HHZ production at 3 TeV CLIC

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HHZ at 3 TeV

Concentrate on HH Z →bb bb qq:

Full hadronic signature, very low statistic:
Old samples:
total cross section: 6.6e-2 (4.23e-2) fb^{-1} for -80 % (+80 %) electron beam polarisation
→242 (42) events in total (all Z decays)
→ 68 (12) in bb bb qq final state

NEW sample: HH qq, concentrate on **HH qq→bb bb qq**
For -80 % polarisation: cross section: 4.18e-2 fb^{-1}
→ 167 events in total
→ 68 events in desired phase space of bb bb qq
For +80 % polarisation: cross section: 2.30e-2 fb^{-1}
→ 29 events in total
→ 12 events in bb bb qq final state

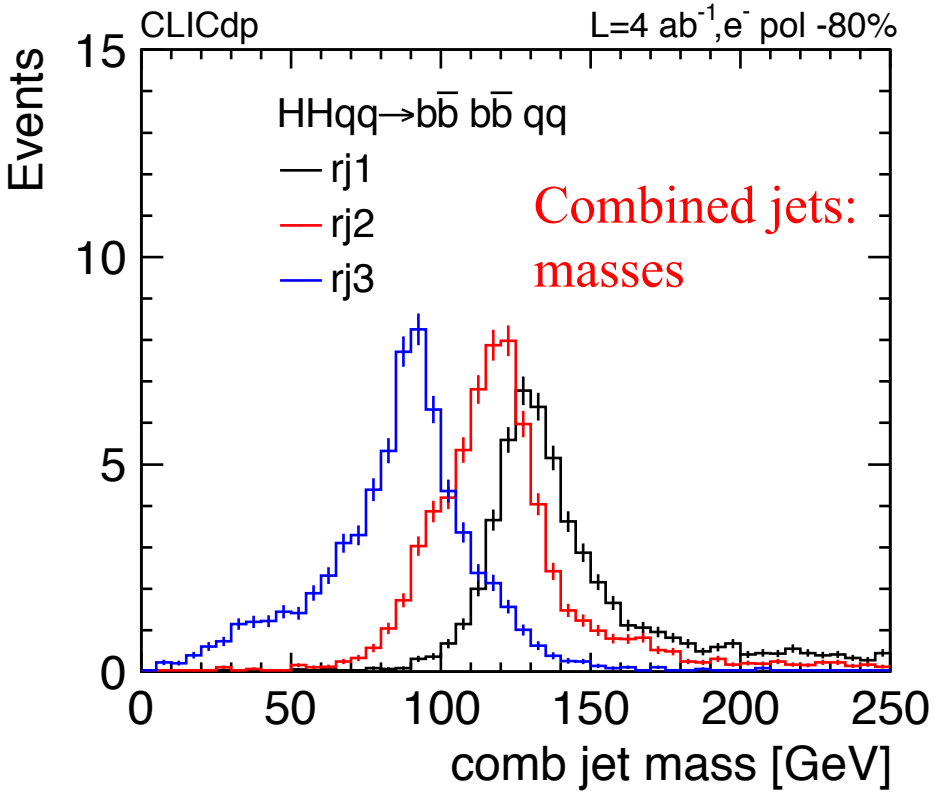
Consistent yield between new and old samples

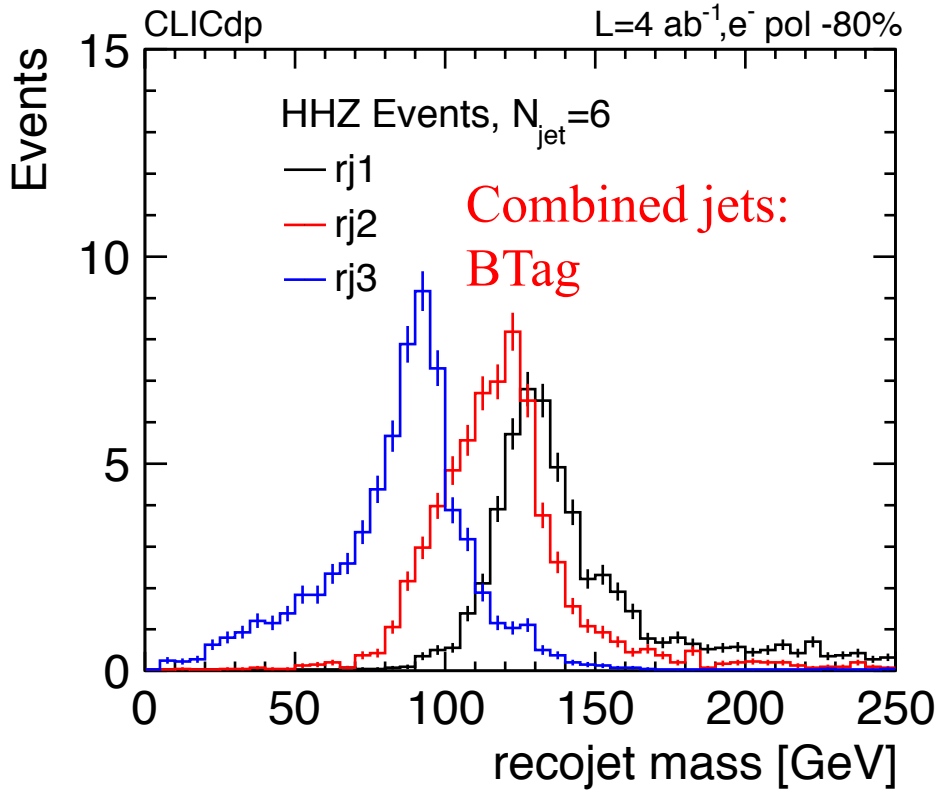
Jets

Reminder: combine 6 refined instead of FastJet jets

Use refined jets from LCFIPlus with VLC algorithm R=1.10, β=γ=1.0, run in exclusive mode with 6 jets

Combine 6 jets into 3, minimizing sum= $(rj(x)-m_H)^2 + (rj(y)-m_H)^2 + (rj(z)-m_Z)^2$





Can use BTagging information based on refined jets right away, use BTag information from larger BTagged original jet as measure for BTag of combined jet

Backgrounds

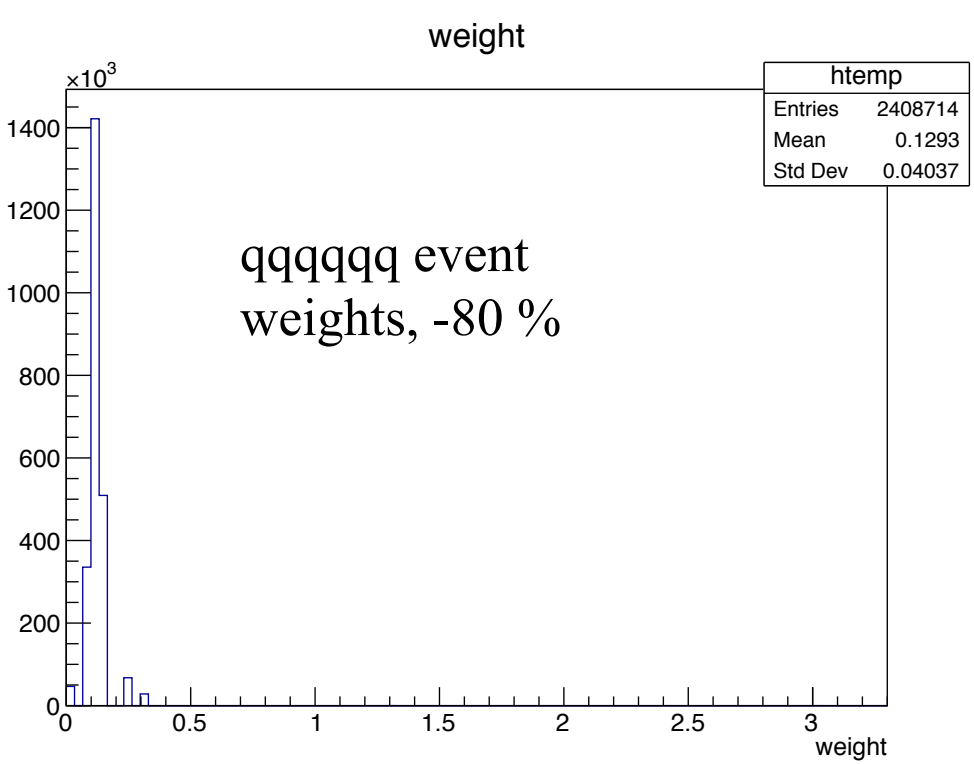
Background composition

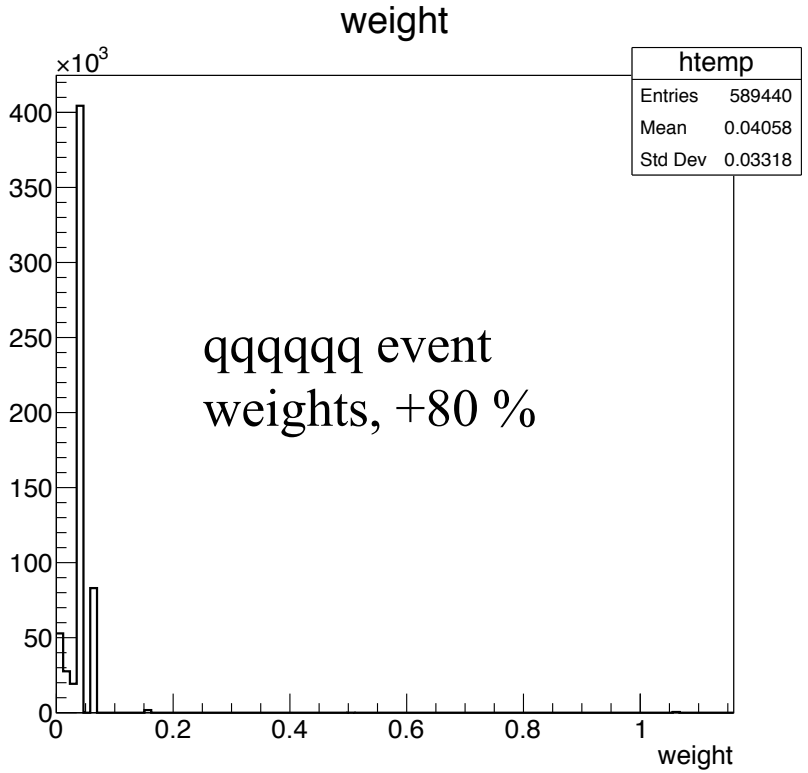
Sample Pol (e^-) -80 %	Events	Cross-section [fb]	Produced Events
HHqq	167	4.18e-2	9600
HHqq→bbbbqq	68	1.70e-2	3948
Hqq	15320	3.83	115174
ee→qq	5.07 M	1269	1.56 M
ee→qqqq	3.61 M	902	1.9 M
ee→qqqqqq			2.41 M

Sample Pol (e^-) +80 %	Events	Cross-section [fb]	Produced Events
HHqq	29	2.898e-2	9552
Hqq	2670	2.67	29034
ee→qq	786 000	786	388 190
ee→qqqq	120 000	120	478 995
ee→qqqqqq			589440

qqqqqq is mixture of several samples, containing tri-bosons as well as ttbar

qqqqqq composition: Weights under control

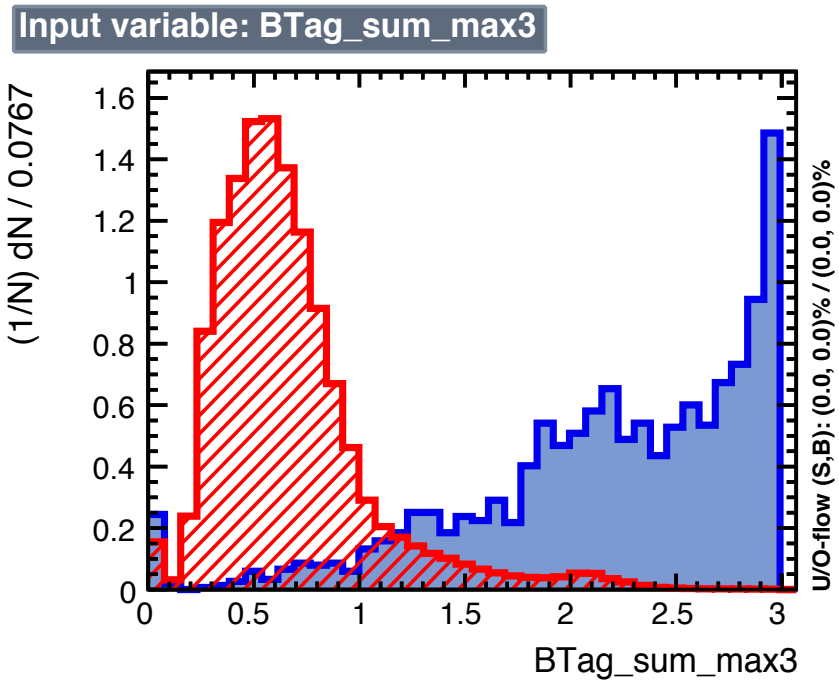


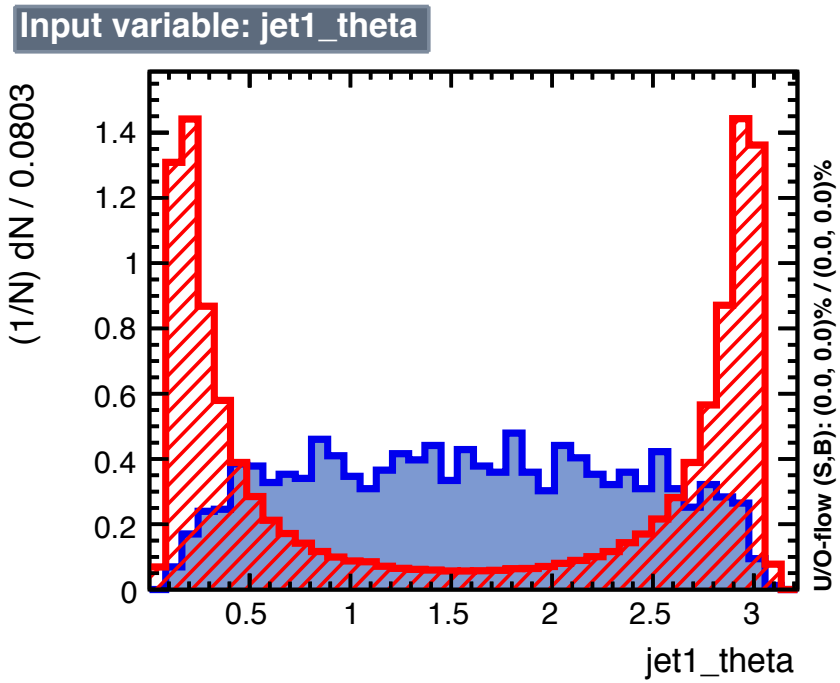


Event weights for six quark sample under control, typically around 0.2, largest weight, outliers of events around 1 or 3

Pre-Selection: look at discriminating distributions

Run BDT without any pre-selection: reduces background yield significantly, but still signal drowned within background → preselect events to enhance relevant region





Sum of 3 largest BTag (out of the 6 jets) → cut on BTag-sum (max3) >0.5
Cut on highest energetic jets E(j1)>150 GeV, E(j2)>>100 GeV, E(j4)>40 GeV
Cut on polar angle of highest energetic jets 10 °< θ(j2), θ (j2) < 170°

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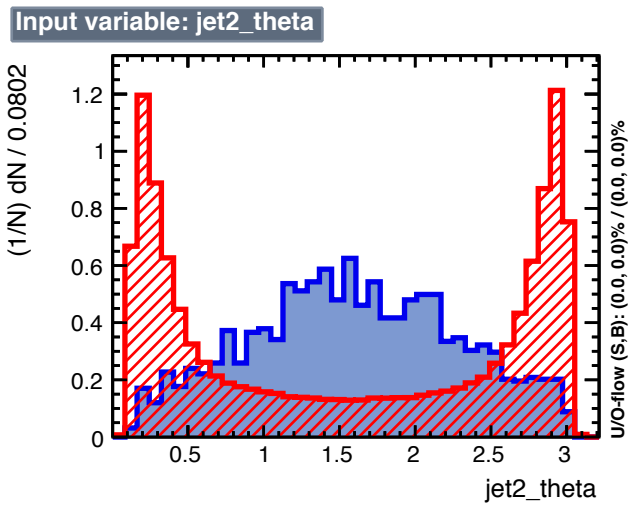

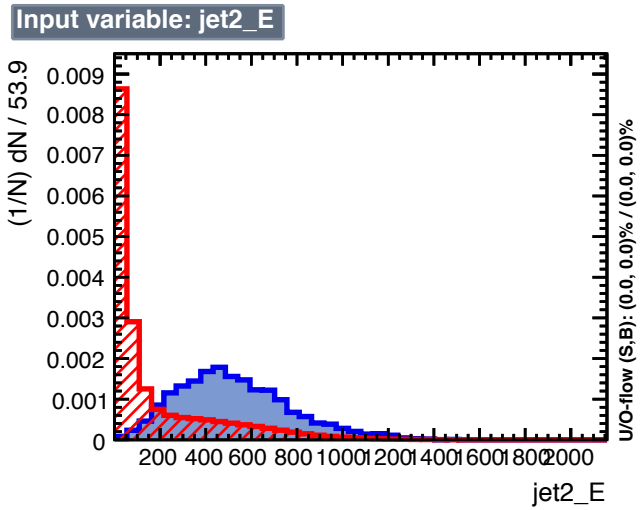

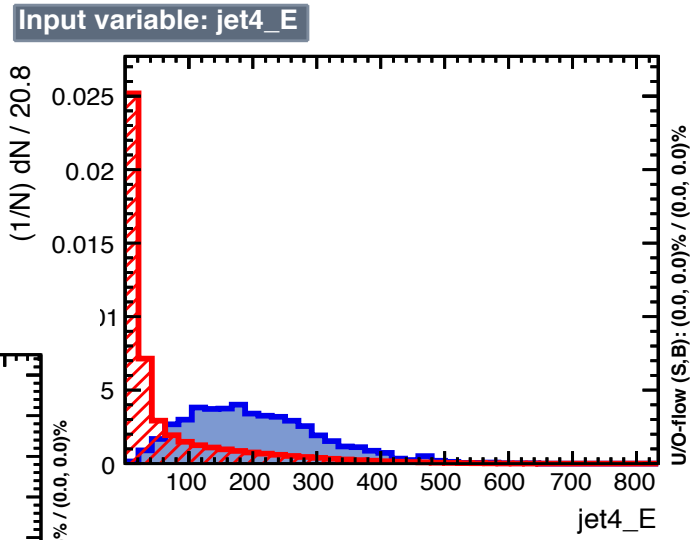

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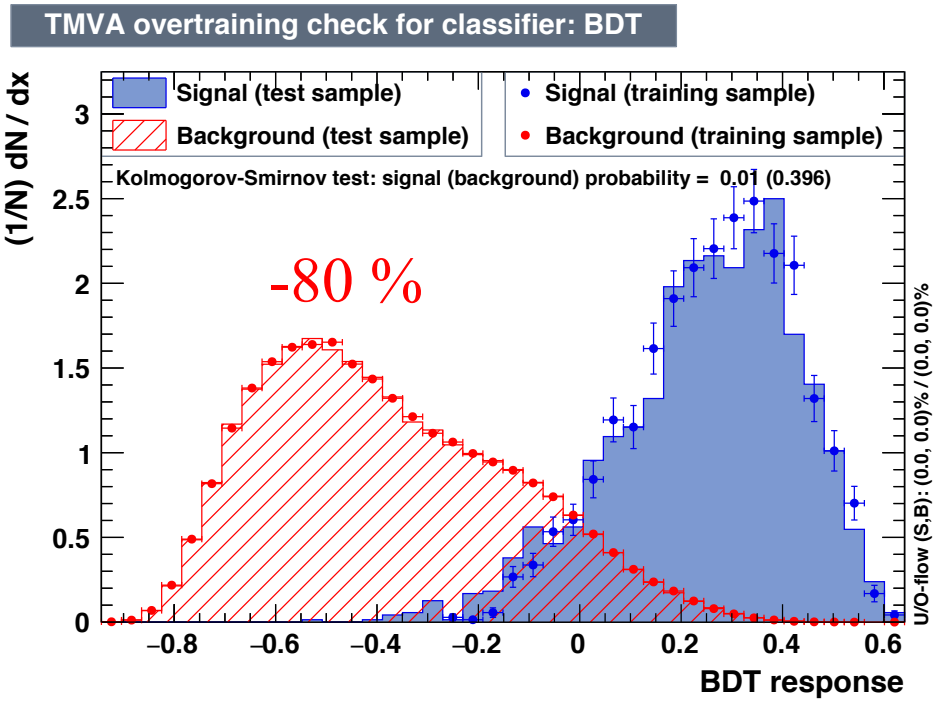
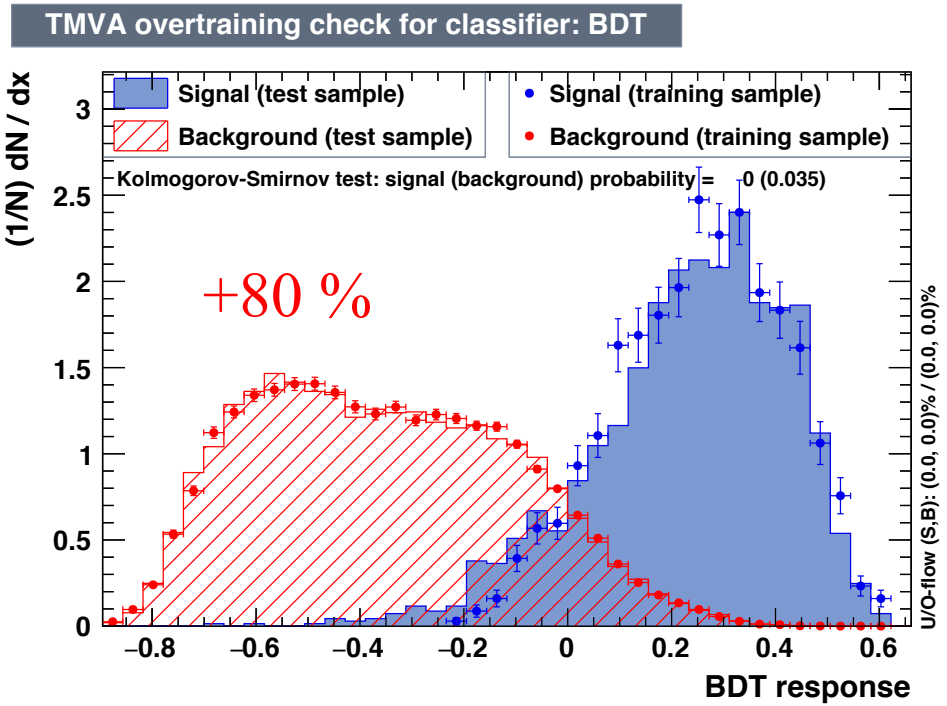
Preselection efficiencies

Sample Pol (e^-) -80 %	Efficiency Jet E-cuts In %	Efficiency Jet E & θ cuts In %	Efficiency Jet E,θ & Btag cuts In %
HHqq→bbbbqq	95.7	92.5	85.1
Hqq	74	70	56
ee→qq	16.4	14.9	6.9
ee→qqqq	38.2	25.6	1.1
ee→qqqqqq	92	78	60

BDT training

Gradient Boosting performs less well than Adaptive Boosting

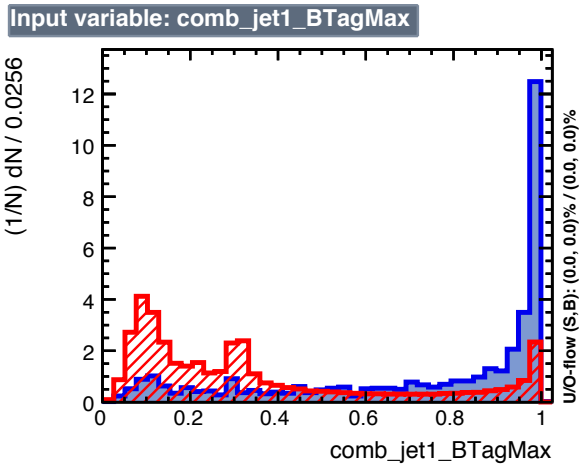


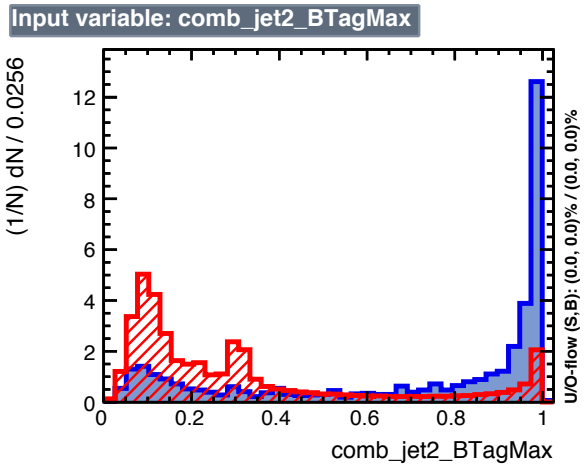


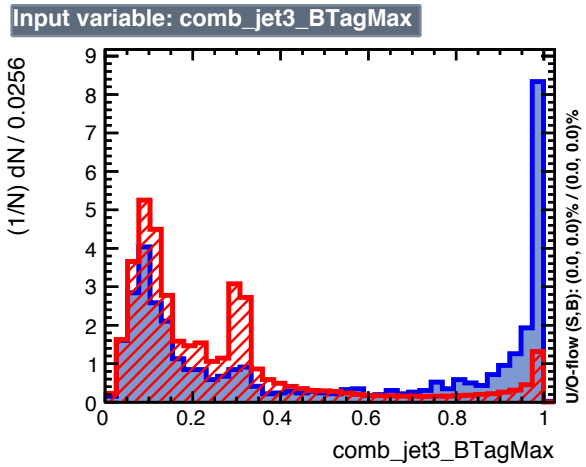
No sign of vast overtaining, maybe could need a bit more statistics for signal sample

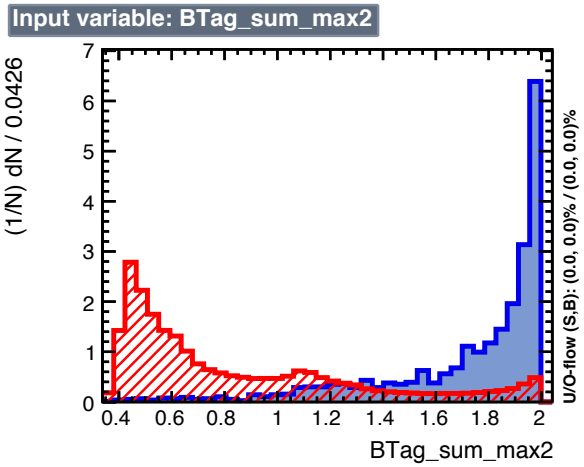
BDT training variables (I)

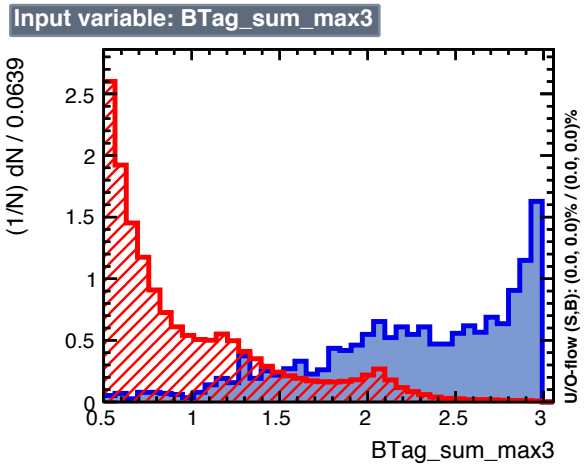
Gradient Boosting performs less well than Adaptive Boosting

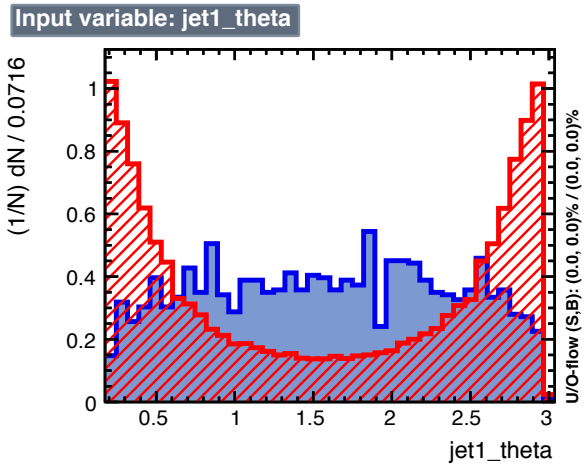












BDT training variables (II)

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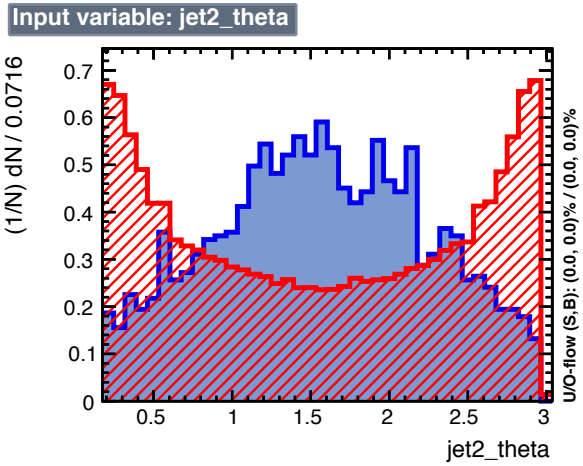
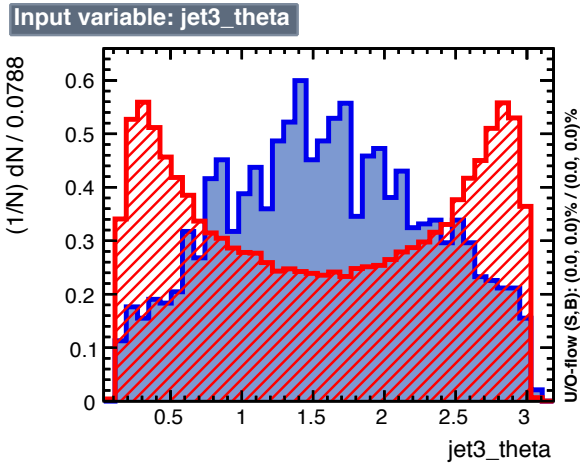
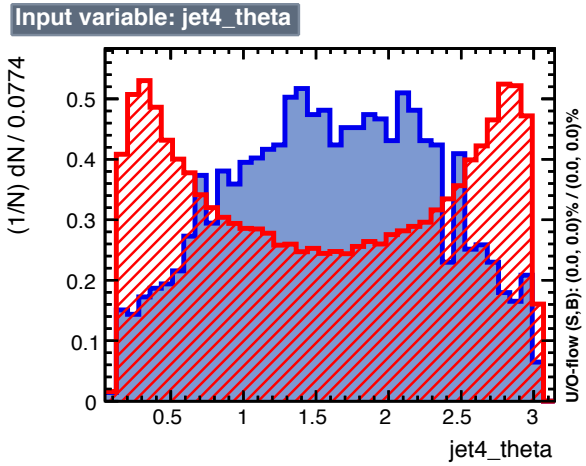
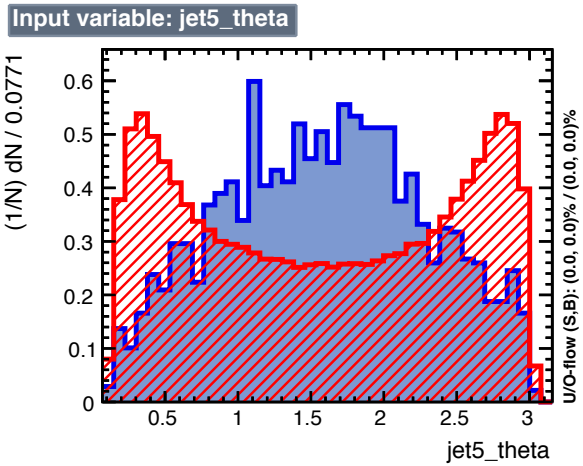
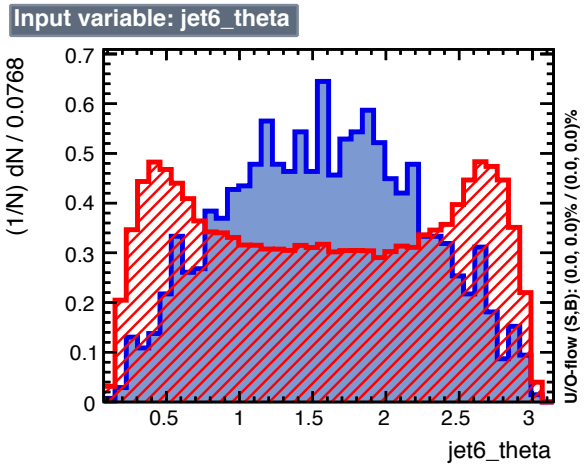
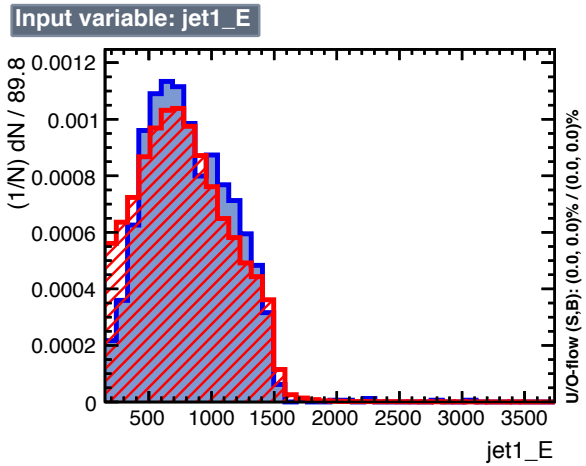






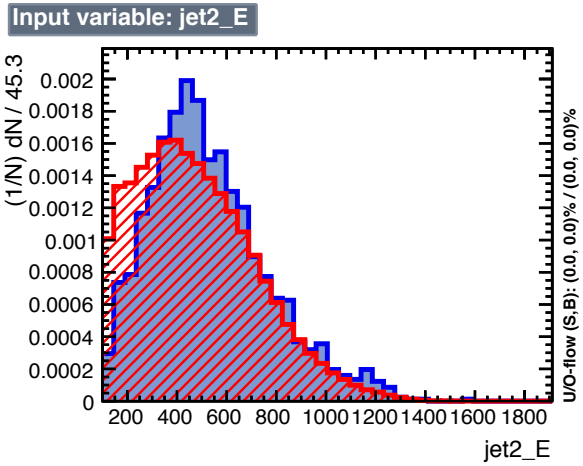


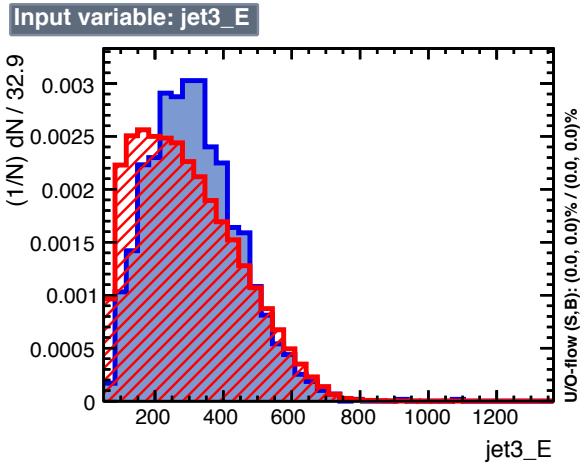


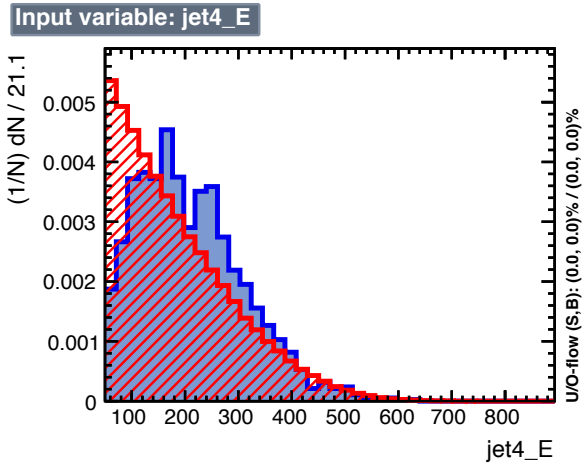


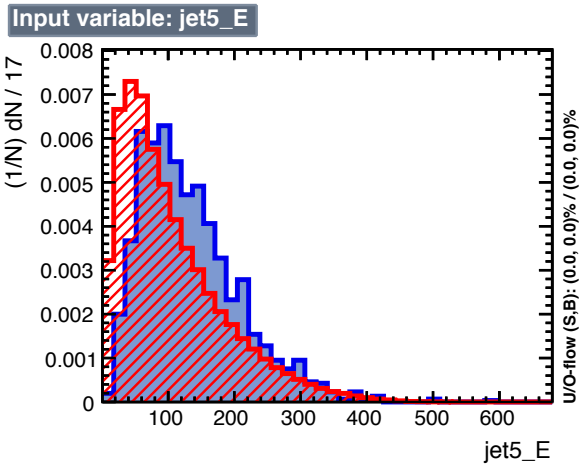
BDT training variables (III)

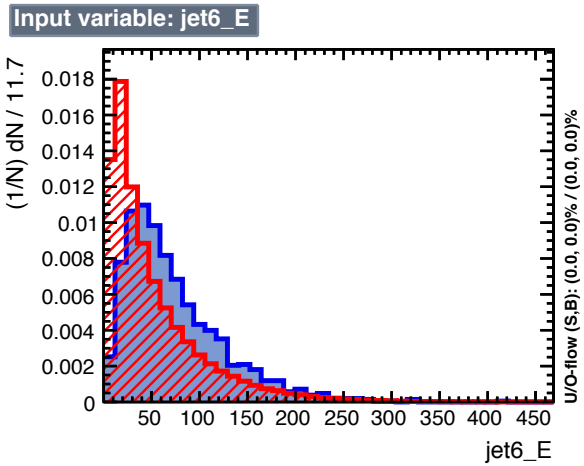
Gradient Boosting performs less well than Adaptive Boosting

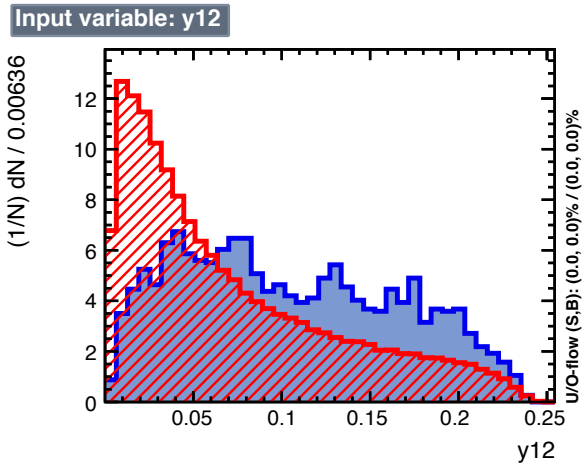






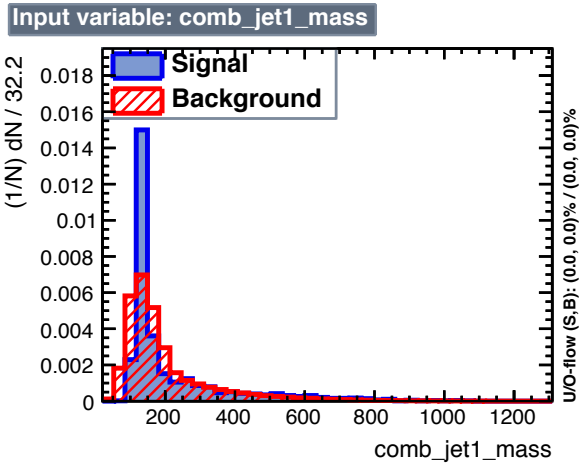


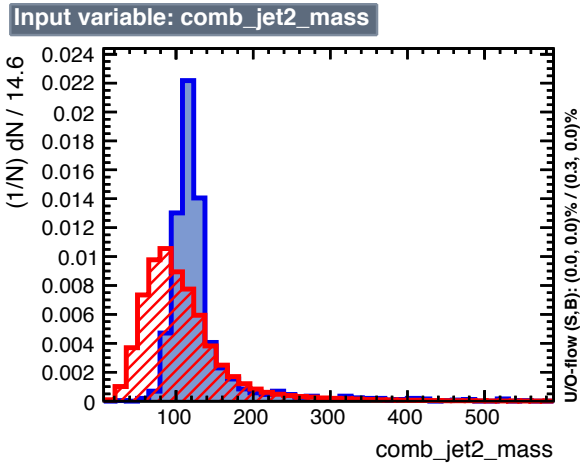


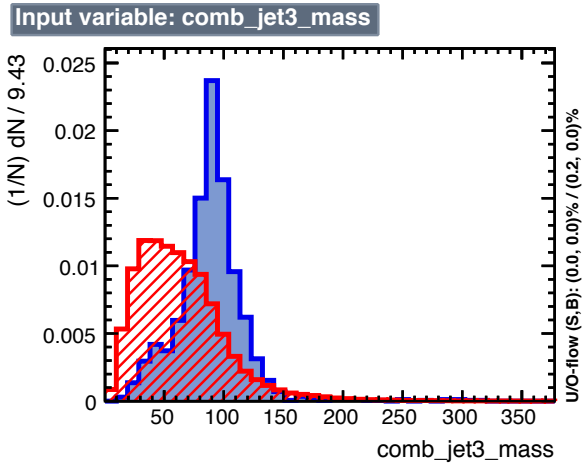


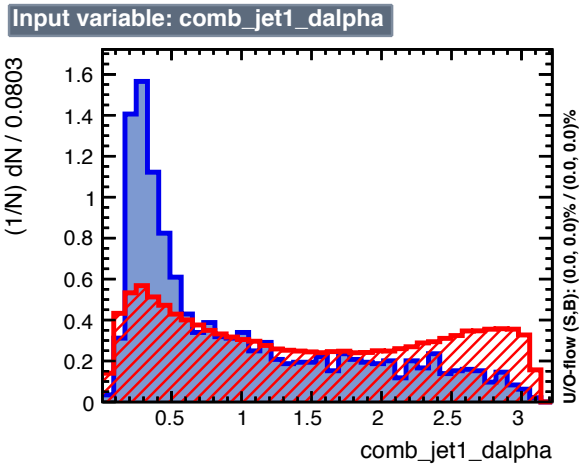
BDT training variables (IV)

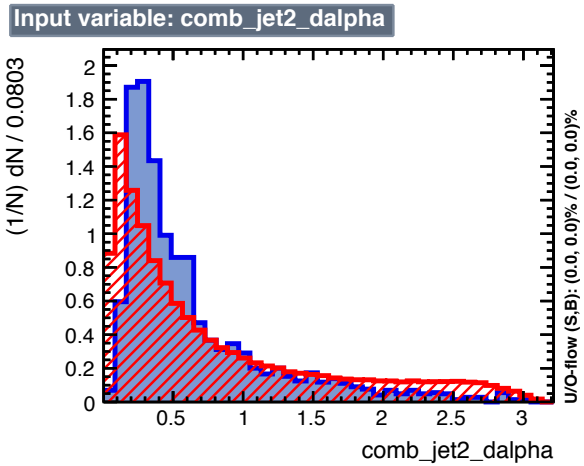
Gradient Boosting performs less well than Adaptive Boosting

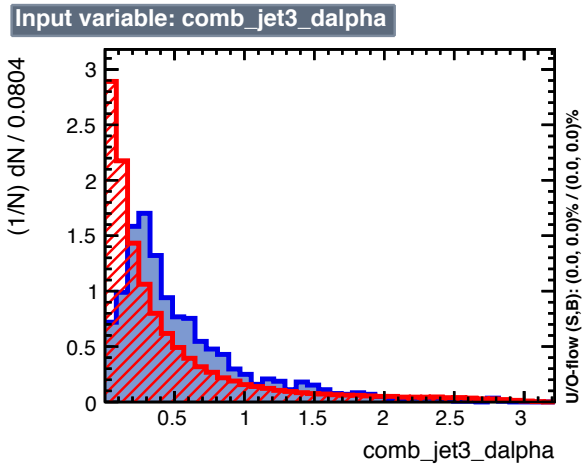












BDT training variables (V)

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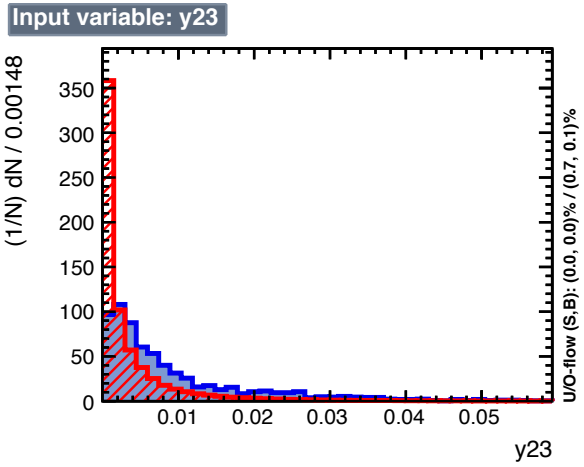

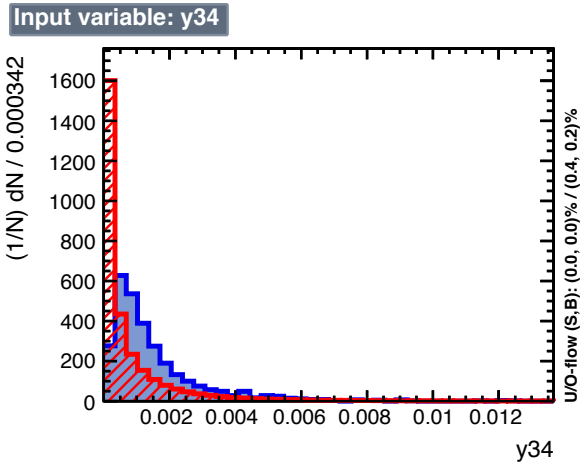

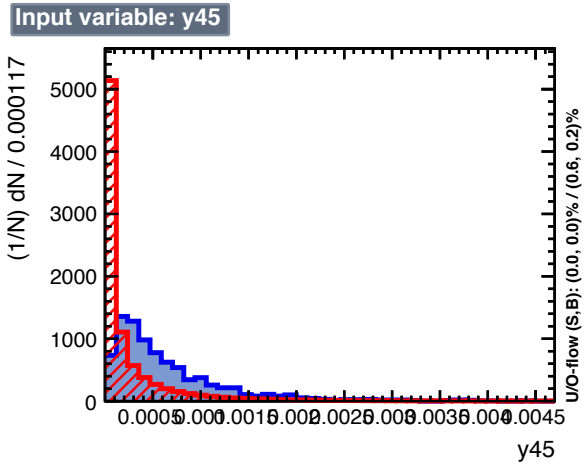

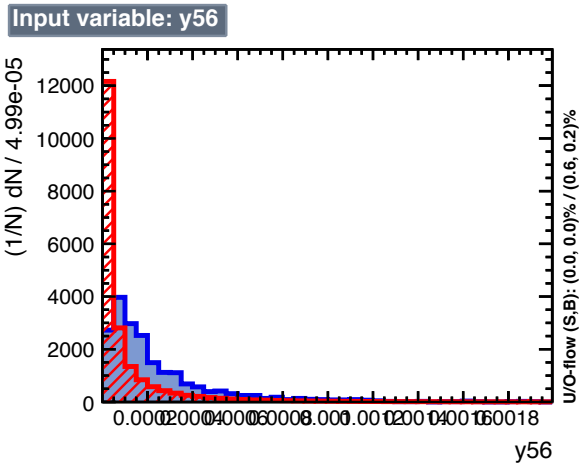

BDT results

Sample Pol (e^-) -80 %	BDT>0.42	BDT>0.45	BDT>0.50
HHqq→bbbbqq	10.0	8.3	3.4
HHqq all decays	12.9	10.6	4.2
Hqq	1.86	1.3	0.13
ee→qq	52.3	32.7	0
ee→qqqq	15.1	11.3	3.8
ee→qqqqqq	114.1	76	11.3

Summary

Not really a boosted analysis anymore

- Combining 6 jets into 3 jets, use refined VLC jets, R=1.1

Discriminating Variables:
Opening angle between two original jets combining jets, jet mass of 3 combined jets, leading BTag in combined jets, BTag sum of highest 3 b-tagged jets, jet resolution thresholds $y_{ij,}$ all jet energies, all jet polar angles

Only after pre-selection BDT leads to appearance of signal
→ Signal is very tiny, selection efficieny about 16 % to make signal appear

No sign of vast overtraining, could still benefit from larger signal statistics