

Z PLUS JET MEASUREMENTS AT LHC*b*
AND WHAT THEY TELL ABOUT THE PROTON
JOINT ETH AND UNIVERSITY PH. D. SEMINAR
ZÜRICH, SWITZERLAND
ALBERT BURSCHÉ

August 27th 2012



**University of
Zurich**^{UZH}



OVERVIEW

INTRODUCTION

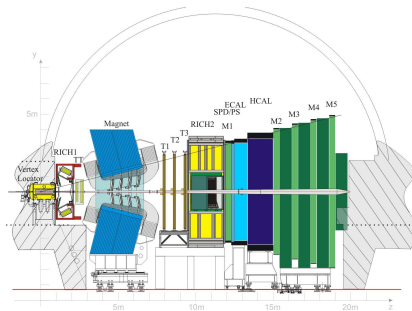
- Detector Overview
- Physics Motivation

MEASUREMENTS

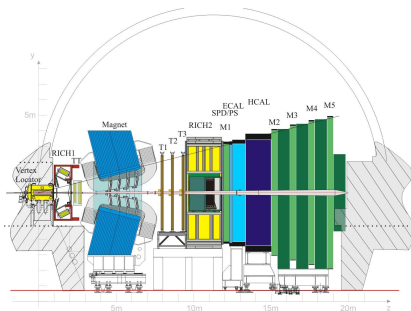
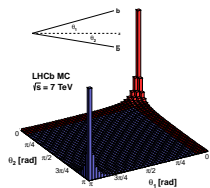
- Z^0 plus jets
- Electroweak Bosons and Charmed Hadrons

CONCLUSION

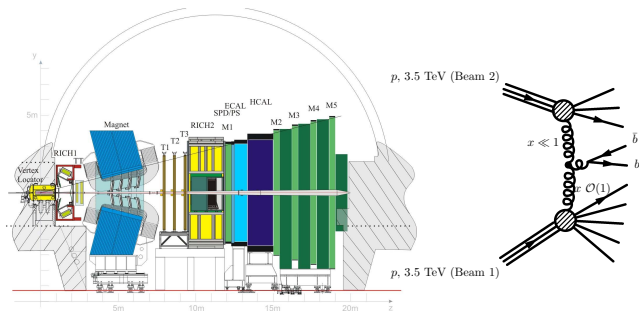
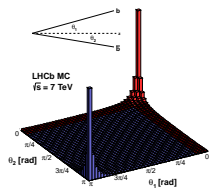
LHC*b*



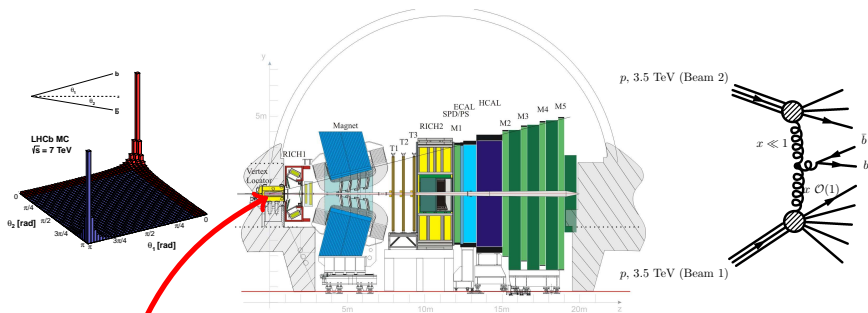
LHCb



LHCb

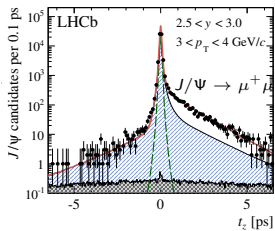
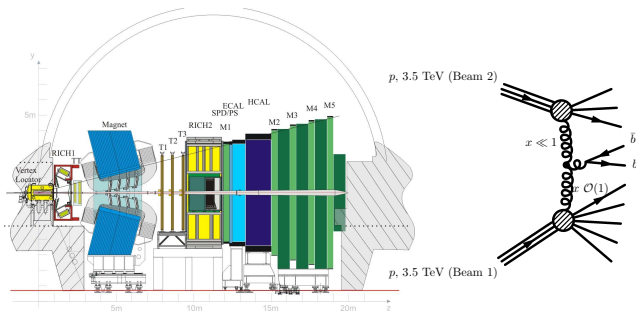
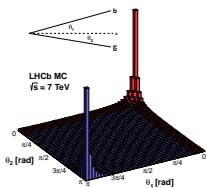


LHCb

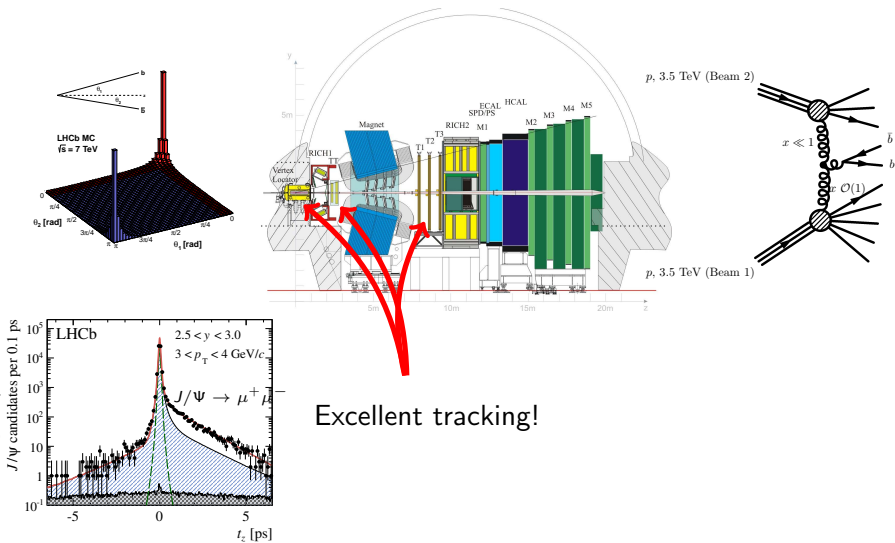


Excellent vertex detection with the Vertex Locator close to the Interaction region. (8mm)

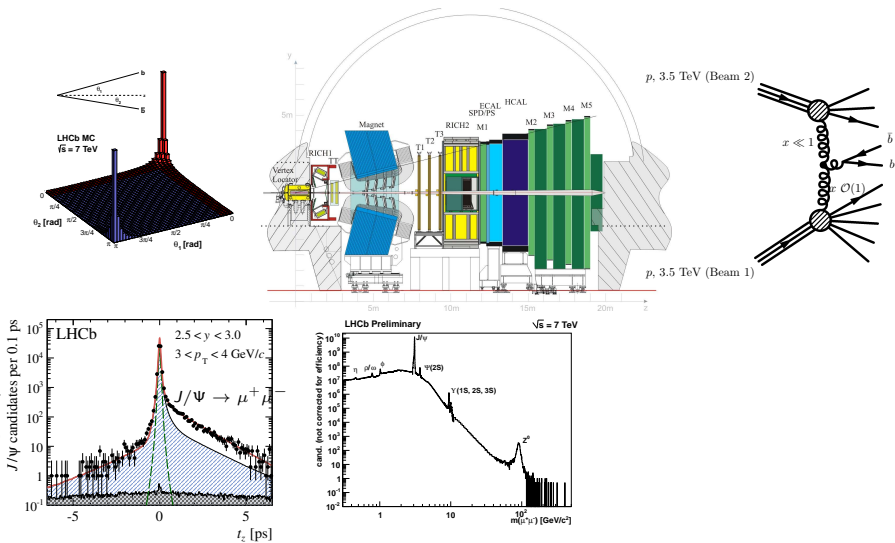
LHCb



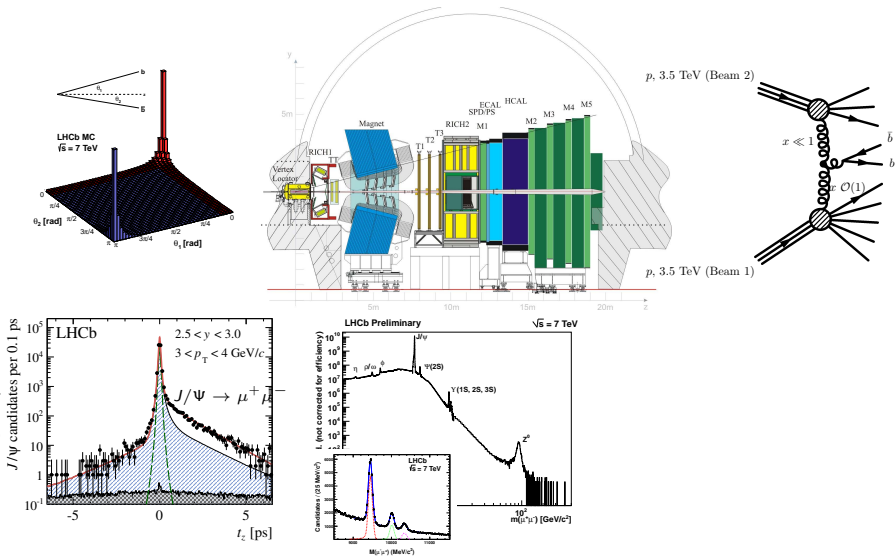
LHCb



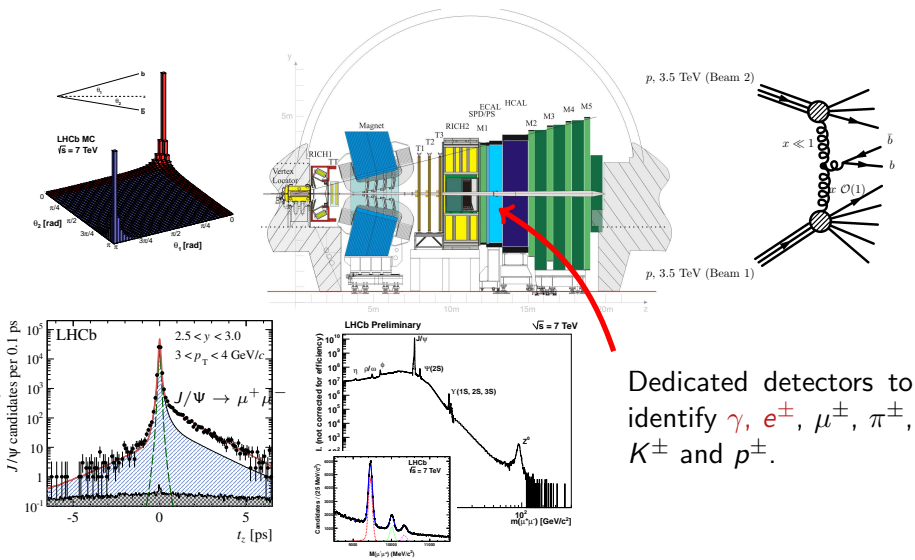
LHCb



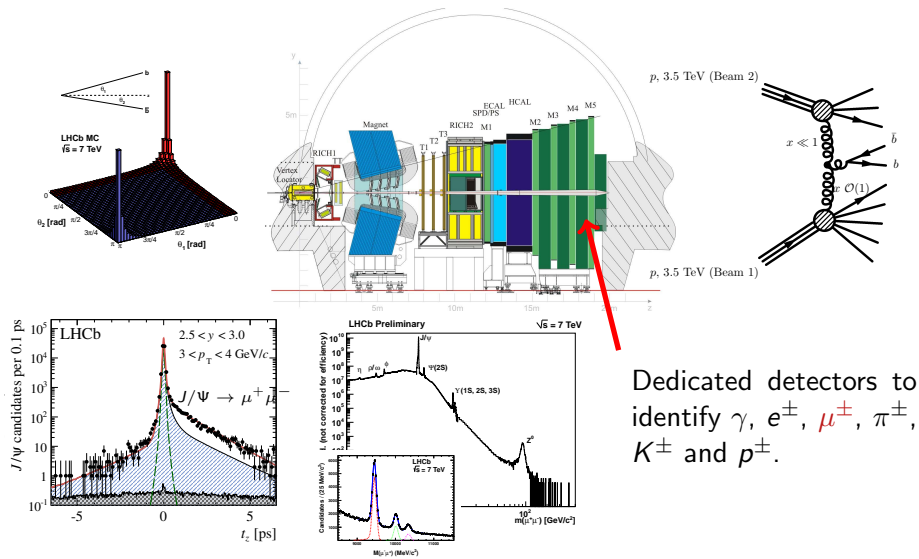
LHCb



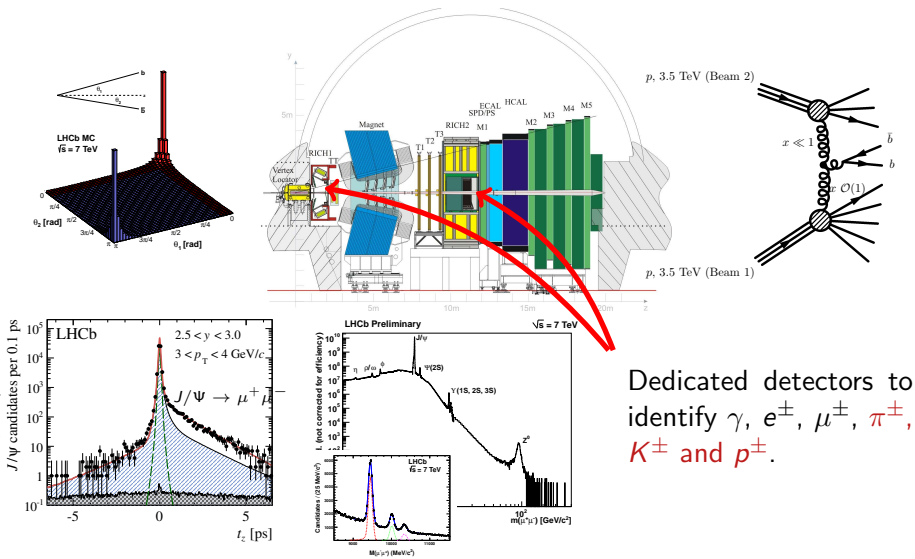
LHCb



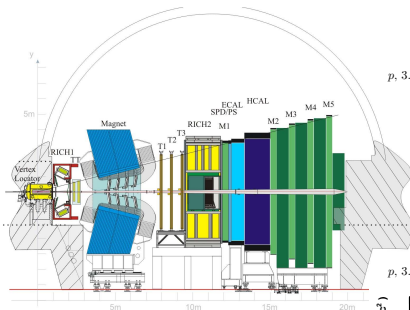
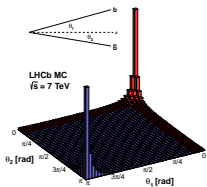
LHCb



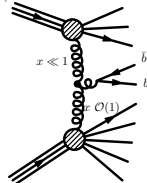
LHCb



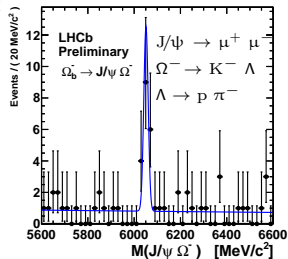
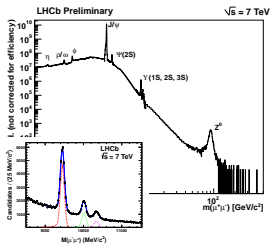
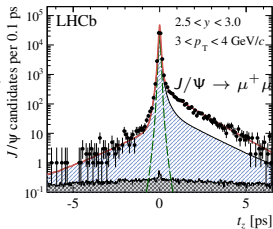
LHCb



p, 3.5 TeV (Beam 2)



p, 3.5 TeV (Beam 1)





LHCb:
COME TO WHERE THE FLAVOUR IS...

© Elizabeth Haslam

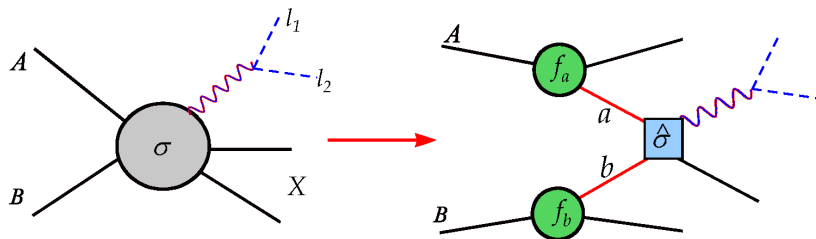
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QCD FACTORISATION THEOREM

$$\begin{aligned}\sigma(s, \tau)/\sigma_0(s) &= f_a \otimes \hat{\sigma}^{ab} \otimes f_b \\ &= \int \int dx_1 dx_2 \sum_{a,b} f_a(x_1, Q) \hat{\sigma}^{ab}(x_1 x_2 \tau, \alpha_s(Q)) f_b(x_2, Q)\end{aligned}$$

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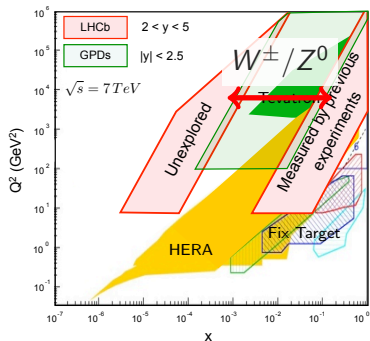


ELECTROWEAK GAUGE BOSONS



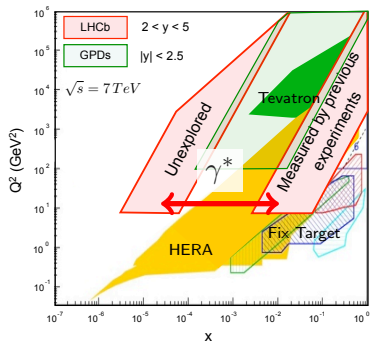
$$Q^2 = M^2, x_{1,2} = \frac{M}{\sqrt{s}} e^{\pm y}$$

ELECTROWEAK GAUGE BOSONS



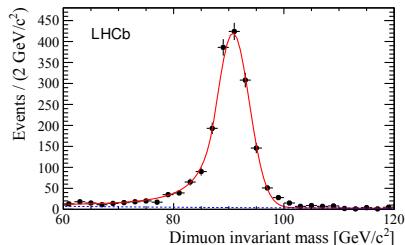
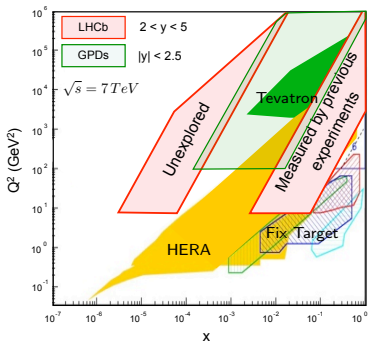
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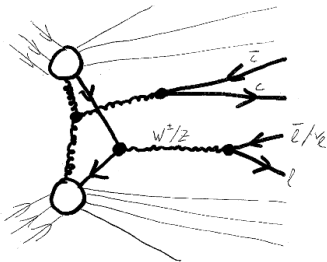
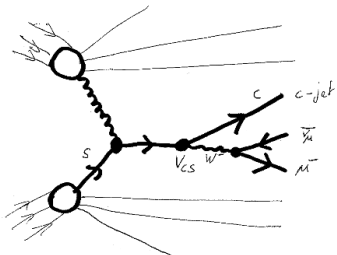
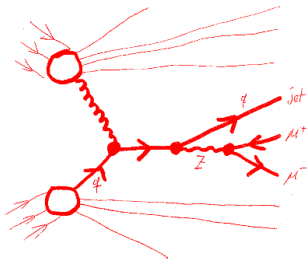
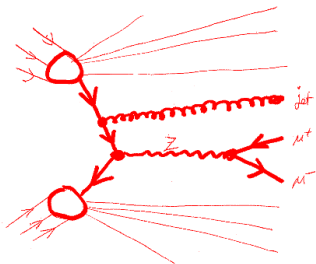
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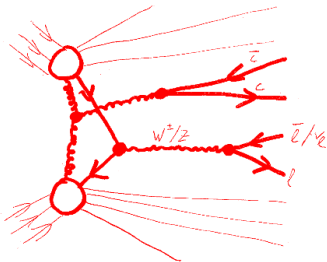
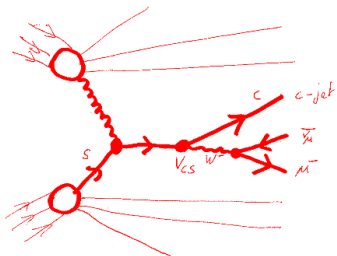
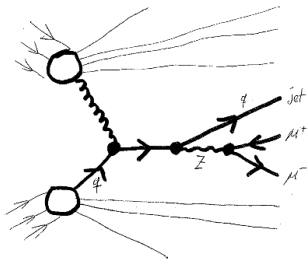
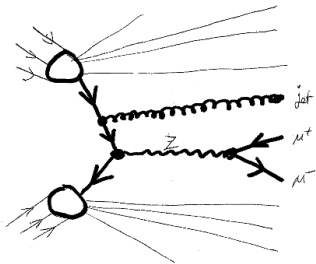
JHEP 2012, **6** (2012), 58,

DOI: 10.1007/JHEP06(2012)058

ASSOCIATED PRODUCTION



ASSOCIATED PRODUCTION



Z^0 PLUS JETS

INTRODUCTION

Detector Overview

Physics Motivation

MEASUREMENTS

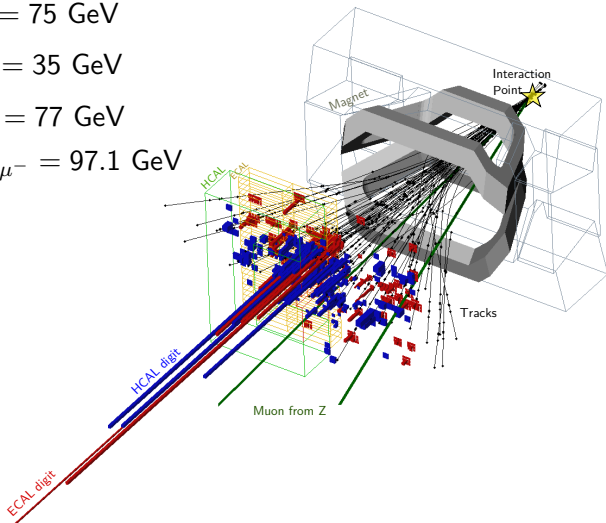
Z^0 plus jets

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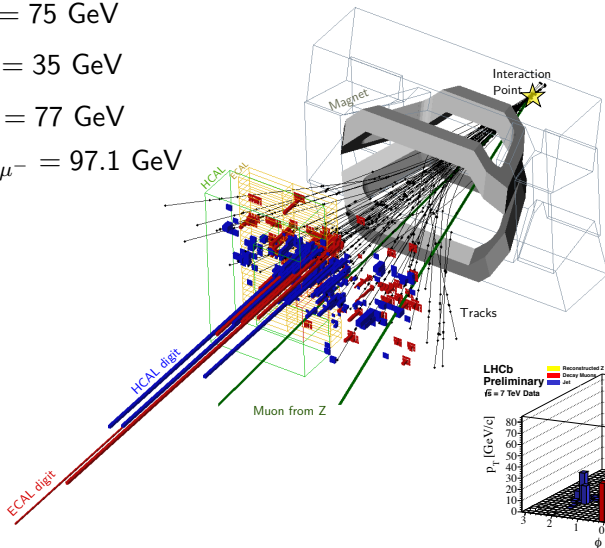
$Z^0 \rightarrow \mu\mu$ PLUS JET EVENT

- ▶ $p_T^{\text{jet}} = 75 \text{ GeV}$
- ▶ $p_T^{\mu^+} = 35 \text{ GeV}$
- ▶ $p_T^{\mu^-} = 77 \text{ GeV}$
- ▶ $m_{\mu^+\mu^-} = 97.1 \text{ GeV}$



Z⁰ → μμ PLUS JET EVENT

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JET DEFINITION

JET INPUT – PARTICLE FLOW

- ▶ Charged particles. Tracks with π^\pm mass hypothesis.
- ▶ Reconstructed neutral resonances (K_S^0 , Λ^0).
- ▶ Photons and π^0 s as reconstructed in the ECAL.
- ▶ Neutral hadrons from HCAL.

JET DEFINITION

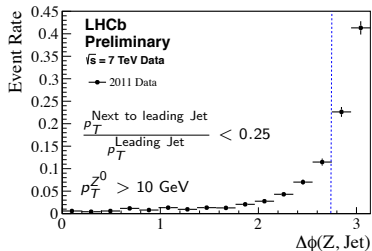
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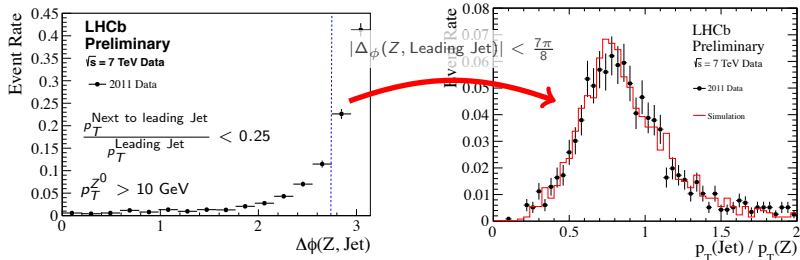
JET DEFINITION AND SELECTION

- ▶ Jets are clustered with the anti- k_T algorithm ($R=0.5$).
- ▶ The jets are reconstructed for each primary vertex.
- ▶ Corrected $p_T > 10$ GeV
- ▶ $2 < \eta^{\text{jet}} < 4.5$
- ▶ $\Delta R(\mu, \text{jet}) > 0.4$
- ▶ $Z^0 \rightarrow \mu\mu$ selection is the same as in the $Z^0 \rightarrow \mu\mu$ analysis.

JET ENERGY CORRECTION

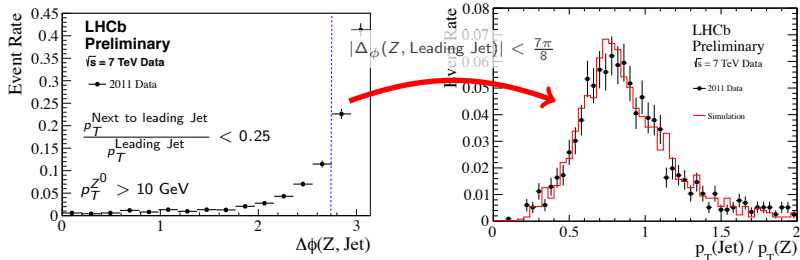


JET ENERGY CORRECTION



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JET ENERGY CORRECTION



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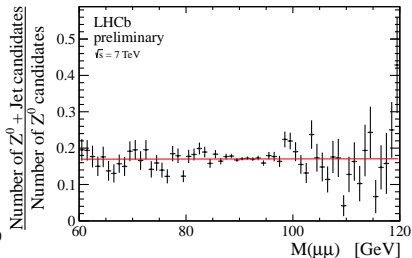
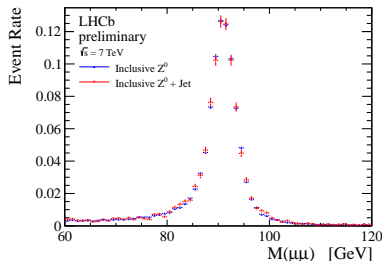
- ▶ Not all energy in the jet is reconstructed.
- ▶ The energy loss is well described by simulation.
- ▶ This is corrected by comparing to “hadron level” using simulation.

$Z^0 \rightarrow \mu\mu$ PLUS JET BACKGROUND ESTIMATION

Background is estimated by comparing $Z^0 \rightarrow \mu\mu$ events with $Z^0 \rightarrow \mu\mu$ plus jet events.

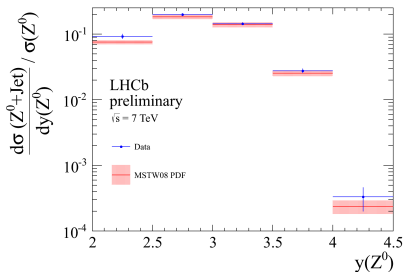
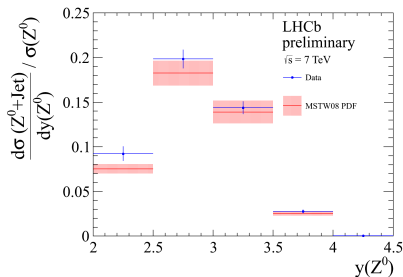
Z⁰ → μμ PLUS JET BACKGROUND ESTIMATION

Background is estimated by comparing Z⁰ → μμ events with Z⁰ → μμ plus jet events.



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Fit to ratio yields background *enhancement* compatible with zero.
 Background fraction: $3.3 \pm 0.6 \text{ ‰}$.

Z⁰ → μμ PLUS JET RAPIDITY DISTRIBUTION

Results are shown as ratios to the total inclusive $Z^0 \rightarrow \mu\mu$ cross section and compared to FEWZ+MSTW08 prediction.

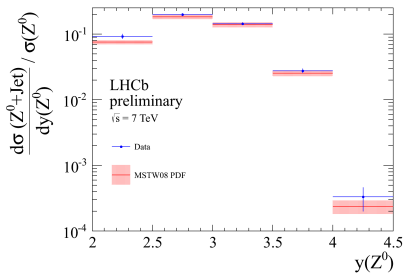
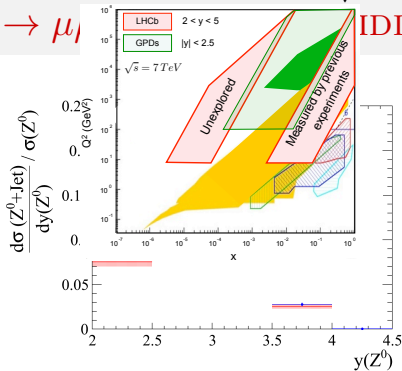
LHCb PRELIMINARY $\sigma_{Z+\text{jet}}/\sigma_Z = 0.229 \pm 0.011$

MSTW08+FEWZ $\sigma_{Z+\text{jet}}/\sigma_Z = 0.216^{+0.006}_{-0.009} \pm 0.016 \text{ (N)NLO}$

$$Q^2 = M^2, x_{1,2} = \frac{M}{\sqrt{s}} e^{\pm y}$$

 $Z^0 \rightarrow \mu\mu$

IDENTITY DISTRIBUTION

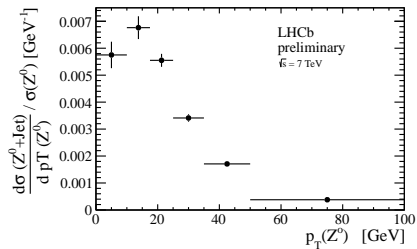


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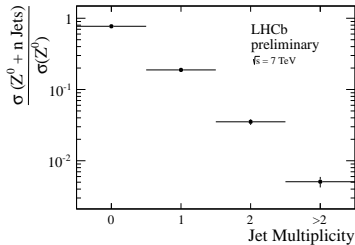
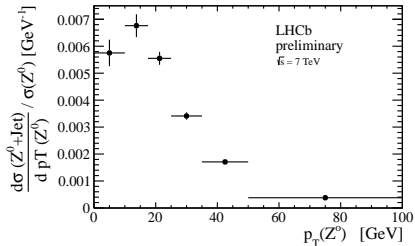
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$Z^0 + \text{JETS} - p_T$ DISTRIBUTION AND JET MULTIPLICITY



$Z^0 + \text{JETS} - p_T$ DISTRIBUTION AND JET MULTIPLICITY



LHCb-CONF-2012-016

ELECTROWEAK BOSONS AND CHARMED HADRONS

INTRODUCTION

Detector Overview

Physics Motivation

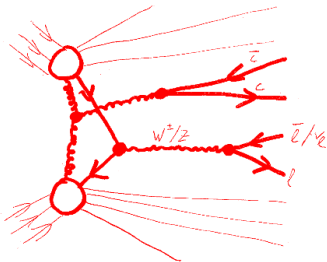
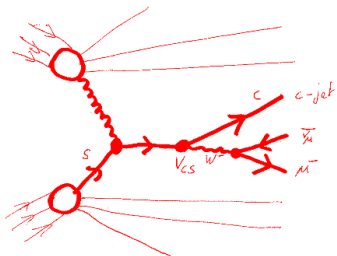
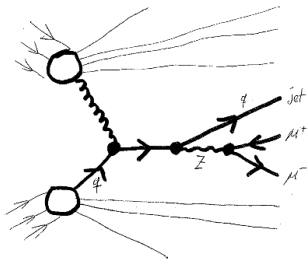
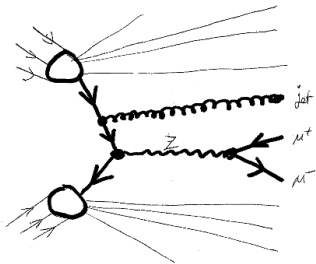
MEASUREMENTS

Z^0 plus jets

Electroweak Bosons and Charmed Hadrons

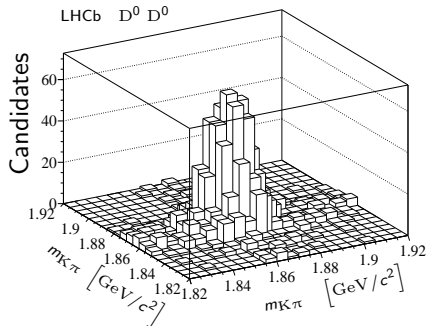
CONCLUSION

ASSOCIATED PRODUCTION



OUTLOOK

- ▶ c -hadron candidates are combined in pairs.
- ▶ A fit with the hypothesis of two prompt c -hadrons from the same primary vertex is performed.
- ▶ $\chi^2/n_{dof} < 5$ is required.
- ▶ Purity from fit to χ^2 distribution.
- ▶ Efficiencies mostly from data.

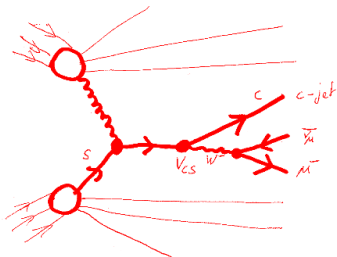


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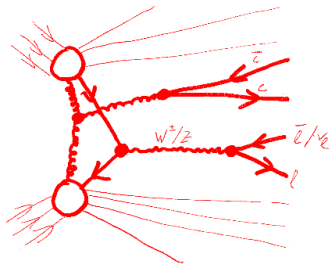
arXiv:1205.0975

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OUTLOOK



- ▶ Do the same with W/Z bosons
- ▶ Low statistics
- ▶ Different production processes with unknown fractions



- ▶ Low background in $Z+D^0$ events
- ▶ Difficult purity estimation for $W+D^0$ events
- ▶ The method from inclusive W measurements can't be used

CONCLUSION

- ▶ LHC*b* is not only about flavour physics
- ▶ The measurements using W and Z bosons done by LHC*b* help to understand the proton
- ▶ Good agreement between measurement and NNLO predictions for the Z plus jet production
- ▶ Reconstruction of charmed hadrons can shed light about the Strange and the Charm content in the proton

THANK YOU FOR YOUR ATTENTION

