Search for SM Higgs Production in the $H \rightarrow WW \rightarrow l\nu jj$ Channel with the DZero Detector

PHENO 09, Madison

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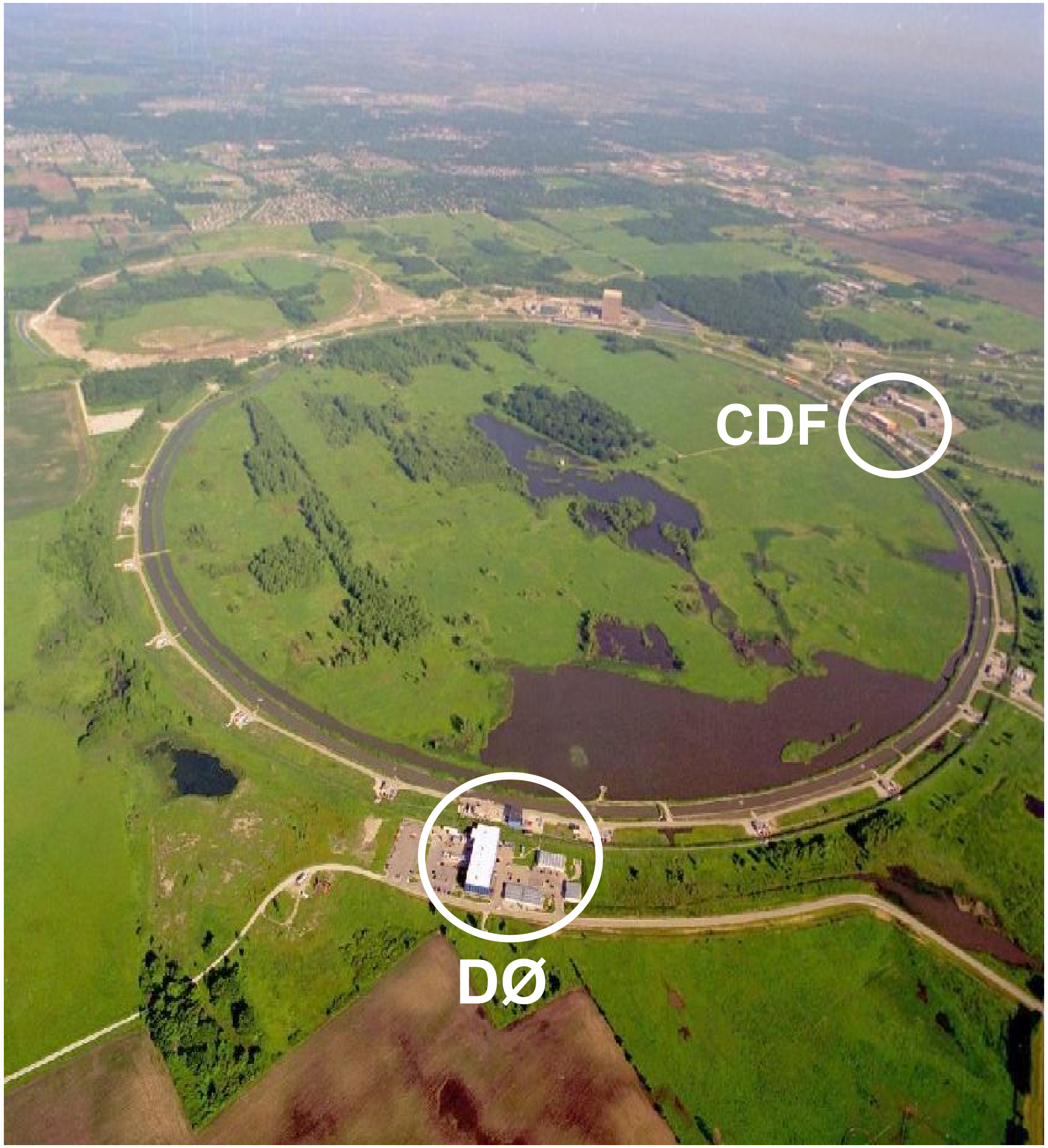
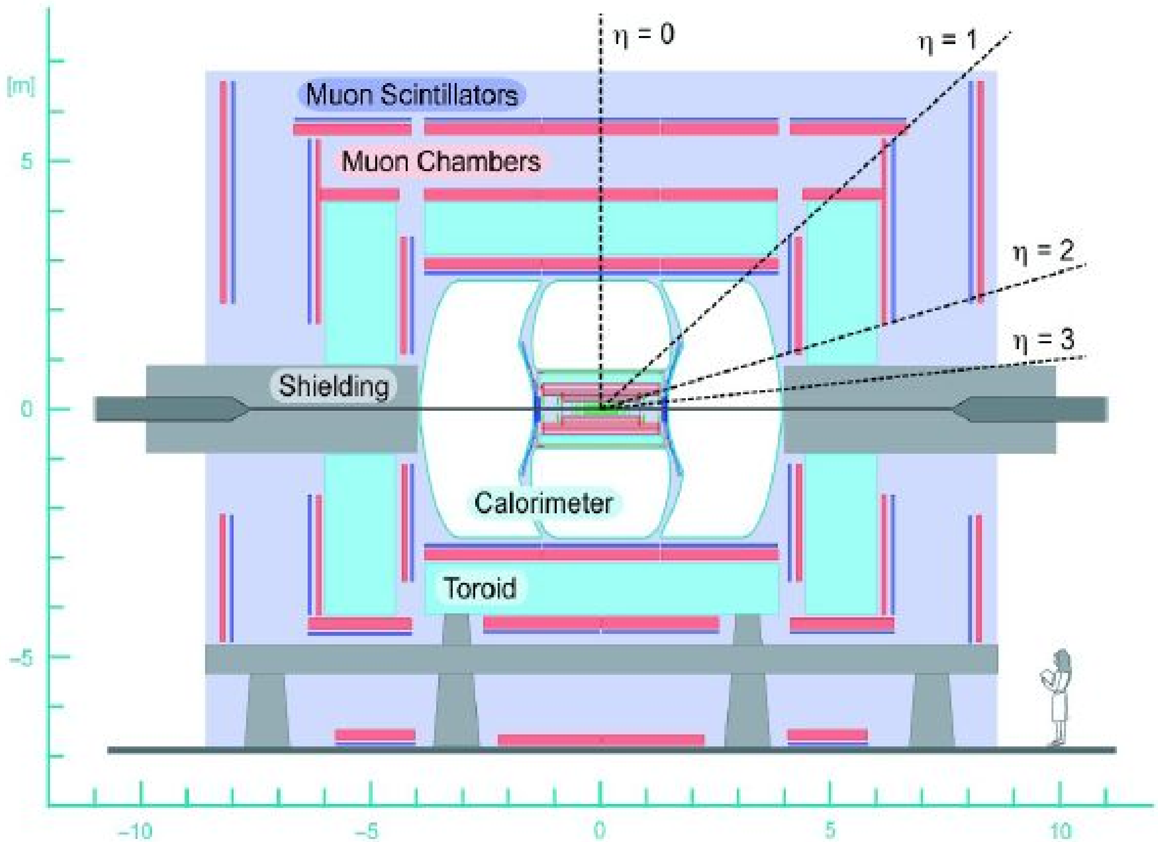
On behalf of the DØ collaboration

Tevatron Collider in Run II



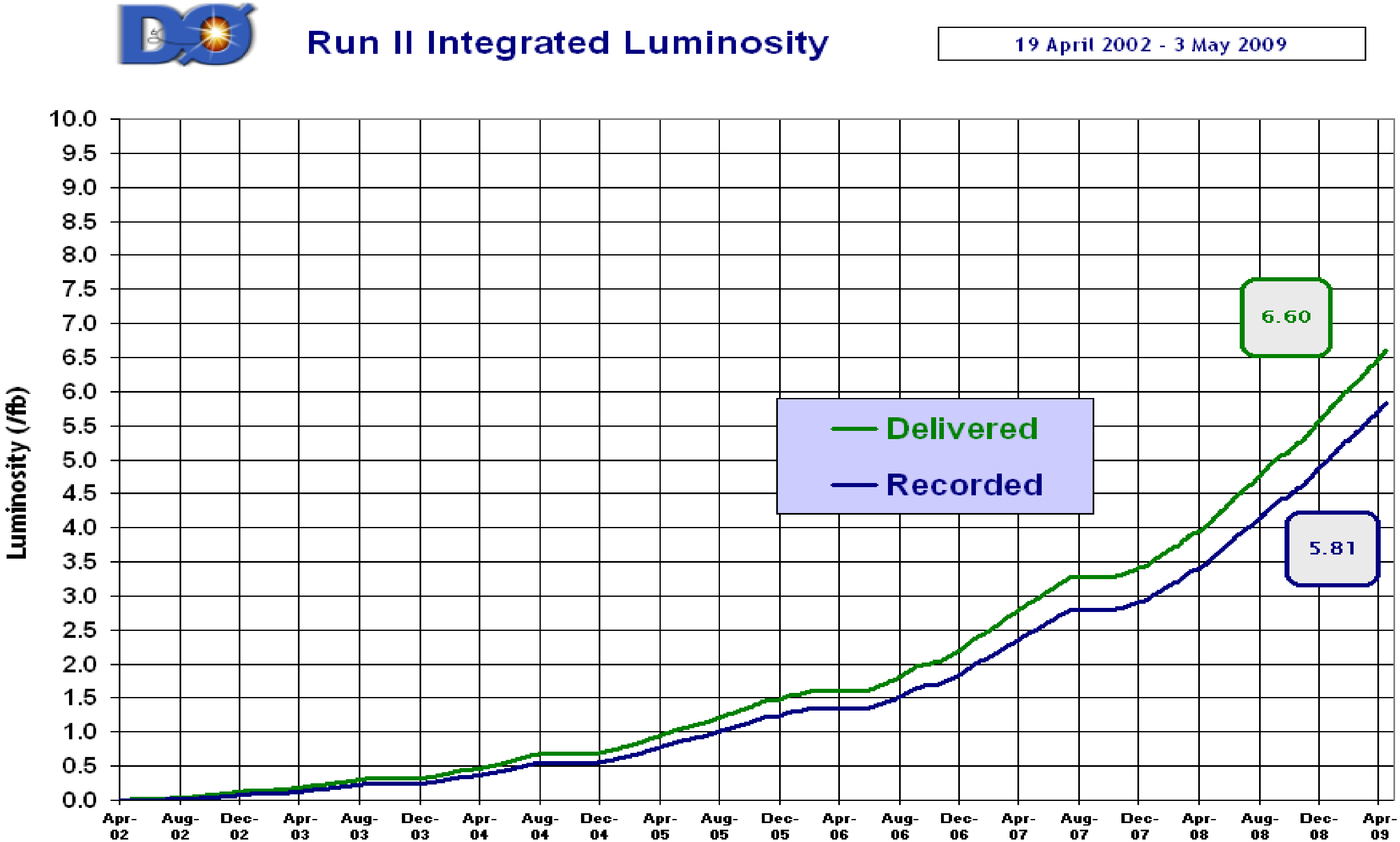
- Run II ongoing since 2001
- Colliding protons and antiprotons at $\sqrt{s}$=1.96TeV
- Delivers a dataset equal to Run I (~100pb^{-1}) every 2 weeks (per detector)
- Total delivered integrated luminosity for Run II is >6fb^{-1} (per detector)
- **Still the high energy frontier**

The DØ Detector



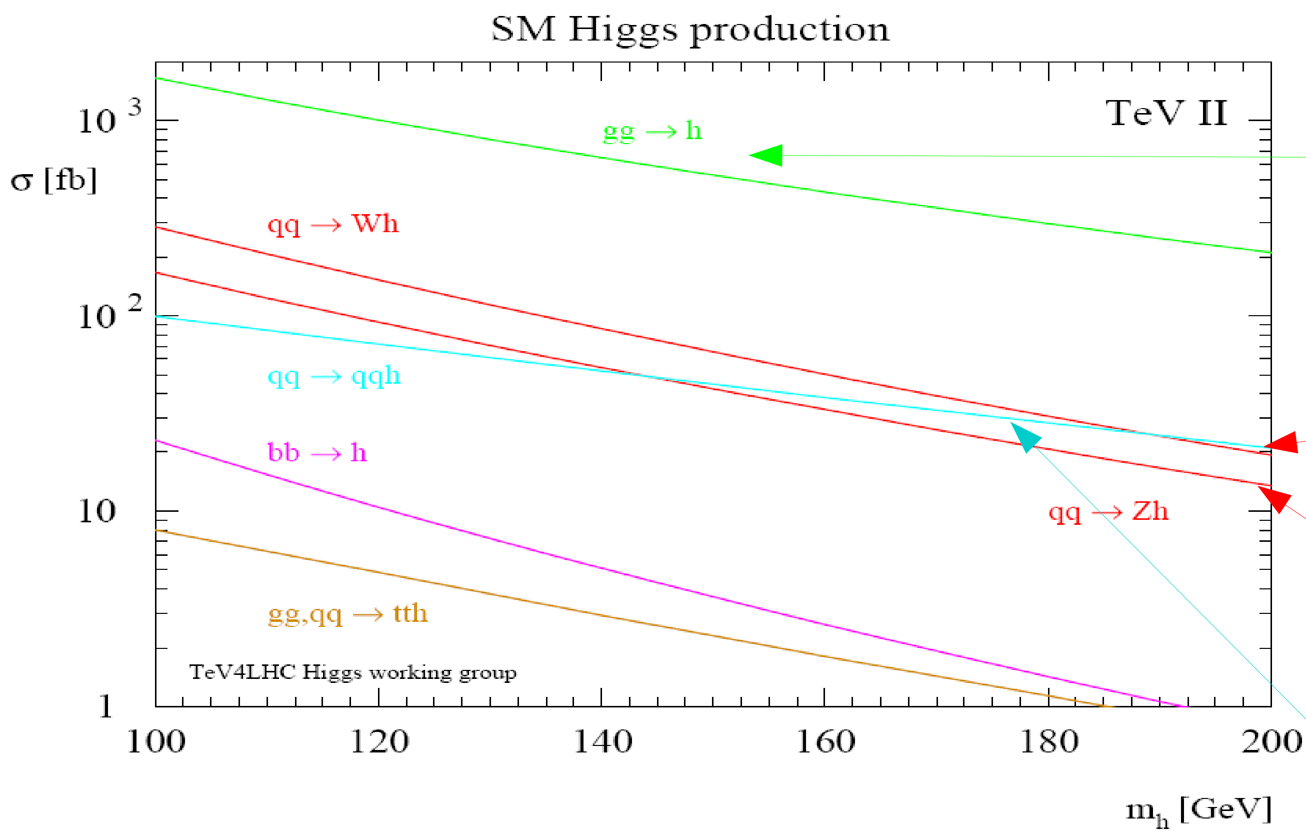
- 5k ton multi-purpose detector
- Silicon detector and Fiber Tracker in solenoidal magnetic field
- Sampling calorimeter surrounding the superconducting solenoid magnet
- Muon system consists of scintillators and drift chambers
- Detector is running smoothly with high data taking efficiency (>90%)

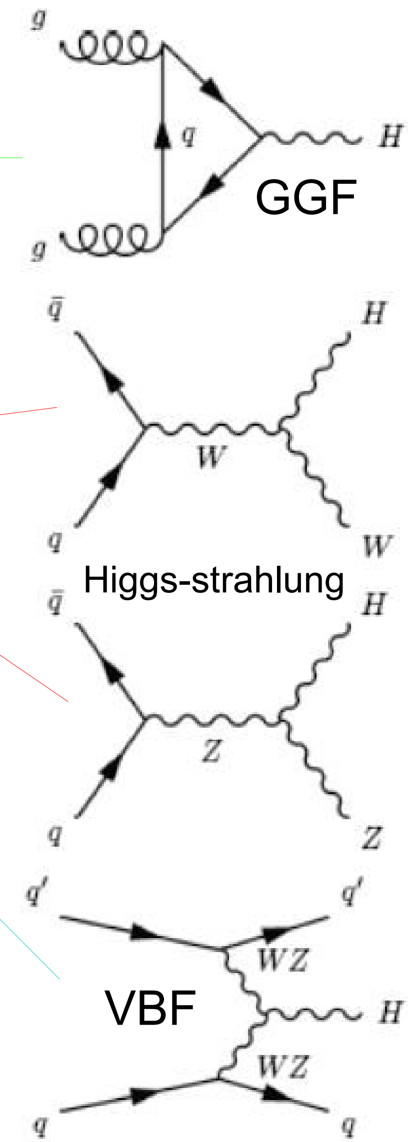
The Dataset



- Results presented here are based on ~3fb^{-1}
- We have more data waiting to be analyzed (>5.8fb^{-1} on tape)

Higgs Production ...

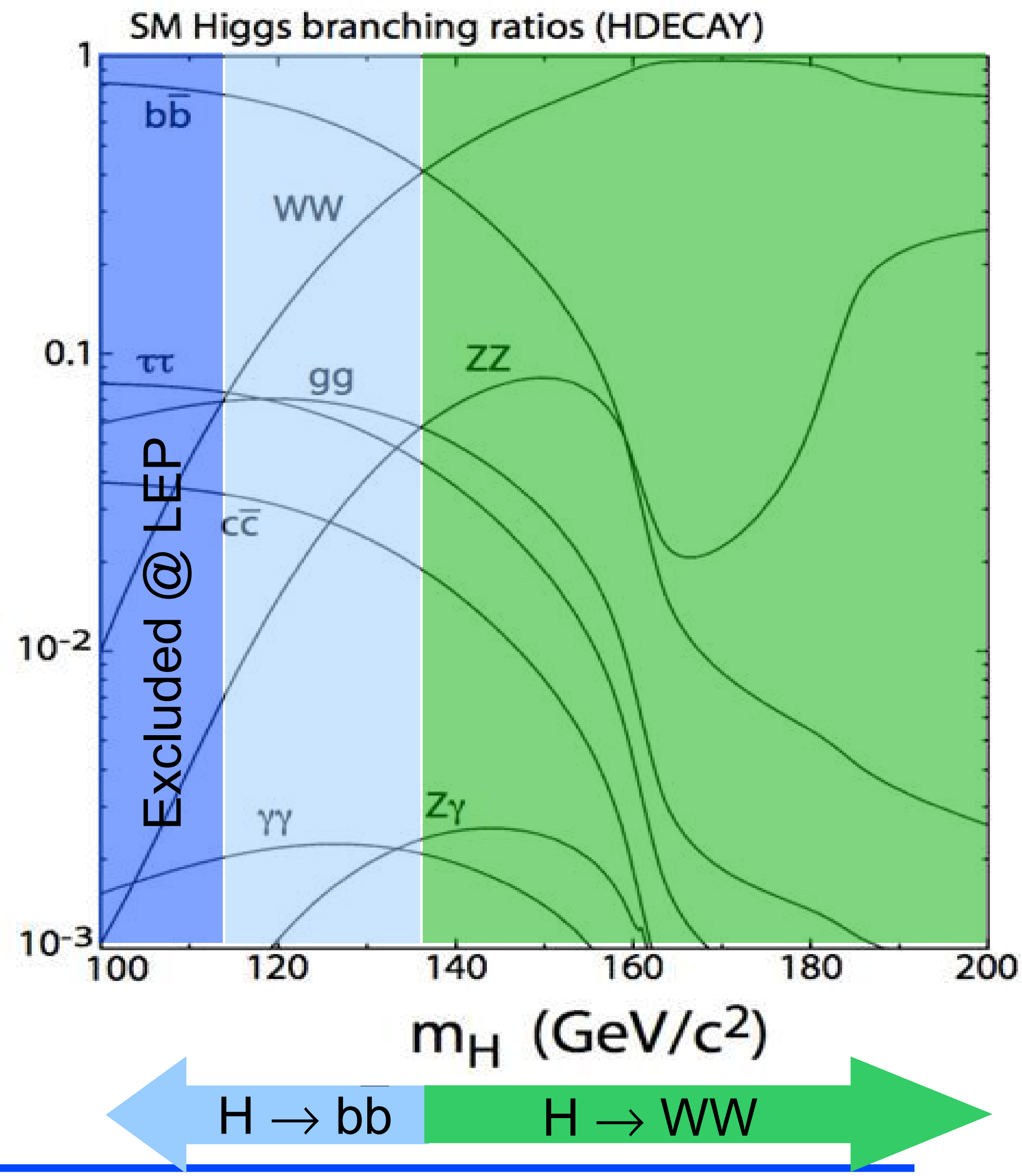




- Most SM Higgs bosons are produced via gluon-gluon fusion (GGF) and Higgs-strahlung (W/Z-associated production)
- For high-mass Higgs searches vector-boson fusion (VBF) becomes relevant as well

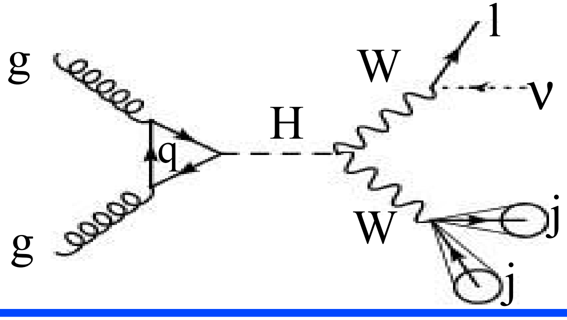
... and Decay

- Light Higgs: m_H < 135 GeV:
  - $H \to b\bar{b}$ decay
- Heavy Higgs: m_H > 135 GeV:
  - $H \to$ WW decay
- Search strategy at the Tevatron:
  - Low mass: Cannot use GGF due to the overwhelming multijet background ($pp \to bb$). Use W/Z-associated production instead.
  - High mass: Use GGF process.
  - Take advantage of leptonic W/Z decays to suppress multijet background



Analysis Introduction

- This analysis searches for a high mass SM Higgs boson
- $H \to WW$ is the most sensitive search channel at the Tevatron
- Approaching SM sensitivity
- So far only leptonic final states have been included in the Higgs search combination ($gg \to H \to WW \to l\nu l\nu$)
- Our analysis looks at semi-leptonic final states: $gg \to H \to WW \to l\nu jj$ ($l=\mu,e$)
  - H production via gluon-fusion
  - Large branching fraction for hadronic W decays
  - Large backgrounds from W+Jets production
- We use a Neural Network (NN) to discriminate Signal from Background



Data & MC Samples

- Data:
  - Trigger:
    - Combination of Lepton+Jets and Single Lepton triggers
  - Luminosity:
    - **Electron channel: 3.1fb^{-1}**
    - **Muon channel: 2.6fb^{-1}**
- MC:
  - Gluon fusion HWW (Pythia)
  - W/Z+Jets (Alpgen+Pythia) **Dominant background**
  - Dibosons: WW, WZ, ZZ (Pythia)
  - ttbar (Alpgen+Pythia)
  - Single top (CompHEP+Pythia)

Event Selection

- Leptons:
  - $p_T > 15$ GeV
  - $|\eta_{Electron}| < 1.1$, $|\eta_{Muon}| < 2$
- MET > 15 GeV
- Triangle Cut:
  $M_{trans\ W} > 40 - MET/2$
- At least 2 jets with associated primary vertex tracks:
  - Jet cone algorithm (dR=0.5)
  - $p_T > 20$ GeV
  - $|\eta| < 2.5$

Number of events passing pre-selection in the muon channel

Data	Total Background	W/Z+Jets	Diboson	Top	Multijet
25503	25502	18912	504	691	5395

Number of events passing pre-selection in the electron channel

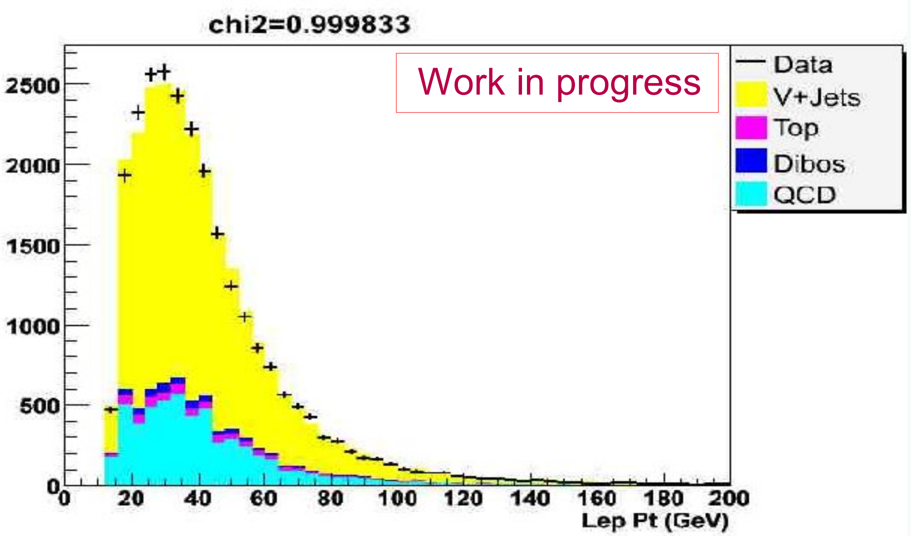
Data	Total Background	W/Z+Jets	Diboson	Top	Multijet
41214	41132	32110	868	1595	6559

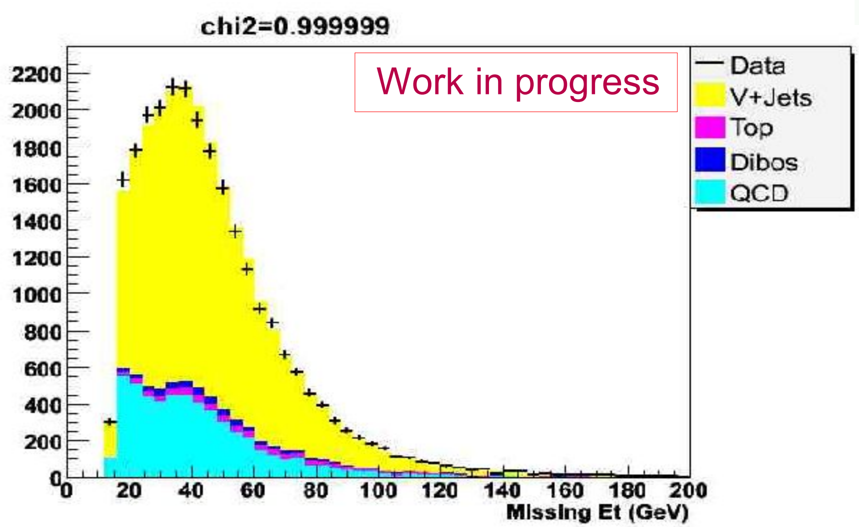
Background from Multijet Production

- Jets can mimic electrons through fluctuations in hadronic showers. Muons can be produced via heavy flavor decay or in the process of jet showering.
- Estimated from data using the following procedure:
  - Define 3 samples: Loose, Tight, Orthogonal (=Loose-Tight)
    - Loose and Tight are used to measure ε_{QCD} and ε_{Sig}
    - Orthogonal is used to derive shape of multijet background
- Muon channel: 21% multijet background events
- Electron channel: 16% multijet background events
- Using lepton p_T dependent ε_{QCD} and ε_{Sig}

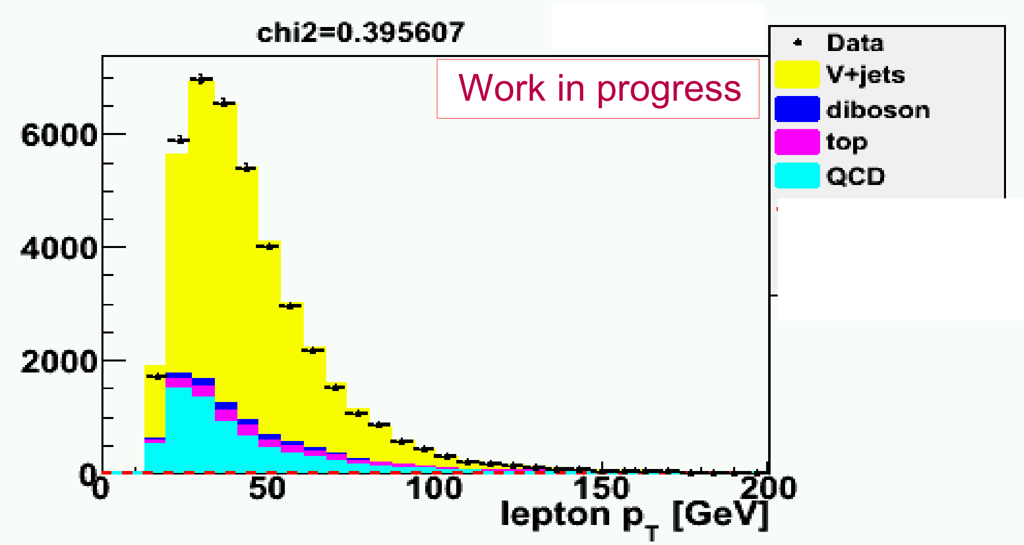
Data vs MC (1)

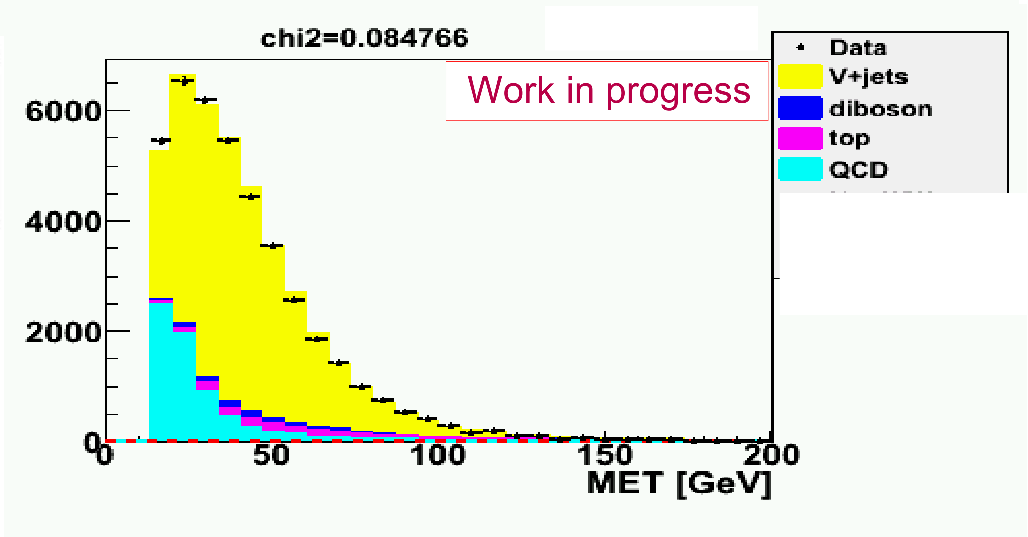
Muon Channel





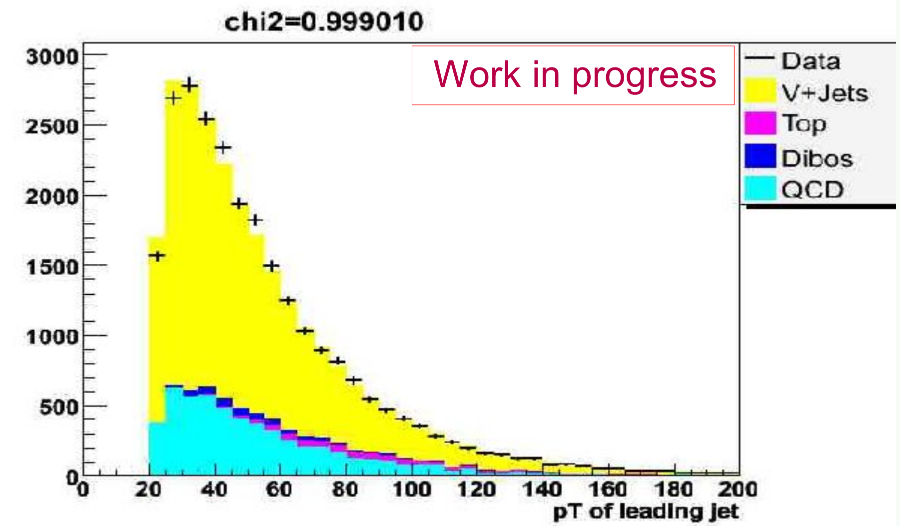
Electron Channel

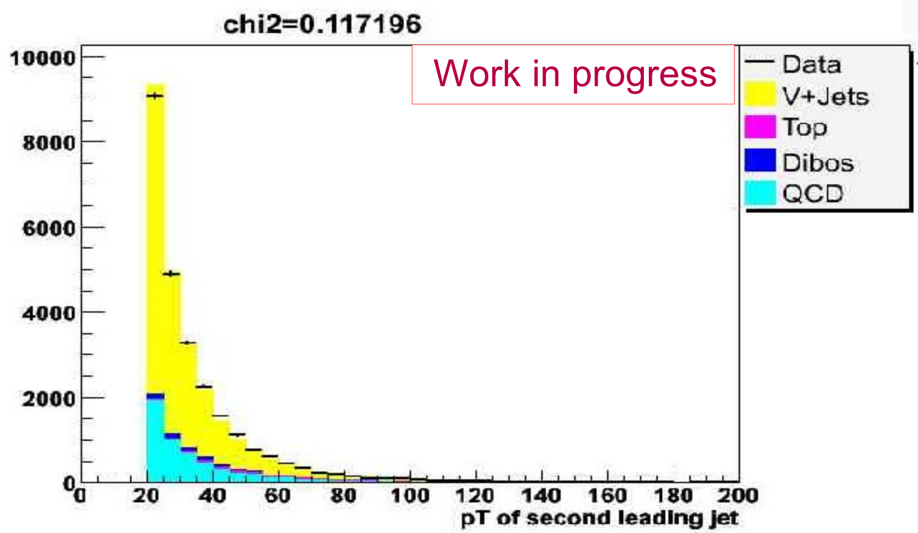




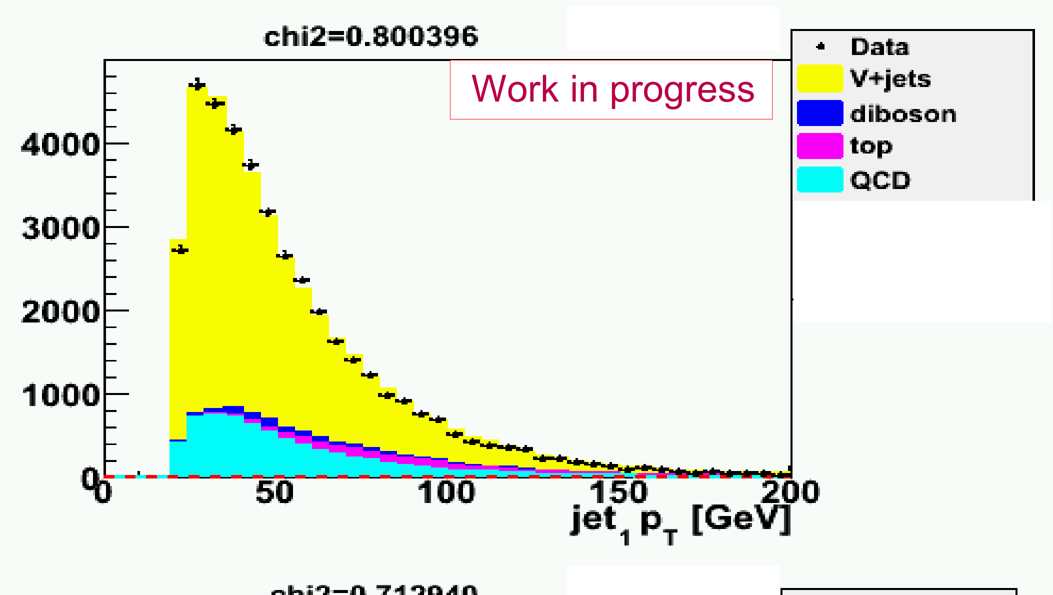
Data vs MC (2)

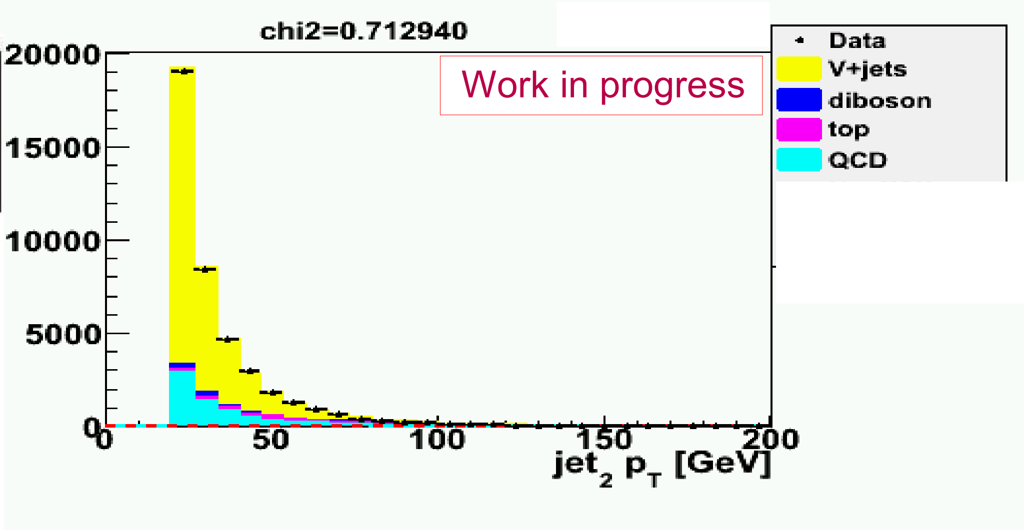
Muon Channel





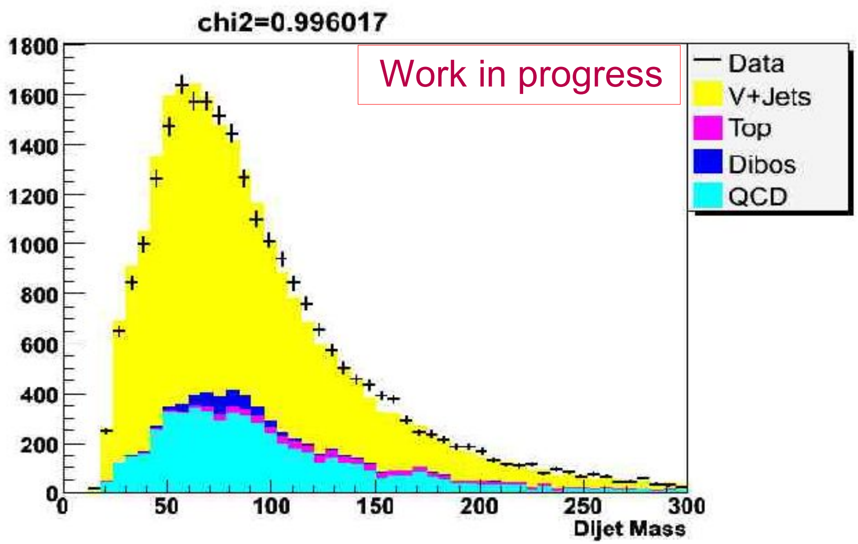
Electron Channel

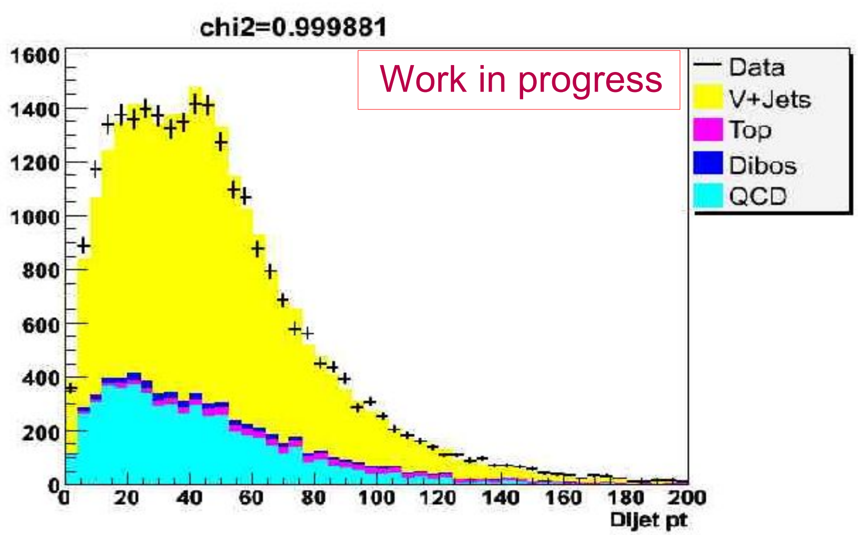




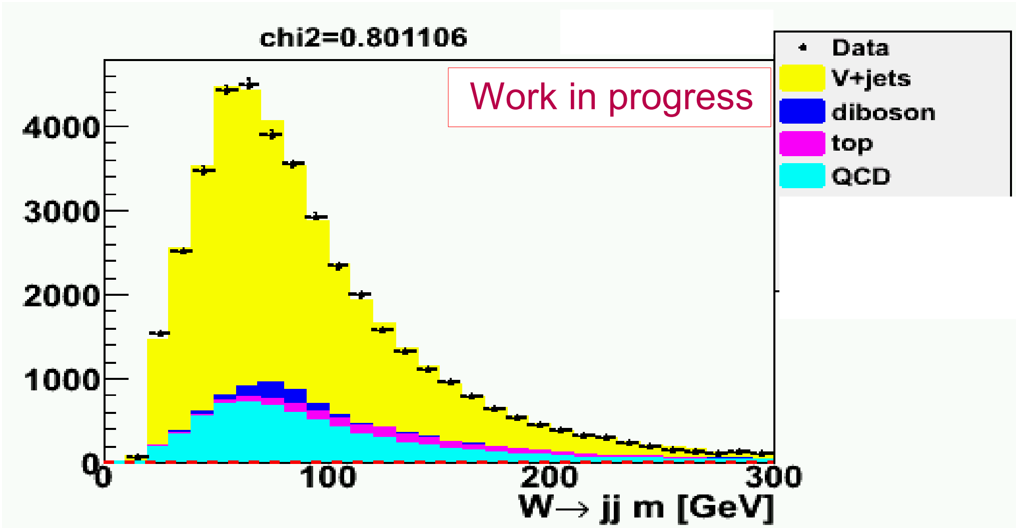
Data vs MC (3)

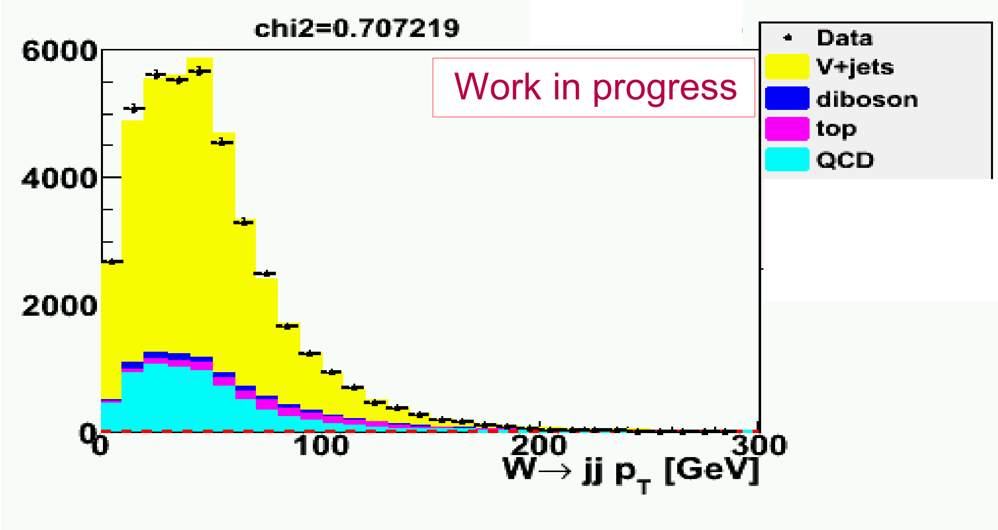
Muon Channel





Electron Channel

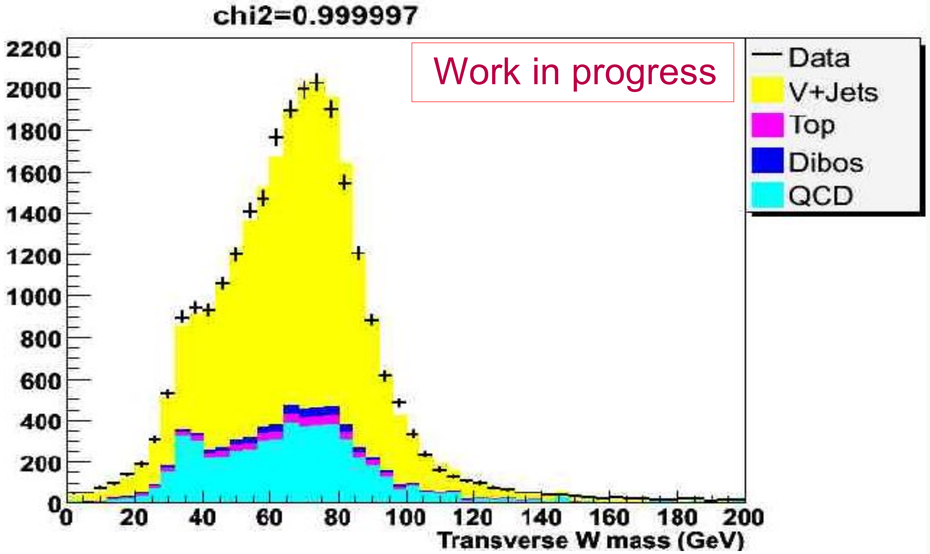


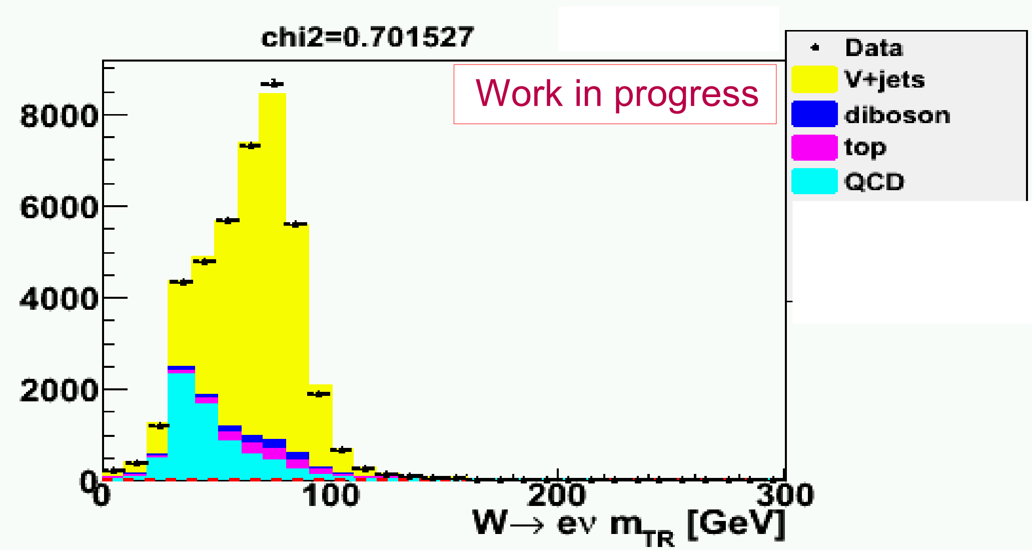


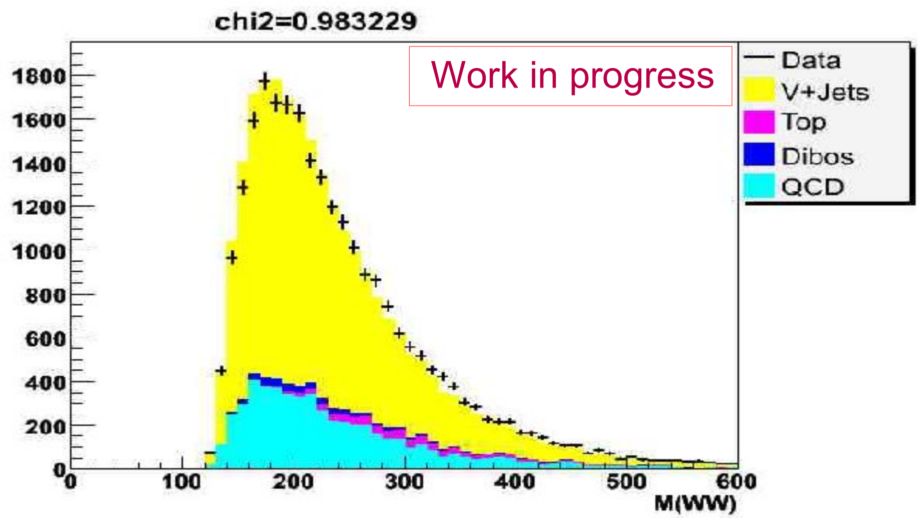
Data vs MC (4)

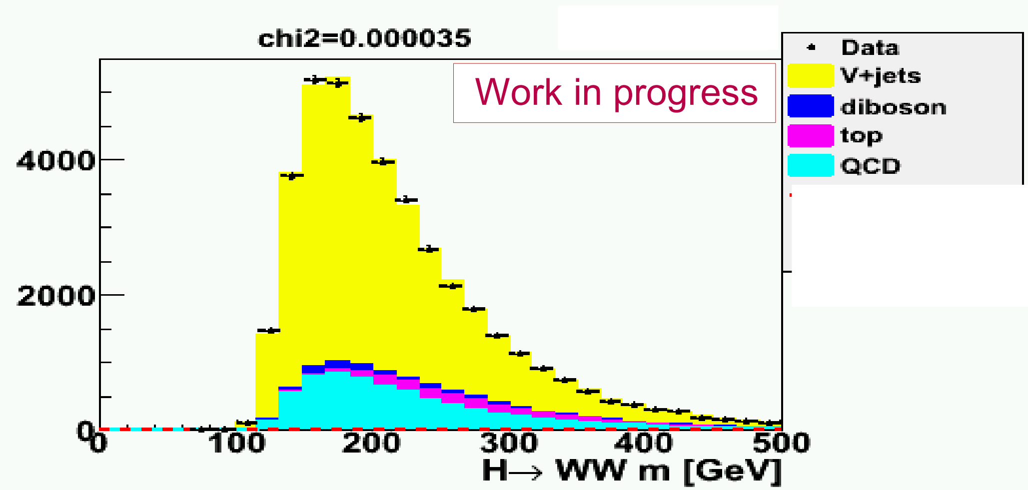
Muon Channel

Electron Channel









Neural Network

- Using NN based on TMultilayerPerceptron class in ROOT
- Train signal and combined background samples for each Higgs mass point
- Looked at many variables for good signal/background discrimination (using KS distance parameter as a quantitative measure)
- Found that best discriminant variables vary with Higgs mass
- Chose 3 separate NNs depending on Higgs mass:
  - M_H<150GeV
  - 155 GeV < M_H < 170 GeV
  - M_H > 175 GeV
- NN output distributions are used as a discriminant to set upper limits on the rate of Higgs production with decay to $H \rightarrow WW \rightarrow l\nu jj$

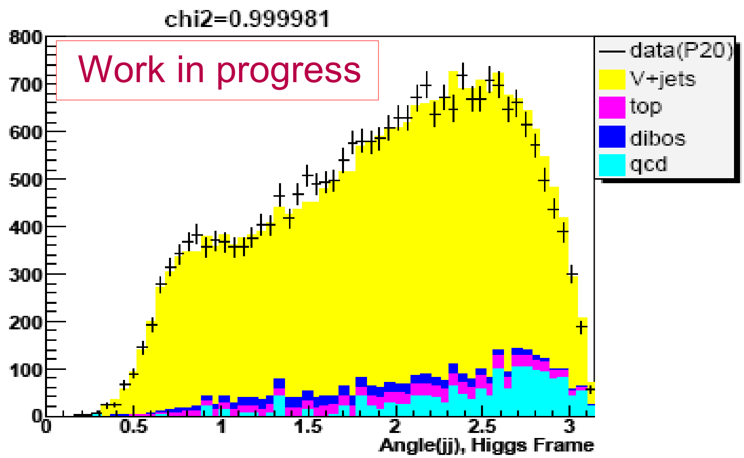
NN Variables

	low mass NN mH < =150	medium mass NN 155 <= mH <= 170	high mass NN mH >= 175	
AngleWj0higgs	E	B	B	3D angle betw. j0 and lep W in H CM frame
Aplanarityjjlnu			M	
Beta		B	B	|p|/E for hadronic W
Centrality		E	E	Sum of pT / Sum of E for lep and all good jets
CMThetajj	B	B	B	3D angle between dijet pair in H CM frame
DijetPt	B	B		
DijetMass	M	M	B	
DijetTrMass		E		
Htjets			B	
Htjjlepnu	B	B		Sum of pt for lepton, MET, and all good jets
Jet0leptonDR	E	E		dR(lepton, lead jet associated w/ W_had
Jet1leptonDR	E			
Ktmax		M	E	dR(j1,j2)*ET(j1)/(ET(lep)+MET)
Ktmin	E	E		dR(j1,j2)*ET(j2)/(ET(lep)+MET)
LepE	B	B		
LepPT	E			
MET	E	E		
METbis	E			Dot product of MET and dijet bisector
METLepDPhi	E	B		
Ptrel		B	B	Magnitude of j1 pT perpendicular to dijet syst.
RatioJetEnHiggs		B		
SphericityLepjj		M	B	Sphericity calculated from lepton and dijet pair
Wpt	B	B		
Wtrmass	E			
WWBisDPhi	B	B		dPhi between leptonic W and dijet bisector
WWTrMass	B			
WWMass		B	B	
WWDphi	E	E		
WWDR			E	

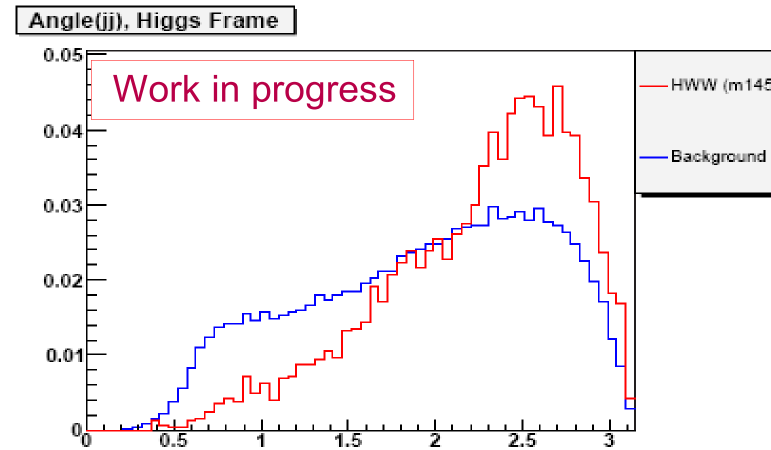
E = Electron Channel, M = Muon Channel, B = Both Channels

NN Input: (Data vs Bkg) & (S vs Bkg)

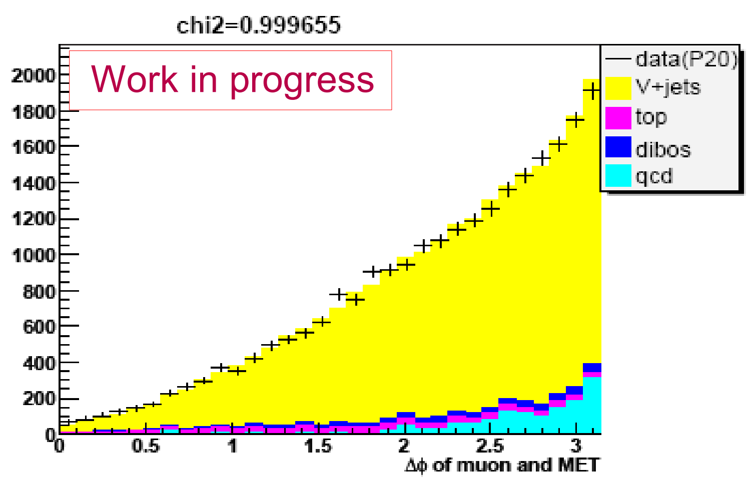
Muon Channel



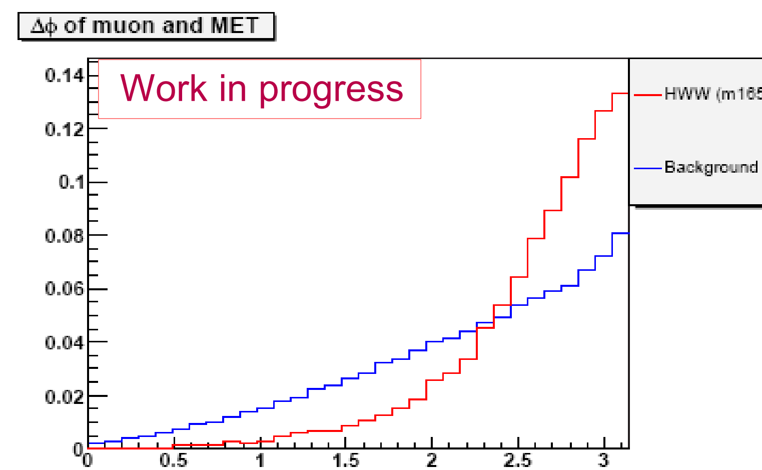
Angle between jets in Higgs frame (data vs background)



Angle between jets in Higgs frame (signal vs background)



Delta Phi between muon and MET (data vs background)



Delta Phi between muon and MET (signal vs background)

Systematics

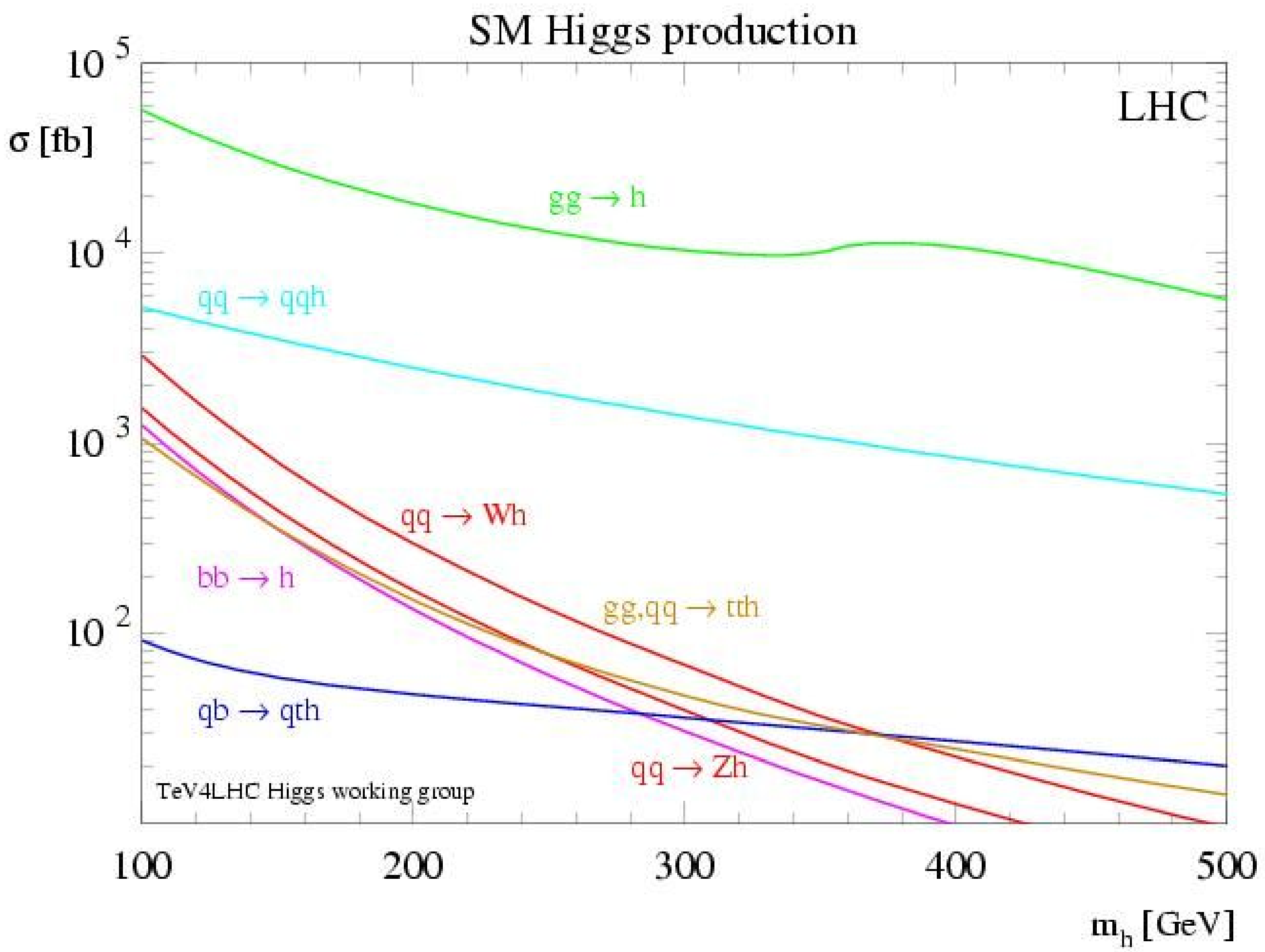
- Two types of systematic uncertainties are considered for this analysis:
  - Overall systematics that affect relative normalizations:
    - Cross Sections
    - Multijet Background Estimation
    - Luminosity
    - PDF
    - Jet Energy Resolution
  - Differential systematics that affect the NN-output distributions:
    - Jet Energy Scale
    - Jet ID
    - Electron ID
    - Trigger
    - ALPGEN Tuning

Status & Outlook

- Currently working on finalizing trigger selection and corrections for data vs MC comparisons
- Next steps:
  - Revisiting NN and limits
  - Inclusion in Tevatron combination
- Improvements:
  - Utilizing all available data ($\sim 5 fb^{-1}$)
  - Compare different multivariate analysis techniques (NN, Boosted Decision Tree, Random Forest, ...)

Backup

SM Higgs Production at the LHC



Luminosity Projection