Working Towards a Boosted Z→bb Measurement with ATLAS

IoP 2013, Liverpool

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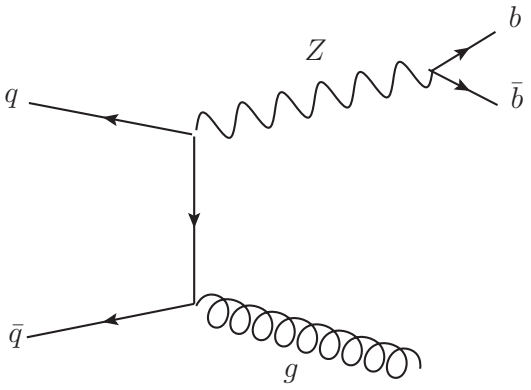
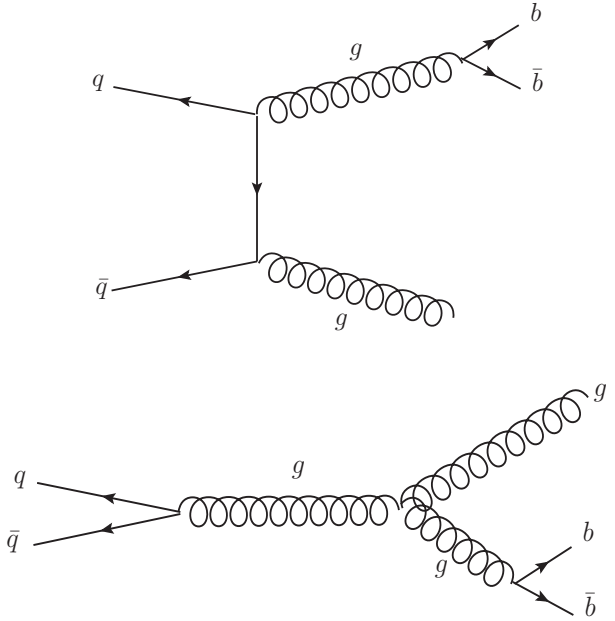
Boosted Z→bb: Motivation

- For searches in hadronic decay channels it is often advantageous to look for the decay of objects with a high p_T, so-called 'boosted objects'
  - Observing boosted Z→bb would be an important stepping stone in the development of boosted hadronic analyses at the LHC
- The Z→bb peak could be used:
  - To help assess systematics for analyses involving b-jets, e.g. H→bb
  - As a test bed for techniques to improve the bb mass resolution, e.g. substructure
- Everything shown is work in progress



Z→bb Signal

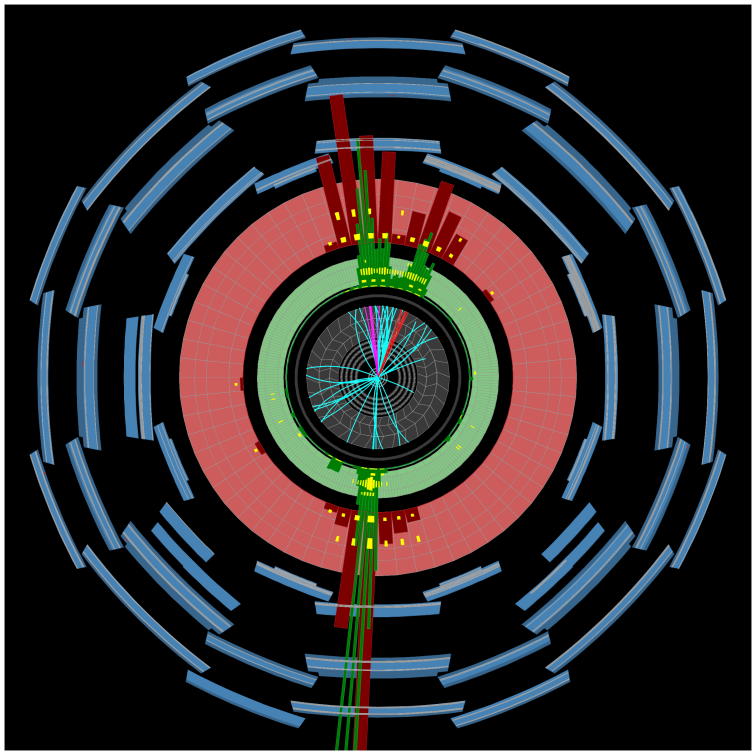


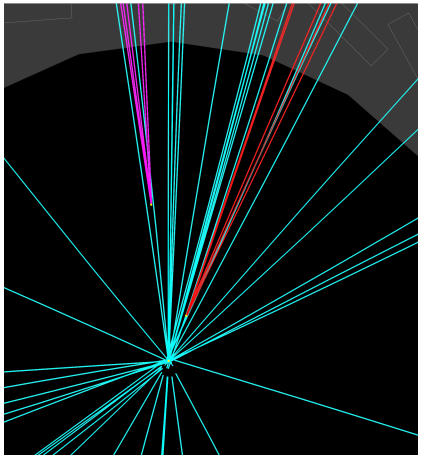
QCD bb background

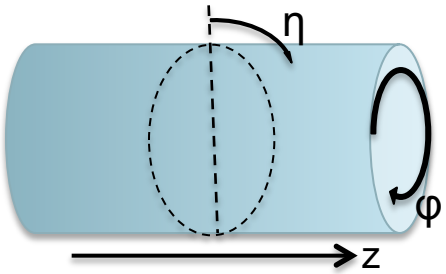
Z→bb Topology and Selection

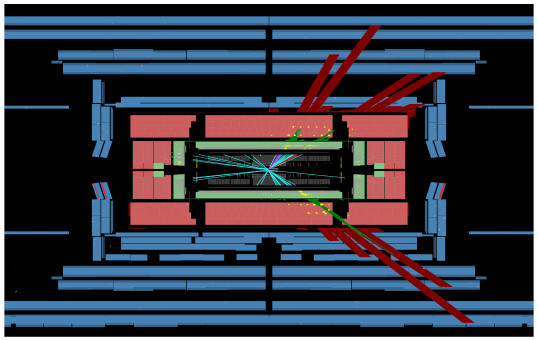
Basic Event Selection

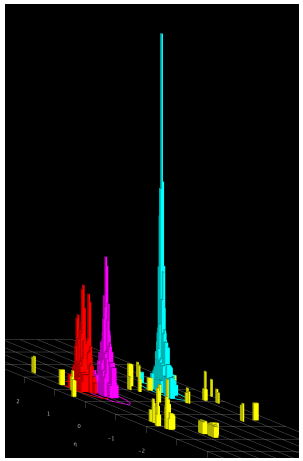
- Two anti-k_t R = 0.4 jets, both jets with p_T > 30 GeV
- Two of these jets with a vector added p_T > 200 GeV
- Both of these jets b-tagged
- $\Delta R = \sqrt{((\Delta\eta)^2 + (\Delta\varphi)^2)}$ between the two jets < 1.2











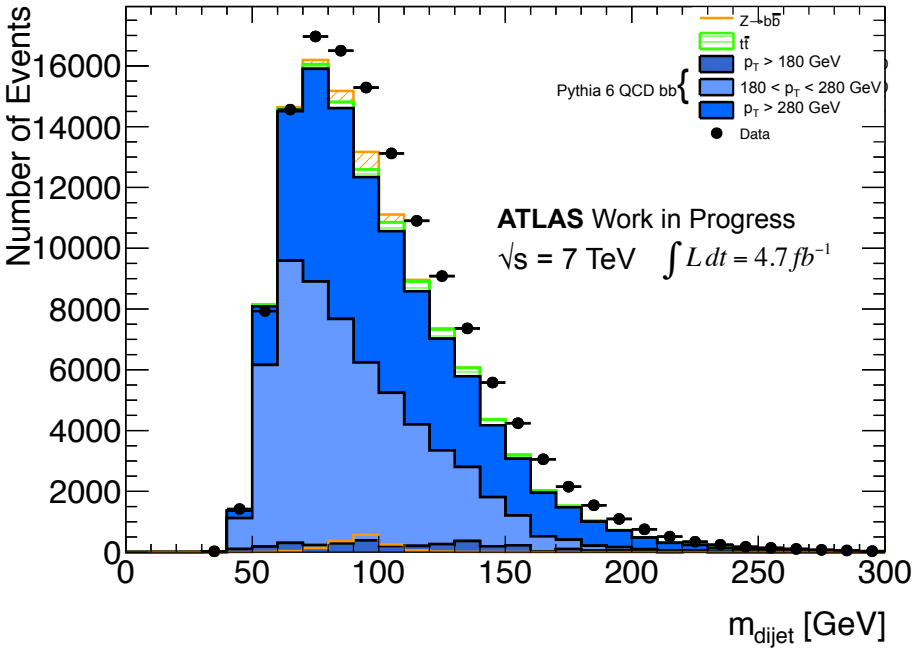
An event display showing the Z→bb signal topology: 3 high p_T jets: 1 that balances the Z and two nearby b-jets from the Z decay

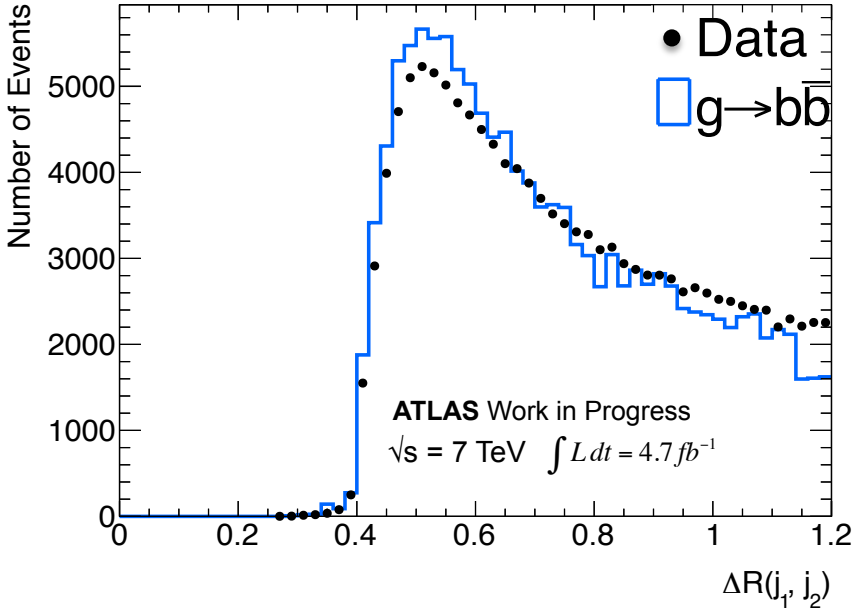
Background MC and S/B

Key challenges facing analysis:

Bad MC description of background (Pythia 6 and Herwig+Jimmy)

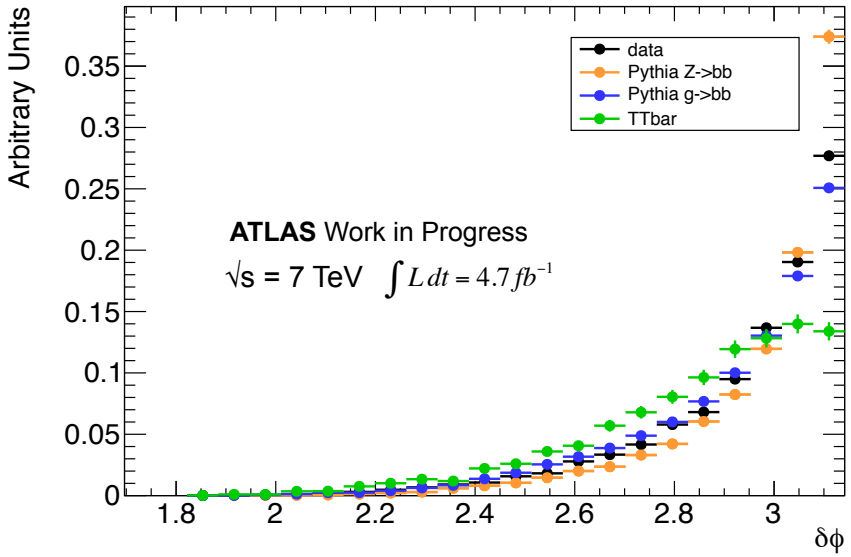
Low S/B

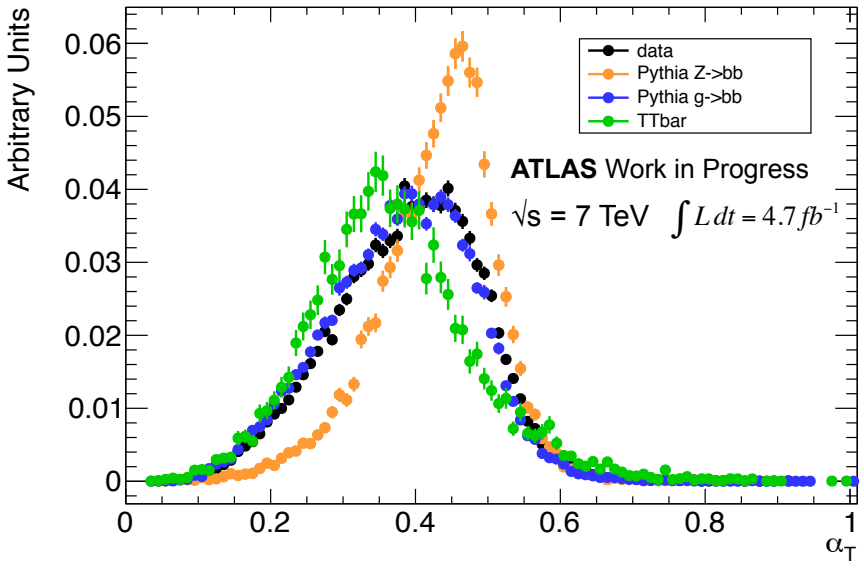




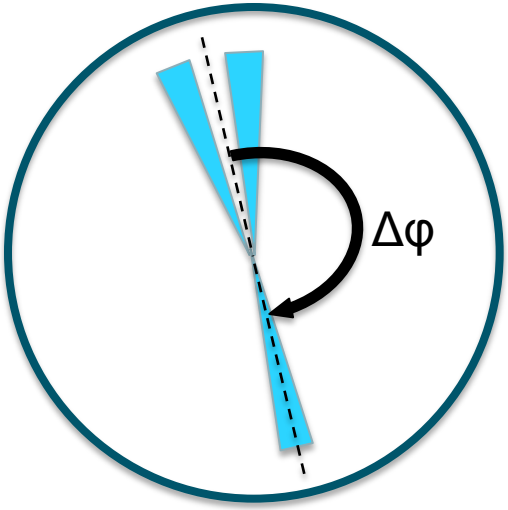
- After the initial selection the S/B is ~1% over the whole mass range
- The signal/background, in the mass window [80,110] GeV, predicted by simulation is **3.3%** with **~950 recorded events** for 2011 data
  - Need to increase this to stand a chance of observing Z→bb!
- So search for variables that discriminate QCD from Z→bb

Properties of Balancing jet in Event





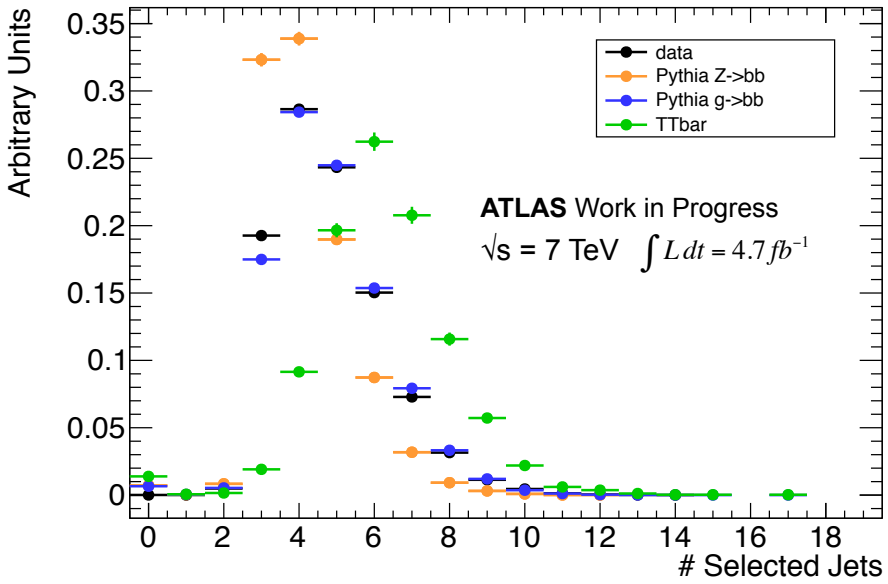
Here we define the balancing jet in the event as the one that best balances the bb dijet, in the transverse plane, when added vectorially.

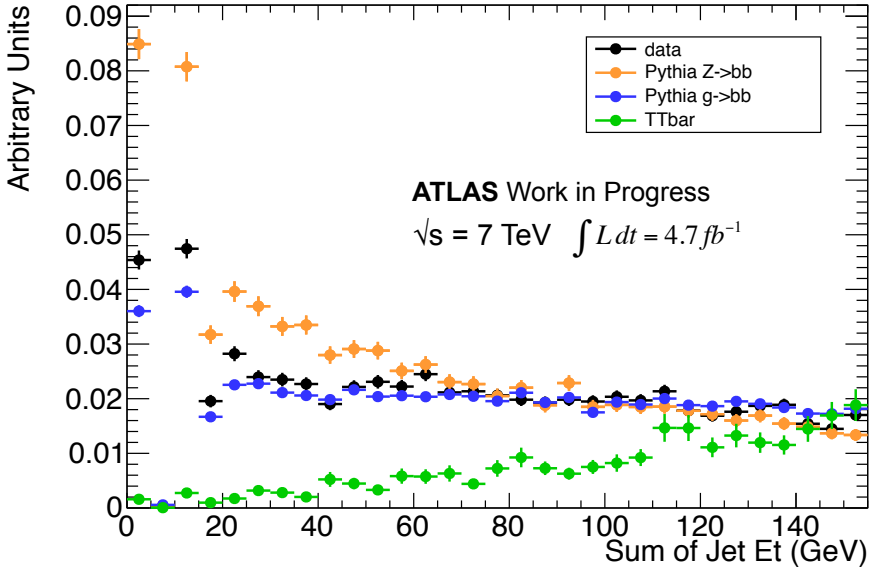


$$\alpha_T = \frac{p_T \text{ of balancing jet}}{\text{mass of dijet-balancing jet system}}$$

All MC in these plots is Pythia 6

The Variables: Number of Jets and Sum of Extra Jet E_T

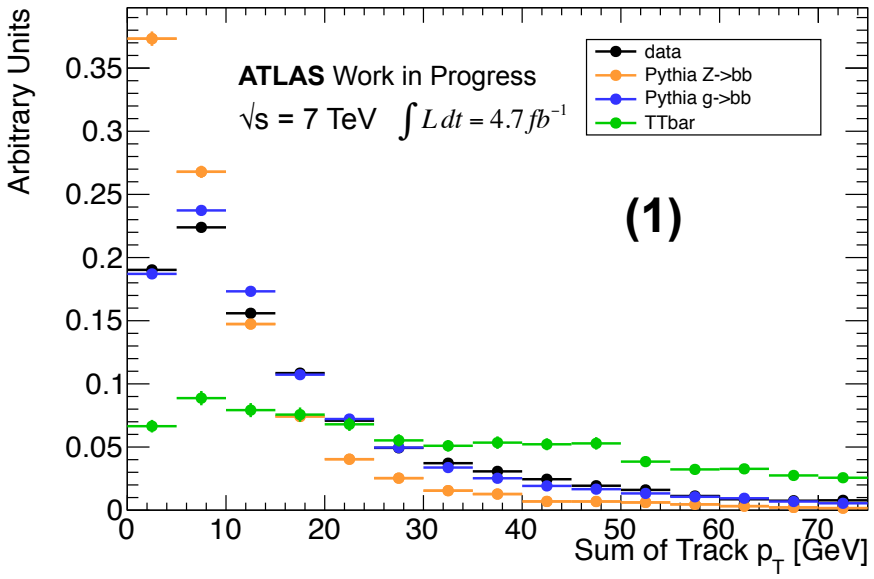


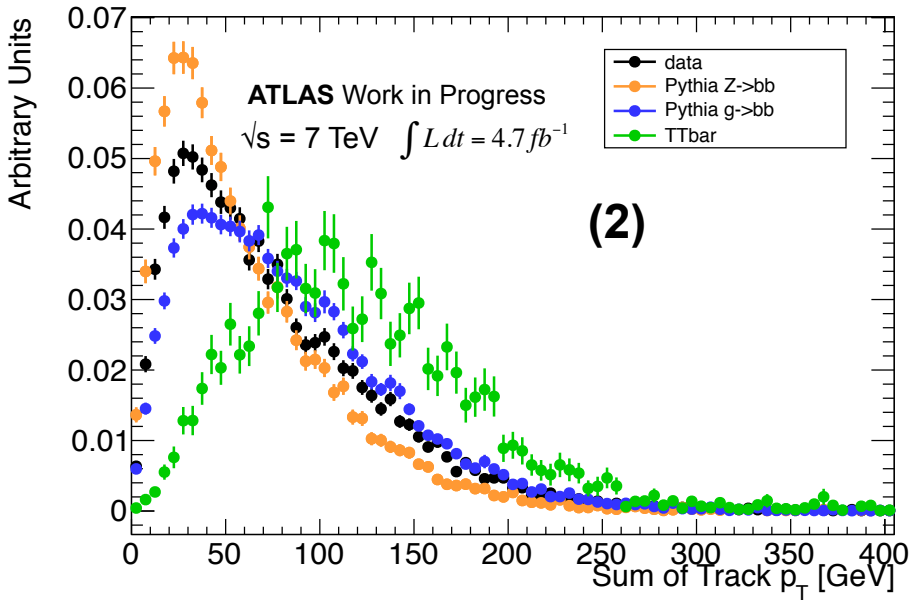


Plot on the left shows the number of jets in the event

Plot on the right shows the scalar sum of the E_T of jets in the event. This excludes the two b-tagged Z candidate jets and the balancing jet.

The Variables: Sum of Track p_T





Here, we look at the scalar sum of track p_T in the event. We exclude tracks associated to the two Z candidate b-tagged jets and the balancing jet in the event. The tracks pass a series of quality cuts.

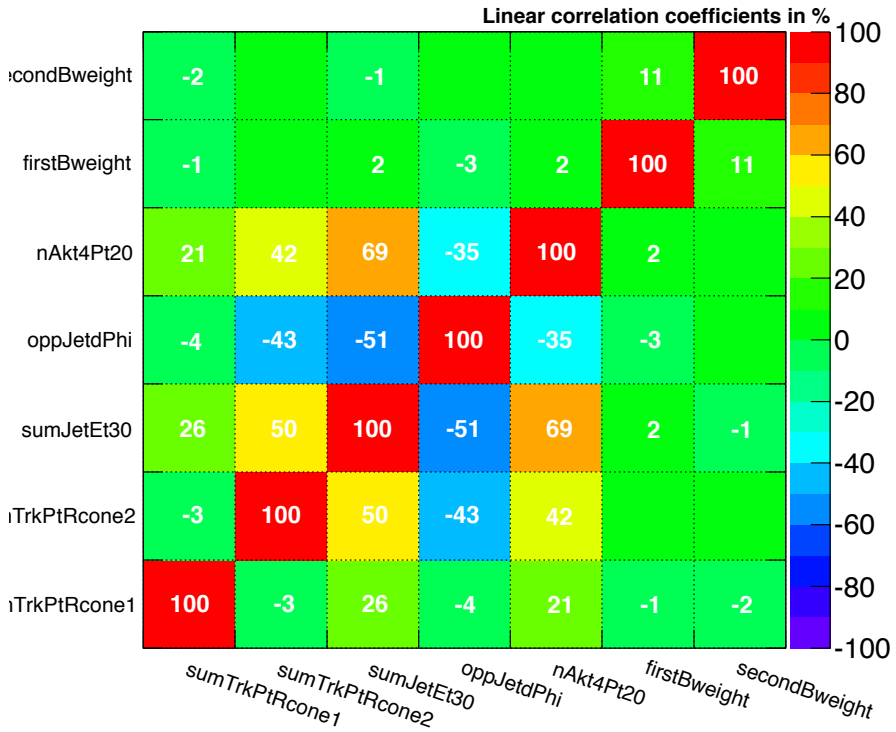
This is split into two areas:

(1) A cone of R=1.5 around the bb dijet axis

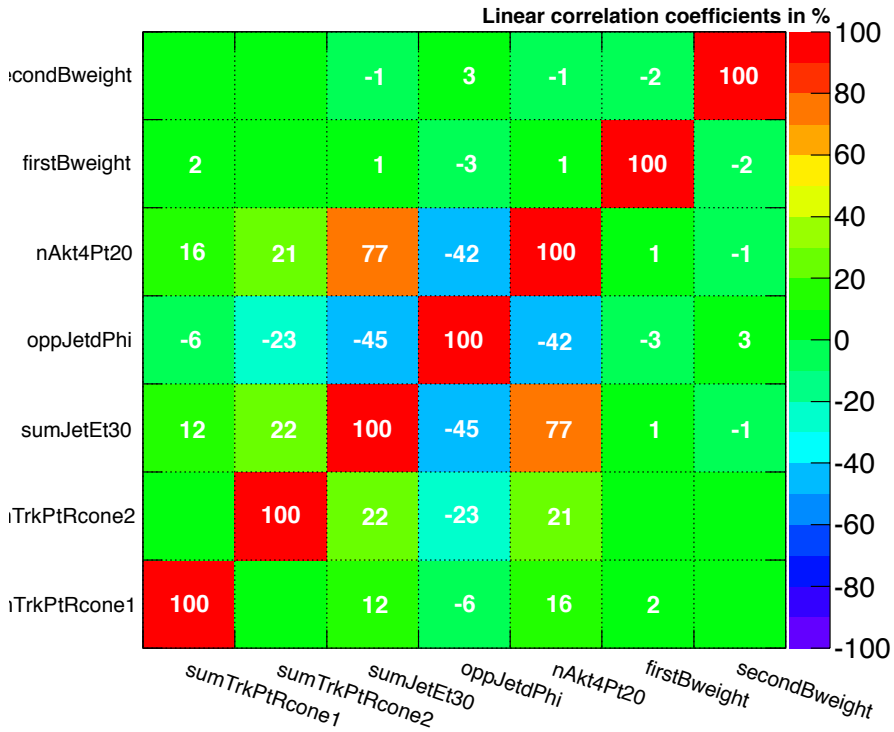
(2) The rest of the event

Correlations

Correlation Matrix (background)



Correlation Matrix (signal)



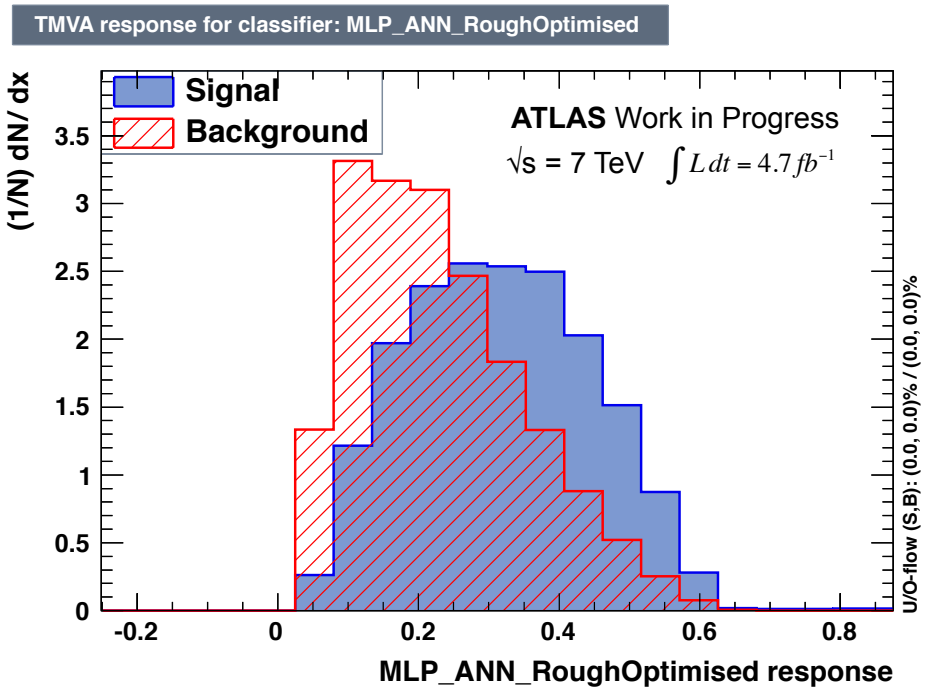
Also use the b-tagging weights of the two b-tagged jets together with the other variables. Combine them into an MVA to take account of the correlations to get maximum discrimination of signal from background.

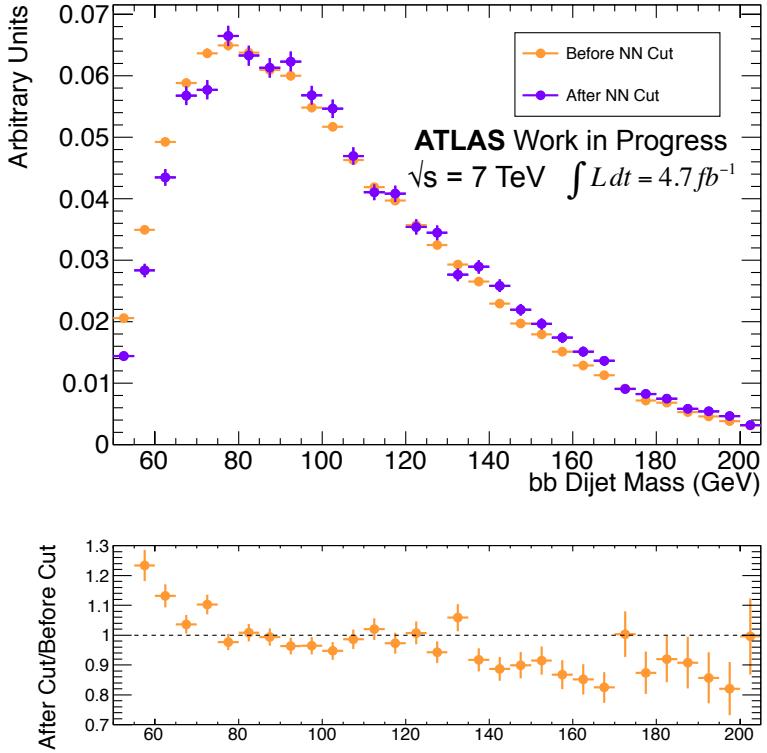
Neural Network

A neural network was found to give the best separation between signal and background.

A cut at 70% signal efficiency improves the s/d by a factor of ~2 and doesn't have much of an impact on the data mass distribution.

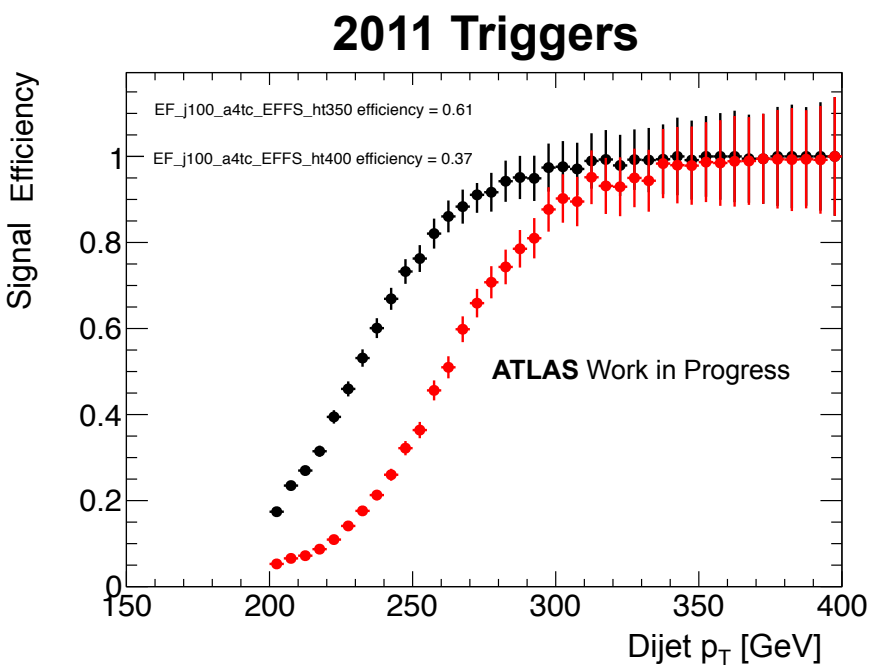
In Mass Window [80,110] GeV:	S/B	S/√B
Before NN cut	3.1%	4.7
After cut on NN	6.4%	5.9

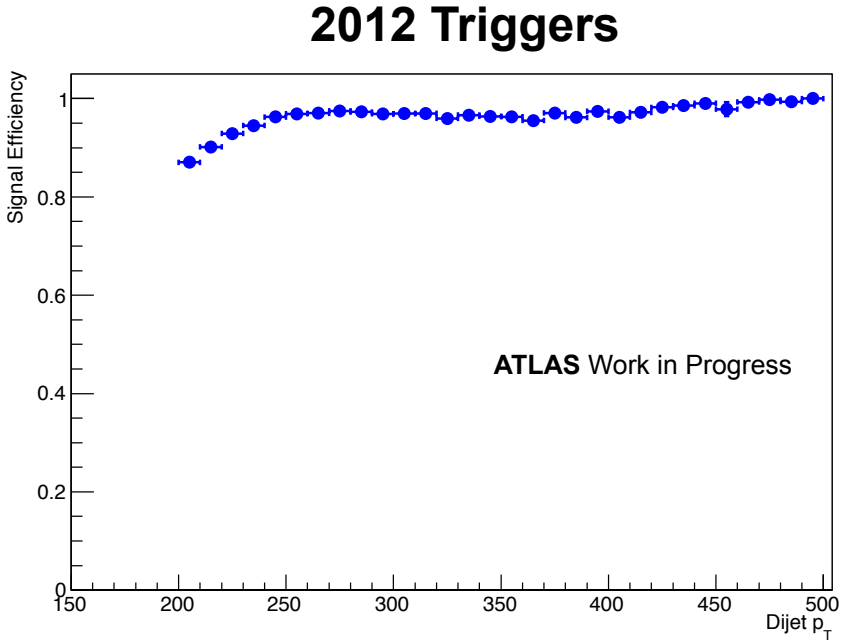




Prospects for Boosted Z→bb in 2012 Data

- The trigger we use for 2011 data consisted of a high-p_T cut on a single jet as well as a cut on the overall energy in the event
  - Signal efficiency of **~45%**
- The idea for the 2012 trigger is to look for events with at least 3 high-p_T jets, with at least 2 of those jets b-tagged, to keep the trigger rate low
- Trigger ran in 2012 menu and combining with a few others we get **~90%** overall signal efficiency





Conclusions/Outlook

- The boosted Z→bb analysis effort is ongoing
- Pythia and Herwig do a bad job of modeling QCD high p_T bb events
- Using an MVA of event topology variables, we can increase the, initially low, signal to background ratio by a factor of ~2
- There was a more efficient trigger running unprescaled for the 2012 data-taking period. This gives us access to a significantly larger sample of Z→bb events in data than in 2011

Backup Slides

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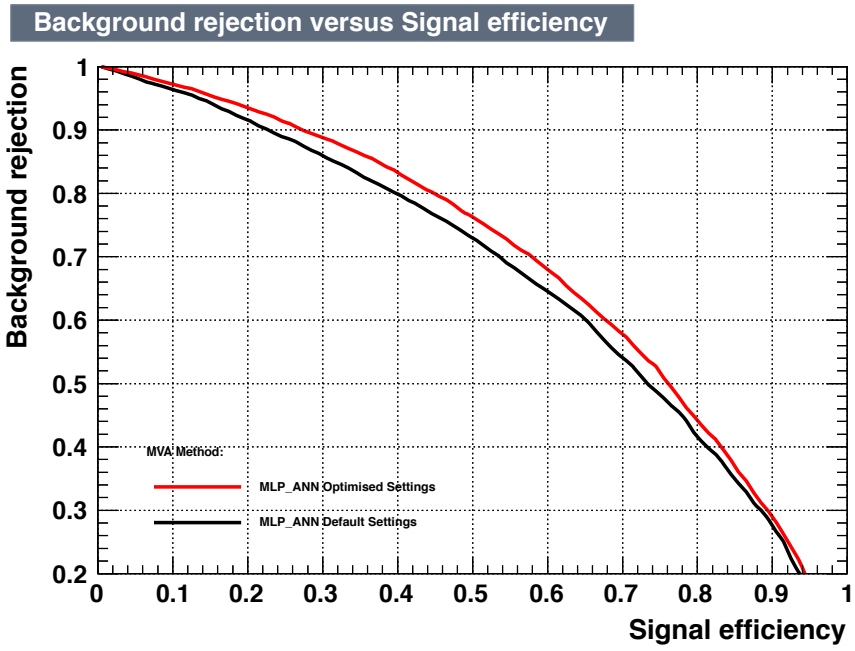
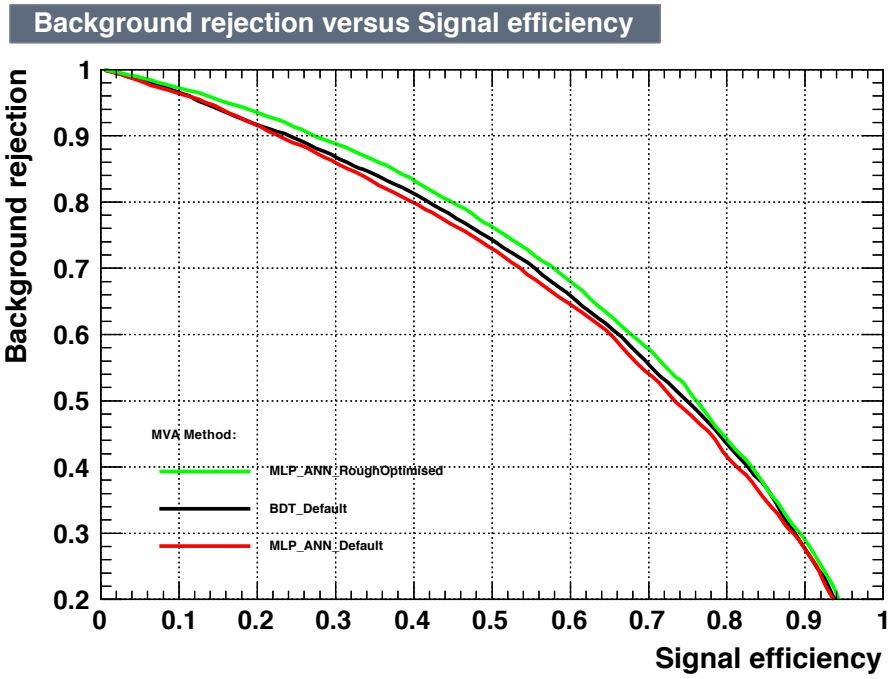

Background rejection versus Signal efficiency
Background rejection
Signal efficiency
MVA Method:
MLP_ANN Optimised Settings
MLP_ANN Default Settings
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


Background rejection versus Signal efficiency
Background rejection
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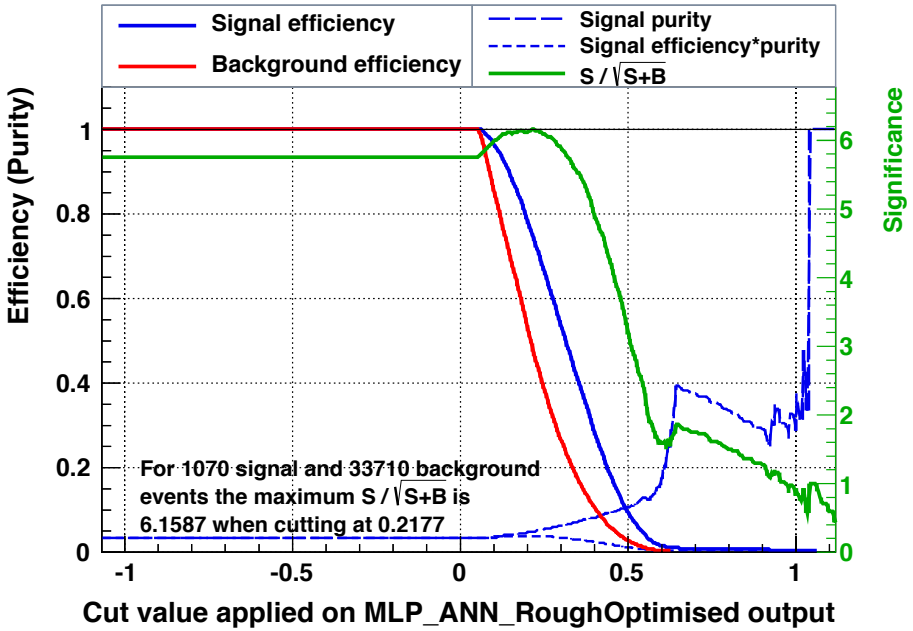
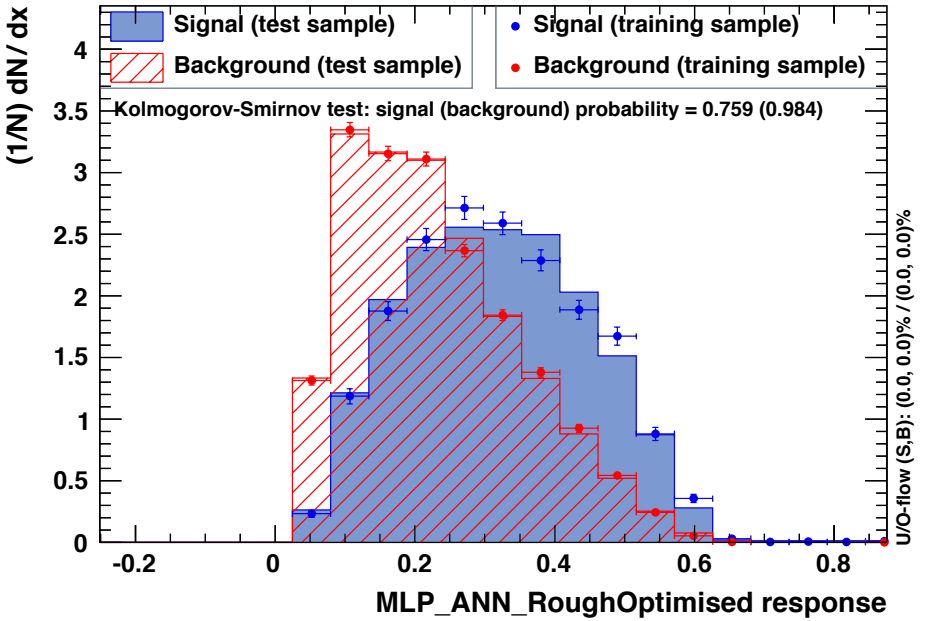
MVA Method:
MLP_ANN RoughOptimised
BDT_Default
MLP_ANN Default
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

Cut efficiencies and optimal cut value



TMVA overtraining check for classifier: MLP_ANN_RoughOptimised



ATLAS Coordinates System