Probing photon polarization in $B_s \rightarrow \phi \gamma$ decay at LHCb
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On behalf of the LHCb collaboration

The LHC beauty experiment

- Is dedicated for precise measurements of CP-violation and rare decays of B mesons.
- Forward geometry at high energies both the b and b-hadrons are produced at the same forward (backward) cone.
- Operating luminosity $L=2.0\times10^{34} cm^{-2} \text{s}^{-1}$; 80% of bunch-crossings produce 1 pp-collision.
- Vertex Locator allows precise resolution of B production ($\tau_{br}=1.5 \text{~ns}$, $\sigma_{\theta}=2.4 \text{~mrad}$) and decay vertices.
- 2 Ring Imaging Cherenkov detectors provide hadron identification in a wide momentum range (1-100 GeV/c).

Measured decay rate

- Tagged events:
  \[ \Gamma(B \rightarrow \phi \gamma) \propto (\psi_{tag} - \psi_{cut}) \times \gamma_{MC} \]

- Untagged events:
  \[ \Lambda_{B}^{+} - \Lambda_{B}^{-} \propto (\psi_{reco} - \psi_{cut}) \times \gamma_{MC} \]

Event selection and yield

- At LHCb we will select per 2 fb$^{-1}$: $B^{+} \rightarrow K^{+}\gamma$: 68k, $B^{0}\rightarrow 0.60\pm0.16$.
- $B^{0}\rightarrow \phi:B$ or $B^{0}\rightarrow \phi$.

Background treatment

- Left sideband (4.4.5.1)
- Right sideband (5.7.6.4)

Signal proper time resolution

- $\Delta\tau$ measurement of $\phi^0\gamma$ after 1 year
- $\Delta\tau=114 \pm 7 \text{~fs}$, PS = 98% for LHCb.

To describe the effect measured proper time errors used for per-event resolution.

Toy Monte Carlo studies

- $\gamma \times 10^{5}$ experiments with RooFit.
- Unbinned maximum likelihood fit:
  - mass, proper time and its error distributions.
  - Proper time resolution from per-event proper time errors.
  - Signal acceptance function will be extracted from the control channels.

- $\Delta\tau=0.12$ for the main study, will be known from other LHCb measurements.
- $\Delta\tau=17.77 \pm 2.4 \text{~ps}$
- Background mass-time shape is found from the sidebands.

Summary and follow-ups

- The expected sensitivity to the measurement of photon polarization after 1 year is $\sigma(A^{0})=0.02$, $\sigma(S)=0.11$, $\sigma(C)=0.12$.
- The proper time acceptance should be determined from data: $B^{+}\rightarrow K^{+}\gamma$ or $B^{0}\rightarrow \phi\phi$.

This issue is under study now.

- The precision of $A^{0}$ measurement won’t suffer in case we have worse proper time resolution than found from full MC.
- Dependence on the background composition is quite moderate but on its amount is more pronounced. The background shape can be precisely determined from the sidebands.

Signal proper time function will be extracted from the control channels.

$\Delta\tau=0.12$ and $\Delta\tau=17.77 \pm 2.4 \text{~ps}$

Background mass-time shape is found from the sidebands.