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

Table from Tim Barklow

MarlinFastJet Jet Clustering
KT algo, 0.7, 6 jets

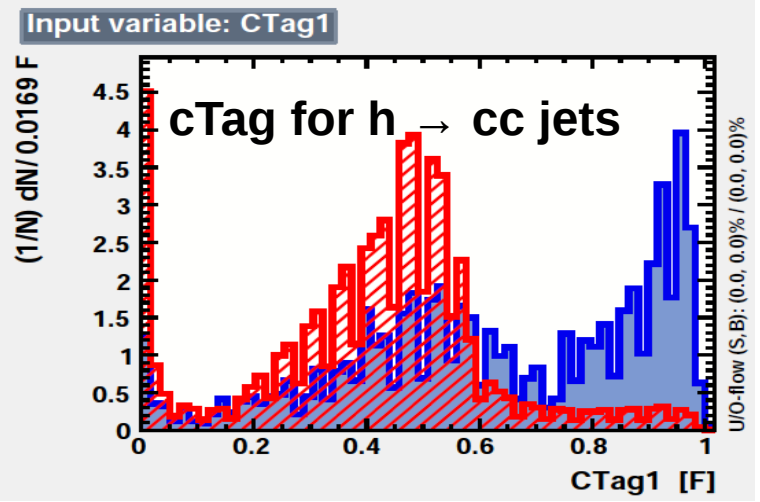
MarlinFastJet Jet Clustering
KT algo, 1.5, 2 jets

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

Preselection

TMVA (Fisher)

Flavor Tagging



best εfficiency*purity

			bb	cc	qq
For charm tagging: →	Classifier #2	: bdt	0.577	0.655	0.220
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 #2	: bdt	0.580	0.661	0.227
Classifier #4	: bdt	0.922	0.365	0.105

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}

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

#Events Passings Cuts

(Cut Name	):	all	others	evW	SM	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	evW	SM	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	evW	SM	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+$\nu\nu$Z

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

#Events Passings Cuts

(Cut Name	all	others	evW	SM	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 (bprob1<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 (cprob1>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

Fraction*100 of events passing cuts

(Cut Name	all	others	evW	SM	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 (bprob1<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 (cprob1>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

Fraction*100 of events passing each individual cut

(Cut Name	all	others	evW	SM	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 (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 (cprob1>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+$\nu\nu$Z

Preselection Cut Flow Table for $h \to g\,g$ Selection

#Events Passings Cuts

(Cut Name	all	others	evW	SM	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

Fraction*100 of events passing cuts

(Cut Name	all	others	evW	SM	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

Fraction*100 of events passing each individual cut

(Cut Name	all	others	evW	SM	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+$\nu\nu$Z

Preselection Cut Flow Table for $h \to W\,W$ Selection

#Events Passings Cuts

(Cut Name	all	others	evW	SM	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

Fraction*100 of events passing cuts

(Cut Name	all	others	evW	SM	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

Fraction*100 of events passing each individual cut

(Cut Name	all	others	evW	SM	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 $\gamma\gamma$

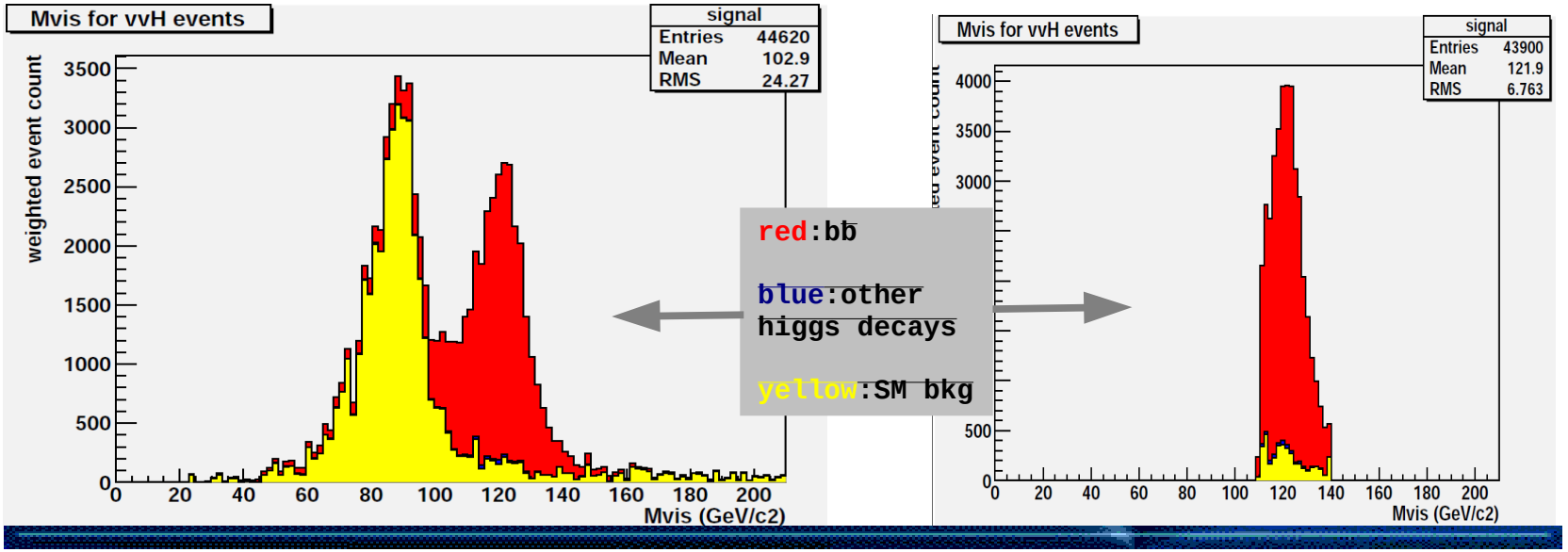
evW:: evW+eeZ+$\nu\nu$Z

Composition of Final Samples after applying Fisher discriminants

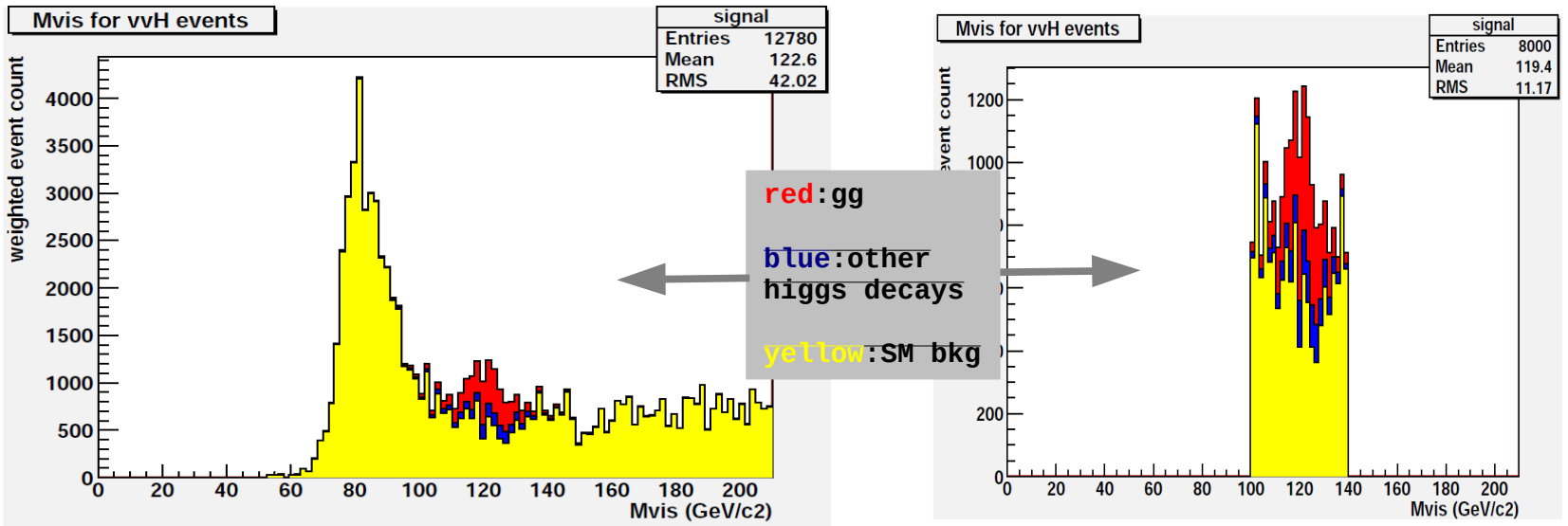
$h \to b\bar{b}$	$h \to c\bar{c}$	$h \to WW$	$h \to gg$
$evW + eeZ + \nu\nu Z$			
7.5%	62.9%	61.4%	64.5%
all other Standard Model Backgrounds			
1.9%	19.5%	10.0%	16.7%
Higgs decays			
$h \to c\bar{c}$: 0.0% $h \to b\bar{b}$: 89.7% $h \to \tau\tau$: 0.8% $h \to gg$: 0.3% $h \to ZZ$: 0.5%	$h \to c\bar{c}$: 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%

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 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).