

Brief update on VBF Higgs- \rightarrow b \bar{b} (looking at 2- \rightarrow 3 ONLY background)

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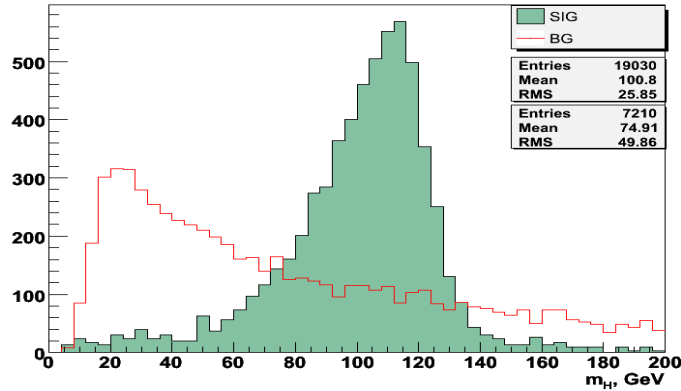
1. What's new

- **Background:**
- Erik generated 2 x more (2->2 && 2->3) $\gamma t=25$ events, total $\sim 30\text{M}$. However, this is still not enough to see the shape of BG after all cuts.
- Erik also generated $\gamma[t] = 50 \text{ GeV}$; 2->3 ONLY samples, total 1M. $X_{\text{sec}} = 1.4\text{E}6 \text{ pb}$ – two orders of magnitude smaller. This looks better.
- **Conventions:** Using a more realistic 300 fb^{-1} to estimate significance.
- **Algorithm:**
- Instead of a direct Mbb cut, I deduce the shape of the background and estimate the uncertainty on the number of BG events in the higgs mass range using a toy Monte-Carlo. Previously I used \sqrt{N} .
- more on this below
- NOTE: the only reliable way to do this so far has been *direct error propagation*. This means that I can only assume the background shape that is nicely integrable. So far implemented symbolic integration for: arbitrary-degree polynomial and 2-parameter exponential.

115 GeV
Higgs

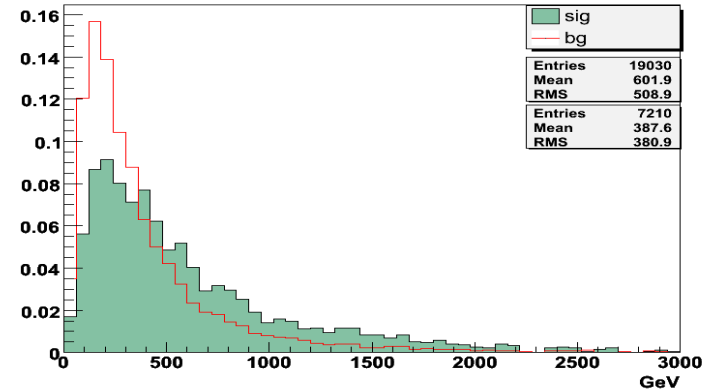
2. Before cuts and trigger

1. Higgs mass reconstructed for real and for BG events, norm to unity



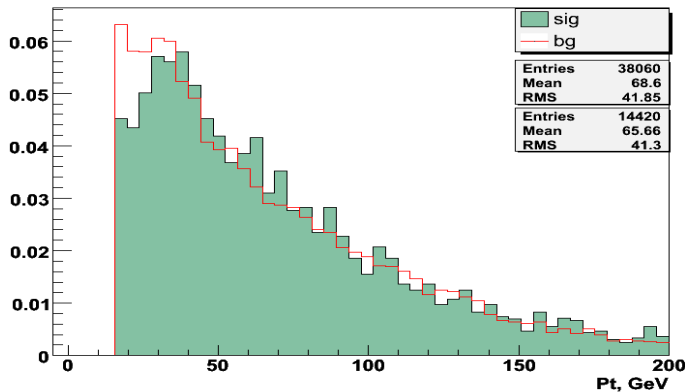
Mbb

1. Mjj distribution, sig and bg



Mjj

1. Pt of tagging jets, sig and bg

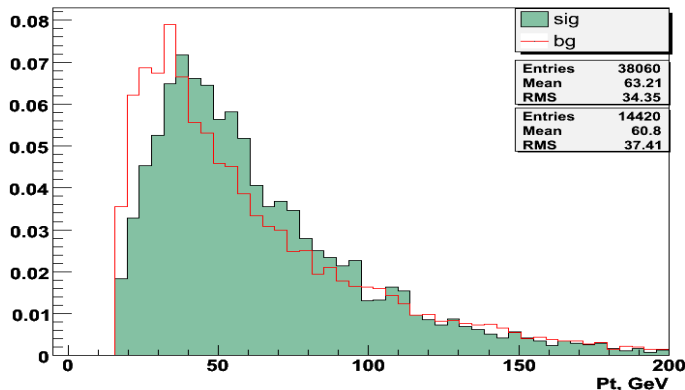


PtQ

Statistics:

- *Passing efficiency:*
 - 0.74% of BG (based on 7k);
 - 19% of signal (based on 20k)
- *#events after 300 fb⁻¹:*
 - 3 billion of BG;
 - 180k of signal
- $\#sig/\sqrt{\#bg} = 3.25$

1. Pt of b-jets, sig and bg

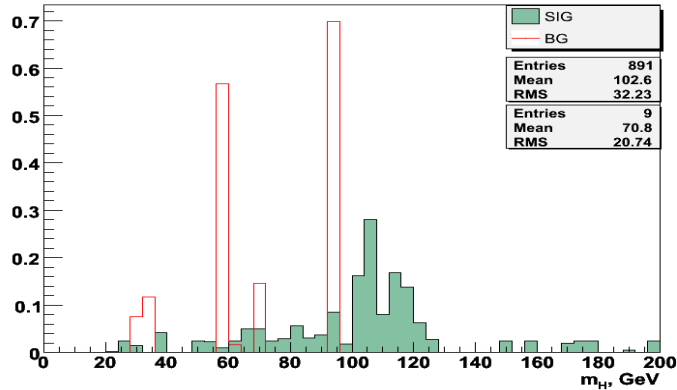


PtB **Notes:**

Since the BG sample already requires $y_t=60\text{GeV}$, we see that the Pt cuts aren't very effective. In fact, only Mjj cut increased significance (to 3.35)

115 GeV Higgs 3. After trigger, 4j60 (no Mbb cut)

1. Higgs mass reconstructed for real and for BG events, norm to unity

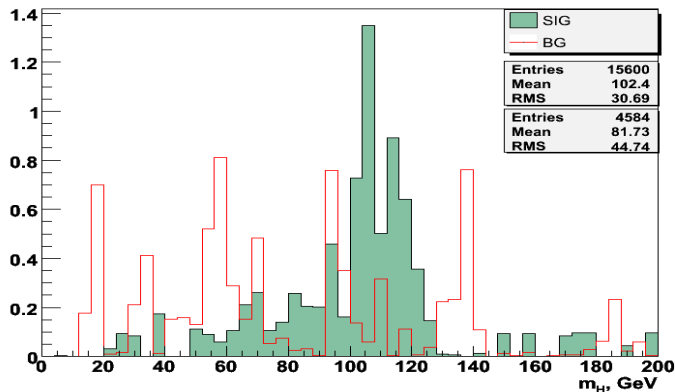


Mbb,
binary

Statistics:

- *Passing efficiency:*
 - 0.0009% of BG (based on 9 events);
 - 0.89% of signal (based on 890 events)
- *#events after 300 fb⁻¹:*
 - 4M of BG;
 - 8.5k of signal
- $\#sig/\sqrt{\#bg} = 4.31$

1. Higgs mass reconstructed for real and for BG events, norm to unity



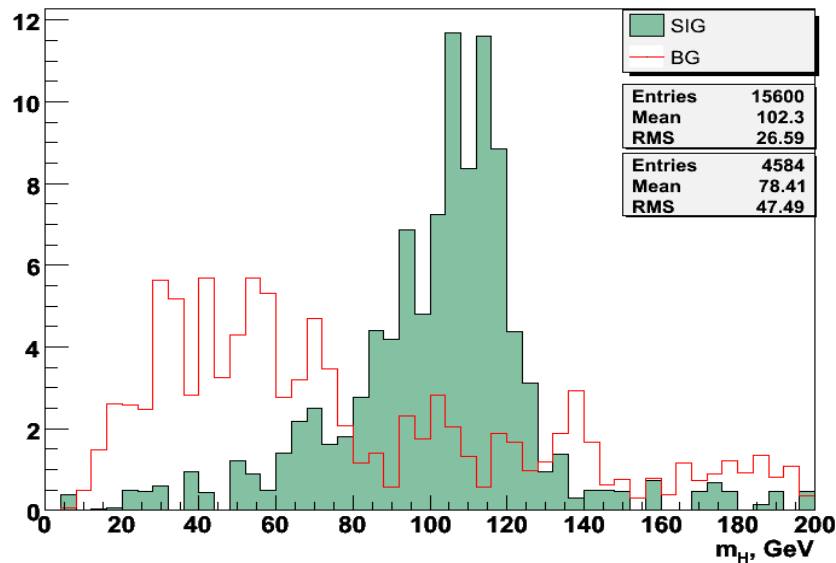
Mbb, weighted
(sorry for different signal normalization)

NEED MORE STATISTICS!

4. After trigger, 4j40 (no Mbb cut)

Mbb,
weighted

1. Higgs mass reconstructed for real and for BG events, norm to unity



Statistics:

- *Passing efficiency:*
 - 0.01% of BG (based on 122.3 events);
 - 2.3% of signal (based on 2305.9 events)
- *#events after 300 fb⁻¹:*
 - 52M of BG;
 - 22k of signal
- *#sig/sqrt(#bg) = 3.02*

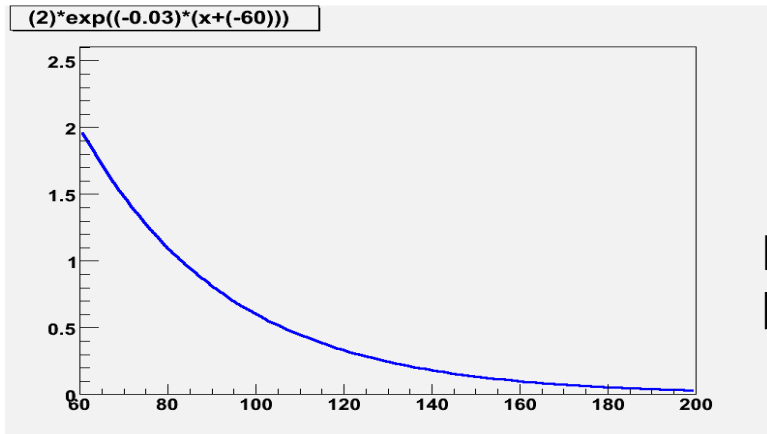
Notes:

Cannot trust this particular result too much, because the generated BG has $y_{t>50}$ GeV, but we are requiring a threshold of 40 GeV, so not phase space is covered!

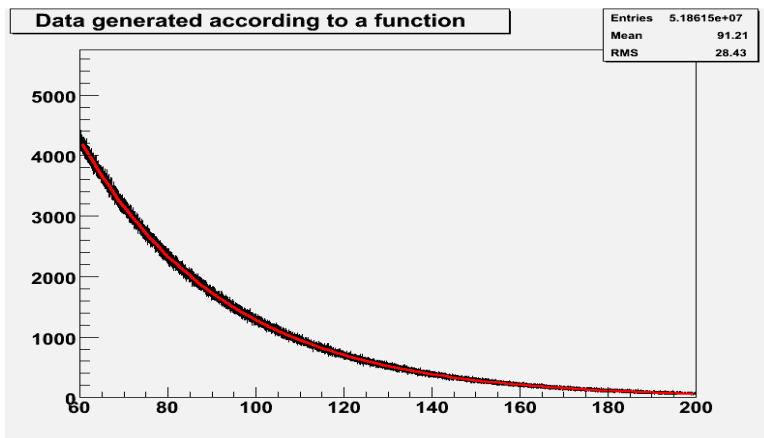
I used 40 GeV just to show that we can kind-of deduce the shape of BG – in this case, it is roughly a falling exponent beyond 60 GeV

5. Plan: how to estimate the error on #bg

115 GeV
Higgs



Mbb,
binary



In the case shown: #[expect]=52M
If we integrate between 85 and 135 GeV:
 $\Delta[\#BG] = 2941$; $\sqrt{N} = 7201$
Consistency check:
If we integrate between 60 and 200 GeV:
 $\Delta[\#BG] = 7200$; $\sqrt{N} = 7201$

1. Get enough BG data to deduce its shape. Suppose it follows a falling exponent from 60 GeV to 200 GeV. Guess the functional form [blue curve]
2. Generate random events that follow this curve [black histogram]. # of events generated = # of BG events expected after 300 fb^{-1} , which is calculated using Xsection and pass probability.
3. Fit the histogram to the given functional shape and obtain errors on the parameters [red curve]
4. Propagate these errors to the integral under this curve over the region where we expect Higgs signal.

Note: as a consistency check, when I integrate over the entire region, I obtain \sqrt{N}

6. New estimate on significance

Continuing from the previous page, let us estimate the significance with 4j40 after applying the Mbb correction, as described.

Original significance:

$$\#sig/\sqrt{\#bg} = 22k/\sqrt{52M} = 22k/7201 = 3.02$$

New estimate using the Mbb correction (very rough):

$$\#sig/\delta(\#bg) = 22k/2941 = 7.4$$

TODO:

- Obtain more 2->3 yt=50GeV background and repeat with 4j60 (more realistic)
- Estimate the uncertainty on significance
- Is the 2->3 sample correct, or does it have to be (2->3 && 2->4) for sherpa to work correctly?