LHCb-中国组研究进展

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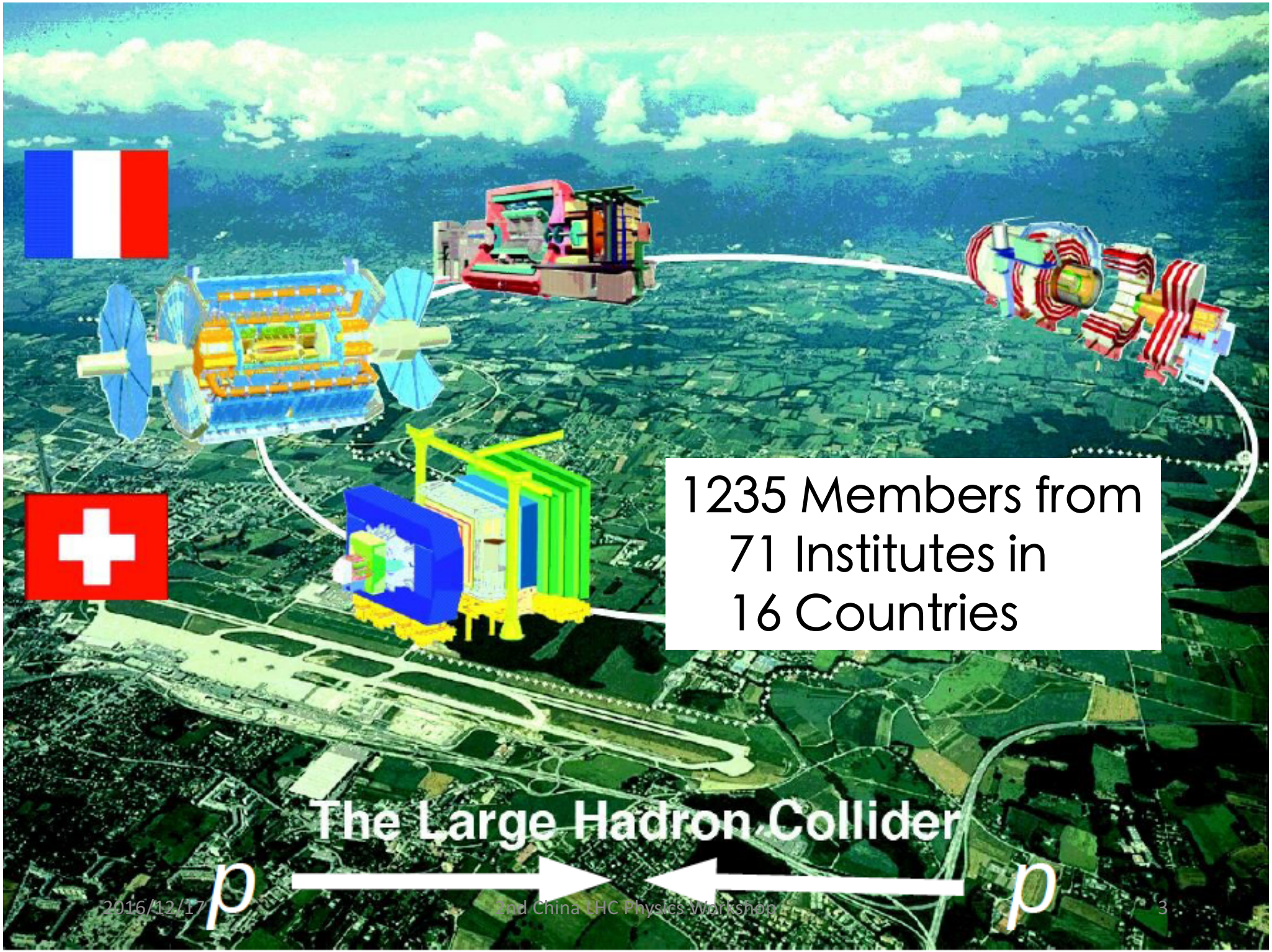
代表LHCb-中国组

第二届中国LHC物理工作会议
北京大学，2016.12.16-19

报告内容

- LHCb 实验进展
- 2016 中国组研究进展：亮点工作和总结
- LHCb-中国组
- 探测器升级

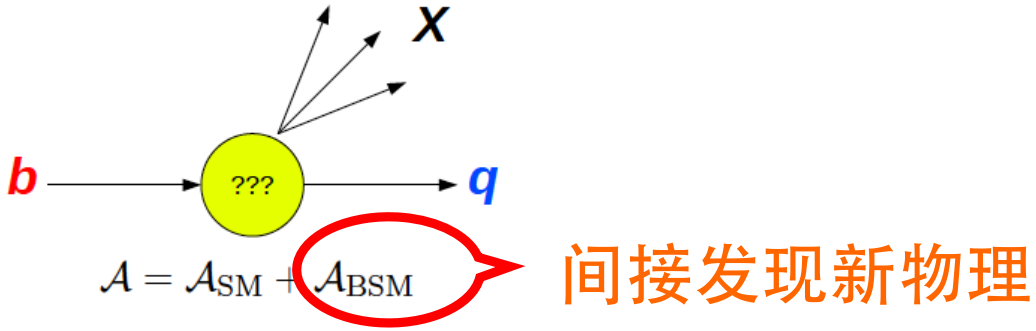

1235 Members from
71 Institutes in
16 Countries
The Large Hadron Collider
p
p

LHC的科学目标

- LHC 实验 = ALICE + ATLAS, CMS + LHCb + ..

  - ALICE 高能核物理前沿
  - ATLAS, CMS 粒子物理高能量前沿
  - LHCb 粒子物理高精度前沿

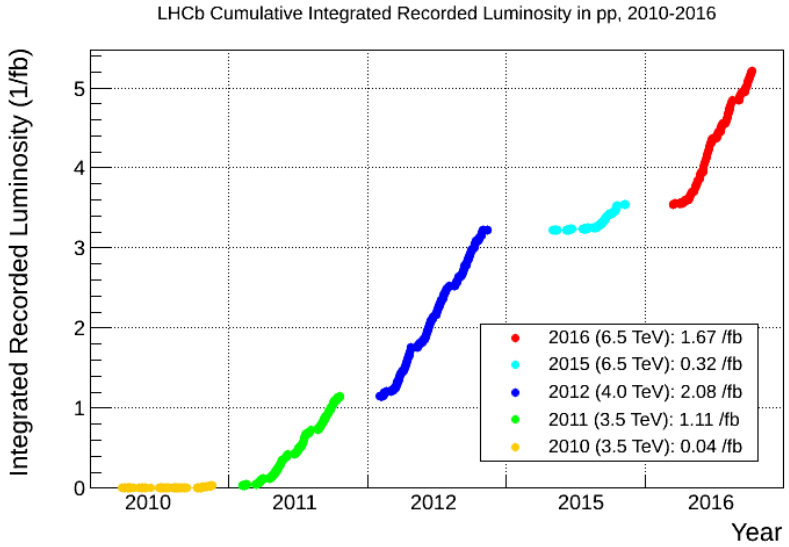
- LHCb的主要科学目标是寻找超出标准模型的新物理



+ QCD, Electroweak, Hadron spectroscopy …

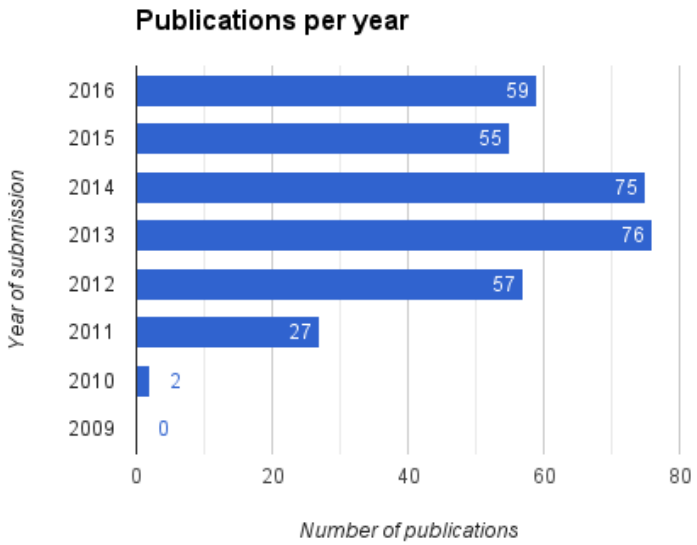
LHCb 实验进展

- $1.7\ \mathrm{fb}^{-1}$ (2016) + $0.3\ \mathrm{fb}^{-1}$ (2015) @ 13 TeV



- 2016 提交论文 59篇 （共350篇）

  中国组：5 (25)



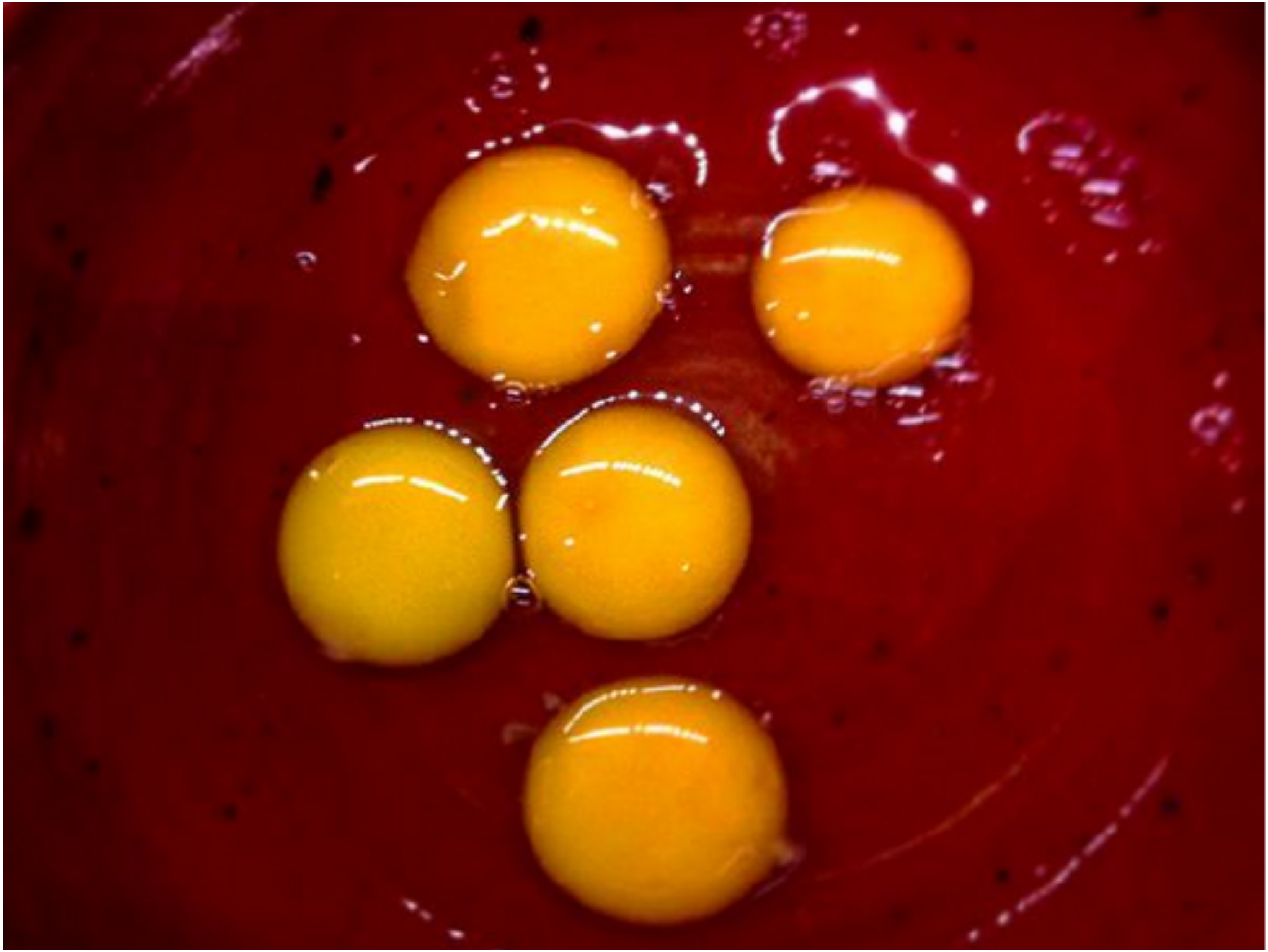
LHCb 物理工作组召集人（PWG Conveners）

WG	1/1/2014 - 31/3/2016	1/1/2015 - 31/3/2017	1/1/2016 - 31/3/2018
QEE	P. Ilten* (MIT, US)	W. Hulsbergen (NIKHEF, NL)	Xabier Cid Vidal (Santiago, ES)
BNOC	E. Rodrigues (Manchester, UK)	T. Latham (Warwick, UK)	Stefano Perazzini (CERN)
B2OC	C. Fitzpatrick** (EPFL, CH)	S. Malde (Oxford, UK)	Dan Johnson (CERN)
B2CC	Y. Xie (CCNU, CN)	Y. Amhis (LAL, FR)	Liming Zhang (Tsinghua, CN)
CHARM	C. Gobel (PUC, BR)	A. Di Canto (CERN)	Patrick Spradlin (Glasgow, UK)
SLB	M. Vesterinen (Heidelberg, DE)	C. Bozzi (Ferrara, IT)	Patrick Owen (Imperial, UK)
RD	T. Blake (Warwick, UK)	M.-O. Bettler (CERN)	Albert Puig (EPFL, CH)
BANDQ	M. Pappagallo (Glasgow, UK)	Z. Yang (Tsinghua, CN)	Lucio Anderlini (Firenze, IT)

- QEE = QCD, Electroweak & Exotica
- BNOC = Charmless b-hadron decays
- B2OC = B decays to open Charm
- B2CC = B decays to Charmonia
- CHARM = Charm physics
- SLB = Semileptonic B decays
- RD = Rare decays
- BANDQ = B hadron and Quarkonia

2016年亮点工作

II



五夸克态的发现

PRL 115, 072001 (2015)

- **Inspire-HEP上引用：285 次**
- **国内外科学与大众媒体广泛报道**
- **多个国际会议为其增设特邀报告**

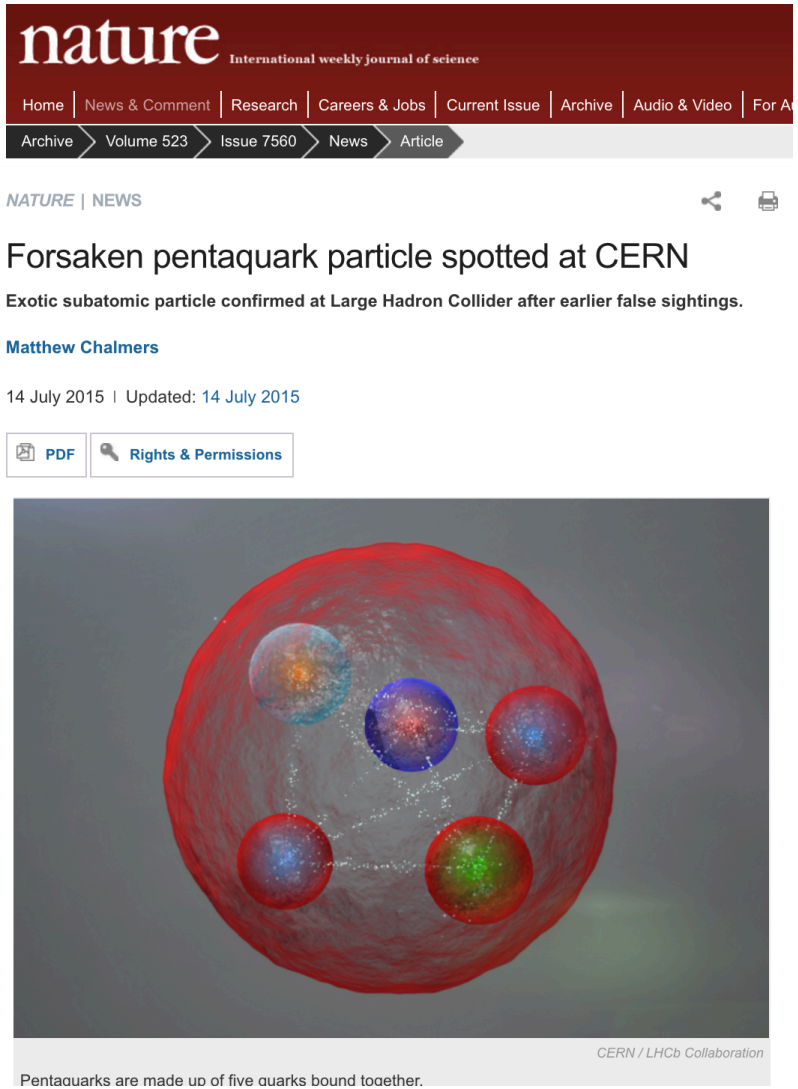
诺贝尔物理奖获得者(2004)
Frank Wilczek (MIT教授)
在当日的评论：

【Nature 523, 267–268】

"It's about the most exciting discovery in QCD I could imagine," says **Frank Wilczek**, of … himself an architect of QCD.

诺贝尔物理奖获得者(1969) 夸克模型的提出者Gell-Mann教授的评论：

"This is part of a long process of discovery of particle states," he says, regarding pentaquarks.



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Archive > Volume 523 > Issue 7560 > News > Article

NATURE | NEWS

Forsaken pentaquark particle spotted at CERN

Exotic subatomic particle confirmed at Large Hadron Collider after earlier false sightings.

Matthew Chalmers

14 July 2015 | Updated: 14 July 2015

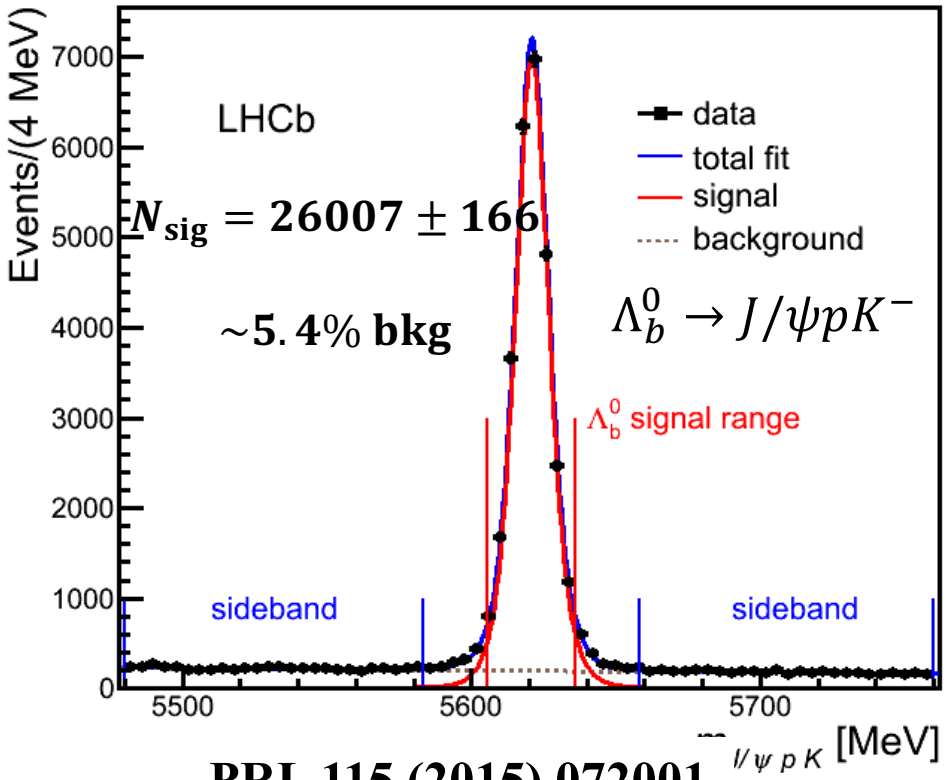
PDF | Rights & Permissions

CERN / LHCb Collaboration

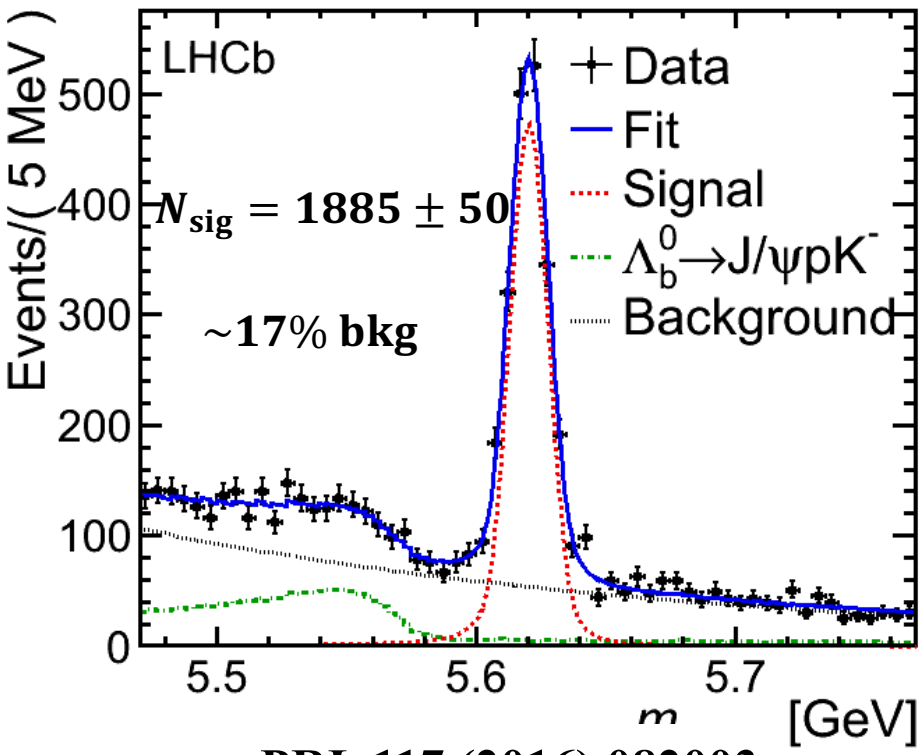
Pentaquarks are made up of five quarks bound together.

$\Lambda_b^0 \to J/\psi p \pi^-$ 衰变的分波分析

- 在其它衰变中看到相同的P_c^+态的产生，可以帮助理解其产生机制和内部结构
- $\Lambda_b^0 \to J/\psi p \pi^-$是Cabibbo压低的衰变，分支比大约是$\Lambda_b^0 \to J/\psi p K^-$的1/10



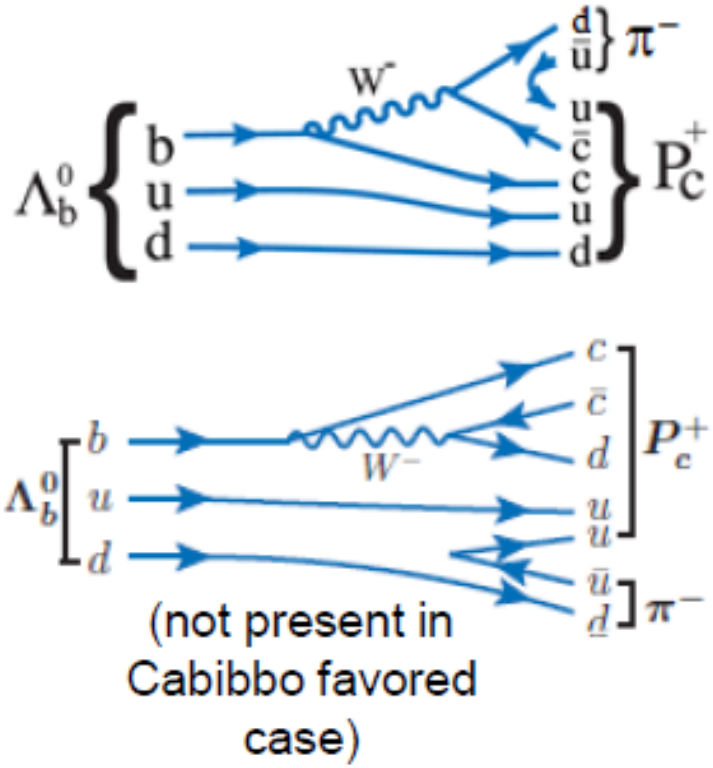
PRL 115 (2015) 072001

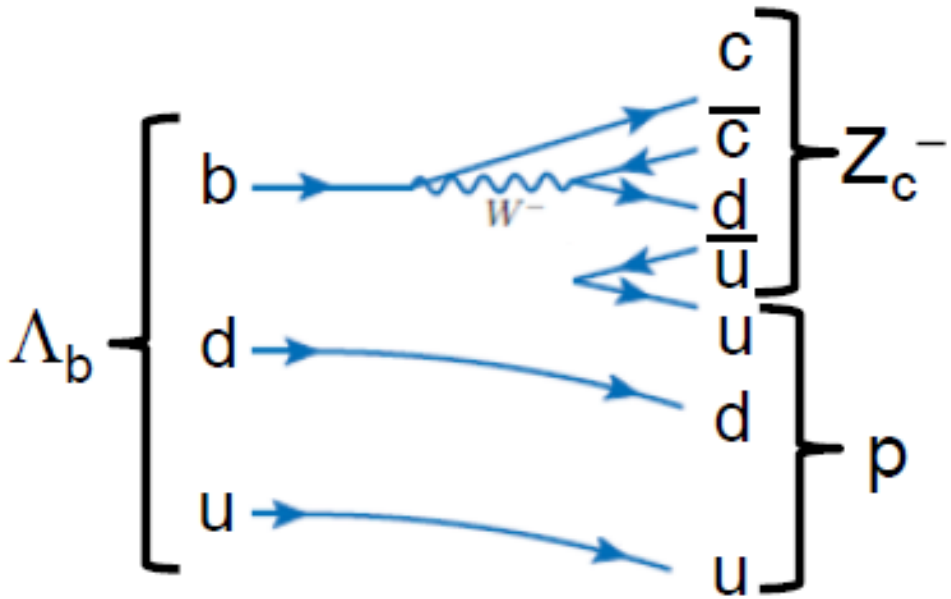


PRL 117 (2016) 082003

$\Lambda_b^0 \to J/\psi p \pi^-$衰变中可能的奇特强子

- LHCb在 $\Lambda_b^0 \to J/\psi p K^-$ 衰变中观测到的 $P_c(4380)^+$ 和 $P_c(4450)^+$ $(\to J/\psi p)$
- Belle在 $B^0 \to J/\psi \pi^+ K^-$ 中观测到 $Z_c(4200)^+ \to J/\psi \pi^+$

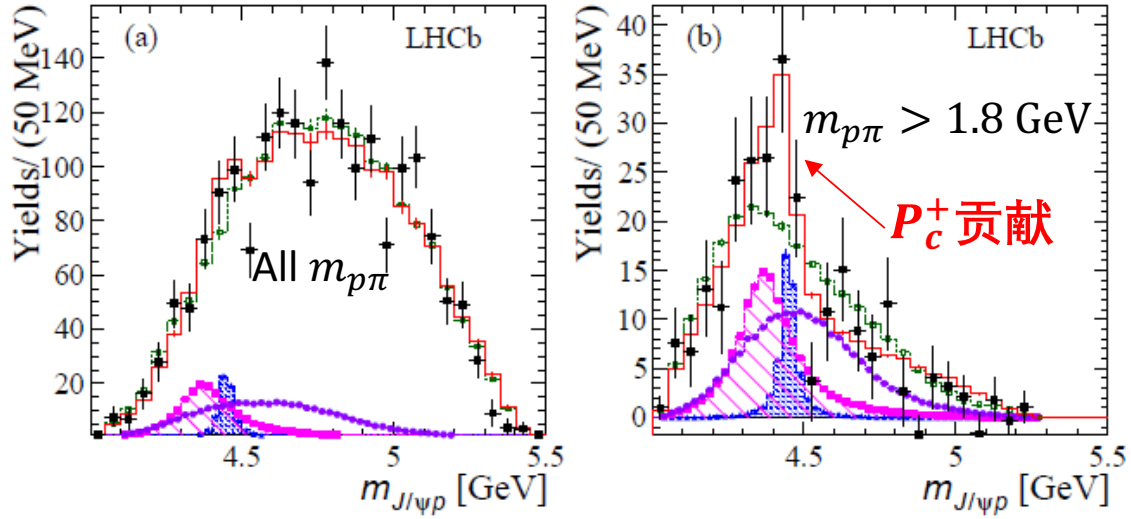


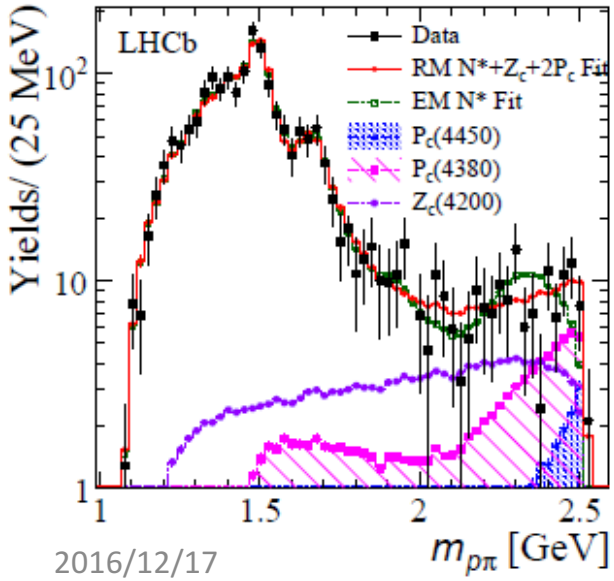


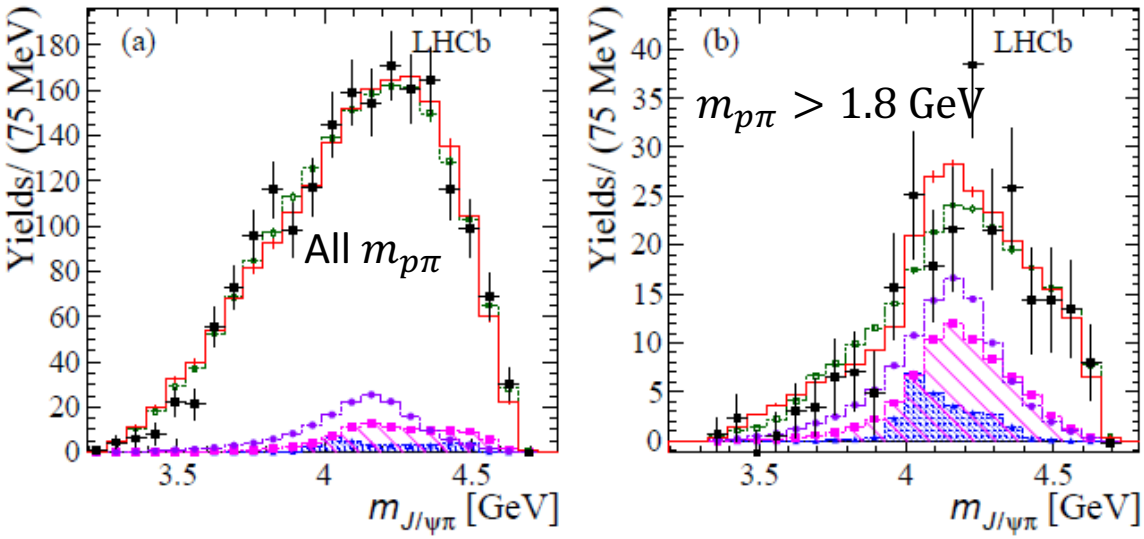
$\Lambda_b^0 \to J/\psi p\pi^-$的分波分析

PRL 117 (2016) 082003

- 拟合用14个 $N^* \to p\pi^-$ 共振态和 $p\pi^-$ 的非共振态贡献
- $P_c(4380)^+$, $P_c(4450)^+$, $Z_c(4200)^-$一起考虑的置信度为 **3.1 σ**







$\Lambda_b^0 \to J/\psi p \pi^-$的拟合结果

PRL 117 (2016) 082003

- $P_c(4380)^+$，$P_c(4450)^+$，$Z_c(4200)^-$ 一起考虑的置信度为 $3.1\,\sigma$ ➔ 存在奇特强子态贡献的迹象
- 单独每个奇特强子态的单独贡献不够显著
- 如果假设 $Z_c(4200)^-$ 的贡献可以忽略，P_c^+ 的显著度为 $3.3\,\sigma$

State	Fit fraction (%)	$R_{\pi/K} \equiv \mathcal{B}(\Lambda_b^0 \to P_c^+\pi^-)/\mathcal{B}(\Lambda_b^0 \to P_c^+K^-)$
$Z_c(4200)^-$	$7.7 \pm 2.8^{+3.4}_{-4.0}$	–
$P_c(4380)^+$	$5.1 \pm 1.5^{+2.1}_{-1.6}$	$0.050 \pm 0.016^{+0.020}_{-0.016} \pm 0.025$
$P_c(4450)^+$	$1.6^{+0.8}_{-0.6}{}^{+0.6}_{-0.5}$	$0.033^{+0.016}_{-0.014}{}^{+0.011}_{-0.009} \pm 0.025$

[H.-Y Cheng and C.-K Chua, PRD92 (2015) 096009] ：$R_{\pi/K} = 0.07\sim0.08$

[Y. K. Hsiao and C. Q. Geng, PLB751 (2015) 572] ：$R_{\pi/K} = 0.58 \pm 0.05$ （排除这种预言认为P_c^+中$c\bar{c}$来自真空）

$\Lambda_b^0 \to J/\psi p \pi^-$ 衰变中 P_c^+ 产生几率与 $J/\psi p K^-$ 的结果一致。

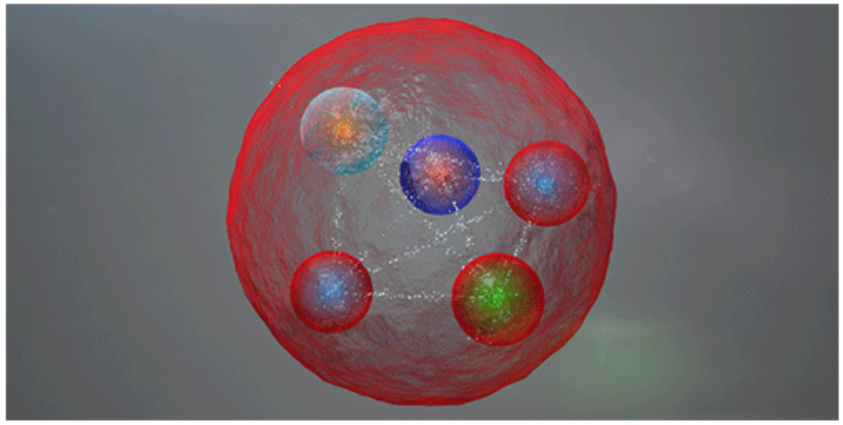
Physics (APS) Synopsis: 2016.08.18

Synopsis: Pentaquark Discovery Confirmed

Print

August 18, 2016

New results from the LHCb experiment confirm the 2015 discovery that quarks can combine into groups of five.



CERN

Pentaquarks are here to stay. Two new studies from the LHCb collaboration at CERN's Large Hadron Collider quash any remaining doubts about the discovery of the exotic five-quark particles that was announced last year (see 12 August 2015 Viewpoint). One study demonstrates that the evidence for pentaquarks in the discovery data is model independent. Another reports evidence for exotic hadronic particles—whose properties are consistent with those of

Evidence for Exotic Hadron Contributions to $\Lambda_b^0 \to J/\psi p \pi^-$ Decays

R. Aaij *et al.* (LHCb Collaboration)

Phys. Rev. Lett. 117, 082003 (2016)

Published August 18, 2016

Model-Independent Evidence for $J/\psi p$ Contributions to $\Lambda_b^0 \to J/\psi p K^-$ Decays

R. Aaij *et al.* (LHCb Collaboration)

Phys. Rev. Lett. 117, 082002 (2016)

Published August 18, 2016

Announcements

Neutrinos

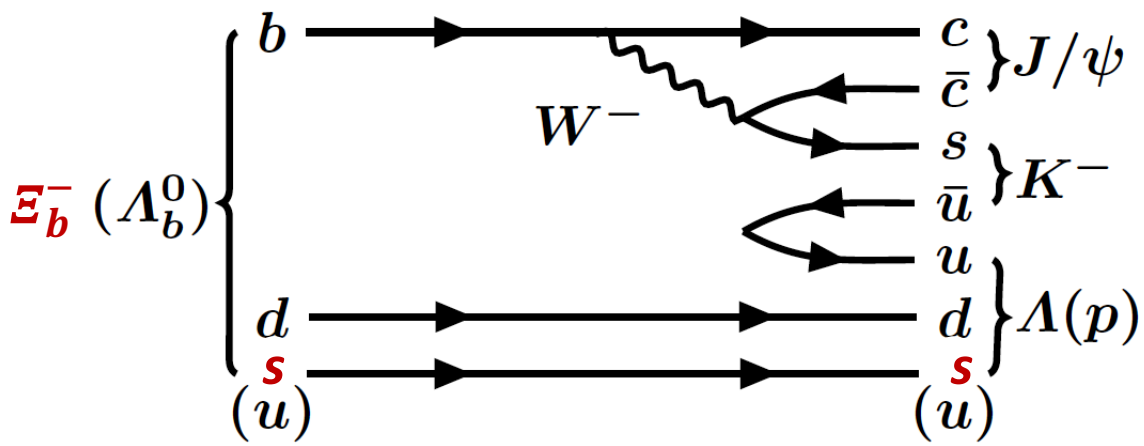
Find out more about research on neutrinos in this collection of articles from the archive of *Physics*.

More Announcements »

http://physics.aps.org/synopsis-for/10.1103/PhysRevLett.117.082003

首次观测 $\Xi_b^- \to J/\psi \Lambda K^-$ 衰变

- 理论还预言了含有 s 夸克的五夸克（$udsc\bar{c}$）→ $J/\psi\Lambda$ ［JJ. Wu et al. PRL 105, 232001 (2010), HX. Chen et al. PR C93, 065203 (3016)］
- $\Lambda_b^0 \to J/\psi p K^-$ 中把 u 夸克换成 s 得到 $\Xi_b^- \to J/\psi \Lambda K^-$
- $\Lambda_b^0 \to J/\psi \Lambda$ 衰变作为参考道



首次观测 $\Xi_b^- \to J/\psi \Lambda K^-$ 衰变

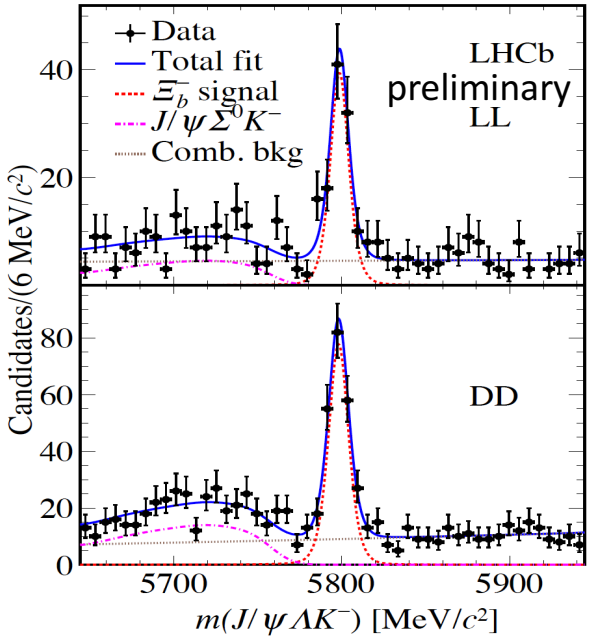
- 观测到**308 ± 21** Ξ_b^- 信号，显著度21σ

$$\frac{f_{\Xi_b^-}}{f_{\Lambda_b^0}} \frac{\mathcal{B}(\Xi_b^- \to J/\psi \Lambda K^-)}{\mathcal{B}(\Lambda_b^0 \to J/\psi \Lambda)} = (4.19 \pm 0.29\,(\text{stat}) \pm 0.14\,(\text{syst})) \times 10^{-2}$$

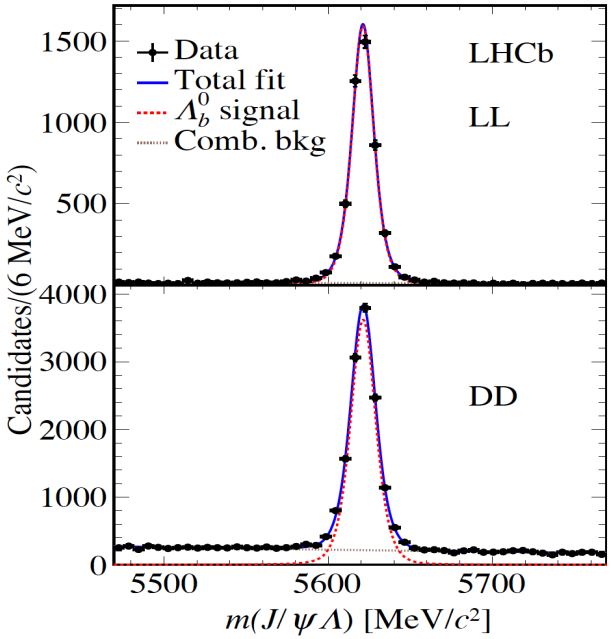
$$M(\Xi_b^-) - M(\Lambda_b^0) = 177.08 \pm 0.47\,(\text{stat}) \pm 0.16\,(\text{syst})\ \text{MeV}$$

CKM会议上报告了结果，文章即将投稿

$\Xi_b^- \to J/\psi \Lambda K^-$



$\Lambda_b^0 \to J/\psi \Lambda$



LHCb-PAPER-2016-053
in preparation

长寿命$\Lambda \to p\pi^-$通过两类径迹从建（LL，DD）

计划 Run2 结束后，通过分波分析来寻找含有 s 夸克的五夸克态

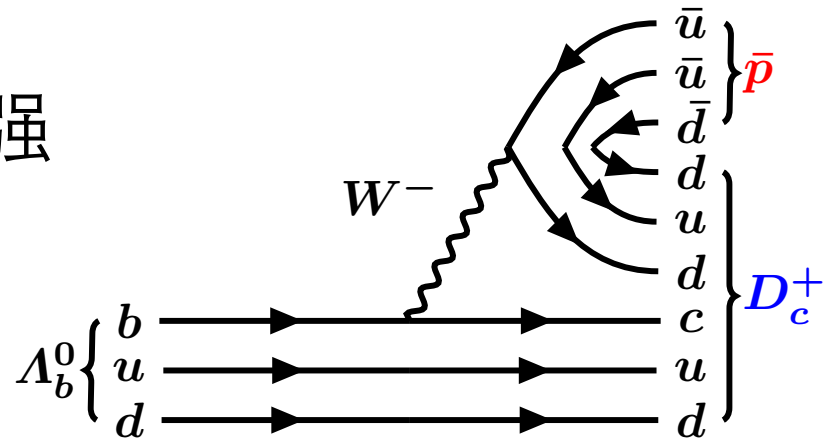
正在进行的分析

$\Lambda_b^0 \to \Lambda_c^+ \pi^- p\bar{p}$

- L. Maiani et al. 建议在此衰变里寻找六夸克态$\mathbb{D}_c^+$

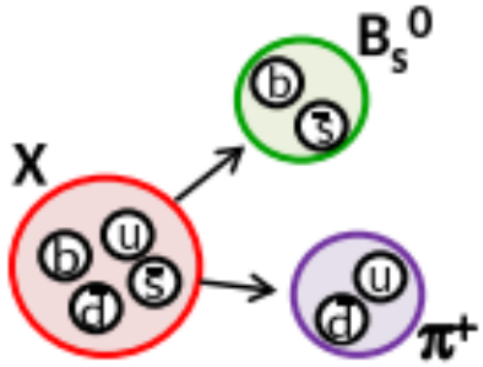
$$\Lambda_b^0 \to \bar{p} + [cd][ud][ud] = \bar{p} + \mathbb{D}_c^+$$

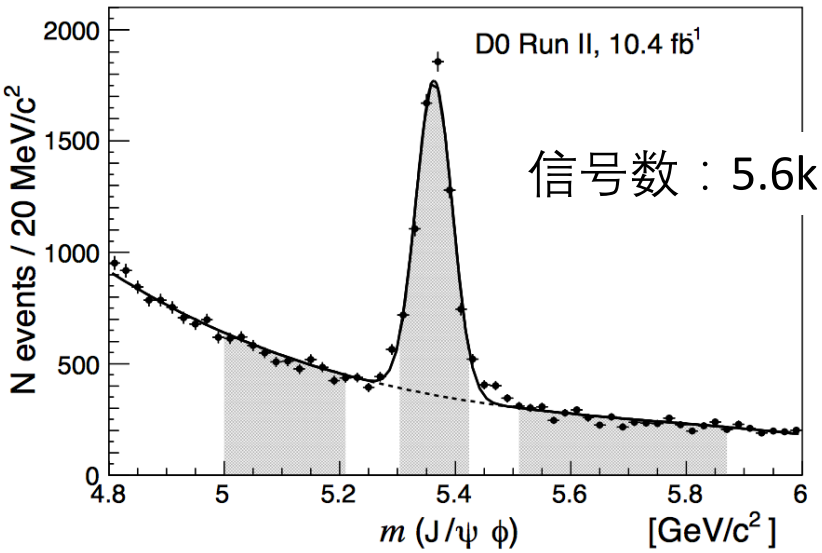
- **还可以研究 $m(p\bar{p})$** 阈值增强

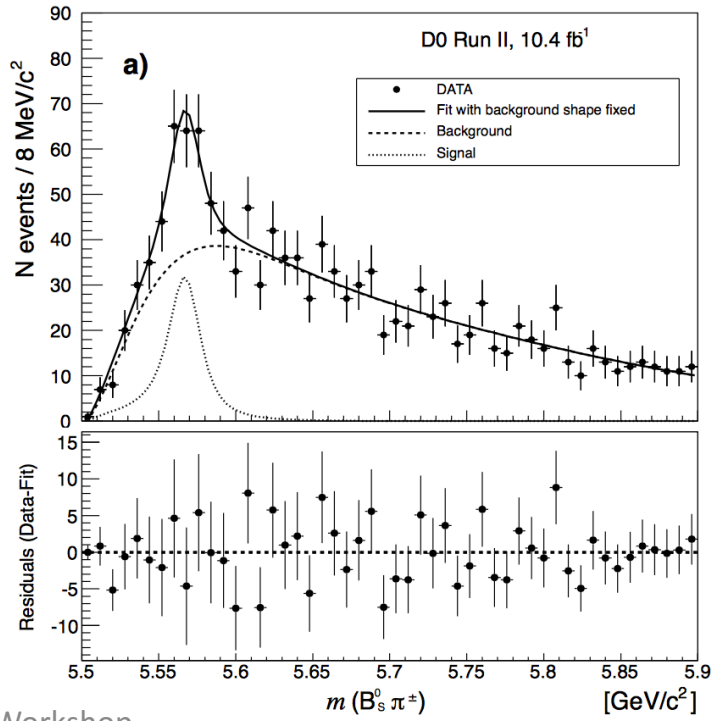


四夸克态：$X(5568)^+ \rightarrow B_s\pi^+$

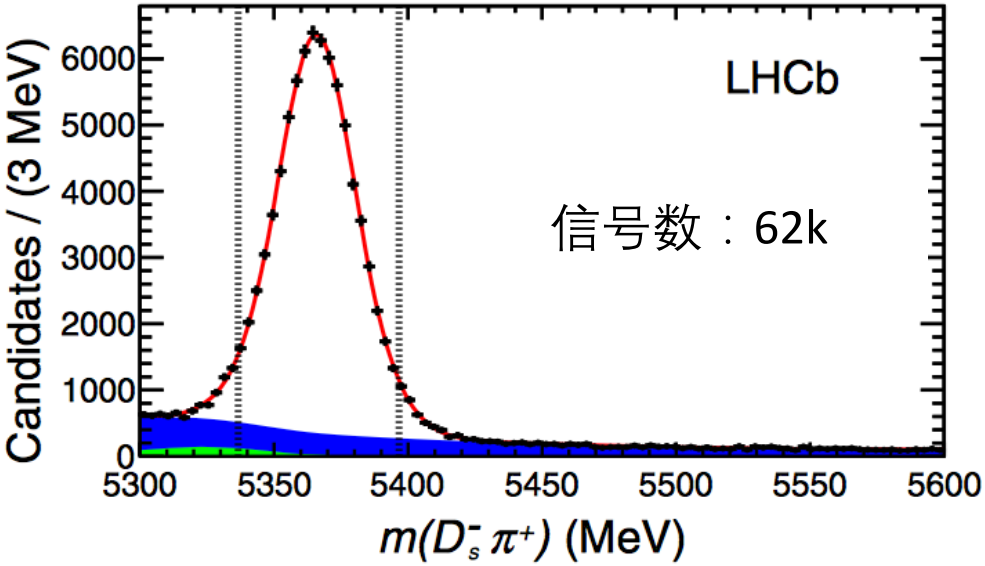
- 费米实验室的D0实验发现一个新的态
- 第一个含开放底夸克的四夸克态？
  - 与以往奇异态都不一样
  - 如被证实，有助于理解奇异态性质

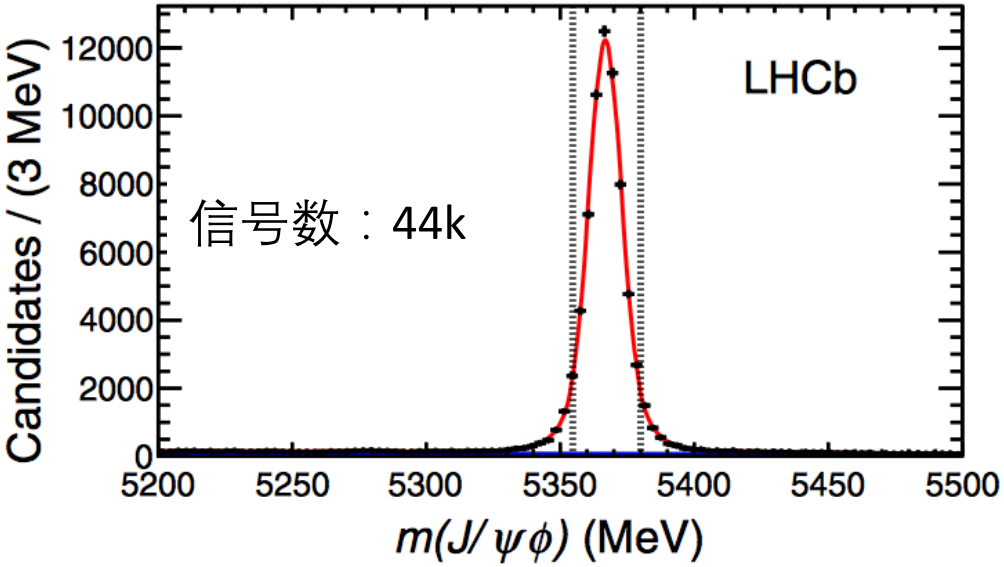






X(5568)$^+$：未被LHCb证实





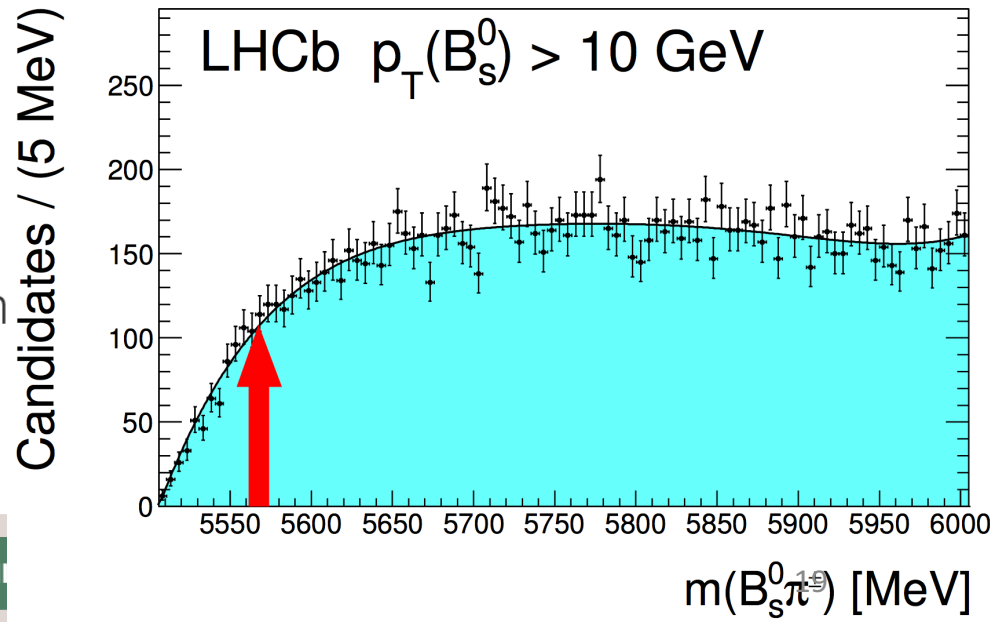
- 发表在PRL，被选为编辑推荐

Editors' Suggestion　Open Access

Search for Structure in the $B_s^0\pi^\pm$ Invarian

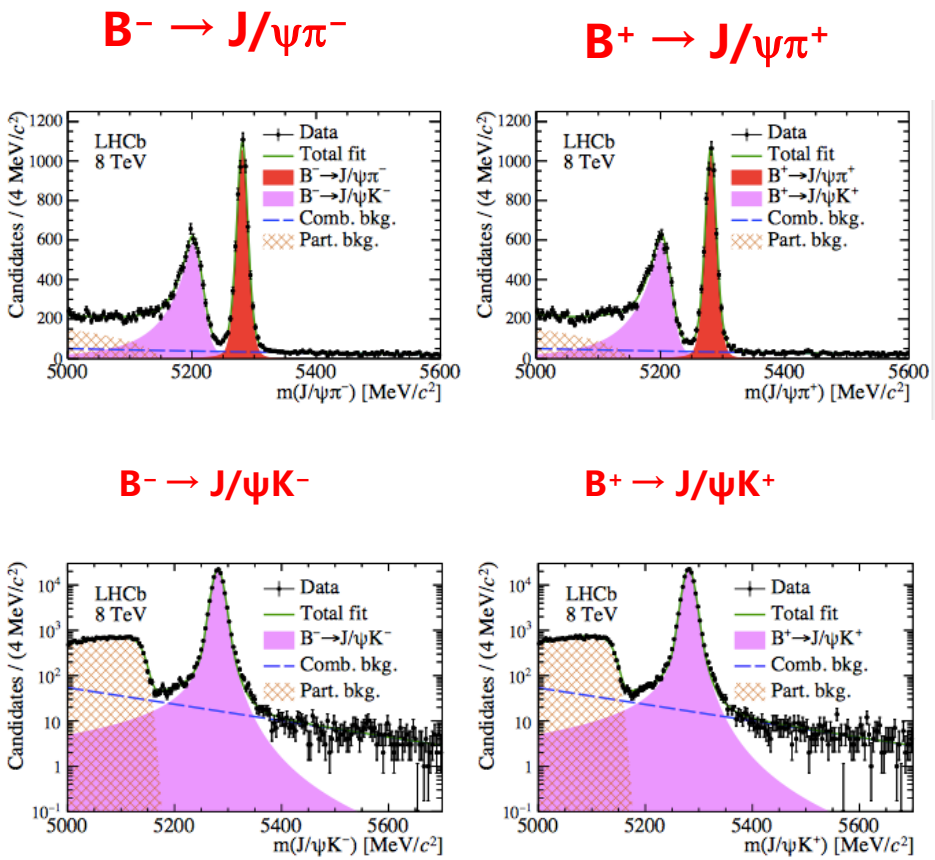
R. Aaij *et al.* (LHCb Collaboration)
Phys. Rev. Lett. **117**, 152003 – Published 5 October 2016

Article　References　No Citing Articles　PDF　HTM



$B^+ \to J/\psi h^+$（h=K, π）相对BR和ΔA_{CP}测量（Run 1）

- b→ccs过程的圈图相对于树图受λ^2 ~0.05压制，但对sin2β测量造成的影响难以从理论上直接结算。
- $B^+ \to J/\psi \pi^+$通过b→ccd跃迁进行，圈图贡献不受λ^2压低，效应更明显。
- 测量$B(B^+ \to J/\psi \pi^+)/B(B^+ \to J/\psi K^+)$和$A_{CP}(B^+ \to J/\psi \pi^+)$有助于控制sin2β测量中由圈图效应引起的偏差。



利用LHCb run-1数据得到世界最精确结果

$B(B^+ \to J/\psi \pi^+)/B(B^+ \to J/\psi K^+) = (3.83 \pm 0.02 \pm 0.03) \times 10^{-2}$

$A_{CP}(B^+ \to J/\psi \pi^+) - A_{CP}(B^+ \to J/\psi K^+) = (1.82 \pm 0.86 \pm 0.12) \times 10^{-2}$

利用已有的$A_{CP}(B^+ \to J/\psi K^+)$测量结果可以得到$A_{CP}(B^+ \to J/\psi \pi^+)$

LHCb-PAPER-2016-051

20

Run 2研究计划

B介子产生截面研究

通过$B^+ \to J/\psi K^+$过程测量13 TeV pp对撞的B^+产生截面，并与理论预言比较。分析进入合作组审核阶段。

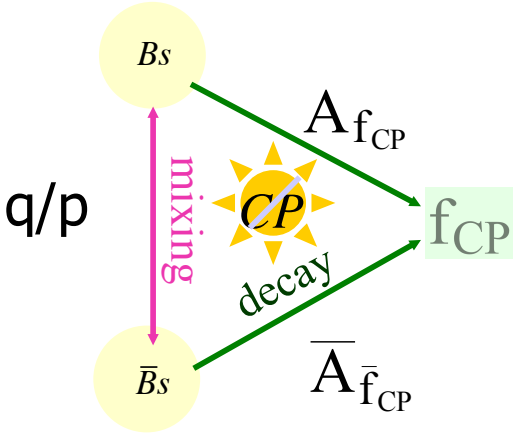
CP破坏研究

1. 研究重点：在$B_s \to J/\psi\phi$ 衰变中精确测量弱相位角ϕ_s，寻找B_s介子混合中的新物理效应
2. 测量$B_s \to \phi\phi$ 和$B_s \to \phi\mu^+\mu^-$过程CP破坏，探索$b \to s$跃迁中的新物理贡献
3. 在$\Lambda_c^+ \to \Lambda^0\pi^+$ 衰变中比较正反Λ^0的极化，寻找c重子衰变中的CP破坏
4. 寻找$\Lambda_b^0 \to \Lambda_c^+\pi^-$和$\Lambda_b^0 \to \Lambda_c^+ D_S^-$等b重子衰变中的CP破坏

稀有衰变研究

1. 寻找重子数不守恒、轻子数不守恒或轻子味量子数不守恒等禁戒过程，比如$B^+ \to p^-\mu^+\mu^+$, $B_{s/d} \to p^+\mu^-$
2. 寻找W/Z 波色子的稀有衰变，比如$Z \to D^0\gamma$和$W^+ \to D_s^+\gamma$

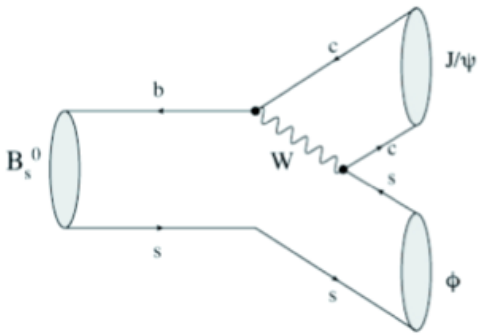
LHCb关键课题：ϕ_s测量



ϕ_s 为$B_s \to J/\psi\phi$或$B_s \to J/\psi\pi^+\pi^-$直接衰变振幅和振荡后衰变振幅间的相位差。在标准模型中：

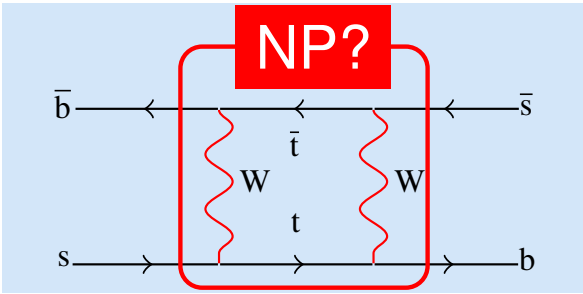
ϕ_s^{SM} = -0.038 ± 0.001 rad

(忽略圈图引起的较小修正)



ϕ_s 对B_s混合中的新物理贡献非常敏感

$\phi_s = \phi_s^{SM} + \Delta\phi^{NP}$



华师和清华在Run-1的ϕ_s测量中起主导作用

ϕ_s = -0.010 ± 0.039 rad (联合$B_s \to J/\psi\phi$ 和 $B_s \to J/\psi\pi^+\pi^-$)

与理论预言精度相比，测量精度有待进一步提高

Phys.Rew.Lett. 114（2015）041801

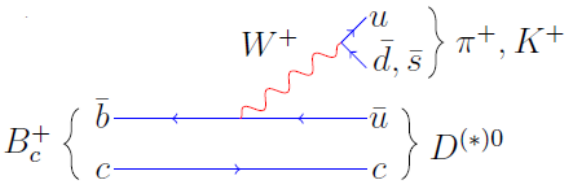
Run 2的 ϕ_s 测量

Run 2分析中，中国组继续发挥主导作用，利用2015+2016年的2fb^{-1}数据对$B_s \to J/\psi\phi$或$B_s \to J/\psi\pi^+\pi^-$衰变进行分析，预计2017年春季有初步结果。

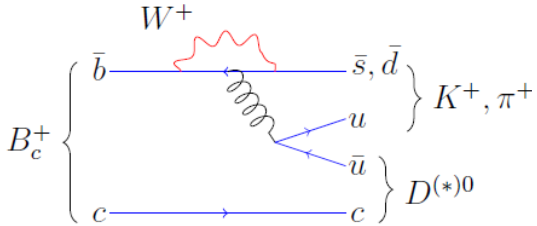
- 衰变时间分辨率的刻度工作已初步完成（华师，清华）
- 利用“决定树”方法在保持信号效率不变的情况下减少了40%的本底（华师）
- 对味道标记的刻度工作正在进行（华师）
- 对时间和角度的多维数据拟合程序已经基本准备就绪，并利用蒙特卡洛模拟数据对拟合程序进行了检验（清华）
- 下一步着重研究与探测器效应有关的各种系统误差

清华大学张黎明继华中师范大学谢跃红之后担任相关物理组负责人

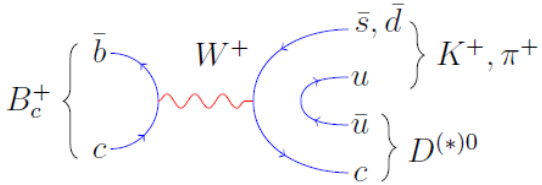
“意外” 的B_c衰变道?



tree



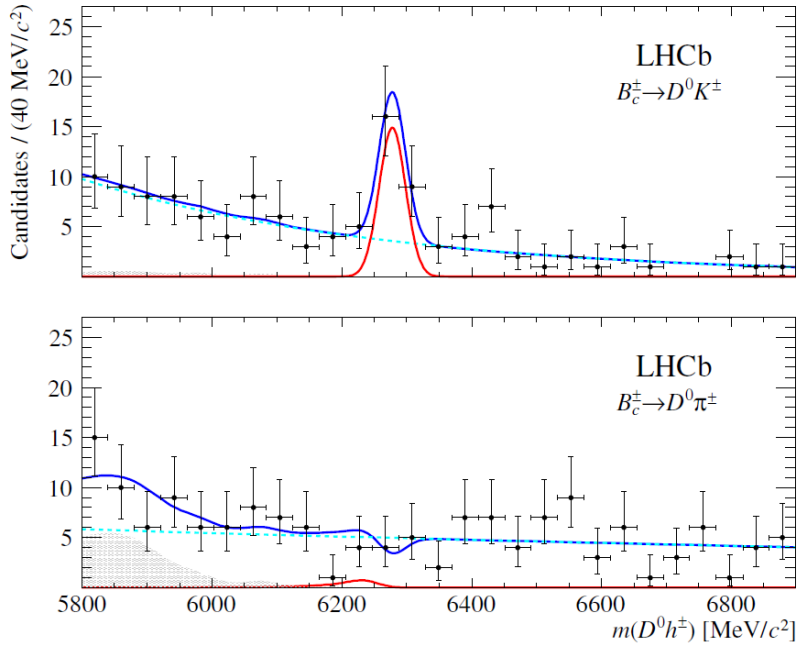
penguin



annihilation

(Almost all known B_c decays so far)

- B_c is very difficult to produce thus much less studied, most of its experimental knowledge from LHCb
  - For every ~200 B^+ only 1 B_c^+
- $B_c^+ \to D^0\pi^+$ is favoured decay, so is expected to appear first …
- … but it is not seen. In contrast the suppressed $B_c^+ \to D^0K^+$ shows a very clean signal (5.1σ)!

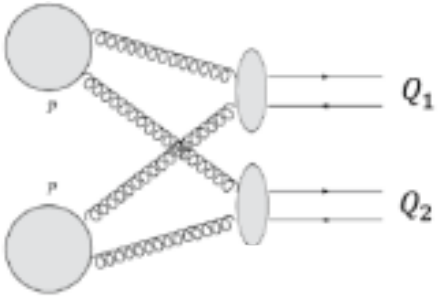


LHCb-PAPER-2016-058, in prep.

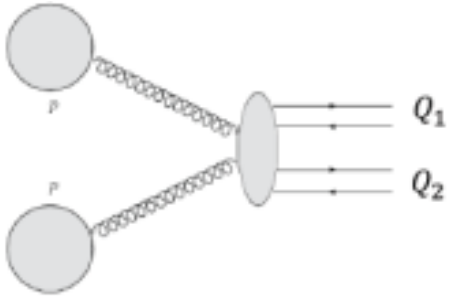
双部分子散射过程的研究

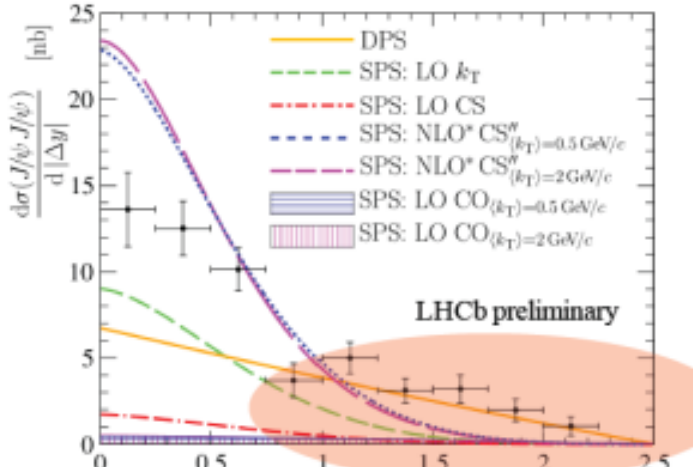
- 质子-质子对撞中双部分子散射过程可提供额外的信息，帮助理解某些新物理过程的本底

双部分子散射（DPS）

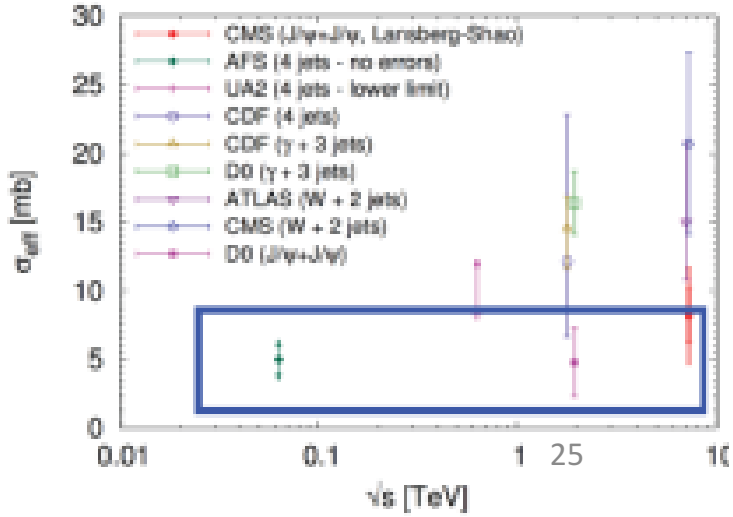


单部分子散射（SPS）





- 利用2015年质子-质子对撞数据研究了$2\times J/\psi$的性质
  - ✓ $|\Delta y| > 1.5$区间DPS贡献很重要
  - ✓ 与$\sigma_{\mathrm{eff}} = 14.5 \pm 1.7^{+1.7}_{-2.3}$的预期一致
  - ✓ 不支持更小的σ_{eff}的结果



LHCb-PAPER-2016-057

发表论文列表 （2011-2015）

20 篇：PRL 5 + PLB 1 + PRD 3 + JHEP 8 + EPJC 3

1. *Measurement of J/ψ production in pp collisions at $\sqrt{s} = 7$ TeV*， Eur. Phys. J. C71 (2011) 1645.
2. *Measurement of b-hadron masses,* Phys. Lett. B 708 (2012) 241.
3. *Measurements of B_c production and mass with the $B_c \to J/\psi\pi$ decay*, Phys. Rev. Lett. 109 (2012) 232001.
4. *Measurement of the $B^{\pm}$ production cross-section in pp collisions at $\sqrt{s} = 7$ TeV*, JHEP 04 (2012) 093.
5. Observation of the decay $B_c \to J/\psi(2S)\pi$, Phys. Rev. D 87 (2013) 071103 (Rapid Communication).
6. *Measurement of B meson production cross-section in proton-proton collisions at $\sqrt{s} = 7$ TeV*, JHEP 08 (2013) 117.
7. *First observation of the $B_c \to J/\psi K$ decay,* JHEP 09 (2013) 075.
8. *Measurement of J/ψ polarization in pp collisions at $\sqrt{s} = 7$ TeV*, Euro. Phys. J. C73 (2013) 2631.
9. *Search for the doubly charmed baryon Ξ_{cc}*, JHEP 12 (2013) 090.
10. *Measurement of $\psi(2S)$ polarisation in pp collisions at $\sqrt{s} = 7$ TeV*, Euro. Phys. J. C74 (2014) 2872.

11. *Study of J/ψ production and cold nuclear matter effects in pPb collisions at $\sqrt{s_{NN}} = 5$ TeV,* JHEP 02 (2014) 072.
12. *Study of Υ produciton and cold nuclear matter effects in pPb collisions at $\sqrt{s_{NN}} = 5$ TeV*, JHEP 07 (2014) 094.
13. *Measurement of CP violation in $B_s^0 \to \phi\phi$ decays,* Phys. Rev. D 90 (2014) 052001.
14. *First observation of a baryonic B_c decay*, Phys. Rev. Lett. 113 (2014) 152003.
15. *Precision measurement of CP violation in $B_s^0 \to J/\psi K^+K^-$ decays,* Phys. Rev. Lett. 114 (2015) 041801.
16. *Measurement of the CP-violating phase β in $B^0 \to J/\psi\pi^+\pi^-$ decays and limits on penguin effects*, Phys. Lett. B 742 (2015) 38.
17. *Measurement of B_c production in proton-proton collisions at $\sqrt{s} = 8$ TeV,* Phy. Rev. Lett. 114 (2015) 132001.
18. *Observation of $J/\psi p$ resonances consistent with pentaquark states in $\Lambda_b^0 \to J/\psi pK$ decays*, Phys. Rev. Lett. 115 (2015) 072001.
19. *Measurement of the branching fraction ratio $\mathcal{B}(B_c^+ \to \psi(2S)\pi^+)/\mathcal{B}(B_c^+ \to J/\psi\pi^+)$*, Phys. Rev. D 92 (2015) 072007.
20. *Measurement of forward J/ψ production cross-sections in pp collisions at $\sqrt{s} = 13$ TeV*, JHEP 10 (2015) 172.

发表论文列表（2016）

21. *Study of the production of Λ_b^0 and $\bar{B}^0$ hadrons in pp collisions and first measurement of the $\Lambda_b^0 \to J/\psi p K^-$ branching fraction*, Chin. Phys. Lett. C40 (2016) 011001
22. *Study of $\psi(2S)$ production and cold nuclear matter effects in pPb collisions at $\sqrt{s_{NN}} = 5\ TeV$*, JHEP 03 (2016) 133
23. *Evidence for exotic hadron contributions to $\Lambda_b^0 \to J/\psi p \pi^-$ decays*, Phys. Rev. Lett. 117 (2016) 082003
24. *Measurement of the ratio of branching fractions $B(B_c^+ \to J/\psi K^+)/B(B_c^+ \to J/\psi \pi^+)$* JHEP 09 (2016) 153
25. *Search for structure in the $B_s \pi^\pm$ invariant mass spectrum*, Phys. Rev. Lett. 117 (2016) 152003

即将投稿论文列表

- *Observation of triply charmed* $B_c^+ \to J/\psi D^{(*)} K^{(*)}$ *decays*, LHCb-PAPER-2016-055
- *Measurement of the* J/ψ *pair production cross-section in pp collisions at* $\sqrt{s} = 13\ TeV$, LHCb-PAPER-2016-057
- *Observation of the* $\Xi_b^- \to J/\psi \Lambda^0 K^-$ *decay*, LHCb-PAPER-2016-053
- *Measurement of the branching fraction ratio and CP asymmetry difference of* $B^- \to J/\psi \pi^-$ *and* $B^- \to J/\psi K^-$, LHCb-PAPER-2016-051

LHCb talks at this workshop

- Plenary (2016.12.18)
  - 8:30am Liming Zhang (Tsinghua Univ)

    Spectroscopy and Exotic states
  - 9:20am Jibo He (UCAS)

    CP Violation and Rare Decays at LHCb
- Parallel (2016.12.18)
  - 14:00 Hang Yin (CCNU)

    Study of Bc physics at LHCb
  - 14:15 Xuesong Liu

    b baryon decays and the search for exotic hadrons at LHCb
  - 16:15 Liupan An

    Study of Double parton scattering at LHCb

LHCb中国组

III

LHCb-中国组成员

- 清华大学 (member 2000-)
  - 高原宁，杨振伟，张黎明，朱相雷
  - 博士后 2，博士生 5， 硕士生 3
- 华中师范大学 (associate member 2013 -)
  - 谢跃红，尹航
  - 博士后 1， 硕士生 6
- 中国科学院大学 (associate member 2015-)
  - 郑阳恒，吕晓睿，何吉波，钱文斌 （2016青千）
  - 博士后 4， 博士生 2，硕士生 2
- 武汉大学 (associate member 2016-)
  - 孙亮（2016青千），蔡浩

LHCb-中国组学术组织

- 大学实验组人数少，LHCb-中国组成员少， 新成多

- LHCb-中国组是一个整体
  - 人力 + 研究资源
  - 共同组会，联合指导学生

- 各大学组发展态势良好，提高了LHCb-中国组的影响力，也促进了所在高校的学科建设
  - 华中师大顺利通过LHCb三年期评估
  - 谢跃红教授牵头自然科学基金重点项目、科技部重点专项项目申请

LHCb 合作组对CCNU 组的评估

加入LHCb实验三年后，LHCb合作组于2016年10月13日对CCNU组进行了一次正式评估。 结果如下：

"The Membership Committee reviewed the contributions of the CCNU group, associated to Tsinghua.

We congratulate the group for their high profile contributions to the physics analyses, surpassing any expectations given the limited size of the team.

Furthermore, the group is currently making important contributions to the tasks of common interest on vertexing, tracking and material description."

-- LHCb Spokesperson, Prof. Guy Wilkinson, University of Oxford

IV

探测器升级和经费需求

LHCb探测器升级主要内容

1. 主要内容

LHCb up to LS2

- running at levelled luminosity of ~ $4 \cdot 10^{32}$ $cm^{-2}s^{-1}$, pile-up ~1
- first level hardware trigger running at ~1 MHz
- record ~3-5 kHz

LHCb upgrade

- increase luminosity to a levelled $1\text{-}2 \cdot 10^{33}$ $cm^{-2}s^{-1}$, pile-up ~5
- run fully flexible & efficient software trigger up to 40 MHz
- record ~20-50 kHz

2. 只计划了一次升级，2019年完成

3. 升级经费 80M CHF

(cf. 探测器造价 78M CHF）

LHCb statistical sensitivity to flavour observables

Expected statistical uncertainties before and after the upgrade, compared to theory

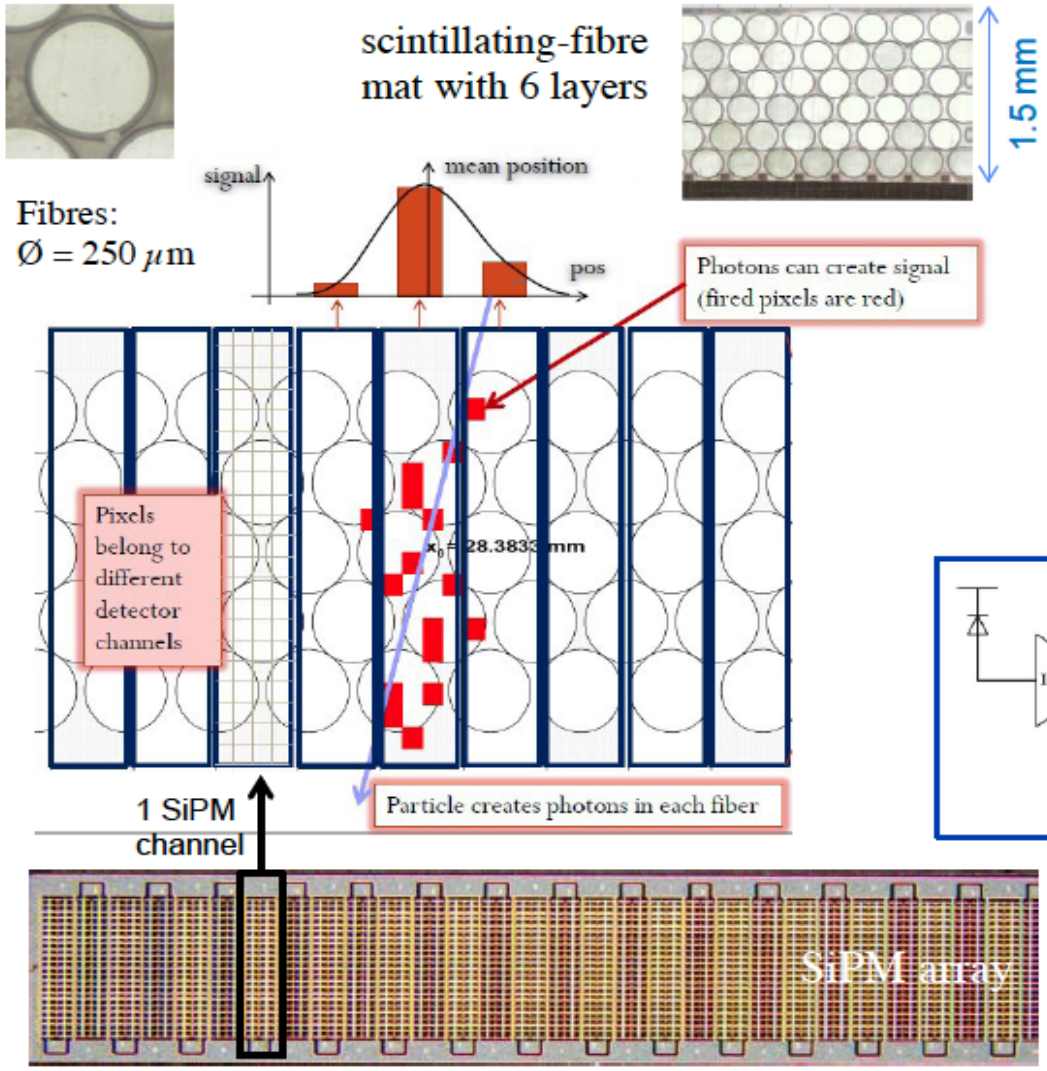
Type	Observable	LHC Run 1	LHCb 2018	Upgrade 50/fb	Theory
B_s^0 mixing	$\phi_s(B_s^0 \to J/\psi\,\phi)$ (rad)	0.049	0.025	**0.009**	~ 0.003
	$\phi_s(B_s^0 \to J/\psi\ f_0(980))$ (rad)	0.068	0.035	**0.012**	~ 0.01
	$A_{\rm sl}(B_s^0)$ (10^{-3})	2.8	1.4	**0.5**	0.03
Gluonic penguin	$\phi_s^{\rm eff}(B_s^0 \to \phi\phi)$ (rad)	0.15	0.10	**0.018**	0.02
	$\phi_s^{\rm eff}(B_s^0 \to K^{*0}\bar{K}^{*0})$ (rad)	0.19	0.13	**0.023**	< 0.02
	$2\beta^{\rm eff}(B^0 \to \phi K_S^0)$ (rad)	0.30	0.20	**0.036**	0.02
Right-handed currents	$\phi_s^{\rm eff}(B_s^0 \to \phi\gamma)$ (rad)	0.20	0.13	**0.025**	< 0.01
	$\tau^{\rm eff}(B_s^0 \to \phi\gamma)/\tau_{B_s^0}$	5%	3.2%	**0.6%**	0.2 %
Electroweak penguin	$S_3(B^0 \to K^{*0}\mu^+\mu^-; 1 < q^2 < 6\,{\rm GeV}^2/c^4)$	0.04	0.020	**0.007**	0.02
	$q_0^2\, A_{\rm FB}(B^0 \to K^{*0}\mu^+\mu^-)$	10%	5%	**1.9%**	$\sim 7\%$
	$A_{\rm I}(K\mu^+\mu^-; 1 < q^2 < 6\,{\rm GeV}^2/c^4)$	0.09	0.05	**0.017**	~ 0.02
	$\mathcal{B}(B^+ \to \pi^+\mu^+\mu^-)/\mathcal{B}(B^+ \to K^+\mu^+\mu^-)$	14%	7%	**2.4%**	$\sim 10\%$
Higgs penguin	$\mathcal{B}(B_s^0 \to \mu^+\mu^-)$ (10^{-9})	1.0	0.5	**0.19**	0.3
	$\mathcal{B}(B^0 \to \mu^+\mu^-)/\mathcal{B}(B_s^0 \to \mu^+\mu^-)$	220%	110%	**40%**	$\sim 5\,\%$
Unitarity triangle angles	$\gamma(B \to D^{(*)}K^{(*)})$	7°	4°	**0.9°**	negligible
	$\gamma(B_s^0 \to D_s^\mp K^\pm)$	17°	11°	**2.0°**	negligible
	$\beta(B^0 \to J/\psi\, K_S^0)$	1.7°	0.8°	**0.31°**	negligible
Charm CP violation	$A_\Gamma(D^0 \to K^+K^-)$ (10^{-4})	3.4	2.2	0.4	–
	ΔA_{CP} (10^{-3})	0.8	0.5	0.1	–

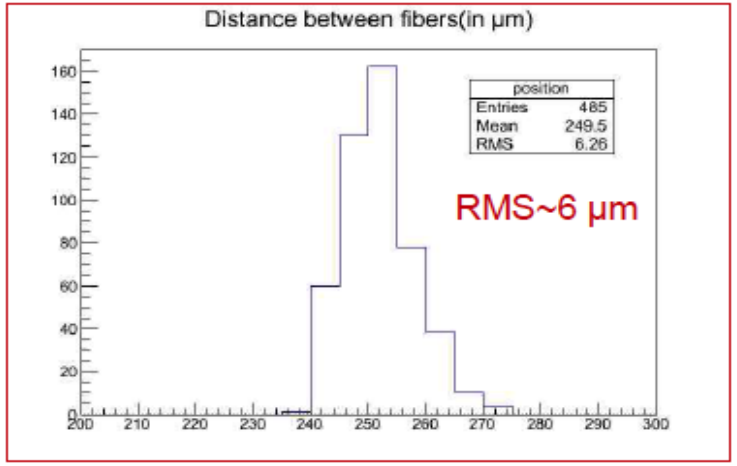
Eur. Phys. J. C 73 (2013) 2373

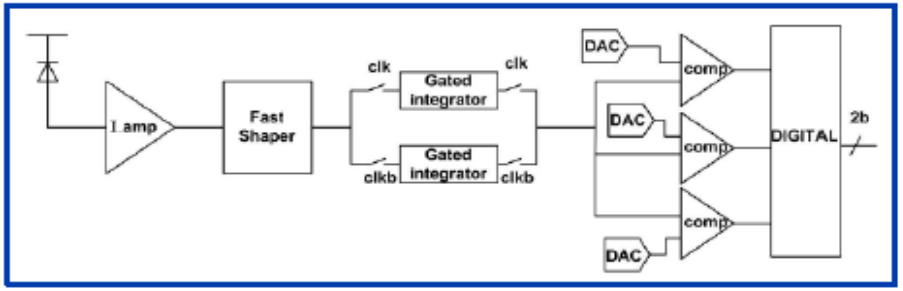
→ Experimental precision with upgraded detector comparable to theoretical uncertainties!

中国组的任务

- 参加SciFi Tracker的升级，主要是电子学读出







readout by dedicated 128 ch.
40 MHz PACIFIC chip
- 3 thresholds (2 bits)
- sum threshold (FPGA)

V

总结

总结

- LHCb-中国组在2016 的物理研究中取得好成绩
  - 五夸克态和其它奇特态研究
  - 重夸克偶素+*b*强子产生机制研究 (pp, pA)
  - B_c物理的系统研究
  - *CP* 破坏研究具有显示度

  - 5 发表论文，4即将投稿论文，～10国际会议报告
  - 3 人担任物理工作组召集人

    （谢跃红，杨振伟，张黎明）

未来经费需求

- 探测器升级的经费
  - MoU：　　2016科技部专项
  - 科研和维护：？？？

- 物理研究经费
  - 50%　2017科技部专项（申请中）？
  - 50%　（？？？）