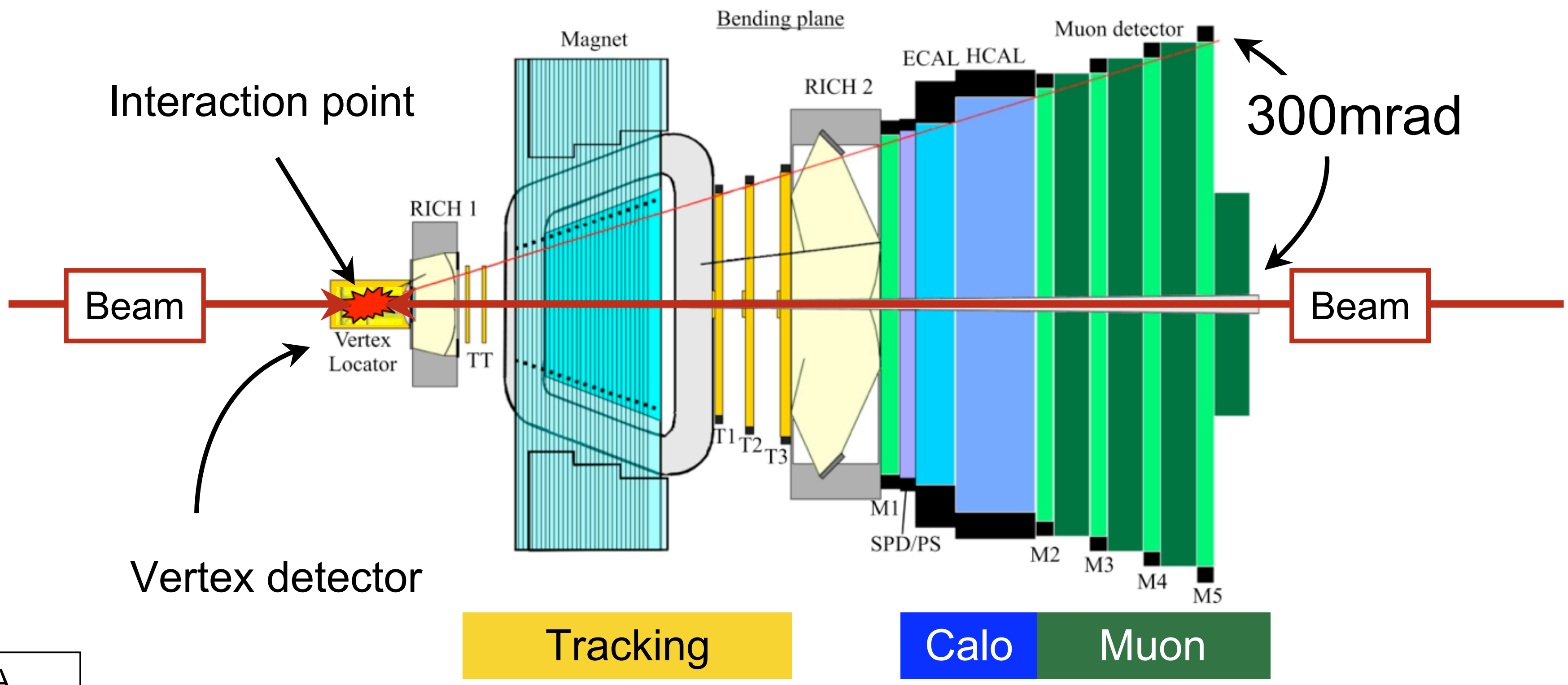
Studies of W and Z production with LHCb

Tara Shears, for the LHCb collaboration

LHCb

Kinematic range



See A. Golutvin plenary.

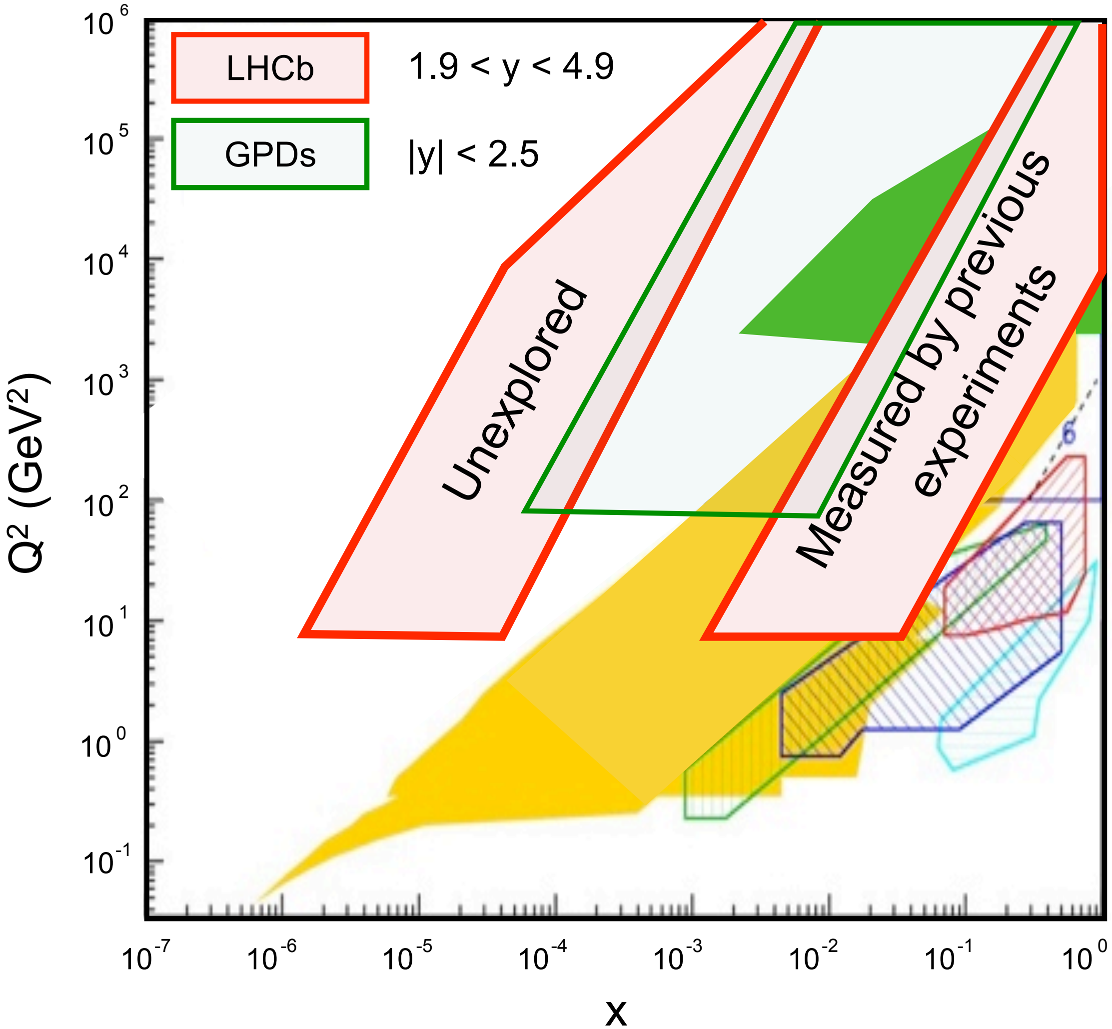
Fully instrumented within $1.9 \leq \eta \leq 4.9$

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

LHCb

Kinematic range

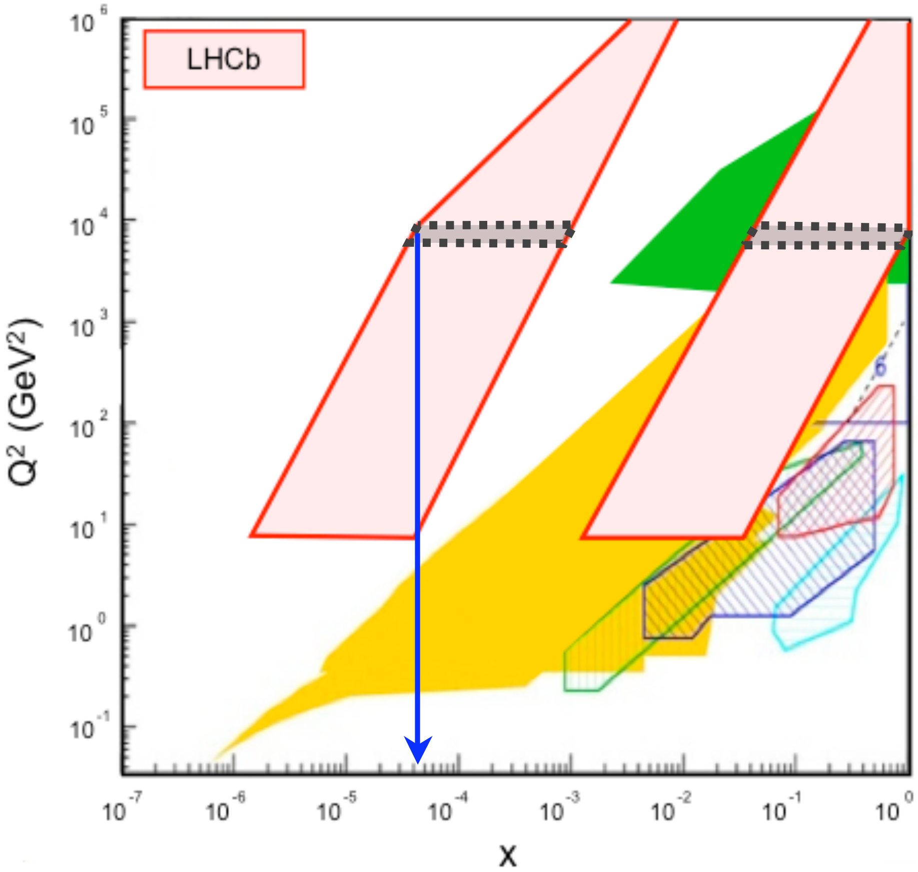
Angular acceptance + trigger thresholds ensure range of low x, high and low Q^2 can be probed.

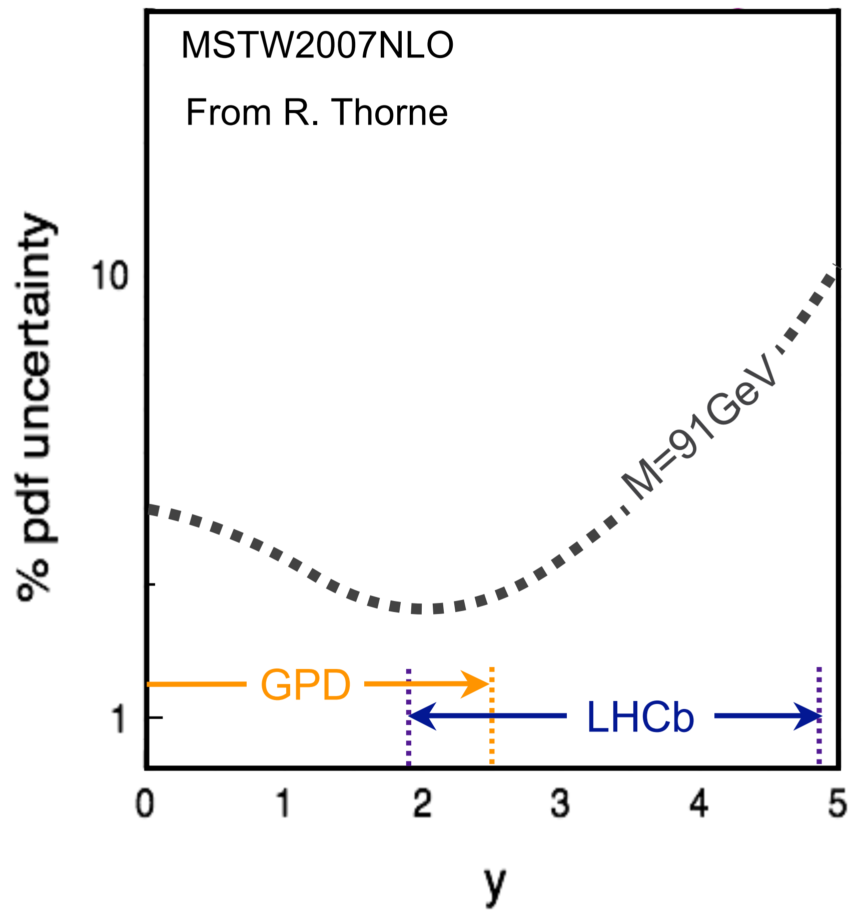


Low x capability: see talk by S. Ochesanu (no. 889)

LHCb
Kinematic range

$$\sigma_{pp\to Z} = \int dx_1 dx_2 \hat{\sigma}_{q\bar{q}\to Z} \sum_q [f_{q/p_1}(x_1, Q^2) f_{\bar{q}/p_2}(x_2, Q^2) + (q \leftrightarrow \bar{q})]$$





Selection studies:

Pythia
CTEQ5(6)L
Multiple interactions simulated
Underlying event tune

PDF sensitivity studies:

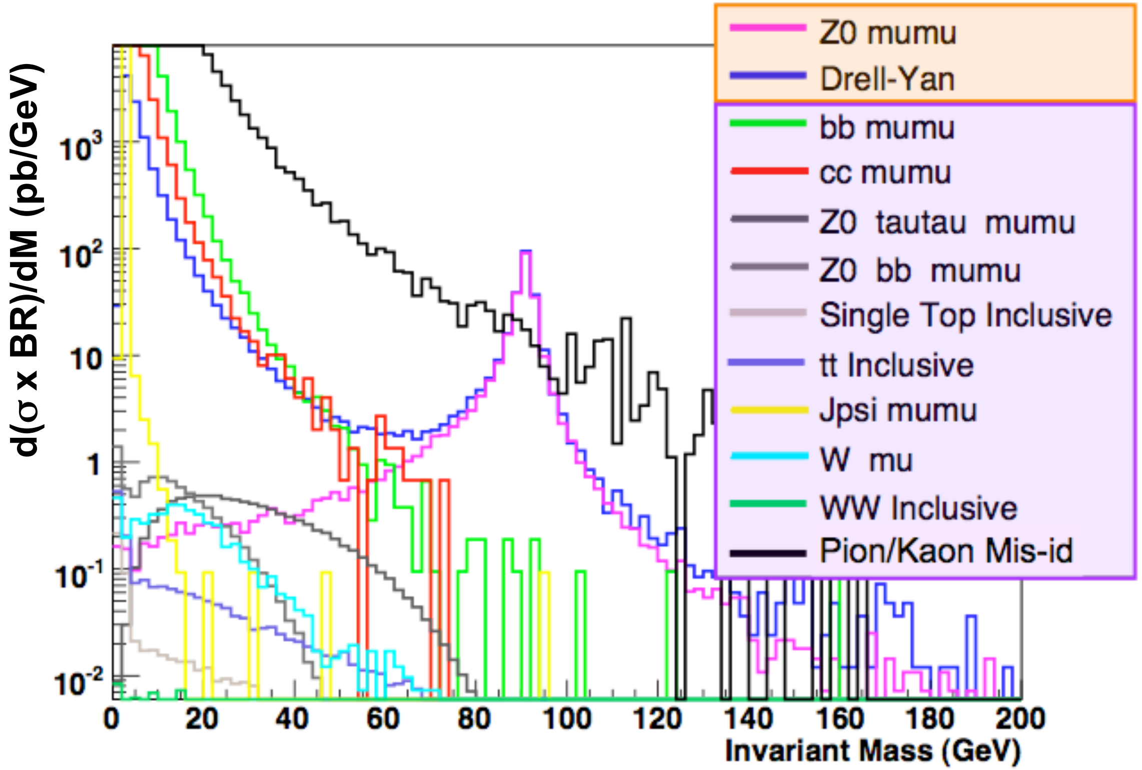
MCFM
CTEQ6.6/MSTW08/
NNPDF1.0/Alekhin

Trigger:

L0:
- $2\ \mu,\ \Sigma p_{T\mu} > 1.5$ GeV

HLT:
- $2\ \mu,\ p_{T\mu} > 10$ GeV
- $M_{\mu\mu} > 50$ GeV

Trigger efficiency 91%

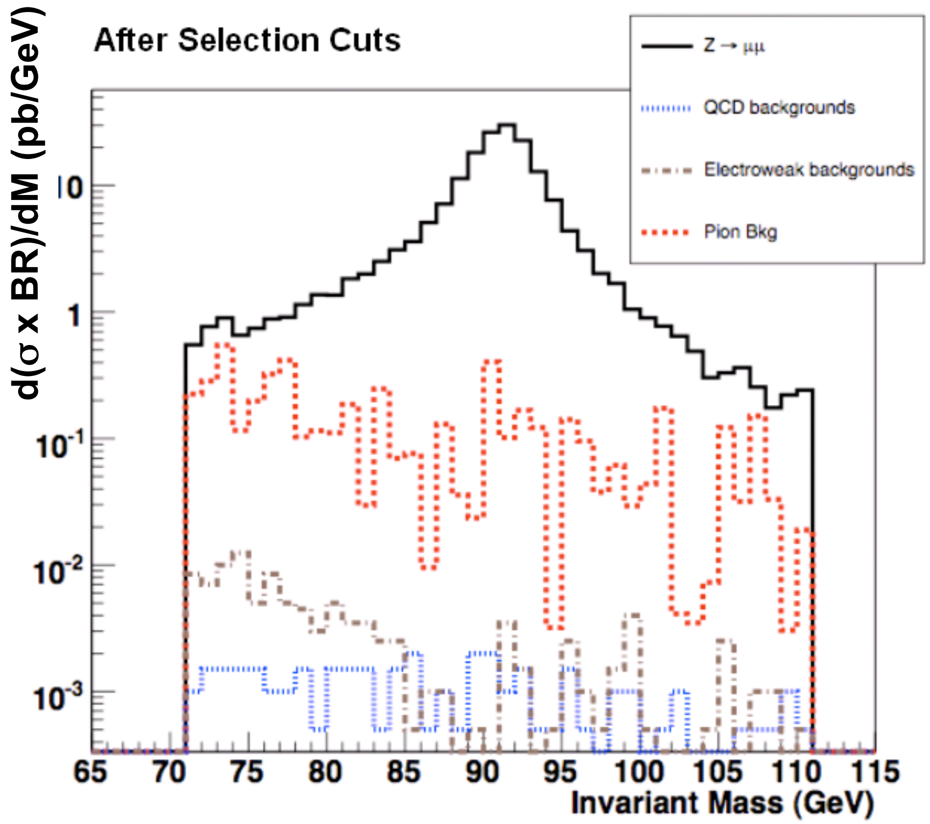


See J. Anderson, CERN-THESIS-2009-020

Reconstruct:

- $p_{T\mu}^{1(2)} > 20$ (15) GeV
- IP_{μ} significance < 5
- $E_{had} < 50$ GeV
- $71 < M_{\mu\mu} < 111$ GeV

Selection efficiency 91%;
Purity 97%.

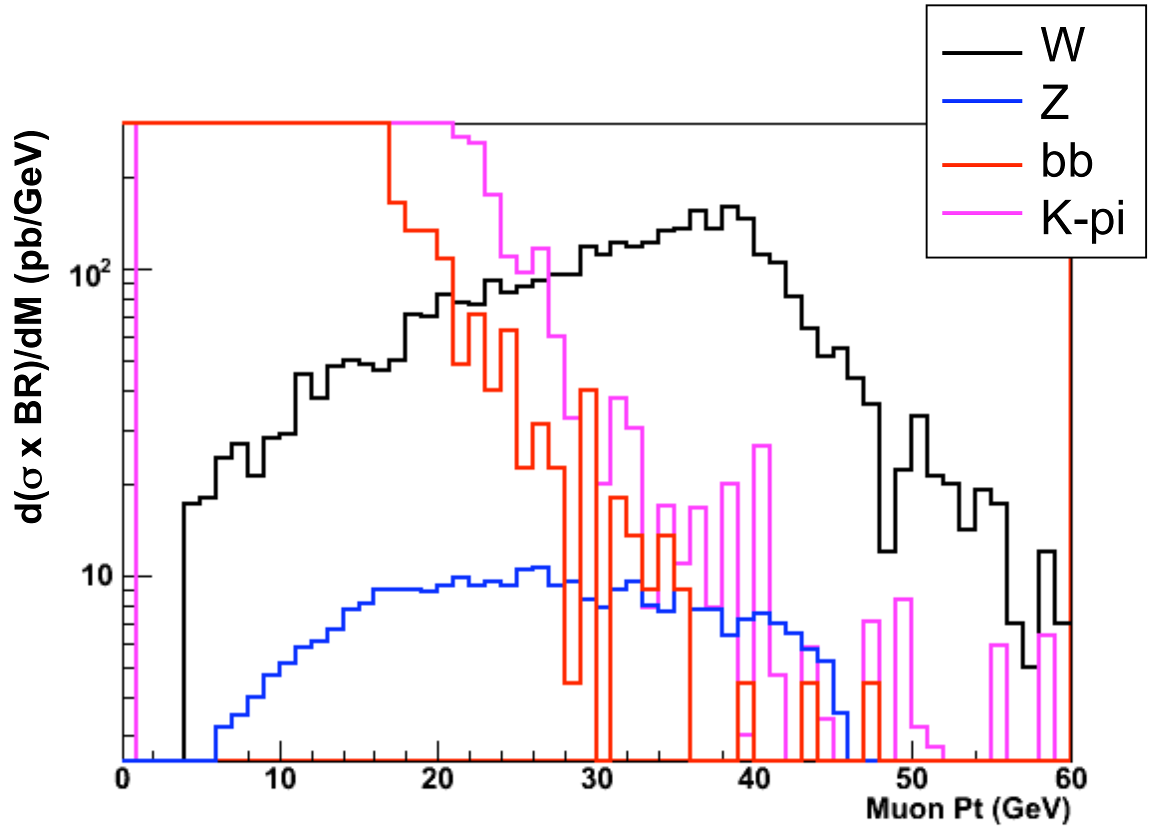


Trigger:

L0:
– $p_{T\mu}$ > 1.1 GeV

HLT:
– $p_{T\mu}$ > 20 GeV

Trigger efficiency 74%

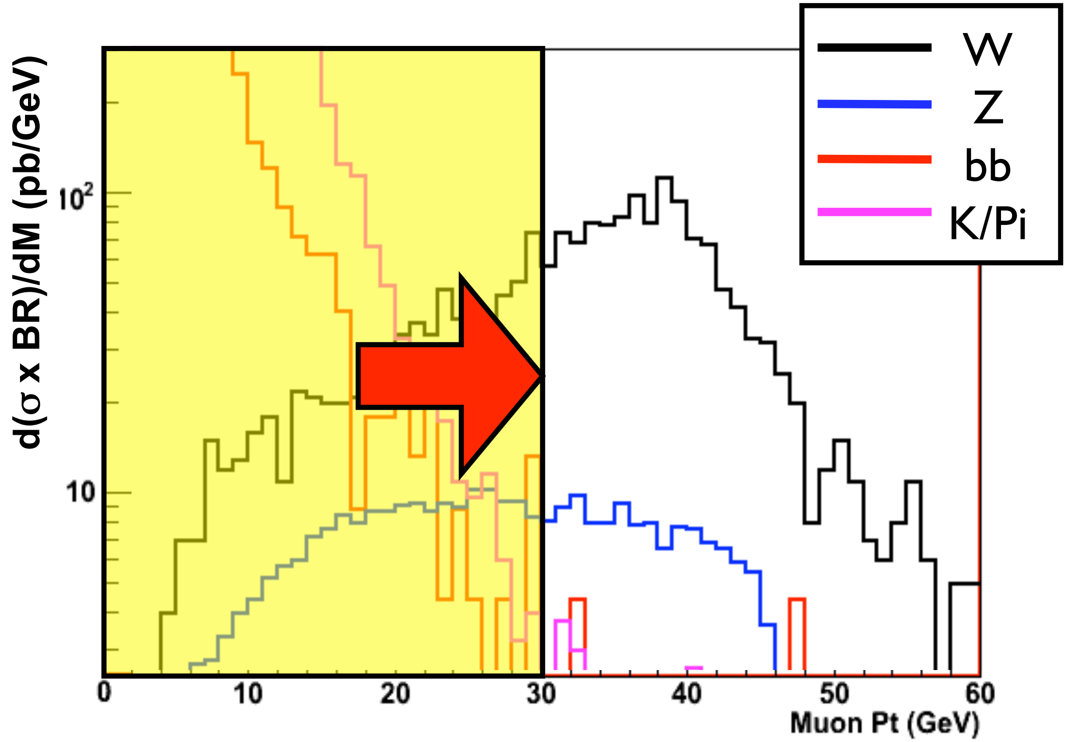


See S. Traynor, DIS09

Reconstruct:

- $p_{T\mu}$ > 30 GeV
- p_T asymmetry A_{pT} > 0.85

$$A_{pT} = \frac{p_{T\mu} - p_{Trest}}{p_{T\mu} + p_{Trest}}$$



Selection efficiency 35%;
Purity 90%.

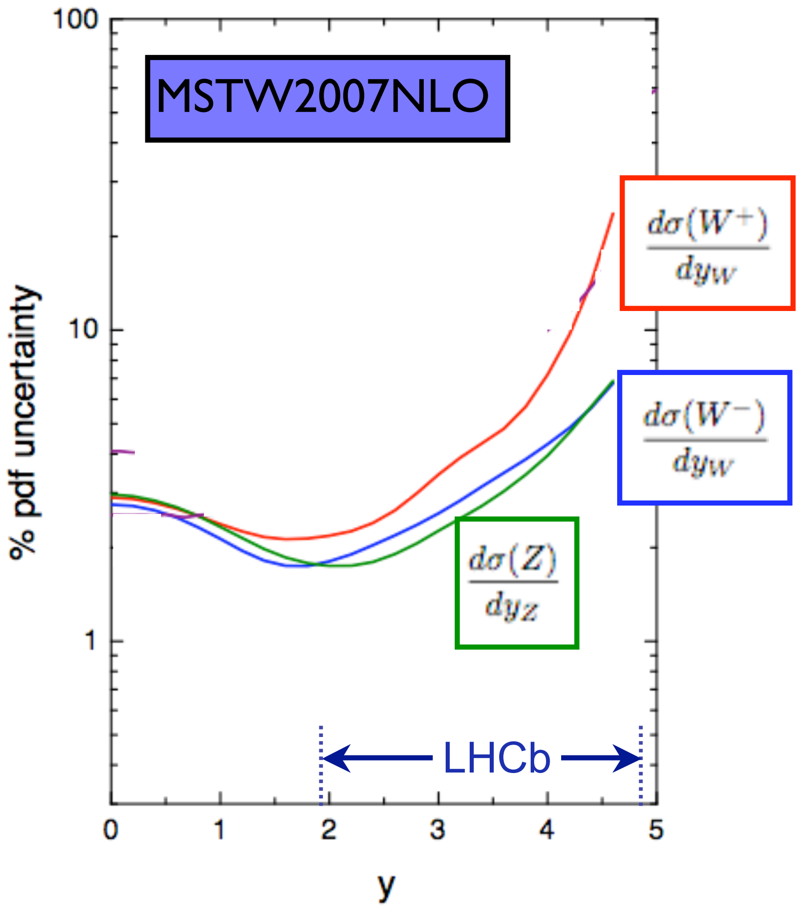
Precision

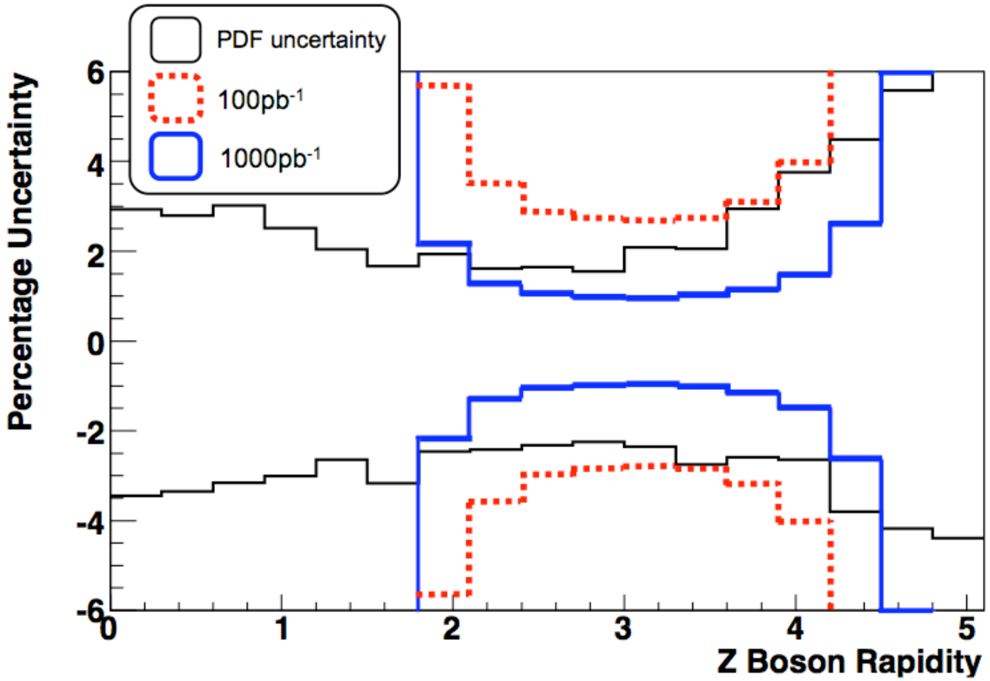
% Measurement Uncertainties with $100 pb^{-1}$		
	$\sigma(W \to \mu\nu_\mu : 1.9 < \eta_\mu < 4.9)$	$\sigma(Z \to \mu\mu : 1.9 < \eta_{\mu\mu} < 4.9)$
Statistical	**0.5**	**0.8**
Background	0.3	0.2
Reconstruction efficiency	0.2	0.3
Trigger Efficiency	0.1	0.1
Luminosity (*)	**1-5**	**1-5**

Note: **estimates** (still under study).

Comparing precision

Ratios
Fitting dσ/dy





Similar experimental precision for W.
Method works if luminosity known.

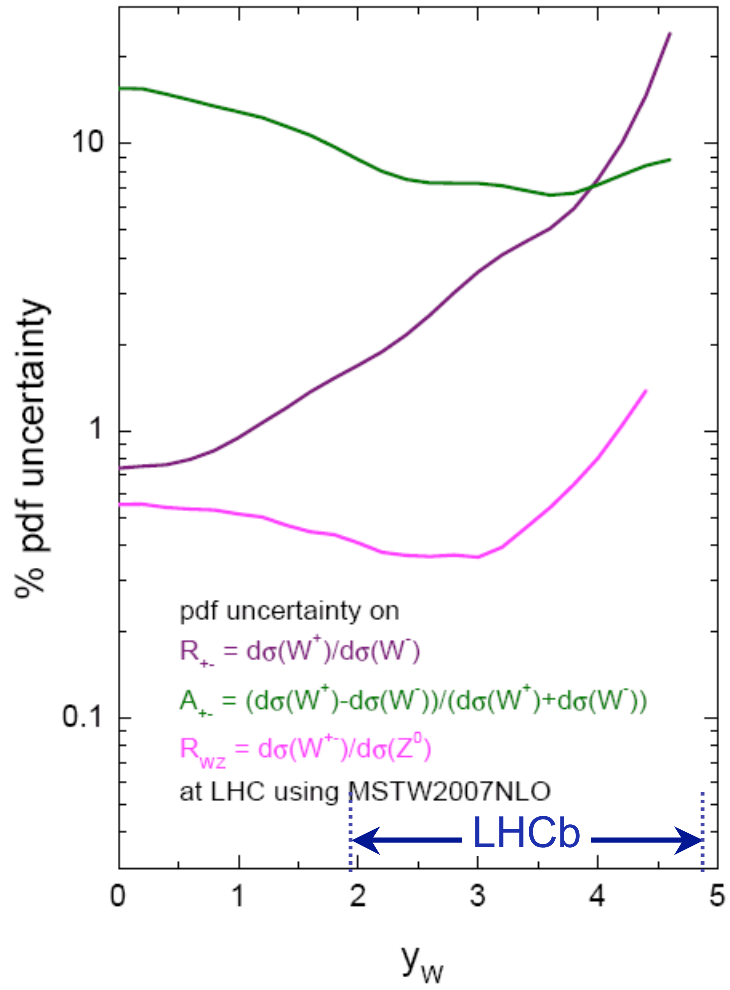
Ratios of W, Z production reduce lumi dependence

R_{+-} : sensitive to d/u ratio

R_{WZ}: many theoretical uncertainties cancel: test Standard Model (0.4%)

A_{+-}: sensitive to u_V - d_V difference

But more information obtained by fitting W, Z **together** …



Eg.

compare measured dσ/dy for W, Z to prediction,
constraining PDFs and fitting integrated luminosity.

Method tested:

using MCFM and CTEQ6.6, MSTW08, Alekhin, NNPDF1.0 PDF sets
many simulated pseudoexperiments to deduce

- statistical precision
- bias

See F. De Lorenzi DIS09,
R. McNulty PDF4LHC 29/05/09,
Poster, abstract no. 31

Comparing precision
Ratios
Fitting dσ/dy

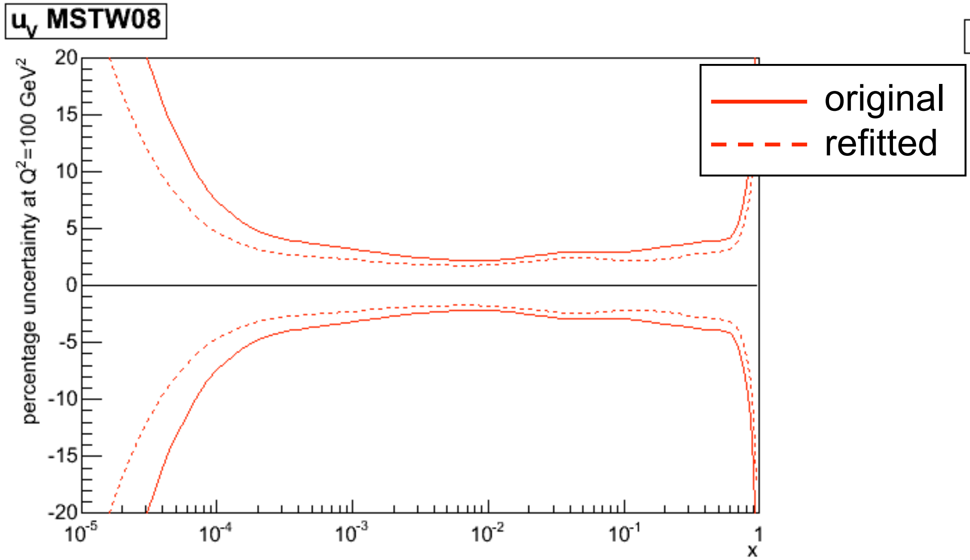
	0.1 fb^{-1}			
	MSTW08	CTEQ66	Alekhin	NNPDF
W+	1.8	2.4	2.0	2.7
W-	1.9	2.6	2.2	2.3
Z	1.9	2.4	2.2	2.2
WWZ	**1.7**	**2.3**	**1.8**	**1.9**
	1 fb^{-1}			
	MSTW08	CTEQ66	Alekhin	NNPDF
W+	1.6	2.2	1.8	2.3
W-	1.6	2.3	2.1	2.2
Z	1.7	2.1	1.9	1.9
WWZ	**1.3**	**2.0**	**1.4**	**1.6**
	10 fb^{-1}			
	MSTW08	CTEQ66	Alekhin	NNPDF
W+	1.3	2.0	1.5	2.1
W-	1.2	1.9	1.6	2.1
Z	1.4	1.9	1.9	1.8
WWZ	**0.8**	**1.7**	**1.0**	**1.3**

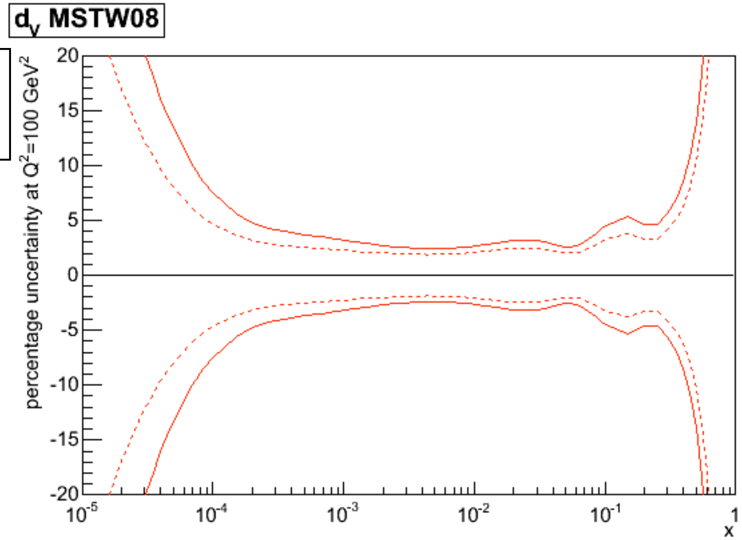
Percentage statistical uncertainty on **fitted luminosity**

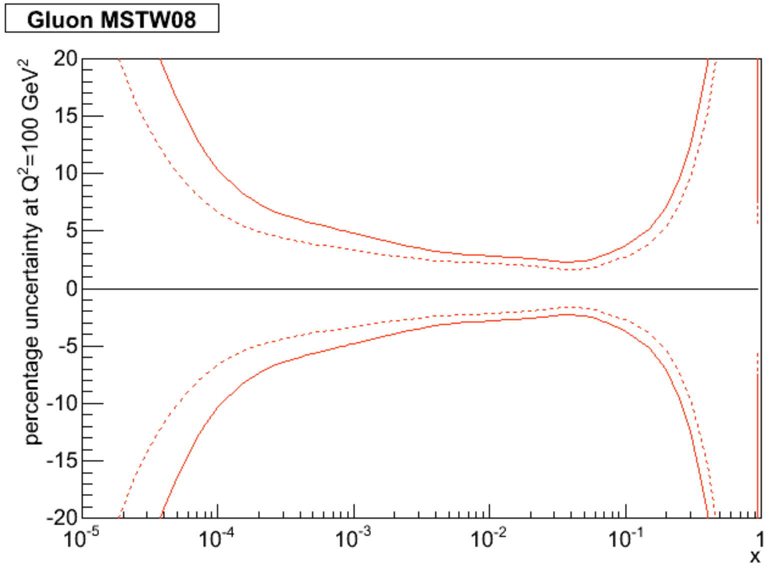
	1 fb^{-1}		
	CTEQ66	Alekhin	NNPDF
W+	3.5	4.1	-1.6
W-	0.8	1.9	2.0
Z	2.1	4.8	-3.6
WWZ	**2.3**	**3.5**	**-0.3**

Percentage **bias** on fitted luminosity

Fitting dσ/dy







Effect on u_V, d_V, gluon MSTW08 PDFs from using 1 fb^{-1} of WWZ data

(* assuming data have full weight in fit)

LHCb can trigger and reconstruct W, Z bosons within $1.9 < \eta < 4.9$.

Selection studies estimate a statistical precision < 1% with ~100 pb^{-1} of data.

Systematic errors dominated by luminosity uncertainty.

Measurements probe low x values of ~10^{-4}, and can help constrain PDFs even if luminosity not well known.

Backup: LHCb luminosity measurement methods

Direct measurements:

Van der Meer scan:

- Measure event rate as beams are moved across each other
- Ultimate precision 5-10%

Beam gas:

- inject small amount of gas into beam and measure vertices to image bunch shape; CERN-PH-EP-2005-023
- Ultimate precision < 5 %

Indirect measurements:

$pp \rightarrow p+\mu\mu+p$:

- QED process; CERN-THESIS-2009-020
- Estimated precision 1% (1 fb^{-1})

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

- Estimated precision 1-2% (using method referred to in talk)

Backup: distinguishing PDF descriptions

	0.1 fb^{-1}			
	MSTW08	CTEQ66	Alekhin	NNPDF
W+	99	98	98	97
W-	99	86	65	97
Z	99	95	96	98
WWZ	**99**	**89**	**77**	**93**
	1 fb^{-1}			
	MSTW08	CTEQ66	Alekhin	NNPDF
W+	99	91	93	63
W-	99	54	4	82
Z	99	73	57	87
WWZ	**99**	**25**	**0**	**5**
	10 fb^{-1}			
	MSTW08	CTEQ66	Alekhin	NNPDF
W+	99	34	12	0
W-	99	6	0	0
Z	99	23	1	0
WWZ	**99**	**0**	**0**	**0**

Percentage failure rate to fit data (generated with MSTW08)