Muon Identification using Neural Networks with the Muon Telescope Detector at STAR

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STAR Detector with MTD

MTD is a Multigap Resistive Plate Chamber (MRPC) based detector installed outside magnet steel.

Particle identification information:
• Hit location with spatial resolution of ~ 1-2cm in $\Delta Y$ and $\Delta Z$
• Precise time resolution ~100 ps of hits

Magnet Steel

Muon Telescope Detector
How is the network architecture decided?

- **optimize** signal vs. background separation power on a grid of #hidden layers and #neurons in each layer + prefer simplest architecture

### Signal
Primary muons and secondary muons that decay inside tracking detector

### Background
- $\pi, K, p$ punch through
- $\pi \rightarrow \mu + \nu$ and $K \rightarrow \mu + \nu$ decays outside tracking detector
1. Apply DNN to muon candidate tracks in data (grey)
2. Generate signal and background templates by evaluating DNN on MC tracks
3. Template fit the data distribution (grey) to extract the yields of $\mu$, $\pi$, K, and p.
Comparison of several techniques shows that Deep Neural Networks perform the best (up to 5% better than BDT for low $p_T$ tracks).

Monte Carlo shows that DNN vastly out-performs traditional PID techniques.

Can we see this improvement in the data?
Significance and S/B of $\omega$ and $\phi$ peaks drastically improve

Measurement of $\Psi(2S)$ possible with neural net PID

Neural network clearly out-performs traditional identification techniques