中国科学技术大学

University of Science and Technology of China

PhD Qualification Report

Yuan Zhang

Supervisor: Yi Jiang

2024/04/23

Outline

- Resume
- Scientific research
  - Introduction of charmonia
  - Data analysis procedure
  - Results
- Summary and future research plan

Resume

- Basic information
  - Name: Yuan Zhang
  - Student ID: SA22004065
  - Master supervisor: Yi Jiang
  - PhD supervisor: Yi Jiang
- Education:
  - 2018 to 2022: University of Science and Technology of China
  - 2022 to now: University of Science and Technology of China

Course

课程名称	学分	成绩	绩点值
对撞物理	4	85	3.7
高能物理实验数据分析	4	93	4
高能核物理实验前沿	3	93	4
研究生综合英语	2	通过	
日常交流英语	2	通过	
新时代中国特色社会主义理论与实践	2	通过	
自然辩证法概论	1	通过	
高等量子力学	4	88	3.7
量子场论	4	85	3.7
核与粒子物理实验方法	4	90	4
物理学中的群论	4	82	3.3
近代物理进展	4	86	3.7

GPA:3.75
Average score of basic course: 87
Total Credit: 35

计算时间：2024-04-23 14:33:09

您适用的培养计划标准		2022年级070200物理学硕士	校验结果:尚未合格
培养计划校验详情		未完成必修环节：学位论文开题报告(2学分) 您的成绩课程类别有空值，对校验结果有影响，请联系教学秘书修改	
培养计划备注		老系统迁移	
培养计划要求		已经获得学分	是否合格
总学分(带必修环节)>=35		总学分=35	合格
基础课【加权平均】>=75		基础课【加权平均】=87	合格
公共课程学分>=7（<=7）		公共课程学分=7	合格
其他课程学分>=0		其他课程学分=3	合格
课程类别合并组学分>=16	专业基础课学分>=0	专业基础课学分=12 合格	合格
	学科基础课学分>=8	学科基础课学分=16 合格	
学位论文开题报告(2学分)			尚未合格

Introduction of charmonia

- **Charmonia: bound states of charm and anti-charm quark pairs.**
- **Crucial for studying charmonium production mechanisms and testing different QCD-based models.**
  - Heavy-quark production (perturbative QCD)
  - Formation of the charmonium states (non-perturbative QCD)

NRQCD:

$$(2\pi)^3 2P_H^0 \frac{d\sigma_H}{d^3P_H} = \sum_n d\hat{\sigma}_n(P_H)\langle \mathcal{O}_n^H \rangle$$

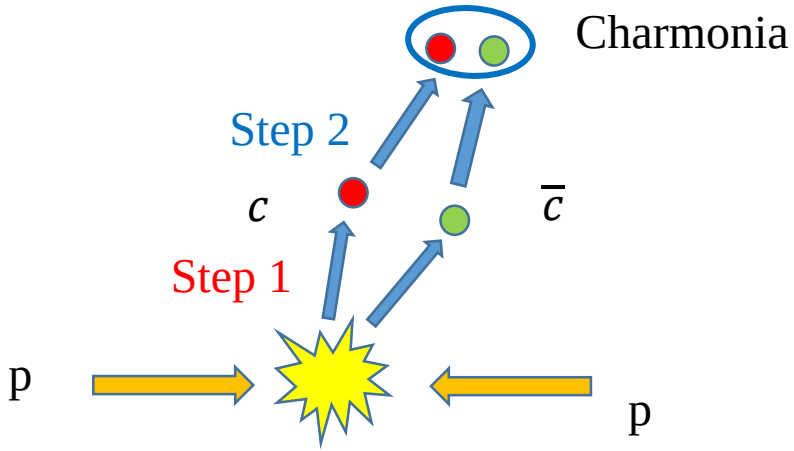
Production of a heavy quark pair
Expansion in: α_s

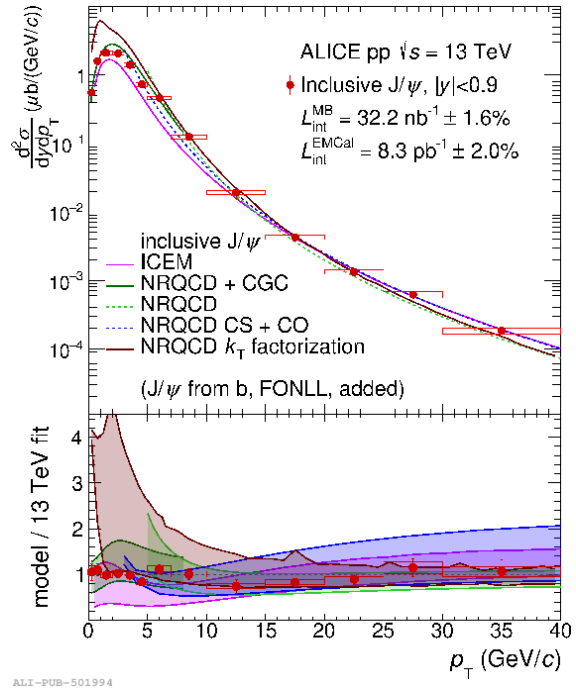
Hadronization (LDMEs)
Expansion in: v

ICEM:

$$\frac{d\sigma_\psi(P)}{d^3P} = F_\psi \int_{M_\psi}^{2M_D} d^3P' dM \frac{d\sigma_{c\bar{c}}(M,P')}{dMd^3P'} \delta^3(P - \frac{M_\psi}{M}P')$$

- **Measurement of ψ(2S)-to-J/ψ ratio can give further restrictions on the model.**





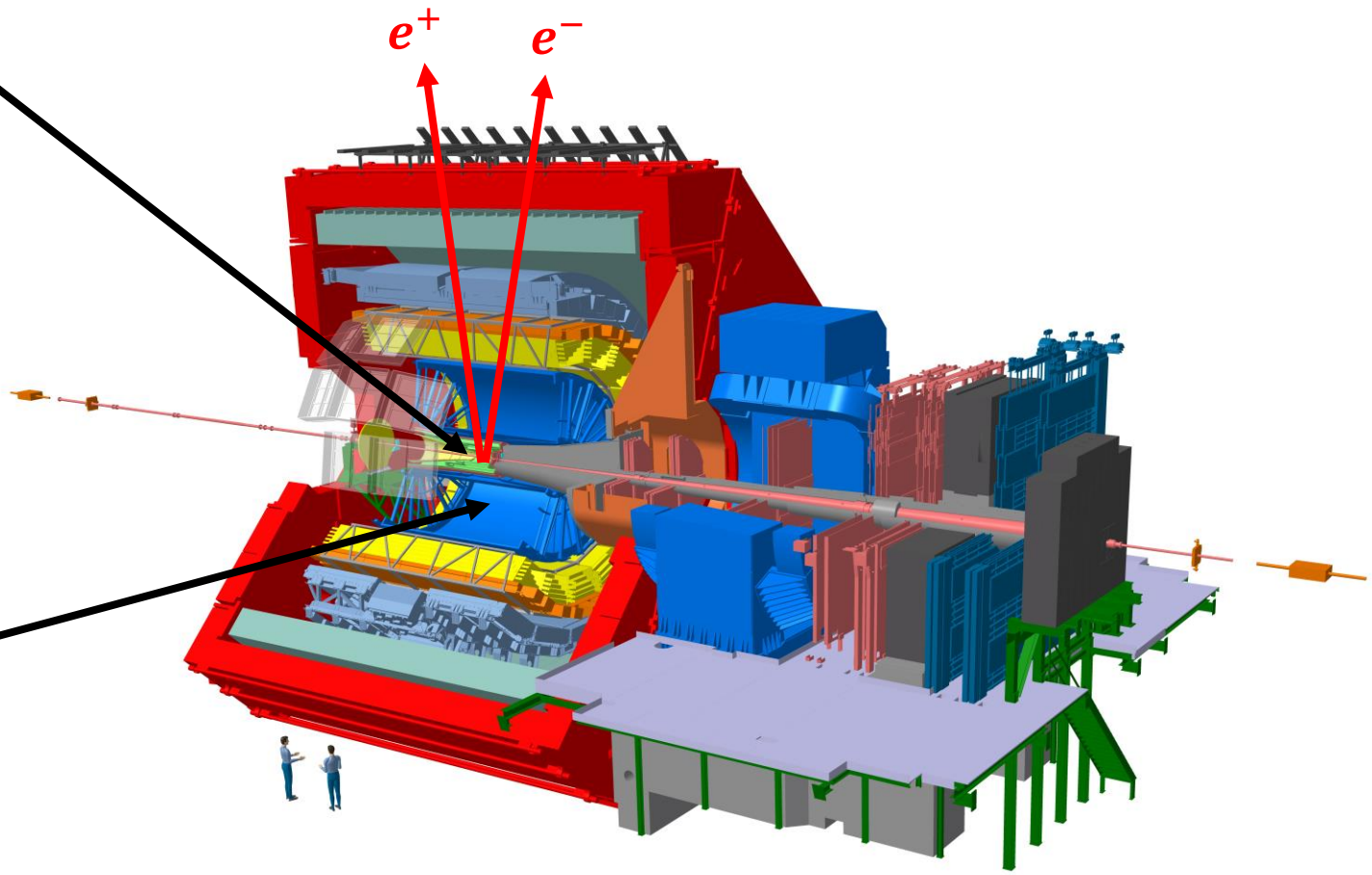
Charmonium reconstruction with ALICE

- Inner Tracking System (ITS)
  - Tracking
  - Vertex reconstruction
- ITS upgrade:
  - 6 layers ⟹ 7 layers equipped with Monolithic Active Pixel Sensors (MAPS).
  - Radius of innermost layer reduced.
  - Material budget for each of the 3 innermost layers reduced.

- Time Projection Chamber (TPC)
  - Tracking
  - Particle identification via dE/dx measurement
  - Momentum measurement
- TPC upgrade:
  - Readout chambers replaced with Gas Electron Multiplier (GEM) chambers.

Enable continuous readout of Pb–Pb events at an interaction rate up to 50 kHz (~10^2 w.r.t. run 2).

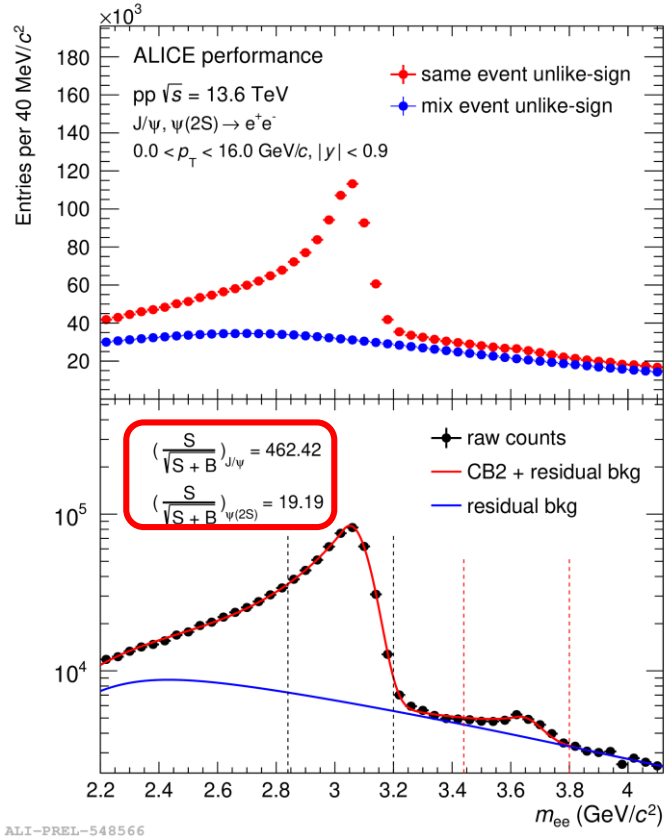
- Inclusive J/ψ, ψ(2S) can be reconstructed in e^+e^- channel at midrapidity ($|y| < 0.9$) down to $p_T = 0$.



Data analysis procedure

- Inclusive charmonia are reconstructed in e^+e^- channel at midrapidity ($|y| < 0.9$) down to $p_T = 0$.

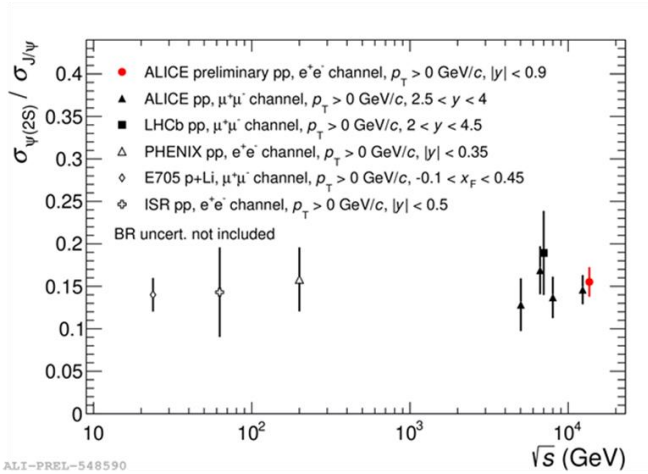
$$\frac{\sigma_{\psi(2S)}}{\sigma_{J/\psi}} = \frac{N_{\psi(2S)}}{N_{J/\psi}} \frac{(A \times \varepsilon)_{J/\psi}}{(A \times \varepsilon)_{\psi(2S)}} \frac{BR_{J/\psi \to ee}}{BR_{\psi(2S) \to ee}}$$

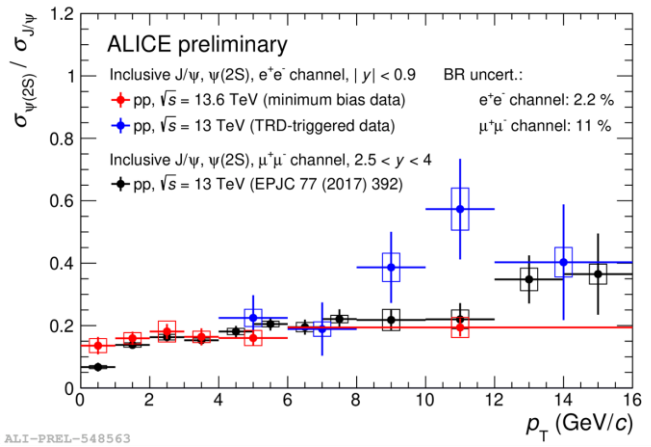


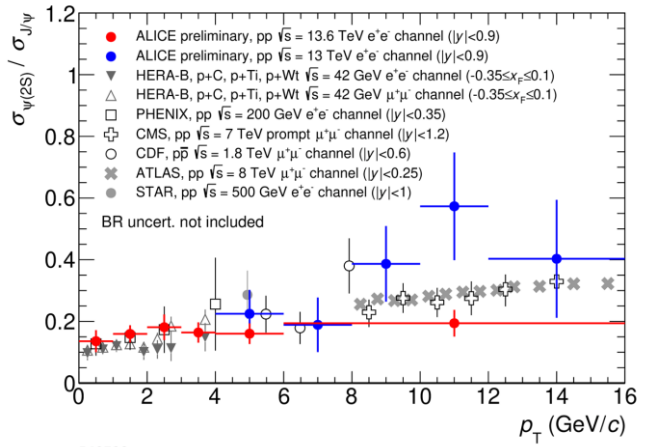
- Dataset:
  - pp collisions at $\sqrt{s}$ = 13.6 TeV collected in 2022 with the ALICE upgraded detector.
  - 524×10^9 minimum-bias (MB) events used in this analysis thanks to the continuous readout.
- Electron identification via TPC dE/dx.
- Signal extraction:
  - Signal shapes are described by two Crystal Ball functions. Possible differences between the J/ψ and ψ(2S) shapes are assigned as systematic uncertainties.
- The significance of J/ψ is about 462 and the significance of ψ(2S) reach to nearly 20.

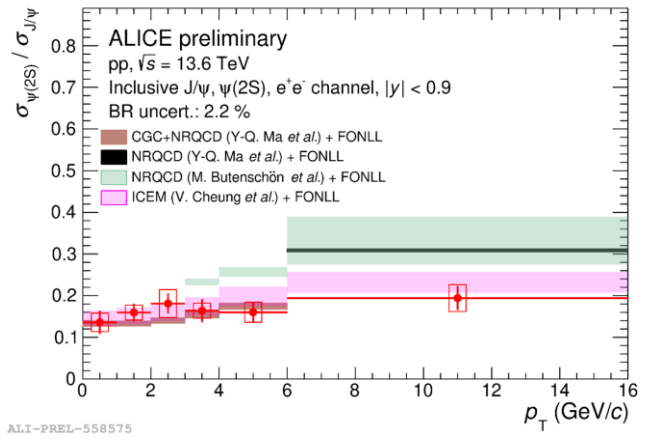
Results

- The result (red point) is shown together with existing results from ALICE at forward rapidity and from other experiments.
  - The uncertainty is reduced because of the improvement of statistics.
  - In agreement with other results.
  - No significant energy and rapidity dependence.
  - Slight p_T dependence (also expected from models).
- Comparison with models:
  - NRQCD overestimates the ratio.
  - CGC + NRQCD describes the ratio at low p_T up to 6 GeV/c.
  - ICEM can reproduce the data.

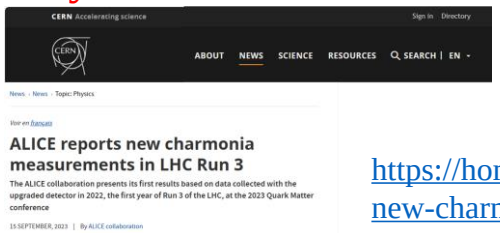








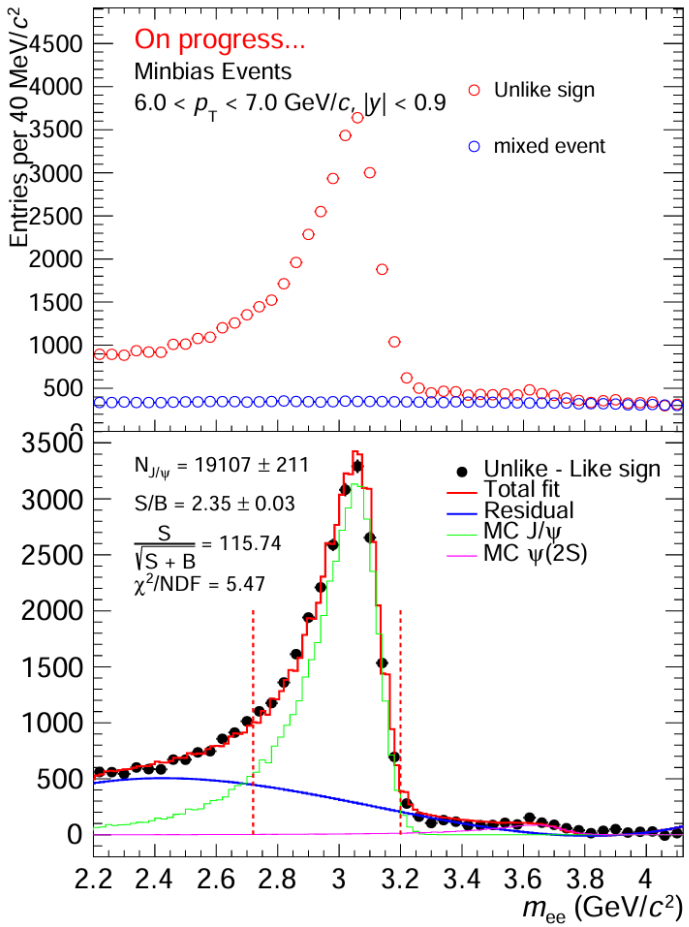
- The first preliminary results in ALICE Run 3.
- Reported by CERN News.

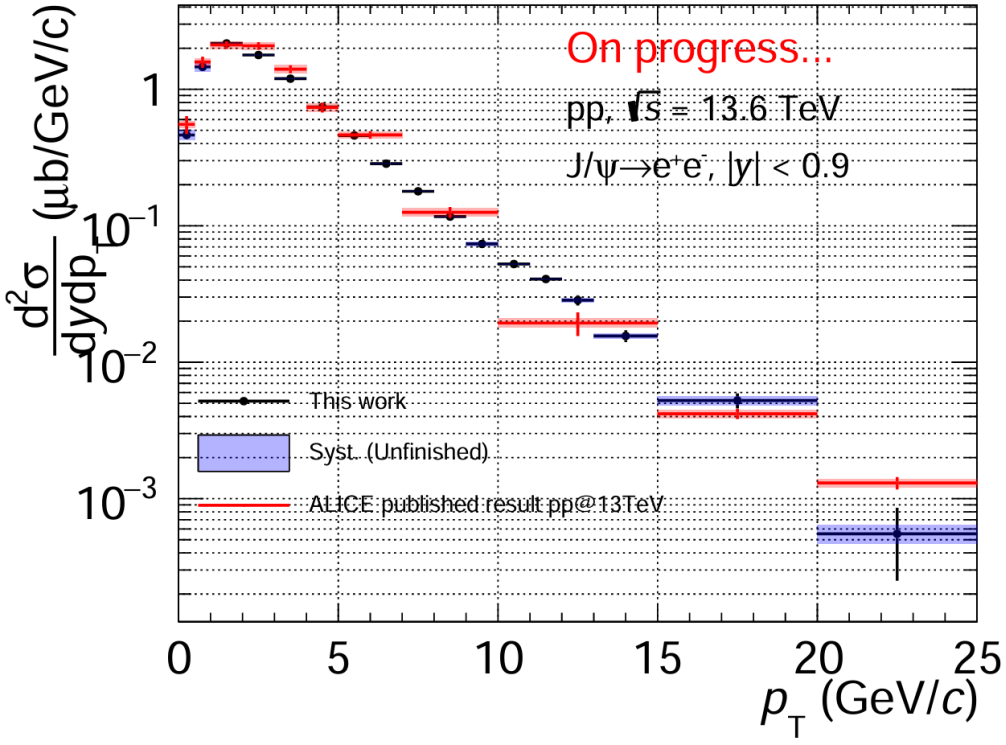


https://home.cern/news/news/physics/alice-reports-new-charmonia-measurements-lhc-run-3

- Paper proposal is ongoing.

J/ψ cross section measurement





- The measurement of J/ψ cross section is still ongoing and requesting the preliminary.

Conference

- Quark matter 2023 (Houston, America) Poster : Measurements of inclusive J/ψ and ψ(2S) production at midrapidity in pp collisions at $\sqrt{s}$ = 13.6 TeV with ALICE.
- CLHCP 2023 (Shanghai, China) Talk : Measurements of inclusive J/ψ and ψ(2S) production at midrapidity in pp collisions at $\sqrt{s}$ = 13.6 TeV with ALICE.
- QPT 2023 (Guangdong, China) Poster : Measurements of inclusive J/ψ and ψ(2S) production at midrapidity in pp collisions at $\sqrt{s}$ = 13.6 TeV with ALICE.
- QWG 2024 (Mohali, India) Talk : First psi(2S) measurement at midrapidity and Upsilon(nS) cross sections at forward rapidity in pp collisions at sqrt(s) =13 TeV at ALICE.

Summary and future plan

- The score and credit achieve the requirements.
- Scientific research:
  - Preliminary results of measurement of ψ(2S)-to-J/ψ ratio at midrapidity in pp collisions at 13.6 TeV using ALICE Run 3 datasets. Paper proposal is ongoing.
  - Measurement of J/ψ production cross section at midrapidty in pp collisions at 13.6 TeV using ALICE Run 3 datasets is ongoing and requesting the preliminary results.
- Future plan:
  - Finish the paper proposal of ψ(2S)-to-J/ψ ratio and preliminary requests of J/ψ production cross section.
  - Measure the prompt and non-prompt ψ(2S)-to-J/ψ ratio as a functions of p_T and multiplicity in Run 3.