

A_{FB} from $B \rightarrow X\ell\nu$ decays at Belle II

Belle II Summer Workshop

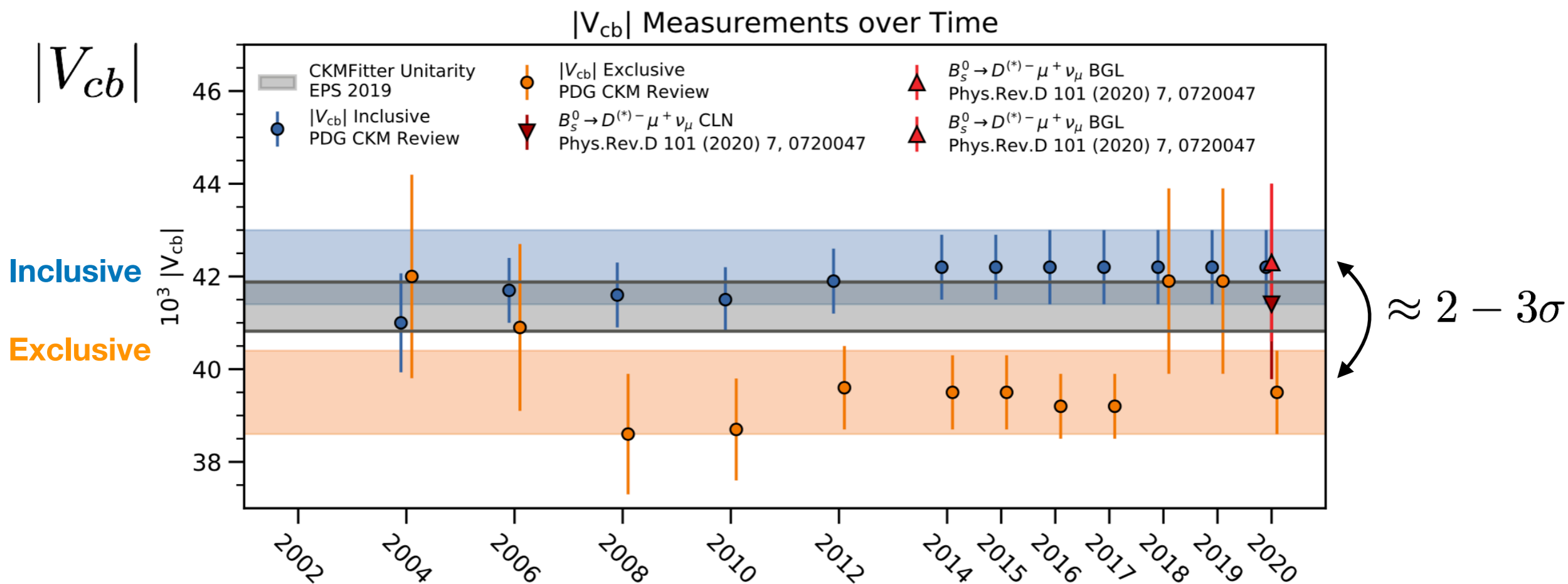
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26 July 2023



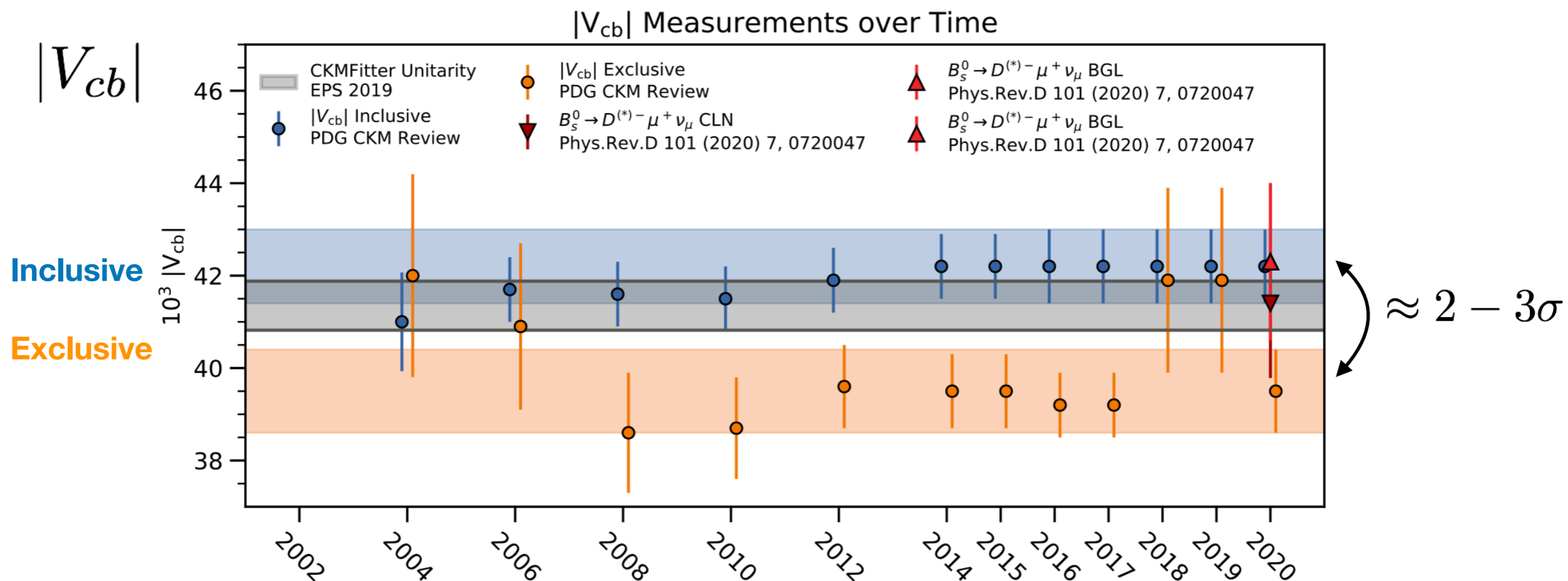
A longstanding



What could Belle II do to shed light on this puzzle?



A longstanding



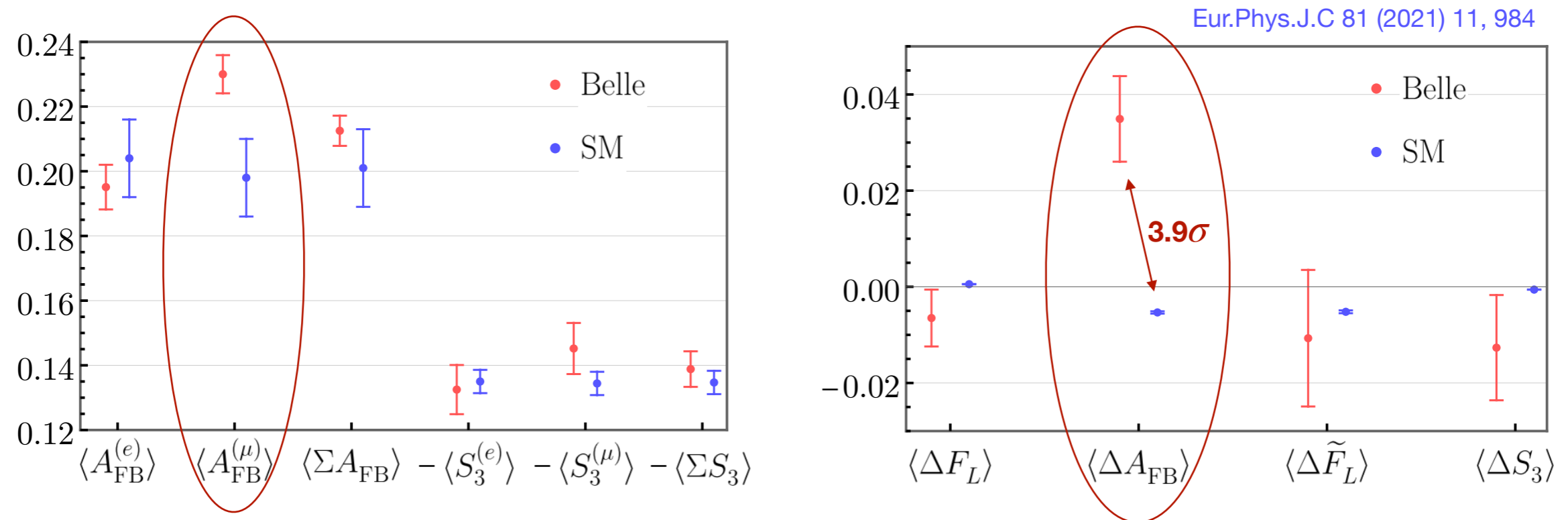
What could Belle II do to shed light on this puzzle?



- Systematically reproduce legacy measurements
- Investigate previously unmeasured variables that could reduce model uncertainties
- Employ data-driven analysis strategies

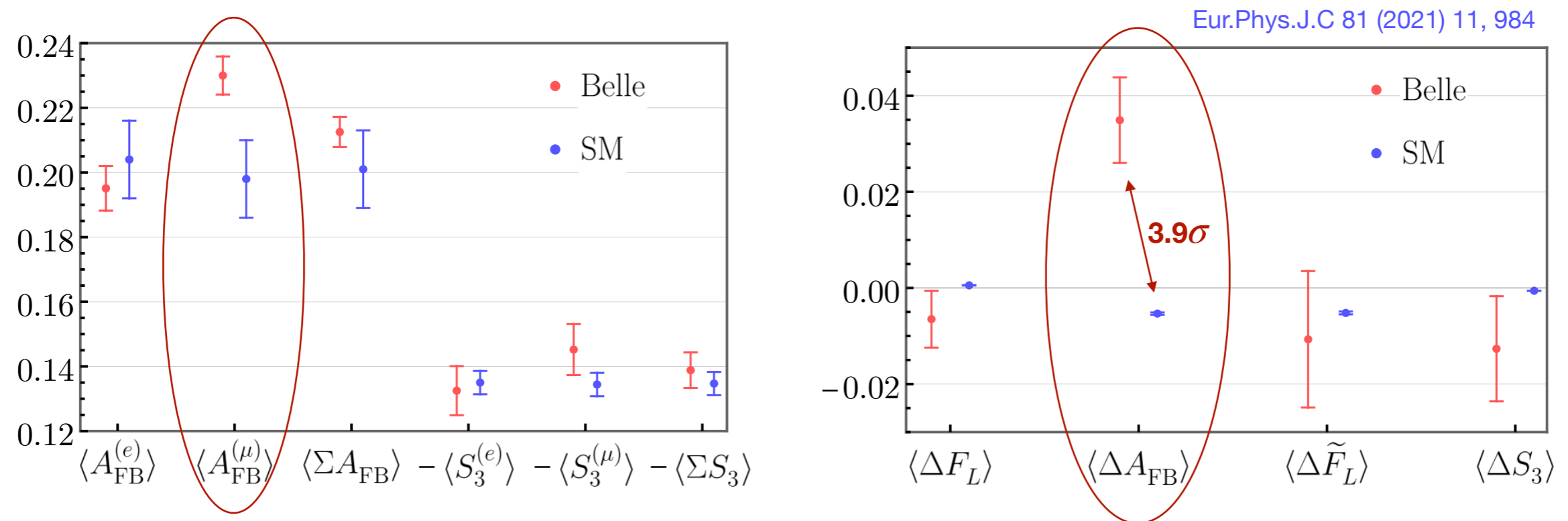
Forward-backward asymmetry

Current measurements of A_{FB} from $B^0 \rightarrow D^{*-} \ell^+ \nu_\ell$ decays display a **discrepancy** with the SM prediction



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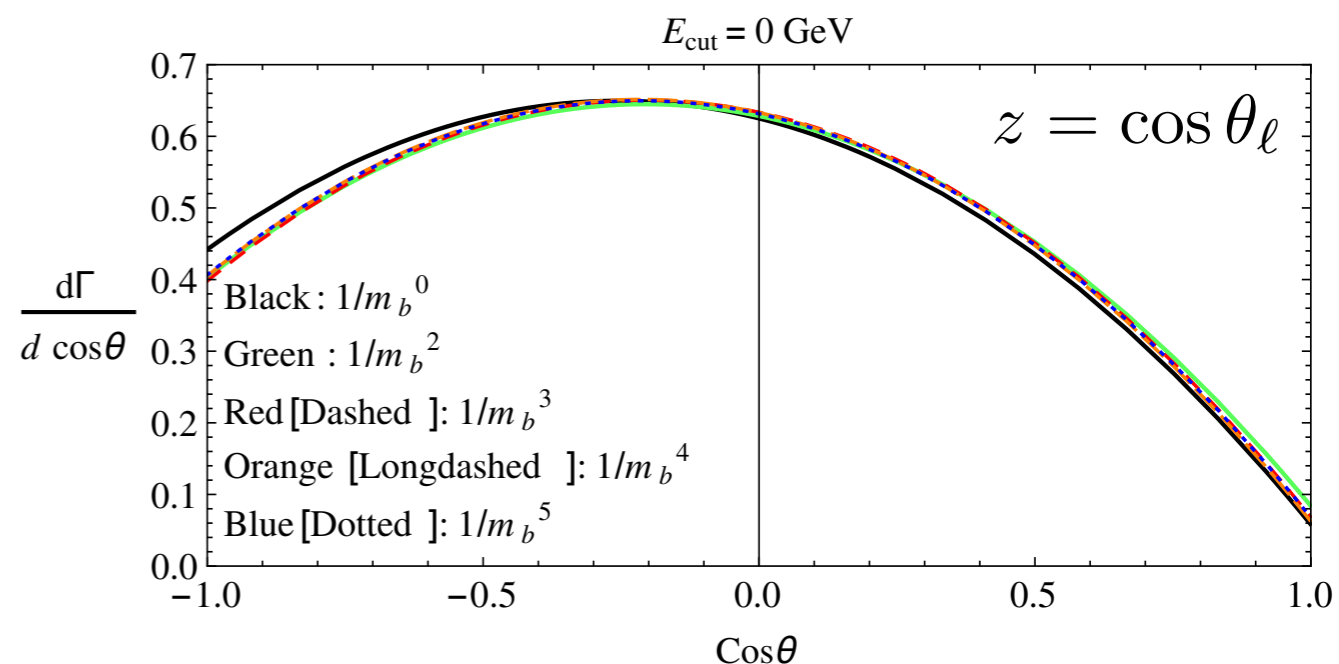
- **First** measurement of A_{FB} from **inclusive** $B \rightarrow X \ell \nu_\ell$ decays would provide an **orthogonal, complementary** study [JHEP 04 \(2016\) 131](#)
 - $X_u \ell \nu_\ell$ component **easily subtracted** in the HQE with **smaller uncertainties** than traditional MC approach [arXiv:2205.03427](#) & [JHEP 09 \(2021\) 51](#)
- Additional information leads to **greater sensitivity** in global fits, particularly the HQE parameter $\hat{\mu}_G$

Incl. A_{FB} at Belle II

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- Goal: Measure A_{FB} from **inclusive** $B \rightarrow X\ell\nu$ decays using **hadronic tagging**

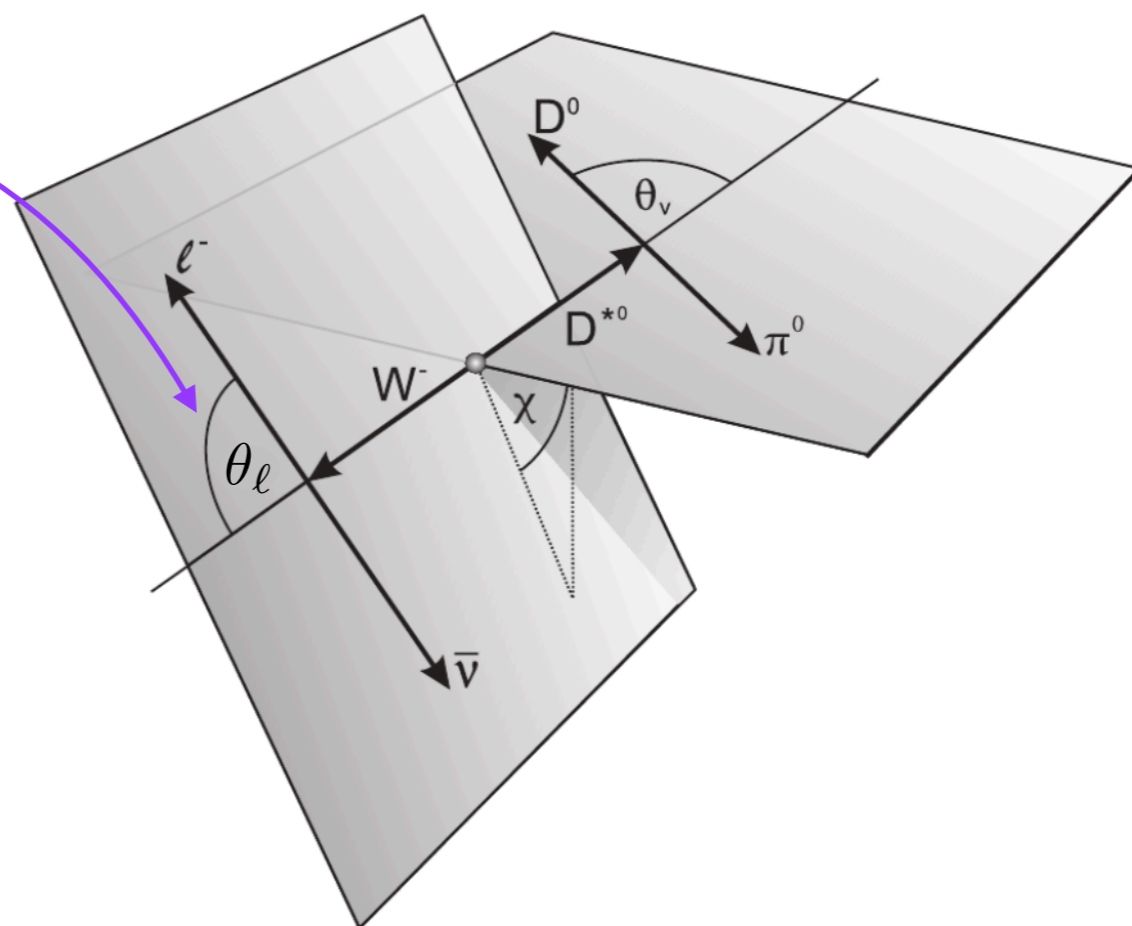
$$A_{FB} = \frac{1}{\Gamma} \left(\int_{-1}^0 dz \frac{d\Gamma}{dz} - \int_0^1 dz \frac{d\Gamma}{dz} \right)$$



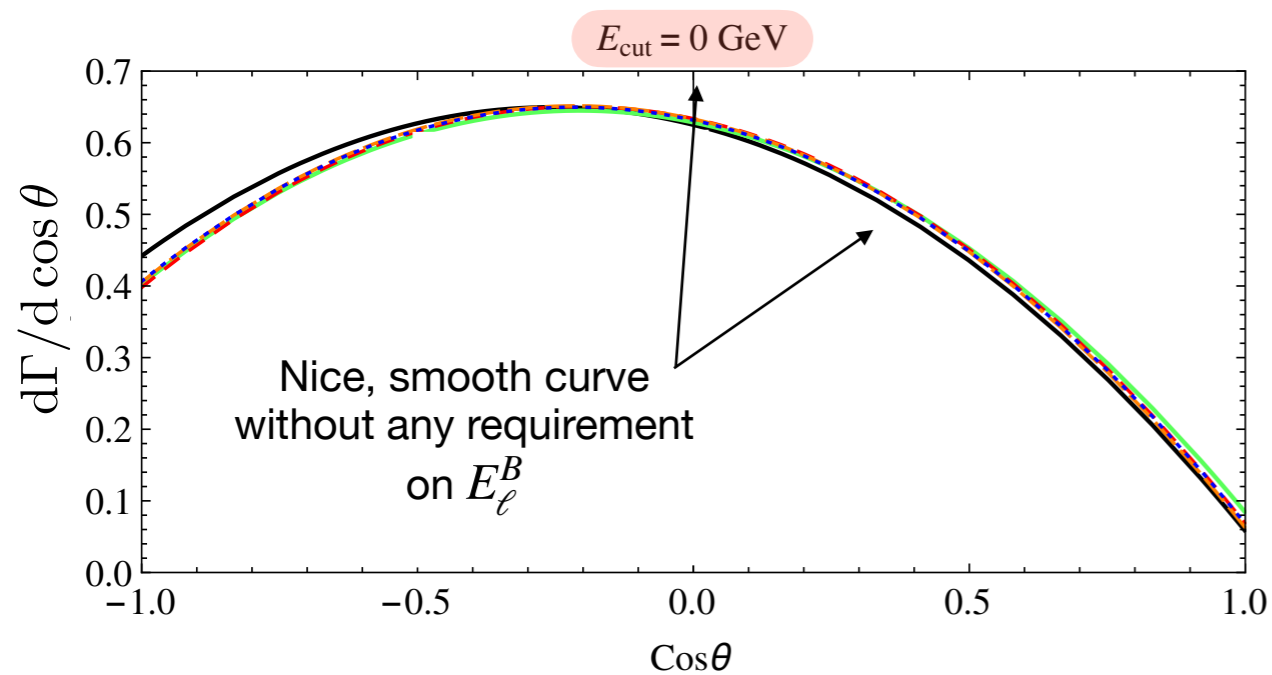
- Reconstruct:

$$z = \frac{E_{\nu\ell}^B - E_\ell^B}{\sqrt{(E_{\nu\ell}^B + E_\ell^B)^2 - q^2}}$$

- Missing energy and q^2 **easily accessible** variables with tagged approach
- Separate electron and muon channels for further **LFU tests**

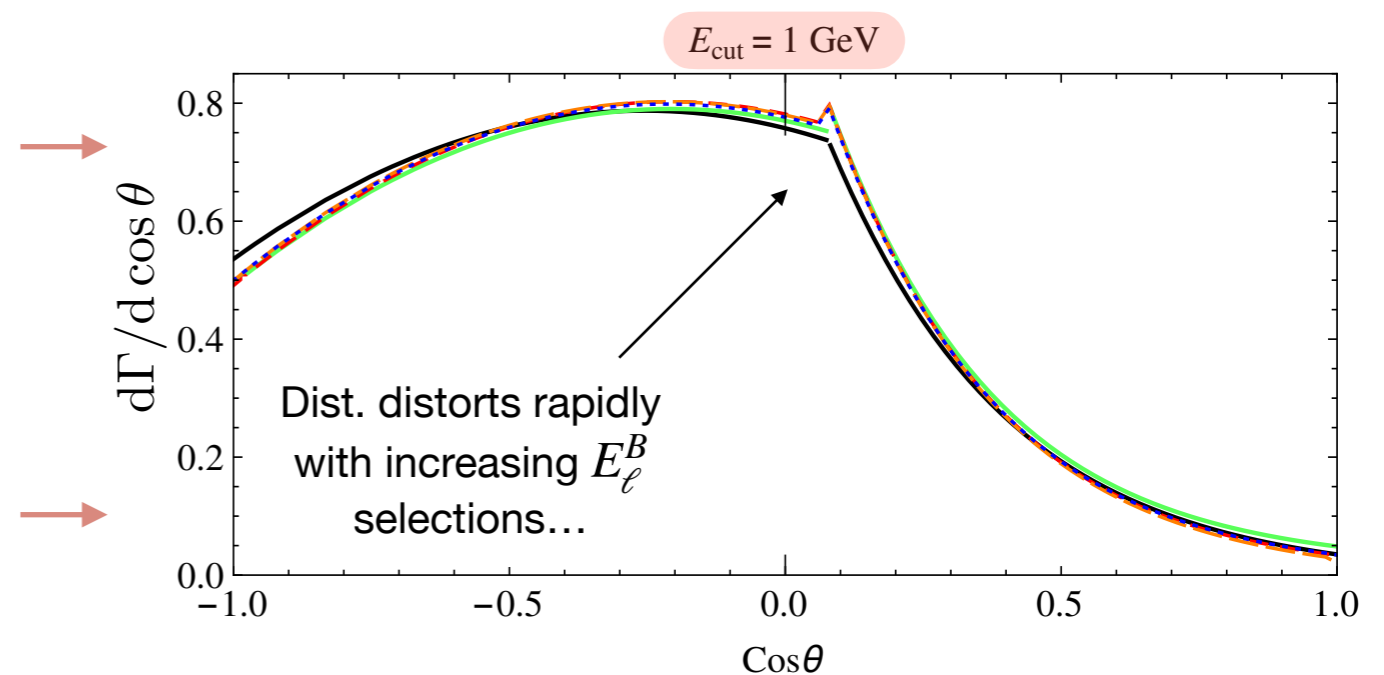
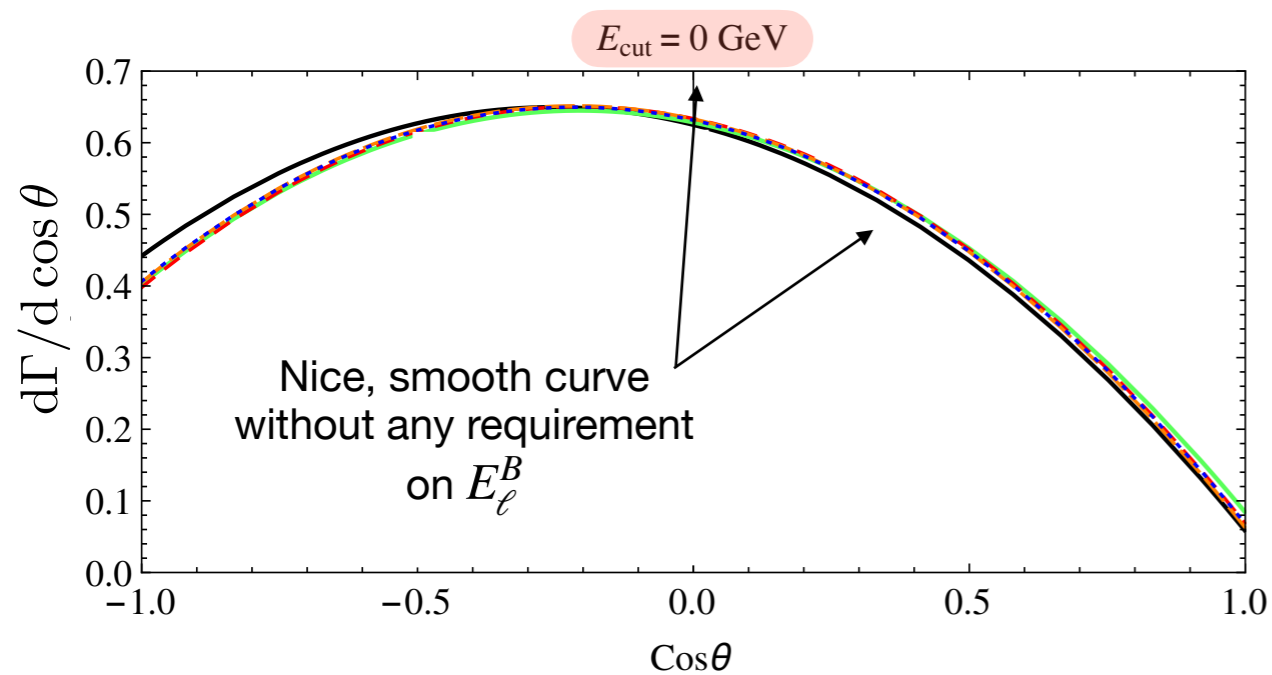


Impact of an E_ℓ requirement



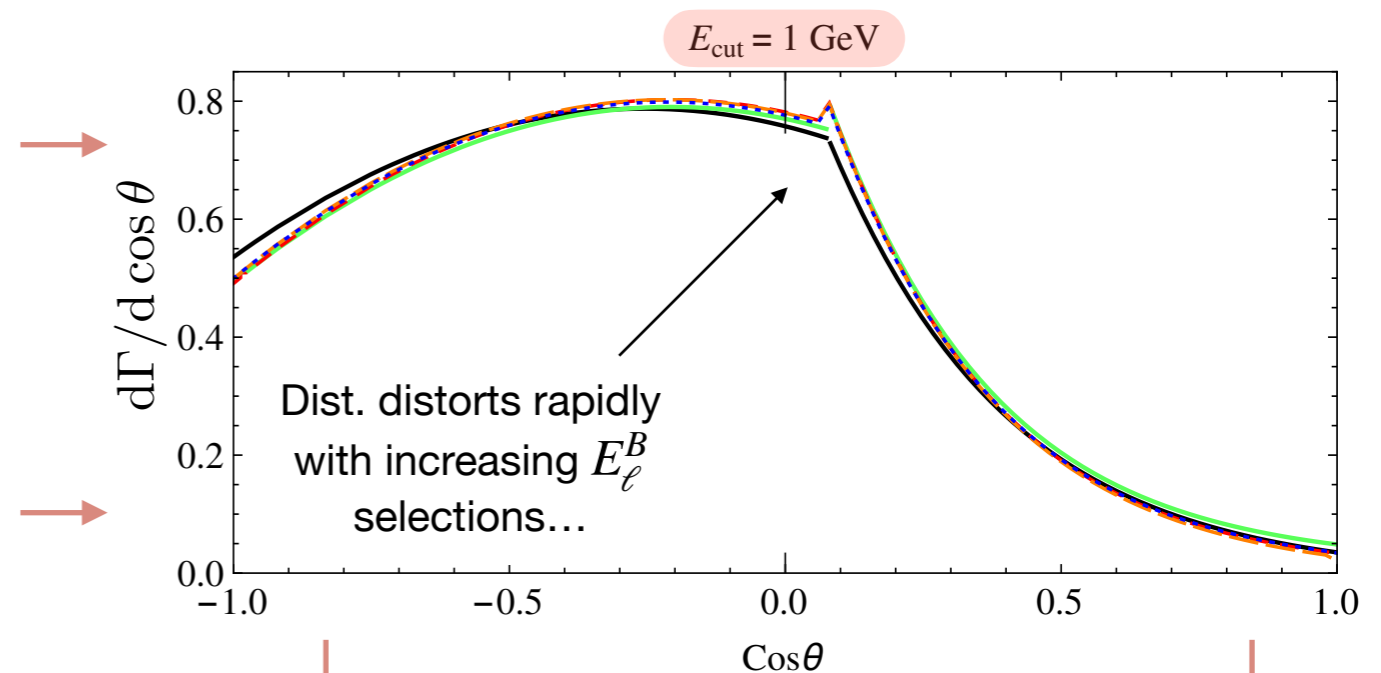
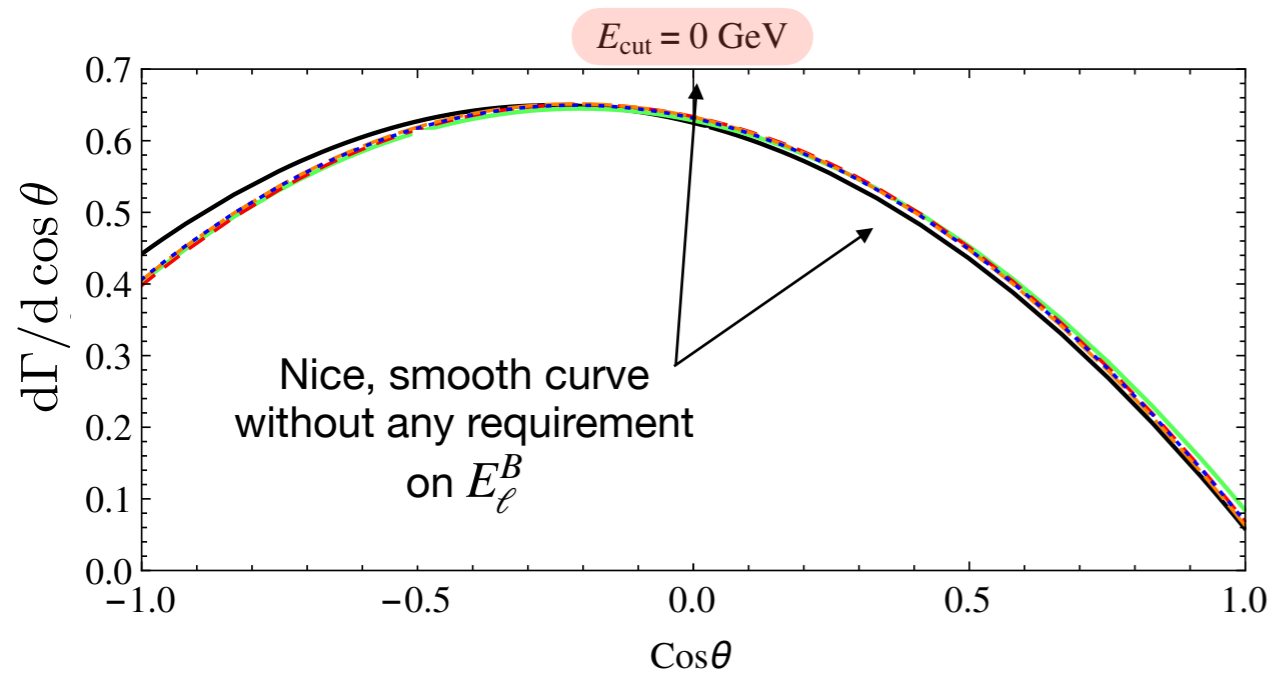
- A minimum energy is required for leptons to be successfully **reconstructed & identified** by the Belle II detector
- Higher E_ℓ selects a **less inclusive** sample

Impact of an E_ℓ requirement



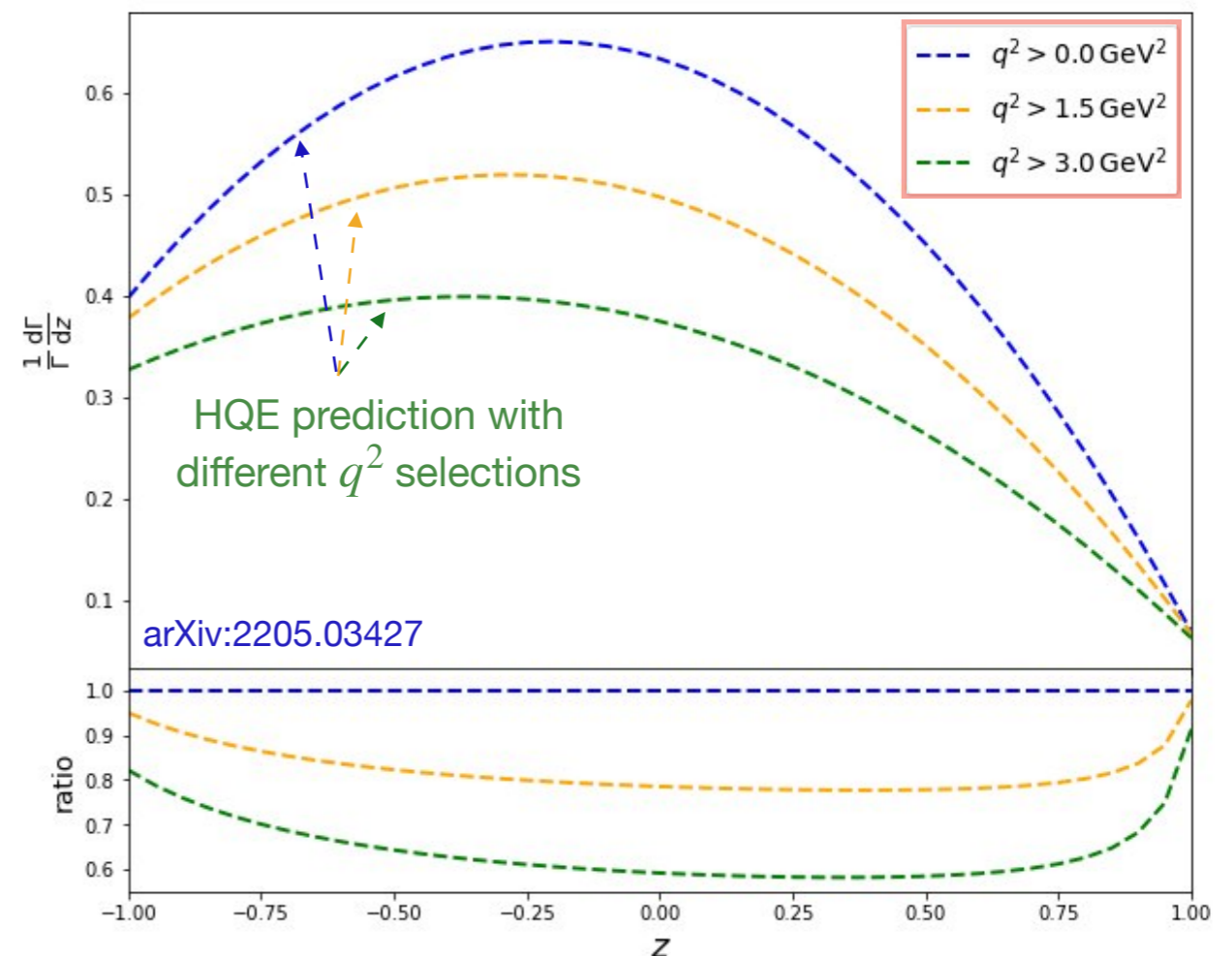
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- Imposing an E_ℓ requirement **introduces a kink**, which would smooth out due to detector resolution
- Potential challenges in **unfolding** reconstructed to the underlying distribution?

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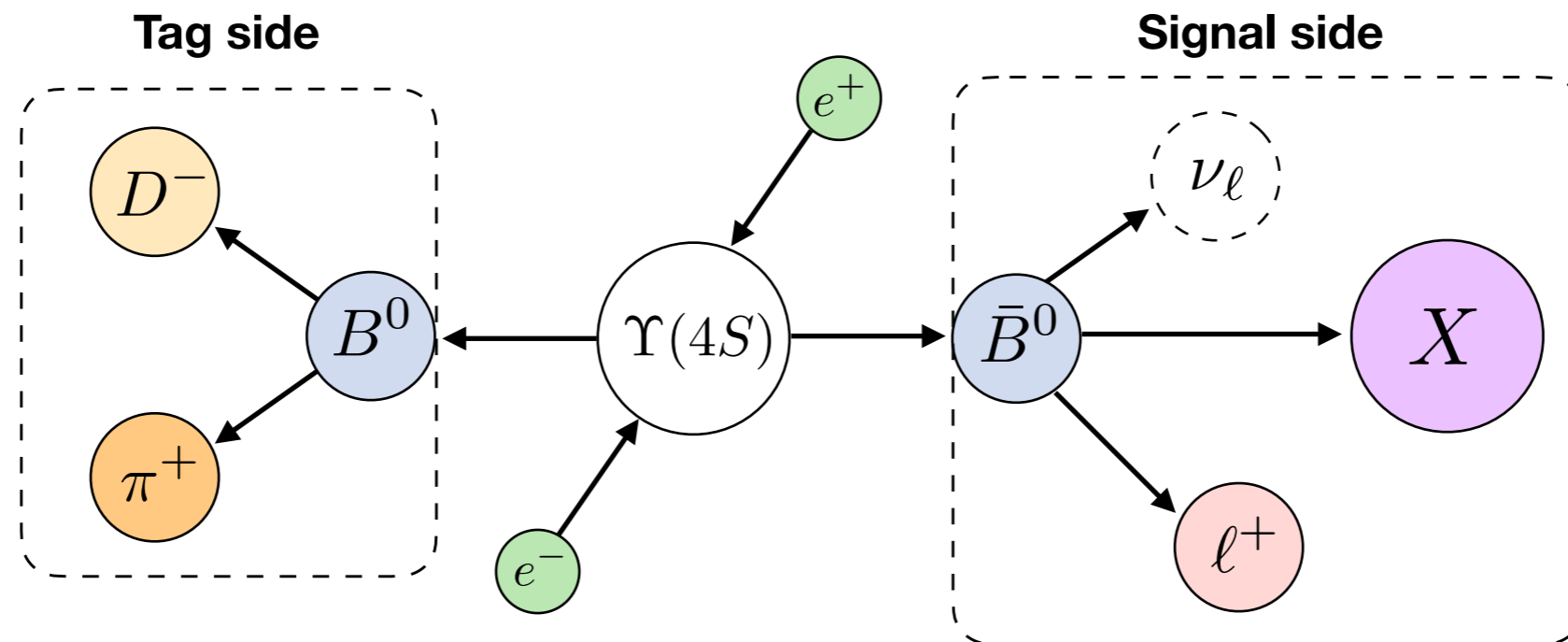
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Suggestion:
Use a q^2 selection instead



Analysis overview

- Reconstruct inclusive $B \rightarrow X\ell\nu$ decays using hadronic tagging
 - Tag side reconstructed with Full Event Interpretation (FEI)
 - Select one well-defined signal lepton
 - X system defined as ROE of the $B_{\text{tag}}\ell$ pair



- Samples: Run-independent MC14 (hadronic FEI skim)
- Goal: Measure A_{FB} from $B \rightarrow X\ell\nu$ decays for different q^2 selections
 - Separate e/μ and B^0/B^+ channels as a test of lepton flavour and isospin universality
 - Extend analysis to measure moments outlined in [arXiv:2205.03427](https://arxiv.org/abs/2205.03427)
- Basf2 release: light-2207-bengal

Pre-selection

...to be optimized

FEI Event selection

- $n_{\text{cleaned tracks}} > 3$
- $n_{\text{cleaned clusters}} > 3$
- $E_{\text{visible}} > 4 \text{ GeV}$
- $2 \text{ GeV} < E_{\text{Total}} < 7 \text{ GeV}$
- $|\Delta E| < 0.2 \text{ GeV}$
- Signal Prob. > 0.001
- $M_{bc} > 5.27 \text{ GeV}$
- Offline BCS of best B_{tag}

Tracks

- Track quality:
 - θ in CDC acceptance
 - CDC hits > 0
- IP:
 - $|d_0| < 0.5 \text{ cm}$
 - $|z_0| < 2 \text{ cm}$

Electrons

- BDTScore_e > 0.9
- $p_{\text{lab}} > 0.4 \text{ GeV}$
- Brems corrections

Muons

- MuonID_noSVD > 0.9
- $p_{\text{lab}} > 0.4 \text{ GeV}$

Kaons

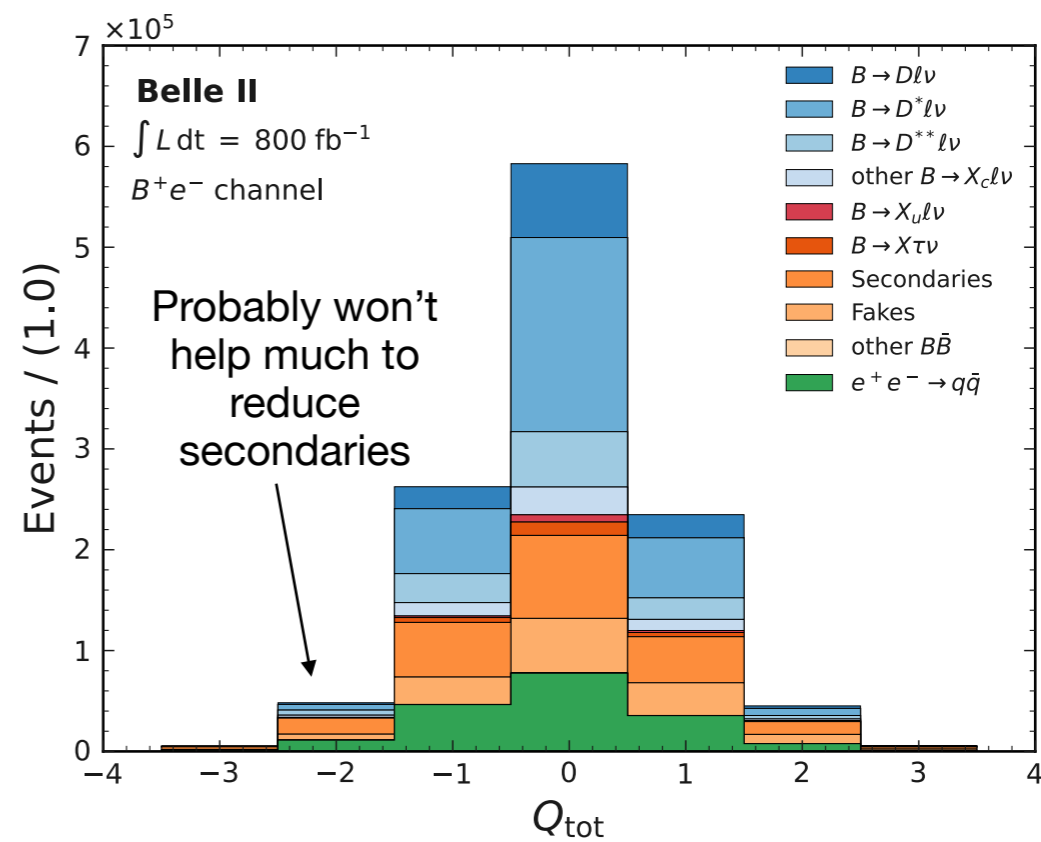
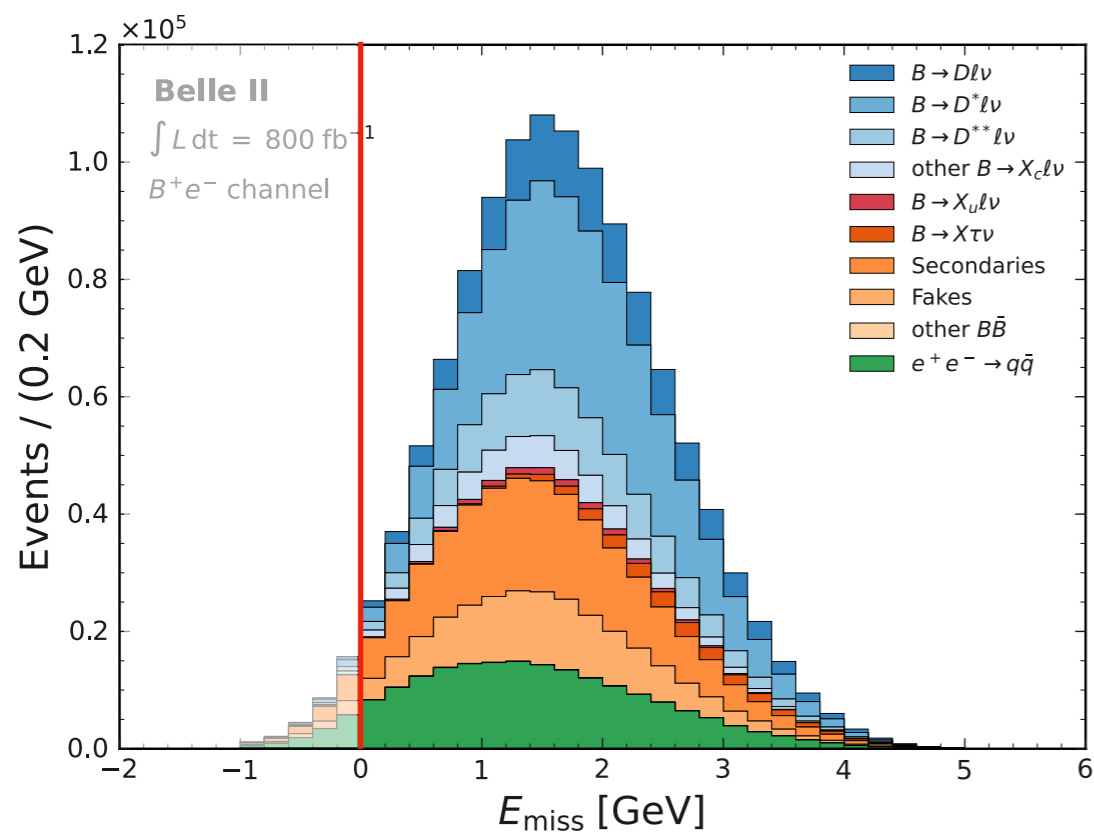
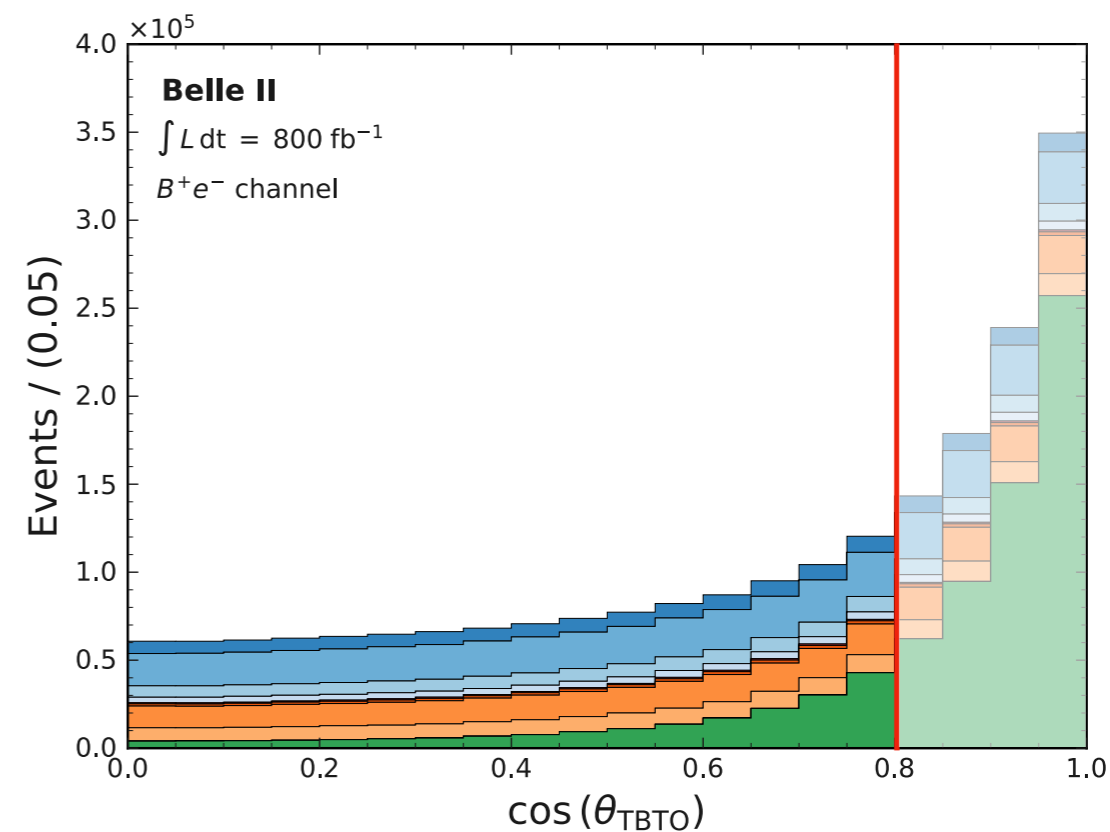
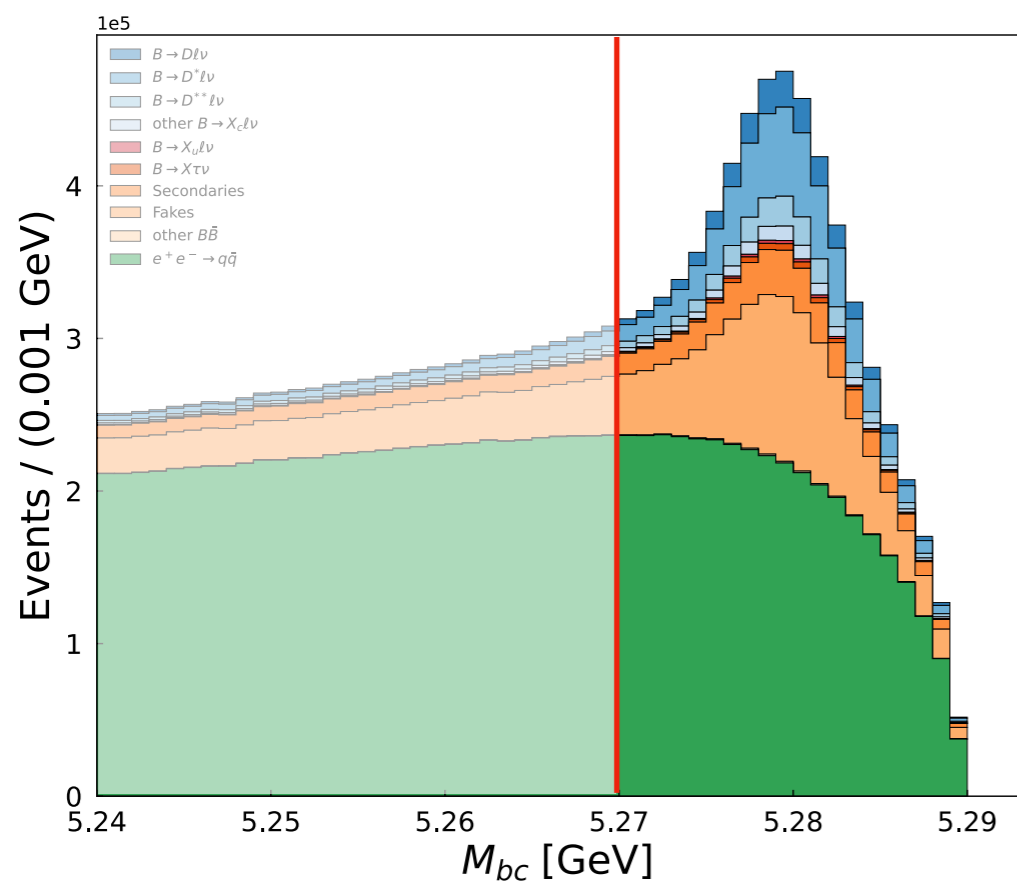
- KaonID > 0.6

Rest of Event

- Charged:
 - $|d_0| < 2 \text{ cm} \ \& \ |z_0| < 4 \text{ cm}$
 - θ in CDC acceptance
 - CDC hits > 0
 - $p_T > 0.1 \text{ GeV}$
 - [extraInfo(isCurl) == 0]
- Neutral:
 - Barrel: $p_T > 0.03 \text{ GeV} \ \& \ \text{clusterZernikeMVA} > 0.15$
 - Forward: $p_T > 0.02 \text{ GeV} \ \& \ \text{clusterZernikeMVA} > 0.35$
 - Backward: $p_T > 0.02 \text{ GeV} \ \& \ \text{clusterZernikeMVA} > 0.4$

Further selections

...to be optimized



To-do list

