Di-Hadron Photoproduction in Au+Au Ultra-Peripheral Collisions at 200 GeV

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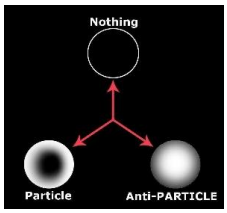
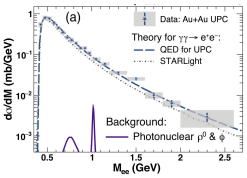
Abstract

Relativistic heavy-ion collisions generate extremely strong electromagnetic fields, providing an ideal environment to study the electromagnetic excitation of the vacuum. This poster shows the first measurements of baryon-antibaryon pair production from QED vacuum excitation in Au+Au ultra-peripheral collisions at $\sqrt{s_{NN}}$ = 200 GeV by the STAR experiment. These measurements will shed new lights on the understanding of the QED vacuum.

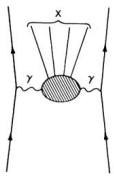
Motivation

- The ground state of quantum system is characterized by zero-point motion, and consequentially the creation and annihilation of virtual matter and antimatter particle pairs occur all the time in QED vacuum.
- An electromagnetic field which reaches the Schwinger limit would separate the virtual particle pairs. These virtual particle pairs will evolve to real particle pairs in a dynamic environment and be observed.
- The Breit-Wheeler process has been observed by STAR[1], however, higher excitation mode of QED vacuum from pure electromagnetic fields has never been observed.





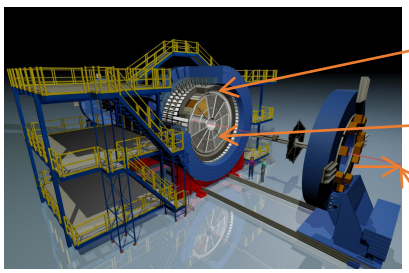
Breit-Wheeler process



$\gamma\gamma \rightarrow h\bar{h}$?

[1] STAR Collaboration, Phys.Rev.Lett. 121 (2018) 13, 132301

The Solenoidal Tracker At RHIC (STAR)



Time of Flight: particle identification

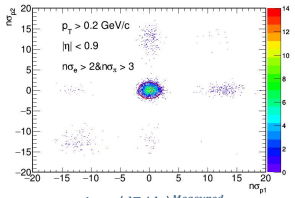
Time Projection Chamber: track reconstruction, particle identification

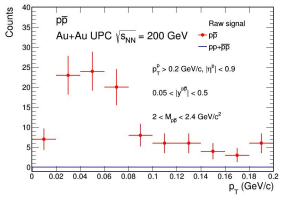
Zero Degree Calorimeter: neutron detection

Event Selection

- Dataset: Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV taken in 2010, 2011 and 2014
- Triggered events: ultra-peripheral collisions with Coulomb excitation in both sides
- Luminosity: 679 μb^{-1} (2010), 621 μb^{-1} (2011), 1270 μb^{-1} (2014)

PID and Raw pp̄ Signal

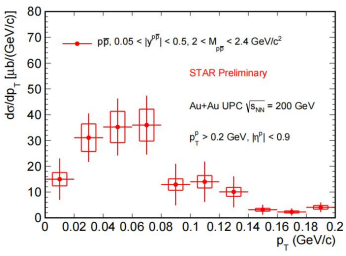


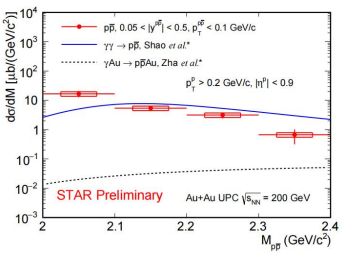


$$n\sigma_x = \frac{1}{\sigma}\log\frac{\langle dE/dx\rangle^{Measured}}{\langle dE/dx\rangle_x^{Theory}}, \quad \chi^2_{x_1x_2} = n\sigma_{x_1}{}^2 + n\sigma_{x_2}{}^2$$

- PID: $\chi^2_{p\bar{p}}$ <4 & $n\sigma_e$ > 2 & $n\sigma_\pi$ > 3, pairs with |y|<0.05 are rejected to remove cosmic rays.
- Significant pp̄ signals are observed at p_T < 0.1 GeV/c.

Cross Section





- $\sigma_{AuAu\rightarrow AuAup\bar{p}}$ = 2.59 ± 0.43($stat$) ± 0.47(sys) μb.
- The pp̄ pairs located at very low p_T region.
- The pp̄ pair production cross section is comparable to the γγ→ pp̄ theoretical calculation (within the measured acceptance), the Drell-Soding background (γAu → pp̄Au) is negligible.

* Calculation results from private communication

Summary and Outlook

- The vacuum excitation pp̄ pairs has been observed, and the invariant mass spectra are compared to theoretical calculations.
- Next to do: Measure the angular modulation to extract the polarization information.

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