# Study of HH->WW*WW*->2Lss channel analysis

# status report

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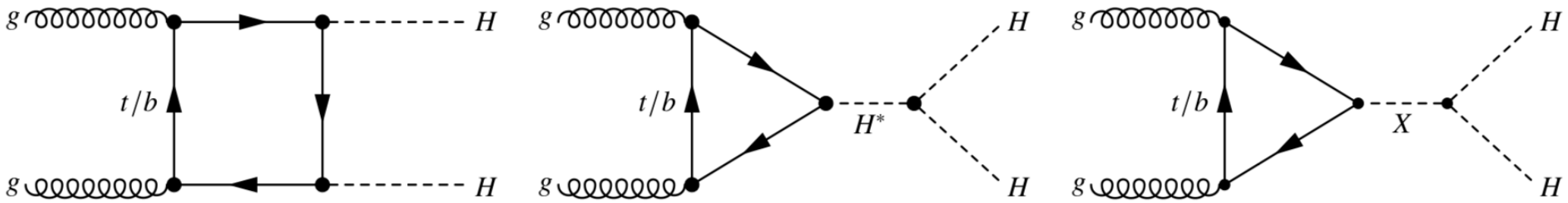
# Overview

- A review of 2LSS analysis
- Work on the ttHMultiGFW2 framework

# di-Higgs production in SM and BSM




- SM gluon-gluon fusion via a heavy-quark loop and Higgs self-coupling

  $pp \to HH \to WW^{(*)}WW^{(*)}$

- BSM though an intermediate resonance

  $pp \to X \to WW^{(*)}WW^{(*)}$

- Final state

  $WW^{(*)}WW^{(*)} \to \ell\nu + \ell\nu + 4q$ Required same-signed leptons to suppress ttbar, Drell-Yan,W+W- processes

# Object definition

Loose selection: all leptons are required, used for defining CR and estimating background
Tight selection: define SR.

- Leptons

| | | |
|---|---|---|
| electron | ET > 10 GeV, \|η\| < 2.47 ,removed 1.37 < \|η\| < 1.52 | |
| | Loose selection | Tight selection |
| | LooseLH ID<br>Loose isolation<br>$\lvert z_0 \sin\theta \rvert < 0.5\text{mm}, d_0 / \sigma(d_0) < 5$ | TightLH ID, FixedCutTight<br>$E_{\text{T}}^{\text{cone}20} / p_{\text{T}} < 0.06, p_{\text{T}}^{\text{varcone}20} / p_{\text{T}} < 0.06$ |
| moun | $p$T > 10 GeV,\|η\| < 2.5 | |
| | Loose selection | Tight selection |
| | Loose ID, Loose isolation<br>$\lvert z_0 \sin\theta \rvert < 0.5\text{mm}, d_0 / \sigma(d_0) < 3$ | Tight ID, FixedCutTightTrackOnly<br>$p_{\text{T}}^{\text{varcone}\ 20} / p_{\text{T}} < 0.06$ |

- jets

$p_{\text{T}} > 25\text{GeV}, |\eta| < 2.5 \quad |\text{JVT}| < 0.59 \text{ if } p_{\text{T}} < 60\text{GeV and } |\eta| < 2.4$

- Missing transverse energy

$p_{\text{T}}^{\text{track}} > 500\text{MeV}$

$\lvert z_0 \sin\theta \rvert < 3\text{mm}, \text{d}_0 / \sigma(\text{d}_0) < 2$

- Overlap removal

| Keep | Remove | Cone size ($\Delta R$) |
|---|---|---|
| muon | electron | 0.1 |
| electron | electron (lower $p_{\text{T}}$) | 0.1 |
| electron | jet | 0.3 |
| jet | muon | min(0.4, 0.04+10[GeV]/$p_{\text{T}}(\mu)$) |

# Event selection

- Pre-selections

| | |
|---|---|
| Pre-selections | GRL<br>Event clean criteria<br>Pass any trigger applied<br>Select objects following object definitions<br>Overlap removal<br>Two tight same-signed leptons, with at least one trigger matched<br>$p_T(\ell_1) > 30$ GeV, $p_T(\ell_2) > 20$ GeV<br>$b$ veto<br>$E_T^{miss}$ >10 GeV<br>$M(\ell\ell)$ >15 GeV<br>$\|M(\ell\ell) - M(Z)\|$ >10 GeV in $ee$ channel<br>$N_{\text{jet}} \geq 2(3)$ |

- Signal optimization
  - For high mass work point , 400 GeV, 500 GeV, N_jet >=3
  - For low mass work point , 260 GeV and 300 GeV , N_jet >=2
  - Some kinematic variables are used to form optimization cuts.

# Background estimation

- Background source

  - PromptSS: ttV,  VV ($W^{\pm}W^{\pm}$, $WZ$, $ZZ$), $tV$ and $t\bar{t}H$ ($H \rightarrow W^{\pm}W^{\mp}$, ττ, and $ZZ$)
    Estimated by MC
  - QmisID: Z+jets and $t\bar{t}$
    Likelihood function technique -> ATL-COM-PHYS-2012-164 (2012).
  - fakes : W+jets  and $t\bar{t}$
    Fake factor method ->http://dx.doi.org/10.1007/978-3-319-10344-0_9

# Fake factor estimation

- Fake factor: $\theta_\ell = \frac{N_{\ell\ell}}{N_{\ell\not\ell}}$
- Definition of tight and anti-tight lepton
  - Electron

| | tight electron | anti-tight electron |
|---|---|---|
| ID | TightLH | fail TightLH |
| isolation | isolationFixedCutTight | - |
| QmisID | ChargeIDBDTTight>0.067 | ChargeIDBDTTight>0.067 |

  - muon

| | tight muon | anti-tight muon |
|---|---|---|
| ID | Tight | - |
| isolation | isolationFixedCutTightTrackOnly | fail isolationFixedCutTightTrackOnly |

- The result is agree with previous paper

# Fake factor estimation

- Summary of fake factor

| | | |
|---|---|---|
| N_jet=1 | theta_e | 0.5401 |
| | theta_u | 0.5033 |
| 1<N_jet<2 | theta_e | 0.5472 |
| | theta_u | 0.4544 |

- Jet fakes in three channels

| selection | N_jet>=2 | | | N_jet>=3 | | |
|---|---|---|---|---|---|---|
| | ee | eu | uu | ee | eu | uu |
| Event yield | 318.27±9.64 | 256.20±8.06 | 332.69±9.62 | 127.38±6.10 | 122.97±5.58 | 138.25±6.16 |

# ttHMultiGFW2 framework


- Apply event selection, slim GFW1 ntuples to GFW2 ntuples to meet our needs
- Try to test GFW2 package locally (succeed).
- Problem occurred when ran on the grid.

# What to do

- Optimize signal region

  TMVA package is used. How about new method?

- Systematic study

  Analysis the uncertainty of fakes, and other Systematic uncertainties

- Update new datas and samples

- Develop ttHMultiGFW2  framework

  To dump N2 that we require.