Update on BSM Higgs searches

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2HDM Hhh->??yy

- gg → H → hh → WW/ZZ yy
  - Let's take SM branching ratios for h → WW/ZZ @ mh=125GeV
  - 21.5% h → WW
  - 2.64% h → ZZ, very small, not yet multiplied by Z decay brs
- Well, 6.32%, H → ττ, no need to multiply any further brs
  - Coud be a channel to search in the future
  - But needs a lot of manpower (hadhad, hadlep, leplep)
  - Evidence in paper [ATLAS-CONF-2013-108]

WWyy

- Consider h → WW → jjjj
  - jjjj features:
    - Largest branching ratio
    - need to exlude bbbb carefully (small fraction of events) if combination
    - Backgrounds mainly from continuum jjjjyy, jjjjjy, jjjjjj, and ggh, vbf, Vh, tth, qcd, ttbar
  - Event counting, because bbyy analysis has very small statistics after all cuts and their branching ratio even after being multiplied by 70% btagging eff is still larger than ours with fully hadronic W decays

Comparison:
h → WW → jjjj: 0.215*0.676*0.676 = 0.098
h → bb * btag%: 0.577 * 50% *50% = 0.283

  - Stream: Egamma stream?
  - Trigger: EF_g35_loose_g25_loose?
  - This is the best channel maybe, but quite challenging

WWyy

- Consider h → WW → jj+lv
  - jj+lv features:
    - Branching ratio is close to jjjj due to the two flavors (e,mu) and the permutation
    - Backgrounds mainly from ? V(lv)H(yy), tth, single top, ttbar, qcd
    - It is difficiult to reconstruct W boson due to existances of one neutrino and one off-shell W*

Comparison:
h → WW → jjlv: 0.215*0.676*0.108*2*2 = 0.063
h → bb * btag%: 0.577 * 50% *50% = 0.283

WWyy

- Consider h → WW → lv+lv
  - lv+lv features:
    - Branching ratio is very small
    - Backgrounds mainly from ? tth, Vh, ttbar, single top, WW
    - It is very difficiult to reconstruct W boson due to existances of two neutrino and one off-shell W*
    - If possible, fit on transverse mass of h(WW) or H, concerned about the very low statistics

Comparison:
h → WW → lvlv: 0.215*0.108*2*0.108*2 = 0.01
h → bb * btag%: 0.577 * 50% *50% = 0.283

ZZyy

- Consider h → ZZ → jjjj
  - jjjj features:
    - Branching ratio is very small
    - Backgrounds mainly from continuum jjjjyy, jjjjjy, jjjjjj, and ggh, vbf, Vh, tth, qcd, ttbar
    - Maybe it is better to be merged into WW → jjjj analysis by enlarging the mass windows to cover both Z and W masses
    - Event counting with respect to this statistics

Comparison:
h → ZZ → jjjj: 0.0264*0.70*0.70 = 0.013
h → bb * btag%: 0.577 * 50% *50% = 0.283

ZZyy

- Consider h → ZZ → jj+ll
  - jj+ll features:
    - Branching ratio is very small, but more clear signature
    - Backgrounds mainly from V(ll)H(yy), tth, single top, ttbar, qcd
    - It is better than WW → jj+ll, since one can check inv.mass(ll) close to on-shell Z mass, if yes, then good, if not, then constrain jj by requiring the on-shell Z mass
    - Maybe there is a possibility of fitting inv. mass of H, since no MET exsits

Comparison:
h → ZZ → jjll: 0.0264*0.70*0.034*2 = 0.0126
h → bb * btag%: 0.577 * 50% *50% = 0.283

ZZyy

- Consider h → ZZ → llll
  - llll features:
    - Branching ratio is extremely small, but very clear signature
    - Backgrounds mainly from ZZ
    - Fully reconstruct all masses
    - Event counting with probably zero backgrounds?!

Comparison:
h → ZZ → llll: 0.0264*0.034*2*0.034*2 = 0.0001
h → bb * btag%: 0.577 * 50% *50% = 0.283

ZZyy

- Consider h → ZZ → jj+inv.
  - jj+inv. features:
    - Branching ratio is quite small, signature is not clear
    - Backgrounds mainly from V(lv)H(yy), tth, single top, ttbar, qcd
    - Can be hacked in very high MET regime, in which case jets are probably boosted
    - Fit on MET distirbution if statistics allows

Comparison:
h → ZZ → jjinv.: 0.0264*0.70*0.20*2 = 0.007
h → bb * btag%: 0.577 * 50% *50% = 0.283

All channel or which channel

- Look at jjjj final states including WW and ZZ by event counting
- Look at WW → jj+lv by transverse mass
- Look at ZZ → jj+ll with fully reconstructed H
- Maybe look at ZZ → llll with probably zero background

- There are many promising channels, well, we cannot look at them all since we need a sizable amount of manpower

MC

- It is good to discuss after making sure which final state we will focus on
- Jianming proposed inclusive samples:
  - With 500k, the statistics for individual final states will be:
    - WW → 4j: 100k
    - WW → l+2j: 62k
    - ZZ → 4j: 13k
    - ZZ → 2l2j: 2400 ?
    - ZZ → vv2j: 7k

So the other ~300k events?

- I am not sure this is the best idea
  - One cannot guarantee the interesting final states dominate in the inclusive sample
  - The branching ratios are functions of H mass which vary