The Higgs boson and Top quark masses as test of Electroweak Vacuum Stability (+ impact of neutrinos)

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University of Ferrara and CP3-Origins Denmark

Neutrino Oscillation Workshop
Conca Specchiulla, Otranto, Lecce, Italy
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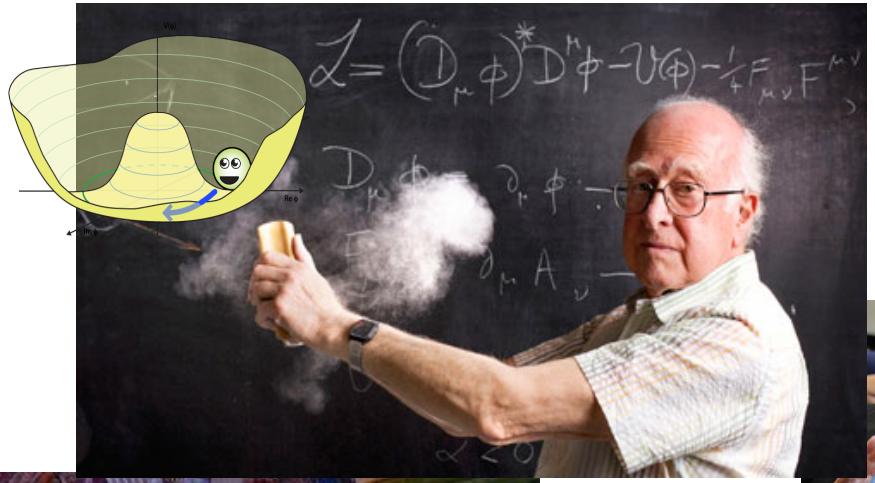
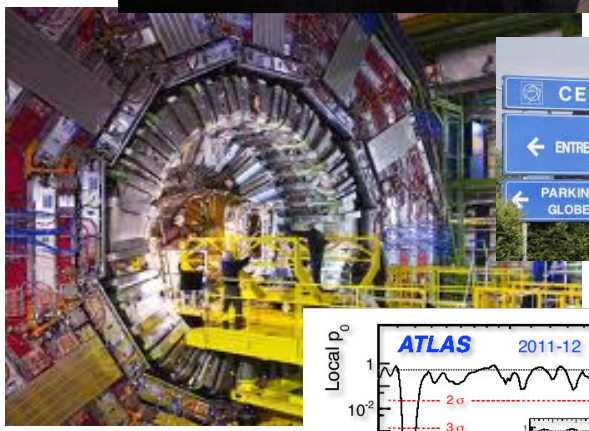
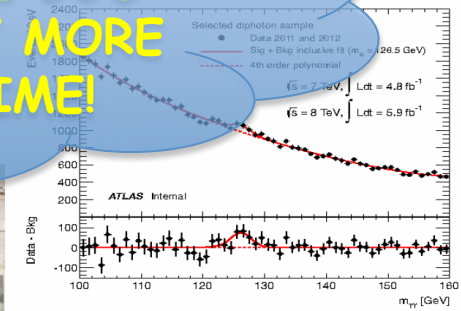
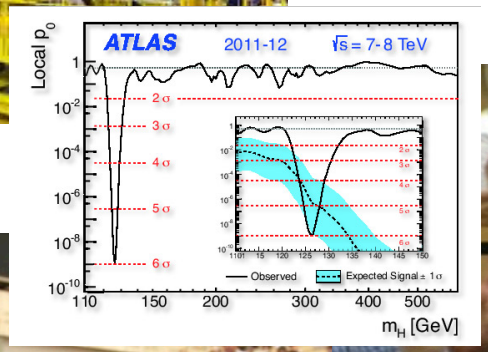
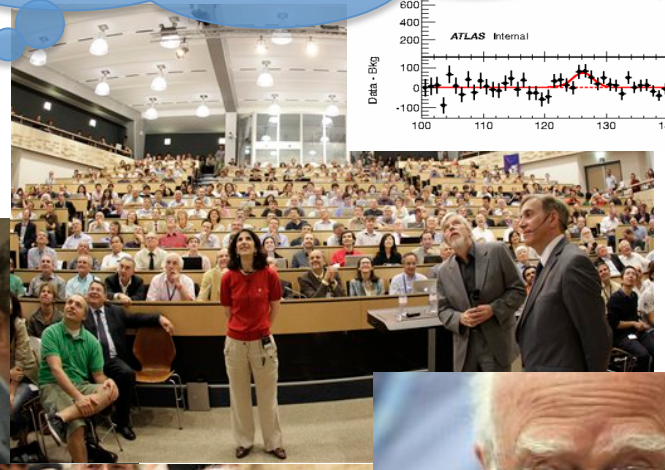


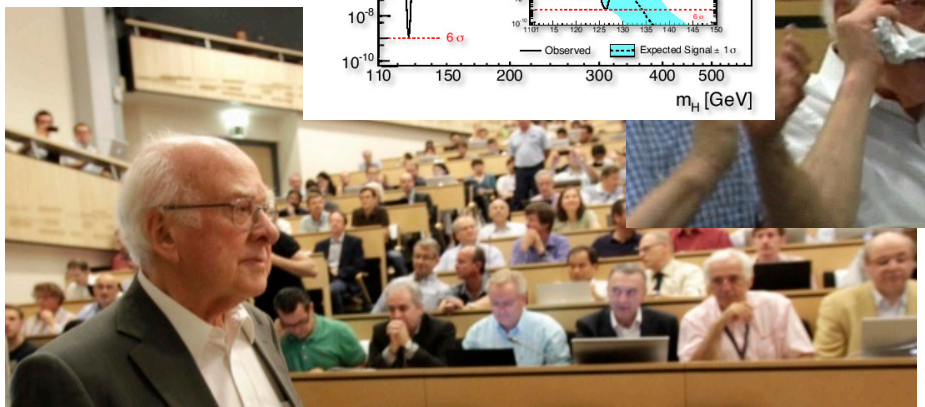
DON'T CALL ME GOD
PARTICLE ONCE MORE
GODDAMN TIME!

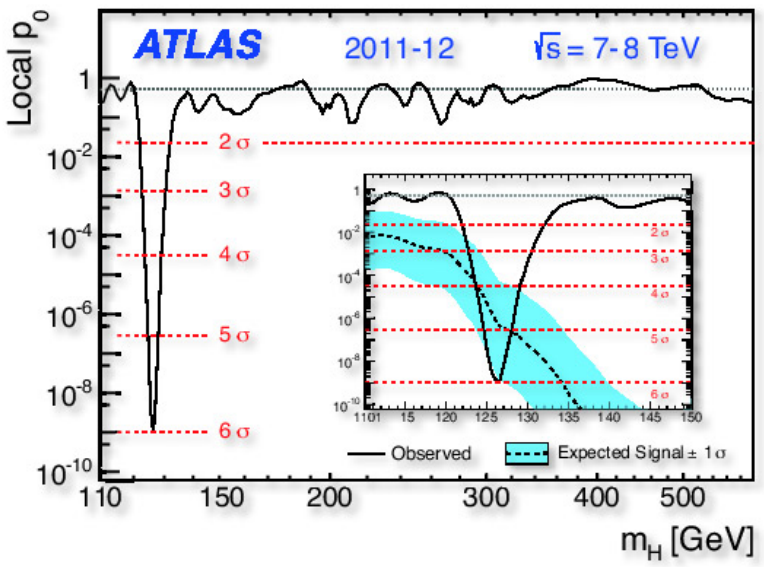


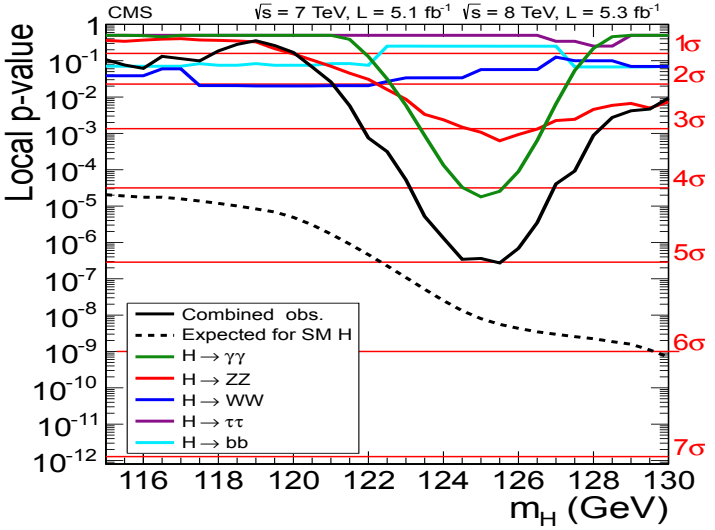










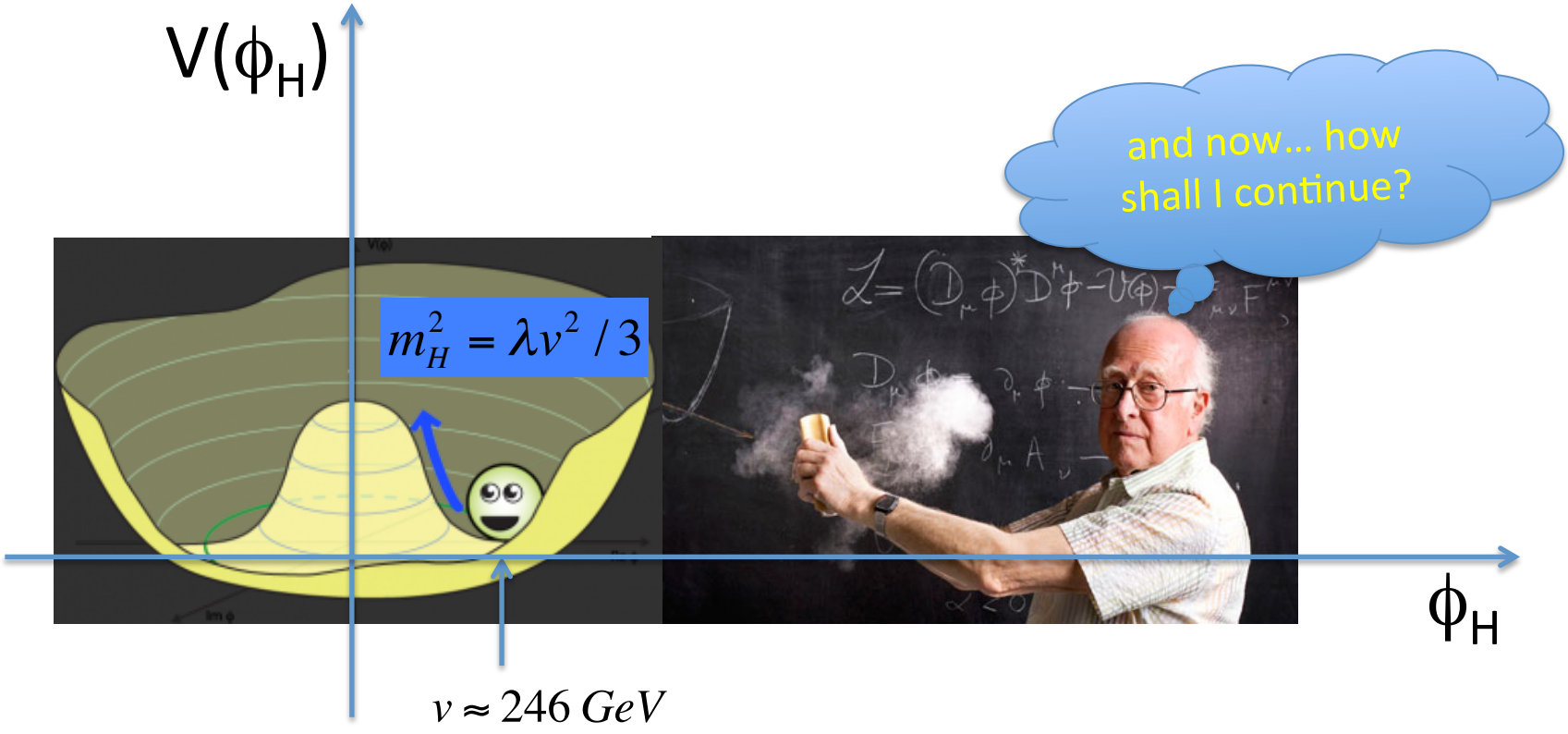


$$m_H = 124.8 - 126.5\ GeV$$ @2σ

SO WHAT?

Consider the Higgs doublet $H = (0, (\phi_H + v)/\sqrt{2})$

and the SM Higgs potential: $V(\phi_H) = \frac{\lambda}{6}\left(|H|^2 - \frac{v^2}{2}\right)^2 \approx \frac{\lambda}{24}\phi_H^4$



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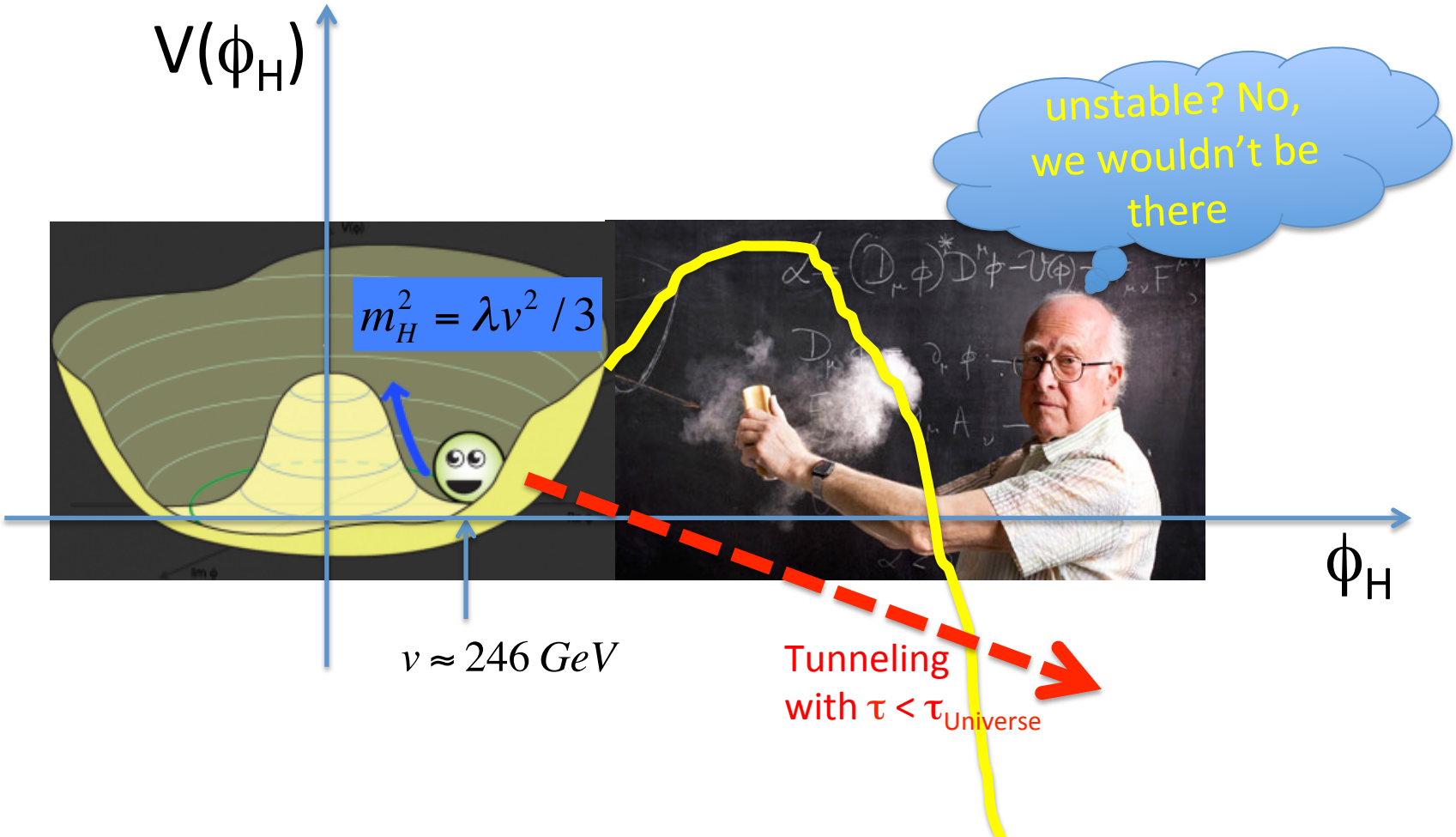

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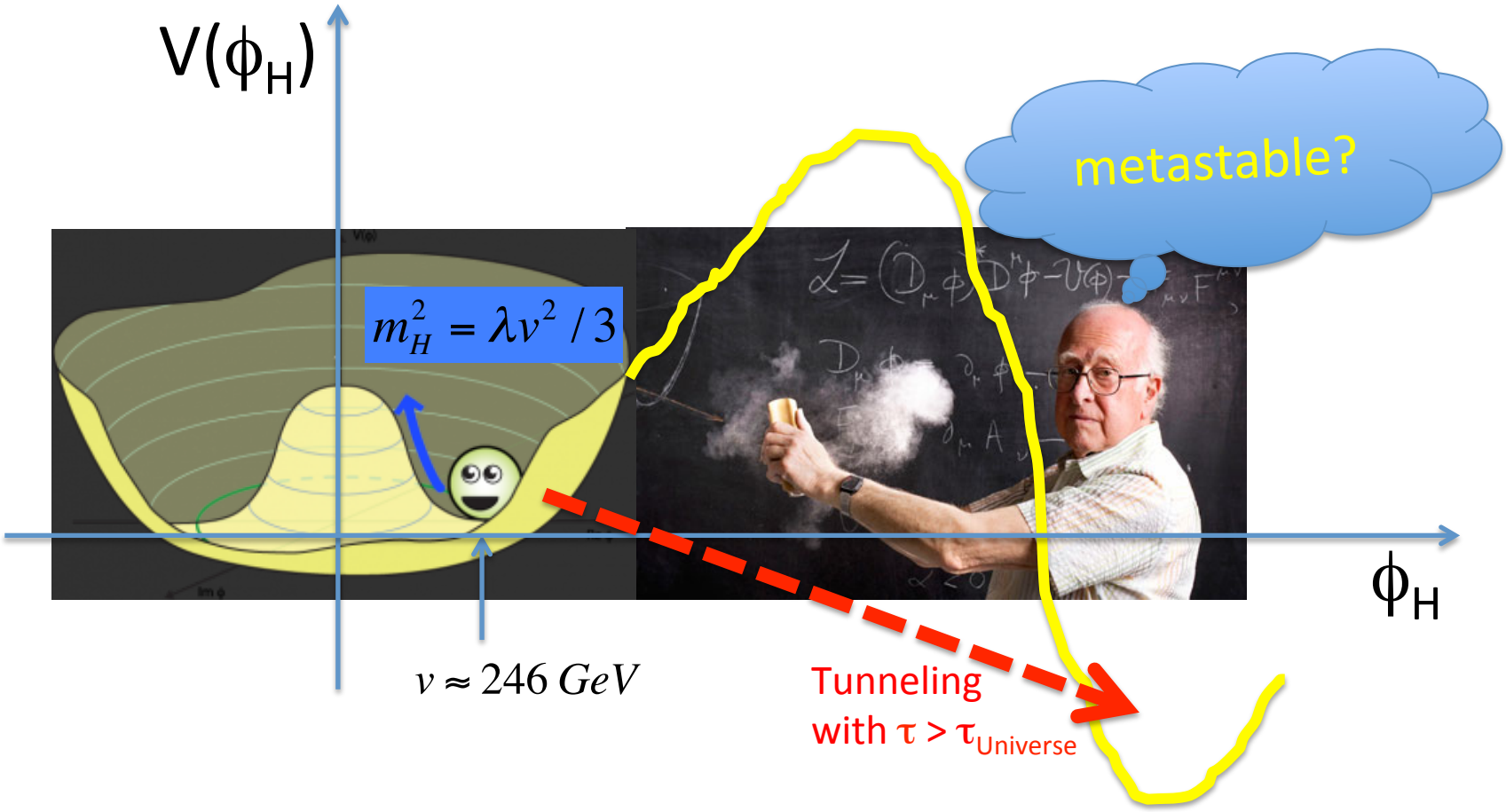

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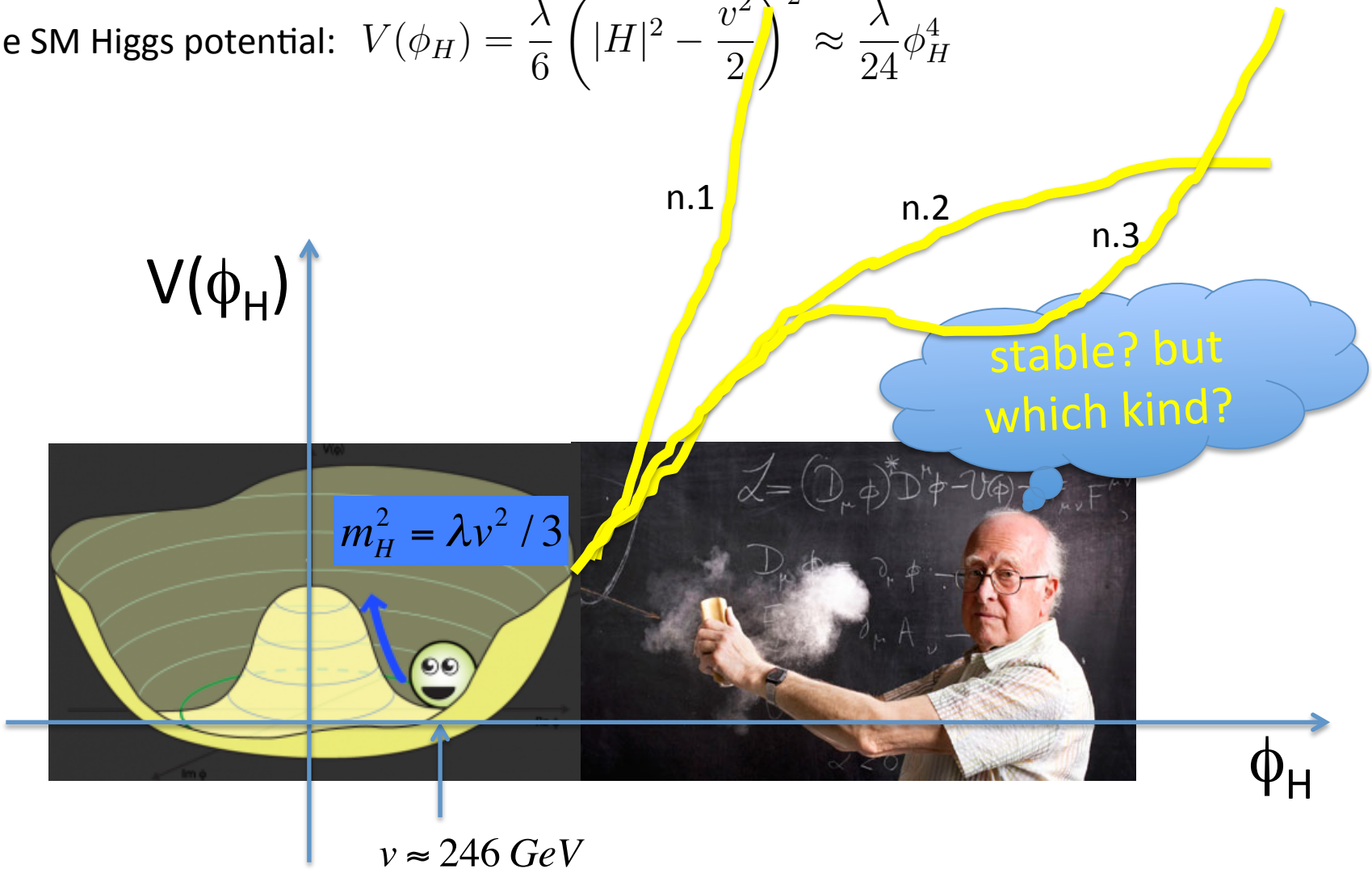

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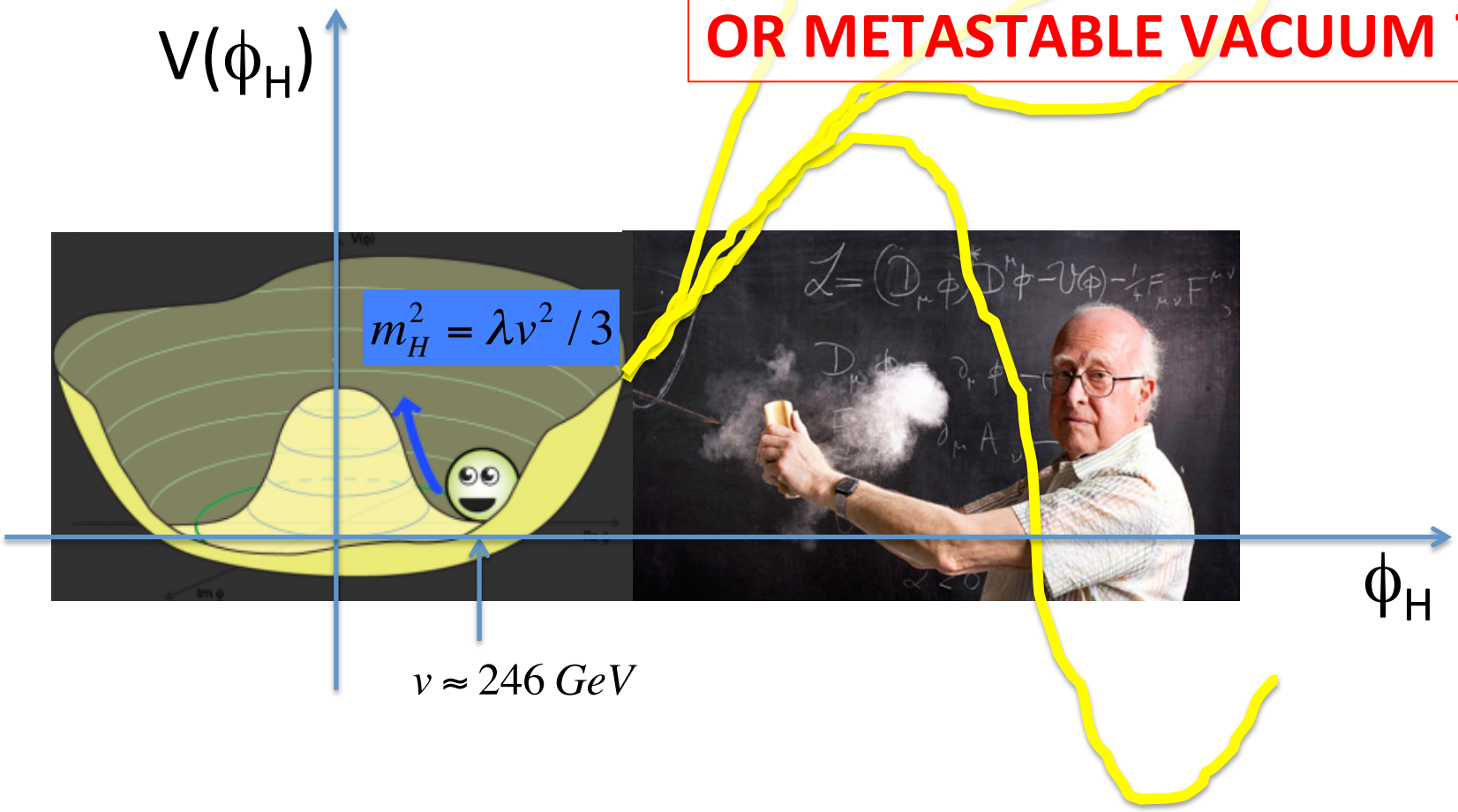

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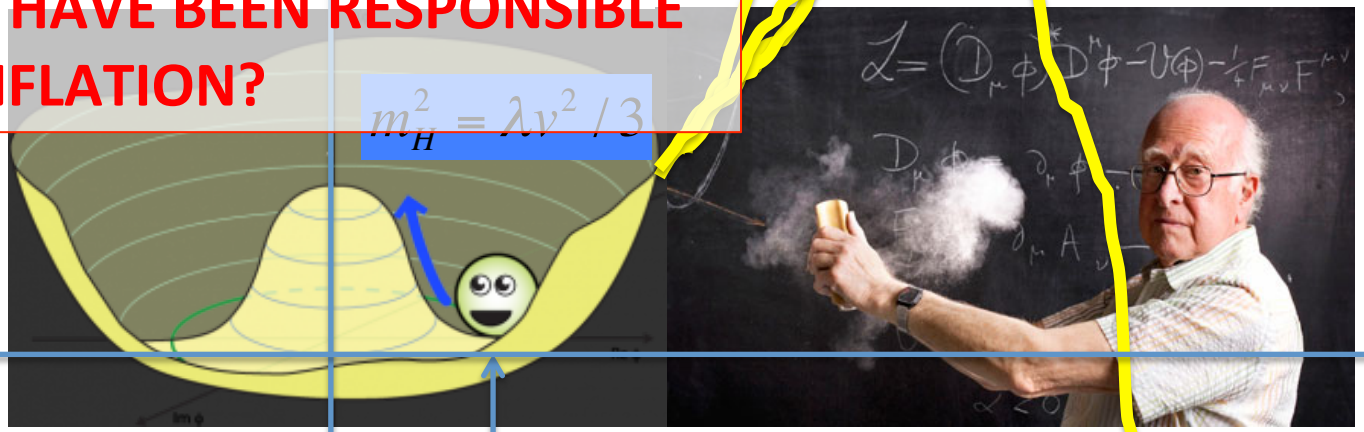
2) IF STABLE, CAN THE HIGH POTENTIAL ENERGY OF THE HIGGS HAVE BEEN RESPONSIBLE FOR INFLATION?



$V(\phi_H)$

ϕ_H

$v \approx 246\ GeV$

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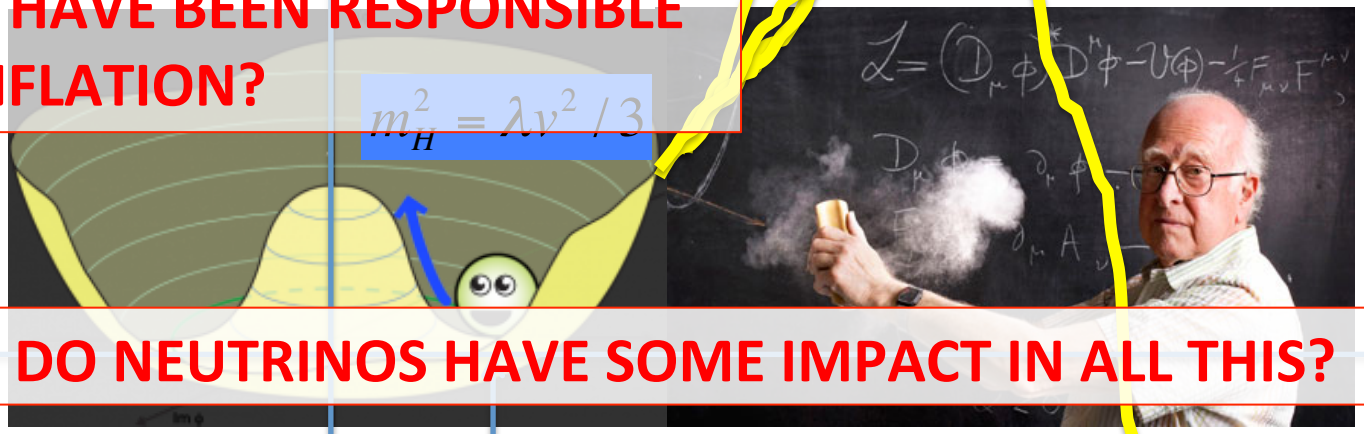

3) DO NEUTRINOS HAVE SOME IMPACT IN ALL THIS?

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[Hung, Cabibbo et al '79, Lindner, Sher, Casas, Espinosa, Quiros, Giudice, Riotto, Isidori, Strumia, etc]

(Assuming desert) extrapolate the SM Higgs potential at renormalization scale μ via RGE.
This can now be done at NNLO!!

3-loop running for: $g(\mu)$, $g'(\mu)$, $g_3(\mu)$, $\lambda(\mu)$, $y_t(\mu)$

[Mihaila Salomon Steinhauser, arXiv:1201.5868]

[Chetyrkin Zoller, arXiv:1205.2892]

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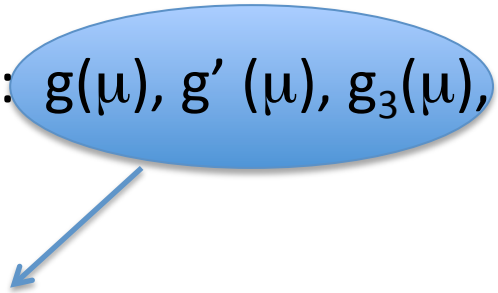

matched directly at m_Z
(larger exp error in α_3)

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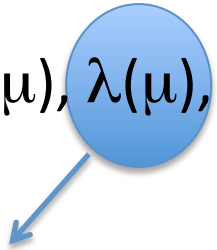

matched at 2-loop via m_H (unavoidable theor error)

[Bezrukov Kalmykov Kniehl Shaposhnikov, arXiv:1205.2893]

[Degrassi Di Vita Elias-Miro Espinosa Giudice Isidori Strumia, arXiv:1205.6497]

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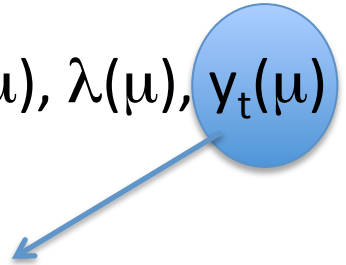

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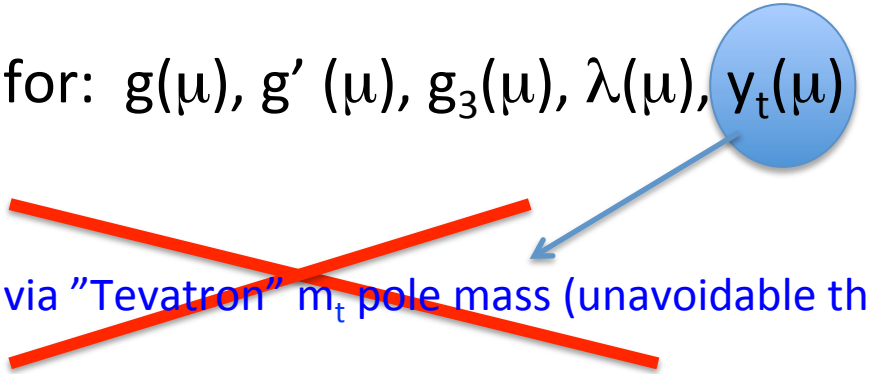


matched at 2-loop via "Tevatron" m_t pole mass (unavoidable theor error)

[Alekhin Djouadi Moch, arXiv:1207.0980]

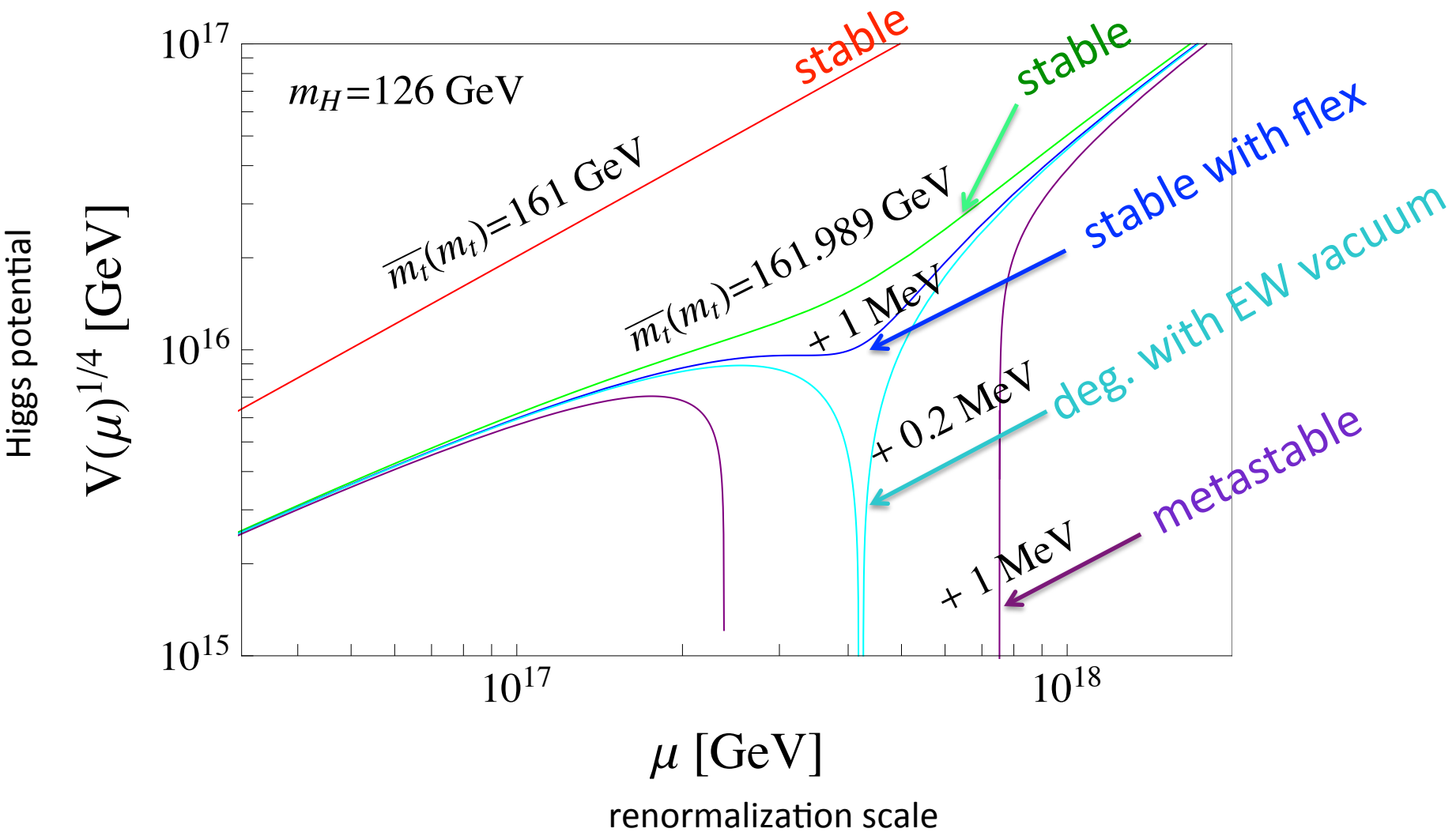
It is inconsistent to use Tevatron measure

BETTER to match directly with MSbar running m_t

$$\overline{m_t}(m_t) = 163.3 \pm 2.7 \text{ GeV}$$

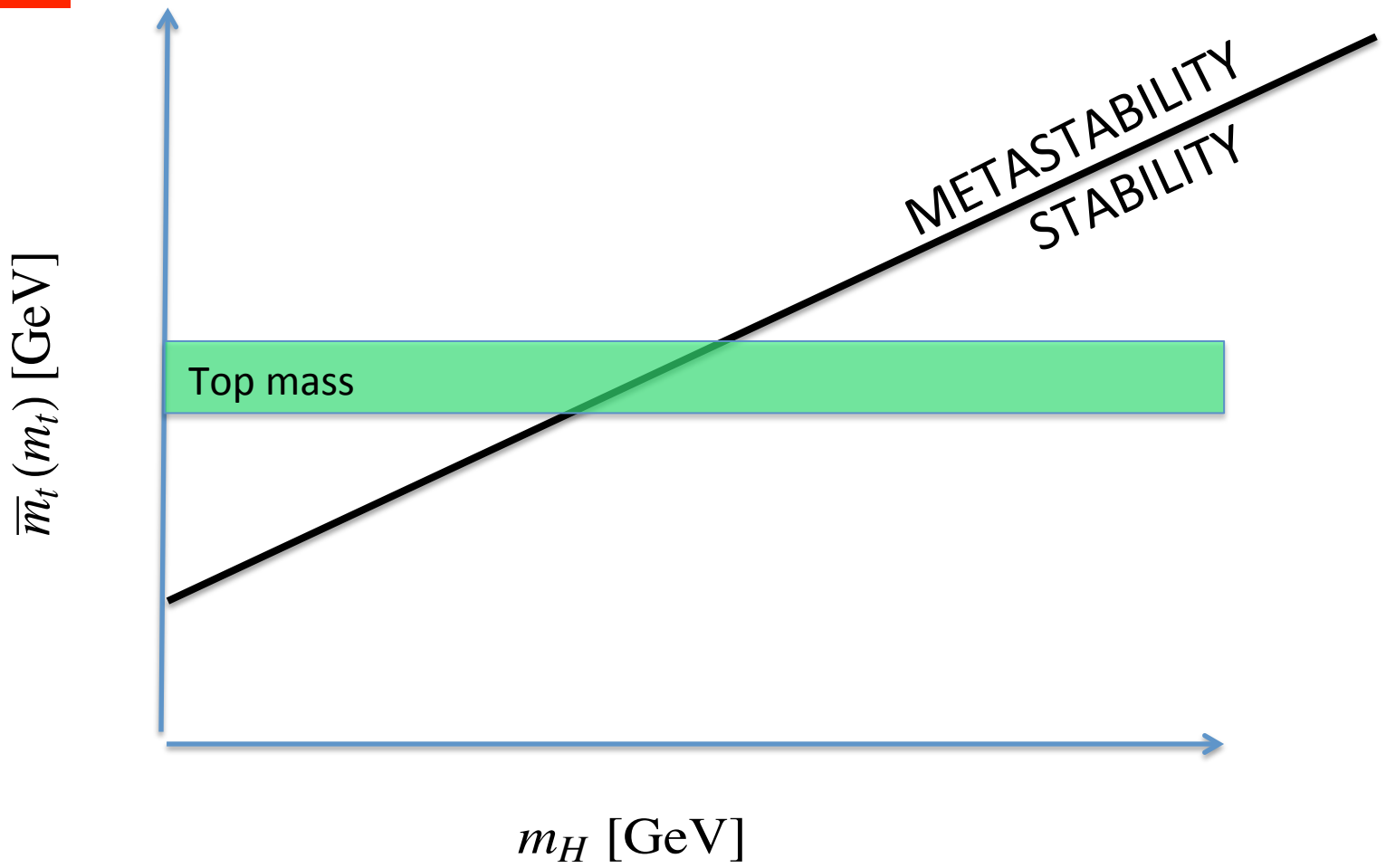
as done in [IM, arXiv:1209.0393]

POSSIBLE SHAPES FOR THE HIGGS POTENTIAL CLOSE TO THE PLANCK SCALE



[IM, arXiv:1209.0393]

RESULTS



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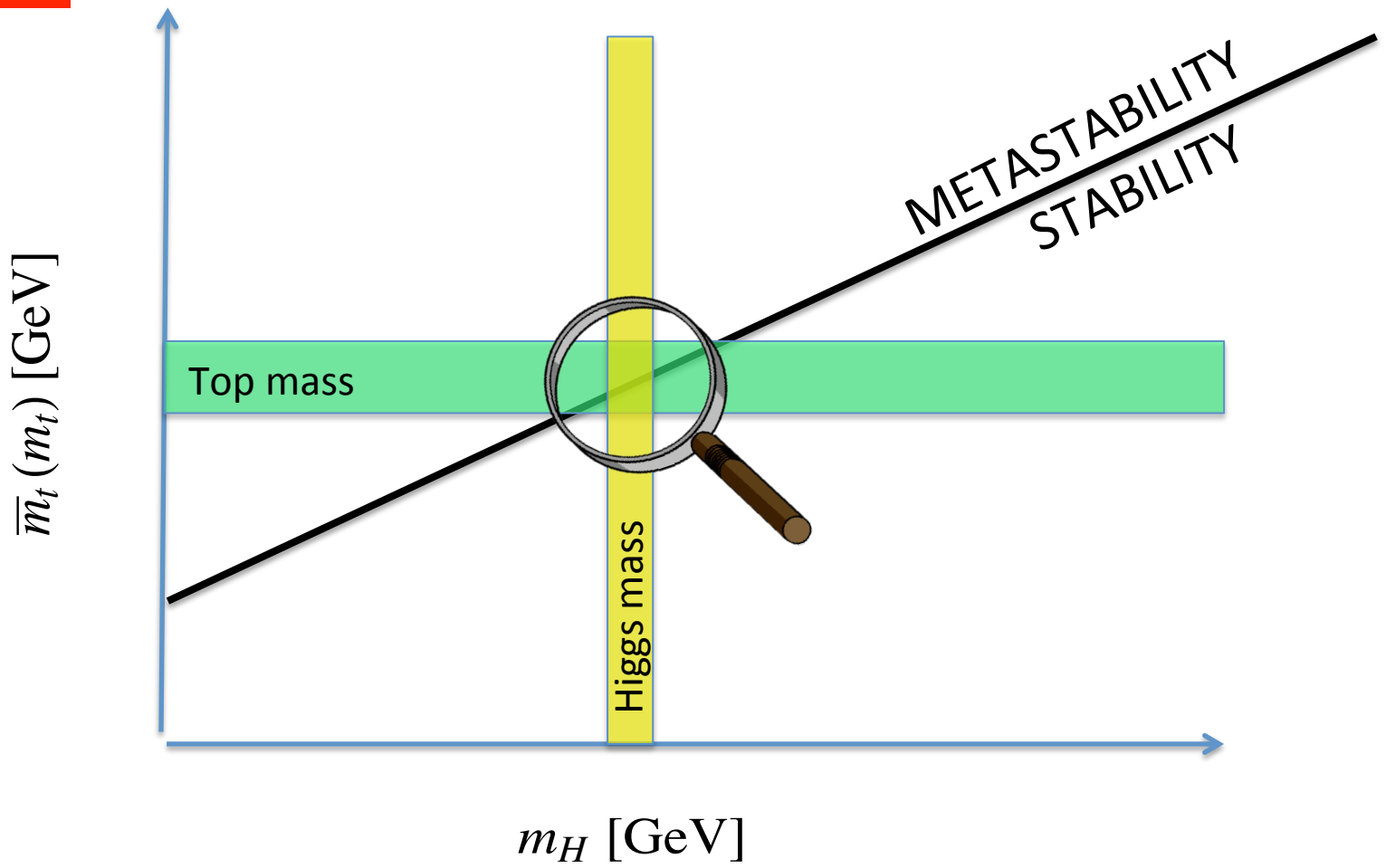

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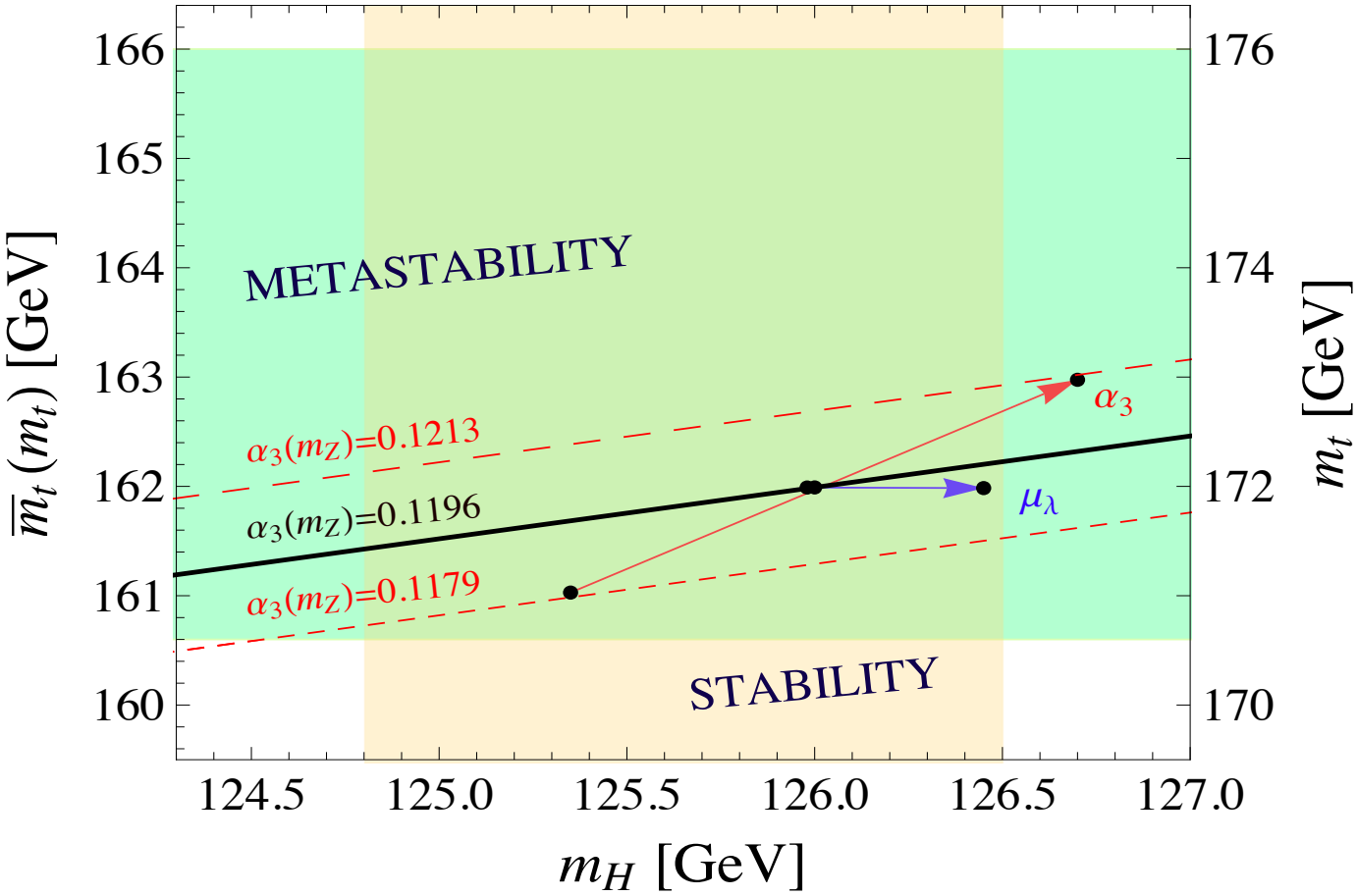

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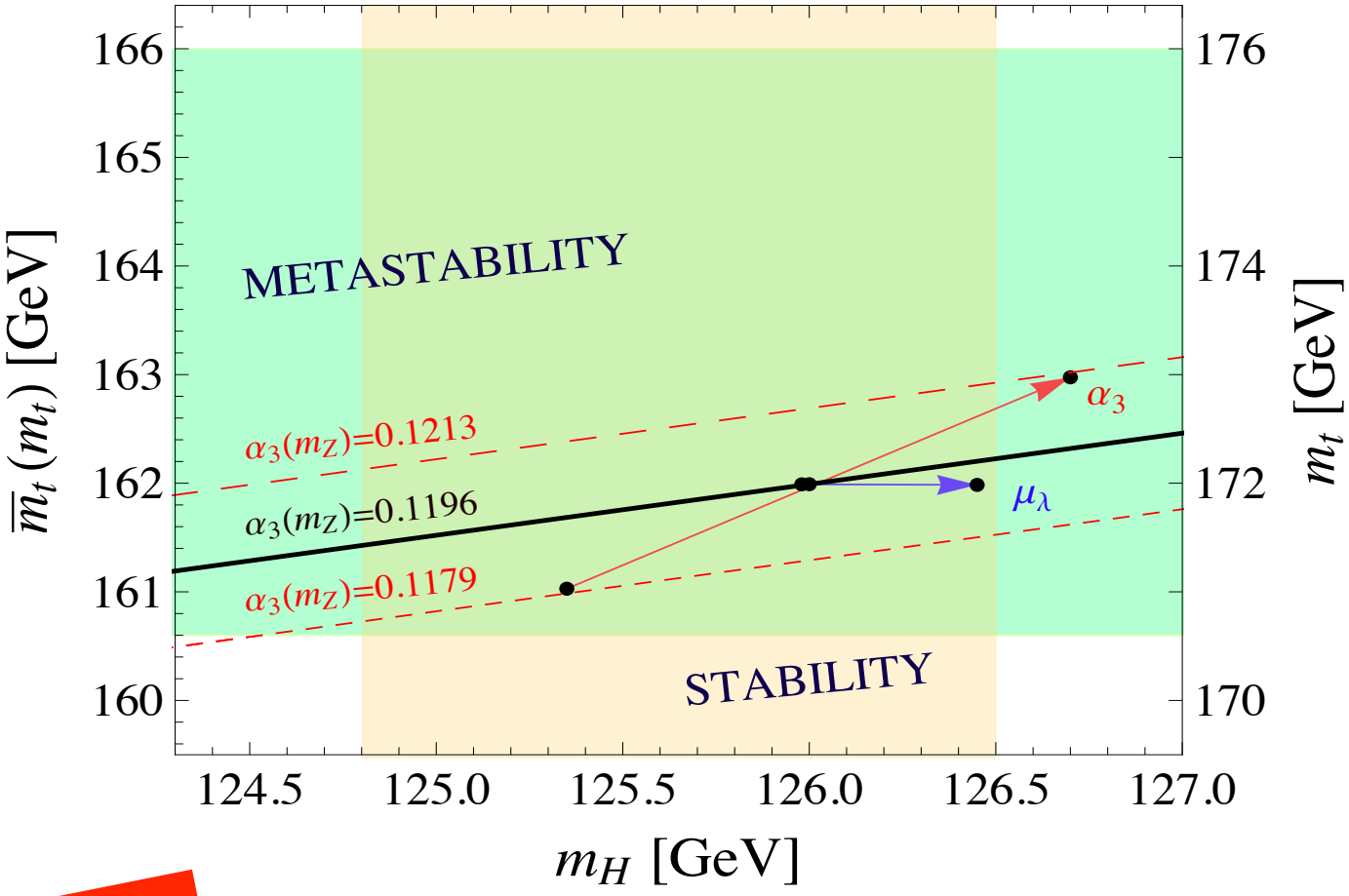


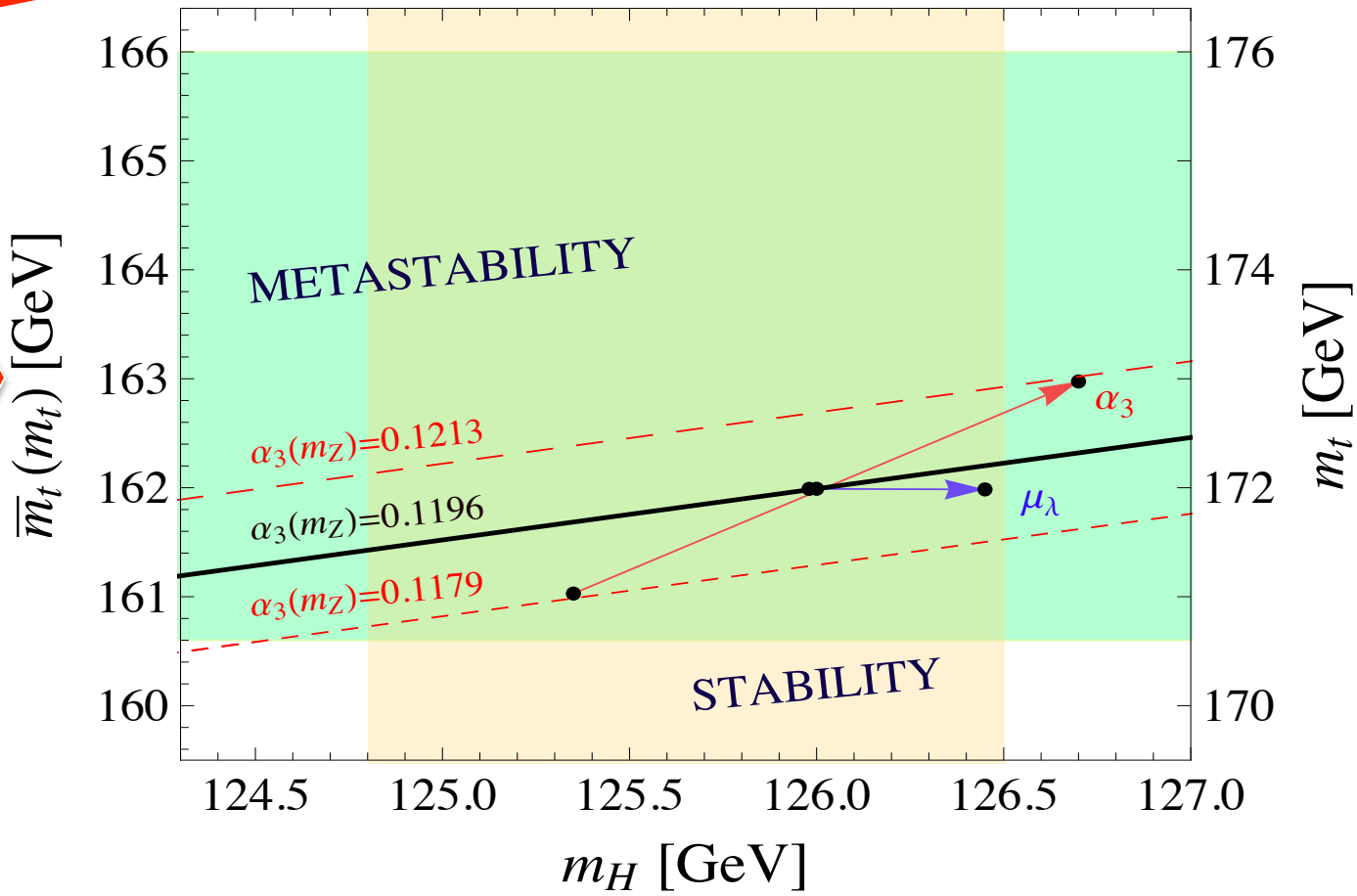
STABILITY BOUND

$$\overline{m_t}(m_t)[\mathrm{GeV}] \leq 162.0 + 0.47\,(m_H[\mathrm{GeV}] - 126) \pm 0.7_{\alpha_3} - 0.2_{\mu_\lambda}$$

[IM, arXiv:1209.0393]

PROSPECTS

NEED MORE PRECISE MEASURE



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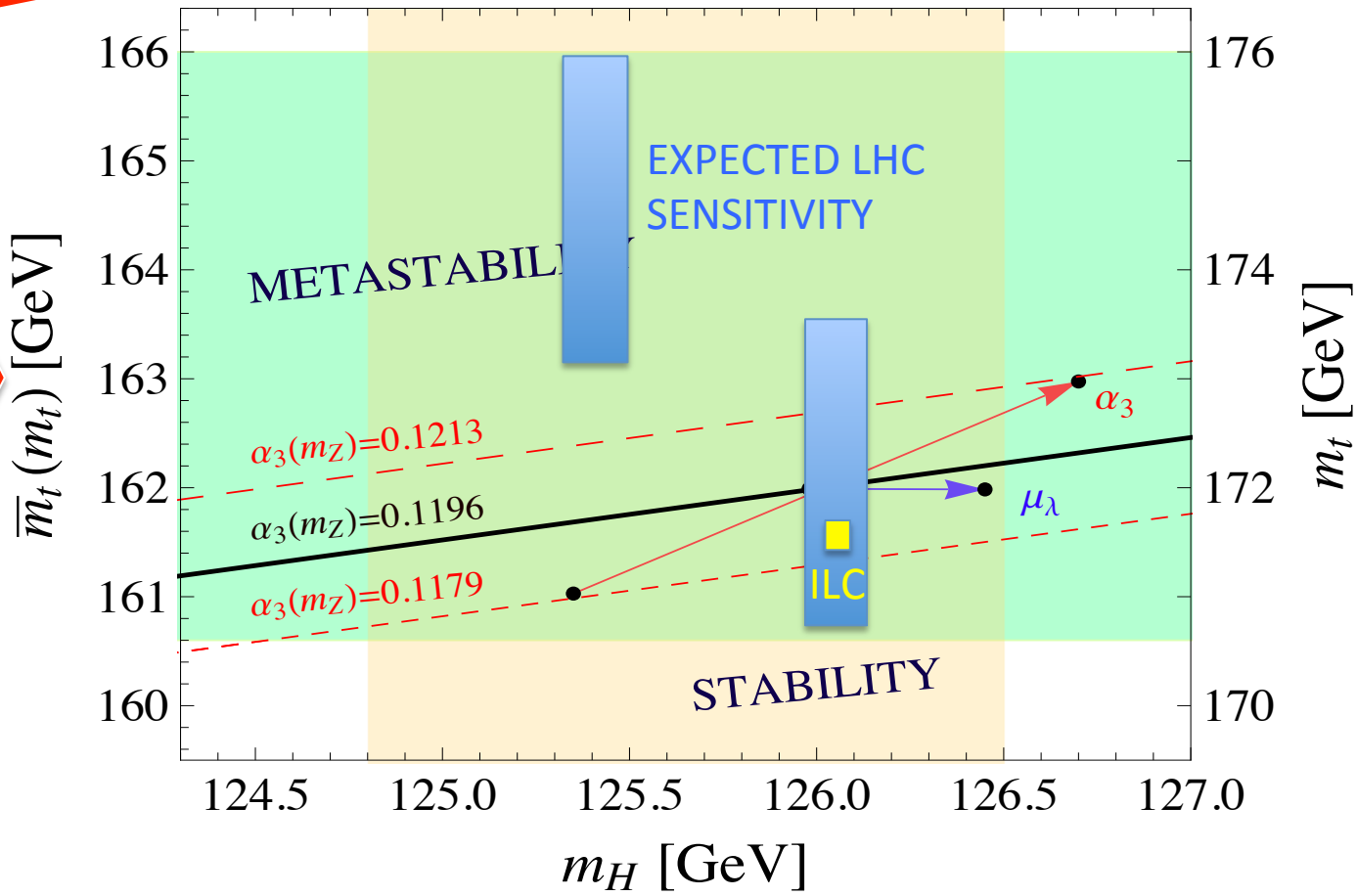

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YES! If, for some reason, there has been a period in which the Hubble rate was dominated by a nearly constant V

$$\left(\frac{\dot{a}(t)}{a(t)}\right)^2 \equiv H(t)^2 \cong \frac{V(\mu_0)}{3M_{Pl}^2}$$

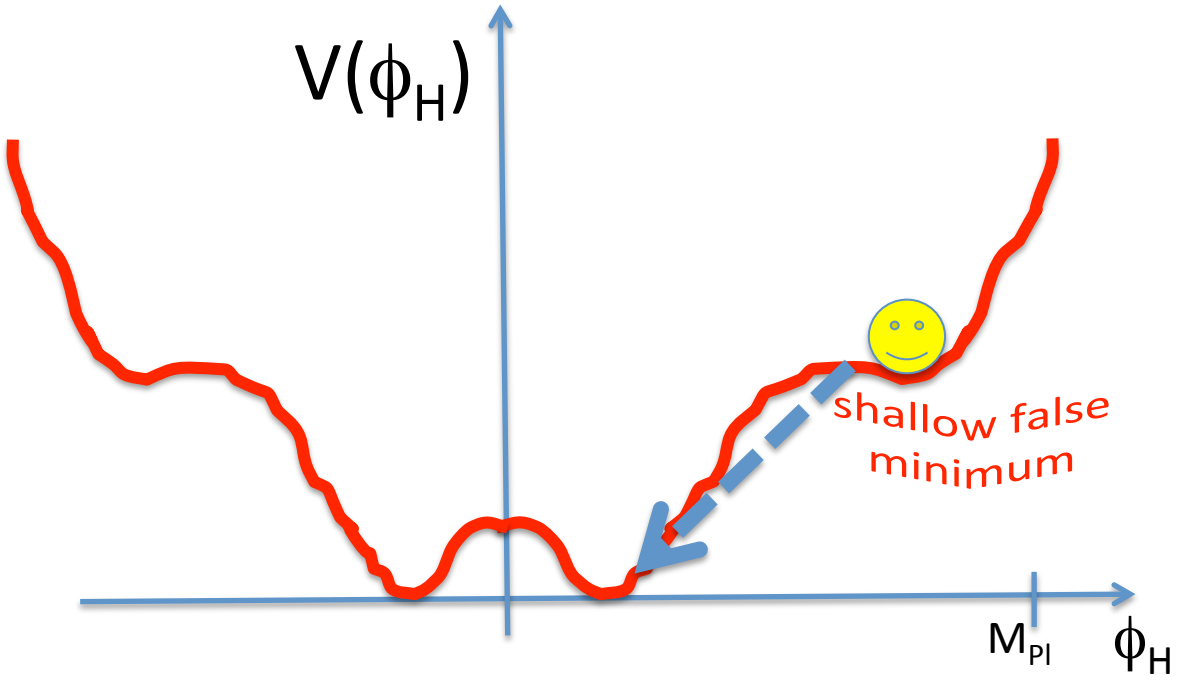
V acts as cosmological constant term

$$a(t) \propto e^{Ht}$$

EXPONENTIAL EXPANSION

EXAMPLE 1

A stable configuration like a shallow false minimum with the Higgs trapped in it during inflation, which ends because of some other mechanism



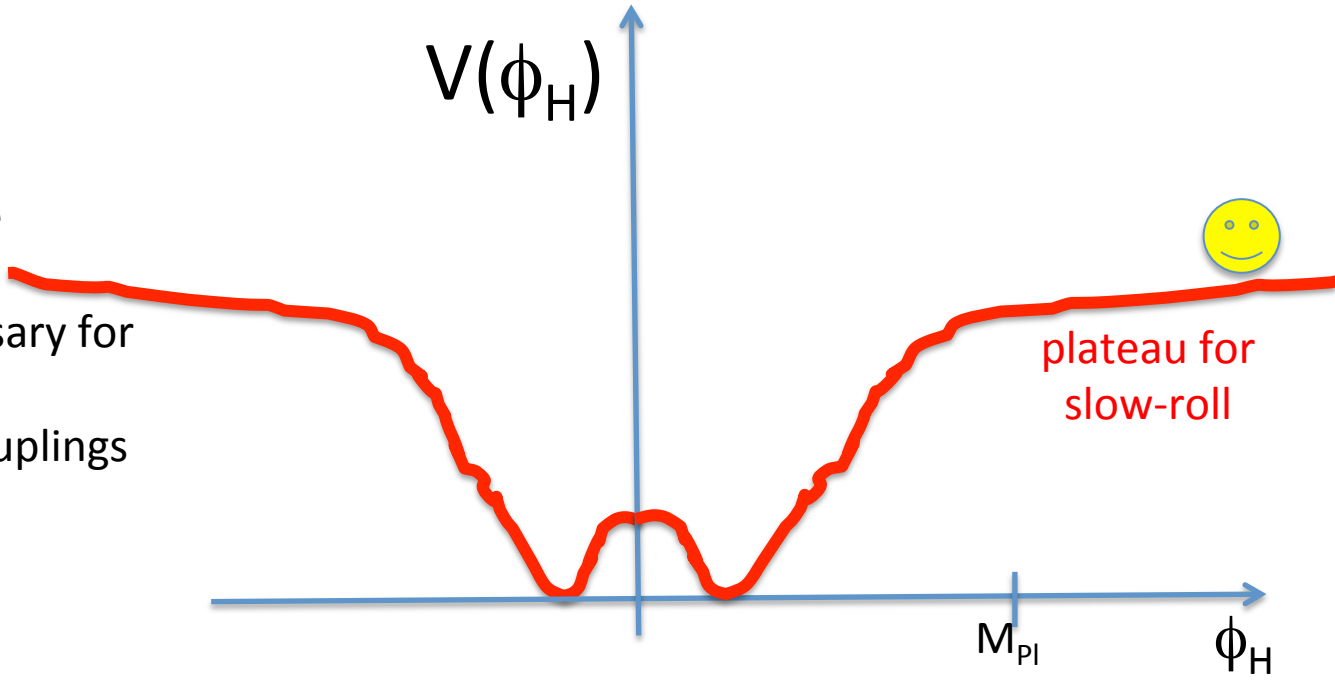
A model in scalar-tensor gravity & a model with hybrid inflation

IM Notari, arXiv:1112.2659, 1204.4155

n_s is quite model dependent but tensor-to-scalar-ratio r is not
→ these models can be tested IM Notari, arXiv:1112.5430

EXAMPLE 2

A configuration more
(or as stable as)
an inflection point is necessary for
Higgs inflation via
non-minimal gravitation couplings



Model discussed in

Bezrukov Shaposhnikov, arXiv:0710.3755, …, 1205.2893

3) DO NEUTRINOS HAVE SOME IMPACT IN ALL THIS?

[Casas Ibarra Quiros, Okada Shafi, Giudice Strumia Riotto, Rodejohann Zhang, etc]

Type I seesaw Dirac Yukawa interactions neutrinos could destabilize V…

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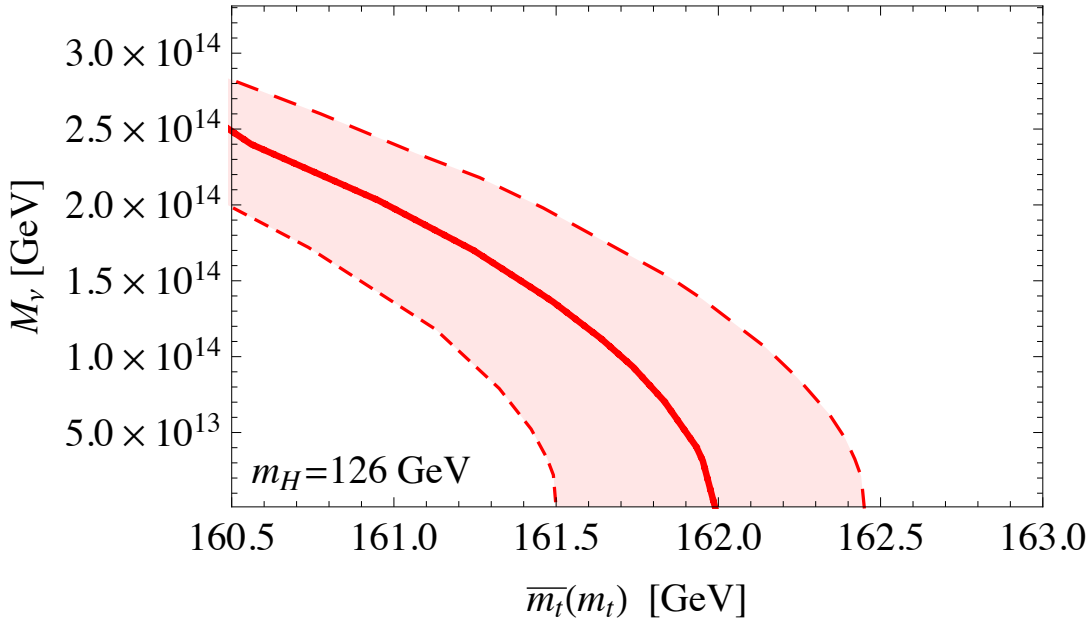

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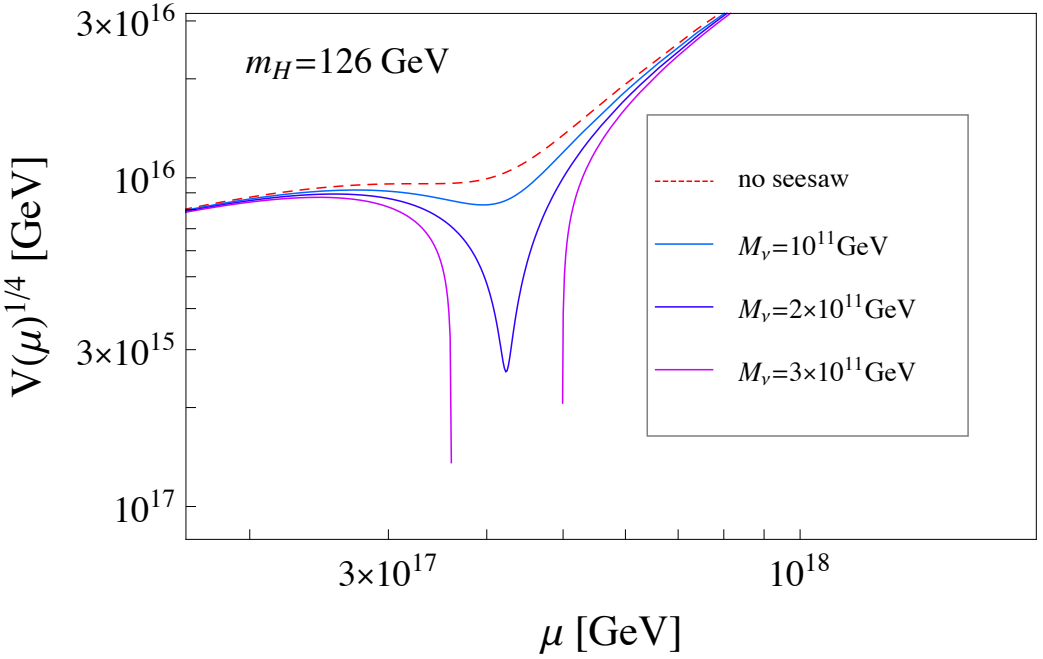
More stringent if one starts from an inflection point configuration



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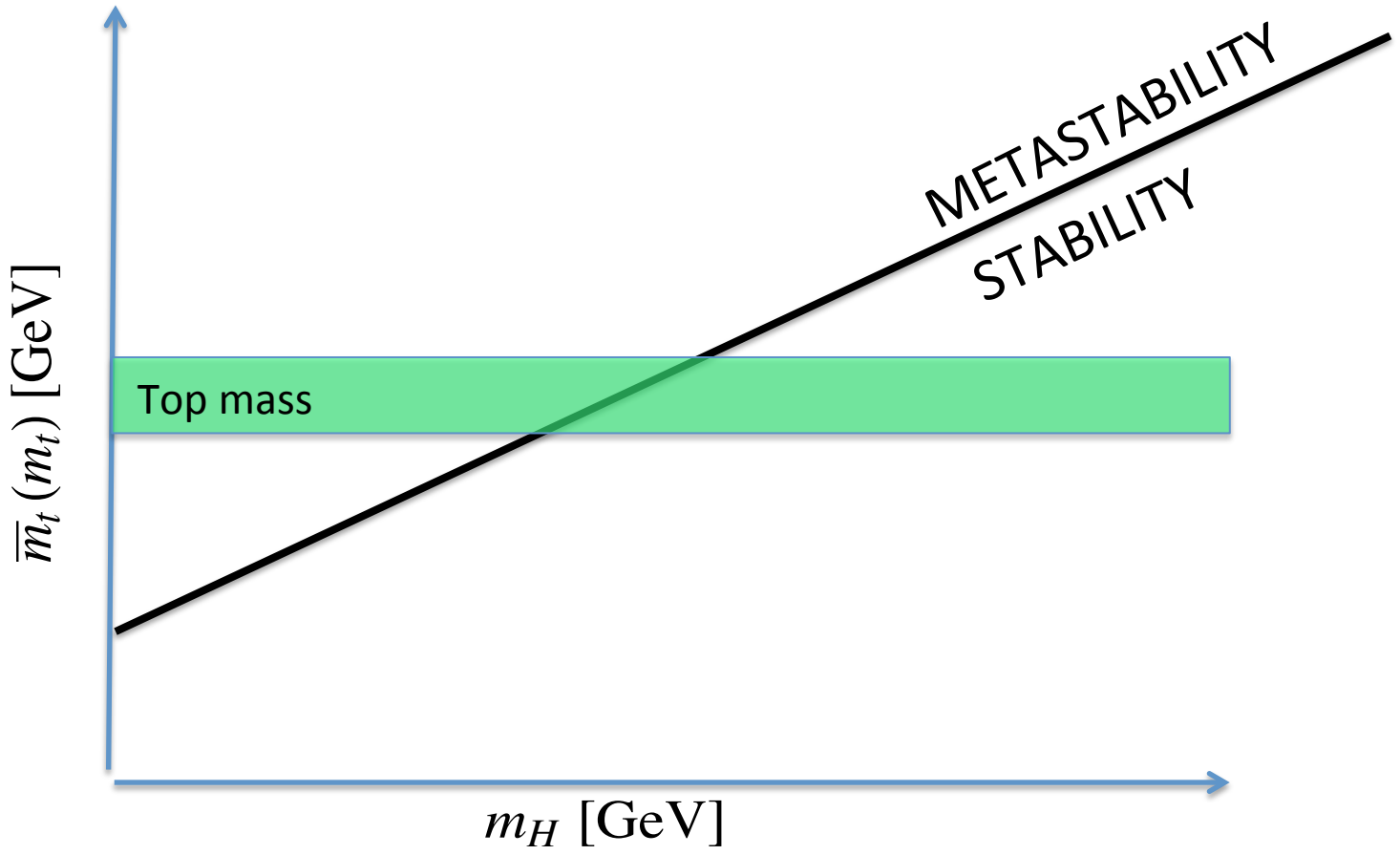
CONCLUSIONS



CONCLUSIONS

1) Intriguing that m_H was found right at the transition between stability and metastabilty

2) Some stable SM configurations very close to transition line (like e.g. shallow false minimum) might have been relevant for primordial inflation