y_{CP} MEASUREMENT IN MESON D^0 DECAY AT LHCB

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D^0 MESON MIXING

- Mixing phenomenon in neutral mesons refers to their capability to fluctuate into their antiparticle.
- Transition probablity in D^0 $(\bar{u}c)$ meson case $|D^0\rangle \rightarrow |\overline{D^0}\rangle$ is in fact different from zero.
- By the diagonalisation of the weak interaction Hamiltonian we can obtain $|D_L\rangle$ and $|D_H\rangle$ mass eigenstates.

$$|D_L\rangle = p\left|D^0\right\rangle + q\,|\overline{D^0}\rangle \qquad |D_H\rangle = p\left|D^0\right\rangle - q\,|\overline{D^0}\rangle$$

D^0 MESON MIXING

- Their corresponding eigenvalues depends on mass $m_{H,L}$ and decay width $\Gamma_{H,L}$ values. Thanks to those values we can define adimentional mixing parameters:

$$x = \frac{\Delta m}{\Gamma},\ y = \frac{\Delta \Gamma}{2\Gamma} \quad \text{with } \Delta m = m_H - m_L,\ \Delta\Gamma = \Gamma_H - \Gamma_L,\ \Gamma = \frac{\Gamma_H + \Gamma_L}{2}$$

- x and y are directly related to the physical quantities resposible for neutral meson mixing.
- Mixing occurs if either x or y is different from zero.

y_{CP} OBSERVABLE

- The parameter y_{CP} measured in this analysis quantifies the difference of the half life between CP even eigenstates and $K\pi$ eigenstates.

$$y_{CP}^{hh} = \frac{\tau_{K\pi}}{\tau_{hh}} - 1, \text{ with } h = (K, \pi)$$

- In the limit of CP conservation we expect $y_{CP} = y$.

Observable	*Value (%)*
y_{CP}	0.697 ± 0.028
x	0.407 ± 0.044
y	0.647 ± 0.024

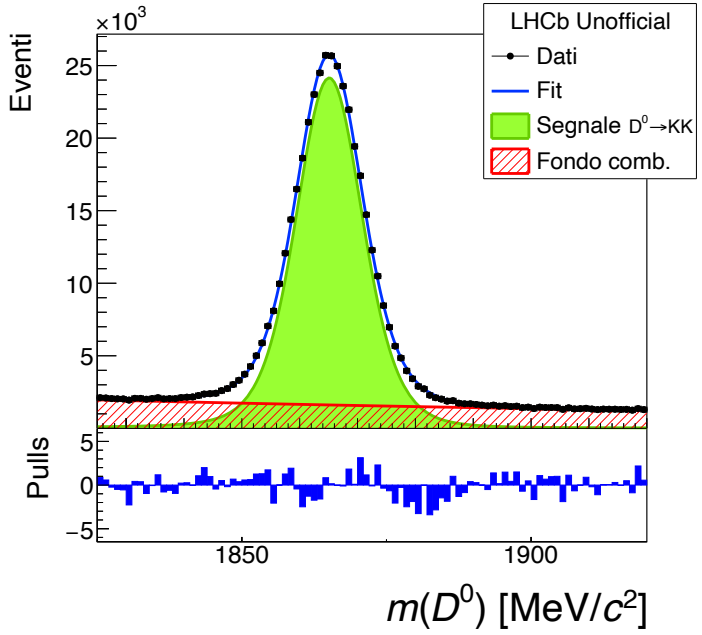
D^0 INVARIANT MASS FIT

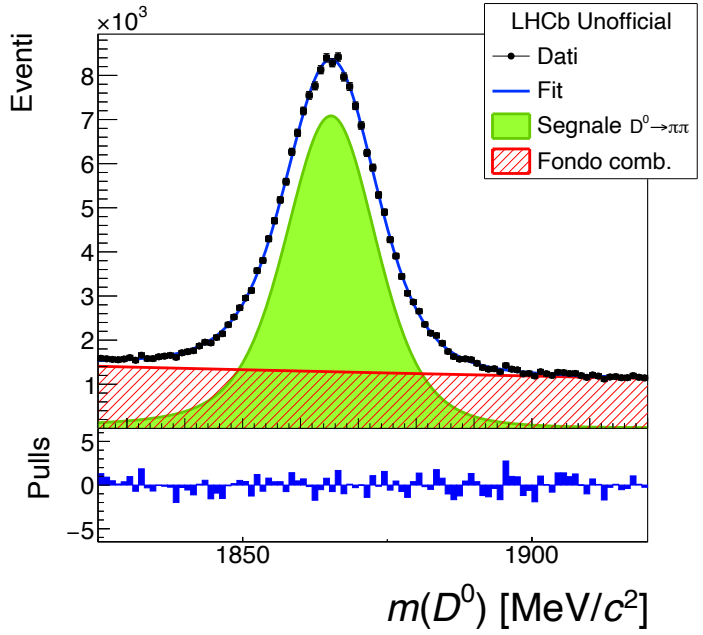
- The data sample of D^0 meson coming from semileptonic B decays ($B \to D\mu\nu X$) is divided in 3 decay channels: $D^0 \to K^+K^-$, $D^0 \to \pi^+\pi^-$ and $D^0 \to K^-\pi^+$.
- Every sample has been divided in 18 bin of D^0 decay time, from 0.15 ps to 1.95 ps.
- Fit function needed to extract the number of signal events:

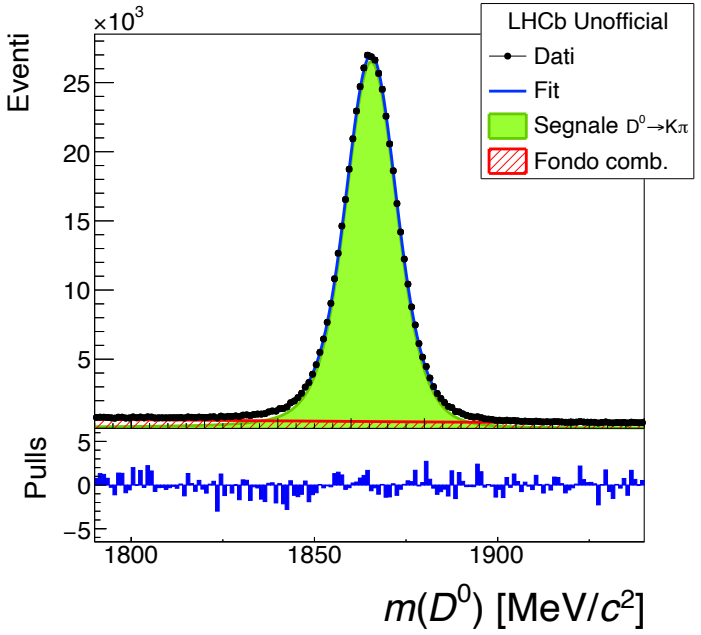
$$PDF = \frac{N_{sig}}{N_{sig} + N_{bkg}} \left[\sum_{i=1}^{4} c_i \, \mathcal{G}_i(x|\mu_i, \sigma_i, s) \right] + \frac{N_{bkg}}{N_{sig} + N_{bkg}} \exp(\lambda x)$$

$$\mathcal{G}(x|\mu,\sigma,s) = \int \Theta(\mu - x')(\mu - x')^s \exp\left(-\frac{(x'-x)^2}{2\sigma^2}\right) dx'$$

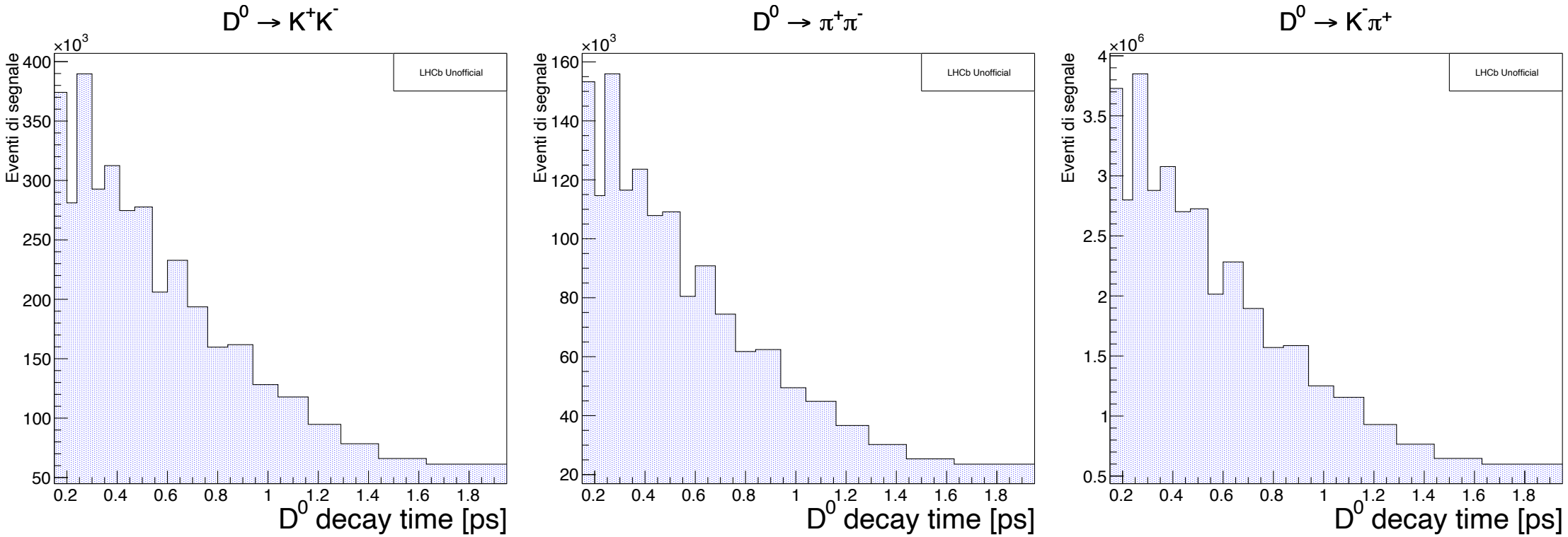
- The components of the signal distributions have different μ_i and σ_i respectively shifted ($\mu_i = \mu_1 + \delta_i$) and scaled ($\sigma_i = k_i\sigma_1$).
- Some of the PDF parameters are estimated by the MC simulation and they're kept constant in the fit.







SIGNAL EVENTS HISTOGRAMS TAKEN FROM FIT



Number of signal events (units 10^6):

3.7 in the channel KK, 1.4 in the channel $\pi\pi$ and 36 in the channel $K\pi$.

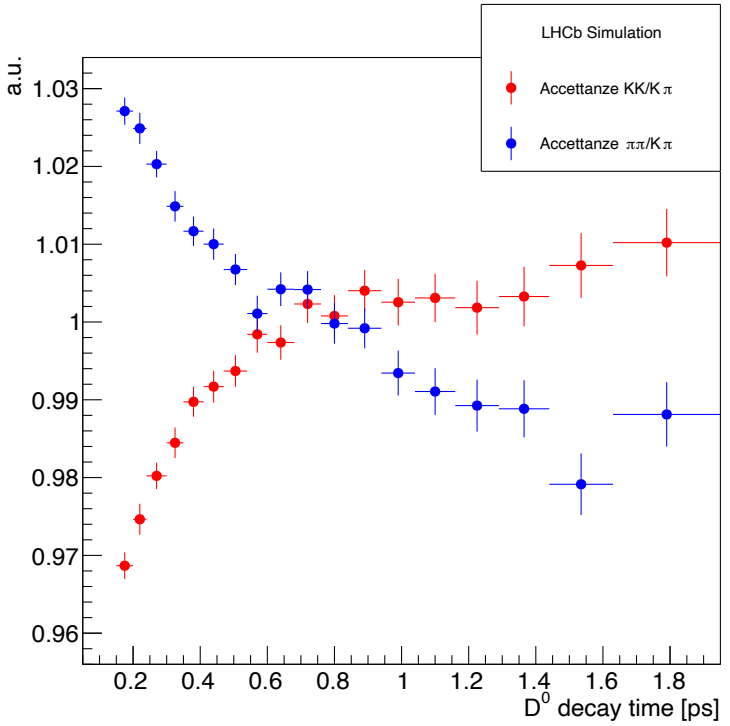
FIT ON SIGNAL EVENTS RATIO

- y_{CP} final value is extracted from a fit on signal events ratio, with proper correction given by reconstruction efficiencies.

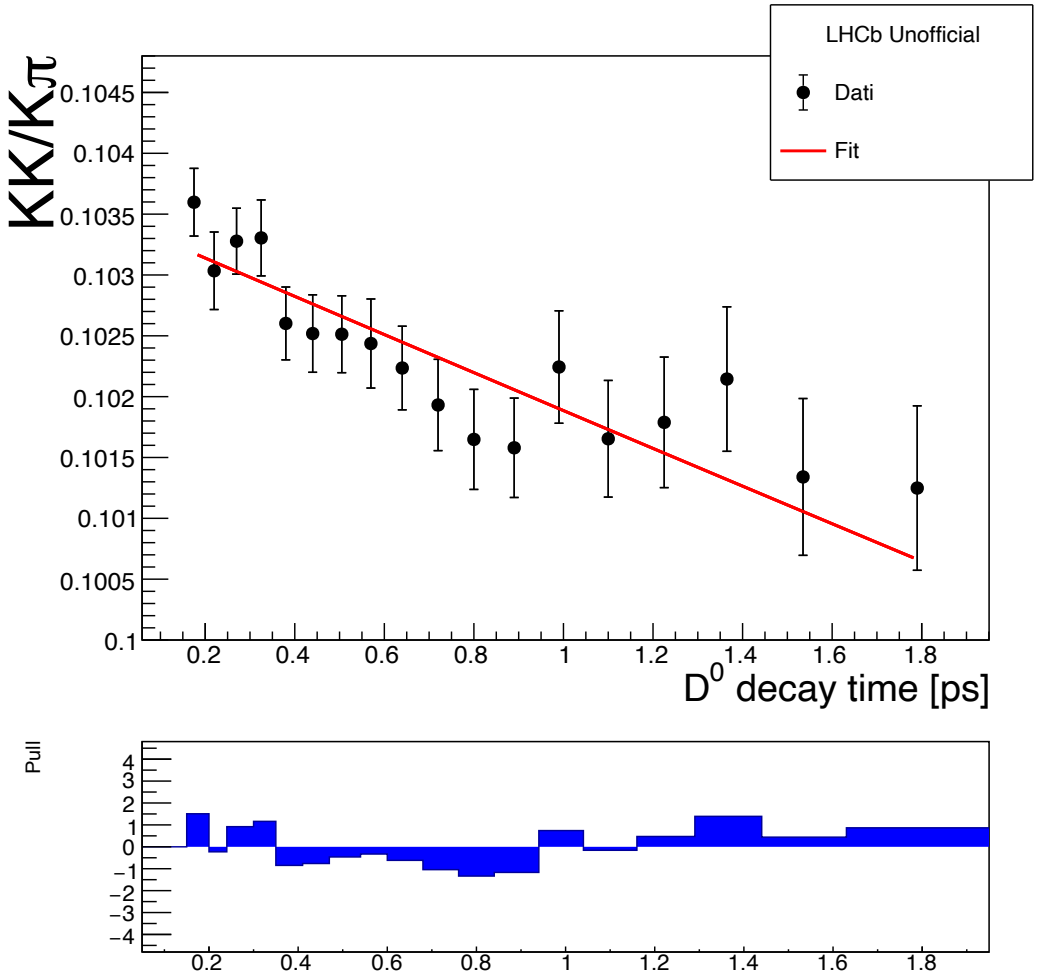
$$\frac{N(hh,t)}{N(K\pi,t)} = \frac{\varepsilon(hh,t)}{\varepsilon(K\pi,t)} \frac{\Gamma(hh,t)}{\Gamma(K\pi,t)}, \text{ with } h = (K,\pi)$$

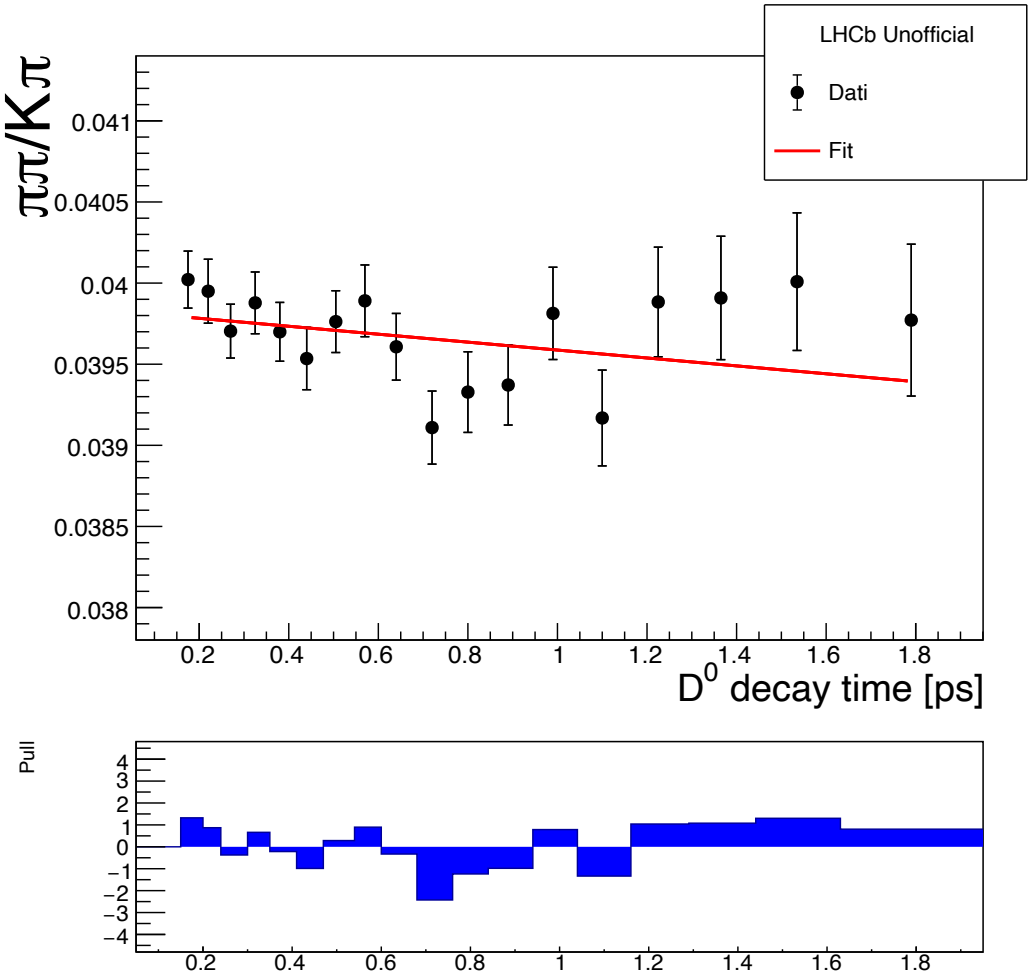
$$Ne^{-\Delta_\Gamma t} = \frac{N(hh,t)}{N(K\pi,t)} \frac{\varepsilon(K\pi,t)}{\varepsilon(hh,t)}$$

$$y_{CP} = \Delta_\Gamma \tau_{D^0}$$



RESULTS


LHCb Unofficial
Dati
Fit
KK/Kπ
0.1045
0.104
0.1035
0.103
0.1025
0.102
0.1015
0.101
0.1005
0.1
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
D0 decay time [ps]
Pull
4
3
2
1
0
−1
−2
−3
−4


LHCb Unofficial
Dati
Fit
ππ/Kπ
0.041
0.0405
0.04
0.0395
0.039
0.0385
0.038
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
D0 decay time [ps]
Pull
4
3
2
1
0
−1
−2
−3
−4

RESULTS

Parameters	*Fit Values*	
	$KK/K\pi$	$\pi\pi/K\pi$
$\Delta\Gamma[ps^{-1}]$	0.015 ± 0.002	0.0063 ± 0.0038
χ^2/dof	14.4/16	20.5/16
$y_{CP}(\%)$	0.63 ± 0.10	0.26 ± 0.16

- $\Delta\Gamma$ and y_{CP} central values are blind.
- y_{CP}^{KK} and $y_{CP}^{\pi\pi}$ obtained in the fit are compatible with each other within 2.0 standard deviations.

CONCLUSIONS

- y_{CP} measure has been made using data taken by LHCb in Run 2 at $\sqrt{s} = 13$ TeV, corresponding to an integrated luminosity of $L = 6\ fb^{-1}$.
- D^0 invariant mass fit has given the number of signal events.
- A fit on signal events ratio scaled with acceptances lead to the two blind values (with statistic uncertainty):

$$y_{CP}^{KK} = (0.63 \pm 0.10)\%$$
$$y_{CP}^{\pi\pi} = (0.26 \pm 0.16)\%$$

- Once the analysis is complete, the two values will be combined with an expected improvement factor of 2 with respect to previous results with semileptonic decays

THANKS FOR YOUR ATTENTION