$H \to \pi_v \left(\to b\bar{b}\right) \pi_v \left(\to b\bar{b}\right)$ at 350 GeV

analysis summary

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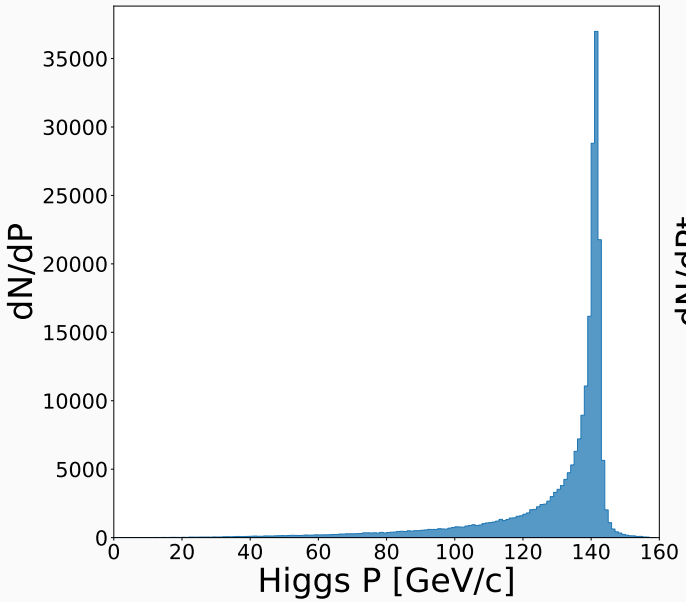
status

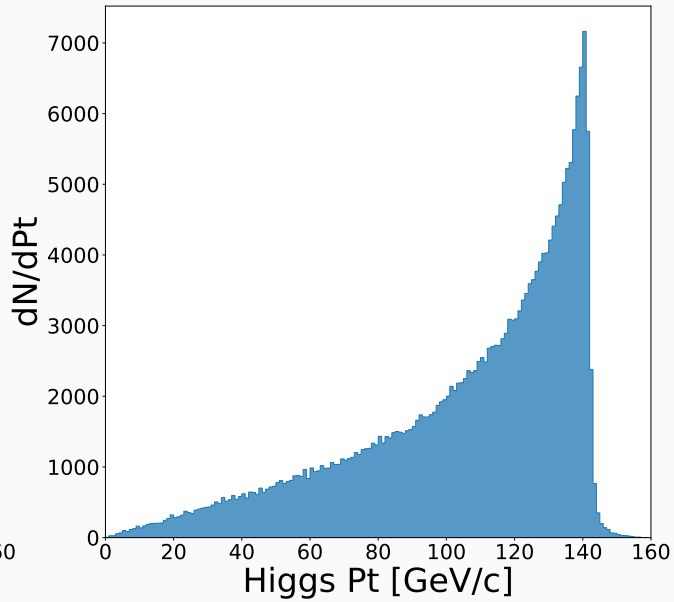
- previous presentations (latest first)
  - https://indico.cern.ch/event/1069993/contributions/4508785/attachments/2303477/3918548/CLIC_HVHiggs_4.pdf
  - https://indico.cern.ch/event/1027612/contributions/4323275/attachments/2228603/3775742/CLIC_HVHiggs_3.pdf
  - https://indico.cern.ch/event/987017/contributions/4222769/attachments/2185726/3693068/CLIC_HVHiggs_2.pdf
  - https://indico.cern.ch/event/895818/contributions/3788995/attachments/2007112/3353099/CLIC_HVHiggs.pdf
- updates:
  - TMVA redone with combined background and for each signal separately
    - weight of each background sample taken as $\sigma \cdot \epsilon(>=2DV)/N_{events}$
    - even split for training and testing
  - switched to BDTG for best significance across all samples

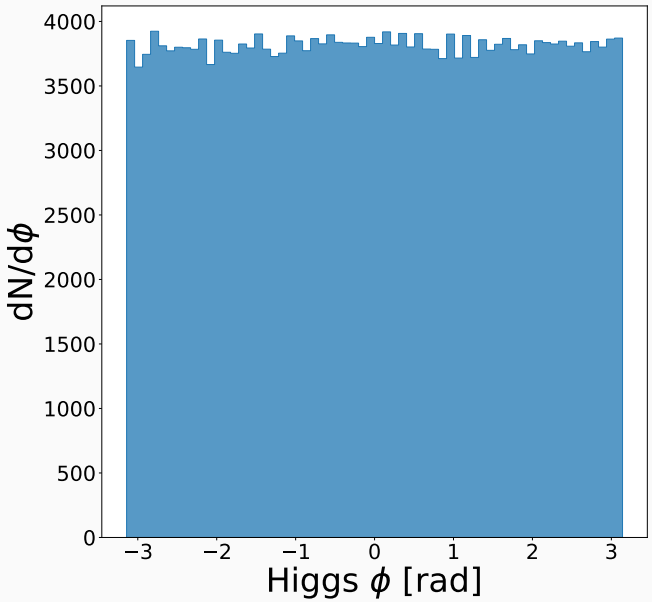
samples

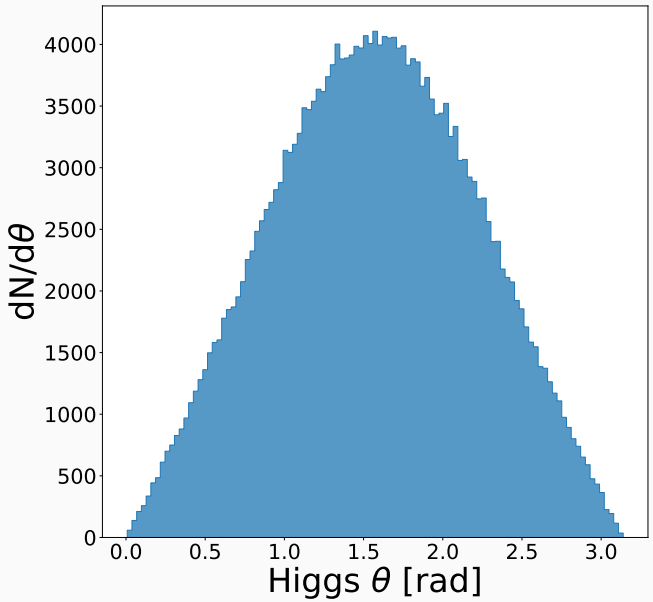
description	ID	σ [fb]	# events	>= 2 DV events [%]
25 GeV, 1 ps	10953	93.44	$\sim$ 240 K	77
25 GeV, 10 ps	10944	93.44	$\sim$ 240 K	93
25 GeV, 100 ps	10932	93.44	$\sim$ 240 K	98
25 GeV, 300 ps	10962	93.44	$\sim$ 240 K	96
35 GeV, 1 ps	10956	93.44	$\sim$ 240 K	75
35 GeV, 10 ps	10947	93.44	$\sim$ 240 K	92
35 GeV, 100 ps	10453	93.44	$\sim$ 240 K	98
35 GeV, 300 ps	10965	93.44	$\sim$ 240 K	98
50 GeV, 1 ps	10959	93.44	$\sim$ 240 K	72
50 GeV, 10 ps	10950	93.44	$\sim$ 240 K	89
50 GeV, 100 ps	10935	93.44	$\sim$ 240 K	99
50 GeV, 300 ps	10968	93.44	$\sim$ 240 K	99
qq	4698	24405.4	$\sim$ 2 KK	12
qqqq	2871	5847	$\sim$ 1.44 KK	8
qq$\nu\nu$	2862	324.6	$\sim$ 306 K	12
WWZ	1439	10	$\sim$ 40 K	13
$t\bar{t}$	1369+1434	450	$\sim$(21+220) K	2

Higgs

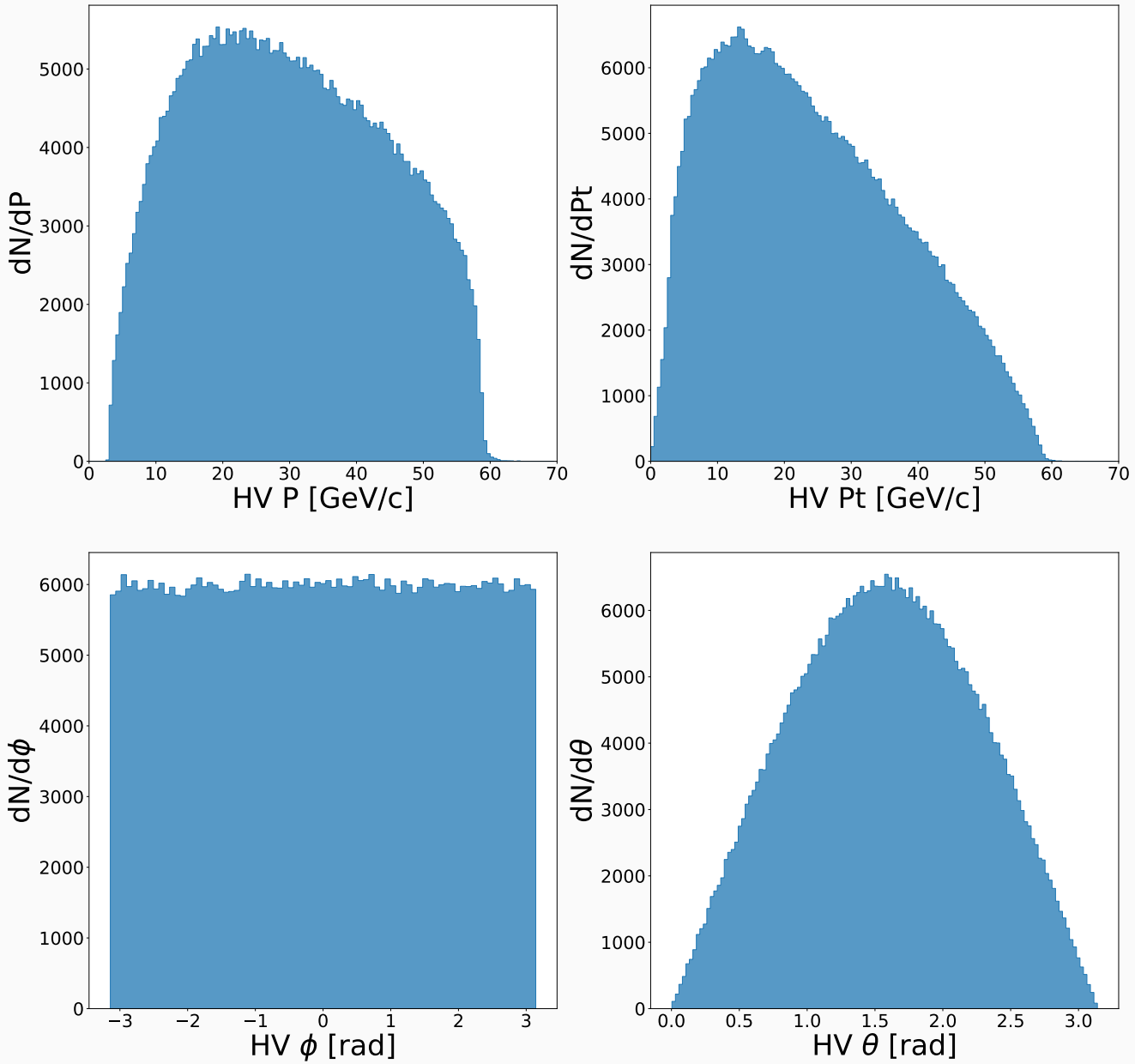

dN/dP
Higgs P [GeV/c]


dN/dPt
Higgs Pt [GeV/c]

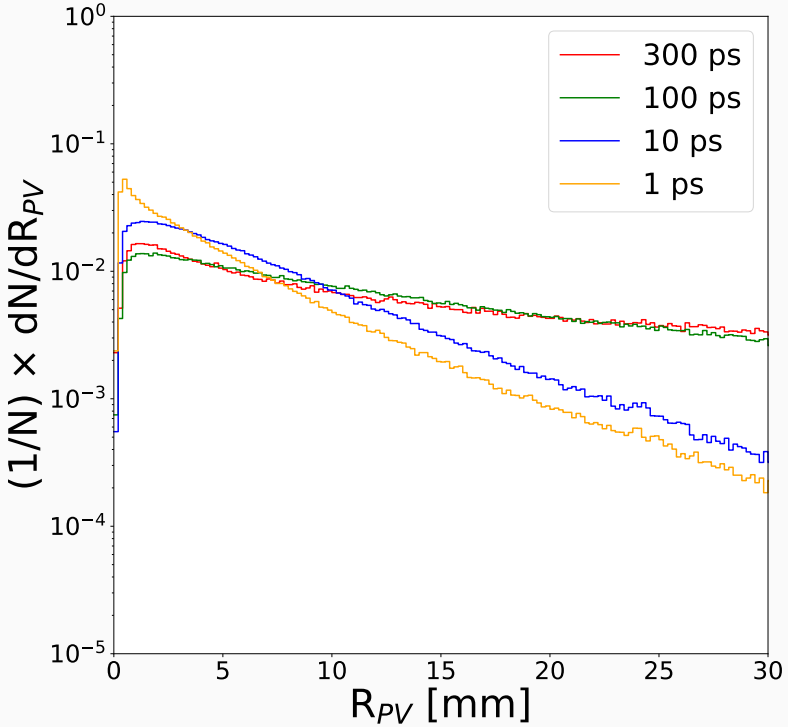

dN/dϕ
Higgs ϕ [rad]

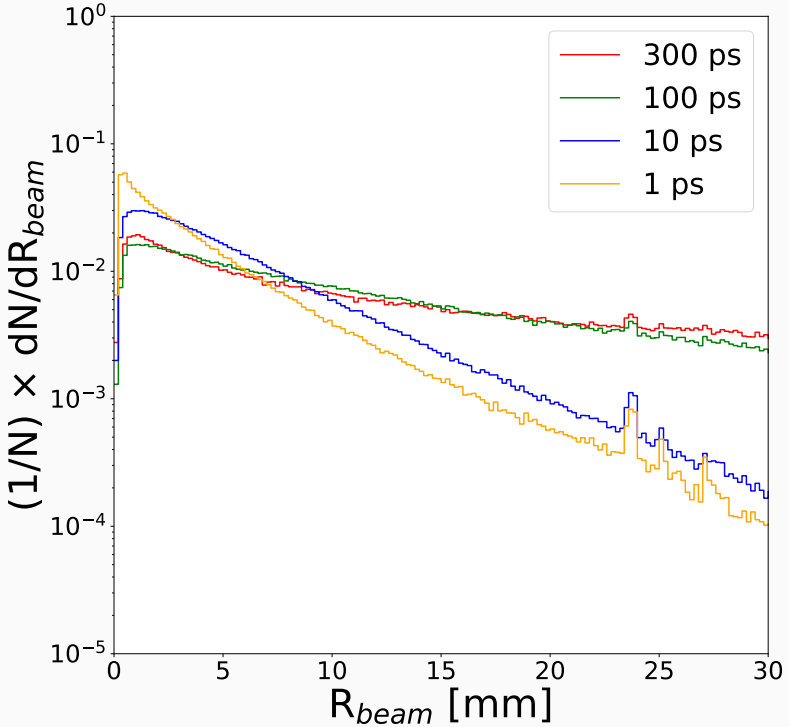

dN/dθ
Higgs θ [rad]

Hidden Valley pions (35 GeV, 10 ps)

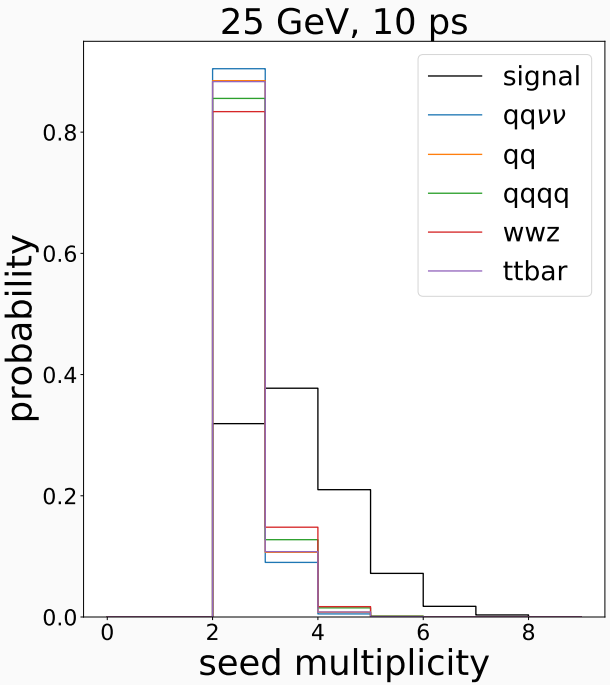


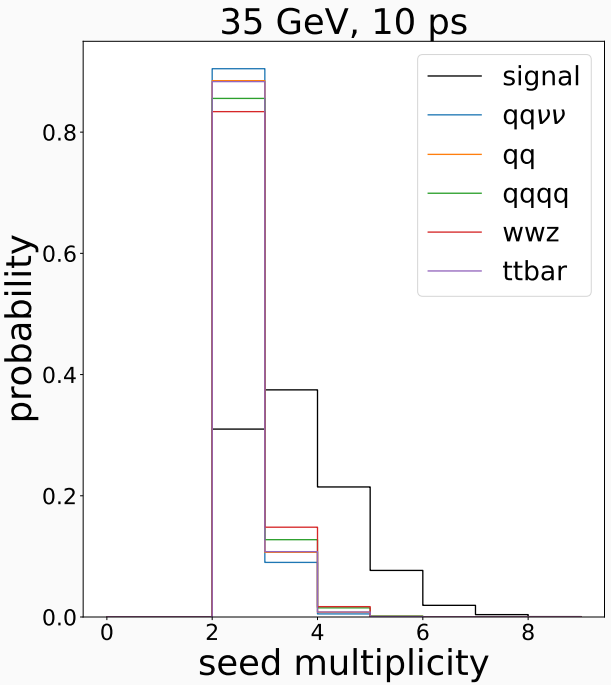
displaced vertices (35 GeV)

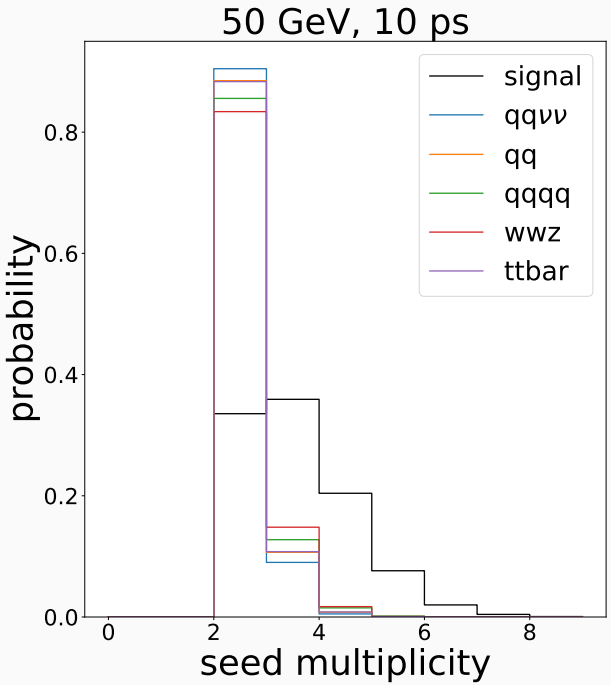


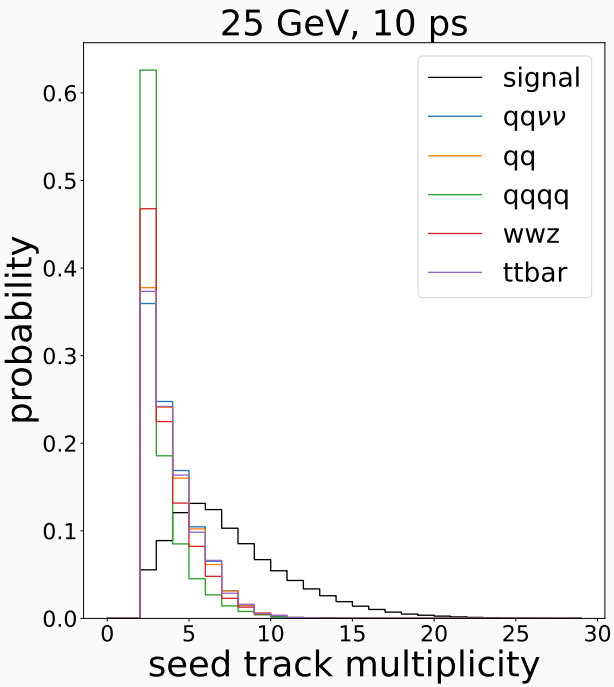


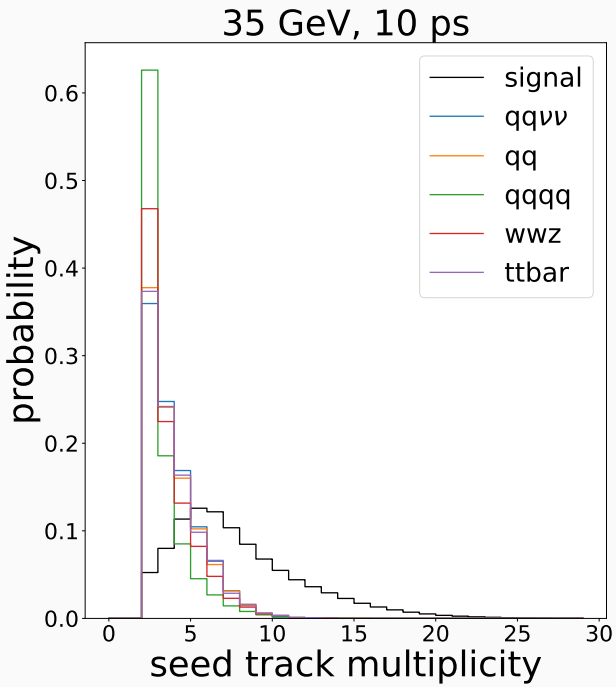
TMVA – variables

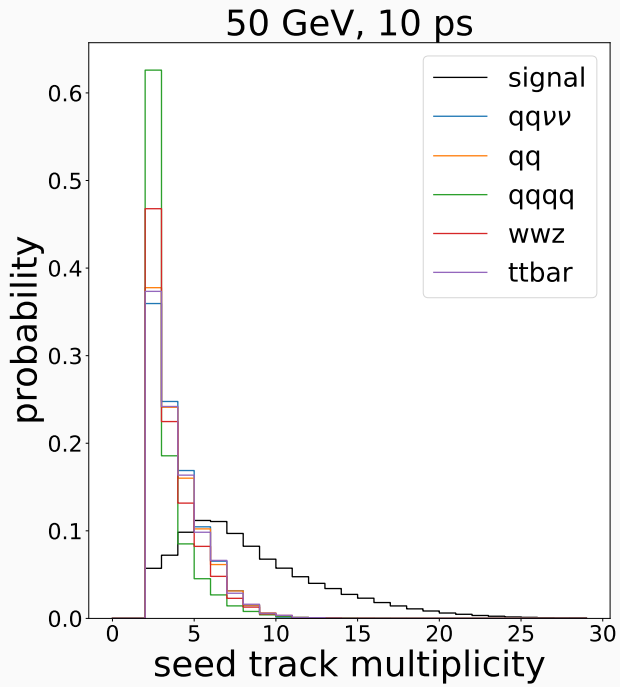


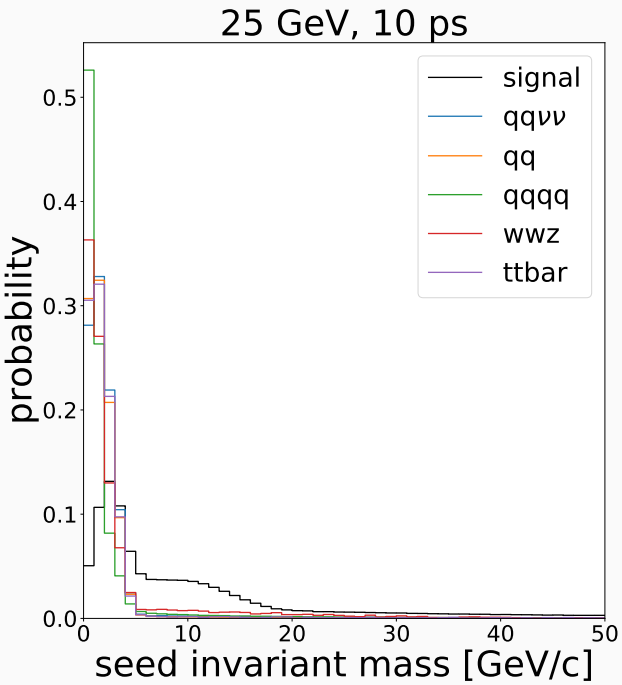


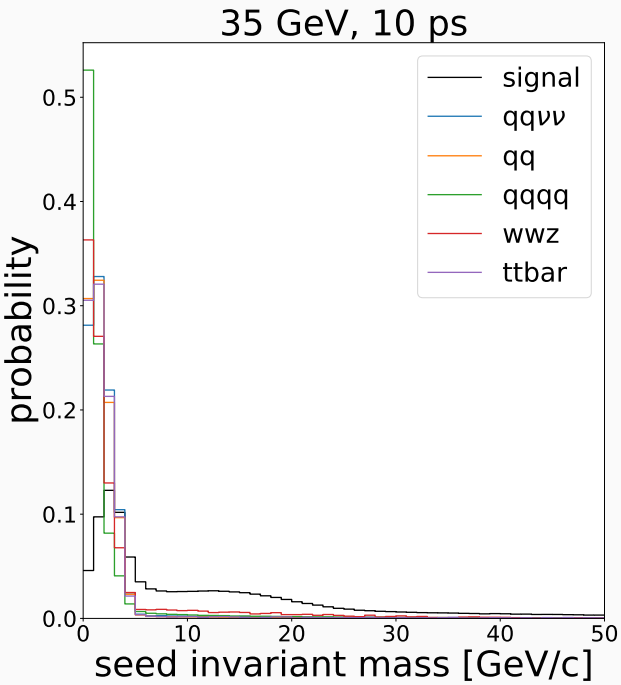


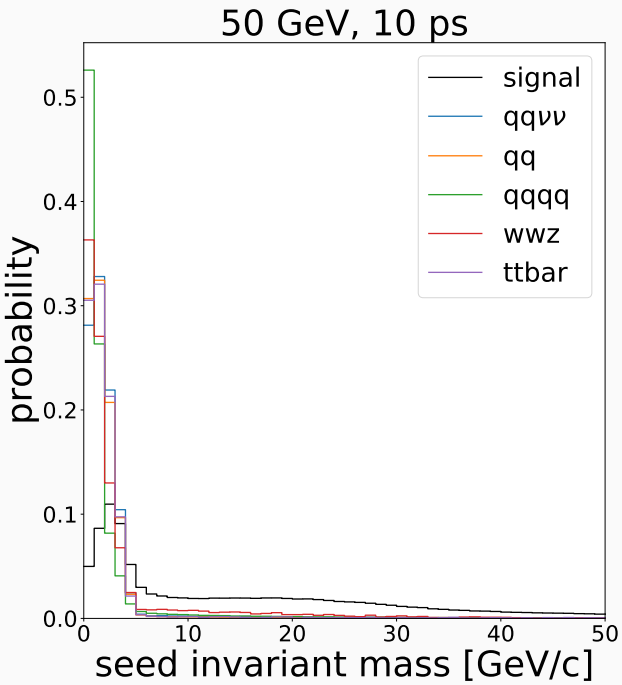

25 GeV, 10 ps
signal
qqνν
qq
qqqq
wwz
ttbar
probability
seed track multiplicity
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0
5
10
15
20
25
30

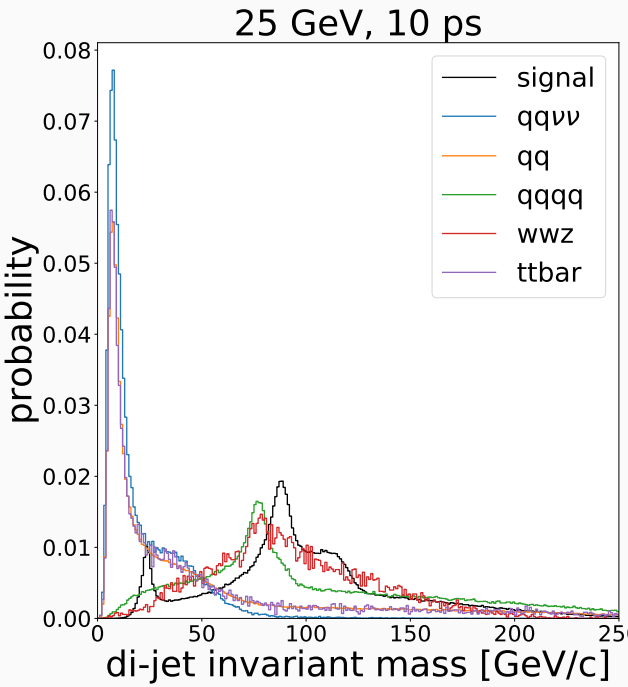

35 GeV, 10 ps
signal
qqνν
qq
qqqq
wwz
ttbar
probability
seed track multiplicity
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0
5
10
15
20
25
30

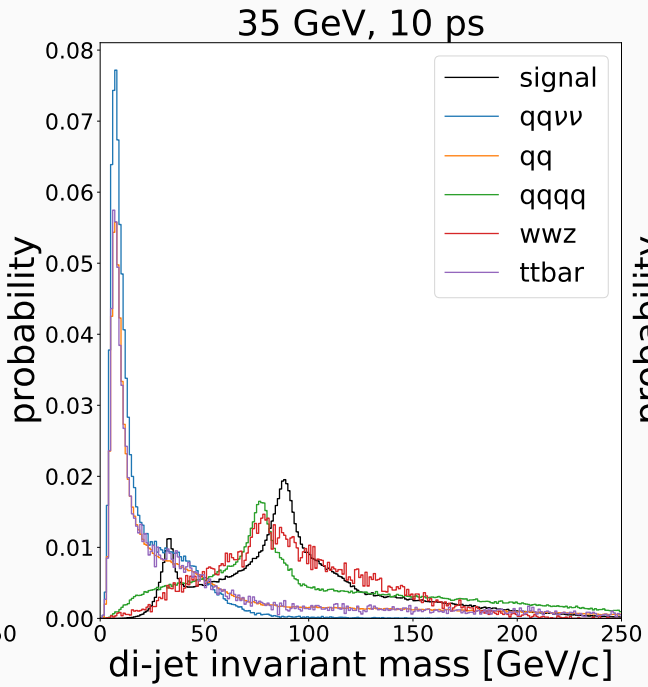

50 GeV, 10 ps
signal
qqνν
qq
qqqq
wwz
ttbar
probability
seed track multiplicity
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0
5
10
15
20
25
30

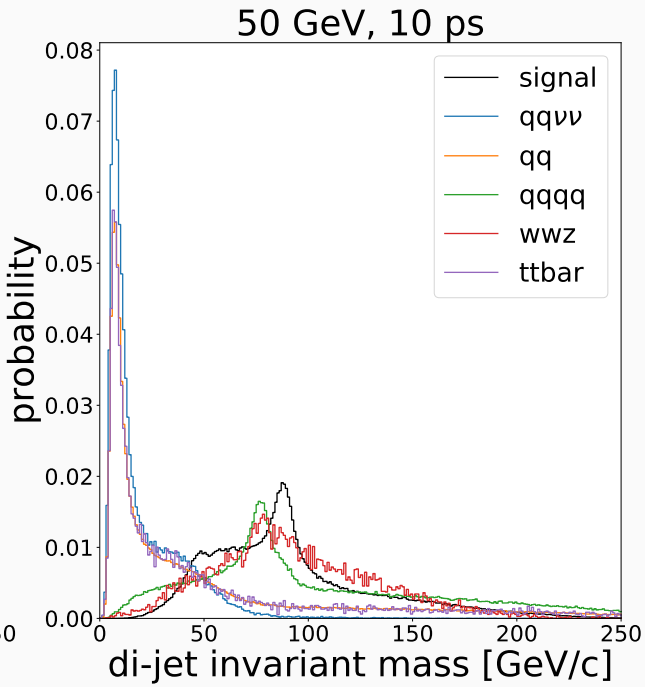

25 GeV, 10 ps
signal
qqνν
qq
qqqq
wwz
ttbar
probability
seed invariant mass [GeV/c]

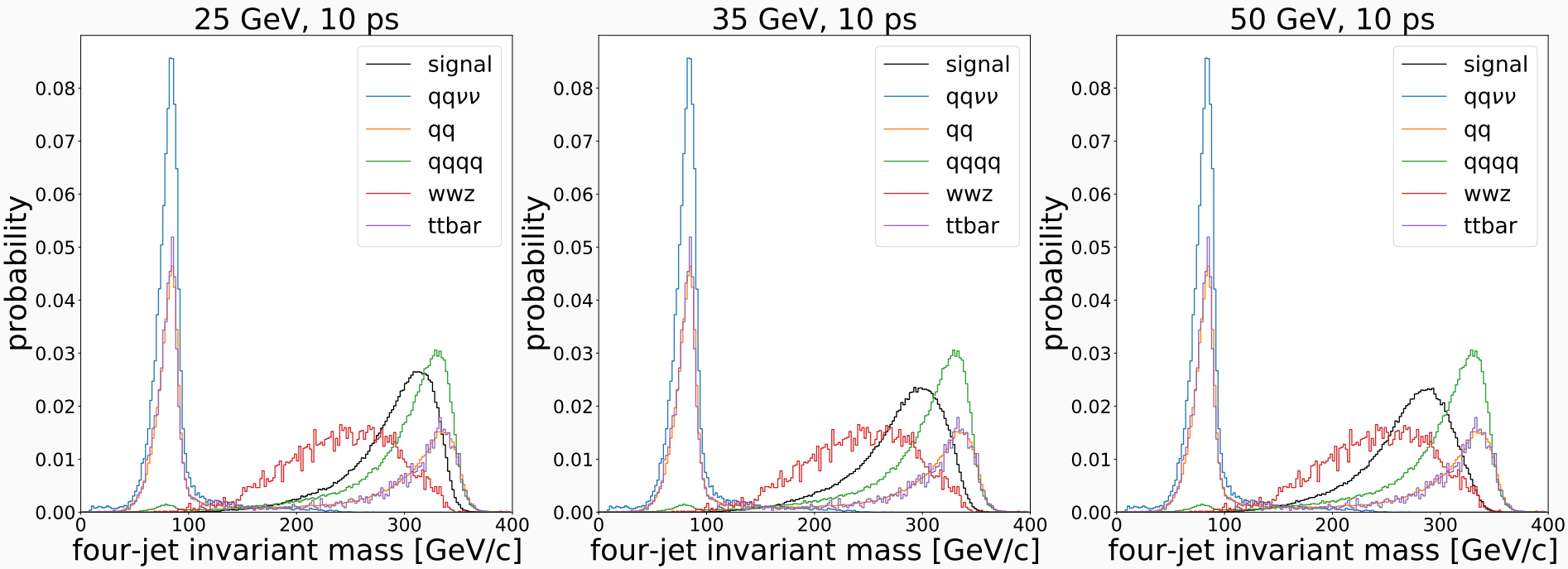

35 GeV, 10 ps
signal
qqνν
qq
qqqq
wwz
ttbar
probability
seed invariant mass [GeV/c]

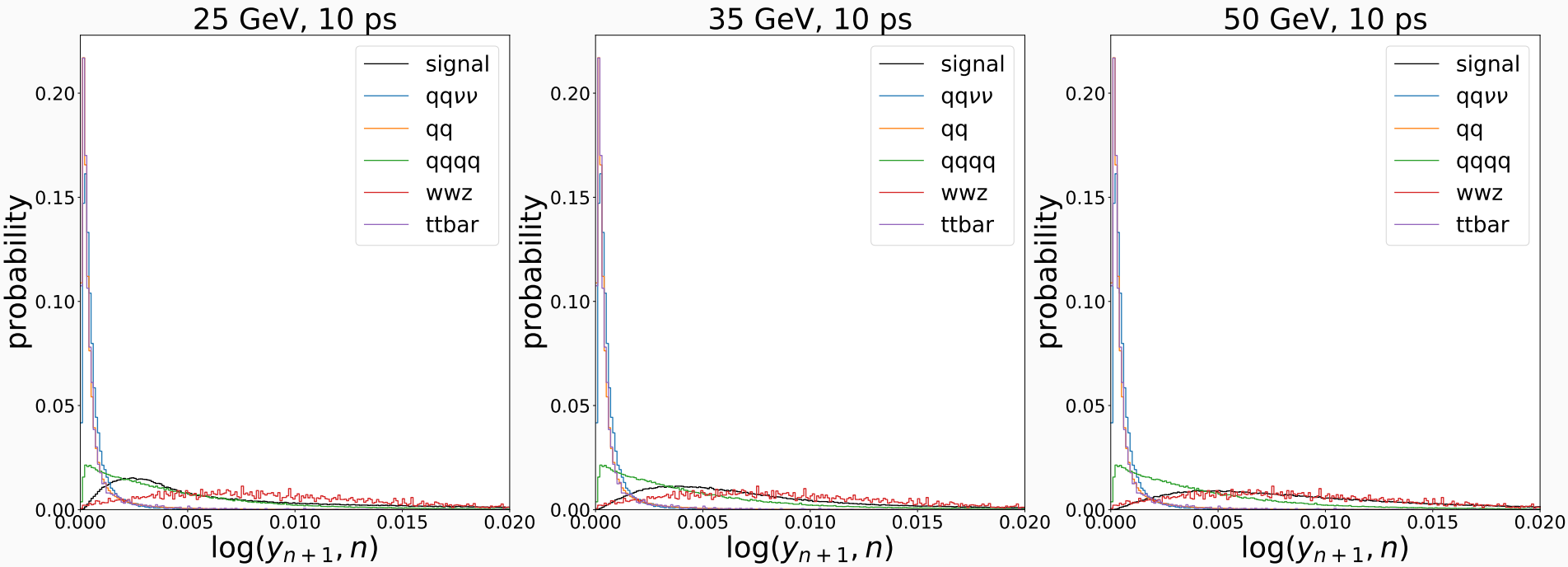

50 GeV, 10 ps
signal
qqνν
qq
qqqq
wwz
ttbar
probability
seed invariant mass [GeV/c]

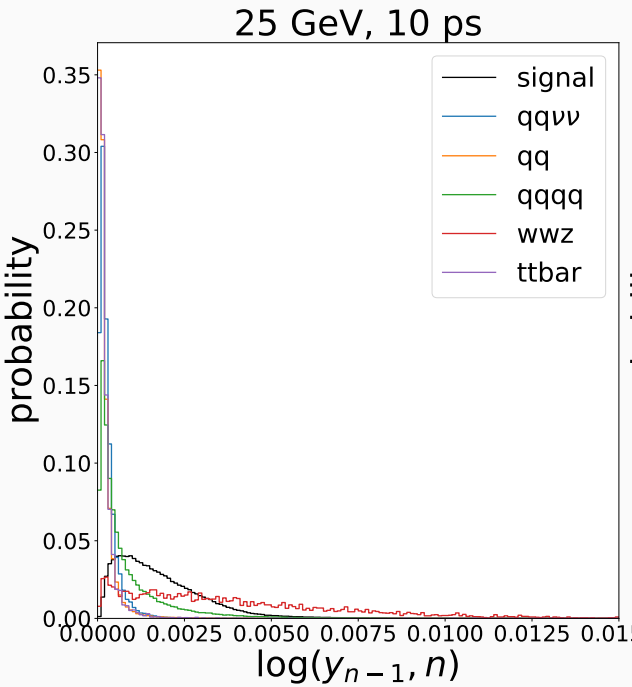

25 GeV, 10 ps
probability
di-jet invariant mass [GeV/c]
signal
qqνν
qq
qqqq
wwz
ttbar

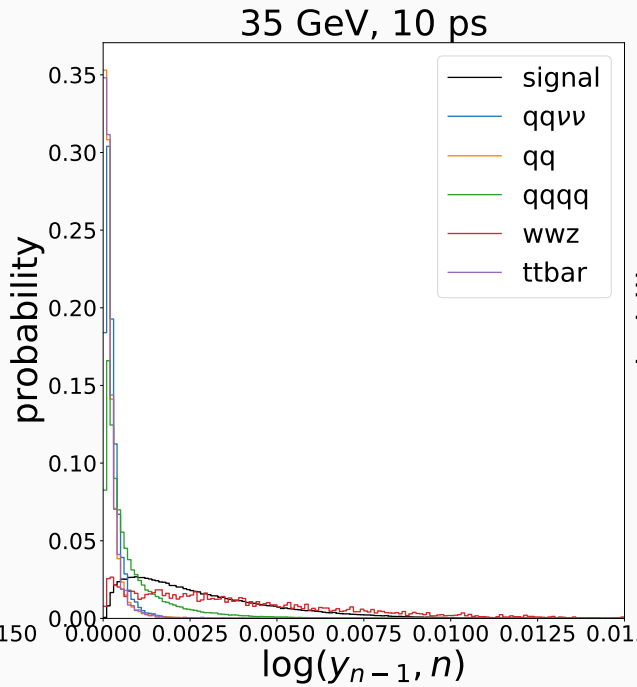

35 GeV, 10 ps
probability
di-jet invariant mass [GeV/c]
signal
qqνν
qq
qqqq
wwz
ttbar

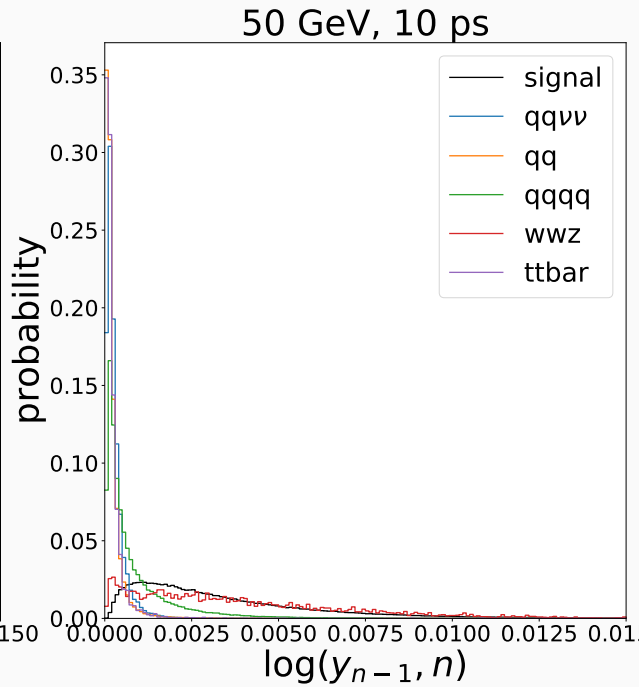

50 GeV, 10 ps
probability
di-jet invariant mass [GeV/c]
signal
qqνν
qq
qqqq
wwz
ttbar


25 GeV, 10 ps
35 GeV, 10 ps
50 GeV, 10 ps
signal
qqνν
qq
qqqq
wwz
ttbar
probability
four-jet invariant mass [GeV/c]
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0
100
200
300
400

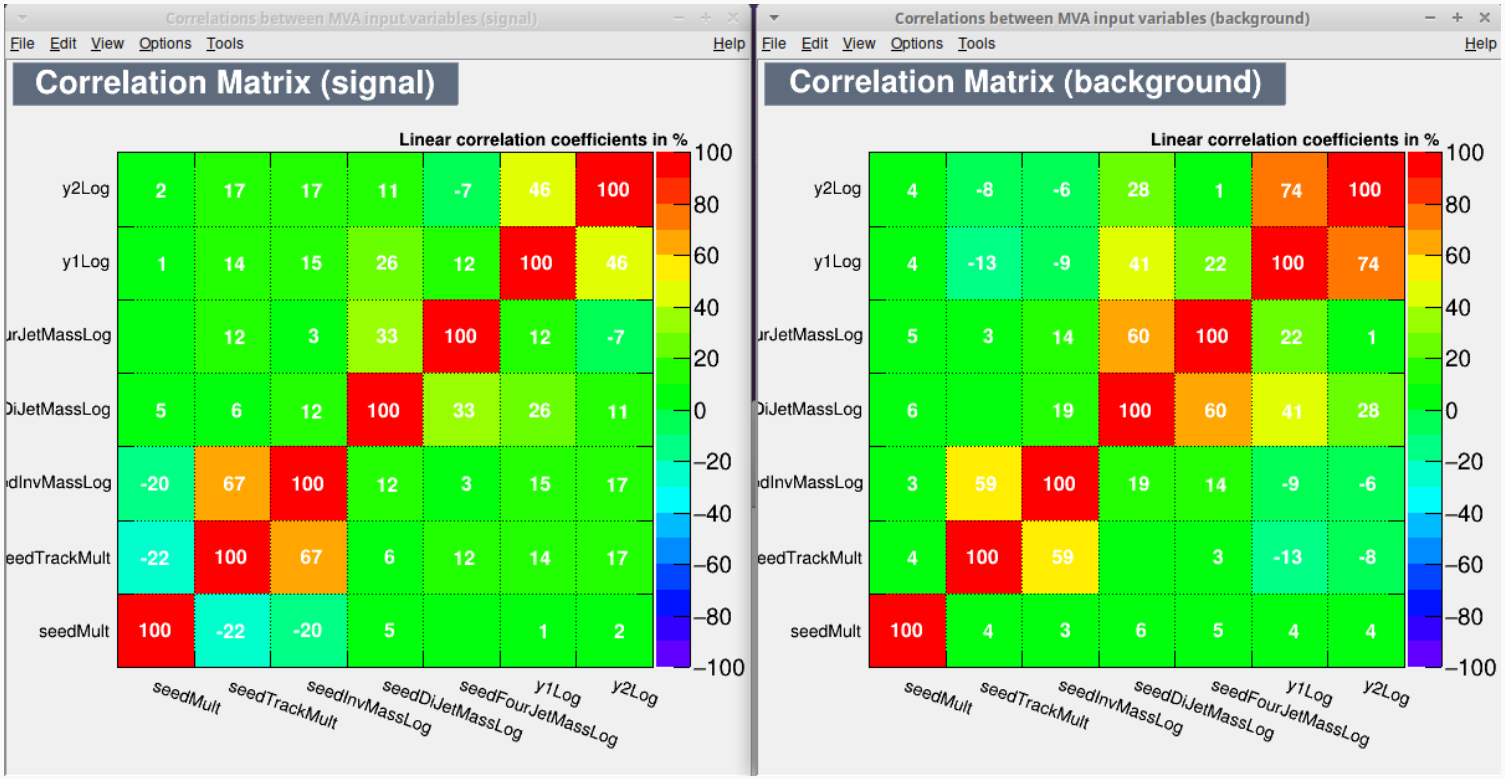

25 GeV, 10 ps
35 GeV, 10 ps
50 GeV, 10 ps
signal
qqνν
qq
qqqq
wwz
ttbar
probability
0.00
0.05
0.10
0.15
0.20
0.000
0.005
0.010
0.015
0.020
log(y_{n+1}, n)


25 GeV, 10 ps
probability
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.0000 0.0025 0.0050 0.0075 0.0100 0.0125 0.0150
$\log(y_{n-1}, n)$
signal
qqνν
qq
qqqq
wwz
ttbar


35 GeV, 10 ps
probability
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.0000 0.0025 0.0050 0.0075 0.0100 0.0125 0.0150
$\log(y_{n-1}, n)$
signal
qqνν
qq
qqqq
wwz
ttbar

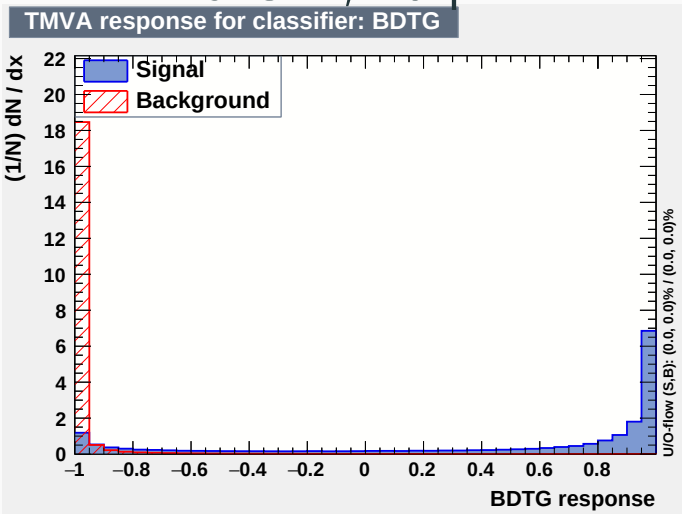

50 GeV, 10 ps
probability
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.0000 0.0025 0.0050 0.0075 0.0100 0.0125 0.0150
$\log(y_{n-1}, n)$
signal
qqνν
qq
qqqq
wwz
ttbar

- 35 GeV, 10 ps signal and combined background

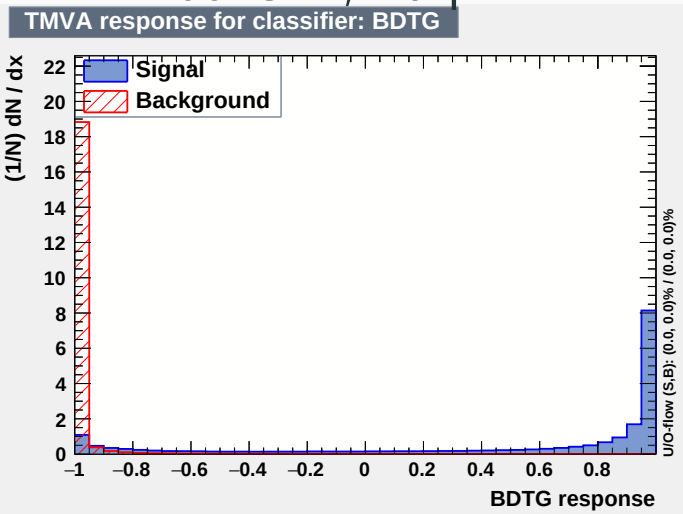


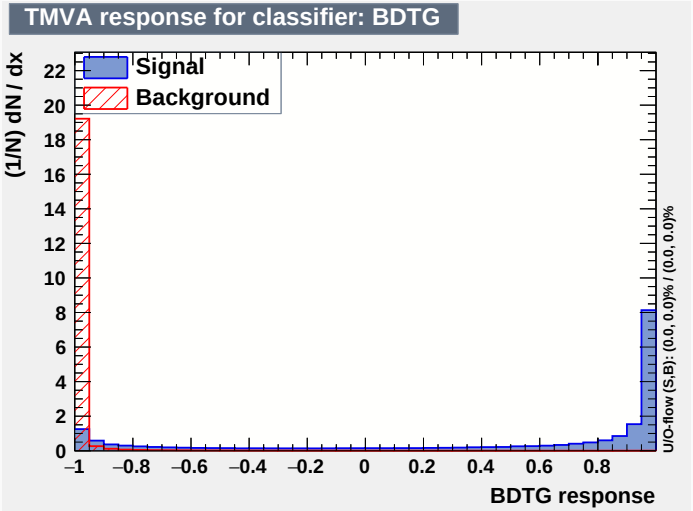
TMVA – BDT response

25 GeV, 10 ps



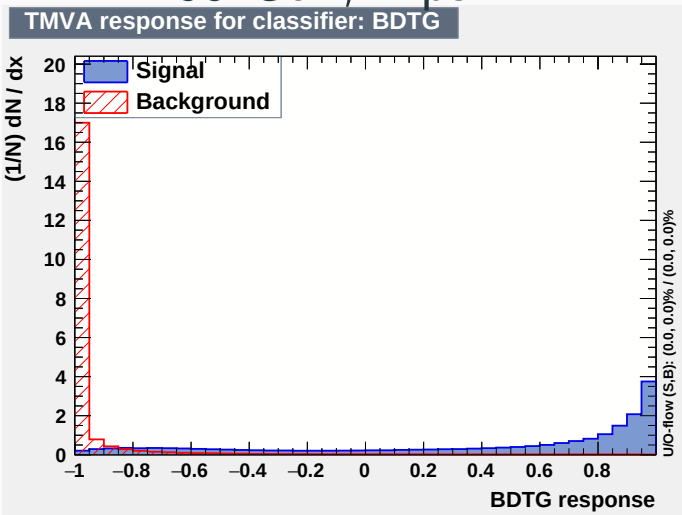
35 GeV, 10 ps



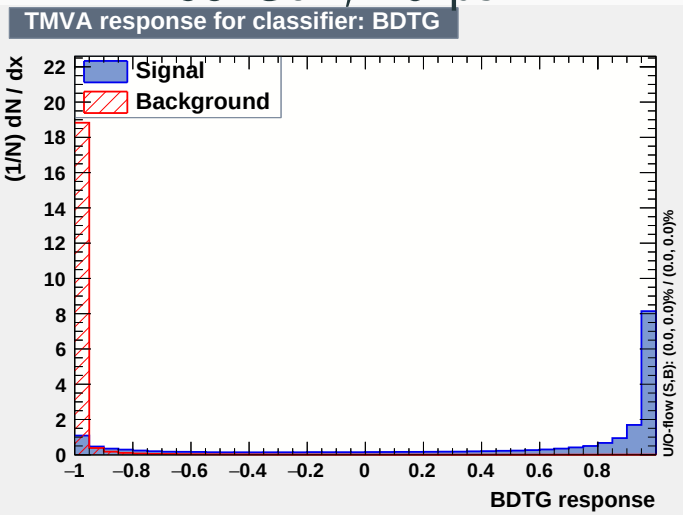


50 GeV, 10 ps

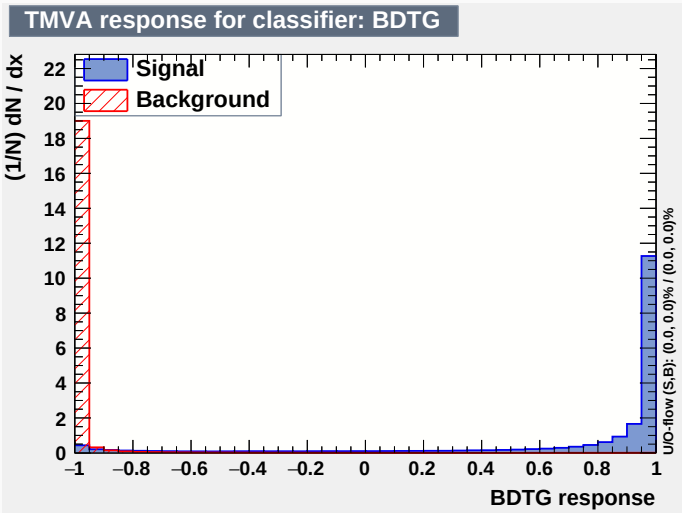
35 GeV, 1 ps



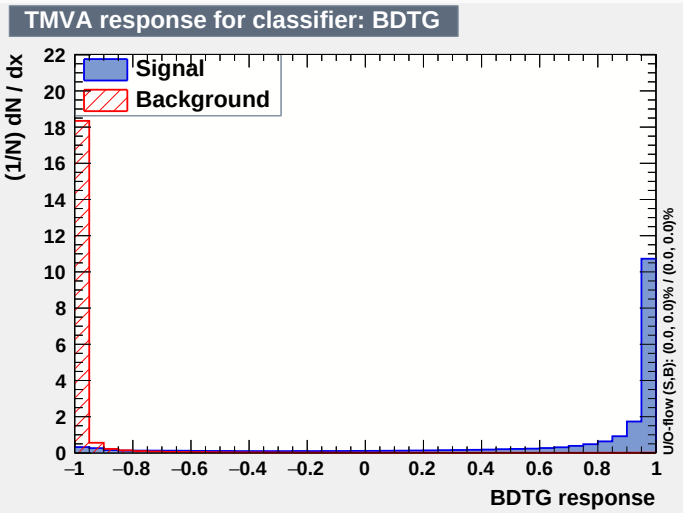
35 GeV, 10 ps



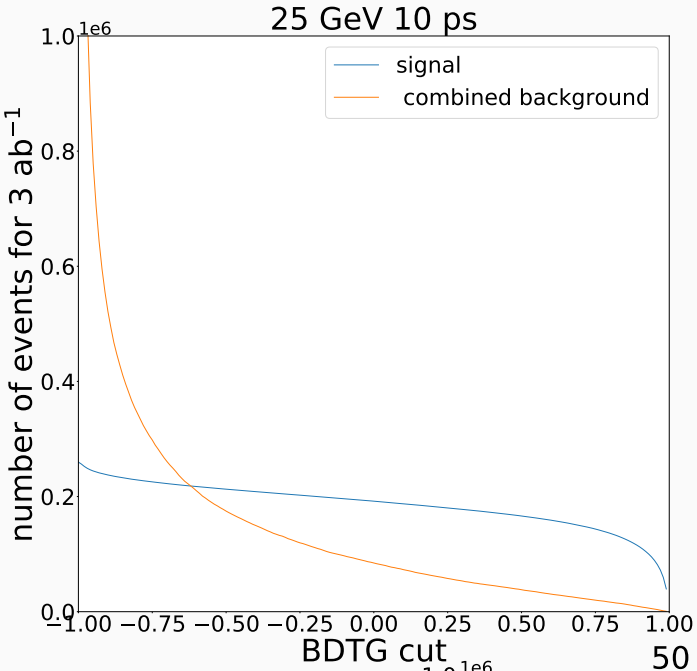
35 GeV, 100 ps

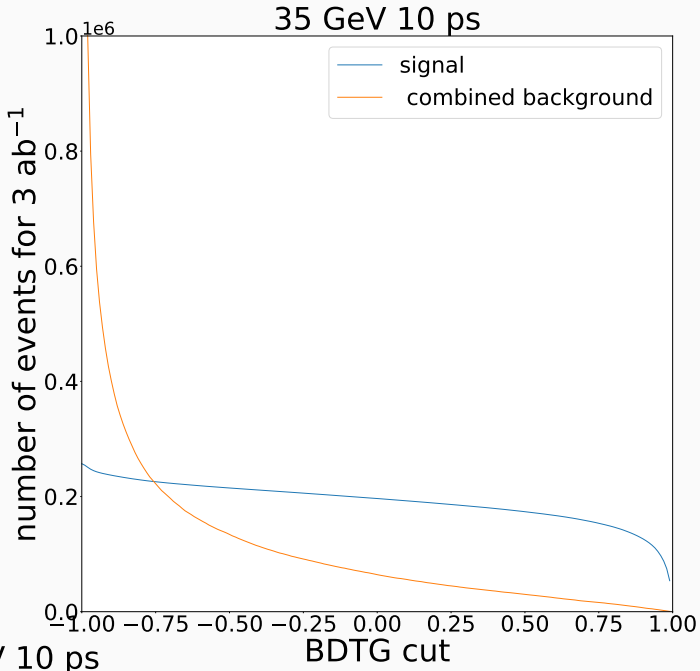


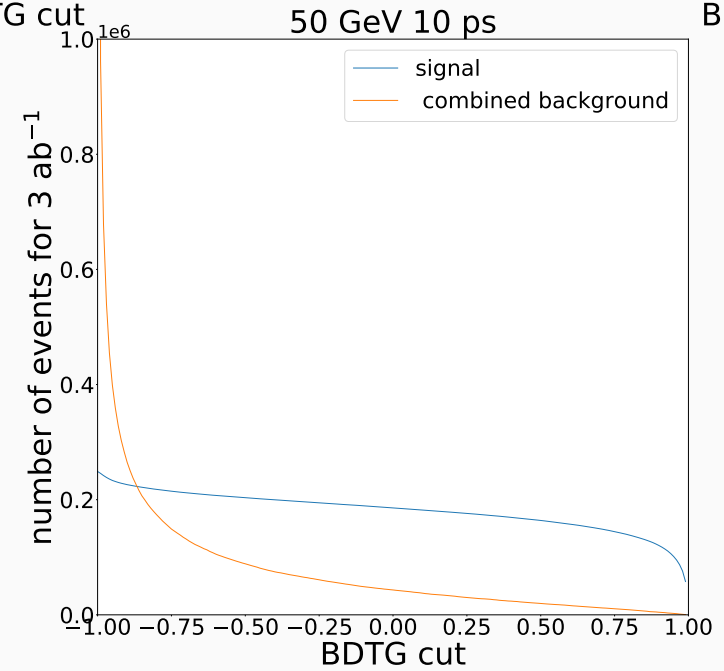
35 GeV, 300 ps

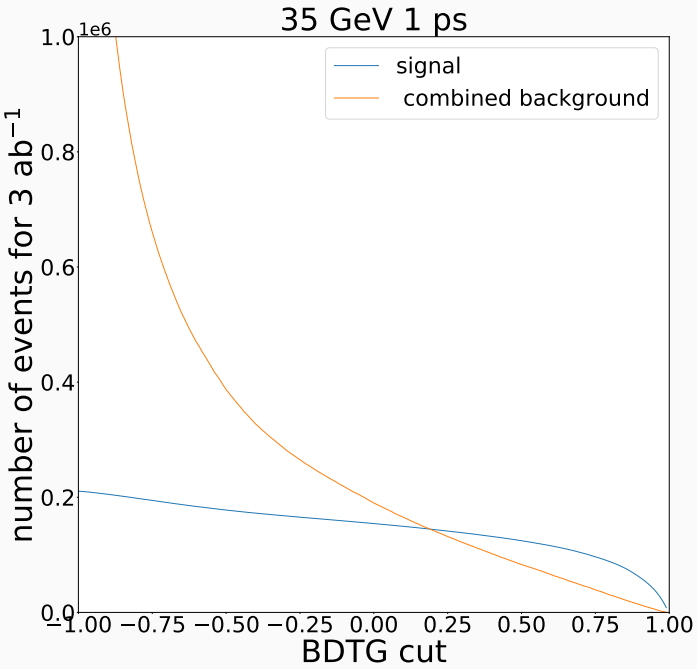


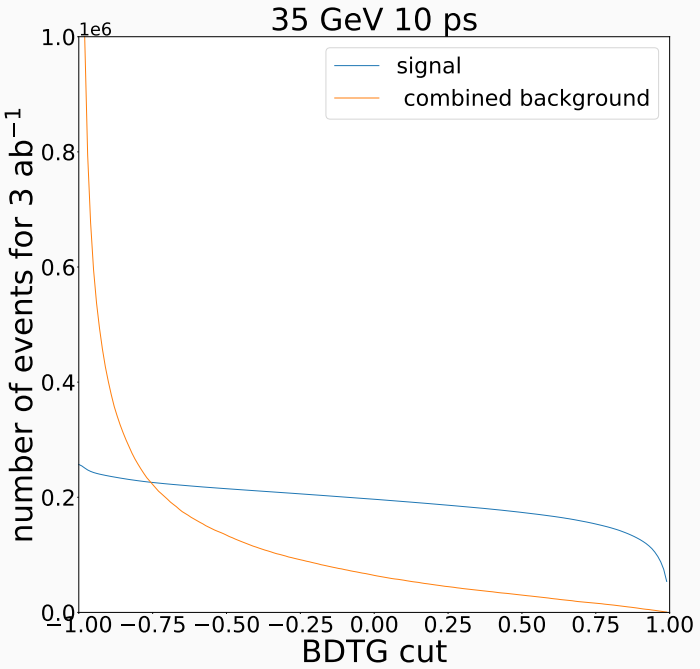
TMVA – number of events

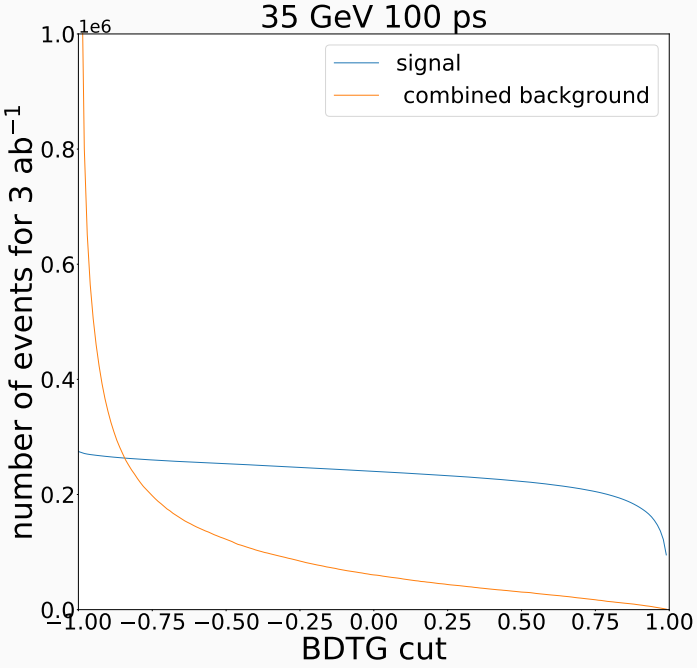


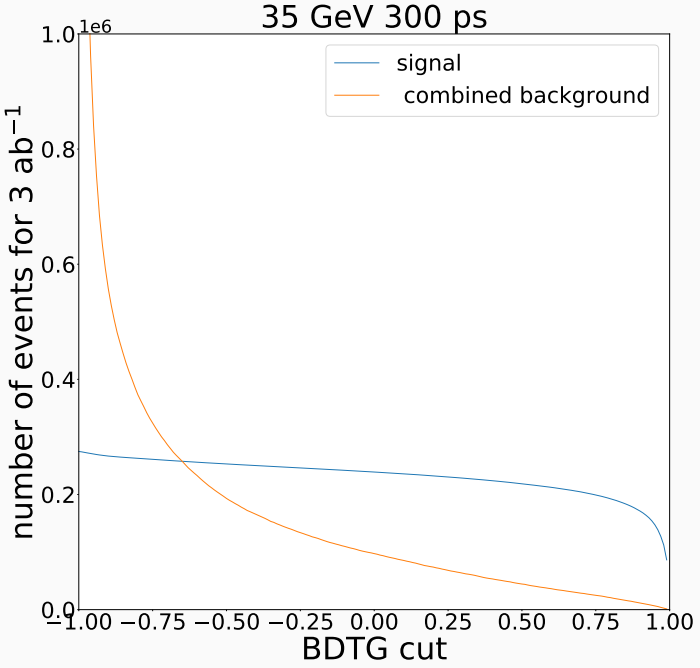




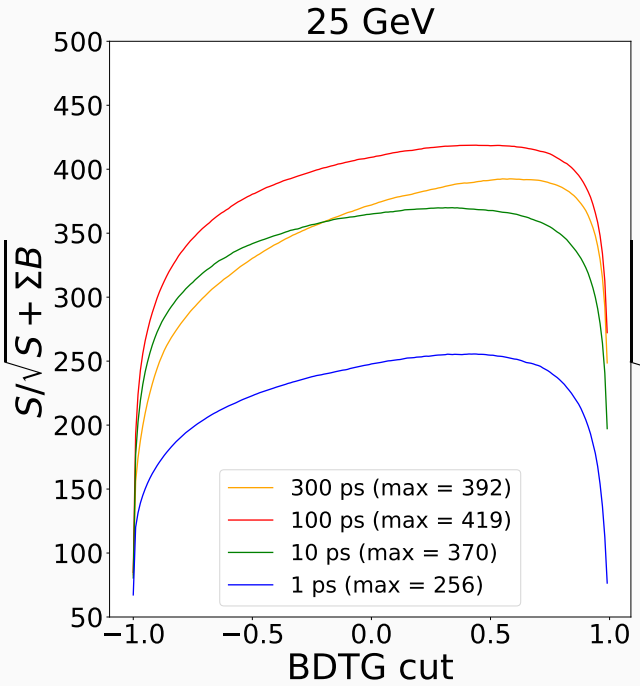

35 GeV 1 ps
1e6
1.0
0.8
0.6
0.4
0.2
0.0
number of events for 3 ab^{-1}
signal
combined background
−1.00 −0.75 −0.50 −0.25 0.00 0.25 0.50 0.75 1.00
BDTG cut

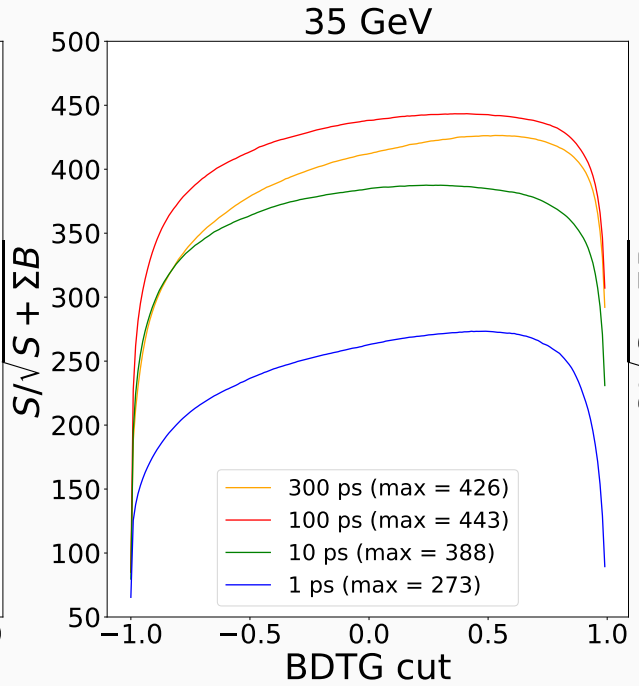

35 GeV 10 ps
1e6
1.0
0.8
0.6
0.4
0.2
0.0
number of events for 3 ab^{-1}
signal
combined background
−1.00 −0.75 −0.50 −0.25 0.00 0.25 0.50 0.75 1.00
BDTG cut

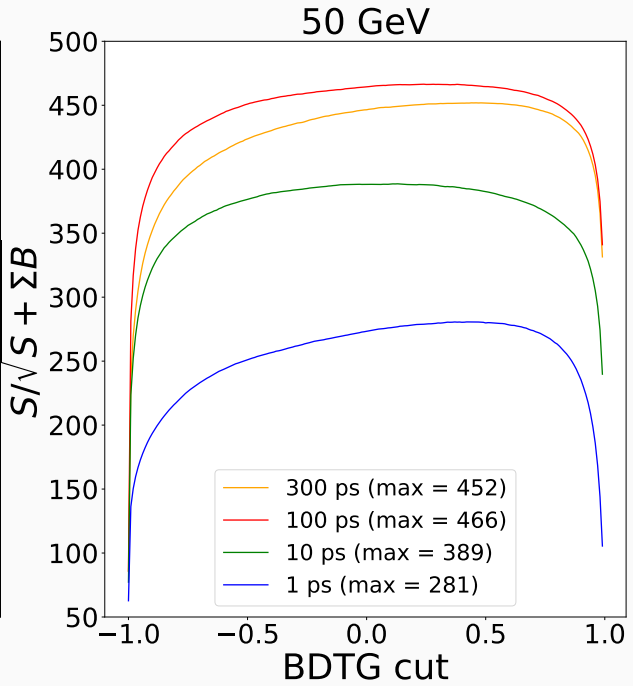

35 GeV 100 ps
1e6
1.0
0.8
0.6
0.4
0.2
0.0
number of events for 3 ab^{-1}
signal
combined background
−1.00 −0.75 −0.50 −0.25 0.00 0.25 0.50 0.75 1.00
BDTG cut


35 GeV 300 ps
1e6
1.0
0.8
0.6
0.4
0.2
0.0
number of events for 3 ab^{-1}
signal
combined background
−1.00 −0.75 −0.50 −0.25 0.00 0.25 0.50 0.75 1.00
BDTG cut

TMVA – signficance







Summary

- this study is a follow-up to an analysis at 3 TeV
- it uses the same custom SV reconstruction algorithms
  - corrects SV track multiplicity
  - provides a variable with good signal/background separation
- all relevant backgrounds have been considered (including WWZ and $t\bar{t}$) and are heavily suppressed by the requirement of at least 2 displaced vertices
- signal significance determined for each sample and combined background
  - 1 ps samples have significantly lower significance
  - significance grows with π_{HV} mass and with a given mass is highest for 100 ps lifetimes
- the last step (if we get a green light) is to calculate upper limits and write an analysis note