



W and Z production in forward region at LHCb

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on behalf of the LHCb collaboration

Introduction Cross Section Measurement (W,Z, Ratio) Outlook: PDF Sensitivity Conclusion Designed to look at CP violation in 14 TeV pp collisions at the LHC $\,$ in B decays Fully instrumented within 1.9 \leq η \leq 4.9

Overlap with Atlas/CMS: $1.9 \le \eta \le 2.5$ unique to LHCb: $2.5 \le \eta \le 4.9$



Experiment

- $Z \rightarrow \mu\mu$, $W \rightarrow \nu\mu$: clean signature
- easily recontructable final state
- low statistical and systematic errors

Theoretical predictions

- Cross-sections known to NNLO to 1%
- PDF uncertainty dominates at large rapidities 1% at y <2, 6-8% at y~5

 \rightarrow Cross section measurement at LHCb can constrain PDFs at large y

Uncertainty from parton density functions (PDF)



Cancel or highlight PDF uncertainties with ratios

- R₊₋=dσ(W⁺)/dσ(W⁻) tests valence quarks: d_v/u_v ratio
- $A_w = (d\sigma(W^+) d\sigma(W^-))/(d\sigma(W) + d\sigma(W^-))$ tests valence quarks: difference btw. u_v and d_v
- $R_{WZ} = d\sigma(W^{+-})/d\sigma(Z)$ almost insensitive to PDFs
- and: many systematic errors cancel



Introduction



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$Z \rightarrow \mu\mu$ selection



 ϵ^{z} : Acceptance and efficiencies (trigger, muon identification, track, selection) Acceptance = 1 in given kinematical range Efficiencies estimated from data



φ -z view (Radius=z)



Background: $Z \rightarrow \mu\mu$ (1 μ in acceptance) $Z \rightarrow \tau\tau$ (data+simulation) $W \rightarrow \tau\nu$ (simulation) QCD bkground (data+simulation)



Selection efficiency: $\epsilon_w = 55.0 \pm 1.0 \%$ from data, using Z events



Define

• Background: anti cuts

ip sig > 4 $p_{tcone} > 5 \text{ GeV}$ $m_{rest} > 40 \text{ GeV}$ $pt_{rest} > 5 \text{ GeV}$

signal very much supressed in this region

 Pseudo–W events: Z events with one muon removed

Use these event samples to estimate selection efficiency and purity

- Simulation: pseudo-W shape can be used to describe W
- Data: pseudo-W shape described by simulation
- Data: background and signal shapes look different
- Define cuts \rightarrow efficiency from data
- Get purity by fit to templates

W selection efficiency and purity

Impact parameter sign.

Mass in rest of event



* Background sample: no cut on variable which is investigated eg. M_{rest}

Selection efficiency for W $\epsilon_w = 55.0 \pm 1.0 \%$

Single muon trigger p_{T} > 10 GeV

Efficiency is flat in η , ϕ , p_{τ} .

No evidence for charge bias

 $\begin{array}{l} \varepsilon_w = 72 \ \pm \ 1\% \\ \varepsilon_z \ = 86 \ \pm \ 1\% \end{array}$



Method: tag and probe in Z sample Tag: identified muon track Probe: rough trajectory from muon and minimal tracking information





Efficiency flat in ϕ , $p_{T_{\tau}}$ two regions in η

$$\varepsilon_{W+} = 73 \pm 3\%$$

 $\varepsilon_{W-} = 78 \pm 3\%$
 $\varepsilon_{Z} = 83 \pm 3\%$
(+, - different average efficiency due to
different n distribution)

Method: tag and probe in Z sample Tag: identified muon Probe: identified track





Efficiency flat in ϕ , η , p_T No evidence of charge bias

 $\epsilon_{w} = 98.2 \pm 0.5\%$ $\epsilon_{z} = 96.5 \pm 0.7\%$

Results

$$\sigma_{Z \to \mu \mu} = \frac{N_{tot}^{Z} - N_{bkg}^{Z}}{\epsilon^{Z} L}$$



Fit muon p_T spectrum in data to expected shapes for signal and background, extract N_{bkg+} , N_{bkg-} Perform fit in η -bins for differential results



Results

W cross section



Sensitivity to low x quark content of the protons at high Q^2

Cracow Epiphany Conference Katharina Müller, 10. January 11

Compare results to MCFM NLO prediction (MSTW08)



All W,Z observations consistent with NLO predictions

Outlook

Uncertainty on PDF with LHCb data



Conclusions

- All W, Z observations consistent with NLO predictions
- Measurements complementary to ATLAS/CMS
- Luminosity uncertainty dominates for cross-sections
- W/Z ratio already now test SM to 6%



Outlook:

- Distinguish different PDF models
- Probe PDFs in previously unexplored region, expect significant improvement to gluon PDF
- 1 fb⁻¹ can improve PDF uncertainty significantly expect 1-5 fb⁻¹ next year: analyses limited by systematics.







Introduction

2010: 37.7 pb⁻¹ on tape 16.5 \pm 1.7 pb⁻¹ used for this analysis 2011: expect 1-5 fb⁻¹ of data

