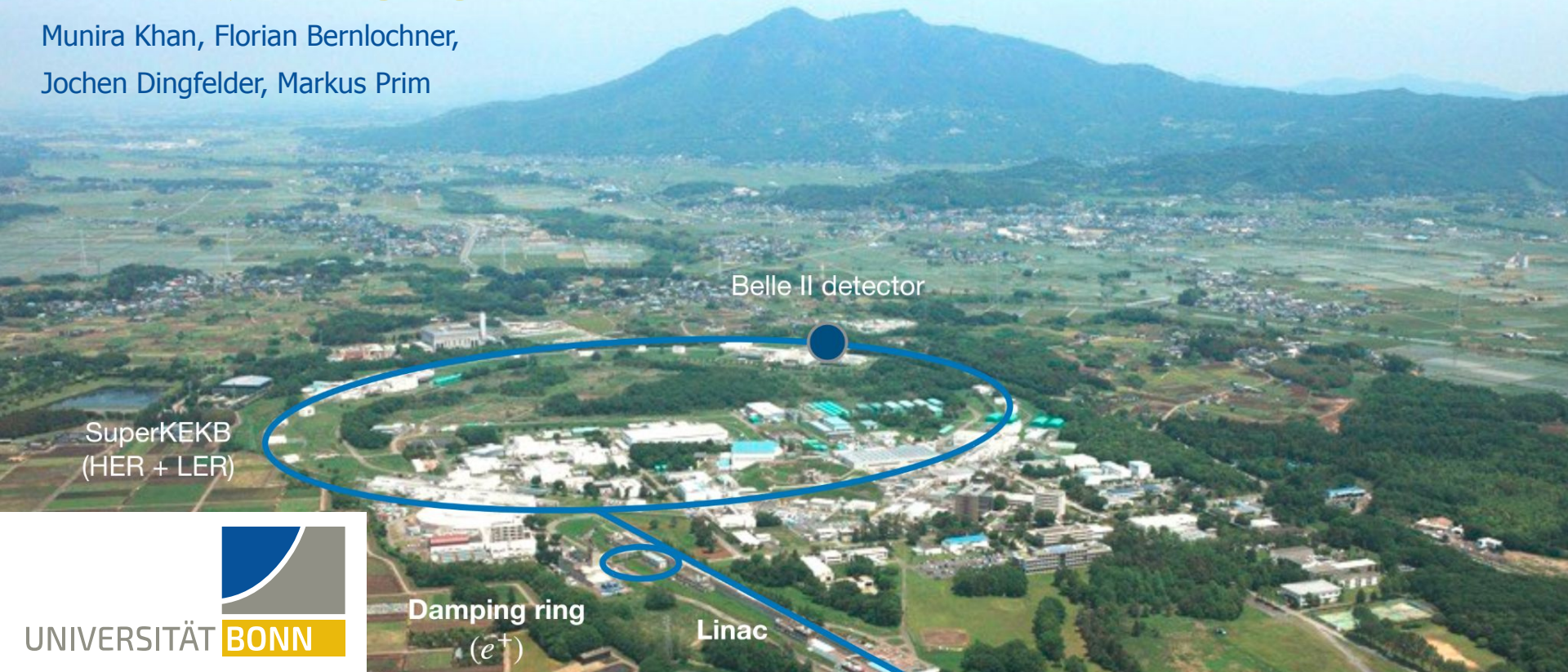


Kinematic moments of semileptonic B-meson decays with Run 1 data set of Belle II

DPG Frühjahrstagung 2024

Munira Khan, Florian Bernlochner,
Jochen Dingfelder, Markus Prim

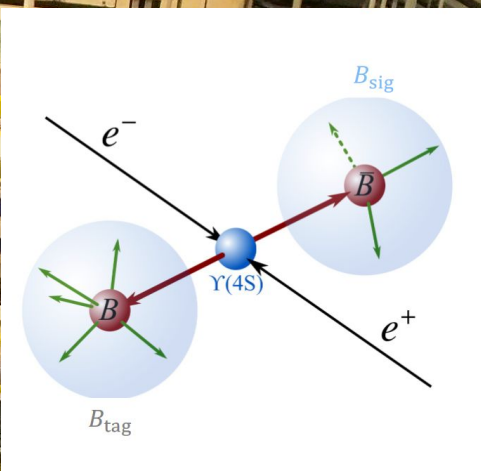
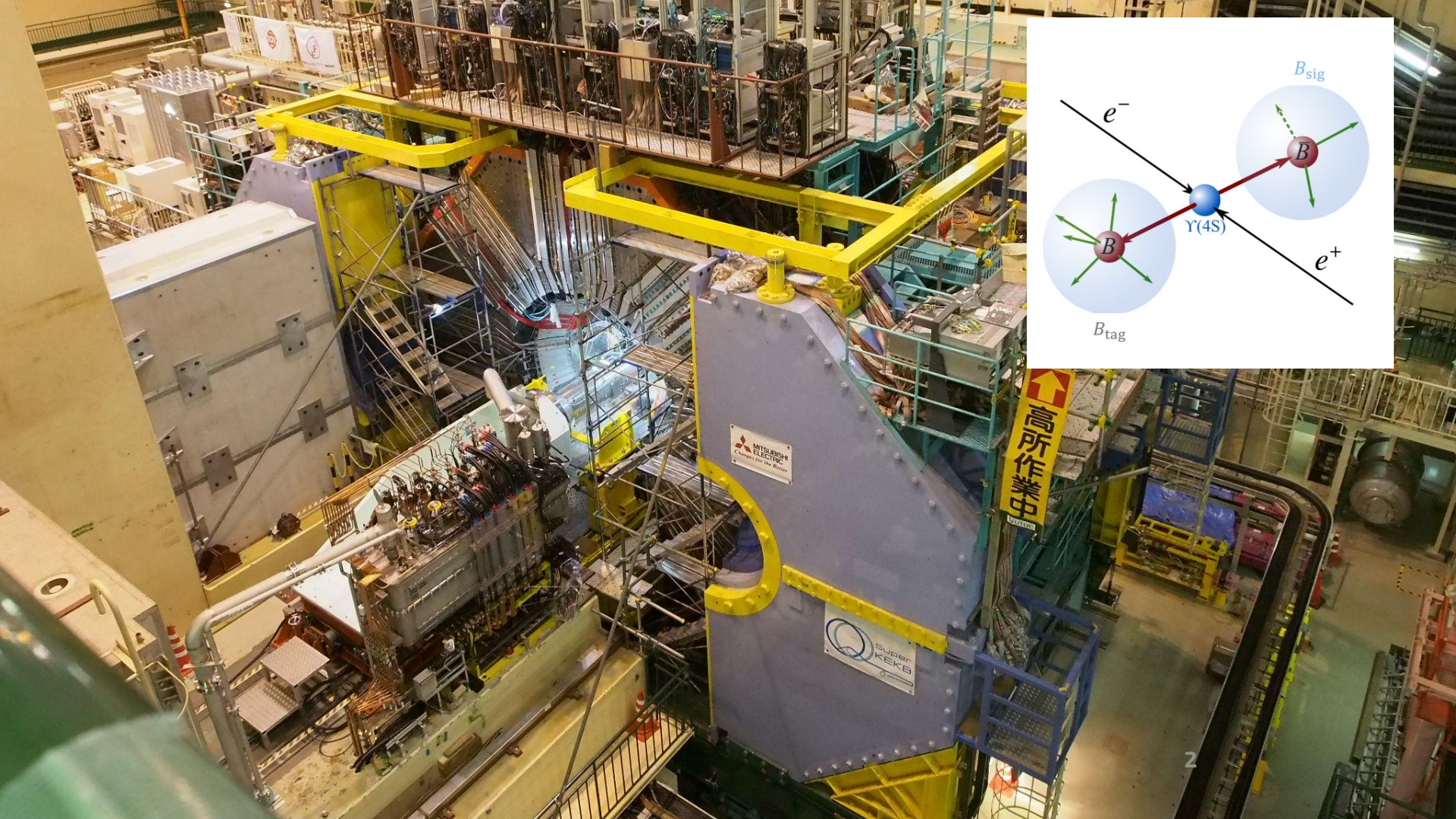


Belle II detector

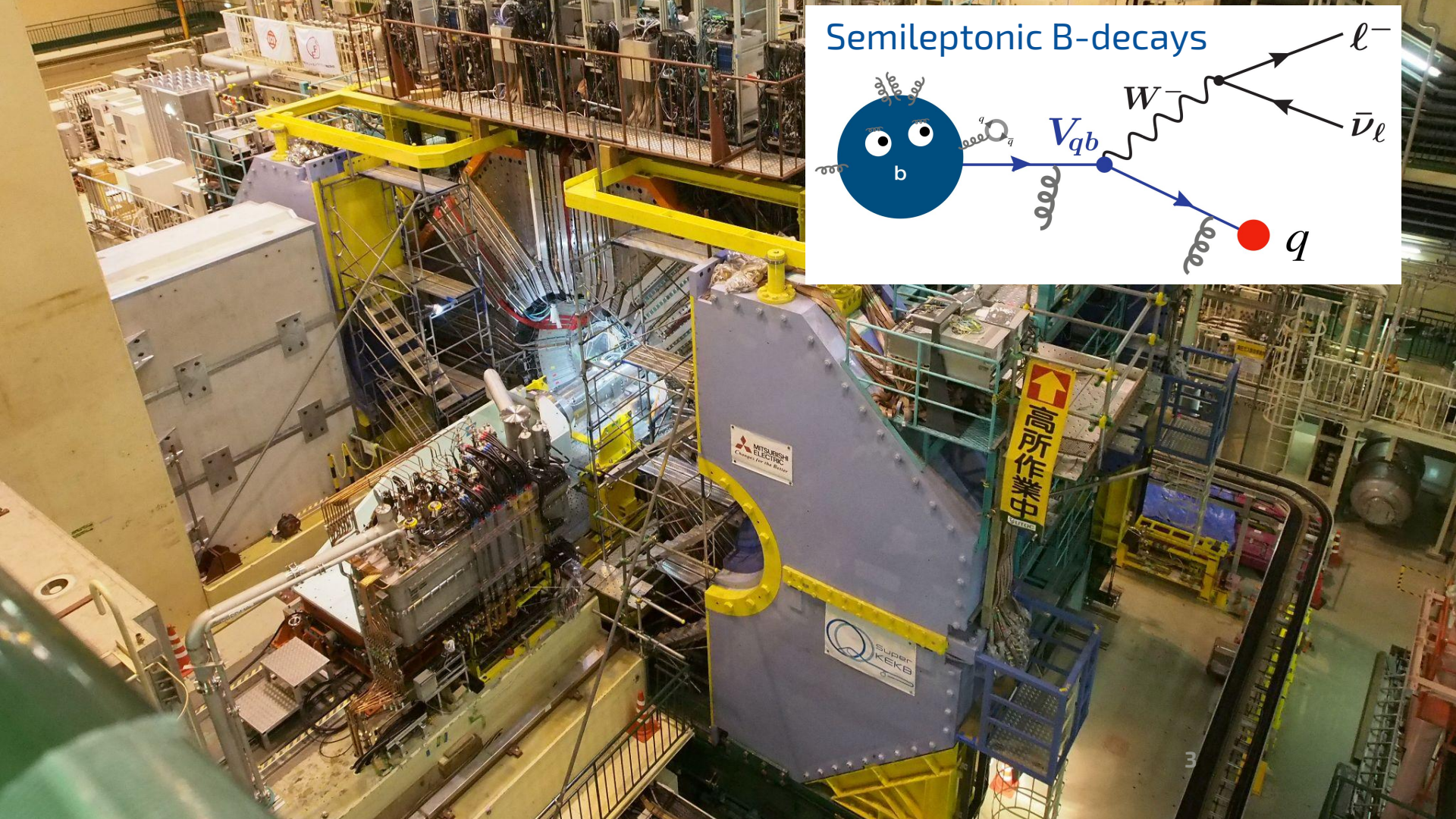
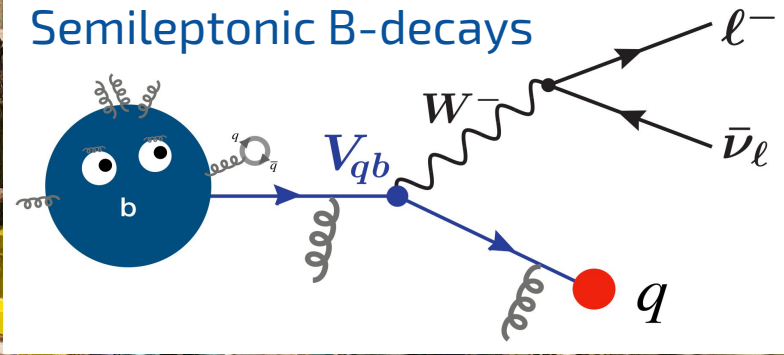
SuperKEKB
(HER + LER)

Damping ring
(e^+)

Linac



Semileptonic B-decays



CPV Kaon Mixing



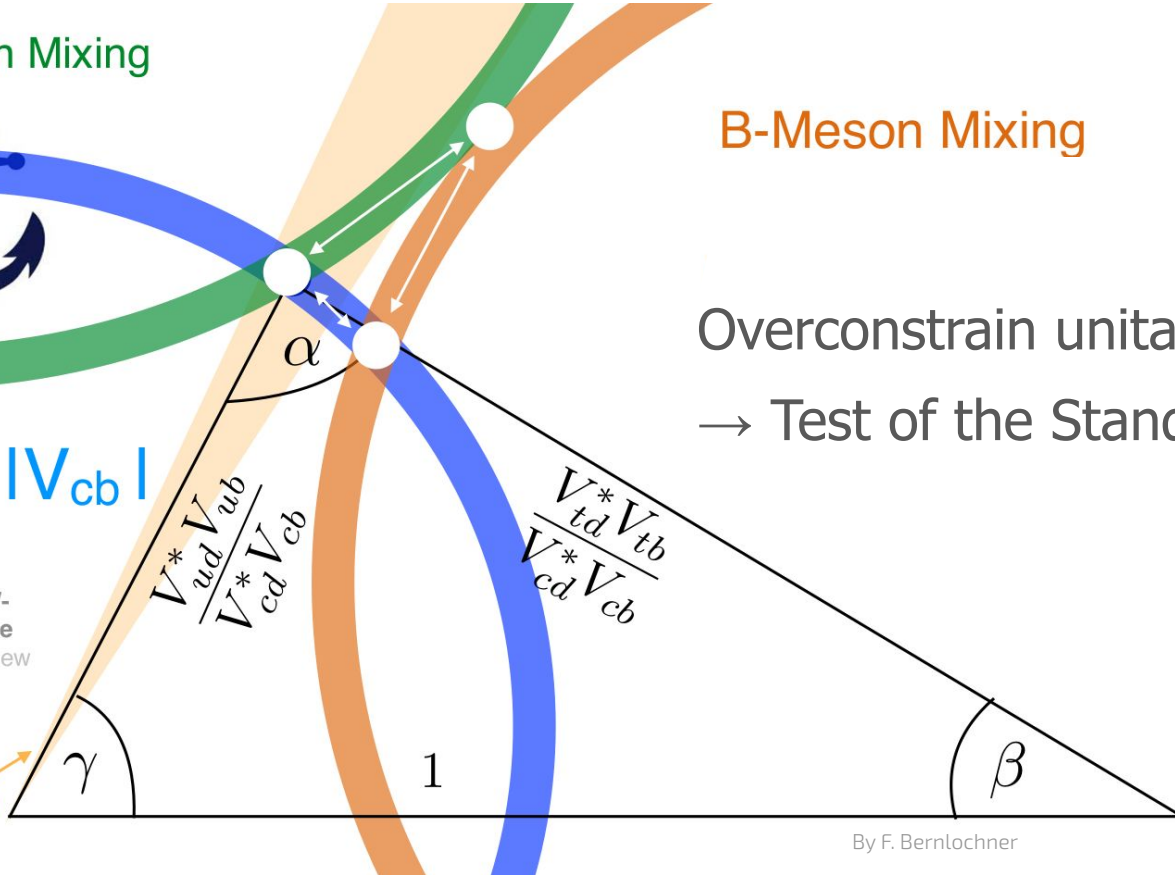
$$|V_{ub}| / |V_{cb}|$$

Dominated by W-Boson exchange
a-priori free from new physics

CKM γ can also be measured using tree-level decays

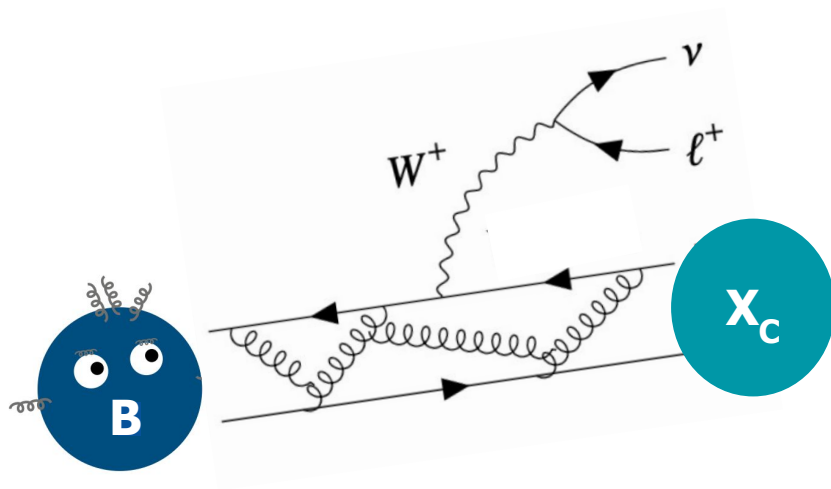
B-Meson Mixing

Overconstrain unitarity condition
→ Test of the Standard Model



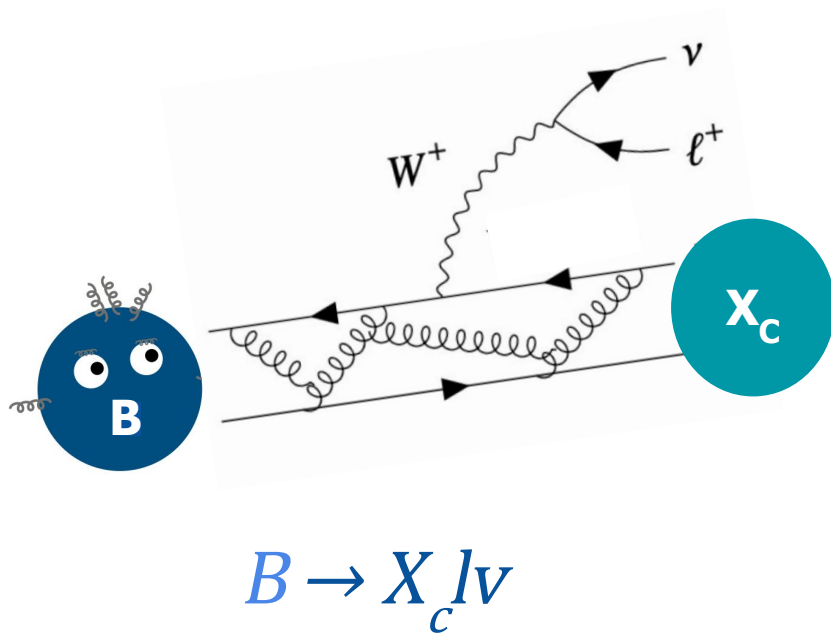
By F. Bernlochner

$|V_{cb}|$ from inclusive moments



1. Non-perturbative QCD dynamics
2. Need experimental data
3. Spectral moments!!

State of the art: Previous measurements



E_l^B Energy of the lepton (in frame of B)



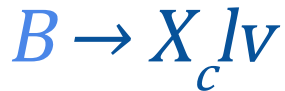
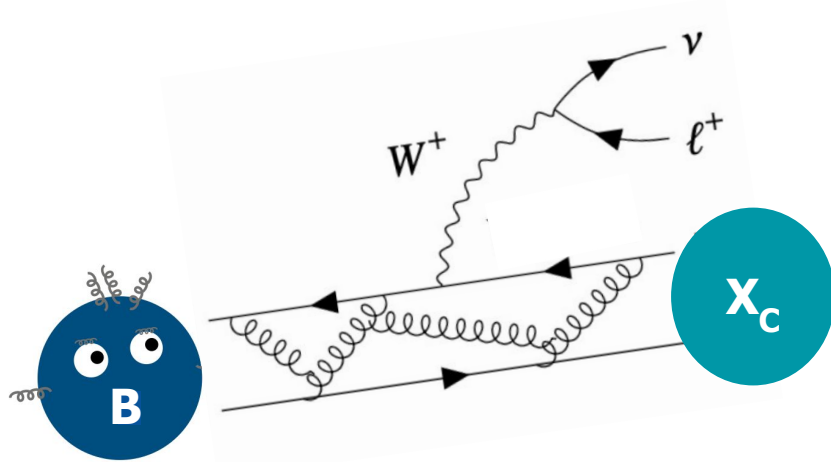
M_X Mass of the inclusive X system



q^2 Lepton mass squared



State of the art: Now



E_1^B
 M_X
 q^2

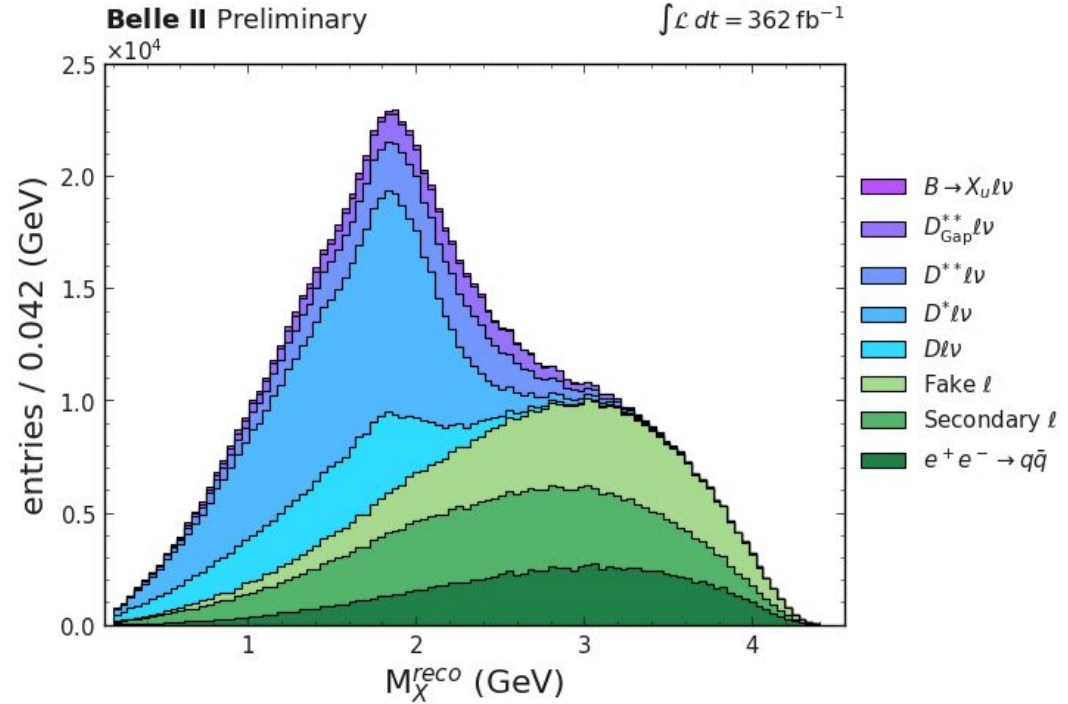


Gotta catch 'em all!
(and their correlations!)

Capturing moments



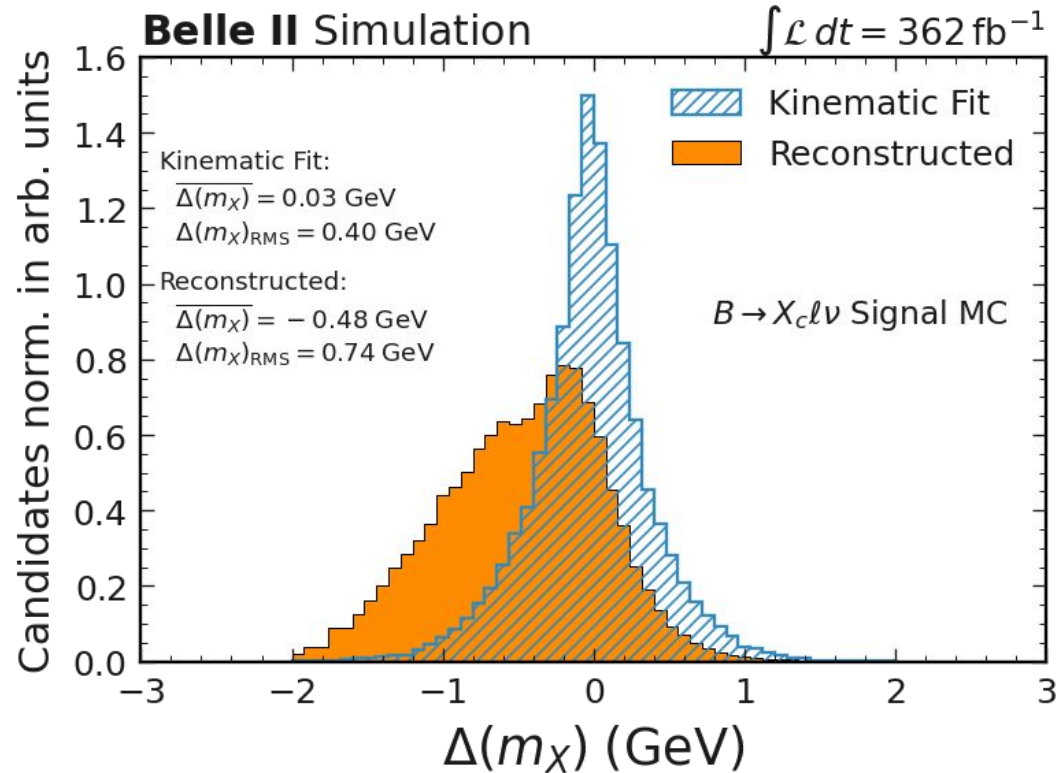
1. Good resolution
2. Know the background
3. Calibration



Improve resolution

Kinematic Fit:

- B meson mass
- No missing momentum
- Positive M_X^2



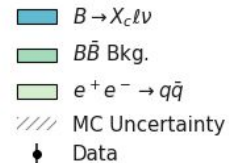
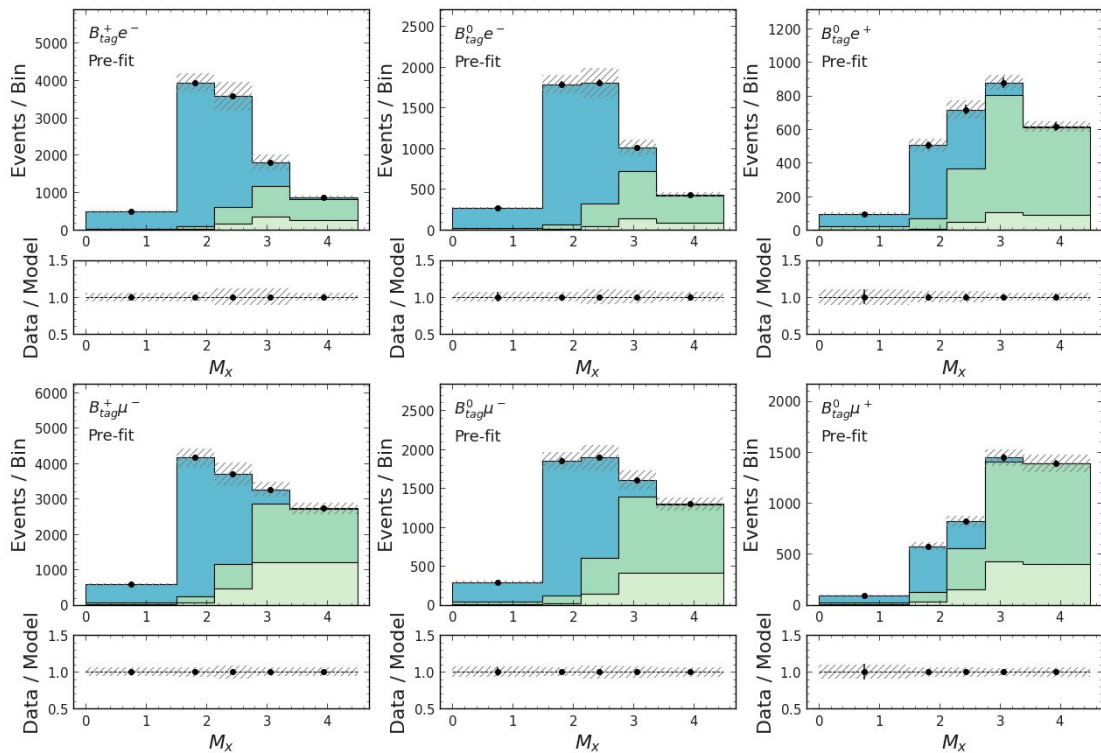
Background subtraction

$$\langle q^{2n} \rangle = \frac{\sum_i^{N_{\text{data}}} w(q_i^2) \times q_{\text{calib},i}^{2n}}{\sum_j^{N_{\text{data}}} w(q_j^2)} \times C_{\text{calib}} \times C_{\text{gen}}$$

Equivalent for M_x and E_1^B

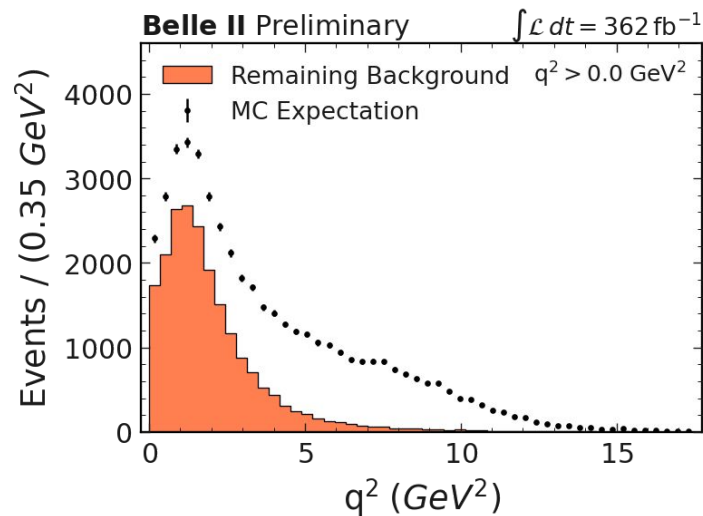
1. **Signal-probability**
2. **Linear calibration**
3. Correct **bias** of linear calibration
4. **Reconstruction** effects

Background subtraction fit



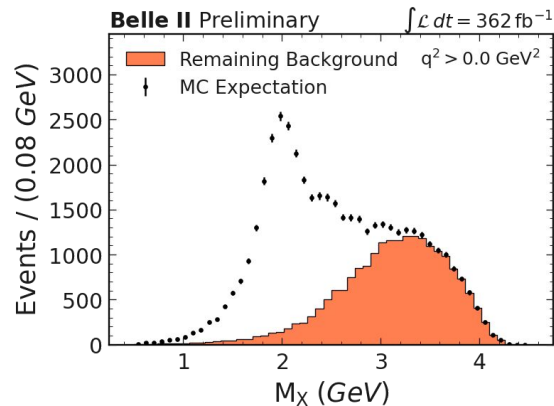
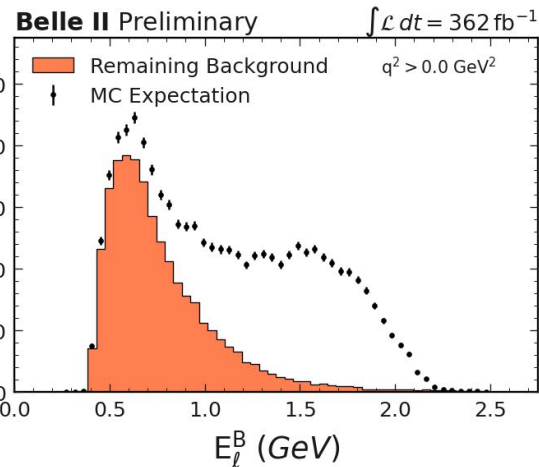
- Binned likelihood fit:
pyhf & cabinetry
- Nuisance parameters:
particle identification,
charm modelling,
formfactors etc.

Bin-wise signal probability

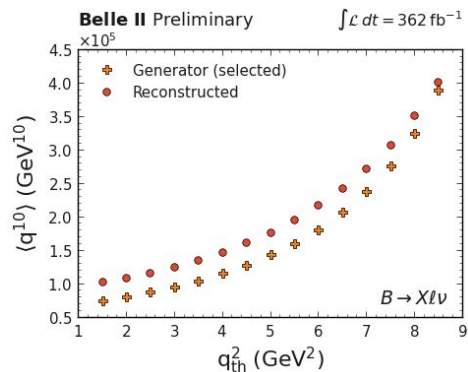
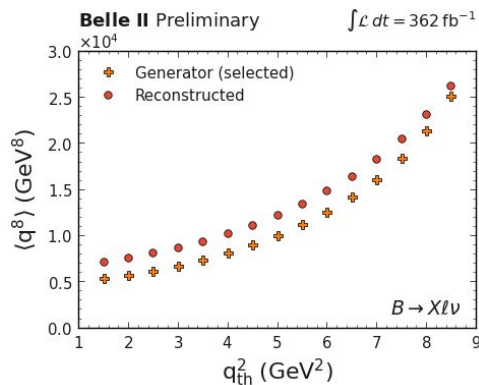
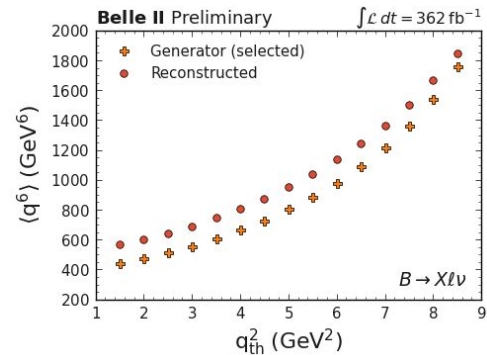
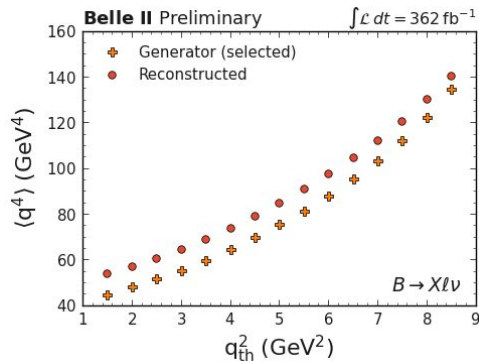
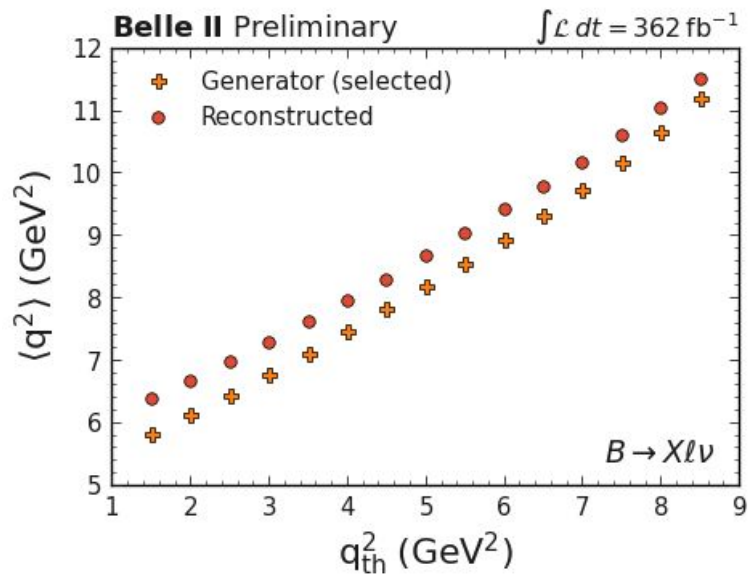


Background shape from simulation

Normalization from fit

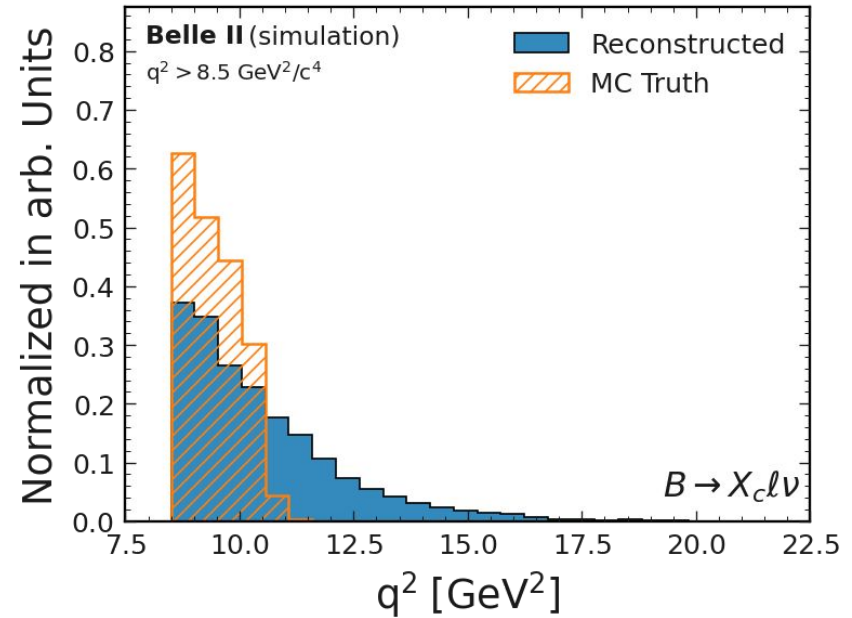
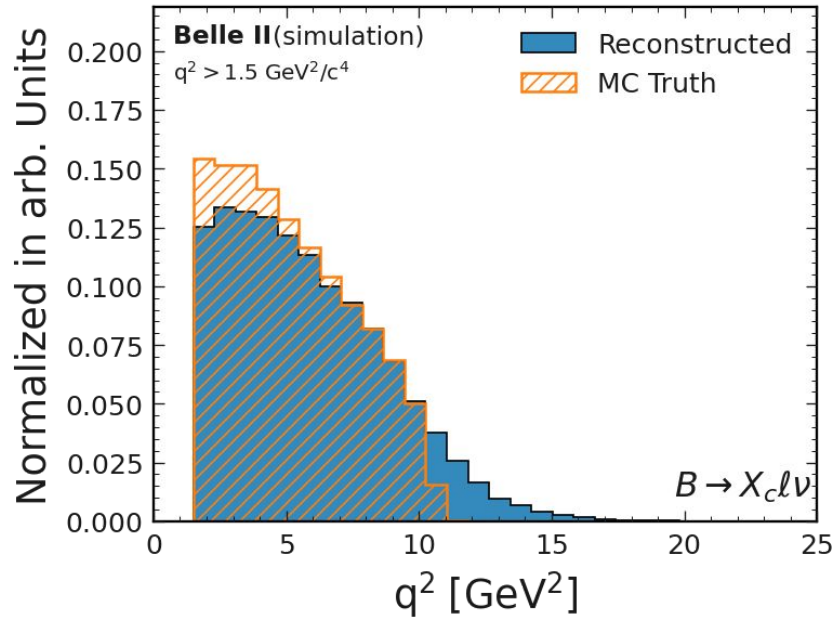


Generated vs Reco



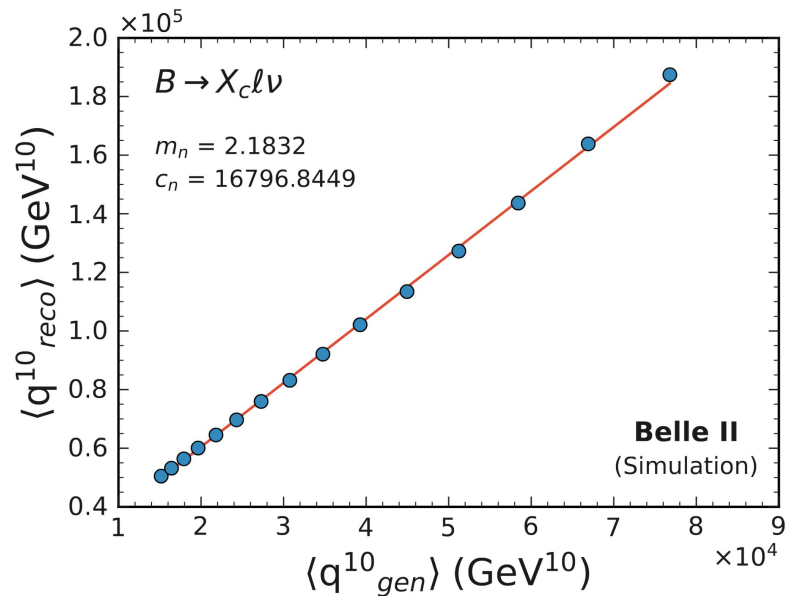
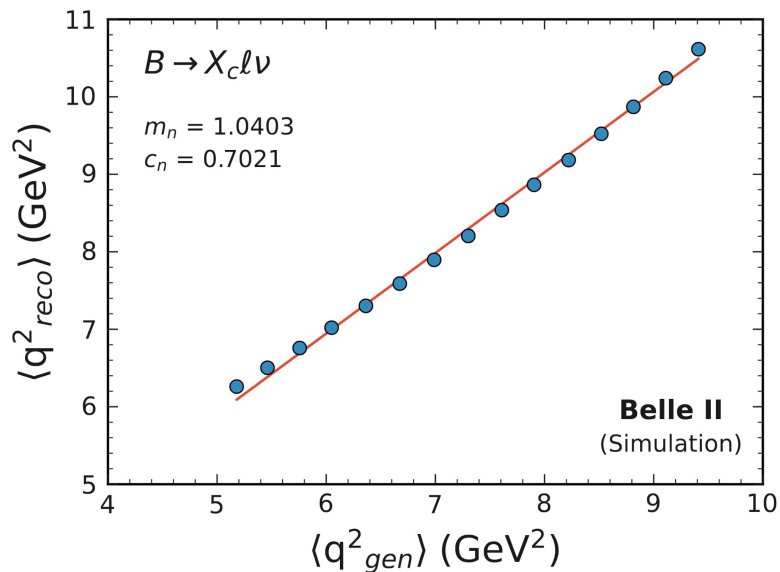
Correct for the mismatch between generated and reconstructed $\langle q^{2n} \rangle$

Spectra of generated and reconstructed $B \rightarrow X_c l \nu$



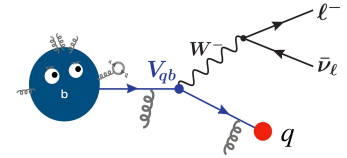
Linear calibration

$$\langle q_{\text{reco}}^{2n} \rangle = m_n \times \langle q_{\text{gen,sel}}^{2n} \rangle + c_n$$



Each point corresponds to a different lower thresholds $q_{\text{th}} = (1.5, 2, 2.5, \dots 8.5)$ GeV

Moments of inclusive semileptonic B decays



$$\langle q^{2n} \rangle = \frac{\sum_i^{N_{\text{data}}} w(q_i^2) \times q_{\text{calib},i}^{2n}}{\sum_j^{N_{\text{data}}} w(q_j^2)} \times C_{\text{calib}} \times C_{\text{gen}}$$

Status

- Kinematic fit to improve resolution in M_X
- Background subtraction via signal probability $w_i(q^2)$
- Apply event-wise calibration

On-going

- Further calibration steps and systematics
- Background enriched sidebands and resolution studies

