Other Searches for a High Mass Higgs Boson at the Tevatron

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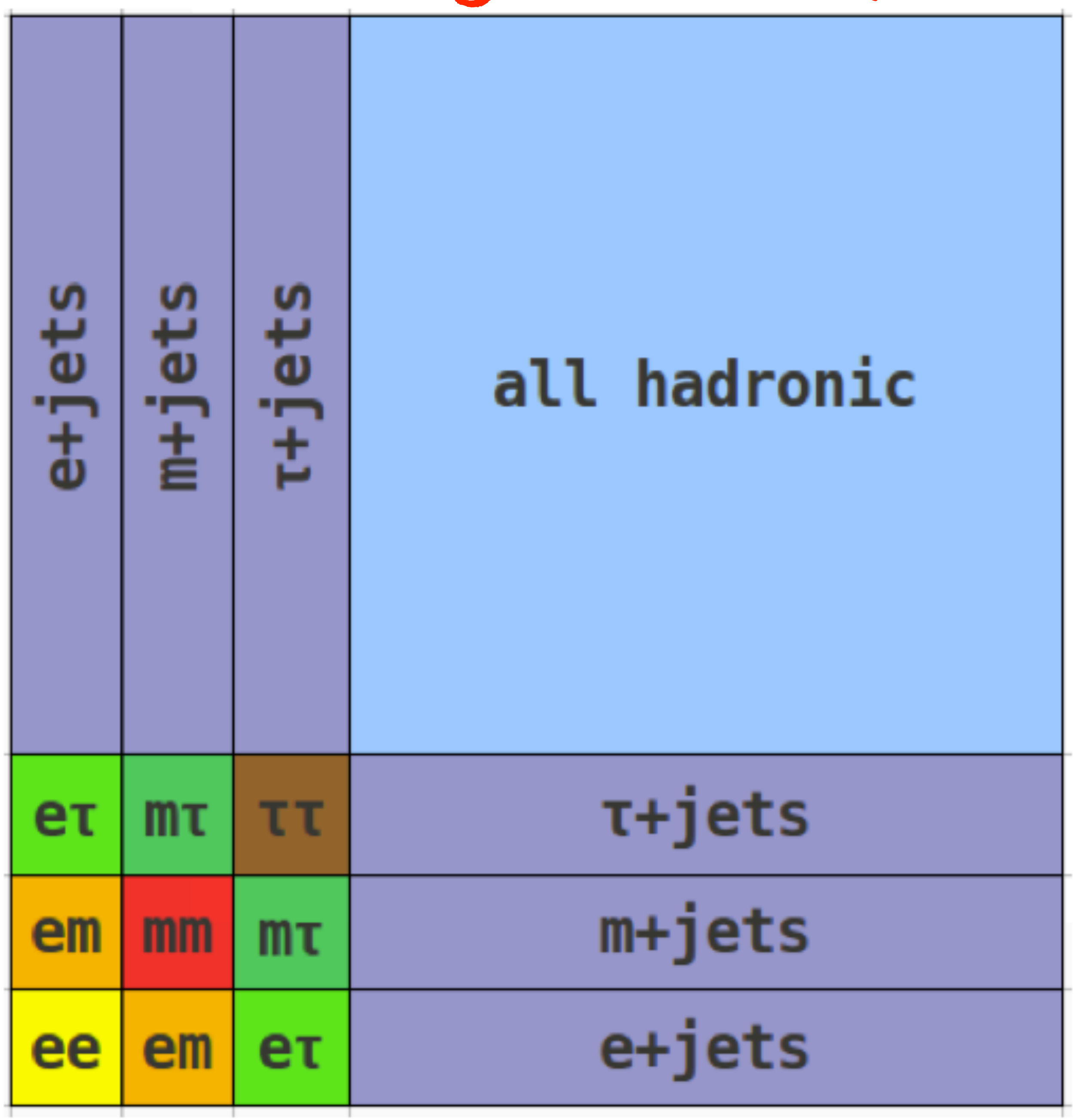
On Behalf of the CDF and DO collaborations

Other High Mass Final States

WW Decay Phase Space



Most sensitive $H \to WW \to l\nu l\nu$

All hadronic final state has too poor a signal to background ratio. Requiring a lepton, be it charged or neutral, improves the sensitivity

To increase acceptance include

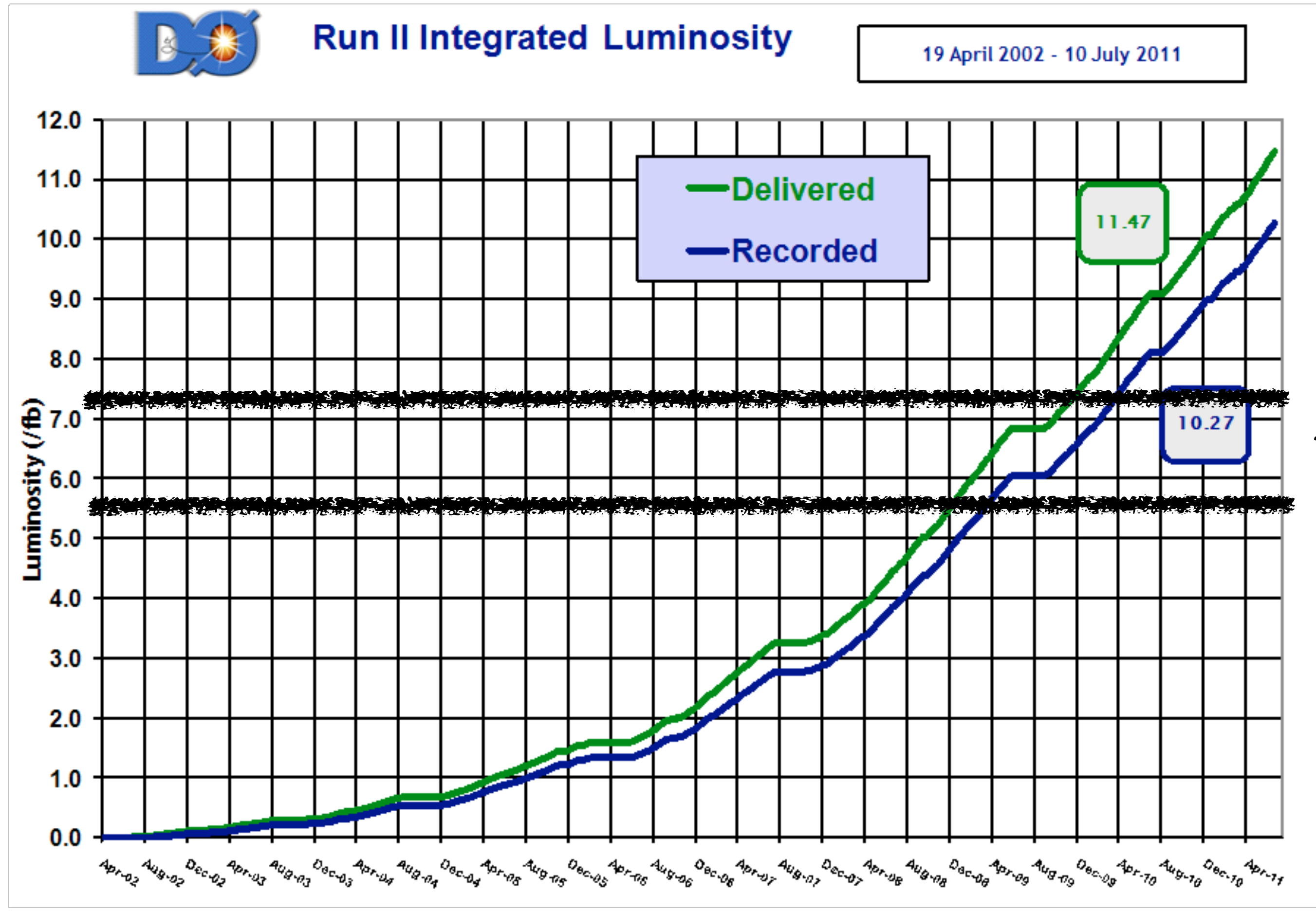
I) Semileptonic decay $l\nu qq'$

II) Hadronic τ decay channels $l\nu\tau_h\nu$ (+additional jets)

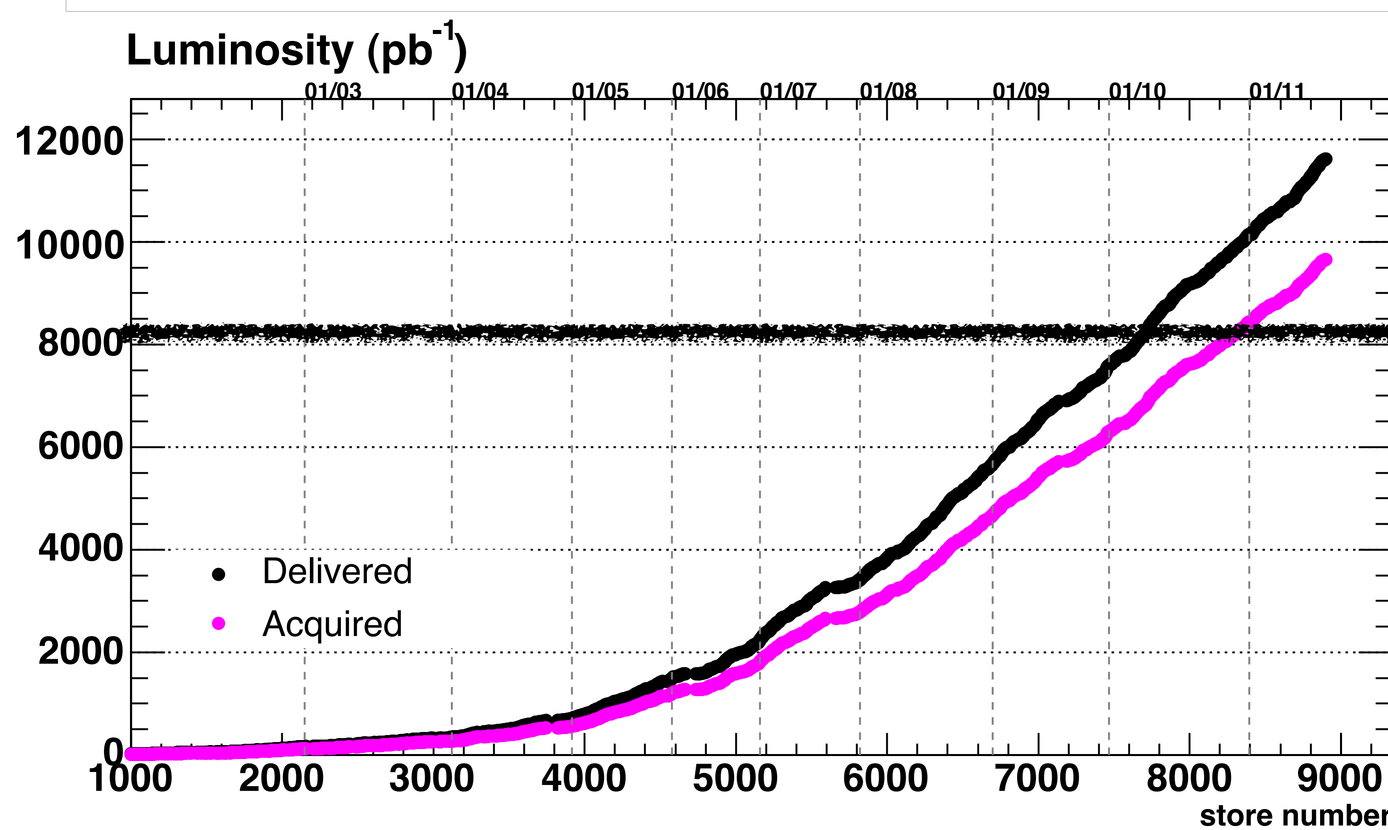
III) Trilepton final states
($WH \to WWW \to l\nu l\nu l\nu$)
($ZH \to ZWW \to lll\nu qq$)

IV) Four-lepton final states
($ZH \to ZWW \to lll\nu l\nu$)
($H \to ZZ \to llll$)

Data for Analyses Presented Here



Up to $7.3\ fb^{-1}$

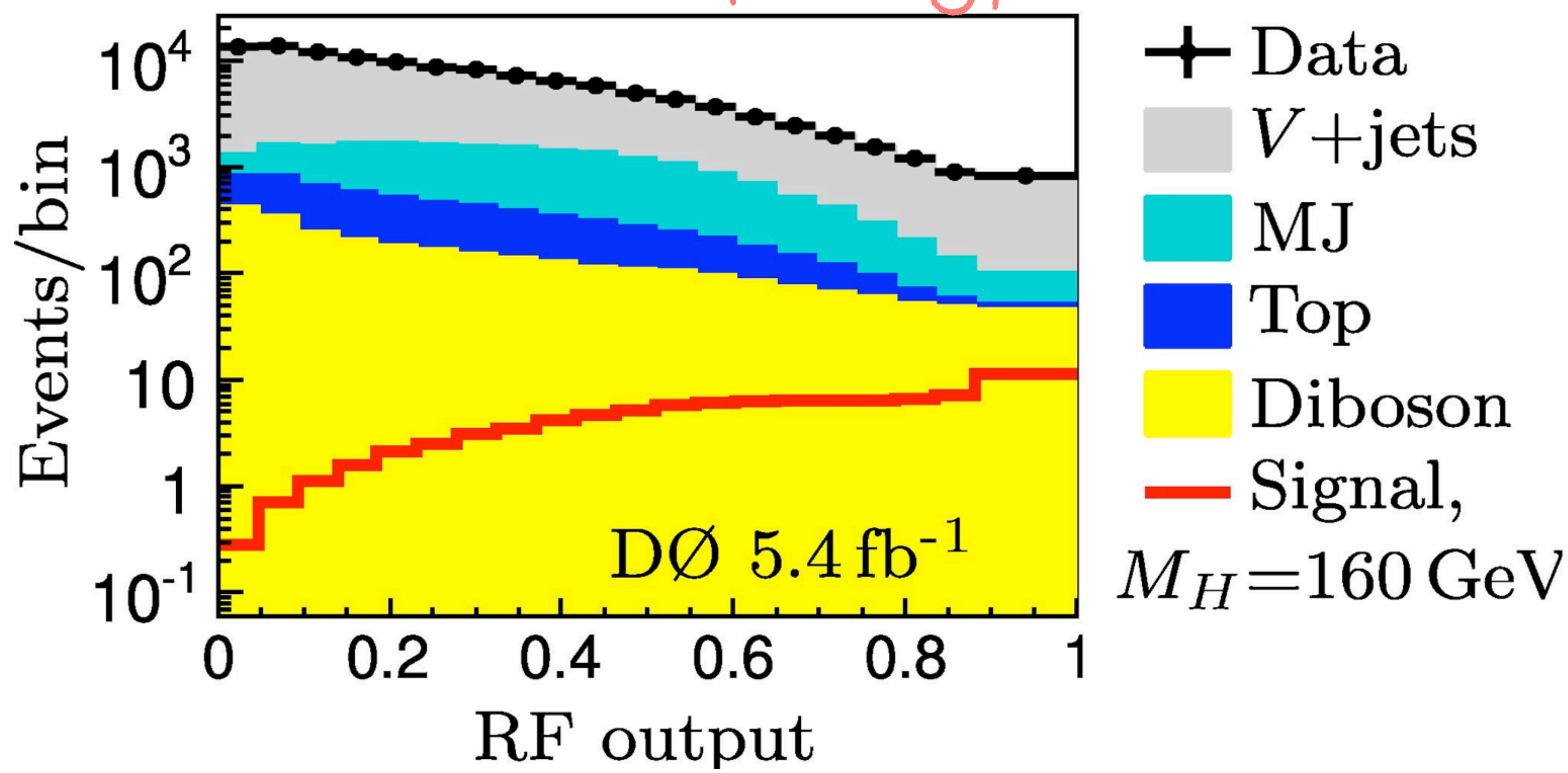


All $8.2\ fb^{-1}$

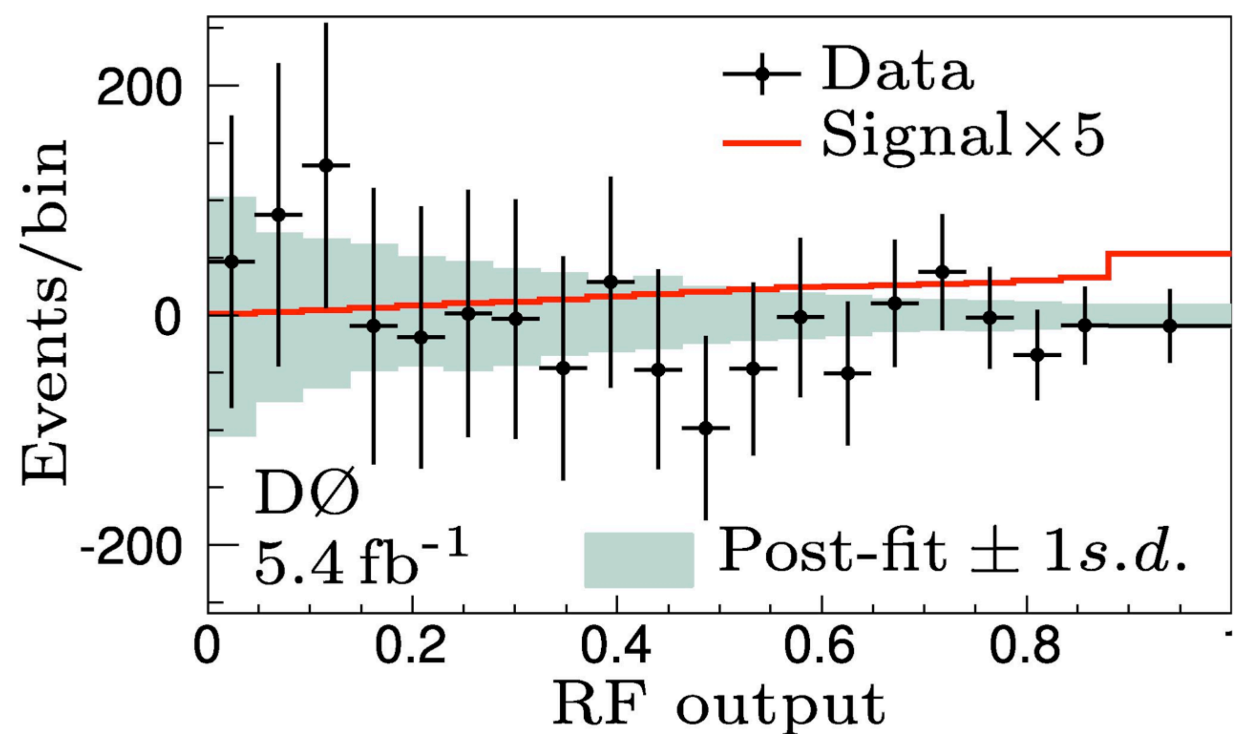
Semileptonic ($l\nu$) (qq') @ 5.4 fb^{-1}

First search of its type!

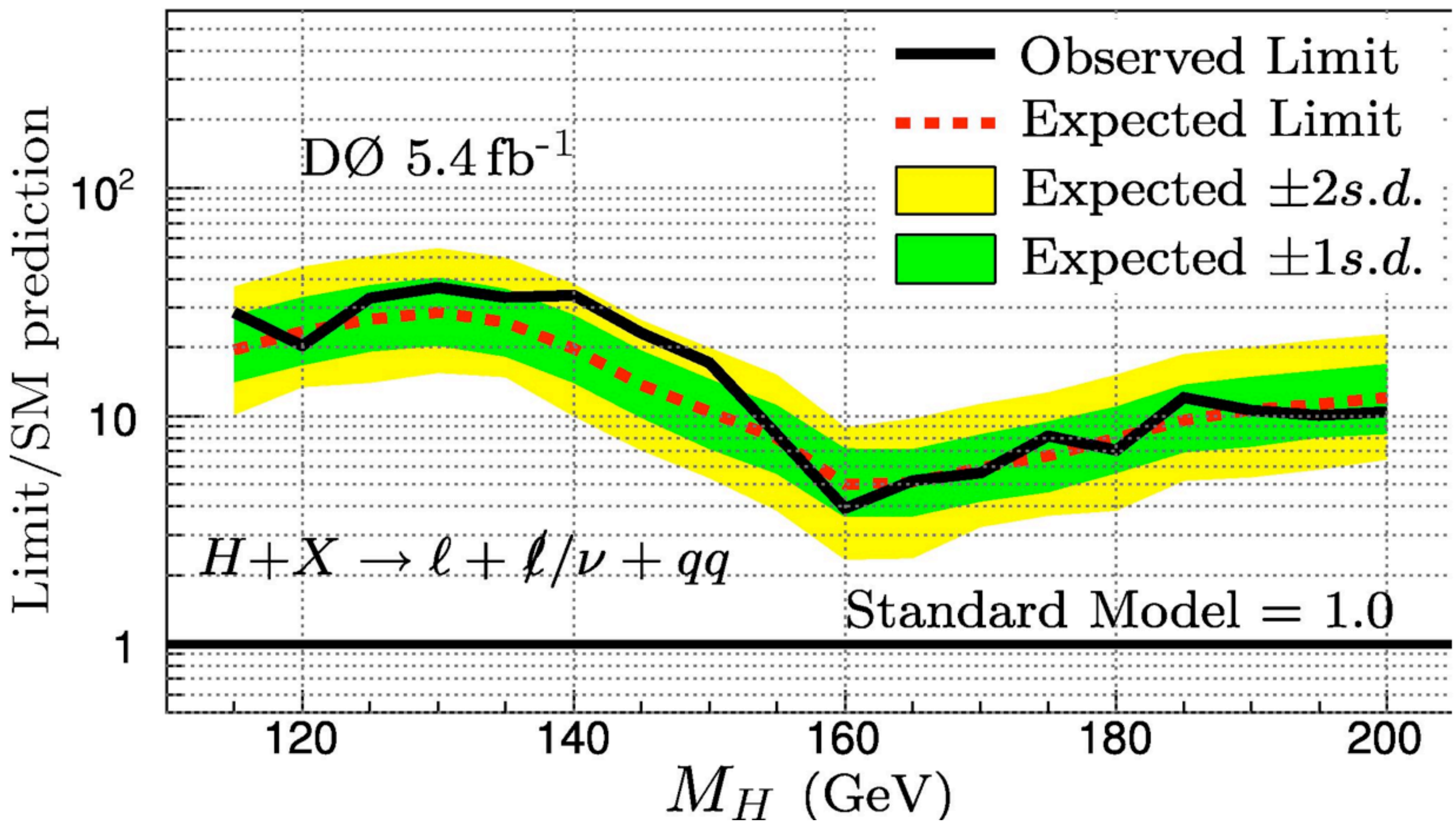
- Signal from $H \to WW \to l\nu qq$: BF~30%.
- High P_T lepton, missing E_T, at least 2 jets
- On average S/B ~ 1/1000
- RF - Random Forest of Decision Trees



Process	e channel	μ channel
$gg \to H$	46.3	34.7
$qq \to qqH$	6.4	4.4
V+jets	52158	47970
Multijet	11453	2720
top	2433	1598
Dibosons	1584	1273
Data	67627	52433



(lν) (qq) @ 5.4 fb^{-1} Limits

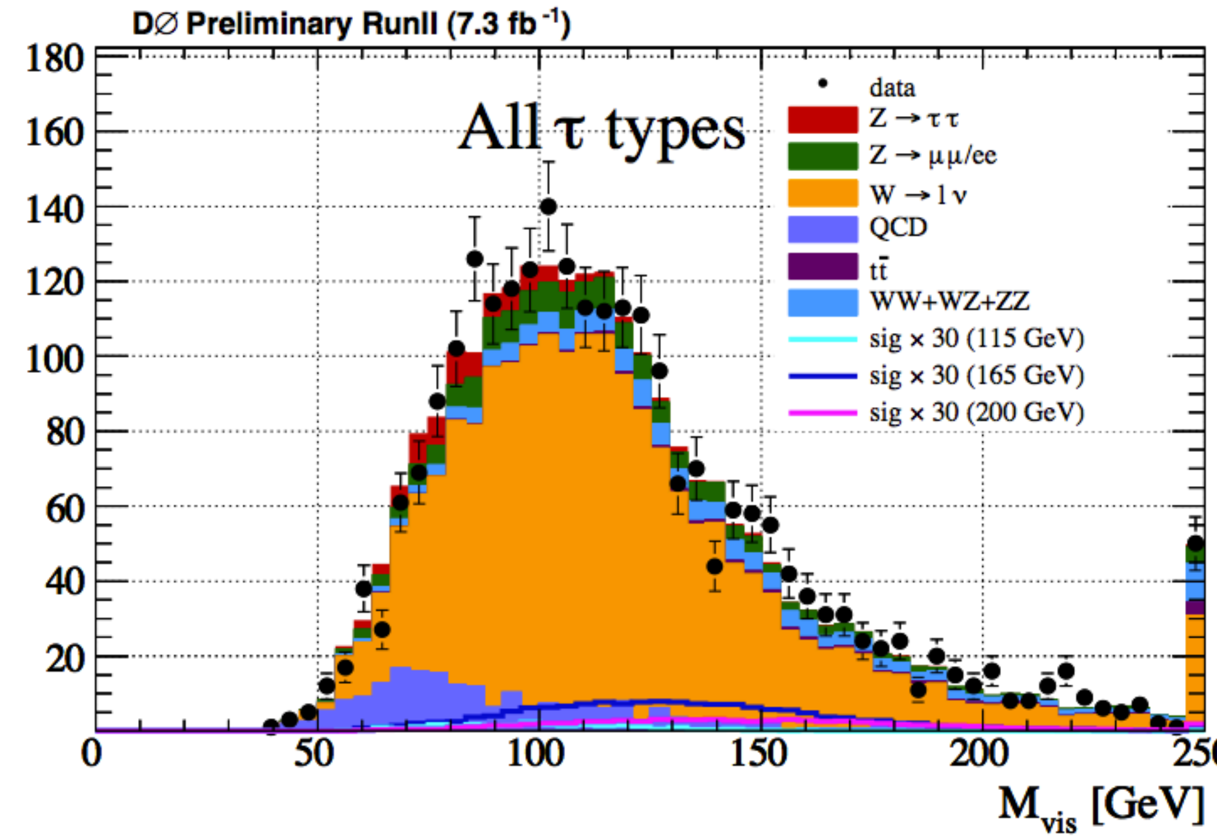


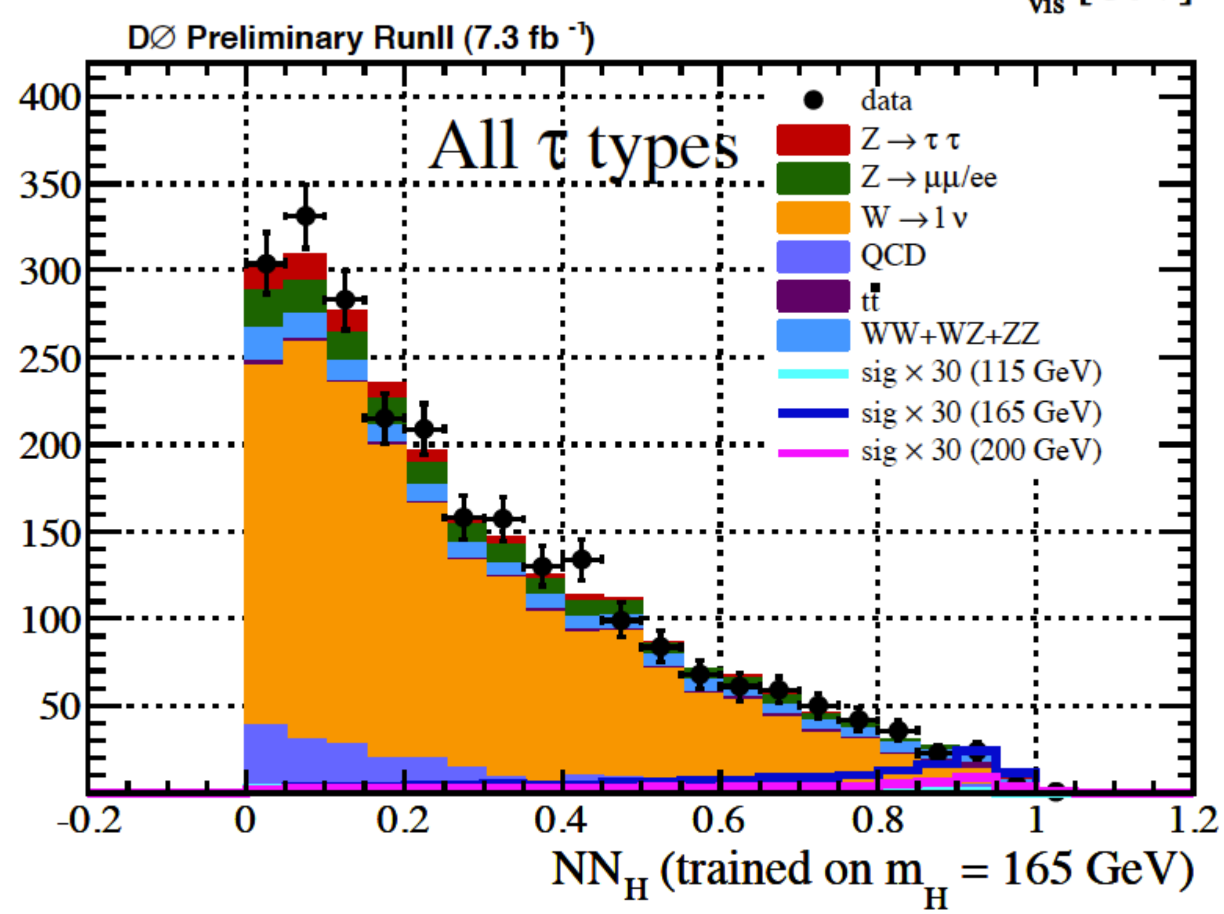
- hep-ex arXiv:1101.6079 : Submitted to Physical Review Letters
- Best Observed (Expected) at m_H=160 GeV/c^2 of 3.9 (5.0) x σ_{SM}

(lν) (τ$_{had}$ν) + 0, 1 jets@7.3 fb^{-1}

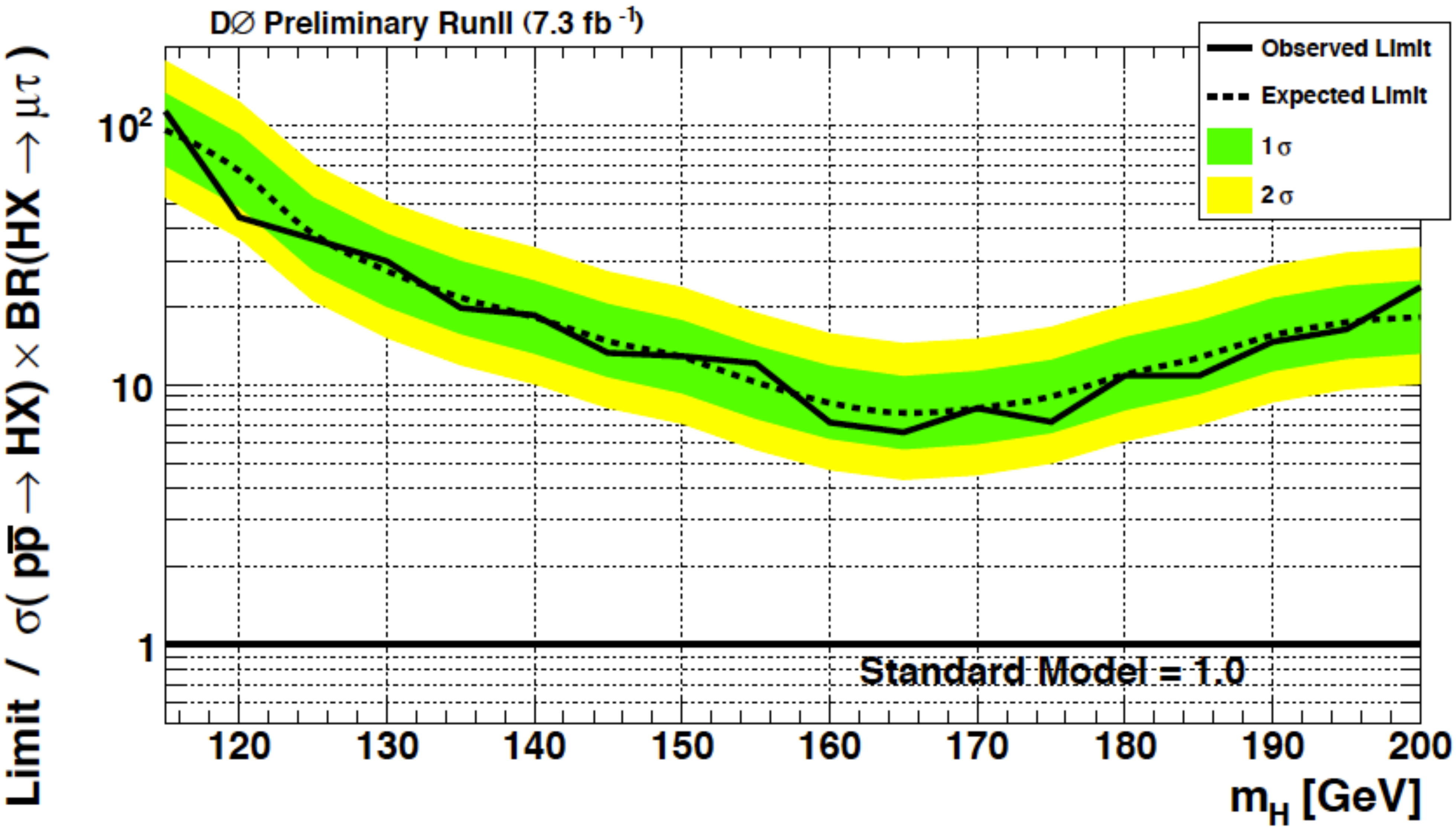
- Signal from H→WW →lντ$_{had}$ν : BF~5%
- Tau NN based ID: Separate 1-prong with/out π^0 and 3-prong (3 Tau types)
  - 55% sig. eff. with ~2% fake rate
- Use Neural Network output to extract a signal

$Z(\rightarrow \tau\tau)$	83.7 ± 3.4
$Z(\rightarrow \mu\mu/ee)$	168 ± 3.6
$W(\rightarrow \mu\nu)$	1773 ± 21.3
$t\bar{t}$	28.9 ± 0.4
diboson	160 ± 1.9
MJ	212 ± 10.5
Exp. background	2428 ± 24.3
Data	2473
Higgs 165 GeV	5.3 ± 0.1





$(l\nu)(\tau_{had}\nu)$ + 0, 1 jets@7.3 fb^{-1} Limits

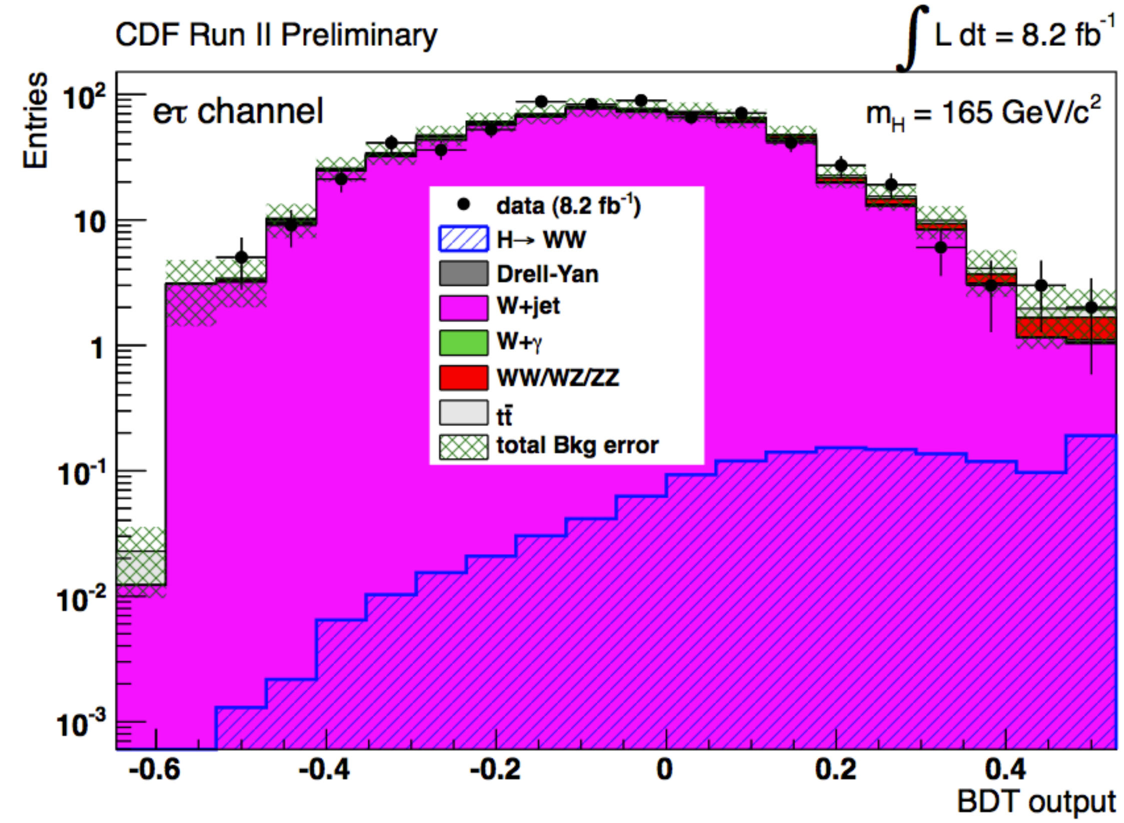


- Best Observed (Expected) at m_H=165 GeV/c^2 of 6.6 (7.8) x σ_{SM}

Conference Note D0 Note 6179-CONF

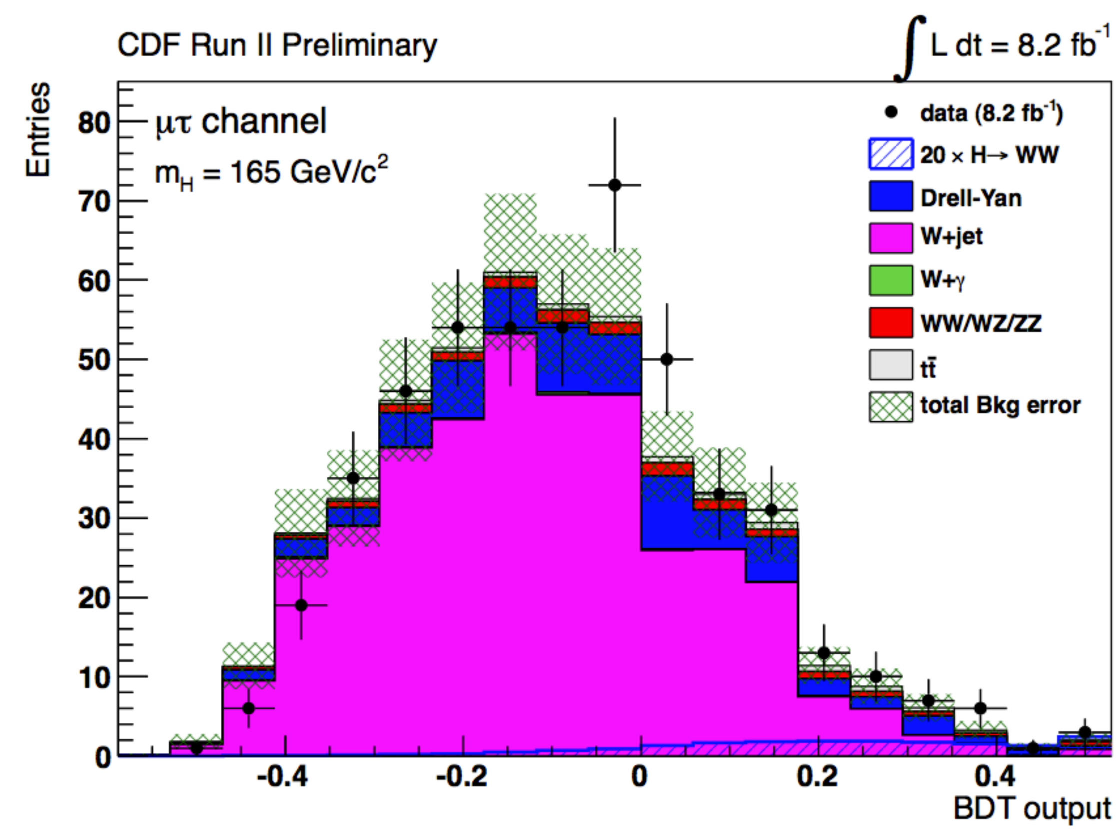
$(l\nu)(\tau_{had}\nu)$ @ 8.2 fb^{-1} updated!

- Signal from $H \to WW \to l\nu\tau\nu$: BR ~5%
  ggH, VH, VBF
- Improved Tau and Muon Acceptance (+30%)
- BDTs for signal extraction: Use τ ID and event kinematic variables
- S/B~1/500

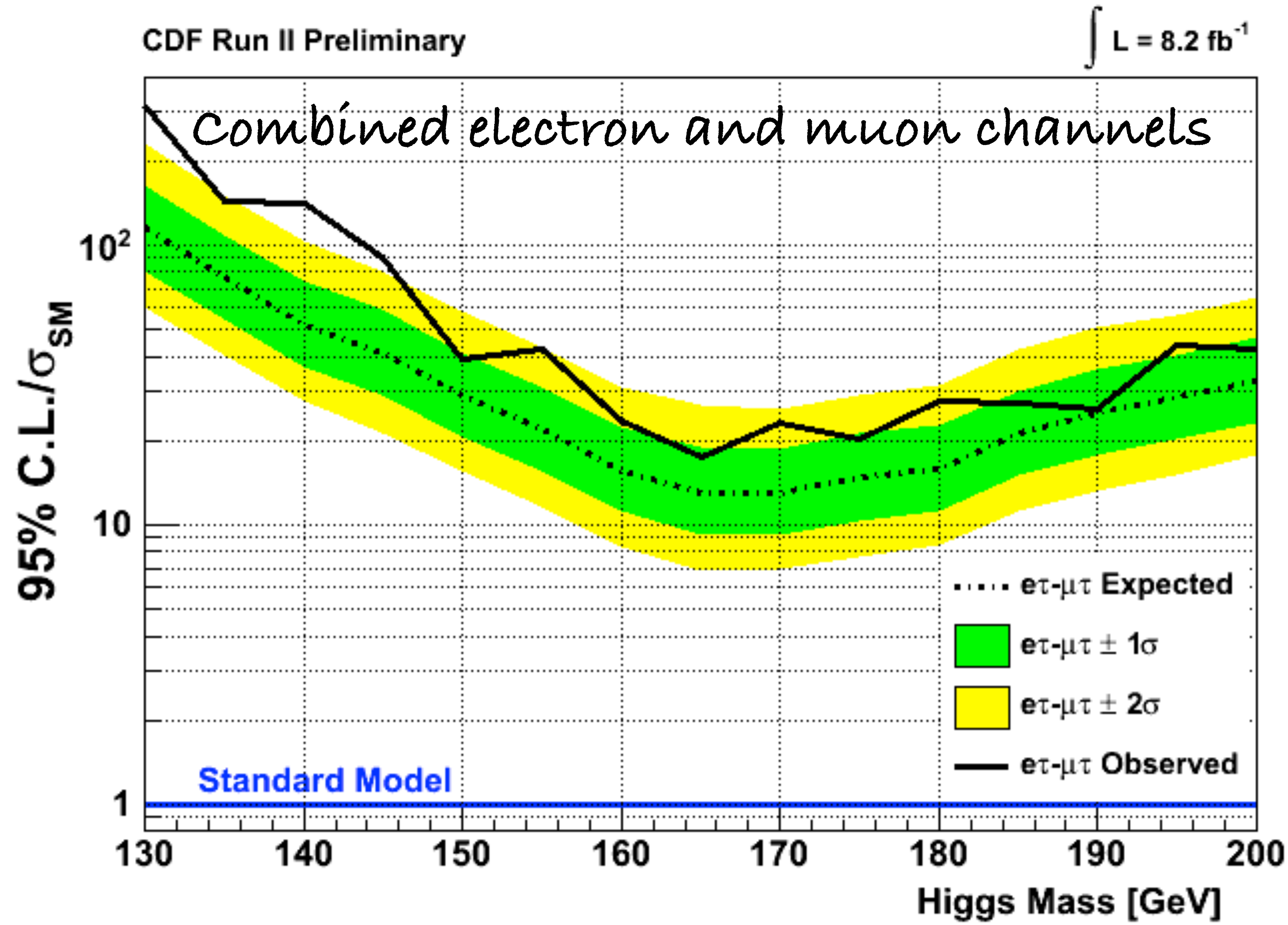


CDF Run II Preliminary $\int \mathcal{L} = 8.2$ fb^{-1}

$m_H = 160$ GeV$/c^2$	Electron	Muon
dijet, γ+ jet	0 ± 35	0 ± 28
$Z \to \tau\tau$	0.4 ± 0.2	1.2 ± 0.7
$Z \to \ell\ell$	12.0 ± 2.8	67 ± 10
W+jets	601 ± 100	383 ± 64
$W\gamma$	2.2 ± 0.3	1.8 ± 0.3
Diboson (WW, WZ, ZZ)	21.4 ± 3.2	15.7 ± 2.3
$t\bar{t}$	13.5 ± 2.2	9.0 ± 1.5
Total Background	651 ± 106	478 ± 71
$gg \to H$	0.85 ± 0.14	0.589 ± 0.096
WH	0.207 ± 0.028	0.142 ± 0.020
ZH	0.131 ± 0.018	0.091 ± 0.013
VBF	0.078 ± 0.012	0.053 ± 0.009
Total Signal	1.27 ± 0.14	0.875 ± 0.099
Data	658	494
	$e\tau$ channel	$\mu\tau$ channel



$(l\nu)(\tau_{had}\nu)$ Limits



- Best Observed (Expected) at m_H = 165 GeV/c² of 17 (13) x σ_{SM}

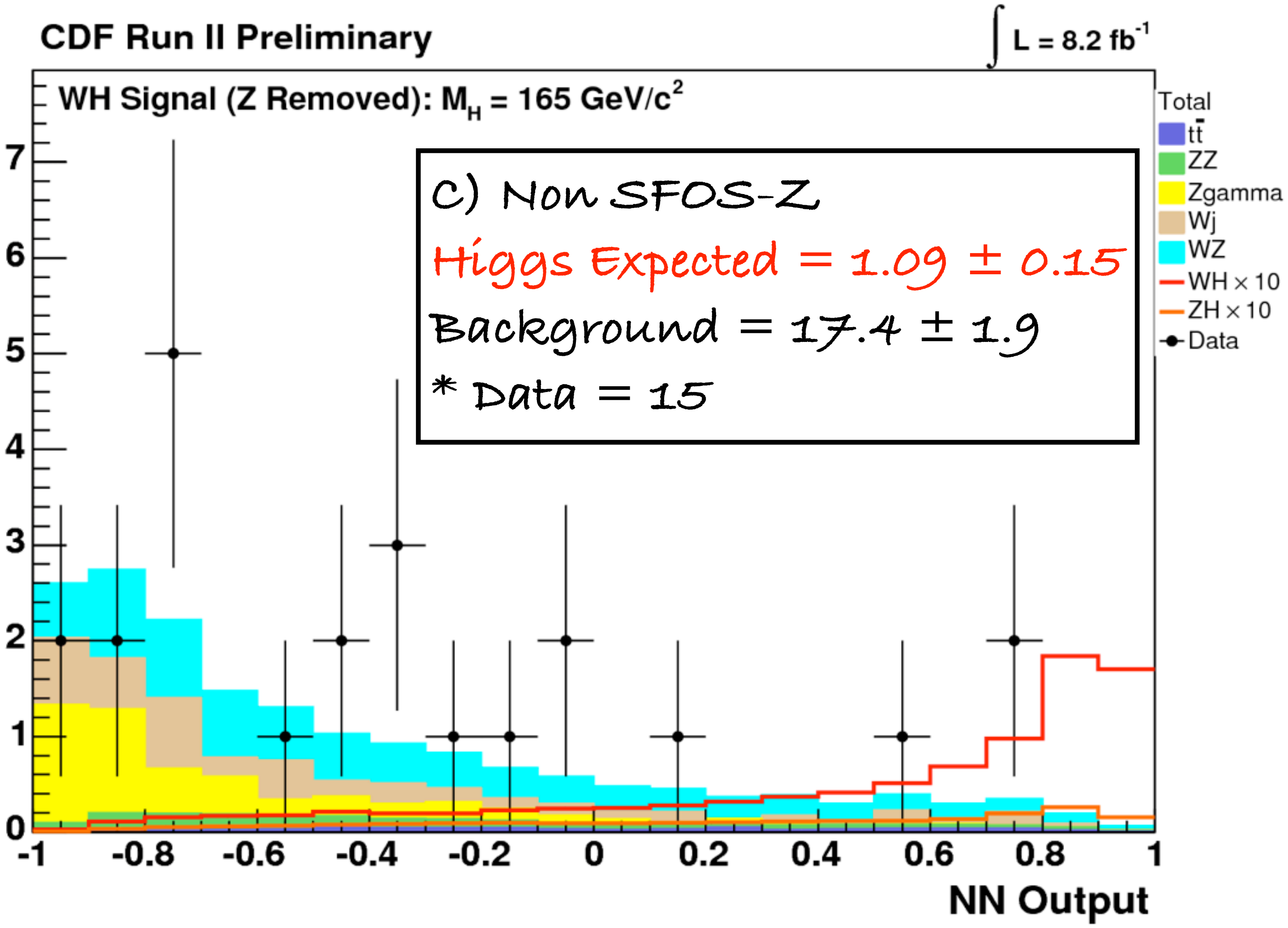
Trileptons @ 8.2 fb^{-1} updated!

- Signal from $WH \rightarrow WWW$ and $ZH \rightarrow ZWW$
- Main background is WZ production
- Improved electron acceptance
- Split analysis into 3: same flavour, opposite sign (SFOS) within 10 GeV of Z mass (Z)

(A) SFOS-Z, $E_{T,miss}$>10 GeV, 1 jet

(B) SFOS-Z, $E_{T,miss}$>10 GeV, ≥2 jet (Higgs mass reconstruction)

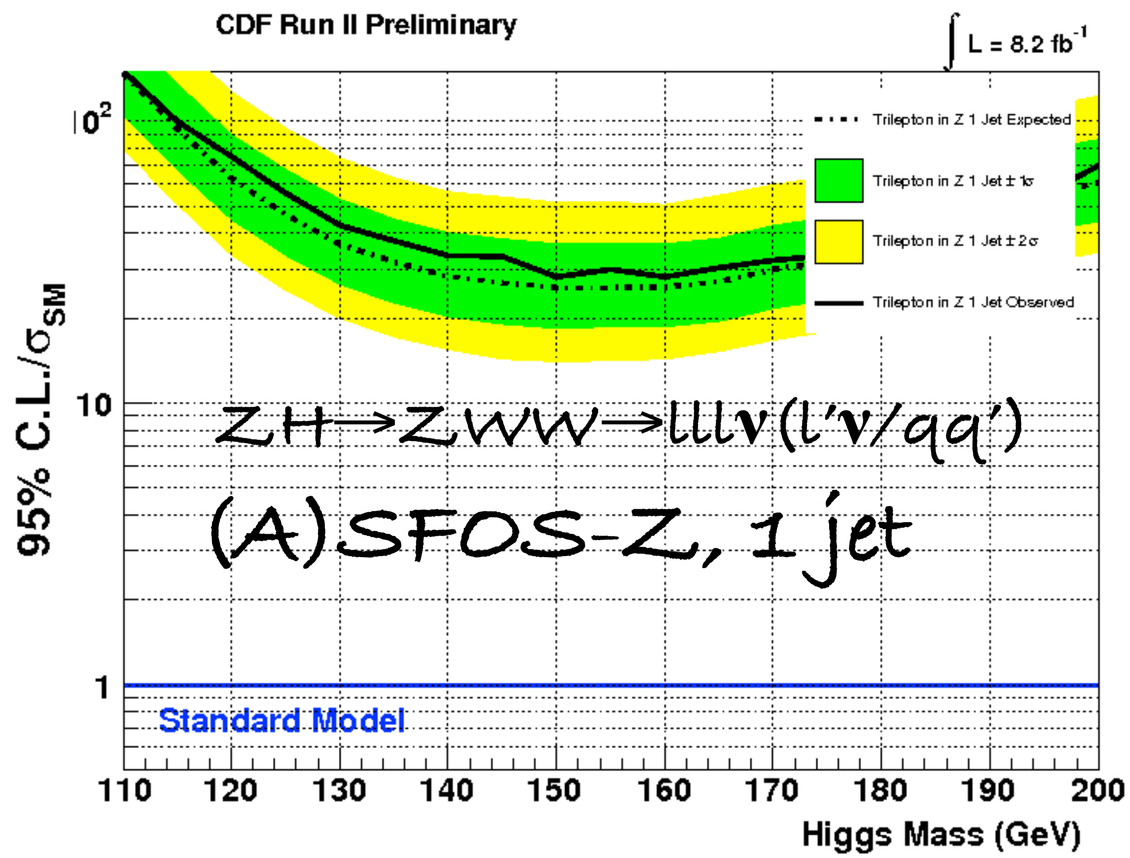
(C) Non SFOS-Z, $E_{T,miss}$>20 GeV, dominated by $WH \rightarrow WWW$

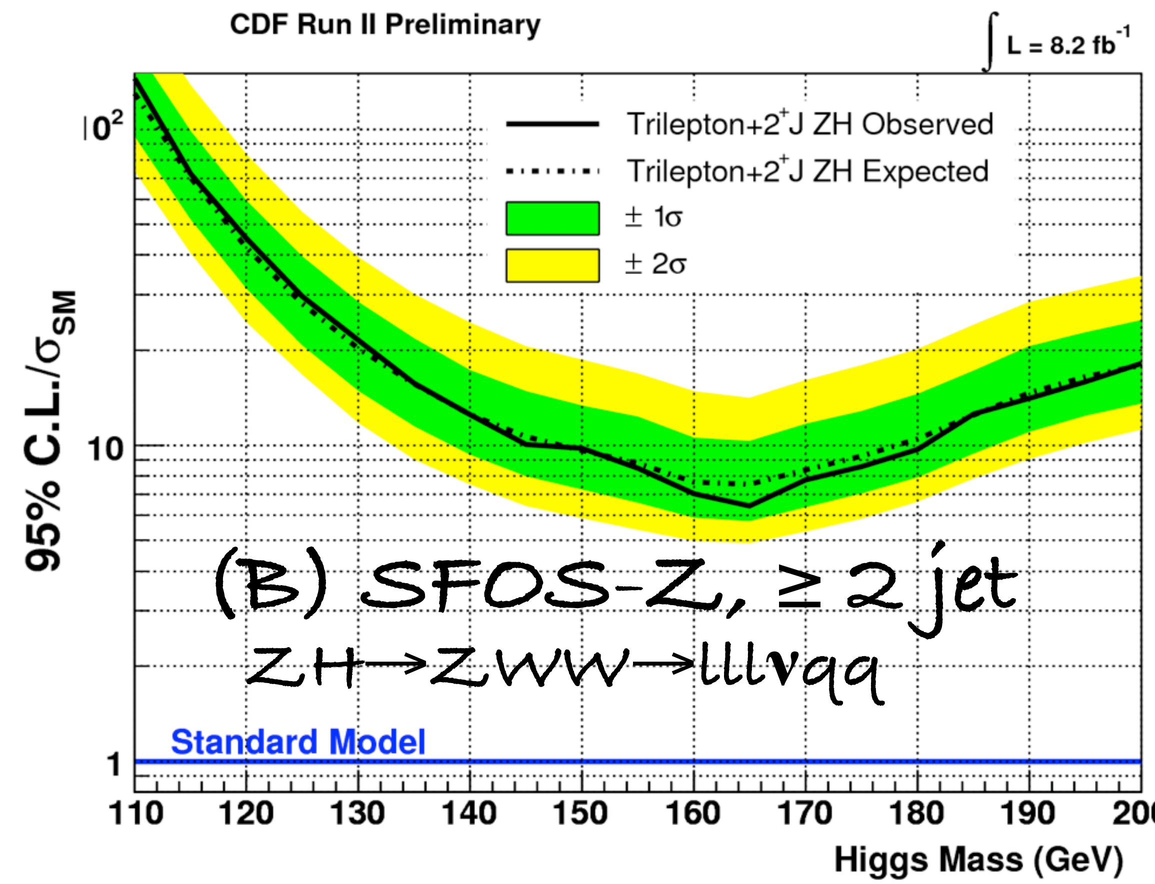


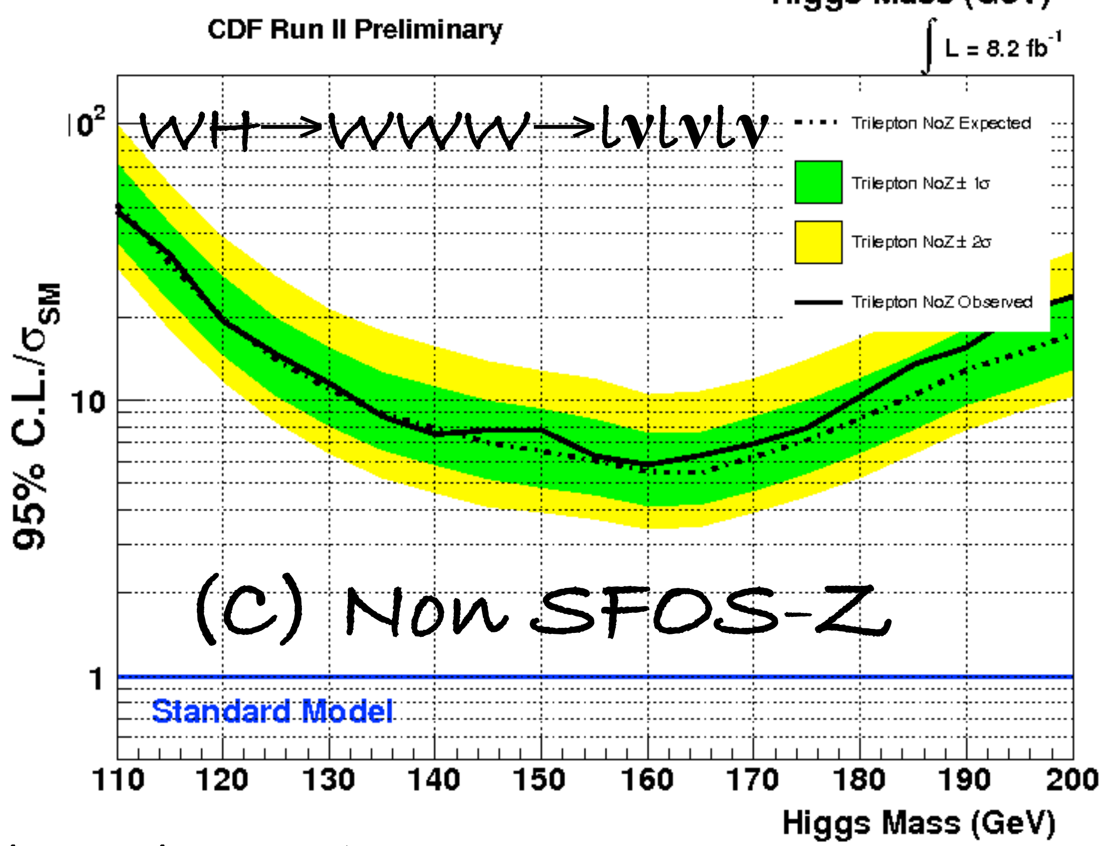
CDF Run II Preliminary $\int \mathcal{L} = 8.2$ fb^{-1}

$M_H = 165$ GeV/c^2	(A)	(B)	(C)
$t\bar{t}$	0.105 ± 0.047	0.141 ± 0.038	0.64 ± 0.20
WZ	12.1 ± 2.0	3.65 ± 0.84	7.1 ± 1.0
ZZ	4.98 ± 0.71	1.91 ± 0.38	1.61 ± 0.23
Z+jets	7.9 ± 1.9	6.4 ± 1.6	3.84 ± 0.89
$Z\gamma$	6.5 ± 1.4	2.55 ± 0.66	4.21 ± 0.84
Total Background	31.6 ± 3.8	14.6 ± 2.4	17.4 ± 1.9
WH	0.0380 ± 0.0058	0.0133 ± 0.0034	0.89 ± 0.12
ZH	0.270 ± 0.042	0.72 ± 0.11	0.203 ± 0.028
Total Signal	0.308 ± 0.046	0.74 ± 0.11	1.09 ± 0.15
Data	35	21	15
	AllSB-trilepZ1j	AllSB-trilepZ2j	AllSB-trilepNoZ

Trileptons @ 8.2 fb^{-1}



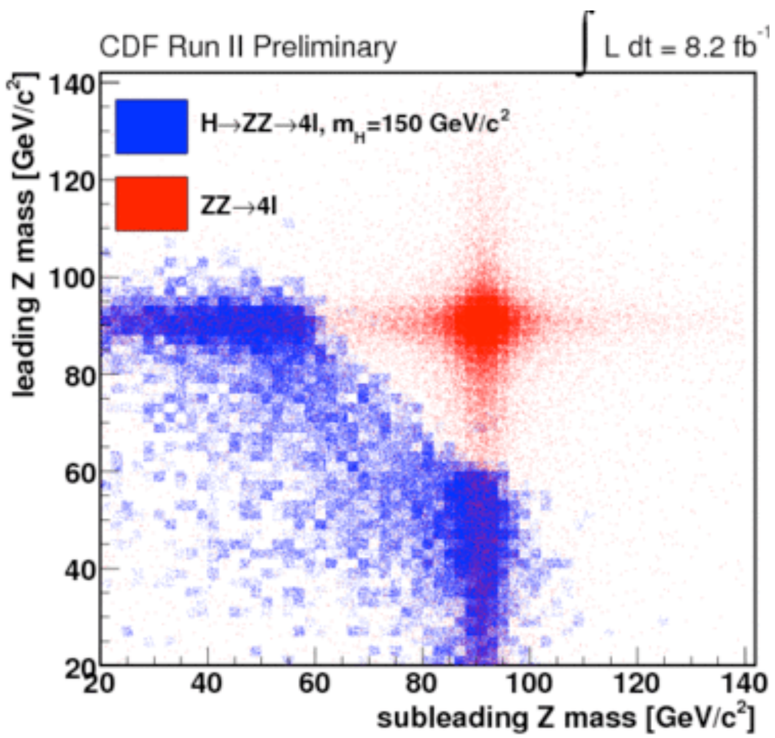


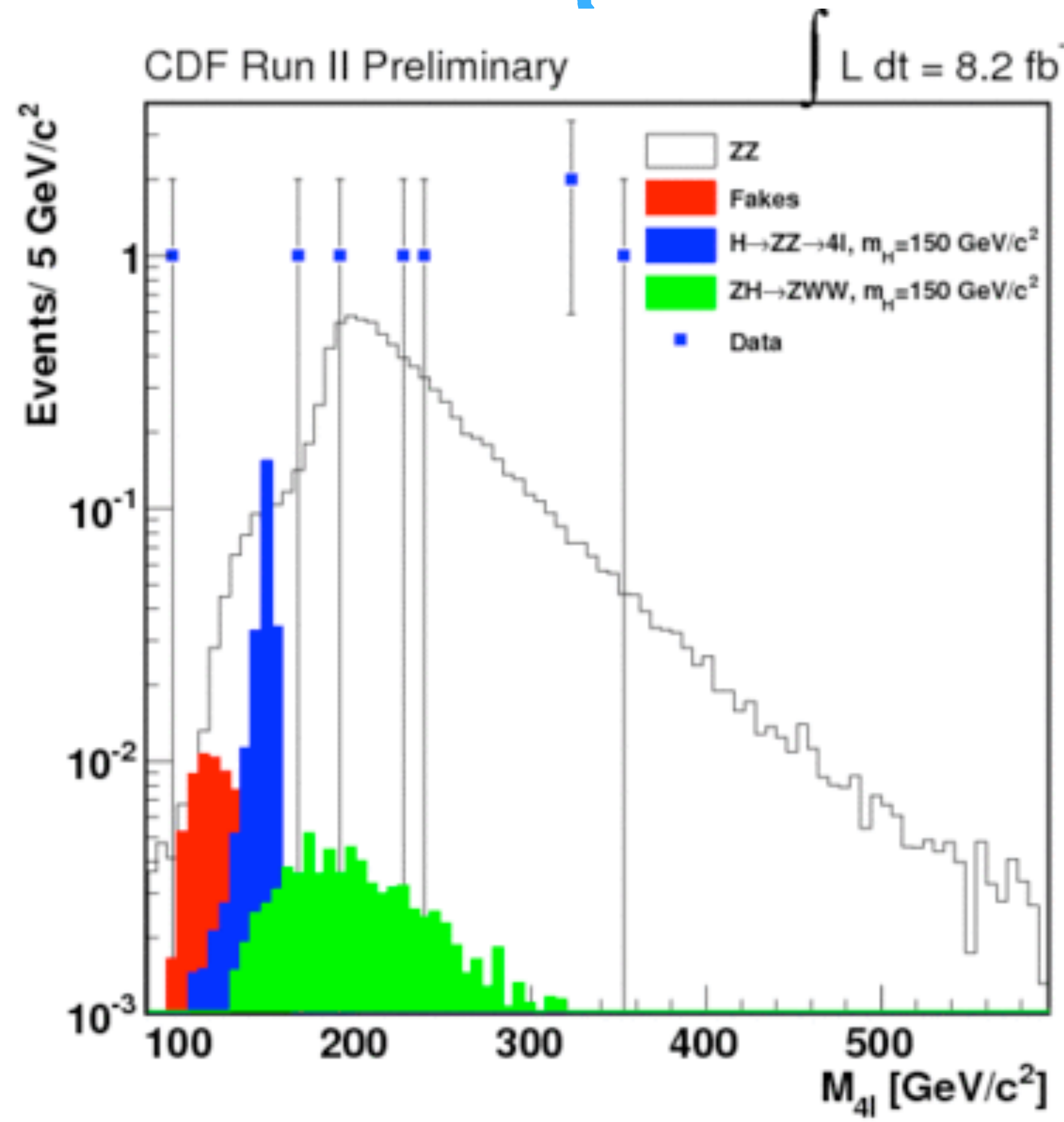


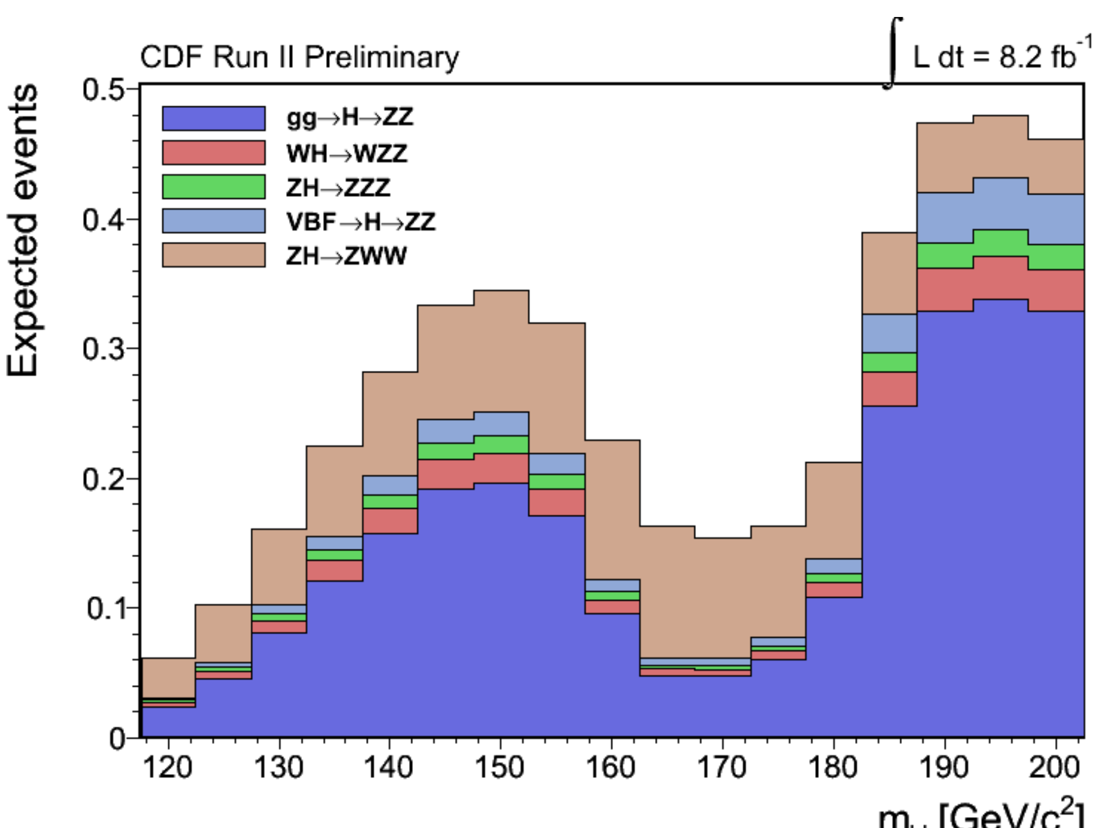
- Best Observed (Expected) at mH= 160 GeV/c^2 of 5.5 (5.8) x σ_{SM} in the (C) channel

Four-leptons @ 8.2 fb^{-1} NEW!

- 4e, 4μ, 2e2μ Final states
  Exactly 4 leptons
- Trigger lepton
  $E(P)_T > 20$ GeV
- Other 3 $E(P)_T > 10$ GeV
- min separation $\Delta R \geq 0.1$
- Loose mass cuts :
  $20 \leq M_{ll}/(GeV/c^2) \leq 140$

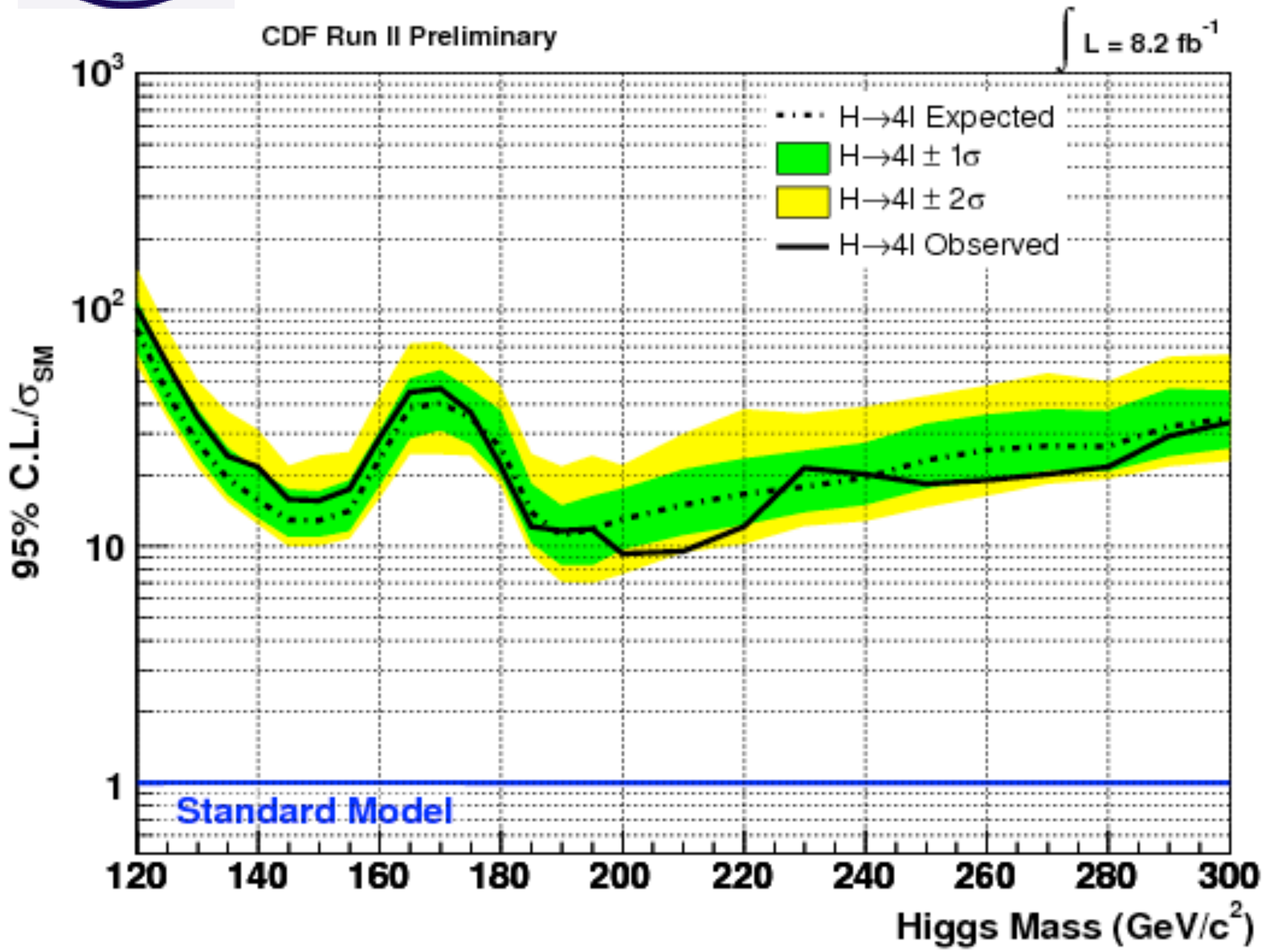






ZZ	8.83±1.12
Z(γ)+jets	0.30±0.10
$m_H(150)$	0.33±0.03
$m_H(190)$	0.48±0.04
Data	8

Four-leptons @ 8.2 fb^{-1} Limits



- Observed (Expected) at m_H= 150 GeV/c^2 of 15.5 (12.8) x σ_{SM}
- Observed (Expected) at m_H= 200 GeV/c^2 of 9.3 (12.9) x σ_{SM}

- First inclusive SM H→4l search
- ZH→ZWW→4l improves limit even though 4l mass not optimal
- Comparable sensitivity at intermediate mass (140-155 GeV) as at high mass (185-220 GeV). Not just a very high mass channel!

Summary

Modes	Experiment	Higgs Mass (GeV/c²)			
	/Lum	Best Expected and Observed Limits (x σ_{SM})			
	(fb^{-1})	Mass	Expected	Mass	Observed
($l\nu$) (qq)	D0/5.4	160	5.0	160	3.9
$l\tau_{had}$ + 0, 1 j	D0/7.3	165	7.8	165	6.6
$l\tau_{had}$	CDF/8.2	165	13.0	165	17.5
Trileptons A	CDF/8.2	155	25.7	160	28.0
Trileptons B	CDF/8.2	165	7.5	165	6.4
Trileptons C	CDF/8.2	165	5.5	160	5.8
Four-leptons	CDF/8.2	190	11.1	200	9.3

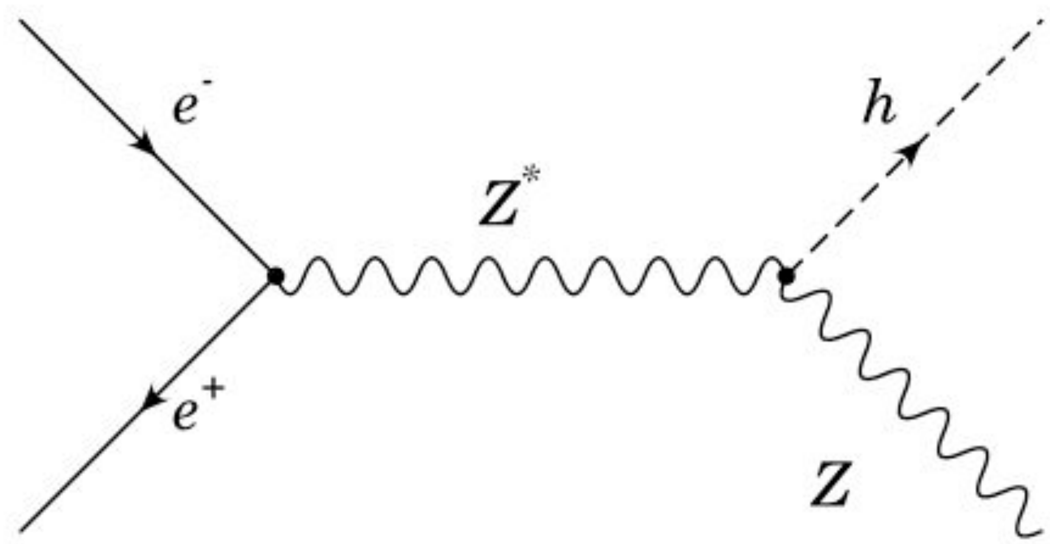
- http://www-cdf.fnal.gov/physics/new/hdg/Results.html
- http://www-d0.fnal.gov/Run2Physics/WWW/results/higgs.htm
- PARALLEL"CDF" and "D0" combination talks tomorrow morning. PLENARY "Tevatron combination" next Wednesday

Supplementary Material

Higgs Search

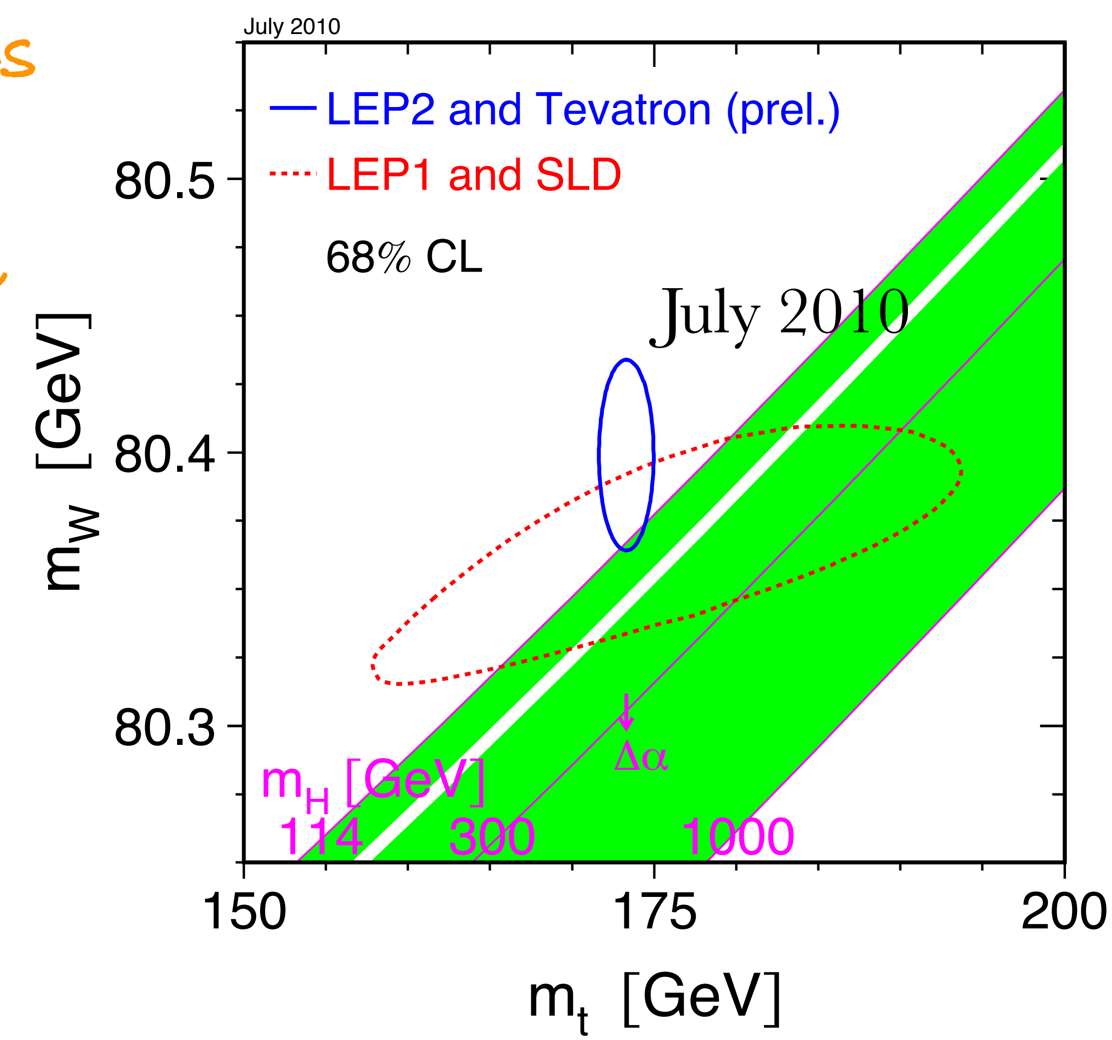
Where it's not!

Search at LEP via Higgs-strahlung

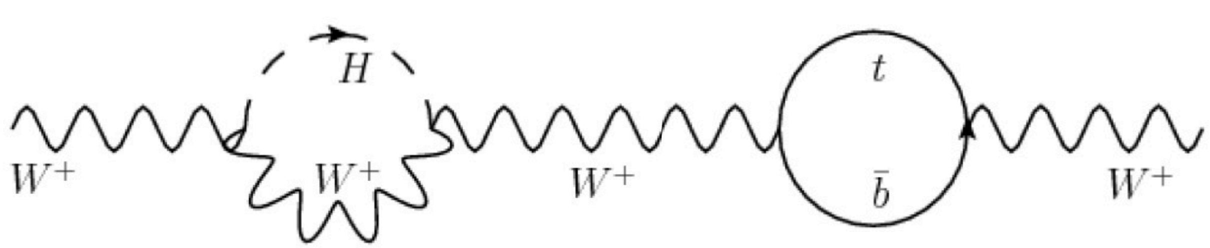


$M_H \geq 114$ GeV/c² @ 95% C.L.

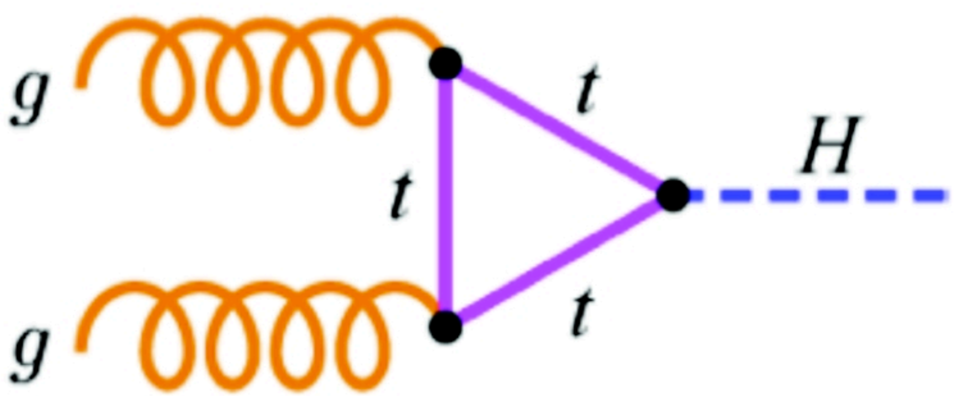
Constraints from loop corrections calculated with Electroweak precision data of LEP+Tevatron



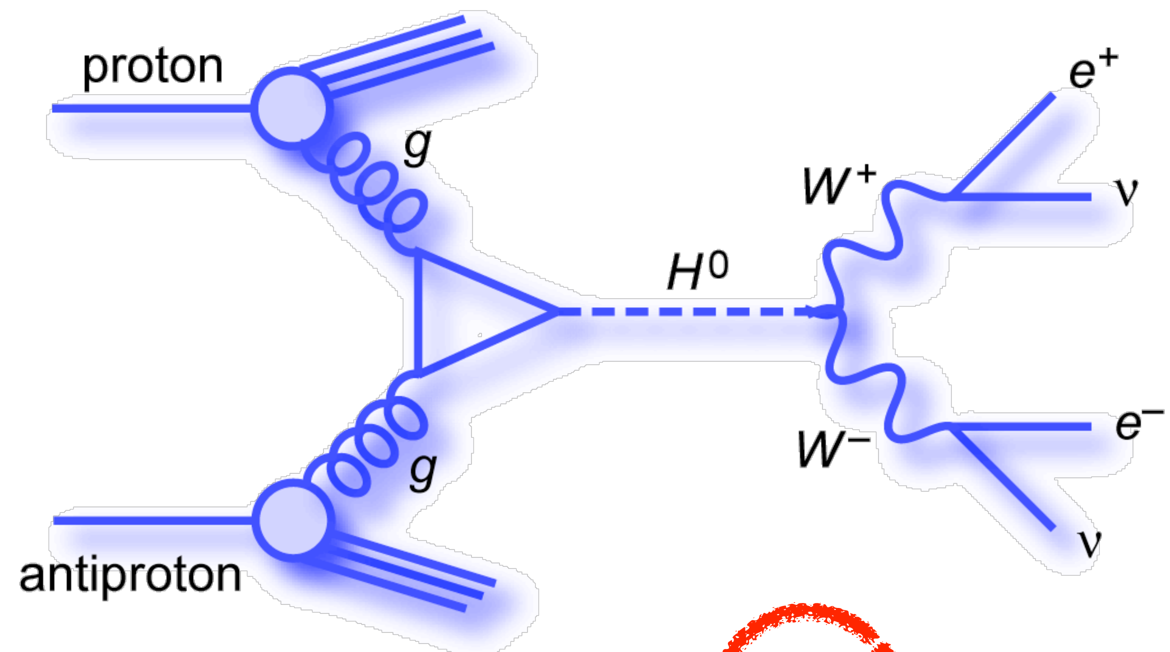
$M_H \leq 185$ GeV/c² @ 95% C.L.

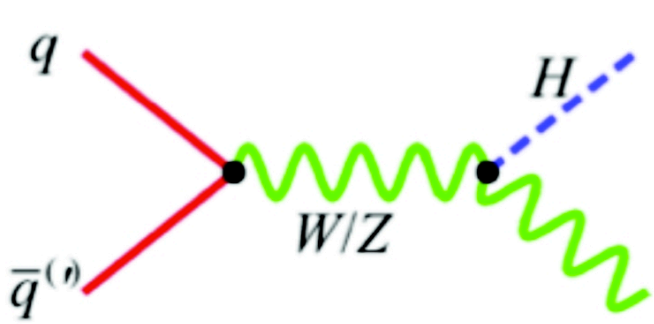


Higgs Production and Decay

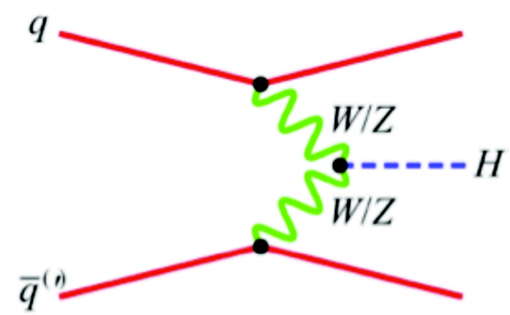


gluon-gluon fusion (gg→H)

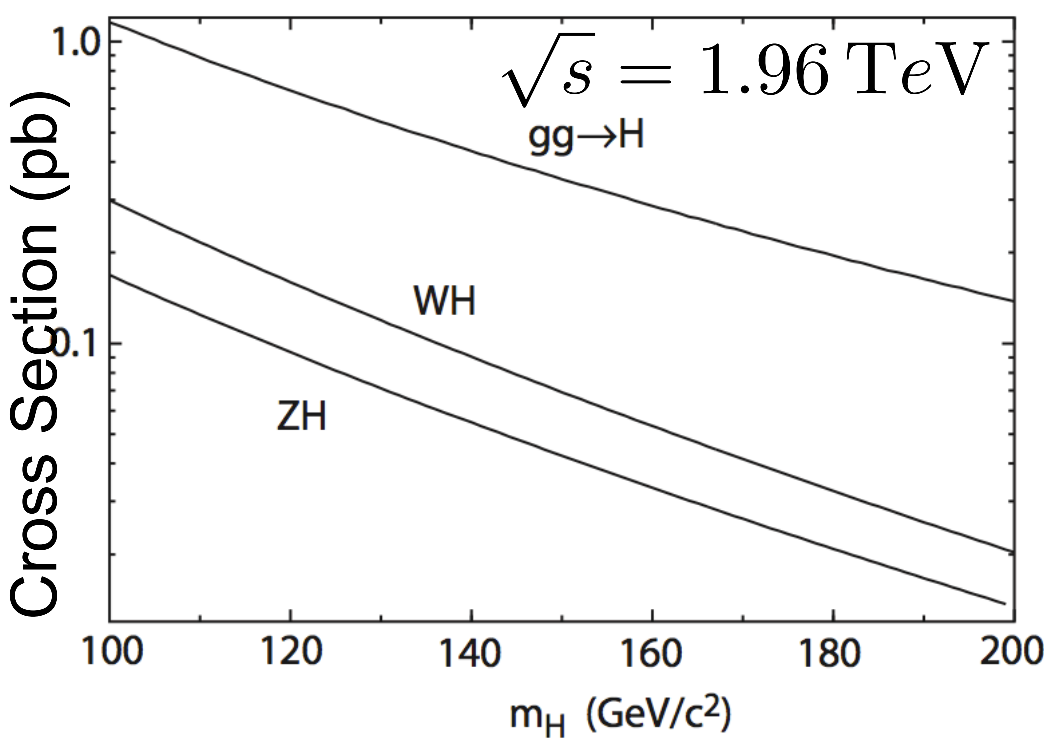


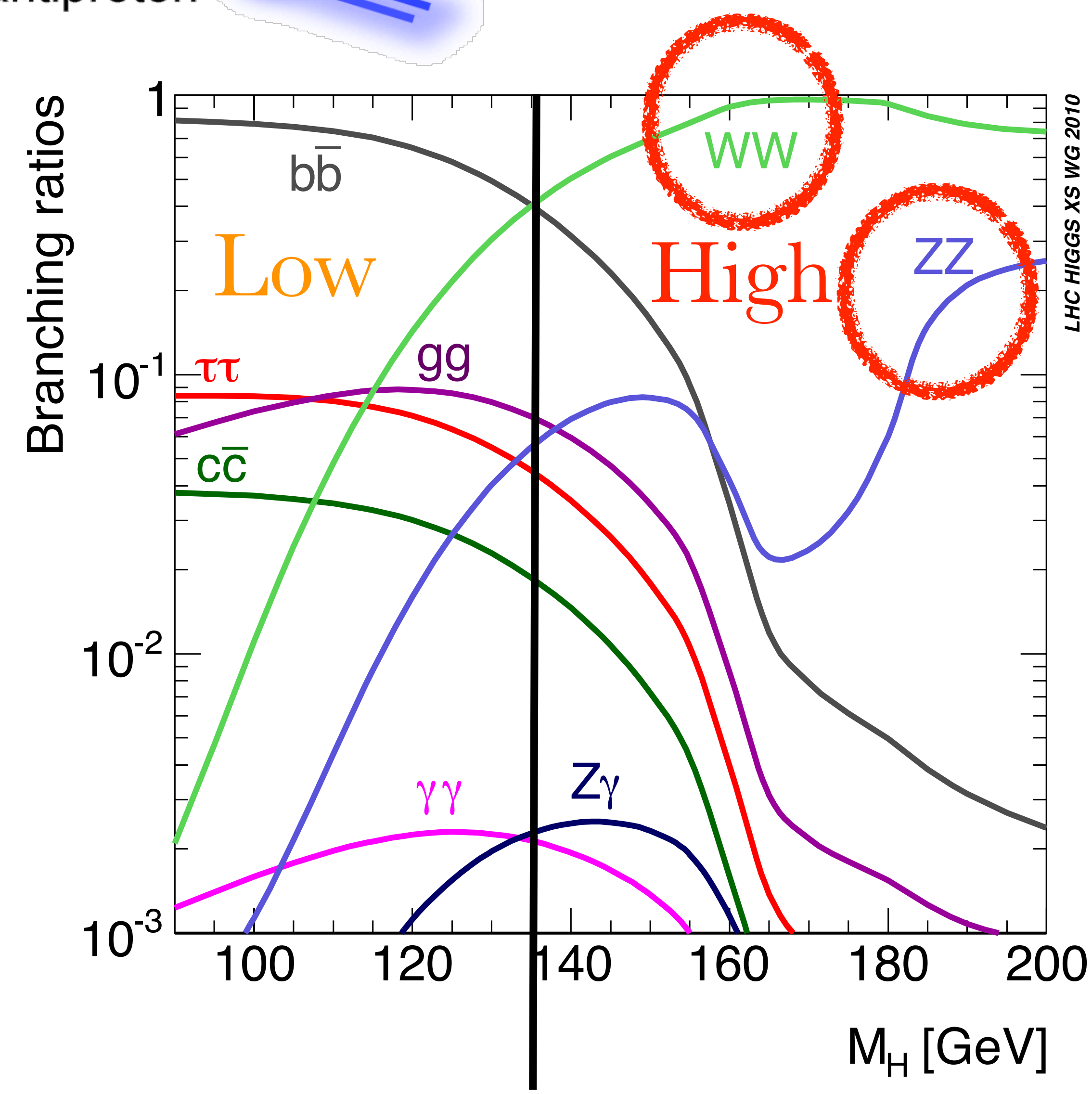


Associated Producion

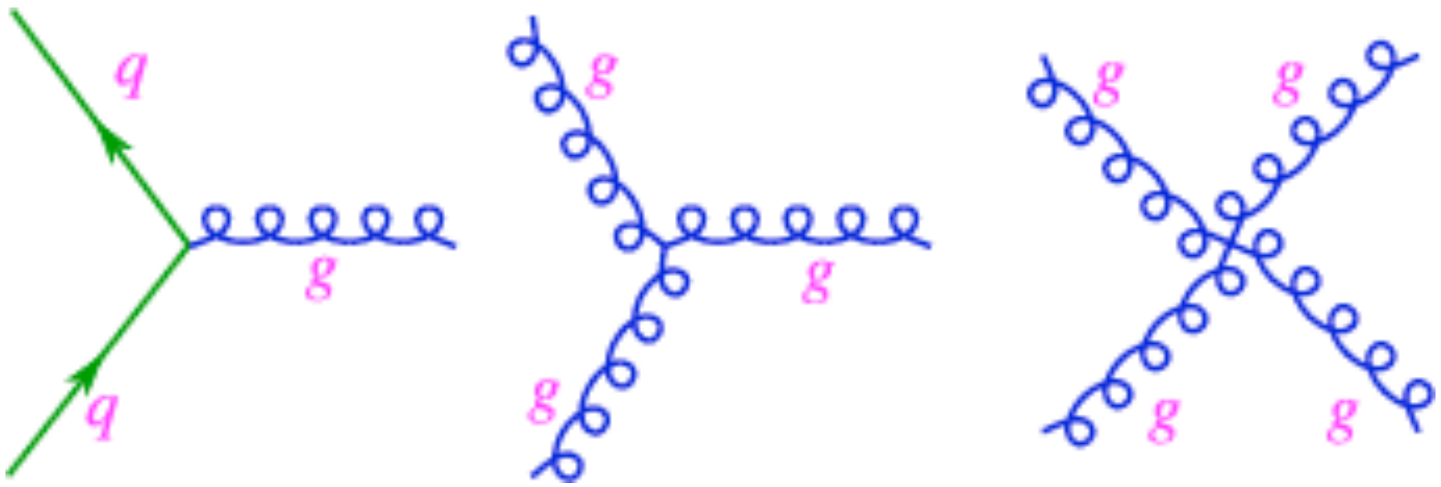


Vector Boson fusion

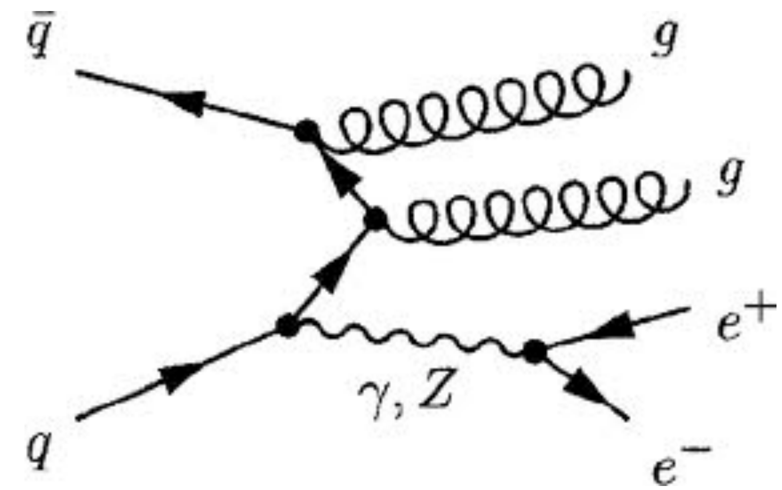




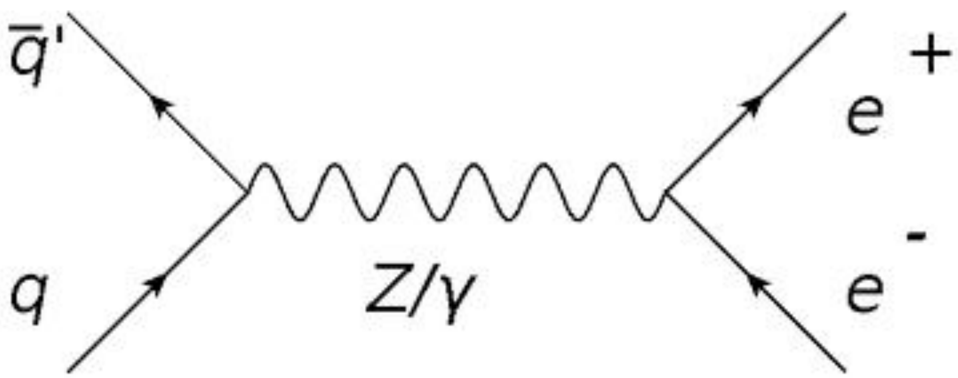
Backgrounds



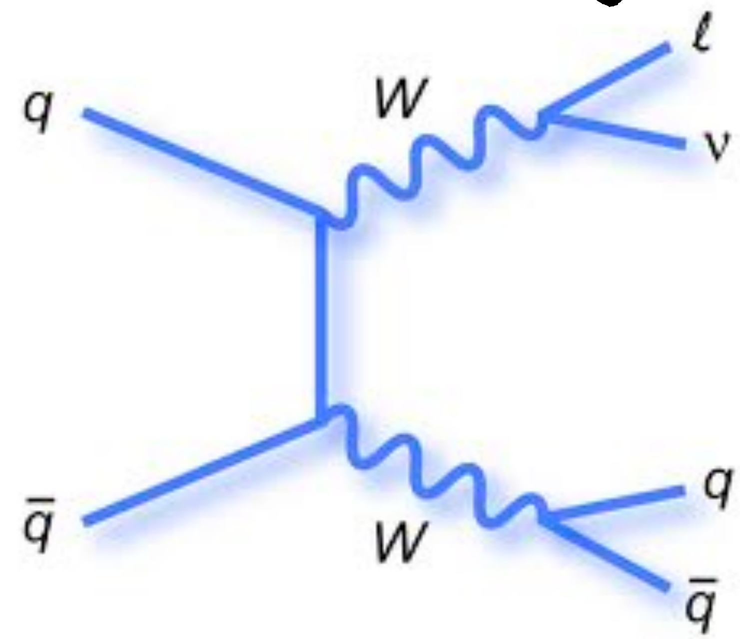
Multi-jet QCD (MJ)



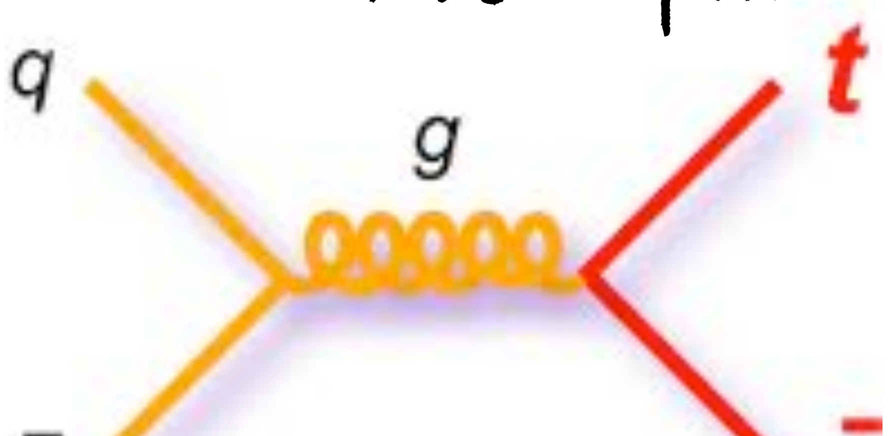
W/Z + jets / γ



Drell-Yan



Diboson WW, WZ, ZZ

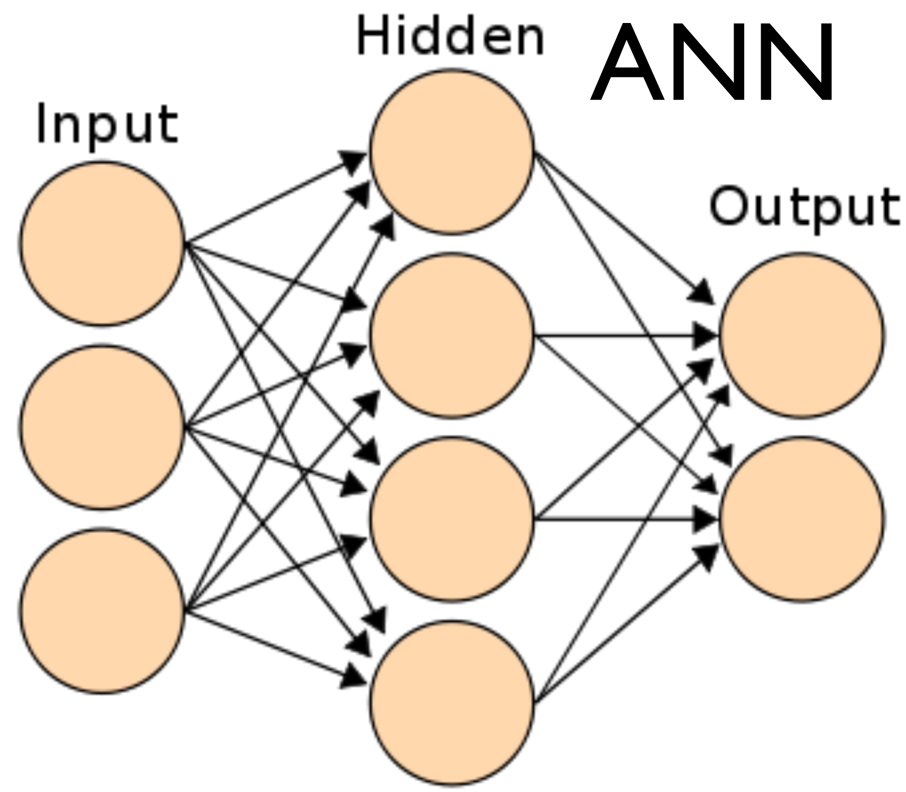


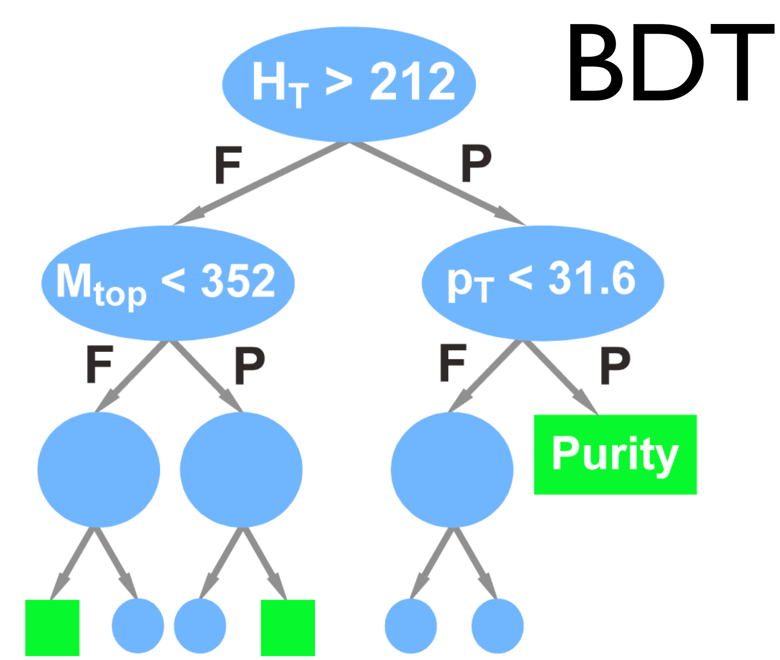
Top-pair

Use (N)NLO precision for normalising cross sections

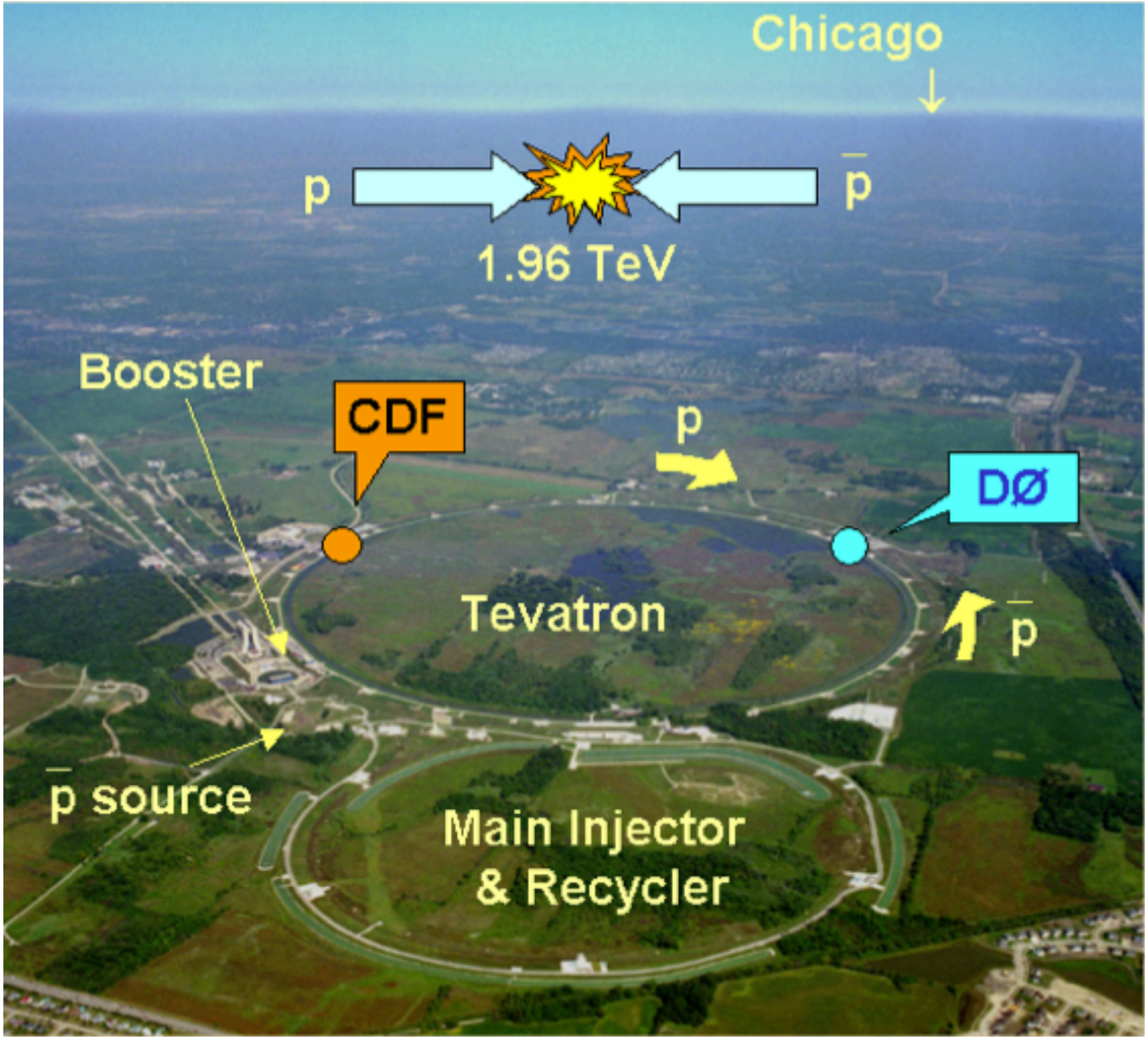
Analysis Strategies

- Aim : Maximise significance
- Method: Use Multivariate Analysis techniques
  - Artificial Neural Networks (ANN)
  - "Forest of Random Trees" (RF)
  - Boosted Decision Trees (BDT)
  - Typically using about 10 to 30 kinematic variables
    - Object level : p_T, mass, ΔR, $\Delta\eta$, $\Delta\phi$
    - Event level : missing E_T (significance), H_T, V_T
- Require agreement between MC and data
- Separate signal according jet multiplicity and lepton flavor
- Kinematic control regions to check background models



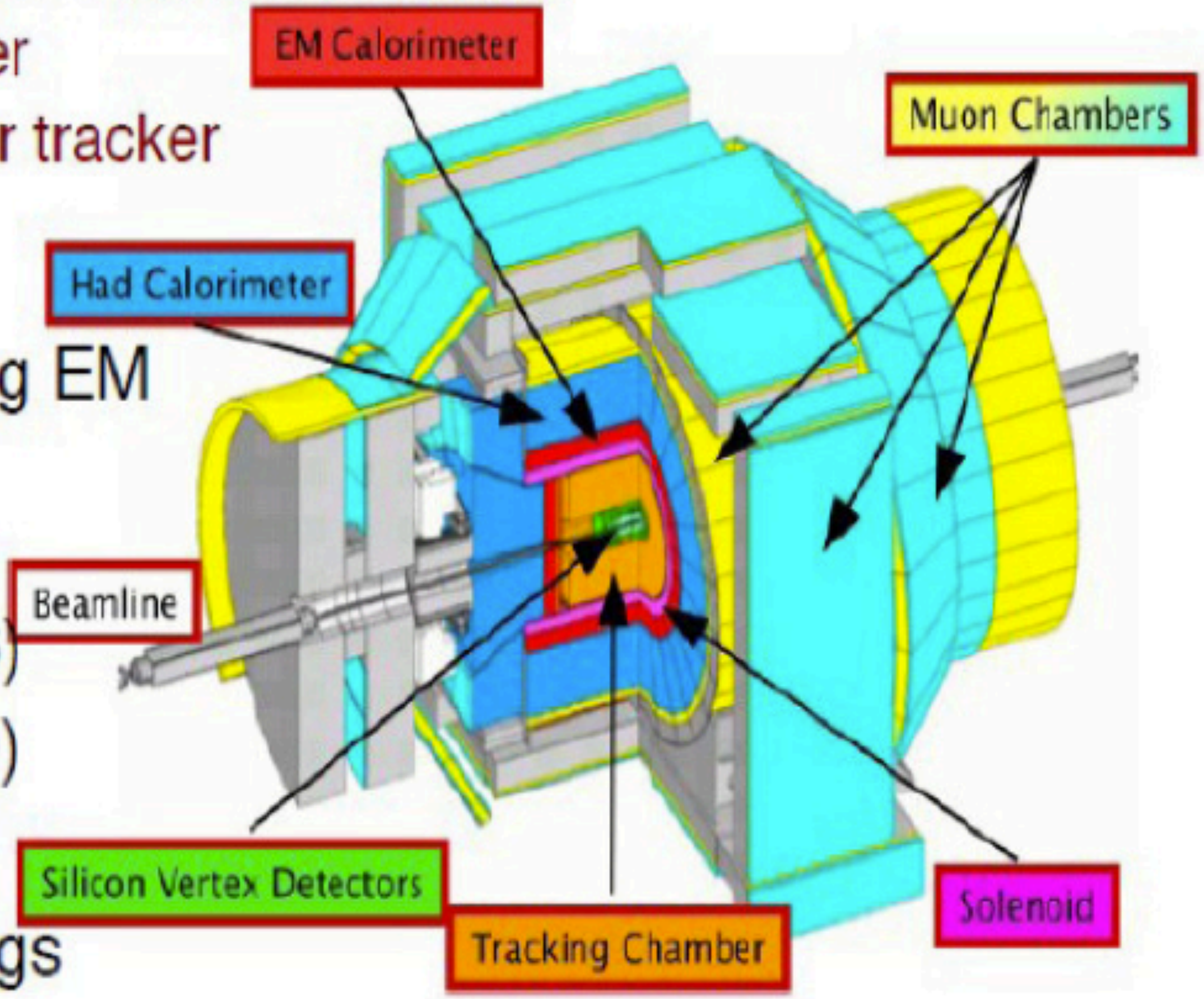


Tevatron

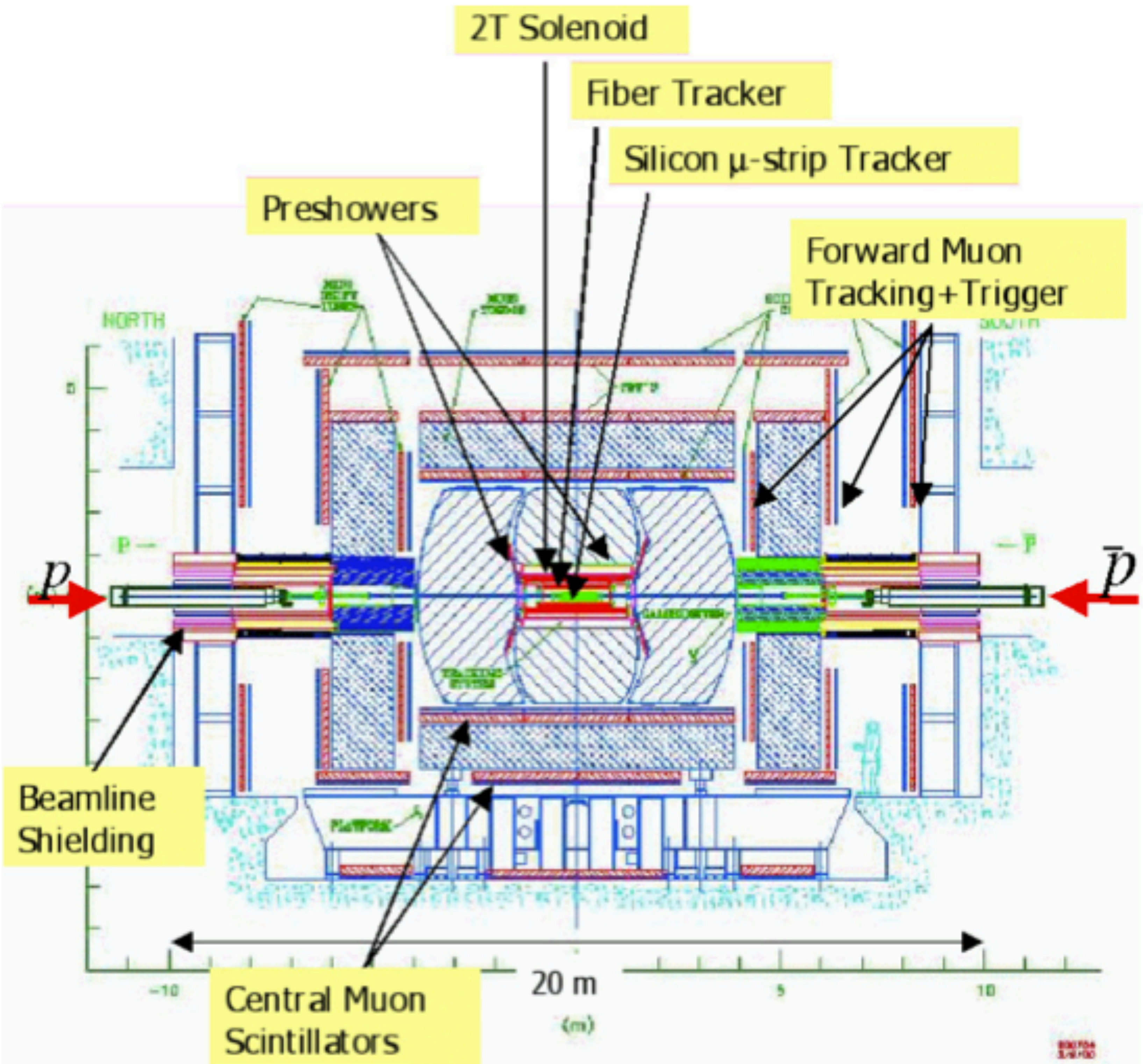

Chicago
p
$\bar{p}$
1.96 TeV
Booster
CDF
p
DØ
Tevatron
$\bar{p}$
$\bar{p}$ source
Main Injector
& Recycler

CDF

- General multipurpose detector
  - Excellent tracking and mass resolution:
    - Silicon inner tracker
    - Drift chamber outer tracker
- Calorimeters
  - Segmented sampling EM and Hadronic
- Muon chambers
  - CMU/CMP ($|\eta| < 0.6$)
  - CMX ($0.6 < |\eta| < 1.0$)
- Complex geometry
  - Try to maximize Higgs acceptance



D0



- New in RunII
  - Tracking in B-field
  - Silicon detector
  - fiber tracker
- Upgraded for Run II
  - Calorimeter,
  - muon system
  - DAQ/trigger
- RunIIb (2006):
  - Silicon layer 0
  - Cal Trigger
- Typical coverage
  - Muons $\eta < 2$
  - Electrons
    - $\eta<1.1$
    - $1.5<\eta<2.5$
  - Jets $\eta< 2.5$

Semileptonic $(l\nu)(qq')$

- Upper limits derived using the modified frequentist CL_S approach
- Systematics
  - Calibration of jet energies 0.7-6%
  - jet resolution 0.5-3%
  - jet reconstruction efficiency 0.5-4%
  - lepton ID and trigger modelling 4%
  - Multi-jet background 6.5-26%
  - Luminosity 6.1%

$(l\nu)\ (\tau_{had}\nu)$ + 0, 1 jets

NN Analysis Variables	
Object Variables	
p_T of muon	$p_T(\mu)$
p_T of tau	$p_T(\tau)$
charge times pseudo-rapidity of muon	$Q_\mu \times \eta_\mu$
pseudo-rapidity of $\tau_{\rm had}$	η_τ
$\rm NN_\tau$ output	$\rm NN_\tau$
Event Kinematics	
invariant mass of both leptons	$M_{\rm inv}(\mu,\tau)$
minimal transverse mass of leptons and $\not\!\!E_{\rm T}$	$M_T^{\rm min}$
missing transverse energy	$\not\!\!E_{\rm T}$
visible mass	$M_{\rm vis}$
minimum center of mass energy	$\sqrt{\hat{s}_{\rm min}}$
Number of jets	$n^{\rm jet}$
Leading jet p_T	$p_T^{\rm jet}$
Topological Variables	
azimuthal angle between selected leptons	$\Delta\varphi(\mu,\tau)$
azimuthal angle between muon and $\not\!\!E_{\rm T}$	$\Delta\varphi(\not\!\!E_{\rm T},\mu)$
azimuthal angle between τ and $\not\!\!E_{\rm T}$	$\Delta\varphi(\not\!\!E_{\rm T},\tau)$
angle between muon and beam axis	$\cos(\tilde{\theta})$
angle between τ and muon	$\theta(\tau,\mu)$

- Upper limits derived using the modified frequentist CL_s approach
- Systematics
  - Muon ID efficiency 2.3%
  - Trigger efficiency 5%
  - Tau ID 1/2/3 : 10/4/5%
  - Z/ttbar/DB cross-section 4/10/7%
  - DB pT modelling 1%
  - ggH modelling 3%
  - W+jets background 10-15%
  - Neural Network shape
    - Tau Energy Scale 1%
    - Jet Energy Scale/Resolution/ID 1-9%/3-9%/1-7%
    - MJ background estimation 20-50%

$(\ell\nu)(\tau_{had}\nu)$ + 2 jets

variable	definition
${p_T}^{\ell}$	p_T of the lepton candidate
${p_T}^{j1}$	p_T of the leading jet candidate
$\not\!\!E_T$	missing transverse energy
$M_{\tau\tau}$	invariant mass of the $(\tau_\ell, \tau_{\rm had})$ system
$M_{\rm jj}$	invariant mass of the two candidate jets
$\Delta R_{\rm jj}$	$\Delta R = \sqrt{(\Delta\phi)^2 + (\Delta\eta)^2}$ distance between the 2 leading jets
$M_{\rm T}^{\ell}$	transverse mass calculated from ${p_T}^{\ell}$ and $\not\!\!E_T$
$M_{\rm T}^{\tau}$	transverse mass calculated from ${p_T}^{\tau}$ and $\not\!\!E_T$
H_T	scalar sum of the p_T of all jets with $p_T > 15$ GeV and $\|\eta\| < 2.5$
S_T	scalar sum of the p_T of ℓ, τ, the two jets and $\not\!\!E_T$
V_T	magnitude of the vector sum of the p_T of ℓ, τ, the 2 jets and $\not\!\!E_T$
$A(\not\!\!E_T, \not\!\!H_T)$	asymmetry between $\not\!\!E_T$ and $\not\!\!H_T$, $(\not\!\!E_T - \not\!\!H_T)/(\not\!\!E_T + \not\!\!H_T)$. $\not\!\!H_T$ is $\Sigma \vec{p_T}$ for jets
$\min \Delta\phi(\not\!\!E_T, jets)$	the smaller $\Delta\phi$ between the $\not\!\!E_T$ and any jet
$\mathcal{S}$	the $\not\!\!E_T$ significance [16]
$\Delta\eta$(jj)	$\|\Delta\eta\|$ between the 2 leading jets
p_T^{τ}	transverse momentum of the tau candidate that decays $\tau \to$ hadrons

Source	type	Uncertainty (%)
Luminosity (DØ specific)	flat	4.1
Luminosity (Tevatron common)	flat	4.6
μ ID, track match, iso.	flat	2.9
μ trigger	flat	8.6
e ID, track match, iso.	flat	4
e trigger	flat	2
τ energy correction	flat	9.8
τ track efficiency	flat	1.4
τ selection types 1,2,3	flat	12, 4.2, 7
W/Z+light flavor XS	flat	6.0
$t\bar{t}$, single top XS	flat	10.0
diboson XS	flat	7.0
VH signal XS	flat	6.2
VBF signal XS	flat	4.9
GGF signal XS normalization	flat	33
GGF signal XS PDF	flat	29
GGF p_T^H	shape	1.0
vertex confirmation for jets	flat	4.0
Jet ID/reco eff.	shape	$\approx$ 20%
Jet E resolution.	shape	$\approx$ 15%
JES	shape	$\approx$ 15%
jet p_T	flat	5.5
PDF	shape	2.0
MJ $\mu\tau jj$ normalization	flat	5.3
MJ $e\tau jj$ normalization	flat	4.7
MJ shape ($\mu\tau jj$)	shape	15%
MJ shape ($e\tau jj$)	shape	15%

TABLE VI: Systematic uncertainties (in percent) on the final cBDT.

$(\ell\nu)(\tau_{had}\nu)$ @ 8.2 fb^{-1}

Uncertainty source	WW	WZ	ZZ	$t\bar{t}$	$Z\rightarrow\tau\tau$	$Z\rightarrow\ell\ell$	W+jet	$W\gamma$	$gg\rightarrow H$	WH	ZH	VBF
Cross section	6.0	6.0	6.0	10.0	5.0	5.0			14.3	5	5	10
Measured W cross-section							12					
PDF Model	1.6	2.3	3.2	2.3	2.7	4.6	2.2	3.1	2.5	2.0	1.9	1.8
Higher order diagrams	10	10	10	10	10	10		10		10	10	10
Trigger Efficiency	0.5	0.6	0.6	0.6	0.7	0.5	0.6	0.6	0.5	0.5	0.6	0.5
Lepton ID Efficiency	0.4	0.5	0.5	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.4
τ ID Efficiency	1.4	1.8	2.8	2.1	2.3			0.3	4.3	2.2	2.4	4.1
Jet into τ Fake rate	5.8	4.8	2.0	5.1		0.1	8.8			4.2	4.0	0.4
Lepton into τ Fake rate	0.2	0.1	0.6	0.2		2.3		2.1	0.15	0.06	0.15	0.11
W+jet scale							1.6					
Luminosity	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
Total	14.5	14.2	13.9	16.5	13.2	13.7	16.3	13.1	16.3	13.7	13.6	16.0

TABLE II: Systematic uncertainties on the backgrounds and signals for the $e\tau$ (expressed in %) .

Uncertainty source	WW	WZ	ZZ	$t\bar{t}$	$Z\rightarrow\tau\tau$	$Z\rightarrow\ell\ell$	W+jet	$W\gamma$	$gg\rightarrow H$	WH	ZH	VBF
Cross section	6.0	6.0	6.0	10.0	5.0	5.0			14.3	5	5	10
Measured W cross-section							12					
PDF Model	1.5	2.1	2.9	2.1	2.5	4.3	2.0	2.9	2.6	2.2	2.0	2.2
Higher order diagrams	10	10	10	10	10	10		10		10	10	10
Trigger Efficiency	1.3	0.7	0.7	1.1	0.9	1.3	1.0	1.0	1.3	1.3	1.2	1.3
Lepton ID Efficiency	1.1	1.4	1.4	1.1	1.2	1.1	1.4	1.3	1.0	1.0	1.0	1.0
τ ID Efficiency	1.3	1.5	1.5	2.1	2.8				4.4	2.2	2.3	4.3
Jet into τ Fake rate	5.8	5.0	4.4	4.4		0.2	8.8			4.5	4.2	0.4
Lepton into τ Fake rate	0.06	0.05	0.09	0.04		1.9		1.2	0.04	0.02	0.02	0.04
W+jet scale							1.4					
Luminosity	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
Total	14.5	14.3	14.3	16.3	13.3	13.6	16.3	13.0	16.4	13.9	13.8	16.2

TABLE III: Systematic uncertainties on the backgrounds and signals for the $\mu\tau$ (expressed in %).

Trileptons A @ 8.2 fb^{-1}

Uncertainty Source	WZ	ZZ	$Z\gamma$	$t\bar{t}$	Fakes	WH	ZH
Cross Section							
Total	*6.0%*	*6.0%*	10.0%	7.0%		**5.0%**	**5.0%**
Acceptance							
Higher-order Diagrams	*10.0%*	*10.0%*	15.0%	10.0%		**10.0%**	**10.0%**
Jet Energy Scale	*-7.6%*	*-2.3%*	*-5.3%*	*9.4%*		*-9.0%*	*8.1%*
Jet Fake Rates					24.8%		
b-Jet Fake Rates				42.0%			
MC Run Dependence			5.0%				
Lepton ID Efficiencies	*5.0%*	*5.0%*		*5.0%*		*5.0%*	*5.0%*
Trigger Efficiencies	*2.0%*	*2.0%*		*2.0%*		*2.0%*	*2.0%*
Luminosity	*5.9%*	*5.9%*		*5.9%*		*5.9%*	*5.9%*

Trileptons B @ 8.2 fb^{-1}

Uncertainty Source	WZ	ZZ	$Z\gamma$	$t\bar{t}$	Fakes	WH	ZH
Cross Section							
Total	*6.0%*	*6.0%*	10.0%	7.0%		**5.0%**	**5.0%**
Acceptance							
Higher-order Diagrams	*10.0%*	*10.0%*	15.0%	10.0%		**10.0%**	**10.0%**
Jet Energy Scale	*-17.8%*	*-13.1%*	*-18.2%*	*-3.6%*		*-15.4%*	*-4.9%*
Jet Fake Rates					25.6%		
b-Jet Fake Rates				22.2%			
MC Run Dependence			5.0%				
Lepton ID Efficiencies	*5.0%*	*5.0%*		*5.0%*		*5.0%*	*5.0%*
Trigger Efficiencies	*2.0%*	*2.0%*		*2.0%*		*2.0%*	*2.0%*
Luminosity	*5.9%*	*5.9%*		*5.9%*		*5.9%*	*5.9%*

Trileptons C @ 8.2 fb^{-1}

Uncertainty Source	WZ	ZZ	$Z\gamma$	$t\bar{t}$	Fakes	WH	ZH
Cross Section							
Total	*6.0%*	*6.0%*	10.0%	7.0%		**5.0%**	**5.0%**
Acceptance							
Higher-order Diagrams	*10.0%*	*10.0%*	15.0%	10.0%		**10.0%**	**10.0%**
Jet Energy Scale			*-2.7%*				
Jet Fake Rates					25.6%		
b-Jet Fake Rates				27.3%			
MC Run Dependence			5.0%				
Lepton ID Efficiencies	*5.0%*	*5.0%*		*5.0%*		*5.0%*	*5.0%*
Trigger Efficiencies	*2.0%*	*2.0%*		*2.0%*		*2.0%*	*2.0%*
Luminosity	*5.9%*	*5.9%*		*5.9%*		*5.9%*	*5.9%*

Four-leptons @ 8.2 fb^{-1}

CDF Run II Preliminary $\int \mathcal{L} = 8.2\ \text{fb}^{-1}$

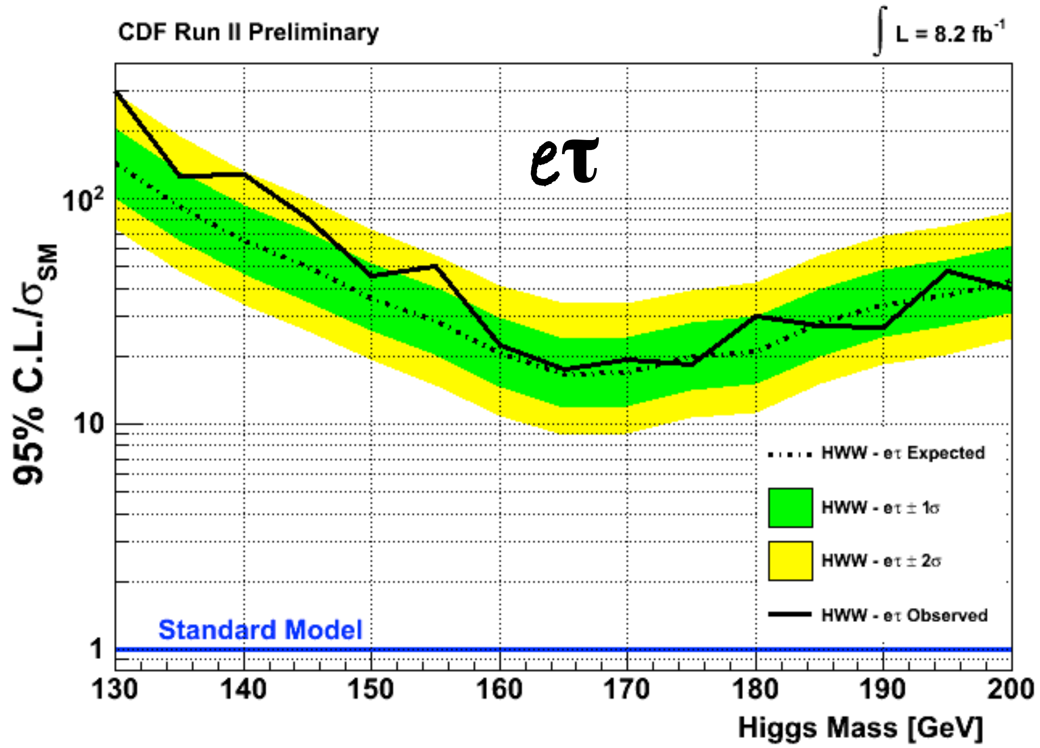
Uncertainty Source	ZZ	$Z(\gamma^*)$	gg→H	WH	ZH	VBF
Cross Section						
Scale			7.0%			
PDF			7.7%			
Total	10%			5%	5%	10%
$\mathcal{BR}$(H→VV)			3%	3%	3%	3%
Acceptance						
Higher-order Diagrams	2.5%					
PDF	2.7%					
Luminosity	5.9%		5.9%	5.9%	5.9%	5.9%
Lepton ID Efficiencies	3.6%		3.6%	3.6%	3.6%	3.6%
Trigger Efficiencies	0.4%		0.5%	0.5%	0.5%	0.5%
Fake Rates		50%				

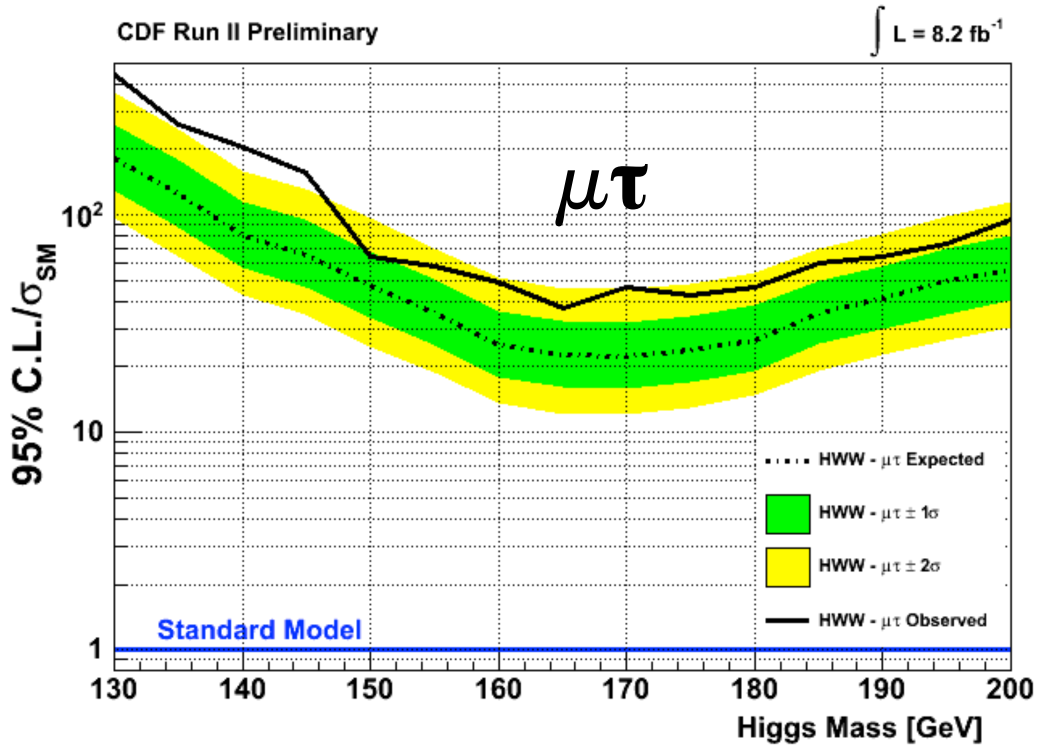
CDF Run II Preliminary $\int \mathcal{L} = 8.2\ \text{fb}^{-1}$

H→ 4ℓ	120	130	140	150	160	170	180	190	200	210	2 20	230	240	250	260	270	280	290	300
$-2\sigma/\sigma_{SM}$	58.0	21.5	12.4	10.0	15.9	24.4	18.1	7.1	7.6	9.4	10.2	12.2	12.7	14.6	16.3	18.3	19.2	21.7	23.0
$-1\sigma/\sigma_{SM}$	67.0	23.9	13.2	10.9	18.0	30.9	19.9	8.3	9.7	11.1	12.3	13.9	15.0	17.5	19.0	20.9	20.8	24.0	26.0
Median/σ_{SM}	**82.8**	**27.2**	**15.6**	**12.8**	**23.3**	**40.2**	**26.2**	**11.1**	**12.9**	**14.9**	**16.6**	**17.8**	**19.4**	**23.0**	**25.4**	**26.6**	**26.3**	**32.0**	**34.6**
$+1\sigma/\sigma_{SM}$	111.2	38.0	21.0	17.0	30.6	55.7	37.4	14.8	17.4	21.1	23.5	25.3	27.4	32.9	36.0	38.0	37.2	46.3	45.6
$+2\sigma/\sigma_{SM}$	149.3	49.9	31.1	24.2	43.3	73.2	47.4	21.7	22.0	29.8	37.8	36.4	38.9	43.1	47.7	54.1	49.5	63.1	64.6
Observed/σ_{SM}	**101.7**	**35.1**	**21.6**	**15.5**	**28.5**	**46.4**	**21.9**	**11.6**	**9.3**	**9.5**	**12.1**	**21.3**	**20.1**	**18.3**	**19.0**	**20.1**	**21.6**	**29.1**	**33.3**

H → 4ℓ

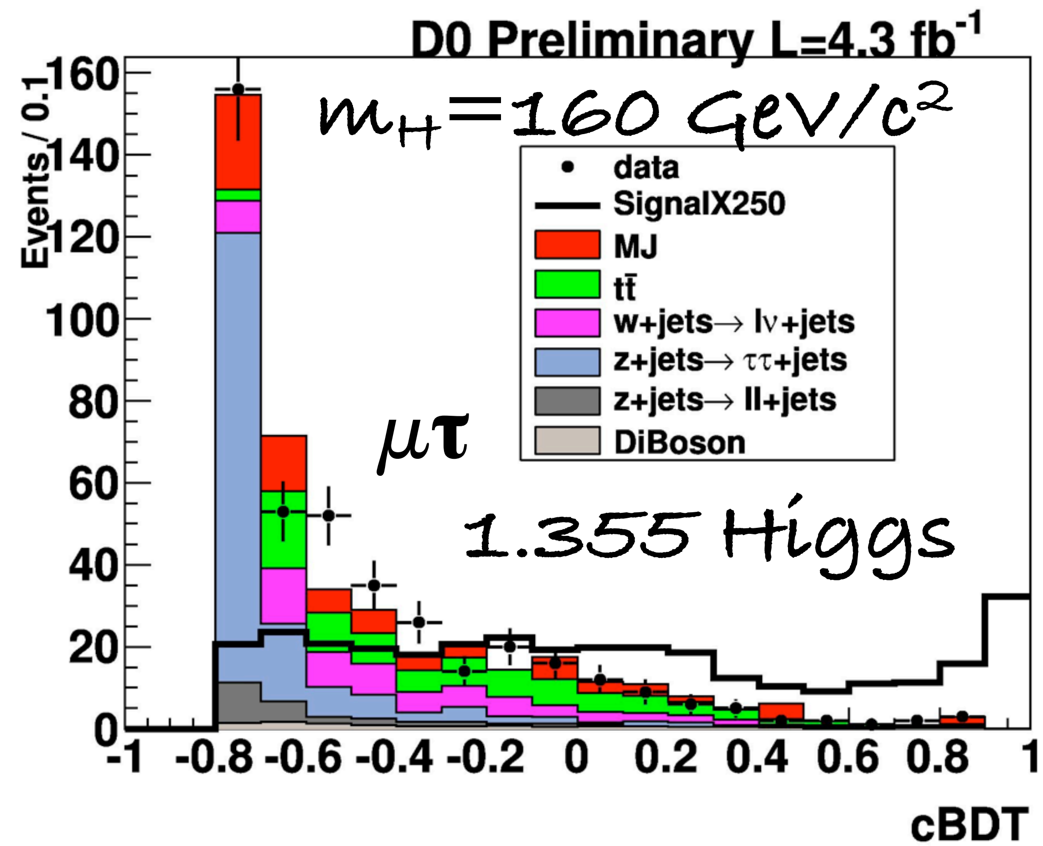
$(l\nu)\ (\tau_{had}\nu)$ Limits





$(l\nu)\ (\tau_{had}\nu)$ + 2 or more jets @ 4.3 fb^{-1}

- Signal from both $H \rightarrow WW$ and $H \rightarrow \tau\tau$
- Train Boosted Decision Trees (BDT)
  - Low $\tau\tau$: GGF
  - Intermediate $\tau\tau$, WW : GGF, VH
  - High WW : GGF, VH, VBF
- Form a combined BDT
- Muon channel: B=405, Data=414
- Electron channel: B=198, Data=188

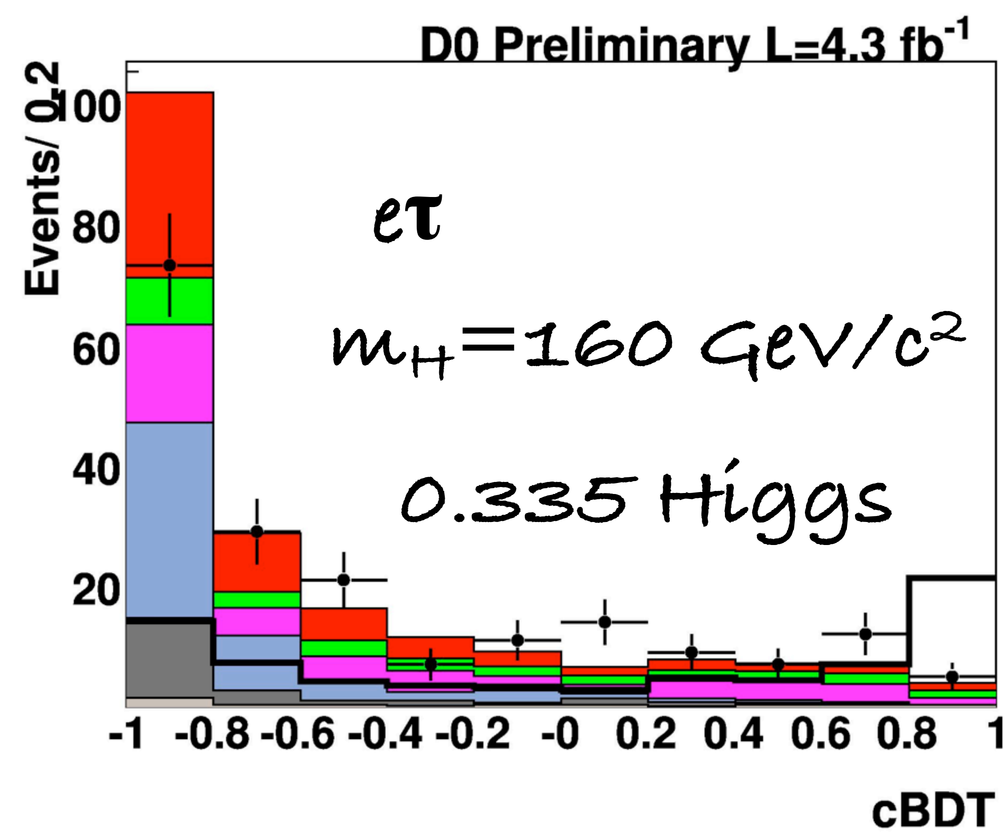


$\mu\tau$

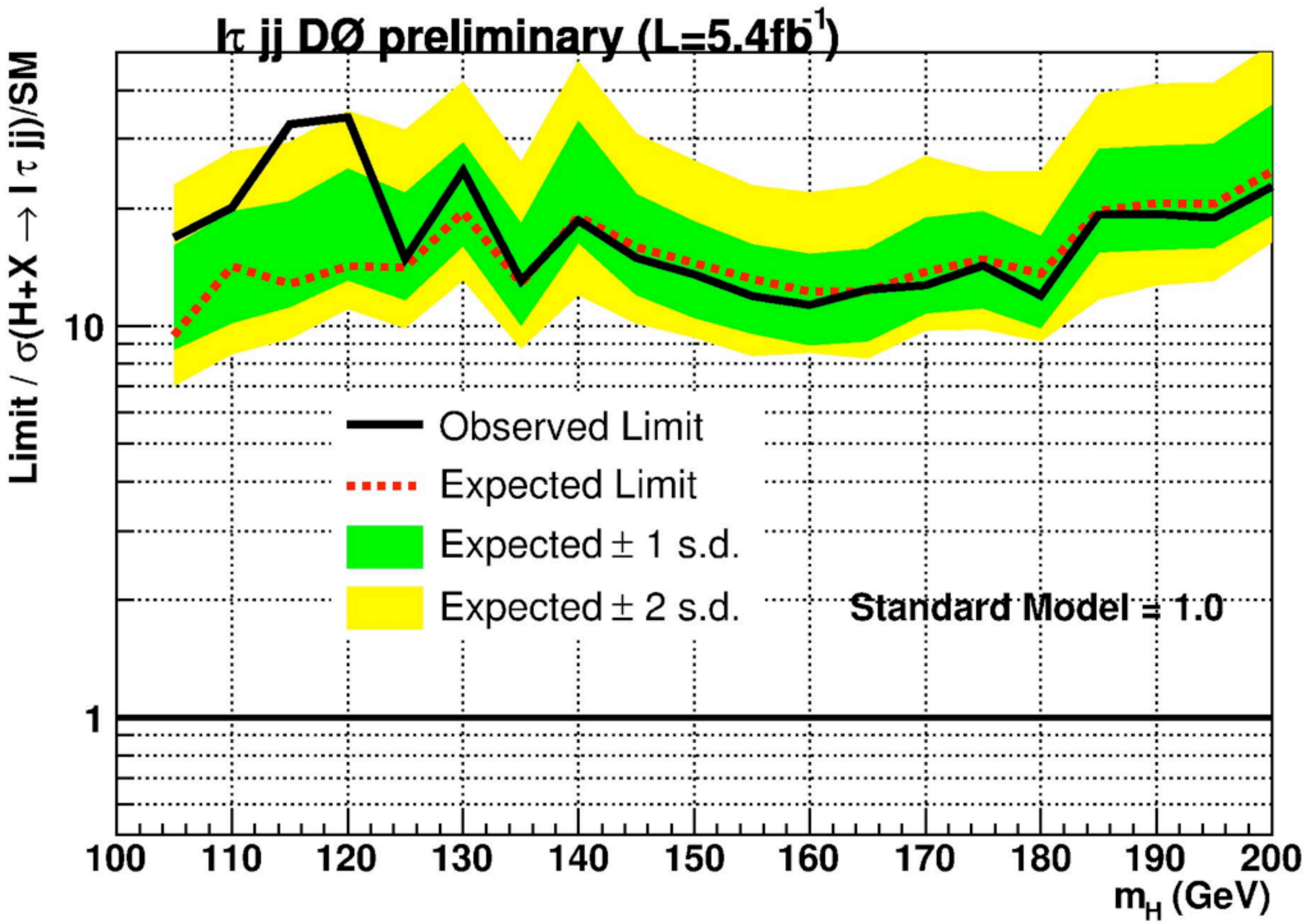
τ type	$t\bar{t}$	W+jets	$Z_{\mu\mu}$+jets	$Z_{\tau\tau}$+jets	DB	MJ	ΣBkgd	Data
type 1	7.9	5.7	2.9	17.9	1.3	11.4	47.2	56
type 2	65.7	37.5	16.7	108.8	8.3	40.4	277.6	287
type 3	8.3	21.6	2.7	27.7	1.6	18.2	80.2	71
All	82.0	64.8	22.3	154.5	11.3	70.0	404.9	414

$e\tau$

τ type	$t\bar{t}$	W+jets	Z_{ee}+jets	$Z_{\tau\tau}$+jets	DB	MJ	ΣBkgd	Data
type 1	2.3	2.9	0.6	6.3	0.6	6.0	18.8	10
type 2	14.9	21.8	17.2	30.9	1.5	32.0	118.4	117
type 3	7.2	17.8	2.0	11.4	1.4	21.7	61.1	61
All	24.4	42.6	19.8	48.6	3.6	59.2	198.3	188



(lν) ($\tau_{had}\nu$) + 2 or more jets Limits



- Flat sensitivity over a wide mass range
- Best Observed (Expected) at m_H= 160 GeV/c^2 of 11 (12) x σ_{SM}

[Conference Note D0 Note 6171-CONF]