

年度工作汇报

朱凯（高能物理所）

2019年12月7日

中国科学院粒子物理前沿 卓越中心

个人简历

朱凯 Kai Zhu

1978

本科

研究生

博士后 助研

副研

1996

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2000

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2006

2007

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2010

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2012

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2019



武汉大学



中国科学院高能物理研究所

- BESIII 粲偶素物理组从事分析物理分析工作
 - 曾任 η_c 工作组召集人
 - 自 2016 年下半年起任粲偶素组召集人
- 其他：触发、软件（2013年起负责dE/dx 刻度与模拟）、CEPC 预研究等

2019主要工作

- 北京谱仪（BESIII）
 - 粲偶素工作组召集人
 - 个人物理分析
 - dE/dx 刻度与模拟
- 其他

BESIII 粲偶素工作组（组内会议）

Jan. Feb. Mar. of 2019 Charmonium

from Tuesday, 1 January 2019 at **08:00** to Sunday, 31 March 2019 at **B410**

Vidyo Info	Room Name	charmonium
	Link	http://vidyo.ihep.ac.cn/flex.html?
	Extension	
	PIN	2015

Apr. May. Jun. of 2019 Charmonium

from Sunday, 7 April 2019 at **08:00** to Sunday, 30 June 2019 at **18:00** (Asia/Shanghai) at **Main Building (B410)**

Vidyo Info	Room Name	charmonium
	Link	http://vidyo.ihep.ac.cn/flex.html?roomdirect.html&key=YifzugsW1y9S
	Extension	
	PIN	2015

Wednesday, 10 April 2019

Tuesday, 8 January 2019

09:00 - 09:30 Analysis of eta_c going to Lambda anti-Lambda
Speaker: Mr. guangrui liao (Guangxi Normal University)

Oct. Nov. Dec. of 2019 Charmonium

from Monday, 7 October 2019 at **08:00** to Tuesday, 31 December 2019 at **18:00** (Asia/Shanghai) at **Main Building (B410)**



Vidyo Info	Room Name	charmonium
	Link	http://vidyo.ihep.ac.cn/flex.html?roomdirect.html&key=YifzugsW1y9S
	Extension	
	PIN	2015

Jul. Aug. Sep. of 2019 Charmonium

from Monday, 1 July 2019 at **08:00** to Monday, 30 September 2019 at **Main Building of IHEP (B410)**

Vidyo Info	Room Name	charmonium
	Link	http://vidyo.ihep.ac.cn/flex.html?
	Extension	
	PIN	2015

Wednesday, 10 July 2019

15:00 - 15:30 Further consideration on the search for $\psi(3770)$
Speaker: Mr. Weiping WANG (University of Science and Technology of China)
Material:  

- 2019年组织召开 BESIII 粲偶素组
- 例会 26 次
- 48 个物理分析报告

Wednesday, 9 October 2019
12:15 - 12:45 Update report about $\pi^+\pi^-X(3823)$ with 2019 data 30'
Speaker: Prof. Zhigang Liu (Shandong University)
15:30 - 16:00 Study of $e^+e^- \rightarrow \gamma D_s^+ D_s^-$ at BESIII 30'
Speaker: wenjing Zhu (高能所)
Material:  

BESIII 粲偶素工作组（新提交的分析）

名称	修改日期
36.190212.chicJSigma.pdf	2019-2-13 16:24
37.190212.X3872_chic0.pdf	2019-2-17 11:38
37.190309.X3872_chic0.pdf	2019-3-9 9:01
38.190219.etac2S.pdf	2019-2-25 11:14
38.190310.etac2S.pdf	2019-3-10 9:58
38.190323.etac2S.pdf	2019-3-23 8:47
39.190219.amplitudeOmega.pdf	2019-2-27 10:21
39.190305.amplitudeOmega.pdf	2019-3-9 9:08
40.190315.Ds2460.pdf	2019-3-27 7:54
40.190419.Ds2460.pdf	2019-4-15 15:03
41.190425.Xipara.pdf	2019-4-22 15:03
41.190516.Xipara.pdf	2019-5-15 15:03
42.190613.xec8LH.pdf	2019-6-13 7:05
42.190801.xec8LH.pdf	2019-8-7 7:05
42.190808.xec8LH.pdf	2019-8-11 10:03
43.190619.pipipsip.pdf	2019-6-27 17:11
43.190709.pipipsip.pdf	2019-7-13 8:19
43.190716.pipipsip.pdf	2019-7-20 11:50
44.190620.pppp.pdf	2019-6-22 17:32
44.190628.pppp.pdf	2019-7-8 14:41
44.190722.pppp.pdf	2019-7-22 16:07

名称	修改日期
17.190103.OmegaOmega.pdf	2018-1-10 0:41
18.180306.LambdaX.pdf	2018-3-16 11:21
33.181114.JPofZc4025.pdf	2018-11-27 16:43
45.190810.Xi1530pair.pdf	2019-8-21 12:15
45.190908.Xi1530pair.pdf	2019-9-15 17:11
45.190921.Xi1530pair.pdf	2019-9-21 10:44
46.190818.energy.pdf	2019-8-25 18:37
46.190831.energy.pdf	2019-9-5 17:20
46.190910.energy.pdf	2019-9-17 20:58
46.190928.energy.pdf	2019-9-29 16:26
46.191021.energy.pdf	2019-10-20 20:08
46.191022.energy.pdf	2019-10-21 15:21
46.191023.energy.pdf	2019-10-21 20:34
47.190823.philamlamb.pdf	2019-8-31 11:17
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48.191014.philamlamb.pdf	2019-10-20 21:02
48.191024.philamlamb.pdf	2019-10-27 13:28
49.191014.ppbareta.pdf	2019-10-27 13:28
49.191026.ppbareta.pdf	2019-10-26 19:00
49.191107.ppbareta.pdf	2019-11-8 22:27
50.191023.Pipijpsi.pdf	2019-10-23 21:10
51.191023.psiptoLLbarphi.pdf	2019-11-2 14:02

2019年新提交 17 份物理分析 memo
召集人阅读memo，提出意见，改进分析质量
后续：协调分析、计算资源、推动分析工作等

BESIII 粲偶素工作组 (2019年物理成果)

2019: 18 Published-Accepted / 5 Submitted Papers

1. Measurement of $J/\psi \rightarrow \Xi(1530)\Xi^+\text{-bar}$ and evidence for the radiative decay $\Xi(1530)^+ \rightarrow \gamma\Xi^+$,
arXiv:1911.06689, submitted to Phys. Rev. D
2. Observation of the decays $\chi_{c0} \rightarrow \phi\pi\eta$,
arXiv:1911.02988, submitted to Phys. Rev. D
3. Cross section measurement of $e^+e^- \rightarrow \eta^* J/\psi$ from $\sqrt{s} = 4.178$ to 4.600 GeV,
arXiv:1911.00885, submitted to Phys. Rev. D
4. Measurement of the cross section for $e^+e^- \rightarrow \Xi\Xi^+\text{-bar}$ and observation of an excited Ξ baryon,
arXiv:1910.04921, submitted to Phys. Rev. Lett.

13. Observation of $\chi_{c0} \rightarrow 4 K_0$,
arXiv:1901.08207, published in Phys. Rev. D 99, 052008 (2019)
14. Measurement of $\chi_{c0} \rightarrow \mu^+\mu^- J/\psi$,
arXiv:1901.06627, published in Phys. Rev. D 99, 051101(R) (2019)
15. Observation of the decay $X(3872) \rightarrow \pi^0 \chi_{c1}(1P)$,
arXiv:1901.03992, published in Phys. Rev. Lett. 122, 202001 (2019)
16. Observation of $\psi(3686) \rightarrow p \text{ pbar } \eta'$ and improved measurement of $J/\psi \rightarrow p \text{ pbar } \eta'$,
arXiv:1810.05900, published in Phys. Rev. D 99, 092006 (2019)

• 多项新的重要成果，特别是

• **X(3872) 的衰变测量**

• **开粲的截面 (Y 粒子)**

• **Zc(3900) 新的衰变模式**

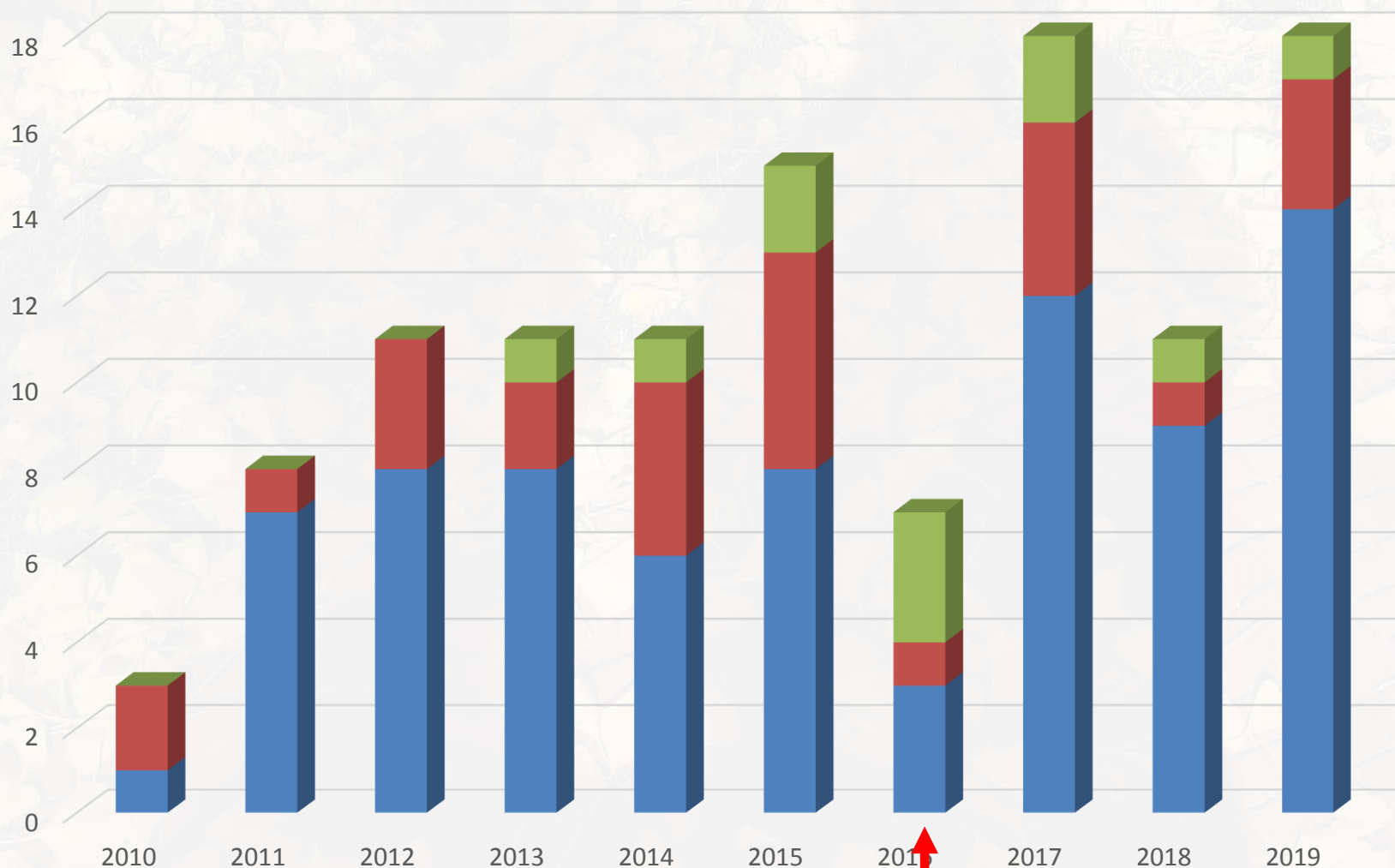
新的实验结果有助理解这些强子奇特态的本性

11. Study of $e^+e^- \rightarrow \gamma\omega J/\psi$ and observation of $X(3872) \rightarrow \omega J/\psi$,
arXiv:1903.04695, published in Phys. Rev. Lett. 122, 232002 (2019)
12. Cross section measurements of $e^+e^- \rightarrow \omega\chi_{c0}$ from $\sqrt{s} = 4.178$ to 4.278 GeV,
arXiv:1903.02359, published in Phys. Rev. D 99, 091103(R) (2019)

22. Evidence of a new state in the $\psi(3686) \rightarrow \pi^0 \chi_{c0} \pi^0$ cross section at 4.10 and 4.60 GeV,
arXiv:1808.02847, published in Phys. Rev. Lett. 122, 102002 (2019)
23. Observation of $e^+e^- \rightarrow \eta Y(2175)$ at center-of-mass energies above 3.7 GeV
arXiv:1709.04323, published in Phys. Rev. D 99, 012014 (2019)

[Link to Charmonium Web Site](#)

BESIII 粲偶素工作组（已发表物理结果）

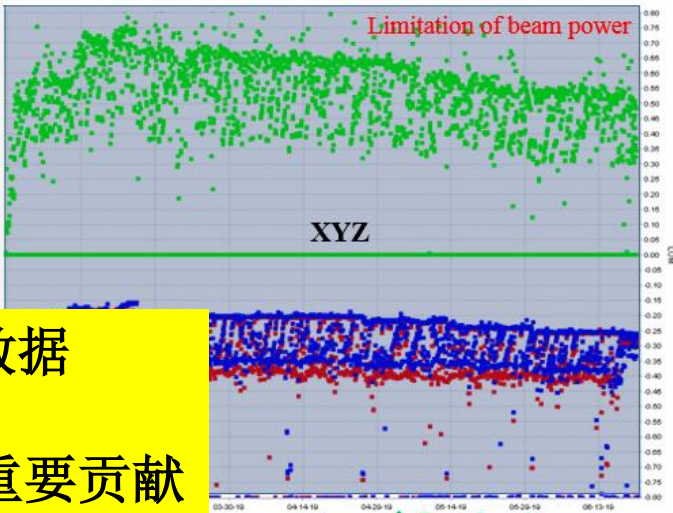
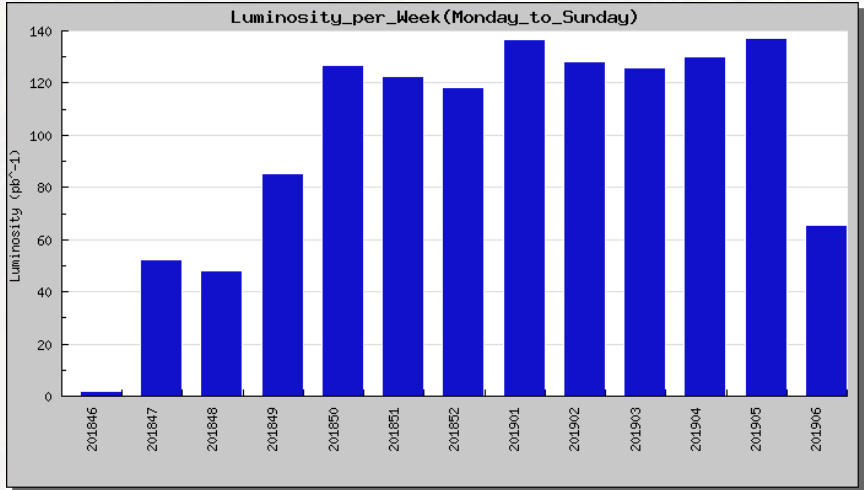
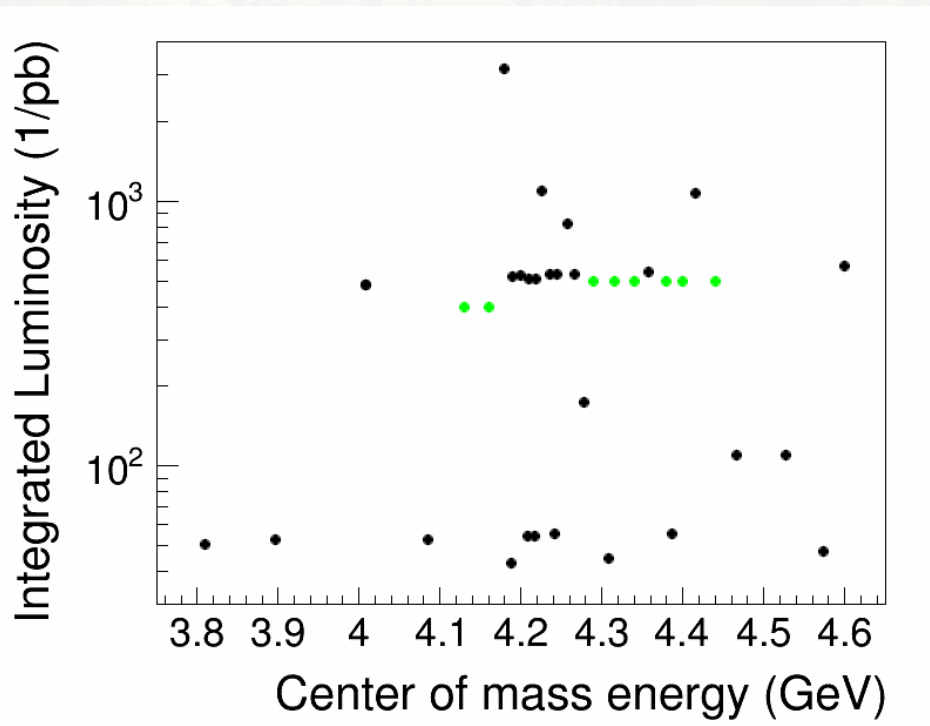


2018/11/23

■ PRD ■ PRL ■ OTH

担任召集人始于2016年夏

BESIII 粲偶素工作组 (2019新的数据)



**2019年在4.13-4.16 GeV 新获取约3.8/fb 数据
更多更好的 XYZ 研究
报告人在建议、获取、质检数据过程中均有重要贡献**

BESIII 粲偶素工作组（白皮书及国际评估）

White Paper on the Future Physics Programme of BESIII

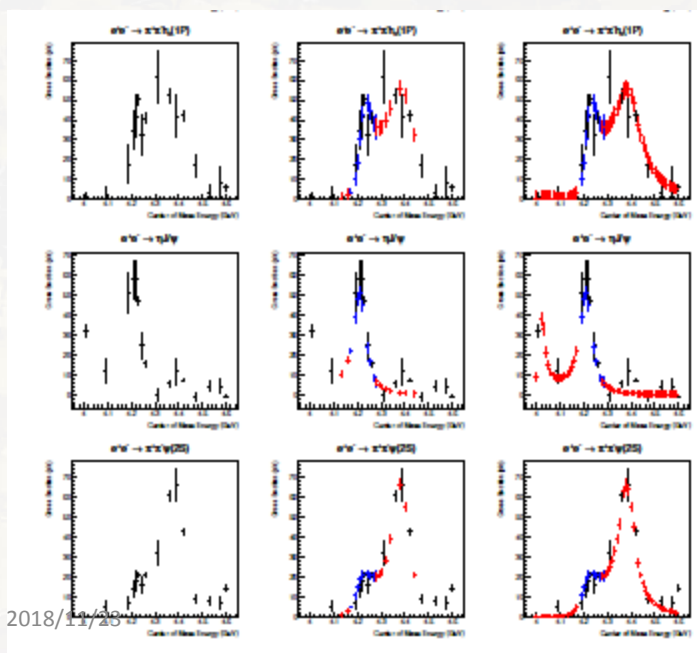
The BESIII collaboration¹

and

L. Calibbi^c, J. Charles^a, H. Y. Cheng^d, S. I. Eidelman^{b,g},
S. Descotes-Genon^f, F.-K. Guo^{c,d},
A. A. Petrov^j, J. L. Rosner^h, Z.-Q. Zhang^c

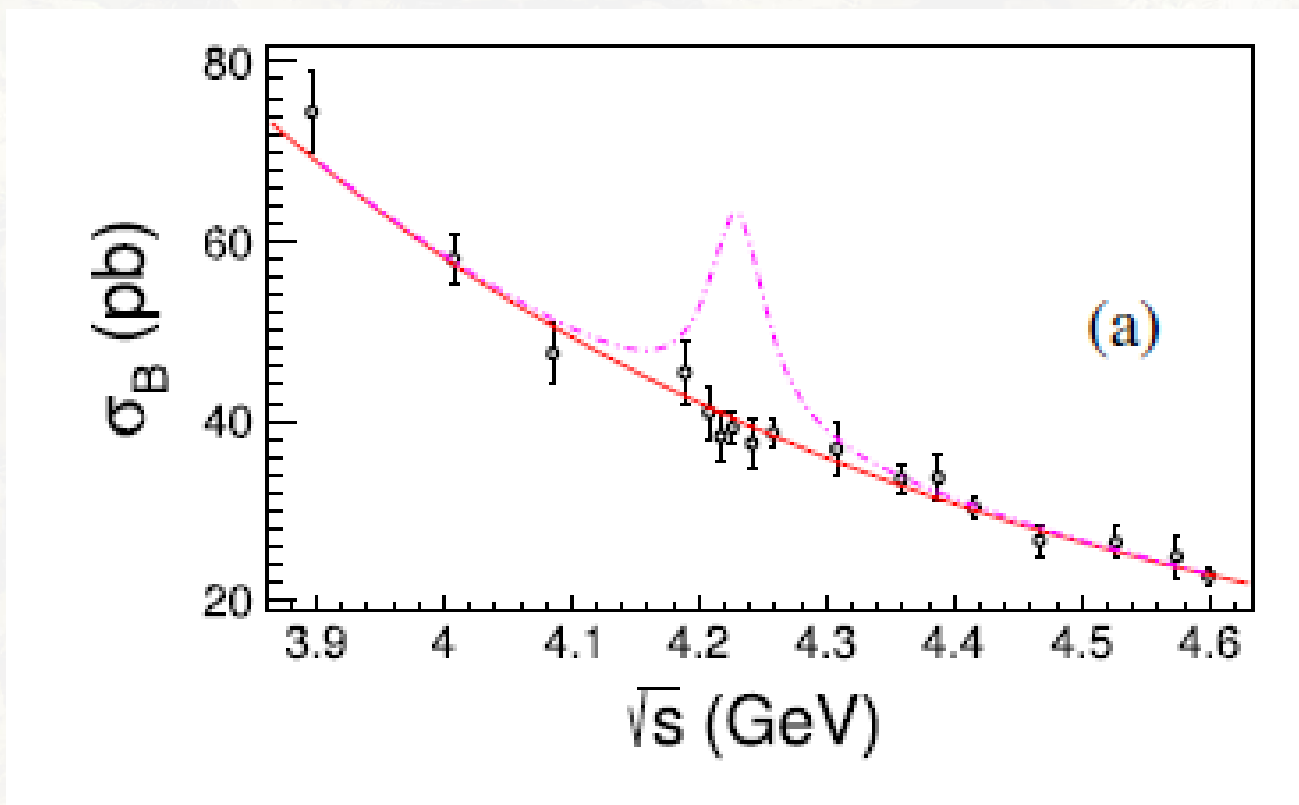
Table 3.4: Data-taking requirements for XYZ physics (top) and charmonium physics (bottom).

Plan	Data Sets
XYZ plan (1)	500 pb ⁻¹ at a large number of points between 4.0 and 4.6 GeV
XYZ plan (2)	5 fb ⁻¹ at 4.23, 4.42 GeV for large Z _c samples
XYZ plan (3)	5 fb ⁻¹ above 4.6 GeV
charmonium plan	3 × 10 ⁹ ψ(3686) decays



国际评审专家：
高度评价已有成果，支持未来研究计划
“These successes provide clear-cut evidence of the **world leadership position** which BESIII currently enjoys in charmonium physics.”
“This physics program will particularly benefit from the proposed BEPCII and BESIII upgrade.”

个人物理分析工作（2019年发表）

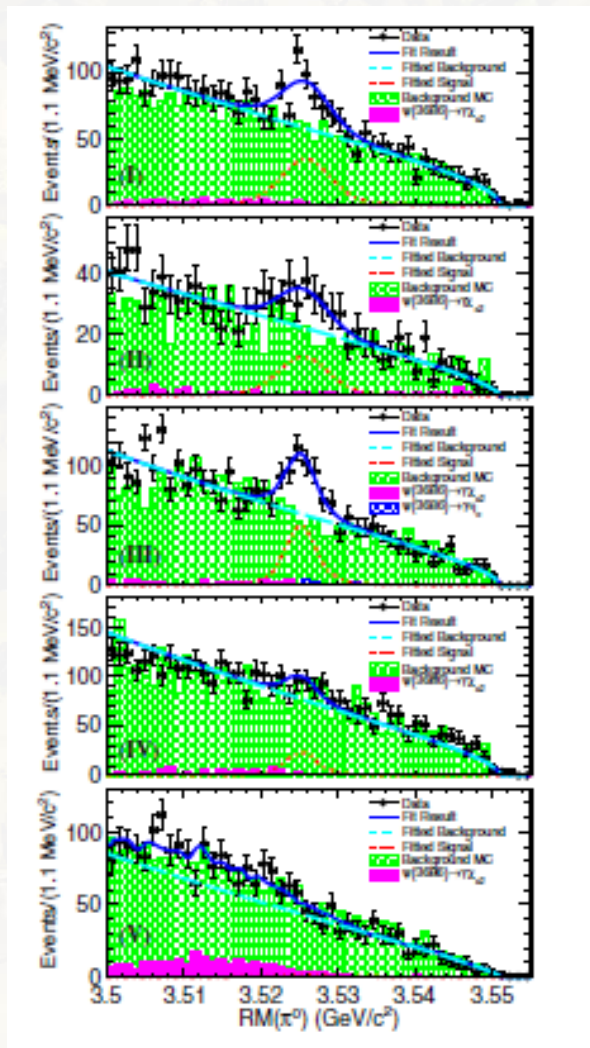


杨柳

给出了 $\Upsilon(4260)$ 及 $Z_c(3900)$ 衰变到轻强子末态 $K_s^0 K^\pm (\pi^{\mp,0}) \pi^{\pm,0} / \eta$ 的精确上限
 Z_c 中不可能只含轻夸克； Z_c 中的粲夸克对不可能靠得很近。

PHYSICAL REVIEW D99, 012003 (2019)

个人物理分析工作（2019年发表）



首次观测到自旋单态 $h_c(1P)$ 衰变到强子末态
(以前仅有迹象)

$$p\bar{p}\pi^+\pi^- \quad 7.4\sigma$$

$$\pi^+\pi^-\pi^0 \quad 4.6\sigma$$

$$2(\pi^+\pi^-)\pi^0 \quad 9.1\sigma$$

为粲偶素的衰变机制研究提供了重要输入
也为 XYZ 含 h_c 末态研究提供新的可能分析道

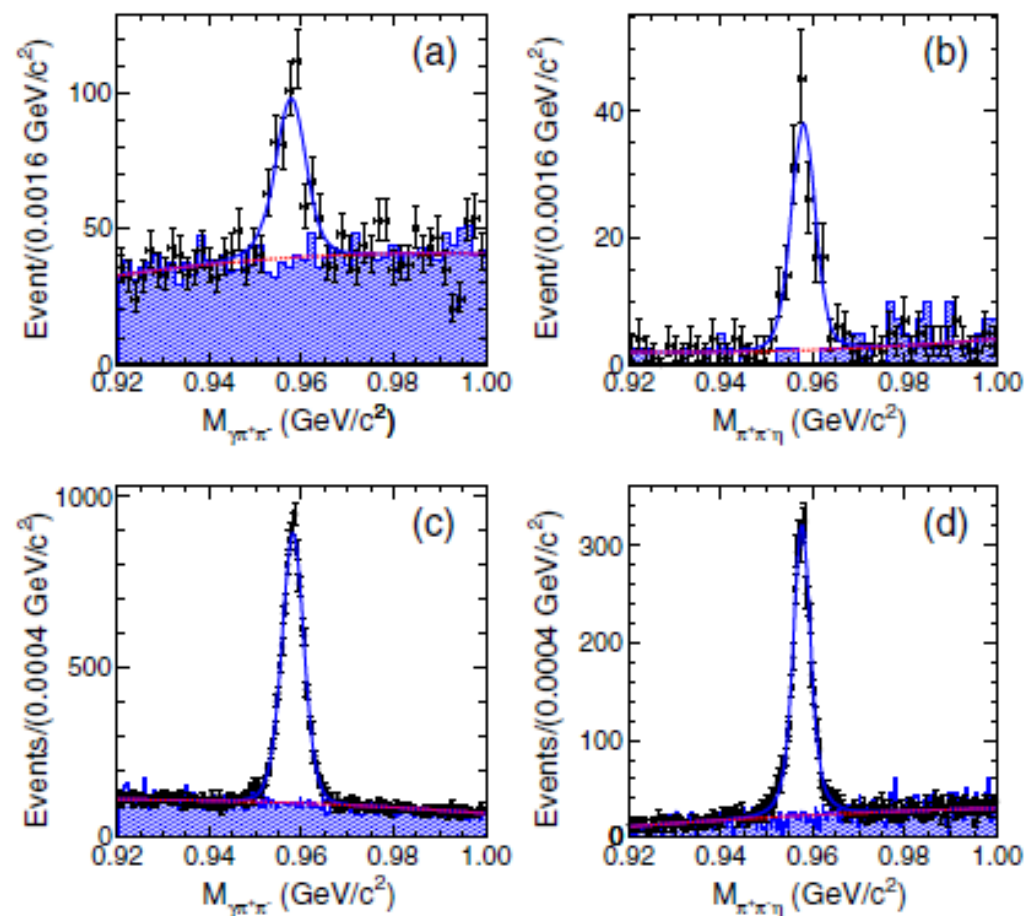
PHYSICAL REVIEW D 99, 072008 (2019)

个人物理分析工作（2019年发表）

首次测量了 $\psi(2S)$ 衰变到 $p\bar{p}\eta'$
改进了 J/ψ 衰变到同样末态的分支比

- 检验12%规则
- $\eta - \eta'$ 混合角

PHYSICAL REVIEW D99, 032006 (2019)



吴连近

个人物理分析工作（正在进行）

- $e^+e^- \rightarrow \phi \eta'$ （王成伟，合作组内review）
- $e^+e^- \rightarrow \eta \eta J/\psi$ （吴连近，新提交memo）
- $e^+e^- \rightarrow \Lambda \bar{\Lambda}$ （莫玉俊、王雄飞，合作组内review）
- $\psi(3686) \rightarrow \Sigma \bar{\Lambda} + c.c., \chi_{cJ} \rightarrow \Lambda \bar{\Lambda}$ （莫玉俊、王婷，合作组内review，刚完成了交叉检查）
- $\psi(3686) \rightarrow \Delta^{++} \Delta^{--}$ （苏可馨，初步结果）
- $\eta_c(2S) \rightarrow K_S K 3\pi$ （王婷，起始）
- $\eta_c(2S) \rightarrow \pi^+ \pi^- \eta$ （廖广睿，起始）
- $\psi(3770) \rightarrow \eta J/\psi$ （周祎卓，起始）
- $\psi(3686) \rightarrow \phi \pi \pi, \phi K K$ （蔡浩、董翔，初步结果）

BESIII 上 dE/dx 刻度与模拟

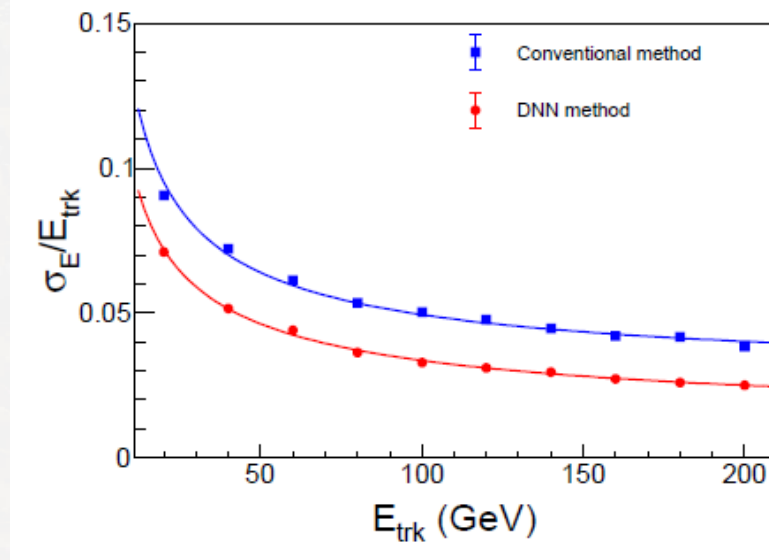
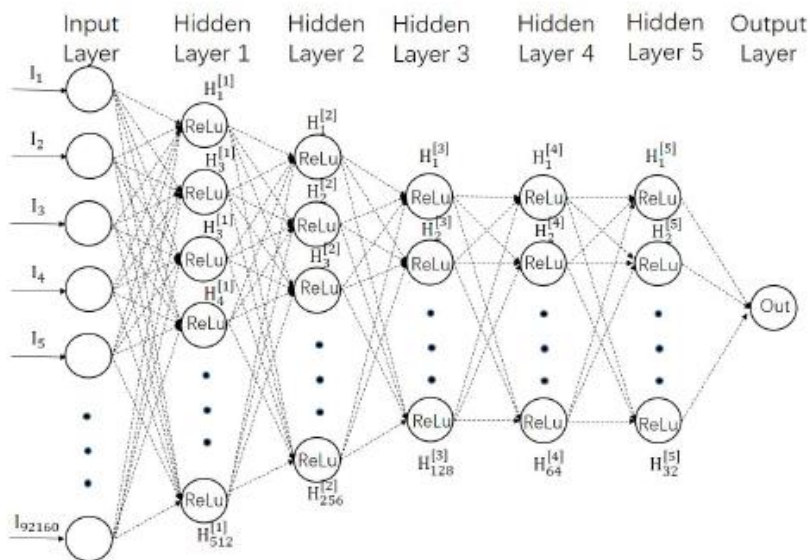
- 完成了18-19 获取的 J/ψ 数据的 dE/dx 的刻度与MC 调参（邱进发）

- 针对top-up 的 dE/dx 刻度方案升级
改动底层数据结构，关联程序包修改
正确，向下兼容

Modified packages	Notes
CalibData	Items
CalibTreeCnv	Connection with database
DedxCorrecSvc	Service for both rec. and cal.
MdcDedxAlg	Reconstruction
DedxCalibAlg	Calibration

```
*****
runno *      evtfrom *      evtto *      runmean *      rungain *
*****
62732 *      0 *      144238 *      784.05222 *      1.4255495 *
62732 *      144239 *      292097 *      780.73388 *      1.4195161 *
62732 *      292098 *      444754 *      780.50630 *      1.4191023 *
62732 *      444755 *      587411 *      784.16148 *      1.4257481 *
62732 *      587412 *      731694 *      782.76552 *      1.4232100 *
62732 *      731695 *      880868 *      780.60529 *      1.4192823 *
62732 *      880869 *      1029356 *      784.35976 *      1.4261086 *
62732 *      1029357 *      1179053 *      783.50840 *      1.4245607 *
62732 *      1179054 *      1e+09 *      783.66632 *      1.4248478 *
62733 *      0 *      142244 *      781.52918 *      1.4209621 *
62733 *      142245 *      286564 *      781.92136 *      1.4216752 *
*****
```

环形正负电子对撞机（CEPC） 亮度探测器预研究



杨柳

基于深度学习的重建方法大幅提高效率、明显改善分辨
可为未来（硬件设计改动之后）重建算法之参考

NIMA 929 (2019) 42–49

与广西师范大学合办了一个小型研讨会

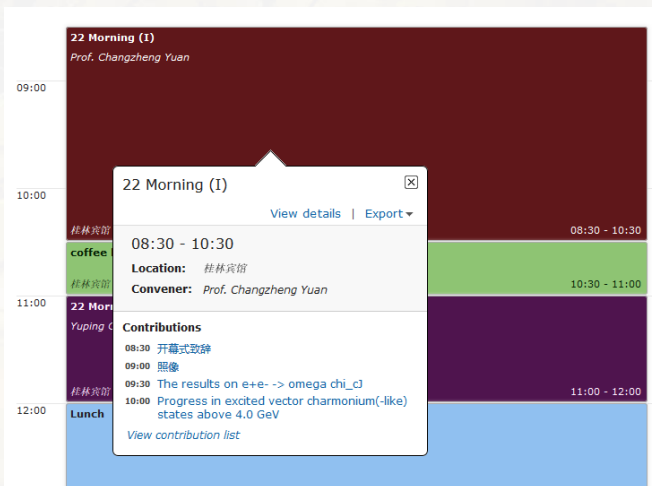
2019年粲偶素及类粲偶素物理研讨会

22-24 August 2019

桂林宾馆

Asia/Shanghai timezone

理论与实验、不同思想相碰撞的一次成功会议



(部分) 国内外学术活动

- International Workshop on $e+e-$ collisions from Phi to Psi, 25 Feb. 2019 –1 Mar. 2019, BudkerINP, Novosibirsk, “Baryon form factors at BESIII”
- BESIII/JPAC meeting, April 2-4, Beijing, “An overview of $e+ e-$ cross sections and the Y states”
- STCF物理模拟研讨会, 2019/3/23-24, 国科大玉泉路校区, “Chance of XYZ states in STCF”
- 南辽河三校联合物理培训班, 2019年5月18-19日, 新乡, “BESIII 物理及物理分析进阶”
- New Physics Workshop at BESIII, USTC, Hefei, China, May 24-26, 2019, “Prospects of the new physics in rare and forbidden charmonium decays at BESIII”
- Hadron 2019, 2019 Aug. 17, Guilin, China, “Recent BESIII results of X(3872)”
- Workshop of the Baryon Production at BESIII 14-16 September 2019, Hefei, China, “Nucleon pair production in Charmonium states”
- Symposium on 30 years of BES Physics, 6-Sep-2019, IHEP, Beijing, “BES Physics Achievements, Charmonium and Charmonium-like states”
- BESIII上高激发态粲偶素研讨会, 2019年10月19日-20日, 南开大学, 天津, “BESIII 实验的(类)粲偶素总结报告”

唯象工作

Strong and electromagnetic amplitudes of the J/ψ decays into baryons and their relative phase

Rinaldo Baldini Ferroli^a, Alessio Mangoni^{b,c}, Simone Pacetti^{b,c} and Kai Zhu^d

1. Introduction

The decays of the J/ψ meson into a baryon-antibaryon, $B\bar{B}$, final states proceed via strong and electromagnetic (EM) interactions. The Feynman amplitude can be written as a sum of three sub-amplitudes [1]

$$\mathcal{A}_{B\bar{B}} = \mathcal{A}_{B\bar{B}}^{ggg} + \mathcal{A}_{B\bar{B}}^{\gamma} + \mathcal{A}_{B\bar{B}}^{gg\gamma},$$

where $\mathcal{A}_{B\bar{B}}^{ggg}$ is the purely strong, $\mathcal{A}_{B\bar{B}}^{\gamma}$ is the purely EM and $\mathcal{A}_{B\bar{B}}^{gg\gamma}$ is the mixed strong-EM sub-amplitude.

At leading order, these sub-amplitudes are characterized by: a three-gluon (ggg), a one-photon (γ), and two-gluon-plus-

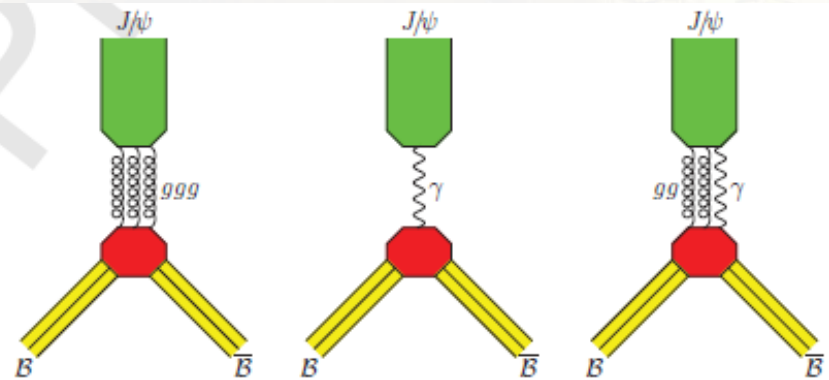
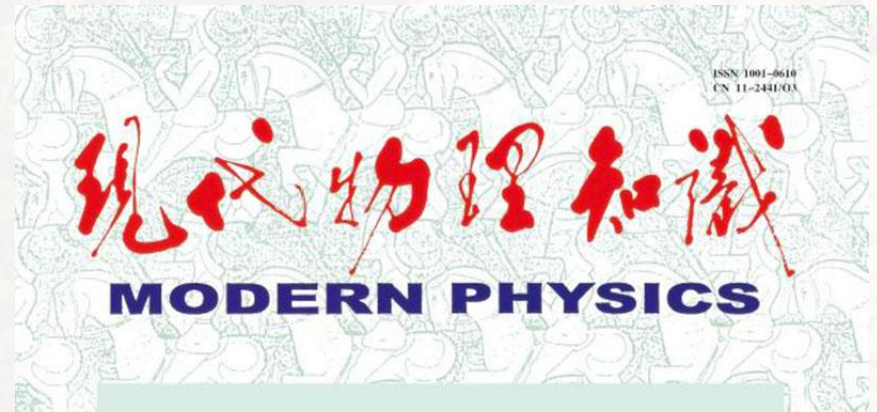
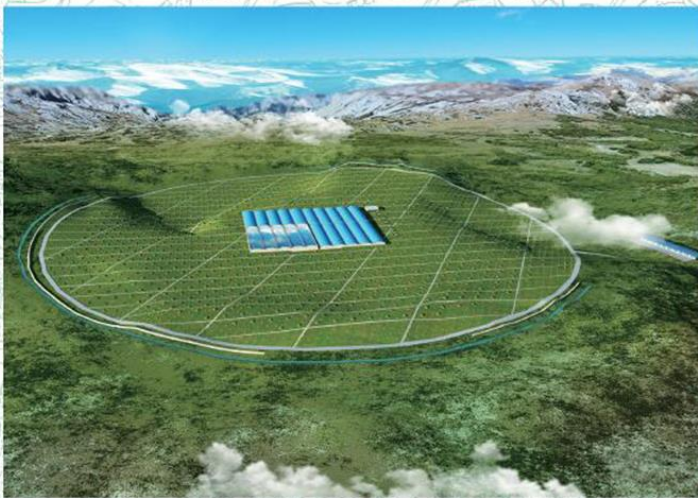
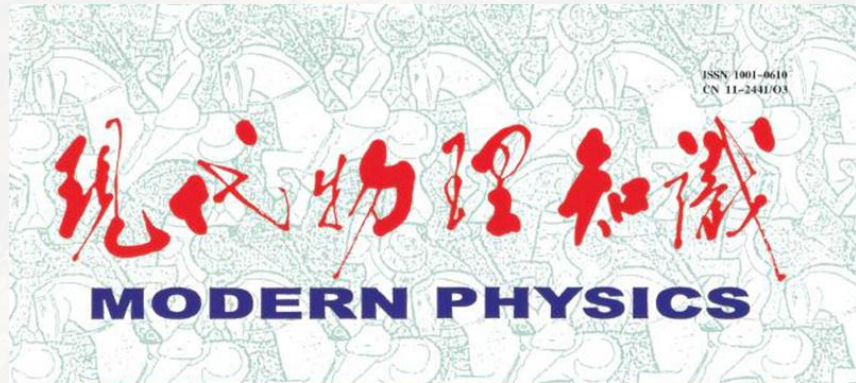


Figure 1: Feynman diagrams of the the purely strong, purely EM and strong-EM contributions.

得到 J/ψ 衰变的电磁与强振幅之间相角约为90度
新的振幅贡献，新的预言，期待实验检验

Phys. Lett. B, 135041 (2019)

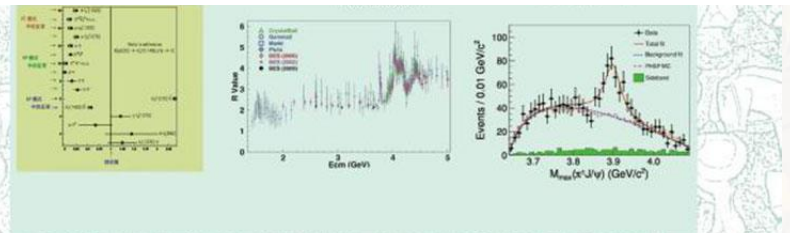
科普宣传



现代物理知识

粲偶素与类粲偶素的故事

朱 凯¹ 郭奉坤^{2,3}



- LHAASO和宇宙线专题
- 从蜻蜓翅痣谈飞机机翼颤振及其抑制
- X射线自由电子激光：原理、现状及应用
- BES III 测量了Zc(3900)的自旋宇称量子数
- 推荐一本好的科普书——《从夸克到宇宙》

2
2019

- 北京谱仪实验30年专题
- AdA——一个影响深远的小加速器
- 关于物质-反物质对称性破缺的发现
- 磁场在微流控芯片中颗粒分离的发展和应用
- 地球是人类唯一的家园
——《生活在极限之内》书评

4
2019

小结

- 北京谱仪（BESIII）

- 粲偶素工作组召集人

- 粲偶素工作组持续活跃（会议、报告、分析、论文发表等方面进展良好）、新获取 XYZ 数据、完成白皮书及国际评估

- 个人物理分析

- 兴趣集中在 XYZ 及粲偶素物理：今年发表三篇物理分析文章、有多项分析工作正在开展

- dE/dx 刻度与模拟

- 常规刻度模拟正常进行（保障 BESIII 的分析）、针对 top-up 模式进行刻度方案升级（已完成）

- 其他

- CEPC亮度探测器预研究、组织小型研讨会、唯象工作、科普写作等

2019发表文章列表

- == Physics paper===
- “Measurements of $e^+ e^- \rightarrow K_s K \pi \pi^0$ and $K_s K \pi \eta$ at a center mass energy from 3.90 to 4.60 GeV”, BESIII, Physical Review D99, 012003 (2019)
- “Observation of $\psi(3686) \rightarrow p \bar{p} \eta'$ and improved measurement of $J/\psi \rightarrow p \bar{p} \eta'$ ”, BESIII, Physical Review D99, 032006 (2019)
- “Deep learning based track reconstruction on CEPC luminometer”, Yang Liu, Cai Hao, **Zhu Kai**, Nuclear Inst. and Methods in Physics Research, A 929 (2019) 42–49
- “First observations of $hc \rightarrow \text{hadrons}$ ”, BESIII, PHYSICAL REVIEW D 99, 072008 (2019)
- “Strong and electromagnetic amplitudes of the J/ψ decays into baryons and their relative phase”, Rinaldo Baldini Ferroli, Alessio Mangoni, Simone Pacetti, **Kai Zhu**, Phys. Lett. B, 135041 (2019)
- === Proceedings ===:
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A photograph of a path covered in fallen yellow ginkgo leaves. The path is made of red bricks with a circular pattern. The leaves are scattered across the grass and the path. In the center, there is a white rectangular box containing the Chinese characters '谢谢!' (Thank you!) in blue. Below this box, the same characters are faintly visible on a semi-transparent grey background.

谢谢!

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