

Study of heavy quarkonia and B_c^+ mesons at LHCb

Zhenwei YANG (杨振伟)
Tsinghua University

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中国科学院粒子物理前沿卓越创新中心

CAS Center for Excellence in Particle Physics

CV

- 1998: Bachelor degree, Department of Physics, Tsinghua
- 2004: PhD in Physics, Department of Physics, Tsinghua
Supervised by Prof. Pengfei Zhuang
- 2004-2007: Postdoc in Department of Engineering Physics
- 2007-2011: Assistant Researcher in DEP, Tsinghua
- 2011- : Associate Professor in DEP, Tsinghua

- **Started since 2004 to work for HEP experiments**
- **Dedicated to LHCb since 2009**
 - Heavy quarkonia
 - B_c physics

Outline

➤ Introduction

➤ Research activities (2013.09 – 2014.09)

- Prompt $\psi(2S)$ polarisation in pp collisions
- B_c^+ baryonic decay in pp collisions
- J/ψ and Υ productions in pPb collisions
 - ✓ Detecting cold nuclear matter effects by J/ψ , b hadrons, and $\Upsilon(1S)$

➤ Plan of 2015

➤ Summary

- A forward single-arm spectrometer at the LHC
- Dedicated to beauty and charm physics
- 17 countries, 68 institutes, 1110 members
Tsinghua (清华) and CCNU (华师)

Geneva



CERN



LHC Tunnel

LHCb in a nutshell

Pseudorapidity acceptance
 $2 < \eta < 5$

Impact parameter:

$$\sigma_{IP} = 20 \mu\text{m}$$

Proper time:

$$\sigma_{\tau} = 45 \text{ fs for } B_s^0 \rightarrow J/\psi\phi \text{ or } D_s^+\pi^-$$

Momentum:

$$\Delta p/p = 0.4 \sim 0.6\% (5 - 100 \text{ GeV}/c)$$

Mass :

$$\sigma_m = 8 \text{ MeV}/c^2 \text{ for } B \rightarrow J/\psi X \text{ (constrained } m_{J/\psi})$$

RICH $K - \pi$ separation:

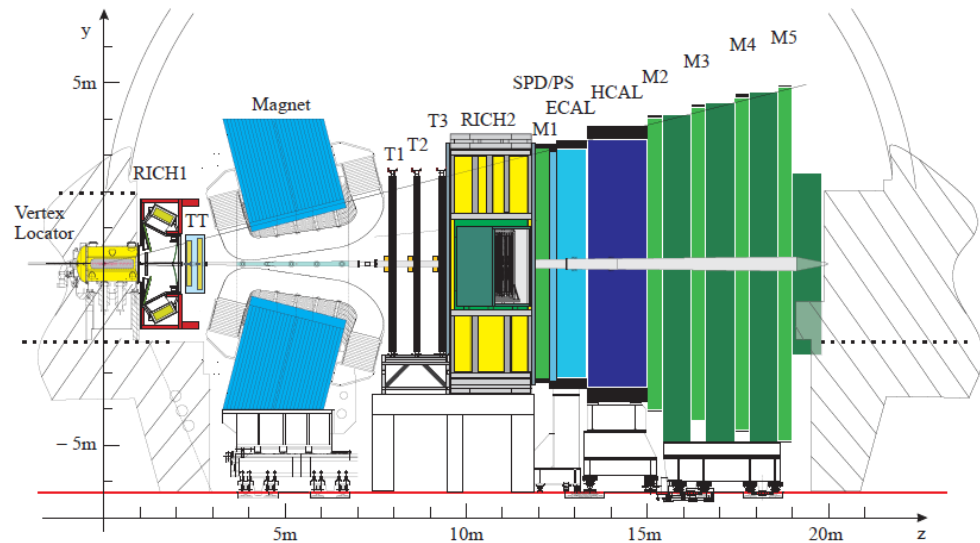
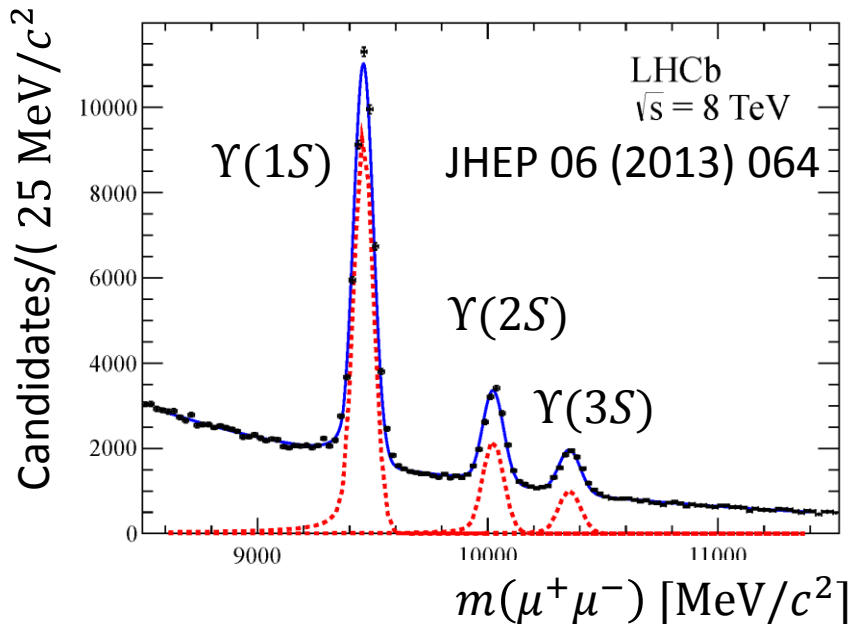
$$\epsilon(K \rightarrow K) \sim 95\% \text{ mis-ID } \epsilon(\pi \rightarrow K) \sim 5\%$$

Muon ID:

$$\epsilon(\mu \rightarrow \mu) \sim 97\% \text{ mis-ID } \epsilon(\pi \rightarrow \mu) \sim 1 - 3\%$$

ECAL:

$$\Delta E/E = 1\% + 10\%/\sqrt{E(\text{GeV})}$$



LHCb organisation

- 8 Physics Working Group (WG) (8 red color)
- Conveners from LHCb-China in 2 WG's (2 red color)
- **Zhenwei Yang** nominated as **BandQ WG convener** (2015.01 – 2017.03)

WG & Sub-WG	Conveners	WG & Sub-WG	Conveners
• QCD, Electroweak and Exotica	Katharina Müller & Philp Ilten	• B decays to Charmonia	Diego M. Santos & 谢跃红(华师)
• B hadrons and Quarkonia	Vanya Belyaev & Marco Pappagallo	- B2CC time dependent	- Greig Cowan
- Production & Polarization	- 杨振伟(清华)	- B2CC time independent	- 张黎明(清华)
- B-hadrons and Bc	- 李一鸣(清华)	• B decays to Open Charm	Anton Poluektov & Moritz Karbach
- Exotic spectroscopy	- Michal Kreps	• Charmless b-hadron decays	Angelo Carbone & Eduardo Rodrigues
• Charm physics	Marco Gersabeck & Carla Göbel	• Semileptonic B decays	Jeroen van Tilburg & Mika Vesterinen
• Rare decays	Gaia Lanfranchi & Tom Blake		

B hadrons and Quarkonia Working Group

➤ **BandQ: most productive WG in LHCb**

- 48 out of 229 LHCb papers ~ 20%

➤ **Tsinghua plays an important role in BandQ WG**

- **Two subgroup conveners**

- **12 out of 48 BandQ papers ~ 25%**

- ✓ 3 papers of J/ψ production and $\psi^{(\prime)}$ polarisations
- ✓ 2 papers of B -meson productions
- ✓ 5 papers of B_c^+ physics (**2 PRL's**)
- ✓ 2 papers of quarkonia in p Pb collisions

Research activities

(2013.09 – 2014.09)

Benefit from

- **Activities of LHCb-Tsinghua** in last 10 years
- **Collaborations with other institutes**
- **Collaboration with theorists**

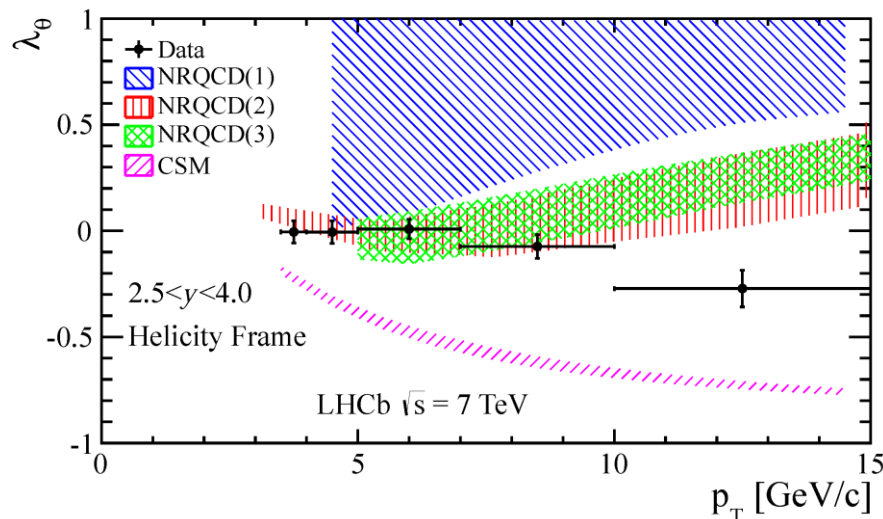
Prompt $\psi(2S)$ polarisation in pp collisions

- **Full angular analysis** to determine all three polarisation parameters $(\lambda_\theta, \lambda_\varphi, \lambda_{\theta\varphi})$:

$$\frac{d^2N}{d\cos\theta d\phi} \propto 1 + \lambda_\theta \cos^2\theta + \lambda_\varphi \sin^2\theta \cos^2 2\varphi + \lambda_{\theta\varphi} \sin 2\theta \cos\varphi$$

- **Fighting with systematics, higher background (cf. J/ψ)**

- **MVA technique** to suppress high background
- **sPlot technique** for background subtraction
- **$B^+ \rightarrow J/\psi K^+$** to validate MC

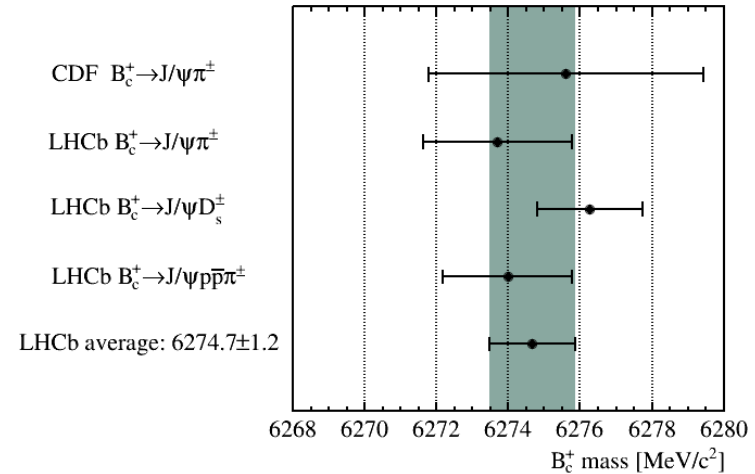
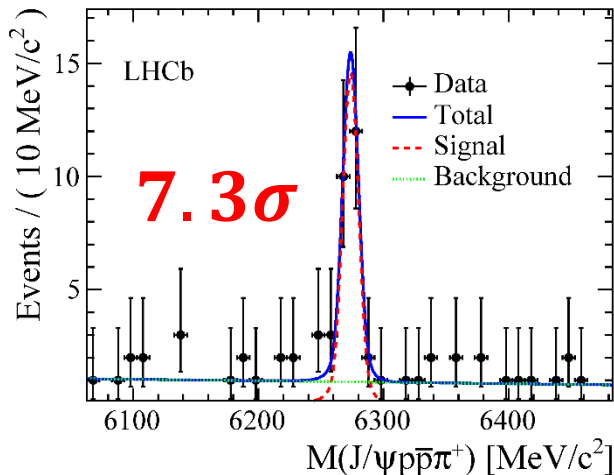


EPJ C74 (2014) 2872

Observation of $B_c^+ \rightarrow J/\psi p \bar{p} \pi^+$

➤ First observation of baryonic B_c^+ decay: 7.3σ

- (Potential) precise mass measurement due to low Q^2
 - ✓ $m = 6274.0 \pm 1.8(\text{stat}) \pm 0.4(\text{syst}) \text{ MeV}/c^2$
 - ✓ Can be improved with larger sample



Published in PRL 113 (2014) 152003

➤ Proton and pion identification essential

- New proton ID calibration developed for LHCb

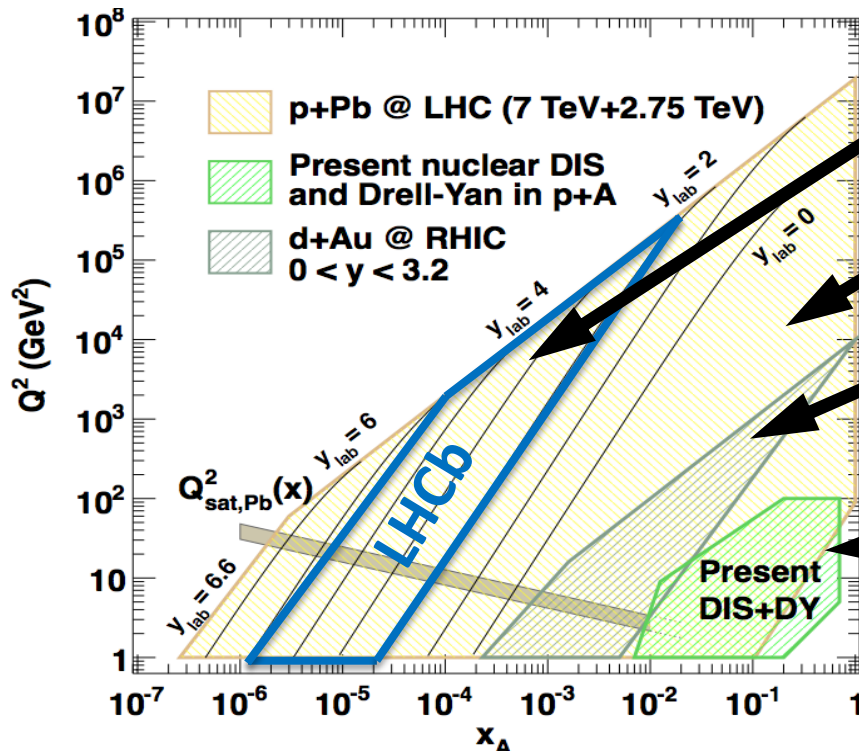
Heavy quarkonia production in pPb

➤ Power of proton-nucleus collisions

- Insight to unexplored region of QCD phenomena
- Constrain nuclear Parton Density Function (nPDF) at low x

➤ Unique kinematic range with full PID at LHCb

- Only muon detection at ALICE



LHCb accessible

p+Pb @ LHC (7 TeV + 2.75 TeV)

d+Au @ RHIC ($0 < y < 3.2$)

Present nuclear DIS
and Drell-Yan in pA

Heavy quarkonia production in $p\text{Pb}$ (cont.)

➤ Leading role by Tsinghua

- First 2 out of 3 $p\text{Pb}$ papers

- ✓ JHEP 02 (2014) 072

- ✓ JHEP 07 (2014) 094

- J/ψ , b hadrons and Υ studied

- ✓ Extract J/ψ from b -hadron decays

- ✓ High background different to pp collisions

- ✓ Systematic uncertainties

➤ J/ψ results selected as LHCb highlight

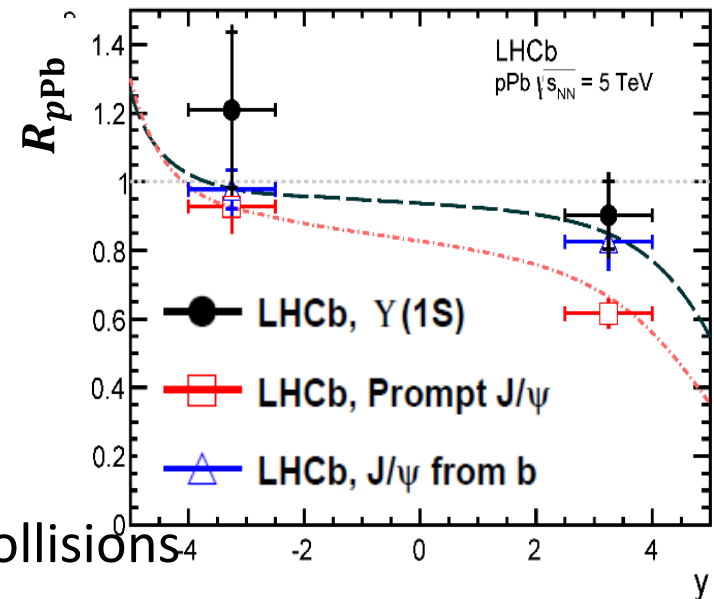
➤ Announce J/ψ results with ALICE at the same day!

Announce Υ results 2 months in advance!

I was selected as $p\text{A}$ session convener of workshop

“Implications of LHCb measurements and future prospects”

(15 – 17 October, 2014, CERN)



Publication list (2014)

1. First observation of a baryonic B_c^+ decay, **PRL 113 (2014) 152003**
Contact authors: Yanxi Zhang (I am the co-supervisor)
2. Study of Y production and cold nuclear matter effects in $p\text{Pb}$ collisions at $\sqrt{s_{NN}} = 5$ TeV, **JHEP 07 (2014) 094**
Contact authors: Fanfan Jing and Zhenwei Yang
3. Study of J/ψ production and cold nuclear matter effects in $p\text{Pb}$ collisions at $\sqrt{s_{NN}} = 5$ TeV, **JHEP 02 (2014) 072**
Contact authors: Fanfan Jing and Zhenwei Yang
4. Measurement of $\psi(2S)$ polarisation in pp collisions at $\sqrt{s} = 7$ TeV, **EPJ C74 (2014) 2872**
Contact authors: Yanxi Zhang and Zhenwei Yang

Conference talks

- Production of J/ψ and Y mesons in proton-lead collisions at $\sqrt{s_{NN}} = 5$ TeV, [Quark Matter 2014, XXIV International Conference on Ultrarelativistic Nucleus-Nucleus Collisions](#) (Quark Matter 2014), 19-24 May, 2014, Darmstadt, Germany. (A proceeding accepted by **Nucl. Phys. A**, [available online](#))
doi:10.1016/j.nuclphysa.2014.08.046
- First simulations with a LHCb-like forward detector for AFTER@LHC, [probing the strong interaction at A Fixed Target ExpeRiment with the LHC beams](#), 12-17 January, 2014, Ecole de Physique des Houches, France.



Nuclear Physics A

Available online 20 August 2014

In Press, Corrected Proof — Note to users



Production of J/ψ and Y mesons in proton–lead collisions at

$\sqrt{s_{NN}} = 5.02$ TeV

Zhenwei Yang, (for the LHCb Collaboration,

Plan of 2015

➤ Early Measurements with 2015 data

- **Representative in Early Measurements Task Force (EMTF)**
- **Organising activities on early measurements**
 - ✓ Production cross-sections of heavy quarkonia and b hadrons
 - ✓ Leading contributions in 2 or more papers expected

➤ Search for Ξ_{cc}^+ baryons using 2011-2012 data

➤ CPV study using 2011-2012 data

- Direct CPV in B^+ decays
- 1 paper expected

➤ pA physics

- $\psi(2S)$ and open charm in pPb collisions
- 2 papers expected

Summary

➤ A productive year in LHCb physics analyses

- 4 papers in heavy quarkonia and B_c^+ in pp and pPb collisions
 - ✓ First baryonic B_c^+ decay, **PRL 113 (2014) 152003**
 - ✓ Υ in pPb collisions, **JHEP 07 (2014) 094**
 - ✓ J/ψ in pPb collisions, **JHEP 07 (2014) 094**
 - ✓ $\psi(2S)$ polarisation, **EPJ C74 (2014) 2872**
- 2 conference talks
- 2 LHCb conference notes (public results)

➤ Nominated as “BandQ” **WG convener** for 2015.01-2017.03

Thank you

Nomination as “BandQ” WG convener

➤ Email from LHCb Physics Coordinator

☆ **Patrick Koppenburg**

November 14, 2014 at 19:25

To: Vanya Belyaev, Marco Pappagallo

[Hide Details](#)

Cc: Zhenwei Yang

[Inbox - CERN](#) 1

B&Q convenership



Dear Marco and Vanya,

I am happy to announce that Zhenwei (cc-ed) has accepted the convenership. The information will not be official until the CB on 3 December, so please do not broadcast this information publicly. You are of course welcome to discuss about the transition and the organisation of the group. I understand Zhenwei will be at CERN Mon-Wed (but quite busy).

Will be officially announced on 3 December

Cheers,

Patrick

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Patrick Koppenburg

LHCb Physics Coordinator

Nikhef, Amsterdam & CERN

<http://www.koppenburg.org/address.html>

Backup slides

Other issues

- NSFC Major Project granted in 2014
- Co-supervisor of PhD students
 - Fanfan JING
 - Liang ZHONG
- AFTER@LHC
- Student training

Cold Nuclear Matter Effects

