$h \to \tau^+\tau^-$ BR study

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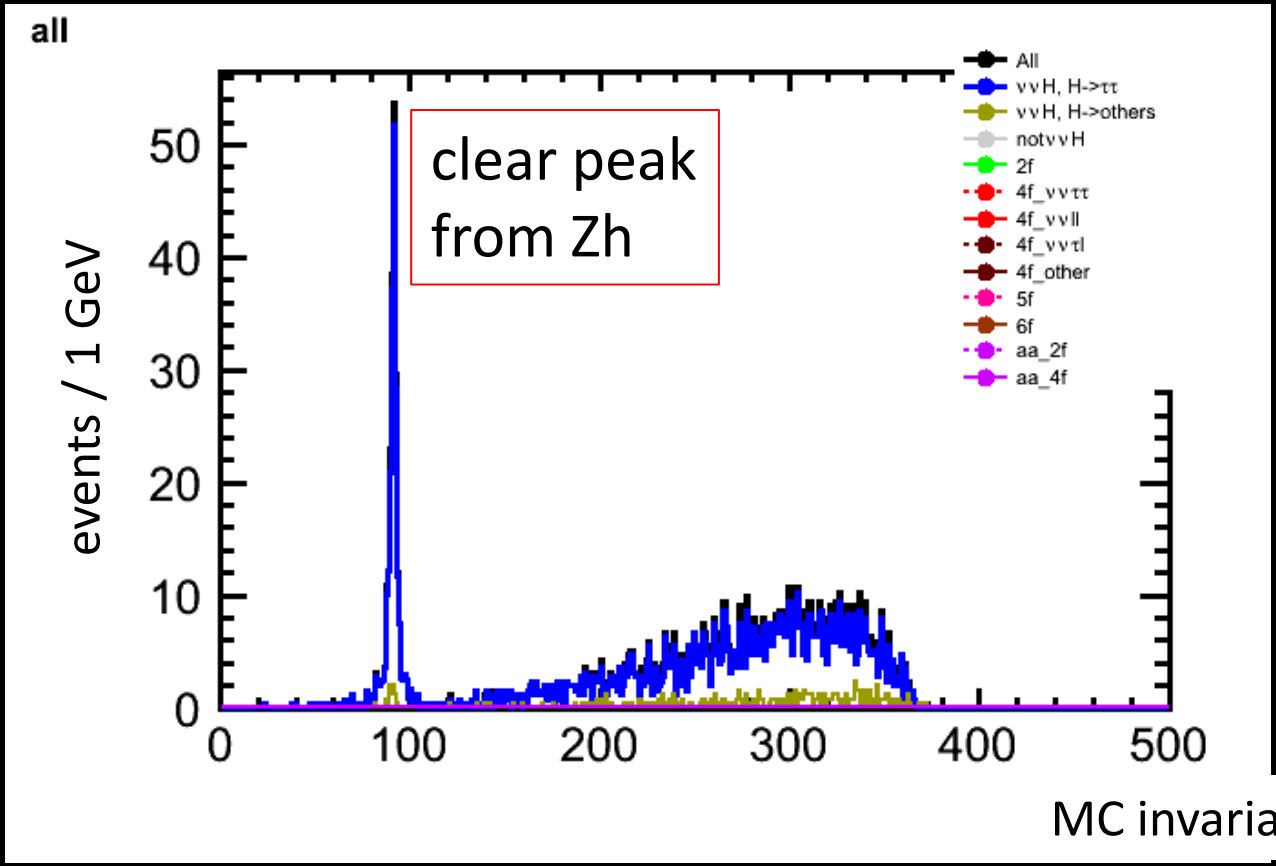
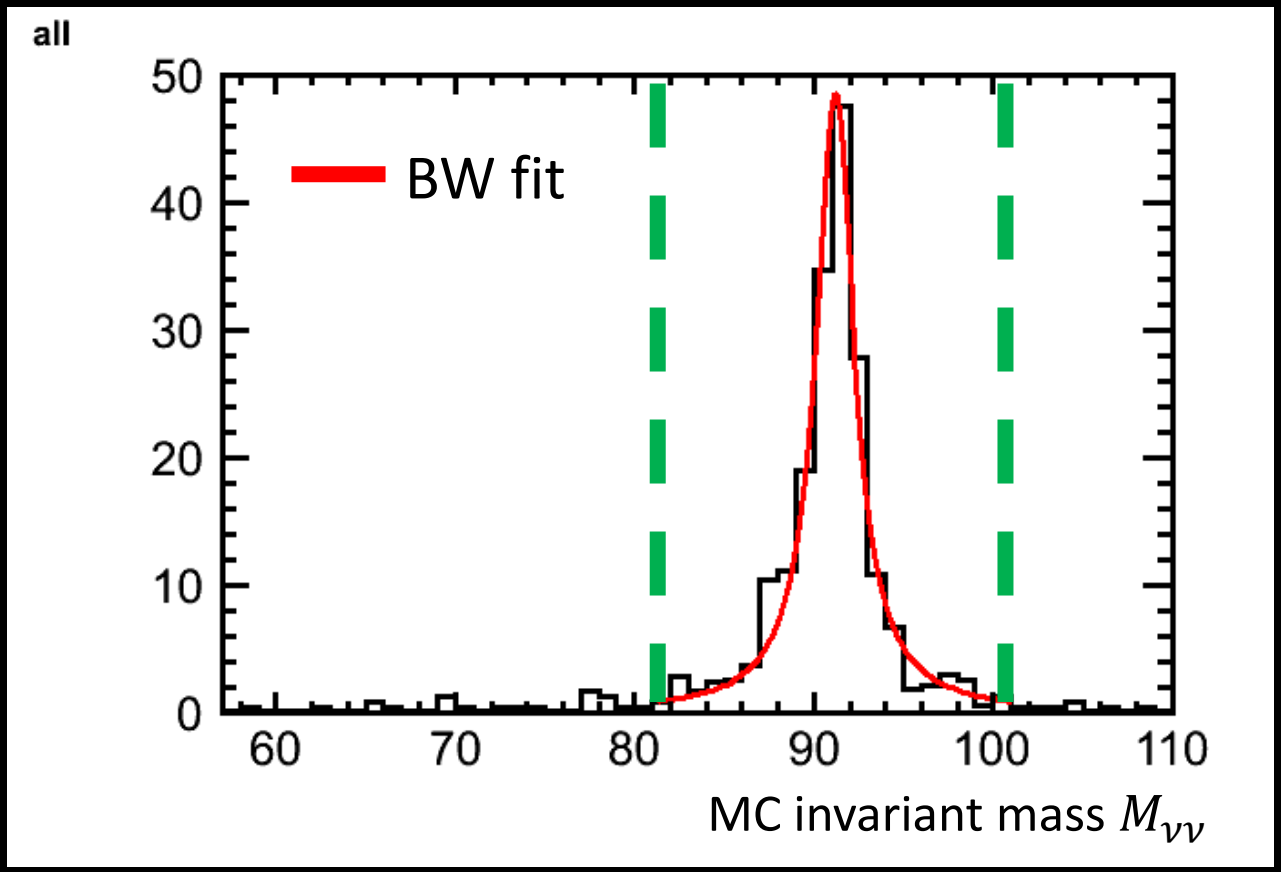
Separation of Zh & WW-fusion

- First look: I checked the MC invariant mass of $M_{\nu\nu}$ after applying cuts.



Separation: making categories



I defined...

Zh-like:

$M_{\nu\nu}$ = 81.2 - 101.2

fusion-like:

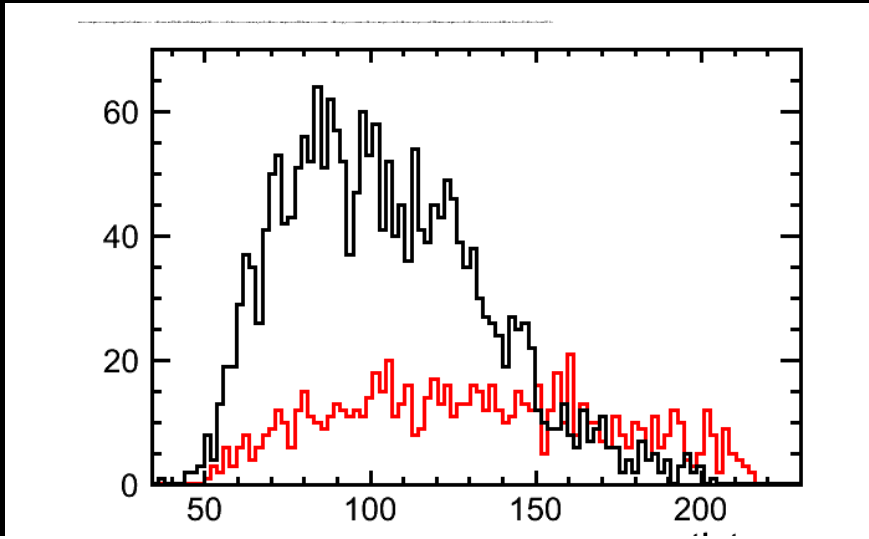
other region

Then I checked the reconstructed particle in both category.

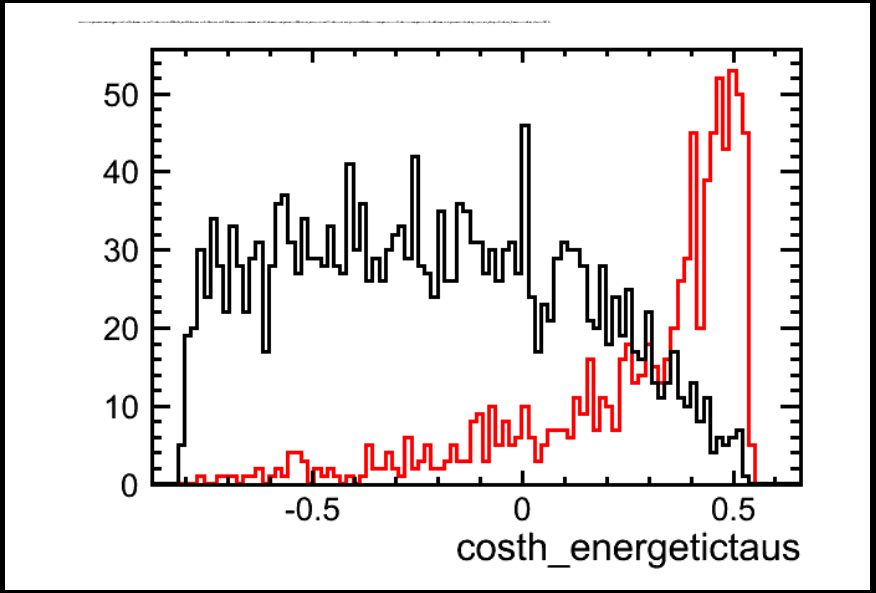
Separation: some variables

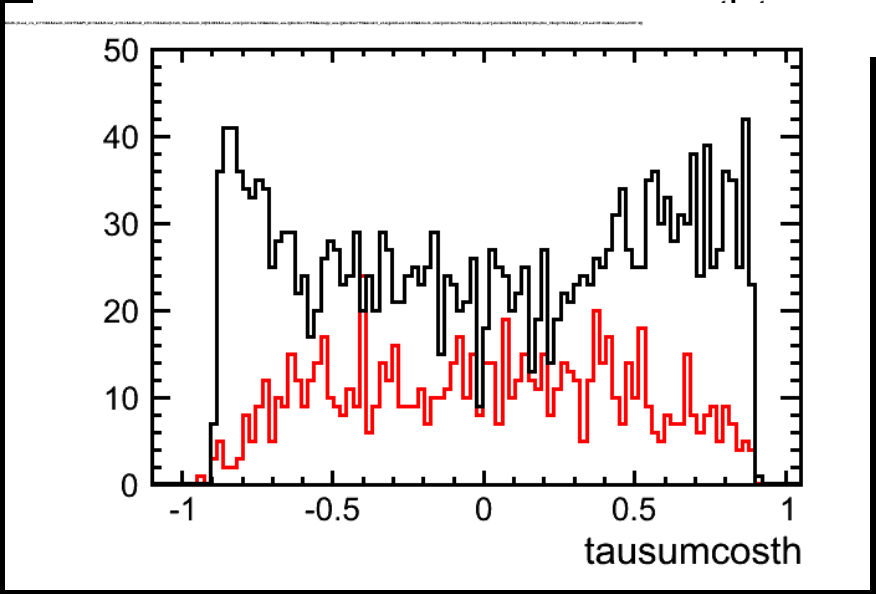
Zh-like
fusion-like

τ^+ energy + τ^- energy



$\cos\theta_{\tau^+\tau^-}$





angle between
(τ^+ 3-momentum + τ^- 3-momentum) vector
and beam axis

Separation

- $\cos\theta_{\tau^+\tau^-}$ looks good variable for separation.
- Next step: try to fit $\cos\theta_{\tau^+\tau^-}$ with (bkg) + (Zh-like) + (fusion-like)

250 GeV analysis

- Practice analysis just started.
  - All TDR samples were used: 2f, 4f, 1f_3f, aa_2f, higgs_ffh
  - Tau polarization is not included properly in TDR samples. It should be replaced to new samples which used in Yokoyama-san's CP study.
- I analyzed qqh process because of high statistics.

Reconstruction

- Beam-induced background is small in 250 GeV, I didn't apply the kT clustering.

1. Applying tau finder for qqh to reconstruct tau
2. Applying collinear approximation to reconstruct Higgs mass
3. Applying Durham 2-jet clustering to reconstruct Z boson

Cut-based analysis

Cut 0: # of q jets = 2, # of $\tau^+(\tau^-)$ = 1,
# of tracks >= 9, $M_{\mathrm{col}} > 0$, $E_{\mathrm{col}} > 0$

Cut 1: thrust < 0.96

Cut 2: $|\cos\theta_{\mathrm{miss}}| < 0.96$

Cut 3: $M_Z(M_{qq}) > 80$

Cut 4: $95 < E_Z(E_{qq}) < 125$

Cut 5: $M_{\tau\tau} < 110$

Cut 6: $E_{\tau\tau} < 125$

Cut 7: $\cos\theta_{\tau\tau} < -0.55$

Cut 8: $100 < M_{\mathrm{col}} < 190$

Cut 9: $E_{\mathrm{col}} < 210$

Cut 10: $M_{\mathrm{recoil}} > 117$

Cut table

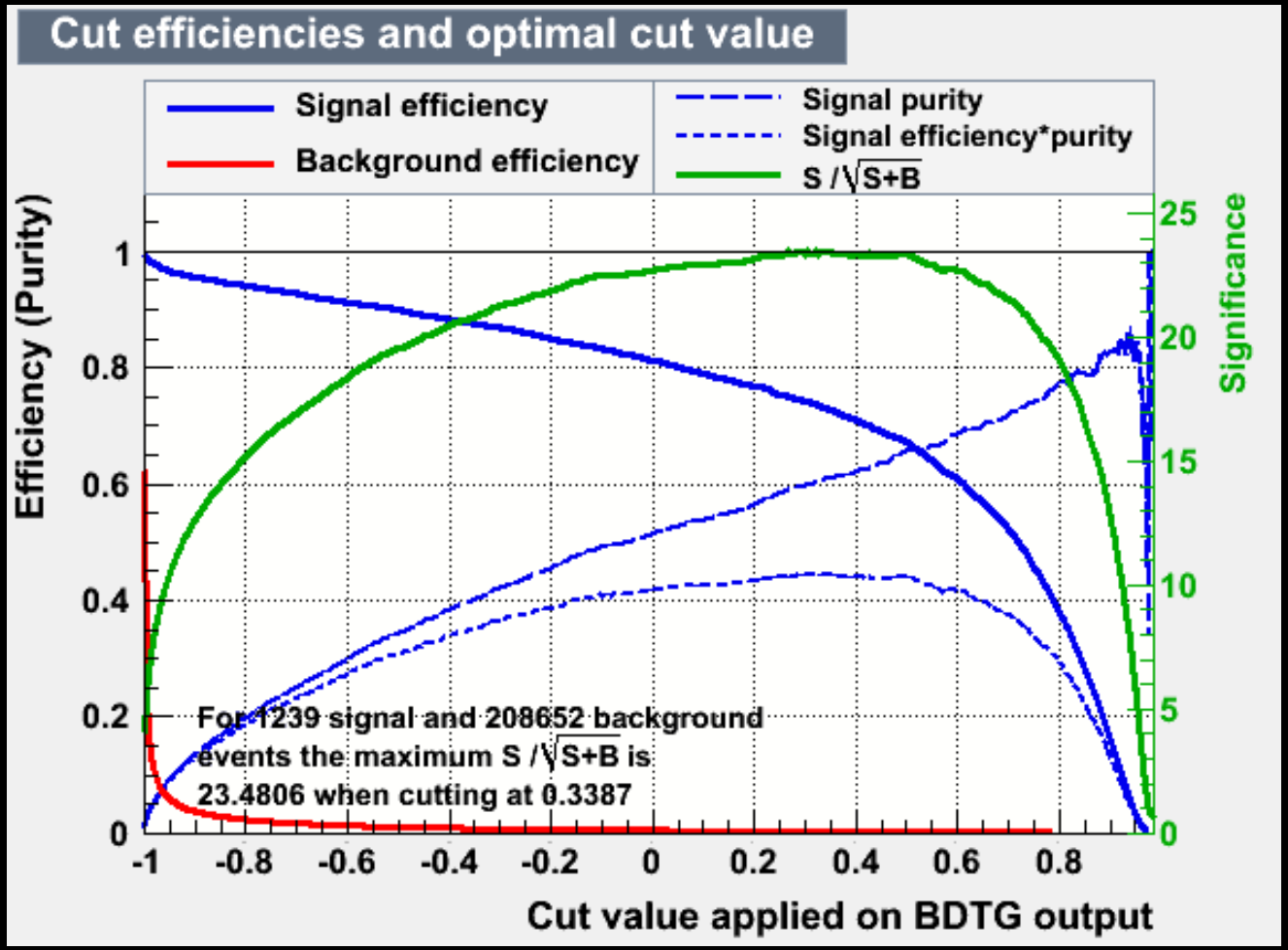
	signal qqh $h \to \tau\tau$	qqh $h \nrightarrow \tau\tau$	llh $\nu\nu h$	2f	4f	1f_3f	aa_2f	others	signi.
Cut 0	1234.625	458.666	3135.347	4.444e+04	2.067e+05	4.382e+04	1.528e+05	0	1.84
…	1234.324	458.666	3135.321	3.737e+04	2.019e+05	3.875e+04	1.505e+05	0	1.88
	1190.960	414.712	2827.822	1.116e+04	1.737e+05	1828.858	2.479e+04	0	2.56
	1069.250	389.695	2711.341	6329.353	6.326e+04	652.089	161.821	0	3.92
	1000.591	165.557	541.237	196.383	2.376e+04	105.484	0	0	6.23
	967.144	160.329	527.236	107.774	2.108e+04	98.127	0	0	6.38
	963.979	160.320	525.446	83.117	1.525e+04	91.376	0	0	7.38
	947.099	22.852	242.857	38.799	3295.347	13.051	0	0	14
	844.105	7.164	62.827	1.635	1020.556	1.800	0	0	19.2
…	843.632	7.018	61.786	1.635	982.007	1.800	0	0	19.4
Cut 10	800.271	5.952	39.783	0.088	411.903	0.900	0	0	22.6

$$\frac{800.3}{\sqrt{800.3 + 458.6}} = 22.6\sigma$$

TMVA analysis

- Applied pre cuts before TMVA
  - pre cuts : # of q jets = 2, # of $\tau^+(\tau^-)$ = 1, # of tracks >= 9, $M_{\mathrm{col}} > 0$, $E_{\mathrm{col}} > 0$
  - suppress trivial background: $90 < E_{\mathrm{vis}} < 280$, $P_t > 50$, thrust < 0.97, $40 < E_Z(E_{qq}) < 200$, $E_{\tau\tau} < 160$
- 17 parameters were used
  - # of tracks · M_{vis} · P_t · thrust · $\cos\theta_{\mathrm{miss}}$ · $M_{qq}(M_Z)$ · $E_{qq}(E_Z)$ · $\cos\theta_{qq}$ · $M_{\tau\tau}$ · $E_{\tau\tau}$ · $\cos\theta_{\tau\tau}$ · $\cos\theta_{\mathrm{acop}}$ · $\log_{10}|d_0\mathrm{sig}(\tau^+)| + \log_{10}|d_0\mathrm{sig}(\tau^-)|$ · $\log_{10}|z_0\mathrm{sig}(\tau^+)| + \log_{10}|z_0\mathrm{sig}(\tau^-)|$ · M_{col} · E_{col} · M_{recoil}

TMVA results



BDTG output > 0.3387

N_{sig} = 905.826, N_{bkg} = 582.4139, sig = 23.4806

250 GeV super preliminary results qqh only

LoI study Mh = 120 GeV Cut-based (previous study)	Extrapolation to Mh = 125 GeV	TDR sample Mh = 125 GeV Cut-based	TDR sample Mh = 125 GeV TMVA
25.7	20.2	22.6	23.5

Better significance was obtained, even Xsec and BR($h \to \tau\tau$) are dropping from 120 GeV case.
---> better separation in Z and Higgs?

Next step: replace to new sample, and analyze