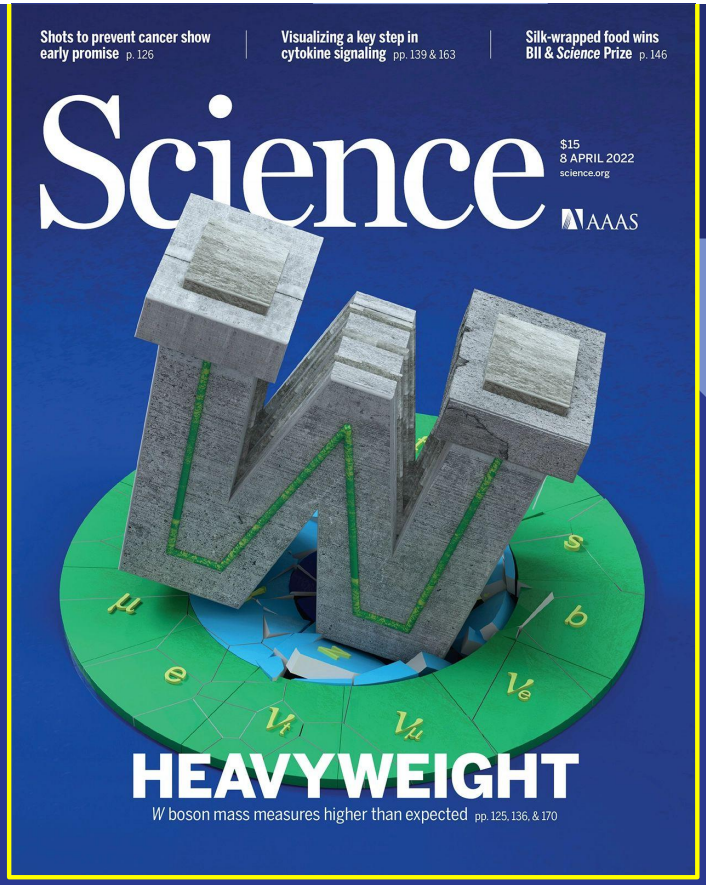
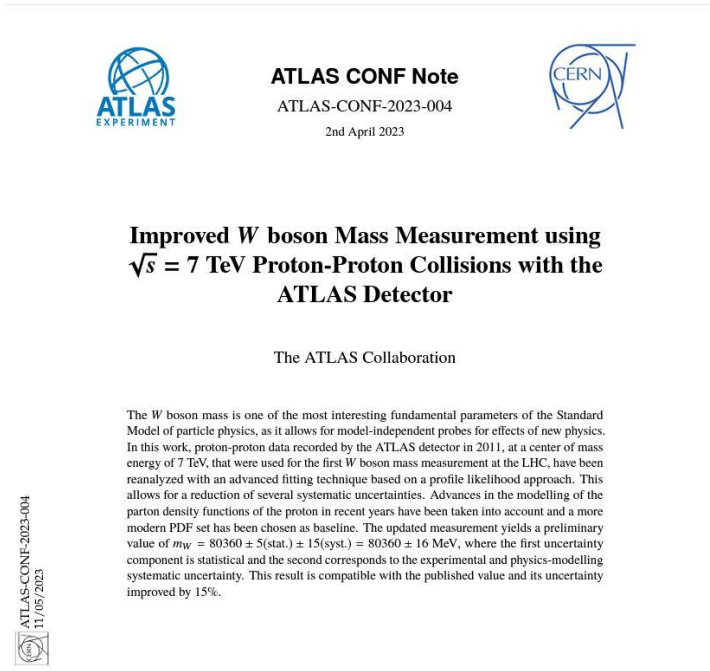
One man’s thoughts a year after the CDF W Mass Announcement



Dave Toback - *NOT* on behalf of the CDF Collaboration
Texas A&M University
Mitchell Institute Workshop - 5/17/2023

Outline

- This is an “informal” musings talk where I take <u>off</u> my CDF Spokesperson hat, and do <u>not</u> speak on behalf of the collaboration
- A mish-mosh of the view from in the trenches and from 50,000 ft
  - (and that I probably shouldn’t put in writing)
- The CDF Result was published just over a year ago
  - Detailed talks have been given around the world gathering feedback on the methods/result
  - Large amount of experimental detail in the paper, associated NIM’s and other documents
  - A re-analysis of the ATLAS result was posted as a conference proceedings



ATLAS CONF Note

ATLAS-CONF-2023-004

2nd April 2023

Improved W boson Mass Measurement using $\sqrt{s} = 7$ TeV Proton-Proton Collisions with the ATLAS Detector

The ATLAS Collaboration

The W boson mass is one of the most interesting fundamental parameters of the Standard Model of particle physics, as it allows for model-independent probes for effects of new physics. In this work, proton-proton data recorded by the ATLAS detector in 2011, at a center of mass energy of 7 TeV, that were used for the first W boson mass measurement at the LHC, have been reanalyzed with an advanced fitting technique based on a profile likelihood approach. This allows for a reduction of several systematic uncertainties. Advances in the modelling of the parton density functions of the proton in recent years have been taken into account and a more modern PDF set has been chosen as baseline. The updated measurement yields a preliminary value of $m_W = 80360 \pm 5(\text{stat.}) \pm 15(\text{syst.}) = 80360 \pm 16$ MeV, where the first uncertainty component is statistical and the second corresponds to the experimental and physics-modelling systematic uncertainty. This result is compatible with the published value and its uncertainty improved by 15%.

ATLAS-CONF-2023-004
11/05/2023

Some fun(?) phrases I've heard (or have been relayed to me*)

- **"Yes I know that nobody can find anything wrong with the CDF measurement, I just don't believe it"**
- **"Dave, can you send us a Colloquium speaker? We were looking for a talk on "*How CDF messed up the W mass?*"**
- **"CDF has the most precise W mass measurement, but ATLAS has the most accurate measurement"**
- **"Wait… the new ATLAS result is just a re-analysis of the old data?"**
- **"When people tell me they haven't discovered anything, I believe them."**

** Name's will not be given to protect the guilty*

The press since the recent ATLAS re-analysis has also been amusing

https://gizmodo.com/w-boson-mass-measurement-large-hadron-collider-cdf-1850320408#replie

To be fair, the article itself is excellent and doesn't reflect the title at all

(I have been told that the "editors" pick the headlines, not the writers)

The history of results “Agreeing over time, with smaller and smaller error bars” is…… revisionist history

Sometimes it’s a simple march

Sometimes an experimentalist has to stick their neck out… It’s important to do, but it isn’t “fun”

https://pdg.lbl.gov/2022/reviews/rpp2022-rev-history-plots.pdf

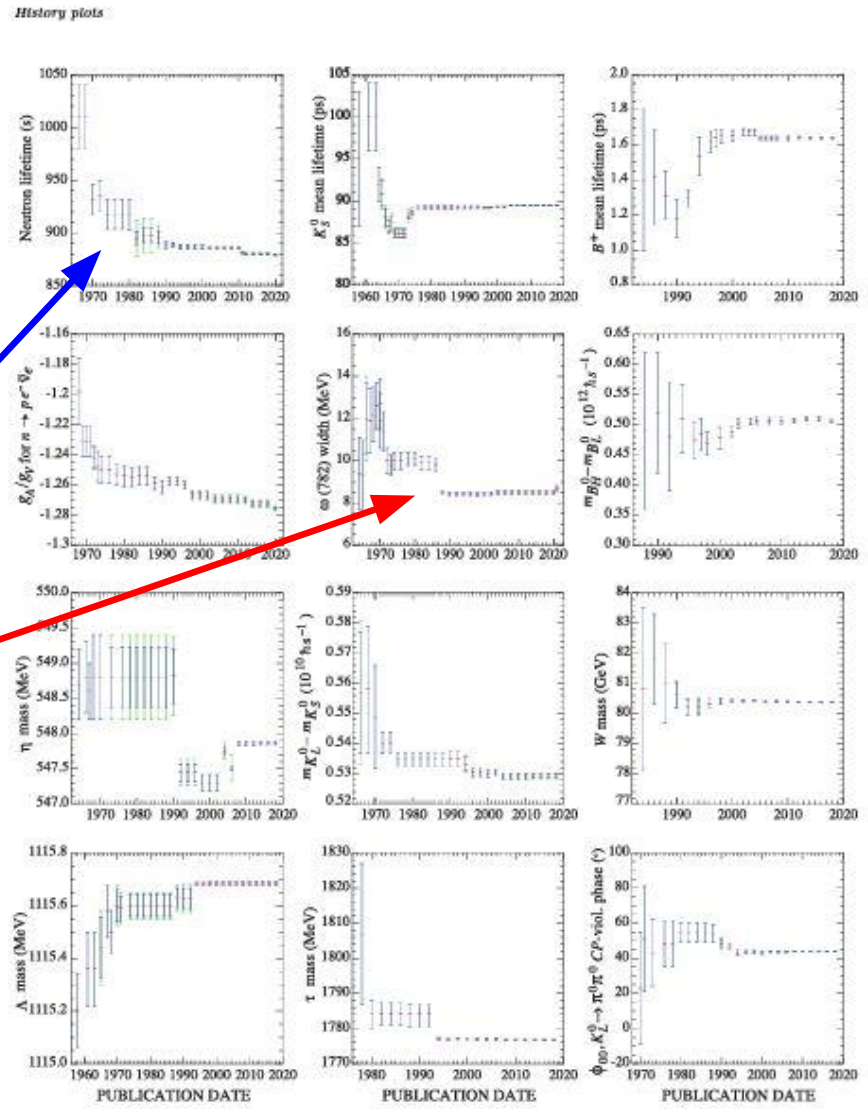


Figure 1: A historical perspective of values of a few particle properties tabulated in this *Review* as a function of date of publication of the *Review*. A full error bar indicates the quoted error; a thick-lined portion indicates the same bar without the “scale factor.”

Blind Analysis has it's values

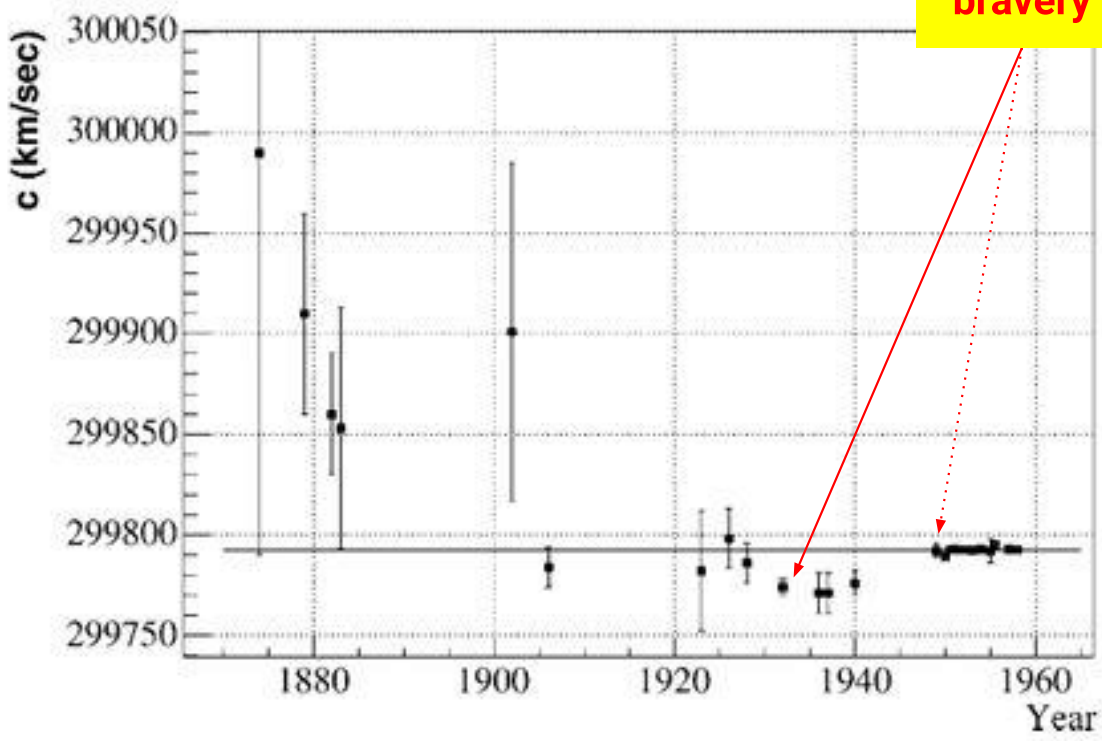


Figure 1 Summary of speed of light measurements. The line indicates the ultimate experimental value. Among other interesting features, the series of four measurements from 1930–1940 displays a 17 km/sec systematic shift from the true value (5).

BLIND ANALYSIS IN NUCLEAR AND PARTICLE PHYSICS

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Attempts at a World Combination of the W Mass

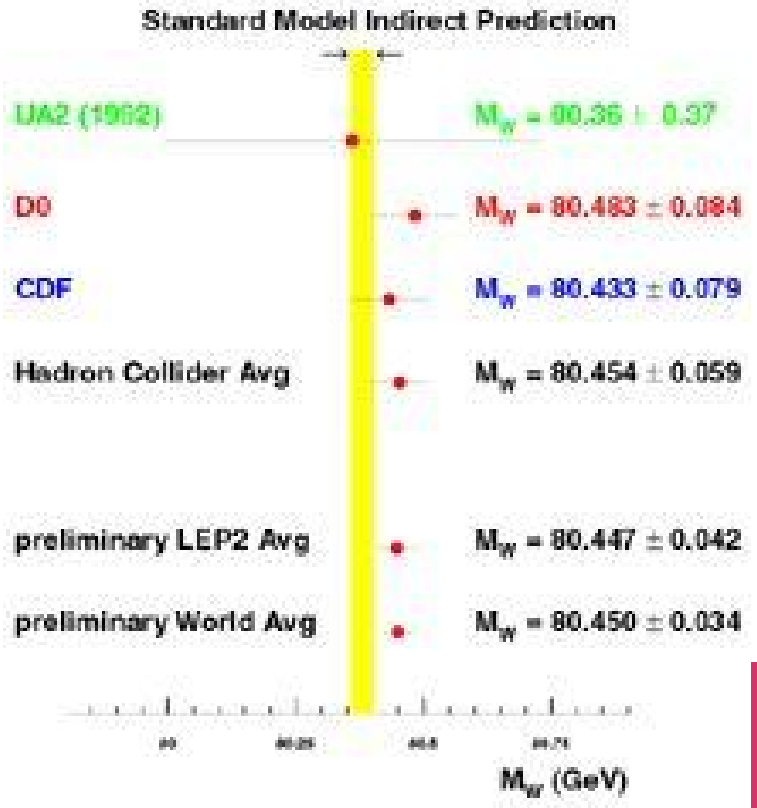
- **There are no known methods of changing things, like the PDFs, that "fix" the discrepancy**
  - **Picking a PDF set which simply blows up the errors can make CDF result and the "other" results "agree," but isn't good science**
- **There have been attempts at combining the W mass measurements but fancy statistical methods don't change the reasonable conclusion that the two results are statistically consistent with being from "different parent distributions"**

Things that my experimental colleagues, not on CDF, have found compelling

- **Blind result**
- **Precision alignment of the tracking chamber using cosmics/track fitting**
- **Using very little detector simulation so each piece can be checked with real data**
- **Using the J/Psi and Upsilon to calibrate the detector, and then unblind the measurement of the Z^0 (in electron and muons). THEN after that is shown to be in agreement, fold in the extra data rather than just starting with the Z^0 as the calibration**
- **…(Already heard from Ashutosh)**

People used to like the central value of the CDF measurement

While people forget, the measurement has a history of being “higher than expected”



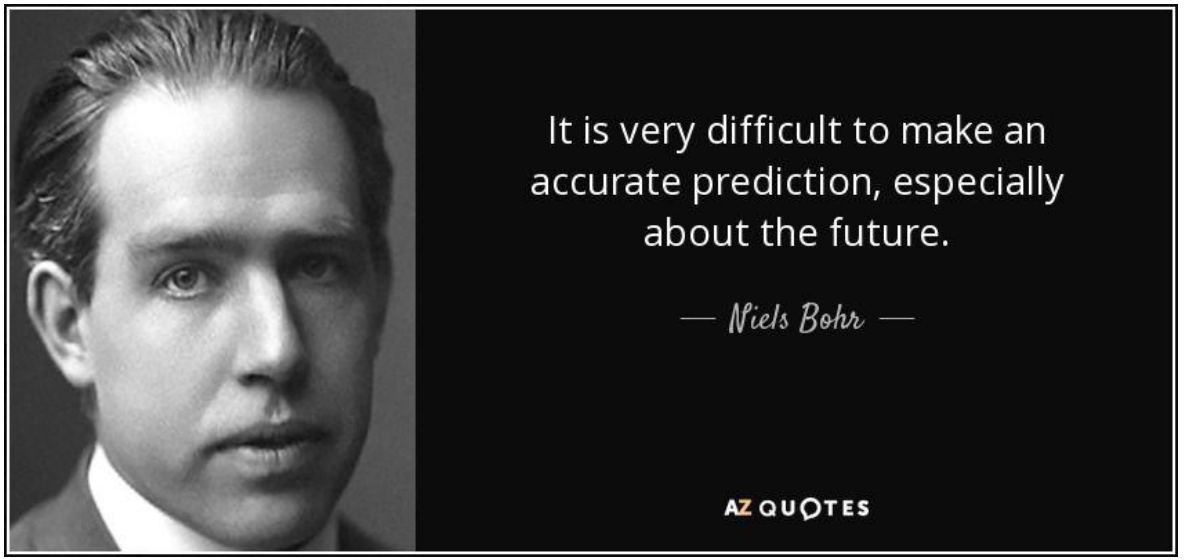
Interpreting the discrepancy with *g*-2 results

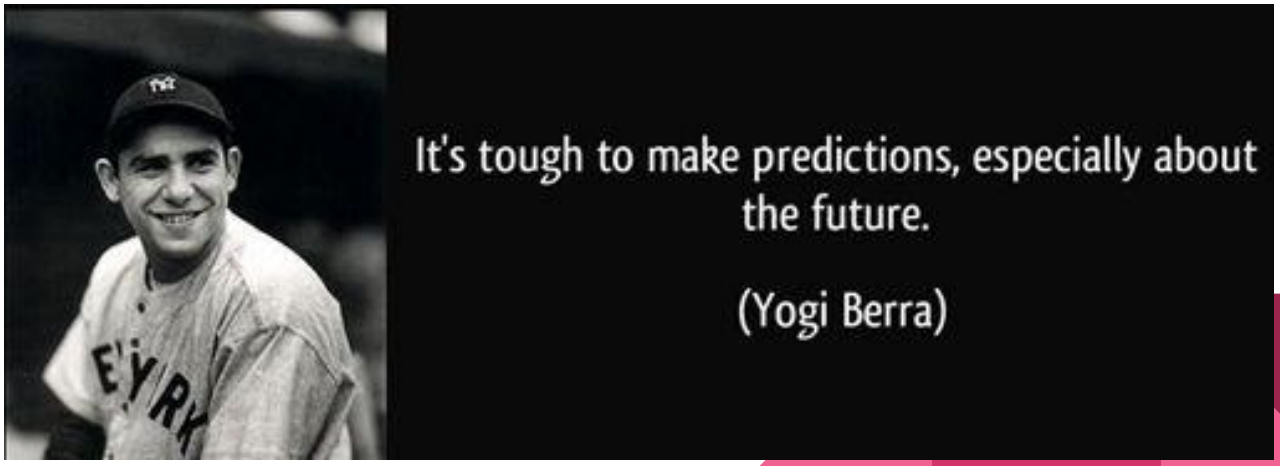
Hadronic uncertainties versus new physics for the W boson mass and Muon g − 2 anomalies*

- To summarize: The theory prediction of muon *g*-2 and of M_W depends on hadronic corrections to the photon vacuum polarizations (HVP). If the HVP are ad-hoc modified such that the *g*-2 discrepancy decreases, inevitably the electroweak precision fit discrepancy increases.
  - Previous, related studies have reached similar conclusions in other ways
- While I'm not sure I agree with the following statement from the paper, I'll quote it here: "...the case for new physics in either the W mass or muon *g*−2 is inescapable regardless of the size of the SM hadronic contributions."

* https://www.nature.com/articles/s41467-023-36366-7

How will things turn out?





How would I LIKE to see things go?

3 Things I think would be most helpful:

1. Real support for our phenomenology colleagues to produce PDF and boson production modeling which are version controlled and highly documented, and allows for experimentalists to dig into the pieces
    a. We understand that this isn't good for getting a job or tenure… Not sure how to solve it
2. Get the "WHO" out of the discussions…
    a. Oversimplified version of a fun story: When brought a petition of over 200 scientists saying Special Relativity must be wrong Einstein said "Why 200 names? If any one of them was right, that one would have been enough". What is correct and WHY is more important that WHO
    b. How do we get PHYSICISTS (theory, experiment, from all collaborations) together to solve this quandary without artificial boundaries?
        i. Don't get me wrong… we NEED independent verification and methods

Conclusions… Part 2…

3. A world-wide effort to allow us to take apart each and every PIECE of the measurements and assumptions that go into them
   - Dig deep into the details of the detectors AND theoretical modeling
   - Don't allow things to be covered up by "sophisticated fitting procedures" or powerful "statistical techniques"
   - More "terra firma" at all levels of the analyses
   - Less "opinions" and "belief," more science