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Measurement of prompt Λ_c^+ baryon production cross-section and Λ_c^+/D^0 production ratio in pPb collisions at $\sqrt{s_{\mathrm{NN}}} = 8.16\,\mathrm{TeV}$ in LHCb

Chenxi Gu[1], Giulia Manca[2], Yiheng Luo[3], Jiayin Sun[2], Jianqiao Wang[4], Di Yang[4], Xianglei Zhu[4]

[1] *Laboratoire Leprince-Ringuet, Palaiseau, France*
[2] *Peking University, Beijing, China*
[3] *Universita e INFN, Cagliari, Italy*
[4] *Tsinghua University, Beijing, China*

Abstract

Open heavy charmed baryon Λ_c^+ is a good probe to nuclear matter effects in heavy-ion collisions. Due to the large charm quark mass, perturbative QCD is applicable in calculating their production cross sections in the initial hard parton scatterings. With the data of proton-lead collisions at $\sqrt{s_{\mathrm{NN}}} = 8.16\,\mathrm{TeV}$ collected by LHCb during Run 2 in 2016, the double-differential production cross section of Λ_c^+ baryon is measured in the transverse momentum region of $2-15$ GeV/c, corresponding to a center-of-mass rapidity region of $1.5 < y^* < 4.0$ for forward configurations while $-5.0 < y^* < -2.5$ for backward configurations. Open charm baryon over meson ratio Λ_c^+/D^0 is presented to study hadronisation mechanism and compared with results measured by ALICE in proton-proton and proton-lead collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02\,\mathrm{TeV}$ and results obtained by LHCb in proton-lead and peripheral lead-lead collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02\,\mathrm{TeV}$.

History

- 0.0, Feb. 8$^{\text{th}}$ 2024:

Contents

1 Introduction

To study the creation and property of the quark-gluon plasma (QGP) is one of the most important goals of high energy nuclear physics, i.e. heavy-ion collision physics. The QGP can be created and studied in laboratory through high energy nucleus-nucleus (AA) collisions. In central AA collisions, which are also called 'large system', lots of energy is deposited in a sizeable volume, where the vacuum is heated up and the phase transition from hadron gas to QGP is expected to occur. However in proton-proton and proton-nucleus collisions (*a.k.a.* 'small systems'), the system volume is too small, and the deconfined QGP matter is not supposed to be formed. These collisions are usually treated as the baseline for the studies of QGP in AA collisions.

With the formation of the QGP in the early stage of heavy-ion collisions, the production yields and momentum spectra of those final-state hadrons might be modified compared to the expectations based on the measurements in proton-proton collisions. These QGP effects are called hot nuclear matter (HNM) effects.

One of the HNM effects that can be studied is how the major feature of QGP, deconfinement of quarks and gluons, influences the hadronisation mechanism. Hadronisation, the process in which quarks/gluons are transformed into hadrons, are quite different depending on whether a QGP is formed or not. In principle, hadronisation should be calculated with first-principle QCD, however phenomenological functions are widely used due to the non-perturbative nature of hadronization. This is called fragmentation hadronisation, and these functions are applicable no matter a QGP is formed or not. When QGP is formed, quarks can also hadronise into hadrons through recombination with other quarks in QGP, and this is called recombination or coalescence. The recombination/coalescence explains the enhancement of the baryon-to-meson ratio at intermediate transverse momentum, and is not supposed to occur without the deconfined medium.

The so-called 'baryon enhancement' phenomena were first observed in anti-protons and pions in gold-gold collisions at RHIC in 2000s and inspired the proposal of coalescence hadronization mechanism. Thereafter similar phenomena are observed in strange and charm hadrons in AA collisions. However, the enhancement of Λ_c^+/D^0 ratio at intermediate transverse momentum, are also observed by ALICE experiment in proton-proton and proton-lead collisions at the nucleon-nucleon center-of-mass energy of 5.02TeV, where no QGP is expected to be formed. The data can't be reproduced by fragmentation models but are consistent with some coalescence models, and this is named as 'Λ_c^+ puzzle' and calls for deeper understanding and more precise measurement of hadronisation in proton-lead collisions. The Λ_c^+/D^0 in proton-lead collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV also is measured with LHCb, and also shows enhancement at intermediate $p_{\rm T}$, which is described well by coalescence models.

Besides hot nuclear matter effects, the production yields and momentum spectra of final-state hadrons in heavy-ion collisions may also be affected by those mechanisms not related to the QGP, which are called cold nuclear matter effects (CNM). To determine whether QGP is formed in heavy-ion collisions, it is essential to distinguish cold nuclear matter effects and hot nuclear matter effects. These CNM effects include the nuclear modification of parton distribution function, which is called nuclear parton distribution function (nPDF), and rescatterings of final-state hadrons produced in heavy-ion collisions.

Cold nuclear matter effects can be studied through proton-nucleus (pA) collisions where the HNM effects are supposed to be non-dominant. These collisions, with smaller size of systems compared to AA collisions and lager number of produced hadrons compared to proton-proton collisions, are ideal for the study of CNM effects. For example, the nPDFs can be probed or constrained by the production asymmetry of final-state particles between forward and backward rapidities.

Open heavy charmed baryon Λ_c^+ is a good probe to nuclear matter effects in heavy-ion collisions. Due to the large charm quark mass, perturbative QCD is applicable in calculating their production cross sections in the initial hard parton scatterings. The charm quarks produced in QGP thermally or produced by rescattering of final-state hadrons can be neglected since the medium temperature is much less than the charm quark mass.

The LHCb experiment provides unique measurements of Λ_c^+ production in proton-lead collisions in forward rapidities. Designed as a detector whose primary goals is to study heavy-flavour physics in hadron collisions, LHCb has more precise tracking system and particle identification system compared to other heavy-ion experiments, well suitable for precise charm hadron reconstructions. With its pseudo-rapidity coverage of $2.0<\eta<5.0$, very small Bjoken-x regions ($\sim 10^{-5}$) can be probed with open charm hadrons, significantly beyond the coverage of other heavy-ion experiments such as ALICE and STAR, giving unique information for constraining nPDFs.

2 Data sets and selections

2.1 Data sets

The data for this analysis was pPbdata collected by LHCb detector at late 2016, including two different configurations due to the asymmetry of collisions: forward (Fwd) collision(p beam coming from upstream of VELO) and backward (Bwd) collision(Pb beam coming from upstream of VELO). The configurations, corresponding to positive and negative rapidity regions respectively, are illustrated in the two pannels of Fig. 1: The integrated

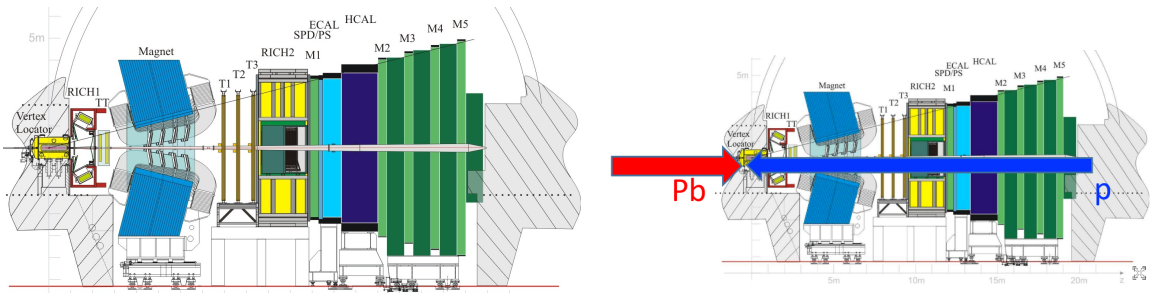

Figure 1: Skeches of the two beam configurations of pPb data taking, left for Fwd(pPb) and right for Bwd(Pbp).

luminosity for Fwd collision is $12.18 \pm 0.32\ \mathrm{nb}^{-1}$ and $18.57 \pm 0.46\,\mathrm{nb}^{-1}$ for Bwd. The centre-of-mass energy per nucleon pair $\sqrt{s_{\mathrm{NN}}}$ corresponds to 8.16 TeV. The bookkeeping

Table 1: Online (L0, HLT1) tigger on Λ_c^+ baryons

Quantity	Selection
	L0
nSPDHits	> 0
	HLT1TrackMVA
$\chi^2/\mathrm{ndf}(\mathrm{track})$	< 4.0
ProbNNghost(track)	< 0.3
$\chi^2_{\mathrm{IP}}(\mathrm{track})$ for $p_{\mathrm{T}} > 10.0\,\mathrm{GeV}/c$	> 6.0
$\chi^2_{\mathrm{IP}}(\mathrm{track})$ for $0.5 < p_{\mathrm{T}} < 10.0\,\mathrm{GeV}/c$	$> 6.0 \cdot \exp\left(\frac{0.3}{p_{\mathrm{T}}^2} + 0.2 \cdot \left(1 - \frac{p_{\mathrm{T}}}{10.0}\right)\right)$
	HLT1TwoTrackMVA
$p_{\mathrm{T}}(\mathrm{track})$	$> 0.3\,\mathrm{GeV}/c$
$p(\mathrm{track})$	$> 2\,\mathrm{GeV}/c$
$\chi^2/\mathrm{ndf}(\mathrm{track})$	< 4.0
$\chi^2_{\mathrm{IP}}(\mathrm{track})$	> 4.0
$\chi^2_{\mathrm{IP}}(\mathrm{vtx})$ for $2 < \eta(\mathrm{track}) < 5\,\mathrm{GeV}/c$	< 10
cos(DIRA) for $M_{\mathrm{corr}} > 0.5\,\mathrm{GeV}/c$	> 0.0

paths for Fwd and Bwd are:

/LHCb/Protonion16/Beam6500GeV-VeloClosed-MagDown/Real Data
/Turbo03pLead/94000000/TURBO.MDST;
/LHCb/Ionproton16/Beam6500GeV-VeloClosed-MagDown/Real Data
/Turbo03pLead/94000000/TURBO.MDST.

The data samples are triggered online in three levels. The first level (Level-0) is a hardware level trigger L0SPD for pPb data, which requires at least ones hit in the SPD detector. Thus it is an minmum biased trigger with $\varepsilon_{\mathrm{L0}} \approx 1$. The (software) high-level triggers HLT1 and HLT2 provide real time reconstruction and selection of tracks and particles. For hadron-final-state channels, such as $D^0 \to K^-\pi^+$ and $\Lambda_c^+ \to pK^-\pi^+$, the HLT1 triggers are Hlt1TrackMVADecision_TOSorHlt1TwoTrackMVADecision_TOS == 1, which require either one detached long track or two detached long tracks to originate from a common vertex in an event. The selections are cut-based and the explicit expressions are listed in Table **??** from Ξ_c^+ production [1] note (LHCb-ANA-2022-039). Hlt2 triggers serve as online selections on different particle, in order to save more signal cadidates as possible. The Λ_c^+ candidates are reconstructed by final-state p, K^- and π^+ tracks. The HLT2 selections for Λ_c^+ candidates in the HLT2 line Hlt2CharmHadLc2KPPi$_{\mathrm{X}}$SecTurbo are shown in Table 2.

The simulation samples include ∼36M $\Lambda_c^+ \to pK^-\pi^+$ & c.c. decays for both rapidities, used for obtaining information of prompt Λ_c^+ baryon and for calculating efficiencies. The event type is 25103000 and the production tag is sim09c/j/k. For sim09k simulation samples (16M), the multiplicity distributions is fixed by increasing the number of pill-up.

Table 2: Hlt2 (Turbo) selection on Λ_c^+ baryons

Quantity	Selections
$p_{\mathrm{T}}(\text{track})$	$> 200\,\mathrm{MeV}/c$
$\chi^2_{\mathrm{IP}}(\text{track})$	> 4
$\chi^2/\mathrm{ndf}(\text{track})$	< 3
$p(\text{track})$	$> 1\,\mathrm{GeV}/c$
$p(p)$	$> 10\,\mathrm{GeV}/c$
$\mathrm{DLL}_{K\pi}(K)$	> 5
$\mathrm{DLL}_{K\pi}(\pi)$	< 5
$\mathrm{DLL}_{p\pi}(p)$	> 5
$\mathrm{DLL}_{pK}(p)$	> 5
$N(p_{\mathrm{T}}(\text{track}) > 400\,\mathrm{MeV}/c)$	≥ 2
$N(p_{\mathrm{T}}(\text{track}) > 1000\,\mathrm{MeV}/c)$	≥ 1
$N(\chi^2_{\mathrm{IP}}(\text{track}) > 10)$	≥ 2
$N(\chi^2_{\mathrm{IP}}(\text{track}) > 50)$	≥ 1
$m(\Lambda_c^+)$	$2210 < m(\Lambda_c^+) < 2543\,\mathrm{MeV}/c^2$
DIRA	< 34.6mrad
$\chi^2/\mathrm{ndf}(\text{vtx})$	< 25
Lifetime	$\tau > 0.075$ps

The paths are:

/MC/2016/pPb-Beam6500GeV-2560GeV-2016-MagDown-Fix1-Epos
/Sim09c(j,k)/Trig0x61421621/Reco16pLead/Turbo03/25103000/DST;
/MC/2016/Pbp-Beam2560GeV-6500GeV-2016-MagDown-Fix1-Epos
/Sim09c(j,k)/Trig0x61421621/Reco16pLead/Turbo03/25103000/DST.

The Λ_c^+ baryon from b hadrons are simulated by 2M $\Lambda_b^0 \to \Lambda_c^+\pi^-$ for both configurations. The paths are:

/MC/2016/pPb-Beam6500GeV-2560GeV-2016-MagDown-Fix1-Epos
/Sim09c(h)/Trig0x61421621/Reco16pLead/Turbo03/12163001/DST;
/MC/2016/Pbp-Beam2560GeV-6500GeV-2016-MagDown-Fix1-Epos
/Sim09c(h)/Trig0x61421621/Reco16pLead/Turbo03/12163001/DST.

2.2 Offline selections

To further improve the signal purity of the samples, tighter selections are applied offline, mainly following the analysis of Λ_c^+ production at 5.02 TeV in pPb [2]. The transeverse momentum lower limit on $400\,\mathrm{MeV}/c$, pseudo-rapidity region of $2-5$ and the selection of $\mathrm{ProbNN}_{\mathrm{ghost}}(\text{track}) < 0.3$ are introduced to improve the final-track quality. The direction angle and χ^2/ndf of vertex fit cuts help to obtain better Λ_c^+ decay vertices. Since the lifetime of Λ_c^+ baryon is approximately 0.2 ps, the vertex displacement (VD) and decay time cuts are applied to exclude some of the background and Λ_c^+ baryons from beauty decays. More tight PID cuts are applied to reduce misID backgrounds. A signal window

Table 3: Offline selections on Λ_c^+ baryons

Quantity	Selections
p_{T}(track)	$> 400\,\mathrm{MeV}/c$
η(track)	$2 < \eta < 5$
ProbNNGhost(track)	< 0.3
p(track)	$3.2 < p < 100\,\mathrm{GeV}/c$
$\mathrm{DLL}_{K\pi}(\pi)$	< 0
$\mathrm{DLL}_{pK}(p)$	> 15
cos(DIRA)	> 0.99975
$\chi^2_{\mathrm{VD}}(\Lambda_c^+)$	> 50
$\chi^2/\mathrm{ndf}(\mathrm{vtx})$	< 6
$m(\Lambda_c^+)$	$2237 < m(\Lambda_c^+) < 2337\,\mathrm{MeV}/c^2$
$\log_{10}\chi^2_{\mathrm{IP}}(\Lambda_c^+)$	$-5 < \log_{10}\chi^2_{\mathrm{IP}}(\Lambda_c^+) < 5$
Lifetime	$0.2 < \tau < 1.2$ps

of invariant-mass varied by $50\,\mathrm{MeV}/c^2$ around $2287\,\mathrm{MeV}/c^2$ and $\log_{10}\chi^2_{\mathrm{IP}}$ $[-5, 5]$ for Λ_c^+ is set for convenience of mass and $\log_{10}\chi^2_{\mathrm{IP}}$ fit. An extra selection on track momemtum is introduced due to the fiducial regions of tracking and PID calibration tables.

3 Analysis strategy

For this analysis, the key measurement is the Λ_c^+ production cross-section as a function $p_{\mathrm{T}}(\Lambda_c^+)$ and $y^*(\Lambda_c^+)$, where y^* is the rapidity defined in the nucleon-nucleon centre-of-mass frame. Here prompt Λ_c^+ baryons refer to those produced directly from collisions or from the strong decay of other charm hadrons (*e.g.* $\Sigma_c^{++} \to \Lambda_c^+\pi^+$). Whereas non-prompt Λ_c^+ baryon, or Λ_c^+-from-b, refer to those from the weak decay of B hadrons (*e.g.* $\Lambda_b^0 \to \Lambda_c^+\pi^-$). The centre-of-mass frame does not coincide with laboratory frame due to the asymmetry of the collision, so y^* is shifted by a constant value with respect to the rapidity in the laboratory frame:

$$y^* = y - \delta y \ , \tag{1}$$

where $\delta y = 0.5\log(A_{\mathrm{Pb}}/Z_{\mathrm{Pb}}) = 0.465$. The direction of proton beam is defined as the positive z-axis.

the double differential cross-section is defined as:

$$\frac{\mathrm{d}^2\sigma}{\mathrm{d}p_{\mathrm{T}}\mathrm{d}y^*} = \frac{N(\Lambda_c^+ \to pK^-\pi^+)}{\mathcal{L} \times \epsilon_{\mathrm{tot}} \times \mathcal{B}(\Lambda_c^+ \to pK^-\pi^+) \times \Delta p_{\mathrm{T}} \times \Delta y^*} \ , \tag{2}$$

- $N(\Lambda_c^+ \to K^{\mp}\pi^{\pm})$ is the prompt Λ_c^+ signal candidates reconstructed through $\Lambda_c^+ \to K^{\mp}\pi^{\pm}$ decay channels, including their charge conjugate channels. It is measured in Section 4.

- $\mathcal{L}$ is the integrated luminosity, for Fwd $\mathcal{L}_{\mathrm{Fwd}} = 0.01218 \pm 0.00032\,\mathrm{pb}^{-1}$, for Bwd $\mathcal{L}_{\mathrm{Bwd}} = 0.01857 \pm 0.00046\,\mathrm{pb}^{-1}$, which is determined as the Ref. [?] described.

- ϵ_{tot} is the total efficiency in each (p_{T}, y^*) bin, evaluated in Section **??**.

- $\mathcal{B}(\Lambda_c^+ \to K^{\mp}\pi^{\pm}) = (6.26 \pm 0.29)\%$ is the branching fraction of decay $\Lambda_c^+ \to pK^-\pi^+$, obtained from PDG 2022 [3].

- Δp_{T} is the bin width of the Λ_c^+ transverse momentum, with a p_{T} range of $[0, 15]$ GeV/c.

- $\Delta y^* = 0.5$ is the bin width of the Λ_c^+ rapidity, for Fwd $1.5 < y^* < 4.0$, for Bwd $-5.0 < y^* < -2.5$.

Then the forward-backward production ratio can be derived from the cross-section as

$$R_{\mathrm{FB}}(p_{\mathrm{T}}, y^*) \equiv \frac{\mathrm{d}^2\sigma_{p\mathrm{Pb}}(p_{\mathrm{T}}, +|y^*|)/\mathrm{d}p_{\mathrm{T}}\mathrm{d}y^*}{\mathrm{d}^2\sigma_{\mathrm{Pb}p}(p_{\mathrm{T}}, -|y^*|)/\mathrm{d}p_{\mathrm{T}}\mathrm{d}y^*} \ , \tag{3}$$

which is calculated among common rapidity bins $2.5 < |y^*| < 4.0$. By comparing the production cross-section with that D^0 meson, the Λ_c^+/D^0 production ratio $R_{\Lambda_c^+/D^0}$ can be given as

$$R_{\Lambda_c^+/D^0} \equiv \frac{\sigma_{\Lambda_c^+}}{\sigma_{D^0}} \ . \tag{4}$$

$R_{\Lambda_c^+/D^0}$ can also be measured as functions of (p_{T}, y^*), as well as multiplicity variables such as $N_{\mathrm{PV}}^{\mathrm{tracks}}$ and $N_{\mathrm{VELO}}^{\mathrm{Clusters}}$, in order to study the system size dependence of hadronisation processes.

4 Signal yield

Two steps of fit are performed to determine the prompt signal yield in each kinematic intervals, which are both extended unbinned maximum likelihood fit. The first step is performed on the invariant mass $M(pK^-\pi^+)$ distribution in the selected signal window. Following previous analyses [4, 5], a Crystal Ball (CB) function [6] plusk a Gaussian function is used to describe the signal shape, where

$$f \times \mathrm{CB} + (1-f) \times \mathrm{Guass} \ , \tag{5}$$

$$f_{\mathrm{CB}}(x; M, \sigma, \alpha, n) = \begin{cases} \frac{\left(\frac{n}{|\alpha|}\right)^n e^{-\frac{1}{2}\alpha^2}}{\left(\frac{n}{|\alpha|} - |\alpha| - \frac{x-M}{\sigma}\right)^n}, & \text{if } \frac{x-M}{\sigma} < -|\alpha| \ , \\ \exp\left(-\frac{1}{2}\left(\frac{x-M}{\sigma}\right)^2\right), & \text{if } \frac{x-M}{\sigma} \geq -|\alpha| \ . \end{cases} \tag{6}$$

A linear function is used to describe the shape of background. In this PDF, n of CB function is always fixed to 1 from physical constraint, and CB and Gaussian function share a common mean value. Due to limited statistics in some kinematic intervals, fit results will be unstable or hard to converge if all parameters. Thus, a global fit is performed to fix α in CB, the ratio between width of Gaussian over that of CB r_{width}, and the fraction of the CB function f. To ensure the stability of the fits, the mass fits are repeated with 50 times, varying the initial values of all parameters randomly. The fit result with the smallest minimal negative likelihood (NLL) is chosen to be the final result. Such *best* results for two rapidities are shown in Fig. 2.

This invariant mass fit is performed in the signal window around Λ_c^+ PDG mass $M(\Lambda_c^+) \pm 50\,\mathrm{MeV}$ as listed in Table **??**. Here, *best* fit results are also selected following

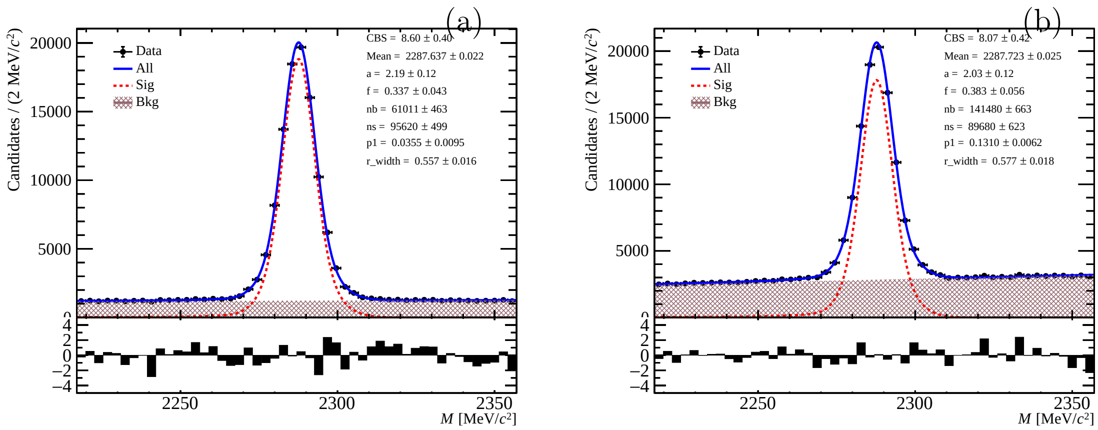

Figure 2: Fit on kinematic-unbinned $M(K\pi)$ distribution for Fwd (left) and Bwd (right) rapidities.

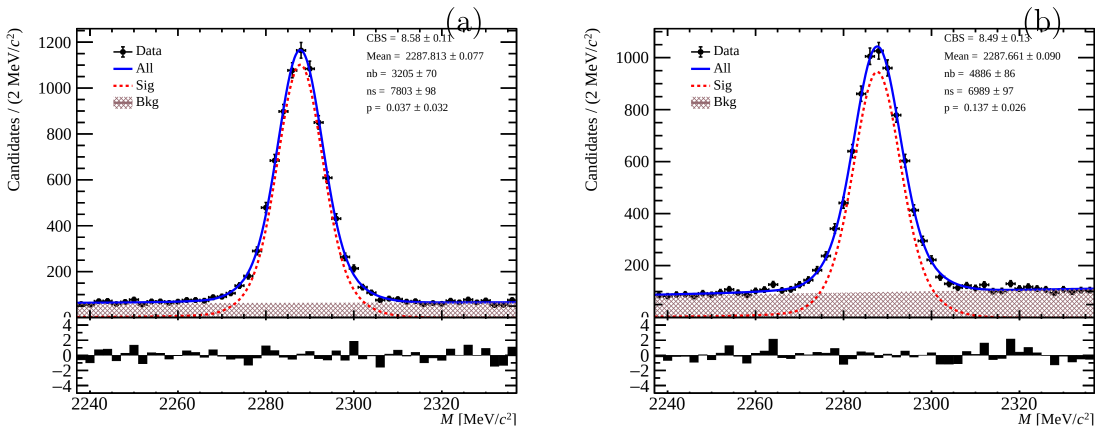

Figure 3: Fit on $M(K\pi)$ distribution for Fwd ($4 < p_{\mathrm{T}}(\Lambda_c^+) < 5\,\mathrm{GeV}/c$ and $2.5 < y^* < 3.0$, left) and Bwd ($4 < p_{\mathrm{T}}(\Lambda_c^+) < 5\,\mathrm{GeV}/c$ and $-4.0 < y^* < -3.5$, right) rapidities.

the method above. Two examples for Fwd and Bwd rapidities are shown in Fig. 3, and all results are summarized in Appendix **??**.

A second step of fit on the $\log_{10}\chi^2_{\mathrm{IP}}$ (Λ_c^+) is performed to get prompt yields from total yields, following previous analyses [2, 5] Here χ^2_{IP} is defined as the difference in the vertex-fit χ^2 of a given PV reconstructed with and without the candidate under consideration. which is approximate to the significance of IP significance IP/σ(IP). So non-prompt Λ_c^+ baryons have larger IP than prompt ones due to the decay length of B hadrons, and the two different components can be distinguished with this parameter. To suppress the background component, a *sPlot* method [**?**] is performed using the fit result from $M(K\pi)$ fit. So the $\log_{10}\chi^2_{\mathrm{IP}}$ distribution of weighted data contains only prompt Λ_c^+ component and non-prompt component. The PDF describing the shapes is a Bukin

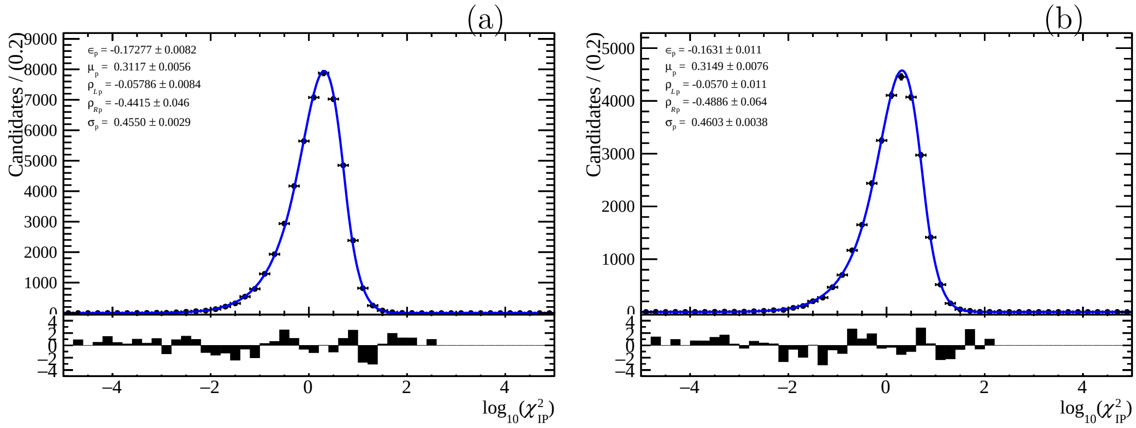

Figure 4: Global fit on $\log_{10}\chi^2_{\rm IP}$ distribution of prompt Λ_c^+ simulation for Fwd (left) and Bwd (right) rapidities.

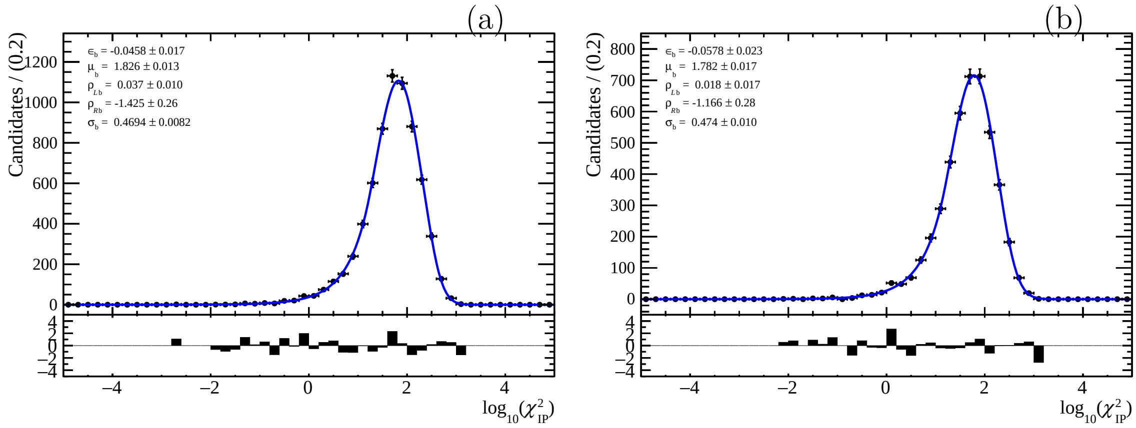

Figure 5: Global fit on $\log_{10}\chi^2_{\rm IP}$ distribution of from-b Λ_c^+ simulation for Fwd (left) and Bwd (right) rapidities.

function [7] as follows:

$$\mathcal{P}(x;\mu,\sigma,\epsilon,\rho_L,\rho_R) = \begin{cases} \exp\left\{\frac{(x-x_1)\epsilon\sqrt{\epsilon^2+1}\sqrt{2\ln 2}}{\sigma\left(\sqrt{\epsilon^2+1}-\epsilon\right)^2\ln\left(\sqrt{\epsilon^2+1}+\epsilon\right)} + \rho_L\left(\frac{x-x_1}{\mu-x_1}\right)^2 - \ln 2\right\} & x \leq x_1, \\ \exp\left\{-\left[\frac{\ln\left(1+2\epsilon\sqrt{\epsilon^2+1}\frac{x-\mu}{\sigma\sqrt{2\ln 2}}\right)}{\ln\left(1+2\epsilon^2-2\epsilon\sqrt{\epsilon^2+1}\right)}\right]^2 \times \ln 2\right\} & x_1 < x < x_2, \\ \exp\left\{\frac{(x-x_2)\epsilon\sqrt{\epsilon^2+1}\sqrt{2\ln 2}}{\sigma\left(\sqrt{\epsilon^2+1}-\epsilon\right)^2\ln\left(\sqrt{\epsilon^2+1}+\epsilon\right)} + \rho_R\left(\frac{x-x_2}{\mu-x_2}\right)^2 - \ln 2\right\} & x \geq x_2. \end{cases} \tag{7}$$

$$x_1 = \mu + \sigma\sqrt{2\ln 2}\left(\frac{\epsilon}{\sqrt{\epsilon^2+1}} - 1\right), x_2 = \mu + \sigma\sqrt{2\ln 2}\left(\frac{\epsilon}{\sqrt{\epsilon^2+1}} + 1\right).$$

It is a asymmetric gaussian function, with ϵ discribing the asymmetry and two ρs discrbing the left and right tail length. For both configurations, ρ_L and ρ_R of prompt component are fixed while ϵ, ρ_L and ρ_R of non-prompt component are fixed, all using simulation results of from-b ($\Lambda_b^0 \to \Lambda_c^+\pi^-$) simulation fit as shown Fig. 4 and 5.

From the fit of second step, the prompt Λ_c^+ yield yield in signal window $[1815, 1915]\,\mathrm{MeV}/c^2 \times [-5, 5]$ can be directly obtained, as summarized in Fig. 6. There

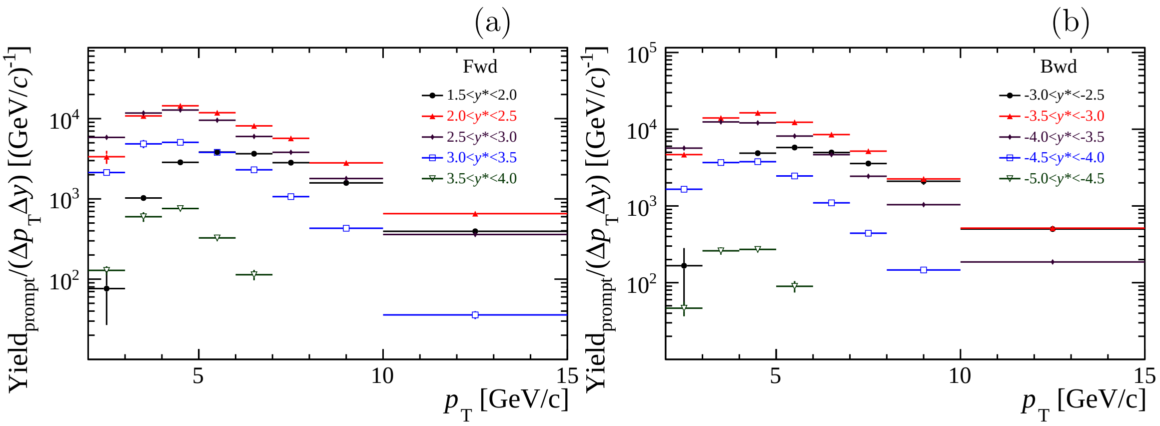

Figure 6: Prompt yields obtained from $\log_{10}\chi^2_{\mathrm{IP}}$ fit for Fwd (left) and Bwd (right), statistical uncertainties only.

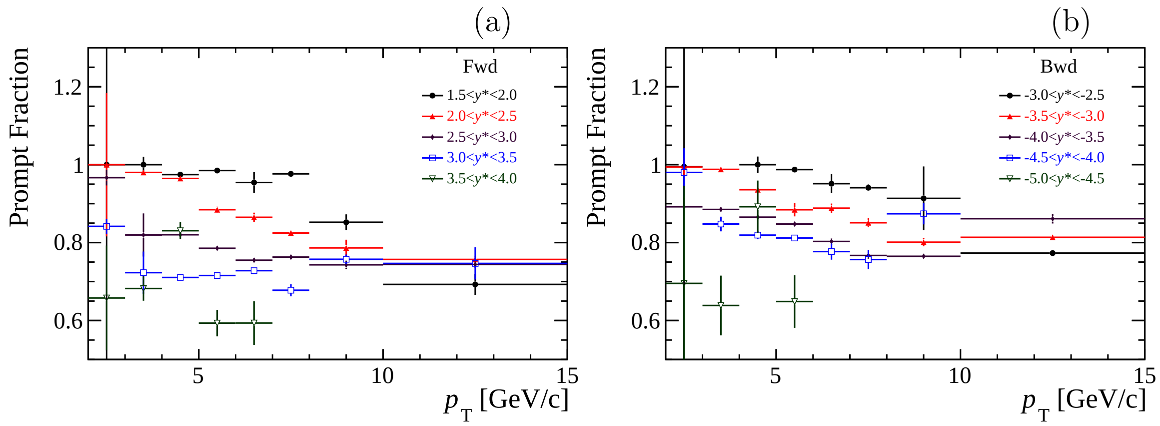

Figure 7: The fraction of prompt Λ_c^+ component from fit for Fwd (left) and Bwd (right), statistical uncertainties only.

may be some Λ_c^+ signals outside the window so its effect is considered in the evaluation of selection efficiencies. The fraction of prompt component is also given from as Fig. 7. It is however not multiplied with raw yield because their correlation should be considered while calculating the uncertainty of prompt yield, which is of more difficulties.

Appendices

A Standard References

Below is a list of common references, as well as a list of all LHCb publications. As they are already in prepared bib files, they can be used as simply as `\cite{LHCb-DP-2008-001}` to get the LHCb detector paper. The references are defined in the files `main.bib`, `LHCb-PAPER.bib`, `LHCb-CONF.bib`, `LHCb-DP.bib` `LHCb-TDR.bib` files, with obvious contents. Each of these have their `LHCb-ZZZ-20XX-0YY` number as their cite code. If you believe there is a problem with the formatting or content of one of the entries, then get in contact with the Editorial Board rather than just editing it in your local file, since you are likely to need the latest version just before submitting the article.

Table 4: Standard references.

Description	Ref.	`cite` code
Lee, Weinberg, Zumino	[8]	`Lee:1967iu`
Cabibbo, Kobayashi, Maskawa	[9]	`Cabibbo:1963yz,*Kobayashi:1`
Gell-Mann, Zweig	[10]	`GellMann:1964nj,*Zweig:3523`
Baryon asymmetry & SM *CP*	[11]	`Gavela:1994dt`
Baryon asymmetry & SM *CP*	[12]	`Gavela:1993ts`
EW Baryogenesis & *CP*	[13]	`Huet:1994jb`
Dalitz Plot[1]	[14]	`Dalitz:1953cp,*Fabri:1954zz`
PDG 2022	[3]	`PDG2022`
PDG 2020	[15]	`PDG2020`
PDG 2019	[16]	`PDG2019`
PDG 2018	[17]	`PDG2018`
PDG 2016	[18]	`PDG2016`
PDG 2014	[19]	`PDG2014`
HFLAV 2021	[20]	`HFLAV21`
HFLAV 2018	[21]	`HFLAV18`
HFLAV 2016	[22]	`HFLAV16`
HFLAV (pre-2016)	[23]	`Amhis:2014hma`
CKMfitter group	[24]	`CKMfitter2005`
CKMfitter group	[25]	`CKMfitter2015`
UTfit (Standard Model/CKM)	[26]	`UTfit-UT`
UTfit (New Physics)	[27]	`UTfit-NP`
Pythia	[28]	`Sjostrand:2007gs,*Sjostrand`
LHCb Pythia tuning	[29]	`LHCb-PROC-2010-056`
EvtGen	[30]	`Lange:2001uf`
Photos	[31]	`davidson2015photos`
Geant4	[32]	`Allison:2006ve, *Agostinell`
LHCb simulation	[33]	`LHCb-PROC-2011-006`
RapidSim	[34]	`Cowan:2016tnm`
Dirac	[35]	`Tsaregorodtsev:2010zz,*Bell`

[1]Dalitz invented the method, Fabri added relativistic corrections.

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HLT2 topological trigger	[36]	`BBDT`
Topological trigger reoptimization — Run 2	[37]	`LHCb-PROC-2015-018`
Turbo and real-time alignment — Run 2	[38]	`LHCb-PROC-2015-011`
TisTos method	[39]	`LHCb-PUB-2014-039`
Allen	[40]	`Aaij:2019zbu`
PIDCalib (for Run 1)	[41]	`LHCb-PUB-2016-021`
Ghost probability	[42]	`DeCian:2255039`
Primary vertex reconstruction	[43]	`Kucharczyk:1756296`
DecayTreeFitter	[44]	`Hulsbergen:2005pu`
SMOG	[45]	`FerroLuzzi:2005em`
Run-2 tagging	[46]	`Fazzini:2018dyq`
OS K, μ, e and VS tagging	[47]	`LHCb-PAPER-2011-027`
OS charm tagging	[48]	`LHCb-PAPER-2015-027`
SS kaon tagging	[49]	`LHCb-PAPER-2015-056`
SS proton and pion tagging	[50]	`LHCb-PAPER-2016-039`
Reommendations for multiple candidates	[51]	`Koppenburg:2017zsh`
See also Table 5 for LHCb performance references.		
sPlot	[52]	`Pivk:2004ty`
sFit	[53]	`Xie:2009rka`
Punzi's optimization	[54]	`Punzi:2003bu`
BDT	[55]	`Breiman`
BDT training	[56]	`AdaBoost`
TMVA[2]	[57]	`Hocker:2007ht,*TMVA4`
RooUnfold	[58]	`Adye:2011gm`
scikit-learn	[59]	`Scikit-learn-paper`
LAURA++	[60]	`Back:2017zqt`
`hep_ml`	[61]	`Rogozhnikov:2016bdp`
`root_numpy`	[62]	`root-numpy`
`GammaCombo`[3]	[64]	`GammaCombo`
TENSORFLOW	[65]	`tensorflow2015-whitepaper`
Crystal Ball function[4]	[6]	`Skwarnicki:1986xj`
Hypatia function	[66]	`Santos:2013gra`
Modified Novosibirsk function	[67]	`Ikeda:1999aq`
Bukin function	[68]	`Bukin:2007`
Wilks' theorem	[69]	`Wilks:1938dza`
CL$_s$ method	[70]	`CLs`
BLUE method	[71]	`Nisius:2020jmf`
Bootstrapping	[72]	`efron:1979`
Blatt–Weisskopf barrier	[73]	`Blatt:1952ije`
f_s/f_d at 7–8 TeV	[74]	`fsfd`

[2] Do not cite this instead of the actual reference for the MVA being used.

[3] Always cite this along with Ref. [63] as `\cite{GammaCombo,*LHCb-PAPER-2016-032}` (unless `LHCb-PAPER-2016-032` is cited elsewhere).

[4] A valid alternative for most papers where the normalisation is not critical is to use the expression"Gaussian function with a low-mass power-law tail" or "Gaussian function with power-law tails". In that case, no citation is needed

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LHC beam energy uncertainty	[75]	PhysRevAccelBeams.20.081003
Exotic hadron naming conventrion	[76]	LHCb-PUB-2022-013
Measurement of the instrumental asymmetry for $K^-\pi^+$-pairs at LHCb in Run 2	[77]	LHCb-PUB-2018-004

Table 5: LHCb detector performance papers.

LHCb-DP number	Title
LHCb-DP-2023-003 [78]	Momentum scale calibration of the LHCb spectrometer
LHCb-DP-2023-002 [79]	Helium indentification with LHCb
LHCb-DP-2023-001 [80]	Charge-dependent curvature-bias corrections using a pseudomass method
LHCb-DP-2022-002 [81]	The LHCb Upgrade I
LHCb-DP-2021-005 [?]	TBD
LHCb-DP-2021-004 [?]	TBD
LHCb-DP-2021-003 [?]	TBD
LHCb-DP-2021-002 [82]	Centrality determination in heavy-ion collisions with the LHCb detector
LHCb-DP-2021-001 [?]	TBD
LHCb-DP-2020-003 [83]	TBD
LHCb-DP-2020-002 [84]	TBD
LHCb-DP-2020-001 [85]	TBD
LHCb-DP-2019-006 [86]	TBD
LHCb-DP-2019-005 [87]	TBD
LHCb-DP-2019-004 [88]	Diphoton discrimination
LHCb-DP-2019-003 [89]	Electron reconstruction efficiency
LHCb-DP-2019-002 [90]	Real-Time analysis
LHCb-DP-2019-001 [91]	Run 2 trigger performance
LHCb-DP-2018-004 [92]	ReDecay
LHCb-DP-2018-003 [93]	Radiation damage in TT
LHCb-DP-2018-002 [94]	VeLo material map using SMOG
LHCb-DP-2018-001 [95]	PIDCalib for Run 2 (use Ref. [41] for Run 1)
LHCb-DP-2017-001 [96]	Performance of the Outer Tracker — Run 2
LHCb-DP-2016-003 [97]	HeRSCheL
LHCb-DP-2016-001 [98]	TESLA project — Run 2
LHCb-DP-2014-002 [99]	LHCb detector performance
LHCb-DP-2014-001 [100]	Performance of the LHCb Vertex Locator
LHCb-DP-2013-003 [101]	Performance of the LHCb Outer Tracker — Run 1
LHCb-DP-2013-002 [102]	Measurement of the track reconstruction efficiency at LHCb
LHCb-DP-2013-001 [103]	Performance of the muon identification at LHCb
LHCb-DP-2012-005 [104]	Radiation damage in the LHCb Vertex Locator
LHCb-DP-2012-004 [105]	The LHCb trigger and its performance in 2011
LHCb-DP-2012-003 [106]	Performance of the LHCb RICH detector at the LHC
LHCb-DP-2012-002 [107]	Performance of the LHCb muon system
LHCb-DP-2012-001 [108]	Radiation hardness of the LHCb Outer Tracker
LHCb-DP-2011-002 [109]	Simulation of machine induced background ...

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LHCb-DP-2011-001 [110]	Performance of the LHCb muon system with cosmic rays
LHCb-DP-2010-001 [111]	First spatial alignment of the LHCb VELO ...
LHCb-DP-2008-001 [112]	LHCb detector

Table 6: LHCb TDRs.

LHCb-TDR number	Title
LHCb-TDR-023 [113]	Framework TDR for LHCb Upgrade II
LHCb-TDR-022 [114]	PLUME
LHCb-TDR-021 [115]	Allen
LHCb-TDR-020 [116]	SMOG Upgrade
LHCb-TDR-018 [117]	Upgrade computing model
LHCb-PII-Physics [118]	Phase-II upgrade physics case
LHCb-PII-EoI [119]	Expression of interest for Phase-II upgrade
LHCb-TDR-017 [120]	Upgrade software and computing
LHCb-TDR-016 [121]	Trigger and online upgrade
LHCb-TDR-015 [122]	Tracker upgrade
LHCb-TDR-014 [123]	PID upgrade
LHCb-TDR-013 [124]	VELO upgrade
LHCb-TDR-012 [125]	Framework TDR for the upgrade
LHCb-TDR-011 [126]	Computing
LHCb-TDR-010 [127]	Trigger
LHCb-TDR-009 [128]	Reoptimized detector
LHCb-TDR-008 [129]	Inner Tracker
LHCb-TDR-007 [130]	Online, DAQ, ECS
LHCb-TDR-006 [131]	Outer Tracker
LHCb-TDR-005 [132]	VELO
LHCb-TDR-004 [133]	Muon system
LHCb-TDR-003 [134]	RICH
LHCb-TDR-002 [135]	Calorimeters
LHCb-TDR-001 [136]	Magnet

Table 7: LHCb-PAPERs (which have their identifier as their cite code). DNE: Does not exist.

LHCb-PAPER-2024-003 [137]	LHCb-PAPER-2024-002 [138]	LHCb-PAPER-2024-001 [139]	LHCb-PAPER-2023-047 [140]	LHCb-PAPER-2023-046 [141]
LHCb-PAPER-2023-045 [142]	LHCb-PAPER-2023-044 [143]	LHCb-PAPER-2023-043 [144]	LHCb-PAPER-2023-042 [145]	LHCb-PAPER-2023-041 [146]
LHCb-PAPER-2023-040 [147]	LHCb-PAPER-2023-039 [148]	LHCb-PAPER-2023-038 [149]	LHCb-PAPER-2023-037 [150]	LHCb-PAPER-2023-036 [151]
LHCb-PAPER-2023-035 [152]	LHCb-PAPER-2023-034 [153]	LHCb-PAPER-2023-033 [154]	LHCb-PAPER-2023-032 [155]	LHCb-PAPER-2023-031 [156]
LHCb-PAPER-2023-030 [157]	LHCb-PAPER-2023-029 [158]	LHCb-PAPER-2023-028 [159]	LHCb-PAPER-2023-027 [160]	LHCb-PAPER-2023-026 [161]
LHCb-PAPER-2023-025 [162]	LHCb-PAPER-2023-024 [163]	LHCb-PAPER-2023-023 [164]	LHCb-PAPER-2023-022 [165]	LHCb-PAPER-2023-021 [166]
LHCb-PAPER-2023-020 [167]	LHCb-PAPER-2023-019 [168]	LHCb-PAPER-2023-018 [169]	LHCb-PAPER-2023-017 [170]	LHCb-PAPER-2023-016 [171]
LHCb-PAPER-2023-015 [172]	LHCb-PAPER-2023-014 [173]	LHCb-PAPER-2023-013 [174]	LHCb-PAPER-2023-012 [175]	LHCb-PAPER-2023-011 [176]
LHCb-PAPER-2023-010 [177]	LHCb-PAPER-2023-009 [178]	LHCb-PAPER-2023-008 [179]	LHCb-PAPER-2023-007 [180]	LHCb-PAPER-2023-006 [181]
LHCb-PAPER-2023-005 [182]	LHCb-PAPER-2023-004 [183]	LHCb-PAPER-2023-003 [184]	LHCb-PAPER-2023-002 [185]	LHCb-PAPER-2023-001 [186]
LHCb-PAPER-2022-060 [187]	LHCb-PAPER-2022-059 [188]	LHCb-PAPER-2022-058 [189]	LHCb-PAPER-2022-057 [190]	LHCb-PAPER-2022-056 [191]
LHCb-PAPER-2022-055 [192]	LHCb-PAPER-2022-054 [193]	LHCb-PAPER-2022-053 [194]	LHCb-PAPER-2022-052 [195]	LHCb-PAPER-2022-051 [196]
LHCb-PAPER-2022-050 [197]	LHCb-PAPER-2022-049 [198]	LHCb-PAPER-2022-048 [199]	LHCb-PAPER-2022-047 [200]	LHCb-PAPER-2022-046 [201]
LHCb-PAPER-2022-045 [202]	LHCb-PAPER-2022-044 [203]	LHCb-PAPER-2022-043 [204]	LHCb-PAPER-2022-042 [205]	LHCb-PAPER-2022-041 [1]
LHCb-PAPER-2022-040 [206]	LHCb-PAPER-2022-039 [207]	LHCb-PAPER-2022-038 [208]	LHCb-PAPER-2022-037 [209]	LHCb-PAPER-2022-036 [210]
LHCb-PAPER-2022-035 [211]	LHCb-PAPER-2022-034 [212]	LHCb-PAPER-2022-033 [213]	LHCb-PAPER-2022-032 [214]	LHCb-PAPER-2022-031 [215]
LHCb-PAPER-2022-030 [216]	LHCb-PAPER-2022-029 [217]	LHCb-PAPER-2022-028 [218]	LHCb-PAPER-2022-027 [219]	LHCb-PAPER-2022-026 [220]
LHCb-PAPER-2022-025 [221]	LHCb-PAPER-2022-024 [222]	LHCb-PAPER-2022-023 [223]	LHCb-PAPER-2022-022 [224]	LHCb-PAPER-2022-021 [225]
LHCb-PAPER-2022-020 [226]	LHCb-PAPER-2022-019 [227]	LHCb-PAPER-2022-018 [228]	LHCb-PAPER-2022-017 [229]	LHCb-PAPER-2022-016 [230]

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LHCb-PAPER-2022-015 [231]	LHCb-PAPER-2022-014 [232]	LHCb-PAPER-2022-013 [233]	LHCb-PAPER-2022-012 [234]	LHCb-PAPER-2022-011 [235]
LHCb-PAPER-2022-010 [236]	LHCb-PAPER-2022-009 [237]	LHCb-PAPER-2022-008 [238]	LHCb-PAPER-2022-007 [5]	LHCb-PAPER-2022-006 [239]
LHCb-PAPER-2022-005 [240]	LHCb-PAPER-2022-004 [241]	LHCb-PAPER-2022-003 [242]	LHCb-PAPER-2022-002 [243]	LHCb-PAPER-2022-001 [244]
LHCb-PAPER-2021-053 [245]	LHCb-PAPER-2021-052 [246]	LHCb-PAPER-2021-051 [247]		
LHCb-PAPER-2021-050 [248]	LHCb-PAPER-2021-049 [249]	LHCb-PAPER-2021-048 [250]	LHCb-PAPER-2021-047 [251]	LHCb-PAPER-2021-046 [252]
LHCb-PAPER-2021-045 [253]	LHCb-PAPER-2021-044 [254]	LHCb-PAPER-2021-043 [255]	LHCb-PAPER-2021-042 [256]	LHCb-PAPER-2021-041 [257]
LHCb-PAPER-2021-040 [258]	LHCb-PAPER-2021-039 [259]	LHCb-PAPER-2021-038 [260]	LHCb-PAPER-2021-037 [261]	LHCb-PAPER-2021-036 [262]
LHCb-PAPER-2021-035 [263]	LHCb-PAPER-2021-034 [264]	LHCb-PAPER-2021-033 [265]	LHCb-PAPER-2021-032 [266]	LHCb-PAPER-2021-031 [267]
LHCb-PAPER-2021-030 [268]	LHCb-PAPER-2021-029 [269]	LHCb-PAPER-2021-028 [270]	LHCb-PAPER-2021-027 [271]	LHCb-PAPER-2021-026 [272]
LHCb-PAPER-2021-025 [273]	LHCb-PAPER-2021-024 [274]	LHCb-PAPER-2021-023 [275]	LHCb-PAPER-2021-022 [276]	LHCb-PAPER-2021-021 [277]
LHCb-PAPER-2021-020 [278]	LHCb-PAPER-2021-019 [279]	LHCb-PAPER-2021-018 [280]	LHCb-PAPER-2021-017 [281]	LHCb-PAPER-2021-016 [282]
LHCb-PAPER-2021-015 [283]	LHCb-PAPER-2021-014 [284]	LHCb-PAPER-2021-013 [285]	LHCb-PAPER-2021-012 [286]	LHCb-PAPER-2021-011 [287]
LHCb-PAPER-2021-010 [288]	LHCb-PAPER-2021-009 [289]	LHCb-PAPER-2021-008 [290]	LHCb-PAPER-2021-007 [291]	LHCb-PAPER-2021-006 [292]
LHCb-PAPER-2021-005 [293]	LHCb-PAPER-2021-004 [294]	LHCb-PAPER-2021-003 [295]	LHCb-PAPER-2021-002 [296]	LHCb-PAPER-2021-001 [297]
LHCb-PAPER-2020-048 [298]	LHCb-PAPER-2020-047 [299]	LHCb-PAPER-2020-046 [300]		
LHCb-PAPER-2020-045 [301]	LHCb-PAPER-2020-044 [302]	LHCb-PAPER-2020-043 [303]	LHCb-PAPER-2020-042 [304]	LHCb-PAPER-2020-041 [305]
LHCb-PAPER-2020-040 [306]	LHCb-PAPER-2020-039 [307]	LHCb-PAPER-2020-038 [308]	LHCb-PAPER-2020-037 [309]	LHCb-PAPER-2020-036 [310]
LHCb-PAPER-2020-035 [311]	LHCb-PAPER-2020-034 [312]	LHCb-PAPER-2020-033 [313]	LHCb-PAPER-2020-032 [314]	LHCb-PAPER-2020-031 [315]
LHCb-PAPER-2020-030 [316]	LHCb-PAPER-2020-029 [317]	LHCb-PAPER-2020-028 [318]	LHCb-PAPER-2020-027 [319]	LHCb-PAPER-2020-026 [320]
LHCb-PAPER-2020-025 [321]	LHCb-PAPER-2020-024 [322]	LHCb-PAPER-2020-023 [323]	LHCb-PAPER-2020-022 [324]	LHCb-PAPER-2020-021 [325]
LHCb-PAPER-2020-020 [326]	LHCb-PAPER-2020-019 [327]	LHCb-PAPER-2020-018 [328]	LHCb-PAPER-2020-017 [329]	LHCb-PAPER-2020-016 [330]
LHCb-PAPER-2020-015 [331]	LHCb-PAPER-2020-014 [332]	LHCb-PAPER-2020-013 [333]	LHCb-PAPER-2020-012 [334]	LHCb-PAPER-2020-011 [335]
LHCb-PAPER-2020-010 [336]	LHCb-PAPER-2020-009 [337]	LHCb-PAPER-2020-008 [338]	LHCb-PAPER-2020-007 [339]	LHCb-PAPER-2020-006 [340]
LHCb-PAPER-2020-005 [341]	LHCb-PAPER-2020-004 [342]	LHCb-PAPER-2020-003 [343]	LHCb-PAPER-2020-002 [344]	LHCb-PAPER-2020-001 [345]
LHCb-PAPER-2019-046 [346]				
LHCb-PAPER-2019-045 [347]	LHCb-PAPER-2019-044 [348]	LHCb-PAPER-2019-043 [349]	LHCb-PAPER-2019-042 [350]	LHCb-PAPER-2019-041 [351]
LHCb-PAPER-2019-040 [352]	LHCb-PAPER-2019-039 [353]	LHCb-PAPER-2019-038 [354]	LHCb-PAPER-2019-037 [355]	LHCb-PAPER-2019-036 [356]
LHCb-PAPER-2019-035 [357]	LHCb-PAPER-2019-034 [358]	LHCb-PAPER-2019-033 [359]	LHCb-PAPER-2019-032 [360]	LHCb-PAPER-2019-031 [361]
LHCb-PAPER-2019-030 [362]	LHCb-PAPER-2019-029 [363]	LHCb-PAPER-2019-028 [364]	LHCb-PAPER-2019-027 [365]	LHCb-PAPER-2019-026 [366]
LHCb-PAPER-2019-025 [367]	LHCb-PAPER-2019-024 [368]	LHCb-PAPER-2019-023 [369]	LHCb-PAPER-2019-022 [370]	LHCb-PAPER-2019-021 [4]
LHCb-PAPER-2019-020 [371]	LHCb-PAPER-2019-019 [372]	LHCb-PAPER-2019-018 [373]	LHCb-PAPER-2019-017 [374]	LHCb-PAPER-2019-016 [375]
LHCb-PAPER-2019-015 [376]	LHCb-PAPER-2019-014 [377]	LHCb-PAPER-2019-013 [378]	LHCb-PAPER-2019-012 [379]	LHCb-PAPER-2019-011 [380]
LHCb-PAPER-2019-010 [381]	LHCb-PAPER-2019-009 [382]	LHCb-PAPER-2019-008 [383]	LHCb-PAPER-2019-007 [384]	LHCb-PAPER-2019-006 [385]
LHCb-PAPER-2019-005 [386]	LHCb-PAPER-2019-004 [387]	LHCb-PAPER-2019-003 [388]	LHCb-PAPER-2019-002 [389]	LHCb-PAPER-2019-001 [390]
LHCb-PAPER-2018-051 [391]				
LHCb-PAPER-2018-050 [392]	LHCb-PAPER-2018-049 [393]	LHCb-PAPER-2018-048 [394]	LHCb-PAPER-2018-047 [395]	LHCb-PAPER-2018-046 [396]
LHCb-PAPER-2018-045 [397]	LHCb-PAPER-2018-044 [398]	LHCb-PAPER-2018-043 [399]	LHCb-PAPER-2018-042 [400]	LHCb-PAPER-2018-041 [401]
LHCb-PAPER-2018-040 [402]	LHCb-PAPER-2018-039 [403]	LHCb-PAPER-2018-038 [404]	LHCb-PAPER-2018-037 [405]	LHCb-PAPER-2018-036 [406]
LHCb-PAPER-2018-035 [407]	LHCb-PAPER-2018-034 [408]	LHCb-PAPER-2018-033 [409]	LHCb-PAPER-2018-032 [410]	LHCb-PAPER-2018-031 [411]
LHCb-PAPER-2018-030 [412]	LHCb-PAPER-2018-029 [413]	LHCb-PAPER-2018-028 [414]	LHCb-PAPER-2018-027 [415]	LHCb-PAPER-2018-026 [416]
LHCb-PAPER-2018-025 [417]	LHCb-PAPER-2018-024 [418]	LHCb-PAPER-2018-023 [419]	LHCb-PAPER-2018-022 [420]	LHCb-PAPER-2018-021 [2]
LHCb-PAPER-2018-020 [421]	LHCb-PAPER-2018-019 [422]	LHCb-PAPER-2018-018 [423]	LHCb-PAPER-2018-017 [424]	LHCb-PAPER-2018-016 [425]
LHCb-PAPER-2018-015 [426]	LHCb-PAPER-2018-014 [427]	LHCb-PAPER-2018-013 [428]	LHCb-PAPER-2018-012 [429]	LHCb-PAPER-2018-011 [430]
LHCb-PAPER-2018-010 [431]	LHCb-PAPER-2018-009 [432]	LHCb-PAPER-2018-008 [433]	LHCb-PAPER-2018-007 [434]	LHCb-PAPER-2018-006 [435]
LHCb-PAPER-2018-005 [436]	LHCb-PAPER-2018-004 [437]	LHCb-PAPER-2018-003 [438]	LHCb-PAPER-2018-002 [439]	LHCb-PAPER-2018-001 [440]
LHCb-PAPER-2017-050 [441]	LHCb-PAPER-2017-049 [442]	LHCb-PAPER-2017-048 [443]	LHCb-PAPER-2017-047 [444]	LHCb-PAPER-2017-046 [445]
LHCb-PAPER-2017-045 [446]	LHCb-PAPER-2017-044 [447]	LHCb-PAPER-2017-043 [448]	LHCb-PAPER-2017-042 [449]	LHCb-PAPER-2017-041 [450]
LHCb-PAPER-2017-040 [451]	LHCb-PAPER-2017-039 [452]	LHCb-PAPER-2017-038 [453]	LHCb-PAPER-2017-037 [454]	LHCb-PAPER-2017-036 [455]
LHCb-PAPER-2017-035 [456]	LHCb-PAPER-2017-034 [457]	LHCb-PAPER-2017-033 [458]	LHCb-PAPER-2017-032 [459]	LHCb-PAPER-2017-031 [460]
LHCb-PAPER-2017-030 [461]	LHCb-PAPER-2017-029 [462]	LHCb-PAPER-2017-028 [463]	LHCb-PAPER-2017-027 [464]	LHCb-PAPER-2017-026 [465]
LHCb-PAPER-2017-025 [466]	LHCb-PAPER-2017-024 [467]	LHCb-PAPER-2017-023 [468]	LHCb-PAPER-2017-022 [469]	LHCb-PAPER-2017-021 [470]
LHCb-PAPER-2017-020 [471]	LHCb-PAPER-2017-019 [472]	LHCb-PAPER-2017-018 [473]	LHCb-PAPER-2017-017 [474]	LHCb-PAPER-2017-016 [475]
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Table 8: LHCb-CONFs (which have their identifier as their cite code). Most CONF notes have been superseded by a paper and are thus retired. This is indicated in the bibtex entry. Do not cite retired CONF notes. DNE: Does not exist.

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LHCb-CONF-2011-015 [1001]	LHCb-CONF-2011-014 [1002]	LHCb-CONF-2011-013 [1003]	LHCb-CONF-2011-012 [1004]	LHCb-CONF-2011-011 [1005]
LHCb-CONF-2011-010 [1006]	LHCb-CONF-2011-009 [1007]	LHCb-CONF-2011-008 [1008]	LHCb-CONF-2011-007 [1009]	LHCb-CONF-2011-006 [1010]
LHCb-CONF-2011-005 [1011]	LHCb-CONF-2011-004 [1012]	LHCb-CONF-2011-003 [1013]	LHCb-CONF-2011-002 [1014]	LHCb-CONF-2011-001 [1015]
LHCb-CONF-2010-014 [1016]	LHCb-CONF-2010-013 [1017]	LHCb-CONF-2010-012 [1018]	LHCb-CONF-2010-011 [1019]	
LHCb-CONF-2010-010 [1020]	LHCb-CONF-2010-009 [1021]	LHCb-CONF-2010-008 [1022]		
Earlier documents in LHCb-CONF series are actually proceedings.				

[5]LHCb-PAPER-2011-039 does not exist.

[6]If you cite the gamma combination, always also cite the latest gamma paper as `\cite{LHCb-PAPER-2013-020,*LHCb-CONF-2018-002}` (unless you cite LHCb-PAPER-2013-020 separately too).

B Standard symbols

As explained in Sect. ?? this appendix contains standard typesetting of symbols, particle names, units etc. in LHCb documents.

In the file `lhcb-symbols-def.tex`, which is included, a large number of symbols is defined. While they can lead to quicker typing, the main reason is to ensure a uniform notation within a document and between different LHCb documents. If a symbol like `\CP` to typeset *CP* violation is available for a unit, particle name, process or whatever, it should be used. If you do not agree with the notation you should ask to get the definition in `lhcb-symbols-def.tex` changed rather than just ignoring it.

All the main particles have been given symbols. The B mesons are thus named B^+, B^0, B^0_s, and B^+_c. There is no need to go into math mode to use particle names, thus saving the typing of many $ signs. By default particle names are typeset in italic type to agree with the PDG preference. To get roman particle names you can just change `\setboolean{uprightparticles}{false}` to `true` at the top of this template.

There is a large number of units typeset that ensures the correct use of fonts, capitals and spacing. As an example we have $m_{B^0_s} = 5366.3 \pm 0.6\,\mathrm{MeV}/c^2$. Note that μm is typeset with an upright μ, even if the particle names have slanted Greek letters.

A set of useful symbols are defined for working groups. More of these symbols can be included later. As an example in the Rare Decay group we have several different analyses looking for a measurement of $\mathcal{C}_7^{\prime(\mathrm{eff})}$ and $\mathcal{O}_7^{\prime}$.

C List of all symbols

C.1 Experiments

`\lhcb`	LHCb	`\atlas`	ATLAS	`\cms`	CMS
`\alice`	ALICE	`\babar`	BaBar	`\belle`	Belle
`\belletwo`	Belle II	`\besiii`	BESIII	`\cleo`	CLEO
`\cdf`	CDF	`\dzero`	D0	`\aleph`	ALEPH
`\delphi`	DELPHI	`\opal`	OPAL	`\lthree`	L3
`\sld`	SLD	`\cern`	CERN	`\lhc`	LHC
`\lep`	LEP	`\tevatron`	Tevatron	`\bfactories`	B Factories
`\bfactory`	B Factory	`\upgradeone`	Upgrade I	`\upgradetwo`	Upgrade II

216 C.1.1 LHCb sub-detectors and sub-systems

	`\velo`	VELO	`\rich`	RICH	`\richone`	RICH1
	`\richtwo`	RICH2	`\ttracker`	TT	`\intr`	IT
	`\st`	ST	`\ot`	OT	`\herschel`	HeRSCheL
	`\spd`	SPD	`\presh`	PS	`\ecal`	ECAL
217	`\hcal`	HCAL	`\MagUp`	*MagUp*	`\MagDown`	*MagDown*
	`\ode`	ODE	`\daq`	DAQ	`\tfc`	TFC
	`\ecs`	ECS	`\lone`	L0	`\hlt`	HLT
	`\hltone`	HLT1	`\hlttwo`	HLT2		

218 C.2 Particles

219 C.2.1 Leptons

	`\electron`	e	`\en`	e^-	`\ep`	e^+
	`\epm`	$e^\pm$	`\emp`	$e^\mp$	`\epem`	e^+e^-
	`\muon`	μ	`\mup`	μ^+	`\mun`	μ^-
	`\mupm`	$\mu^\pm$	`\mump`	$\mu^\mp$	`\mumu`	$\mu^+\mu^-$
	`\tauon`	τ	`\taup`	τ^+	`\taum`	τ^-
	`\taupm`	$\tau^\pm$	`\taump`	$\tau^\mp$	`\tautau`	$\tau^+\tau^-$
220	`\lepton`	ℓ	`\ellm`	ℓ^-	`\ellp`	ℓ^+
	`\ellpm`	$\ell^\pm$	`\ellmp`	$\ell^\mp$	`\ellell`	$\ell^+\ell^-$
	`\neu`	ν	`\neub`	$\overline{\nu}$	`\neue`	ν_e
	`\neueb`	$\overline{\nu}_e$	`\neum`	ν_μ	`\neumb`	$\overline{\nu}_\mu$
	`\neut`	ν_τ	`\neutb`	$\overline{\nu}_\tau$	`\neul`	ν_ℓ
	`\neulb`	$\overline{\nu}_\ell$				

221 C.2.2 Gauge bosons and scalars

	`\g`	γ	`\H`	H^0	`\Hp`	H^+
	`\Hm`	H^-	`\Hpm`	$H^\pm$	`\W`	W
222	`\Wp`	W^+	`\Wm`	W^-	`\Wpm`	$W^\pm$
	`\Z`	Z				

223 C.2.3 Quarks

	`\quark`	q	`\quarkbar`	$\overline{q}$	`\qqbar`	$q\overline{q}$
	`\uquark`	u	`\uquarkbar`	$\overline{u}$	`\uubar`	$u\overline{u}$
	`\dquark`	d	`\dquarkbar`	$\overline{d}$	`\ddbar`	$d\overline{d}$
224	`\squark`	s	`\squarkbar`	$\overline{s}$	`\ssbar`	$s\overline{s}$
	`\cquark`	c	`\cquarkbar`	$\overline{c}$	`\ccbar`	$c\overline{c}$
	`\bquark`	b	`\bquarkbar`	$\overline{b}$	`\bbbar`	$b\overline{b}$
	`\tquark`	t	`\tquarkbar`	$\overline{t}$	`\ttbar`	$t\overline{t}$

225 ### C.2.4 Light mesons

\hadron	h	\pion	π	\piz	π^0
\pip	π^+	\pim	π^-	\pipm	$\pi^\pm$
\pimp	$\pi^\mp$	\rhomeson	ρ	\rhoz	ρ^0
\rhop	ρ^+	\rhom	ρ^-	\rhopm	$\rho^\pm$
\rhomp	$\rho^\mp$	\kaon	K	\Kbar	$\overline{K}$
\Kb	$\overline{K}$	\KorKbar	$\overset{(-)}{K}$	\Kz	K^0
226 \Kzb	$\overline{K}^0$	\Kp	K^+	\Km	K^-
\Kpm	$K^\pm$	\Kmp	$K^\mp$	\KS	K^0_{S}
\Vzero	V^0	\KL	K^0_{L}	\Kstarz	K^{*0}
\Kstarzb	$\overline{K}^{*0}$	\Kstar	K^*	\Kstarb	$\overline{K}^*$
\Kstarp	K^{*+}	\Kstarm	K^{*-}	\Kstarpm	$K^{*\pm}$
\Kstarmp	$K^{*\mp}$	\KorKbarz	$\overset{(-)}{K}{}^0$	\etaz	η
\etapr	η'	\phiz	ϕ	\omegaz	ω

227 ### C.2.5 Charmed mesons

\Dbar	$\overline{D}$	\D	D	\Db	$\overline{D}$
\DorDbar	$\overset{(-)}{D}$	\Dz	D^0	\Dzb	$\overline{D}^0$
\Dp	D^+	\Dm	D^-	\Dpm	$D^\pm$
\Dmp	$D^\mp$	\DpDm	D^+D^-	\Dstar	D^*
\Dstarb	$\overline{D}^*$	\Dstarz	D^{*0}	\Dstarzb	$\overline{D}^{*0}$
\theDstarz	$D^*(2007)^0$	\theDstarzb	$\overline{D}^*(2007)^0$	\Dstarp	D^{*+}
228 \Dstarm	D^{*-}	\Dstarpm	$D^{*\pm}$	\Dstarmp	$D^{*\mp}$
\theDstarp	$D^*(2010)^+$	\theDstarm	$D^*(2010)^-$	\theDstarpm	$D^*(2010)^\pm$
\theDstarmp	$D^*(2010)^\mp$	\Ds	D^+_s	\Dsp	D^+_s
\Dsm	D^-_s	\Dspm	$D^\pm_s$	\Dsmp	$D^\mp_s$
\Dss	D^{*+}_s	\Dssp	D^{*+}_s	\Dssm	D^{*-}_s
\Dsspm	$D^{*\pm}_s$	\Dssmp	$D^{*\mp}_s$	\DporDsp	$D^+_{(s)}$
\DmorDsm	$D^-_{(s)}$	\DpmorDspm	$D^\pm_{(s)}$		

229 ### C.2.6 Beauty mesons

\B	B	\Bbar	$\overline{B}$	\Bb	$\overline{B}$
\BorBbar	$\overset{(-)}{B}$	\Bz	B^0	\Bzb	$\overline{B}^0$
\Bd	B^0	\Bdb	$\overline{B}^0$	\BdorBdbar	$\overset{(-)}{B}{}^0$
\Bu	B^+	\Bub	B^-	\Bp	B^+
230 \Bm	B^-	\Bpm	$B^\pm$	\Bmp	$B^\mp$
\Bs	B^0_s	\Bsb	$\overline{B}^0_s$	\BsorBsbar	$\overset{(-)}{B}{}^0_s$
\Bc	B^+_c	\Bcp	B^+_c	\Bcm	B^-_c
\Bcpm	$B^\pm_c$	\Bds	$B^0_{(s)}$	\Bdsb	$\overline{B}^0_{(s)}$
\BdorBs	$B^0_{(s)}$	\BdorBsbar	$\overline{B}^0_{(s)}$		

231 ### C.2.7 Onia

\jpsi	J/ψ	\psitwos	$\psi(2S)$	\psiprpr	$\psi(3770)$
\etac	η_c	\psires	ψ	\chic	χ_c
\chiczero	χ_{c0}	\chicone	χ_{c1}	\chictwo	χ_{c2}
\chicJ	χ_{cJ}	\Upsilonres	Υ	\OneS	$\Upsilon(1S)$
232 \TwoS	$\Upsilon(2S)$	\ThreeS	$\Upsilon(3S)$	\FourS	$\Upsilon(4S)$
\FiveS	$\Upsilon(5S)$	\chib	χ_b	\chibzero	χ_{b0}
\chibone	χ_{b1}	\chibtwo	χ_{b2}	\chibJ	χ_{bJ}
\theX	$\chi_{c1}(3872)$				

233 ### C.2.8 Light Baryons

\proton	p	\antiproton	$\overline{p}$	\neutron	n
\antineutron	$\overline{n}$	\Deltares	Δ	\Deltaresbar	$\overline{\Delta}$
\Lz	Λ	\Lbar	$\overline{\Lambda}$	\LorLbar	$\overset{(-)}{\Lambda}$
\Lambdares	Λ	\Lambdaresbar	$\overline{\Lambda}$	\Sigmares	Σ
\Sigmaz	Σ^0	\Sigmap	Σ^+	\Sigmam	Σ^-
234 \Sigmaresbar	$\overline{\Sigma}$	\Sigmabarz	$\overline{\Sigma}^0$	\Sigmabarp	$\overline{\Sigma}^+$
\Sigmabarm	$\overline{\Sigma}^-$	\Xires	Ξ	\Xiz	Ξ^0
\Xim	Ξ^-	\Xiresbar	$\overline{\Xi}$	\Xibarz	$\overline{\Xi}^0$
\Xibarp	$\overline{\Xi}^+$	\Omegares	Ω	\Omegaresbar	$\overline{\Omega}$
\Omegam	Ω^-	\Omegabarp	$\overline{\Omega}^+$		

235 ### C.2.9 Charmed Baryons

\Lc	Λ_c^+	\Lcbar	$\overline{\Lambda}_c^-$	\Xic	Ξ_c
\Xicz	Ξ_c^0	\Xicp	Ξ_c^+	\Xicbar	$\overline{\Xi}_c$
\Xicbarz	$\overline{\Xi}_c^0$	\Xicbarm	$\overline{\Xi}_c^-$	\Omegac	Ω_c^0
236 \Omegacbar	$\overline{\Omega}_c^0$	\Xicc	Ξ_{cc}	\Xiccbar	$\overline{\Xi}_{cc}$
\Xiccp	Ξ_{cc}^+	\Xiccpp	Ξ_{cc}^{++}	\Xiccbarm	$\overline{\Xi}_{cc}^-$
\Xiccbarmm	$\overline{\Xi}_{cc}^{--}$	\Omegacc	Ω_{cc}^+	\Omegaccbar	$\overline{\Omega}_{cc}^-$
\Omegaccc	Ω_{ccc}^{++}	\Omegacccbar	$\overline{\Omega}_{ccc}^{--}$		

237 ### C.2.10 Beauty Baryons

\Lb	Λ_b^0	\Lbbar	$\overline{\Lambda}_b^0$	\Sigmab	Σ_b
\Sigmabp	Σ_b^+	\Sigmabz	Σ_b^0	\Sigmabm	Σ_b^-
\Sigmabpm	$\Sigma_b^\pm$	\Sigmabbar	$\overline{\Sigma}_b$	\Sigmabbarp	$\overline{\Sigma}_b^+$
238 \Sigmabbarz	$\overline{\Sigma}_b^0$	\Sigmabbarm	$\overline{\Sigma}_b^-$	\Sigmabbarpm	$\overline{\Sigma}_b^-$
\Xib	Ξ_b	\Xibz	Ξ_b^0	\Xibm	Ξ_b^-
\Xibbar	$\overline{\Xi}_b$	\Xibbarz	$\overline{\Xi}_b^0$	\Xibbarp	$\overline{\Xi}_b^+$
\Omegab	Ω_b^-	\Omegabbar	$\overline{\Omega}_b^+$		

C.3 Physics symbols

C.3.1 Decays

`\BF`	$\mathcal{B}$	`\BR`	$\mathcal{B}$	`\BRvis`	$\mathcal{B}_{\text{vis}}$
`\ra`	$\rightarrow$	`\to`	$\rightarrow$		

C.3.2 Lifetimes

`\tauBs`	$\tau_{B^0_s}$	`\tauBd`	τ_{B^0}	`\tauBz`	τ_{B^0}
`\tauBu`	τ_{B^+}	`\tauDp`	τ_{D^+}	`\tauDz`	τ_{D^0}
`\tauL`	τ_{L}	`\tauH`	τ_{H}		

C.3.3 Masses

`\mBd`	m_{B^0}	`\mBp`	m_{B^+}	`\mBs`	$m_{B^0_s}$
`\mBc`	$m_{B_c^+}$	`\mLb`	$m_{\Lambda_b^0}$		

C.3.4 EW theory, groups

`\grpsuthree`	$\mathrm{SU}(3)$	`\grpsutw`	$\mathrm{SU}(2)$	`\grpuone`	$\mathrm{U}(1)$
`\ssqtw`	$\sin^2\theta_{\mathrm{W}}$	`\csqtw`	$\cos^2\theta_{\mathrm{W}}$	`\stw`	$\sin\theta_{\mathrm{W}}$
`\ctw`	$\cos\theta_{\mathrm{W}}$	`\ssqtwef`	$\sin^2\theta^{\mathrm{eff}}_{\mathrm{W}}$	`\csqtwef`	$\cos^2\theta^{\mathrm{eff}}_{\mathrm{W}}$
`\stwef`	$\sin\theta^{\mathrm{eff}}_{\mathrm{W}}$	`\ctwef`	$\cos\theta^{\mathrm{eff}}_{\mathrm{W}}$	`\gv`	g_{V}
`\ga`	g_{A}	`\order`	$\mathcal{O}$	`\ordalph`	$\mathcal{O}(\alpha)$
`\ordalsq`	$\mathcal{O}(\alpha^2)$	`\ordalcb`	$\mathcal{O}(\alpha^3)$		

C.3.5 QCD parameters

`\as`	α_s	`\MSb`	$\overline{\mathrm{MS}}$	`\lqcd`	Λ_{QCD}
`\qsq`	q^2				

C.3.6 CKM, *CP* violation

`\eps`	ε	`\epsK`	ε_K	`\epsB`	ε_B
`\epsp`	ε'_K	`\CP`	CP	`\CPT`	CPT
`\T`	T	`\rhobar`	$\overline{\rho}$	`\etabar`	$\overline{\eta}$
`\Vud`	V_{ud}	`\Vcd`	V_{cd}	`\Vtd`	V_{td}
`\Vus`	V_{us}	`\Vcs`	V_{cs}	`\Vts`	V_{ts}
`\Vub`	V_{ub}	`\Vcb`	V_{cb}	`\Vtb`	V_{tb}
`\Vuds`	V_{ud}^*	`\Vcds`	V_{cd}^*	`\Vtds`	V_{td}^*
`\Vuss`	V_{us}^*	`\Vcss`	V_{cs}^*	`\Vtss`	V_{ts}^*
`\Vubs`	V_{ub}^*	`\Vcbs`	V_{cb}^*	`\Vtbs`	V_{tb}^*

252 ### C.3.7 Oscillations

	\dm	Δm	\dms	Δm_s	\dmd	Δm_d
	\DG	$\Delta\Gamma$	\DGs	$\Delta\Gamma_s$	\DGd	$\Delta\Gamma_d$
	\Gs	Γ_s	\Gd	Γ_d	\MBq	M_{B_q}
	\DGq	$\Delta\Gamma_q$	\Gq	Γ_q	\dmq	Δm_q
	\GL	$\Gamma_{\rm L}$	\GH	$\Gamma_{\rm H}$	\DGsGs	$\Delta\Gamma_s/\Gamma_s$
253	\Delm	Δm	\ACP	$\mathcal{A}^{CP}$	\Adir	$\mathcal{A}^{\rm dir}$
	\Amix	$\mathcal{A}^{\rm mix}$	\ADelta	$\mathcal{A}^{\Delta}$	\phid	ϕ_d
	\sinphid	$\sin\phi_d$	\phis	ϕ_s	\betas	β_s
	\sbetas	$\sigma(\beta_s)$	\stbetas	$\sigma(2\beta_s)$	\stphis	$\sigma(\phi_s)$
	\sinphis	$\sin\phi_s$				

254 ### C.3.8 Tagging

	\edet	$\varepsilon_{\rm det}$	\erec	$\varepsilon_{\rm rec/det}$	\esel	$\varepsilon_{\rm sel/rec}$
	\etrg	$\varepsilon_{\rm trg/sel}$	\etot	$\varepsilon_{\rm tot}$	\mistag	ω
255	\wcomb	$\omega^{\rm comb}$	\etag	$\varepsilon_{\rm tag}$	\etagcomb	$\varepsilon_{\rm tag}^{\rm comb}$
	\effeff	$\varepsilon_{\rm eff}$	\effeffcomb	$\varepsilon_{\rm eff}^{\rm comb}$	\efftag	$\varepsilon_{\rm tag}(1-2\omega)^2$
	\effD	$\varepsilon_{\rm tag}D^2$	\etagprompt	$\varepsilon_{\rm tag}^{\rm Pr}$	\etagLL	$\varepsilon_{\rm tag}^{\rm LL}$

256 ### C.3.9 Key decay channels

	\BdToKstmm	$B^0\to K^{*0}\mu^+\mu^-$	\BdbToKstmm	$\overline{B}^0\to \overline{K}^{*0}\mu^+\mu^-$	\BsToJPsiPhi	$B^0_s\to J/\psi\phi$
	\BdToJPsiKst	$B^0\to J/\psi K^{*0}$	\BdbToJPsiKst	$\overline{B}^0\to J/\psi \overline{K}^{*0}$	\BsPhiGam	$B^0_s\to \phi\gamma$
	\BdKstGam	$B^0\to K^{*0}\gamma$	\BTohh	$B\to h^+h'^-$	\BdTopipi	$B^0\to\pi^+\pi^-$
257	\BdToKpi	$B^0\to K^+\pi^-$	\BsToKK	$B^0_s\to K^+K^-$	\BsTopiK	$B^0_s\to\pi^+K^-$
	\Cpipi	$C_{\pi^+\pi^-}$	\Spipi	$S_{\pi^+\pi^-}$	\CKK	$C_{K^+K^-}$
	\SKK	$S_{K^+K^-}$	\ADGKK	$A^{\Delta\Gamma}_{K^+K^-}$		

258 ### C.3.10 Rare decays

	\BdKstee	$B^0\to K^{*0}e^+e^-$	\BdbKstee	$\overline{B}^0\to \overline{K}^{*0}e^+e^-$	\bsll	$b\to s\ell^+\ell^-$
	\AFB	$A_{\rm FB}$	\FL	$F_{\rm L}$	\AT#1 \AT2	$A_{\rm T}^2$
259	\btosgam	$b\to s\gamma$	\btodgam	$b\to d\gamma$	\Bsmm	$B^0_s\to\mu^+\mu^-$
	\Bdmm	$B^0\to\mu^+\mu^-$	\Bsee	$B^0_s\to e^+e^-$	\Bdee	$B^0\to e^+e^-$
	\ctl	$\cos\theta_\ell$	\ctk	$\cos\theta_K$		

260 ### C.3.11 Wilson coefficients and operators

261	\C#1 \C9	$\mathcal{C}_9$	\Cp#1 \Cp7	$\mathcal{C}_7'$	\Ceff#1 \Ceff9	$\mathcal{C}_9^{(\rm eff)}$
	\Cpeff#1 \Cpeff7	$\mathcal{C}_7^{\prime(\rm eff)}$	\Ope#1 \Ope2	$\mathcal{O}_2$	\Opep#1 \Opep7	$\mathcal{O}_7'$

262 ### C.3.12 Charm

263	\xprime	x'	\yprime	y'	\ycp	y_{CP}
	\agamma	A_{Γ}	\dkpicf	$D^0\to K^-\pi^+$		

264 #### C.3.13 QM

265 `\bra[1]` `\bra{a}` $\langle a|$ `\ket[1]` `\ket{b}` $|b\rangle$ `\braket[2]` `\braket{a}{b}` $\langle a|b\rangle$

266 ## C.4 Units (these macros add a small space in front)

267 `\aunit[1]` `\aunit{kg}` kg

268 ### C.4.1 Energy and momentum

269

`\tev`	TeV	`\gev`	GeV	`\mev`	MeV
`\kev`	keV	`\ev`	eV	`\gevgev`	GeV^2
`\mevc`	MeV/c	`\gevc`	GeV/c	`\mevcc`	MeV/c^2
`\gevcc`	GeV/c^2	`\gevgevcc`	GeV^2/c^2	`\gevgevcccc`	GeV^2/c^4

270 ### C.4.2 Distance and area (these macros add a small space)

271

`\km`	km	`\m`	m	`\ma`	m^2
`\cm`	cm	`\cma`	cm^2	`\mm`	mm
`\mma`	mm^2	`\mum`	µm	`\muma`	µm^2
`\nm`	nm	`\fm`	fm	`\barn`	b
`\mbarn`	mb	`\mub`	µb	`\nb`	nb
`\invnb`	nb^{-1}	`\pb`	pb	`\invpb`	pb^{-1}
`\fb`	fb	`\invfb`	fb^{-1}	`\ab`	ab
`\invab`	ab^{-1}				

272 ### C.4.3 Time

273

`\sec`	s	`\ms`	ms	`\mus`	µs
`\ns`	ns	`\ps`	ps	`\fs`	fs
`\mhz`	MHz	`\khz`	kHz	`\hz`	Hz
`\invps`	ps^{-1}	`\invns`	ns^{-1}	`\yr`	yr
`\hr`	hr				

274 ### C.4.4 Temperature

275 `\degc` °C `\degk` K

276 ### C.4.5 Material lengths, radiation

277

`\Xrad`	X_0	`\NIL`	λ_{int}	`\mip`	MIP
`\neutroneq`	n_{eq}	`\neqcmcm`	$n_{\mathrm{eq}}/\mathrm{cm}^2$	`\kRad`	kRad
`\MRad`	MRad	`\ci`	Ci	`\mci`	mCi

278 ### C.4.6 Uncertainties

279

`\sx`	σ_x	`\sy`	σ_y	`\sz`	σ_z
`\stat`	(stat)	`\syst`	(syst)	`\lumi`	(lumi)

280 C.4.7 Maths

281

\order	$\mathcal{O}$	\chisq	χ^2	\chisqndf	χ^2/ndf
\chisqip	χ^2_{IP}	\chisqvs	χ^2_{VS}	\chisqvtx	χ^2_{vtx}
\chisqvtxndf	$\chi^2_{\mathrm{vtx}}/\mathrm{ndf}$	\chisqfd	χ^2_{FD}	\gsim	$\gtrsim$
\lsim	$\lesssim$	\mean[1] \mean{x}	$\langle x \rangle$	\abs[1] \abs{x}	$\lVert x \rVert$
\Real	$\mathcal{R}e$	\Imag	$\mathcal{I}m$	\PDF	PDF
\sPlot	*sPlot*	\sFit	*sFit*	\deriv	d

282 C.5 Kinematics

283 C.5.1 Energy, Momenta

284

\Ebeam	E_{BEAM}	\sqs	$\sqrt{s}$	\sqsnn	$\sqrt{s_{\mathrm{NN}}}$
\pt	p_{T}	\ptsq	p_{T}^2	\ptot	p
\et	E_{T}	\mt	M_{T}	\dpp	$\Delta p/p$
\msq	m^2	\dedx	$\mathrm{d}E/\mathrm{d}x$		

285 C.5.2 PID

286

\dllkpi	$\mathrm{DLL}_{K\pi}$	\dllppi	$\mathrm{DLL}_{p\pi}$	\dllepi	$\mathrm{DLL}_{e\pi}$
\dllmupi	$\mathrm{DLL}_{\mu\pi}$				

287 C.5.3 Geometry

288

\degrees	$^{\circ}$	\murad	μrad	\mrad	mrad
\rad	rad				

289 C.5.4 Accelerator

290

\betastar	β^*	\lum	$\mathcal{L}$	\intlum[1] \intlum{2 fb^{-1} }	$\int\mathcal{L} = 2\ \mathrm{fb}^{-1}$

291 C.6 Software

292 C.6.1 Programs

293

\bcvegpy	Bcvegpy	\boole	Boole	\brunel	Brunel
\davinci	DaVinci	\dirac	Dirac	\evtgen	EvtGen
\fewz	Fewz	\fluka	Fluka	\ganga	Ganga
\gaudi	Gaudi	\gauss	Gauss	\geant	Geant4
\hepmc	HepMC	\herwig	Herwig	\moore	Moore
\neurobayes	NeuroBayes	\photos	Photos	\powheg	Powheg
\pythia	Pythia	\resbos	ResBos	\roofit	RooFit
\root	Root	\spice	Spice	\tensorflow	TensorFlow
\urania	Urania				

294 C.6.2 Languages

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\cpp	C++	\ruby	Ruby	\fortran	Fortran
\svn	svn	\git	git	\latex	LaTeX

C.6.3 Data processing

`\kbit`	kbit	`\kbps`	kbit/s	`\kbytes`	kB
`\kbyps`	kB/s	`\mbit`	Mbit	`\mbps`	Mbit/s
`\mbytes`	MB	`\mbyps`	MB/s	`\gbit`	Gbit
`\gbps`	Gbit/s	`\gbytes`	GB	`\gbyps`	GB/s
`\tbit`	Tbit	`\tbps`	Tbit/s	`\tbytes`	TB
`\tbyps`	TB/s	`\dst`	DST		

C.7 Detector related

C.7.1 Detector technologies

`\nonn`	n^+-on-n	`\ponn`	p^+-on-n	`\nonp`	n^+-on-p
`\cvd`	CVD	`\mwpc`	MWPC	`\gem`	GEM

C.7.2 Detector components, electronics

`\tell1`	TELL1	`\ukl1`	UKL1	`\beetle`	Beetle
`\otis`	OTIS	`\croc`	CROC	`\carioca`	CARIOCA
`\dialog`	DIALOG	`\sync`	SYNC	`\cardiac`	CARDIAC
`\gol`	GOL	`\vcsel`	VCSEL	`\ttc`	TTC
`\ttcrx`	TTCrx	`\hpd`	HPD	`\pmt`	PMT
`\specs`	SPECS	`\elmb`	ELMB	`\fpga`	FPGA
`\plc`	PLC	`\rasnik`	RASNIK	`\elmb`	ELMB
`\can`	CAN	`\lvds`	LVDS	`\ntc`	NTC
`\adc`	ADC	`\led`	LED	`\ccd`	CCD
`\hv`	HV	`\lv`	LV	`\pvss`	PVSS
`\cmos`	CMOS	`\fifo`	FIFO	`\ccpc`	CCPC

C.7.3 Chemical symbols

`\cfourften`	C_4F_{10}	`\cffour`	CF_4	`\cotwo`	CO_2
`\csixffouteen`	C_6F_{14}	`\mgftwo`	MgF_2	`\siotwo`	SiO_2

C.8 Special Text

`\eg`	*e.g.*	`\ie`	*i.e.*	`\etal`	*et al.*
`\etc`	*etc.*	`\cf`	*cf.*	`\ffp`	*ff.*
`\vs`	*vs.*				

C.8.1 Helpful to align numbers in tables

`\phz`

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