LHCb electroweak results

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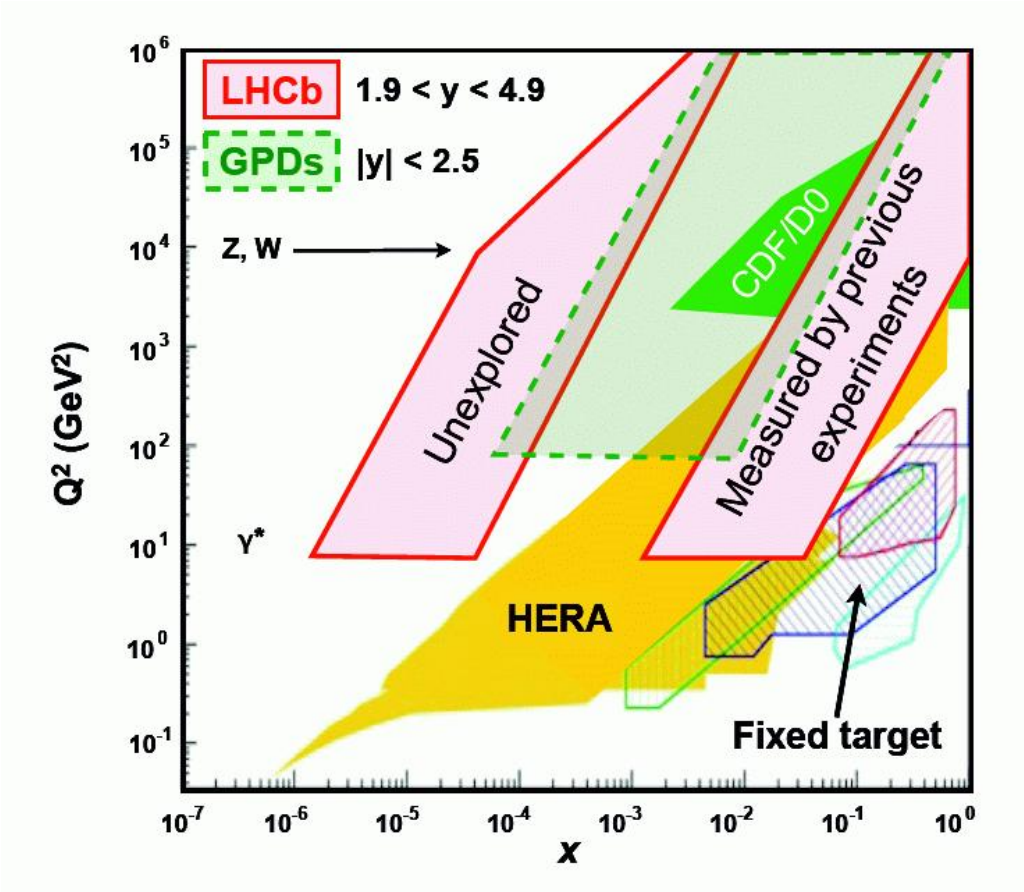
- Introduction
- W,Z cross-section measurements
- Low mass Drell Yan production
- Outlook for 2011/2012
- Conclusions

Note: only new (post winter conference) results will be shown.

Motivation
Dataset



LHCb probes two x-Q^2 regions:

Medium Q^2 (10'000 GeV^2):

- Z,W measurements: x= 5 x10^{-5}

Low Q^2 (25 GeV^2):

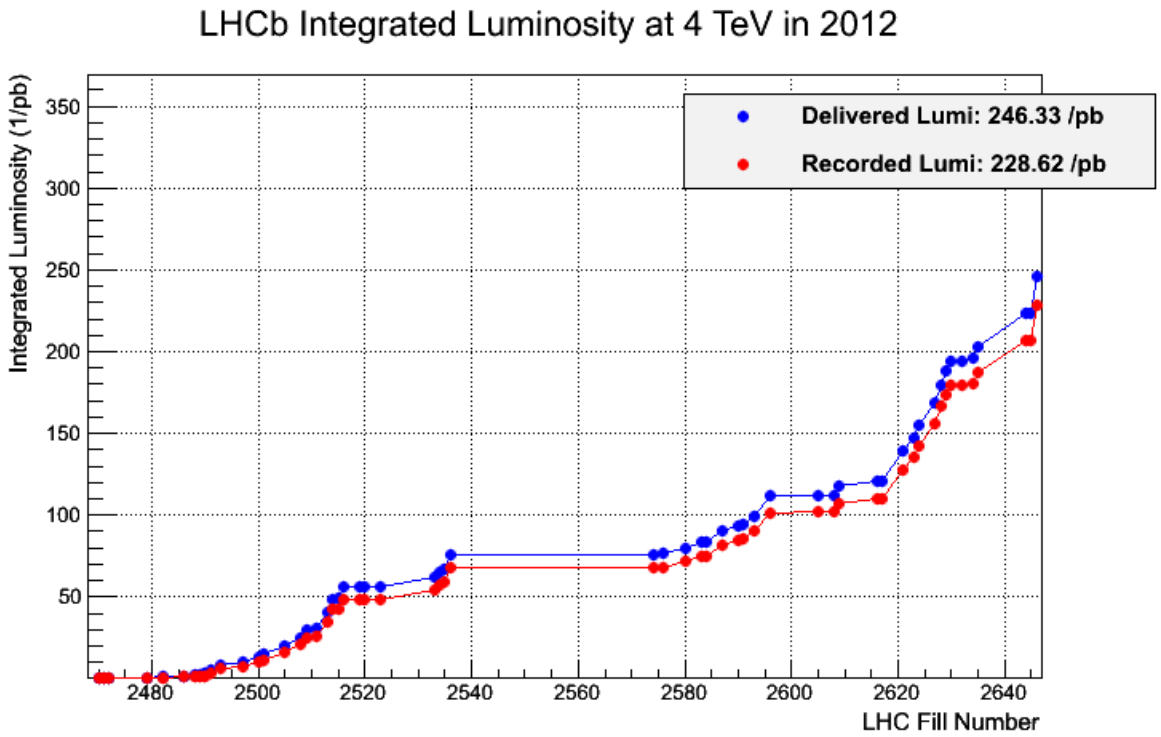
- Drell-Yan (γ*): x= 10^{-6}

Dataset

2010:
37.7 pb^{-1} data recorded

2011:
~1.1 fb^{-1} recorded

2012:
~230 pb^{-1} recorded



note: low average no. of interactions (~1.5) due to luminosity levelling

arXiv: 1204.1620 LHCb-PAPER-2012-008, submitted to JHEP

Trigger:

Single μ, $p_T > 10$ GeV

Muon:

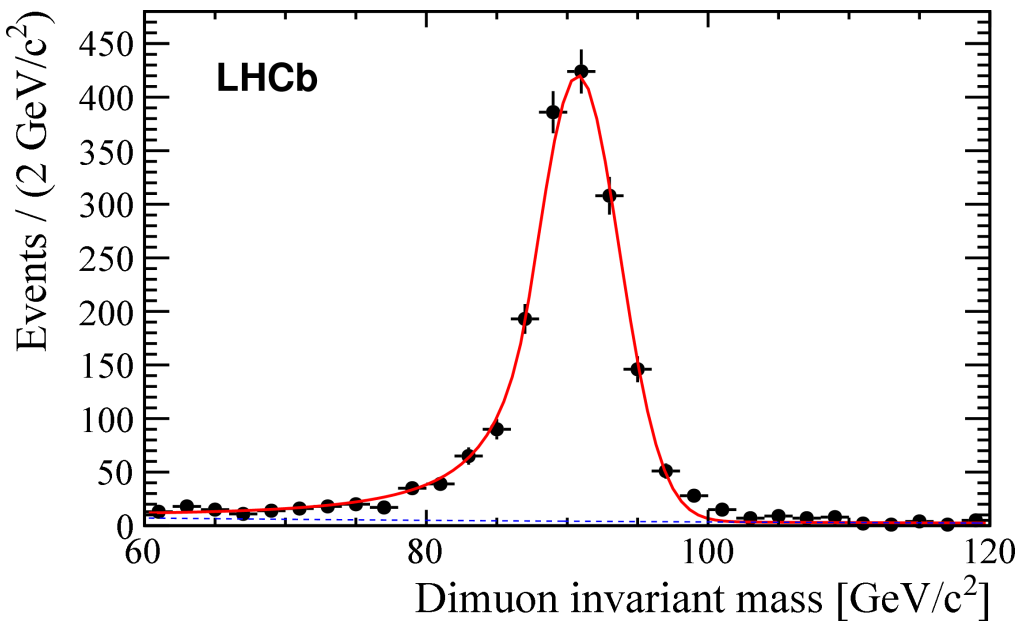
$p_T > 20$ GeV
$2.0 < \eta < 4.5$

Z:

$60 < M(\mu\mu) < 120$ GeV

Backgrounds:

- $Z \to \tau\tau$ (MC)
- W-pair (MC)
- Top-pair (MC)
- Heavy flavour (Data)
- K/π misid. (Data)



2010 data: L = 37 pb^{-1}
1966 candidates
4.8 background

LHCb-CONF-2012-011

Trigger:

Single e, p_T > 15 GeV

Electron:

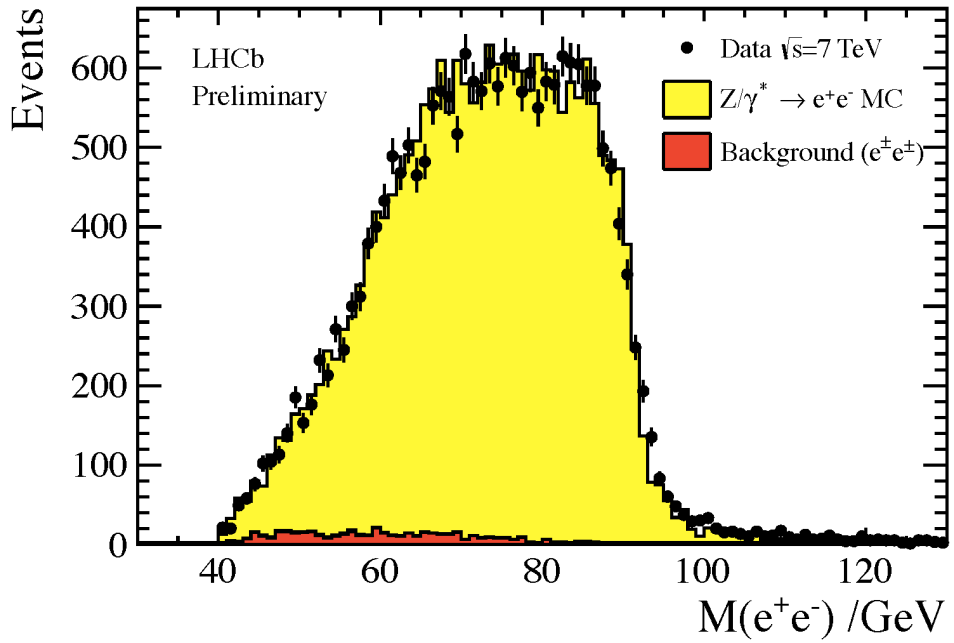
p_T> 20 GeV
2.0 < η < 4.5

Z:

M(ee) > 40 GeV

Backgrounds:

- Z→ττ (MC)
- Top-pair (MC)
- QCD (Data)



2011 data: L = 945 pb^{-1}
21535 candidates
473 background

arXiv: 1204.1620 LHCb-PAPER-2012-008, submitted to JHEP

Trigger:

Single μ, $p_T > 10$ GeV

Muon:

$p_T > 20$ GeV
$2.0 < \eta < 4.5$
Σp_T, $\Sigma E(\gamma)$ in $R=\sqrt{(\Delta\eta^2+\Delta\phi^2)}=0.5$ cone around $\mu < 2$ GeV
Unbiased impact parameter < 40 μm
E/p < 0.04
No other μ with $P_T > 2$ GeV

Backgrounds:

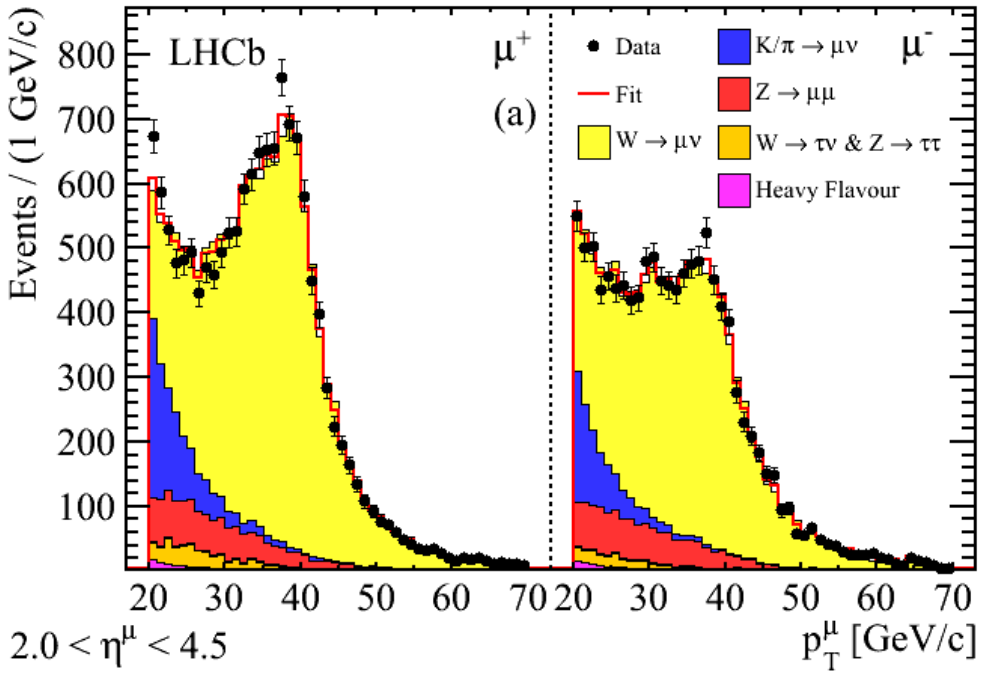
- Electroweak (W, Z/γ)
- QCD (heavy flavour, decay in flight)

2010 data: L = 37 pb^{-1}
$N_+ = 14\,660$
$N_- = 11\,618$

Fit muon p_T spectrum in data to expected shapes for signal and background, extract N_{W+}, N_{W-}

Shape	Source
W →μν	Simulation
K/π decay in flight	Data
γ*/Z→μμ	Simulation/Data
W→τν , Z→ττ	Simulation/Data
Heavy Flavour	Data

Normalisation
- Signal and decay in flight: fitted
- Others : data driven methods



W+ (W-) Purity: 78.8% (78.4%)

Efficiencies: all determined from data.

Precision:

	Z→ μμ	Z→ ee	W→ μν W+/W-
Statistical	2.2%	0.7%	1.1/1.2%
Luminosity	3.5%	3.5%	3.5%
Systematic	4.3%	3.1%	3.2/2.9
Luminosity[pb]	37.5	945	37.5

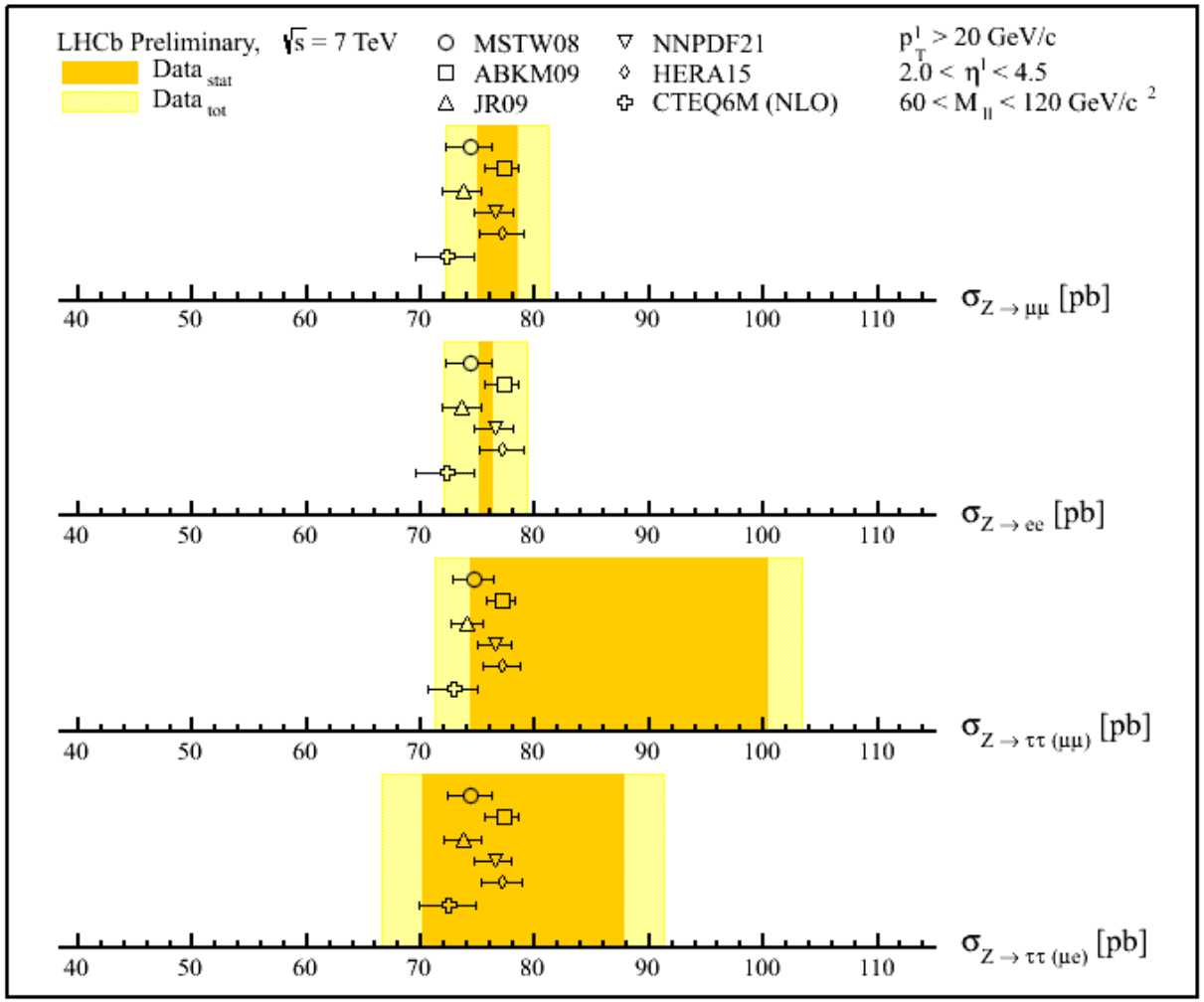
Systematic uncertainties will reduce with more statistics

Dominant sources:

- Efficiencies
- Purity for W analysis
- Z→ μμ : limited by efficiency uncertainty (statistical)
- Z→ ee , W→ μν: luminosity uncertainty

arXiv: 1204.1620
LHCb-CONF-2012-011
LHCb-CONF-2011-041

NNLO (DYNNLO) PDF uncertainties at 68% CL



Z→μμ

Z→ee

Z→ττ (μμ)

Z→ττ (eμ)

arXiv: 1204.1620
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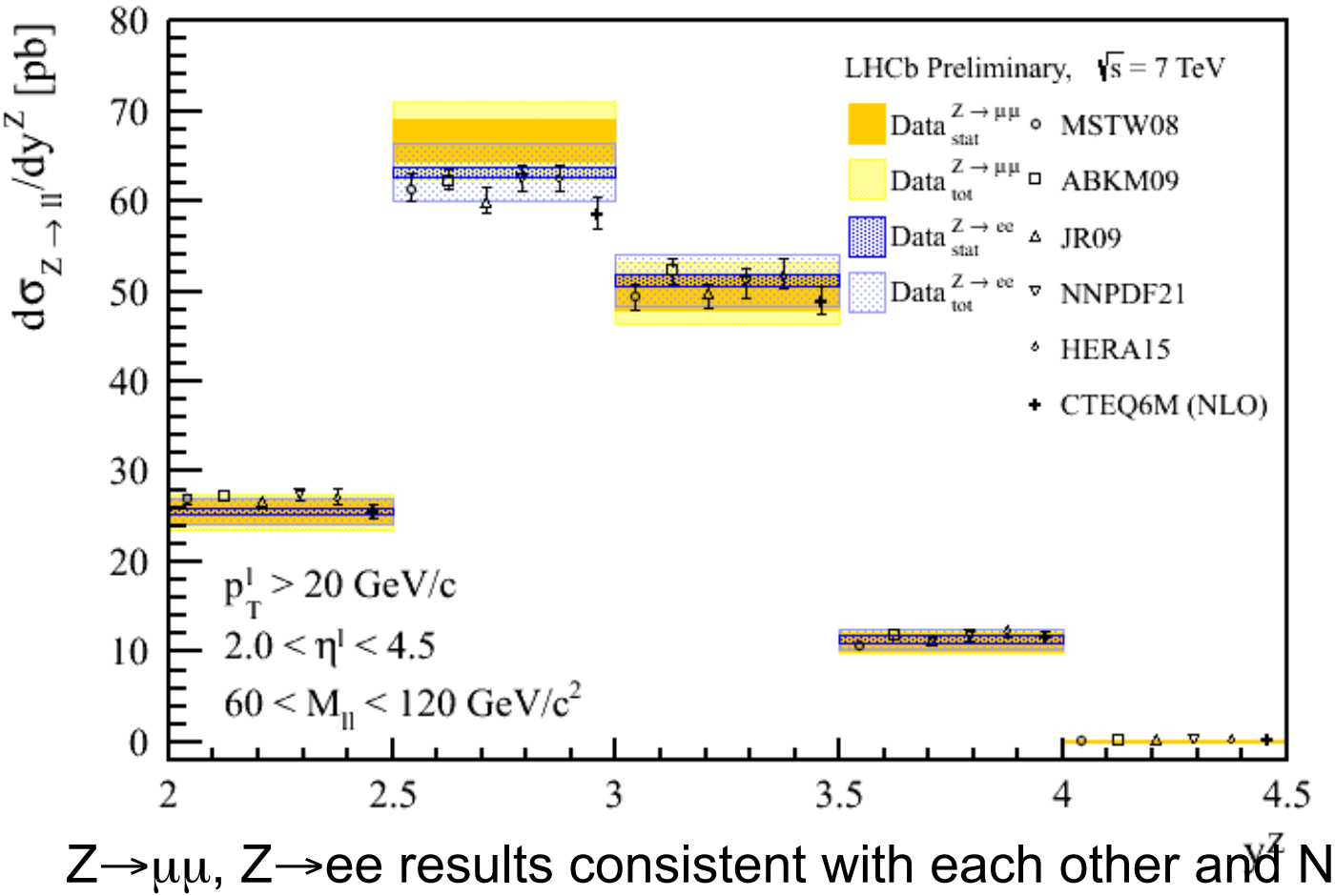
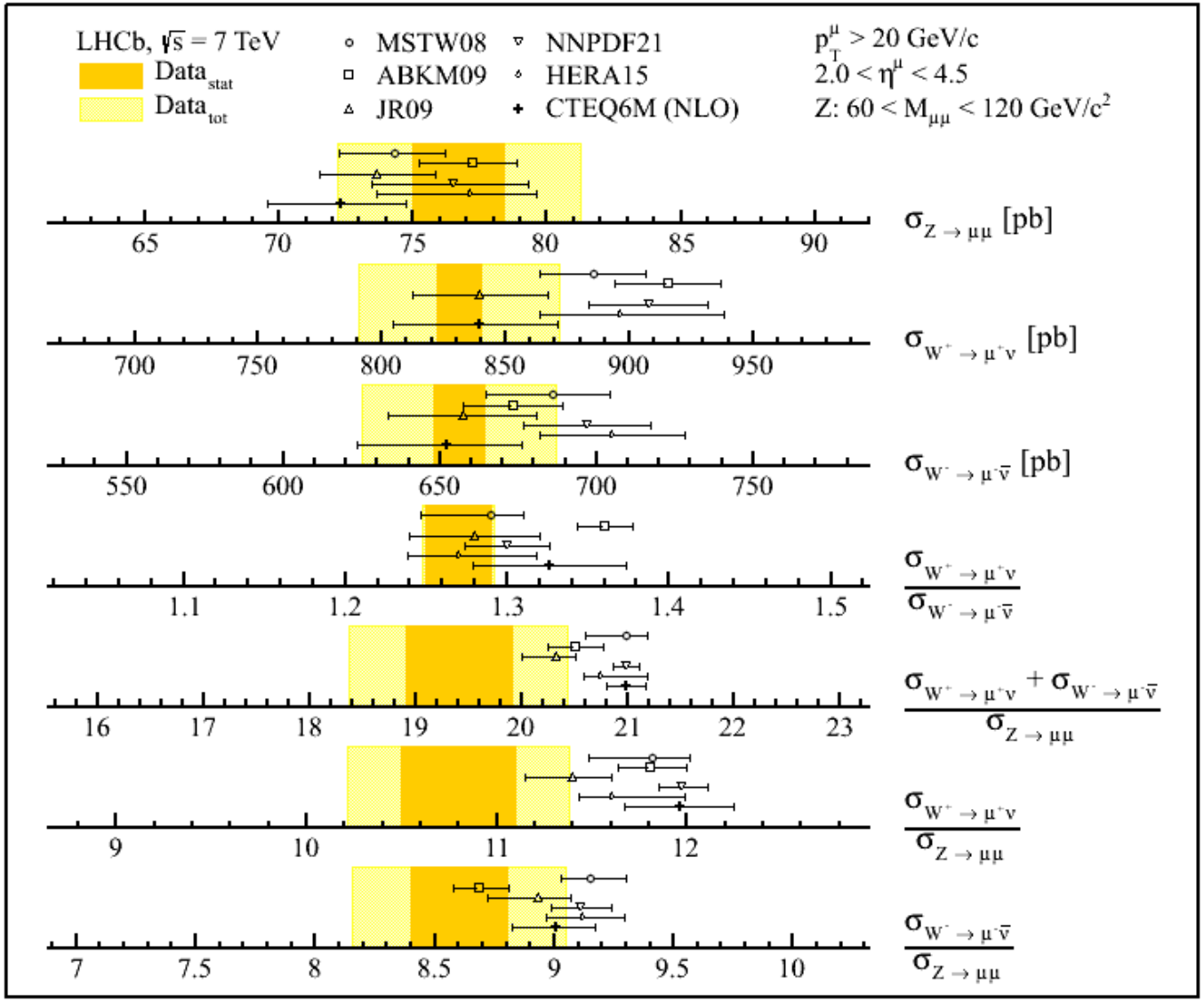


Z→μμ, Z→ee results consistent with each other and NNLO

arXiv: 1204.1620



Z→μμ

W⁺→μν

W⁻→μν

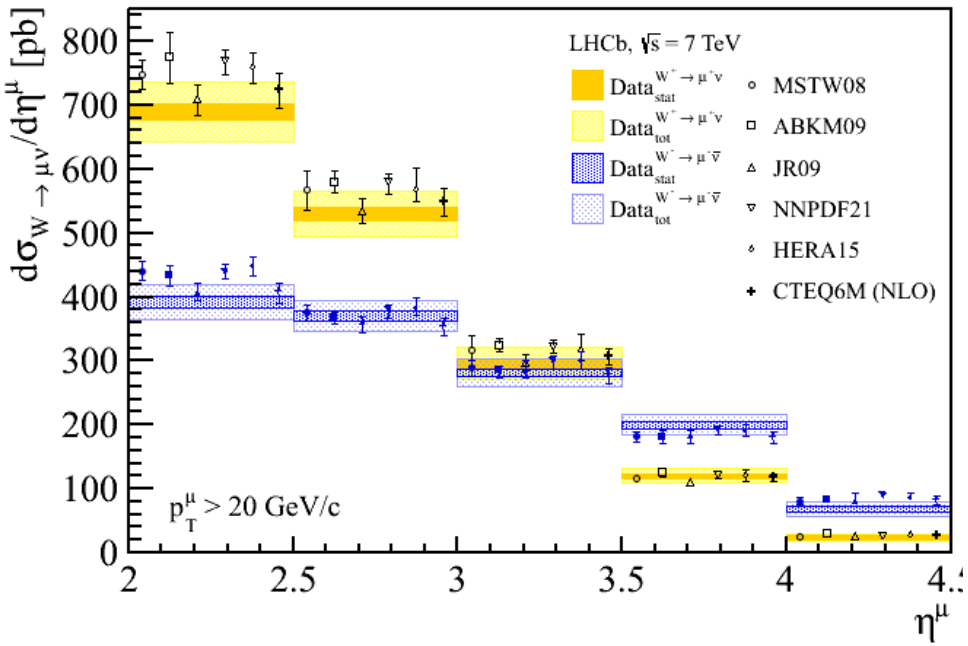
W+/W-

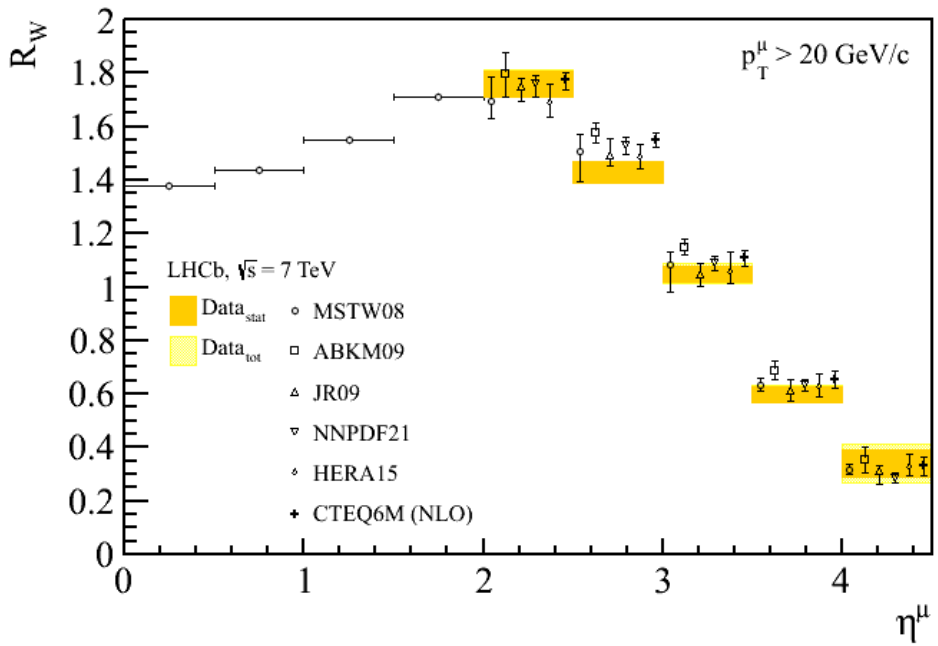
W/Z

W+/Z

W-/Z

arXiv: 1204.1620



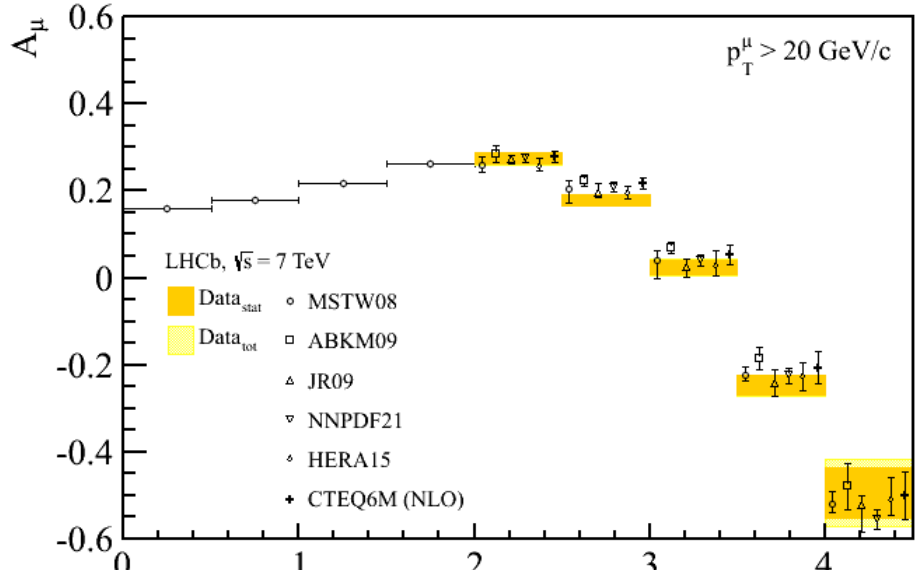


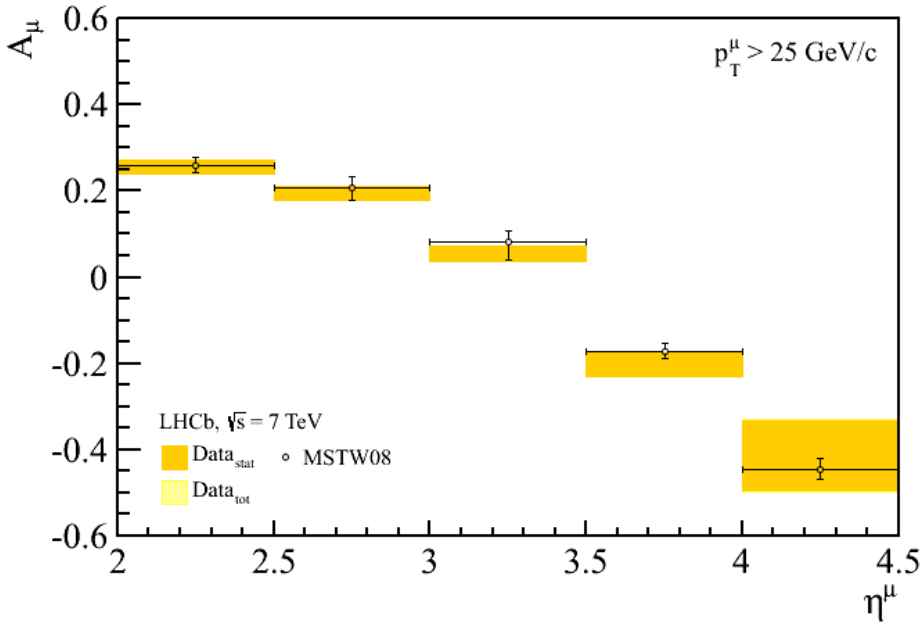
Differential W+ and W- cross-sections as a function of muon η
Ratio of W+ to W- production as a function of muon η

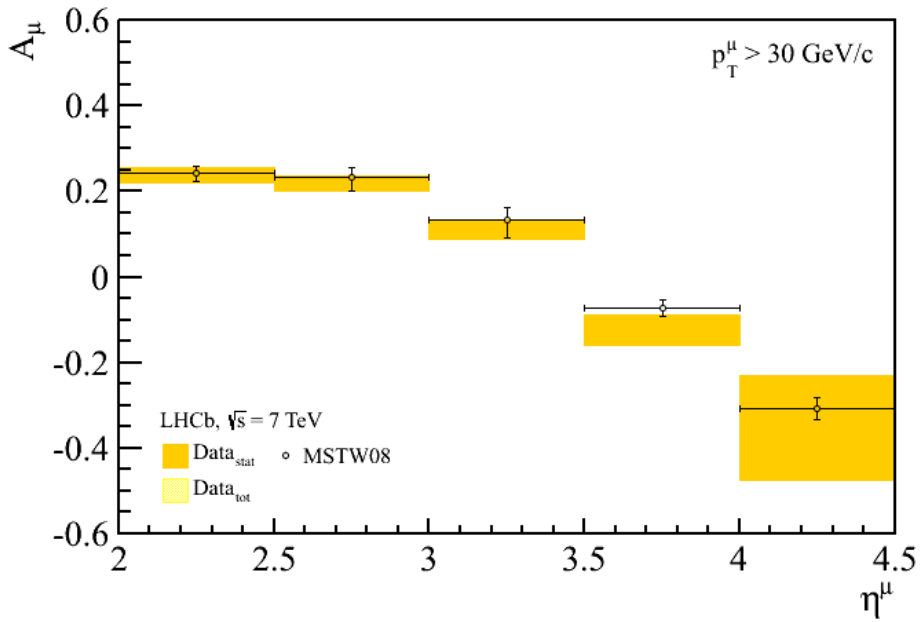
(note: full correlation matrix available for W+,W-,Z results)

arXiv: 1204.1620

W charge asymmetry as a function of η
P_T>20, P_T>25, P_T>30 GeV







LHCb-CONF-2012-013

Trigger:

Di- μ, p_T > 2.5 GeV

Muon:

pT > 3 GeV/c, p > 10 GeV/c

2.0 < ημ < 4.5

γ^*:

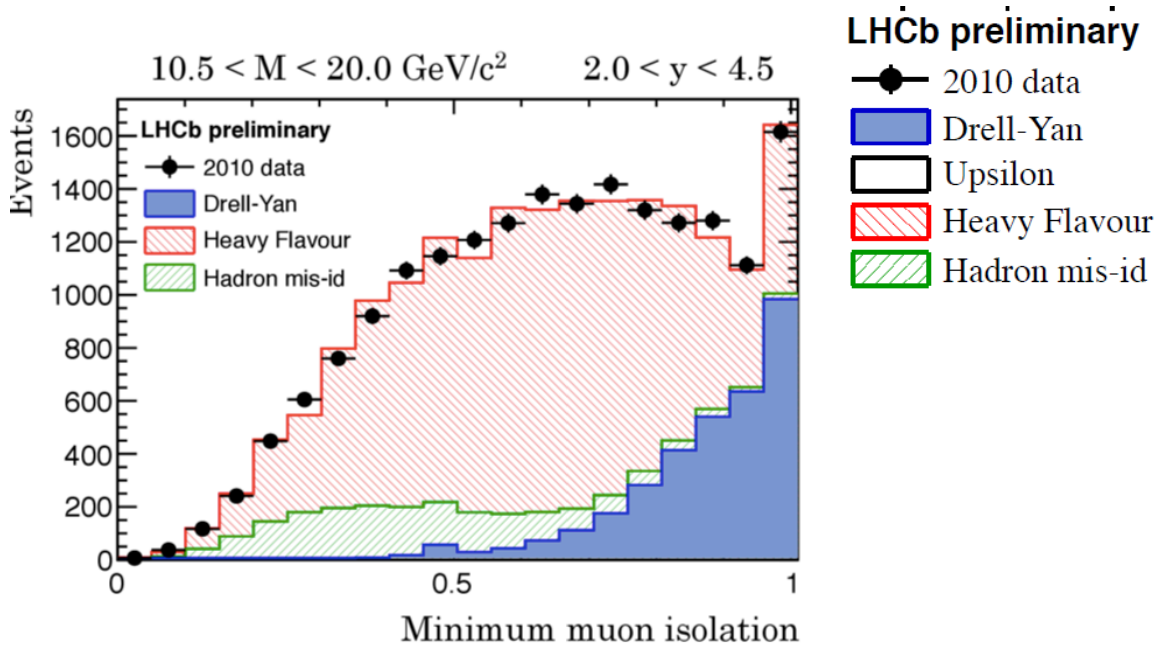
5 < M(μμ) < 120 GeV

Backgrounds:

- Heavy flavour (Data)
- K/π misid. (Data)
- Radiative tail of Upsilon (M<10 GeV/c^2)

2010 data: L = 37 pb^{-1}

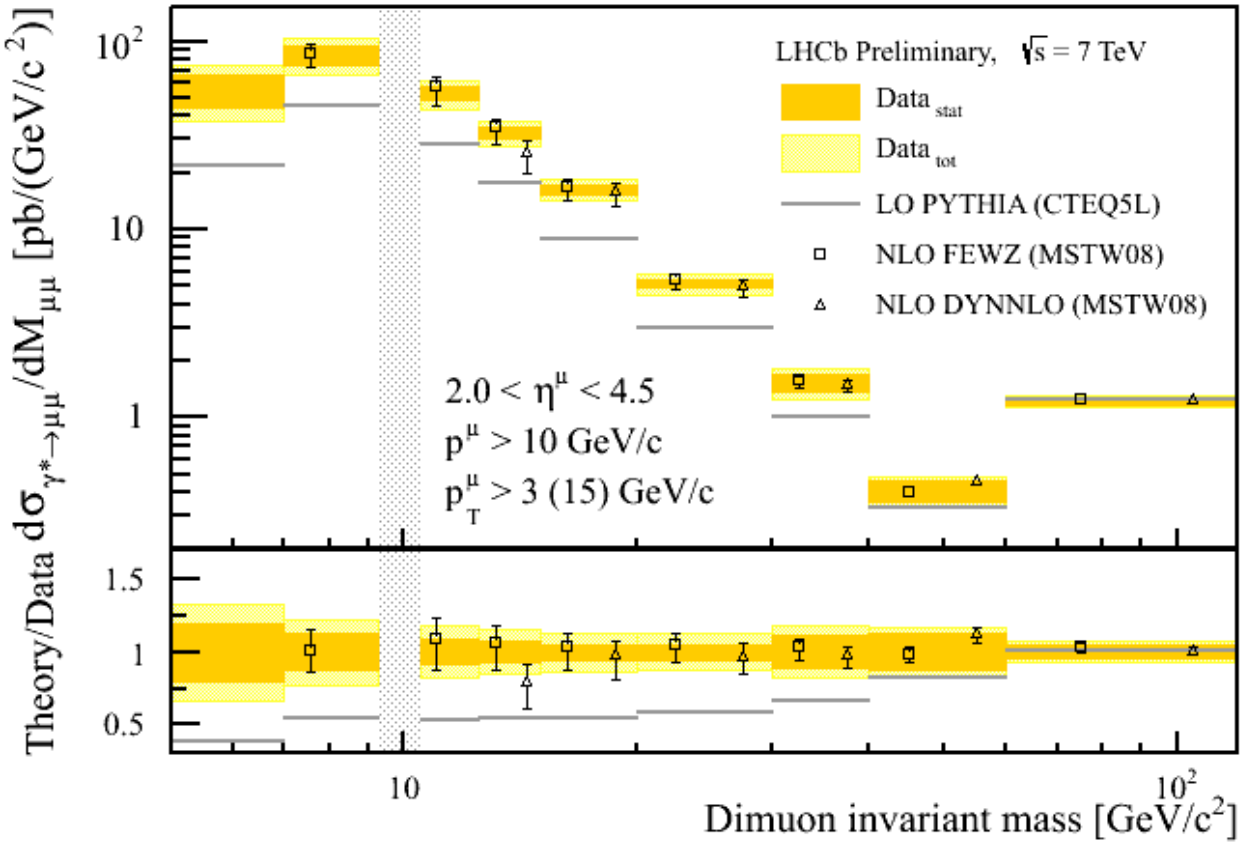
Fit minimum muon isolation ($p_T(\mu)/p_T(\mu\text{-Jet})$) in data to shapes expected for signal and background, extract Nsig



Mass [GeV/c²]	Purity [%]
5-7.5	6.8
7.5-9	9.0
10.5-12.5	14.9
12.5-15	20.4
15-20	32.1
20-30	54.9
30-40	70.5
40-60	91.4
60-120	100

Efficiencies determined from data.
Main systematic errors: (low masses) shapes used for template fit 24%, efficiencies.

LHCb-CONF-2012-013



Differential cross-section as function of $M_{\mu\mu}$ (9 bins), cf. Pythia, FEWZ, DYNNLO

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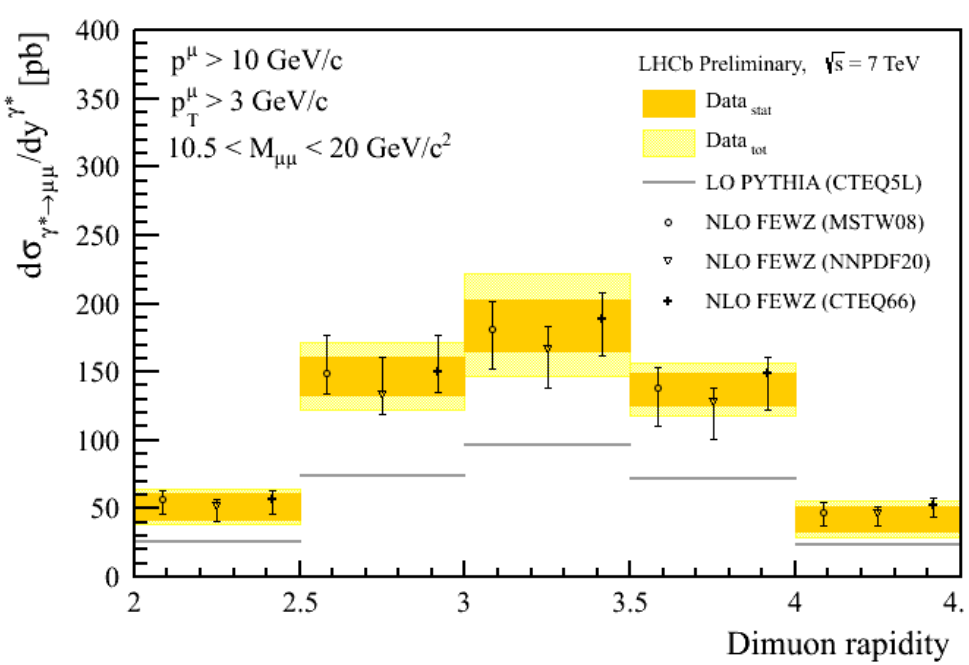

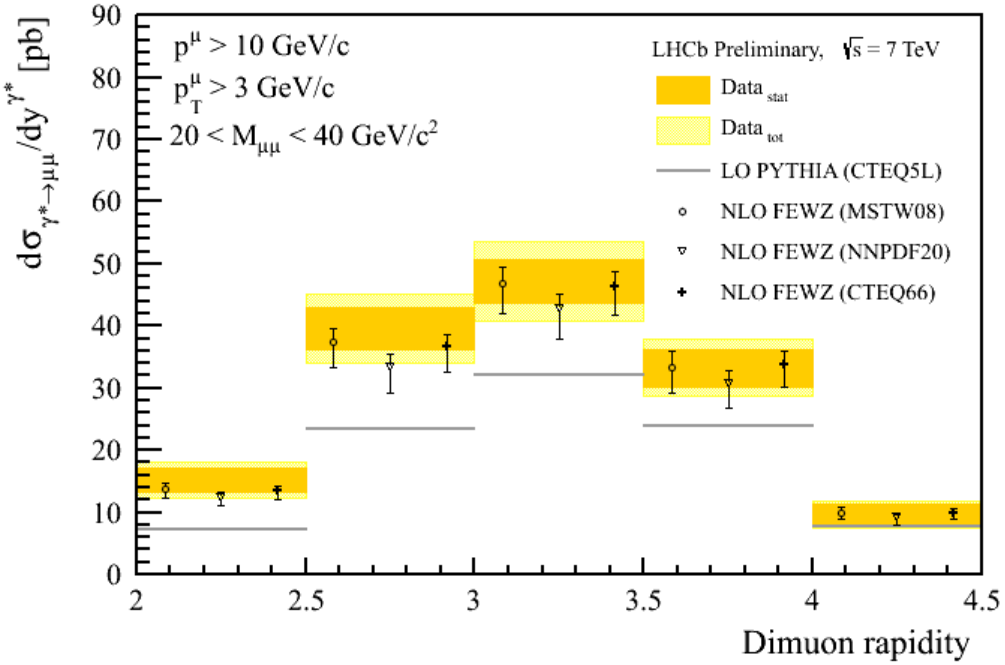

Differential cross-section as function of $y_{\mu\mu}$, for two mass regions.

2011 data:

- Update W, Z cross-sections in muon final states
  - Expect stat. error reduced by factor 5
  - Expect sys. error reduced (theory: understanding W P_T)
- Update Z-> $\tau\tau$, adding hadronic tau decay modes
- Update DY
  - $d\sigma/dMdy$ below M_Z
  - Add $d\sigma/dM$ above M_Z
- First Z+jet production measurements
  - Z+b, Z+c, W+b, W+c
- A_{FB}

2012 data:

- As above.

Note: **stable running conditions**; no changes to thresholds foreseen.

Most recent LHCb electroweak measurements presented:

$W \rightarrow \mu\nu$, $Z \rightarrow \mu\mu$:

In agreement with NNLO predictions

$Z \rightarrow ee$:

First measurement, in agreement with NNLO

Low mass Drell Yan:

First measurement, for $M_{\mu\mu} > 5$ GeV

In agreement with NLO (where predictions available).

Backup

Source	$\Delta\sigma_{Z\to\mu\mu}$ (%)	$\Delta\sigma_{W^+\to\mu^+\nu}$ (%)	$\Delta\sigma_{W^-\to\mu^-\bar{\nu}}$ (%)
Signal purity	±0.1	±1.2	±0.9
Template shape (fit)	–	±0.9	±1.0
Efficiency (trigger, tracking, muon id)	±4.3	±2.2	±2.0
Additional selection	–	±1.8	±1.7
FSR correction	±0.02	±0.01	±0.02
Total	±4.3	±3.2	±2.9
Luminosity	±3.5	±3.5	±3.5