SM Low Mass search "secondary channels"

(H->γγ, HX->ττjj, VH->qqbb)

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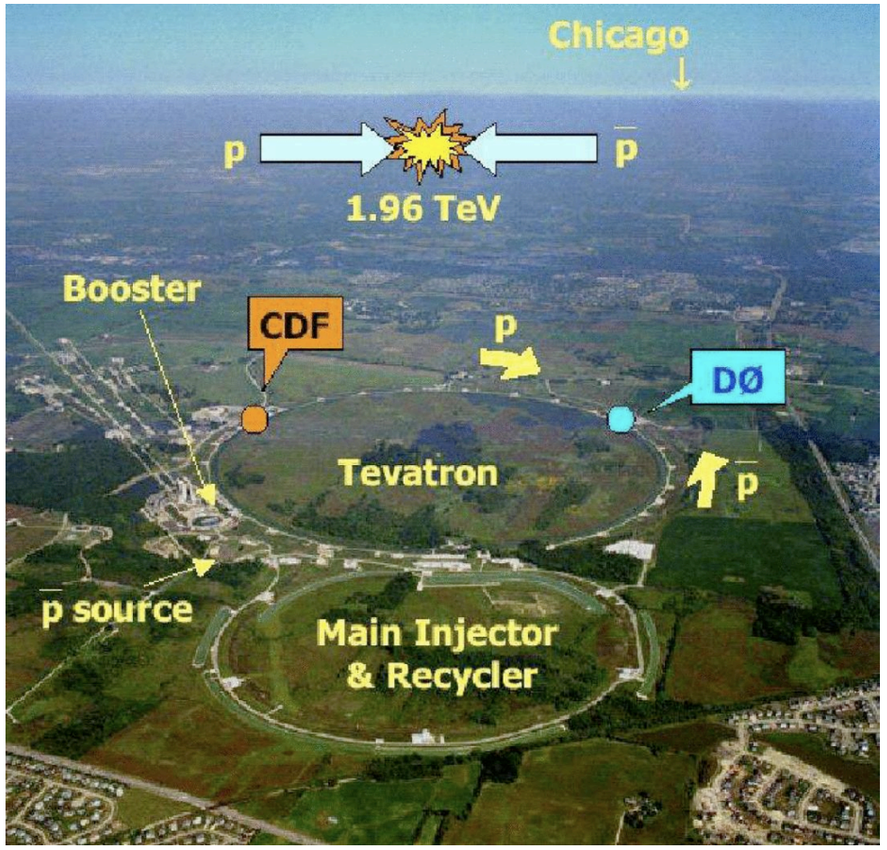
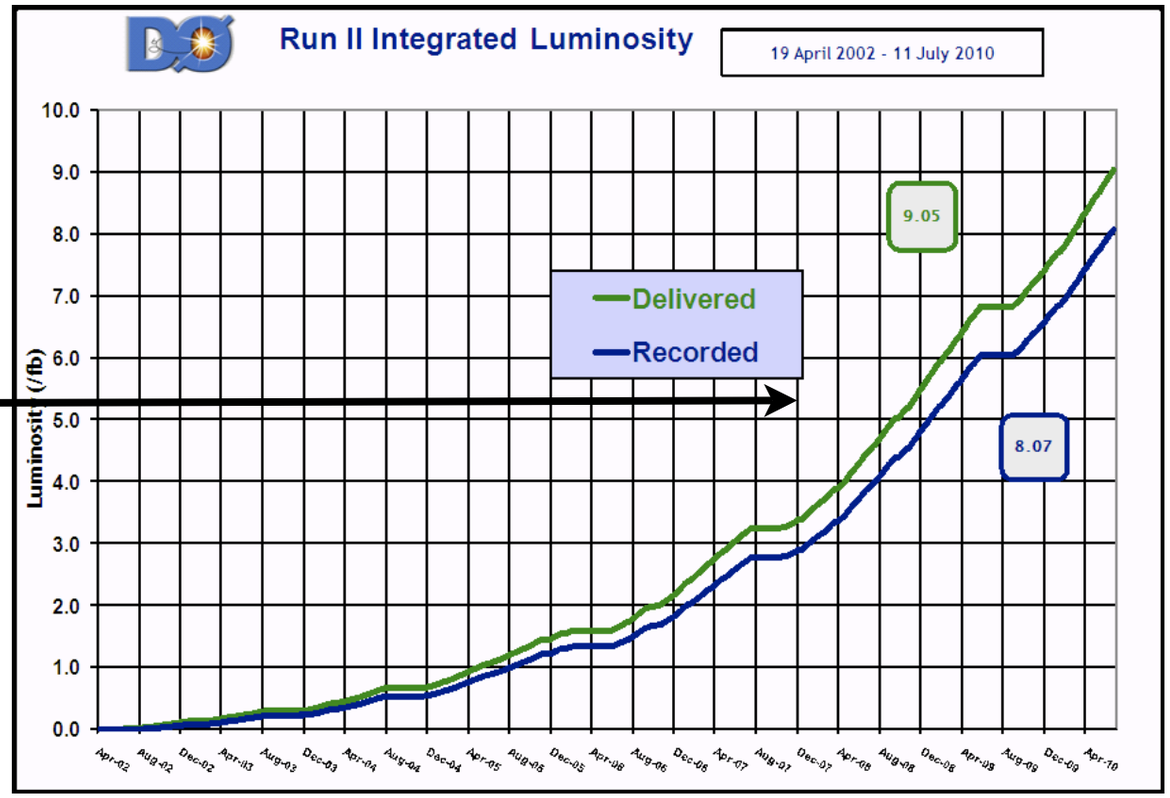
Outline

- Motivation
- H->γγ @ D0/CDF
- XH->ττjj @ D0/CDF
- VH->qqbb @CDF
- Results
- Summary

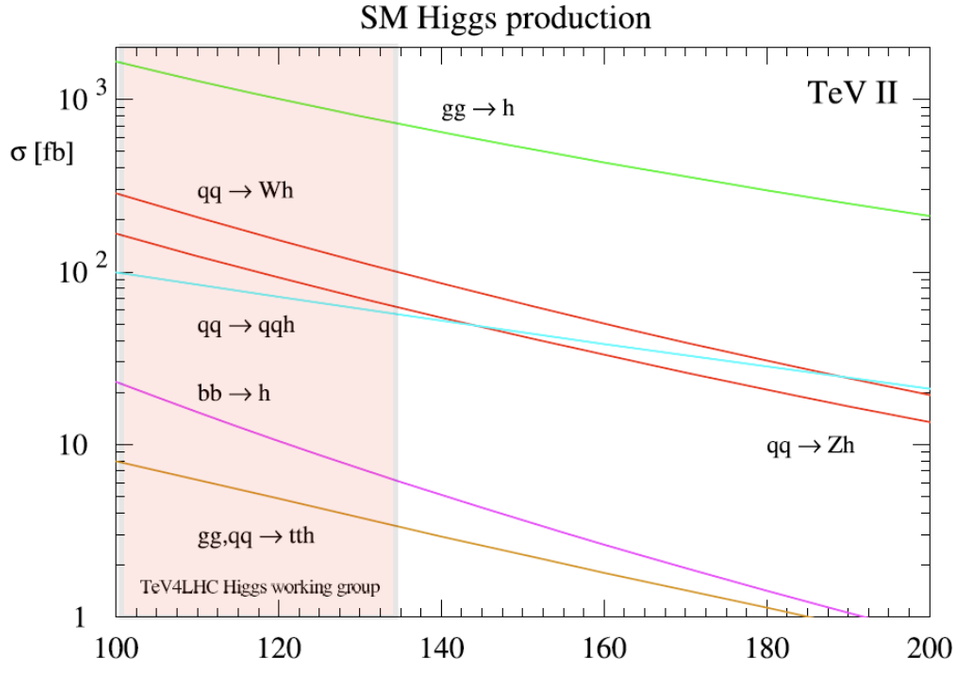
Analysis presented here 2.3-5.4 fb-1

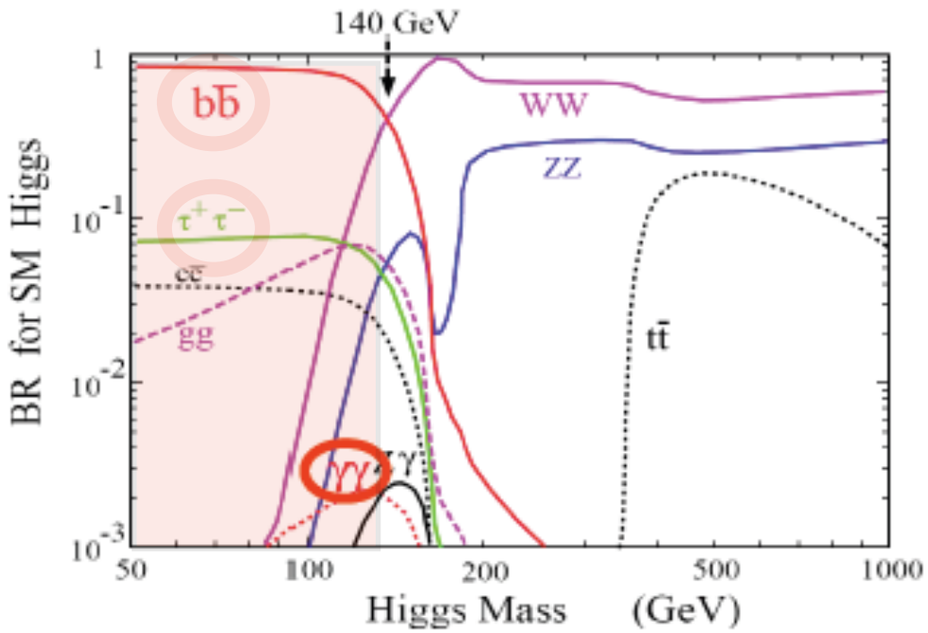




Motivation

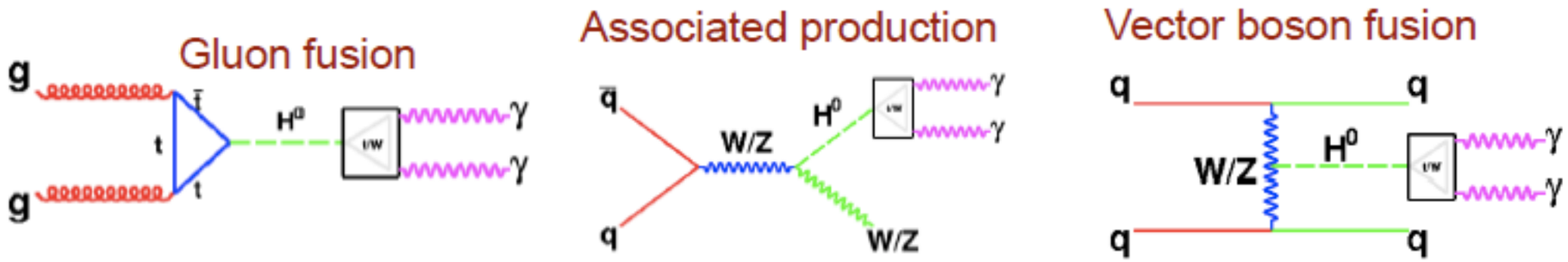
- Tevatron collecting large dataset where we maximize sensitivity for Higgs searches
- For secondary channels, γγ/ττ decays have small BR and bb decay has large QCD background.
- Experimental challenges include difficult detection of γ/τ final states
- However they can add up to Higgs sensitivity
- Moreover, relative model independence of these channels can be used to search for new physics





H→γγ @D0/CDF

L=4.2/5.4 fb-1



Add ~30% more signal

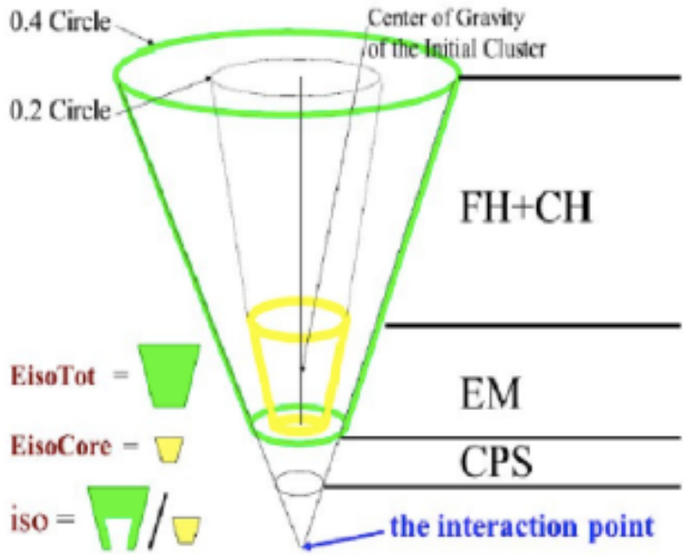
- SM Higgs decay to two photons
- BR only 0.2% but better mass resolution
- Diphoton mass bump observable in falling spectrum
- Background model by data driven techniques (sideband technique)
- Search can probe for any narrow resonance decaying into di-photons in quasi-model independent way

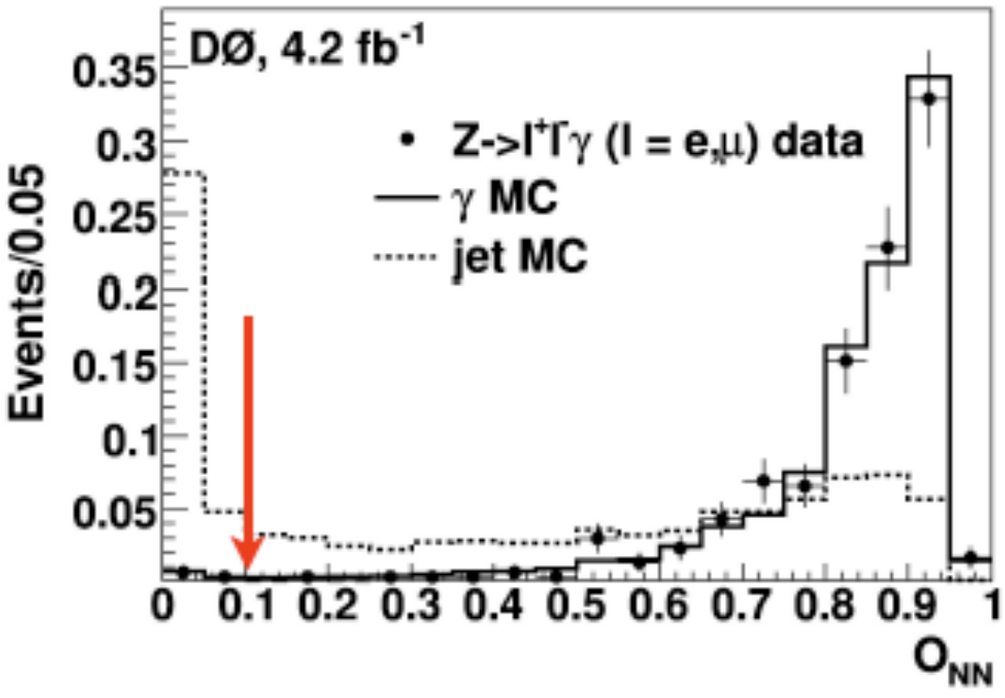
- Event Selection
- DiEM cal-only trigger suites, Single photon with high pT (50-70 GeV) threshold CDF only
- Primary vertex should be inside acceptance of tracking
- EM object in central calorimeter
- pT>25/15 GeV (D0/CDF)
- Mγγ > 60/30 GeV

H→γγ Preselection

Photon Identification

- High EM fraction/cluster in shower
- Calorimeter and tracker isolation
- Transverse shower profile and no associated track
- D0 also uses a 5 variable NN cut >0.1

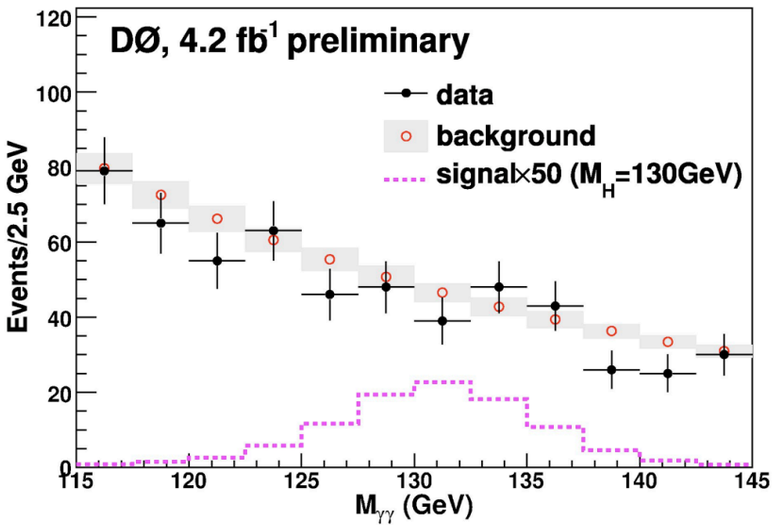


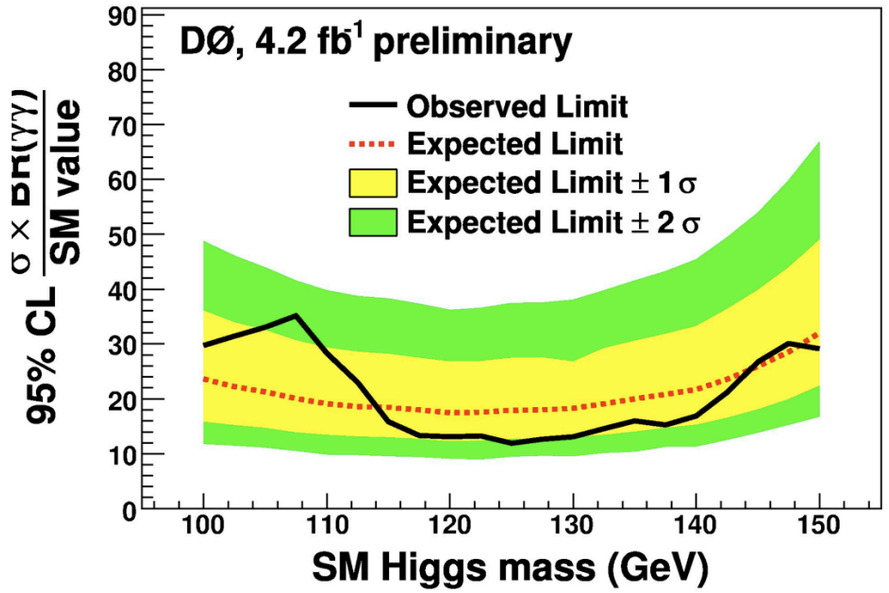


Main Backgrounds

- Reducible backgrounds : Electrons misidentified as photons Z/γ*->ee, Jets misidentified as photons,dijet and γ+jet, using NNLO MC
- Irreducible backgrounds : direct QCD di-photon production using a sideband fitting method from data
- CDF analysis use the sum of all backgrounds is taken from a inclusive sideband fitting method

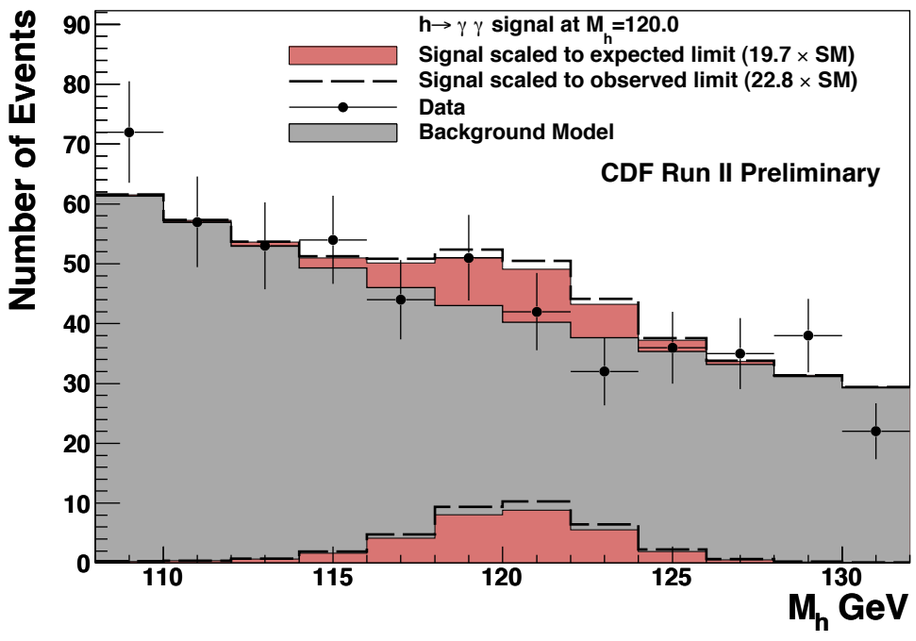
H→γγ Results @D0/CDF

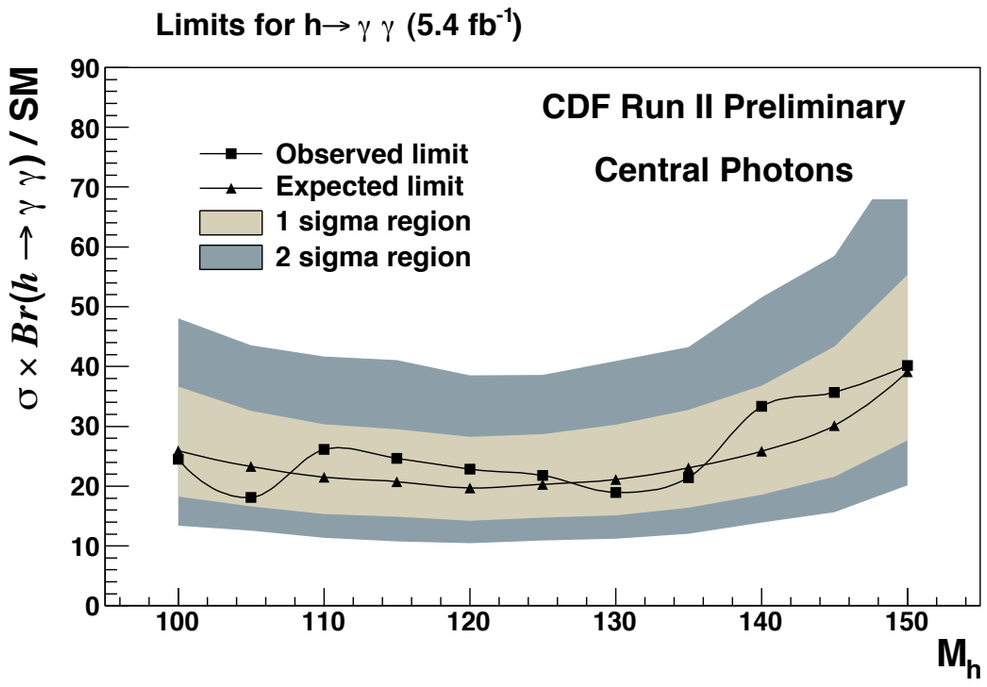




source	uncertainty
luminosity	6.1% [21]
trigger	0.1%
PDF for $h \to \gamma\gamma$ acceptance	1.7% - 2.2%
electron misidentification efficiency	19.0%
$Z/\gamma^*(ee)$ cross section	3.9%
photon identification efficiency	6.8%
background subtraction	shape
photon energy scale	shape

- Myy spectrum in the search region for derivation of Obs(Exp) limits 15.8(18.5) D0/24.6(20.8) CDF times SM higgs cross section @Mh=115 GeV



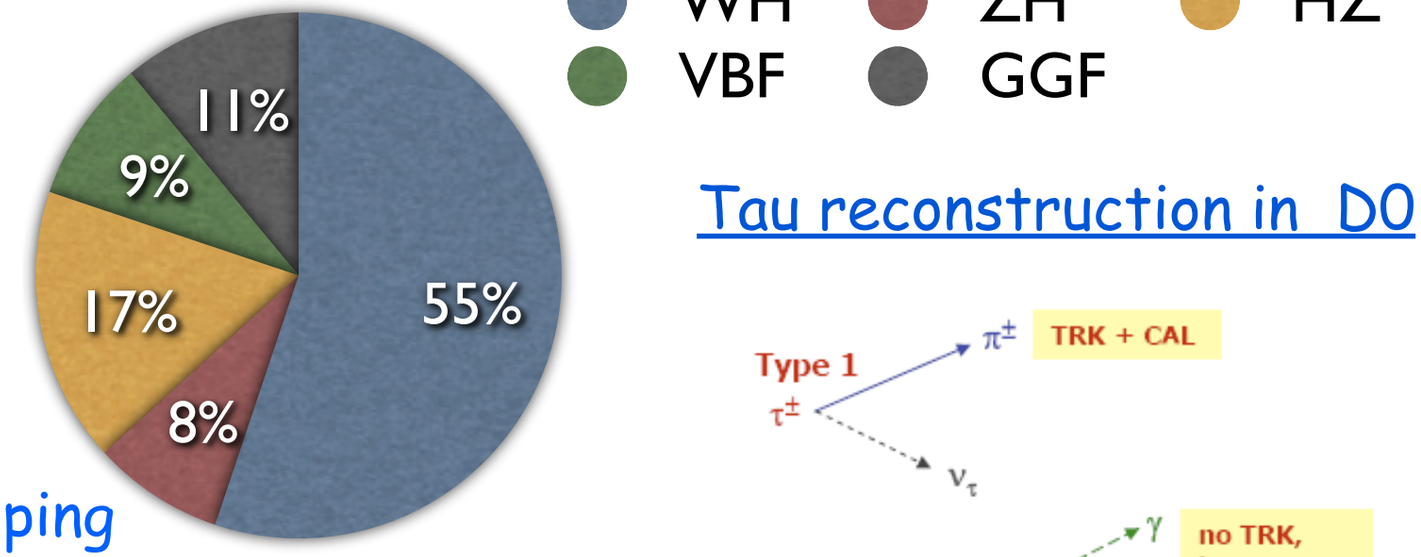


VH/VBF→ττjj @D0

L=4.9 fb-1

- W(→ qq') H(→ τ+τ-)
- Z(→ qq) H(→ τ+τ-)
- H(→ bb) Z(→ τ+τ-)
- VBF qHq'→ q' τ+τ-q
- gg → H → τ+τ-+≥ 2jets

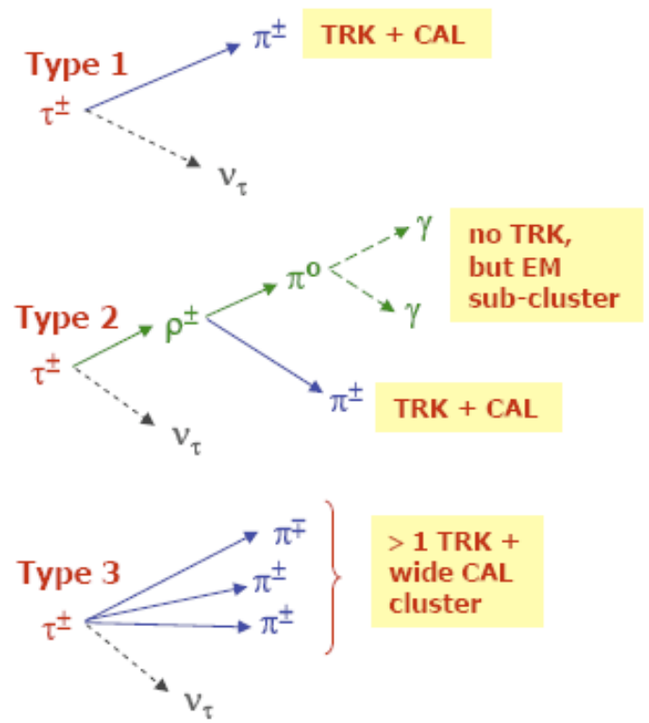
Signal contribution after preselection



- Simultaneous search by grouping all possible tau signals
- Difficult with only 7% higgs ->tautau BR

- Event Selection
- Only one isolated muon
- One hadronic tau candidate pT>15 GeV
- At least two jets pT>20 GeV and |η|<3.4
- Opposite sign mu-tau pair requirement
- Electron veto and no b tagging

Tau reconstruction in D0

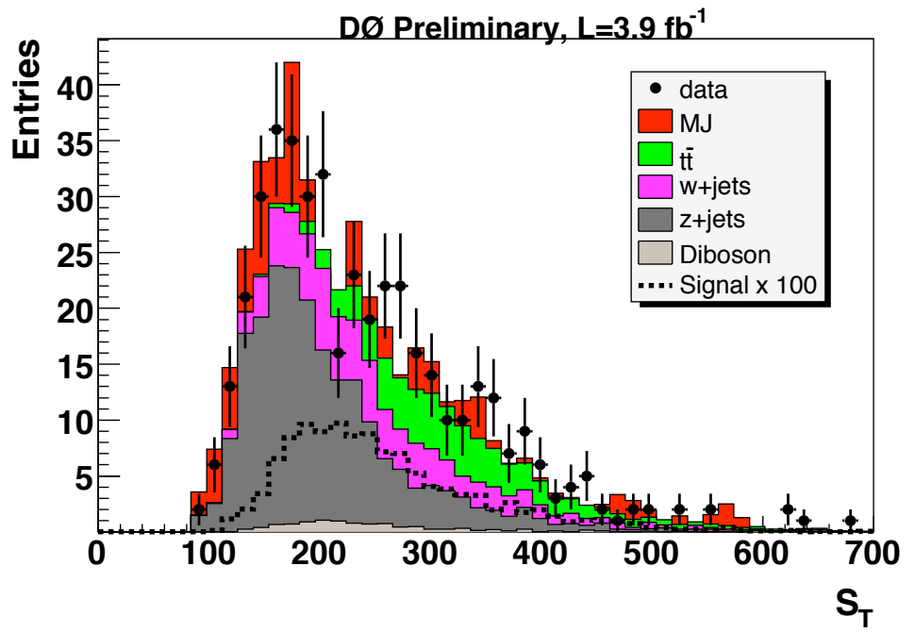


D0: simple cone algorithm, cone size R = 0.3.
Isolation cone, R = 0.5
EM cells in other layers
Associate up to 3 tracks with pT > 1.5 GeV to the tau

ttjj Preselection @DO

- After preselection Multivariate technique used for optimum sensitivity
- Variables used for BDT training showing good data montecarlo agreement
- QCD estimated from data used in BDT training

ST

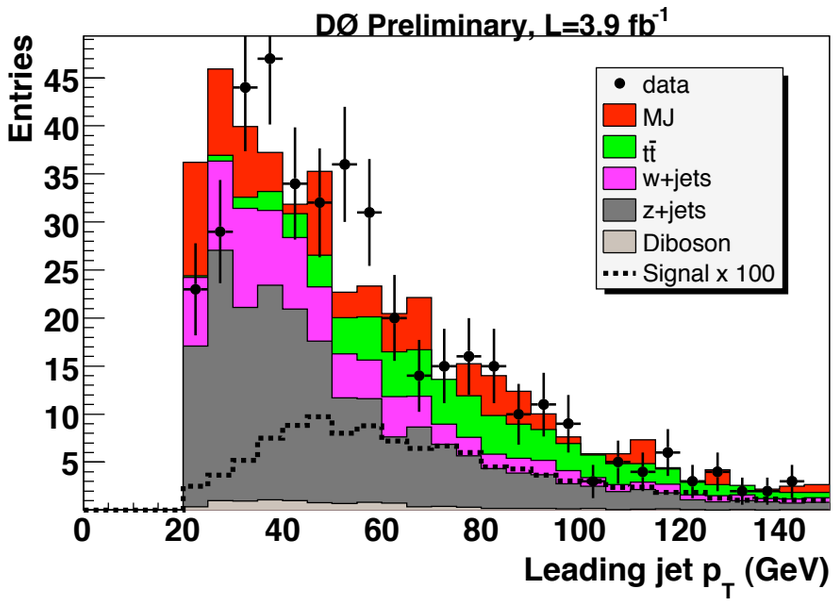


Event Yield

data	433
ttbar	66.7
w+jets	81.5
z+jets	222.7
diboson	10.2
QCD	80.7
total	439.9
signal	1.33

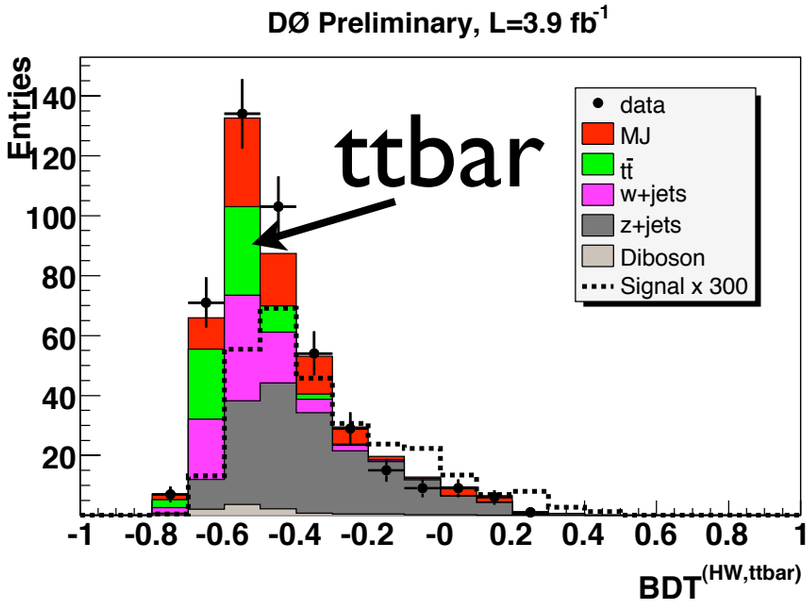
Total Signal 1.33

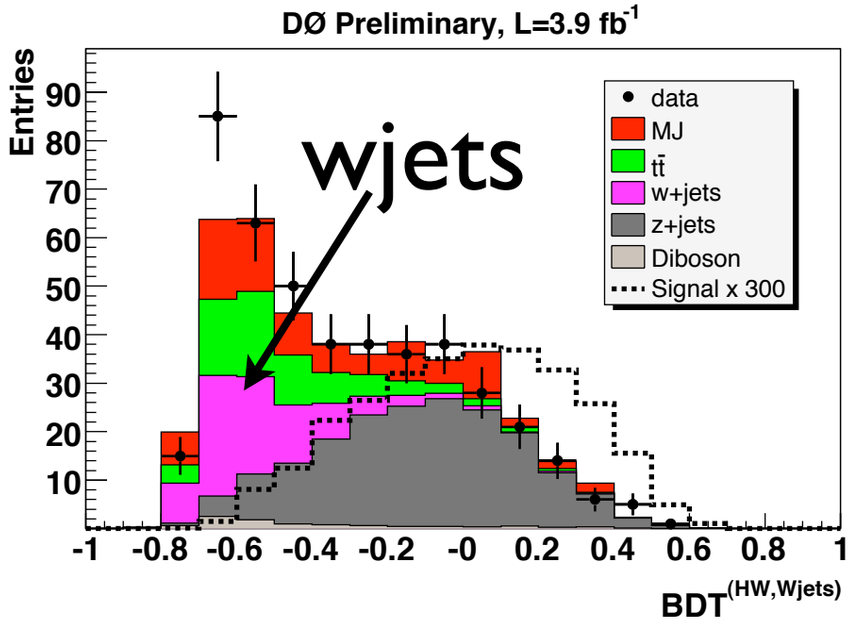
leading jet pT

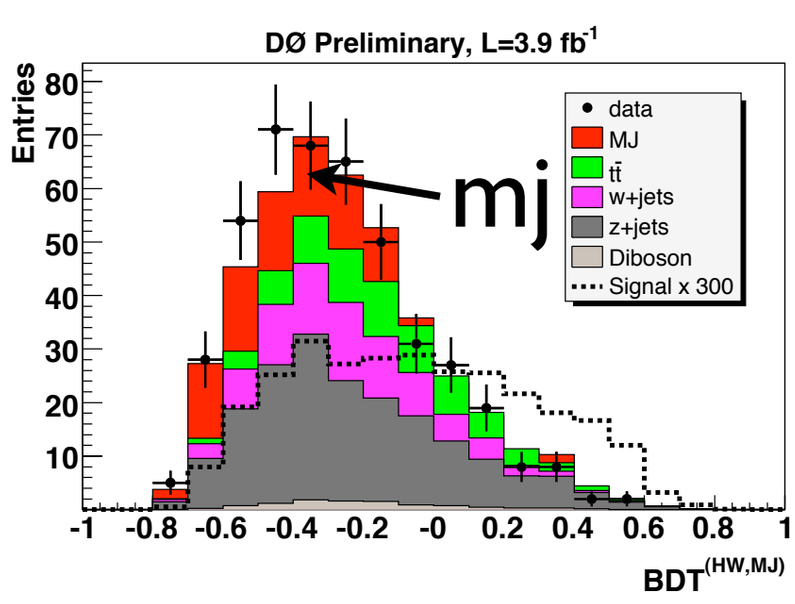


BDTs for ττjj @DØ

- 32 Boosted Decision Trees for four signals to four bkgd BDTs output in two mass regions
- 17 variables used for each BDT





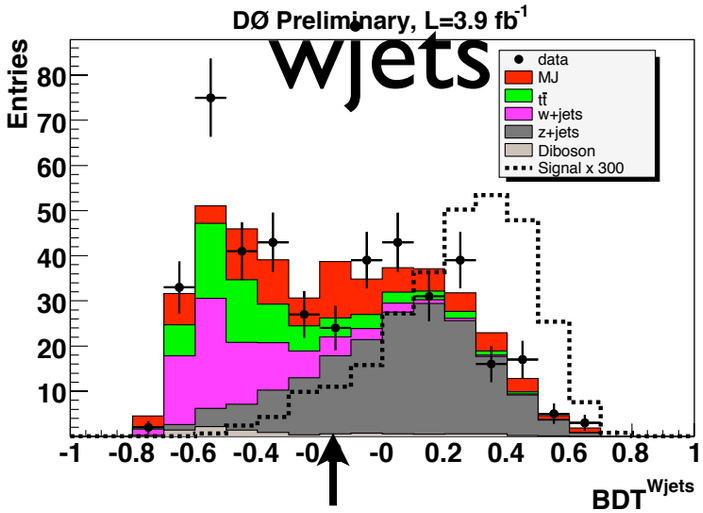


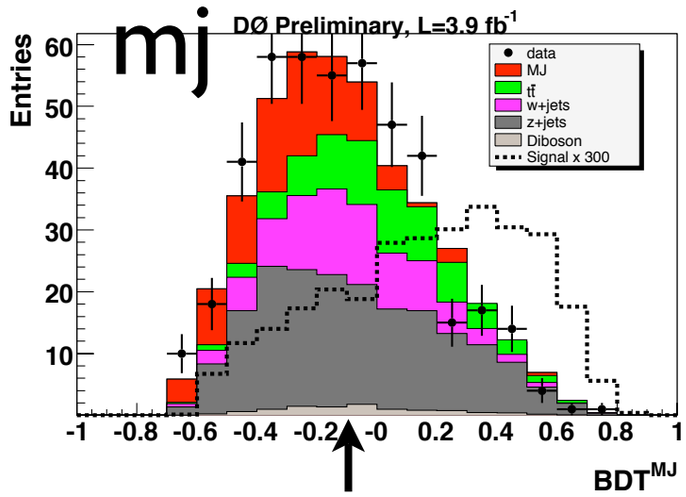
- BDT training WH signal vs different backgrounds

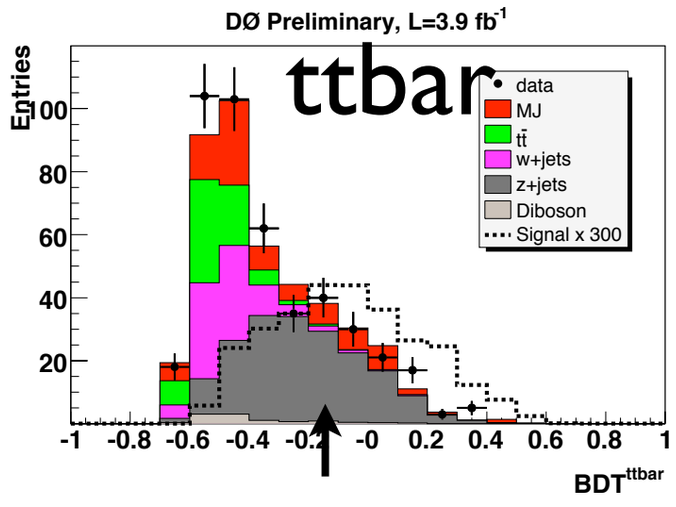
BDTs for ttjj@DO

L=4.9 fb-1

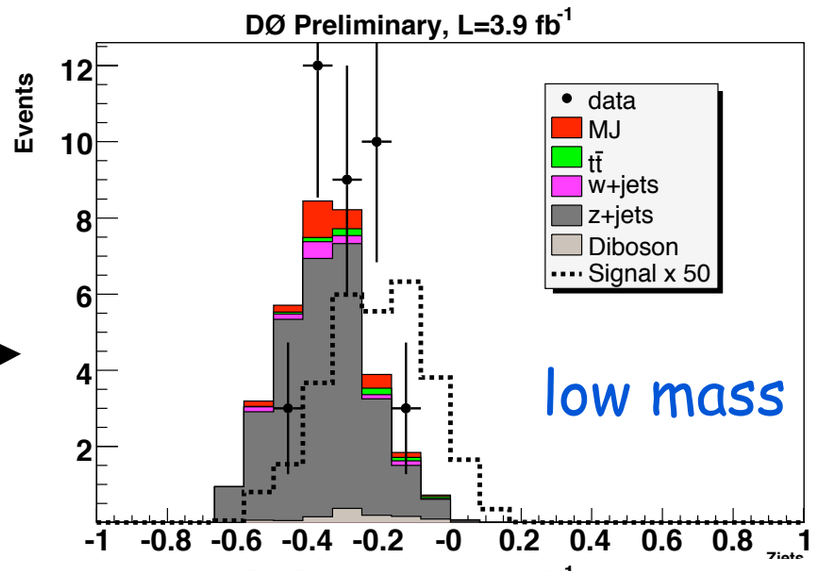
- Final selection cut on average over maxBDT of ttbar,wjets and MJ BDTs







- Final distribution weighted average Zjets BDT for limit setting

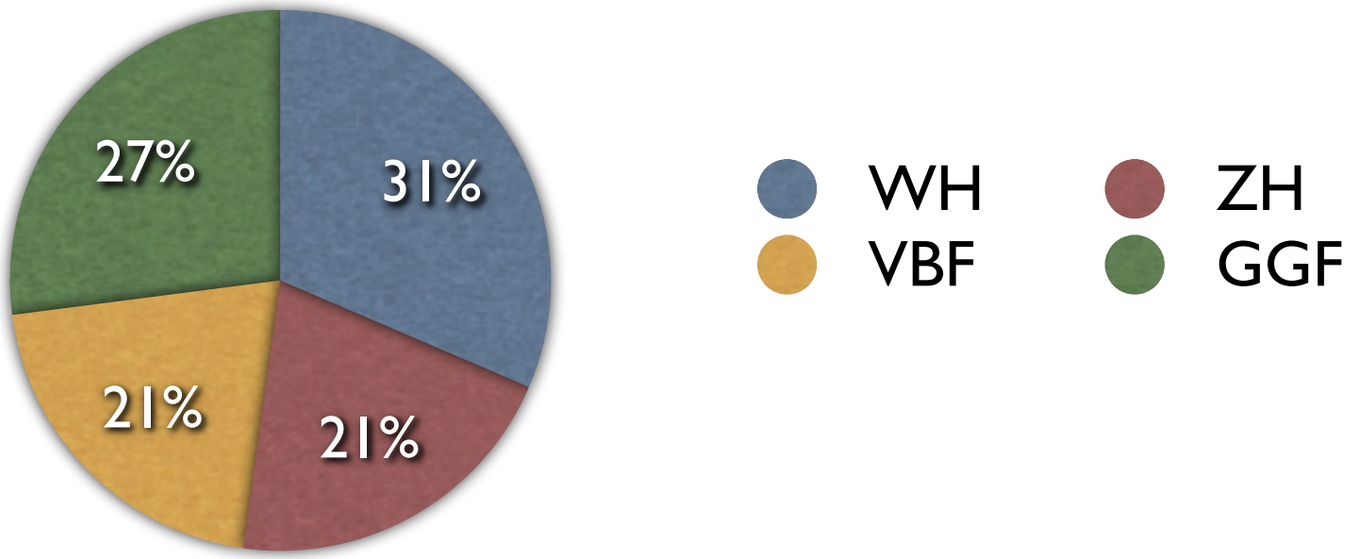


- Major systematics
  Tau ES 4.5%
  Lumi 6.1%
  QCD 15%
  Cross sec 10%
  JES 7.5%

VH/VBF→ττjj @ CDF

L=2.3 fb-1

- W(→ qq') H(→ τ+τ-)
- Z(→ qq) H(→ τ+τ-)
- VBF qHq' → q' τ+τ-q
- gg → H → τ+τ-± 2jets

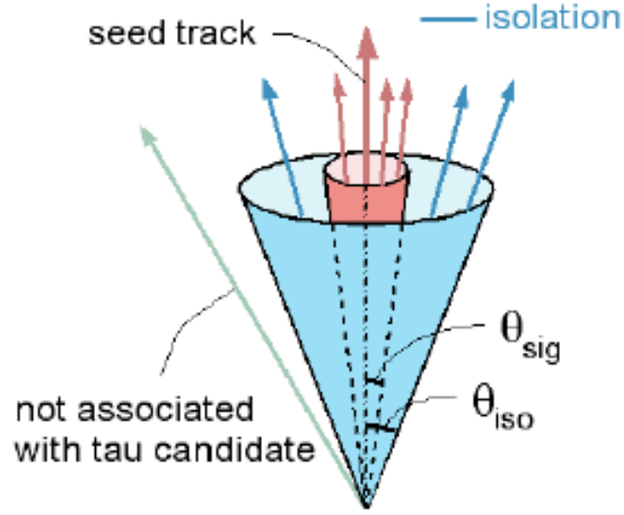


Simultaneous search for tau signals

Orthogonal to b tagged low mass searches

τ identification @CDF

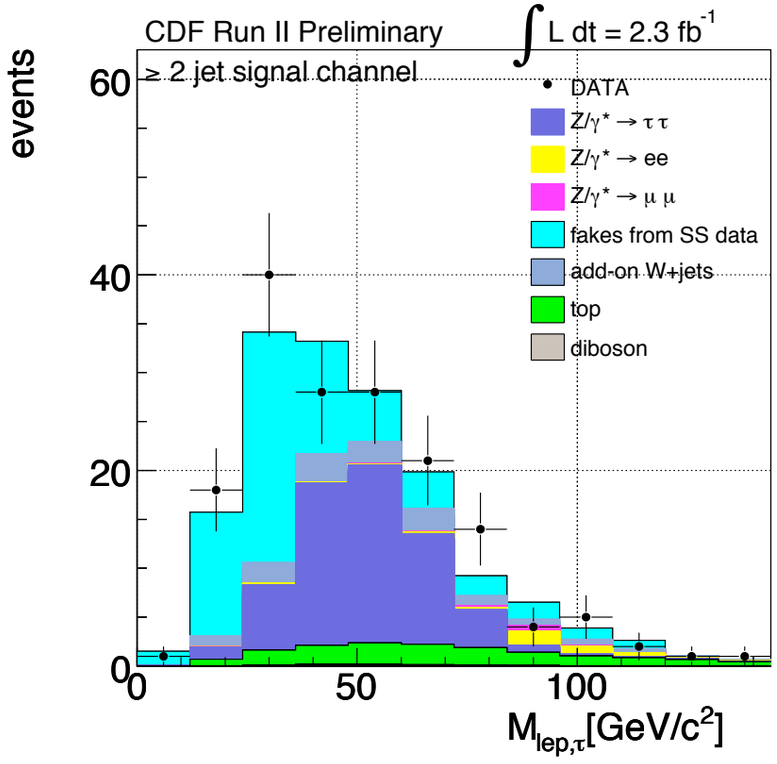
CDF: Start with a calorimeter tower, ET > 6 GeV.
Add up to 6 contiguous towers with ET > 1 GeV.
Associate tracks with the calorimeter cluster,
At least one track with pT > 6 GeV.
Tau cone defined by seed track,
Isolation annulus 1 or 3 tracks,
Reconstruct π0's.
Require M(tracks,π0's) < 1.8 GeV



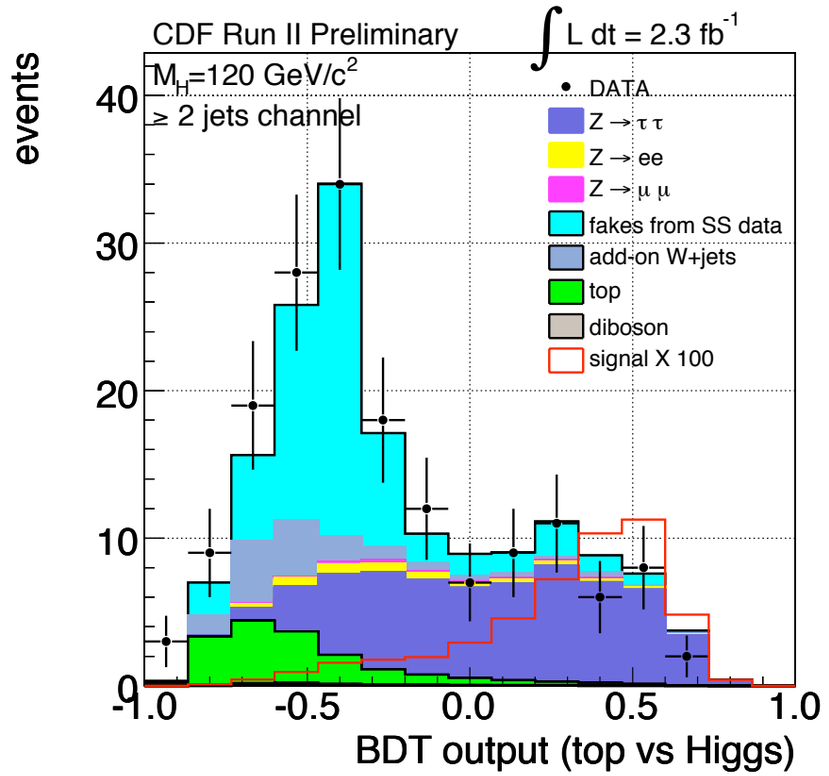
Event Yield @ CDF

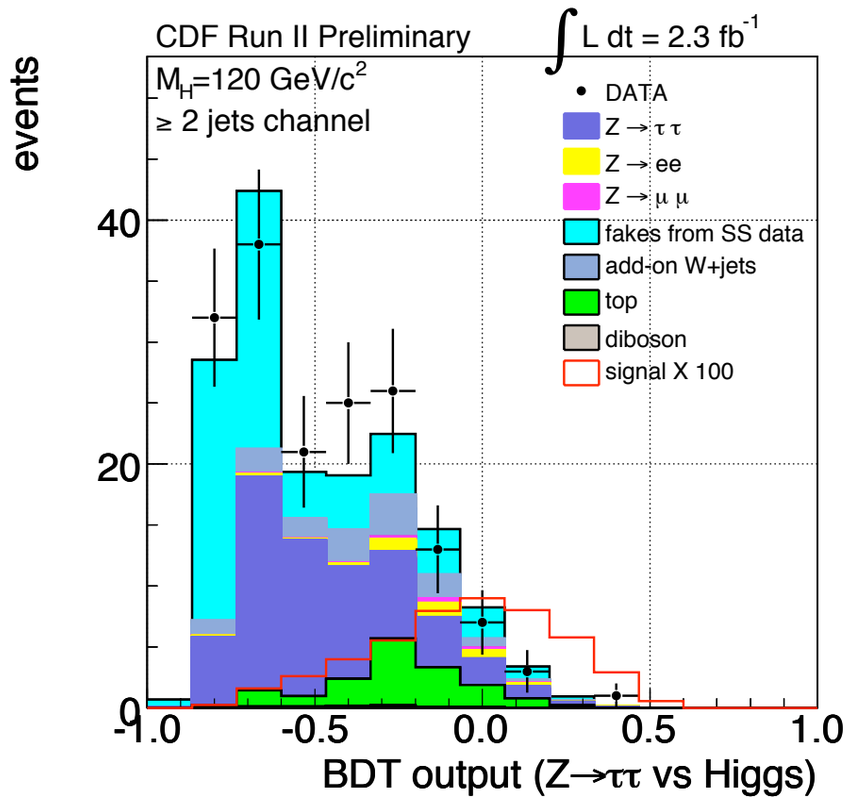
- Event Selection
- Exactly 1 Lepton: Central (|η| < ~1.0) isolated electron or muon with Pt > 10 GeV
- Exactly 1 Hadronic Tau: Central hadronic τ (|η| < 1.0, 1 or 3 track in signal cone) with visible Pt > 15 GeV
- OS requirement: Lepton and Hadronic τ candidates have to be opposite sign
- At least 1 Jet and 2 or more jet: Et > 20 GeV and |η| < 2.5
- Z boson veto (for Z→ee/μμ)

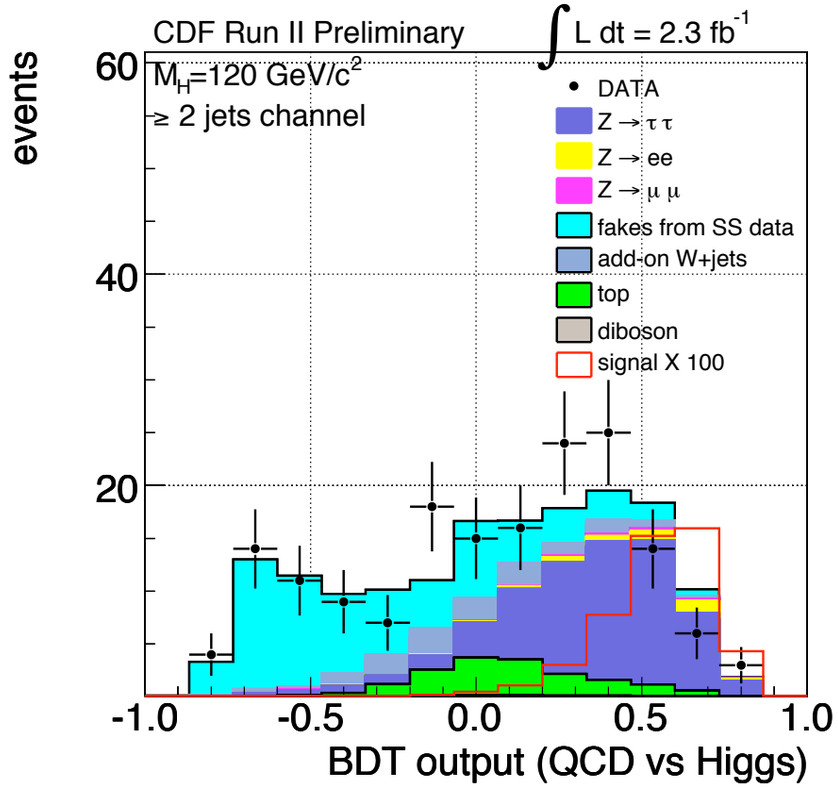
DATA	965, 166 (1,2 jet)
Z-tautau+jets	357.9, 59.3
zmumu+jets	26.4, 4.8
ttbar	3.9, 16.3
diboson	4.6, 0.9
QCD	483, 64
w+jets	45.8, 14.1
total background	921.7, 159.4
Total signal (mh=120)	0.746, 0.477



BDTs selection @ CDF





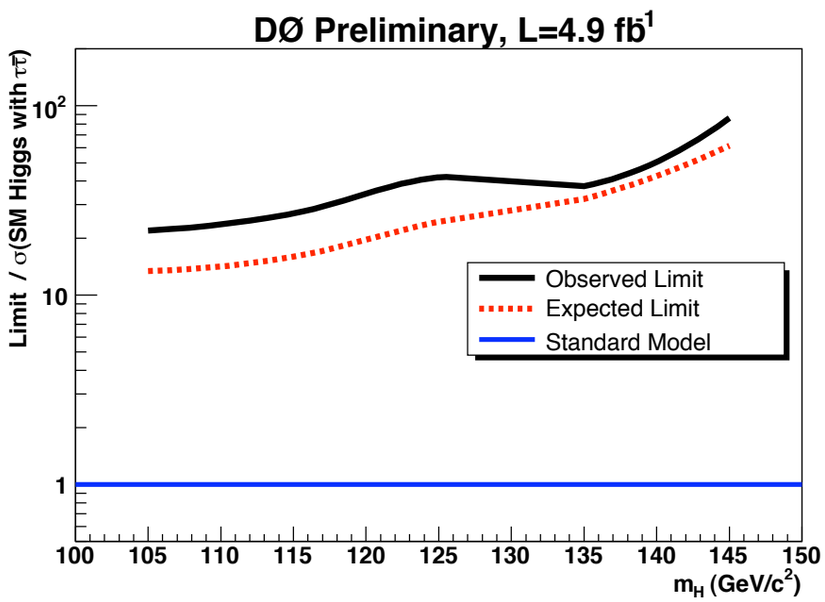


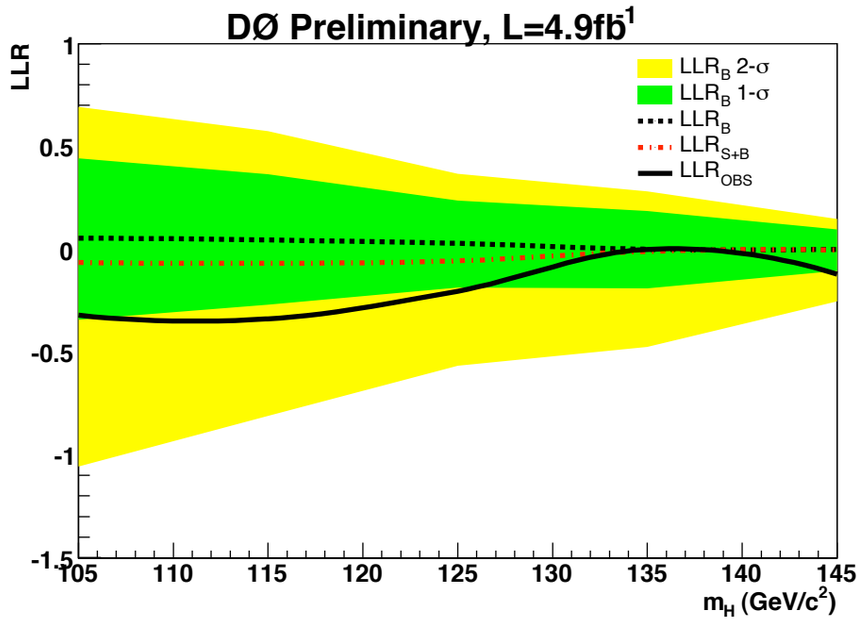
- Three BDTs trained with mixed Signal vs zee,top, qcd backgrounds
- Final discriminator minimum of three BDTs
- Major Systematics
  JES 15%
  Lumi 6.0%
  tau ID 3%
  Signal 10-22%

Limits

- Good agreement with background prediction. No significant excess in signal region
- D0 uses modified frequentist approach to set 95% CL LLR plots shown below
- D0 sets limits for combined ττjj analysis expected limit range 13.4 to 61.4

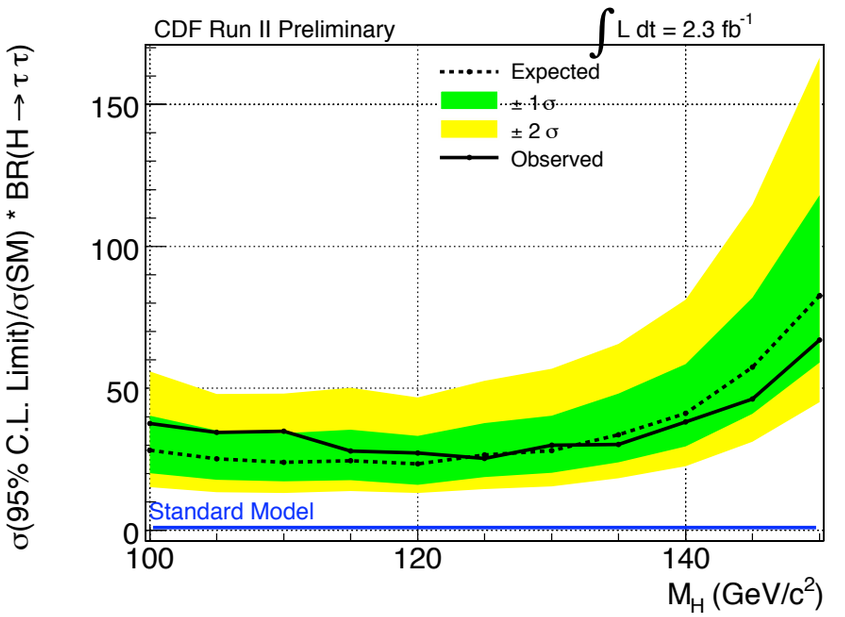
D0 ττ





- CDF uses a Bayesian approach
- CDF sets limits for ττjj analysis with 2.3 fb-1 data
- The expected limit ranges from 23.9 to 82.6

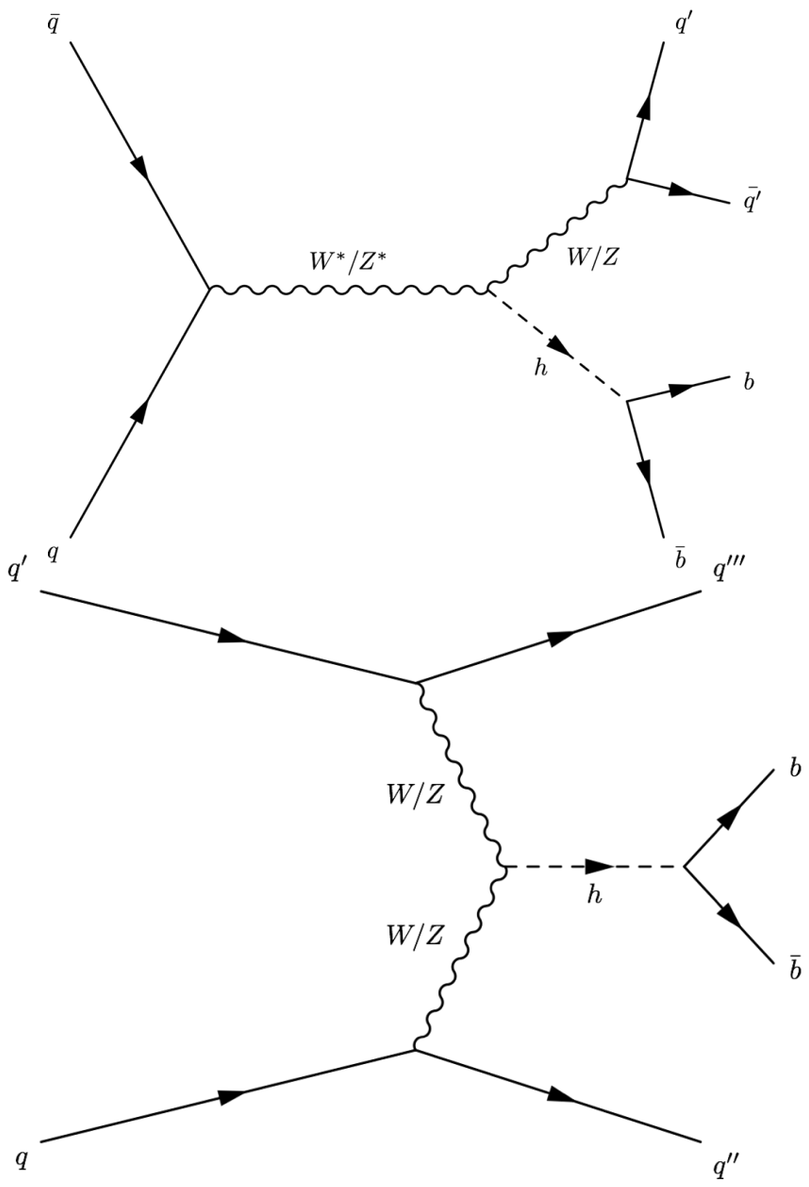
Mh=115	Exp	Obs
D0	15.9	27.9
CDF	24.5	27.9



VH/VBF→qqbb@CDF

L=4.0 fb-1

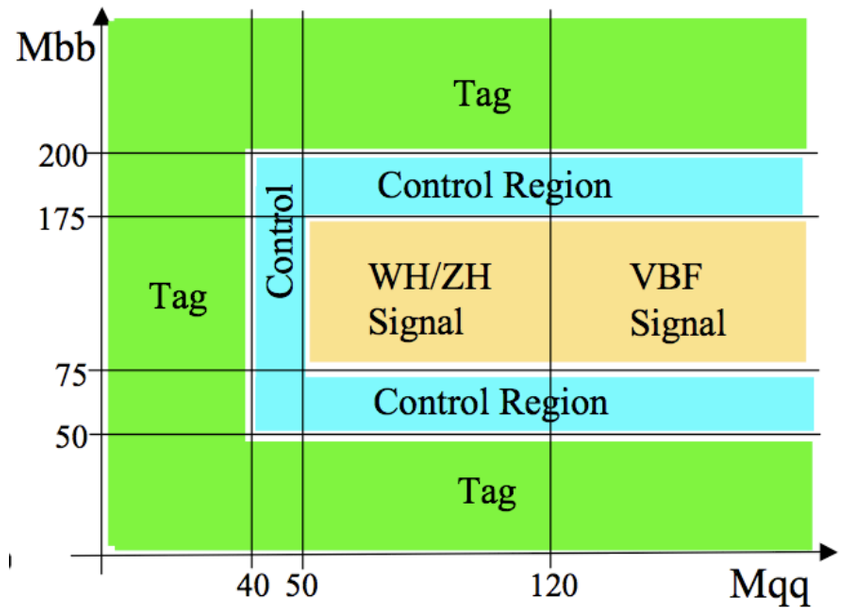
- Large signal yield as it profits from the largest cross-section x branching ratio
- Complete event information. No missing energy to infer
- large QCD background



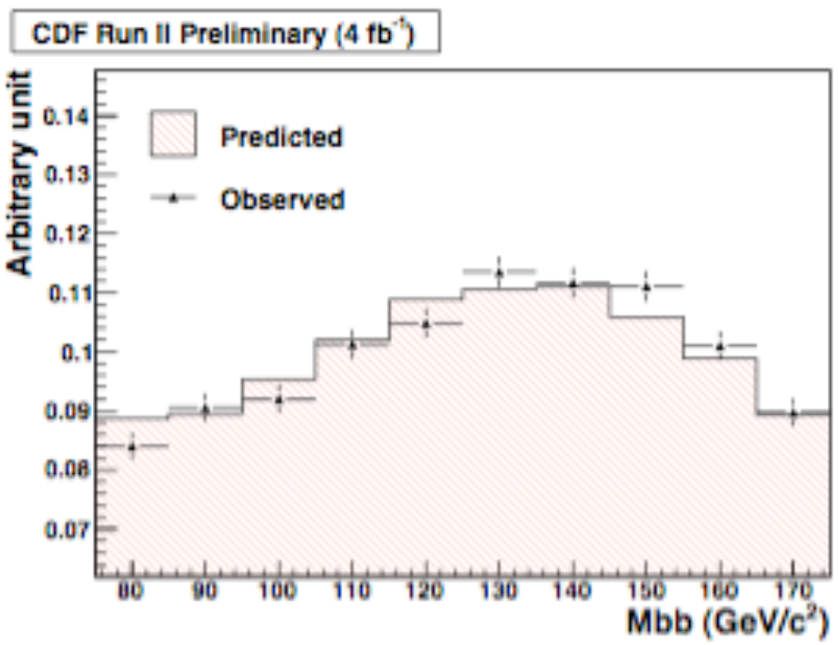
- Event Selection
- Pass CDF multi-jet trigger
- Veto lepton events
- 4 or 5 jets with E_T > 15 GeV
- Small MET significance to reduce contribution from ttbar background
- Exactly two jets must be tagged as b-jets Two b tagging methods in CDF referred as SS/SJ
- Sum of the transverse energy of the selected jets > 220 GeV to suppress QCD

Preselection qqbb @CDF

- VH Signal Region: 75 < M_{bb} 175 & 50 < M_{qq} < 120
- VBF Signal Region: 75 < M_{bb} 175 & M_{qq} > 120
- Backgrounds:
- QCD (98%) ,ttbar , Z + jets (where Z decays to b/c quarks), Single-Top, W + bb/ cc jets,WW/WZ/ZZ



- QCD Modeling : Data-based approach using Tag-Rate-Function (TRF), the probability that a jet is b-tagged given an event with a tagged b-jet as a function of three variables: E_T, η of the probe jet and Δ R between the b and the probe jet.
- The TRF is parameterized in the TAG region and applied into the signal region to predict the double b-tagged QCD multi-jet events in the signal region.

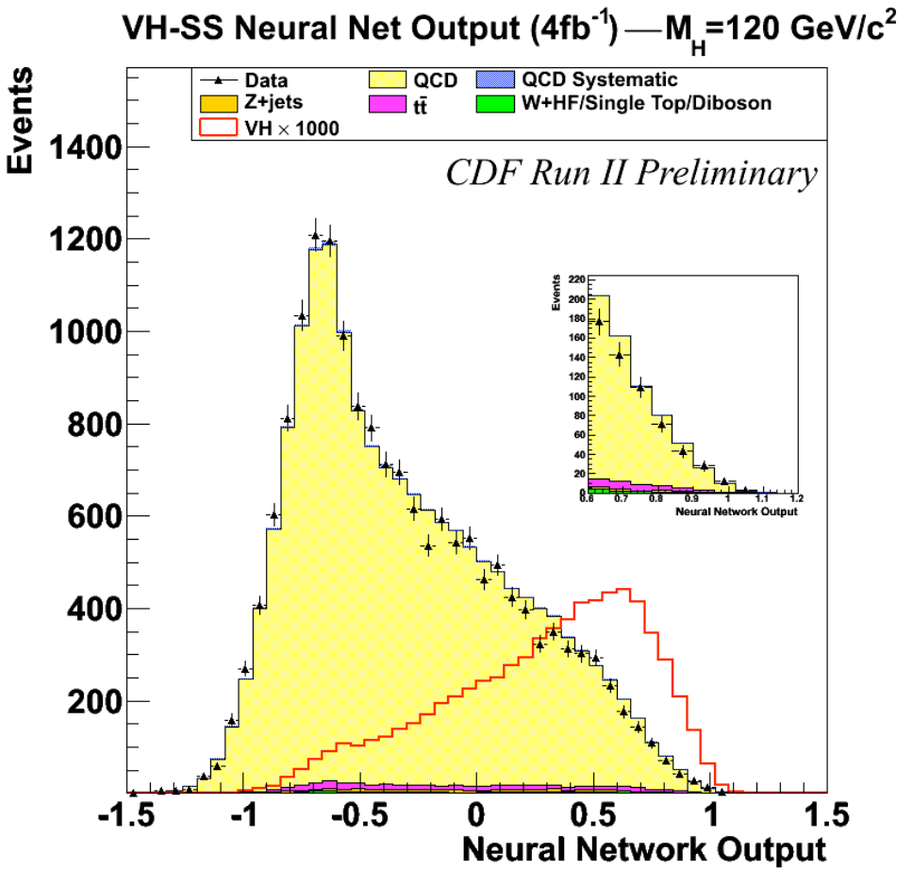


Four orthogonal channels were studied:

1. •VH where both b-jets are tagged by tight SecVtx (SS)
2. •VH where one b-jet is tagged by tight SecVtx and the other by JetProb (SJ 1%)
3. •VBF where both b-jets are tagged by tight SecVtx
4. •VBF where one b-jet is tagged by tight SecVtx and the other by JetProb(1%)

The results from the 4 channels are combined which gives a better result than the individual channels.

Limits qqbb@CDF

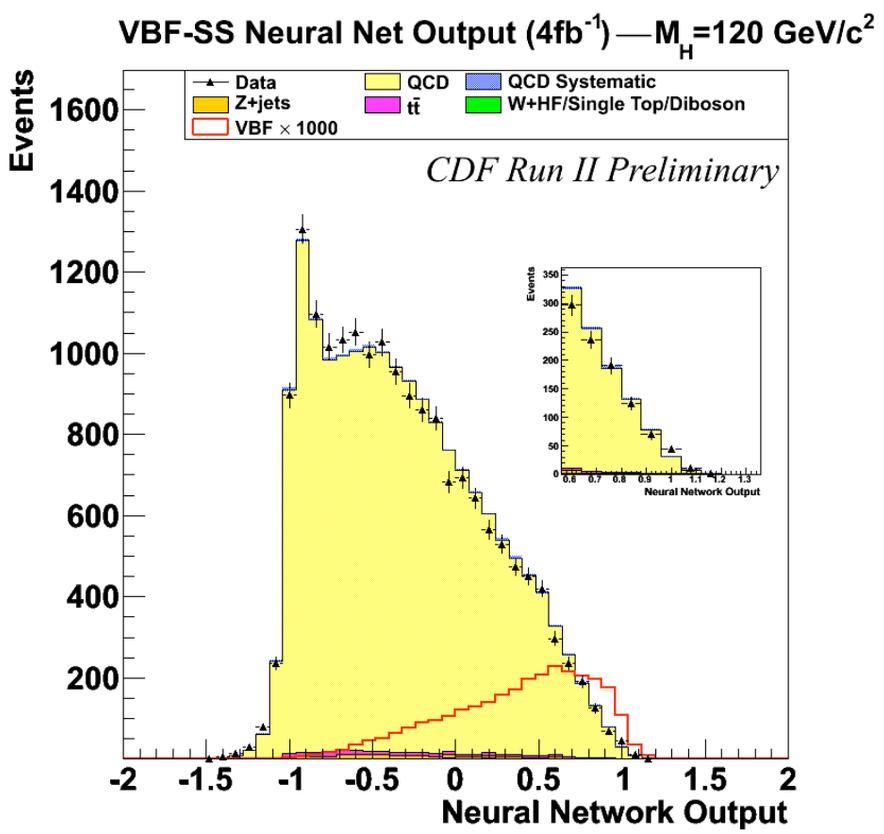


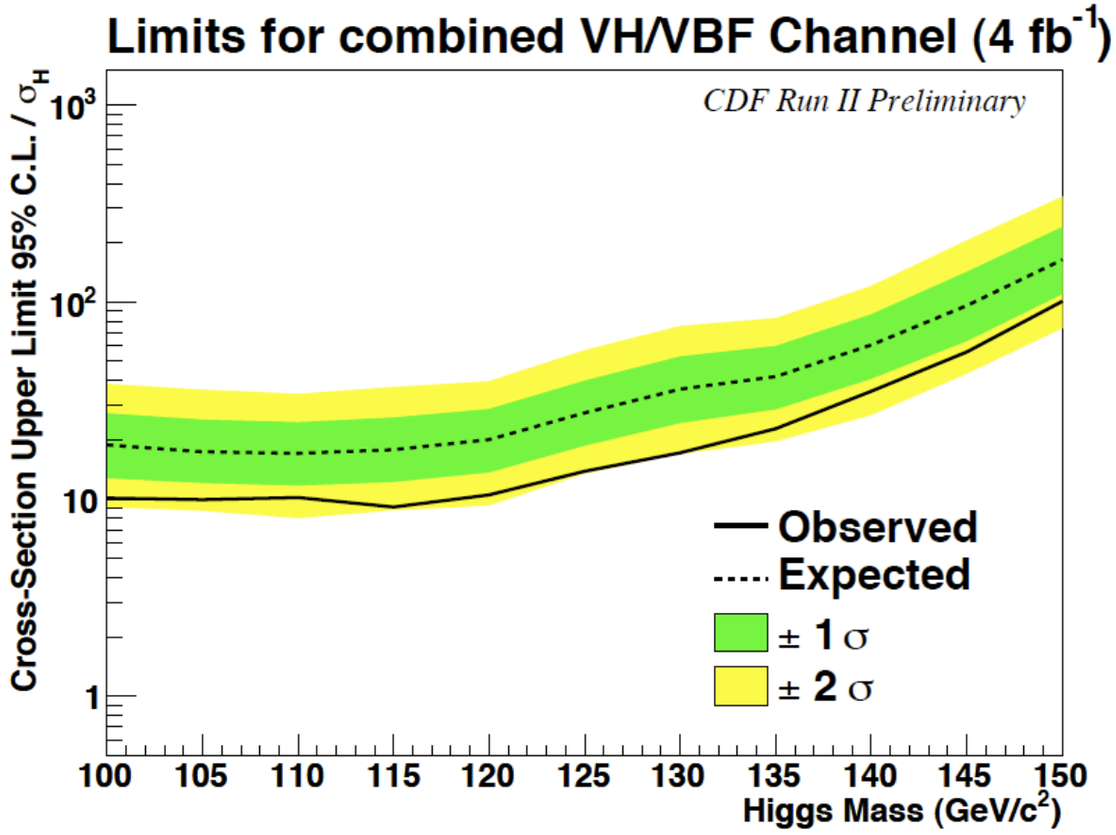
- Good DATA-MC agreement
- Put a limit on SM Higgs production cross section*BR

Major Systematics Sources

- QCD Modeling (shape)
- Luminosity (6%)
- b-tag scale factor (7.6-9.7%)
- Jet Energy Scale (7%)

Expected cross section x BR limit/SM < 18 @115GeV





Summary

- Presented results from Higgs search at Tevatron with secondary search channels
- These channels were included in the combined CDF D0 limits shown below.
- Sensitive at low and intermediate mass region.
- These channels can serve as search for New physics.
- With more data and improved analysis techniques results will be updated. Stay tuned.