A method to measure the absolute branching fractions of $\Lambda_c$ decays

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Abstract
It is proposed to exploit the decay of the meson $B^+ \rightarrow p\pi^+\pi^-\Sigma_c^-$ and of its charge conjugate $B^-\rightarrow p\pi^+\pi^-\Sigma_c^-$ copiously produced at LHC to obtain a sample of $\Lambda_c$ baryons through the strong decay $\Sigma_c \rightarrow \Lambda_c\pi$. The sample thus obtained is not affected by biases typically introduced by selections that depend on specific decay modes. Therefore it allows a measurement of the absolute branching fraction for the decay of the $\Lambda_c$ baryon into $pK\pi$ or into other observable final states to be performed in a model independent manner. The accuracy that can be achieved with this method is discussed and it is shown that it would be either competitive with or an improvement over current measurements.

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1 Introduction

The value of $5.0 \pm 1.3\%$ for the absolute branching fraction (BR) of the decay $\Lambda_c \rightarrow pK\pi$ quoted by the PDG \cite{1} is obtained as the average of two different measurements by the CLEO \cite{2} and the ARGUS \cite{3} collaborations. These measurements are marginally consistent with one another and each has been deduced making assumptions which are model dependent. Only recently the Belle collaboration \cite{4} has reported a measurement of this BR, obtained from the reconstruction of the system $D^*\bar{p}\pi$ recoiling against the $\Lambda_c$ produced in $e^+e^-$ annihilation, which has a significantly better precision and is model independent.

In this paper it is suggested to exploit a particular decay of charged $B$ mesons, produced with high yield at LHC, to measure the absolute branching fraction for the decay $\Lambda_c$ into $Kp\pi$ - or any other observable decay mode - also in a model independent manner. The proposed method has the additional advantage of being applicable in a hadron collider environment since it does not require the reconstruction of the complete event. The paper is organised as follows. In Section 2 a description is given of the principle at the basis of the proposed method and in Section 3, by means of a simulation, the relations imposed by kinematics are exploited. In Section 4 selection efficiencies are evaluated, using an approximate experimental setup, to demonstrate the intrinsic feasibility of the proposed measurement and the effects of non-resonant $B$-decays into the same final state are also discussed. In Section 5 the accuracy achievable with current data or with data available in the near future at LHC is evaluated.

2 Principle of $\Lambda_c$ reconstruction

Even though the measured branching fraction of the decay $B^+ \rightarrow p\pi^+\pi^+\Sigma_c^{--}$ is only $2.8 \cdot 10^{-4}$ \cite{1} the abundant production of charged $B$-mesons at LHC makes it possible to obtain samples containing $O(10^7 - 10^8)$ decays of this type. The method proposed in this paper takes advantage of the decay chain $B^+ \rightarrow p\pi^+\pi^+\Sigma_c^{--} \rightarrow \Lambda_c^-\pi^-$ whose diagram is shown in Fig. \ref{fig:1} to measure absolute $\Lambda_c$ branching fractions \cite{5}. The principle which the method relies upon is based on the kinematics of the decay itself and is summarised in the following. Assume that in the decay all charged particles are observed with the exception of the $\Lambda_c$. If the direction of flight of the $B$-meson is known, it is possible to infer the existence of the $\Lambda_c$ and to determine its momentum \cite{6} without observing its decay, thus generating an unbiased sample of $\Lambda_c$’s in which one would search for the mode whose branching fraction is sought to be measured.

\textsuperscript{1}Unless otherwise indicated, charge conjugation is implicitly assumed throughout.

\textsuperscript{2}Up to a quadratic ambiguity.
The decay vertex of the $B^+$ ($B^-$) is identified by the presence of four charged particles (4-prong decay), namely $p\pi^+\pi^+\pi^-$ ($\bar{p}\pi^-\pi^-\pi^+$), having a total charge of $+2(-2)$. The $B$ meson direction of flight is determined from the line joining the production (primary) and decay vertices.

Furthermore, the pion whose sign of charge is opposite to that of the three remaining particles certainly originates from the decay of $\Sigma^-$ through strong interactions and, in what follows, it will be referred to as pion from $\Sigma^-$, $\pi_{\Sigma}$. In addition the presence of a proton would serve the purpose of tagging the decays of interest in experiments with good particle identification.

The $B$-meson decay vertex will be measured with an accuracy which depends on the experiment and is separated from the production vertex by a distance which would depend on the momentum spectrum of the $B$. The separation between the production and decay vertex and hence the direction of flight of the $B$-meson will be measured with an experiment dependent accuracy as well. These factors will be taken into account in Section 4.

Let $\hat{e}_B$ be a unit vector in the $B$ direction of flight and $P_4 = (E_4, \mathbf{p}_4) (P'_4)$ be the resultant four-momentum of all charged particles at the $B$-decay vertex - not including the $\Lambda_c$ - in the laboratory frame ($B$ rest frame). $P_3$ and $P'_3$ are the corresponding quantities of the three like-sign particles at the same vertex. Let the invariant mass of the two systems be $M_4$ and $M_3$ respectively and $\gamma$ be the Lorentz $\gamma$-factor of the decaying $B$-meson.

Assuming that a $\Lambda_c$ is the only missing particle in the decay, through simple algebra, it can be shown that the following two solutions are obtained for $\gamma$ depending on whether the system of four-particles moves forward or backward in the $B$ rest frame

$$\gamma_{1,2} = \frac{E_4 \cdot E'_4 + |\mathbf{p}^L_4| \cdot |\mathbf{p}^{L'}_4|}{M_4^2 + |\mathbf{p}^L_4|^2}$$

(1)
where $\vec{p}_T^4$ and $\vec{p}_L^4$ are the transverse and longitudinal momentum with respect to the B-flight direction and $E_4^*$, the energy of the system of four particles in the B rest frame, is determined by the relation

$$E_4^* = \frac{M_B^2 - M_{\Lambda_c}^2 + M_4^2}{2M_B}$$

Hence $E_B = \gamma \cdot M_B$ and $\vec{P}_B = (E_B^2 - M_B^2) \cdot \hat{e}_B$, since the B flight direction in known. The $\Lambda_c$ four-momentum will be determined by imposing conservation of energy and momentum, $P_\Lambda = P_B - P_4$, and therefore, if the $\Lambda_c$ truly originates from a $\Sigma_c$ decay, its momentum would be such that the combination $(P_\Lambda + P_{\pi\Sigma})^2$ must be equal to the $\Sigma_c$ mass squared.

This should result in a peaking of the mass distribution around the true value of the $\Sigma_c$ mass when the correct choice for the Lorentz $\gamma$ factor has been made.

In this manner, an unbiased sample of $\Lambda_c$ could be selected without actually observing the decay products of that particle and therefore it would be sufficient to identify within it the presence of decays into $pK\pi$ to measure the absolute branching fraction.

### 3 Feasibility of the proposed method

To demonstrate the viability of the proposed method, $pp$ interactions were generated at centre of mass energy of 14 TeV, using the PYTHIA generator [6]. $B^+$, produced over the whole solid angle, were forced to decay in the channel of interest $B^+ \rightarrow p\pi^+\pi^+\Sigma_c^-$ using the software package EVTGEN [7]. Different samples in which the decay was of the non-resonant types $B^+ \rightarrow p\pi^+\pi^+\pi^-\Lambda_c^-$ and $B^+ \rightarrow p\pi^+\pi^+\pi^-\Lambda_c^-\pi^0$ were also generated to investigate possible kinematical variables which allow to separate the different decays.

There are indeed specific experimental advantages in using the suggested decay chain, some of which can be exploited by detectors with excellent particle identification, namely:

i) The four-prong decay vertex has charge +2. It is therefore relatively easy to identify and, in real experimental conditions, would help in reducing background from decays of particles other than the $B^+$.

ii) There is a proton at this vertex and therefore it can be efficiently identified to tag the $B^+$ decay. Furthermore, the charge of this proton is opposite to that of the proton from $\Lambda_c$ decays and therefore no bias is introduced from a specific $\Lambda_c$ decay mode.

iii) The pion from the $\Sigma_c$ has sign of charge opposite to that of the other three particles and therefore it can be unambiguously distinguished.

iv) Conditions that events lie within kinematical boundaries can be applied in the selection to separate decays that occur through the resonance $\Sigma_c$ from the non-resonant mode $B^+ \rightarrow p\pi^+\pi^+\pi^-\Lambda_c^-$, which has a branching fraction about 8 times larger, or from $B^+ \rightarrow p\pi^+\pi^+\pi^-\Lambda_c^-\pi^0$. In fact, if the final state $\bar{\Lambda}_c^-\pi^-p\pi^+\pi^+$ is reached via the resonance $\Sigma_c^-$, $M_4$ should have values between the minimum

$$\left( M_4^2 \right)_{\text{min}} = (E_3 + E_{\pi\Sigma}'^2)^2 - \left( \sqrt{E_3^2 - M_3^2} + \sqrt{E_{\pi\Sigma}^2 - m_{\pi\Sigma}^2} \right)^2$$
and the maximum

$$(M_4^2)^{\text{max}} = (E_3' + E'_{\pi\Sigma})^2 - (\sqrt{E_3'^2 - M_3^2} - \sqrt{E_{\pi\Sigma}^2 - m_{\pi\Sigma}^2})^2$$

where $E_3'$ and $E_{\pi\Sigma}'$ are the energies, in the $\Sigma$ rest frame, of the system of three-particles and of the $\pi\Sigma$, respectively.

Figure 2: Distribution of the 4-particle invariant mass squared versus 3-particle invariant mass squared in resonant $B^+ \rightarrow p\pi^+\pi^-\Sigma^-$ and non-resonant $B^+ \rightarrow p\pi^+\pi^-\Lambda_c^-$ and $B^+ \rightarrow p\pi^+\pi^-\Lambda_c^0\pi^0$ decays. The dashed line represents the kinematics boundaries for the resonant decay, while within the contour lines are contained the indicated fractions of non-resonant decays. The fraction of such decays within the kinematic boundaries is $(21.98 \pm 0.02)$% for $B^+ \rightarrow p\pi^+\pi^-\Sigma^-$ and $(50.46 \pm 0.03)$% for the $B^+ \rightarrow p\pi^+\pi^-\Lambda_c^0\pi^0$ mode. In Section 4 a quantitative estimate of the contribution from these decay modes will be given, once further selections have been applied. At this stage it is sufficient to observe that requiring a minimum value of $M_3^2$ and $M_4^2$ would be effective in reducing the fraction of non-resonant decays, in particular of $B^+ \rightarrow p\pi^+\pi^-\Lambda_c^0\pi^0$ whose branching fraction is not measured at present and only an upper limit exists [1].

Detector acceptance was simulated in a simple manner, by assuming that particles with momentum greater than 2 $GeV/c$ and within the pseudo-rapidity range $2 < \eta < 4.5$ would be detected. In the decay $B^+ \rightarrow p\pi^+\pi^+(\Sigma_c^- \rightarrow \Lambda_c^-\pi^-)$, the spatial distributions
of particles are generated according to phase space, therefore, at generator level, there is no preferential direction for the $\Lambda_c$ in the $B$ rest frame. However, requiring that the decay products - other than the $\Lambda_c$ - be within a detector acceptance, introduces asymmetries of order of 20%. This is shown in Fig. 3 where the distributions of the cosine of the angle between the direction of the momentum of the $\Lambda_c$ in the $B$ rest frame and the $B$ direction of flight in various situations are compared.

There are indeed also losses introduced by this selection and these will be included in the efficiencies discussed in Section 4. At this stage it is sufficient to observe that requiring that the three like-sign particles be in acceptance favours slightly backward-going $\Lambda_c$’s, while the further requirement that the pion from $\Sigma_c$ be measurable, i.e. within the geometrical acceptance as well, would preferentially select forward-going $\Lambda_c$, as shown by the dashed lines in Fig. 3.

![Angular distributions of the $\Lambda_c$ baryon in the $B$ rest frame before and after applying selection criteria](image)

Figure 3: Angular distributions of the $\Lambda_c$ baryon in the $B$ rest frame before and after applying selection criteria

This selection of different regions of phase space will have an effect on the preferred value for the Lorentz $\gamma$ factor. In fact, with the definition given in Eq. 1, $\gamma_1$ is always smaller than $\gamma_2$ and therefore choosing the first over the latter selects $B$’s of lower energy. If for instance experimental acceptance is such that forward going $\Lambda_c$ are slightly favoured, then $\gamma_2$ would be more often the correct solution. On the other hand, additional selections - that might prove necessary when dealing with the real experimental conditions - are likely to change the favoured value. However this would have no effect on the proposed measurement, as long as no bias is introduced by the decay mode of the $\Lambda_c$, which is the case here since the $\Lambda_c$ decay products are not and will not be considered in the selection.

For each event, the two values of the Lorentz $\gamma$ factor given by Eq. 1 are computed using true quantities at generator level. $\sqrt{(P_{\Lambda} + P_{\pi})^2}$ is then computed assuming, as solution, either $\gamma_1$ or $\gamma_2$. The mass distribution obtained in this manner is shown in Fig. 4.
as solid histogram. As already mentioned there is complete symmetry forward-backward at this stage and therefore choosing either solution, $\gamma_1$ or $\gamma_2$, leads to the same result. As expected, a peak around the $\Sigma_c$ mass is observed. Its width is affected by the cases in which the wrong solution for $\gamma$ was chosen, yet the result was close to its true value and, as a consequence, a value about 10% larger than expected is observed.$^3$

![Figure 4: Distributions of the reconstructed $\bar{\Sigma}_c^-$ mass before and after applying selection criteria.](image)

Using either value of $\gamma$ and requiring $2.44 \text{ GeV}/c^2 < M_{\Sigma} < 2.47 \text{ GeV}/c^2$, would allow a selection of a sample of $\Lambda_c$ whose size is about 64% of the original sample of generated events. On the other hand choosing particles that fall within the geometrical acceptance would produce different mass distributions for the two choices of $\gamma$, as illustrated in Fig. 4 with slightly different efficiencies which will be discussed quantitatively in Section 4.

Even though the choice of $\gamma_1$ or of $\gamma_2$ is irrelevant since either one would allow the selection of an unbiased sample of $\Lambda_c$’s, efficiencies are different and this would affect the size of the final sample and ultimately the statistical accuracy. To minimize the statistical error on the measurement, it would be required in addition that the decay products of the $\Lambda_c$ be detected and hence it is the number of observable decays that ought to be maximized.

4 Effects of experimental resolution and efficiencies

Experimental resolution on the determination of momenta of particles and of positions of the vertices so far have not been taken into account. It was found that, of the two, the

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$^3$At this level, if the correct solution were chosen, one would expect to obtain a width of 2.6 MeV/$c^2$ for the $\Sigma_c$, which is the value coded in the Montecarlo.
error on the vertex position has the largest effect since it enters in the determination of the 
$B$ direction of flight. The effect is shown in Fig. 5 where the $M_{\Sigma_c}$ distribution is displayed 
for the $\gamma_2$ solution and all four-particles within the geometrical acceptance, assuming the 
true $B$ direction or that obtained having applied a gaussian smearing to the position of the $B$ decay vertex of $\sigma_z = 400 \mu m$ along the beam direction and of $\sigma_T = 35 \mu m$ in the 
transverse direction.

The effect of the experimental resolution is to reduce the event sample to about 45% 
of its original size and it is mostly due to the fact that the transverse momentum relative 
to the measured $B$-direction exceeds the maximum value allowed by kinematics and hence 
no acceptable solutions for $\gamma$ are found.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure5.png}
\caption{Distributions of the reconstructed $\Sigma_c^{--}$ mass before and after applying resolution 
smearing.}
\end{figure}

Tables 1 and 2 summarise the effects of the selections listed below and applied to the 
$B^+ \rightarrow p\pi^+\pi^+\Sigma_c^{--}$ sample as well as to the non-resonant samples, i.e. 
to the samples of events in which the final state $\Lambda_c\pi p\pi\pi$, with or without the presence of an additional 
nutral pion, is reached directly from B decay and not via the resonance $\Sigma_c$ for the two 
possible choices of $\gamma$:

- **Selection A**: $(M_4^2)_{min} < M_4^2 < (M_4^2)_{max}$
- **Selection B**: Mass of the $\Sigma_c$, computed as $\sqrt{(P_{\Lambda_c} + P_{\pi_c})^2}$, is within $\pm 15$ MeV/$c^2$ 
  from its nominal value of 2.455 GeV/$c^2$.
- **Selection C**: $p\pi\pi$ like-sign within geometrical acceptance.
- **Selection D**: $\pi\Sigma$ within geometrical acceptance.
- **Selection E**: Smearing is applied to B-decay vertex.
• Selection \( P: M_2^2 > 4(\text{GeV}/c^2)^2 \) and \( M_4^2 > 6(\text{GeV}/c^2)^2 \)

The criteria were applied in order, i.e. each selection implies that all the preceeding conditions were satisfied.

Table 1: Accepted solution \( \gamma_1 \) - Fraction of events kept

| Condition | \( B^+ \rightarrow p\pi^+\pi^+\Sigma_c^- \) | \( B^+ \rightarrow p\pi^+\pi^+\pi^-\Lambda_c^- \pi^0 \) | \( B^+ \rightarrow p\pi^+\pi^+\pi^-\Lambda_c^- \pi^0 \) |
|-----------|---------------------------------|---------------------------------|---------------------------------|
| Selection A | \( 1 \) | \( (21.98 \pm 0.02) \cdot 10^{-2} \) | \( (50.46 \pm 0.03) \cdot 10^{-2} \) |
| Selection B | \( (62.19 \pm 0.03) \cdot 10^{-2} \) | \( (1.986 \pm 0.005) \cdot 10^{-2} \) | \( (2.493 \pm 0.006) \cdot 10^{-2} \) |
| Selection C | \( (6.501 \pm 0.009) \cdot 10^{-2} \) | \( (2.00 \pm 0.02) \cdot 10^{-3} \) | \( (2.39 \pm 0.02) \cdot 10^{-3} \) |
| Selection D | \( (2.554 \pm 0.009) \cdot 10^{-2} \) | \( (6.98 \pm 0.09) \cdot 10^{-4} \) | \( (3.03 \pm 0.06) \cdot 10^{-4} \) |
| Selection E | \( (1.055 \pm 0.004) \cdot 10^{-2} \) | \( (3.79 \pm 0.07) \cdot 10^{-4} \) | \( (2.76 \pm 0.06) \cdot 10^{-4} \) |
| Selection F | \( (8.52 \pm 0.03) \cdot 10^{-3} \) | \( (2.96 \pm 0.06) \cdot 10^{-4} \) | \( (1.07 \pm 0.04) \cdot 10^{-4} \) |

Table 2: Accepted solution \( \gamma_2 \) - Fraction of events kept

| Condition | \( B^+ \rightarrow p\pi^+\pi^+\Sigma_c^- \) | \( B^+ \rightarrow p\pi^+\pi^+\pi^-\Lambda_c^- \) | \( B^+ \rightarrow p\pi^+\pi^+\pi^-\Lambda_c^- \pi^0 \) |
|-----------|---------------------------------|---------------------------------|---------------------------------|
| Selection A | \( 1 \) | \( (21.98 \pm 0.02) \cdot 10^{-2} \) | \( (50.46 \pm 0.03) \cdot 10^{-2} \) |
| Selection B | \( (64.02 \pm 0.04) \cdot 10^{-2} \) | \( (2.014 \pm 0.005) \cdot 10^{-2} \) | \( (2.581 \pm 0.006) \cdot 10^{-2} \) |
| Selection C | \( (5.784 \pm 0.009) \cdot 10^{-2} \) | \( (1.94 \pm 0.02) \cdot 10^{-3} \) | \( (2.17 \pm 0.02) \cdot 10^{-3} \) |
| Selection D | \( (3.403 \pm 0.007) \cdot 10^{-2} \) | \( (1.029 \pm 0.01) \cdot 10^{-3} \) | \( (1.79 \pm 0.02) \cdot 10^{-3} \) |
| Selection E | \( (1.536 \pm 0.004) \cdot 10^{-2} \) | \( (8.3 \pm 0.1) \cdot 10^{-4} \) | \( (1.43 \pm 0.01) \cdot 10^{-3} \) |
| Selection F | \( (1.117 \pm 0.004) \cdot 10^{-2} \) | \( (5.62 \pm 0.08) \cdot 10^{-4} \) | \( (3.49 \pm 0.07) \cdot 10^{-4} \) |

From the tables it can be concluded that efficiencies at the percent level for the indicated selections are obtained and that \( \gamma_2 \) would be the favoured solution when requiring that \( \pi_{\Sigma} \) be within geometrical acceptance, as expected.

As it was also expected, the requirements imposed on kinematics and detector geometry are less effective for the non-resonant channels, the efficiencies being smaller by a factor of about 20. This reduction will be partly compensated for by the larger B-decay branching fraction into these channels. Quantitatively this is shown in Fig. 6 where the \( \Sigma_c \) mass distribution is displayed for the resonant and non-resonant channels properly weighted with the B-decay branching fractions and the efficiencies quoted in Table 2 for the selection A. For the decay \( B^+ \rightarrow p\pi^+\pi^+\pi^-\Lambda_c^- \pi_0 \), since only an upper limit exists for the branching fraction, it was assumed to be equal to that of \( B^+ \rightarrow p\pi^+\pi^+\pi^-\Lambda_c^- \). In the mass range \( 2.44 - 2.47 \text{GeV}/c^2 \), considered as the signal region, the total non-resonant fraction, with the above assumption, is \( \sim 36\% \) of the total. In real experimental conditions this signal would be superimposed to a combinatorial background, therefore it would not be meaningful to extract a function describing its shape, at this stage.

As already pointed out, it is the number of observable decays that should be maximised. Table 3 shows, for the decay \( \Lambda_c \rightarrow pK\pi \), the fraction of events, satisfying the indicated
selections, in which the decay products of the $\Lambda_c$ are also within geometrical acceptance, both for the resonant and non-resonant components. Efficiencies are of order of $\sim 40\%$ irrespective of the choice of $\gamma$ and depend weakly on whether the $\Lambda_c$ is produced directly from $B$ decay or through the $\Sigma_c$ resonance. This was to be expected, since essentially only geometrical factors enter in the determination of these fractions.

Table 3: Fraction of events for the indicated selections in which the $\Lambda_c$ decay products are also within geometrical acceptance

| Condition     | $B^+ \rightarrow p\pi^+\pi^+\Sigma_c^-$ | $B^+ \rightarrow p\pi^+\pi^+\pi^-\bar{\Lambda}_c$ | $B^+ \rightarrow p\pi^+\pi^+\pi^-\bar{\Lambda}_c\pi^0$ |
|---------------|----------------------------------------|---------------------------------------------------|---------------------------------------------------|
| Selection D and Solution $\gamma_1$ | $39.82 \pm 0.12$ | $42.6 \pm 0.8$ | $40.9 \pm 1.1$ |
| Selection E and Solution $\gamma_1$ | $39.17 \pm 0.18$ | $40.7 \pm 1.0$ | $41.5 \pm 1.1$ |
| Selection F and Solution $\gamma_1$ | $39.16 \pm 0.2$ | $41.4 \pm 1.1$ | $42.3 \pm 1.9$ |
| Selection D and Solution $\gamma_2$ | $40.54 \pm 0.10$ | $41.4 \pm 0.5$ | $39.5 \pm 0.4$ |
| Selection E and Solution $\gamma_2$ | $40.03 \pm 0.15$ | $40.3 \pm 0.6$ | $39.8 \pm 0.5$ |
| Selection F and Solution $\gamma_2$ | $40.04 \pm 0.18$ | $41.9 \pm 0.8$ | $41.8 \pm 1.0$ |

Figure 6: Distributions of the reconstructed $\Sigma_c^-$ mass in resonant ($B^+ \rightarrow p\pi^+\pi^+\Sigma_c^-$) and non-resonant decays ($B^+ \rightarrow p\pi^+\pi^+\pi^-\bar{\Lambda}_c$ and $B^+ \rightarrow p\pi^+\pi^+\pi^-\bar{\Lambda}_c\pi^0$).
5 Results and Conclusions

LHCb has measured a cross section of 38.9 $\mu$b for the production of charged B mesons within the experimental acceptance and with transverse momentum in the range $0 - 40 \text{ GeV}/c$ [8], in $pp$ collisions at centre of mass energy of 7 TeV. This would correspond to a cross section of 193$\mu$b over the whole solid angle, assuming that B-mesons are produced as in PYTHIA generator. Scaling the production cross-section with $\sqrt{s}$, this would yield about $3.9 \cdot 10^{11}$ charged B-decays per $fb^{-1}$ of integrated luminosity.

Selecting, for the sake of illustration, the efficiencies corresponding to the $\gamma_2$ solution in Table 2 and assuming that these do not have a strong dependence on the $pp$ centre-of-mass energy, using an integrated luminosity of 3 $fb^{-1}$ (currently available in the LHCb experiment at centre of mass energies of 7 and 8 TeV), with the measured branching fraction of $2.8 \cdot 10^{-4}$ for $B^+ \rightarrow p\pi^+\pi^+\Sigma^-$, about 2.5 million decays of interest would be reconstructed within the detector: a sizeable, unbiased sample of $\Lambda_c$ decays.

Even assigning an efficiency of 2% to other selections that in general is necessary to apply and that have not be considered here, using the efficiencies of Table 3 for the $\Lambda_c$ decay products, about 1000 decays of the type $\Lambda_c \rightarrow pK\pi$ from the resonant sample would be observed in the detector. The statistical error therefore would be comparable with that of Belle [4], which is the most precise currently available measurement. The result could be improved by devising dedicated, more efficient selections at trigger level and when more data and at higher centre of mass energy become available. Furthermore the decays from $\Lambda_c$’s originating from the non-resonant channels could be added to the sample, since their detection efficiency is similar to that for $\Lambda_c$ coming from the resonant channel and therefore large corrections would not be required.

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