is our measurement, the error bars and the box depict the statistical and systematic uncertainties, respectively. To illustrate the acceptance in rapidity, we also show the unlike-sign pairs after like-sign background subtraction, $N_{+-} - 2\sqrt{N_{++}N_{--}}$, in the Υ region $8 < m_{ee} < 11$ GeV/c^2 as a hashed histogram. The scale on the right axis of the figure is used for the counts in the histogram, and the scale in the left axis of the figure is used for the cross section. We compare our measurement with NLO CEM predictions [32] of the Υ(1S) rapidity distribution. Since we measure all three states and only in the dielectron channel, the calculation of the Υ(1S) is scaled by a factor

$$\frac{\mathcal{B}(1S)\times\sigma(1S)+\mathcal{B}(2S)\times\sigma(2S)+\mathcal{B}(3S)\times\sigma(3S)}{\sigma(1S)} \quad (9)$$

in order to compare it to our measurement of the cross section for all three states. The branching ratios and cross sections used for this scale factors are those from Table II. The calculation is in agreement with our measurement. The two dotted lines in the plot are the upper and lower bounds of the cross section obtained from a calculation in the CSM for direct Υ(1S) production [18] based on NLO code developed for quarkonium production at hadron colliders [33]. Since the calculation is for the 1S state alone and for direct Υ production (ignoring feed-down from P-states), to compare to our measurement, which includes all 3 states and feed-down contributions, the values from the calculation were divided by a factor 0.42 to account for this (see Ref [18] for details). The bounds in the calculation are obtained by varying the bottom quark mass and the renormalization and factorization scales. The CSM prediction is lower than our data, indicating that additional contributions are needed beside production via color singlet.

In Fig. 14, we also compare our Υ(1S+2S+3S) result with measurements done in $p+A$, $p+p$ and $p+\bar{p}$ collisions at center-of-mass energies ranging from 20 GeV up to 1.8 TeV [24, 29, 34–41], and to NLO CEM predictions [16] for a wide range of center-of-mass energies.

Our result is consistent with the overall trend, and provides a reference for bottomonium production at the top RHIC energy.

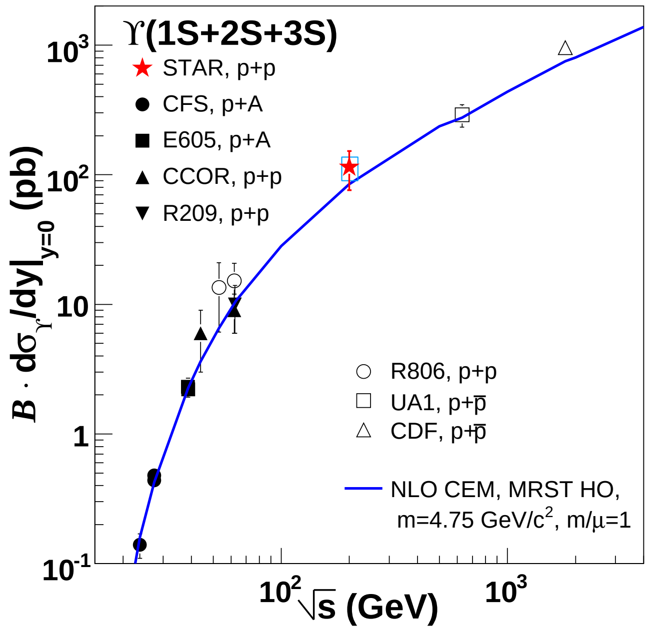

FIG. 14: Evolution of the Υ(1S+2S+3S) cross section with center-of-mass energy for the world data and an NLO CEM calculation. The error bars on the STAR datum point are statistical and systematic as in Fig. 13.

VII. CONCLUSIONS

The STAR experiment has measured the Υ(1S+2S+3S) $\to e^+e^-$ cross section at midrapidity, $|y_{ee}| < 0.5$, in $p+p$ collisions at $\sqrt{s} = 200$ GeV to be $(\mathcal{B}\times d\sigma/dy)^{1S+2S+3S} = 114 \pm 38$ (stat. + fit)$^{+23}_{-24}$ (syst.) pb. Calculations done in the Color Evaporation Model at NLO are in agreement with our measurement, while calculations in the Color Singlet Model underestimate our cross section by $\approx 2\sigma$. Our result is consistent with the trend as a function of center-of-mass energy based on data from other experiments. We report a combined continuum cross section, Drell-Yan plus b-$\bar{b} \to e^+e^-$, measured in the kinematic range $|y_{ee}| < 0.5$ and $8 < m_{ee} < 11$ GeV/c^2, of $(\sigma_{\rm DY} + \sigma_{b\text{-}\bar{b}}) = 38 \pm 24$ pb. The STAR measurement presented here will be used as a baseline for studying cold and hot nuclear matter effects in d+Au and Au+Au collisions, as the relatively clean environment provided by the STAR high-mass dielectron trigger permits the approach outlined in this paper to be deployed up to the most central Au+Au collisions. With increased luminosity, a better determination of the cross section, its $p_\perp$ dependence and a separation of the 2S and 3S states will be possible. The projected luminosity upgrades to RHIC should increase the Υ yield to $\approx$ 8300 in $p+p$ and $\approx$ 11200 in Au+Au collisions during one RHIC year [16]. The increased statistics will greatly reduce the uncertainty in the determination of the continuum cross section and will allow a thorough study of the bottomonium sector by resolving the 2S and 3S states.

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