LHCb Strategies for $\gamma$ from $B \to DK$

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**ADS** with $B^+ \to DK^+$
and $B^0 \to DK^{*0}$

**Dalitz** with $B^+ \to DK^+$
and $B^0 \to DK^{*0}$
Physics Aim

- It is generally assumed tree processes are dominated by SM contributions.
- Disagreement between the tree-determined triangle ($|V_{ub}| + \gamma$ from $B \rightarrow DK$) and the loop-determined triangle ($\varepsilon_K, \Delta m_d, \Delta m_s, \sin 2\beta, \ldots$) indicates new physics.
- They are consistent within current measurement precision.
- Have big uncertainty in $\gamma$ used for tree fit. Improvement needed!
- Require sensitivity of $\gamma$ from tree $\sim 5^\circ$ to match the precision of indirect determination.
- LHCb: $\gamma$ from $B_s \rightarrow D_s K$ is clean and unaffected by new physics, but has sensitivity of $14^\circ$ with 2 fb$^{-1}$ of data. We will see $B \rightarrow DK$ is more promising for LHCb.

![Tree fit](image1)

**Tree fit**

![Loop fit](image2)

**Loop fit**
**LHCb detector**

**Tracking:**
- Vertex Locator
- TT
- T1-T3
- Magnet

**PID:**
- RICH1/RICH2
- SPD/PS
- ECAL
- HCAL
- M1-M5

**RICH PID performance**
- $2 < p < 100 \text{ GeV}$
- $\langle \varepsilon (K \rightarrow K,P) \rangle = 93\%$
- $\langle \varepsilon (\pi \rightarrow K,P) \rangle = 4.7\%$

**Tracking efficiency**
- 94% for physics tracks with $p > 10\text{ GeV}$

**Detector status:**
Talk by Lluis Garrido

**Trigger:**
Talk by Eduardo Rodrigues
Data simulation

- LHCb will start data-taking in 2007.
- Full Pythia+Geant4 simulations are used for trigger, reconstruction and event selection studies.
- Used event samples include
  - 260m minimum bias events for trigger study,
  - 140m Inclusive bb events for background study,
  - Dedicated signal events.
- Sensitivities are obtained using fast simulations according to efficiencies, resolutions and background level from full simulations.
Event selection criteria

- Hadron particle identification using RICH
- Composite particle invariant masses ($B, D, K^*, K_s$)
- Impact parameters and transverse momentum of $B$ and decay products
- Vertex $\chi^2$ of $B, D, K^*, K_s$
- Angle between $B$ momentum and flight direction
- Event topology

Cuts are optimized to reject most background events from a large inclusive $bb$ sample and retain high signal efficiencies. Final $B/S$ ratios are assessed based on a separate $bb$ sample.
B → DK decays

- Three parameters for CKM favoured B → DK and disfavoured B → ĐK
  - weak phase difference $\gamma = \text{Arg}(-(V_{ub}V_{cs}^*)/(V_{cb}V_{us}^*))$
  - strong phase difference $\delta_B$ and
  - amplitude ratio $r_B = |A(B \rightarrow DK)|/|A(B \rightarrow ĐK)|$

- Interference allows to extract $\gamma$, if same $D^0$ and $Đ^0$ final states

B$^\pm$ decays ($r_B \sim 0.1$)

\[ \begin{align*}
\text{b} & \rightarrow \text{s} \quad \text{ubar} \\
\text{c} & \rightarrow \text{cbar} \\
\text{ubar} & \rightarrow \text{ubar} \\
\hline
\text{b} & \rightarrow \text{s} \quad \text{ubar} \\
\text{c} & \rightarrow \text{cbar} \\
\text{ubar} & \rightarrow \text{ubar} \\
\hline
\end{align*} \]

B$^0$ decays (both diagrams colour suppressed $\rightarrow r_B \sim 0.4$)

\[ \begin{align*}
\text{b} & \rightarrow \text{s} \quad \text{ubar} \\
\text{c} & \rightarrow \text{cbar} \\
\text{ubar} & \rightarrow \text{ubar} \\
\hline
\text{b} & \rightarrow \text{s} \quad \text{ubar} \\
\text{c} & \rightarrow \text{cbar} \\
\text{ubar} & \rightarrow \text{ubar} \\
\hline
\end{align*} \]
Consider a final state common to $D^0$ and $\bar{D}^0$, e.g. $K\pi$

**DCS**

$$D^0 \begin{cases} c \\ u \end{cases} \begin{cases} u \\ \bar{s} \end{cases} K^+$$

$$\bar{D}^0 \begin{cases} \bar{c} \\ u \end{cases} \begin{cases} d \\ \bar{s} \end{cases} \pi^-$$

**Define**

$$\frac{A(DCS)}{A(\text{favoured})} = \frac{A(D^0 \rightarrow K^-\pi^+)}{A(D^0 \rightarrow K^-\pi^+)} = \frac{A(D^0 \rightarrow K^+\pi^-)}{A(\bar{D}^0 \rightarrow K^+\pi^-)} \equiv r^K_{D} e^{-i\delta^K_{D}}$$

There are four possible charged B decays

$$\Gamma(B^- \rightarrow (K^-\pi^+)_{D} K^-) \propto 1 + (r_B r^K_{D})^2 + 2 r_B r^K_{D}\cos(\delta_B - \delta^K_{D} - \gamma), \quad (1)$$

$$\Gamma(B^- \rightarrow (K^+\pi^-)_{D} K^-) \propto r_B^2 + (r^K_{D})^2 + 2 r_B r^K_{D}\cos(\delta_B + \delta^K_{D} - \gamma), \quad (2)$$

$$\Gamma(B^+ \rightarrow (K^+\pi^-)_{D} K^+) \propto 1 + (r_B r^K_{D})^2 + 2 r_B r^K_{D}\cos(\delta_B - \delta^K_{D} + \gamma), \quad (3)$$

$$\Gamma(B^+ \rightarrow (K^-\pi^+)_{D} K^+) \propto r_B^2 + (r^K_{D})^2 + 2 r_B r^K_{D}\cos(\delta_B + \delta^K_{D} + \gamma) \quad (4)$$

Interference $\sim O(1)$ for suppressed (2) and (4)
ADS tailored for LHCb

- $D^0 \to K\pi$: 3 observables from the relative rates of the 4 processes depends on 4 unknowns $\gamma$, $r_B$, $\delta_B$, $\delta_D^{K\pi}$
  - $r_D^{K\pi}$ is already well measured
  - May benefit from $\cos(\delta_D)$ measurements in CLEO-c and/or BES III
  - Need another $D^0$ decay channel to solve for all unknowns

- 4-body decay $D^0 \to K\pi\pi\pi$ provides 3 observables which depends on 4 unknowns $\gamma$, $r_B$, $\delta_B$, $\delta_D^{K3\pi}$ – only $\delta_D^{K3\pi}$ new (4-body Dalitz, p.17)

- Each CP mode $D^0 \to KK/\pi\pi$ provides one more observables with no new unknowns

$$
\Gamma(B^- \to (h^+h^-)_D K^-) \propto 1 + r_B^2 + 2r_B \cos(\delta_B - \gamma)
$$
$$
\Gamma(B^+ \to (h^+h^-)_D K^+) \propto 1 + r_B^2 + 2r_B \cos(\delta_B + \gamma)
$$

The ADS method constrains $\gamma$ only if we can see suppressed decays! Good opportunity for LHCb.
Example: $B^+ \rightarrow (K\pi)_D K^+$, $r_B = 0.077$

- **Favoured modes**
  - Background from $D^0\pi$ decays dominates (BR $\sim 13 \times D^0K$)
    - Use RICH information to separate $D^0K$ and $D^0\pi$
    - Use dedicated sample of $D^0\pi$ decays
    → Expect $\sim 17k$ background events/year from $D^0\pi$
  - Use bb sample to assess combinatorial background
    → Expect $\sim 0.7k$ background events/year

$\sim 28k$/year $B^+ \rightarrow (K^+\pi^-)_D K^+$  B/S $\sim 0.6$
$\sim 28k$/year $B^- \rightarrow (K^-\pi^+)_D K^-$  B/S $\sim 0.6$

- **Suppressed modes**
  - bb sample indicates that the combinatorial contribution dominates:
    → Expect $\sim 0.7k$ background events/year
  - $D^0\pi$: 17k $R_{D\pi}^{BELLE} \sim 60$ events/year

$\sim 530$/year $B^+ \rightarrow (K^-\pi^+)_D K^+$  B/S $\sim 1.5$
$\sim 180$/year $B^- \rightarrow (K^+\pi^-)_D K^-$  B/S $\sim 4.3$
(depending on $r_B$)
Performance with $B^+ \rightarrow DK^+$

- Take $\gamma = 60^\circ$, $r_B = 0.077$
  
  $\delta_B = 130^\circ$
  
  $r_{DK} = r_{DK3} = 0.06$
  
  $-25^\circ < \delta_{DK} < 25^\circ$ and
  
  $-180^\circ < \delta_{DK3} < 180^\circ$

- Combine $K\pi$ with

  ✓ $K3\pi$ similar yields and background level as $K\pi$
  
  ✓ KK and $\pi\pi$ modes

  $\sim 4.3k B^+ \rightarrow D^0(hh)K^+$ B/S $\sim 1$
  
  $\sim 3.3k B^- \rightarrow D^0(hh)K^-$ B/S $\sim 1$

σ(γ) $\sim 5^\circ -15^\circ$ in a year, depending on $r_B$, $\delta_{DK}\pi$ and $\delta_{DK3}\pi$

<table>
<thead>
<tr>
<th>$\delta_{DK}\pi$, $\delta_{DK3}\pi$</th>
<th>-25</th>
<th>-16.6</th>
<th>-8.3</th>
<th>0</th>
<th>8.3</th>
<th>16.6</th>
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<tr>
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<tr>
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<td>3.3</td>
<td>4.6</td>
<td>6.6</td>
<td>9.4</td>
<td>11.0</td>
</tr>
<tr>
<td>120</td>
<td>3.4</td>
<td>3.6</td>
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<td>3.2</td>
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<td>2.6</td>
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w/o bkgrd

<table>
<thead>
<tr>
<th>$\delta_{DK}\pi$, $\delta_{DK3}\pi$</th>
<th>-25</th>
<th>-16.6</th>
<th>-8.3</th>
<th>0</th>
<th>8.3</th>
<th>16.6</th>
<th>25</th>
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<td>6.5</td>
<td>6.8</td>
<td>7.2</td>
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<td>-120</td>
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<td>7.8</td>
<td>7.4</td>
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<td>6.2</td>
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<td>12.1</td>
<td>13.1</td>
<td>13.0</td>
</tr>
<tr>
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<td>12.9</td>
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<td>6.8</td>
<td>7.1</td>
<td>7.3</td>
<td>6.5</td>
</tr>
</tbody>
</table>

estimated bkgrd

(Highlighted are RMS quoted for non-Gaussian distribution of fit results due to close ambiguous solutions, will disappear as statistics increase. Global analysis using all modes will also help.)
ADS with D*K

- **Attractive feature**
  - $D^* \rightarrow D^0 \pi^0$ (BR~2/3) – has strong phase $\delta_B$
  - $D^* \rightarrow D^0 \gamma \square$ (BR~1/3) – strong phase $\delta_{B+\pi}$
  - if can distinguish the two decays → powerful additional constraint!

- **Potential**
  - Including D*K without background improves precision to $\sigma(\gamma) = 2^\circ - 5^\circ$

- **However**
  - Reconstruction efficiency is small for soft $\gamma$ while background is enormous
  - Non-trivial to separate $D^0 \pi^0$ and $D^0 \gamma$

- **Fit DK mass shape to get $\pi^0$ and $\gamma$ components ignoring neutrals**
  - all favoured modes can reach 10k/year or more with B/S $\sim O(1)$
  - Suppressed modes still problematic: under study

- **Idea to use the event topology to reconstruct momentum of $\pi^0/\gamma$ is being investigated**

Background dominating:
1 bb event here represents 5k/year!
The same method can be applied to $B^0 \rightarrow D^0 K^*$ with $D^0 \rightarrow K \pi$ and $K K$, (historically treated with “GLW” method)

- $r_B \sim 0.4$, big interference in CP modes ($r_D^{CP}=1$)

<table>
<thead>
<tr>
<th>Mode</th>
<th>Yields</th>
<th>S/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>favoured $B^0 \rightarrow (K^+ \pi^-)_D K^{*0}$ + c.c.</td>
<td>3400</td>
<td>$&gt; 3.3$</td>
</tr>
<tr>
<td>disfavoured $B^0 \rightarrow (K^- \pi^+)_D K^{*0}$ + c.c.</td>
<td>500</td>
<td>$&gt; 0.6$</td>
</tr>
<tr>
<td>$B^0 \rightarrow (K^+K^-/\pi^+\pi^-)_D K^{*0}$ + c.c.</td>
<td>600</td>
<td>$&gt; 0.7$</td>
</tr>
</tbody>
</table>

$\sigma(\gamma) \sim 7^\circ$-$10^\circ$ in a year (2 fb$^{-1}$) 
(55$^\circ$ $< \gamma < 105^\circ$, $r_B \sim 0.4$, $-20^\circ < \delta_B < 20^\circ$)
**Dalitz:** $B^+ \rightarrow (K_s \pi^+ \pi^-)_D K^+$

- Three body decay $D^0 \rightarrow K_s \pi^+ \pi^-$ fully parameterized with two parameters $m_+^2 = m^2(K_s \pi^+)$ and $m_-^2 = m^2(K_s \pi^-)$
- Use pre-determined model to describe $D^0$ decay amplitudes as a function of $(m_+^2, m_-^2)$

Total $B$ decay amplitude as sum of contributions via $\bar{D}^0$ and $D^0$

$$A^- = f(m_-^2, m_+^2) + r_B e^{i(-\gamma + \delta_B)} f(m_+^2, m_-^2)$$

$$A^+ = f(m_-^2, m_+^2) + r_B e^{i(\gamma + \delta_B)} f(m_+^2, m_-^2)$$

$$f(m_+^2, m_-^2) = \left[ \sum_{j=1}^{N} a_j e^{i\alpha_j} A_j(m_+^2, m_-^2) \right] + be^{i\beta}$$

Interference has sensitivity to $\gamma$

$$\Gamma(m_-^2, m_+^2) = |f(m_-^2, m_+^2)|^2 + r_B^2 |f(m_+^2, m_-^2)|^2 + 2 r_B \Re \left[ f(m_-^2, m_+^2)f^*(m_+^2, m_-^2)e^{i(-\gamma + \delta_B)} \right]$$

---

Input values for Amplitudes and phases used for 3 body analysis (from BaBar):

<table>
<thead>
<tr>
<th>Resonance</th>
<th>Amplitude</th>
<th>Phase (degrees)</th>
<th>Fraction (%)</th>
<th>Mass MeV/c²</th>
<th>Width MeV/c²</th>
<th>Functional form</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K^*(892)$</td>
<td>$1.777 \pm 0.018$</td>
<td>$133.9 \pm 0.81$</td>
<td>$55.51$</td>
<td>$891.96$</td>
<td>$50.8$</td>
<td>BW</td>
</tr>
<tr>
<td>$\rho^0(770)$</td>
<td>$1$ (fixed)</td>
<td>$0$ (fixed)</td>
<td>$22.33$</td>
<td>$776.8$</td>
<td>$144.4$</td>
<td>GS</td>
</tr>
<tr>
<td>$\omega(782)$</td>
<td>$0.0391 \pm 0.0016$</td>
<td>$-44.9 \pm 2.4$</td>
<td>$0.09$</td>
<td>$861.66$</td>
<td>$50.8$</td>
<td>BW</td>
</tr>
<tr>
<td>$f_0(1510)$</td>
<td>$0.69 \pm 0.011$</td>
<td>$213.4 \pm 2.2$</td>
<td>$5.81$</td>
<td>$975$</td>
<td>$42$</td>
<td>BW</td>
</tr>
<tr>
<td>$f_0(1370)$</td>
<td>$2.32 \pm 0.31$</td>
<td>$144.1 \pm 4.4$</td>
<td>$3.39$</td>
<td>$1434$</td>
<td>$173$</td>
<td>BW</td>
</tr>
<tr>
<td>$f_0(1270)$</td>
<td>$0.915 \pm 0.041$</td>
<td>$-229.9 \pm 2.9$</td>
<td>$2.96$</td>
<td>$1275.4$</td>
<td>$184.1$</td>
<td>BW</td>
</tr>
<tr>
<td>$K^*(1430)$</td>
<td>$2.45 \pm 0.074$</td>
<td>$-7.9 \pm 2.0$</td>
<td>$8.47$</td>
<td>$1412$</td>
<td>$294$</td>
<td>BW</td>
</tr>
<tr>
<td>$K^*(1430)$ DCS</td>
<td>$0.33 \pm 0.009$</td>
<td>$341.4 \pm 10.4$</td>
<td>$0.09$</td>
<td>$1412$</td>
<td>$294$</td>
<td>BW</td>
</tr>
<tr>
<td>$K^*(1430)$ DCS</td>
<td>$1.035 \pm 0.045$</td>
<td>$-53.1 \pm 2.6$</td>
<td>$2.70$</td>
<td>$1225.6$</td>
<td>$98.8$</td>
<td>BW</td>
</tr>
<tr>
<td>$K^*(1430)$ DCS</td>
<td>$0.0741 \pm 0.003$</td>
<td>$-98.3 \pm 0.9$</td>
<td>$0.11$</td>
<td>$1225.6$</td>
<td>$98.8$</td>
<td>BW</td>
</tr>
<tr>
<td>$K^*(1410)$</td>
<td>$0.52 \pm 0.073$</td>
<td>$-157 \pm 10$</td>
<td>$0.49$</td>
<td>$1414$</td>
<td>$232$</td>
<td>BW</td>
</tr>
<tr>
<td>$K^*(1680)$</td>
<td>$0.99 \pm 0.34$</td>
<td>$-144 \pm 18$</td>
<td>$0.35$</td>
<td>$1717$</td>
<td>$352$</td>
<td>BW</td>
</tr>
<tr>
<td>$\rho(1450)$</td>
<td>$0.654 \pm 0.097$</td>
<td>$35 \pm 12$</td>
<td>$0.88$</td>
<td>$1400$</td>
<td>$455$</td>
<td>GS</td>
</tr>
<tr>
<td>$\sigma_1$</td>
<td>$1.36 \pm 0.041$</td>
<td>$-177.5 \pm 2.5$</td>
<td>$9.11$</td>
<td>$484.9$</td>
<td>$383.8$</td>
<td>BW</td>
</tr>
<tr>
<td>$\sigma_2$</td>
<td>$0.292 \pm 0.025$</td>
<td>$-206.8 \pm 4.3$</td>
<td>$0.98$</td>
<td>$1014.7$</td>
<td>$88.1$</td>
<td>BW</td>
</tr>
<tr>
<td>Non resonant</td>
<td>$3.31 \pm 0.18$</td>
<td>$-233.9 \pm 5.0$</td>
<td>$6.82$</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
## Comparison to BELLE data

<table>
<thead>
<tr>
<th>Naïve model amplitude</th>
<th>Isobar amp. + non-res.</th>
<th>Belle data with model fit</th>
</tr>
</thead>
</table>

### $m^2_+$

![Graph of $m^2_+$ data](image)

### $m^2_-$

![Graph of $m^2_-$ data](image)
Performance of $B^+ \rightarrow (K_S \pi^+ \pi^-)_D K^+$

for $r_B = 0.077$

- 5k events/year assuming “good” $K_S$ efficiency at HLT, combinatorial B/S < 0.7, $D(K_S \pi \pi) \pi$ B/S in (0.11, 12) at 95% C.L.
  - Need large $D(K_S \pi \pi) \pi$ sample to clarify
- Model parameters from B and charm factories
- $\sigma(\gamma) \sim 8^\circ +$ model uncertainty, w/o b.g. and detector effect in fit
- Two-fold ambiguity ($\gamma$, $\delta_B$), ($\gamma-\pi$, $\delta_B-\pi$)

Statistical precision depends on $r_B$, e.g., $\sigma(\gamma) \sim 4^\circ$ for $r_B = 0.15$

Current $K_S$ problem in HLT:
Only 25% of $K_S$ decay inside active region of VELO, giving 1.5k events/year. Online reconstruction of the pion tracks from other $K_S$ requires special treatment and is challenging due to HLT time limit. Great efforts are being made to speed up the online reconstruction of no-VELO tracks. Depending on how this will be accomplished, annual yield can vary between 1.5k - 5k, leading to $\delta(\gamma) \sim 8^\circ - 16^\circ$ for $r_B = 0.077$. 
Acceptance studies

- Selection tuned to maximise signal-to-background ratio
- Flat phase space MC generated
- Overall acceptance not flat as a result of trigger and offline selection

Acceptance evaluation with isobar model in progress – as expected similar acceptance function is indicated. Can be checked with $B \rightarrow D\pi$ data.
Dalitz: $B^+ \rightarrow (K_\bar{s}K^+K^-)_D K^+$

- Same method works for $D^0 \rightarrow K_\bar{s}K^+K^-$ decay
  - BR reduced by factor of 6
    $$BR(D^0 \rightarrow K^0K^+K^-) = (1.03 \pm 0.10)\%$$
  - But less background because of two more particle identification constraints from RICH
- Dalitz model has fewer resonances ($\phi$, $a_0$) but complex threshold effects (Babar hep-ex/0507026)
- Work on event selection and sensitivity ongoing
The idea for 3-body D^0 decays can be extended to 4-body D^0 decays. Need 5 parameters to describe D^0 decays: not really a Dalitz plot.

\[ B^+ \rightarrow (\pi\pi KK)_D K^+ \]

for \( \gamma = 60^\circ, \delta_B = 130^\circ, r_B = 0.08 \)

- \( \sim 1.5k \) events in a year
- Preliminary number \( \delta(\gamma) \sim 15^\circ \) w/o b.g. and detector effect

\[ B^+ \rightarrow (\pi\pi\pi K)_D K^+ \]

- The same channel as used in ADS, but to take into account strong phase dependence on Dalitz space
- \( r_B \sim r_D \) big interference
- Sensitivity under study
Dalitz: $B^0 \rightarrow (K_S \pi^+ \pi)^D K^{*0}$

- Branching ratio reduced by factor 10 compared with $B^+$ mode
- Same method as in $B^+$
- Annual yield < 600 events
- Big interference ($r_B \sim 0.4$)
- Will complement the "GLW" modes $D^0 \rightarrow K\pi$, $KK$ and $\pi\pi$
- Also suffers $K_S$ HLT problem
Summary of performances: 2 fb⁻¹

<table>
<thead>
<tr>
<th>B mode</th>
<th>D mode</th>
<th>δ(γ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B⁺ → DK⁺</td>
<td>Kπ + KK/ππ + K3π</td>
<td>5° - 15°</td>
</tr>
<tr>
<td>B⁺ → DK⁺</td>
<td>Kₛππ</td>
<td>8° ~ 16°</td>
</tr>
<tr>
<td>B⁺ → DK⁺</td>
<td>KKππ</td>
<td>~ 15°</td>
</tr>
<tr>
<td>B⁰ → DK⁺⁺</td>
<td>Kπ + KK</td>
<td>7° - 10°</td>
</tr>
<tr>
<td>B⁰ → DK⁺⁺</td>
<td>Kₛππ</td>
<td>Under study</td>
</tr>
</tbody>
</table>

More modes are being investigated.

Combined precision should not be far away from 5°
Sources of systematics

As we approach statistical error of 10°, understanding and controlling systematical uncertainty becomes more and more important for LHCb

- Dalitz model dependence
  \[ \gamma = 92° \pm 41° \pm 11° \pm 12° \text{(Babar)} \quad \gamma = 58° \pm 18° \pm 3° \pm 9° \text{(Belle)} \]
  - Improve D decay model by work of B and Charm factories (LHCb for 4-body)

- Other contributions to K\(^*\) region in B→DK\(^*\)
  - To be studied

- Dalitz acceptance not flat
  - Currently obtained using Mont Carlo simulation, should be calibrated with data

- Production asymmetry and detection charge asymmetry to be studied

- D\(^0\)-\overline{D}\(^0\) mixing and CP violation
  - CP-conserving D\(^0\) mixing is a very small effect and can be neglected
  - New physics with big CP violation in D\(^0\) mixing may change the value of \(\gamma\) extracted from B→DK. Not really a systematic error but a new physics effect.
  - D\(^0\) mixing and CP violation can be probed in LHCb. See Raluca Muresan’s talk Friday.
Conclusions

- LHCb will be able to extract $\gamma$ from $B \to DK$ to the required $5^\circ$ precision to match the indirect determination with $\sim 2$ fb$^{-1}$

- Comparison of $\gamma$ from $B \to DK$ and indirect determination will become a stringent test of the SM

- Together with improvement on $|V_{ub}|$ the measured $\gamma$ from $B \to DK$ will enable to construct a reference Unitarity Triangle needed for new physics search

- A lot of work to do before data-taking
Multiple pass track finding:

**Velo seeds**
**T seeds**

Long tracks ⇒ highest quality for physics
Downstream tracks ⇒ needed for efficient $K_S$ finding
Upstream tracks ⇒ lower $p$, worse $p$ resolution, useful for RICH1 pattern recognition
CKM global fit