Higgs/EWSB group, workplan discussion, CERN, Nov. 24, 2014

Designing $\mathbf{gg \to HH}$ study at 100 TeV

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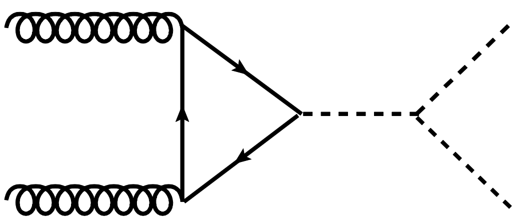
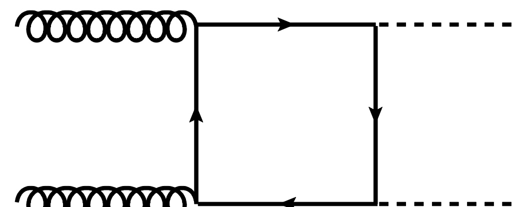
Work in progress
with A. Azatov, R. Contino, G. Panico

New Physics are sensitive to the diff. energy scale

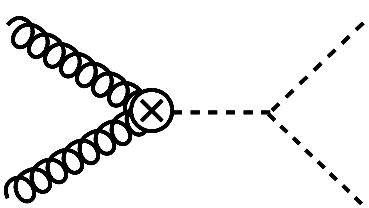
In a large $\hat{\mathbf{s}}$ limit (only $\hat{s}$ dep shown)



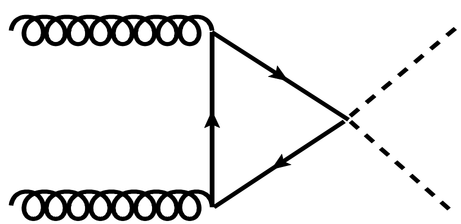
$\sim \frac{m_h^2}{\hat{s}} \log^2 \frac{m_t^2}{\hat{s}}$



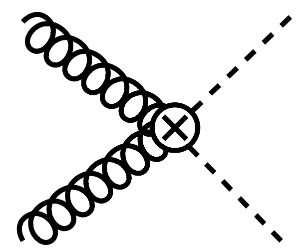
$\sim const$



$\sim const$



$\sim \log^2 \frac{m_t^2}{\hat{s}}$



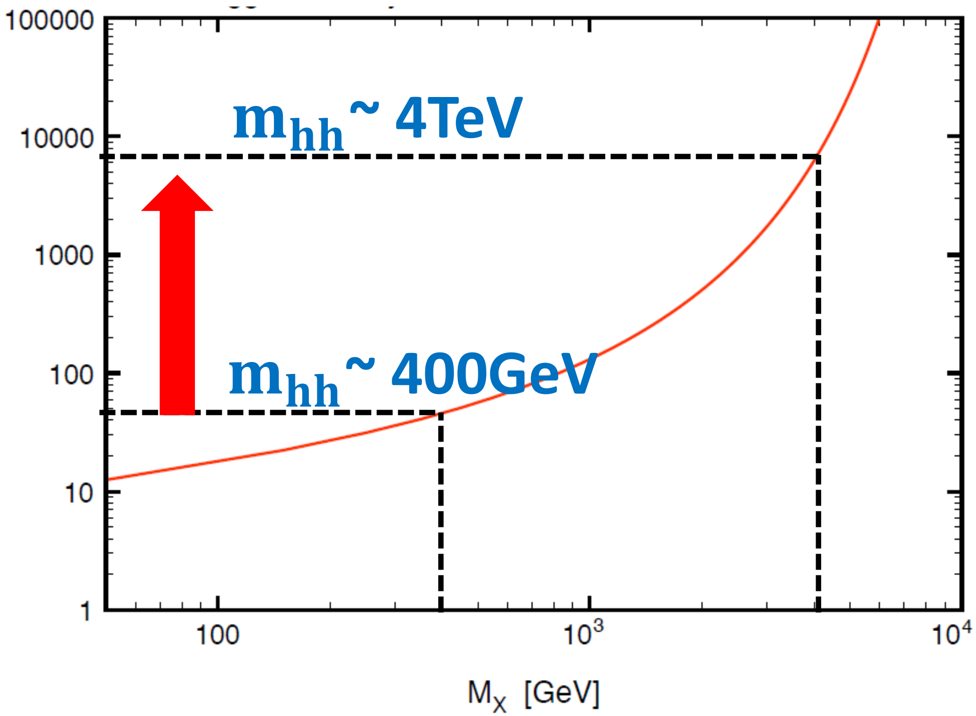
$\sim \frac{\hat{s}}{v^2}$

- $\mathbf{m_{hh}} (= \sqrt{\hat{\boldsymbol{s}}}\ )$ perfect candidate for shape variable
- HH can probe arbitrarily high new physics scale via $\mathbf{m_{hh}}$

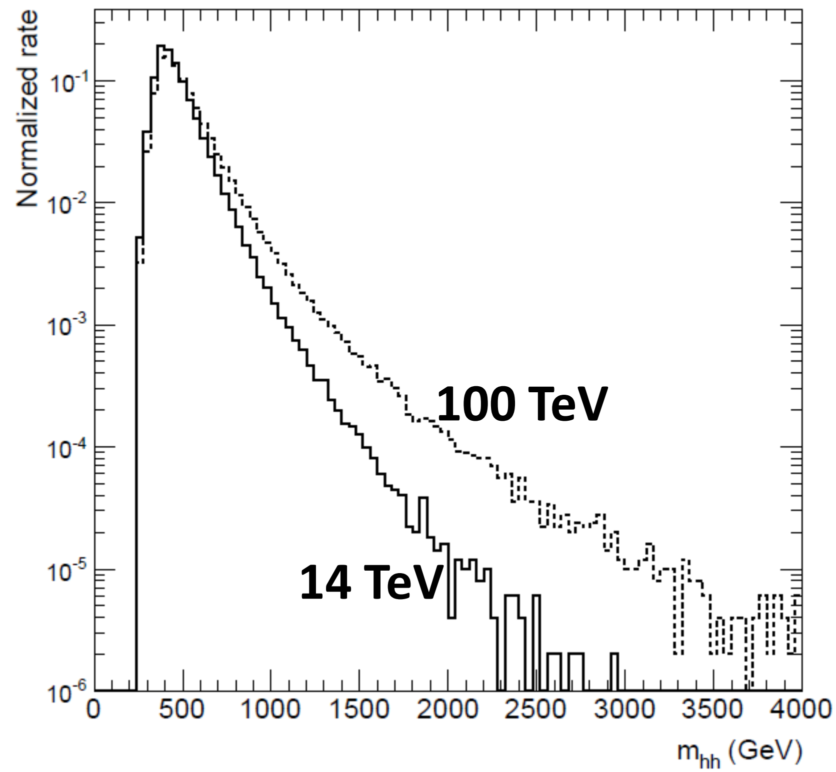
(within validity of EFT)

Pay attention to the tail

gg luminosity ratio
100TeV/14TeV-CTEQ6L1



m_{hh} distribution



- Discrepancy of m_{hh} is pronounced in the tail

Tail is new door to access dim-8 operator

$$\mathbf{A(gg \to hh)} \sim \left(\frac{\alpha_s}{4\pi}\right) \times \left[y_t^2 \left(1 + O\left(\frac{v^2}{f^2}\right)\right) + g_{dim-6}^2(E) + g_{dim-8}^2(E) + \ \dots \right]$$

$$O_{dim-6} \ni \ \mathbf{GGHH} \times \frac{\lambda^2}{g_*^2}$$

λ: GB sym breaking

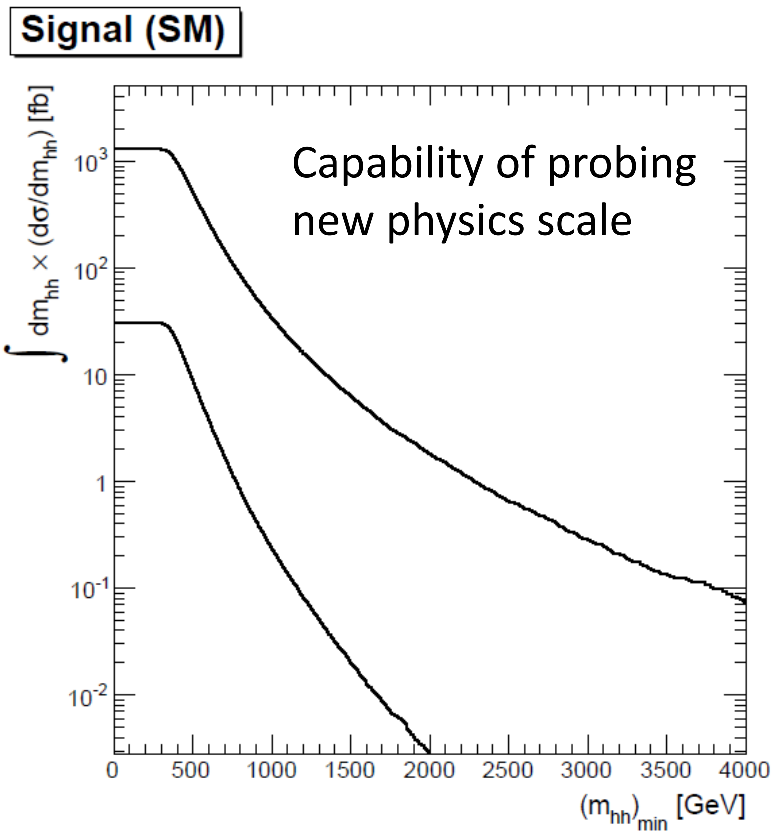
$$\frac{\lambda^2}{g_*^2} \quad \text{vs.} \quad \frac{E^2}{m_*^2}$$

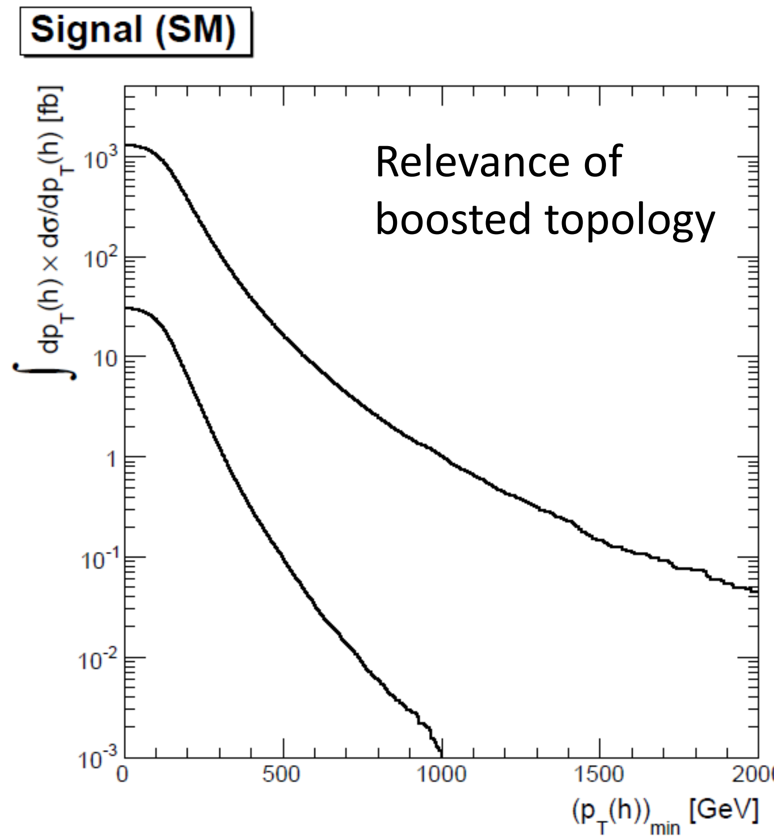
$$O_{dim-8} \ni \ \mathbf{GG\partial H \partial H} \times \frac{1}{m_*^2}$$

"Angular distribution"

SPIN-0 vs SPIN-2

How far can we reach?



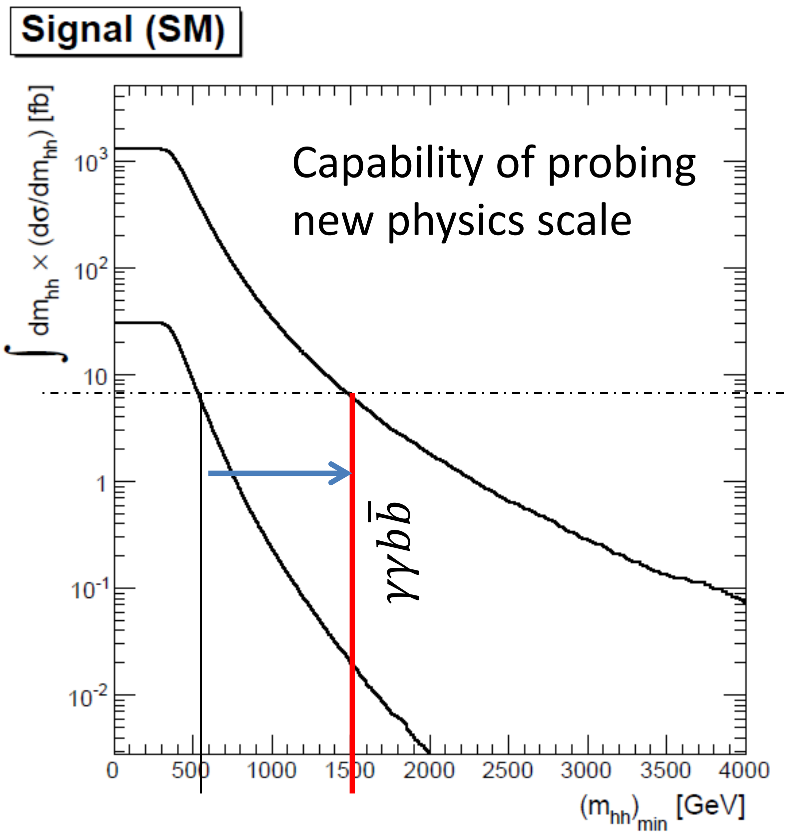


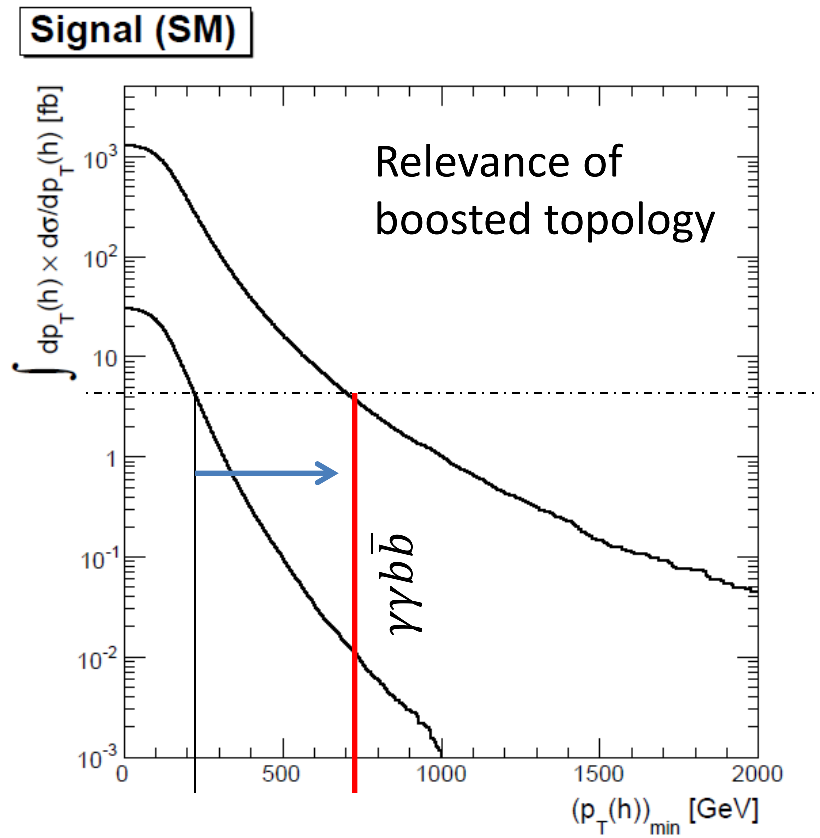
- Demanding at least some fixed number of events can be translated into the various scales, e.g. p_T, m_{hh} that can be reached!

$$\sigma \geq \frac{5\ \mathrm{Events}}{\mathrm{BR}(hh \to X) \times \epsilon_s \times 3000\ \mathrm{fb}^{-1}}$$

Let us assume 10% signal efficiency

How far can we reach?

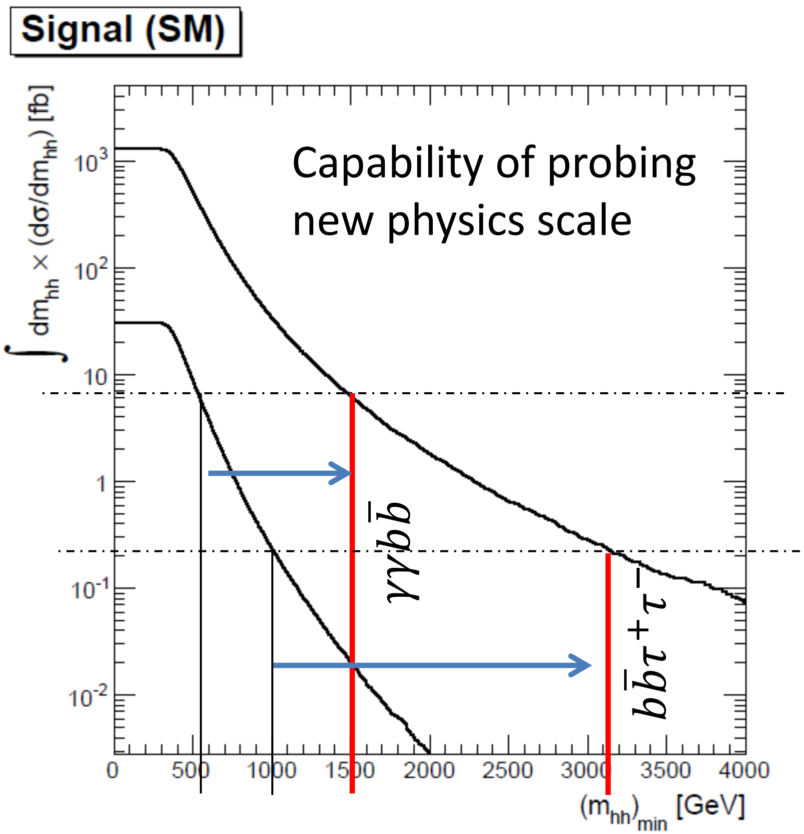


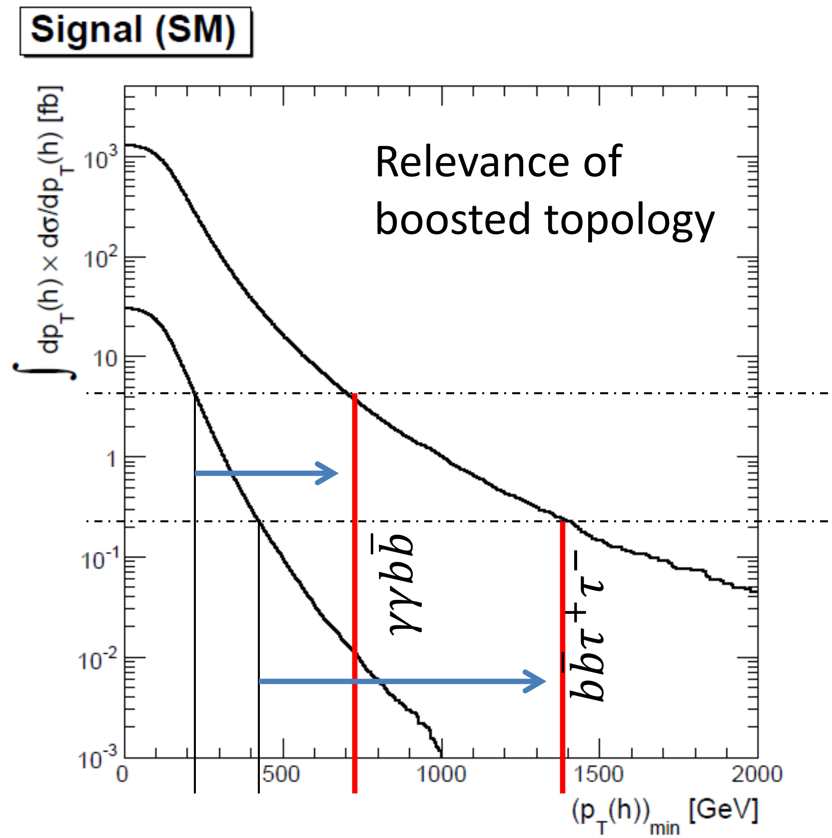


Channel	$b\bar{b}b\bar{b}$ (33.3%)	$b\bar{b}WW^*$(24.9%)	$b\bar{b}\tau^+\tau^-$(7.35%)	$\gamma\gamma b\bar{b}$ (0.264%)
Cross section	> 0.05 fb	> 0.067 fb	> 0.227 fb	> 6.31 fb
m_{hh} [GeV]				< 538 (1499)
$p_T(h)$ [GeV]				< 200 (640)

* Notation: @14TeV(@100TeV)

How far can we reach?





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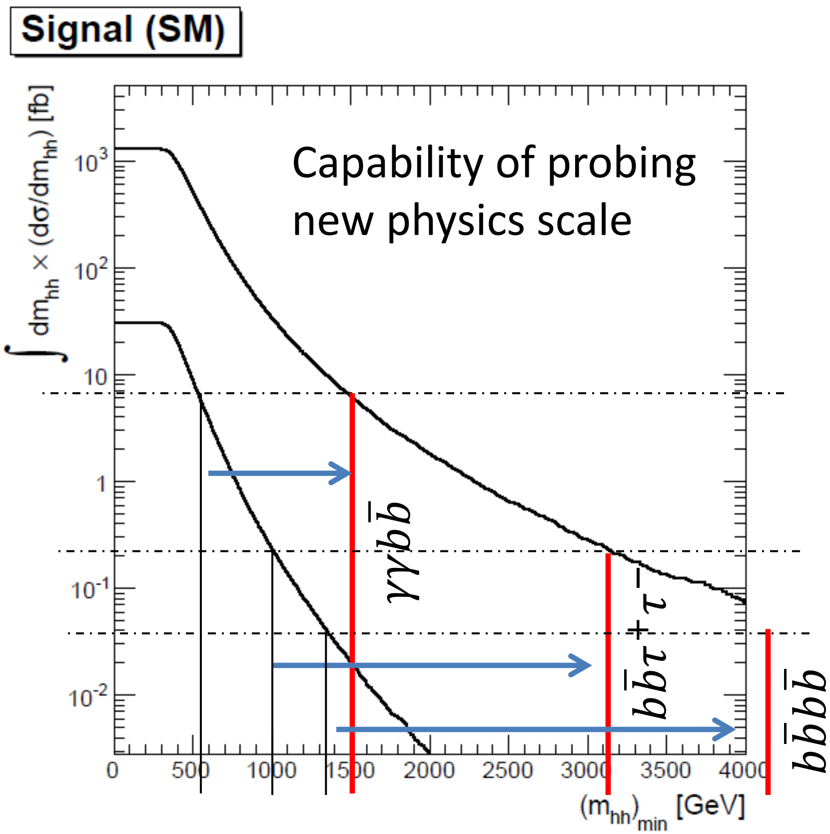
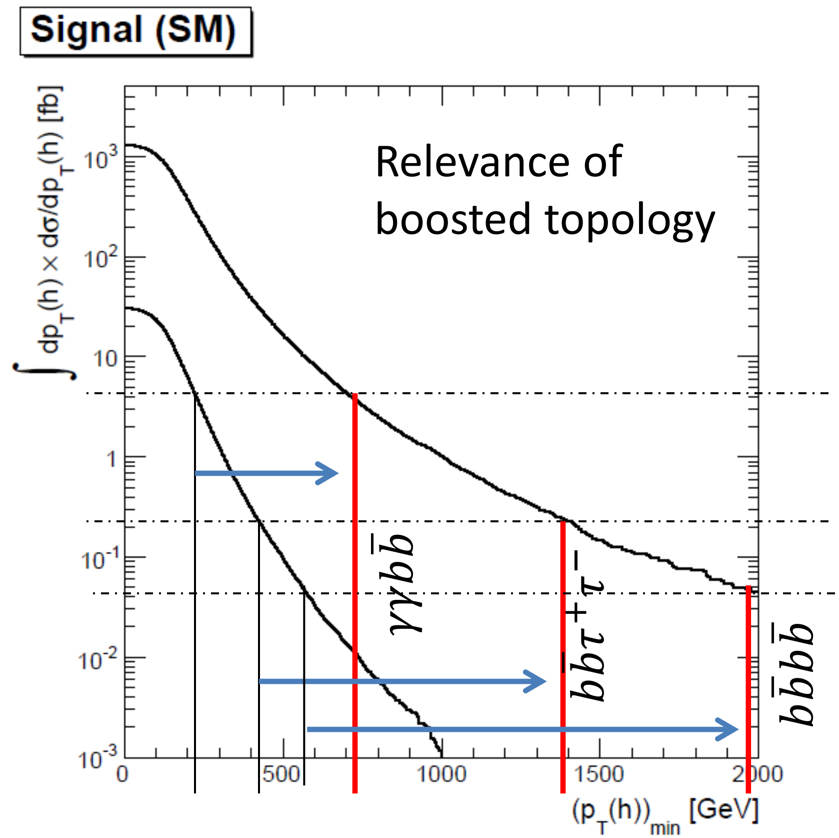
Cross section	> 0.05 fb	> 0.067 fb	> 0.227 fb	> 6.31 fb
m_{hh} [GeV]			< 1006 (3141)	< 538 (1499)
$p_T(h)$ [GeV]			< 424 (1399)	< 200 (640)

* Notation: @14TeV(@100TeV)

How far can we reach?

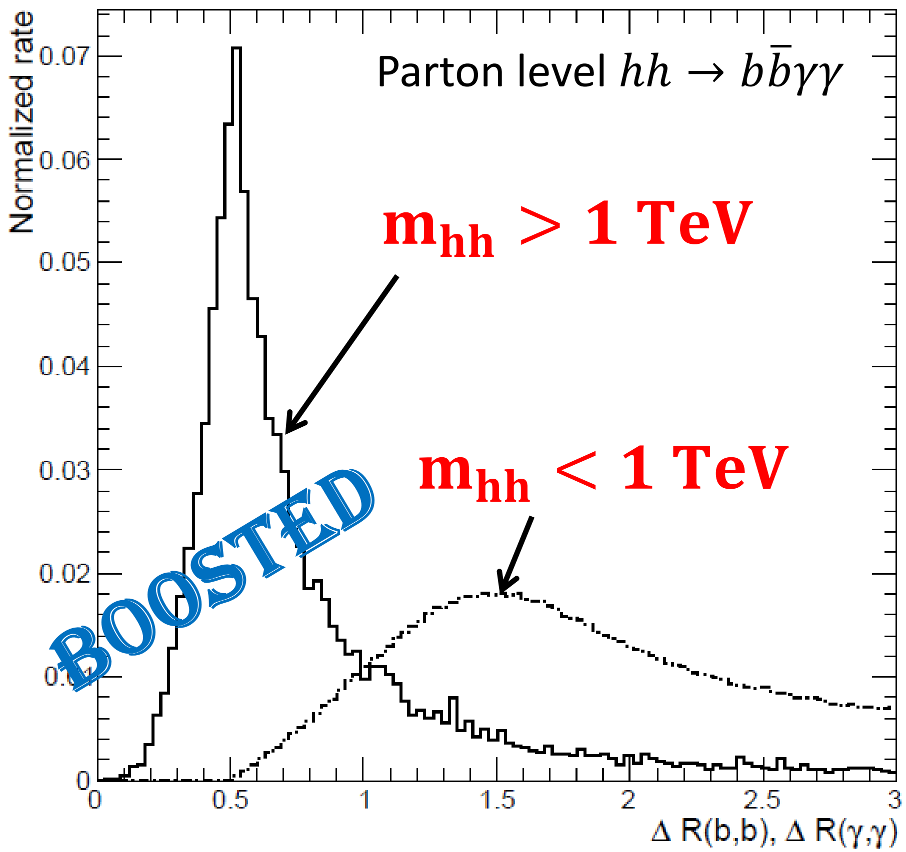




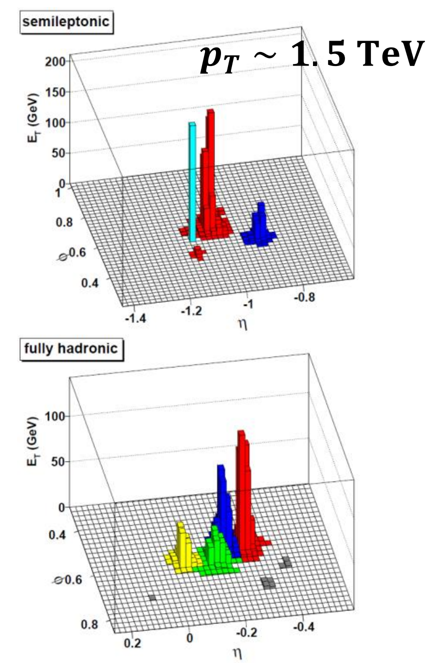
Channel	$b\bar{b}b\bar{b}$ (33.3%)	$b\bar{b}WW^*$(24.9%)	$b\bar{b}\tau^+\tau^-$(7.35%)	$\gamma\gamma b\bar{b}$ (0.264%)
Cross section	> 0.05 fb	> 0.067 fb	> 0.227 fb	> 6.31 fb
m_{hh} [GeV]	< 1300 (4200)	< 1240 (4070)	< 1006 (3141)	< 538 (1499)
$p_T(h)$ [GeV]	< 560 (1900)	< 530 (1830)	< 424 (1399)	< 200 (640)

* Notation: @14TeV(@100TeV)

Events split into m_{hh} > 1 TeV and < 1 TeV categories

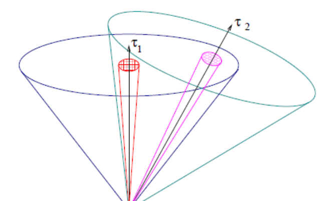


(WW^*)-jet



Son, Spethmann, Tweedie, JHEP 1208

$(\tau\tau)$-tagging



Kats, Son, Tweedie, PRD 83

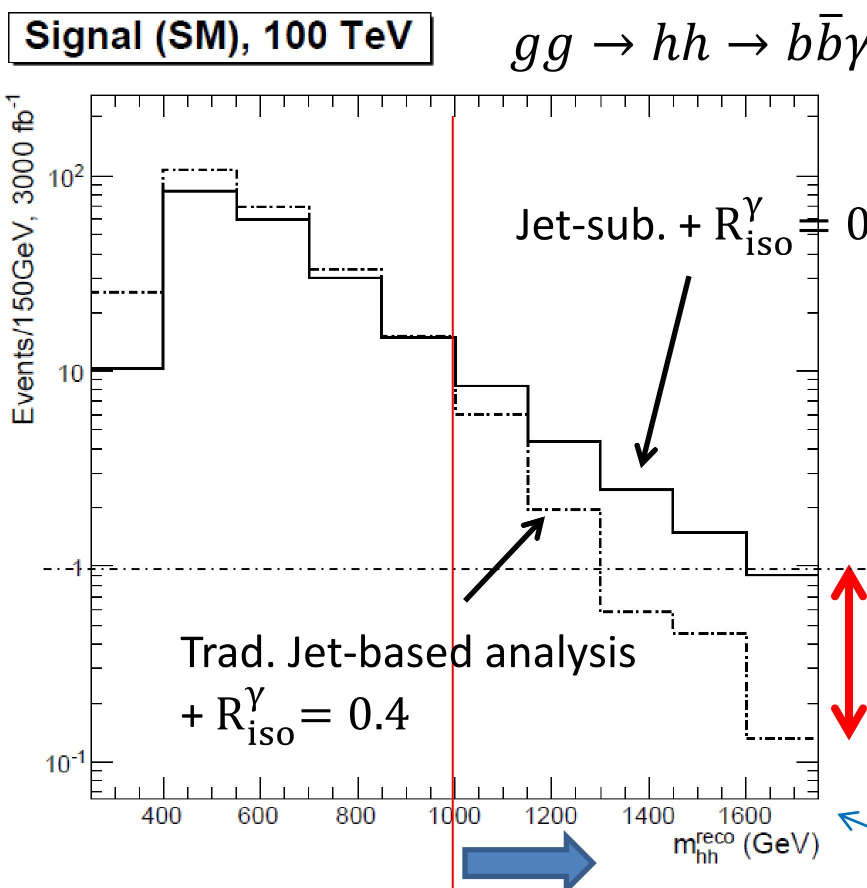
→ new classification of Higgs-jets

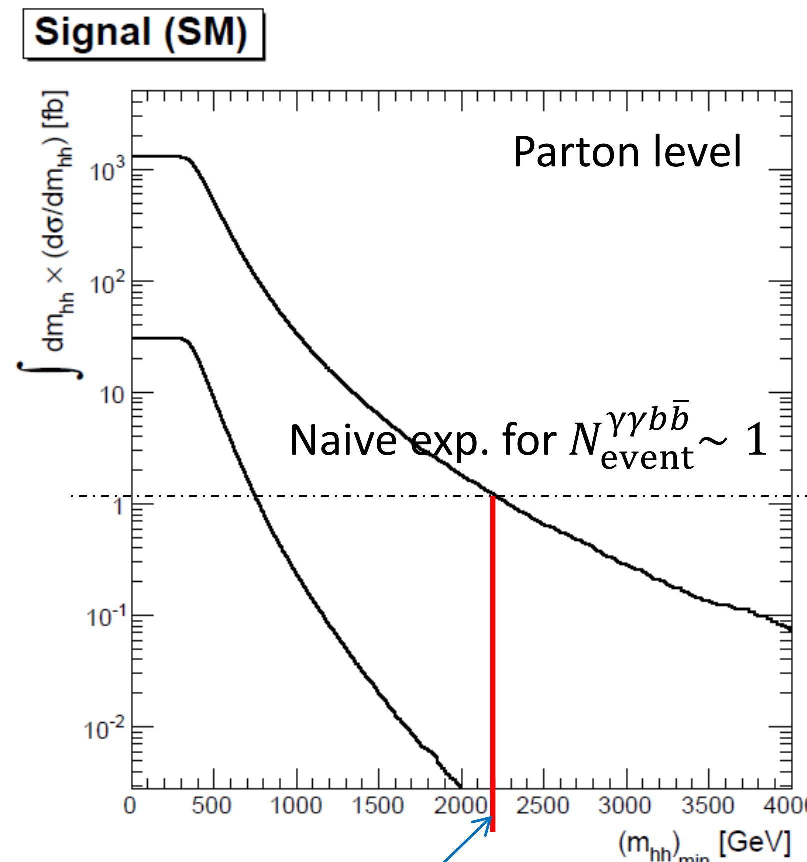
E.g. $(b\bar{b})$-jet, diγ-tagging , diboson-jet, diτ-tagging

“Jet-based” vs. “jet-substructure”

Jet sub recovers the naive expectation

$gg \to hh \to b\bar{b}\gamma\gamma$





JET-SUB WINS

MATCHES!