Recent V_{cb}, charm and tau measurements at Belle II

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on behalf of the Belle II collaboration

Rencontres de Moriond:
Electroweak Interactions & Unified Theories
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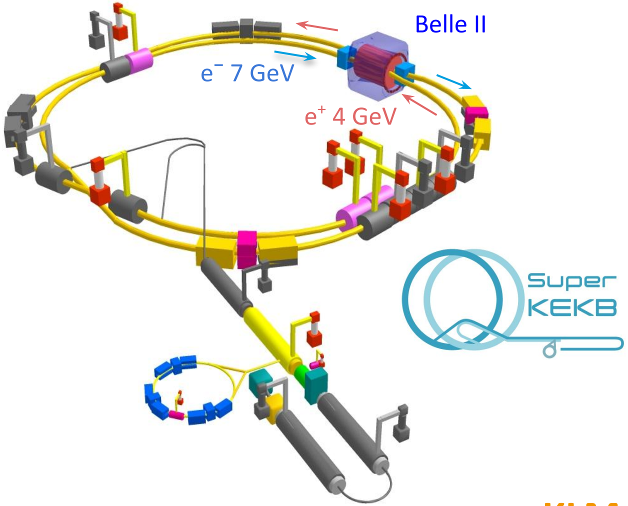
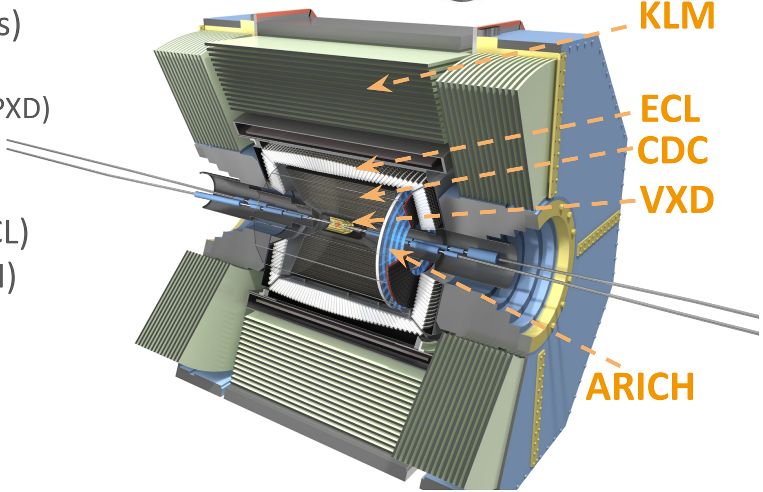
SuperKEKB and the Belle II detector

- SuperKEKB
  - energy-asymmetric e^+e^- collider in Tsukuba, Japan
  - center-of-mass energy at (and near) $m(\Upsilon(4S))=10.58$ GeV
  - Target:
    - instantaneous lumi of $6\text{x}10^{35}\text{cm}^{-2}\text{s}^{-1}$ (30 larger than KEKB)
    - integrated lumi: 50 ab^{-1} (50 times larger than KEKB)
  - improvement achieved via the nanobeam scheme
- Belle II detector
  - upgraded Belle for higher luminosities (and its challenges)
  - inner track detectors system (VXD) fully replaced
    - 2 (currently 1+2/12) new layers of DEPFET pixel detector (PXD)
    - 4 layers of double-sided silicon strip detector
  - new drift chamber (CDC)
  - upgraded electronic readouts for the EM calorimeter (ECL)
  - Cherenkov detectors for particle ID (PID) (TOP and ARICH)
  - K_L and muon detector (KLM)

⇒ Nearly 100/fb of data collected since 2019!





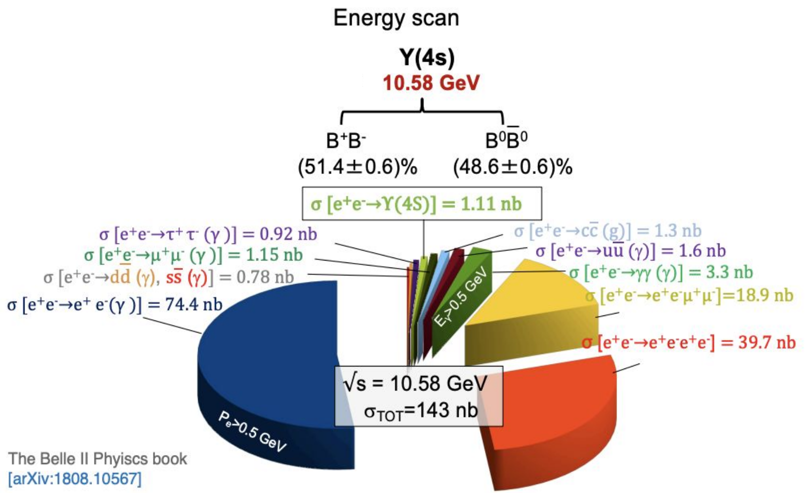
Physics at Belle II

- Not *just* a B-factory!
  - τ, c, and b pairs have similar cross sections at $\sqrt{s}$ = 10.58 GeV

$\sigma(e^+e^- \to \Upsilon(4S)) = 1.11$ nb

$\sigma(e^+e^- \to c\bar{c}) = 1.3$ nb

$\sigma(e^+e^- \to \tau^+\tau^-) = 0.92$ nb



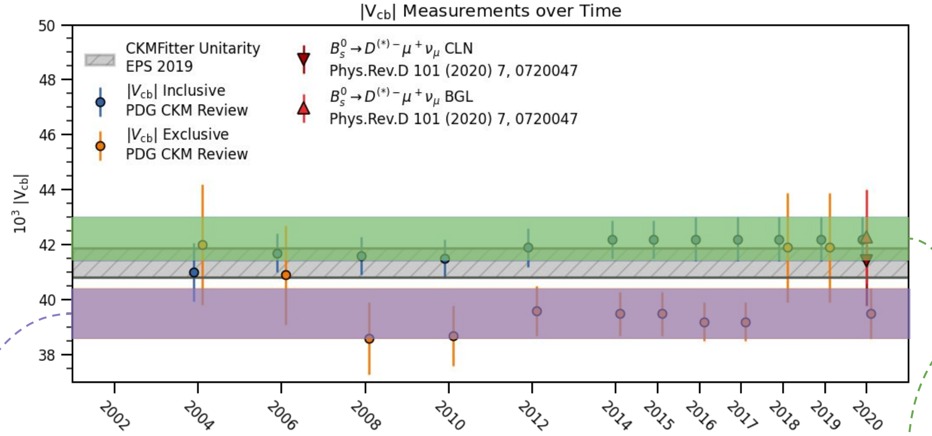
The Belle II Phyiscs book
[arXiv:1808.10567]

- Wide physics program
  - precision measurements of time-dependent CPV and CKM parameters
  - searches for lepton flavor universality/number violations
  - dark-sector searches
  - and many more

- Shown today:
  - recent results towards V_{cb}
  - New: time-indep. χ_d measurement
  - New: Rediscovery of $B \to \eta' K$
  - D^0 lifetime measurement
  - New: $D^{*+} \to D^0 (\to \pi^+\pi^-\pi^0)\, \pi^+_s$
  - tau mass measurement

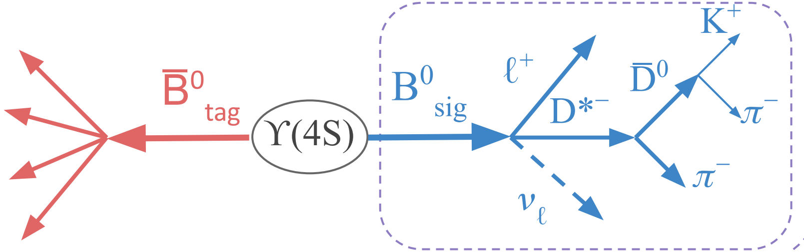
$|V_{cb}|$ Current situation...

- Precision measurement of CKM matrix:
  - one of the main focuses of any flavor factory
- Long-standing tension: ***inclusive*** vs. ***exclusive*** measurements $|V_{cb}|$ and $|V_{ub}|$
- *Semileptonic* decays of B-meson leading $|V_{cb}|$ and $|V_{ub}|$ measurements



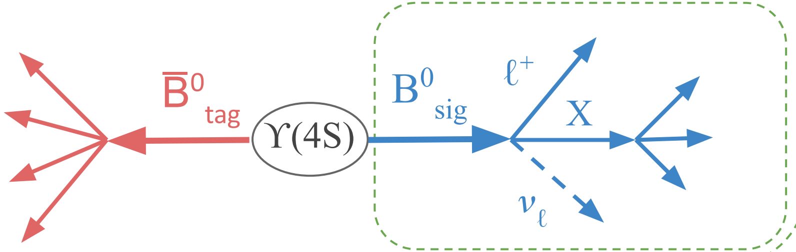
Exclusive approach:

- reconstruct the semi-leptonic decays of the B meson
- can be tagged or untagged



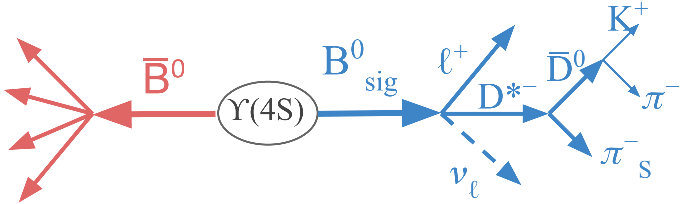
***Inclusive* approach:**

- only require ℓ for a signal
- don't fully reconstruct the leptonic decay system (X system)

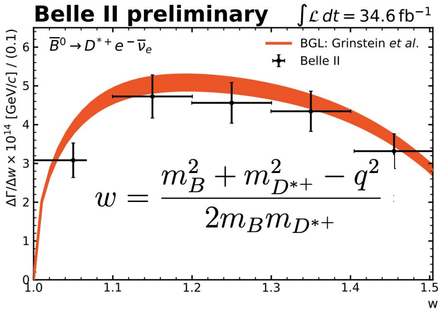


[arXiv:2008.07198](https://arxiv.org/abs/2008.07198)

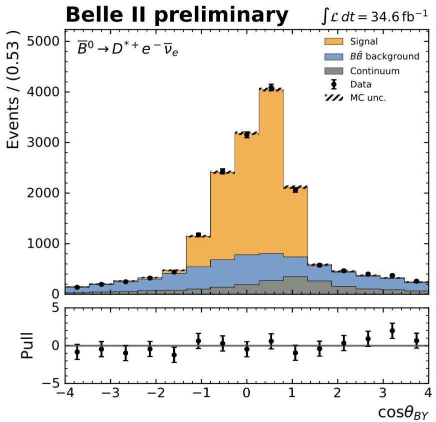
Exclusive $B^0 \to D^* \ell \nu$ (untagged)



$$\cos\theta_{BY} = \frac{2\,E_B^* E_Y^* - m_B^2 - m_Y^2}{2|p_B^*||p_Y^*|},$$



$$w = \frac{m_B^2 + m_{D^{*+}}^2 - q^2}{2 m_B m_{D^{*+}}}$$



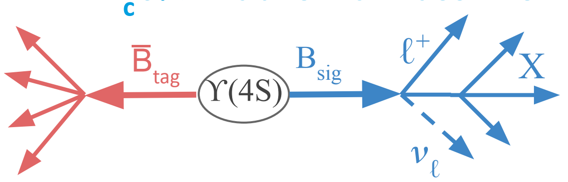
- **Results:**
  - measured BR compatible with PDG

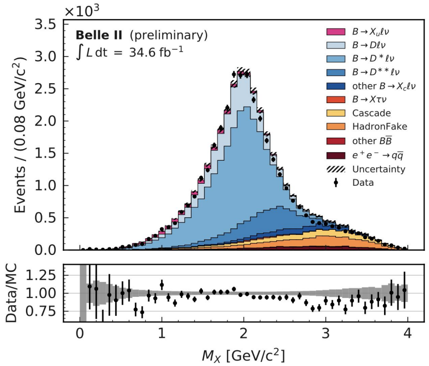
$$\mathcal{B}(\overline{B}^0 \to D^{*+}\ell^-\overline{\nu}_l) = (4.60 \pm 0.05_{\rm stat} \pm 0.17_{\rm syst} \pm 0.45_{\pi_s})\,\%\,,$$

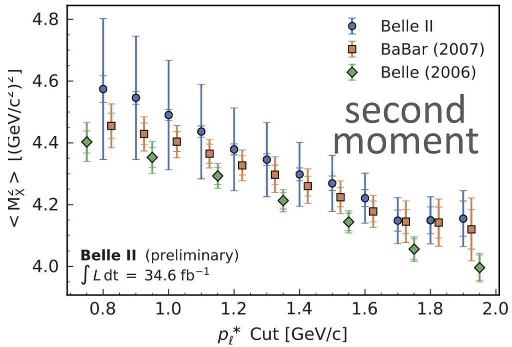
⇒ slow-pion systematics expected to improve with updated correction factors…updates coming soon!

[arXiv:2009.04493](https://arxiv.org/abs/2009.04493)

Inclusive $B \to X_c \ell \nu$: Hadronic Mass Moments







$$\langle M_X^n \rangle = \frac{\sum_i w_i(M_X) M_{X,\mathrm{calib}\,i}^{\,n}}{\sum_i w_i(M_X)} \times \mathcal{C}_{\rm calib} \times \mathcal{C}_{\rm true}.$$

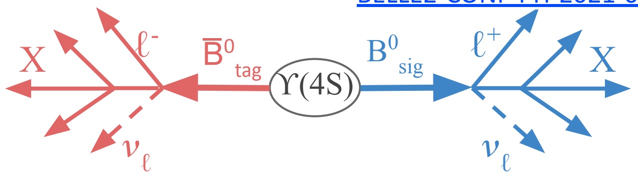
...Related upcoming analysis: measurement of q^2 moments

- alternative method based on [arXiv:1812.07472](https://arxiv.org/abs/1812.07472)
- includes corrections up to $1/m_b^4$
- see Belle YSF talk by Raynette van Tonder

⇒ brand new inclusive V_{cb} measurement…. coming soon!

BELLE2-CONF-PH-2021-004

Time-integrated mixing probability χ_d



- Measuring χ_d can help constrain B^0-$\overline{B}^0$ mixing parameters x_d and y_d:

$$x_d = \Delta m_d / \Gamma_d \,, \qquad y_d = \Delta\Gamma_d / \Gamma_d \,,$$

- Measure by counting number of same-sign (N_{SS}) and opposite-sign (N_{OS}) semileptonic* BB decay:

$$\chi_d = \frac{N_{\rm SS}}{N_{\rm SS} + N_{\rm OS} \cdot (\epsilon_{OS}/\epsilon_{SS})^{-1}} \cdot (1 + r_B)$$

r_B: accounts for contribution due to charged B-mesons

$\epsilon_{OS}/\epsilon_{SS}$ ratio of OS and SS signal efficiencies

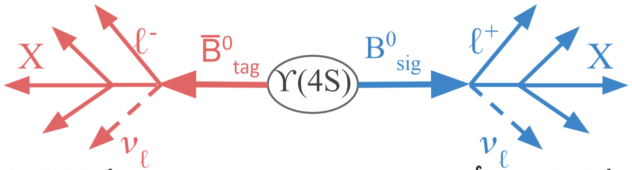
*here only electrons are used

- Infer the B flavor from the lepton charge
  - same sign leptons *may* indicate mixing
  - But not if it is a secondary lepton
  - or if both leptons from the same B

⇒ in MC classify event as as signal only if both leptons daughters of different B's

- Reconstructing the candidates:
  - 2 high momentum electrons
  - tight electron ID requirements
- Backgrounds:
  - veto events with a track pair compatible w J/Ψ, photo-conversions, π^0 decays
  - continuum background described by 'off-resonance' data
  - and suppressed using Fox-Wolfram moments (R_2) and track multiplicity

Time-integrated mixing probability χ_d



- Signal yield extraction:
  - sum of lepton momenta used:

$$p^*_{ee} = |p^*_{e1}| + |p^*_{e2}|$$

  - six-component binned-likelihood fit
  - from extracted signal yields calculate χ_d

- Result:
  - systematics dominated by electron ID

$$\boxed{\chi_d^{\text{meas.}} = 0.193 \pm 0.010\ (\text{stat}) \pm 0.016\ (\text{syst})}$$

current world average:

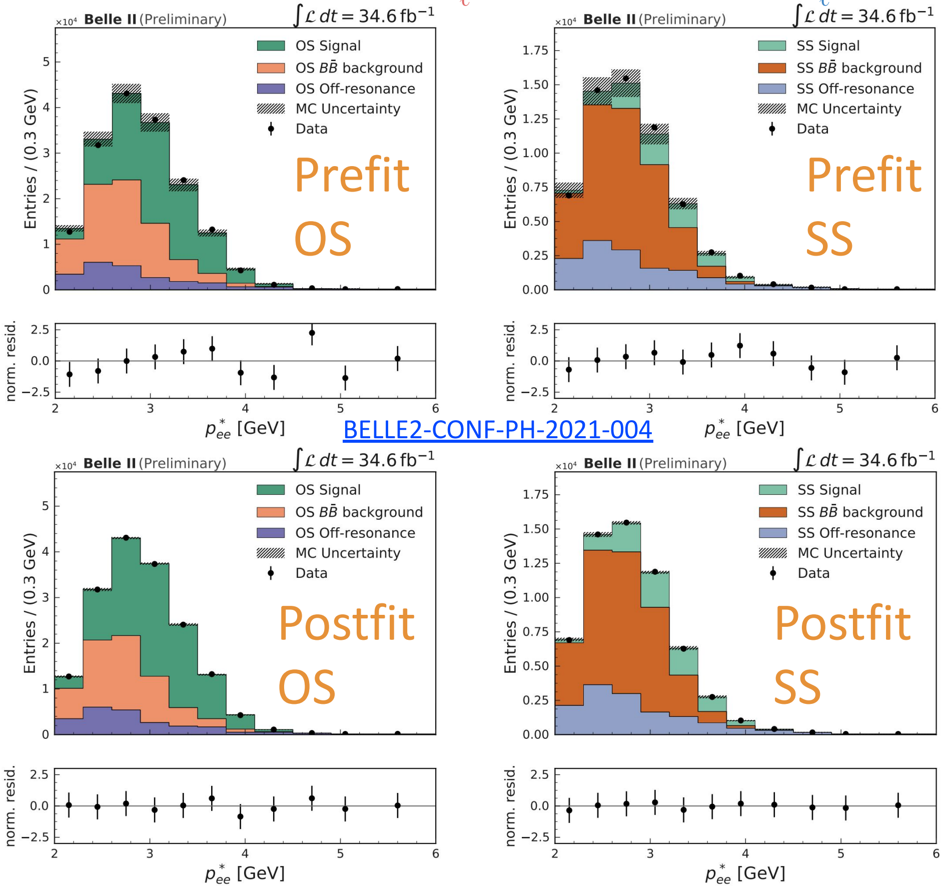
$$\chi_d^{\text{PDG}} = 0.1858 \pm 0.0011$$

current time-independent average:

$$\chi_d^{\text{time-in}} = 0.182 \pm 0.015$$

⇒ compatible with world-average

⇒ and comparable uncertainty to the world-average of time-integrated measurements!



BELLE2-CONF-PH-2021-004

New from Belle II

Rediscovery of B⟶ η' K

- Motivation
  - rare charmless B-decay, mediated by hadronic penguin diagram
  - sensitive to new physics contributions
  - theoretically clean mode to calculate

- towards time-dependent analysis:
  - *rediscovery of the decay and BR measurement*

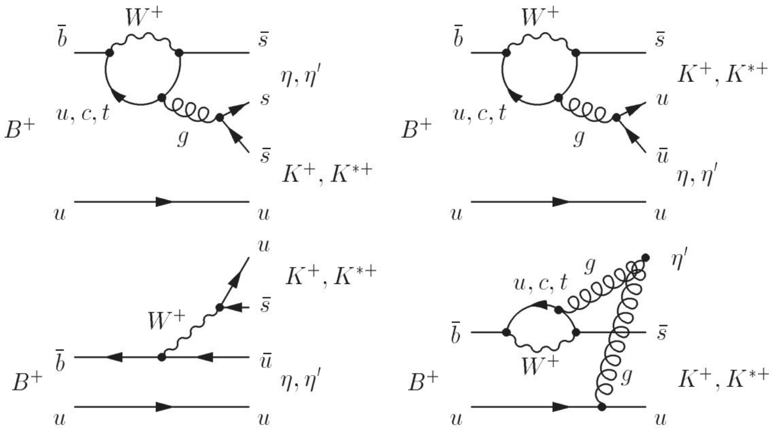
- Reconstruct <u>charge and neutral</u> modes:

  $B^+ \rightarrow \eta' K^+$

  $B^0 \rightarrow \eta' K^0$ (only $K_S \rightarrow \pi^+\pi^-$)

- Included η' decays:
  - $\eta' \rightarrow \eta\ (\rightarrow \gamma\gamma)\ \pi^+\pi^-$
  - $\eta' \rightarrow \rho\ (\rightarrow \pi^+\pi^-)\ \gamma$

- Background
  - signal self-cross-feed (SxF)
    - wrong π, γ or a combination
  - continuum suppression dedicated BDT (CS_{var})
  - validated on off-resonance data



- Signal extraction:
  - three components:
    - **signal+SxF**
    - **continuum**
    - **peaking background**
  - observables:
    - M_{bc}, ΔE, CS_{var}

$$M_{\mathrm{bc}} = \sqrt{E^{*2}_{\mathrm{beam}}/c^4 - p^{*2}_B/c^2}$$

$$\Delta E = E^*_B - E_{beam}$$

New from Belle II

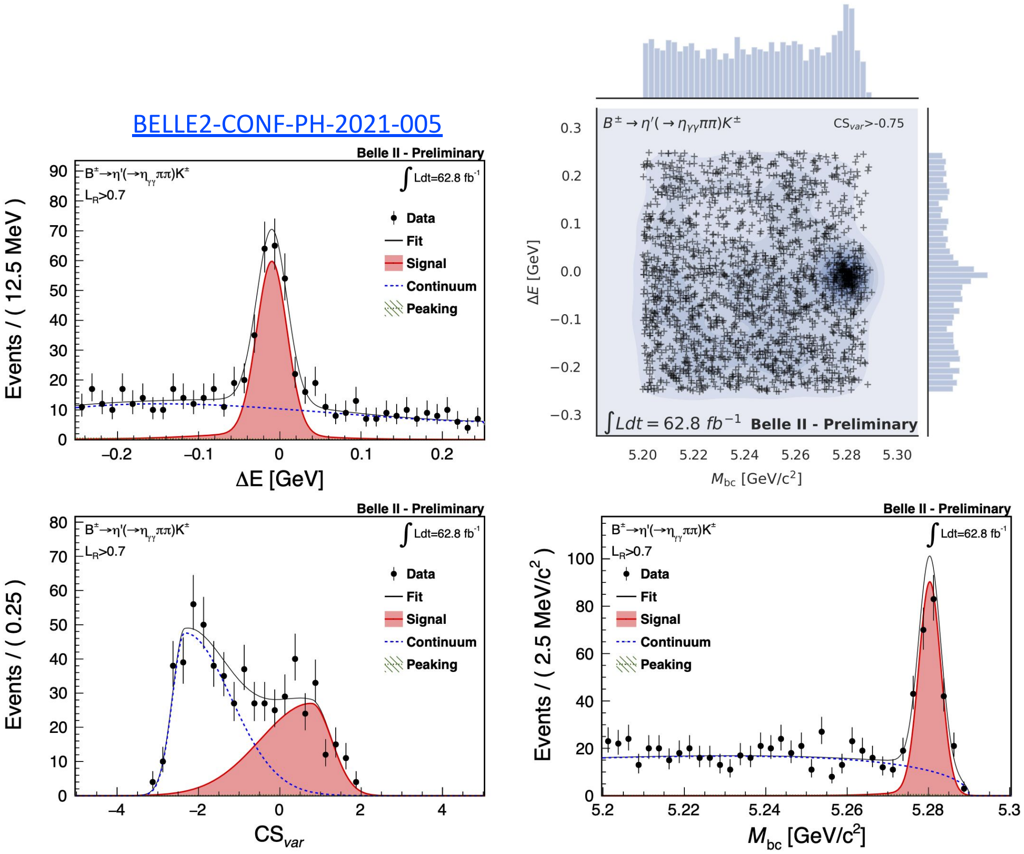
Rediscovery of B⟶ η' K

- Fit results:
  - PDF's for each observable and component modelled independently
  - fit seen to have no bias in toy MC validation
- Systematics:
  - depending on the channel dominated by continuum suppression, SxF contamination, or K_S efficiency
- Results
  - BR's are obtained from signal yields in each of the four channels.
  - Results consistent within channels, and with Belle, BaBar and world-average

$$\mathcal{B}\left(B^{\pm} \to \eta' K\right) = \left(63.4\ ^{+3.4}_{-3.3}\,(\mathrm{stat}) \pm 3.2\,(\mathrm{syst})\right) \times 10^{-6}$$

$$\mathcal{B}\left(B^{0} \to \eta' K^{0}\right) = \left(59.9\ ^{+5.8}_{-5.5}\,(\mathrm{stat}) \pm 2.9\,(\mathrm{syst})\right) \times 10^{-6}$$

BELLE2-CONF-PH-2021-005

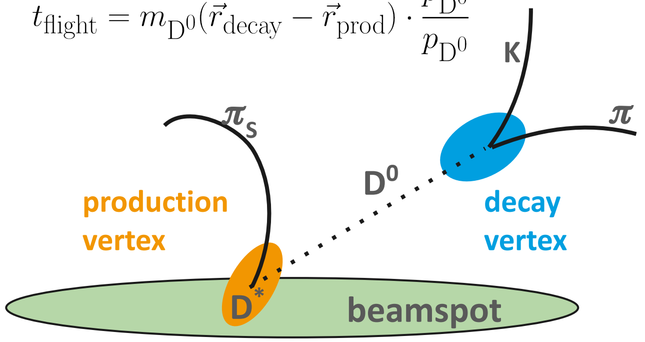


⇒ work toward the time-dependent CPV analysis!

D^0 lifetime

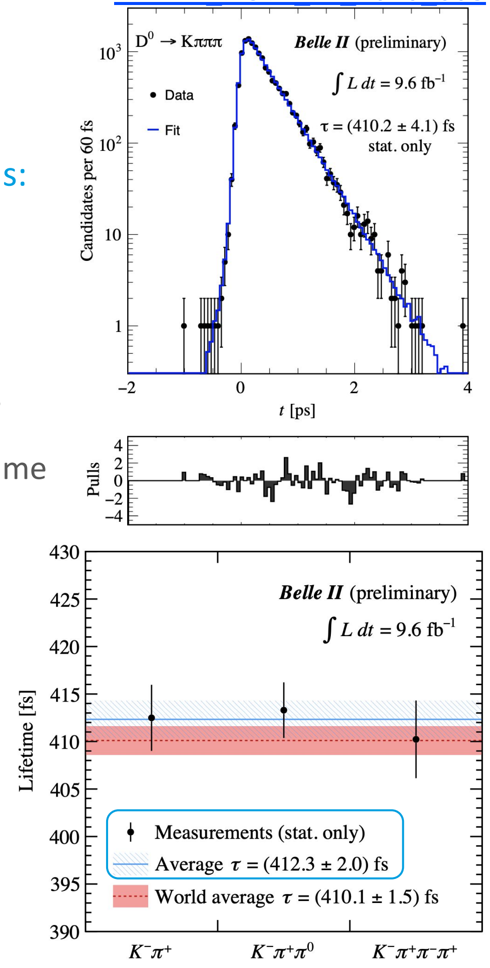
- Measurement done in 3 D*-tagged D^0 channels:
  - $D^0 \to K^+\pi^-$, $D^0 \to K^+\pi^-\pi^0$, $D^0 \to K^+\pi^-\pi^+\pi^-$
  - veto D* candidates from B decay (require $p^*(D^*) \geq 2.5$ GeV)
  - **decay-vertex:** From K and π's
  - **production-vertex:** extrapolate from D^0 to π_s with beamspot as a constraint
  - from vertex fit the decay-time (t) and decay-time uncertainty (σ_t) are obtained

$$t_{\text{flight}} = m_{D^0}(\vec{r}_{\text{decay}} - \vec{r}_{\text{prod}}) \cdot \frac{\hat{p}_{D^0}}{p_{D^0}}$$



†blobs not to scale

BELLE2_NOTE_PL_2020_008



- Challenge:
  - average D^0 flight distance around 220 µm
- Advantages w.r.t Belle
  - nanobeam scheme of SuperKEKB
  - innermost layer of vertex detector 1.4 cm from IP (half of Belle)

⇒ proper-time resolution 2x better than Belle!

- What to expect next:
  - Full-fledged blinded analysis currently ongoing with 72/fb
  - precision expected to be competitive with world average!
  - $D^\pm$, D_s and Λ_c lifetimes also on the way!

⇒ already with 72/fb Belle II life-time measurements expected to be competitive with world-averages!

New from Belle II

Dalitz analysis $D^{*+} \to D^0 (\to\pi^+\pi^-\pi^0)\, \pi^+_s$

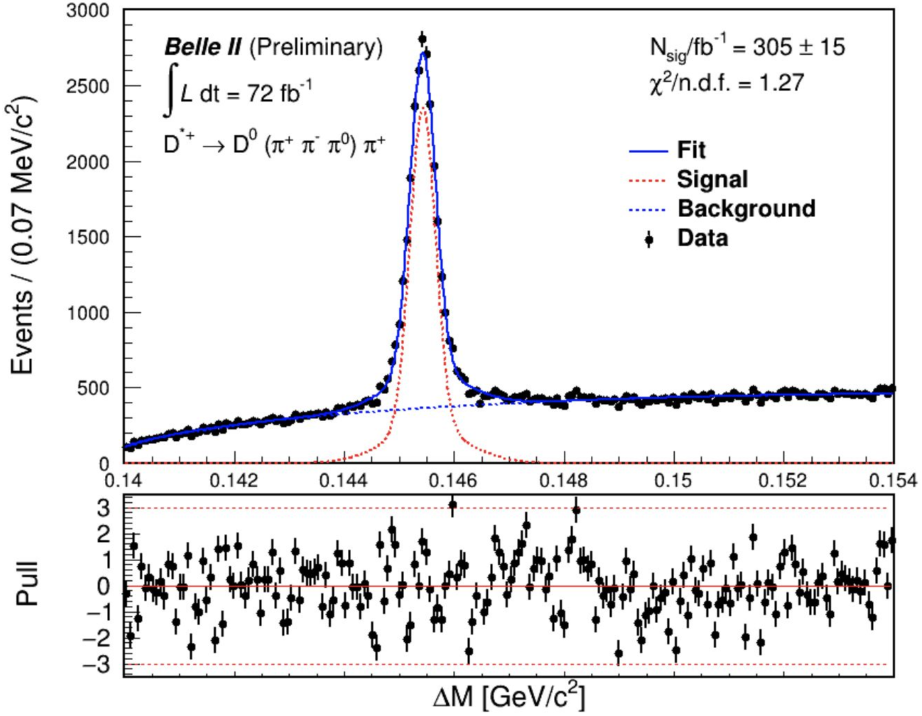
- Target: time-integrated Dalitz analysis to study CPV in D^0 decay
  - *for now:* demonstrate ability to extract yields
- Reconstruction:
  - pion ID used to reduce mis-ID Kaons
  - veto D*'s from B: require $p^*(D^*) > 2.5$ GeV
  - Vertex fit on D* using IP and mass of and π^0 as constraints
  - allow up to two D* candidates per event
- Results:
  - extract yield/fb^{-1} from the ΔM distribution

    $\Delta M = M(D^*) - M(D^0)$
  - Fit using a gaussian sum as signal and threshold pdf for background
  - Fit result corrected for peaking-background contribution

$N_{sig}/fb^{-1} = 305 \pm 15$*

*includes stat and impact of peaking-background-correction

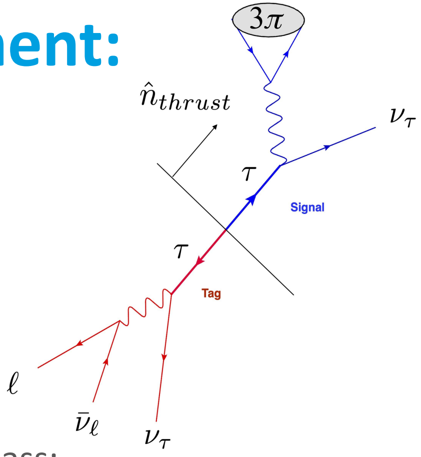
BELLE2-NOTE-PL-2021-003

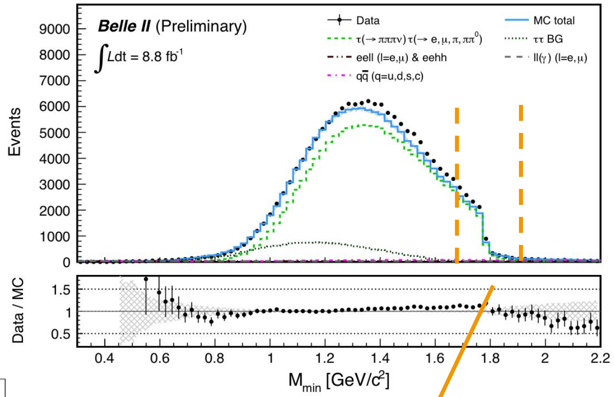


Tau lepton mass measurement:

arXiv:2008.04665

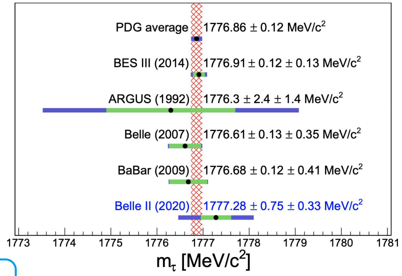
- Topology:
  - 3x1 decays of the τ are used
  - signal: $\tau^- \to \pi^+\pi^-\pi^+\nu_\tau$
  - tag: $\tau^- \to \ell\nu_\ell\nu_\tau, \pi^-\nu_\tau, \pi^-\pi^0\nu_\tau$





- Pseudomass variable (M_{min}) :
  - calculated from the 3π system
  - kinematic edge exploited to extract the mass:

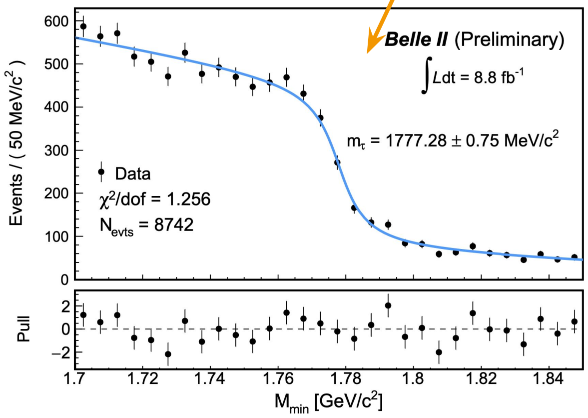
$$M_{min} = \sqrt{M_{3\pi}^2 + 2(E_{beam} - E_{3\pi})(E_{3\pi} - P_{3\pi})} \leq m_\tau$$



- Results:
  - bias in fit corrected using dedicated MC
  - the tau mass is measured in data:

m_τ = 1777.28 ± 0.75 (stat) ± 0.33 (syst) MeV

  - systematics already comparable with Belle and expected to improve further
  - Future: test of CPV in tau mass



Summary

- We're constantly improving our understanding of the detector
- Many systematics already comparable to Belle and BaBar
  - impressive since Belle II is still at an early stage
- Many more exciting results expected in the coming months and years!

- For more from Belle II see:

Dark Sector searches by Giacomo

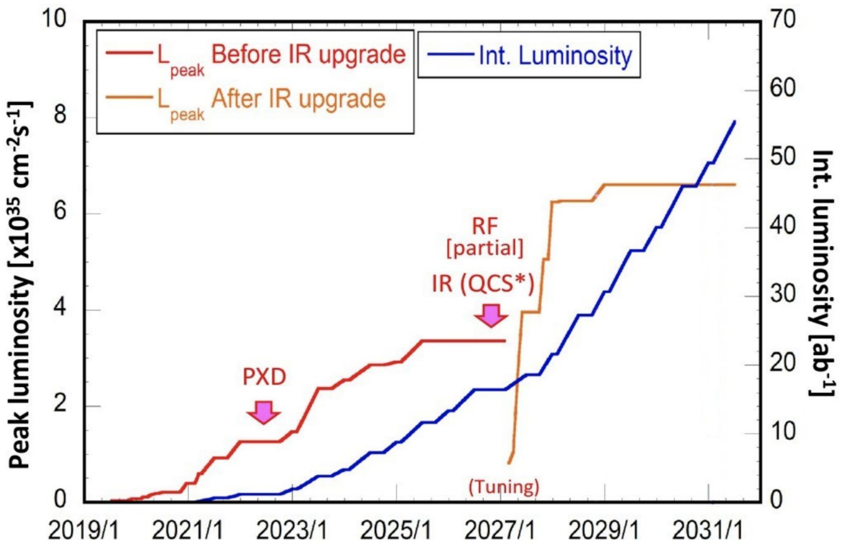
Search for $B^+ \rightarrow K^+ \nu\bar{\nu}$ by Filippo

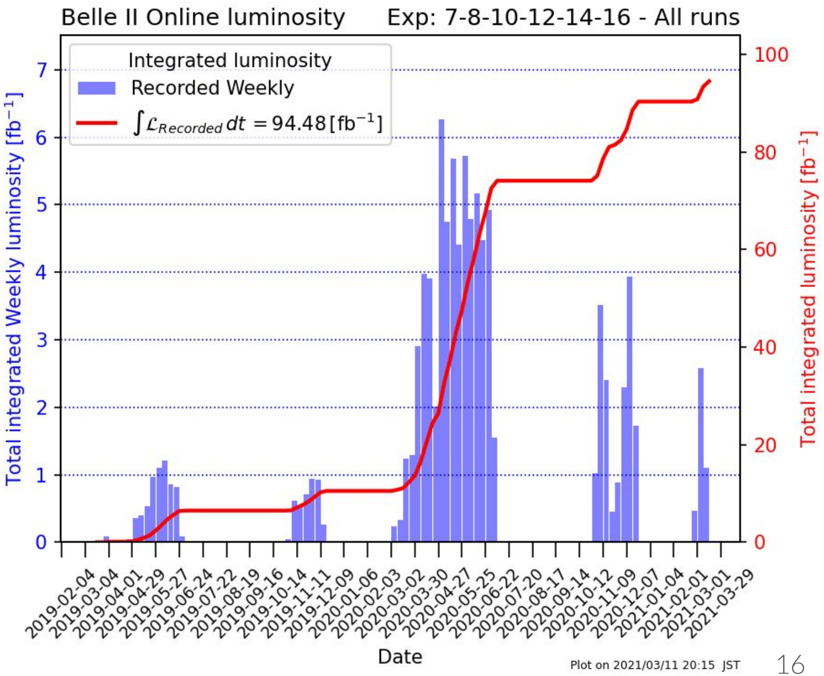
Thank you!

Backup

Luminosity status and plans

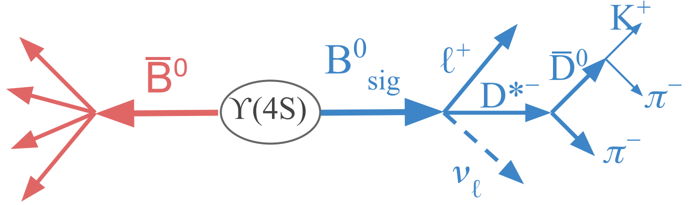
- Nearly 100/fb of data collected since 2019!
- Challenges in the pandemic:
  - data taking efficiency largely unaffected
  - thanks to extra remote shifts, socially distanced in-person ones
  - most importantly, super hard work from local colleagues





More on V_{cb} results:

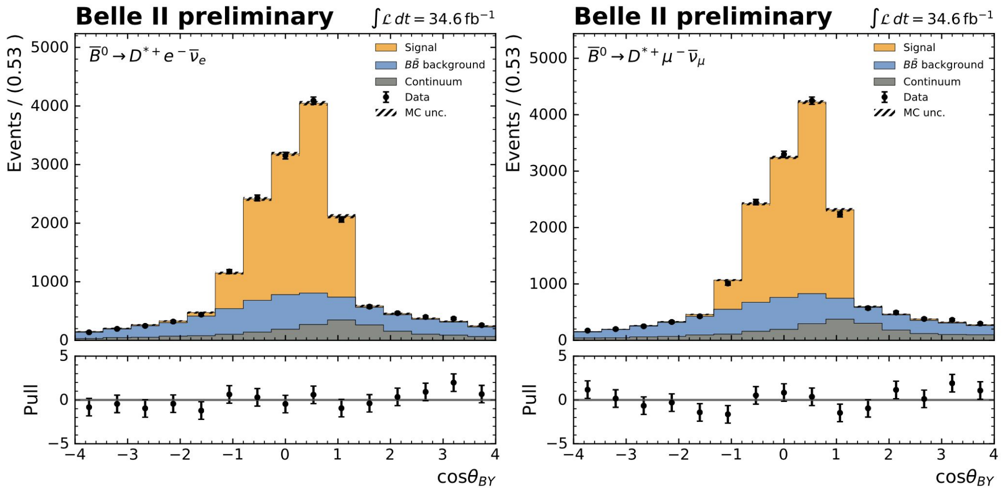
Exclusive $B^0 \to D^* \ell \nu$ (untagged)



[arXiv:2008.07198](https://arxiv.org/abs/2008.07198)

- Exclusively reconstruct the B−>D*$\ell\nu$ decay
  - first identify lepton using a PID algorithm
  - reconstruct D^0 from K and π
  - combine the D^0 with a π_s (slow pion)
- Continuum background suppression:
  - apply cuts on momentum of D* and ratio of the Fox-Wolfram moments (R_2)
- Signal yield
  - extracted by fitting cos(θ_{BY}) (Y: D*ℓ system)

$$\cos\theta_{BY} = \frac{2\,E_B^* E_Y^* - m_B^2 - m_Y^2}{2|p_B^*||p_Y^*|},$$



- Branching fraction measured as:

$$\mathcal{B}(\overline{B}^0 \to D^{*+}\ell^-\overline{\nu}_l) = (4.60 \pm 0.05_{\text{stat}} \pm 0.17_{\text{syst}} \pm 0.45_{\pi_s})\,\%\,,$$

- Ratio of μ and e BRs:
  - consistent with the SM expectation

$$R_{e\mu} = \frac{\mathcal{B}(\overline{B}^0 \to D^{*+}e^-\overline{\nu}_e)}{\mathcal{B}(\overline{B}^0 \to D^{*+}\mu^-\overline{\nu}_\mu)} = 0.99 \pm 0.03$$

Exclusive $B^0 \to D^*\ell\nu$ (untagged)

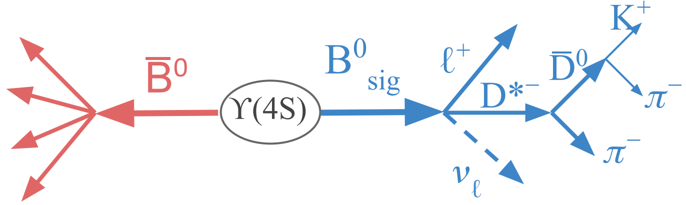
- Hadronic recoil parameter (w)

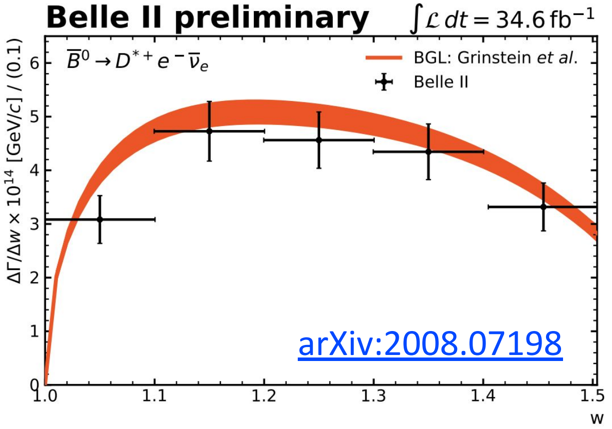
$$w = \frac{m_B^2 + m_{D^{*+}}^2 - q^2}{2m_B m_{D^{*+}}} = v_B \cdot v_{D^{*+}}$$

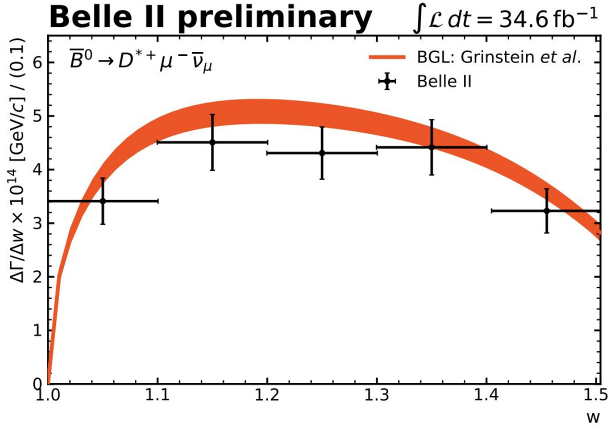
  - q: momentum transfer (B to D*)
  - partial branching fractions in bins of w
  - signal yields in each bin measured from the $\cos(\theta_{BY})$ fit
  - results unfolded to account for resolution and efficiency effects

- Important step towards precision measurements of $|V_{cb}|$

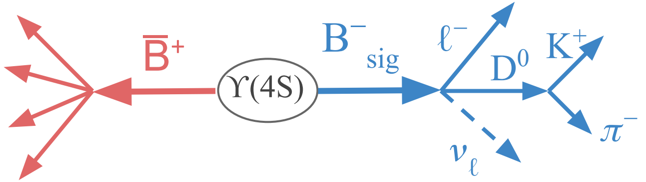
- Systematics:
  - dominated by tracking of slow pions.
  - expected to improve with larger control samples





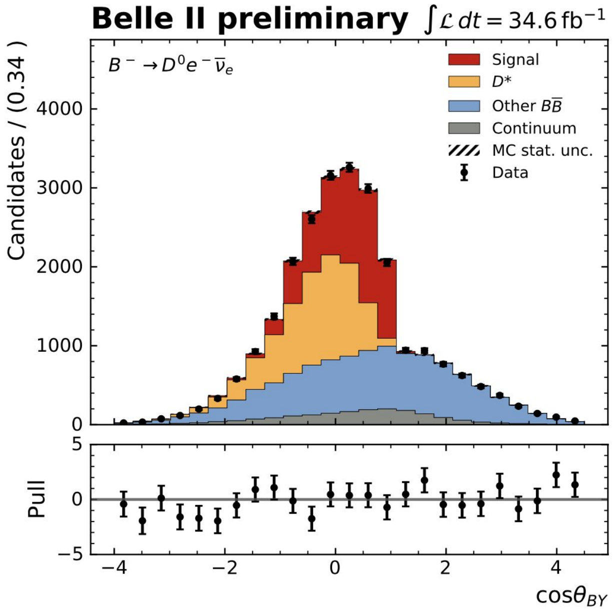


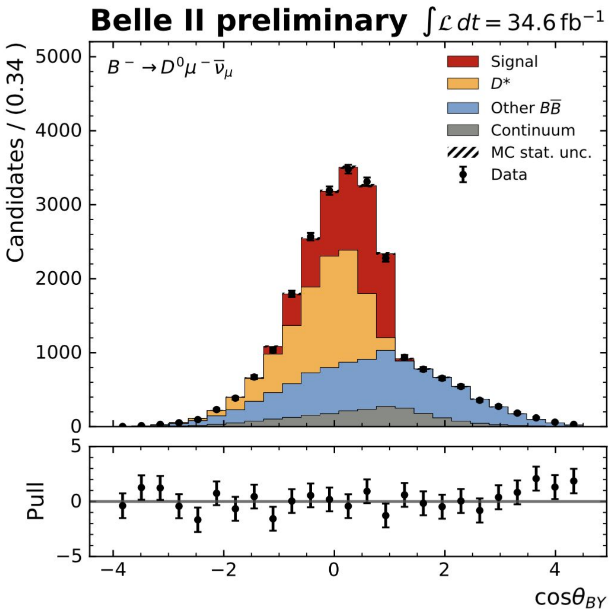
Exclusive $B^- \rightarrow D^0 \ell \nu$ search (untagged)



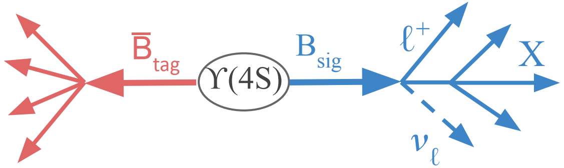
[arXiv:2008.07198](https://arxiv.org/abs/2008.07198)

- Similar to $B^0 \rightarrow D^* \ell \nu$
  - apply D* veto:
  - try to reconstruct D* from D^0 and a soft π
  - veto if mass compatible with D* mass
- Large background contamination from D*
- Good agreement between data and MC





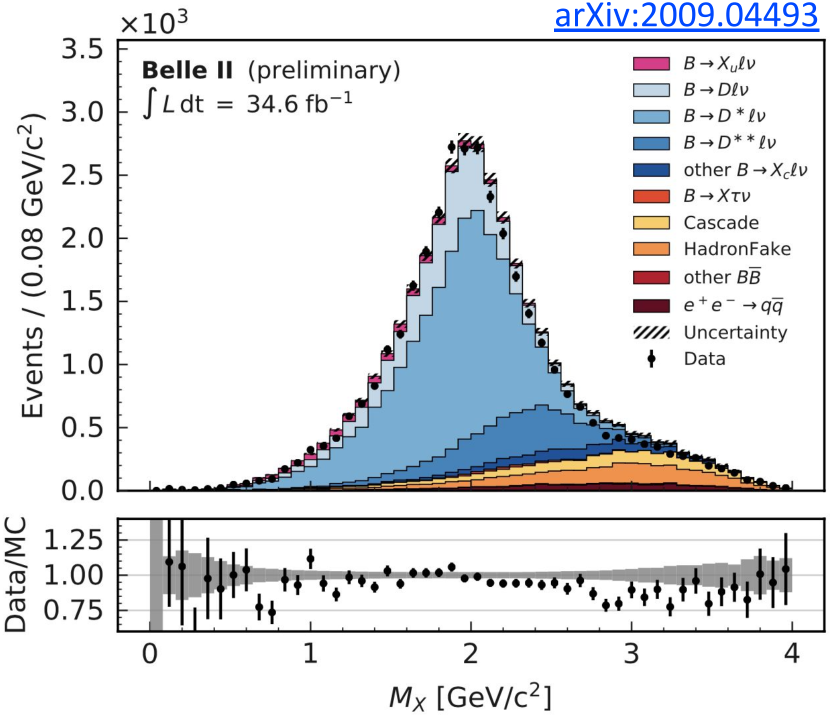
Inclusive $B \to X_c \ell\nu$: Hadronic Mass Moments



- Mass moments:
  - can be used to determine V_{cb} and m_b within the Heavy Quark Expansions (HQE) of QCD
- Reconstruction
  - Signal B selected using a high momentum lepton
  - Tag B fully reconstructed using *Full Event Interpretation*
  - X_c system defined as Rest of the Event (ROE)
- Background subtraction:
  - continuum suppression by a dedicated BDT
  - Signal probability estimated as a function of M_X
  - Verified in the background enriched $B^+\ell^+$, $B^-\ell^-$ control samples
- Extraction of moments
  - The mass moments are calculated using the weighted means of the M_x distributions. (weighted by the signal probability)
  - First need to calibrate M_x

$$\langle M_X^n \rangle = \frac{\sum_i w_i(M_X) M_{X,\mathrm{calib}\,i}^{\;n}}{\sum_i w_i(M_X)} \times \mathcal{C}_{\mathrm{calib}} \times \mathcal{C}_{\mathrm{true}}.$$

arXiv:2009.04493

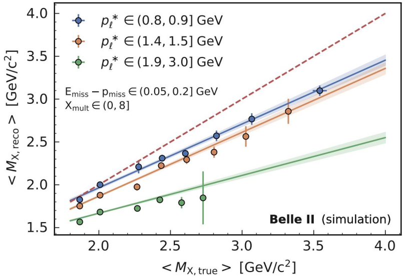


arXiv:2009.04493

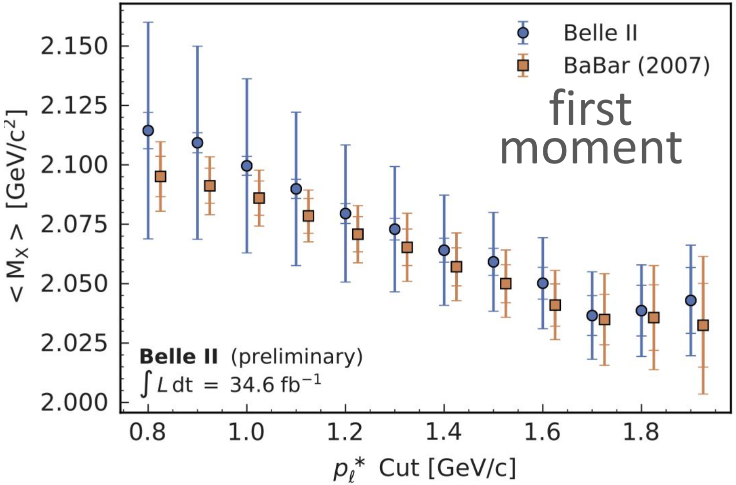
Inclusive B → $X_c \ell \nu$: Hadronic Mass Moments

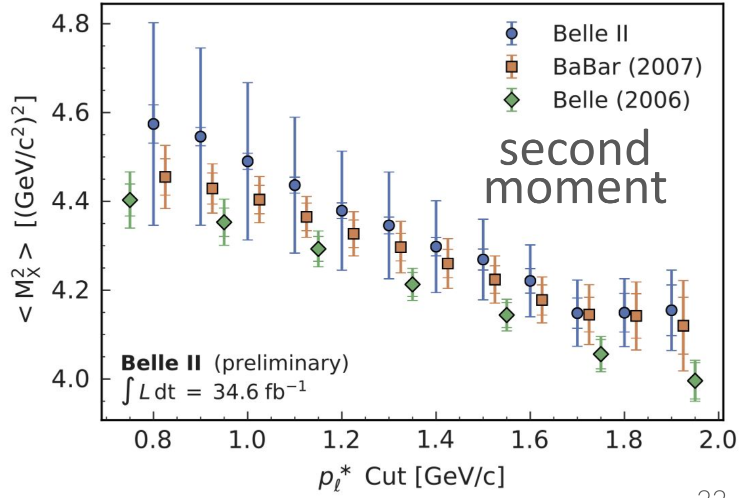
- Calibration of the M_x distribution:
  - corrected for resolution and reconstruction distortions
  - factors obtained from MC truth info
  - various kinematic bins ($p^*(\ell)$, multiplicity of the X system, difference of E_{miss} and p_{miss})

$$M^n_{X,\mathrm{calib}} = \frac{M^n_X - c(E_{\mathrm{miss}} - p_{\mathrm{miss}}, \mathrm{X}_{\mathrm{mult}}, p^*_\ell)}{m(E_{\mathrm{miss}} - p_{\mathrm{miss}}, \mathrm{X}_{\mathrm{mult}}, p^*_\ell)}$$



⇒ moments compatible with Belle and BaBar results (here shown first two. The first sixt moments in the backup)

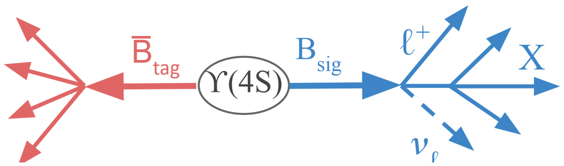




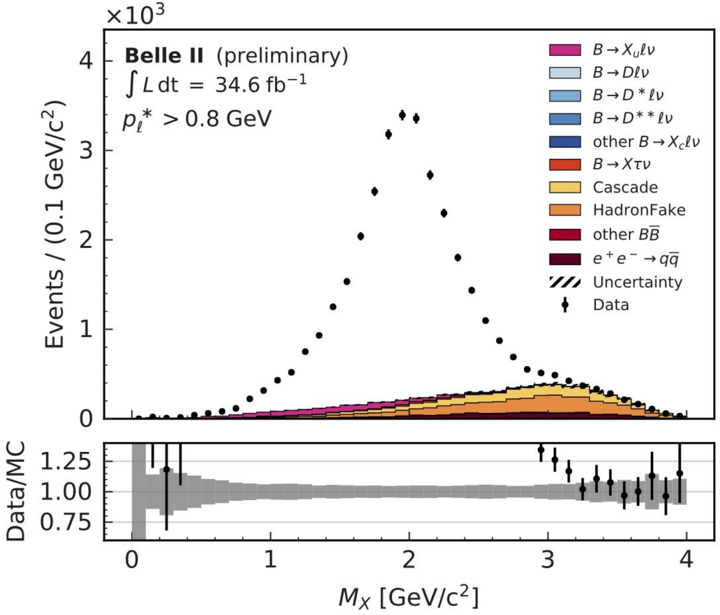
...Related upcoming analysis: measurement of q^2 moments

- alternative method based on arXiv:1812.07472
- reduce model dependence and include corrections up to $1/m_b^4$

Hadronic Mass Moments: Background subtraction



[arXiv:2009.04493](https://arxiv.org/abs/2009.04493)



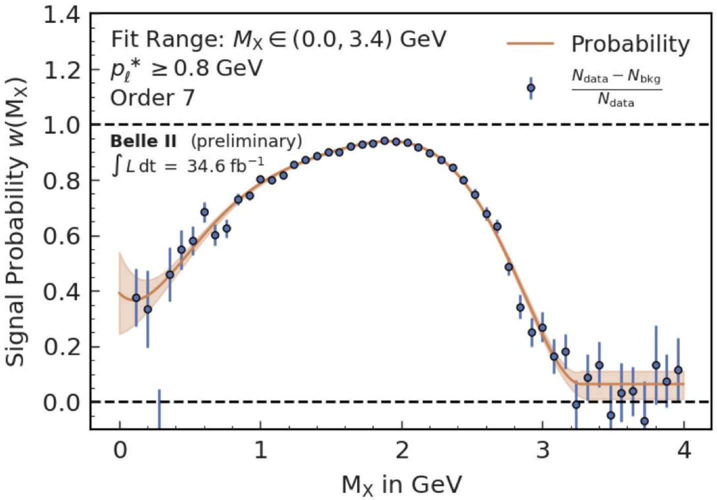
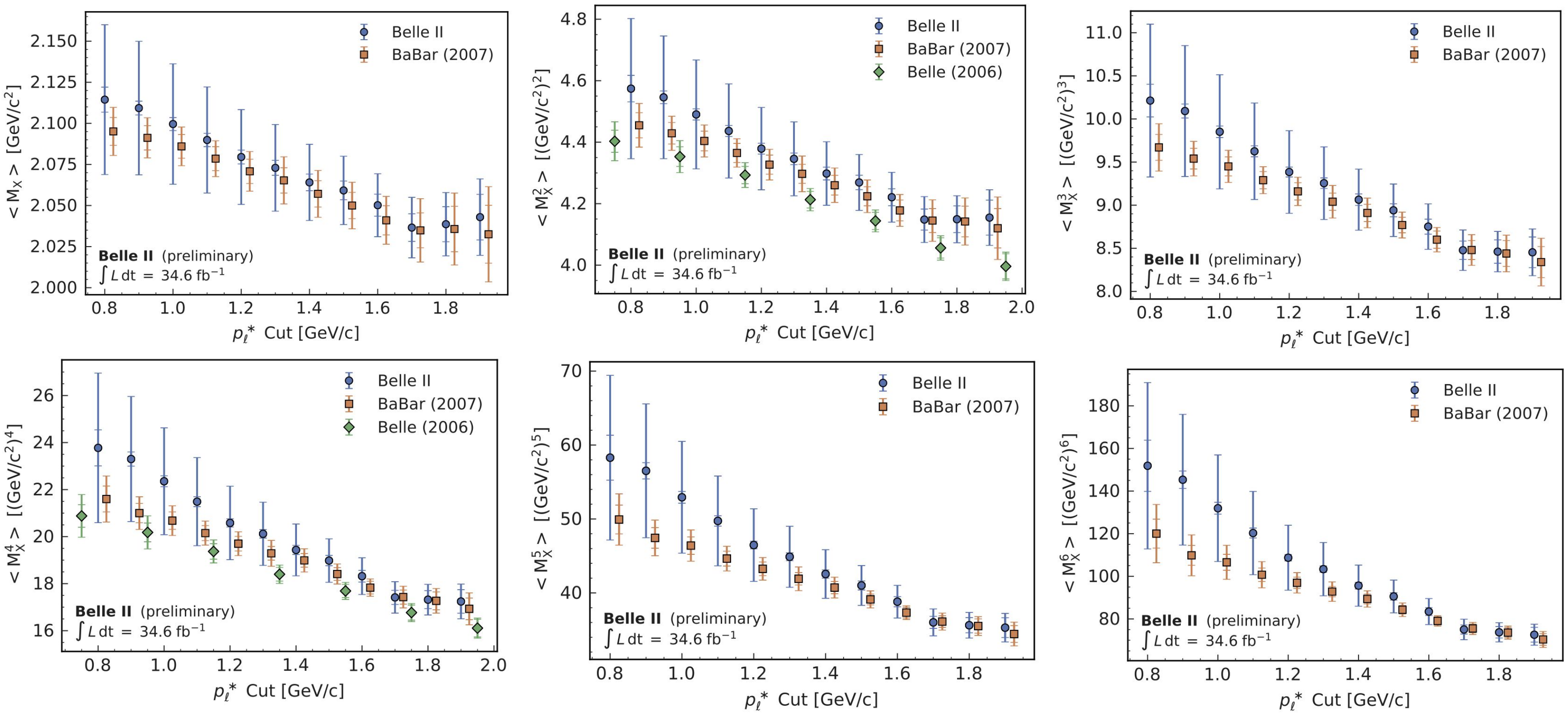


FIG. 3: The left column shows the M_X distribution in data and background MC (normalized to the events in data) for $p_\ell^* > 0.8\,\mathrm{GeV}/c$. The corresponding background subtraction factors w_i are shown in the right column together with a fitted Legendre polynomial of degree 7. If the fit has a minimum at the left or right tail, the polynomial is replaced with a constant value. The uncertainties are from statistical uncertainties only.

Hadronic Mass moments

arXiv:2009.04493



Rediscovery of $B \longrightarrow \eta' K$

New from Belle II

Rediscovery of B⟶ η' K

invariant mass distribution of **η'**

Systematics:

TABLE 2. Summary of systematics uncertainties (in %) by category and channel.

Channel	$B^\pm \to \eta' K^\pm$	$B^0 \to \eta' K^0_S$	$B^\pm \to \eta' K^\pm$	$B^0 \to \eta' K^0_S$
Source	$\eta' \to \eta\pi^+\pi^-$		$\eta' \to \rho\gamma$	
Tracking efficiency	2.1	2.8	2.1	2.8
Photon efficiency	0.5	0.5	0.5	0.5
K^0_S efficiency	-	4.5	-	4.5
$\pi^\pm$ PID	-	-	2.4	2.4
$K^\pm$ PID	2.5	-	2.5	-
Cont. supp. modelling	5.0	1.0	5.5	2.3
SxF fraction	2.6	1.8	5.9	3.2
N($B\bar{B}$)		1.4		
Total	6.6	5.9	9.1	7.2

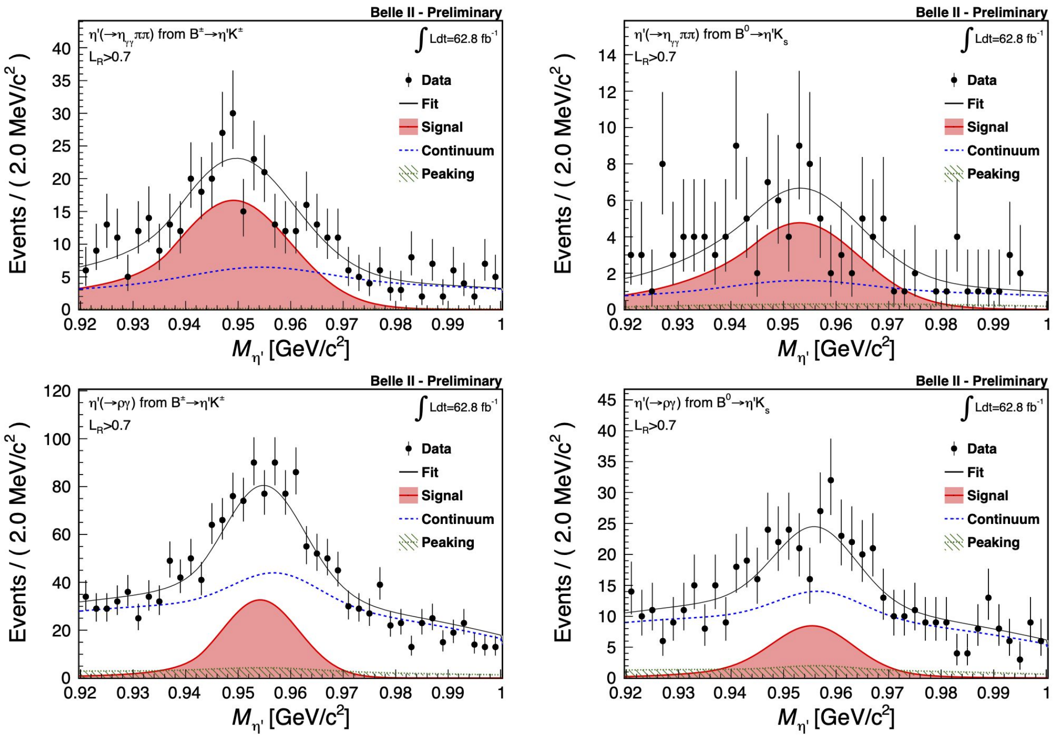
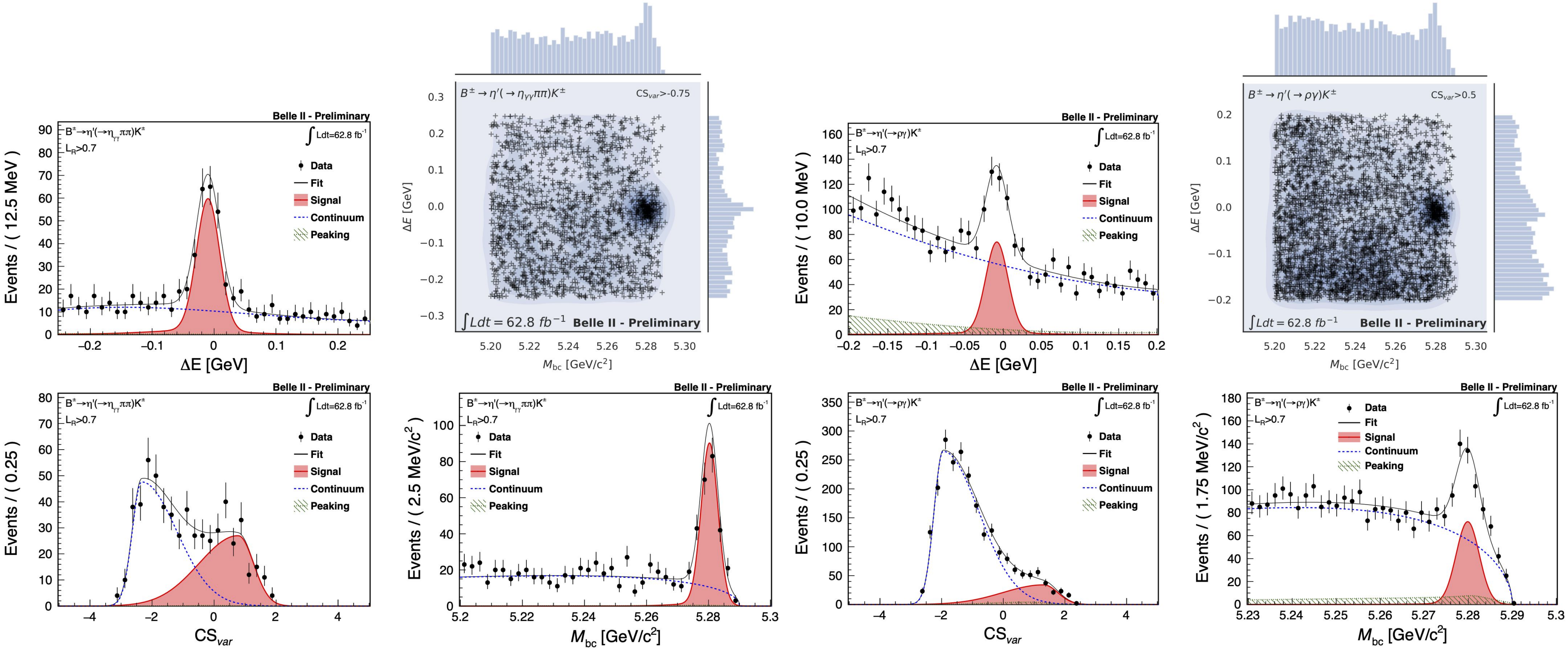


FIG. 6. Distribution of invariant mass of η', without any mass constraint, for the four channels in the signal-enriched region ($\mathcal{L}_R > 0.7$).

New from Belle II

Rediscovery of B⟶ η’ K

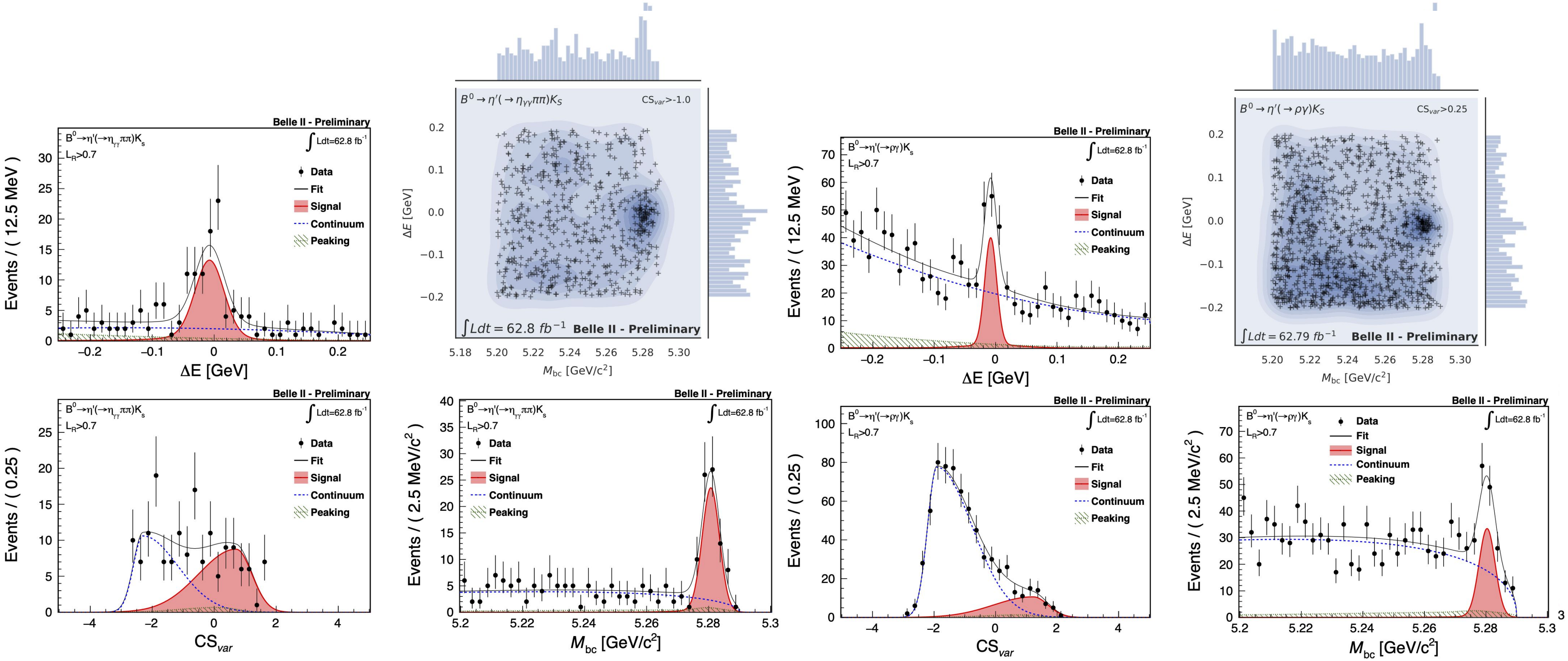
Fit results: $B^{\pm}$⟶ η’ $K^{\pm}$



New from Belle II

Rediscovery of B→ η’ K

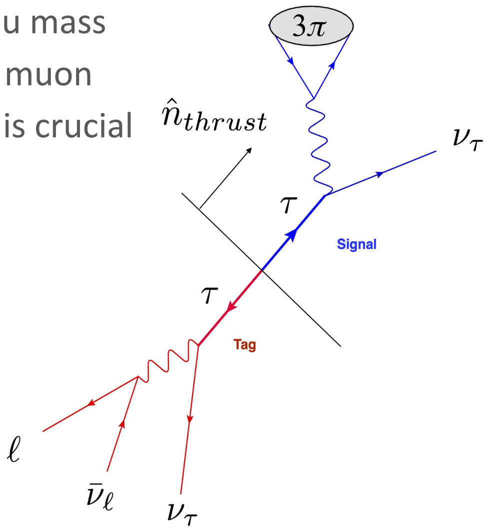
Fit results: $B^0 \rightarrow \eta' K^0$

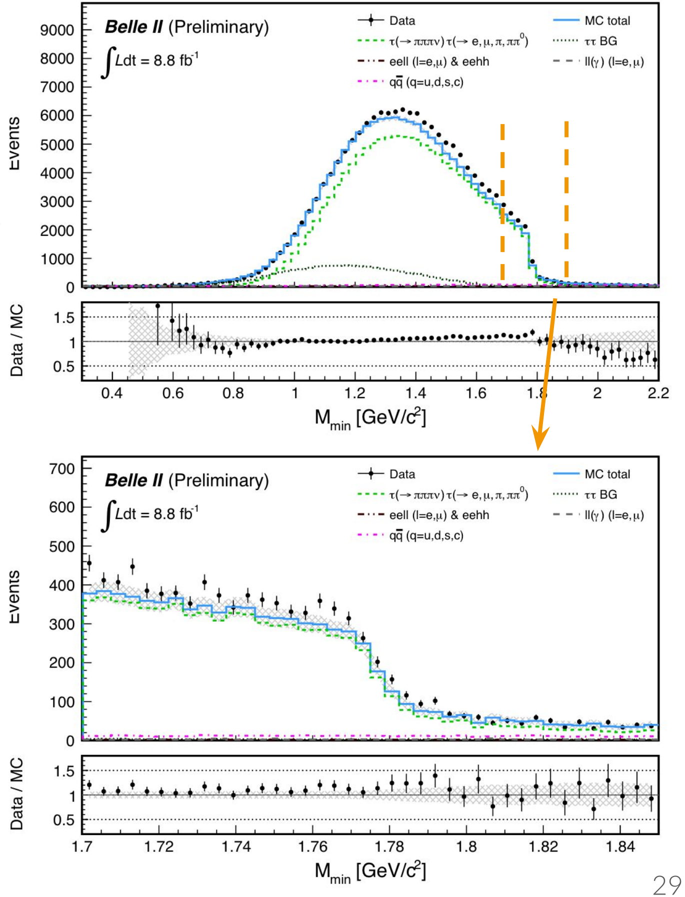


Tau lepton mass measurement:

- Motivation:
  - ~10^3 worse relative precision in tau mass compared to that of electron and muon
  - A precise tau mass measurement is crucial for lepton universality tests of SM
- Topology:
  - 3x1 decays of the τ are used
  - signal: $\tau^- \to \pi^+\pi^-\pi^+\nu_\tau$
  - tag: $\tau^- \to \ell\nu_\ell\nu_\tau, \pi^-\nu_\tau, \pi^-\pi^0\nu_\tau$
- Pseudomass variable (M_{min}) :
  - calculated from 4-momentum of the 3π system
  - kinematic edge exploited to extract the mass:

$$M_{min} = \sqrt{M_{3\pi}^2 + 2(E_{beam} - E_{3\pi})(E_{3\pi} - P_{3\pi})} \leq m_\tau$$

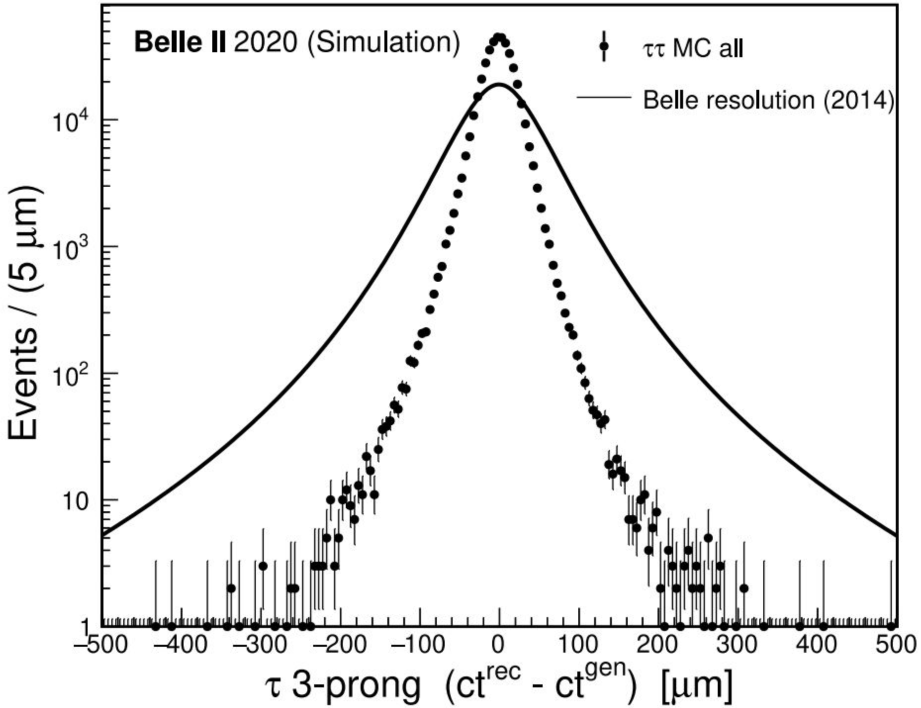




Bonus:

Tau lifetime proper-time resolution

Stefano Moneta (EPIPHANY 2021)



Belle II → Factor ≃2 narrower

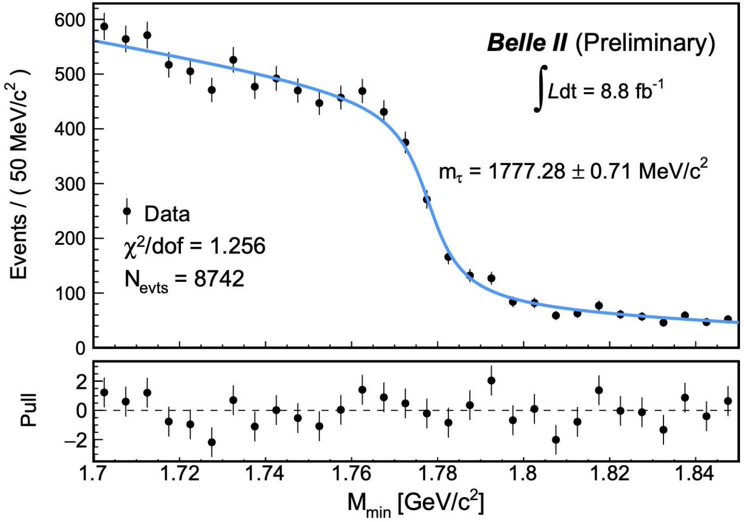
Extracting the mass:

- Mass extracted using an unbinned ML fit
    - An empirical edge function used:

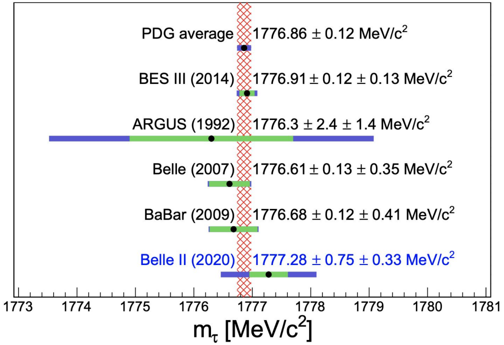
$$F(M_{min}|\vec{P}) = (P_3 + P_4 \cdot M_{min}) \cdot tan^{-1}(\frac{M_{min}-P_1}{P2}) + P_5 \cdot M_{min} + 1$$

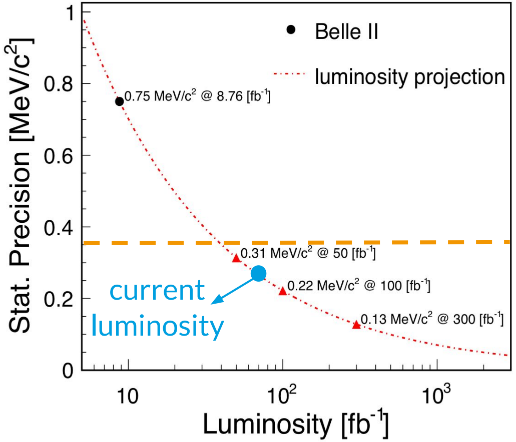
    - The bias in the fit is estimated from dedicated MC
    - The tau mass is measured in data:

m_τ = 1777.28 ± 0.75 (stat) ± 0.33 (syst) MeV



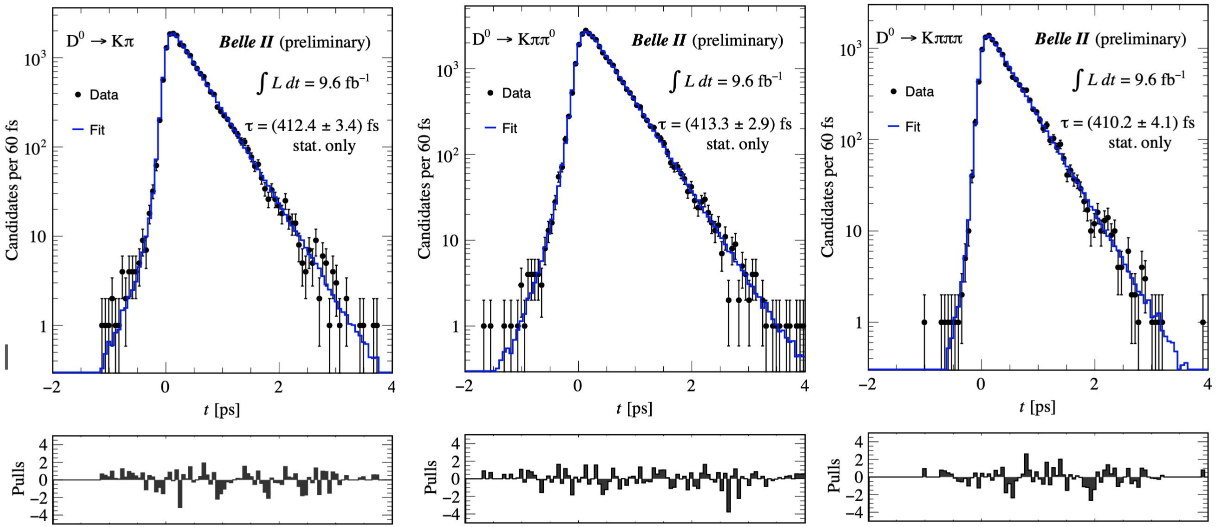
- Systematics:
    - similar to previous measurement using this method
    - dominated by tracking corrections
    - expected to improve as we gain better understanding of the detector
- Future:
    - Expect to achieve the best precision using the pseudomass technique
    - Eventually perform CPV test as well





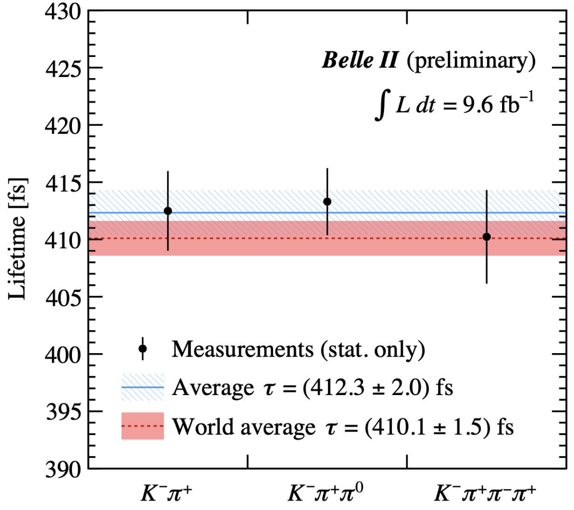
D^0 lifetime

- Lifetime extracted with a fit:
  - unbinned 2D ML fit
  - decay-time (t) and decay-time uncertainty (σ_t)
  - PDF: convolution of exponential function and a resolution function.



- Average of the three channels:

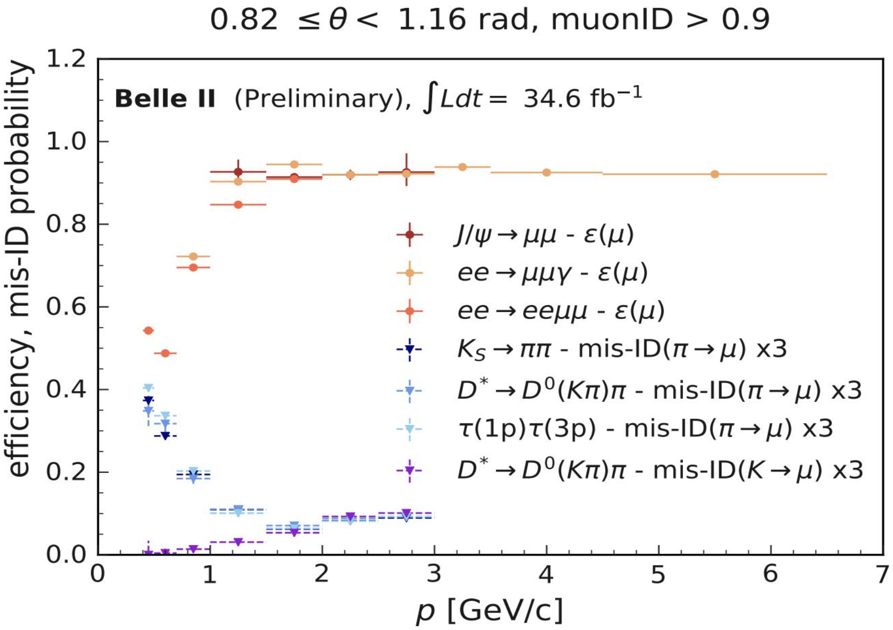
$\tau(D^0)$ = 412.3 ± 2.0 fs (stat. only)

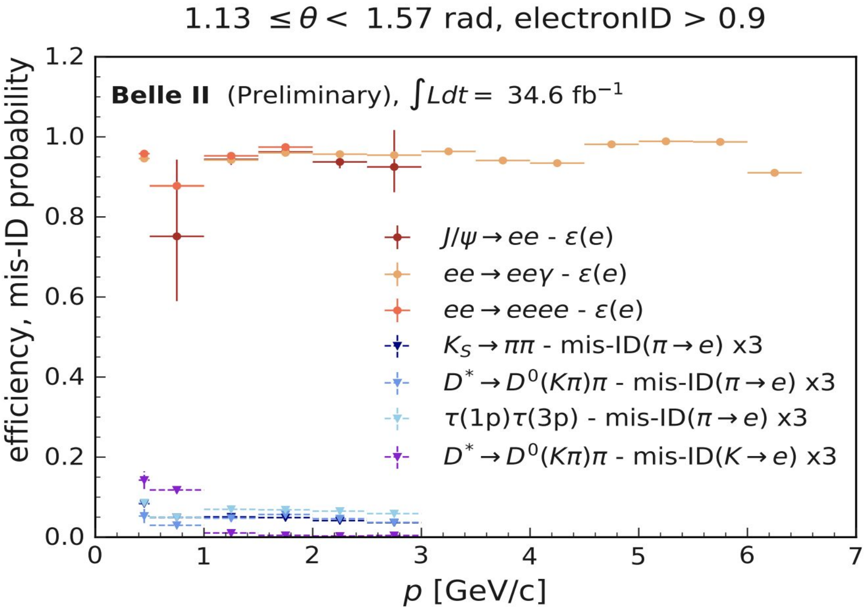


Lepton ID

[BELLE2-NOTE-PL-2020-027]

- electron and muon identification efficiencies measured in data

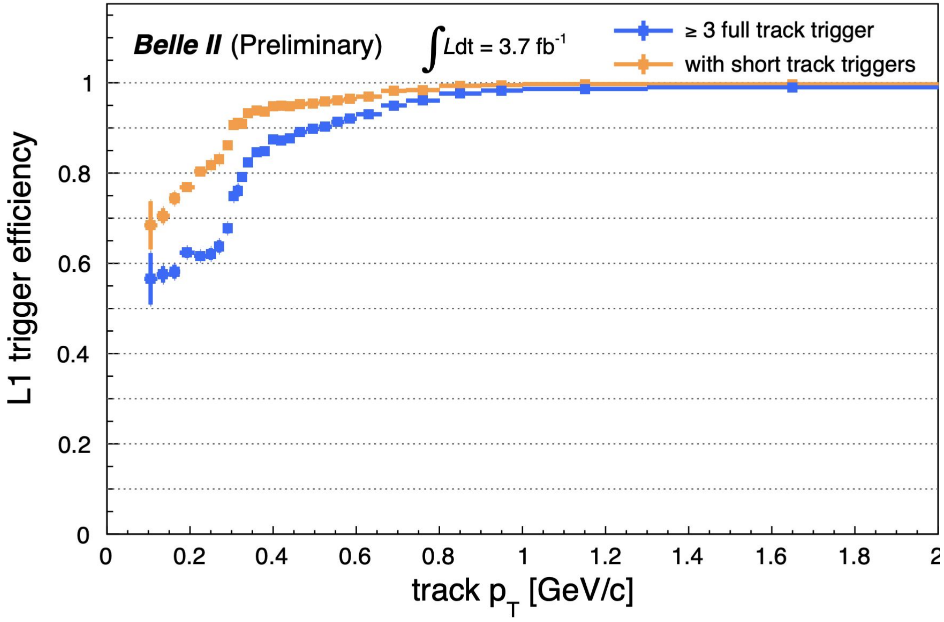


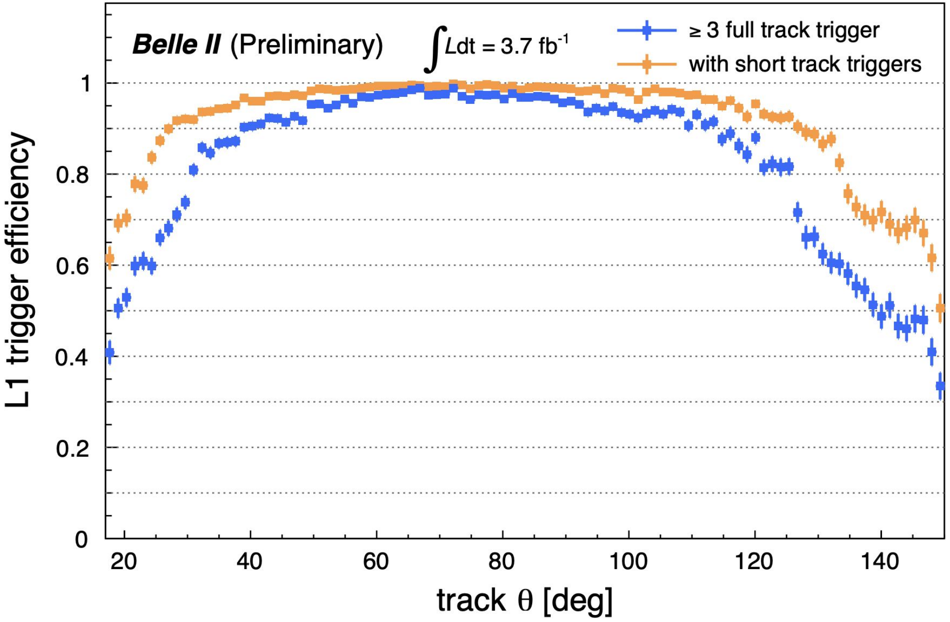


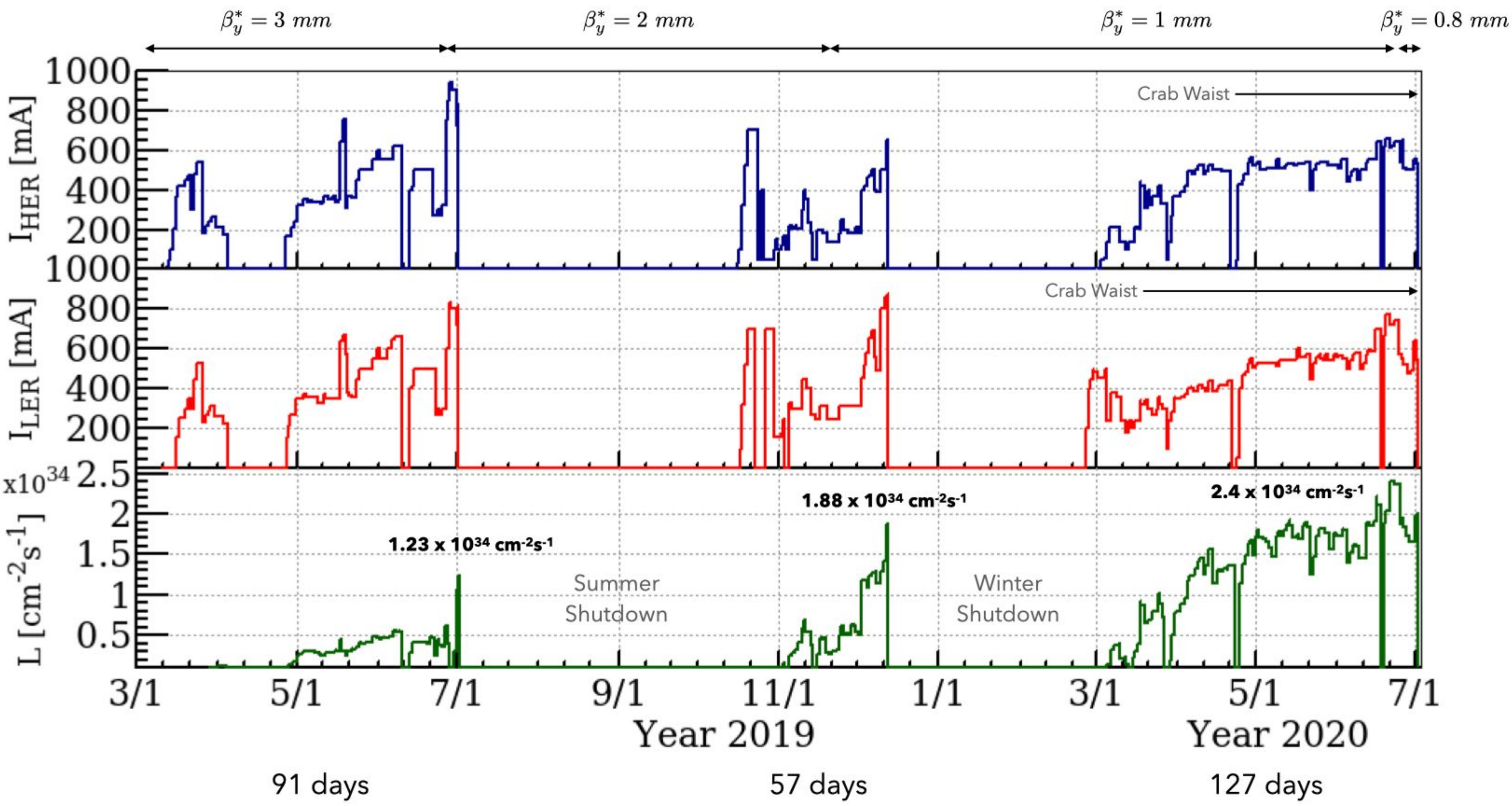
Trigger Efficiency

- Measured in 3x1 tau decays:
  - CDC track trigger efficiencies measured w.r.t to ECL trigger

BELLE2-NOTE-PL-2020-015







$\beta_y^* = 3\ mm$
$\beta_y^* = 2\ mm$
$\beta_y^* = 1\ mm$
$\beta_y^* = 0.8\ mm$
Crab Waist
I_{HER} [mA]
Crab Waist
I_{LER} [mA]
$L\ [cm^{-2}s^{-1}]$ x10^{34}
1.23 x 10^{34} $cm^{-2}s^{-1}$
1.88 x 10^{34} $cm^{-2}s^{-1}$
2.4 x 10^{34} $cm^{-2}s^{-1}$
Summer Shutdown
Winter Shutdown
3/1 5/1 7/1 9/1 11/1 1/1 3/1 5/1 7/1
Year 2019
Year 2020
91 days
57 days
127 days

SuperKEKB designed machine parameters

Machine Parameters

2017/September/1	LER	HER	unit	
E	4.000	7.007	GeV	
I	3.6	2.6	A	
Number of bunches	2,500			
Bunch Current	1.44	1.04	mA	
Circumference	3,016.315		m	
$\varepsilon_x/\varepsilon_y$	3.2(1.9)/8.64(2.8)	4.6(4.4)/12.9(1.5)	nm/pm	():zero current
Coupling	0.27	0.28		includes beam-beam
β_x^*/β_y^*	32/0.27	25/0.30	mm	
Crossing angle	83		mrad	
α_p	3.20×10^{-4}	4.55×10^{-4}		
σ_δ	$7.92(7.53)\times10^{-4}$	$6.37(6.30)\times10^{-4}$		():zero current
V_c	9.4	15.0	MV	
σ_z	6(4.7)	5(4.9)	mm	():zero current
ν_s	-0.0245	-0.0280		
ν_x/ν_y	44.53/46.57	45.53/43.57		
U_0	1.76	2.43	MeV	
$\tau_{x,y}/\tau_s$	45.7/22.8	58.0/29.0	msec	
ξ_x/ξ_y	0.0028/0.0881	0.0012/0.0807		
Luminosity	8×10^{35}		$cm^{-2}s^{-1}$	