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

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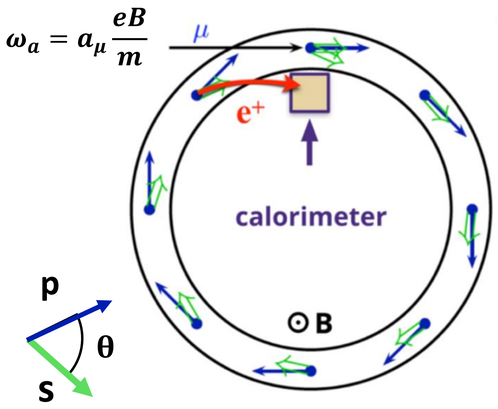
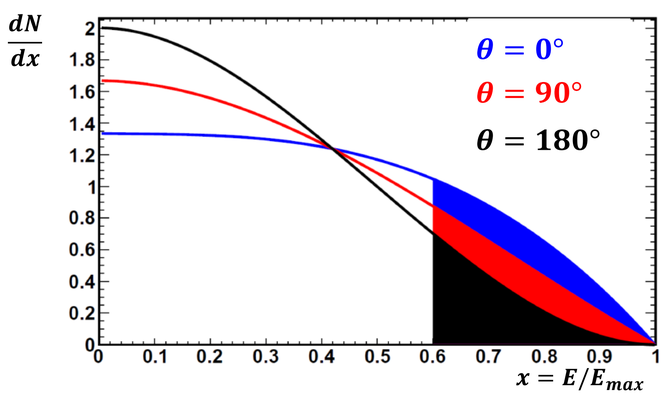
## Muon's Magnetic Anomaly

### Anomalous Spin Precession

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

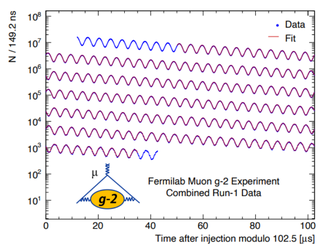


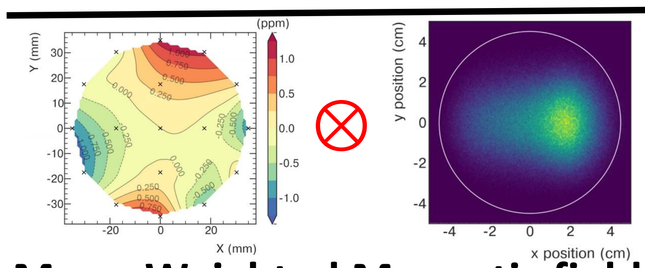

### $e^+$ Spectrum Modulation




### $\omega_a$ Analysis

$a_\mu \propto$



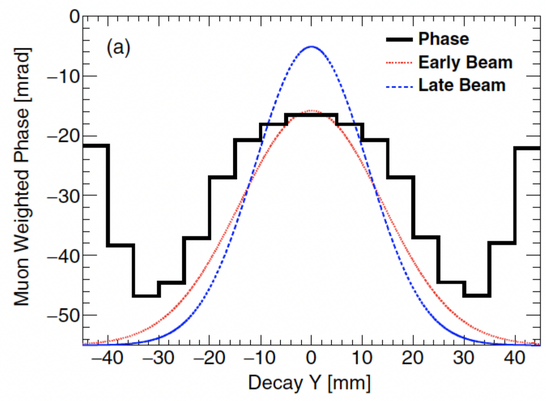




### Muon Weighted Magnetic field

## Phase-Acceptance Systematic Correction

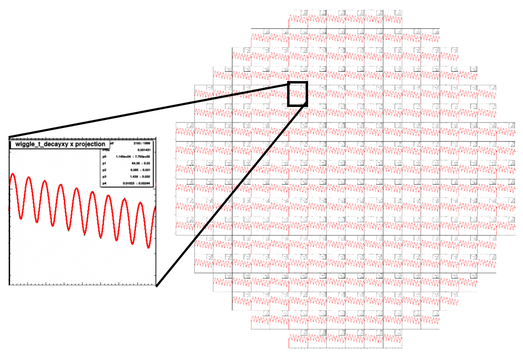
### Time Dependent Shift in Fitted $\omega_a$ Phase




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

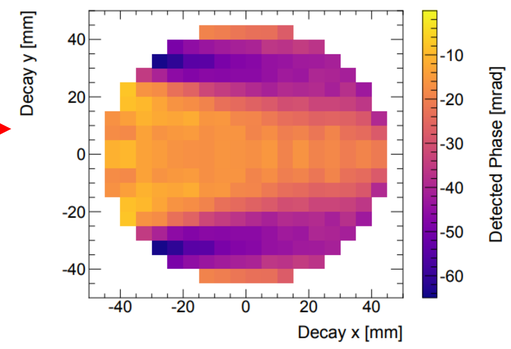
1. Time dependent beam effect
2. Dependent of phase on decay position (Phase-acceptance)

### Phase Map Construction



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

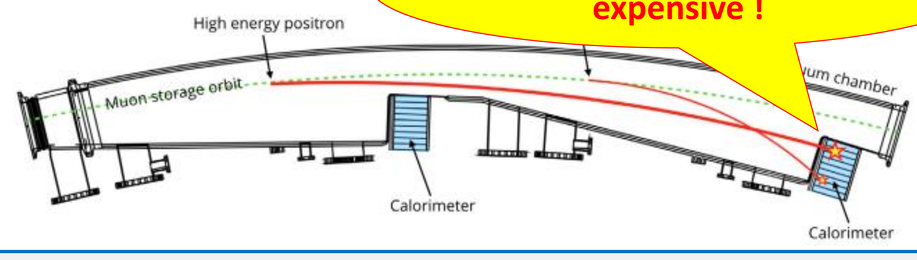
$\Delta\phi \sim 2$ mrad
Limited by Geant4 simulation !




## Fast Simulation of the 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 !



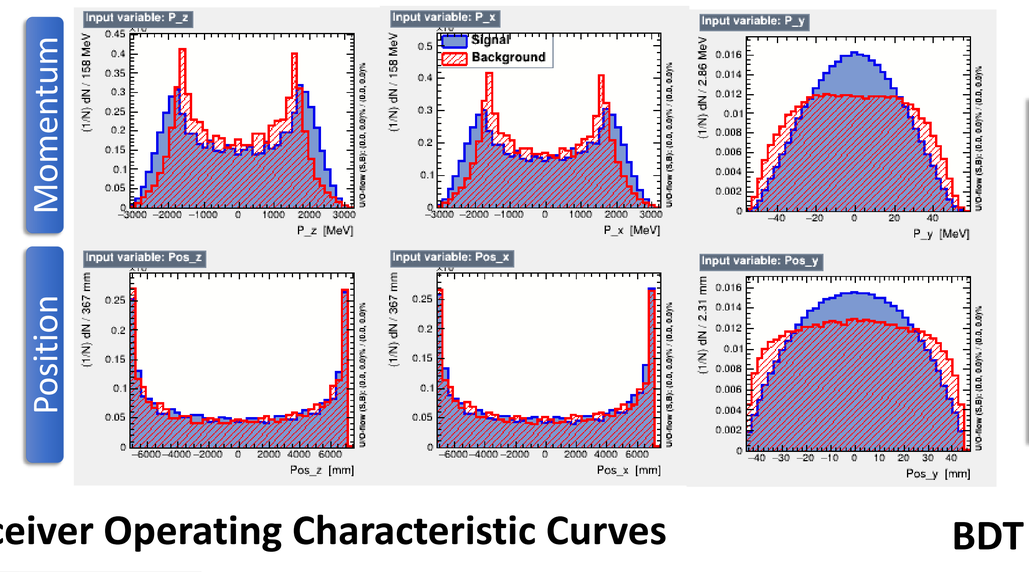

## Boosted Decision Tree Model for Calorimeter Positron Acceptance

**Training data (from gm2ringsim simulation )**

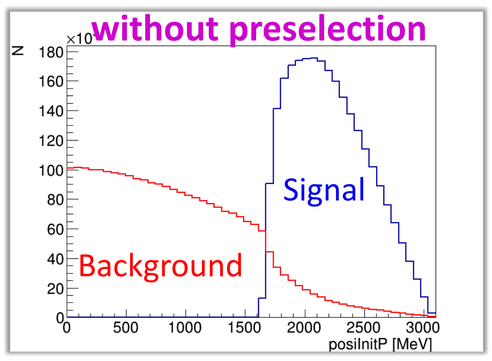
**Energy Deposition**

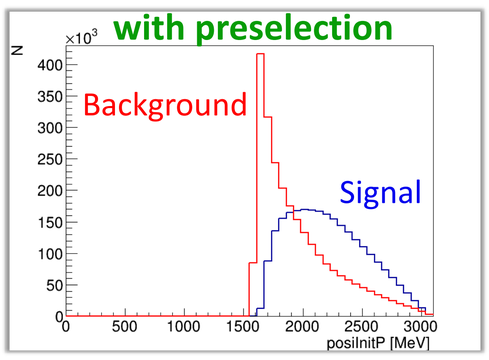
**Signal : > 1.6GeV**

**Background: Otherwise**

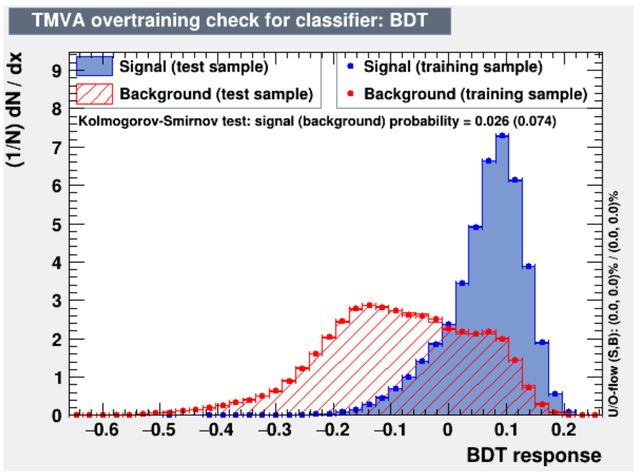


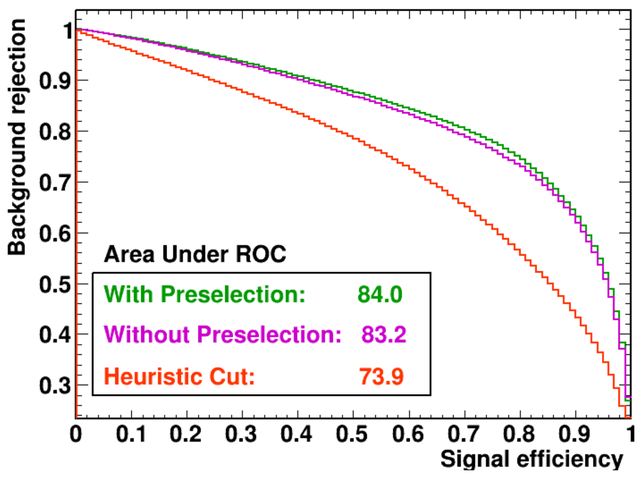

### Training With Data Preselection Cut: Energy>1.6 GeV



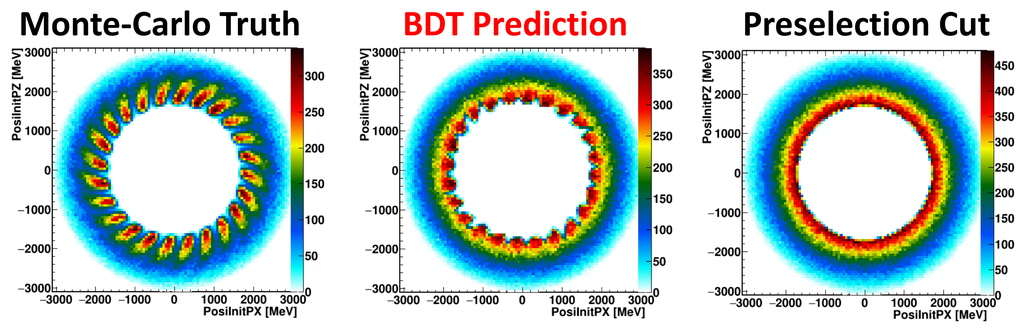

### BDT Response and Receiver Operating Characteristic Curves



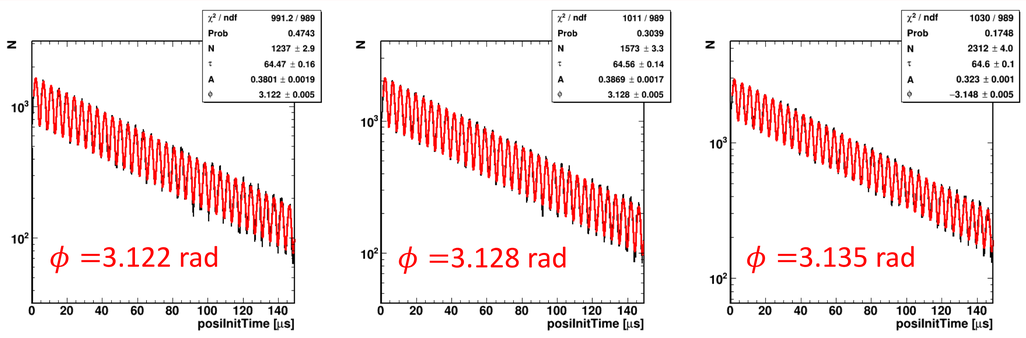




### BDT Application

**PZ:PX predicted by BDT has MC truth's main features**




**The fitted phase from BDT is close to MC truth**




## References

A. Hoecker *et al*. *TMVA: The toolkit for multivariate data analysis* (2007)

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T. Albahri *et al.* (Muon g−2 Collaboration) *Phys. Rev. Accel. Beams* **24**, 044002 (2021)