

Measurement of Boson Production in Pb-Pb Collisions at 2.76 TeV with ATLAS

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on behalf of the ATLAS Collaboration



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Heavy Ion Collisions and Bosons

Primary goal of HI physics (AA, pA): Understand hot and dense matter

For example:

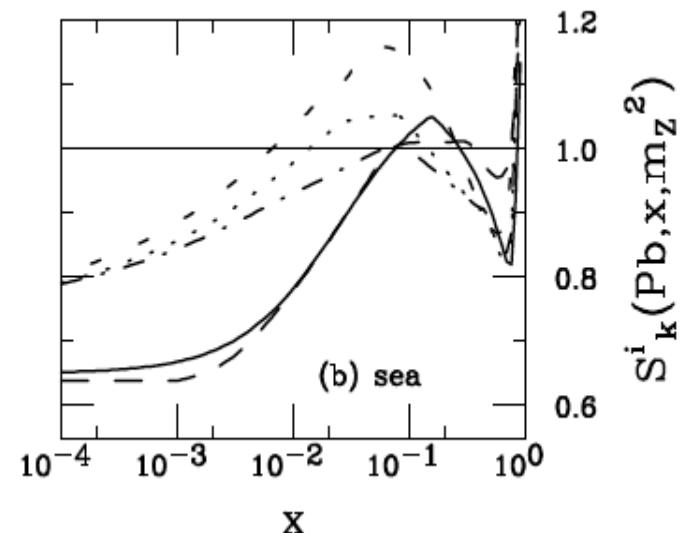
- J/Ψ suppression as a sign for deconfined matter formation (colour screening)
- Large anisotropy of non-central elliptic flow: fluid model of QGP
- Large transverse momenta to understand jet quenching mechanism etc

However:

γ, W, Z should not be affected by the QGP

- To be investigated experimentally
- As in pp, W and Z should constrain PDFs
(J/Ψ is dominantly gg produced but W,Z is qq)

Shadowing effects in acceptance range of LHC:



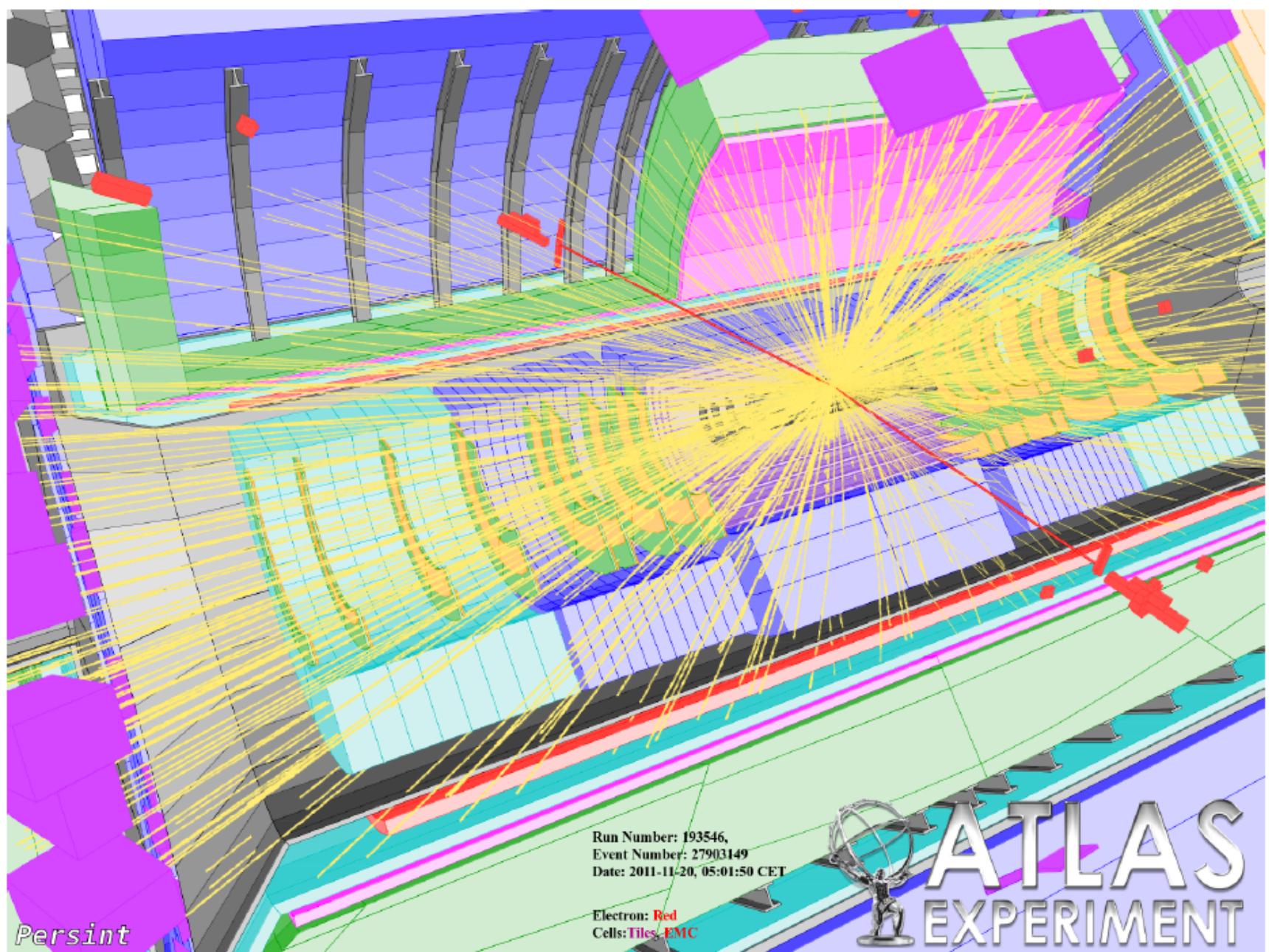
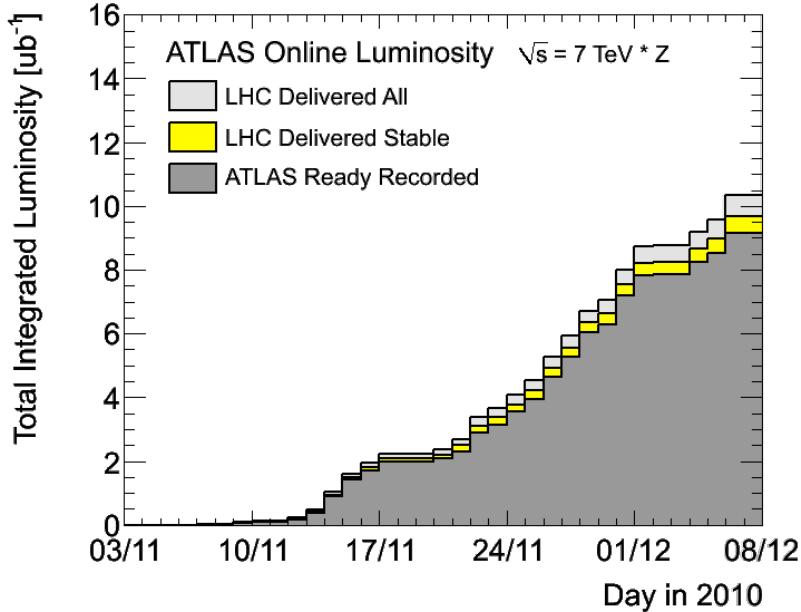


Figure 11: ATLAS event display showing $Z \rightarrow ee$ candidate. FCal $\sum E_T = 1.58 \text{ TeV}$ (10-20% Centrality), $m_{ee} = 92.2 \text{ GeV}$, $p_T^Z = 4.8 \text{ GeV}$, $y^Z = -0.2$.

Data taken in Pb-Pb Collisions

2010 - initial HI run [$8 \mu\text{b}^{-1}$]

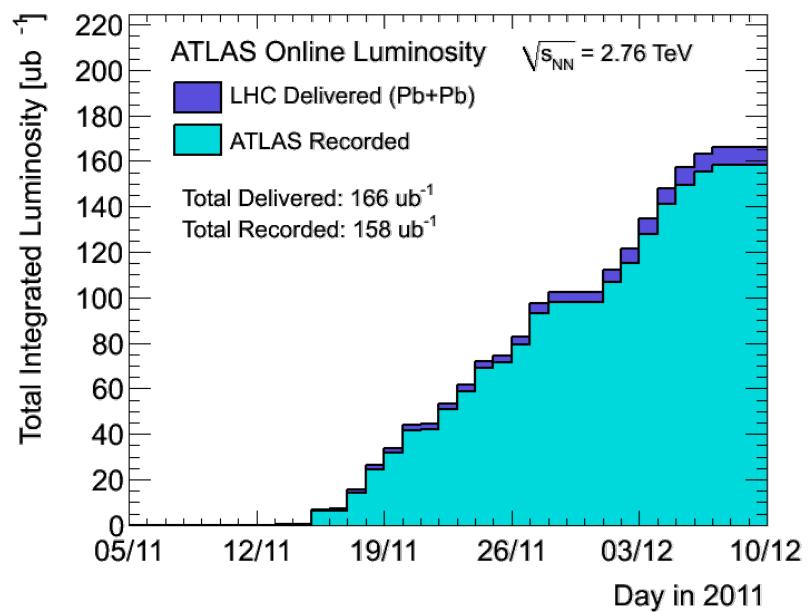


minimum bias trigger

~40 M (0-80%) events

399 W $\rightarrow \mu\nu$ for first
single differential
distributions and charge
separated ratios

2011 – $160 \mu\text{b}^{-1}$ (20 times more L)

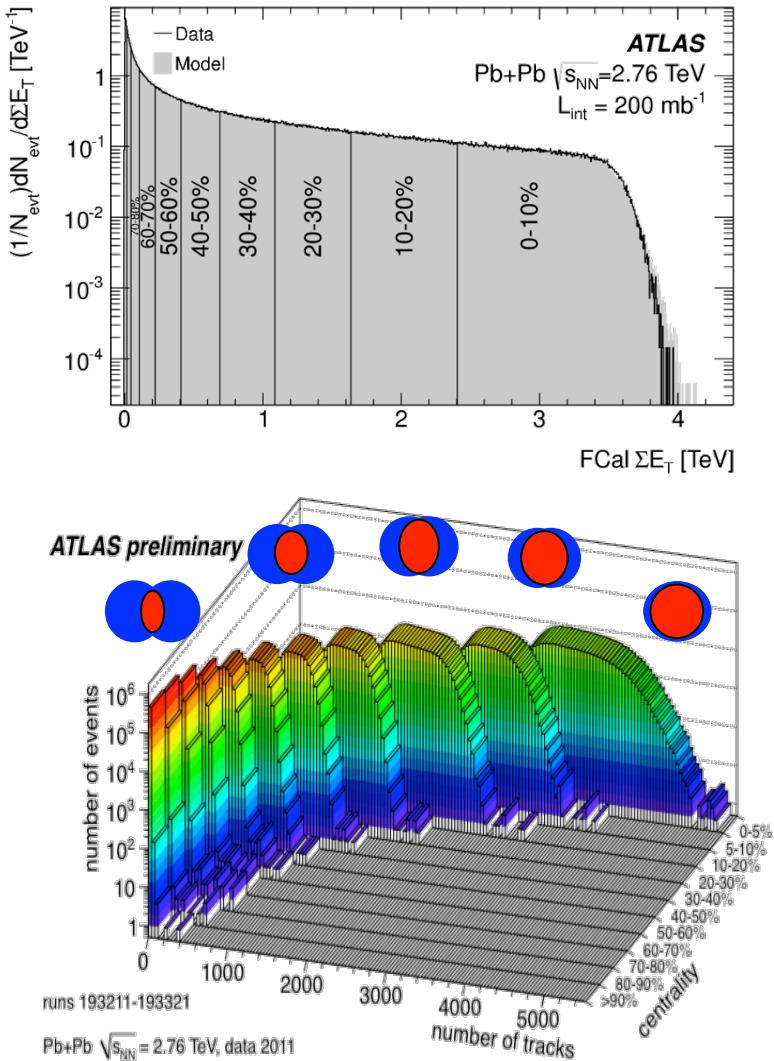


$\gamma(e)$, μ , jets minbias, UPC

~800 M (0-80%) events

Z $\rightarrow ee$ and $\mu\mu$
prompt photons
for detailed studies

Centrality and Suppression Factors



Centrality measured with “FCAL”, which detects 98% of all inelastic collisions
Most central: C=0-10%: $\Sigma E_{\text{T}} > 2.4 \text{ TeV}$.

$$N_X = L_{AA} \sigma_{tot}^{AA} \frac{\langle N_{coll} \rangle}{\sigma_{tot}^{pp}} \sigma_X^{pp}$$

$$N_X = N_{event} T_{AA} \sigma_X^{pp}$$

$$R_{AA} = \frac{N_X / N_{event}}{T_{AA} \sigma_X^{pp}}$$

N_X = number of events in AA of process X

L_{AA} = integrated luminosity in AA collisions

σ_{tot}^{AA} = total inelastic cross section (7.6b in PbPb)

$\langle N_{coll} \rangle$ mean number of binary collisions

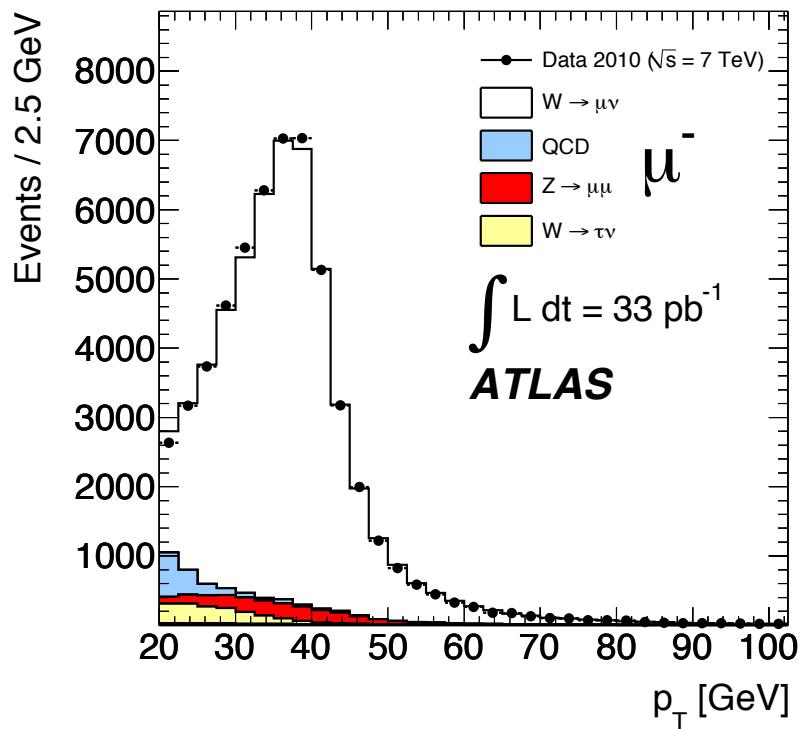
σ_X^{pp} cross section of process X in pp collisions

σ_{tot}^{pp} = total inelastic pp cross section

N_{event} total number of inelastic events

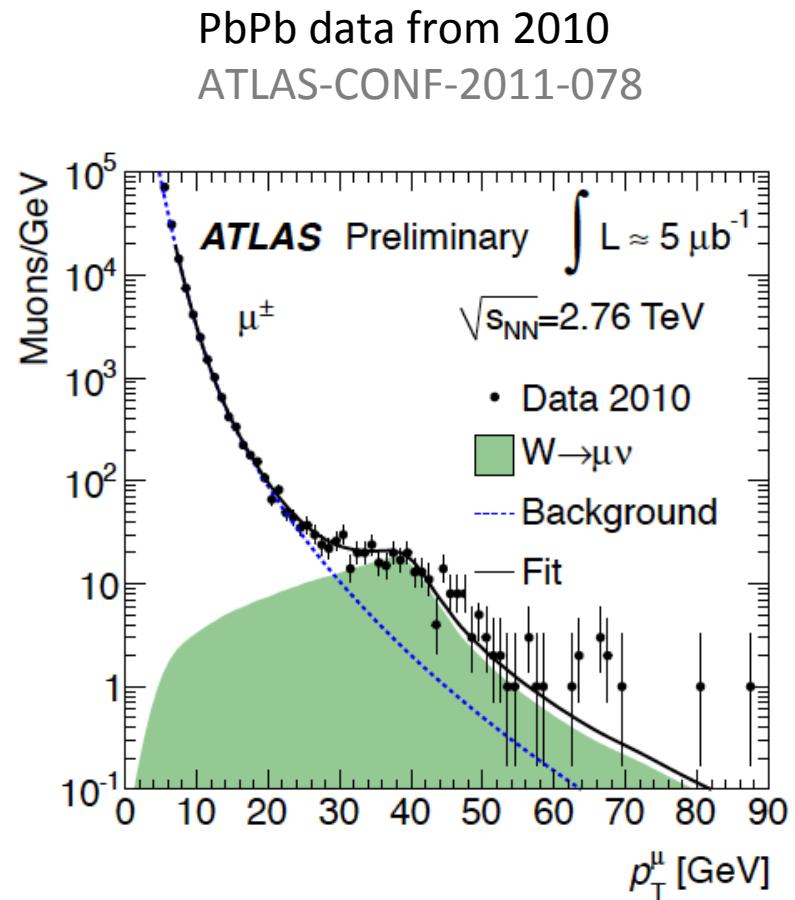
T_{AA} nuclear thickness function

Observation of W



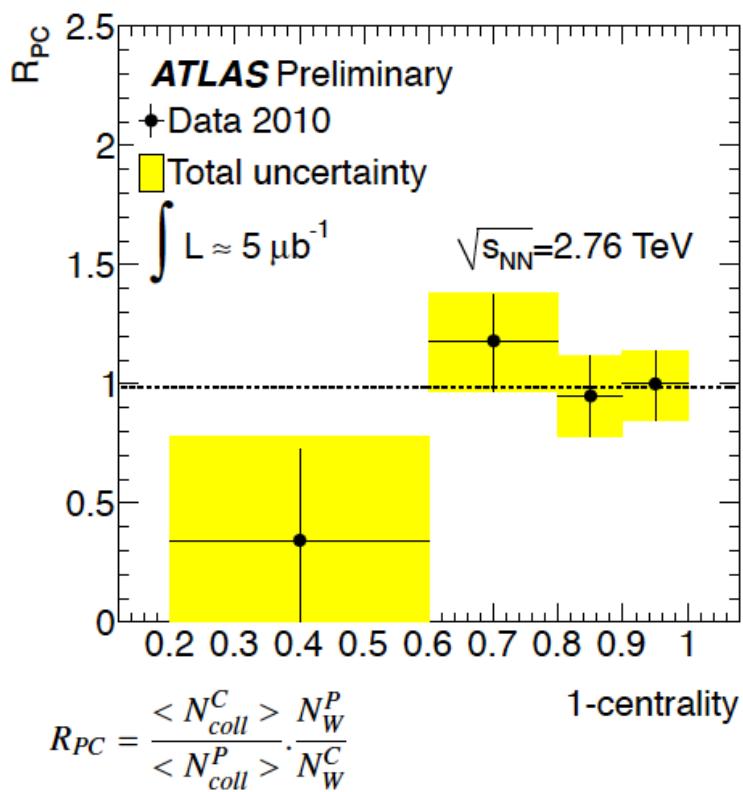
pp data from 2010
PRD85(2012)072004

Larger combinatorial background than in pp, but clear W signal in Pb-Pb collisions



Signal: parameterization based on PYTHIA (from pp for 2.76 TeV)
Background shape:
from cc and bb $\rightarrow \mu$ decays in pp

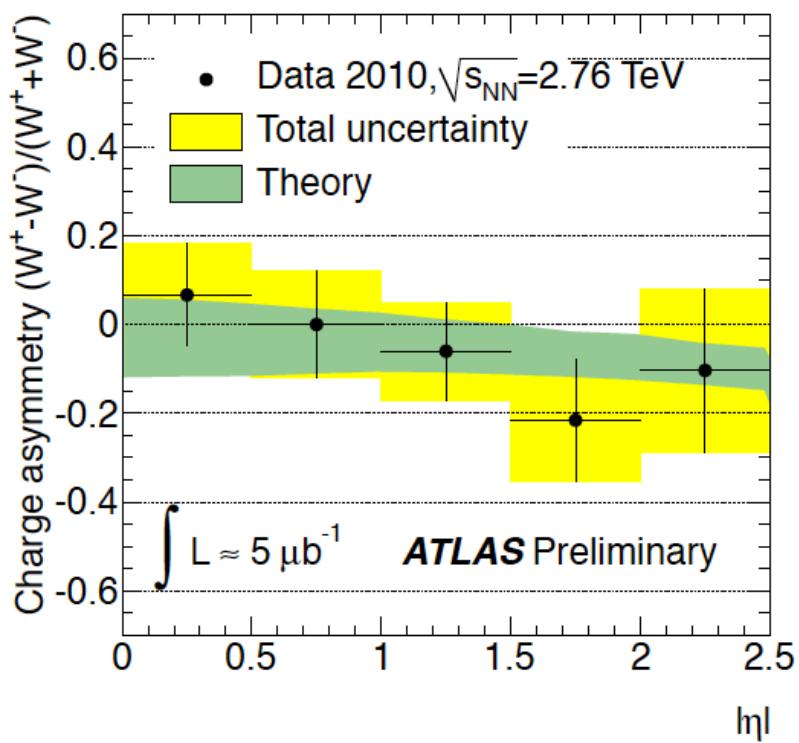
W Results



W bosons are produced at the initial phase of the collisions and do not interact with the medium, nor decay leptons

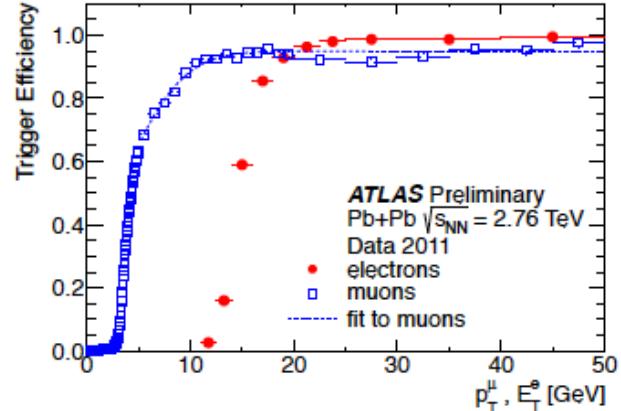
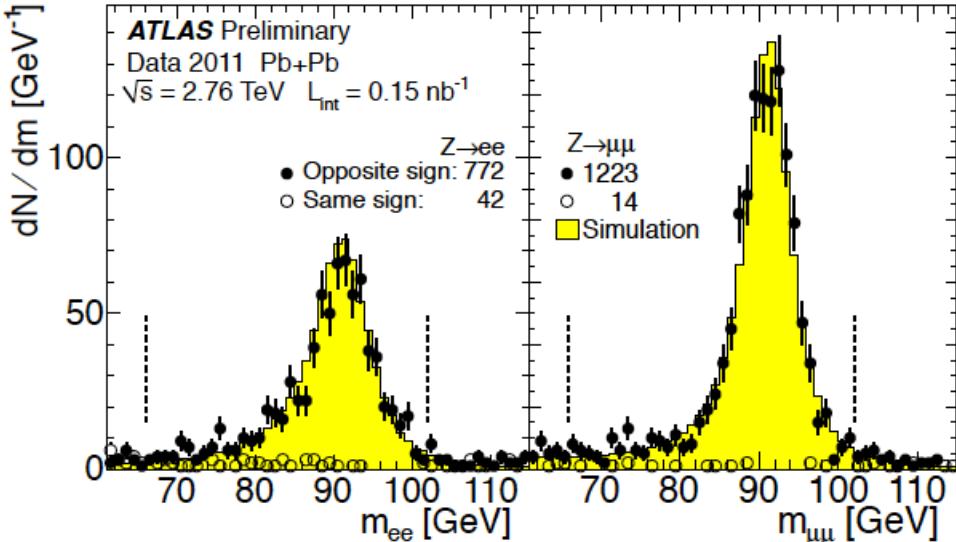
No significant charge asymmetry

W^+/W^- : pp: 1.65 ± 0.03 , nn: 0.62 ± 0.03
MSTW08 NNLO, 2.76 TeV



$$R_{W^+/W^-} = \frac{198^{+25}_{-26}}{204^{+27}_{-31}} = 0.97^{+0.18}_{-0.19}$$

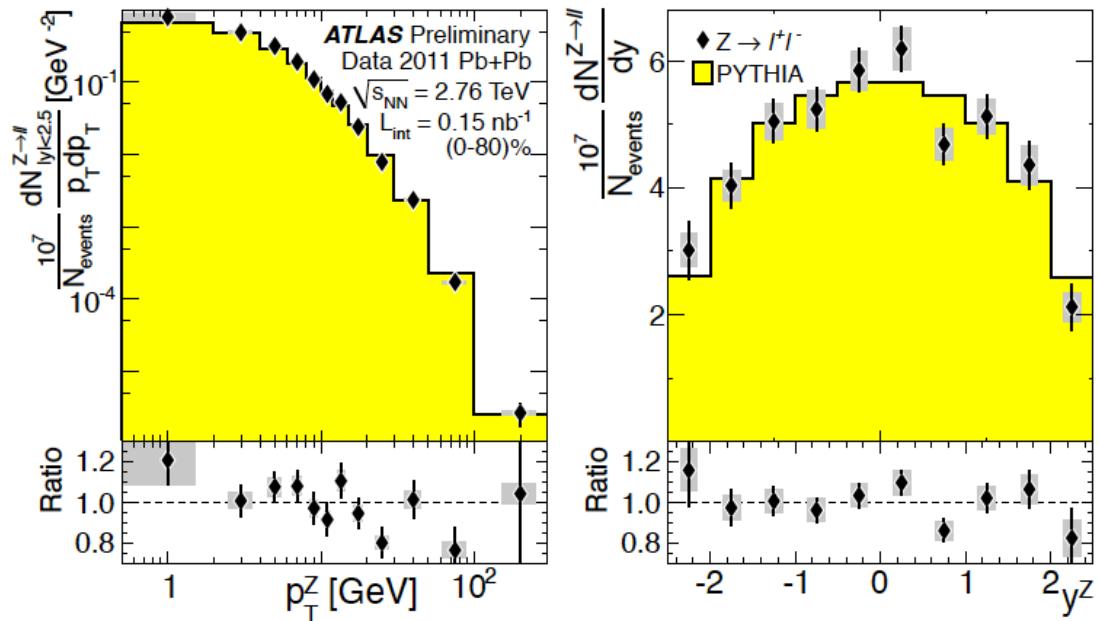
Z Observation and Cross Sections



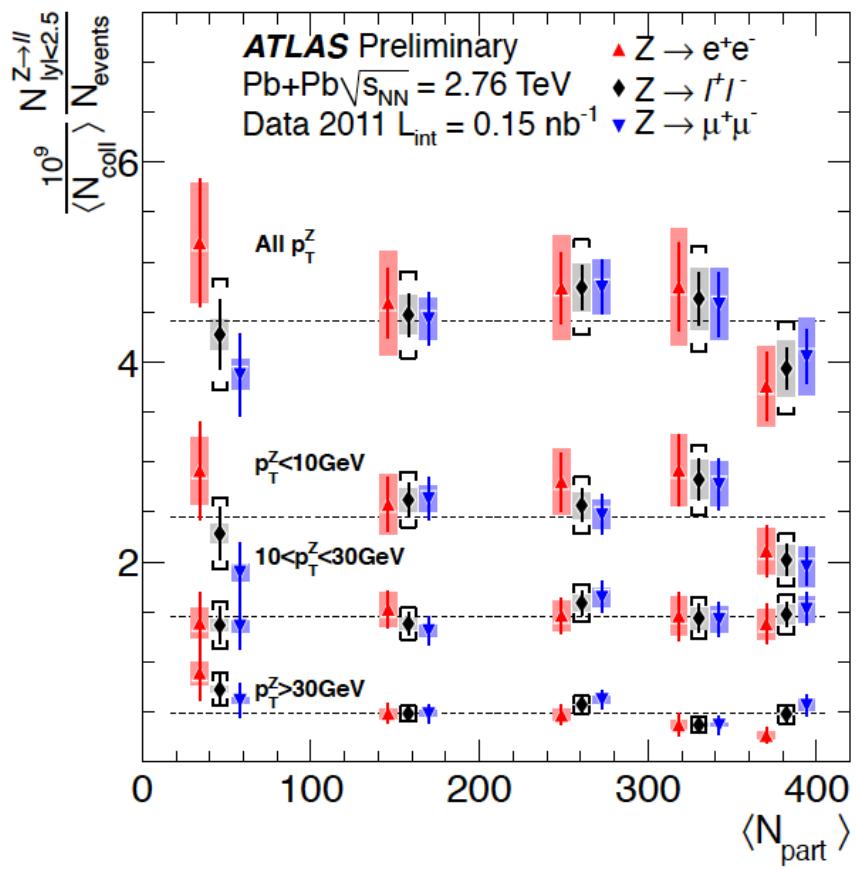
High e and μ trigger efficiency using adequate thresholds

Agreement with PYTHIA pp normalised to area

(shadowing corrections flat 30% in y up to 2.5 - R.Vogt PRC64(01)044901)

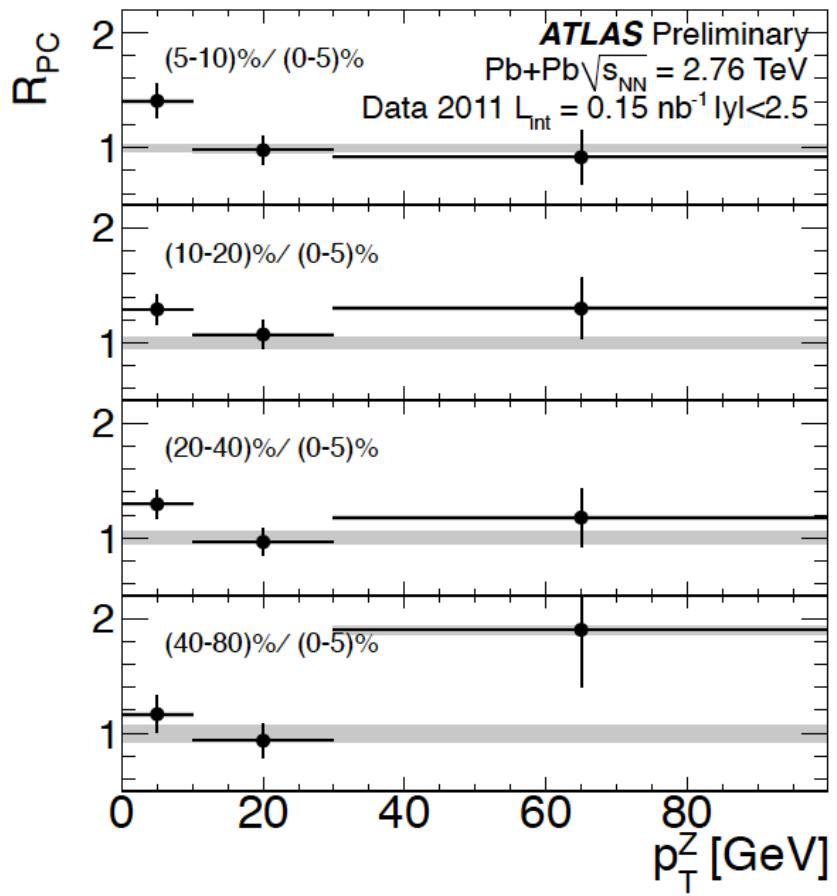


Z Results

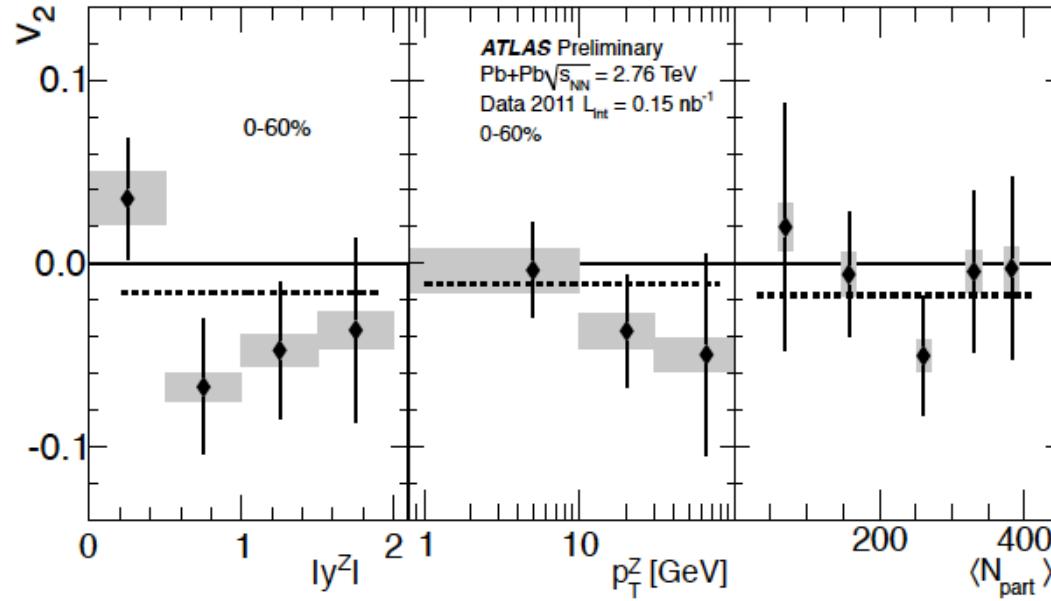


Consistent e and μ : binary scaling
 N_{part} obtained from MC Glauber model

No suppression of Z, as for W



Elliptic Flow of Z



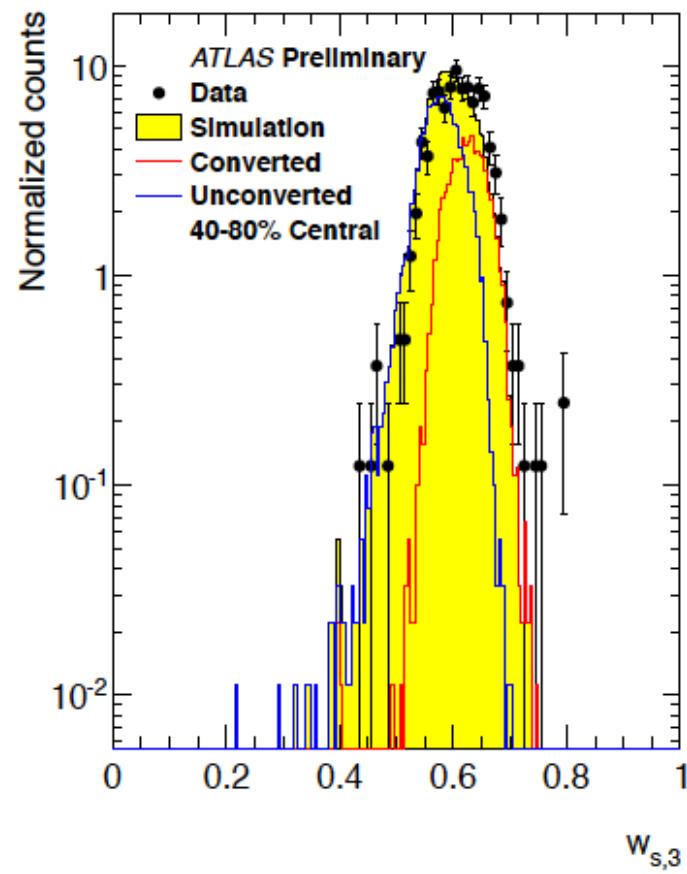
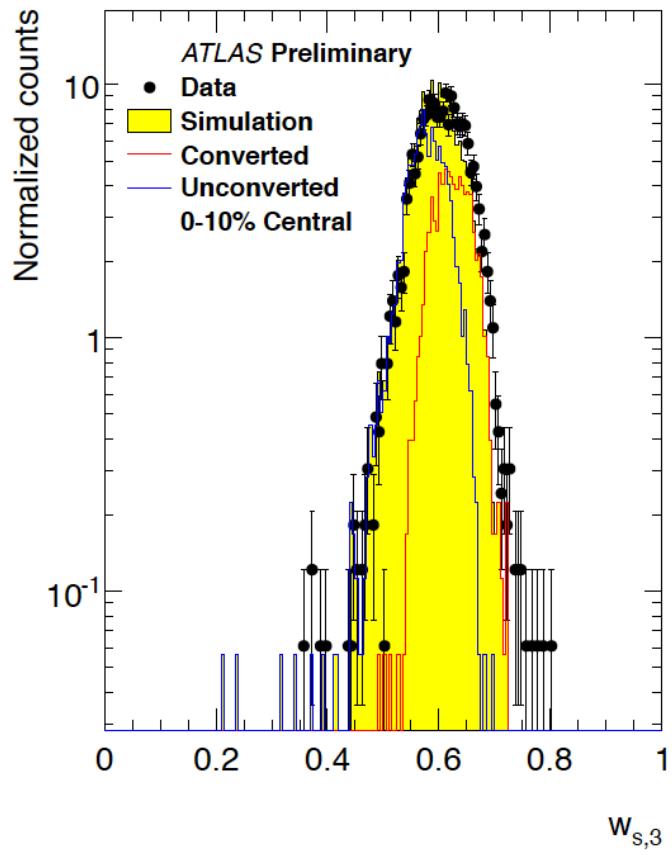
Elliptic flow of Z consistent with zero
Consistent with binary scaling.
Expected to be zero as Z decays
before the plasma is formed ...

$$\frac{dN}{d\Phi_Z} \propto \sum_n [1 + v_n \cos(n(\Phi_Z - \Phi_{EP}))]$$

Φ_Z boson azimuthal emission angle
 Φ_{EP} event plane azimuth

Photon Observation

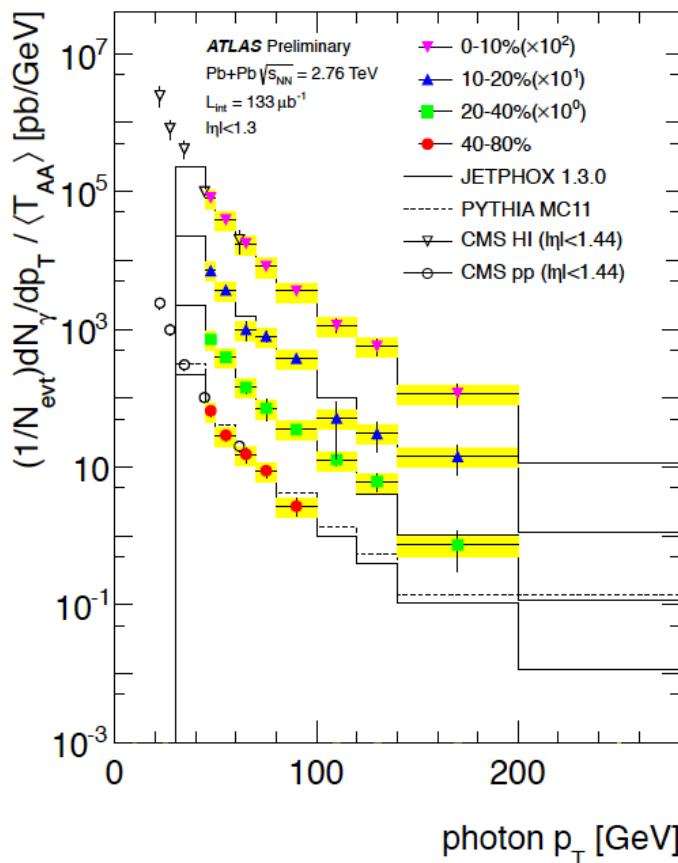
Isolation, double sideband method to remove jet contribution, D/MC ϵ corrections..



Shower shape agrees with simulation. $w_{s,3} - \eta$ width in layer 1 (strip units)

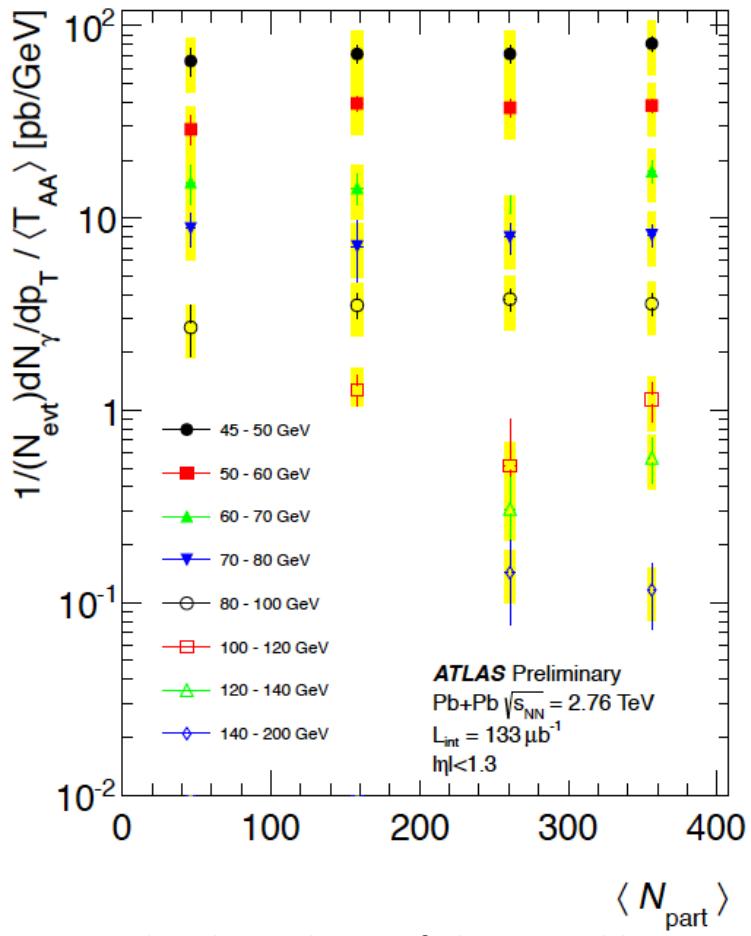
Photon Results

Prompt photon p_T in extended range.
 Rather independent of centrality.
 Good agreement with JETPHOX, pp



JETPHOX: NLO CTEQ6.6, no nuclear corrections, ..
 P. Aurenche et al., PRD 73, 094007 (2006)

Binary scaling of prompt photon production



Centrality dependence of photon yield per event scaled by average nuclear thickness of that bin,
 $\langle T_{AA} \rangle = \langle N_{\text{coll}} \rangle / \sigma_{\text{pp}}$

Summary

W^\pm and Z,γ have been observed in lead-lead collisions with ATLAS based on data taken in 2010, with 0.005nb^{-1} , and 2011, with 0.15nb^{-1}

Their properties, within the uncertainties (mainly stat γ , W and syst Z), can be reproduced with JETPHOX and PYTHIA, based on pp at 2.76 TeV.

The charge asymmetry in $W \rightarrow l\nu$ is found to be consistent with zero.

Binary scaling, the absence of suppression effects and a zero elliptic flow (measured for the Z) are consistent with the W,Z bosons to not be affected by the hot, dense state.

One can therefore expect that W and Z measurements in HI at the LHC will become useful to unfold nuclear effects in the parton distributions. $W,Z + \text{jets}$ will become interesting testing ground for QCD in HI.