

DBD Higgs Branching Ratio Analysis

Presented by
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The Joint SiD/ILD Mtg. (17 Jan. 2013)



Issues

- Uncertainties are currently not comfortably consistent with those of ILD and the concern is that this is not reflective of the detector performance but incomplete optimization (possibly missing useful selection variables or charm tagging not performant enough or ...)
- Are we using a consistent set of backgrounds?
- In the process of doing $h \rightarrow \mu^+ \mu^-$
- Results for 500 fb^{-1}
- **All results shown for SiD are for 1 ab^{-1}**

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

Process	\mathcal{L} ab^{-1} per pol.	# Events (10^5) P(e^-/e^+) -0.8/+0.2
$e\gamma \rightarrow e\gamma$	$4 \cdot 10^{-5}$	0.5
$e^+e^- \rightarrow 2f, 4f$	0.034	3.7
$e\gamma \rightarrow 3f$	0.003	3.5
$e\gamma \rightarrow 5f$	0.25	3.1
$e^+e^- \rightarrow 6f$	1.0	1.8
$\Upsilon \rightarrow 2f$	0.001	5.7
$\Upsilon \rightarrow 4f$	0.083	2.5
$\Upsilon \rightarrow$ minijets:		
$4 < p_T < 40 \text{ GeV}$	0.012	9.2
$p_T > 40 \text{ GeV}$	0.105	2.3

MarlinFastJet Jet Clustering
KT algo, 0.7, 6 jets

MarlinFastJet Jet Clustering
KT algo, 1.5, 2 jets

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

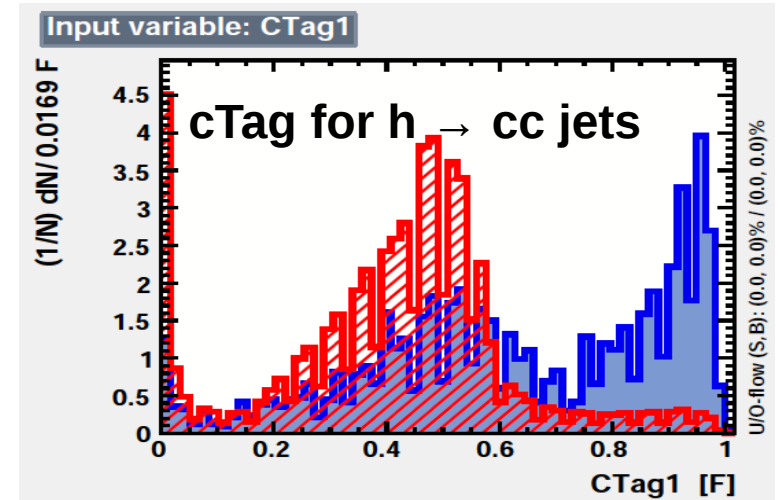
Preselection

TMVA (Fisher)

Table from Tim Barklow

SiD/ILD Joint Mtg. - January 2013

Flavor Tagging



best efficiency*purity

bb cc qq

For charm tagging: \rightarrow <u>Classifier #2</u>	: bdt	0.577	0.655	0.220
For b tagging: \rightarrow <u>Classifier #4</u>	: bdt	0.922	0.365	0.105

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

<u>Classifier #2</u>	: bdt	0.580	0.661	0.227
<u>Classifier #4</u>	: bdt	0.922	0.365	0.105

Pre-Selection Cuts

Higgs decay	Preselection cuts	Signal eff.	Background eff.
$h \rightarrow b\bar{b}$	$50. < P_{t,vis} < 250.$ $100. < E_{vis} < 400$ $110 < M_{vis} < 140$ $|\cos(\theta_{jet})| < 0.90$ $\#Trks > 15$ $B_{tag1,2} > 0.8$	14.9%	5.9×10^{-7}
$h \rightarrow c\bar{c}$	$50 < P_{t,vis} < 250$ $150 < E_{vis} < 400$ $110 < M_{vis} < 140$ $|\cos(\theta_{jet})| < 0.90$ $10 < \#Trks < 50$ $B_{tag1,2} < 0.8$ $C_{tag1\ or\ 2} > 0.8$ $M_{jet1,2} > 10.$	12.9%	1.1×10^{-6}
$h \rightarrow gg$	$50. < P_{vis}^T < 250.$ $150. < E_{vis} < 400.$ $100. < M_{vis} < 140.$ $|\cos(\theta_{JET})| < 0.90$ $\#Trks > 20$ $B_{tag1,2} < 0.8$ $M_{jet2} > 20.$	13.6%	2.4×10^{-6}
$h \rightarrow W^+W^-$	$50. < P_{vis}^T < 250.$ $150. < E_{vis} < 400.$ $100. < M_{vis} < 140.$ $|\cos(\theta_{JET})| < 0.90$ $\#Trks > 15$ $B_{tag1,2} < 0.8$ $M_{jet2} > 40.$	6.9%	5.5×10^{-6}

Preselection Cut Flow Table for $h \rightarrow b \bar{b}$ Selection

(Cut Name	#Events Passings Cuts									
):	all	others	SM	evW	bb	cc	gg	WW	ss	
cut #0 (all	6.97e+09	3.86e+04	6.87e+09	9.47e+07	2.40e+05	1.10e+04	3.46e+04	8.89e+04	1.66e+02	
cut #1 (ptvis>50. && ptvis<250.	5.05e+07	2.06e+04	3.32e+07	1.69e+07	1.72e+05	8.13e+03	2.56e+04	6.05e+04	1.24e+02	
cut #2 (evis>100. && evis<400.	2.47e+07	1.76e+04	1.07e+07	1.38e+07	1.62e+05	7.73e+03	2.45e+04	5.35e+04	1.18e+02	
cut #3 (MvisJETS>110. && MvisJETS<140.	1.28e+06	4.31e+03	8.37e+05	3.09e+05	9.81e+04	5.48e+03	1.51e+04	1.37e+04	8.48e+01	
cut #4 (fabs(cjet1)<0.90 && fabs(cjet2)<0.90	4.86e+05	3.24e+03	2.17e+05	1.67e+05	7.25e+04	4.08e+03	1.14e+04	1.10e+04	5.69e+01	
cut #5 (bprob1>0.8 && bprob2>0.8	4.20e+04	2.13e+02	1.16e+03	3.33e+03	3.71e+04	1.20e+01	1.26e+02	1.42e+01	0.00e+00	
cut #6 (nTrks>15	4.06e+04	2.10e+02	1.13e+03	3.14e+03	3.60e+04	1.20e+01	1.26e+02	1.42e+01	0.00e+00	

Fraction*100 of events passing cuts										
cuts__ (Cut Name	):	all	others	SM	evW	bb	cc	gg	WW	ss
cut #0 (all	):	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
cut #1 (ptvis>50. && ptvis<250.	):	0.72	53.45	0.48	17.89	71.70	73.77	74.08	68.10	74.65
cut #2 (evis>100. && evis<400.	):	0.35	45.71	0.16	14.52	67.79	70.15	70.88	60.22	71.18
cut #3 (MvisJETS>110. && MvisJETS<140.	):	0.02	11.19	0.01	0.33	40.93	49.78	43.63	15.46	51.14
cut #4 (fabs(cjet1)<0.90 && fabs(cjet2)<0.90	):	0.01	8.41	0.00	0.18	30.25	36.98	33.01	12.37	34.31
cut #5 (bprob1>0.8 && bprob2>0.8	):	0.00	0.55	0.00	0.00	15.48	0.11	0.37	0.02	0.00
cut #6 (nTrks>15	):	0.00	0.55	0.00	0.00	15.02	0.11	0.36	0.02	0.00

Fraction*100 of events passing each individual cut										
cuts__ (Cut Name	):	all	others	SM	evW	bb	cc	gg	WW	ss
cut #0 (all	):	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
cut #1 (ptvis>50. && ptvis<250.	):	0.72	53.45	0.48	17.89	71.70	73.77	74.08	68.10	74.65
cut #2 (evis>100. && evis<400.	):	2.96	63.81	2.59	29.38	90.01	91.73	91.91	76.59	94.05
cut #3 (MvisJETS>110. && MvisJETS<140.	):	0.31	14.87	0.29	1.57	55.04	66.75	58.21	19.86	67.35
cut #4 (fabs(cjet1)<0.90 && fabs(cjet2)<0.90	):	29.05	65.14	28.90	39.06	67.42	68.24	69.26	71.32	65.66
cut #5 (bprob1>0.8 && bprob2>0.8	):	0.15	2.84	0.14	0.68	43.69	0.44	1.57	0.29	0.00
cut #6 (nTrks>15	):	10.20	26.87	9.89	32.37	87.20	82.40	96.37	68.92	75.83

Others::event types for which there is no other column. This is entirely Higgs decays to
 ZZ, $\tau\tau$ and $\gamma\gamma$

evW:: evW+eeZ+vvZ

Preselection Cut Flow Table for $h \rightarrow c \bar{c}$ Selection

(Cut Name	#Events Passings Cuts									
):	all	others	SM	evW	bb	cc	gg	WW	ss	
cut #0 (all	6.97e+09	3.86e+04	6.87e+09	9.47e+07	2.40e+05	1.10e+04	3.46e+04	8.89e+04	1.66e+02	
cut #1 (ptvis>50. && ptvis<250.	5.05e+07	2.06e+04	3.32e+07	1.69e+07	1.72e+05	8.13e+03	2.56e+04	6.05e+04	1.24e+02	
cut #2 (evis>150. && evis<400.	1.43e+07	1.14e+04	6.75e+06	7.32e+06	1.33e+05	6.60e+03	2.03e+04	3.72e+04	1.02e+02	
cut #3 (MvisJETS>110. && MvisJETS<140.	1.09e+06	3.89e+03	7.12e+05	2.57e+05	8.78e+04	4.97e+03	1.36e+04	1.26e+04	7.79e+01	
cut #4 (fabs(cjet1)<0.90 && fabs(cjet2)<0.90	3.72e+05	2.87e+03	1.48e+05	1.34e+05	6.34e+04	3.63e+03	1.01e+04	9.90e+03	5.16e+01	
cut #5 (bprobl<0.8 && bprob2<0.8	2.93e+05	2.34e+03	1.42e+05	1.22e+05	4.30e+03	3.34e+03	9.35e+03	9.36e+03	5.00e+01	
cut #6 (cprobl>0.8 || cprob2>0.8	4.72e+04	4.50e+02	1.54e+04	2.41e+04	1.73e+03	2.22e+03	6.04e+02	2.68e+03	3.69e+00	
cut #7 (nTrks>=10. && nTrks<=50.	4.47e+04	3.30e+02	1.40e+04	2.33e+04	1.71e+03	2.21e+03	5.87e+02	2.65e+03	3.69e+00	
cut #8 (mjet1>10. || mjet2>10.	4.23e+04	3.07e+02	1.26e+04	2.23e+04	1.67e+03	2.13e+03	5.87e+02	2.65e+03	3.16e+00	

(Cut Name	Fraction*100 of events passing cuts									
):	all	others	SM	evW	bb	cc	gg	WW	ss	
cut #0 (all	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
cut #1 (ptvis>50. && ptvis<250.	0.72	53.45	0.48	17.89	71.70	73.77	74.08	68.10	74.65	
cut #2 (evis>150. && evis<400.	0.20	29.55	0.10	7.73	55.69	59.94	58.64	41.80	61.65	
cut #3 (MvisJETS>110. && MvisJETS<140.	0.02	10.09	0.01	0.27	36.63	45.14	39.36	14.18	47.02	
cut #4 (fabs(cjet1)<0.90 && fabs(cjet2)<0.90	0.01	7.45	0.00	0.14	26.44	32.98	29.08	11.13	31.13	
cut #5 (bprobl<0.8 && bprob2<0.8	0.00	6.06	0.00	0.13	1.79	30.27	27.04	10.53	30.18	
cut #6 (cprobl>0.8 || cprob2>0.8	0.00	1.17	0.00	0.03	0.72	20.14	1.75	3.01	2.22	
cut #7 (nTrks>=10. && nTrks<=50.	0.00	0.86	0.00	0.02	0.71	20.03	1.70	2.98	2.22	
cut #8 (mjet1>10. || mjet2>10.	0.00	0.80	0.00	0.02	0.70	19.29	1.70	2.98	1.91	

(Cut Name	Fraction*100 of events passing each individual cut									
):	all	others	SM	evW	bb	cc	gg	WW	ss	
cut #0 (all	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
cut #1 (ptvis>50. && ptvis<250.	0.72	53.45	0.48	17.89	71.70	73.77	74.08	68.10	74.65	
cut #2 (evis>150. && evis<400.	1.10	37.18	0.91	14.79	68.16	73.01	70.65	49.79	77.21	
cut #3 (MvisJETS>110. && MvisJETS<140.	0.31	14.87	0.29	1.57	55.04	66.75	58.21	19.86	67.35	
cut #4 (fabs(cjet1)<0.90 && fabs(cjet2)<0.90	29.05	65.14	28.90	39.06	67.42	68.24	69.26	71.32	65.66	
cut #5 (bprobl<0.8 && bprob2<0.8	96.90	88.41	96.96	92.95	9.96	90.14	90.61	94.61	97.78	
cut #6 (cprobl>0.8 || cprob2>0.8	3.63	16.38	3.52	11.84	10.71	59.09	9.01	21.04	5.72	
cut #7 (nTrks>=10. && nTrks<=50.	31.51	45.77	31.08	62.64	97.12	96.53	97.19	86.58	95.23	
cut #8 (mjet1>10. || mjet2>10.	5.30	46.92	4.89	34.83	90.49	90.64	97.35	82.37	90.76	
cut #6 (nTrks>=15	10.20	26.87	9.89	32.37	87.20	82.40	96.37	68.92	75.83	

Others::event types for which there is no other column. This is entirely Higgs decays to ZZ, $\tau\tau$ and $\gamma\gamma$

evW:: evW+eeZ+vvZ

Preselection Cut Flow Table for $h \rightarrow gg$ Selection

(Cut Name	#Events Passings Cuts									
):	all	others	SM	evW	bb	cc	gg	WW	ss	
cut #0 (all	6.97e+09	3.86e+04	6.87e+09	9.47e+07	2.40e+05	1.10e+04	3.46e+04	8.89e+04	1.66e+02	
cut #1 (ptvis>50. && ptvis<250.	5.05e+07	2.06e+04	3.32e+07	1.69e+07	1.72e+05	8.13e+03	2.56e+04	6.05e+04	1.24e+02	
cut #2 (evis>150. && evis<400.	1.43e+07	1.14e+04	6.75e+06	7.32e+06	1.33e+05	6.60e+03	2.03e+04	3.72e+04	1.02e+02	
cut #3 (MvisJETS>100. && MvisJETS<140.	1.68e+06	5.33e+03	1.03e+06	5.03e+05	1.06e+05	5.52e+03	1.57e+04	1.70e+04	8.64e+01	
cut #4 (fabs(cjet1)<0.90 && fabs(cjet2)<0.90	5.77e+05	3.86e+03	1.81e+05	2.89e+05	7.51e+04	3.97e+03	1.14e+04	1.30e+04	5.79e+01	
cut #5 (bprob1<0.8 && bprob2<0.8	4.72e+05	3.17e+03	1.74e+05	2.63e+05	5.55e+03	3.64e+03	1.05e+04	1.23e+04	5.63e+01	
cut #6 (mjet2>20.	2.44e+05	1.71e+03	6.24e+04	1.54e+05	3.10e+03	1.88e+03	8.31e+03	1.16e+04	2.63e+01	
cut #7 (nTrks>20	1.50e+05	1.05e+03	2.58e+04	1.02e+05	2.44e+03	1.48e+03	7.98e+03	9.73e+03	1.90e+01	

(Cut Name	Fraction*100 of events passing cuts									
):	all	others	SM	evW	bb	cc	gg	WW	ss	
cut #0 (all	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
cut #1 (ptvis>50. && ptvis<250.	0.72	53.45	0.48	17.89	71.70	73.77	74.08	68.10	74.65	
cut #2 (evis>150. && evis<400.	0.20	29.55	0.10	7.73	55.69	59.94	58.64	41.80	61.65	
cut #3 (MvisJETS>100. && MvisJETS<140.	0.02	13.82	0.01	0.53	44.16	50.10	45.41	19.07	52.10	
cut #4 (fabs(cjet1)<0.90 && fabs(cjet2)<0.90	0.01	10.02	0.00	0.30	31.35	36.02	32.85	14.58	34.94	
cut #5 (bprob1<0.8 && bprob2<0.8	0.01	8.23	0.00	0.28	2.32	33.07	30.43	13.81	33.99	
cut #6 (mjet2>20.	0.00	4.45	0.00	0.16	1.30	17.07	24.03	13.00	15.88	
cut #7 (nTrks>20	0.00	2.72	0.00	0.11	1.02	13.40	23.08	10.95	11.44	

(Cut Name	Fraction*100 of events passing each individual cut									
):	all	others	SM	evW	bb	cc	gg	WW	ss	
cut #0 (all	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
cut #1 (ptvis>50. && ptvis<250.	0.72	53.45	0.48	17.89	71.70	73.77	74.08	68.10	74.65	
cut #2 (evis>150. && evis<400.	1.10	37.18	0.91	14.79	68.16	73.01	70.65	49.79	77.21	
cut #3 (MvisJETS>100. && MvisJETS<140.	0.49	21.98	0.45	2.67	68.94	76.00	69.20	28.04	76.24	
cut #4 (fabs(cjet1)<0.90 && fabs(cjet2)<0.90	29.05	65.14	28.90	39.06	67.42	68.24	69.26	71.32	65.66	
cut #5 (bprob1<0.8 && bprob2<0.8	96.90	88.41	96.96	92.95	9.96	90.14	90.61	94.61	97.78	
cut #6 (mjet2>20.	0.90	21.90	0.78	9.69	42.38	43.00	64.10	55.64	42.76	
cut #7 (nTrks>20	3.69	18.06	3.52	15.64	66.86	57.77	87.26	50.47	50.10	

Others::event types for which there is no other column. This is entirely Higgs decays to ZZ, $\tau\tau$ and $\gamma\gamma$

evW:: evW+eeZ+vvZ

Preselection Cut Flow Table for $h \rightarrow W W$ Selection

(Cut Name	#Events Passings Cuts									
):	all	others	SM	evW	bb	cc	gg	WW	ss	
cut #0 (all	6.97e+09	3.86e+04	6.87e+09	9.47e+07	2.40e+05	1.10e+04	3.46e+04	8.89e+04	1.66e+02	
cut #1 (ptvis>50. && ptvis<250.	5.05e+07	2.06e+04	3.32e+07	1.69e+07	1.72e+05	8.13e+03	2.56e+04	6.05e+04	1.24e+02	
cut #2 (evis>150. && evis<400.	1.43e+07	1.14e+04	6.75e+06	7.32e+06	1.33e+05	6.60e+03	2.03e+04	3.72e+04	1.02e+02	
cut #3 (MvisJETS>100. && MvisJETS<140.	1.68e+06	5.33e+03	1.03e+06	5.03e+05	1.06e+05	5.52e+03	1.57e+04	1.70e+04	8.64e+01	
cut #4 (fabs(cjet1)<0.90 && fabs(cjet2)<0.90	5.77e+05	3.86e+03	1.81e+05	2.89e+05	7.51e+04	3.97e+03	1.14e+04	1.30e+04	5.79e+01	
cut #5 (bprob1<0.8 && bprob2<0.8	4.72e+05	3.17e+03	1.74e+05	2.63e+05	5.55e+03	3.64e+03	1.05e+04	1.23e+04	5.63e+01	
cut #6 (mjet2>40.	8.83e+04	8.96e+02	2.90e+04	4.65e+04	9.04e+02	5.02e+02	3.14e+03	7.40e+03	7.90e+00	
cut #7 (nTrks>15	6.92e+04	7.90e+02	1.47e+04	4.20e+04	8.81e+02	4.94e+02	3.13e+03	7.14e+03	7.37e+00	

(Cut Name	Fraction*100 of events passing cuts									
):	all	others	SM	evW	bb	cc	gg	WW	ss	
cut #0 (all	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
cut #1 (ptvis>50. && ptvis<250.	0.72	53.45	0.48	17.89	71.70	73.77	74.08	68.10	74.65	
cut #2 (evis>150. && evis<400.	0.20	29.55	0.10	7.73	55.69	59.94	58.64	41.80	61.65	
cut #3 (MvisJETS>100. && MvisJETS<140.	0.02	13.82	0.01	0.53	44.16	50.10	45.41	19.07	52.10	
cut #4 (fabs(cjet1)<0.90 && fabs(cjet2)<0.90	0.01	10.02	0.00	0.30	31.35	36.02	32.85	14.58	34.94	
cut #5 (bprob1<0.8 && bprob2<0.8	0.01	8.23	0.00	0.28	2.32	33.07	30.43	13.81	33.99	
cut #6 (mjet2>40.	0.00	2.32	0.00	0.05	0.38	4.56	9.08	8.33	4.77	
cut #7 (nTrks>15	0.00	2.05	0.00	0.04	0.37	4.48	9.06	8.03	4.45	

(Cut Name	Fraction*100 of events passing each individual cut									
):	all	others	SM	evW	bb	cc	gg	WW	ss	
cut #0 (all	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
cut #1 (ptvis>50. && ptvis<250.	0.72	53.45	0.48	17.89	71.70	73.77	74.08	68.10	74.65	
cut #2 (evis>150. && evis<400.	1.10	37.18	0.91	14.79	68.16	73.01	70.65	49.79	77.21	
cut #3 (MvisJETS>100. && MvisJETS<140.	0.49	21.98	0.45	2.67	68.94	76.00	69.20	28.04	76.24	
cut #4 (fabs(cjet1)<0.90 && fabs(cjet2)<0.90	29.05	65.14	28.90	39.06	67.42	68.24	69.26	71.32	65.66	
cut #5 (bprob1<0.8 && bprob2<0.8	96.90	88.41	96.96	92.95	9.96	90.14	90.61	94.61	97.78	
cut #6 (mjet2>40.	0.25	8.79	0.23	1.87	11.86	11.98	21.20	22.23	11.29	
cut #7 (nTrks>15	10.20	26.87	9.89	32.37	87.20	82.40	96.37	68.92	75.83	

Others::event types for which there is no other column. This is entirely Higgs decays to ZZ, $\tau\tau$ and $\gamma\gamma$

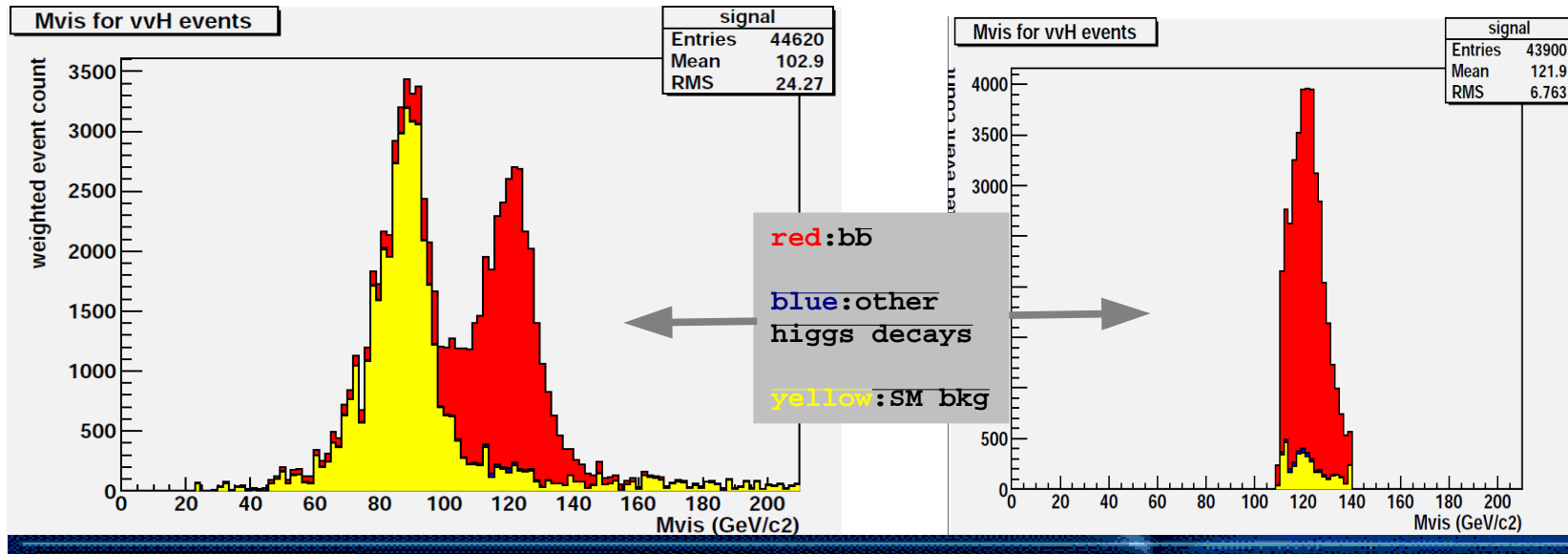
evW:: evW+eeZ+vvZ

Composition of Final Samples after applying Fisher discriminants

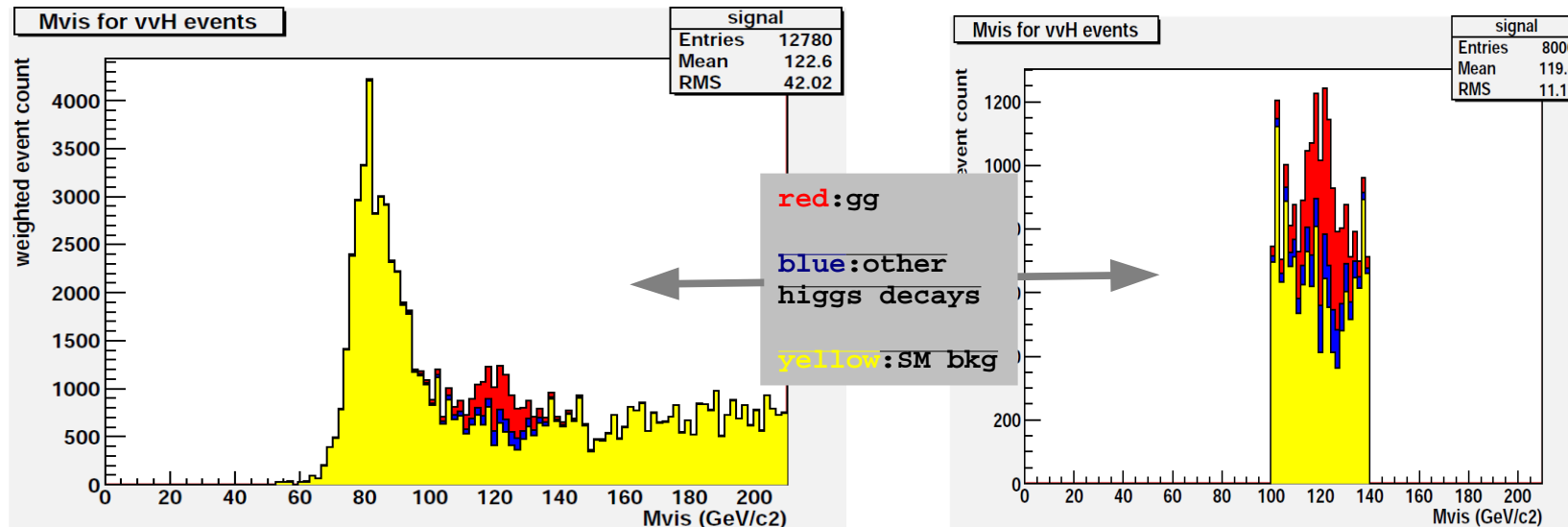
$h \rightarrow b\bar{b}$	$h \rightarrow c\bar{c}$	$h \rightarrow WW$	$h \rightarrow gg$
<i>evW + eeZ + vvZ</i>			
7.5%	62.9%	61.4%	64.5%
all other Standard Model Backgrounds			
1.9%	19.5%	10.0%	16.7%
Higgs decays			
$h \rightarrow c\bar{c} : 0.0\%$	$h \rightarrow c\bar{c} : 10.5\%$	$h \rightarrow c\bar{c}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

Visible Mass Distributions for Selected Events

bb:



gg:



Current 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 $\sqrt{s} = 1 \text{ TeV}$ 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

Note

- Following suggestions from colleagues at the workshop I have added some extra variables to the analysis and will know if they help soon (~this weekend).