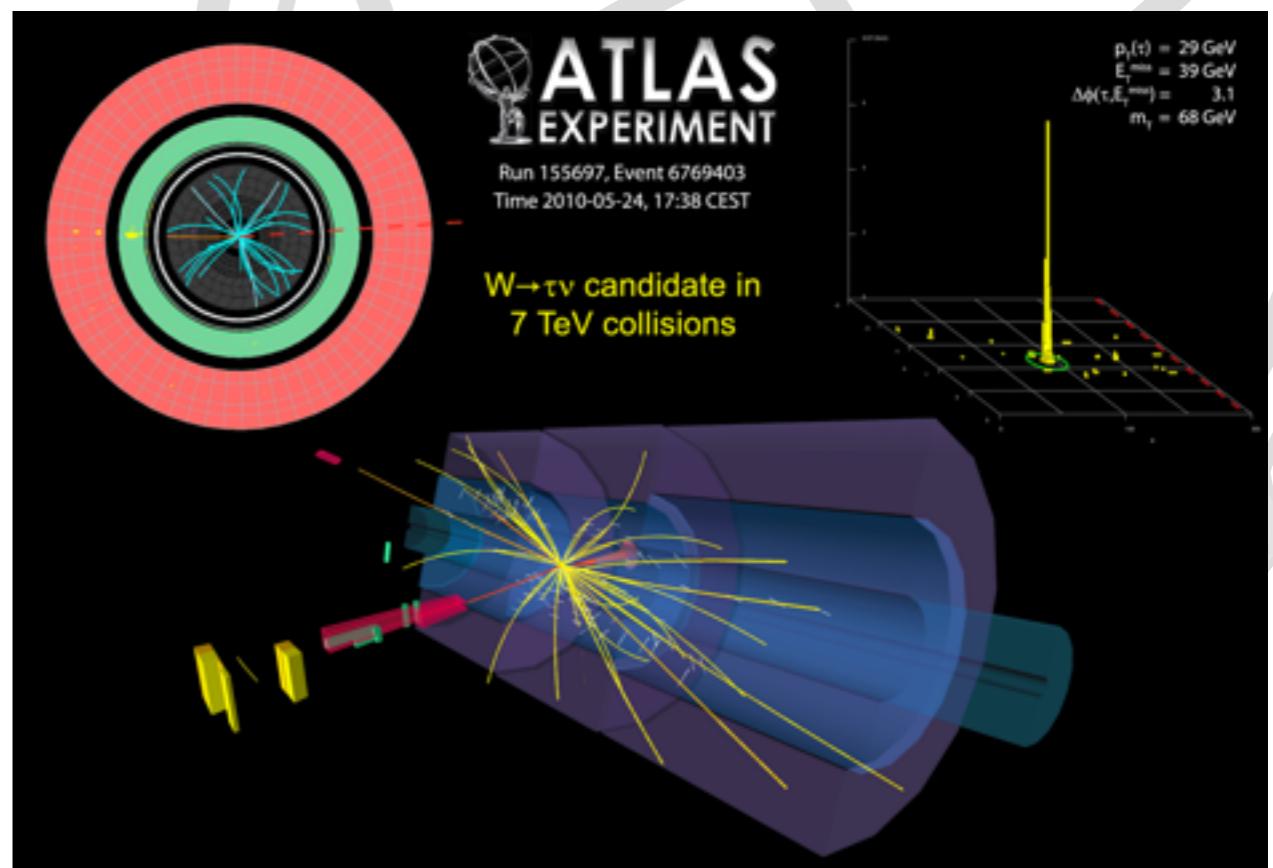


ATLAS in the Context of Heavy-Ion Physics

Significance	Measurement	Physics
Unique	Prompt photons, tagged photons Fragmentation photons	Medium-induced photon emission Jet energy loss mechanism
Excellent	γ -jet correlations Full jet reconstruction Di/multijets Tagged heavy flavour jets	Modified fragmentation functions Jet energy loss mechanism Heavy quark quenching
Competitive/ Complementary	Global observables Jet fragmentation Quarkonia Z bosons	Initial state properties & collective phenomena Medium-modified jet properties Debye screening Parton Distribution Functions

Conclusion

- The exploration of the LHC physics potential by ATLAS has begun
- The ATLAS detector performance and reconstruction quality are better than expected at the initial stage of the experiment
- Many interesting SM processes have been studied and searches have begun
- ATLAS is gearing up for this year's heavy-ion run
 - Plan to exploit unique capabilities to study the properties of the hot, dense matter produced in heavy-ion collisions
 - Stay tuned for exciting results!



More results at: <https://twiki.cern.ch/twiki/bin/view/Atlas/AtlasResults>