Upsilon production in p+p collisions at $\sqrt{s}$ = 500 GeV measured by the STAR experiment

Leszek Kosarzewski *for the STAR collaboration*
Faculty of Nuclear Sciences and Physical Engineering
Czech Technical University in Prague

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Abstract

Studies of Υ production in p+p collisions can shed lights on quarkonium production mechanism. Recently, a strong dependence of normalized Υ yield as a function of normalized charged particle multplicity has been observed at the LHC [JHEP04,103(2014)]. Possible explanations of such a behavior include string percolation and quarkonium production in multi-parton interactions among others. These studies provide information on the correlation of quarkonium and soft particle production. Furthermore, studying ratios of different Υ states vs. multiplicity may provide an estimate of Υ interaction with hadronic comovers.

This poster presents the preliminary results of Υ production in p+p collisions at $\sqrt{s}$ = 500 GeV measured by the STAR experiment using high-p_T electron trigger. The data were collected in 2011. Cross sections of Υ(1S), Υ(2S)+Υ(3S) and all three states combined are measured as a function of transverse momentum and rapidity. In addition, the normalized Υ yield is studied as a function of the normalized multiplicity. Cross section ratios, Υ(nS)/Υ(1S), are studied as a function of multiplicity.

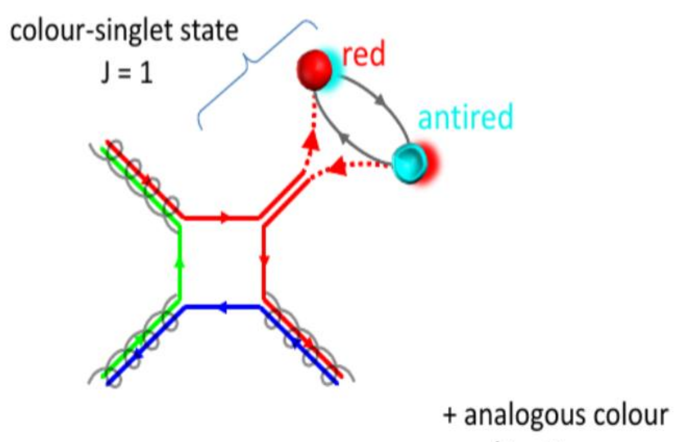
Motivation

Quarkonium production mechanism

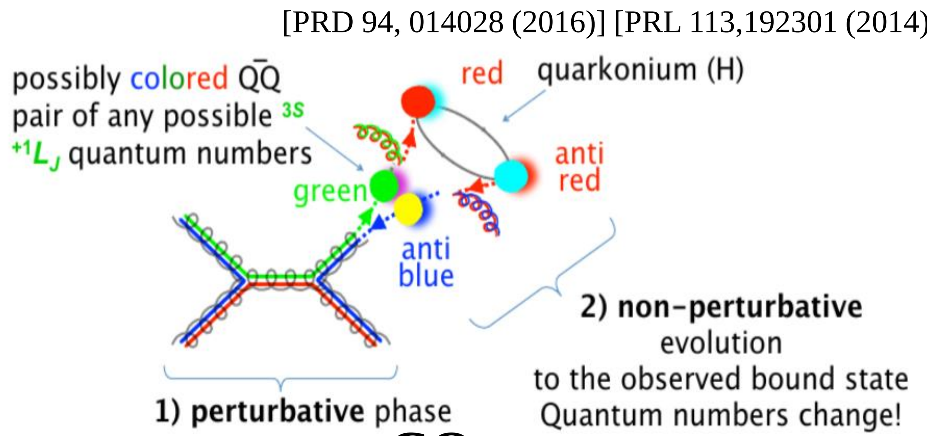
Differential cross section measurements provide constraints for quarkonium production models and information about quarkonium production mechanism:

- **Color Evaporation Model** – a fixed fraction of $Q\bar{Q}$ pairs forms a particular bound state [Phys.Rev. C92 (2015)034909]
- **CGC+NRQCD** model - combines color glass condensate initial condidtions with non-relativistic QCD framework including color singlet (**CS**) and color octet (**CO**) contributions

[PRD 94, 014028 (2016)] [PRL 113,192301 (2014)]



CS



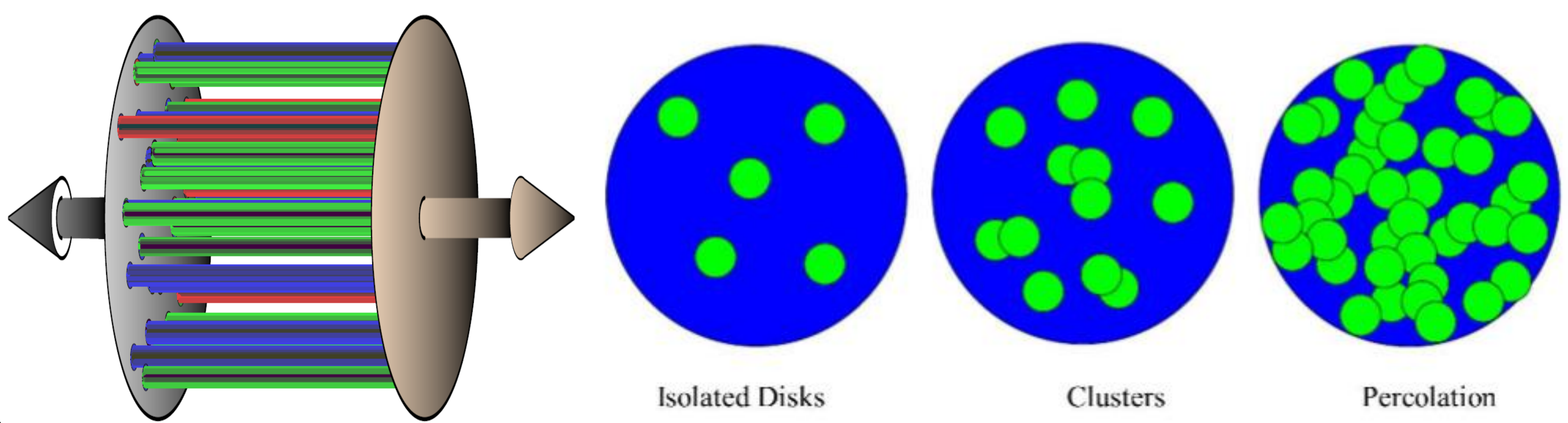
CO

High multiplicity p+p collisions

Enhancement of normalized Υ production ($\Upsilon/\langle\Upsilon\rangle$) vs. normalized charged particle multiplicity ($N_{ch}/\langle N_{ch}\rangle$) observed in high-multiplicity p+p collisions. Possible explanations: [JHEP04,103(2014)], [Phys.Lett.B 712,165{175(2012)], [Nucl.and Part.Phys. Proc.,276-278, pp.261{264(2016)]

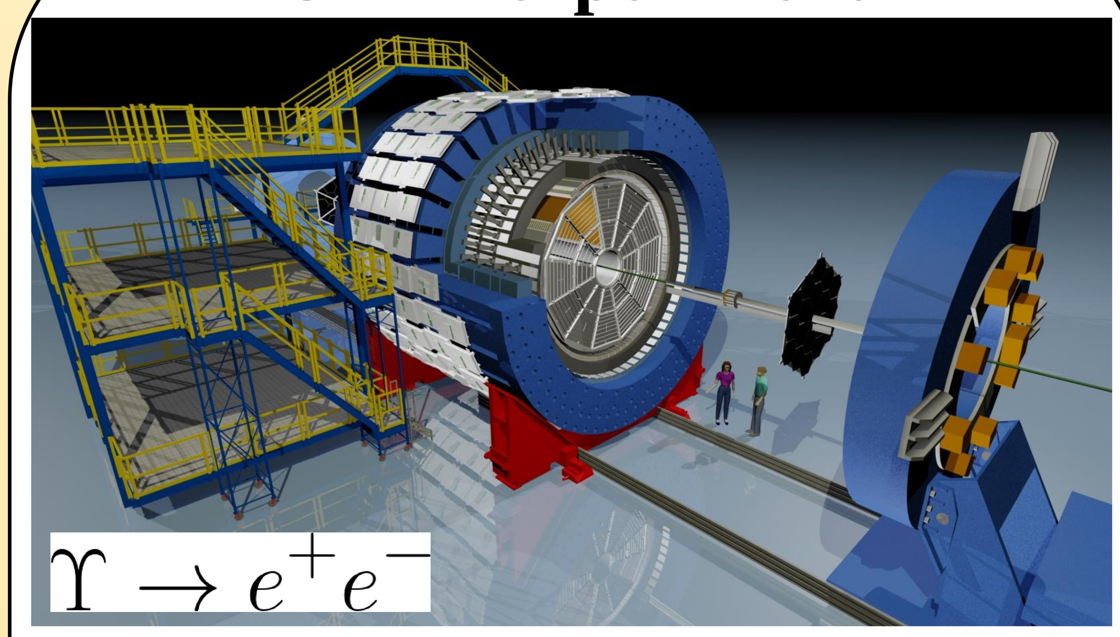
- **MPI** – multi-parton interactions
- **String Percolation** – interactions between strings of color field cause suppression of soft particle production:

[Phys.Rev. C, 86, 034903 (2012)]
$$\frac{N_{hard}}{\langle N_{hard}\rangle} = \langle\rho\rangle \left(\frac{\frac{dN_{ch}}{d\eta}}{\left\langle\frac{dN_{ch}}{d\eta}\right\rangle}\right)^2$$



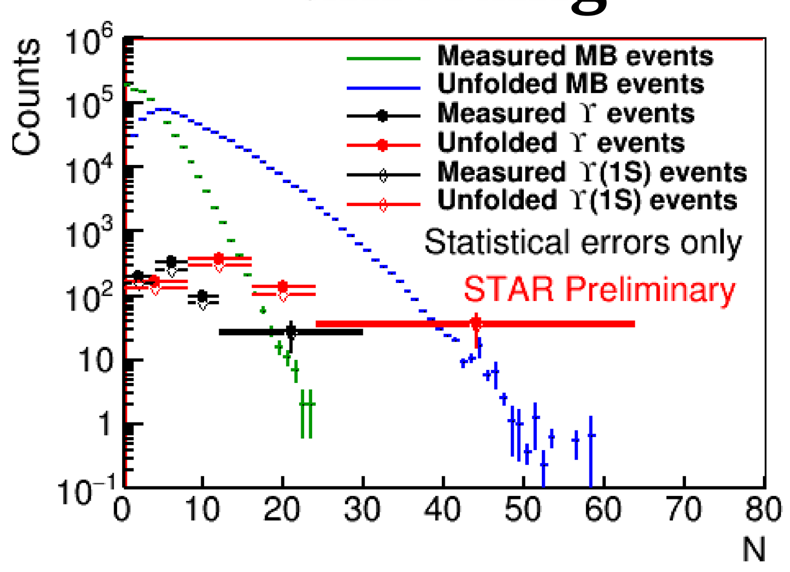
[Ann.Rev.Nucl.Part.Sci.60, 463-489(2010)] [Proceedings of SPIE, 100313U(2016)]

STAR experiment



- **TPC** – tracking and particle identification at midrapidity
- **BEMC** – electron identification and triggering on high-p_T electrons
- **TOF** – TPC tracks matched to TOF to reject pile-up for measuring N_{ch}

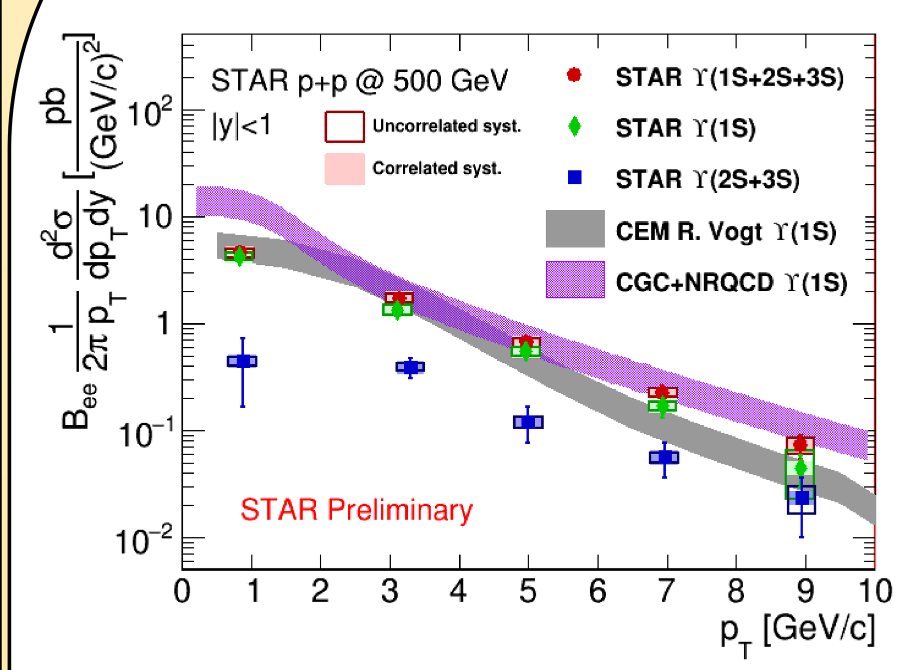
Multiplicity correction via unfolding

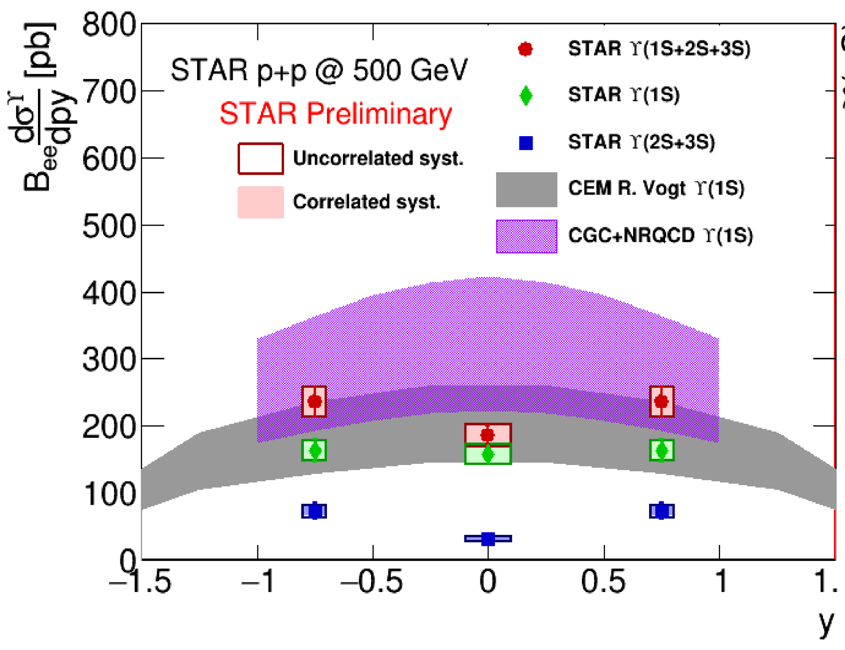


- Response matrix determined from PYTHIA simulation and STAR detector simulation [arXiv:1105.1160]
- Measured distributions unfolded with this matrix to obtain corrected ones

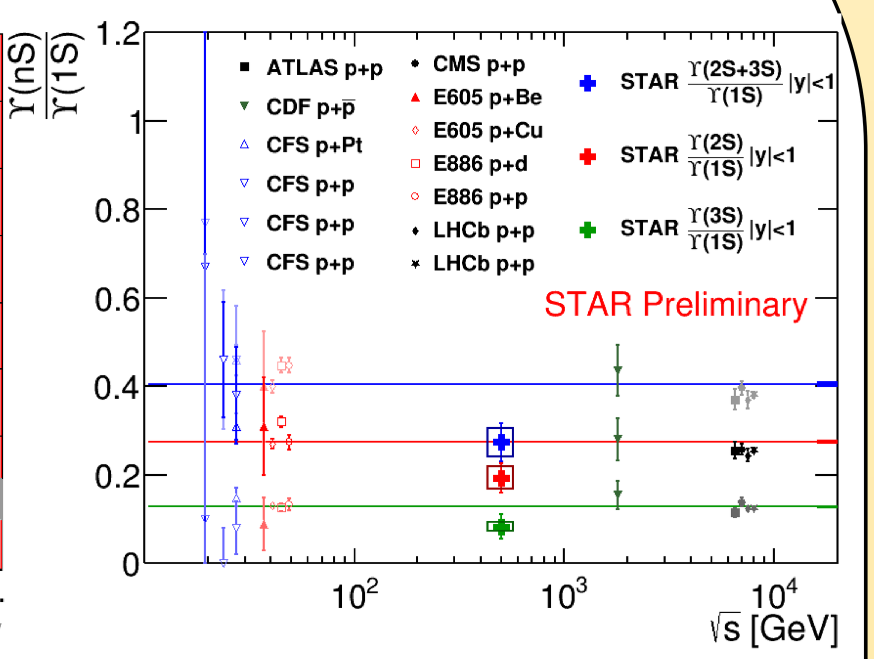
Results

Spectra



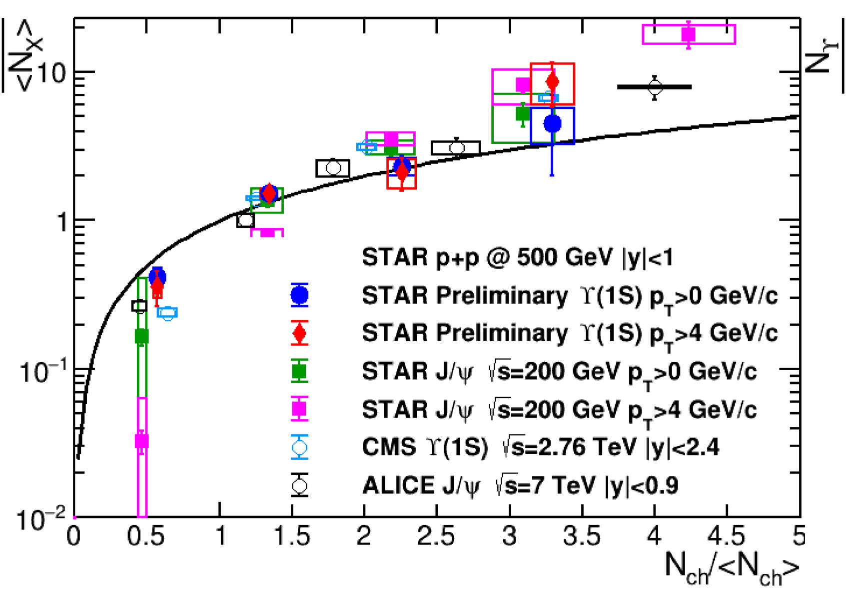


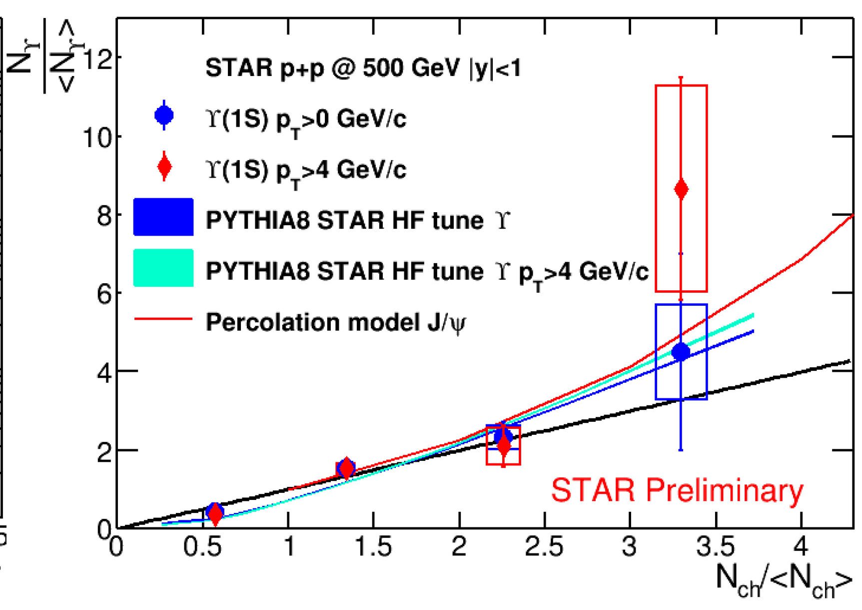
[Phys.Rev.C 88,067901(2013)]

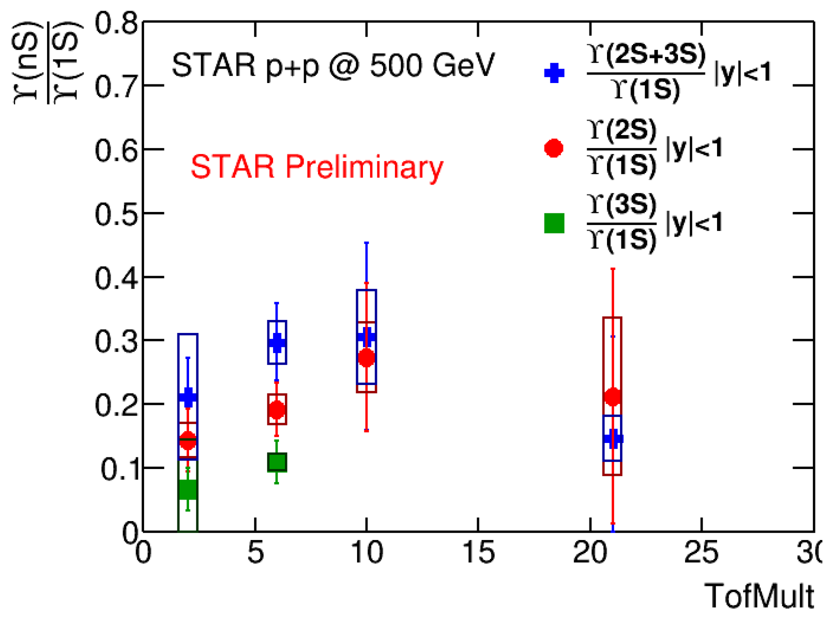


- CEM for inclusive Υ(1S) agrees with the data reasonably well [Phys.Rev. C92 (2015)034909]
- CGC+NRQCD for direct Υ(1S) above the data [PRD 94, 014028 (2016)] [PRL 113,192301 (2014)]
- Υ(nS)/Υ(1S) ratios below world average, but within 2σ

Multiplicity dependence







- Similar trend observed for Υ and J/ψ at RHIC and LHC [JHEP04,103(2014)], [Nucl.and Part.Phys. Proc., 276-278, pp.261-264(2016)], [Phys.Lett.B 712,165-175(2012)], [Phys.Lett.B 786,87-93(2018)]
- Both PYTHIA8 with MPI and Percolation Model qualitatively describe the trend in the data
  - Measurements of better precision at higher multiplicities are needed to distinguish among different models
- Υ(nS)/Υ(1S) vs. TOF multiplicity consistent with being flat

ČVUT ČESKÉ VYSOKÉ UČENÍ TECHNICKÉ V PRAZE

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