$B_s^0 \to \mu^+\mu^-$ Cross Check Analysis

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Abstract

The aim of this analysis note is to provide supporting material for the cross check analysis for the search for $B_s^0 \to \mu^+\mu^-$ and $B^0 s \to \mu^+\mu^-$ decays. It follows closely the documentation provided in [1] and includes direct comparison to the results in that note.

1 Datasets

The datasets used are shown in table **??**.

The events are selected using the same triggers as described in the reference [1].

The analysis is based on a boosted decision tree (BDT) algorithm to select $B_s^0 \to \mu^+\mu^-$ events from the background. A preselection is applied to the data and MC samples to reduce the size and remove outliers that might confuse the BDT training. The signal is taken from the $B_s^0 \to \mu^+\mu^-$ MC sample, while the background is taken from the sidebands in the data sample.
Despite the availability of the full 2012 dataset, in order to allow a direct comparison with the results in [1] this study is limited to runs <= 203002. The dataset is split in three different categories according the remainder of "event number%3".

2 Selection

The same preselection as in [1] is used. The muons are chosen to pass global muon prompt tight selection (GM_PT).

Official MC datasets
BsToMuMu_BsFilter_8TeV-pythia6-evtgen/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM
Data /MuOnia/Run2012A-13Jul2012-v1/AOD /MuOnia/Run2012A-recover-06Aug2012-v1/AOD /MuOnia/Run2012B-13Jul2012-v1/AOD /MuOnia/Run2012C-24Aug2012-v1/AOD /MuOnia/Run2012C-PromptReco-v2/AOD /MuOnia/Run2012C-EcalRecover_11Dec2012-v1/AOD /MuOnia/Run2012D-PromptReco-v1/AOD

	0		1		2	
rank	variable	separation	variable	separation	variable	separation
1	alpha	5.524e-01	alpha	5.477e-01	alpha	5.474e-01
2	closetrk	3.972e-01	closetrk	3.932e-01	closetrk	3.961e-01
3	fls3d	3.678e-01	fls3d	3.611e-01	fls3d	3.641e-01
4	docatrk	2.873e-01	docatrk	2.873e-01	docatrk	2.901e-01
5	iso	2.525e-01	iso	2.561e-01	iso	2.579e-01
6	pvips	2.015e-01	pvips	2.024e-01	pvips	2.035e-01
7	pvip	1.945e-01	pvip	1.928e-01	pvip	1.947e-01
8	maxdoca	1.291e-01	maxdoca	1.290e-01	maxdoca	1.344e-01
9	chi2/dof	1.028e-01	chi2/dof	1.033e-01	chi2/dof	1.090e-01
10	pt	3.893e-02	pt	3.643e-02	pt	3.841e-02
11	eta	1.226e-02	eta	1.086e-02	eta	1.218e-02

Table 1: Variable ranking for events of the three different event samples in the barrel before BDT training.

	0		1		2	
rank	variable	separation	variable	separation	variable	separation
1	alpha	5.224e-01	alpha	5.201e-01	alpha	5.221e-01
2	closetrk	4.053e-01	closetrk	4.071e-01	closetrk	4.060e-01
3	fls3d	3.453e-01	fls3d	3.465e-01	fls3d	3.454e-01
4	docatrk	3.200e-01	docatrk	3.163e-01	iso	3.179e-01
5	iso	3.148e-01	iso	3.134e-01	docatrk	3.171e-01
6	pvips	1.951e-01	pvips	1.958e-01	pvips	1.933e-01
7	pvip	1.630e-01	pvip	1.643e-01	pvip	1.612e-01
8	maxdoca	1.112e-01	maxdoca	1.146e-01	maxdoca	1.128e-01
9	chi2/dof	9.549e-02	chi2/dof	9.809e-02	chi2/dof	9.981e-02
10	eta	2.645e-02	eta	2.690e-02	eta	2.592e-02
11	pt	1.145e-02	pt	1.168e-02	pt	1.099e-02

Table 2: Variable ranking for events of the three different event samples in the endcaps before BDT training.

The distributions of the variables used for the BDT training are shown in Figures 1 and 2.

Tables **??** and **??** show the ranking of variables before the BDT training.

3 Boosted Decision Tree

The data sample is split in three different subsamples according to the rule $index = eventNumber\%3$. These samples are then used as follows:

- events of type 0: analyzed by BDT0, trained on type-1 events, tested on type-2 events
- events of type 1: analyzed by BDT1, trained on type-2 events, tested on type-0 events

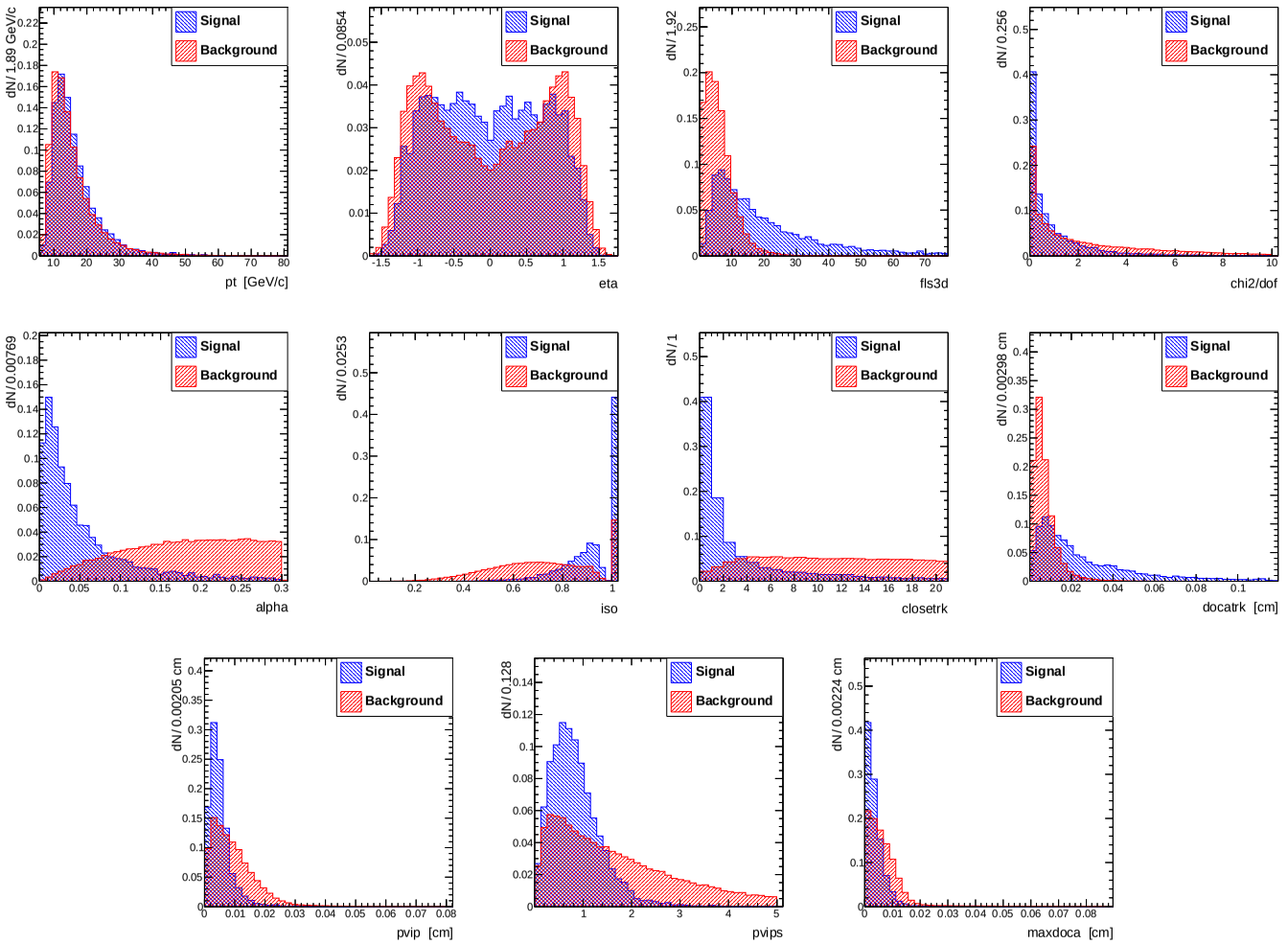

Figure 1: Standard TMVA plot of the input variables for the barrel BDT for signal (blue) and background (red). The background is extracted from data dimuon sidebands.

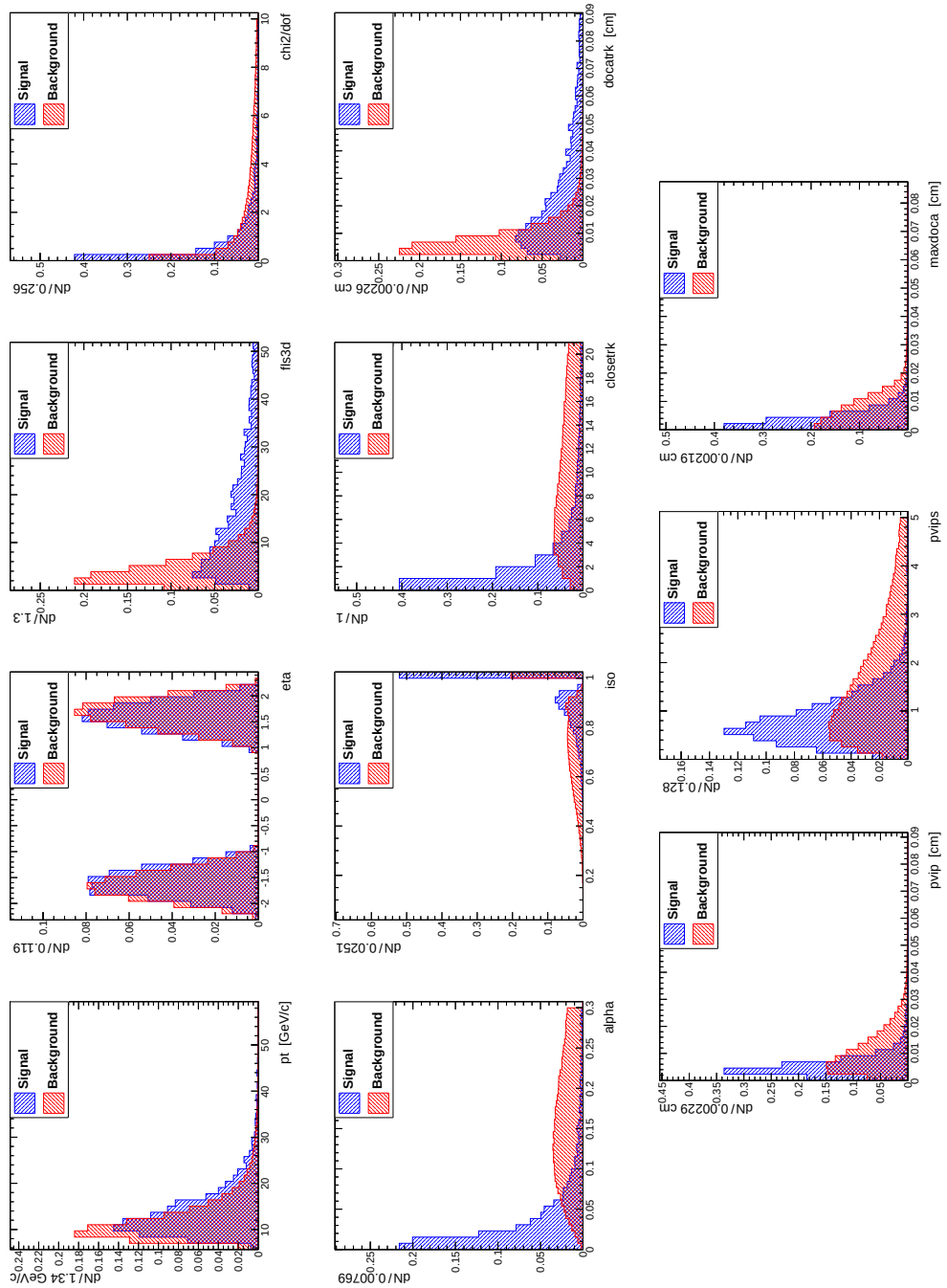

Figure 2: Standard TMVA plot of the input variables for the endcaps BDT for signal (blue) and background (red). The background is extracted from data dimuon sidebands.

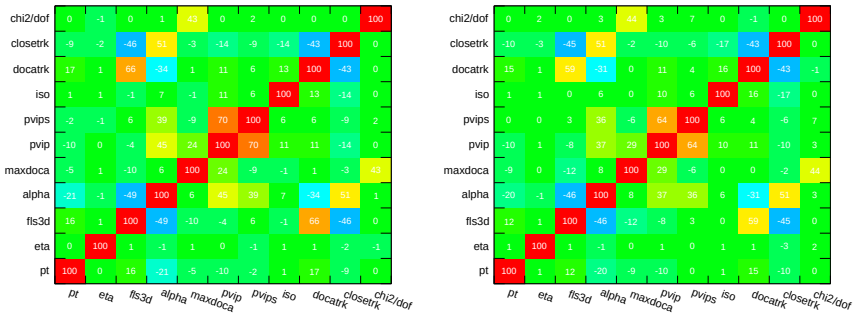

Figure 3: Correlation matrix for signal events in the barrel (left) and the endcap (right).

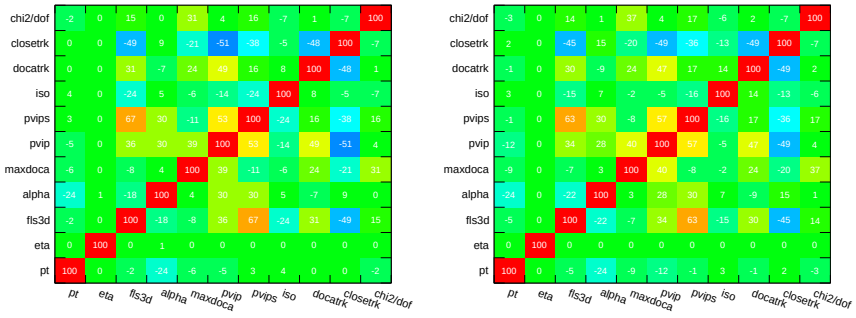

Figure 4: Correlation matrix for background events in the barrel (left) and the endcap (right).

	0		1		2	
rank	variable	separation	variable	separation	variable	separation
1	alpha	5.524e-01	alpha	5.477e-01	alpha	5.474e-01
2	closetrk	3.972e-01	closetrk	3.932e-01	closetrk	3.961e-01
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Table 3: Variable ranking for events of the three different event samples in the barrel before BDT training.

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10	eta	2.645e-02	eta	2.690e-02	eta	2.592e-02
11	pt	1.145e-02	pt	1.168e-02	pt	1.099e-02

Table 4: Variable ranking for events of the three different event samples in the endcaps before BDT training.

- events of type 2: analyzed by BDT2, trained on type-0 events, tested on type-1 events

for the training and testing.

Tables **??** and **??** show the ranking of variables before the BDT training.

References

[1] U. Langenegger et al. AN-12-358: "Search for $B_s \to \mu^+\mu^-$ and $B_s^0 \to \mu^+\mu^-$ with the 2011 and 2012 data". Technical report, CMS Collaboration, 2012.