Jet fragmentation, electro-weak boson, and charmonium production in pp and p-Pb

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Motivation

• Study nuclear modification of PDFs
• Benchmark for studies of AA collisions
• Search for final state effects, normally attributed to QGP (?)
Datasets

**p-Pb @ 5 TeV**

- ATLAS Online Luminosity
- \( \sqrt{S_{NN}} = 5.0 \text{ TeV} \)
- LHC Delivered (p+Pb)
- ATLAS Recorded
- Total Delivered: 31.2 nb\(^{-1}\)
- Total Recorded: 29.8 nb\(^{-1}\)

**pp @ 2.76 TeV**

- ATLAS Online Luminosity
- LHC Delivered All
- LHC Delivered Stable
- ATLAS Ready Recorded

28.1 nb\(^{-1}\) ± 2.7%

3.9 pb\(^{-1}\) ± 3.1%
Electroweak Bosons
W and Z bosons

W measured in muon channel

Z measured in electron and muon channels.
Z boson cross-section

- Hints of excess on Pb-going side
- Otherwise consistent with calculations
- Uncertainties limit discrimination power of different PDFs and nuclear effects
W boson cross-section

- Hints of excess on the Pb-going side (specially W-)
- Otherwise consistent with calculations with CT10 PDF
- Asymmetry well reproduced
Centrality determination

- Uses forward calorimeters on the Pb-going side
- Glauber model, and extensions used to determine mean number of participants
- Analysis assumes no correlation between hard scattering and soft underlying activity
Centrality bias correction

- Estimate of impact of correlation between hard scattering and soft underlying event from model [arXiv:1412.0976] and data.

**ATLAS**

p+Pb 2013, $L_{\text{int}} = 29 \text{ nb}^{-1}$

$\sqrt{s_{\text{NN}}} = 5.02 \text{ TeV}$

**Bias Correction Factor**

- Data Driven Calculation
- Model Calculation, Glauber ($\omega_s=0$)
- Model Calculation, GGCF $\omega_s=0.11$
- Model Calculation, GGCF $\omega_s=0.2$

**Centrality Bin**

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Z boson, centrality dependence

- Reasonable scaling observed with standard Glauber model + centrality bias correction

- Some hints of slope in Glauber-Gribov extensions that include colour fluctuations
**W boson, centrality dependence**

- Reasonable scaling observed with standard Glauber model + centrality bias correction

- Some hints of slope in Glauber-Gribov extensions that include colour fluctuations
ATLAS

$p+\text{Pb} 2013, L_{\text{int}} = 29 \text{ nb}^{-1}$

$\sqrt{s_{\text{NN}}} = 5.02 \text{ TeV}$

$-3.0<y_{z}^{*}<2.0$

Glauber ($\omega_{A} = 0$)

Data

$\langle N_{\text{coll}} \rangle$ Uncertainty

Data (No Bias Correction)

CT10 (NLO)

$10^{3}N_{Z}(\langle N_{\text{coll}} \rangle^{-1}N_{\text{pPb MB}})$

Glauber ($\omega_{A} = 0$)

CT10 Data

$W^{+}$

$W^{-}$

$W^{+, W^{-}}$

No Bias Correction

$\langle N_{\text{coll}} \rangle$ Uncertainty

GGCF $\omega_{A} = 0.11$

GGCF $\omega_{A} = 0.2$

$\langle N_{\text{part}} \rangle$
Charmonium
2D fit to mass and pseudo-lifetime

- Maximum likelihood fit to extract yields and fraction from $b$-hadron decays
- Event-by-event weighting for acceptance, reconstruction, and trigger efficiencies
  \[ w_{\text{total}}^{-1} = A \cdot \varepsilon_{\text{reco}} \cdot \varepsilon_{\text{trig}} \]
\[ R_{p\text{Pb}} = \frac{1}{\langle T_{p\text{Pb}} \rangle_{\text{cent}}} \frac{1/N_{\text{evt}} \, d^2 N_{\psi}^{p+\text{Pb}}/dy^* dp_T}{d^2 \sigma_{\psi}^{pp}/dy dp_T} \]

**Prompt \( J/\psi \)**

ATLAS Preliminary

Glauber \((\omega_a = 0)\)

\( p+\text{Pb} \sqrt{s_{NN}} = 5.02 \text{ TeV} \)

**\( J/\psi \) from b**

ATLAS Preliminary

Glauber \((\omega_a = 0)\)

\( p+\text{Pb} \sqrt{s_{NN}} = 5.02 \text{ TeV} \)

After centrality bias correction, ratio is flat.
\[ R_{p\text{Pb}} = \frac{1}{\langle T_{p\text{Pb}} \rangle_{\text{cent}}} \frac{1/N_{\text{evt}}}{d^2 N_{\psi}^{p+\text{Pb}} / dy^* dp_T} \bigg|_{\text{cent}} \frac{d^2 \sigma_{\psi}^{pp}}{dy dp_T} \]

**Hint of centrality dependence**

**ATLAS Preliminary**

- $p+\text{Pb}$ $\sqrt{s_{\text{NN}}} = 5.02$ TeV
- $-1.5 < y^* < 1.5$
- $10 < p_T < 30$ GeV

Data

Data (No Bias Correction)
Use Z boson as a model independent reference of centrality
Prompt $J/\psi$ to Z ratio vs multiplicity

Flat ratio suggests no strong modification
$J/\psi$ from $b$ to $Z$ ratio vs multiplicity

$N^J/N^Z$

10 < $p_T^\psi$ < 30 GeV
-1.5 < $y^\psi$ < 1.5
-3.0 < $y_Z$ < 2.0

**ATLAS** Preliminary

$p+\text{Pb} \sqrt{s_{NN}} = 5.02$ TeV

Non-Prompt $J/\psi$ to $Z$ ratio

Flat ratio suggests no strong modification
Prompt $\psi(2S)$ to Z ratio vs multiplicity

$N_{\psi}^Z / N_{\psi}$

10 < $p_T^\psi$ < 30 GeV
-1.5 < $y_{\psi}$ < 1.5
-3.0 < $y_Z$ < 2.0

ATLAS Preliminary
$p+$Pb $|\sqrt{s_{NN}}| = 5.02$ TeV

Prompt $\psi(2S)$ to Z ratio

Hint of suppression at high multiplicities
Jet fragmentation
Fragmentation functions in pp and pA collisions

- Jets reconstructed with anti-kT algorithm
- Fragmentation functions measured over wide jet pT range for charged particles with pT > 3.5 GeV
The ability of these generators to describe the data is in qualitative agreement with the comparisons of fragmentation functions at 7 TeV.
Ratio of p-Pb data to (extrapolated) pp reference

Clear enhancement at high-z for high-pT jets
Conclusions

• Electroweak bosons
  - Hints of excess on the Pb-going side
  - Reasonable scaling with Ncoll in the standard Glauber model, once bias correction applied

• Charmonium
  - Hint of suppression of excited state

• Jet fragmentation
  - Excess at high-z

Stay tuned: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/HeavylonsPublicResults
Looking forward for updated results with \textbf{5 TeV} pp data!
BACKUP SLIDES
Extrapolation

\[ D_{pp}(z)_{5.02\TeV} = D_{pp}(z)_{2.76\TeV} \times \frac{D_{\text{PYTHIA6}}(z)_{5.02\TeV}}{D_{\text{PYTHIA6}}(z)_{2.76\TeV}} \]
Forward-to-backward ratio

\[ R_{FB}(p_T, y^*) \equiv \frac{d^2\sigma(p_T, y^* > 0)/dp_Tdy^*}{d^2\sigma(p_T, y^* < 0)/dp_Tdy^*} \]

- Consistent with unity within uncertainties in both cases
- Consistent with expectations from calculations that include shadowing
Not reviewed, for internal circulation only

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Comparison with LHCb

- Combined data suggest strong kinematic dependence of nuclear effects