Muon g-2 $\Longleftrightarrow$ $\Delta\alpha$ connection

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Workshop
"HVP from lattice QCD at high precision"
16-20.11.2020

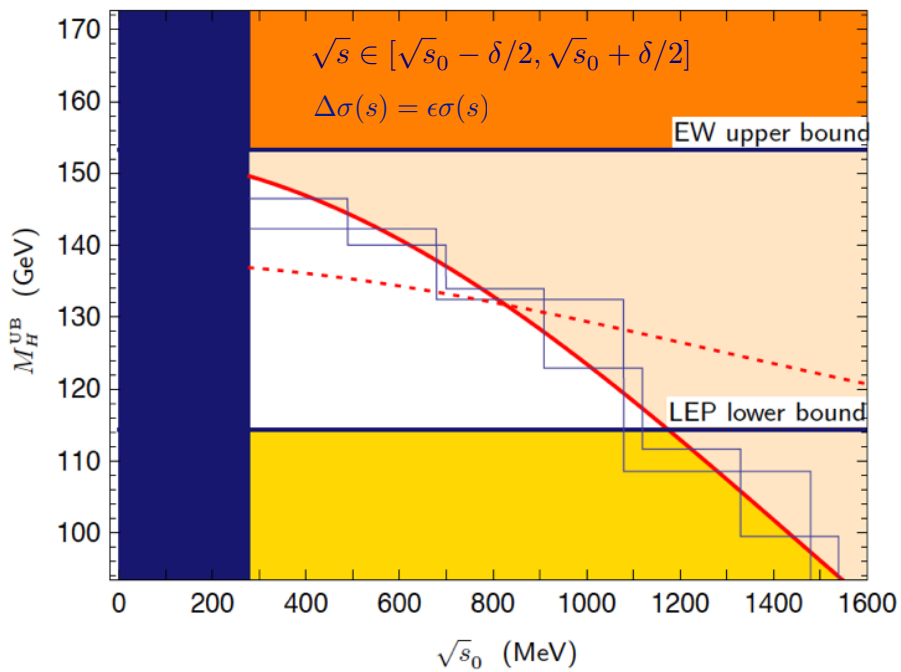
Muon g-2 ⇔ Δα connection (2008)

- Can Δa_μ be due to missing contributions in the hadronic σ(s)?
  An upward shift of σ(s) also induces an increase of $\Delta\alpha_{had}^{(5)}(M_Z^2)$:

$$a_\mu^{\rm HLO} \rightarrow \quad a = \int_{4m_\pi^2}^{s_u} ds\, f(s)\,\sigma(s), \qquad f(s) = \frac{K(s)}{4\pi^3},\ s_u < M_Z^2,$$

$$\Delta\alpha_{\rm had}^{(5)}(M_Z^2) \rightarrow \quad b = \int_{4m_\pi^2}^{s_u} ds\, g(s)\,\sigma(s), \qquad g(s) = \frac{M_Z^2}{(M_Z^2 - s)(4\alpha\pi^2)},$$

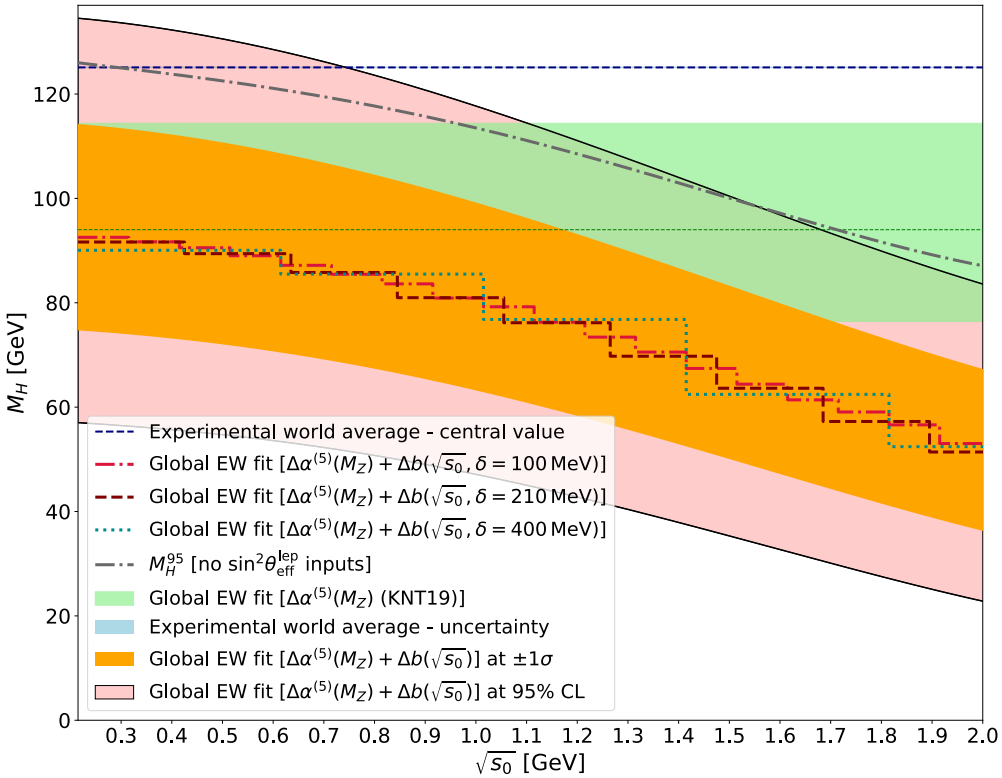
- EW fit: change of the Higgs mass upper bound when σ(s) is shifted up to fix Δa_μ:



Marciano, MP, Sirlin
PRD 2008

Muon g-2 ⇔ Δα connection (2020)

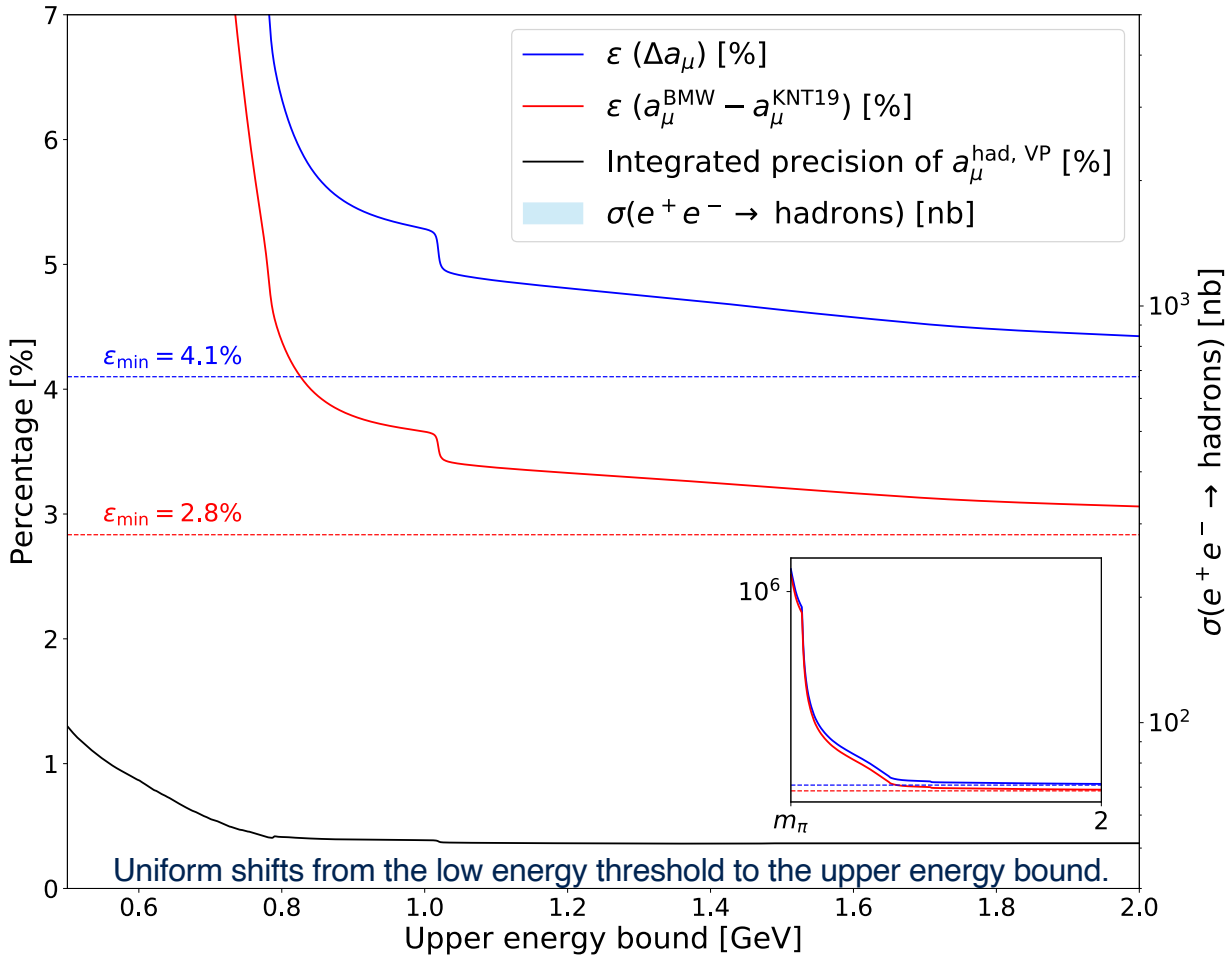
Major update: Higgs discovered, improved EW observables (M_W, $\sin^2\theta$, M_{top}, …), updates to σ(s), theory improvements, global fit, …



Shifts Δσ(s) to fix Δa_μ are possible,
but conflict with the EW fit if they occur above ~ 1 GeV

Keshavarzi, Marciano, MP, Sirlin PRD 2020

How large are the required shifts Δσ(s) ?



Shifts below ~ 1 GeV conflict with the quoted experimental precision of σ(s)

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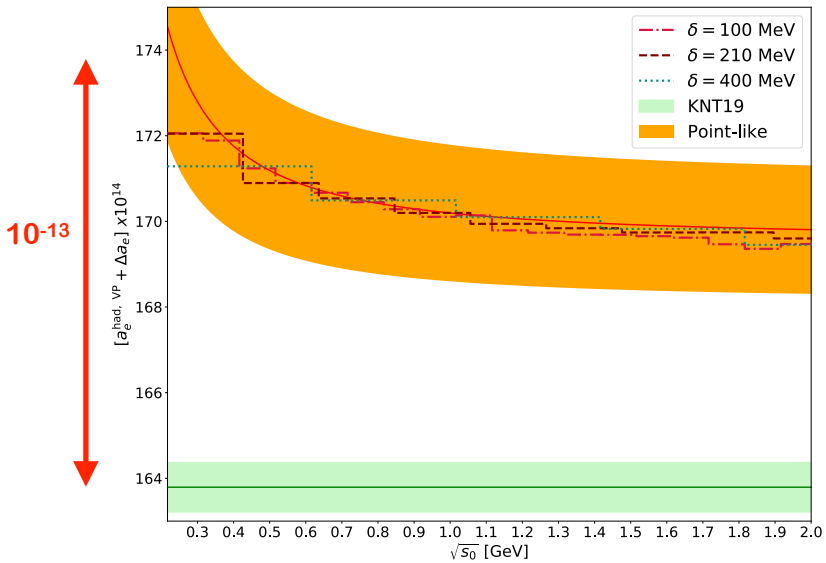
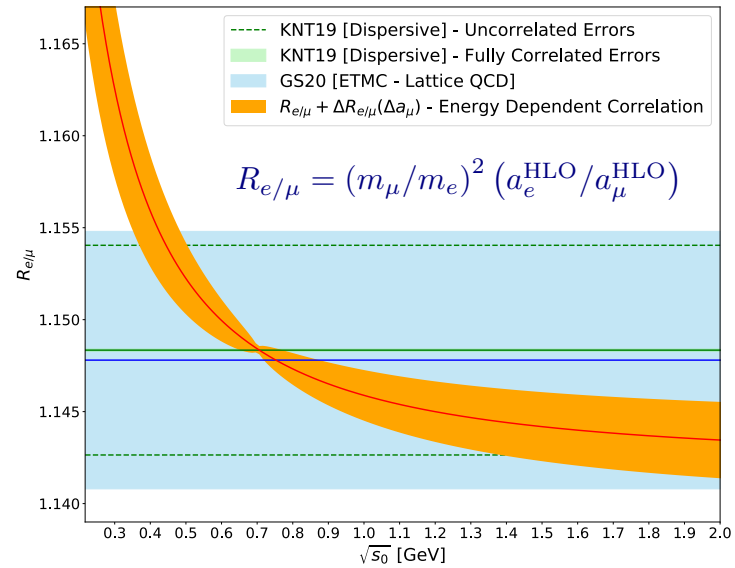
Electron g-2 & e/μ scaled HLO ratio





Shifts $\Delta\sigma(s)$ to fix Δa_μ slightly increase the $|\Delta a_e| \sim 10^{-12}$ 2.5σ tension

$R_{e/\mu}$: good agreement between lattice & KNT19. Future bounds on very low energy shifts?

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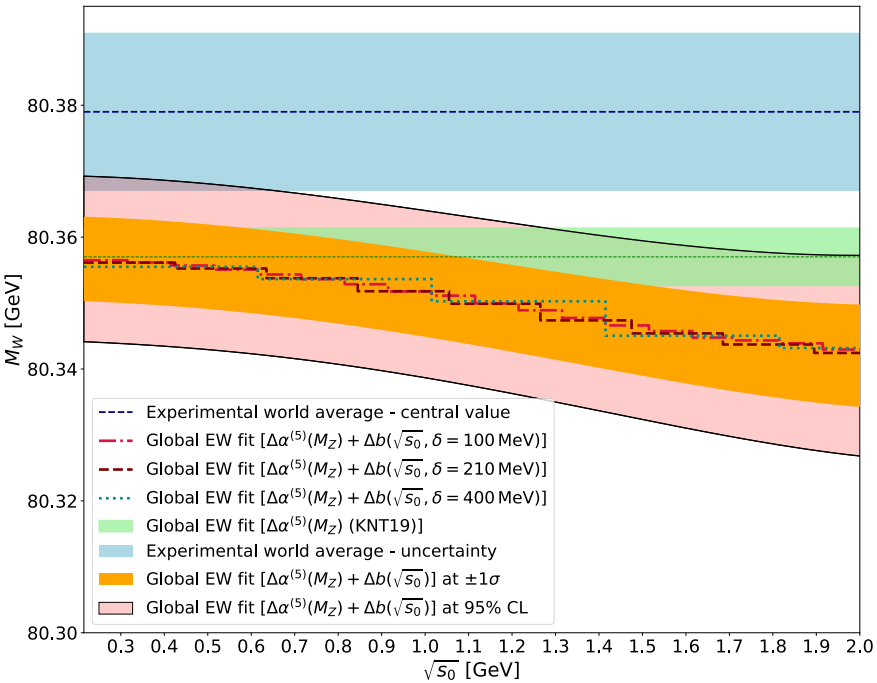
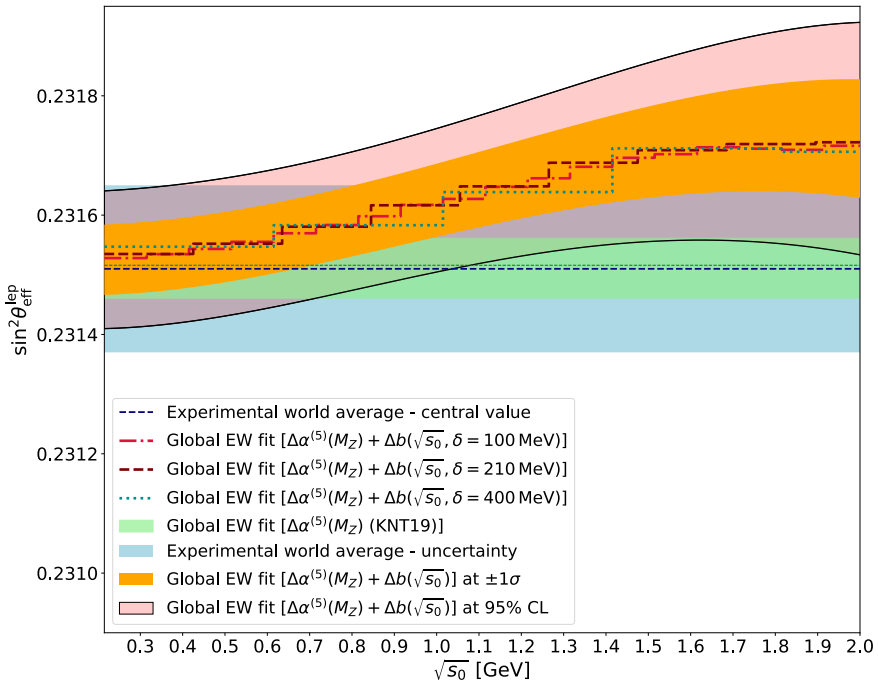
MUonE at CERN will provide a new independent spacelike determination of a_μ^{HLO} alternative to the dispersive and lattice ones (test run approved for 2021).

https://cds.cern.ch/record/2677471/files/SPSC-I-252.pdf

Backup

Muon g-2: connection with M_W and $\sin^2\theta$





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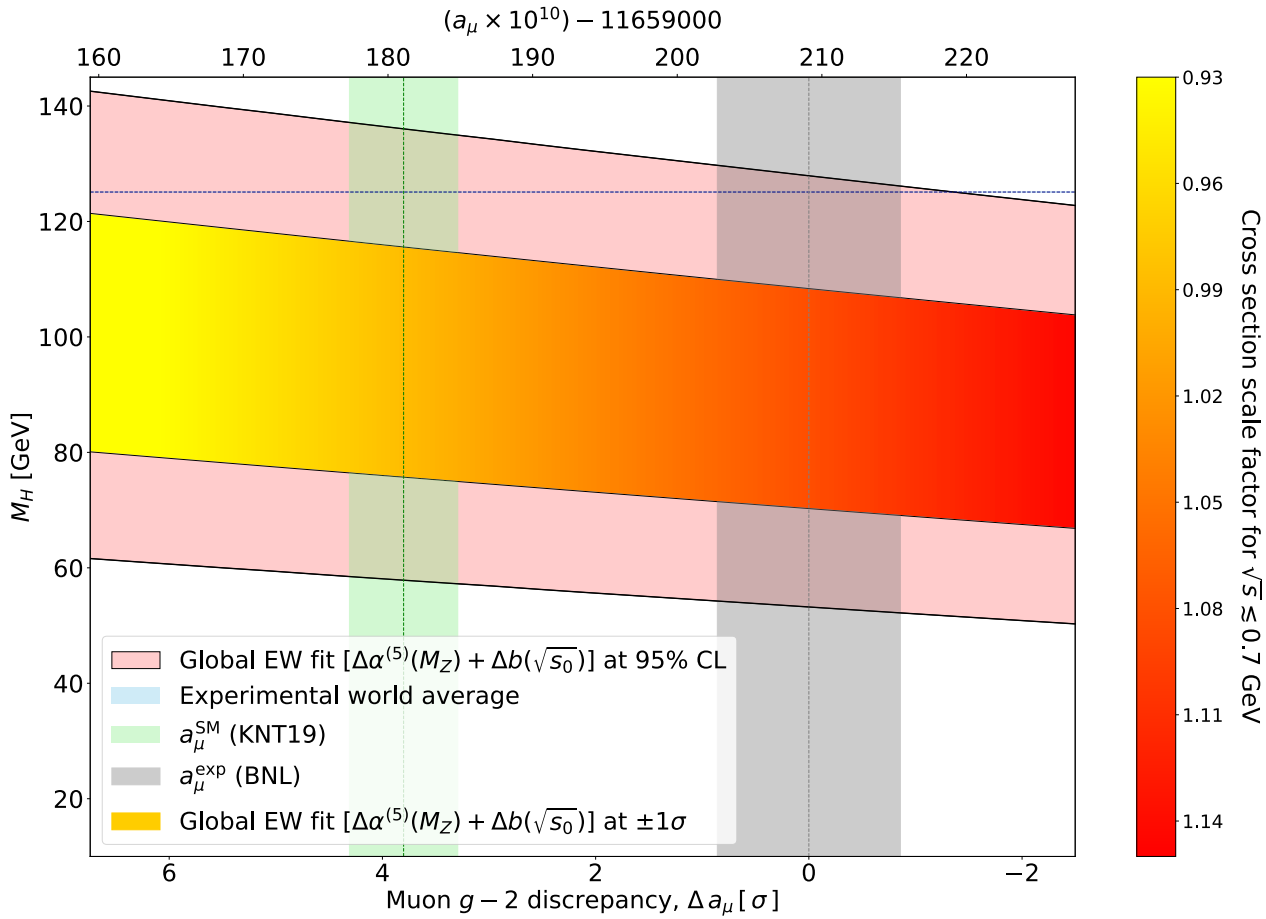
Muon g-2: connection with the SM Higgs mass



Uniform scaling of σ(s) below ~0.7 GeV to fix Δa_μ: +9% required

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Parameter	Input value	Reference	Fit result	Result w/o input value
M_W (GeV)	80.379(12)	[5]	80.359(3)	80.357(4)(5)
M_H (GeV)	125.10(14)	[5]	125.10(14)	94^{+20+6}_{-18-6}
$\Delta\alpha^{(5)}_{\rm had}(M_Z^2) \times 10^4$	276.1(1.1)	[23]	275.8(1.1)	272.2(3.9)(1.2)
m_t (GeV)	172.9(4)	[5]	173.0(4)	...
$\alpha_s(M_Z^2)$	0.1179(10)	[5]	0.1180(7)	...
M_Z (GeV)	91.1876(21)	[5]	91.1883(20)	...
Γ_Z (GeV)	2.4952(23)	[5]	2.4940(4)	...
Γ_W (GeV)	2.085(42)	[5]	2.0903(4)	...
$\sigma^0_{\rm had}$ (nb)	41.541(37)	[108]	41.490(4)	...
R^0_l	20.767(25)	[108]	20.732(4)	...
R^0_c	0.1721(30)	[108]	0.17222(8)	...
R^0_b	0.21629(66)	[108]	0.21581(8)	...
$\bar{m}_c$ (GeV)	1.27(2)	[5]	1.27(2)	...
$\bar{m}_b$ (GeV)	$4.18^{+0.03}_{-0.02}$	[5]	$4.18^{+0.03}_{-0.02}$	...
$A^{0,l}_{\rm FB}$	0.0171(10)	[108]	0.01622(7)	...
$A^{0,c}_{\rm FB}$	0.0707(35)	[108]	0.0737(2)	...
$A^{0,b}_{\rm FB}$	0.0992(16)	[108]	0.1031(2)	...
A_ℓ	0.1499(18)	[75,108]	0.1471(3)	...
A_c	0.670(27)	[108]	0.6679(2)	...
A_b	0.923(20)	[108]	0.93462(7)	...
$\sin^2\theta^{\rm lep}_{\rm eff}(Q_{\rm FB})$	0.2324(12)	[108]	0.23152(4)	0.23152(4)(4)
$\sin^2\theta^{\rm lep}_{\rm eff}$(Had Coll)	0.23140(23)	[100]	0.23152(4)	0.23152(4)(4)

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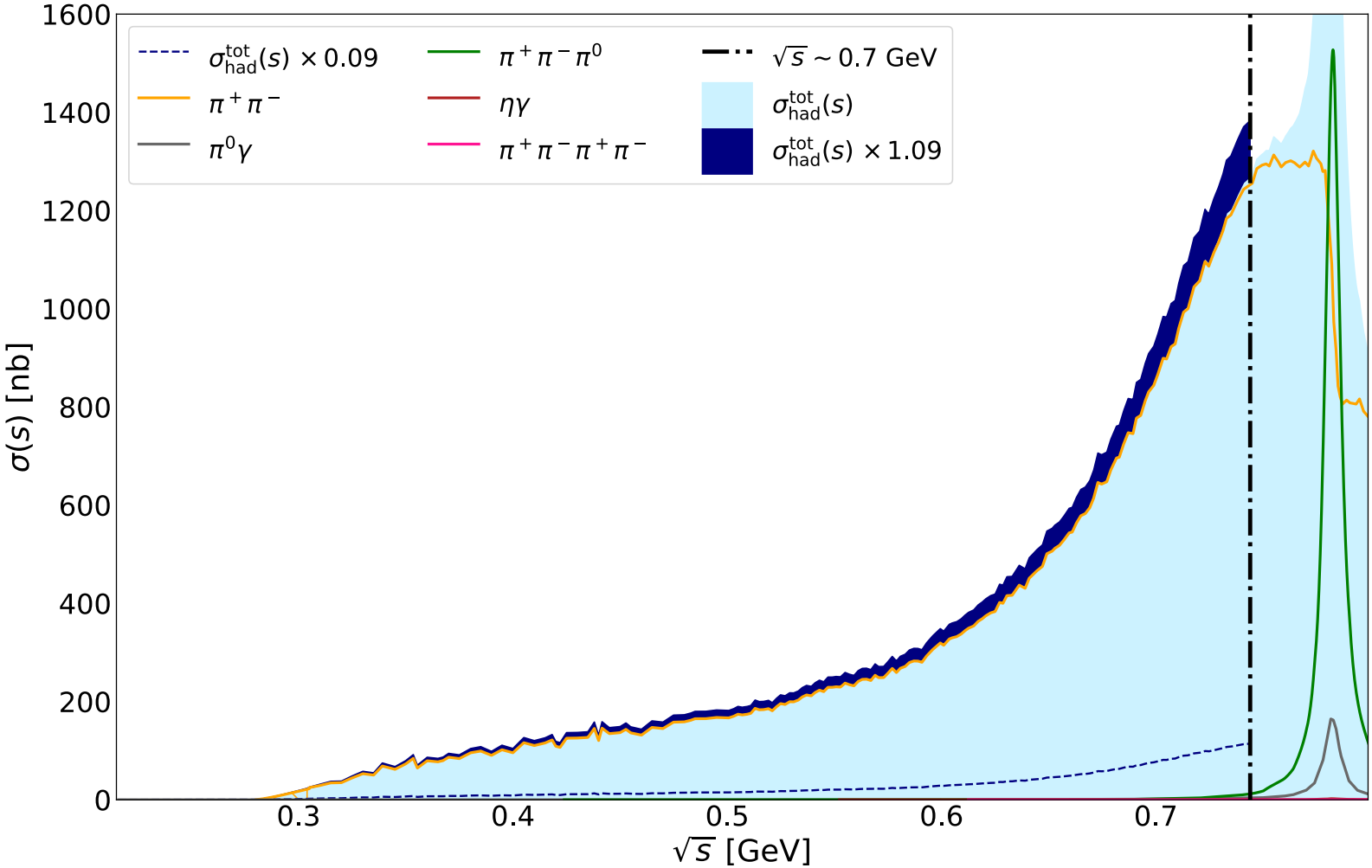

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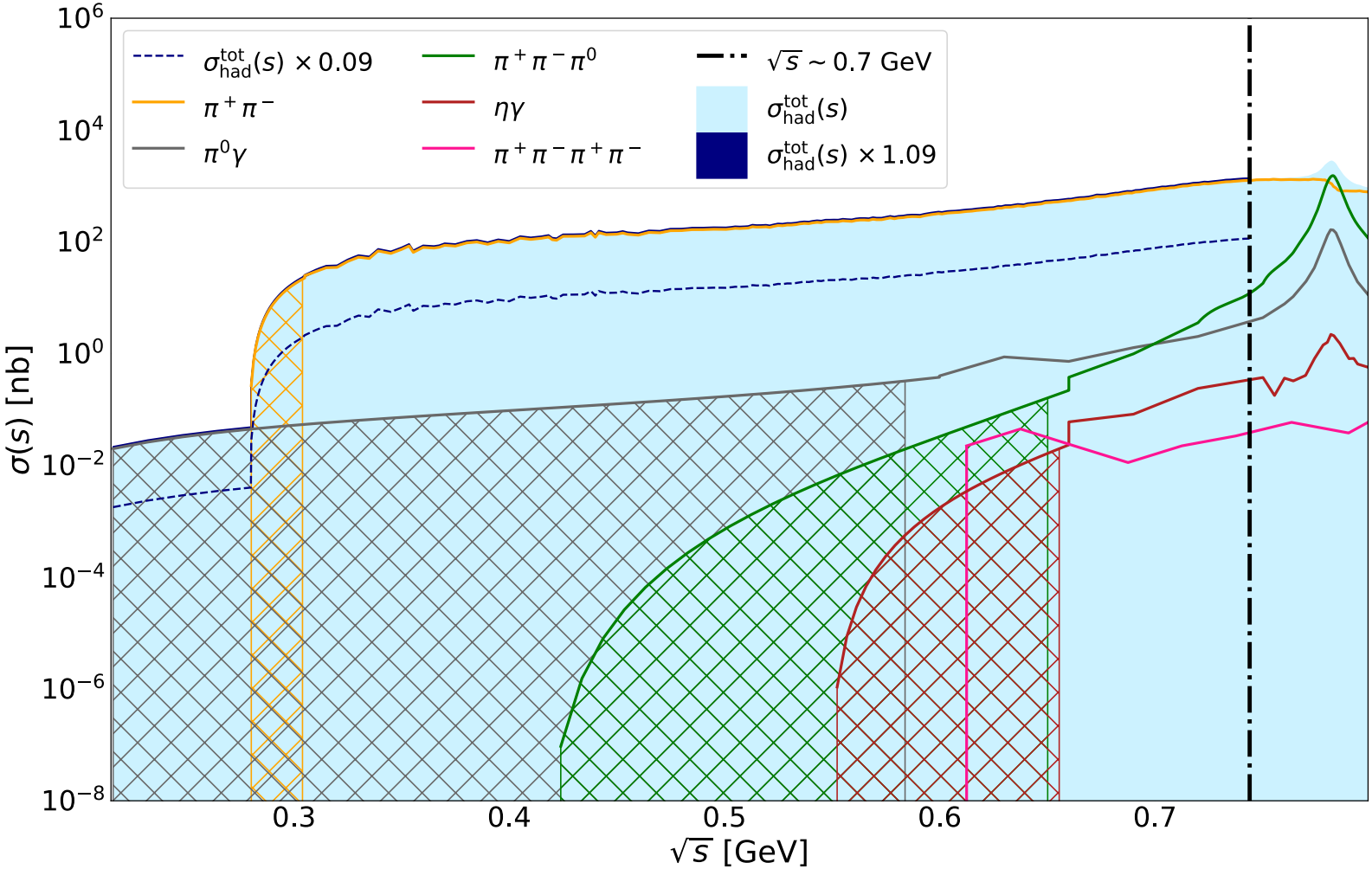

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