Karlsruhe Institute of Technology

Search for Higgs + single top production with CMS

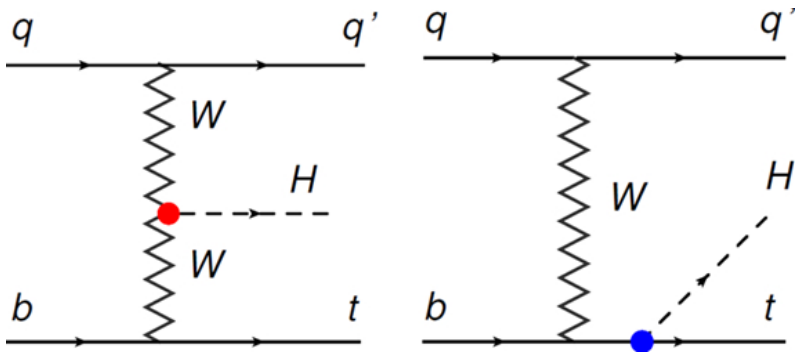
$H \rightarrow b\bar{b}$ Channel

Simon Fink on behalf of the tH working group | 03.12.2013

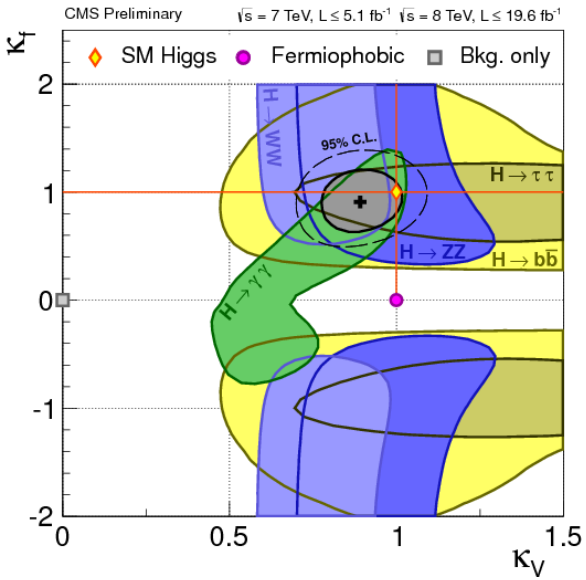
KARLSRUHE INSTITUTE OF TECHNOLOGY

Motivation

- There are two dominant *tH* production processes



- Production amplitude $\mathcal{A} \propto (c_V - c_f) \rightarrow \sigma_{SM} = 18.3\,\text{fb}$
- *tH* production is sensitive on relative sign of c_V and c_f



- In some BSM models with $c_f = -1$, enhanced cross section $\rightarrow \sigma_{BSM} = 233.8\,\text{fb}$
- Shown in `arXiv:1211.3736` by Farina *et al.* that $pp \rightarrow tH$ can confirm or exclude $c_f = -1$

Analysis Outline

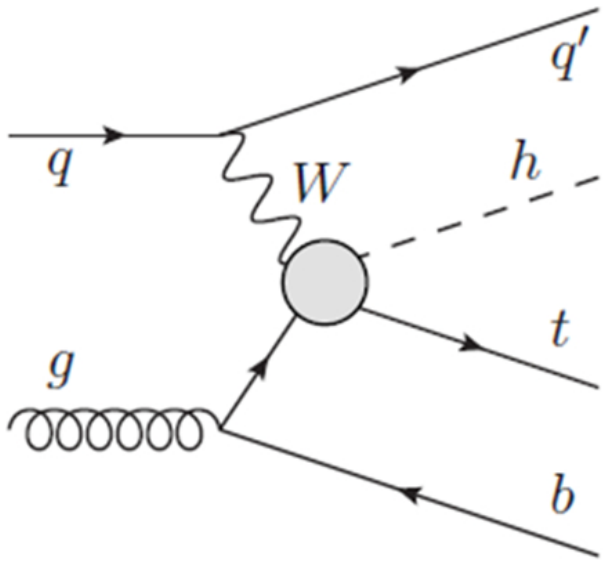
- We focus on the $H \to b\bar{b}$ final state in two analysis bins
- Start with search for $c_f = -1$ scenario
- Examining leptonically decaying Top quark
- Dominant background: $t\bar{t}$ (semi-leptonic/full-leptonic)

3t Bin

- One isolated lepton
- #jets = 4,5,6
- $\#\text{jets}_{\text{CSV tight}} = 3$

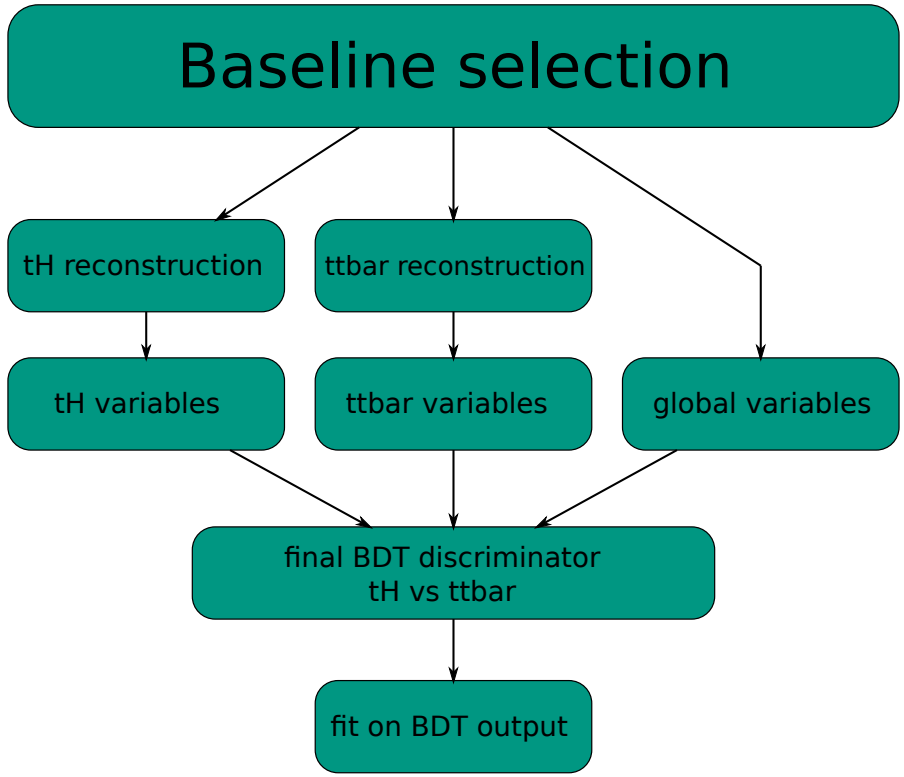
4t Bin

- One isolated lepton
- #jets = 5,6
- $\#\text{jets}_{\text{CSV tight}} = 4$



Analysis Overview

- BDT is trained for separation of signal and background
- Using three variable categories:
  - tH reco variables
    - $|\eta(j')|$,$\Delta R(top, j')$, $\cos_{T+H}(\theta^*)$, CSV(h_1), ...
  - $t\bar{t}$ reco variables
    - mass(t_{had}), mass(W_{had}), $\Delta R(j_W, j_W)$, $|\eta(t_{had})|$,...
  - Global variables
    - $\sqrt{\hat{s}}$, sphericity, p_T (j_1), ...

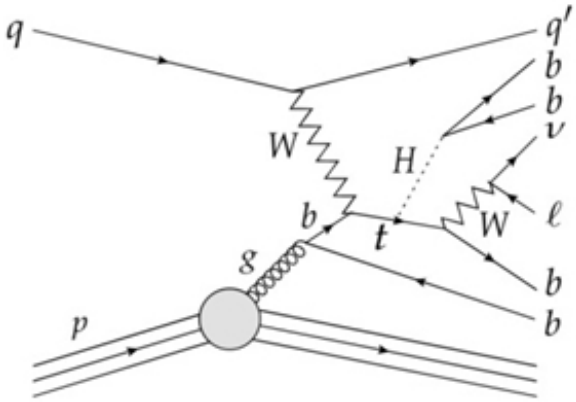


Reconstruction

- Every event is subjected to a signal and a $t\bar{t}$ reconstruction
- Train BDT for each of them

Signal

- Reconstructed Signal objects:
  - 2 Higgs *b* jets
  - 1 Top quark
  - 1 Additional *b* quark
  - 1 Light forward jet

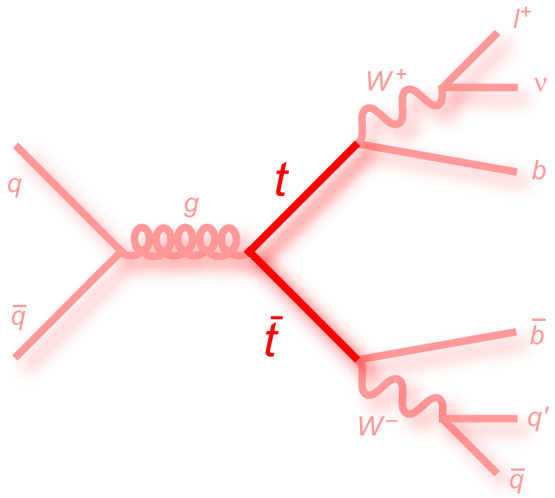


- Calculate for every possible jet assignment the hypothesis metric *D*
- Train BDT to separate between right and wrong hypothesis
- In the end hypothesis with the highest BDT output is chosen

$$D = \Sigma_{i=t,h,q} \Delta R(i^{reco}, i^{gen}) + \frac{|p_T(i^{reco}) - p_T(i^{gen})|}{p_T(i^{gen})}$$

Reconstruction - semileptonic $t\bar{t}$ background

- Additionally, reconstruction of main background topology to help in the separation
- Reconstructed $t\bar{t}$ objects:
  - Top quark with leptonically decaying W quark
  - Top quark with hadronically decaying W quark

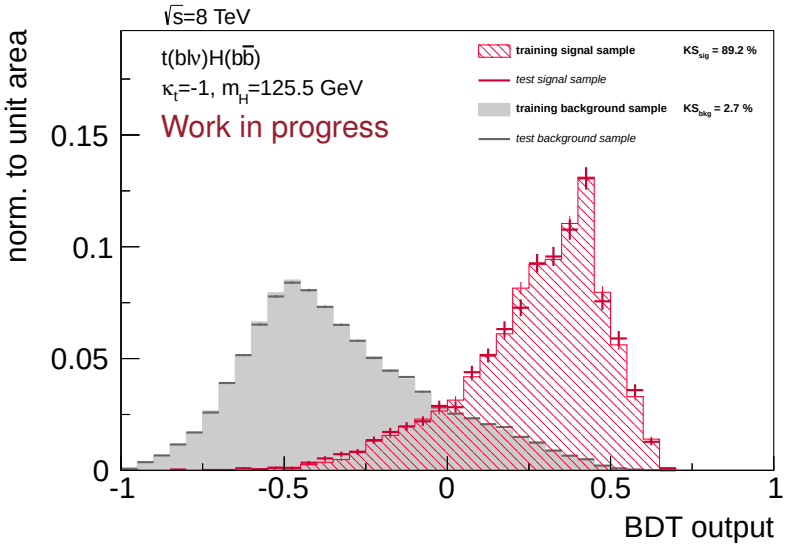


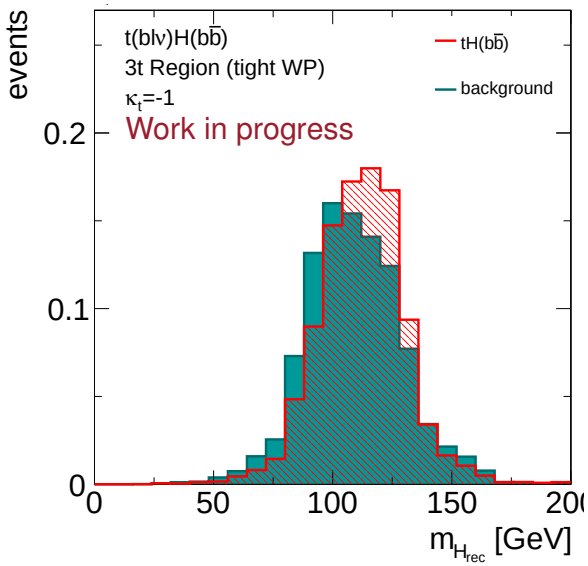
- Again hypothesis with the highest BDT output is chosen

$$D = \Sigma_{i=t_{had},t_{lep}} \Delta R(i^{reco}, i^{gen}) + \frac{|p_T(i^{reco}) - p_T(i^{gen})|}{p_T(i^{gen})}$$

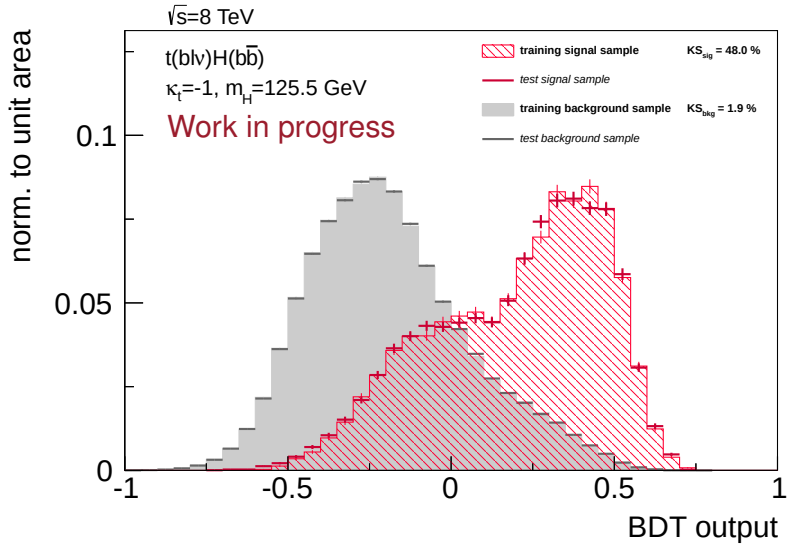
Reconstruction - Performance

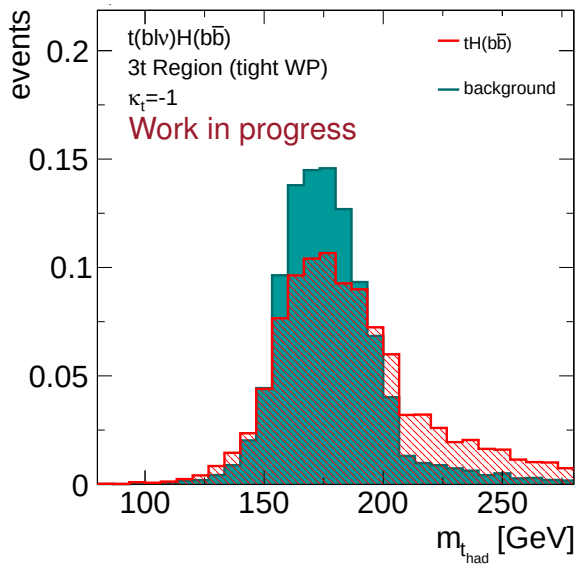
tH reconstruction





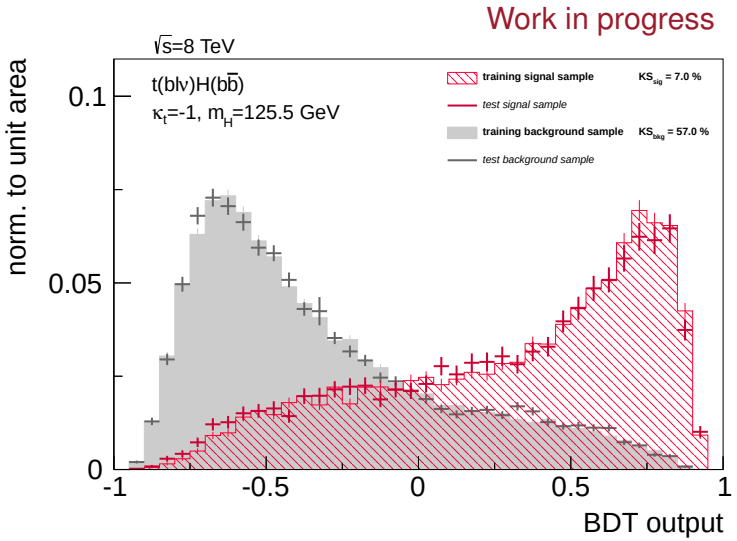
$t\bar{t}$ reconstruction

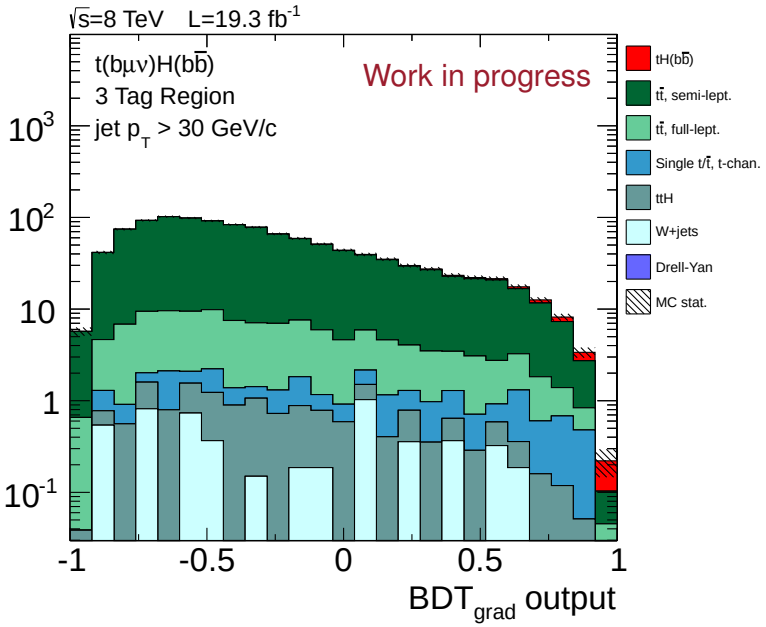




Signal extraction

- Good separation between signal and background
- No noticeable overtraining





- Limits are obtained by fitting the final BDT output over the full range
- Currently finalizing the list of systematics

Analysis' Future

- Short term:
  - Currently looking into data driven approach for $t\bar{t}$
  - Aim for a full analysis for Moriond 2014
- Long term:
  - Preparing analysis for Run2 of LHC
  - Confirming/Excluding $c_f = -1$ case
  - Setting limits on SM case

Thank you for your attention!

Any Questions?