

Overview of WG1 status

- Detailed QED/EW overview given today by Mauro
- Resummation benchmarking status captured briefly in talk by Tobias on Tuesday
- Pseudo-data for run-2 weak mixing angle combination
- NP physics sensitivity using LHC data: pseudo-data exercise proposal
- PDF correlation benchmarking : still ongoing despite obstacles and lack of dedicated people
- Documentation of work done to-date: two publications planned plus one CERN report : work is basically complete and has lasted almost five years, so general consensus is that we shall publish asap now
- We will have a workshop next year which will most likely take place in Pavia, Italy.
Dual-purpose workshop with completion/documentation of past work and discussion of further/new work in the WG (see next slides)
Time slot in April (?) to be defined with organisers

Completion/documentation : QED/EW

- Clara covered almost completely where we stand in her overview report last meeting.
Mauro will give a very similar overview on behalf of our WG on Thursday afternoon
- Outstanding items for completion:
 - missing calculations (eg WZGRAD2)
 - everything LO QCD until now, last step is to run Powheg-EW in the same setup for all aspects with LO to NLO QCD as the only change.
This should give us a feeling on whether any significant changes in the shape of the corrections to A4/AFB might be expected from QCD itself.
 - uncertainties (Ayres for virtual corrections and Stefan for QED corrections)
 - photon-induced processes will be discussed in a factorised way based on work done by Alessandro (HORACE) and Sergey/Lidia (MC-SANC)

Completion/documentation : QED/EW

- **Documentation status:**
- **Good news! Recently, Alessandro/Doreen/Stefan/Ayres have started on the main body of the paper, building partly on what had been built up over the years in git repository by Elzbieta/Daniel**
- **Fulvio and Daniel will act as main editors for this paper**
- **Goal would be to have skeleton fleshed out enough by end January or so, such that all appendices by each calculation can really be written using this as a foundation over February/March**
- **Paper could be in good shape by April workshop if this works out.**

Completion/documentation : resummation benchmarking

- Outstanding items for completion:
 - presentation of uncertainties at level 3 (and also possibly 2) using agreed upon categorisation of uncertainties in broad terms as Sudakov and non-Sudakov like.
Need to come to grips with quantitative comparison of these uncertainties between the different calculations and with a building of consensus on how to deal with the regions of large spread between them.
 - producing level 3 moving beyond DYTurbo $\mathcal{O}(\alpha_s^2)$ predictions to the higher-order predictions from MCFM and NNLOJET for the fixed order predictions.
 - probably need to deal also with “N3LO” PDFs from MHST?
 - agree definitely to postpone pTW and pTW/pTZ to a future publication?
 - section on NP physics will be written as planned, factorised from the rest of the paper for simplicity (see later slides for future work in this area)

Completion/documentation : resummation benchmarking

- **Documentation status:**
- **Frank and Aram will act as main editors for this paper**
- **Goal would be to have skeleton fleshed out enough by end January or so, such that all appendices by each calculation can really be written using this as a foundation over February/March**

Since unified notation (as much as feasible) would greatly help the readability of this paper, a proposal will be circulated by Aram/Frank before end of January, such that major issues which might appear for certain calculations and authors can be resolved before things are cast in stone.

- **Paper could be in good shape by April workshop if this works out.**

Completion/documentation : other items

- **Beyond publications in journals, there will be an overall CERN report, where we would :**
 - a) summarise the two publications**
 - b) document the work done using pseudo-data for weak mixing angle to establish a strategy for combination of run-2 measurements by the three experiments**
 - c) perhaps if feasible document early work on eg pseudo-data for NP physics fits if time-scale allows?**

Pseudo-data for weak mixing angle combination

Purpose of the exercise (reminder)

- **Preparation** for combined Run-2 (and future) LHC measurements of $\sin^2 \theta_{\text{eff}}^{\ell}$
 - Each experiment measures unfolded $A_4(y, m)$
 - Need same or equivalent interpretation model for $\sin^2 \theta_{\text{eff}}^{\ell}$
 - Consistent treatment of PDF and theory uncertainties
 - Common measurement bins
- **Exercise**
 - 1) Fit of pseudo-measurements from 3 experiments
 - 2) Test latest theory developments in WG1

A. Khukhunaishvili

Pseudo-data for weak mixing angle combination

Common setup for pseudo-data exercise (reminder)

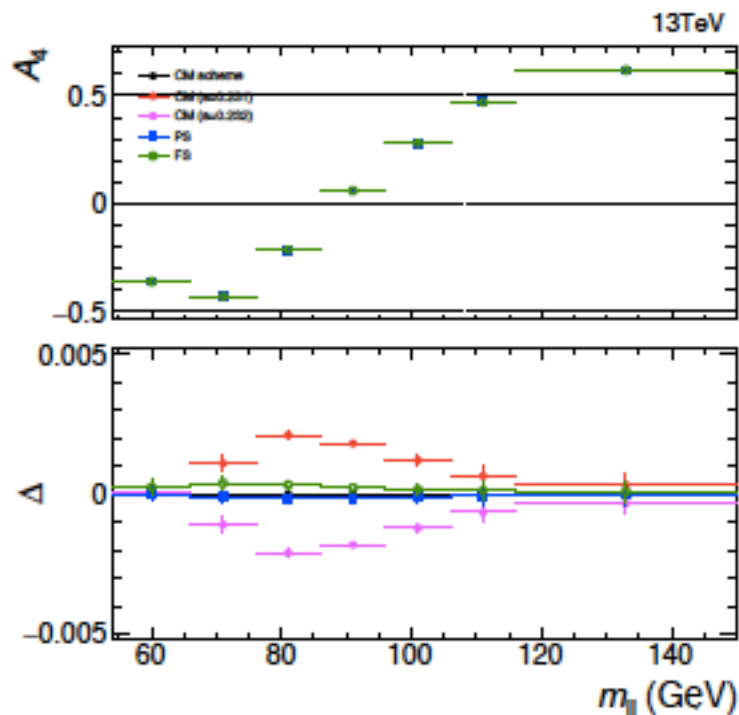
- **Observable:** Born-level $A_4(m, y)$
 - Equal $y_{\ell\ell}$ bins with width of $\Delta y = 0.4$
 - 7 $m_{\ell\ell}$ bins: 54, 66, 76, 86, 96, 106, 116, 150
- $(\sin^2 \theta_{\text{eff}}^\ell, m_Z, G_\mu)$ scheme: with $\sin^2 \theta_{\text{eff}}^\ell = 0.23150 \pm 0.00050$
- **PDF:** NNPDF31_nnlo_hessian_pdfas
- $\sqrt{s} = 13 \text{ TeV}$

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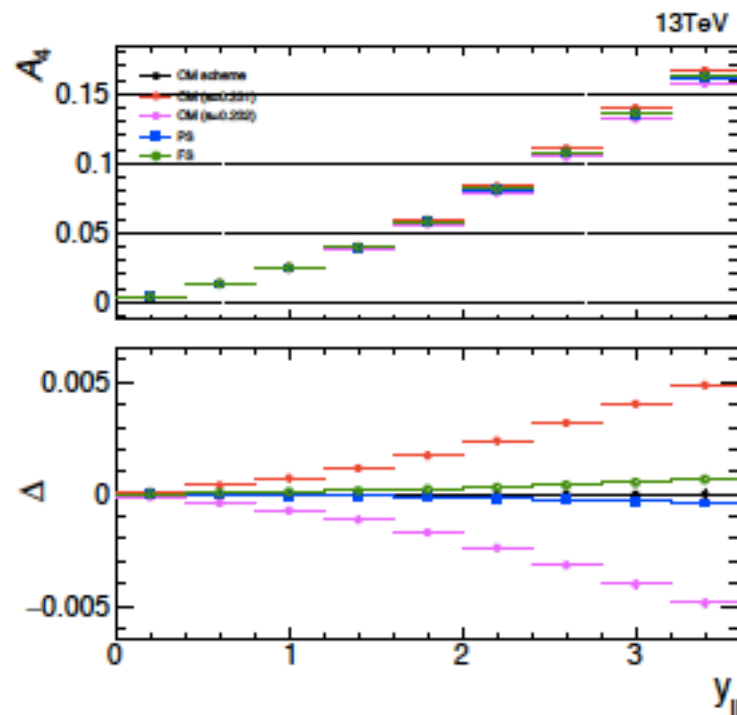
Pseudo-data for weak mixing angle combination

CM scheme, PS and FS at 13 TeV

$A_4(m_{\ell\ell})$ for $y_{\ell\ell} < 3.6$



$A_4(y_{\ell\ell})$ for $86 < m_{\ell\ell} < 96$



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- Difference between PS and CM-scheme corresponds to about 1/10 of $\delta \sin^2 \theta_{\text{eff}}^\ell = \pm 0.00050$ variation

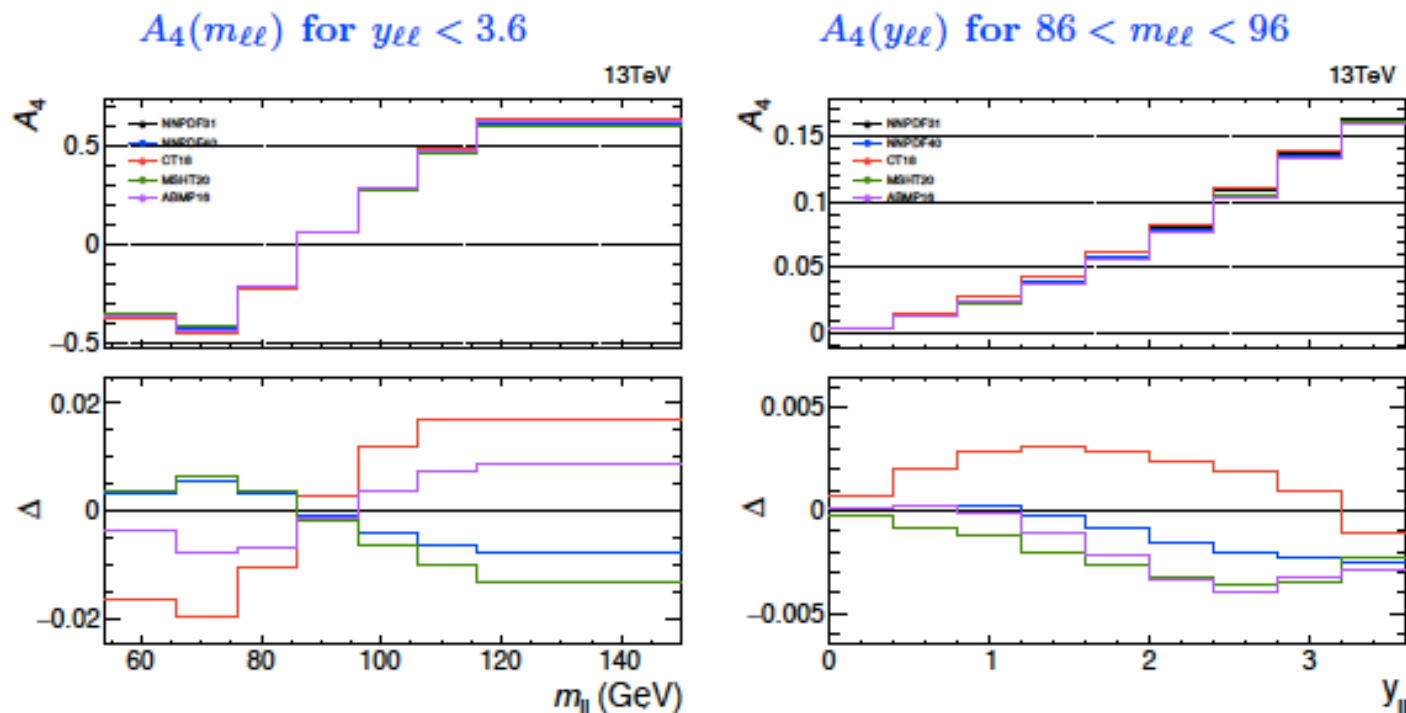
Pseudo-data for weak mixing angle combination

See related NNPDF presentation by J. Rojo

<https://indico.cern.ch/event/1193956/contributions/5060792/attachments/2521384/4335493/rojo-EWWG-AFB.pdf>

Comparison of central PDFs

PDF uncertainties are expected to dominate in this measurement starting Run-2

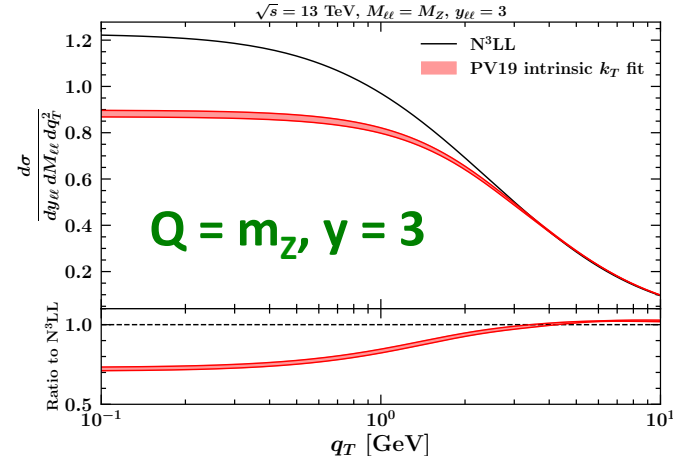
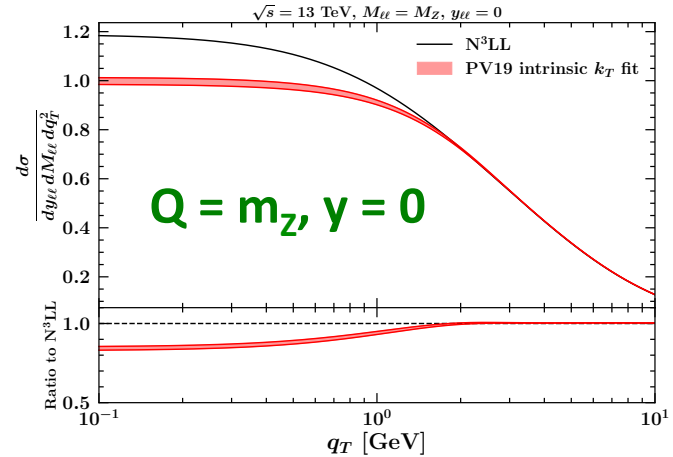
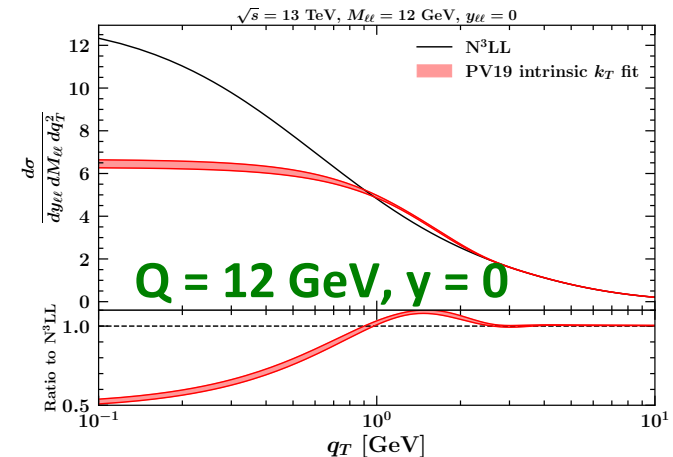
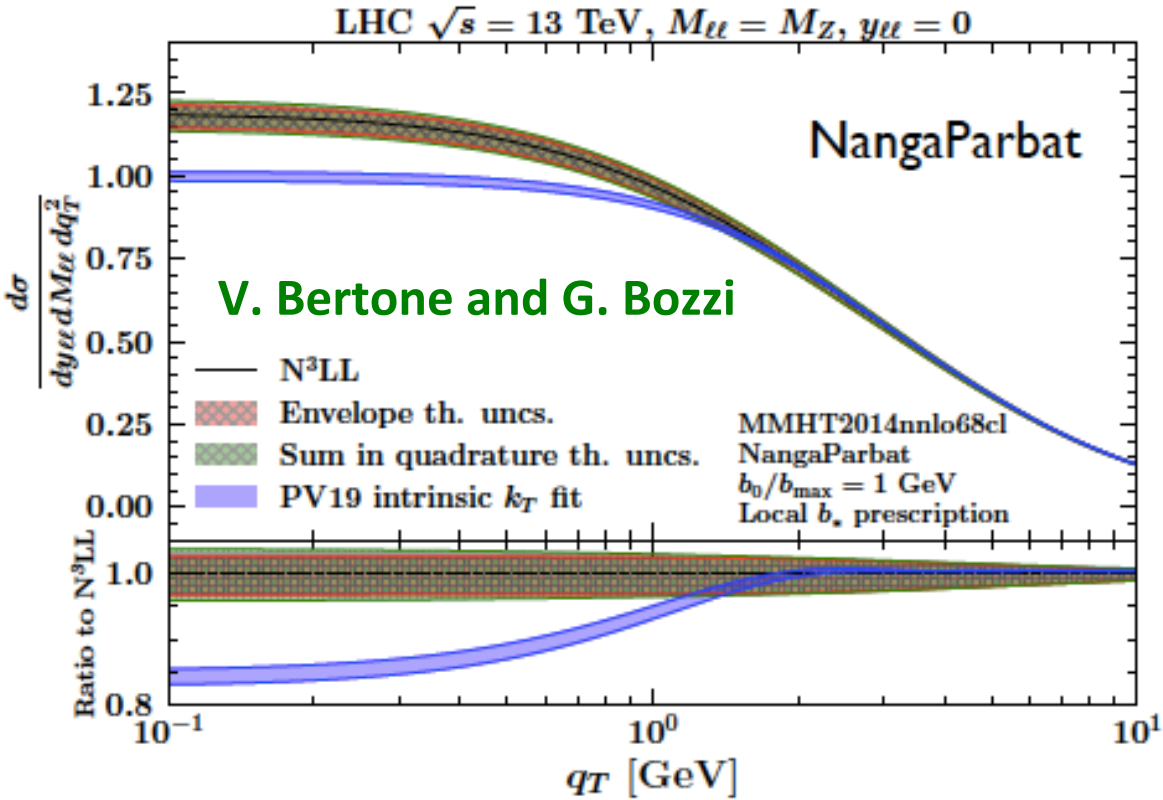


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- Mostly dilution-like differences
– but non-trivial y -dependence (see CT18-NNPDF3.1)

Probing NP physics using low- q_T , low Q DY?

- Subject of great interest in particular to TMDs
https://indico.cern.ch/event/1194333/contributions/5019978/attachments/2504748/4303452/2022_09_lowpT.pdf
<https://indico.cern.ch/event/1194333/contributions/5025986/attachments/2504677/4303324/CERN-2022-Overviewwp.pdf>
- Experimentally challenging : best sensitivity below 2 GeV in q_T and for $Q = m_{||}$ as low as feasible
- Measuring ϕ^* with limited q_T might provide the best recipe for the future
- Use Powheg+Pythia8 to generate pseudo-data



Probing NP physics using low- q_T , low Q DY?

What we would need

Set of pseudodata with the following kinematics:

- $12 \text{ GeV} < Q < 1 \text{ TeV}$ (3-4 bins below/above M_Z)
- $0 < q_T < 5 \text{ GeV}$
 - with the smallest possible bin width (ideally, 0.5)
 - extending to $q_T/Q < 0.2$ if possible
- $0 < y < \text{highest possible}$
 - high enough to see decrease of cross section
 - small bin width not as crucial as in the q_T case
- no fiducial cuts

G. Bozzi

Probing NP physics using low- q_T , low Q DY?

Items to discuss

- Impact of PDF variations
 - use different sets both for pseudodata and predictions
 - normalised vs. non-normalised cross-sections
- Heavy flavours
 - analyse separate channels w.r.t. PDF variation
 - thresholds: explore $n_f = 5$ vs. VFNS
 - Hard-to-estimate effects: power corrections $\mathcal{O}(m_{HF}/Q, m_{HF}/q_T)$
- Blinding of pseudodata
 - “single(theorist)-blind” variation of Q_0 and intrinsic- k_T in shower
- Extras
 - range of luminosities? definition of metric to quantify fit quality?

G. Bozzi

Future work directions

- **Topics critical to W mass measurements:**
 - PDF toys and correlation measurements: the saga goes on with as main primary goal at the moment work focused on toys produced based on a minimal set of data similar but not identical to that used by PDF4LHC21 to be fitted by several flavours of MHST parametrisations. Before proceeding with the real goal of measuring the correlations between different global PDFs, this work should likely be documented properly first.
 - QED effects as discussed in our last meeting : we may have enough people in the various experiments with different tools (WINHAC, HORACE, Powheg-EW) to compare Z and W on the same footing, i.e. differently than what was done for pure neutral current for weak mixing angle, and to derive an optimal recipe for W mass measurements together with its uncertainties **(should be few MeV in the end?)**
 - **combination of p_T^Z and ϕ^* fiducial measurements (topic discussed between ATLAS and CMS for 36 fb-1 papers a year or so ago)**

Correlation benchmarking of global PDFs

S. Amoroso

- * PDFs limiting uncertainty in m_W , $\sin^2 \theta_{eff}^l$ determinations

- ▶ Difference of measurements done with different PDF sets can be as large as the PDF uncertainty of a given set

[1806.00863]

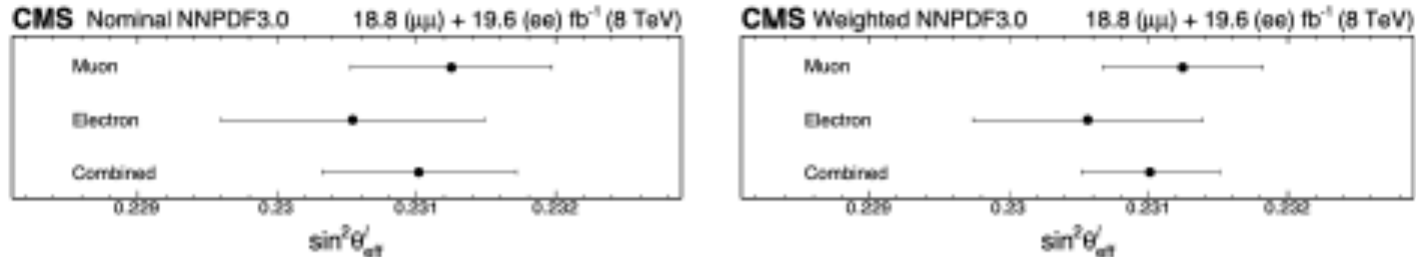


Figure 7: The extracted values of $\sin^2 \theta_{eff}^l$ in the muon and electron channels, and their combination. The horizontal bars include statistical, experimental, and PDF uncertainties. The PDF uncertainties are obtained both without (left) and with (right) using the Bayesian χ^2 weighting.

- * But many correlations between PDF sets from different groups:
 - ▶ Common data samples used (e.g. HERA combined data)
 - ▶ Theory predictions (NNLO DGLAP, NNLO coefficient functions, NLO APPLgrids)
- * Currently impossible to quantify statistically how significant these differences are

Correlation benchmarking of global PDFs

S. Amoroso

AIM OF THE STUDY

- * Aim to determine correlations among different PDFs for the new generation global PDF fits
 - ▶ Proposal first presented by Daniel, Bogdan at a PDF4LHC I ([link](#)) and further discussed in Durham LHCEWWG ([link](#)) and in other LHCEWWG meetings
- * Correlations to be measured using fits to pseudo-experiments generated for the datasets used by the PDF fitters
 - ▶ xFitter identified as the tool to generate the pseudo-data (open-source, easy interface)
 - ▶ PDF groups would then need to fit these toys to allow for subsequent stat. analysis
 - ▶ Similar approach later used in [\[2110.08274\]](#), although we disagree with the conclusions
- * Code for pseudo-data production and validation developed in the past years by S. Mikhalcov and V. Novik: <https://gitlab.cern.ch/smikhalc/test>
- * A first set of 1000 pseudo-experiments was generated and looked at by MSHT (T.Cridge)
- * Then effort died-out with students leaving ...

Correlation benchmarking of global PDFs

PSEUDO-DATA GENERATION

Proposed strategy

- Use Gaussian errors
- Use symmetrized uncertainties
- Develop scripts for toy generation/monitoring.
- Store tools in a common repository
- Apart from generated toys, keep steering cards/validation results for reproducibility
- Validate setup on selected data sample.
- Review data sets used by the fitting groups, check if they are present in xFitter, add missing.
- Validate matching of toys to files used by the fitting groups.

(S. Glazov)

Correlation benchmarking of global PDFs

DATASETS CONSIDERED

- * Considering same dataset as for the PDF4LHC21 benchmarking:
 - ▶ HERA2 inclusive DIS (1506.06042)
 - ▶ NuTeV dimuon cross-sections (0102049)
 - ▶ E866 Drell-Yan (0103030)
 - ▶ D0 electron rapidity in $W \rightarrow e\nu$ (1412.2862) and Z rapidity (0702025)
 - ▶ CDF Z rapidity distribution (0908.3914)
 - ▶ ATLAS 7 TeV W, Z cross-sections (1612.03016)
 - ▶ CMS 7 TeV inclusive jets cross-sections (1212.6660)
 - ▶ LHCb 7 (1212.4620, 1505.07024) and 8 TeV (1503.00963, 1511.08039) W and Z cross-sections
- * I have now resurrected the effort and generated 1000 pseudo-experiments for the full dataset, only need to find a day or two to convert the results in the correct format

S. Amoroso