**Abstract**

Studies of quarkonium production in heavy-ion collisions can provide insight into thermodynamic properties of the quark-gluon plasma (QGP). Suppression of $\Upsilon$ states is expected at a sufficiently high temperature in the QGP and can be measured using the nuclear modification factor $R_{AA}$. Measurements of $p_T$ spectra for separate $\Upsilon$ states in $p+p$ collisions provide constraints for models of the quarkonium production, which is an important factor in the interpretation of the heavy-ion results. In addition, high-quality data from $p+p$ collisions at $\sqrt{s} = 500$ GeV can be used as a baseline for $R_{AA}$ as a function of $p_T$ in Au+Au collisions at $\sqrt{s} = 200$ GeV, after rescaling to lower energy. Also, studies of ratios of $\Upsilon$ states as a function of event multiplicity may help better understand the interactions with hadronic co-movers, because the higher states have larger geometrical sizes and thus should have larger cross section for such interactions compared to $\Upsilon(1S)$. In this poster, we will focus on experimental aspects of $\Upsilon$ measurements in $p+p$ collisions at $\sqrt{s} = 500$ GeV with the STAR experiment. Furthermore, the prospects of $\Upsilon$ measurements with the newly installed Muon Telescope Detector (MTD) will be discussed.

1. **Motivation**

- $\Upsilon$ mesons provide a clean probe of QGP, but production mechanism and cold nuclear matter effects (CNM) are not well known. Measurements of $p_T$ spectrum and multiplicity dependence of the production help to constrain the models.
- Each of the $\Upsilon$ states ($\Upsilon(1S, 2S, 3S)$) has different dissociation temperature (due to different binding energy) and can have different interaction cross section with hadrons (due to different size) → Separate measurements for each of the states vs. event multiplicity could help understand this effect.

2. **STAR experimental setup**

**Acceptance** $|n|<1$ 0<|φ|<2π

Detectors used in this analysis:
- Time projection Chamber (TPC) for tracking and particle identification
- Time of Flight (TOF) for measuring particle multiplicity
- Barrel Electromagnetic Calorimeter (BEMC) for electron identification and triggering

3. **Upsilon measurement**

**Dielectron channel**

$\Upsilon \rightarrow e^+e^-$ (BR = 2.38 ± 0.11) [1]

- Measurements are done in dielectron channel.
- The data are collected by triggering on high energy tower in BEMC.

**Triggers**

- $p>1$ GeV/c for partner track
- Partner $e$ BEMC cluster

- Electrons are identified in TPC via normalized dE/dx:
  \[
  n\sigma = \frac{dE}{dx} \frac{dx}{dE} \bigg|_{x_{beam}} \propto e
  \]
  \[
  n\sigma = 1.2e\pm0.3
  \]

**Electron acceptance** 10.0$e^-<1.5$

**Distance between track projection and center of a cluster** $R = \sqrt{(\Delta y)^2 + (\Delta \phi)^2}$

**BEMC e**

- $E_{e}\geq E_{p}\geq 0.5$
- $0.55 \leq E_{e}/p_{T} < 1.45$
- $R<0.028$

**TPC e**

- $6<p<8$ GeV/c

**Upsilon signal**

- $\Upsilon$ signal is reconstructed from $e^+e^-$ pairs.
- Signal lineshape for 1S,2S,3S states from MC simulation and backgrounds are fitted simultaneously to like-sign and unlike-sign pairs.
- Largest signal measured by STAR to date → high precision results.
- Estimation of Drell-Yan [2] and b$\bar{b}$ cross sections possible in the future.

4. **Event activity studies**

- Tracks matched to TOF (TofMult) used to measure multiplicity in an event (a measure of activity in a collision).
- Upsilon signal presented in 4 TofMult bins.

5. **Prospects for $\Upsilon$ measurements**

- New Muon Telescope Detector (MTD) installed in 2014.
- Makes measurements in dimuon channel possible $\Upsilon \rightarrow \mu^+\mu^-$ (BR = 2.48 ± 0.05) [1] with clean signal.
- It will allow separation of 1S, 2S and 3S states.
- Precision measurements of $R_{AA}$.

6. **Summary**

- Presented $\Upsilon$ measurements in $p+p$ collisions at $\sqrt{s} = 500$ GeV.
- Signal presented in 4 TofMult bins ("event activity").


The STAR Collaboration: http://drupal.star.bnl.gov/STAR/presentations