LHCb electroweak measurements: W, Z, low mass DY

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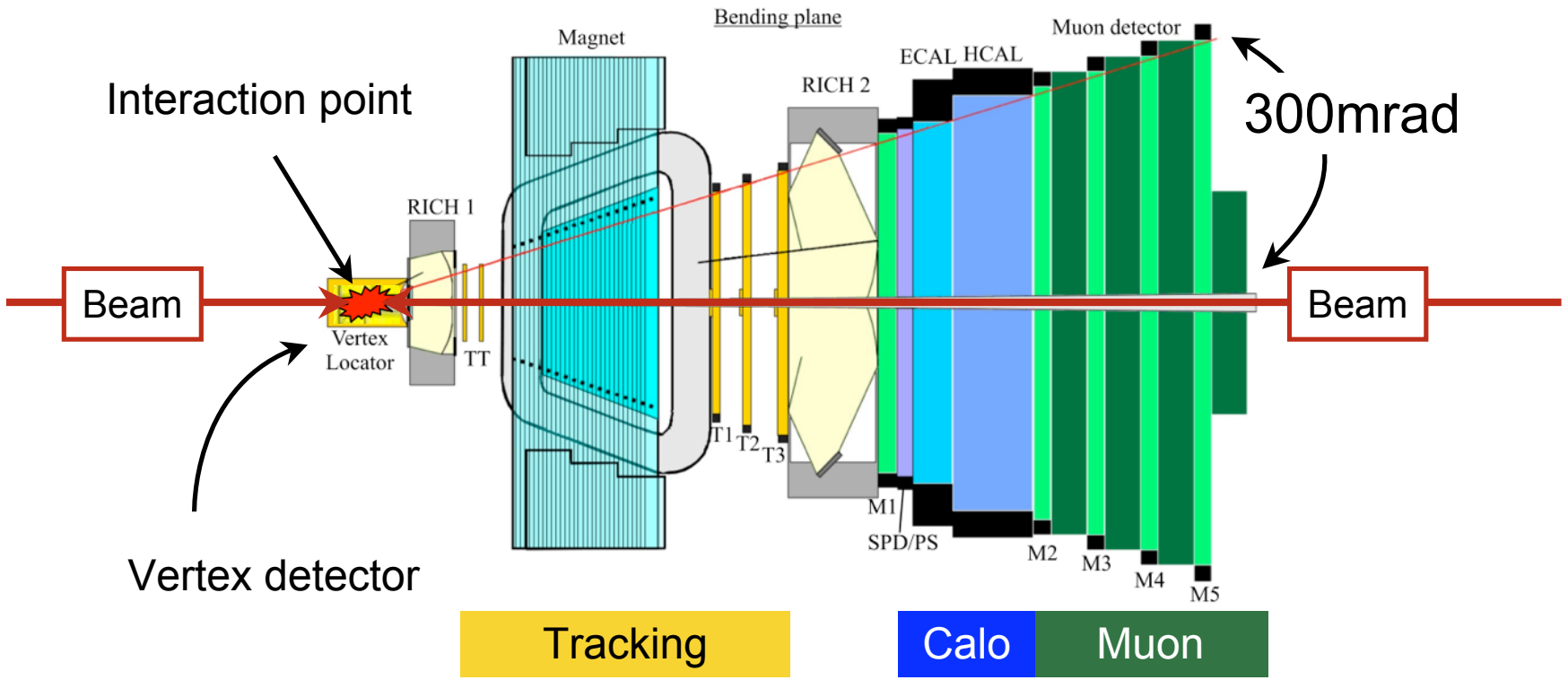
On behalf of the LHCb collaboration.

Introduction

Results: Z, W, ratios and charge asymmetry

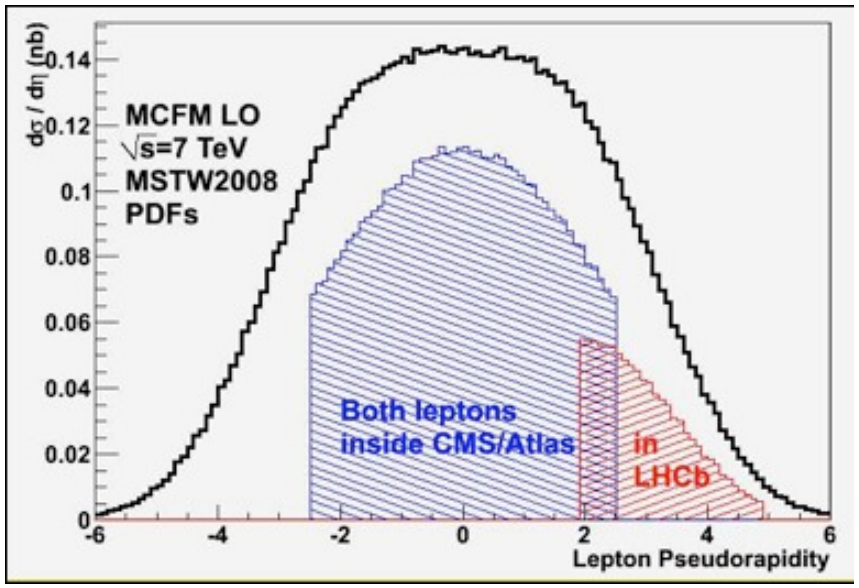
Other ongoing work: low mass DY, other channels.

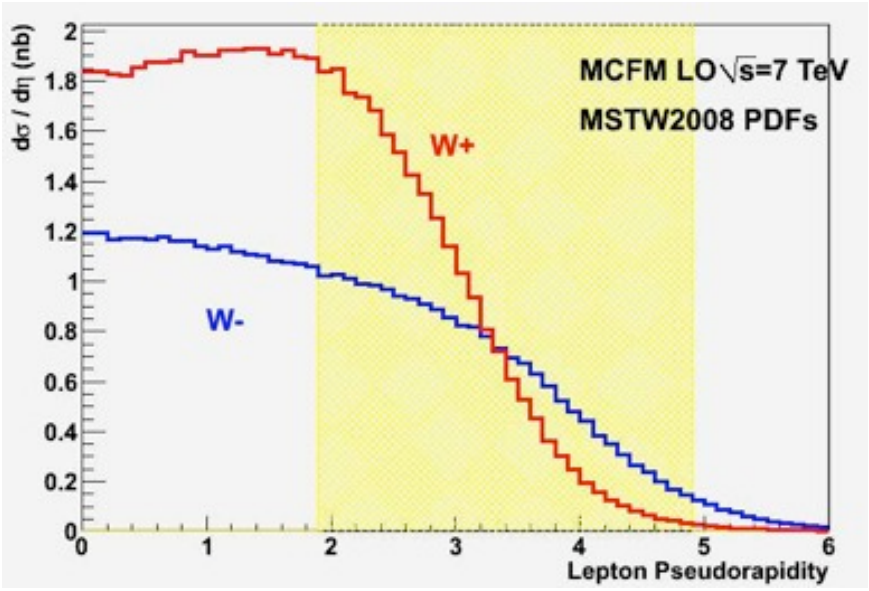
Conclusions



Fully instrumented within $1.9 \leq \eta \leq 4.9$

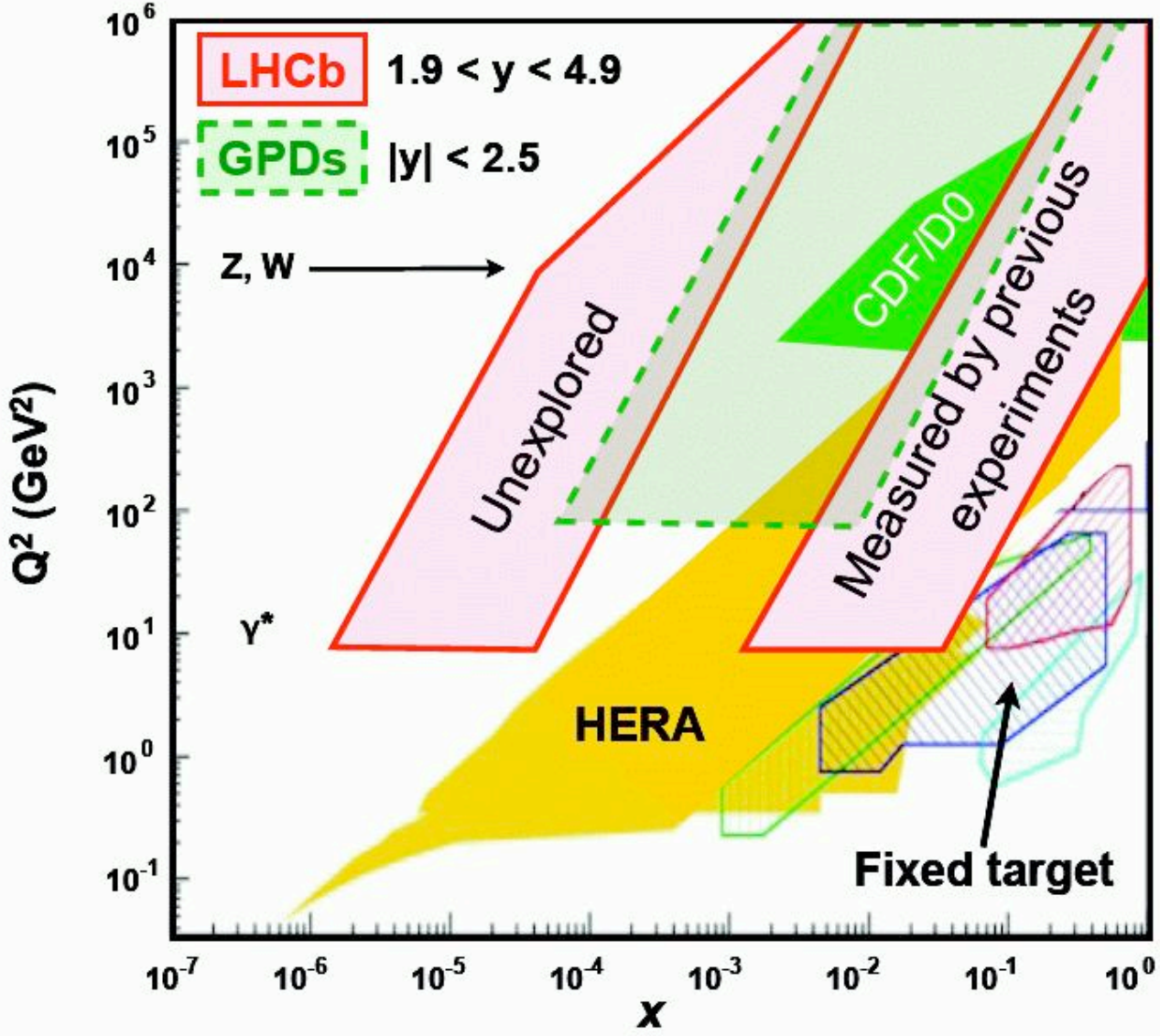
Trigger: $p_\mu > 3$ GeV, $pt_\mu > 0.5$ GeV, $m_{\mu\mu} > 2.5$ GeV





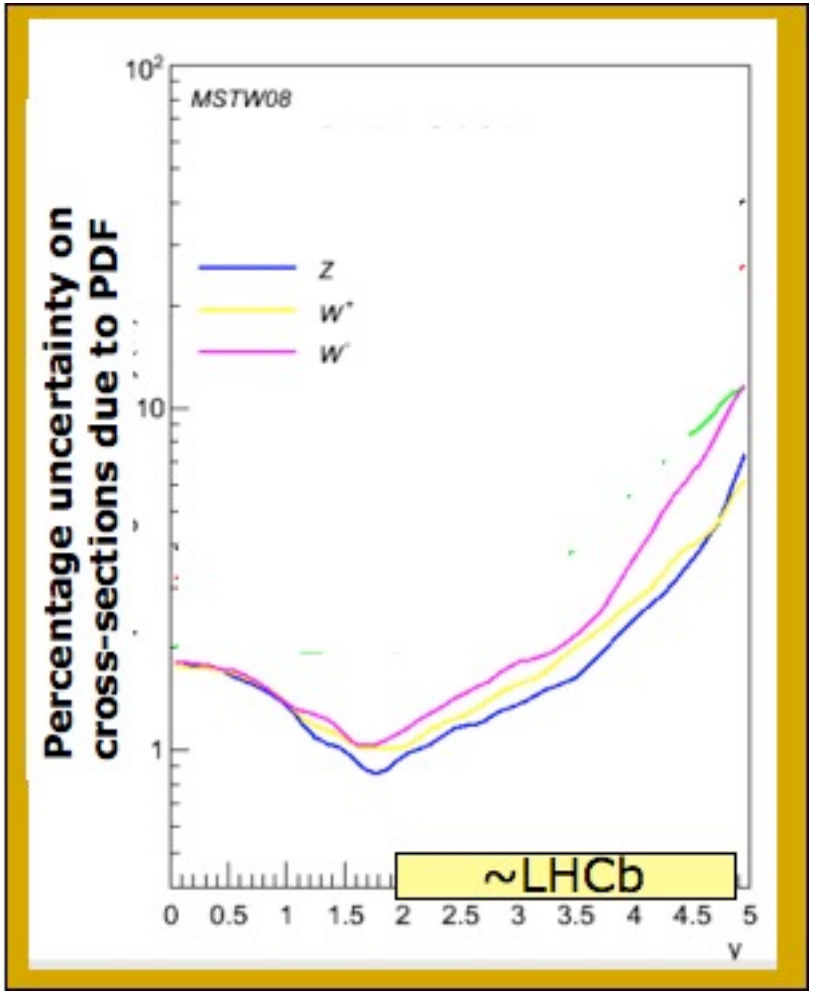
8% of Z within LHCb acceptance

17% (16%) of W^+ (W^-) within LHCb acceptance



Z, W: x of 10^{-4}, 10^{-1}
(low mass $\gamma^* \rightarrow 10^{-6}$)

Cross-sections known to NNLO
PDF uncertainty dominates
Known to ~1% at y ~1.5-2, 6-8% at y~5
Low mass DY more uncertain.

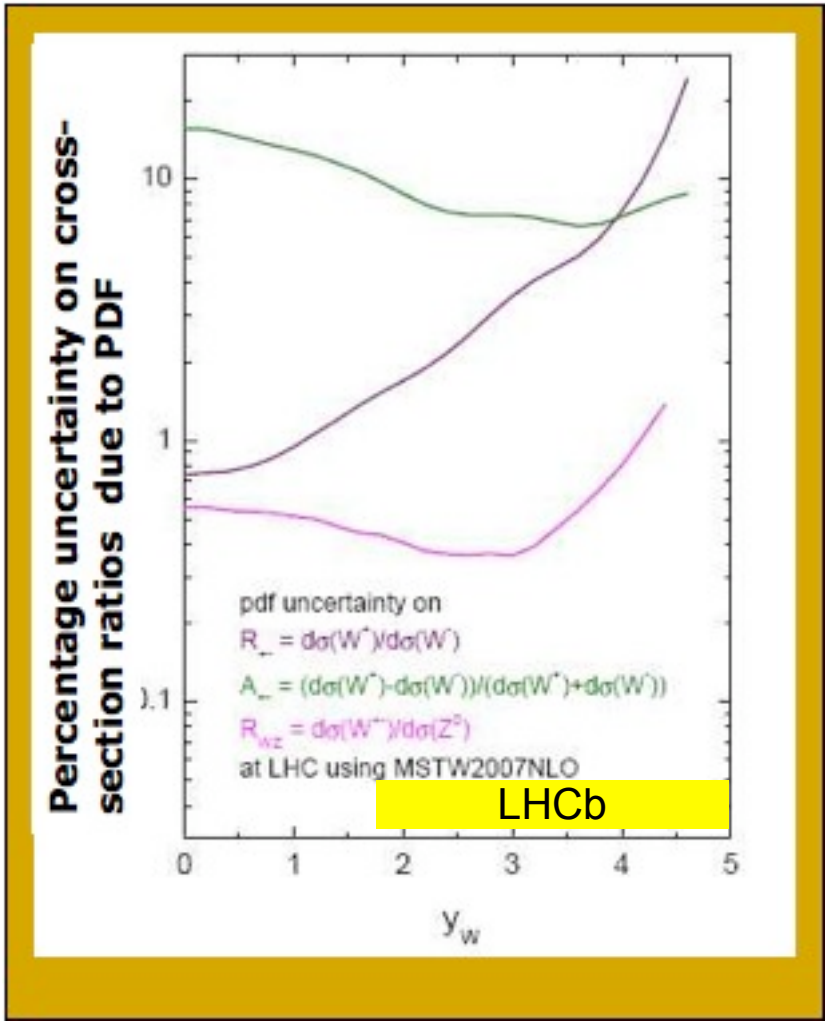


Cancel or highlight PDF uncertainties with ratios

R_+ tests d_V/u_V ratio

A_W tests difference between u_V and d_V

R_{WZ} almost insensitive to PDFs



Definition of measured cross-sections:

$$\sigma(Z \to \mu\mu : 2 < \eta_\mu < 4.5, P_{T\mu} > 20GeV, 81 < M_{\mu\mu} < 101GeV)$$

(as function of Z rapidity)

$$\sigma(W \to \mu\nu : 2 < \eta_\mu < 4.5, P_{T\mu} > 20GeV)$$

(as function of muon pseudorapidity)

Using 16.5 pb^{-1} data, single μ trigger (p_T>10 GeV)

$$\sigma_{Z\to\mu\mu}(\Delta y) = \frac{N^Z_{tot} - N^Z_{bkg}}{\varepsilon_Z L}$$

Z selection

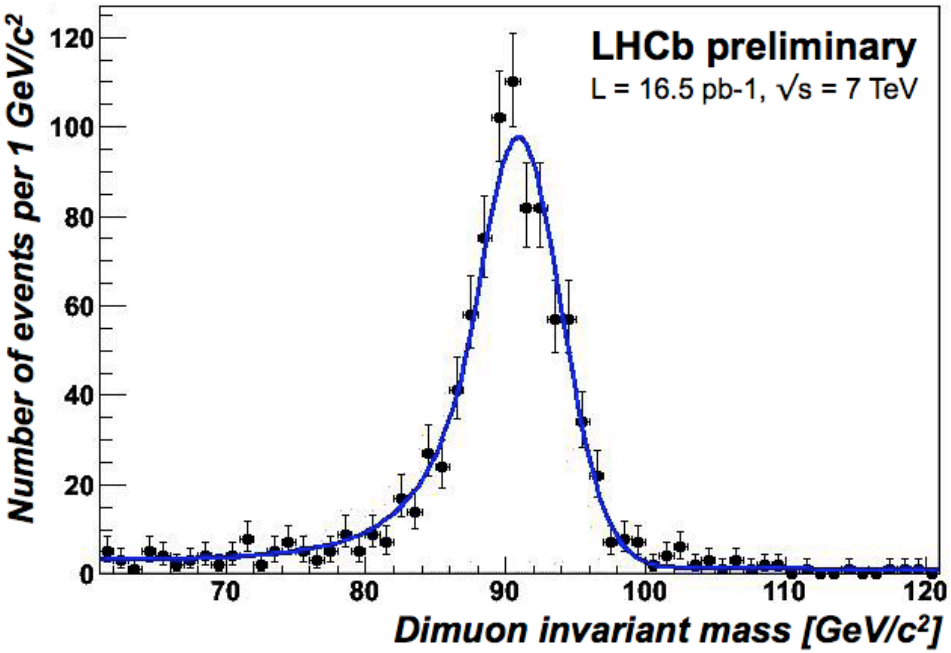
Z background estimation

Muon:

Good track quality (σ_p/p, χ^2 probability)
$p_T > 20$ GeV
$2.0 < \eta < 4.5$

Z:

$81 < m(\mu\mu) < 101$ GeV



Backgrounds:

$Z \rightarrow \tau\tau$ (~ 0.2)
Heavy flavour (~ 1)
K/π (< 0.03)
$N_{bkg} = 1.2 \pm 1.2$

Data, simulation

$N_Z = 833$

$\varepsilon_Z = 1.00$ (by definition to compare with theory)

$$\sigma_{W\to\mu\nu}(\Delta\eta) = \frac{N_{tot}^{W} - N_{bkg}^{W}}{\varepsilon_W L}$$

W selection

W background estimation

Muon:

Good track quality (σ_p/p, χ^2 probability)

$p_T > 20$ GeV

$2.0 < \eta < 4.5$

Impact parameter significance < 2

Σp_T in $R=\sqrt{(\Delta\eta^2+\Delta\phi^2)}=0.5$ cone around μ < 2 GeV

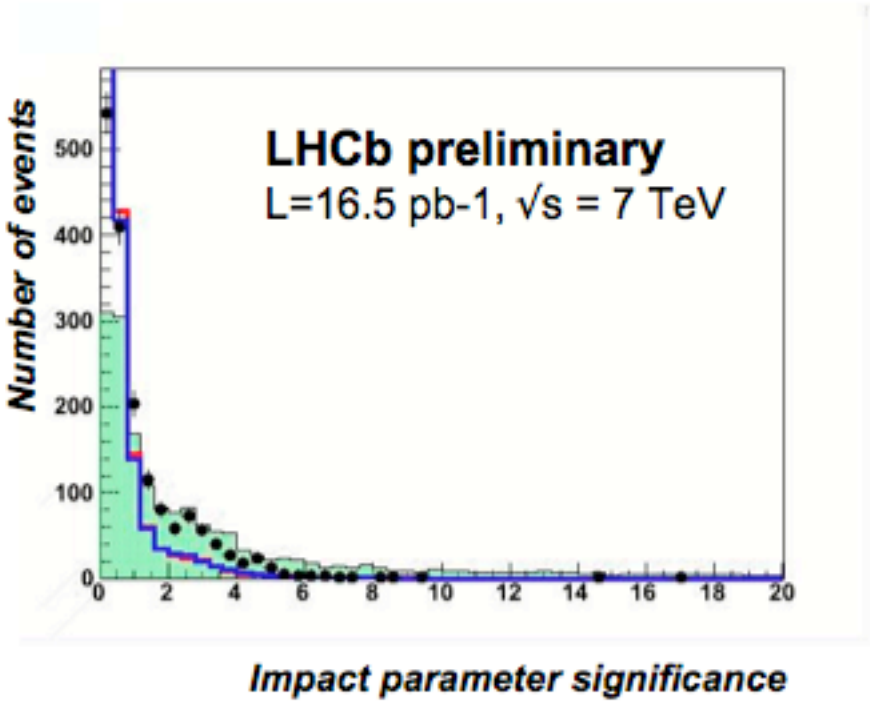
Rest of event:

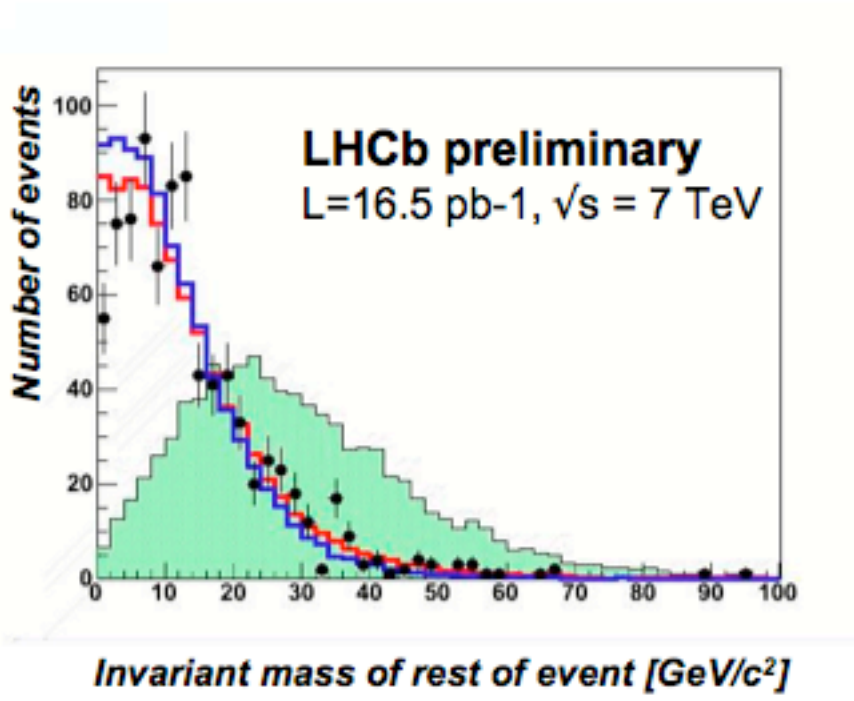
Invariant mass < 20 GeV

$\Sigma p_T < 10$ GeV

$\varepsilon_W = 55.0 \pm 1.0\%$

(data driven, using Z events)





Z data: points
Z MC, W MC, QCD

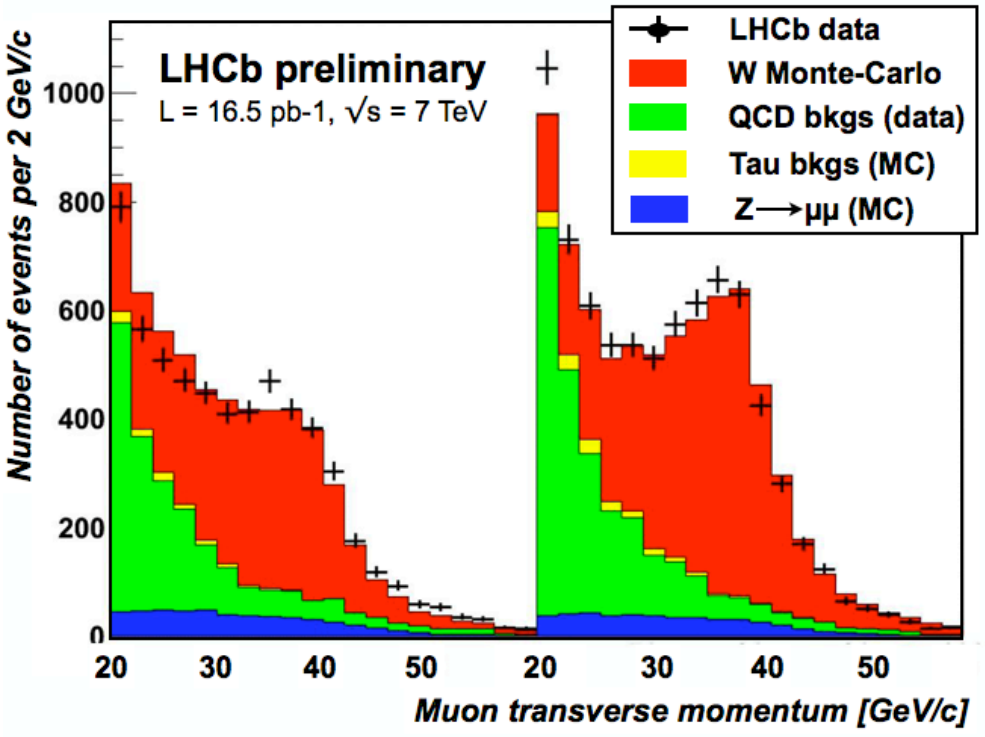
$N_{W+} = 7624$
$N_{W-} = 5732$

Background sources:

- $Z \rightarrow \mu\mu$ (1 μ in acceptance)
- $Z \rightarrow \tau\tau$
- $W \rightarrow \tau\nu$
- Hadronic events

Data
Simulation
Data + simulation

Note: Background charge asymmetric, QCD background large.



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

$$\varepsilon_Z = A_Z \varepsilon_Z^{trig} \varepsilon_Z^{track} \varepsilon_Z^{muon} \varepsilon_Z^{selection}$$

$$\varepsilon_W = A_W \varepsilon_W^{trig} \varepsilon_W^{track} \varepsilon_W^{muon} \varepsilon_W^{selection}$$

Measurements made in kinematic acceptance

A_Z, A_W = 1

Note: as much information taken from data as possible

$$\varepsilon_Z = A_Z \varepsilon_Z^{trig} \varepsilon_Z^{track} \varepsilon_Z^{muon} \varepsilon_Z^{selection}$$

$$\varepsilon_W = A_W \varepsilon_W^{trig} \varepsilon_W^{track} \varepsilon_W^{muon} \varepsilon_W^{selection}$$

Determine from data (Z sample)

Tag: 1 identified muon having fired single muon trigger

Probe: 1 identified muon

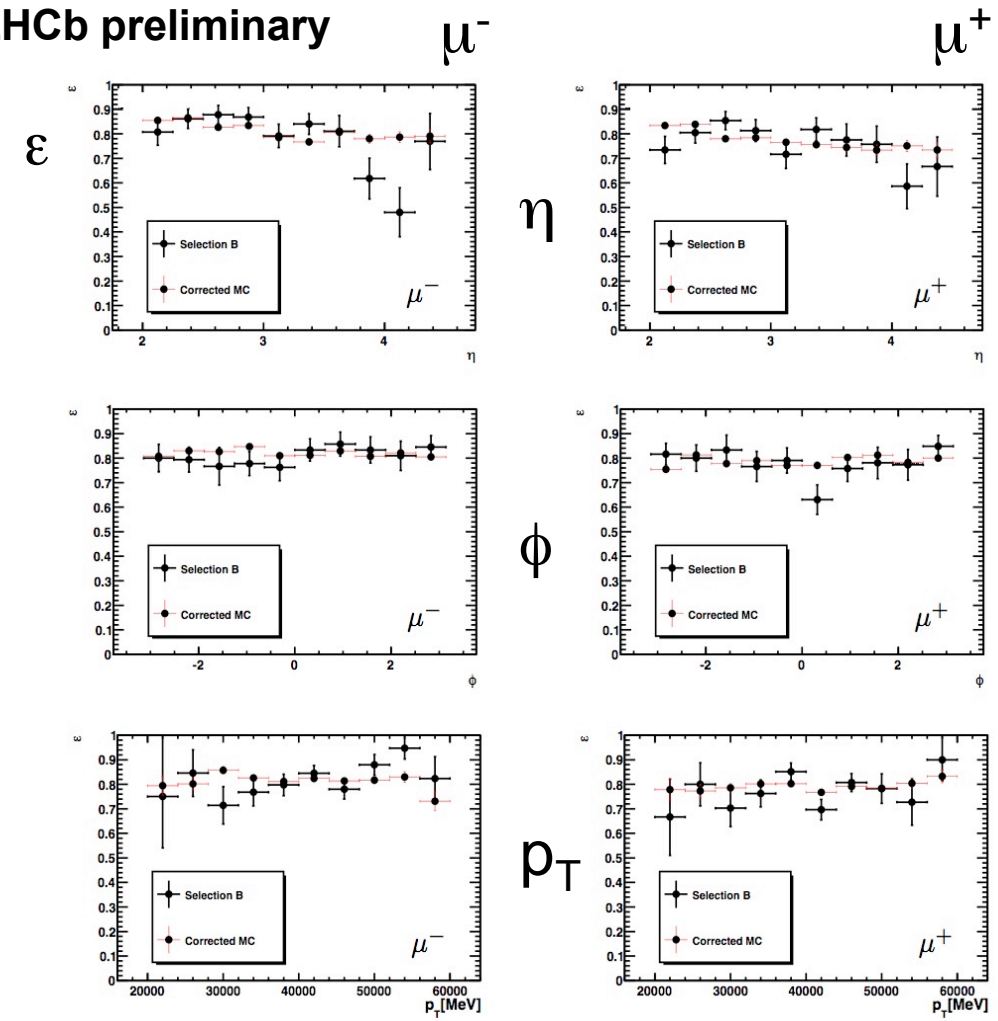
Efficiency is **flat** in η, ϕ, p_T.

No evidence for charge bias

$\varepsilon_W = 72 \pm 1\%$
$\varepsilon_Z = 86 \pm 1\%$

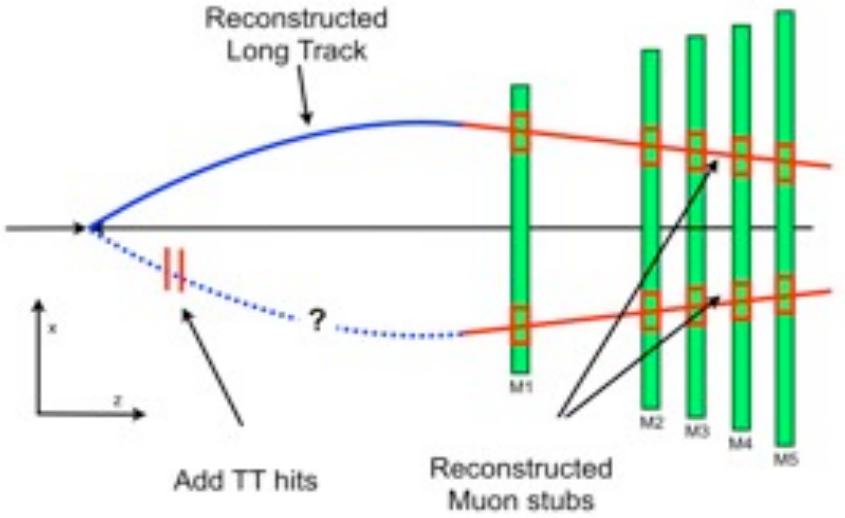
(includes global trigger cuts on maximum multiplicity)

LHCb preliminary



$$\varepsilon_Z = A_Z \varepsilon_Z^{trig} \varepsilon_Z^{track} \varepsilon_Z^{muon} \varepsilon_Z^{selection}$$

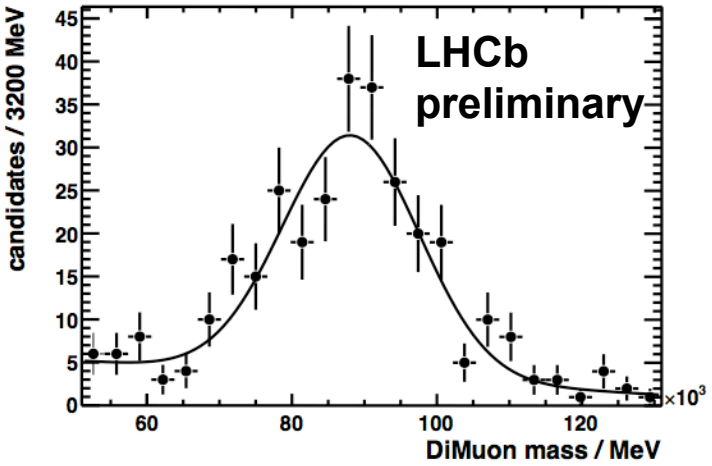
$$\varepsilon_W = A_W \varepsilon_W^{trig} \varepsilon_W^{track} \varepsilon_W^{muon} \varepsilon_W^{selection}$$



Determine from data (Z sample)

Tag: 1 identified muon

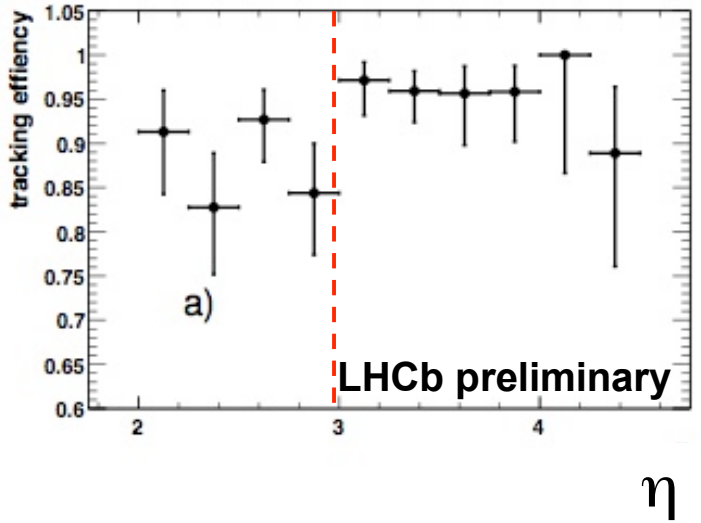
Probe: 1 muon stub + TT hit
(TT not used in tracking)



Efficiency **flat** in ϕ, p_T

Two regions considered in η

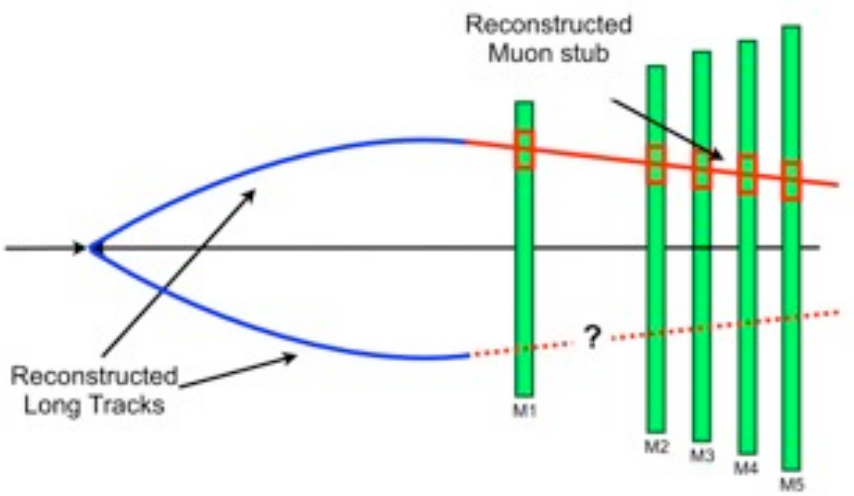
$\varepsilon_{W+} = 73 \pm 3\%$
$\varepsilon_{W-} = 78 \pm 3\%$
$\varepsilon_Z = 83 \pm 3\%$



(+, - different average efficiency due to different η distribution)

$$\varepsilon_Z = A_Z \varepsilon_Z^{trig} \varepsilon_Z^{track} \varepsilon_Z^{muon} \varepsilon_Z^{selection}$$

$$\varepsilon_W = A_W \varepsilon_W^{trig} \varepsilon_W^{track} \varepsilon_W^{muon} \varepsilon_W^{selection}$$



Determine from data (Z sample)

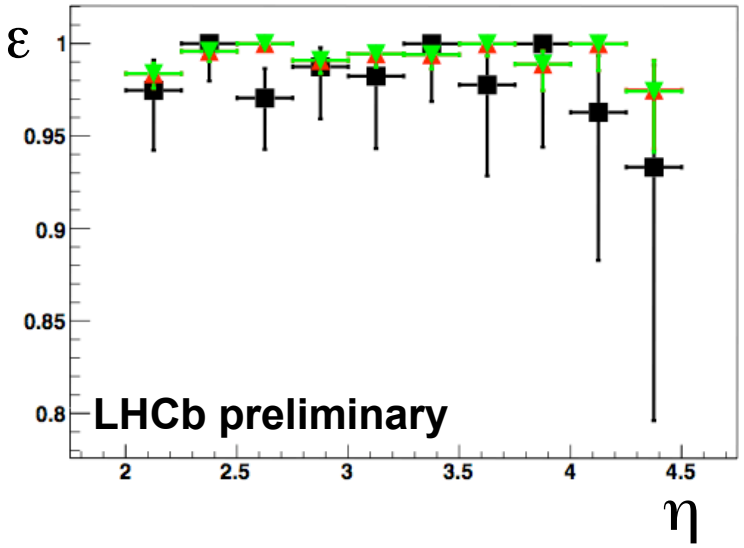
Tag: 1 identified muon

Probe:1 identified track

Efficiency **flat** in η, ϕ, p_T

No evidence of charge bias

$\varepsilon_W = 98.2 \pm 0.5\%$
$\varepsilon_Z = 96.5 \pm 0.7\%$



data
simulation
truth level

$$\varepsilon_Z = A_Z \varepsilon_Z^{trig} \varepsilon_Z^{track} \varepsilon_Z^{muon} \varepsilon_Z^{selection}$$

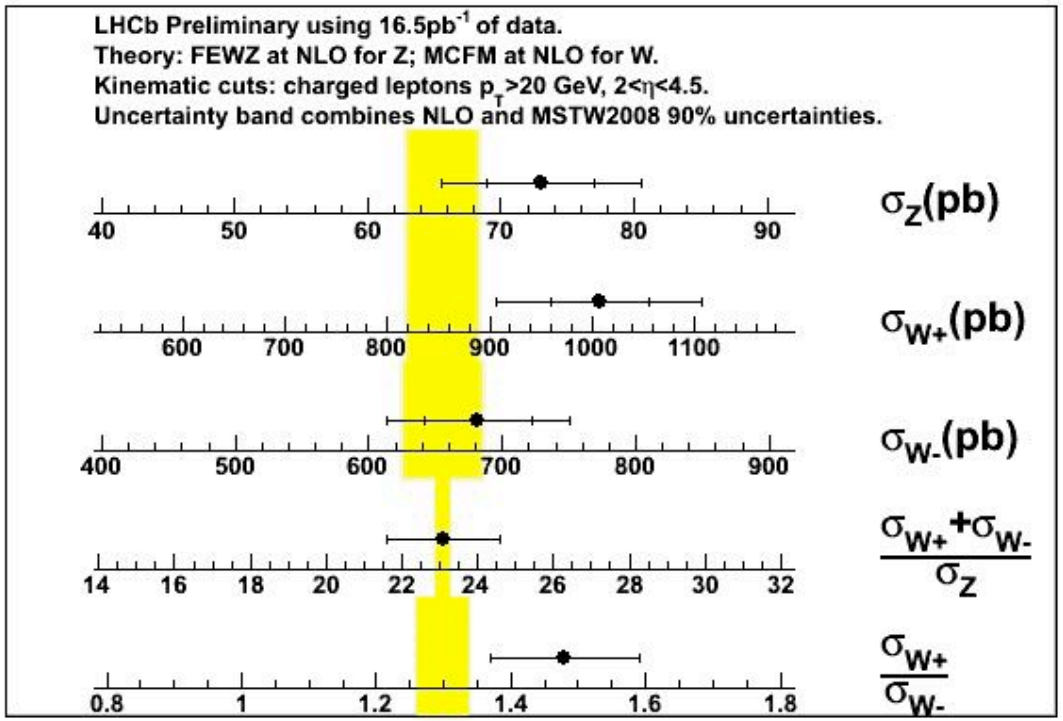
$$\varepsilon_W = A_W \varepsilon_W^{trig} \varepsilon_W^{track} \varepsilon_W^{muon} \varepsilon_W^{selection}$$

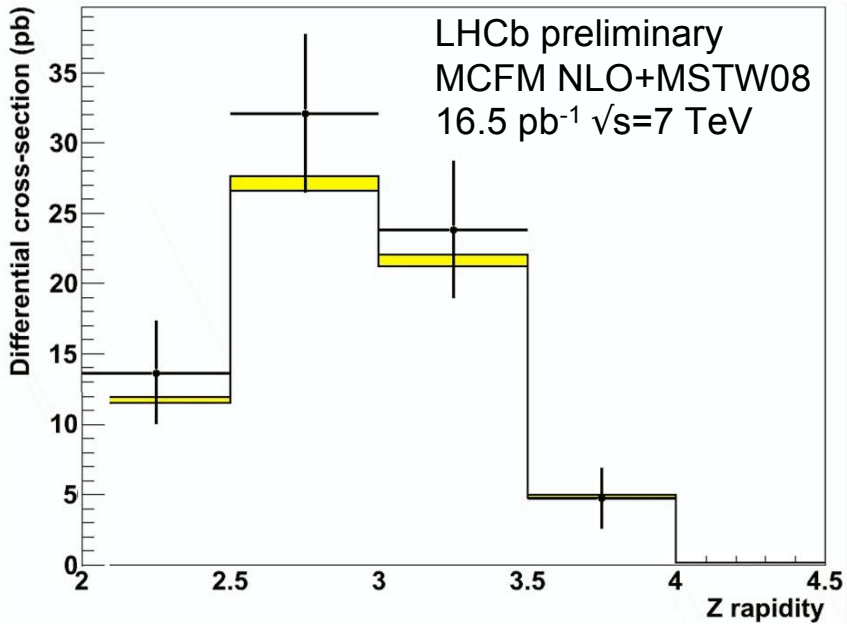
Found before:
Z: (simulation) 1.00
W: (data driven, using Z events) 55.0 ± 1.0%

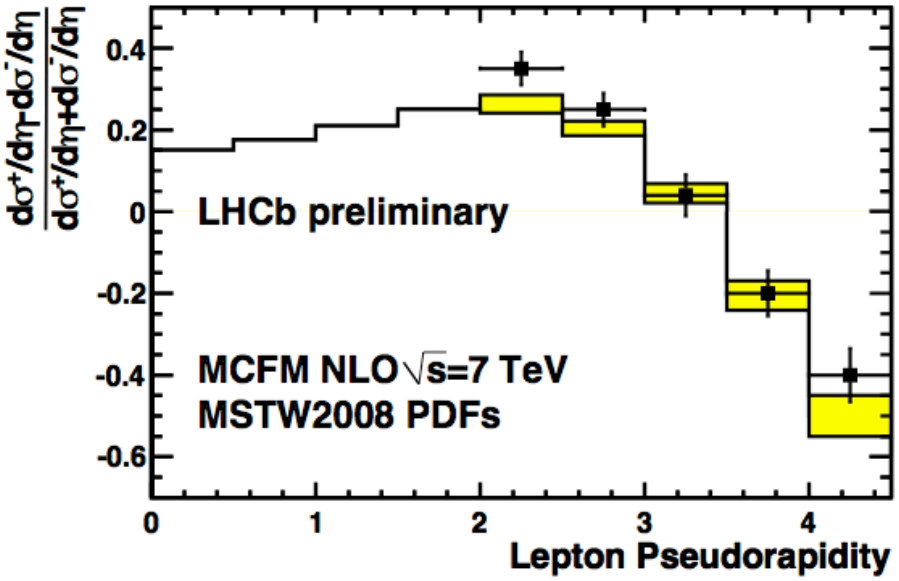
Systematic errors (%):

Source	σ_Z	σ_{W+}	σ_{W-}
Background	0.1	3	5
Trigger efficiency	1	1	1
Muon id efficiency	0.7	0.5	0.5
Track efficiency	4	4	4
Selection efficiency	n/a	2	2
Luminosity	10	10	10
Total systematic error	11	11	12
Stat. error	4	1	1

Largest source is luminosity uncertainty
Background: uncertainty large for W (shape variation in fit)
Efficiencies: statistical error on data-driven method


LHCb Preliminary using 16.5pb-1 of data.
Theory: FEWZ at NLO for Z; MCFM at NLO for W.
Kinematic cuts: charged leptons pT>20 GeV, 2<η<4.5.
Uncertainty band combines NLO and MSTW2008 90% uncertainties.
40 50 60 70 80 90
σZ(pb)
600 700 800 900 1000 1100
σW+(pb)
400 500 600 700 800 900
σW-(pb)
14 16 18 20 22 24 26 28 30 32
(σW+ + σW-) / σZ
0.8 1 1.2 1.4 1.6 1.8
σW+ / σW-





(note: x2 statistics coming soon)

Low mass Drell Yan → μμ

Z→ee,ττ,Z+jet, Z p_T

Trigger:

$p_T^{\mu} > 1$ GeV

$M_{\mu\mu} > 2.5$ GeV

Backgrounds:

Inclusive b

Inclusive c

Misidentified muons

Selection:

Muon:

Good track quality (σ_p/p, χ^2 probability)

$p_T^{\mu} > 1$ GeV, $p^{\mu} > 10$ GeV

$2.0 < \eta^{\mu} < 4.5$

$A(p_T^{\mu}, \Sigma p_T^{0.5}) > 0.5$

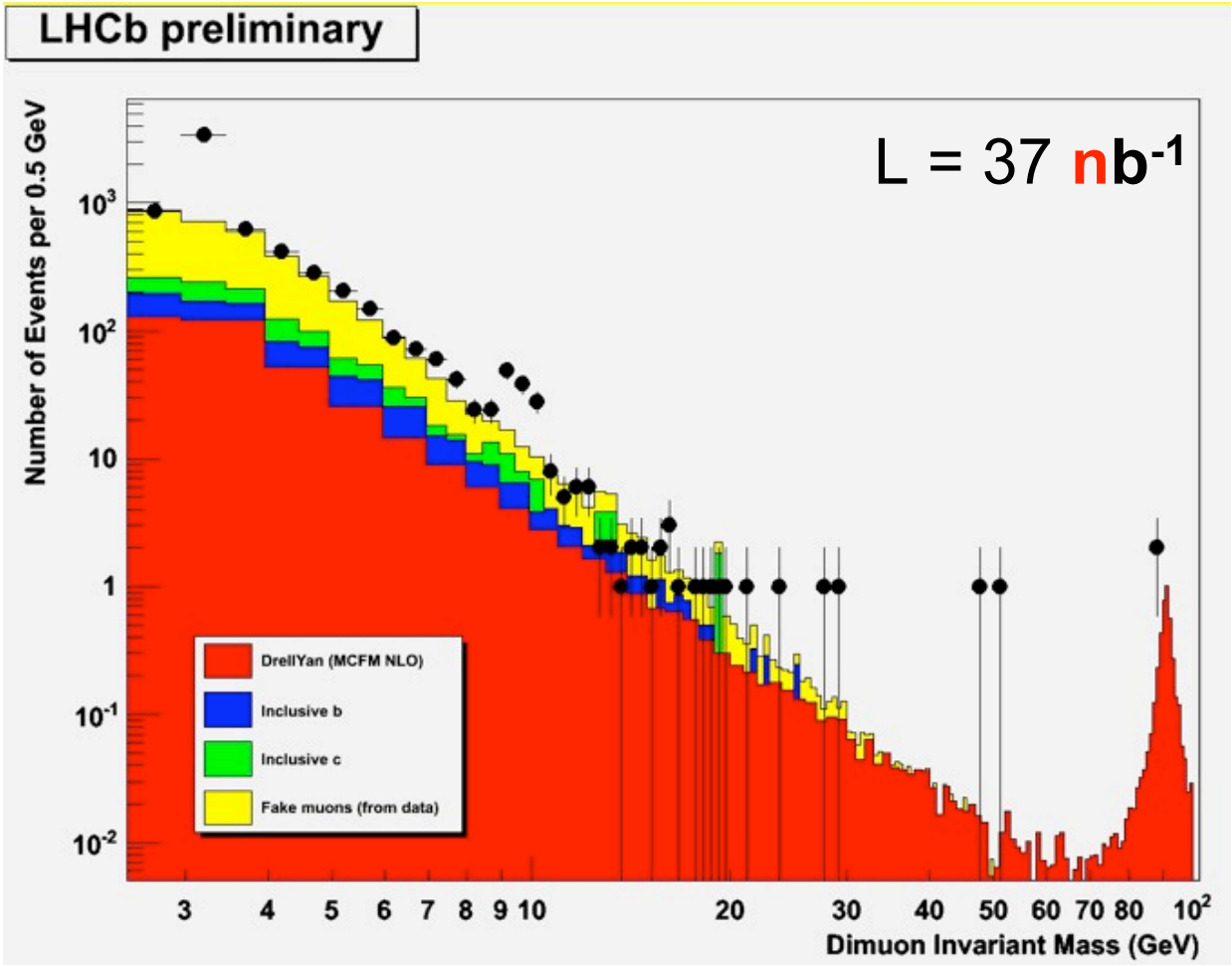
γ^*:

$M_{\mu\mu} > 2.5$ GeV

Note: analysis **ongoing**; no results yet.

Low mass Drell Yan → μμ

Z→ee,ττ,Z+jet, Z p_T

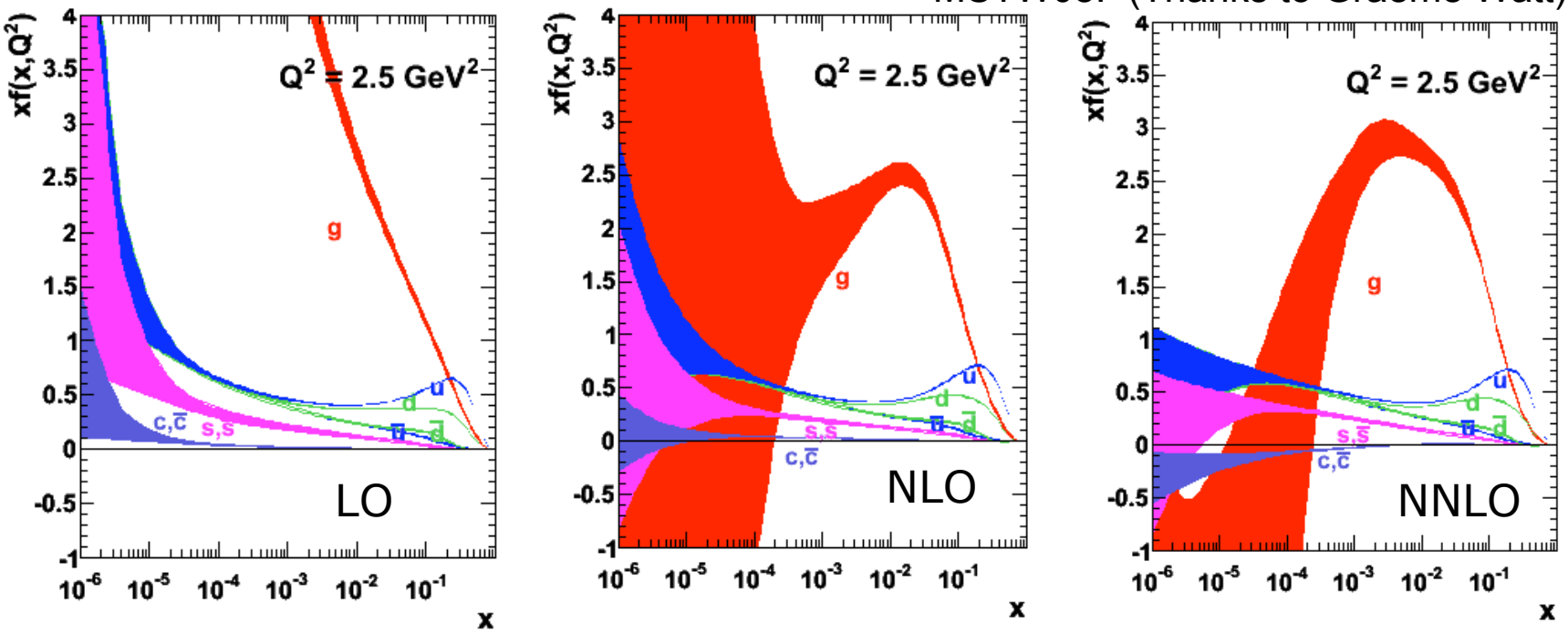


- Low Mμμ background dominated (more work needed)
- MCFM/Pythia give **very** different predictions at low Mμμ

Low mass Drell Yan → μμ

Z→ee,ττ,Z+jet, Z p_T

MSTW08. (Thanks to Graeme Watt)

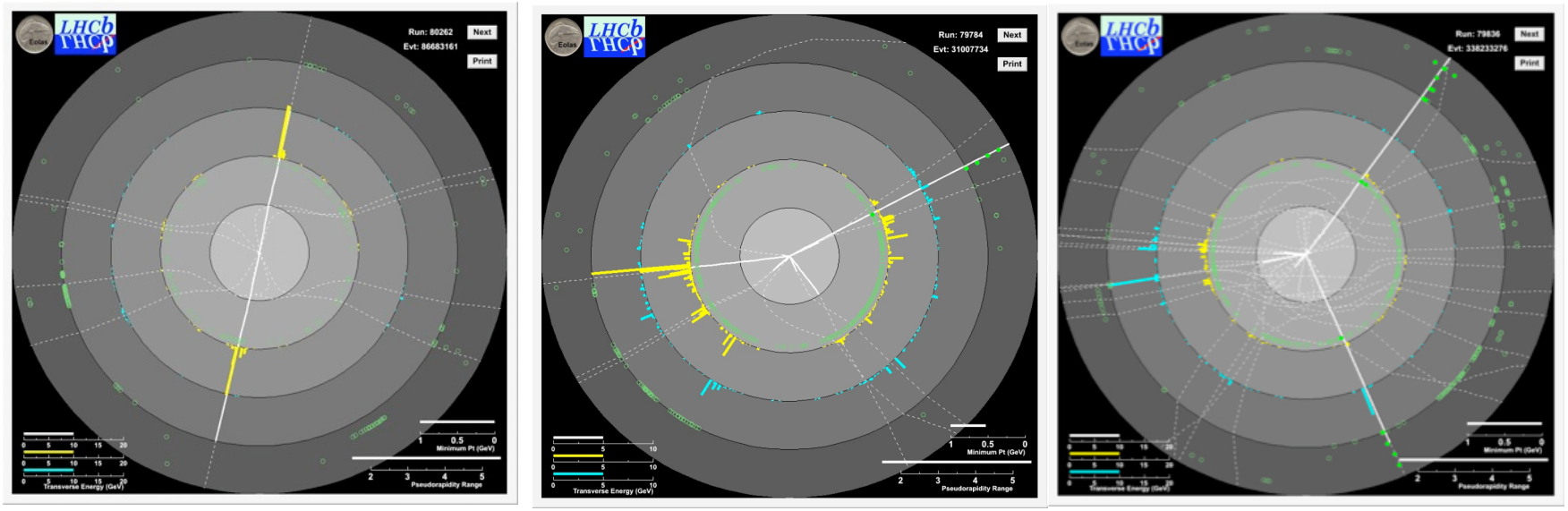


Theory uncertainty:

PDFs; different behaviour and uncertainty with order of calculation; gluon essentially unconstrained by data below 10^{-4}.

DGLAP evolution not trustworthy in this region; gluon re-summation effects; near saturation regime?

Work ongoing in other channels: Z→ee, Z → ττ , Z+jet
Work ongoing on $d\sigma(Z)/dp_T$



W,Z production measurements made with 16.5 pb^{-1}

- agreement with NLO
- update with ~36 pb^{-1} in progress.

Work ongoing:

- Low mass Drell Yan
- Differential Z production as function of p_T
- Other Z decay modes, Z+jets.