

Selection step	$0\ell + 2\tau_h$	$1\ell + 1\tau_h$
Targeted $t\bar{t}H$ decays	$t \rightarrow bqq', t \rightarrow bqq'$ with $H \rightarrow \tau\tau \rightarrow \tau_h\nu\tau_h\nu$	$t \rightarrow bqq', t \rightarrow bqq'$ with $H \rightarrow \tau\tau \rightarrow \ell\nu\nu\tau_h\nu$
Trigger	Double- $\tau_h$ trigger	Single-lepton and lepton+ $\tau_h$ triggers
Lepton $p_T$	—	$p_T > 30$ (e) or 25 GeV ( $\mu$ )
Lepton $\eta$	—	$ \eta  < 2.1$
$\tau_h p_T$	$p_T > 40$ GeV	$p_T > 30$ GeV
$\tau_h \eta$	—	$ \eta  < 2.1$
$\tau_h$ identification	loose	medium
Charge requirements	$\sum_{\tau_h} q = 0$	$\sum_{\ell, \tau_h} q = 0$
Multiplicity of central jets	—	$\geq 4$ jets
b tagging requirements	$\geq 1$ tight b-tagged jet or $\geq 2$ loose b-tagged jets	$\geq 2$ loose b-tagged jets
Dilepton invariant mass	—	$m_{\ell\ell} > 12$ GeV

Selection step	$1\ell + 2\tau_h$	$2\ell + 2\tau_h$
Targeted $t\bar{t}H$ decays	$t \rightarrow b\ell\nu, t \rightarrow bqq'$ with $H \rightarrow \tau^+\tau^- \rightarrow \tau_h\nu\tau_h\nu$	$t \rightarrow b\ell\nu, t \rightarrow b\ell\nu$ with $H \rightarrow \tau^+\tau^- \rightarrow \tau_h\nu\tau_h\nu$
Trigger	Single-lepton and lepton+ $\tau_h$ triggers	Single- and double-lepton triggers
Lepton $p_T$	$p_T > 30$ (e) or 25 GeV ( $\mu$ )	$p_T > 25 / 10$ (15) GeV (e)
Lepton $\eta$	$ \eta  < 2.1$	$ \eta  < 2.5$ (e) or 2.4 ( $\mu$ )
$\tau_h p_T$	$p_T > 30 / 20$ GeV	$p_T > 20$ GeV
$\tau_h \eta$	$ \eta  < 2.1$	$ \eta  < 2.3$
$\tau_h$ identification	medium	medium
Charge requirements	$\sum_{\ell, \tau_h} q = \pm 1$	$\sum_{\ell, \tau_h} q = 0$
Multiplicity of central jets	$\geq 3$ jets	$\geq 2$ jets
b tagging requirements	$\geq 1$ tight b-tagged jet or $\geq 2$ loose b-tagged jets	$\geq 2$ loose b-tagged jets
Missing transverse momentum	—	$L_D > 0 / 30 / 45$ GeV <sup>†</sup>
Dilepton invariant mass	—	$m_{\ell\ell} > 12$ GeV

<sup>†</sup> A complete description of this requirement can be found in the main text.