Weak Mixing Angle: LHCb Pseudodata Studies

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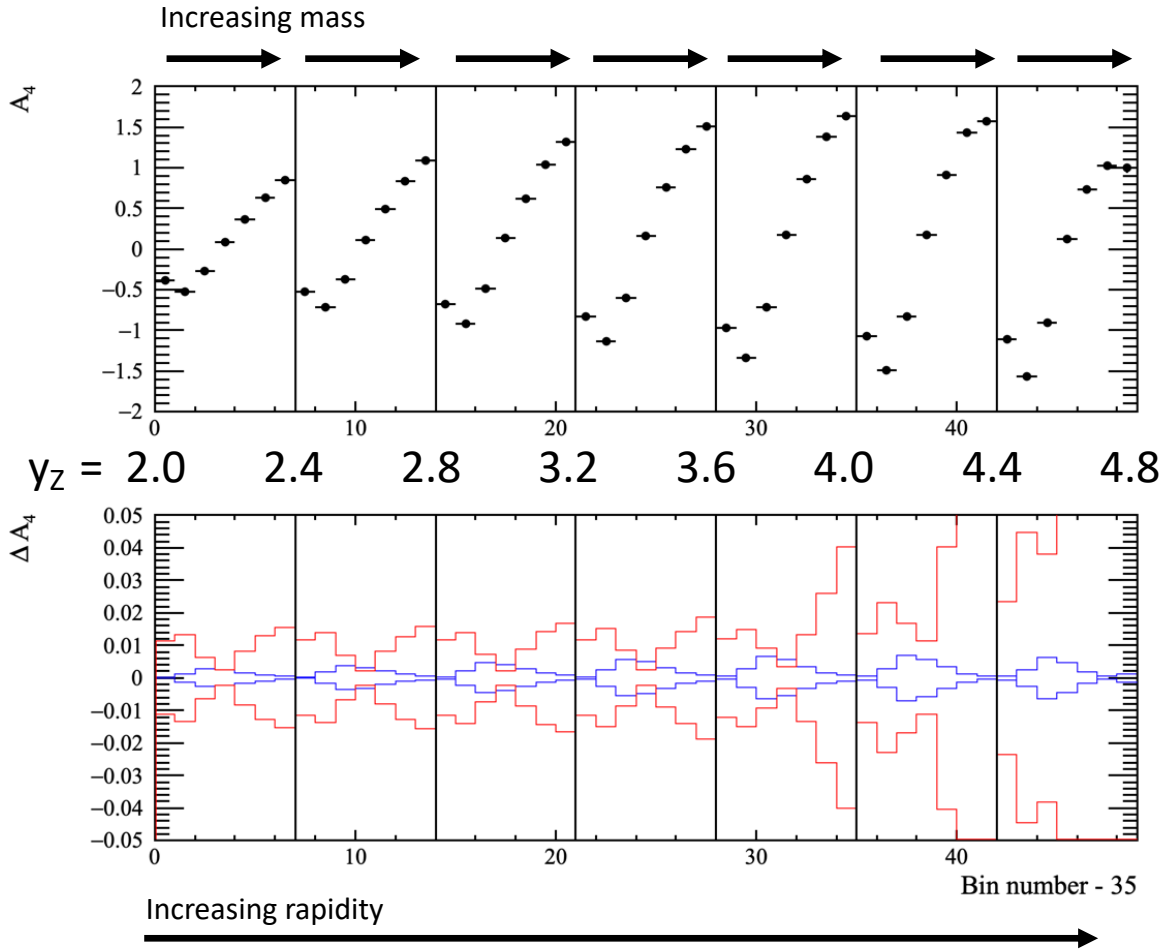
Details

- Compare and combine pseudodata of measurements of A_4 at different experiments.
- Use a common framework for these studies:
  - POWHEG + Pythia8; LO EW, NLO(+PS) QCD
  - PDF: NNPDF31_nnlo_as_0118_hessian
  - Bins of width 0.4 in |y|
  - 7 bins in dimuon invariant mass: {50, 66, 76, 86, 96, 106, 116, 150 GeV}
- Since last time:
  - Sample size increased (750M events generated in 4pi, sample in LHCb equivalent to a luminosity >30 times larger than Run III)
  - Sensitivity per bin determined.

LHCb acceptance



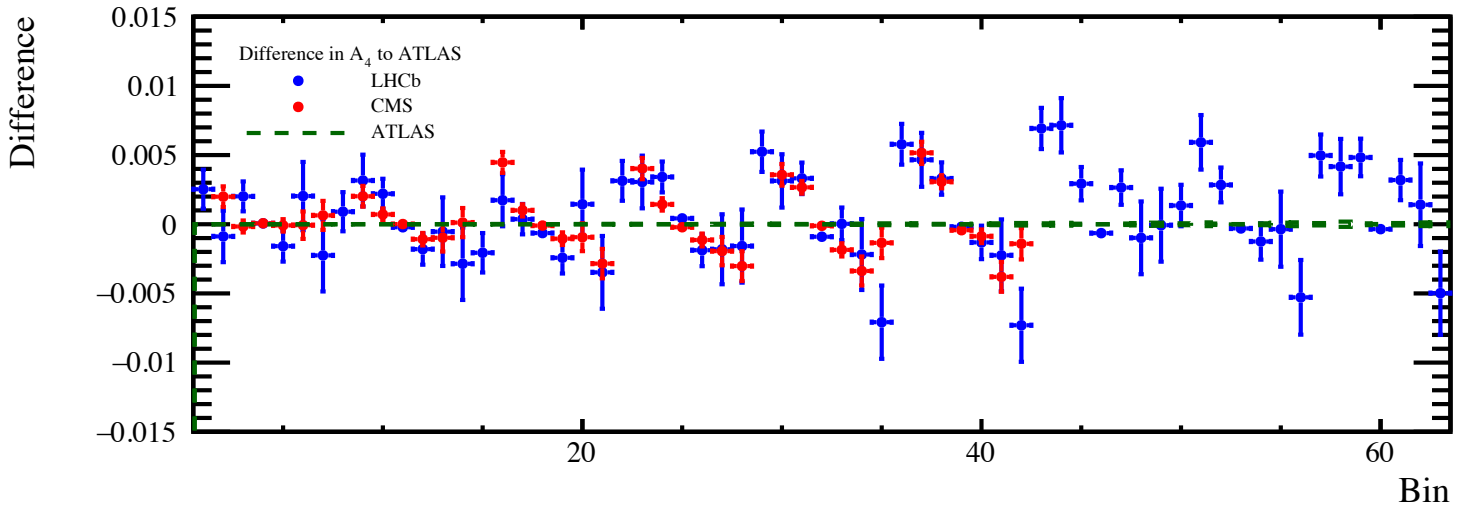
- A_4 determined with fit to generator level data (leptons in 4π).
- Bins in mass and rapidity; shift from weak mixing angle in blue ($\pm 50 \times 10^{-5}$); uncertainty from PDFs in red.
- Binning scheme here:

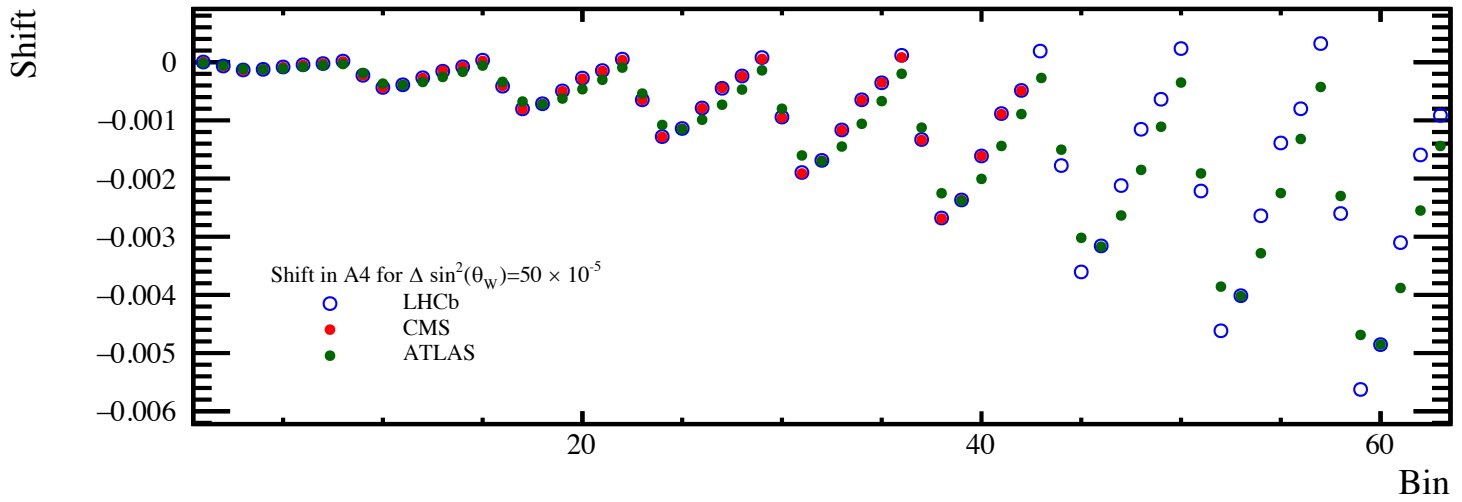
  Bin number = Mass Bin + Rapidity Bin * 7

CMS values from: aleko_sw2_v1.root
Is there a version without “first mass bin” cuts?

Validation

- ATLAS, CMS, LHCb all produce A_4 predictions, and we see excellent agreement on the Z peak.
- We also agree on the shift in A_4 at mZ that is induced by a shift in the weak mixing angle.
- Plot excludes lowest mass CMS bin.

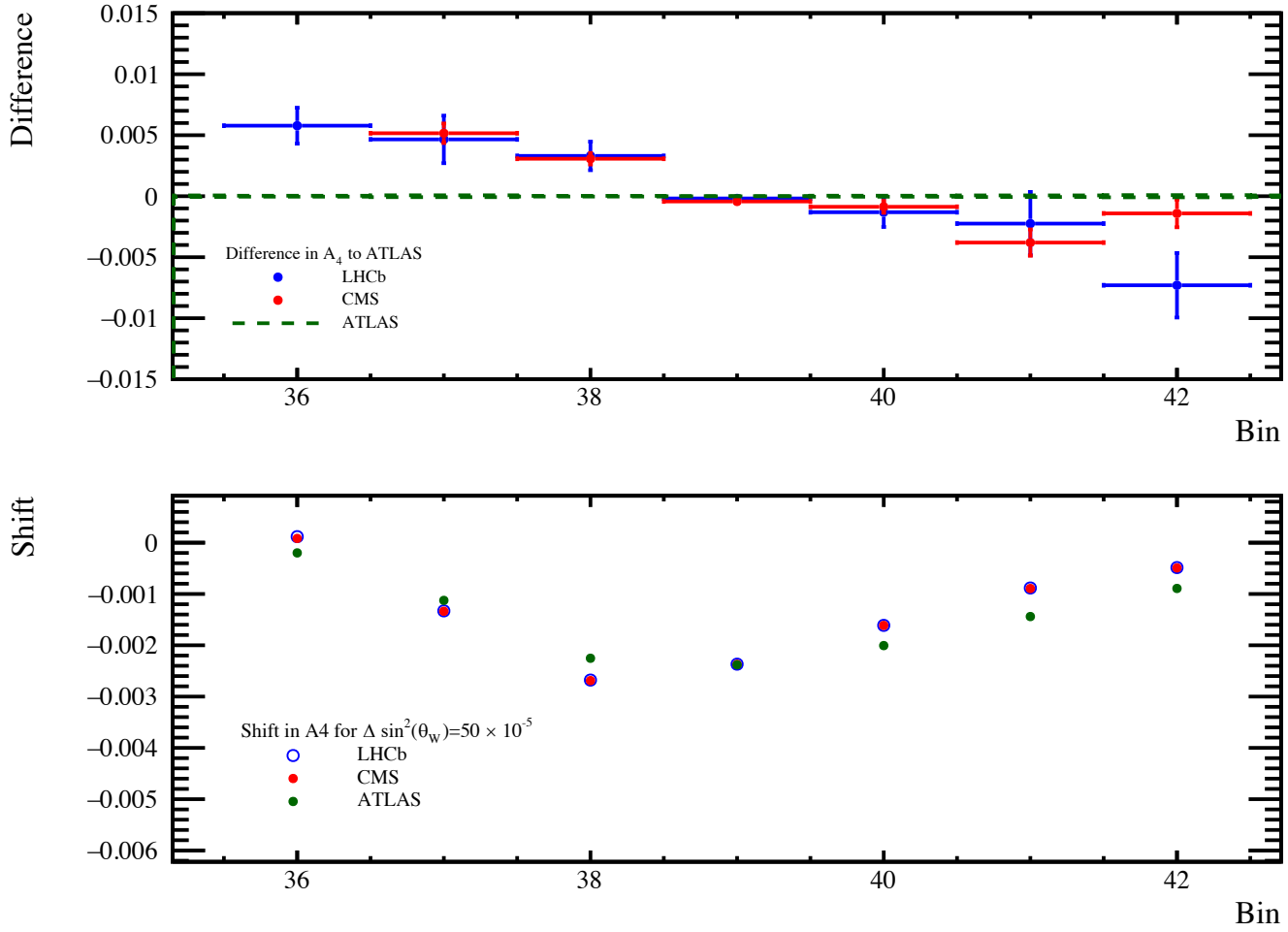




Bin = Mass Bin + Rapidity Bin * 7

Validation

- Zoom in on the overlap region between the LHCb, ATLAS and CMS acceptance.
- Very good agreement between CMS and LHCb in A4 values.
- In the Z bin: Very good agreement between all 3 studies.

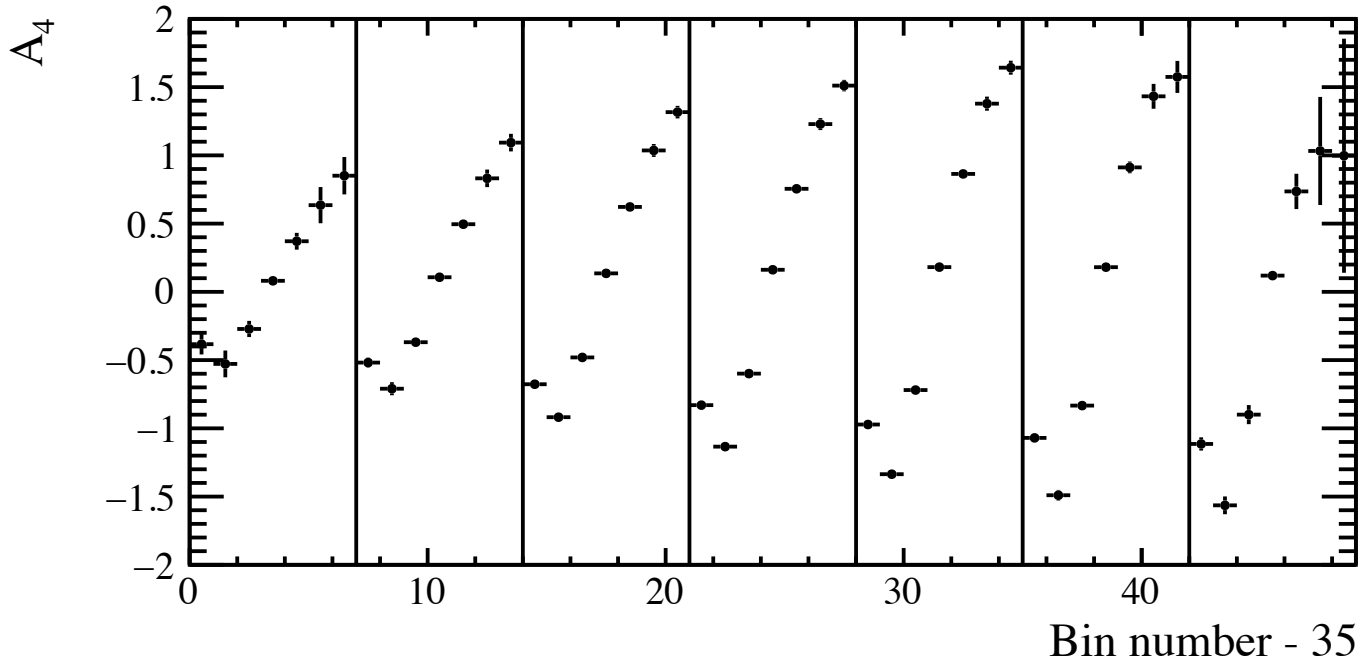


LHCb pseudodata

- Consider events within LHCb acceptance:
  - Kinematic selection defined by previous analyses and current plans for weak mixing angle measurement.
  - Consider $2 < y_Z < 4.8$.
- Study performed at generator level (no smearing).
- Normalise expected yields to those found in $\sqrt{s} = 13$ TeV cross-section analysis, scaled by full Run II integrated luminosity (6/fb) – so include effects of detection efficiency ≠ 100%.
- Expect roughly 1M events in LHCb acceptance in Run II dataset.
- Fit $\cos\theta$ distribution for $A_4(m,y)$.

LHCb pseudodata

- Fit to extract A4 values (and expected statistical uncertainty on these values).



LHCb pseudodata

- Extract favoured value of weak mixing angle from pseudodata.
- For Run II, LHCb expects Stat Unc: 31×10^{-5}; PDF Unc (not profiled): 21×10^{-5}
  - Asimov and Poisson-fluctuated sets agree.
  - Eigenvector with largest contribution to uncertainty is eigenvector 29
    - Aleko showed profiling had biggest impact on this eigenvector.
  - Use of PDF reweighting techniques (and MC replica sets) already show that LHCb Run II dataset does not significantly further reduce the PDF uncertainty in the LHCb acceptance.
    - Work to be done: implement PDF profiling (numerically equivalent to reweighting)
- LHCb Run III (using LHCb upgrade) should reduce this statistical uncertainty by a factor 2.
- Will upload data to /afs/cern.ch/user/w/wbarter/public/ForEWWG/ in next few days.

LHCb pseudodata

bin	yZ	sensitivity / 1E-5
36		32000
37		3700
38		1100
39	2.0 - 2.4	330
40		1900
41		7500
42		14000
43		11000
44		1300
45		410
46	2.4 - 2.8	120
47		720
48		2800
49		5100
50		6300
51		780
52		240
53	**2.8 - 3.2**	**74**
54		440
55		1700
56		2900

bin	yZ	sensitivity / 1E-5
57		4400
58		610
59		190
60	**3.2 - 3.6**	**60**
61		360
62		1400
63		2300
64		3400
65		570
66		190
67	**3.6 - 4.0**	**63**
68		390
69		1600
70		2900
71		3100
72		660
73		240
74	4.0 - 4.4	91
75		650
76		3400
77		13000

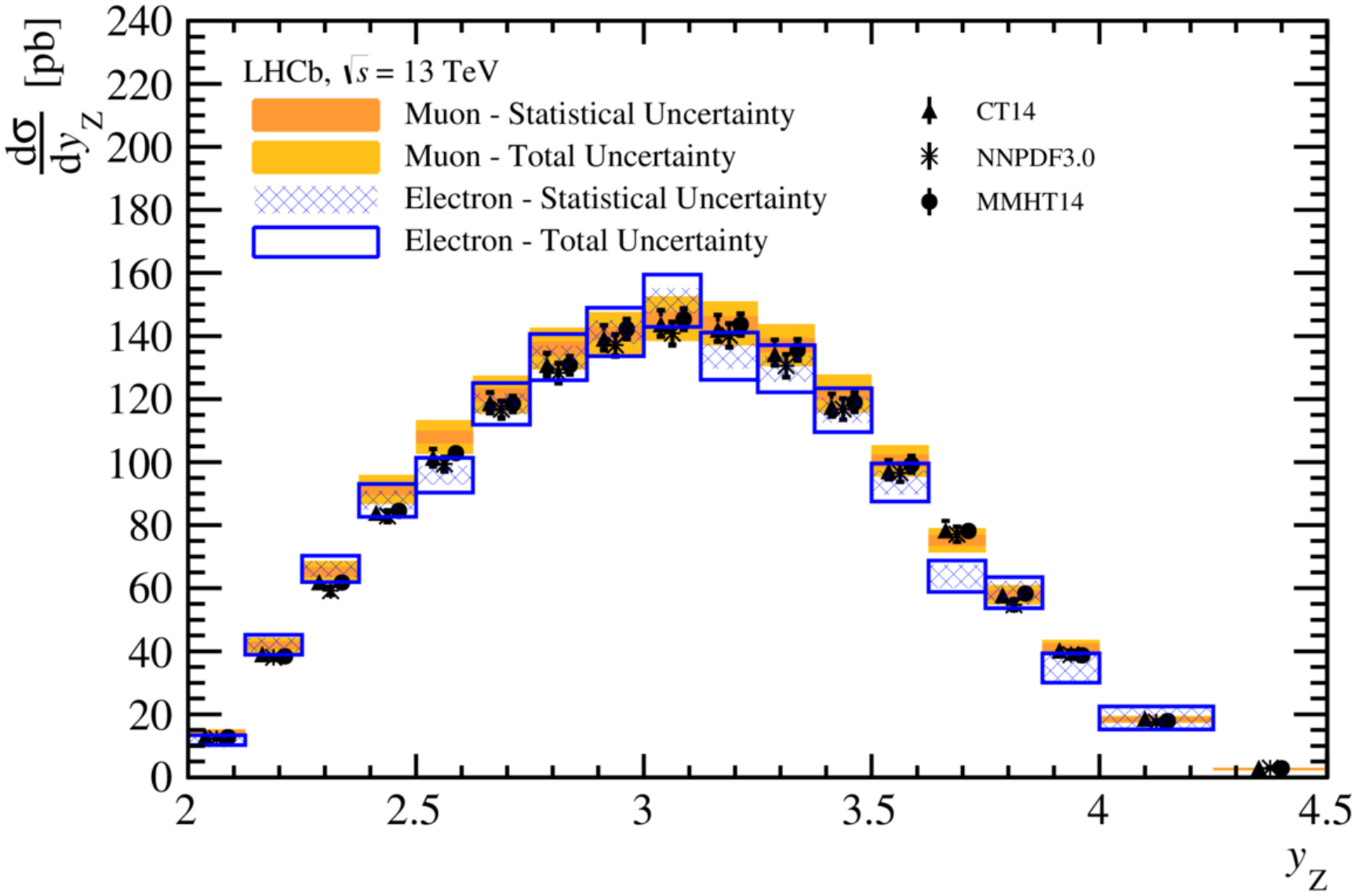
bin	yZ	sensitivity / 1E-5
78		3400
79		1300
80		560
81	4.4 - 4.8	290
82		3700
83		38000
84		34000

- Pseudodata assumes use of full LHCb Run II dataset.
- Sensitivity to the weak mixing angle in each bin.
- Note majority of LHCb events in region 2.4<yZ<3.6

Conclusions

- CMS and LHCb A4 predictions agree well.
- All 3 experiments agree well at mZ.
- LHCb pseudodata analysed assuming Run II yields.
- Sensitivity to the weak mixing angle shown in each bin.
- To Do: PDF profiling (reweighting of MC replica PDF sets shows expected impact is small).

Backup


LHCb, $\sqrt{s}$ = 13 TeV
Muon - Statistical Uncertainty
Muon - Total Uncertainty
Electron - Statistical Uncertainty
Electron - Total Uncertainty
CT14
NNPDF3.0
MMHT14
$\frac{d\sigma}{dy_Z}$ [pb]
y_Z
0
20
40
60
80
100
120
140
160
180
200
220
240
2
2.5
3
3.5
4
4.5