PUZZLES IN PARTICLE PHYSICS AND COSMOLOGY

QuarkNet Summer Workshop
Josh Erlich
William & Mary

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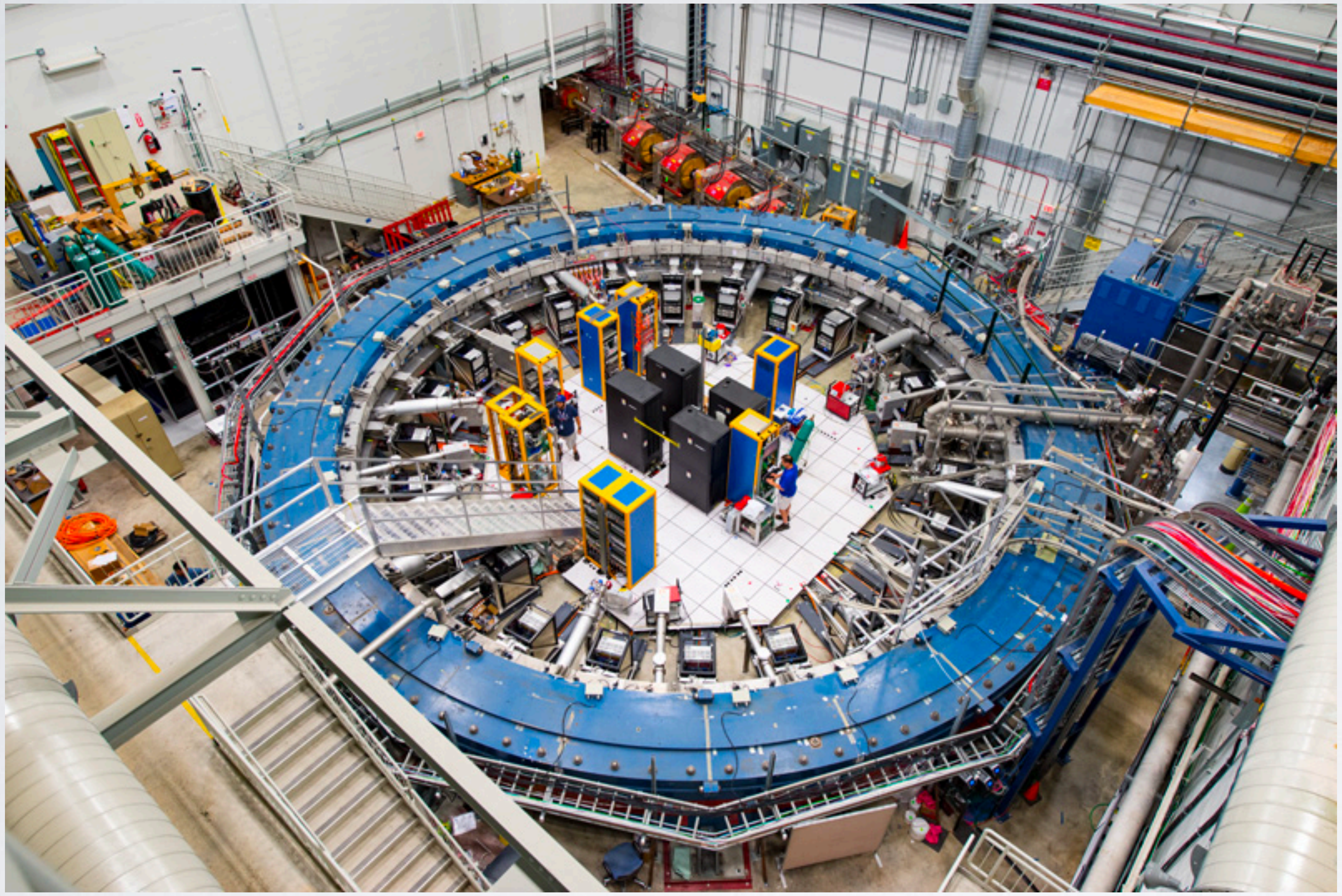
WILLIAM & MARY
CHARTERED 1693

NSF

QuarkNet

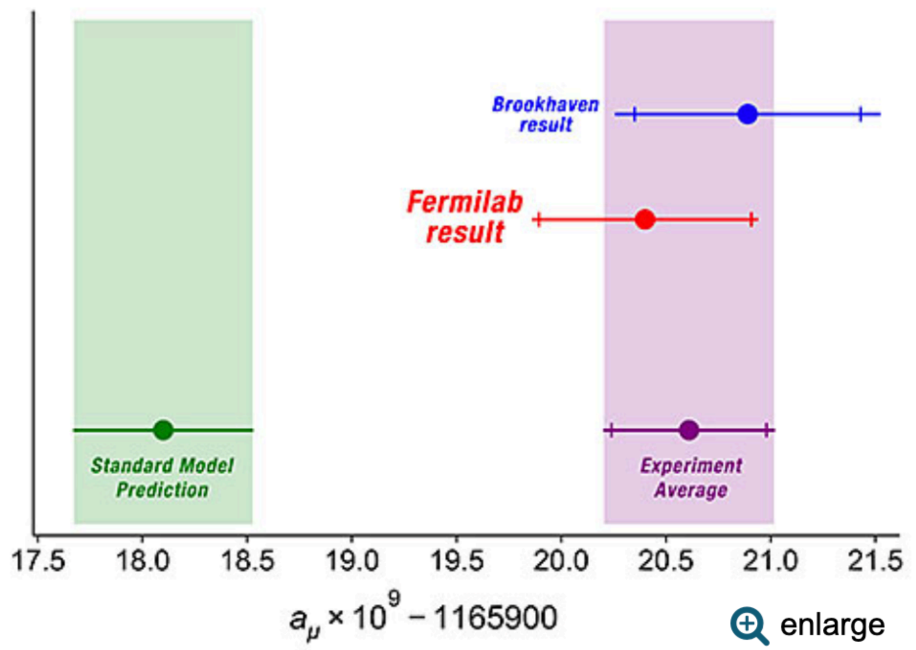
Muon g-2



Muon g-2 ring, Fermilab

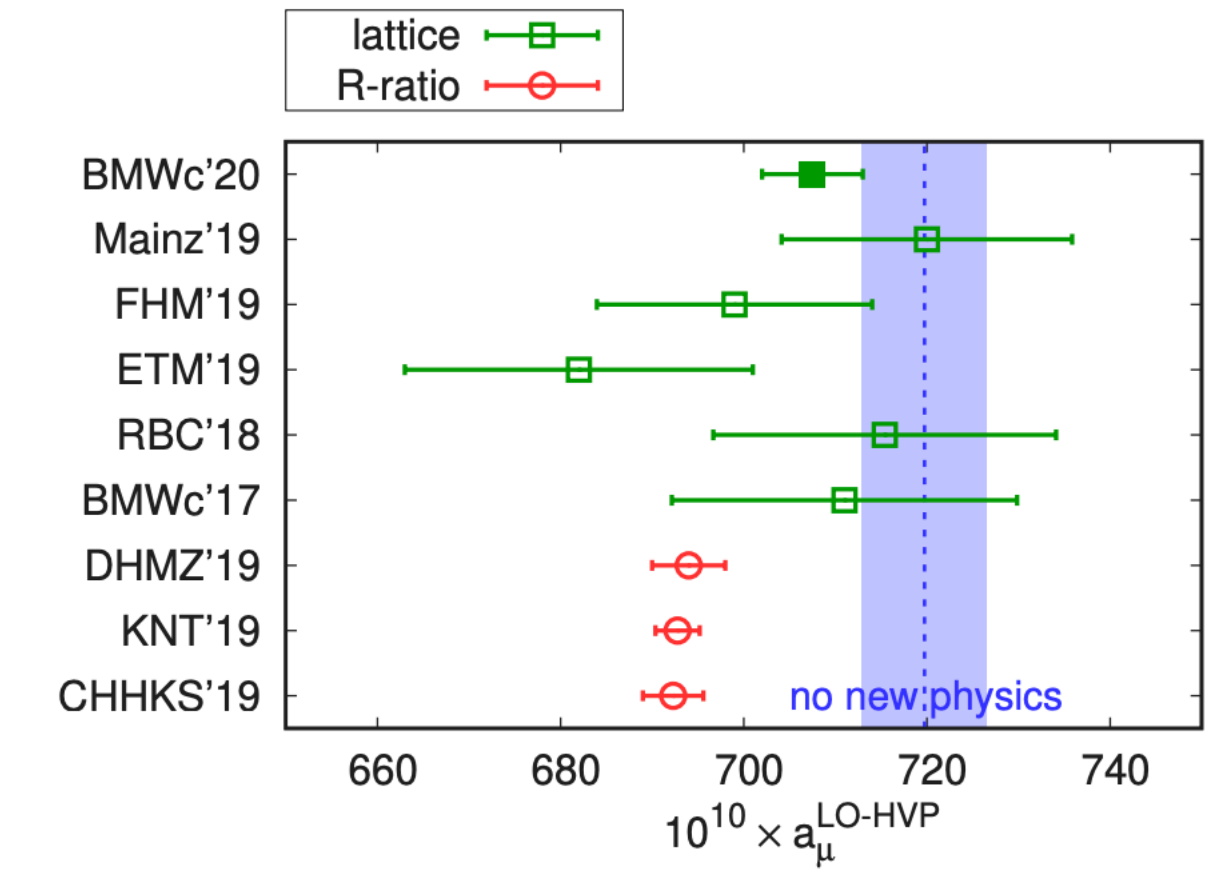
$$\mu = \frac{e}{2m}\left(\mathbf{L} + g\mathbf{S}\right)$$

Muon g-2



The first result from the Muon g-2 experiment at Fermilab confirms the result from the experiment performed at Brookhaven National Lab two decades ago. Together, the two results show strong evidence that muons diverge from the Standard Model prediction. *(Image credit: Ryan Postel, Fermilab/Muon g-2 collaboration)*

Fermilab



BMW Lattice QCD collaboration
(Zoltan Fodor)

4.2 sigma discrepancy

No significant discrepancy

M_W

Abstract

The mass of the *W* boson, a mediator of the weak force between elementary particles, is tightly constrained by the symmetries of the standard model of particle physics. The Higgs boson was the last missing component of the model. After observation of the Higgs boson, a measurement of the *W* boson mass provides a stringent test of the model. We measure the *W* boson mass, M_W, using data corresponding to 8.8 inverse femtobarns of integrated luminosity collected in proton-antiproton collisions at a 1.96 tera–electron volt center-of-mass energy with the CDF II detector at the Fermilab Tevatron collider. A sample of approximately 4 million *W* boson candidates is used to obtain $M_W = 80,433.5 \pm 6.4_{\text{stat}} \pm 6.9_{\text{syst}} = 80,433.5 \pm 9.4\ \text{MeV}/c^2$, the precision of which exceeds that of all previous measurements combined (stat, statistical uncertainty; syst, systematic uncertainty; MeV, mega–electron volts; *c*, speed of light in a vacuum). This measurement is in significant tension with the standard model expectation.

CDF Collaboration

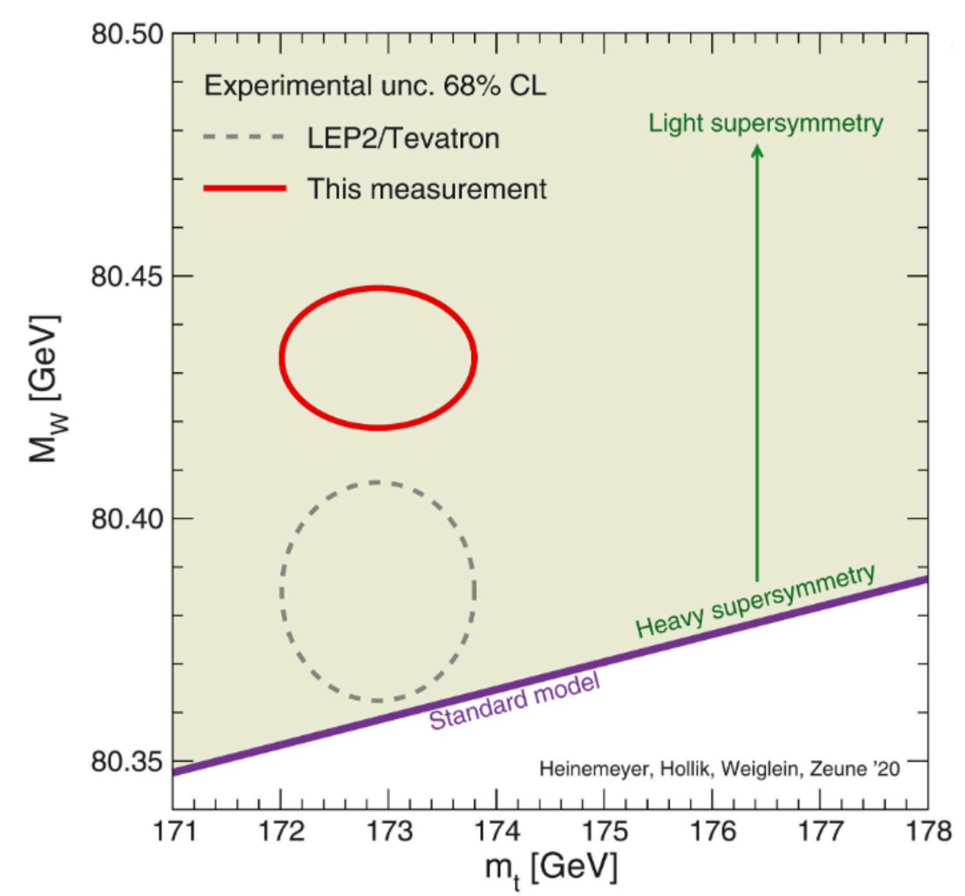
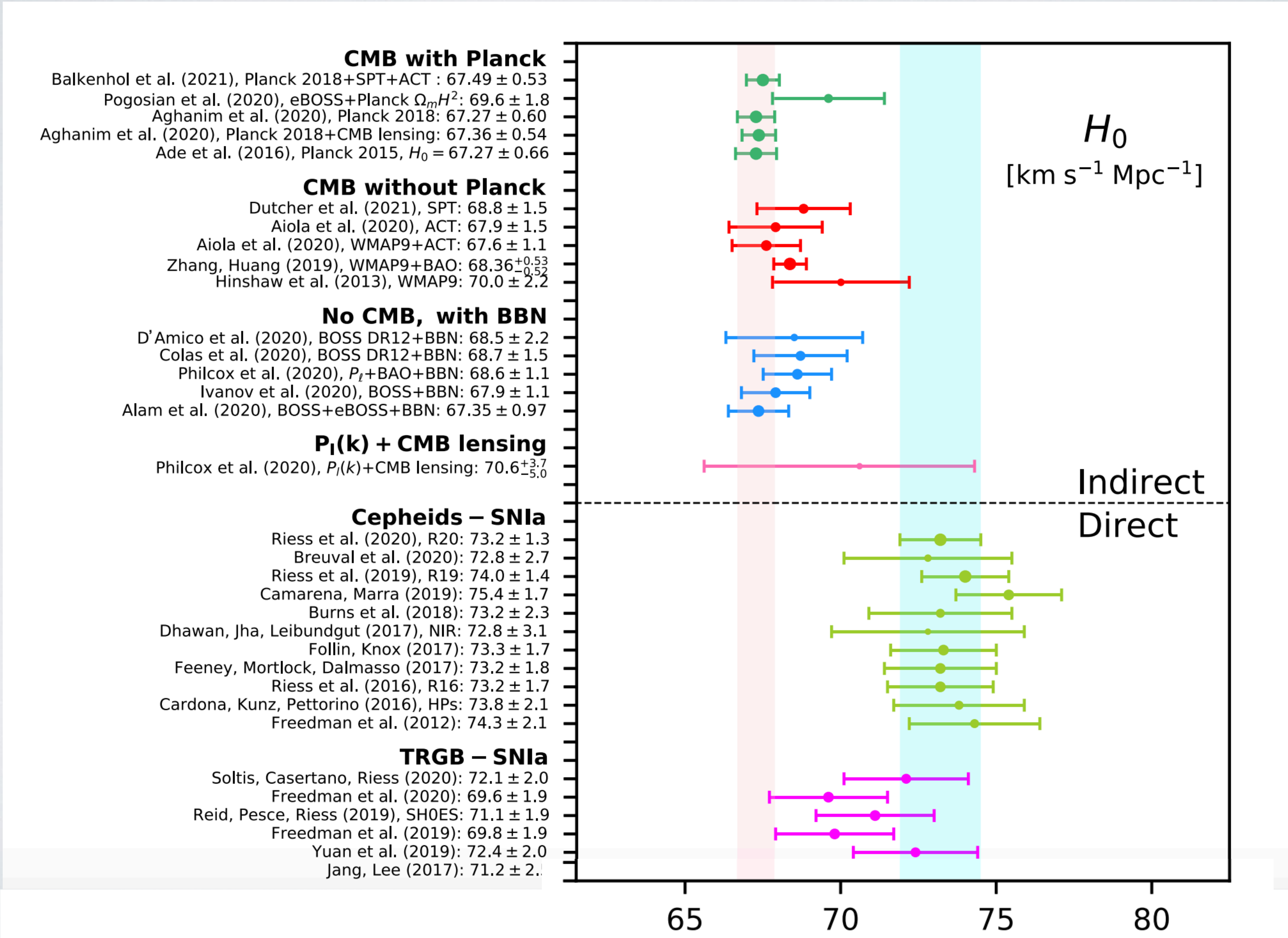


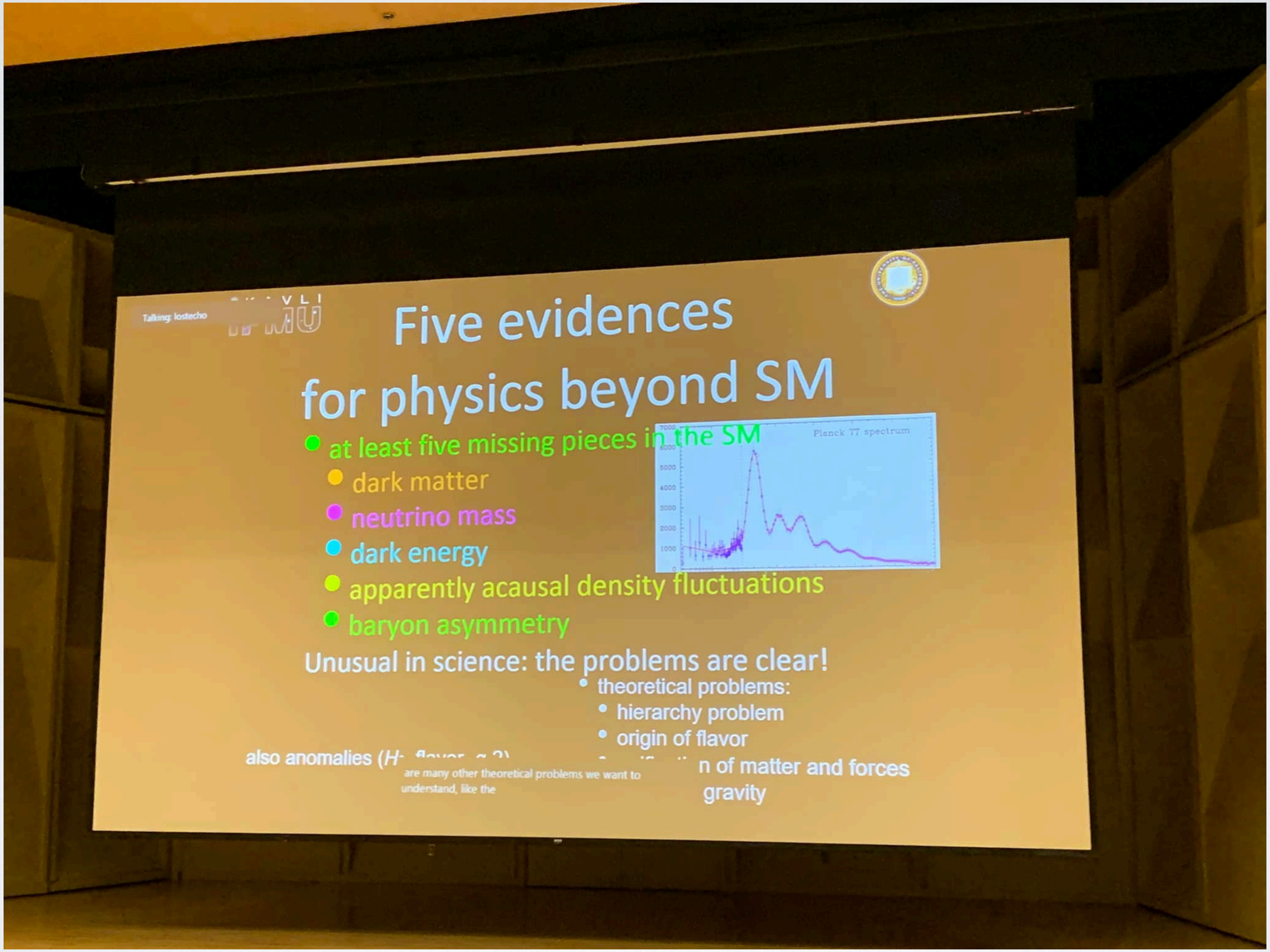
Fig. 1. Experimental measurements and theoretical predictions for the *W* boson mass.

7 sigma discrepancy

Hubble Tension



Evidence for New Physics



Hitoshi Murayama, Snowmass 2022
Photo, Alexey Petrov