Higgs to W^+W^- Analysis Overview at CDF

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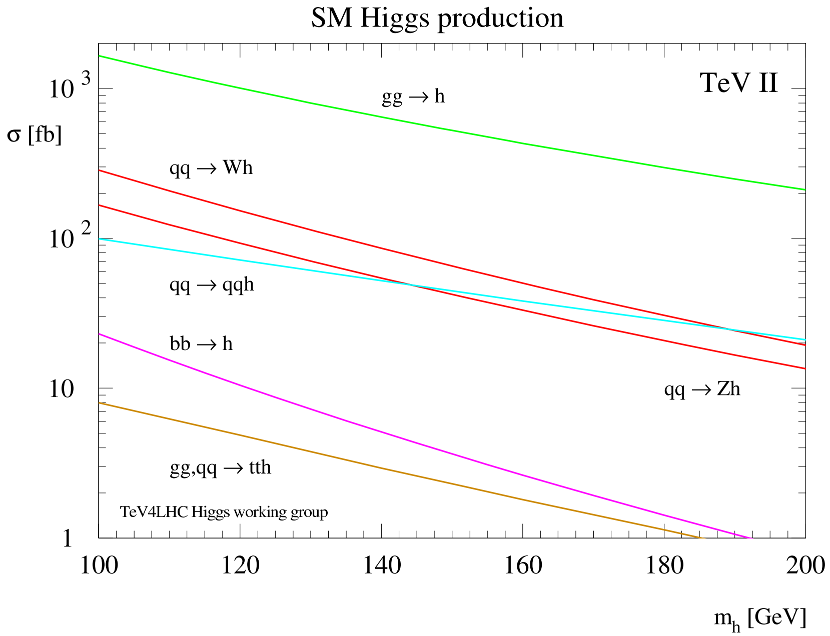
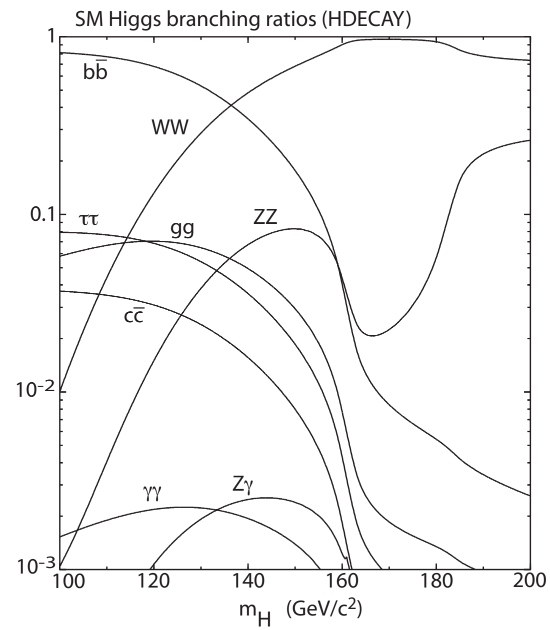
Production and Decay at CDF

CDF is a general purpose detector gathering collision data from the Tevatron proton-antiproton accelerator at Fermilab



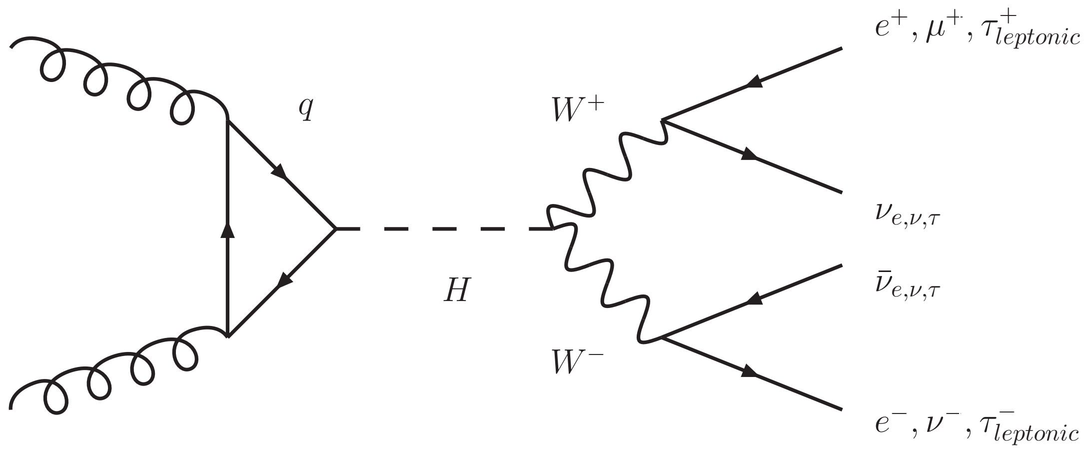
production cross section

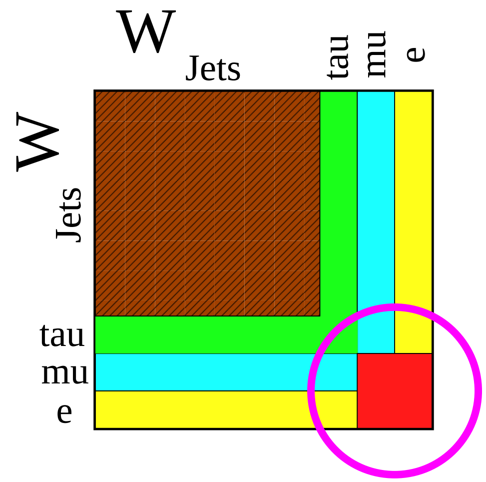


decay branching ratios

- Greatest production cross-section is gluon fusion
- for high M_H largest decay is to W^+W^-
- comparable sensitivity to $b\bar{b}$ channel at M_H=130

Decay Channel





- Only investigating W decaying leptonically, (also with τ decaying leptonically)
- Large backgrounds in hadronically decaying channels; also easier triggering
- Br($W \to e, \mu, \tau$)=33%; Br($W^+W^- \to (e, \mu, \tau_{leptonic}) + (e, \mu, \tau_{leptonic})$)=5%

Matrix Element

The probability of the observed values fitting in to the profile of a Higgs event is equal to the differential cross-section given the observed values in proportion to the total cross-section

$$P(x_{obs};M_H) = \frac{1}{\sigma_{H\rightarrow WW}(M_H)} \int \frac{d\sigma_{LO}(y;M_H)}{dy} \varepsilon(y) G(x_{obs},y) dy$$

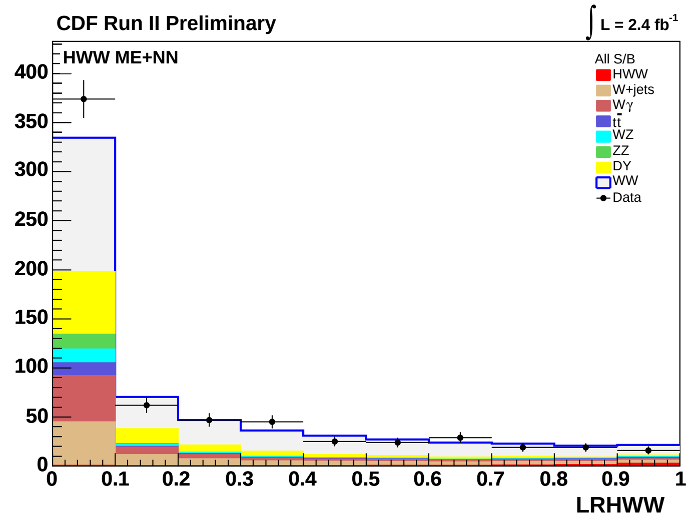
- y : phase space. These are real values as opposed to measured values
- $\frac{1}{\sigma_{H\rightarrow WW}(M_H)}$: total cross-section normalises the probability
- $\varepsilon(y)$: detector acceptance efficiency
- $\frac{d\sigma_{LO}(y;M_H)}{dy}$: leading order differential cross section
- $G(x_{obs},y)$: transfer function accounts for the detector mis-measurement
- $\int dy$: integration over phase space
- a separate calculation is done for 10 M_H mass points in the region M_H 110-200 GeV/c^2

Matrix Element Discriminator

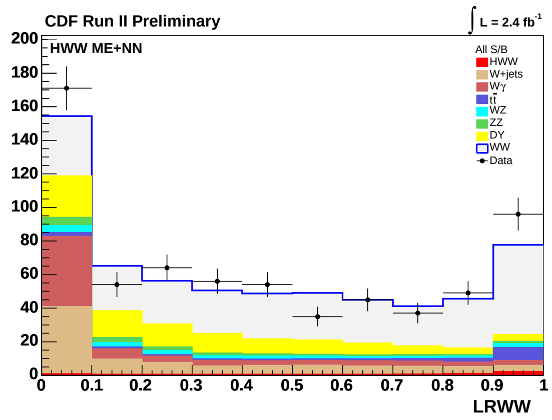
- The matrix element is calculated for $H \to W^+W^-$ and several major backgrounds, W^+W^-, $W+\gamma$, W+jets, and ZZ
- A 'Likelihood Ratio' discriminator variable is created:

$$LR = \frac{P_s}{P_s + \sum k_{bi} P_{bi}}$$

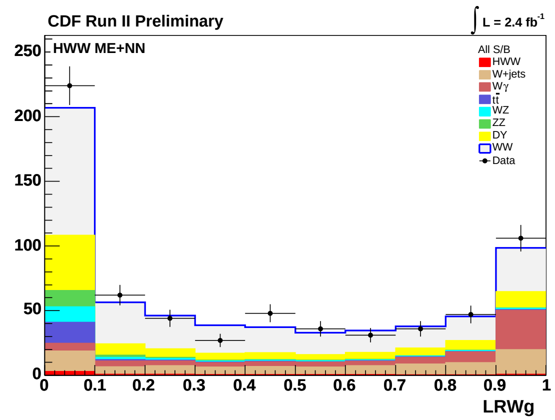
- $P_{s,b}$: ME probabilities of the signal and background
- k_{bi} : ith background weighting based on cross-section



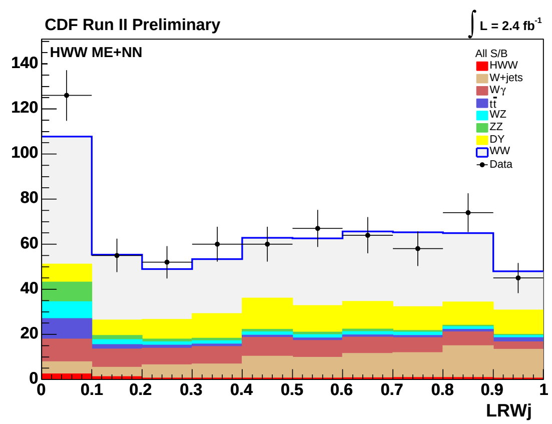
Other Matrix Element Variables



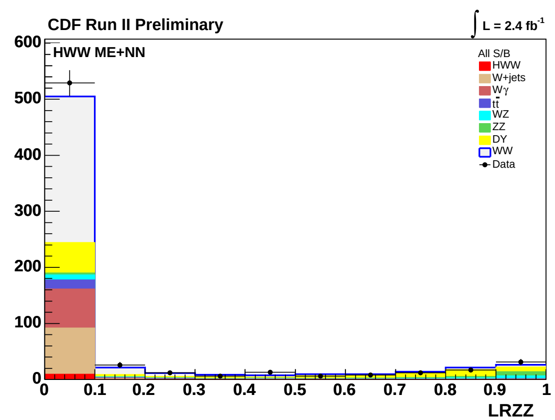
W^+W^-



$W+\gamma$



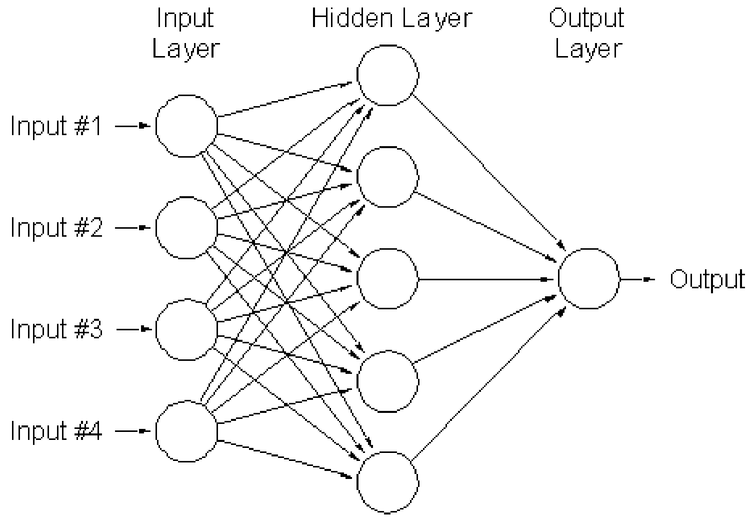
$W+$jets



ZZ

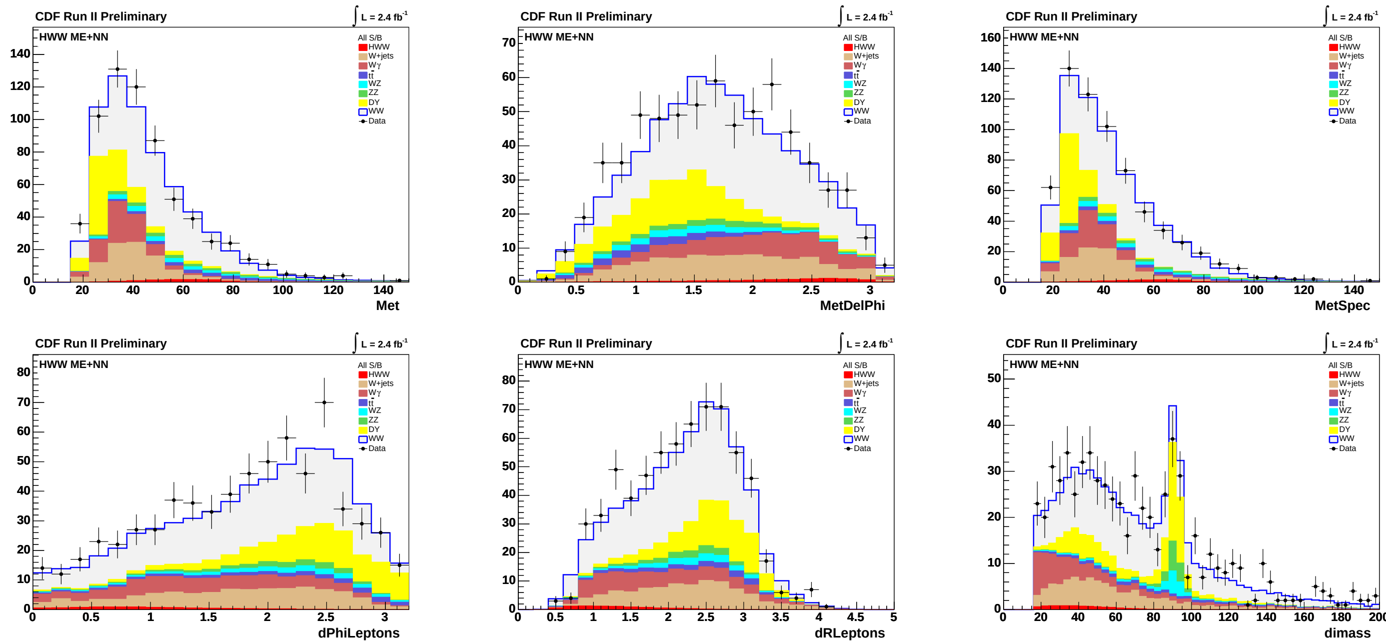
Neural Network

To gain extra 10-15% sensitivity, the matrix element variables are combined with kinematic variables in a neural net analysis



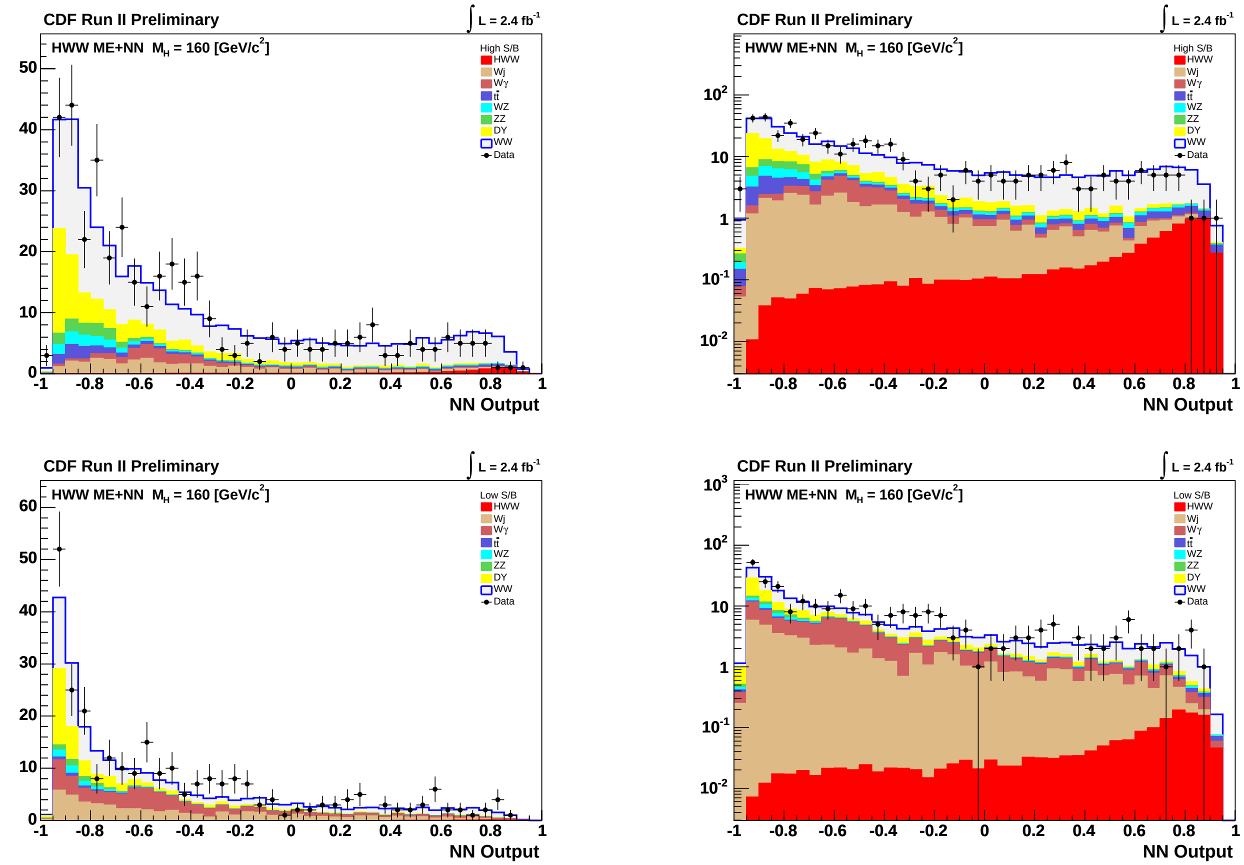
- The neural network is a series of weighted sums of the input variables
- Inputs correspond to the variables used, the output varies from -1 (background) to +1 (signal)
- The net is trained on signal and background Monte Carlo, with the background comprising of all physics backgrounds appropriately weighted by cross section

Supplemental Neural Net Variables



The most important of these is $dR_{leptons}$, the separation in angle between the leptons. This is due to the opposite spin correlation of the W particles: the helicity of the neutrino forces the visible leptons to be released in the same direction as each other.

Neural Net Stacked Templates



high s/b

low s/b

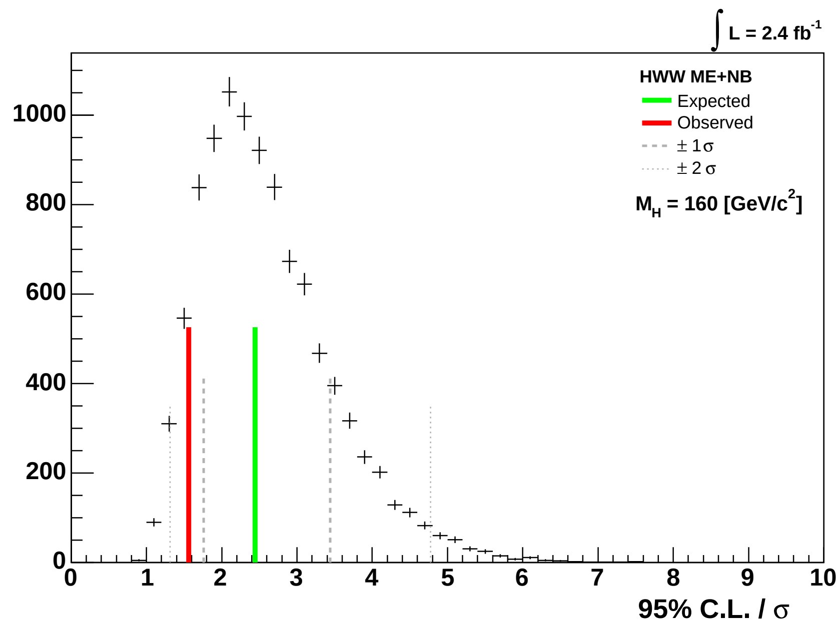
linear

log

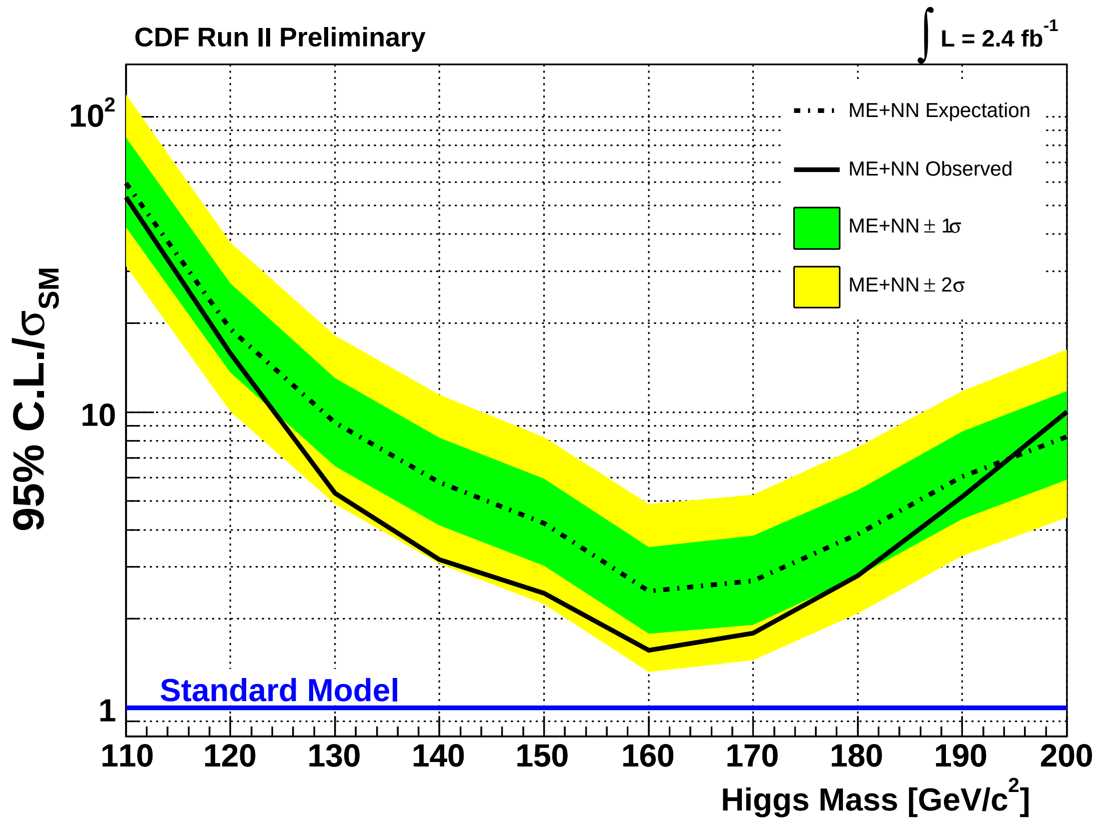
The sample is separated by lepton fiduciality into high and low signal/background samples to increase sensitivity

Likelihood Method for Limit setting

- calculate a log-likelihood of data fitting to background with no signal
- iteratively add signal, increasing σ; calculate the likelihood at each step
- integrate over the likelihoods; 95% confidence limit is set when 95% of the total likelihood lies below that cross-section
- for expected limits, create 10,000 pseudo experiments. The median corresponds to the expected limit



Limits



The cross-section limit is closest to the Standard Model prediction at M_H = 160. The observed limit is within 2 sigma of the expected limit.