Prospects for $D^0 \to h^+h^-\mu^+\mu^-$ ($h=K,\pi$) decays at LHCb

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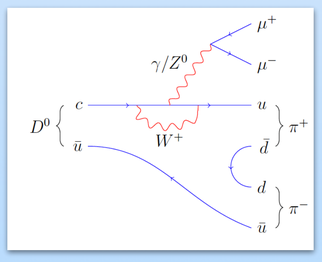
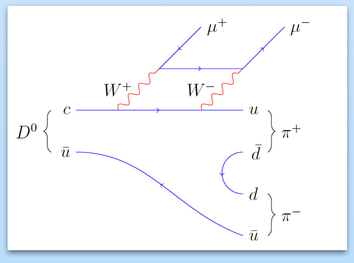
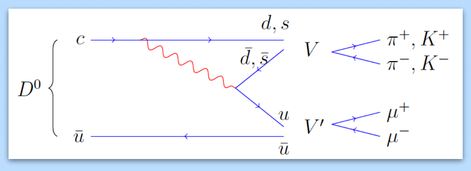
(1) Why is it interesting?

- Rare charm decays may proceed via highly suppressed FCNC process
  - SM short-distance contributions are $\mathcal{O}(10^{-9})$ or below [1]
  - Perfect place to look for physics beyond the SM





- Long-distance contributions 100-1000 times larger [1-3]



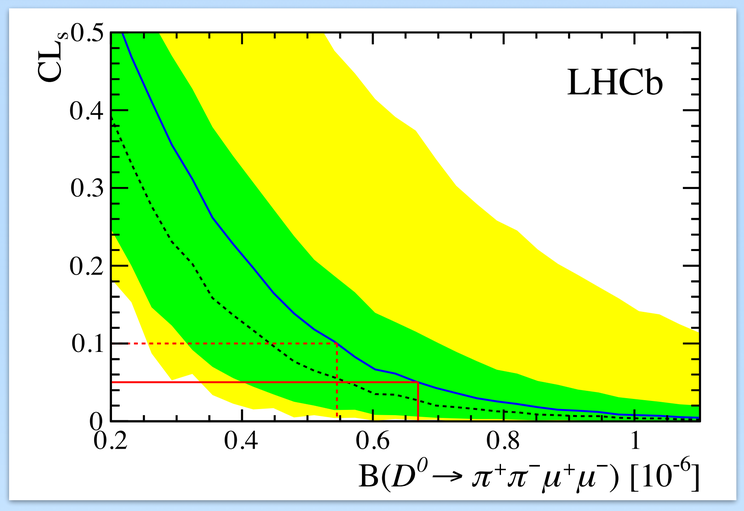
- The rich dynamics of 4-body final states allow to disentangle the two contributions and gain sensitivity to new physics [3-7]

"In a nutshell, the penalty of small branching fractions one naturally pays in 4-body decays as opposed to 2 or 3-body decays is overly compensated by the diversity (and the size) of the asymmetries one can build." [3]

(2) First LHCb measurement [8]

- Search for the decay $D^0 \to \pi^+\pi^-\mu^+\mu^-$ where muons do not come from a resonance using $1fb^{-1}$ recorded at $\sqrt{s}$ = 7TeV [8]
  - Most stringent limit to date on short-distance contributions
  - $\mathcal{B}$ in resonant regions not measured due to lack of a suitable normalization decay

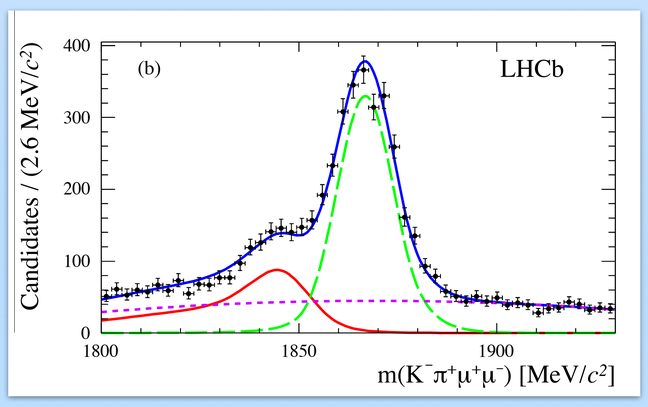
$\mathcal{B}(D^0 \to \pi^+\pi^-\mu^+\mu^-) < 5.5\times10^{-7}$ (90% C.L.)



(3) New normalization channel [9]

- First observation of the decay $D^0 \to K^-\pi^+\mu^+\mu^-$ in the ρ^0/ω region of the dimuon mass spectrum using $2fb^{-1}$ recorded at $\sqrt{s}$ = 8TeV [9]

$\mathcal{B}(D^0 \to K^-\pi^+\mu^+\mu^-) = (4.17\pm4.12(stat)\pm0.40(syst))\times10^{-6}$



total PDF
$D^0 \to K^-\pi^+\mu^-\mu^+$ (signal)
$D^0 \to K^-\pi^+\pi^-\pi^+$ (misID)
combinatorial

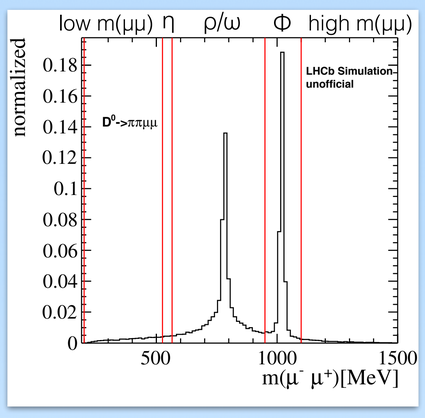
- Tree-level amplitude dominates, no contributions of new physics expected
- Can serve as normalization for $D^0 \to h^+h^-\mu^+\mu^-$ $\mathcal{B}$ measurements

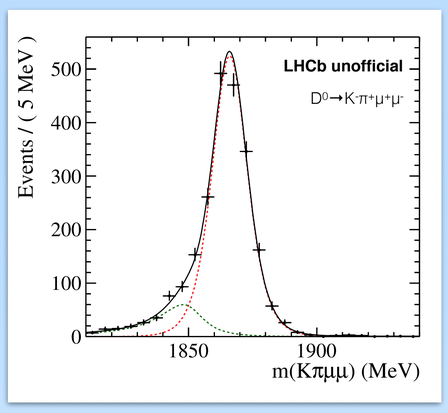
(4) Ongoing analysis

- Update $D^0 \to \pi^+\pi^-\mu^+\mu^-$ and first $D^0 \to K^-K^+\mu^+\mu^-$ measurement using $2fb^{-1}$ recorded at $\sqrt{s}$ = 8TeV
- Measure/set limits on $\mathcal{B}$ relative to $D^0 \to K^-\pi^+\mu^+\mu^-$

$$\mathcal{B}(D^0 \to h^+h^-\mu^+\mu^-) = \frac{N(D^0 \to h^+h^-\mu^+\mu^-)}{N(D^0 \to K^-\pi^+\mu^+\mu^-)} \cdot \frac{\epsilon(D^0 \to K^-\pi^+\mu^+\mu^-)}{\epsilon(D^0 \to h^+h^-\mu^+\mu^-)} \cdot \mathcal{B}(D^0 \to K^-\pi^+\mu^+\mu^-)$$

- Reconstruct D^0 from $D^{*+} \to D^0\pi^+$ to suppress combinatorial background
- Binning in dimuon mass to separate short and long-distance contributions





total PDF
$D^0 \to K^-\pi^+\mu^-\mu^+$ (signal)
$D^0 \to K^-\pi^+\pi^-\pi^+$ (misID)

(5) Expected sensitivities

- New analysis still blinded

Decay mode	Dimuon mass $[\mathrm{MeV}/c^2]$	Expected uncertainties σ_{stat} $[10^{-8}]$	σ_{syst}/B [%]	Expected UL at 90% C.L. $[10^{-8}]$
$D^0 \to \pi^+\pi^-\mu^+\mu^-$	< 525	1.8	$5 \pm 10_{\mathrm{norm}}$	2.6
	$525 - 565$	0.67	$8 \pm 10_{\mathrm{norm}}$	1.1
	$565 - 950$	3.2	$4 \pm 10_{\mathrm{norm}}$	–
	$950 - 1100$	2.8	$4 \pm 10_{\mathrm{norm}}$	–
	> 1100	0.78	$8 \pm 10_{\mathrm{norm}}$	1.1
$D^0 \to K^+K^-\mu^+\mu^-$	< 525	1.3	$5 \pm 10_{\mathrm{norm}}$	1.6
	> 565	2.4	$5 \pm 10_{\mathrm{norm}}$	2.1

- Improved limits in regions away from resonances
  - By one order of magnitude ($D^0 \to \pi^+\pi^-\mu^+\mu^-$) [7]
  - By three orders of magnitude ($D^0 \to K^+K^-\mu^+\mu^-$) [10]
- LHCb might measure rarest charm decay with $\mathcal{B} \sim \mathcal{O}(10^{-7})$
- Measure asymmetries in regions where we see a signal including Run2 data

References

[1]A. Paul et al., Phys. Rev. D 83 (2011) 114006, arXiv:1101.6053
[2]S. Fajfer et al., Phys. Rev. D 76 (2007) 074010, arXiv:0706.1133
[3]L. Cappiello et al., J. High Energy Phys. 04 (2013) 135, arXiv:1209.4235
[4]A. Paul et al., Phys. Rev. D 90 (2014) 014035, arXiv:1212.4849
[5]S. Fajfer et al., arXiv:1510.00965
[6]S. de Boer et al., arXiv:1510.00311
[7]S. Fajfer et al., Phys. Rev. D 73 (2006) 054026, arXiv:hep-ph/0511048
[8]LHCb collaboration, Phys. Lett. B 728 (2014) 234-243
[9]LHCb collaboration, Phys. Lett. B 757 (2016) 558–567
[10]Fermilab E791 Collaboration, Phys. Rev. Lett.86 (2001) 3969-3972

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