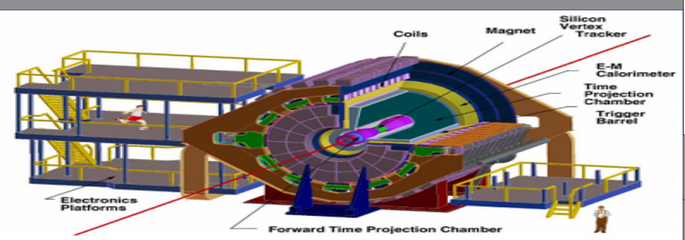
Simulation Study of Background Particles in the Muon Telescope Detector at the STAR Experiment

Matthew Breen, Advisor: Dr. Saskia Mioduszewski
Cyclotron Institute, Texas A&M University

Abstract

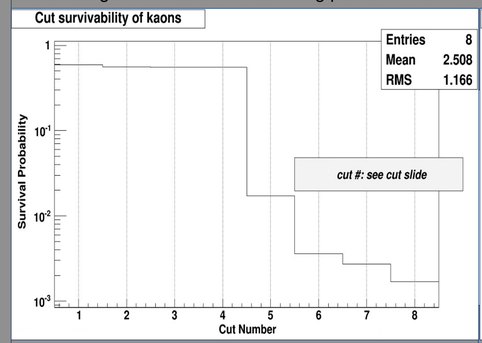
The newly constructed Muon Telescope Detector (MTD) at STAR studies the fundamental properties of the Quark Gluon Plasma (QGP) through the detection of muons, which have (relative to electrons) reduced Bremsstrahlung radiation, allowing for more precise measurements. It is important to examine the response of the MTD to background particles. The response is studied with simulated Ω and Φ particles, decaying into pions, kaons and protons (our background particles). These particles are embedded into real events (14.5 GeV Au+Au collision data), and then the tracks and MTD hits of the charged-particle decay products are simulated/reconstructed. The simulated particles have known kinematics and particle identifications, enabling targeted analysis of the MTD response to specified particles. The particles are subjected to the same analysis cuts applied to the muons to study their survival probability and the sensitivity of the MTD to the background particles. The distributions of the coordinates of the tracks projected to the MTD relative to reconstructed MTD hits are also analyzed and compared to actual data.



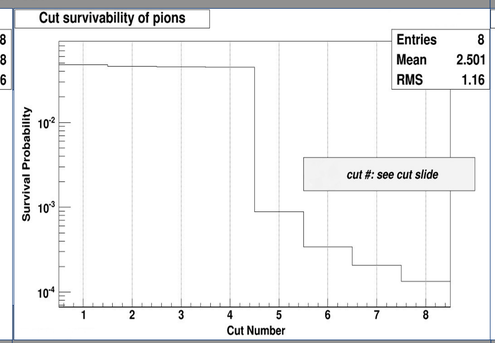
Projection Chamber (TPC) is the main tracking detector for STAR. The STAR detector is shaped like cylindrical barrel around the interaction point for the beams. The MTD was installed on the outer part of the barrel, behind all other detectors and behind the steel of the magnet, providing the material for absorption of background particles (non muons).

Particle Survivability

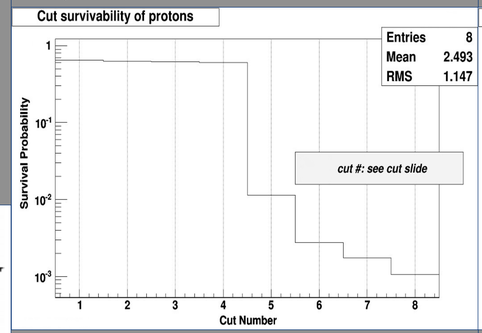
We investigate the number of surviving particles after each cut



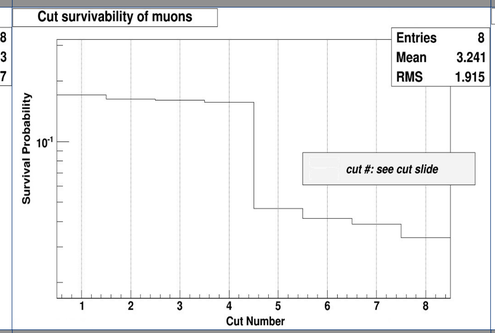
0.28% of the pions, that have a pt > 1.2 GeV, survive the cuts



0.29% of the kaons, that have a pt > 1.2 GeV, survive the cuts



0.16% of the protons, that have a pt > 1.2 GeV, survive the cuts

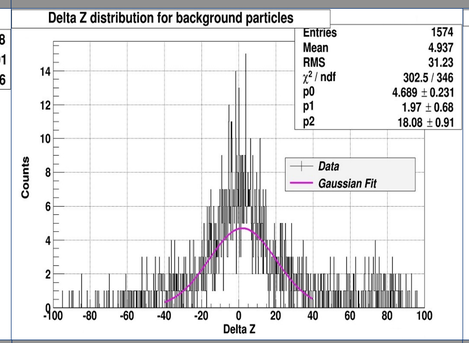


20% of the muons, that have a pt > 1.2 GeV, survive the cuts

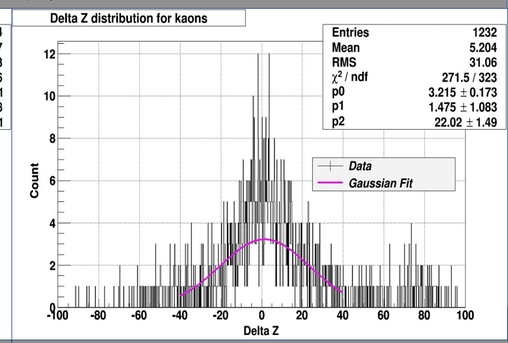
The Muons have about 100X greater survival probability than that of the background particles, displaying the response of the MTD to the background particles.
We can also observe at the transverse momentum distributions of muons and background particles that survive cut 7 and juxtapose them with their Delta Z distributions.

Delta Z Distributions

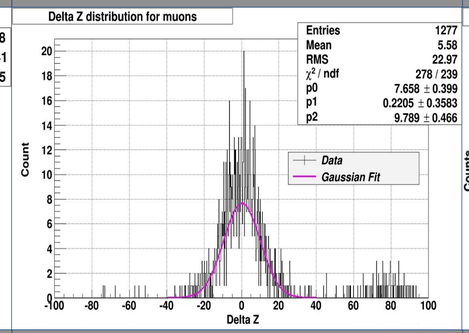
We examine the distributions of Z coordinate of the tracks projected to the MTD relative to reconstructed MTD hits



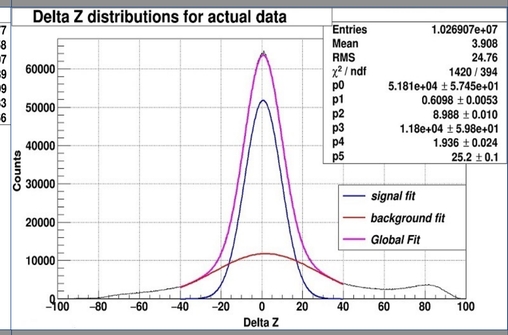
The background particles have a width of 18.08 ± 0.91.



The kaons have a width of 22.02 ± 1.49



The muons have a width of 9.789 ± 0.466



The signal fit has a width of 8.988 ± 0.010
The background fit has a width of 25.2 ± 0.1

The Delta Z distributions of the signal fit and background fit are in agreement with our muons and background particles. From this we can speculate the signal is composed of muons, and the background is composed of a majority of kaons with additional pions and protons.

Simulation Data

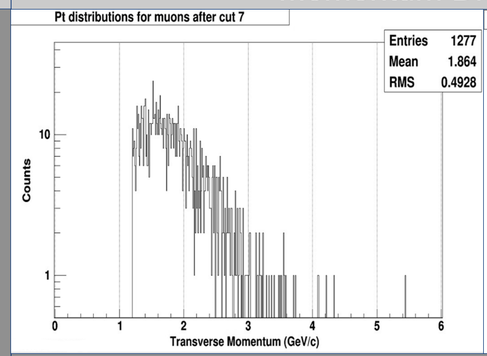
14.5 GeV Au+Au collision
- Omega production
  - $\Omega^- \rightarrow \Lambda + K^-$
  - $\Lambda \rightarrow p + \pi^-$
  - $K^- \rightarrow \mu^- + \nu^-_\mu$
  - #K : 141866
  - # π : 138300
  - # p: 172865
  - # μ: 16564
- Phi production
  - $\phi \rightarrow K^- + K$
  - $K^\pm \rightarrow \pi^\pm + \pi^\pm + \pi^\mp$
  - # K : 309034
  - # π : 11912
  - # p: 4790
  - # μ : 15882

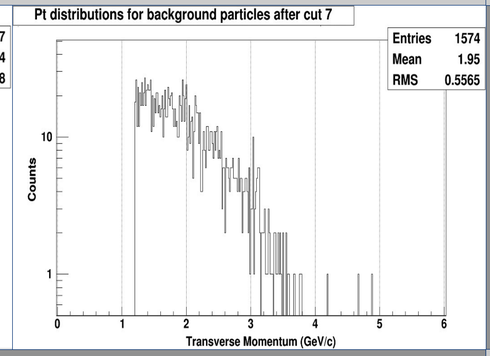
Analysis cuts

Cut Numbers

1. pt cut: 1.2 GeV/c < Pt < 30 GeV/c
2. NHitsFit cut: NHitsFit > 20
3. NHitsDedx cut: NHitsDedx > 15
4. Eta cut: |eta| <= .65
5. MTD cut: MTDTraitsIndex > -1
6. NSigma cut: -1 < NSigmaPion < 3
7. Delta Y cut: |ΔY| < 20
8. Delta Z cut: |ΔZ| < 20

Momentum Distributions





- After cut 7
  - 1277 muons survive out of the original 32446
  - 31 pions survive out of the original 150212
  - 1225 kaons survive out of the original 141866
  - 309 protons survive out of the original 177665

Conclusion

- The survival probability is 20% for muons (p_T > 1.2 GeV./c) with a mean of p_T of 1.86 GeV/c after all 8 cuts.
- The background particles, having a greater p_T mean, 1.95 GeV/c, have a 100 times less of a chance of surviving the same cuts
- The Delta Z distributions of the match tracks to MTD are in agreement
- The Background fit and background particle distributions have a width of about 20 ± 3.0, and the signal fit and muons have a width of 10 ± .05

Acknowledgements

This material is based upon work supported by the U.S. Department of Energy Office of Science, Office of Basic Energy Sciences Energy Frontier Research Centers program under Award Number DOE Grant Number DE-FG02-07ER41485
This material is based upon work supported by the National Science Foundation Graduate Research Fellowship under Grant Number 1263281.