Abstract:
Data taken over the last decade have demonstrated that RHIC has created a hot, dense medium with partonic degrees of freedom. One of the physics goals for the next decade is to study the fundamental properties of this medium such as temperature, density profile, and color screening length via electro-magnetic probes such as di-muons. Muons have a clear advantage over electrons due to reduced Bremsstrahlung radiation in the detector material. This is essential for separating the ground state (1S) of the Upsilon from its excited states (2S+3S) which are predicted to melt at very different temperatures. We propose a novel and compact Muon Telescope Detector (MTD) in the Solenoidal Tracker at RHIC (STAR) at mid-rapidity to measure different Upsilon states, J/psi over a broad transverse momentum range through di-muon decays to study color screening features, and muon-e correlations to distinguish heavy flavor correlations from initial lepton pair production. In this poster, we present the physics cases for the proposed MTD. We report the R&D including simulations and MTD prototype performance at STAR.

Physics motivation
A large area of MTD at mid-rapidity, allows for the detection of:
- di-muon pairs from QGP thermal radiation, quarkonia, light vector mesons, resonances in QGP, and Drell-Yan production
- single muons from the semi-leptonic decays of heavy flavor hadrons
- advantages over electrons: no conversion, much less Dalitz decay contribution, less affected by radiative losses in the detector materials, trigger capability in Au+Au
- trigger capability for low to high p_T J/ψ in central Au+Au collisions

High mass di-muon capability
• J/ψ, B_c(B_s) in di-muon and di-S/π in central Au+Au
• With HFT, study B(ś)→J/ψX; J/ψ+p using displaced vertices
• Excellent mass resolution: separate different upsilon states

Concept of design
A detector with long MRPCs covers the whole iron bars and leaves the gaps in between uncovered. Acceptance 40% at J/ψ+3S
118 modules, 1416 readout strips, 2832 readout channels
Long-MRPC detector technology, RPTDC electronics (same as STAR-TOP)

Simulation: single muon and J/ψ/μ efficiency
1. muon efficiency at J/ψ: 0.5-30%, pion efficiency: 0.5-1% at p_T=0 GeV/c
2. muon-to-pion enhancement factor: 50-100
3. muon-to-hadron enhancement factor: 100-1000 including track matching, tof and e-to-mu
4. dimuon trigger enhancement factor from online trigger: 40-200 in central Au+Au collisions
Upsilon in 500 GeV p+p-collisions can also be measured with good precision.

R&D summary table

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Counts</th>
<th>MTD summary and method</th>
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<tbody>
<tr>
<td>Cosmic ray and Fermilab 182 beam tests</td>
<td>N/A</td>
<td>MTD summary: Trigger Efficiency 65% p_T &lt; 500 MeV/c, 45% p_T &lt; 1500 MeV/c</td>
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<tr>
<td>N_TU/AA (11)</td>
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<td>MTD summary: Trigger Efficiency 65% p_T &lt; 500 MeV/c, 45% p_T &lt; 1500 MeV/c</td>
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</table>

MTD schedule

<table>
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<th>Phase</th>
<th>Overview</th>
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Summary
MTD will advance our knowledge of Quark Gluon Plasma: low to high p_T J/ψ in central Au+Au collisions (trigger capability) separate different upsilon states (excellent mass resolution) distinguish heavy flavor production from initial lepton pair production (e-mu correlation) rare decay and exotics complementary measurements for dileptons (different background contributions)...


