

HH Reconstruction

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Detector and Physics simulation 26/05/2020

Selection of events for the BDT

- Selection of signal and background events with $N_{\text{jets}} > 3$
- Jets are combined in pairs and for each combination the invariant mass is calculated

$$(m_{ij}, m_{kl})$$

- The following relation is calculated for each pair:

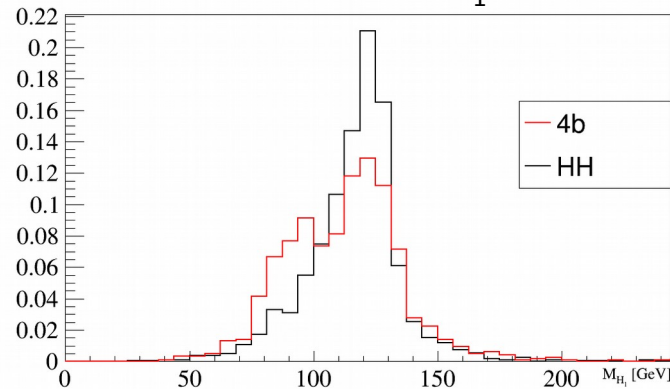
$$(m_h - m_{ij})^2 + (m_h - m_{kl})^2$$

- The pair of jets which minimize the above relation, is selected
- Requirement on the minimum P_T of all jets: **20 GeV**

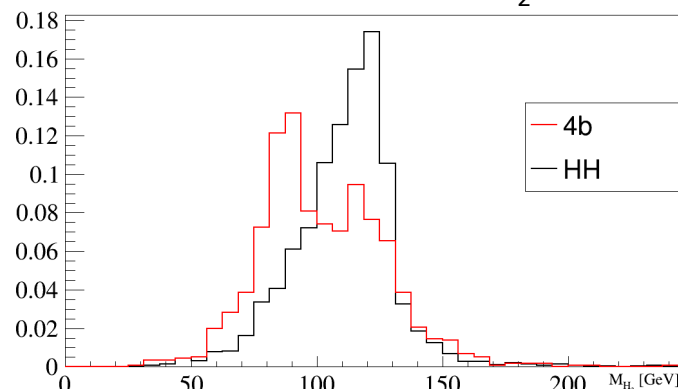
Input variables for training

- Selected variables for training:

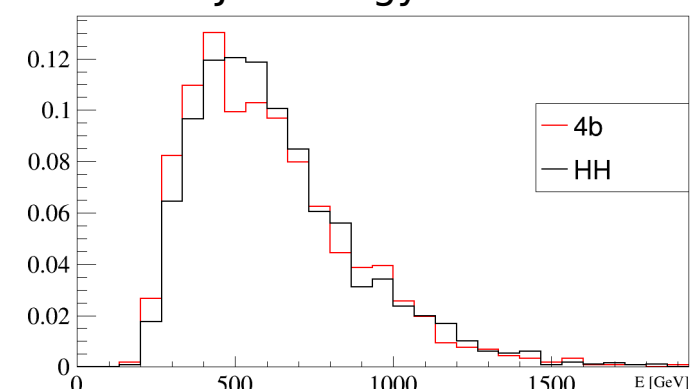
Invariant mass H_1



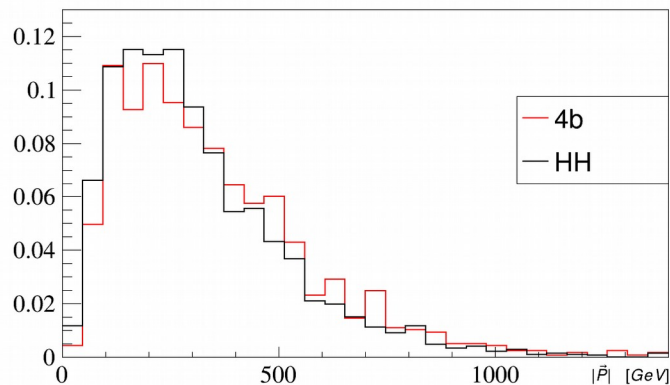
Invariant mass H_2



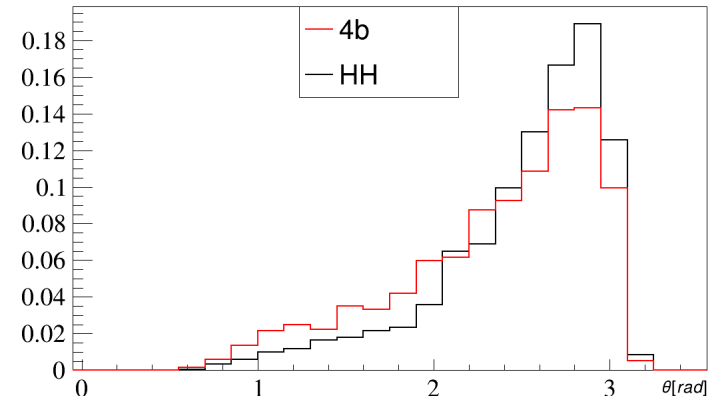
Jet energy sum



Module of the vectorial sum of 4 jets momentum

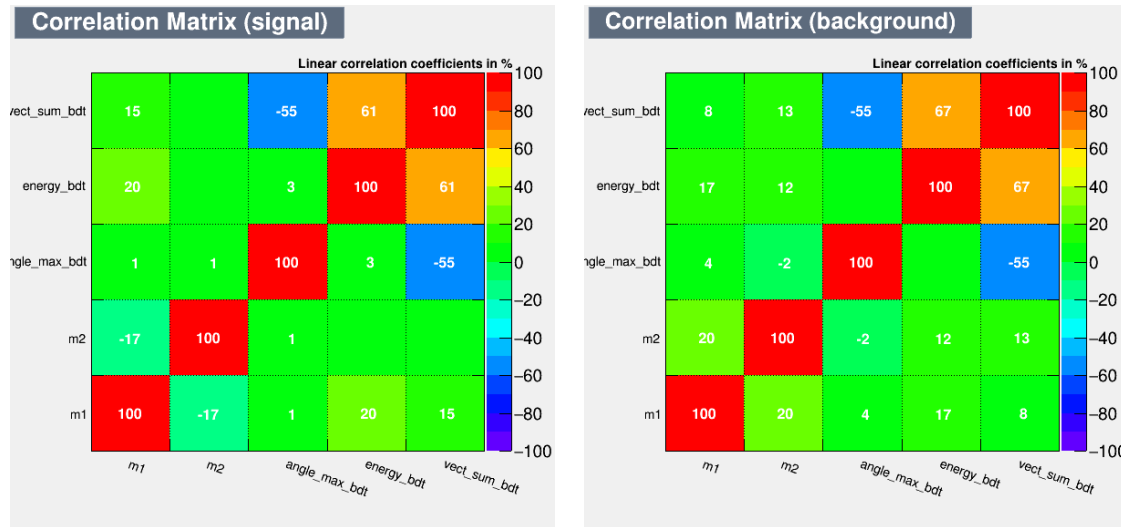


Maximum angle between jets

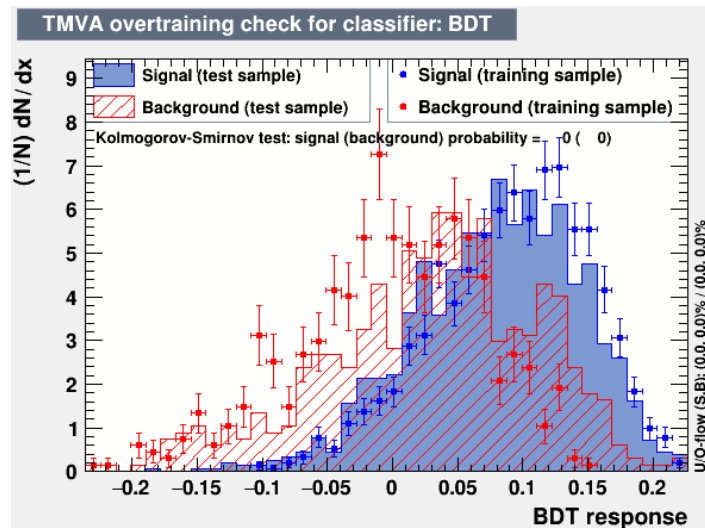
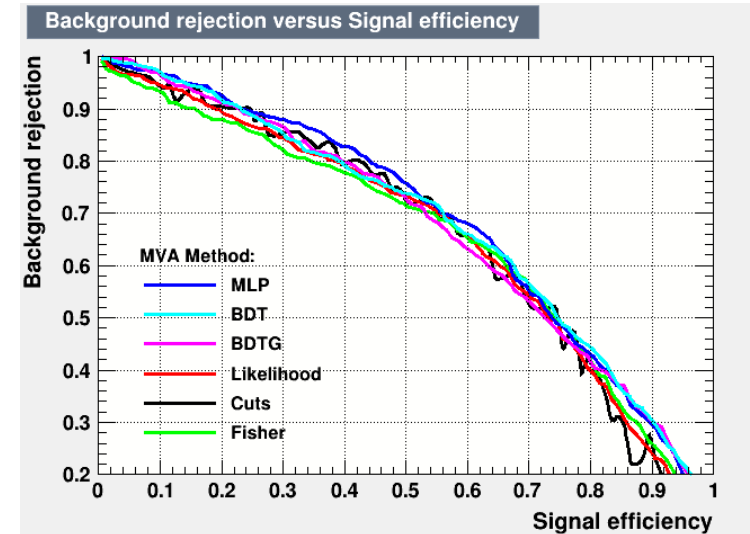


Evaluation of input variables and classification

Correlation between input variables.



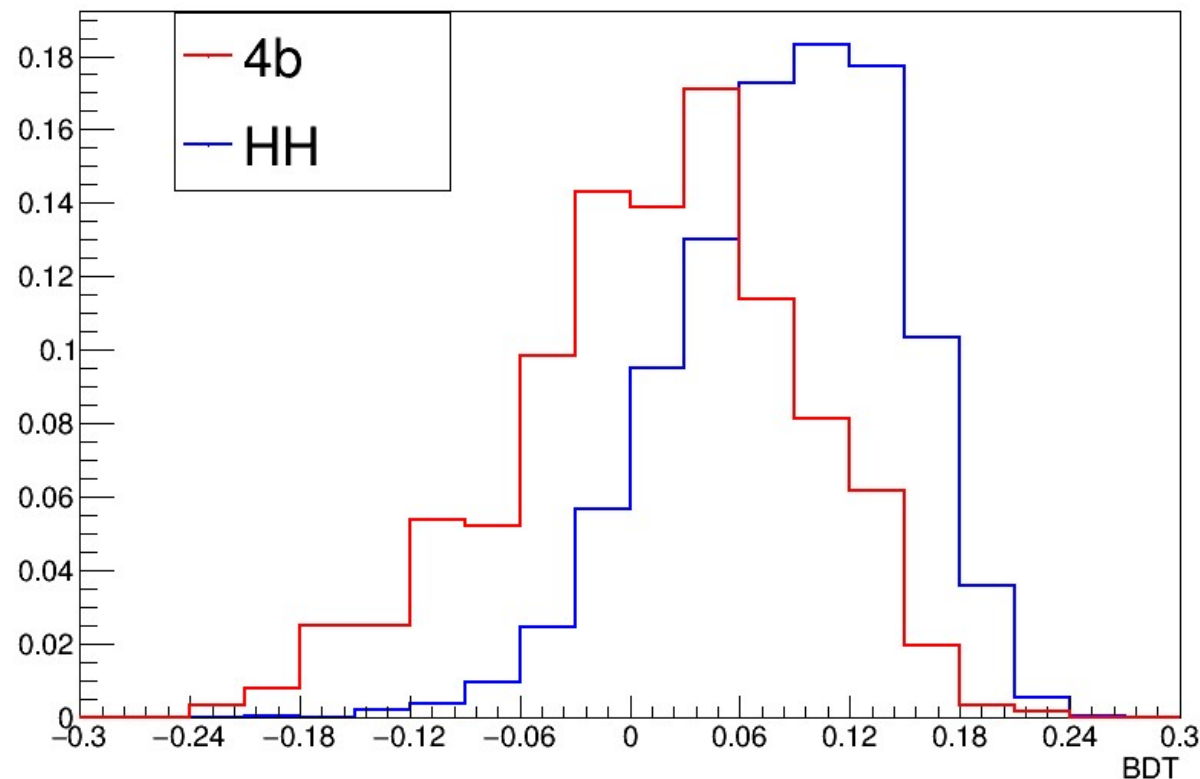
ROC curve



Classifier output distributions
for signal and background events

Boosted Decision Tree application

- BDT applied to signal and test samples



- Cut on the BDT output is applied and the significance is calculated

Significance calculation

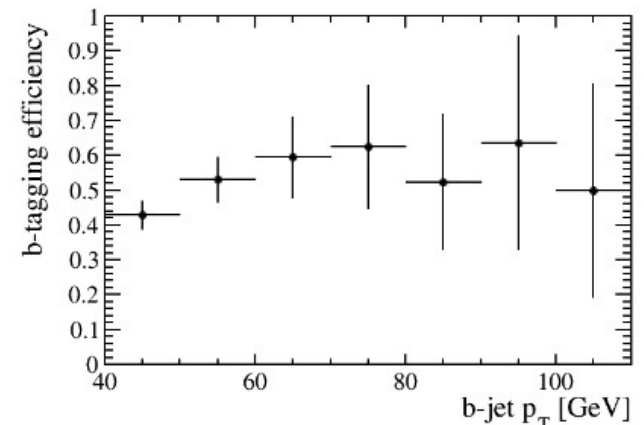
$$\text{Significance} = \frac{S}{\sqrt{S+B}}$$

$$S = \sigma_{HH} \text{Br}(H \rightarrow b\bar{b})^2 L_{\text{int}} W_{\text{sign}}/N_{\text{sign}}$$

$$L_{\text{int}} = 1300 \text{ fb}^{-1}$$

$$B = \sigma_{bbbb} L_{\text{int}} W_{\text{bkg}}/N_{\text{bkg}}$$

- W_{sign} and W_{bkg} are the number of events of signal and background which remains after cuts, and re-weighted for the b-tag efficiency
- It is required that one jet for each pair is tagged
- b-tag efficiencies as a function of the P_T jet
- Only jets with $P_T > 40$ GeV are tagged

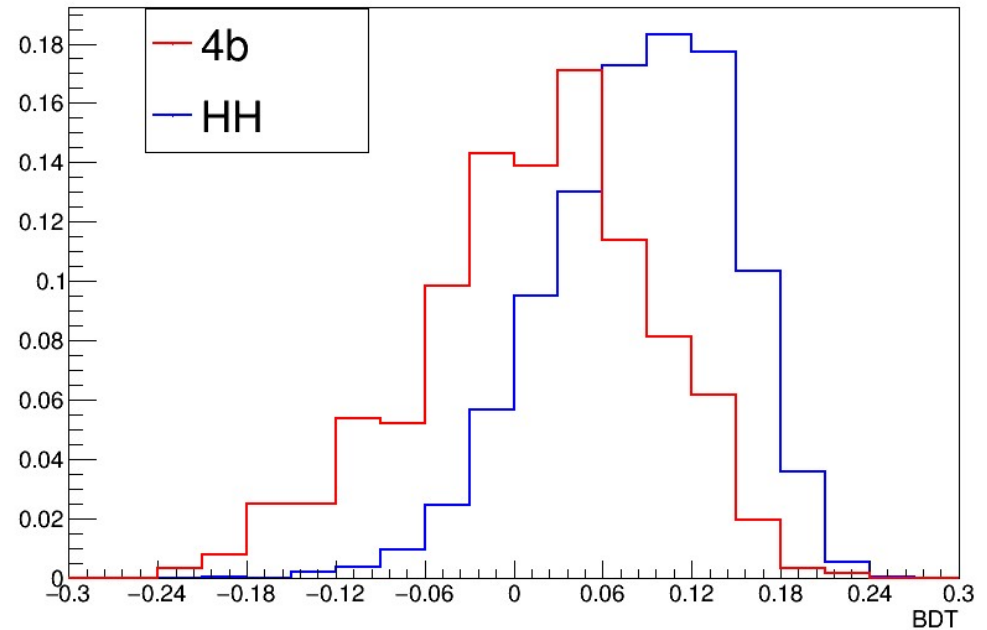


Results

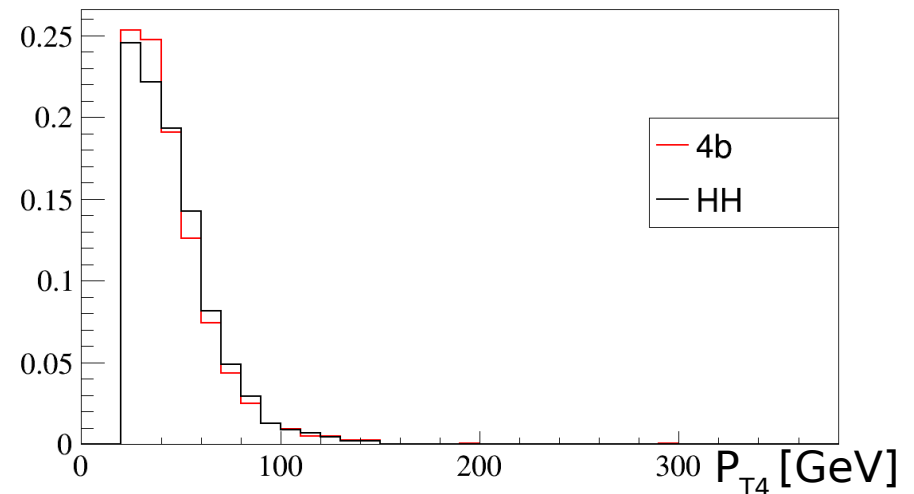
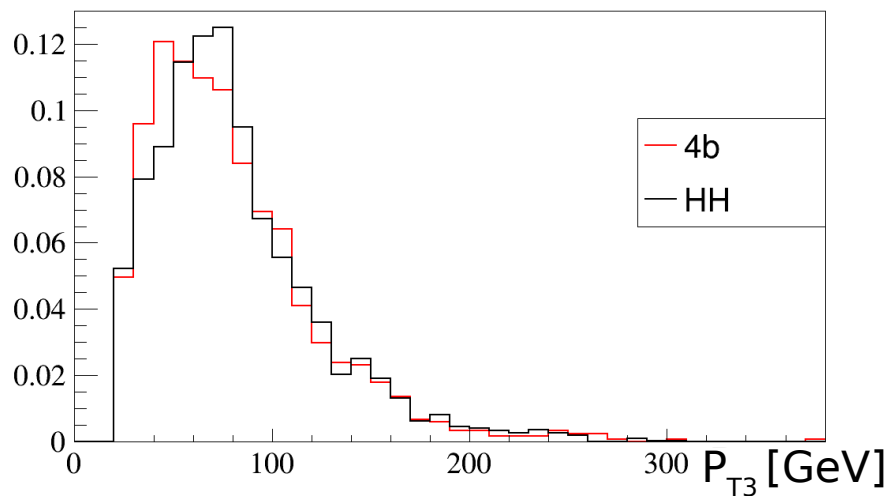
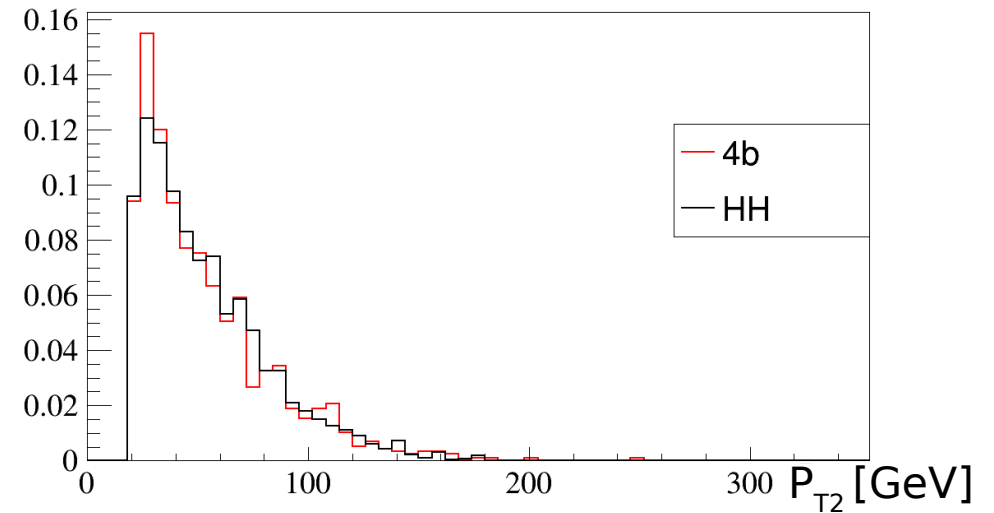
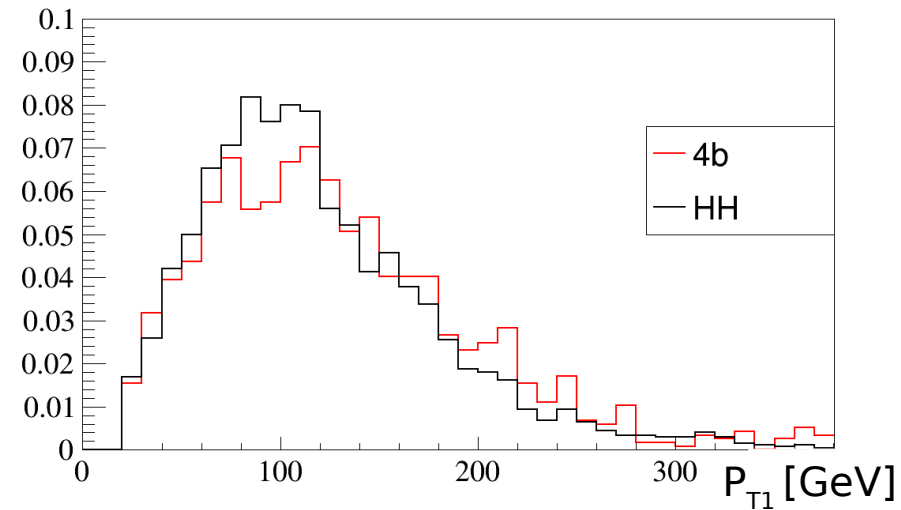
BDT cut	S	B	Significance	$\Delta\sigma/\sigma$
-0.06	50	469	2.21	0.45
-0.03	49	417	2.28	0.44
0	47	340	2.39	0.42
0.03	43	266	2.44	0.41
0.06	37	172	2.55	0.39
0.09	28	102	2.47	0.40
0.12	19	51	2.22	0.45
0.15	8	16	1.73	0.58
0.18	2	3	1.06	0.94

$$S = \sigma_{HH} \text{Br}(H \rightarrow b\bar{b})^2 L_{\text{int}} W_{\text{sign}} / N_{\text{sign}}$$

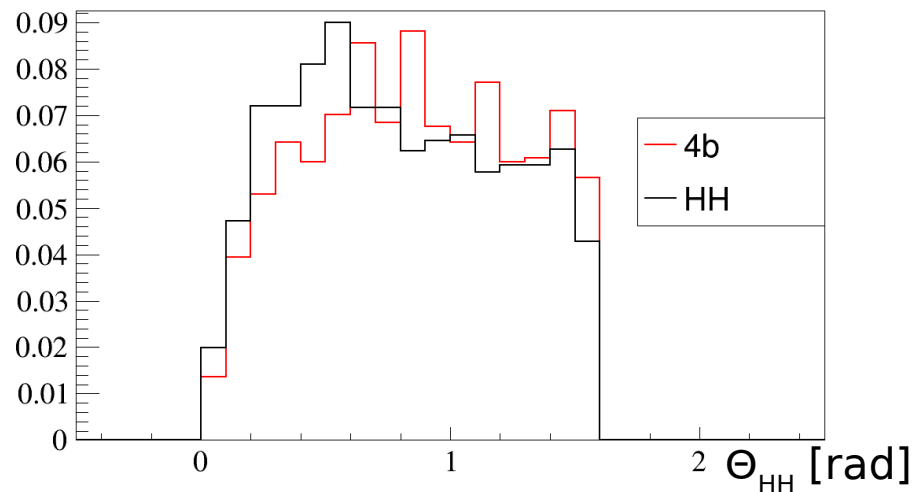
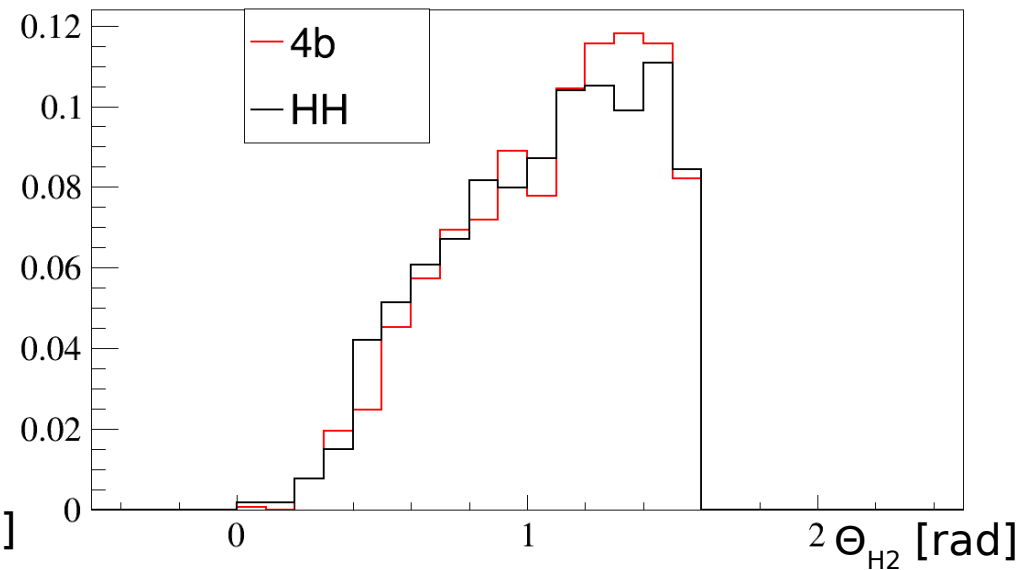
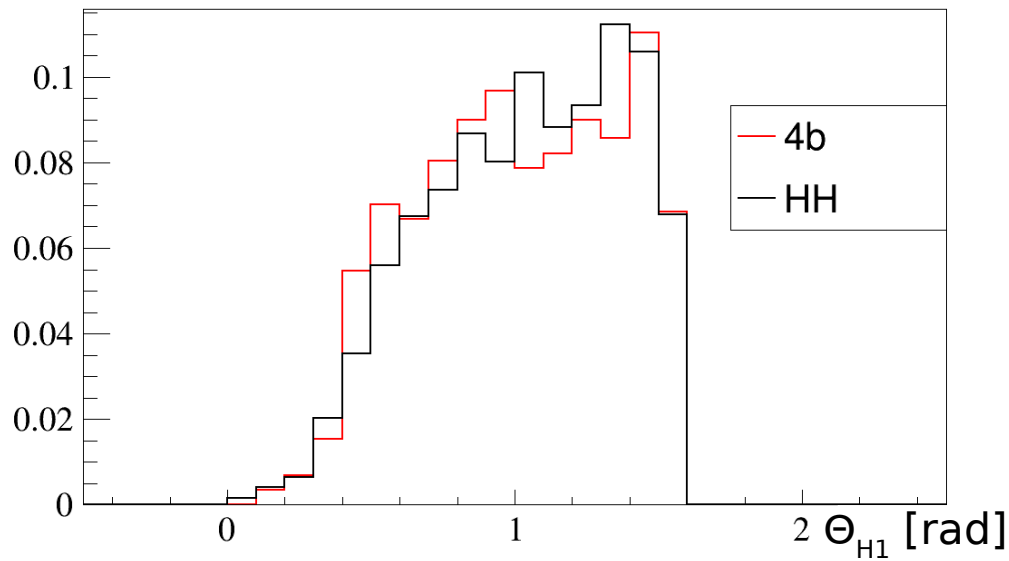
$$B = \sigma_{bbbb} L_{\text{int}} W_{\text{bkg}} / N_{\text{bkg}}$$



Other distributions: jets P_T



Other distributions: ellicity angles



Next steps

Optimization of the BDT:

- **Increase the number of events as input for the BDT**
- **Try to use other input variables for the BDT training and test**