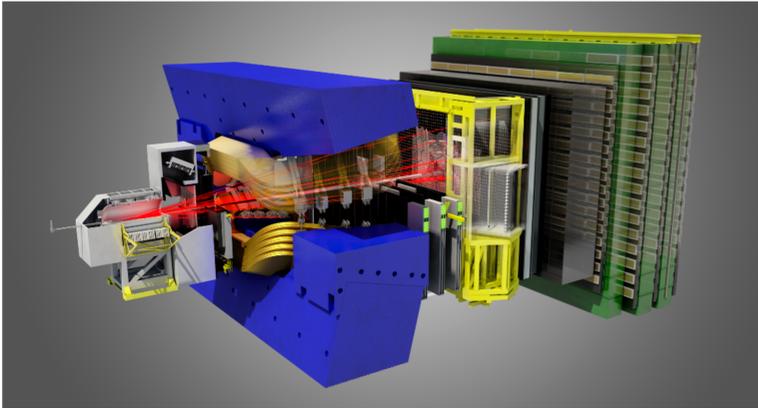


## Introduction

A measurement of the  $Z(\rightarrow \mu^+\mu^-) + \text{jet}$  production cross-section at  $\sqrt{s} = 7$  TeV is presented. The Z + jet cross-section in the forward region is sensitive to the PDFs at low Bjorken-x, and can be used to test different parametrisations. It also provides a benchmark measurement of a standard model process, validating jet reconstruction at LHCb [1].

## LHCb detector

The LHCb detector is a single-arm forward spectrometer covering the pseudorapidity range  $2.0 < \eta < 5.0$ , designed for the study of particles containing b or c quarks.



- ▶ Excellent tracking: resolution  $\delta p/p \sim 0.4\%$  at 5 GeV;
- ▶ Integrated luminosity:  $1.0 \text{ fb}^{-1}$  at  $\sqrt{s} = 7$  TeV (2011);
- ▶ Very stable running conditions with low pile-up (average 1.7 pp collisions per bunch crossing);

## Jet Reconstruction and Performance

### Jets Reconstruction

- ▶ FastJet implementation of the anti- $k_T$  with radius  $R = 0.5$ ;
- ▶ Particle Flow algorithm with inputs:
  - ▶ **Charged particles** - well reconstructed tracks from PV;
  - ▶ **Neutral particles** - energy deposits in the calorimeters not matched to tracks;
- ▶  $2 < \eta^{\text{jet}} < 4.5$ .

### Jet ID

- ▶ at least two tracks matched to the same PV;
- ▶ at least one track with  $p_T > 1.8$  GeV;
- ▶ no single particle with  $\geq 75\%$  of the jet's transverse momentum.

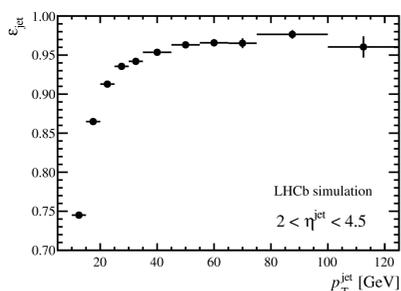


Figure 1 : Jet ID efficiency as function of the true jet  $p_T$ , as obtained from simulation.

### Jets Energy Correction

- ▶ correct the energy for detector effects with simulation;
- ▶ correction factor varies between 0.9 and 1.1;
- ▶ energy resolution typically 10 - 15 %.

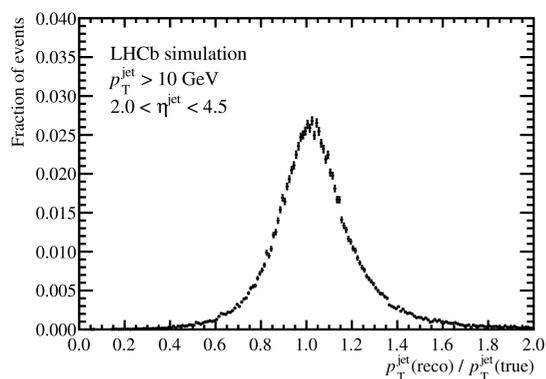


Figure 2 : Resolution of the jet transverse momentum in LHCb simulated data.

## Selection

- ▶ Trigger: at least 1 muon with  $p_T > 10$  GeV;
- ▶ Z boson requirements the same as for the inclusive measurement:
  - ▶ two reconstructed muons with  $p_T^\mu > 20$  GeV;
  - ▶ within acceptance  $2 < \eta < 4.5$ ;
  - ▶ invariant mass of the dimuon pair  $60 < M_{\mu\mu} < 120$  GeV;
  - ▶ in total 53182  $Z \rightarrow \mu^+\mu^-$  candidates are selected;
- ▶ Jet selection:
  - ▶ jet separated from Z muons decay:  $\Delta R > 0.4$ ;
  - ▶ jet within  $2 < \eta < 4.5$  and  $p_T > 10$  GeV or 20 GeV;
  - ▶ in total 10576 Z+jet events with  $p_T^{\text{jet}} > 10$  GeV are selected.

Energy scale validated in data: good agreement in  $p_T$  balance of selected back-to-back Z+jet events.

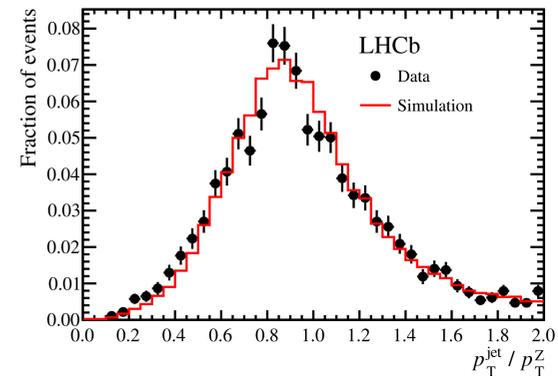
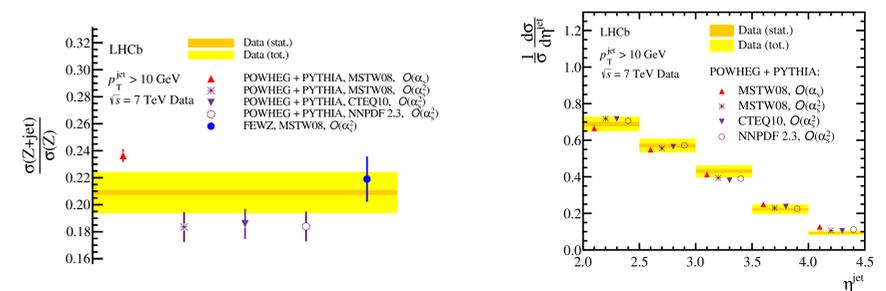


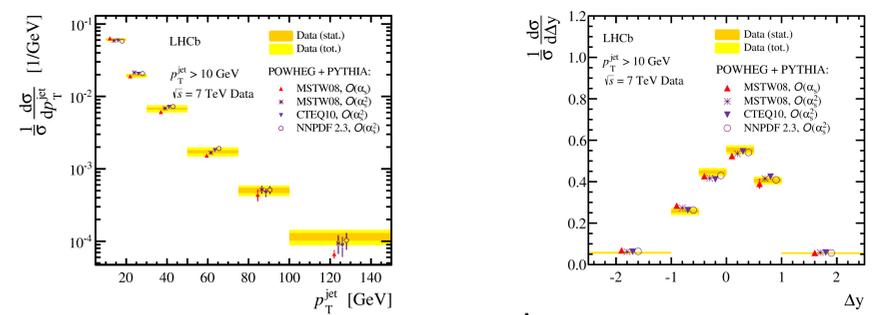
Figure 3 : Comparison between data (black points) and simulation (red line) in the  $p_T^{\text{jet}}/p_T^Z$  distribution for 1-jet events with Z and jet back-to-back.

## Results

Cross-section ratio  $\sigma(\text{Z+jet})/\sigma(\text{Z})$  measured at the Born level in QED (left) and differential in the leading jet pseudorapidity (right).



Differential cross-section in the leading jet  $p_T^{\text{jet}}$  (left) and in the difference in rapidity between the Z and the leading jet (right).



### Total cross-section $p_T^{\text{jet}} > 20$ GeV

$$\sigma(\text{Z+jet}) = 6.3 \pm 0.1(\text{stat.}) \pm 0.5(\text{syst.}) \pm 0.2(\text{lumi.})\text{pb,}$$

### Total cross-section $p_T^{\text{jet}} > 10$ GeV

$$\sigma(\text{Z+jet}) = 16.0 \pm 0.2(\text{stat.}) \pm 1.2(\text{syst.}) \pm 0.6(\text{lumi.})\text{pb,}$$

## Summary

The total and differential cross-sections are measured for Z+jet production, as a function of variables describing the jet and Z boson kinematic properties and correlations between them.

The measured cross-section shows reasonable agreement with expectation from  $\mathcal{O}(\alpha_s^2)$  calculations, for all the PDF parametrisations studied.

## Reference

LHCb collaboration.

Study of forward Z+jet production in pp collisions at  $\sqrt{s} = 7$  TeV. *J. High Energy Phys.*, 01(arXiv:1310.8197. LHCb-PAPER-2013-058. CERN-PH-EP-2013-198):033. 19 p, Oct 2013.