

BDT test for HL VBF $H \rightarrow \gamma\gamma$

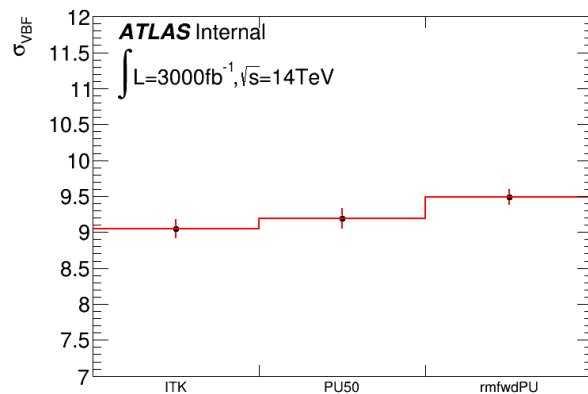
FANGYI GUO, IHEP

Previous review

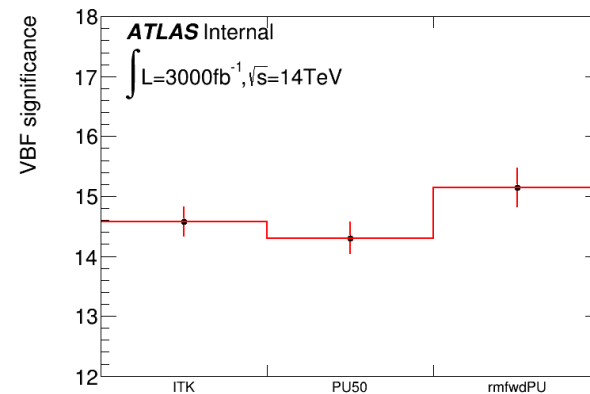
Study the physical performance in different forward PU environment in VBF $H \rightarrow \gamma\gamma$ channel.

- ITK: default setting, using expected ITK performance(resolution, eff, etc.)
- PU50: manually remove half of forward($2.5 < |\eta| < 3.8$) PU jets.
- rmfwdPU: ideal condition, remove all forward PU jets.

Performance: VBF significance



Cut-based analysis result



BDT-based analysis result

BDT test

Training sample:

- Signal: 14TeV VBF Higgs $H \rightarrow \gamma\gamma$
- Background: 13TeV $\gamma\gamma + jets$ final state. Scaled the cross section to 14TeV.

| | VBF(PU50) | ggH(PU50) | Bkg(ITK) | Bkg(PU50) | Bkg(rfp) |
|---------------------|-----------|-----------|----------|-----------|----------|
| $N_{initial}$ | 0.7M | 1M | 86325000 | 67901500 | 56804000 |
| $N_{after\ precut}$ | 49030 | 10453 | 349480 | 263520 | 209418 |

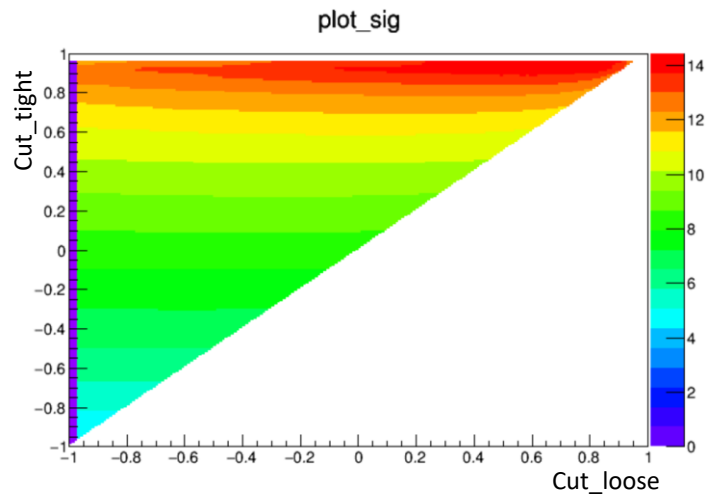
Test the performance with different training sample

| | case1 | case2 | case3 | case4 | case5 |
|----------|-------|-------|-------|--------------|--------------|
| Training | 14% | 21% | 28% | 14% (random) | 28% (random) |
| Test | 6% | 9% | 12% | 6% (random) | 12% (random) |
| Used | 80% | 70% | 60% | 80% (random) | 60% (random) |

BDT test

BDT categorization:

- 3 categories: tight, loose, rest.
- Scan the cut_1 and cut_2 in 2D to simultaneously determine 3 categories.



ITK scenario, VBF significance vs. BDT cut criteria in tight and loose category.

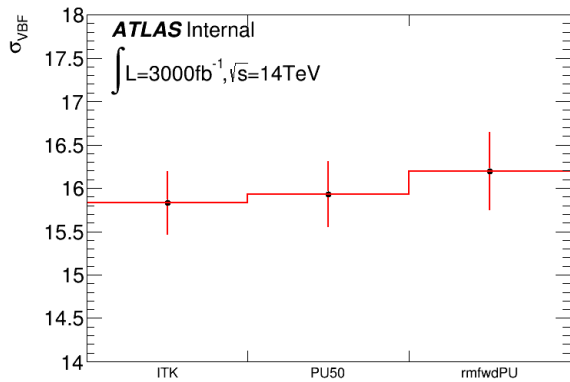
So here define 3 category:

Tight: $BDT > 0.92$

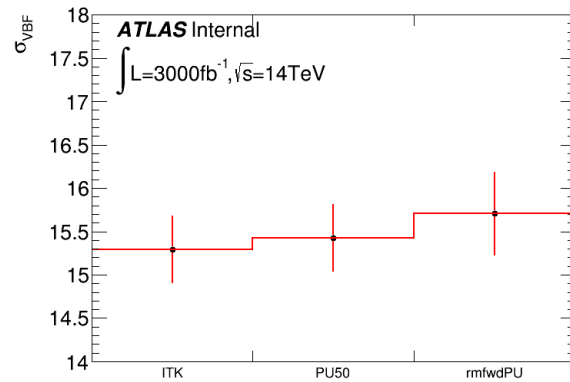
Loose: $0.92 < BDT < 0.67$

Rest: $BDT < 0.67$

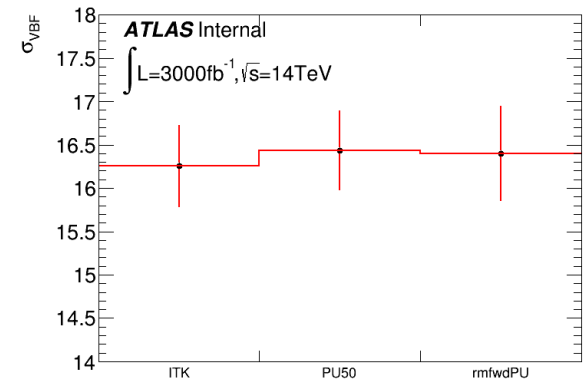
BDT test



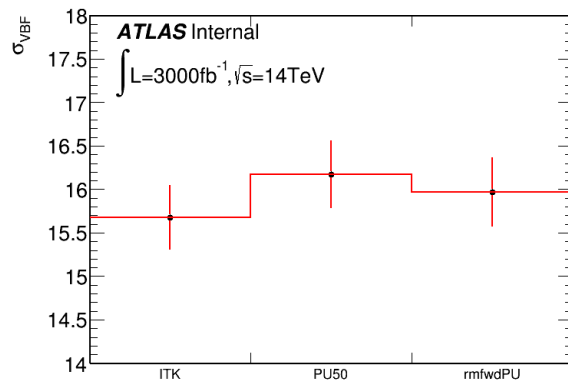
case1



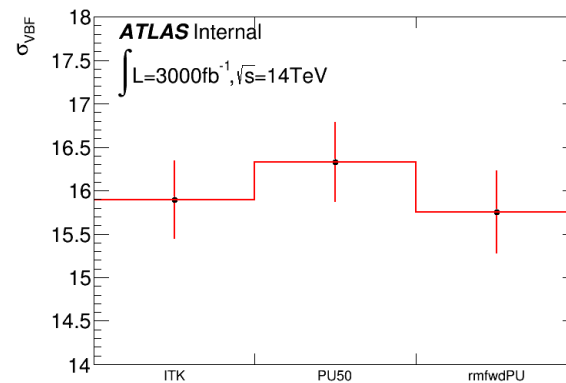
case2



case3



case4



case5

Conclusion

BDT training result is not very stable

- The VBF significance in each scenario is not the same in different training sample. Also the trend is not always the same.
- This influence might be considered as a kind of systematic uncertainty. So it's not always workable to increase statistics.

Backup: exact number in each case.

Case1

| | ITK | | | | PU50 | | | | rfp | | | |
|-----------------------|--------------|---------|---------|---------|---------------|----------|----------|----------|---------------|----------|----------|----------|
| | tight | loose | rest | total | tight | loose | rest | total | tight | loose | rest | total |
| Nvbf | 320.798 | 617.207 | 997.27 | 1935.28 | 325.293 | 497.179 | 1097.49 | 1919.962 | 331.869 | 667.067 | 906.541 | 1905.477 |
| δN_{VBF} | 5.17 | 7.17 | 9.11 | 12.69 | 5.20 | 6.43 | 9.56 | 12.64 | 5.26 | 7.45 | 8.69 | 12.59 |
| Nggh | 122.115 | 545.796 | 3166.06 | 3833.97 | 117.275 | 400.598 | 3140.37 | 3658.243 | 115.042 | 585.632 | 2789.29 | 3489.964 |
| δN_{ggh} | 6.74 | 14.25 | 34.33 | 37.78 | 6.61 | 12.21 | 34.19 | 36.90 | 6.54 | 14.77 | 32.23 | 36.05 |
| Nbkg | 363.68 | 4828.7 | 166208 | 171400 | 384.65 | 2960.64 | 157026 | 160371.3 | 376.197 | 5471.12 | 149866 | 155713.3 |
| δN_{bkg} | 33.34 | 121.48 | 712.71 | 723.76 | 34.29 | 95.12 | 692.74 | 700.08 | 41.80 | 159.41 | 834.29 | 850.41 |
| $S/(B_1 + B_2)$ | 0.6603 | 0.1148 | 0.00589 | | 0.648091 | 0.147915 | 0.006852 | | 0.675575 | 0.110136 | 0.005938 | |
| δsob | 0.047 | 0.0029 | 0.00006 | | 0.046 | 0.0046 | 0.00007 | | 0.059 | 0.0032 | 0.00006 | |
| σ | 13.2794 | 8.26515 | 2.42083 | | 13.2665 | 8.37621 | 2.73917 | | 13.637 | 8.42083 | 2.31794 | |
| $\delta \sigma_{VBF}$ | 0.44 | 0.131 | 0.023 | | 0.44 | 0.1557 | 0.024 | | 0.533 | 0.142 | 0.023 | |
| Combined σ | 15.828+-0.37 | | | | 15.927+-0.376 | | | | 16.194+-0.455 | | | |
| Combined sob | 0.67+-0.046 | | | | 0.665+-0.045 | | | | 0.684+-0.058 | | | |

Case2

| | ITK | | | | PU50 | | | | rfp | | | |
|-----------------------|---------------|----------|---------|---------|---------------|----------|----------|----------|---------------|----------|----------|----------|
| | tight | loose | rest | total | tight | loose | rest | total | tight | loose | rest | total |
| Nvbf | 302.069 | 600.726 | 1032.48 | 1935.28 | 312.474 | 465.382 | 1142.1 | 1919.956 | 322.879 | 688.792 | 893.806 | 1905.477 |
| δN_{VBF} | 5.01 | 7.07 | 9.27 | 12.69 | 5.10 | 6.22 | 9.75 | 12.64 | 5.18 | 7.57 | 8.63 | 12.59 |
| Nggh | 110.574 | 520.107 | 3203.29 | 3833.97 | 112.435 | 344.752 | 3201.06 | 3658.247 | 112.808 | 608.715 | 2768.44 | 3489.963 |
| δN_{ggH} | 6.42 | 13.92 | 34.53 | 37.78 | 6.47 | 11.33 | 34.52 | 36.90 | 6.48 | 15.05 | 32.10 | 36.05 |
| Nbkg | 352.766 | 4907.28 | 190626 | 195886 | 381.874 | 2824.09 | 180076 | 183282 | 376.861 | 6491.56 | 171089 | 177957.4 |
| δN_{bkg} | 35.10 | 130.92 | 815.97 | 827.15 | 36.52 | 99.32 | 793.07 | 800.10 | 44.73 | 185.63 | 952.96 | 971.90 |
| $S/(B_1 + B_2)$ | 0.651938 | 0.110684 | 0.00532 | | 0.632143 | 0.146862 | 0.006232 | | 0.659382 | 0.097009 | 0.005141 | |
| δsob | 0.051 | 0.003 | 0.00006 | | 0.048 | 0.005 | 0.00006 | | 0.062 | 0.0028 | 0.00006 | |
| σ | 12.8162 | 8.01031 | 2.34308 | | 12.8658 | 8.07631 | 2.66503 | | 13.3141 | 8.0472 | 2.14178 | |
| $\delta \sigma_{VBF}$ | 0.461 | 0.132 | 0.022 | | 0.454 | 0.161 | 0.023 | | 0.555 | 0.134 | 0.021 | |
| Combined σ | 15.294+-0.392 | | | | 15.422+-0.388 | | | | 15.704+-0.475 | | | |
| Combined sob | 0.661+-0.050 | | | | 0.649+-0.047 | | | | 0.666+-0.061 | | | |

Case3

| | ITK | | | | PU50 | | | | rfp | | | |
|-----------------------|---------------|----------|---------|---------|---------------|----------|----------|----------|---------------|----------|----------|----------|
| | tight | loose | rest | total | tight | loose | rest | total | tight | loose | rest | total |
| Nvbf | 291.831 | 609.383 | 1034.06 | 1935.28 | 306.98 | 482.196 | 1130.78 | 1919.956 | 309.145 | 517.322 | 1079.01 | 1905.477 |
| δN_{VBF} | 4.93 | 7.12 | 9.28 | 12.69 | 5.05 | 6.34 | 9.70 | 12.64 | 5.07 | 6.56 | 9.48 | 12.59 |
| Nggh | 99.0325 | 522.341 | 3212.6 | 3833.97 | 107.968 | 368.58 | 3181.7 | 3658.248 | 103.128 | 386.823 | 3000.02 | 3489.971 |
| δN_{ggh} | 6.07 | 13.95 | 34.58 | 37.78 | 6.34 | 11.71 | 34.42 | 36.90 | 6.20 | 12.00 | 33.42 | 36.05 |
| Nbkg | 273.015 | 4388.61 | 166890 | 171400 | 300.467 | 2616.14 | 157491 | 160407.6 | 309.627 | 3133.43 | 152783 | 156226.1 |
| δN_{bkg} | 33.35 | 133.73 | 824.65 | 723.76 | 34.99 | 103.25 | 801.10 | 808.48 | 43.79 | 139.30 | 972.68 | 983.58 |
| $S/(B_1 + B_2)$ | 0.784392 | 0.124087 | 0.00608 | | 0.751601 | 0.161555 | 0.007038 | | 0.748979 | 0.146956 | 0.006926 | |
| δsob | 0.073 | 0.0037 | 0.00006 | | 0.066 | 0.006 | 0.00007 | | 0.0812 | 0.0061 | 0.00007 | |
| σ | 13.6093 | 8.52462 | 2.50468 | | 13.7136 | 8.60321 | 2.81773 | | 13.7419 | 8.5177 | 2.73065 | |
| $\delta \sigma_{VBF}$ | 0.552 | 0.149 | 0.023 | | 0.537 | 0.18 | 0.025 | | 0.645 | 0.193 | 0.0254 | |
| Combined σ | 16.253+-0.469 | | | | 16.432+-0.458 | | | | 16.397+-0.550 | | | |
| Combined sob | 0.794+-0.072 | | | | 0.769+-0.064 | | | | 0.763+-0.080 | | | |

Case4

| | ITK | | | | PU50 | | | | rfp | | | |
|-----------------------|---------------|----------|---------|---------|---------------|----------|----------|----------|---------------|----------|----------|----------|
| | tight | loose | rest | total | tight | loose | rest | total | tight | loose | rest | total |
| Nvbf | 326.208 | 605.637 | 1003.43 | 1935.28 | 336.363 | 549.119 | 1034.48 | 1919.962 | 412.526 | 594.317 | 898.634 | 1905.477 |
| δN_{VBF} | 5.21 | 7.10 | 9.14 | 12.69 | 5.29 | 6.76 | 9.28 | 12.64 | 5.86 | 7.03 | 8.65 | 12.59 |
| Nggh | 112.435 | 543.19 | 3178.35 | 3833.98 | 119.509 | 451.975 | 3086.76 | 3658.244 | 157.856 | 557.709 | 2774.4 | 3489.965 |
| δN_{ggH} | 6.47 | 14.22 | 34.40 | 37.78 | 6.67 | 12.97 | 33.90 | 36.90 | 7.67 | 14.41 | 32.14 | 36.05 |
| Nbkg | 400.354 | 4804.25 | 165579 | 170783 | 376.879 | 3951.4 | 154893 | 159221.3 | 599.129 | 5406.09 | 148835 | 154840.2 |
| δN_{bkg} | 34.98 | 121.17 | 711.36 | 722.45 | 33.94 | 109.89 | 688.02 | 697.57 | 52.75 | 158.46 | 831.41 | 848.02 |
| $S/(B_1 + B_2)$ | 0.636145 | 0.113257 | 0.00595 | | 0.677621 | 0.124704 | 0.006548 | | 0.544959 | 0.099654 | 0.005927 | |
| δsob | 0.045 | 0.0029 | 0.00006 | | 0.048 | 0.0035 | 0.00006 | | 0.039 | 0.0029 | 0.00006 | |
| σ | 13.1808 | 8.1327 | 2.44021 | | 13.7465 | 8.11148 | 2.59984 | | 13.8714 | 7.57306 | 2.30564 | |
| $\delta \sigma_{VBF}$ | 0.434 | 0.129 | 0.023 | | 0.45 | 0.138 | 0.024 | | 0.461 | 0.132 | 0.023 | |
| Combined σ | 15.679+-0.371 | | | | 16.172+-0.389 | | | | 15.971+-0.405 | | | |
| Combined sob | 0.646+-0.044 | | | | 0.689+-0.047 | | | | 0.554+-0.038 | | | |

Case5

| | ITK | | | | PU50 | | | | rfp | | | |
|-----------------------|---------------|---------|---------|---------|---------------|----------|----------|---------|---------------|----------|----------|----------|
| | tight | loose | rest | total | tight | loose | rest | total | tight | loose | rest | total |
| Nvbf | 292.664 | 560.855 | 1081.76 | 1935.28 | 308.146 | 547.121 | 1064.69 | 1919.96 | 350.264 | 446.653 | 1108.56 | 1905.477 |
| δN_{VBF} | 4.93 | 6.83 | 9.49 | 12.69 | 5.06 | 6.75 | 9.41 | 12.64 | 5.40 | 6.10 | 9.61 | 12.59 |
| Nggh | 100.522 | 444.157 | 3289.29 | 3833.97 | 108.712 | 432.988 | 3116.55 | 3658.25 | 123.232 | 338.051 | 3028.68 | 3489.963 |
| δN_{ggh} | 6.12 | 12.85 | 34.99 | 37.78 | 6.36 | 12.70 | 34.06 | 36.91 | 6.77 | 11.22 | 33.58 | 36.05 |
| Nbkg | 301.539 | 3785.54 | 170981 | 175068 | 300.467 | 3626.33 | 159983 | 163910 | 464.441 | 2631.83 | 158207 | 161303.3 |
| δN_{bkg} | 35.05 | 124.20 | 834.70 | 844.61 | 34.99 | 121.56 | 807.41 | 817.26 | 53.63 | 127.66 | 989.80 | 999.44 |
| $S/(B_1 + B_2)$ | 0.728 | 0.1325 | 0.00620 | | 0.753084 | 0.134782 | 0.006528 | | 0.596019 | 0.150394 | 0.006875 | |
| δsob | 0.066 | 0.0042 | 0.00006 | | 0.067 | 0.0044 | 0.00007 | | 0.056 | 0.0068 | 0.00007 | |
| σ | 13.213 | 8.443 | 2.589 | | 13.7509 | 8.4045 | 2.63346 | | 13.284 | 8.00244 | 2.7576 | |
| $\delta \sigma_{VBF}$ | 0.528 | 0.156 | 0.023 | | 0.537 | 0.158 | 0.024 | | 0.556 | 0.196 | 0.025 | |
| Combined σ | 15.892+-0.447 | | | | 16.330+-0.459 | | | | 15.751+-0.479 | | | |
| Combined sob | 0.740+-0.065 | | | | 0.765+-0.066 | | | | 0.615+-0.054 | | | |