Results in Higgs Precision Analysis updated 2018

Po-Yan Tseng (Kavli IPMU)

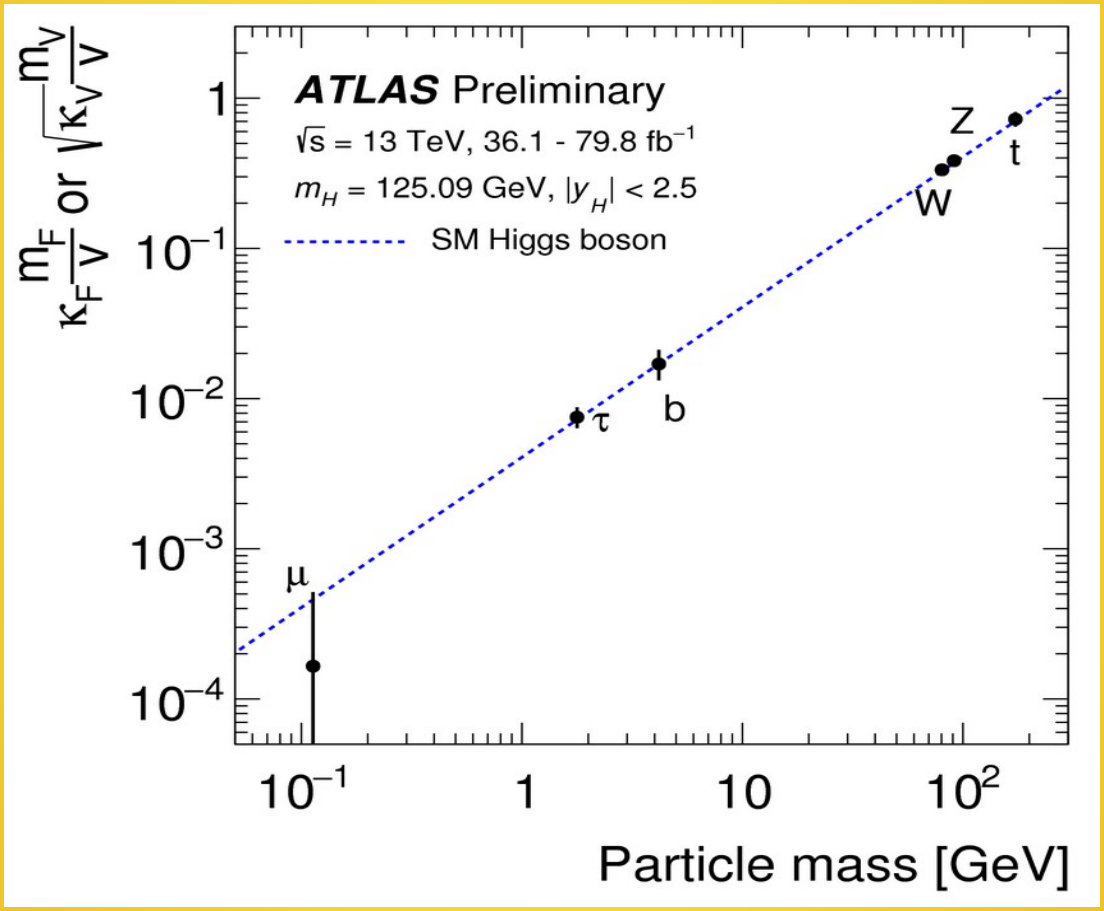
Collaborators:
Kingman Cheung(NTHU, NCTS)
Jae Sik Lee(Chonnam National U.)

ArXiv: 1810.02521

NCTS Annual Meeting 2018, 17th-20th Dec. 2018

Introduction

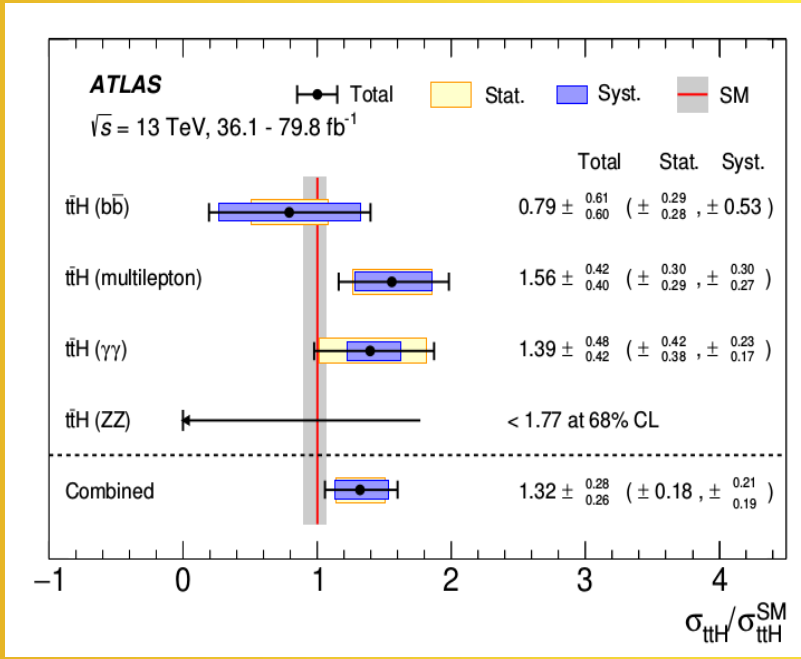
- 125 GeV Higgs is very SM like:



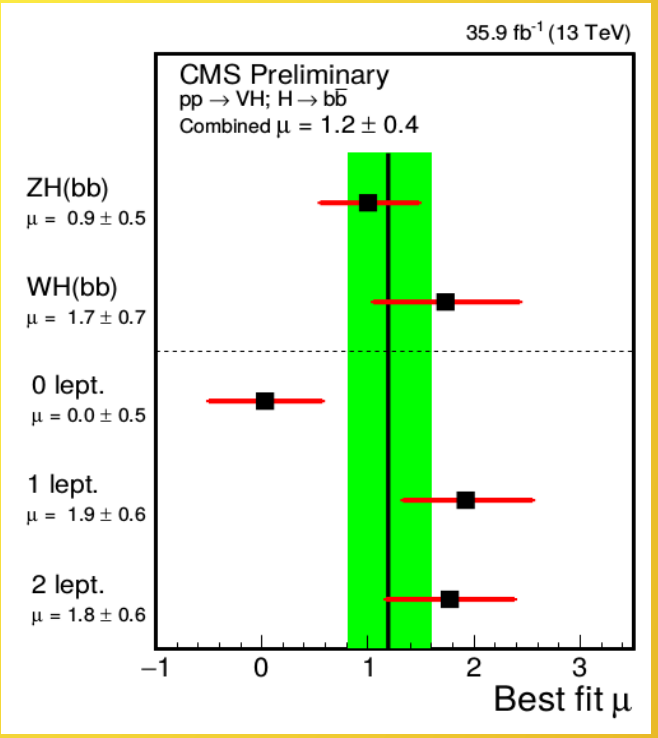
ATLAS Higgs Public Results

Introduction

- 2018 updated of the 125 GeV Higgs results.
- The **ttH** and **bbH** couplings are established.



ATLAS 1806.00425



CMS-HIG-16-044

Introduction

- From prof. Kai-Feng's talk this morning
- At 13 TeV:

$$\mathrm{ATLAS}: \quad \mu = 1.13^{+0.09}_{-0.08}$$

$$\mathrm{CMS}: \quad \mu = 1.17^{+0.10}_{-0.10}$$

Higgcision

- Combine the **ATLAS**, **CMS**, and **Tevetron** signal strength data.

Energy	ATLAS	CMS	Combined
1.96 TeV [Table VII]			1.44 ± 0.55
7+8 TeV [14]	$1.20^{+0.15}_{-0.14}$	$0.97^{+0.14}_{-0.13}$	$1.09^{+0.11}_{-0.10}$
13 TeV [Table I]	1.09 ± 0.08	$1.11^{+0.09}_{-0.08}$	1.10 ± 0.06
			1.10 ± 0.05

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- **2-sigma** deviation from SM?

Higgcision

- For each decay and production modes.

	Decay mode						
Production mode	$H \to \gamma\gamma$	$H \to ZZ^{(*)}$	$H \to WW^{(*)}$	$H \to bb$	$H \to \tau^+\tau^-$	$\mu^{\rm prod}_{\rm combined}$	$\chi^2_{\rm SM}(\chi^2_{\rm min})$
ggF	$1.02^{+0.12}_{-0.11}$	$1.09^{+0.11}_{-0.11}$	$1.29^{+0.16}_{-0.16}$	$2.51^{+2.43}_{-2.01}$	$1.06^{+0.40}_{-0.37}$	$1.11^{+0.07}_{-0.07}$	5.42(3.15)
VBF	$1.23^{+0.32}_{-0.31}$	$1.51^{+0.59}_{-0.59}$	$0.54^{+0.32}_{-0.31}$	-	$1.15^{+0.36}_{-0.34}$	$1.02^{+0.18}_{-0.18}$	7.53(7.51)
VH/WH	$1.42^{+0.51}_{-0.51}$	$0.71^{+0.65}_{-0.65}$	$3.27^{+1.88}_{-1.70}$	$1.07^{+0.23}_{-0.22}$	$3.39^{+1.68}_{-1.54}$	$1.15^{+0.20}_{-0.19}$	7.05(6.44)
ZH	-	-	$1.00^{+1.57}_{-1.00}$	$1.20^{+0.33}_{-0.31}$	$1.23^{+1.62}_{-1.35}$	$1.19^{+0.32}_{-0.30}$	0.45(0.02)
ttH	$1.36^{+0.38}_{-0.37}$	$0.00^{+0.53}_{-0.00}$	-	$0.91^{+0.45}_{-0.43}$	-	$0.93^{+0.24}_{-0.24}$	5.96(5.86)
ttH (excl.)	$1.39^{+0.48}_{-0.42}$	-	$1.59^{+0.44}_{-0.43}$	$0.77^{+0.36}_{-0.35}$	$0.87^{+0.73}_{-0.73}$	$1.16^{+0.22}_{-0.22}$	4.17(3.62)
$\mu^{\rm dec}_{\rm combined}$	$1.10^{+0.10}_{-0.10}$	$1.05^{+0.11}_{-0.11}$	$1.20^{+0.14}_{-0.13}$	$1.05^{+0.19}_{-0.19}$	$1.15^{+0.24}_{-0.23}$	$1.10^{+0.06}_{-0.06}$	
$\chi^2_{\rm SM}(\chi^2_{\rm min})$	6.83(5.72)	9.13(8.88)	9.48(7.32)	1.56(1.51)	3.58(3.20)		30.58(27.56)

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Higgcision

- Non-SM contribution to Higgs decay width:

$$B(H \to \mathcal{D}) = \frac{\Gamma(H \to \mathcal{D})}{\Gamma_{\rm tot}(H) + \Delta\Gamma_{\rm tot}}$$

- The best fit value is:

After ICHEP 2014

$$\Delta\Gamma_{\rm tot} = -0.020^{+0.97}_{-0.66}\ {\rm MeV}$$

After ICHEP 2018

$$\Delta\Gamma_{\rm tot} = -0.285^{+0.18}_{-0.17}\ {\rm MeV}$$

- Assume the center value is consistent with SM,

$$B(H \to \text{nonstandard}) < 19\%$$

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$$B(H \to \text{nonstandard}) < 8.4\%$$

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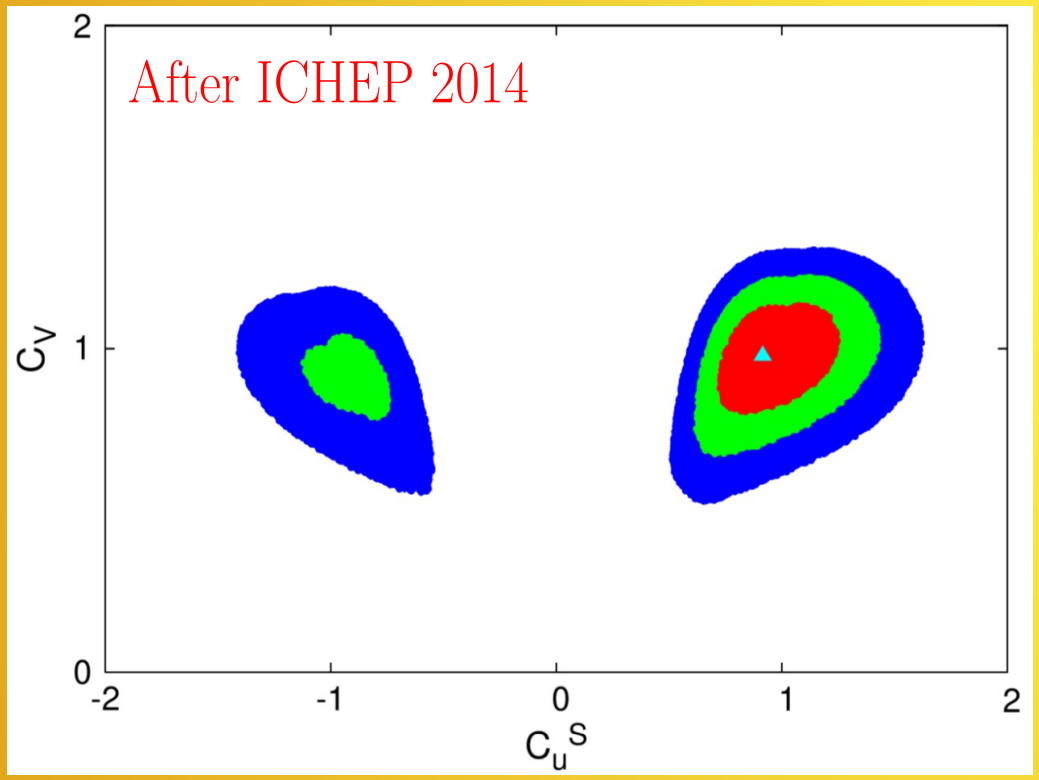
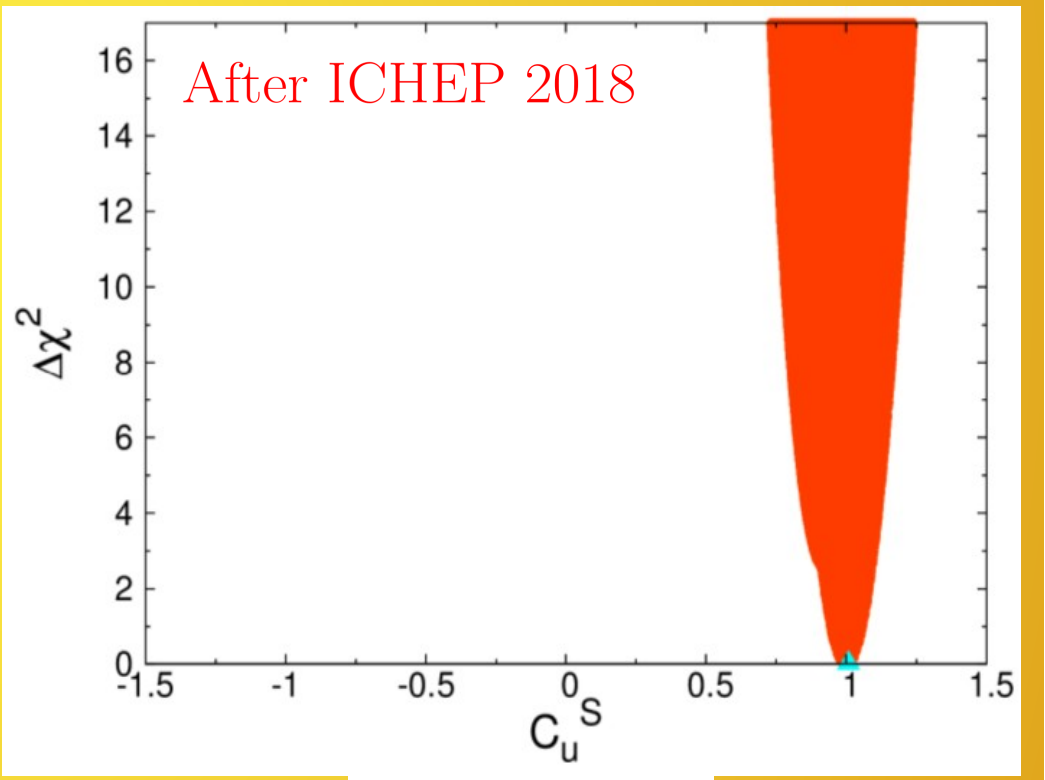
Higgcision

- **Negative ttH** couplings with respect to the **VVH** coupling is **ruled out**:





ttH coupling

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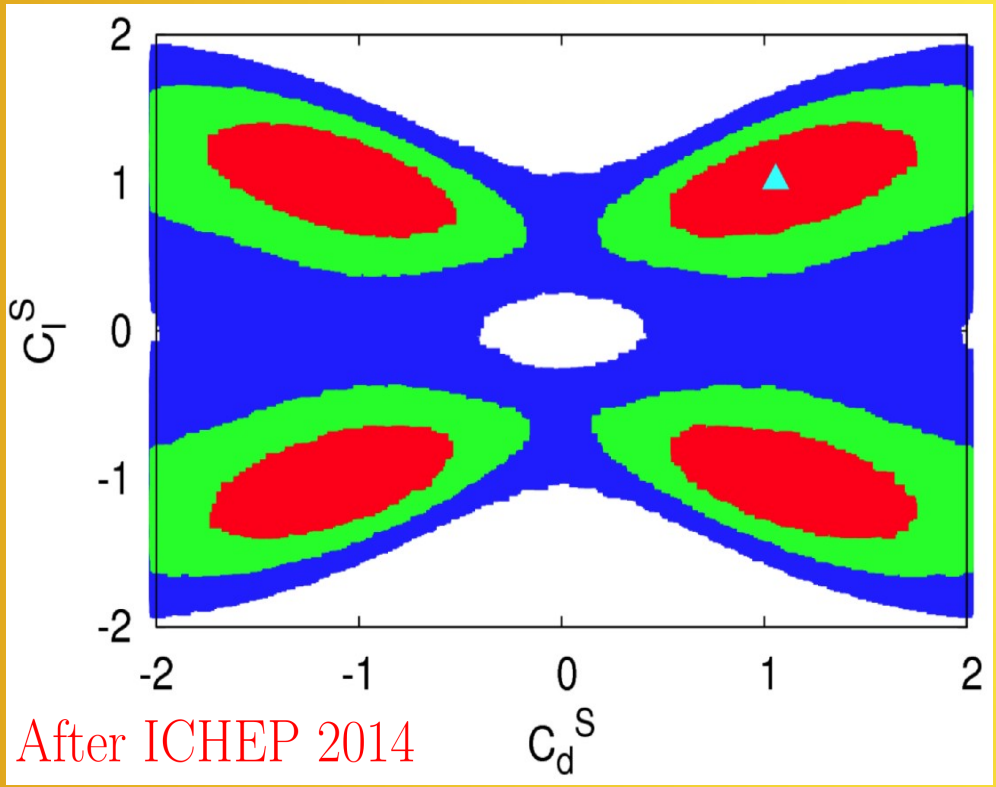
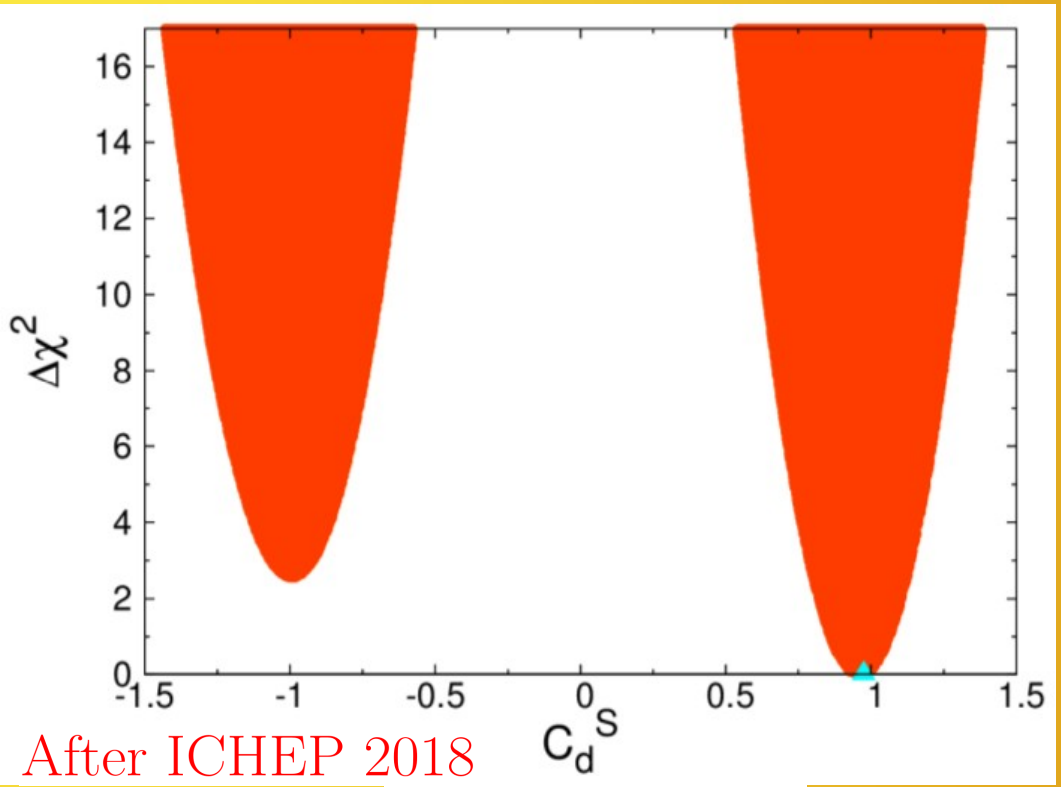
Higgcision

- For the first time, **negative** and **positive bbH** couplings is statistically different:





bbH coupling

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Higgcision

- Negative **ttH** and **bbH** couplings with respect to the **VVH** coupling:

- Because of the **precise** measurements of **Higgs-photon-photon** and **Higgs-gluon-gluon** couplings:

$$S^{\gamma} \simeq -8.35\, g_{HWW} + 1.76\, g^{S}_{H\bar{t}t} + (-0.015 + 0.017\, i)\, g^{S}_{H\bar{b}b}$$

$$S^{g} \simeq 0.688\, g^{S}_{H\bar{t}t} + (-0.037 + 0.050\, i)\, g^{S}_{H\bar{b}b}$$

- Flip the sign of **bbH** coupling gives 10% changes of the **Higgs-gluon-gluon** coupling

Higgcision

- For each decay and production modes.

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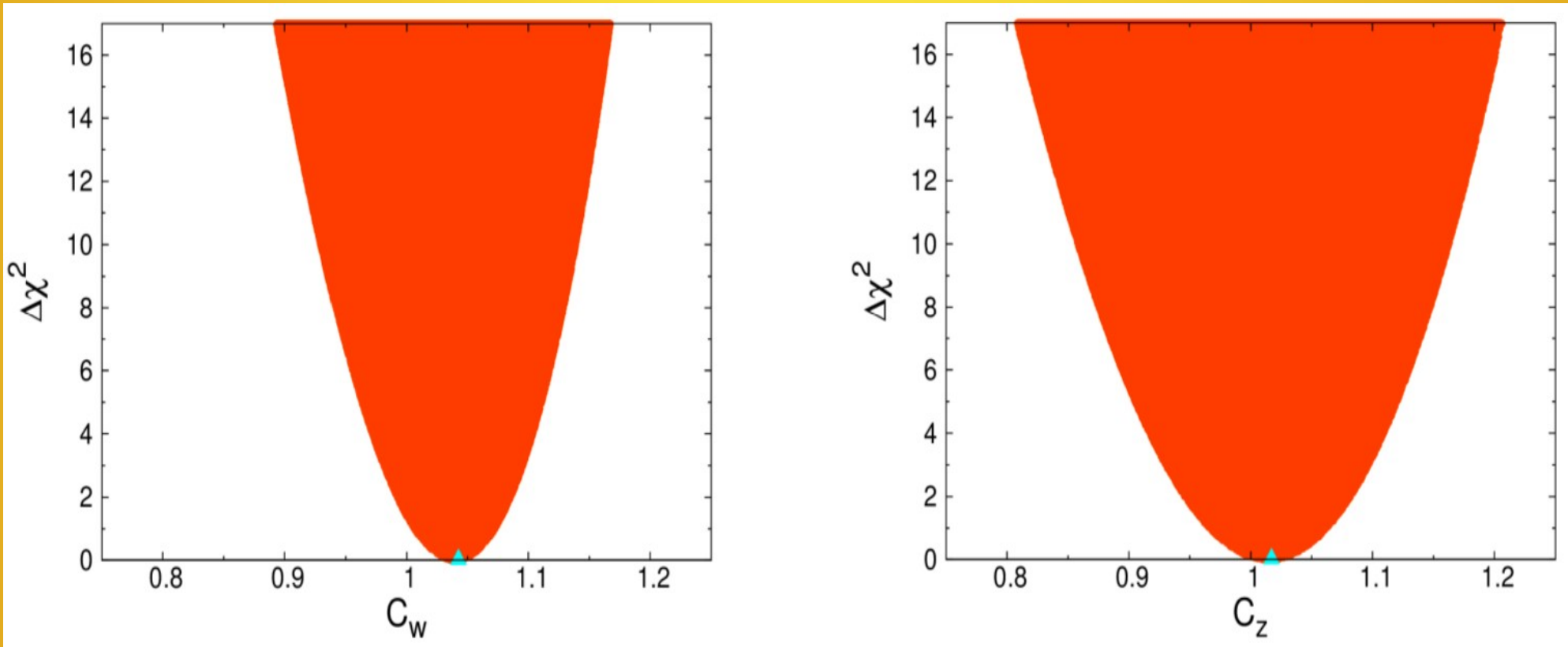
Higgcision

- **Custodial** symmetry: **WWH** and **ZZH** couplings



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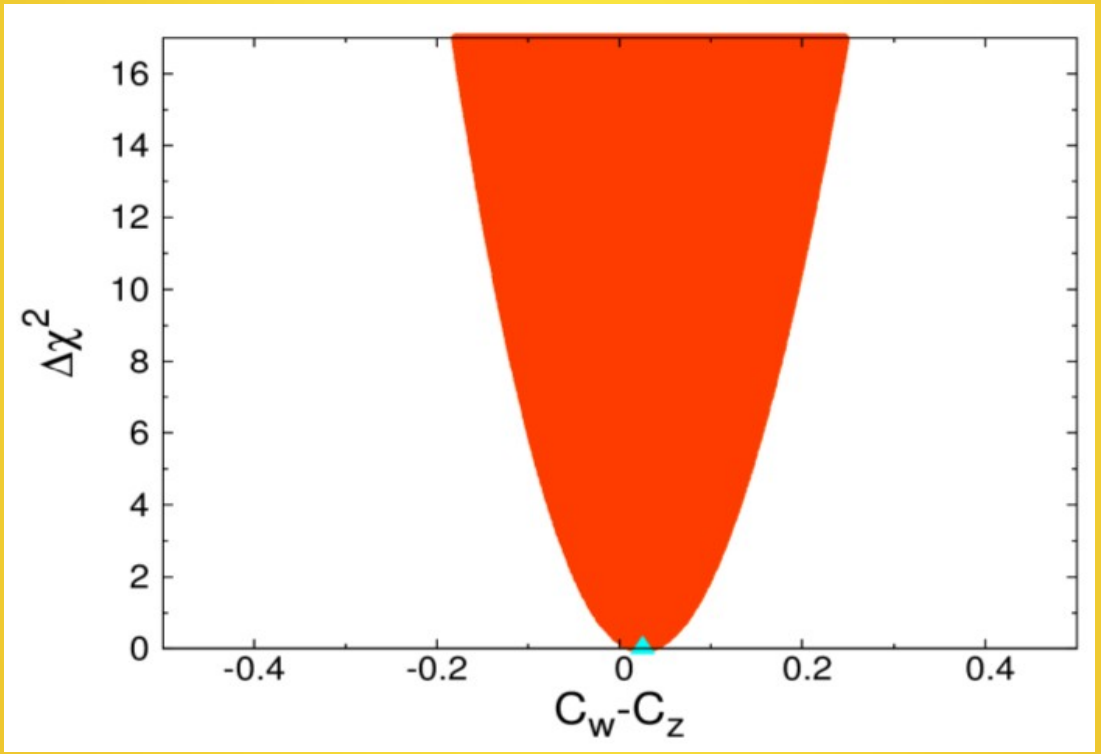

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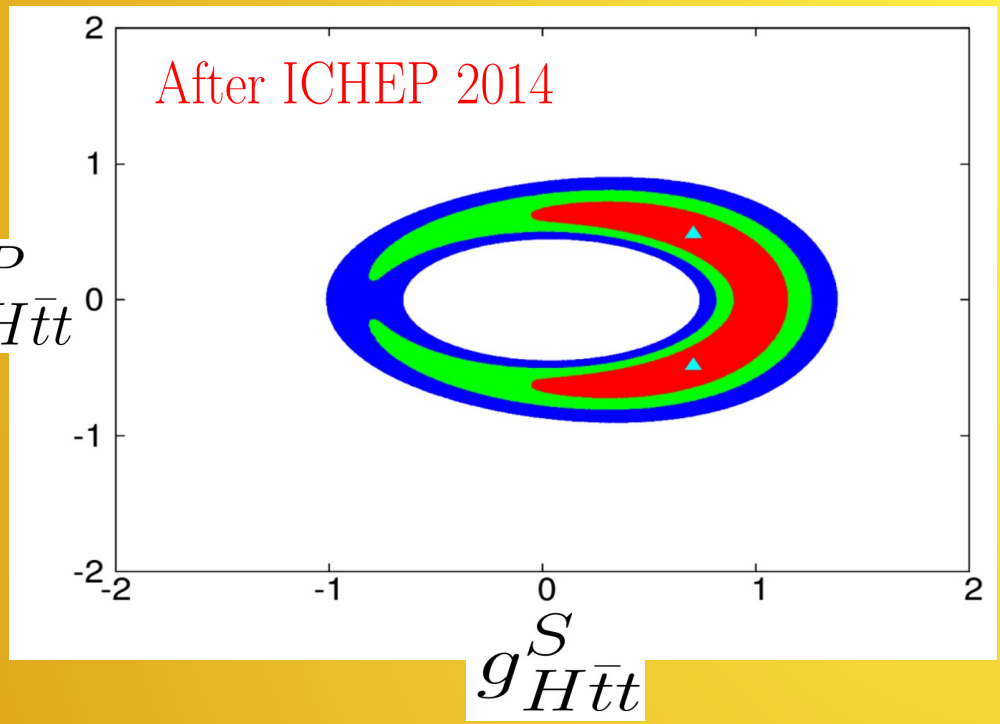
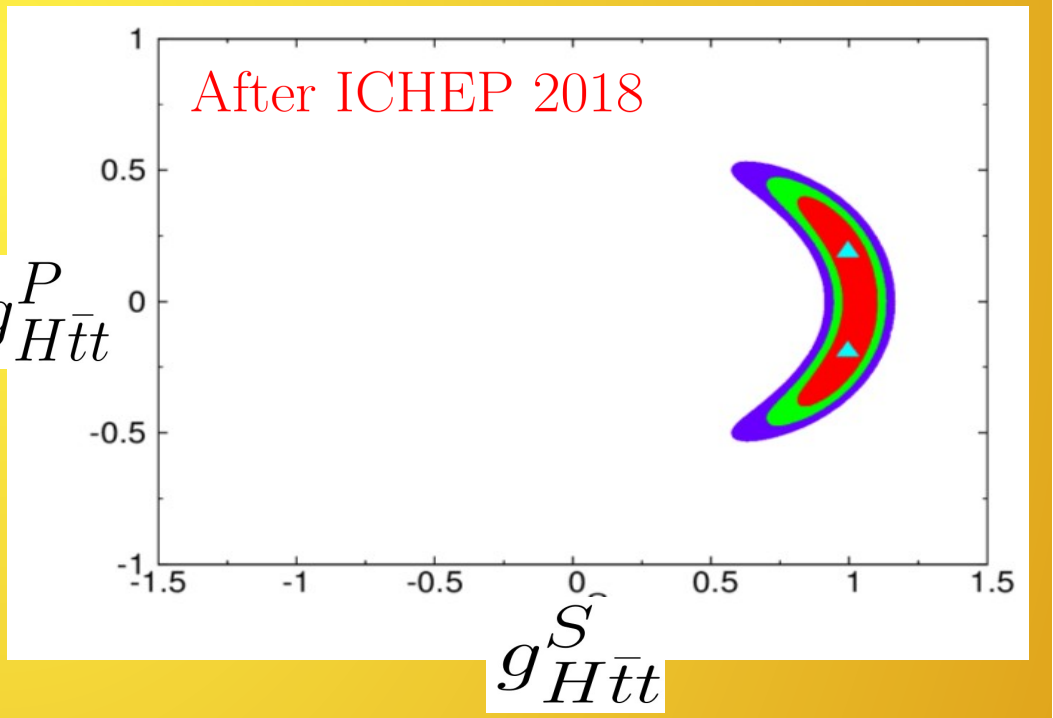
Higgcision

- **CP violating ttH** coupling:

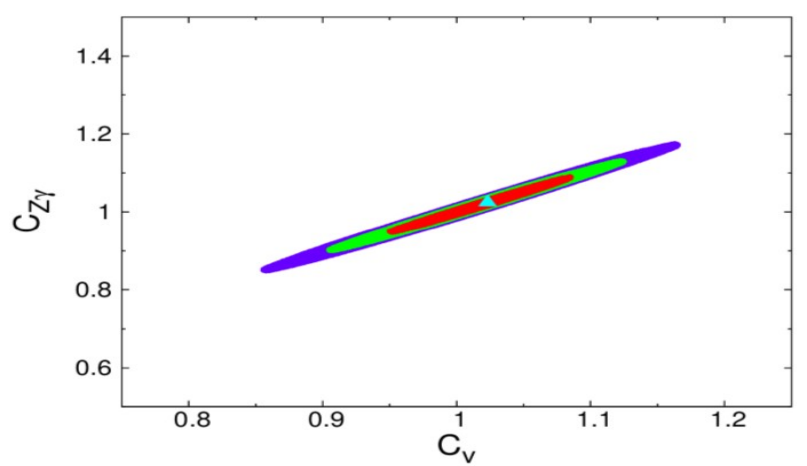
$$\mathcal{L}_{H\bar{f}f} = -\sum_{f=u,d,l} \frac{gm_f}{2M_W} \sum_{i=1}^{3} H\,\bar{f}\left(g^S_{H\bar{f}f} + ig^P_{H\bar{f}f}\gamma_5\right) f$$





Higgcision

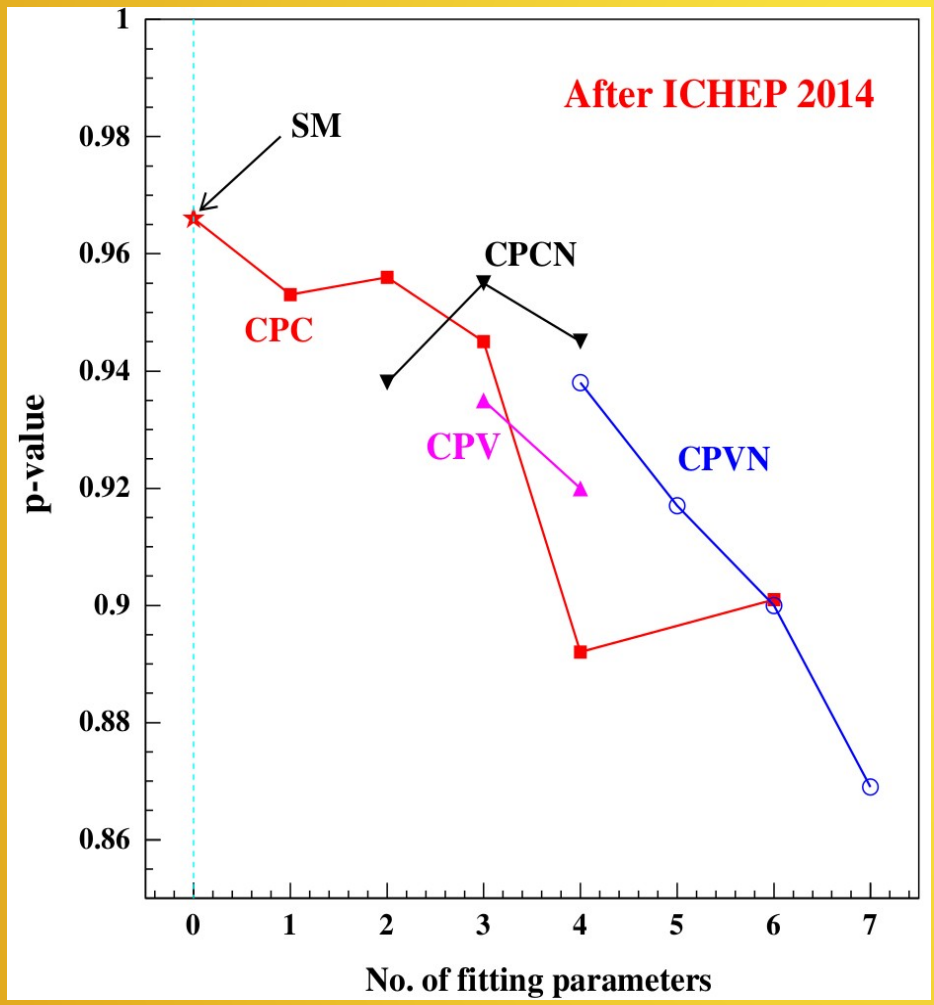
- Predictions for the **Z-photon** signal strength:
- Strong correlation between **H-Z-photon** and **HVV** couplings

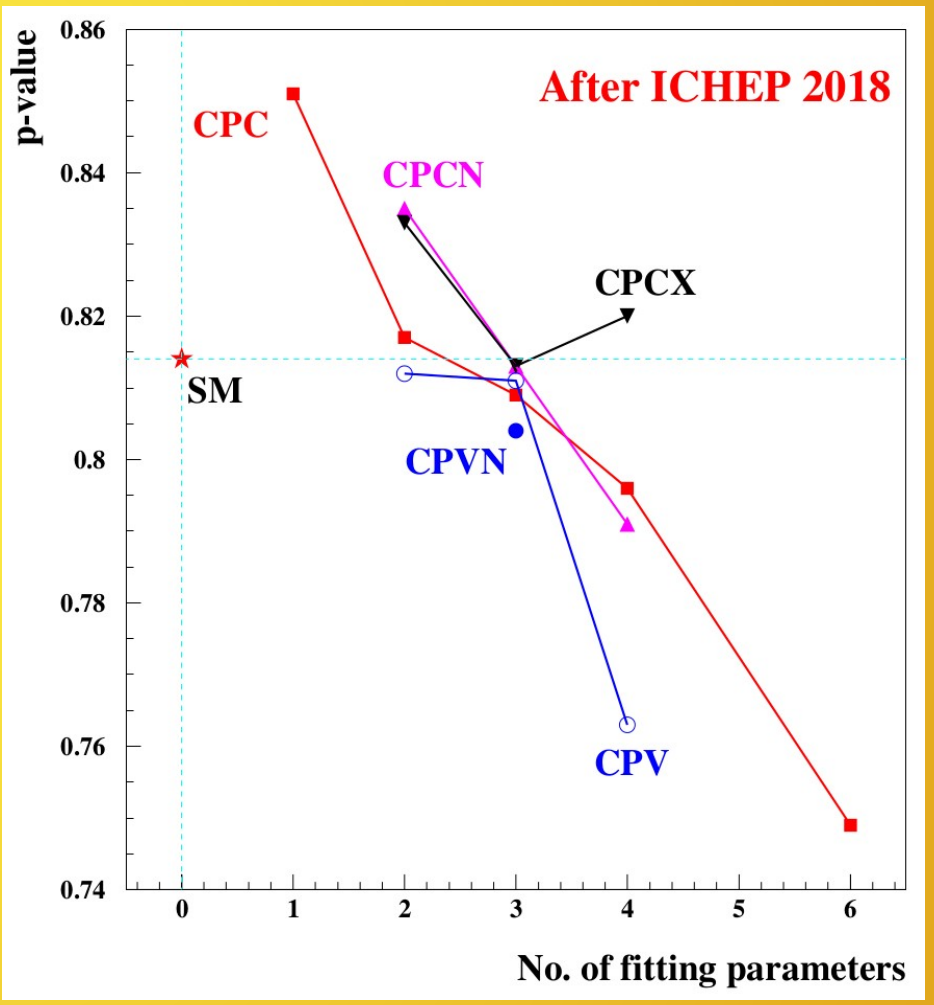


- **H-Z-photon coupling** can be **1.2** times larger implies signal strength can be **1.4** times larger.

Higgcision

- Status of **SM**:





Summary

- The combined signal strength **2-sigma** deviation from SM.
- Bottom-Yukawa coupling ***statistic difference*** between **positive** and **negative** signs.
- **Negative** Top-Yukawa coupling is **ruled out**.
- Higgs **nonstandard decay** branching ratio is less than **8.4%**.

Summary

- We tested **Custodial symmetry**: **WWH** is larger than **ZZH** but still within **1-sigma**.

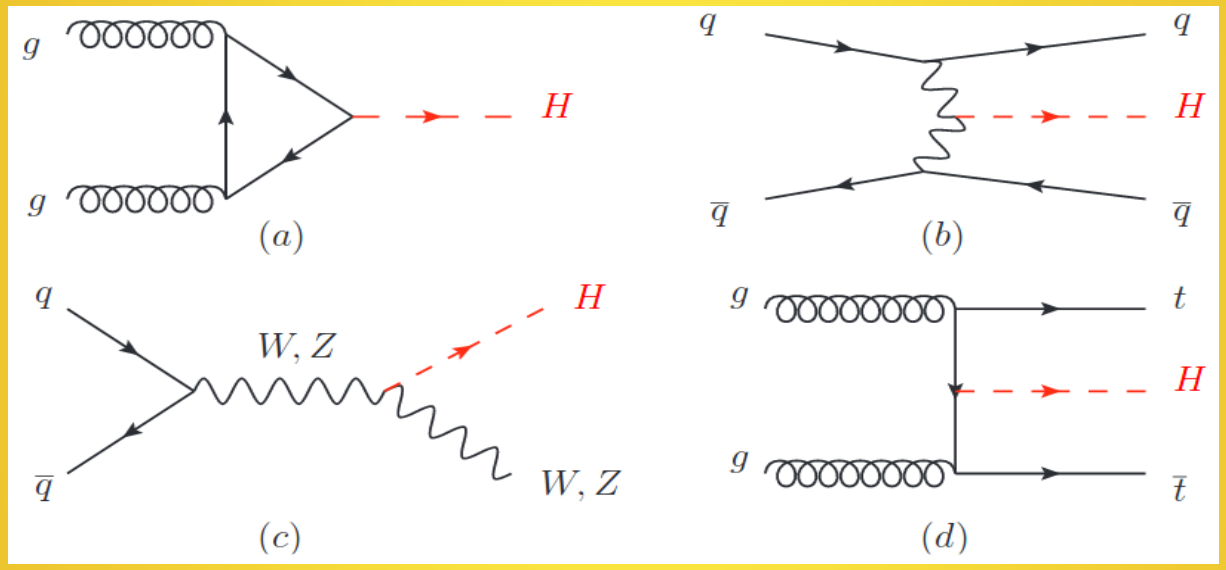
- We predict the **Higgs-->Z+photon.** In general, it is **consistent** with SM. In extreme case, branching ratio is **enhanced** by **40%**.

Thank You !

Back Up

Higgs Production at LHC

- The production mechanism: ggF, VBF, Vh, tth.



C.Grojean: 1708.00794

$$\text{ProductionRate}:$$

$$\text{ggF} = 80\%, \text{VBF} = 15\%, \text{Vh} = 4.5\%, \text{t}\bar{\text{t}}\text{h} = 0.5\%$$

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Higgcision

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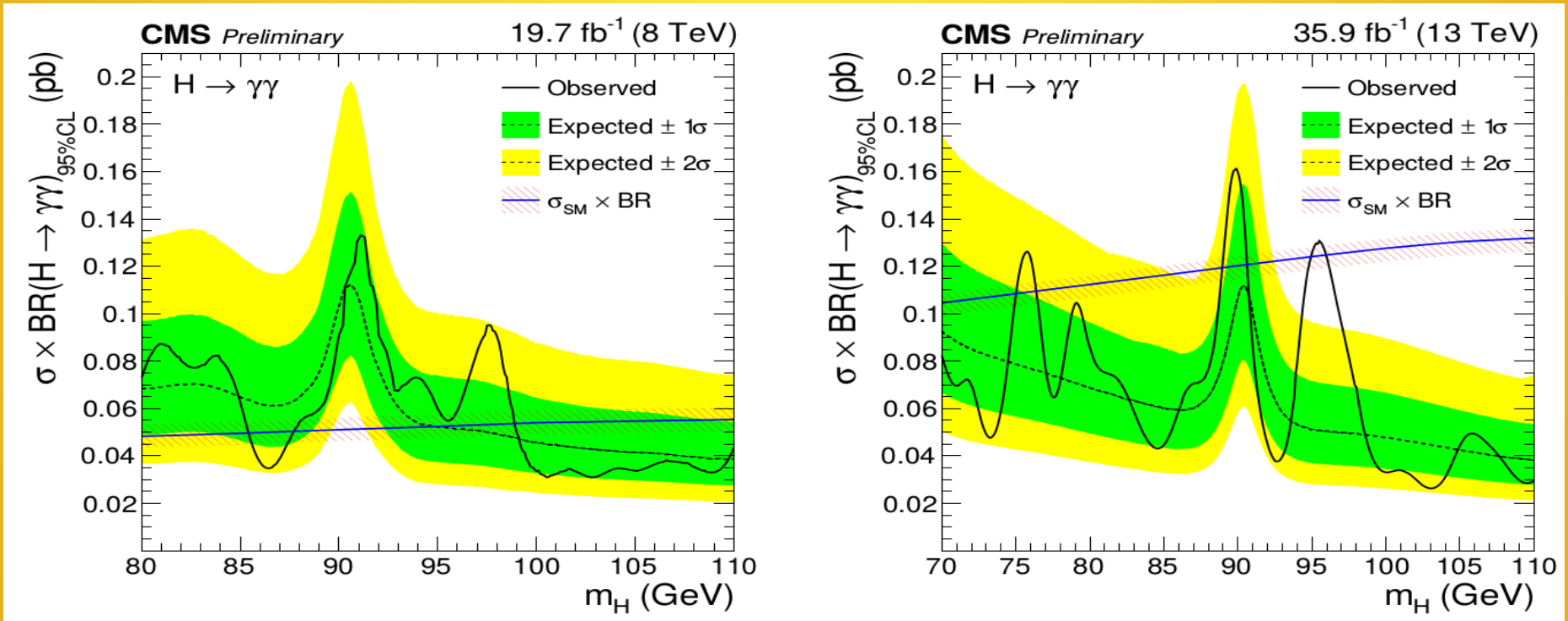
Introduction

- Di-photon channel at 96 GeV has **2-sigma** excess from **CMS**:



CMS PAS HIG-17-013