$h \to \tau^+\tau^-$ BR Study Status

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Status

- Try to start analysis with proper tau polarization sample
- Before that, found a bug in tau finder for qqh...
  - Particle satisfies $M_{\mathrm{combine}} < 2$ GeV && $\cos\theta > 0.98$ will be combined, but it was $\theta < 0.98$ rad...
- I need to re-evaluate with TDR sample before new sample. <--- Today's topic
- JPS meeting @ Saga (Sep./18 - 21)
  - my talk: Sep./19

Previous results

- @ 250 GeV qqh (TDR sample)
  - Cut-based: $22.6\sigma \leftrightarrow 4.4\%$
  - TMVA: $23.5\sigma \leftrightarrow 4.3\%$

- Now I'm working on 250 GeV qqh (TDR sample) with fixed tau finder
  - $M_{\mathrm{combine}} < 2$ GeV && $\cos\theta > 0.98$

Reconstruction

1. Tau finder: get taus
2. Collinear approx.: get tau pair mass (Higgs mass)
3. Durham 2-jet clustering: get Z boson

- didn’t use kT clustering because the number of overlaid process is small

Cut-based analysis

Before bug fix

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

After bug fix

Cut 0: # of q jets = 2, # of $\tau^+(\tau^-)$ = 1,
# of tracks >= 9, $M_{\mathrm{col}} > 0$, $E_{\mathrm{col}} > 0$
Cut 1: $|\cos\theta_{\mathrm{miss}}| < 0.98$
Cut 2: $75 < M_Z(M_{qq}) < 120$
Cut 3: $90 < E_Z(E_{qq}) < 120$
Cut 4: $M_{\tau\tau} < 115$
Cut 5: $E_{\tau\tau} < 125$
Cut 6: $\cos\theta_{\tau\tau} < -0.52$
Cut 7: $100 < M_{\mathrm{col}} < 175$
Cut 8: $E_{\mathrm{col}} < 200$
Cut 9: $\log_{10}|d_0\mathrm{sig}(\tau^+)| + \log_{10}|d_0\mathrm{sig}(\tau^-)| > -0.8$
Cut 10: $\log_{10}|z_0\mathrm{sig}(\tau^+)| + \log_{10}|z_0\mathrm{sig}(\tau^-)| > -0.3$
Cut 11: $M_{\mathrm{recoil}} > 115$

Cut table

Before bug fix

	$q\bar{q}h$ $h \to \tau\tau$	$q\bar{q}h$ $h \not\to \tau\tau$	$\nu\bar{\nu}h$ $\ell\ell h$	2f	4f	1f_3f	aa_2f	sig.
none	3357	4.920e4	2.730e4	2.863e7	1.021e7	2.305e8	1.634e8	0.161
pre-sel	1235	458.7	3135	4.444e4	2.067e5	4.382e4	1.528e5	1.84
thrust	1234	458.7	3135	3.737e4	2.019e5	3.875e4	1.505e5	1.88
θ_{miss}	1191	414.7	2828	1.116e4	1.737e5	1829	2.479e4	2.56
M_Z	1069	389.7	2711	6329	6.326e4	652.1	161.8	3.92
E_Z	1001	165.6	541.2	196.4	2.376e4	105.5	0	6.23
$M_{\tau\tau}$	967.1	160.3	527.2	107.8	2.108e4	98.13	0	6.38
$E_{\tau\tau}$	964.0	160.3	525.4	83.12	1.525e4	91.38	0	7.38
$\theta_{\tau\tau}$	947.1	22.85	242.9	38.80	3295	13.05	0	14.0
M_{col}	844.1	7.164	62.83	1.635	1021	1.800	0	19.2
E_{col}	843.6	7.018	61.79	1.635	982.0	1.800	0	19.4
M_{recoil}	800.3	5.952	39.78	0.088	411.9	0.900	0	22.6

After bug fix

	$q\bar{q}h$ $h \to \tau\tau$	$q\bar{q}h$ $h \not\to \tau\tau$	$\nu\bar{\nu}h$ $\ell\ell h$	2f	4f	1f_3f	aa_2f	sig.
None	3357	4.920e4	2.730e4	2.863e7	1.021e7	2.305e8	1.634e8	0.161
pre-sel	1358	435.1	3366	2.924e4	1.891e5	3.053e4	9.898e4	2.29
θ_{miss}	1337	412.3	3164	1.265e4	1.706e5	2336	1.796e4	2.93
M_Z	1227	219.1	1246	1732	5.783e4	618.4	40.97	4.89
E_Z	1160	181.9	397.7	264.5	1.702e4	190.5	20.99	8.36
$M_{\tau\tau}$	1145	176.1	393.0	96.27	1.428e4	138.4	20.99	8.98
$E_{\tau\tau}$	1132	176.1	391.9	57.55	1.087e4	130.2	20.99	10.0
$\theta_{\tau\tau}$	1123	28.84	204.7	25.00	3449	40.48	9.992	16.1
M_{col}	979.2	7.310	45.40	4.731	978.8	3.855	0	21.8
E_{col}	979.0	7.138	44.80	4.731	950.2	3.855	0	21.9
$d_0$sig	966.6	5.917	36.55	4.731	829.8	3.855	0	22.5
$z_0$sig	935.3	3.518	22.32	4.731	605.7	3.104	0	23.6
M_{recoil}	918.3	3.226	20.18	3.008	418.9	1.550	0	24.9

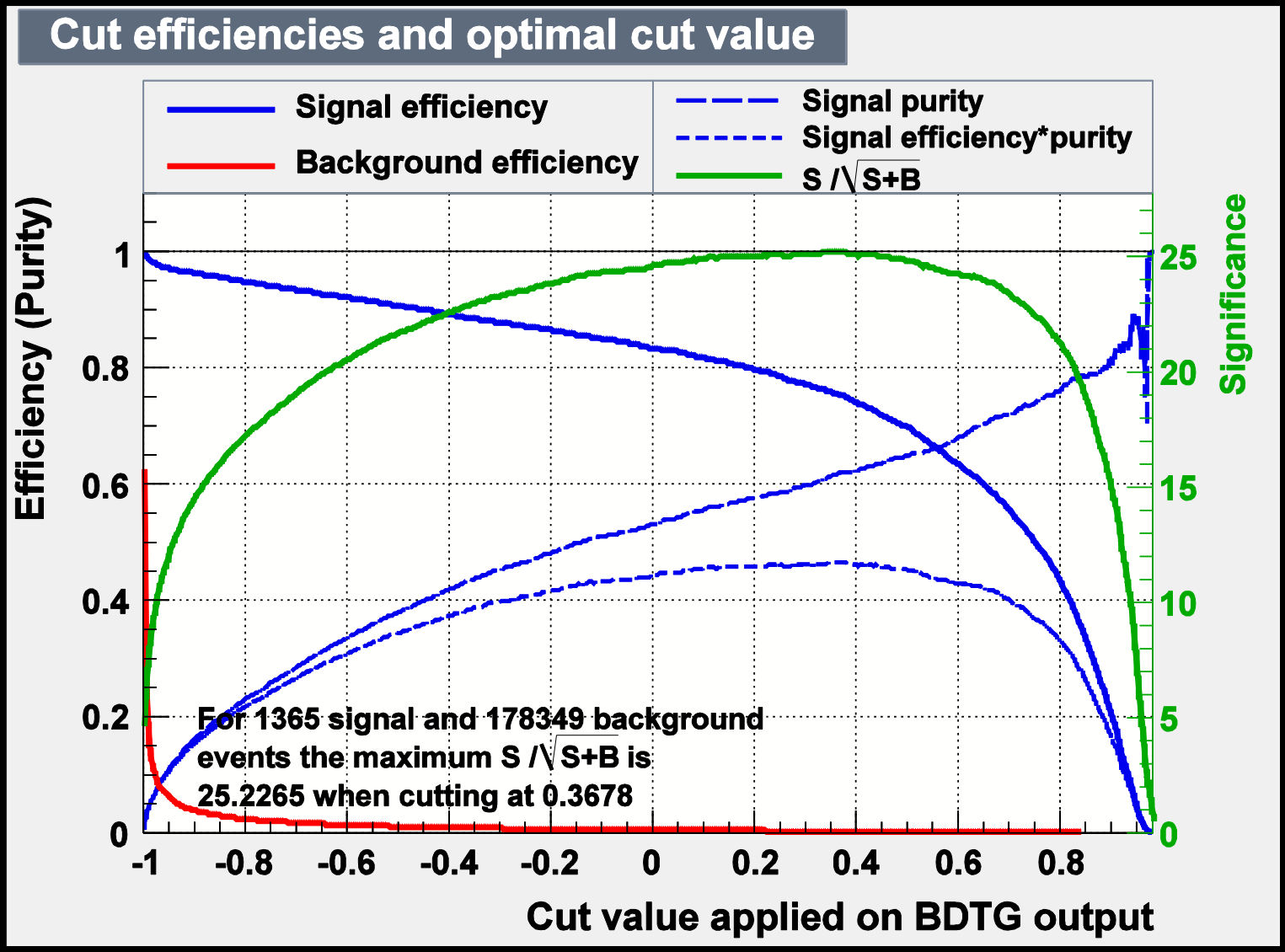
Cut-based results

- Before bug fix 22.6σ
- After bug fix $\boldsymbol{24.9\sigma}$: relatively 10% improved!
- At the pre-selection level: number of signals increased ~10%

TMVA analysis

- 17 parameters
  - # 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}
  - Applied following cuts to suppress trivial background: $90 < E_{\mathrm{vis}} < 285, 85 < M_{\mathrm{vis}} < 285, P_t > 50$, thrust < 0.97, $40 < E_Z(E_{qq}) < 205, 15 < E_Z(E_{qq}) < 200, E_{\tau\tau} < 160, M_{\tau\tau} < 145$

TMVA results (BDTG)



TMVA results

- Before bug fix 23.5σ
- After bug fix $\mathbf{25.2\sigma}$: relatively 7% improved!
- Relatively 1% improved from bug-fixed cut-based analysis.

Summary

- Tau finder now works much better!
- Analyzed with TDR samples @ 250 GeV qqh
  - Cut-based: $24.9\sigma \leftrightarrow 4.0(4.02)\%$
  - TMVA: $25.2\sigma \leftrightarrow 4.0(3.96)\%$

- Plan: try to analyze with new samples and get results before JPS meeting <--- now working on...