Study of Upsilon-pion azimuthal correlations

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Upsilon meson

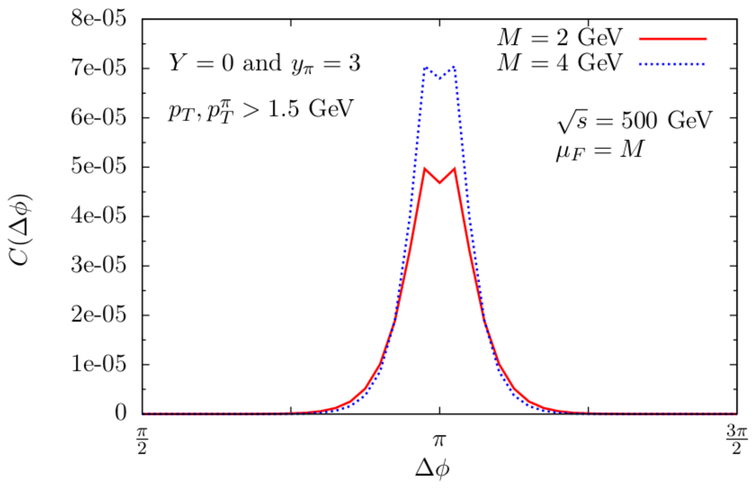
The Upsilon meson is classified as a bottomonium, a bound state composed of a bottom quark and its corresponding antiquark. The Upsilon was discovered in 1977 at Fermilab by a team led by Leon Lederman. The Upsilon meson exists in multiple energy states, including the ground state Υ(1S) and excited states such as Υ(2S) and Υ(3S). The production of Upsilon is described by models:

- Color octet model - $Q\bar{Q}$ are produced directly in a colour neutral state in association with a gluon
- Color singlet model - $Q\bar{Q}$ can be produced in any coloured or colour-neutral state

The goal is to investigate CS and CO Upsilon production mechanism by studying Upsilon-hadron azimuthal correlations.

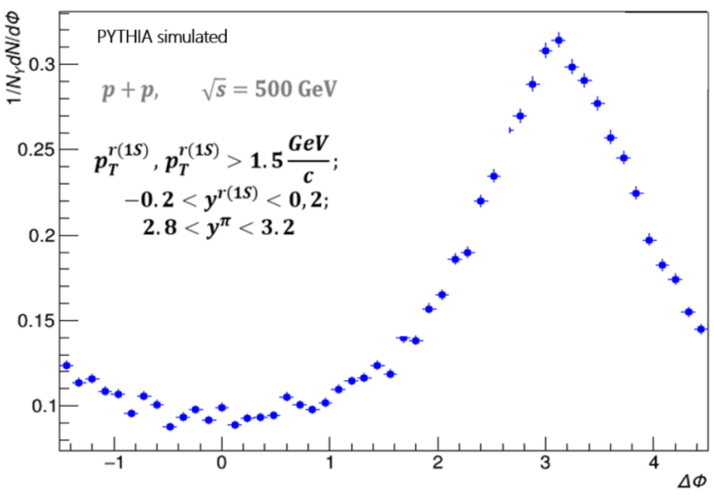
Theoretical Predictions

- Away-side double peak is predicted in p+p collisions of the photon (central) and pion (forward).
- The correlation function $C(\Delta\varphi)$ for the DY pair ($\gamma^* \rightarrow l\bar{l}$) and pion production in $p+p$ collisions at $\sqrt{s}$=500 GeV [1].
- The double peak structure of $C(\Delta\varphi)$ arises only for pions at large forward rapidities.
- The double peak is expected also for Υ-hadron azimuthal correlations.



Simulations

- Υ-hadron correlation from PYTHIA simulation [2].
- Only charged pions and directly produced Υ(1S) without feed-down contribution via CS channel.



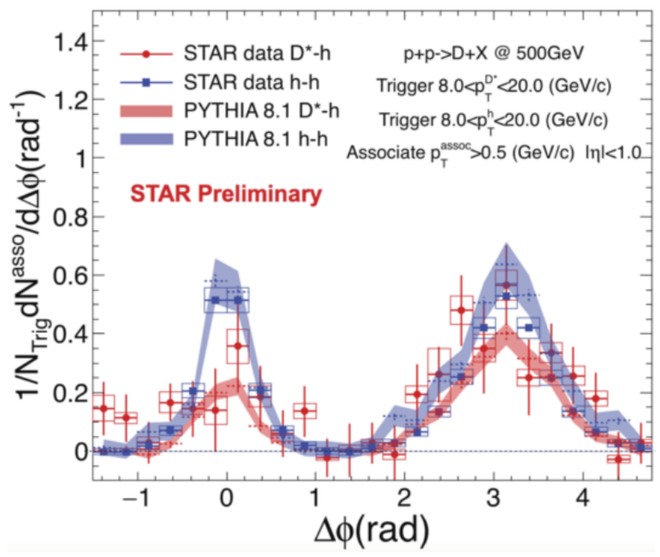
- Selection of Upsilon and pion coming from the same event and calculation $\Delta\varphi = \varphi_\Upsilon - \varphi_\pi$
- The double peak structure is not observed.

Similar Measurements

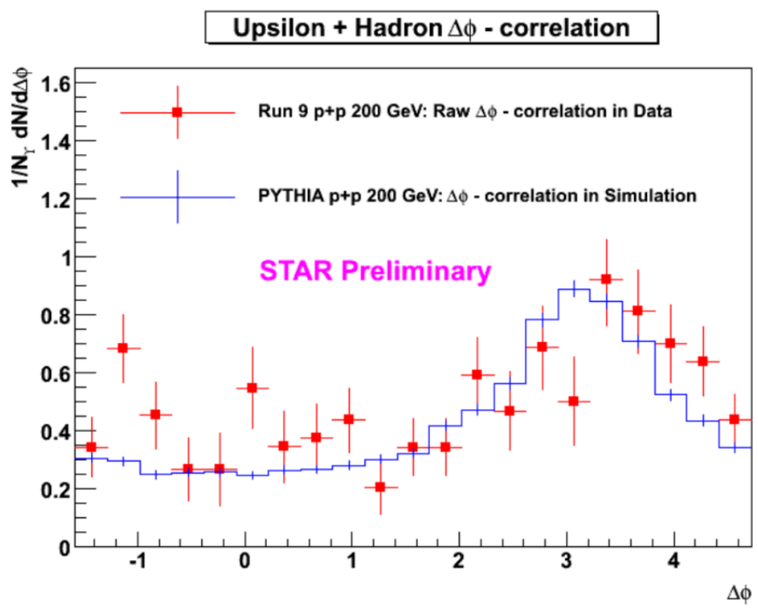
- Azimuthal correlation between $D^{*\pm}$ and charged hadrons measured by the STAR experiment in $p+p$ collisions at the centre-of-mass energy $\sqrt{s} = 500$ GeV [4].
- Signal extraction formula:

$$C_{signal} = C(\Delta\varphi)_{RS} - \frac{BG_{RS}}{BG_{SB}} C(\Delta\varphi)_{SB},$$

where BG is background, RS are $D^{*\pm}$ candidates and SB stands for side-band background.



Previous results



- Upsilon-hadron correlation from experiment STAR using $p+p$ collisions at the center-of-mass energy $\sqrt{s}$ =200 GeV from Run 9 and PYTHIA simulation [3].
- My aim is to study the Upsilon-pion azimuthal correlations in p+p $\sqrt{s}$ = 500 GeV collisions. Upsilons will be identified in the e^+e^- channel at velocities $|y|$<1 and pions at $|y|$<1. I will compare the results with PYTHIA to see if we are sensitive to the production mechanism and feed-down.

Summary

- The Υ-hadron correlations are characterized by an away-side peak at $\Delta\varphi = \pi$.
- The double peak was not observed in the PYTHIA simulations contrary to the theoretical predictions.
- Analysis is a work in progress.
- The aim is to get the similar results like in [4], but for Upsilon.

Acknowledgements

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References

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[2] O. Mezhenska, SQM 2024
[3] M. C. Cervantes, J. Phys.: Conf. Ser. 316 012023 (2011)
[4] L. Ma, Nucl. Part. Phys. Proc. 289–290 (2017) 329–332