

Status Report: neutron-tagging

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mPMT Japan meeting

Status of n-tag algorithm

- Missing characters of 3 inch PMTs on mPMT in variable relating to acceptances: cross section and dark-rate
 - Might cause worse efficiency for hybrid configuration
- Modified this variable (new update)

PMT Acceptance

Note) Now, I missed information about PMT's cross section, darkrate. These should be fixed future. For B&L only case, there are no problem

14

- Defined LLR for PMT acceptance

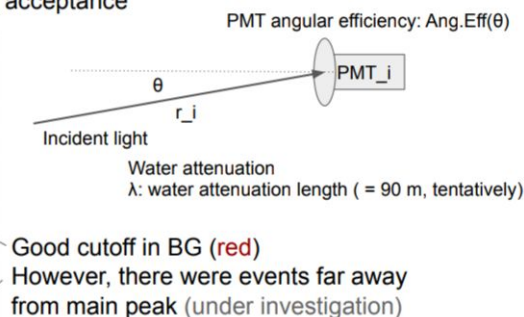
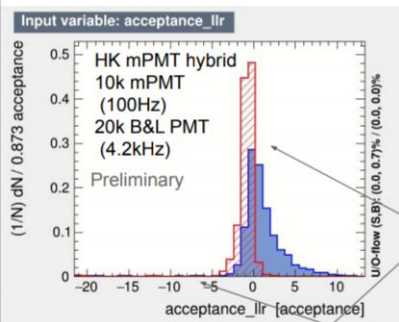
$$LLR := L_{acc., B\&L, signal} - L_{acc., B\&L, darkhit} + L_{acc., mPMT, signal} - L_{acc., mPMT, darkhit}$$

- Where

$$L_{acc., B\&L, (mPMT), signal} := \sum_i^{\text{all hit B\&L (mPMT)}} \log \left[\frac{\text{Ang.Eff.}(\theta_i) \exp(r_i/\lambda) / r_i^2}{\sum_j^{\text{all B\&L (mPMT)}} \text{Ang.Eff.}(\theta_j) \exp(r_j/\lambda) / r_j^2} \right]$$

$$L_{acc., B\&L, (mPMT), darkhit} := \sum_i^{\text{all hit B\&L (mPMT)}} \log \left[\frac{1}{\# \text{ of B\&L (3 inch PMT in mPMT)}} \right]$$

Darkhits are not related with acceptance



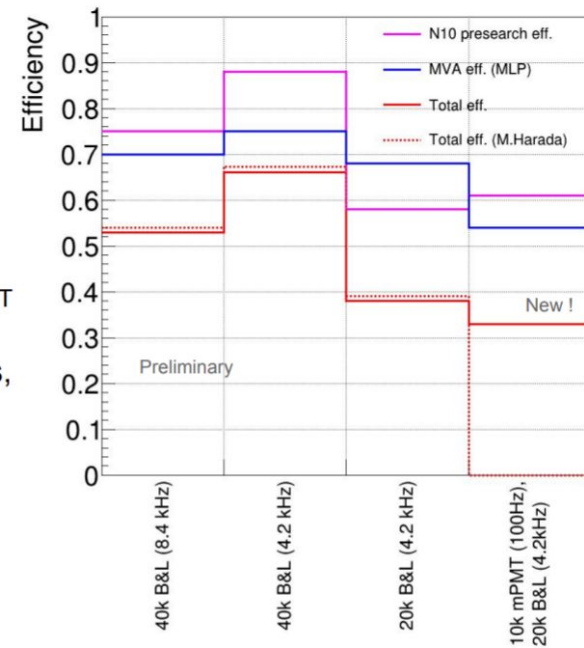
Comparison of different detector config.

18

- Tested with other configurations:

- 40k B&L PMTs
8.4 / 4.2 kHz darkrate
- 20k B&L PMTs
4.2 kHz darkrate
- 20k B&L PMTs of
4.2 kHz darkrate
+ 10k B&L mPMTs of
100 Hz darkrate/PMT

- Comparing to Harada-san's results, they look consistent within error (> 0.01)
- As for mPMT, it looks not good
 - Under investigation



Modification of PMT acceptance

- Old
(HK meeting)

$$LLR := L_{acc, B\&L, signal} - L_{acc, B\&L, darkhit} + L_{acc, mPMT, signal} - L_{acc, mPMT, darkhit}$$

◦ Where

$$L_{acc, B\&L (mPMT), signal} := \sum_i^{\text{all hit B\&L (mPMT)}} \log \left[\frac{\text{Ang.Eff.}(\theta_i) \exp(r_i/\lambda) / r_i^2}{\sum_j^{\text{all B\&L (mPMT)}} \text{Ang.Eff.}(\theta_j) \exp(r_j/\lambda) / r_j^2} \right]$$

$$L_{acc, B\&L (mPMT), darkhit} := \sum_i^{\text{all hit B\&L (mPMT)}} \log \left[\frac{1}{\# \text{ of B\&L (3 inch PMT in mPMT)}} \right]$$

- New
(this meeting)

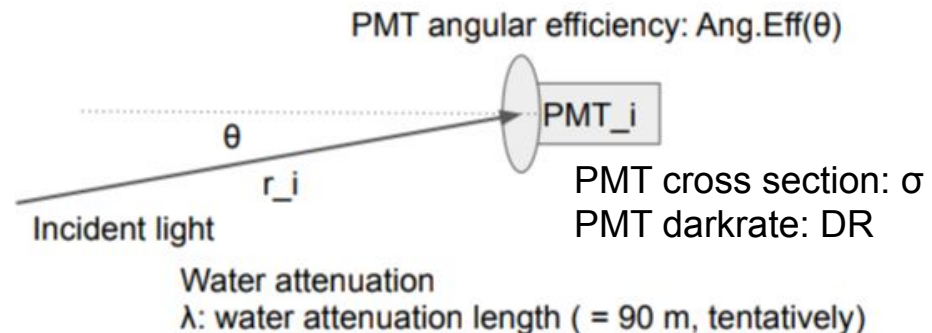
$$Prob(PMT|HIT == DR) := \frac{DR(PMT)}{(\# \text{ of B\&L}) \times DR(B\&L) + (\# \text{ of 3inchPMT}) \times DR(3inchPMT)}$$

$$Prob(PMT|HIT == signal) := \frac{\text{Ang.Eff.}(\theta) \exp(r/\lambda) \sigma(PMT) / r^2}{\sum_j^{\text{all PMTs}} \text{Ang.Eff.}(\theta_j) \exp(r_j/\lambda) \sigma(PMT_j) / r_j^2}$$

- In old definition,
PMT types were not
considered, and thus
 σ and darkrate
were canceled

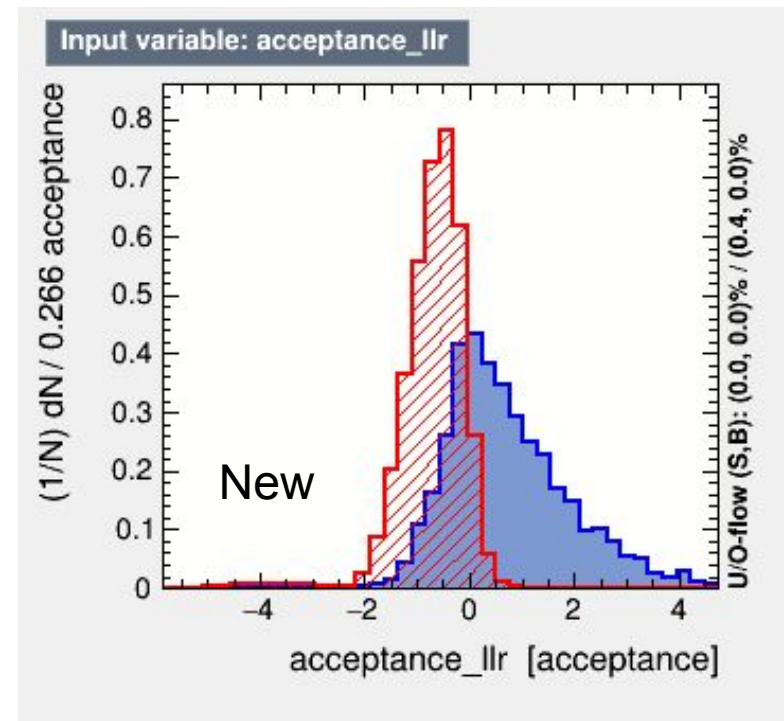
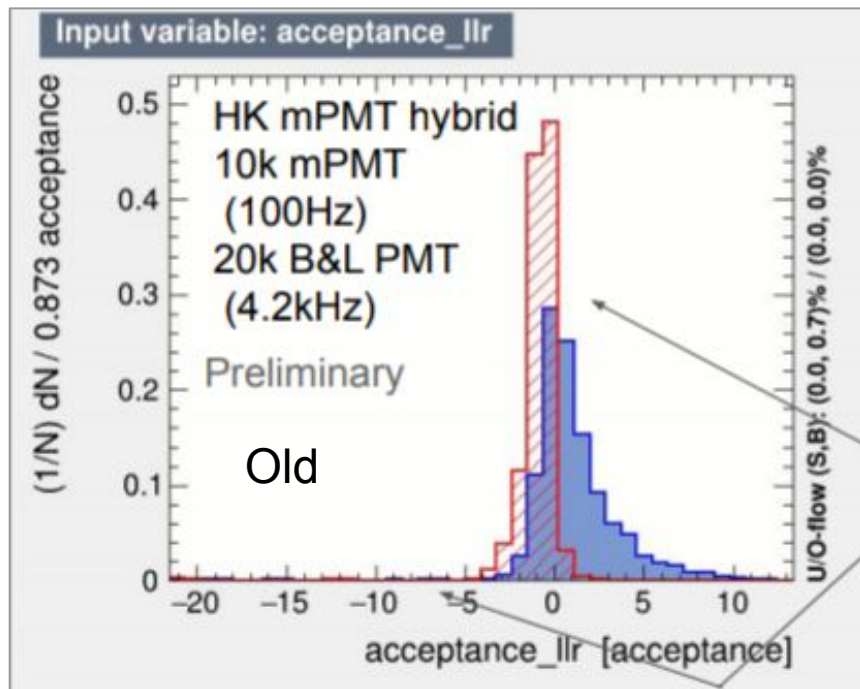
$$LL_{signal} := \sum_{PMT_i}^{\text{all hit PMTs}} \log[Prob(PMT_i|HIT==signal)]$$

$$LL_{dark-mimic} := \sum_{PMT_i}^{\text{all hit PMTs}} \log[Prob(PMT_i|HIT==DR)]$$



Distribution before/after modification

- Old (left): missed events in $[-20, -7]$
- New (right):
 - No missed events around $[-20, -7]$ ← recovered
 - However, there are small clusters around ~ -4 for both signal and background

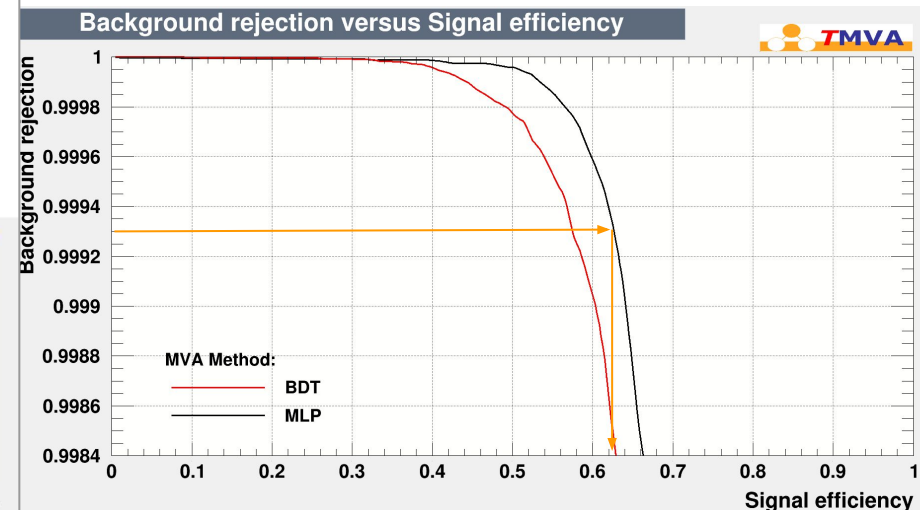
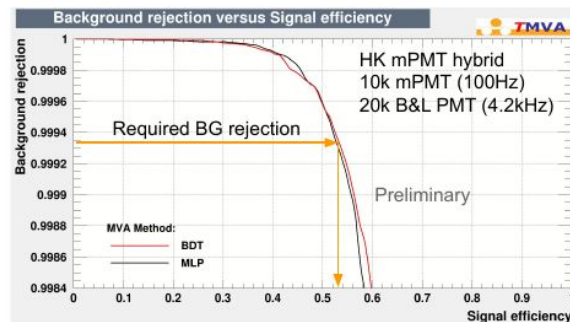


Ntag efficiency after modification

- Trained MVA with new calculation again
- → Tagging efficiency for hybrid case:
 - Left (before modification):
MVA efficiency $\sim 0.54 \rightarrow$ total efficiency ~ 0.33
 - Right (after modification):
MVA efficiency $\sim 0.63 \rightarrow$ total efficiency ~ 0.38 (+ 5 %)

- Defined allowed mis-identification = 0.1 evt. / primary evt.

HK mPMT hybrid N10 ≥ 6	# of signal / primary evt.	# of background / primary evt.
After N10 presearch	0.6052	148.6
Required MVA BG rejection	-	$1 - 6.7\text{E-}4 = 0.99933$
MVA Signal efficiency	0.54	-
Total ntag efficiency	~ 0.33	-



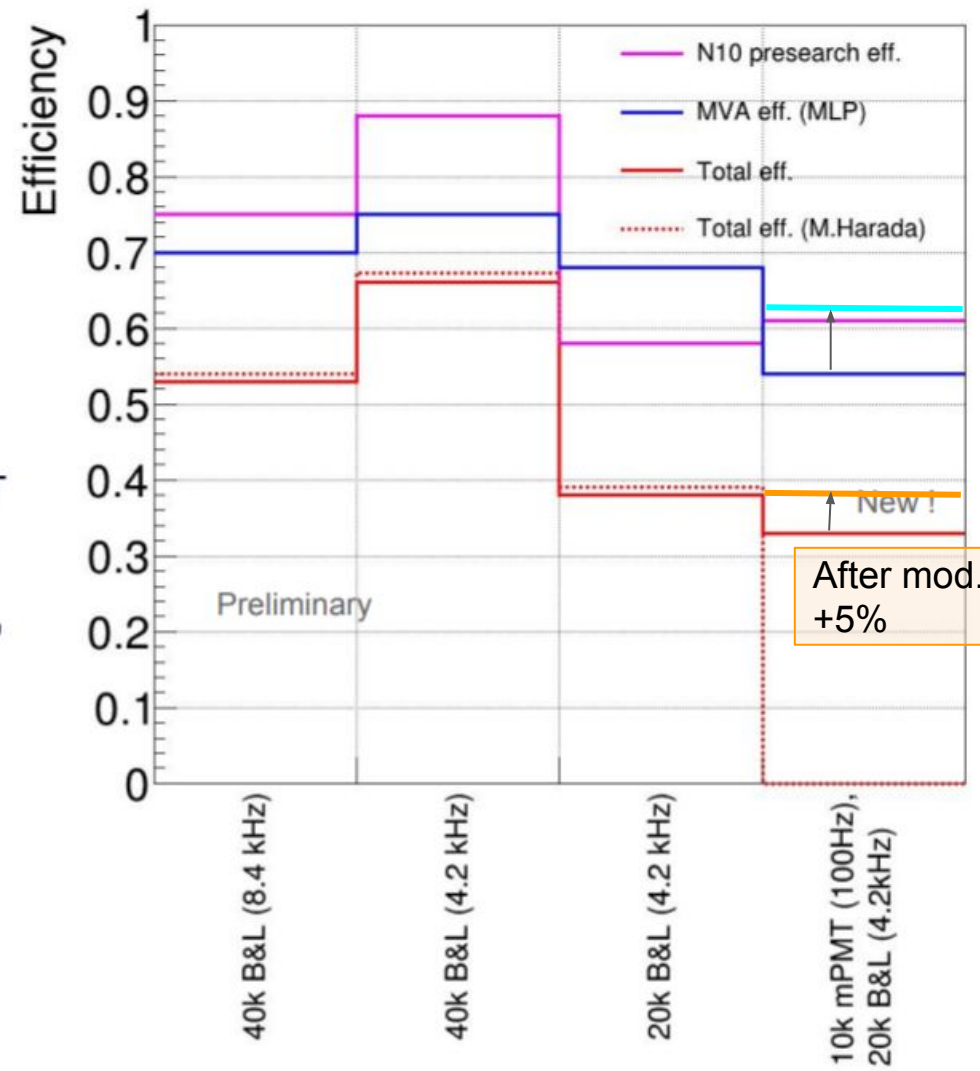
Comparison with different configuration

- Recovered to almost same level with "20k B&L configuration"

Comparison of different detector config.

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- Tested with other configurations:
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8.4 / 4.2 kHz darkrate
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4.2 kHz darkrate
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4.2 kHz darkrate
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100 Hz darkrate/PMT
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Summary

- Modified variable related to PMT's acceptance
- → Recovered n-tagging efficiency: 33 % → 38 %
 - Same level with 20k B&L configuration

Next plan:

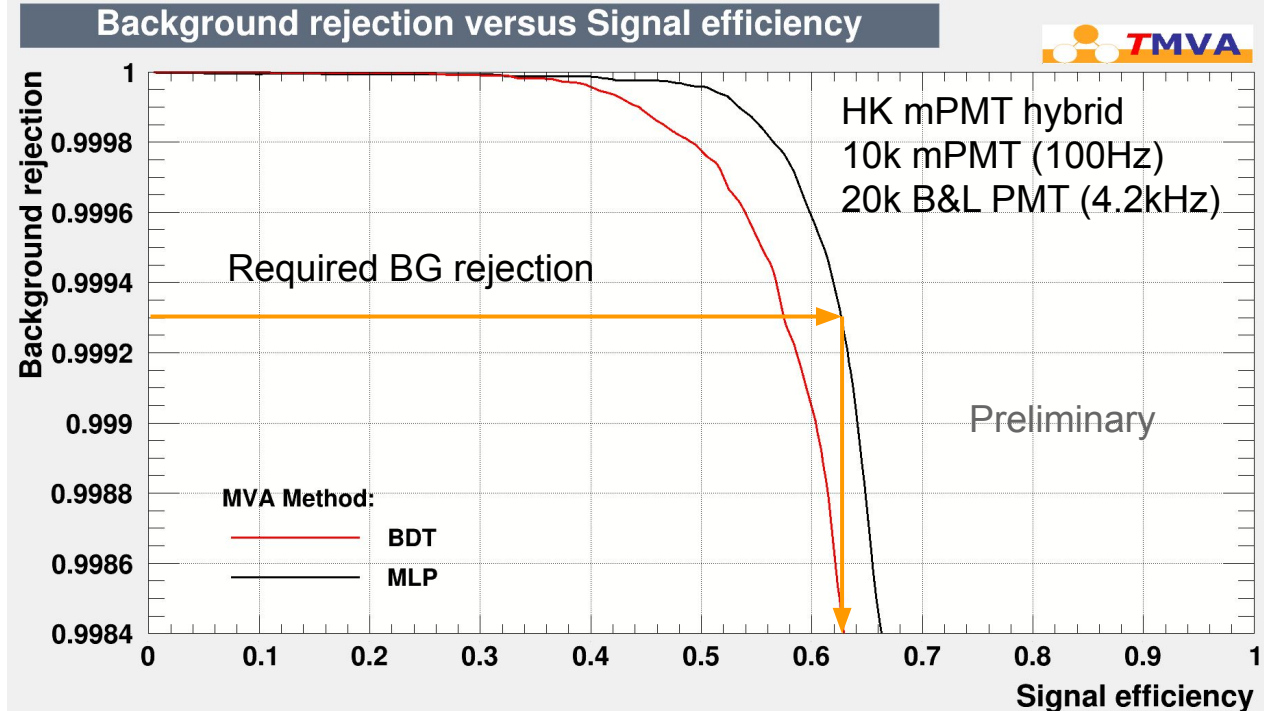
- Validate LEAF outputs
- Compare different darkrate

Backup

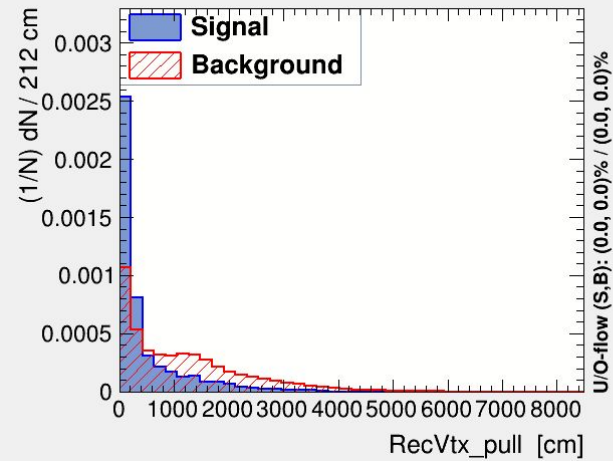
HK mPMT hybrid (new)

- Defined allowed mis-identification = 0.1 evt. / primary evt.

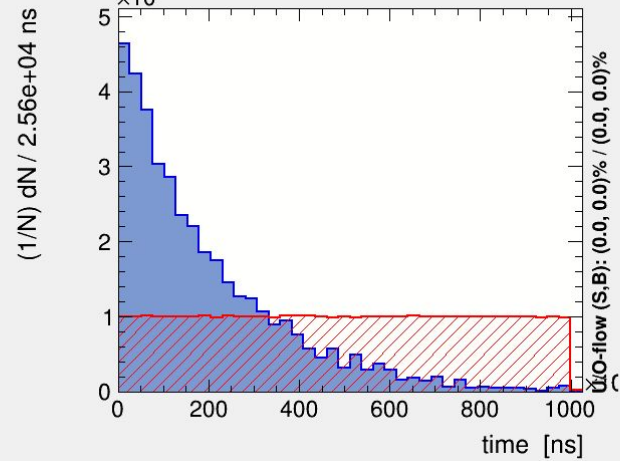
HK mPMT hybrid N10 ≥ 6	# of signal / primary evt.	# of background / primary evt.
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Required MVA BG rejection	-	$1 - 6.7\text{E-}4 = 0.99933$
MVA Signal efficiency	0.63	-
Total ntag efficiency	~ 0.38	-



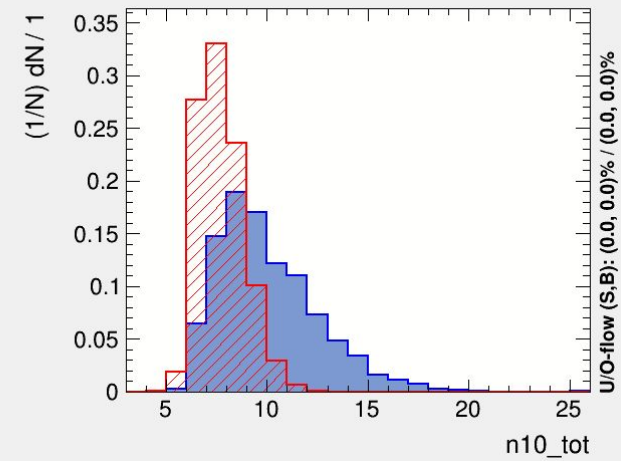
Input variable: RecVtx_pull



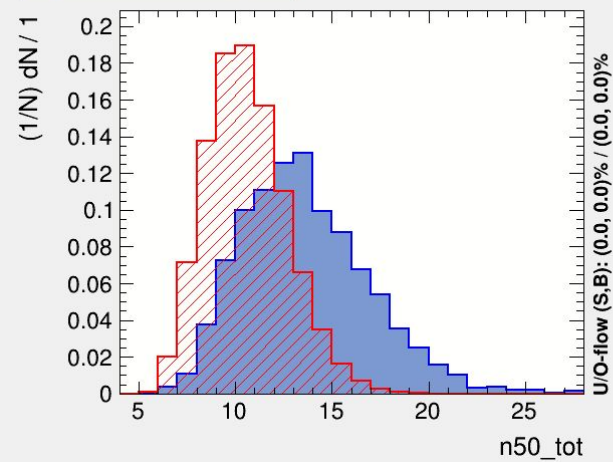
Input variable: time



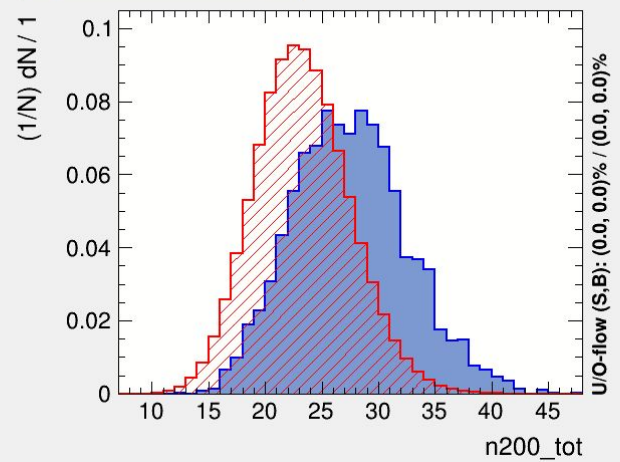
Input variable: n10_tot



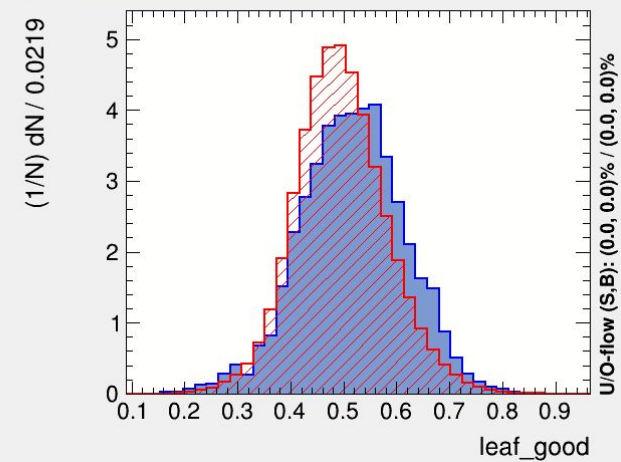
Input variable: n50_tot



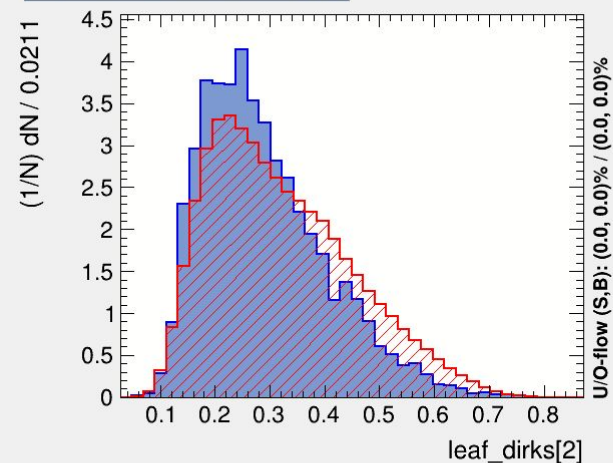
Input variable: n200_tot



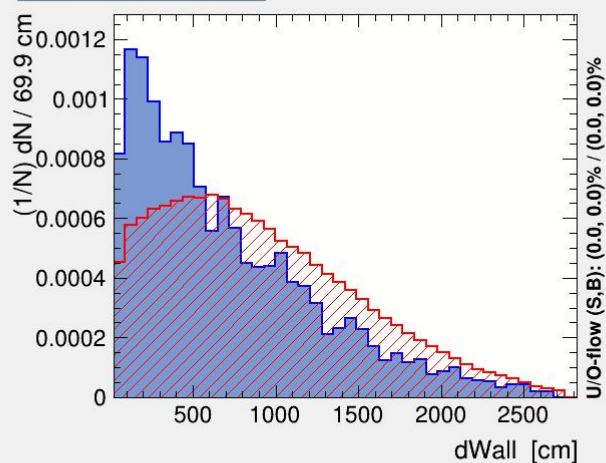
Input variable: leaf_good



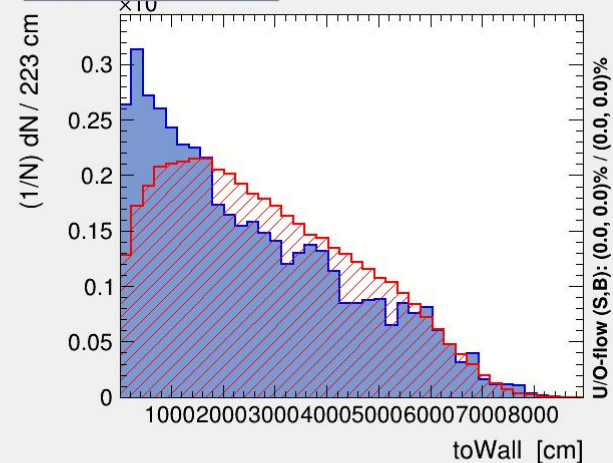
Input variable: leaf_dirks[2]



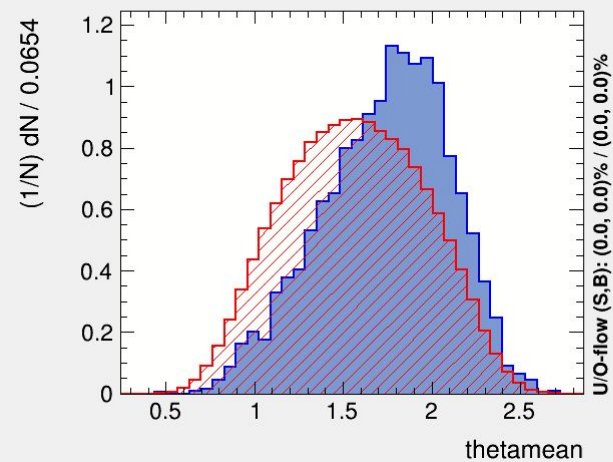
Input variable: dWall



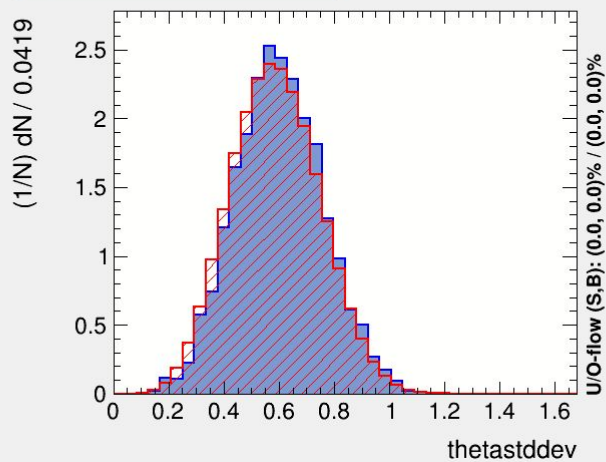
Input variable: toWall



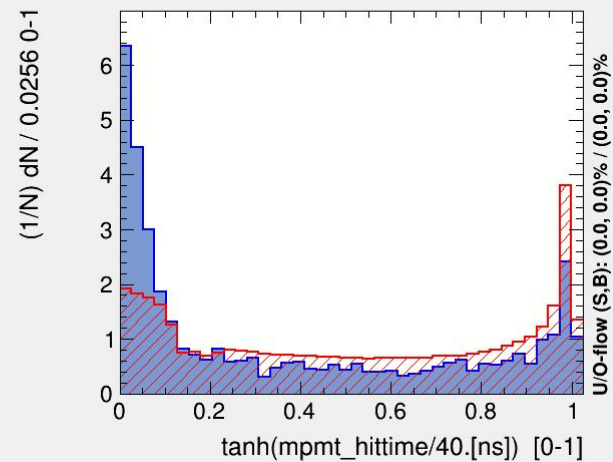
Input variable: thetamean



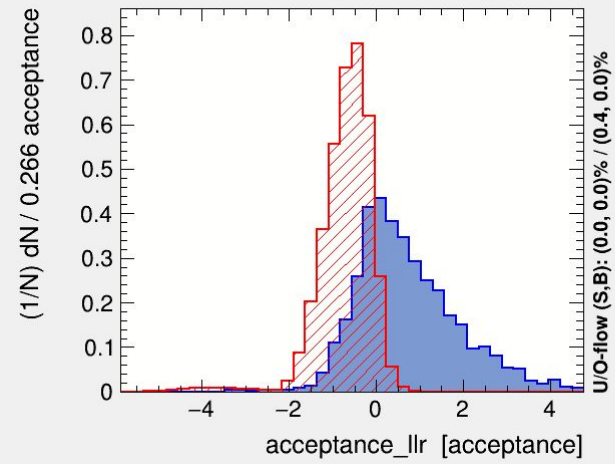
Input variable: thetastddev



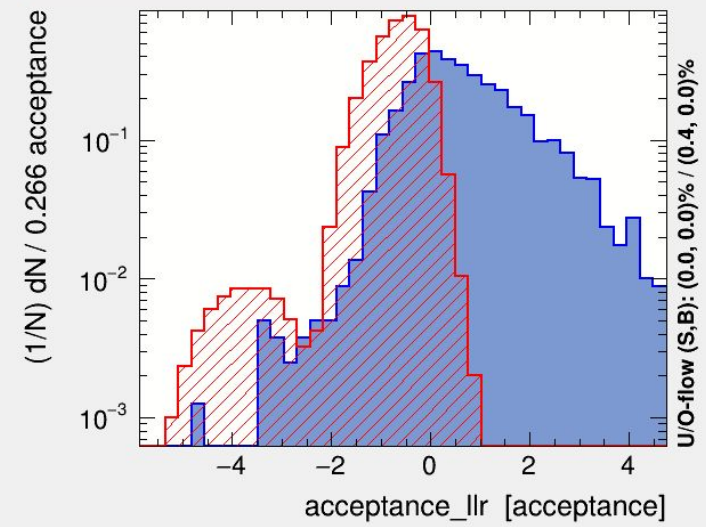
Input variable: tanh(mpmt_hitime/40.[ns])



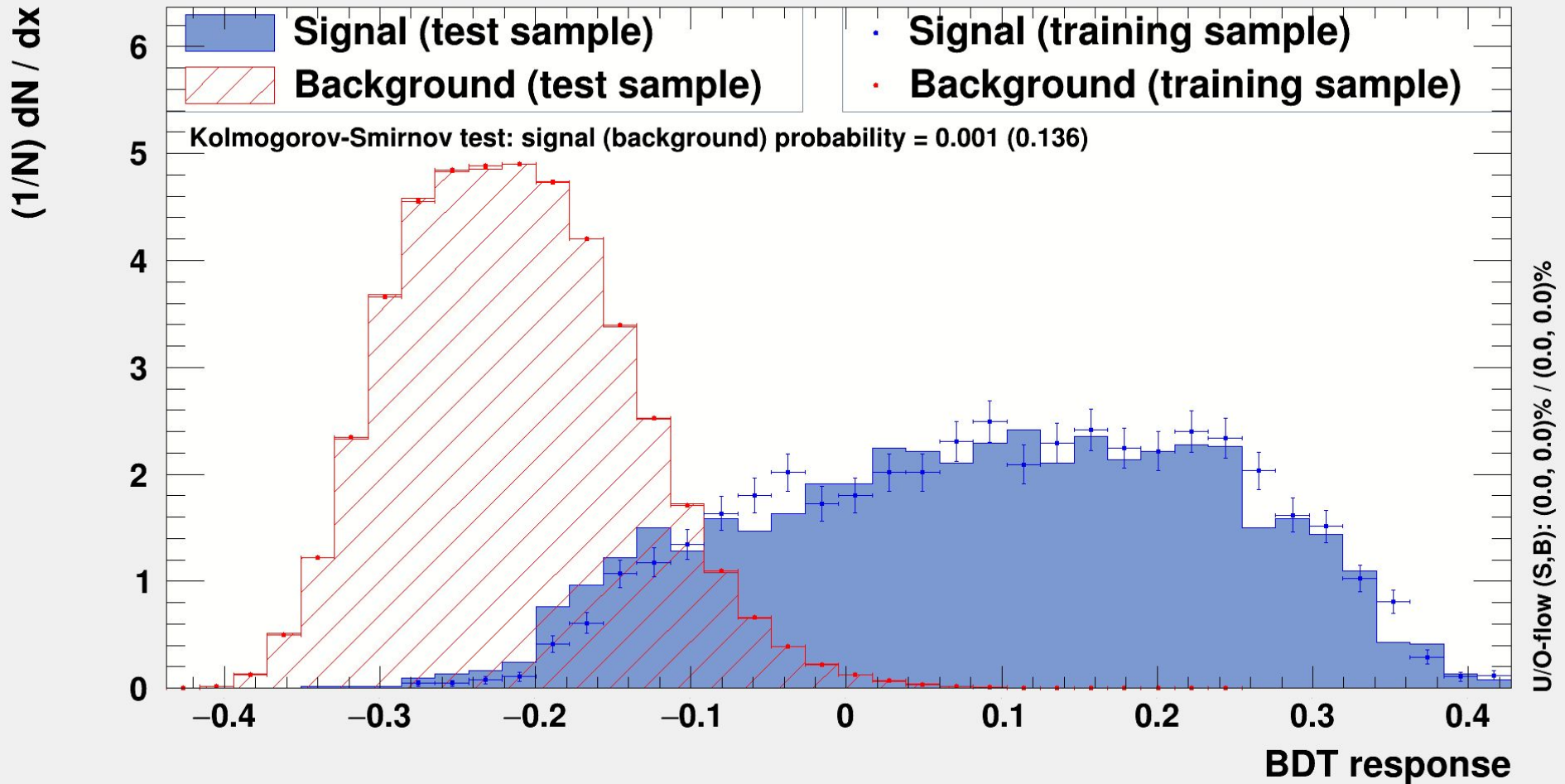
Input variable: acceptance_llr



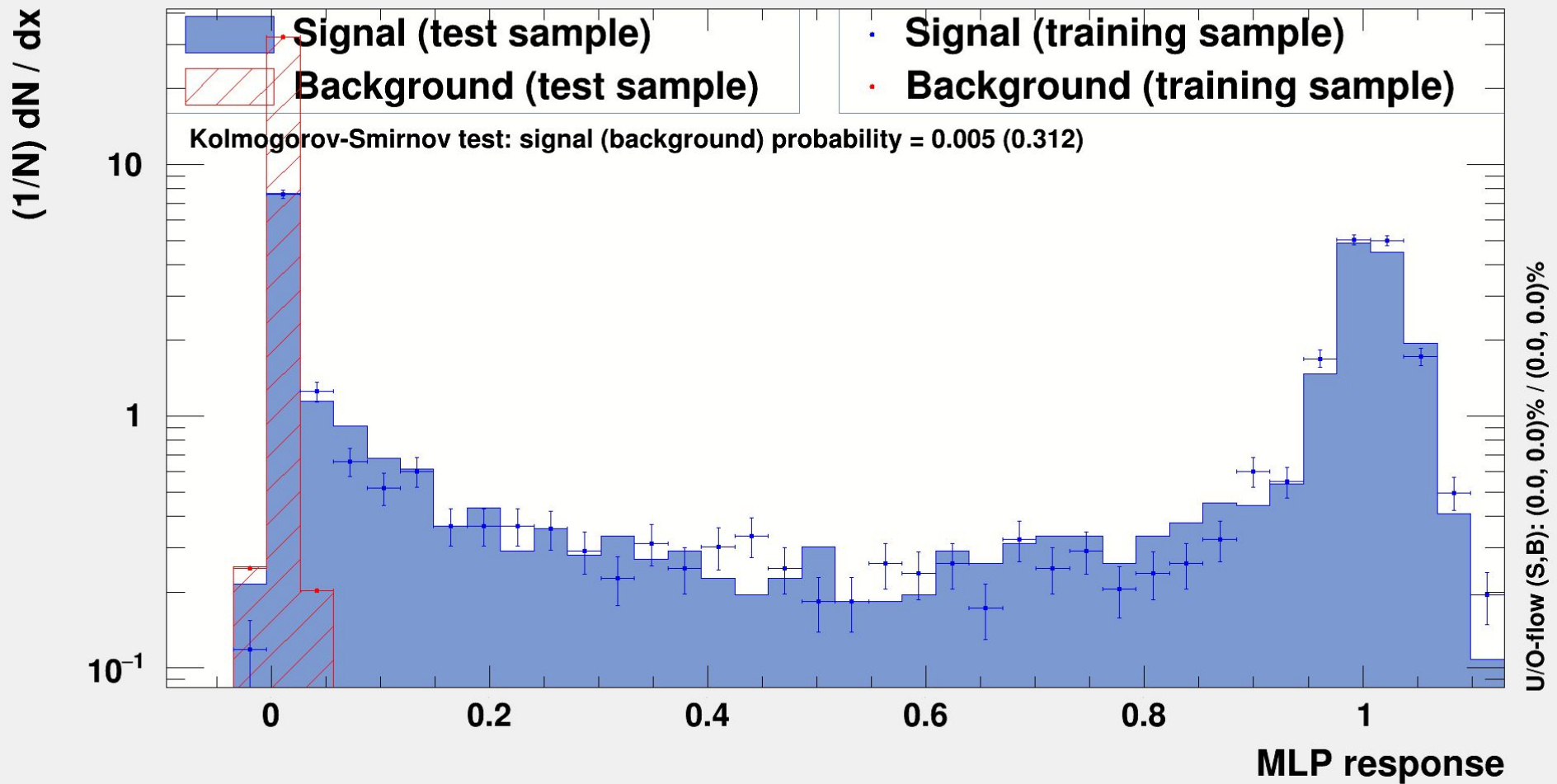
Input variable: acceptance_llr



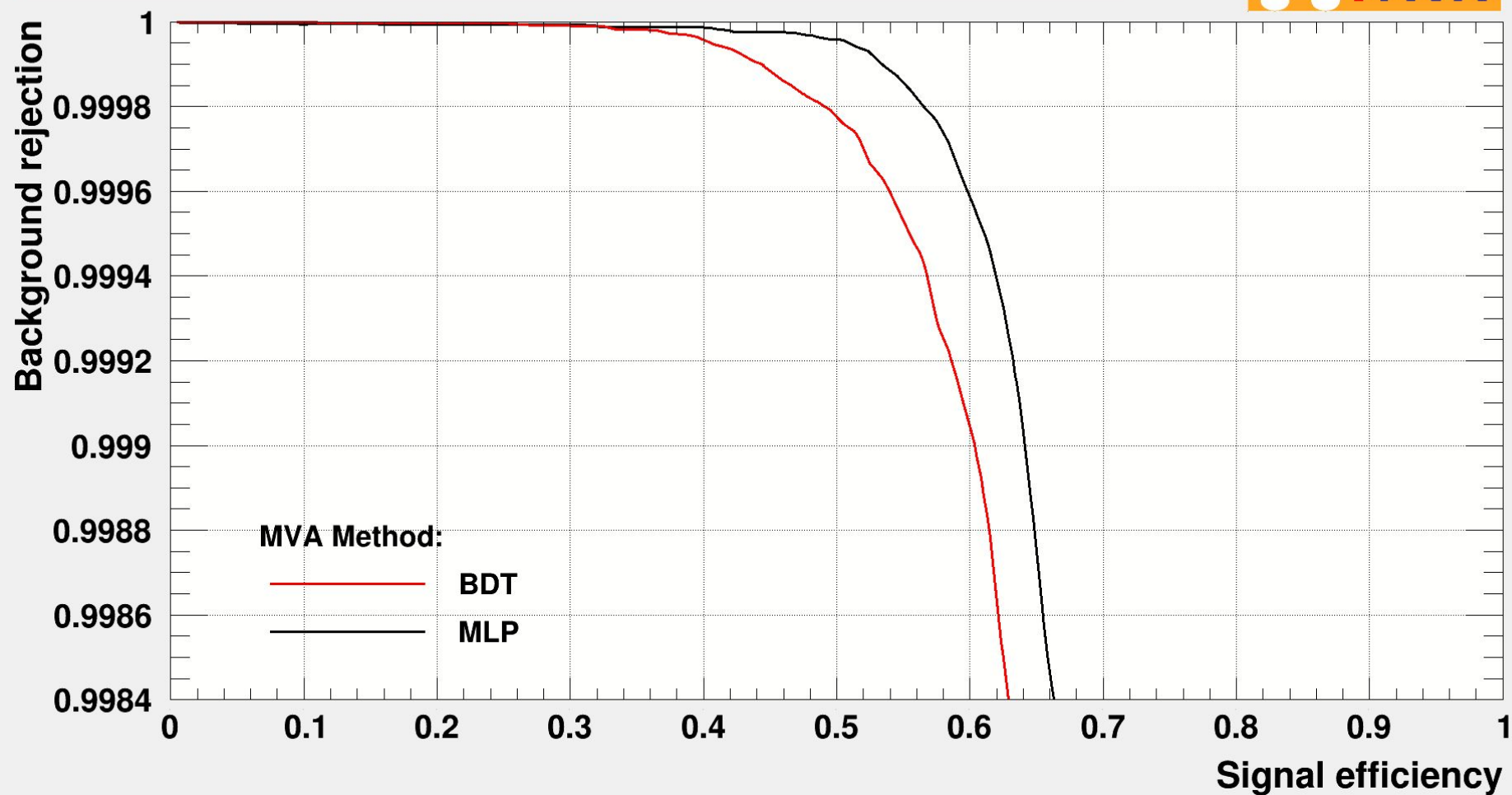
TMVA overtraining check for classifier: BDT



TMVA overtraining check for classifier: MLP



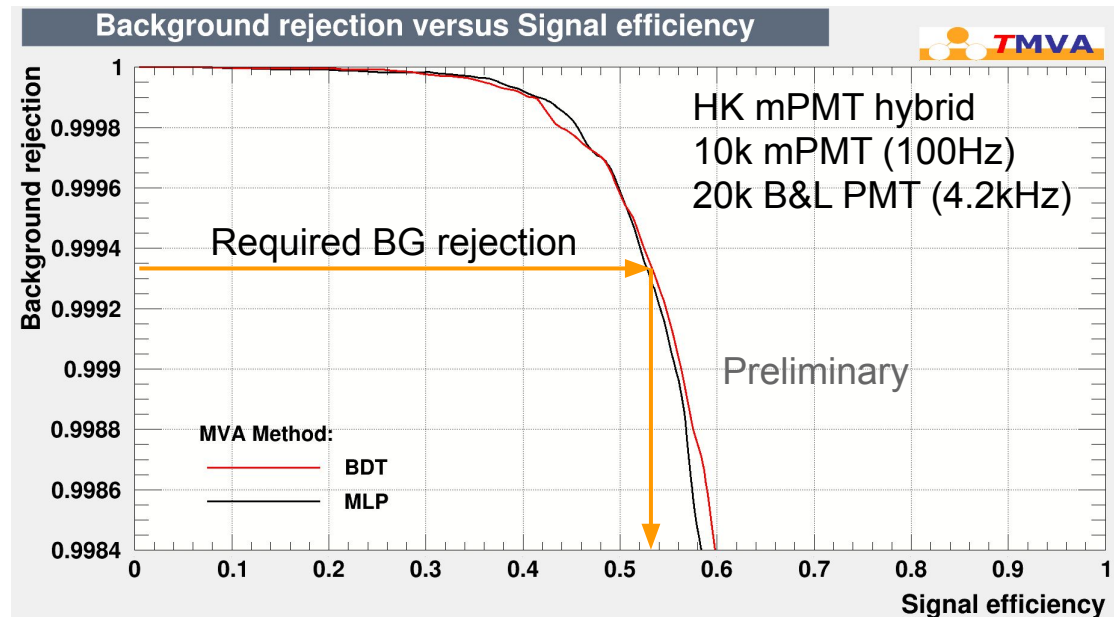
Background rejection versus Signal efficiency



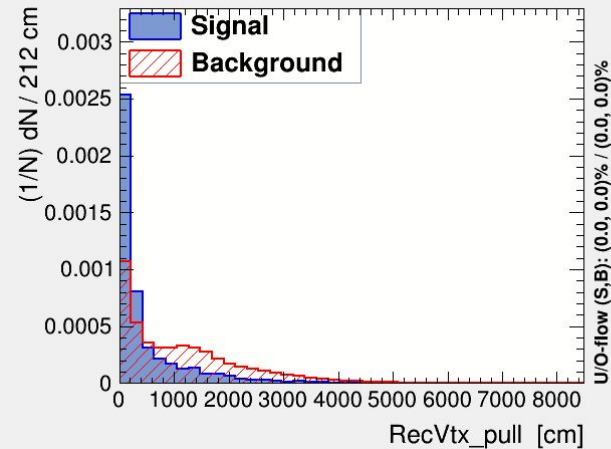
HK mPMT hybrid (old)

- Defined allowed mis-identification = 0.1 evt. / primary evt.

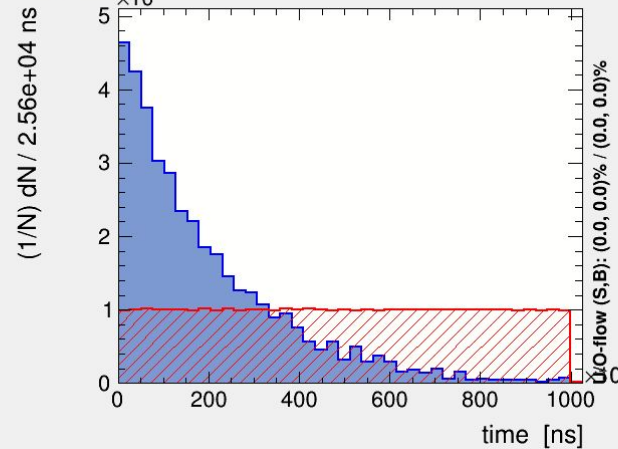
HK mPMT hybrid N10 ≥ 6	# of signal / primary evt.	# of background / primary evt.
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Required MVA BG rejection	-	$1 - 6.7\text{E-}4 = 0.99933$
MVA Signal efficiency	0.54	-
Total ntag efficiency	~ 0.33	-



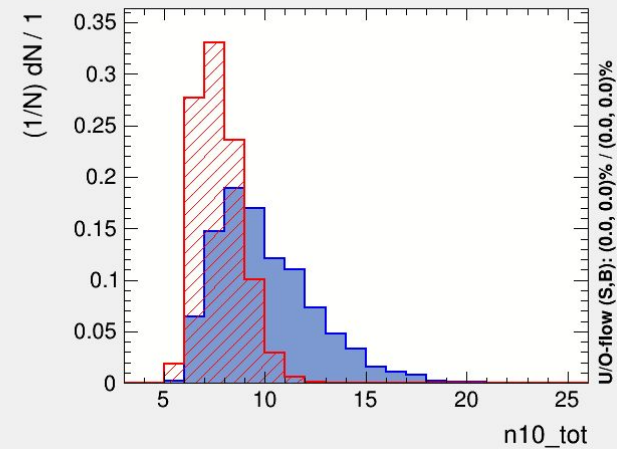
Input variable: RecVtx_pull



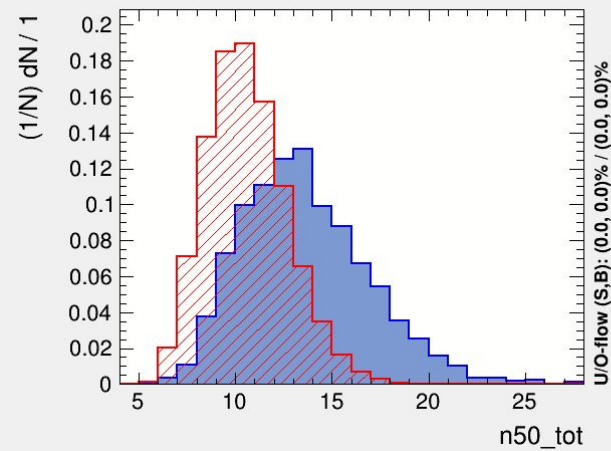
Input variable: time



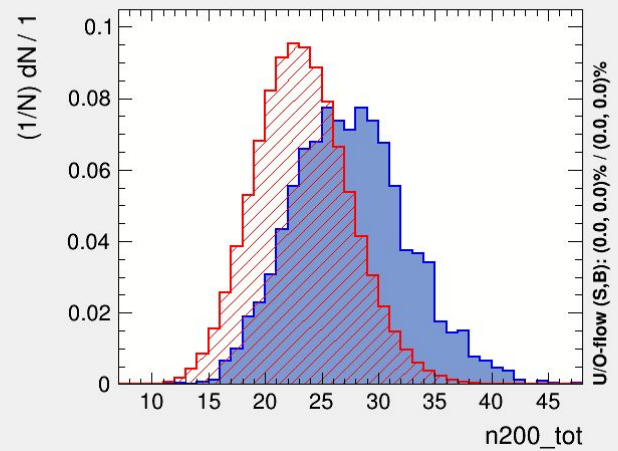
Input variable: n10_tot



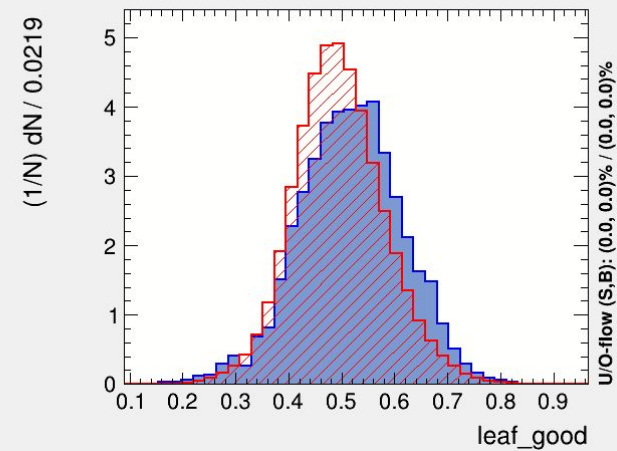
Input variable: n50_tot



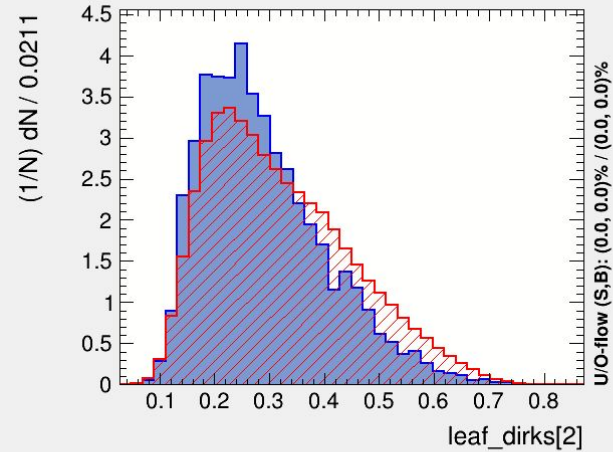
Input variable: n200_tot



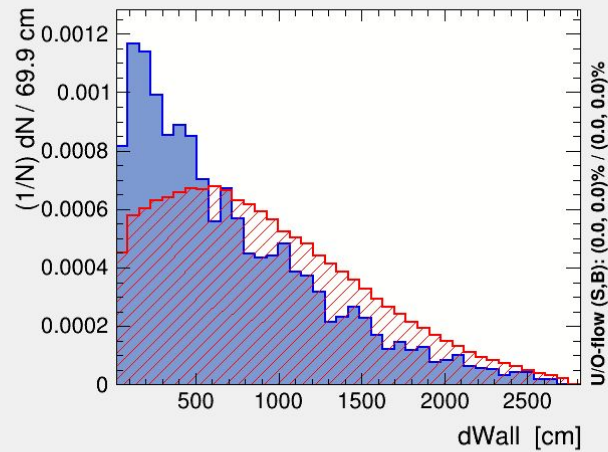
Input variable: leaf_good



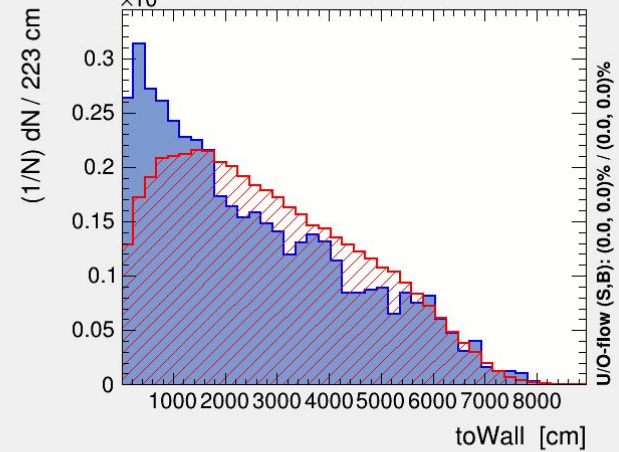
Input variable: leaf_dirs[2]



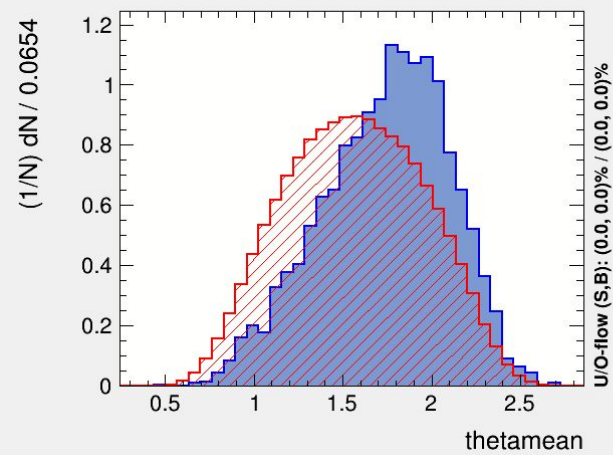
Input variable: dWall



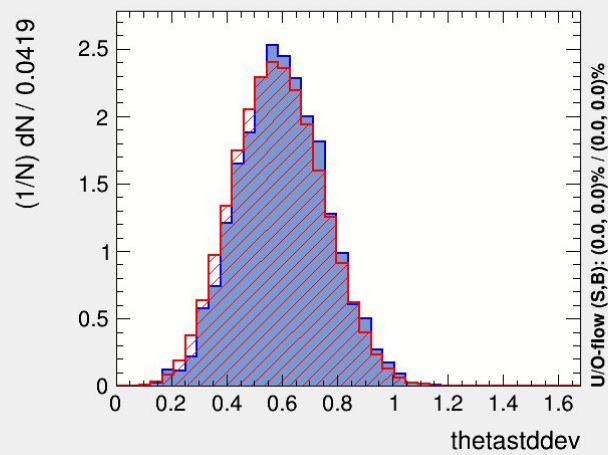
Input variable: toWall



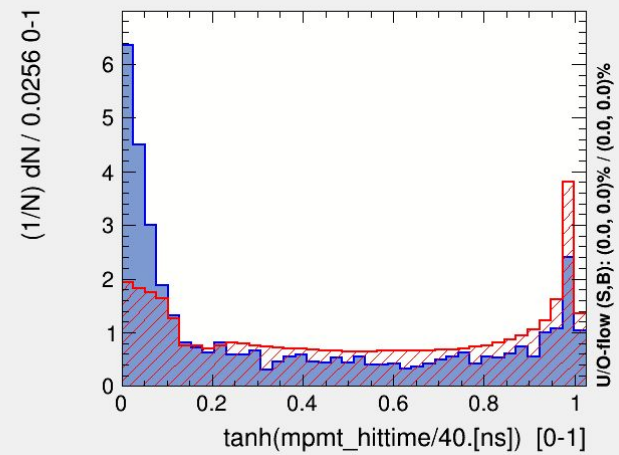
Input variable: thetamean



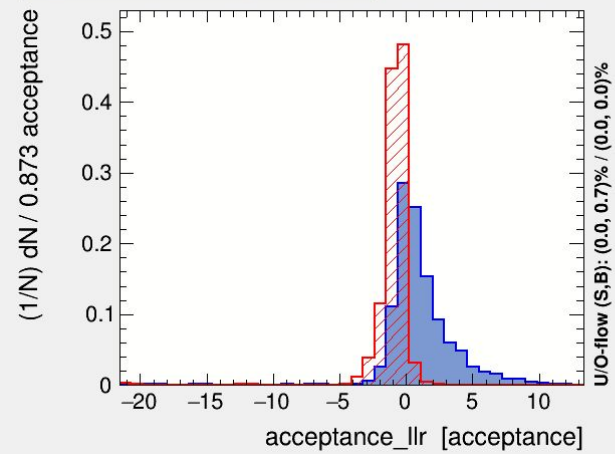
Input variable: thetastddev



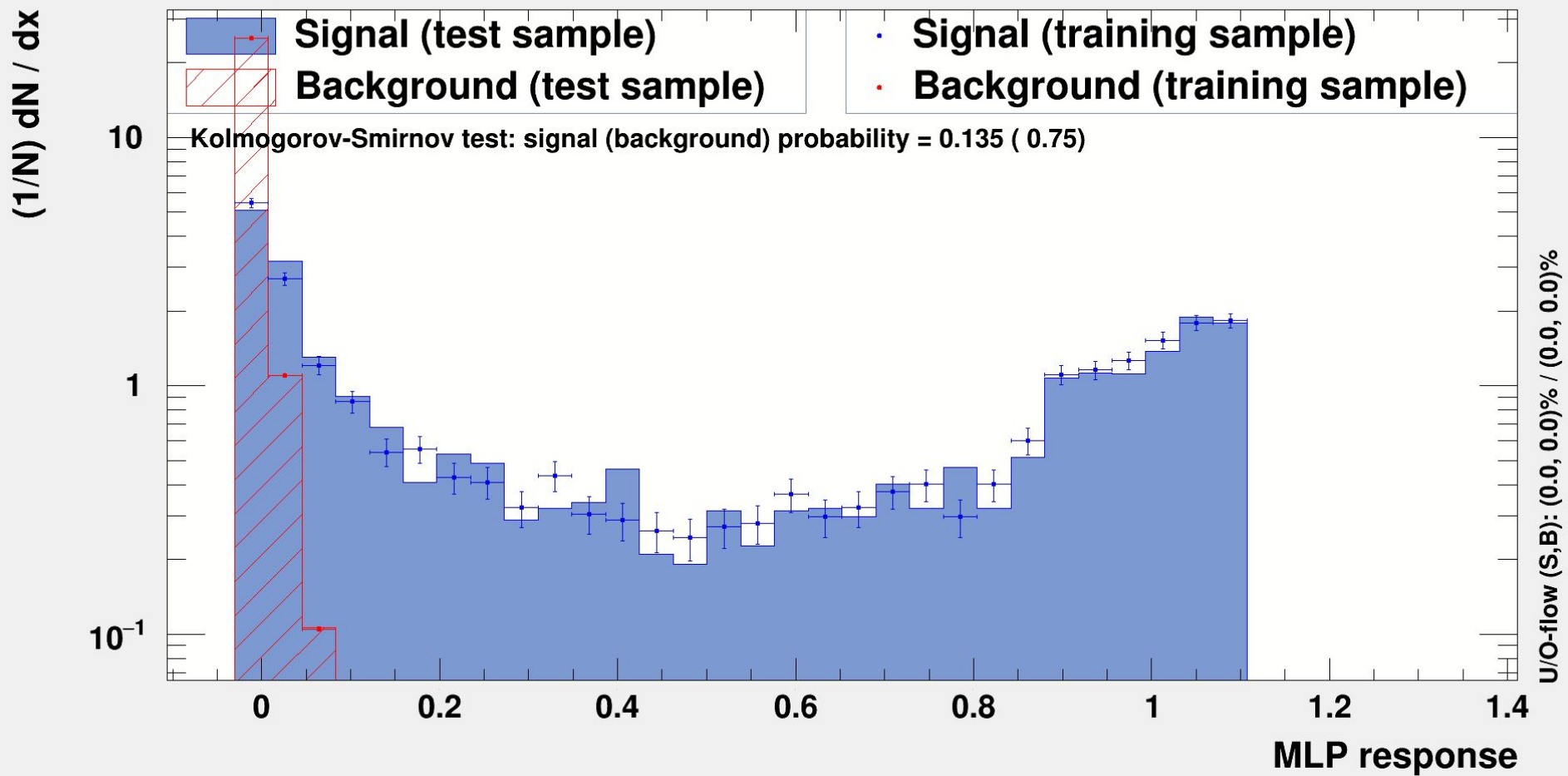
Input variable: tanh(mpmt_hitime/40.[ns])



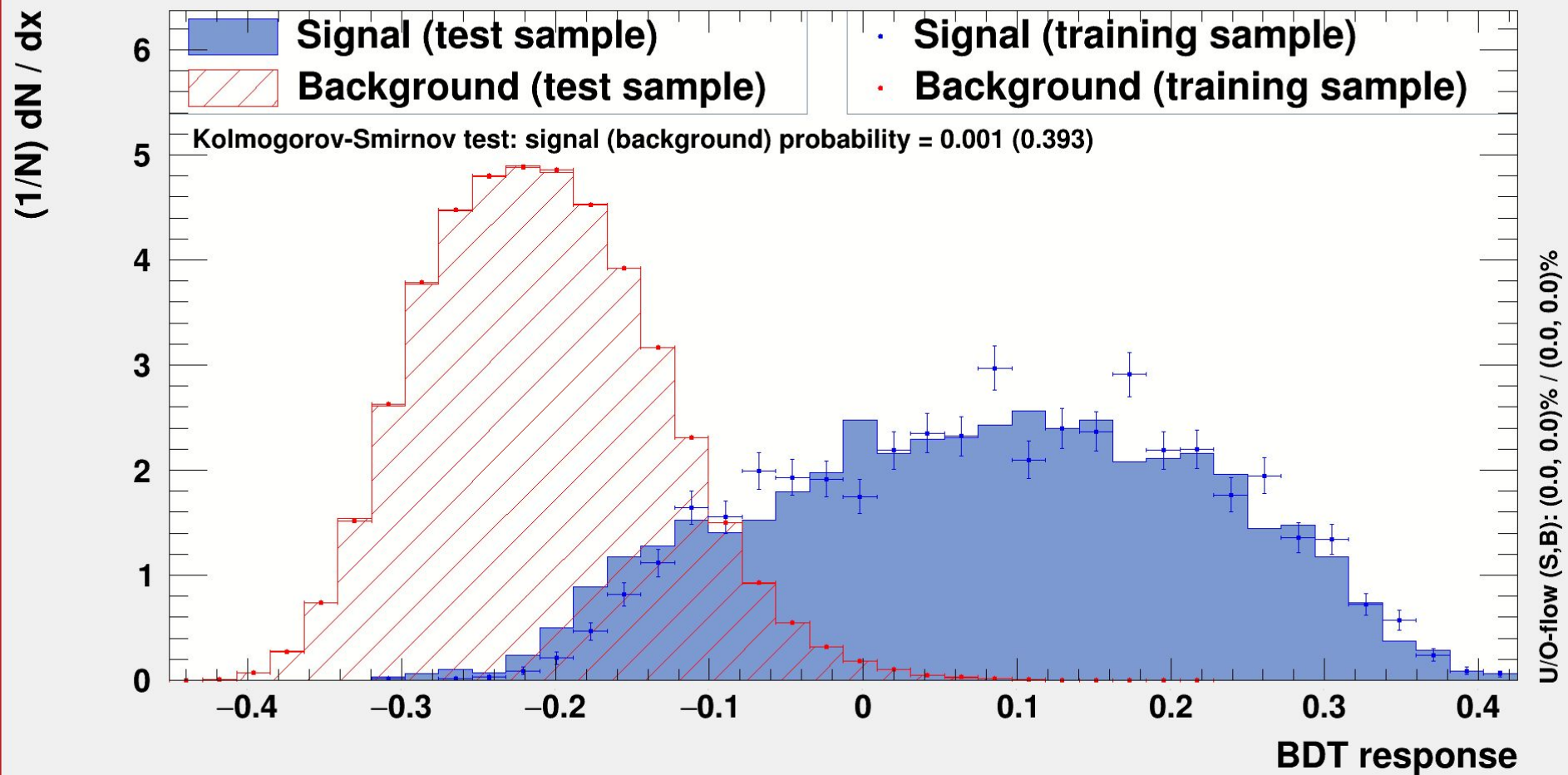
Input variable: acceptance_llr



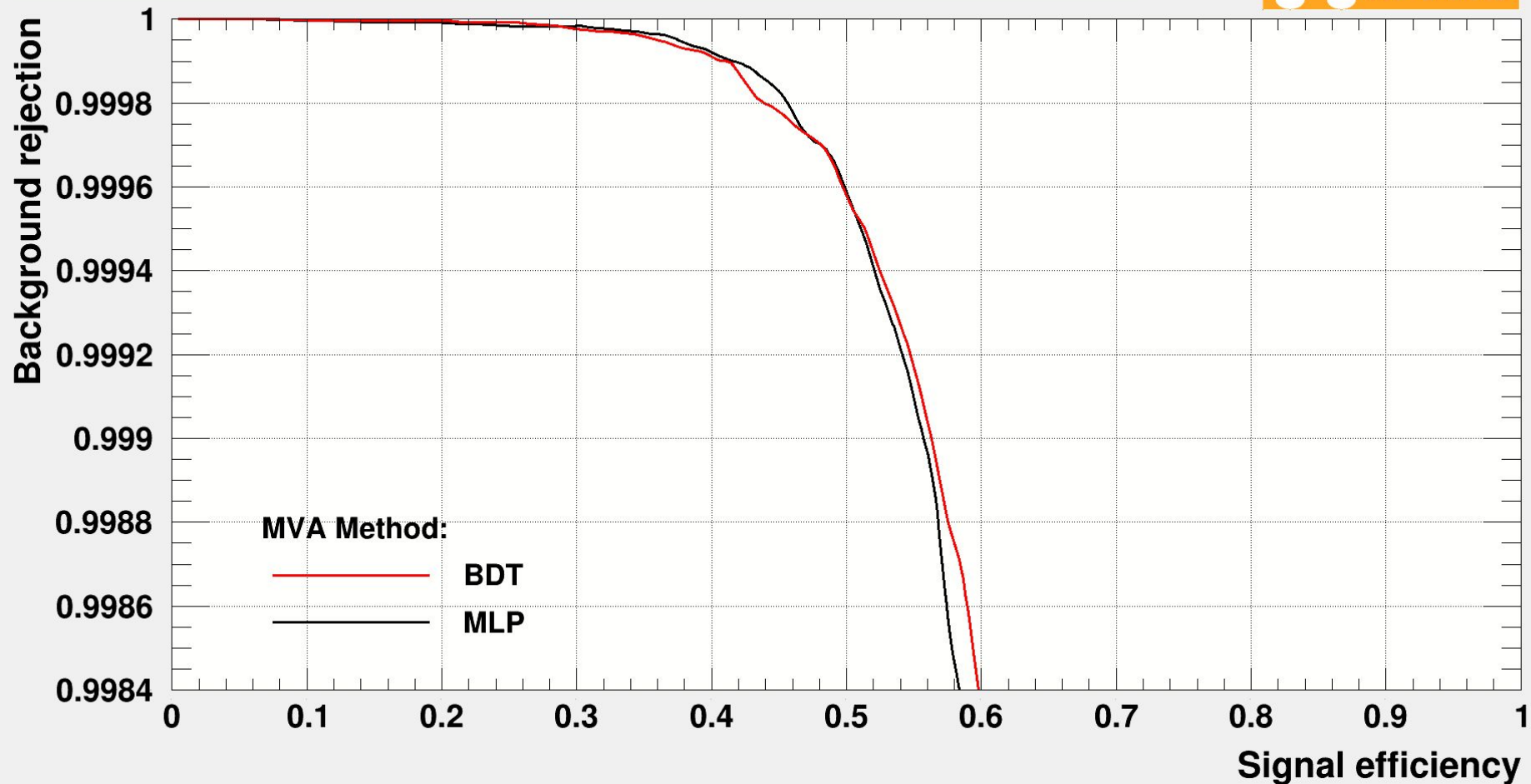
TMVA overtraining check for classifier: MLP



TMVA overtraining check for classifier: BDT



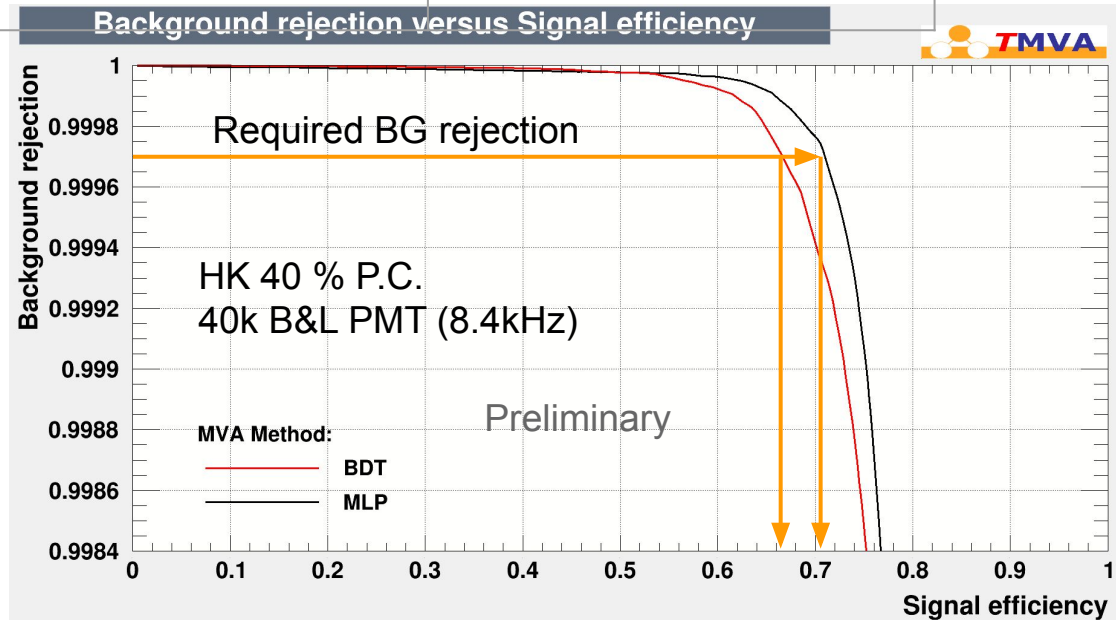
Background rejection versus Signal efficiency



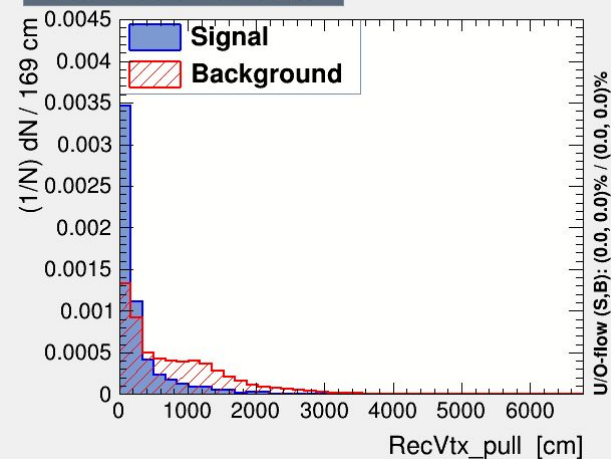
HK 40 % PC, 8.4 kHz

- Defined allowed mis-identification = 0.1 evt. / primary evt.

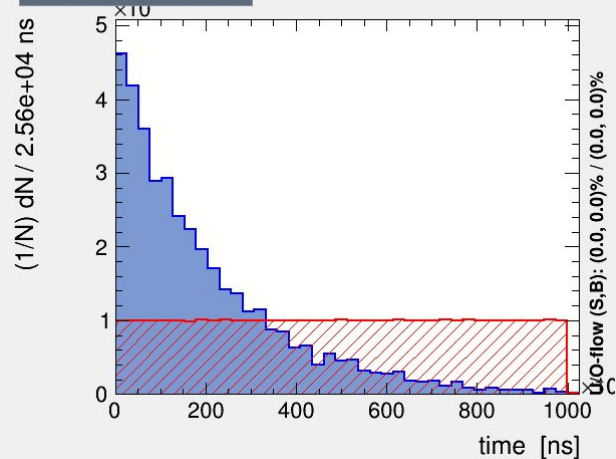
HK 40 % PC, 8.4 kHz N10 >= 11	# of signal / primary evt.	# of background / primary evt.
After N10 presearch	0.7515	338.2
Required MVA BG rejection	-	$1 - 3.0\text{E-}4 = 0.99970$
MVA Signal efficiency (BDT / MLP)	0.66 / 0.70	-
Total ntag efficiency (BDT / MLP)	$\sim 0.50 / 0.53$	-



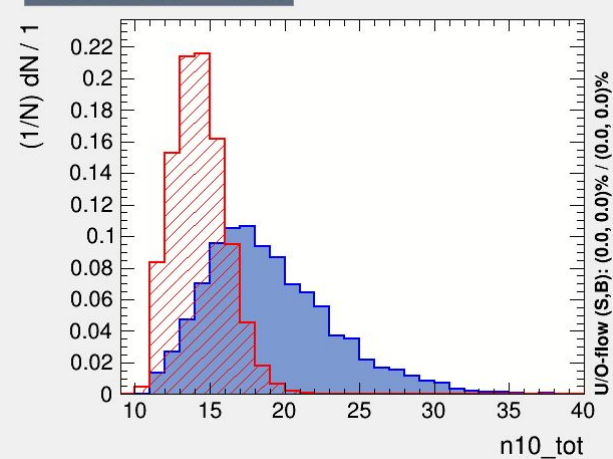
Input variable: RecVtx_pull



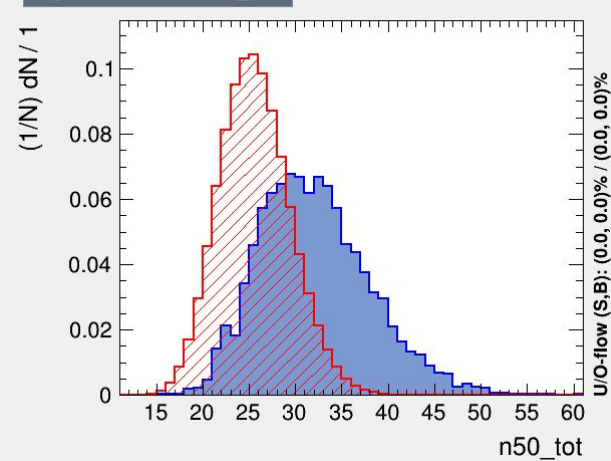
Input variable: time



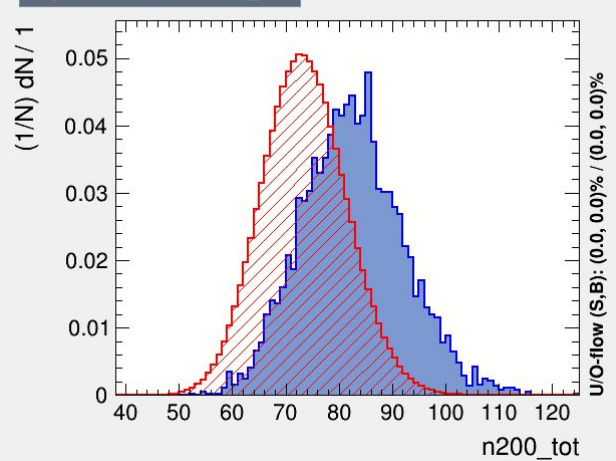
Input variable: n10_tot



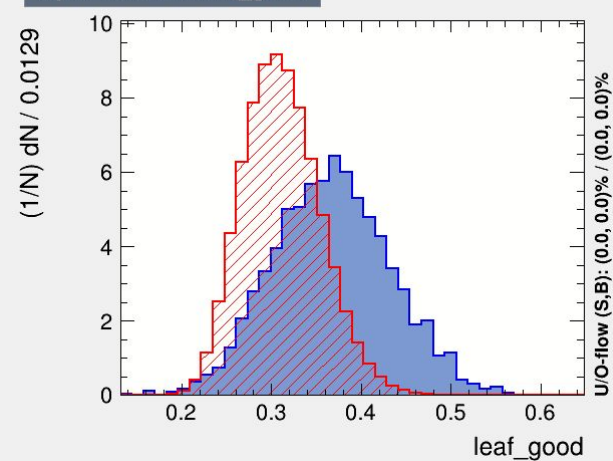
Input variable: n50_tot



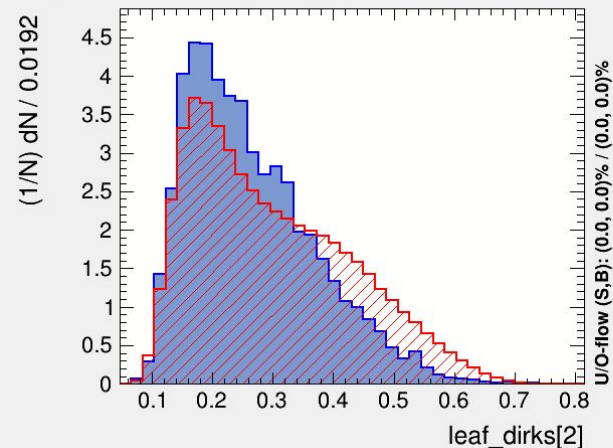
Input variable: n200_tot



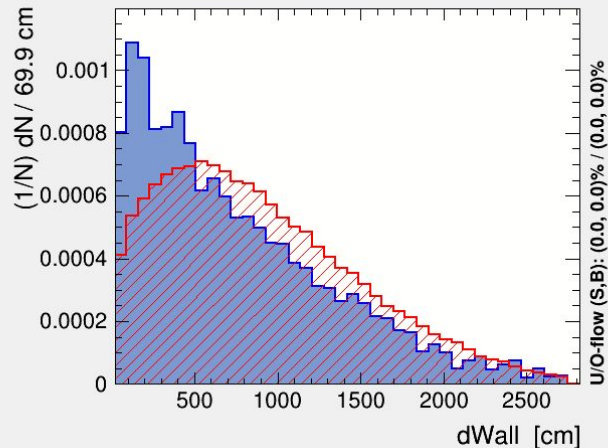
Input variable: leaf_good



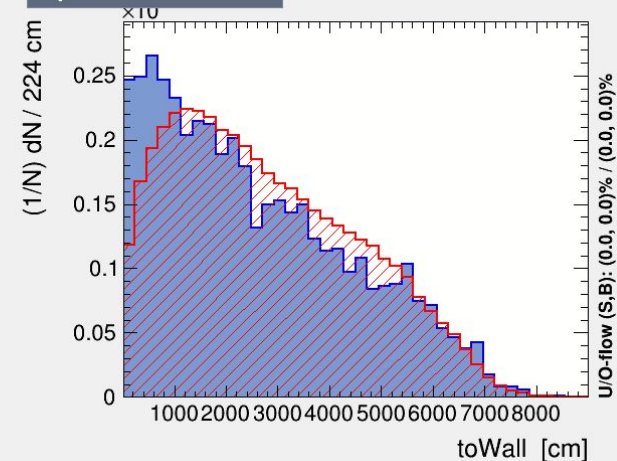
Input variable: leaf_dirs[2]



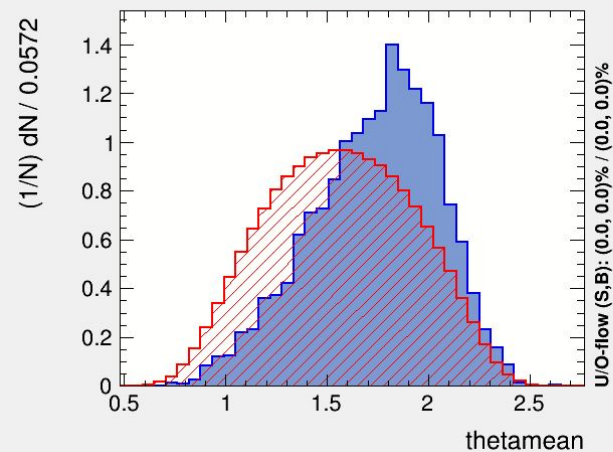
Input variable: dWall



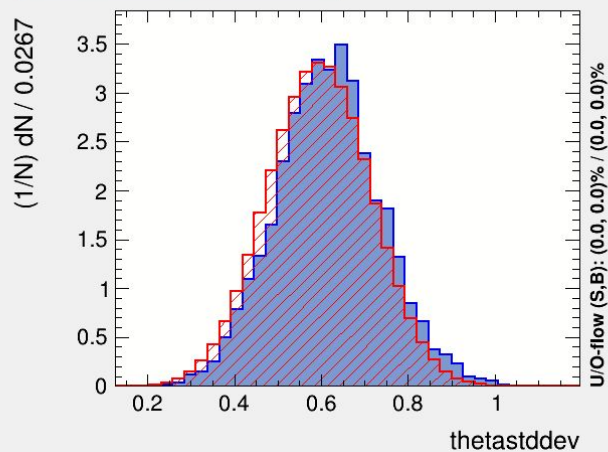
Input variable: toWall



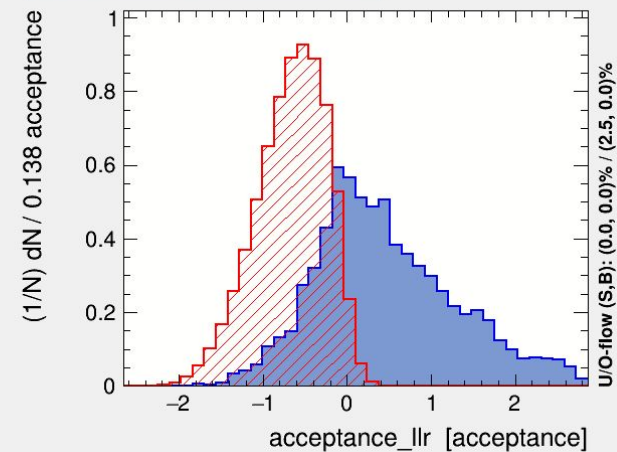
Input variable: thetamean



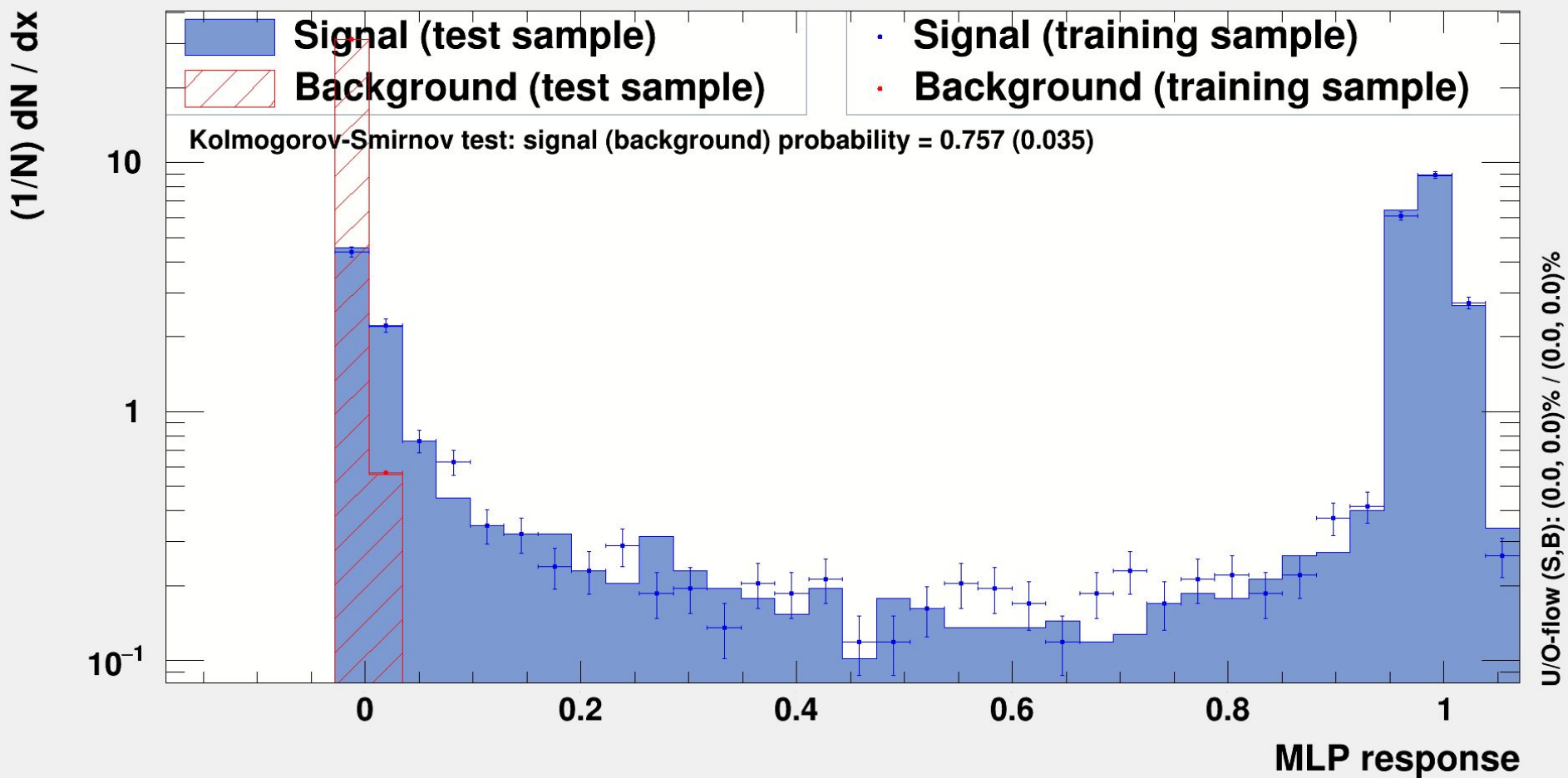
Input variable: thetastddev



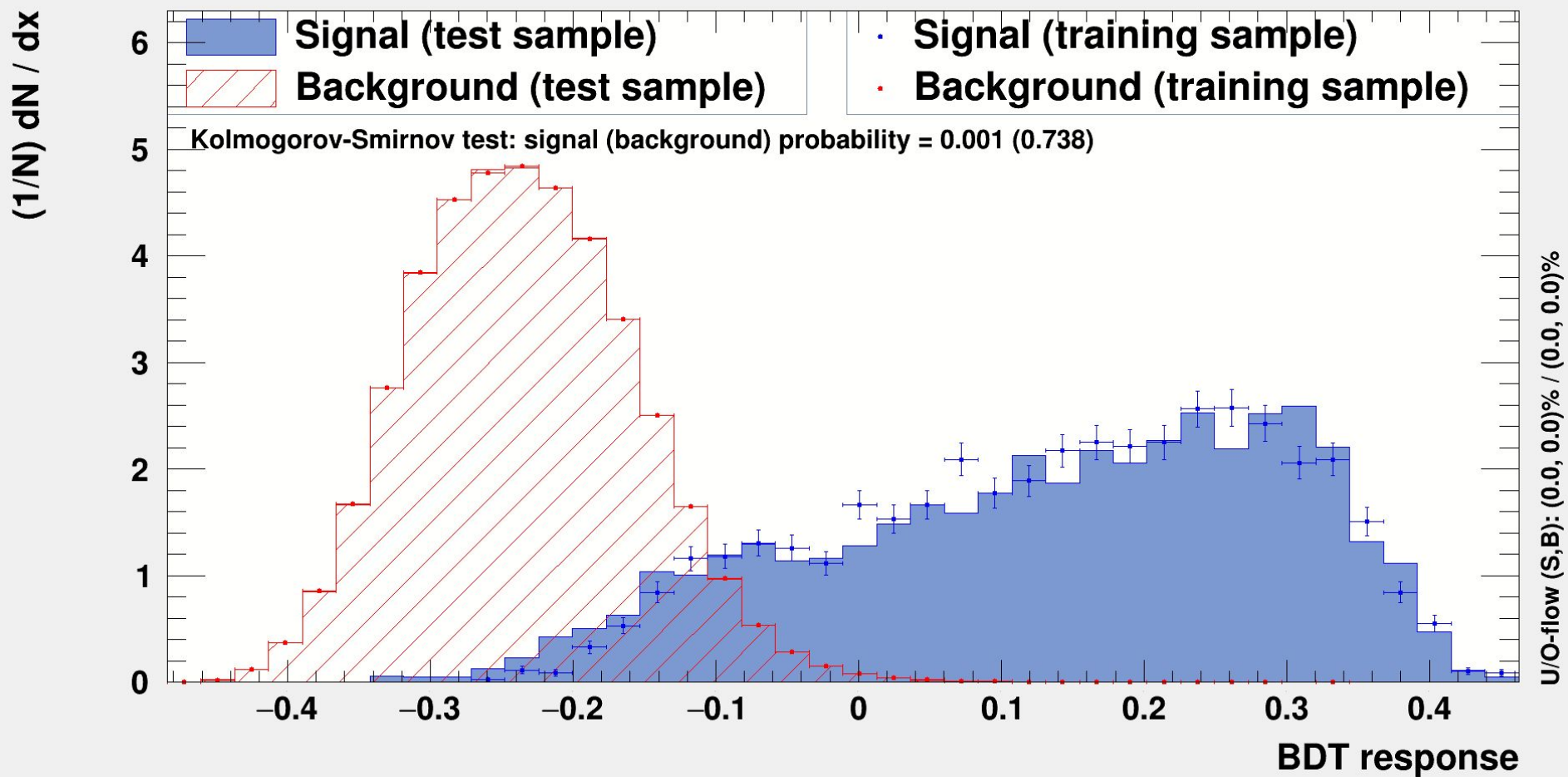
Input variable: acceptance_llr



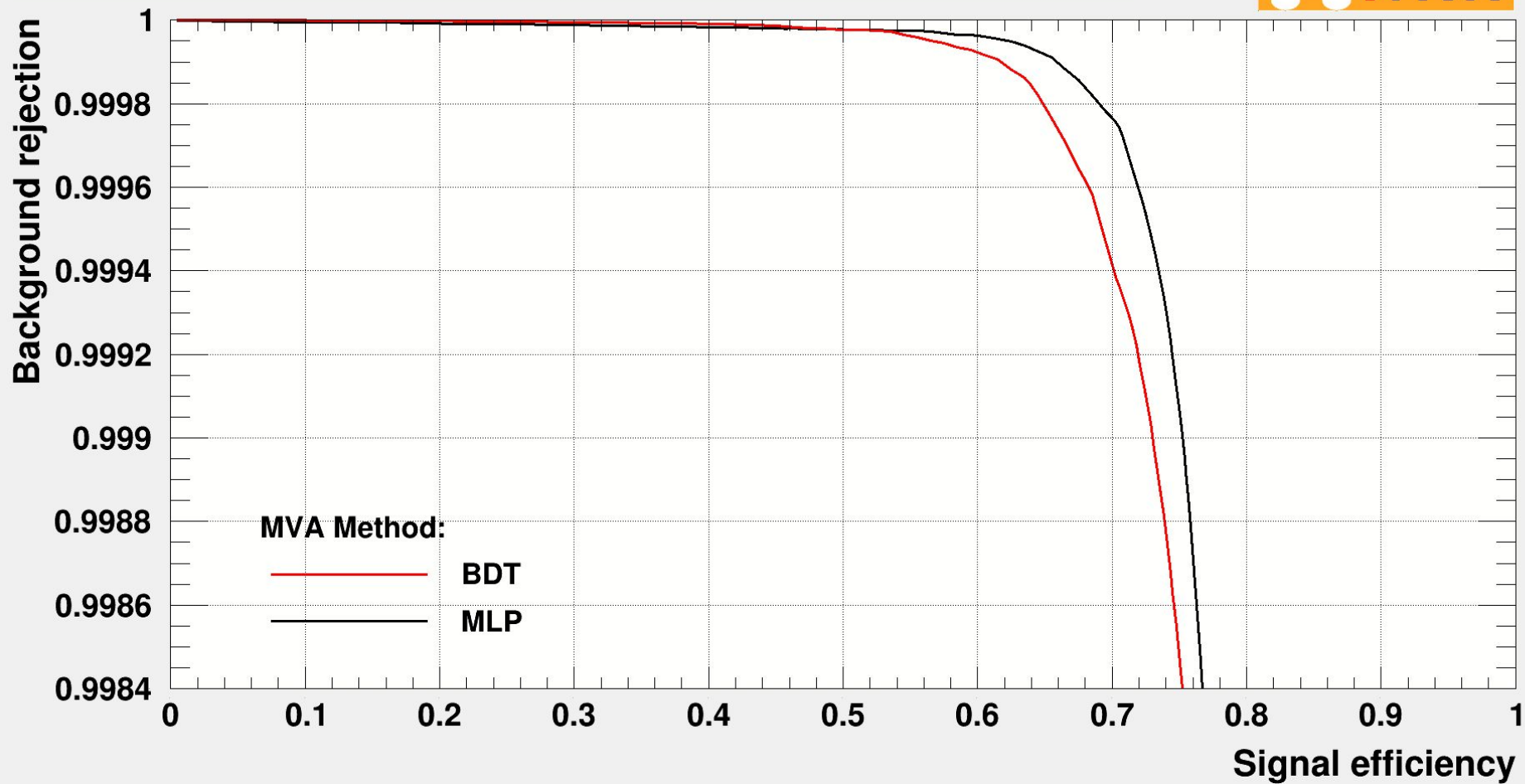
TMVA overtraining check for classifier: MLP



TMVA overtraining check for classifier: BDT



Background rejection versus Signal efficiency

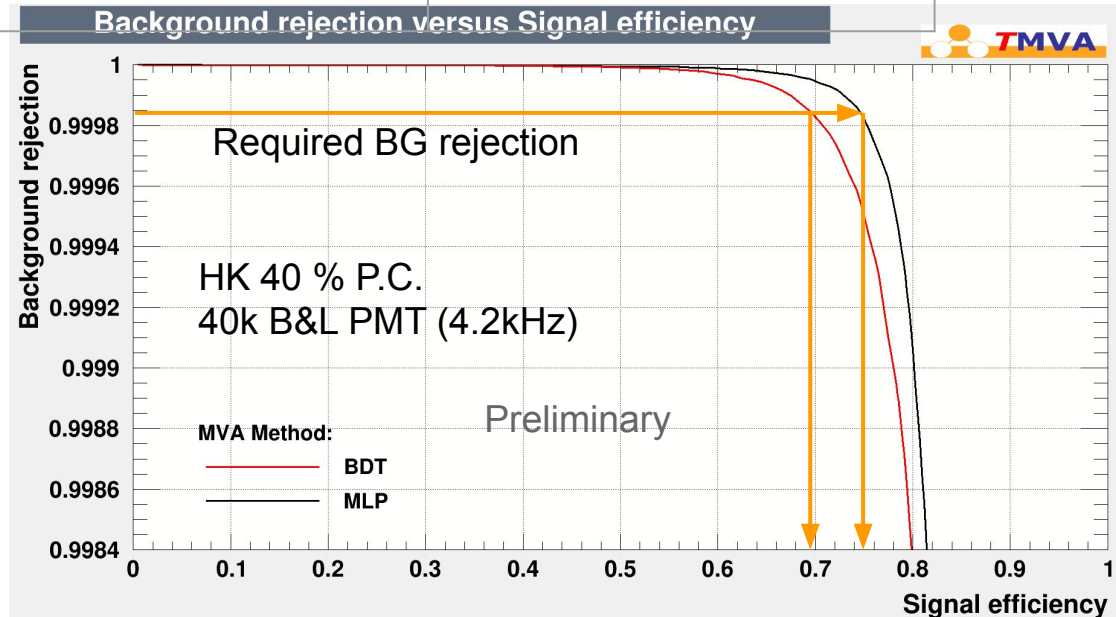


HK 40 % PC, 4.2 kHz

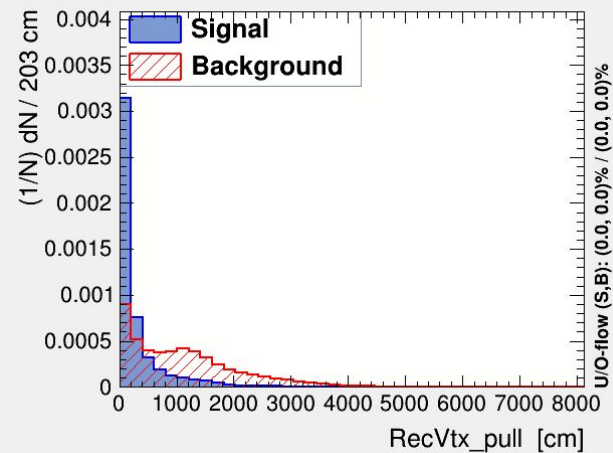
- Defined allowed mis-identification = 0.1 evt. / primary evt.

HK 40 % PC, 4.2 kHz N10 $\geq$ 7	# of signal / primary evt.	# of background / primary evt.
After N10 presearch	0.8835	649.1
Required MVA BG rejection	-	$1 - 1.5\text{E-}4 = 0.99985$
MVA Signal efficiency (BDT/MLP)	0.70 / 0.75	-
Total ntag efficiency (BDT / MLP)	$\sim 0.62 / 0.66$	-

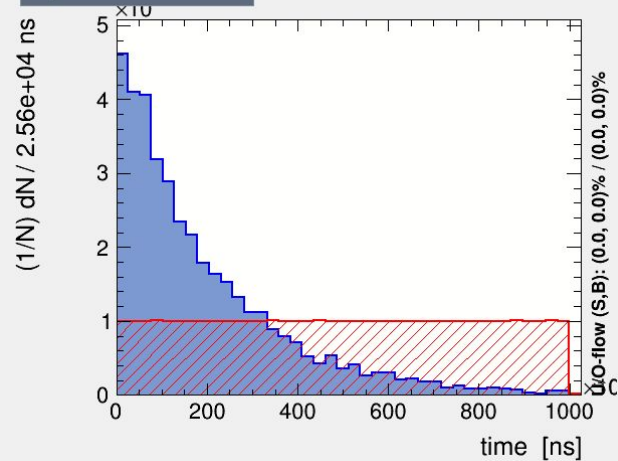
- Stat. err:
of signal / primary
 ~ 0.03



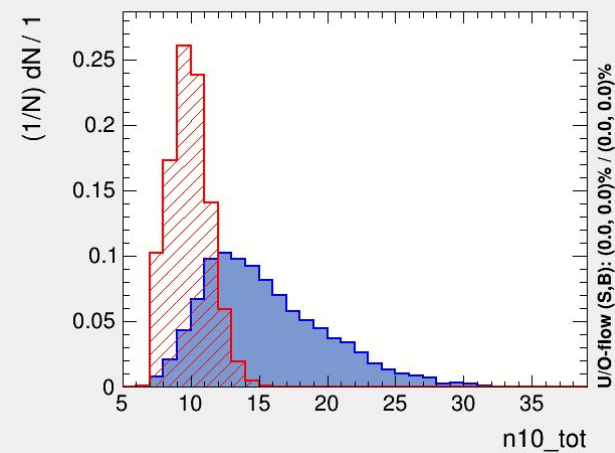
Input variable: RecVtx_pull



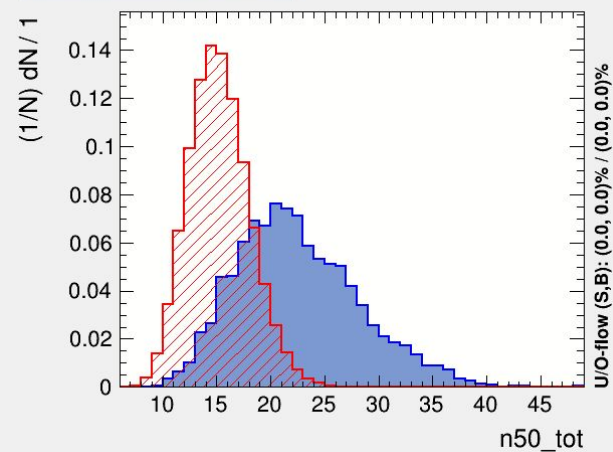
Input variable: time



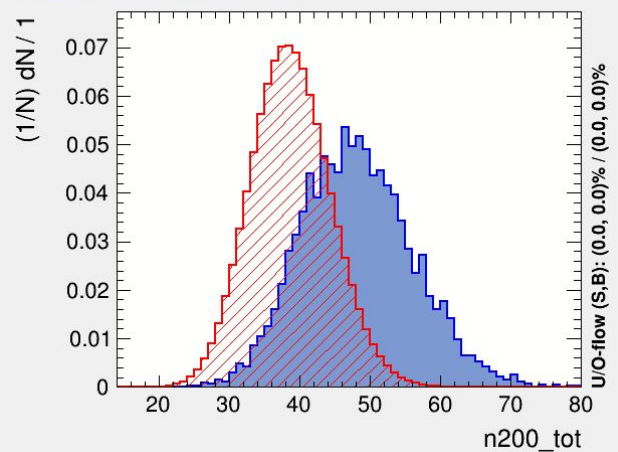
Input variable: n10_tot



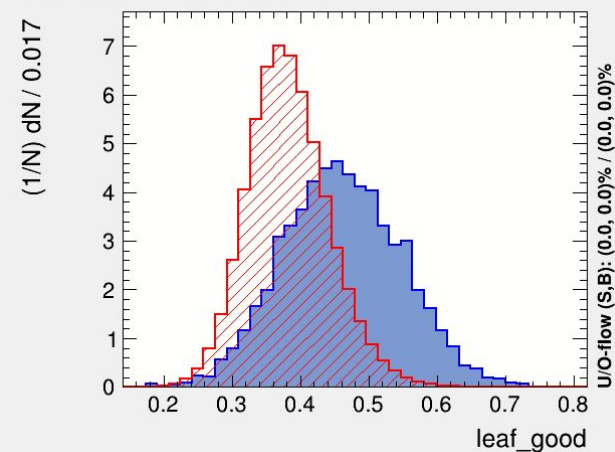
Input variable: n50_tot



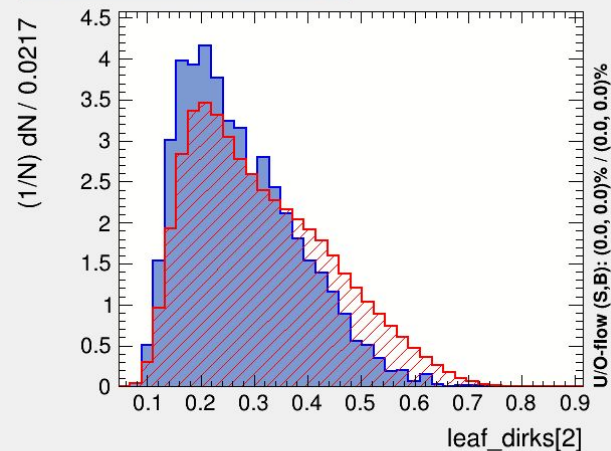
Input variable: n200_tot



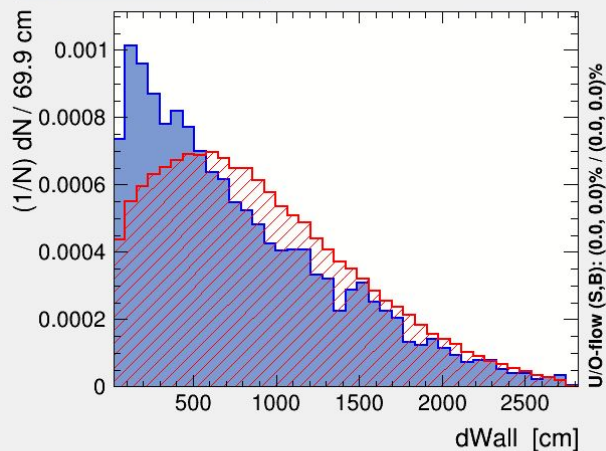
Input variable: leaf_good



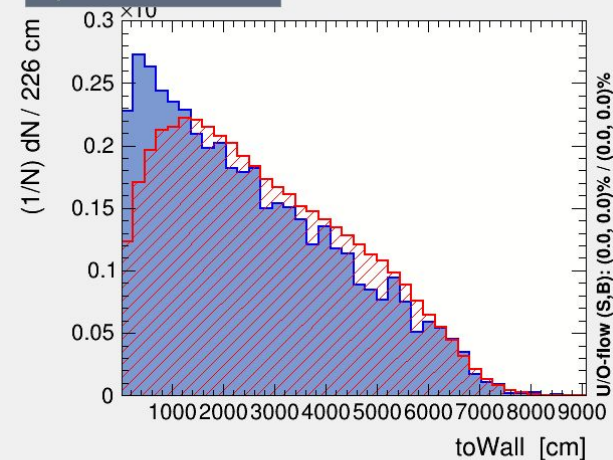
Input variable: leaf_dirs[2]



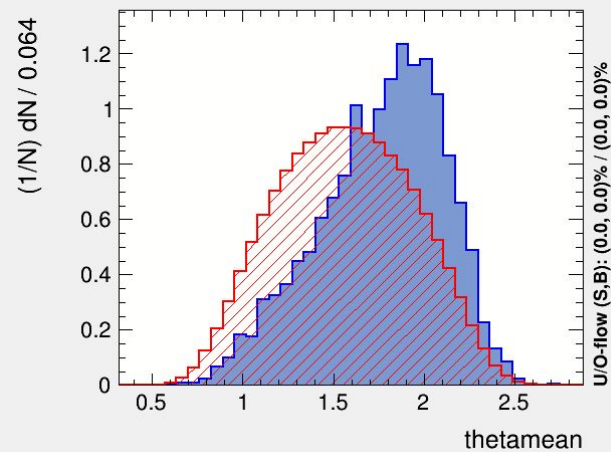
Input variable: dWall



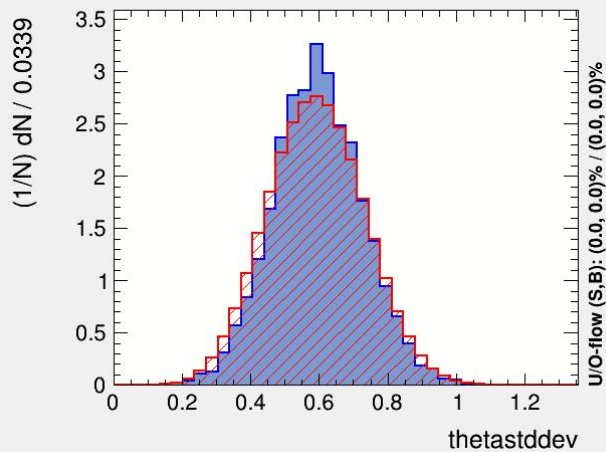
Input variable: toWall



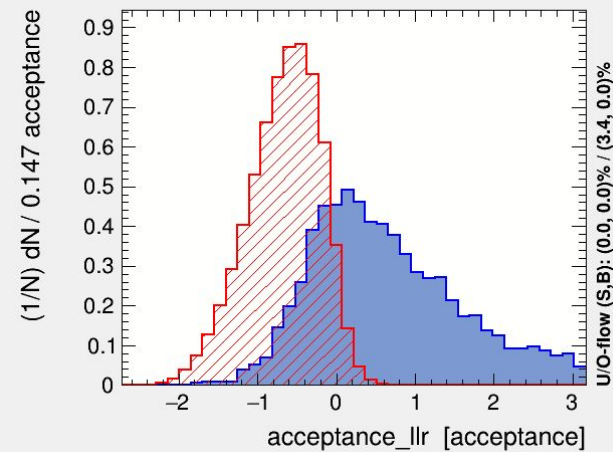
Input variable: thetamean



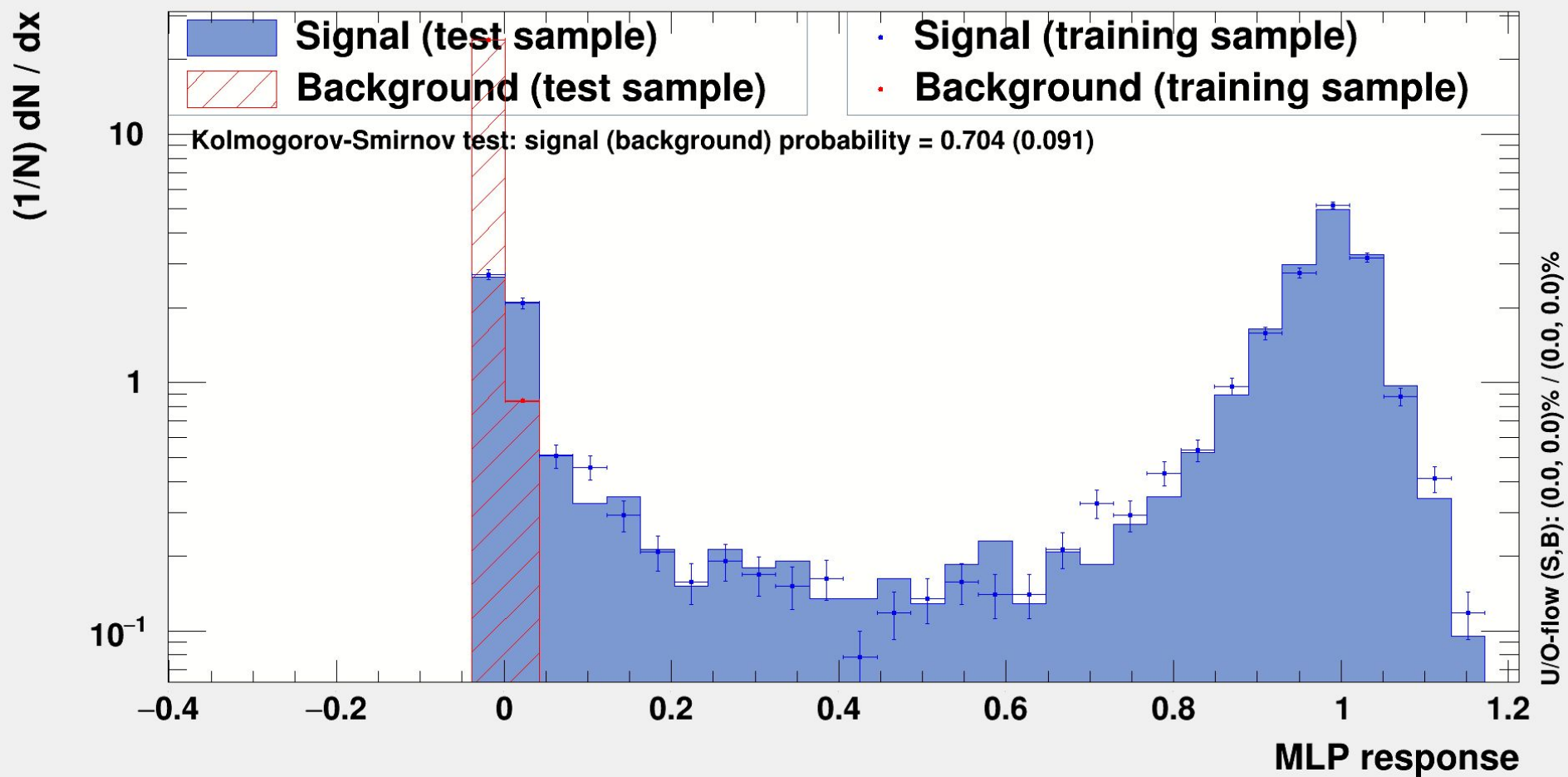
Input variable: thetastddev



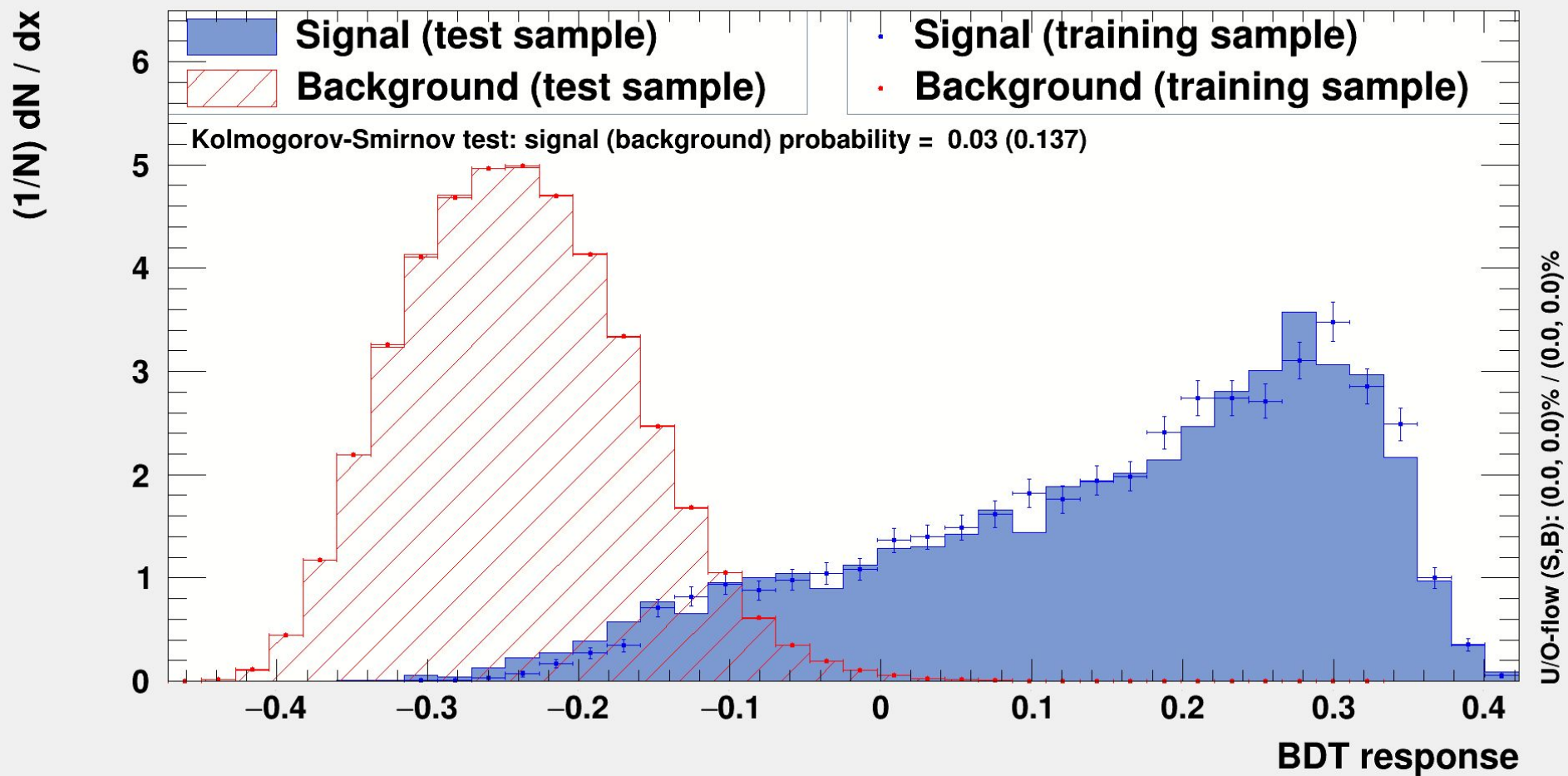
Input variable: acceptance_llr



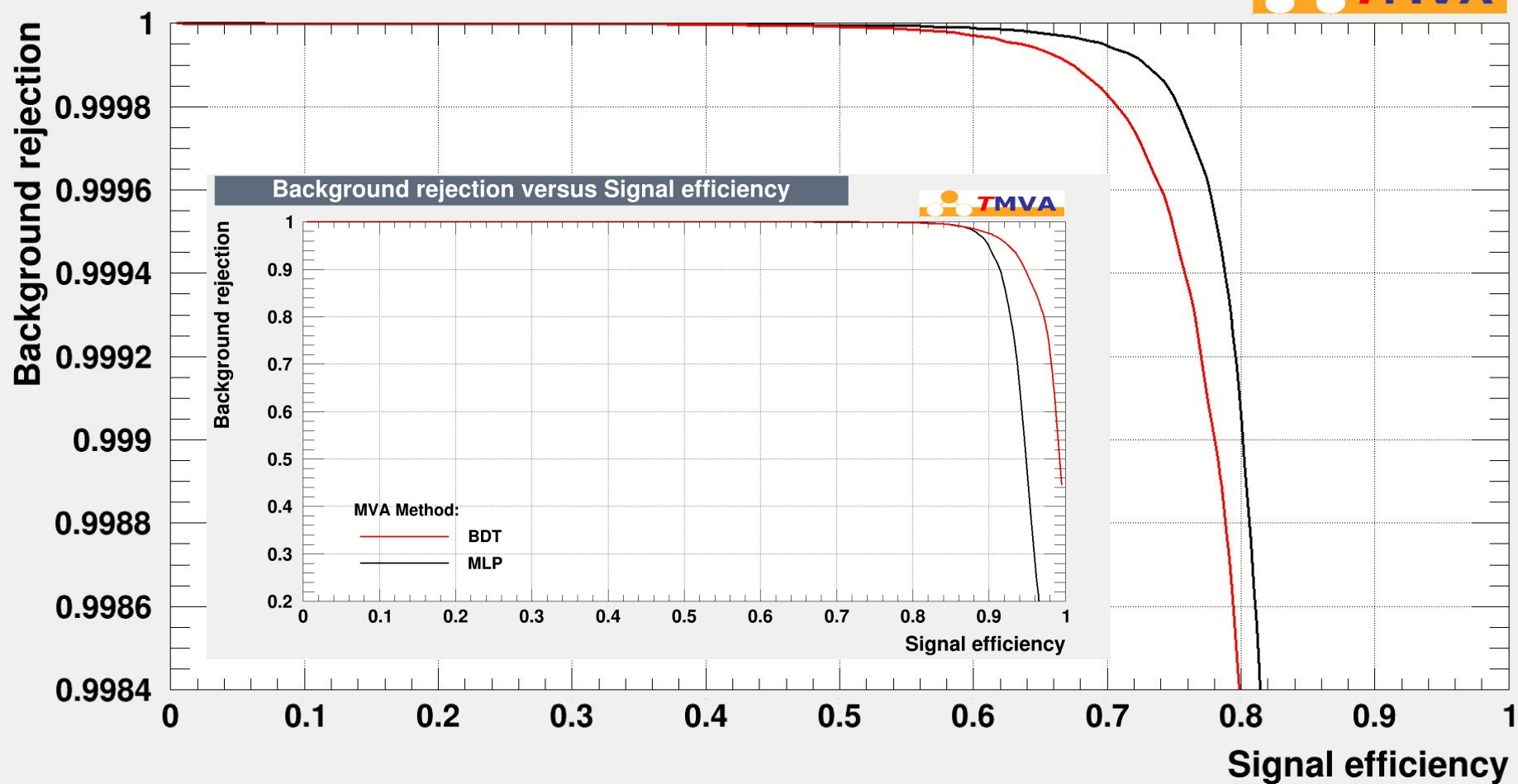
TMVA overtraining check for classifier: MLP



TMVA overtraining check for classifier: BDT



Background rejection versus Signal efficiency

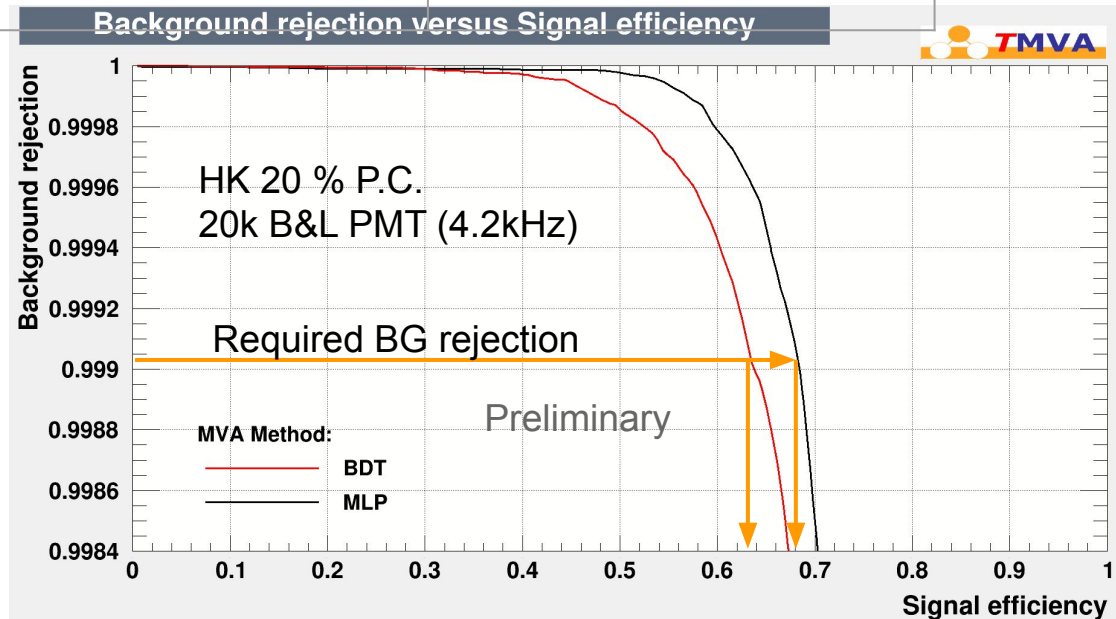


HK 20 % PC, 4.2 kHz

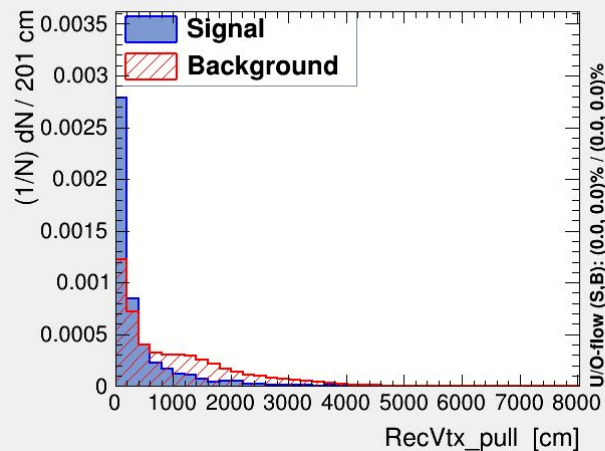
- Defined allowed mis-identification = 0.1 evt. / primary evt.

HK 20 % PC, 4.2 kHz N10 ≥ 6	# of signal / primary evt.	# of background / primary evt.
After N10 presearch	0.5830	101.9
Required MVA BG rejection	-	$1 - 9.8\text{E-}4 = 0.99902$
MVA Signal efficiency (BDT/MLP)	0.63 / 0.68	-
Total ntag efficiency (BDT / MLP)	$\sim 0.37 / 0.38$	-

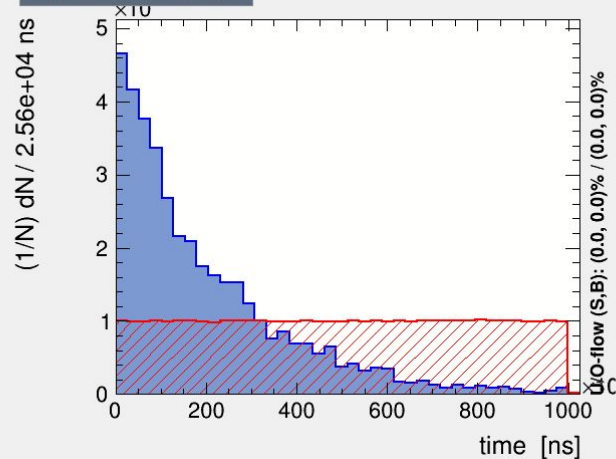
- Stat. err:
of signal / primary
 ~ 0.01



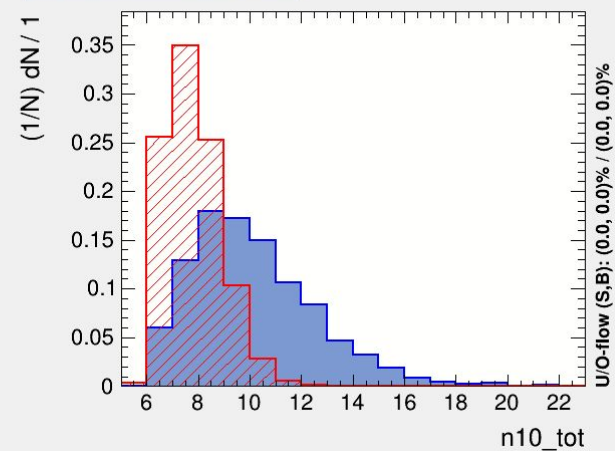
Input variable: RecVtx_pull



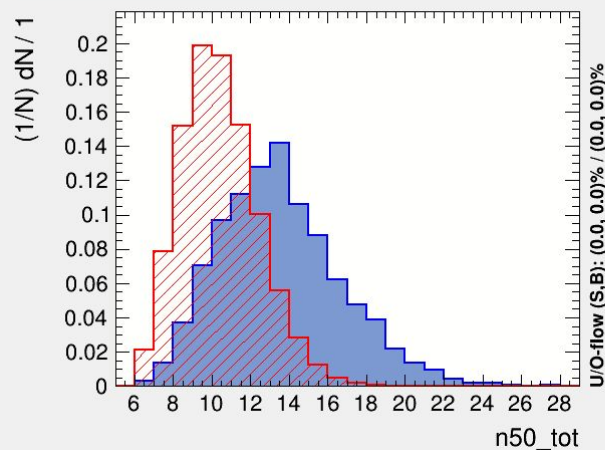
Input variable: time



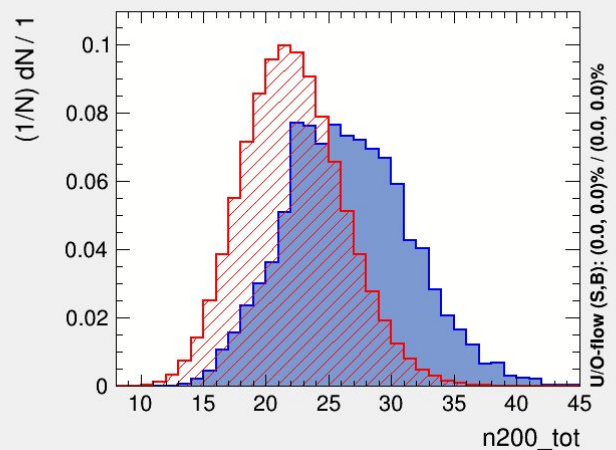
Input variable: n10_tot



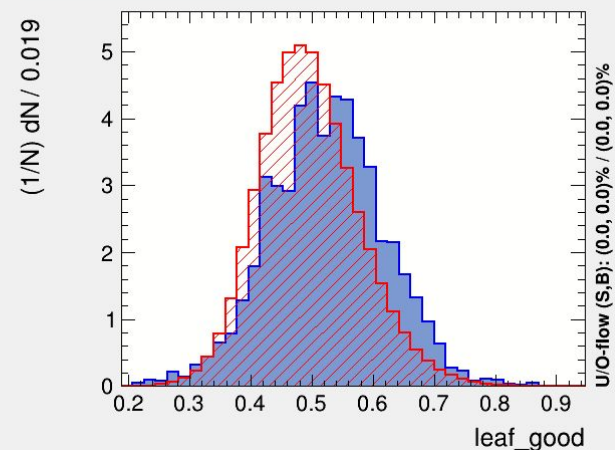
Input variable: n50_tot



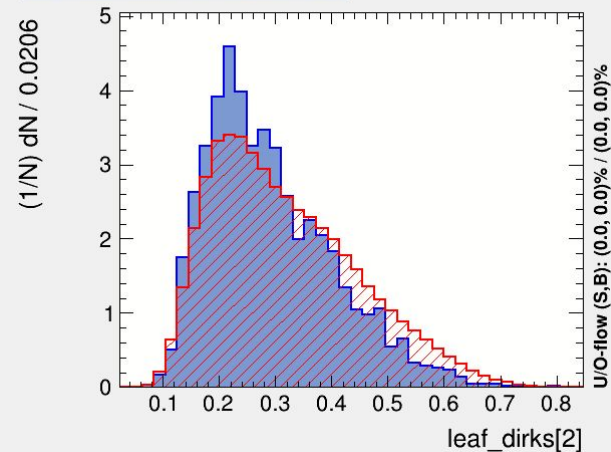
Input variable: n200_tot



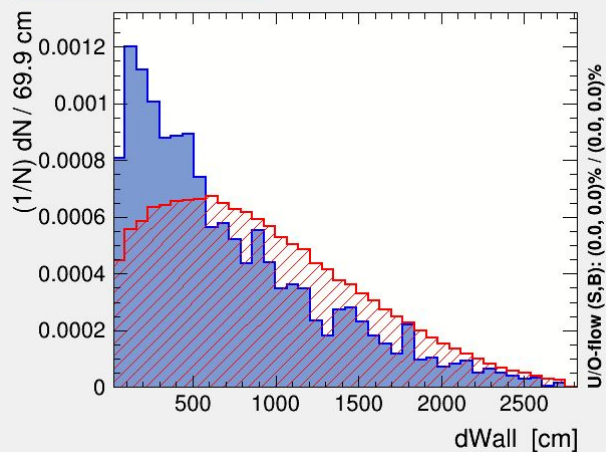
Input variable: leaf_good



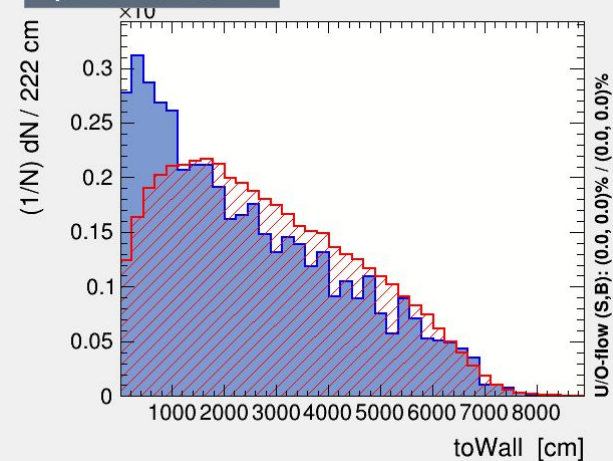
Input variable: leaf_dirs[2]



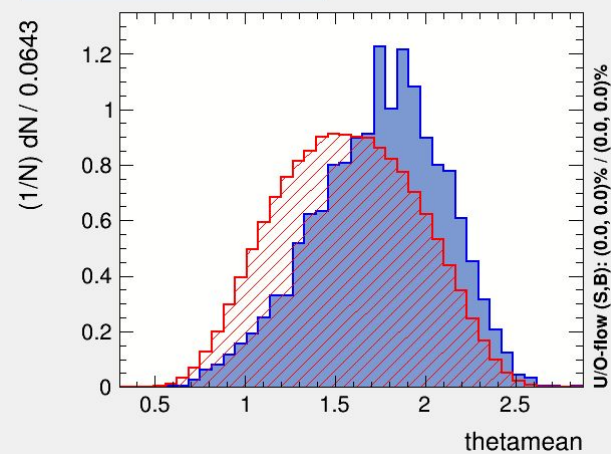
Input variable: dWall



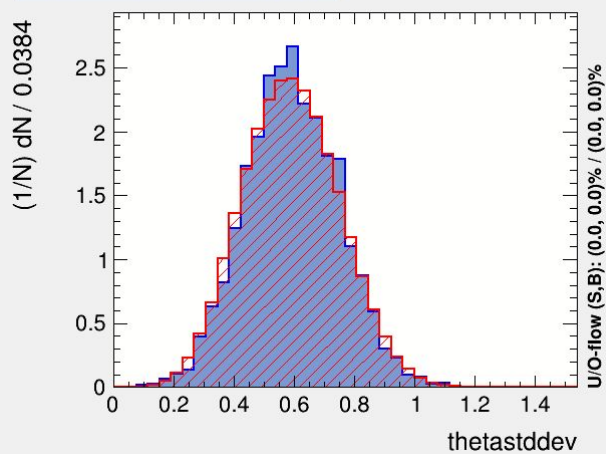
Input variable: toWall



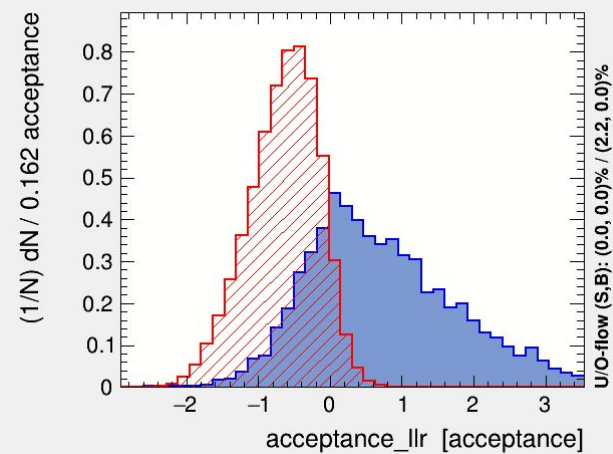
Input variable: thetamean



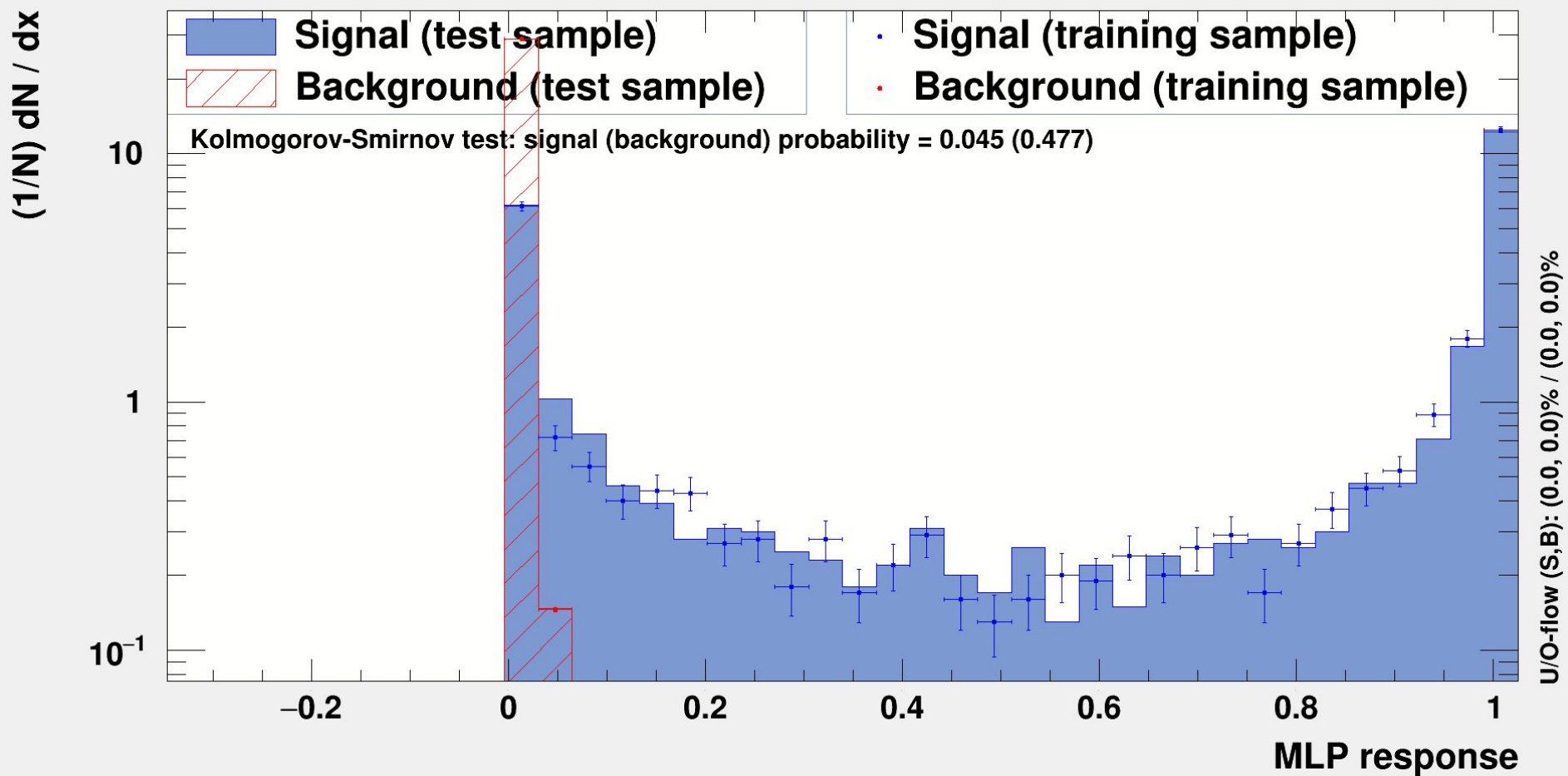
Input variable: thetastddev



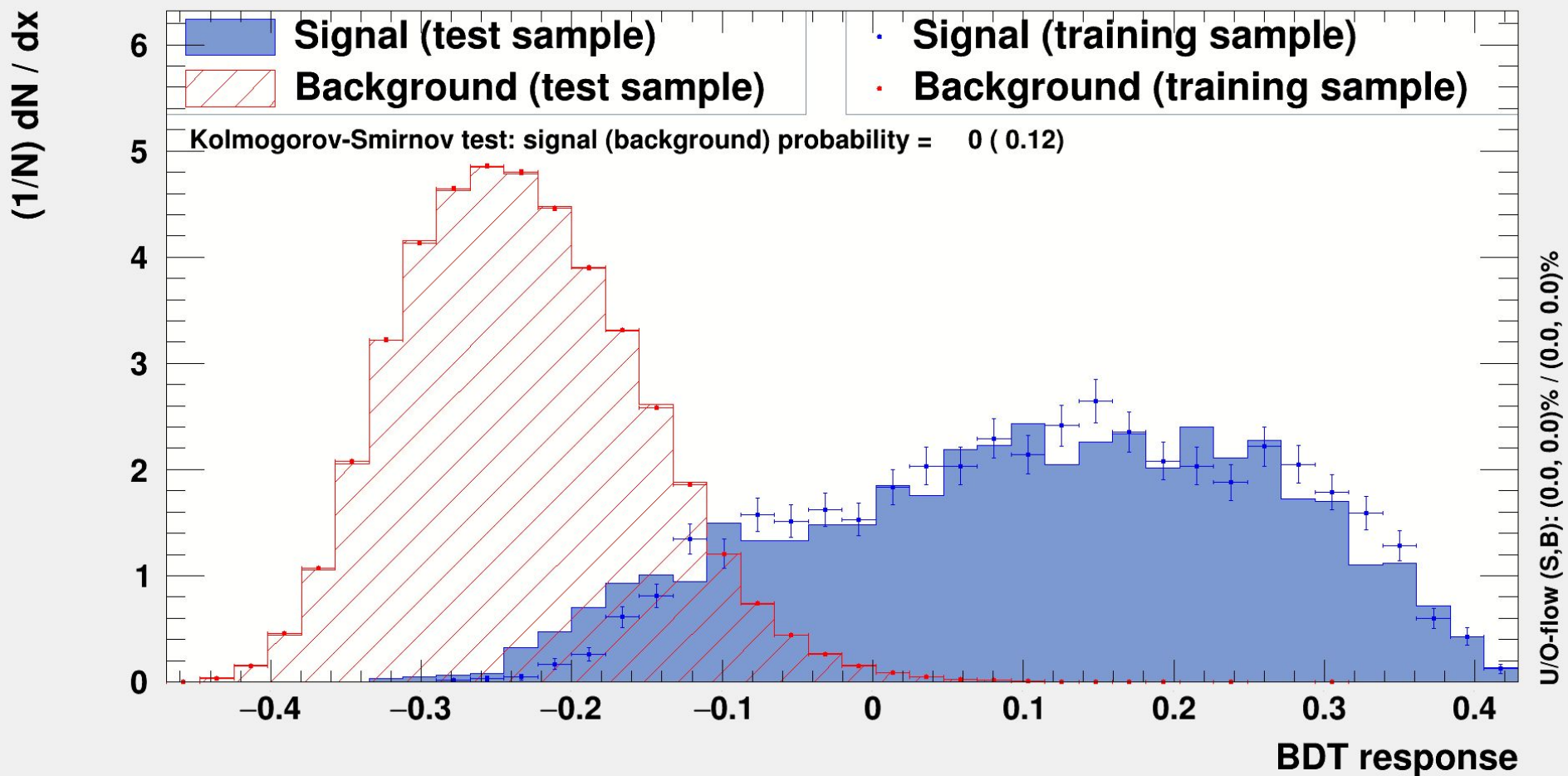
Input variable: acceptance_llr



TMVA overtraining check for classifier: MLP



TMVA overtraining check for classifier: BDT



Background rejection versus Signal efficiency

