MANCHESTER 1824
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ATLAS EXPERIMENT

A measurement of the ϕ_η^* angle in Drell-Yan di-lepton pairs

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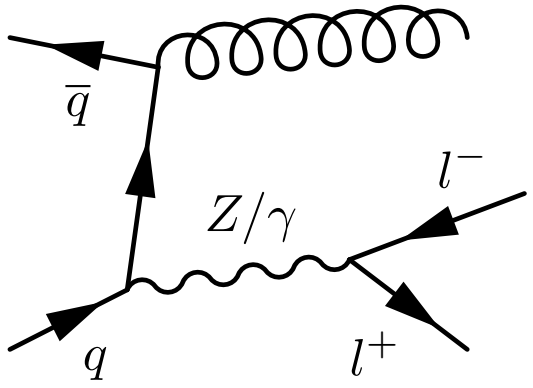
Motivation

- Intermediate boson in Drell-Yan process can be produced with non-zero transverse momentum, p_T :
  - initial state gluon radiation



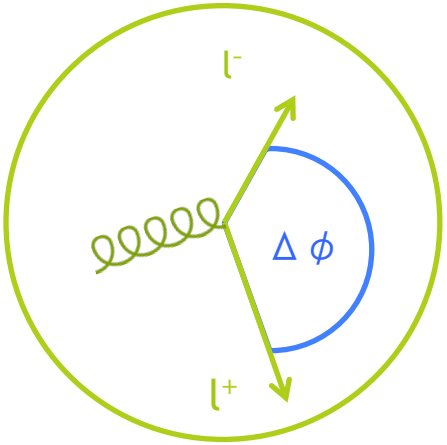
process of interest

- Understanding this is important for:
  - testing QCD predictions (at low and high p_T)
    - resummation techniques
  - modelling Z, W and Higgs production

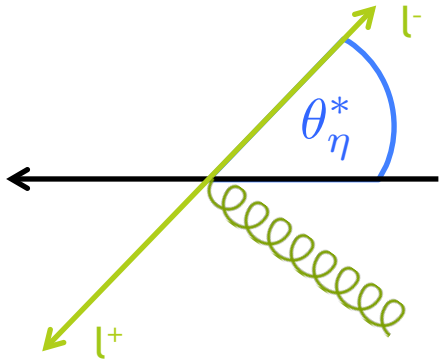
- Boson p_T measurement limited experimentally by momentum resolution
- Motivates introduction of ϕ^*_η

ϕ^*_η definition

define $$\phi^*_\eta = \tan\left(\frac{\pi - \Delta\phi}{2}\right)\sin\theta^*_\eta$$



transverse plane

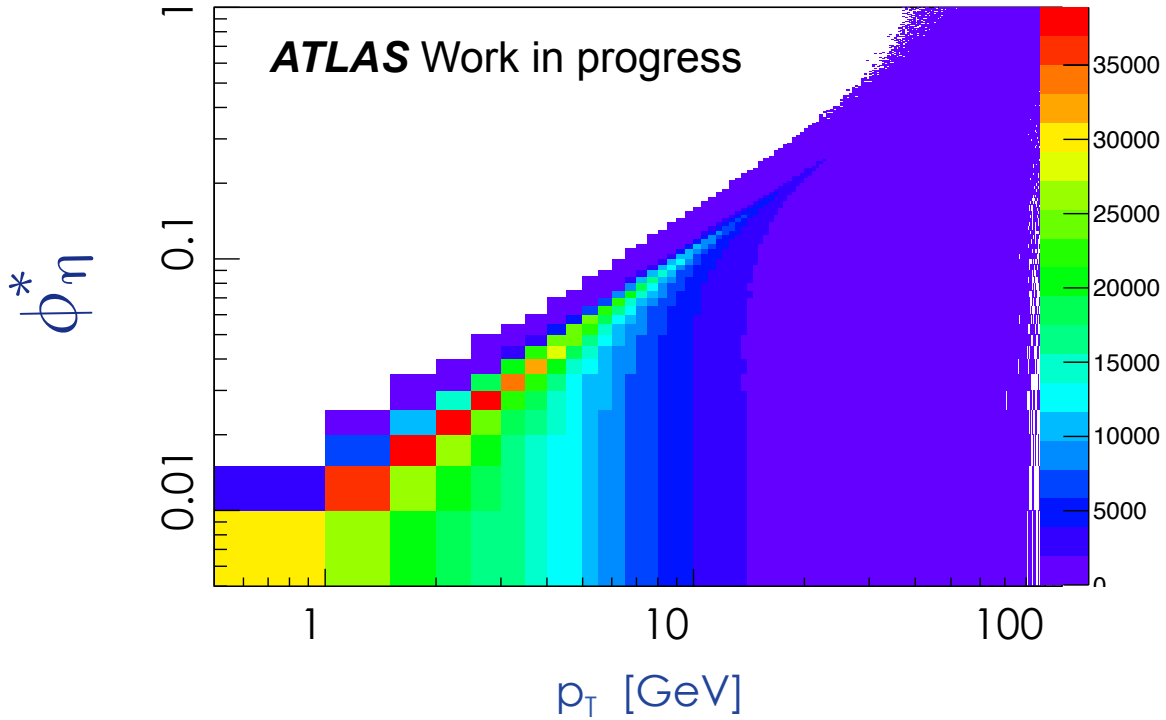


longitudinal plane
*(**boson rest frame**)*

$$\cos\theta^*_\eta = \tanh\frac{\eta^- - \eta^+}{2}$$

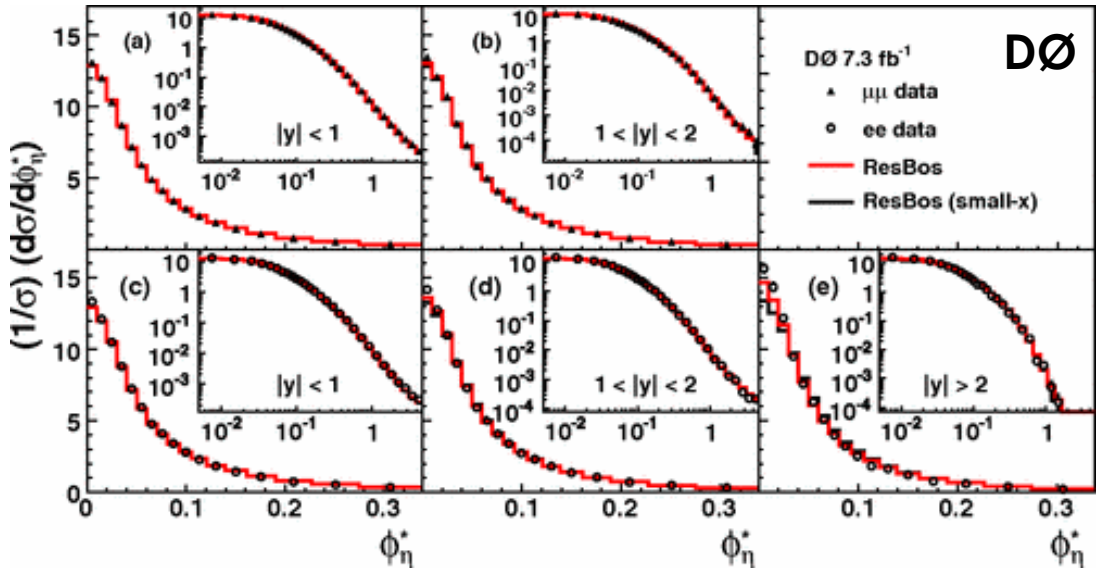
ϕ^*_η definition

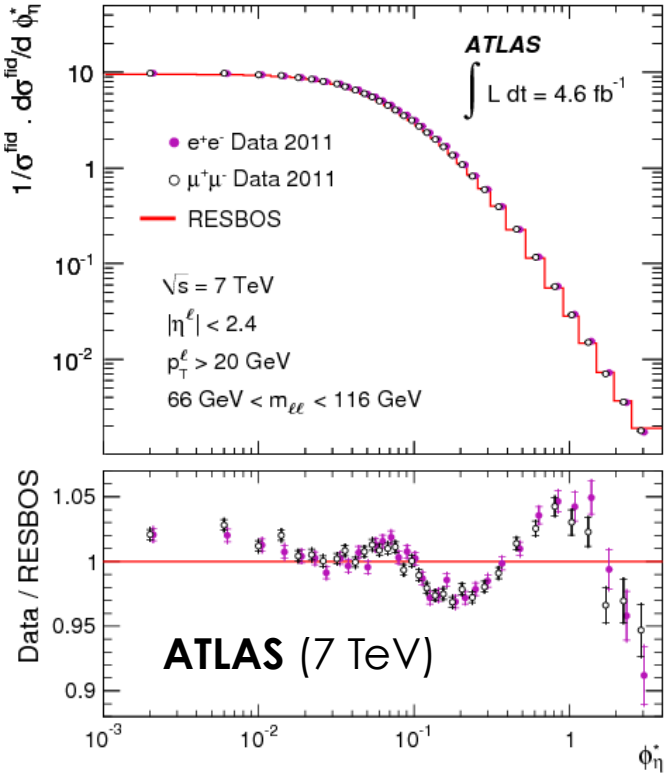
- ✓ sensitive to boson p_T
- ✓ only relies on lepton directions: η , ϕ
  - ✓ minimal dependence on momentum resolution

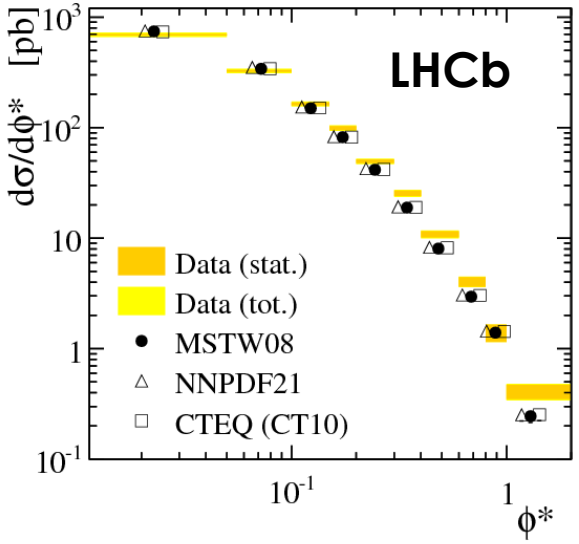


ϕ^*_η against p_T
66 GeV < M_Z < 116 GeV

Previous measurements







- Used to tune Monte Carlo generators
  - RESBOS with DØ data (arXiv:1205.4311)
  - PYTHIA and POWHEG with ATLAS data (ATL-PHYS-PUB-2013-017)
- Also compared to NLO + NNLL calculation
  - Banfi et al. – J. High Energy Phys. 1201, 044; Phys. Lett. B715, 152

ATLAS 8 TeV measurement

- Measure normalised triply differential cross section
  - in ϕ^*_η, mass (M) and rapidity (y)
  - using 20.3 fb^{-1} of 8 TeV data at ATLAS

$$\frac{1}{\sigma}\frac{d^3\sigma}{d\phi^*_\eta dM dy}$$

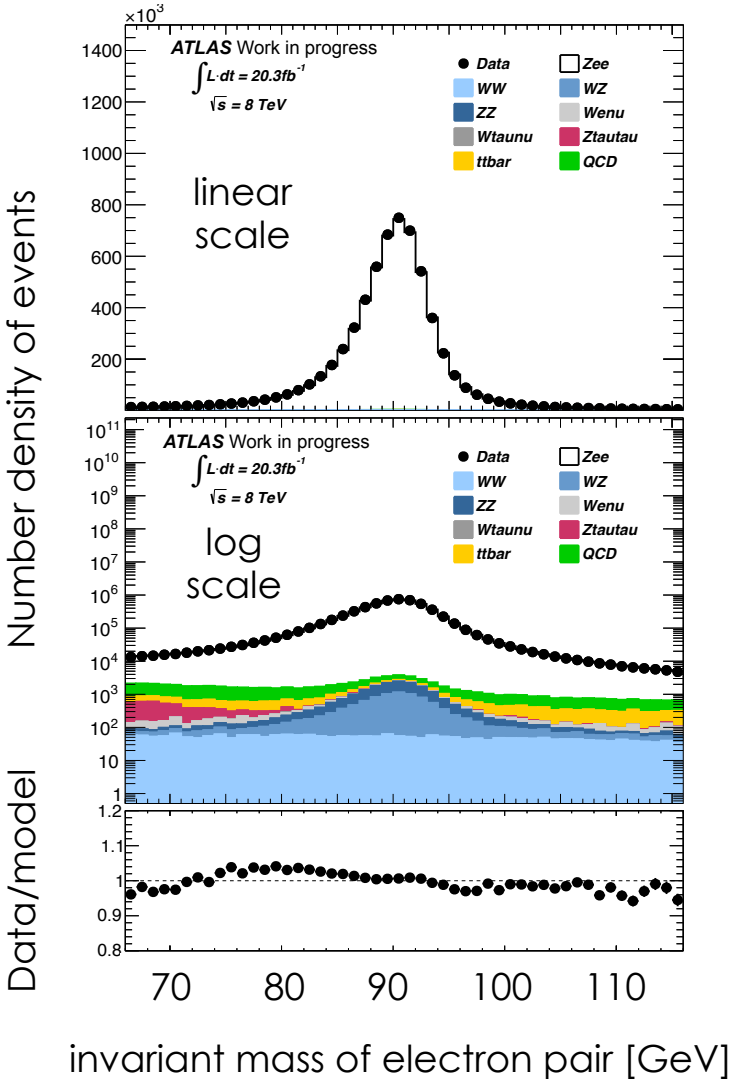
- Perform measurement in di-electron and di-muon channels
  - and then combine

- Extension of the 7 TeV analysis - *Phys. Lett. B 720 (2013) 32*
  - measure ϕ^*_η above and below Z-peak
  - and in coarse rapidity bins
  - Extend to higher ϕ^*_η to benefit from increased statistics

Event selection

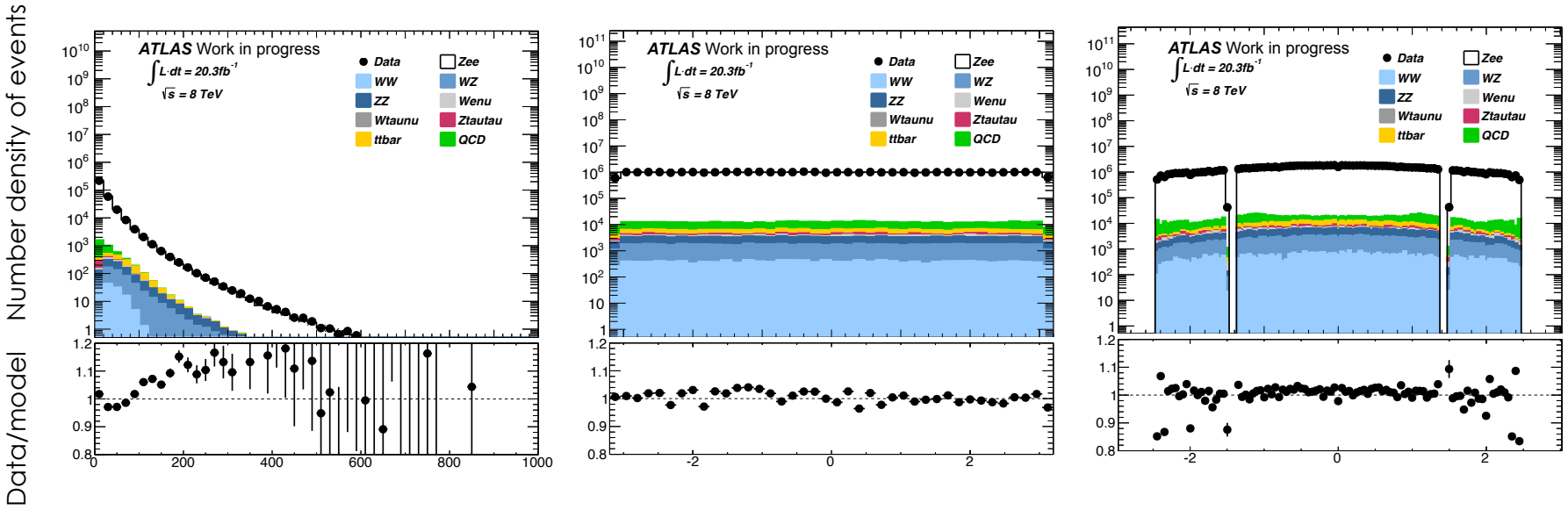
- Low background (~1% at Z peak)
  - → minimal cuts required
  - → signal modelled using Powheg + Pythia

- Di-lepton trigger
- Exactly two electrons / muons
  - passing quality and identification requirements
  - p_T > 20 GeV
  - geometric acceptance cuts



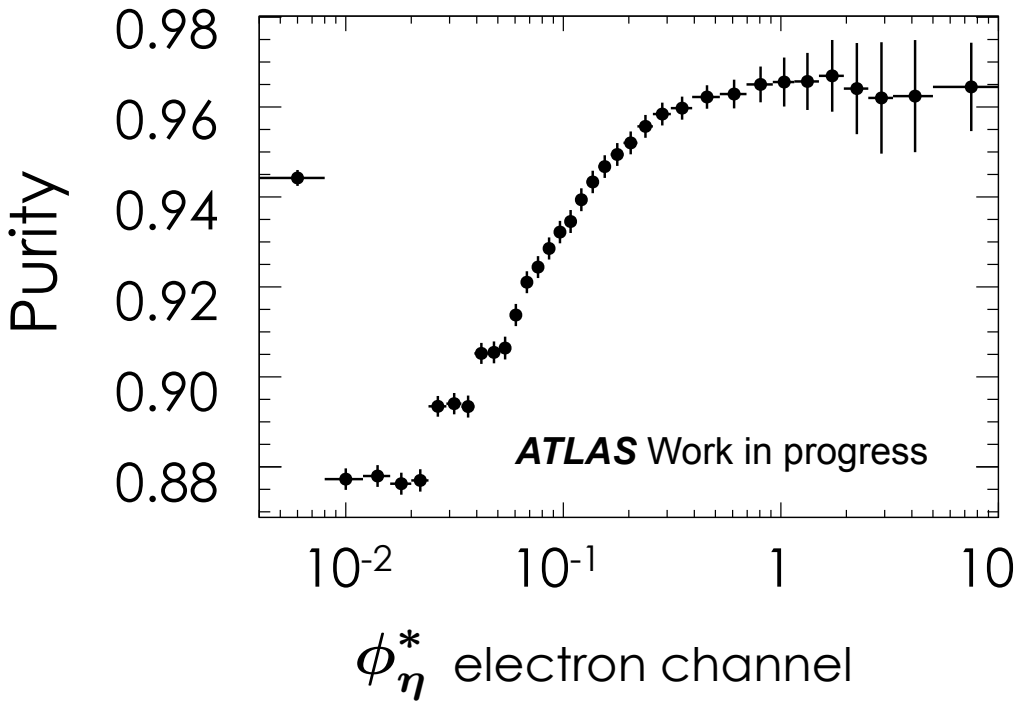
Data / model comparison

- Reasonable agreement between data and model in di-electron channel
  - similar agreement seen in di-muon channel
  - still work in progress



Binning

- Wide bins in mass and rapidity
- Binning in ϕ^*_η mostly influenced by detector angular resolution

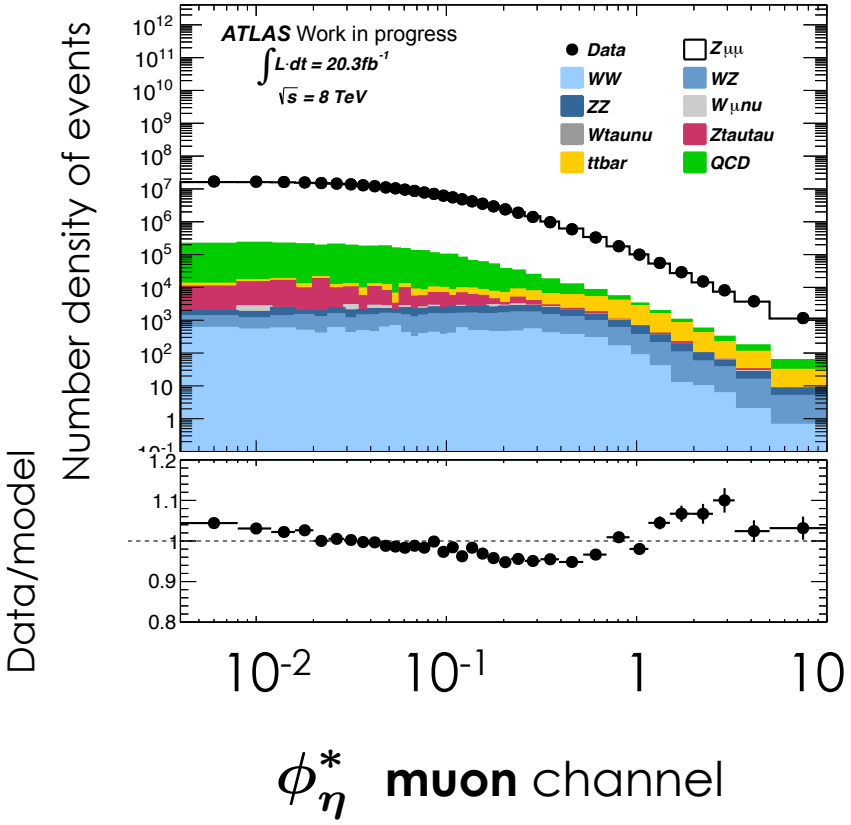


$$\text{purity} = \frac{\text{Number generated \& reconstructed in bin}}{\text{Number reconstructed in bin}}$$

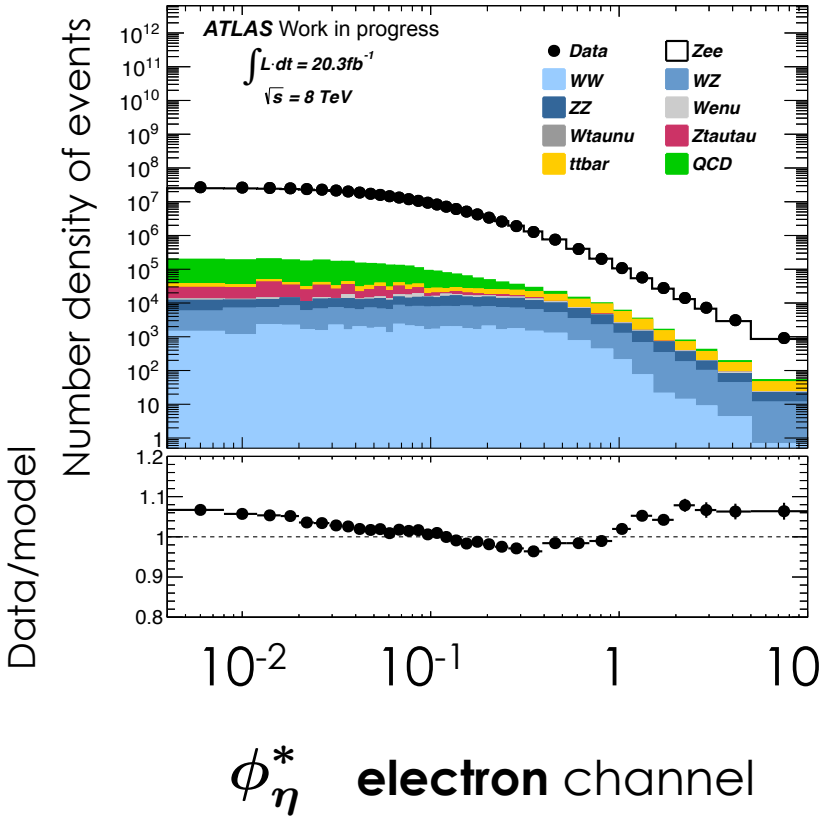
ϕ_η^* distribution

- Reasonable agreement between data and model
  - signal modelled using Powheg + Pythia
  - will also compare to NLO + NNLL calculation (resummed)

66 GeV < M_Z < 116 GeV
0 < |Rapidity$_Z$ |< 0.8



ϕ_η^* **muon** channel



ϕ_η^* **electron** channel

Systematic uncertainties

- Dominant systematic uncertainties (based on 7 TeV analysis around the Z peak) expected to be from:
  - estimation of the number of background events from:
    - multi-jet / QCD background (estimation taken from data)
    - $t\bar{t}$, $Z/\gamma \rightarrow \tau^+\tau^-$, $W \rightarrow l\nu$, and di-boson processes
    - (~ 0.3%)
  - modelling of QED final state radiation (~ 0.3%)
    - important in correction of measured leptons to born, dressed and bare levels
  - modelling of detector angular resolution by Monte Carlo (~0.3%)
- Other uncertainties expected to be smaller
  - lepton identification and trigger efficiencies
  - pileup effects
  - method for correcting for detector effects

Summary

- Measuring triply differential cross section in ϕ^*_η , mass (M) and rapidity (y)

$$\frac{1}{\sigma}\frac{d^3\sigma}{d\phi^*_\eta dM dy}$$

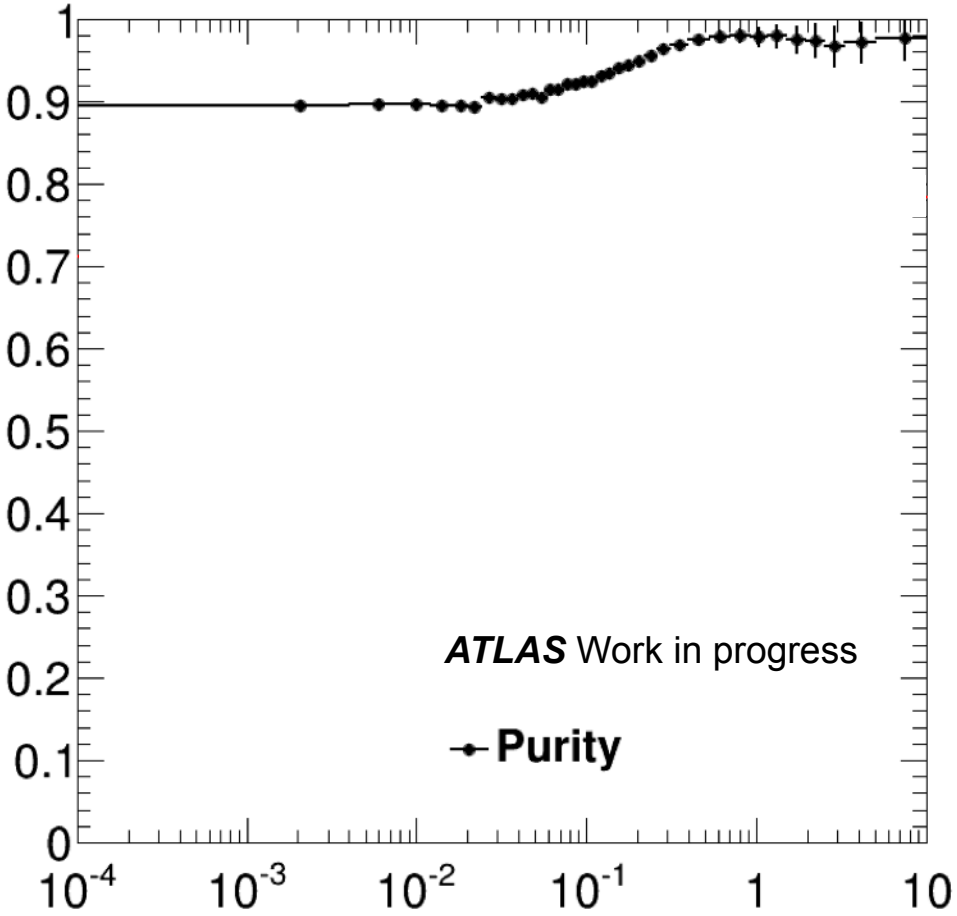
- Definition of ϕ^*_η relies only upon well measured lepton directions
  - A complementary probe to p_T of initial state radiation in Drell-Yan events

- Will correct data for detector effects and compare to NLO + NNLL resummed calculation

thanks to Lee Tomlinson and Terry Wyatt

Additional Material

Purity in di-muon channel



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