3-Pole Approximation to $D^0 \to \pi^- e^+ \nu$ Form Factors

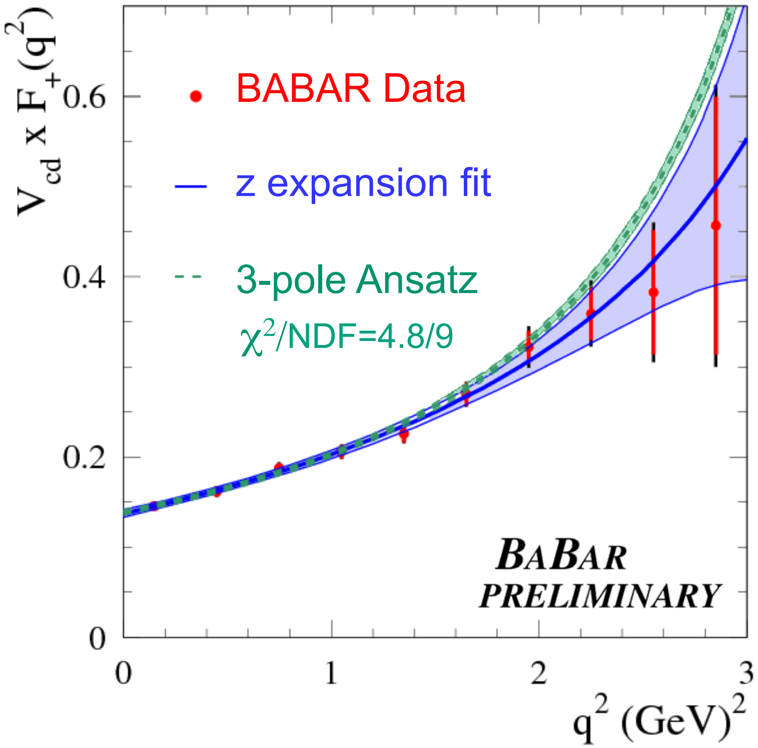
Becirevic et al. arXiv:1407.1019

- As recently proposed, the addition of a 3rd effective pole greatly improves the prediction

$$\boxed{f_+(q^2) = \frac{\gamma_0}{m^2_{D^*} - q^2} + \frac{\gamma_1}{m^2_{D^{*\prime}} - q^2} + \frac{\gamma_{\text{eff}}}{m^2_{\text{eff}} - q^2}}$$

with

$$\boxed{\gamma_n = \operatorname*{Res}_{q^2 = m^2_{D^*_n}} f_+^{D\pi}(q^2)}$$



Constraining the residua γ_0 and γ_1 to expectation,

γ_0= 4.17±0.13 GeV^2 γ_1= - 1.1±0.4 GeV^2

based on various LQCD calculations

with $m_{D^{*+}}$=2,010±0.13 MeV $m_{D^{*\prime}}$ =2,610±4 MeV

and imposing $\gamma_{\text{eff}} + \gamma_0 + \gamma_1 = 0$

results in

$\boxed{m_{\text{eff}} = (3.6 \pm 0.3) \text{ GeV}}$

a value larger than the mass of the next $J^P=1^-$ state of 3.1 GeV predicted by quark models.

3-pole ansatz fits the data very well up to ~2 GeV^2!

3-Pole Fit to $B \to \pi\, l^+ \nu$ Decay Rate

- Following suggestions by theorists, we applied the same ansatz to B decays

$$f_+^{B\pi}(q^2) = \frac{\beta_0}{m_{B^*}^2 - q^2} + \frac{\beta_1}{m_{B^{*\prime}}^2 - q^2} + \frac{\beta_{\rm eff}}{m_{\rm eff}^2 - q^2}$$

constraining the residua β_0 and β_1 to expectation,

β_0= 24.9±4.2 GeV^2 β_1= - 8±2 GeV^2

based on various LQCD calculations

and imposing $\beta_{eff} + \beta_0 + \beta_1 = 0$

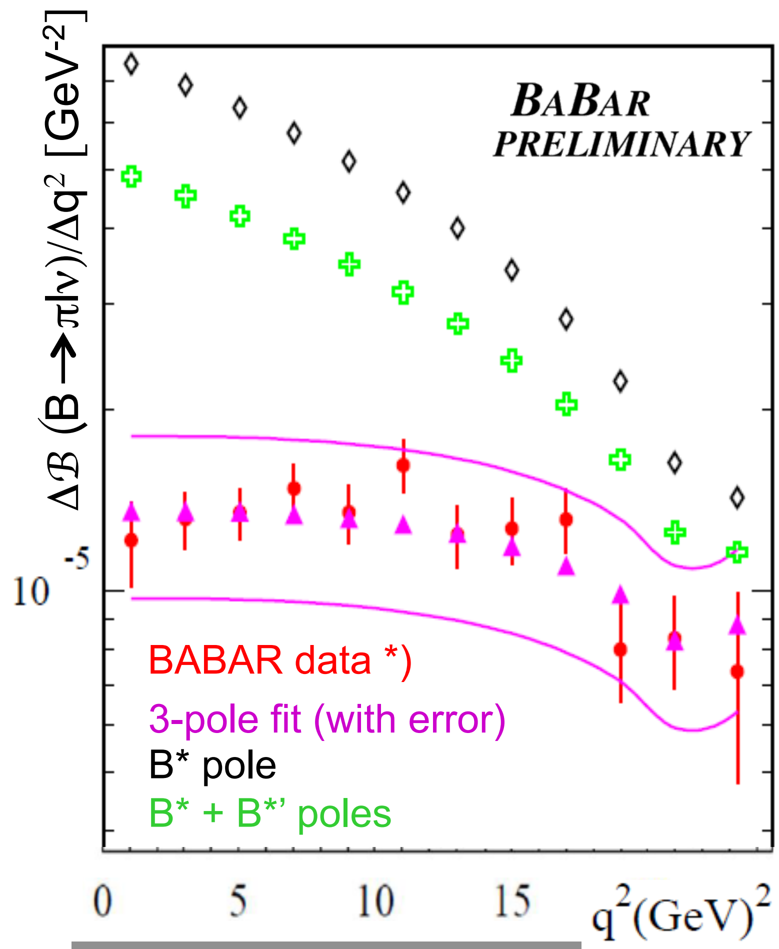
with m_{B^*}=5.325 GeV $m_{B^{*\prime}}$=5.491 GeV

we obtain

m_{eff} = (7.4 ± 0.4) GeV

$|V_{ub}| = (2.6 \pm 0.2_{exp} \pm 0.4_{LQCD})$

Uncertainties (15%) dominated by uncertainty in coupling constants $g_{B^*B\pi}$, taken from LQCD!



*) BABAR PRD, 092004 (2012)

Extrapolation of FF from $D^0 \to \pi^- e^+ \nu$ to $B^0 \to \pi^- l^+ \nu$

- It has been suggested years ago, that dynamics of D and B meson decays should be closely related.
- Specifically, for $w_B = w_D$ kinematic factors cancel

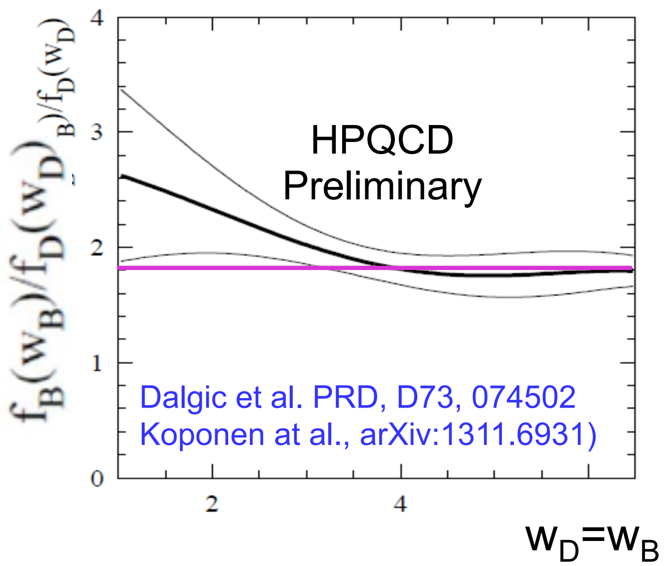
$$\boxed{\frac{d\mathcal{B}^B}{dw} = \frac{d\mathcal{B}^D}{dw}\bigg|_{\text{meas.}} \frac{m_B\ \tau_B}{m_D\ \tau_D} \left(\frac{|V_{ub}|}{|V_{cd}|}\right)^2 R^2_{BD}}$$

with $w_{B,D} = \dfrac{M_{B,D}{}^2 + m_\pi^2 - q^2}{2M_{B,D} m_\pi}$

Kinematically, there is a common range for

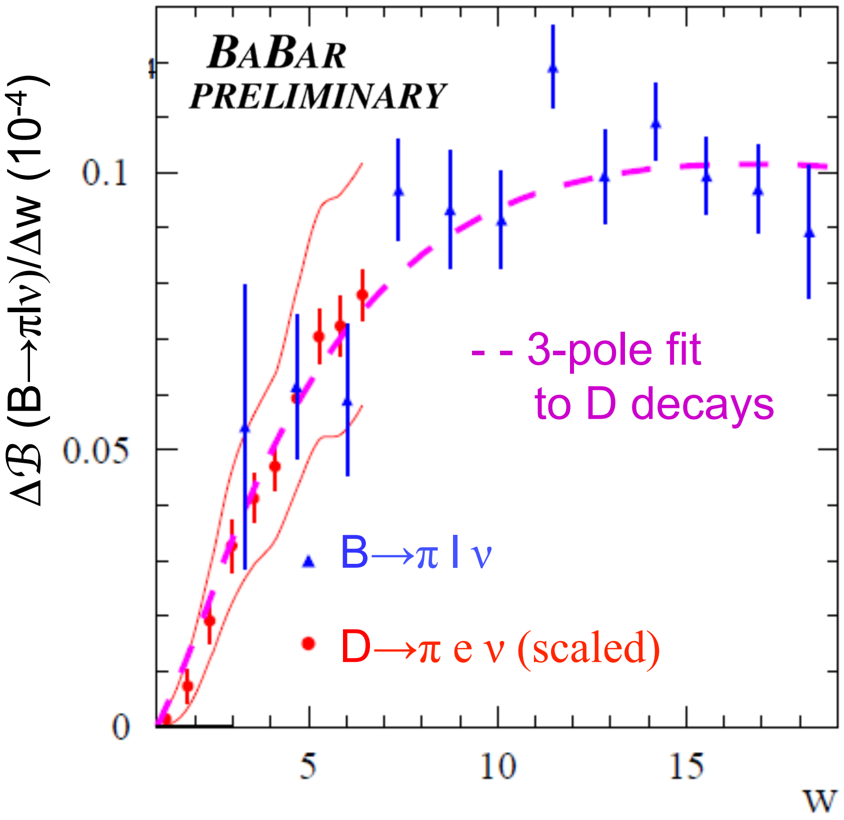
$w_B = w_D$ { 1.0 – 6.7 } $\quad q^2_{max} \longrightarrow w=1$

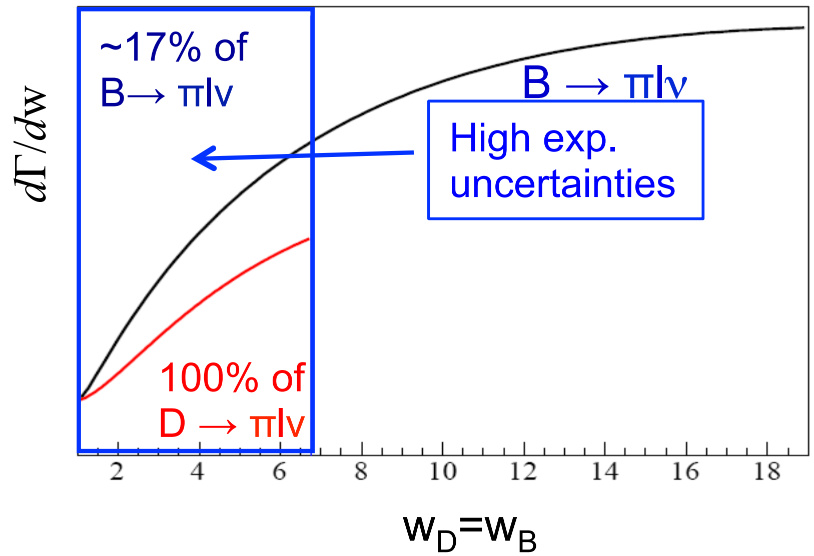
- Future LQCD calculation might determine the FF ratio R_{BD} with high precision.
- Preliminary calculation by HPQCD indicate small variation of the ratio of individual FF R_{BD} as function of w; average for w>4: $\langle R_{BD} \rangle = 1.8 \pm 0.2$



Extrapolation of FF from $D^0 \to \pi^- e^+ \nu$ to $B^0 \to \pi^- l^+ \nu$

Derive $\mathcal{B}(B^0 \to \pi^- l^+ \nu)$ from $D^0 \to \pi^- e^+ \nu$ data with R_{BD}=1.8±0.2 and adjust $|V_{ub}|$ to 3.65×10^{-3}





- Agreement very good, may not be a surprise: Translation based on same LQCD calculation for B s.l. decays, used to extract $|V_{ub}|$
- Alternatively, use 3-pole FF fit to fit to $\mathcal{B}(D^0 \to \pi^- l^+ \nu)$ and extrapolate to unphysical region, obtain independent result for $|V_{ub}|$

$$|V_{ub}| = (3.65 \pm 0.18_{exp} \pm 0.40_{RD}) \times 10^{-3}$$

Need improvement in LQCD calculation!