Closeout talk

Xiao-Rui Lyu（吕晓睿）

University of Chinese Academy of Sciences (UCAS)

2015年BESIII粲强子物理研讨会，高能所，北京市

https://indico.ihep.ac.cn/event/5339/

2016年BESIII粲强子物理研讨会(同一会议室)，高能所，北京市

https://indico.ihep.ac.cn/event/6434

Hadronic decay	**2014：0.567 fb^{-1} at 4.6 GeV**
$\Lambda_c^+ \to pK^-\pi^+$ + 11 CF modes	PRL 116, 052001 (2016)
$\Lambda_c^+ \to pK^+K^-$, $p\pi^+\pi^-$	PRL 117, 232002 (2016)
$\Lambda_c^+ \to nK_S\pi^+$	PRL 118, 12001 (2017)
$\Lambda_c^+ \to p\eta$, $p\pi^0$	PRD 95, 111102(R) (2017)
$\Lambda_c^+ \to \Sigma^-\pi^+\pi^+\pi^0$	PLB 772, 388 (2017)
$\Lambda_c^+ \to \Xi^{0(*)}K^+$	PLB783, 200 (2018)
$\Lambda_c^+ \to \Lambda\eta\pi^+$	**PRD99, 032010 (2019)**
$\Lambda_c^+ \to \Sigma^+\eta, \Sigma^+\eta'$	**CPC43, 083002 (2019)**
$\Lambda_c^+ \to$ BP decay asymmetries	**PRD100, 072004 (2019)**
$\Lambda_c^+ \to pK_S\eta$	**PLB 817, 136327 (2021)**
Λ_c^+ spin determination	**PRD 103, L091101(2021)**
Semi-leptonic decay	
$\Lambda_c^+ \to \Lambda e^+\nu_e$	PRL 115, 221805(2015)
$\Lambda_c^+ \to \Lambda\mu^+\nu_\mu$	PLB 767, 42 (2017)
Inclusive decay	
$\Lambda_c^+ \to \Lambda X$	PRL121, 062003 (2018)
$\Lambda_c^+ \to e^+X$	**PRL 121 251801(2018)**
$\Lambda_c^+ \to K_S^0X$	**EPJC 80, 935 (2020)**
Production	
$\Lambda_c^+\bar{\Lambda}_c^-$ cross section	PRL 120,132001(2018)

2018年BESIII粲强子物理研讨会，武汉大学，湖北省武汉市

https://indico.ihep.ac.cn/event/8756/

2017、2019年，因BESIII-Belle-LHCb粲强子物理联合研讨会，暂停

2020年BESIII粲强子物理研讨会，南华大学，湖南省衡阳市

https://indico.ihep.ac.cn/event/12626/

2021年，因疫情暂停

2022年，BESIII实验上粲强子、QCD及新物理研讨会，兰州大学+线上，甘肃省兰州市

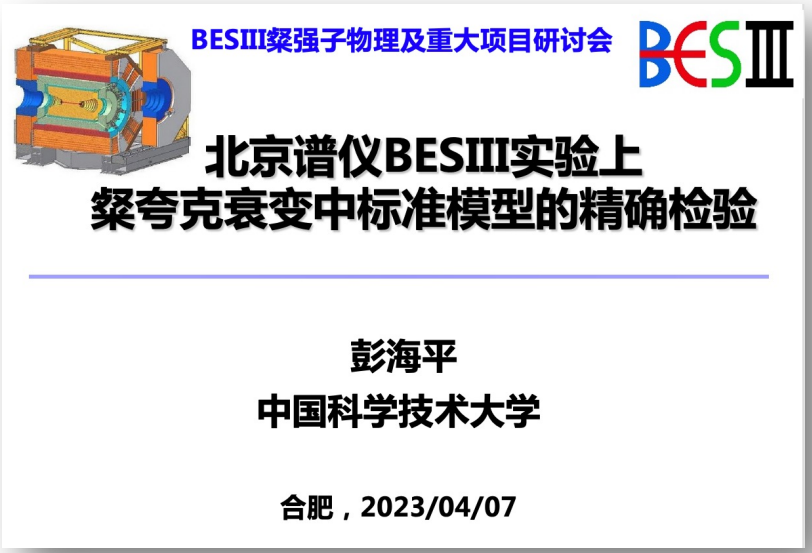
https://indico.ihep.ac.cn/event/17186/

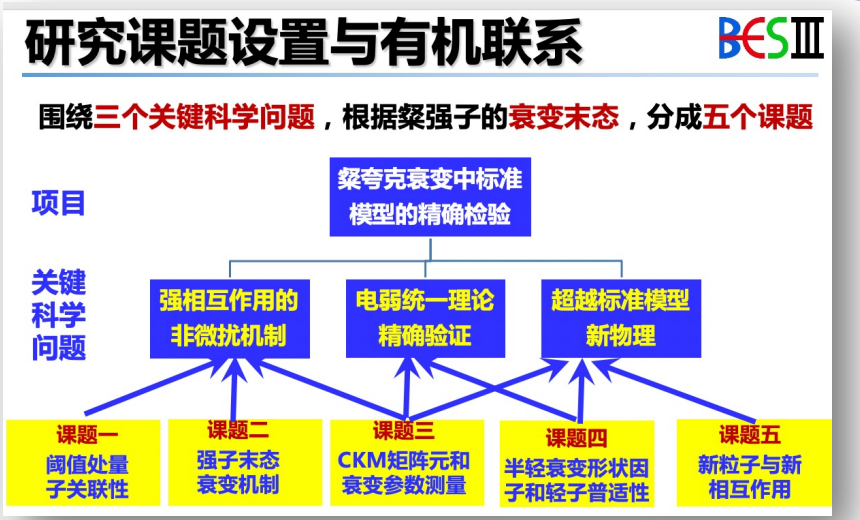
2023年BESIII粲强子物理研讨会暨国家自然科学基金《粲夸克衰变中标准模型的精确检验》重大项目研讨会，中科大，安徽省合肥市

http://cicpi.ustc.edu.cn/indico/conferenceDisplay.py?confId=5723

	注册人数	实验报告	理论报告	报告总数
2015	<40	7	3	10
2016	<40	7	3	10
2018	73	7	7	14
2020	93	10	4	14
2023	**151**	**21**	**19**	**40**

实验报告不包括项目汇报报告





Session I: Chair Prof. 何小刚（上海交通大学）

08:30 **Opening** *10′*
Speaker: Prof. Xiao-Rui Lyu (University of Chinese Academy of Sciences)

08:40 **《粲夸克衰变中标准模型的精确检验》重大项目汇报** *30′*
Speaker: Prof. Haiping Peng (University and science and Technology of China)
Material: Slides

09:10 **中性粲介子量子关联性研究课题汇报** *20′*
Speaker: Prof. Haiping Peng (University and science and Technology of China)
Material: Slides

09:30 **精确测量CKM矩阵元|Vcd|和|Vcs|以及粲介子衰变常数课题汇报** *20′*
Speaker: Dr. Bai-Cian Ke (Zhengzhou University)
Material: Slides

Session II: Chair Prof. 吕晓睿（中国科学院大学）

Location: 威尼斯厅

10:20 **精确测量粲介子半轻衰变形状因子和检验轻子普适性课题汇报** *20′*
Speaker: Prof. Hailong Ma (Institute of High Energy Physics, CAS)
Material: Slides

10:40 **粲夸克衰变中标准模型的精确检验课题汇报** *20′*
Speaker: Prof. Liaoyuan Dong (Institute of High Energy Physics, CAS)
Material: Slides

11:00 **粲强子衰变中探索新粒子和新相互作用课题汇报** *20′*
Speaker: Prof. Liang Sun (Wuhan University)
Material: Slides

11:20 **粲介子含轻衰变的LQCD计算** *20′*
Speaker: Prof. 朝峰 刘 (Institute of High Energy Physics, CAS)
Material: Slides

11:40 **动量测量中的能损修正** *20′*
Speaker: 新南 王 (Institute of High Energy Physics, CAS)
Material: Slides

实验报告21个

BESIII报告 (18)

- BESIII上Λc含轻衰变 李蕾(人民大学)
- BESIII上Λc 强子衰变研究 胥英超(烟台大学)
- Study of Λc decays with a neutron in the final state at BESIII 耿聪(中山大学)
- Amplitude analysis framework TF-PWA and its application in $\Lambda_c^+ \to \Lambda\pi^+\pi^0$ 蒋艺(国科大)
- BESIII上粲介子纯轻衰变研究 王腾蛟(南开大学)
- BESIII上D -> P半轻衰变研究 潘祥(苏州大学)
- BESIII上D -> V半轻衰变研究 张书磊 (湖南大学)
- BESIII上粲介子稀有半轻衰变的研究 李晓宇(IHEP, CAS)
- BESIII上粲强子稀有衰变的寻找 姜候兵(武汉大学)
- Amplitude Analyses of multibody hadronic $D^{0/+}$ Decays at BESIII 潘越(东南大学)
- BESIII上粲介子DCS衰变研究 上官剑锋(苏州大学)
- BESIII上D_s介子多体强子衰变的 振幅分析 卢泽辉 (IHEP, CAS)
- Two-Body Hadronic $D_{(s)}$ Decays at BESIII 单心钰(中科大)
- BESIII 上粲介子强子衰变绝对分支比的测量 葛潘婷(武汉大学)
- BESIII上中性D介子量子关联相关的测量 张宇(南华大学)
- BESIII上D(s)*衰变研究和展望 刘英(兰州大学)
- Physics via open charm production at BESIII 李培荣(兰州大学)

Charm physics at Belle (II) 贾森(东南大学)

Charm physics at LHCb Miroslav Saur(北京大学)

Input for gamma measurements from BESIII 周晓康(华中师范大学)

Prospect of charm physics at STCF 李慧静(河南师范大学)

理论报告(一)

(含)重子衰变 (10个)

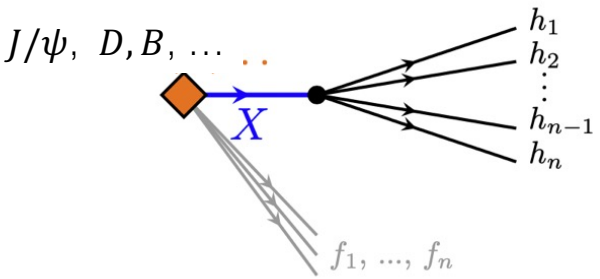
- Charm-Flavor-Conserving Weak Decays of Charmed Baryons: A Story That Has Lasted 30 Years 郑海扬(中研院)
- Equivalent SU(3) flavor approaches for two-body anti-triplet charmed baryon decays 萧佑国(山西师范大学)
- A data-driven approach to charmed baryon weak decays 徐繁荣(暨南大学)
- Mixing effects of Ξ_c- Ξ_c' in charm baryon decays 刘佳韦(国科大杭高院)
- Flavor sum rules for charmed hadron weak decays 王迪(湖南师范大学)
- Recent progress in SU(3) symmetry and its breaking effects in charm baryon decays 邢志鹏 (TDLI&SJTU)
- Baryons in the light-front approach: the three-quark picture 赵振兴(内蒙古大学)
- 正负电子散射到正负重子对的微扰QCD研究 韩佳杰(兰州大学)
- Charmed baryon Ξ_c decays from lattice QCD 张其安(北航)
- 双粲重子非轻弱衰变$\Xi_{cc} \to \Xi_c \pi$中W交换图的光锥求和规则计算 施瑀基(华东理工大学)

介子衰变 (4个)

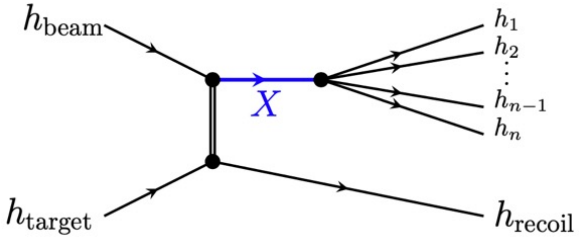
- Polarization puzzles in $D^0 \to VV$ 赵强(IHEP)
- Exclusive weak decays of strange-charm mesons with the LCSRs form factors 程山(湖南大学)
- Semileptonic decay of charm hadron 康现伟(北京师范大学)
- Three and Four Body Semileptonic D_s Meson Decays Based on SU(3) Flavor Analysis 王茹敏 (江西师范大学)

理论报告(二)

BESIII, LHCb, Belle (II) …



GlueX, Compass, …

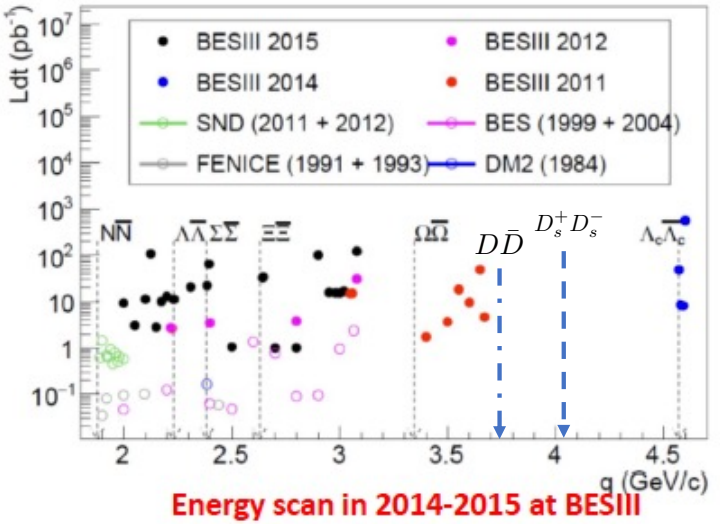


Hadron Spectroscopy (5个)

- Newly observed a0(1817) as the scaling point of constructing the scalar meson spectroscopy — Dan Guo (兰州大学)
- Repercussion of the a0(1710) [a0(1817)] resonance and future developments — 耿立升(北航)
- The study of the singly anti-charmed pentaquark production in b-factory — 胡晓会(中国矿业大学)
- Prediction of a 0^{--} exotic state and its possible detection 纪腾(ITP, CAS)
- Charmonium-like states in the $D\bar{D} - D_s\bar{D}_s$ coupled-channel system — 石盼盼(ITP, CAS)

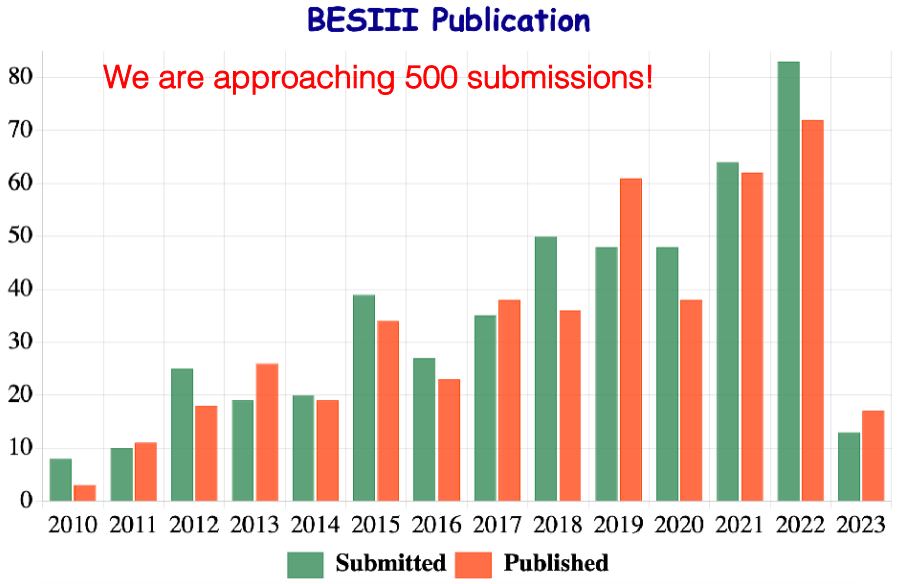
BESIII data sample

2009: 106M $\psi(2S)$
225M J/ψ
2010: 975 pb^{-1} at $\psi(3770)$
2011: 2.9 fb^{-1} *(total)* at $\psi(3770)$
482 pb^{-1} at 4.01 GeV
$D^{0/+}$
2012: 0.45B *(total)* $\psi(2S)$
1.3B *(total)* J/ψ
2013: 1092 pb^{-1} at 4.23 GeV
826 pb^{-1} at 4.26 GeV
540 pb^{-1} at 4.36 GeV
10 × 50 pb^{-1} scan 3.81 — 4.42 GeV
2014: 1029 pb^{-1} at 4.42 GeV
110 pb^{-1} at 4.47 GeV
110 pb^{-1} at 4.53 GeV
48 pb^{-1} at 4.575 GeV
567 pb^{-1} at 4.6 GeV
Λ_c^+
0.8 fb^{-1} R-scan 3.85 — 4.59 GeV
2015: R-scan 2 — 3 GeV + 2.175 GeV
2016: ~3fb^{-1} at 4.18 GeV (for D_s)
2017: 7 × 500 pb^{-1} scan 4.19 — 4.27 GeV
D_s^+
2018: more J/ψ *(and tuning new RF cavity)*
2019: 10B *(total)* J/ψ
8 × 500 pb^{-1} scan 4.13, 4.16, 4.29 — 4.44 GeV
2020: 3.8 fb^{-1} scan **4.61-4.7 GeV**
Λ_c^+
2021: 2 fb^{-1} scan **4.74-4.95 GeV**; 2.55B $\psi(2S)$
2022: 5.1 fb^{-1} at $\psi(3770)$
2023: ~8 fb^{-1} will be taken at $\psi(3770)$
$D^{0/+}$



Energy scan in 2014-2015 at BESIII

Nsubmitted = 489, Npublished = 458



Feature of threshold data

- **Meson and Baryon pair-productions near thresholds:**
  form-factors in the time-like production, precision branching fractions, relative phase;
- **Quantum-entangled pair productions of charmed mesons**
- **Baryon spin polarization in quantum entangled productions**

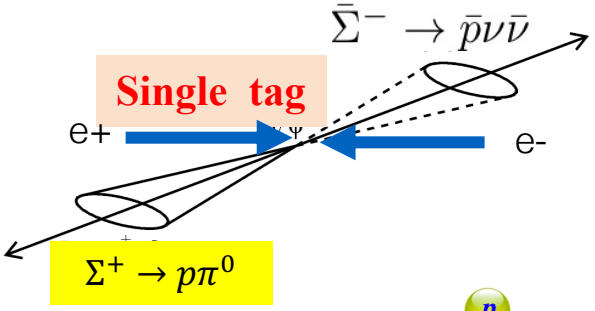
Known initial 4-momentum

Known beam energy: pair productions

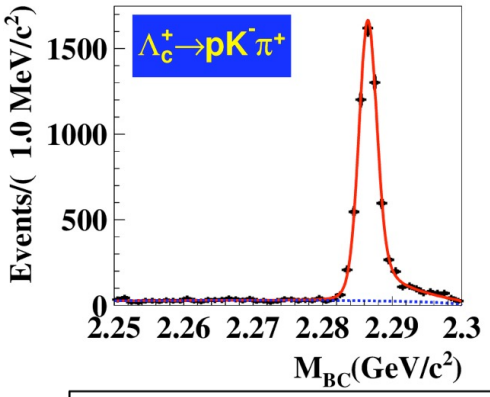
Decay with neutron & π^0

Decay with invisibles: neutrinos

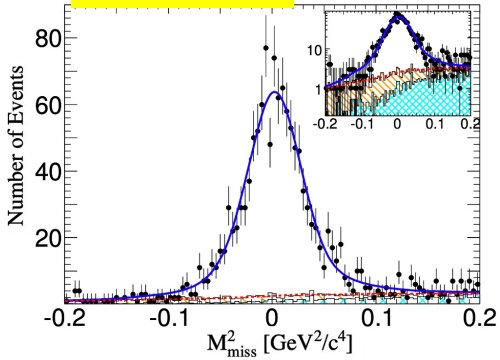
Missing mass or missing energy

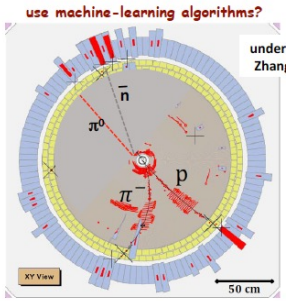


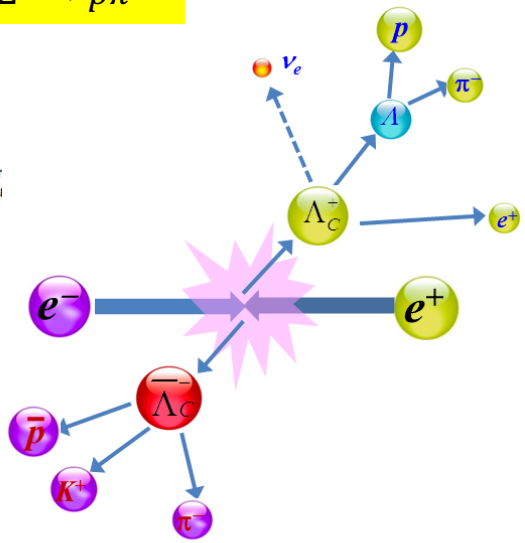
Excellent resolution
Beam-constraint Λ_c mass

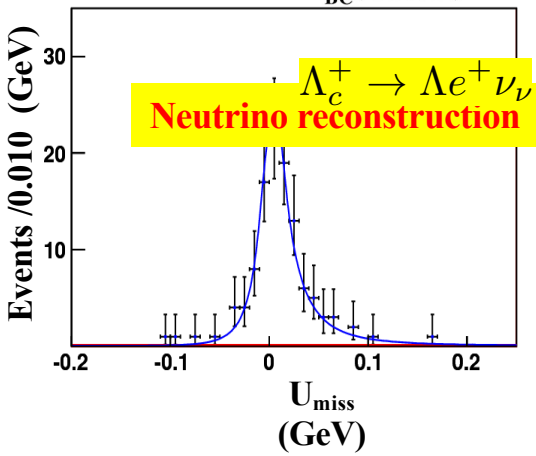


Missing mass

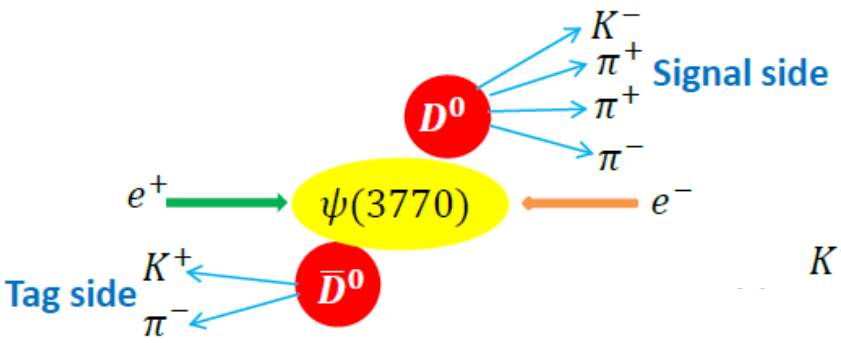




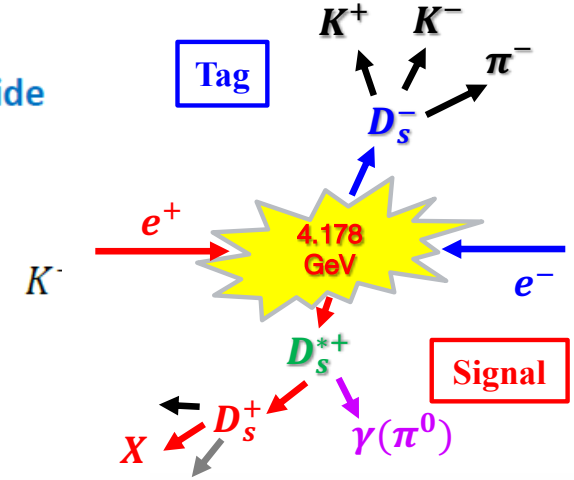


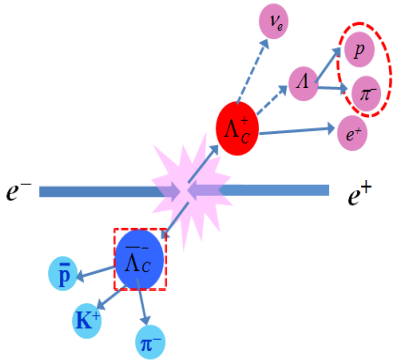


Charm hadron decays

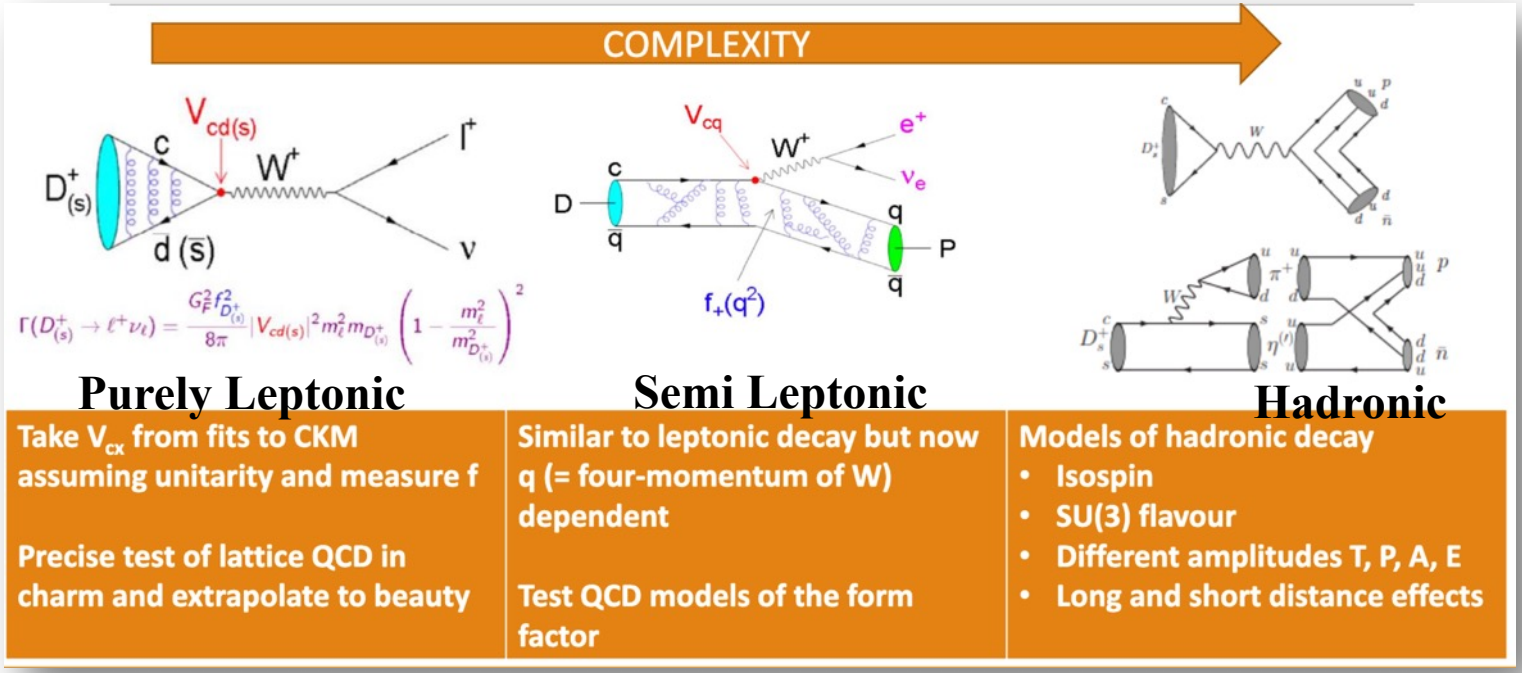


2.93/fb at $\psi(3770)$





0.567/fb at 4.6 GeV



Planned future data set

Table 7.1: List of data samples collected by BESIII/BEPCII up to 2019, and the proposed samples for the remainder of the physics program. The most right column shows the number of required data taking days in current (T_C) or upgraded (T_U) machine. The machine upgrades include top-up implementation and beam current increase.

Energy	Physics motivations	Current data	Expected final data	T_C / T_U
1.8 - 2.0 GeV	R values Nucleon cross-sections	N/A	0.1 fb^{-1} (fine scan)	60/50 days
2.0 - 3.1 GeV	R values Cross-sections	Fine scan (20 energy points)	Complete scan (additional points)	250/180 days
✓ J/ψ peak	Light hadron & Glueball J/ψ decays	3.2 fb^{-1} (10 billion)	3.2 fb^{-1} (10 billion)	N/A
✓ $\psi(3686)$ peak	Light hadron & Glueball Charmonium decays	0.67 fb^{-1} (0.45 billion)	4.5 fb^{-1} (3.0 billion)	150/90 days
$\psi(3770)$ peak	$D^0/D^{\pm}$ decays	2.9 fb^{-1}	20.0 fb^{-1}	610/360 days
3.8 - 4.6 GeV	R values XYZ/Open charm	Fine scan (105 energy points)	No requirement	N/A
4.180 GeV	D_s decay XYZ/Open charm	3.2 fb^{-1}	6 fb^{-1}	140/50 days
4.0 - 4.6 GeV	XYZ/Open charm Higher charmonia cross-sections	16.0 fb^{-1} at different $\sqrt{s}$	30 fb^{-1} at different $\sqrt{s}$	770/310 days
4.6 - 4.9 GeV	Charmed baryon/XYZ cross-sections	0.56 fb^{-1} at 4.6 GeV	15 fb^{-1} at different $\sqrt{s}$	1490/600 days
4.74 GeV	$\Sigma_c^+\Lambda_c^-$ cross-section	N/A	1.0 fb^{-1}	100/40 days
4.91 GeV	$\Sigma_c\Sigma_c$ cross-section	N/A	1.0 fb^{-1}	120/50 days
4.95 GeV	Ξ_c decays	N/A	1.0 fb^{-1}	130/50 days

to be complete in 2022-24

~55 fb^{-1}

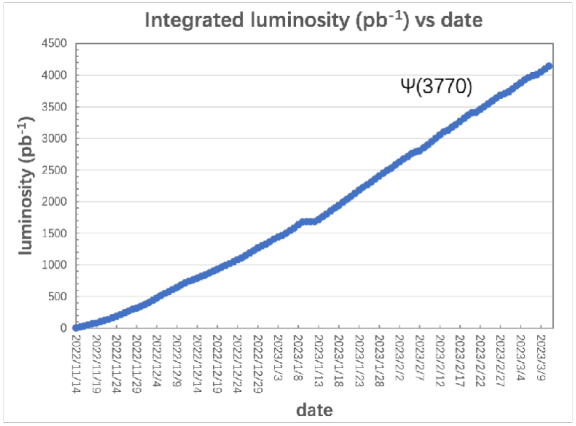
future: 50M D^0, 50M D^+, 15M Ds, 2M Λc

Data taking of $\psi(3770)$

from Mingyi Dong

The target is to take 17.1 fb^{-1} $\psi(3770)$ data before BEPCII-U (July, 2024)

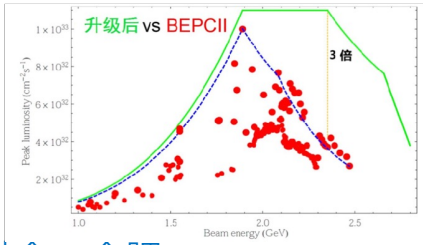
Psi(3770) data taking	Planed lum. (fb^{-1})	Finished lum. (fb^{-1})	Will be finished lum. (fb^{-1})
2010, 2011	2.9	2.9	
2021-2022	5	5	
2022-2023	6	4.2	3.5~4
2023-2024	6.1		4.4~3.9
total	20	12.1	7.9



- **About 3.5~4 fb^{-1} data will be collected in the remaining 100 days**
- **About 2 ~ 3 months may be saved in next run period**

More data taking proposals in 2024

- We will implement BEPCII upgrade in July, 2024
- Data taking proposals for the remaining 2-3 months need to be seriously discussed and optimized.

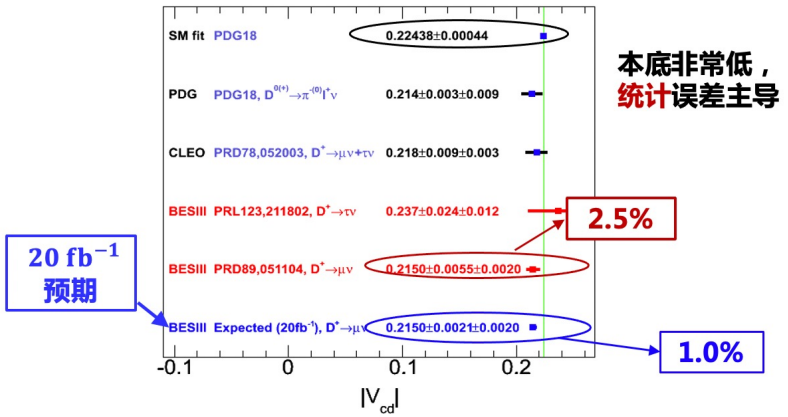


BESIII data @3770 MeV (2.93 fb^{-1} ➔ 20 fb^{-1})

from Haiping

BESIII实验纯轻子衰变测量

当前矩阵元$|V_{cd(s)}|$的世界平均值由BESIII实验测量结果主导



本底非常低，统计误差主导

2.5%

20 fb^{-1} 预期

1.0%

BESIII实验20 fb^{-1}的数据能够大幅度提升测量精度

11

Determination of γ/ϕ_3 angle

Runs	Collected / Expected integrated luminosity	Year attained	γ/ϕ_3 sensitivity
LHCb Run-1 [7, 8 TeV]	3 fb^{-1}	2012	8°
LHCb Run-2 [13 TeV]	5 fb^{-1}	2018	4°
Belle II Run	50 ab^{-1}	2025	1.5°
LHCb upgrade I [14 TeV]	50 fb^{-1}	2030	< 1°
LHCb upgrade II [14 TeV]	300 fb^{-1}	(>)2035	< 0.4°

BESIII 20/fb: σ(γ) ~0.4°

STCF is needed!

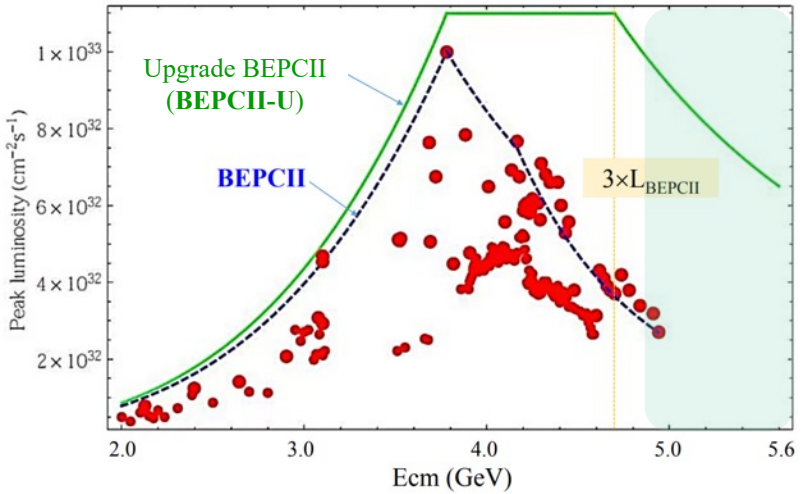
Three methods for exploiting interference (choice of D^0 decay modes):

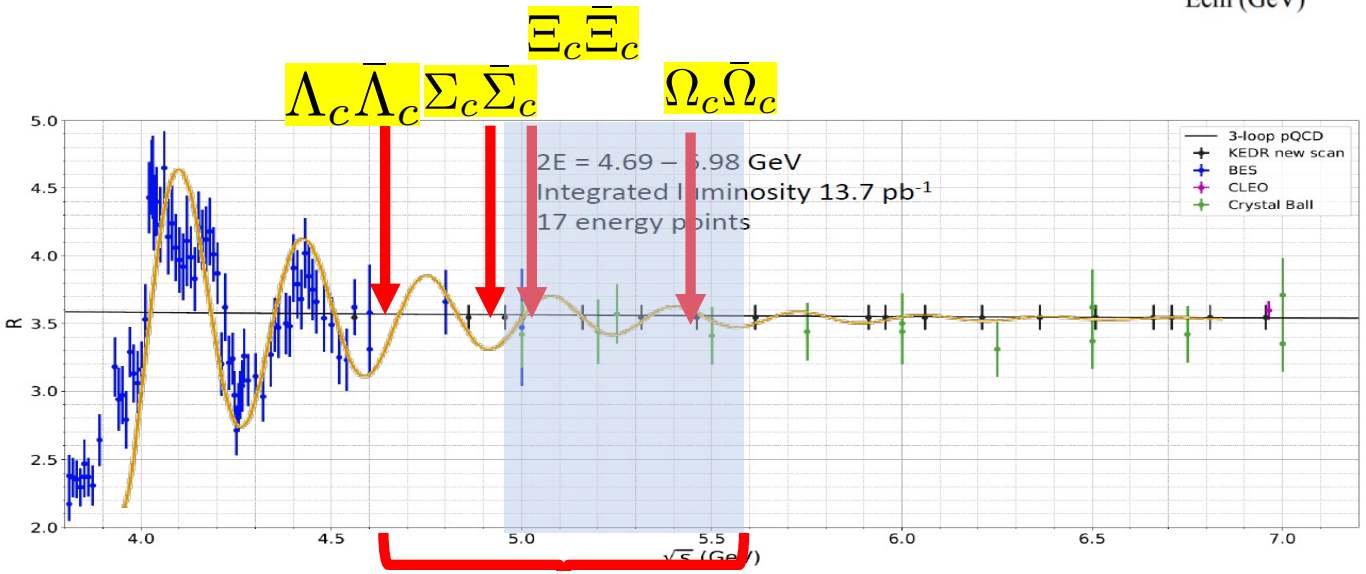
- Gronau, London, Wyler (GLW): Use CP eigenstates of $D^{(*)0}$ decay, e.g. $D^0 \to K_S\pi^0$, $D^0 \to \pi^+\pi^-$
- Atwood, Dunietz, Soni (ADS): Use doubly Cabibbo-suppressed decays, e.g. $D^0 \to K^+\pi^-$
  - With 1 ab^{-1} @ STCF : $\sigma(\cos\delta_{K\pi}) \sim 0.007$; $\sigma(\delta_{K\pi}) \sim 2^o$ ➔ $\sigma(\gamma) < 0.5^o$
- Giri, Grossman, Soffer, Zupan (GGSZ): Use Dalitz plot analysis of 3-body D^0 decays, e.g. $K_S\pi^+\pi^-$; high statistics; need precise Dalitz model
  - STCF reduces the contribution of D Dalitz model to a level of ~0.1°

	BESIII	BESIII	Belle	Belle II
Luminosity	2.9 fb^{-1} at 3.773 GeV	20 fb^{-1} at 3.773 GeV	1 ab^{-1} at $\Upsilon(nS)$	50 ab^{-1} at $\Upsilon(nS)$
$\mathcal{B}(D^+ \to \mu^+\nu_\mu)$	$5.1\%_{stat.}1.6\%_{syst.}$[4]	$1.9\%_{stat.}1.3\%_{syst.}$	–	$3.0\%_{stat.}1.8\%_{syst.}$[54]
f_{D^+}(MeV)	$2.6\%_{stat.}0.9\%_{syst.}$[4]	$1.0\%_{stat.}0.8\%_{syst.}$	–	–
$\lvert V_{cd}\rvert$	$2.6\%_{stat.}1.0\%^*_{syst.}$[4]	$1.0\%_{stat.}0.8\%^*_{syst.}$	–	–
$\mathcal{B}(D^+ \to \tau^+\nu_\tau)$	$20\%_{stat.}13\%_{syst.}$ [5]	$8\%_{stat.}5\%_{syst.}$	–	–
$\frac{\mathcal{B}(D^+\to\tau^+\nu_\tau)}{\mathcal{B}(D^+\to\mu^+\nu_\mu)}$	$20\%_{stat.}13\%_{syst.}$ [5]	$8\%_{stat.}5\%_{syst.}$	–	–

Proposal of the upgrade BEPCII

- ✓ An upgrade of BEPCII (**BEPCII-U**) has been approved in July 2021:
  the optimized energy is 2.35 GeV with luminosity 3 times higher than current BEPCII and extend the maximum energy to 5.6 GeV



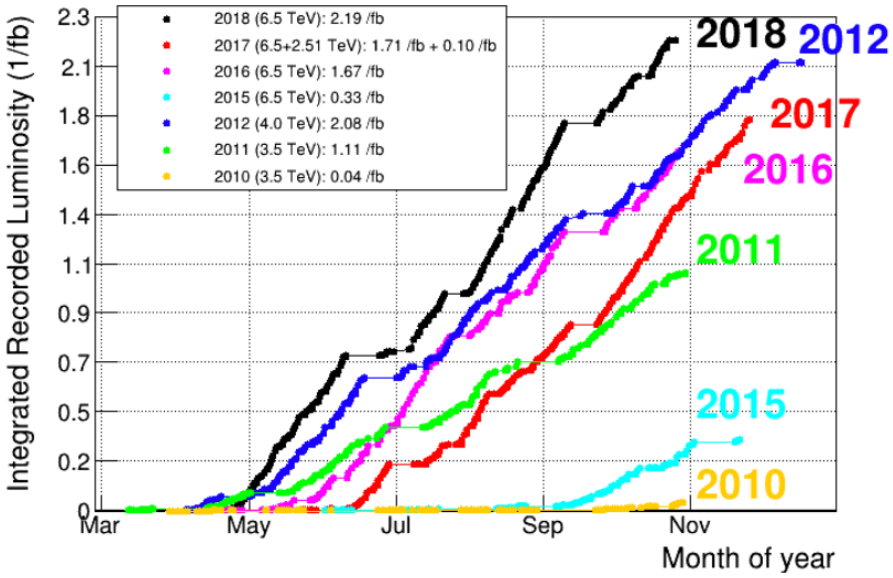


Cover all the ground-state charmed baryons: production & decays, CPV search

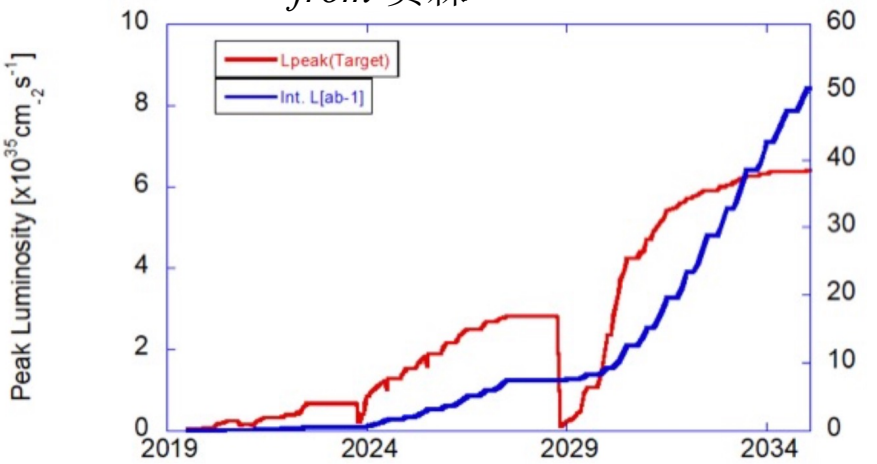
Complementary to LHCb and Belle (II)

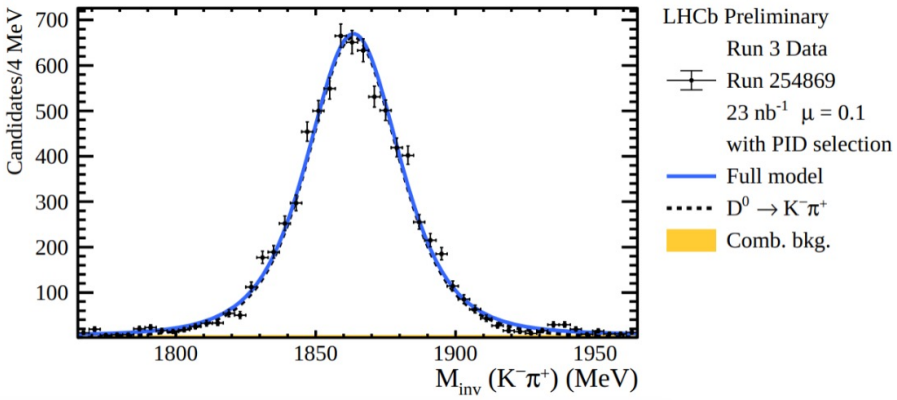
LHCb run3 and Belle II begin new data taking

from Miroslav Saur



from 贾森





Summary

- **The first measurements of A_{CP}^{dir} and A_{CP}^{α} for singly Cabibbo-suppressed (SCS) decays of charmed baryons [$\Lambda_c^+ \to \Lambda K^+$ and $\Lambda_c^+ \to \Sigma^0 K^+$] at Belle.**
- **The observation of $\Lambda_c(2910)^+ \to \Sigma_c(2455)^{0/++}\pi^{\pm}$ at Belle**
- **The evidence for $\Omega_c^0 \to \Xi^- K^+$ at Belle**
- **Measurements of D, Λ_c^+, and Ω_c^0 lifetimes at Belle II**

SuperKEKB achieved world record peak luminosity: 4.7 x 10^{34} $cm^{-2}s^{-1}$
Belle II collected ~ 428 fb^{-1} of data

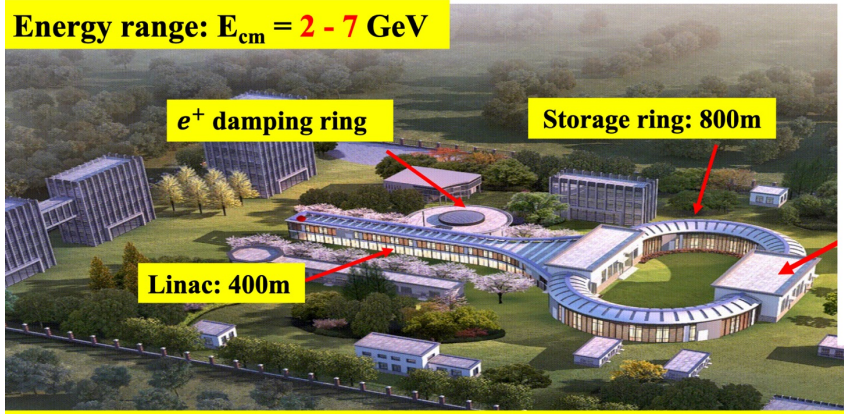
Stay tuned for more results!!

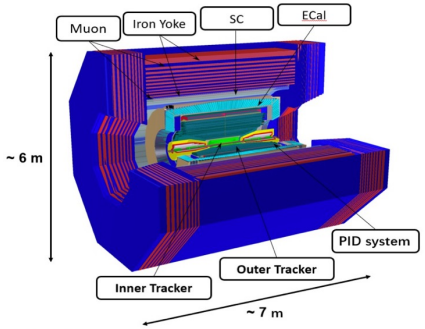
from Huijing LI

Future facility

Super Tau-Charm Facility (STCF) in China

Energy range: E_{cm} = 2 - 7 GeV





- **Peaking luminosity: > 0.5×10^{35} cm^{-2} s^{-1} @ 4 GeV**
- **Potential to increase luminosity & realize beam polarization**
- **Total cost: 5.5B RMB**

100 times more statistics than BESIII

Data sample produced per year

CME (GeV)	Lumi (ab^{-1})	Samples	σ(nb)	No. of Events	Remarks
3.097	1	J/ψ	3400	3.4×10^{12}	
3.670	1	$\tau^+\tau^-$	2.4	2.4×10^{9}	
3.686	1	$\psi(3686)$	640	6.4×10^{11}	
		$\tau^+\tau^-$	2.5	2.5×10^{9}	
		$\psi(3686)\to\tau^+\tau^-$		2.0×10^{9}	
3.770	1	$D^0\bar{D}^0$	3.6	3.6×10^{9}	
		$D^+\bar{D}^-$	2.8	2.8×10^{9}	
		$D^0\bar{D}^0$		7.9×10^{8}	Single tag
		$D^+\bar{D}^-$		5.5×10^{8}	Single tag
		$\tau^+\tau^-$	2.9	2.9×10^{9}	
4.009	1	$D^{*0}\bar{D}^0+c.c$	4.0	1.4×10^{9}	$CP_{D^0\bar{D}^0}=+$
		$D^{*0}\bar{D}^0+c.c$	4.0	2.6×10^{9}	$CP_{D^0\bar{D}^0}=-$
		$D_s^+D_s^-$	0.20	2.0×10^{8}	
		$\tau^+\tau^-$	3.5	3.5×10^{9}	
4.180	1	$D_s^{+*}D_s^-$+c.c.	0.90	9.0×10^{8}	
		$D_s^{+*}D_s^-$+c.c.		1.3×10^{8}	Single tag
		$\tau^+\tau^-$	3.6	3.6×10^{9}	
4.230	1	$J/\psi\pi^+\pi^-$	0.085	8.5×10^{7}	
		$\tau^+\tau^-$	3.6	3.6×10^{9}	
		$\gamma X(3872)$			
4.360	1	$\psi(3686)\pi^+\pi^-$	0.058	5.8×10^{7}	
		$\tau^+\tau^-$	3.5	3.5×10^{9}	
4.420	1	$\psi(3686)\pi^+\pi^-$	0.040	4.0×10^{7}	
		$\tau^+\tau^-$	3.5	3.5×10^{9}	
4.630	1	$\psi(3686)\pi^+\pi^-$	0.033	3.3×10^{7}	
		$\Lambda_c\bar{\Lambda}_c$	0.56	5.6×10^{8}	
		$\Lambda_c\bar{\Lambda}_c$		6.4×10^{7}	Single tag
		$\tau^+\tau^-$	3.4	3.4×10^{9}	
4.0–7.0	3	300-point scan with 10 MeV steps, 1 fb^{-1}/point			
> 5	2–7	Several ab^{-1} of high-energy data, details dependent on scan results			

感谢当地组委会的周到安排

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下次研讨会再聚会！