Karlsruhe Institute of Technology

BELLE

$B \to u\ell\nu$ MC

Improvement of exclusive predictions and the Hybrid MC

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Why talk about this? We know about . . .

. . . Resonant Decays

- Different models available, commonly used are BCL, ISGW2, . . .
- Models describe the double differential decay rate $\mathrm{d}\Gamma(\mathrm{B} \to X_\mathrm{u} \ell\nu) \,/\, \mathrm{d}E_l^\mathrm{B} \mathrm{d}q^2$
- They can not produce n-π-final states

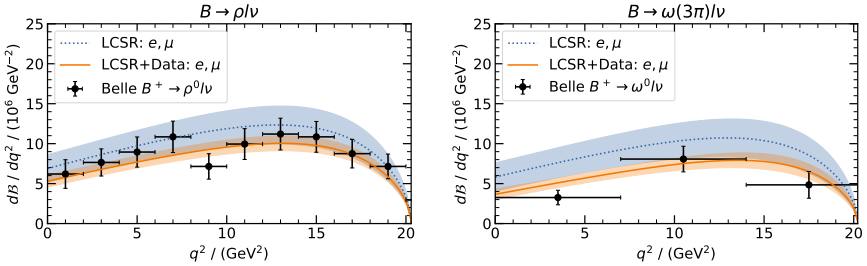
. . . Inclusive Decays

- Different models available, commonly used DFN, BLNP, . . .
- Models describe the triple differential decay rate $\mathrm{d}\Gamma(\mathrm{B} \to X_\mathrm{u} \ell\nu) \,/\, \mathrm{d}m_X \mathrm{d}E_l^\mathrm{B} \mathrm{d}q^2$
- They neither produce hadronic states with $m_X < 2m_\pi$ nor any resonant structures in the m_X spectrum

But we do not have a model which describes both at the same time!

Improvement of $B \to V \ell \nu$, $V = \{\pi, \rho, \omega\}$ Predictions

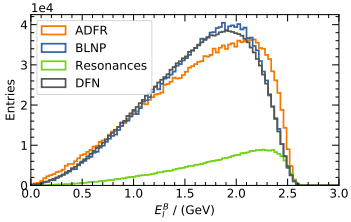
- π Improvement only relevant for Belle MC, as the implementation of the form factors is flawed for high q^2. Omitted here, because it is a Belle II meeting (feel free to ask).
- Assumption: BCL coefficients are the correct parametrization for the form factors.
- Up to now: Predictions rely on LCSR calculations.
- Now: Use measured differential branching fractions (Belle & BaBar) of $B \to \rho/\omega \ell \nu$ decays and fit them together with the LCSR predictions $\to$ reduce error by half.

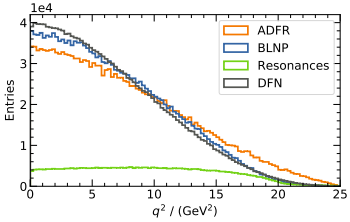


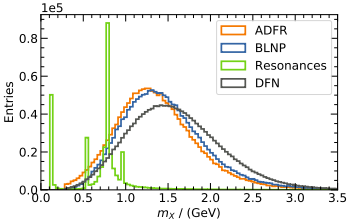
The Hybrid Model - Puzzle Pieces

Latest measurements and used models

B^+	$\to \pi\ell\nu$	$\to \eta\ell\nu$	$\to \eta'\ell\nu$	$\to \omega\ell\nu$	$\to \rho\ell\nu$	$\to u\ell\nu$ incl.
$\mathcal{B}$	$7.8 \cdot 10^{-5}$	$3.9 \cdot 10^{-5}$	$2.3 \cdot 10^{-5}$	$1.19 \cdot 10^{-4}$	$1.58 \cdot 10^{-4}$	$2.2 \cdot 10^{-3}$
Model	BCL	ISGW2	ISGW2	BCL	BCL	DFN, ADFR, BLNP







Inclusive models differ significantly!

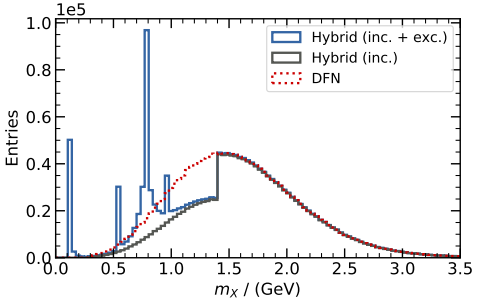
Putting the pieces together

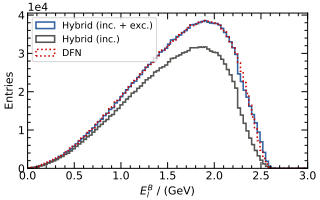
- Inclusive models predict the total inclusive rate
- $\rightarrow$ We have to subtract the resonances

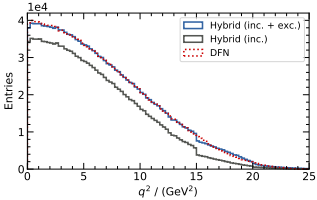
Hybrid Model

- $H_i = R_i + \omega_i N_i$, H_i: total, R_i: resonant, N_i: inclusive
- Calculate weights ω_i in the 3D phase space, so above equation holds
- Phase space bins
  - m_X = [0., 1.4, 1.6, 1.8, 2., 2.5, 3., 3.5]
  - E_l^B = [0., 0.5, 1., 1.25, 1.5, 1.75, 2., 2.25, 3.]
  - q^2 = [0., 2.5, 5., 7.5, 10., 12.5, 15., 20., 25.]

1st Result: The DFN Hybrid





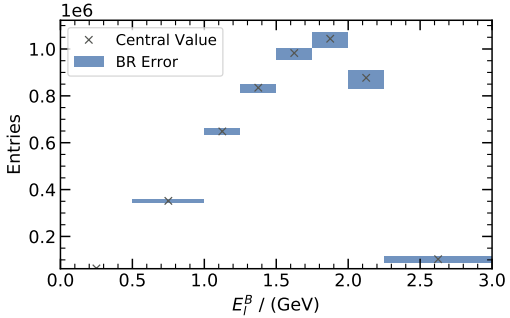


Hybrid Uncertainties (Branching Ratio)

Inclusive BR Uncertainty

- $\mathcal{B}(B^+ \to X_u \ell \nu) = (2.2 \pm 0.3) \cdot 10^{-3}$

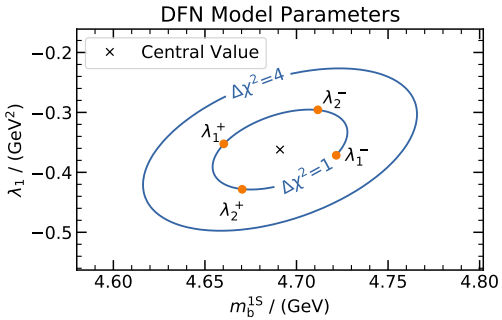
Errors are estimated by varying the total inclusive BR.

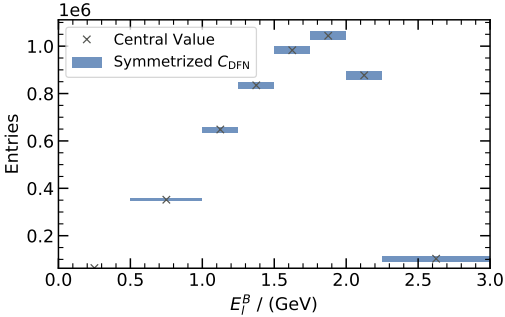


Hybrid Uncertainties (DFN Model)

DFN Model Uncertainty

- $m_b(1S) = (4.691 \pm 0.037)\,\mathrm{GeV}$
- $\lambda_1 = (-0.362 \pm 0.067)\,\mathrm{GeV}^2$





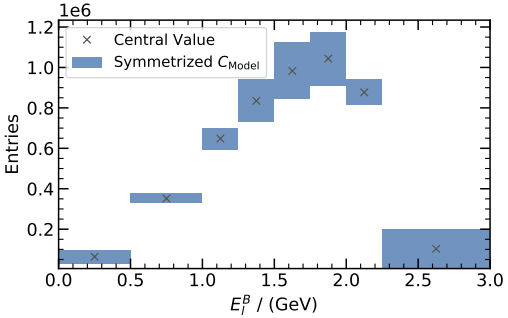
Errors are estimated by variation of the Eigenvalues.

Hybrid Uncertainties (Other Models)

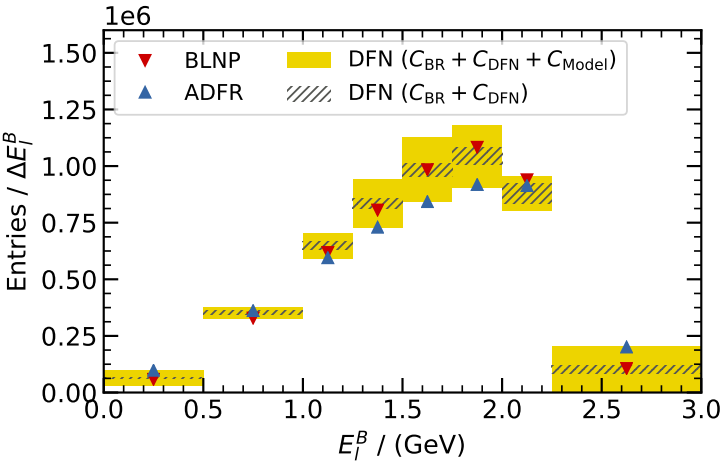
Comparison to other models

- Create Hybrid MC for other inclusive models
- Estimate error as: $\sigma = N_{\mathrm{DFN}} - N_{\mathrm{other}}$
- And use $\sigma = \max(\sigma_{\mathrm{BLNP}}, \sigma_{\mathrm{ADFR}})$

Errors are estimated by the envelope.



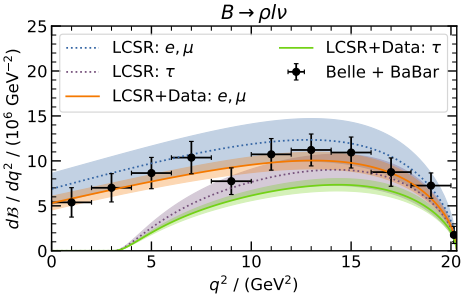
2nd Result: Hybrid Model Uncertainties

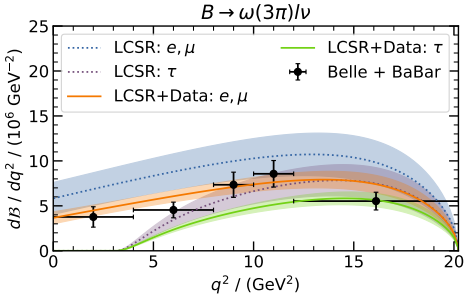


We have a Hybrid model with good error estimates!

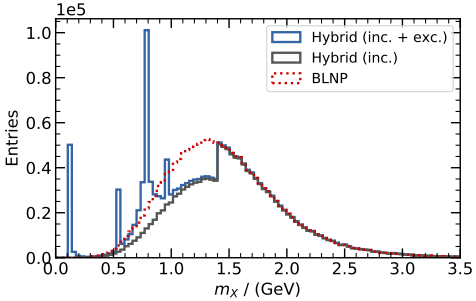
Backup

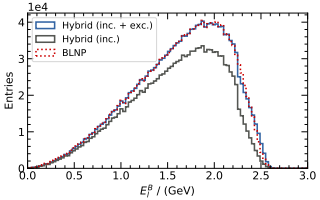
$B \to \rho/\omega \ell \nu$

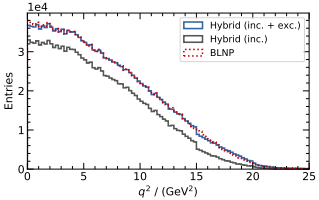




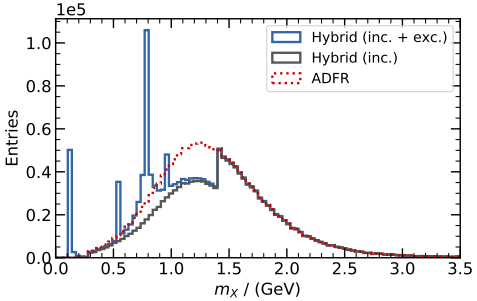
BLNP Hybrid

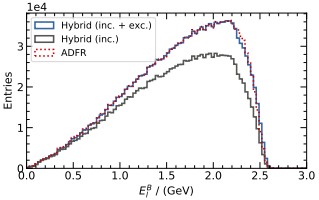

1e5
Hybrid (inc. + exc.)
Hybrid (inc.)
BLNP
Entries
m_X / (GeV)

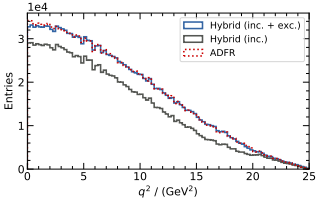

1e4
Hybrid (inc. + exc.)
Hybrid (inc.)
BLNP
Entries
E_l^B / (GeV)


1e4
Hybrid (inc. + exc.)
Hybrid (inc.)
BLNP
Entries
q^2 / (GeV^2)

ADFR Hybrid


1e5
Hybrid (inc. + exc.)
Hybrid (inc.)
ADFR
Entries
m_X / (GeV)


1e4
Hybrid (inc. + exc.)
Hybrid (inc.)
ADFR
Entries
E_l^B / (GeV)


1e4
Hybrid (inc. + exc.)
Hybrid (inc.)
ADFR
Entries
q^2 / (GeV^2)