The modified Higgs potential and the new physics at the collider

Takuya Kakuda

Niigata/Osaka

PRD.88 (2013) 035007

TK, K.Nishiwaki, K.Oda, R.Watanabe
& work in progress with K.Oda

Current status of Universal Extra Dimensions in LHC era

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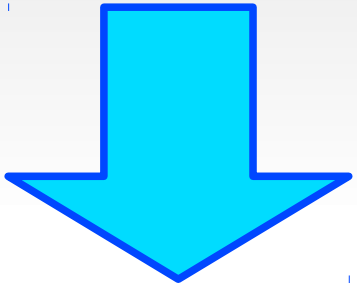
Theme

How extra dimensions excluded by LHC?



1.Culclation of **KK loop effects**

2.Estimate **vacuum stability**

Theme

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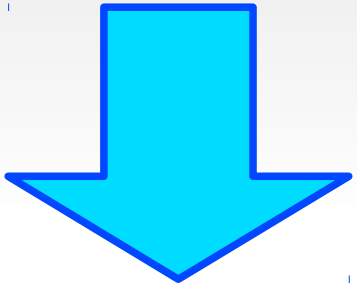

1. Culclation of **KK loop effects**

   LHC Higgs search & S,T parameters

2. Estimate **vacuum stability**

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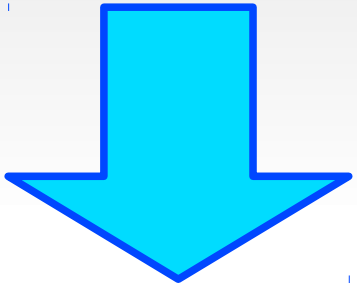


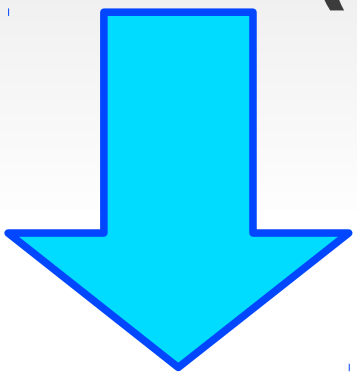
1. Culclation of **KK loop effects**

   LHC Higgs search & S,T parameters

2. Estimate **vacuum stability**

We focus on KK loop

Standard Extra-Dim. analysis searches KK number violation effect (or marks of mass splitting)



Strongly depend on models...

KK mass spectrum is almost detail independent!

→ KK loops effects are universal

We focus on KK loop

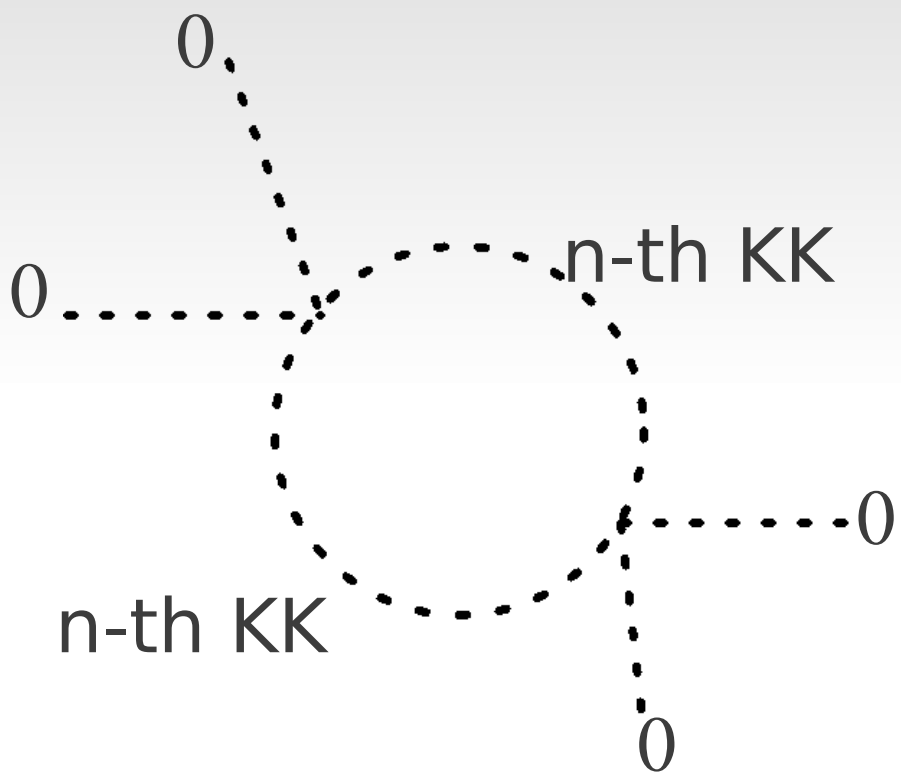
Standard Extra-Dim. analysis searches **KK number violation** effect (or marks of mass splitting)

We focus on 5D and 6D Universal Extra Dimensions.

→ **KK loops effects are universal**

We calculated KK loops

$$\sum_{n}$$



+ ...

contents

1,We focus on KK loop analysis in UEDS

2,Bound on M_{KK} from LHC Higgs search ~around 1TeV

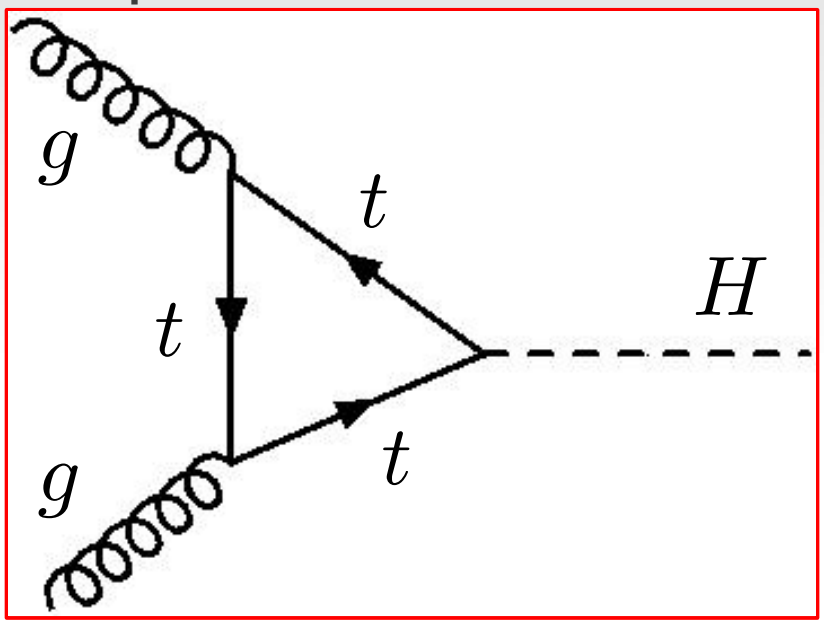
3,126GeV Higgs killed 6D UEDs

2,Bound on M_{KK} from LHC Higgs search

$\sim$around 1TeV

KK top loops enhance Higgs production

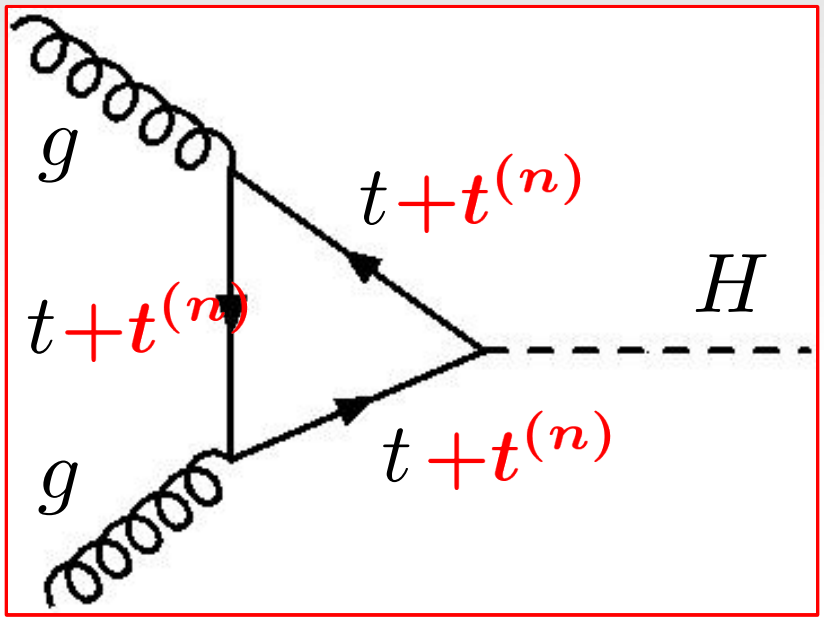
Main production channel(~90%)



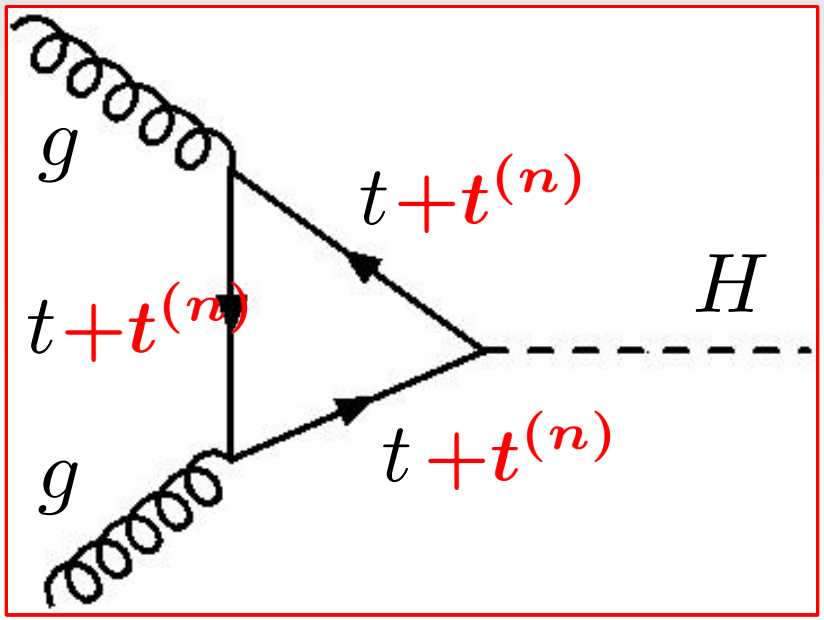
+

Vector boson fusion, etc..(~10%)

KK top loops enhance Higgs production



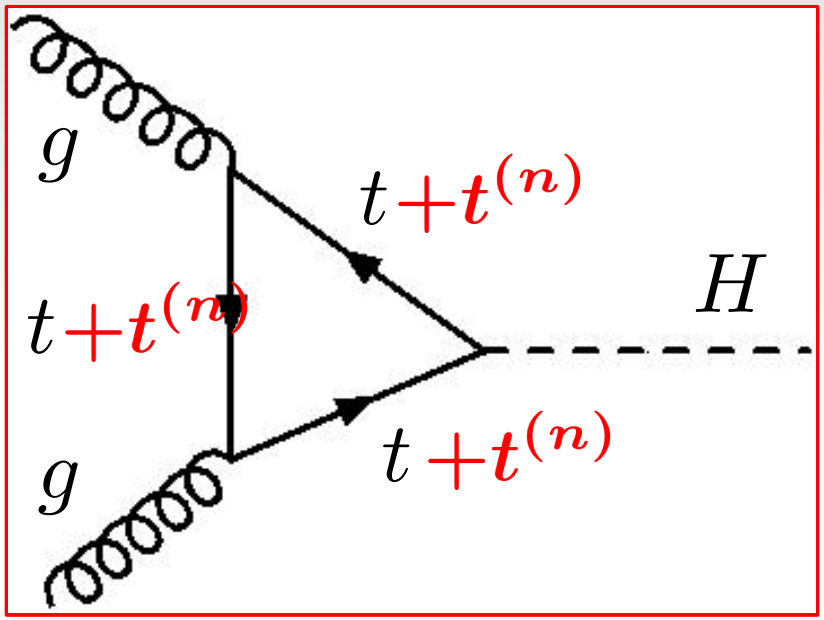
KK top loops enhance Higgs production



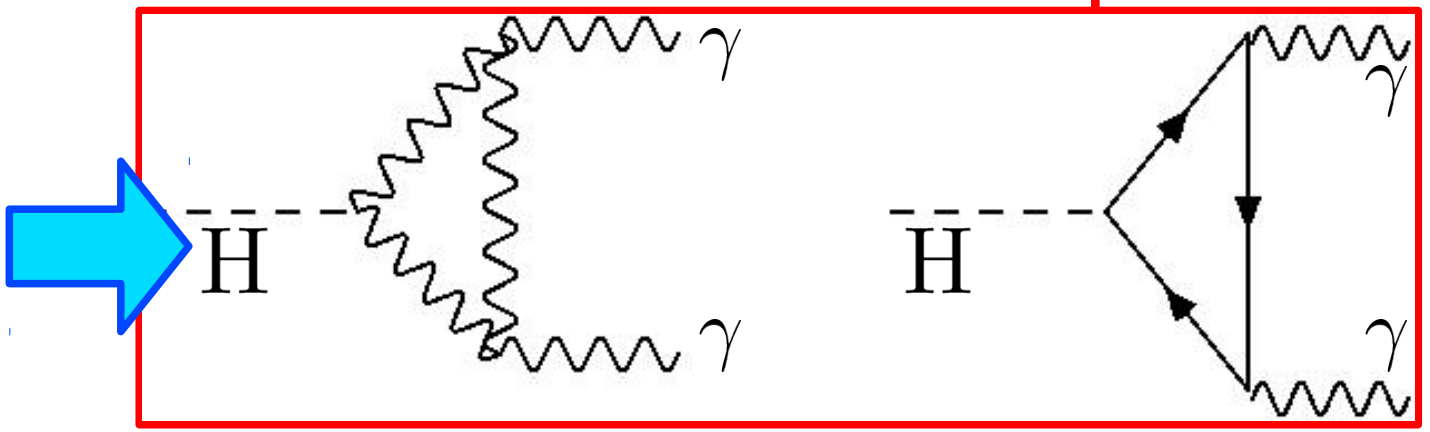
$$H \to \gamma\gamma$$
$$H \to ZZ$$
$$H \to WW$$
$$H \to bb$$
$$H \to \tau\tau$$

We search signal strength in UED

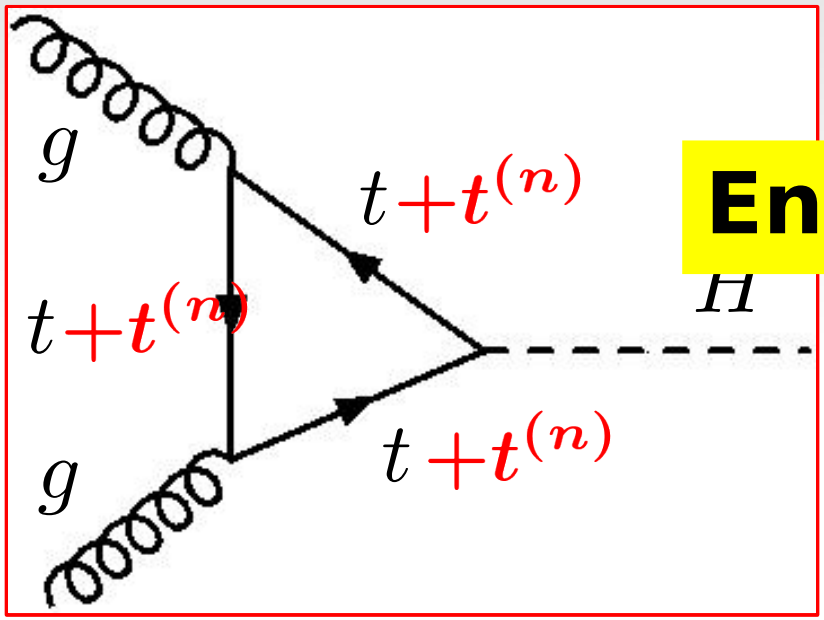
KK top loops enhance Higgs production



γγ decay also loop induced....

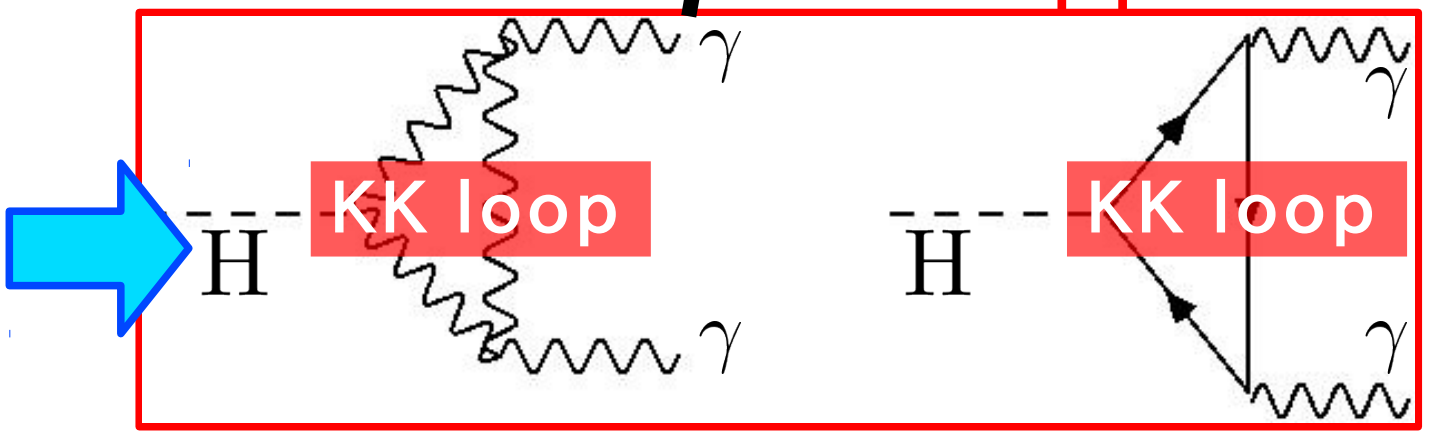


KK top loops enhance Higgs production



Enhancement>Suppression

γγ decay suppressed



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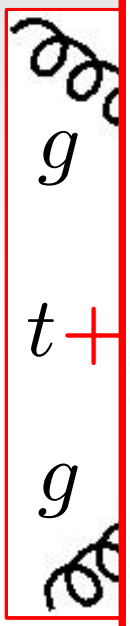
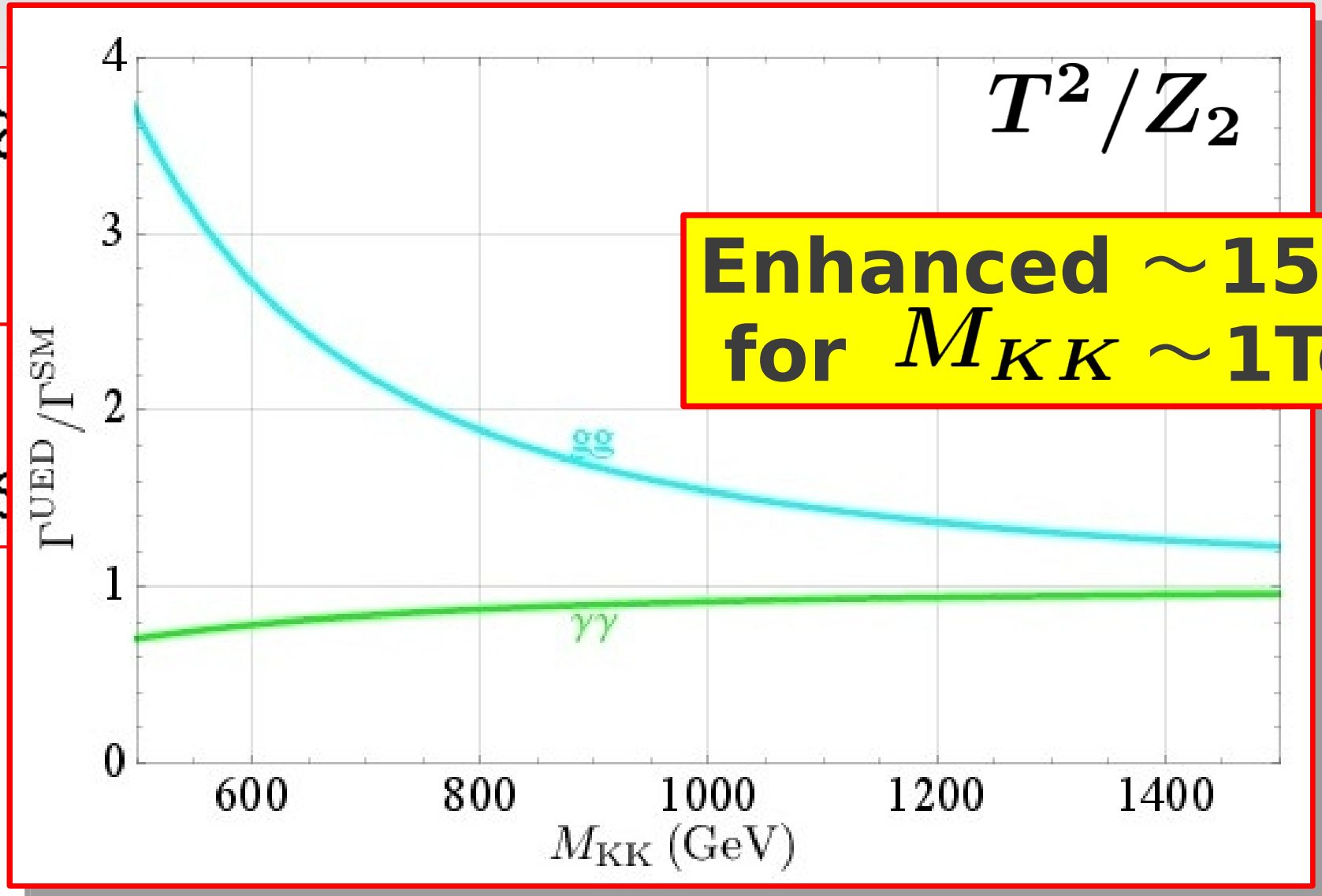
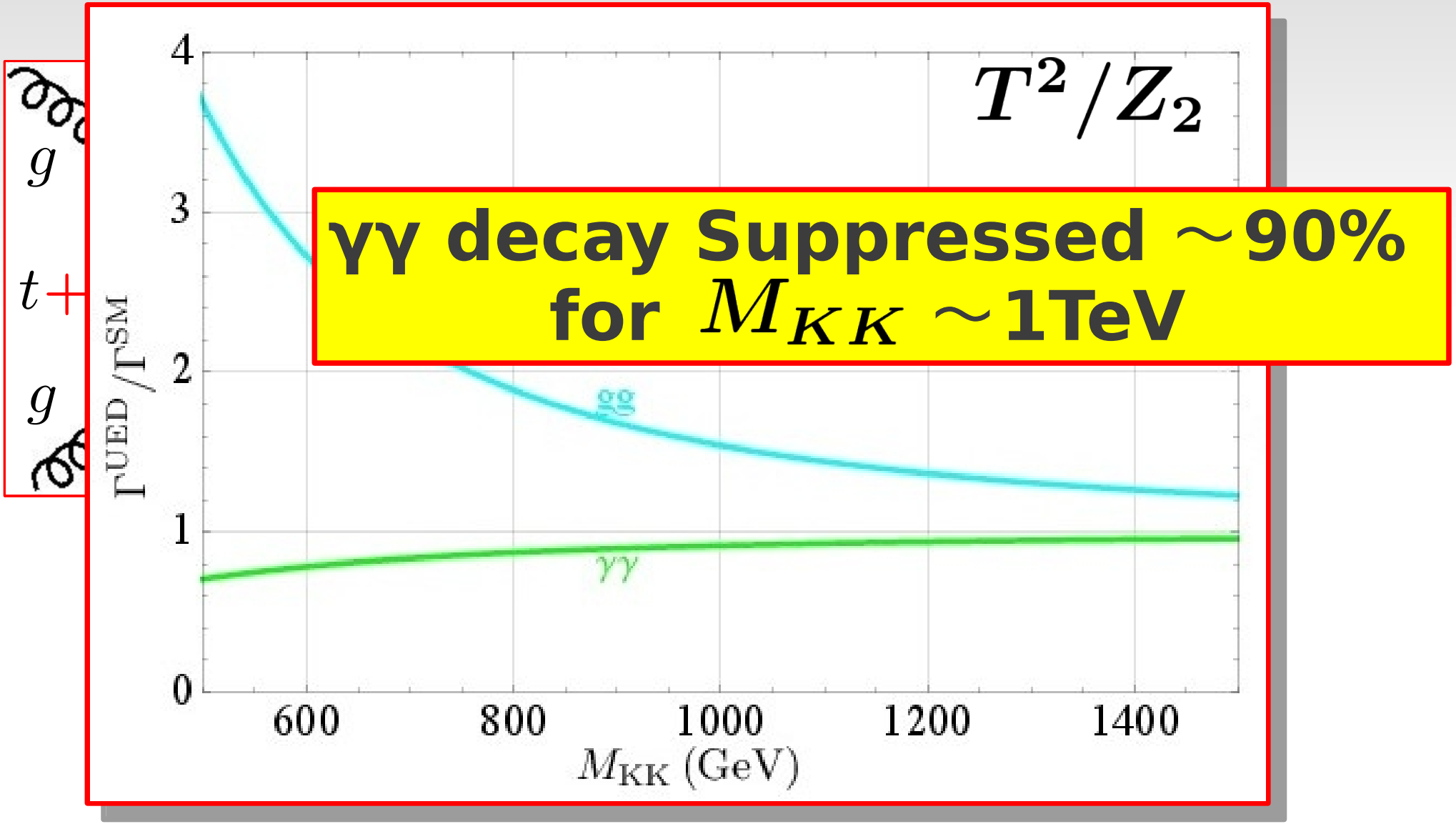


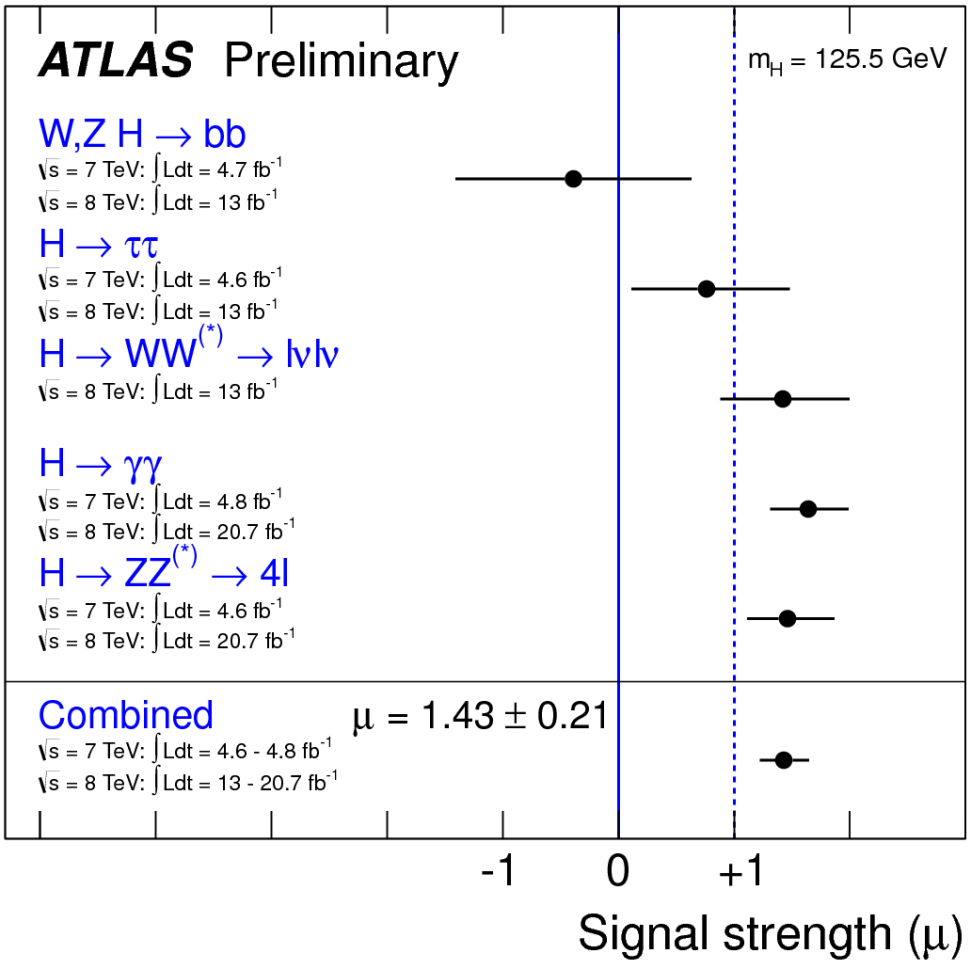


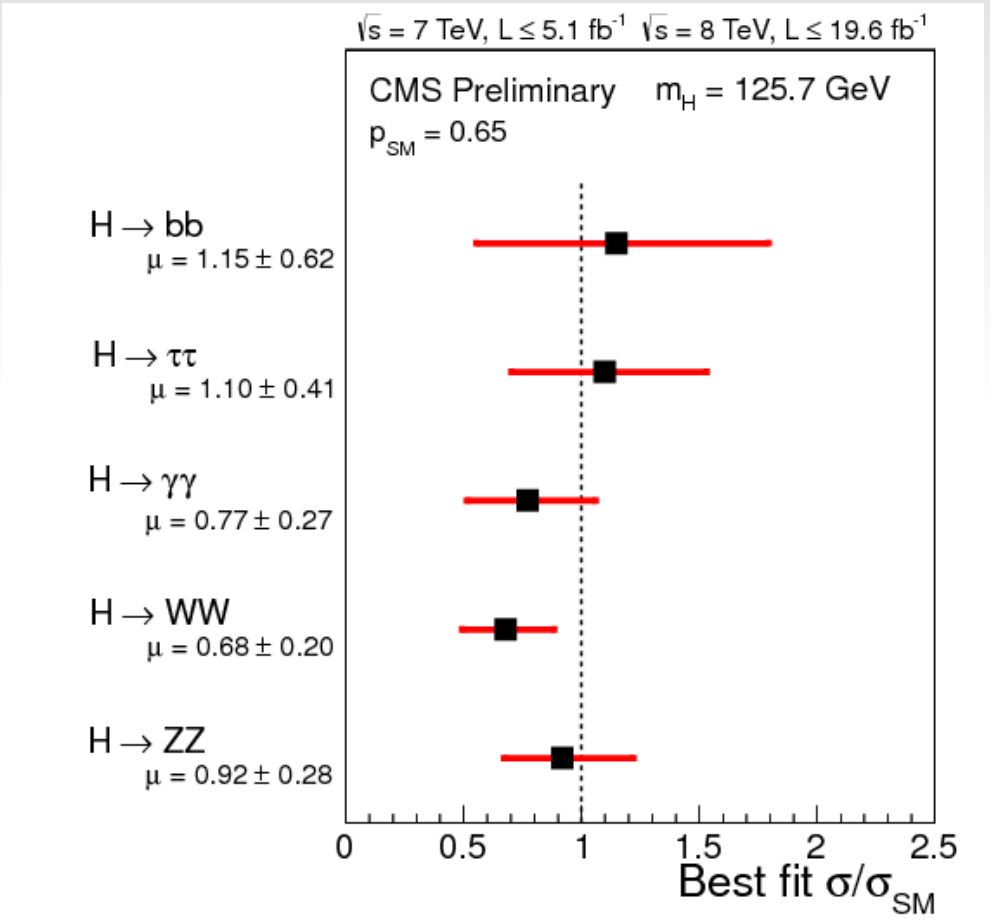
Enhanced ~150% for M_{KK} ~1TeV

KK top loops enhance Higgs production



Signal strength data at LHC

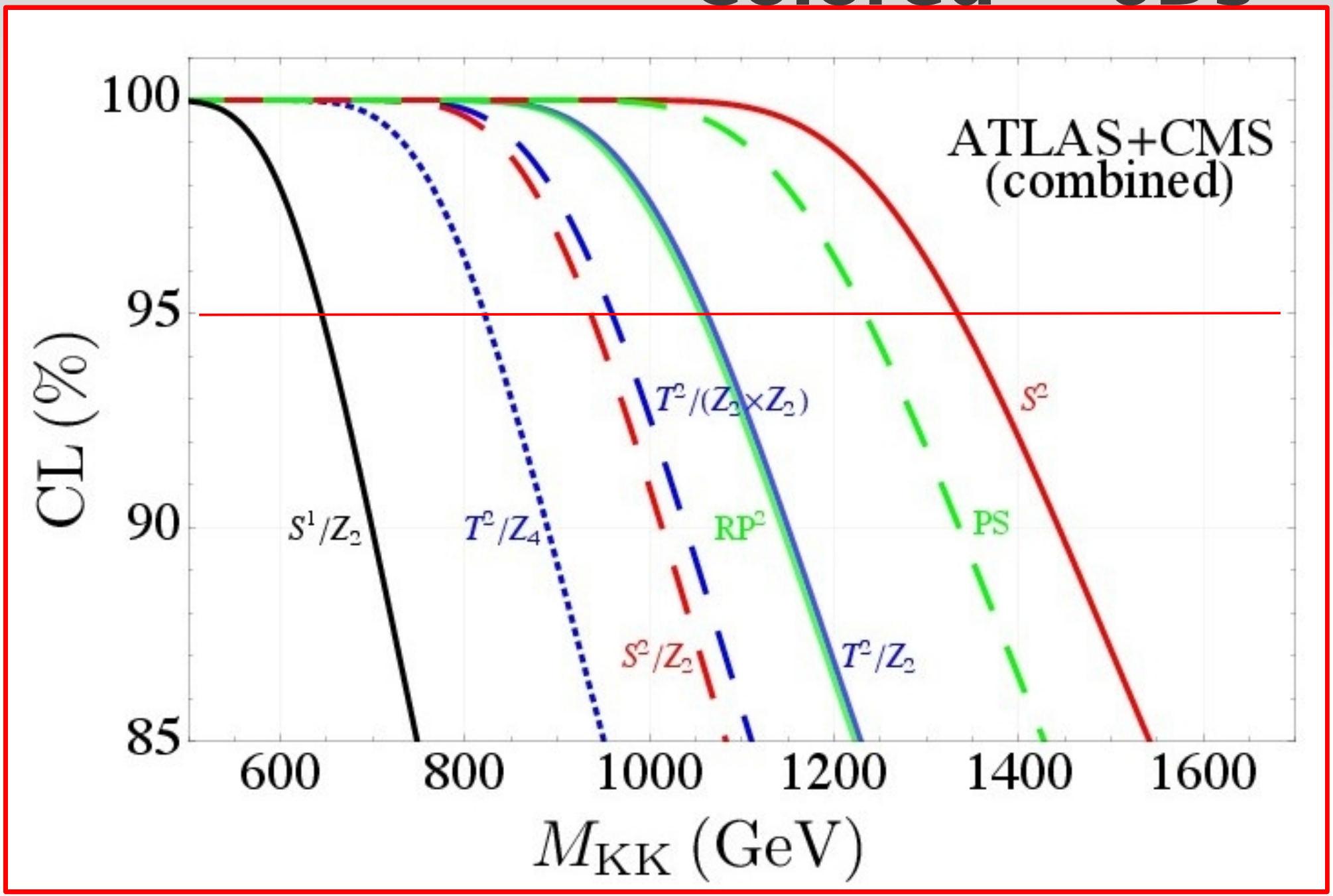




March 2013

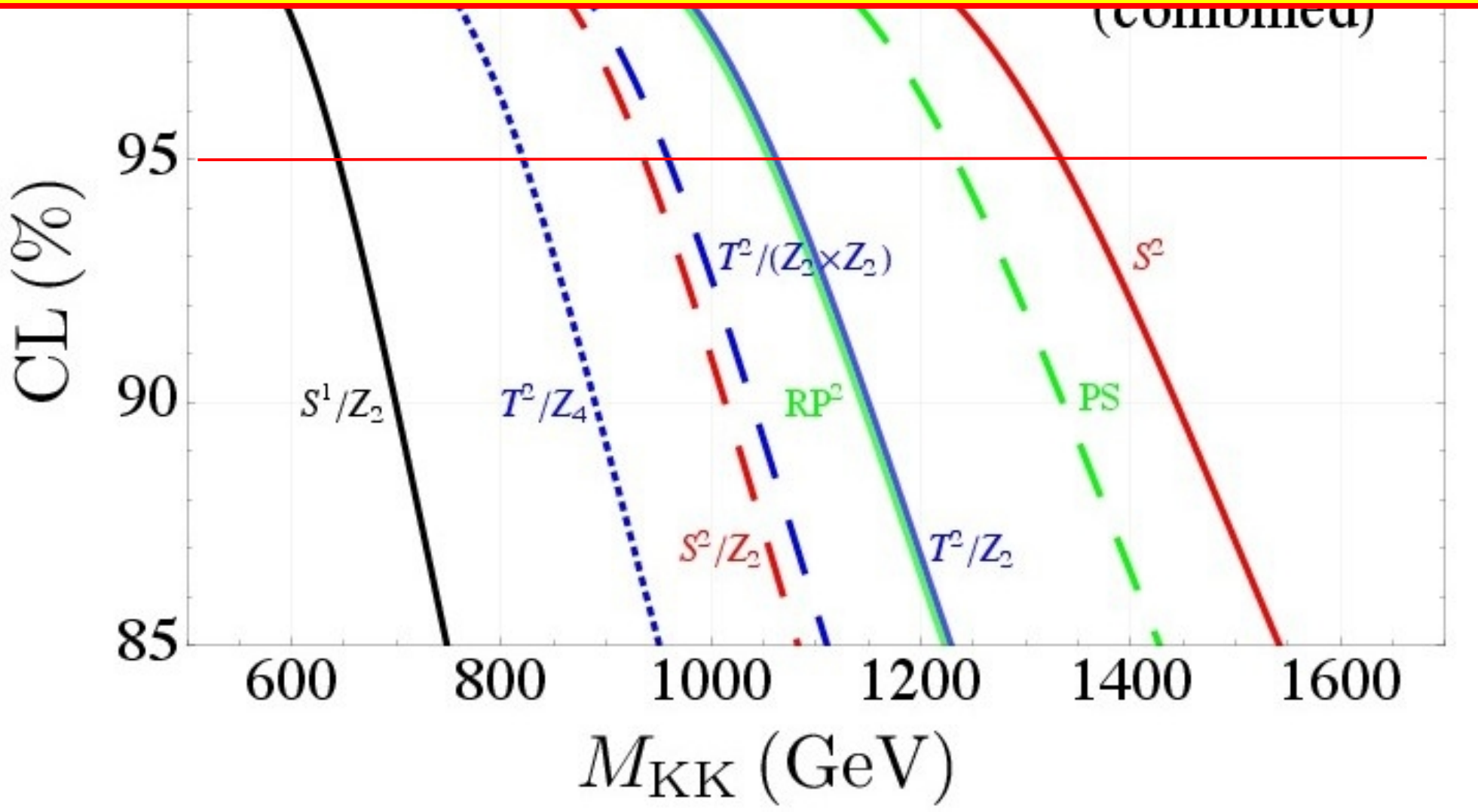
M_{KK} fitting

Black = 5D
Colored = 6Ds



mUED : $M_{KK} > 650$ GeV

6D UED : $M_{KK} > 850$ GeV-1.4 TeV



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3,126GeV Higgs killed

6D UEDs

Tree effective potential

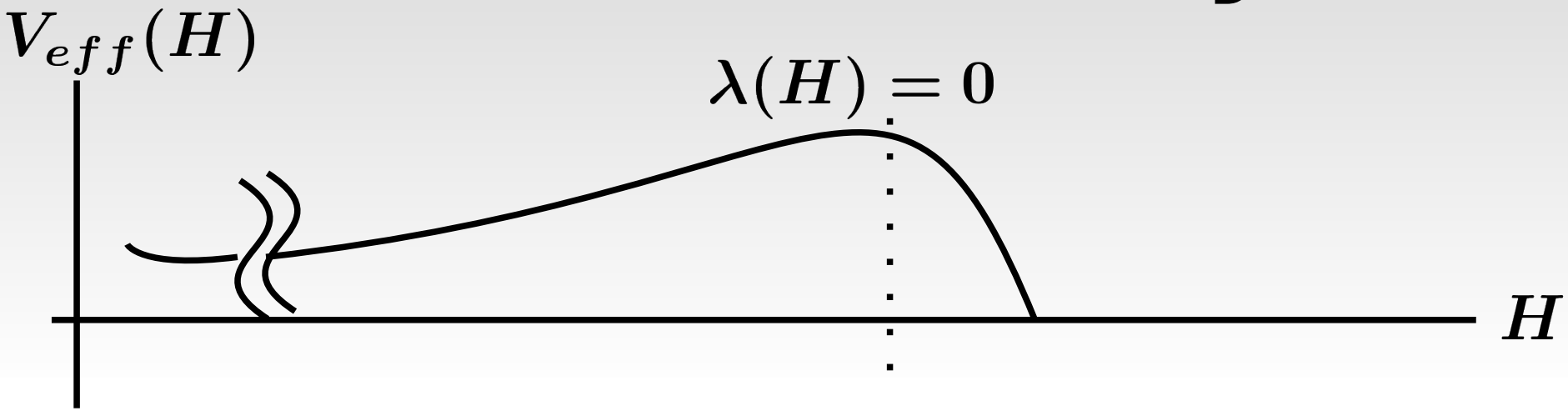
$$V_{eff} = m^2 H^2 + \lambda H^4$$

↑improve by 1-loop RGE in UED

Higgs discovery→RGE solved

RGE in UED? → Rapid running by KK loops

We focus on vacuum stability



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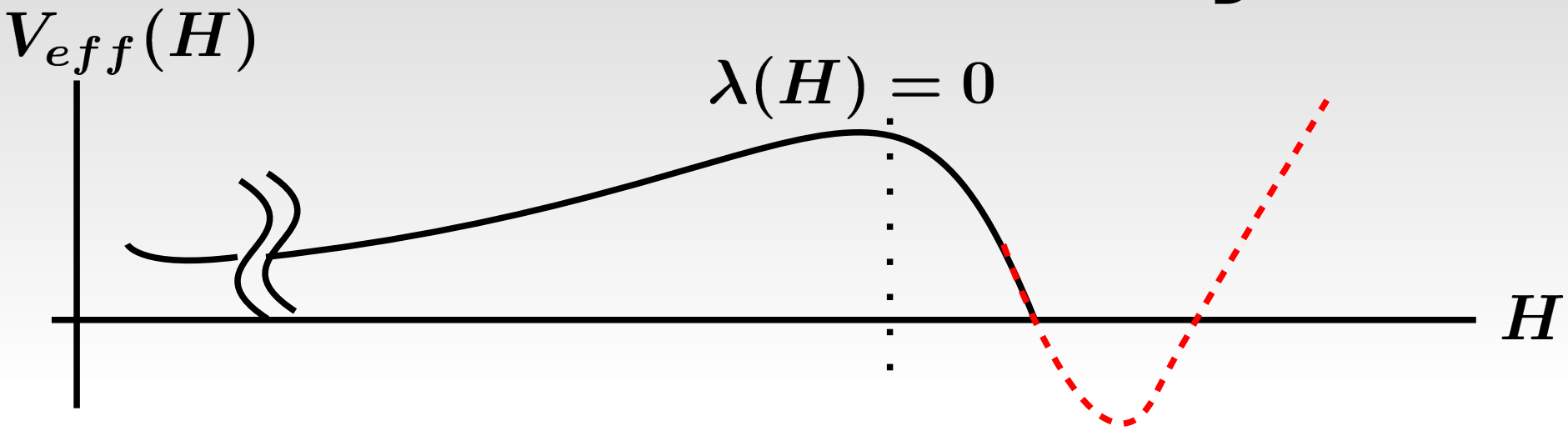

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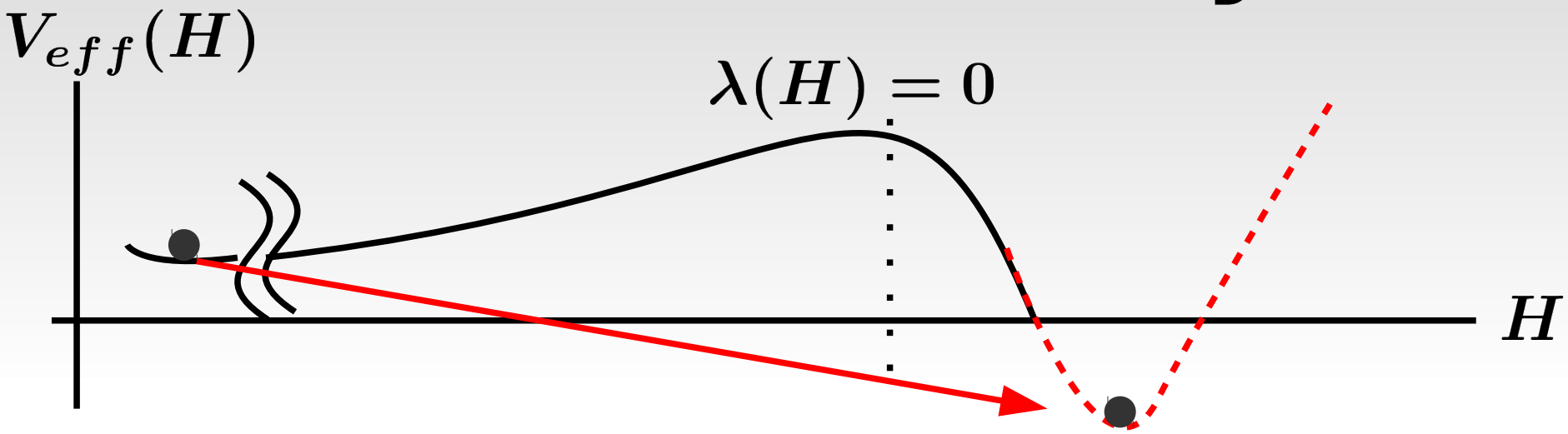

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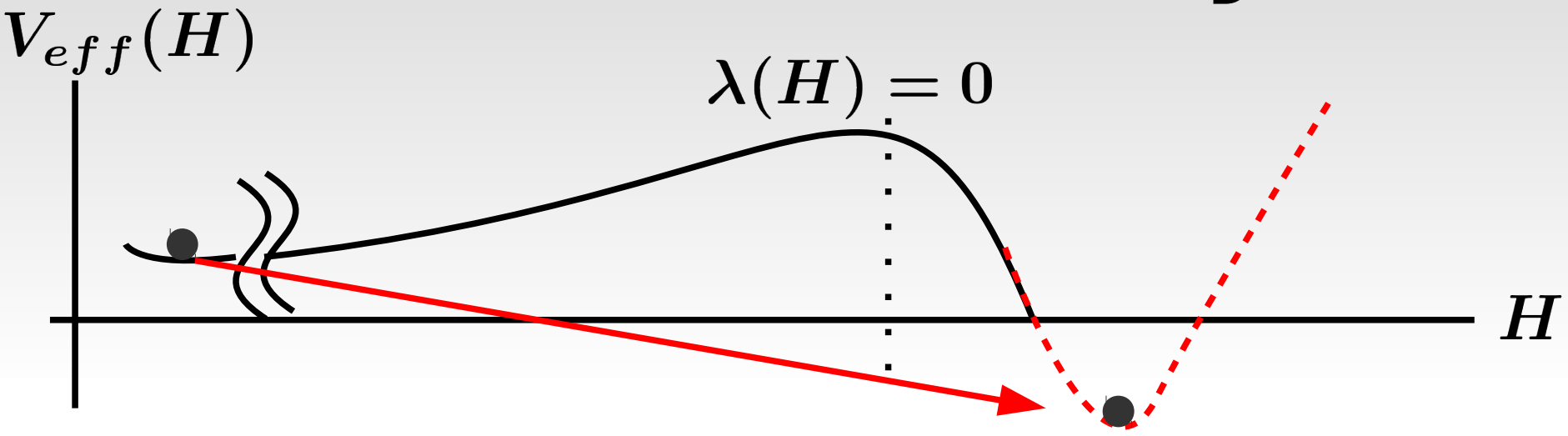
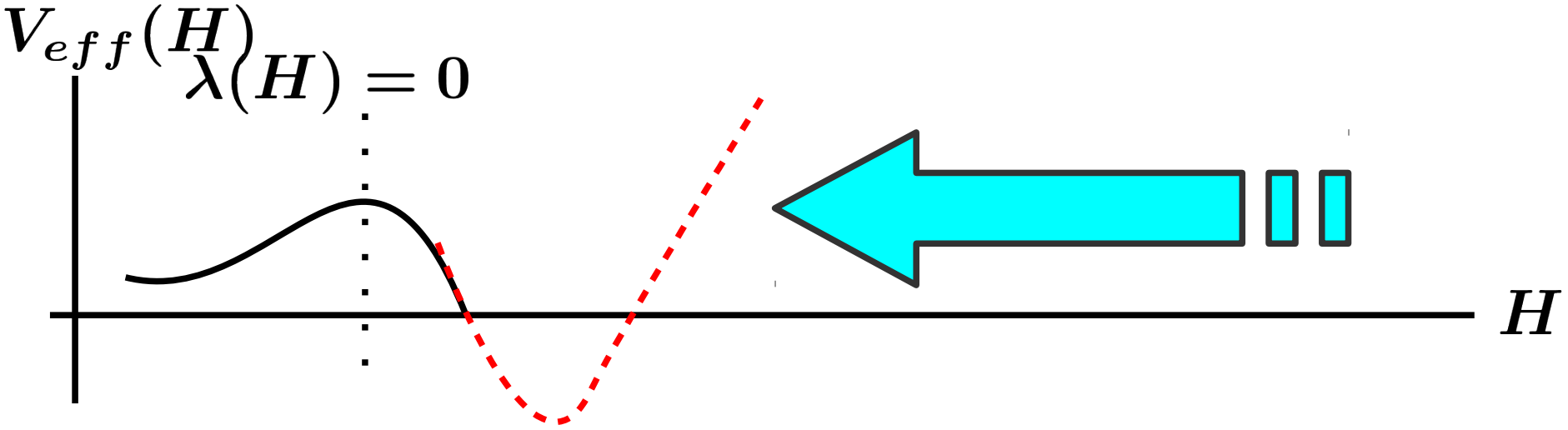


UED case



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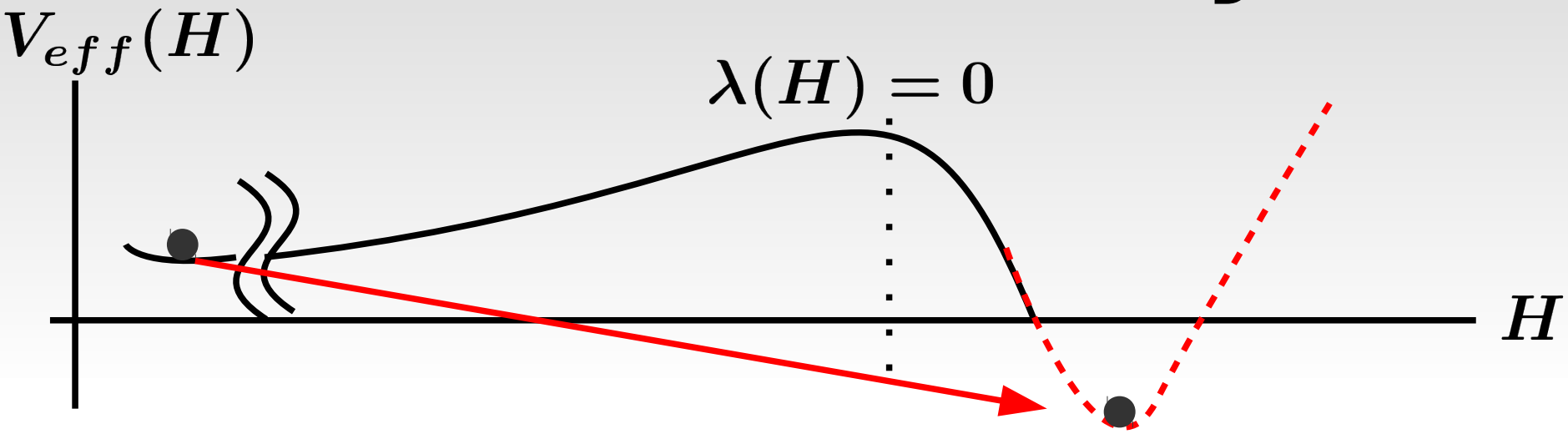

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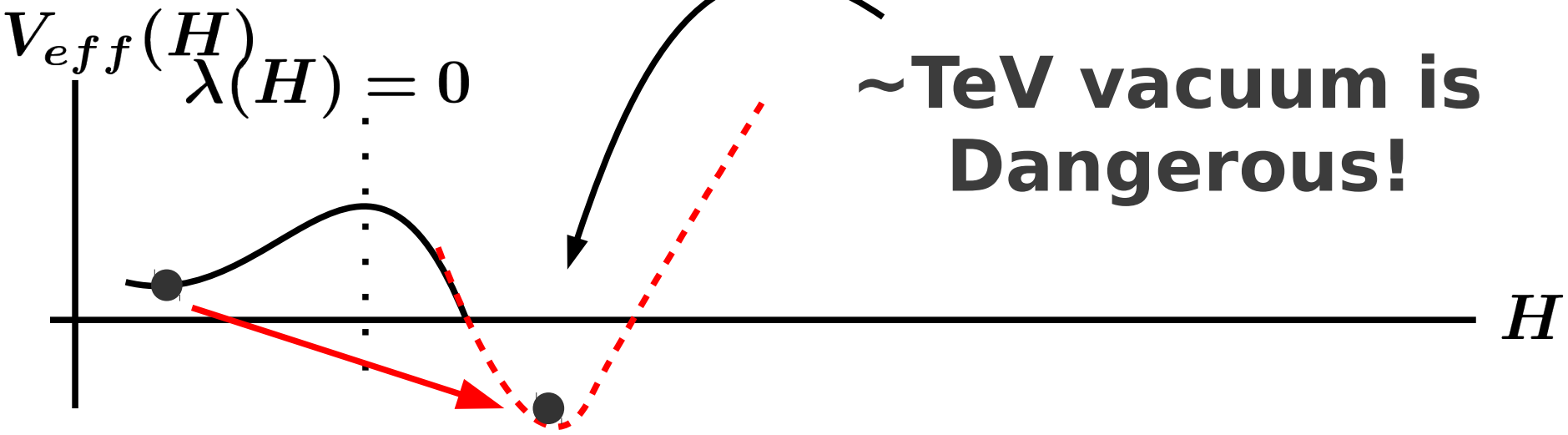
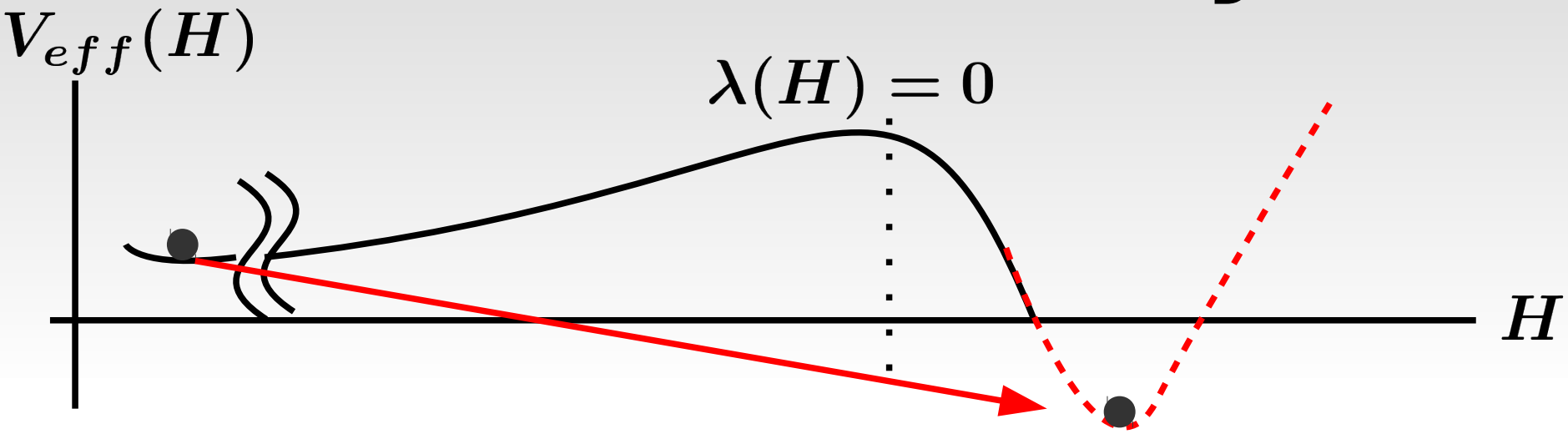


~TeV vacuum is Dangerous!

We focus on vacuum stability



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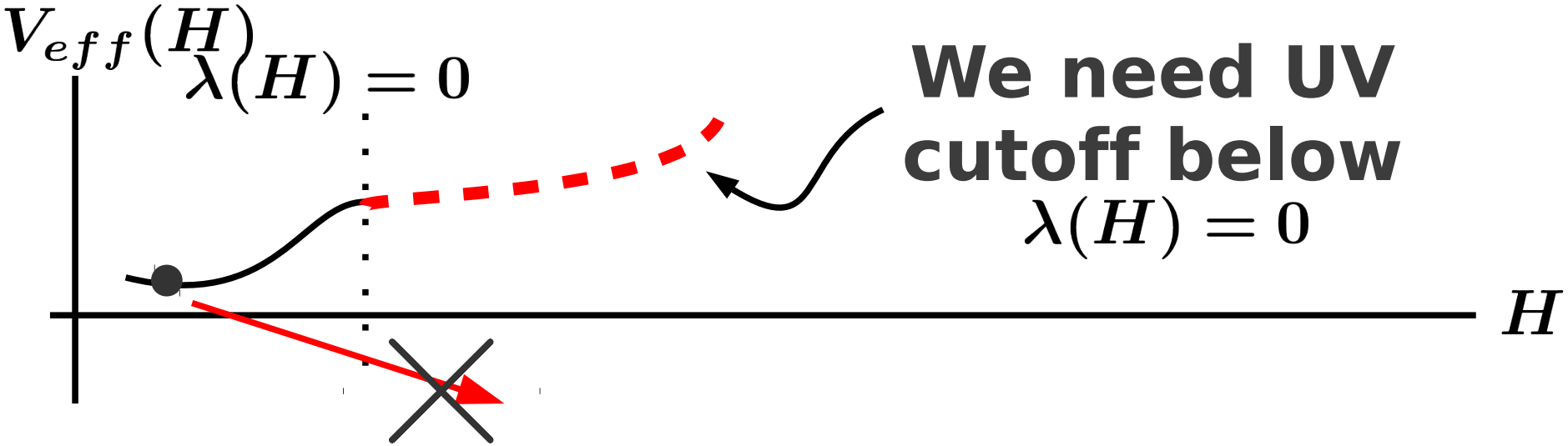

UV cutoff required in very low scale !

	models	UV cut upper bound
6D models	PS	1.9 M_{KK}
	S^2/Z_2	2.3 M_{KK}
	S^2	3.2 M_{KK}
	RP^2	2.3 M_{KK}
	T^2/Z_2	2.5 M_{KK}
	T^2/Z_4	3.4 M_{KK}
	$T^2/Z_2 \times Z_2'$	3.2 M_{KK}
5D model →	mUED	5.0 M_{KK}

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	T^2/Z_4	3.4 M_{KK}
	$T^2/Z_2 \times Z_2'$	3.2 M_{KK}
5D →	mUED	5.0 M_{KK}

Everything is heavy

or

Too small cutoff

KK tower analysis

↓

Cutoff operator analysis

Summary

We focus on KK loop analysis

Bounds from LHC Higgs search

mUED : $M_{KK} > 650$ GeV

6D UED : $M_{KK} > 850$-1390 GeV

We also found similar bounds from S,T parameters

UV cutoffs are small (especially 6D)

UEDs are heavy?

KK tower analysis → contact term analysis

Summary

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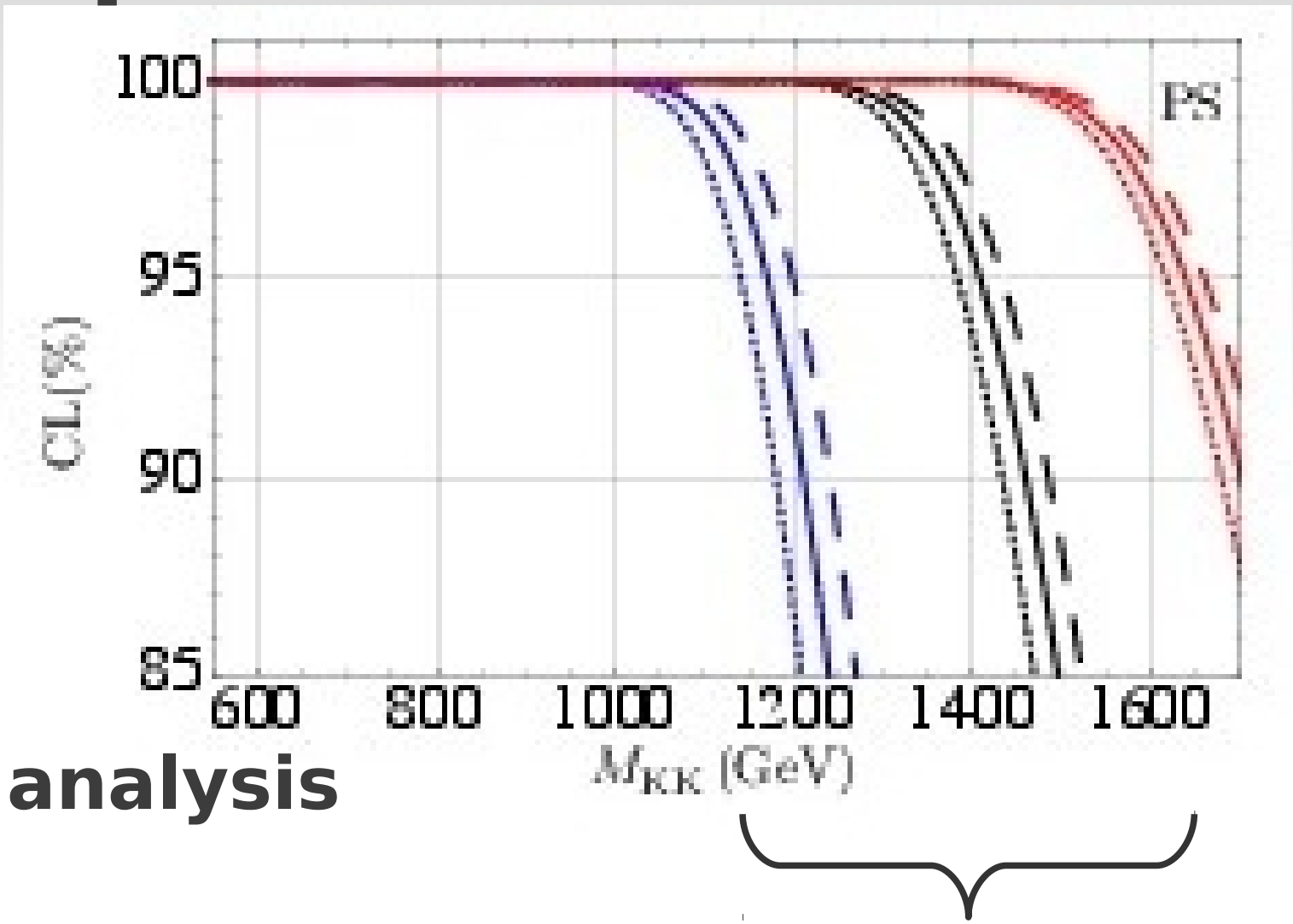
UEDs are heavy?

We can say anything !

analysis

Back up

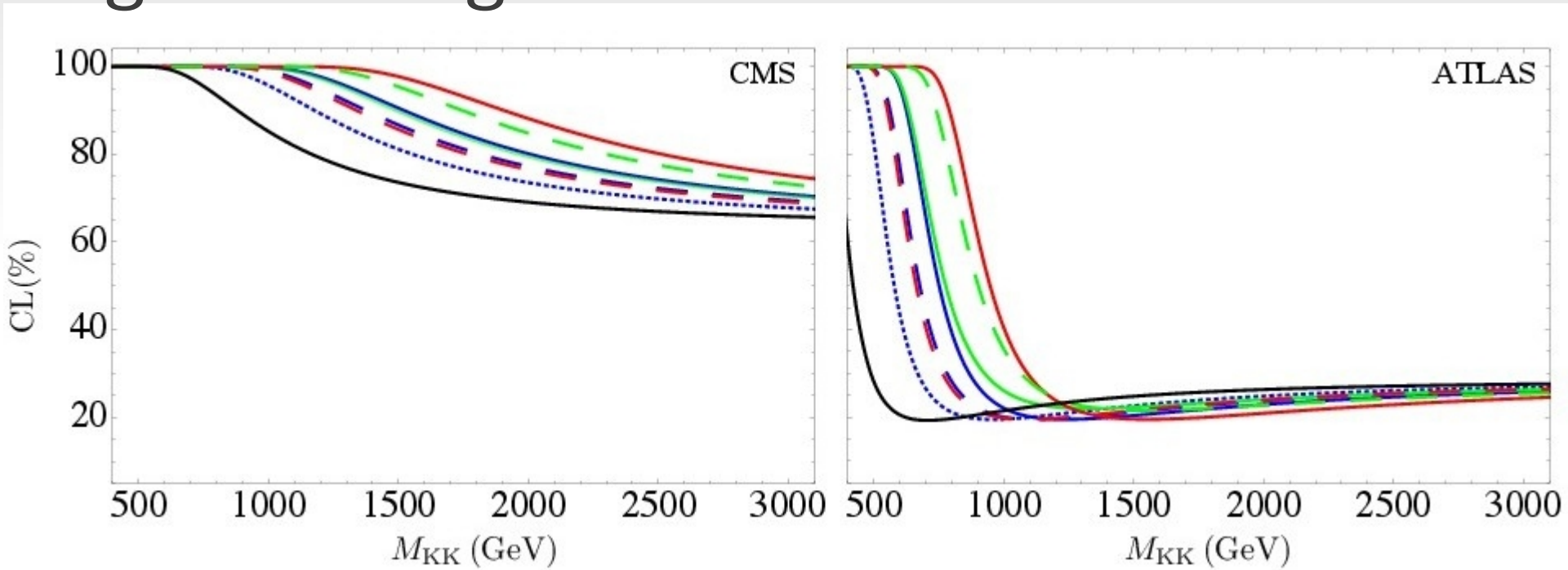
Higher dimensional operator in low scale



S,T analysis

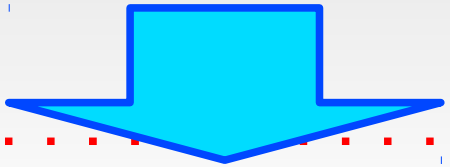
Ambiguity 500GeV (!)

Signal strength bound ATLAS and CMS



Question

V_{eff} is n-point function with external momenta $p = 0$



Should "RGE improvement" treat external legs differently?

V_{eff} has **different field renormalization** in external leg

RGE for V_{eff} must be modified !!

Problem

How we can take into account this difference?

Now we are trying