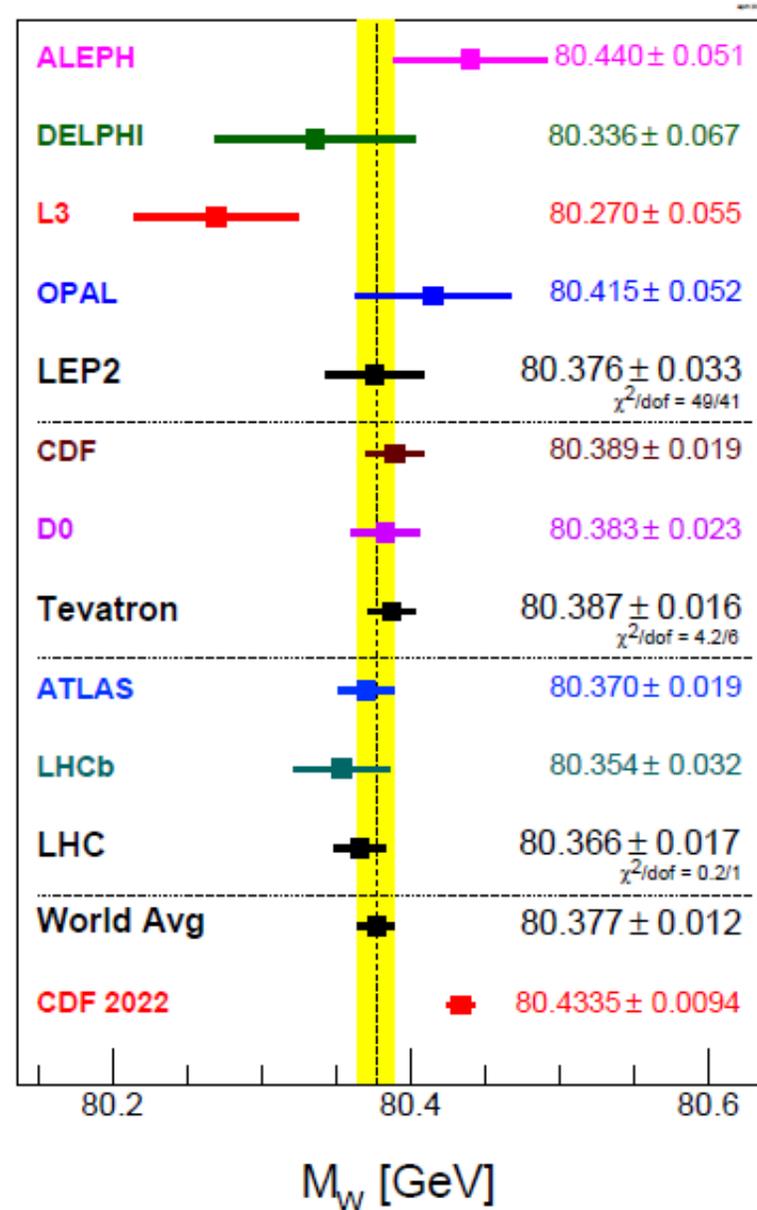


# PDG Advisory Committee Meeting: W-mass Plans

**Atul Gurtu & Martin Grünewald**  
**(W/Z Encoders/Overseers)**  
**CERN, 4 Nov 2022**

# SM fit to all relevant data excluding W-mass yields $80.356 \pm 0.006$



Pre-March  
2022 data

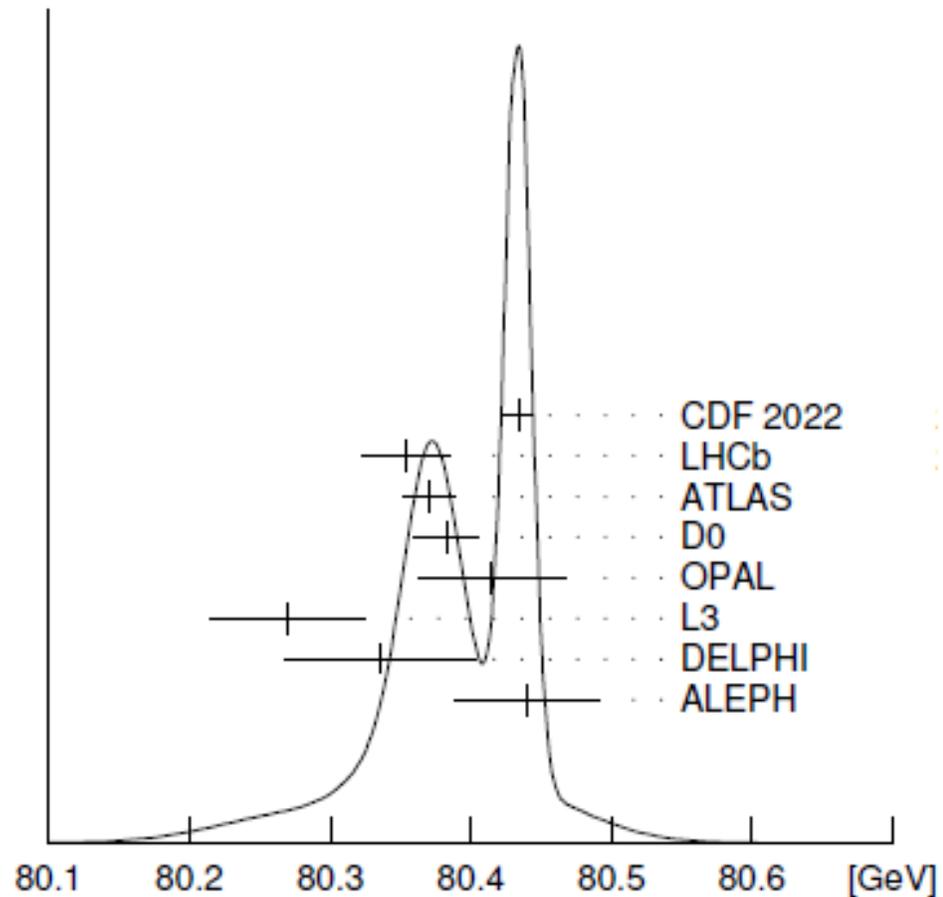


# RPP 2022 W-mass Header

- April 2022: CDF II paper
- ~3 months past the PDG deadline
- In April 2022, after the cut-off of results for this review, the CDF collaboration published a determination of the W mass based on their full Run-2 dataset of  $8.8 \text{ fb}^{-1}$  [AALTONEN 22], with much reduced uncertainty:  $80433.5 \pm 9.4 \text{ MeV}$ . This new CDF result, which includes the data of their previous result [AALTONEN 12E] and thus supersedes it, is of higher precision than our world average quoted above. However, the two determinations disagree significantly. More information is given in M. Grunewald and A. Gurtu, “Mass and Width of the W Boson” review [PDG 22].

# RPP 2022 Mini review: Mass & Width of the W boson

- This new CDF Run-II result is of higher precision than our world average of  $80.377 \pm 0.012$  GeV. However, the two determinations disagree significantly, as visible in Fig. 54.1. A probability ideogram comparing the results from Fig. 54.1 is shown in Fig. 54.3 (see Section 5.2 in the Introduction of this review on the construction of ideograms).



# A brief reminder about PDG averaging procedures

RPP 2022, p. 16...

$$\bar{x} \pm \delta\bar{x} = \frac{\sum_i w_i x_i}{\sum_i w_i} \pm \left(\sum_i w_i\right)^{-1/2}$$

$$w_i = 1/(\delta x_i)^2$$

$$\chi^2 = \sum w_i (\bar{x} - x_i)^2$$

$\chi^2/(N-1) \leq 1$ , accept average & error

$\chi^2/(N-1) \gg 1$ , may not quote average, or give conservative guesstimate...

$\chi^2/(N-1) > 1$ , introduce SCALE factor so that  $\chi^2/(N-1) \approx 1$ . Average **UNCHANGED** and ERROR scaled by S.

$$S = [\chi^2/(N-1)]^{1/2}$$

# RPP 2022 Mass & Width of the W boson...

- For calculating a new world average, replacing the old CDF Run-II result [3] by the new one [11], **the uncertainties of all results need to be scaled by a factor of about two in order to achieve a  $\chi^2$  per degree of freedom of unity** (see Section 5.2 in the Introduction of this review on the definition of the scale factor). The **world average** quoted above ( $80.377 \pm 0.012$  GeV) **increases** significantly in central value, **by up to 40MeV**, while its scaled **uncertainty increases** by up to **6MeV**, with the exact changes depending on the assumptions made concerning correlated uncertainties. **A detailed understanding of the results and their correlations is needed. Corresponding studies are currently being undertaken by the experiments.**

# W-mass Averaging Group (WMAG)!

- PDG welcomes the formation of the WMAG for averaging of hadron collider W-mass data.
- Looking forward to the presentation and discussion today, and eventually to the understanding of the common systematics and averaging of results.

## PDG Deadlines:

- **Mar 1, 2023** Overseers sign off encodings, verification starts, any fits from external groups requested
- **Apr 4, 2023** Overseers complete corrections from verification, add external fits, update ConservationLaws.

# Some slides from WMAG presentation

## mW combination status

Josh Bendavid (MIT)  
for the LHC-Tevatron mW combination working group  
PDG meeting  
Nov. 2, 2022



## mW combination working group

- Formal combination working group created in 2020 by agreement of ATLAS, CMS, CDF, D0 spokespersons
- LHCb started to participate following the release of their result
- <https://twiki.cern.ch/twiki/bin/view/LHCPhysics/MWCOMB>
- **Main goal:**
  - Official combinations of published mW results with proper treatment of correlations of systematic uncertainties
  - Publication signed by corresponding collaborations
- **Prerequisites**
  - Discussion (documentation) of statistical methodology
  - Discussion (documentation) of theoretical modeling issues entering the measurements and their uncertainties (in close connection with LHC Electroweak Working group/WG1: Drell-Yan physics and EW precision measurements)

# : Preliminary/Interim result

CERN-LPCC-2022-06  
FERMILAB-TM-2779-V  
7th July 2022

## **Towards a combination of LHC and TeVatron W-boson mass measurements**

The LHC–TeVatron *W*-boson mass combination working group<sup>1</sup>

# Open Questions

- How to disambiguate between a priori equally valid PDF sets?
  - Compatibility with W/Z cross sections and asymmetries?
  - Compatibility amongst channels and/or experiments in mW combination?
- Does the combination need to choose a single unique PDF?
  - Quote shifted input central values and uncertainties + combination for multiple PDF sets
  - Choose one by combination of compatibility and/or uncertainties?
  - Average final combination over different PDF sets? (and inflate the PDF uncertainty for the spread?)
    - PDF4LHC-like prescription
- How to deal with tensions between measurements?
  - Quote sub-combinations in addition to overall, with  $\chi^2/\text{dof}$  given in all cases
    - Tevatron-only, LHC-only, N-1 combinations with one experiment removed
  - Inflate uncertainties a la PDG in case of tensions?
- Comprehensive set of information on shifts/uncertainties/statistical compatibility to be given in paper
- Not clear yet if/what exactly will be written in abstract/conclusion as far as final unique number for central value and uncertainty

# Conclusions

- Significant progress towards combination (and understanding) of existing mW measurements
  - Detailed study of decay angle/polarization effects
  - Final numbers, also for PDF shifts and uncertainties to be evaluated
  - LHCb measurement being fully incorporated
  - Central values may shift from QCD and PDF updates, and final PDF uncertainty may be different e.g. for different PDF sets, but unlikely to completely resolve tension of CDF measurement with SM or other measurements
  - Discussion ongoing how to deal with:
    - choice and/or combination of different pdf sets for central value/uncertainties of individual measurements and combination
    - Possible large remaining tensions/incompatibilities between measurements even after applying relevant theory updates
- 

# Our Comments

- **PDG deadlines** have been conveyed (March 2023)
- No results yet from WMAG, but their **Conclusions** slide hints at **tension between measurements persisting even after application of all corrections etc.**

# PDG line to follow for 2023 edition

- Remain in touch with WMAG (Maarten, Josh, ....).

**Martin Grunewald has been regularly attending their meetings/discussions.**

Any other type of contact/communication needed?

- **Early March 2023:** Hold (Hybrid) meeting where WMAG presents their progress to PDG.
- **Immediately thereafter:** PDG meeting to decide course of action based upon inputs from WMAG.

# Possible scenarios

- **→ PDG has depended & still depends on various groups for complex averaging of results. W-mass is in this category.**
- Possible scenarios from WMAG:
  - (a) WMAG completes work and presents a solution and gives a value of world average  $m_W$  that is also satisfactory to PDG...
  - (b) WMAG is unable to complete its studies
  - (c) They have already indicated that tensions between data may not be removed by their studies. They will also likely make sub-averages (Tevatron, LHC, & removing 1 experiment at a time).

# Case (b) Plan B

- PDG has to then decide how to proceed.
  - (i) For 2023 the CDF II measurement needs to be added in the Listings (for 2022 their paper was 3 months beyond the deadline)
  - (ii) Decide whether to quote ONE  $W$ -mass average, or NOT, i.e., possibly leave the situation as in RPP 2022.
  - (iii) What to do in the Summary Table (one or two values?)
  - (iv) The PDG scale factor method can be used (if not used by WMAG).
  - (v) In any case, the  $W$ -mass header and the mini-review would need to be revised.

# Continuing discussions needed in PDG

- At present the situation remains very fluid.
- Martin is attending WMAG meetings so could report back any interesting/useful development...
- Some more thought could be given towards Plan B...
  
- Suggestions are welcome
- Arrange some online meetings from time to time as necessary...

Thank you!