Flavour Anomalies:
Weekly Update

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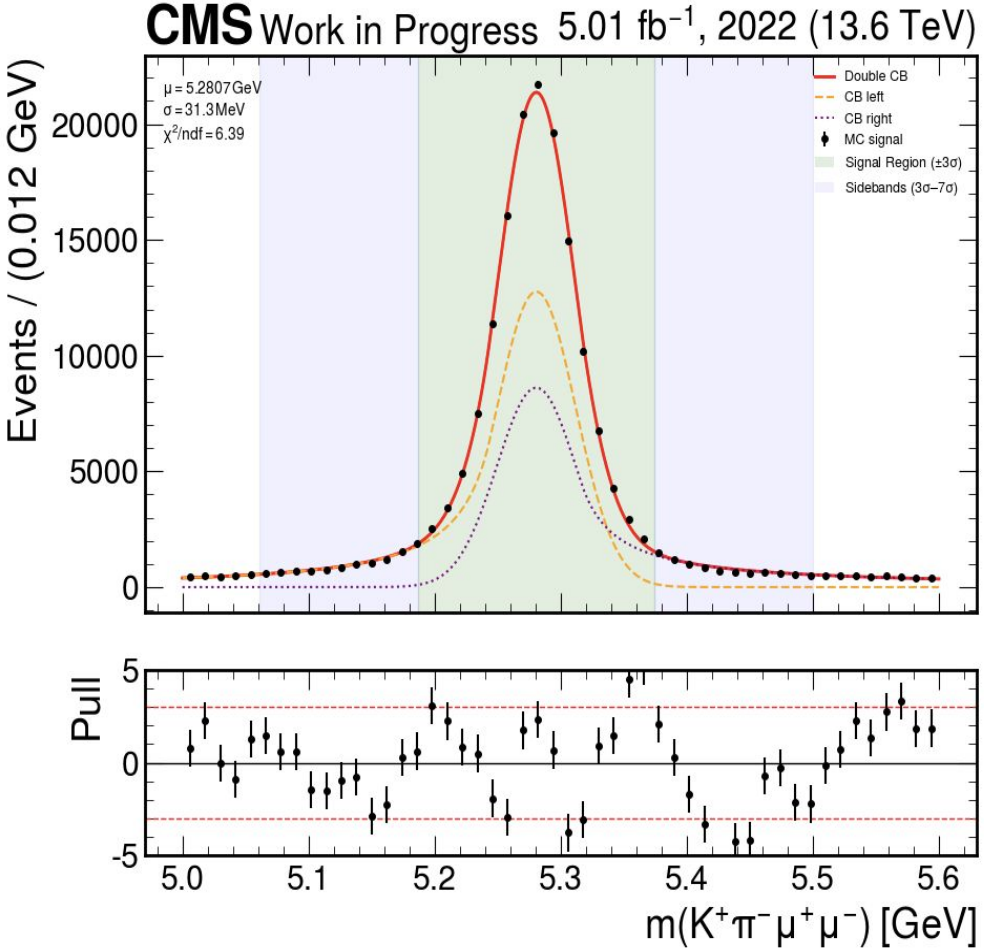
Machine Learning Analysis

Variable	Condition	Description
MuMu_pt	> 6.9	Dimuon transverse momentum.
MuMu_svprob	> 0.1	Vertex fit probability.
MuMu_l_xyMuMu_l_xy_unc	> 3	Vertex displacement significance.
MuMu_fit_cos2D	> 0.9	Cosine of pointing angle.
$M_{K\pi} - 0.896$	$< M_{\pi K} - 0.896$	$K^*(892)$ mass hypothesis (absolute-value comparison).
BToTrkTrkMuMu_fit_l1_pt	> 4	Muon 1 transverse momentum.
BToTrkTrkMuMu_fit_l1_eta	< 2.4	Muon 1 pseudorapidity.
BToTrkTrkMuMu_fit_l2_pt	> 4	Muon 2 transverse momentum.
BToTrkTrkMuMu_fit_l2_eta	< 2.4	Muon 2 pseudorapidity.
BToTrkTrkMuMu_fit_trk1_pt	> 0.8	Hadron track transverse momentum.
BToTrkTrkMuMu_fit_trk1_eta	< 2.4	Hadron track pseudorapidity.
HLT_DoubleMu4_LowMass_Displaced	$= 1$	Trigger requirement.
Muon_softMvaRun3	> 0.74 (both)	Muon ID quality.
BToTrkTrkMuMu_fit_mass_Kpi	$5.0 < m < 5.133542769$ or $5.416657231 < m < 5.6$	Sideband regions.

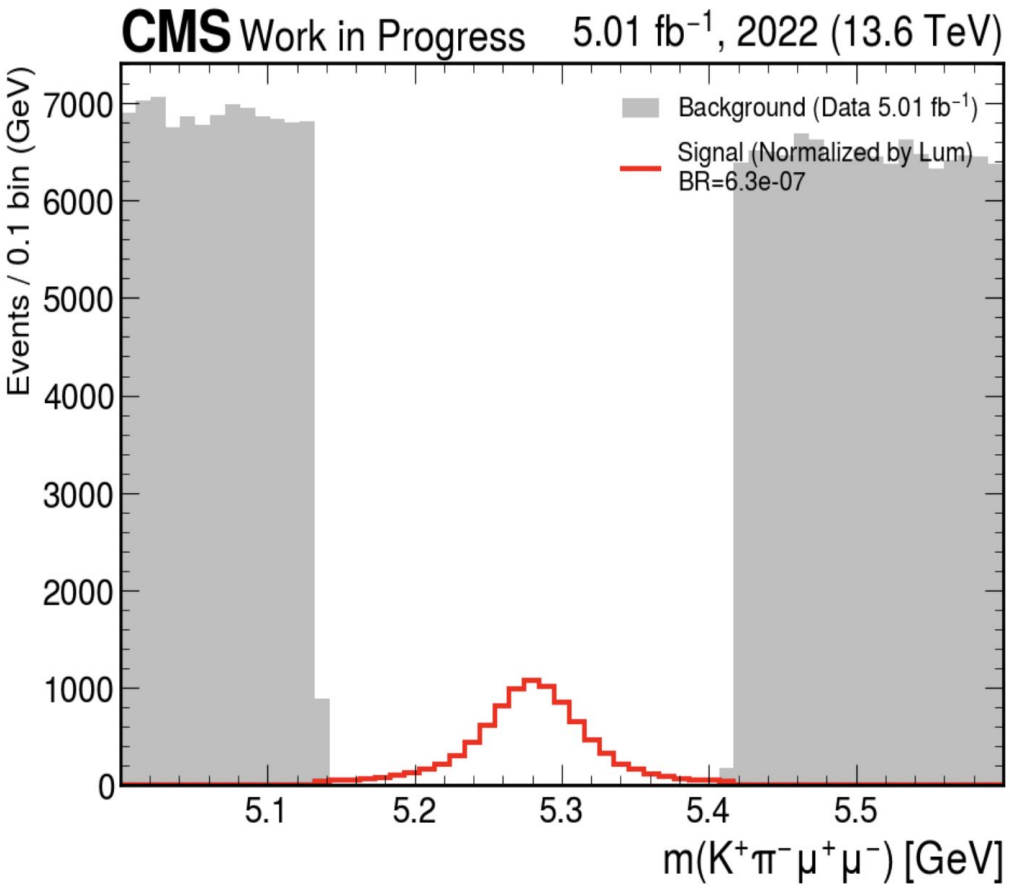
- Also the dimuon mass cut in the region (1 - 2.9 , 4.0 - 4.8) GeV excluding the resonant channels, The above selections are the same as done in the Run II analysis and it's performed in the BPH Nano central production code.
- The selection includes requirements on the dimuon vertex fit quality, displacement significance, pointing angle, and the transverse momenta of final-state particles. Additional trigger and muon identification criteria are also imposed.

Machine Learning Analysis



- **Analysis Strategy:** The signal region is optimized using non-resonant dimuon Monte Carlo (MC) samples.
- **Signal Window:** Defined as the region within ±3σ of the B^0 mass mean ($MB^0 \pm 3\sigma$).
- **Background Region (Sidebands):** Defined as the mass range between 3σ and 7σ from the mean ($3\sigma < |MB^0| < 7\sigma$).

Machine Learning Analysis

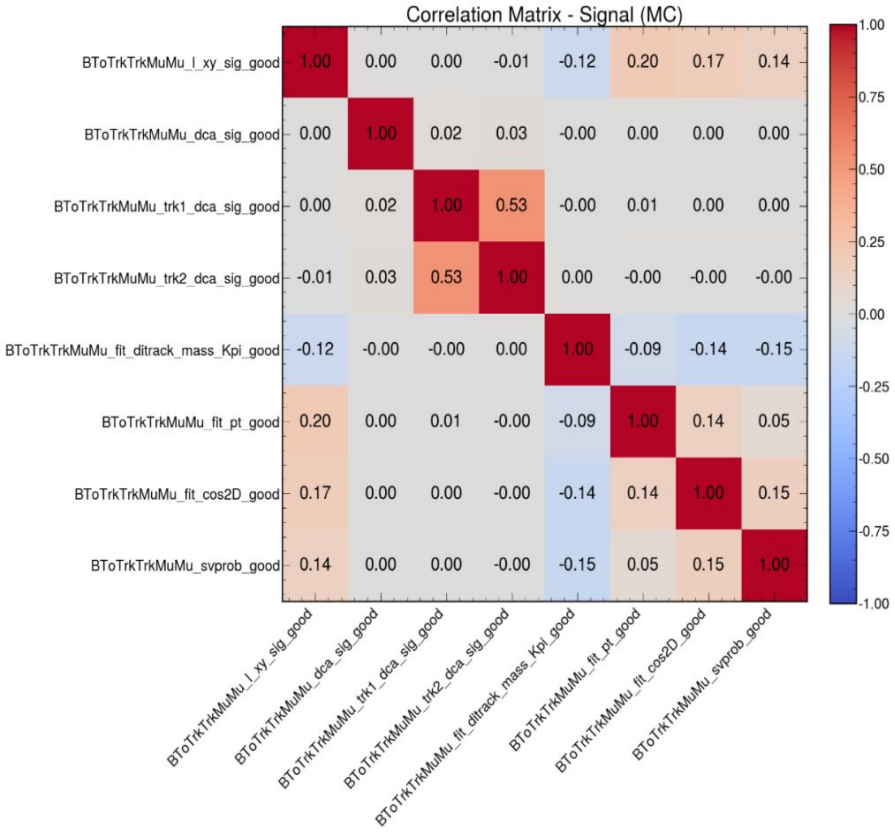


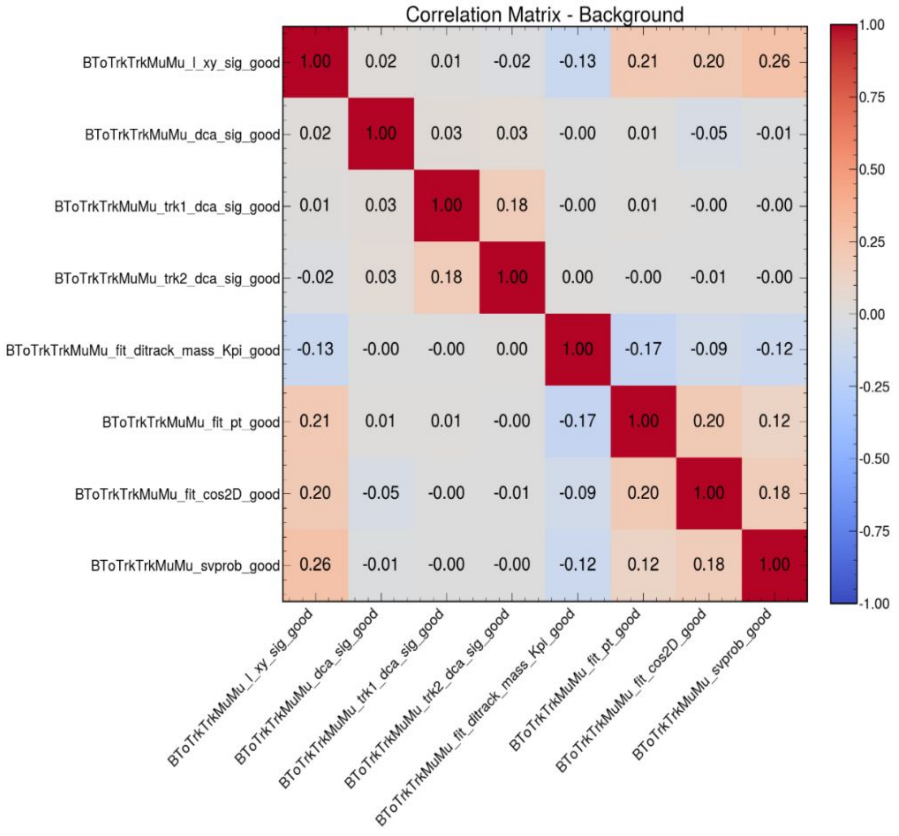
- **Grey Shaded Region:** Background data extracted from the defined sidebands (3σ−7σ).
- **Red Histogram:** Signal Monte Carlo (MC) distribution (B0 mass window).

Observation:

- The distributions are normalized by luminosity witch will be important to choose the best BDT output.

Machine Learning Analysis





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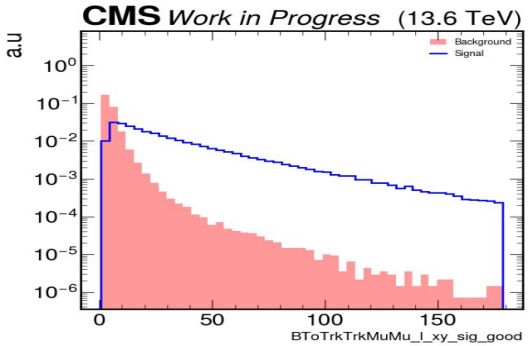

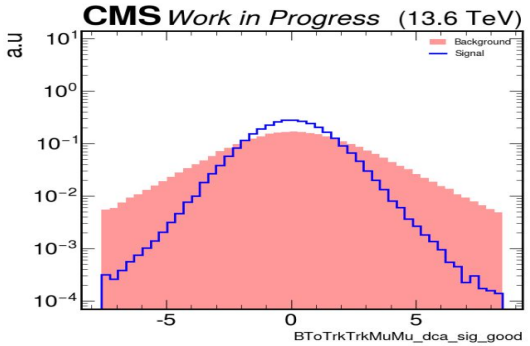

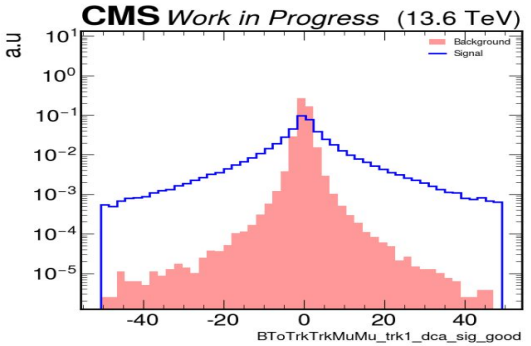

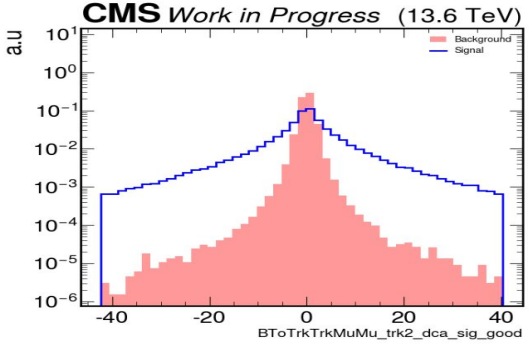

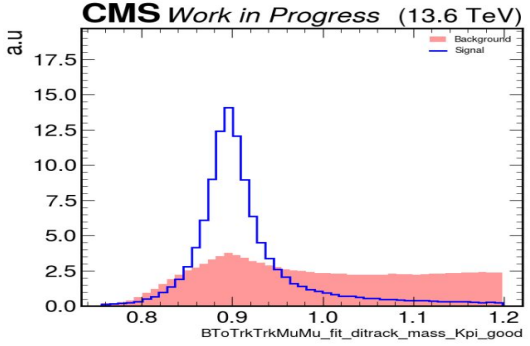

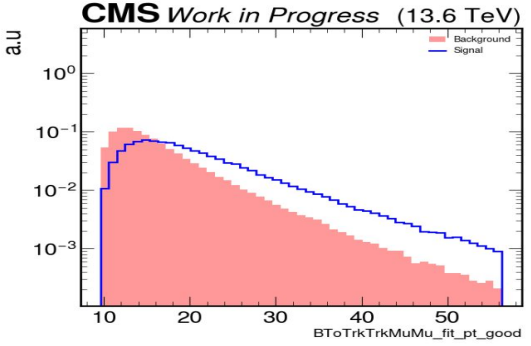

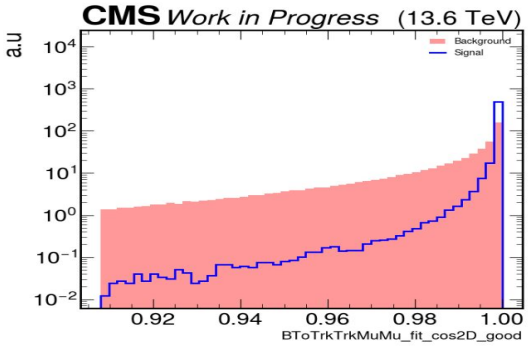

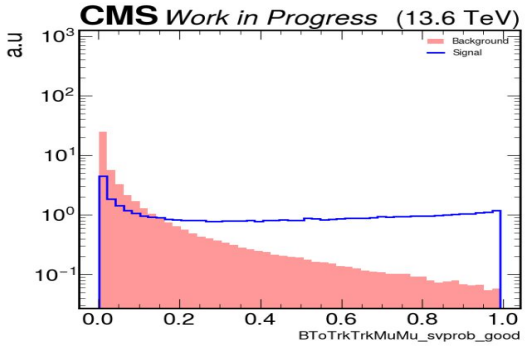

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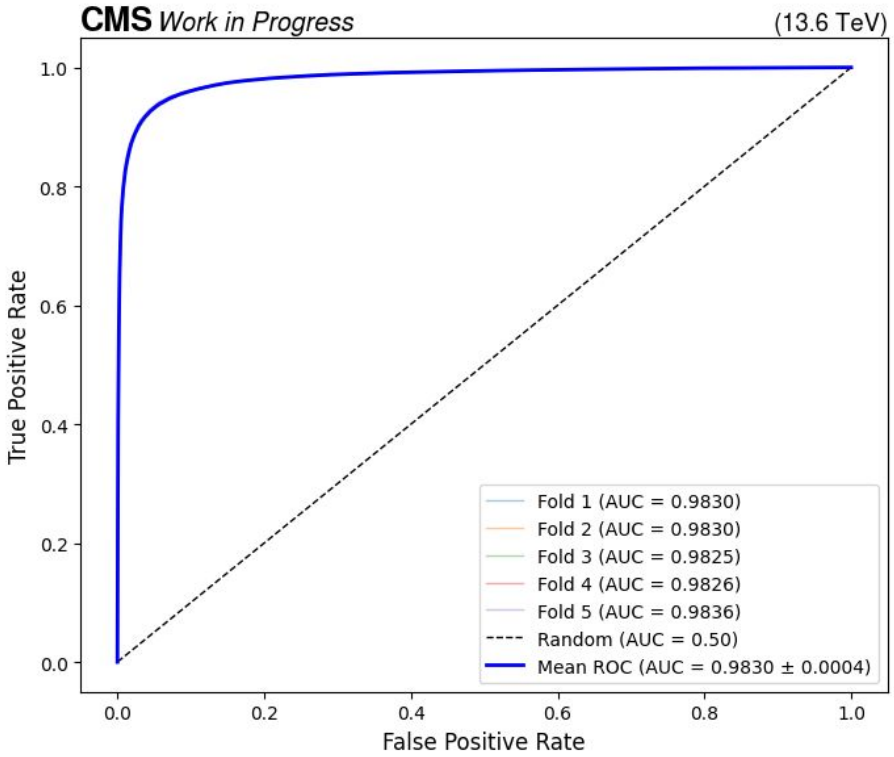
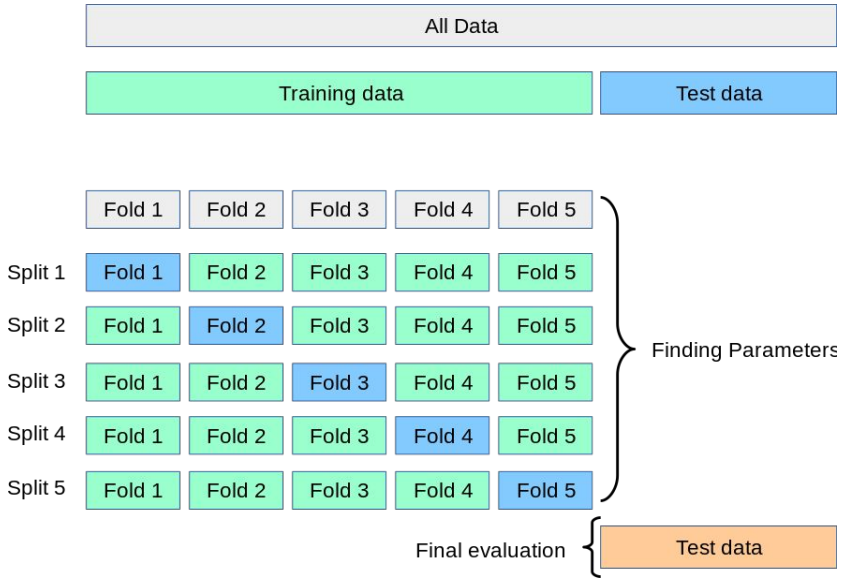
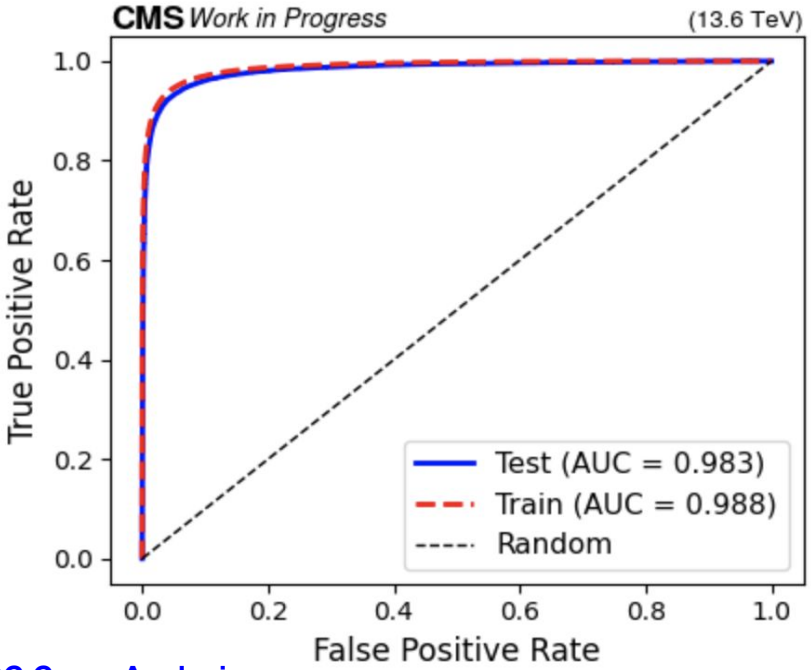
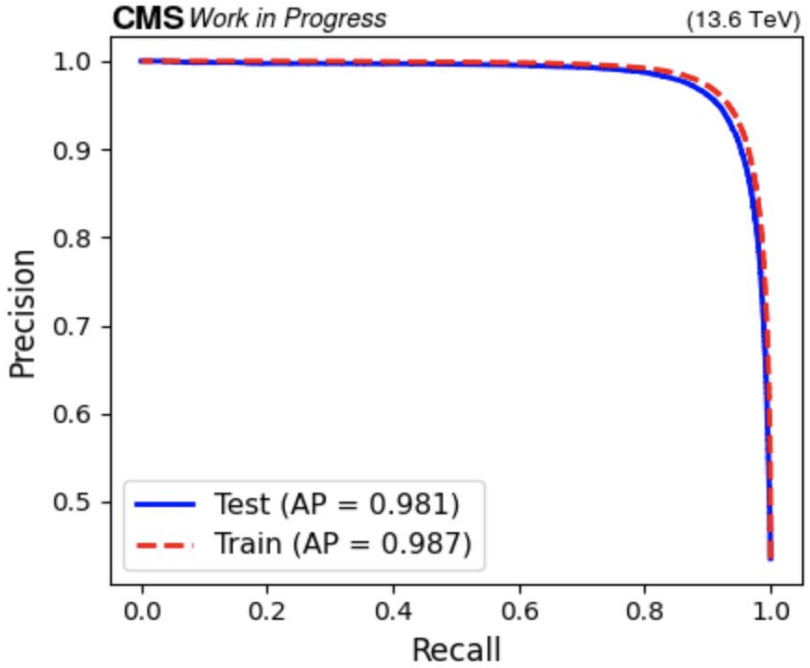




- The plot illustrates the ROC curves for each fold of the cross-validation process. The curves overlap perfectly, and the AUC values are consistent across all folds. This stability confirms that the BDT is robust and not overfitted to a specific subset of the Monte Carlo.

Machine Learning Analysis





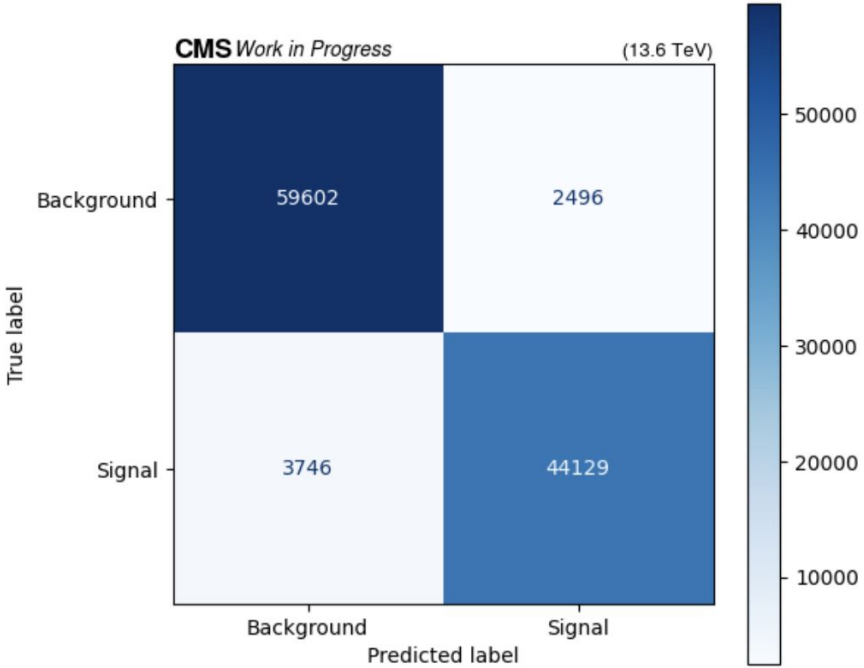
ROC Curve Analysis:

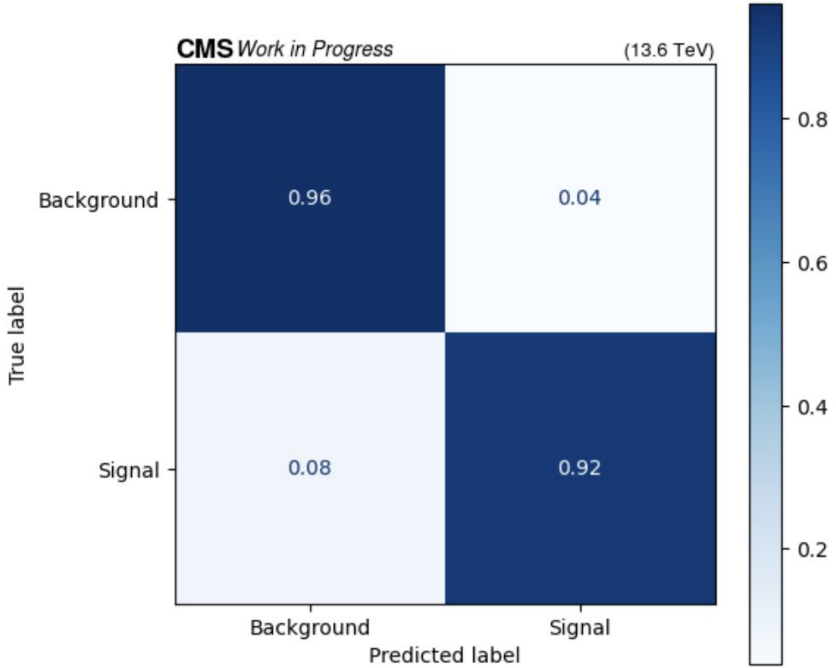
- Shows excellent discrimination power between Signal and Background.
- **Generalization:** Strong agreement between Training and Testing sets (overlapping curves), confirming no overtraining.

Precision-Recall (PR) Curve:

- Displays a significantly improved profile compared to the previous Monte Carlo sample.
- The shape indicates a more stable performance in the high-precision regime, validating the quality of the current MC simulation.

Machine Learning Analysis





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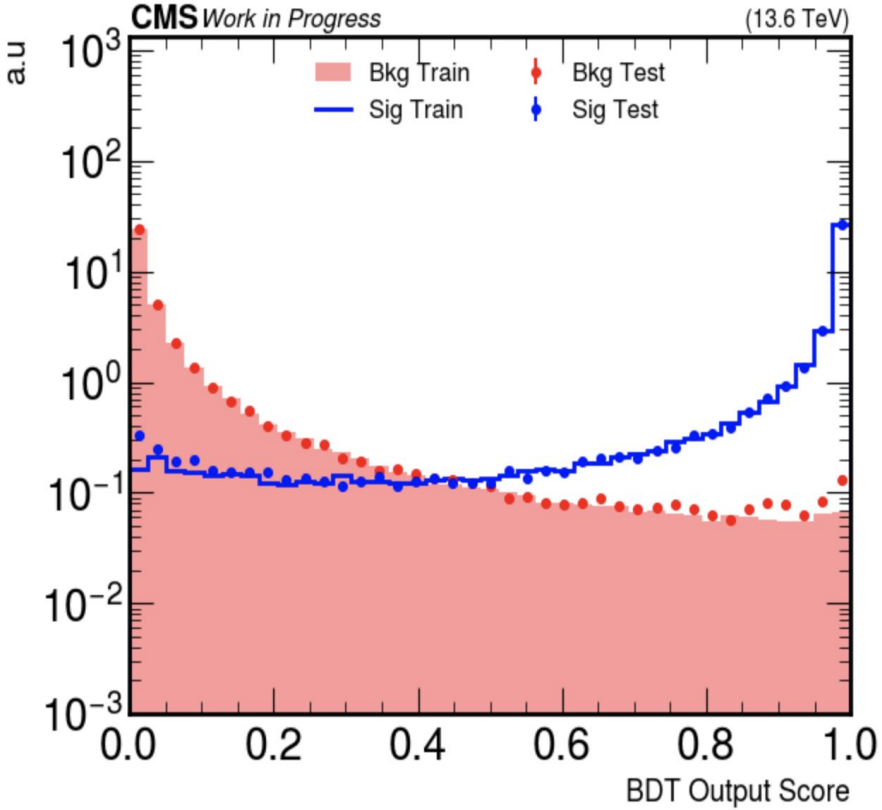

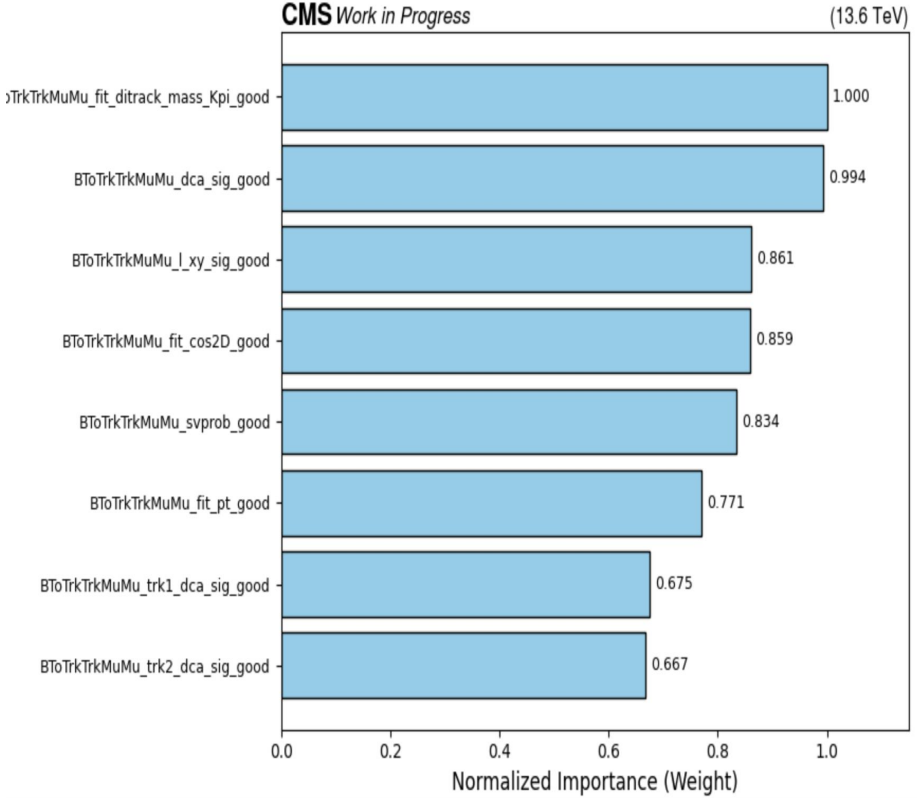

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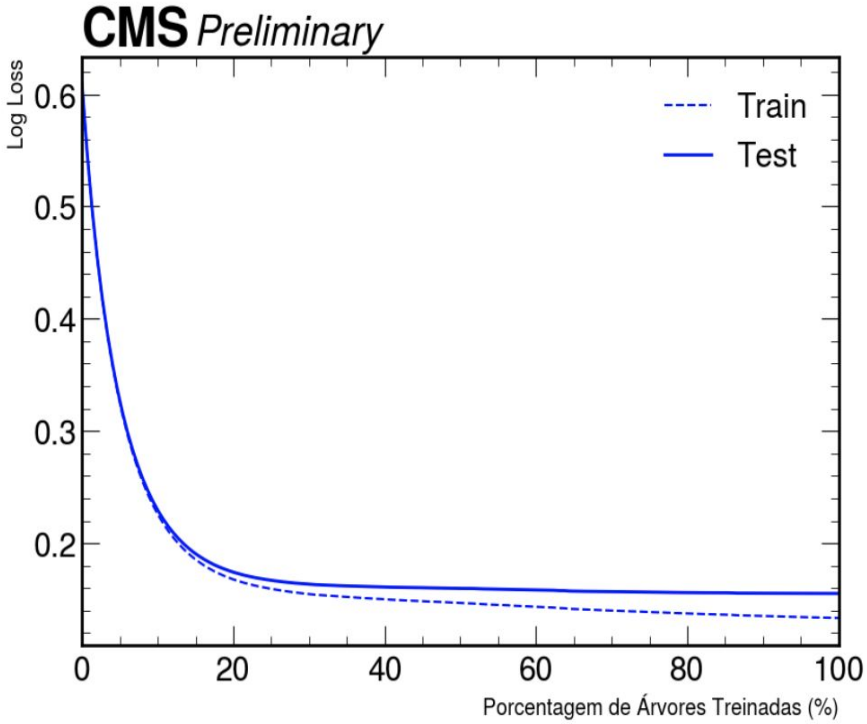

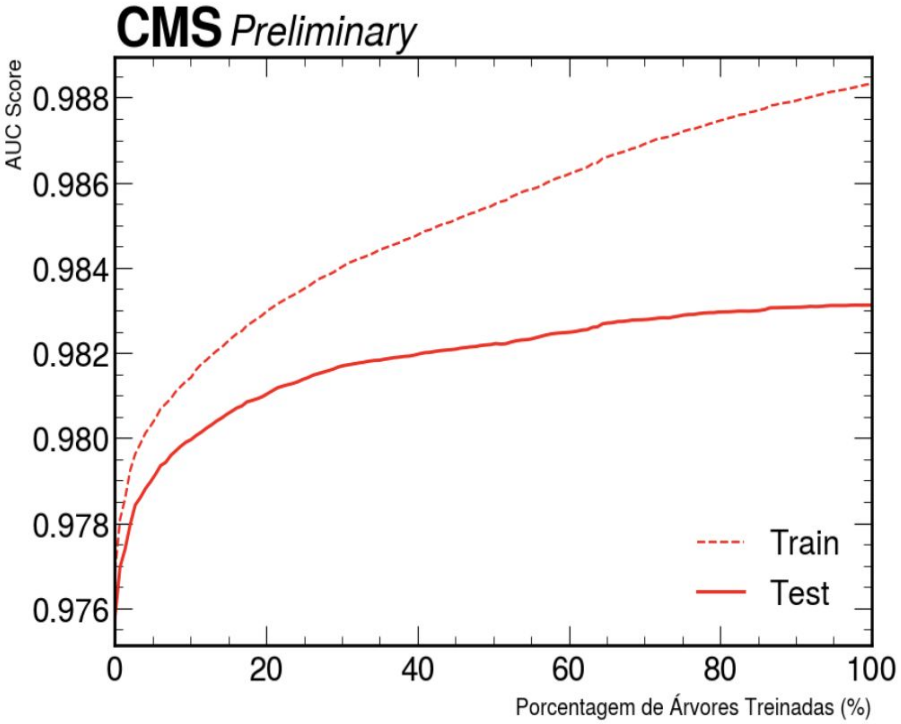

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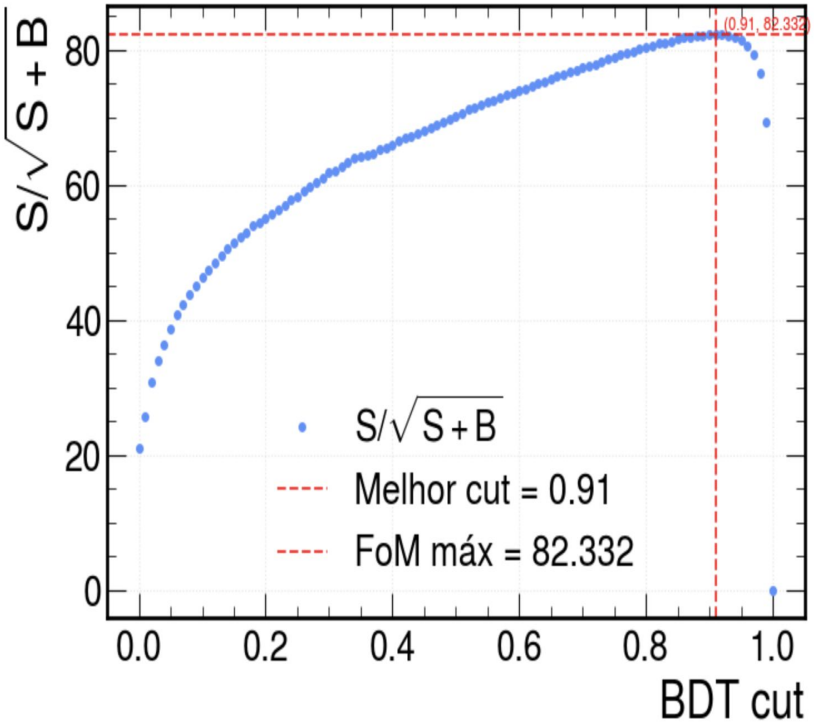
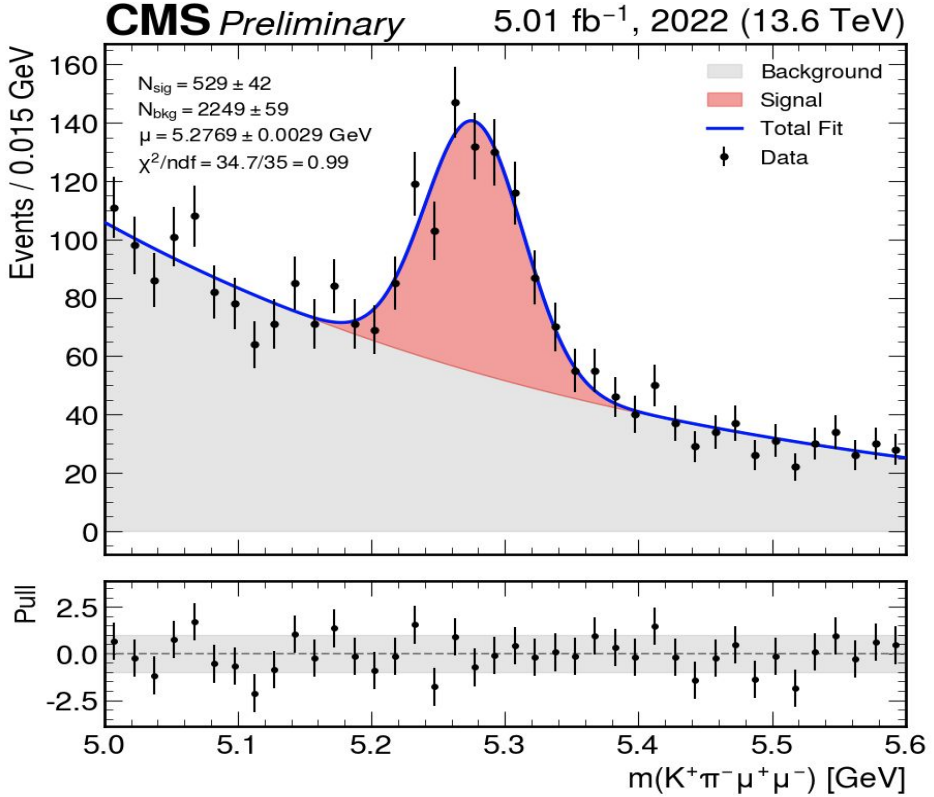
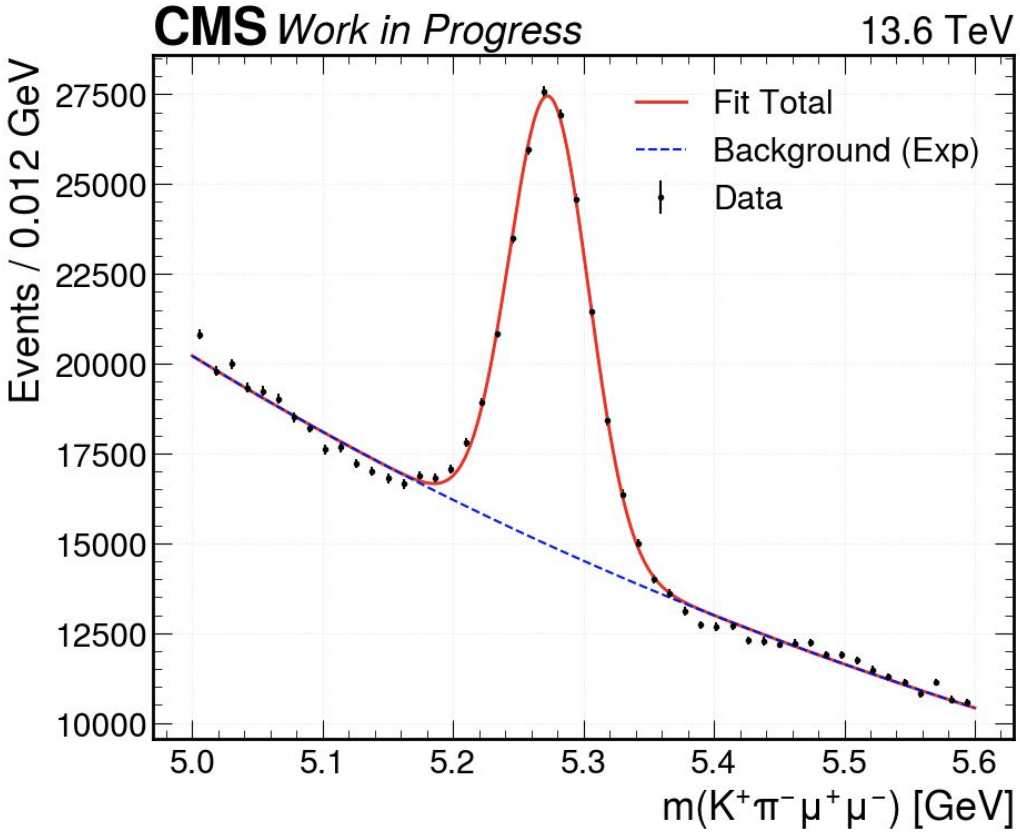




- Calculated using **normalized yields** (S,B) scaled to the target luminosity.
- Performed via a continuous scan over the BDT response range.
- The maximum value defines the final BDT selection threshold.

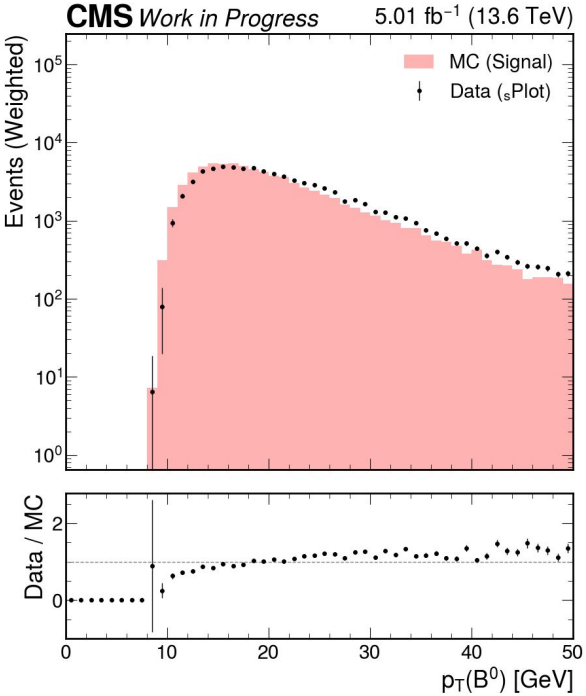
Comparison to MC

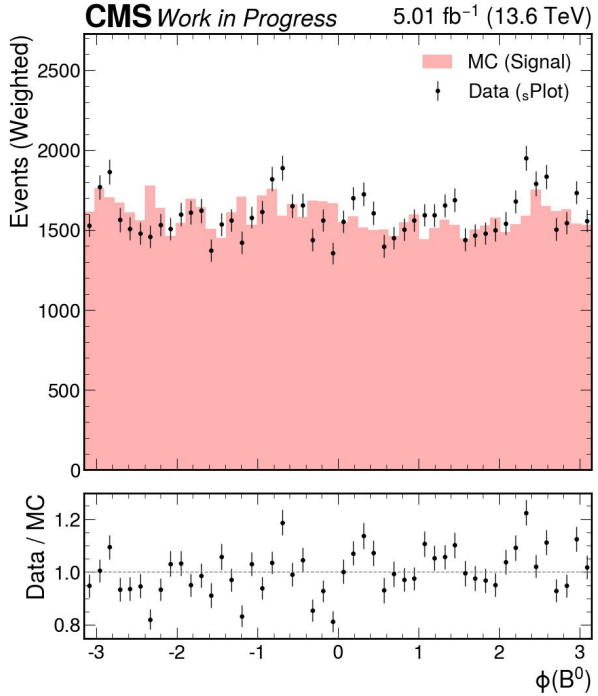


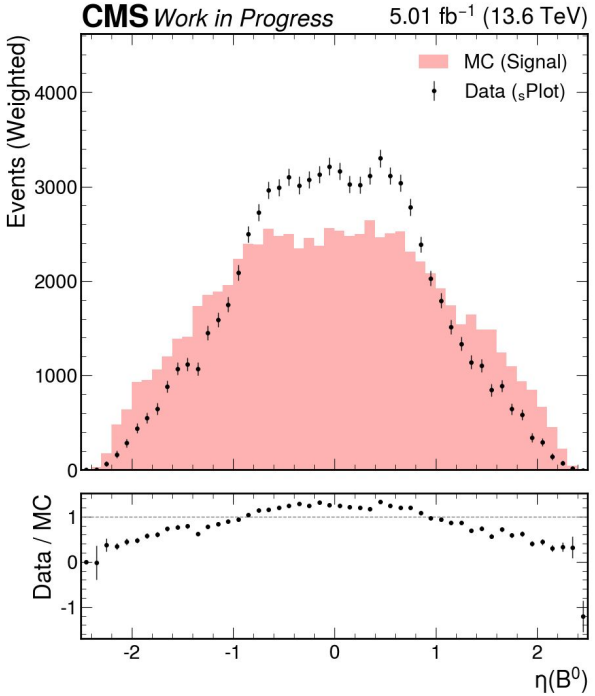
Validate the Monte Carlo simulation kinematics using the high-statistics $J/\psi \rightarrow \mu^+\mu^-$ resonant mode.

- Applied the **sPlot technique** to statistically subtract background from Data.
- The dimuon invariant mass was used as the discriminating variable to compute *sWeights*.

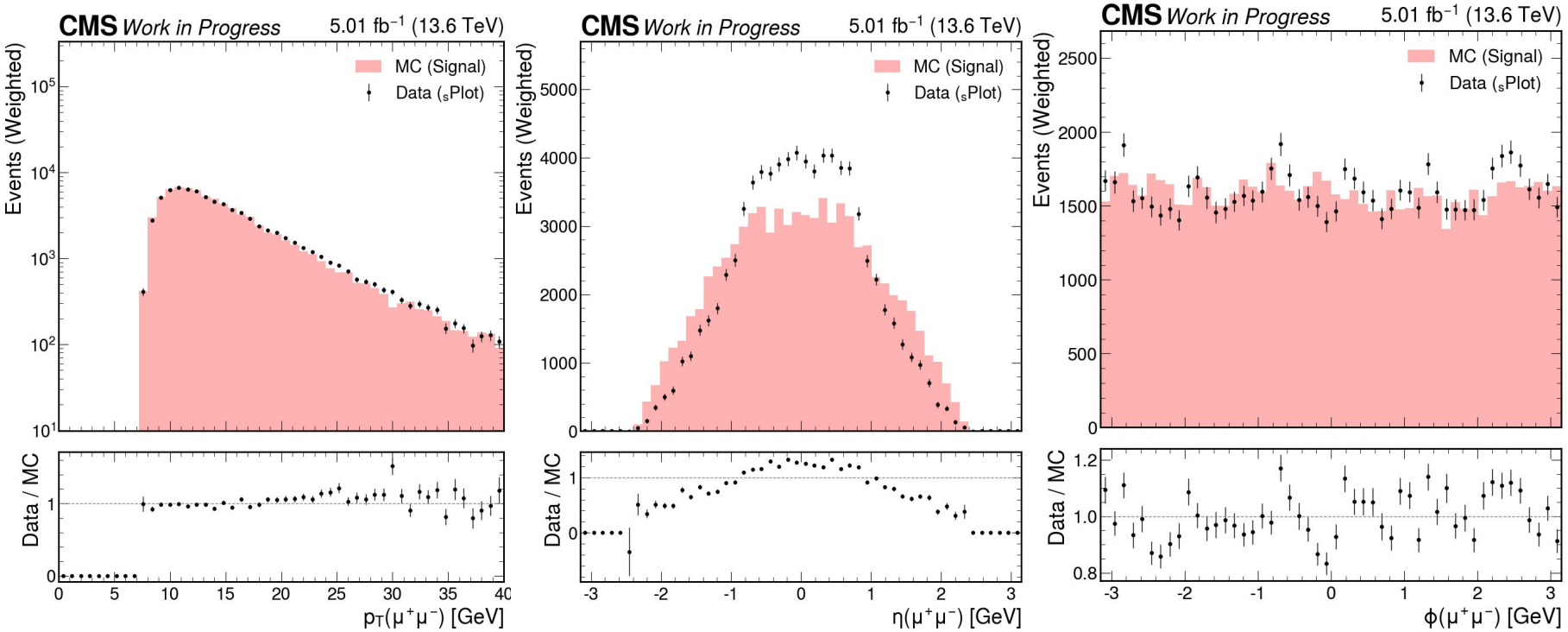
Comparison to MC







Comparison to MC



Next Steps

- Perform background studies (starting with the $B^+ \rightarrow J/\psi K^+$ channel).
- Apply BDT reweighting to improve Data/MC agreement.
- Implement additional MC corrections, Trigger selections, and Scale Factors.
- Analyze and correct for Flavour Mistag rates.
- Measure the Branching Fraction in bins of q2.
- **Goal:** Finalize the analysis BF for presentation at **ICHEP in poster format**.

Thanks for the attention !!!

DataSets

/ParkingDoubleMuonLowMass*/Run2022C-PromptReco-v1/MINIAOD, * [0-7]

/BdToJpsiKstar_BMuonFilter_SoftQCDnonD_TuneCP5_13p6TeV_pythia8-evtgen/Run3Summer22MiniAODv4-130X_mcRun3_2022_realistic_v5-v2/MINIAODSIM

/BdtoKstar2Mu_KstartoKPi_MuFilter_TuneCP5_13p6TeV_pythia8-evtgen/Run3Summer22MiniAODv4-130X_mcRun3_2022_realistic_v5-v2/MINIAODSIM