

## Path to Yellow Report

- **We believe we are ready to seriously start documenting the work done since April 2018 in this activity of the working group. We propose to work on this documentation as an independent part or volume of a Yellow Report structured along the lines of the attached skeleton document.**
- **We would propose to work towards this with the following timescale and caveats:**
  - **Complete the calculations by ~ end of this year and to this end monitor progress every few weeks rather than few months (for example we propose to hold our next topical meeting on these issues in the week of 30/09 midway to the October workshop)**
  - **Finalise scope of YR by ~ end of this year**
  - **Produce complete draft of YR by ~ March 2020**
  - **Produce theory publications on specific items (virtual EW correction benchmarking would be one paper, QED ISR and IFI benchmarking would be another paper)**
  - **Complete report by summer 2020**

## Path to Yellow Report

- We believe working on the overall YR together is quite important from now on because the interplay between experiment and theory is the key to a useful report which in our minds has the goal of laying out a possible strategy (not necessarily unique!) of how experiments would publish their full run-2 results and how they would this be optimally ready for an overall LHC combination once all the individual results (and interpretations) are out.
- The prospects look good that this future LHC combination could have very similar precision to the overall LEP/SLC result ( $16 \cdot 10^{-5}$ )
- However, achieving that will surely require work beyond what will be in a YR published in summer 2020 (eg PDF uncertainty)
- So the YR will be a guideline showing what we can strive towards and work will surely continue beyond it on all fronts, but based on a, hopefully sound, written document vetted by the whole community.

# Path to Yellow Report

- **First part focuses on setting the context: LEP/SLD briefly with the best references available today, using also similar work done in the context of FCC\_ee studies, and then hadron colliders with the Tevatron and early LHC measurements.**

## Contents

<b>1</b>	<b>Introduction</b>	<b>3</b>
1.1	Electroweak pseudo-observables at LEP . . . . .	3
1.2	The weak mixing angle and effective weak mixing angle . . . . .	3
1.3	Observables sensitive to the weak mixing angle at hadron colliders . . . . .	6
1.4	Interpretation of early hadron collider measurements in terms of the effective weak mixing angle .	6

- **Include available uncertainty tables from most precise measurements from ATLAS (preliminary) and CMS (published)**

# Path to Yellow Report

- Second part is devoted to so-called virtual EW corrections.
- It contains current status of calculations with tables and plots from available results based on Dizet, Powheg-EW and MC-SANC

<b>2</b>	<b>Virtual EW corrections</b>	<b>7</b>
2.1	Introduction . . . . .	7
2.2	Overview of calculations/tools and input schemes . . . . .	7
2.3	Numerical results for virtual EW corrections . . . . .	7
2.3.1	Loops and box corrections with different EW schemes . . . . .	7
2.3.2	$\alpha_Q ED$ with different EW schemes . . . . .	10
2.3.3	$\sin^2 \theta_W$ with different EW schemes . . . . .	11
2.3.4	Improved Born Approximation and Effective Born . . . . .	12
2.3.5	The Z-boson lineshape . . . . .	12
2.3.6	The $A_{FB}$ distribution . . . . .	13
2.4	Benchmark results from Powheg_ew, MCSANC, PowhegZj+wt <sup>EW</sup> . . . . .	16
2.4.1	Benchmarks at EW LO . . . . .	17
2.4.2	Benchmarks at EW NLO, NLO+HO . . . . .	19
2.5	Theoretical uncertainties and conclusions . . . . .	19

# Path to Yellow Report

- Third part is devoted to so-called QED ISR and IFI and also to the impact of photon-induced processes which belongs here.
- At this point PDFs come in, and comparisons are done
  - a) without including photon-induced processes at all and using standard PDFs and
  - b) including photon-induced processes but using PDFs matched to LUXQED

<b>3</b>	<b>QED emissions</b>	<b>25</b>
3.1	Introduction . . . . .	25
3.2	Overview of calculations and tools . . . . .	25
3.3	Numerical results for QED ISR and IFI . . . . .	25
3.4	Photon-induced processes . . . . .	25
3.5	Theoretical uncertainties and conclusions . . . . .	25

# Path to Yellow Report

- Fourth part is the key one to facilitate and harmonise (within reason) experimental measurements and combinations at the LHC using full run-2 data.
- Final numbers will be needed at 13 TeV energy

<b>4</b>	<b>A possible strategy for run-2 measurements and combinations at the LHC</b>	<b>26</b>
4.1	Introduction . . . . .	26
4.2	Observables used for comparisons of expectations between experiments . . . . .	26
4.3	Interpretation tools . . . . .	26
4.3.1	QCD tools: DYTURBO, NNLOJET . . . . .	26
4.3.2	QED/EW tools: DIZET, POWHEG EW, MC-SANC, ZGRAD2? . . . . .	26
4.4	Combination tools . . . . .	26
4.4.1	Correlations between measurements: PDFs, QCD, QED/EW . . . . .	26
4.4.2	Profile likelihood fit to all observables and direct extraction of weak mixing angle . . . . .	26
4.4.3	Compatibility tests between measurements of different experiments . . . . .	26
4.4.4	Profile likelihood fit to all observables and direct extraction of weak mixing angle . . . . .	26
4.5	Expected breakdown of uncertainties and conclusions . . . . .	26
4.5.1	Measurement uncertainties . . . . .	26
4.5.2	PDF uncertainties . . . . .	26
4.5.3	QED/EW uncertainties . . . . .	26
4.5.4	QCD uncertainties . . . . .	26
4.5.5	Parametric uncertainties . . . . .	26
4.5.6	Conclusions . . . . .	26

## Path to Yellow Report

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- Goal would be to arrive at finest possible breakdown of expected (mostly theoretical) uncertainties although correlated experimental uncertainties may be of interest too

Table 3: Summary of the theoretical uncertainties for the dimuon and dielectron channels, as discussed in the text.

	Modeling parameter	Muons	Electrons
<b>CMS</b>	Dilepton $p_T$ reweighting	0.00003	0.00003
	$\mu_R$ and $\mu_F$ scales	0.00011	0.00013
	POWHEG MINLO Z+j vs. Z at NLO	0.00009	0.00009
	FSR model (PHOTOS vs. PYTHIA 8)	0.00003	0.00005
	Underlying event	0.00003	0.00004
	Electroweak $\sin^2 \theta_{\text{eff}}^\ell$ vs. $\sin^2 \theta_{\text{eff}}^{\text{u,d}}$	0.00001	0.00001
	Total	0.00015	0.00017



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## ATLAS

$m^{\ell\ell}$ (GeV)	70 – 80			80 – 100				100 – 125		
$ y^{\ell\ell} $	0 – 0.8	0.8 – 1.6	1.6 – 2.5	0 – 0.8	0.8 – 1.6	1.6 – 2.5	2.5 – 3.6	0 – 0.8	0.8 – 1.6	1.6 – 2.5
Prediction (MMHT14)	-0.0870	-0.2907	-0.5970	0.0144	0.0471	0.0928	0.1464	0.1045	0.3444	0.6807
	Uncertainties			Uncertainties				Uncertainties		
Total	0.0176	0.0202	0.0404	0.0015	0.0015	0.0025	0.0044	0.0083	0.0098	0.0230
Stat.	0.0153	0.0164	0.0333	0.0013	0.0013	0.0021	0.0036	0.0072	0.0078	0.0188
Syst.	0.0087	0.0117	0.0229	0.0007	0.0008	0.0013	0.0025	0.0041	0.0060	0.0133
PDF (meas.)	0.0013	0.0049	0.0048	0.0001	0.0002	0.0004	0.0007	0.0007	0.0016	0.0043
$p_T^Z$ modelling	0.0002	0.0004	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	< 0.0001	0.0002
Leptons	0.0023	0.0059	0.0118	0.0002	0.0001	0.0003	0.0007	0.0014	0.0037	0.0070
Background	0.0004	0.0011	0.0064	< 0.0001	< 0.0001	< 0.0001	0.0001	0.0004	0.0017	0.0031
MC stat	0.0082	0.0088	0.0179	0.0007	0.0007	0.0012	0.0023	0.0038	0.0041	0.0100

Table 7: Expected measurement uncertainties in  $A_4$  and their breakdown, based on MMHT14 pseudo-data. Also shown as a reference are the predictions for the central values using the MMHT14 PDF set, as obtained from Table 2.



# Path to Yellow Report

ATLAS

- Table below needs further breakdown!!

Channel	$eeCC$	$\mu\mu CC$	$eeCF$	$eeCC + \mu\mu CC$	$eeCC + \mu\mu CC + eeCF$
Total	65	59	42	48	34
Stat.	47	39	29	30	21
Syst.	45	44	31	37	27
Uncertainties in measurements					
PDF (meas.)	7	7	7	7	4
$p_T^Z$ modelling	< 1	< 1	1	< 1	< 1
Lepton scale	5	4	6	3	3
Lepton resolution	3	1	3	1	2
Lepton efficiency	1	1	1	1	1
Electron charge misidentification	< 1	0	< 1	< 1	< 1
Muon sagitta bias	0	4	0	2	1
Background	1	1	1	1	1
MC. stat.	25	22	18	16	12
Uncertainties in predictions					
PDF (predictions)	36	37	21	32	22
QCD scales	5	5	9	4	6
EW corrections	3	3	3	3	3

Table 8: Expected measurement uncertainties in  $\sin^2 \theta_{\text{eff}}^\ell$  and their breakdown, based on MMHT14 pseudo-data. The values are given in units of  $10^{-5}$ , assuming an effective value of  $\sin^2 \theta_W = 0.23152$ . The uncertainties are broken down separately for those arising from the  $A_4$  measurements and from the predictions. The PDF uncertainties are treated as uncorrelated between the  $A_4$  measurements and the predictions (see text).