Feasibility study of the reconstruction of the decay $D^0 \to K^-\mu^+\nu_\mu$ at LHCb

Simone Montesano

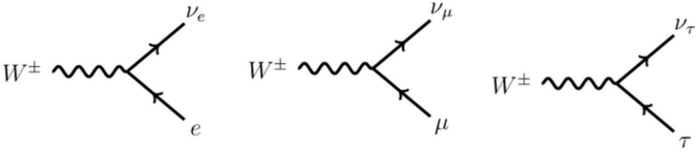
BCD HEP School, Cargèse 2017

5/4/2017

Theoretical motivation

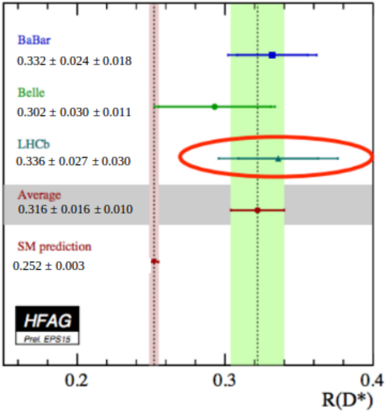
Lepton Flavour Universality

One of the predictions of the Standard Model states that the electroweak interaction should couple to all charged leptons equally.



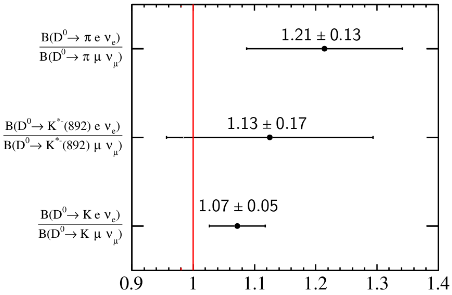
Recent experimental results

- $R_{D^*} \equiv Br(B \to D^* \tau \nu)/Br(B \to D^* \mu \nu)$
- 3.9σ above Standard Model
- Can we do the same in Charm using $D^0 \to K \ell \nu_\ell$?



Charm semileptonic decays

- It is interesting to measure $R_{\mu/e} \equiv Br(D \to K^- \mu\nu)/Br(D \to K^- e\nu)$
- Standard Model predicts $R_{\mu/e}$=1



- These measurement are never been realised at LHCb.
- It is possible to obtain a precision < 1% using data from RUN-1 and RUN-2

Analytical reconstruction of the neutrino momentum components

$$
\begin{cases}
(E_K + E_\mu + E_\nu)^2 - (\mathbf{p}_K + \mathbf{p}_\mu + \mathbf{p}_\nu)^2 = m^2_{D^0} & (1.1) \\
\frac{x_{D^0} - x_{D*}}{z_{D^0} - z_{D*}} = \frac{p^x_K + p^x_\mu + p^x_\nu}{p^z_K + p^z_\mu + p^z_\nu} & (1.2) \\
\frac{y_{D^0} - y_{D*}}{z_{D^0} - z_{D*}} = \frac{p^y_K + p^y_\mu + p^y_\nu}{p^z_K + p^z_\mu + p^z_\nu} & (1.3)
\end{cases}
\quad (1)
$$

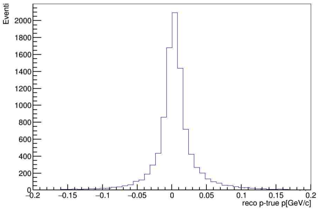
- 1.1: relativistic four-momentum conservation
- D^0 must come from primary vertex (x_{D*}, y_{D*}, z_{D*})
- 1.2: constraint of the D^0 flight direction on plane xz
- 1.3: constraint of the D^0 flight direction on plane yz
- We have three equations for three unknows: it is possible to obtain a solution
- N.B. The system is not linear, so we expect a double solution

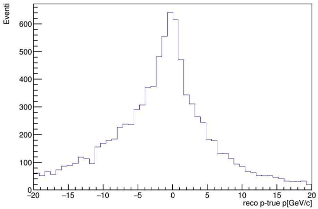
Final solution

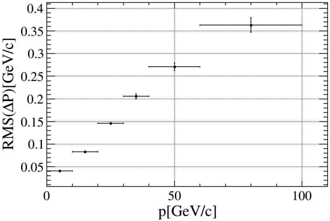
$$
\begin{cases}
p_\nu^x = A(p_a^z + p_\nu^z) - p_a^x \\[2ex]
p_\nu^y = B(p_a^z + p_\nu^z) - p_a^y \\[2ex]
p_z^\nu = \frac{sT^2 \pm E_a \sqrt{(A^2+B^2+1)(T^4 - 4m_{D^0}^2 E_a^2) + 4m_{D^0}^2 s^2}}{2(E_a^2(A^2+B^2+1) - s^2)} - p_a^z
\end{cases}
\tag{2}
$$

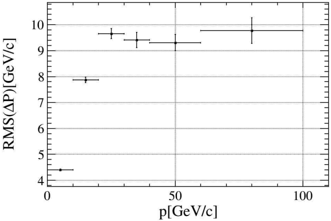
- $p_a^i = p_K^i + p_\mu^i, \qquad i = x, y, z$
- $t \equiv p_a^z + p_\nu^z$
- $A \equiv \frac{x_{D^0} - x_{D*}}{z_{D^0} - z_{D*}}$
- $B \equiv \frac{y_{D^0} - y_{D*}}{z_{D^0} - z_{D*}}$
- $s \equiv Ap_a^x + Bp_a^y + p_a^z$

Momentum resolutions





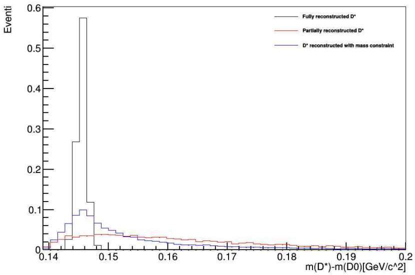


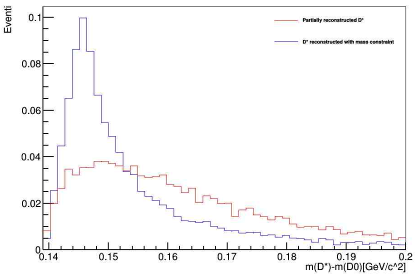


Neutrino resolution (right) is not comparable to muon resolution (left), but still acceptable

Comparison between δm

The δm resolution, basic element for the $R_{\mu/e}$ measurement, improves significantly using the informations about neutrino





Thanks for your attention