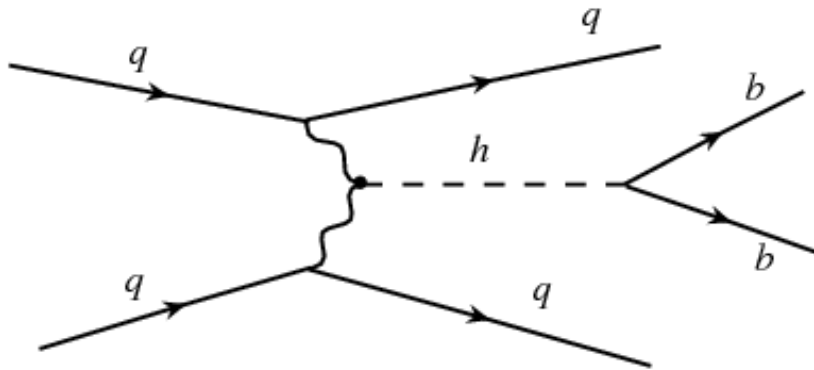


Updates on VBF Higgs- \rightarrow b \bar{b}

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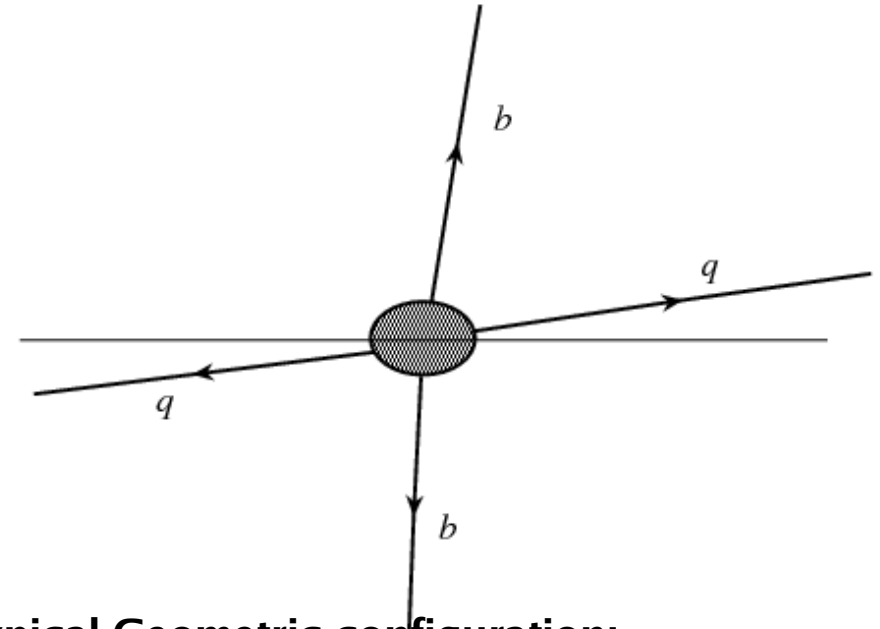
June 14 2006

1. Reminder: process



Vector boson fusion (VBF), SM Higgs

- Considering both W and Z boson fusion
- In the outgoing state:
 - Two b-quarks
 - Two tagging quarks (mostly u,d,c)



Typical Geometric configuration:

- B-jets forming in the central eta-region
- Tagging jets in the forward direction
- Little activity in between due to lack of color exchange between interacting partons

2. Data samples

- Generated within the framework of Athena v11.0.42
- **Signal:** Pythia and AtfastB. 3 samples, 100k each
 - 115 GeV Higgs, Xsec = 3.15 pb
 - 130 GeV Higgs, Xsec = 1.97 pb
 - 140 GeV Higgs, Xsec = 1.15 pb
- **Background:** Erik's 2->2 & 2->3 sherpa samples, total 1M events
 - Xsec = 3.7E8 pb (almost a billion times larger)

The same background was used for all three signal samples.

This presentation only deals with simulated data. Truth-level plots are here:

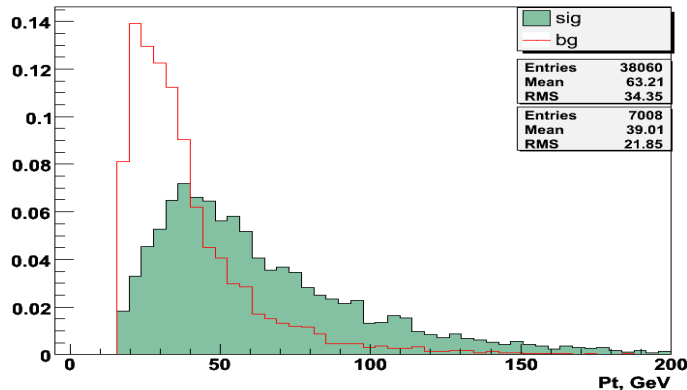
http://hep.uchicago.edu/cdf/shochet/ftk_06_06/Anton.pdf

3. Algorithm

- $N_{\text{JETS}} \geq 4$ - we need two b's and two tagging jets
- # b-jets=2. Although we could require ≥ 2 , very few events have >2 b-jets
- Among the remaining jets, choose the highest-pt jet in $\eta > 0$ region, and separately – in $\eta < 0$. If no jet is found in either region, skip the event
- New cuts (based on Iacopo's studies and on hep-ph/0210261:
 - Pt of leading and second-leading b-jets and q-jets (=tagging aka forward jets)
 - Delta Eta between forward jets (upgrade of the Eta cut for forward jets)
 - Highest-Pt jet in the Eta region **between** forward jets (upgrade of the veto cut)
 - M_{jj} – invariant mass of two forward jets
 - M_{bb} – invariant mass of two b-jets, aka reconstructed Higgs mass
- Implemented Erik's parametrizations, so now I can (optionally) apply **trigger cuts**.
- TODO: manually apply tagging probabilities (right now AtIfastB does this)
- CAVEAT: jet energies and Pt's are **not perfectly calibrated!**

4. Signal-vs-BG, b-jet Pt, no cuts

1. Pt of b-jets, sig and bg



115 GeV

Comment:

Signal-Background:

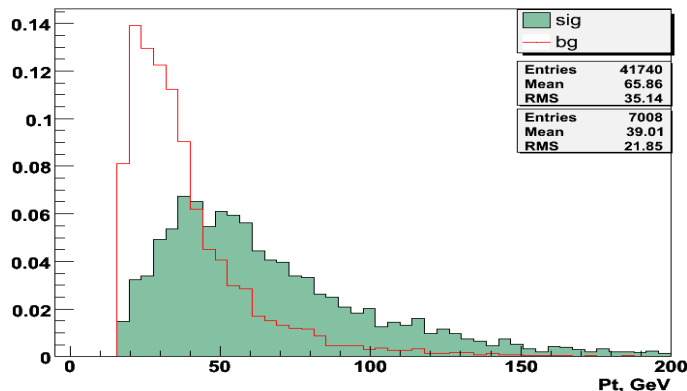
* Apply a cut of 50 GeV to leading and 40 GeV to second-leading b-jet.

Different Higgs masses:

* Little overall difference between different Higgs masses.

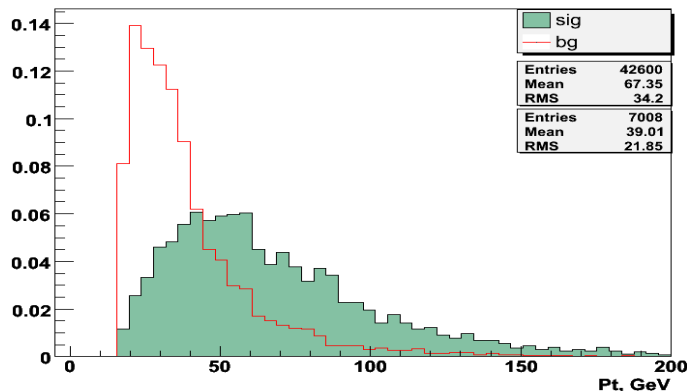
* The signal slowly crawls towards higher-Pt as higgs mass increases (just as expected).

2. Pt of b-jets, sig and bg



130 GeV

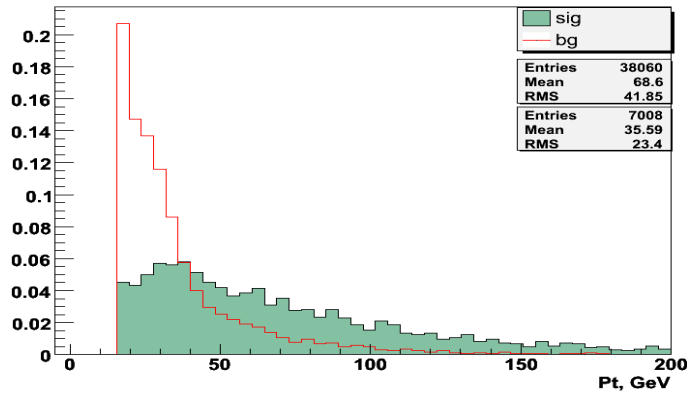
3. Pt of b-jets, sig and bg



140 GeV

5. Signal-vs-BG, q-jet Pt, no cuts

1. Pt of tagging jets, sig and bg



115 GeV

Comment:

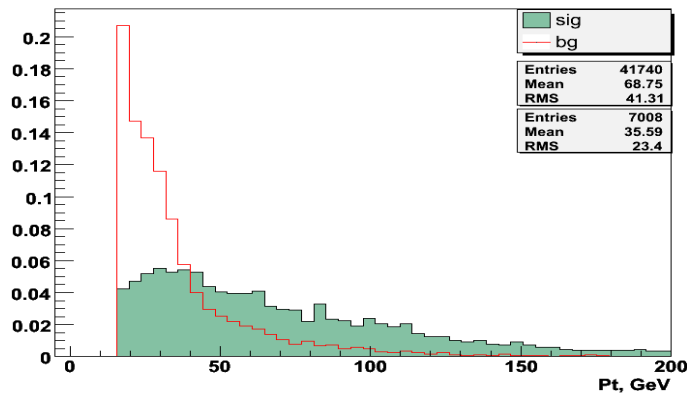
Signal-Background:

* Apply a cut of 40 GeV both to leading and second-leading b-jet.

Different Higgs masses:

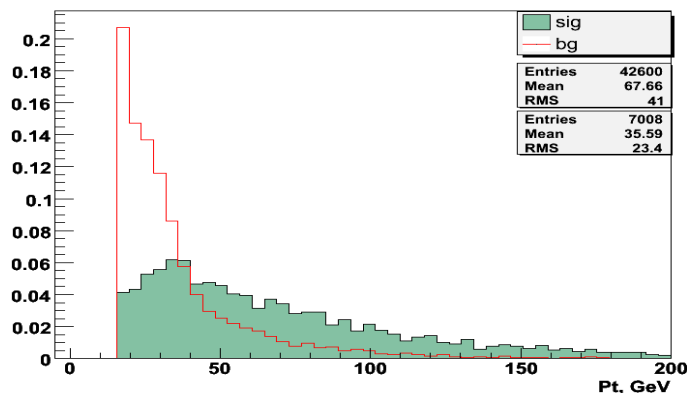
* Apparently doesn't change at all as Higgs mass increases from 115 to 140 GeV

2. Pt of tagging jets, sig and bg



130 GeV

3. Pt of tagging jets, sig and bg

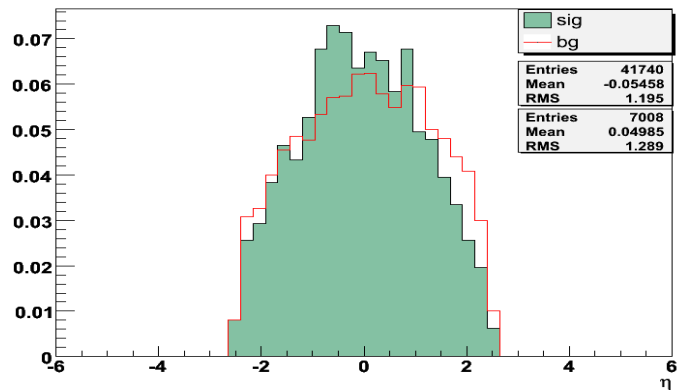


140 GeV

6. Signal-vs-BG, Eta stuff, no cuts

(Only showing for 130 GeV Higgs, because there is little difference for other masses)

2. Eta of b-jets, sig and bg

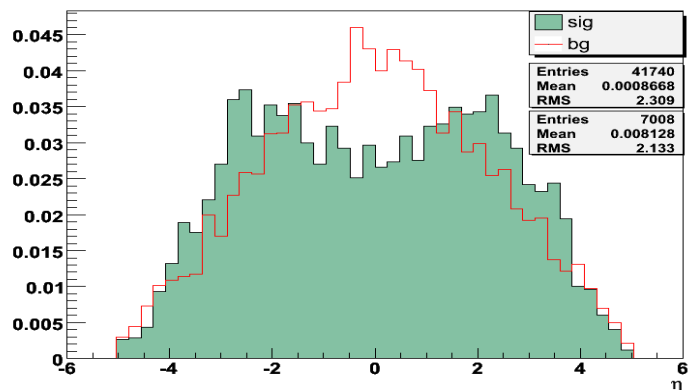


Eta, b-jets
130 GeV

Comment:

Very similar for SIG and BG, so cannot use to discriminate against BG.

2. Eta of tagging jets, sig and bg

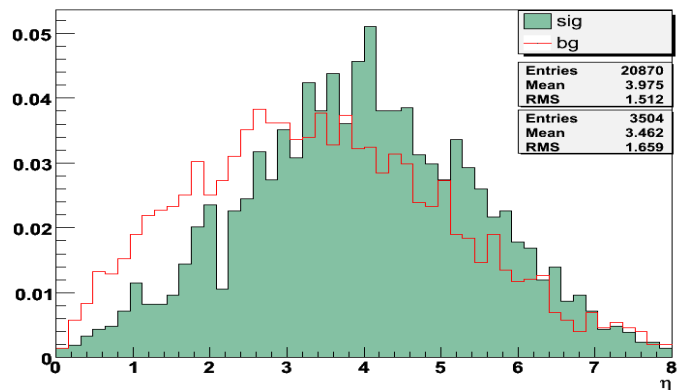


Eta, q-jets
130 GeV

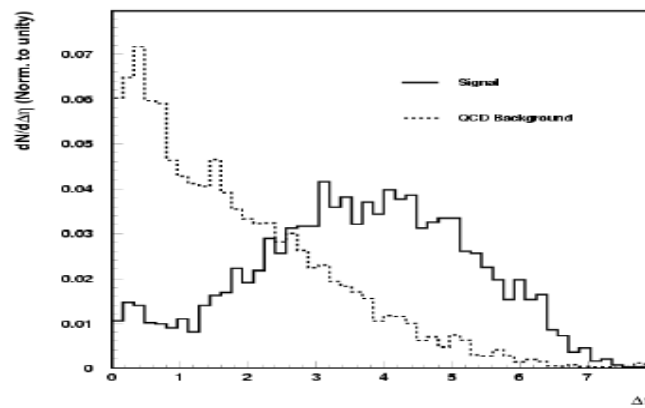
Comment:

It would be hard to exploit the fact that background peaks at zero, so I am not actively using this cut.

2. Delta-Eta between tagging jets, sig and bg



DeltaEta,
q-jets



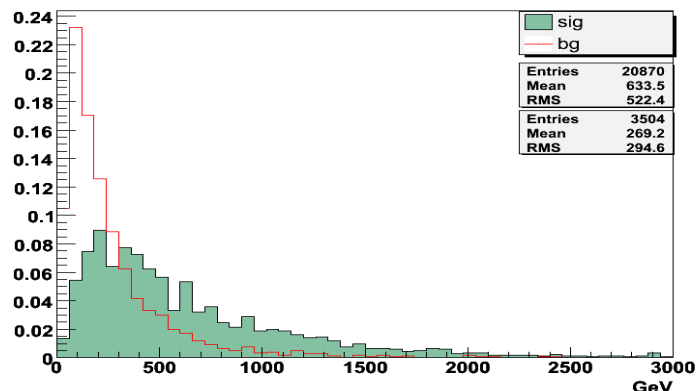
Same plot from Iacopo



7. Signal-vs-BG, M_{jj}, no cuts

(Only showing for 130 GeV Higgs, because there is little difference for other masses)

2. M_{jj} distribution, sig and bg



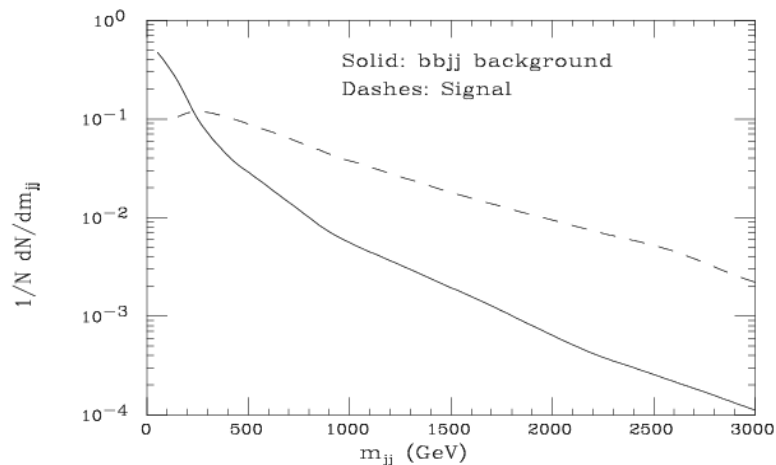
130 GeV

Comment:

Signal-Background:

* Apply a cut of 300 GeV (or sometimes - 500 GeV).

This cut was also applied by the Japanese group (hep-ph/0210261). Here is their plot:



Note: Log scale!!!

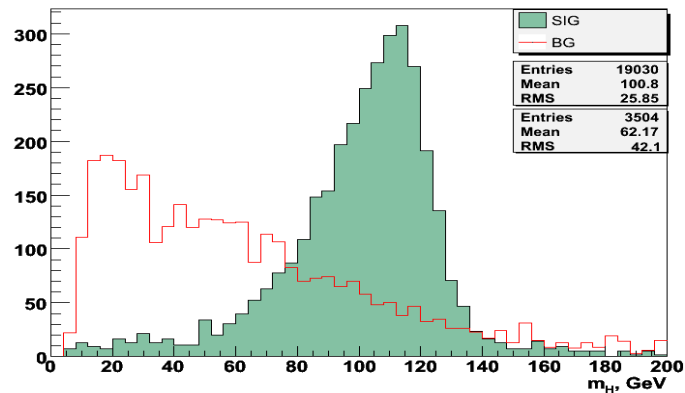
Comment:

Note that signal becomes dominant at around 300 GeV (same as in my plot).

However, they propose to cut at $M_{jj} > 1000$. In my case, I don't have enough BG statistics to accommodate such a cut.

8. Signal-vs-BG, Mbb, no cuts

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



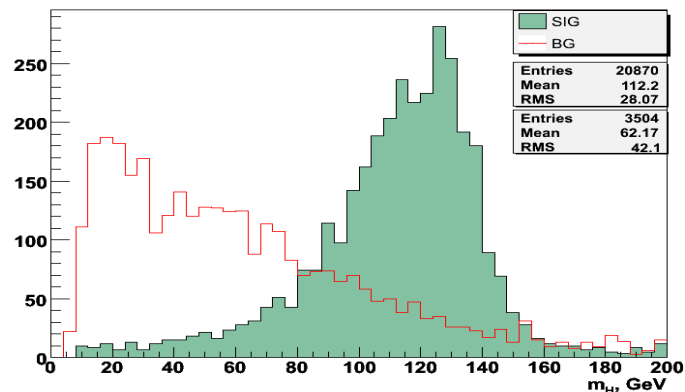
115 GeV

Note: normalized to unity!

Comment:

1. Since b-quarks can radiate before they reach the Calo, the distributions are shifted to lower Higgs mass. However, they peak at the correct value.

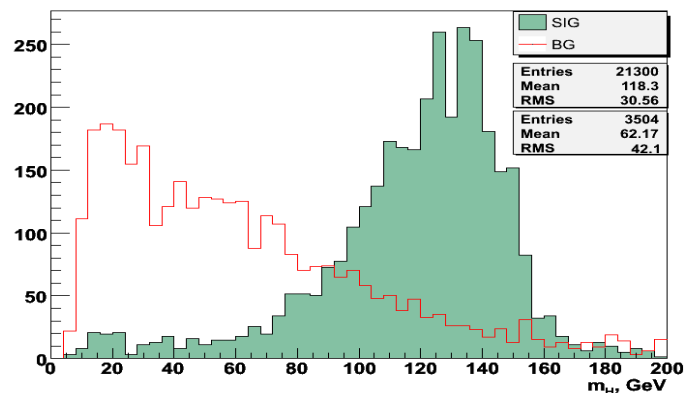
2. Higgs mass reconstructed for real and for BG events, norm to unity



130 GeV

2. We can apply a cut on Mbb if we know approximately where to expect Higgs. Because of point (1), I specify asymmetric mass windows: about 30-35 to the left and 20-25 to the right of nominal Higgs mass.

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



140 GeV

9. Performance

- Assuming 600 fb^{-1} of data (3 years worth of running at full luminosity)
- With no cuts:
 - 0.03% of BG passes
 - 19% of 115 GeV Higgs (~360k signal events, Significance=1.35)
 - 20% of 130 GeV Higgs (~250k signal events, Significance=0.92)
 - 21% of 140 GeV Higgs (~150k signal events, Significance=0.55)
- With cuts discussed above, without Mbb cut (i.e. using as a discovery channel):
 - $1\text{E-}5\%$ of BG passes
 - 2.11% of 115 GeV Higgs (~53k signal events, Significance=3.4)
 - 3.1% of 130 GeV Higgs (~43k signal events, Significance=2.8)
 - 3.27% of 140 GeV Higgs (~26k signal events, Significance=1.7)
- With cuts discussed above, requiring broad range of Mbb=130 +25/-35 GeV:
 - $3.7\text{E-}5\%$ of BG passes
 - 2.11% of 115 GeV Higgs (~40k signal events, Significance=4.4)
 - 3.1% of 130 GeV Higgs (~37k signal events, Significance=4.1)
 - 3.27% of 140 GeV Higgs (~23k signal events, Significance=2.5)
- Same as above, but looking in a narrow window for Mbb=115 +20/-25 GeV:
 - $2.7\text{E-}5\%$ of BG passes
 - 2.27% of 115 GeV Higgs (~43k signal events, **Significance=5.5**). 3 BG events passed!

10. Preliminary results on trigger

- All results above assumed a perfect trigger.
- I implemented Erik's parameterizations. The events that passed all other cuts are accepted **with weights** determined by the probability of passing a trigger. However, the final number of events that passed is **cast into an integer** before significance is calculated.
- Using trigger value of 40 for Erik's passProb function.
- Shouldn't trust these because too little BG statistics left after cuts!
- With cuts discussed above, requiring broad range of $M_{bb}=130 \pm 25/-35$ GeV:
 - 3.7E-5% of BG passes – 5 events passed all cuts
 - 2.11% of 115 GeV Higgs (~40k signal events, Significance=4.4)
 - 3.1% of 130 GeV Higgs (~37k signal events, Significance=4.1)
 - 3.27% of 140 GeV Higgs (~23k signal events, Significance=2.5)
- Same, but with trigger:
 - 8.3E-6% of BG passes - 1.05 events passed all cuts AND trigger. Rounded to (int)1
 - 0.8% of 115 GeV Higgs (~15k signal events, Significance=3.6)
 - 1.18% of 130 GeV Higgs (~14k signal events, Significance=3.3)
 - 1.24% of 140 GeV Higgs (~9k signal events, Significance=2.0)

11. Conclusions

- ★ I haven't focused too much on optimizing the cuts, so I am sure the significance can be improved.
- ★ I've been really low on BG statistics (1-10 BG events left out of 10M). This is bad, because a change in BG from 3 to 6 events changes significance by $\sqrt{2}$. Erik generated some more BG data (x2), so this should help a bit.
- ★ I can also write code to manually apply tagging probabilities, which will allow me to pass ~30% more events (although each will come with some weight).
- ★ I don't think this channel can be used as a discovery channel (i.e. dropping the Mbb requirement greatly reduces significance)