Flavour Tagging with the LHCb experiment
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Flavour Tagging in Run I

Strategy

- universal calibration for each tagger
- systematic uncertainties from
  - calibration methods
  - portability
- mode-specific calibration if FT becomes leading systematic uncertainty in precision analyses

Performance in analyses

<table>
<thead>
<tr>
<th>Analysis</th>
<th>$\varepsilon_{\text{eff}}$ on data [%]</th>
<th>ratio latest/previous</th>
<th>references</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B \to J/\psi \pi^+\pi^-$</td>
<td>2.43</td>
<td>3.89</td>
<td>1.60</td>
</tr>
<tr>
<td>$B \to J/\psi K K^*$</td>
<td>3.13</td>
<td>3.73</td>
<td>1.19</td>
</tr>
<tr>
<td>$B \to J/\psi K$</td>
<td>-</td>
<td>4.00</td>
<td></td>
</tr>
<tr>
<td>$B \to \psi K$</td>
<td>3.29</td>
<td>5.38</td>
<td>1.64</td>
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<tr>
<td>$B \to D K$</td>
<td>1.9</td>
<td>5.07</td>
<td>2.64</td>
</tr>
<tr>
<td>$B \to D^0 K^-$</td>
<td>- 10</td>
<td>5.33</td>
<td></td>
</tr>
<tr>
<td>$B^+ \to J/\psi K^+$</td>
<td>2.38</td>
<td>3.02</td>
<td>1.27</td>
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<tr>
<td>$B^+ \to J/\psi \pi^+$</td>
<td>-</td>
<td>3.26</td>
<td></td>
</tr>
</tbody>
</table>

Performance improvements in Run I

- OS tagging improved $\mathcal{O}(15\%)$
- SS kaon tagging improved $\mathcal{O}(40\%)$

$\Rightarrow$ Flavour Tagging has been a success in Run I

Developments

SS kaon calibration with excited $D_s$ states

- SS kaon taggers calibrated with $B_s^0 \to D_s^+ \pi^-$ only
- limited statistics
- time-dependent analysis required
- new idea: calibrate with $B_s^0 \to D_s^+ K^-$ decays
- narrow states
- reconstruct in $B_s^0 \to D_s^+ K^-$ decays
- calibrate by counting, as in other charged modes

SS pion calibration

- calibration performed with $B_s^0 \to D_s^0 K^0$
- full evaluation of systematic uncertainties
- used for the first time in the measurements of
  - $\sin(2\phi)$ with $B_s^0 \to D_s^0 K^0$
  - precision comparable to $B$-factories
    - $\varepsilon_{\text{eff}}(\sin(2\phi)) = 0.38\%$
  - $\sin(2\phi)_{\text{mix}}$ with $B_s^0 \to \phi\phi$
    - $\varepsilon_{\text{eff}} = 0.54\%$

OS and SS Kaon tagging using neural nets (NN)

- basic idea: use two NN
  - first NN distinguishes between: 1. fragmentation tracks; $\Rightarrow$ signal for SS kaon nnet
  - 2. OS $b$ hadron tracks; $\Rightarrow$ signal for OS kaon nnet
  - 3. underlying event tracks

OS charm tagger

- reconstruct $D^0/D_s^0/D^+$ decays related to $S$ decay
- one boosted decision tree (BDT) for each mode
- clean measure of $B$ meson flavour (low mistag)
- adds about $0.37\%$ to $\varepsilon_{\text{eff}}$

SS pion BDT and SS proton

- promising new taggers based on BDT's
- development ongoing

Outlook on Run II

Effects of new conditions

- LHC will run at $\sqrt{s} = 13$ TeV
  - higher track multiplicity (degrades OS/SS taggers)
  - higher $B$ momentum (improves SS taggers)
- luminosity leveling at LHCb
  - lower PV multiplicity (improves OS/SS taggers)

Preparations

- taggers are optimised for Run II
  - need to optimise tagging candidates’ selections
  - retrain with simulations of the 2015 conditions...
  - ...and check performances with first data
  - recalibrate and reoptimize all taggers

References