Time-dependent amplitude analysis of semileptonically-tagged $D^0 \rightarrow K_S^0 \pi^+\pi^-$ decays at LHCb

Motivation

Decay-time dependent amplitude-model analysis of self-conjugate $D^0 \rightarrow K_S^0 \pi^+\pi^-$ decays:
- Access to charm mixing parameters $x_D$ and $y_D$
- Measure indirect CP violation via parameters $|q/p|$ and $\phi = \arg(p/q)$
- Expected sensitivities at $\mathcal{L} = 3 fb^{-1}$ (2011 & 2012 data) [1]:
  - 0.2% for $x_D$ and 0.17% for $y_D$
  - 0.2 for $|q/p|$ and 11.7 for $\phi$
- HFAG averages allowing CP violation [2]:
  - $x_D = (0.49^{+0.17}_{-0.14})$% and $y_D = (0.74 \pm 0.09)$%
  - $|q/p| = 0.69^{+0.17}_{-0.14}$ and $\phi = (-29.6^{+2.9}_{-2.5})^o$

Selection

- $D^0 \rightarrow K_S^0 \pi^+\pi^-$ decays accessible through:
  - prompt $D^0 \rightarrow D^0\pi$: high yield, access only to high $D^0$ decay times
  - semileptonic $B \rightarrow D^0\mu\nu$: high trigger efficiency, access to all $D^0$ decay times
  - semileptonic $B \rightarrow D^0\mu\nu$: high trigger efficiency, clean signature, access to all $D^0$ decay times, low yield

Semileptonically-tagged $D^0 \rightarrow K_S^0 \pi^+\pi^-$ decays:
- LHCb trigger:
  - hardware trigger: muon $p_T$
  - two-staged software-based trigger
- Revision of preselection to remove possible biases of Dalitz variables $m_{K_S^0\pi^+\pi^-}$, $m_{K_S^0\pi^+\pi^-}$, $m_{K_S^0\pi^+\pi^-}$ as well as to increase and flatten efficiency across Dalitz plane
- Selection:
  - Trigger selection, preselection and offline selection
  - Multivariate analysis: Boosted Decision Tree (BDT in TMVA) and Neural Network (NeuroBayes) studied
    $\Rightarrow$ similar performance but BDT chosen (simpler implementation)

GPU fitting

- $D^0 \rightarrow K_S^0 \pi^+\pi^-$ decays formulated as quasi two-body decays via intermediate resonances $K_S^0\rho(770), K_S^0f_0(980), K_S^0f_2(1370), K_S^0f_2(1270), K_S^0\omega(782), K_S^0\phi(965), K_S^0(892)\pi^-, K_S^0(1430)\pi^-, K_S^0(1430)\pi^+$, $\rightarrow$ interfere in Dalitz plane as shown in plot to the left for semileptonically-tagged $D^0 \rightarrow K_S^0 \pi^+\pi^-$ decays (generator-level Monte-Carlo simulation)
- Time-dependent amplitude-analysis:
  - relative phases and amplitudes
  - mixing parameters $x_D$ and $y_D$
  - indirect CP violation parameters $|q/p|$ and $\phi$
- Parallel amplitude-analysis fit on GPUs $\Rightarrow$ significant speed-up compared to CPUs