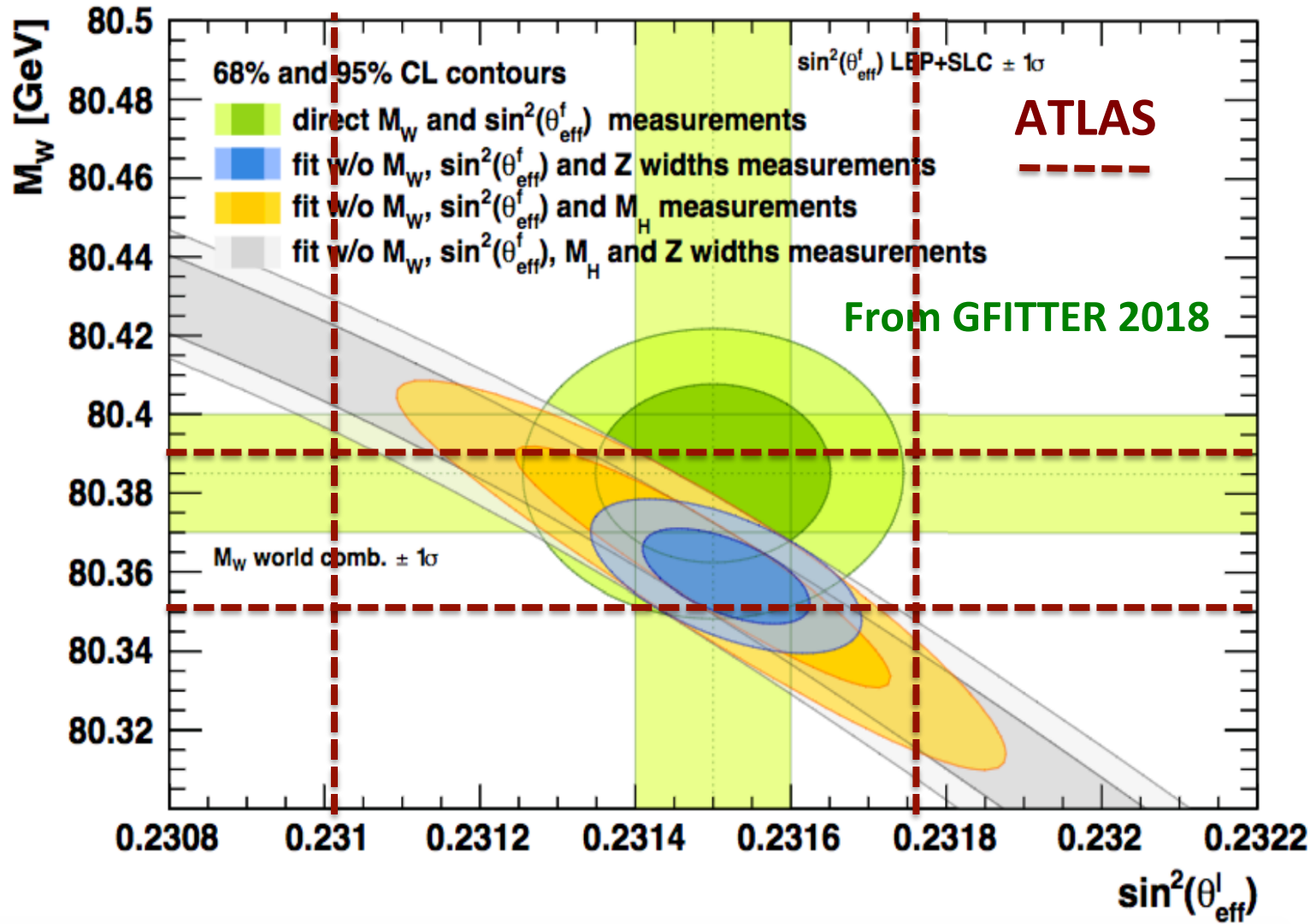


LHC precision DY measurements and PDFs

“Preparation for PDF4LHC forum meeting on 13/12/2018”

- Note was sent to PDF4LHC forum on behalf of LHC precision EW working group, it has been uploaded to this agenda at https://indico.cern.ch/event/766590/contributions/3204370/attachments/1751457/2838117/PDFnote_221019.pdf
- Summarise main questions in this introduction, taking into account feedback already received

Precision tests of the EW sector



LHC ellipse in this plot has axes mostly defined by PDF

LHC precision DY measurements and PDFs

Questions about PDF uncertainties:

- the most important point in the note is in points 8 and 10 which request a breakdown of uncertainties into their correlated component between PDF global fits and their uncorrelated component.
- we experimentalists would really like to know whether methodology and parameterisation uncertainties specific to each global fit (which must exist at a certain level) are accounted for in the PDF uncertainties or not. And if not, why not? Which closure tests have been done to verify that these uncertainties are negligible if they are considered as such?
- it appears that both CTEQ and MMHT have “tolerance” criteria which contribute in a significant way to their total uncertainties. We are eager to learn more about these: do they reflect tensions between different data? Between theory and data? Both?
- it appears that NNPDF does not need such criteria given its quite different methodology.

LHC precision DY measurements and PDFs

Questions about common set of data to be used for DY-specific PDF global fits:

- we propose to use a common set of data, to be defined together between the PDF experts and the DY measurement experts, as a baseline for future run-2 precision measurements
- this set of data should perhaps contain only precision DY data from the LHC, but in any event should probably only contain data relevant to the (x, Q^2) range of relevance to inclusive DY measurements at the LHC
- Is there anything useful to learn from the PDF4LHC15 PDF set? This seems to many of us to add a layer of complexity to PDF uncertainties.

LHC precision DY measurements and PDFs

Questions about common theoretical treatment:

- Ideally, the DY theory used should be defined jointly and all PDF sets should use this theory (presumably one of the available NNLO QCD calculations).
- The treatment of theoretical uncertainties should be discussed and incorporated if feasible in the fits. In a perhaps decreasing order of priority, QCD scale variations, QED/EW corrections, and parton-shower/resummation corrections should be considered.

Back-up slides

$\sin^2\theta'_{\text{eff}}$ results based on reference PDF set (MMHT14)

Channel	$eeCC$	$\mu\mu CC$	$eeCF$	$eeCC + \mu\mu CC$	$eeCC + \mu\mu CC + eeCF$
Central value	0.23148	0.23123	0.23166	0.23119	0.23140
	Uncertainties				
Total	68	59	43	49	36
Stat.	48	40	29	31	21
Syst.	48	44	32	38	29
	Uncertainties in measurements				
PDF (meas.)	8	9	7	6	4
p_T^Z modelling	0	0	7	0	5
Lepton scale	4	4	4	4	3
Lepton resolution	6	1	2	2	1
Lepton efficiency	11	3	3	2	4
Electron charge misidentification	2	0	1	1	< 1
Muon sagitta bias	0	5	0	1	2
Background	1	2	1	1	2
MC. stat.	25	22	18	16	12
	Uncertainties in predictions				
PDF (predictions)	37	35	22	33	24
QCD scales	6	8	9	5	6
EW corrections	3	3	3	3	3

- Fit using MMHT14 provides best overall result, i.e. best fit χ^2 and also smallest uncertainties from PDFs after profiling

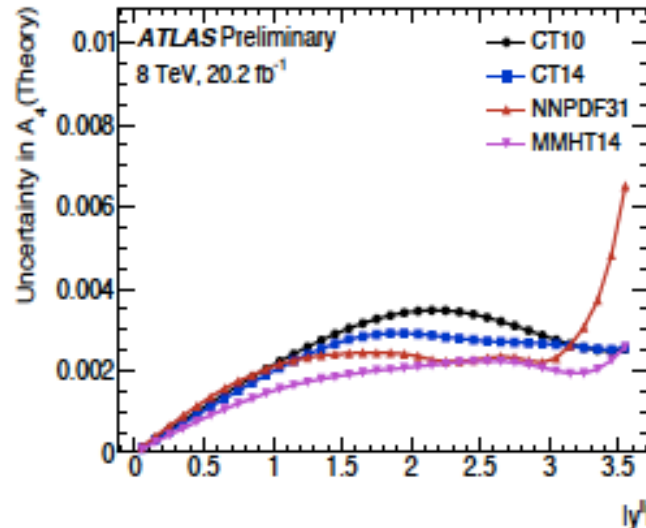
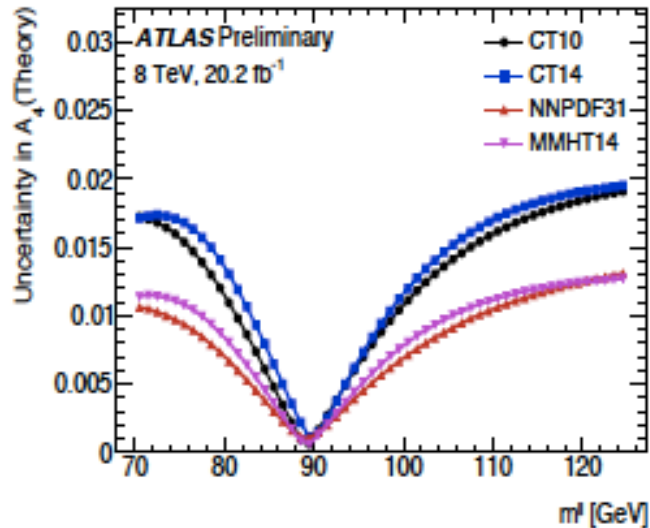
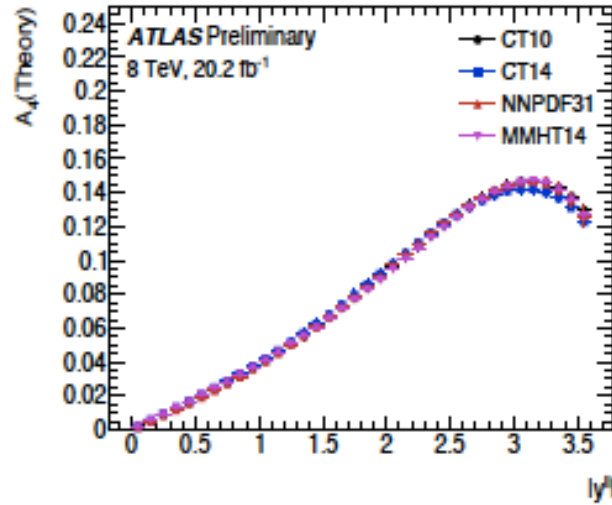
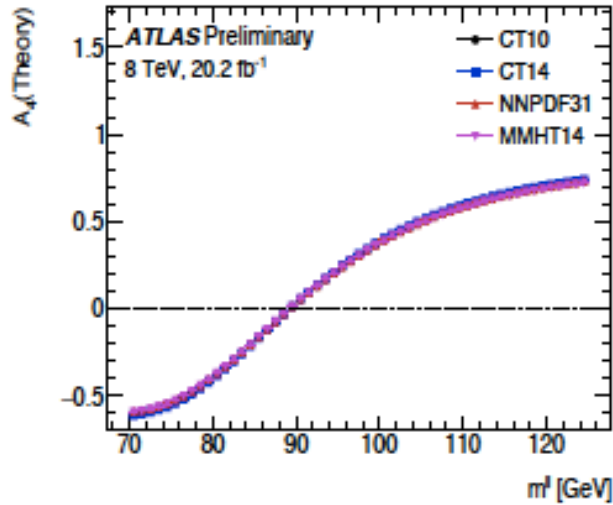
$\sin^2\theta'_{\text{eff}}$ results based on reference PDF set (MMHT14)

	CT10	CT14	MMHT14	NNPDF31
$\sin^2\theta'_{\text{eff}}$	0.23118	0.23141	0.23140	0.23146
	Uncertainties in measurements			
Total	39	37	36	38
Stat.	21	21	21	21
Syst.	32	31	29	31

Table 13: Results for extracted values of $\sin^2\theta'_{\text{eff}}$ with the global breakdown of their uncertainties, shown for the four PDF sets considered in this note. The uncertainty values are given in units of 10^{-5} .

- Fit using MMHT14 provides best overall result, i.e. best fit χ^2 and also smallest uncertainties from PDFs after profiling
- Results quite close for CT14 and NNPDF31, uncertainties a bit larger.
- CT10nnlo also shown since it fits best the ensemble of ATLAS W/Z precision data at 7 TeV used for measurement of m_W .
- Overall $\sin^2\theta'_{\text{eff}}$ range spanned by all PDF sets is $28 \cdot 10^{-5}$
- This is being studied by CTEQ experts (Pavel, Tim and Joey)

A4 analysis: predictions



- Fixed-order predictions of A_4 using DYTurbo (optimised version of DYRES/DYNNLO):

- NLO QCD
- LO EW
- PDG $\sin^2\theta_W$ for central value

A_4 largest at $y^Z \sim 3$

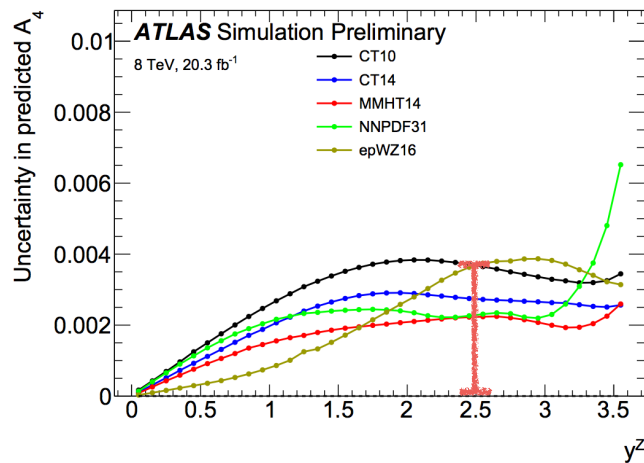
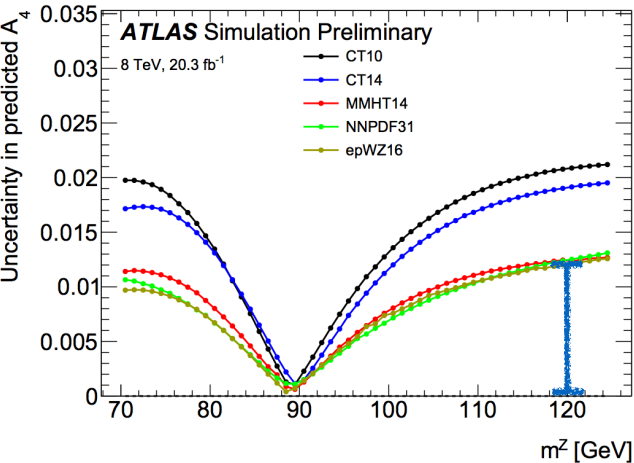
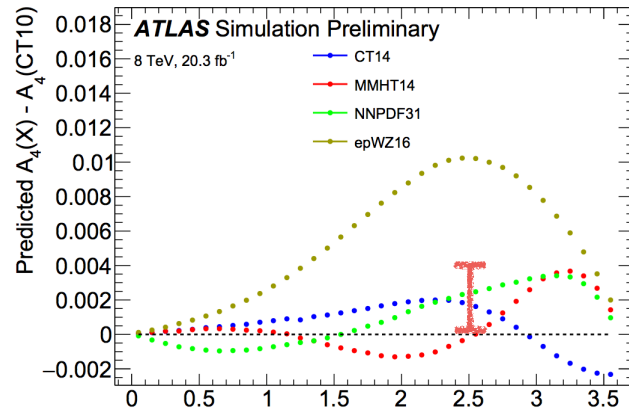
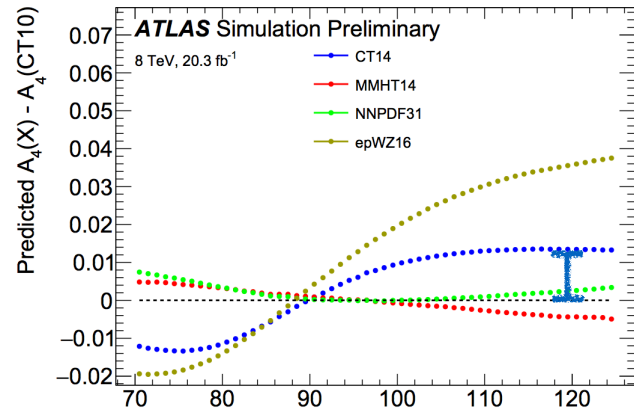
- y^ll shape driven by dilution effects
- m^ll shape driven by Z/γ^* interference

Uncertainty on A_4 largest above and below the mass pole

- Can be used to profile PDFs

A4 analysis: predictions

Predictions of A_4 vs m^Z and y^Z



- Most predictions within 1σ of each other
- ATLAS-epWZ16 is 2-3 σ from others at high y^Z where we have highest sensitivity to $\sin^2\theta_w$
- Differences between PDF sets in m^Z are generally different in sign below and above the pole, while changes in A_4 from $\sin^2\theta_w$ variations peak at the pole and are the same sign above and below the pole
- Differences in y^Z can sometimes have a different sign above and below 2.5 or so

X