# Higgs Signal Optimisation

Joe Bentley and Jake Lane

# Decay mechanism

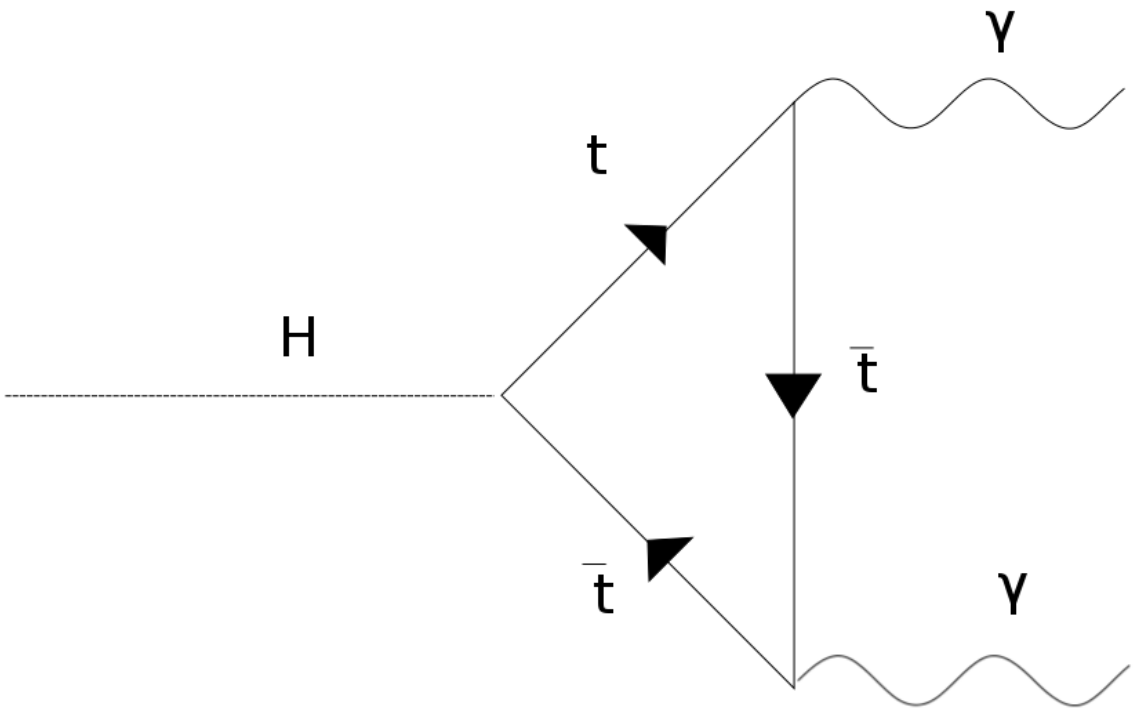


Figure : Higgs decay, $H$, into 2 photons, $\gamma$, via a top, $t$, quark loop

# Branching fraction

1. Ratio of Higgs decays to photons over ratio of all Higgs decays.
2. Branching fraction $B$ for Higgs to 2 photons is of order $10^{-3}$.

# Cross section

1. Probability of producing a Higgs in an interaction, $\sigma_H$.
2. Summed over all possible production modes (most common is the gluon gluon fusion)

$$\sigma_H = \sigma \tag{1}$$

# Weighting

Probability of producing a Higgs and decaying into 2 photons, compared to the probability of producing 2 background photons, $P$.

$$P = \frac{\sigma_H B_{\gamma\gamma}}{\sigma_b} \tag{2}$$

# Kinematic variables

Define 4-momentum by the following parameters:

$$E = p^t = p_T \cosh \eta \tag{3}$$
$$p^x = p_T \cos \theta \tag{4}$$
$$p^y = p_T \sin \theta \tag{5}$$
$$p^z = p_T \sinh \eta \tag{6}$$

# Principle behind selection cuts

1. Higgs decaying into 2 photons will have a distinct signature compared to simulated background.
2. This signature manifests in 2 high energy photons back to back.
3. Further expect the diphoton system to have an invariant mass in the range of measured mass of Higgs.

# Energy cuts

1. Photons produced in a Higgs decay have a large energy.
2. Photons do not get equal distribution of energy from a Higgs decay.

# Transverse cut

1. Magnitude of the momentum perpendicular to the beam, $p_T = \sqrt{p_x^2 + p_y^2}$
2. Photons will get most of their energy from the Higgs decaying outwards from the beam.
3. Similar to the energy filter in construction.

# Cuts using angular distance

1. Ideally the Higgs produces photons back to back
2. Take both the square difference in rapidity, $\eta$ and square difference in azimuthal angle $\phi$.

# Challenges to project