新强子物理平台

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报告提纲

- 研究进展
- 未来规划

下午安排了3个专门的报告：

1. 朱　凯（IHEP）　：BESIII
2. 钱文斌（UCAS）：LHCb
3. 王小龙（FDU）　：Belle & Belle II

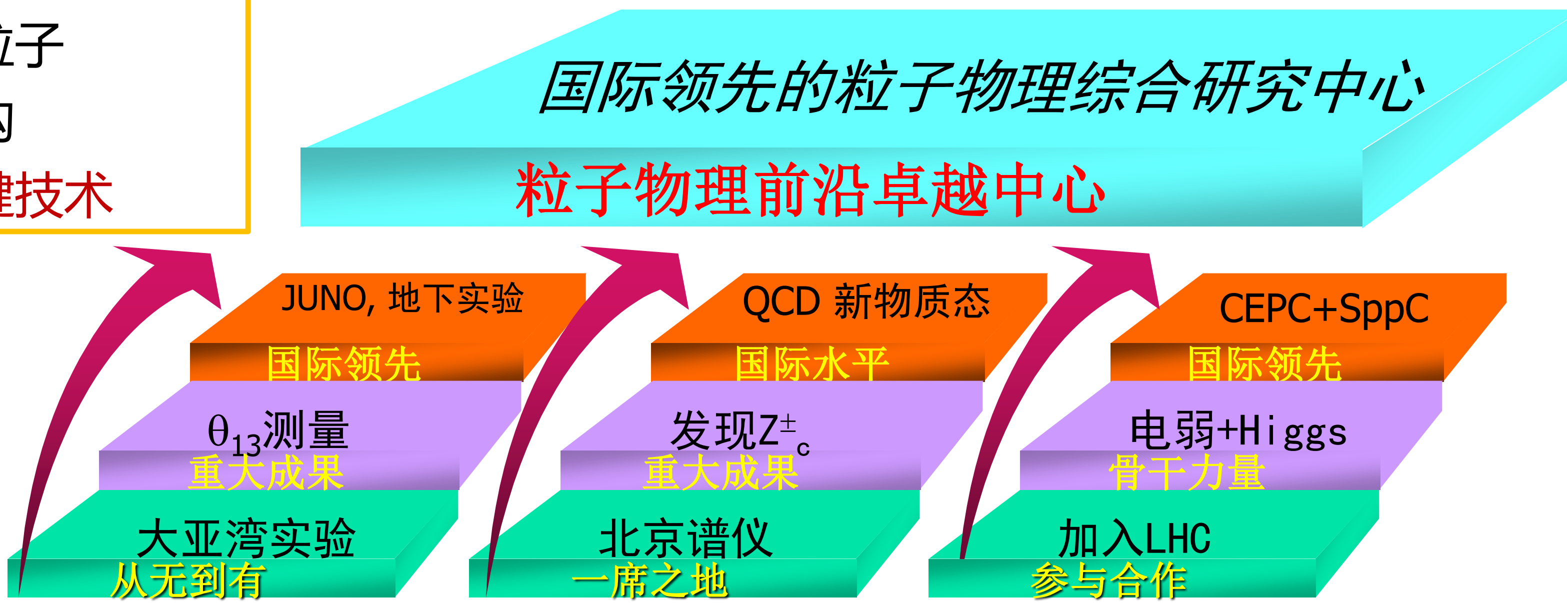
中心战略定位

有效组织国内粒子物理领域的人才队伍，以研究物质深层次结构及其相互作用为根本目标，通过20-30年努力，在中微子物理、强子物理、高能量前沿等领域取得一批重大成果，成为国际领先的粒子物理研究中心。

我们的研究内容

- 中微子、暗物质
- 高能新粒子
- 物质结构
- 相关关键技术

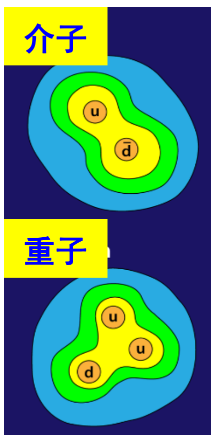
部署三个研究平台，在粒子物理三大前沿（高能量、高精度、宇宙学）占重要地位

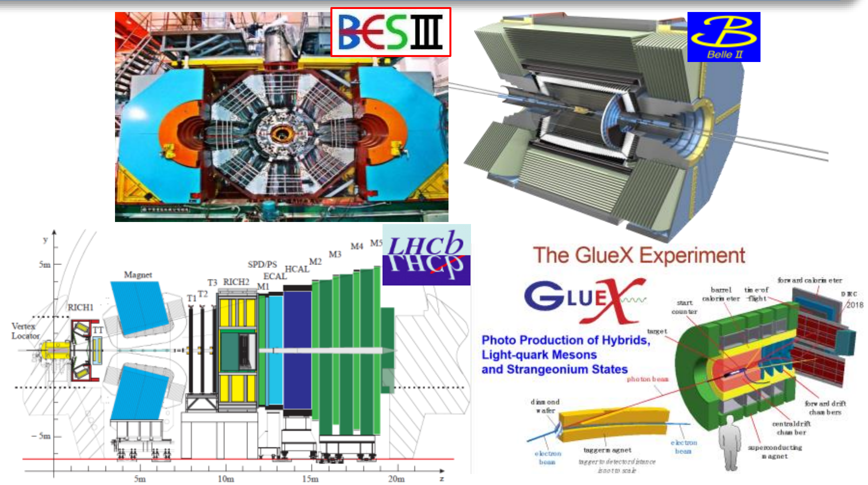


中微子及相关物理　　新强子物理　　高能量前沿物理

理解夸克禁闭机制

强子由夸克通过强作用组成，夸克怎样组成强子，组成什么类型的强子，是粒子物理的根本问题之一。常规强子由2个夸克（介子）或3个夸克（重子）组成，理论预期存在胶子球、混杂态、分子态、多夸克态等**奇特强子态**。





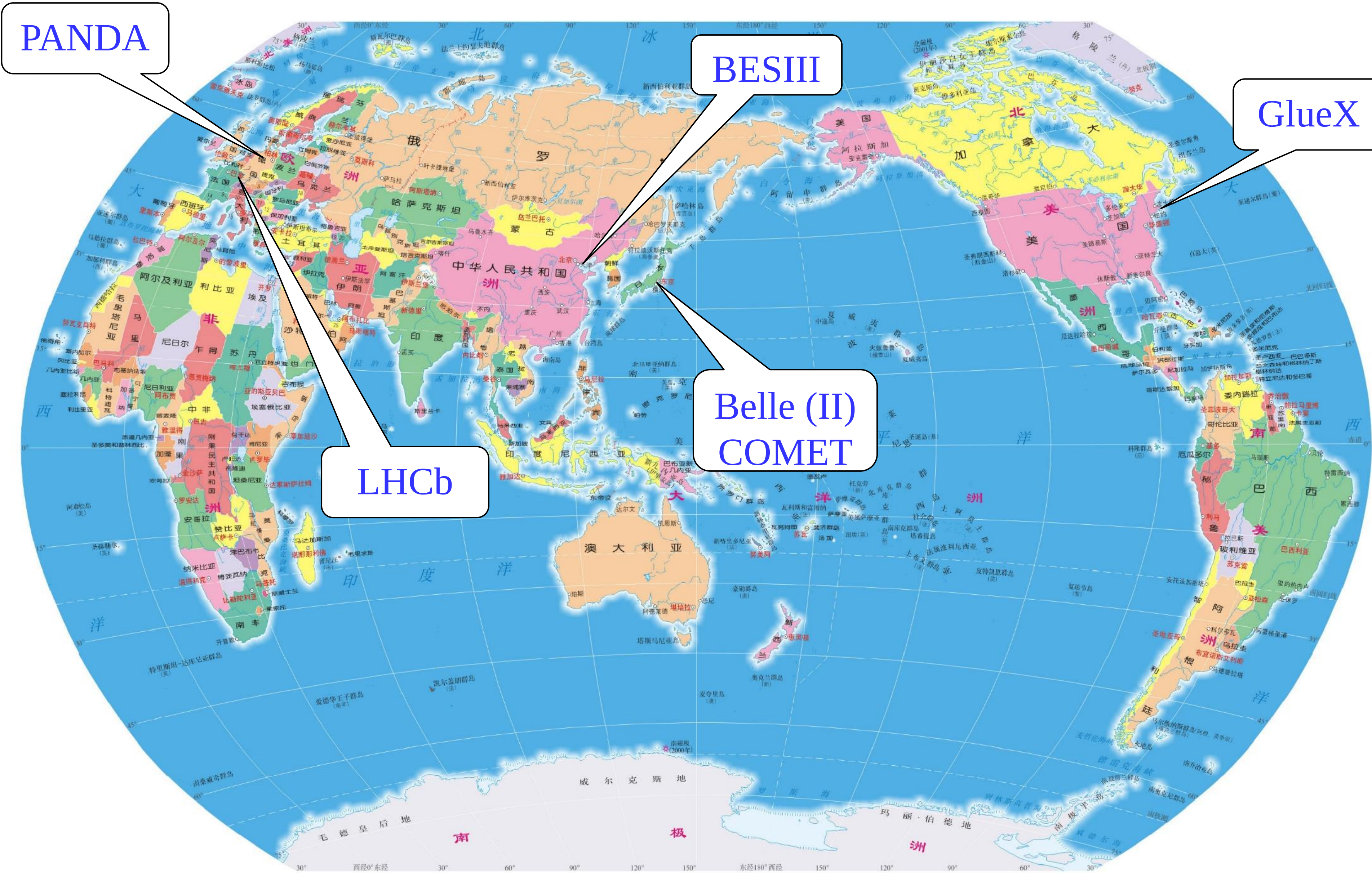
BESIII, Belle II, LHCb, GlueX 等实验为寻找奇特强子创造了条件：

- ✓ BESIII ：能量 = 2.0-4.9 GeV，$L=1\times10^{33}/cm^2s$，2008-202x
- ✓ Belle II：能量 = 9.5-11 GeV，$L=8\times10^{35}/cm^2s$，2018-203x
- ✓ LHCb ：能量 = 7-13 TeV，$\int Ldt=9-300\ fb^{-1}$，2008-203x

重点研究内容：

- ➢ 测量常规强子性质，寻找奇特强子态，深入研究其能谱、产生和衰变性质
- ➢ 与理论研究相结合，理解强作用的夸克禁闭机制

参加的实验+理论合作者



我们不仅在做强子物理

- 强子物理（QCD）
  - 介子谱、重子谱、奇特强子态
  - 形状因子、碎裂函数、产生机制、衰变机制
- 味物理（EW & QCD）
  - 粲物理、B物理、τ物理
  - CKM & CPV
- 新物理（超出标准模型）
  - 轻子味破坏
  - 暗光子、暗物质
  - 对称性破坏

强子谱

We know quark pair makes mesons three quarks makes baryons

M. Gell-Mann

A simpler and more elegant scheme can be constructed if we allow non-integral values for the charges. We can dispense entirely with the basic baryon b if we assign to the triplet t the following properties: spin $\frac{1}{2}$, $z = -\frac{1}{3}$, and baryon number $\frac{1}{3}$. We then refer to the members $u^{\frac{2}{3}}$, $d^{-\frac{1}{3}}$, and $s^{-\frac{1}{3}}$ of the triplet as "quarks" [6] q and the members of the anti-triplet as anti-quarks $\bar{q}$. Baryons can now be constructed from quarks by using the combinations $(q\,q\,q)$, $(q\,q\,q\,q\,\bar{q})$, etc., while mesons are made out of $(q\,\bar{q})$, $(q\,q\,\bar{q}\,\bar{q})$, etc. It is assuming that the lowest baryon configuration $(q\,q\,q)$ gives just the representations **1**, **8**, and **10** that have been observed, while the lowest meson configuration $(q\,\bar{q})$ similarly gives just **1** and **8**.

Published in Physics Letters 8, 214 (1964);
Similar idea by G. Zweig, CERN-TH-401 (1964).

What did we observe?

Meson Summary Table

See also the table of suggested $q\overline{q}$ quark-model assignments in the Quark Model section.
• indicates particles that appear in the preceding Meson Summary Table. We do not regard the other entries as being established.

LIGHT UNFLAVORED ($S = C = B = 0$)

	$I^G(J^{PC})$
• $\pi^\pm$	$1^-(0^-)$
• π^0	$1^-(0^{-+})$
• η	$0^+(0^{-+})$
• $f_0(500)$	$0^+(0^{++})$
• $\rho(770)$	$1^+(1^{--})$
• $\omega(782)$	$0^-(1^{--})$
• $\eta'(958)$	$0^+(0^{-+})$
• $f_0(980)$	$0^+(0^{++})$
• $a_0(980)$	$1^-(0^{++})$
• $\phi(1020)$	$0^-(1^{--})$
• $h_1(1170)$	$0^-(1^{+-})$
• $b_1(1235)$	$1^+(1^{+-})$
• $a_1(1260)$	$1^-(1^{++})$
• $f_2(1270)$	$0^+(2^{++})$
• $f_1(1285)$	$0^+(1^{++})$
• $\eta(1295)$	$0^+(0^{-+})$
• $\pi(1300)$	$1^-(0^{-+})$
• $a_2(1320)$	$1^-(2^{++})$
• $f_0(1370)$	$0^+(0^{++})$
$h_1(1380)$	$?^-(1^{+-})$
• $\pi_1(1400)$	$1^-(1^{-+})$
• $\eta(1405)$	$0^+(0^{-+})$
• $f_1(1420)$	$0^+(1^{++})$
• $\omega(1420)$	$0^-(1^{--})$
$f_2(1430)$	$0^+(2^{++})$
• $a_0(1450)$	$1^-(0^{++})$
• $\rho(1450)$	$1^+(1^{--})$
• $\eta(1475)$	$0^+(0^{-+})$
• $f_0(1500)$	$0^+(0^{++})$
$f_1(1510)$	$0^+(1^{++})$
• $f_2'(1525)$	$0^+(2^{++})$
$f_2(1565)$	$0^+(2^{++})$
$\rho(1570)$	$1^+(1^{--})$
$h_1(1595)$	$0^-(1^{+-})$
• $\pi_1(1600)$	$1^-(1^{-+})$
$a_1(1640)$	$1^-(1^{++})$
$f_2(1640)$	$0^+(2^{++})$
• $\eta_2(1645)$	$0^+(2^{-+})$
• $\omega(1650)$	$0^-(1^{--})$
• $\omega_3(1670)$	$0^-(3^{--})$
• $\pi_2(1670)$	$1^-(2^{-+})$
• $\phi(1680)$	$0^-(1^{--})$
• $\rho_3(1690)$	$1^+(3^{--})$
• $\rho(1700)$	$1^+(1^{--})$
$a_2(1700)$	$1^-(2^{++})$
• $f_0(1710)$	$0^+(0^{++})$
$\eta(1760)$	$0^+(0^{-+})$
• $\pi(1800)$	$1^-(0^{-+})$
$f_2(1810)$	$0^+(2^{++})$
$X(1835)$	$?^?(0^{-+})$
$X(1840)$	$?^?(?^{??})$
$a_1(1420)$	$1^-(1^{++})$
• $\phi_3(1850)$	$0^-(3^{--})$
$\eta_2(1870)$	$0^+(2^{-+})$
• $\pi_2(1880)$	$1^-(2^{-+})$
$\rho(1900)$	$1^+(1^{--})$
$f_2(1910)$	$0^+(2^{++})$
$a_0(1950)$	$1^-(0^{++})$
• $f_2(1950)$	$0^+(2^{++})$
$\rho_3(1990)$	$1^+(3^{--})$
• $f_2(2010)$	$0^+(2^{++})$
$f_0(2020)$	$0^+(0^{++})$
• $a_4(2040)$	$1^-(4^{++})$
• $f_4(2050)$	$0^+(4^{++})$
$\pi_2(2100)$	$1^-(2^{-+})$
$f_0(2100)$	$0^+(0^{++})$
$f_2(2150)$	$0^+(2^{++})$
$\rho(2150)$	$1^+(1^{--})$
• $\phi(2170)$	$0^-(1^{--})$
$f_0(2200)$	$0^+(0^{++})$
$f_J(2220)$	$0^+(2^{++}$ or $4^{++})$
$\eta(2225)$	$0^+(0^{-+})$
$\rho_3(2250)$	$1^+(3^{--})$
• $f_2(2300)$	$0^+(2^{++})$
$f_4(2300)$	$0^+(4^{++})$
$f_0(2330)$	$0^+(0^{++})$
• $f_2(2340)$	$0^+(2^{++})$
$\rho_5(2350)$	$1^+(5^{--})$
$a_6(2450)$	$1^-(6^{++})$
$f_6(2510)$	$0^+(6^{++})$

OTHER LIGHT

Further States

STRANGE ($S = \pm1$, $C = B = 0$)

	$I(J^P)$
• $K^\pm$	$1/2(0^-)$
• K^0	$1/2(0^-)$
• K^0_S	$1/2(0^-)$
• K^0_L	$1/2(0^-)$
$K^*_0(800)$	$1/2(0^+)$
• $K^*(892)$	$1/2(1^-)$
• $K_1(1270)$	$1/2(1^+)$
• $K_1(1400)$	$1/2(1^+)$
• $K^*(1410)$	$1/2(1^-)$
• $K^*_0(1430)$	$1/2(0^+)$
• $K^*_2(1430)$	$1/2(2^+)$
$K(1460)$	$1/2(0^-)$
$K_2(1580)$	$1/2(2^-)$
$K(1630)$	$1/2(?^?)$
$K_1(1650)$	$1/2(1^+)$
• $K^*(1680)$	$1/2(1^-)$
• $K_2(1770)$	$1/2(2^-)$
• $K^*_3(1780)$	$1/2(3^-)$
• $K_2(1820)$	$1/2(2^-)$
$K(1830)$	$1/2(0^-)$
$K^*_0(1950)$	$1/2(0^+)$
$K^*_2(1980)$	$1/2(2^+)$
• $K^*_4(2045)$	$1/2(4^+)$
$K_2(2250)$	$1/2(2^-)$
$K_3(2320)$	$1/2(3^+)$
$K^*_5(2380)$	$1/2(5^-)$
$K_4(2500)$	$1/2(4^-)$
$K(3100)$	$?^?(?^{??})$

CHARMED ($C = \pm1$)

	$I(J^P)$
• $D^\pm$	$1/2(0^-)$
• D^0	$1/2(0^-)$
• $D^*(2007)^0$	$1/2(1^-)$
• $D^*(2010)^\pm$	$1/2(1^-)$
• $D^*_0(2400)^0$	$1/2(0^+)$
$D^*_0(2400)^\pm$	$1/2(0^+)$
• $D_1(2420)^0$	$1/2(1^+)$
$D_1(2420)^\pm$	$1/2(?^?)$
$D_1(2430)^0$	$1/2(1^+)$
• $D^*_2(2460)^0$	$1/2(2^+)$
• $D^*_2(2460)^\pm$	$1/2(2^+)$
$D(2550)^0$	$1/2(?^?)$
$D^*_J(2600)$	$1/2(?^?)$
$D^*(2640)^\pm$	$1/2(?^?)$
$D(2740)^0$	$1/2(?^?)$
$D(2750)$	$1/2(3^-)$
$D(3000)^0$	$1/2(?^?)$

CHARMED, STRANGE ($C = S = \pm1$)

	$I(J^P)$
• $D_s^\pm$	$0(0^-)$
• $D_s^{*\pm}$	$0(?^?)$
• $D^*_{s0}(2317)^\pm$	$0(0^+)$
• $D_{s1}(2460)^\pm$	$0(1^+)$
• $D_{s1}(2536)^\pm$	$0(1^+)$
• $D_{s2}(2573)$	$0(2^+)$
• $D^*_{s1}(2700)^\pm$	$0(1^-)$
$D^*_{s1}(2860)$	$0(1^-)$
$D^*_{s3}(2860)^\pm$	$0(3^-)$
$D_{sJ}(3040)^\pm$	$0(?^?)$

BOTTOM ($B = \pm1$)

	$I(J^P)$
• $B^\pm$	$1/2(0^-)$
• B^0	$1/2(0^-)$
• $B^\pm/B^0$ ADMIXTURE	
• $B^\pm/B^0/B^0_s/b$-baryon ADMIXTURE	
V_{cb} and V_{ub} CKM Matrix Elements	
• B^*	$1/2(1^-)$
• $B_1(5721)^+$	$1/2(1^+)$
• $B_1(5721)^0$	$1/2(1^+)$
$B^*_J(5732)$	$?(?^?)$
• $B^*_2(5747)^+$	$1/2(2^+)$
• $B^*_2(5747)^0$	$1/2(2^+)$
$B_J(5840)^+$	$1/2(?^?)$
$B_J(5840)^0$	$1/2(?^?)$
• $B_J(5970)^+$	$1/2(?^?)$
• $B_J(5970)^0$	$1/2(?^?)$

BOTTOM, STRANGE ($B = \pm1$, $S = \mp1$)

	$I(J^P)$
• B^0_s	$0(0^-)$
• B^*_s	$0(1^-)$
• $B_{s1}(5830)^0$	$0(1^+)$
• $B^*_{s2}(5840)^0$	$0(2^+)$
$B^*_{sJ}(5850)$	$?(?^?)$

BOTTOM, CHARMED ($B = C = \pm1$)

	$I(J^P)$
• B^+_c	$0(0^-)$
$B_c(2S)^\pm$	$0(0^-)$

$c\overline{c}$

	$I^G(J^{PC})$
• $\eta_c(1S)$	$0^+(0^{-+})$
• $J/\psi(1S)$	$0^-(1^{--})$
• $\chi_{c0}(1P)$	$0^+(0^{++})$
• $\chi_{c1}(1P)$	$0^+(1^{++})$
• $h_c(1P)$	$?^?(1^{+-})$
• $\chi_{c2}(1P)$	$0^+(2^{++})$
• $\eta_c(2S)$	$0^+(0^{-+})$
• $\psi(2S)$	$0^-(1^{--})$
• $\psi(3770)$	$0^-(1^{--})$
• $\psi(3823)$	$?^?(2^{--})$
• $X(3872)$	$0^+(1^{++})$
• $X(3900)$	$1^+(1^{+-})$
• $X(3915)$	$0^+(0/2^{++})$
• $\chi_{c2}(2P)$	$0^+(2^{++})$
$X(3940)$	$?^?(?^{??})$
• $X(4020)$	$1(?^?)$
• $\psi(4040)$	$0^-(1^{--})$
$X(4050)^\pm$	$?(?^?)$
$X(4055)^\pm$	$?(?^?)$
• $X(4140)$	$0^+(?^{?+})$
• $\psi(4160)$	$0^-(1^{--})$
$X(4160)$	$?^?(?^{??})$
$X(4200)^\pm$	$?(1^+)$
$X(4230)$	$?^?(1^{--})$
$X(4240)^\pm$	$?^?(0^-)$
$X(4250)^\pm$	$?(?^?)$
• $X(4260)$	$?^?(1^{--})$
$X(4350)$	$0^+(?^{?+})$
• $X(4360)$	$?^?(1^{--})$
• $\psi(4415)$	$0^-(1^{--})$
• $X(4430)^\pm$	$?(1^+)$
• $X(4660)$	$?^?(1^{--})$

$b\overline{b}$

	$I^G(J^{PC})$
• $\eta_b(1S)$	$0^+(0^{-+})$
• $\Upsilon(1S)$	$0^-(1^{--})$
• $\chi_{b0}(1P)$	$0^+(0^{++})$
• $\chi_{b1}(1P)$	$0^+(1^{++})$
• $h_b(1P)$	$?^?(1^{+-})$
• $\chi_{b2}(1P)$	$0^+(2^{++})$
$\eta_b(2S)$	$0^+(0^{-+})$
• $\Upsilon(2S)$	$0^-(1^{--})$
• $\Upsilon(1D)$	$0^-(2^{--})$
• $\chi_{b0}(2P)$	$0^+(0^{++})$
• $\chi_{b1}(2P)$	$0^+(1^{++})$
$h_b(2P)$	$?^?(1^{+-})$
• $\chi_{b2}(2P)$	$0^+(2^{++})$
• $\Upsilon(3S)$	$0^-(1^{--})$
• $\chi_{b1}(3P)$	$0^+(1^{++})$
• $\Upsilon(4S)$	$0^-(1^{--})$
• $X(10610)^\pm$	$1^+(1^+)$
• $X(10610)^0$	$1^+(1^+)$
$X(10650)^\pm$	$?^+(1^+)$
• $\Upsilon(10860)$	$0^-(1^{--})$
• $\Upsilon(11020)$	$0^-(1^{--})$

Baryon Summary Table

This short table gives the name, the quantum numbers (where known), and the status of baryons in the Review. Only the baryons with 3- or 4-star status are included in the Baryon Summary Table. Due to insufficient data or uncertain interpretation, the other entries in the table are not established baryons. The names with masses are of baryons that decay strongly. The spin-parity J^P (when known) is given with each particle. For the strongly decaying particles, the J^P values are considered to be part of the names.

p	$1/2^+$	****	$\Delta(1232)$	$3/2^+$	****	Σ^+	$1/2^+$	****	Ξ^0	$1/2^+$	****	Λ_c^+	$1/2^+$	****
n	$1/2^+$	****	$\Delta(1600)$	$3/2^+$	***	Σ^0	$1/2^+$	****	Ξ^-	$1/2^+$	****	$\Lambda_c(2595)^+$	$1/2^-$	***
$N(1440)$	$1/2^+$	****	$\Delta(1620)$	$1/2^-$	****	Σ^-	$1/2^+$	****	$\Xi(1530)$	$3/2^+$	****	$\Lambda_c(2625)^+$	$3/2^-$	***
$N(1520)$	$3/2^-$	****	$\Delta(1700)$	$3/2^-$	****	$\Sigma(1385)$	$3/2^+$	****	$\Xi(1620)$		*	$\Lambda_c(2765)^+$		*
$N(1535)$	$1/2^-$	****	$\Delta(1750)$	$1/2^+$	*	$\Sigma(1480)$		*	$\Xi(1690)$		***	$\Lambda_c(2880)^+$	$5/2^+$	***
$N(1650)$	$1/2^-$	****	$\Delta(1900)$	$1/2^-$	**	$\Sigma(1560)$		**	$\Xi(1820)$	$3/2^-$	***	$\Lambda_c(2940)^+$		***
$N(1675)$	$5/2^-$	****	$\Delta(1905)$	$5/2^+$	****	$\Sigma(1580)$	$3/2^-$	*	$\Xi(1950)$		***	$\Sigma_c(2455)$	$1/2^+$	****
$N(1680)$	$5/2^+$	****	$\Delta(1910)$	$1/2^+$	****	$\Sigma(1620)$	$1/2^-$	*	$\Xi(2030)$	$\geq \frac{5}{2}?$	***	$\Sigma_c(2520)$	$3/2^+$	***
$N(1700)$	$3/2^-$	***	$\Delta(1920)$	$3/2^+$	***	$\Sigma(1660)$	$1/2^+$	***	$\Xi(2120)$		*	$\Sigma_c(2800)$		***
$N(1710)$	$1/2^+$	****	$\Delta(1930)$	$5/2^-$	***	$\Sigma(1670)$	$3/2^-$	****	$\Xi(2250)$		**	Ξ_c^+	$1/2^+$	***
$N(1720)$	$3/2^+$	****	$\Delta(1940)$	$3/2^-$	**	$\Sigma(1690)$		**	$\Xi(2370)$		**	Ξ_c^0	$1/2^+$	***
$N(1860)$	$5/2^+$	**	$\Delta(1950)$	$7/2^+$	****	$\Sigma(1730)$	$3/2^+$	*	$\Xi(2500)$		*	$\Xi_c'^+$	$1/2^+$	***
$N(1875)$	$3/2^-$	***	$\Delta(2000)$	$5/2^+$	**	$\Sigma(1750)$	$1/2^-$	***				$\Xi_c'^0$	$1/2^+$	***
$N(1880)$	$1/2^+$	**	$\Delta(2150)$	$1/2^-$	*	$\Sigma(1770)$	$1/2^+$	*	Ω^-	$3/2^+$	****	$\Xi_c(2645)$	$3/2^+$	***
$N(1895)$	$1/2^-$	**	$\Delta(2200)$	$7/2^-$	*	$\Sigma(1775)$	$5/2^-$	****	$\Omega(2250)^-$		***	$\Xi_c(2790)$	$1/2^-$	***
$N(1900)$	$3/2^+$	***	$\Delta(2300)$	$9/2^+$	**	$\Sigma(1840)$	$3/2^+$	*	$\Omega(2380)$		**	$\Xi_c(2815)$	$3/2^-$	***
$N(1990)$	$7/2^+$	**	$\Delta(2350)$	$5/2^-$	*	$\Sigma(1880)$	$1/2^+$	**	$\Omega(2470)^-$		**	$\Xi_c(2930)$		*
$N(2000)$	$5/2^+$	**	$\Delta(2390)$	$7/2^+$	*	$\Sigma(1900)$	$1/2^-$	*				$\Xi_c(2970)$		***
$N(2040)$	$3/2^+$	*	$\Delta(2400)$	$9/2^-$	**	$\Sigma(1915)$	$5/2^+$	****				$\Xi_c(3055)$		***
$N(2060)$	$5/2^-$	**	$\Delta(2420)$	$11/2^+$	****	$\Sigma(1940)$	$3/2^+$	*				$\Xi_c(3080)$		***
$N(2100)$	$1/2^+$	*	$\Delta(2750)$	$13/2^-$	**	$\Sigma(1940)$	$3/2^-$	***				$\Xi_c(3123)$		*
$N(2120)$	$3/2^-$	**	$\Delta(2950)$	$15/2^+$	**	$\Sigma(2000)$	$1/2^-$	*				Ω_c^0	$1/2^+$	***
$N(2190)$	$7/2^-$	****				$\Sigma(2030)$	$7/2^+$	****				$\Omega_c(2770)^0$	$3/2^+$	***
$N(2220)$	$9/2^+$	****	Λ	$1/2^+$	****	$\Sigma(2070)$	$5/2^+$	*						
$N(2250)$	$9/2^-$	****	$\Lambda(1405)$	$1/2^-$	****	$\Sigma(2080)$	$3/2^+$	**				Ξ_{cc}^+		*
$N(2300)$	$1/2^+$	**	$\Lambda(1520)$	$3/2^-$	****	$\Sigma(2100)$	$7/2^-$	*						
$N(2570)$	$5/2^-$	**	$\Lambda(1600)$	$1/2^+$	***	$\Sigma(2250)$		***				Λ_b^0	$1/2^+$	***
$N(2600)$	$11/2^-$	***	$\Lambda(1670)$	$1/2^-$	****	$\Sigma(2455)$		**				$\Lambda_b(5912)^0$	$1/2^-$	***
$N(2700)$	$13/2^+$	**	$\Lambda(1690)$	$3/2^-$	****	$\Sigma(2620)$		**				$\Lambda_b(5920)^0$	$3/2^-$	***
			$\Lambda(1710)$	$1/2^+$	*	$\Sigma(3000)$		*				Σ_b	$1/2^+$	***
			$\Lambda(1800)$	$1/2^-$	***	$\Sigma(3170)$		*				Σ_b^*	$3/2^+$	***
			$\Lambda(1810)$	$1/2^+$	***							Ξ_b^0, Ξ_b^-	$1/2^+$	***
			$\Lambda(1820)$	$5/2^+$	****							$\Xi_b'(5935)^-$	$1/2^+$	***
			$\Lambda(1830)$	$5/2^-$	****							$\Xi_b(5945)^0$	$3/2^+$	***
			$\Lambda(1890)$	$3/2^+$	****							$\Xi_b^*(5955)^-$	$3/2^+$	***
			$\Lambda(2000)$		*							Ω_b^-	$1/2^+$	***
			$\Lambda(2020)$	$7/2^+$	*									
			$\Lambda(2050)$	$3/2^-$	*							$P_c(4380)^+$		*
			$\Lambda(2100)$	$7/2^-$	****							$P_c(4450)^+$		*
			$\Lambda(2110)$	$5/2^+$	***									
			$\Lambda(2325)$	$3/2^-$	*									
			$\Lambda(2350)$	$9/2^+$	***									
			$\Lambda(2585)$		**									

**** Existence is certain, and properties are at least fairly well explored.

*** Existence ranges from very likely to certain, but further confirmation is desirable and/or quantum numbers, branching fractions, etc. are not well determined.

** Evidence of existence is only fair.

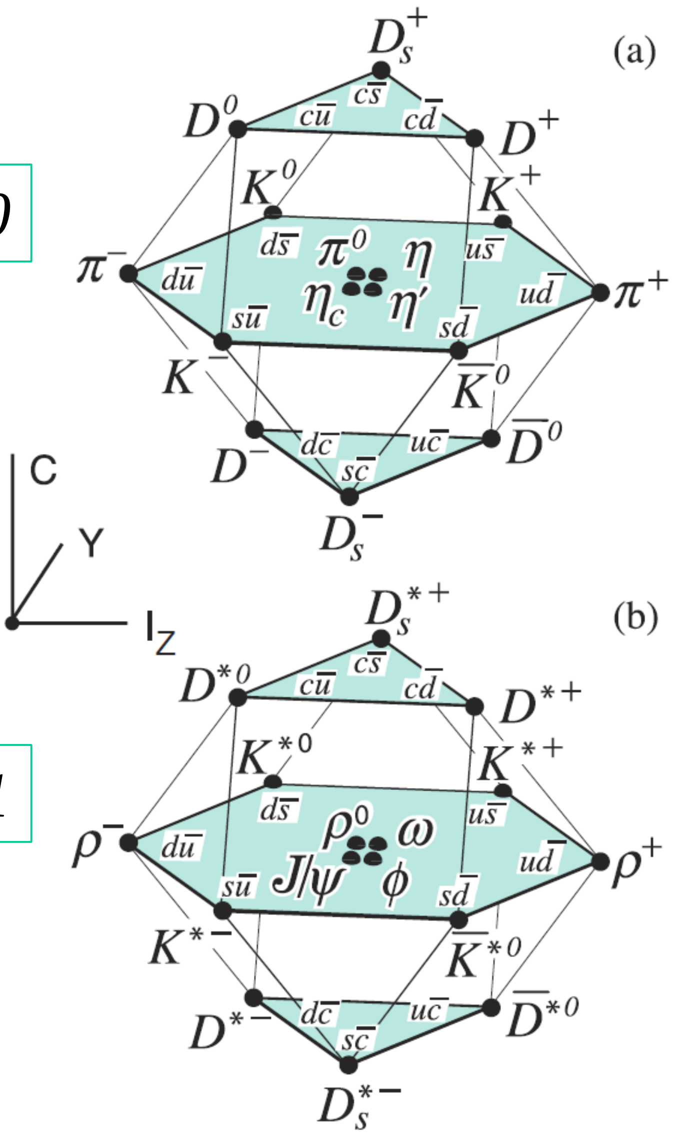
* Evidence of existence is poor.

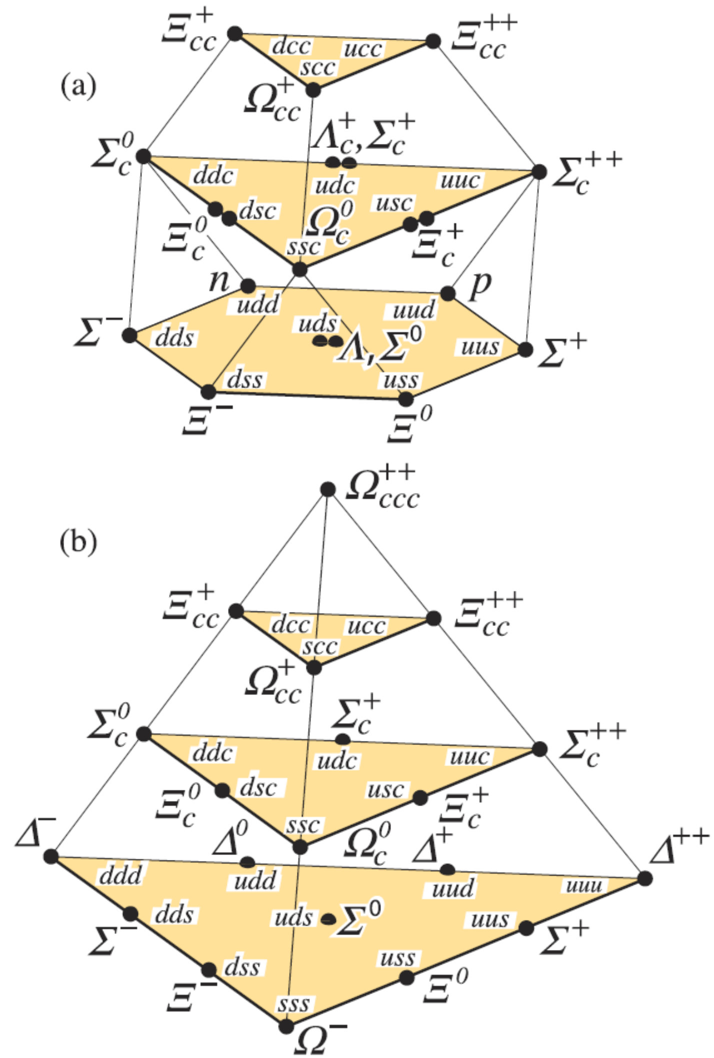
From PDG 2018

We can put (all of) them in a simple picture!

J=0

J=1





J=1/2

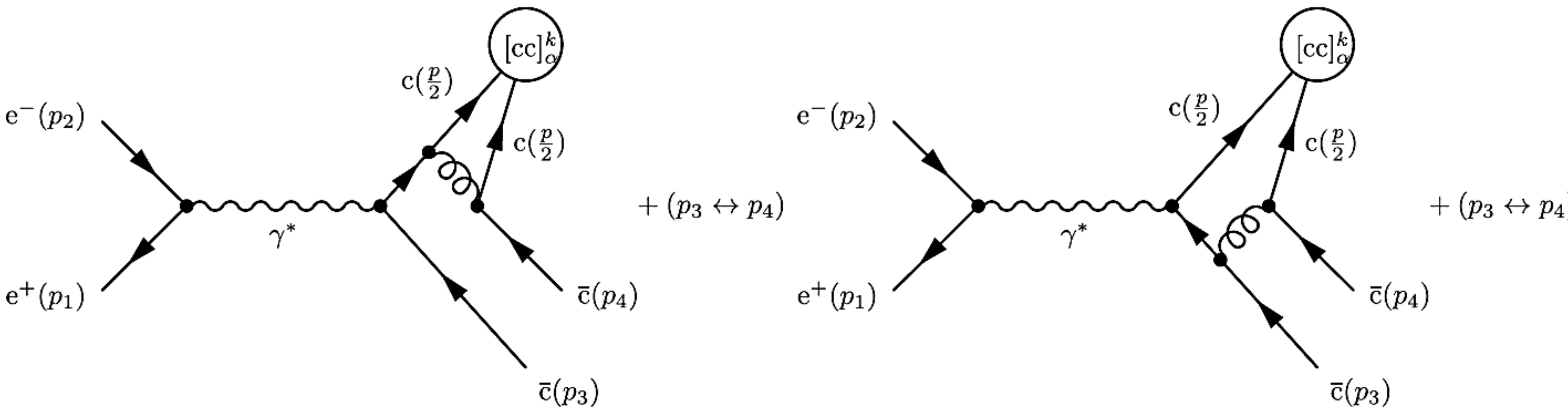
J=3/2

X(1835), X(2340), …

Ξ_c, Ω_c, Ξ_{cc}, …

最小组分为四个夸克的态

- $Z_c(3900) = c\ \bar{c}\ u\ \bar{d}$ 含一对可湮灭的粲夸克对
- 新型四夸克态：Tcs（$c\ s\ \bar{u}\ \bar{d}$、$c\ s\ \bar{u}\ \bar{u}$ 等）
- 新型四夸克态：Tcc（$c\ c\ \bar{u}\ \bar{d}$、$c\ c\ \bar{u}\ \bar{s}$ 等）

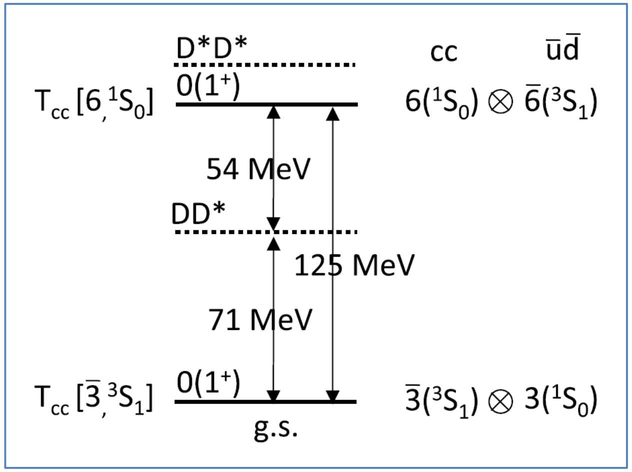


Tcs产生阈为4.73 GeV；Tcc产生阈为7.74 GeV

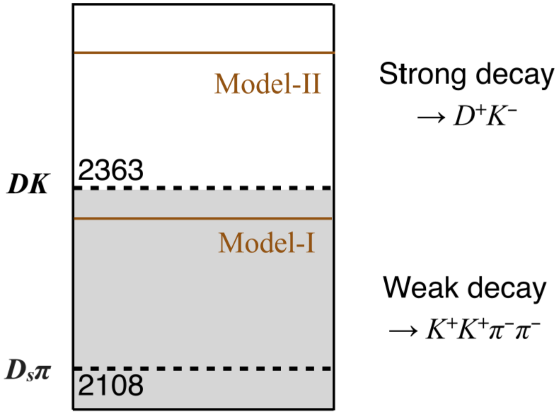
不能在BESIII实验产生；可以在Belle II, LHCb实验寻找

理论预期

- **Tcc：**
  T. Hyodo, Y. R. Liu, et al., Physics Letters B 721, 56 (2013)
  Estia J. Eichten & Chris Quigg, PRL 119, 202002 (2017)
  Marek Karliner & Jonathan L. Rosner, PRL 119, 202001 (2017)
  - 质量：M(DD)~M(DD*)+100 MeV
  - 截面：O(10fb) @ Belle II
  - 衰变模式：
    - γDD
    - DD*

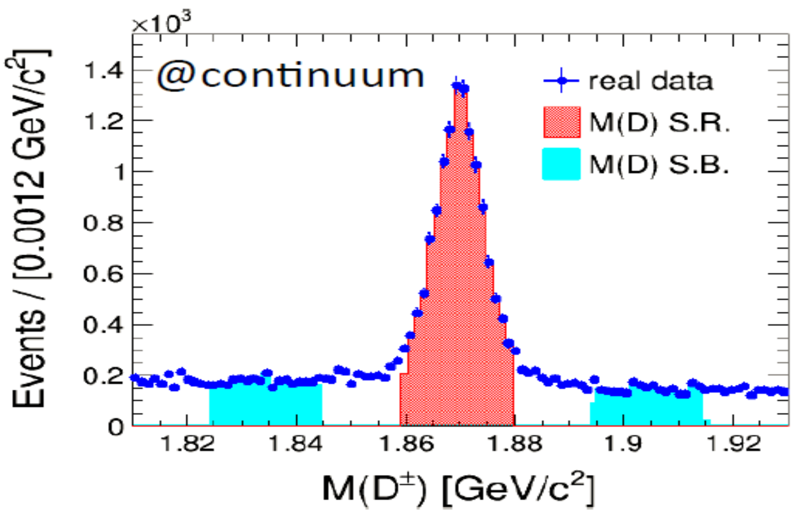


- **Tcs：**
  Fu-Sheng Yu, arXiv:1709.02571
  - 质量：2.3-2.6 GeV
  - 截面：>Tcc @ Belle II
  - 衰变模式：
    - $K^+K^+\pi^-\pi^-$
    - D^+K^-

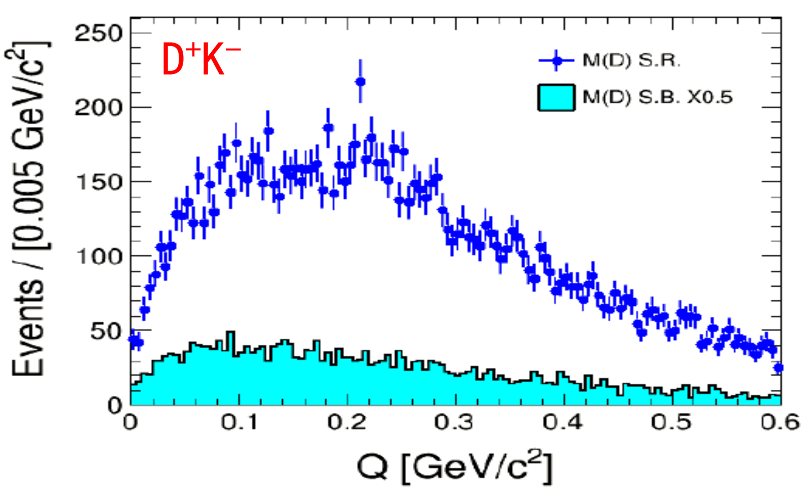


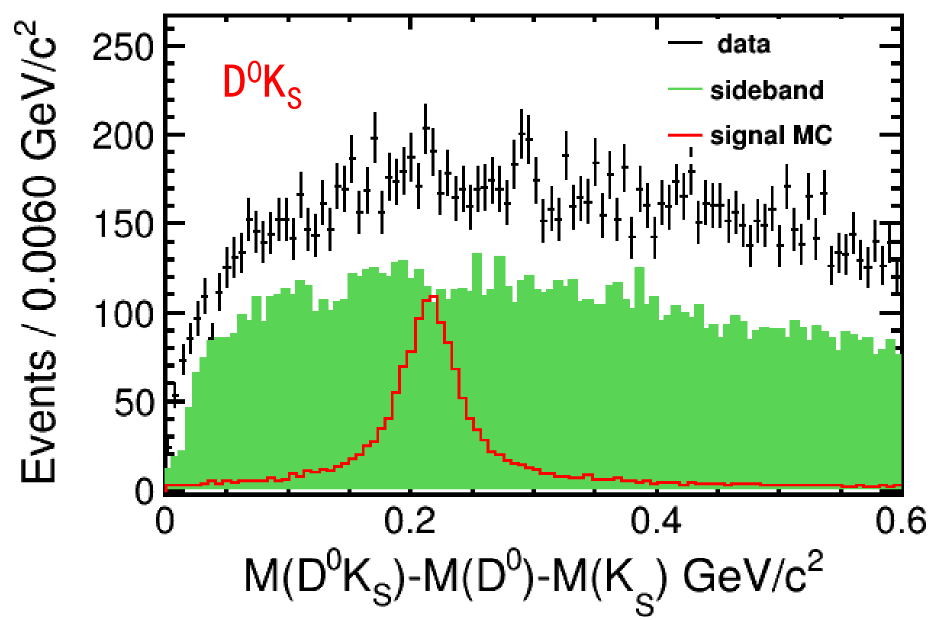
Tcs ？

- M>DK质量阈，主要衰变为D^+K^-或D^0K_S末态

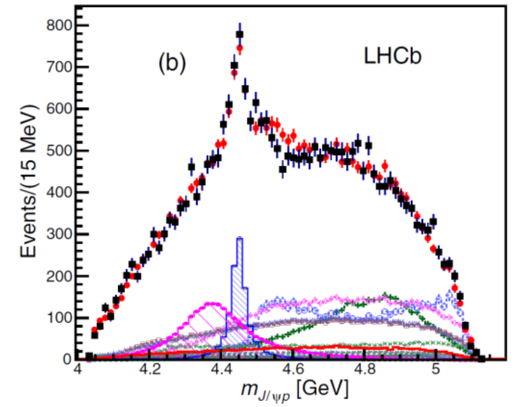


数据中看到清晰的带电和中性D介子，压低非D本底和组合本底是分析的关键。

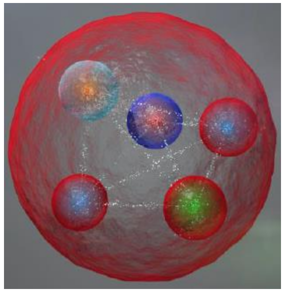




- Pc (4380) 、Pc (4450) 是很好的5夸克态候选者

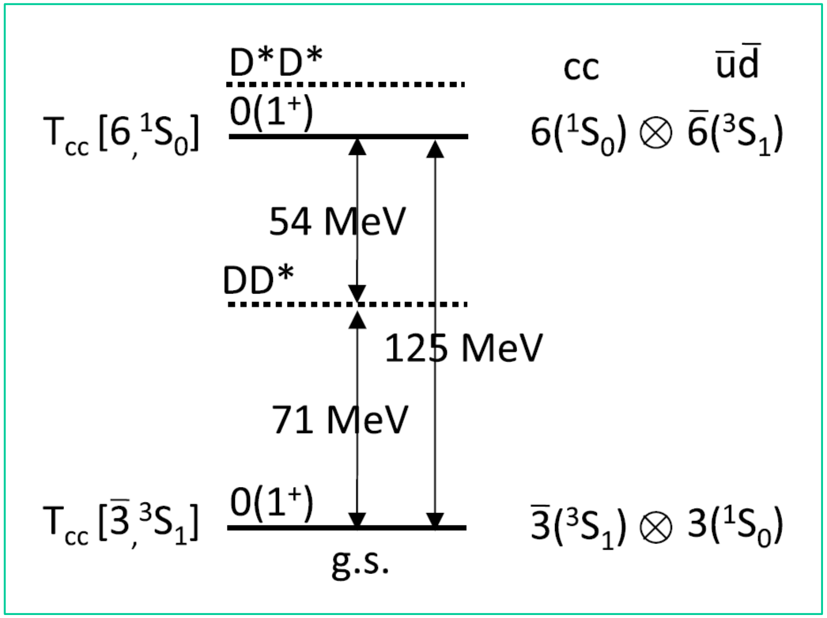


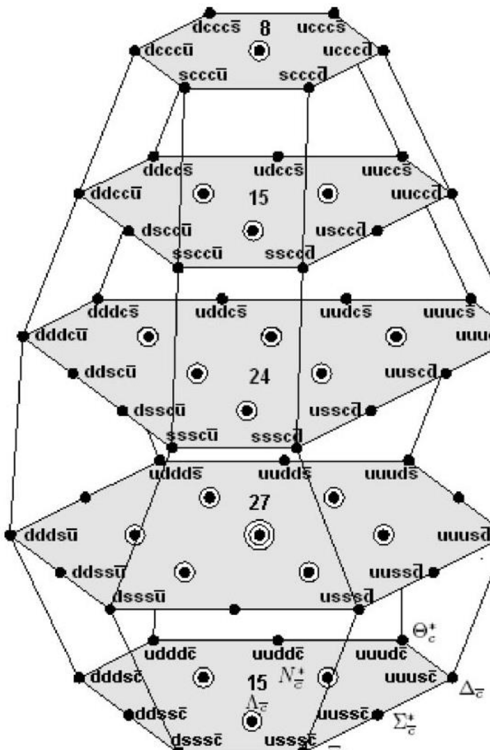
- 寻找其他五夸克态?
  - 五夸克态 Pcc（ $\bar{u}ccdd$、 $\bar{u}ccds$等）
  - 五夸克态 Θc（ $\bar{c}uudd$、 $\bar{c}uuds$等）

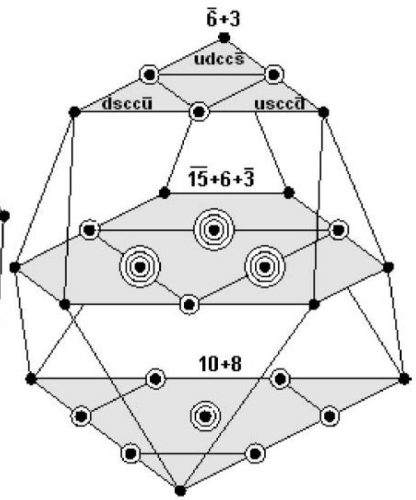


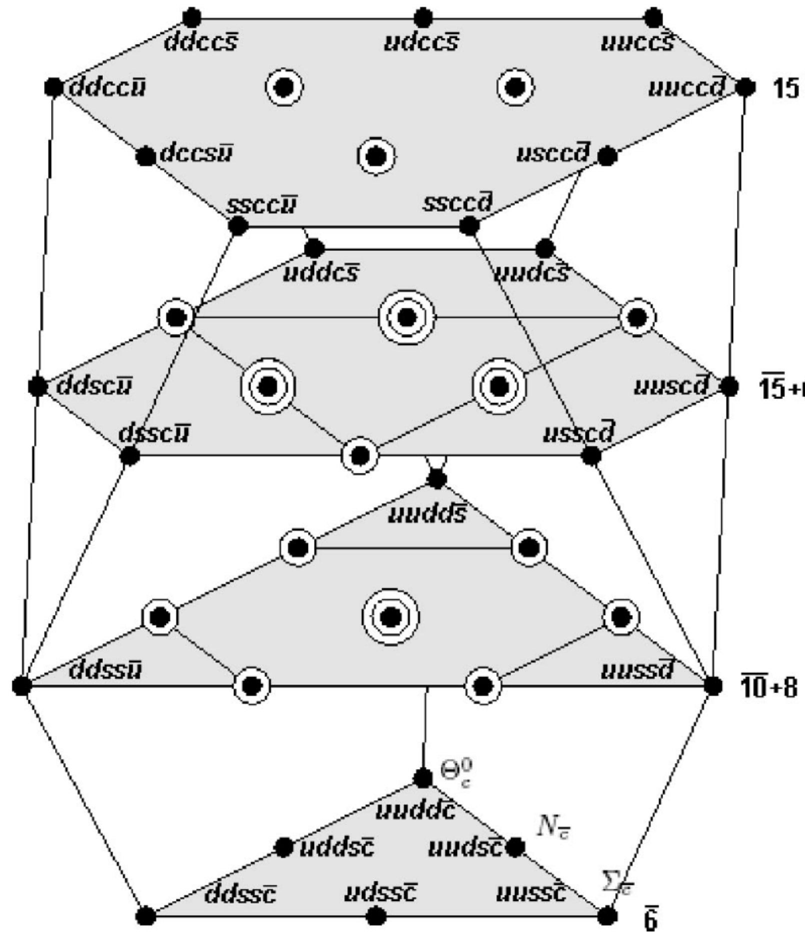
理论预期

对称性、模型、LQCD





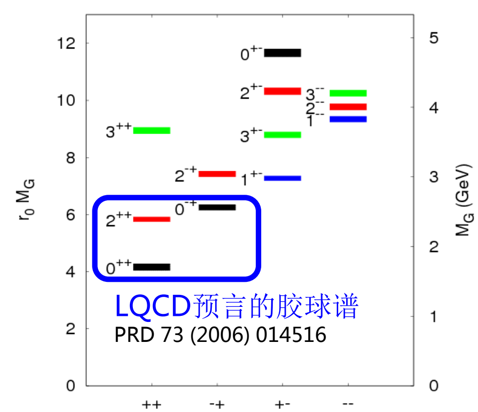




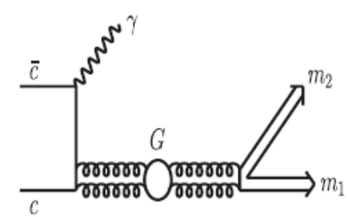
胶球的系统研究

- 胶球→体现胶子自由度的奇特强子态→胶子场→夸克禁闭
- 较轻的胶球具有常规量子数，与普通介子可能发生混合，无法直接区分

- ~~找到一个胶球~~
- 需要从多个产生/衰变过程，系统研究介子谱，寻找超出夸克模型的行为



- J/ψ 辐射衰变是丰胶子过程，理论预期胶球有较大产额



Systematic study of glueball at BESIII 刘北江报告

Scalar : already " saturated "

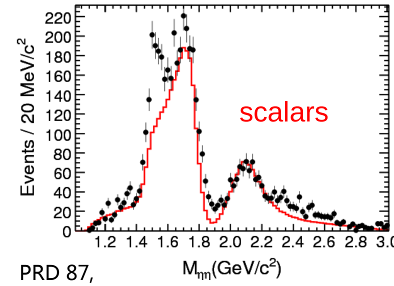
- LQCD : ground state 0^+ glueball ~1.7 GeV, first excitation ~2.1 GeV

✓ **Strong production of $f_0(1710)/f_0(2100)$ in $J/\psi \to \gamma\, \eta\eta/KK/\pi\pi$**, the pattern consists with LQCD's prediction ➔ largely overlap

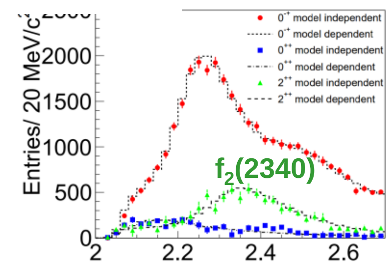
Tensor : more complicated overpopulation

- LQCD : 2^{++}(2.3~2.4 GeV)

✓ **Strong production of $f_2(2340)$ in $J/\psi \to \gamma\eta\eta/KK/\pi\pi/\phi\phi$** ; consists with LQCD's prediction ➔ largely overlap



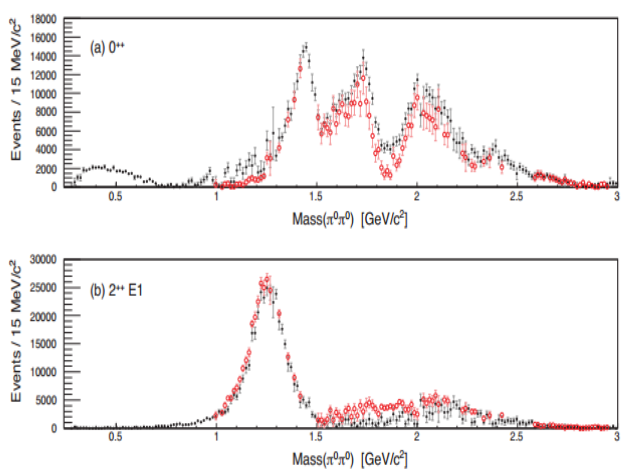
PRD 87, 092009



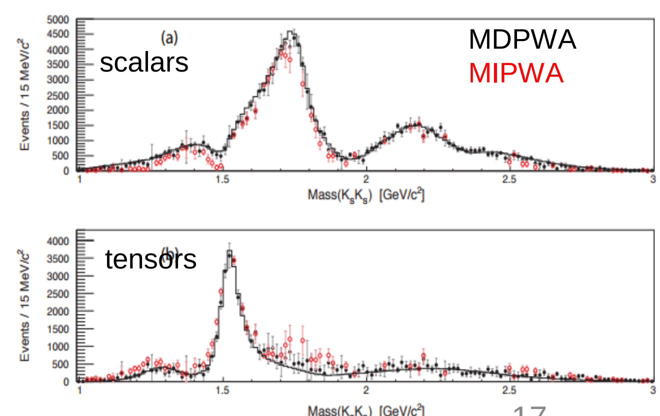
PRD 93, 112011

- **$J/\psi \to \gamma\eta'\eta(')$ is a missing piece to the puzzle**
  - **A key to reveal the flavor structure of $f_0(2100)$ and $f_2(2340)$**
- **$J/\psi \to \phi/\omega + PP$**
- **Coupled channel analysis**
  - **assignment**

PRD 92, 052003



PRD 98, 072003



刘北江报告

Glueball program at BESIII in a nutshell

	0^+	2^+	0^-
J/ψ→γPP			
J/ψ→γVV			
J/ψ→γPPP			

- 0^+, 2^+ : Coupled channel analyses
  - J/ψ→γPP
  - J/ψ→ω/ϕ + X
- 0^- : trajectory, X(2370)
  - J/ψ→γPPP
  - J/ψ→γγ V

J/ψ→γη η /η ′η ′/η η′/$\pi^0\pi^0$/$K_S K_S$

J/ψ→γωϕ/ϕϕ/ωω

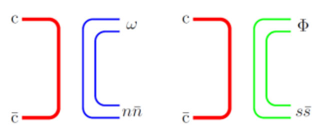
J/ψ→γ $\eta'\pi\pi$ /$\eta' KK$/$\eta\pi\pi$/$KK\pi$/ηKK/ $\pi\,\pi\,\pi$

- PWA published
- Published, PWA undone
- Ongoing

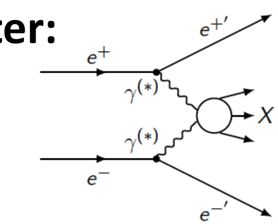
Flavor Filters:

J/ψ→γX →γ γ V

J/ψ→ω/ϕ + X



Anti filter:



Lattice QCD on Glueball spectrum

W. Sun, Y. Chen et al., (CLQCD Collaboration), arXiv:1702.08174

W. Sun, Y. Chen et al., arXiv:1711.00711

	m_π (MeV)	$m_{0^{++}}$ (MeV)	$m_{2^{++}}$ (MeV)	$m_{0^{-+}}$ (MeV)
$N_f = 2$ [this work]	938	1397(25)	2367(35)	2559(50)
	650	1480(52)	2380(61)	2605(52)
$N_f = 2+1$ [E. Gregory]	360	1795(60)	2620(50)	—
quenched [C. Morningstar]	—	1710(50)(80)	2390(30)(120)	2560(35)(120)
quenched [Y. Chen]	—	1730(50)(80)	2400(25)(120)	2590(40)(130)

- **Tensor and pseudoscalar glueball masses at $N_f = 2$ are compatible with those in the quenched approximation.**
- **The pseudoscalar glueball mass is roughly 2.6 GeV. We suggest BESIII to search for the pseudoscalar glueball in this mass region.**
- **The study on the possible mixing between glueball states and conventional meson states is in progress.**

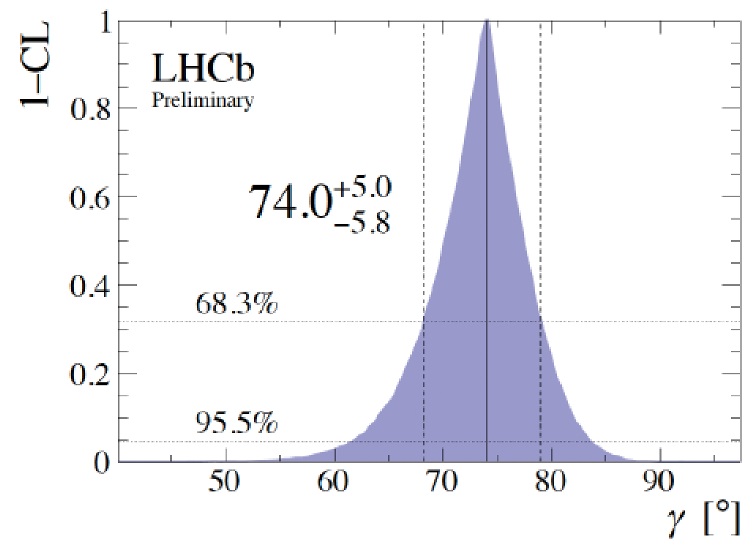
味物理

LHCb-CONF-2018-002

γ combination

➢ **Adding all the measurements, we have**

	B decay	D decay	Method	Ref.	Dataset[†]
	$B^+ \to DK^+$	$D \to h^+h^-$	GLW	[14]	Run 1 & 2
	$B^+ \to DK^+$	$D \to h^+h^-$	ADS	[15]	Run 1
	$B^+ \to DK^+$	$D \to h^+\pi^-\pi^+\pi^-$	GLW/ADS	[15]	Run 1
	$B^+ \to DK^+$	$D \to h^+h^-\pi^0$	GLW/ADS	[16]	Run 1
	$B^+ \to DK^+$	$D \to K^0_S h^+h^-$	GGSZ	[17]	Run 1
New	$B^+ \to DK^+$	$D \to K^0_S h^+h^-$	GGSZ	[18]	Run 2
	$B^+ \to DK^+$	$D \to K^0_S K^+\pi^-$	GLS	[19]	Run 1
	$B^+ \to D^*K^+$	$D \to h^+h^-$	GLW	[14]	Run 1 & 2
	$B^+ \to DK^{*+}$	$D \to h^+h^-$	GLW/ADS	[20]	Run 1 & 2
New	$B^+ \to DK^{*+}$	$D \to h^+\pi^-\pi^+\pi^-$	GLW/ADS	[20]	Run 1 & 2
	$B^+ \to DK^+\pi^+\pi^-$	$D \to h^+h^-$	GLW/ADS	[21]	Run 1
	$B^0 \to DK^{*0}$	$D \to K^+\pi^-$	ADS	[22]	Run 1
	$B^0 \to DK^+\pi^-$	$D \to h^+h^-$	GLW-Dalitz	[23]	Run 1
	$B^0 \to DK^{*0}$	$D \to K^0_S\pi^+\pi^-$	GGSZ	[24]	Run 1
	$B^0_s \to D_s^{\mp}K^{\pm}$	$D_s^+ \to h^+h^-\pi^+$	TD	[25]	Run 1
New	$B^0 \to D^{\mp}\pi^{\pm}$	$D^+ \to K^+\pi^-\pi^+$	TD	[26]	Run 1



World average: $\gamma = (73.5^{+4.2}_{-5.1})^\circ$

HFLAV winter 2018

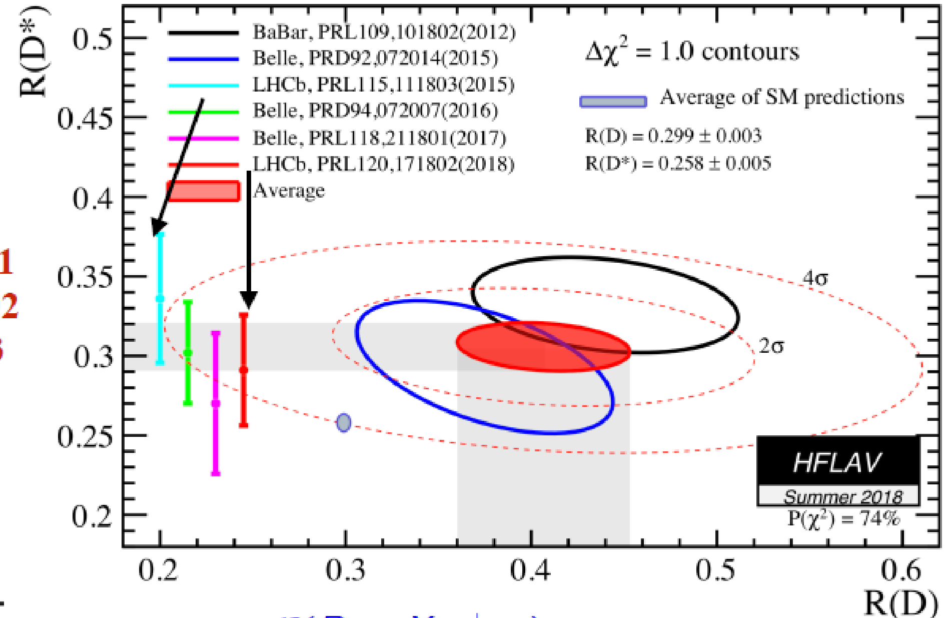
➢ **Inputs from BESIII important, combining efforts will help**

钱文斌报告

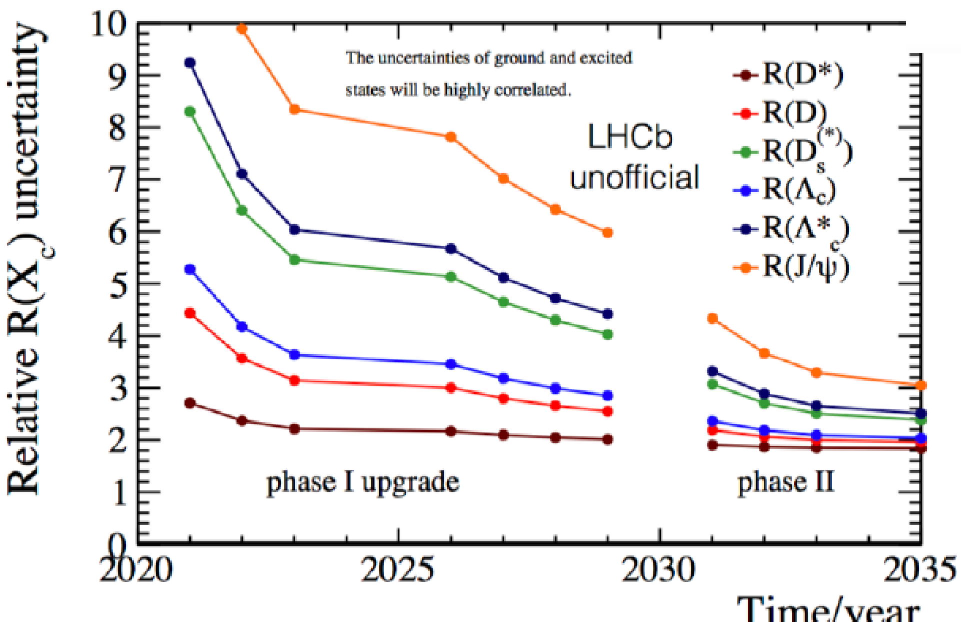
R(D), R(D*) and R(J/ψ)

➢ **Lepton flavor universality test becomes a hot topic after many deviations seen from B-factories and LHCb measurements**

PRL 115 (2015) 112001
PRL 120 (2018) 171802
PRD 97 (2018) 072013



➢ **LHCb has performed $R(D^*)$ in muonic channel in 2015 and now also in hadronic channel**



$$R(X_c) = \frac{\mathcal{B}(B \to X_c \tau^+ \nu_\tau)}{\mathcal{B}(B \to X_c \mu^+ \nu_\mu)}, \quad X_c = D^* \text{ or } J/\psi$$

➢ **Besides measurements in B_c system have also been measured**

PRL 120 (2018) 121801

➢ **Assumes that all the systematic uncertainties scale w.r.t. statistic except those can't or reply on external inputs**

朱凯报告

D 介子半轻衰变测量及轻子普适性检验

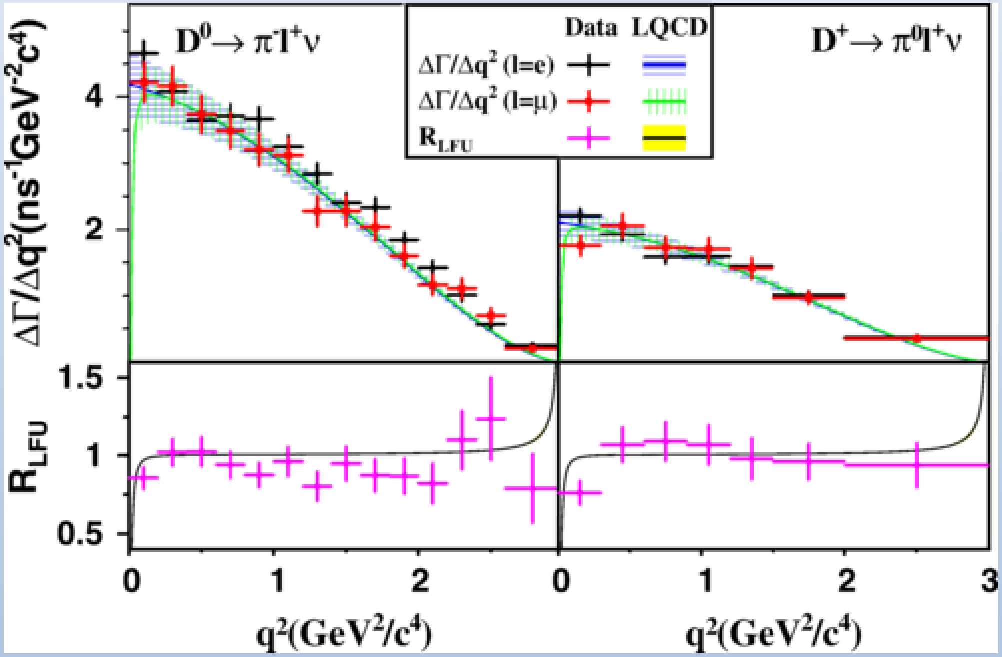
利用BESIII 在 3.773 GeV 获取的$2.93 fb^{-1}$数据 PRL121, 171803 (2018)

精度明显提升

$$B(D^0 \to \pi^- \mu^+ \nu_\mu) = (0.272 \pm 0.008_{stat} \pm 0.006_{sys}) \times 10^{-2}$$

首次测量

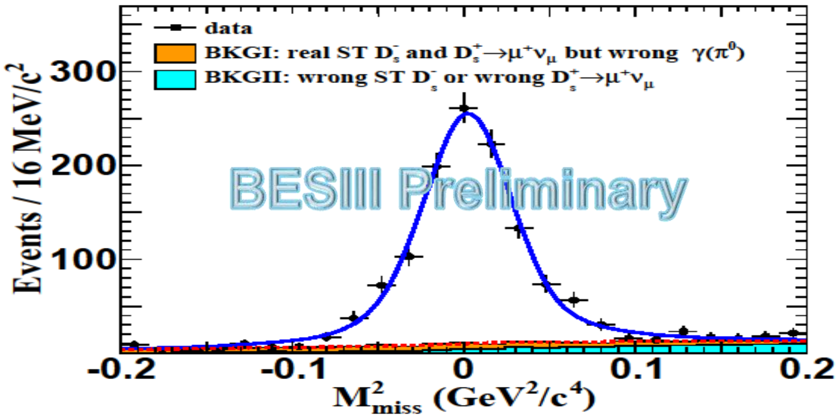
$$B(D^+ \to \pi^0 \mu^+ \nu_\mu) = (0.350 \pm 0.011_{stat} \pm 0.010_{sys}) \times 10^{-2}$$

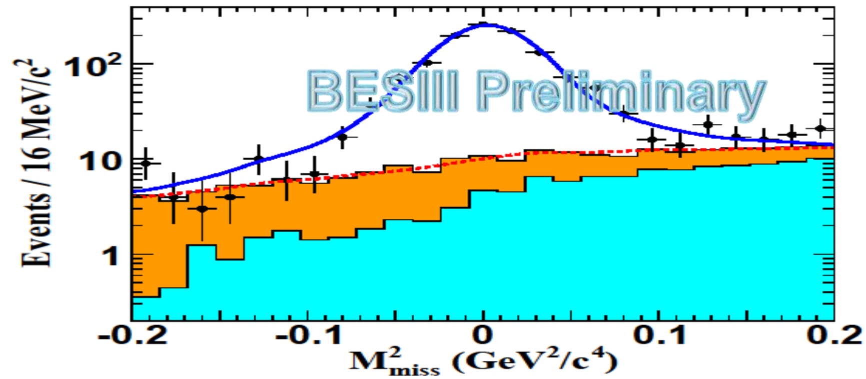


$$\mathcal{R}^+ \equiv \mathcal{B}_{D^+\to\pi^0\mu^+\nu_\mu}/\mathcal{B}_{D^+\to\pi^0 e^+\nu_e} = 0.964 \pm 0.037_{\rm stat} \pm 0.026_{\rm syst}$$

$$\mathcal{R}^0 \equiv \mathcal{B}_{D^0\to\pi^-\mu^+\nu_\mu}/\mathcal{B}_{D^0\to\pi^- e^+\nu_e} = 0.922 \pm 0.030_{\rm stat} \pm 0.022_{\rm syst}$$

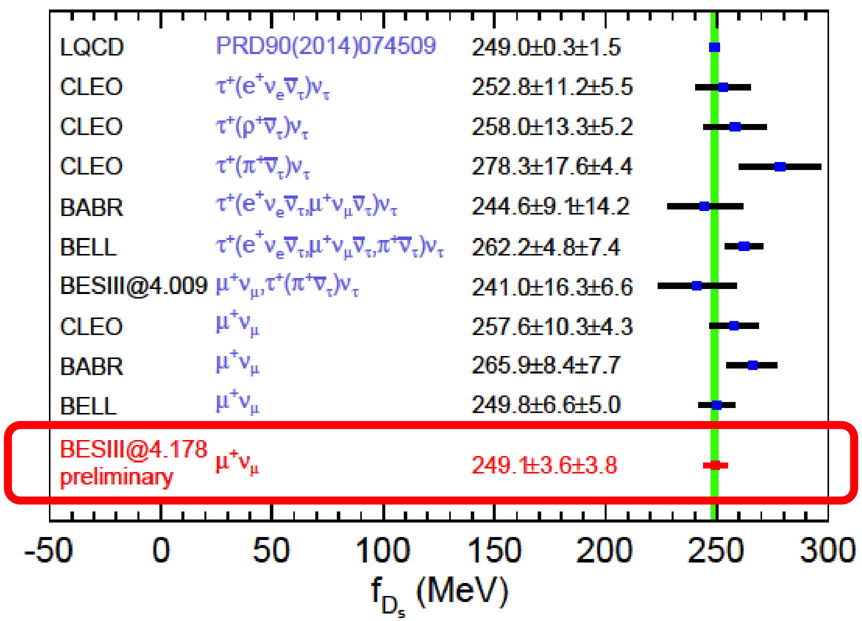
$D_s^+ \to \mu^+ \nu$ @ 4.18 GeV (3.2 fb^{-1})





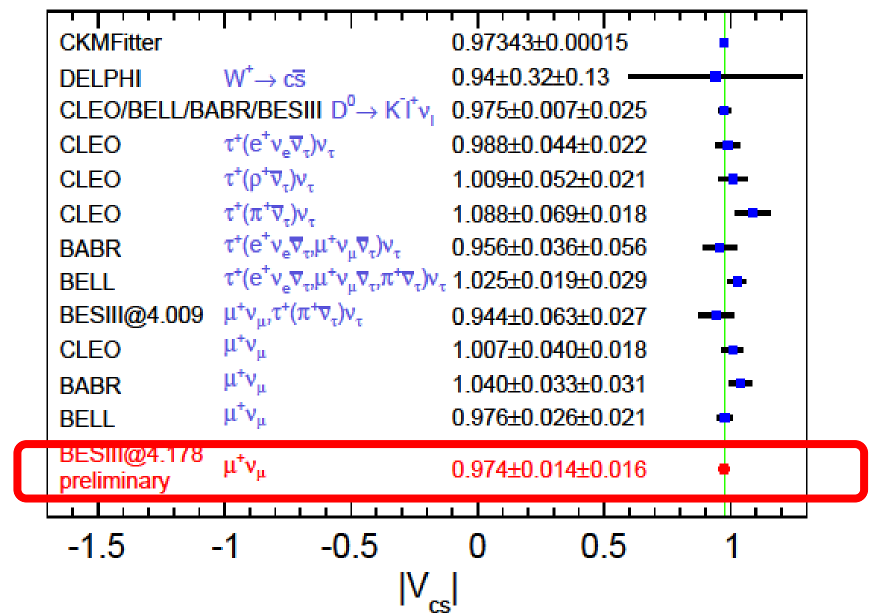
若取$|V_{cs}|^{CKMfitter}$作为输入值：

$$f_{D_s^+} = 249.1 \pm 3.6_{\rm stat.} \pm 3.8_{\rm syst.}\ {\rm MeV}$$



若取$f_{D_s}^{LQCD}$作为输入值：

$$|V_{cs}| = 0.974 \pm 0.014_{\rm stat.} \pm 0.016_{\rm syst.}$$



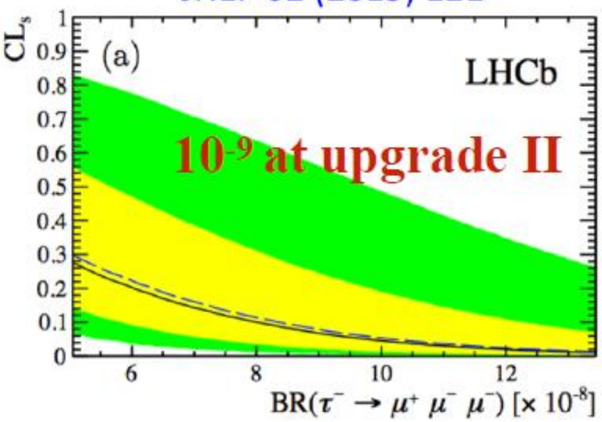
新物理

钱文斌报告

Searches at LHCb

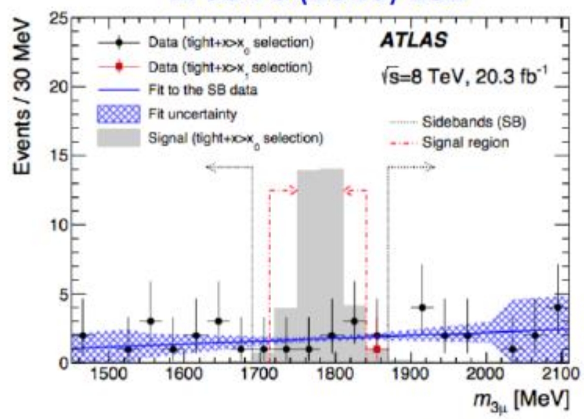
➢ **Sensitivity scaled according to $1/\sqrt{N}$**

JHEP 02 (2015) 121



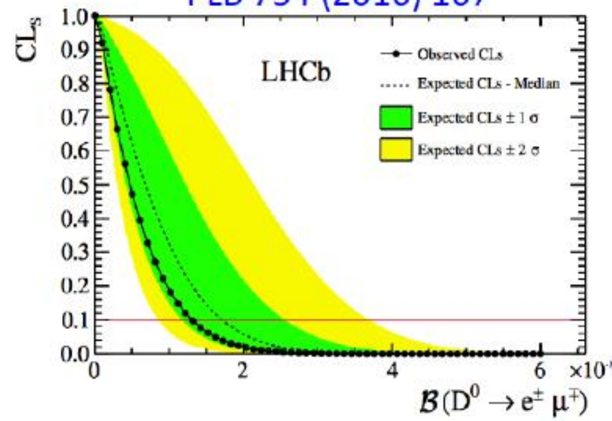
$\mathcal{B}(\tau^- \to \mu^-\mu^+\mu^-) < 4.6\ (5.6) \times 10^{-8}$

EPJC 76 (2016) 232



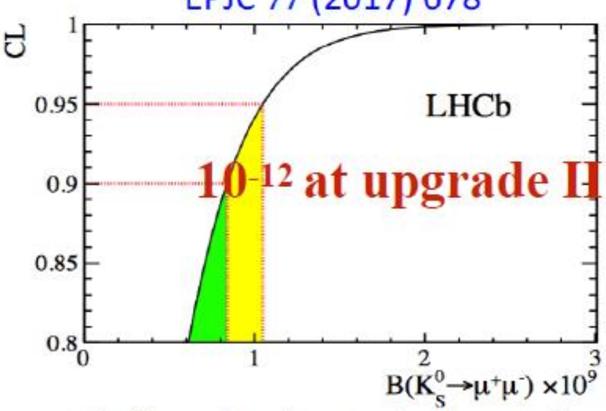
$\mathcal{B}(\tau^- \to \mu^-\mu^+\mu^-) < 3.76\times 10^{-7}$

PLB 754 (2016) 167



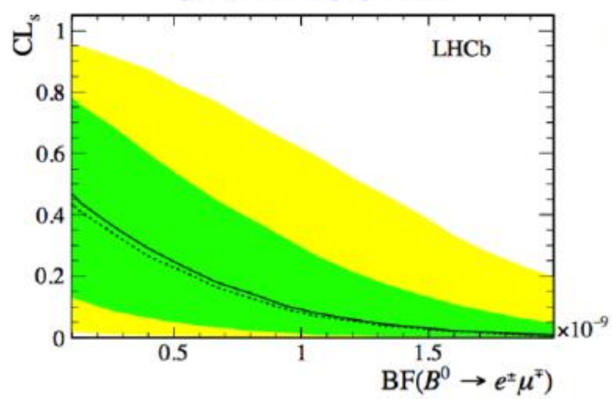
$\mathcal{B}(D^0 \to e^\pm\mu^\mp) < 1.3(1.6)\times 10^{-8}$

EPJC 77 (2017) 678



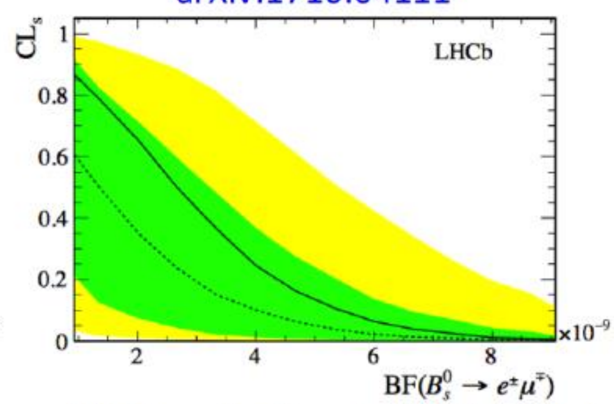
$\mathcal{B}(K^0_S \to \mu^+\mu^-) < 0.8\ (1.0) \times 10^{-9}$

arXiv:1710.04111



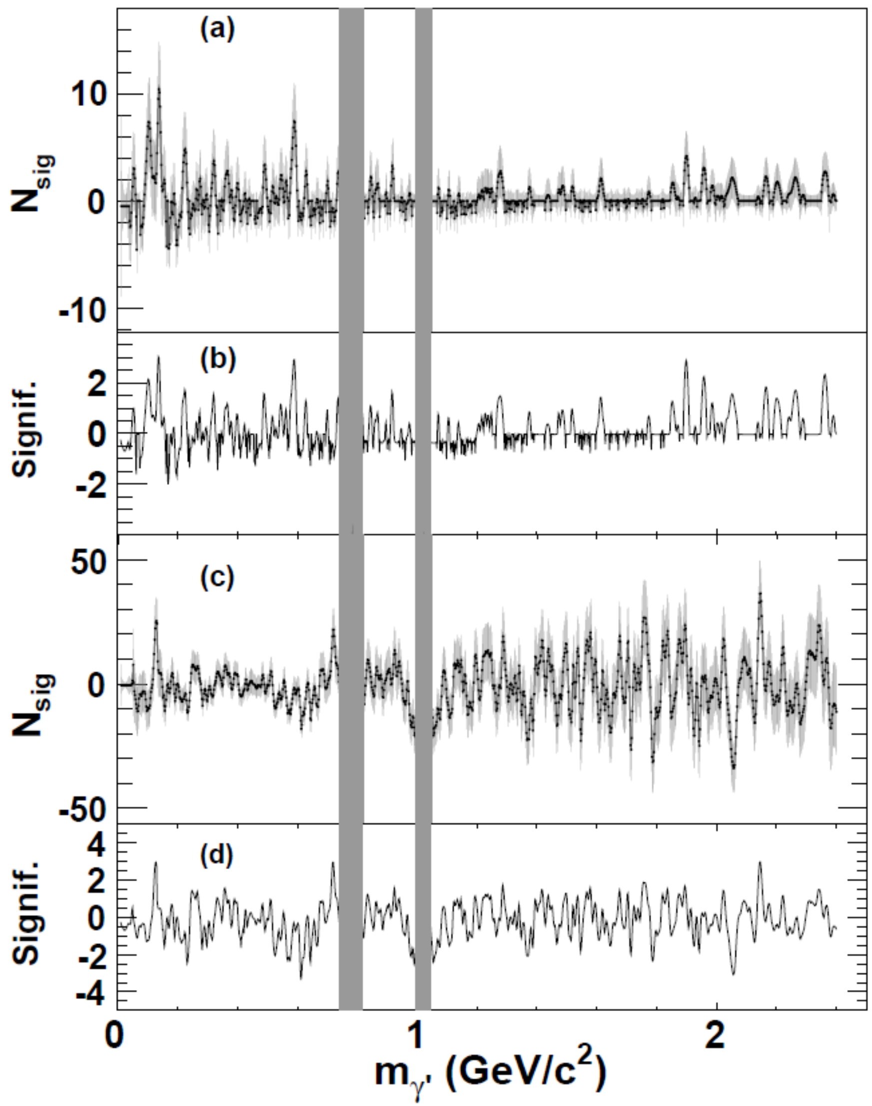
$\mathcal{B}(B^0 \to e^\pm\mu^\mp) < 1.0\ (1.3) \times 10^{-9}$

arXiv:1710.04111



$\mathcal{B}(B^0_s \to e^\pm\mu^\mp) < 5.4\ (6.3) \times 10^{-9}$

Searches at BESIII



- 上穷碧落下黄泉，
  两处茫茫皆不见。
- 众里寻她千百度，
  蓦然回首，
  ……

未来

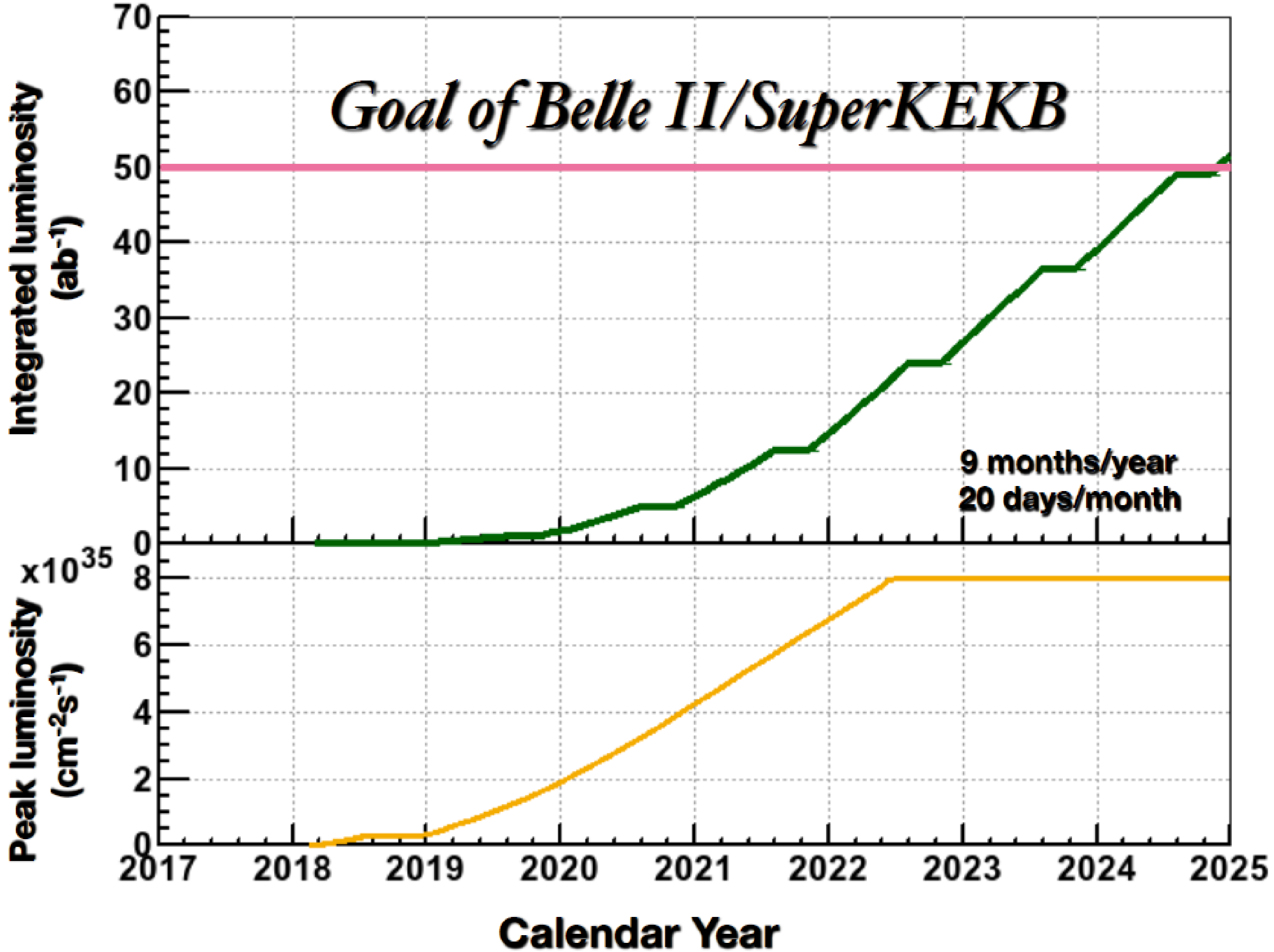
BESIII 白皮书

Energy	physics highlight	Current data # of events or integrated luminosity	Expected final data # of events or integrated luminosity
1.8 - 2.0 GeV	R values cross-sections	N/A	Scan: 3 energy points
2.0 - 3.1 GeV	R values cross-sections	Scan: 20 energy points	No requirement
J/ψ peak	Light Hadron & Glueball Charmonium decay	5.0 billion	10.0 billion
$\psi(3686)$ peak	Light hadron& Glueball Charmonium decay	0.5 billion	3.0 billion
$\psi(3770)$ peak	$D^0/D^\pm$ decays Form-factor/CKM decay constant	2.9 fb^{-1}	20.0 fb^{-1}
3.8 - 4.6 GeV	R value XYZ/Open charm	Scan: 105 energy points	No requirement
4.180 GeV	D_s decay XYZ/Open charm	3.1 fb^{-1}	6.0 fb^{-1}
4.0 - 4.6 GeV	XYZ/Open charm Higher charmonia cross-sections	Scan: 12.0 fb^{-1}	Scan: 30.0 fb^{-1} 10 MeV step/0.5 fb^{-1}/point 30 energy points
4.60 GeV	Λ_c/XYZ	0.56 fb^{-1}	1.0 fb^{-1}
4.64 GeV	Λ_c/XYZ	N/A	5.0 fb^{-1}
4.65 GeV	Λ_c/XYZ	N/A	0.2 fb^{-1}
4.70 GeV	Λ_c/XYZ	N/A	0.65 fb^{-1}
4.80 GeV	Λ_c/XYZ	N/A	1.0 fb^{-1}
4.90 GeV	Λ_c/XYZ	N/A	1.3 fb^{-1}
$\Sigma_c^+\bar{\Lambda}_c^-$ 4.74 GeV	Charm Baryons	N/A	1.0 fb^{-1}
$\Sigma_c\bar{\Sigma}_c$ 4.91 GeV	Charm Baryons	N/A	1.0 fb^{-1}
$\Xi_c\bar{\Xi}_c$ 4.95 GeV	Charm Baryons	N/A	1.0 fb^{-1}

Belle II physics book

KEK Preprint 2018-27
BELLE2-PAPER-2018-001
FERMILAB-PUB-18-398-T
JLAB-THY-18-2780
INT-PUB-18-047
UWThPh 2018-26

1808.10567



LHCb upgrade physics book

1808.08865

CERN-LHCC-2018-026
LHCB-PUB-2018-009
August 28, 2018

9/fb data for physics now!

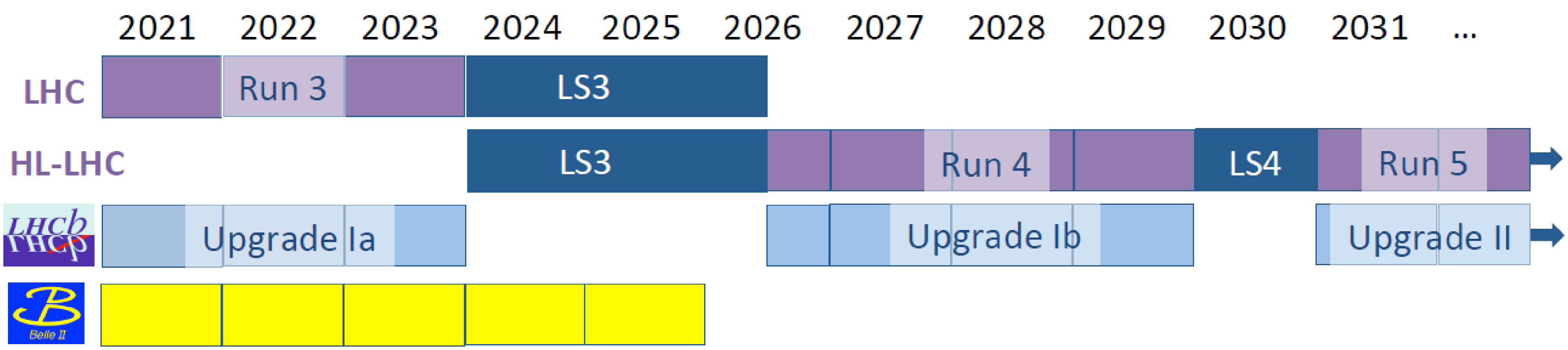


Figure 1.1: Timeline of accelerator and experiment operations over the decade 2021 to 2031. The periods of operations of the LHC and HL-LHC are indicated and the long shutdowns (LS). The LHCb operational periods are shown with gaps where the detector consolidation and upgrades discussed in this document occur. The running period of Belle II, the other major international flavour-physics facility, is also shown.

彭海平报告

STCF in China

Super Tau-Charm Facility (STCF)

- Peak luminosity 0.5-1×10^{35} $cm^{-2}s^{-1}$ at 4 GeV
- Energy range E_{cm} = 2–7GeV
- Polarization available on beam (Phase II)
- Basic Features of machine :
  - Symmetric machine with dual-ring, 600-1000meter
  - Large Piwinski angle collision + crabbed waist solution for the IR
  - Siberia snake for polarization

Organization for STCF

Institutional Board → Steering Committee（Zhenguo Zhao） ← International Advisory Committee (IAC)

Project coordinator
(Haiping Peng, Yangheng Zheng)

彭海平报告

Theory & MC Simulation (Jiangping Ma)
- Light Hadron
- Charmonium
- XYZ
- Charm decay
- Charm Spectroscopy
- Tau
- R&QCQ
- New Physics
- …

Accelerator (Qing Luo)
- Design
- RF
- IP
- Linac
- Vacuum
- Beam diagnose
- …

Det./Soft. (Jianbei Liu/Xingtao Huang)
- Tracking
- PID
- ECAL
- Muon
- SC
- Trigger
- DAQ
- Software
- Computing & Network
- …

CDR Input

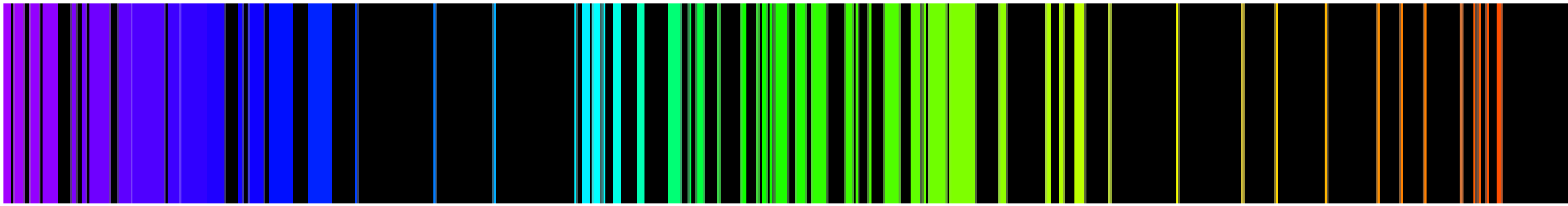
- Physics motivation
- Fast simulation is ready, process simulation
- Accelerator and Detector R&D

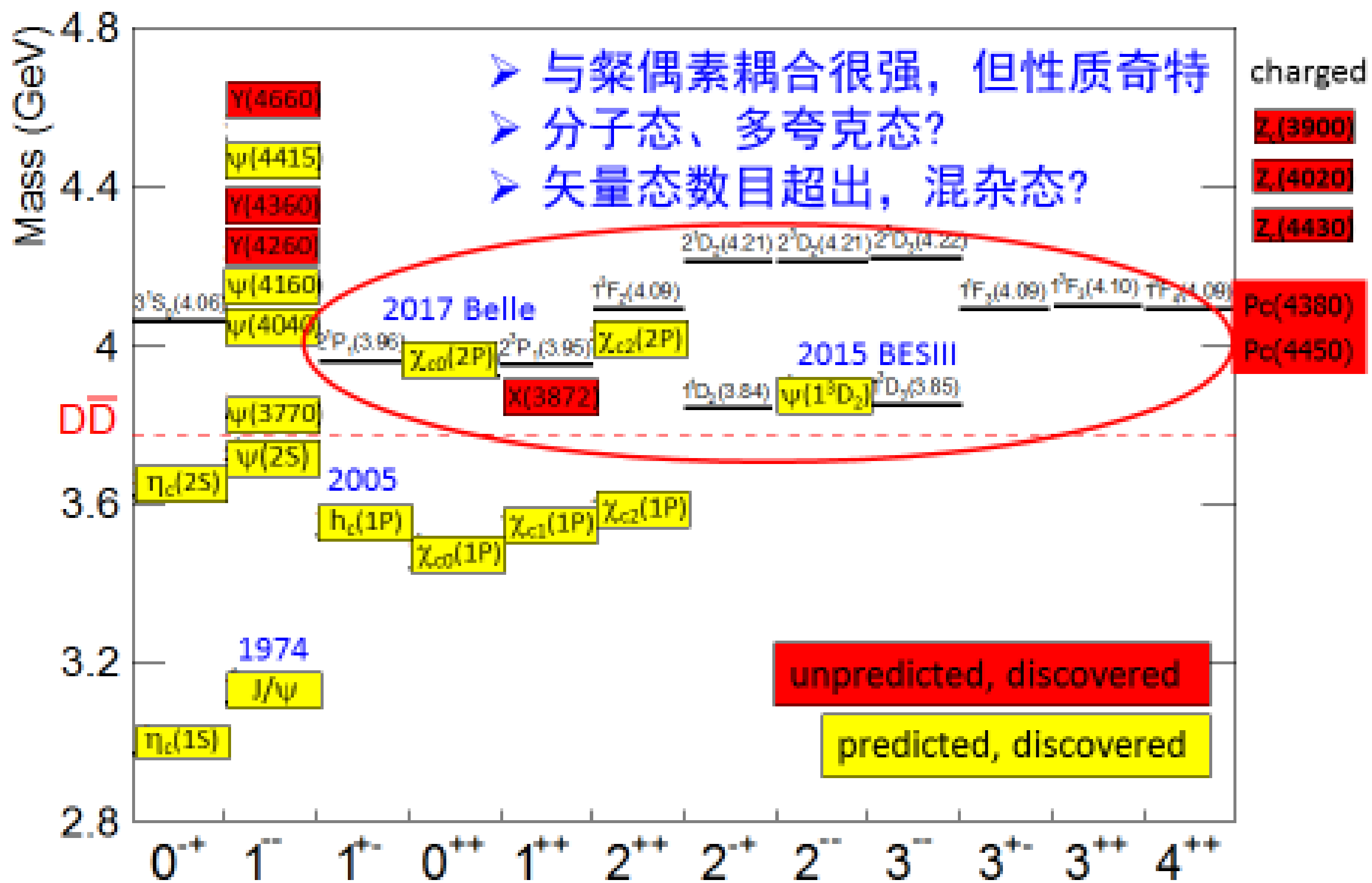
Please contact:

Jianping Ma, Qing Luo, Jiangbei Liu, Xingtao Huang and Haiping

彭海平报告

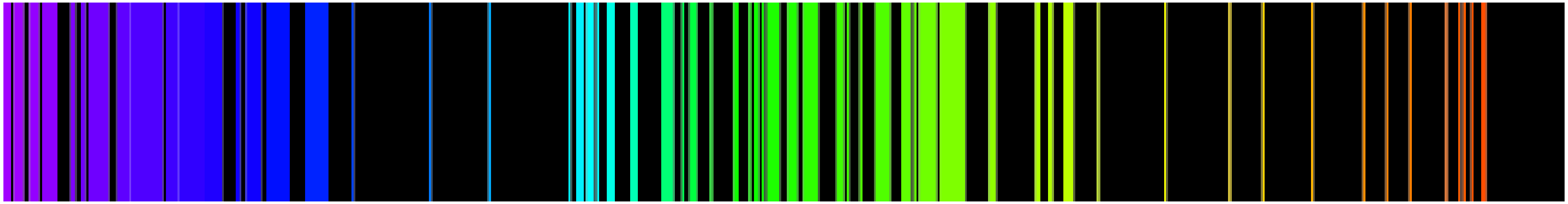
理解夸克禁闭机制

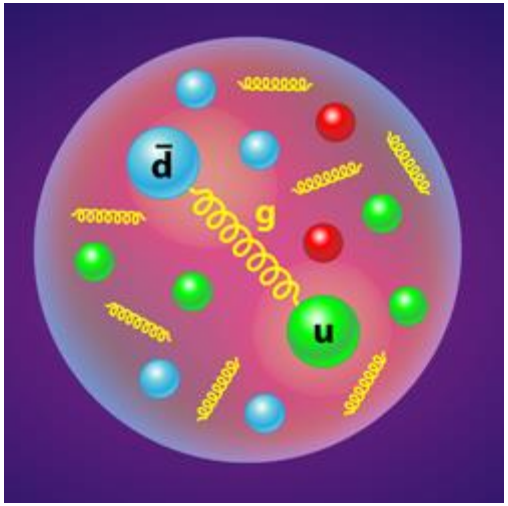


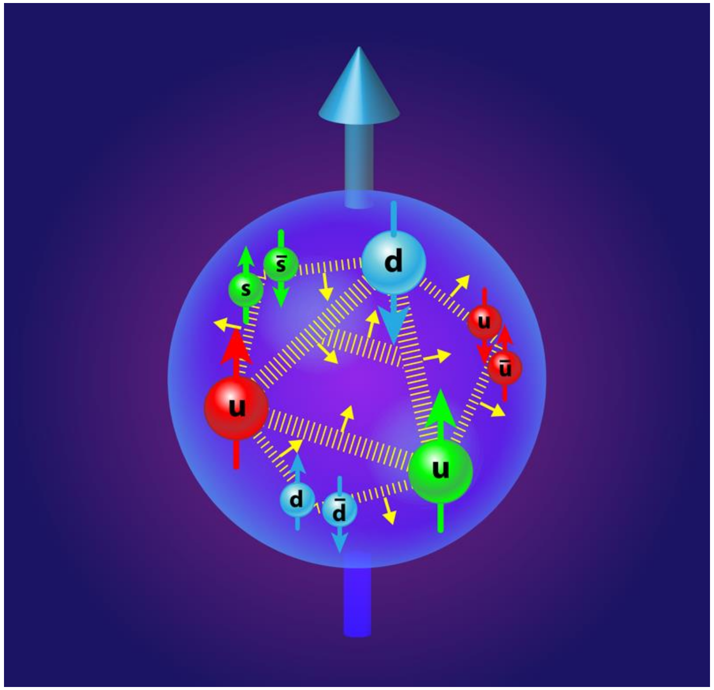


Godfrey & Isgur, PRD32, 189 (1985)

理解夸克禁闭机制







理想还是要有的……

Thanks