Standard Model Higgs Searches at DØ

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The University of Manchester

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On behalf of the DØ Collaboration

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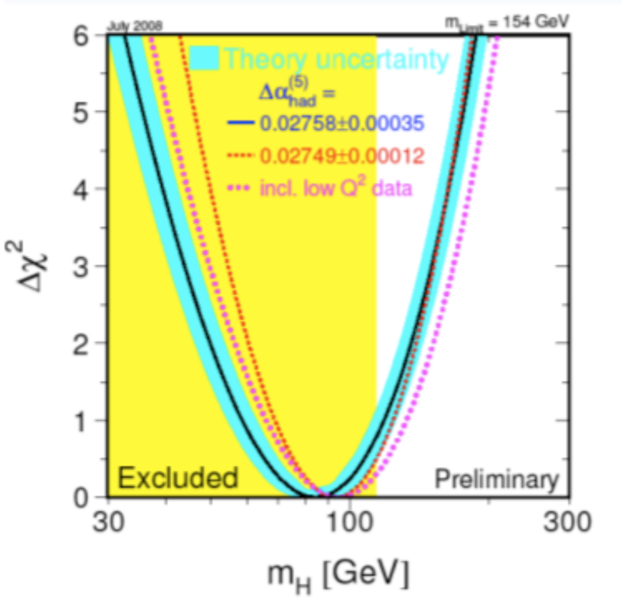
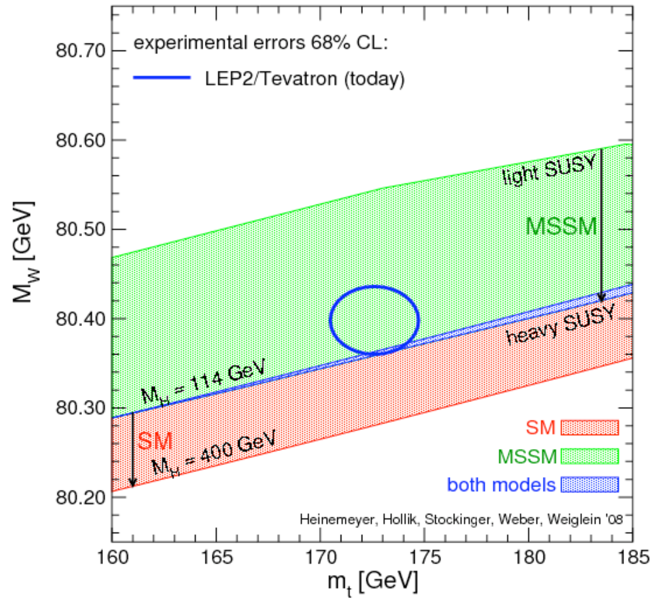
Outline

- The Higgs Boson
- The DØ experiment
- Higgs searches at DØ
- Combined limits on Higgs production
- Future prospects and summary

The Higgs Boson

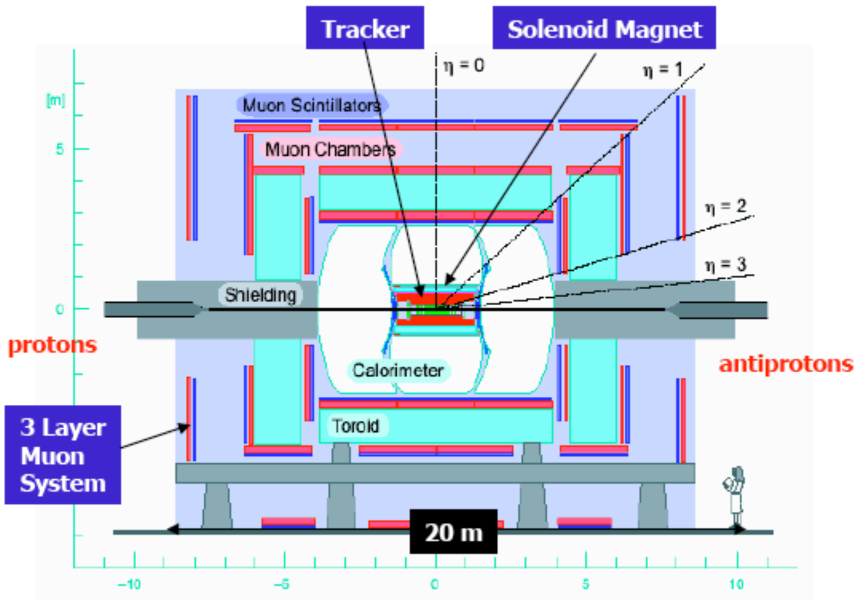
- Postulated as a mechanism to give the W/Z bosons mass.
- The only fundamental Standard Model (SM) particle yet to be observed.
- Direct searches at LEPII yield a lower bound of m(H) > 114.4 GeV.
- Precision EW measurements that are sensitive to the Higgs mass via radiative corrections from LEPII and Tevatron provide further constraints.

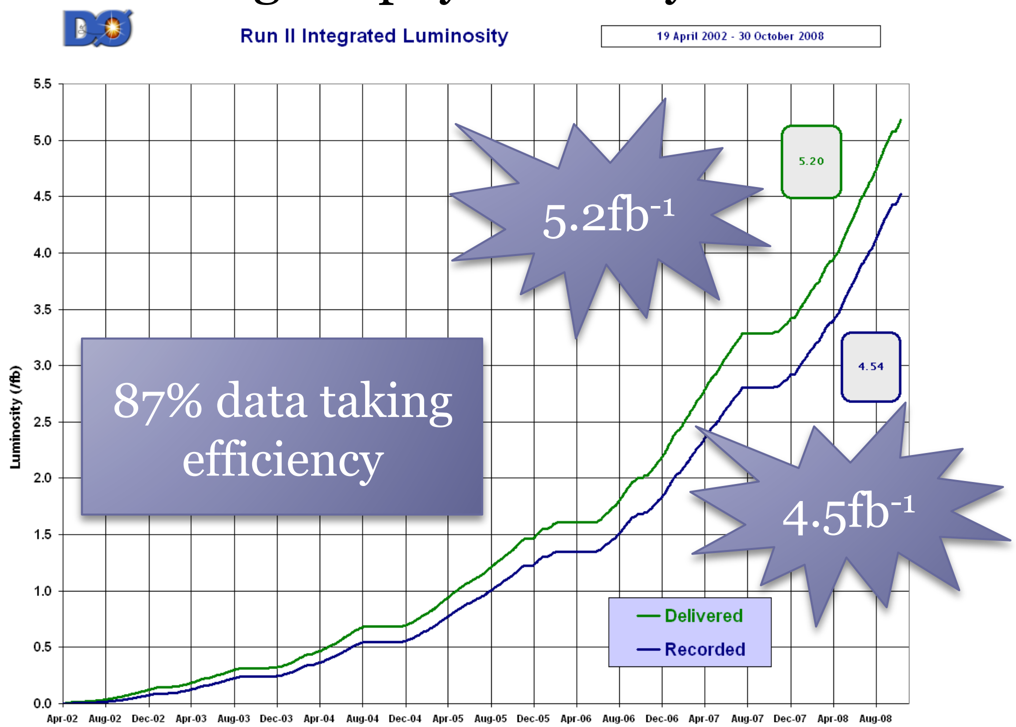




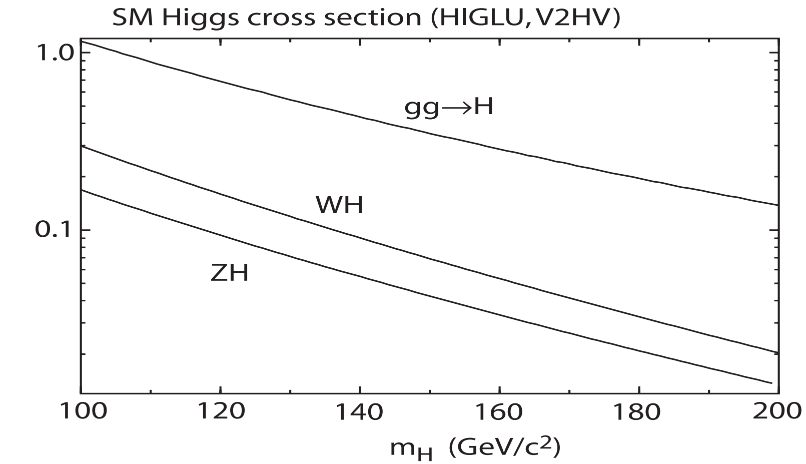
The DØ experiment

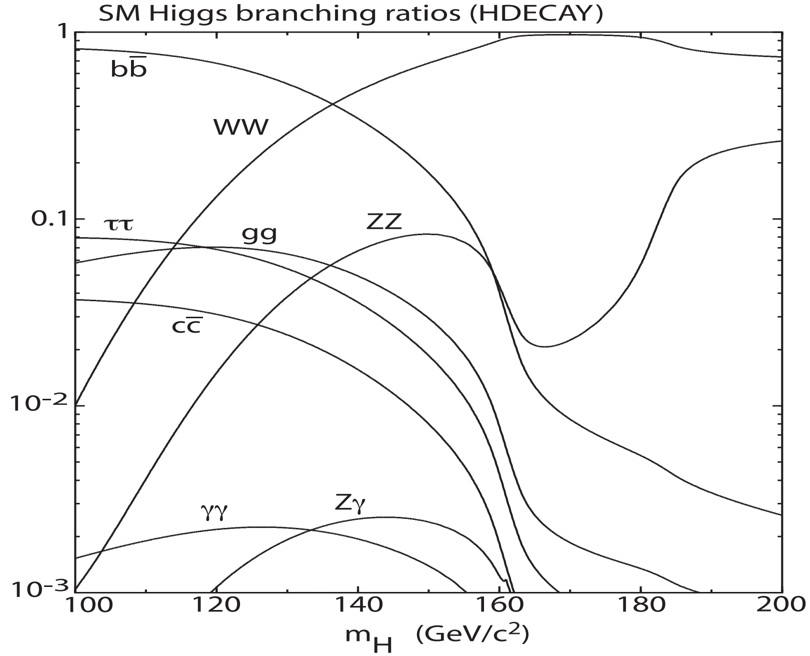
- Situated at Fermilab, IL the Tevatron collides ppbar at $\sqrt{s}$ = 1.96 TeV in RunII, delivering over 5fb^{-1} of data. As much data is collected in 2 weeks now as was in the whole of RunI!
- The DØ experiment has been successfully recording this data at very high efficiency and using it for a wide range of physics analyses.

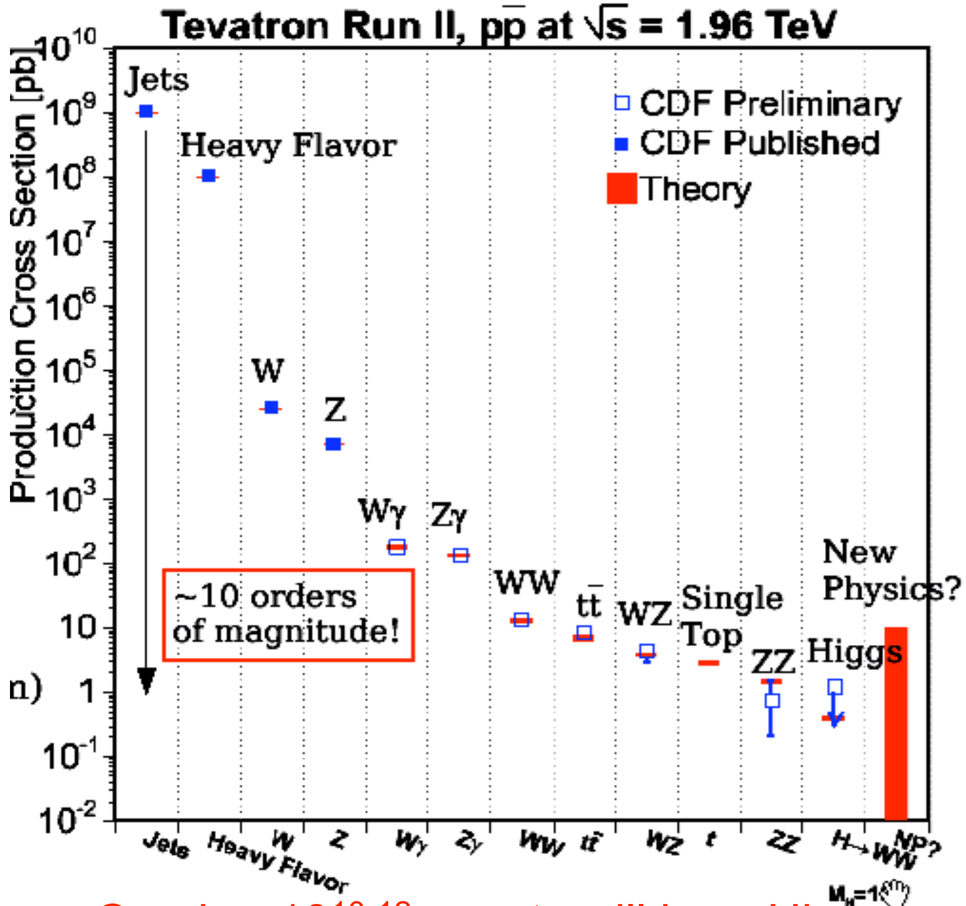




Higgs production at the Tevatron



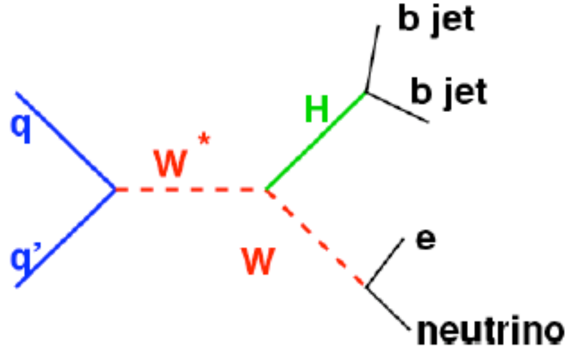


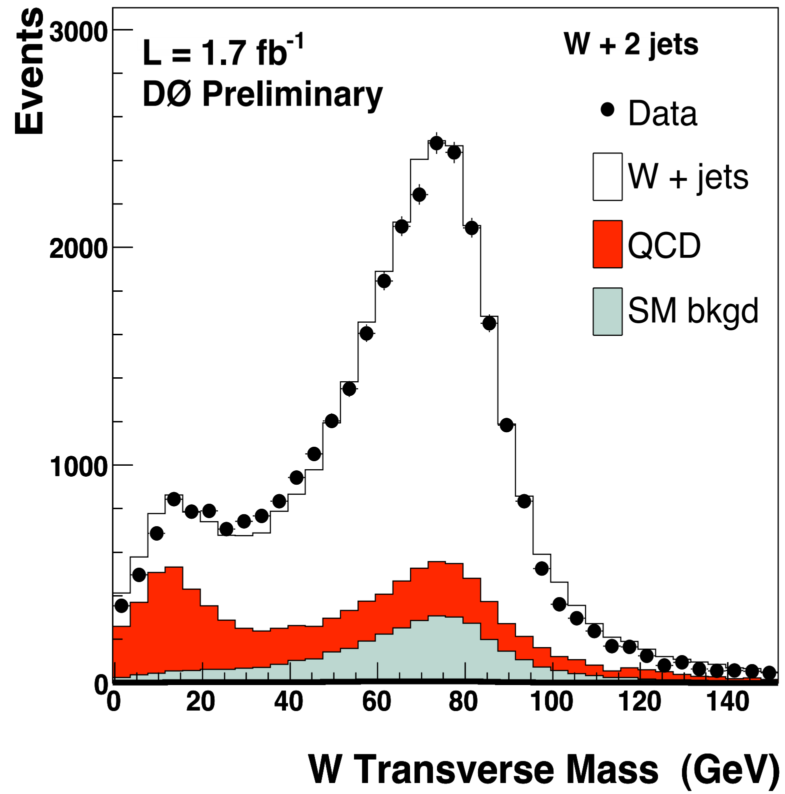


One in $\sim 10^{10\text{-}12}$ events will be a Higgs boson.

Focus on *WH -> lvbb*

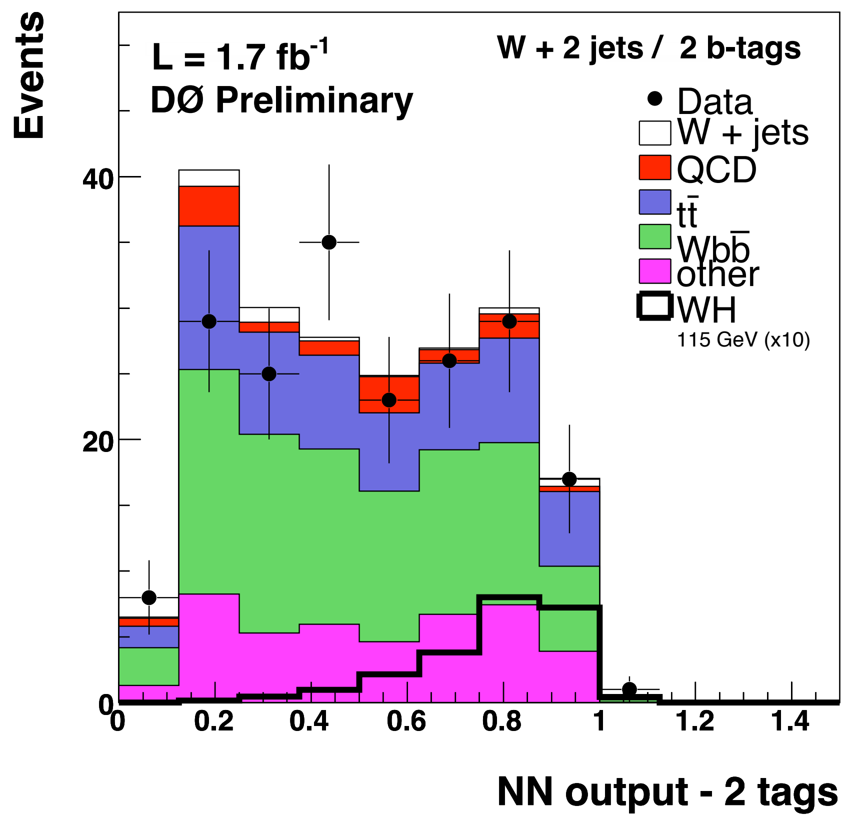
- Analysis strategy is to first understand the background in a high statistics (where signal contribution is negligible) W(->lv)+jj sample, where j is dominated by light flavours.
- Background processes are simulated with the exception of the multi-jet background which is estimated from data.





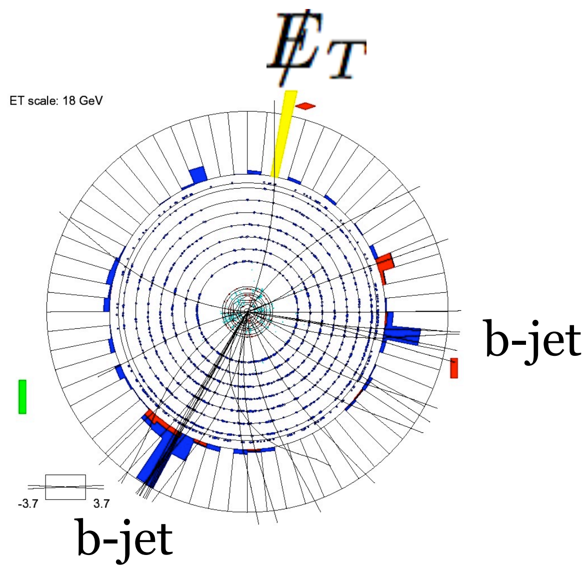
Focus on *WH -> lvbb* continued

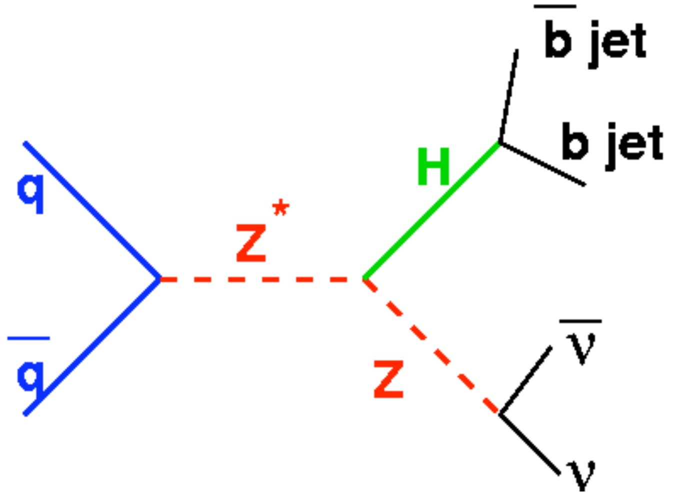
- Then require that there be at least 2 "loose" quality b-tagged jets in the sample, as defined by a neural network (NN) b-tagging algorithm.
- A dedicated analysis NN is then trained using a number of kinematic and topological variables and this discriminant is used to set the final cross section limit.
- 95% CL σ Limit = 10.9 x SM σ for a Higgs mass = 115 GeV.

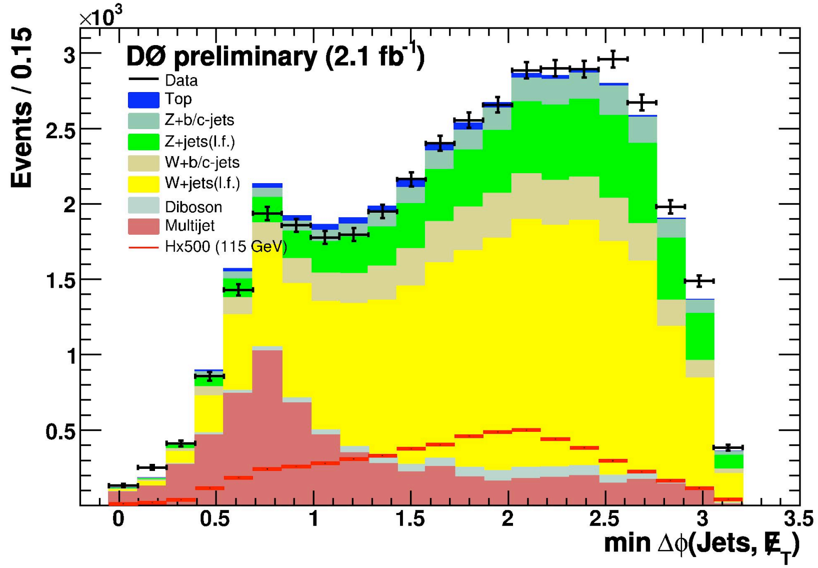


Focus on *ZH -> ννbb*

- Search for two acoplanar jet events with large missing energy (> 50 GeV).
- Model the large multijet contribution from data.
- Sensitive also to *WH -> lνbb* where the lepton is not reconstructed.

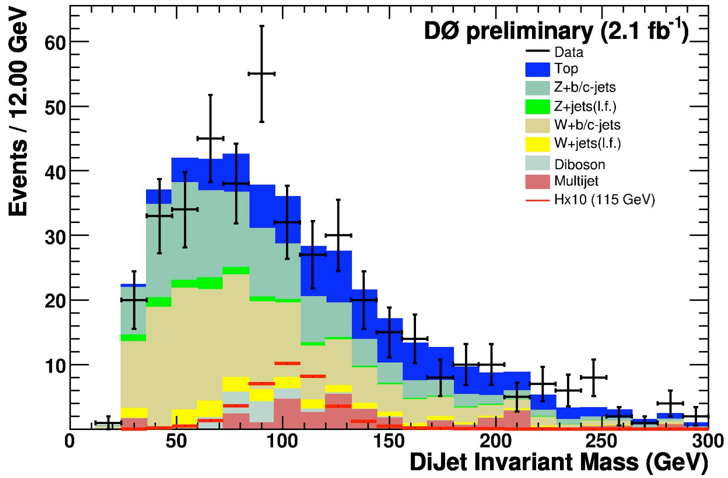


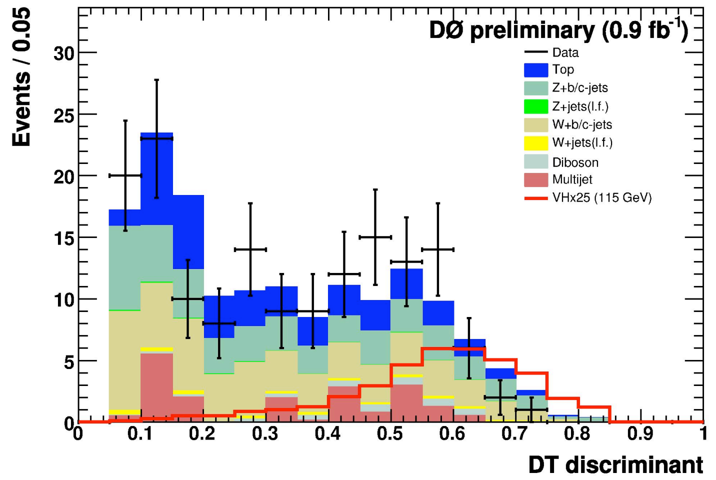




Focus on *ZH -> vvbb* continued

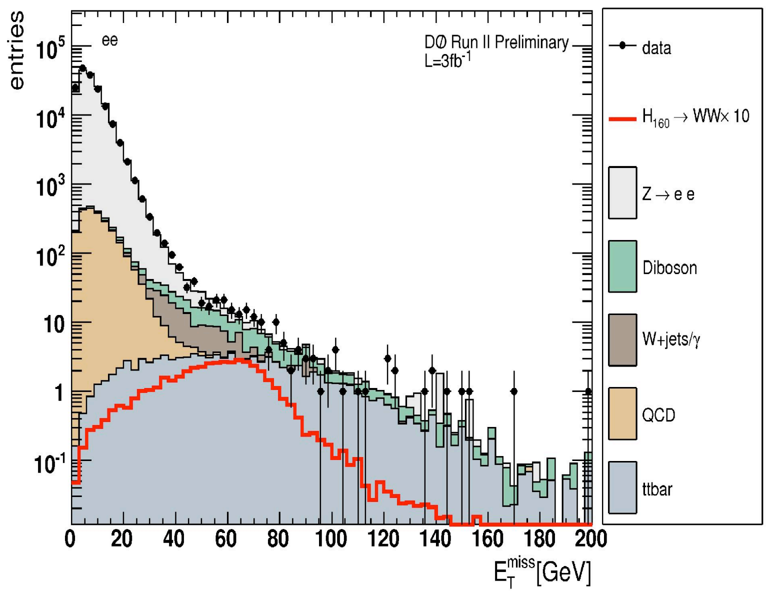
- Two asymmetric btags (one “tight” and one “loose”) are required to increase the heavy flavour content of the sample.
- Dominant backgrounds at this stage are Wbb/Zbb and top.
- A boosted decision tree (BDT) is trained and used as the final limit discriminant.
- 95% CL σ limit = 7.5 x SM σ at Higgs mass = 115 GeV.

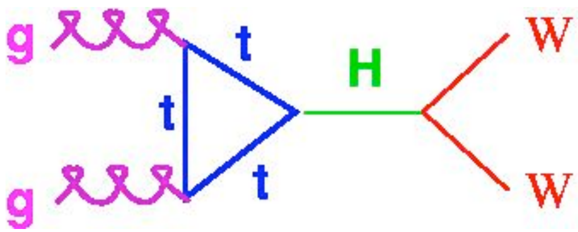


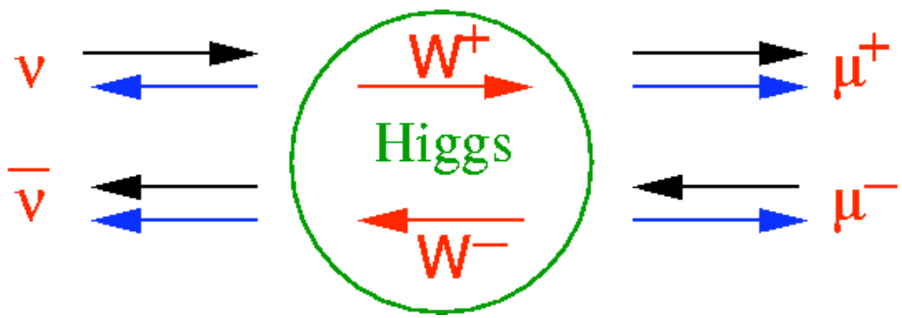


Focus on *H -> WW -> lνlν*

- Search for di-lepton plus missing energy events, a very clean final state with minimal multi-jet contamination.
- Good modeling of the background is achieved in high statistics sample dominated by Z events.
- Discrimination achieved between signal and WW background in the angle between the leptons due to spin correlations.

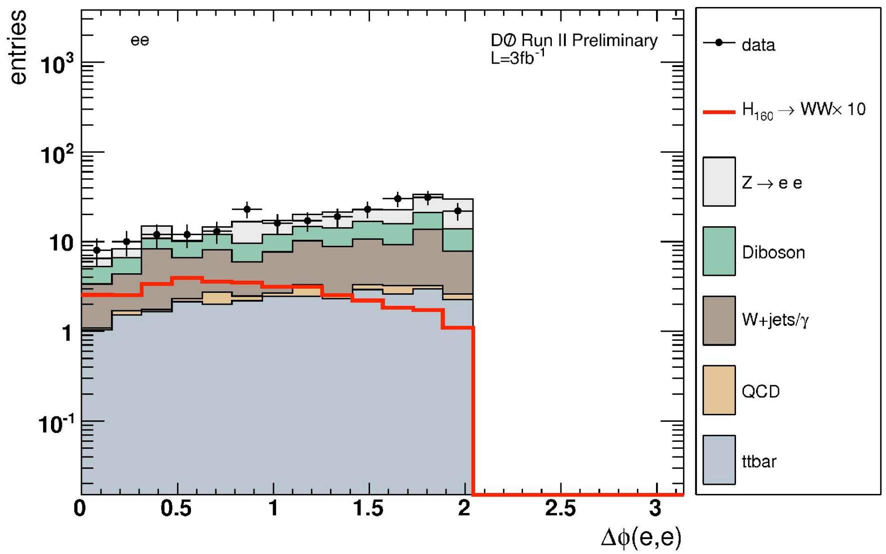




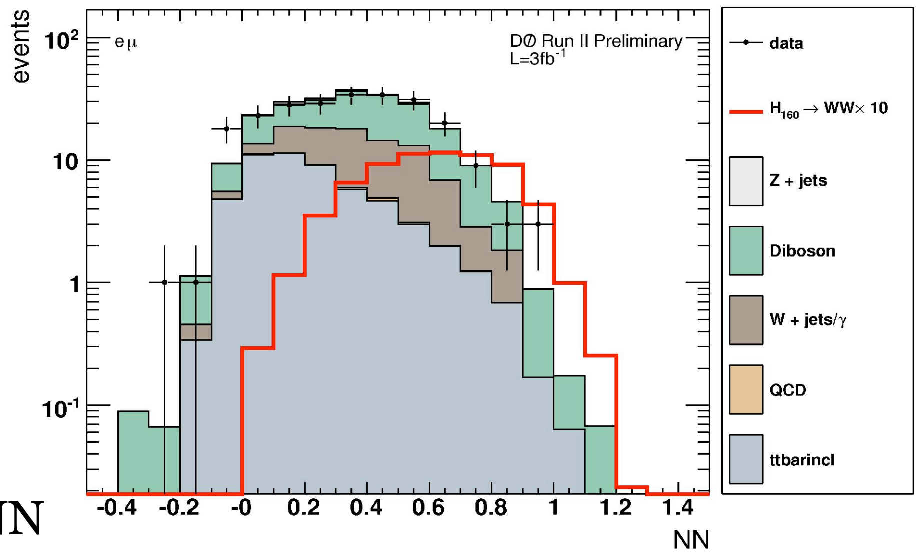


Focus on *H -> WW -> lvlv* continued

- Discrimination is available between signal and other di-lepton events via the angle $\Delta\varphi(l, l)$.
- A neural network is trained to improve this discrimination and the output is used in setting the final limit.
- 95% CL σ limit = 1.7 x SM σ at Higgs mass = 170 GeV.



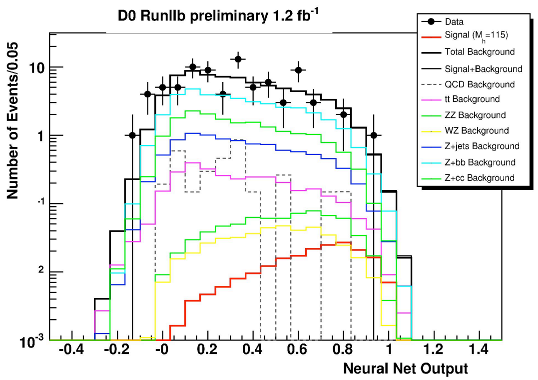
NN



Summary of other channels

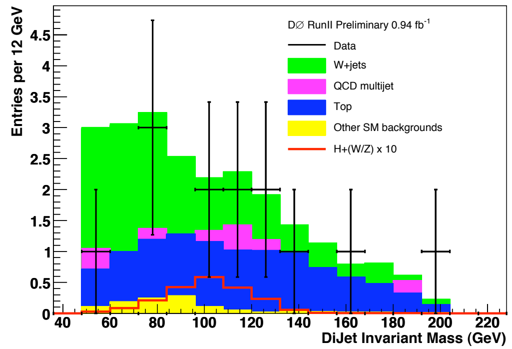
ZH -> llbb

11 x SM σ at 115 GeV



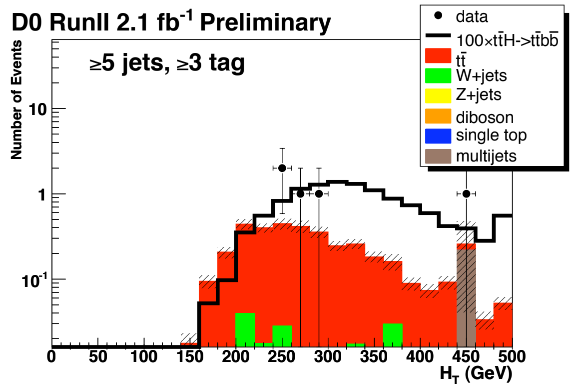
WH -> τνbb

35 x SM σ at 115 GeV



ttH

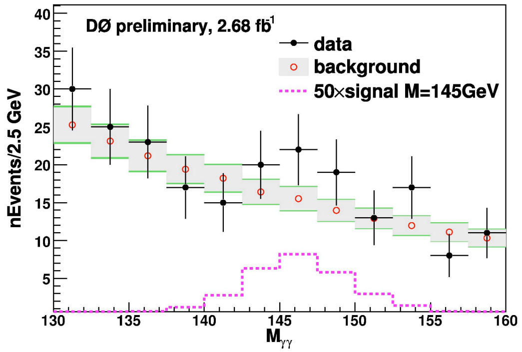
45 x SM σ at 115 GeV



The channels on the right help gain sensitivity in the mass region where the associated production cross section is falling away and the gluon fusion is starting to increase.

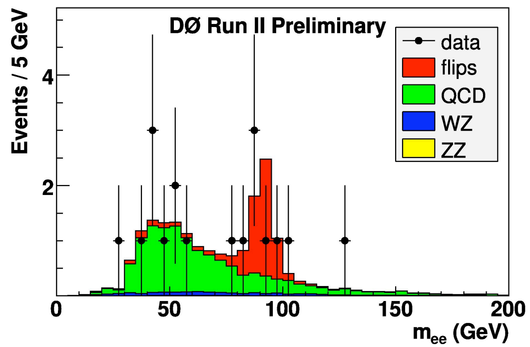
H -> ϒϒ

21 x SM σ at 125 GeV



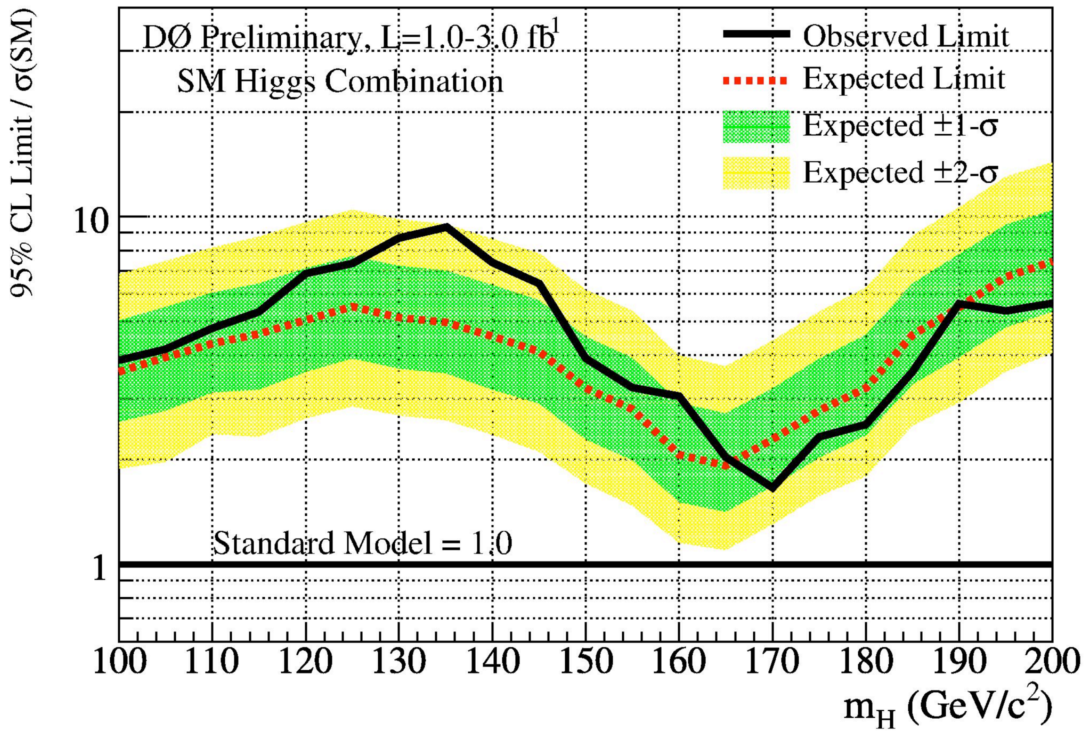
WH -> WWW

20 x SM σ at 125 GeV



Setting limits on DØ Higgs production

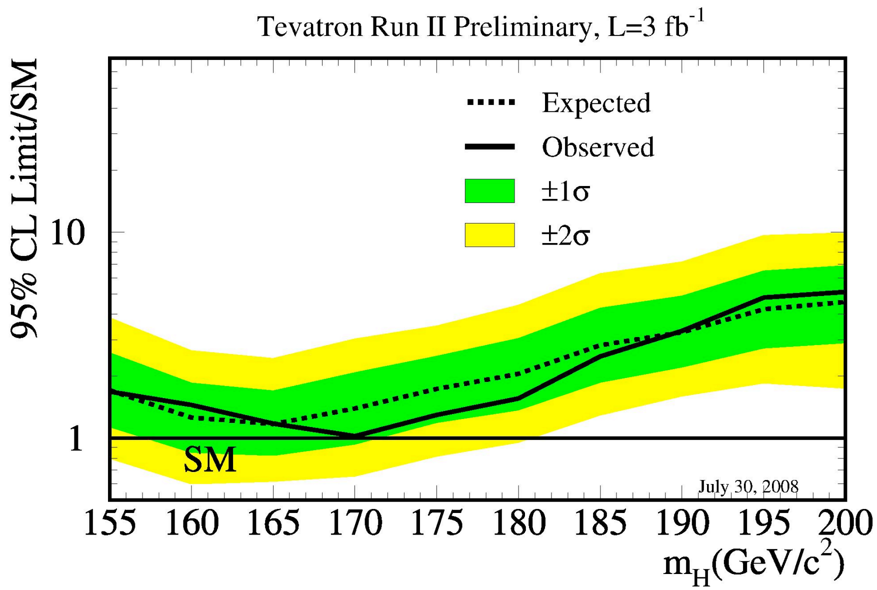
- 95% confidence level (CL) cross section limits are set at 5 GeV Higgs mass intervals.
- These are shown relative to the predicted SM cross section for the DØ combination.



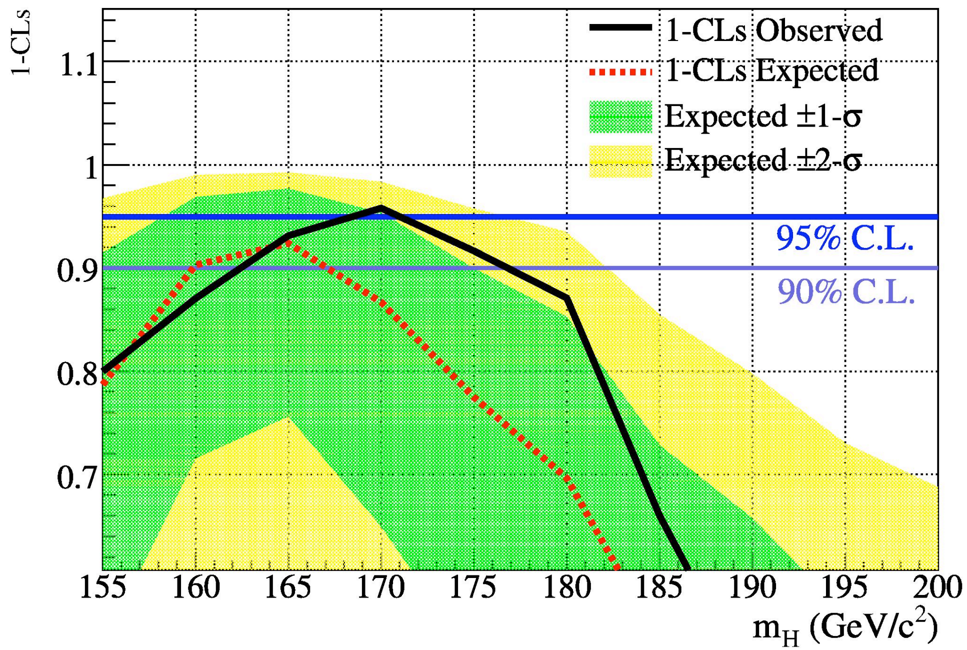
DØ Combination

The Tevatron SM Higgs Combination

- Combining results with CDF allows better sensitivity to a SM Higgs.
- The Tevatron combination has excluded a Higgs mass = 170 GeV at 95% CL!



Tevatron SM Higgs Combination (σ/σ(SM))



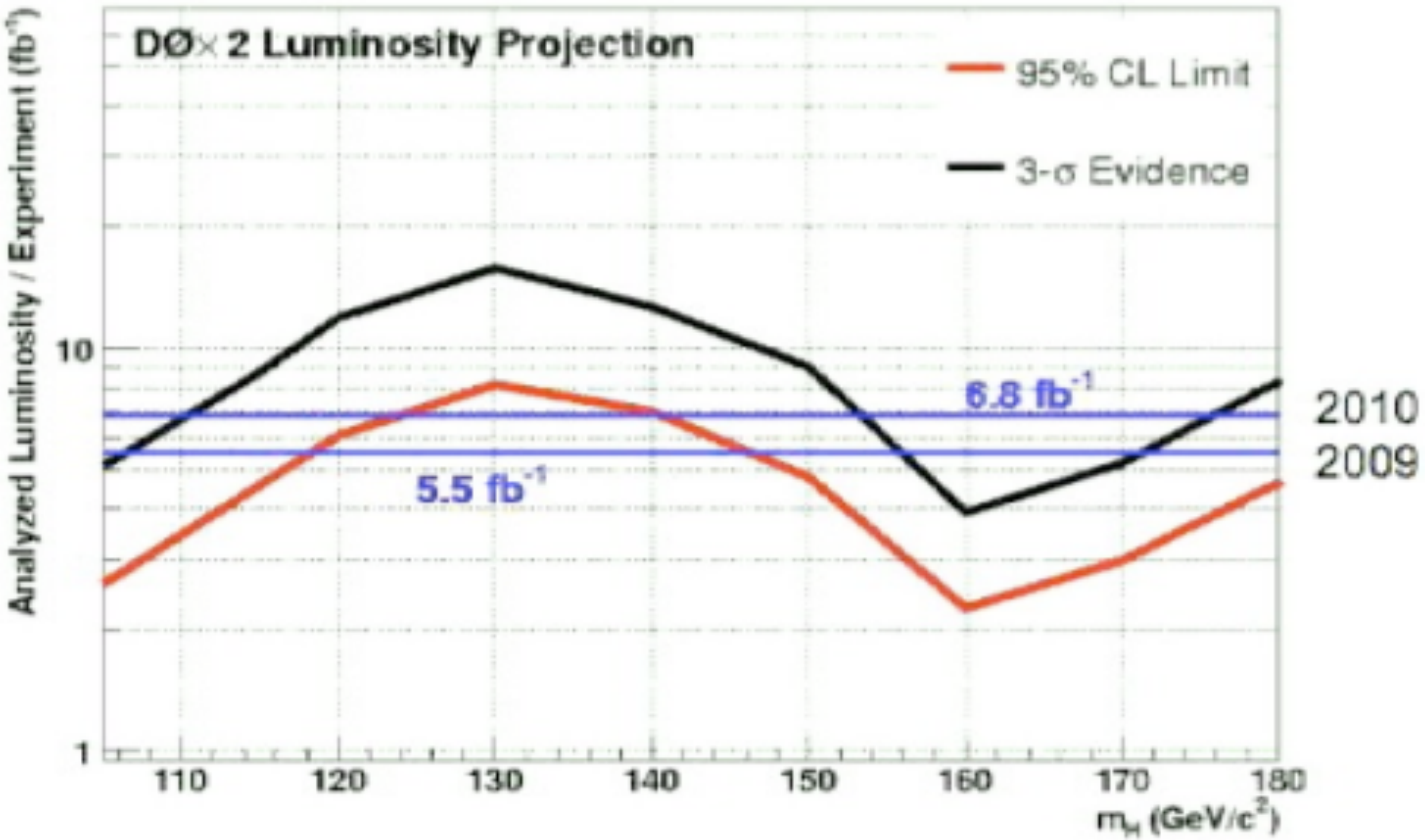
Tevatron SM Higgs Combination (1 - CLs)

Summary and Prospects

- The DØ SM Higgs boson searches continue to improve at greater than √L. Due to improved analysis techniques and inclusion of more channels.
- Having ruled out a Higgs mass = 170 GeV at 95% CL the Tevatron has proved that it is capable of making powerful statements about the Higgs boson before the LHC era.
- With around $8 fb^{-1}$ of data expected to be collected before the end of running sensitivity to a wide range of Higgs masses is very much so in our grasp.

Back Up Slides

Luminosity projections

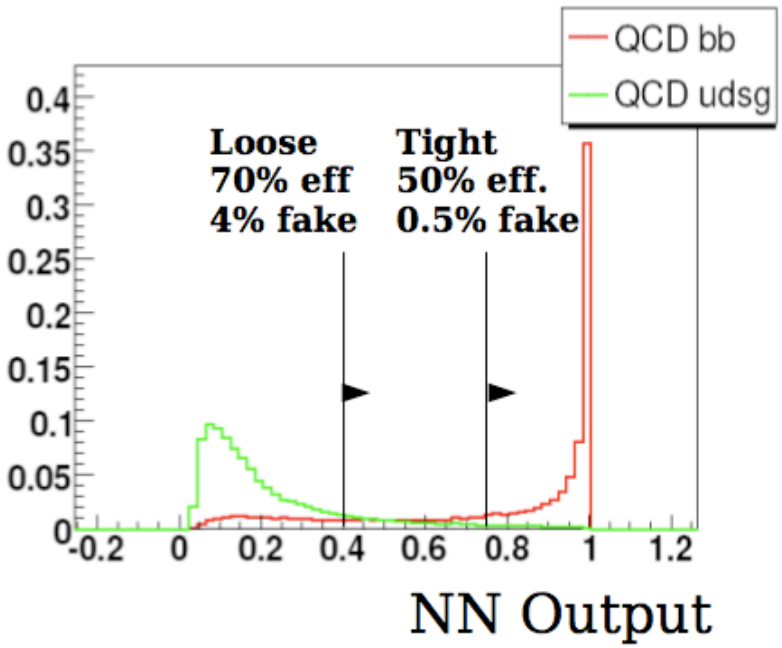


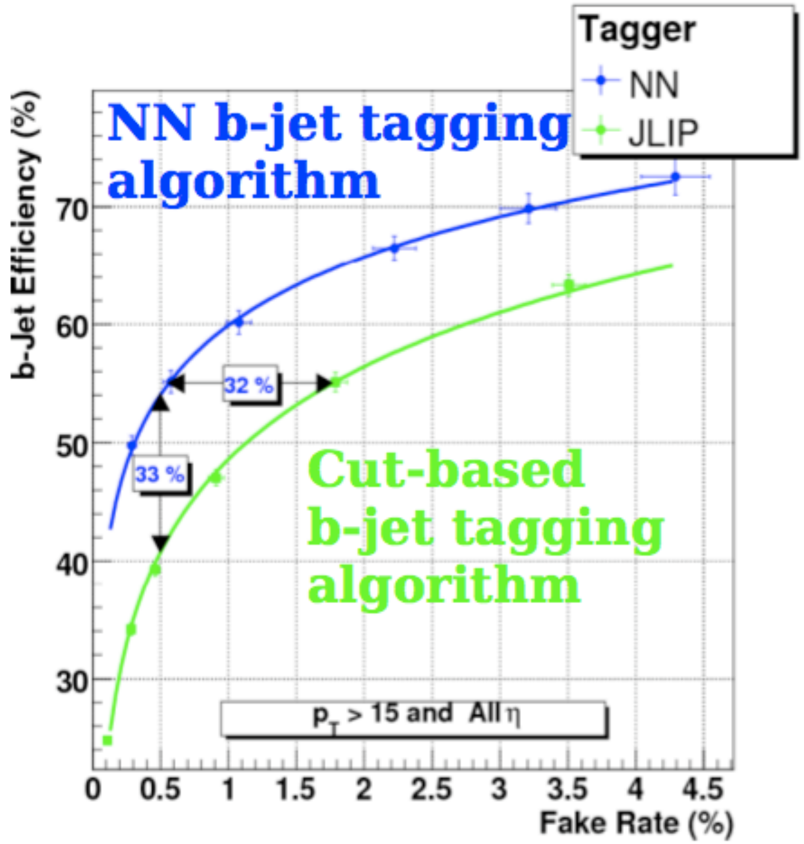
B-tagging

Train artificial Neural Network on simulated events

- optimized inputs, training method, network topology

Test NN efficiency and fake rate using *real data*





Equivalent to 2.5x as much data for a double-b-tag analysis!