A Boosted Decision Tree Model for the Positron Acceptance in the Muon g-2 Experiment

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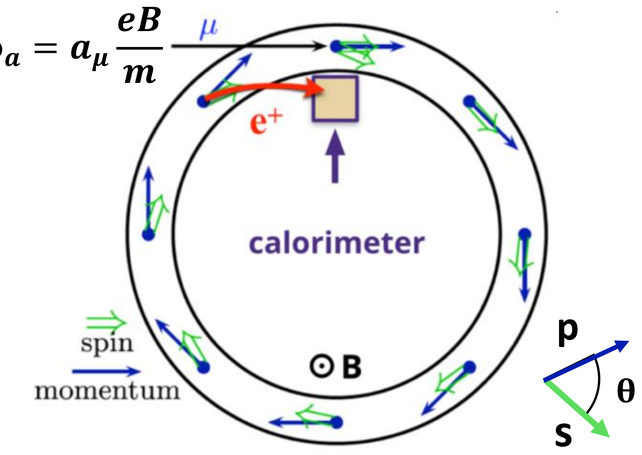
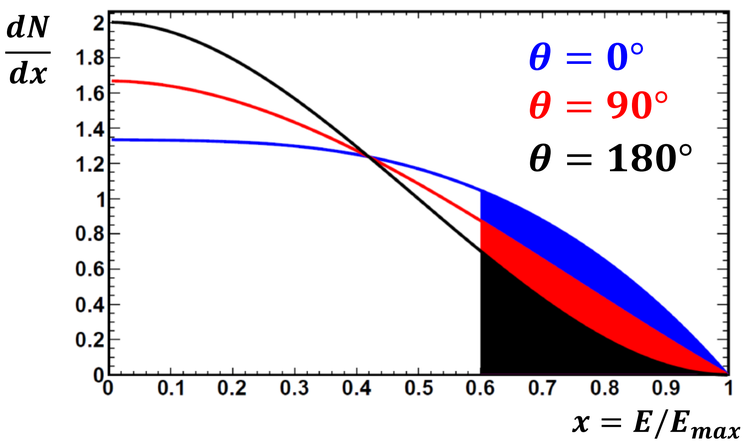
Measurement of Muon's Magnetic Anomaly

Anomalous Spin Precession

$$\omega_a = a_\mu \frac{eB}{m}$$

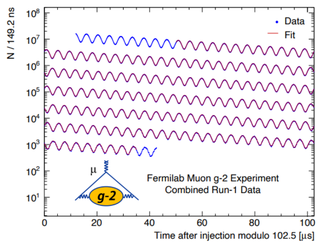


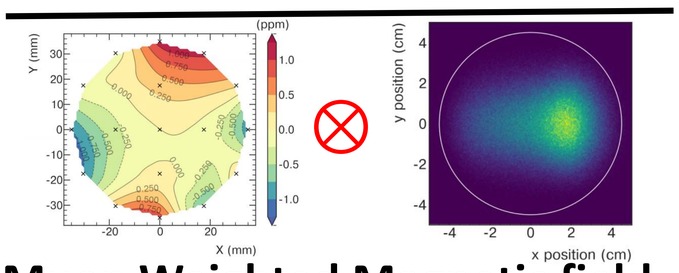
e^+ Energy Spectrum Modulation at ω_a



$$a_\mu \propto$$

ω_a Analysis

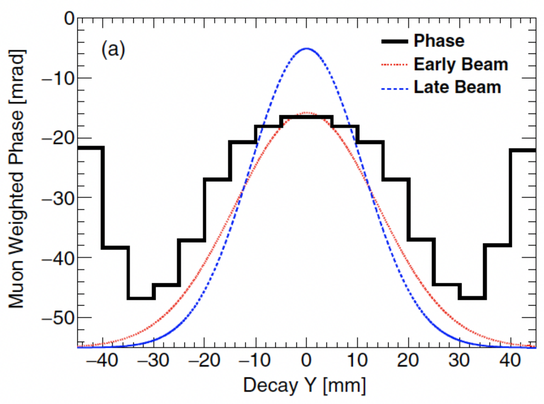




Muon Weighted Magnetic field

Phase-Acceptance Systematic Correction to ω_a

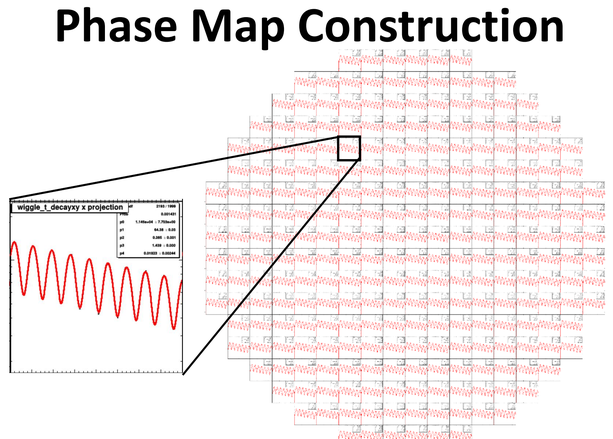
Time Dependent Shift in Fitted ω_a Phase



$$\frac{d\phi}{dt} = \frac{dY_{RMS}}{dt} \cdot \frac{d\phi}{dY_{RMS}}$$

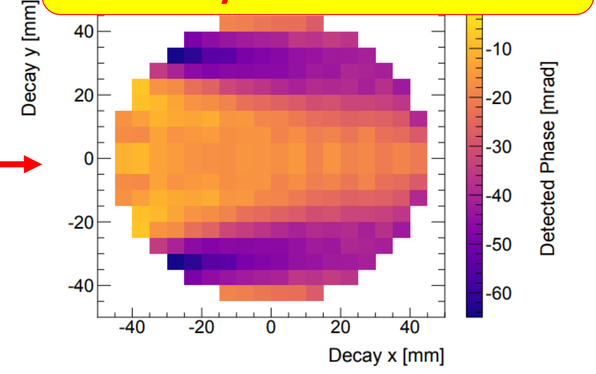
1. Time dependent beam effect
2. Dependent of phase on decay position (Phase-acceptance)

Phase Map Construction



$$N(t) = N_0\, e^{-t/\tau}\,[1 + A\cos(\omega_a t + \phi_a)]$$

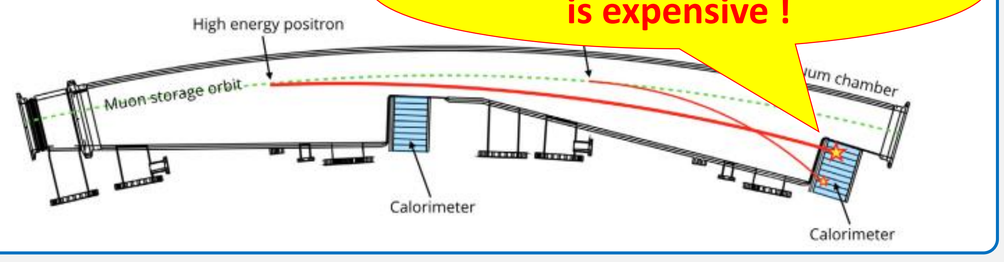
$\Delta\phi \sim 2$ mrad
Limited by Geant4 simulation !



Fast Simulation of Muon Storage Ring

1. Muon beam & spin dynamics → Analytical calculation or Beam Optics Simulations (eg: BMAD, COSY)
2. Muon decay to positrons → Geant4 MuonDecayWithSpin Class
3. Positron transportation and EM Shower Development → Model with Machine Learning **(this work)**

Geant4-based simulation is expensive !

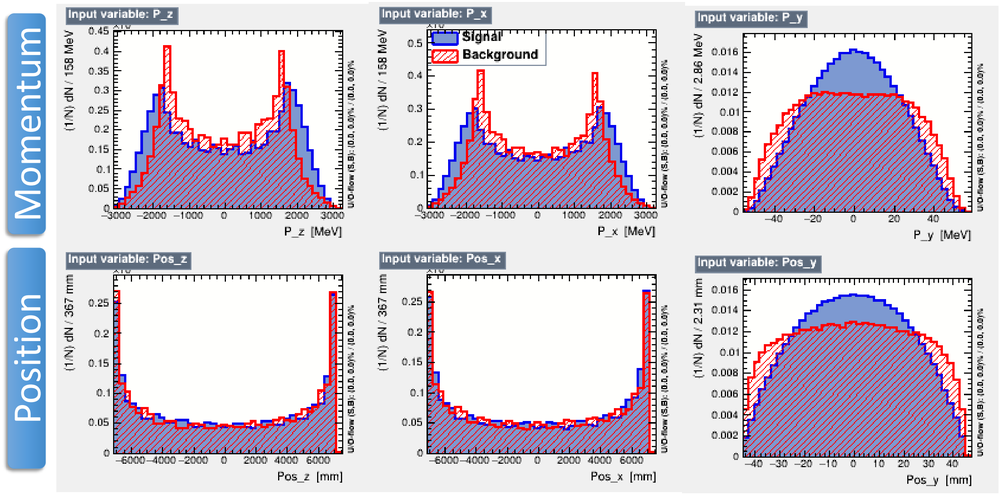


Energy Deposition in Calorimeters via Boosted Decision Tree Algorithm

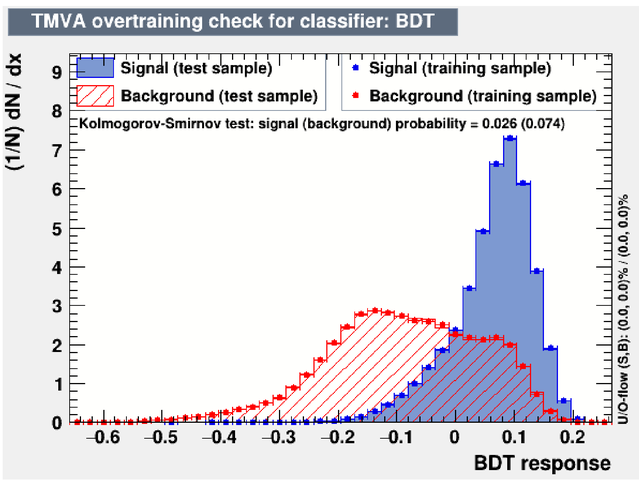
Signal :
Energy Deposition > 1.6GeV

Background: Otherwise

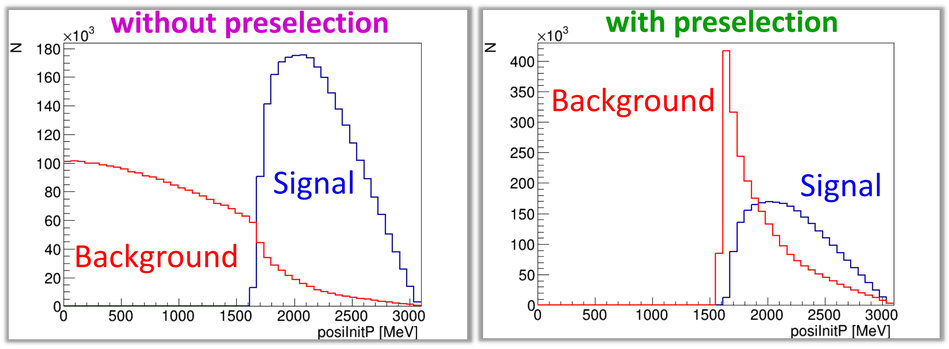
Input variables for training (from gm2ringsim simulation)



BDT Training (TMVA's AdaBoost)

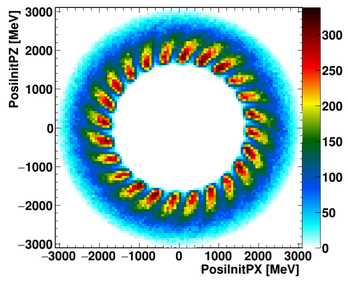


Data Preselection Cut: Energy>1.6 GeV

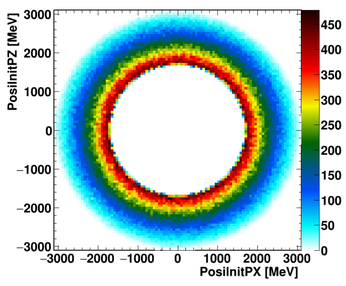


BDT Application

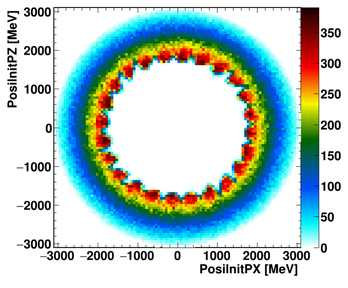
Monte-Carlo Truth



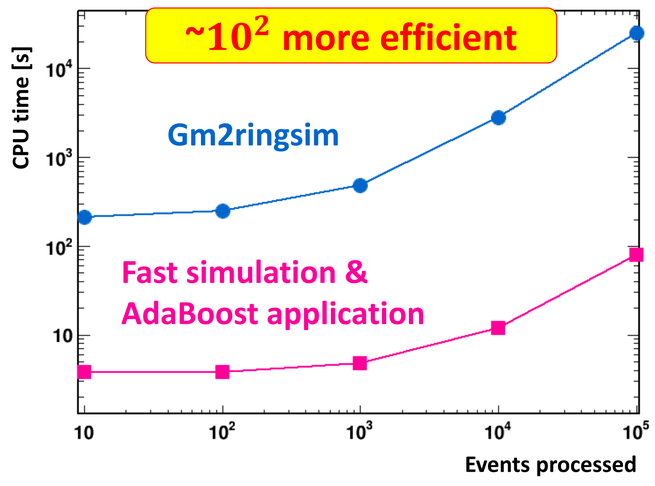
Data Preselection



BDT Prediction

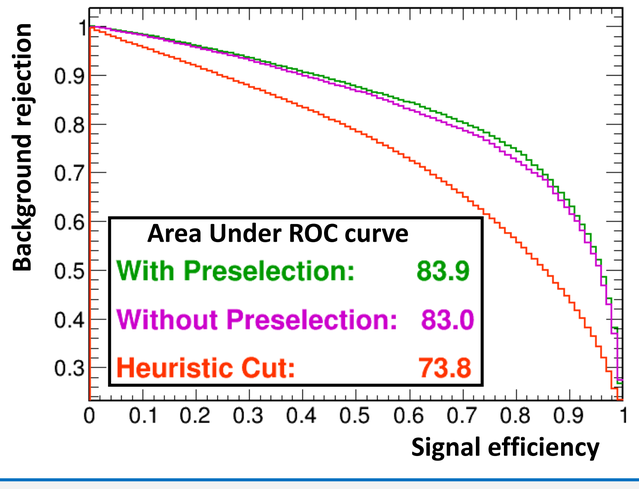


Performance Benchmark



Model trained at preselected data have higher area under ROC curve

Receiver Operating Characteristic Curves



References

A. Hoecker *et al*. *TMVA: The toolkit for multivariate data analysis*, (Preprint arXiv:physics/0703039) (2007)

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