Introduction: revised timescale for YR?

October 2019

- **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.**
- **See back-up slides for more information (shown at last meeting)**
- **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**

YR reports and publications

- **Possibly three+ publications will come out from the work done in the precision EW group:**
  - **Resummation benchmarking of pTW, pTZ and pTW/Z**
  - **QED/EW corrections for precision EW measurements (s2weff and mW)**
  - **PDF benchmarking**
  - **Anything else?**

- **YR report(s) will in general be more extensive in terms of topics than specific publications, but might be more concise concerning the work published in the sister publications by referring to them for details**

- **YR reports can include more material at the boundary between theory and experiment while obeying the publication rules of the experiments (one example is on the next slide)**

Introduction: revised timescale for YR

- We are now mid 2020, two and a half years plus one Covid crisis after the start of the activities in this working group, following on from the smaller group dedicated to the W mass mostly in the previous years.
- We had a consensus that this year should be publication time, and that we should push for convergence and reduction of certain ambitions if time is too short, a somewhat new situation for the group
- So a few people started writing up while completing the work, and the goal for publications plus YR was to have "complete" drafts latest end summer 2020
- This is clearly unfeasible now, could we achieve these same goals by April 2021?
- This would require final results by end of this year or latest February next year
- Next slide discusses how realistic this appears to be today for the three different areas in the QED/EW related part of the work

Introduction: revised timescale for YR

- **Where are we today with respect to our perception of where we would be half a year ago?**

- **Part I : so-called virtual EW corrections**
  - we are apparently further away now, essentially because of present large difference between MC-SANC and Powheg-EW for asymmetry predictions including all corrections
  - work ongoing to trace this back in detail but no report yet today, also very important work by ZGRAD2 which could help untangle issues
  - need to keep connection with DIZET predictions for which Elzbieta has provided using EW weights expected difference in behaviour of asymmetry before and after full corrections for the different schemes under study (see talk by Elzbieta today)
  - we should not be lulled into the impression that maybe the differences we see now (and did not see before) are really due to theoretical uncertainties, the theory uncertainties are expected to be much smaller (an order of magnitude) than the current difference!

Introduction: revised timescale for YR

- **Where are we today with respect to our perception of where we would be half a year ago?**

- **Part II : QED ISR and IFI**
  - here we have progressed since half a year but not sufficiently to be confident fully about convergence by the end of the year.
  - here also we have first results from ZGRAD2 which hopefully will provide inputs with the required accuracy to be compared meaningfully to the others (MC-SANC, Powheg-EW, KKMC-hh)
  - since the impact of QED on the asymmetry and lineshape is very small, the showstopper might be still the issue of getting enough statistics from each calculation
  - and there is still the issue about how KKMC-hh deals with ISR, namely by explicitly calculating the collinear terms rather than letting them be absorbed into the PDFs. However, given the issues with the photon PDF and photon-induced processes, oft discussed by Alessandro, we see this diversity in the calculations rather as a strength of the group

Introduction: revised timescale for YR

- **Where are we today with respect to our perception of where we would be half a year ago?**

- **Part III :**
  pseudodata for combination of s2weff measurements with full run-2 data
  - here there has been a lot of progress on several fronts, so we are confident that this will be available for the YR
  - we have pseudodata for each experiment and also, thanks to Aleko, pseudodata using Powheg-EW with the s2weff input scheme with and without including EW corrections
  - we have agreed on a path to validate these inputs at 13 TeV by comparing Aleko's MC predictions with Powheg-EW at 8 TeV with those from Elzbieta using DIZET and EW weights
  - there is however quite some work to do still to have confidence that all of this can be published on this revised April 2020 timescale

Back-up slides

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 ($16\ 10^{-5}$)**

- **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

- **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**

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

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**

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

CMS

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

Modeling parameter	Muons	Electrons
Dilepton p_T reweighting	0.00003	0.00003
μ_R and μ_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 $\sin^2\theta^{\ell}_{\mathrm{eff}}$ *vs.* $\sin^2\theta^{\mathrm{u,d}}_{\mathrm{eff}}$	0.00001	0.00001
Total	0.00015	0.00017

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

ATLAS

$m^{\ell\ell}$ (GeV)	70 – 80			80 – 100				100 – 125		
$\lvert y^{\ell\ell}\rvert$	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	ee_{CC}	$\mu\mu_{CC}$	ee_{CF}	$ee_{CC} + \mu\mu_{CC}$	$ee_{CC} + \mu\mu_{CC} + ee_{CF}$
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 $\sin^2\theta^{\ell}_{\text{eff}}$ 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).