*Lake Louise 2019*

# «SuperKEKB and Belle II : status and plans»

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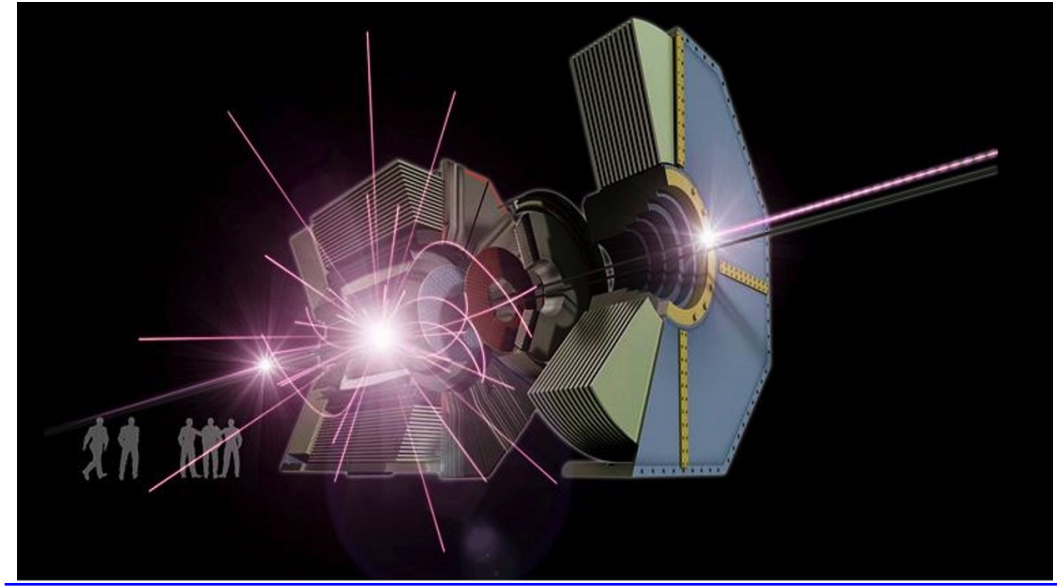
On behalf of the Belle II collaboration

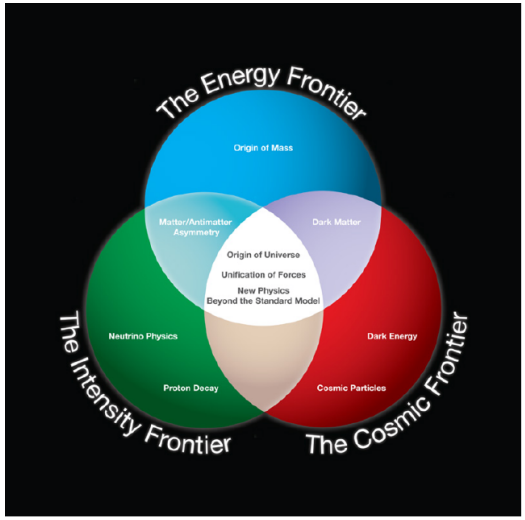
February 16th 2019



**Belle II** is the upgrade of Belle experiment at *KEK Tsukuba Japan*

*Belle and BaBar verified CKM mechanism in quark transition*

*Belle II will mainly search for New physics in b,c,τ sector*

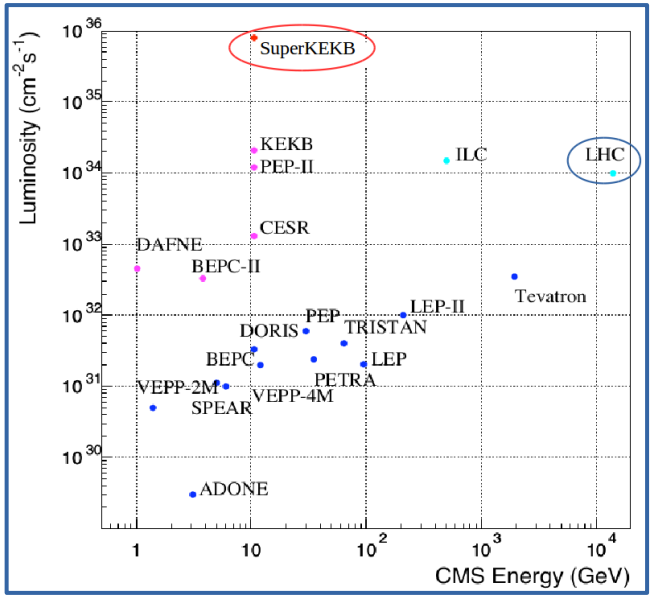



**Intensity frontier** B factory

SuperKEKB is aiming to reach the highest luminosity ever reached

Target data set : 50 $ab^{-1}$ ~ 50x Belle

→ 55 Billion BB pairs

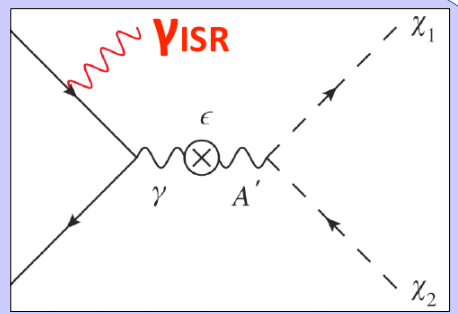



SM effective theory with many open questions,
Several of them can be addressed to Belle II :

- *Additional sources of CP violation* : Time Dependent CP Violation in b → s transitions
- *Lepton Flavour Violation* via rare τ decays
  - SuperKEKB is also a τ factory $\sigma(e^+e^- \to B\bar{B}) \sim \sigma(e^+e^- \to \tau\tau)$

- *Dark sector* :
  - Missing energy decays
  - Specific triggers : single photon trigger
  - *Particulary relevant in early operations*

    → low luminosity and lower beam background allow to open up triggers for low multiplicity event
  - Possible to provide results even with very limited statistics



Asymmetric e + e − circular collider aiming at delivering the **highest instantaneous luminosity** ever reached

*How to reach high luminosity* *with acceptable beam BG level ?*

$$L = \frac{f_0}{2\sqrt{2}\pi(\sigma_z\phi_x)} \frac{N_- N_+ n_b}{\sqrt{(\varepsilon_{y-} + \varepsilon_{y+})\beta_y^*}} \propto \frac{I}{\sigma_{beam}}$$

Spoiler : $BG \propto \frac{I^2}{\sigma_{beam}}$

Rise Current : limited by BG and cost → **2x KEKB**

Decrease Beam size : Need a new colliding strategy

→ Raimondi : Nano beam scheme → **1/20x KEKB**

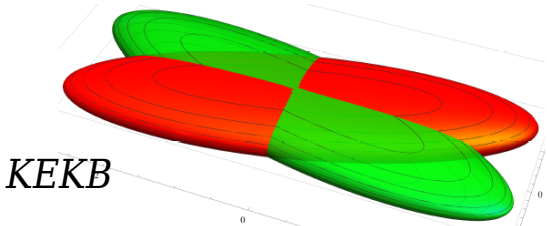
| Parameters (LER / HER) | KEKB crab cavities | SuperKEKB phase 2 | SuperKEKB phase 3 |
|---|---|---|---|
| En. (GeV) | 3.5 / 8.0 | 4.0 / 7.007 | 4.0 / 7.007 |
| $\epsilon_x(nm)$ | 18 / 24 | 2.2 / 5.2 | |
| $\sigma_x^*$ $(\mu m)$ | 147 / 170 | 16.8 / 22.8 | 10 / 11 |
| $\sigma_y^*$ $(\mu m)$ | 0.94 / 0.94 | 0.308 / 0.5 | 0.048 / 0.062 |
| $\beta_x^*$ $(mm)$ | 1200 / 1200 | 128 / 10( | 25 |
| $\beta_y^*$ $(mm)$ | 5.9 / 5.9 | 2.16 / 2.4 | 0.27 / 0.30 |
| $\xi_y$ | 0.129 / 0.09 | 0.0240 / 0.0257 | 0.088 / 0.081 |
| $2\phi(mrad)$ | 22 | 83 | 83 |
| $I_{beam}$ (A) | 1.64 / 1.19 | 1.0 / 0.8 | 3.6 / 2.6 |
| Nb bunches | 1584 | 2500 | 25( |
| $\mathcal{L}(10^{-34}cm^{-2}s^{-1})$ | 2.11 | 1 | 80 |

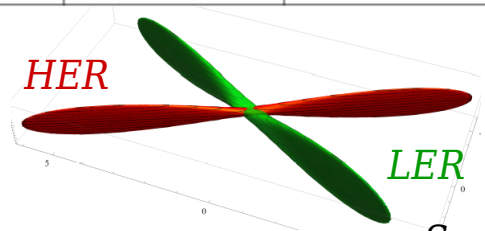
**Boost *2/3**

***B* 1/20***

***I x2***

***L x40***




SuperKEKB

**L = 8.10³⁵ cm⁻²s⁻¹ > 40x world record**

Issues to overcome :
- Beam Background
- High rate
- Boost ~2/3

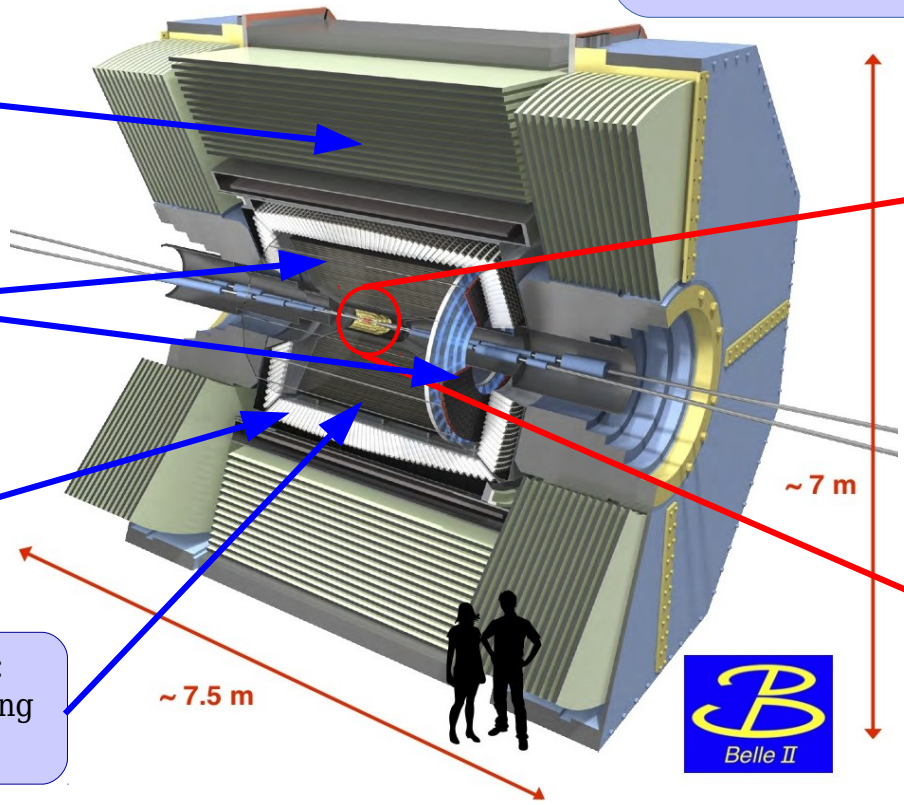
Technical choice :
- Finer segmentation
- Larger angular coverage(CDC,SVD)
- Closer to IP (PXD 3→ 1,4cm
- Particle ID improve K/pi (TOP,ARICH)

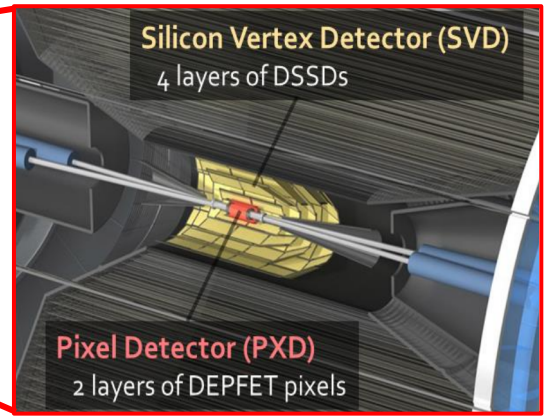
KLongMuon detector

Particle Identification
Barrel : TOP
End Cap: ARICH

Electromagnetical Calorimeter

CDC :
Tracking
dE/dX




Vertex detector

*Phase I:* Single Beam background study

→ No Belle II, No Solenoid , and no final focusing magnet

→January to June 2016

*Phase II :* Experiment commissioning

→ Belle II + Beam background

dedicated sensors @interaction point

→ from **March to July 2018**

→ First Beam : March 19th

→ First collisions : April 26th

Goals:

Collide nano beams and reach $10^{34}$ $cm^{-2}$ $s^{-1}$

Understand and control Machine Background

Calibrate and test detector and DAQ performances

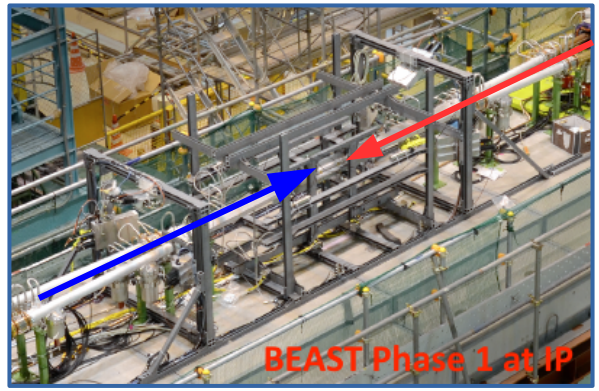
*Phase III :* Physics run

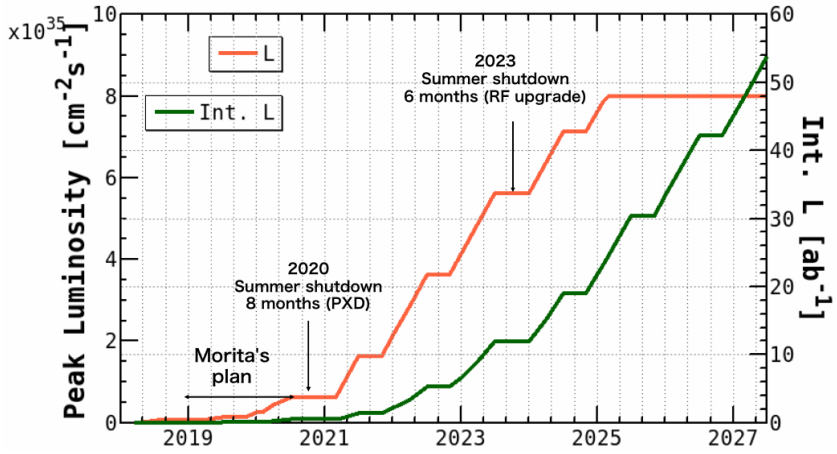
→ From March 2019

Increase luminosity until 2022 and reach $8.10^{35}$ $cm^{-2}$ $s^{-1}$

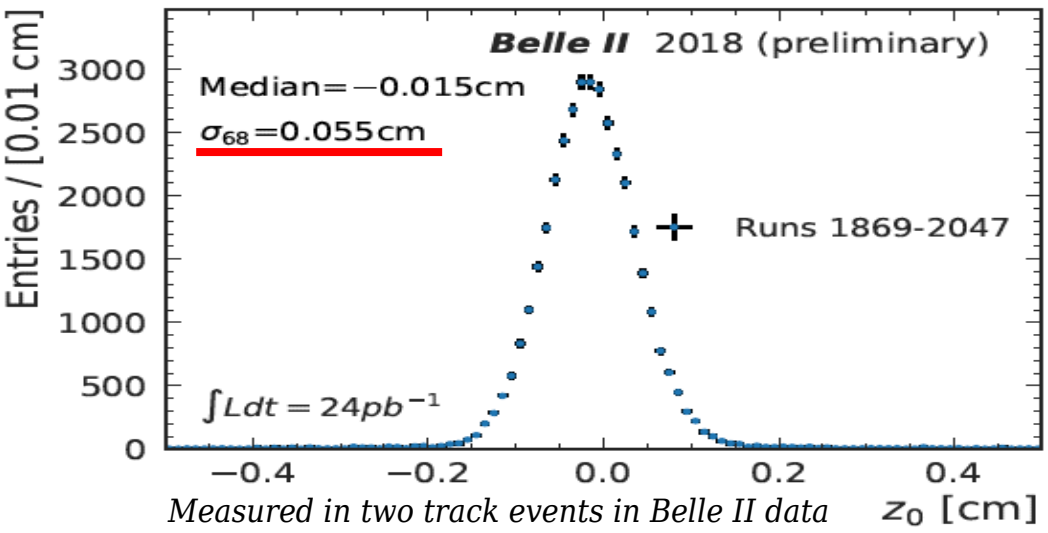
2021 > Babar et Belle

Reach 50 $ab^{-1}$ ~ 2027

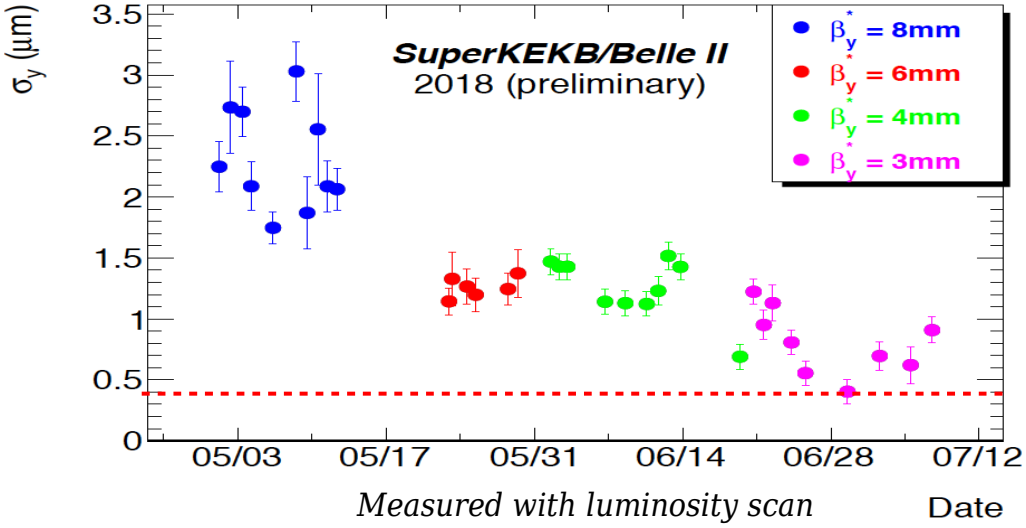


## Goals : Shrink beam dimension and reach KEKB Luminosity($10^{34}$)




*Measured in two track events in Belle II data*




*Measured with luminosity scan*

Effective bunch length is *reduced* from ~10 mm (KEKB) to 0.5 mm (SuperKEKB)
as well as the transverse size reduced from ~6um to 0,33 um

Highest Luminosity reached : **5,3 $10^{33}$ $cm^{-2}s^{-1}$** with I= 0,265 A equiv. 9 $10^{33}$ at 1A

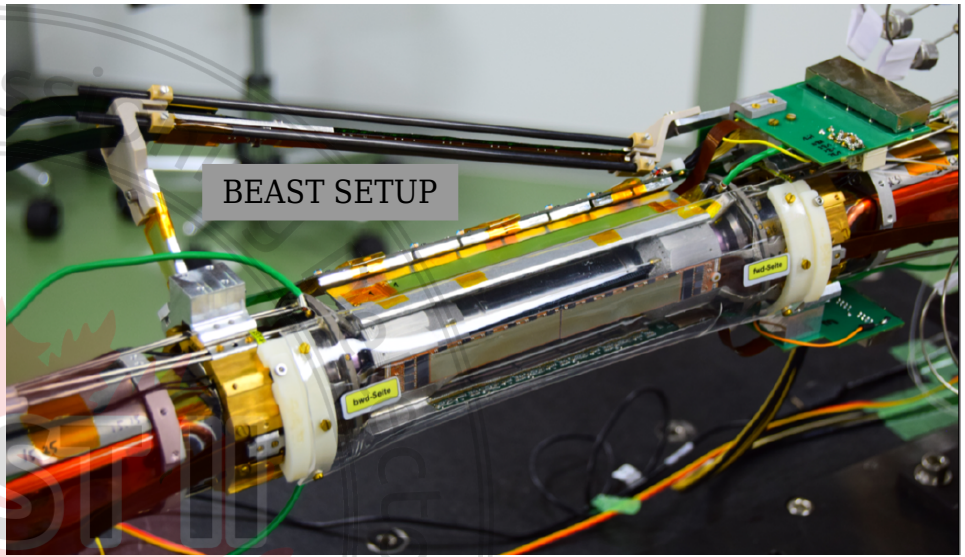
**SuperKEKB has started operation with great success**

## What is BEAST ?

High Luminosity induces large amount of BG

Understand and control BG mandatory for BelleII physics program and detector safety

For safety reasons during PhaseII only a section full VXD installed replaced by a dedicated set of detectors for BG study




## What we observed (in Phase II)

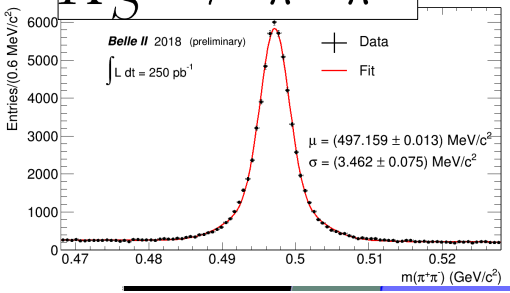
- *Overall BG rate* : **~ 10x MC, dominated by new LER (e+) single beam**

  → **Dominant process**: Coulomb scattering between bunch particles and remaining gas atoms in beam pipe
- *Dose*: Still sustainable by detector

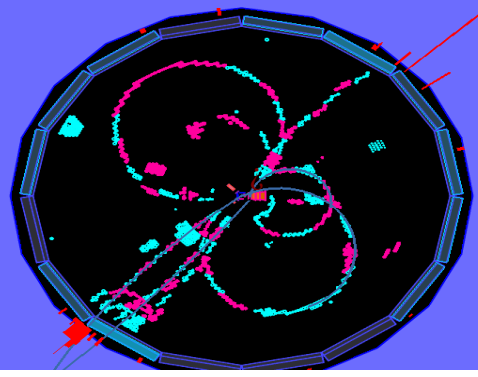
Overall BG is larger than expected (~10x) but there is room for improvement additional collimator will be installed and optimized during early Phase III operations

First collisions took place on 26th of April
Phase II data taking rediscoveries : Helpful to test detector and software performance

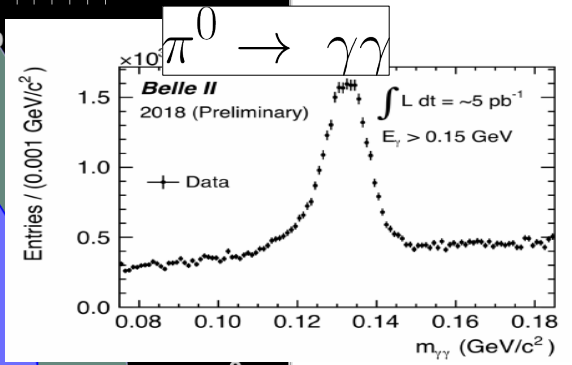
$K_S \to \pi^+\pi^-$



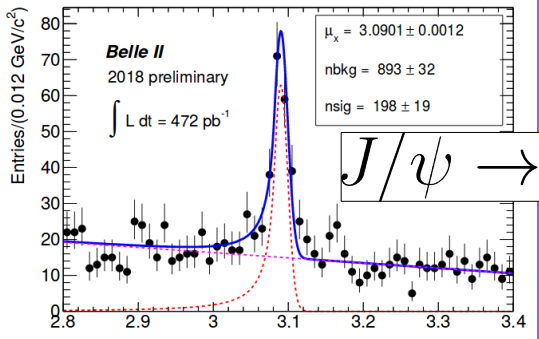

$e^+e^- \to \gamma^* \to q\bar{q}$



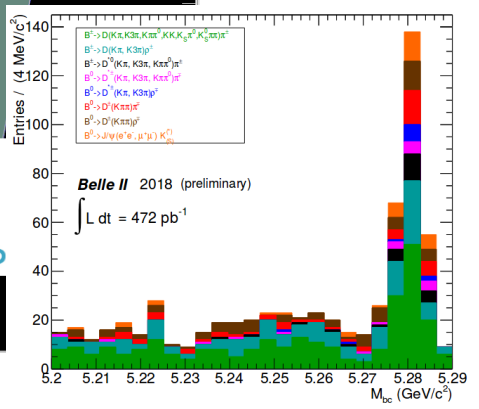
$\pi^0 \to \gamma\gamma$

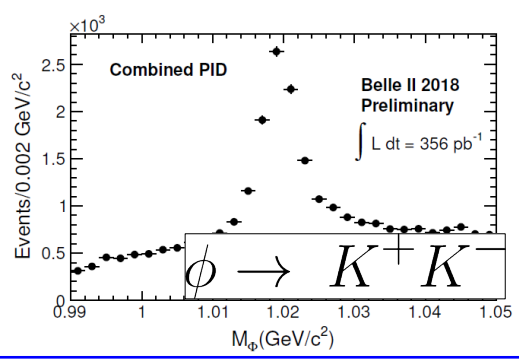



$J/\psi \to ee$

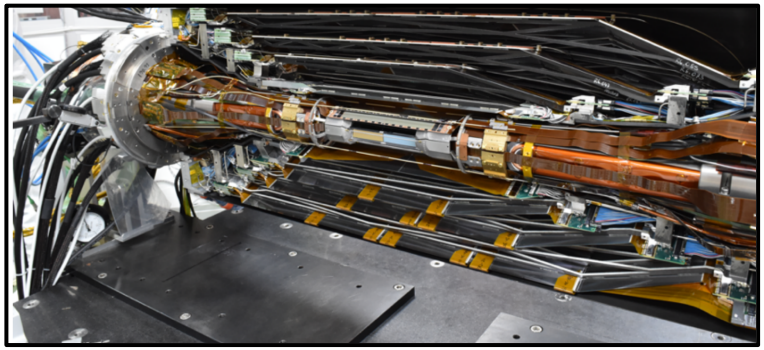




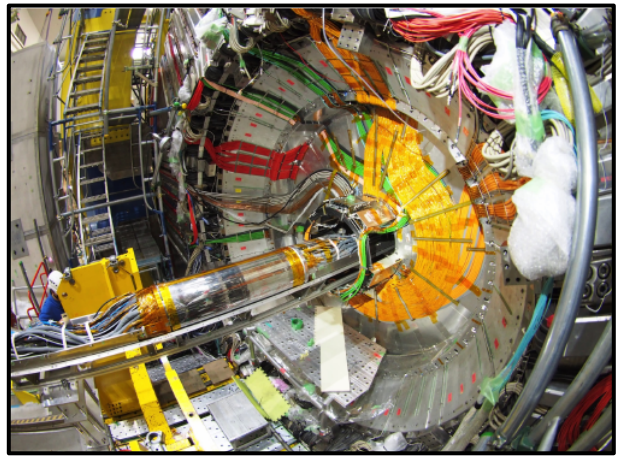

$\phi \to K^+K^-$



## *Installation of the Full VXD*

BEAST setup removed

VXD installed , currently commissioned



## *Machine plans :*

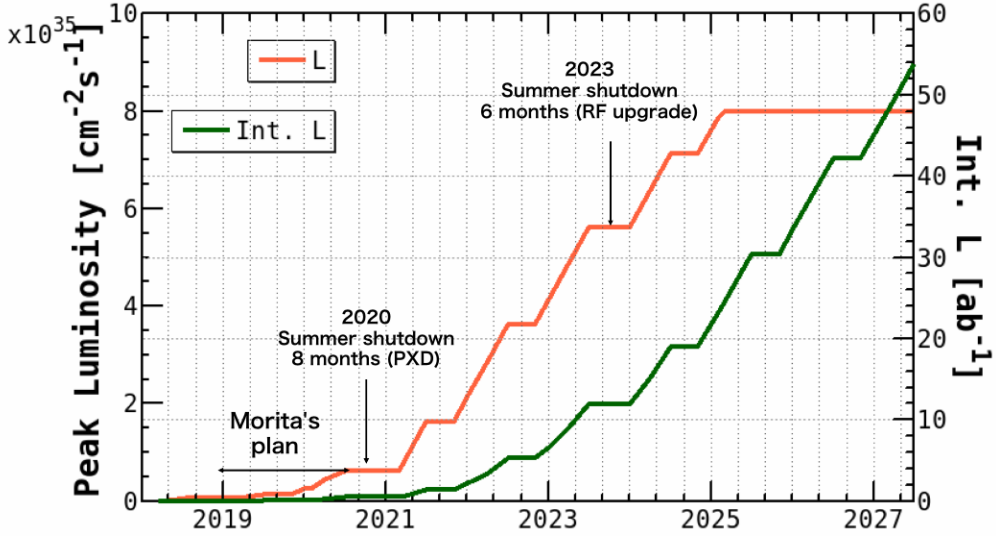
Continue to reduce Beam size → improve luminosity

Additional collimator in LER → BG commissioning to optimize collimator and fine tune beam

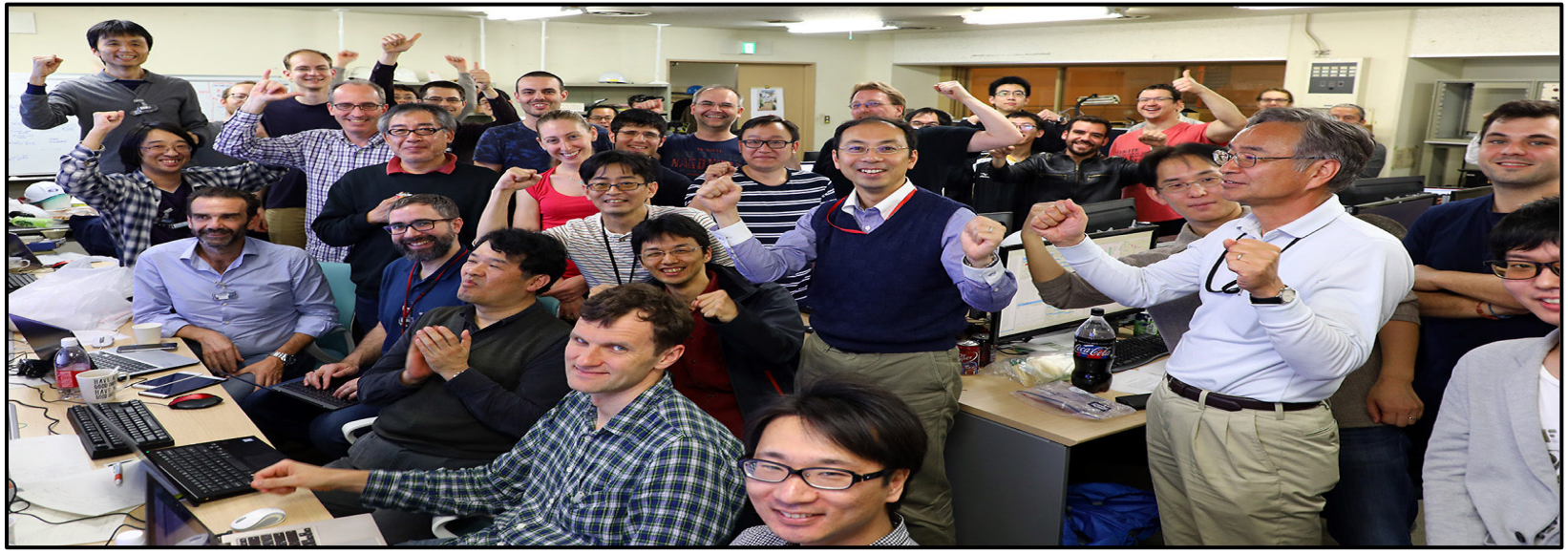
## Data projection for 2019 :

Several sector of the physics program could already provide interesting results (cf. Eldar's talk)

Useful to demonstrate the capability of the experiment



Belle II collaboration successfully started operation with first collisions on 26 April 2018



Peak Luminosity 5.5 $10^{33}$

Data set : 472 $pb^{-1}$ integrated

Detector performances are promising for a good start for data analysis → *cf. Jakub's talk*

Background rates are higher than expected but there is still room for improvement

Physics run will start March 2019 → *cf. Eldar's talk*
→ Target : exceed existing B factory data set by 2021