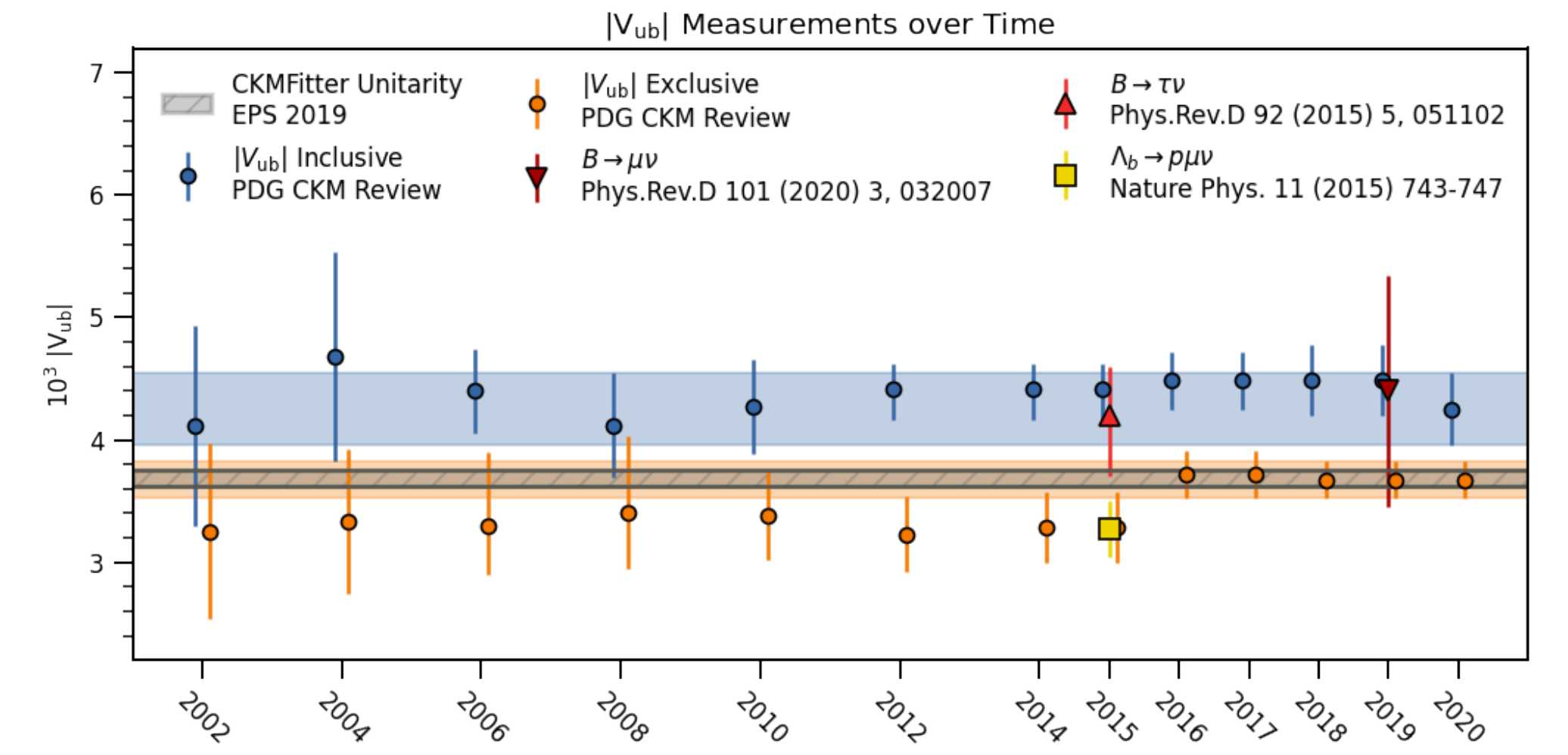


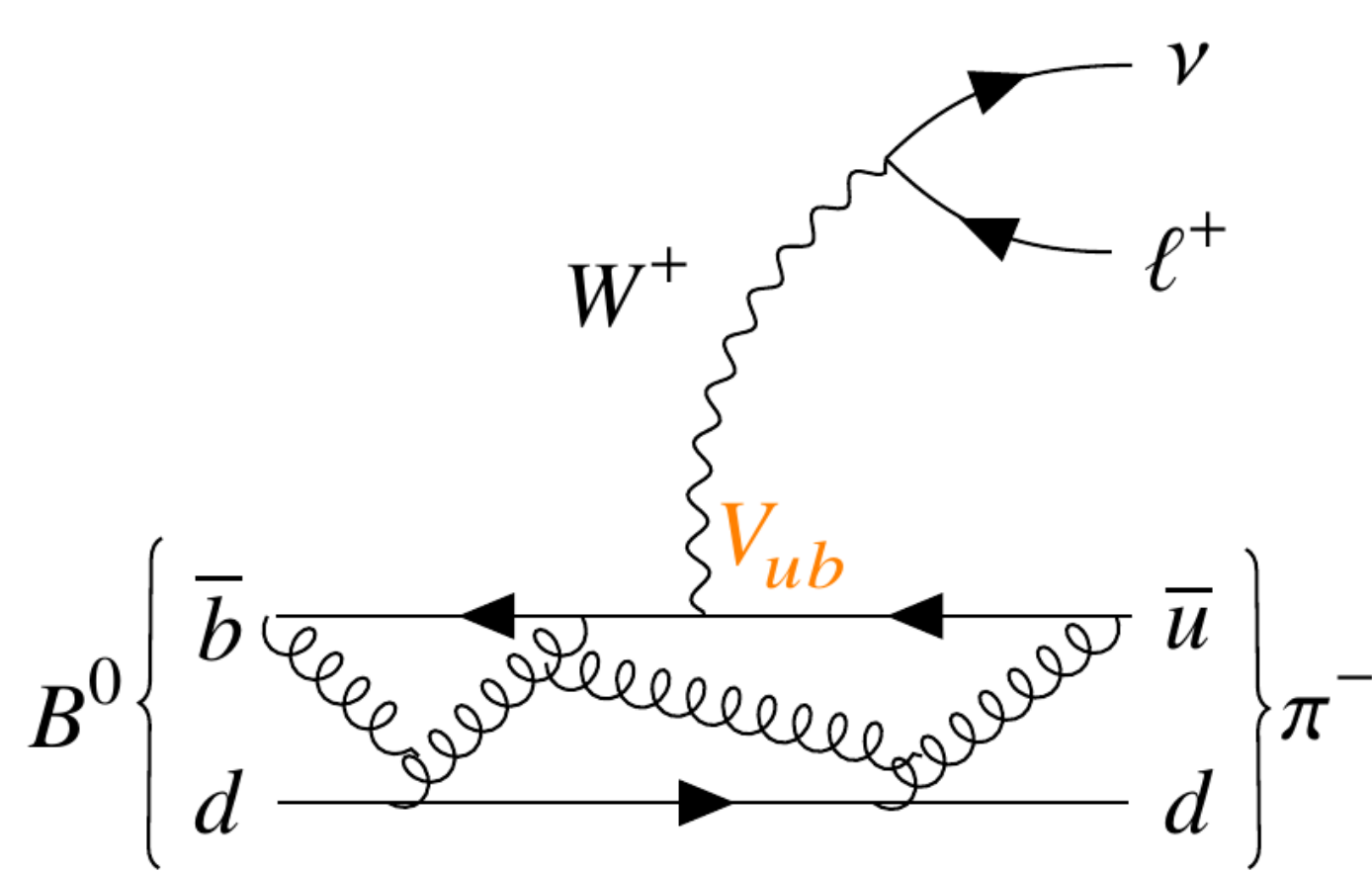
INTRODUCTION

- At Belle II electrons and positrons collide at a centre of mass energy tuned to the $\Upsilon(4S)$ resonance, resulting in the production of B meson pairs
- Large fractions of these B mesons decay semileptonically into lighter mesons, involving quark transitions
- By investigating these decays it is possible to determine Standard Model parameters, such as the CKM matrix elements $|V_{ub}|$ and $|V_{cb}|$
- A tension between inclusive and exclusive measurements of these quantities persists



METHOD

- Most accessible channel to measure $|V_{ub}|$ exclusively is $B \rightarrow \pi \ell \nu$



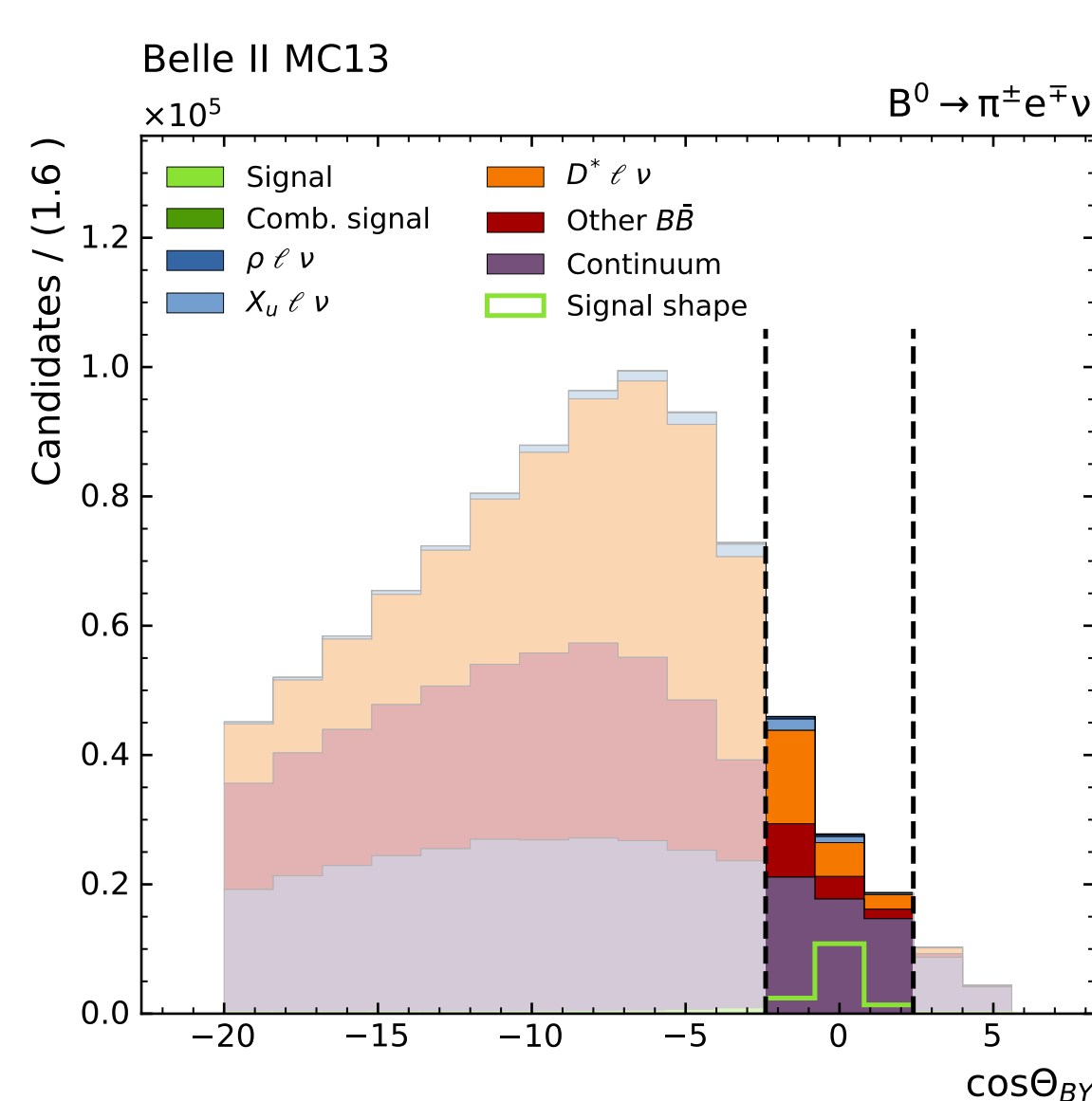
- Describe decay kinematics by the momentum transfer squared:

$$q^2 = (p_B - p_\pi)^2$$

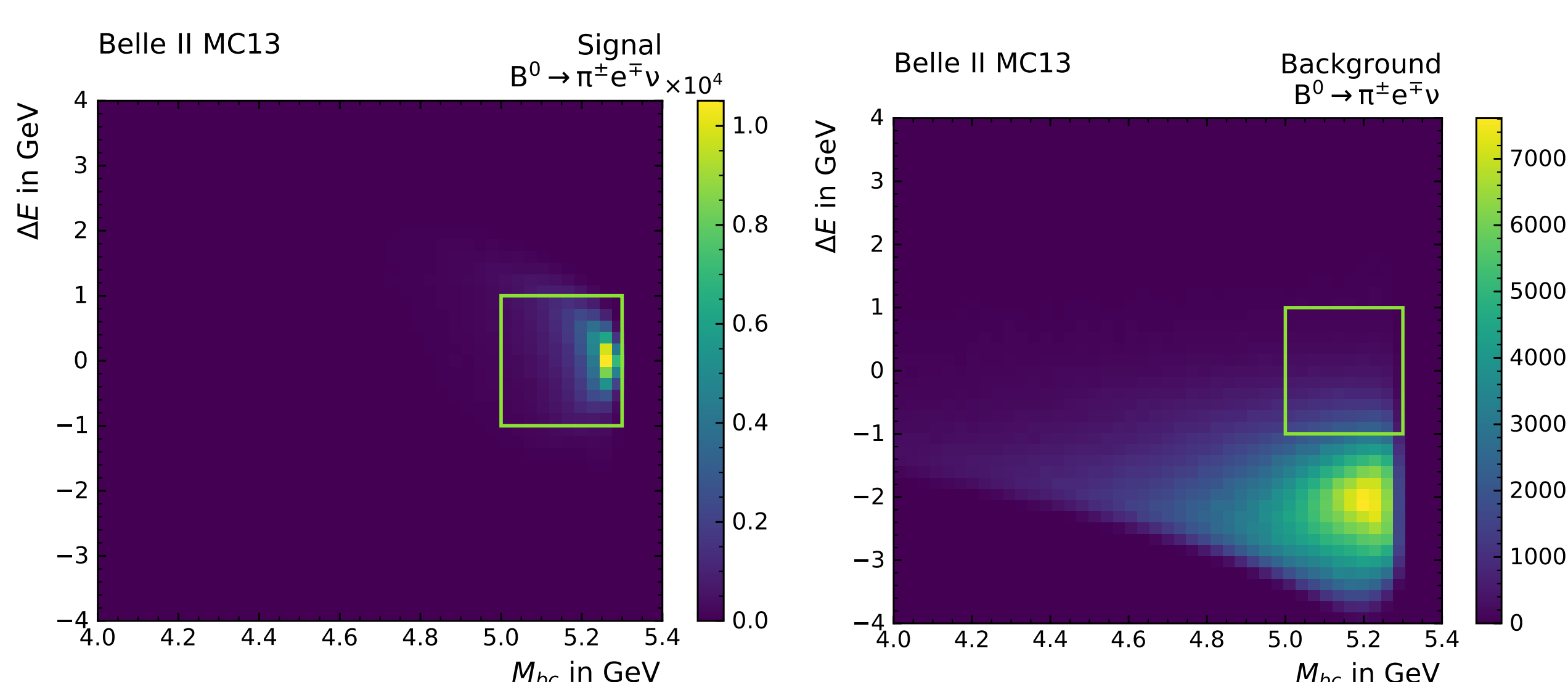
- $BF \propto |V_{ub}|^2 f(q^2)$
- Partial branching fractions determined in five q^2 bins
- Extract $|V_{ub}|$ from a form factor fit to the partial branching fraction spectrum

SIGNAL SELECTION

- Place requirement on the cosine of the angle between Y (lepton and pion combination) and B candidate: $\cos \theta_{BY}$

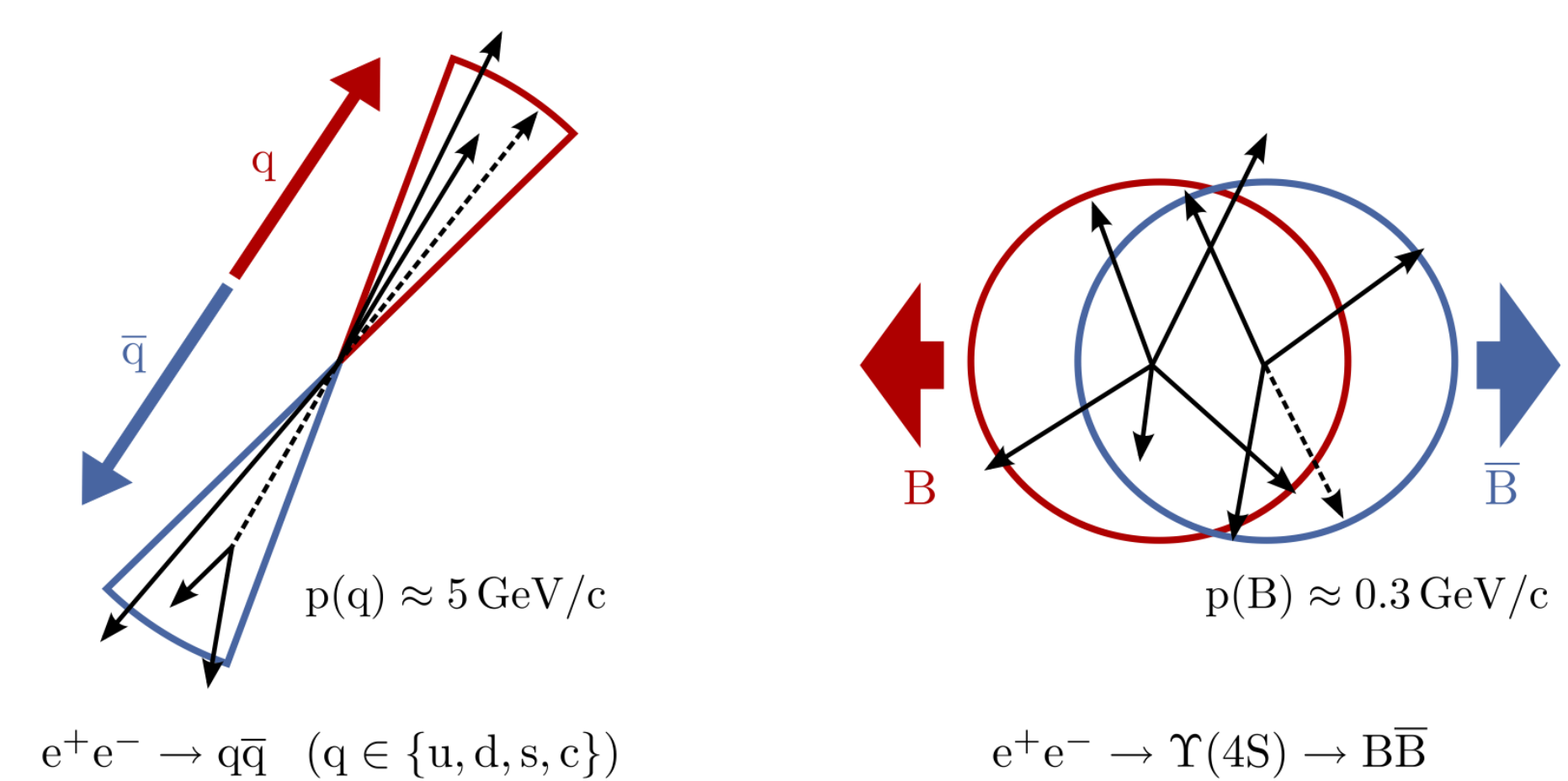


- Energy Difference: $\Delta E = E_B - E_{\text{beam}}$
- Beam-constrained Mass: $M_{bc} = \sqrt{E_{\text{beam}}^2 - |\vec{p}_B|^2}$
- Select two-dimensional region in ΔE and M_{bc}



CONTINUUM SUPPRESSION

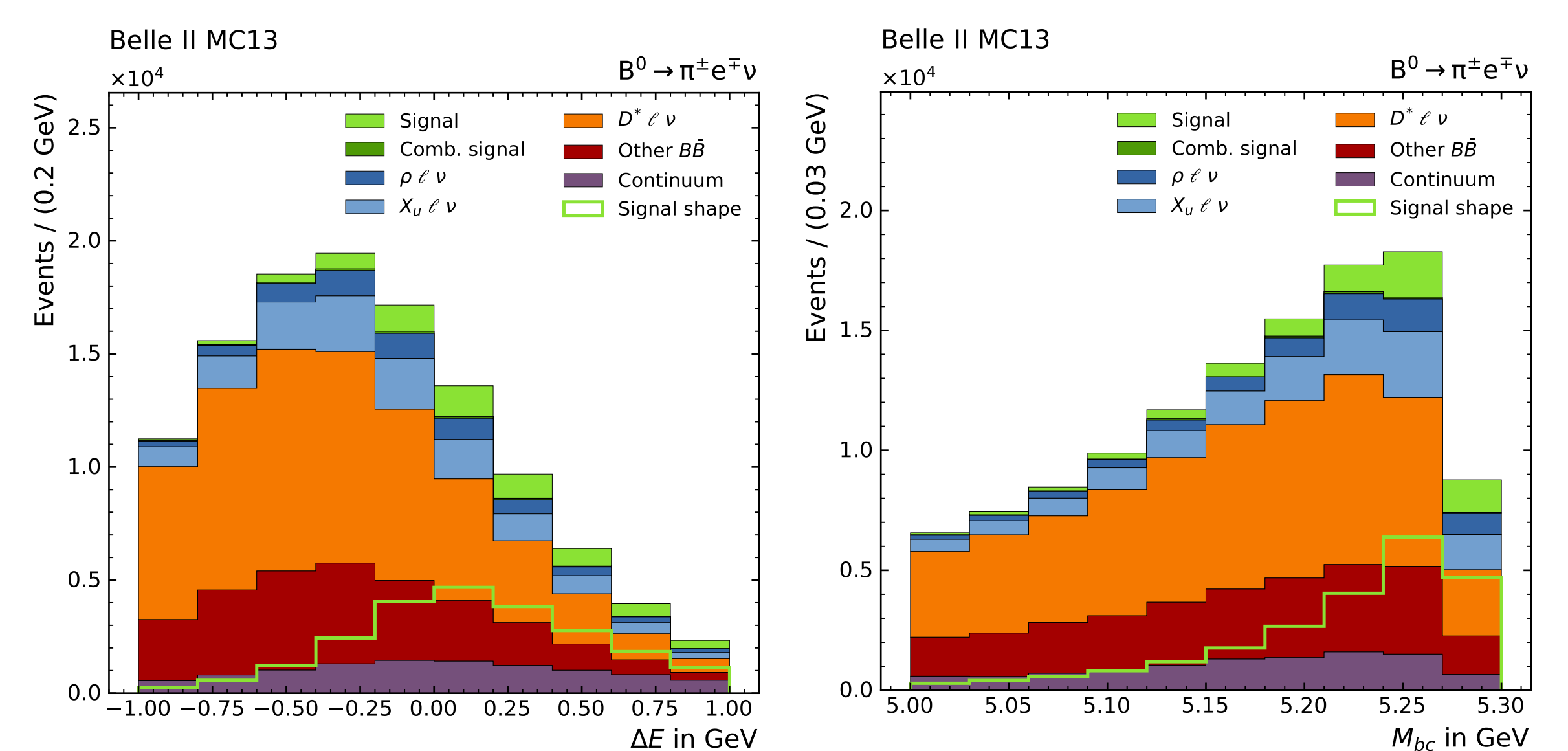
- Event shape is different for continuum and $B\bar{B}$ events



- Use ten training variables to train boosted decision tree in each q^2 bin using FastBDT

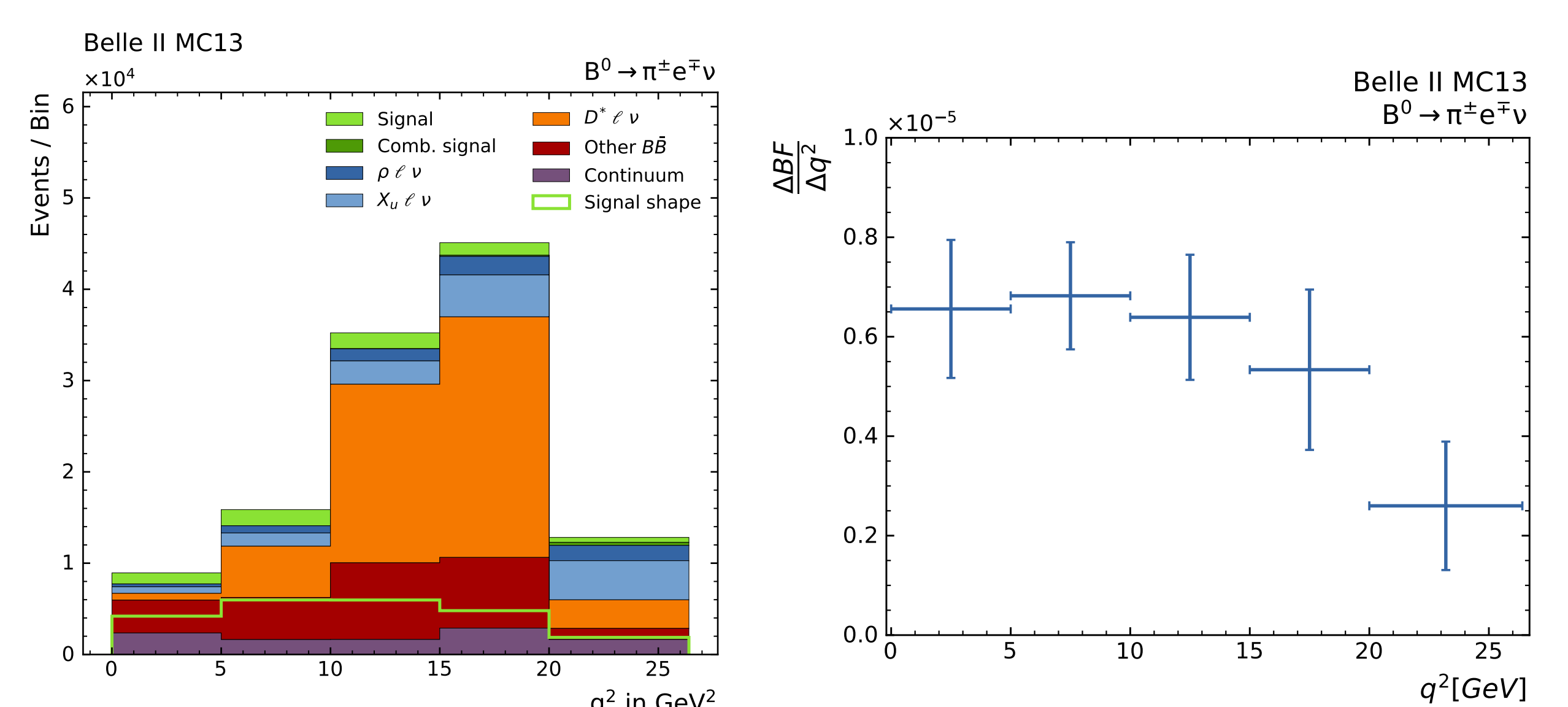
SIGNAL EXTRACTION

- Extract signal from simultaneous binned maximum likelihood fit of the 2D distributions of ΔE and M_{bc} across the five q^2 bins



- Calculate branching fractions from yields and efficiencies:

$$BF = \frac{N}{2\epsilon f_{00} \times N_{BB}}$$



REFERENCES

- [1] M. Prim. WG1 Plots. Belle II Collaboration.
- [2] T. Keck. FastBDT: A speed-optimized and cache-friendly implementation of stochastic gradient-boosted decision trees for multivariate classification. 1609.06119.