The start of the Belle II experiment at the SuperKEKB e^+e^- factory

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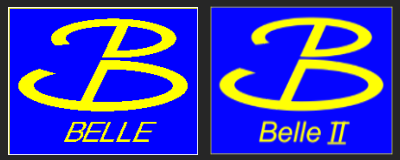
University of Ljubljana/
Jozef Stefan Institute

University
of Ljubljana

"Jozef Stefan"
Institute

ALSO WITH



3rd Jagiellonian Symposium on Fundamental and Applied Subatomic Physics
Krakow
23 - 28 June 2019

- Introduction
- B-Factories
- Belle II
- Luminosity
- Performance
- Measurements

Setting the scene

ELECTROMAGNETIC
WEAK
STRONG
GRAVITATIONAL

The Standard Model (SM) of basic interactions in Nature -
- one of the experimentally best verified physics theories...

...at the current level of experimental precision and energies reached

Several severe shortcomings, for example
degree of CP asymmetry between particles and anti-particles;
responsible for matter dominated Universe,
tested in subatomic world;
10 orders of magnitude too low to explain the matter / anti-matter asymmetry of Universe

search for physics phenomena beyond SM,
new particles, and new interactions often addressed as
New Physics (NP)

TEST OF KOBAYASHI-MASKAWA MECHANISM

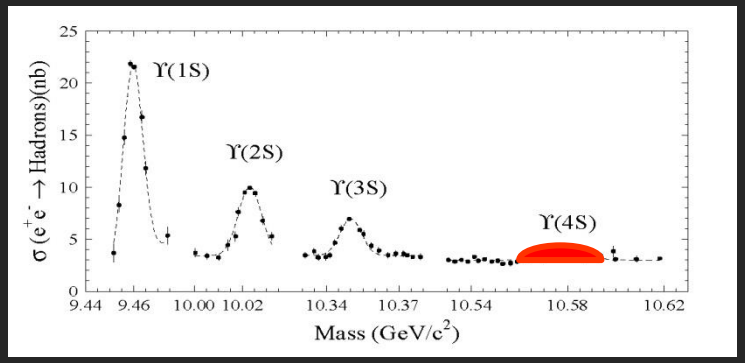
B-FACTORIES, e^+e^-:

BABAR (SLAC)/BELLE (KEK) 1999 – 2010

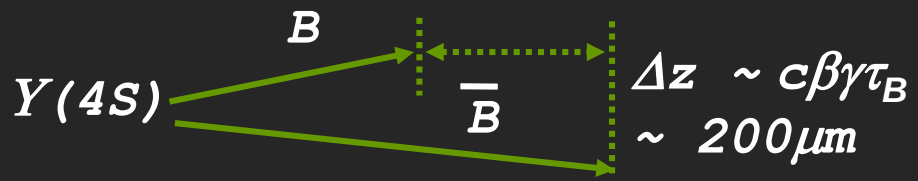
$$dN_f / dt = \sigma(e^+e^- \to f)\mathcal{L}$$

$$N_f = \sigma(e^+e^- \to f)\int \mathcal{L}dt$$

$\mathcal{L}_{MAX} = 2.1 \cdot 10^{34}\ CM^{-2}S^{-1}$

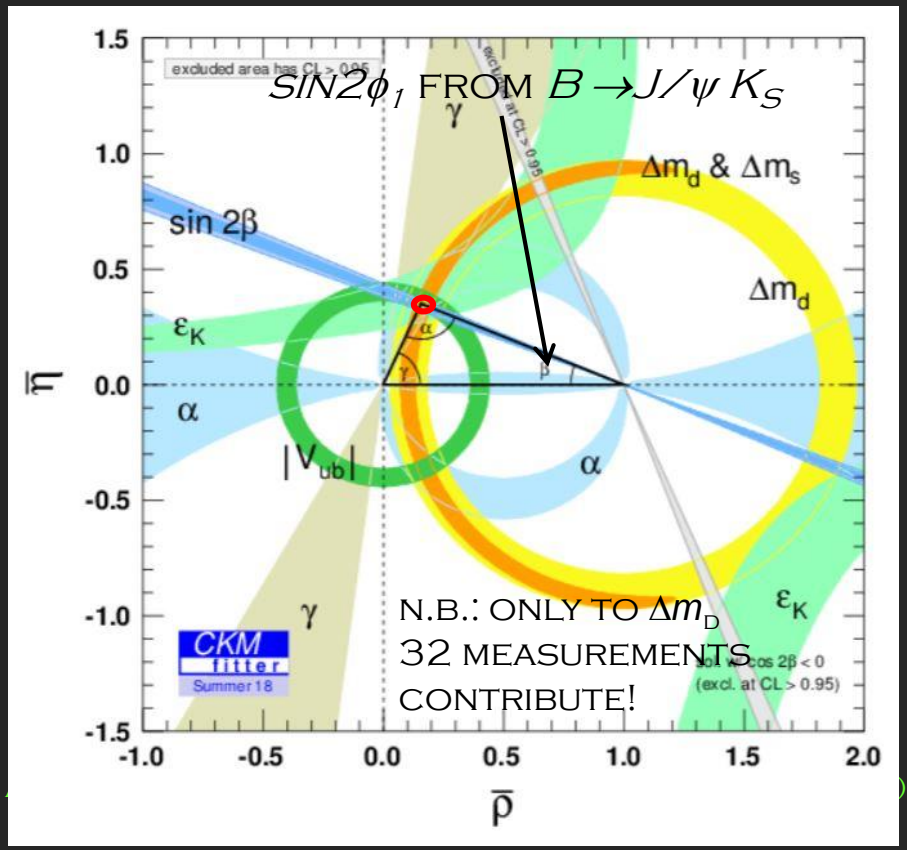


$\sqrt{s}$=10.58 GeV



$p(e^-)$=7 GeV $p(e^+)$=4 GeV

$\beta\gamma \neq 0$



Belle II

Super B-Factory: SuperKEKB & Belle II (KEK) 2018 →

$\mathcal{L}=2 \cdot 10^{34}\ cm^{-2}s^{-1}$

→

$\mathcal{L}=8 \cdot 10^{35}\ cm^{-2}s^{-1}$

$N(B\bar{B}) \approx 50 \cdot N_{BELLE}(B\bar{B})$

Access B decays with ε_{REC} Br >~ 10^{-9} (e.g.

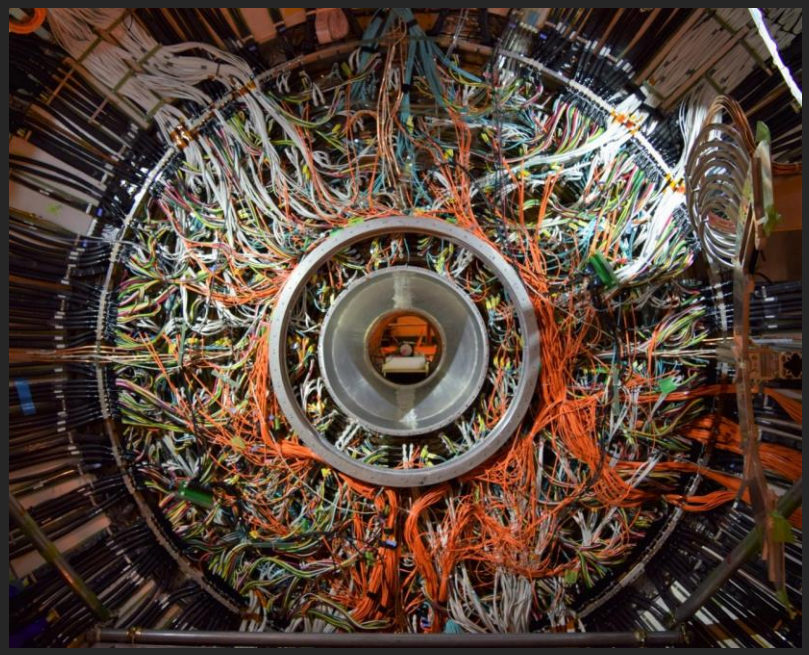
$\varepsilon_{REC}\, Br(B \to \eta' K_S) \sim 1 \cdot 10^{-6}$

$\varepsilon_{REC}\, Br(B \to X_d \gamma) \sim 1 \cdot 10^{-7}$

$\varepsilon_{REC}\, Br(B \to X_u \tau \nu) \sim 4 \cdot 10^{-8}$

$\varepsilon_{REC}\, Br(B \to K^{(*)} \nu\nu) \sim 7 \cdot 10^{-9}$

)



Explore possible deviatons from SM prediction appearing in some rare decays

Detector Belle II

KL and muon detector:
Resistive Plate Counter (barrel outer layers)
Scintillator + WLSF + MPPC (end-caps , inner 2 barrel layers)

EM Calorimeter:
CsI(Tl), waveform sampling (barrel)
Pure CsI + waveform sampling (end-caps)

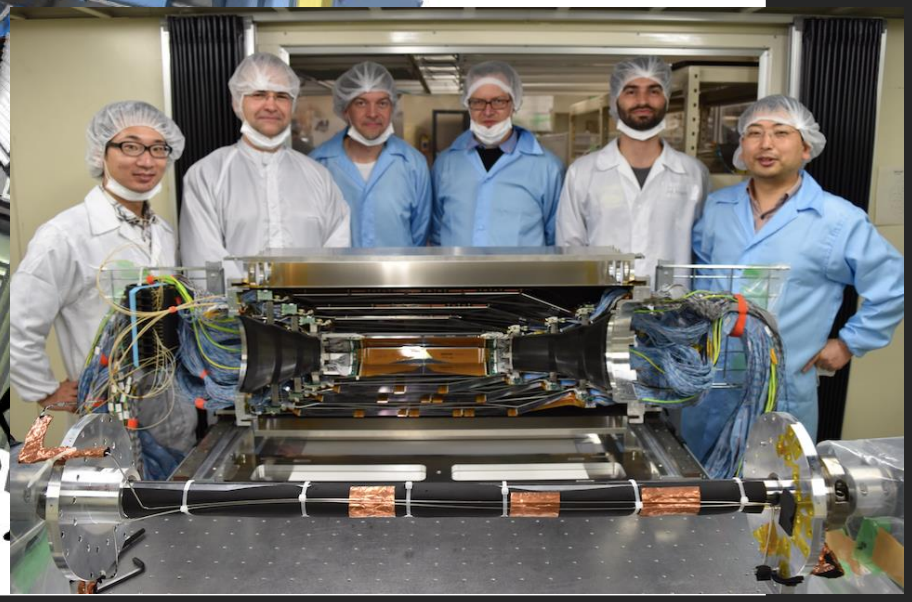
Particle Identification
Time-of-Propagation counter (barrel)
Prox. focusing Aerogel RICH (fwd)

electrons (7GeV)

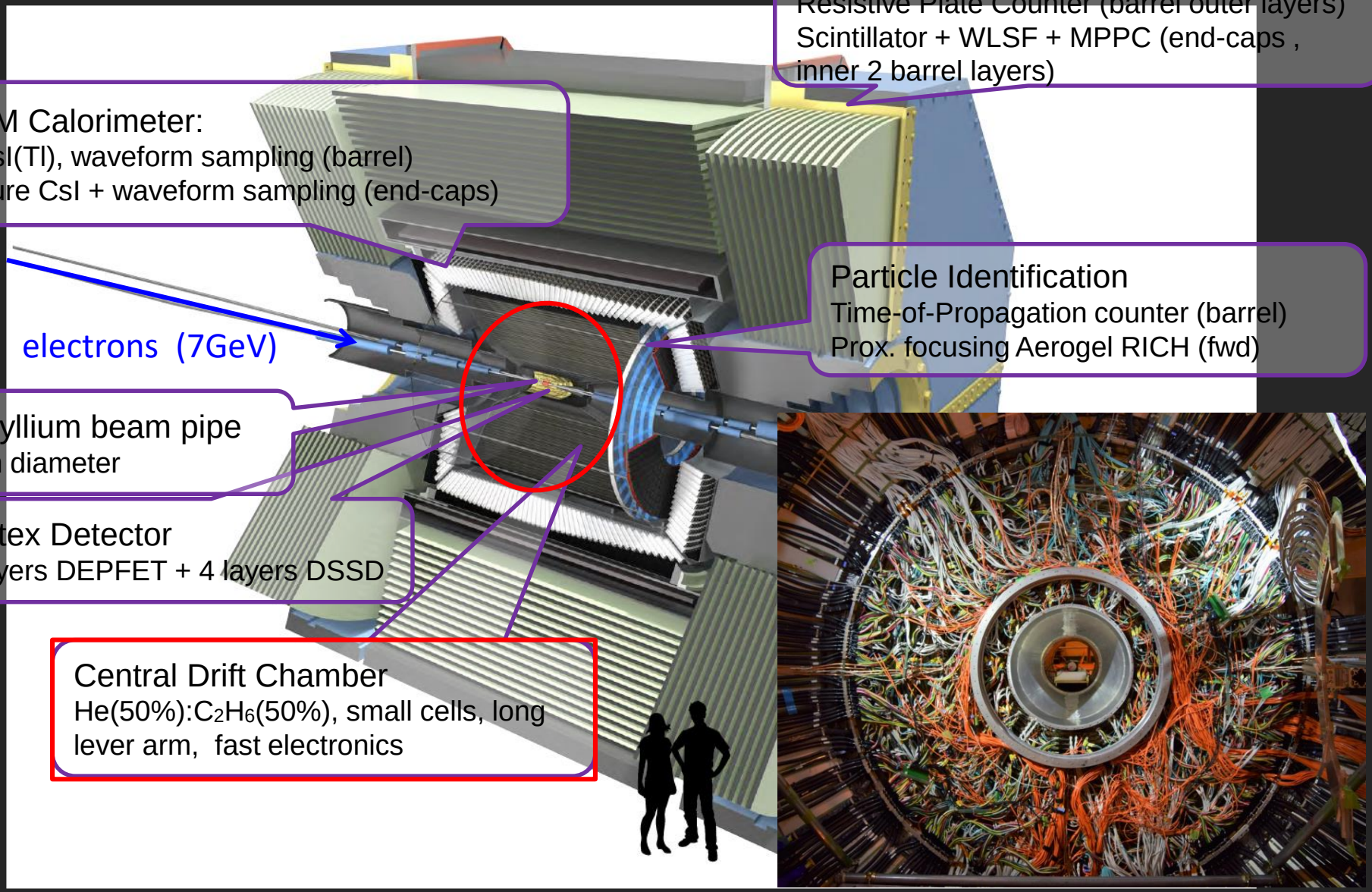
Beryllium beam pipe
2cm diameter

Vertex Detector
2 layers DEPFET + 4 layers DSSD

Central Drift Chamber
He(50%):C_2H_6(50%), small cells, long lever arm, fast electronics



Belle II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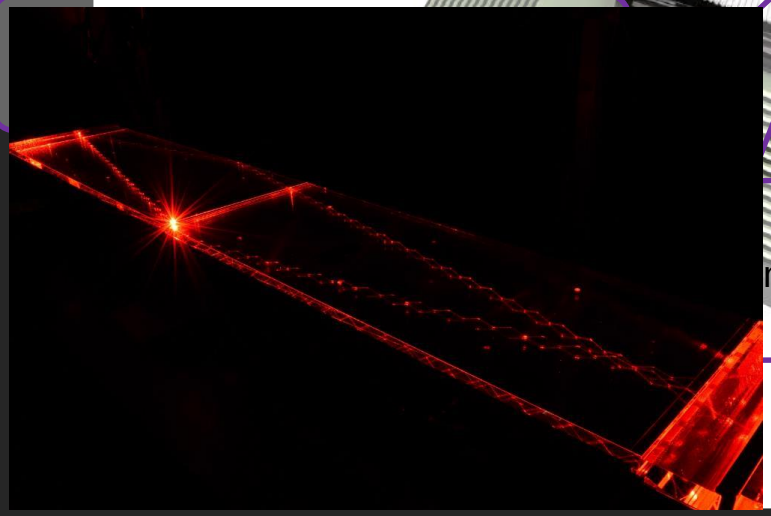

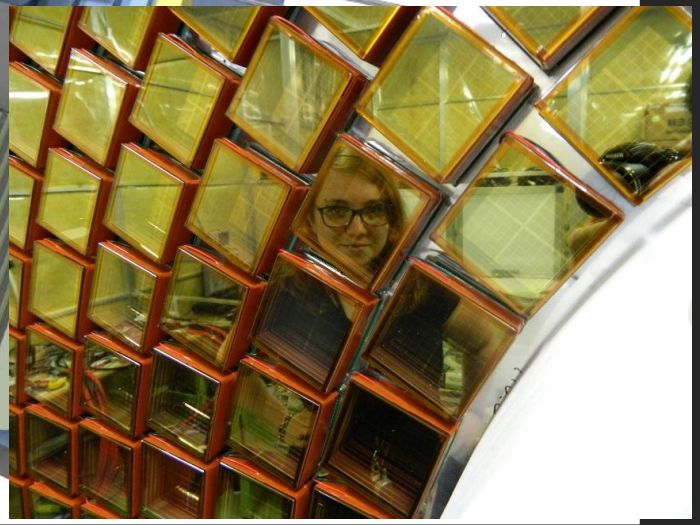

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Particle Identification
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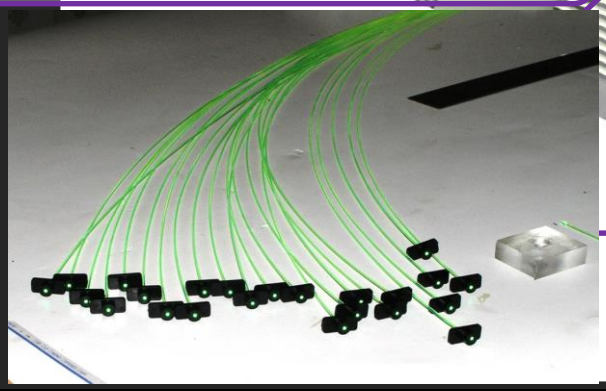
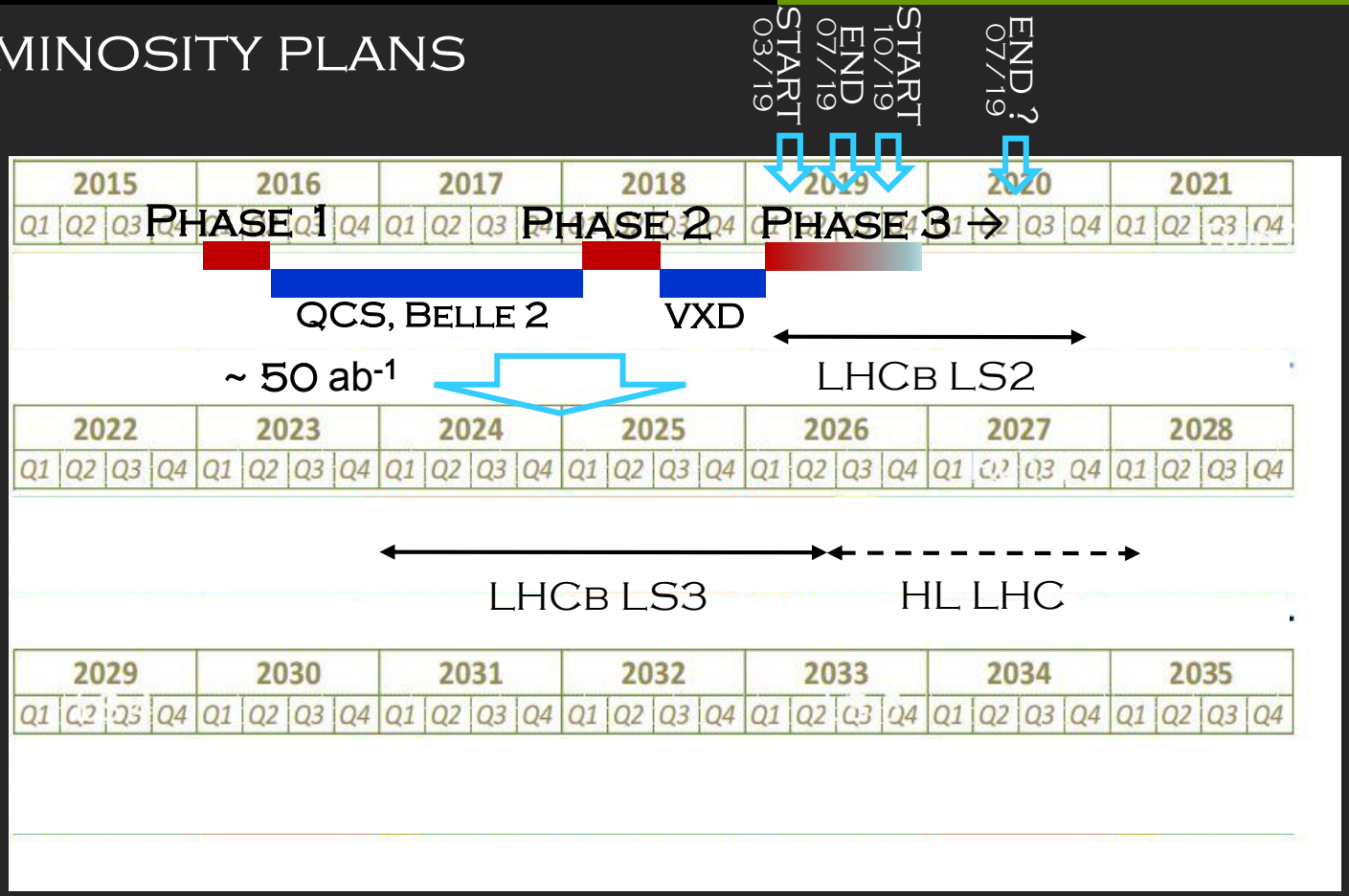
positrons (4GeV)



cells, long

LUMINOSITY PLANS

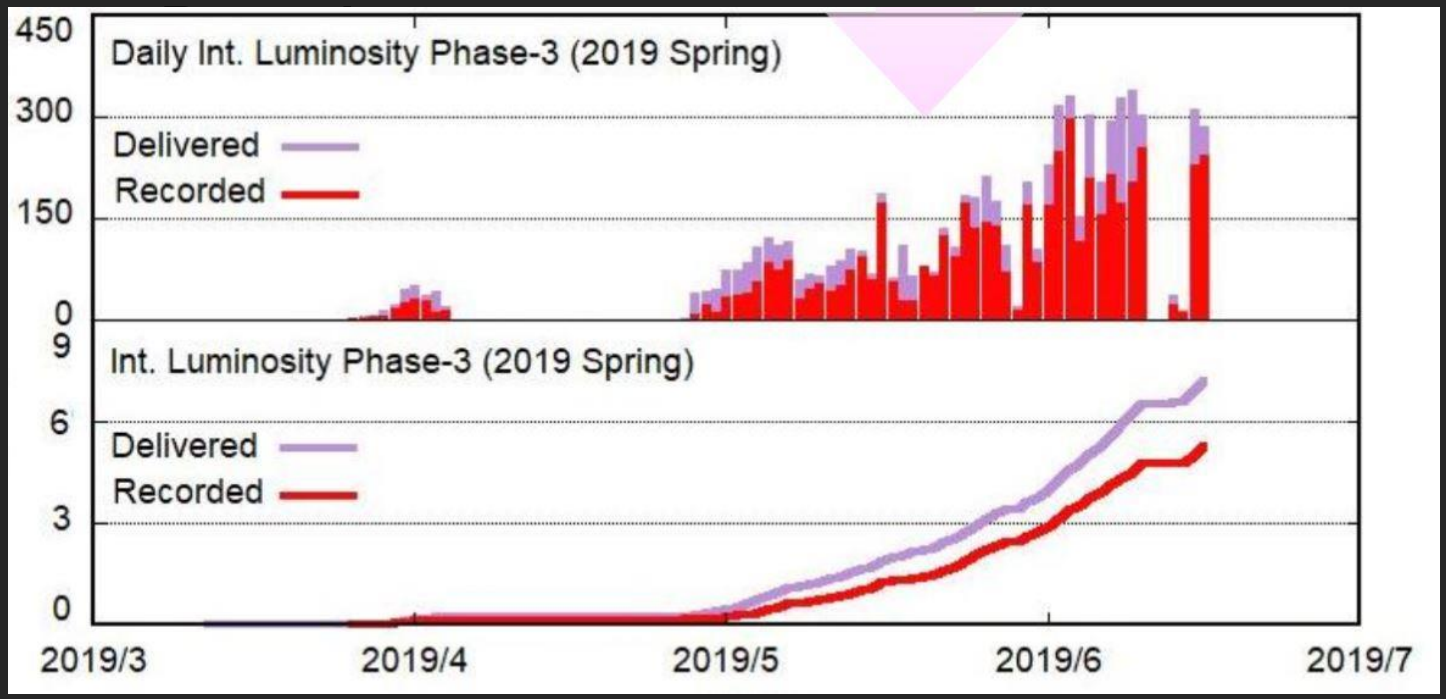


PHASE 1:
W/O QCS
W/O BELLE 2

PHASE 2:
W/ QCS
W/ BELLE 2
(NO VXD)

PHASE 3:
FULL BELLE 2

LUMINOSITY PLANS



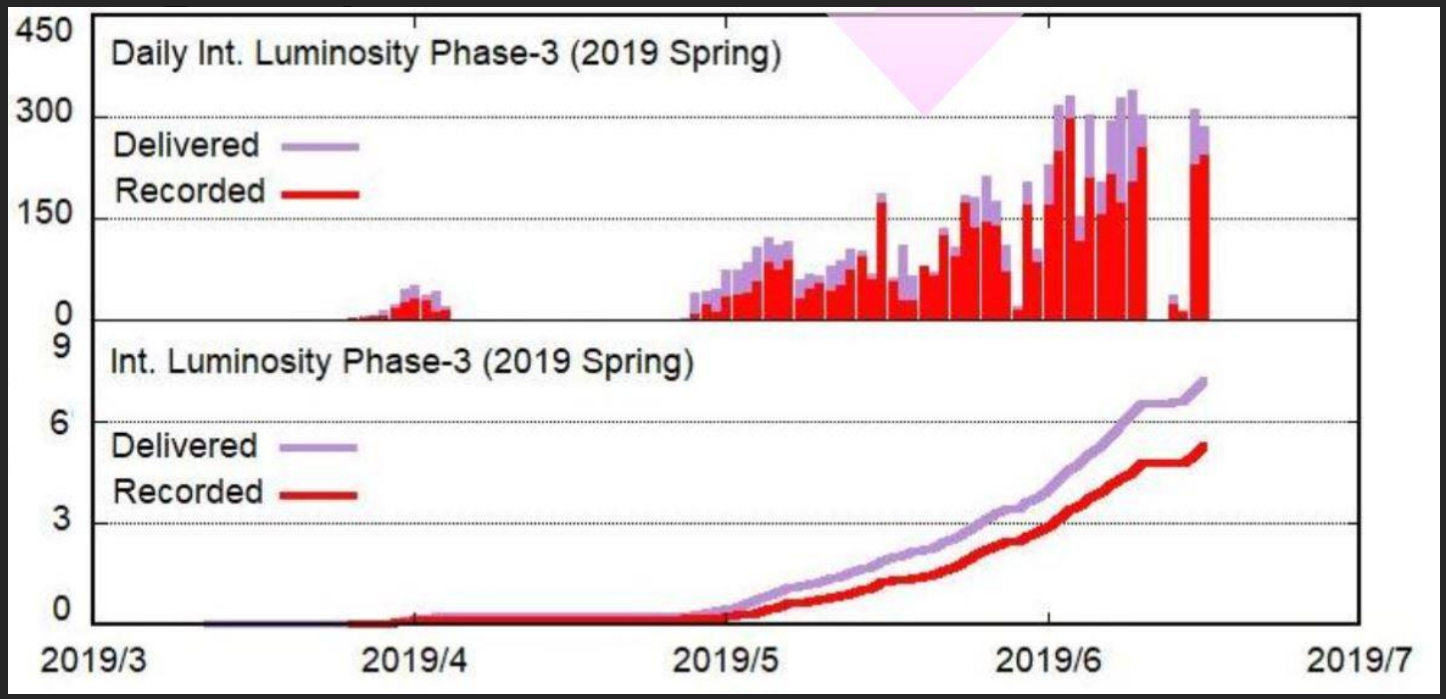
PHASE 1:
W/O QCS
W/O BELLE 2

PHASE 2:
W/ QCS
W/ BELLE 2
(NO VXD)

PHASE 3:
FULL BELLE 2

PLAN:
REACH KEKB LUMINOSITY IN JUNE 2020
> 100 fb^{-1} BY END OF 2020 SPRING RUN

LUMINOSITY PLANS



PHASE 1:
W/O QCS
W/O BELLE 2

PHASE 2:
W/ QCS
W/ BELLE 2
(NO VXD)

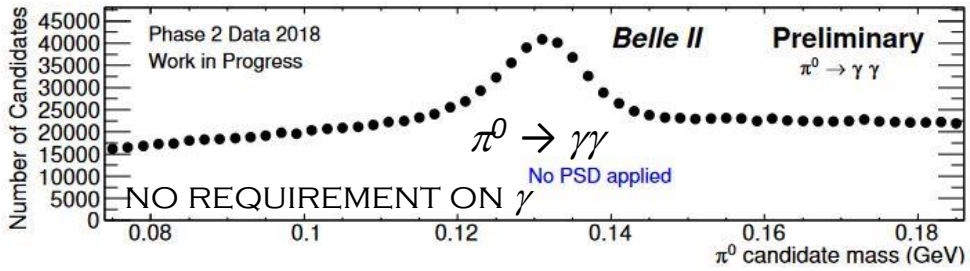
PHASE 3:
FULL BELLE 2

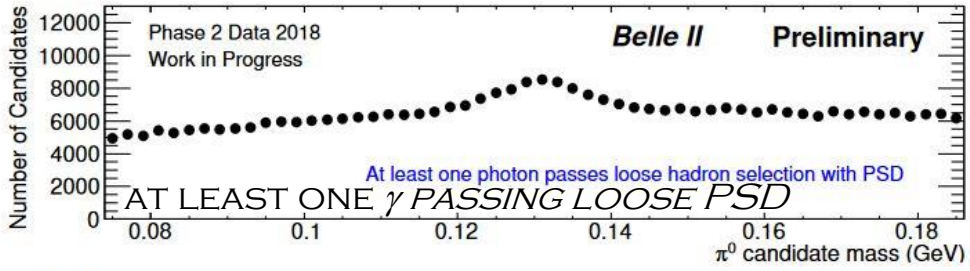
CURRENT ISSUES:
FIRE (4/2019, NOT RELATED TO SUPERKEKB,~2 WEEKS RECOVERY)
INJECTION BKG (REDUCED WITH MACHINE AND COLLIMATORS TUNING)
STORAGE BACKGROUNDS (MAINLY BEAM-GAS, VACUUM SCRUBBING, ADDITIONAL PUMPS)

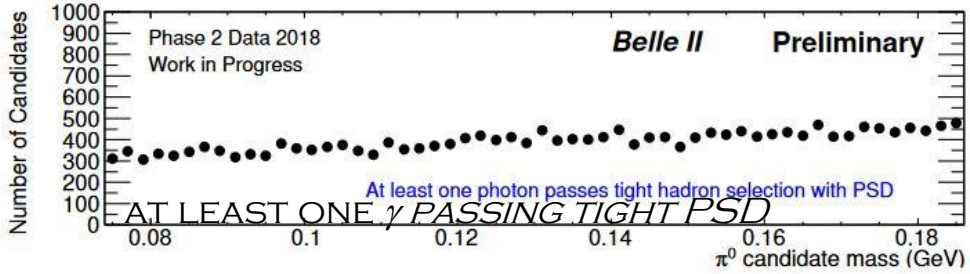
Performance

Physics performance

S. Longo, J.M. Roney et all. (Belle II Coll.), BELLE2-NOTE-PL-2018-027

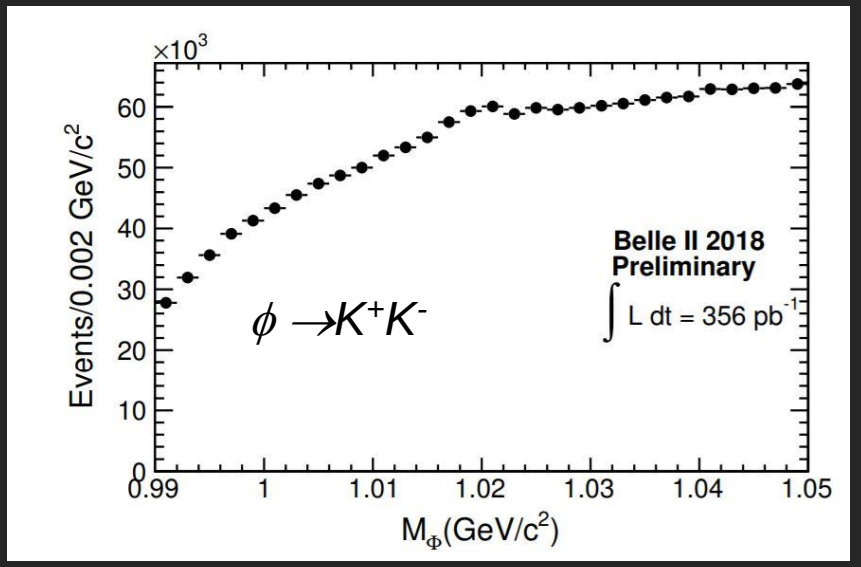


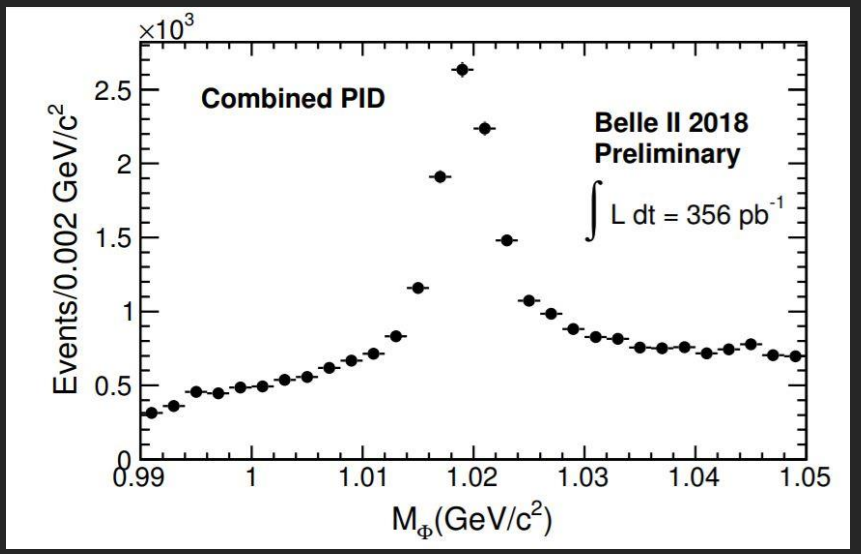




HADRON VETO IN ECL USING
PULSE SHAPE DISCRIMINATION

A. Sangal et all. (Belle II Coll.), BELLE2-NOTE-PL-2018-035

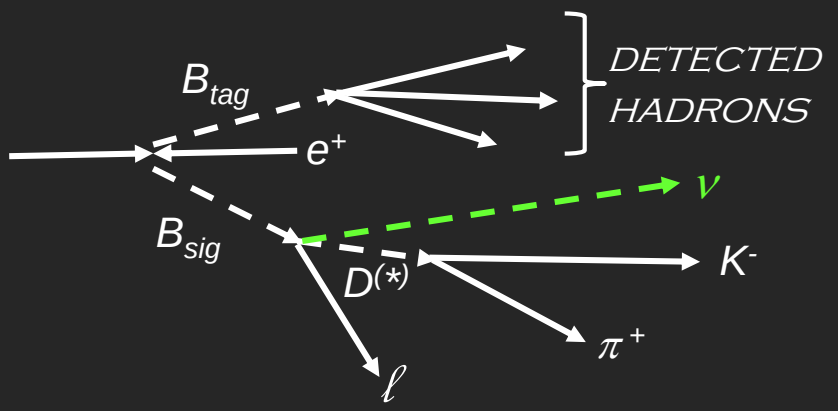




COMBINED PID
(TOP, CDC, ARICH)

FULL EVENT INTERPRETATION

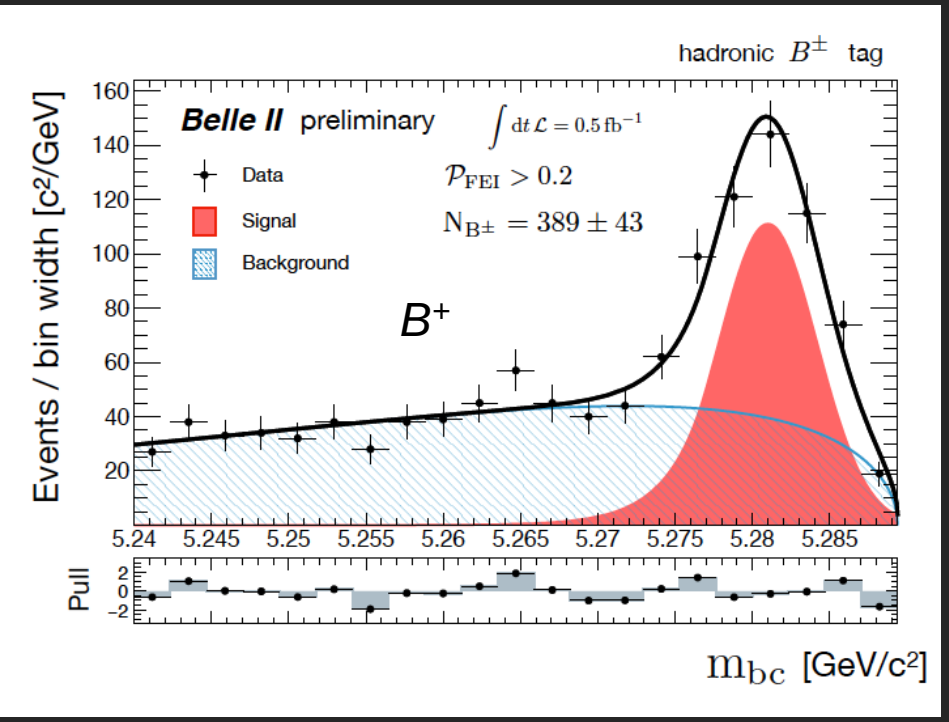
ONLY A SINGLE $B\bar{B}$ PAIR PRODUCED @ $\Upsilon(4S)$ e^-

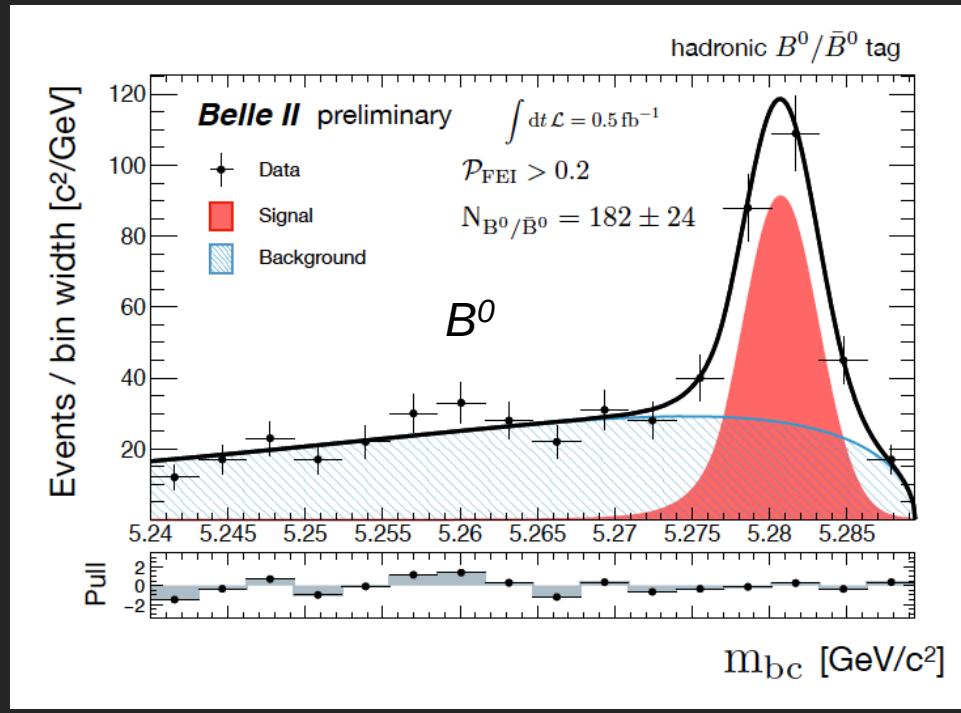


FEI PERFORMED USING MVA

ε_{TAG} ~ 0.2%-0.3% @ P~50%-60%

RECONTRUCTION OF FINAL STATES WITH UNDETECTED PARTICLES

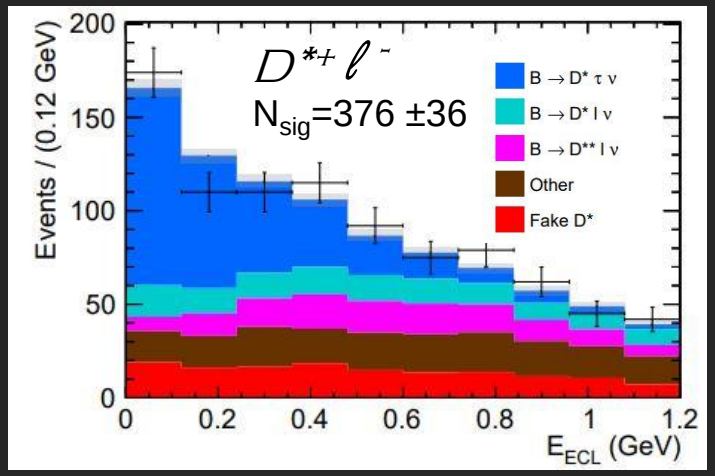




W. SUTCLIFFE, F. BERNLOCHNER, B2NOTE-2018-031-1

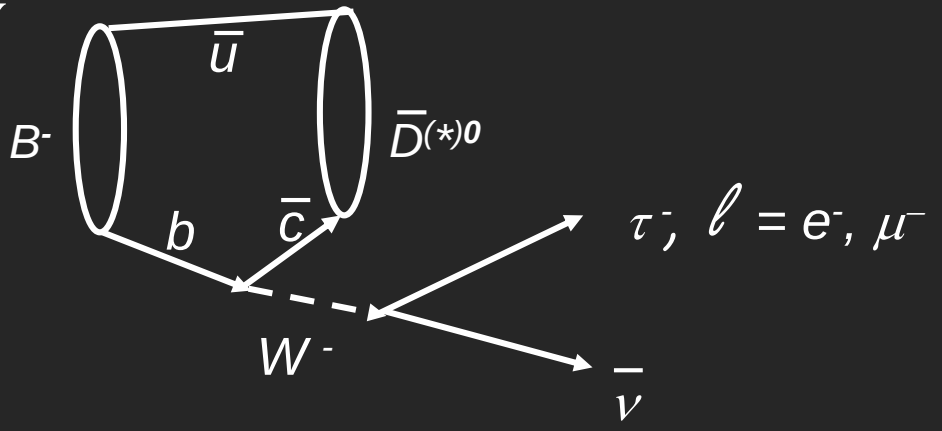
LEPTON FLAVOR UNIVERSALITY

$B \to D^{(*)} \ell \nu$



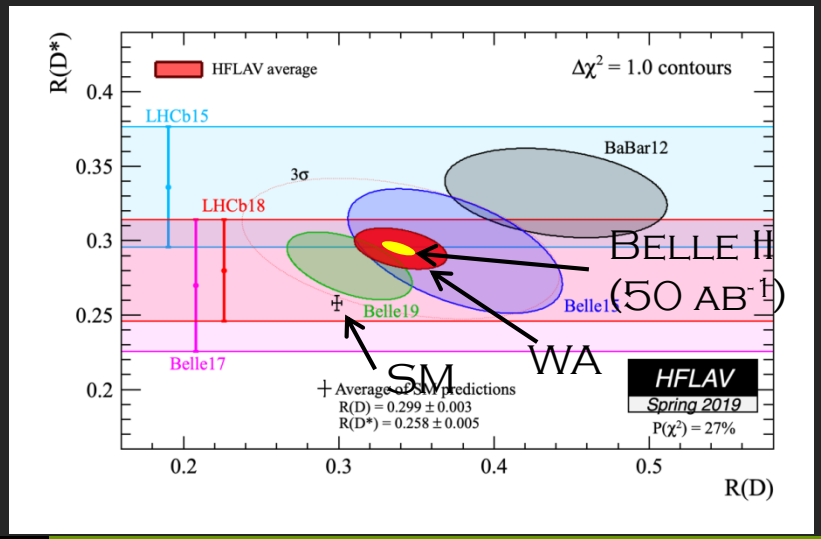
A. ABDESSELAM ET AL. (BELLE COLL.), ARXIV:1904.08794

$R(D) = 0.307 \pm 0.037 \pm 0.016$
$R(D^*) = 0.283 \pm 0.018 \pm 0.014$



$$R(D^{(*)}) \equiv \frac{Br(B \to D^{(*)} \tau \nu)}{Br(B \to D^{(*)} \ell \nu)} = \frac{\Gamma(B \to D^{(*)} \tau \nu)}{\Gamma(B \to D^{(*)} \ell \nu)}$$

$R(D^*)_{SM} = 0.252 \pm 0.003$ S.FAJFER ET AL., PHYS.REV.D85(2012) 094025
$R(D)_{SM} = 0.300 \pm 0.008$ H. NA ET AL., PHYS.REV.D 92, 054410 (2015)



E. KOU, P. URQUIJO EDS., THE BELLE II PHYSICS BOOK TO BE PUBLISHED IN PROG. THEOR. EXP. PHYS.

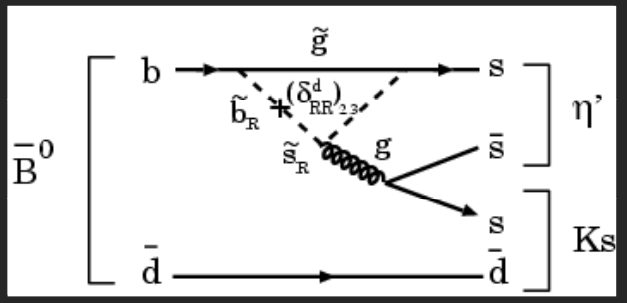
MEASUREMENTS

CPV IN $b \to sq\bar{q}$

SOME UNCERTAINTIES CANCEL IN ΔS

VTX RECONSTR. IMPROVED WITH BETTER TRACKING;

$\varepsilon_{REC}\, BR(B \to \eta' K_S) \sim 1 \cdot 10^{-6}$

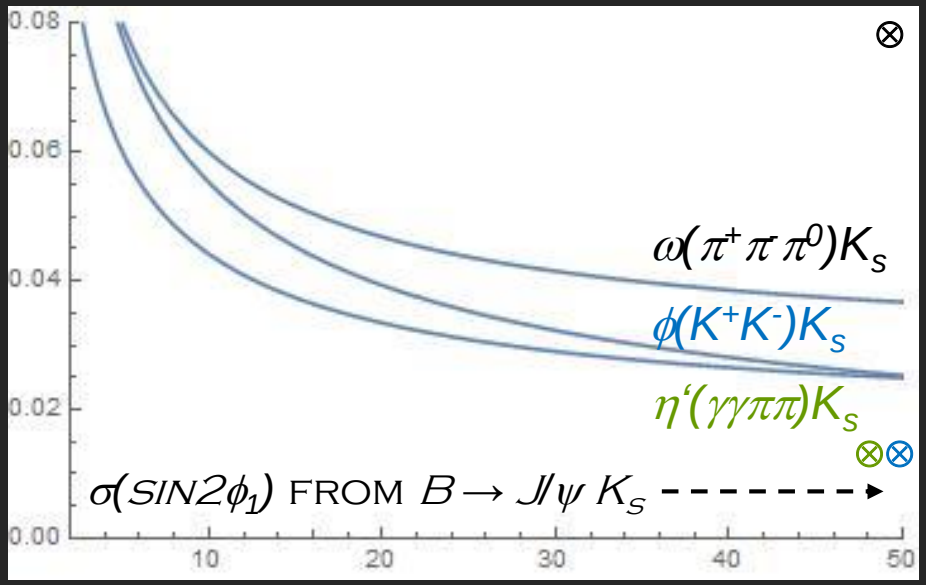


41 NEW PHASES IN MSSM;

$b \to sqq$ $\quad B \to J/\psi\, K_S$

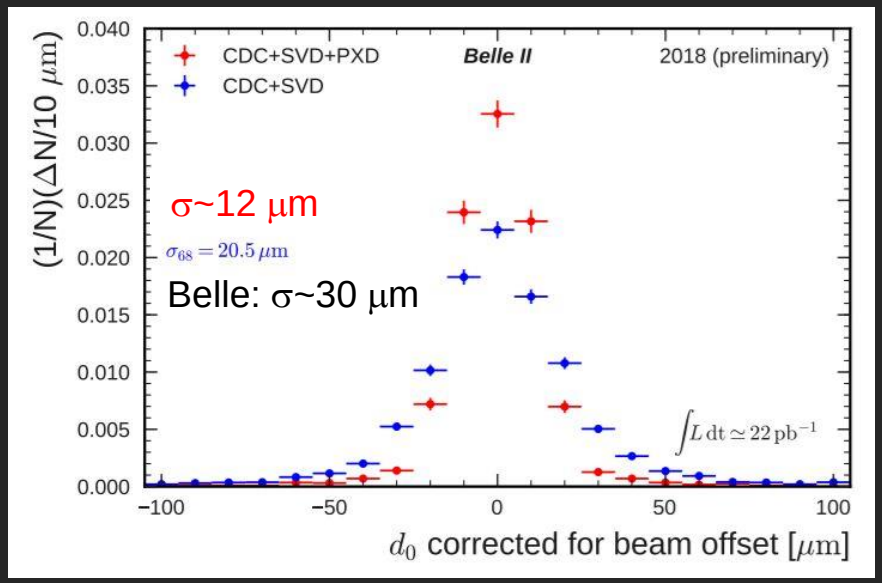
$\Delta S = SIN2\phi_1^{eff} - SIN2\phi_1$

$\sigma(SIN2\phi_1^{eff})$ E. KOU, P. URQUIJO EDS., THE BELLE II PHYSICS BOOK TO BE PUBLISHED IN PROG. THEOR. EXP. PHYS.



⊗ CURRENT TH. UNCERTAINTY
M. BENEKE, PLB620,143 (2005)

$\int \mathcal{L}\, dt\ [AB^{-1}]$



N. BRAUN ET ALL. (BELLE II COLL.), BELLE2-NOTE-PH-2018-040

Summary

- Belle & BaBar: confirmed CKM mechanism
- SuperKEKB: start of data taking in 2018
  luminosity gradually increasing
- Belle II: ~900 members (~45% from Europe), 26 countries
  detector operating as expected
  search for NP
    Lepton Flavor Violation
    Lepton Flavor Universality
    new sources of CPV
    light dark matter
    :

Physics (far) beyond current theoretical understanding (SM)

Severe constraints on possible beyond SM theories