Search for Standard Model Higgs Boson Production in the $WH \rightarrow WWW \rightarrow l\nu.jj.jj$ Channel at DØ.

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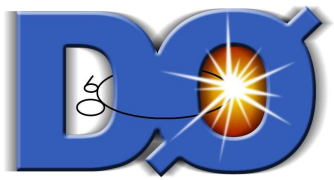
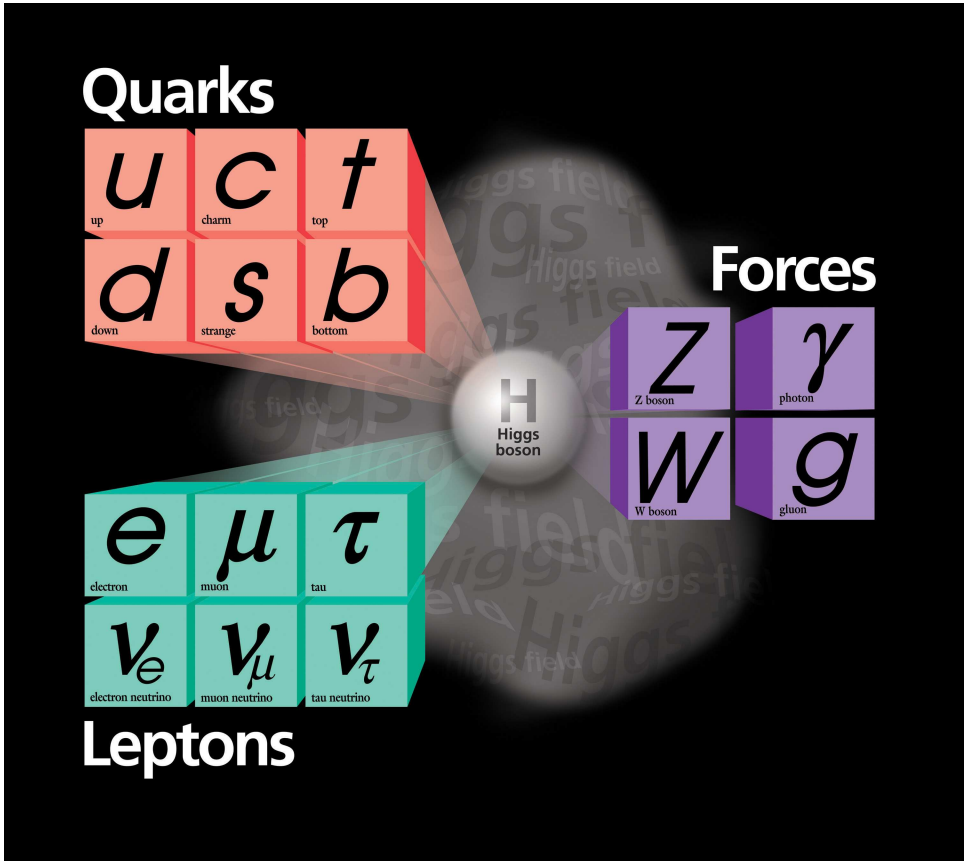


BRADLEY UNIVERSITY

Outline

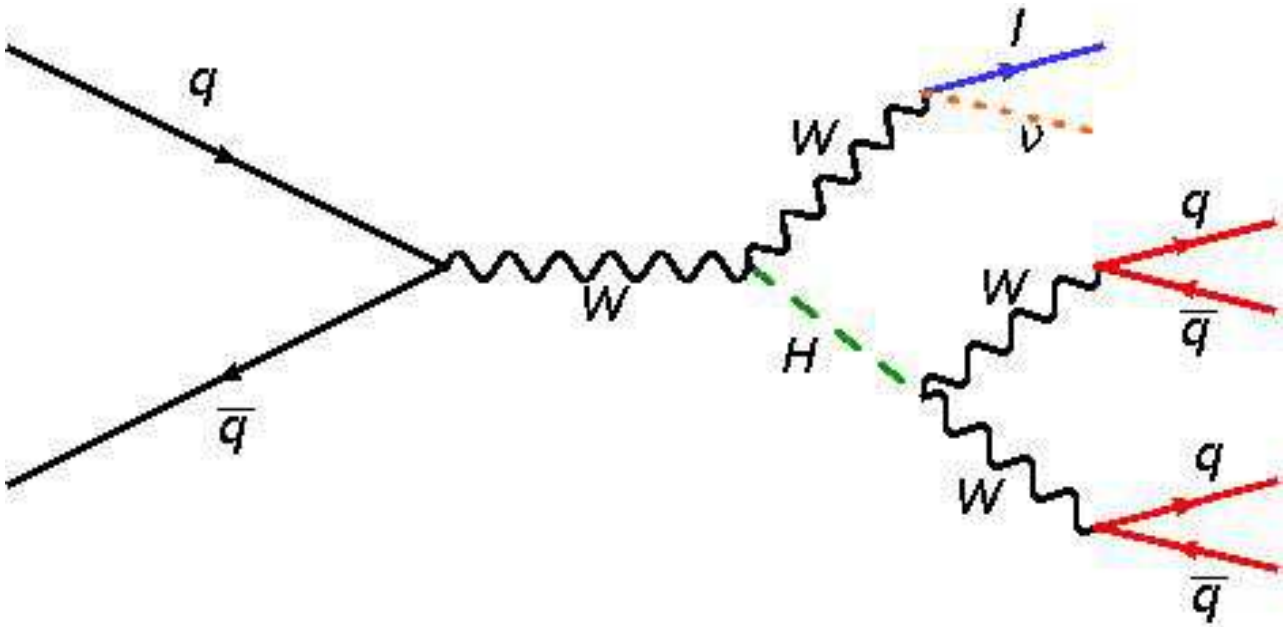
The Standard Model & the Higgs Boson



- Models particles and their interactions
- Higgs Boson is the only missing piece of the Standard Model

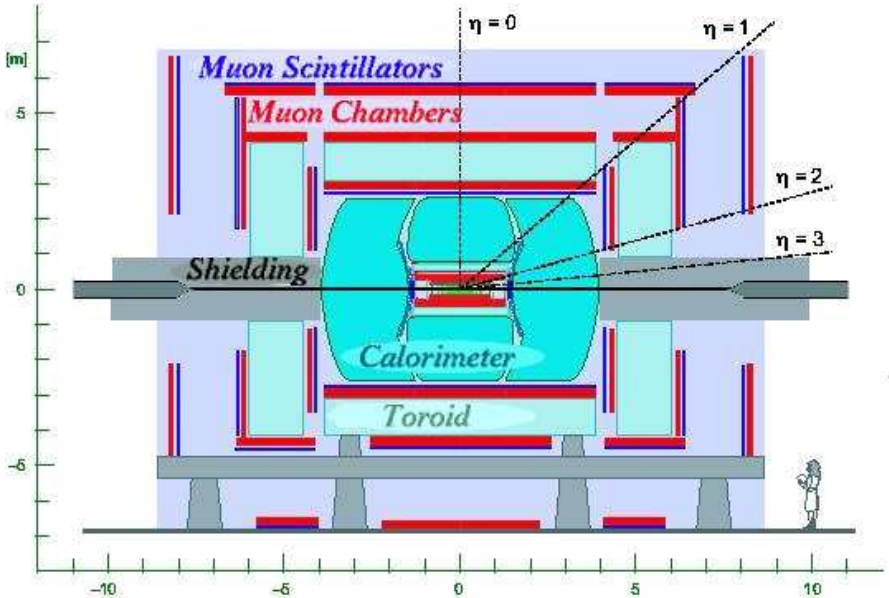
What Exactly Are We Looking For?

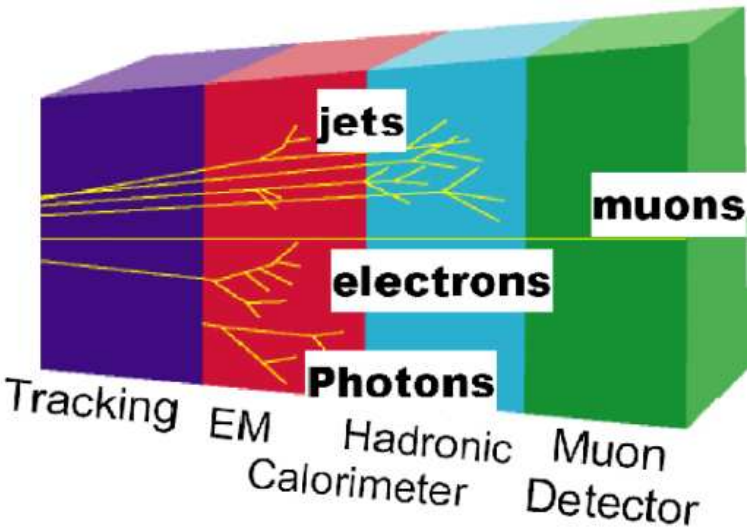
$$WH \rightarrow WWW \rightarrow l\nu.jj.jj$$



- Involves searching for a small Signal in about $1400\times$ as much Background!

How Do We Detect Particles?





Tracker:
For tracking charged particles

EM Calorimeter:
Mostly absorbs energy from electrons and photons

Hadronic Calorimeter:
Mostly absorbs energy from quarks and gluons (jets)

Muon System :
Mainly Muons make it here.

How Do We Look for This Process?

- Overview:
  1. Use a C++ code framework (wh_cafe)
  2. Generate Monte Carlo Simulations corresponding to the signal and background processes
  3. Process kinematic properties of the data & MC
  4. Train Multivariate Classifiers using Computer Learning Techniques
  5. Apply Multivariate Classifiers to the data & MC
  6. Search for excesses corresponding to the signal
  7. Run statistical analyses to determine the significance of the findings (COLLIE)

Machine Learning & Multivariate Analysis

- Many Moderately Significant Variables into One Very Significant One
- We use Machine Learning techniques to perform Multivariate Analyses
- Machine Learning occurs in two phases:

Training:

Computer analyzes two data samples (signal & background MC) for differences based off of a list of variables

Classification:

Computer uses what it "learned" to classify data as signal or background

Progress This Summer

- Where We Began
  - Only Electron subchannel Working
  - Small amount of selections
  - Small subset of the data.
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Progress This Summer

- Where We Began
  - Only Electron subchannel Working
  - Small amount of selections
  - Small subset of the data.
  - No WWW specific variables
- Where We Are Now
  - Both Electron and Muon subchannels Working
  - Added WWW variables
  - MVA Training
  - MVA Application
  - COLLIE Input Generation $\rightarrow$ Preliminary Sensitivity Plots
  - Added more Data (Up to 7.5 fb^{-1})

What I Did

- Maintained and Administrated a fork of wh_cafe
- Integrated $W \rightarrow jj$ Reconstruction Code into wh_cafe
- Developed C++ code for:
  - Multijet MVA
  - Final MVA
  - Statistical Inputs to COLLIE (Sensitivity Plots)
- Debugging

W Reconstruction

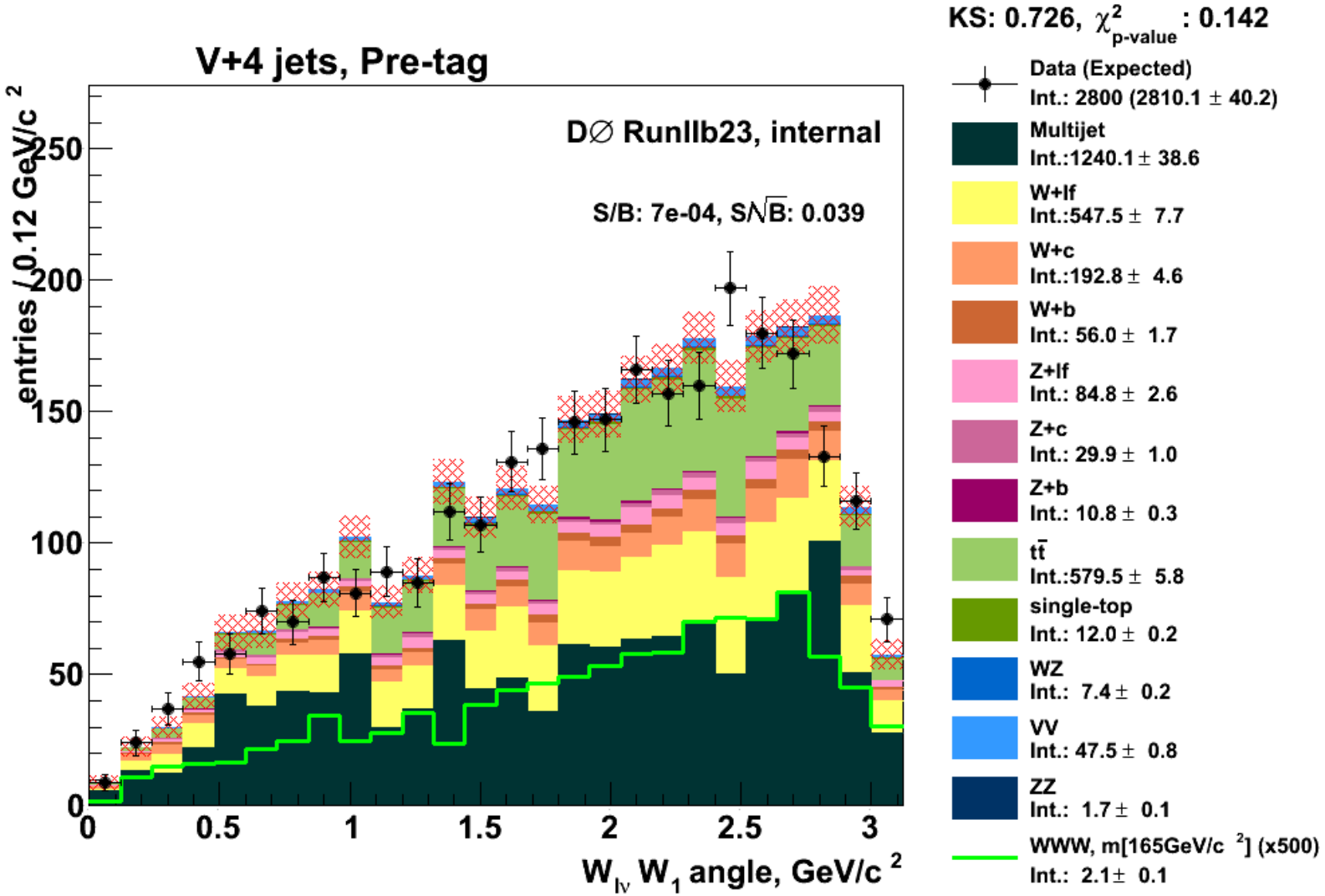
- To be able to analyze the intermediate state of the channel, we needed to reconstruct the W's
- Need to appropriately combine the jet, lepton and neutrino 4-vectors to obtain W's
- Thankfully, $W \rightarrow l\nu$ was already defined in wh_cafe
- $W \rightarrow jj$: required a little thought

$W \to jj$

1. Generate each jet combination (12_34, 13_24, 14_23)
2. Calculate the mass of each jet pair.
3. Calculate Error in each W mass by using
$$\Delta m_{ij} = m_{ij} - m_W,$$
where $m_W = 80.399$ GeV (PDG)
4. Sum the errors together:
$$E[m_{ij\_kl}] = \left|\Delta m_{ij}\right| + \left|\Delta m_{kl}\right|$$
5. Select the combination with the lowest summed error
6. Label lower mass W as W_1 and the Higher Mass W_2

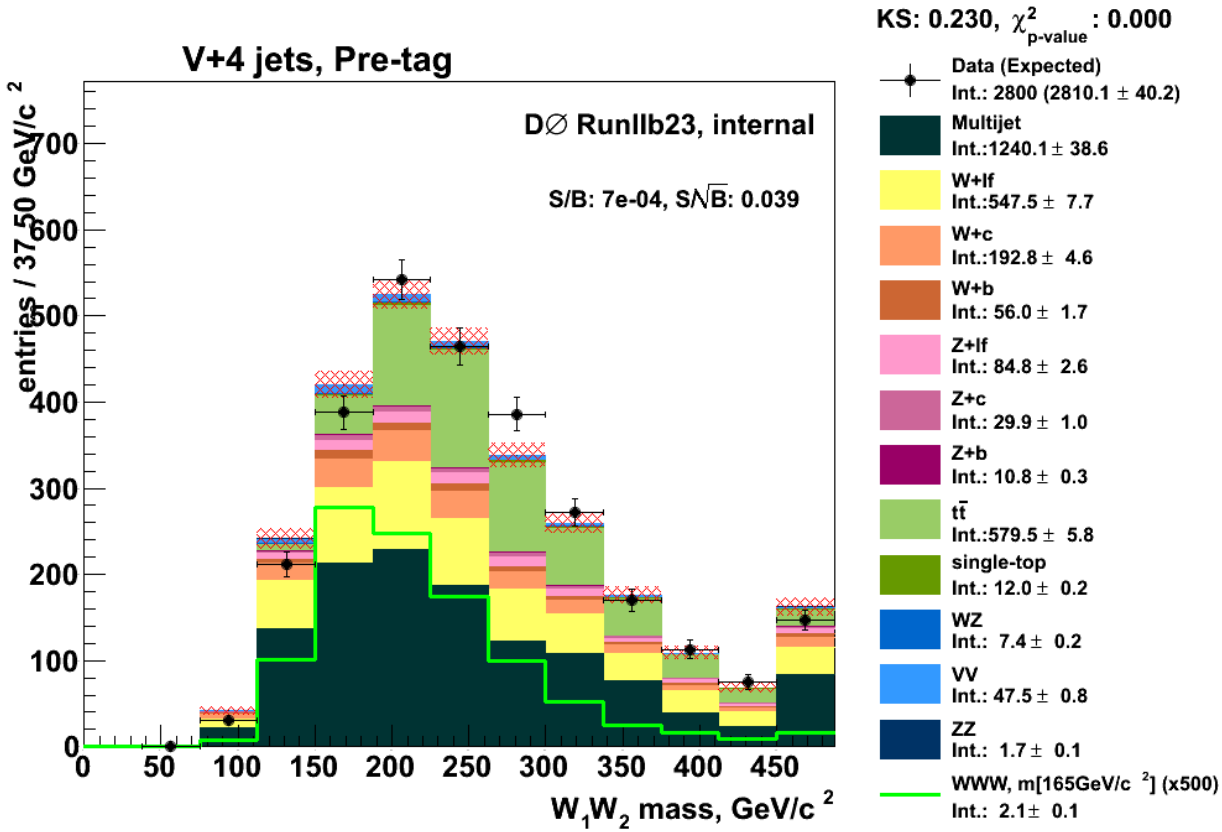
Allowed Us to Add 25 New Variables!

W Variables–Example



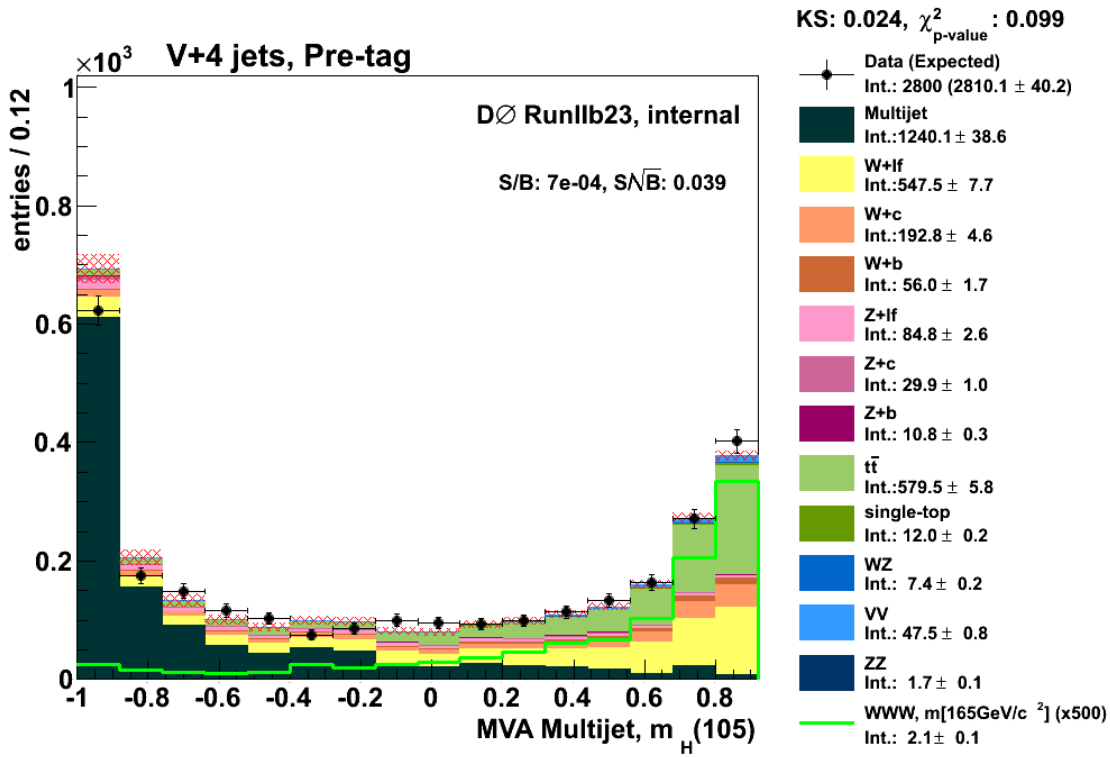
Angle between $W_{l\nu}$ & W_1

Reducing Multijet Background



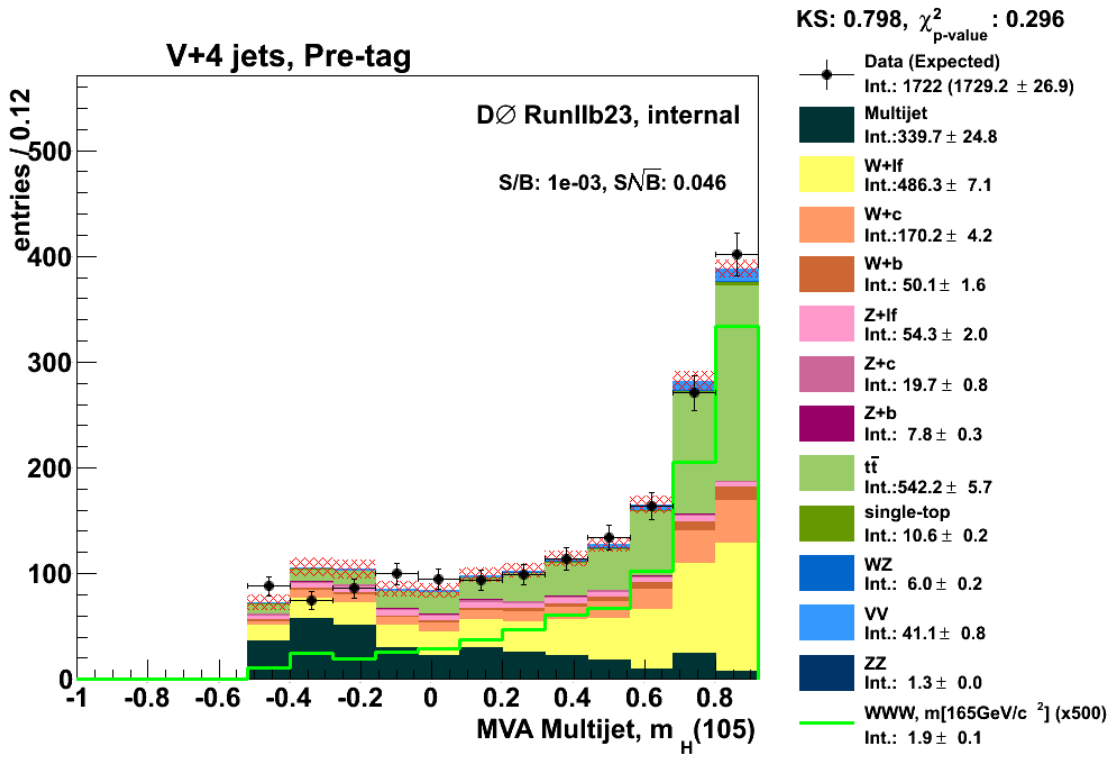
- Multijet Background is dominant
- Occurs when we have 5 jets with one "faking" a lepton
- Solution: Perform a Multivariate Analysis!

Multijet MVA



- Train an MVA using just Multijet Background and Signal
- Reject all events with Multijet MVA Output $\leq$ –0.5

Multijet MVA

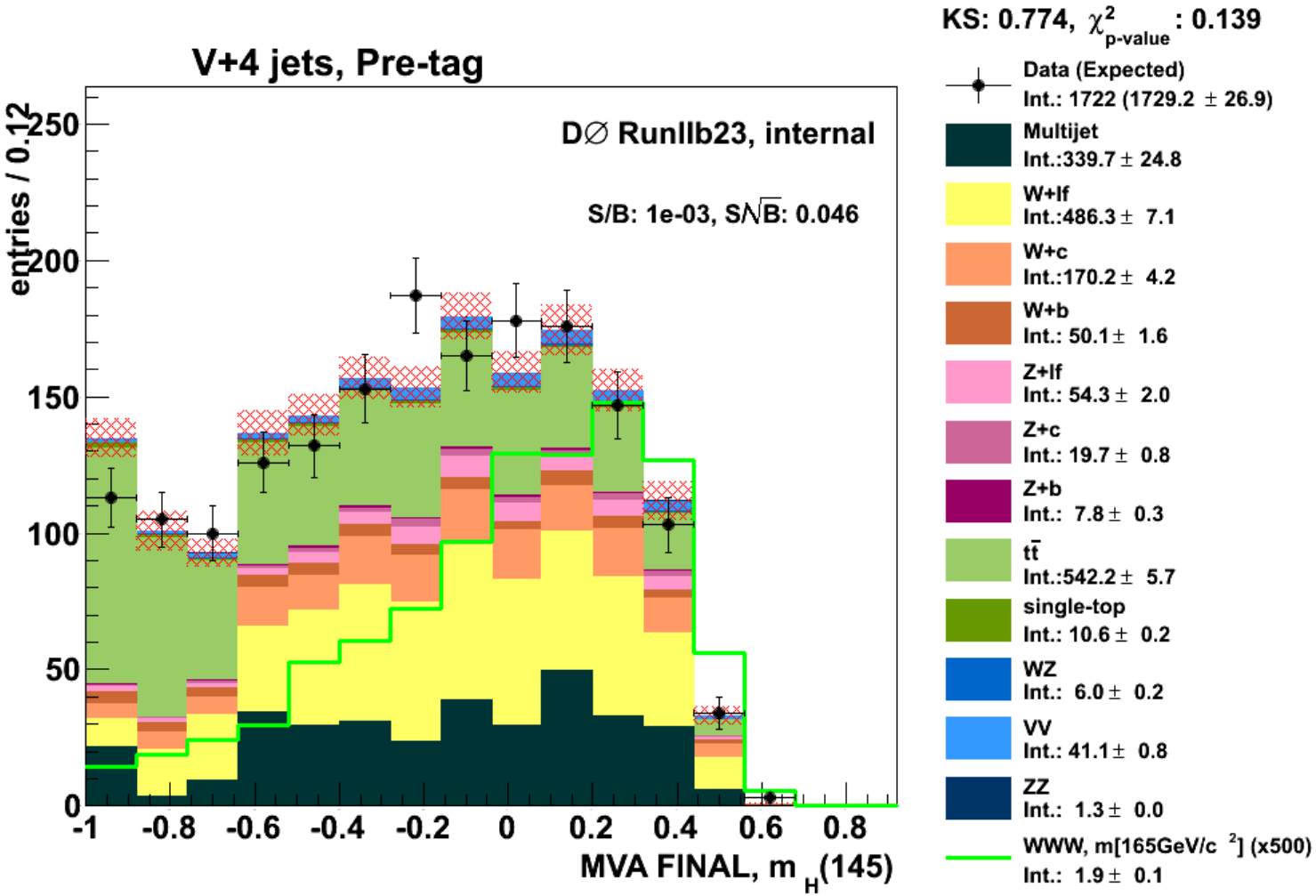


- Removes 72% of Multijet Background at a cost of 0.2 Signal Events (9.5%)
- Results in a 47.1% improvement in the Signal to Background Ratio

Training a Final MVA

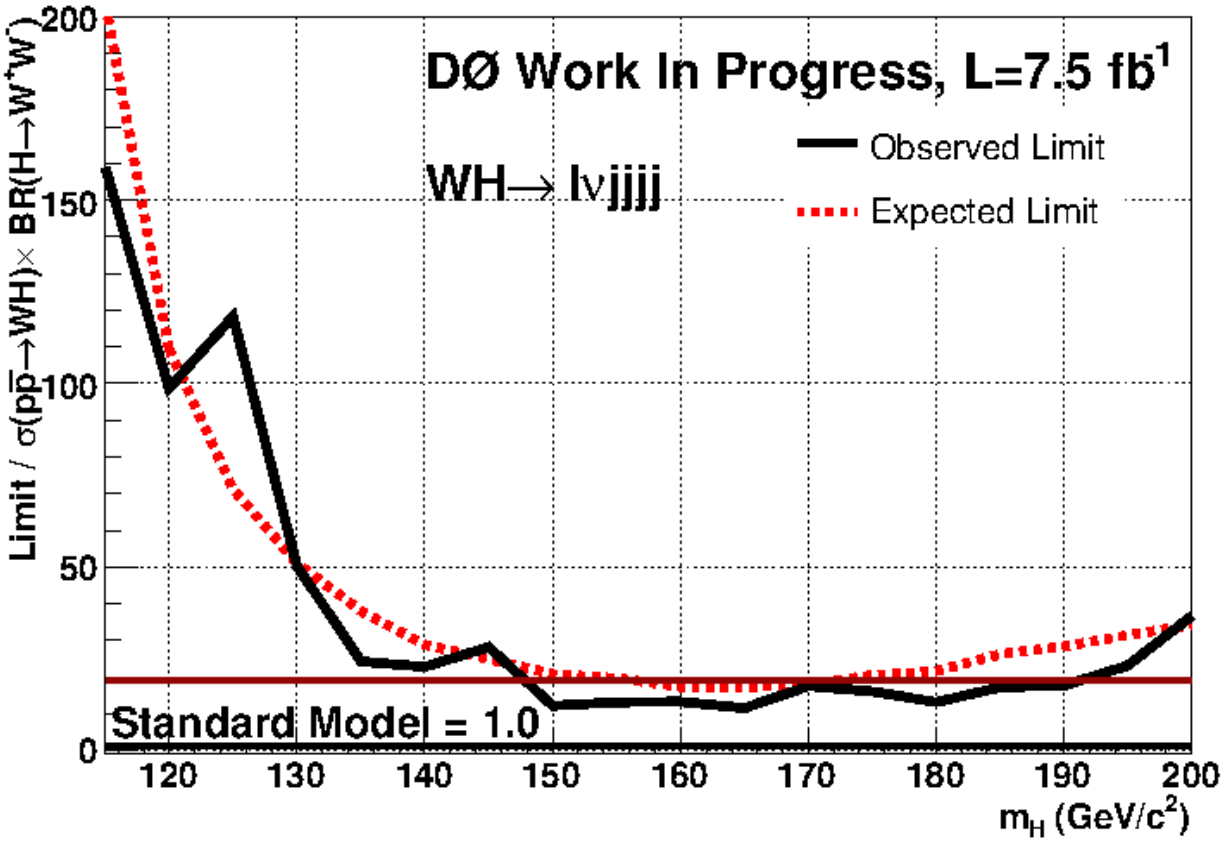
- In order to best discriminate between signal and background, we trained Final MVA's for our channel
- Utilized many of our new WWW Variables
- Trained on all backgrounds, not just Multijet

Final MVA



Preliminary Stages: Further Optimizations to Come!

Results



- Sensitive to $WH \rightarrow WWW \rightarrow l\nu.jj.jj$ to 20 $\times$ SM from $150 - 180$ GeV
- This will only get better as we continue to optimize our MVA's

Recap

- Much has been accomplished this summer.
- Majority of Analysis Code Working:
  - Both Electron and Muon SubChannels.
  - Multivariate Analysis Code.
  - Preliminary Sensitivity Plots.
  - On our way to building a publication.

Acknowledgements

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Questions?

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