Have we found new physics by measuring the W boson mass?

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The Standard Model (SM) of particle physics is one of the most successful scientific theories up to date, being able not only to explain but also to predict a plethora of experimentally tested results. Be that as it may, there are still many experimental facts, such as the existence of Dark Matter or neutrino masses among others, which cannot be explained within this framework and suggest the existence of physics beyond the SM.

Very recently, a new tension between the SM prediction and data arose: the CDF collaboration announced an updated, more precise measurement of the W boson mass [1],

$$M_W^{\rm CDF} = 80.4335 \pm 0.0094 \text{ GeV}, \tag{1}$$

which deviates by about 7σ from the SM prediction, $M_W^{\rm SM} = 80.357 \pm 0.006$ GeV [1].

The W boson is a crucial ingredient of the SM, closely related to the Higgs mechanism generating all particle masses in the model. The recent measurement of the W mass has been obtained analysing data collected from 2002 to 2011 in proton-antiproton collisions at a 1.96 TeV center-of-mass energy with the CDF II detector at the Tevatron collider in Fermilab. The precision exceeds that of all previous measurements, even when combined, thanks to the larger statistical sample and also to the reduction of systematic uncertainties in the analysis [1]. Not only does this new result produce a 7σ tension with the SM prediction, but it also disagrees with the previous global combination of data from LEP, CDF, D0 and ATLAS, $M_W^{\rm comb} = 80.379 \pm 0.012$ GeV [2], although with a lower significance. The different individual measurements and their combination can be compared in Fig. 1 together with the weighted average of all available results, shown in red.

The new measurement of the W mass can be rephrased in terms of corrections to the electroweak parameters S and T, related to the SM gauge boson

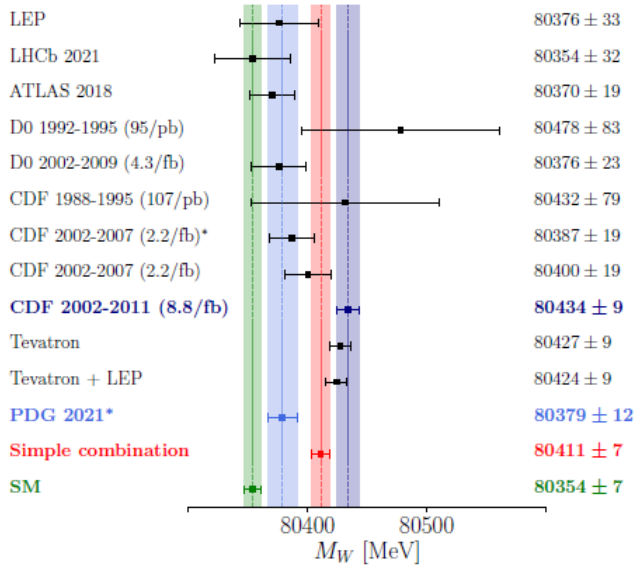

Figure 1: *W mass measurements (blue line is the PDG 2021 value, gray line is the new CDF one) and theoretical prediction from the SM (green line). Figure taken from [4].*

propagators. New physics at the TeV scale could be able to alleviate the tension: in Ref. [3] it is suggested that data could be explained with a new Z' gauge boson whose mass lies around 10 TeV, naturally arising from little-Higgs models or higher-dimensional geometries. The authors of Ref. [4] ruled out the possibility that both the new W mass anomaly and the long-standing one related to the measurement of the muon magnetic moment could be explained at the same time by hadronic uncertainties in the SM, since they contribute in opposite directions. They also provide a viable solution based on a new scalar leptoquark at the TeV scale.

All in all, the new measurement announced by the CDF collaboration, if confirmed, would signal an unquestionable hint for new physics at accessible energy scales, opening the door to probing new exciting scenarios.

References

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