Recent Results from Belle & Belle II experiments

Cristina Martellini on behalf of the Belle & Belle II collaborations

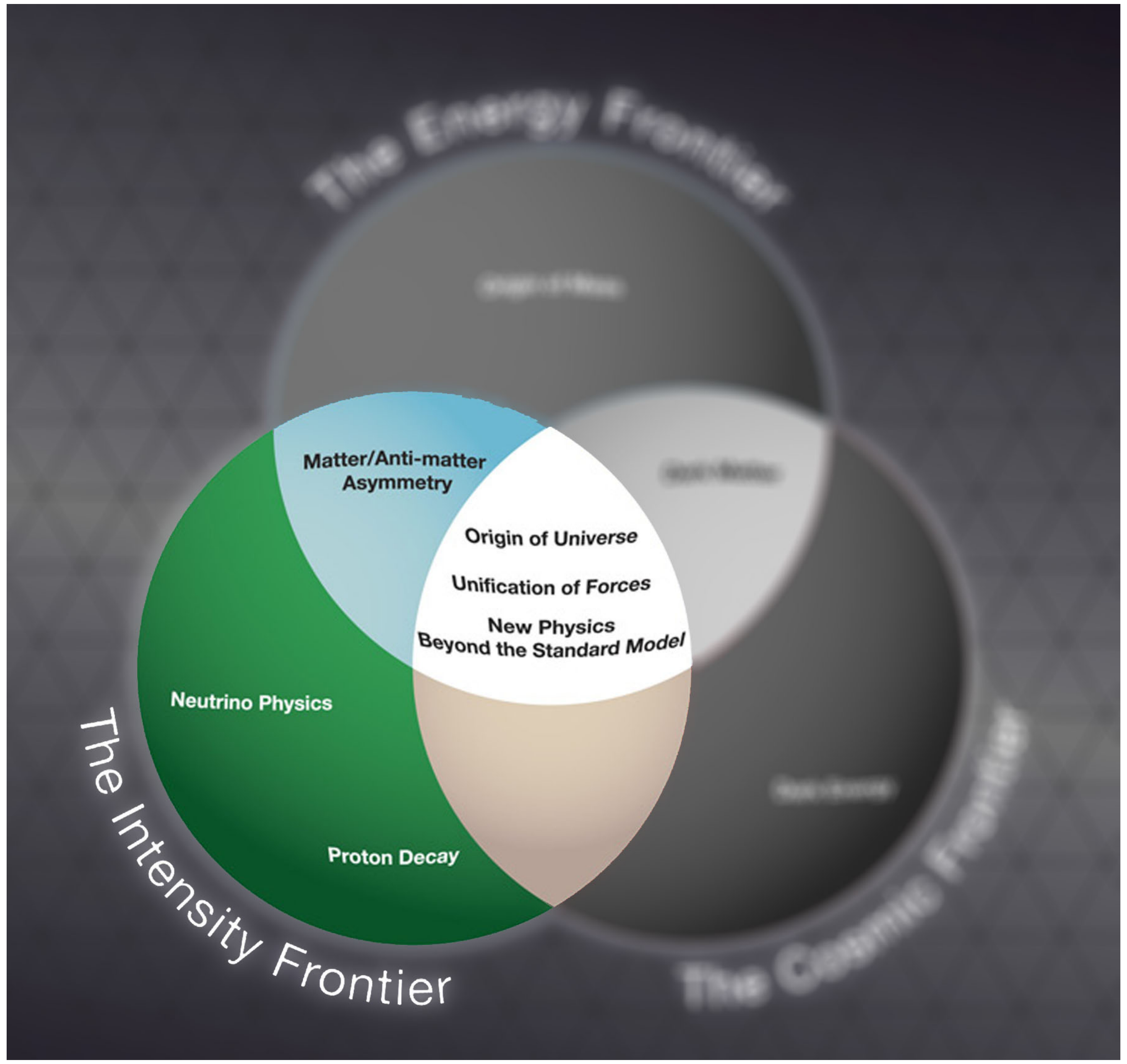
Beyond the SM physics

Open question unexplained by SM → New Physics beyond the SM

Belle & Belle II operates at the "Intensity Frontier"

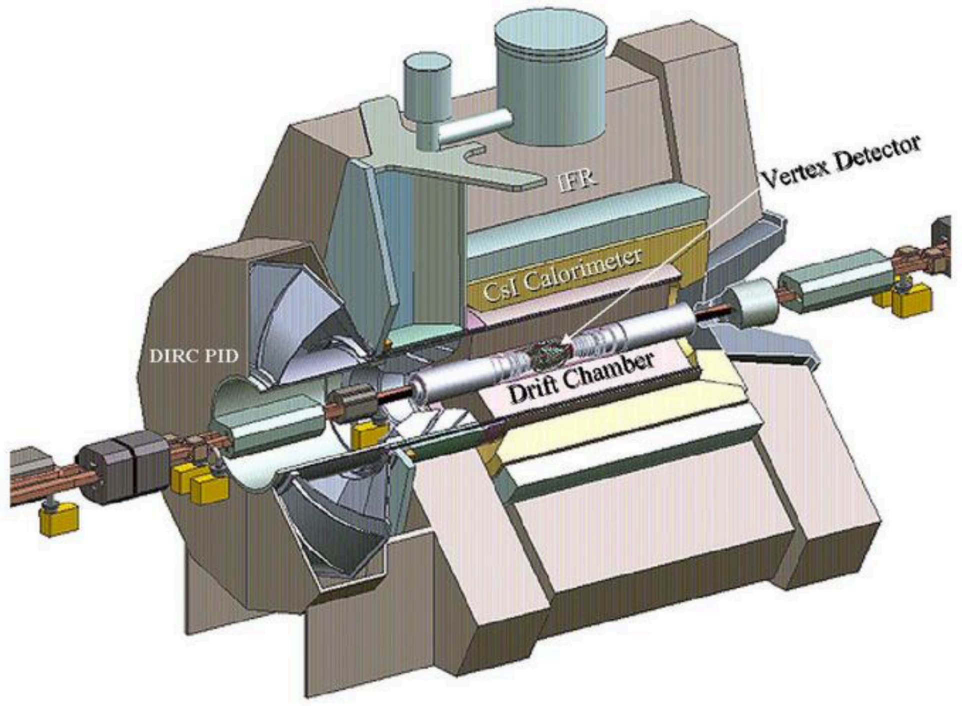
High precision measurements , probing SM indirectly

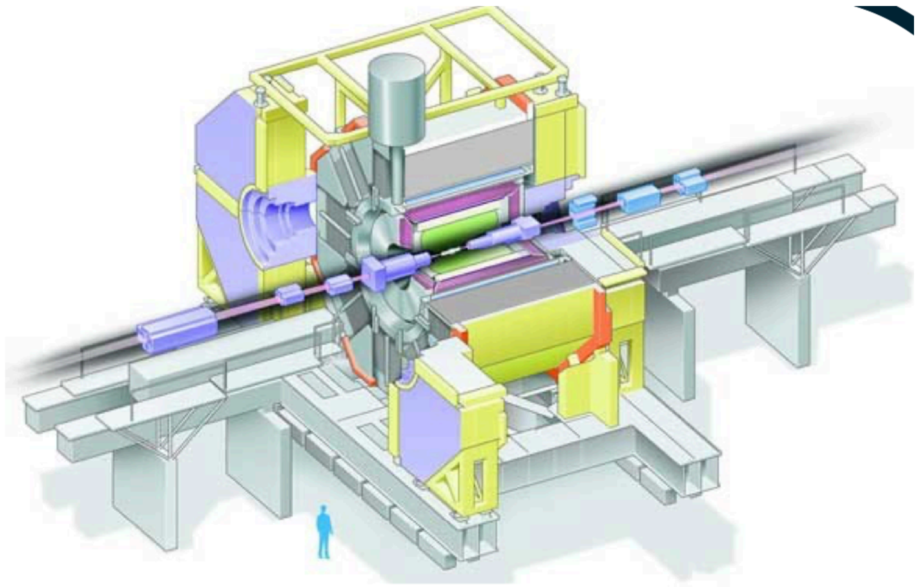
- as measurements of the SM-forbidden or suppressed process

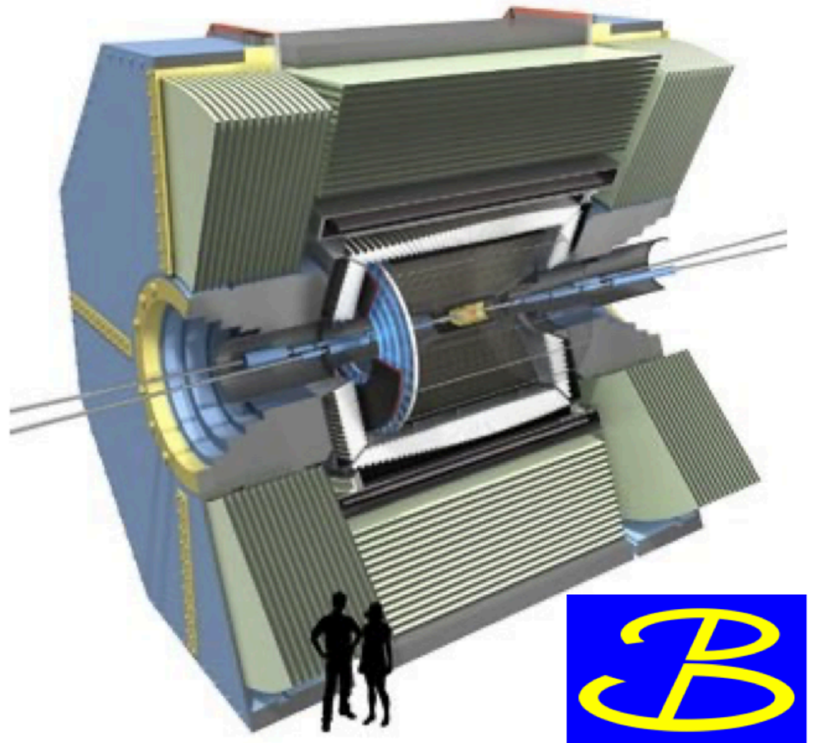


B-factories:

e^+e^- collider @ $\Upsilon(4S) \rightarrow B\bar{B}$







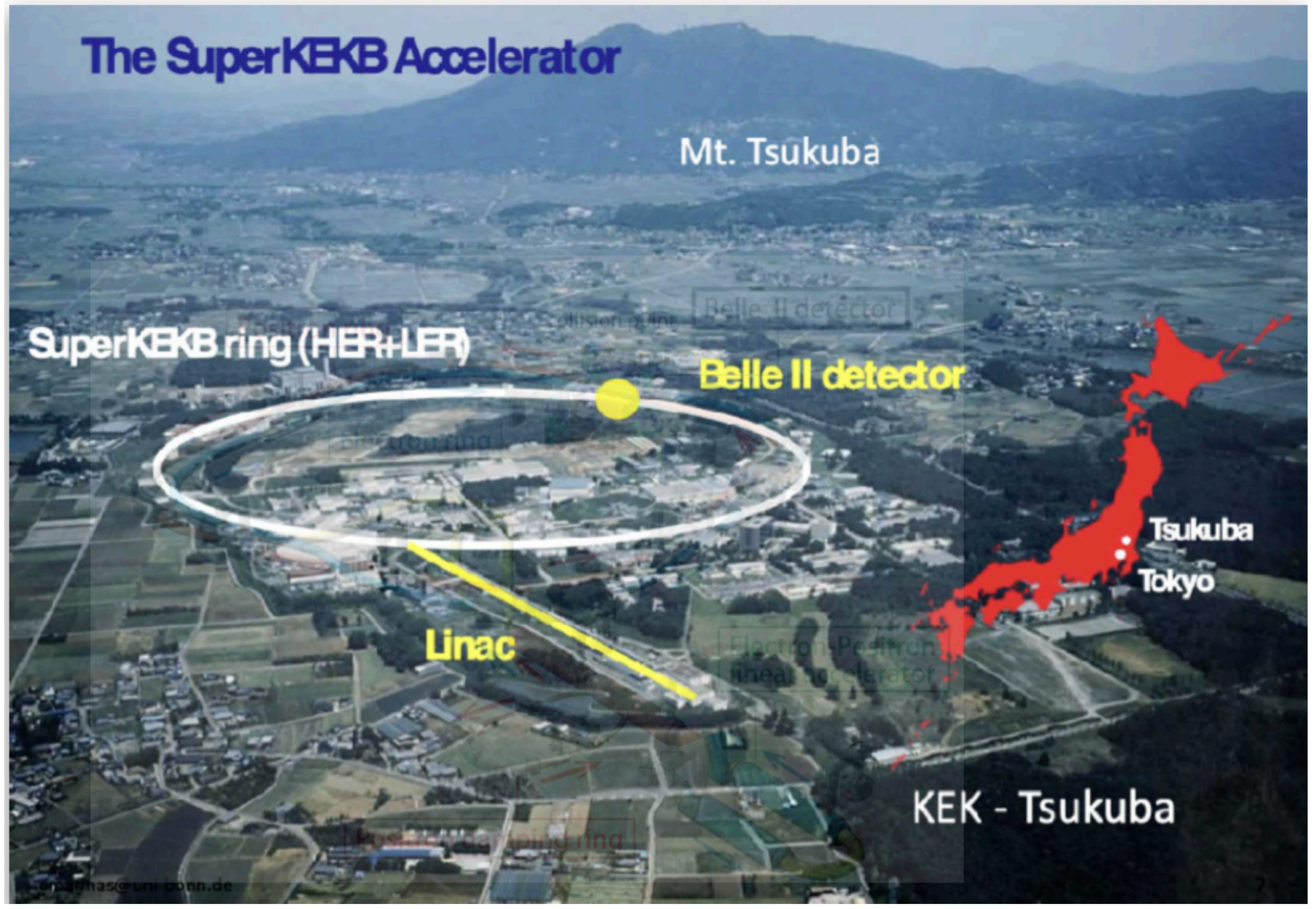
SLAC-PEP II collider : 462 fb^{-1} @ $\Upsilon(4S)$ [1999-2008]

KEKB collider : 711 fb^{-1} @ $\Upsilon(4S)$ [1999-2010]

SuperKEKB collider : 530 fb^{-1} @ $\Upsilon(4S)$ [2019-current]

KEK-SUPERKEKB complex

- Asymmetric e^+e^- colliders
- Collisions mainly at 10.58 GeV , i.e at $\Upsilon(4S)$ resonance



KEKB

1999-2010

- e^+ (3.5 GeV) e^-(8 GeV)
- L_{peak}: $2.1 \times 10^{34}\ cm^{-2}s^{-1}$ [achieved]

SuperKEKB

2019-current

- e^+ (4 GeV) e^-(7 GeV)

Target:

$$\int Ldt = 50\ \ ab^{-1}$$

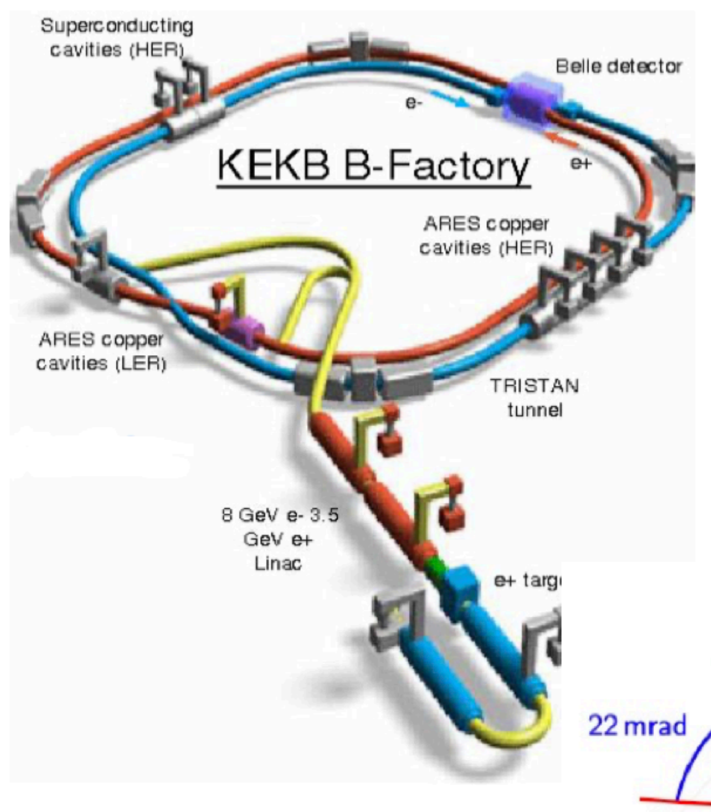
$$L_{peak} = 6 \times 10^{35}\ \ cm^{-2}s^{-1}$$

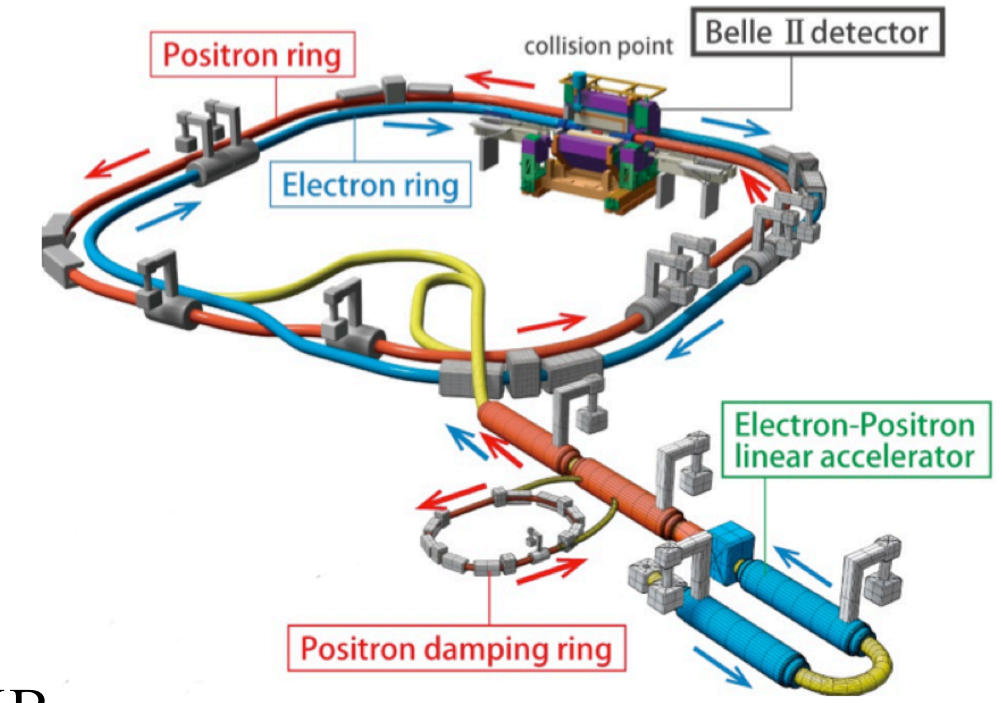
Achieved:

$$\int Ldt > 530\ \ fb^{-1}$$

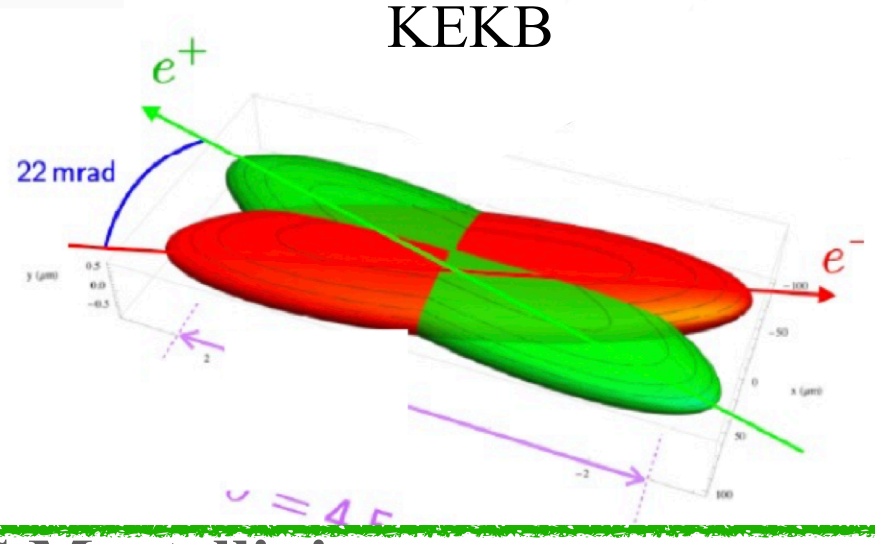
$$L_{peak} = 4.7 \times 10^{34}\ \ cm^{-2}s^{-1}$$

Current world record

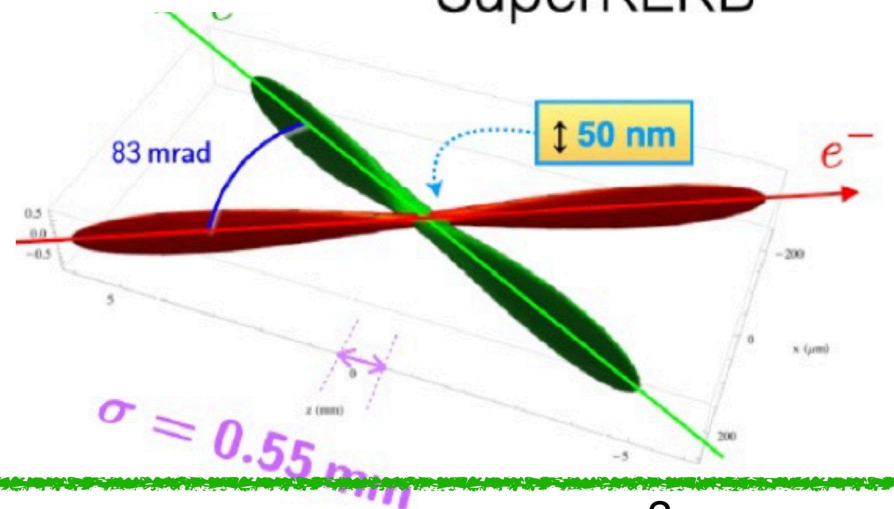




KEKB



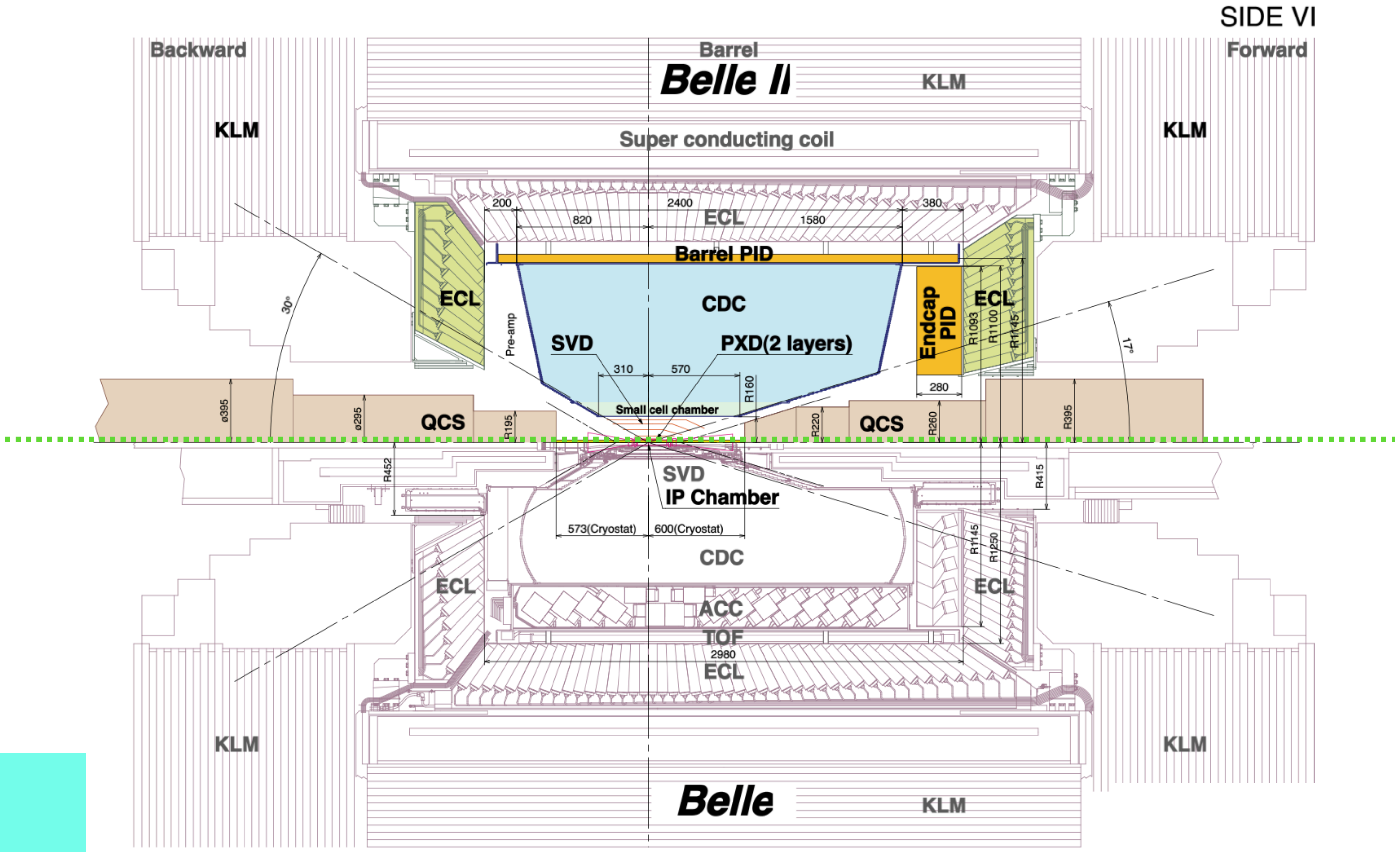
SuperKEKB



Belle & Belle II detectors

PID (**Particle Identification**): Better K/π separation under higher bkg level

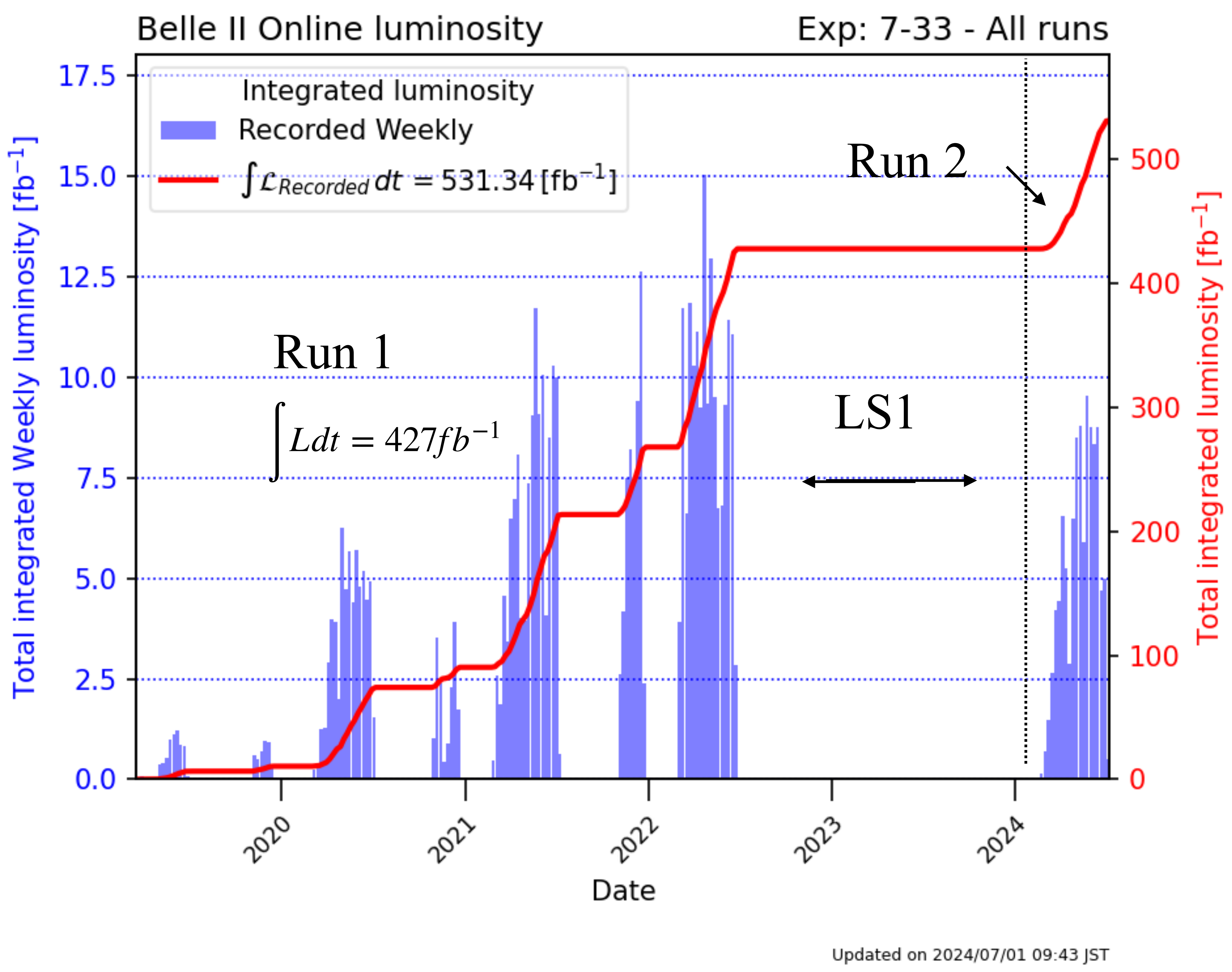
VTX: + 2 layers PXD (pixel detector)
+ 4 layers SVD (Silicon vertex detector)



[Belle II TDR](#)

- Well-known **initial state** condition
- Benefits from **clean environment**
- Efficient reconstruction of **neutrals**
- Boosted center of mass that allows for time-dependent measurements
- Hermetic detectors ⟶ ideal for studying neutral or invisible decays

Belle II data -taking



We are suffering from **sudden beam loss events**, with large doses at the interaction region.

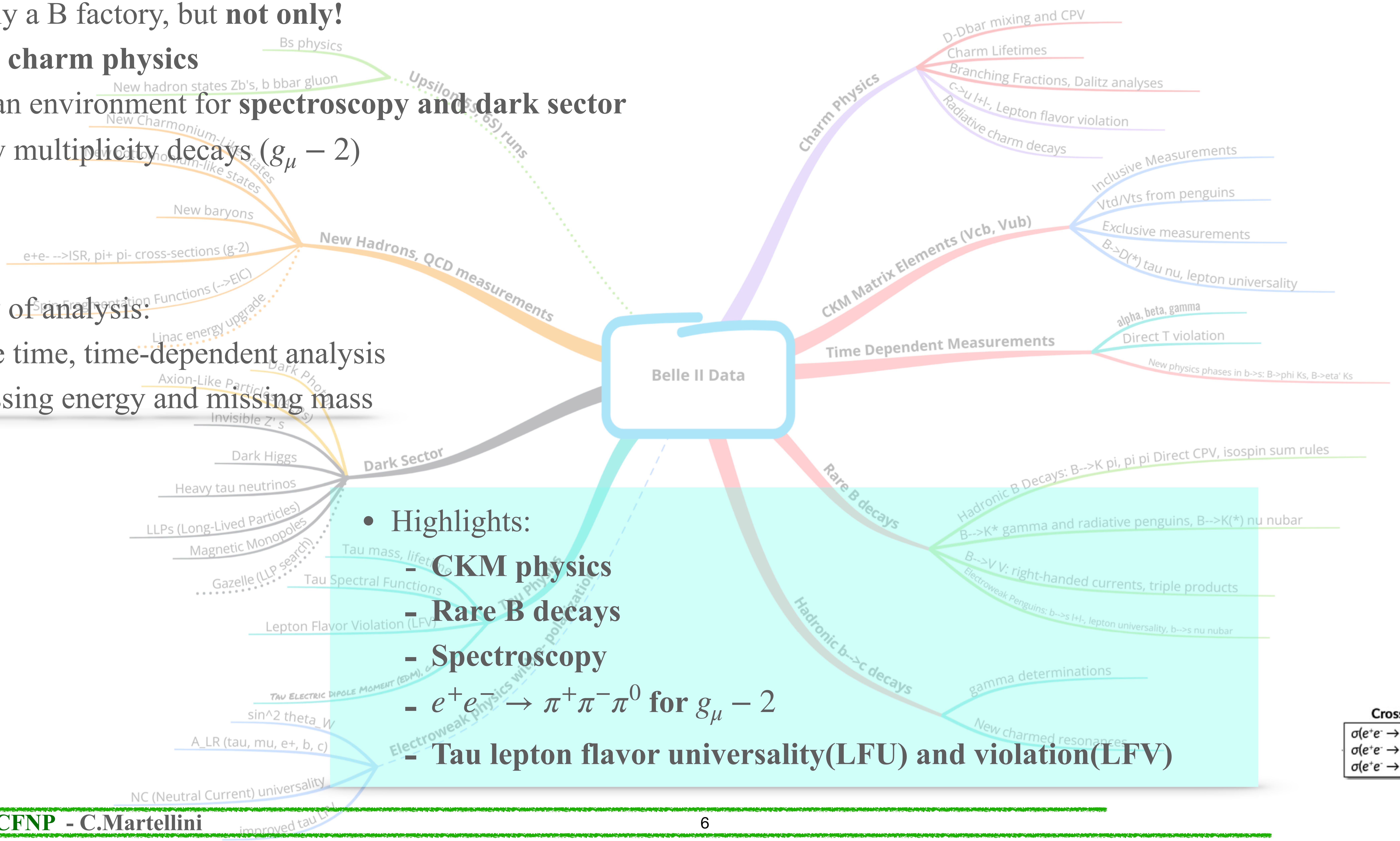
In a couple of them two channels of **PXD were damaged**

- as a precaution, it has been decided to **keep PXD off** while investigating the sources of the sudden beam loss and implement countermeasures to stabilize the beam operation

Belle & Belle II Physics Program

- Primarily a B factory, but **not only!**
  - **tau, charm physics**
  - Clean environment for **spectroscopy and dark sector**
  - Low multiplicity decays ($g_\mu - 2$)

- Variety of analysis:
  - Life time, time-dependent analysis
  - Missing energy and missing mass



- Highlights:
  - **CKM physics**
  - **Rare B decays**
  - **Spectroscopy**
  - $e^+e^- \to \pi^+\pi^-\pi^0$ **for** $g_\mu - 2$
  - **Tau lepton flavor universality(LFU) and violation(LFV)**

Cross sections

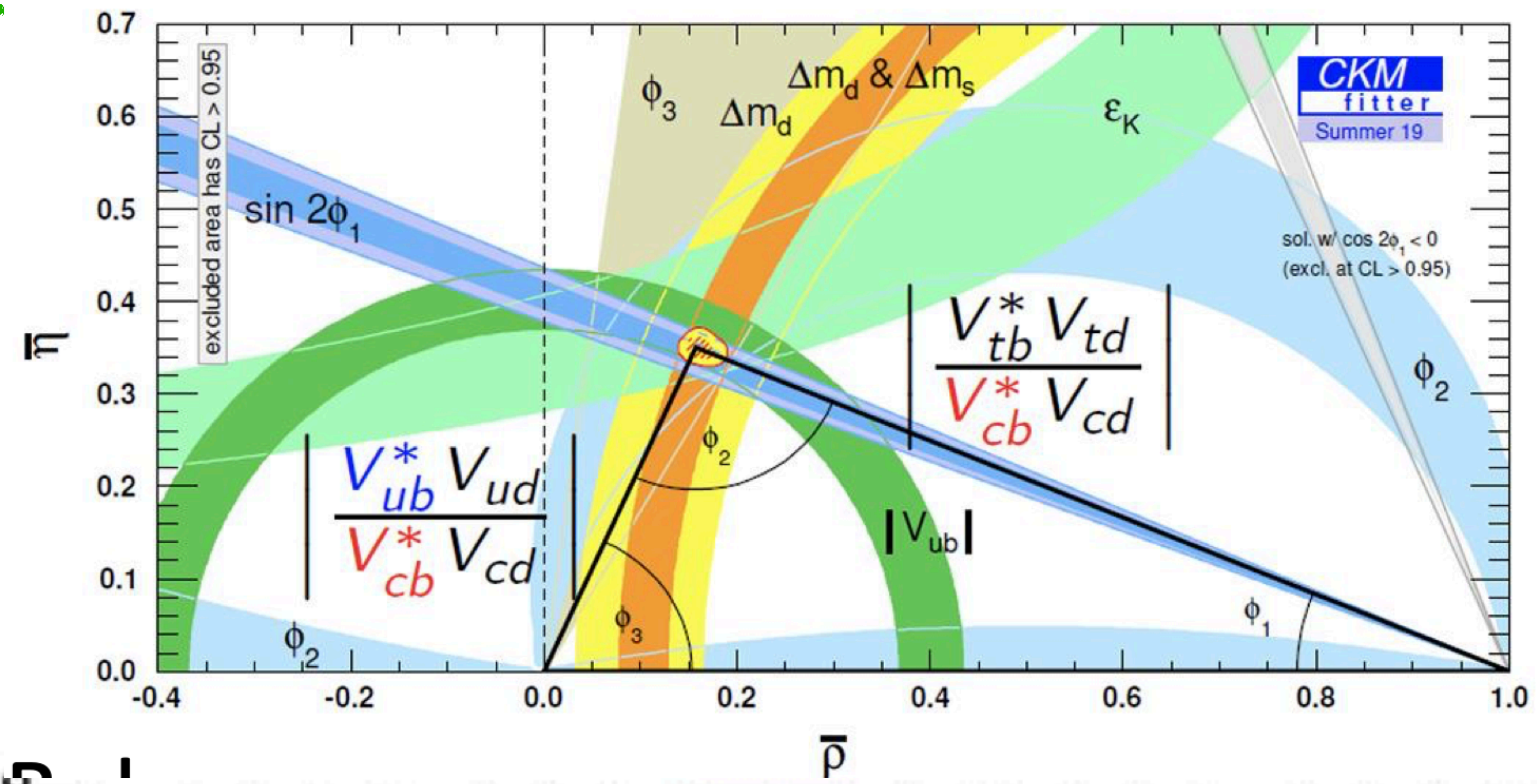
$\sigma(e^+e^- \to b\bar{b}) \simeq 1.1$ nb
$\sigma(e^+e^- \to c\bar{c}) \simeq 1.3$ nb
$\sigma(e^+e^- \to \tau^+\tau^-) \simeq 0.9$ nb

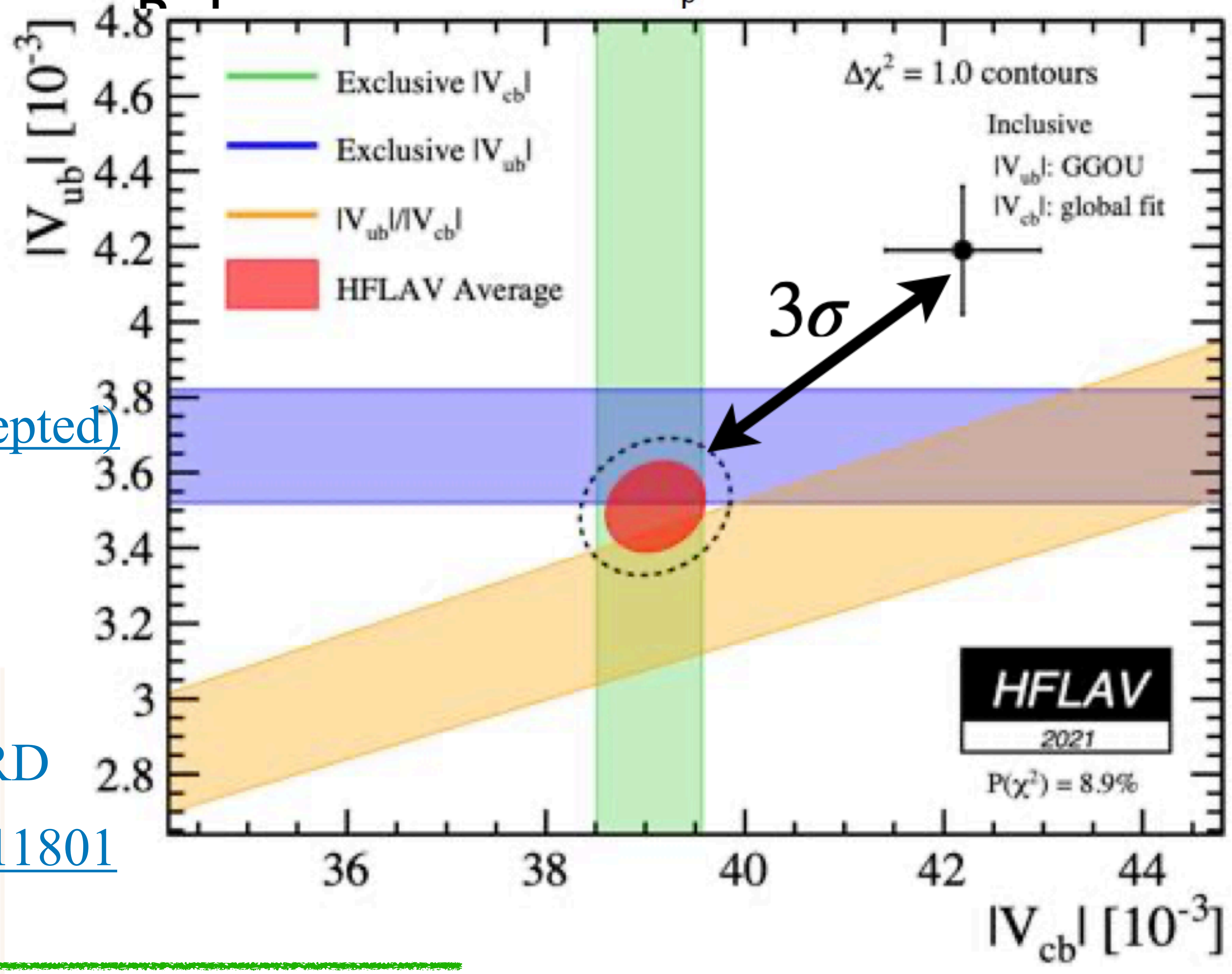
CKM matrix - elements $|V_{cb}|$ and $|V_{ub}|$

- Determine the $|V_{xb}|$:

Exclusive : $B \to \pi l\nu, B \to D^{(*)}l\nu$, etc

Inclusive : $B \to X_u l\nu, B \to X_c l\nu$





Different measures carried out by Belle and Belle II

- $|V_{cb}|$ angular coefficient of $B \to D^* l\nu$ Belle arXiv.2310.20286 (PRL accepted)

- $|V_{ub}|$
  - a. from $B \to (\pi/\rho)l\nu$ simultaneous analysis arXiv.2407.17403 submitted to PRD
  - b. Simultaneous inclusive and exclusive $|V_{ub}|$ Belle PRL.131.211801

CKM matrix - Simultaneous measurement of $B^0 \to \pi^- l^+ \nu, B^+ \to \rho^0 l^+ \nu$

arXiv.2407.17403

submitted to PRD

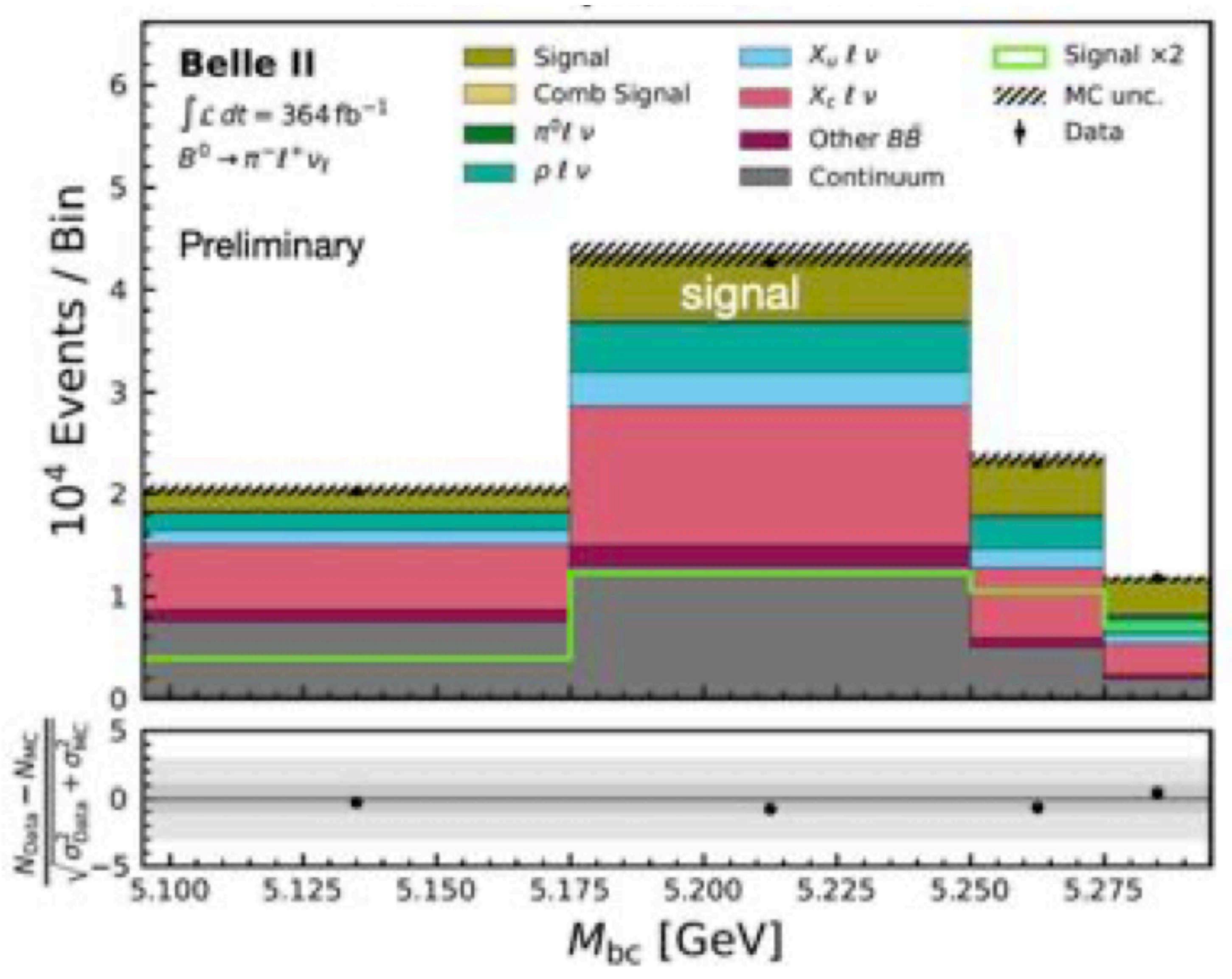
New measurements from Belle II

Full Run1 data of 364 fb^{-1} with inclusive tagging strategy

- Extract signal yield by combined fit of M_{bc} and ΔE for each bin of q^2:
  - 13 bins for π-mode
  - 10 bins of ρ-mode
  - Build up BDT discriminator to suppress $B \to X_c l\nu$ and continuum

$$M_{bc} = \sqrt{E^{*2} - |\overrightarrow{p_B}|^2}$$

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

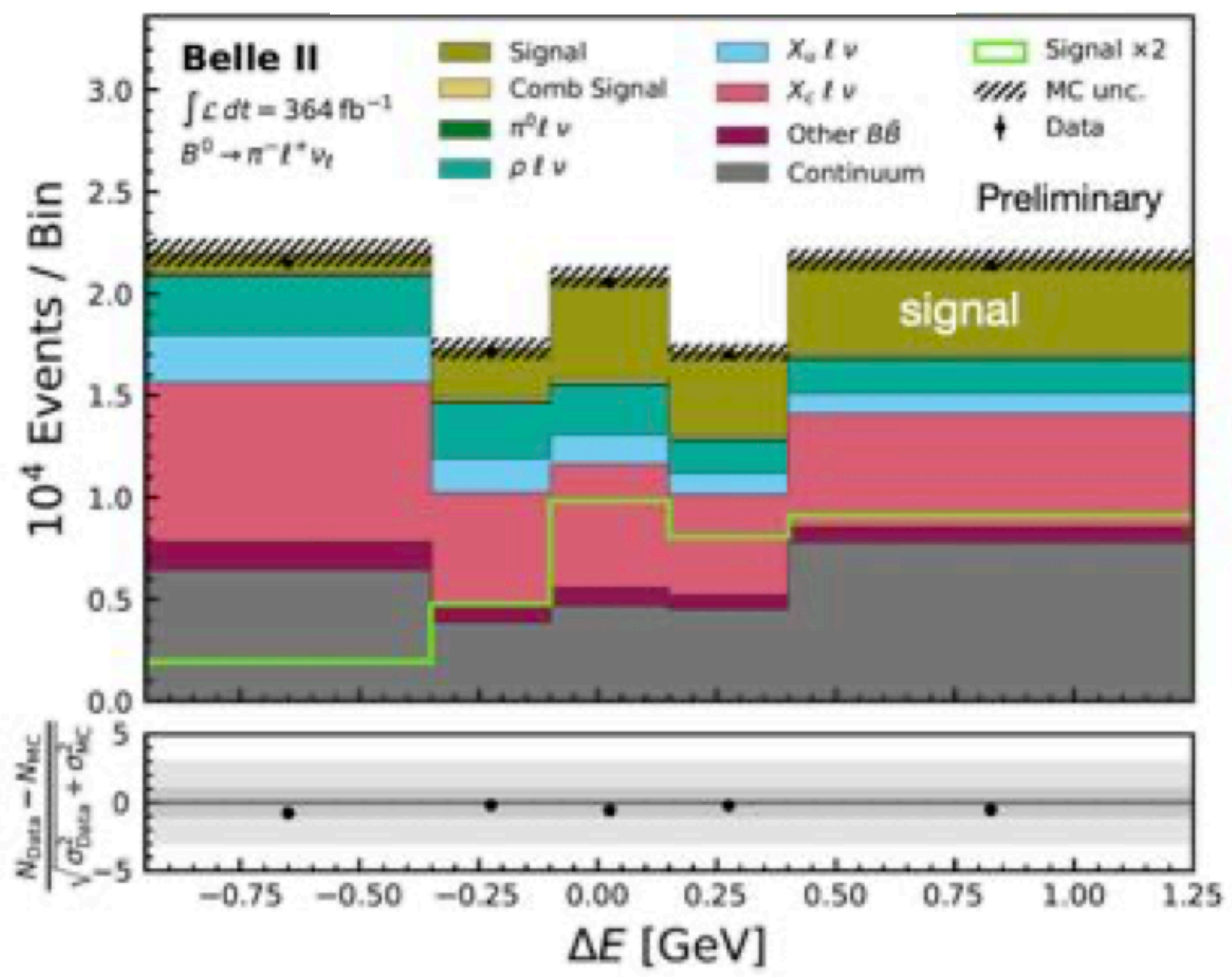


$\mathscr{B}(B^0 \to \pi^- l \nu_l) = (1.516 \pm 0.042(stat) \pm 0.059(sys)) \times 10^{-4}$

$\mathscr{B}(B^0 \to \rho^0 l^+ \nu_l) = (1.625 \pm 0.079(stat) \pm 0.180(sys)) \times 10^{-4}$

Consistent with World Average

Compatible precision w.r.t. Belle and BaBar

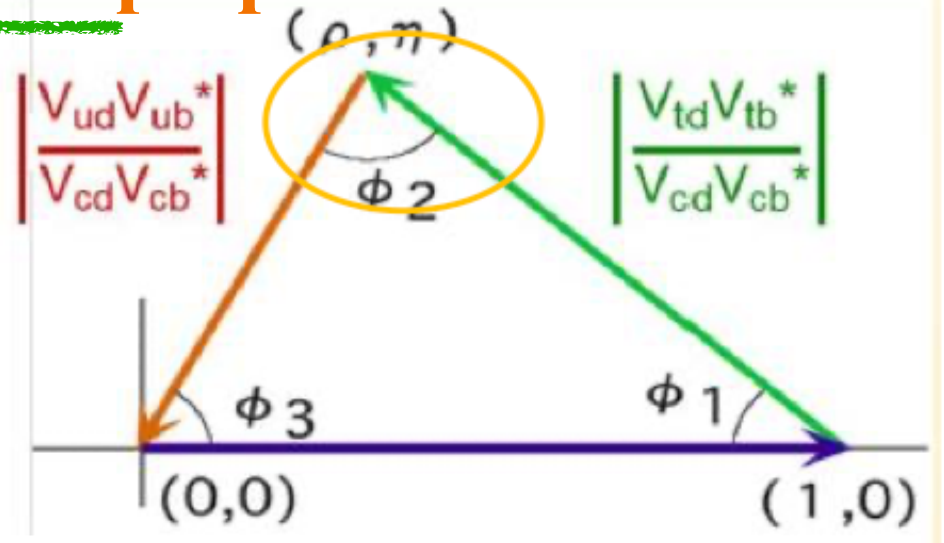


$$|V_{ub}|_{B\to\pi l\nu} = (3.73 \pm 0.07(stat) \pm 0.07(sys) \pm 0.16(theo)) \times 10^{-3}$$

$$|V_{ub}|_{B\to\rho l\nu} = (3.19 \pm 0.12(stat) \pm 0.17(sys) \pm 0.26(theo)) \times 10^{-3}$$

$B^0 \to \pi^0\pi^0$ at Belle II : overview

Preliminary, paper in preparation



Tree level $b \to u$ **processes** allow extraction of ϕ_2 (or α) (least precise CKM angle)

Build upon previous Belle II effort and extend to full **RUN1 data sample with improvements:**

- Improved photon selection
- Bkg mostly from continuum and $B^+ \to \rho^+\pi^0; B^0 \to K_s\pi^0$

- Statistical and systematic uncertainty reduced by 10% and 50% respectively on BF and absolute uncertainty on A_{CP}

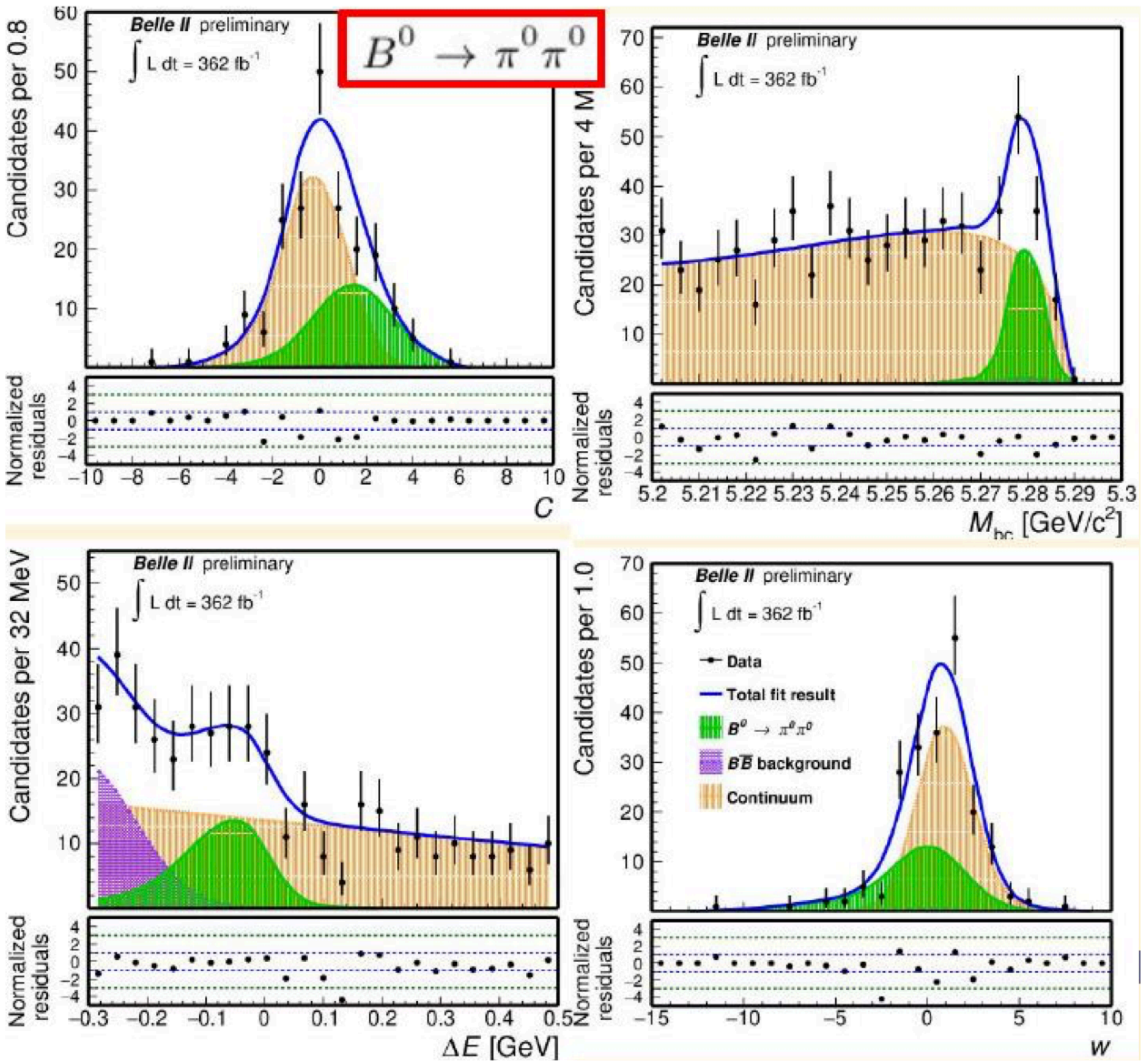
- Simultaneous fit to $M_{bc}, \Delta E, C, w$: - where C is the continuum variable

  - and w is the wrong tag probability

$$\mathscr{B}(B^0 \to \pi^0\pi^0) = (1.26 \pm 0.20 \pm 0.12) \times 10^{-6}$$

$$\mathscr{A}_{CP}(B^0 \to \pi^0\pi^0) = (0.06 \pm 0.30 \pm 0.05)$$

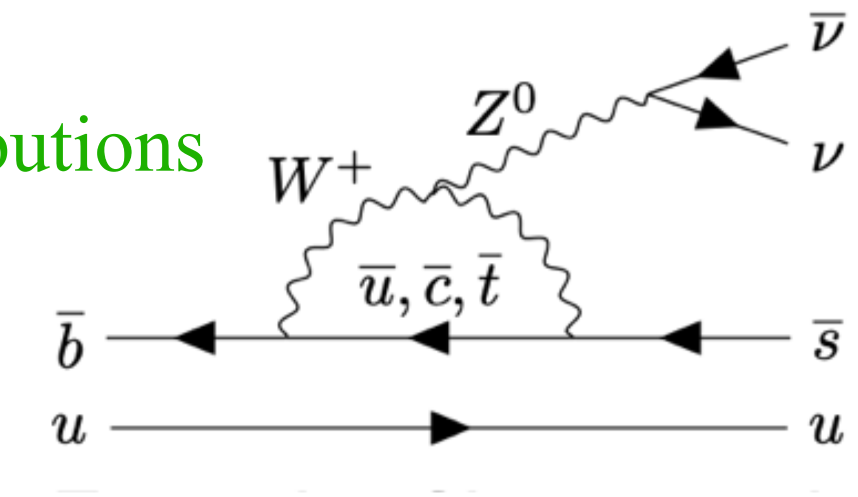
- Agreement with previous measurements
- Comparable precision with world best result from BaBar



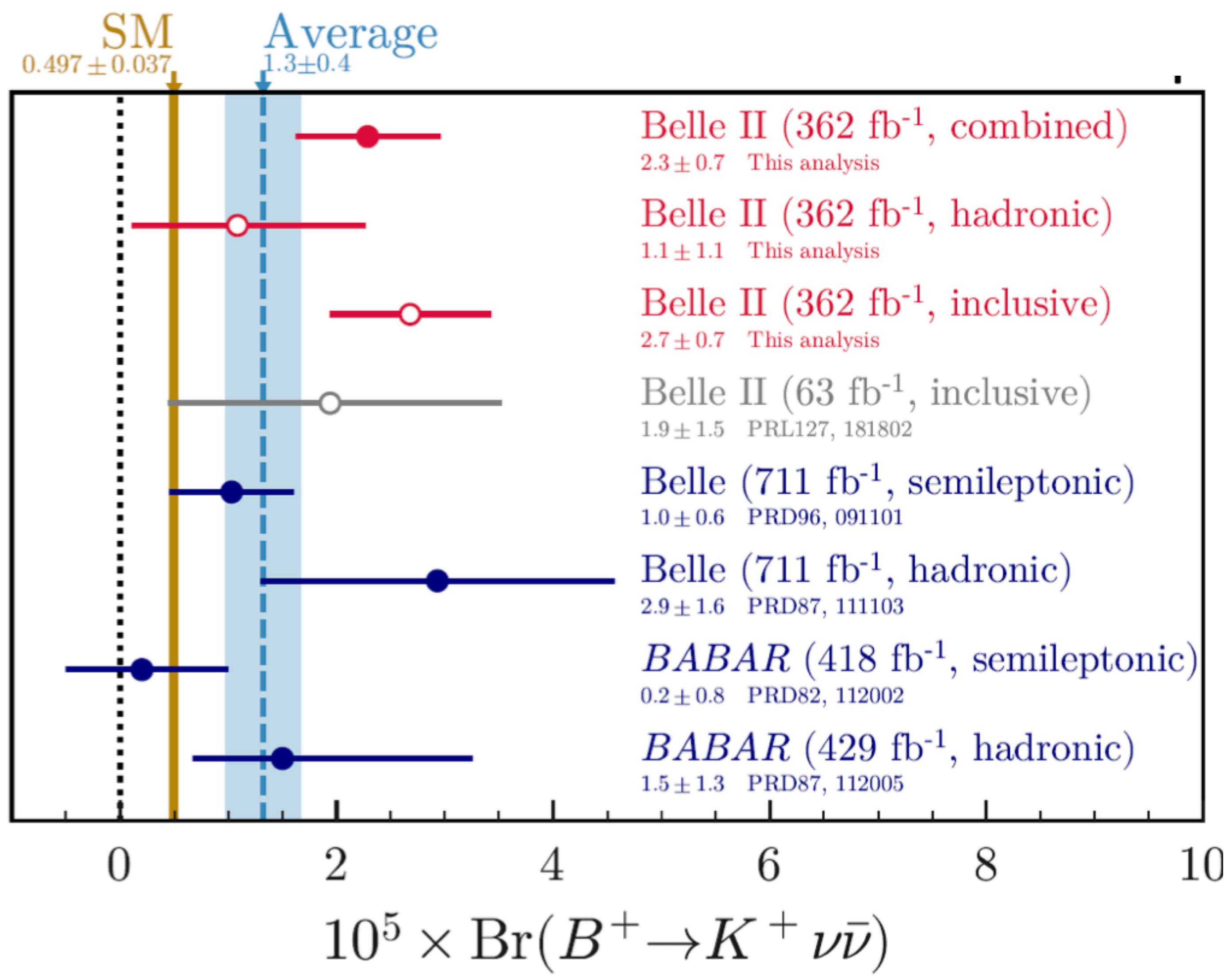
Rare Decays :$B^+ \to K^+\nu\bar{\nu}$ motivation

PhysRevD.109.112006

- $b \to s\nu\bar{\nu}$ are highly ***suppressed*** in the SM Highly sensitive to non-SM contributions

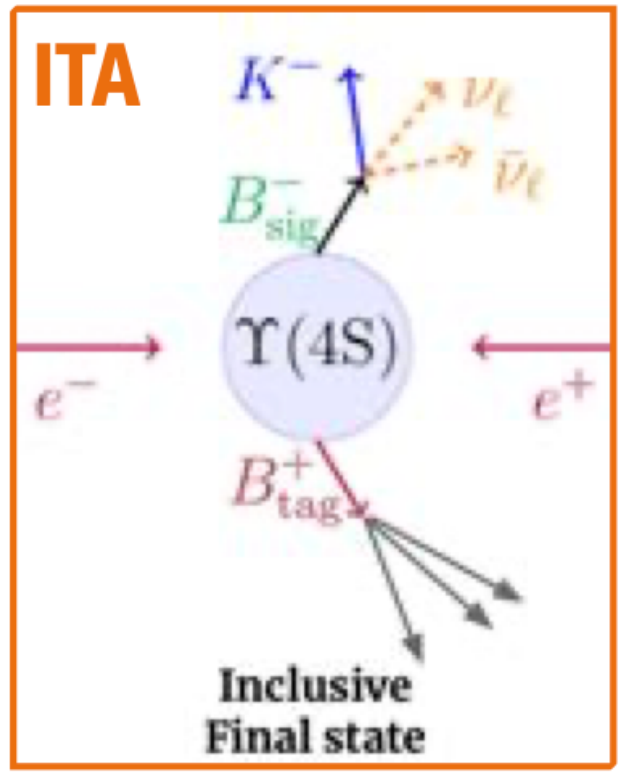


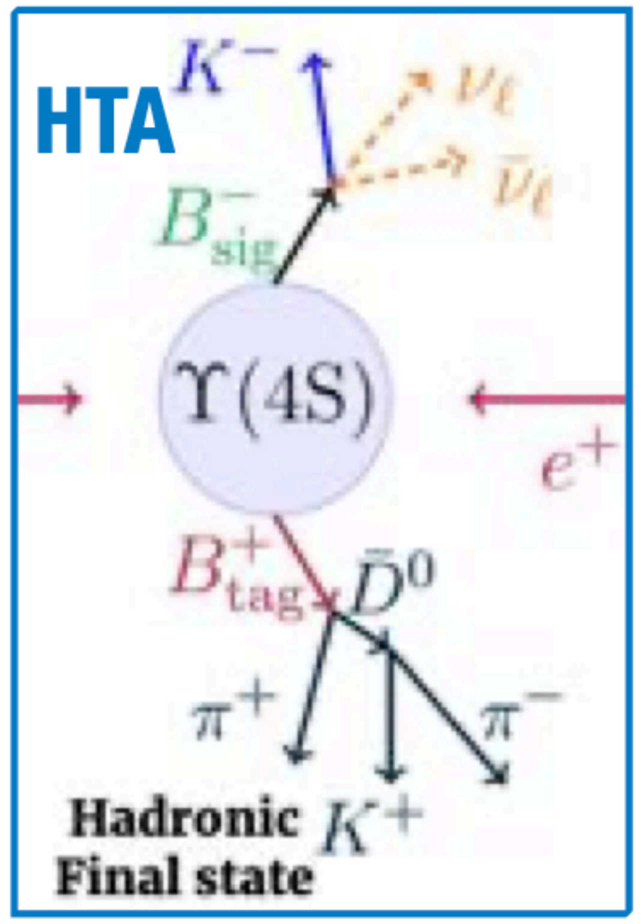
- Precise prediction in the SM: $\mathscr{B}(B^+ \to K^+\nu\bar{\nu}) = (5.6 \pm 0.4) \times 10^{-6}$ arXiv 2207.13371
  - Leading theoretical uncertainties from hadronic form factors
- Existing results are from BaBar (PhysRevD.87.112005) and first analysis with Belle II (Phys.Rev.Lett.127.181802)



Belle reports upper limits only; branching fractions are estimated using published number of events and efficiency

- Experimental challenges: **Low BF with 2 neutrinos in the final state and high bkg contamination mainly from continuum**
  - **Used to complementary B tag approach** : **low purity-high efficiency** (0.8%-8%) **and its opposite** (3.5%-0.4%)
  - Signal selection combines kaon , event topology and the rest of the event properties in MVA classifiers
  - Bkg validation : from semileptonic B-decays: $(B^+ \to K^+ n\bar{n}, B^+ \to K^+ K^0 \bar{K}^0)$
- **Inclusive method validated by** closure test by measuring. $\mathscr{B}(B^+ \to \pi^+ K^0)$





Rare Decays : $B^+ \to K^+\nu\bar{\nu}$ evidence

PhysRevD.109.112006

- Parameter of interest: $\mu = \dfrac{\mathscr{B}(B^+ \to K^+\nu\bar{\nu})}{\mathscr{B}_{\mathcal{SM}}(B^+ \to K^+\nu\bar{\nu})}$

- **Binned fit** to extract μ:
  - ITA : 2D fit on a classifier output $[\eta(BDT_2)]$ bins and q^2 bins
  - HTA: fit on a classifier output $\eta(BDT_h)$

- **Combining ITA & HTA** we have a 10% increase in precision w.r.t ITA alone

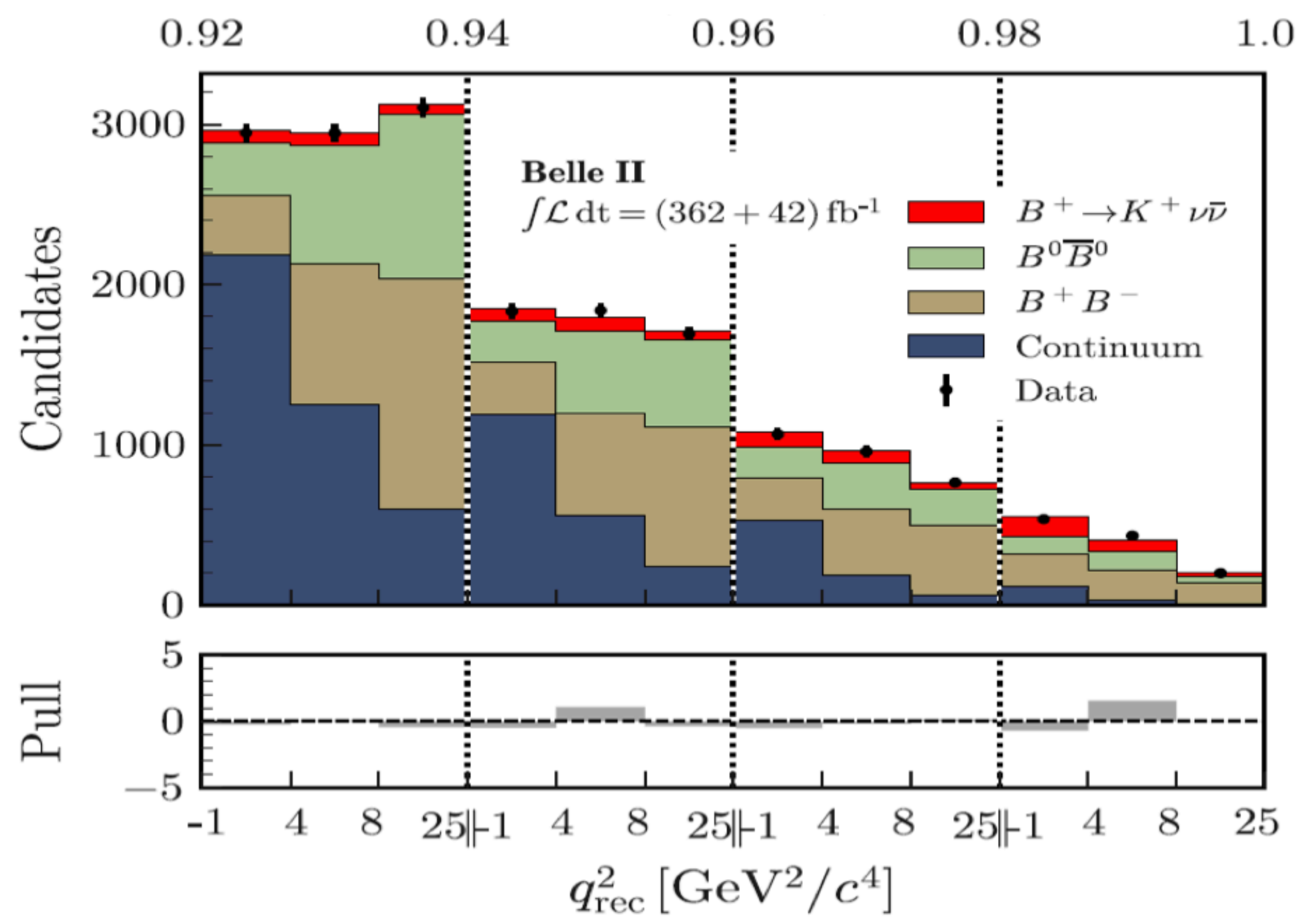
Combined: $\mu = 4.6 \pm 1.0(stat) \pm 0.9(sys)$

3.5 σ significance w.r.t bkg-only hypothesis

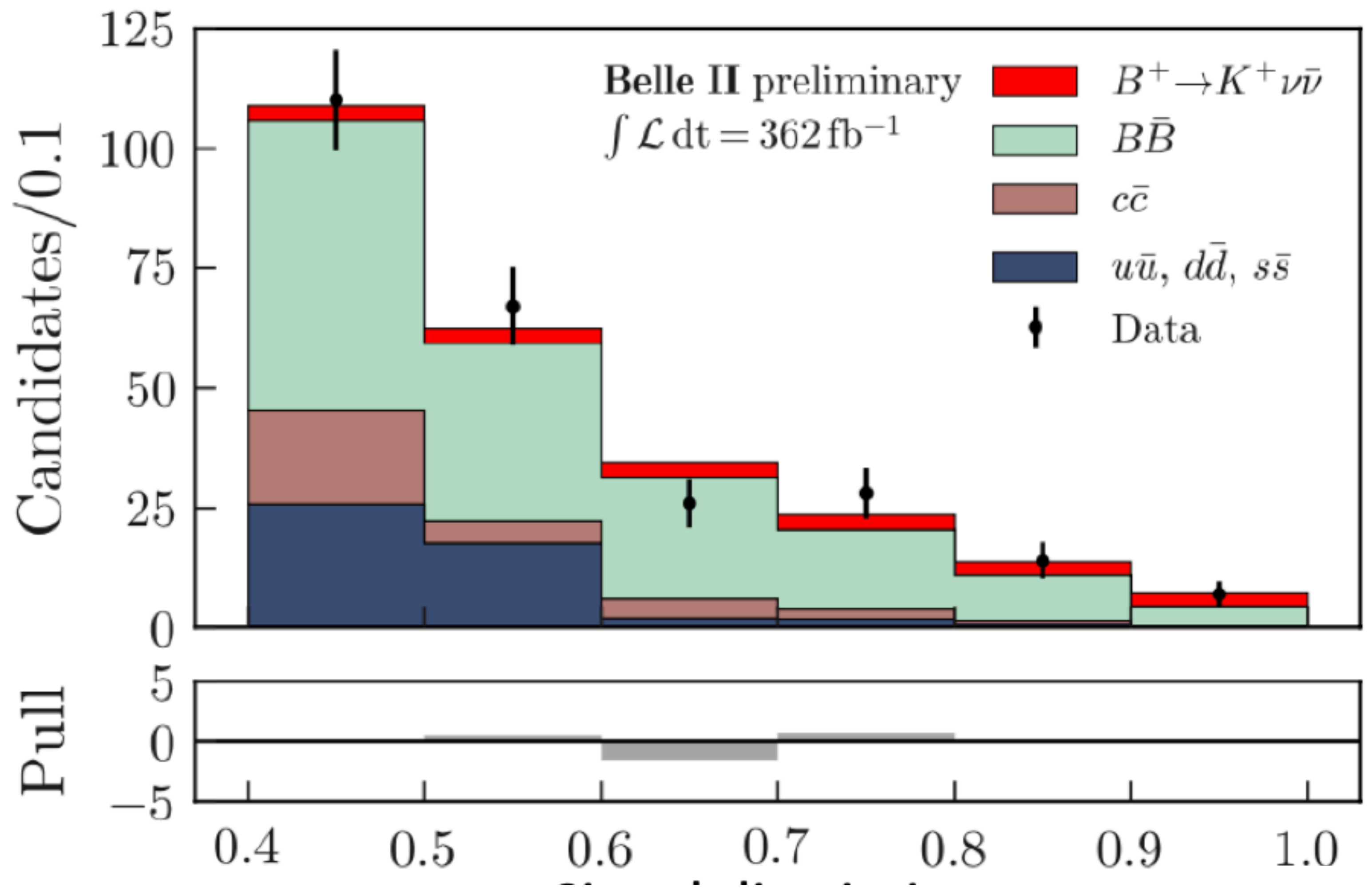
2.7 σ deviation above SM predictions

First evidence of $B^+ \to K^+\nu\bar{\nu}$ process

ITA



HTA



Rare Decays : $B^0 \to K^{*0}\tau^+\tau^-$ motivation

Preliminary, paper in preparation

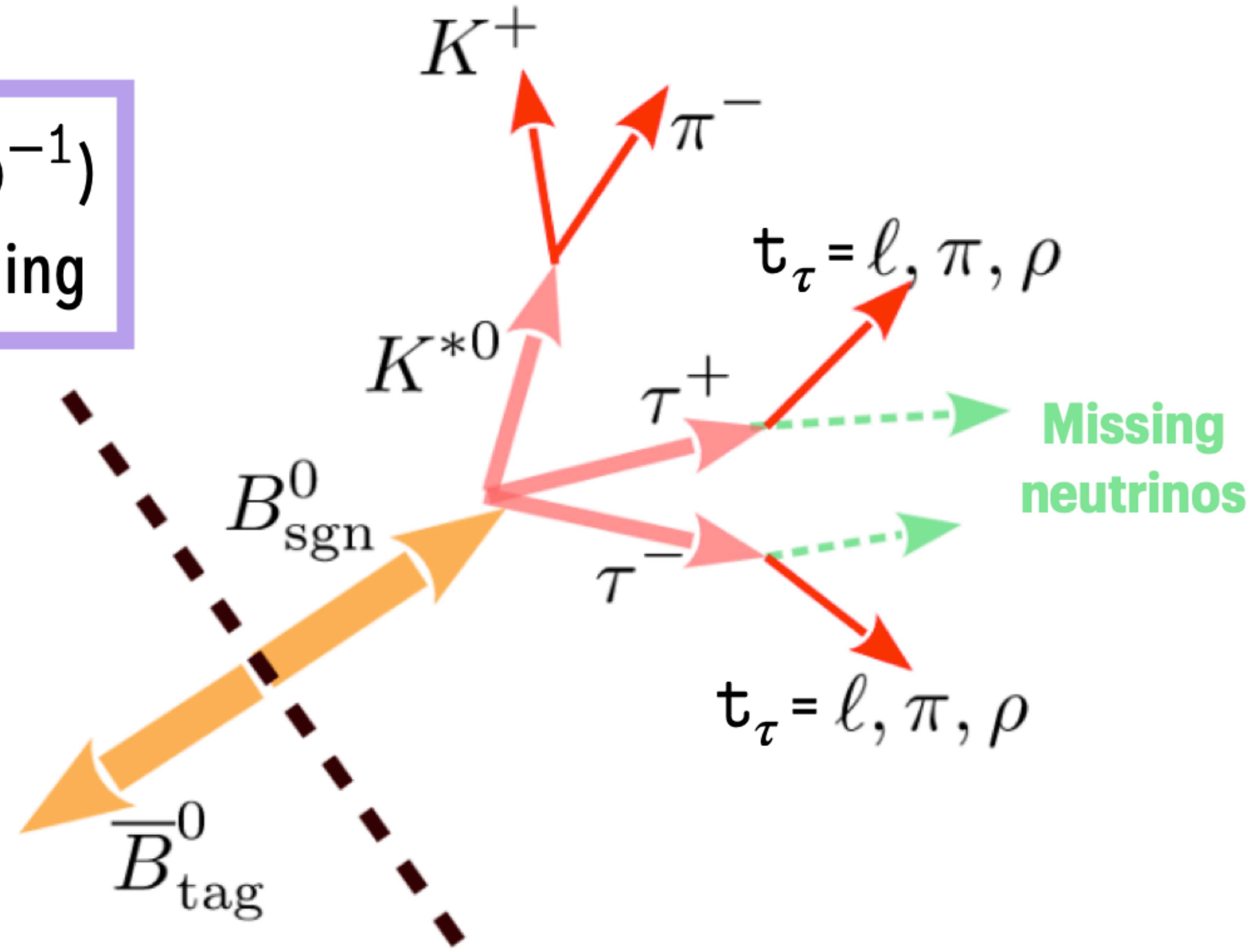
- These processes are suppressed in the SM and occur only a loop level

  $$\mathscr{B}_{SM} = (0.98 \pm 0.10) \times 10^{-7}$$

- Sensitive to new physics models accommodating the $b \to c\tau\nu$ anomalies
  - Might correlate with enhanced $b \to s\tau\tau$ decay rates

- **Belle (711 fb^{-1}) : $\mathscr{B}(B^0 \to K^{*0}\tau^+\tau^-) < 3.1 \times 10^{-3}$ @ 90% C.L.**

Belle II (364 fb^{-1})
hadronic B-tagging



Experimental challenges:

- Low branching fraction
- No signal peaking kinematic observable
- Large background + more than 3 prompt tracks
- Up to 4 neutrinos originating from τ
- K^{*0} has low momentum due to the phase space

Rare Decays : $B^0 \to K^{*0}\tau^+\tau^-$ strategy and results

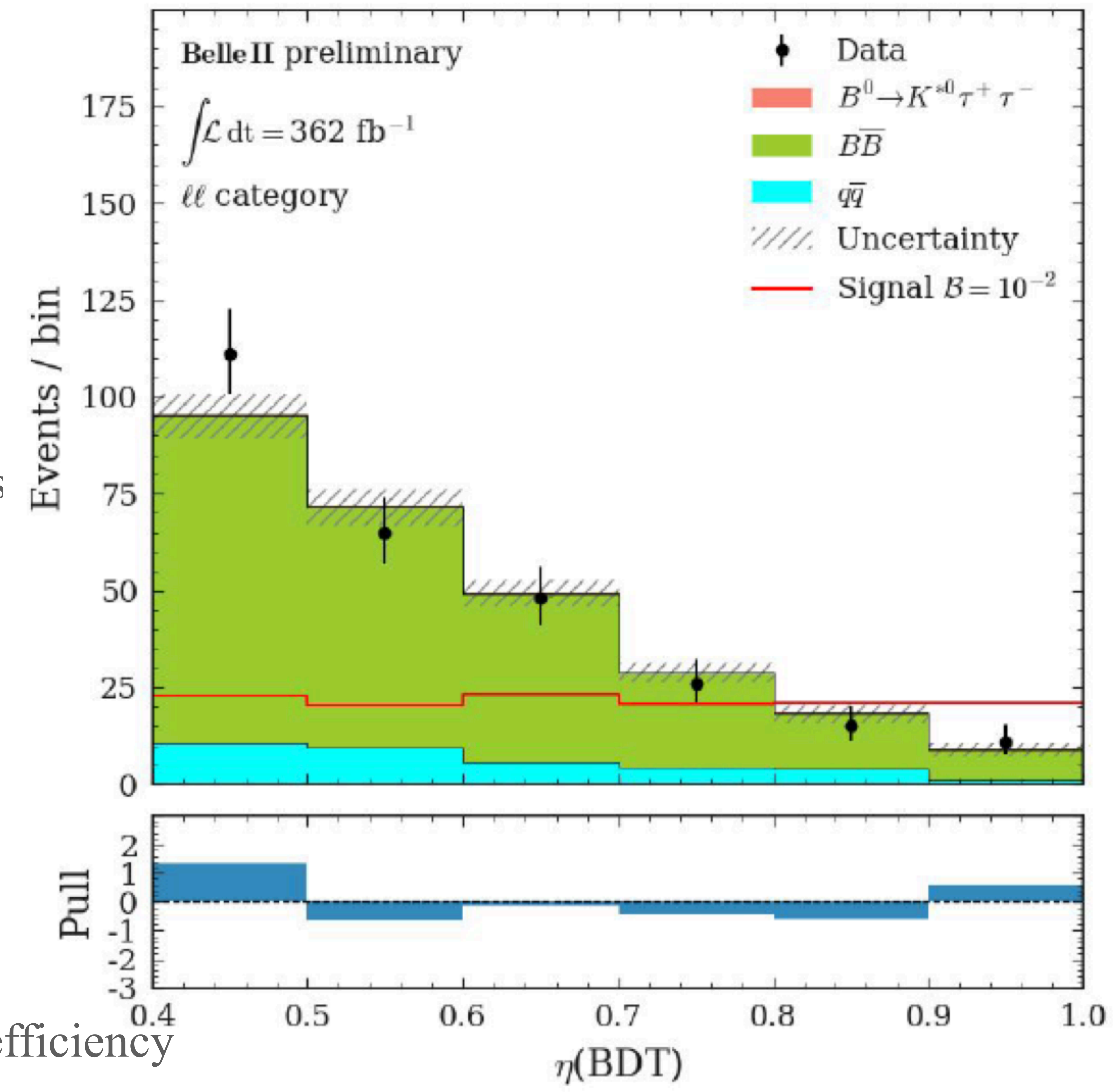
- Combination of charged particle from τ decay lead to 4 categories:

$$ll, l\pi, \pi\pi, \rho X$$

- **BDT** is trained using missing energy, extra cluster energy in EM calorimeter, $M(K^{*0}t_\tau)$, q^2,etc

- BDT output $\eta(BDT)$ is used to extract the signal yield with simultaneous fit to 4 categories

$$\mathscr{B}(B^0 \to K^{*0}\tau^+\tau^-) = 1.8 \times 10^{-3} \quad @\ 90\%\ \text{C.L}$$

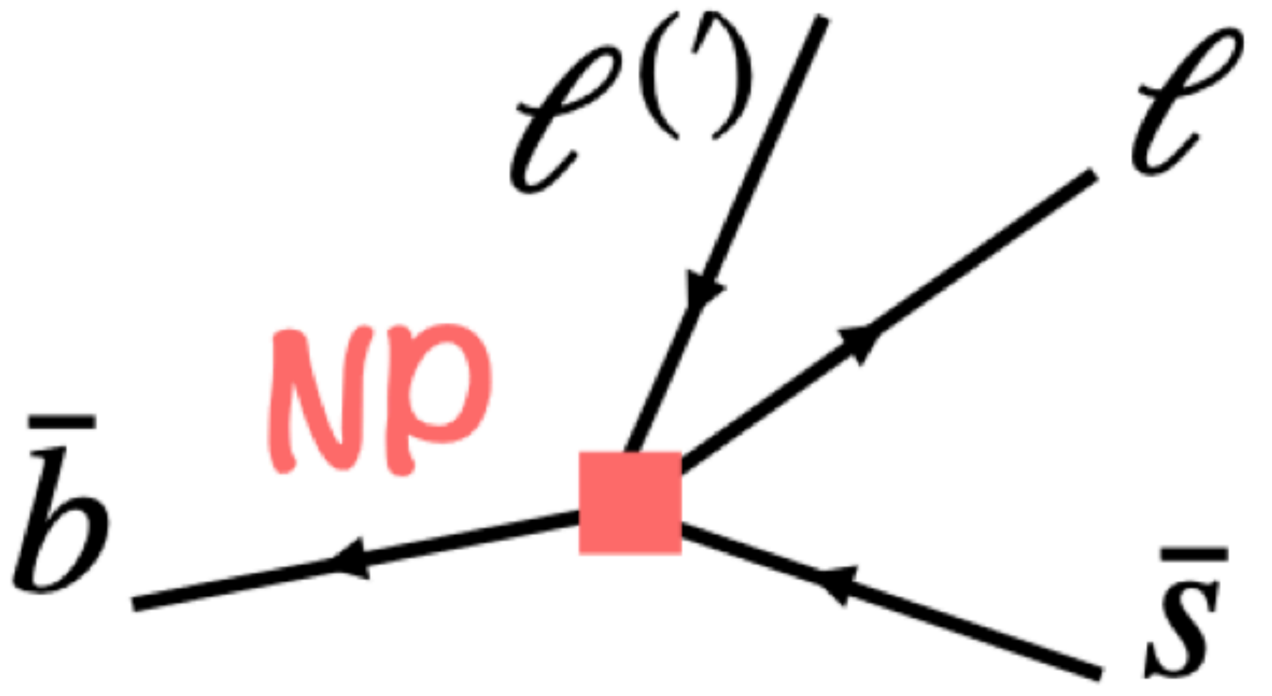


- **Twice better with only half sample w.r.t Belle :** better tagging & signal efficiency

- **The most stringent limit on the $B^0 \to K^{*0}\tau^+\tau^-$ decay and in general on $b \to s\tau\tau$ transition**

Rare Decays : $B^0 \to K_S^0 \tau^\pm l^\mp$ motivation

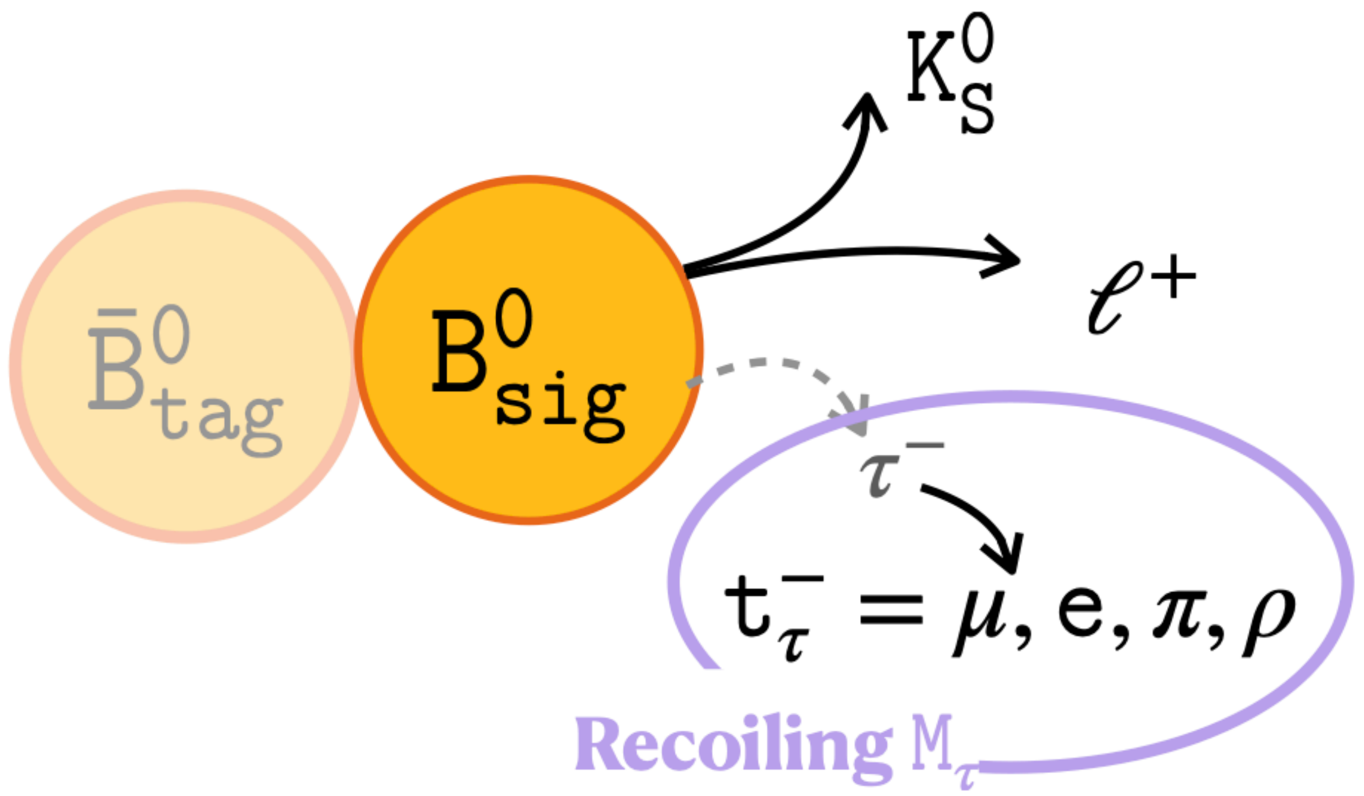
- New heavy particles might accommodate the $\mathscr{B}(B^\pm \to K^\pm \bar{\nu}\nu)$ excess and $b \to c\tau\nu$ anomalies
  - new physics coupling preferentially to 2nd and 3rd generation leptons could result in observable decays to $b \to s\tau l$ (Lepton Flavor Violation-LFV)



- BaBar (428 fb^{-1}) : $B^+ \to K^+\tau^\pm l^\mp$ PRD.86.012004
- LHCb (9 fb^{-1}) : $B^+ \to K^+\tau^+\mu^-$, $B^0 \to K^{*0}\tau^\pm\mu^\mp$ JHEP.06.129, arXiv.2209.09846
- Belle (711 fb^{-1}) : $B^+ \to K^+\tau^\pm l^\mp$ PRL.130.261802

Most stringent UL

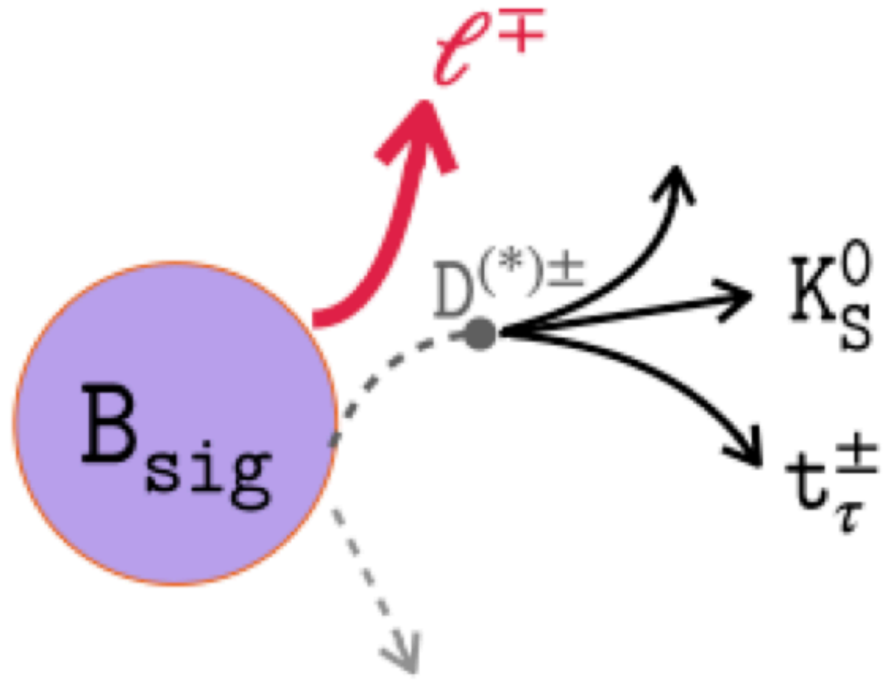
- **First search in $B^0 \to K_s^0\tau^\pm l^\mp$**



- Belle + Belle II (711+364 fb^{-1}) + hadronic B-tagging

Rare Decays : $B^0 \to K_S^0 \tau^{\pm} l^{\mp}$ strategy and results

- Final states involving **presence of neutrinos** ⟶ **can compute recoil mass of τ**
- K_S^0 reconstructed from a pair of opposite charged pions ⟶ after selections more than **98% purity**
- Semileptonic B decays are primarily **background**
- The remaining background is treated with the use of a **BDT**



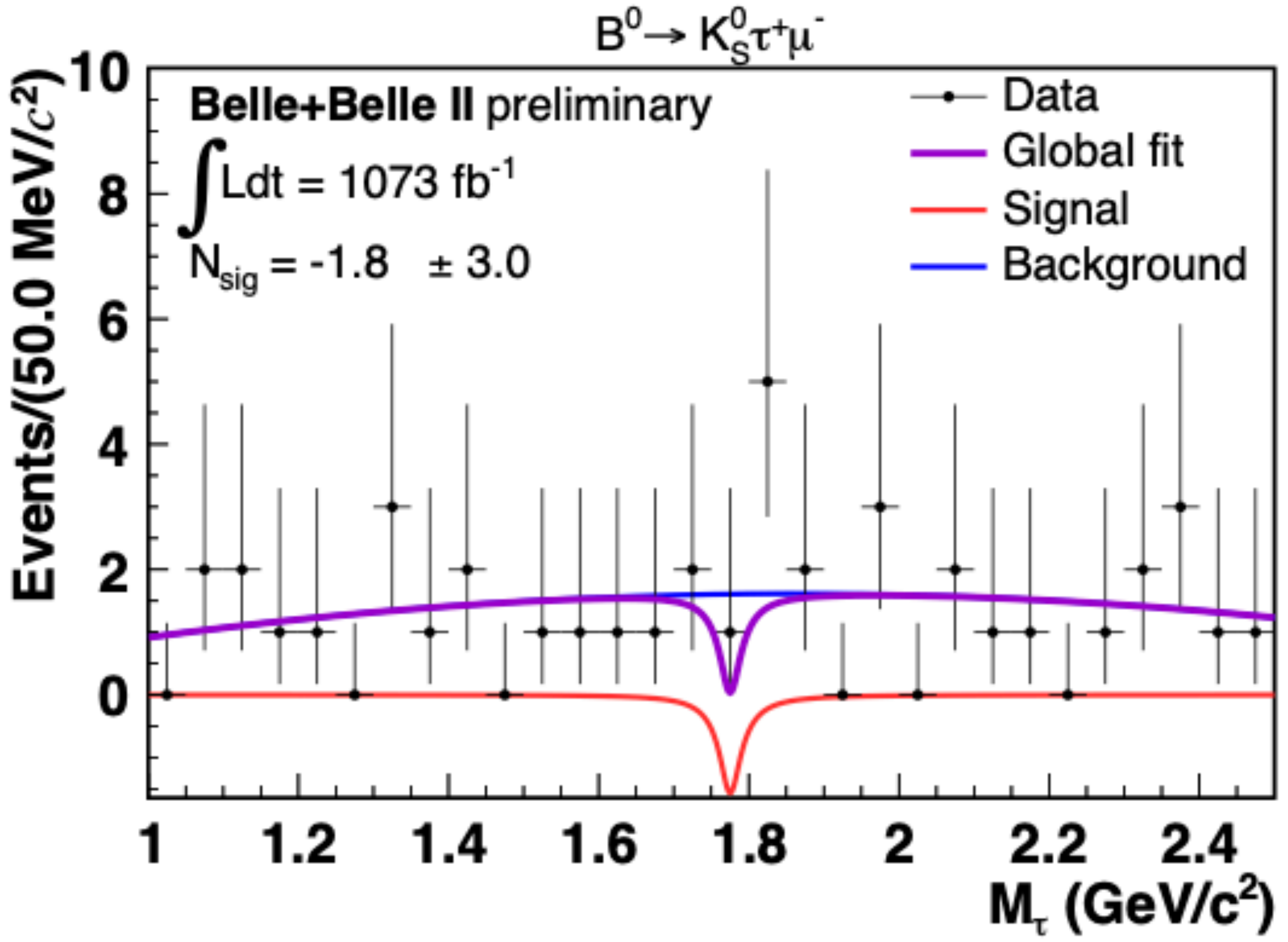
90% U.L. are derived:

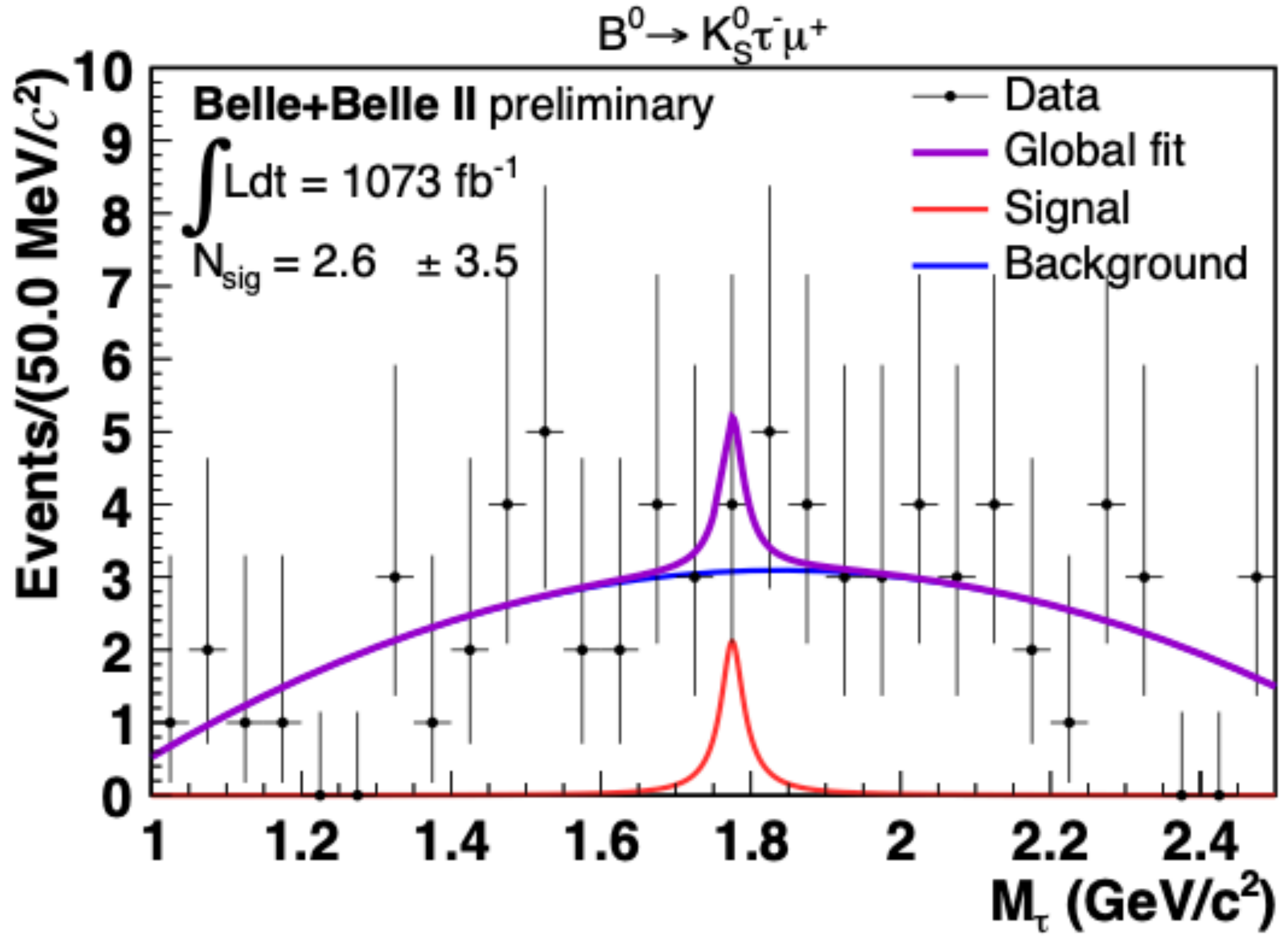
$$\mathscr{B}(B^0 \to K_S^0 \tau^+ \mu^-) < 1.1 \times 10^{-5}$$

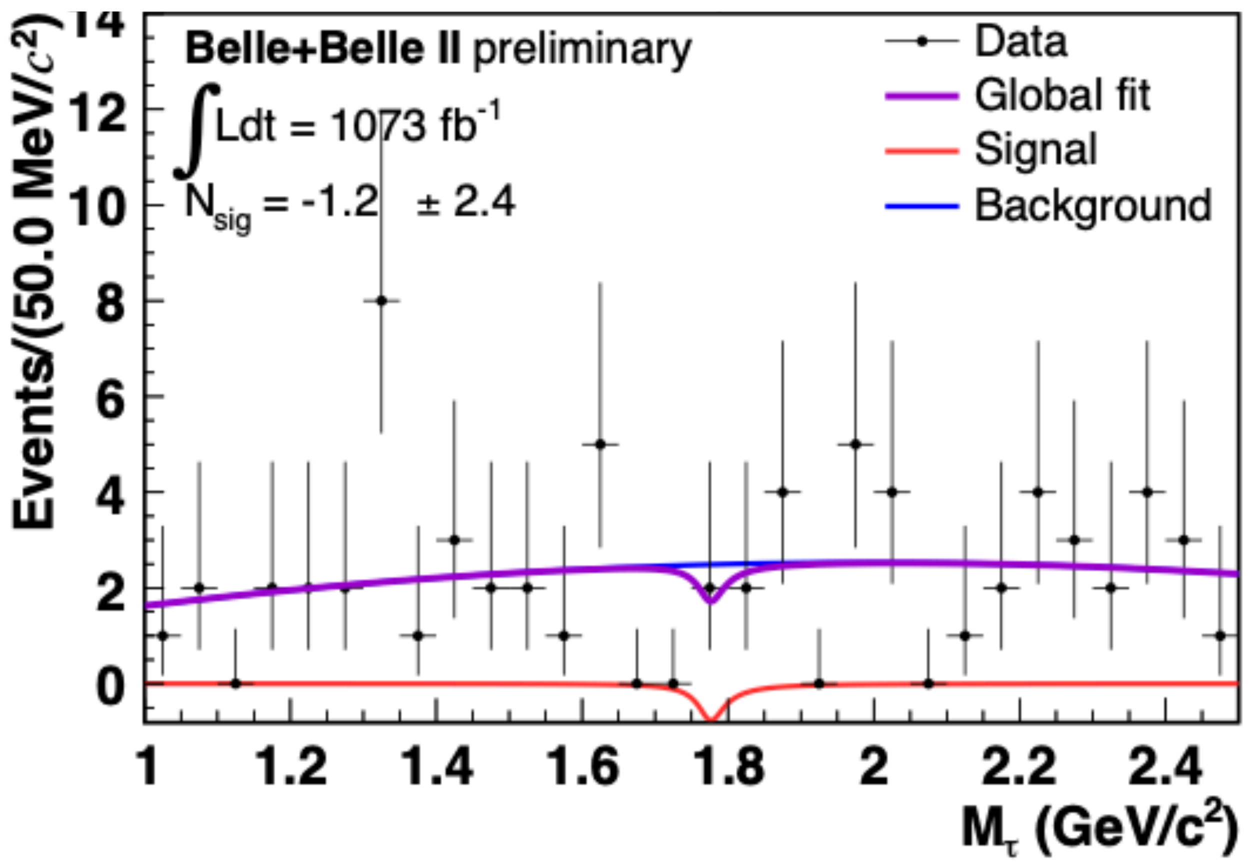
$$\mathscr{B}(B^0 \to K_S^0 \tau^- \mu^+) < 3.6 \times 10^{-5}$$

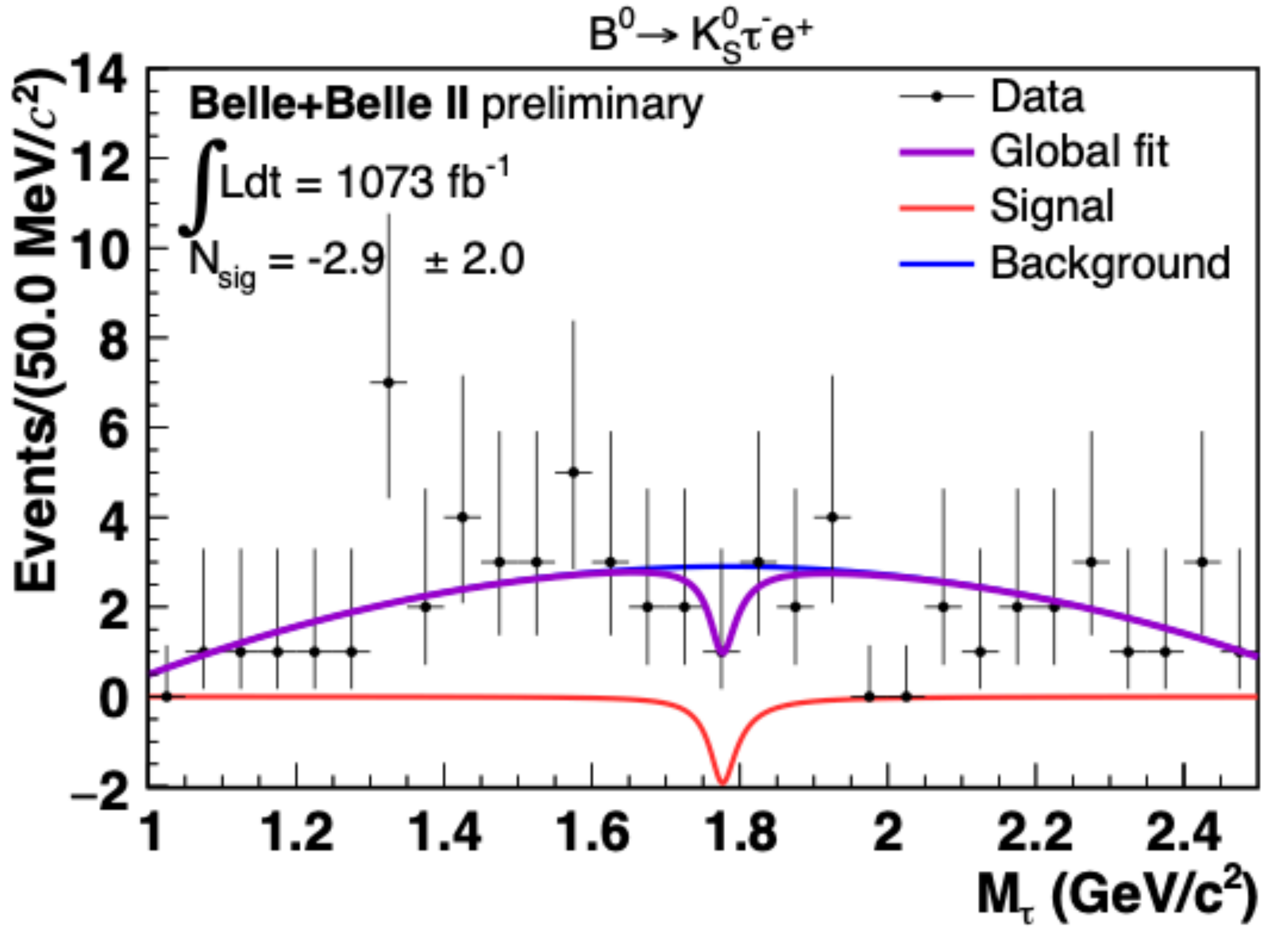
$$\mathscr{B}(B^0 \to K_S^0 \tau^+ e^-) < 1.5 \times 10^{-5}$$

$$\mathscr{B}(B^0 \to K_S^0 \tau^- e^+) < 0.8 \times 10^{-5}$$



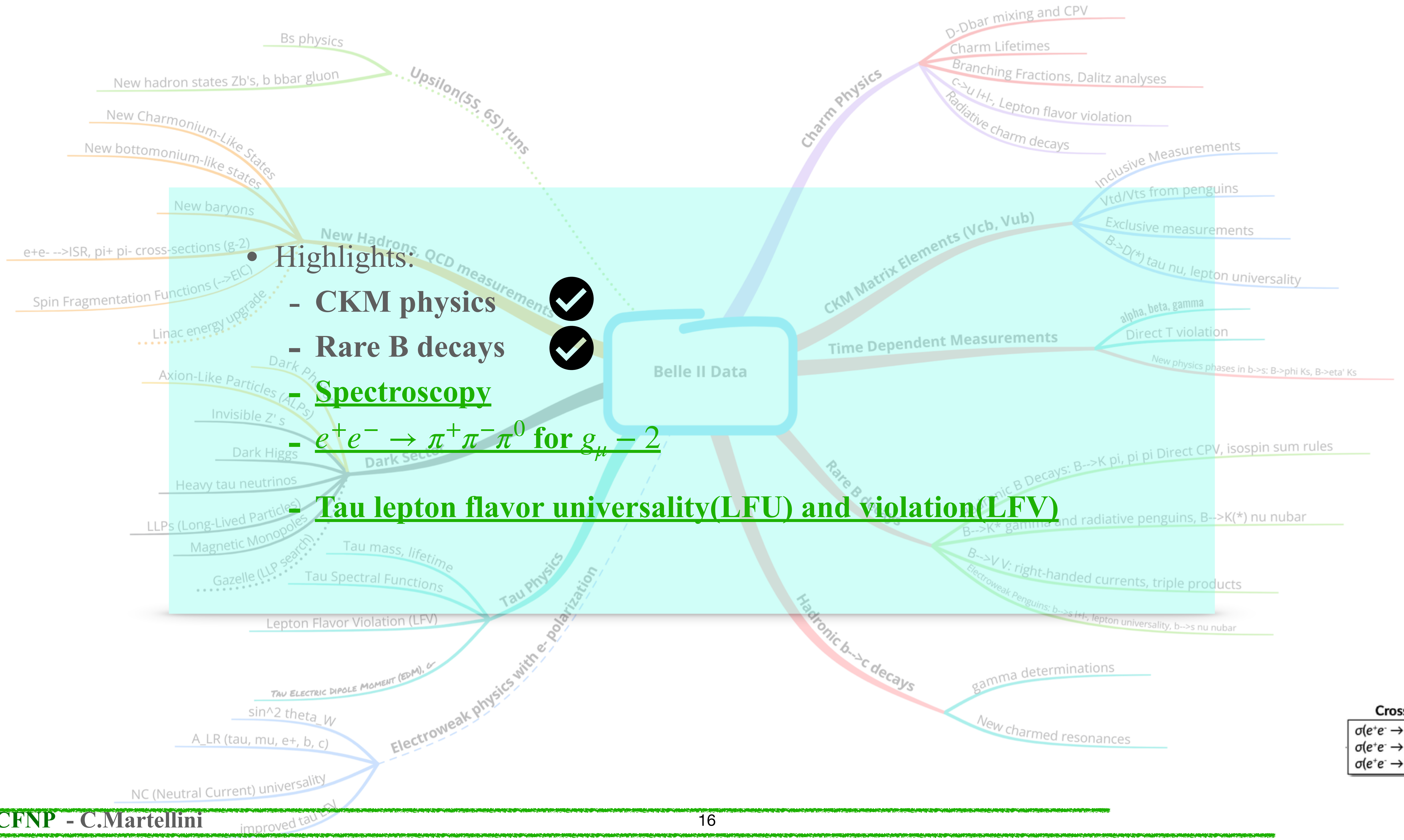






The results are among the most stringent limits

Belle II Physics Programs



- Highlights:
  - **CKM physics** ✔
  - **Rare B decays** ✔
  - **Spectroscopy**
  - $e^+e^- \to \pi^+\pi^-\pi^0$ **for** $g_\mu - 2$
  - **Tau lepton flavor universality(LFU) and violation(LFV)**

Cross sections

$\sigma(e^+e^- \to b\bar{b}) \simeq 1.1$ nb
$\sigma(e^+e^- \to c\bar{c}) \simeq 1.3$ nb
$\sigma(e^+e^- \to \tau^+\tau^-) \simeq 0.9$ nb

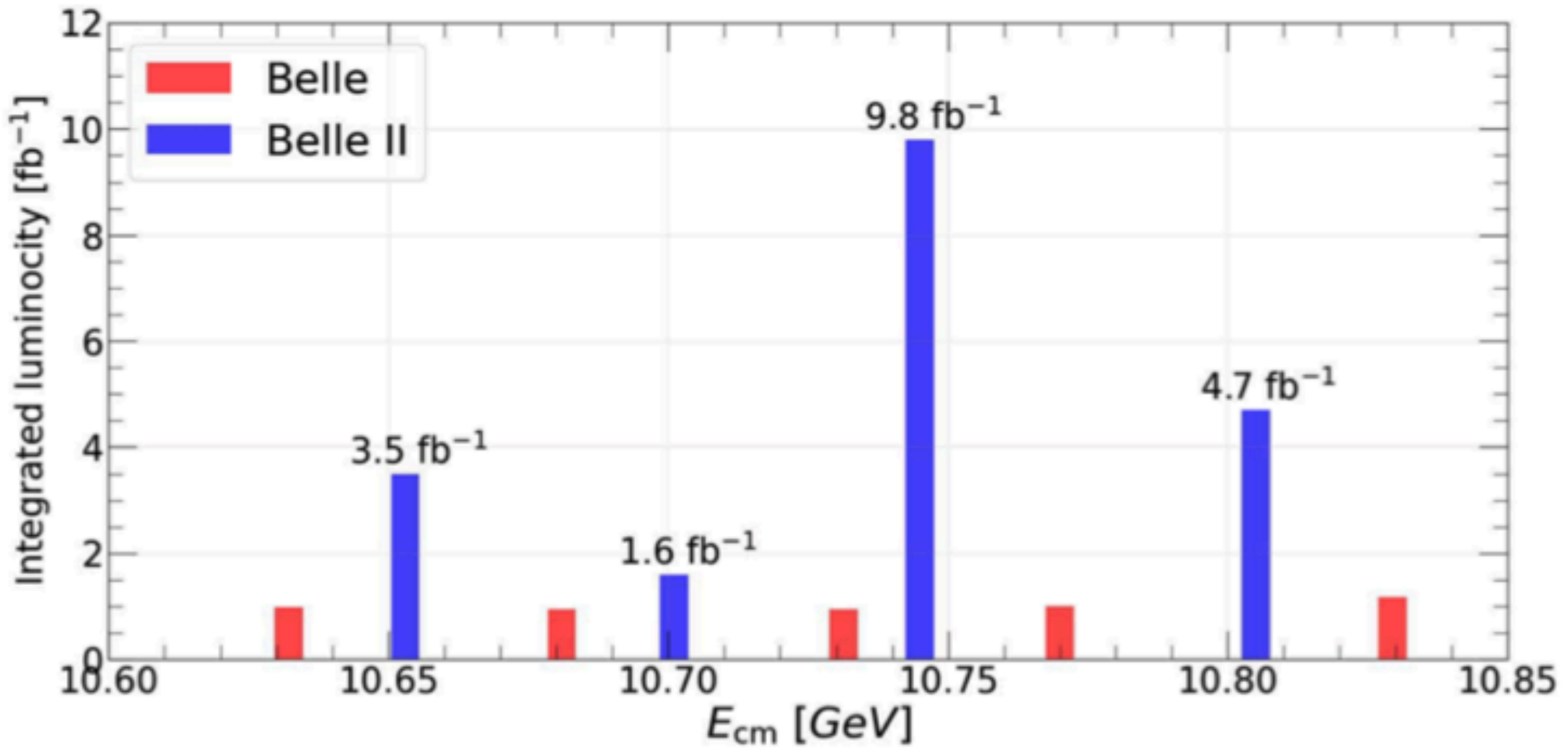
Spectroscopy: Improved measurements of $\Upsilon(10753)$ at Belle II

arXiv.2401.12021

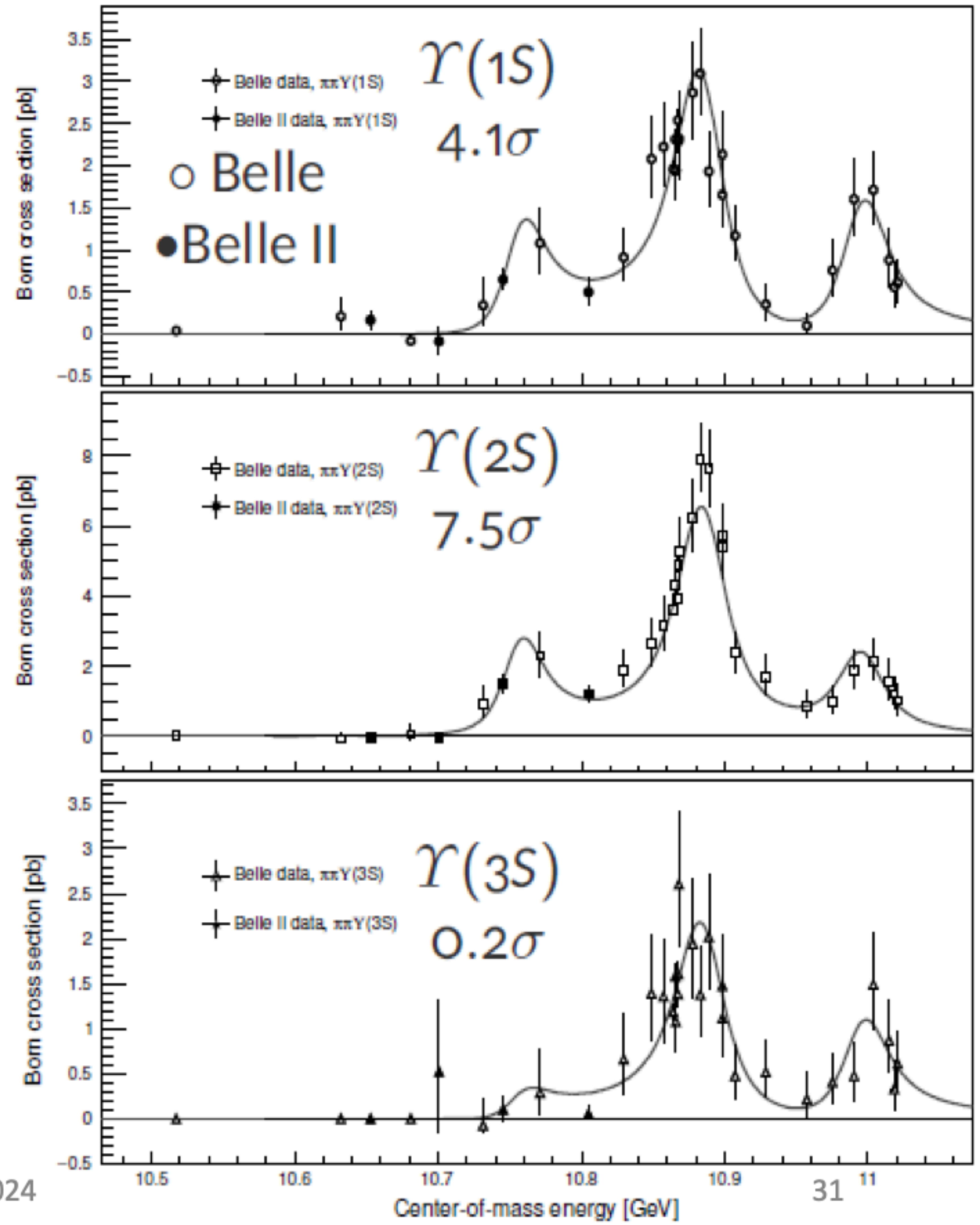
Accepted by JHEP

- New energy scan performed by **Belle II** to fill in the gaps of Belle scan

For a total integrated luminosity of 19 fb^{-1}



Reconstruct $e^+e^- \to \pi^+\pi^-\Upsilon(nS)(\to \mu^-\mu^+)$



- ***Observation of $\Upsilon(10753)$ in agreement with Belle results***

$$M(\Upsilon(10753)) = 10756.6 \pm 2.7 \pm 0.9\ \mathrm{MeV}/c^2$$

$$\Gamma(\Upsilon(10753)) = 29.0 \pm 8.8 \pm 1.2\ \mathrm{MeV}/c^2$$

No signal of intermediate Z_b^+ (10610/10650) observed

Spectroscopy: Search for $\Upsilon(10753) \to \omega\eta_b(1S)/\chi_{b_0}(1P)$ at Belle II

PRD,109.072013

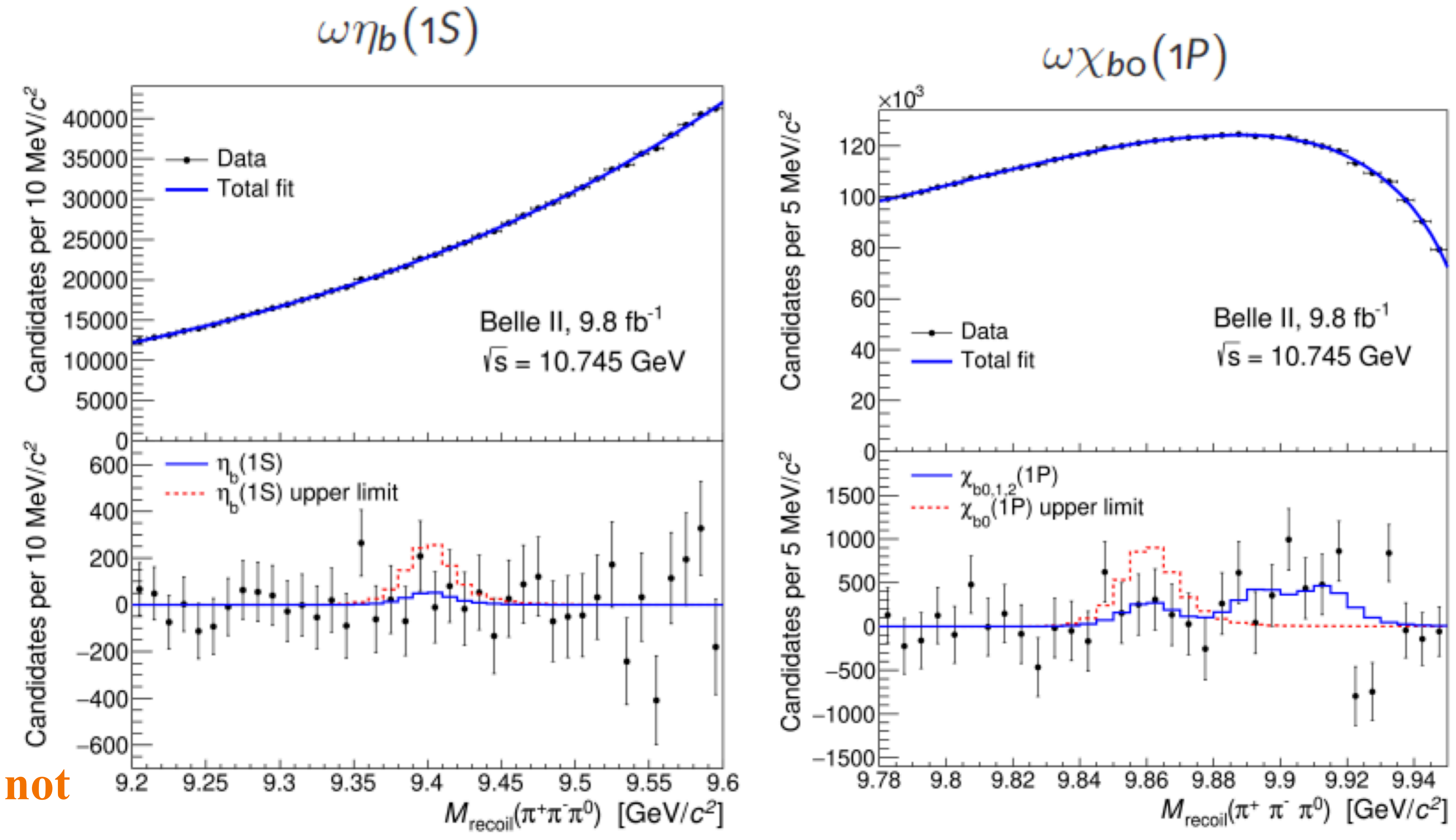
- $\Upsilon(10753)$ tetraquark interpretation predicts a strong transition to $\omega\eta_b(1S)$

Compared to $\pi^+\pi^-\Upsilon(nS)$

- Validate the model with reconstruction of $\omega \to \pi^+\pi^-\pi^0$ and look for a peak in the recoil mass distribution

$$\sigma(e^+e^- \to \omega\chi_{b0}(1P)) < 7.8 \ \text{pb}(*)$$

$$\sigma(e^+e^- \to \omega\eta_b(1S)) < 2.5 \ \text{pb}$$



No significant signal observed ➡ **Tetraquark model not supported**

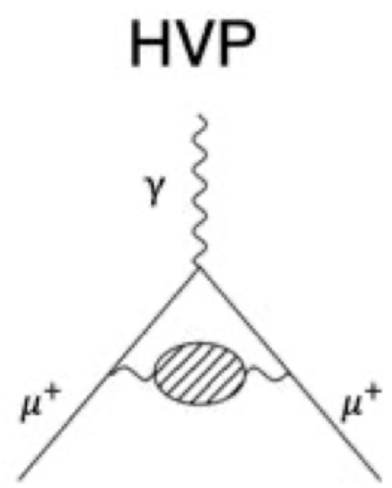
(*)obtained by averaging the result of this analysis with the previously published one Phys. Rev. Lett. 130, 091902

Measurement of $e^+e^- \to \pi^+\pi^-\pi^0$ cross section at Belle II

Preliminary

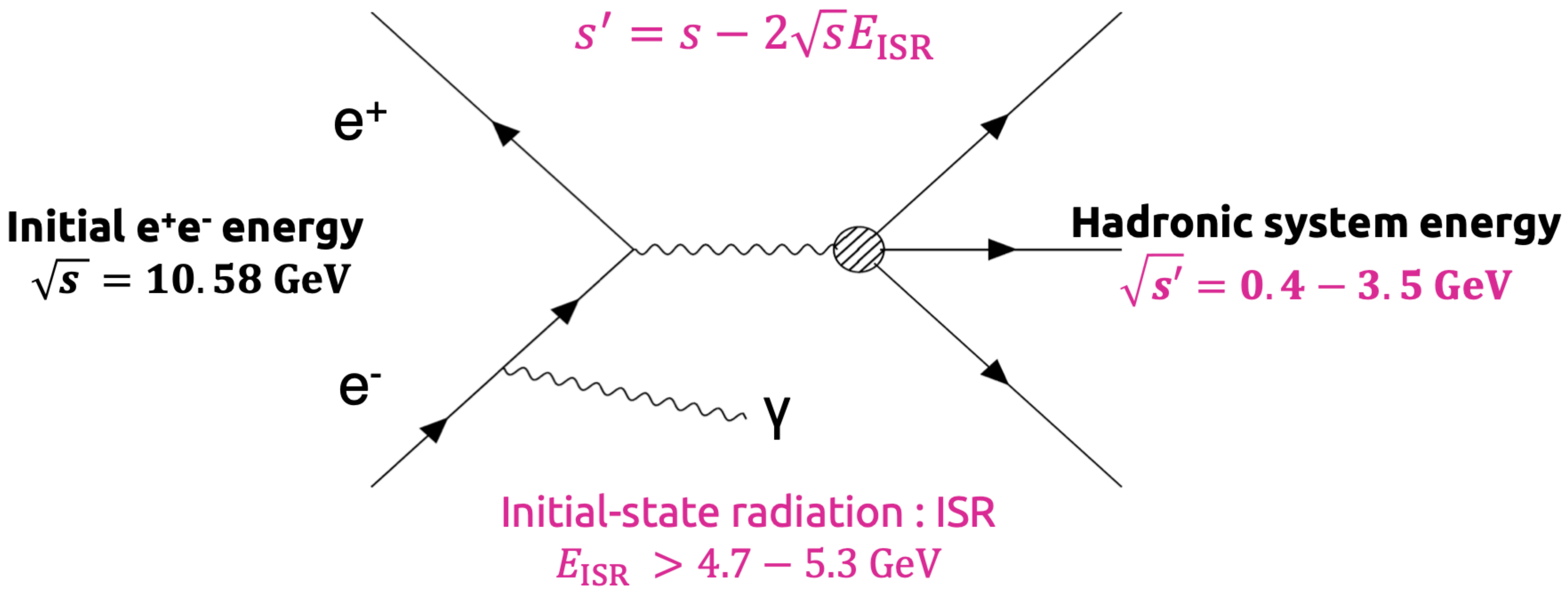
arXiv.2404.04915

- Motivation:
  - Non-negligible uncertainty in the theoretical predictions
  - **hadron vacuum polarisation** produces the largest uncertainty in the dispersive prediction of $(g-2)_\mu$ (HVP, 82%)
  - Cross section $e^+e^- \to hadrons$ is an **input to the dispersive calculation and gives largest uncertainty**



Perform the measurement in the energy range from 0.62 GeV to 3.50 GeV

- Initial-state radiation (ISR) method



Measured at Belle II exploiting $e^+e^- \to \pi^+\pi^-\pi^0\gamma_{ISR}$
$\to$ Scan region $0.7 < \sqrt{s} < 3.5$ GeV by γ_{ISR} reconstruction

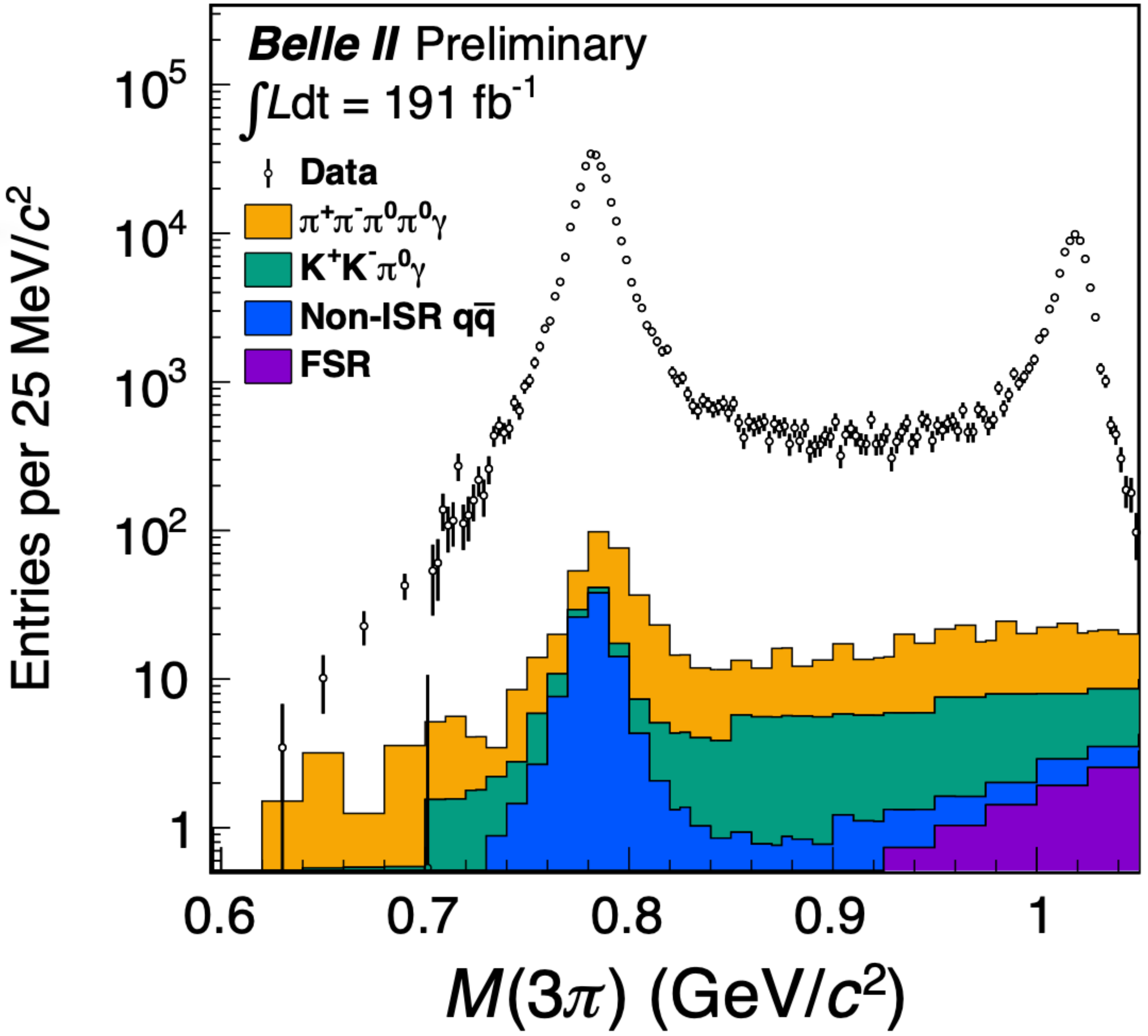
Allows to scan a wide range of M($\pi\pi$)
rather than having to scan the c.m energy

Used 191 fb^{-1} of Belle II data @ $\Upsilon(4S)$

Recent predictions of LQCD show $2-3\sigma$ differences from values based on dispersion relations $\to$ **new experimental measures are important** arXiv.2404.04915

Measured at Belle II with Signal process :

$e^+e^- \to \gamma_{ISR}\pi^+\pi^-\pi^0(\to \gamma\gamma)$



- **Signal extracted** by fitting M($\gamma\gamma$) in each M(3π) bin
- Signal efficiency and DATA/MC corrections:
  - Tracking efficiency
  - π^0 detection efficiency
  - High energy photon detection efficiency
- Systematic uncertainty dominates: modelling of higher-order corrections and efficiency

Integrated over 3π cross section from 0.62 - 1.8 GeV

$$a_\mu^{LO,HVP,3\pi}(0.62 - 1.8GeV) = (48.91 \pm 0.25_{stat} \pm 1.07_{syst}) \times 10^{-10}$$

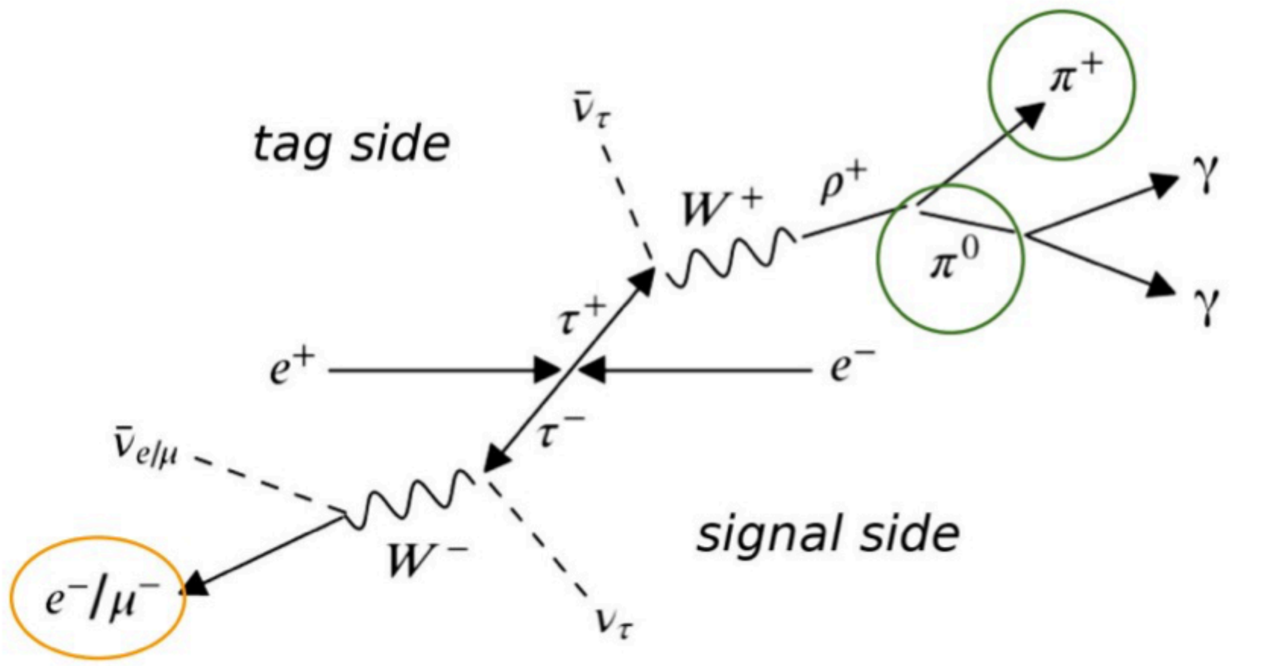
6.7% or 2.5 σ higher than current global average from BaBar, CMD-2 and SND

In the SM all charged leptons have equal coupling strength ($g\ell$) to the W boson: LFU → may be violated by new forces [1]

For each $B\bar{B}$ event we get ~ a $\tau\tau$ pair
→ Belle II optimal for τ physics too

$$R_\mu = \frac{\mathscr{B}(\tau^- \to \mu^- \bar{\nu}_\mu \nu_\tau)}{\mathscr{B}(\tau^- \to e^- \bar{\nu}_e \nu_\tau)}$$

$$\left(\frac{g_\mu}{g_e}\right)_\tau = \sqrt{R_\mu \frac{f(m_e^2/m_\tau^2)}{f(m_\mu^2/m_\tau^2)}}$$



- **Test of μ/e universality in τ decays**
  - In the $e^+e^- \to \tau^+\tau^-$ one can separate the event in two hemispheres: tag τ, and signal τ

Full Belle II RUN1 data sample 364 fb^{-1}

-Signal side: e or μ

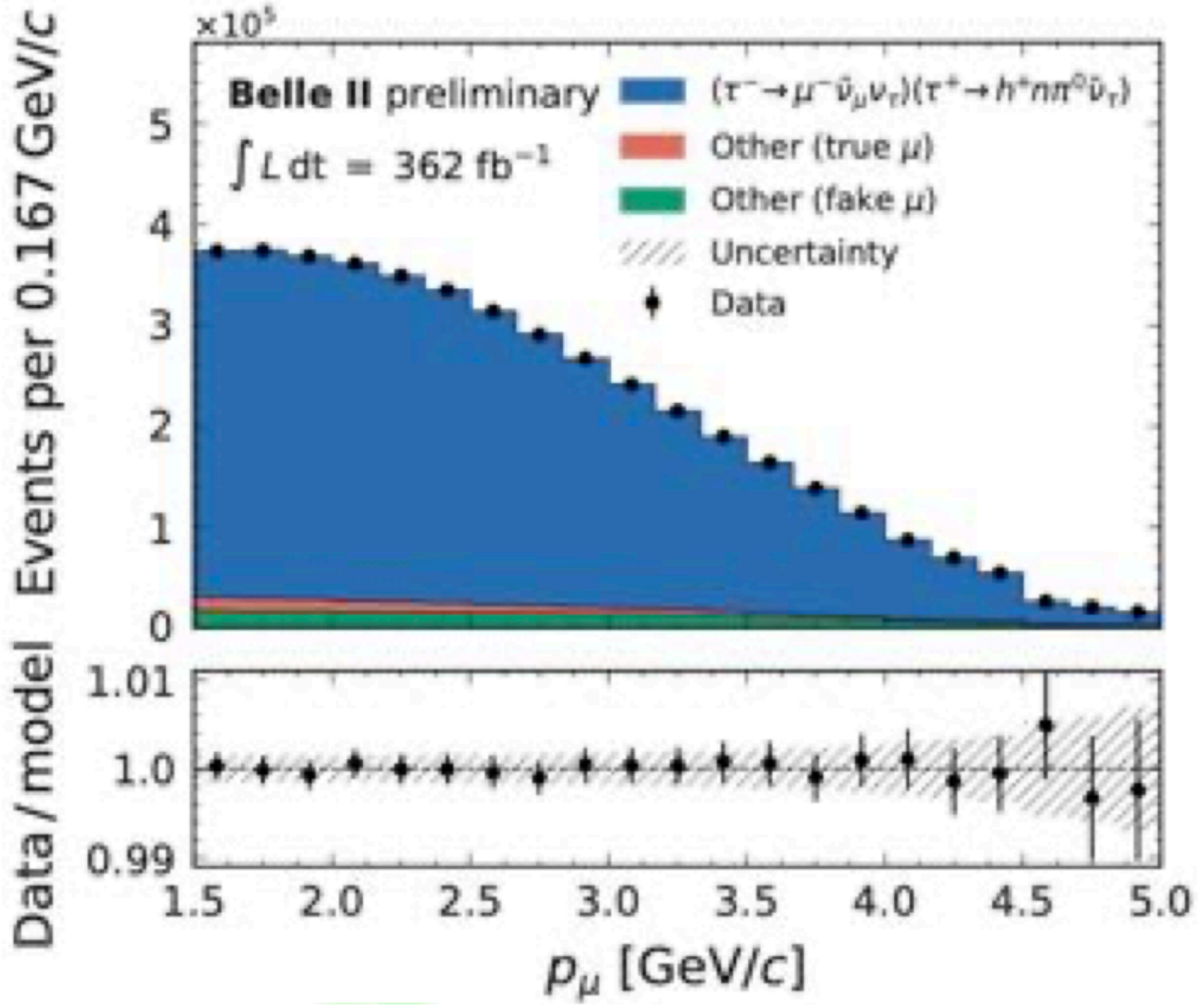
-Tag side: 1 charged hadron + $\geq 1\pi^0$

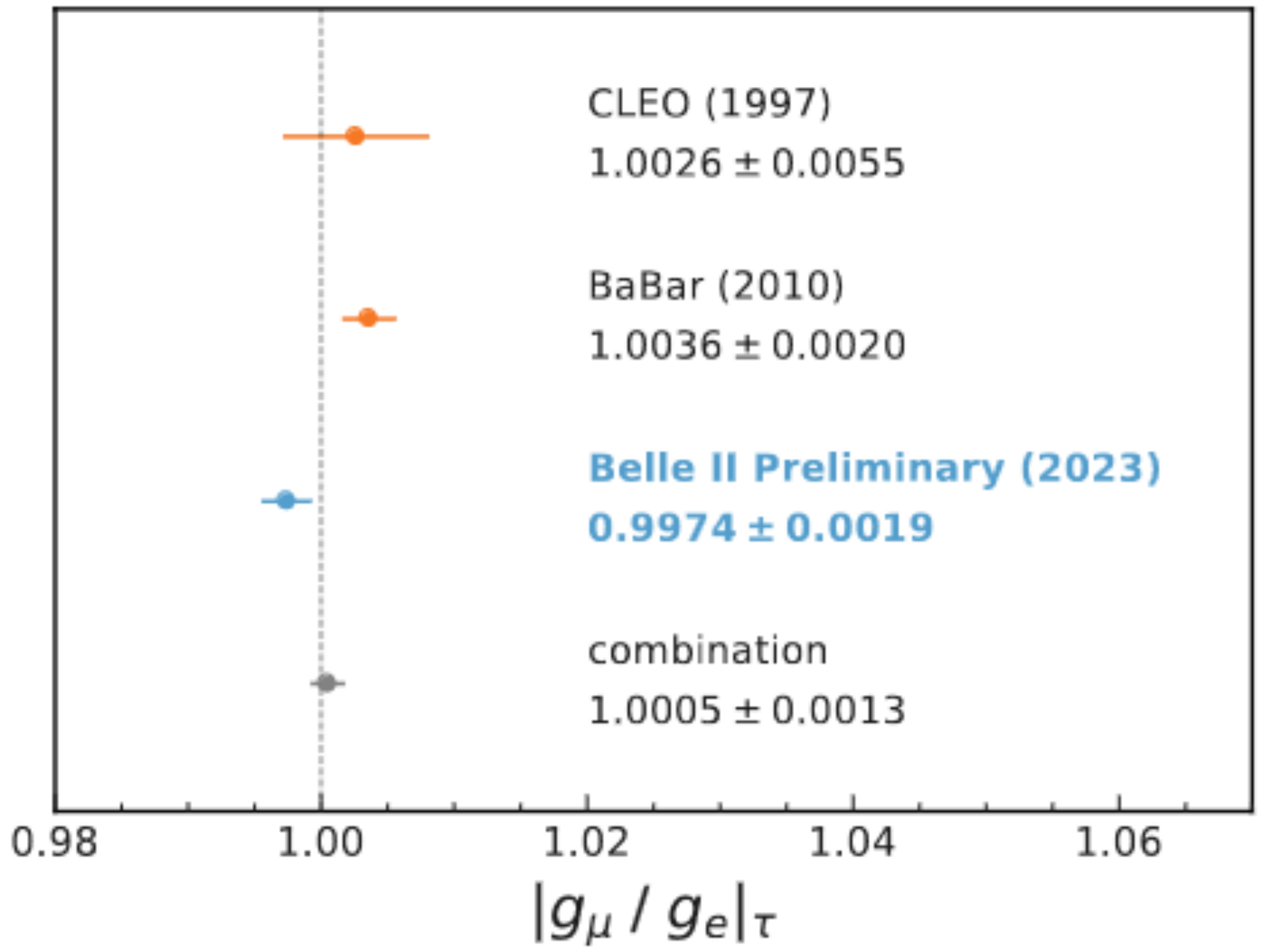
- Background suppression using a Neural Network
- Systematics dominated by eID and trigger

R_μ obtain by binned maximum likelihood fit on momentum spectra on μ/e

Most precise test of light lepton universality in τ decays

Purity 96% and 92% for electron and muon channels





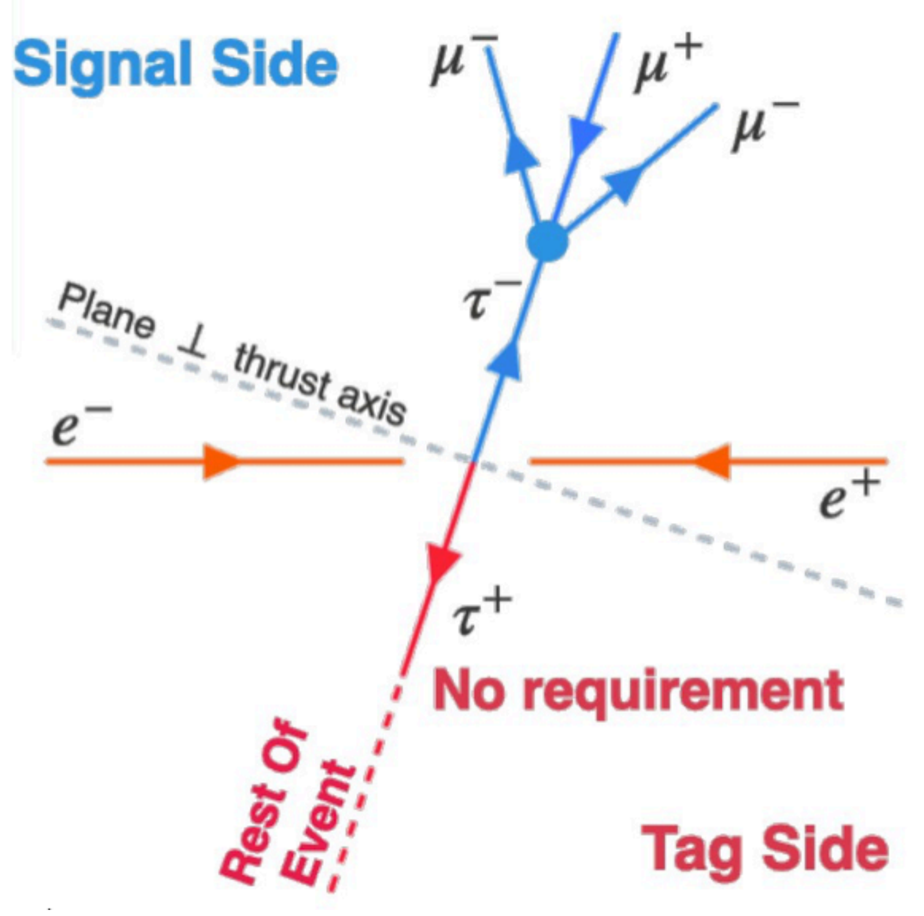
$$R_\mu = 0.9675 \pm 0.0007(stat) \pm 0.0036(sys)$$

$$g_\mu/g_e = 0.9974 \pm 0.0019$$

arXiv:2405.07386

Accepted by JHEP

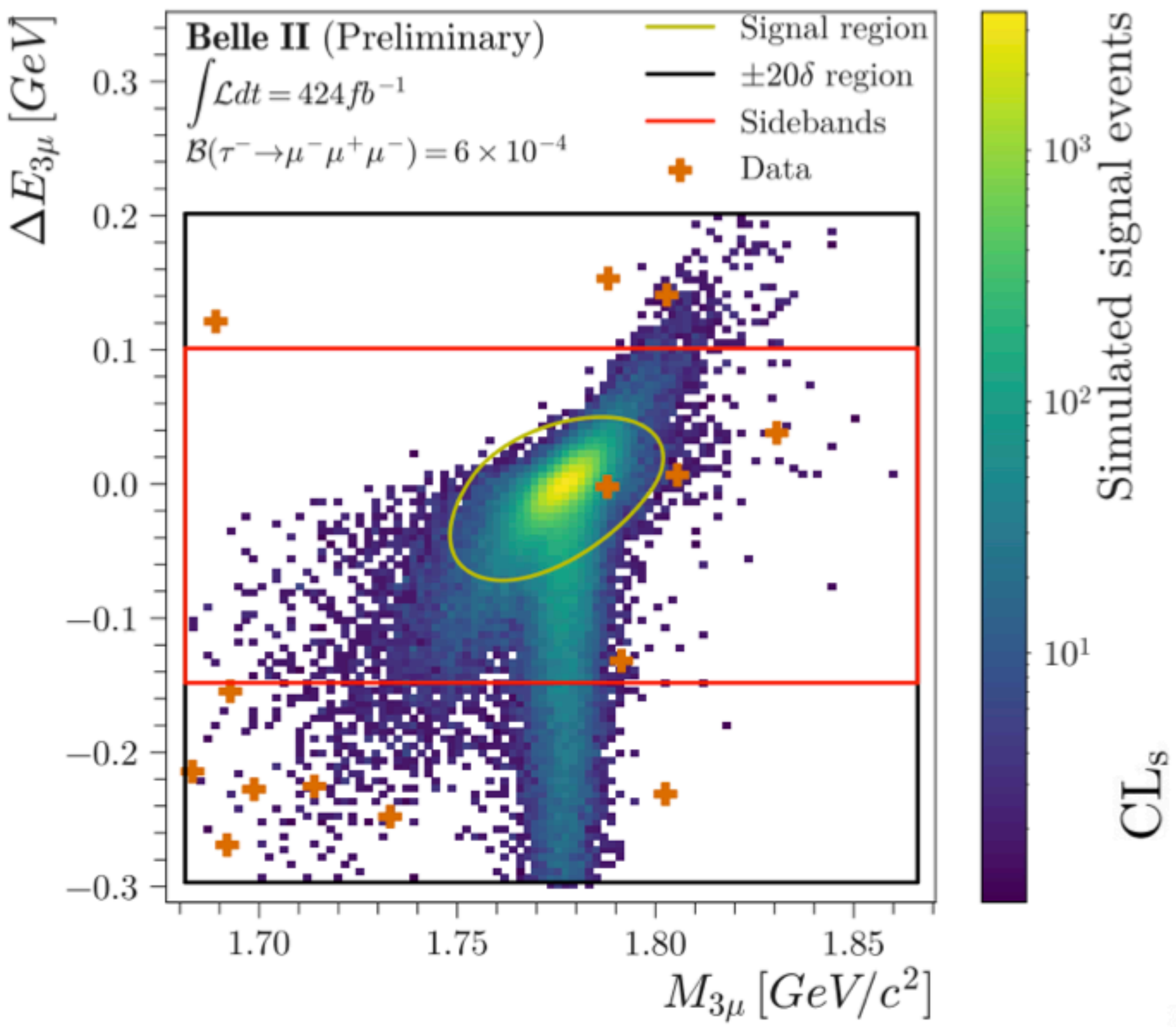
Talk by A.Thaller



A lot of interest in LFV decays at e^+e^- colliders, with ~ 50 modes:
$\tau \to l\gamma, \tau \to l\phi, \tau \to lll$

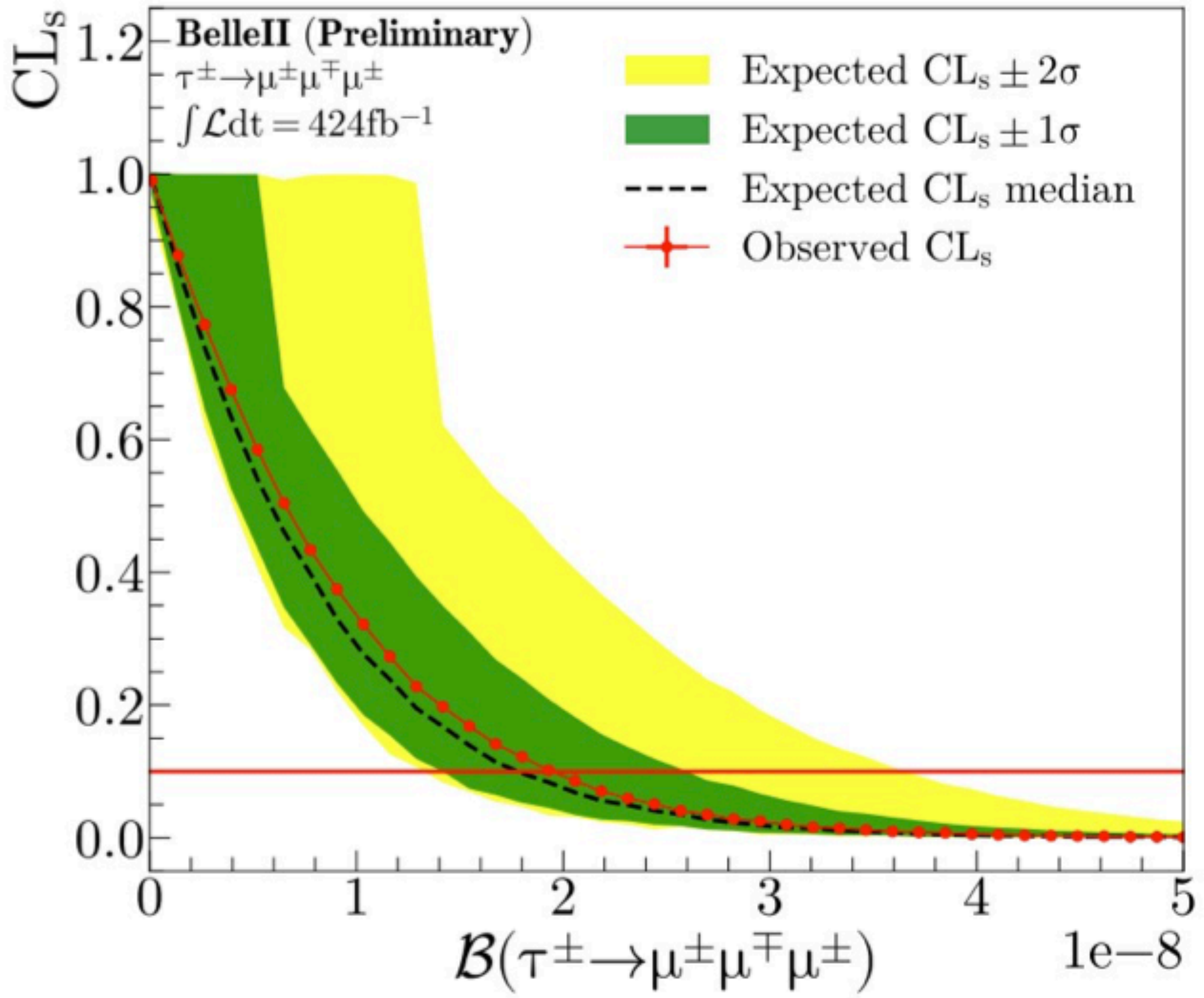
These are rare decays : it's all about **maximising the statistics!**

- Almost free from SM background
- Very good resolution on the energy and the momentum



Signal:
- reconstruction of signal candidate by combining three muons

Background:
- Selections to remove low-multiplicity events
- BDT to reject $q\bar{q}$ events



90% CL upper limit on Branching Fraction

$$\mathcal{B}(\tau \to \mu\mu\mu) < 1.9 \times 10^{-8}$$

World's best limit!!!

No excess is found!

Conclusions

- Belle and Belle II have been and will continue to collect excellent data for various physics programs
- Many more measurements are in progress
- You can find more on our public publications page : https://www.belle2.org/research/physics/publications
- Only a small fraction of the exciting results are included in this talk
- Belle II has restarted collecting data from its Run2, aiming to significantly increase its data sample in the next few years

- Looking forward to more data in the coming years

Thank you for your attention

Back up slides

Belle & Belle II detectors

Belle II

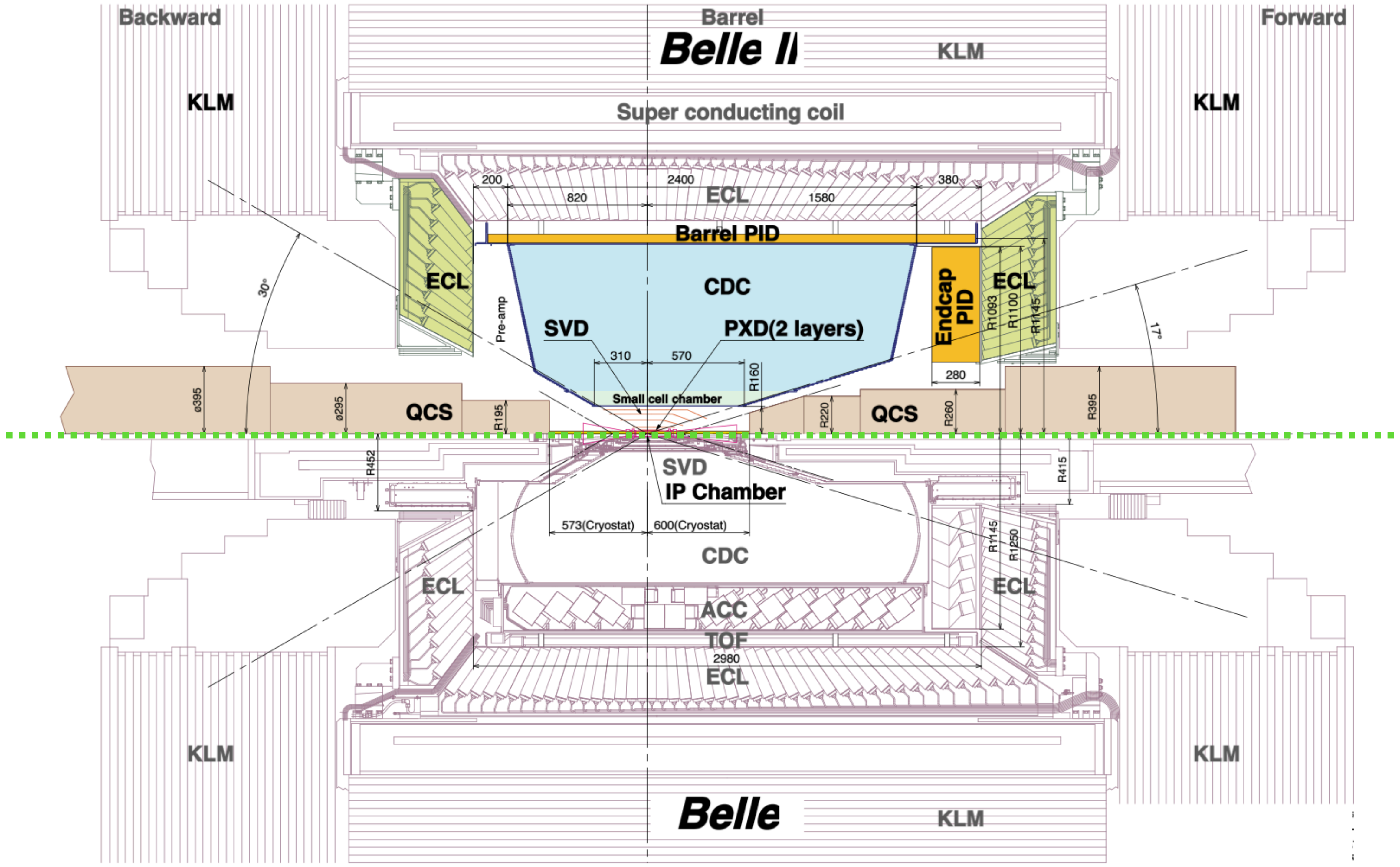
ECL (electromagnetic calorimeter): Updated electronics

PID (Particle Identification): Better K/π separation under higher bkg level

CDC (Central drift chamber): larger volume, smaller drift cells and faster electronics

VTX: + 2 layers PXD (pixel detector)
+ 4 layers SVD (Silicon vertex detector)

BELLE

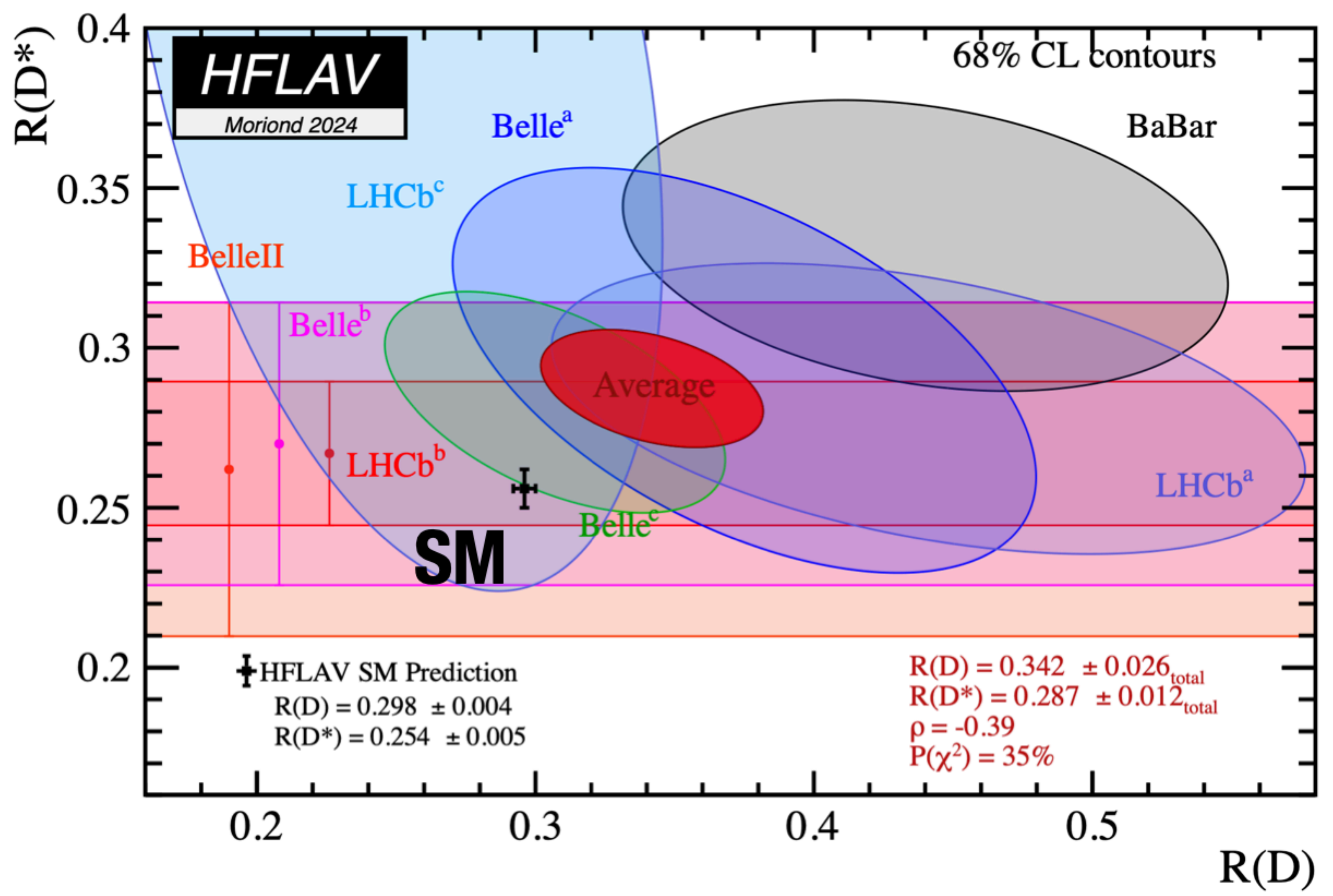


[Belle II TDR]

- Well-known **initial state** condition
- Benefits from **clean environment**
- Efficient reconstruction of **neutrals**
- Boosted center of mass that allows for time-dependent measurements
- Hermetic detectors $\longrightarrow$ ideal for studying neutral or invisible decays

Phy.Rev.Lett.132.211804

- **LFU:** SM expects lepton coupling to EW gauge boson to be **flavour-universal**
- **Ratio** of the branching-fraction of senile-tonic decays

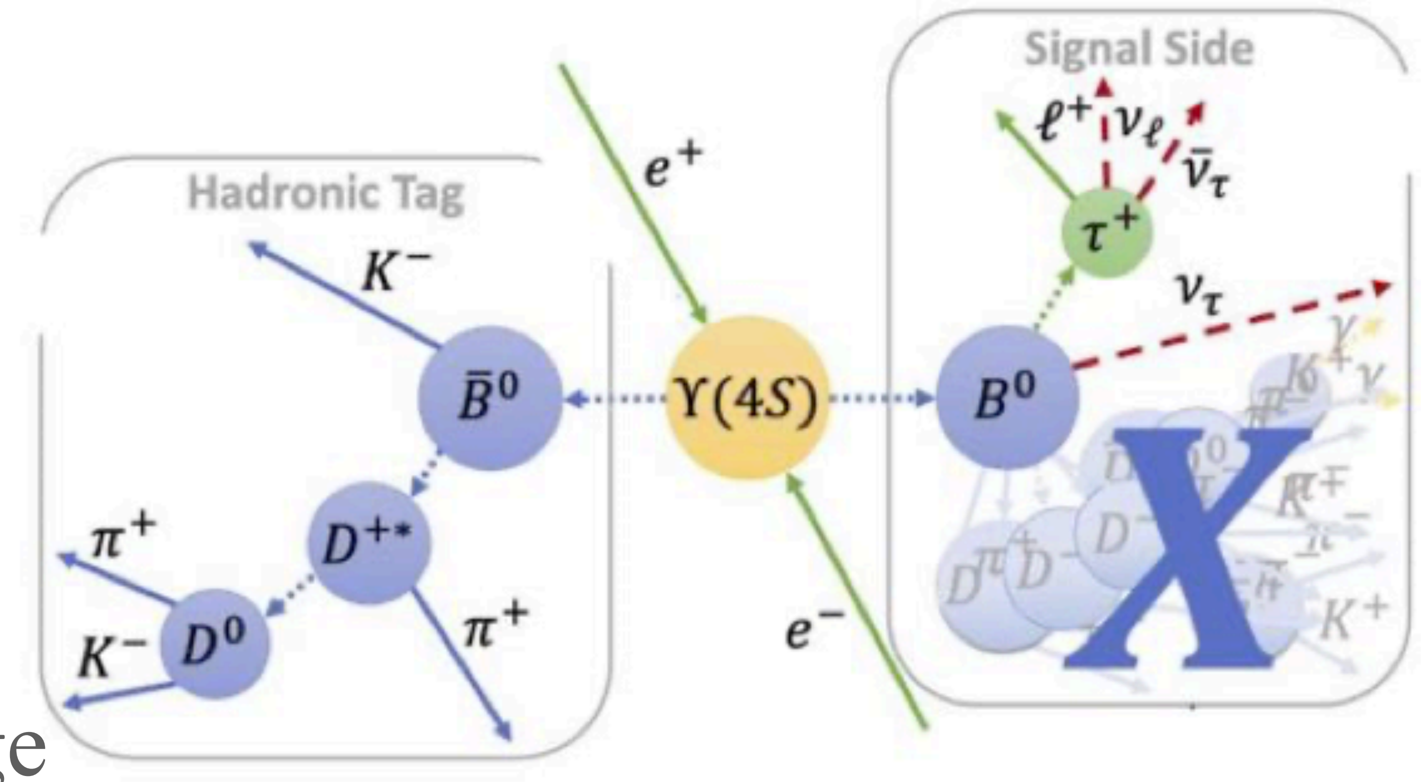


$$R(H_{\tau/l}) = \frac{Br(B \rightarrow H\tau\nu_\tau)}{Br(B \rightarrow Hl\nu_l)}$$

Where H = D,D*, X, π … and l= e, μ

New

- Measurement of R($X_{\tau/l}$) has been carried out with 189 fb^{-1} of Belle II data
  - Reconstruction of $B \rightarrow X\tau\nu_\tau$ and $B \rightarrow Xl\nu_l$:
    - Hadronic tag: tagged B reconstructed in its hadronic decay modes (using **Full Event Interpretation (FEI)**)
    - Signal : $B \rightarrow X\tau\nu_\tau$ with leptonic decays ($\tau \rightarrow e\bar{\nu}_e\nu_\tau / \mu\bar{\nu}_\mu\nu_\tau$)
    - Normalisation: $B \rightarrow Xl\nu_l$ (with l= e, μ)



Background contamination and modeling of many decay channels in signal side is the challenge

LFU tests - Measurement of R($X_{\tau/l}$)

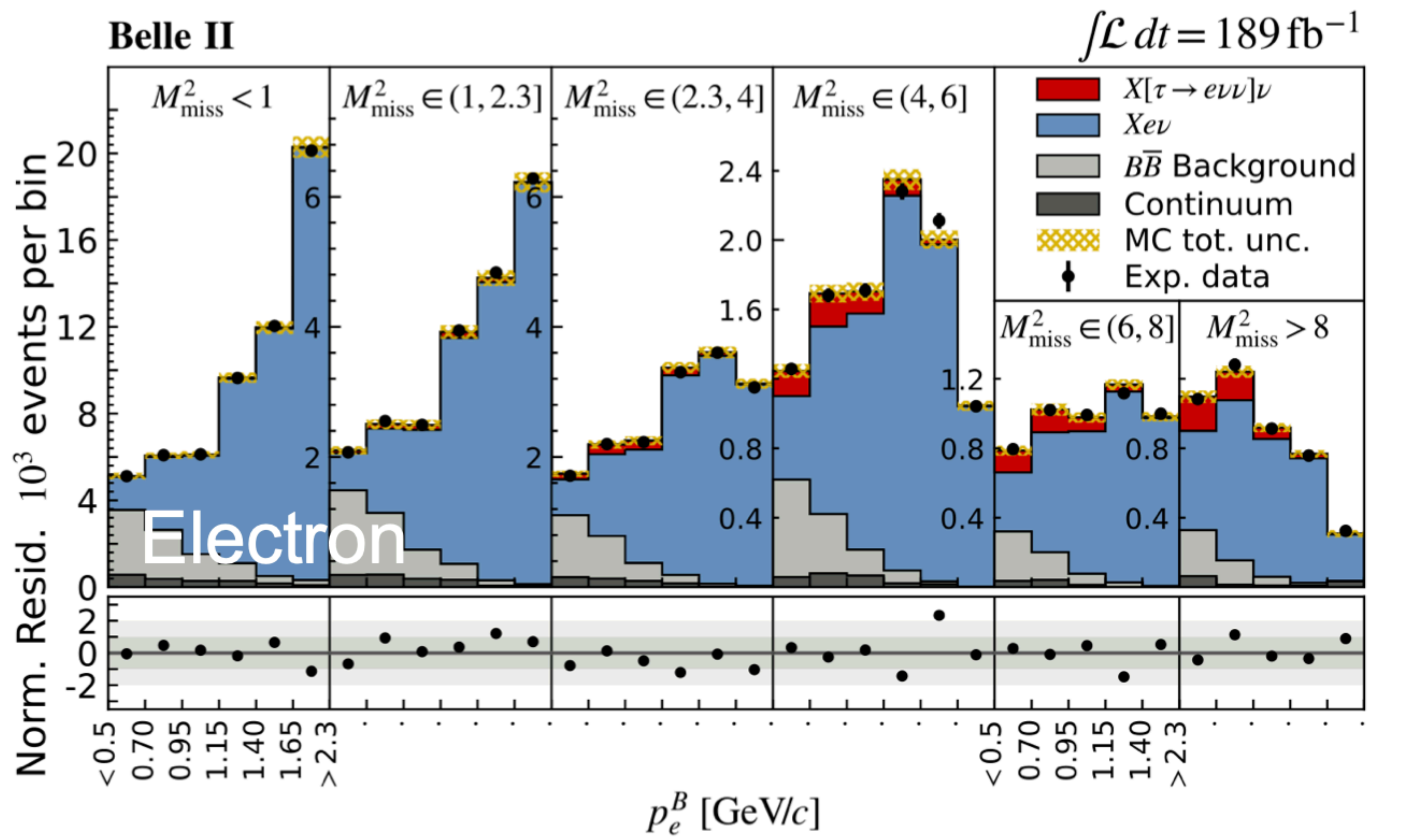
Phy.Rev.Lett.132.211804

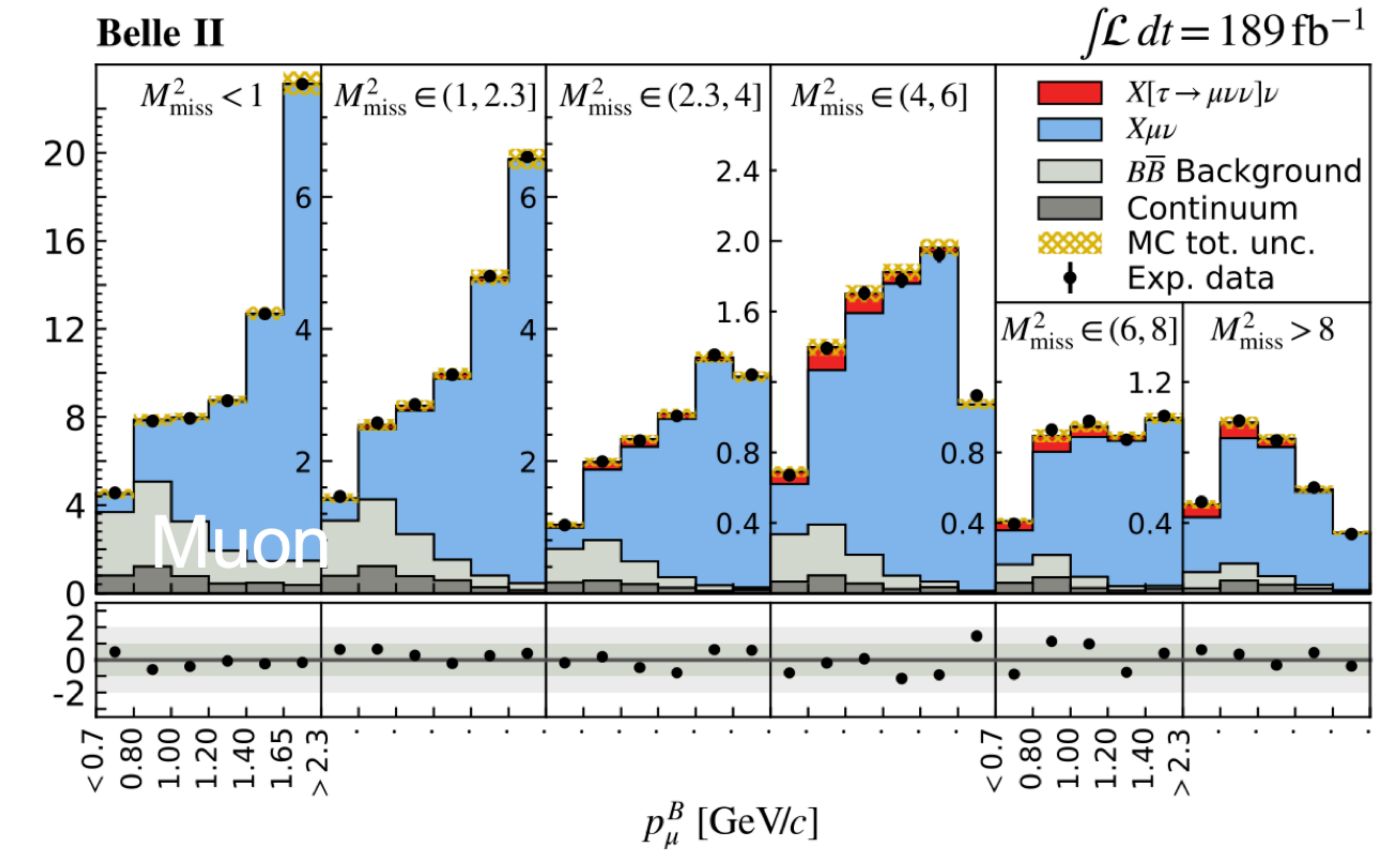
- **Signal extraction:**
  - 2D binned maximum likelihood fit to extract the **signal** and **normalization** yields for both electrons and muons modes simultaneously
    - In bins of p_l^B and M^2_{miss}
      - e channel: $R(X_{\tau/e}) = 0.232 \pm 0.020(stat) \pm 0.037(syst)$
      - μ channel: $R(X_{\tau/\mu}) = 0.222 \pm 0.027(stat) \pm 0.050(syst)$

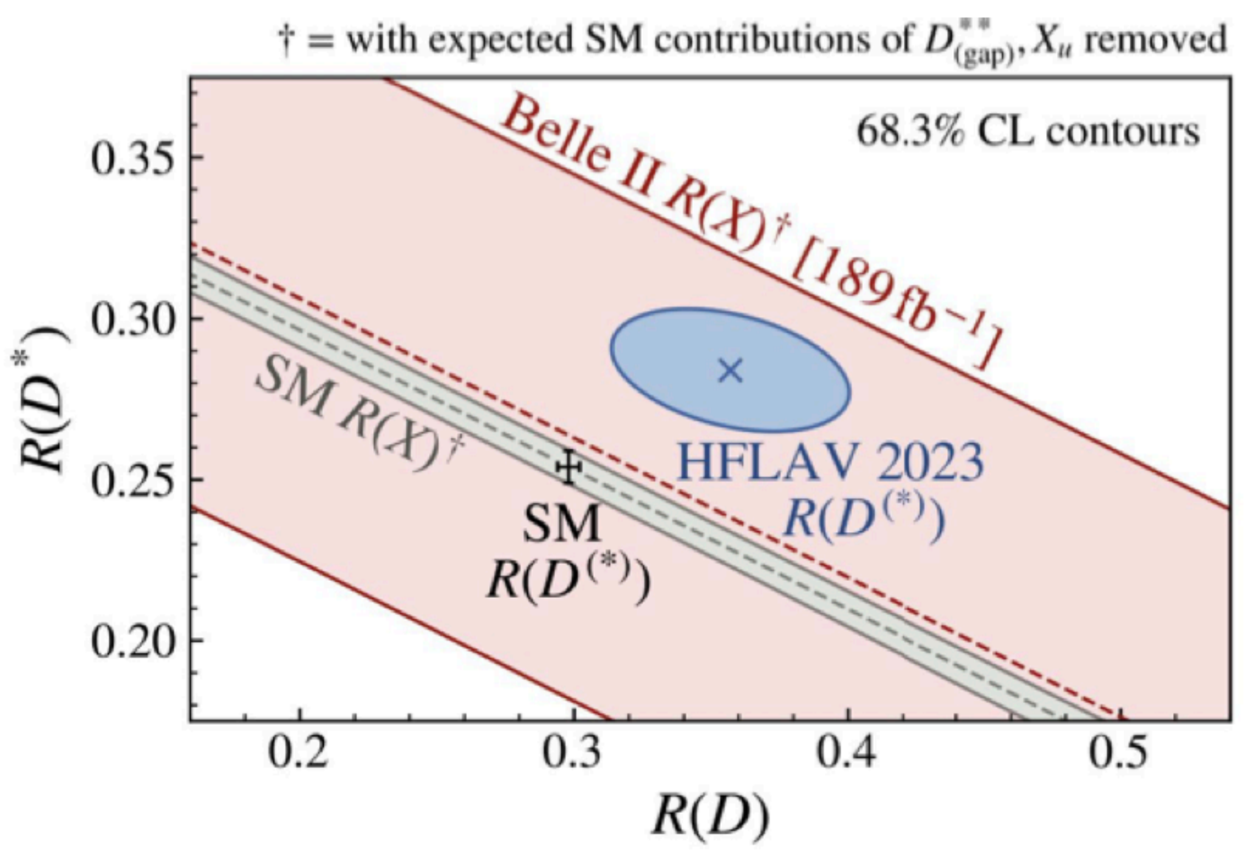
$$R(X_{\tau/l}) = 0.228 \pm 0.016(stat) \pm 0.036(syst)$$

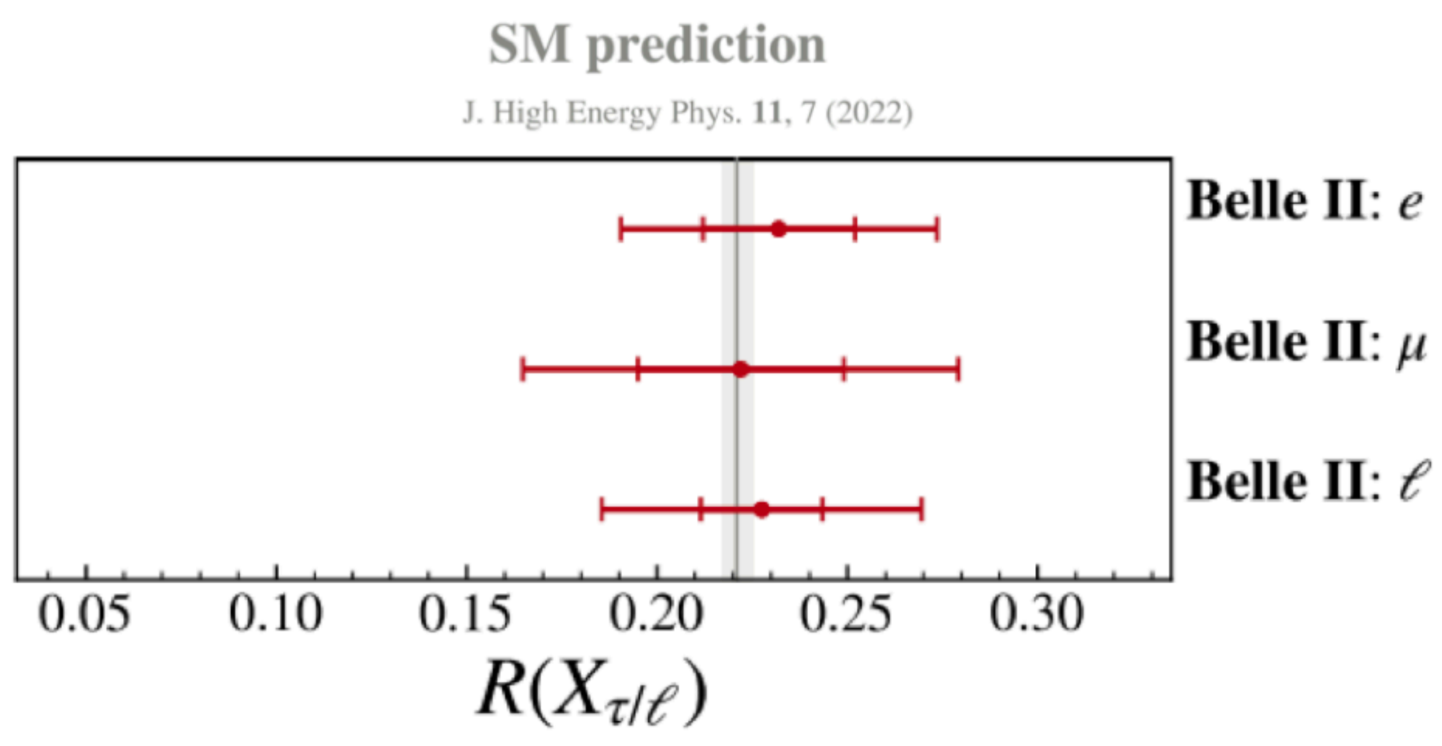
Agreement between the e and μ channel measurements

Consistent with SM prediction (0.221 ± 0.004) and $R(D^*)$ anomalies









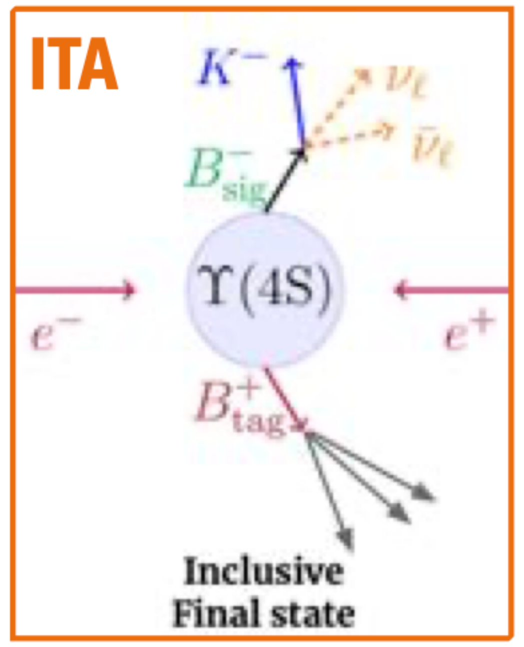
Rare Decays :$B^+ \to K^+\nu\bar{\nu}$ validation and corrections

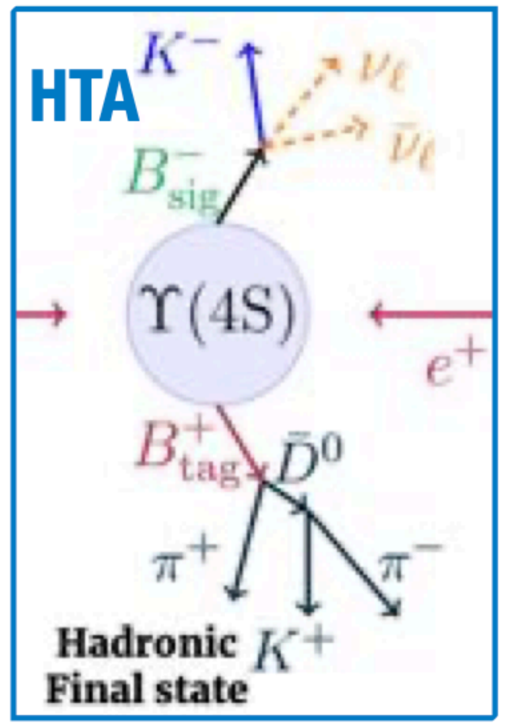
PhysRevD.109.112006

- Used to complementary B tag approach : **low purity-high efficiency** (0.8%-8%) **and its opposite** (3.5%-0.4%)

- **Signal validation:** event selection by combining signal Kaon, event topology, rest of the event in the MVA classifiers

- **Full Belle II Run1 data sample (362 fb^{-1})**





- **Background validation:** background from continuum
  Semileptonic B decays
  $B^+ \to K^+ n\bar{n}$
  $B^+ \to K^+ K^0 \bar{K}^0$
  $B \to K^+ D(\to K_L X)$
  pions fake

- **Inclusive method validation**:
  - Closing test by measuring $\mathscr{B}(B^+ \to \pi^+ K^0)$

Rare Decays : double radiative $B^0 \to \gamma\gamma$ at Belle and Belle II

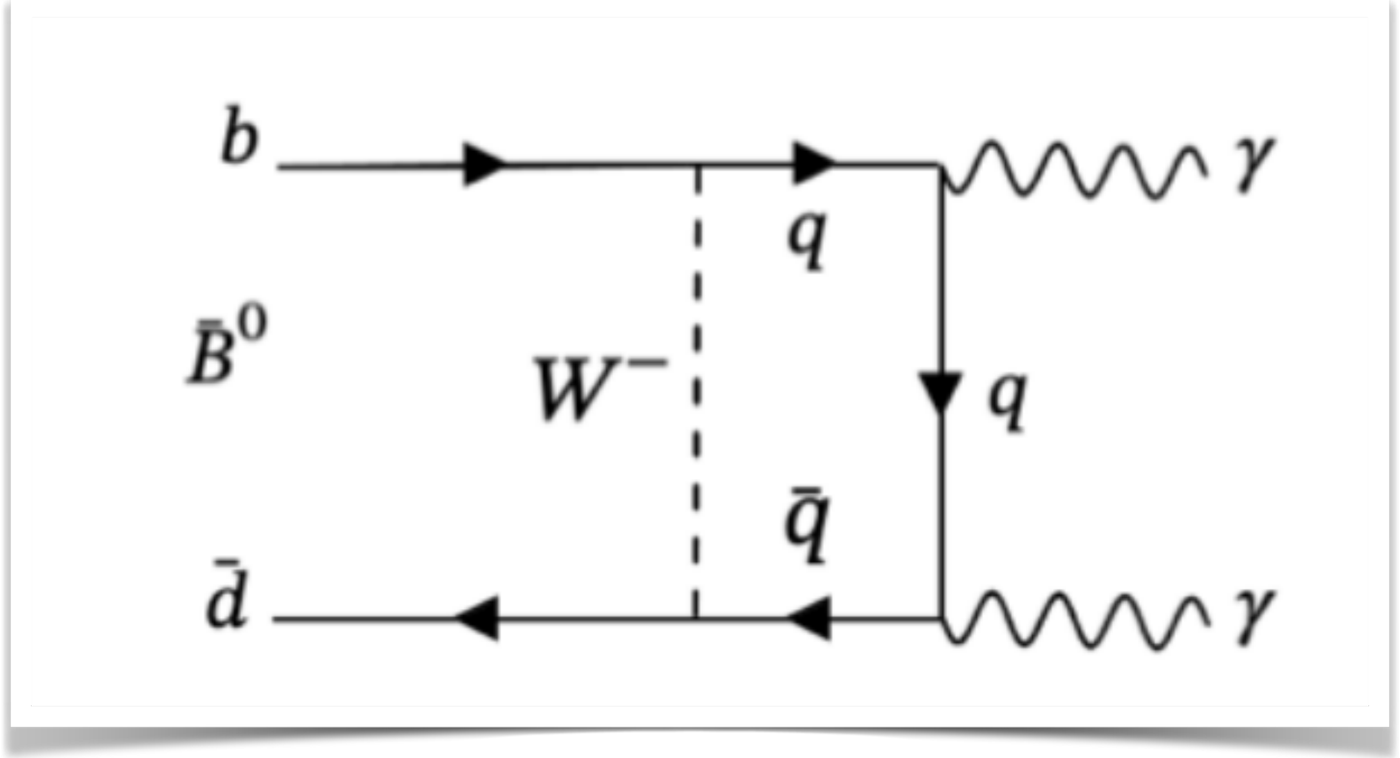
Preliminary

arXiv:2405.19734

Accepted by PRDL

- Flavor-changing Neutral Current (FCNC) b→d decay with $\mathscr{B}(SM) = 1.4^{+1.4}_{-0.8} \times 10^{-8}$

  Highly suppressed in the SM , sensitive to New physics



- Two photons in the final states makes it experimentally challenging
  - Previous measurements only set upper limits

Experiment	$\int \mathscr{L}dt$	Limits @ 90 C.L
L3	73 pb^{-1}	3.9×10^{-5}
Belle	104 fb^{-1}	6.2×10^{-7}
Babar	426 fb^{-1}	3.2×10^{-7}

Phys.Lett.B363 137

Phys.Rev.D.73.051107

Phys.Rev.D.83.032006

- Improve with larger statistics: Belle (694 fb^{-1}) + Belle II Run1 data (362 fb^{-1})

Rare Decays : double radiative $B^0 \to \gamma\gamma$ at Belle and Belle II

Preliminary

arXiv:2405.19734

Accepted by PRDL

- 3D fit to $\Delta E, M_{bc}$
- Belle ($694\ fb^{-1}$) + Belle II Run1 data ($362\ fb^{-1}$)

$$\mathscr{B}(B^0 \to \gamma\gamma) = (3.7^{+2.2}_{-1.8}(stat) \pm 0.7(sys)) \times 10^{-8}$$

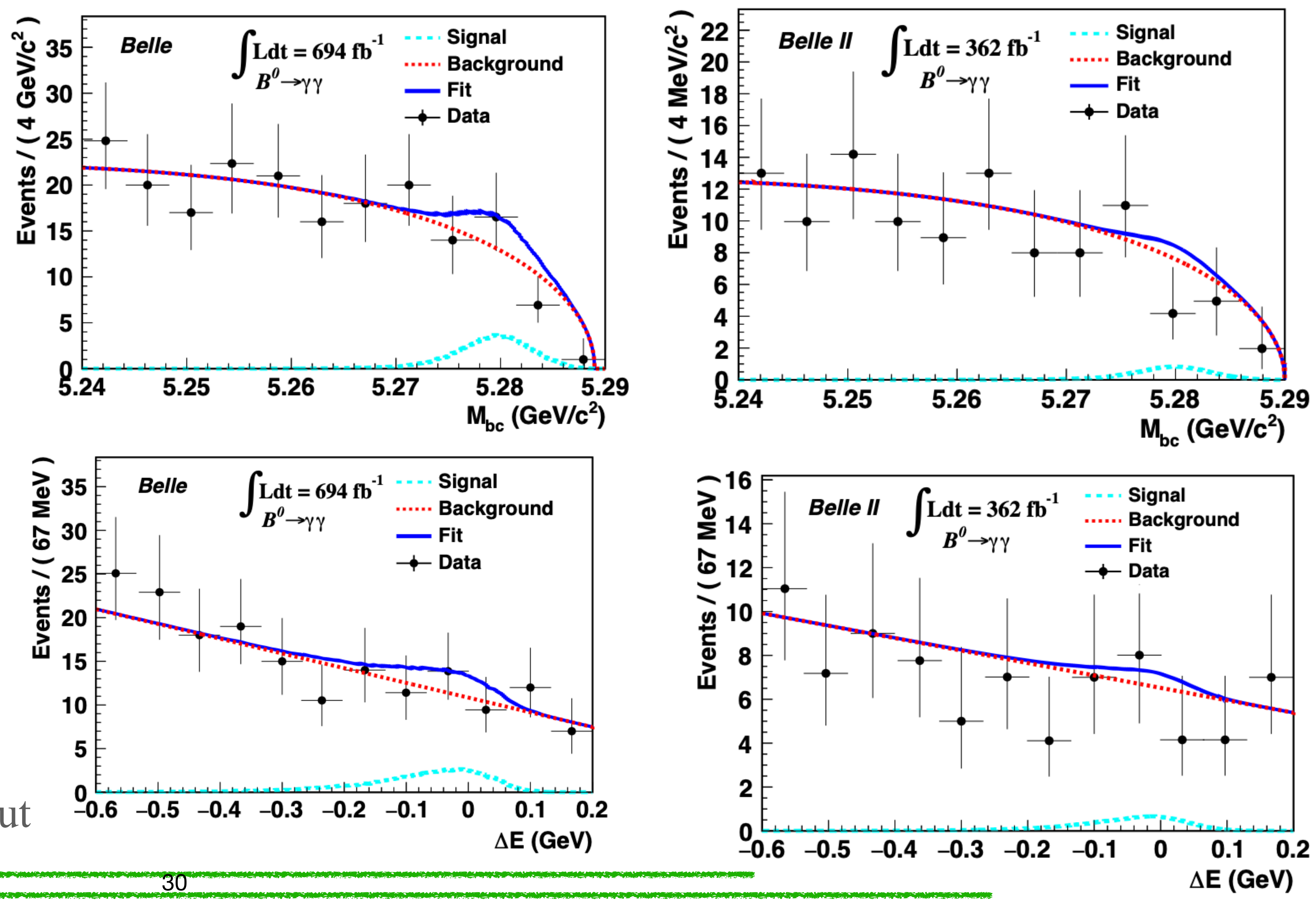
Combined

$$\mathscr{B}(B^0 \to \gamma\gamma) = (5.4^{+3.3}_{-2.6}(stat) \pm 0.5(sys)) \times 10^{-8}$$

$$\mathscr{B}(B^0 \to \gamma\gamma) = (1.7^{+3.7}_{-2.4}(stat) \pm 0.3(sys)) \times 10^{-8}$$

World best Upper Limit:

U.L $< 6.4 \times 10^{-8}$ @ 90% C.L



Fit projections on M_{bc} transformed continuum BDT output