Production of J/ψ and ψ(2S) in $\sqrt{s}$ = 510 GeV p+p collisions in 2017 at STAR

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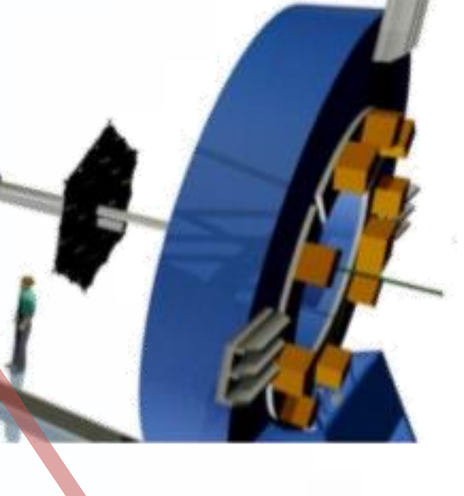
Abstract: Measurements of J/ψ and ψ(2S) production in p+p collisions will provide valuable information to unveil questions of Quantum Chromodynamics. In this poster, we present the status of the measurements of the production cross sections of J/ψ and ψ(2S) in p+p collisions at $\sqrt{s}$ = 510 GeV from the data collected by STAR experiment during 2017 RHIC run. The mesons are reconstructed from the $\mu^+\mu^-$ final state and the muon identification is done using the Likelihood Ratio method [1] with five variables, DCA, Δy·q, Δz, ΔToF and $n\sigma_\pi$.

1. Motivation:

- The STAR Collaboration has recently measured the differential production cross section of J/ψ in p+p collisions at 500 and 510 GeV using the e^+e^- and $\mu^+\mu^-$ final states, respectively [2].
- High-statistic data from year 2017 allow us to significantly improve the precision, mainly in the low-p_T region.
- This will be the first p_T-differential measurement of the ψ(2S) cross section and the ψ(2S) to J/ψ ratio from STAR.

The differential production cross section of J/ψ -> $\mu^+\mu^-$ from 2013 data [1]



The ψ(2S) to J/ψ ratio using the e^+e^- final state [1]

2. The STAR detector:

Time Projection Chamber (TPC):
- Momentum and dE/dx measurement
- Coverage |η| < 1

Muon Telescope detector (MTD):
- Trigger on and identify the muons
- Coverage |η| < 0.5

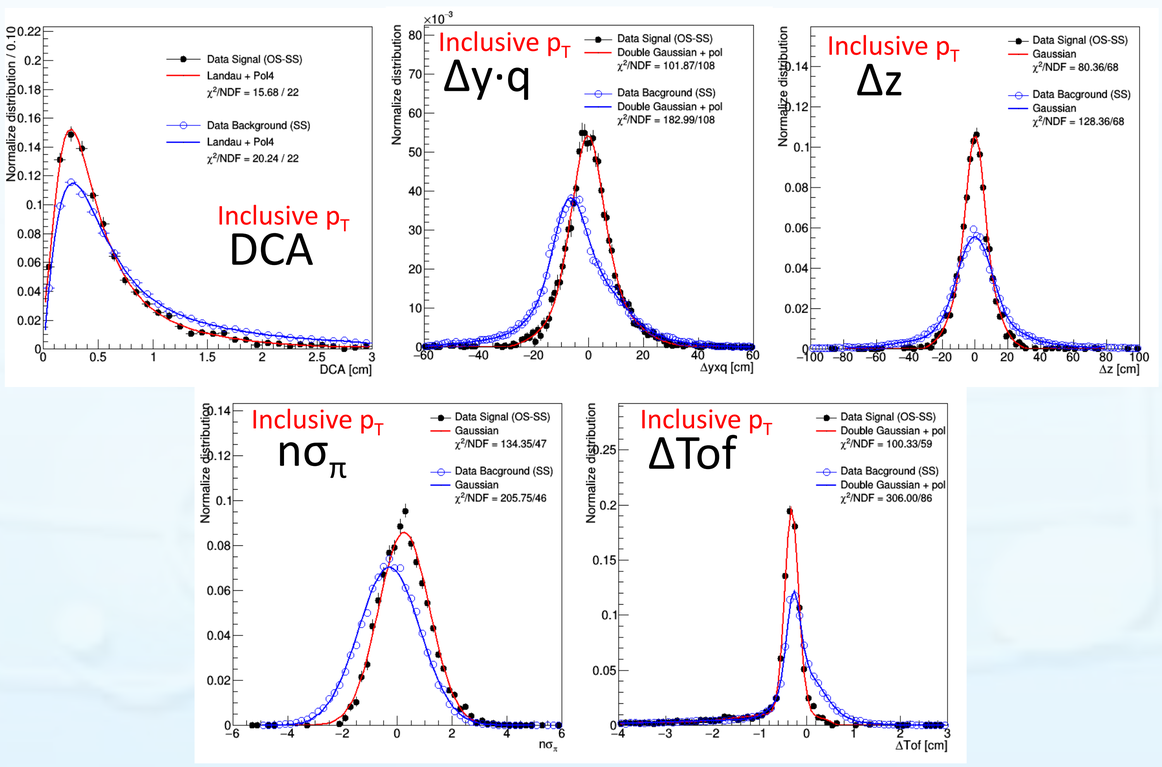
Time Of Flight (TOF):
- Particle identification
- Coverage |η| < 1

3. Muon identification variables:

• The following five variables will be used for the muon identification:

- **DCA:** The muon distance of the closest approach to the collision vertex.
- **Δy & Δz:** The difference between the position of MTD hit and the extrapolated position from the track on the MTD. **Δ**y(rϕ), **Δ**z(ẑ) are for the two different directions.
- **ΔTof:** The difference between the time-of-flight recorded by the TOF and MTD.
- **$n\sigma_\pi$:** The difference between the measured dE/dx and the theoretical calculation for pion:

$$n\sigma_\pi = \frac{(\log\frac{dE}{dx})_{measured} - (\log\frac{dE}{dx})_{\pi,theory}}{\sigma(\log\frac{dE}{dx})_{measured}}$$

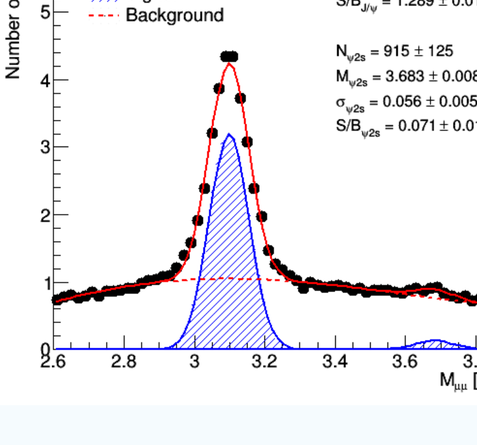


4. Likelihood Ratio method:

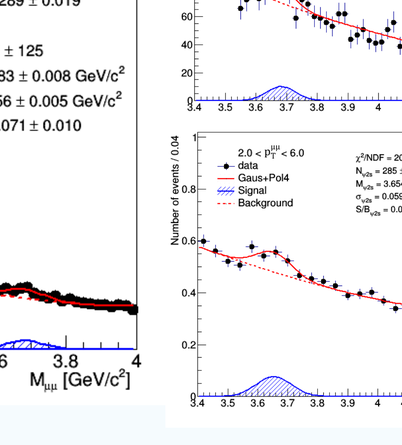
- p_T-dependent selection cuts on muon candidates are used and the discriminating variable "R" in each muon p_T region is defined to distinguish the muon-like candidates:

$$R = \frac{1-Y}{1+Y}, \text{ where } Y = \prod y_i$$

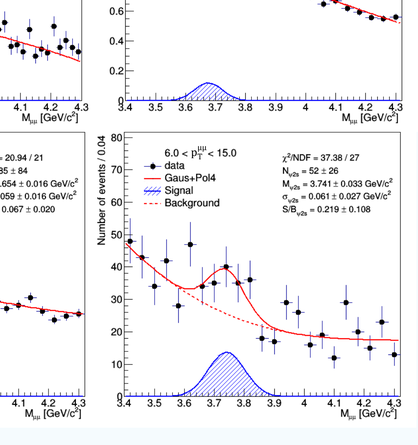
Each $y_i = \frac{PDF^{bkg}}{PDF^{sig}}$ is the ratio between background to signal PDFs with five variables: DCA, Δy·q, Δz, ΔToF and $n\sigma_\pi$.



The distribution of R



The signal efficiency to the background rejection

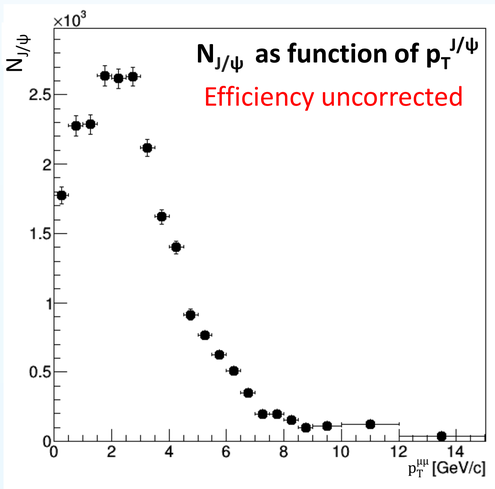


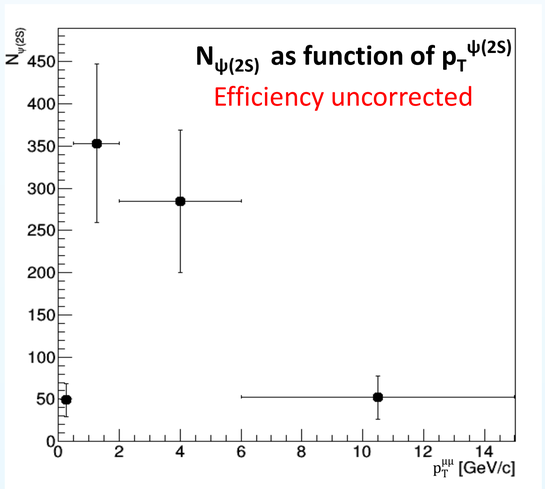
The muon ID efficiency as function of p_T

5. J/ψ and ψ(2S) signals using the Likelihood Ratio method for muon identification:

J/ψ and ψ(2S) signals in 510 GeV p+p collisions from the 2017 data

Raws counts of J/ψ and ψ(2S) as a function of p_T





6. Conclusions:

- The Likelihood Ratio method provides a way to efficiently select muon candidates and significantly reduce combinatorial background.
- There are about 22600 J/ψ and 900 ψ(2S) candidates with the Likelihood Ratio method for the muon identification in the data recorded by STAR in 2017.

7. Future work:

- Measurements of the J/ψ and ψ(2S) production cross sections and the ψ(2S) to J/ψ ratio as a function of p_T.

☐ **The differential production cross section multiplied by the branching ratio:**

$$\mathrm{BR} \times \frac{d^2\sigma}{2\pi p_T dp_T dy} = \frac{N^{corr.}_{J/\psi\to\mu^+\mu^-}}{(2\pi p_T)\cdot\int \mathcal{L}dt \cdot \Delta p_T \cdot \Delta y}$$

☐ **The definition of the corrected number of J/ψ:**

$$N^{corr}_{J/\psi\to\mu^+\mu^-} = \sum_{i=1}^{N_{J/\psi}} w_i \text{ , where } w_i^{-1} = \mathcal{A}\times\varepsilon_{reco}$$

where $\mathcal{A}$ and the ε_{reco} is:

- $\mathcal{A}$ = The kinematic acceptance of J/ψ
- $\varepsilon_{reco.}$ = The total reconstruction efficiency for each muon pair candidate

8. References:

[1] Nucl. Instrum. Meth. A 833 (2016) 88-93.
[2] [arXiv:1905.060675] submitted to PRD.