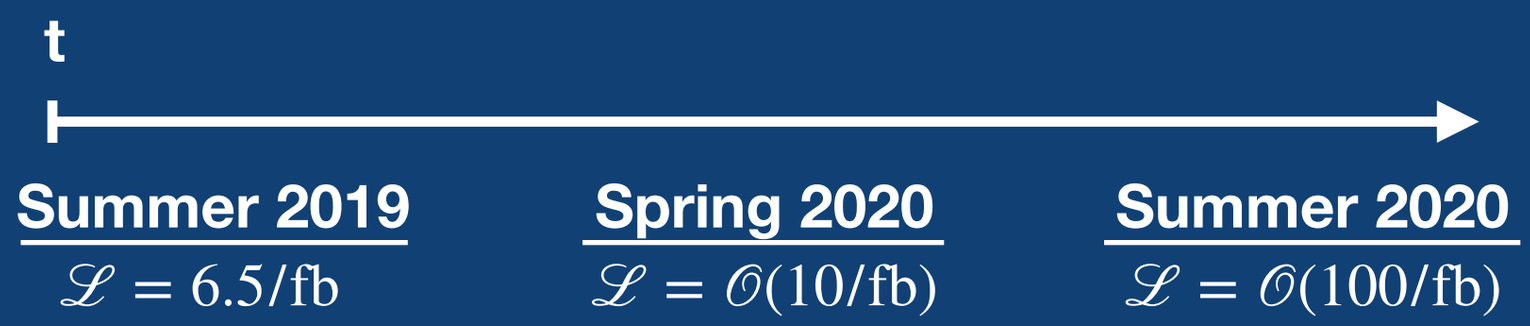


Belle II Summer 2019 results

+ short time prospects

florian.bernlochner@cern.ch

Florian Bernlochner | JENNIFER2 Kickoff Meeting — Vienna, September 2019

UNIVERSITÄT BONN

Belle II at the Summer conferences

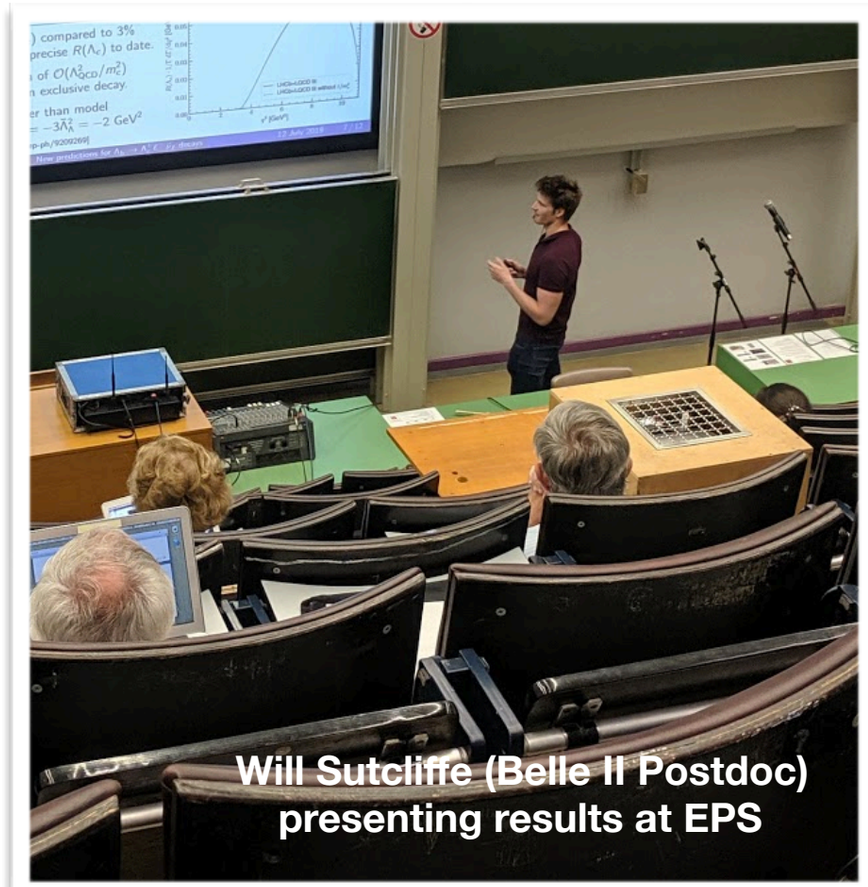
EUROPEAN PHYSICAL SOCIETY EPS HEP2019

11 Contributions

LP2◆19

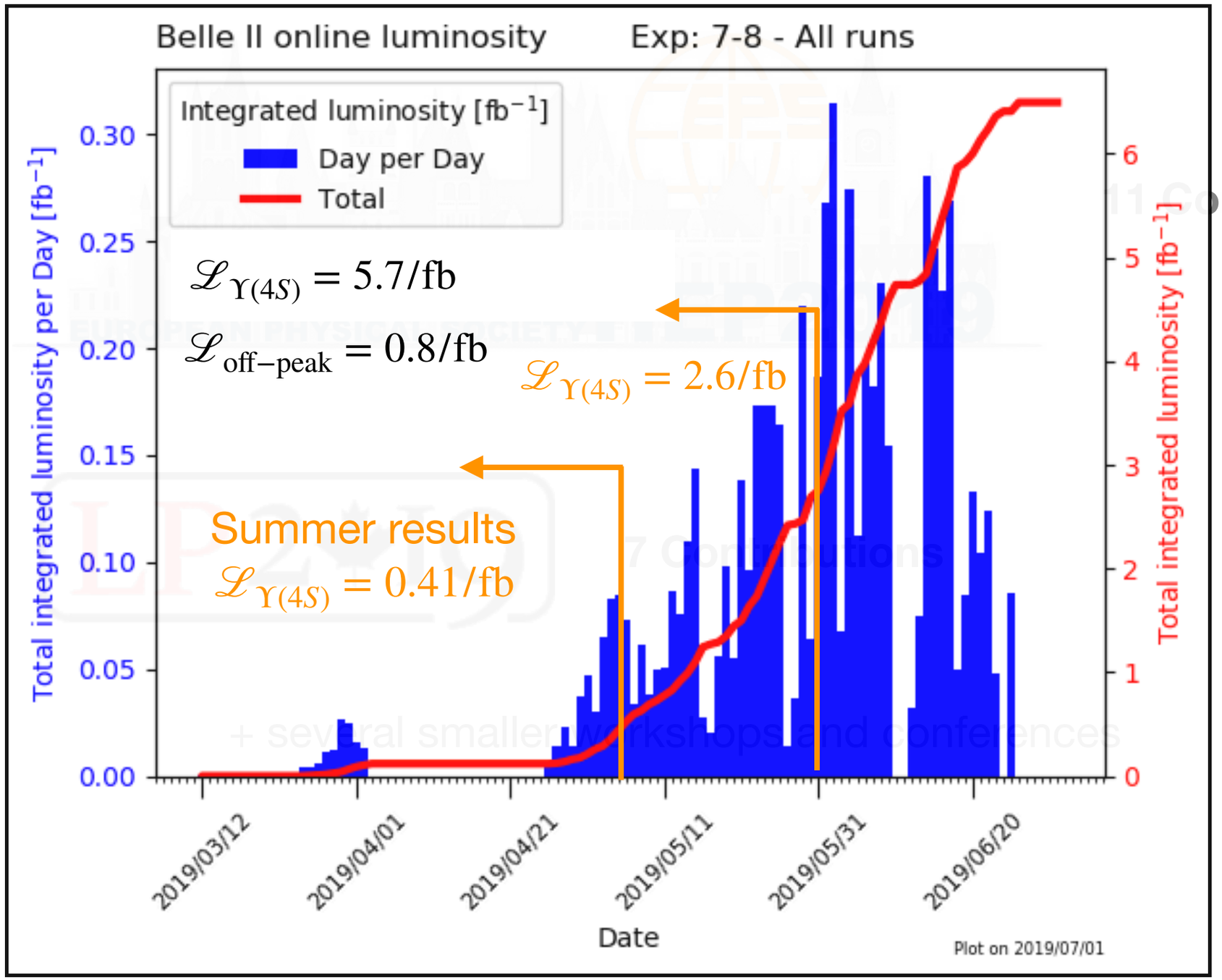
7 Contributions

+ several smaller workshops and conferences



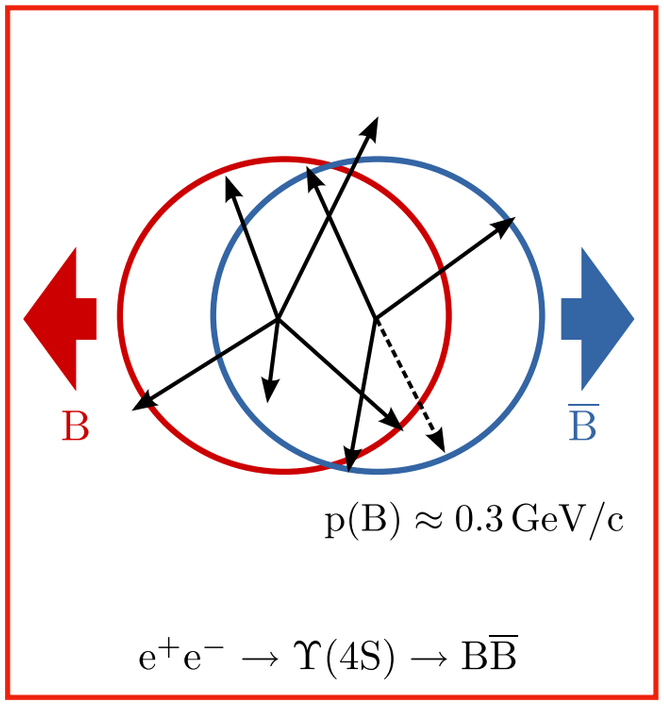
Will Sutcliffe (Belle II Postdoc) presenting results at EPS

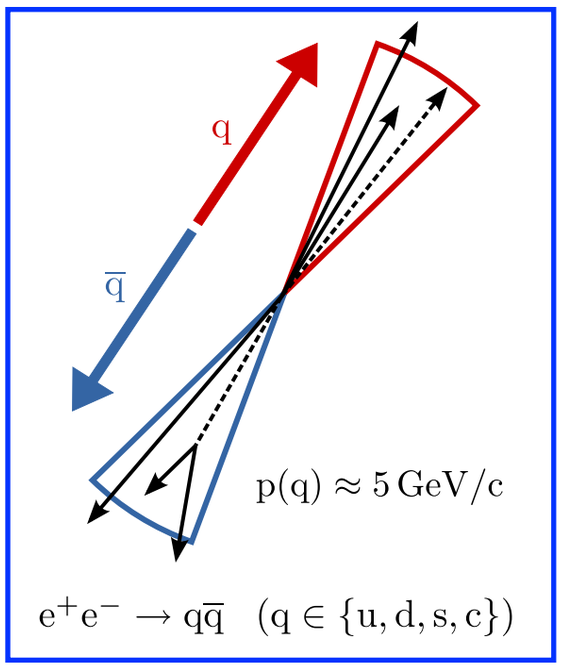
Belle II at the Summer conferences



11 Contributions
7 Contributions
+ several smaller workshops and conferences

B-Meson counting



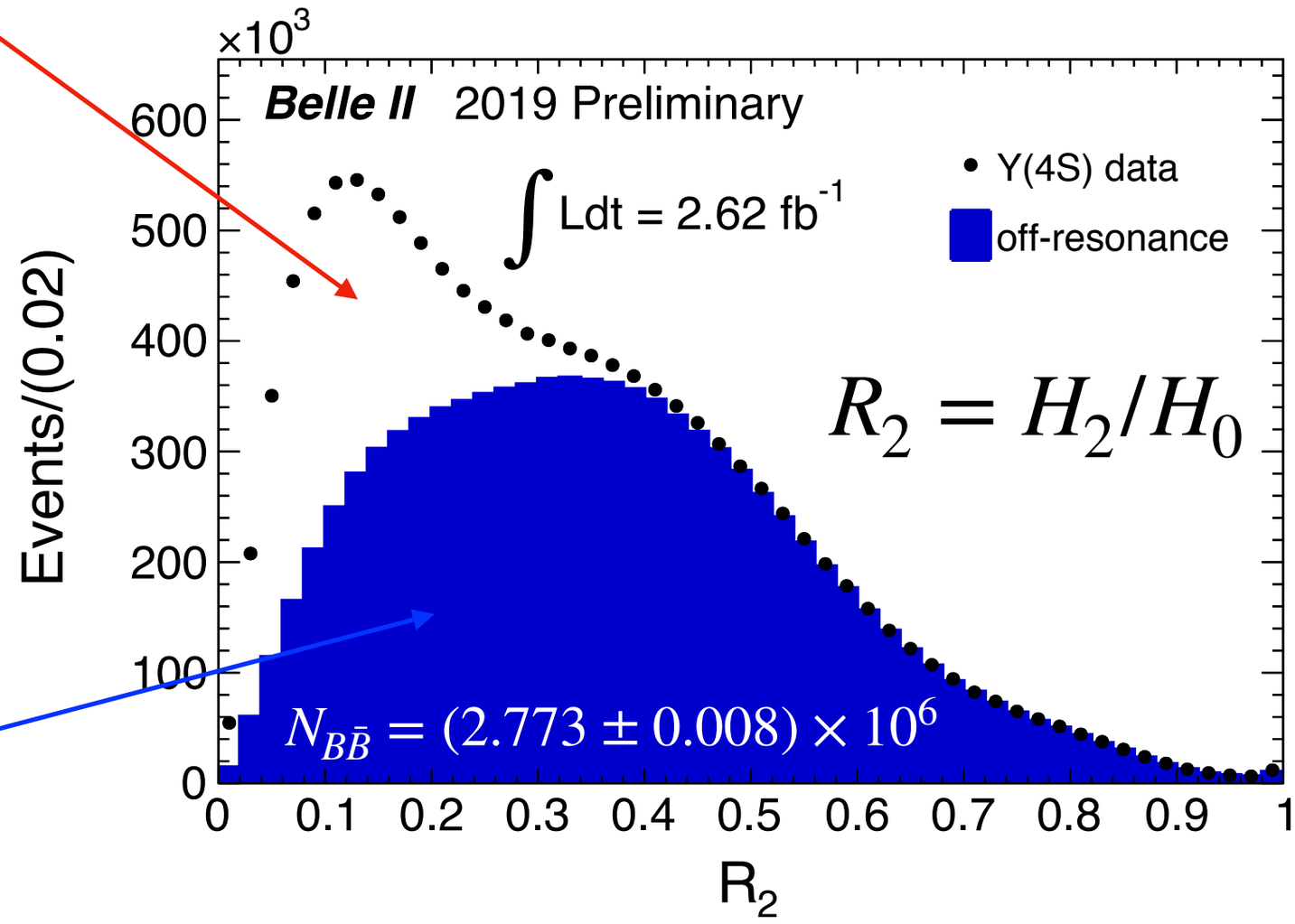


Fox-Wolfram Moment:

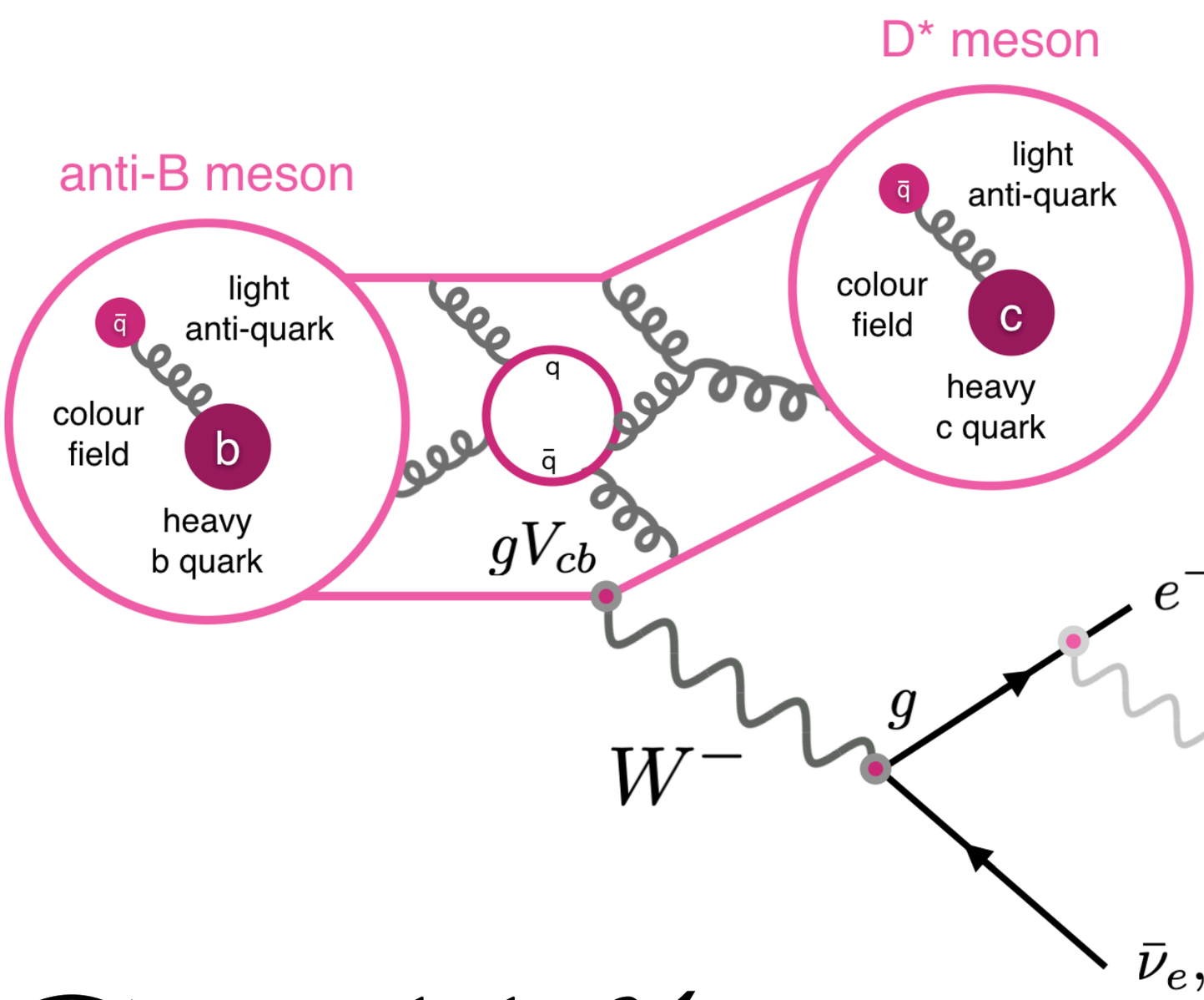
$$H_l = \sum_{i,j} \frac{|P_i||P_j|}{E_j^{vis}} P_l(cos\theta_{ij})$$

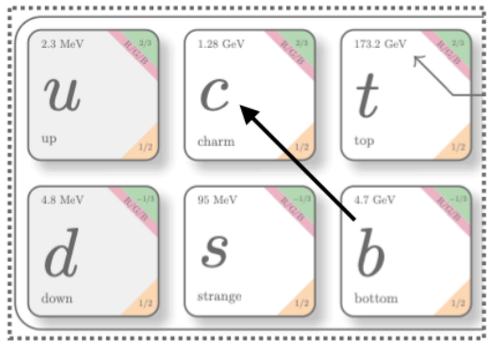
$|P_i|$: Momentum of charged tracks or Energy neutral clusters

θ_{ij} : Opening angle between *ith* and *jth* particle



Rediscovery of $B^0 \to D^{*-}\ell^+\nu_\ell$

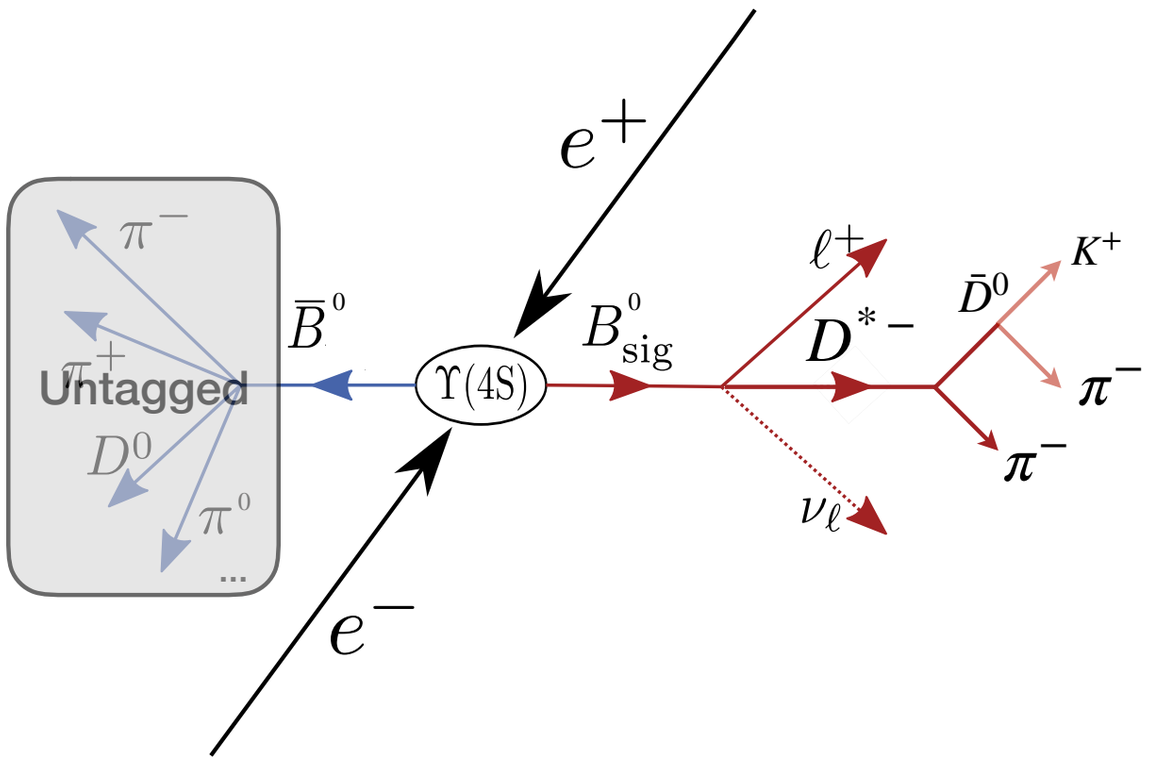




$\tau_B \approx 1.5\,\mathrm{ps}$

$\mathscr{B} \approx 11\,\%$

Rediscovery of $B^0 \to D^{*-}\ell^+\nu_\ell$



Particle	Selection
Tracks	IP in $z < 2$ cm
Tracks	IP in r-ϕ plane < 0.5 cm
ℓ	$1.2 < p^*_\ell < 2.4$ GeV/c
e	Electron likelihood > 0.85
μ	Muon likelihood > 0.9
slow π	$p^*_\pi < 0.5$ GeV/c
D^0	$1.85 < M_D < 1.88$ GeV/c^2
D^*	$0.144 < M_{D^*} - M_D < 0.148$ GeV/c^2
D^*	$p_{D^*} < 2.5$ GeV/c

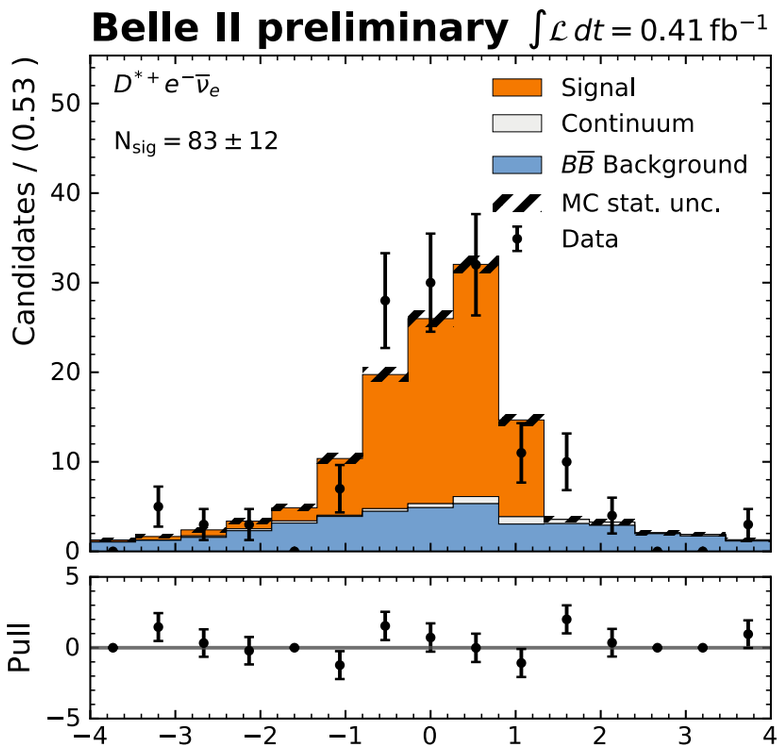
$$m^2_{\text{miss}} = \left((\frac{1}{2}E_{\text{beam}},0,0,0) - p^*_{D^*\ell} \right)^2 \approx p^2_\nu = 0\,\text{GeV}^2$$

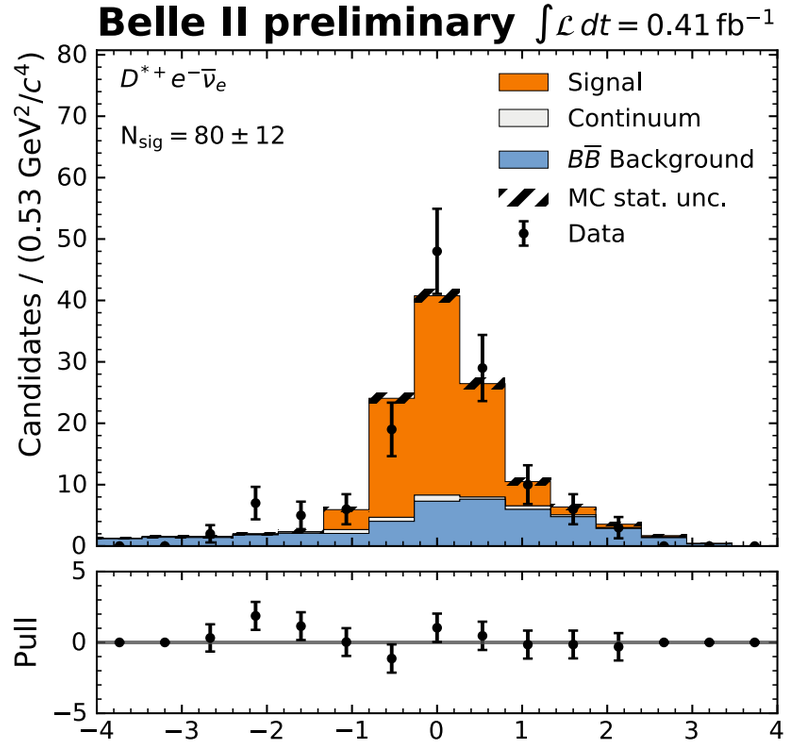
$$\cos\theta_{B,D^*\ell} = \frac{2E_B E_{D^*\ell} - m^2_B - m^2_{D^*\ell}}{2\,|\,\vec{p}^{\,*}_B\,|\,|\,\vec{p}_{\,D^*\ell}\,|} \in [-1,1)$$

$\cos\theta_{B,D^*\ell}$

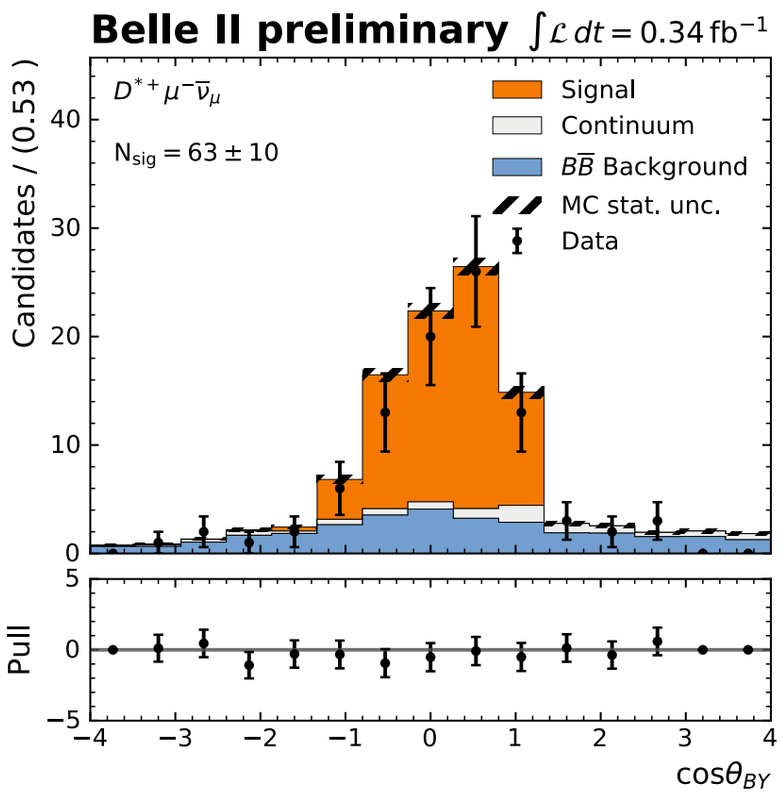
m^2_{miss}

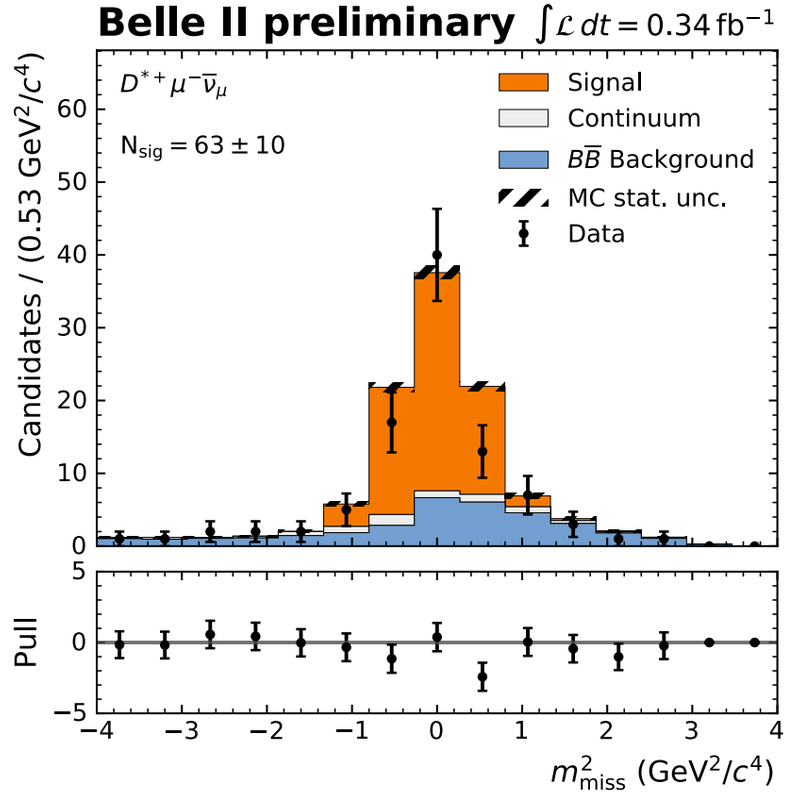
$\ell = e$



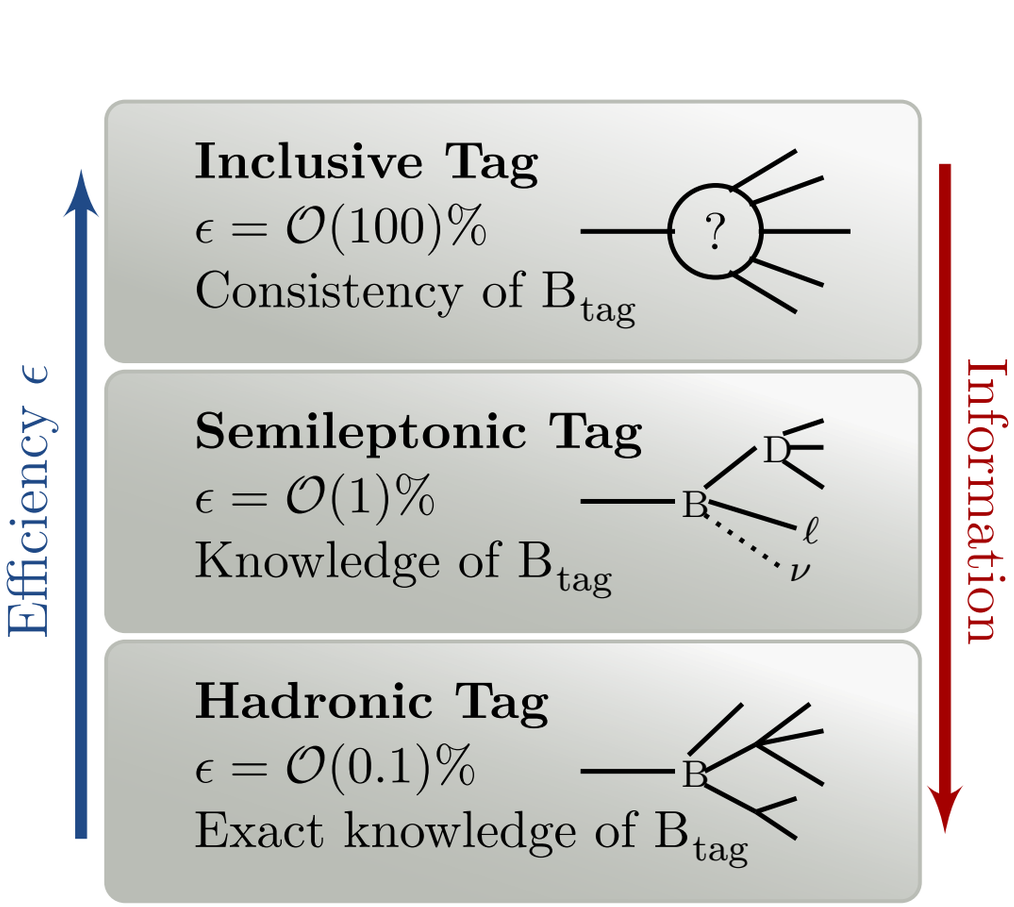


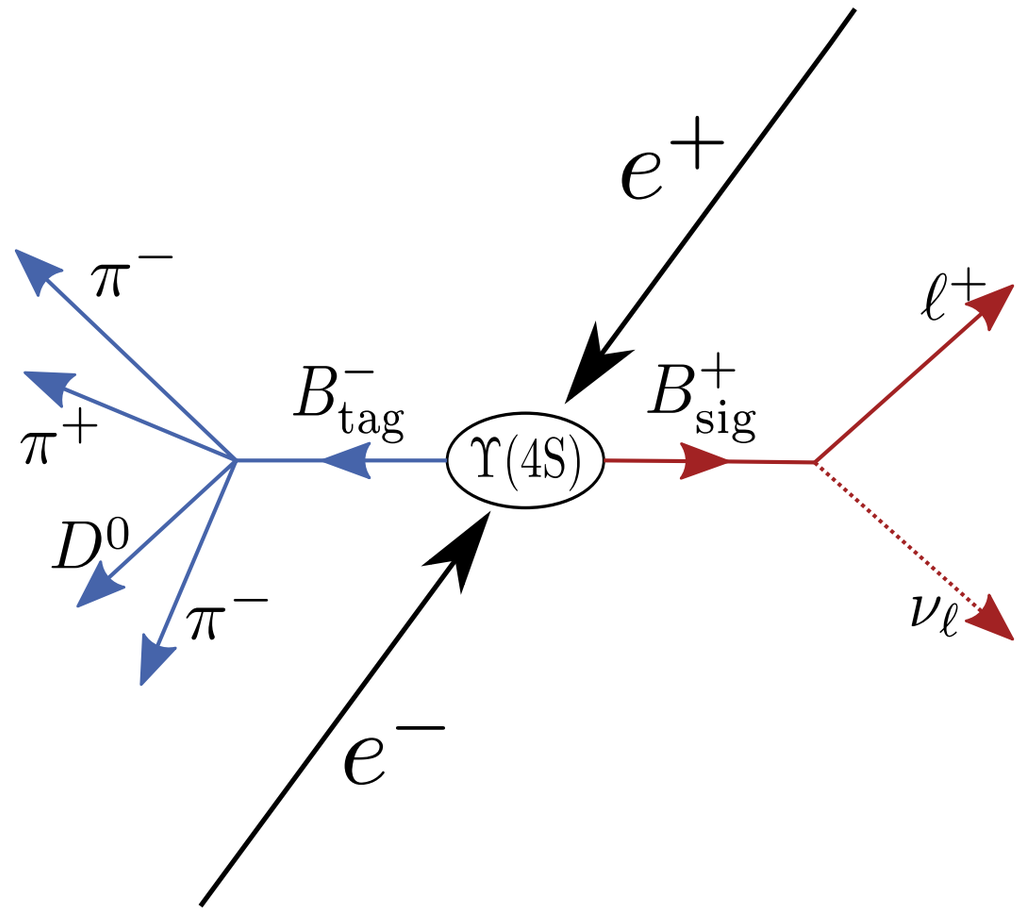
$\ell = \mu$





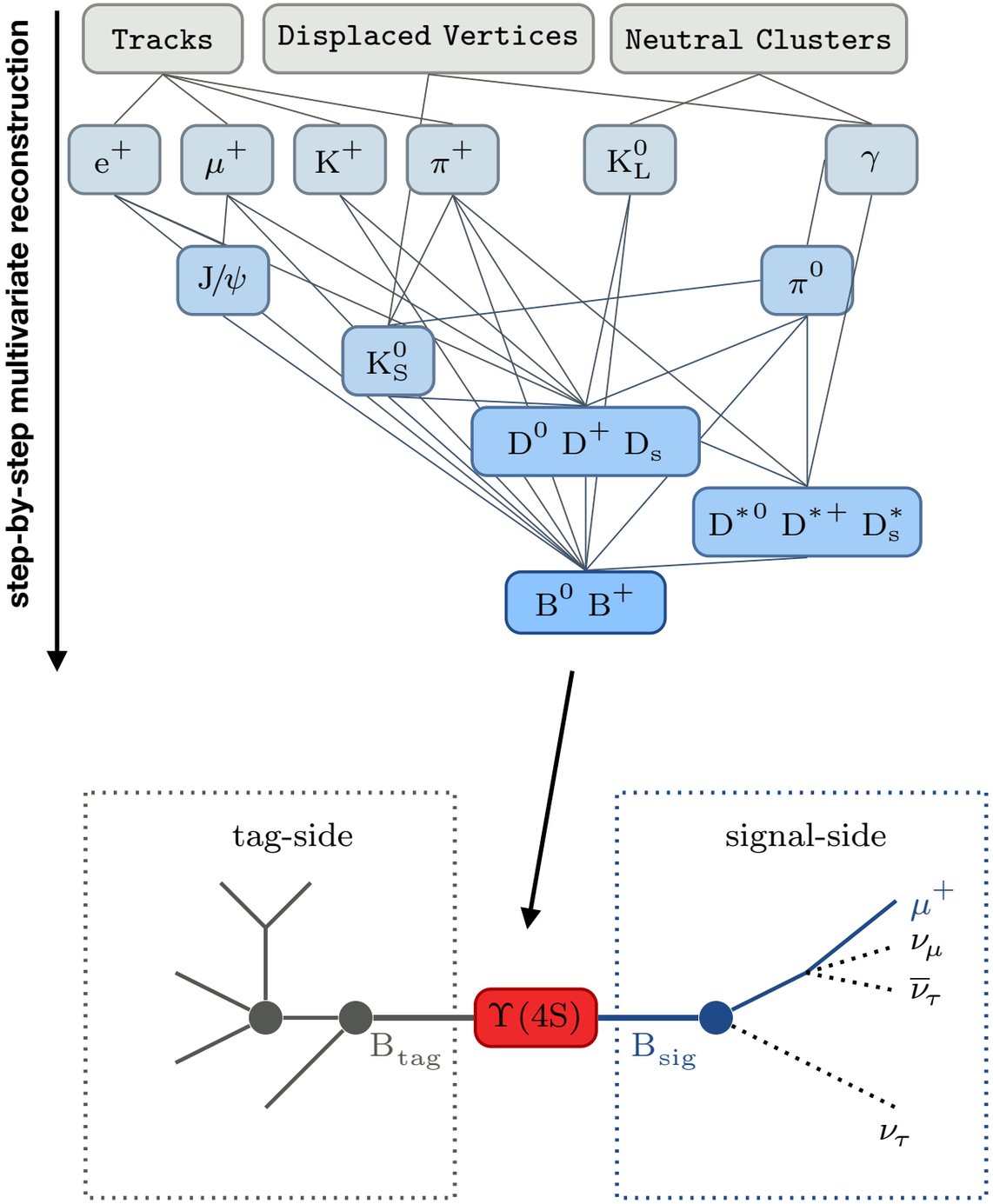
Hadronic Tagging with the Full Event Interpretation



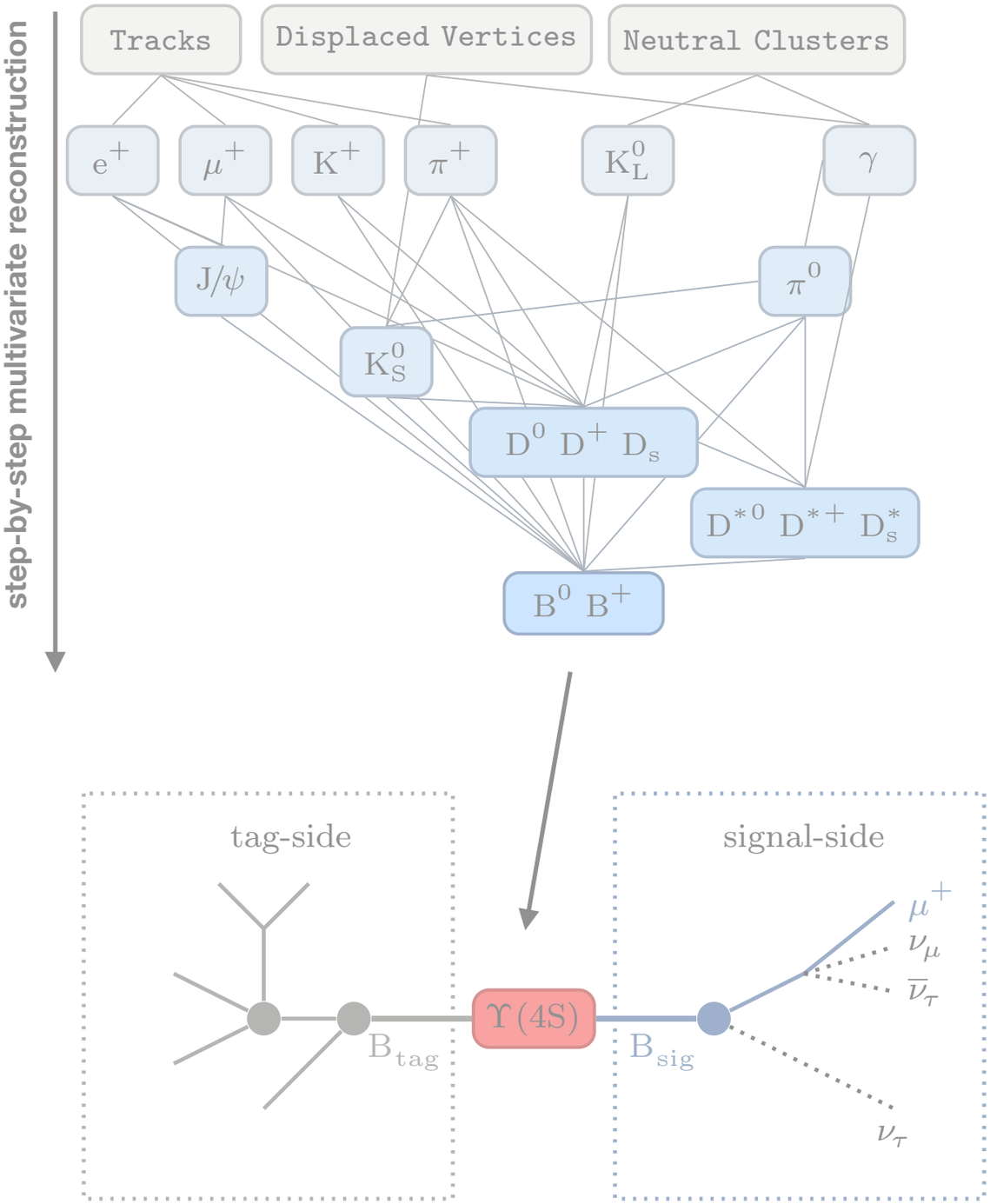


$$p_\nu = \left(p_{e^+e^-} - p_{B_{\text{tag}}} - p_\ell \right)$$

Hadronic Tagging with the Full Event Interpretation



Hadronic Tagging with the Full Event Interpretation

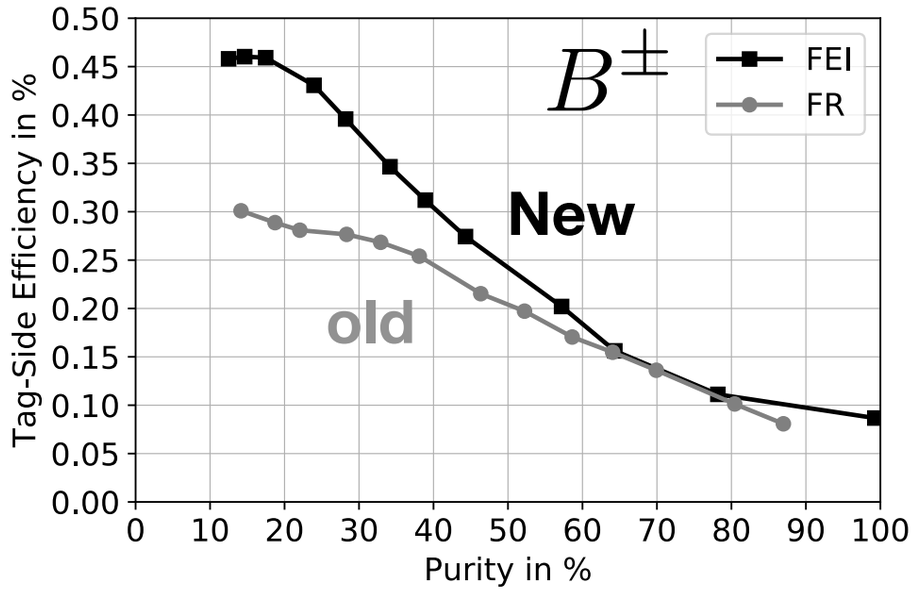


Novel multivariate algorithm for tagging:

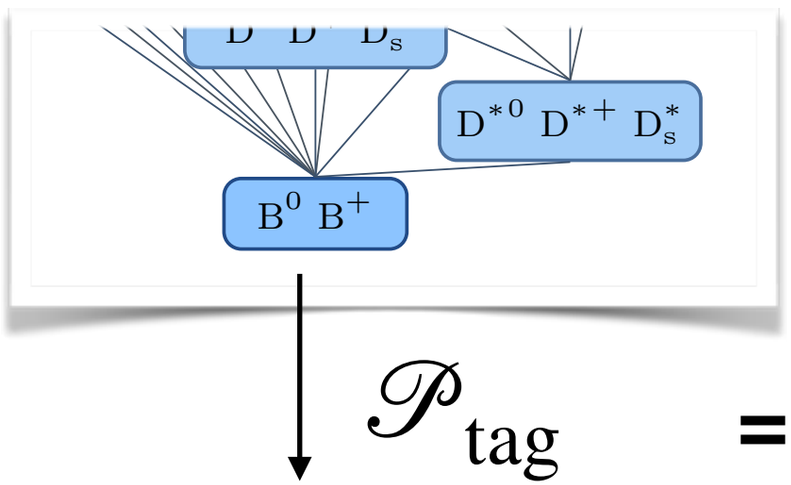
Thomas Keck et al, arXiv:1807.08680
Published in Computing and Software for Big Science

	FEI		old algorithms	
	$B^\pm$	B^0	$B^\pm$	B^0
Hadronic			Hadronic	
FEI with FR channels	0.53 %	0.33 %	FR	0.28 % 0.18 %
FEI	0.76 %	0.46 %	SER	0.4 % 0.2 %
Semileptonic			Semileptonic	
FEI	1.80 %	2.04 %	FR	0.31 % 0.34 %
			SER	0.3 % 0.6 %

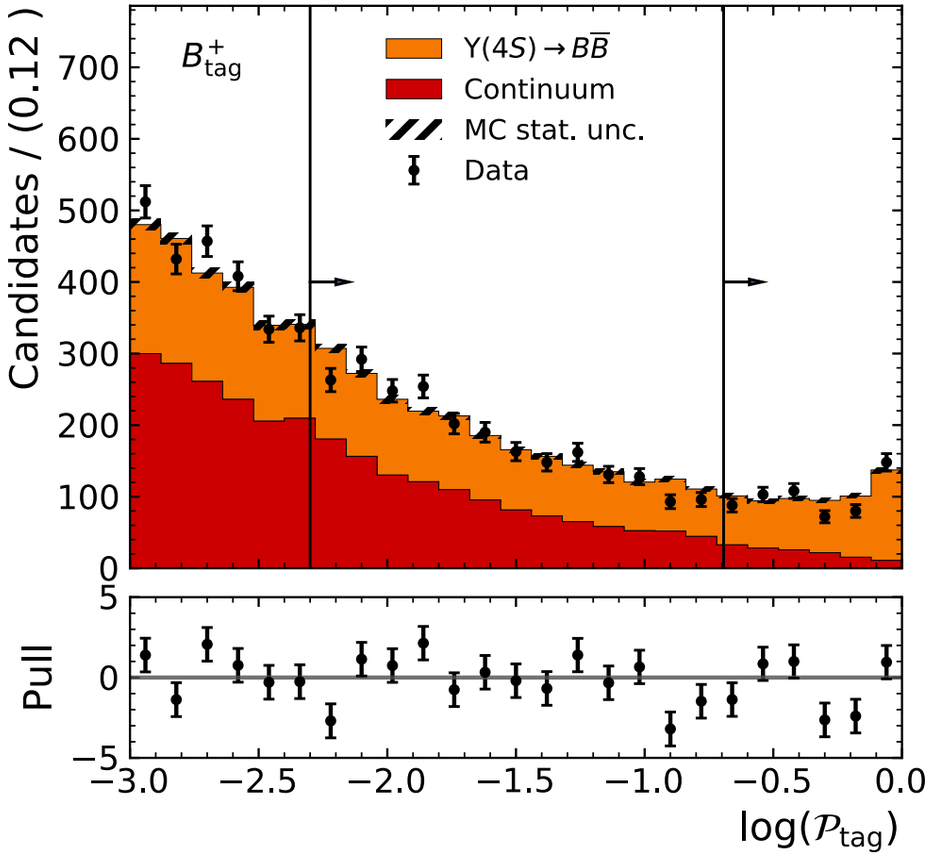
- Significant improvement of performance



Full Event Interpretation (FEI) at Belle II

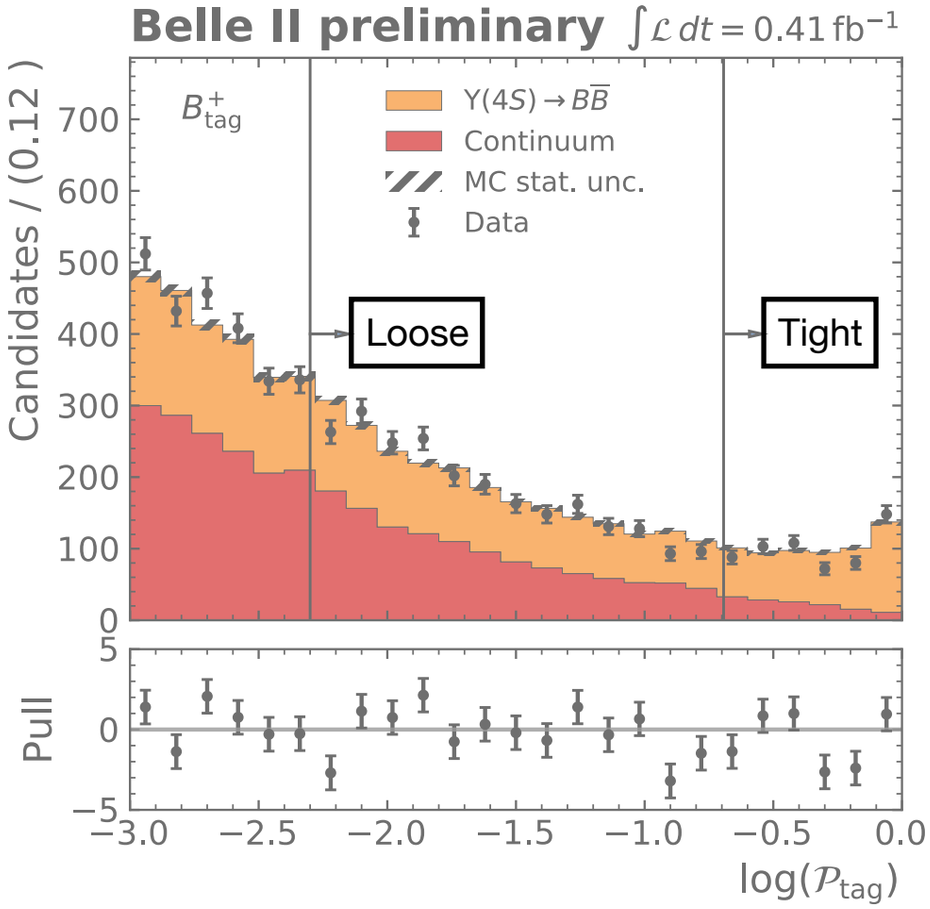


Output classifier = Measure of how well we reconstructed the B-Meson decay

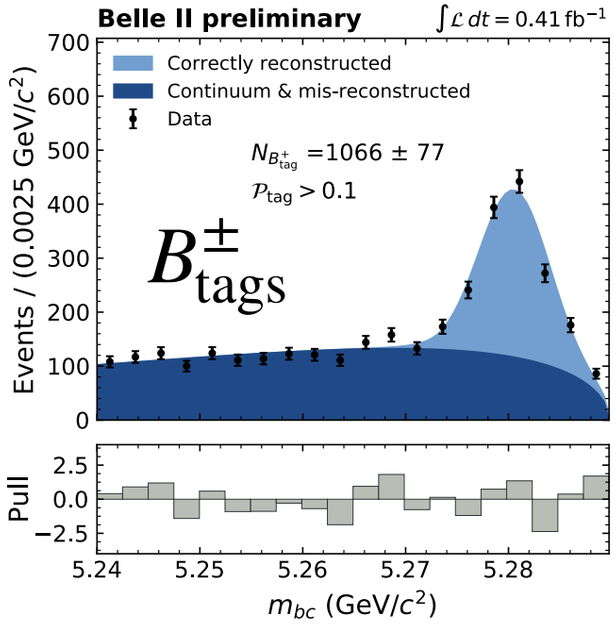


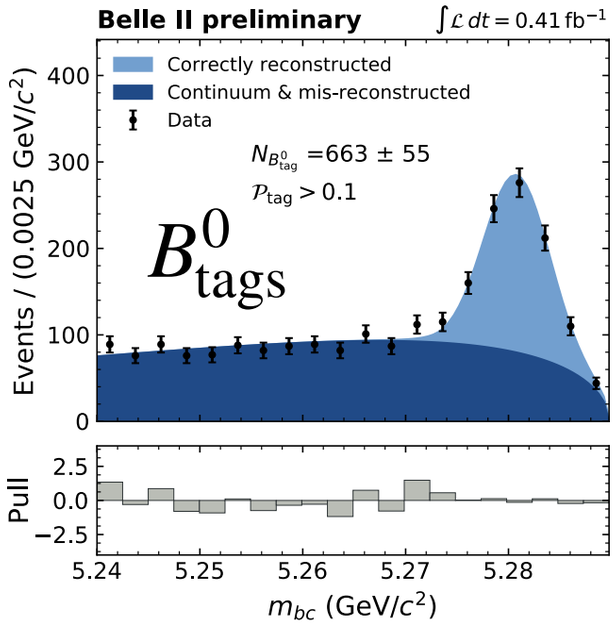
Full Event Interpretation (FEI) at Belle II

$$m_{bc} = \sqrt{E^2_{\text{beam}} - p^{*2}_{B_{\text{tag}}}} \simeq m^2_B$$

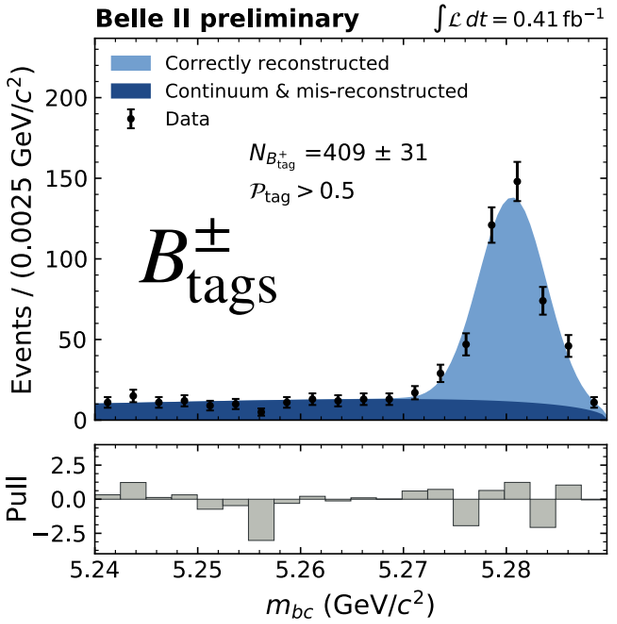


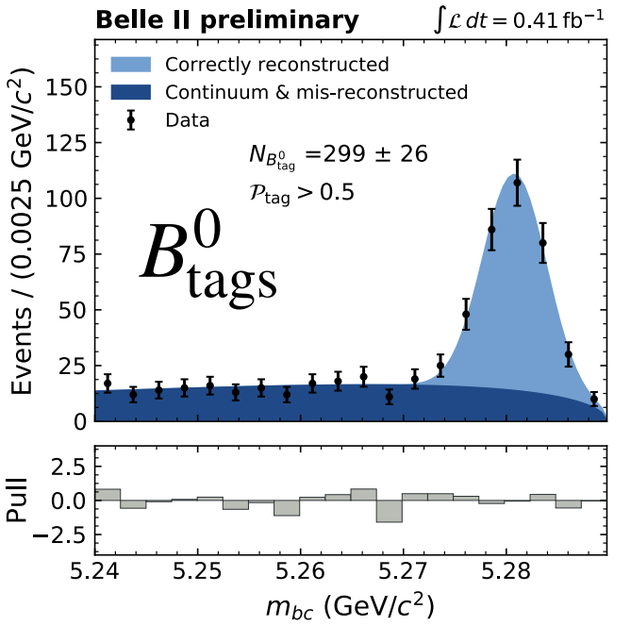
Loose Selection





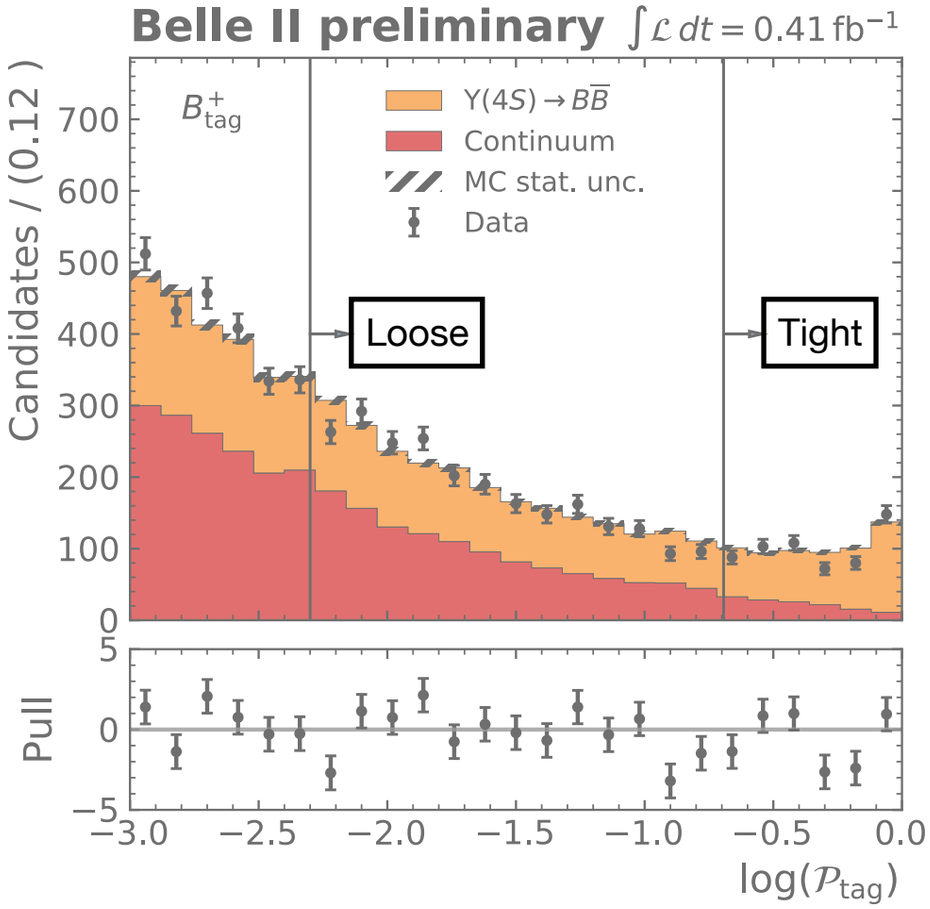
Tight Selection



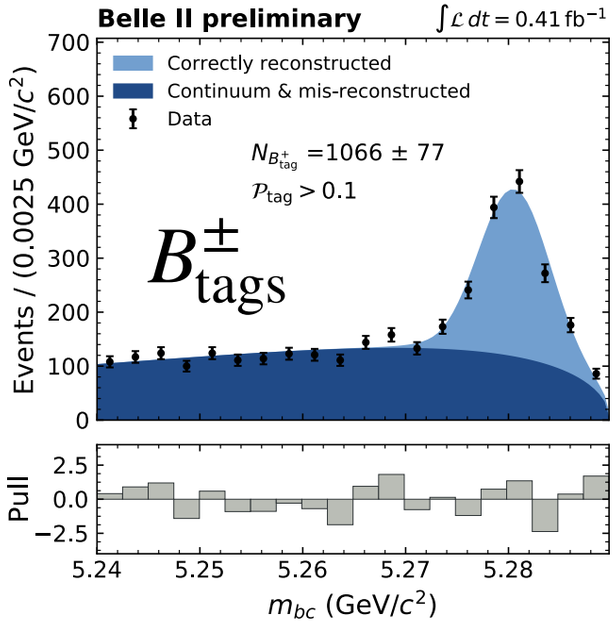


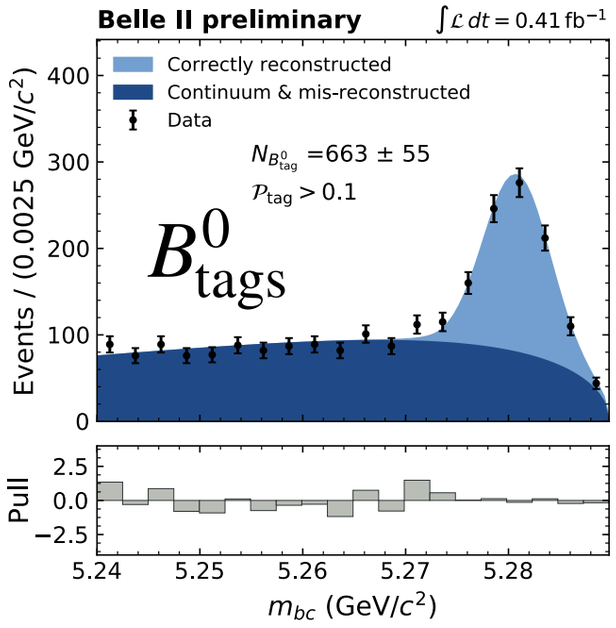
Full Event Interpretation (FEI) at Belle II

$$m_{bc} = \sqrt{E^2_{\text{beam}} - p^{*2}_{B_{\text{tag}}}} \simeq m^2_B$$

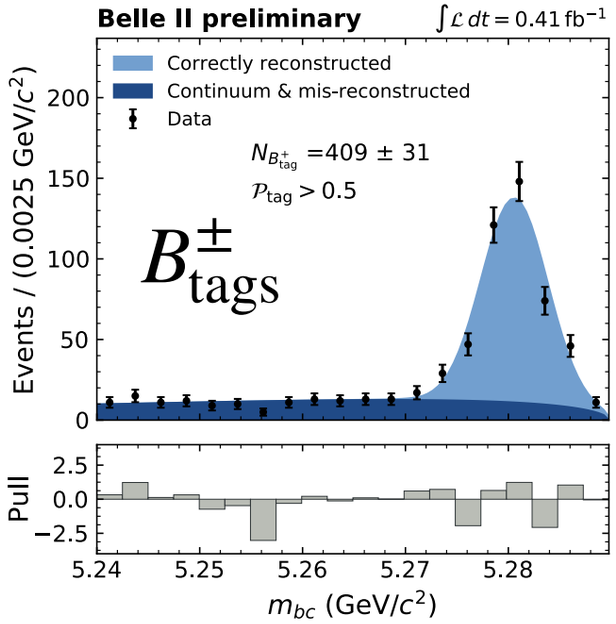


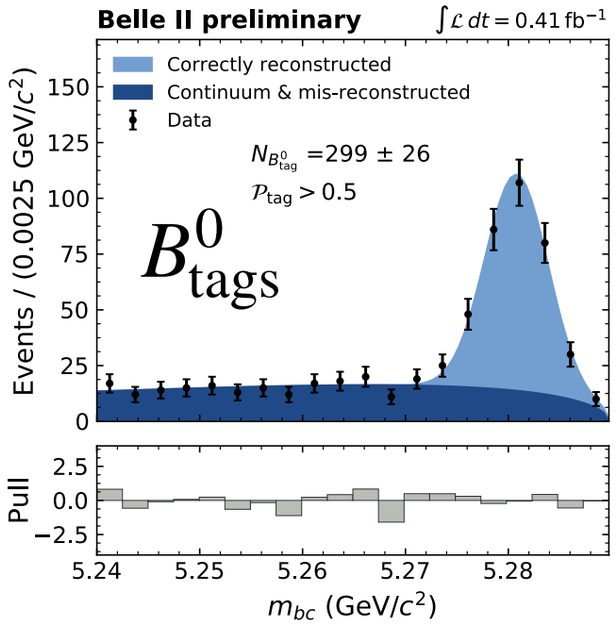
Loose Selection



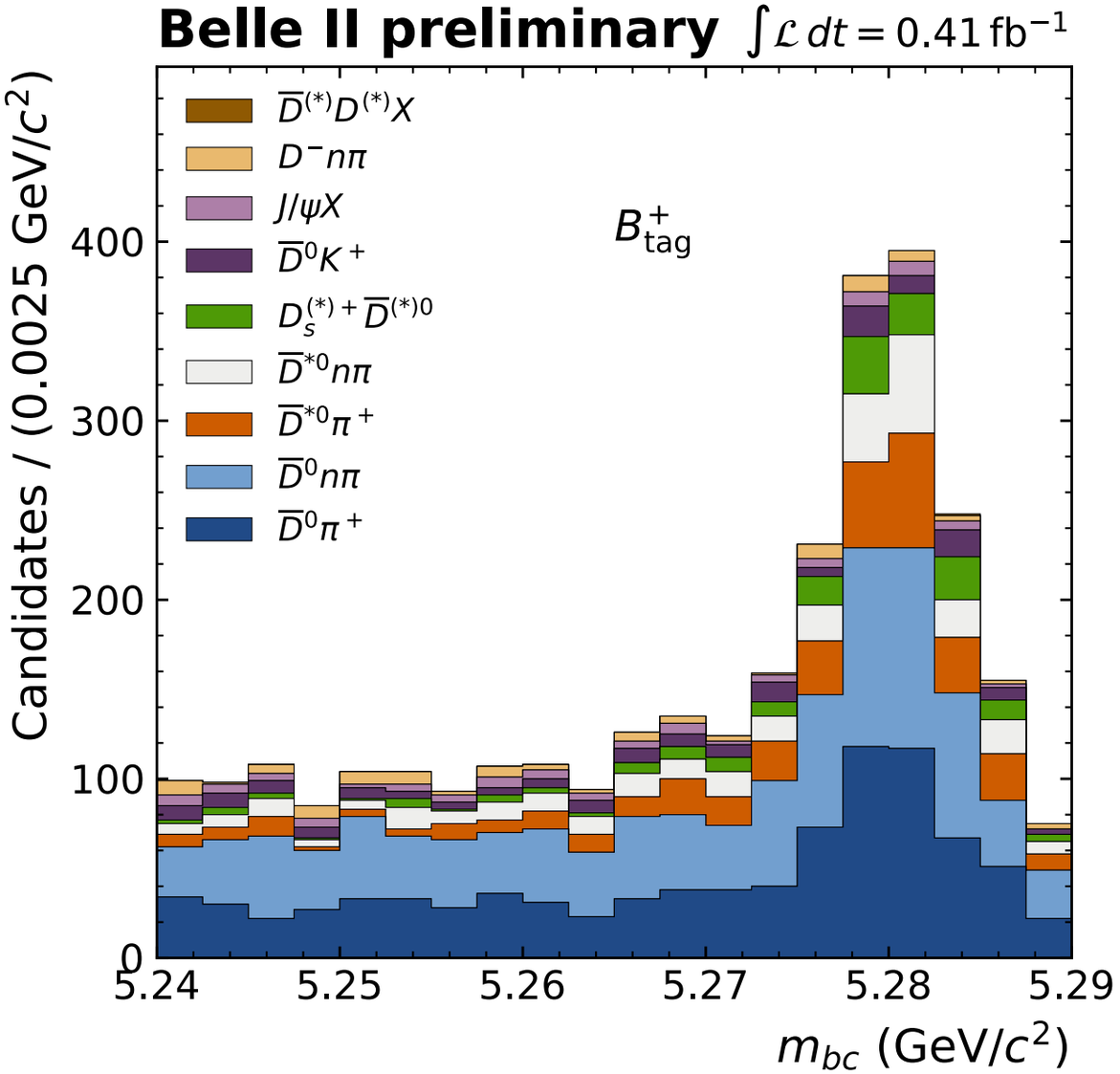


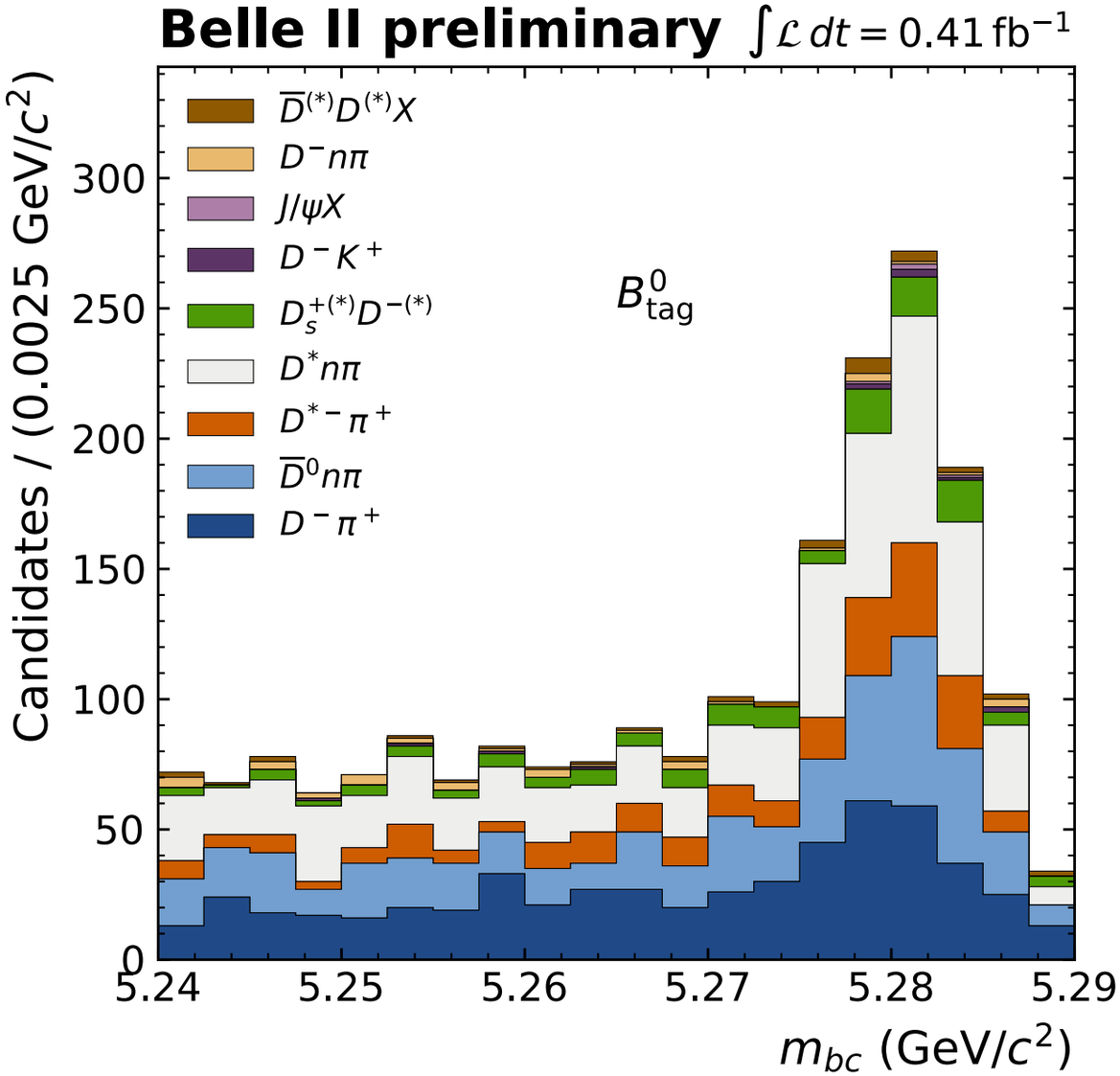
Tight Selection





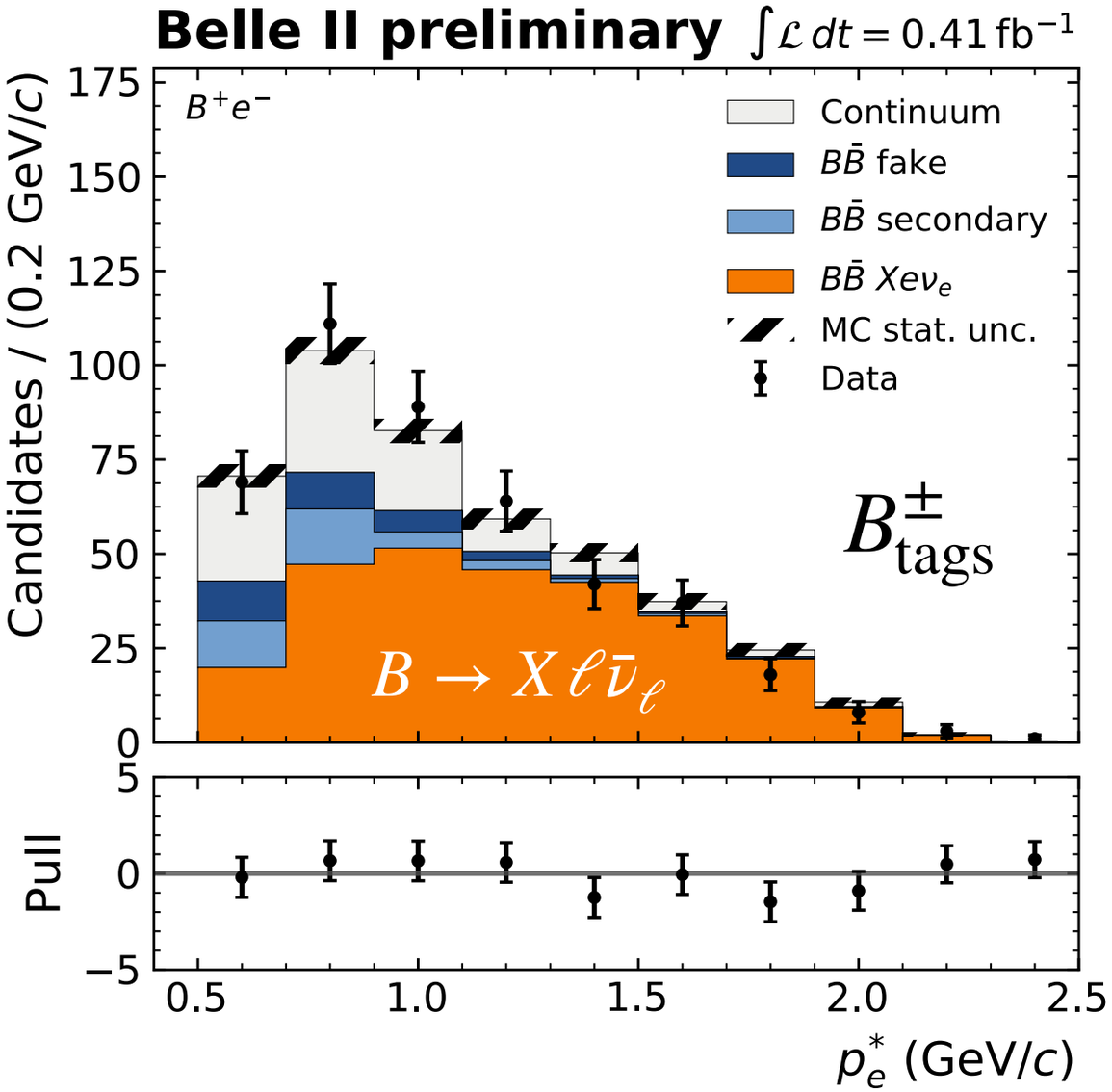
29 and 26 decay modes, respectively, contribute to the B^+_{tag} and B^0_{tag} reconstruction



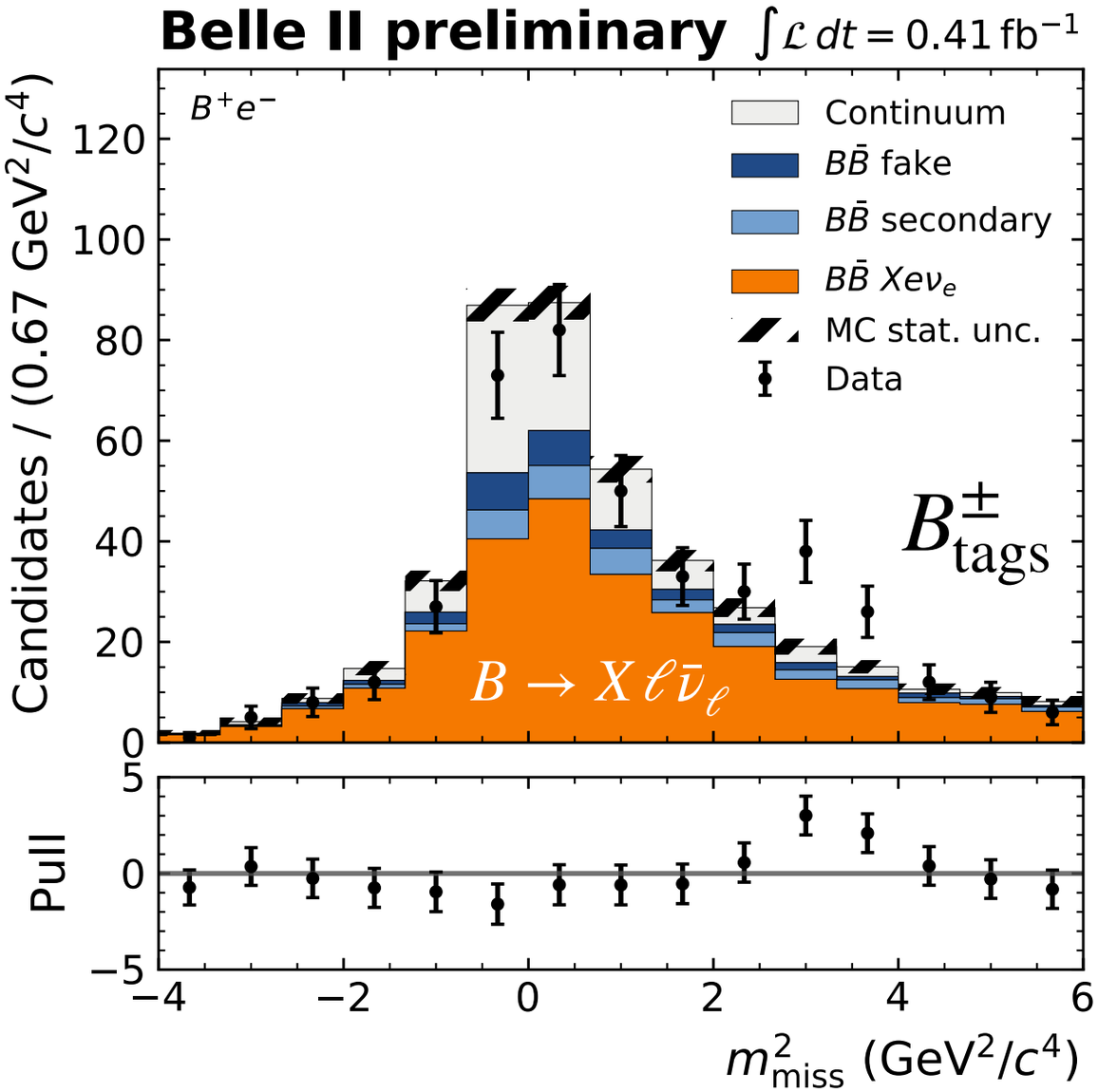


Rediscovering $B \to X \ell \bar{\nu}_\ell$ with the FEI $\mathscr{B} \approx 20\,\%$

Lepton Momentum p_ℓ

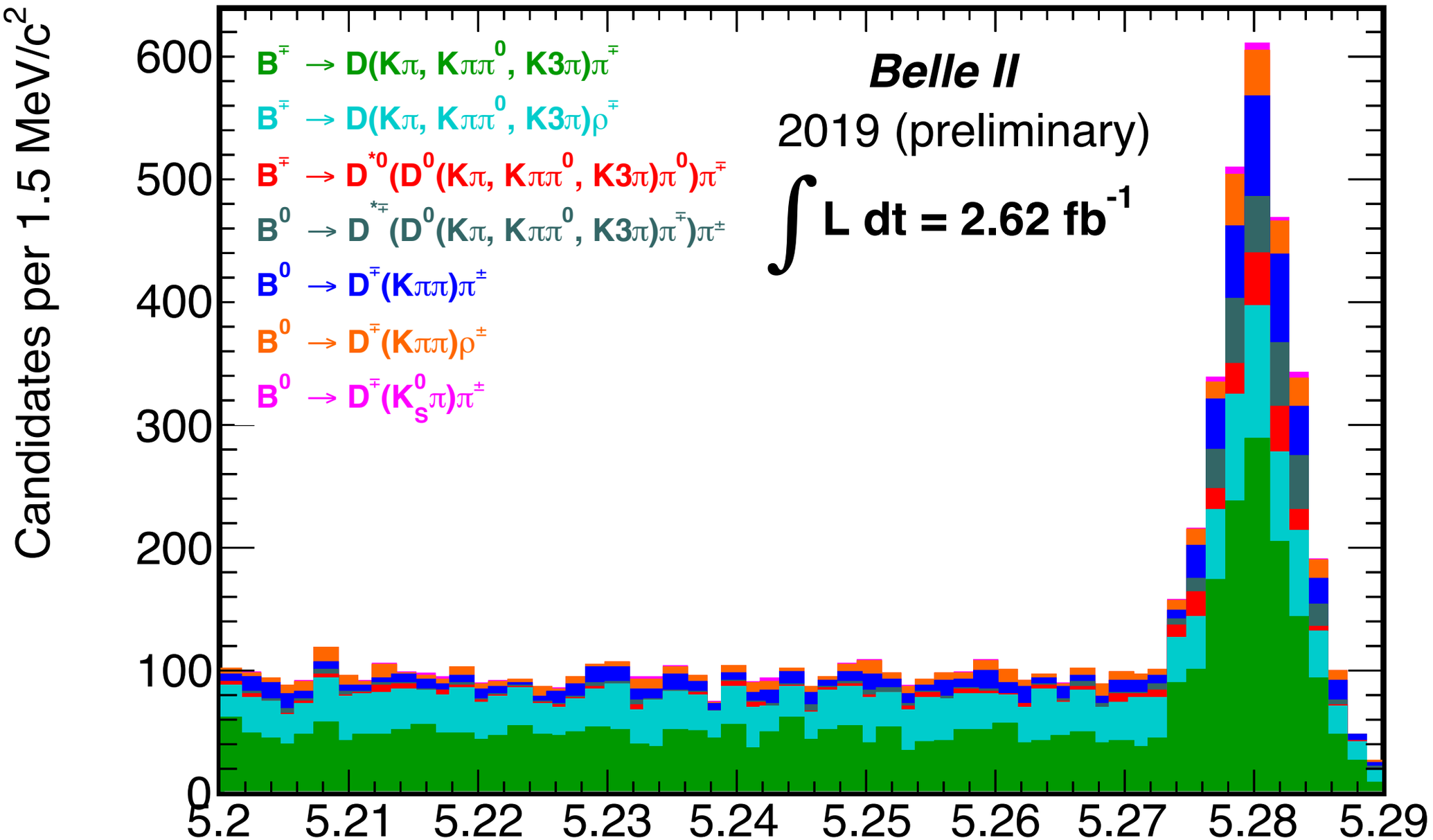


$$p_\nu^2 \approx m_{\mathrm{miss}}^2 = \left(p_{e^+e^-} - p_{B_{\mathrm{tag}}} - p_\ell - p_X\right)^2$$



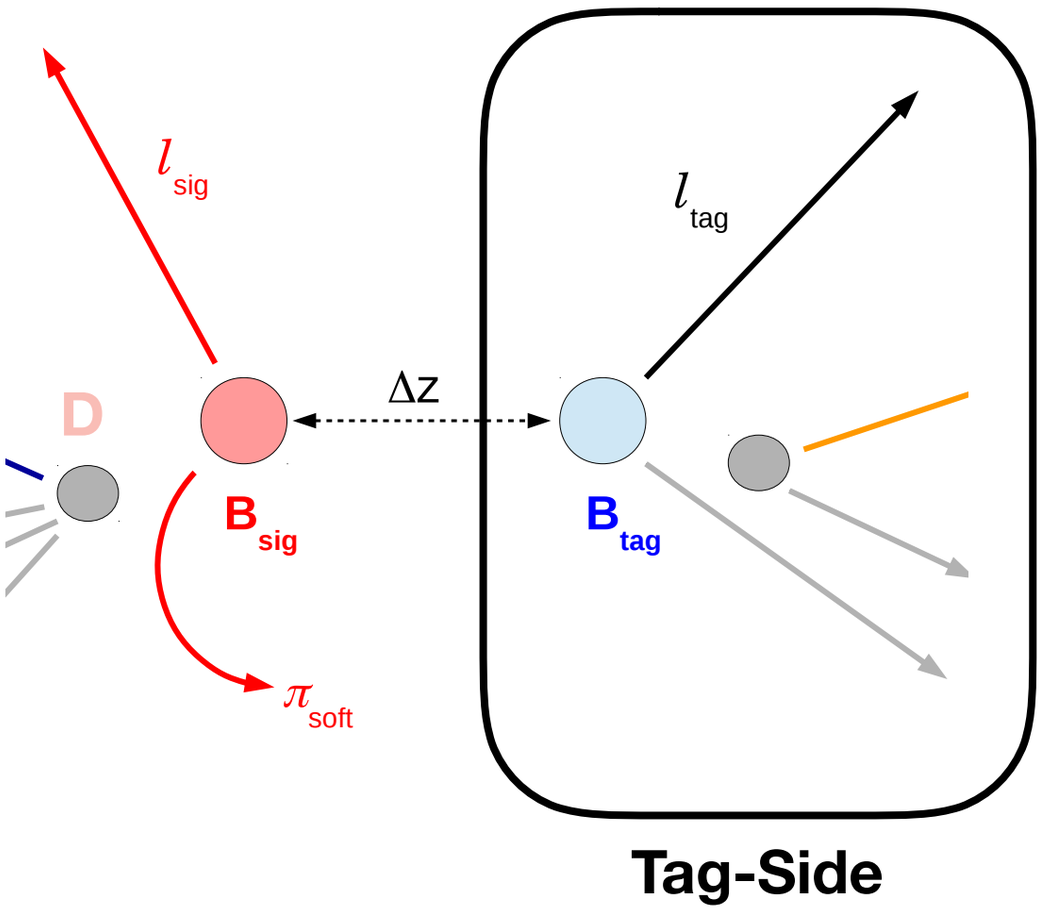
Rediscovery of $B \to D^{(*)}\pi^{\pm}, \rho^{\pm}$

$\mathcal{B} \approx$ several 0.1 %



$$m_{bc} = \sqrt{E_{\text{beam}}^2 - p_B^{*2}} \simeq m_B^2$$

Rediscovering of B-Mixing with $B^0 \to D^{*-}\ell^+\nu_\ell$

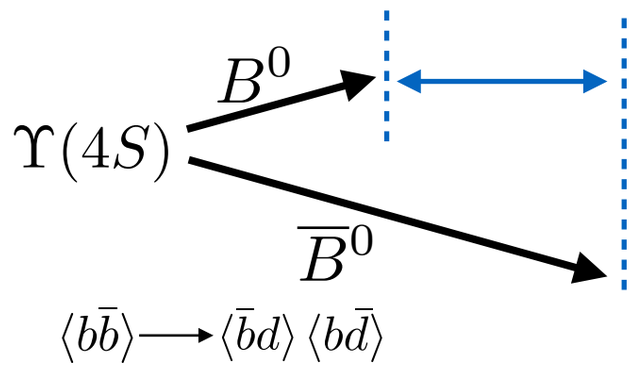


time-integrated mixing probability:

ratio of efficiencies

$$\chi_d = \frac{N_{\ell^+\ell^-} \times \epsilon}{N_{\ell^+\ell^+} + N_{\ell^+\ell^-} \times \epsilon}$$

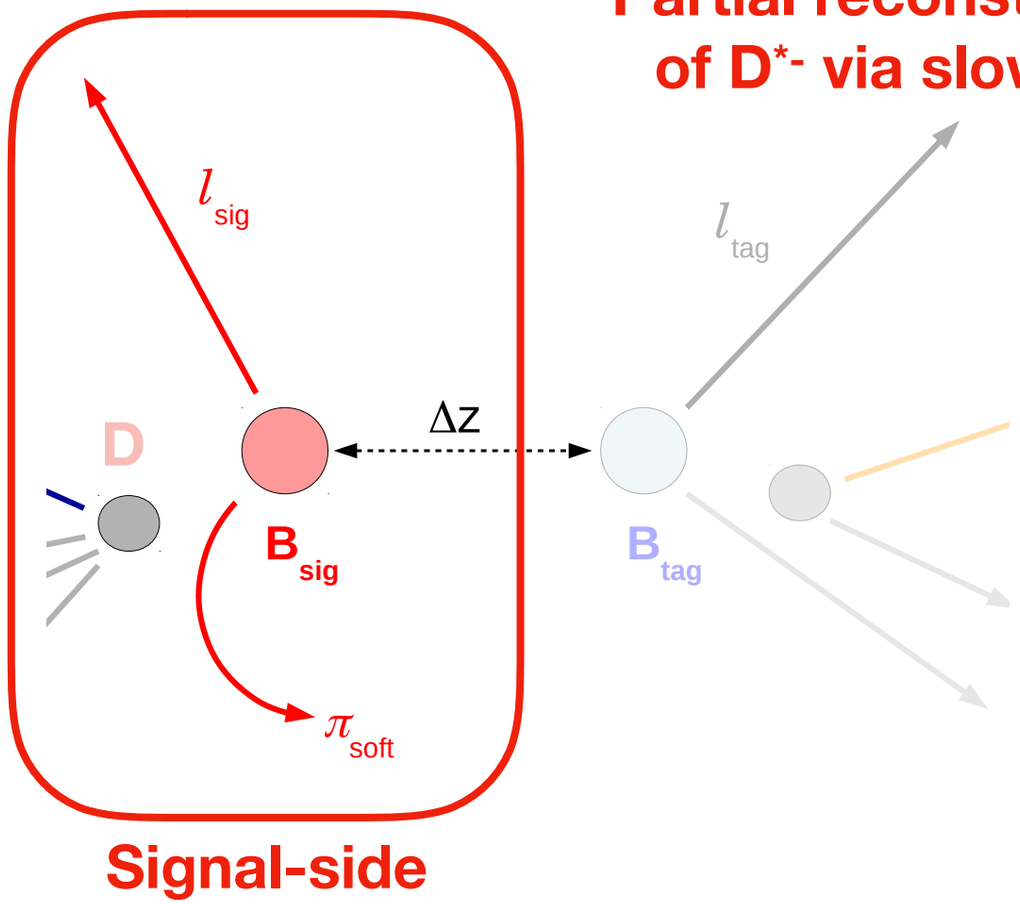
$$\chi_d = 0.174 \pm 0.009$$



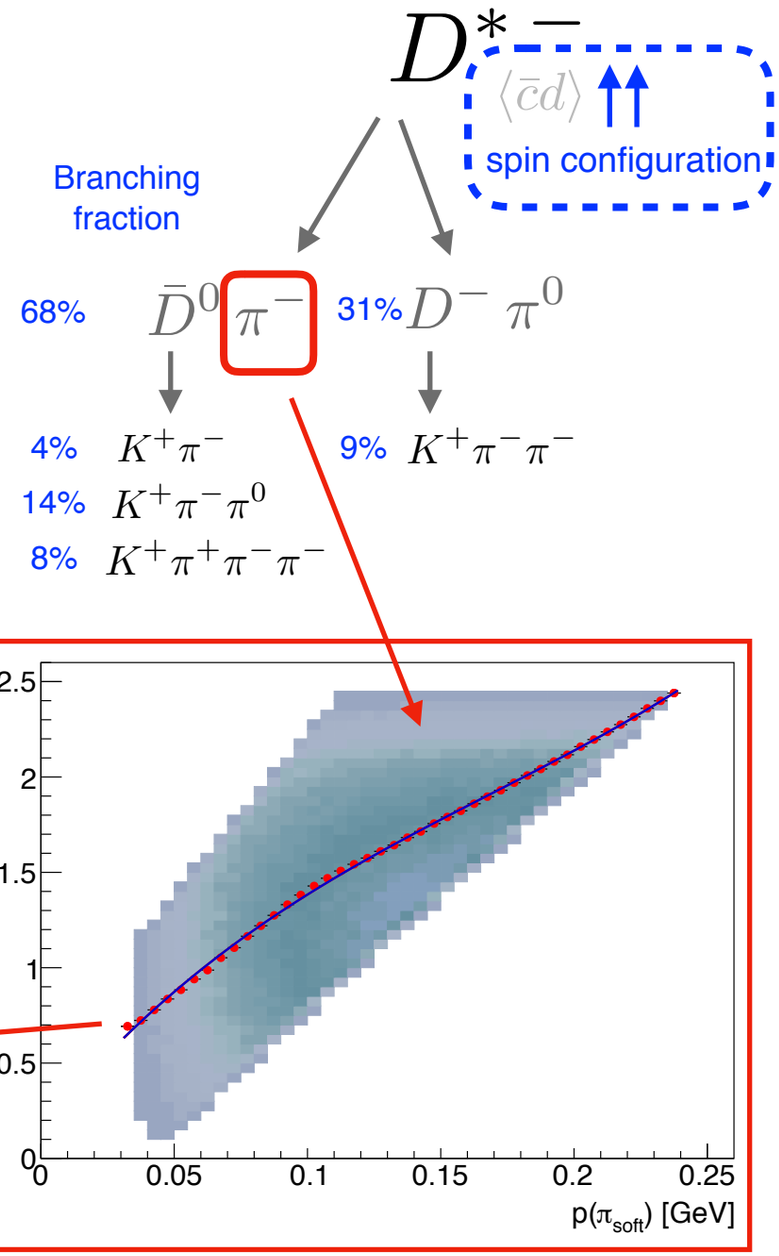
$$\Delta z = c\,\beta\,\gamma\,\Delta t \approx 130\,\mu\text{m}$$

Rediscovering of B-Mixing with $B^0 \to D^{*-}\ell^+\nu_\ell$

Partial reconstruction of D*- via slow pion



Signal-side

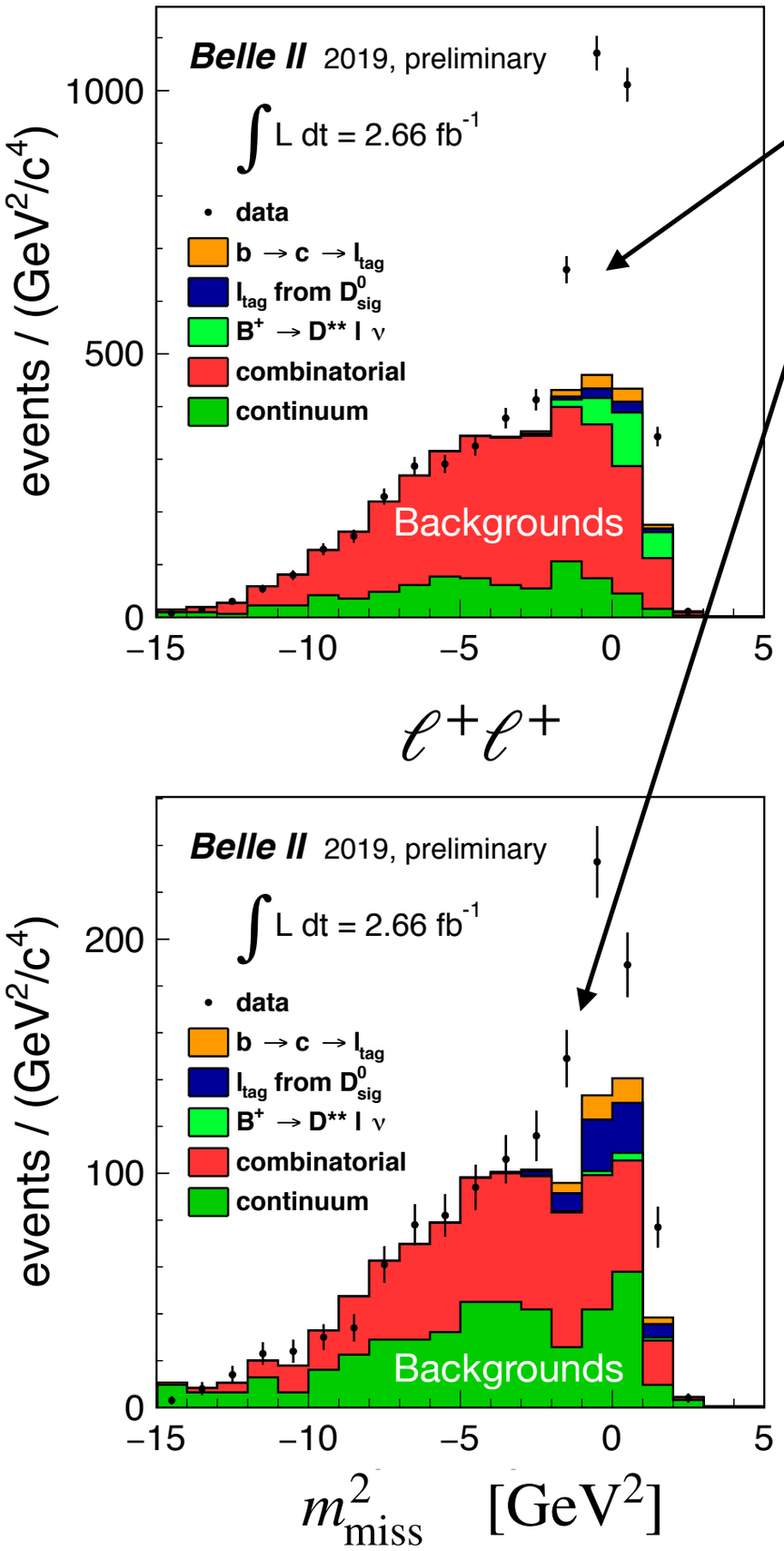


Calibration function from fit to MC:

$$p(D^{*-}) = 0.195 + 15.95\,p(\pi_s^-) - 51.50\,p^2(\pi_s^-) + 101.5\,p^3(\pi_s^-)\,.$$

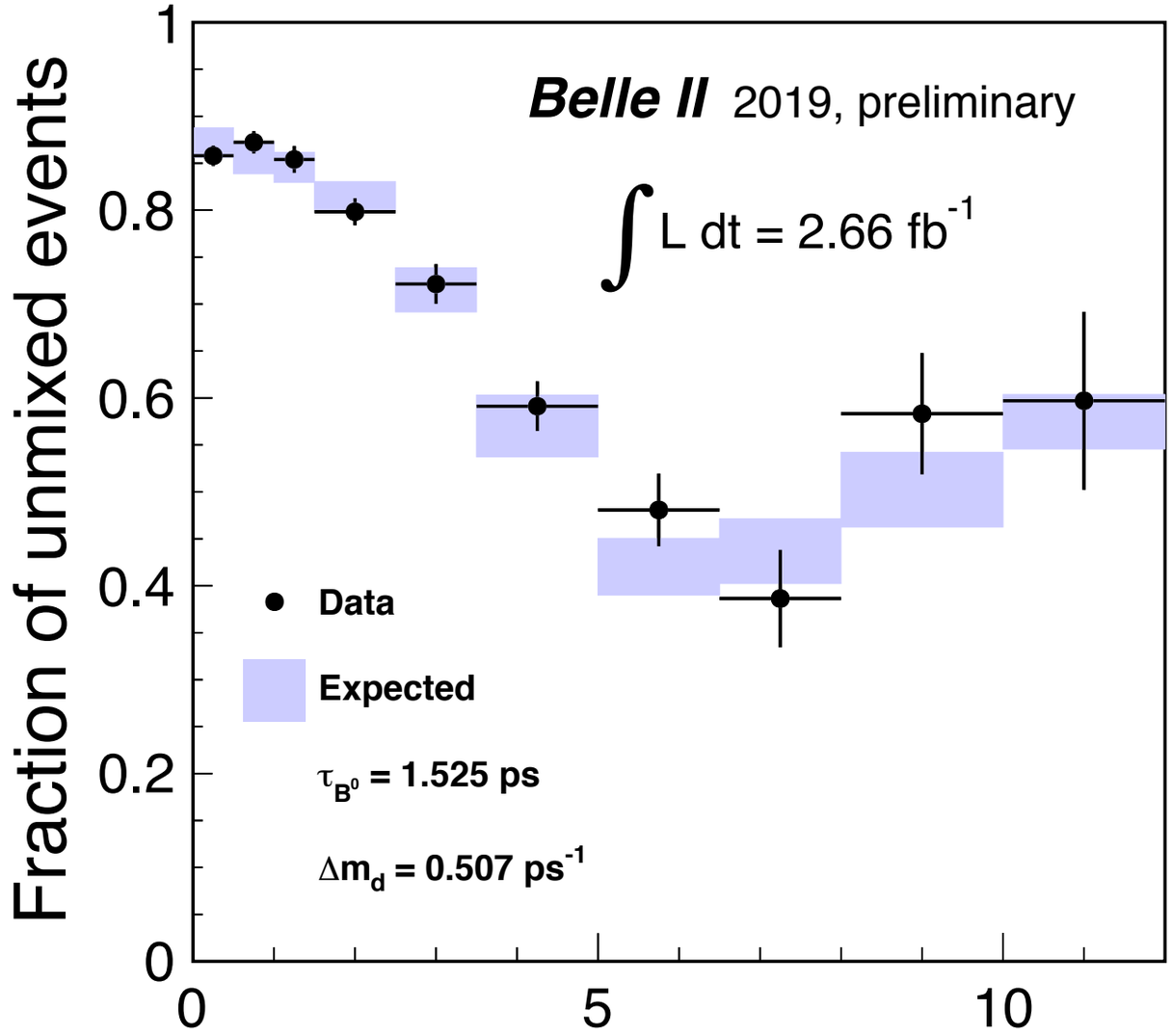
$$m^2_{\text{miss}} = \left((\frac{1}{2}E_{\text{beam}},0,0,0) - p^*_{D^*\ell} \right)^2 \approx p^2_\nu = 0\,\text{GeV}^2$$

$\ell^+\ell^-$

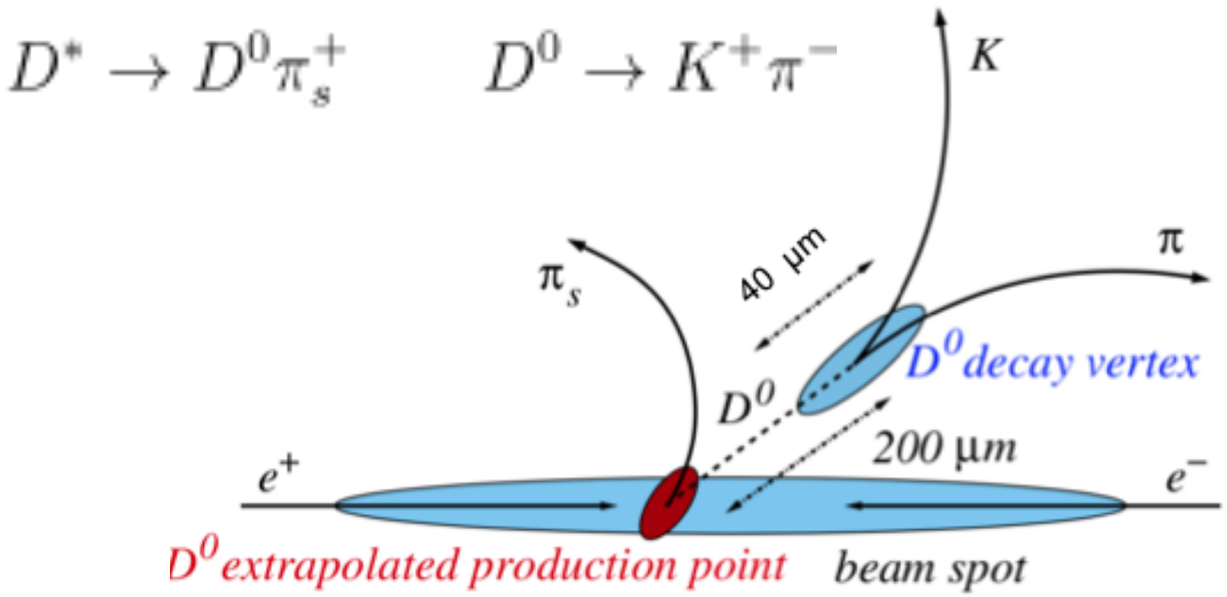


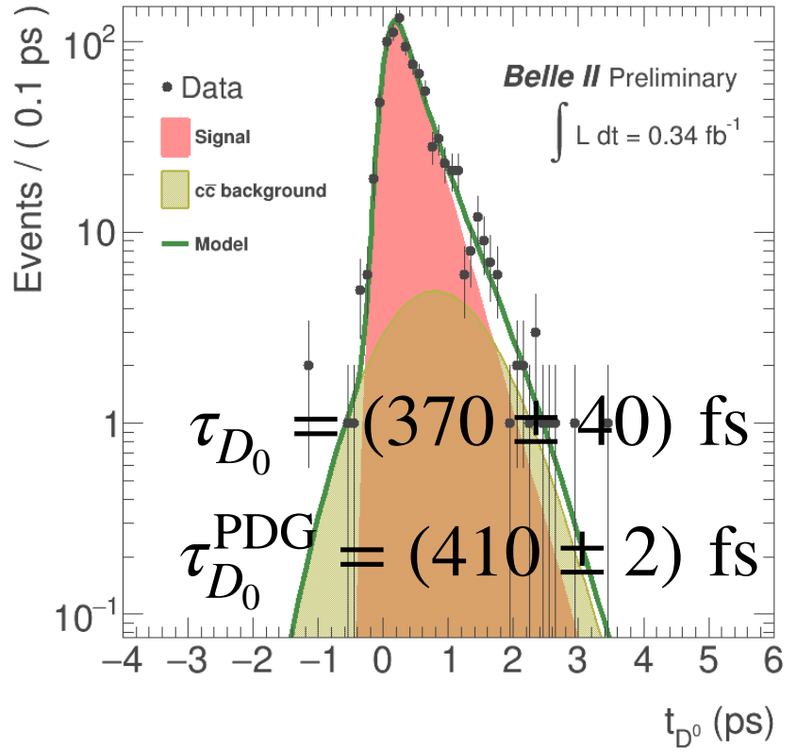
$\ell^+\ell^+$

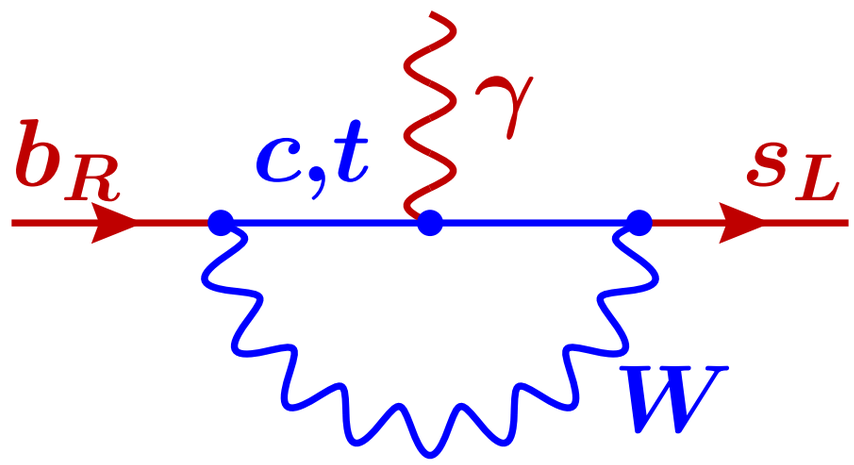
$B^0 \to D^{*-}\ell^+\nu_\ell$ Signal

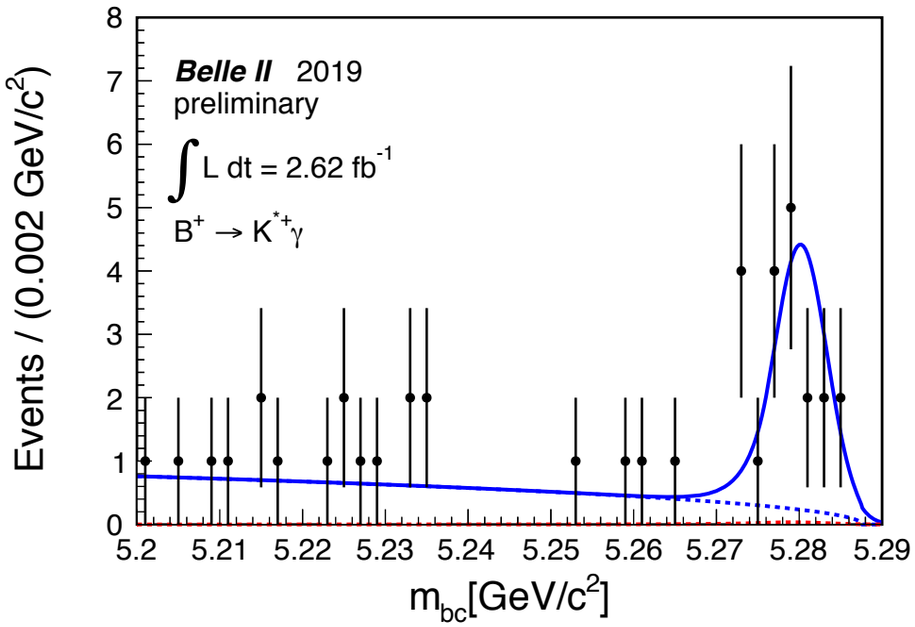


And there was more!





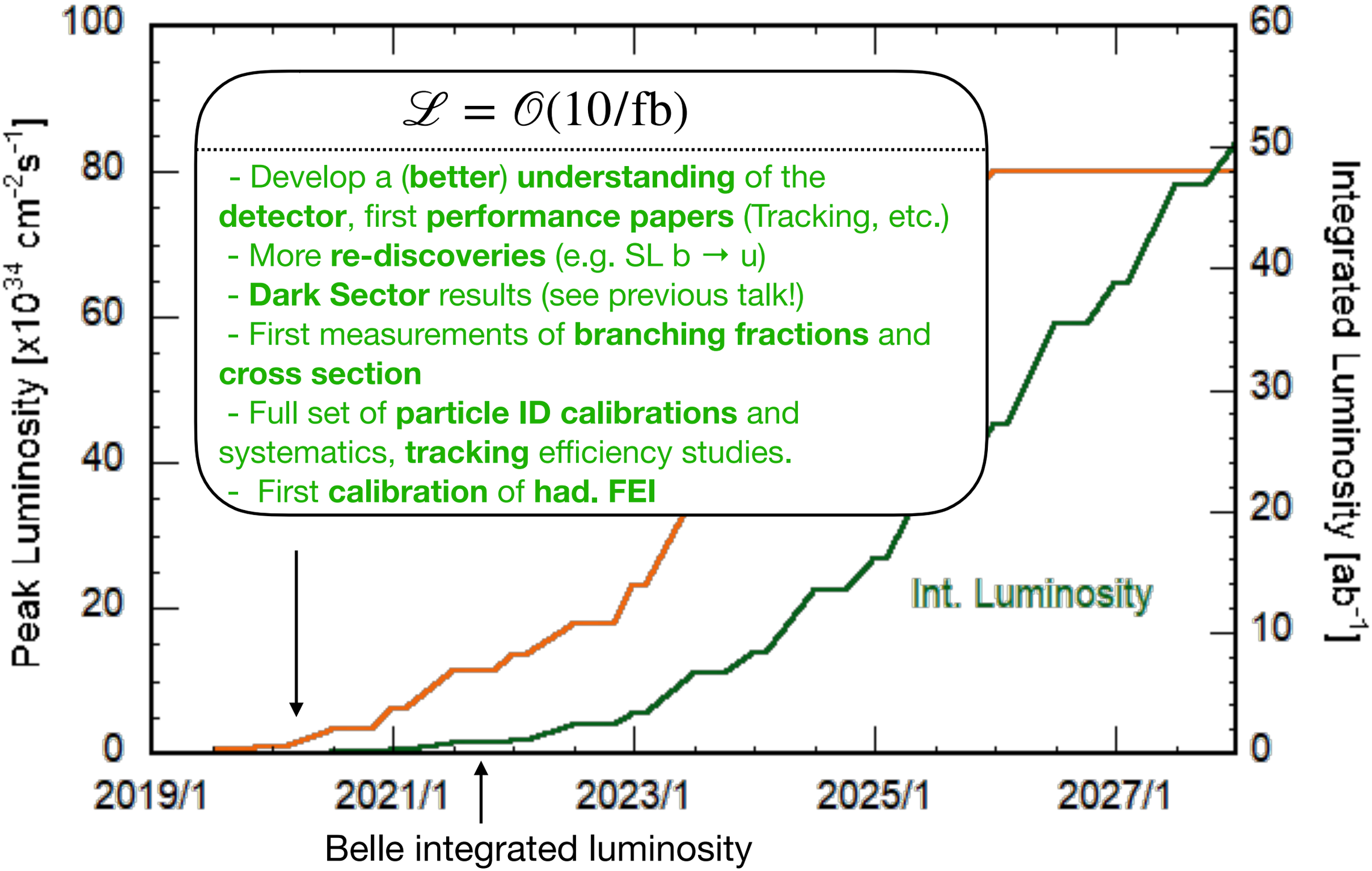




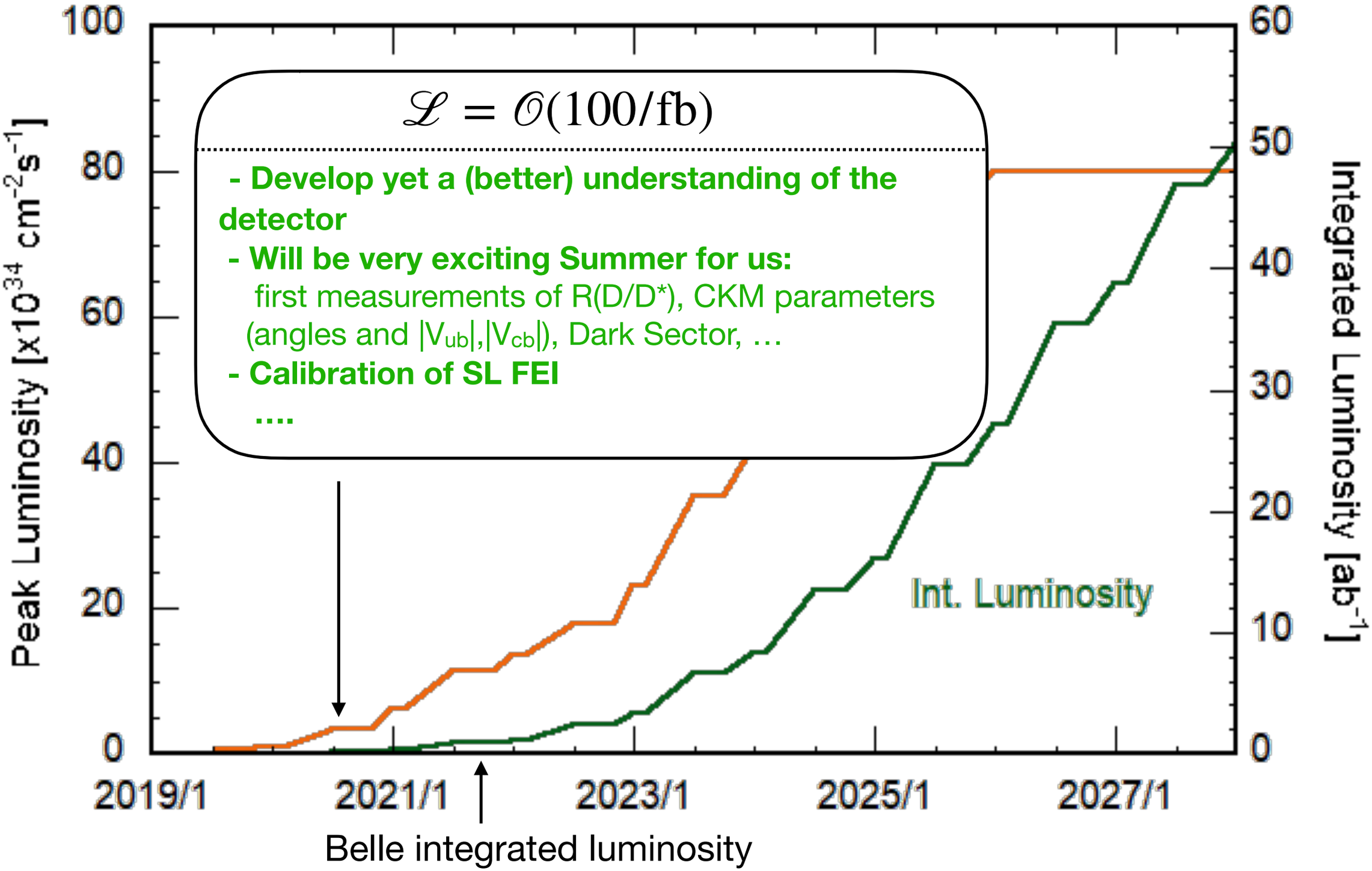
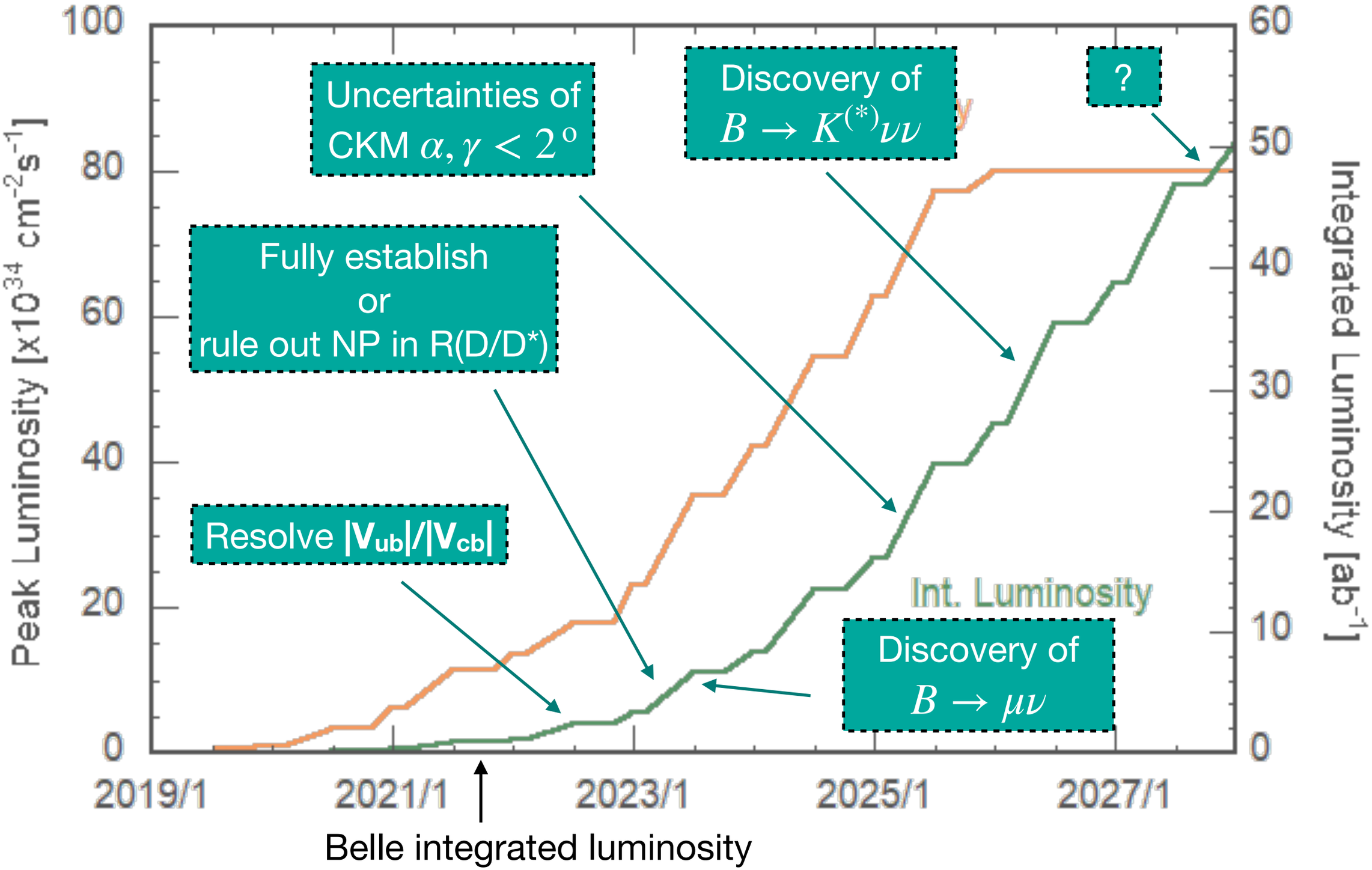
Outlook — Spring 2020

$\mathscr{L} = \mathcal{O}(10/\text{fb})$

- Develop a (**better**) **understanding** of the **detector**, first **performance papers** (Tracking, etc.)
- More **re-discoveries** (e.g. SL b → u)
- **Dark Sector** results (see previous talk!)
- First measurements of **branching fractions** and **cross section**
- Full set of **particle ID calibrations** and systematics, **tracking** efficiency studies.
- First **calibration** of **had. FEI**



Outlook — Summer 2020



Outlook — Beyond 2020