Quarkonium production in p+p collisions measured by the STAR experiment

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Quark Matter 4-10.4.2022, Cracow, Poland

EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research, Development and Education

Supported in part by U.S. DEPARTMENT OF ENERGY Office of Science

MINISTRY OF EDUCATION, YOUTH AND SPORTS

ČVUT ČESKÉ VYSOKÉ UČENÍ TECHNICKÉ V PRAZE

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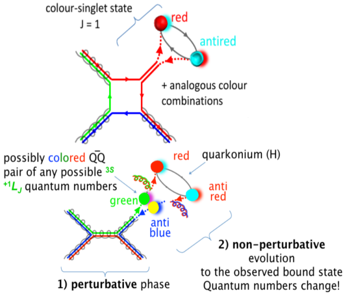
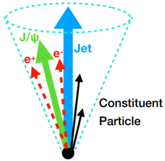
This work was also supported by the grant LTT18002 of Ministry of Education, Youth and Sports of the Czech Republic.

- Quarkonium measurements in p+p collisons are a tool to study their production mechanism
  - Color Singlet, Color Octet/NRQCD(+CGC), Color Evaporation Model

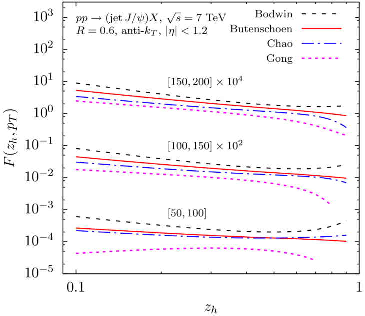


[P. Faccioli, Polarization in LHC physics, Course on Physics at the LHC 2014]

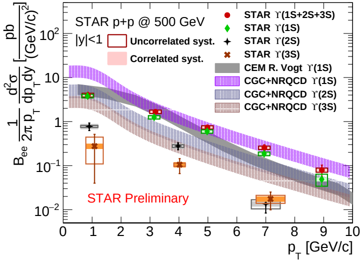
- Study of J/ψ production in a jet provides information about production mechanism and Non-Relativistic QCD (NRQCD) long-distance matrix elements (LDMEs) *[Phys.Rev. Lett. 119 (2017) 032001]*
  - Each LDME set gives different values of J/ψ fragmentation function vs. z (fraction of jet p_T carried by J/ψ)
  - Can distinguish between different sets of LDMEs

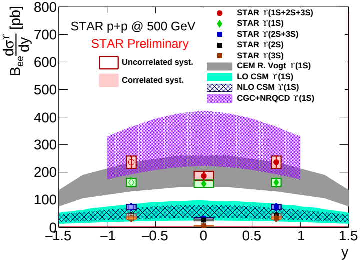


$$Z_h = \frac{p_{J/\psi}}{p_{jet}}$$



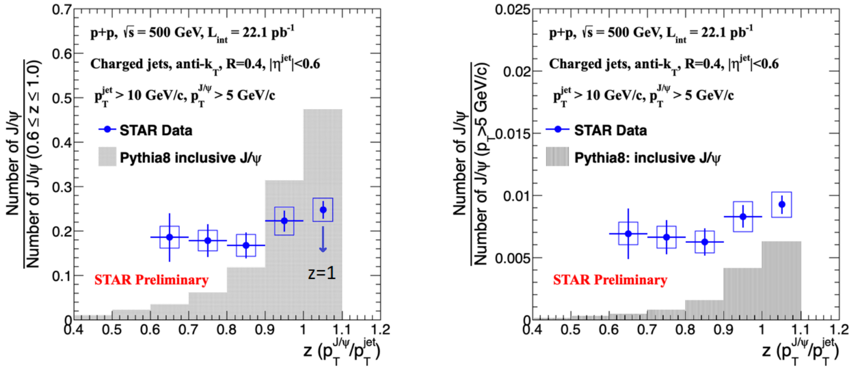
Spectra of $\Upsilon(nS)$ states





- $\Upsilon(nS)$ cross sections measured separately vs. p_T and y
- $\Upsilon(1S)$ data described well by Color Evaporation Model (CEM) model calculation of inclusive production *[Phys. Rev. C 92, 034909 (2015)]*
- $\Upsilon(nS)$ data overestimated by Color Glass Condensate+NRQCD calculation of direct production *[Phys. Rev. Lett. 113, 192301 (2014)],[Phys. Rev. D 94, 014028 (2016)]*
- NLO and LO Color Singlet Model (CSM) calculations for direct $\Upsilon(1S)$ (fraction of direct $= 0.66$) *[Phys. Rev. D 81, 051502 (2010)]* are disfavored by the STAR data

J/ψ production in a jet



- No significant dependence of J/ψ production on z, fraction of jet p_T carried by J/ψ for $0.6 \leq z \leq 1.0$
- Production of J/ψ within a jet is less isolated in the data than predicted by PYTHIA8
- Right: Normalized to measured J/ψ yield with $p_T > 5\,\mathrm{GeV/c}$, which corresponds to $3.7\% \pm 0.3\%(stat.) \pm 0.2\%(syst.)$ of the integrated cross section *[Phys. Rev. D 100, 052009 (2019)]*
- Data show systematically higher probability of J/ψ production in jets than in PYTHIA8 for $p_T > 5\,\mathrm{GeV/c}$
- Ongoing analysis of $336.4\,\mathrm{pb}^{-1}$ 2017 data set

Summary

Υ spectra in $p+p$ at $\sqrt{s} = 500\ \mathrm{GeV}$

- STAR measured p_T and y spectra of individual $\Upsilon(nS)$ states
- CEM model calculation for inclusive $\Upsilon(1S)$ well describes the STAR $\Upsilon(1S)$ spectra
- CGC+NRQCD calculation for direct $\Upsilon(nS)$ states overestimates the data
  - Especially at low p_T
- CSM calculation for direct $\Upsilon(1S)$ at LO and NLO disfavored by the $\Upsilon(1S)$ data

J/ψ production in jets in $p+p$ at $\sqrt{s} = 500\ \mathrm{GeV}$

- Measured J/ψ z fraction distribution for jet $p_T > 10\ \mathrm{GeV/c}$ and J/ψ $p_T > 5\ \mathrm{GeV/c}$
- No significant dependence on z for $0.6 \leq z \leq 1.0$
- Larger measured fraction of J/ψ in jets than predicted by PYTHIA
- J/ψ is less isolated in the data than in PYTHIA