Higgs Self-Coupling with ZHH

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FAST MC ANALYSES

FULL SIMULATION AND RECONSTRUCTION ANALYSIS

IMPLICATIONS FOR LOI

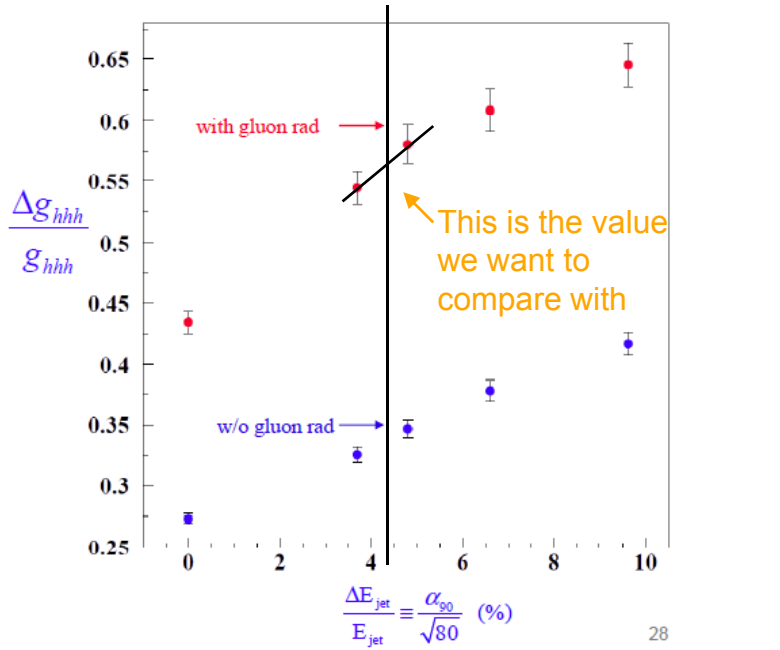
OUTLOOK

Summary of FastMC Analyses

- There were two analyses done of ZHH with FastMC
  - Both confirmed that with gluon FSR the analysis becomes extremely difficult
  - Our best result with the LCFI package was ~60%

- We expect ~400 ZHH events for 2000fb^{-1} luminosity.
  - Leading to about 130 bbbbqq channel (well hidden) events.

Tim Barklow



FastMC Analyses – More Details

- Signal is ZHH when H→ bB and Z → qQ, i.e. 6 jets and at least 4 are b's coming from Higgs.

- The following background was only considered:
  - tbW
  - ZZH
  - ZH
  - ZZ
  - ZZZ
  - ZHH – other channels

- tbW and ZZH being the worst ones

Full Simulation/Reconstruction Analysis

- We have two samples of 200k events each for nominal and 25% shifted values of f_{HHH}
  - Effectively about 133k events due to missing/empty files
  - They passed the complete chain including lepton ID and LCFI package
- The background is our LoI SM 500 sample with 6622k events (of 7196k)
  - Unexpected backgrounds, compared to FastMC
  - Plus imperfections of reconstruction
- FastMC was 100% polarised – now we are at 80/30 pol → less events
- I'm working on this last few days so the analysis may not be enough elaborated. Given the problems it has not much more can be expected for the LoI.

Selection Cuts

- Before Neural Net is trained, events are preselected with the following cuts

1) No isolated lepton
2) $E_{gamma}/E_{jet} < 0.8$ for all jets
3) $E_{jet} > 10$GeV for all jets
4) $E_{visible} > 320$ GeV
5) $0.55 < \text{Thrust} < 0.85$
6) $\text{Cos}(\vartheta_{thrust}) < 0.95$
7) $|pz| < 50$ GeV
8) $14 < N_{charged} < 46$
9) $110 < E_{thrust\_hemisphere} < 320$ GeV
10) $\Sigma b_{NN\ tag} > 2.0$ (2.5)

Neural Net Training

- Neural Net Inputs are

1. The b tagging results for six jets;

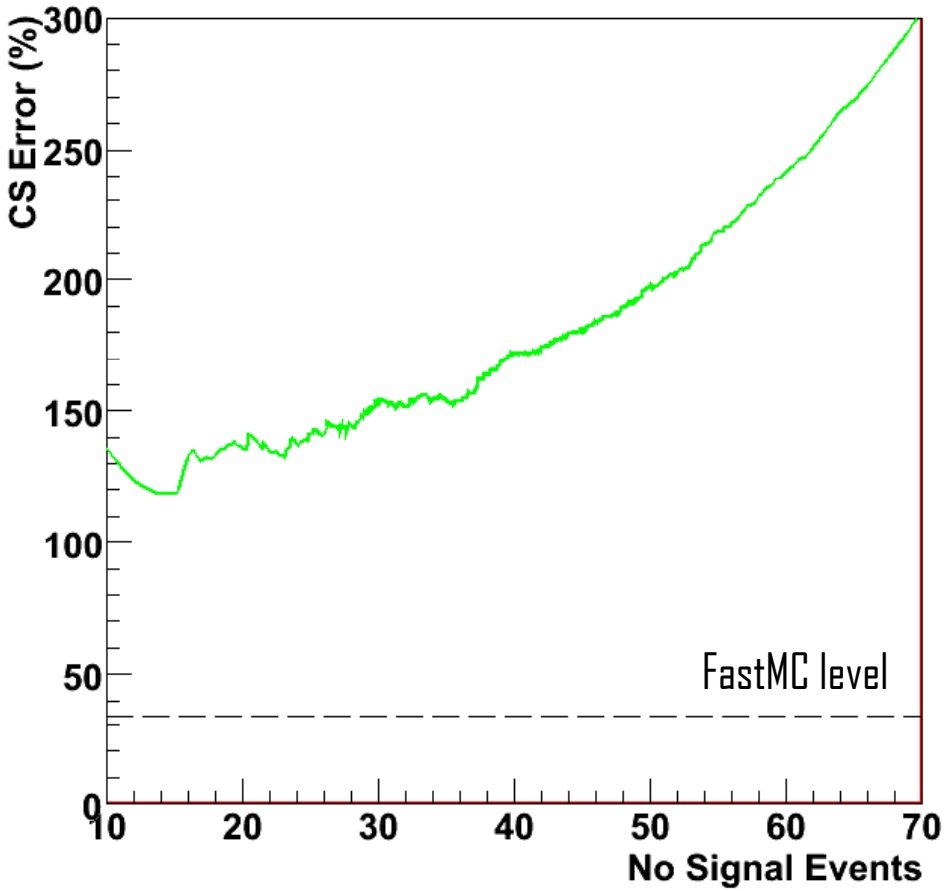
2. Invariant mass for variant jet combinatorics (and the difference with respect to gauge bosons, e.g $Jet12H = (m_{jet1,jet2} - m_H)^2$). All the inputs used are: $Jet12H$, $Jet13H$, $Jet14H$, $Jet23H$, $Jet24H$, $Jet34H$, $Jet56H$, $Jet56Z$, $Jet34W$, $Jet56W$, $Jet25W$, $Jet26W$, $Jet35W$, $Jet36W$, $Jet45W$ and $Jet46W$;

3. The variable representing the mass difference of reconstructed particles with respect to the signal/background final states. For example: $ch2\_zhh = min\{(m_{j1,j2} - m_H)^2 + (m_{j3,j4} - m_H)^2\}$, where $\{j1, j2, j3, j4\}$ are all possible permutations for the first four jets (ordered by b tag value), assuming the two least b-like jets are assumed from Z. Similarly defined such variables are: $ch2\_tt = min\{(m_{j1,j2} - m_W)^2 + (m_{j3,j4} - m_W)^2\}$ (where the two most b-like jets are assumed to be b jets), $ch2\_zzh = min\{(m_{j1,j2} - m_Z)^2 + (m_{j3,j4} - m_H)^2\}$, and $ch2\_zzz = min\{(m_{j1,j2} - m_Z)^2 + (m_{j3,j4} - m_Z)^2\}$.

  - Sums of b_{NN_tag}, c_{NN_tag} and $c(b)_{NN\_tag}$ of all jets.
  - Plus some more: k_T, y_{min}, y_{max}, $N_{leptons}$

Results

- Statistical error of N_{signal} (and ZHH→bbbbqq cross section) as a function of N_{signal} itself
  - Not “template fitted” results.
  - Multiply by ~1.8 to get f_{HHH} measurement error…
  - With some luck I can get to ~80% level but this is likely due to fluctuations (getting rid of few events with large weight) at low N_{signal} side



What's the troublesome background now?

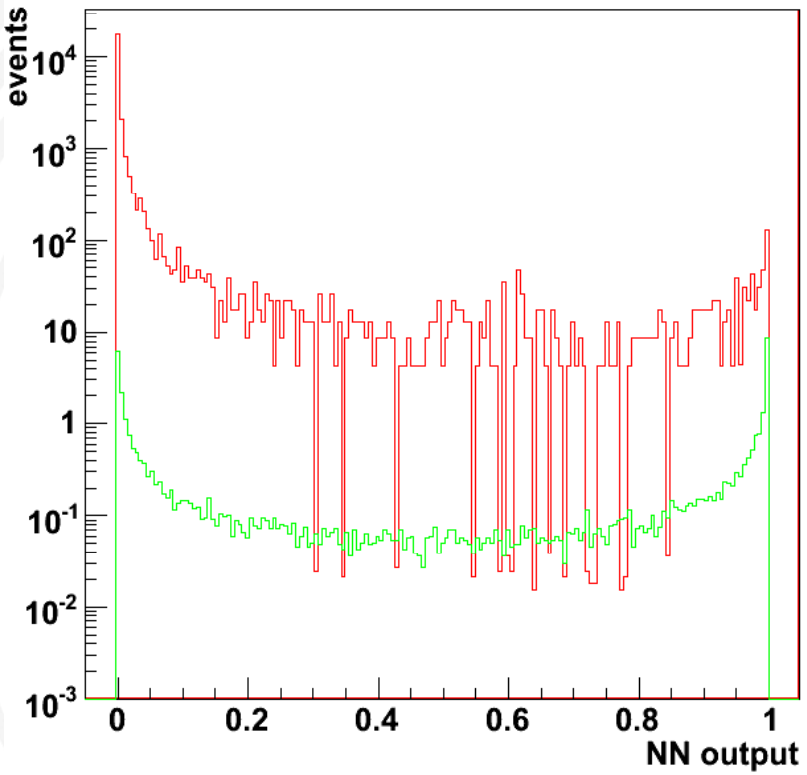
- Assuming some 'random' cut on NN output NN>0.5:

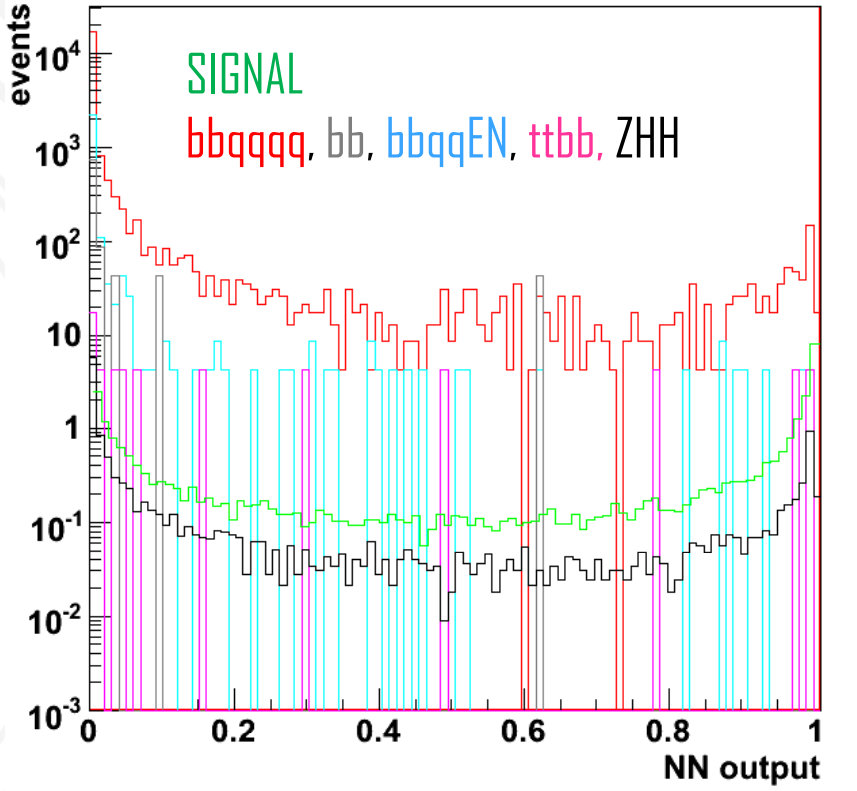
SIGNAL	39.4452	
bbqqqq	2016.88	(tbW, ZZZ,ZZH,…)
bB	86.9344	
bbqqEN	86.9344	
ttbb	26.0803	
ZHH	7.37863	(cross channel contamination)

This would corresponds to stat error of about 170% (x1.8 for f_{HHH})

Neural Net Output

- There is not enough information in inputs provided to separate signal clearly.





Implications for LoI

- Plot of f_{HHH} precision as a function of the jet energy resolution at page 10 of the draft is a pure dream (FastMC without FSR gluons).

- Given the (no)time constrains there is not much more to be expected for LoI from this analysis.