Multiplicity dependence of Υ meson production in $p+p$ collisions at $\sqrt{s} = 510$ GeV at the STAR experiment

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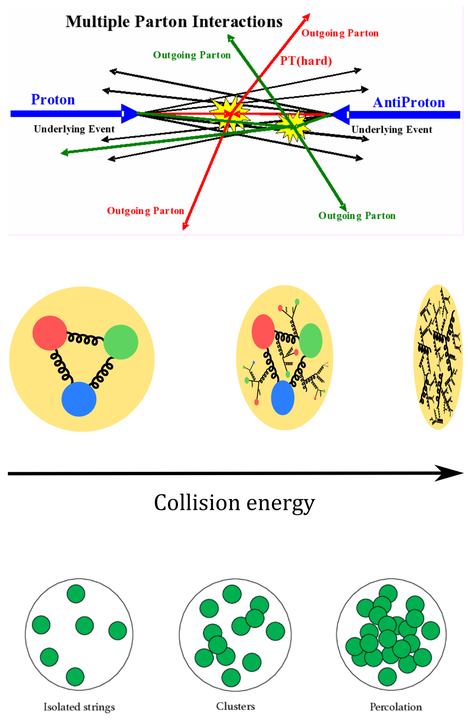
Motivation

Studies of the self-normalised quarkonium yield in dependence on the self-normalised charged particle multiplicity in high-multiplicity $p+p$ collisions at RHIC and the LHC have shown a stronger than linear increase. There are several theories trying to understand this phenomenon, such as:

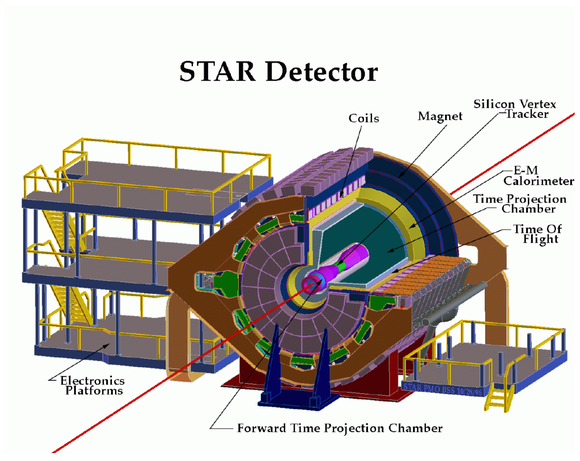
- **Multi-parton interactions (MPIs)** [1, 2, 3, 4]
  - multiplicity proportional to energy density
  - quarkonium yield proportional to number of MPIs
    ⇒ quarkonia produced predominantly in MPIs
- **CGC saturation effects** [5, 6]
  - gluon density saturation @ low-x
    ⇒ influence on soft-QCD particle production
- **String percolation** [7]
  - soft-QCD production suppression due to interactions of overlapping colour field strings



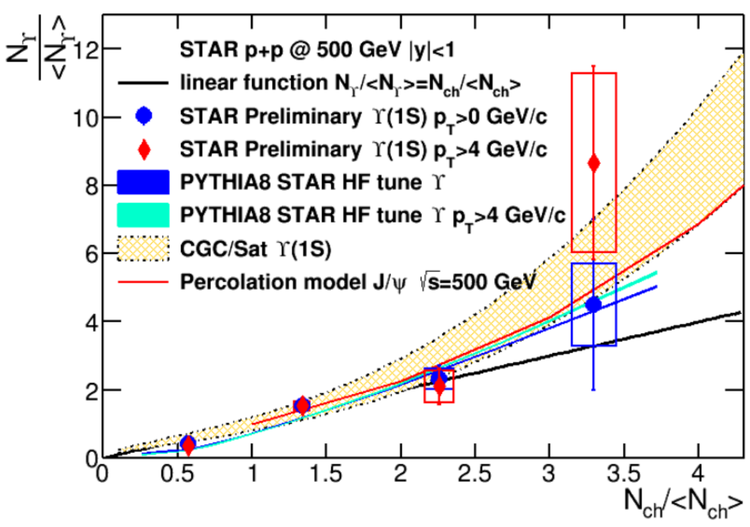
STAR

The STAR experiment is located at the RHIC collider in BNL. Notable subdetectors essential for this analysis are:

- **TPC** - tracking and PID (p, dE/dx)
- **BEMC** - electron ID, high-p_{T} electron trigger (E)
- **TOF** - precise multiplicity measurement due to pile-up removal (TofMult)
- **BBC** - instantaneous luminosity determination to correct for TPC tracking efficiency



Previous results



- Previous STAR results [8] are consistent with the world trend
- The data collected in 2017 offers up to 10 times the sampled integrated luminosity compared to the previous results

Analysis

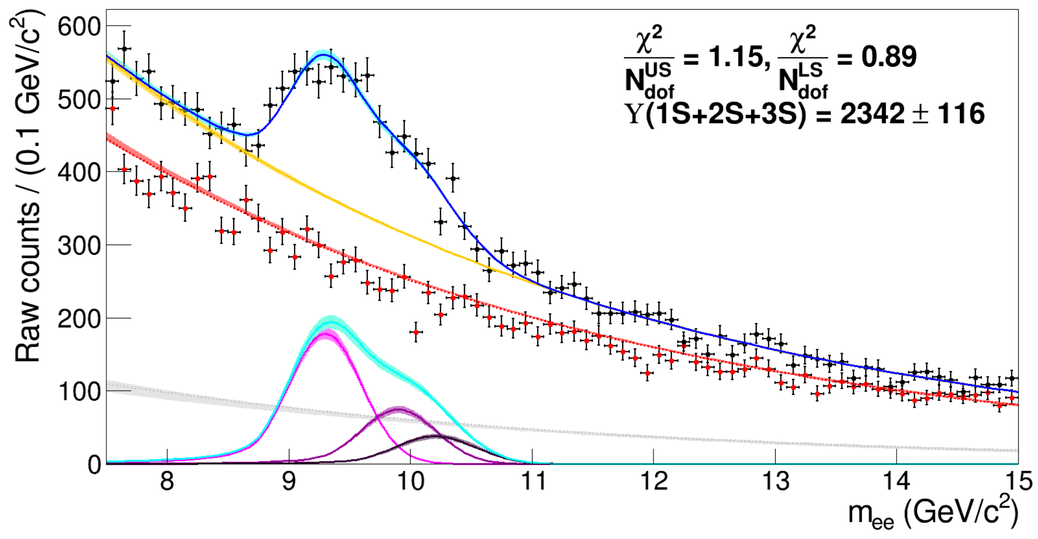
The analysis uses unlike-sign (US) and like-sign (LS) dielectron pairs to reconstruct dielectron invariant mass distributions. The signal extraction is implemented using unbinned likelihood simultaneous fitting of both US and LS mass spectra via recursive fractions. The components of the **total fit** include:

- **background**
  - **combinatorial background** - exponential function, LS mass spectrum fitted
  - **residual background** (Drell-Yan, $b\bar{b}$) - exponential function
- **signal** - 3 one-sided Crystal Ball functions (**Υ(1S)**, **Υ(2S)**, **Υ(3S)**)

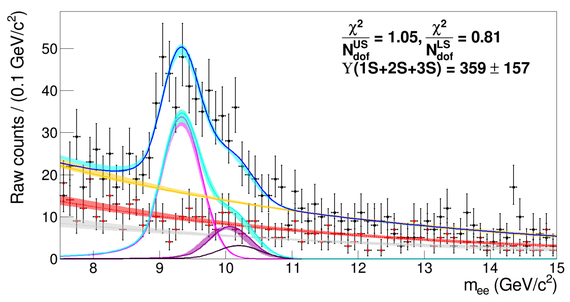
The constraints used include mass separation of 500 MeV/c^2 and 400 MeV/c^2 for the Υ(1S) and Υ(2S), and Υ(2S) and Υ(3S) states respectively. The Υ signal widths and their constraints were chosen to correspond linearly with the state's invariant masses.

Results

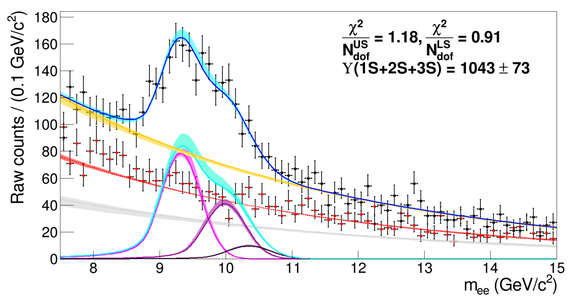
The fit is performed in several normalised TofMult bins (multiplicity determined using TOF; 0-1, 1-2, 2-3, 3-7), which will be then used to obtain the dependence of the self-normalised Υ meson multiplicity on the self-normalised charged-particle multiplicity.



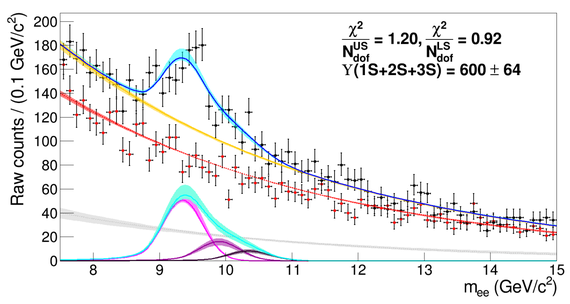
⟨TofMult⟩ integrated



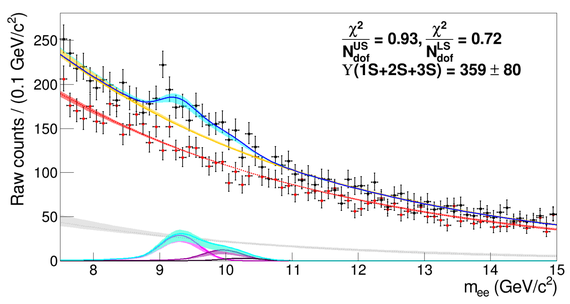
0-1 ⟨TofMult⟩



1-2 ⟨TofMult⟩



2-3 ⟨TofMult⟩



3-7 ⟨TofMult⟩

Conclusions

- Analysis is a work in progress
- Largest Υ sample in $p+p$ STAR has available to date
- Evaluating systematic effects using standard embedding procedure
- Zero bias embedding - instantaneous luminosity independent multiplicity measure via 2D unfolding [9]
- Increased statistics will allow for more precise high-p_{T} Υ measurements and to increase the reach in multiplicity
- Results will provide further model constraints

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Acknowledgements

The work was supported by the Grant Agency of the Czech Technical University in Prague, grant No. SGS22/174/OHK4/3T/14 and by the Ministry of Education, Youth and Sports of the Czech Republic through the project LM2023034 Brookhaven National Laboratory - the participation of the Czech Republic.

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

Presented at the ICHEP24
17. July - 24. July 2024
Prague, CZE

Supported in part by:
U.S. DEPARTMENT OF ENERGY | Office of Science
EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research, Development and Education
MINISTRY OF EDUCATION, YOUTH AND SPORTS