DBD Higgs Branching Ratio Analysis

Presented by
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The January 2013 SiD Workshop

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SLAC NATIONAL ACCELERATOR LABORATORY

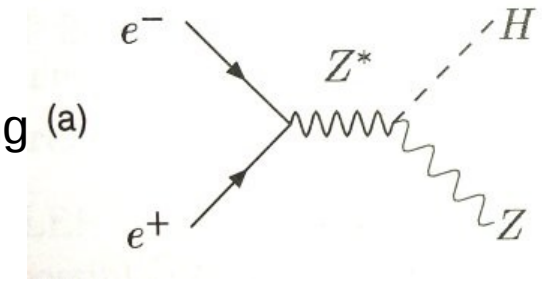
SiD

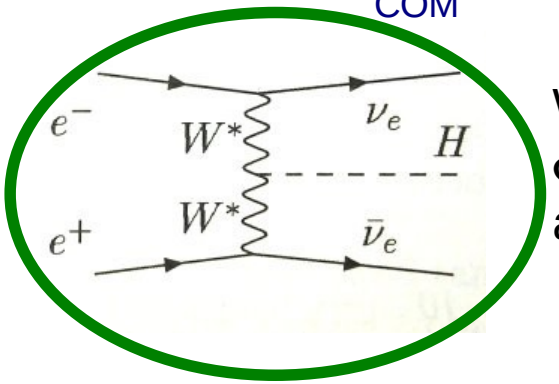
Motivation for using $e^+e^- \rightarrow \nu\nu h$

Goal is to measure BR errors for gg,WW* using $e^+e^- \rightarrow \nu\nu H$ @ 1 TeV

WW fusion cross-section rises with E_{COM}

Higgs-strahlung





WW fusion σ grows as *ln(s)*

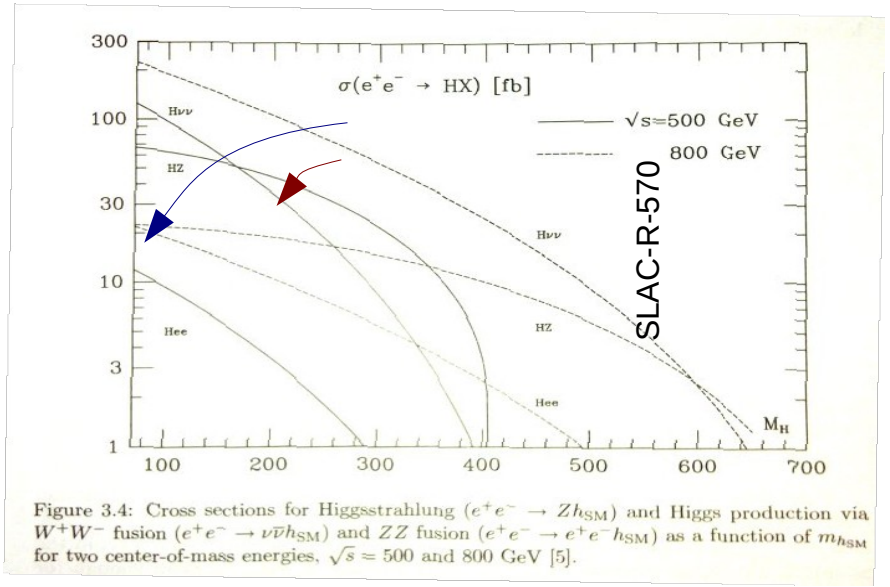


Figure 3.4: Cross sections for Higgsstrahlung ($e^+e^- \rightarrow Zh_{SM}$) and Higgs production via W^+W^- fusion ($e^+e^- \rightarrow \nu\bar{\nu}h_{SM}$) and ZZ fusion ($e^+e^- \rightarrow e^+e^-h_{SM}$) as a function of $m_{h_{SM}}$ for two center-of-mass energies, $\sqrt{s} = 500$ and 800 GeV [5].

This analysis focuses on ννh decays from the dominant WW fusion process in 1 TeV events.

New Elements of the $\nu\nu h$ Benchmark

- flavor/anti-flavor tagging using LCFI+
- Include extra background
- Full simulation using SLIC
- Mixed stdhep from Whizard with polarization (-80%,+20%)
- Beam spot simulation
- Pandora PFA

Outline of the Analysis

Process	Polarization	#events
higgs	-80/+20	1,544,398
$evW + eeZ + \nu\nu Z$ semileptonic	-80/+20	6,570,292
all other SM background mix	-80/+20	3,232,672

MarlinFastJet Jet Clustering
KT algo, 0.7, 6 jets

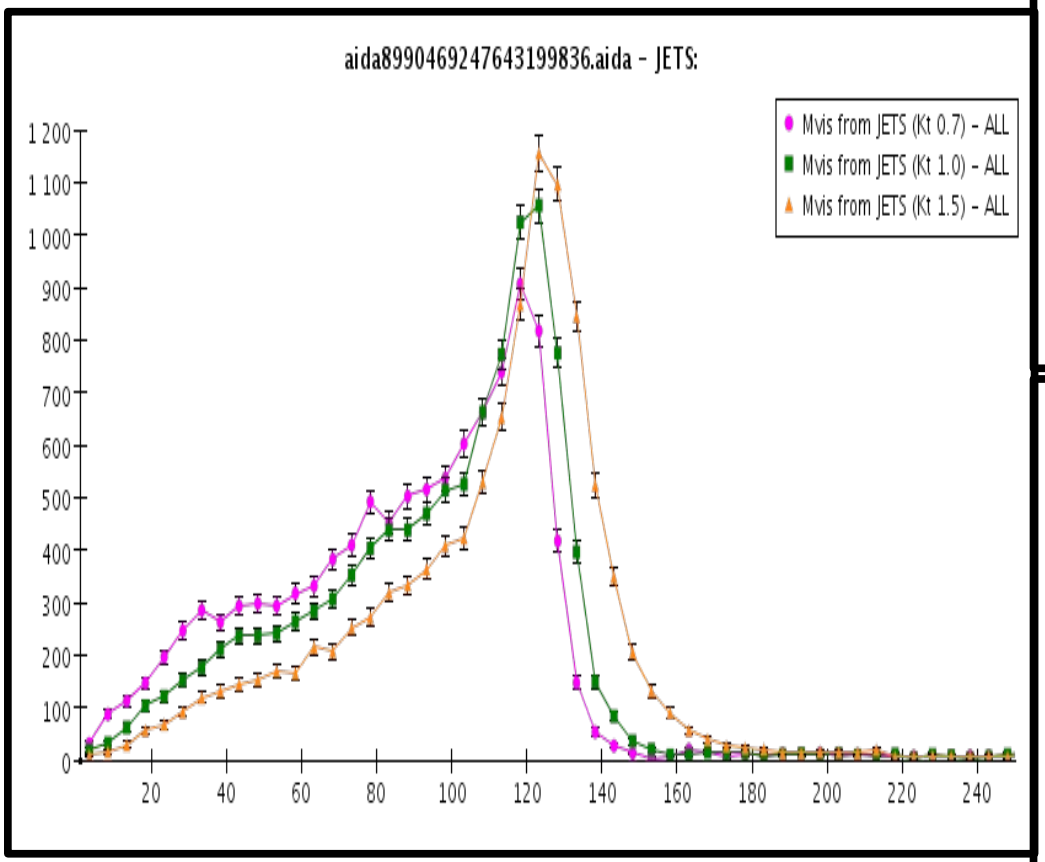
MarlinFastJet Jet Clustering
KT algo, 1.5, 2 jets

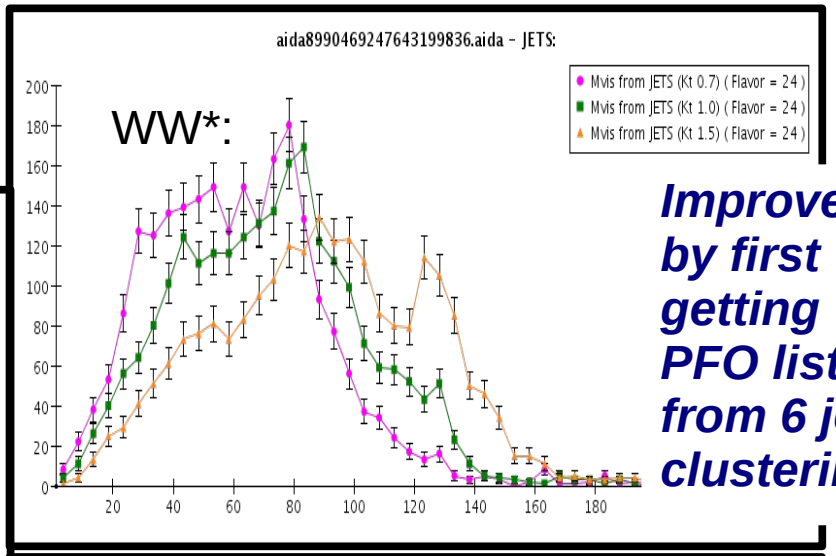
Flavor Tagging
training on 250 GeV Z → bb,cc,qq
and application to all samples

Preselection

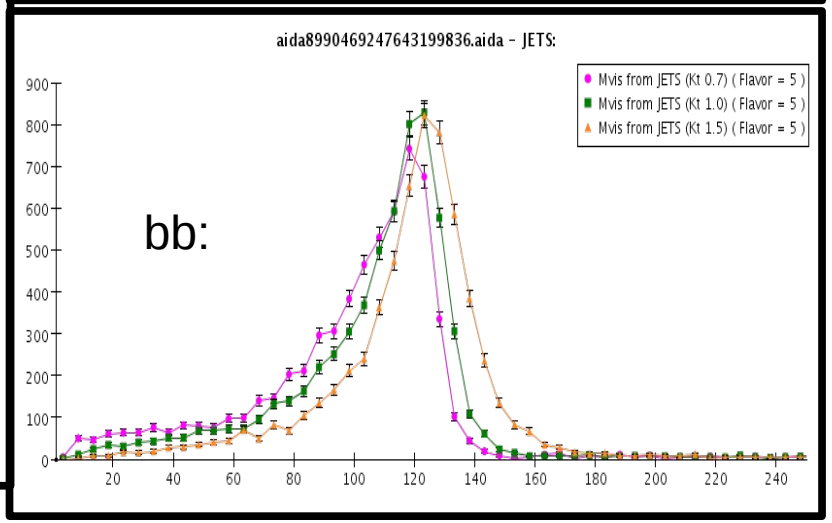
TMVA (Fisher)

Kt Jet Algorithm Parameter Setting





Improved by first getting PFO list from 6 jet clustering



Flavor Tagging

- Four classifiers

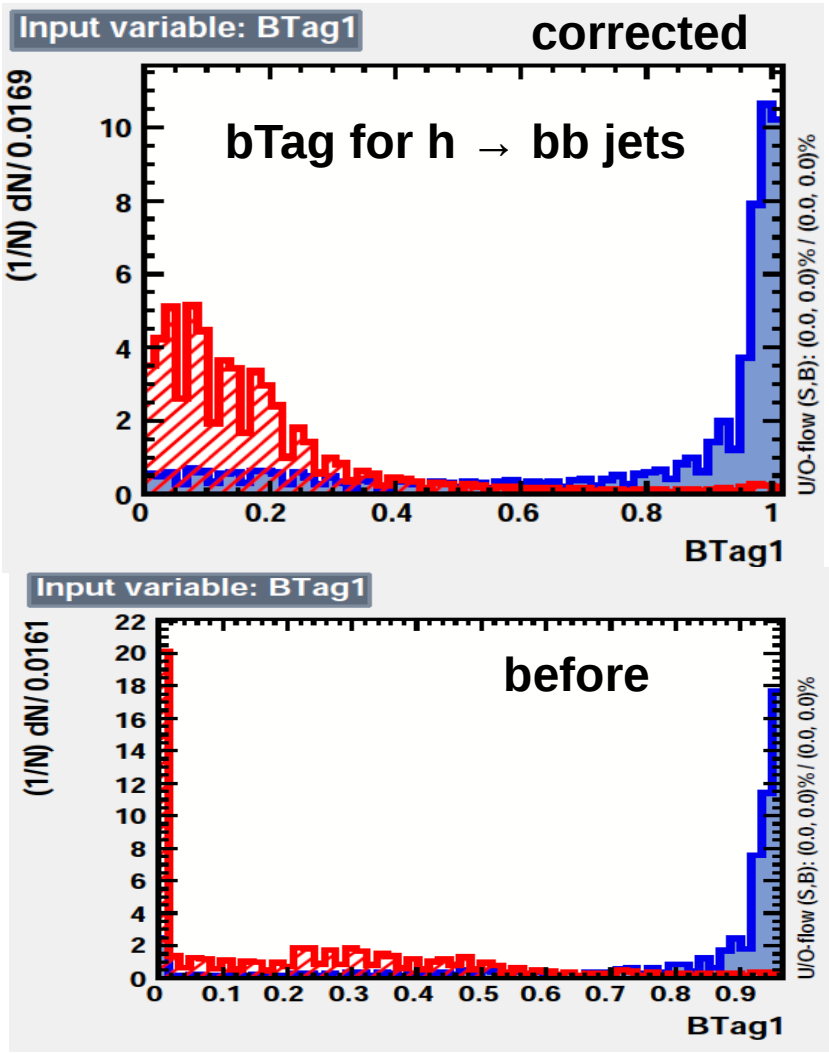
			best εfficiency*purity		
			bb	cc	qq
	Classifier #1	: bdt	0.155	0.430	0.465
For charm tagging: →	Classifier #2	: bdt	0.577	0.655	0.220
	Classifier #3	: bdt	0.873	0.322	0.138
For b tagging: →	Classifier #4	: bdt	0.922	0.365	0.105

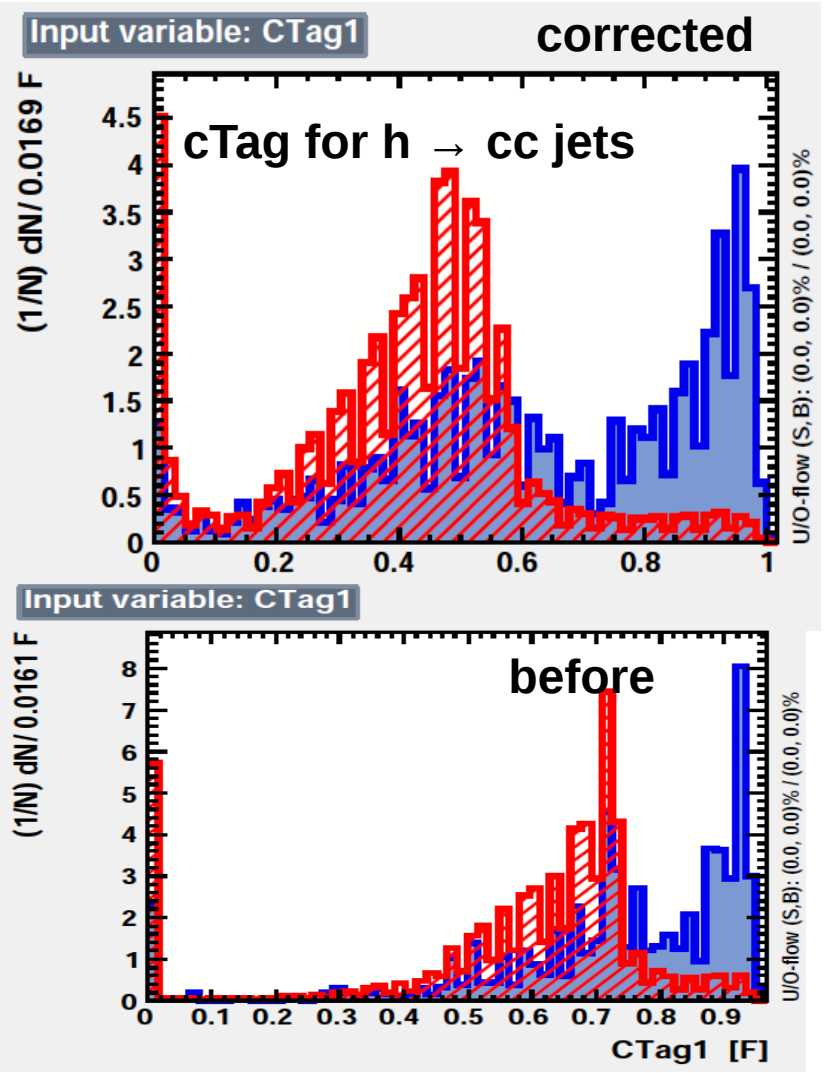
Small improvement from using extra variables used by ILD for charm tagging:

Classifier #1	: bdt	0.155	0.430	0.465
Classifier #2	: bdt	0.580	0.661	0.227
Classifier #3	: bdt	0.873	0.322	0.138
Classifier #4	: bdt	0.922	0.365	0.105

Note: A fix was made to the retrieval of tag values from SLCIO files made last night!

Bottom and Charm Tag Variables

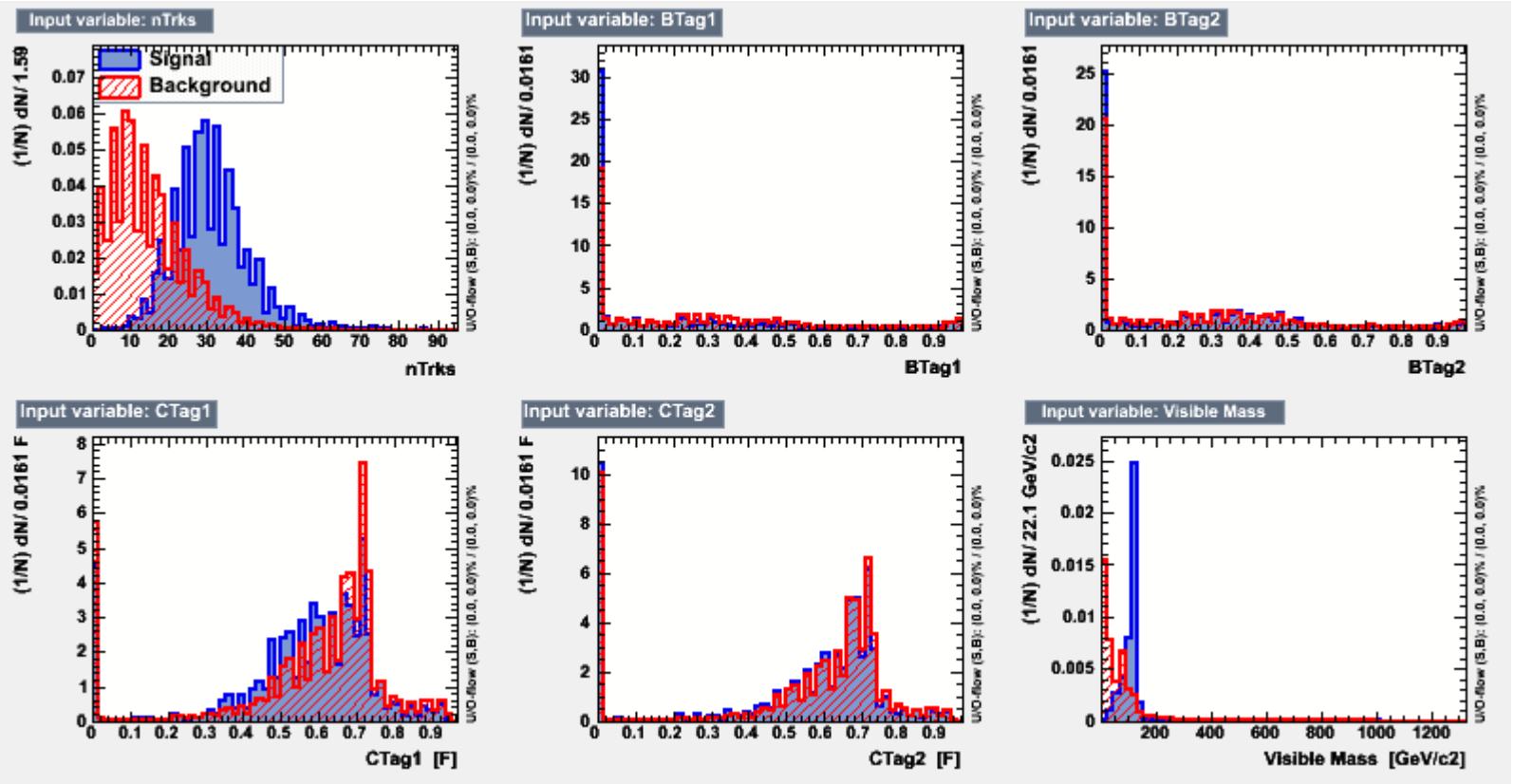




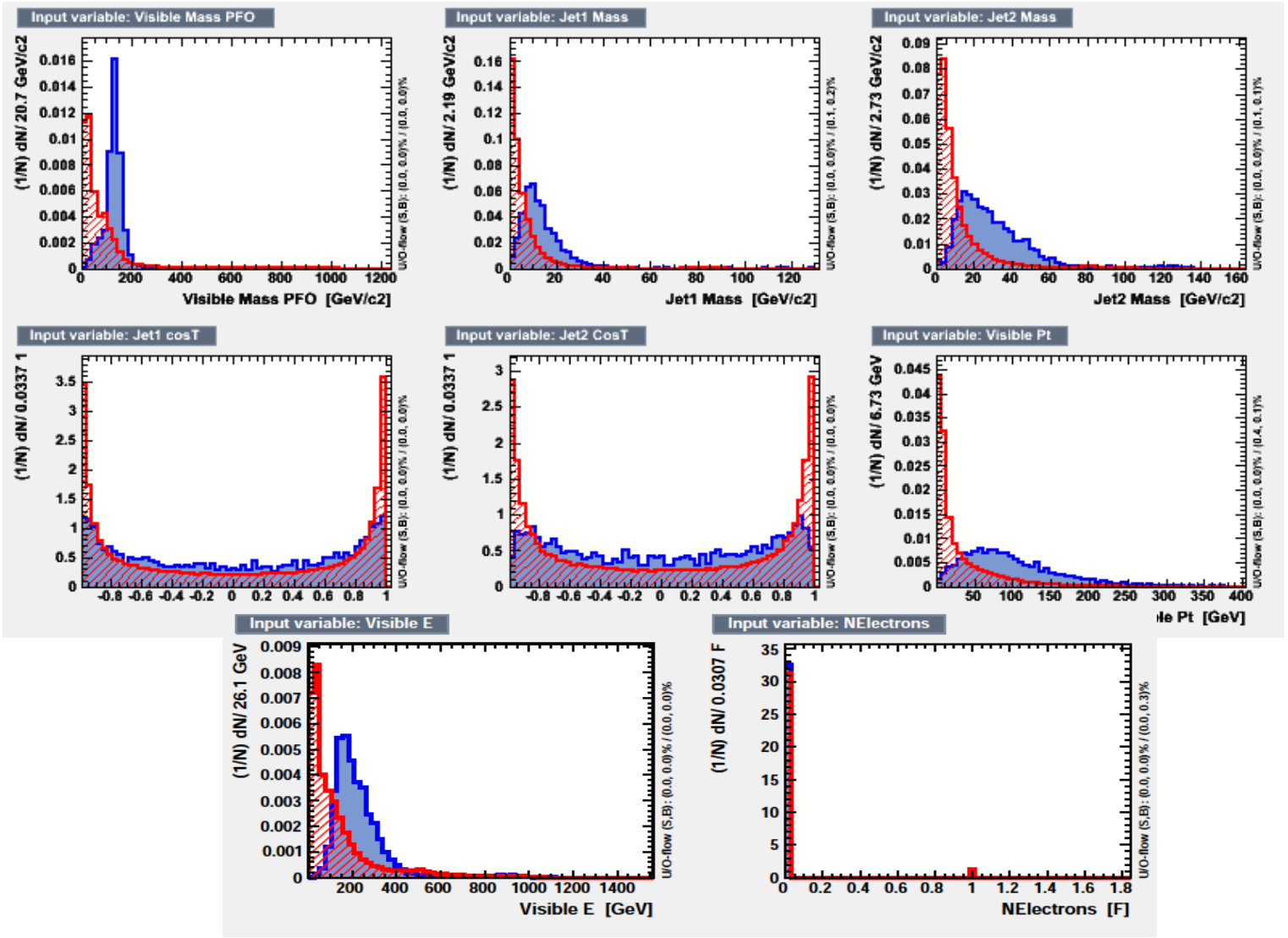
Pre-Selection Cuts

Higgs decay	Preselection cuts	Signal eff.	Background eff.
$h \to b\bar{b}$	$50. < P_{t,\mathrm{vis}} < 250.$ $100. < E_{\mathrm{vis}} < 400$ $110 < M_{\mathrm{vis}} < 140$ $\lvert\cos(\theta_{\mathrm{jet}})\rvert < 0.90$ #Trks>15 $B_{tag_{1,2}} > 0.8$	14.9%	5.9×10^{-7}
$h \to c\bar{c}$	$50 < P_{t,\mathrm{vis}} < 250$ $150 < E_{\mathrm{vis}} < 400$ $110 < M_{\mathrm{vis}} < 140$ $\lvert\cos(\theta_{\mathrm{jet}})\rvert < 0.90$ $10 <$ #Trks < 50 $B_{tag_{1,2}} < 0.8$ $C_{tag_{1\ or\ 2}} > 0.8$ $M_{jet_{1,2}} > 10.$	12.9%	1.1×10^{-6}
$h \to gg$	$50. < P^T_{vis} < 250.$ $150. < E_{vis} < 400.$ $100. < M_{vis} < 140.$ $\lvert cos(\theta_{JET})\rvert < 0.90$ #Trks>20 $B_{tag_{1,2}} < 0.8$ $M_{jet_2} > 20.$	13.6%	2.4×10^{-6}
$h \to W^+W^-$	$50. < P^T_{vis} < 250.$ $150. < E_{vis} < 400.$ $100. < M_{vis} < 140.$ $\lvert cos(\theta_{JET})\rvert < 0.90$ #Trks>15 $B_{tag_{1,2}} < 0.8$ $M_{jet_2} > 40.$	6.9%	5.5×10^{-6}

TMVA Fisher Inputs Set#1



TMVA Fisher Inputs Set#2



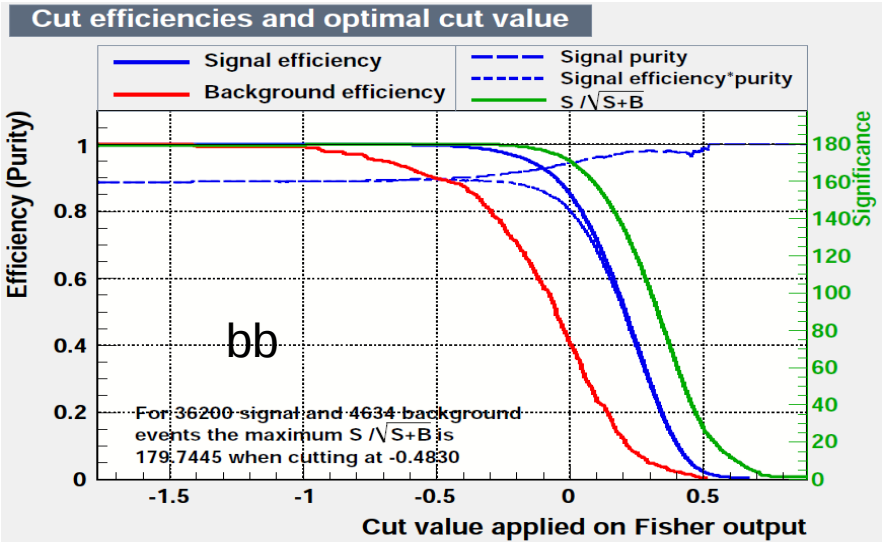
Fisher Selection Results

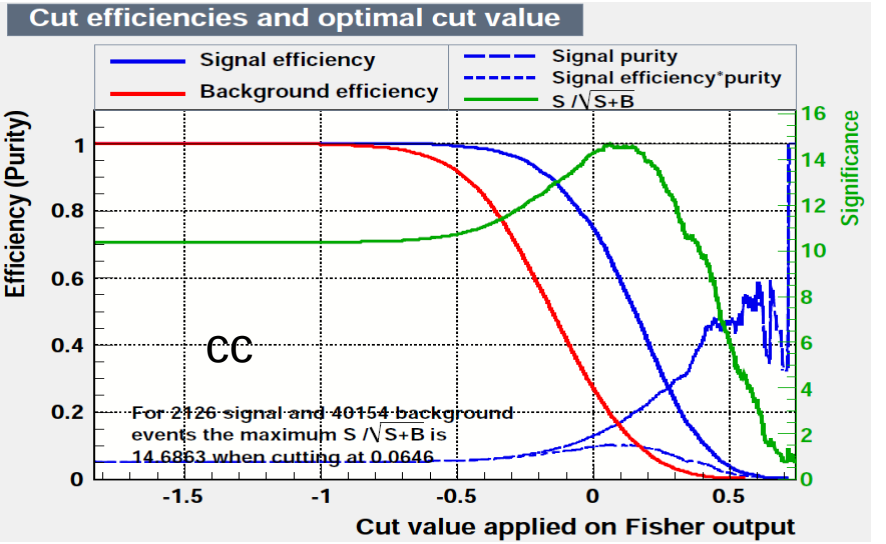
```
h->bb:
--- Classifier   (  #signal, #backgr.)  Optimal-cut  S/sqrt(S+B)      NSig      NBkg   EffSig   EffBkg
--- ------------------------------------------------------------------------------------------------
---     Fisher:  (36199.957,4634.3438)      -0.4830      179.745  36013.03  4129.807   0.9948   0.8911
--- ------------------------------------------------------------------------------------------------

h->cc:
--- ================================================================================================
--- Classifier   (  #signal, #backgr.)  Optimal-cut  S/sqrt(S+B)      NSig      NBkg   EffSig   EffBkg
--- ------------------------------------------------------------------------------------------------
---     Fisher:  (2126.0046, 40153.93)       0.0646      14.6863  1392.334   7595.64   0.6549   0.1892
--- ------------------------------------------------------------------------------------------------

h->gg:
--- Classifier   (  #signal, #backgr.)  Optimal-cut  S/sqrt(S+B)      NSig      NBkg   EffSig   EffBkg
--- ------------------------------------------------------------------------------------------------
---     Fisher:  (8004.5552,142342.67)       0.1288      32.1293  4708.252  16765.92   0.5882   0.1178
--- ------------------------------------------------------------------------------------------------

h->WW:
--- Classifier   (  #signal, #backgr.)  Optimal-cut  S/sqrt(S+B)      NSig      NBkg   EffSig   EffBkg
--- ------------------------------------------------------------------------------------------------
---     Fisher:  (7298.6479,62090.555)      -0.1662      29.2395  6177.718  38461.37   0.8464   0.6194
--- ------------------------------------------------------------------------------------------------
```

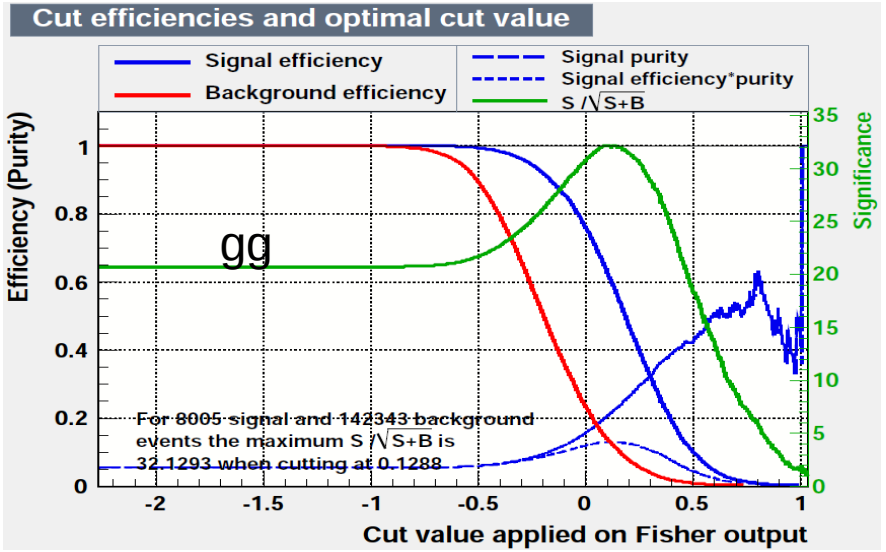
Composition of Final Samples

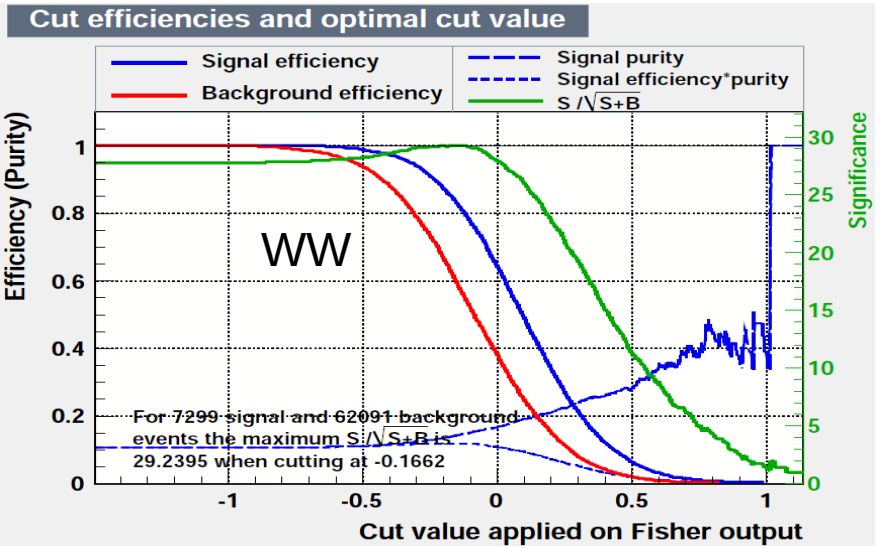
$h \to b\bar{b}$	$h \to c\bar{c}$	$h \to WW$	$h \to gg$
$evW + eeZ + \nu\nu Z$			
7.5%	62.9%	61.4%	64.5%
all other Standard Model Backgrounds			
1.9%	19.5%	10.0%	16.7%
Higgs decays			
$h \to c\bar{c}$: 0.0% $h \to b\bar{b}$: 89.7% $h \to \tau\tau$: 0.8% $h \to gg$: 0.3% $h \to ZZ$: 0.5%	$h \to c\bar{c}$: 10.5% $h \to b\bar{b}$: 5.1% $h \to \tau\tau$: 0.3% $h \to gg$: 0.8% $h \to WW^*$: 0.8%	$h \to c\bar{c}$: 0.7% $h \to b\bar{b}$: 0.7% $h \to gg$: 20.8% $h \to ZZ$: 0.7% $h \to WW^*$: 5.7%	$h \to c\bar{c}$: 0.7% $h \to b\bar{b}$: 1.1% $h \to gg$: 3.4% $h \to ZZ$: 1.2% $h \to WW^*$: 12.4%

Significance and Efficiency Curves



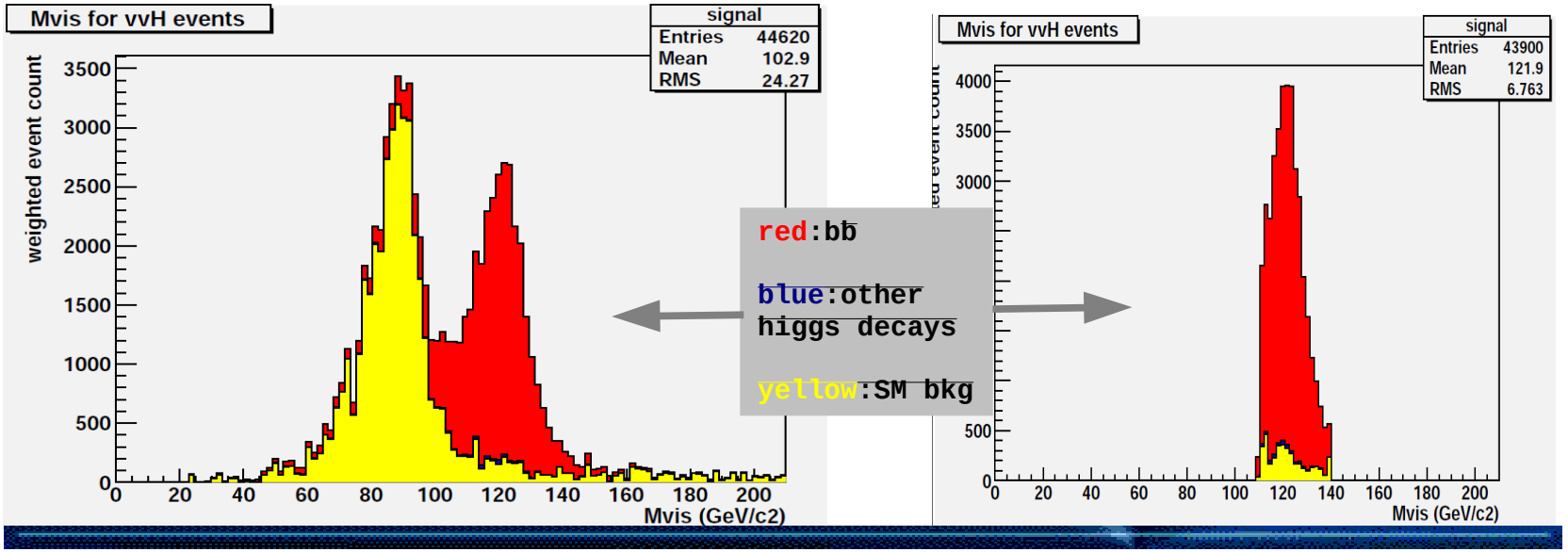




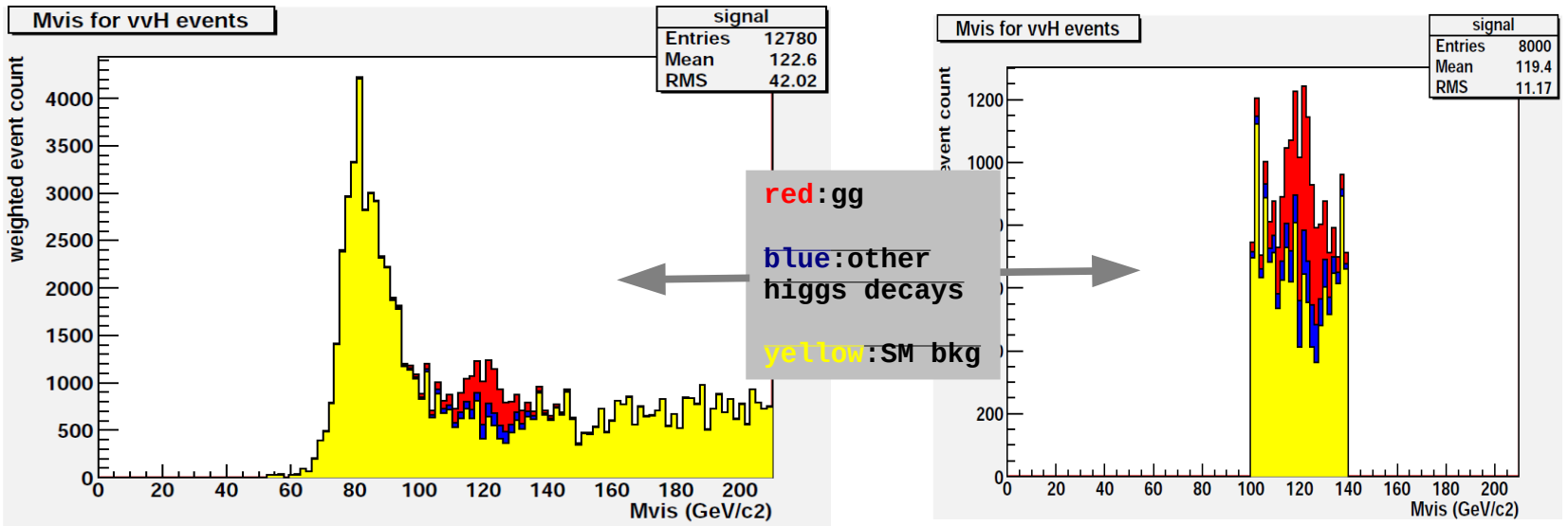


Visible Mass Distributions for Selected Events

bb:



gg:



Results

- S=#signal events passing all cuts
- B=#background events passing all cuts

$$\frac{\Delta(\sigma \cdot BR)}{\sigma \cdot BR} = \frac{\sqrt{S+B}}{S}$$

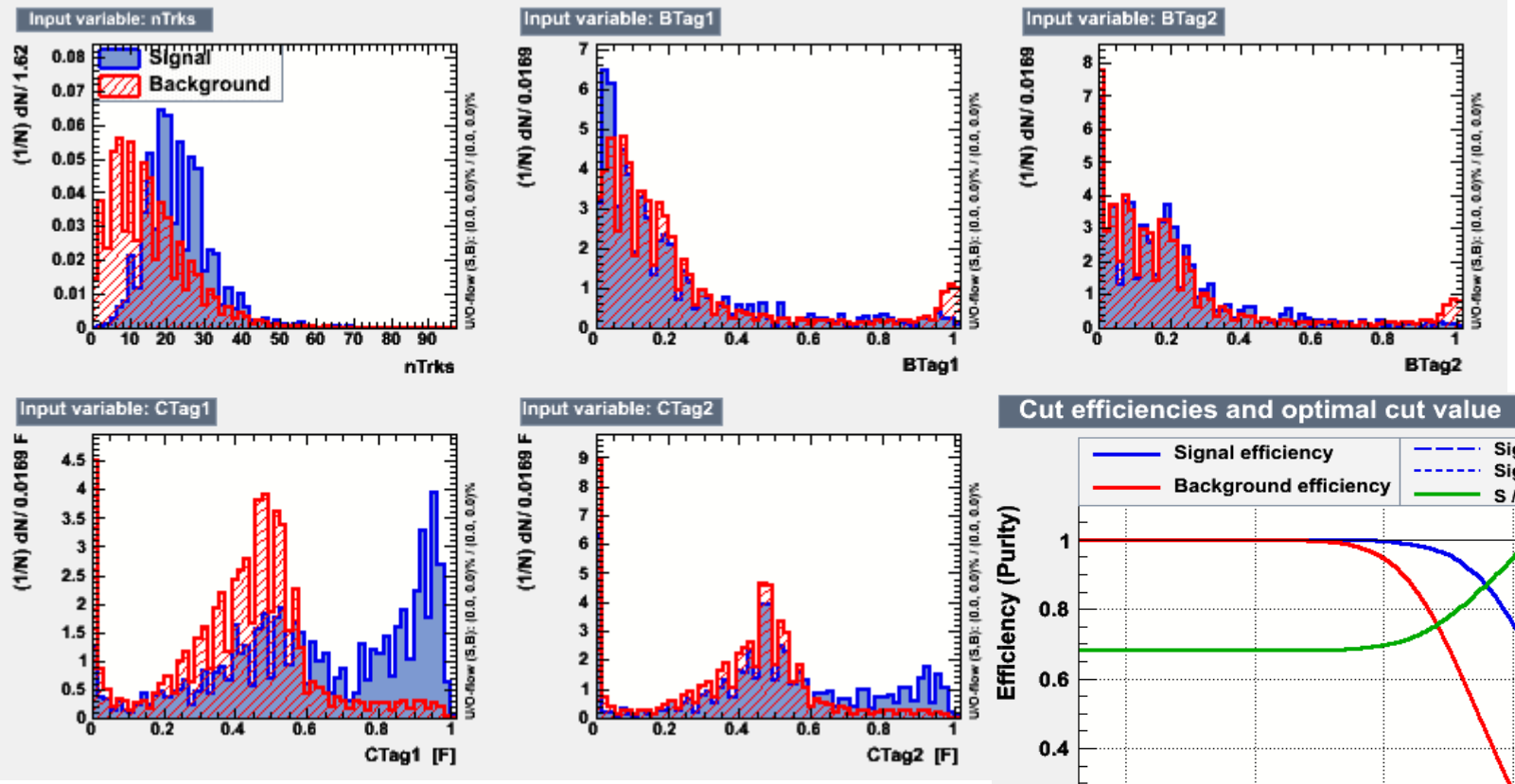
Table 1.8: Relative uncertainties on the Higgs $\sigma \times BR$ expected for an integrated luminosity of 1 ab^{-1} at $\sqrt{s}$ =1 TeV using the SiD detector.

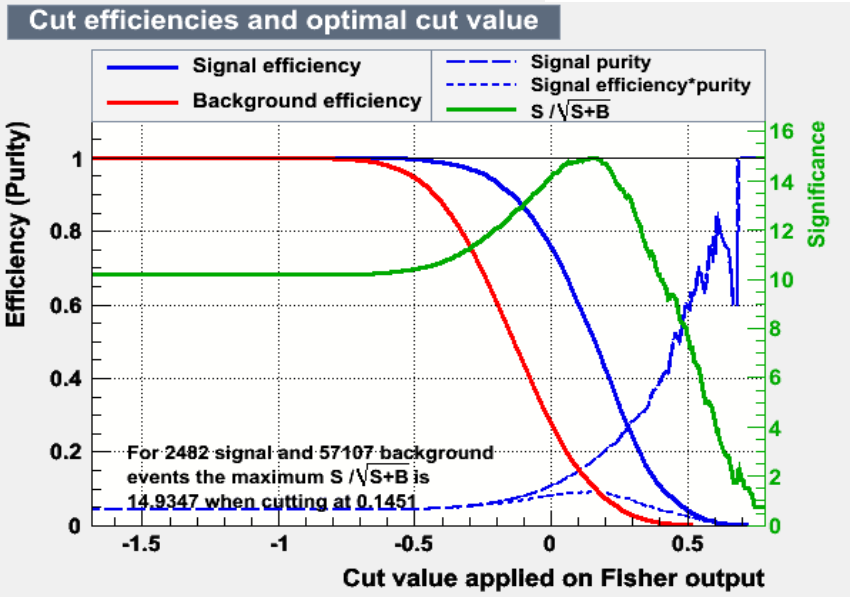
h$\rightarrow$	#events	$\Delta(\sigma \times BR)$
$b\bar{b}$	36013	0.00556 ± 0.00005
$c\bar{c}$	1392	0.069 ± 0.002
gg	4708	0.0319 ± 0.0007
W^+W^-	6178	0.0362 ± 0.0006

Fixes/Hurdles

- Weights Weights Weights
- Higher statistics (downloading files from Grid to SLAC has been a lengthy process)
- LCSIM problem w/reading flavor tag parameters
- Cluster of forward muon detector hits
- LCFI fixes

Fix to retrieval of flavor tag values from the SLCIO files





Plots for cc with fix to retrieval of flavor tag values.

No significant change in results.

Conclusions

- The major issues have been addressed
- Have been pushing hard to improve ultimate uncertainties
- Current results ~frozen
- Many thanks to the whole DBD Benchmarking group and for input from the SiD exec