

Topological Cut Optimization for Λ_c Reconstruction Using the Supervised Learning Algorithm in TMVA at STAR



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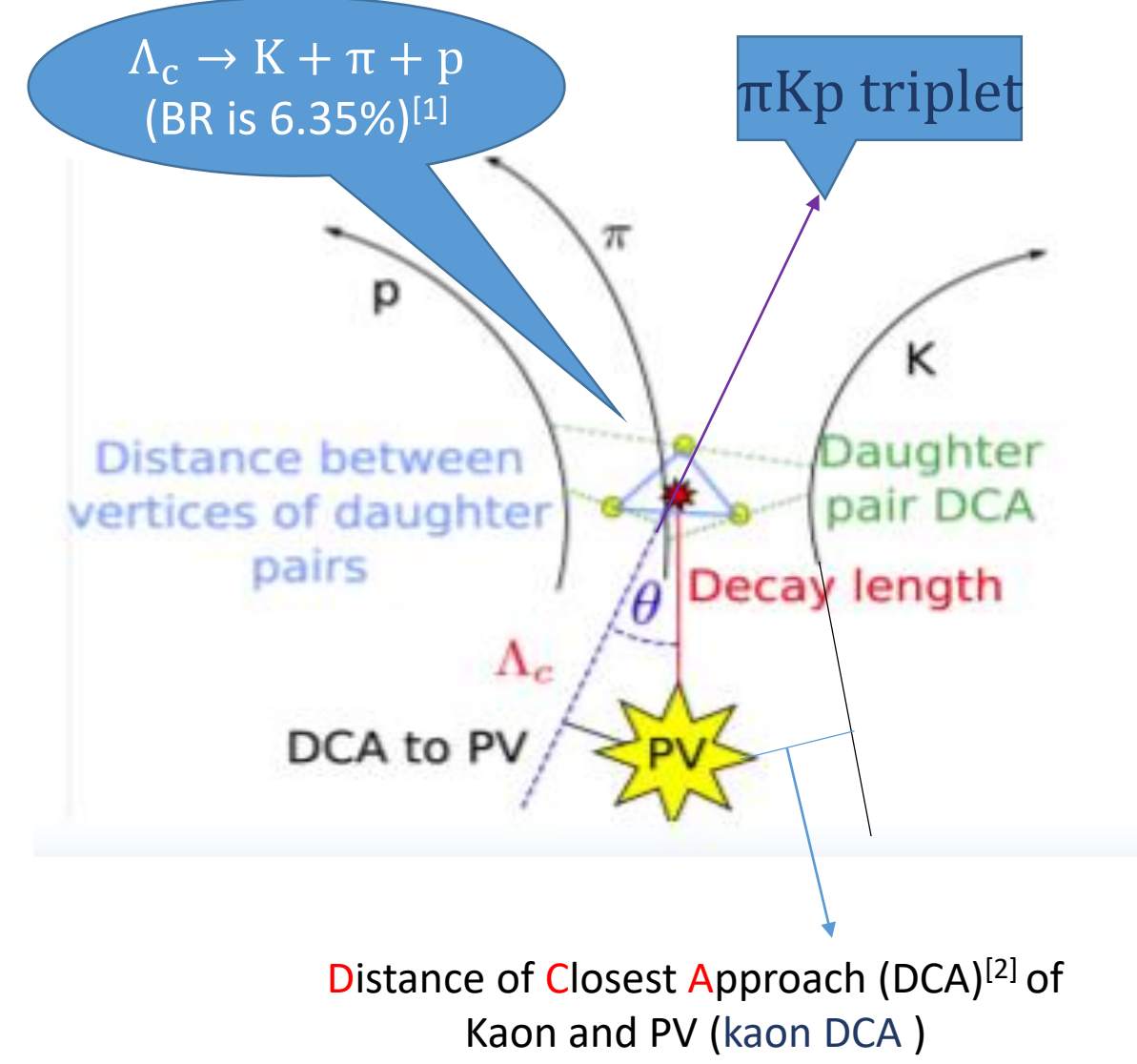
Abstract

Measurement of charmed baryon, Λ_c , provides a unique tool to study the charm quark hadronization in the hot and dense medium created in heavy-ion collisions. With the dataset of Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV recorded by STAR experiment at RHIC in 2014, Λ_c signals were successfully reconstructed through the hadronic decay channel ($\Lambda_c \rightarrow \pi K p$). Measurements of Λ_c production with better precision require refined topological cut optimization.

In this poster, we will present Λ_c reconstruction using the Toolkit for Multivariate Data Analysis (TMVA)-Boosted Decision Trees (BDT) method with data from 2014. The improvement in the significance is notable compared to previous results using the TMVA-Rectangular Cut Optimization method. We will discuss the cut optimization for Λ_c in different transverse momentum (p_T) and centrality bins with the TMVA-BDT method.

Λ_c Decay Topology

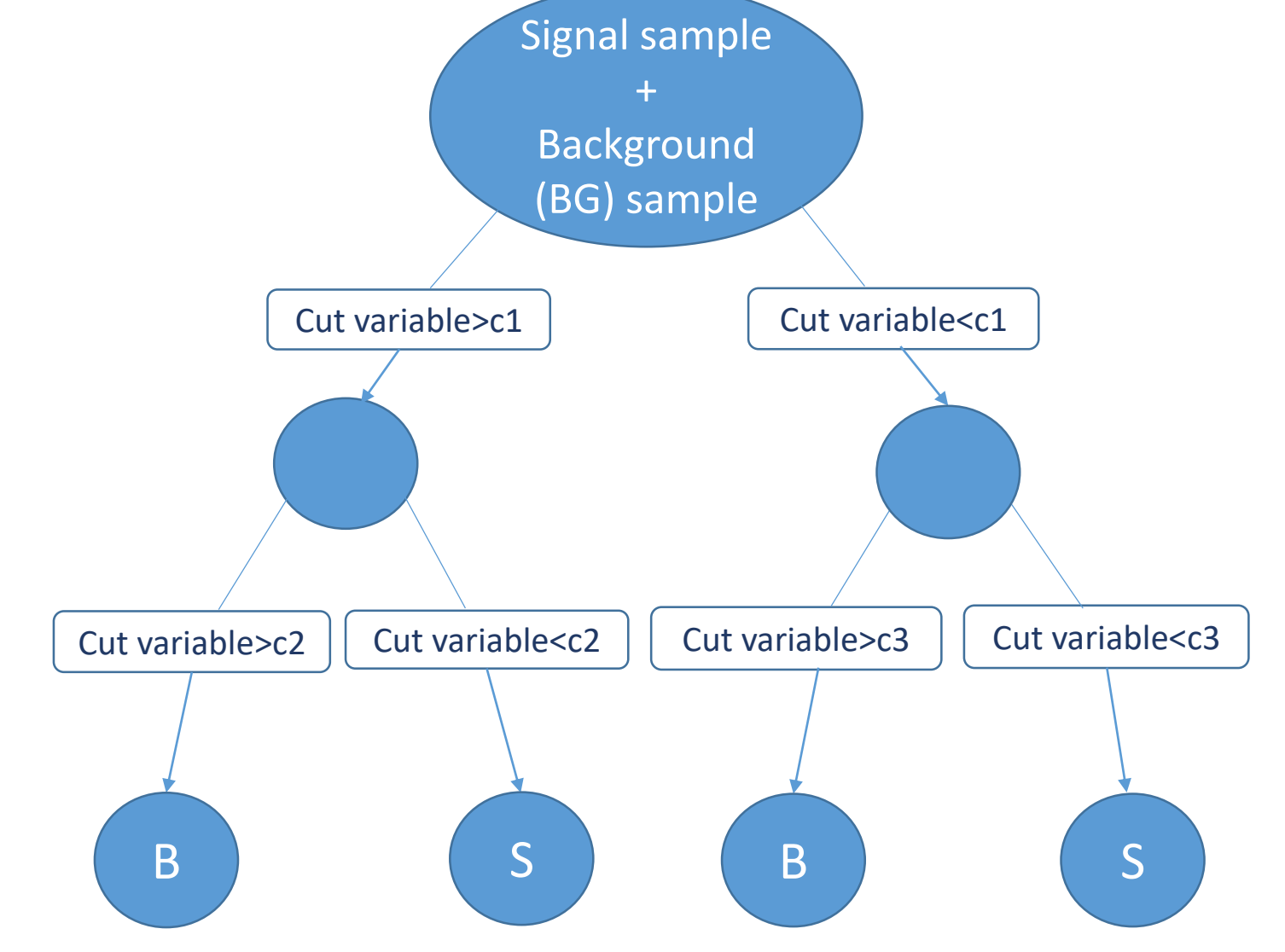
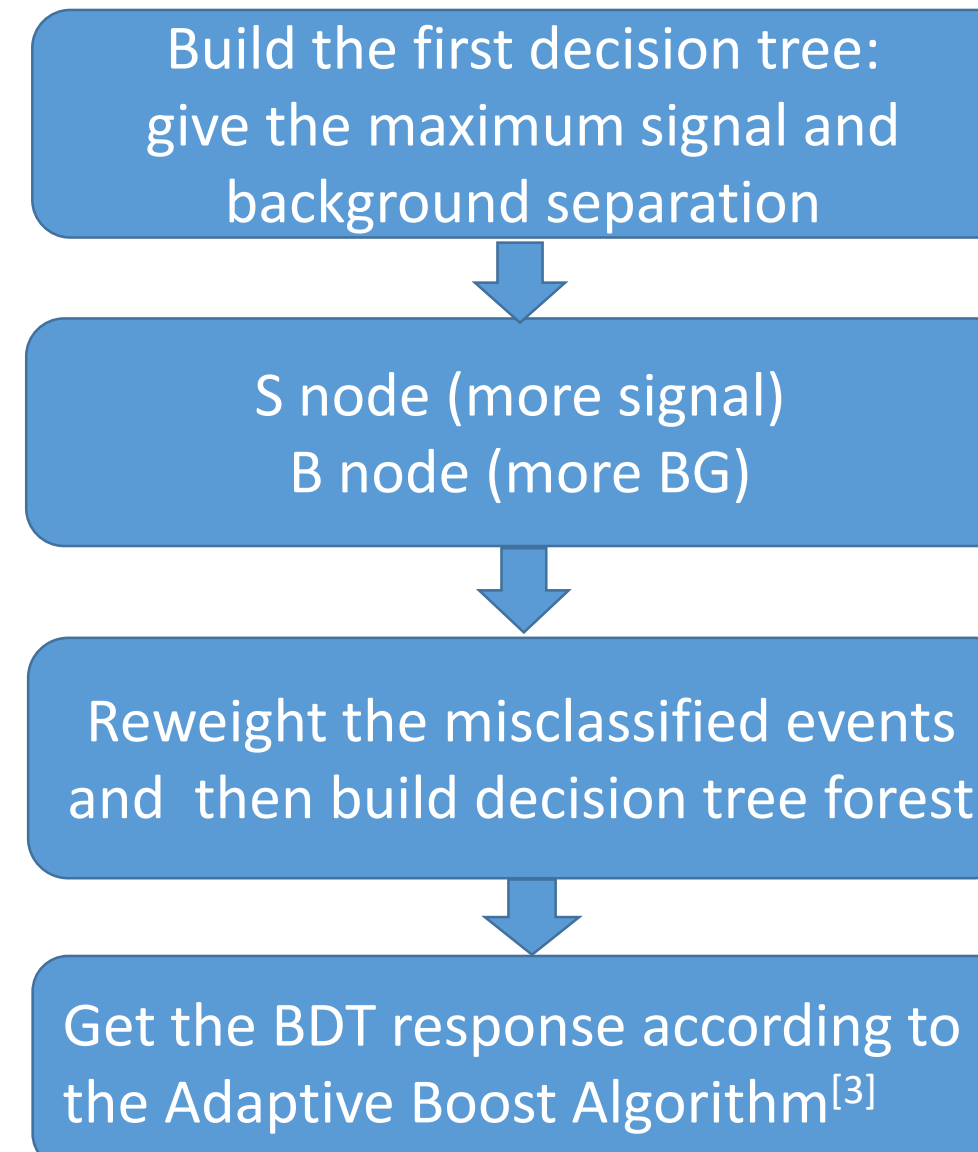
Constituent quarks	$u d c (\bar{u} \bar{d} \bar{c})$
$c\tau$	60 μm
Mass	2286 MeV/ c^2
Right-sign	$K^+ \pi^- \bar{p}, K^- \pi^+ p$
Wrong-sign	$K^+ \pi^+ \bar{p}, K^- \pi^- \bar{p}, K^+ \pi^- p, K^- \pi^+ p$



Cut variables used for TMVA-BDT: daughter pion, Kaon and proton DCA to the primary vertex, DCA between daughters, $\cos\theta$ (θ is shown on the right picture), Decay Length of Λ_c .

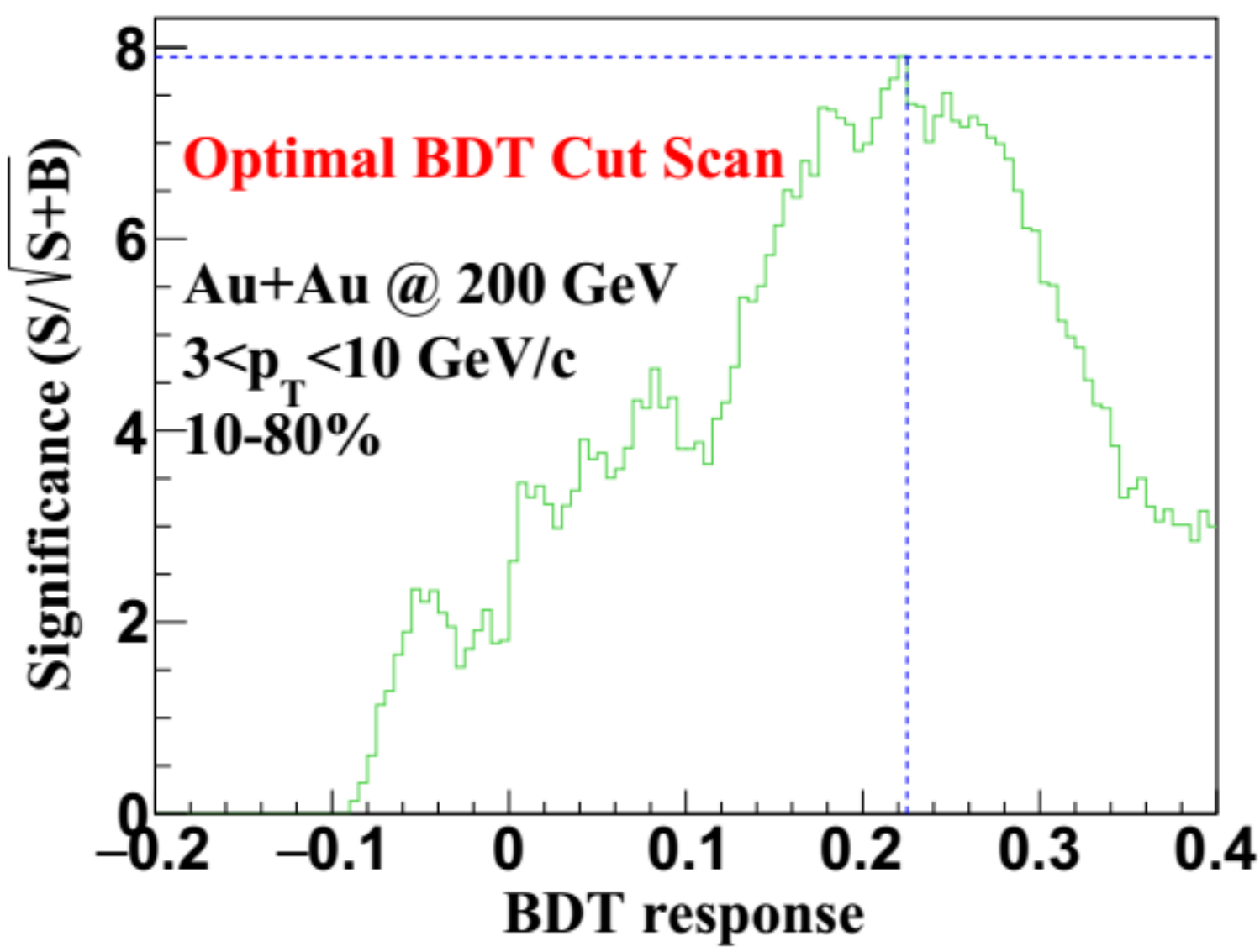
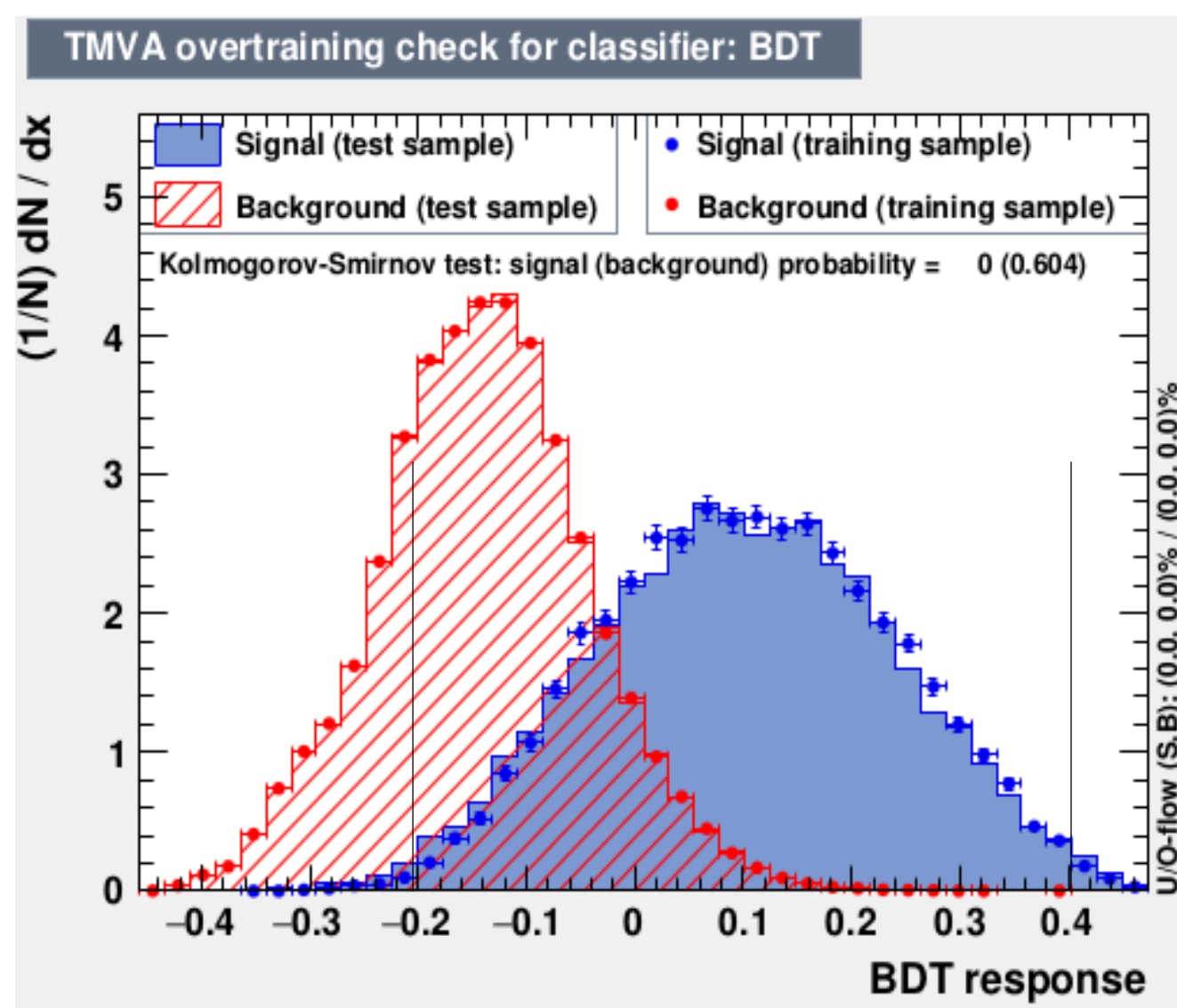
1

TMVA-Boosted Decision Trees



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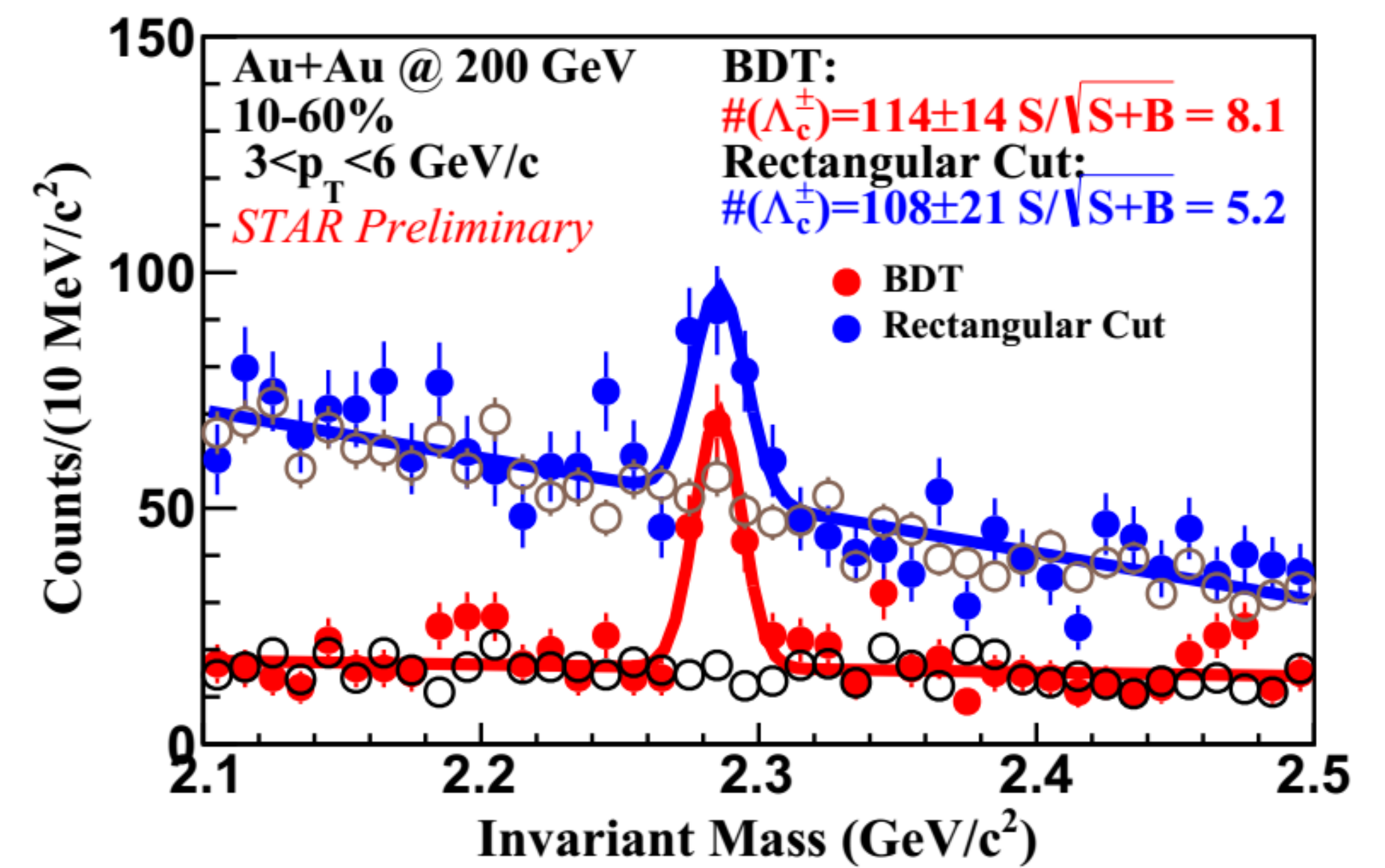
BDT Training and Cut Scan



- Λ_c signal sample is from simulation - Event Generator (EvtGen) + data-driven fast simulator. Background sample is from experimental data.
- Left: one half of the sample was used for the training (symbols) and the other was used to perform the over-training test (curves). -> Consistent with each other: no over-training.
- Right: scan the BDT response from -0.2 to 0.4 to obtain the optimal BDT cut (0.225).

3

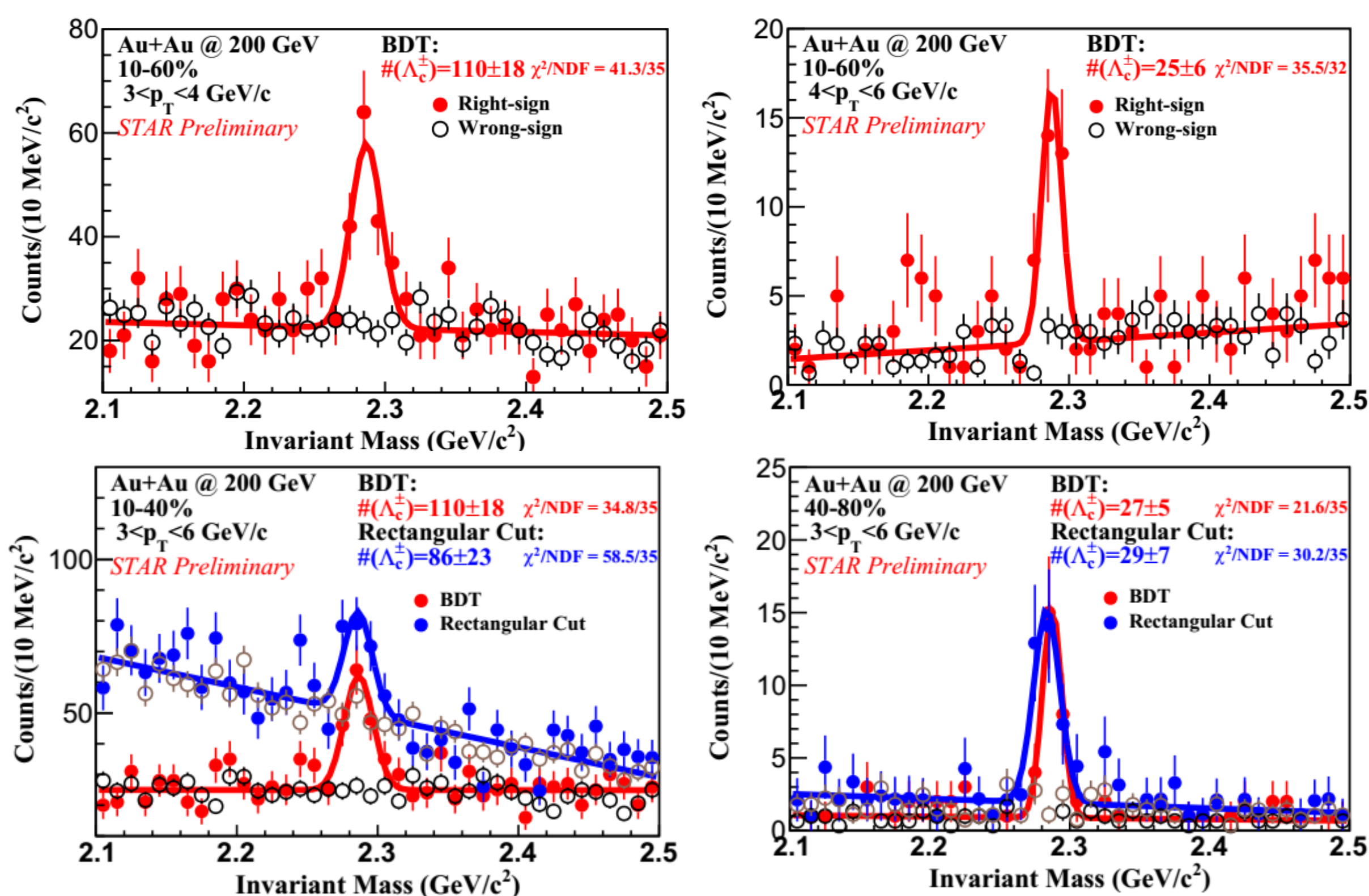
Λ_c Reconstruction Results



- 2014 data, ~ 900 M events: Λ_c candidates from right-sign combination (solid symbols) and background from wrong-sign (open symbols).
- Raw counts and significance are calculated within 3 sigma range by bin counting.
- Compared to the reconstruction result using the TMVA-Rectangular Cut method^{[4][5]}, the TMVA-BDT method increases the significance by about 50%.

4

p_T and Centrality Dependence



	Range	Rectangular Cut	BDT
Significance	$3 < p_T < 4$ GeV/c, 10-60%	4.5	6.7
Significance	$4 < p_T < 6$ GeV/c, 10-60%	4.0	4.2
Significance	$3 < p_T < 6$ GeV/c, 10-40%	4.1	6.6
Significance	$3 < p_T < 6$ GeV/c, 40-80%	4.5	5.1

5

Summary

- Extraction of Λ_c signal from Au+Au data has been optimized using the TMVA-Boosted Decision Trees method in different centrality and p_T bins.
- Compared to the TMVA Rectangular Cut method, the TMVA-BDT method improves the signal significance for Λ_c by about 30-50% depending on p_T and centrality.

6

References

- C. Patrignani et al. (Particle Data Group), Chin. Phys. C, 40, 100001 (2016) and 2017 update.
- Miroslav Šimko for the STAR Collaboration, Measurement of Λ_c baryon production in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV with the STAR experiment.
- A. Hoecker et al. TMVA - Toolkit for Multivariate Data Analysis, PoS ACAT 040 (2007), arXiv:physics/0703039.
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