

# Higgs Branching Ratio

$$H \rightarrow bb, cc, gg$$

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# Status of analysis: Reminder

- Focus on nnH: do not consider separation of ZH and VBF now
- Luminosity:  $4\text{ab}^{-1}$

Polarization	(e-, e+)=(-,+)	(+,-)	(+,+)	(-,-)
Luminosity( $\text{fb}^{-1}$ )	1800	1800	200	200

- Analysis flow



- Signal and backgrounds
  - Signal: use  $\text{nnH} \rightarrow \text{nnbb}, \text{nncc}, \text{nngg}$
  - Backgrounds:  $2f, 4f, 5f, 6f, \text{aa}, \text{ZH}, \text{nnh} \rightarrow \text{nnWW}$

# Cut table: 2weeks ago

- $(e^-, e^+) = (-, +)$  polarization,  $L = 1800 \text{fb}^{-1}$

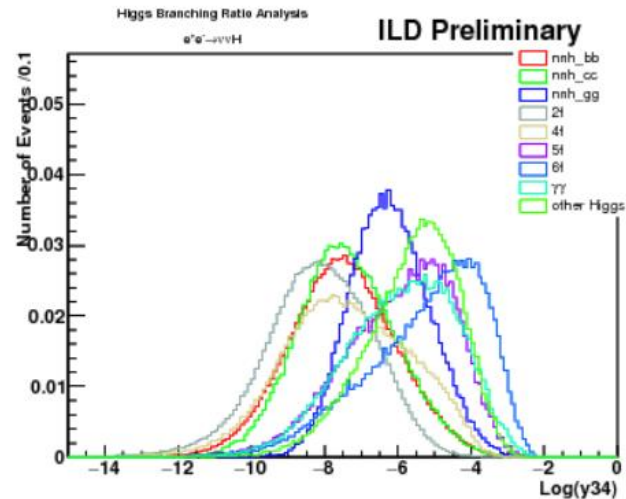
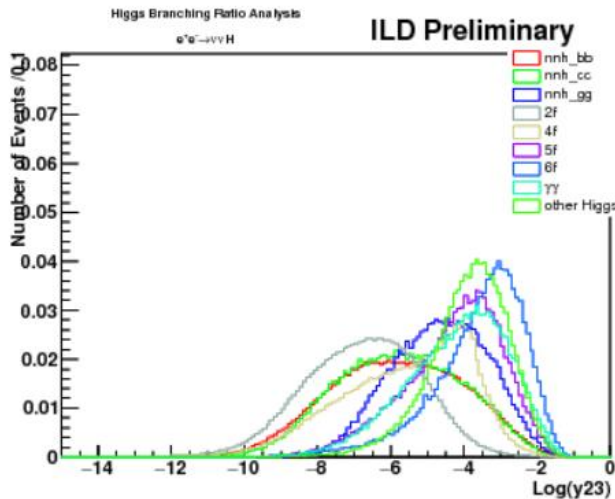
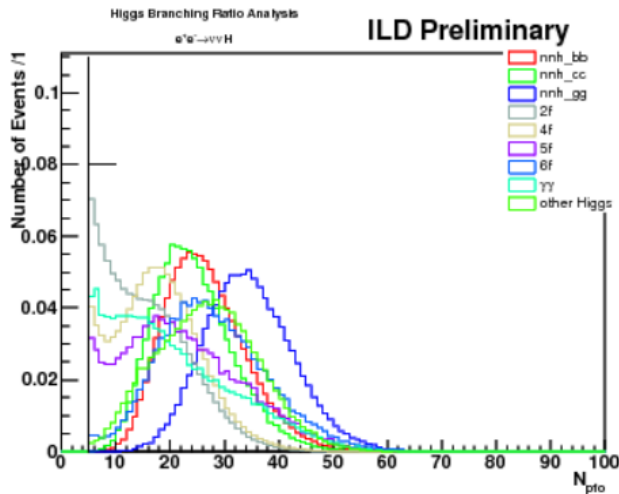
process	H→bb	H→cc	H→gg	2f	4f	5f	6f	γγ	Other Higgs
No cut	176726	8202	26189	3.67e+08	6.29e+07	129014	1.77e+06	457688	226855
$N_{\text{lep}}=0$	171857	8008	25932	2.90e+08	4.25e+07	41116	1.04e+06	282545	160037
$N_{\text{jet}}=2$	171857	8008	25932	2.84e+08	4.23e+07	41101	1.04e+06	267152	160024
$N_{\text{pfo}} \geq 5$	171167	7969	25802	1.87e+08	2.01e+07	29384	116391	243952	54780
$E_{\text{vis}} \leq 300$	169450	7898	25554	4.84e+07	1.16e+07	19510	44885	101863	46512
$40 \leq m_{2\text{jets}} \leq 200$	169448	7898	25554	3.12e+07	9.09e+06	17927	43969	92427	46182
MVA	78568	3425	5468	30484	28934	48.5	452.1	179.3	324.8
Efficiency	0.445	0.418	0.209	8.30e-05	4.60e-04	3.76e-04	2.55e-04	3.92e-04	1.43e-03
Hiroaki's 1TeV	0.350	0.373	0.359						

Very large bias on H→gg

**Need to recover inefficiency of H→gg**

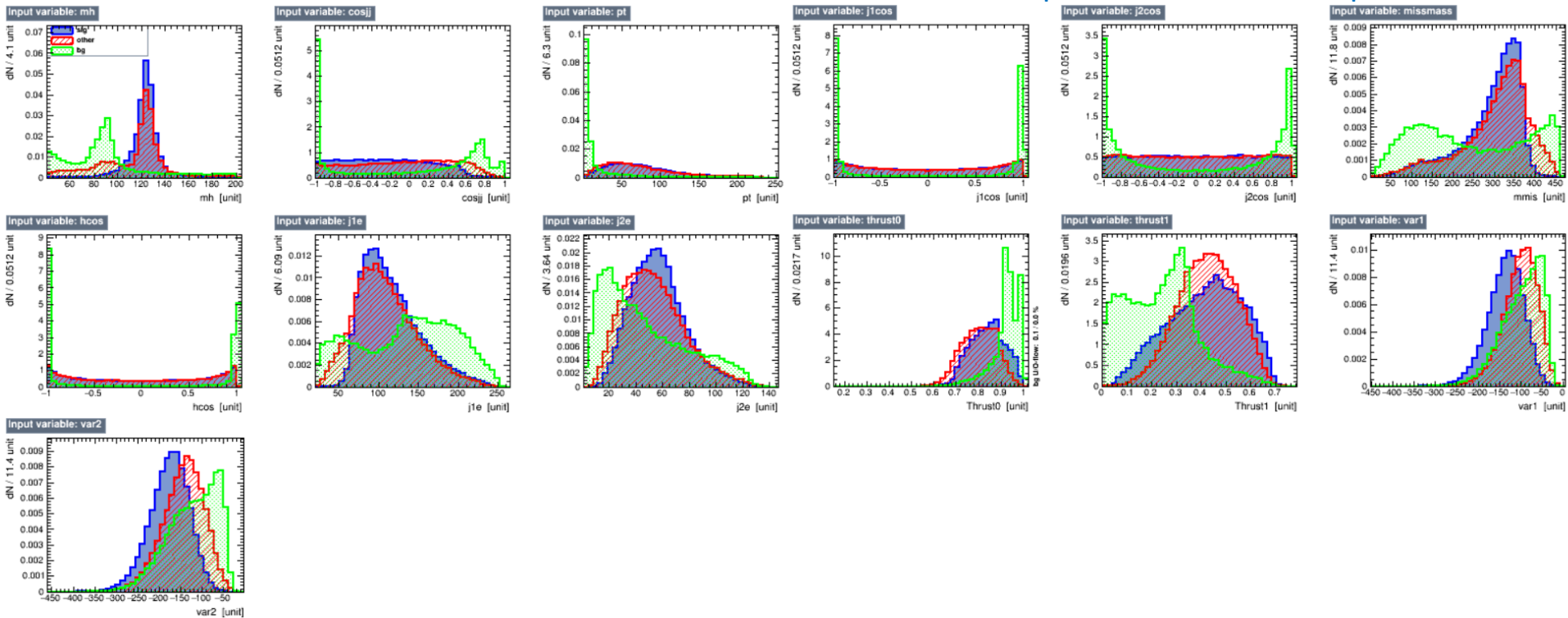
# Cause

- Bias is coming from the difference of input variables for Multivariate Analysis between  $H \rightarrow bb, cc$  and  $H \rightarrow gg$
- These 3 variables create bias...



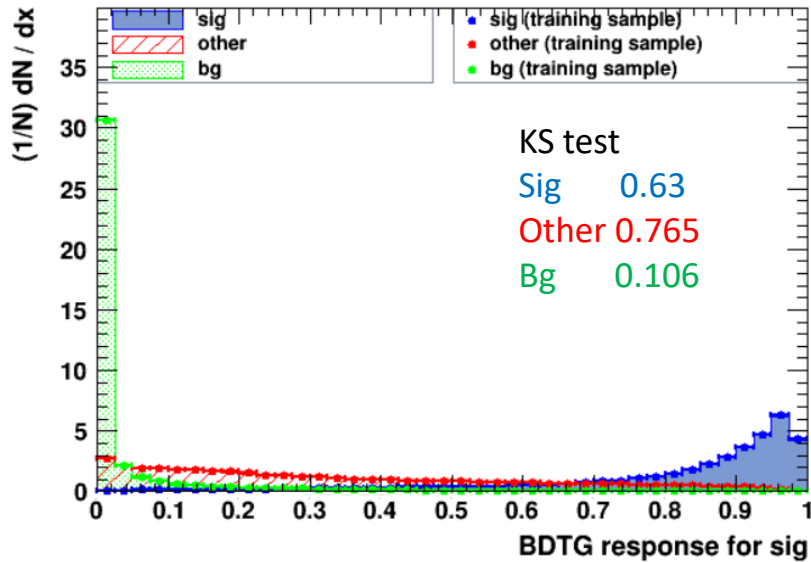
# So,

- Change input variables
- Reduce difference by combining variables
  - $m_{2\text{jets}}$ ,  $\cos\theta_H$ ,  $\cos\theta_{jj}$ ,  $E_{j1}$ ,  $\cos\theta_{j1}$ ,  $E_{j2}$ ,  $\cos\theta_{j2}$ ,  $m_{\text{miss}}$ ,  $P_t$ ,  
Principal Thrust, Major Thrust,  $\text{Log}(y_{23}) * n_{\text{pfo}}$ ,  $\text{Log}(y_{34}) * n_{\text{pfo}}$

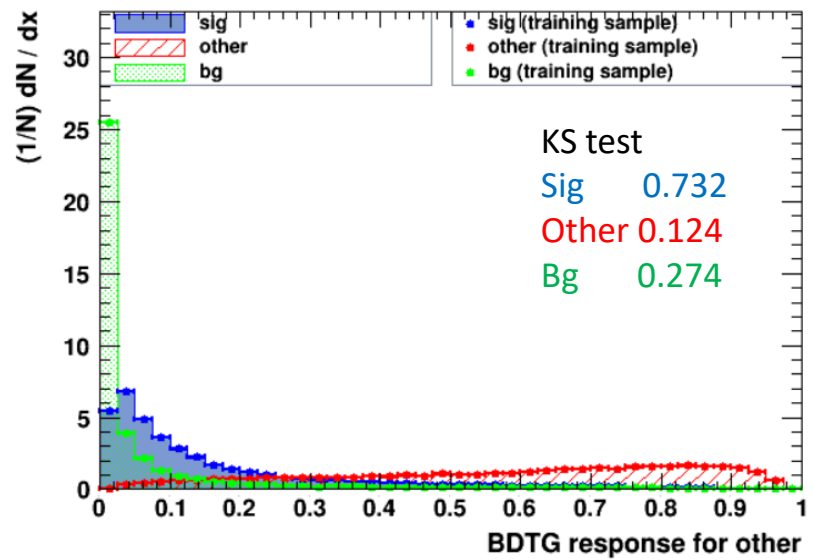


# MVA output

TMVA response for classifier: BDTG

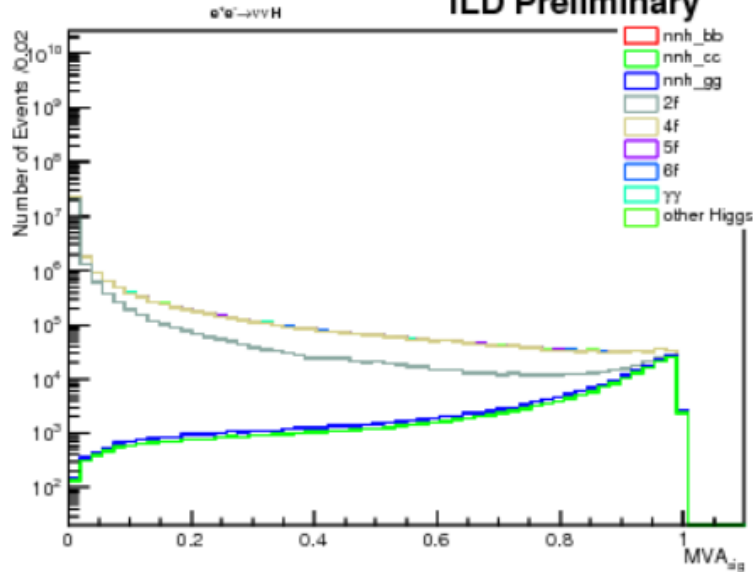


TMVA response for classifier: BDTG



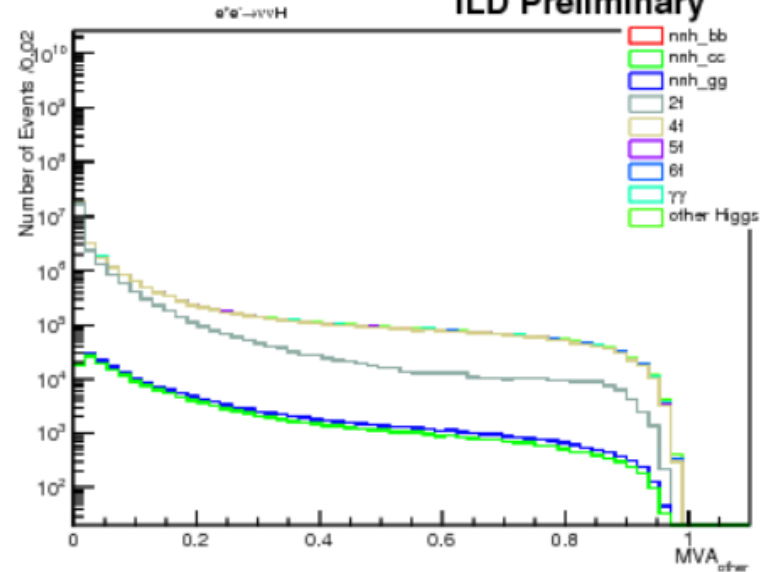
Higgs Branching Ratio Analysis

ILD Preliminary



Higgs Branching Ratio Analysis

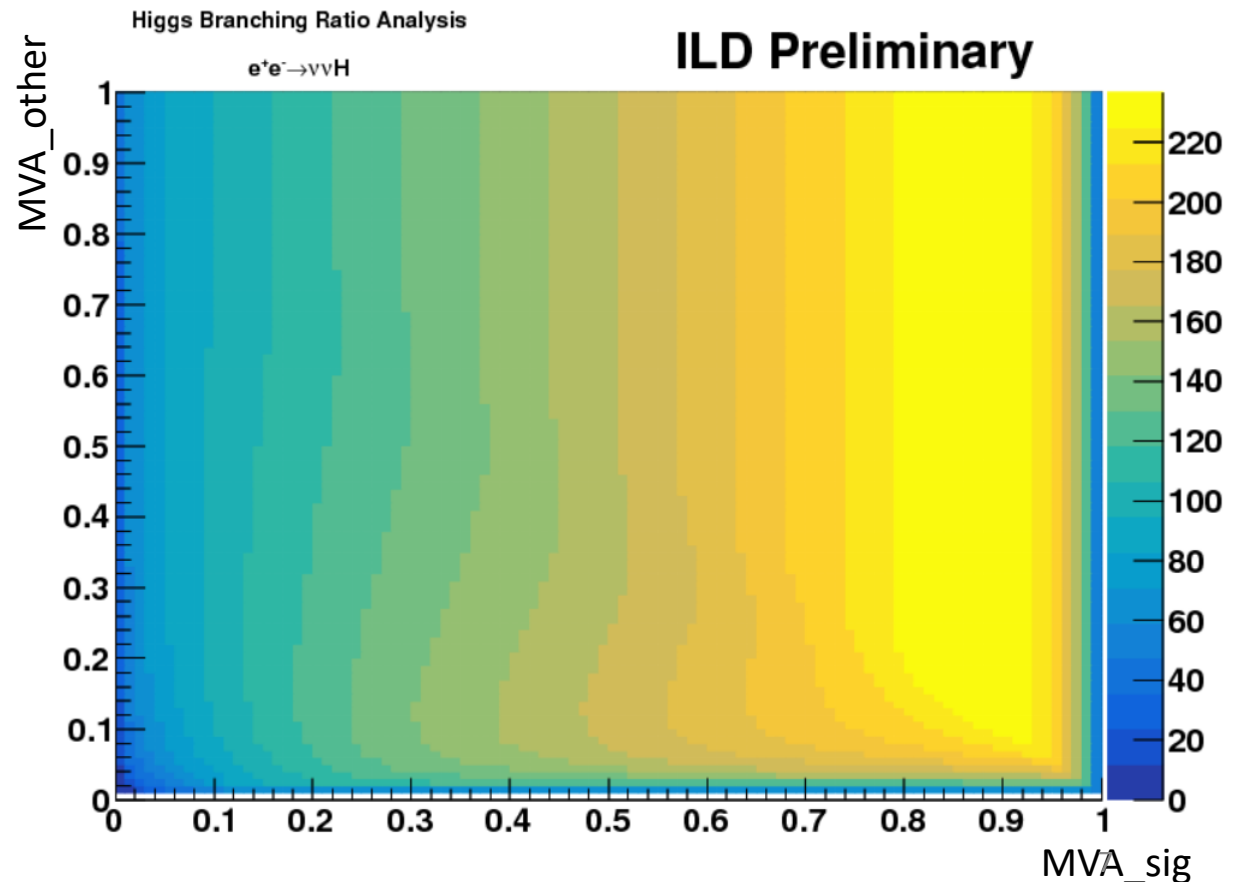
ILD Preliminary



# Optimization

- Determine an operation point:
  - $MVA\_sig > 0.xx \ \&\& \ MVA\_other < 0.yy$
- Optimize the operation point maximizing significance

- Significance:  
220  $\rightarrow$  237



# Cut table

- $(e^-, e^+) = (-, +)$  polarization,  $L = 1800 \text{fb}^{-1}$

process	H→bb	H→cc	H→gg	2f	4f	5f	6f	$\gamma\gamma$	Other Higgs
No cut	176726	8202	26189	3.67e+08	6.29e+07	129014	1.77e+06	457688	226855
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$40 \leq m_{2\text{jets}} \leq 200$	169448	7898	25554	3.12e+07	9.09e+06	17927	43969	92427	46182
MVA	99297	4498	11458	24946	91921	313.2	2333.5	828.9	1811.2
Efficiency	0.562	0.548	0.438	6.79e-05	1.46e-03	2.42e-03	1.32e-03	1.81e-03	7.98e-03
Hiroaki's 1TeV	0.350	0.373	0.359						

H→gg efficiency recovered!

2f & 4f background should be suppressed more



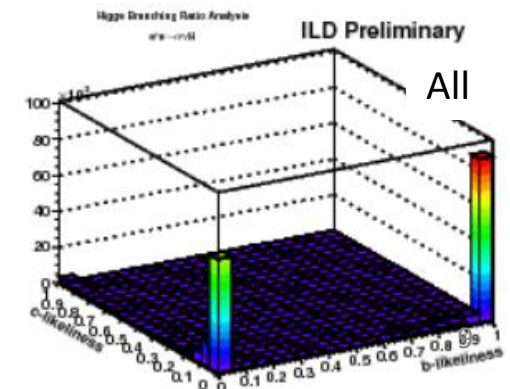
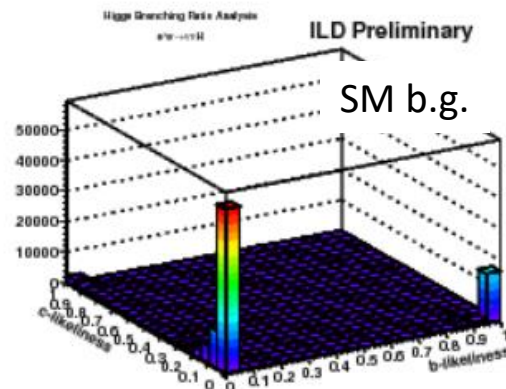
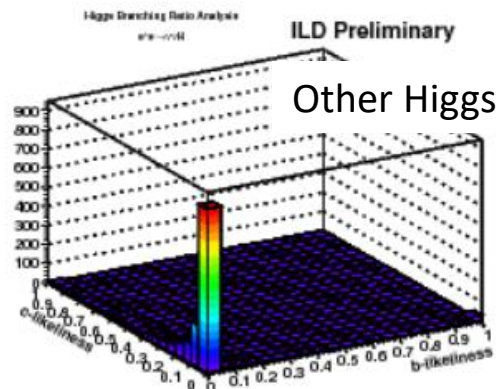
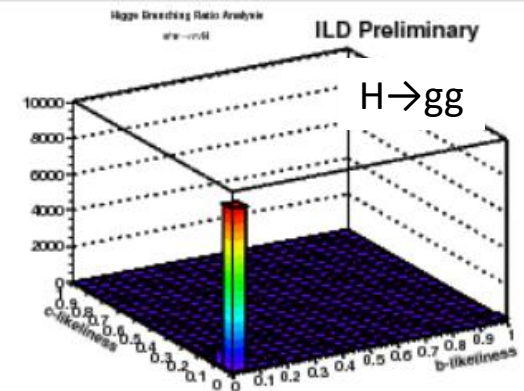
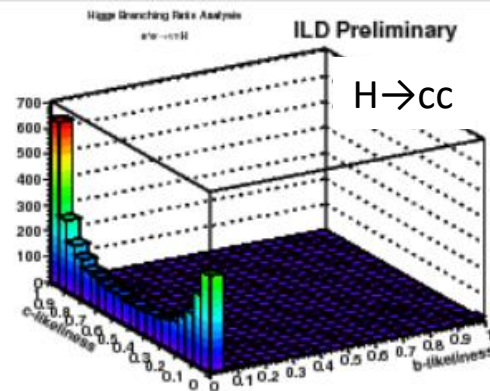
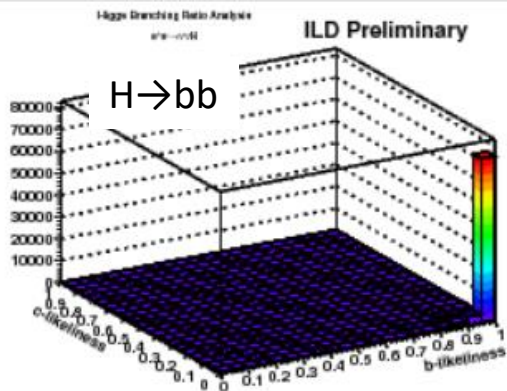
# Template fit

- Toy MC to extract the measurement precision of  $H \rightarrow bb$ ,  $cc$ ,  $gg$

- Using flavor tag templates for fit according to Poisson statistics

- 3-D template of b, c, bc likeliness 
$$N_{ijk}^{\text{template}} = \sum_{s=bb, cc, gg} r_s \cdot N_{ijk}^s + N_{ijk}^{\text{bkg}}$$

- 5000 pseudo-experiments performed



# Very preliminary (updated) results

- Large detector, all the polarization

Process(-,+)	H→bb	H→cc	H→gg
Precision(%)	0.44	4.73	2.79

Process(+,-)	H→bb	H→cc	H→gg
Precision(%)	1.09	12.75	6.94

Process(-,-)	H→bb	H→cc	H→gg
Precision(%)	1.91	26.5	17.4

Process(+,+)	H→bb	H→cc	H→gg
Precision(%)	2.95	39.6	20.8

- Scale to 500fb<sup>-1</sup> (3000)

Process(-,+)	H→bb	H→cc	H→gg
Precision(%)	0.75	9.10	5.27

TDR

Process(-,+)	H→bb	H→cc	H→gg
Precision(%)	0.60	5.2	5.0

- Need to check binning effect of a template

Process(-,+)	H→bb	H→cc	H→gg
(5,5,5) (%)	0.45	5.02	2.89
(10,10,10) (%)	0.44	4.73	2.79
(20,20,20) (%)	0.45	4.57	2.70
(40,40,40) (%)	N/A	N/A	N/A

RooFit prohibits toy-MC

# Prospects

- 3f backgrounds?
- We would like to include  $H \rightarrow \tau\tau$  backgrounds for TMVA separation
  - Now include: ZH and  $nnh \rightarrow nnWW$
- $H \rightarrow gg$  efficiency can be recovered
  - Need to suppress 2f&4f backgrounds more
- Continue to explore better results
  - Focus on 4f rejection
  - Trying to use variables from 4jet clustering
    - Variables have same bias as I mentioned...

# Backups