

# Hadronic B decays in early Belle II data

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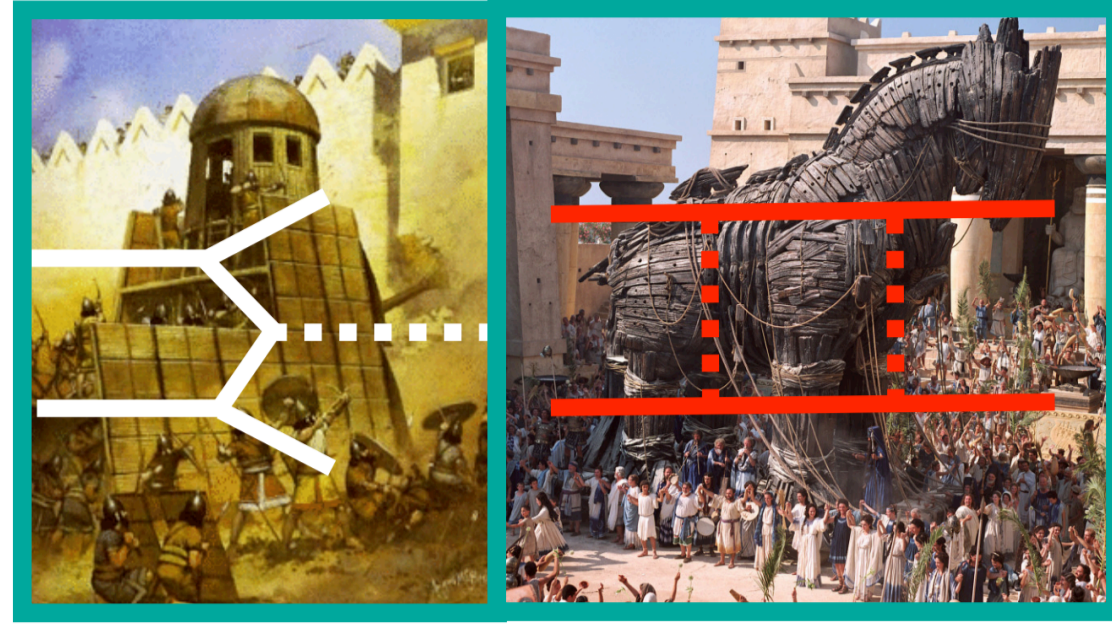
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Seeking possible extensions of the Standard Model at  $10^{-10}$ – $10^{-7}$  TeV is the chief goal of today's particle physics.

Belle II hadronic B program has key role in indirect searches

- Reach  $\sim 2^\circ$  precision on  $\alpha/\varphi_2$ ,  $\gamma/\varphi_3$  to tighten CKM constraints
- Probe non-SM CPV in penguin-dominated  $b \rightarrow s$  and  $b \rightarrow d$  transitions as  $B^0 \rightarrow \eta' K^0$  and  $B^0 \rightarrow \phi K^0$ .

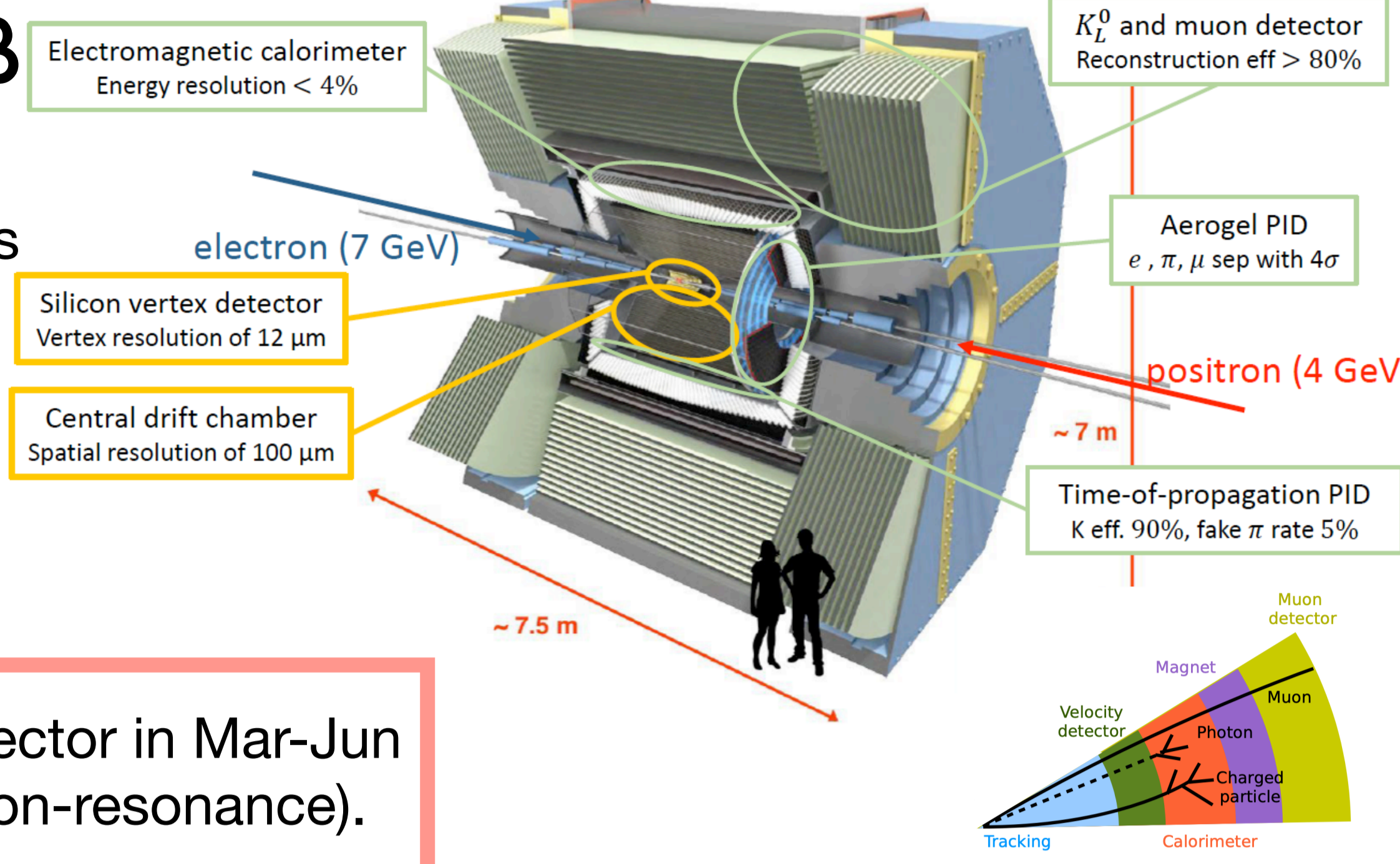
Use hadronic B decays in early data to validate Belle II performance



## Belle II at SuperKEKB

**Goal:** collect > 50 billion  $B\bar{B}$  pairs (50x full Belle data set)

- low background
- known collision energy
- coherent  $B^0\bar{B}^0$  evolution

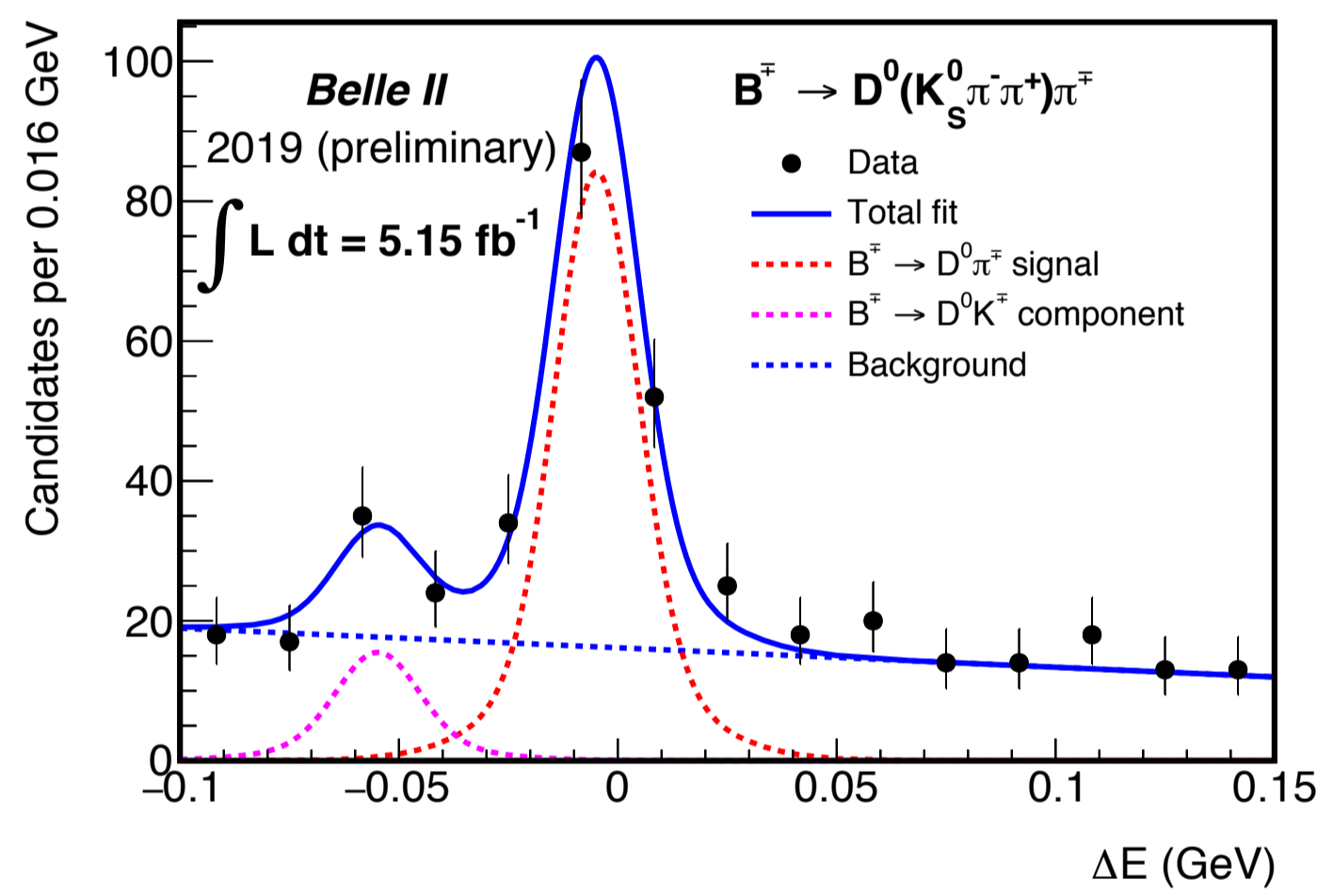
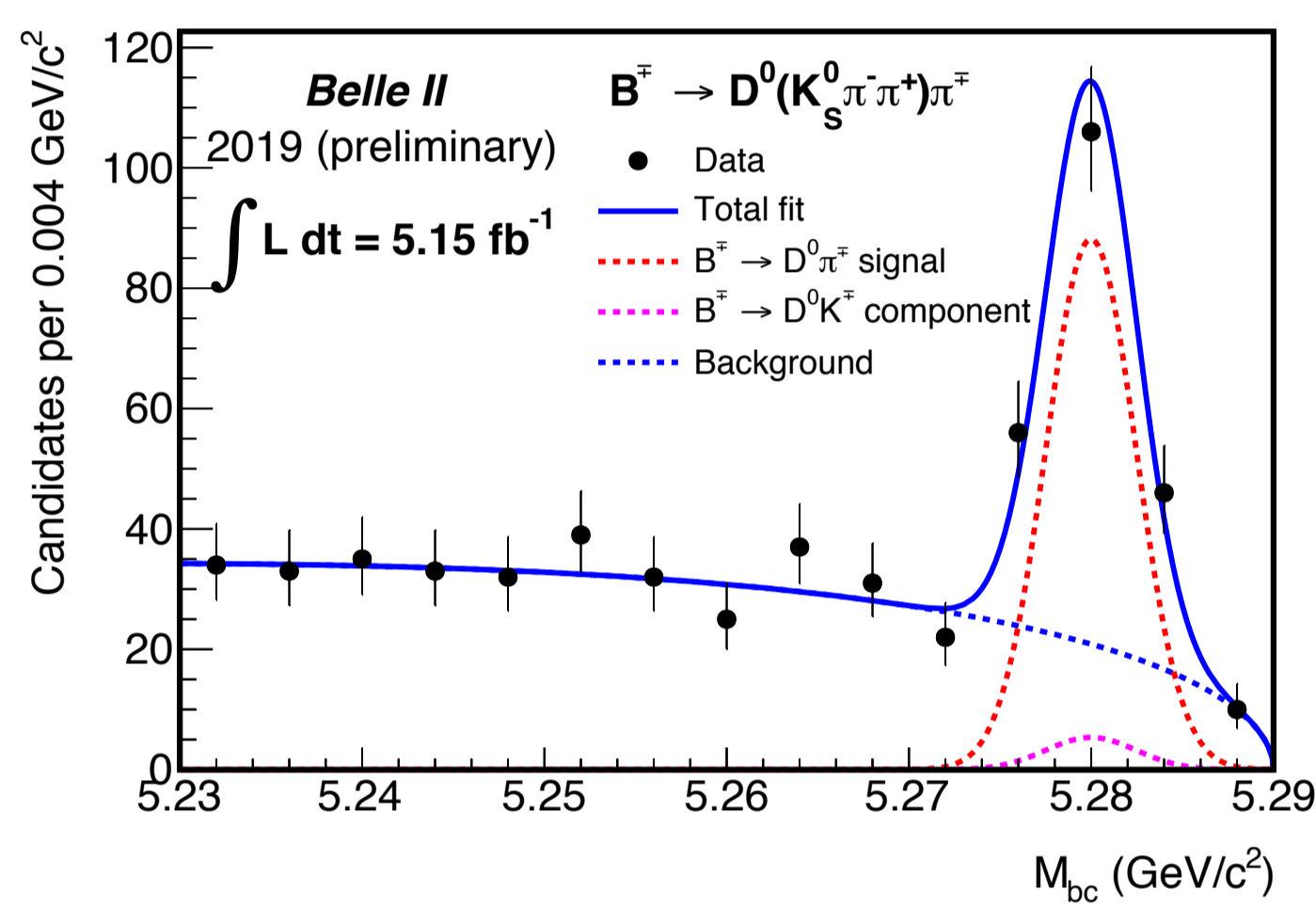


First data with complete detector in Mar-Jun 2019 =>  $\sim 6.5 \text{ fb}^{-1}$  ( $5.15 \text{ fb}^{-1}$  on-resonance).

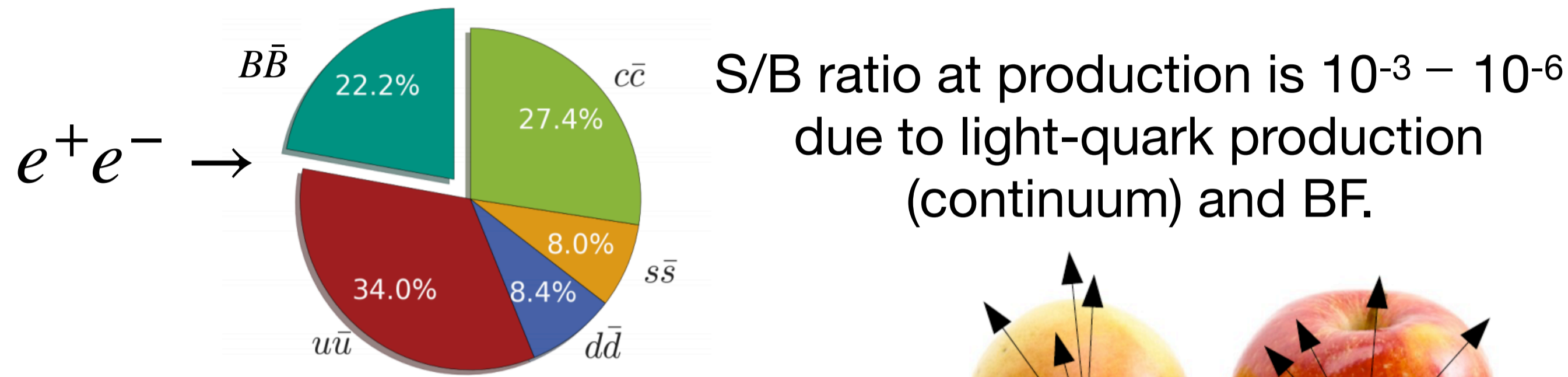
$$\mathcal{L}_{\text{peak}} = 1.2 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1} \text{ (2\% of final target)}$$

## $B^- \rightarrow D^0(K_S \pi^+ \pi^-) \pi^-$

Golden channel for  $\gamma/\varphi_3$ .

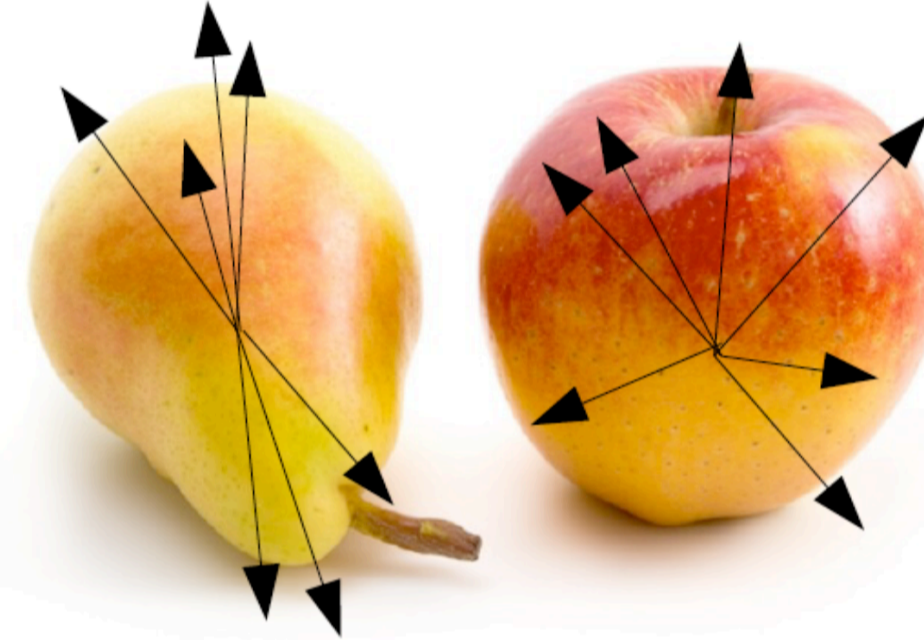


## Key challenge: continuum suppression

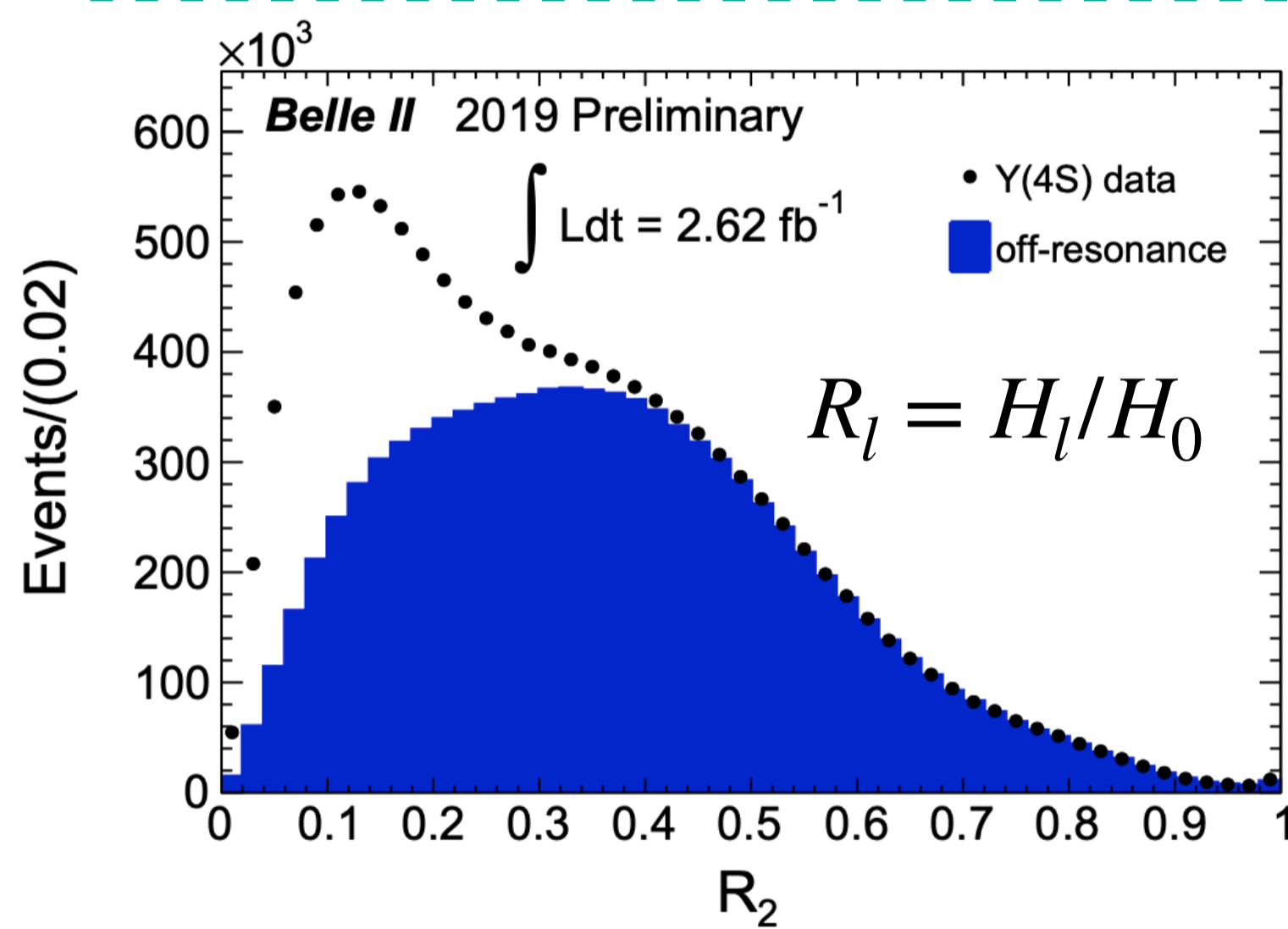


S/B ratio at production is  $10^{-3}$  –  $10^{-6}$  due to light-quark production (continuum) and BF.

$$\text{Fox-Wolfram } H_l = \sum_{ij} \frac{|p_i||p_j|}{E_{\text{vis}}^2} P_l(\cos\theta_{ij})$$



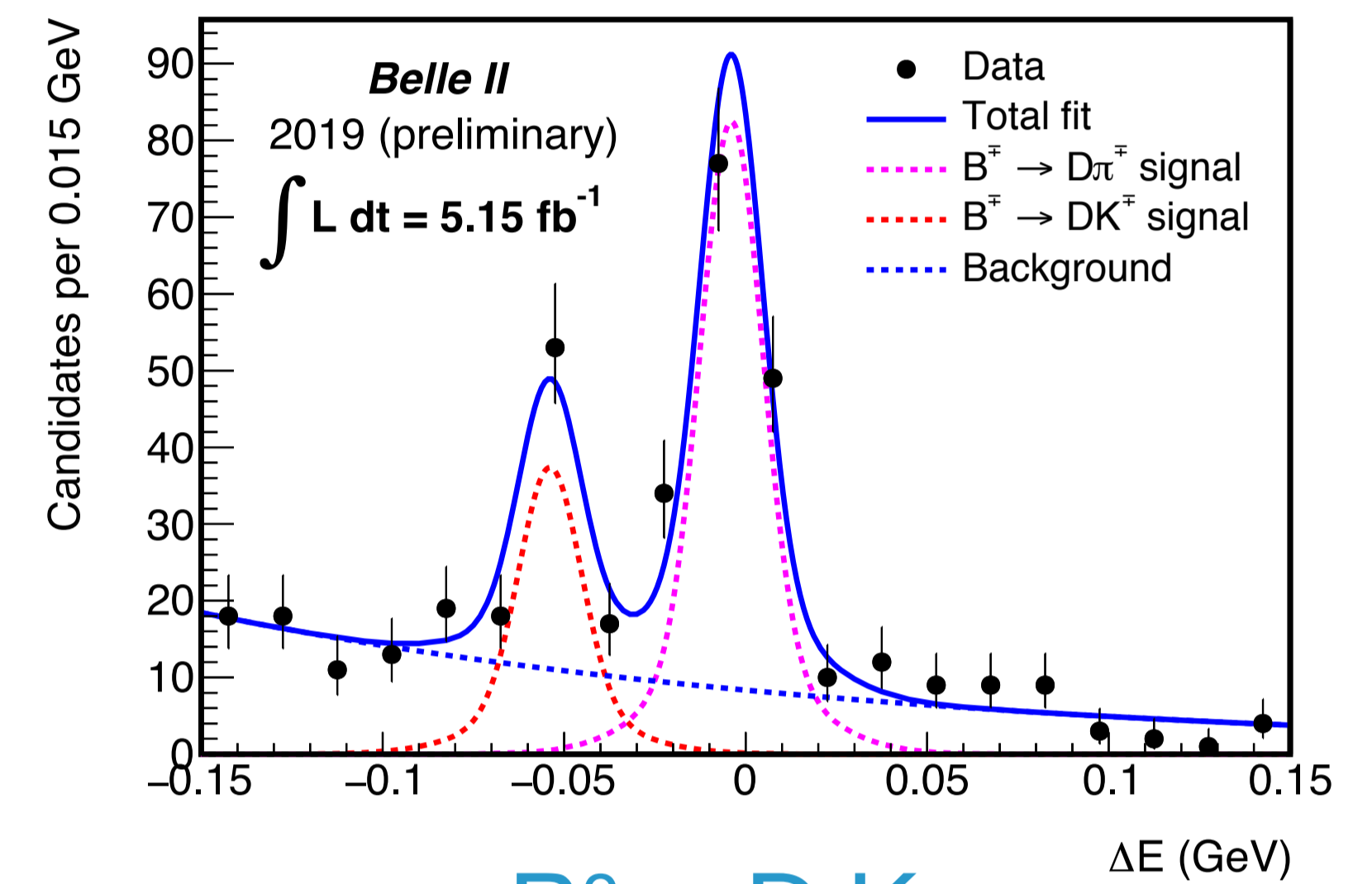
Exploit spatial event-shape to separate "collimated" continuum from "spherical"  $B\bar{B}$  production



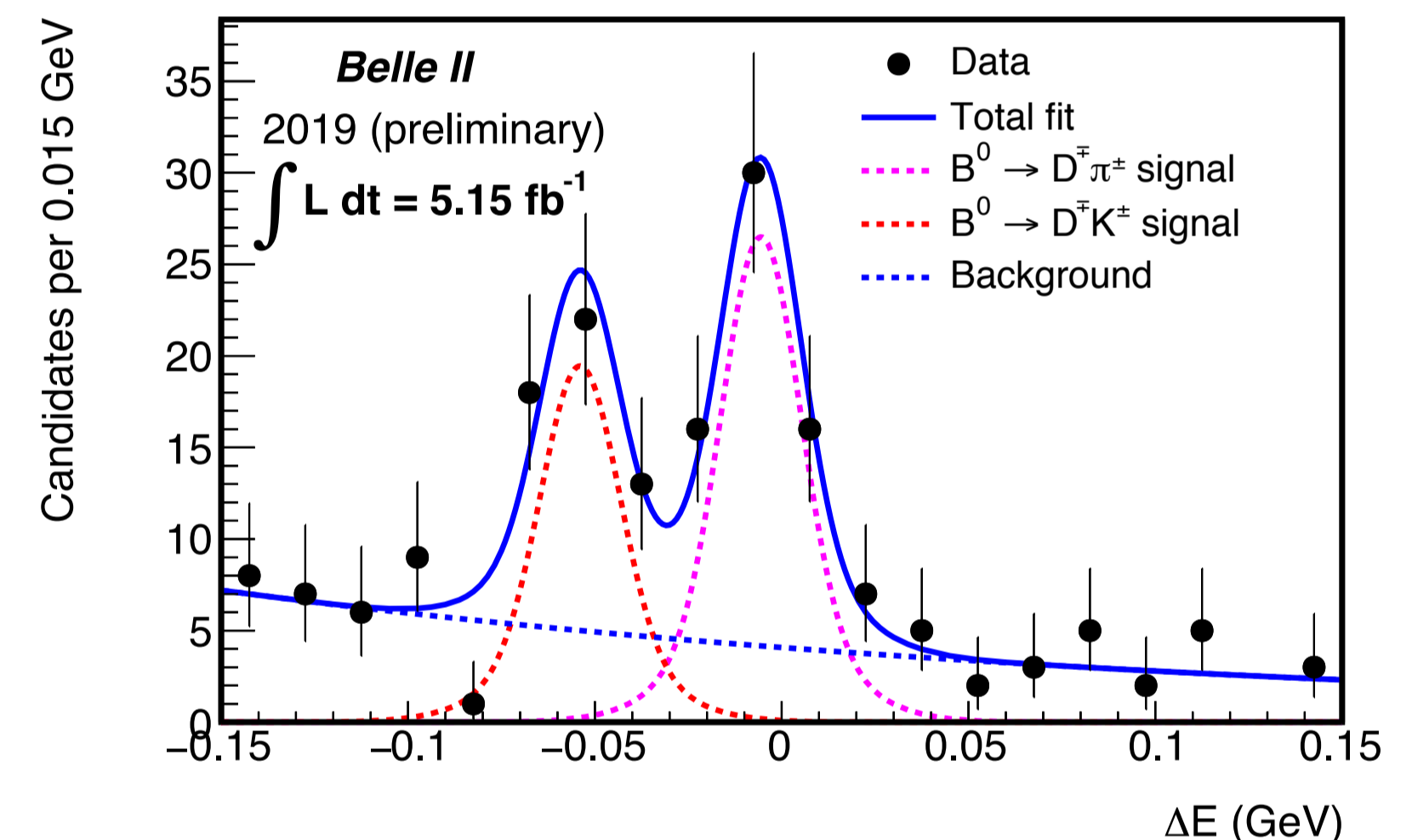
Squeeze out more information: combine nonlinearly 20+ kinematic, decay-time, PID, and topology variables to maximize S/B

## $B^- \rightarrow DK$

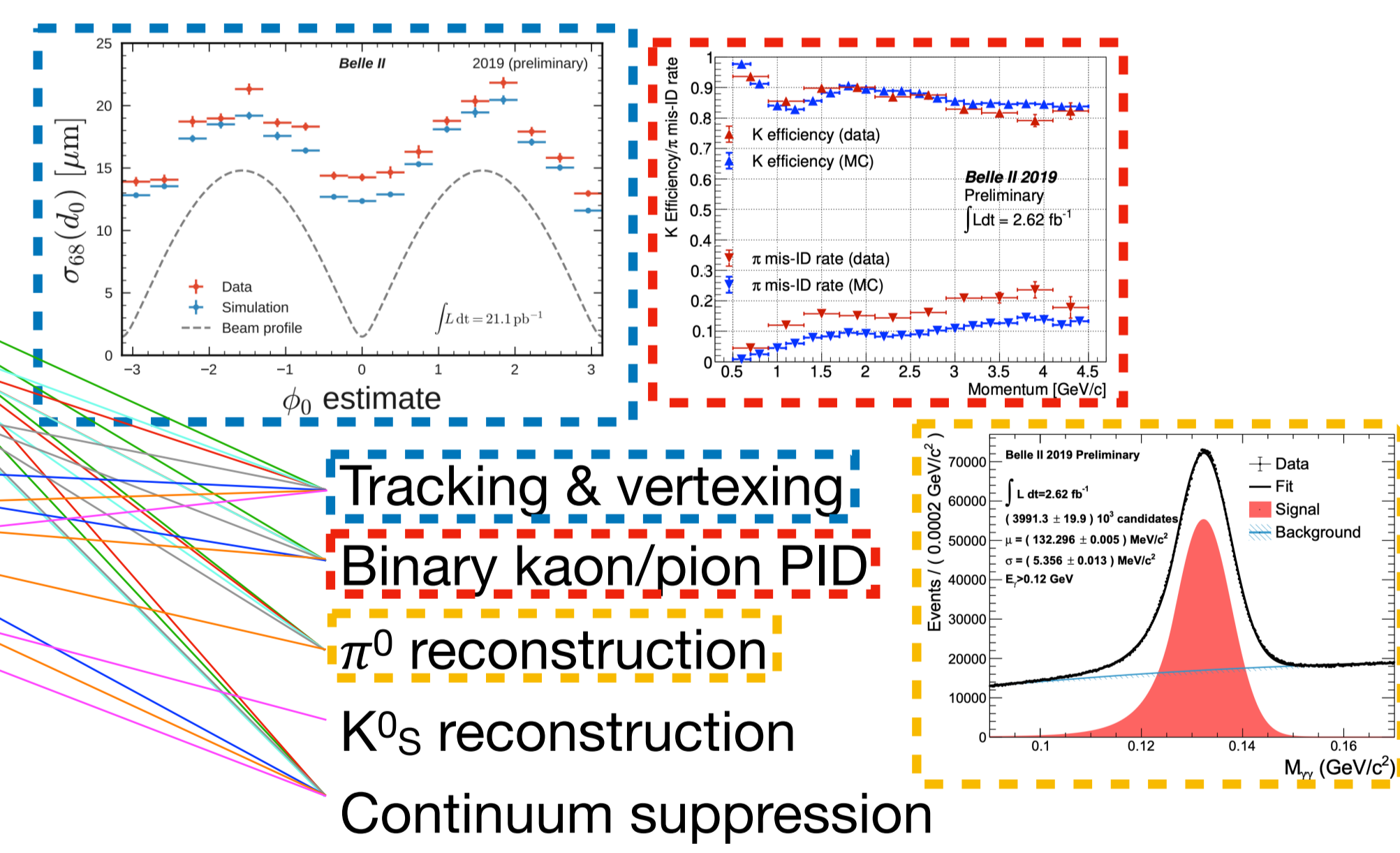
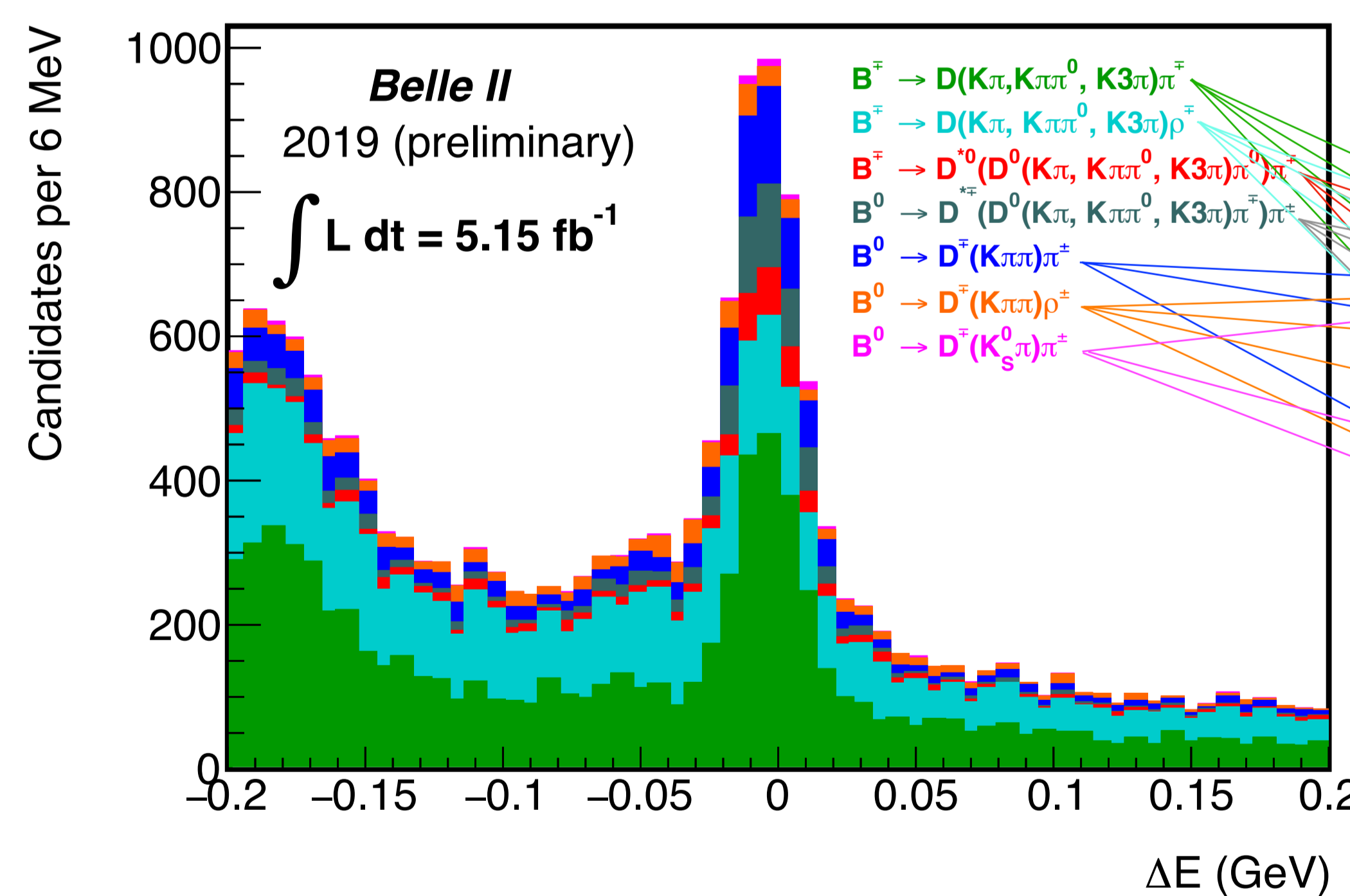
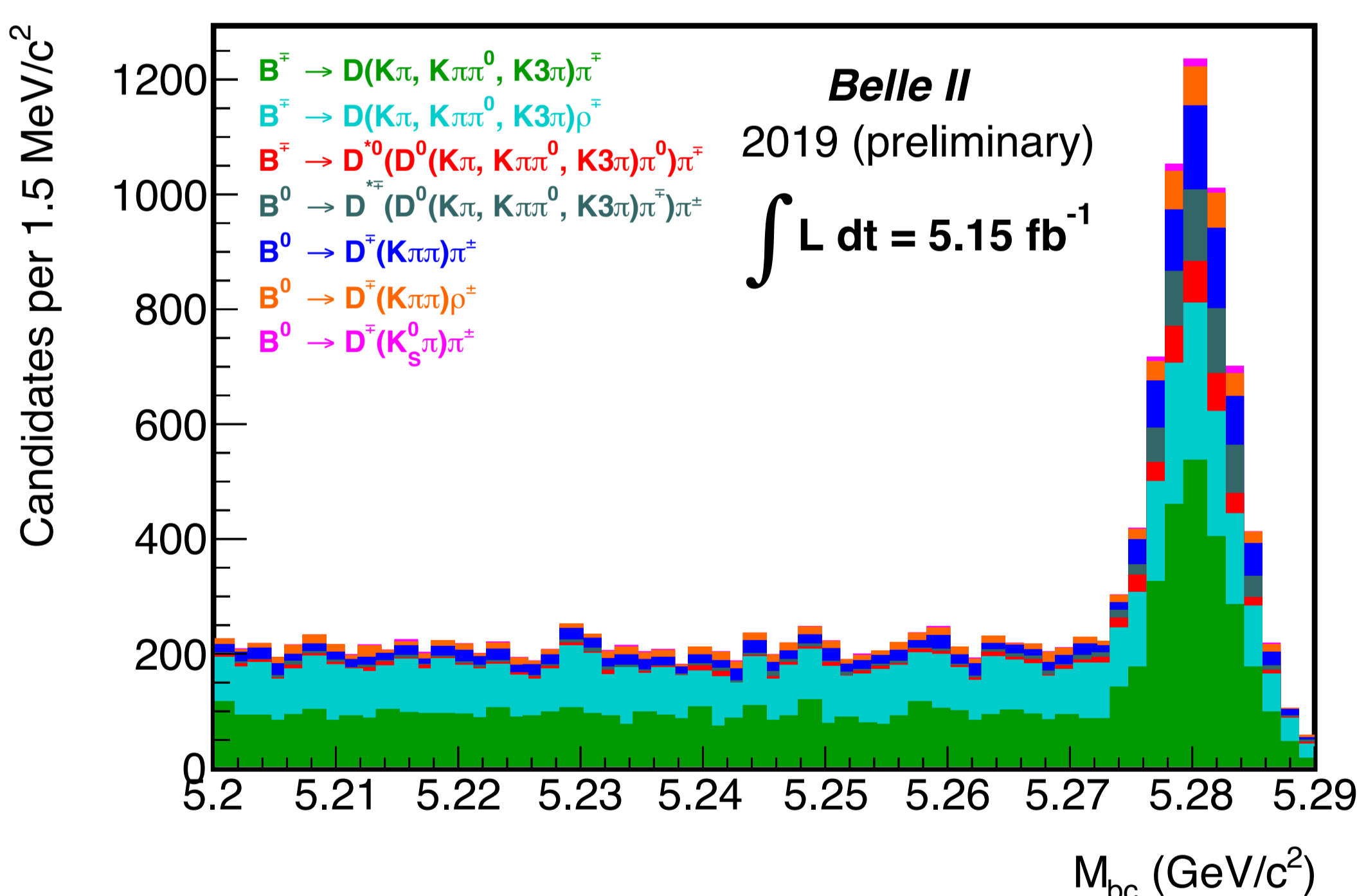
$B^- \rightarrow D^0 K^-$



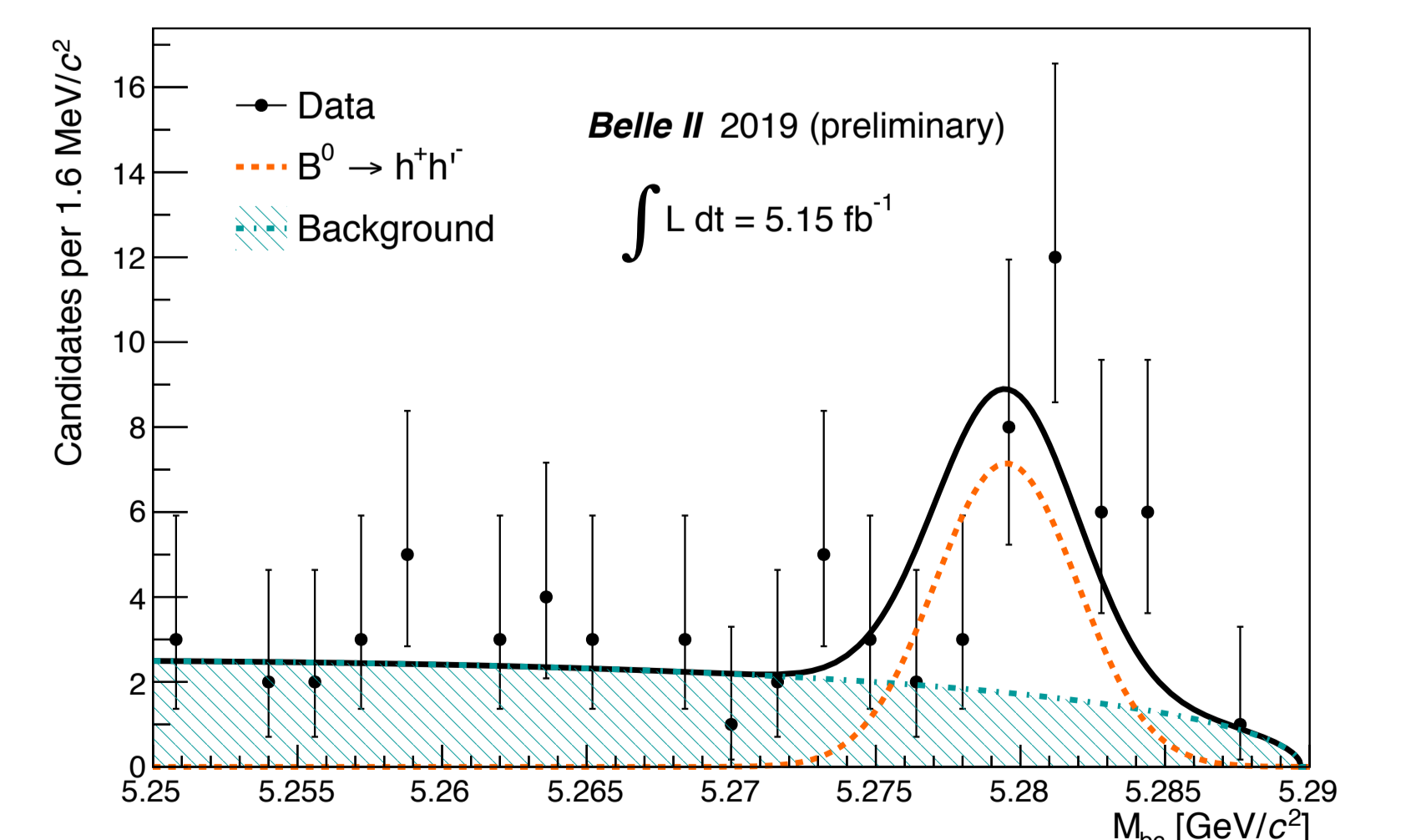
$B^0 \rightarrow D^- K^+$



## Results



## First charmless signal from Belle II - new for BEAUTY!

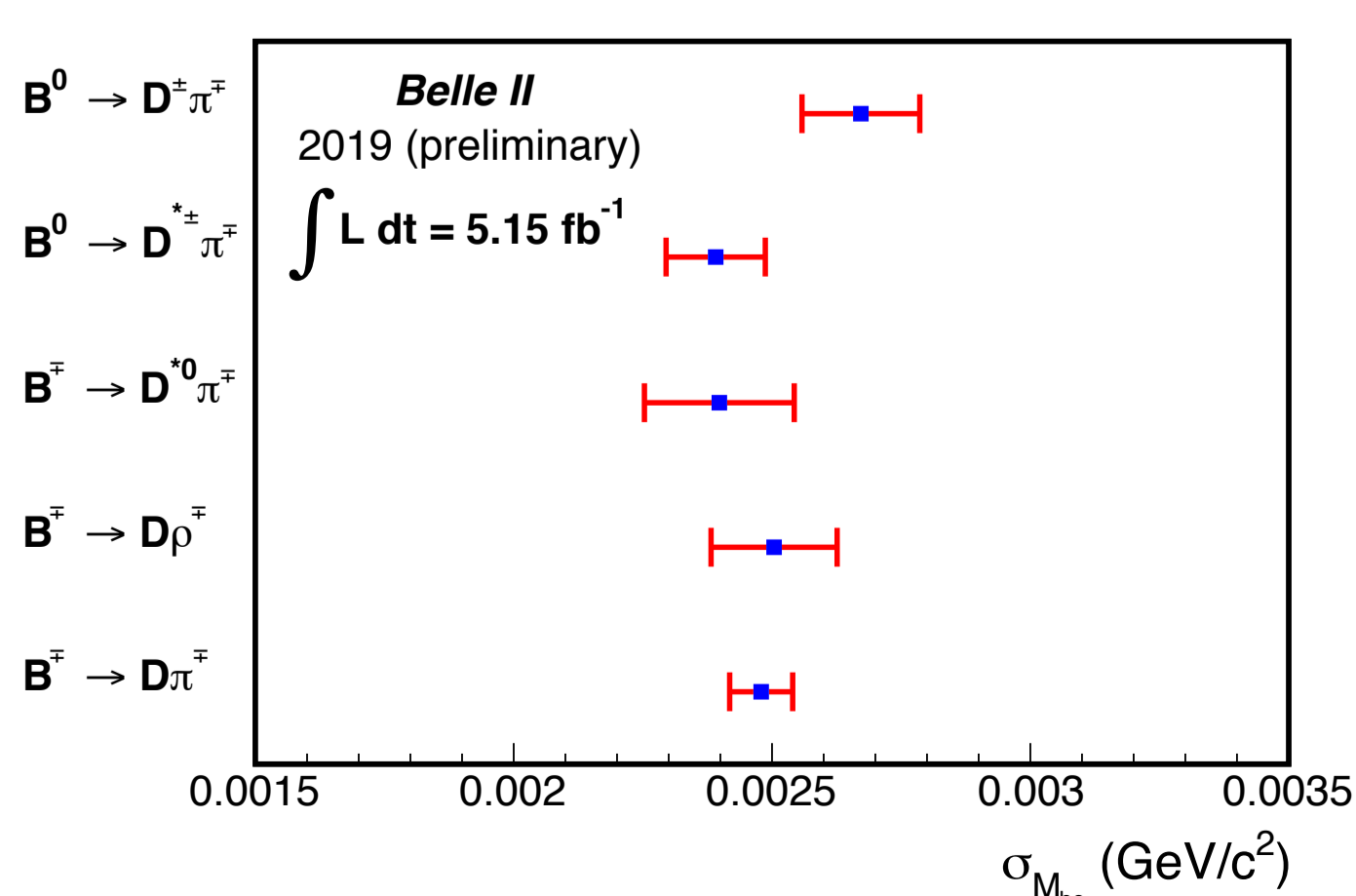


Signal is dominated by  $\sim 25 B^0 \rightarrow K^+ \pi^-$  events

## Beam energy spread

Determine beam-energy spread from

$$M_{bc} = \sqrt{E_{\text{beam}}^2 - p_B^2}$$



- Belle II: at the forefront of indirect exploration of non-SM physics
- Key role for hadronic B decays
- Mid-2019: first  $6.5 \text{ fb}^{-1}$  of data with complete detector offer detailed validation of performance
- 4500  $B \rightarrow D^{(*)} h$  reconstructed in  $5.15 \text{ fb}^{-1}$
- First observation of suppressed  $B \rightarrow DK$  decay in Belle II
- First observation of charmless B decays in Belle II
- Beam energy controlled to  $< 3 \text{ MeV}$
- Remarkable performances — Belle II is ready for physics