NNU · 南京师范大学
NANJING NORMAL UNIVERSITY

The trouble with MW

Peter Athron
(Nanjing Normal University)

A very Surprising New Result..

New experimental result

$$M_W^{\mathrm{CDF}} = 80.4335 \pm 0.0094 \ \mathrm{GeV}$$

Previous world average

$$M_W^{2021} = 80.379 \pm 0.012 \ \mathrm{GeV}$$

Theory predictions

$$M_W^{\mathrm{SM,OS}} = 80.355 \pm 0.006 \ \mathrm{GeV}$$

$$M_W^{\mathrm{SM,\overline{MS}}} = 80.351 \pm 0.006 \ \mathrm{GeV}$$

$$M_W^{\mathrm{SM,\ EW\ fit}} = 80.3591 \pm 0.0052 \ \mathrm{GeV}$$

} Good agreement

$\Rightarrow \approx 7\sigma$ deviation!

But in significant tension with previous measurements…

Naive Combination

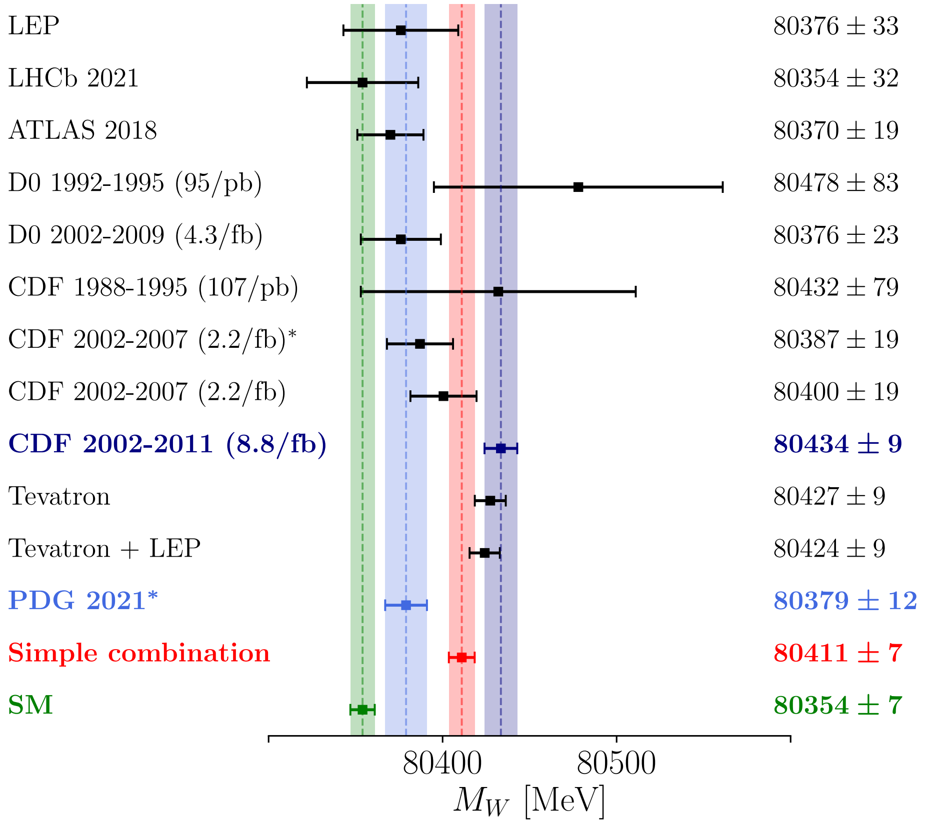
[arXiv:2204.03996,PA, A. Fowlie, C.-T. Lu, L. Wu, Y. Wu, B. Zhu]

Naively combine all measurements,
avoiding double counting
of old CDF results

$$\bar{x} \pm \Delta x = \frac{\sum_{i=1}^{N} w_i x_i}{\sum_{i=1}^{N} w_i} \pm \left(\sum_{i=1}^{N} w_i \right)^{-1/2}$$

$$\Rightarrow M_W^{\text{simple comb.}} = 80.411 \pm 0.007 \text{ GeV}$$

With tension: 2.5σ



I can’t say much about the experimental methods
or the systematic uncertainties,
but...

Systematic Unceratinties

Big question is the remarkable reduction in systematics uncertainies

Early speculation in blogs/comments
pointed finger at using older ResBos, v2

Was my friend Csaba Balazs to blame?

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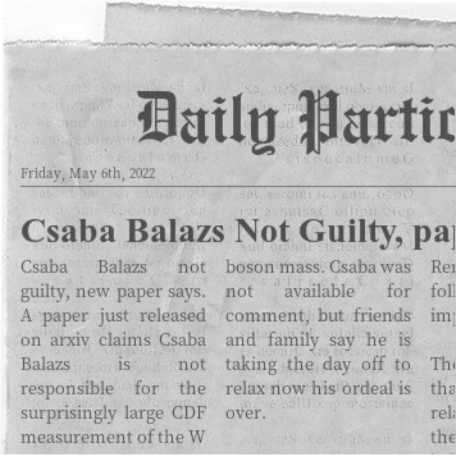
This seems to be ruled out.

https://arxiv.org/abs/2205.02788

Joshua Isaacson, Yao Fu, and C.-P. Yuan


Daily Partic

Friday, May 6th, 2022

Csaba Balazs Not Guilty, pa

Csaba Balazs not guilty, new paper says. A paper just released on arxiv claims Csaba Balazs is not responsible for the surprisingly large CDF measurement of the W boson mass. Csaba was not available for comment, but friends and family say he is taking the day off to relax now his ordeal is over.

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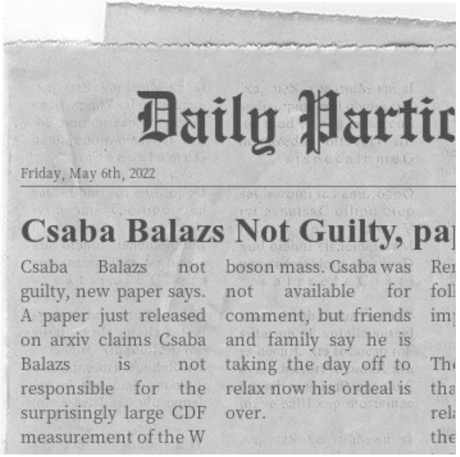

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Csaba is a free man!

Predicting MW

Electroweak sector $\{M_W, M_Z, G_F, \sin\theta_W, \alpha_e\} \xrightarrow{\text{Choose}} \{M_Z, G_F, \alpha_e\}^{\text{EW inputs}}$

Redundancy amongst these quantities

$$M_W^2 = \frac{1}{4} g^2 v^2 \quad M_Z^2 = \frac{1}{4}\sqrt{(g^2 + g'^2)} v^2 \quad \sin^2\theta_W = \frac{g'^2}{g^2 + g'^2}$$

$$\alpha_e = \frac{e^2}{4\pi} \quad e = \frac{gg'}{g^2 + g'^2} = g' \sin\theta_W = g\cos\theta_W$$

$$G_F = \frac{\pi\alpha}{\sqrt{2} M_W^2 \sin^2\theta_W}$$

Tree-level EW relations in SM

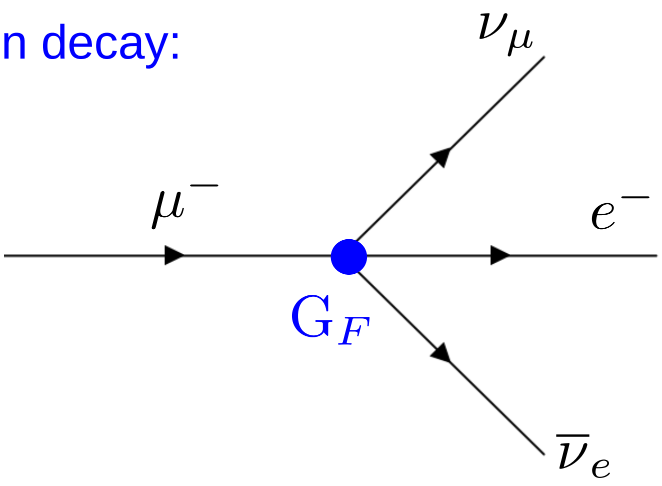
The Fermi constant is very precisely measured

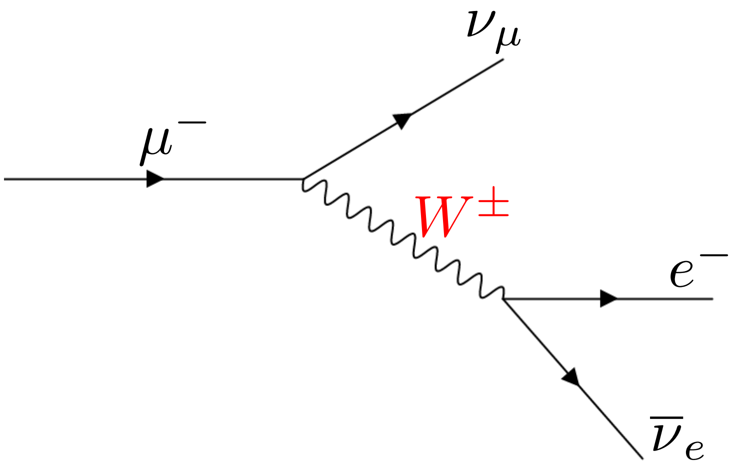
$\Rightarrow$ **Predict M_W from G_F**

Predicting MW from muon decay

Just calculate corrections from W self energy? $M_W^2 = M_W^{2\,\text{tree}} + \Pi_{WW}(M_W^2)$ ✗

Predict through muon decay:





Muon lifetime:

$$\tau_\mu^{-1} = G_F \frac{m_\mu^5}{192\pi^3}(1 + \ldots)$$

$$G_F^{\text{tree}} = \frac{\pi\alpha}{\sqrt{2} M_W^2 \sin^2\theta_W}$$

Calculation of MW

Calculate from muon decay:

$$G_F = \frac{\pi\alpha}{\sqrt{2}M_W^2 \sin^2\theta_W}\left(1+\Delta r\right)$$

$$M_W^2 = M_Z^2\left\{\frac{1}{2}+\sqrt{\frac{1}{4}-\frac{\pi\alpha}{\sqrt{2}G_F M_Z^2}\left(1+\Delta r\right)}\right\}$$

OS calculation of MW

Calculate from muon decay:

$$G_F = \frac{\pi\alpha}{\sqrt{2} M_W^{2\,\mathrm{OS}} \sin^2\theta_W}\left(1 + \Delta r\right)$$

$$M_W^{2\,\mathrm{OS}} = M_Z^2 \left\{ \frac{1}{2} + \sqrt{\frac{1}{4} - \frac{\pi\alpha}{\sqrt{2} G_F M_Z^2}\left(1 + \Delta r\right)} \right\}$$

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At one loop: $\Delta r^{(\alpha)} = \Delta\alpha - \frac{c_W^2}{s_W^2}\Delta\rho + \Delta r^{\mathrm{remainder}}$

Charge renormalisation

$$\Delta\alpha := \Pi_{AA}^{\mathrm{light}}(0) - \Pi_{AA}^{\mathrm{light}}(M_Z^2)$$
$$= \Delta\alpha^{\mathrm{had}} + \Delta\alpha^{\mathrm{lep}}$$

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Correction to the ρ parameter

$$\rho = \frac{M_W^2}{M_Z^2 c_W^2}$$

OS calculation of MW

Calculate from muon decay:

$$G_F = \frac{\pi\alpha}{\sqrt{2} M_W^{2\,\mathrm{OS}} \sin^2\theta_W}\left(1 + \Delta r\right)$$

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← Assumes no tree-level correction to ρ parameter

At one loop: $\Delta r^{(\alpha)} = \Delta\alpha - \frac{c_W^2}{s_W^2}\Delta\rho + \Delta r^{\mathrm{remainder}}$

Charge renormalisation

$$\Delta\alpha := \Pi_{AA}^{\mathrm{light}}(0) - \Pi_{AA}^{\mathrm{light}}(M_Z^2) = \Delta\alpha^{\mathrm{had}} + \Delta\alpha^{\mathrm{lep}}$$

Correction to the ρ parameter

$$\rho = \frac{M_W^2}{M_Z^2 c_W^2}$$

$\overline{\text{MS}}$ calculation of MW

Calculate from muon decay:

$$G_F = \frac{\pi \hat{\alpha}(M_Z)}{\sqrt{2} M_W^2 \hat{s}_{\theta W}} \left(1 + \Delta \hat{r}_W\right)$$

$$M_W^2 = M_Z^2 \hat{\rho} \left\{ \frac{1}{2} + \sqrt{\frac{1}{4} - \frac{\pi \hat{\alpha}(M_Z)}{\sqrt{2} G_F M_Z^2 \hat{\rho}} \left(1 + \Delta r_W\right)} \right\}$$

You may see other fomulations,
many subtleties.

$\overline{\text{MS}}$ calculation of MW

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$$\hat{\alpha}(M_Z) = \frac{\alpha}{1 - \Delta \hat{\alpha}(M_Z)}$$

Also Includes $\Delta\alpha^{\text{had}} + \Delta\alpha^{\text{lep}}$

You may see other fomulations, many subtleties.

Again hadronic contributions to charge renormalisation play a role

Hadronic contributions?

From $\{M_Z, G_F, \alpha_e\}^{\text{EW inputs}}$ least well known is $\alpha_e(M_Z)$

⟶ Non-perturbative estimates, hadronic contributions limit the precision

Estimated through dispersion relations from hadronic e+e- data :

$$\Delta\alpha^{\text{had}} = \frac{M_Z^2}{4\pi^2\alpha}\int_{m_{\pi^0}^2}^{\infty} \frac{\mathrm{d}s}{M_Z^2 - s}\,\sigma^{\text{had}}(\sqrt{s}),$$

Current estimates $\Delta\alpha^{\text{had}} = (276.09 \pm 1.12) \times 10^{-4}$ [KNT, PRD 101 (2020) 1, 014029]

$(275.3 \pm 1.0) \times 10^{-4}$ [BHMZ, EPJC 80 (2020) 3, 241]

$(276.8 \pm 0.7) \times 10^{-4}$ [PDG, 2022 EW Model review]

W mass uncertainties

Do these uncertainties explain the $\Delta M_W^{\mathrm{CDF},2022} \approx 80\ \mathrm{MeV}$ deviation?

	ΔM_W^{SM} (OS)	ΔM_W^{SM} ($\overline{\mathrm{MS}}$)
$M_h \pm 1\sigma$	0.08 MeV	0.08 MeV
$M_t \pm 1\sigma$	1.8 MeV	1.8 MeV
$M_t \pm 1$ GeV	6.0 MeV	6.1 MeV
$M_Z \pm 1\sigma$	2.6 MeV	—
$\Delta\alpha_{\mathrm{had}}^{(5)} \pm 1\sigma$	1.3 MeV	1.3 MeV
$\alpha_s \pm 1\sigma$	0.59 MeV	0.62 MeV

[arXiv:2204.05285, PA, M. Bach, D.H.J. Jacob, W. Kotlarski, D. Stöckinger, A. Voigt]

No! Its not even the largest source of uncertainty.

So why am I even talking about this?

Hadronic uncertainties in muon g-2

Very similar story in muon g-2

$$a_\mu^{\text{exp}} = (116\,592\,061 \pm 41) \times 10^{-11}$$
$$a_\mu^{\text{SM}} = (116\,591\,810 \pm 43) \times 10^{-11}$$
$$\Delta a_\mu = (25.1 \pm 5.9) \times 10^{-10} \quad \Rightarrow 4.2\sigma \text{ deviation}$$

Main doubt:
hadronic uncertainties from

$$a_\mu^{\text{HVP}} = \frac{m_\mu^2}{12\pi^3} \int_{m_{\pi^0}^2}^{\infty} \frac{\mathrm{d}s}{s} K(s) \sigma_{\text{had}}(\sqrt{s}),$$

Same σ_{had} in $\Delta\alpha^{\text{had}}$

$a_\mu^{\text{HVP,LO}} = 694.0 \pm 4$ [KNT, PRD 101 (2020) 1, 014029]

692.78 ± 2.42 [BHMZ, EPJC 80 (2020) 3, 241]

693.1 ± 4 [White Paper, Phys.Rept. 887 (2020) 1-166]

707.7 ± 5.5 [BMW Lattice, Nature 593, 51 (2021)] (not included SM Estimate above)

Hadronic uncertainties in muon g-2

Skepticism exists because:

- Extraordinairy claims require extraordinairy evidence
- $a_\mu^{\mathrm{HVP}} (\mathrm{and}\, \Delta\alpha^{\mathrm{had}})$ are hard to calculate
- The new BMW Lattice result does not agree

  (and some parts agreement in 2206.06582, arXiv:2206.15084)

Early lattice results (at this precsion)
→ need for caution, but increases concerns

Muon g-2 situation already motivated comparsion to EW fits with $\Delta\alpha^{\mathrm{had}}$

If BMW result is correct → tension in EW fits

[A. Crivellin, M. Hoferichter, C. A. Manzari, and M. Montull, PRL 125, 091801 (2020)]

But what about the new W mass measurement?

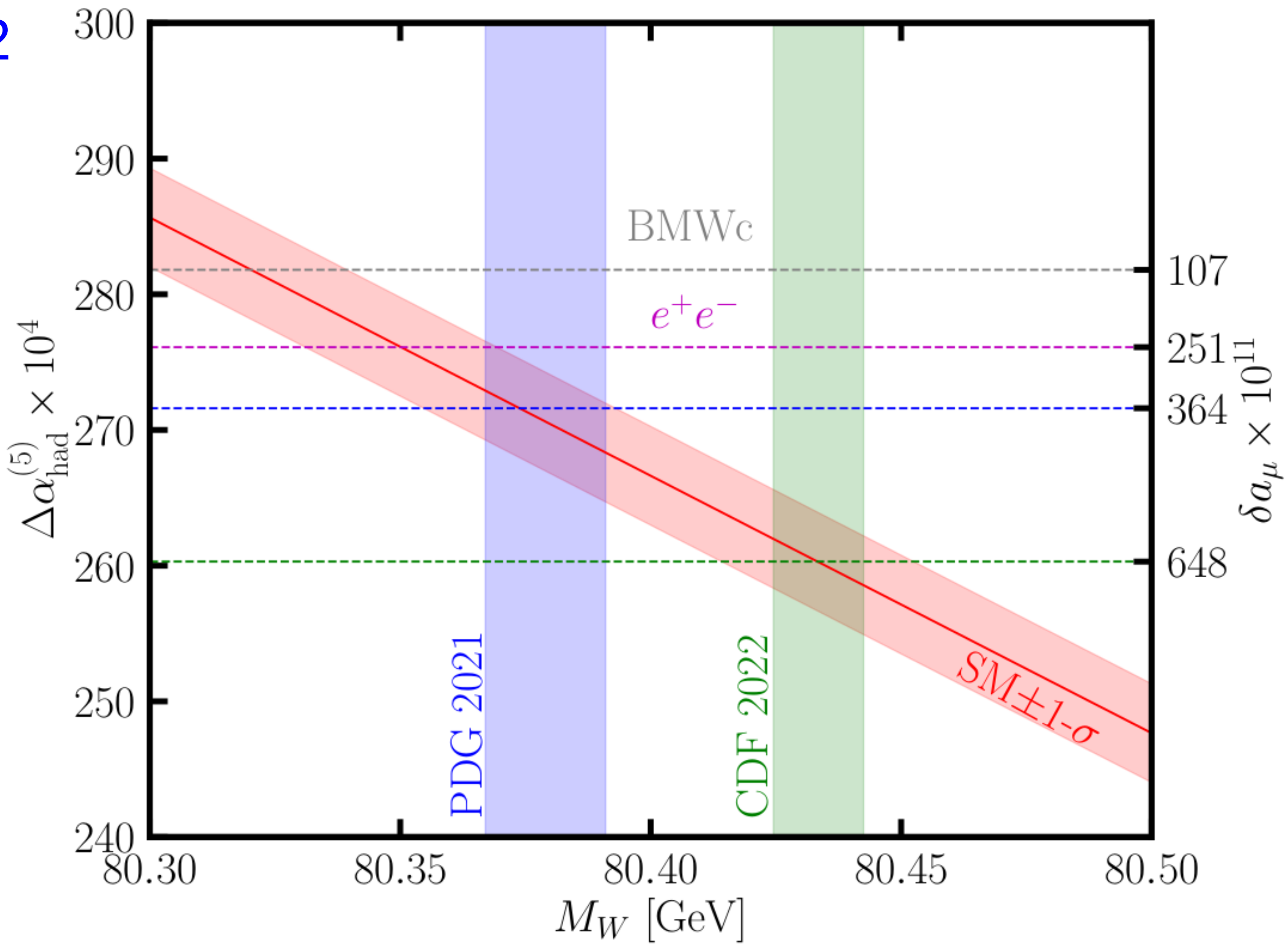
Global EW fit Tension

[arXiv:2204.03996,PA, A. Fowlie, C.-T. Lu, L. Wu, Y. Wu, B. Zhu]

The W mass and muon g-2 pull in opposite directions

Red EW fit band cannot agree with both muon g-2 and CDF MW

Very hard for a change in the hadronic cross section to explain both



Global EW fit Tension

[arXiv:2204.03996,PA, A. Fowlie, C.-T. Lu, L. Wu, Y. Wu, B. Zhu]

Input $\Delta\alpha^{\text{had}}$

$\Delta\alpha_{\text{had}}$ Data	BMWc	e^+e^-
Input $\Delta\alpha_{\text{had}} \times 10^4$	281.8(1.5)	276.1(1.1)
χ^2/dof	18.32/15	16.01/15
M_W [GeV]	80.348(6)	80.357(6)
$\Delta\alpha_{\text{had}} \times 10^4$	280.9(1.4)	275.9(1.1)
δM_W [MeV]	86(11)	77(11)
Tension	7.8σ	7.0σ

BMWc → a_μ deviation 1.7σ

e^+e^- → a_μ deviation 4.2σ

Inputting BMW data increases tension with CDF W mass measurement

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Input M_W [GeV]	80.379(12)	80.4335(94)
χ^2/dof	17.59/15	47.19/15
M_W [GeV]	80.367(7)	80.396(7)
$\Delta\alpha_{\rm had} \times 10^4$	271.7(3.8)	260.9(3.6)
$\delta a_\mu \times 10^{11}$	364(145)	648(137)
Tension	2.5σ	4.7σ
δM_W [MeV]	67(12)	38(12)
Tension	5.6σ	3.2σ

Inputting BMW data increases tension with CDF W mass measurement

Inputting CDF W mass increases tension with muon g-2

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Inputting CDF W mass increases tension with muon g-2

And we have a bad EW fit

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Inputting CDF W mass increases tension with muon g-2

And there is still a tension in the W mass

In general:

For *any* choice to constrain $\Delta\alpha^{\mathrm{had}}$ via
CDF-MW, 2021 PDG-MW, e+e- or BMW lattice data

Reducing the $\Delta M_W^{\mathrm{CDF}}$ anomally increases Δa_μ anomally
and vice versa

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… and every choice has: $\sqrt{(\Delta M_W^{\text{CDF}})^2 + (\Delta a_\mu)^2} > 5\sigma$

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Big Caveat: this all depends on our assumptions about
energy dependence of the hadronic cross-section

(we applied universal scaling over the full integration range)

Alternative hypothesis:

cross section only changes at low energies $m_{\pi_0} \leq \sqrt{s} \leq 1.937$ GeV,

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$\delta a_\mu \times 10^{11}$	748(339)	1997(320)
Tension	2.2σ	6.2σ
δM_W [MeV]	67(12)	38(12)
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BMW doesn’t increase tension with MW as much

CDF data makes muon g-2 anomally even worse

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BMW doesn't increase tension with MW as much

And the EW fit is still bad!

Even if we remove all four of these contraints on $\Delta\alpha^{\rm had}$

(i.e extractions from MW and from e+e- data or BMW lattice data)

We find

$$\Delta M_W^{\rm CDF} = (75 \pm 13)\ {\rm MeV}, \Rightarrow 5.8\sigma\ {\rm Tension}$$

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EW observables are very sensitive to $\alpha(M_Z)$

No way to explain CDF meaurement even without any data driven estimates from hadronic cross sections

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Conversely Δa_μ does depend on the data driven estimates

But inputting a heavy MW pulls us further away from the BMW prediction and the measured value

If the CDF measurement is correct
are there plausible BSM explanations?

BSM calculation of MW ($\overline{\text{MS}}$)

$$M_W^2 = (M_W^{\text{SM}})^2 \left(1 + \Delta_W\right)$$

$$\Delta_W = \frac{s_W^2}{c_W^2 - s_W^2}\left[\frac{c_W^2}{s_W^2}\left(\Delta\hat{\rho}_{\text{tree}} + \Delta\hat{\rho}_{\text{BSM}}\right) - \Delta\hat{r}_{W,} - \Delta\alpha\right]$$

Tree-level contributions to the ρ-parameter

Loop corrections to the ρ-parameter

New FlexibleSUSY approach: [arXiv:2204.05285, PA, M. Bach, D.H.J. Jacob, W. Kotlarski, D. Stöckinger, A. Voigt]

- avoids non-decoupling logs that can spoil prediction
- Nicely separates precise SM part, from one-loop BSM corrections

Calculated via SM $\overline{\text{MS}}$ fit formulae

MRSSM explanation

[arXiv:2204.05285, PA, M. Bach, D.H.J. Jacob, W. Kotlarski, D. Stöckinger, A. Voigt]

Well motivated SUSY model with R-symmetry

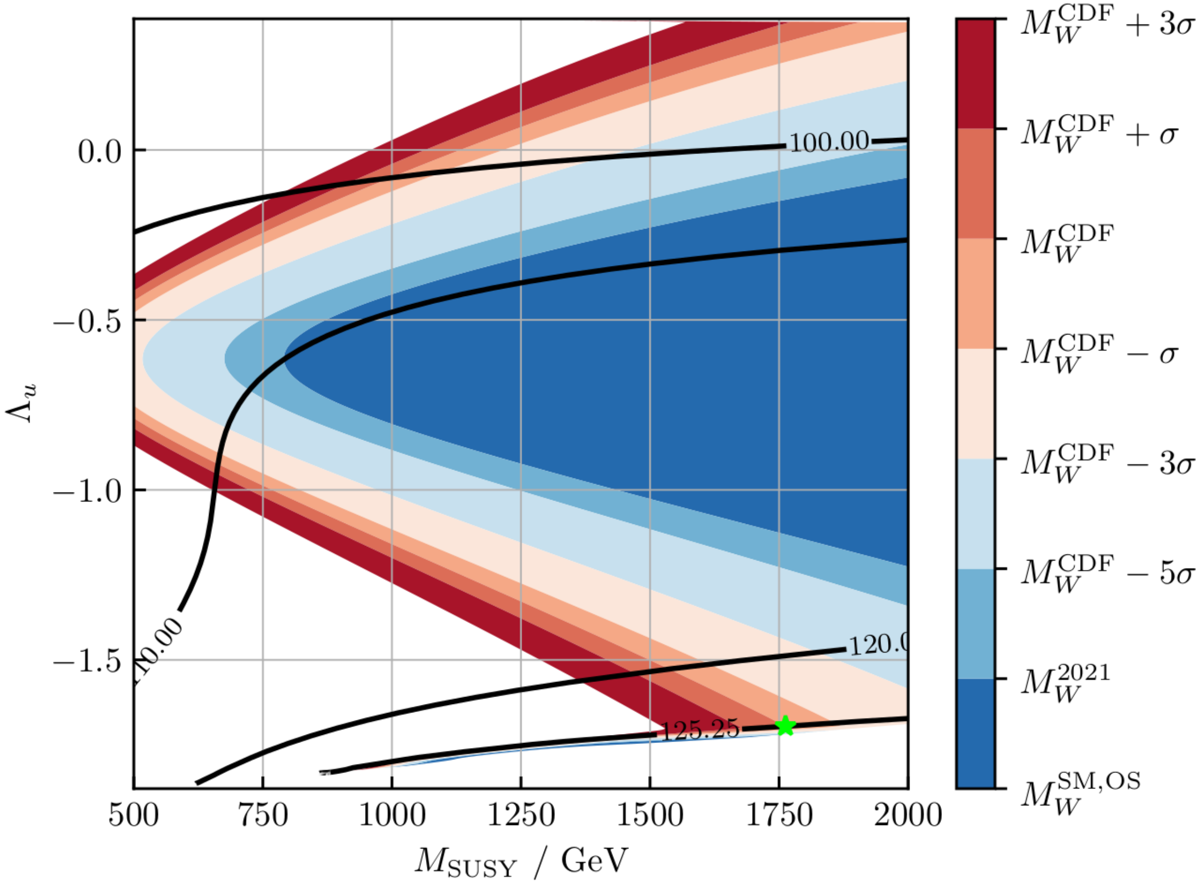
Tree level contribution:

$$\hat{\rho}_{\rm tree} = 1 + \frac{4v_T^2}{v_d^2 + v_u^2}$$

$$\Rightarrow m_W^2 = m_Z^2 \cos^2\theta_W + g_2^2 v_T^2$$

Explaining CDF W mass measurement is easy

Higgs mass is quite constraining though



Simultaneous MW and muon g-2 explanations

[arXiv:2204.03996,PA, A. Fowlie, C.-T. Lu, L. Wu, Y. Wu, B. Zhu]

Two scalar leptoquarks that mix together

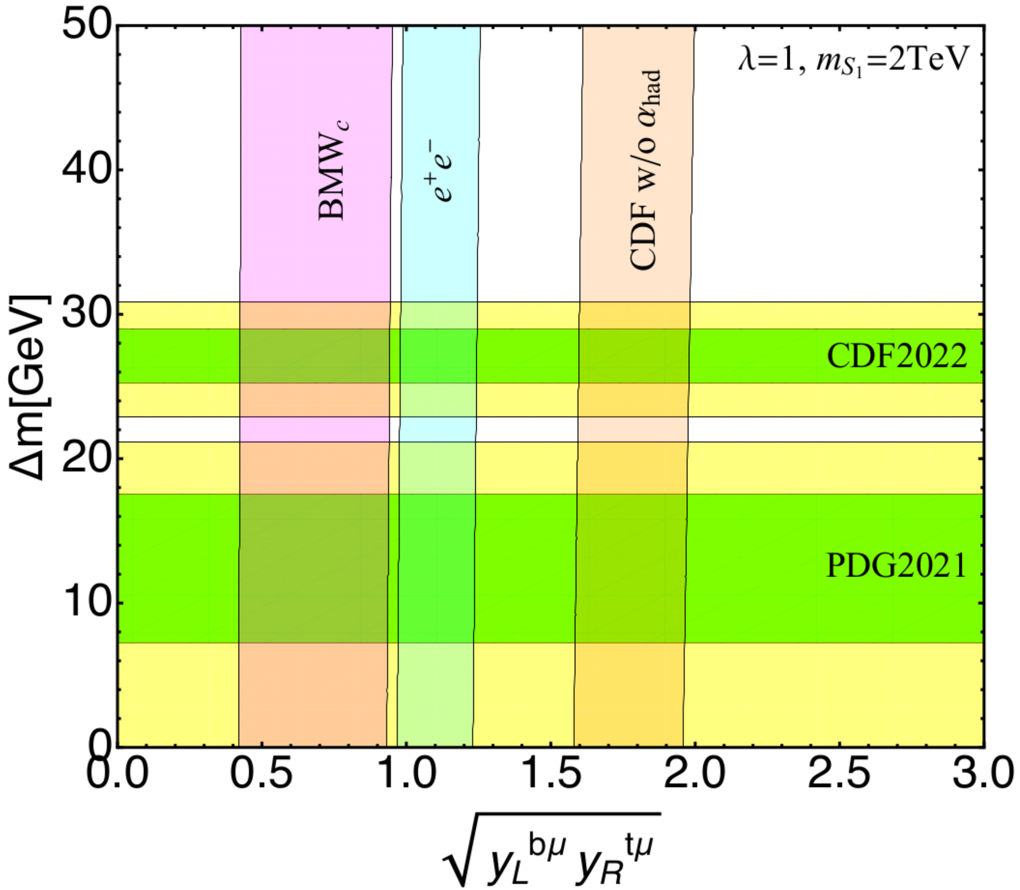
$S_1 \ (\overline{\mathbf{3}}, \mathbf{1}, 1/3)$

$\mathrm{S}_3 \ (\overline{\mathbf{3}}, \mathbf{3}, 1/3)$

$$\mathcal{L}_{S_1 \& S_3} = \mathcal{L}_{\text{mix}} + \mathcal{L}_{\text{LQ}},$$

$$\mathcal{L}_{\text{mix}} = \lambda H^\dagger \left(\vec{\tau} \cdot \overrightarrow{S_3}\right) H S_1^* + \text{ h.c.}$$

$$\mathcal{L}_{\text{LQ}} = y_R^{ij} \bar{u}_{Ri}^C e_{Rj} S_1 + y_L^{ij} \bar{Q}_i^C i\tau_2 \left(\vec{\tau} \cdot \vec{S}_3\right) L_j + \text{h.c.}$$



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Two scalar leptoquarks that mix together

$S_1\ (\bar{\mathbf{3}}, \mathbf{1}, 1/3)$

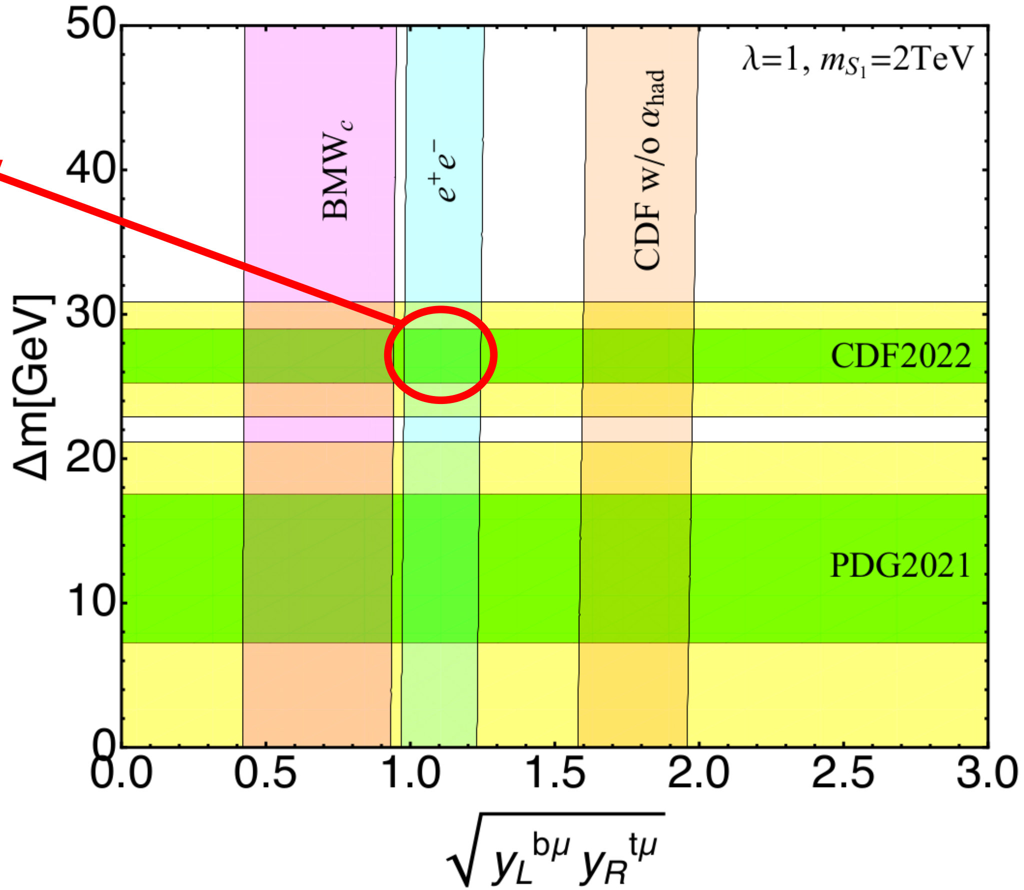
$S_3\ (\bar{\mathbf{3}}, \mathbf{3}, 1/3)$

Dual BSM explanation (SM predictions via dispersion relations)

$$\mathcal{L}_{S_1\&S_3} = \mathcal{L}_{\rm mix} + \mathcal{L}_{\rm LQ},$$

$$\mathcal{L}_{\rm mix} = \lambda H^\dagger \left(\vec{\tau} \cdot \overrightarrow{S_3}\right) H S_1^* + \text{ h.c.}$$

$$\mathcal{L}_{\rm LQ} = y_R^{ij} \bar{u}_{Ri}^C e_{Rj} S_1 + y_L^{ij} \bar{Q}_i^C i\tau_2 \left(\vec{\tau} \cdot \vec{S}_3\right) L_j + \text{h.c.}$$



Conclusions

- The CDF MW measurement is 7 sigma away from SM prediction, but has a 2.5 sigma tension amongst MW measurements
- MW calculations depend on hadronic contributions to the running of α : $\Delta\alpha^{\rm had}$
- EW fits constrain $\Delta\alpha^{\rm had}$ even if we do not use dispersion relation extractions.
$\Rightarrow$ New physics needed to explain CDF MW, regardless of hadronic uncertainties
- Furthermore if CDF MW is assumed with no new physics, this pulls $\Delta\alpha^{\rm had}$ increasing the tension with muon g-2 measurements and BMW $a_\mu^{\rm HVP}$
- If the the BMW extraction of $\Delta\alpha^{\rm had}$ measurement is adopted, SM cannot explain the CDF MW and there is severe tension with EW fits
- CDF MW measurement can be explained by well motivated new physics models, And dual explanations with muon g-2 are also possible

But all such ideas depend on the resolution of the tension amongst MW measurements

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Global EW fit Tension

[arXiv:2204.03996,PA, A. Fowlie, C.-T. Lu, L. Wu, Y. Wu, B. Zhu]

Input $\Delta\alpha^{\text{had}}$

$\Delta\alpha_{\text{had}}$ Data	BMWc	e^+e^-
Input $\Delta\alpha_{\text{had}} \times 10^4$	281.8(1.5)	276.1(1.1)
χ^2/dof	18.32/15	16.01/15
M_W [GeV]	80.348(6)	80.357(6)
$\Delta\alpha_{\text{had}} \times 10^4$	280.9(1.4)	275.9(1.1)
δM_W [MeV]	86(11)	77(11)
Tension	7.8σ	7.0σ

Input M_W

M_W Data	PDG 2021	CDF 2022
Input M_W [GeV]	80.379(12)	80.4335(94)
χ^2/dof	17.59/15	47.19/15
M_W [GeV]	80.367(7)	80.396(7)
$\Delta\alpha_{\text{had}} \times 10^4$	271.7(3.8)	260.9(3.6)
$\delta a_\mu \times 10^{11}$	364(145)	648(137)
Tension	2.5σ	4.7σ
δM_W [MeV]	67(12)	38(12)
Tension	5.6σ	3.2σ

Inputting BMW data increases tension with CDF W mass measurement

Inputting CDF W mass increases tension with muon g-2

Note: lower tension for muon g-2 because EW fit for $\Delta\alpha^{\text{had}}$ has greater uncertainty than extraction from e+e- data

Global EW fit Tension

Input *both* $\Delta\alpha^{\text{had}}$ and M_W

	M_W / $\Delta\alpha_{\text{had}}$	PDG 2021 BMWc	PDG 2021 e^+e^-	CDF 2022 BMWc	CDF 2022 e^+e^-
Input	M_W [GeV]	80.379(12)	80.379(12)	80.4335(94)	80.4335(94)
Input	$\Delta\alpha_{\text{had}} \times 10^4$	281.8(1.5)	276.1(1.1)	281.8(1.5)	276.1(1.1)
Fitted	χ^2/dof	23.41/16	18.74/16	74.51/16	62.58/16
Fitted	M_W [GeV]	80.355(6)	80.361(6)	80.375(5)	80.380(5)
Fitted	$\Delta\alpha_{\text{had}} \times 10^4$	280.3(1.4)	275.6(1.1)	278.6(1.4)	274.7(1.0)
Fitted	$\delta a_\mu \times 10^{11}$	146(68)	264(59)	188(68)	289(57)
Fitted	Tension	2.1σ	4.5σ	2.8σ	5.1σ
Fitted	δM_W [MeV]	79(11)	73(11)	59(11)	54(11)
Fitted	Tension	7.2σ	6.6σ	5.4σ	4.9σ

Input neither

Indirect
-
-
15.89/14
80.359(9)
274.4(4.4)
294(166)
1.8σ
75(13)
5.8σ

Alieviating tension in muon g-2 means worsening tension with the CDF data and vice versa.

We still get a bad fit for W mass

Global EW fit Tension

Assume: $m_{\pi_0} \leq \sqrt{s} \leq \infty$

	M_W	Indirect			PDG 2021			CDF 2022		
	$\Delta\alpha_{\text{had}}$	BMWc	e^+e^-	Indirect	BMWc	e^+e^-	Indirect	BMWc	e^+e^-	Indirect
Input	M_W [GeV]	-	-	-	80.379(12)	80.379(12)	80.379(12)	80.4335(94)	80.4335(94)	80.4335(94)
	$\Delta\alpha_{\text{had}} \times 10^4$	281.8(1.5)	276.1(1.1)	-	281.8(1.5)	276.1(1.1)	-	281.8(1.5)	276.1(1.1)	-
Fitted	χ^2/dof	18.32/15	16.01/15	15.89/14	23.41/16	18.74/16	17.59/15	74.51/16	62.58/16	47.19/15
	M_W [GeV]	80.348(6)	80.357(6)	80.359(9)	80.355(6)	80.361(6)	80.367(7)	80.375(5)	80.380(5)	80.396(7)
	$\Delta\alpha_{\text{had}} \times 10^4$	280.9(1.4)	275.9(1.1)	274.4(4.4)	280.3(1.4)	275.6(1.1)	271.7(3.8)	278.6(1.4)	274.7(1.0)	260.9(3.6)
	$\delta a_\mu \times 10^{11}$	-	-	294(166)	146(68)	264(59)	364(145)	188(68)	289(57)	648(137)
	Tension	-	-	1.8σ	2.1σ	4.5σ	2.5σ	2.8σ	5.1σ	4.7σ
	δM_W [MeV]	86(11)	77(11)	75(13)	79(11)	73(11)	67(12)	59(11)	54(11)	38(12)
	Tension	7.8σ	7.0σ	5.8σ	7.2σ	6.6σ	5.6σ	5.4σ	4.9σ	3.2σ

Global EW fit Tension

Assume: $m_{\pi_0} \leq \sqrt{s} \leq 1.937\,\mathrm{GeV}$

M_W / $\Delta\alpha_{\rm had}$		Indirect			PDG 2021			CDF 2022		
		BMWc	e^+e^-	Indirect	BMWc	e^+e^-	Indirect	BMWc	e^+e^-	Indirect
Input	M_W [GeV]	-	-	-	80.379(12)	80.379(12)	80.379(12)	80.4335(94)	80.4335(94)	80.4335(94)
	$\Delta\alpha^{(5)}_{\rm had}(M_Z^2) \times 10^4$	277.4(1.2)	276.1(1.1)	-	277.4(1.2)	276.1(1.1)	-	277.4(1.2)	276.1(1.1)	-
Fitted	$\chi^2/{\rm dof}$	16.28/15	16.01/15	15.89/14	19.51/16	18.74/16	17.59/15	65.07/16	62.58/16	47.19/15
	M_W [GeV]	80.355(6)	80.357(6)	80.359(9)	80.360(6)	80.361(6)	80.367(7)	80.379(5)	80.380(5)	80.396(7)
	$\Delta\alpha_{\rm had} \times 10^4$	277.1(1.2)	275.9(1.1)	274.4(4.4)	276.8(1.1)	275.6(1.1)	271.7(3.8)	275.6(1.1)	274.7(1.0)	260.9(3.6)
	$\delta a_\mu \times 10^{11}$	-	-	438(396)	173(54)	306(54)	748(339)	306(54)	416(54)	1997(320)
	Tension	-	-	1.1σ	3.2σ	5.7σ	2.2σ	5.7σ	7.7σ	6.2σ
	δM_W [MeV]	79(11)	77(11)	75(13)	74(11)	73(11)	67(12)	55(11)	54(11)	38(12)
	Tension	7.2σ	7.0σ	5.8σ	6.7σ	6.6σ	5.6σ	5.0σ	4.9σ	3.2σ