Di-Higgs Production in HH→bbγγ at the future hadron colliders

Mike Hence and Weiming Yao (LBNL)
FCC Higgs/EWSB Workplane discussion, 11/24/2014.
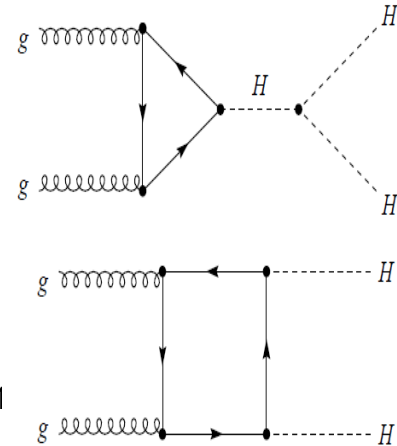
- Observing HH seems challenging at HL-LHC:
  - Destructive interference between HHH and gg→HH
  - CMS/ATLAS reports 2/1.5σ sensitivity at ECFA with $3ab^{-1}$

- Snowmass studies (arXiv:1308.6302) reported the feasibilities to observe

  HH→bbγγ at HL-LHC and VLHC using Delphes with ATLAS responses.

Samples	HL-LHC ($3\,ab^{-1}$)			TeV33 ($3\,ab^{-1}$)			TeV100 ($3\,ab^{-1}$)		
	$\sigma \cdot Br$ (fb)	Acc. (%)	Expect Evnts	$\sigma \cdot Br$ (fb)	Acc. (%)	Expect Evnts	$\sigma \cdot Br$ (fb)	Acc. (%)	Expect Evnts
$HH(b\bar{b}\gamma\gamma)$	0.089	6.2	16.6	0.545	5.04	82.4	3.73	3.61	403.9
$b\bar{b}\gamma\gamma$	294	0.0045	40.1	1085	0.0039	126.4	5037	0.00275	415.4
$z(b\bar{b})h(\gamma\gamma)$	0.109	1.48	4.86	0.278	1.41	11.8	0.875	1.57	41.2
$b\bar{b}h(\gamma\gamma)$	2.23	0.072	4.82	9.84	0.084	24.8	50.5	0.099	150.5
$t\bar{t}h(\gamma\gamma)$	0.676	0.178	3.62	4.76	0.12	16.5	37.3	0.11	124.2
Total B	-	-	53.4	-	-	179.5	-	-	731.3
$S/\sqrt{B}$	-	-	2.3	-	-	6.2	-	-	15.0

- With $3ab^{-1}$, the Higgs self-coupling could be measured to be 50%, 20%, 8% statistically by observing HH→bbγγ at $\sqrt{s}$=14, 33, 100 TeV colliders.

What's Next
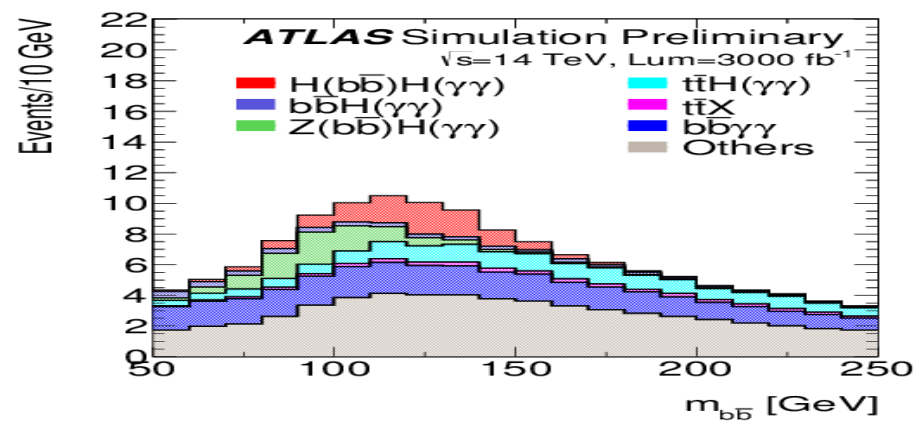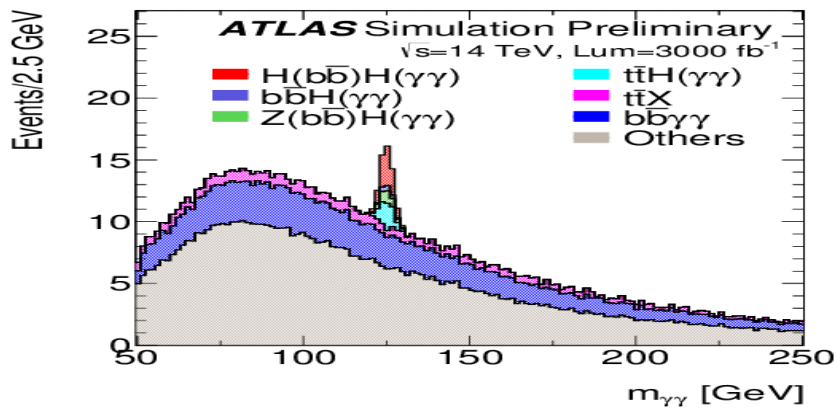
- Both ATLAS/CMS are planning to update diHiggs sensitivities for ECFA next spring, help to build a strong case for for HL-LHC running.
  - ➔Including the pile-up jets at the high-luminosity running with μ=140
  - ➔Improving the signal efficiency and background rejection with MVA.
  - ➔Understanding the detector effects and improving the detector design for phase-II.
  - ➔Including other channels (bbbb, bbττ,bbWW) and other processes (Hhjj, Hhtt, Vhh).
- Some of us will apply what learned from ECFA studies to the VLHC future collider (Mike, Ashutosh, Heather, Weiming...).
  - ➔Understand the signal and background scaling vs √s from HL-LHC to 100 TeV.
  - ➔Repeat the Higgs self-coupling measurement sensitivity vs √s to determine the detector requirements (photon pointing, photon/bjet Et resolution, fakes, btagging...)
    - • Better understand the systematic uncertainties including theoretical issues.