LFC15: physics prospects for Linear and other Future Colliders after the discovery of the Higgs

7-11 September 2015

ECT*, Villa Tambosi, Villazzano (TN), Italy

SUSY and the Higgs

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The Abdus Salam
International Centre
for Theoretical Physics

based on: Javier Pardo Vega and GV
JHEP 1507 (2015) 159 - arXiv:1504.05200

SusyHD

The Quest for SUSY

(beyond the hierarchy problems)

Poincaré → SUSY

$\mathcal{P}$ $\mathcal{S}$

$$\begin{cases} [\mathcal{P},\mathcal{P}] = \mathcal{P} \\ [\mathcal{P},\mathcal{S}] = \mathcal{S} \\ \{\mathcal{S},\mathcal{S}\} = \mathcal{P} \end{cases}$$

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Remarkable features in QFT:

CFT , Dualities , Finiteness , L.P. , etc...

Poincaré → SUSY

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Remarkable features in QFT:

CFT , Dualities , Finiteness , L.P. , etc...

...and in QG:

Supergravity , String Theory

$$\mathcal{P}|0\rangle = 0 \qquad \mathcal{S}|0\rangle \neq 0$$

SUSY breaking scale?

$$\mathcal{P}|0\rangle = 0 \qquad \mathcal{S}|0\rangle \neq 0$$

SUSY breaking scale?

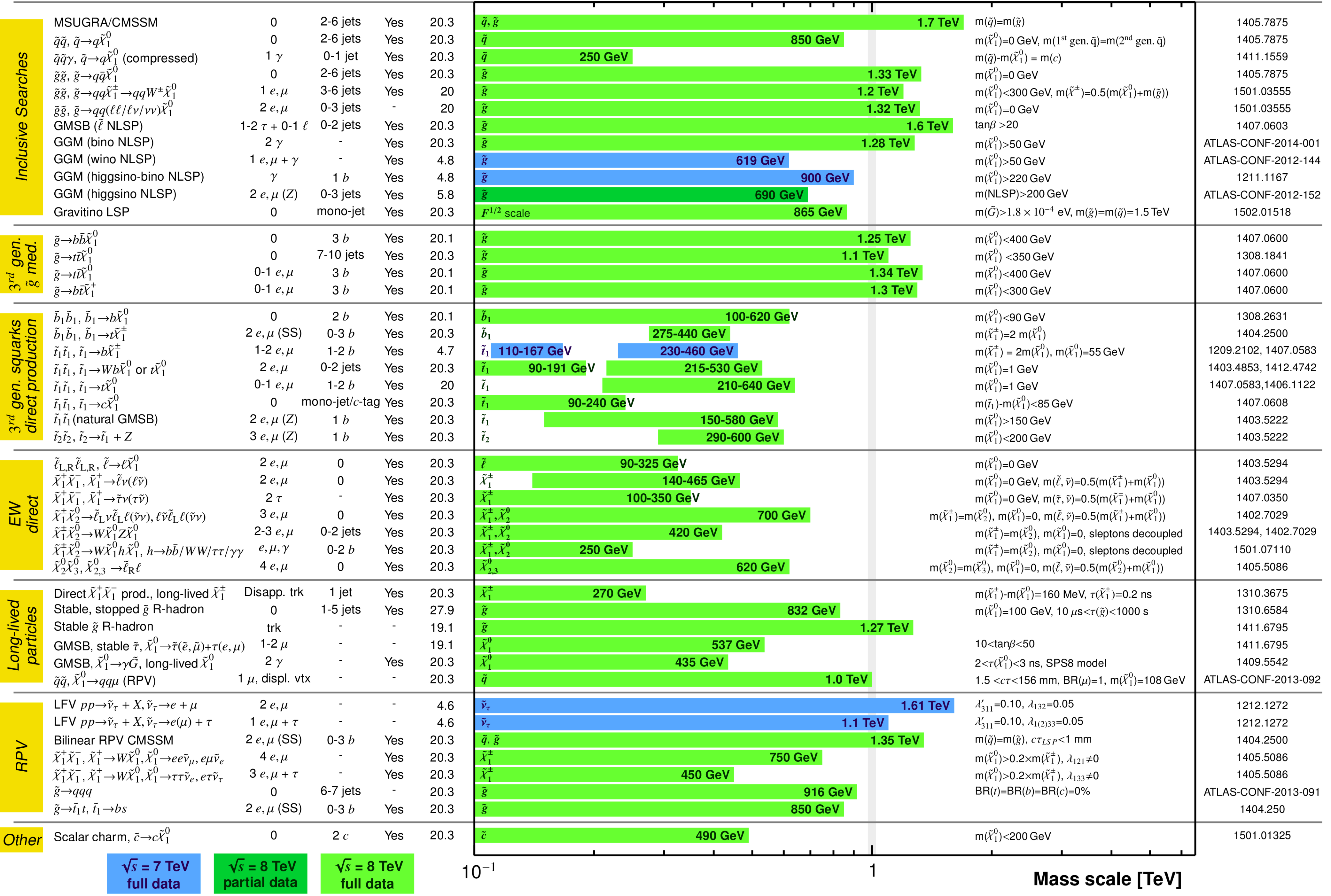
$$\delta m_h^2 \sim m_{\mathrm{SUSY}}^2$$

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: Feb 2015

ATLAS Preliminary

$\sqrt{s}$ = 7, 8 TeV



	Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L}\, dt[\mathrm{fb}^{-1}]$	Mass limit		Reference
Inclusive Searches	MSUGRA/CMSSM	0	2-6 jets	Yes	20.3	$\tilde{q}, \tilde{g}$ 1.7 TeV	m($\tilde{q}$)=m($\tilde{g}$)	1405.7875
	$\tilde{q}\tilde{q}$, $\tilde{q}\to q\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{q}$ 850 GeV	m($\tilde{\chi}_1^0$)=0 GeV, m(1st gen. $\tilde{q}$)=m(2nd gen. $\tilde{q}$)	1405.7875
	$\tilde{q}\tilde{q}\gamma$, $\tilde{q}\to q\tilde{\chi}_1^0$ (compressed)	1 γ	0-1 jet	Yes	20.3	$\tilde{q}$ 250 GeV	m($\tilde{q}$)-m($\tilde{\chi}_1^0$) = m(c)	1411.1559
	$\tilde{g}\tilde{g}$, $\tilde{g}\to q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{g}$ 1.33 TeV	m($\tilde{\chi}_1^0$)=0 GeV	1405.7875
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq\tilde{\chi}_1^\pm\to qqW^\pm\tilde{\chi}_1^0$	1 e, μ	3-6 jets	Yes	20	$\tilde{g}$ 1.2 TeV	m($\tilde{\chi}_1^0$)<300 GeV, m($\tilde{\chi}^\pm$)=0.5(m($\tilde{\chi}_1^0$)+m($\tilde{g}$))	1501.03555
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e, μ	0-3 jets	-	20	$\tilde{g}$ 1.32 TeV	m($\tilde{\chi}_1^0$)=0 GeV	1501.03555
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ + 0-1 ℓ	0-2 jets	Yes	20.3	$\tilde{g}$ 1.6 TeV	tanβ >20	1407.0603
	GGM (bino NLSP)	2 γ	-	Yes	20.3	$\tilde{g}$ 1.28 TeV	m($\tilde{\chi}_1^0$)>50 GeV	ATLAS-CONF-2014-001
	GGM (wino NLSP)	1 $e, \mu + \gamma$	-	Yes	4.8	$\tilde{g}$ 619 GeV	m($\tilde{\chi}_1^0$)>50 GeV	ATLAS-CONF-2012-144
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	4.8	$\tilde{g}$ 900 GeV	m($\tilde{\chi}_1^0$)>220 GeV	1211.1167
	GGM (higgsino NLSP)	2 e, μ (Z)	0-3 jets	Yes	5.8	$\tilde{g}$ 690 GeV	m(NLSP)>200 GeV	ATLAS-CONF-2012-152
	Gravitino LSP	0	mono-jet	Yes	20.3	$F^{1/2}$ scale 865 GeV	m($\tilde{G}$)>1.8×10^{-4} eV, m($\tilde{g}$)=m($\tilde{q}$)=1.5 TeV	1502.01518
3^{rd} gen. $\tilde{g}$ med.	$\tilde{g}\to b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	20.1	$\tilde{g}$ 1.25 TeV	m($\tilde{\chi}_1^0$)<400 GeV	1407.0600
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	$\tilde{g}$ 1.1 TeV	m($\tilde{\chi}_1^0$) <350 GeV	1308.1841
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0-1 e, μ	3 b	Yes	20.1	$\tilde{g}$ 1.34 TeV	m($\tilde{\chi}_1^0$)<400 GeV	1407.0600
	$\tilde{g}\to b\bar{t}\tilde{\chi}_1^+$	0-1 e, μ	3 b	Yes	20.1	$\tilde{g}$ 1.3 TeV	m($\tilde{\chi}_1^0$)<300 GeV	1407.0600
3^{rd} gen. squarks direct production	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\to b\tilde{\chi}_1^0$	0	2 b	Yes	20.1	$\tilde{b}_1$ 100-620 GeV	m($\tilde{\chi}_1^0$)<90 GeV	1308.2631
	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\to t\tilde{\chi}_1^\pm$	2 e, μ (SS)	0-3 b	Yes	20.3	$\tilde{b}_1$ 275-440 GeV	m($\tilde{\chi}_1^\pm$)=2 m($\tilde{\chi}_1^0$)	1404.2500
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	1-2 e, μ	1-2 b	Yes	4.7	$\tilde{t}_1$ 110-167 GeV 230-460 GeV	m($\tilde{\chi}_1^\pm$) = 2m($\tilde{\chi}_1^0$), m($\tilde{\chi}_1^0$)=55 GeV	1209.2102, 1407.0583
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to Wb\tilde{\chi}_1^0$ or $t\tilde{\chi}_1^0$	2 e, μ	0-2 jets	Yes	20.3	$\tilde{t}_1$ 90-191 GeV 215-530 GeV	m($\tilde{\chi}_1^0$)=1 GeV	1403.4853, 1412.4742
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to t\tilde{\chi}_1^0$	0-1 e, μ	1-2 b	Yes	20	$\tilde{t}_1$ 210-640 GeV	m($\tilde{\chi}_1^0$)=1 GeV	1407.0583,1406.1122
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to c\tilde{\chi}_1^0$	0	mono-jet/c-tag	Yes	20.3	$\tilde{t}_1$ 90-240 GeV	m($\tilde{t}_1$)-m($\tilde{\chi}_1^0$)<85 GeV	1407.0608
	$\tilde{t}_1\tilde{t}_1$ (natural GMSB)	2 e, μ (Z)	1 b	Yes	20.3	$\tilde{t}_1$ 150-580 GeV	m($\tilde{\chi}_1^0$)>150 GeV	1403.5222
	$\tilde{t}_2\tilde{t}_2$, $\tilde{t}_2\to\tilde{t}_1 + Z$	3 e, μ (Z)	1 b	Yes	20.3	$\tilde{t}_2$ 290-600 GeV	m($\tilde{\chi}_1^0$)<200 GeV	1403.5222
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}$, $\tilde{\ell}\to\ell\tilde{\chi}_1^0$	2 e, μ	0	Yes	20.3	$\tilde{\ell}$ 90-325 GeV	m($\tilde{\chi}_1^0$)=0 GeV	1403.5294
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e, μ	0	Yes	20.3	$\tilde{\chi}_1^\pm$ 140-465 GeV	m($\tilde{\chi}_1^0$)=0 GeV, m($\tilde{\ell}, \tilde{\nu}$)=0.5(m($\tilde{\chi}_1^\pm$)+m($\tilde{\chi}_1^0$))	1403.5294
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	-	Yes	20.3	$\tilde{\chi}_1^\pm$ 100-350 GeV	m($\tilde{\chi}_1^0$)=0 GeV, m($\tilde{\tau}, \tilde{\nu}$)=0.5(m($\tilde{\chi}_1^\pm$)+m($\tilde{\chi}_1^0$))	1407.0350
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu)$, $\ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e, μ	0	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ 700 GeV	m($\tilde{\chi}_1^\pm$)=m($\tilde{\chi}_2^0$), m($\tilde{\chi}_1^0$)=0, m($\tilde{\ell}, \tilde{\nu}$)=0.5(m($\tilde{\chi}_1^\pm$)+m($\tilde{\chi}_1^0$))	1402.7029
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 Z\tilde{\chi}_1^0$	2-3 e, μ	0-2 jets	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ 420 GeV	m($\tilde{\chi}_1^\pm$)=m($\tilde{\chi}_2^0$), m($\tilde{\chi}_1^0$)=0, sleptons decoupled	1403.5294, 1402.7029
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 h\tilde{\chi}_1^0$, $h\to b\bar{b}/WW/\tau\tau/\gamma\gamma$	e, μ, γ	0-2 b	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ 250 GeV	m($\tilde{\chi}_1^\pm$)=m($\tilde{\chi}_2^0$), m($\tilde{\chi}_1^0$)=0, sleptons decoupled	1501.07110
	$\tilde{\chi}_2^0\tilde{\chi}_3^0$, $\tilde{\chi}_{2,3}^0\to\tilde{\ell}_R\ell$	4 e, μ	0	Yes	20.3	$\tilde{\chi}_{2,3}^0$ 620 GeV	m($\tilde{\chi}_2^0$)=m($\tilde{\chi}_3^0$), m($\tilde{\chi}_1^0$)=0, m($\tilde{\ell}, \tilde{\nu}$)=0.5(m($\tilde{\chi}_2^0$)+m($\tilde{\chi}_1^0$))	1405.5086
Long-lived particles	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}_1^\pm$ 270 GeV	m($\tilde{\chi}_1^\pm$)-m($\tilde{\chi}_1^0$)=160 MeV, τ($\tilde{\chi}_1^\pm$)=0.2 ns	1310.3675
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	27.9	$\tilde{g}$ 832 GeV	m($\tilde{\chi}_1^0$)=100 GeV, 10 μs<τ($\tilde{g}$)<1000 s	1310.6584
	Stable $\tilde{g}$ R-hadron	trk	-	-	19.1	$\tilde{g}$ 1.27 TeV		1411.6795
	GMSB, stable $\tilde{\tau}$, $\tilde{\chi}_1^0\to\tilde{\tau}(\tilde{e}, \tilde{\mu})+\tau(e, \mu)$	1-2 μ	-	-	19.1	$\tilde{\chi}_1^0$ 537 GeV	10<tanβ<50	1411.6795
	GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	-	Yes	20.3	$\tilde{\chi}_1^0$ 435 GeV	2<τ($\tilde{\chi}_1^0$)<3 ns, SPS8 model	1409.5542
	$\tilde{q}\tilde{q}$, $\tilde{\chi}_1^0\to qq\mu$ (RPV)	1 μ, displ. vtx	-	-	20.3	$\tilde{q}$ 1.0 TeV	1.5 <$c\tau$<156 mm, BR(μ)=1, m($\tilde{\chi}_1^0$)=108 GeV	ATLAS-CONF-2013-092
RPV	LFV $pp\to\tilde{\nu}_\tau + X, \tilde{\nu}_\tau\to e + \mu$	2 e, μ	-	-	4.6	$\tilde{\nu}_\tau$ 1.61 TeV	λ'_{311}=0.10, λ_{132}=0.05	1212.1272
	LFV $pp\to\tilde{\nu}_\tau + X, \tilde{\nu}_\tau\to e(\mu) + \tau$	1 $e, \mu + \tau$	-	-	4.6	$\tilde{\nu}_\tau$ 1.1 TeV	λ'_{311}=0.10, $\lambda_{1(2)33}$=0.05	1212.1272
	Bilinear RPV CMSSM	2 e, μ (SS)	0-3 b	Yes	20.3	$\tilde{q}, \tilde{g}$ 1.35 TeV	m($\tilde{q}$)=m($\tilde{g}$), $c\tau_{LSP}$<1 mm	1404.2500
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e, μ	-	Yes	20.3	$\tilde{\chi}_1^\pm$ 750 GeV	m($\tilde{\chi}_1^0$)>0.2×m($\tilde{\chi}_1^\pm$), $\lambda_{121}\neq0$	1405.5086
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to\tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$	3 $e, \mu + \tau$	-	Yes	20.3	$\tilde{\chi}_1^\pm$ 450 GeV	m($\tilde{\chi}_1^0$)>0.2×m($\tilde{\chi}_1^\pm$), $\lambda_{133}\neq0$	1405.5086
	$\tilde{g}\to qqq$	0	6-7 jets	-	20.3	$\tilde{g}$ 916 GeV	BR(t)=BR(b)=BR(c)=0%	ATLAS-CONF-2013-091
	$\tilde{g}\to\tilde{t}_1 t$, $\tilde{t}_1\to bs$	2 e, μ (SS)	0-3 b	Yes	20.3	$\tilde{g}$ 850 GeV		1404.250
Other	Scalar charm, $\tilde{c}\to c\tilde{\chi}_1^0$	0	2 c	Yes	20.3	$\tilde{c}$ 490 GeV	m($\tilde{\chi}_1^0$)<200 GeV	1501.01325

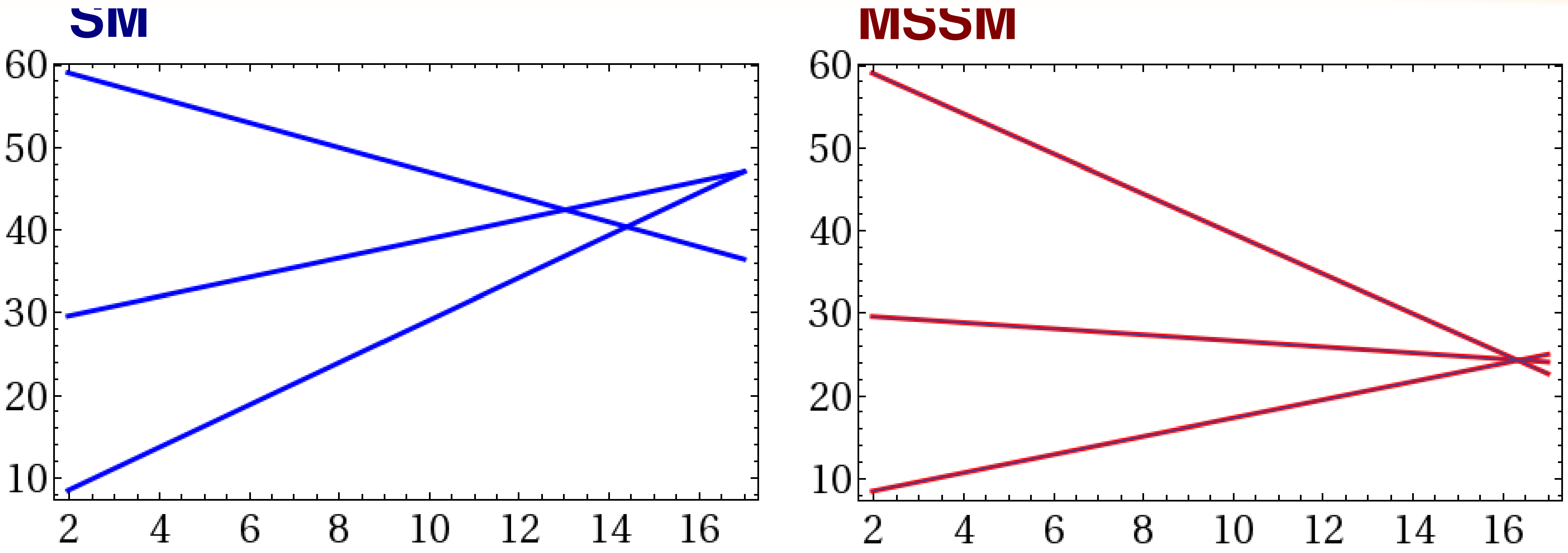
$\sqrt{s}$ = 7 TeV full data

$\sqrt{s}$ = 8 TeV partial data

$\sqrt{s}$ = 8 TeV full data

Weaker argument:

Gauge Coupling Unification

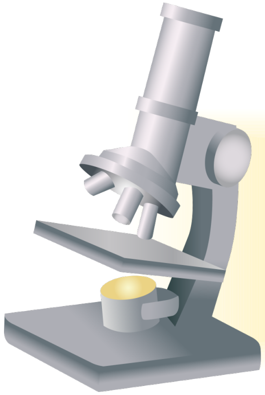


SM

MSSM

$$\boxed{m_{\rm SUSY} \lesssim \text{few} \cdot 10\ \text{TeV}}$$

SUSY breaking scale?



Back to Experiments

Use Precision Data

In SUSY the Higgs mass is calculable:

ATLAS + CMS $m_h^{\text{exp}} = 125.09 \pm 0.24\ \text{GeV}$

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$$m_h^2 \simeq m_Z^2 \cos^2 2\beta + \frac{3}{\pi^2} \frac{m_t^4 \sin^4 \beta}{v^2} \left[\log \frac{m_{\tilde{t}}^2}{m_t^2} + \tilde{X}_t^2 \left(1 - \frac{\tilde{X}_t^2}{12} \right) \right] + \ldots$$

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only *log*-dependence on new physics scale

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only *log*-dependence on new physics scale

⇒ high precision to get reliable constraints

In SUSY the Higgs mass is calculable:

ATLAS + CMS $m_h^{\rm exp} = 125.09 \pm 0.24\ \mathrm{GeV}$

$$\underset{125^2\,\approx}{m_h^2 \simeq} \underbrace{m_Z^2 \cos^2 2\beta}_{90^2} + \underbrace{\frac{3}{\pi^2}\frac{m_t^4 \sin^4\beta}{v^2}\left[\log\frac{m_{\tilde{t}}^2}{m_t^2} + \tilde{X}_t^2\left(1-\frac{\tilde{X}_t^2}{12}\right)\right] + \ldots}_{90^2}$$

$$\Rightarrow\ \ \delta m_h \sim \delta m_t$$

Exploiting the Hierarchy Problem:

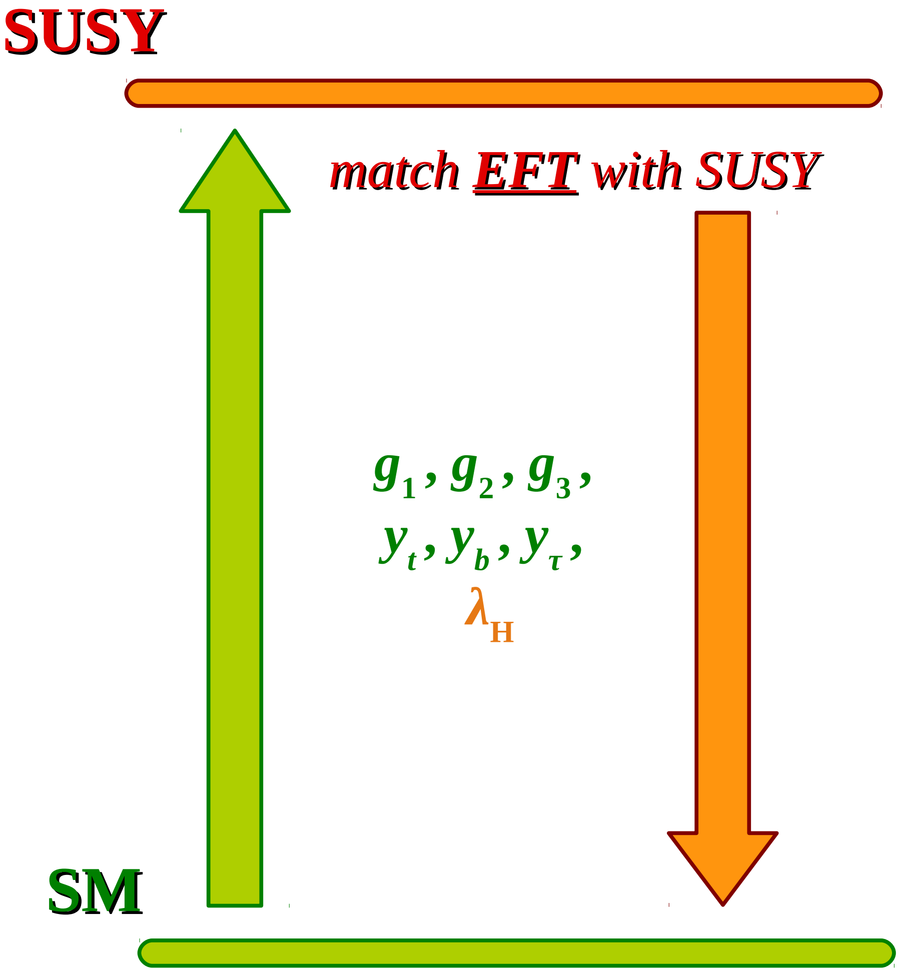
the EFT technique

SUSY

SM

Exploiting the Hierarchy Problem:

the EFT technique



SUSY

*match **EFT** with SUSY*

$g_1, g_2, g_3,$

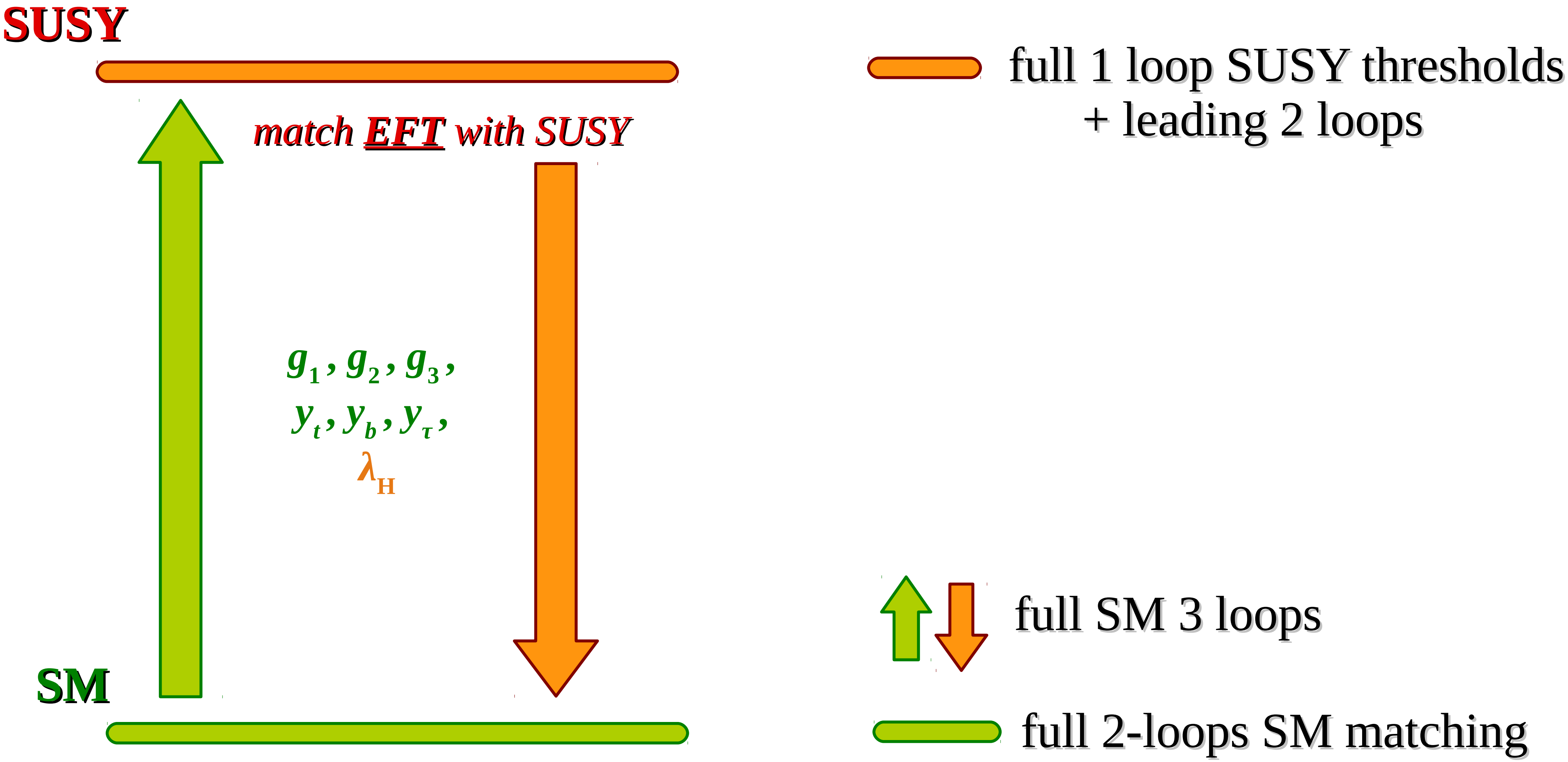
$y_t, y_b, y_\tau,$

λ_H

SM

Exploiting the Hierarchy Problem:

the EFT technique



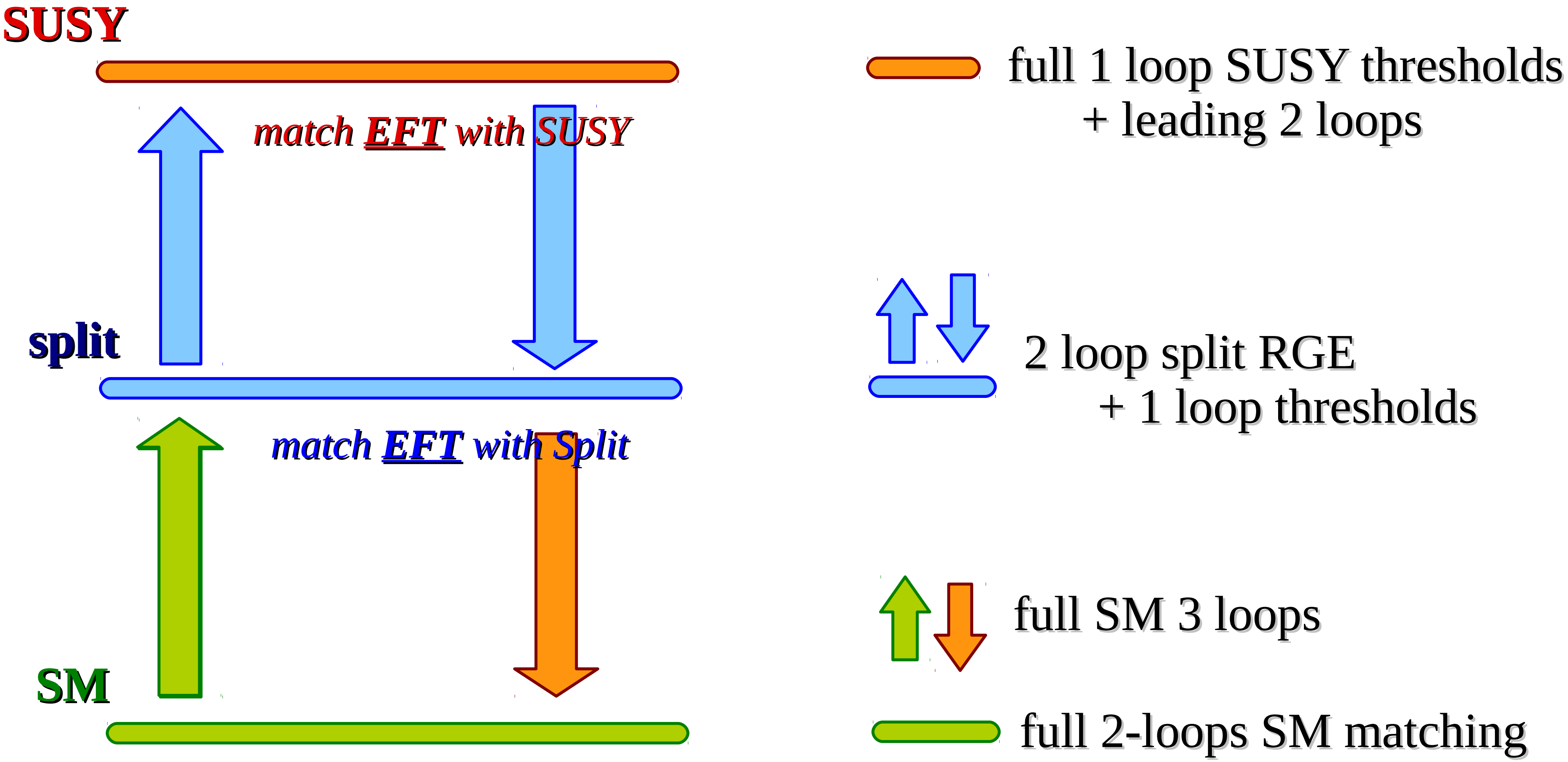
🟧 full 1 loop SUSY thresholds
+ leading 2 loops

⬆⬇ full SM 3 loops

🟩 full 2-loops SM matching

Exploiting the Hierarchy Problem:

the EFT technique



full 1 loop SUSY thresholds
+ leading 2 loops

2 loop split RGE
+ 1 loop thresholds

full SM 3 loops

full 2-loops SM matching

Small improvement w.r.t. to a longstanding effort

Pokorski, Rosiek, Dabelstein, Zhang, Espinosa, Quiros, Hempfling, Hoang, Heinemeyer, Hollik, Weiglein, Brignole, Slavich, Zwirner, Degrassi, Martin, Giudice, Strumia, Wagner … many many others

apologies to the missing ones

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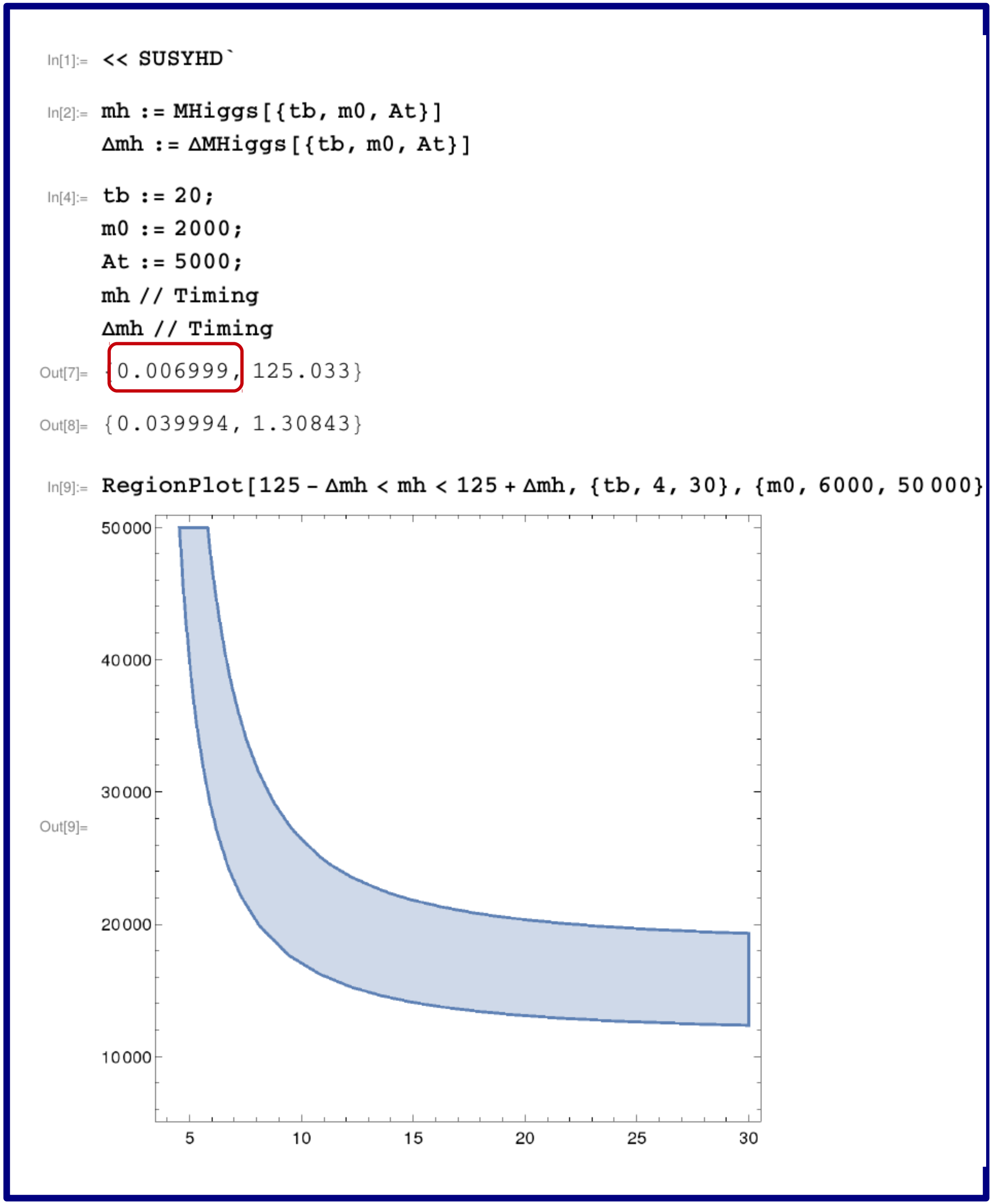
apologies to the missing ones

Our contribution: (mostly w.r.t. Bagnaschi *et al.* '14)

- Recomputation of $O(\alpha_s \alpha_t)$ corrections
- Computation of $O(\alpha_t^2)$ with scale dependence
- Inclusion bottom/tau corrections (w/ resummation of tan*β* enhanced corr.)
- Computation both in DRbar and OS schemes
- Study of the uncertainties and comparison with existing computations
- A “fast” Mathematica® package: SusyHD

SusyHD

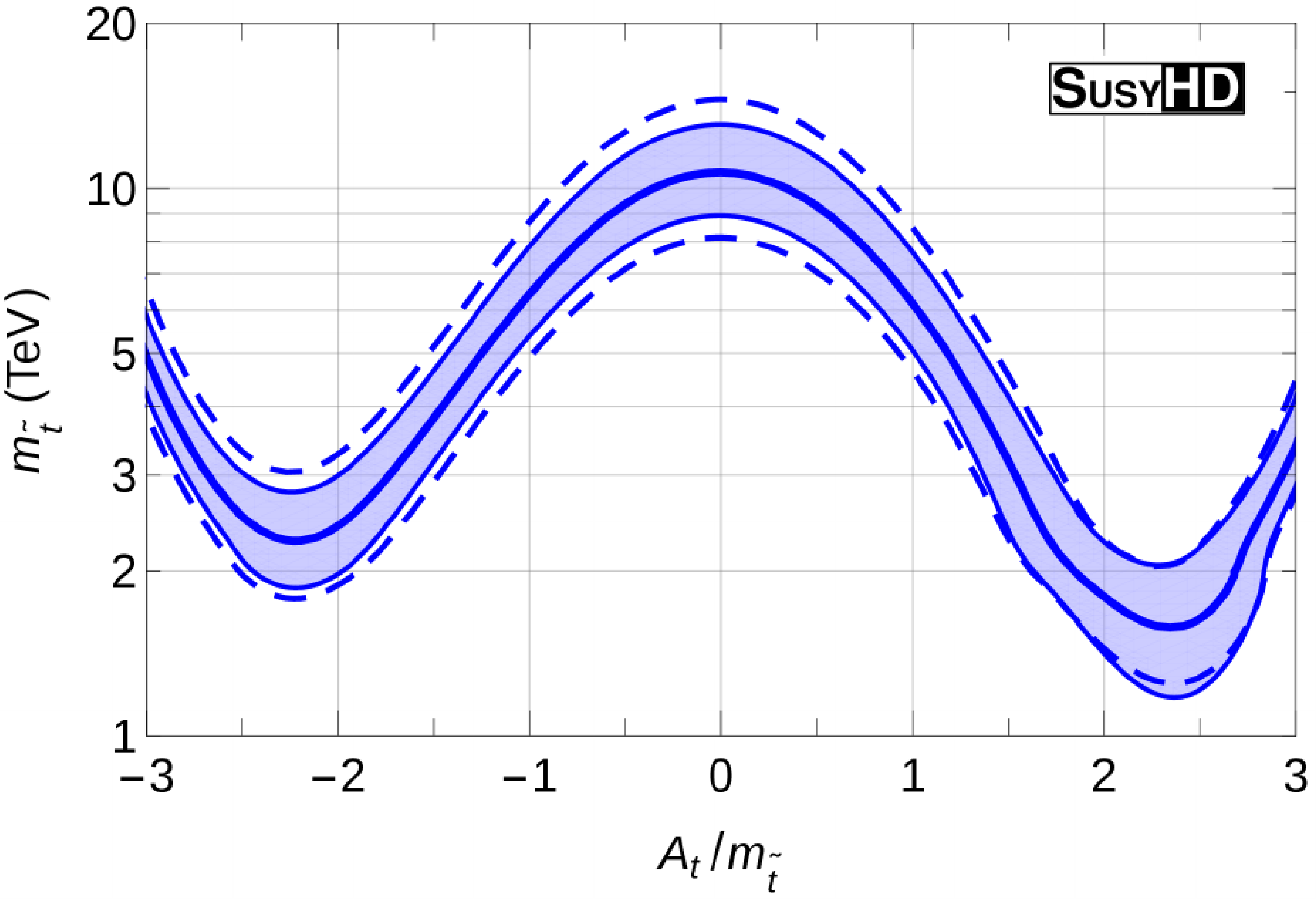
www.ictp.it/~susyhd



```
In[1]:= << SUSYHD`

In[2]:= mh := MHiggs[{tb, m0, At}]
        Δmh := ΔMHiggs[{tb, m0, At}]

In[4]:= tb := 20;
        m0 := 2000;
        At := 5000;
        mh // Timing
        Δmh // Timing

Out[7]= {0.006999, 125.033}

Out[8]= {0.039994, 1.30843}

In[9]:= RegionPlot[125 - Δmh < mh < 125 + Δmh, {tb, 4, 30}, {m0, 6000, 50 000}

Out[9]=
```

A “natural” SUSY-like spectrum:

$\tan\beta = 20$, $\mu = 300$ GeV , $m_{\mathrm{SUSY}} = 2$ TeV

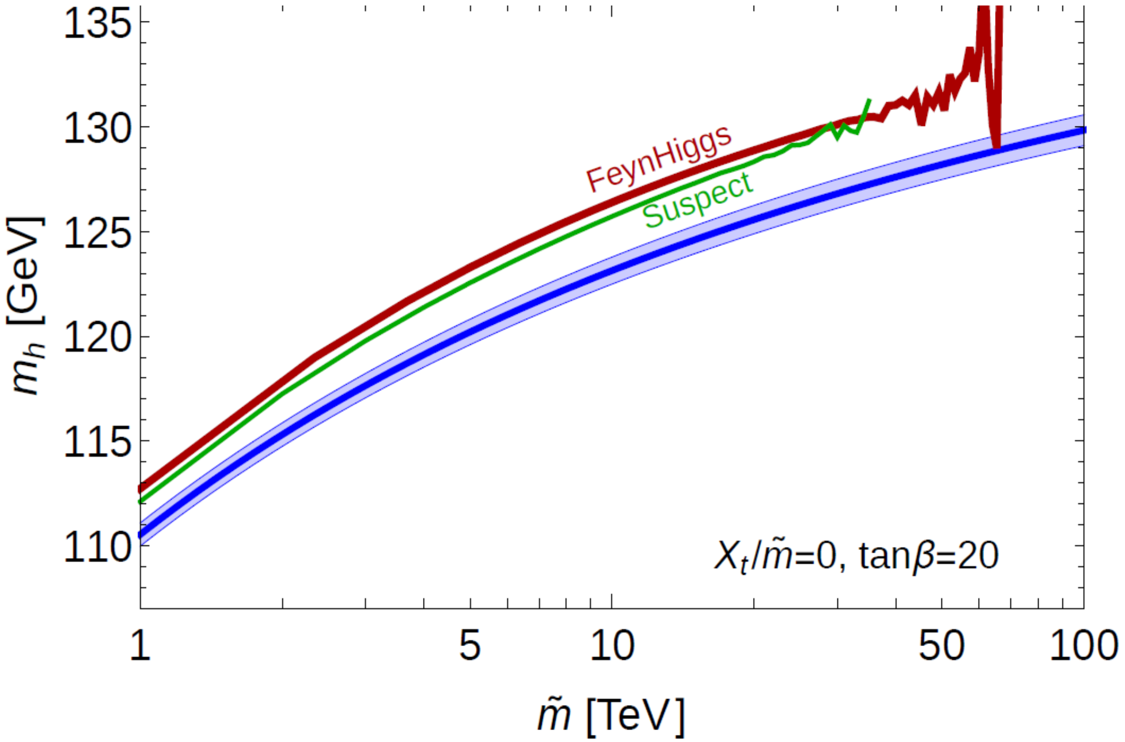


╌ Δ_{exp}

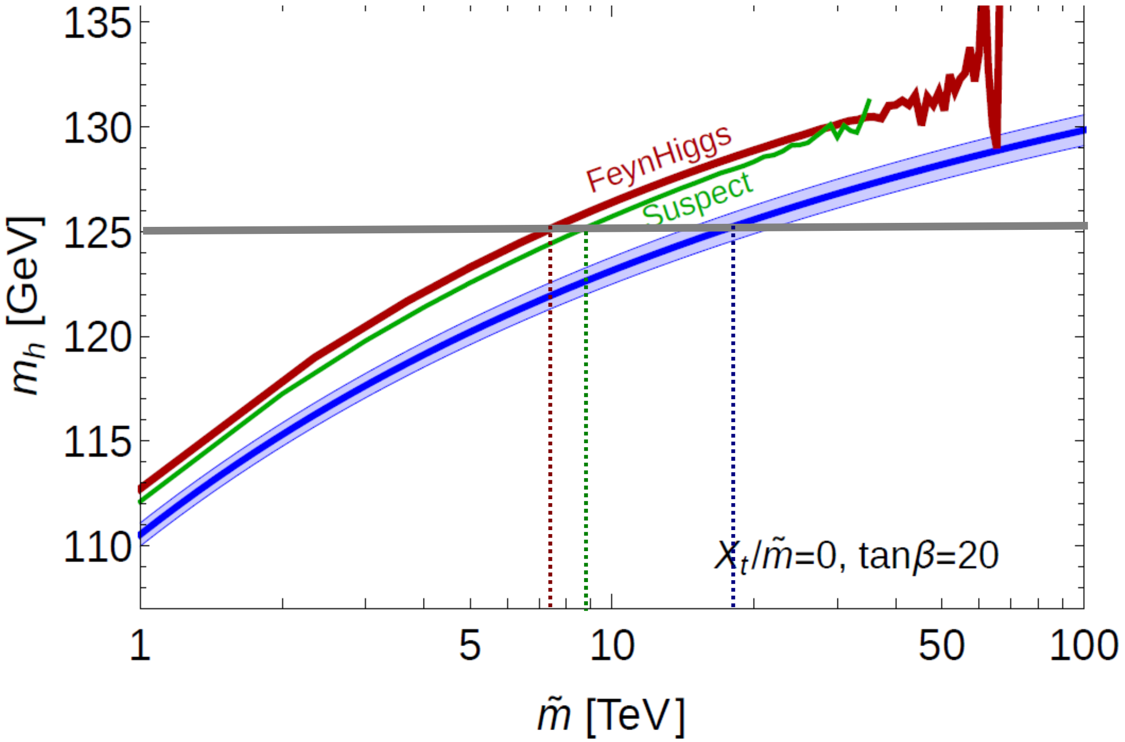
▬ Δ_{th}

$$\partial A_t / \partial \mu > 0$$

Comparison with existing codes



Comparison with existing codes



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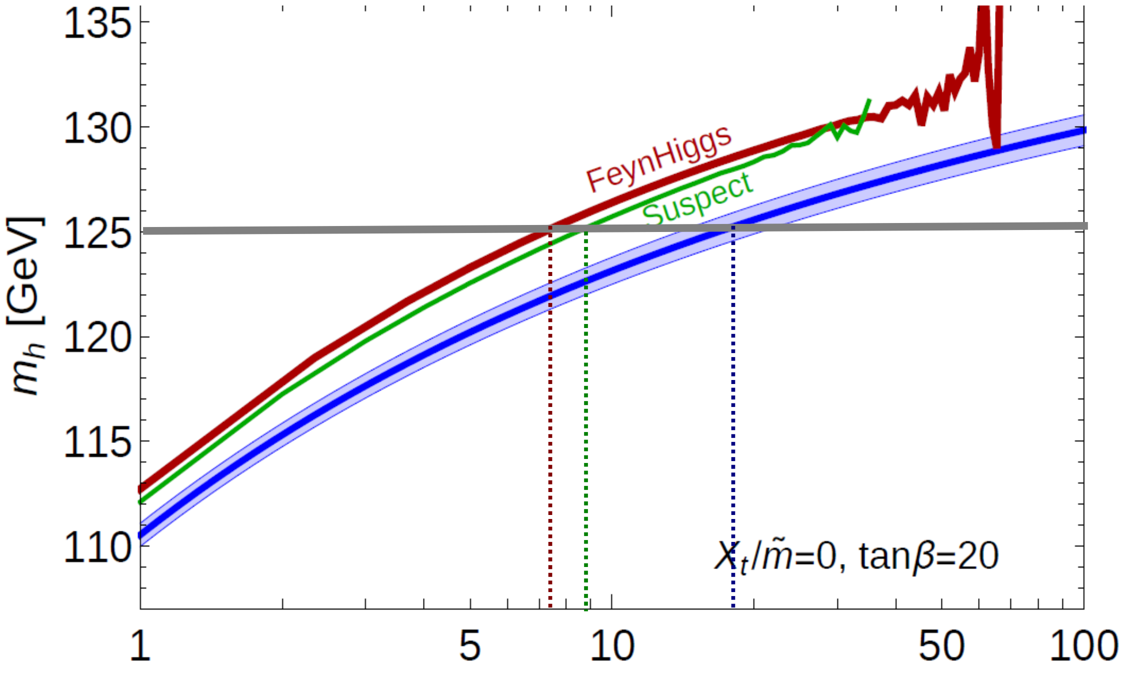
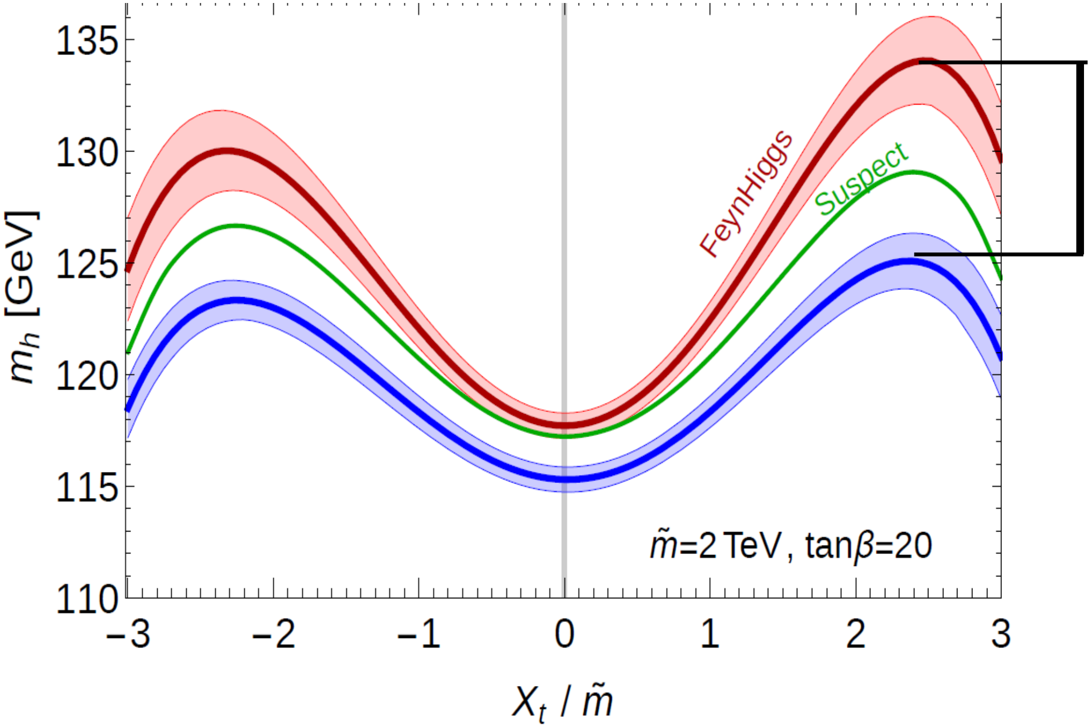
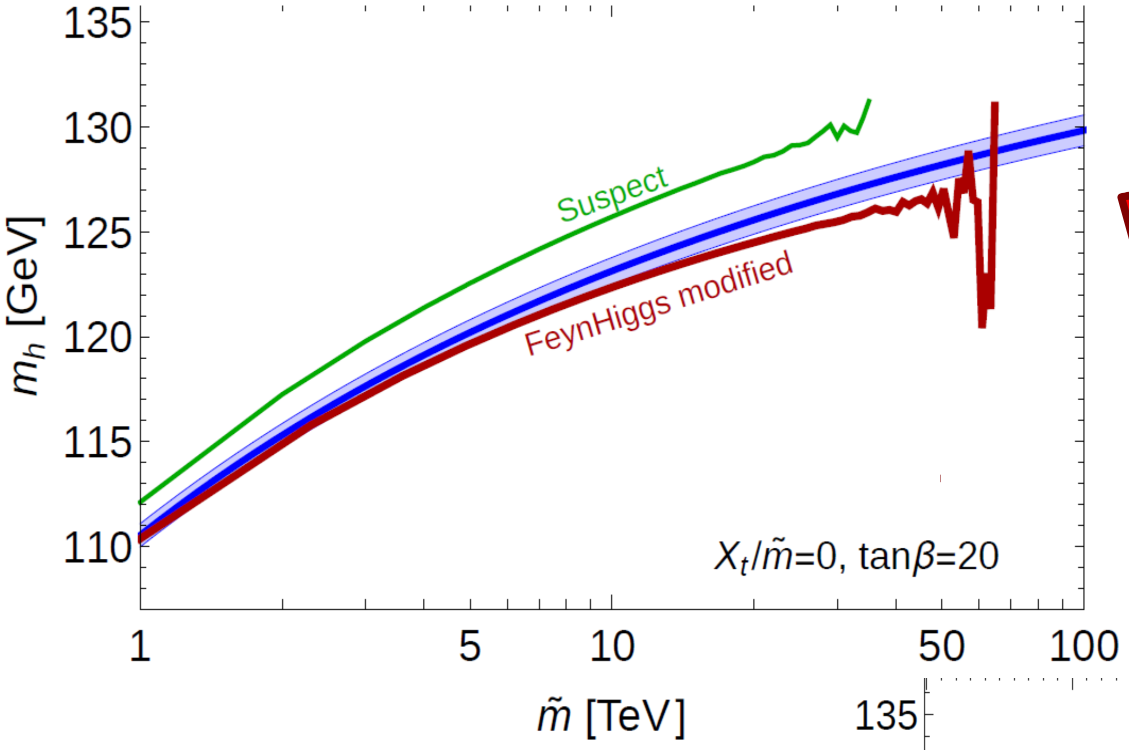


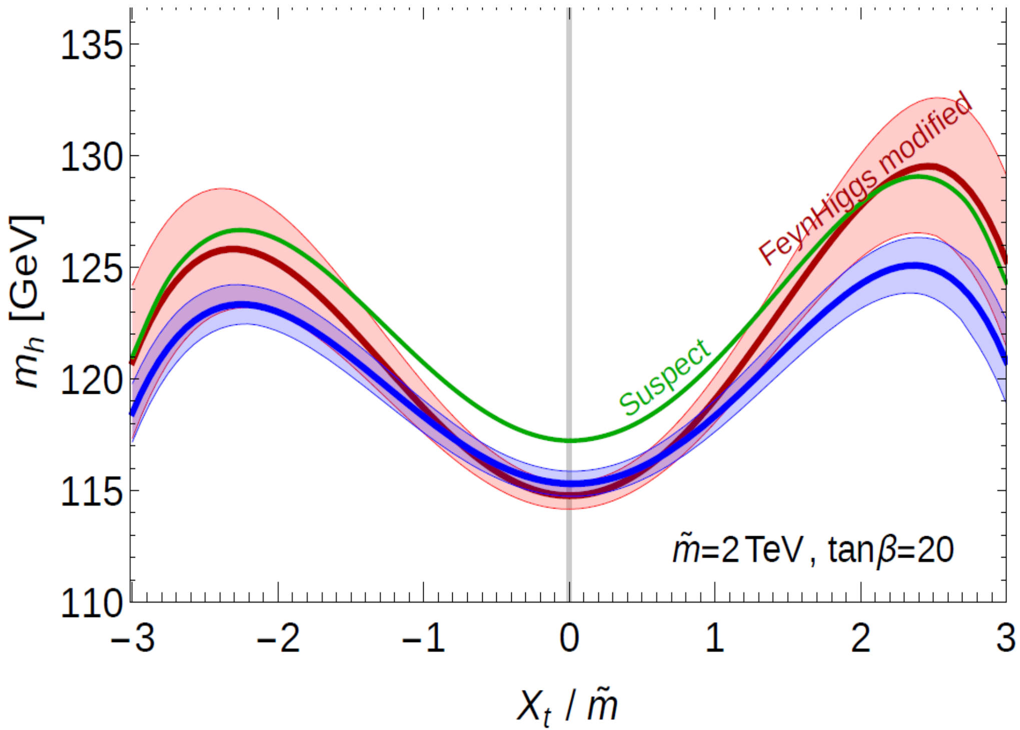


9 GeV!

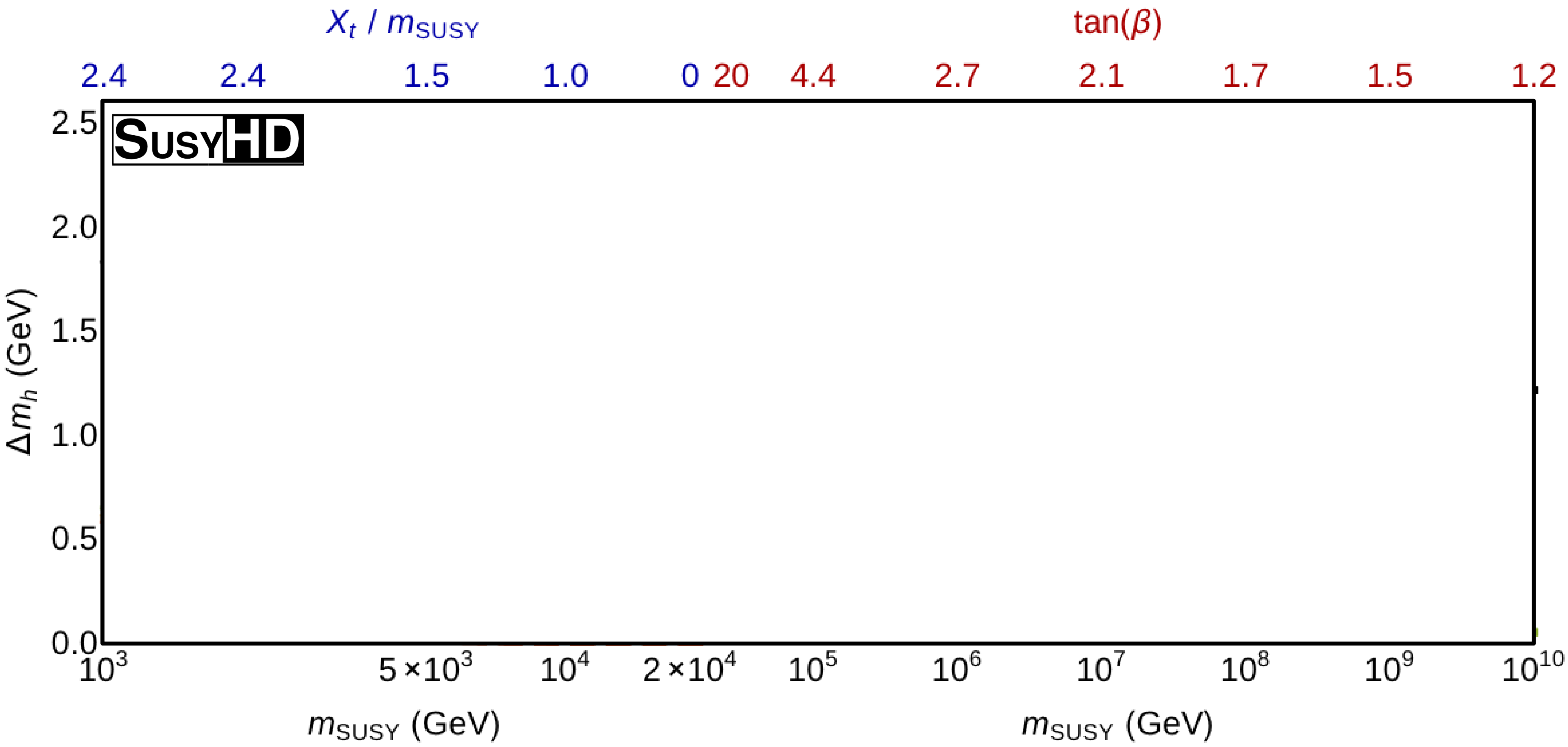
Comparison with existing codes



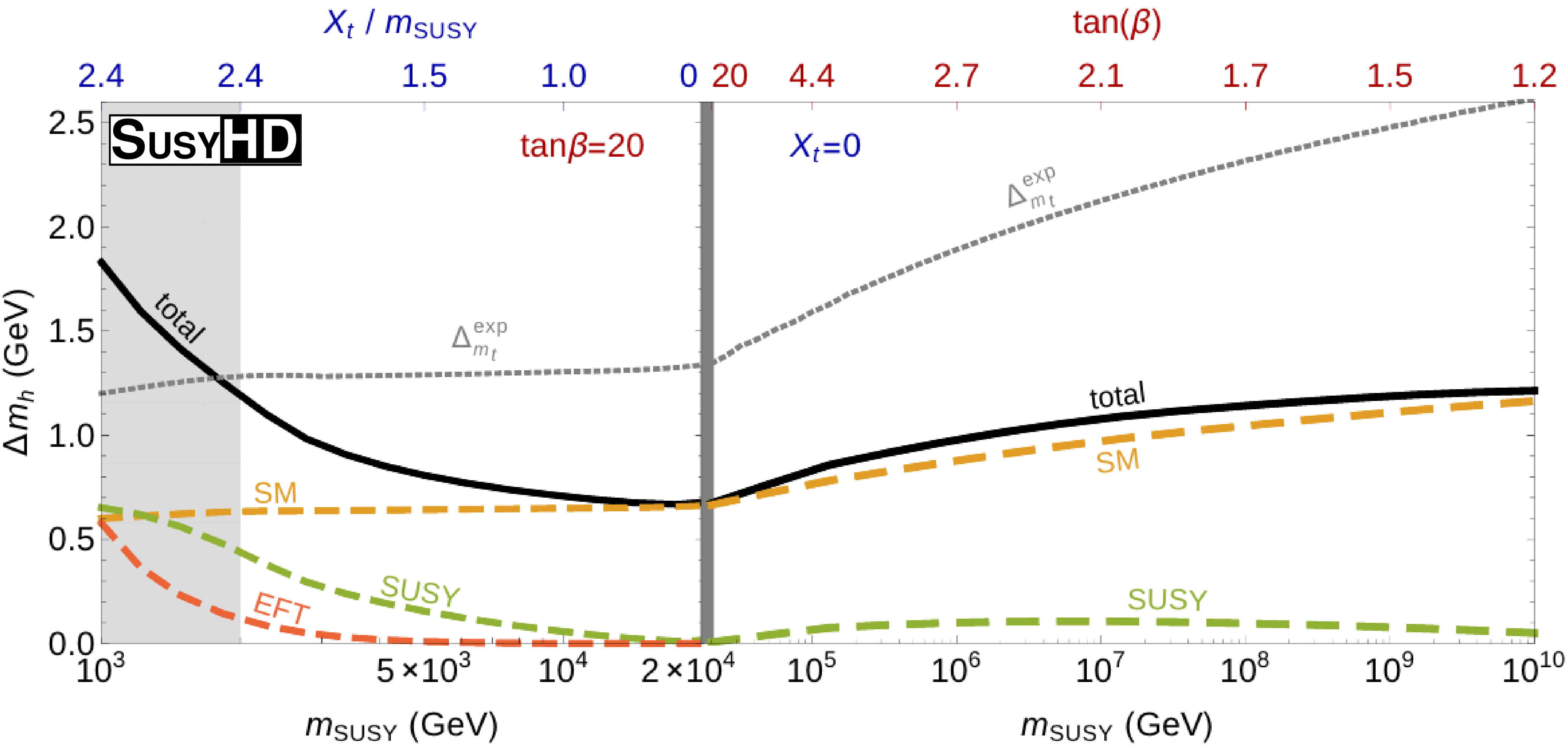
after 1-loop EW + 2-loop strong corrections to top Yukawa



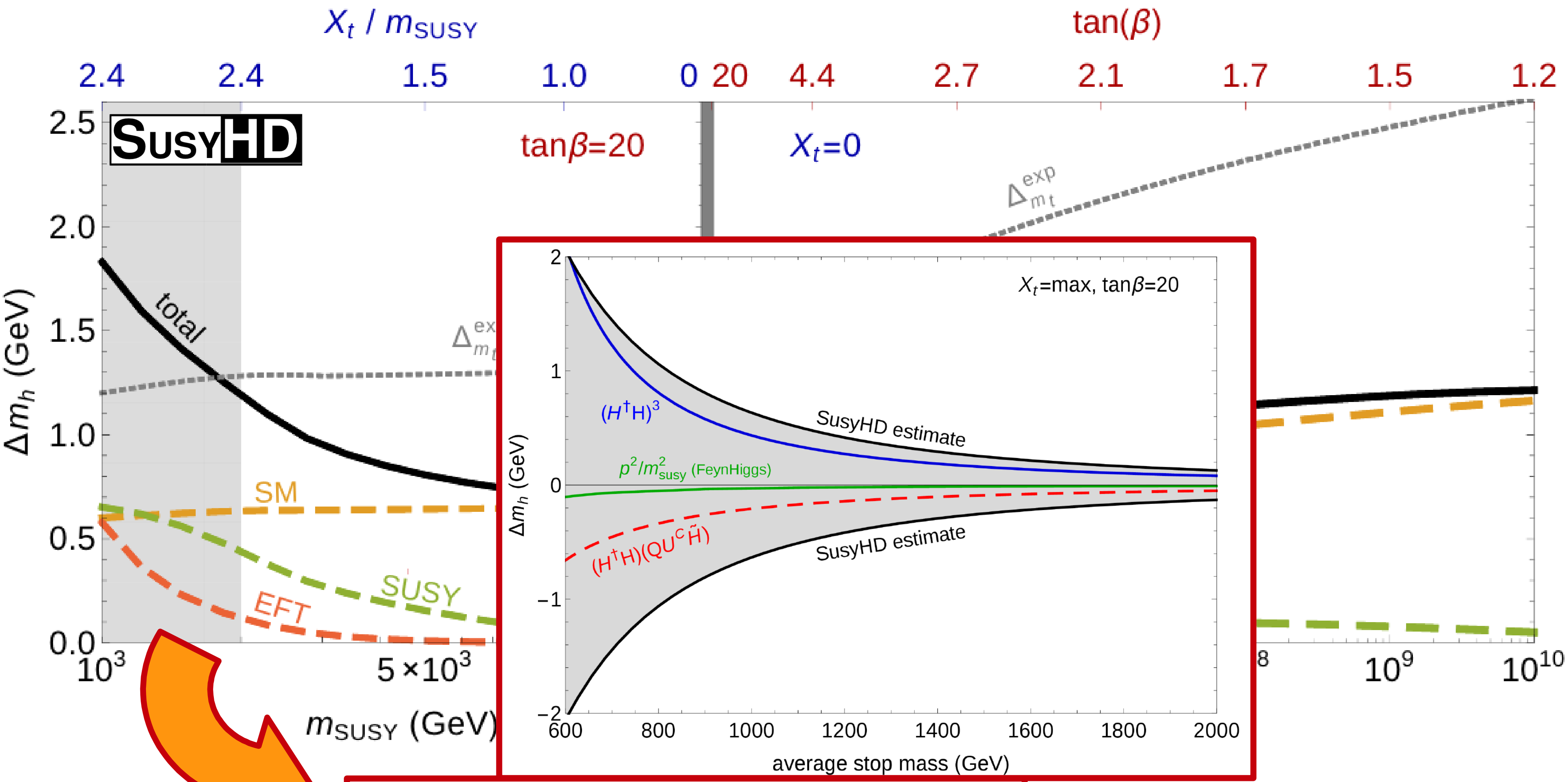
Estimate of the Uncertainties:



Estimate of the Uncertainties:



Estimate of the Uncertainties:



$$c_6\frac{(H^\dagger H)^3}{m^2_{\rm SUSY}}+c_t\frac{H^\dagger H}{m^2_{\rm SUSY}}HQU^c+\ldots$$

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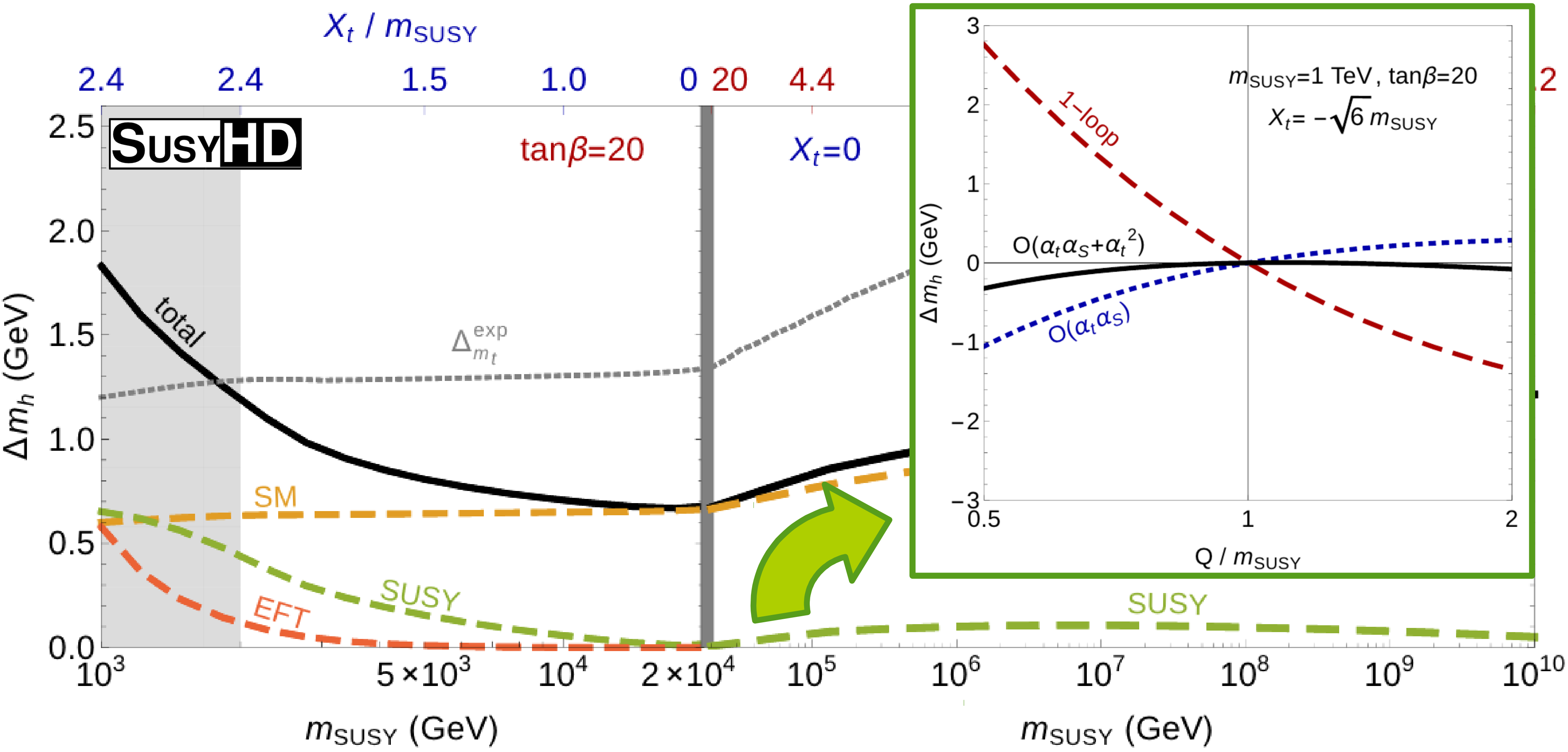

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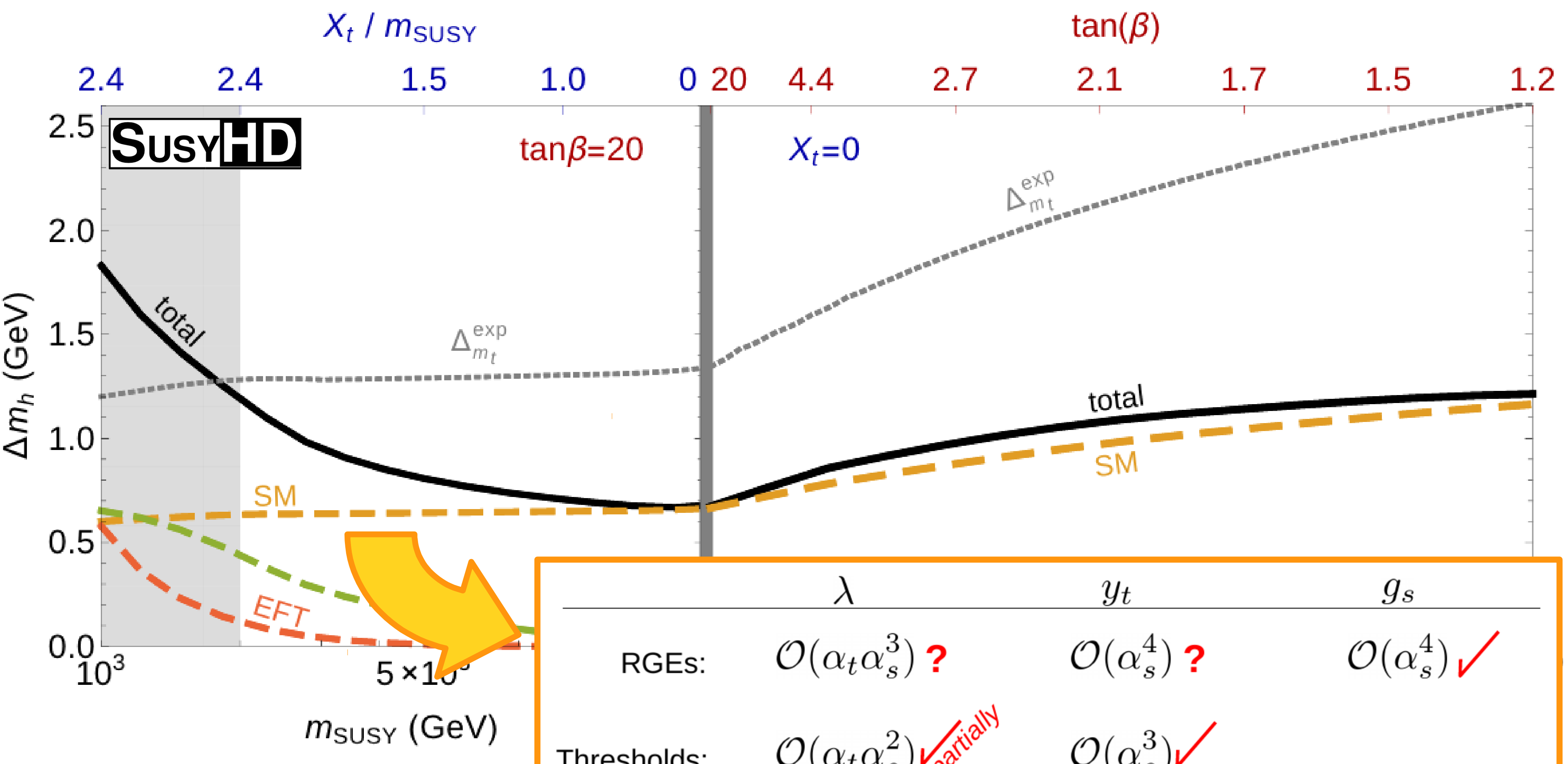

	λ	y_t	g_s
RGEs:	$\mathcal{O}(\alpha_t\alpha_s^3)$?	$\mathcal{O}(\alpha_s^4)$?	$\mathcal{O}(\alpha_s^4)$ ✓
Thresholds:	$\mathcal{O}(\alpha_t\alpha_s^2)$ ✓ partially	$\mathcal{O}(\alpha_s^3)$ ✓	

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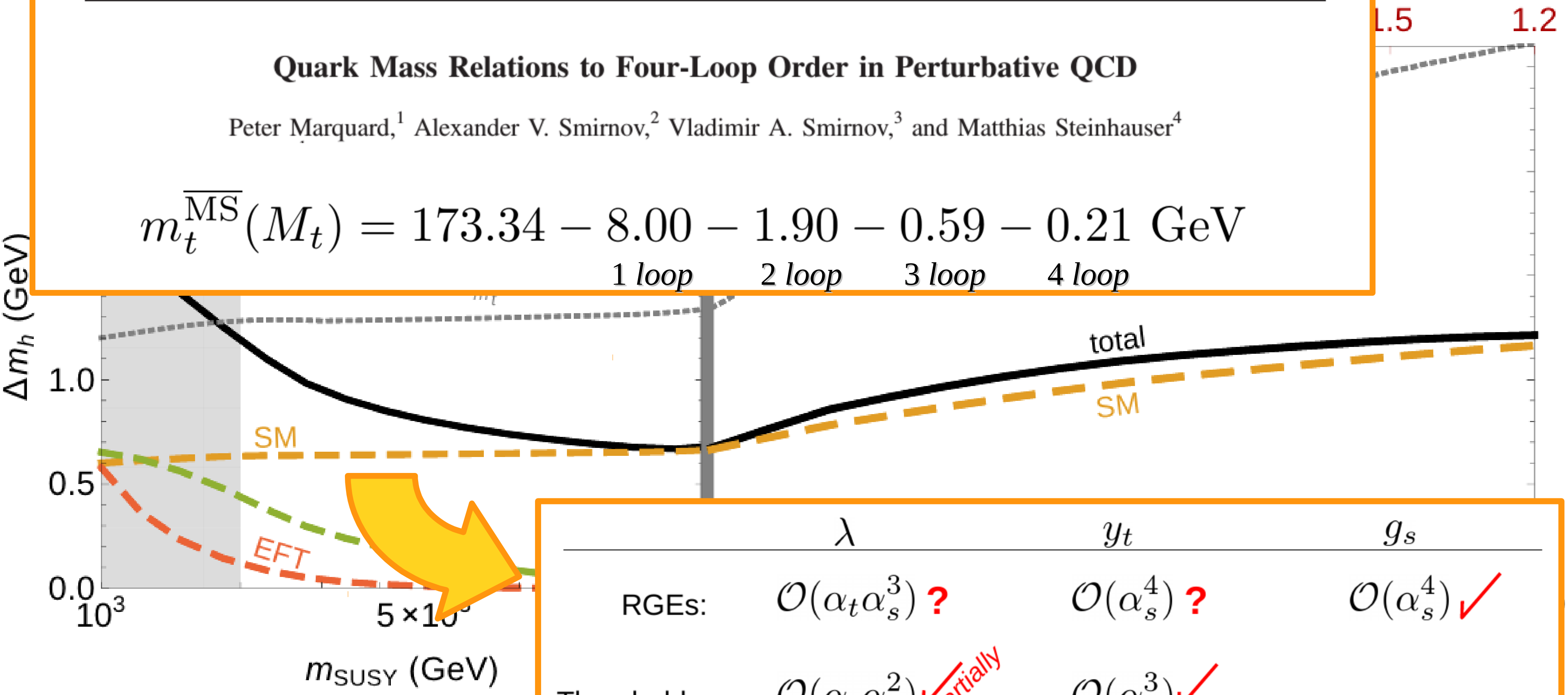

PRL **114,** 142002 (2015) PHYSICAL REVIEW LETTERS week ending 10 APRIL 2015

Quark Mass Relations to Four-Loop Order in Perturbative QCD

Peter Marquard,[1] Alexander V. Smirnov,[2] Vladimir A. Smirnov,[3] and Matthias Steinhauser[4]

$$m_t^{\overline{\text{MS}}}(M_t) = 173.34 - \underset{\textit{1 loop}}{8.00} - \underset{\textit{2 loop}}{1.90} - \underset{\textit{3 loop}}{0.59} - \underset{\textit{4 loop}}{0.21}\ \text{GeV}$$

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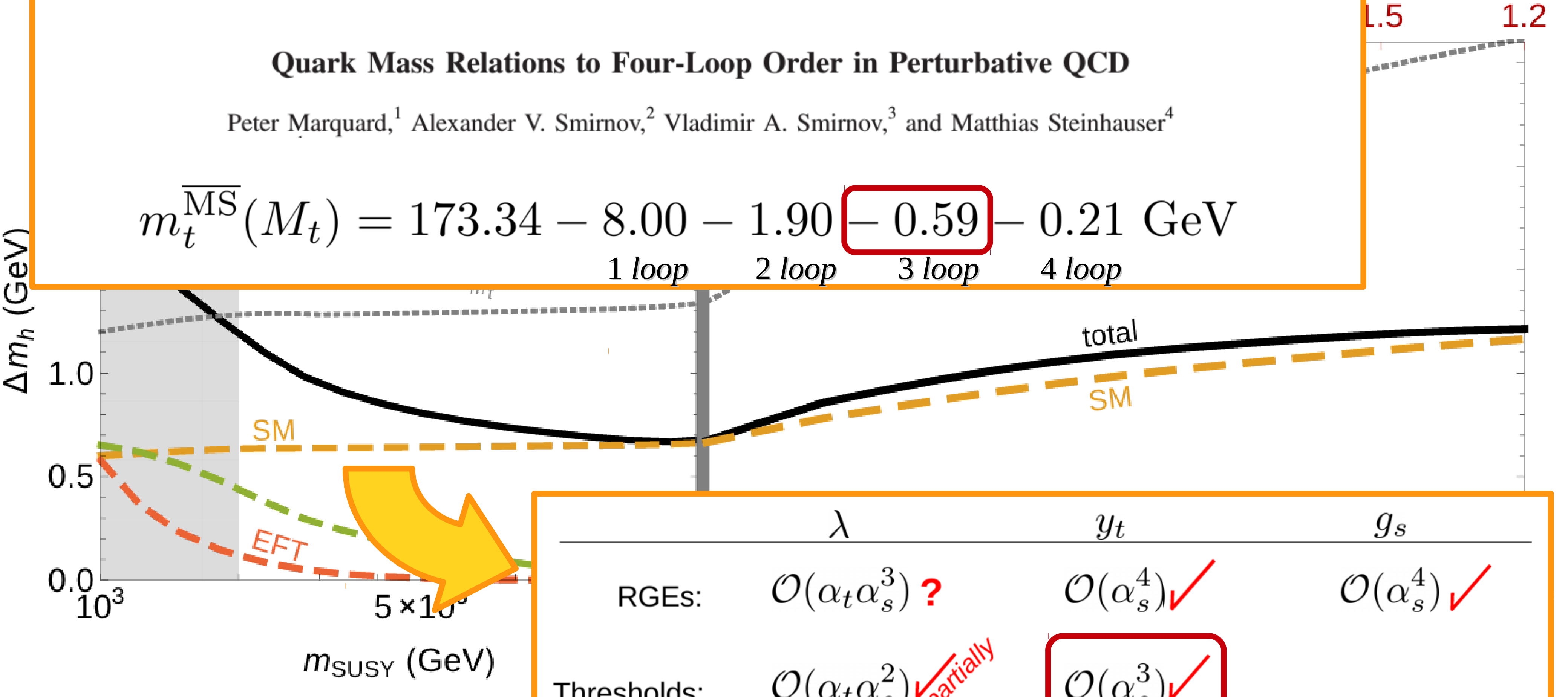

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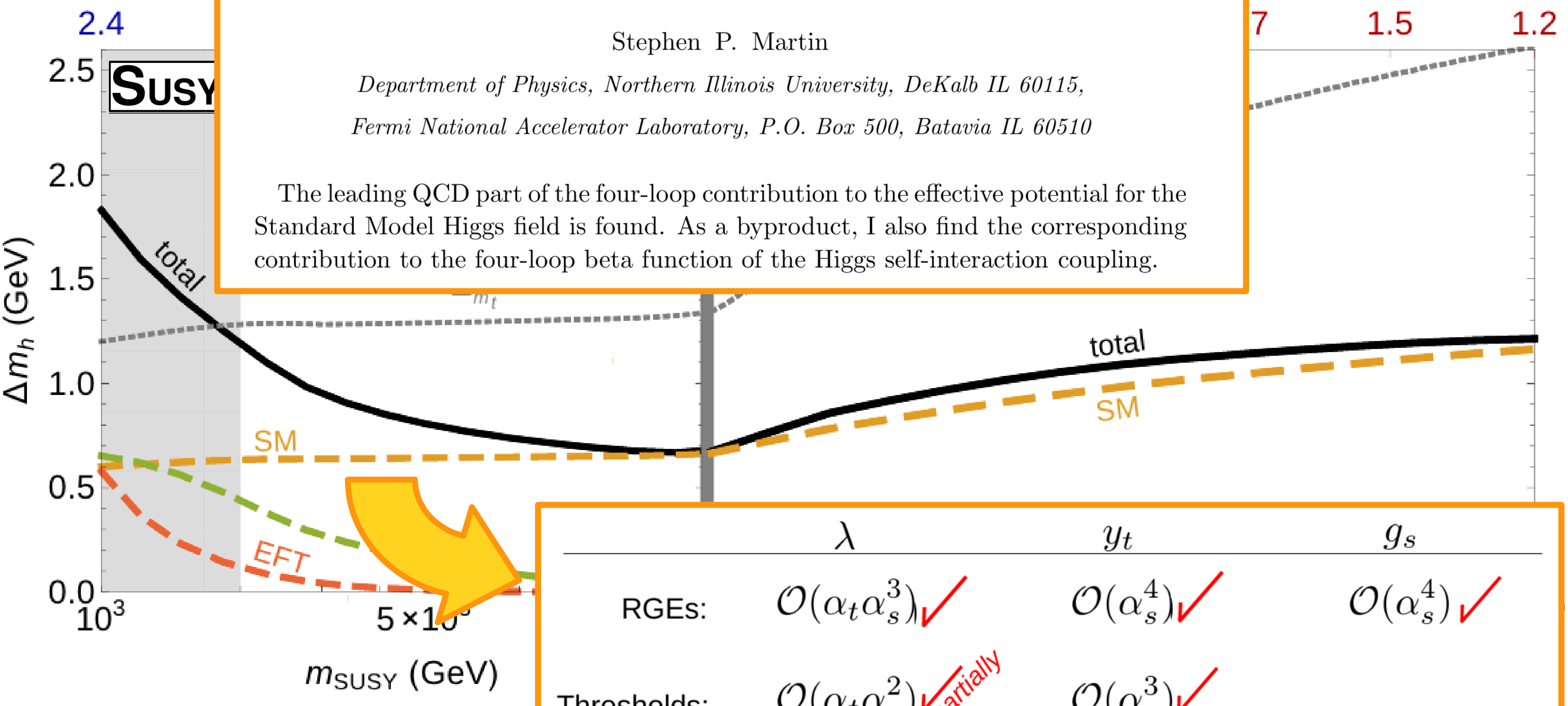

Four-loop Standard Model effective potential at leading order in QCD

Stephen P. Martin

Department of Physics, Northern Illinois University, DeKalb IL 60115,

Fermi National Accelerator Laboratory, P.O. Box 500, Batavia IL 60510

The leading QCD part of the four-loop contribution to the effective potential for the Standard Model Higgs field is found. As a byproduct, I also find the corresponding contribution to the four-loop beta function of the Higgs self-interaction coupling.

	λ	y_t	g_s
RGEs:	$\mathcal{O}(\alpha_t\alpha_s^3)$ ✓	$\mathcal{O}(\alpha_s^4)$ ✓	$\mathcal{O}(\alpha_s^4)$ ✓
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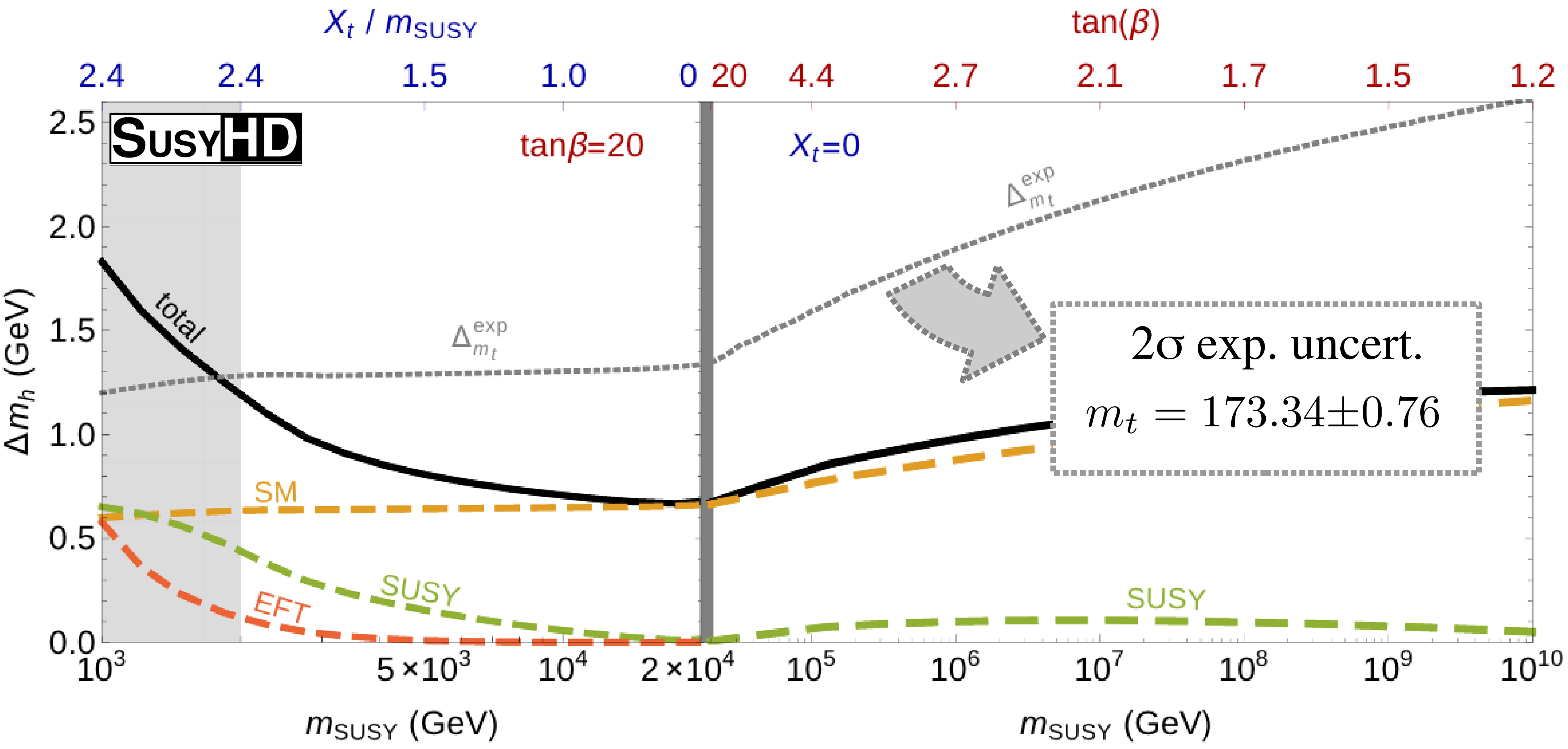
Estimate of the Uncertainties:



2σ exp. uncert.

$m_t = 173.34 \pm 0.76$

Where is the Simplest SUSY?

Minimal Gauge Mediation

Dine, Nir, Shirman
Rattazzi, Sarid '96

GM spectrum:

4 parameters:

gauginos $M_j = N \frac{\alpha_j}{4\pi} \Lambda$

scalars $m_i = 2\sqrt{N} C_{ij} \frac{\alpha_j}{4\pi} \Lambda$

higgsinos μ

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μ – parameter

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- ***M*** **– messengers mass**

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higgsinos μ

⇓

$A_t \leq m_0$ *no maximal mixing*

$B_\mu \ll m_0{}^2$ tan(β) ~ 30 - 60

no CP phases → *no EDMs*

4 parameters:

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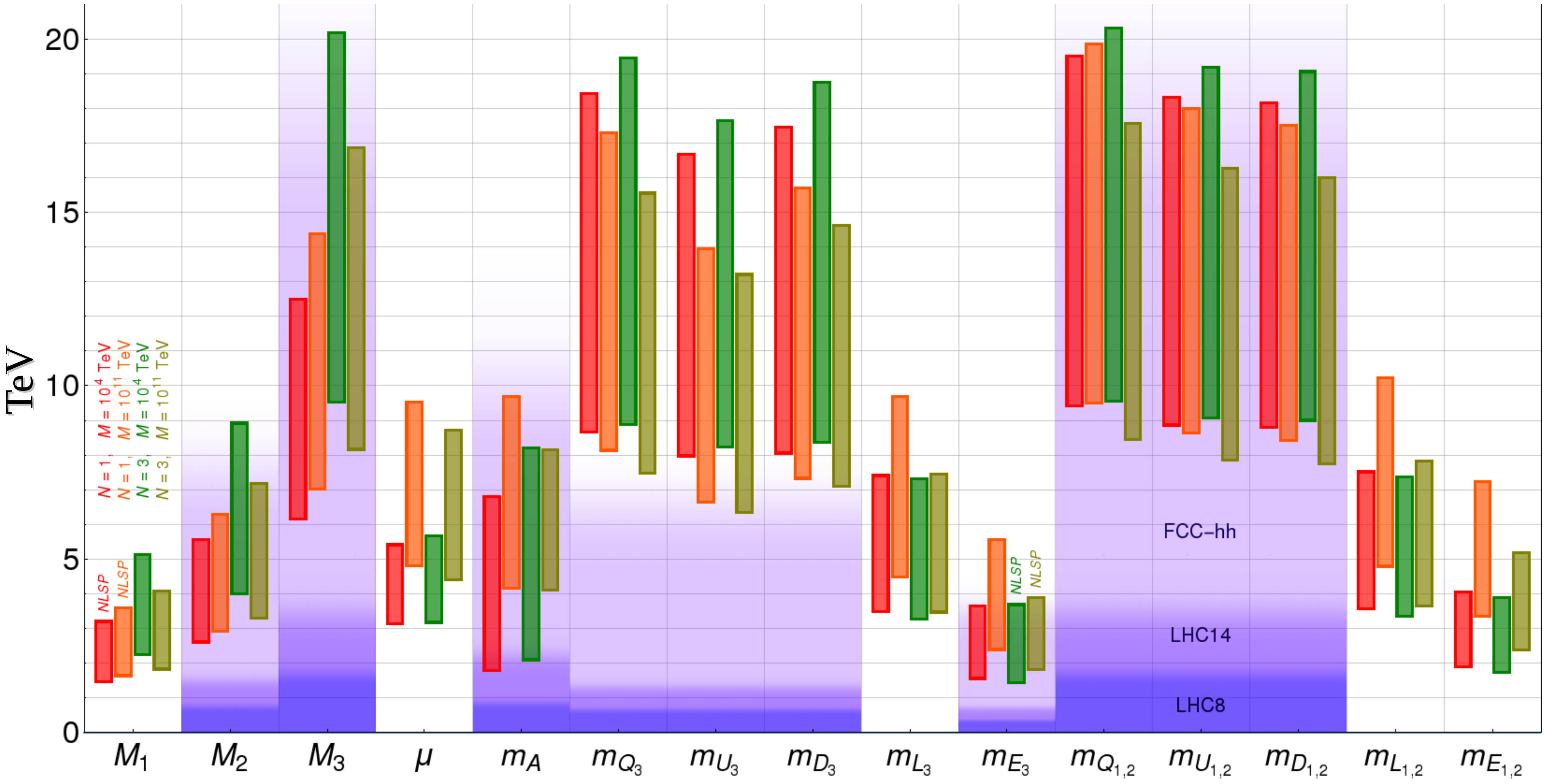
μ and Λ

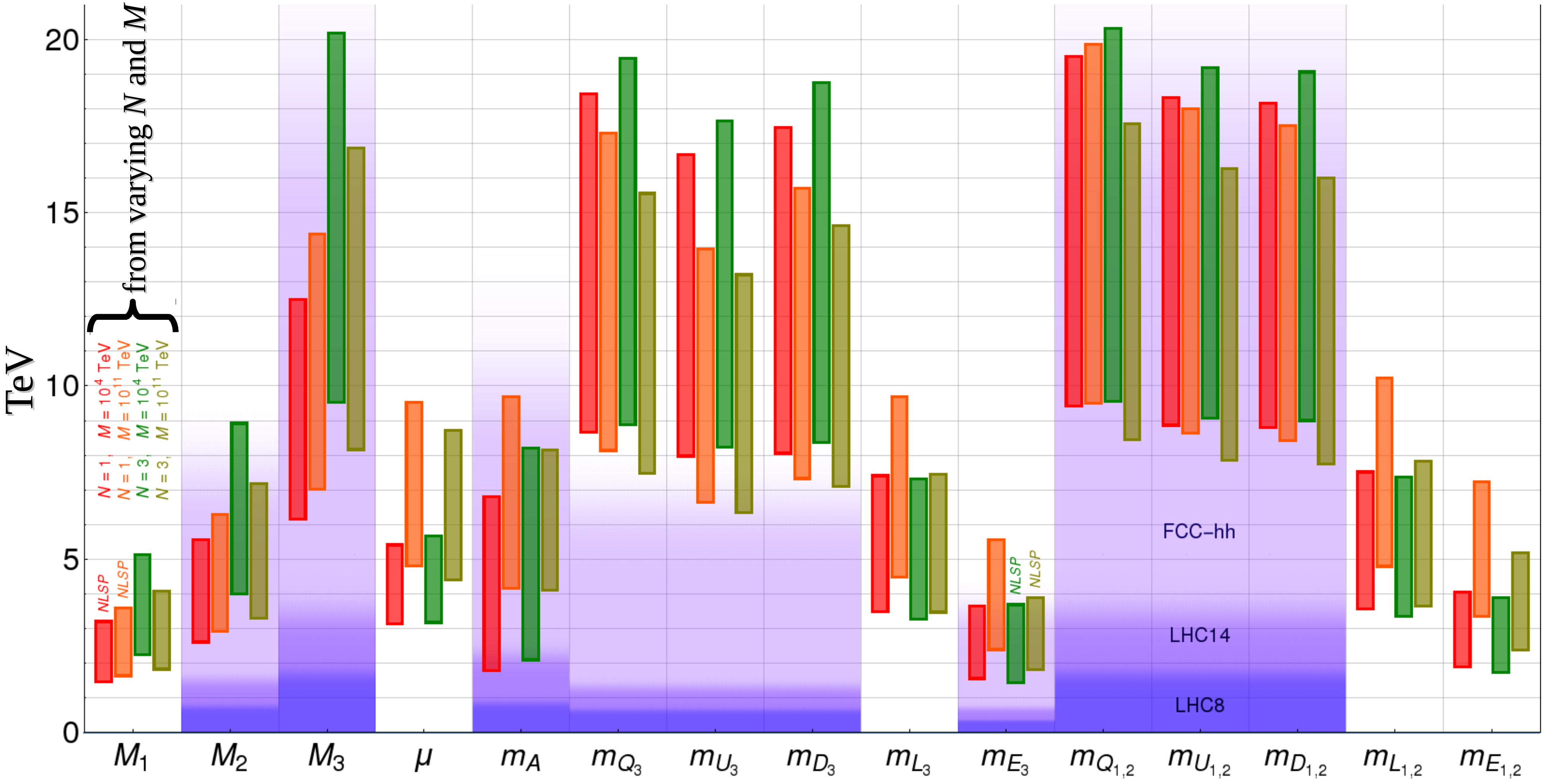
fixed by m_Z and m_h

2 *free parameters*
(N and M)

Predicting the MGM spectrum



Predicting the MGM spectrum



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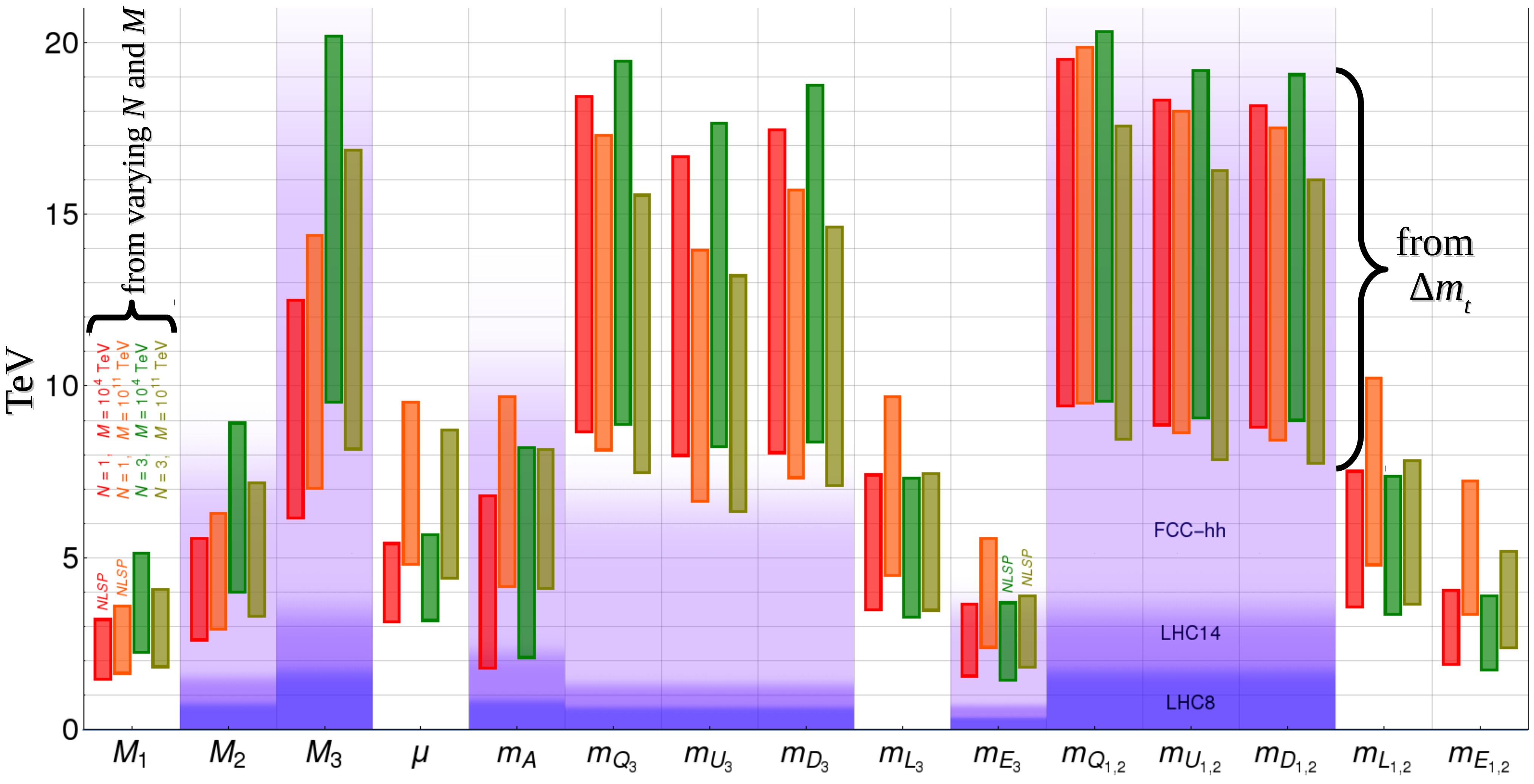
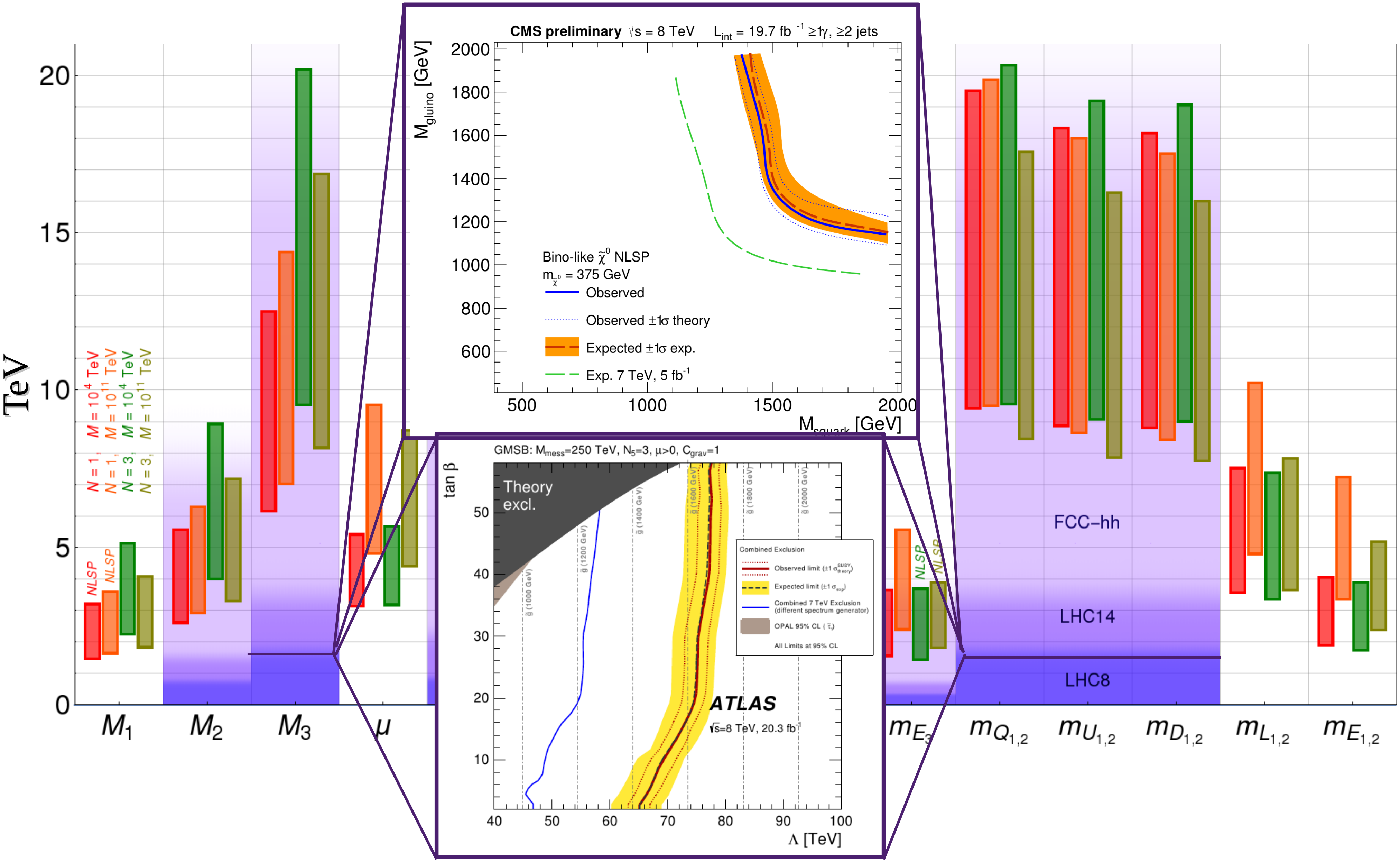


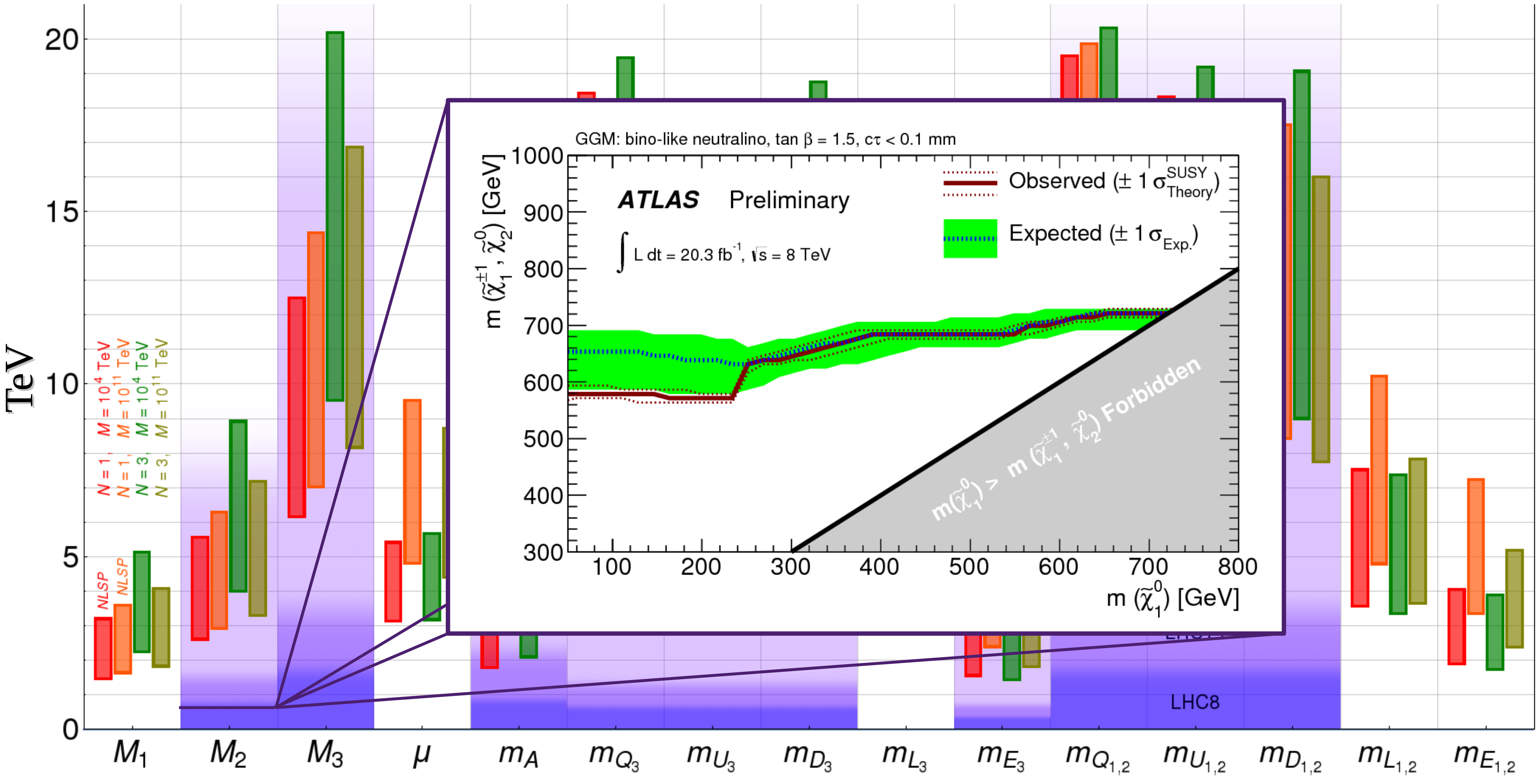
from varying N and M

from Δm_t

Predicting the MGM spectrum



Predicting the MGM spectrum



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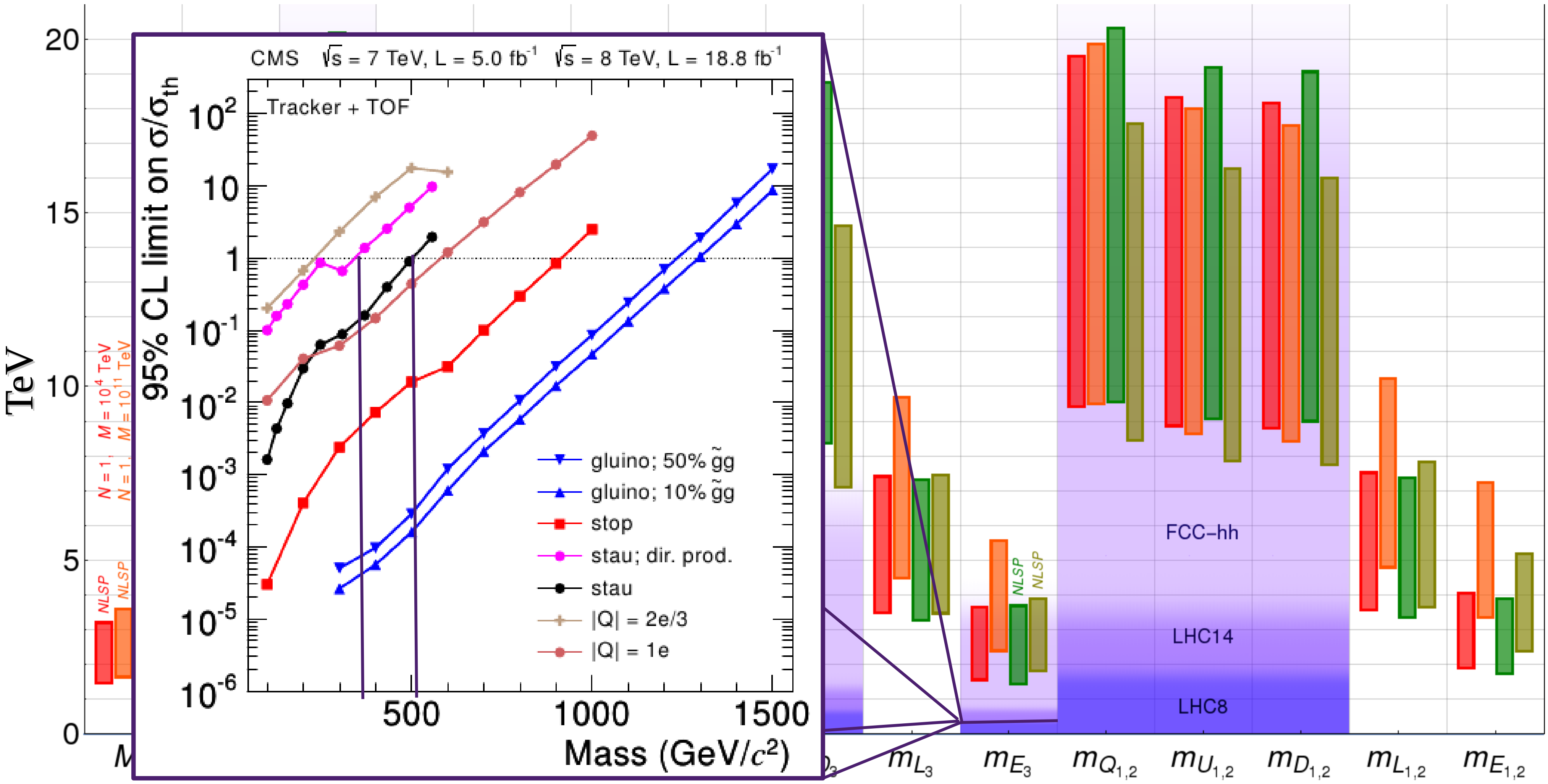

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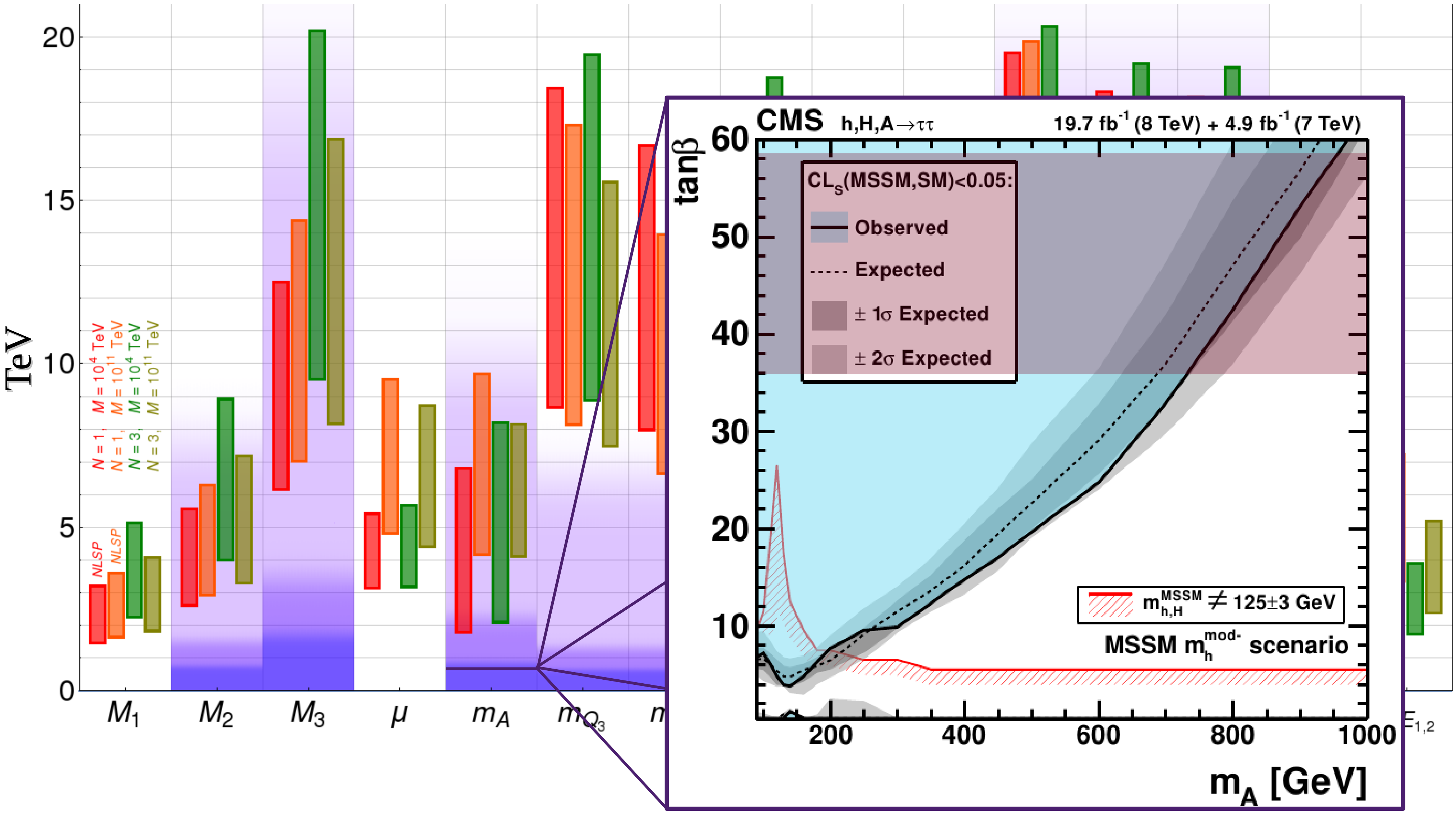

MGM:

minimal and most predictive implementation of SUSY

it explains:

- absense of deviation in flavor
- absence of EDMs
- absence of DM in WIMP searches
- gauge coupling unification
- absence of sparticles at the LHC!

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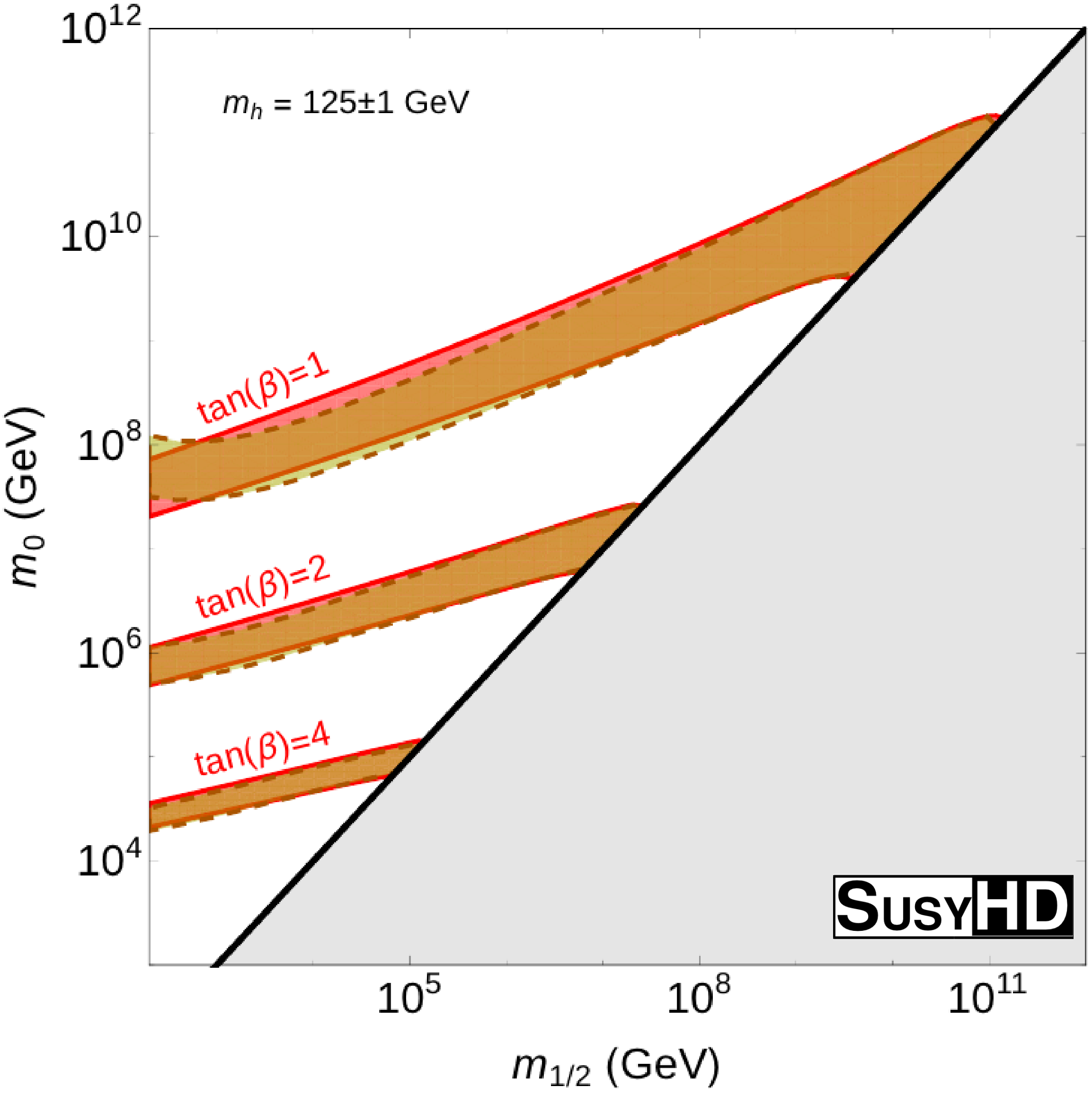
Perfect target for an 100 TeV collider?

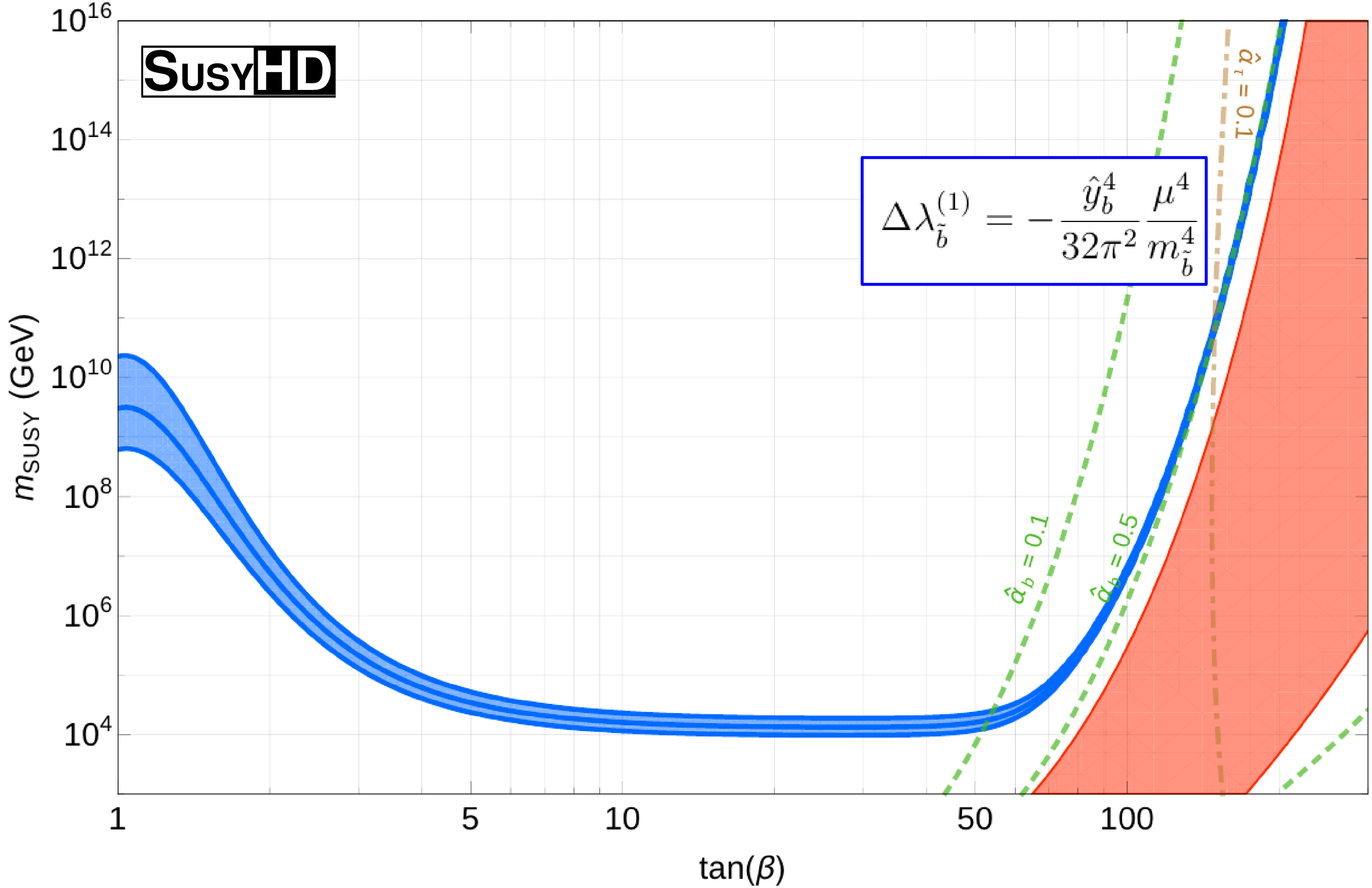
Improvement on *top* mass

(and SM computations) **required**!

Backup

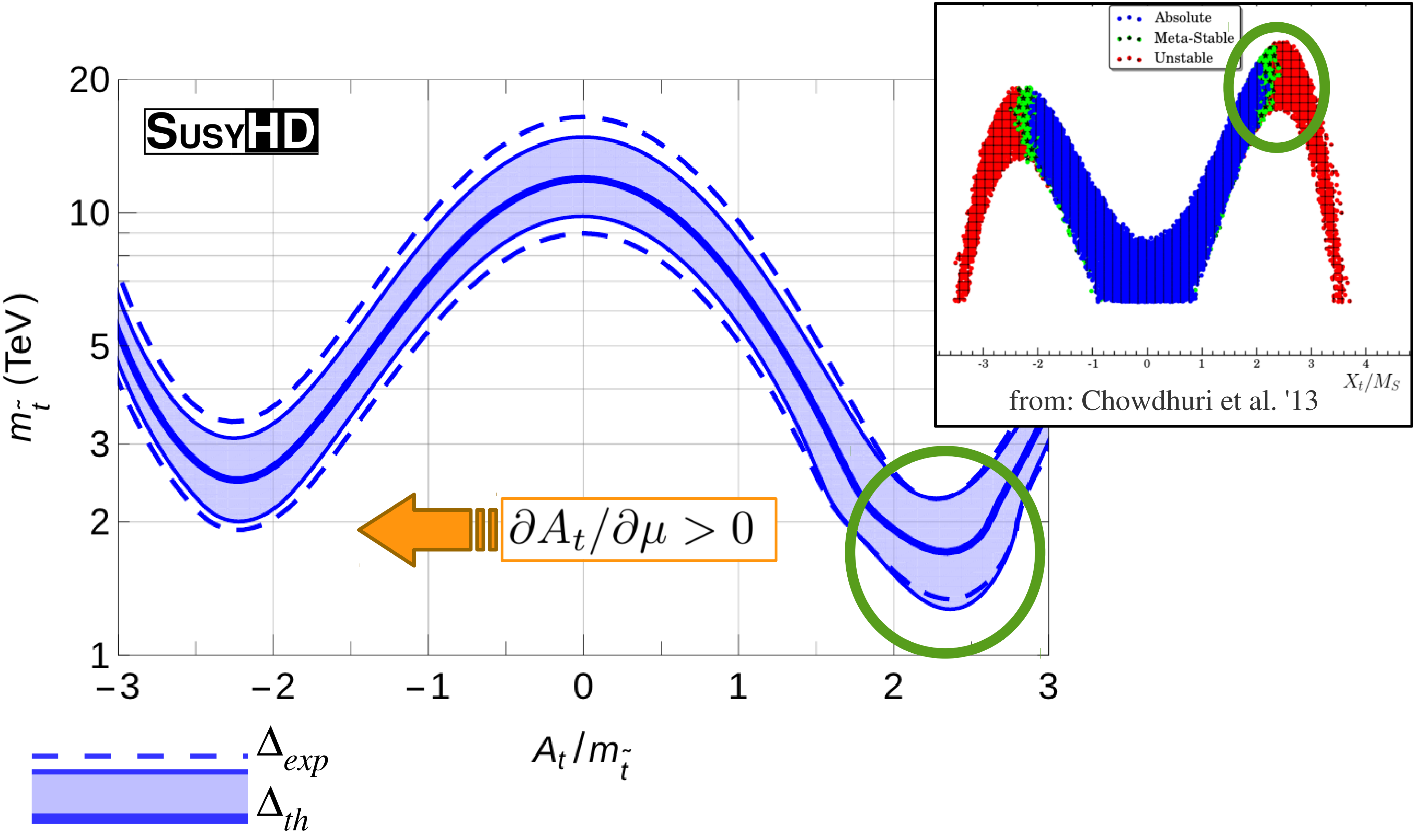
Effects from splitting fermions




SusyHD
$\Delta\lambda^{(1)}_{\tilde{b}} = -\frac{\hat{y}_b^4}{32\pi^2}\frac{\mu^4}{m_{\tilde{b}}^4}$
$\hat{\alpha}_b = 0.1$
$\hat{\alpha}_b = 0.5$
$\hat{\alpha}_t = 0.1$
10^{16}
10^{14}
10^{12}
10^{10}
10^{8}
10^{6}
10^{4}
m_{SUSY} (GeV)
1
5
10
50
100
tan(β)

A “natural” SUSY-like spectrum:

$\tan\beta = 20$, $\mu = 300$ GeV , $m_{SUSY} = 2$ TeV



$\partial A_t / \partial \mu > 0$

from: Chowdhuri et al. '13

SUSY breaking scale?

$$\delta m_h^2 \sim m_{\mathrm{SUSY}}^2$$

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$$\delta \Lambda_{\rm CC} \sim m_{\rm SUSY}^4$$

Bigger pressure to low scale SUSY!

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Bigger pressure to low scale SUSY!

Naturalness not a good criterion to predict SUSY?

No naturalness → no μ problem:

SUSY term

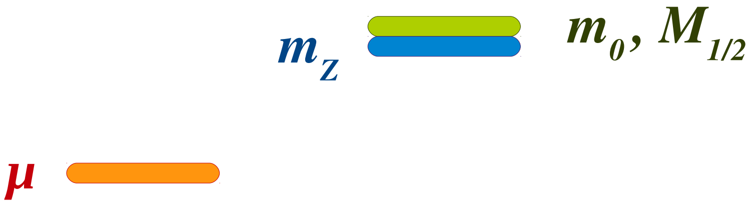
No naturalness → no μ problem:

μ

no EWSB

m_0, $M_{1/2}$

No naturalness → no μ problem:



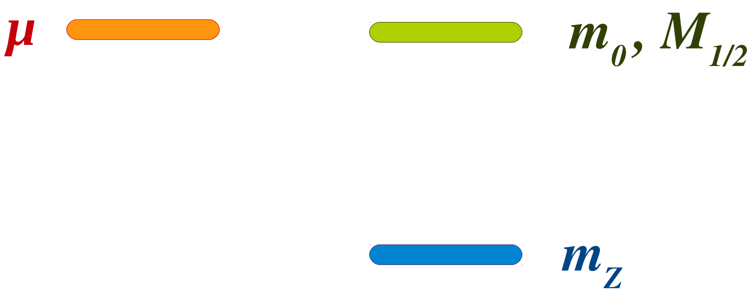
m_Z

$m_0, M_{1/2}$

μ

EWSB ~ m_0

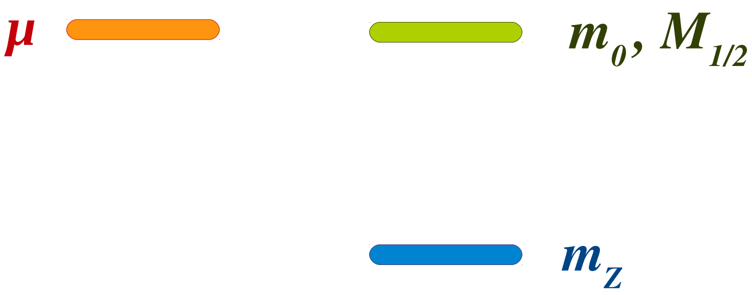
No naturalness → no μ problem:



$$|\mu|^2 \simeq -m_{H_u}^2 + \dots$$

EWSB « m_0

No naturalness → no μ problem:



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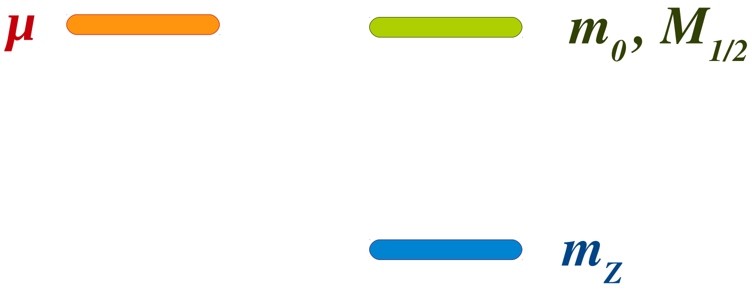
EWSB « m_0

$B_\mu, A = 0$ at the scale M

<u>generated radiatively</u>

No naturalness → no μ problem:



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⇨ $A_t \lesssim m_0$ *no maximal mixing*

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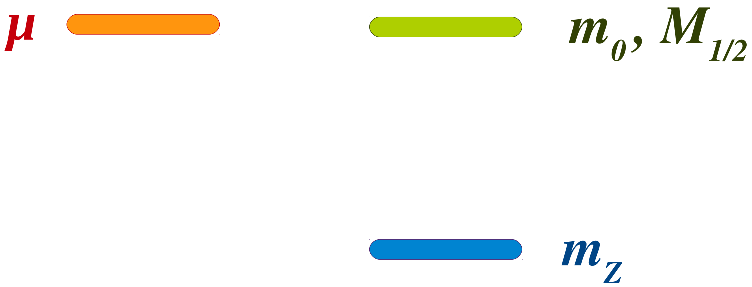

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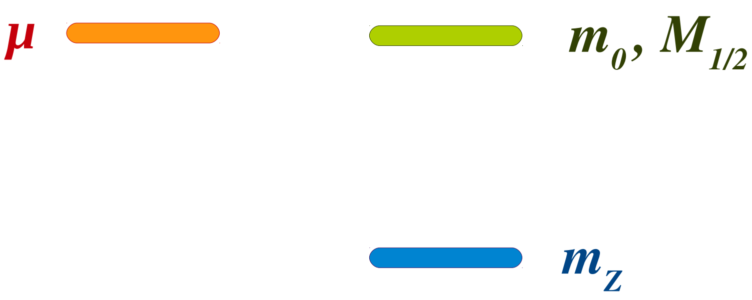

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EWSB « m_0

$B_\mu, A = 0$ at the scale M

generated radiatively

- $A_t \lesssim m_0$ *no maximal mixing*
- $B_\mu \ll m_0^2$ tan(β) ~ 30-60
- *no CP phases* → *no EDMs*