Discussion on Precision Higgs

HE/HL Workshop

FNAL, April 4-6, 2018

What is ultimate theory precision?

- What do we need to improve theory precision?

Are there prospects for further reduction of theory error? PDFs?

ggF QCD scale : $(+7.4,-7.9) \rightarrow$ 3.9 %
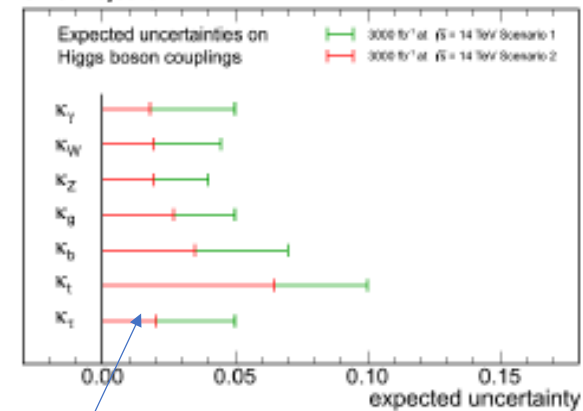
. PDF + α_s : $(+7.1,-6.0) \rightarrow$ 3.2 %

2013   2017

This is total rate

Reducing theory systematics from data?

CMS Projection

Expected uncertainties on Higgs boson couplings

⊢—┤ 3000 fb⁻¹ at √S = 14 TeV Scenario 1
⊢—┤ 3000 fb⁻¹ at √S = 14 TeV Scenario 2

κ_γ
κ_W
κ_Z
κ_g
κ_b
κ_t
κ_τ

0.00   0.05   0.10   0.15
expected uncertainty

Assumes theory error halved from 2013 error

No Good, Terrible Table

What is target precision?
We must do better!

	Coupling to W/Z	Coupling to b	Coupling to γ
Singlet	~6%	~6%	~6%
2HDM	~1%	~10%	~1%
MSSM	~.001%	~1.6%	~-.4%
Composite	~-3%	~-(3-9)%	~-9%
Top Partner	~-2%	~-2%	~1%

Table assumes all new particles degenerate at 1 TeV, tan β=3.2, largest allowed singlet mixing (in 2013) , X_t=0, etc

*I made this in 2013 for Snowmass

What do we learn from precision Higgs measurements?

- Beyond the κ approach (simple rescaling of amplitudes)
- How to decide on which EFT coefficients to fit?
  - To use kinematic distributions, need EFTs
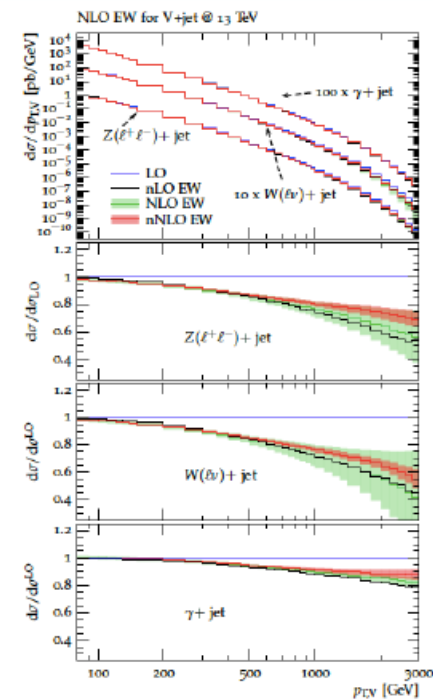 - Electroweak corrections don't factorize

Is it a problem that YR will only have theory studies using EFT?

Can we calculate tails accurately enough?
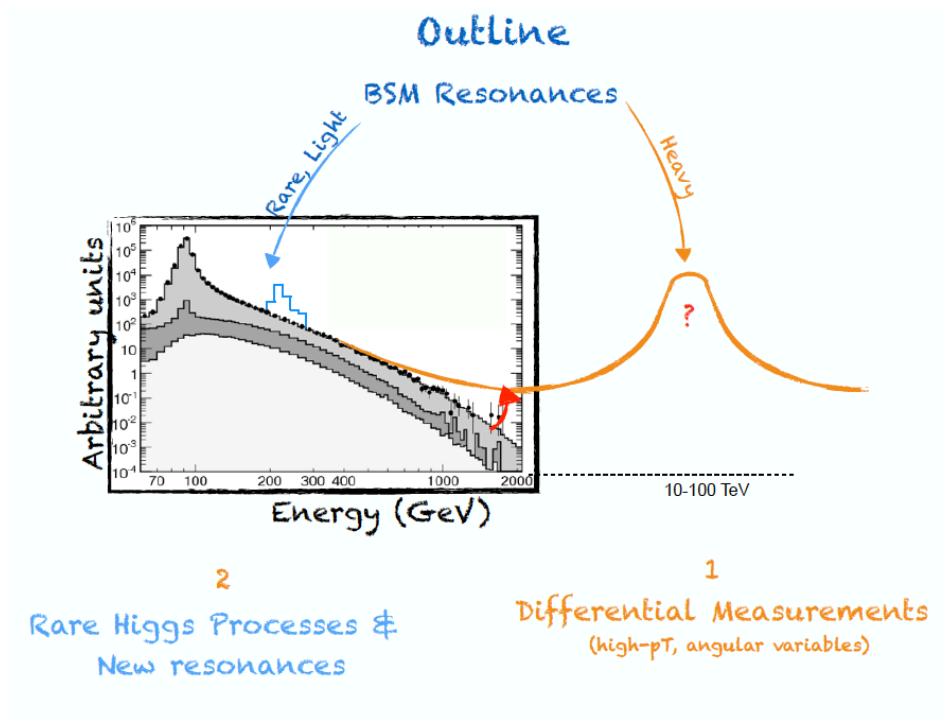
Riva

Maltoni

# Can we measure Higgs couplings to 1st and 2nd generation?

- H $\rightarrow$ $\psi\gamma$, H $\rightarrow$ $\varphi\gamma$ very hard

- LHCb: 5*SM with 300 fb^{-1} from cc $\rightarrow$ VH, V $\rightarrow$ leptons

- New channels: gc $\rightarrow$ cH
  - Better charm taggers?

- New ideas?

What about the Higgs width and decays to invisible particles?

- Large section in YR

- Needed calculations or simulations?

Does it make sense to measure the Higgs tri-linear coupling without an EFT fit?

- Most UV complete models have a pattern of non-zero EFT coefficients
- (ttH, ttHH, ggH, ggHH, HHH....)

1410.3471
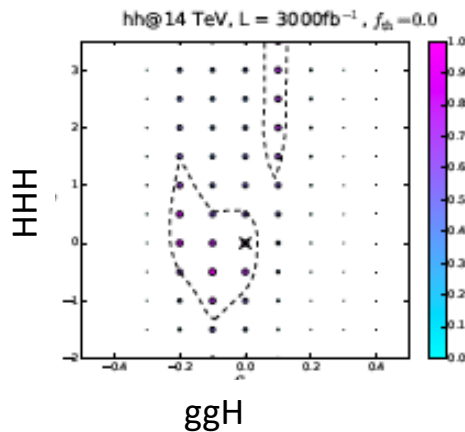
Are there models with $\lambda_3 > 7$, $\lambda_3 < -1$ etc?

- Complex singlet model can have large λ_3, but these models typically have light scalars that will be observed

- *Challenge to theorists*:
  - Find models that have λ_3's that will be accessible to HE/HL.
    - Do any of these models not have light stuff that will have been observed?

HH final state 3000fb^{-1}	ATLAS Significance Coupling limit (95 % C.L.)	CMS Significance
HH → bb$\gamma\gamma$	1.05 σ $-0.8 < \lambda_{HHH}/\lambda_{SM} < 7.7$	1.43 σ
HH → bb$\tau\tau$	0.6 σ $-4.0 < \lambda_{HHH}/\lambda_{SM} < 12.0$	0.39 σ
HH → bbbb	$-3.5 < \lambda_{HHH}/\lambda_{SM} < 11.0$	0.39 σ
HH → bbVV		0.45 σ
ttHH, HH-> bbbb	0.35 σ	

S. Jézéquel. HL-LHC/HE-LHC Workshop 2017

Is the Higgs Composite?

- Nice place to have complementarity of HE (vector resonances) and HL (precision Higgs couplings)
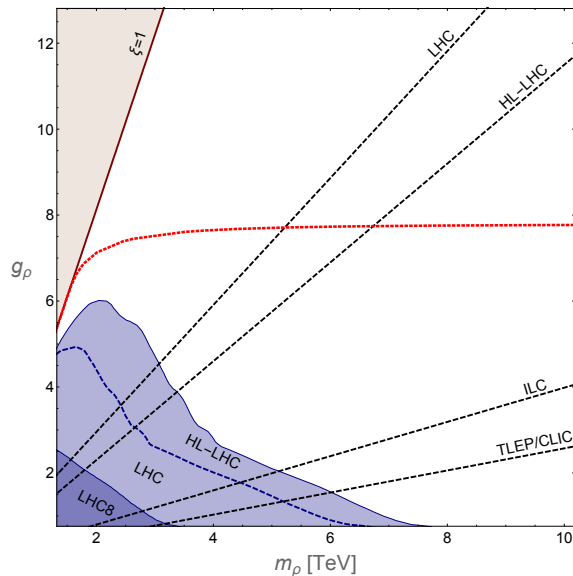
This particular model has Higgs couplings as a function of g, m

In general, what about the complementarity of precision Higgs couplings and direct searches?

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