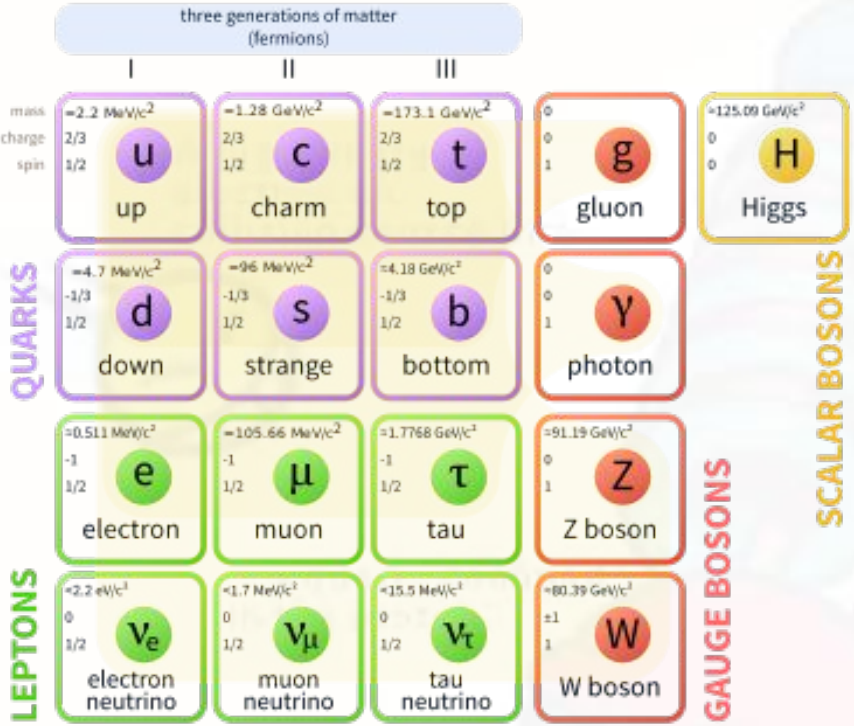
$H->WW^{*}->e\nu\mu\nu$

Dustin Gier

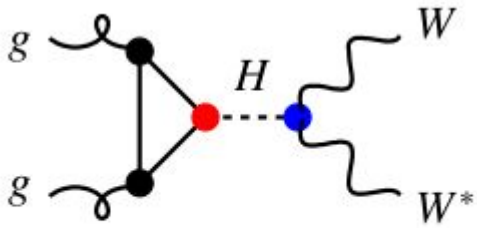
Advisor: Dr. Michael Strauss



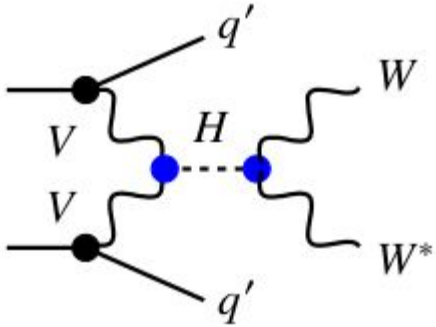
- Looking specifically at the Higgs Boson
  - Decay to two W bosons
- Measure the cross-section (probability measurement) and branching fraction, and check against Standard Model (SM) predictions
  - Provide evidence that this particle is actually the Higgs that was predicated

The Standard Model of Elementary Particles

- Searching for two forms of Higgs Production
  - gluon-gluon Fusion (ggF)
  - Vector Boson (W or Z) Fusion (VBF)
  - The final decay products are two leptons and their associated neutrinos, i.e. $e\nu\mu\nu$
- Need to deal with the high background of the data

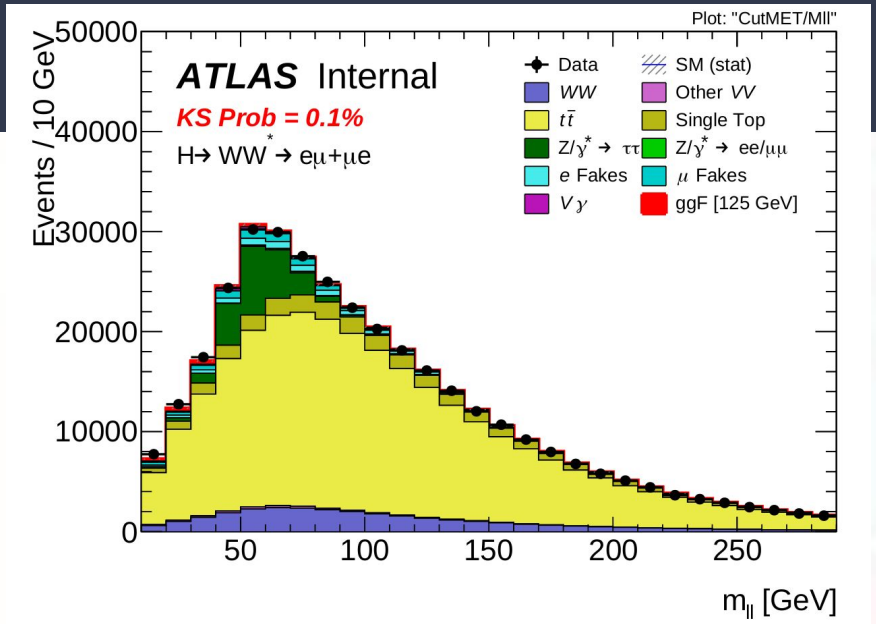


ggF production

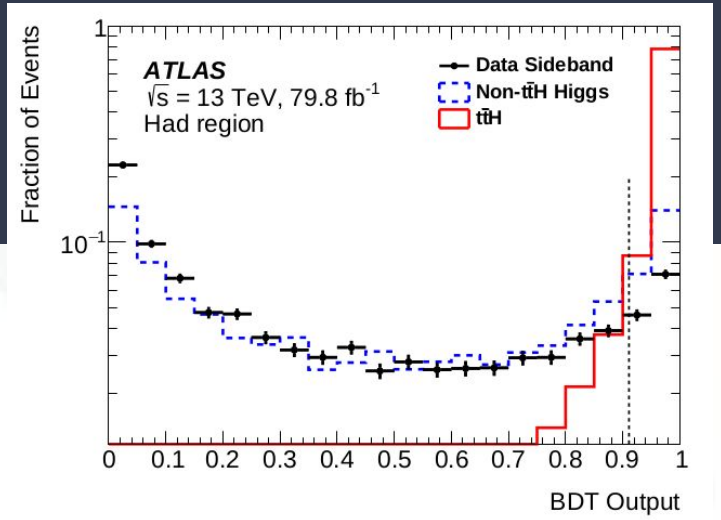


VBF production

Cut Bases



- Cut away data where background is high and signal is low
- Used when there is enough signal that we are only removing a lot of background and only a little signal



- Use neural networks and boosted decision trees to identify if the signal we're looking for occurred in a specific event

Multivariate Analysis (MVA)

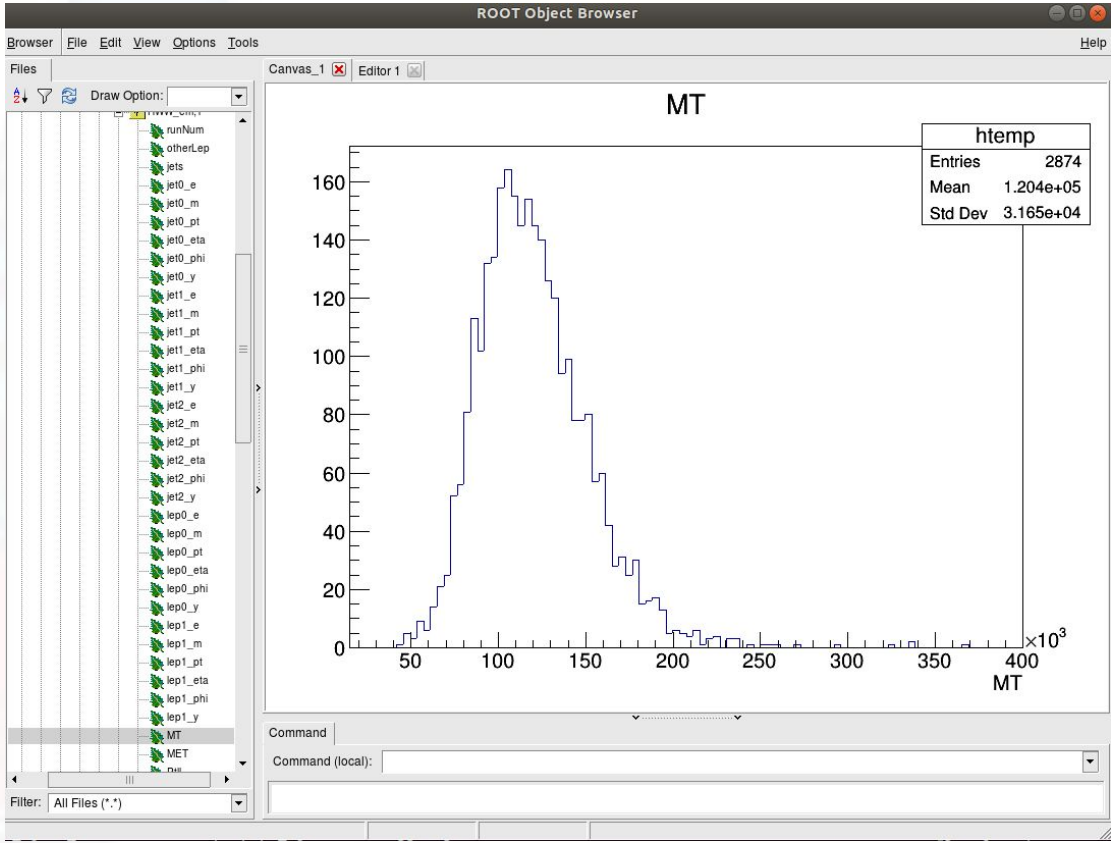
Root and the Common Analysis Framework (CAF)

Updated CAF, HWW Analysis Code

- Code overhaul about a year ago
  - Outdated previous student's code
    - Still useful for learning and working with CAF
  - Moved from svn to git
- Much leaner and better documented
  - READMEs
  - Example files
  - Most specific types of analysis (ggF and VBF included) almost entirely set up
  - Wikis and tutorials slowly coming up-to-date

nTuples

- Generic data structure in Root
  - Can be accessed through pre-made histograms or array-like structure
- Allows for analysis in Root
  - Much faster than CAF (typical CAF run is ~12 hours)



```
root [10] HWW_em->Scan("runNum:otherLep:jets:MT:MET:weight")
************************************************************************
*    Row    *    runNum *  otherLep *      jets *        MT *       MET *    weight *
************************************************************************
*        0 *    304431 *         0 *         0 * 92543.166 * 38142.688 *         1 *
*        1 *    304431 *         0 *         0 * 161231.90 * 65916.404 *         1 *
*        2 *    304431 *         0 *         0 * 163028.31 * 69293.145 *         1 *
*        3 *    304431 *         0 *         0 * 116234.03 * 51272.858 *         1 *
*        4 *    304431 *         0 *         0 * 107772.77 * 61710.346 *         1 *
*        5 *    304431 *         0 *         0 * 78943.946 * 29008.278 *         1 *
*        6 *    304431 *         0 *         0 * 137444.06 * 61965.253 *         1 *
*        7 *    304431 *         0 *         0 * 122186.70 * 60480.523 *         1 *
*        8 *    304494 *         0 *         0 * 140287.05 * 65763.024 *         1 *
*        9 *    304494 *         0 *         0 * 120137.75 * 51082.142 *         1 *
*       10 *    304494 *         0 *         0 * 149075.25 * 75185.439 *         1 *
*       11 *    304494 *         0 *         0 * 152160.64 * 73420.212 *         1 *
*       12 *    305380 *         0 *         0 * 80824.130 * 20985.840 *         1 *
*       13 *    305380 *         0 *         0 * 115903.80 * 53493.614 *         1 *
*       14 *    305380 *         0 *         0 * 91222.602 * 37029.602 *         1 *
*       15 *    305380 *         1 *         1 * 71963.741 * 23177.405 *         1 *
*       16 *    305380 *         0 *         0 * 76764.852 * 29121.819 *         1 *
*       17 *    305380 *         0 *         1 * 149403.24 * 51810.570 *         1 *
*       18 *    305380 *         0 *         0 * 116616.06 * 51902.429 *         1 *
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*       20 *    305380 *         0 *         0 * 101057.51 * 41222.393 *         1 *
*       21 *    305380 *         0 *         0 * 117372.24 * 54586.205 *         1 *
*       22 *    305380 *         0 *         1 * 94262.897 * 36697.817 *         1 *
*       23 *    305380 *         0 *         0 * 133808.83 * 55526.078 *         1 *
*       24 *    305380 *         0 *         0 * 90008.738 * 37276.794 *         1 *
Type <CR> to continue or q to quit ==>
*       25 *    305380 *         0 *         0 * 133704.06 * 65700.382 *         1 *
*       26 *    305380 *         0 *         0 * 132640.81 * 54320.443 *         1 *
*       27 *    305380 *         0 *         1 * 122570.39 * 80477.590 *         1 *
*       28 *    305380 *         1 *         0 * 207412.87 * 84316.323 *         1 *
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*       45 *    276329 *         0 *         0 * 80981.608 * 29206.219 *         1 *
*       46 *    276336 *         0 *         0 * 179159.02 * 83472.354 *         1 *
```
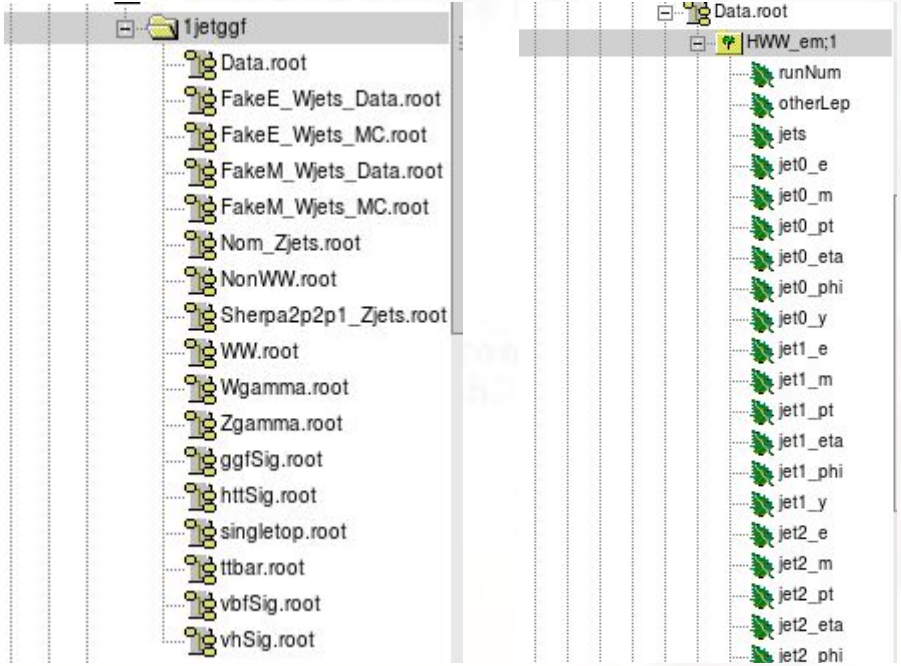
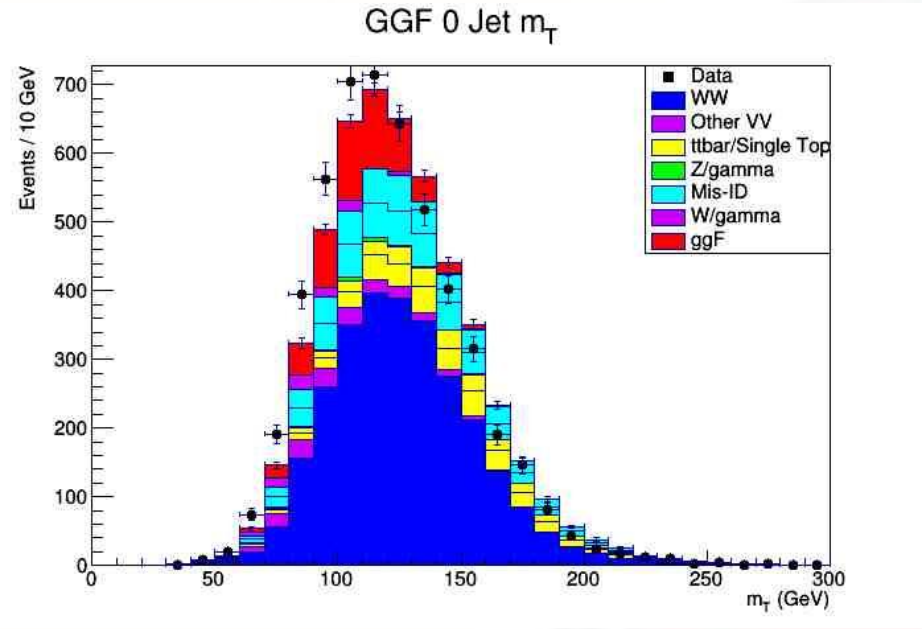

- Variables are dumped in essentially a multidimensional array
  - Root calls them Trees
  - Values can be accessed by looping through each file
- The data from the nTuples can be used to create further cuts, do MVA analysis, or create histograms

nTuples from CAF

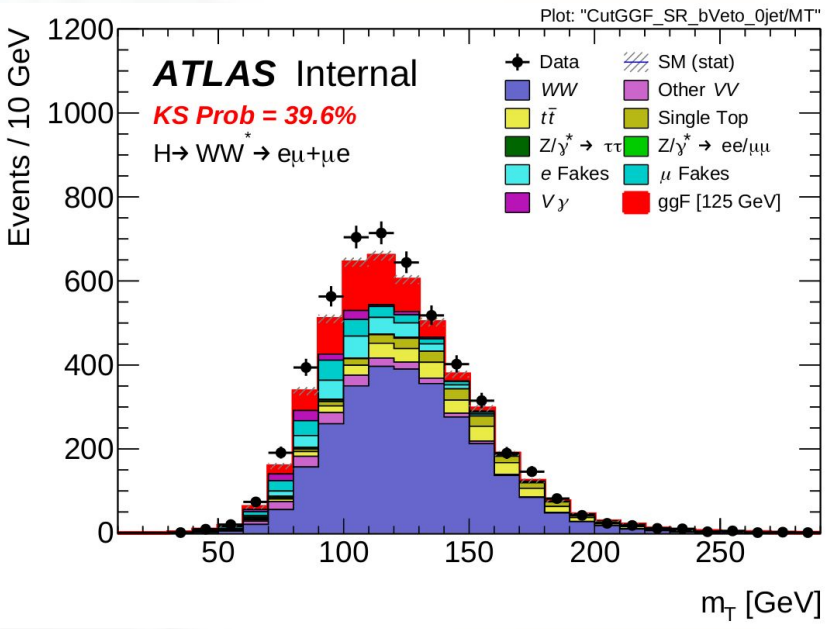


- CAF can be programmed to dump nTuples
  - For each event that passes a certain cut, information about event is dumped to a .root file
- User-defined cuts, event types, and variables
  - If CAF is set up correctly, only one file needs to be changed to edit
  - Allows separation of signal from background
  - Can dump at multiple cuts, and can create custom variables

Root:



CAF:



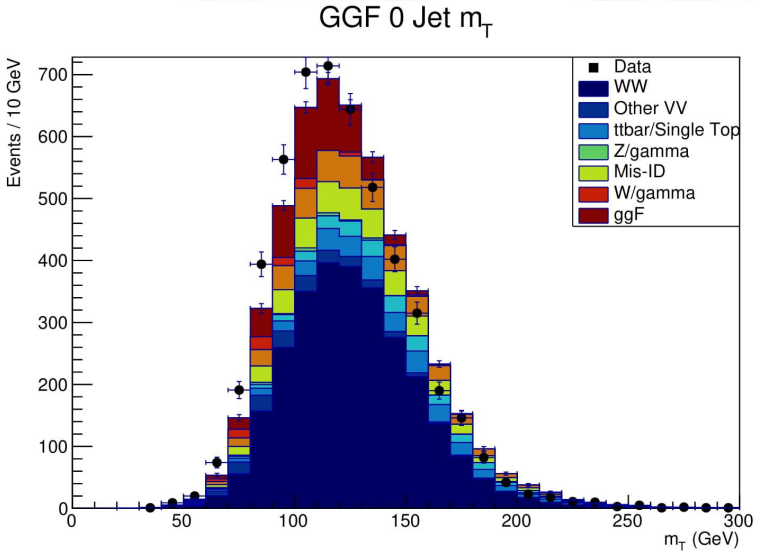
Root versus CAF

Further Research

- Scripts to run CAF with as little input from user as possible
  - Only a couple flags need to be changed to run a full analysis with the updated CAF
  - Allows user unfamiliar with the framework to dump nTuples to use in Root
- Difficulties with outdated code
  - CAF is actively being worked on, need adequate documentation to ensure changes to framework won't make scripts outdated

- MVA Analysis
  - Root contains the libraries necessary for BDT analysis
  - CAF now includes the code necessary to create boosted decision trees (BDTs)
    - Need to create an entire script from scratch instead of simply changing a couple flags
  - Comparison of Root and CAF outputs

Questions?


GGF 0 Jet m_T
Events / 10 GeV
m_T (GeV)
Data
WW
Other VV
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Z/gamma
Mis-ID
W/gamma
ggF
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