Search for the SM Higgs boson in tau final states

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for D0 and CDF collaboration

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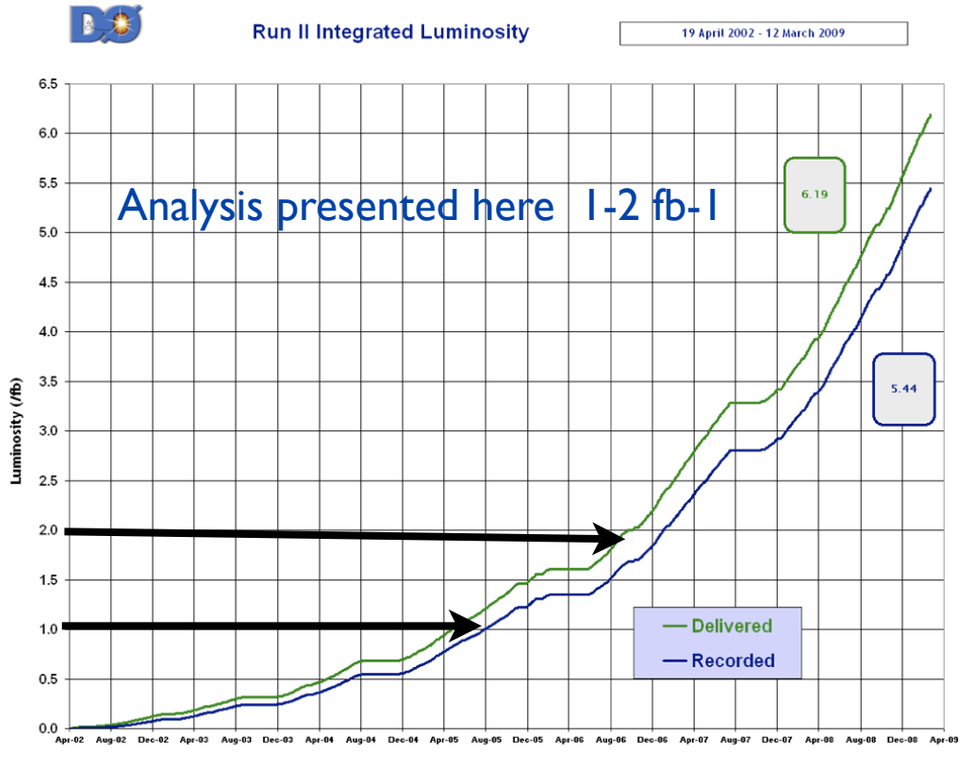
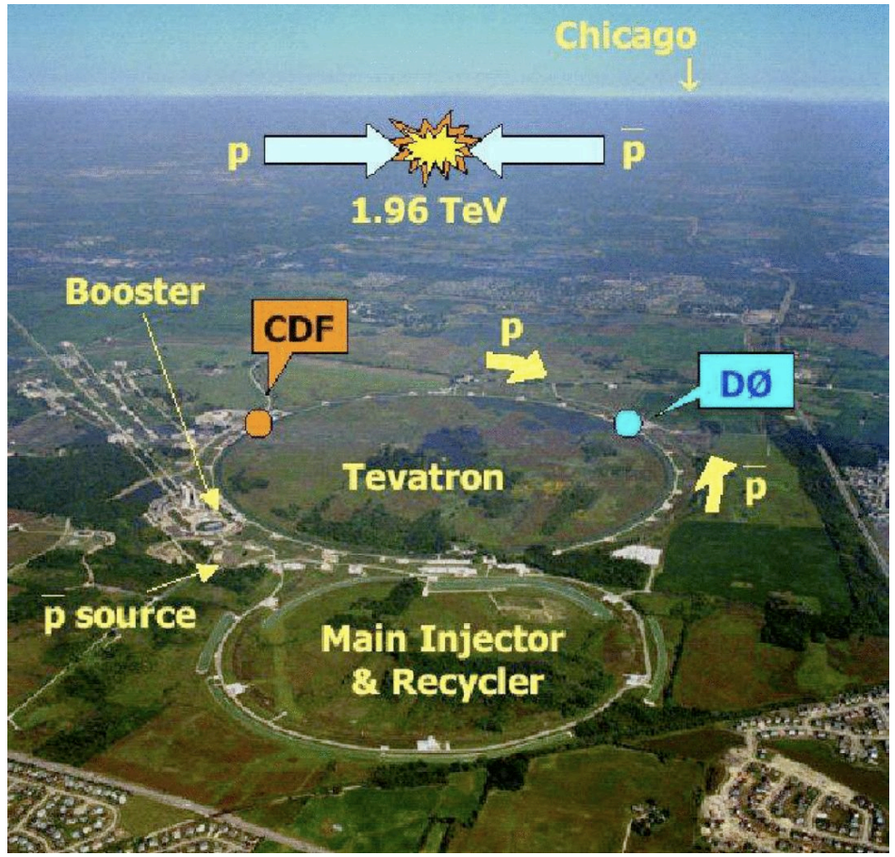
Outline

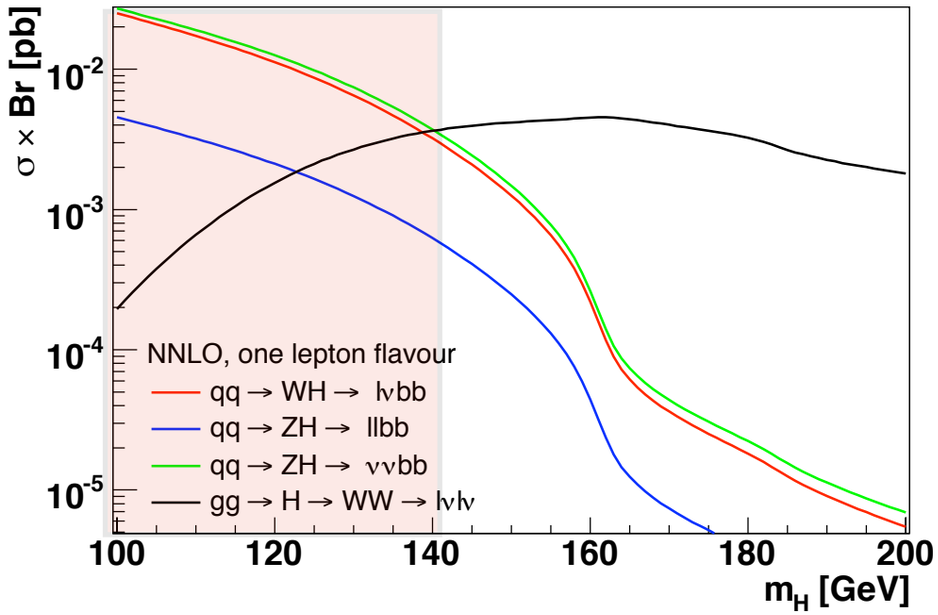
- Motivation
- $\tau\nu bb$ & $\tau\tau jj$ @ D0 L=1 fb^{-1}
- $\tau\tau jj$ @CDF L=2 fb^{-1}
- Preselection
- Multivariate Method
- Results
- Summary

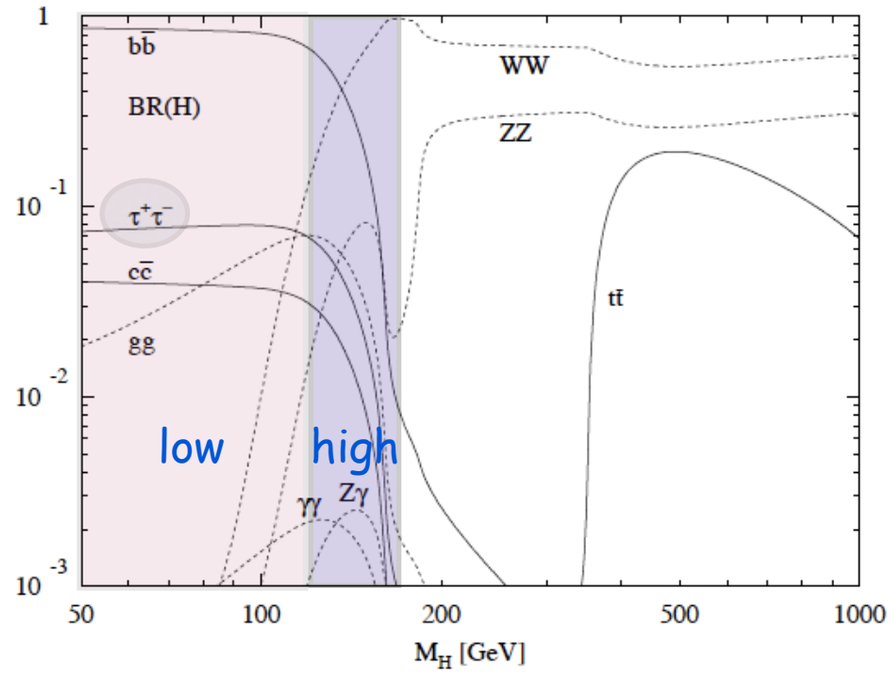


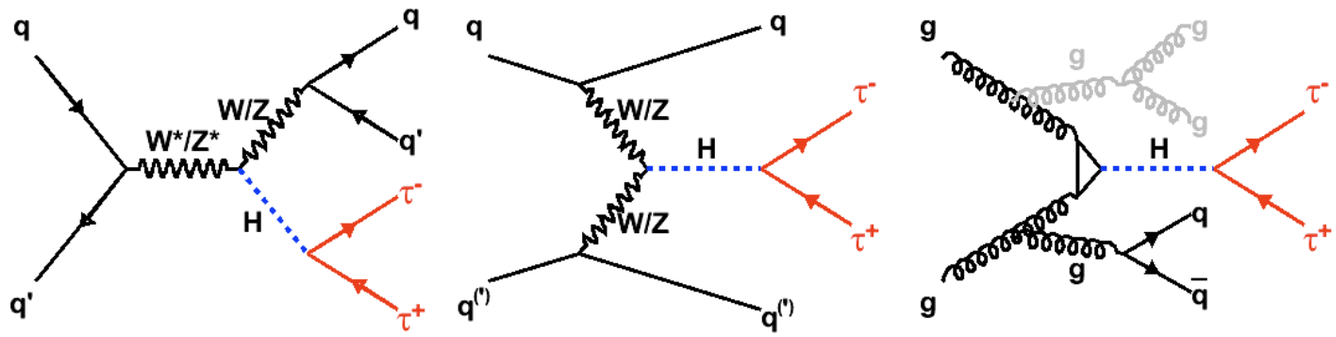


Motivation

- The channels involving tau decays of Higgs or W/Z have about half the XS *BR as the W(lν)H(bb) or Z(νν)H(bb).
- Simultaneous search for VH/Vector Boson Fusion (VBF) signals
- First Search for SM Higgs in tau final states at Tevatron
- Sensitive at low mass

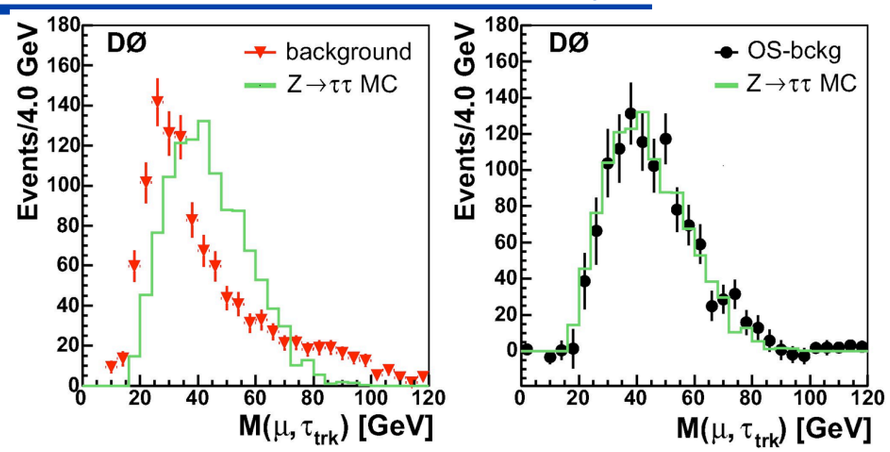




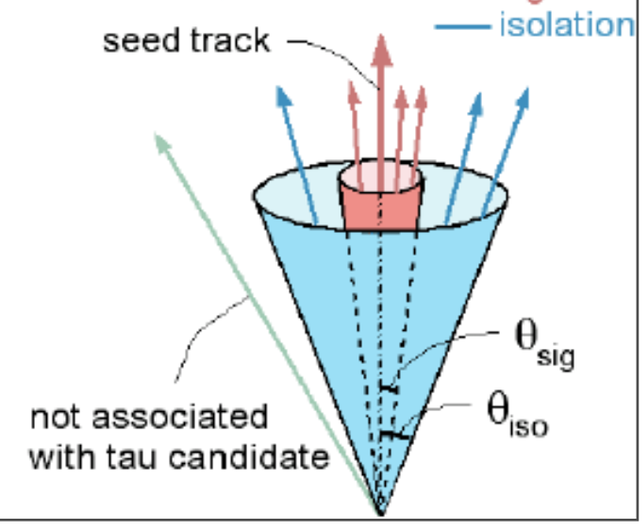


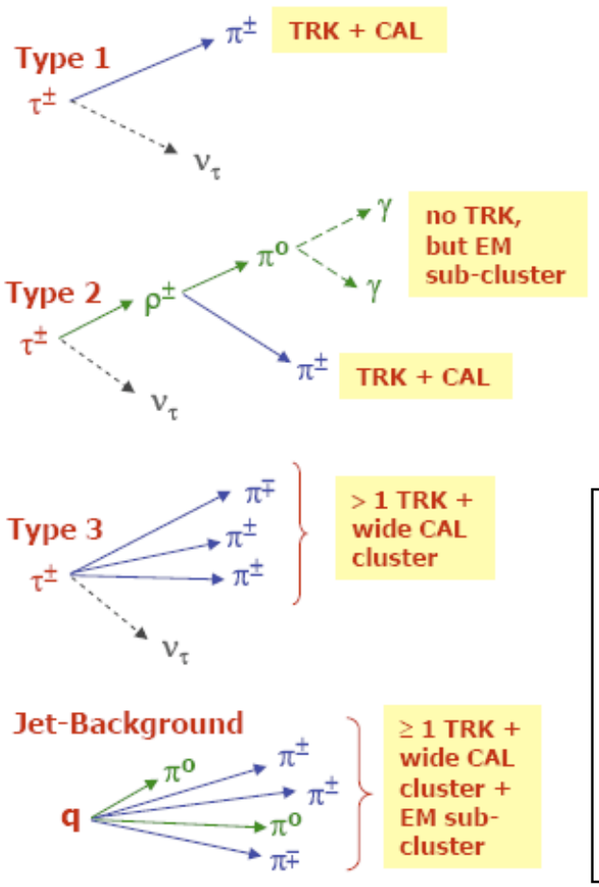
τ identification DO & CDF

- Hadronic tau decay
- Z→ττ Cross Section
- CDF measured in τe τh channel
  ε*BR = 265 ±20 (stat) ±21 (syst)
- DO τμ τh,e
  ε*BR = 237 ±15 (stat) ±18 (syst)



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, must have at least one track with pT > 6 GeV.
Tau cone defined by seed track,
half angle, θsig = 50 – 175 mrad,
depends on cluster energy.
Isolation annulus
1 or 3 tracks, charge = 1, in θsig
Reconstruct π0's.
Require M(tracks,π0's) < 1.8 GeV





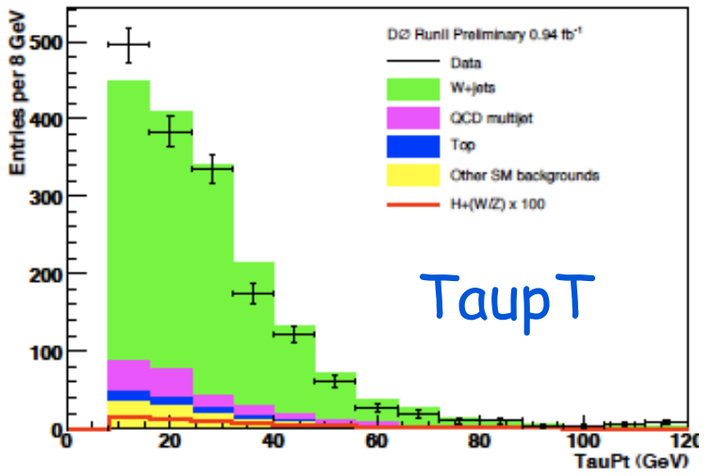
DO: Start with calorimeter cluster, simple cone algorithm, cone size R = 0.3. Isolation cone, R = 0.5, require rms < 0.25
where rms = Energy weighted width of cluster = Associate EM subclusters:
Nearest neighbour algorithm in 3rd EM layer,
EM cells in other layers
Associate up to 3 tracks with pT > 1.5 GeV to the tau

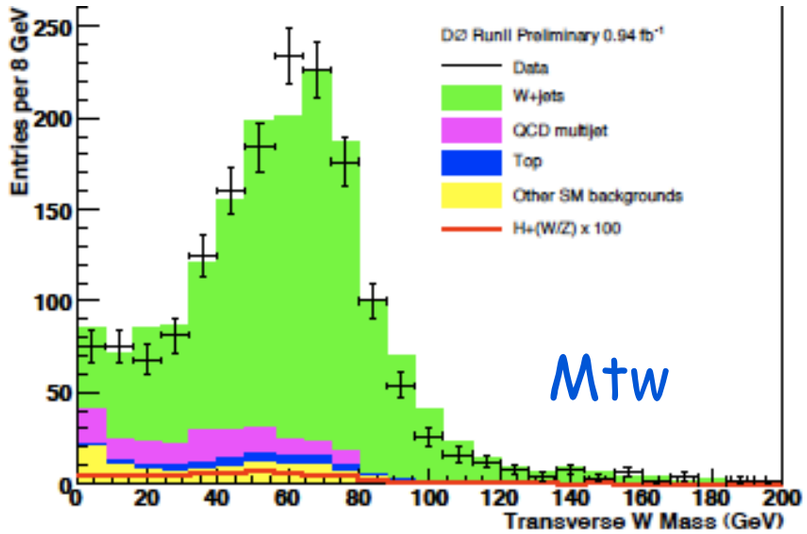
WH/ZH→τνbb @ DØ

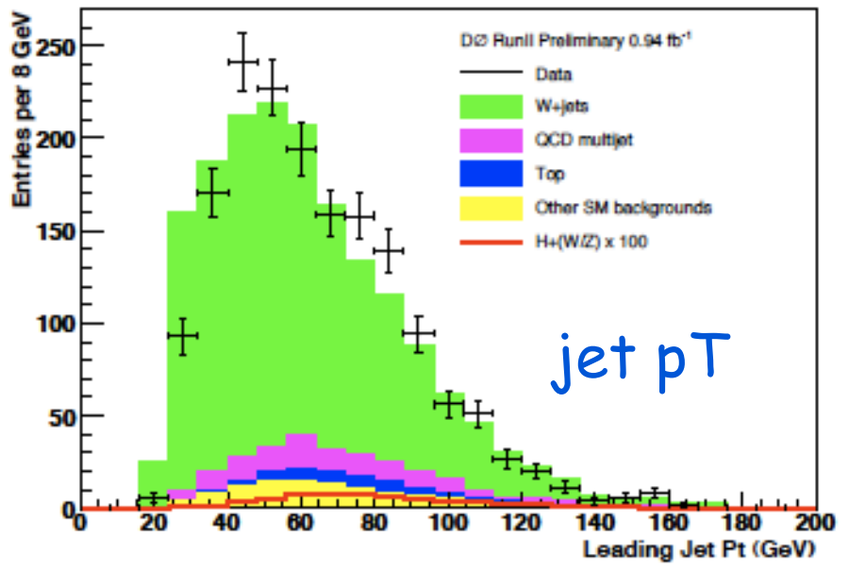
L=0.94 fb-1

- W→τν H→bb
- Z→ττ H→bb

- Common signature τνjj
- Event Selection
- High pT jet MET trigger
- At least one hadronic tau candidate pT>12 GeV
- At least two b tagged jets pT>20 GeV and |η|>2.5
- MET >40 GeV
- e, μ veto





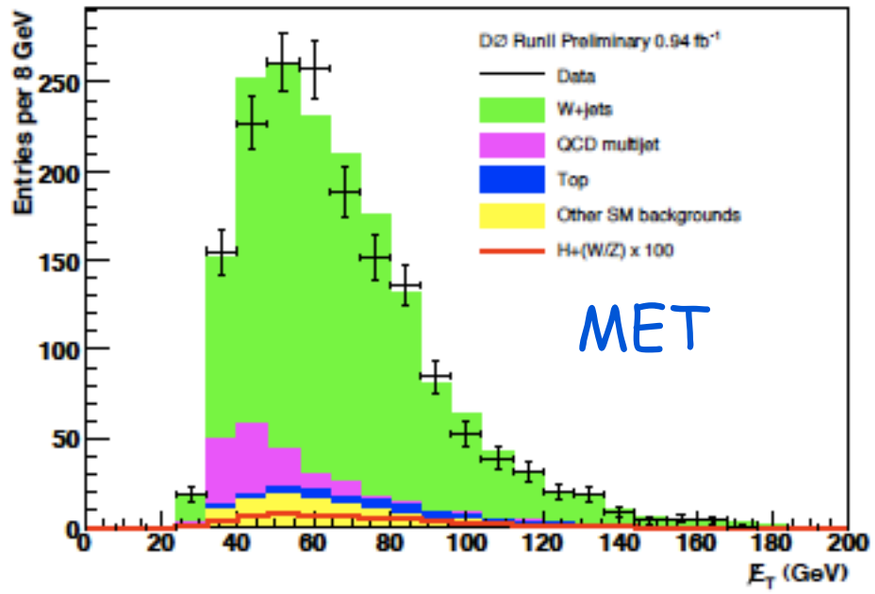


- Preselection event yield before and after B tagging for final selection

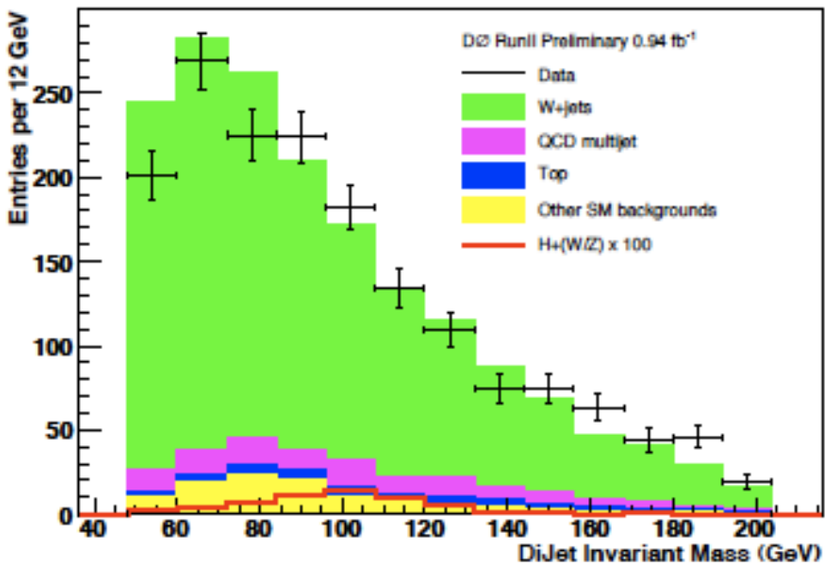
Sample	HW	HZ	W+jets	Z+jets	top	VV	multijet	Total	Observed
before	0.534	0.042	1 430	30.8	46.7	54.9	158.3	$1\,720 \pm 21$	1 666
after	0.192	0.015	11.31	0.41	9.53	0.72	1.54	23.5 ± 1.05	13

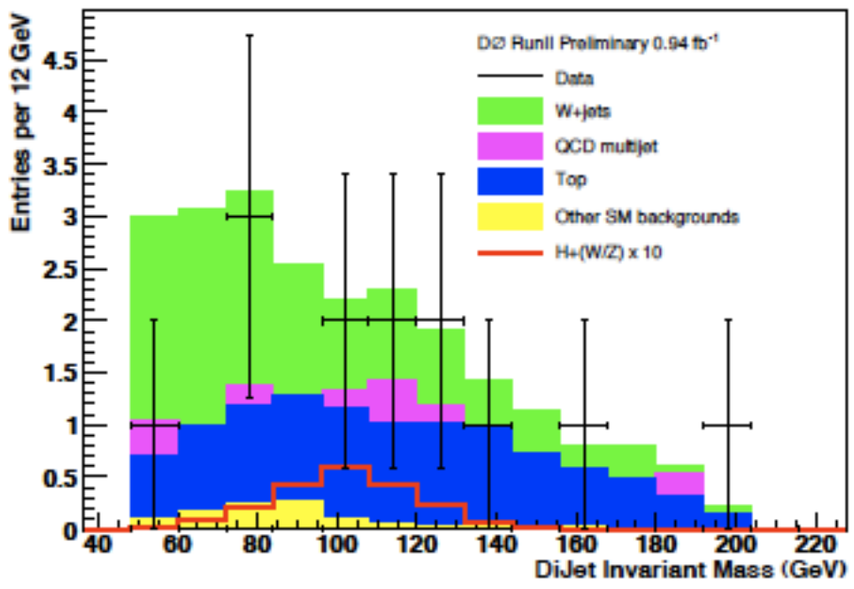
Event Selection τνbb @ DØ

Kinematic variables MET



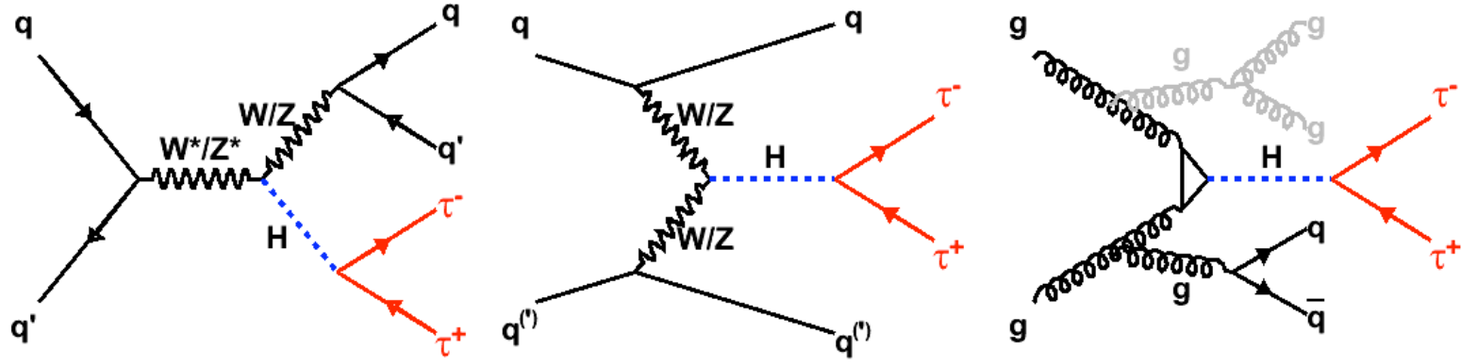
- Dijet invariant mass before and after B tagging





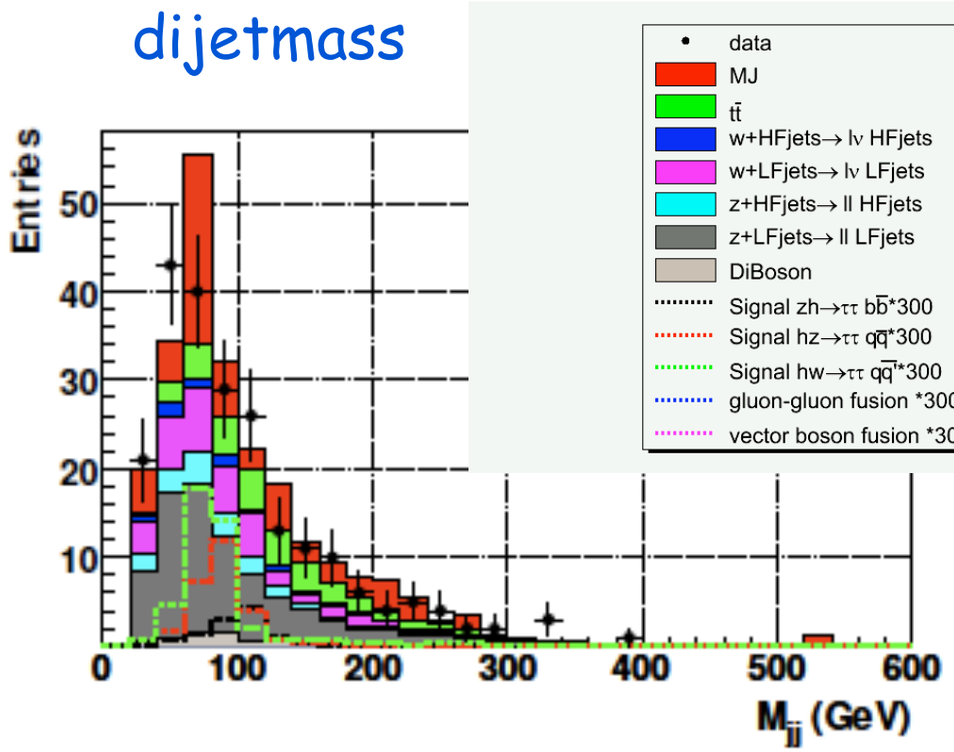
VH/VBF→ττjj@DØ L=1.02 fb-1

- 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



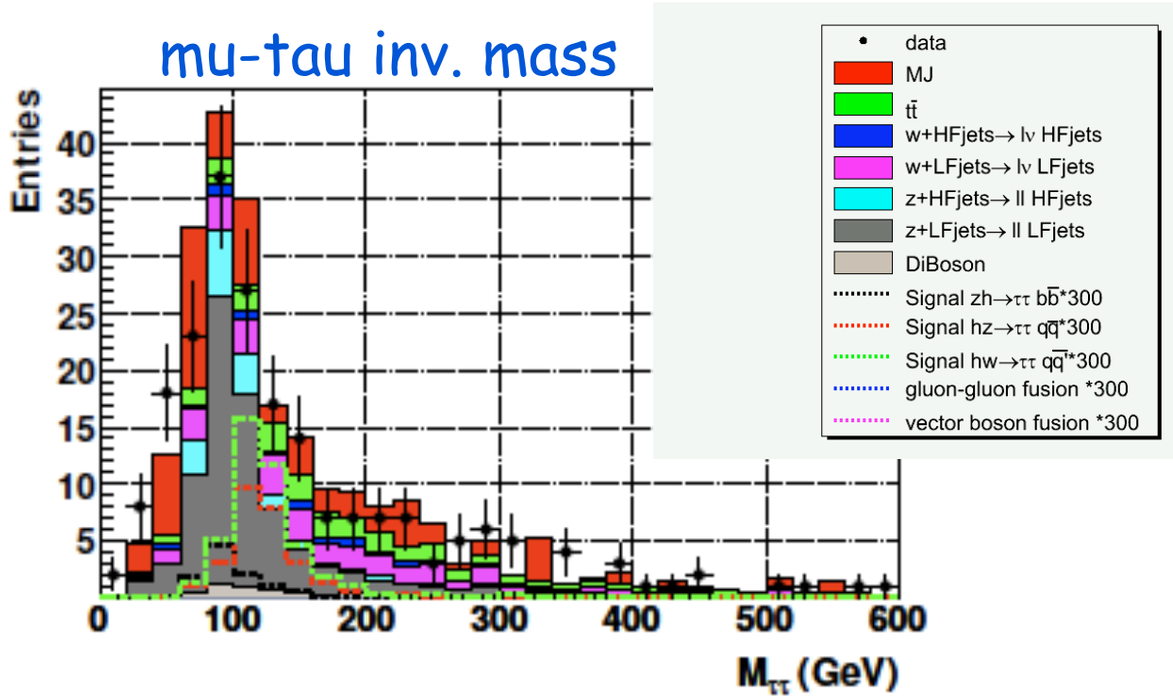
- Event Selection
  - Only one isolated muon
  - One hadronic tau candidate pT>15 GeV
  - At least two jets pT>20 GeV and |η|>2.5
  - Opposite sign mu-tau pair requirement
  - Electron veto
  - No B tagging

dijetmass

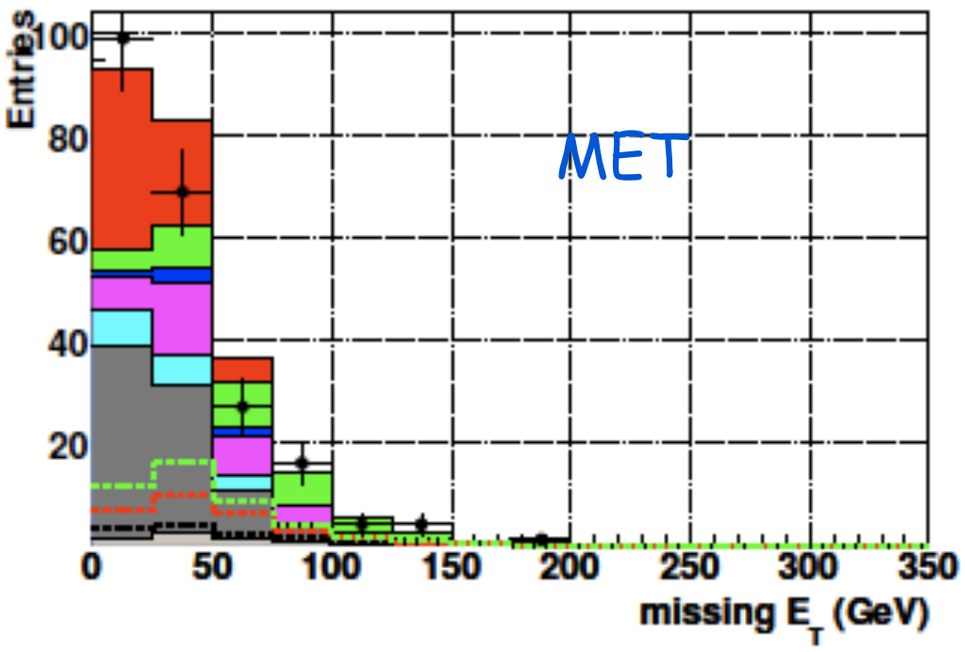


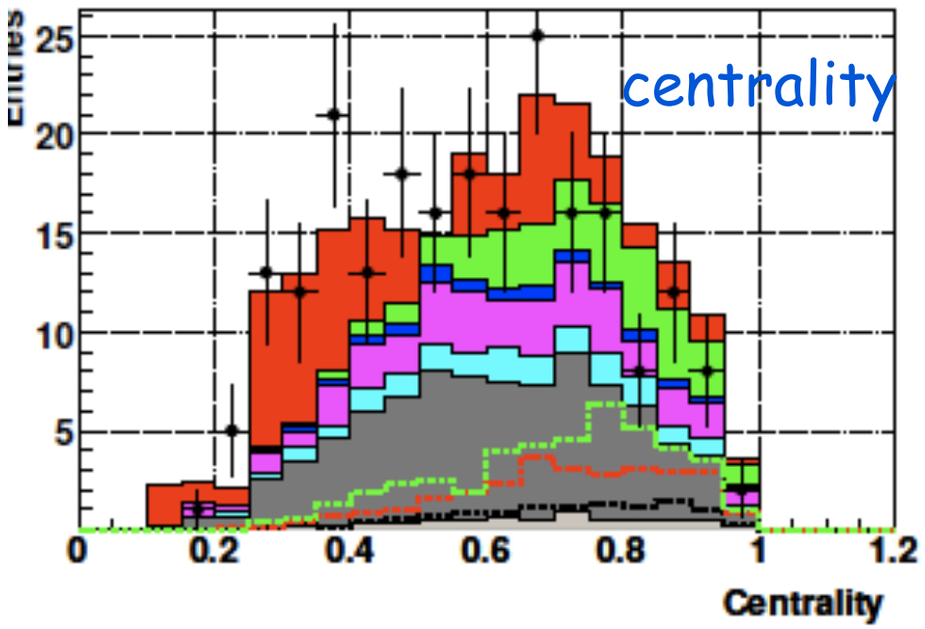
ττjj Preselection @DO

- Variables used for NN training
- Good data montecarlo agreement



(a)

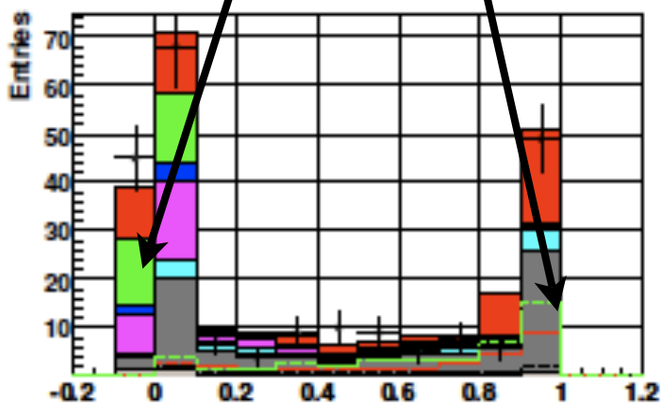




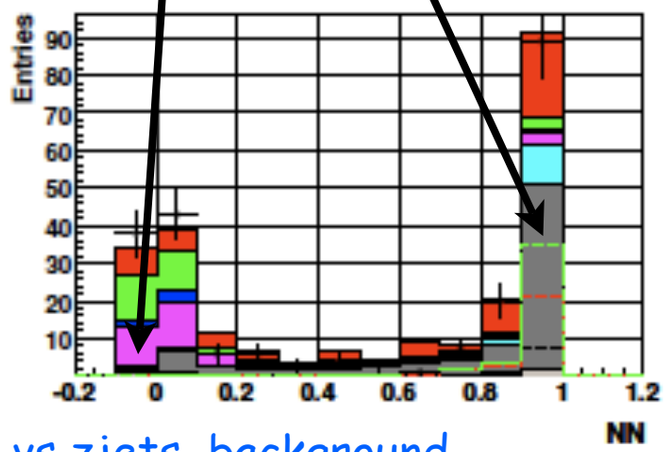
NNs for ττjj selection @D0

- 32 NNs for four signals to four bkgd NN output in two mass regions
- 5-7 variables used for each NN total 17 for all
- Final selection cut on average on maxNN of ttbar,wjets and MJ NNs
- Look at the average NN of zjets as final variable
- NN for WH signal vs tt, wjets, multijet background.

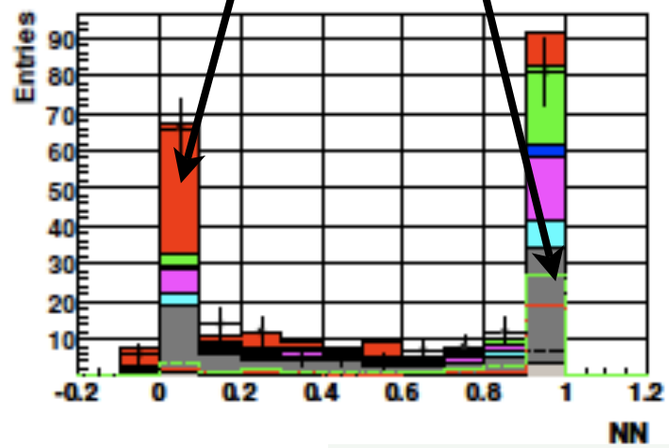
Representative plots ttbar against wh



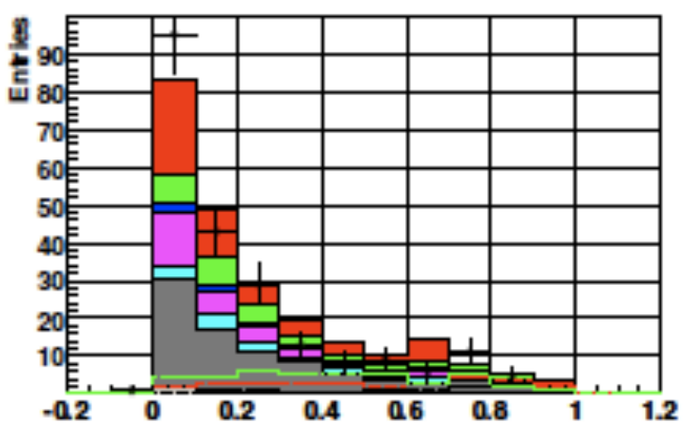
wjets against wh

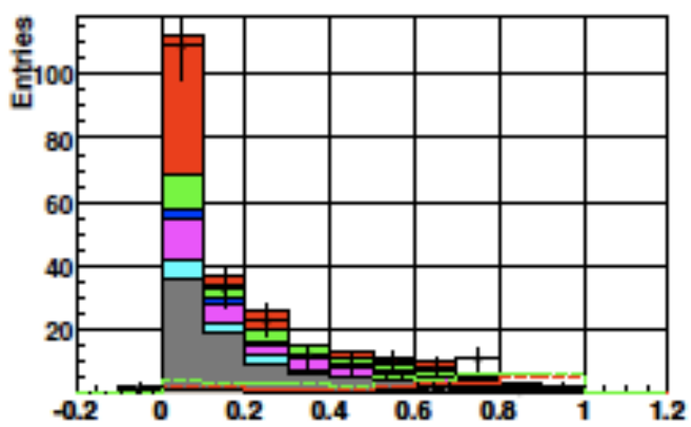


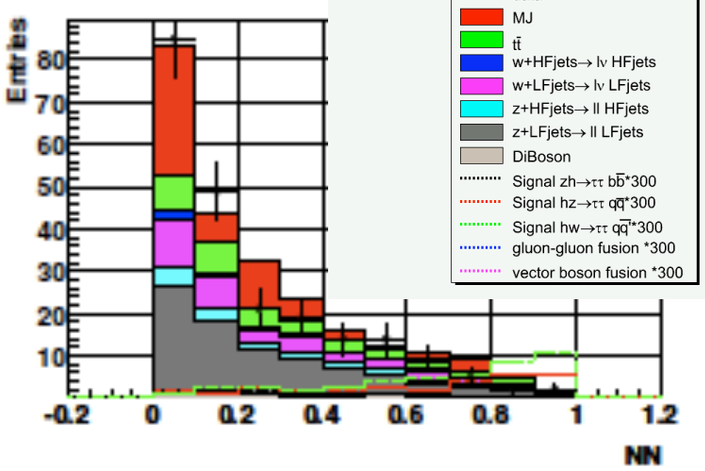
mj against wh



- NN output for ZH,HZ,WH signal vs zjets background







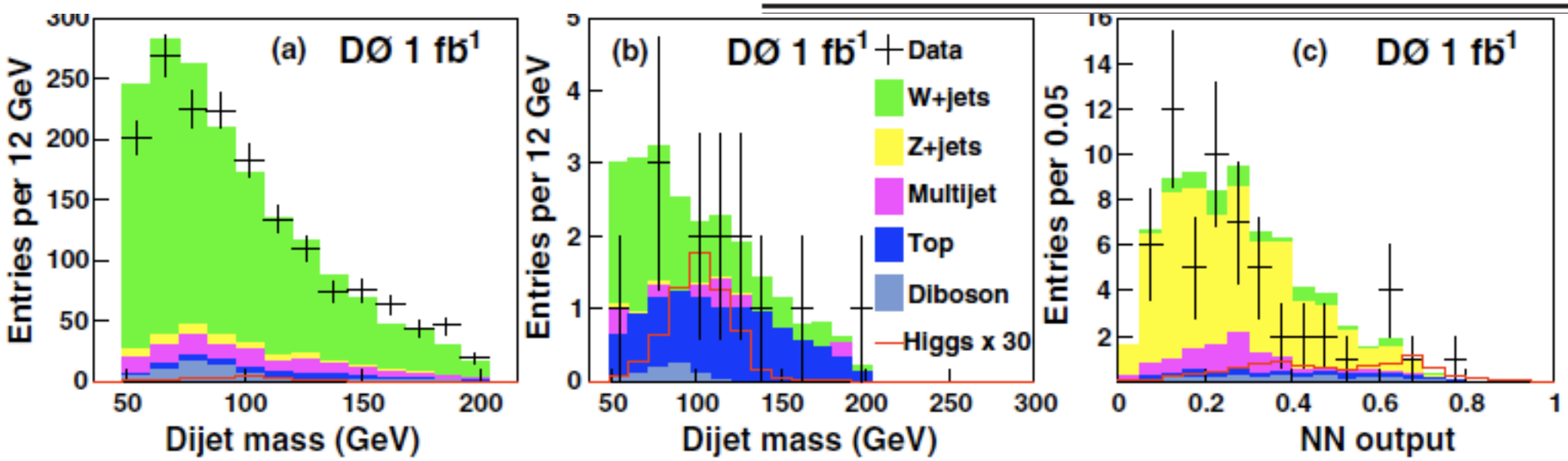
zjets not well discriminated because similar topology with signal

Event Yield τνbb/ττjj@D0

L=1 fb-1

- After preselection
- Final distribution for limit setting
- Major systematics
- Tau ES 4.5% Lumi 6.1% QCD 15%Cross sec 10% JES 7.5%

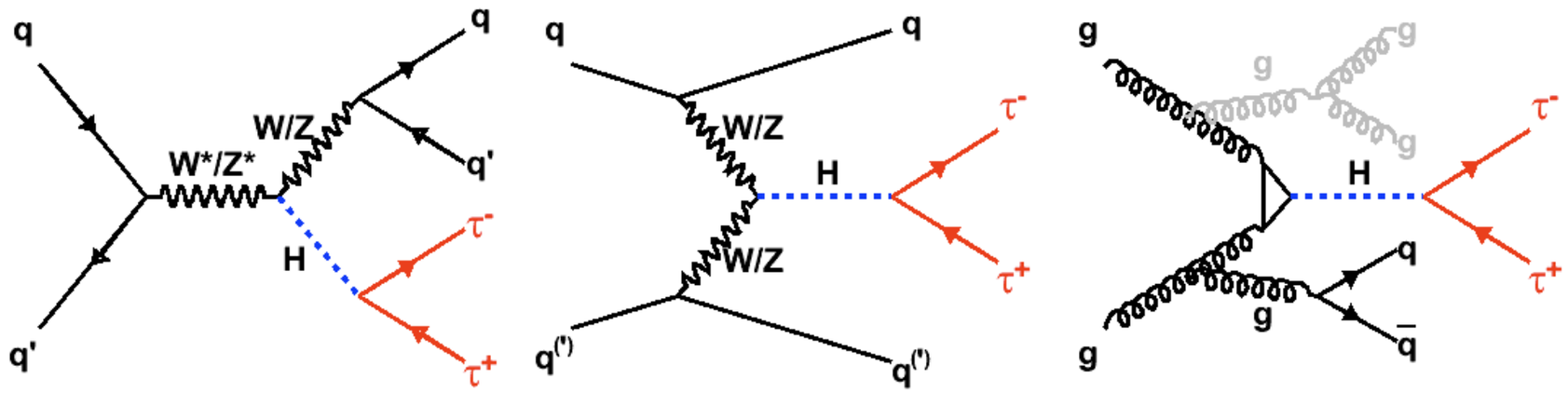
	$\tau\nu$ analysis		$\tau\tau$ analysis	
Source	Preselection	Final	Preselection	Final
W + lp	1124 ± 18	0.5 ± 0.0	37.7 ± 2.1	5.1 ± 0.3
W + hf	308.2 ± 4.8	10.9 ± 0.3	8.2 ± 0.5	0.9 ± 0.1
Z + lp	49.1 ± 1.5	<0.2	78.4 ± 0.9	43.8 ± 0.6
Z + hf	7.8 ± 0.5	0.4 ± 0.0	15.7 ± 1.0	10.1 ± 0.7
$t\bar{t}$	46.7 ± 0.4	9.5 ± 0.1	30.8 ± 0.3	2.8 ± 0.0
Diboson	54.9 ± 1.1	0.7 ± 0.0	6.1 ± 0.5	2.1 ± 0.2
Multijet	122.6 ± 11.2	1.3 ± 0.1	57.2 ± 8.1	6.5 ± 2.8
Sum	1714 ± 22	23.3 ± 0.4	234 ± 9	71.2 ± 3.0
Data	1666	13	220	58
HZ			0.038	0.029
WH	0.543	0.201	0.145	0.106
ZH	0.023	0.015	0.094	0.069
VBF			0.071	0.059
GGF			0.041	0.030
Sum	0.566	0.216	0.389	0.293



VH/VBF→ττjj @ CDF

L=2 fb-1

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



- Event Selection

- Exact 1 Lepton: Central (|η| < ~1.0) isolated electron or muon with Pt > 10 GeV
- Exact 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 2 Jets: Et > 15 GeV and |η| < 2.5
- Z boson veto (for Z→ee/μμ)

Event Yield @ CDF

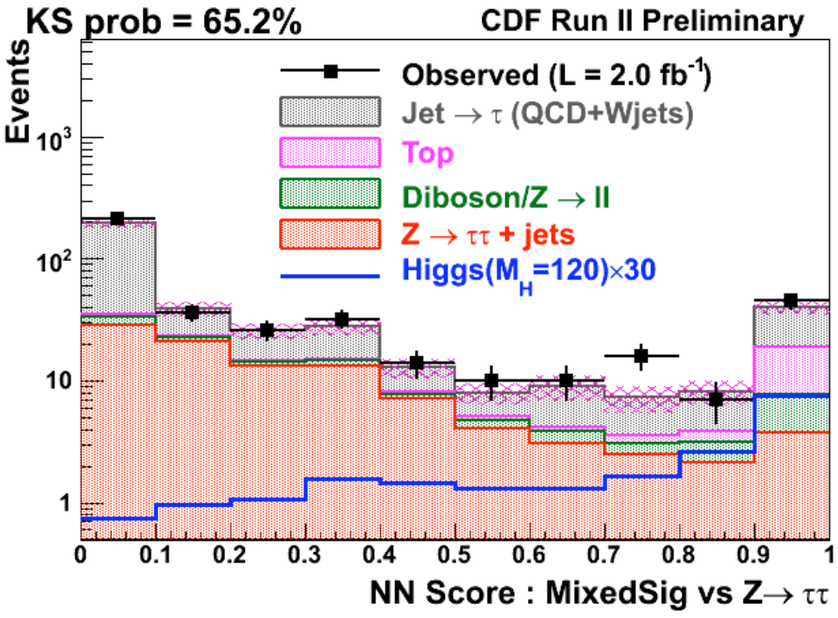
- Signal Yield

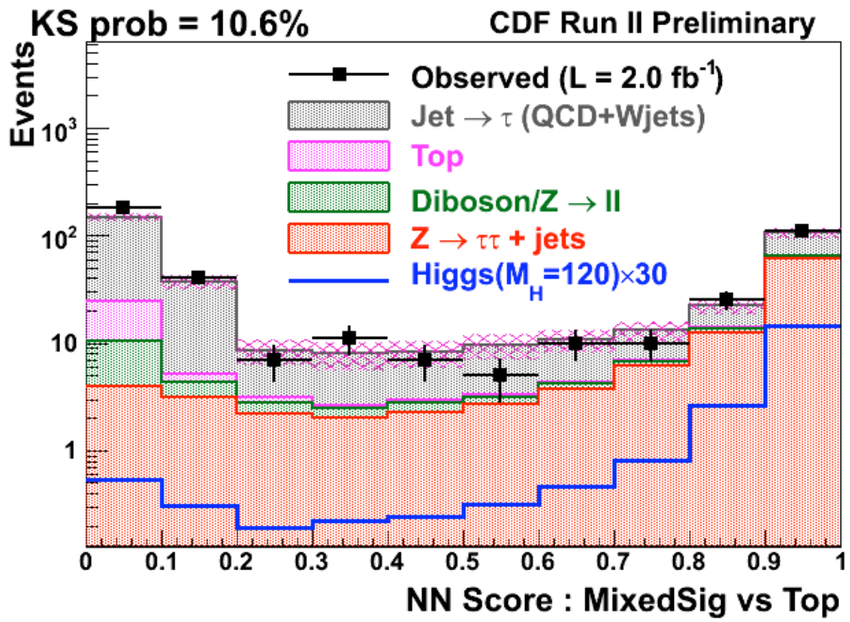
$2fb^{-1}$	M_H=110	M_H=115	M_H=120	M_H=130	M_H=140	M_H=150
WH	0.25(1.5%)	0.21(1.5%)	0.18(1.6%)	0.11(1.7%)	0.06(1.8%)	0.025(1.9%)
ZH	0.16(1.5%)	0.14(1.6%)	0.11(1.6%)	0.07(1.8%)	0.04(1.9%)	0.017(2.0%)
VBF	0.14(1.4%)	0.13(1.4%)	0.12(1.5%)	0.09(1.6%)	0.05(1.7%)	0.024(1.9%)
ggH	0.28(0.18%)	0.28(0.21%)	0.26(0.24%)	0.18(0.26%)	0.11(0.3%)	0.052(0.33%)
Total	0.83±0.01	0.76±0.01	0.67±0.01	0.45±0.004	0.26±0.002	0.12±0.001

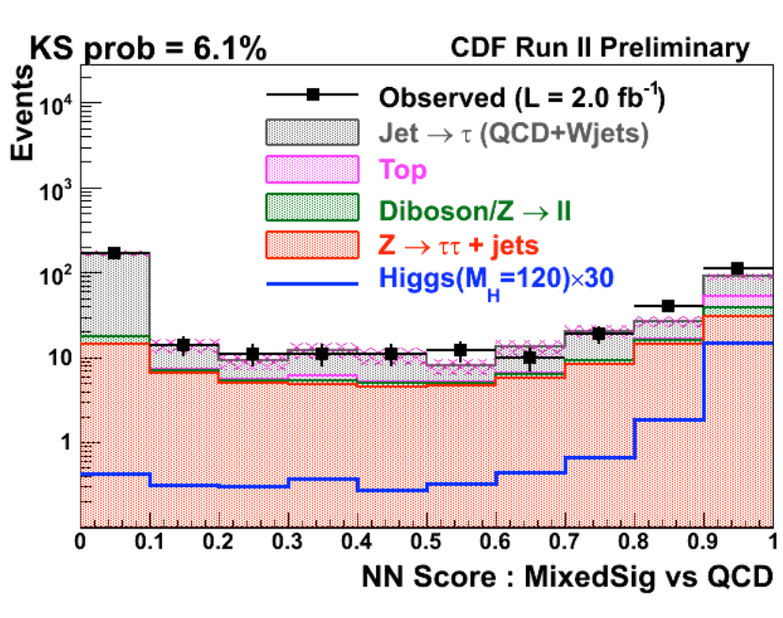
- Background Yield

Source	Model	$e/\mu+\tau_h+0jet$	$e/\mu+\tau_h+1jet$	$e/\mu+\tau_h+\geq 2jet$	Grand Total
$Z\rightarrow \tau\tau+jets$	ALPGEN	2746.8±260.7	465.1±108.3	99.1±25.9	3310.9±394.8
$Z\rightarrow ll+jets$	ALPGEN	216.9±23.0	48.3±7.8	11.7±2.2	276.8±32.2
$t\bar{t}$	PYTHIA	0.10±0.02	2.2±0.4	16.9±2.7	19.3±3.0
Diboson	PTYHIA	21.9±3.0	7.6±1.1	4.6±0.8	34.0±4.8
$jet\rightarrow\tau_{had}$	SS data	3269±57.2	876±29.6	220±14.8	4365±66.1
Add-on $W+jets$	ALPGEN	414.9±61.7	99.6±14.9	21.5±3.2	536.1±79.6
Total Background		6669.6±290.8	1498.8±116.8	373.8±32.4	8542.1±422.8
		Control Region	Control Region	Signal Region	-
Observed ($2\ fb^{-1}$)		6653	1571	410	8634

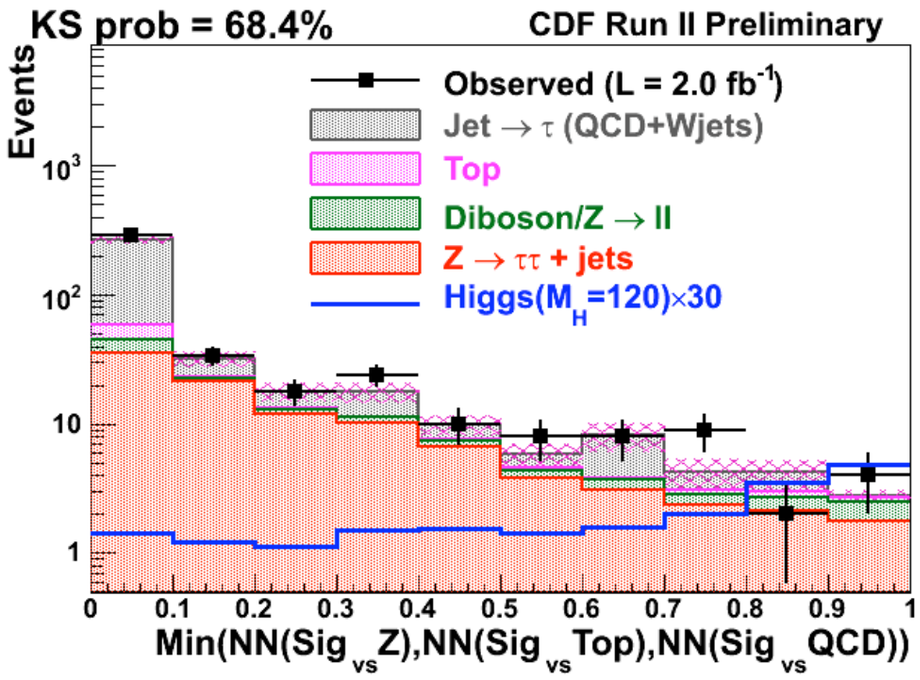
NNs selection @ CDF





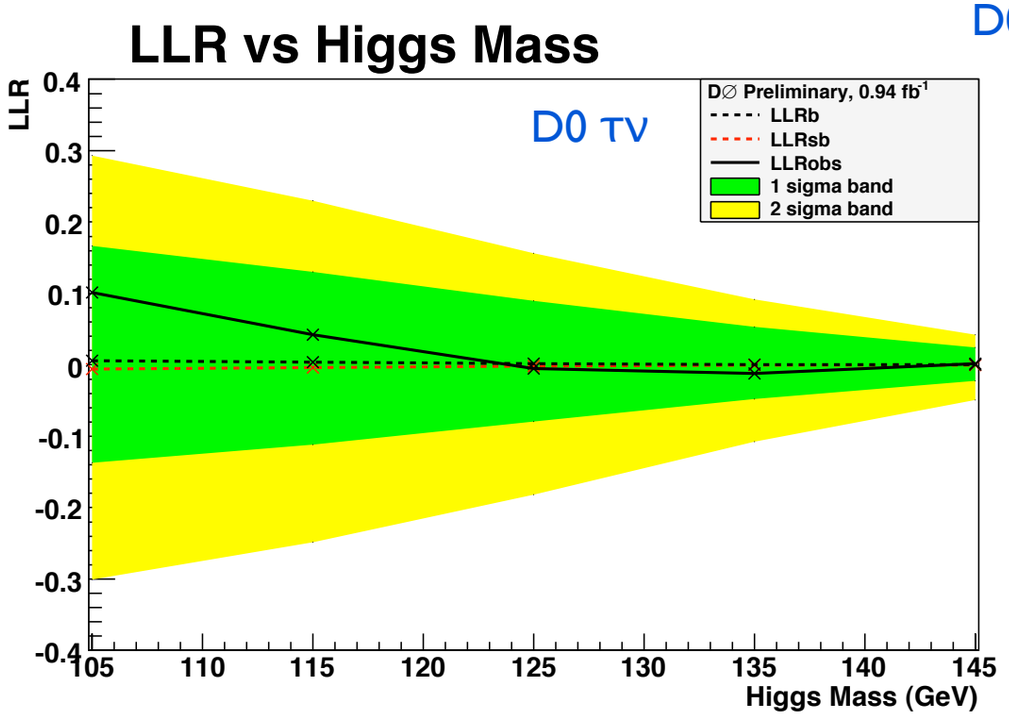


- Three NNs trained with mixed Signal vs zee,top, qcd backgrounds
- Final discriminator minimum of three NNs
- Major Systematics
- JES 15% Lumi 6.0% tau ID 3%
- Signal 10-22%

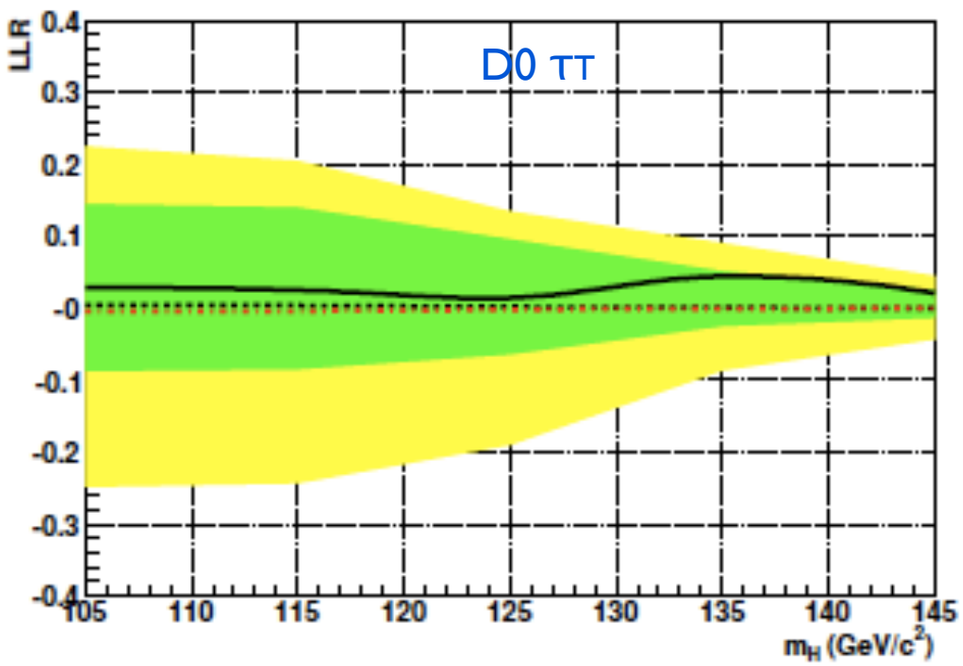


Limits

- Good agreement with background prediction. No significant excess in signal region
- D0 uses modified frequentist approach to set 95% CL LLR plots shown below
- CDF uses Bayesian method to set limits



D0 preliminary



Limits

- D0 sets limits for combined τν & ττ analysis expected limit range 24-120

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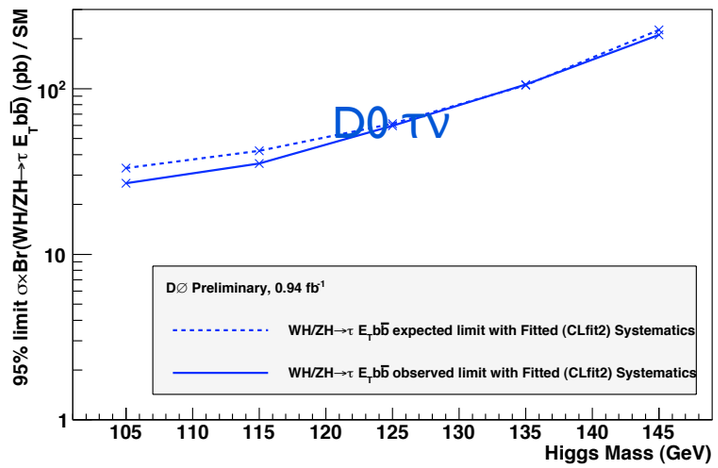
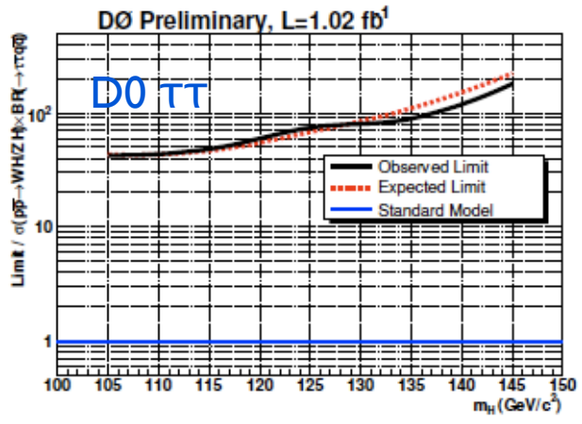
	$\tau\nu$ analysis		$\tau\tau$ analysis		Combined	
M_H (GeV)	exp.	obs.	exp.	obs.	exp.	obs
105	33	27	39	36	24	20
115	42	35	43	47	28	29
125	62	60	60	65	40	44
135	105	106	87	61	63	50
145	226	211	158	95	120	82

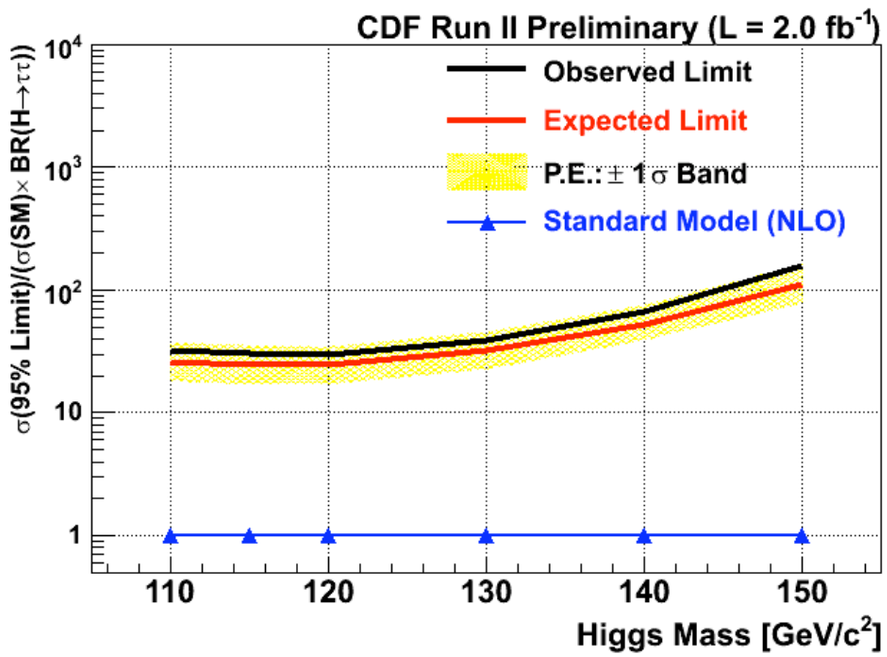




- CDF sets limits ττ analysis with 2 fb-1 data

- The expected limit ranges from 24.2 to 111.7

Mass	Expected Median	Expected Mean (RMS)	Observed
110	$25.8^{+11.5}_{-7.5}$	27.4(10.1)	32.5
115	$24.8^{+10.5}_{-7.5}$	26.1(9.4)	30.5
120	$24.2^{+10.0}_{-7.0}$	25.6(9.0)	30.0
130	$32.3^{+13.1}_{-9.5}$	34.6(13.1)	39.5
140	$52.8^{+22.5}_{-13.5}$	55.2(20.2)	67.5
150	$111.7^{+49.5}_{-33.0}$	119.0(42.3)	159.0



Summary

- Presented first results from Higgs search at Tevatron with tau final states
- The tau channels were included in the combined CDF D0 limits shown below.
- Sensitive at low mass
- With more data results will be updated. Stay tuned.