The LHCb Detector

- Good impact parameter resolution to identify secondary vertices: 20 µm
- Versatile & efficient trigger for b- and c-hadrons and forward EW signals
- Decay time resolution: 45 fs ($B_s^0 \rightarrow J/\psi\phi$)
- Invariant mass resolution: 8 MeV/$c^2$ ($B \rightarrow J/\psi X$)
  22 MeV/$c^2$ ($B \rightarrow hh$)
- Excellent particle identification: 95 % K ID efficiency
  (5 % $\pi \rightarrow K$ mis-ID)
Measuring CP Violation: Interfering Paths

**CP Violation in Mixing:**

\[\text{Prob}(B^0_q \to \bar{B}^0_q) \neq \text{Prob}(\bar{B}^0_q \to B^0_q)\]

- Interference through Virtual (loops) and Real (intermediate decay) contributions
- Key Measurements: \(a^s_{sl}\) from \(B^0_s \to D^-s \mu^+\nu\)

**Direct CP Violation:**

\[\text{Prob}(B \to f) \neq \text{Prob}(\bar{B} \to \bar{f})\]

- Interference between multiple decay paths (for example: Tree + Penguin diagrams)
- Key Measurements: \(B^0_q \to h^+h^-; \gamma\) from \(B^\pm \to D^0h^\pm\)

**Mixing-Induced CP Violation:**

\[\text{Prob}(B^0_q \to f) \neq \text{Prob}(B^0_q \to \bar{B}^0_q \to f)\]

- Interference between direct decay and decay after mixing
- Key Measurements: \(\gamma\) from \(B^0_s \to D^\pm s K^\pm; \phi_s\) from \(B^0_s \to J/\psi h^+h^-\)
**Introduction**

- Search for New Physics in neutral $B$ meson mixing.

  \[ \Gamma(\bar{B}_q^0(t) \rightarrow f) - \Gamma(B_q^0(t) \rightarrow \bar{f}) \]

\[ a_{sI}^q \equiv \frac{\Gamma(\bar{B}_q^0(t) \rightarrow f) - \Gamma(B_q^0(t) \rightarrow \bar{f})}{\Gamma(\bar{B}_q^0(t) \rightarrow f) + \Gamma(B_q^0(t) \rightarrow \bar{f})} \]

- Can be probed using **wrong-charge asymmetry** for flavour specific final state $f$

- Decay time independent quantity

- Measured in semi-leptonic $B_q^0 \rightarrow D_q^- \mu^+ \nu$ decays

- World averages [HFAG]:

\[ a_{sI}^d = 0.0007 \pm 0.0027 \]

\[ a_{sI}^s = -0.0171 \pm 0.0055 \]
$a_{s l}^s$ from $B_s^0 \rightarrow D_s^- \mu^+ \nu$

**LHCb Measurement**

- Data sample: 1 fb$^{-1}$ of 7 TeV data collected in 2011
- Determine

$$A_{\text{meas}} = \frac{\Gamma(D_s^- \mu^+) - \Gamma(D_s^+ \mu^-)}{\Gamma(D_s^- \mu^+) + \Gamma(D_s^+ \mu^-)} = \frac{1}{2} a_{s l}^s + O(10^{-4})$$

through measurement of the $B_s^0 \rightarrow D_s^- (\rightarrow \phi \pi^-) \mu^+ \nu$ yields

- Crucial aspect: Asymmetries affecting the measurement of $a_{s l}^s$

$$A_{\text{meas}} = A_{\mu}^C - A_{\text{track}} - A_{\text{bkg}}$$

- All asymmetries determined on data
- $B$ meson production asymmetry: at most few percent (impact on $a_{s l}^s < 10^{-4}$)
- Detection charge asymmetry: $A_{\mu}^C = (0.04 \pm 0.25)\%$
- Track reconstruction asymmetry: $A_{\text{track}} = (0.02 \pm 0.13)\%$
- Background asymmetry: $A_{\text{bkg}} = (0.05 \pm 0.05)\%$
Latest LHCb Results

\[ a_{sl}^s \text{ from } B_s^0 \rightarrow D_s^- \mu^+ \nu \]

- Measured CP asymmetry:
  \[ a_{sl}^s = (-0.06 \pm 0.50 \pm 0.36)\% \]

- Compatible with the SM
Introduction

- Charmless two-body decays offer sensitive probe to search for New Physics
- Problem: presence of hadronic factors in decay amplitude
- Solution: combine multiple measurements using approximate flavour symmetries

\[
\Delta \equiv \frac{\mathcal{A}_{CP}(B_d^0 \rightarrow \pi^- K^+)}{\mathcal{A}_{CP}(B_s^0 \rightarrow K^- \pi^+)} + \frac{\mathcal{B}(B_s^0 \rightarrow K^- \pi^+)}{\mathcal{B}(B_d^0 \rightarrow \pi^- K^+)} \quad \text{SM} \quad \rightarrow \quad 0
\]

- Allows extraction of CKM angle $\gamma$
- Demonstrate CP violation in $B_s$ system

LHCb Measurements

- Data sample: 1 fb$^{-1}$ of 7 TeV data collected in 2011
- Modes: $B_s^0 \rightarrow K^- \pi^+$ and $B_d^0 \rightarrow \pi^- K^+$ (time integrated analysis)
- Modes: $B_s^0 \rightarrow K^- K^+$ and $B_d^0 \rightarrow \pi^- \pi^+$ (time dependent analysis)
- Crucial aspects: particle identification; $K-\pi$ separation
$B^0_q \rightarrow h^- h^+$

**CP Asymmetries**

▶ Decay time distribution
\[
\frac{d\Gamma}{dt}(B^0_q(t) \rightarrow f) \propto \cosh\left(\frac{\Delta \Gamma_q}{2} t\right) - D_f \sinh\left(\frac{\Delta \Gamma_q}{2} t\right) + C_f \cos(\Delta m_q t) - S_f \sin(\Delta m_q t)
\]

▶ Leads to an asymmetry
\[
\mathcal{A}_{CP} \equiv \frac{\Gamma(\bar{B} \rightarrow \bar{f}) - \Gamma(B \rightarrow f)}{\Gamma(\bar{B} \rightarrow \bar{f}) + \Gamma(B \rightarrow f)} = \frac{-C_f \cos(\Delta m_q t) + S_f \sin(\Delta m_q t)}{\cosh\left(\frac{\Delta \Gamma_q}{2} t\right) - D_f \sinh\left(\frac{\Delta \Gamma_q}{2} t\right)}
\]

▶ Measured asymmetry needs to be corrected for detection and production asymmetries
▶ Time dependent analysis affected by resolution, acceptance, flavour tagging

---

**Raw asymmetry**

LHCb

[arxiv 1308.1428]
$B_s^0 \rightarrow K^- K^+$

**Latest LHCb Results**

### (a) LHCb

![Graph showing invariant mass distribution for $K^+ K^-$ candidates](image)

**Graph:**
- Vertical axis: Candidates / (10 MeV/c^2)
- Data points indicate peaks at certain masses, possibly indicating signal and background regions.

### (b) LHCb

![Graph showing decay time distribution](image)

**Graph:**
- Vertical axis: Candidates / (0.12 ps)
- Horizontal axis: Decay time [ps]
- Data points show a distribution that could be used to infer decay times for $B$ mesons.

- **Observed Patterns:**
  - Peaks and valleys that suggest distinct decay modes.

**Raw asymmetry**

![Graph showing raw asymmetry](image)

**Graph:**
- Vertical axis: Raw asymmetry
- Horizontal axis: $(t-t_0)$ modulo $(2\pi/\Delta m_s)$ [ps]
- Data points illustrating the variation of asymmetry over time.

**Measured CP parameters:**

- $C_{KK} = 0.14 \pm 0.11 \pm 0.03$
- $S_{KK} = 0.30 \pm 0.12 \pm 0.04$

---

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**$B_d^0 \rightarrow \pi^- \pi^+$**

**Latest LHCb Results**

- **$B_s^0 \rightarrow D_s^+ \mu^+ \nu$**
- **$B_q^0 \rightarrow h^- h^+$**
- **$B_s^0 \rightarrow J/\psi h^+ h^-$**
- **$B^\pm \rightarrow D^0 h^\pm$**

![LHCb](image)

- **Measured CP parameters:**
  
  \[
  C_{\pi \pi} = -0.38 \pm 0.15 \pm 0.02 \\
  S_{\pi \pi} = -0.71 \pm 0.13 \pm 0.02 
  \]

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SUSY 2013
$B_S^0 \rightarrow K^-\pi^+$ and $B_d^0 \rightarrow \pi^-K^+$

**Latest LHCb Results**

- Measured CP asymmetries:
  
  \[ \mathcal{A}_{CP}(B_d^0 \rightarrow K^+\pi^-) = -0.080 \pm 0.007 \pm 0.003 \]

  \[ \mathcal{A}_{CP}(B_s^0 \rightarrow K^-\pi^+) = 0.27 \pm 0.04 \pm 0.01 \]

- SM Test:
  
  \[ \Delta = -0.02 \pm 0.05 \pm 0.04 \]

- First observation of CP violation in the $B_s$ system: $B_s^0 \rightarrow K^-\pi^+$

- Compatible with the SM
Introduction

- CP violating phase associated with $B_s^0 - \bar{B}_s^0$ mixing
- Accessible due to interference between mixing and decay
- Precise SM prediction
  \[ \phi_s^{SM} = 0.0364 \pm 0.0016 \text{ rad} \]
  \[ \text{J. Charles et al., [arxiv 1106.4041]} \]
- Small magnitude offers excellent probe to search for New Physics

\[ \phi_s = \phi_s^{SM} + \phi_s^{NP} \]

- Measured in Vector – Vector final state: $B_s^0 \rightarrow J/\psi \phi(\rightarrow K^+K^-)$ (angular analysis)
- Measured in Vector – Pseudo-scalar final state: $B_s^0 \rightarrow J/\psi f_0(\rightarrow \pi^+\pi^-)$
- Simultaneous determination of the $B_s$ lifetime parameters $\Delta \Gamma_s$ and $\Gamma_s$
LHCb Measurement

- Data sample: 1 fb\(^{-1}\) of 7 TeV data collected in 2011
- Includes both resonant (P-wave) and non-resonant (S-wave) contributions
- Includes both opposite- and same-side tagging
- Per event resolution and mistag model
- Fit to signal candidates only (\(s^\prime W\)eighted)
- Unbinned maximum likelihood fit to decay time and decay angles: 8 physics parameters
- \(B_s^0 \rightarrow J/\psi \pi^+ \pi^-\) uses results on \(\Delta \Gamma_s\) and \(\Gamma_s\) from \(B_s^0 \rightarrow J/\psi K^+ K^-\)
$B_s^0 \rightarrow D_s^- \mu^+ \nu$  \hspace{1cm} $B_q^0 \rightarrow h^- h^+$  \hspace{1cm} $B_s^0 \rightarrow J/\psi h^+ h^-$  \hspace{1cm} $B^\pm \rightarrow D^0 h^\pm$

$\phi_s$ from $B_s^0 \rightarrow J/\psi K^+ K^-$ and $B_s^0 \rightarrow J/\psi \pi^+ \pi^-$

Latest LHCb Results

[Graph and data points]

- True solution: decreasing trend
  - Red: $\Delta \Gamma_s < 0$
  - Blue: $\Delta \Gamma_s > 0$

- Measured parameters:
  \[
  \phi_s = 0.01 \pm 0.07 \pm 0.01 \text{ rad} \\
  \Gamma_s = 0.661 \pm 0.004 \pm 0.006 \text{ ps}^{-1} \\
  \Delta \Gamma_s = 0.106 \pm 0.011 \pm 0.007 \text{ ps}^{-1}
  \]

- Compatible with the SM

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Introduction

- Precision test of the SM: overconstraining the Unitarity Triangle
- Discrepancies in position of apex form clear sign of New Physics
- Least constrained parameter: angle $\gamma$
  \[
  \gamma = (66 \pm 12) \degree \quad \text{[CKMfitter]}
  \]
  \[
  \gamma = (70.8 \pm 7.8) \degree \quad \text{[UTfit]}
  \]

LHCb Measurements

- Using decay modes with only Tree diagrams: $B^\pm \rightarrow D^0 h^\pm$ (time integrated analysis)
- Using decay modes also with loop diagrams: $B^0_s \rightarrow D^{\mp} K^\pm$ (time dependent analysis)
- Combination of the three $B^\pm \rightarrow D^0 h^\pm$ measurements by LHCb
Combination Method

- Frequentist approach (cfr. CKMfitter)
- Maximise combined likelihood of experimental observables
- Includes information from the covariance matrices
- Result is limited by statistics
- Measurements take into account $D^0$–$\bar{D}^0$ mixing
- Measurements use external input on hadronic parameters describing $D$ meson decay

Input

- $B^\pm \to D^0 K^\pm$ and $B^\pm \to D^0 \pi^\pm$ with $D^0 \to K^+ K^-, \pi^+ \pi^-, K^\pm \pi^\mp$  
  \[\text{[GLW/ADS Method]}\]
- $B^\pm \to D^0 K^\pm$ with $D^0 \to K_S^0 \pi^+ \pi^-, K_S^0 K^+ K^-$  
  \[\text{[GGSZ Method]}\]
- $B^\pm \to D^0 K^\pm$ and $B^\pm \to D^0 \pi^\pm$ with $D^0 \to K^\pm \pi^\mp \pi^\pm \pi^\mp$  
  \[\text{[ADS Method]}\]
$\gamma$ from $B^\pm \to D^0 K^\pm$ and $B^\pm \to D^0 \pi^\pm$

**GLW/ADS Method**

![GLW/ADS Method](image)

**GGSZ Method**

![GGSZ Method](image)

- **Data sample:** 1 fb$^{-1}$ of 7 TeV data collected in 2011
- **Combination Fit:** 24 input parameters (charge asymmetries, charge averages, ratios of suppressed to favoured final states) + 13 constraints on $D^0$ decay
- **See also Mitesh Patel’s talk**
\[ \gamma \text{ from } B^\pm \to D^0 K^\pm \text{ and } B^\pm \to D^0 \pi^\pm \]

Latest LHCb Results

Systematic uncertainties assigned for

- neglected correlations between fitted parameters
- undercoverage of the combination method

\[ B^\pm \to D^0 K^\pm \]

\[ B^\pm \to D^0 \pi^\pm \]

\[ B^\pm \to D^0 h^\pm \text{ Combined} \]

68% C.L.
\[ \gamma \in [56.4, 86.7]^\circ \]

95% C.L.
\[ \gamma \in [42.6, 99.6]^\circ \]

68% C.L.
\[ \gamma \in [7.4, 99.2]^\circ \]

95% C.L.
No Limit

68% C.L.
\[ \gamma \in [55.4, 82.3]^\circ \]

95% C.L.
\[ \gamma \in [40.2, 92.7]^\circ \]
\( \gamma \) from \( B^\pm \rightarrow D^0 (\rightarrow K_s^0 h^+ h^-)K^\pm \)

**Preliminary Results**

- Data sample: 2 fb\(^{-1}\) of 8 TeV data collected in 2012
- Same analysis procedure as [arxiv 1209.5869]
- Improved selection strategy
- Result combined with previous GGSZ result

\[ \gamma = (57 \pm 16)^\circ \]

- See Mitesh Patel’s talk for more details

**Preliminary Update on Average**

\( B^\pm \rightarrow D^0 K^\pm \) Comparison

\[ \gamma \in [55.1, 79.1]^\circ \]

68% C.L.

95% C.L.

\[ \gamma \in [43.9, 89.5]^\circ \]
Conclusion

- LHCb has produced many first and world’s best CP asymmetry measurements, in many different $B$ decay modes.

- Most of the LHCb results are limited by their statistical uncertainty.

- All results presented here are based on the 1 fb$^{-1}$ dataset collected in 2011. The 2 fb$^{-1}$ dataset collected in 2012 is currently being studied.

Expect many more updates soon!
$B_s^0 \rightarrow D_s^- \mu^+ \nu$

$B_q^0 \rightarrow h^- h^+$

$B_s^0 \rightarrow J/\psi h^+ h^-$

$B^\pm \rightarrow D^0 h^\pm$

Back-up
Performance of the LHCb Detector

Data Taking

- Data taking efficiency: 93.05%
- Percentage of working detector channels: ≈ 99%

Efficiencies

- Trigger efficiency:
  Dimuon channels: ≈ 90%
  Multibody hadronic channels: ≈ 30%
- Track reconstruction efficiency: > 96%

Resolution

- Momentum resolution:
  \( \Delta p/p = 0.4\% \) at 5 GeV/c
  \( \Delta p/p = 0.6\% \) at 100 GeV/c
- ECAL resolution: 1% ± 10%
LHCb Measurement

- Data sample: 1 fb⁻¹ of 7 TeV data collected in 2011
- Reconstructed final states: $D_s^- \rightarrow K^- K^+ \pi^-$, $K^- \pi^+ \pi^-$, $\pi^- \pi^+ \pi^-$
- Optimisation and background study done using $B_s^0 \rightarrow D_s^\mp \pi^\pm$ mode
- Many partially reconstructed background to consider
- Analysis affected by resolution, acceptance, flavour tagging

\[
\begin{align*}
\gamma - 2\beta_s & \text{ from } B_s^0 \rightarrow D_s^\mp K^\mp \\
LHCb-CONF-2012-029
\end{align*}
\]
\[ B_{s}^{0} \rightarrow D_{s}^{\mp}K^{\pm} \]

Latest LHCb Results

Decay time distribution for \( B_{s}^{0} \rightarrow f \)

\[
\frac{d\Gamma(t)}{dt} \propto \cosh\left(\frac{\Delta\Gamma_s}{2}t\right) - D_f \sinh\left(\frac{\Delta\Gamma_s}{2}t\right) + C_f \cos(\Delta m_s t) - S_f \sin(\Delta m_s t)
\]

\[
C = 1.01 \pm 0.50 \pm 0.23 = \frac{(1 - r^2)}{(1 + r^2)}
\]

\[
S_f = -1.25 \pm 0.56 \pm 0.24 = 2r \sin (\delta_s - (\gamma - 2\beta_s)) / (1 + r^2)
\]

\[
S_{\bar{f}} = 0.08 \pm 0.68 \pm 0.28 = 2r \sin (\delta_s + (\gamma - 2\beta_s)) / (1 + r^2)
\]

\[
D_f = -1.33 \pm 0.60 \pm 0.26 = 2r \cos (\delta_s - (\gamma - 2\beta_s)) / (1 + r^2)
\]

\[
D_{\bar{f}} = -0.81 \pm 0.56 \pm 0.26 = 2r \cos (\delta_s + (\gamma - 2\beta_s)) / (1 + r^2)
\]
CP Violation in $D^0 \rightarrow K^-K^+$ and $D^0 \rightarrow \pi^-\pi^+$

LHCb Measurement

- Data sample: 1 fb$^{-1}$ of 7 TeV data collected in 2011
- Use $D^{*+} \rightarrow D^0\pi_s^+$ to tag the initial flavour of the $D^0$
- Or use semileptonic $B$ decays: $\bar{B} \rightarrow D^0\mu^-\bar{\nu}_\mu X$

$$A_{\text{CP}}(f) \equiv \frac{\Gamma(D^0(t) \rightarrow f) - \Gamma(\bar{D}^0(t) \rightarrow f)}{\Gamma(D^0(t) \rightarrow f) + \Gamma(\bar{D}^0(t) \rightarrow f)}$$

- To cancel detector asymmetries (as much as possible) and eliminate the contribution of indirect CP violation, measure

$$\Delta A_{\text{CP}} \equiv A_{\text{CP}}(K^-K^+) - A_{\text{CP}}(\pi^-\pi^+)$$

Latest LHCb Results

$$\Delta A_{\text{CP}} = (-0.34 \pm 0.15 \pm 0.10)\% \text{ from } D^{*0}$$

$$= (+0.49 \pm 0.30 \pm 0.14)\% \text{ from } \bar{B} \rightarrow D^0\mu^-\bar{\nu}_\mu X$$

$$= (-0.15 \pm 0.16)\% \text{ Combination}$$
Symmetry Transformation

\[(\phi_s, \Delta \Gamma_s, \delta_0, \delta_\parallel, \delta_\perp, \delta_S) \leftrightarrow (\pi - \phi_s, -\Delta \Gamma_s, -\delta_0, -\delta_\parallel, \pi - \delta_\perp, -\delta_S)\]

Flavour Tagging Performance

Tagging power: \(\epsilon_{\text{tag}} D^2 = \epsilon_{\text{tag}} (1 - 2\omega)^2\)

- **Opposite-side Tagger Only:**

  \[
  \begin{align*}
  \epsilon_{\text{tag}} &= (33.00 \pm 0.28)\% \\
  \langle \omega \rangle &= (36.83 \pm 0.15)\% \\
  \epsilon_{\text{tag}} D^2 &= (02.29 \pm 0.06)\%
  \end{align*}
  \]

- **Same-side Tagger Only:**

  \[
  \begin{align*}
  \epsilon_{\text{tag}} &= (10.26 \pm 0.18)\% \\
  \epsilon_{\text{tag}} D^2 &= (00.89 \pm 0.17)\%
  \end{align*}
  \]

- **Overlap region (OS+SS):**

  \[
  \begin{align*}
  \epsilon_{\text{tag}} &= (03.90 \pm 0.11)\% \\
  \epsilon_{\text{tag}} D^2 &= (00.51 \pm 0.03)\%
  \end{align*}
  \]

- **Total:**

  \[
  \begin{align*}
  \epsilon_{\text{tag}} &= (39.36 \pm 0.32)\% \\
  \langle \omega \rangle &= 35.9\% \\
  \epsilon_{\text{tag}} D^2 &= (03.13 \pm 0.13 \pm 0.20)\%
  \end{align*}
  \]
GGSZ Method

\begin{align*}
x_- &= r^K_B \cos(\delta^K_B - \gamma) \\
y_- &= r^K_B \sin(\delta^K_B - \gamma) \\
x_+ &= r^K_B \cos(\delta^K_B + \gamma) \\
y_+ &= r^K_B \sin(\delta^K_B + \gamma)
\end{align*}

ADS & GLW Method

- Ignoring corrections due to $D^0 - \bar{D}^0$ mixing

\begin{align*}
R_{K/\pi}^f &= \frac{\Gamma(B^+ \to D^0 [\to f] \pi^-) + \Gamma(B^- \to D^0 [\to \bar{f}] \pi^+)}{\Gamma(B^- \to D^0 [\to f] \pi^-) + \Gamma(B^+ \to D^0 [\to \bar{f}] \pi^+)} = R_{cab} \frac{1 + (r^K_B)^2 + 2r^K_B \cos \delta^K_B \cos \gamma}{1 + (r^K_B)^2 + 2r^K_B \cos \delta^K_B \cos \gamma} \\
A^f_h &= \frac{\Gamma(B^- \to D^0 [\to f] h^-) - \Gamma(B^+ \to D^0 [\to \bar{f}] h^+)}{\Gamma(B^- \to D^0 [\to f] h^-) + \Gamma(B^+ \to D^0 [\to \bar{f}] h^+)} = \frac{2r^h_B \sin \delta^h_B \sin \gamma}{1 + (r^h_B)^2 + 2r^h_B \cos \delta^h_B \cos \gamma} \\
R^\pm_h &= \frac{\Gamma(B^\pm \to D^0 [\to f_{\text{sup}}] h^\pm)}{\Gamma(B^\pm \to D^0 [\to \bar{f}] h^\pm)} = \frac{r^2_f + (r^h_B)^2 + 2r^h_B r_f \cos(\delta^h_B + \delta_f \pm \gamma)}{1 + (r^h_f r_f)^2 + 2r^h_B r_F \cos(\delta^h_B - \delta_f \pm \gamma)}
\end{align*}
### Input for the $\gamma$ Combination

<table>
<thead>
<tr>
<th>Method</th>
<th>[arxiv 1209.5869]</th>
<th>GLW/ADS Method</th>
<th>[arxiv 1203.3662]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GGSZ Method</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$x_-$</td>
<td>$(0.0 \pm 4.3 \pm 1.5 \pm 0.6) \times 10^{-2}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$y_-$</td>
<td>$(2.7 \pm 5.2 \pm 0.8 \pm 2.3) \times 10^{-2}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$x_+$</td>
<td>$(-10.3 \pm 4.5 \pm 1.8 \pm 1.4) \times 10^{-2}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$y_+$</td>
<td>$(0.0 \pm 3.7 \pm 0.8 \pm 3.0) \times 10^{-2}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ADS Method</strong></td>
<td>[arxiv 1303.4646]</td>
<td></td>
<td>[arxiv 1203.4646]</td>
</tr>
<tr>
<td>$R_{K^3\pi}^{K\pi}$</td>
<td>$0.0765 \pm 0.0017 \pm 0.0026$</td>
<td>$0.0774 \pm 0.0012 \pm 0.0018$</td>
<td></td>
</tr>
<tr>
<td>$A_{\pi}^{K3\pi}$</td>
<td>$-0.006 \pm 0.005 \pm 0.010$</td>
<td>$0.0773 \pm 0.0030 \pm 0.0018$</td>
<td></td>
</tr>
<tr>
<td>$A_{K}^{K3\pi}$</td>
<td>$-0.026 \pm 0.020 \pm 0.018$</td>
<td>$0.0803 \pm 0.0056 \pm 0.0017$</td>
<td></td>
</tr>
<tr>
<td>$R_{K^-}^{K3\pi}$</td>
<td>$0.0071 \pm 0.0034 \pm 0.0008$</td>
<td>$-0.0001 \pm 0.0036 \pm 0.0095$</td>
<td></td>
</tr>
<tr>
<td>$R_{K^+}^{K3\pi}$</td>
<td>$0.0155 \pm 0.0042 \pm 0.0010$</td>
<td>$0.0044 \pm 0.0144 \pm 0.0174$</td>
<td></td>
</tr>
<tr>
<td>$R_{\pi^-}^{K3\pi}$</td>
<td>$0.00400 \pm 0.00052 \pm 0.00011$</td>
<td>$1.48 \pm 0.037 \pm 0.010$</td>
<td></td>
</tr>
<tr>
<td>$R_{\pi^+}^{K3\pi}$</td>
<td>$0.00316 \pm 0.00046 \pm 0.00011$</td>
<td>$-0.020 \pm 0.009 \pm 0.012$</td>
<td></td>
</tr>
</tbody>
</table>

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