High Energy Accelerator
Research Organization – KEK, Japan


# Status and prospects of the Belle II experiment

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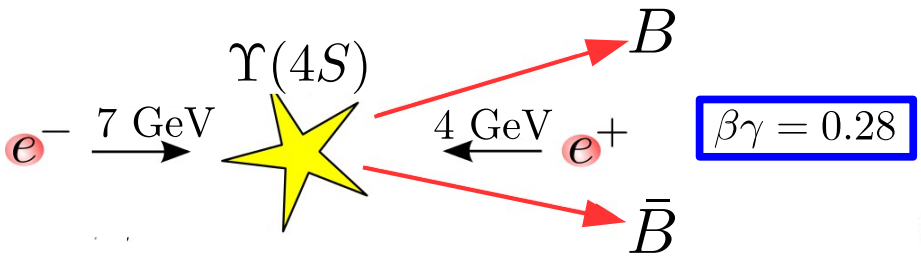
On behalf of the Belle II collaboration


Content:
- Belle II experiment
- SuperKEKB
- The Belle II detector
- Physics prospects
- Summary

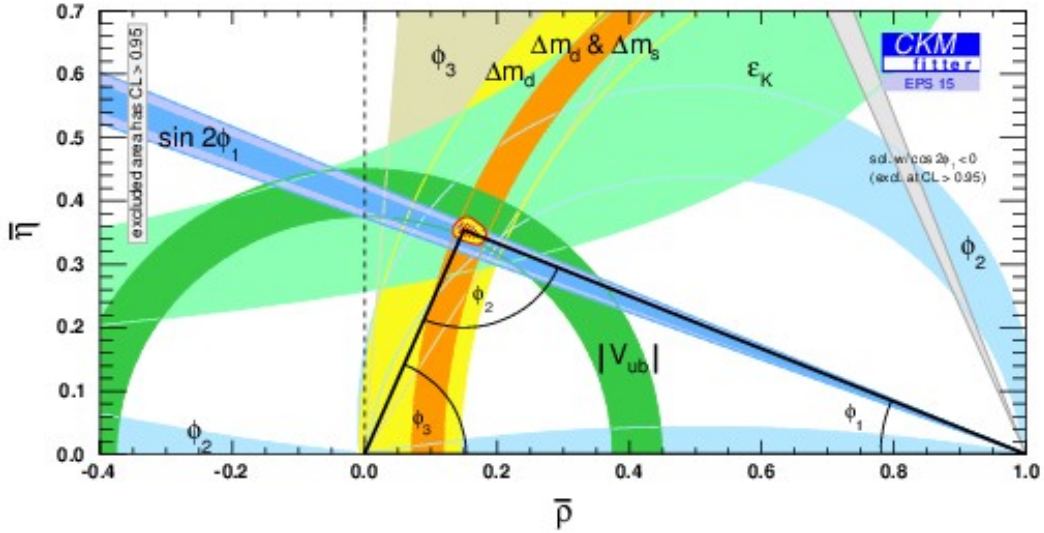
# The Belle II experiment @ SuperKEKB collider

New facility on the **intensity frontier:** **production of virtual particles**
to probe energies beyond the energy frontier
(prime examples: GIM, $m_c$, 3 gen., $m_t$)

**Super B factory**

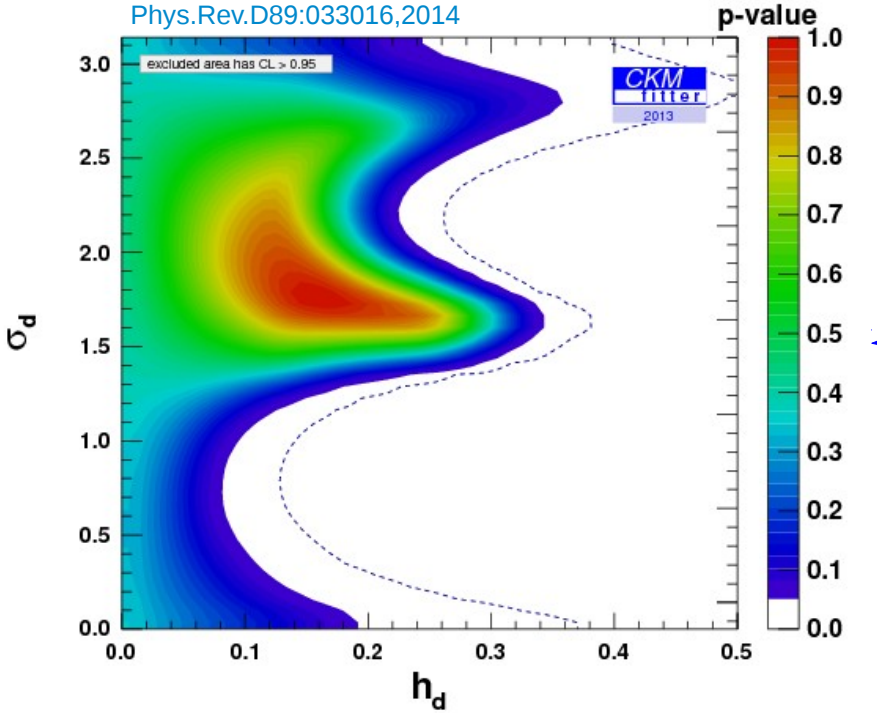



Successor of **Belle @ KEKB & BaBar @ PEP-II**




CKM is the main source of CPV!

Phys.Rev.D89:033016,2014




But with current data ~30% NP amplitude in B mixing cannot be excluded

Significantly more data is needed!

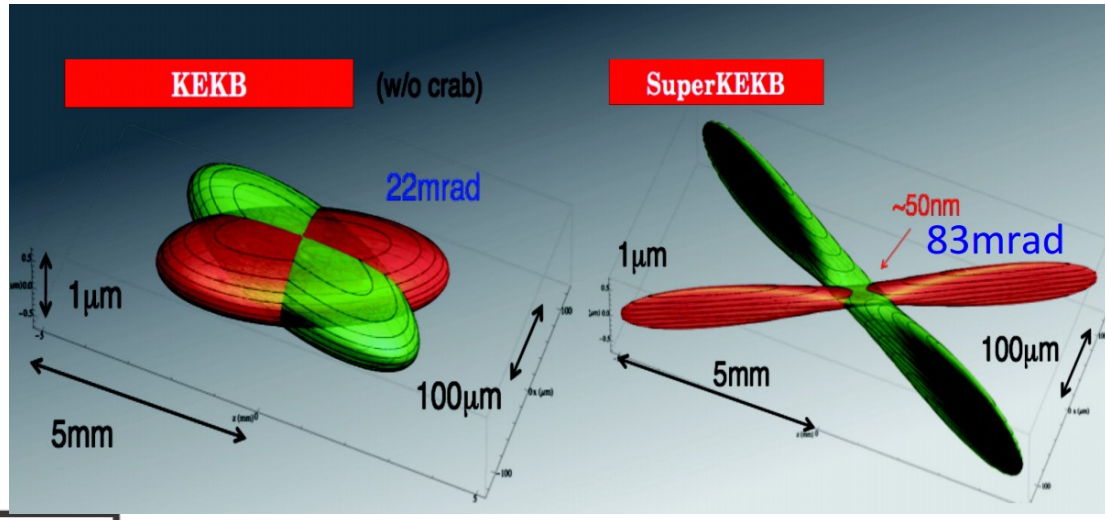
**SuperKEKB / Belle II = 50 x KEK/Belle**

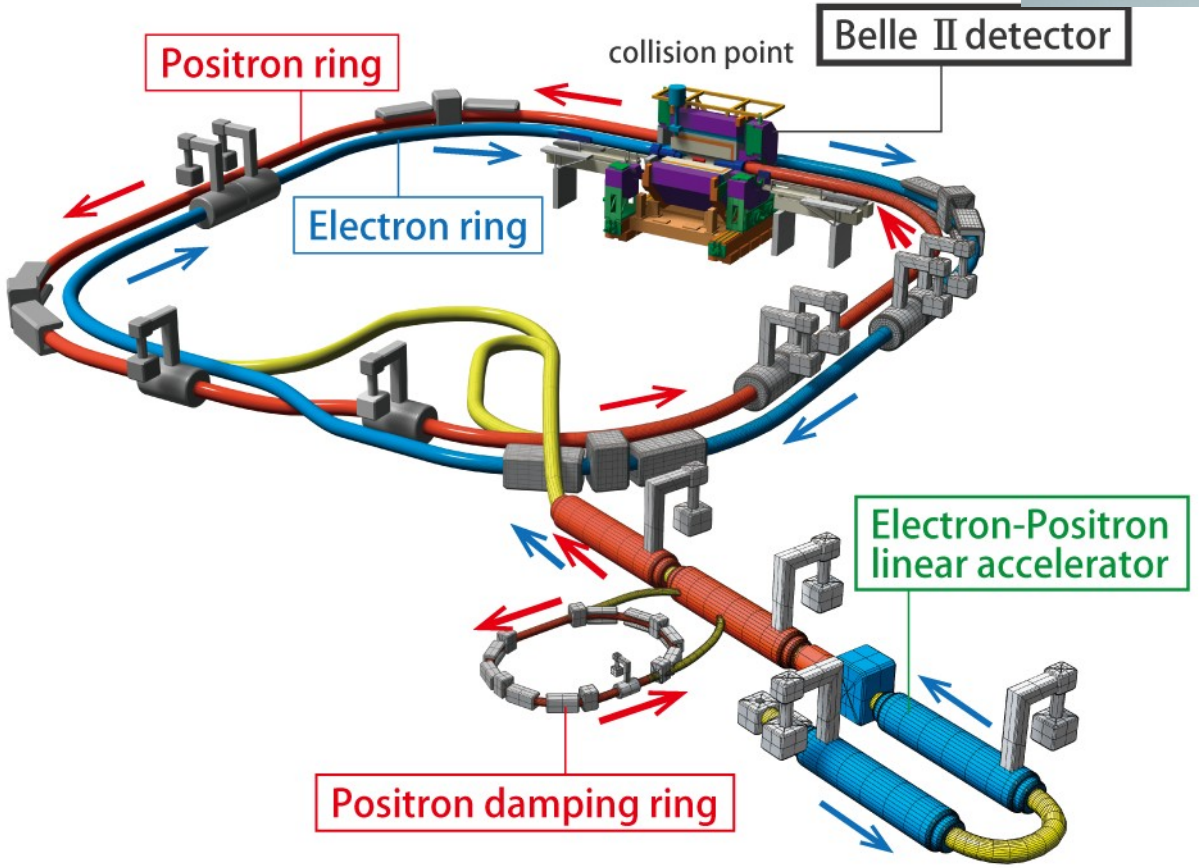
# KEKB → SuperKEKB

- L = **8 x $10^{35}$ $cm^{-2}$ $s^{-1}$** (KEKB x 40)

- Achievable using *nano-beam* scheme:
  → vertical beam size of only **50nm** at the IP

  while doubling the beam current!




- Many upgrades to cope with higher currents (RF system, beampipe, linac & positron damping ring)

- All basic accelerator components now in place

- New SC final focusing magnets to be installed early next year

- Installation and tuning of new damping ring is underway

# KEKB → SuperKEKB

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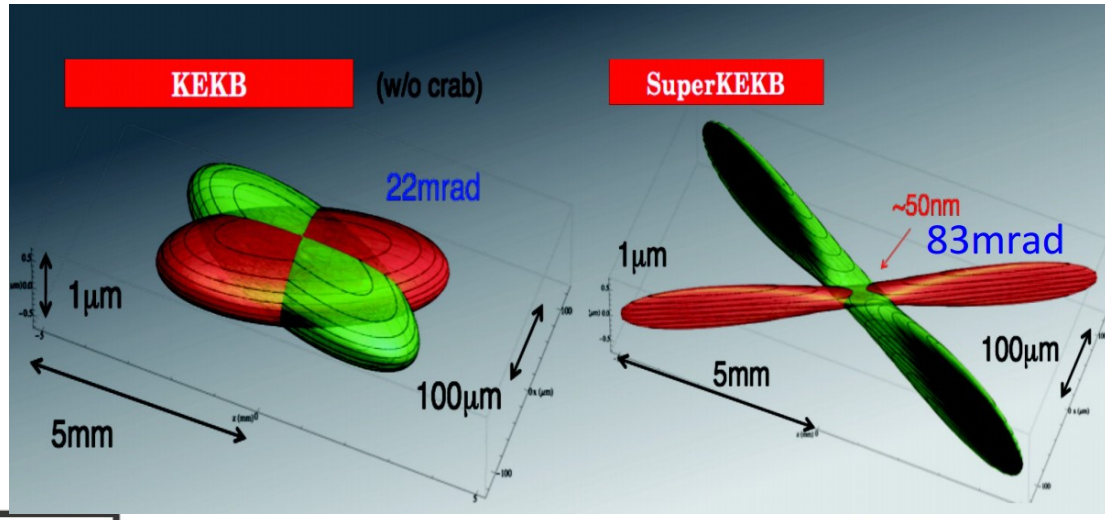
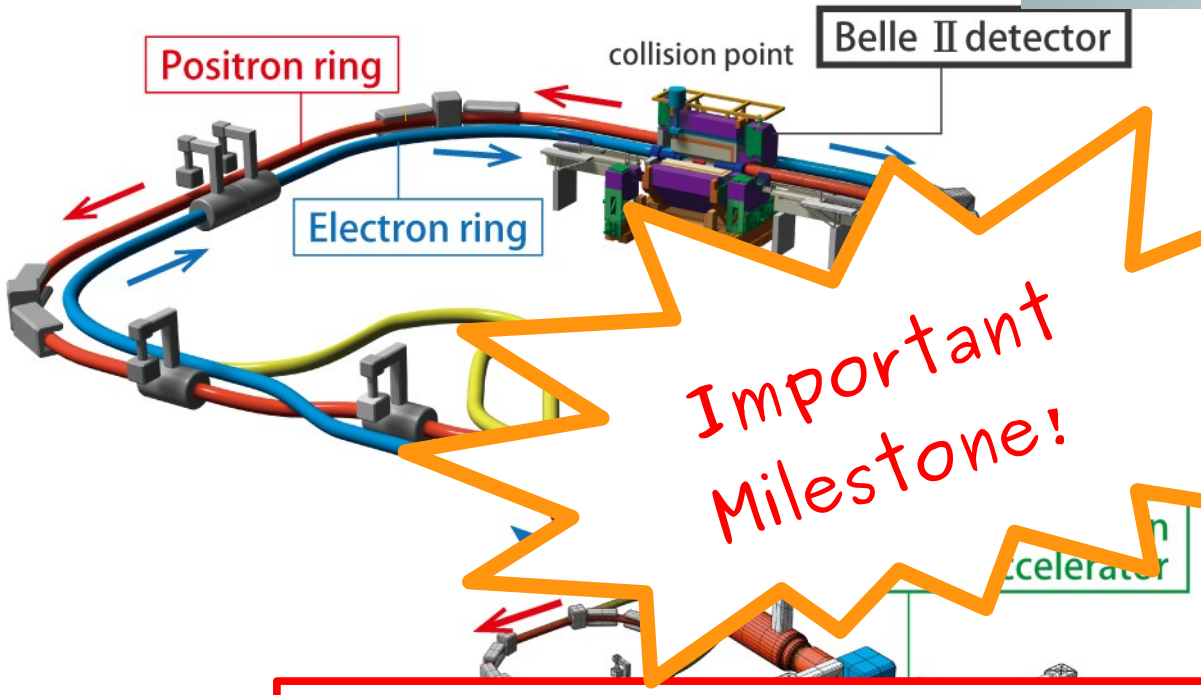



Important Milestone!

- Mar
  cur
  pos

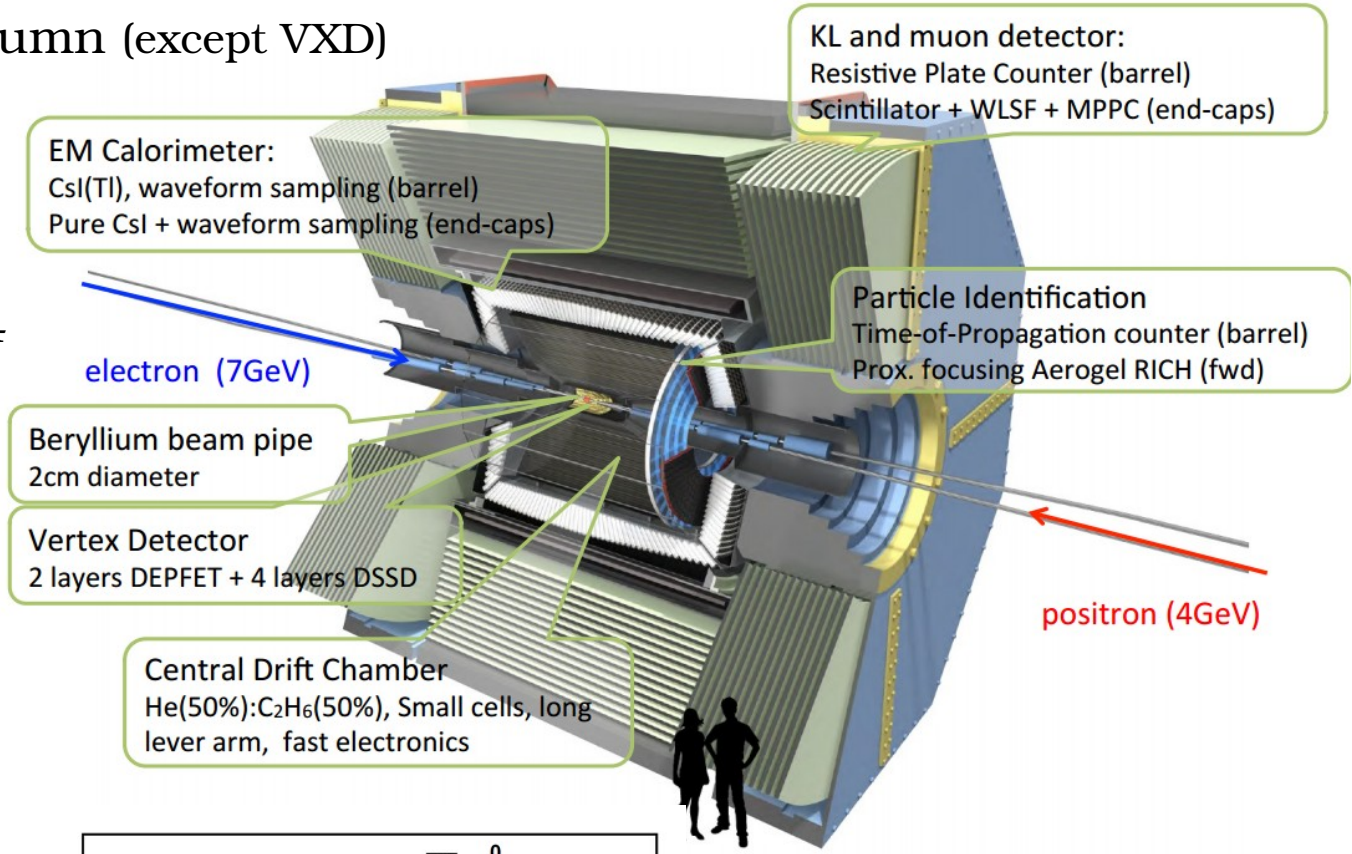
Nev

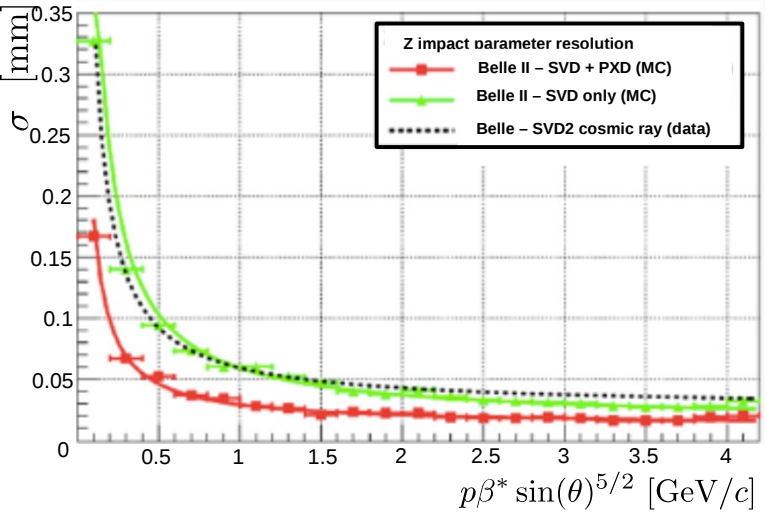
- Ins

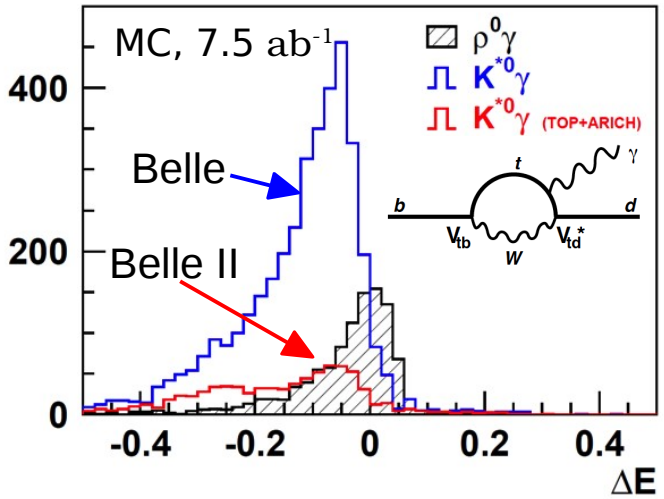

**First turns and successful storage of beams in the electron and positron rings were achieved on Feb. 26$^{th}$ !**

# Belle II detector

- Installation completed by autumn (except VXD)
- First collisions in 2017 (2018 with full Belle II)
- Plan to collect **50 ab$^{-1}$** by 2024
- very clean $e^+e^-$ environment
- High detection efficiency for $\gamma, \pi^0, K^0_{S,L}$



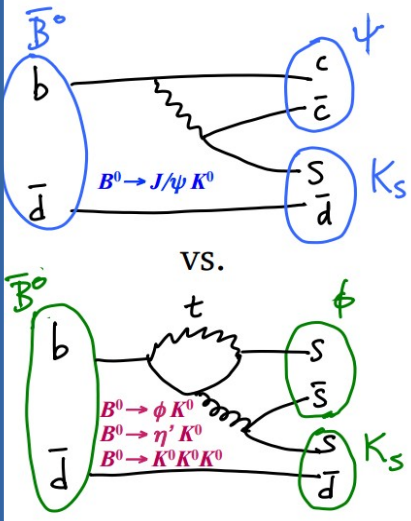




Greatly improved vertexing resolution

and PID performance!

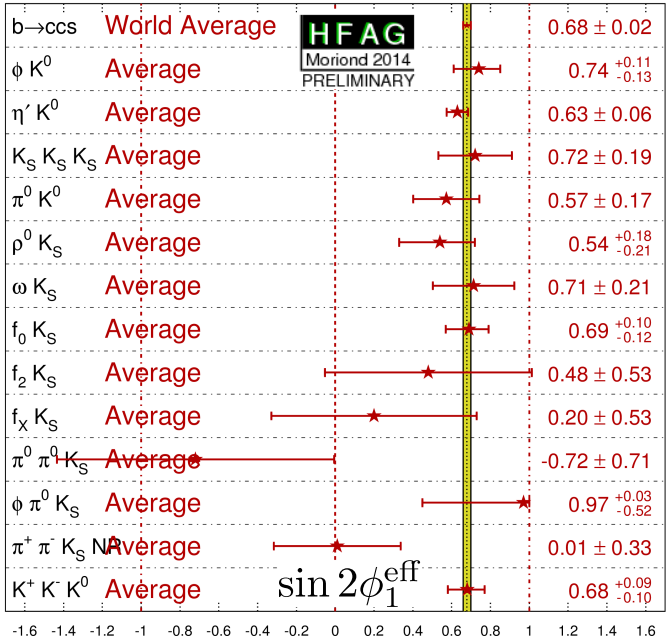
# Physics prospects: Examples

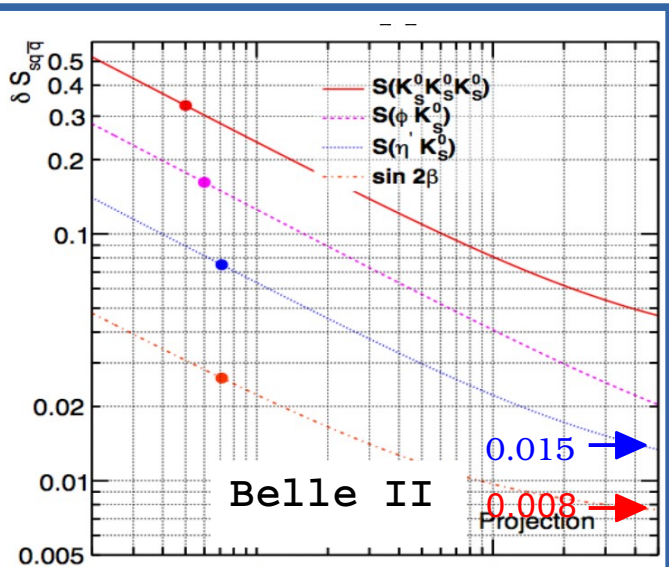
## CPV in $b \to sq\bar{q}$ penguins



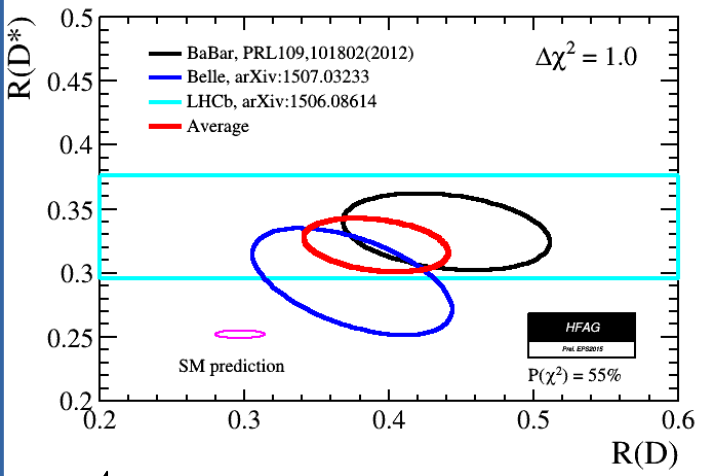

SM:
$|S_{b\to c} - S_{b\to s}| \simeq 0$

NP in loop:
$|S_{b\to c} - S_{b\to s}| > 0$

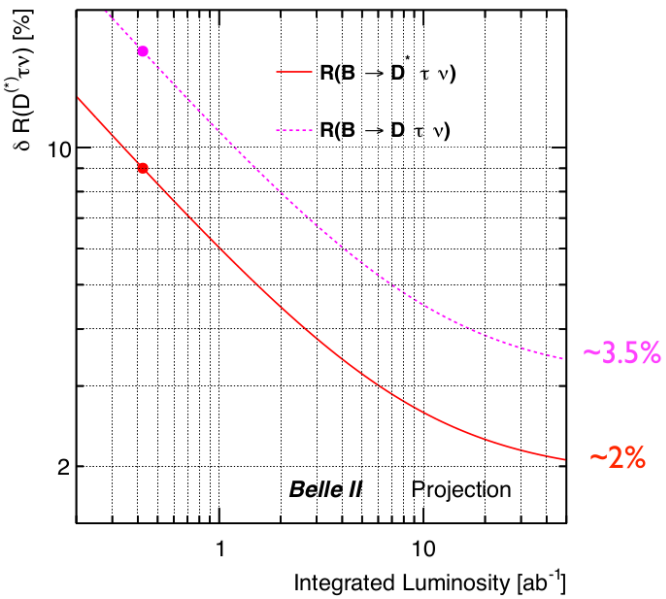


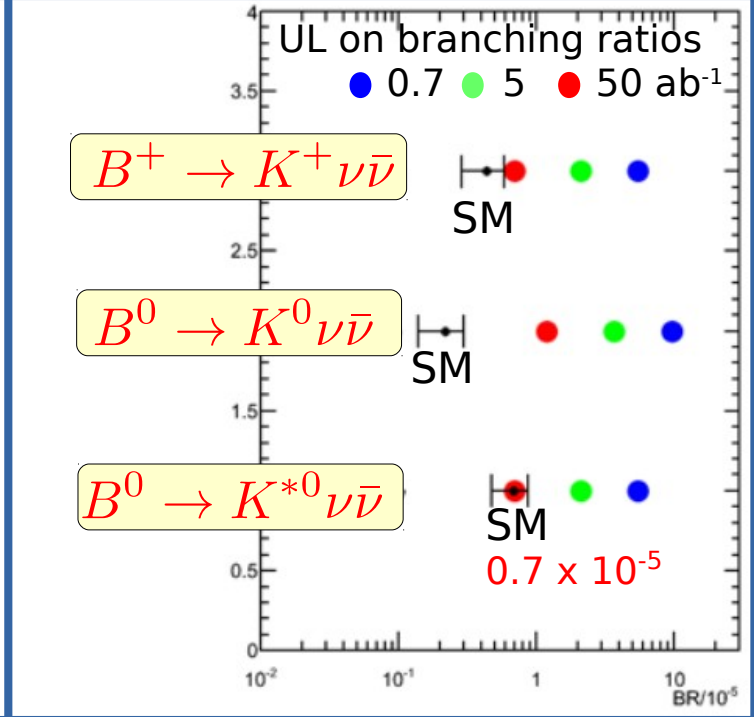




## $B \to D^{(*)}\tau\nu$




$4\sigma$ deviation from the SM!
Belle II can resolve the issue @ 5 ab$^{-1}$



# Physics prospects

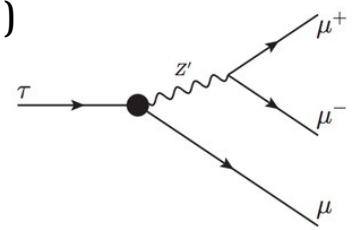
Very rich physics program to uncover NP:

- B physics:
  * constraining unitarity triangle, new CP violating phases, rare B decays
  * $B_s$ decays

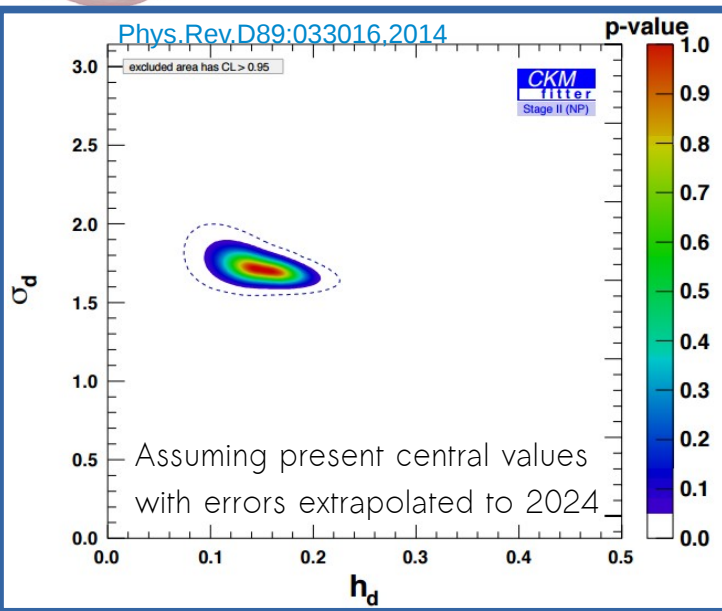
- Charm physics

- Tau physics (e.g. LFV $\tau \to \mu\gamma$ )

$\mathcal{B}(\tau \text{ LFV}) < 10^{-7} \to \ < 10^{-9}$




- Hadron spectroscopy



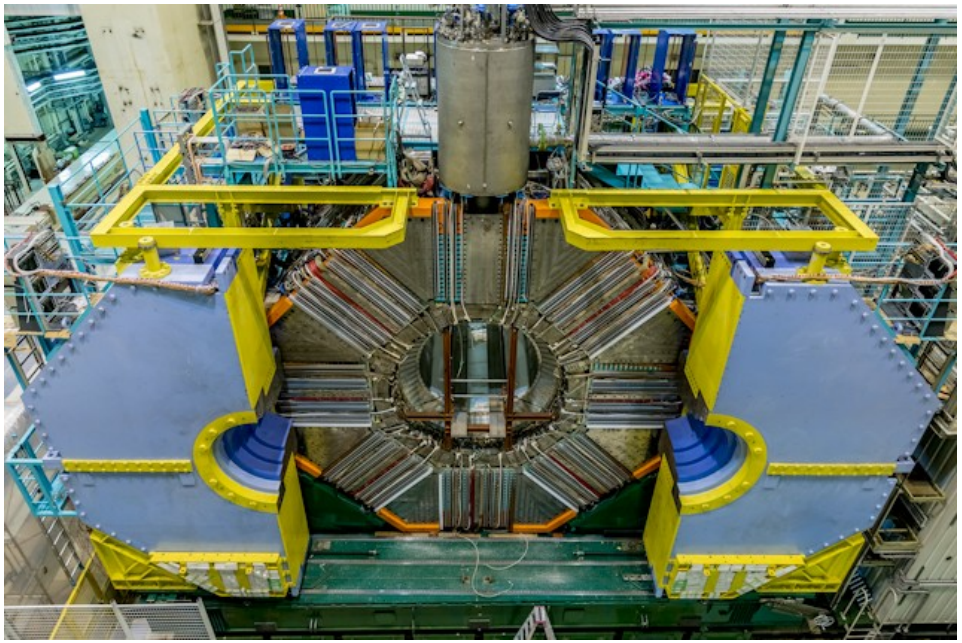

**Projection to 2024:**
**Belle2** @ 50 ab$^{-1}$
\+ **LHCb** @ 50 fb$^{-1}$

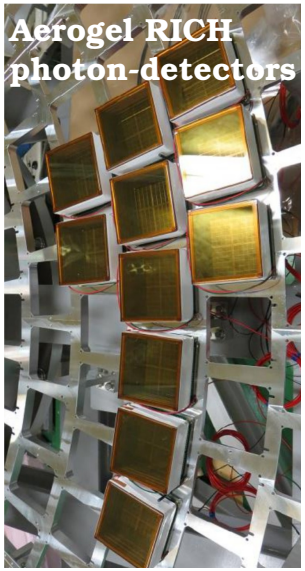
~10% NP contribution to B mixing can be clearly established

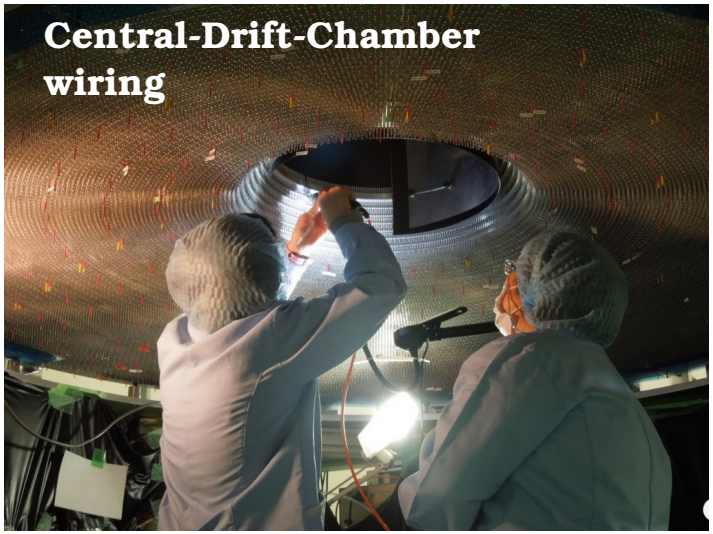
| Observable | future sensitivity | experiment |
|---|---|---|
| CKM matrix | | |
| $\lvert V_{cb}\rvert$ $[B \to X_c l\nu]$ | 1% | **Belle II** |
| $\lvert V_{ub}\rvert$ $[B \to \pi l\nu]$ | 2.5% | **Belle II** |
| $\sin 2\phi_1$ | 0.008 | **Belle II/LHCb** |
| $\phi_2$ | 1.5° | **Belle II** |
| $\phi_3$ $[\text{B}\to DK]$ | 2° | **LHCb/Belle II** |
| CPV | | |
| $\mathcal{S}(B_s \to J/\psi\phi)$ | 0.01 | **LHCb** |
| $\mathcal{S}(B_s \to \phi\phi)$ | 0.05 | **LHCb** |
| $\mathcal{S}(B_d \to \phi K)$ | 0.05 | **Belle II** |
| $\mathcal{S}(B_d \to \eta' K)$ | 0.02 | **Belle II** |
| $\mathcal{S}(B_d \to K^*\gamma)$ | 0.03 | **Belle II** |
| $\mathcal{S}(B_s \to \phi\gamma)$ | 0.05 | **LHCb** |
| $\mathcal{S}(B_d \to \rho\gamma)$ | 0.15 | **Belle II** |
| $\mathcal{A}_{SL}^{d,s}$ | 0.001 | **LHCb/Belle2** |
| $\mathcal{A}_{CP}(B_d \to s\gamma)$ | 0.005 | **LHCb** |
| rare decays | | |
| $\mathcal{B}(B \to \tau\nu)$ | 5% | **Belle II** |
| $\mathcal{B}(B \to \mu\nu)$ | 7% | **Belle II** |
| $\mathcal{B}(B \to D\tau\nu)$ | 3% | **Belle II** |
| $\mathcal{B}(B_s \to \mu\mu)$ | 10% | **LHCb** |
| $\text{A}_{FB}(B \to K^*\mu\mu)_{q_0^2}$ | 0.05 | **LHCb** |
| $\mathcal{B}(B \to K^*\nu\nu)$ | 10% | **Belle II** |
| $\mathcal{B}(B \to s\gamma)$ | 4% | **Belle II** |

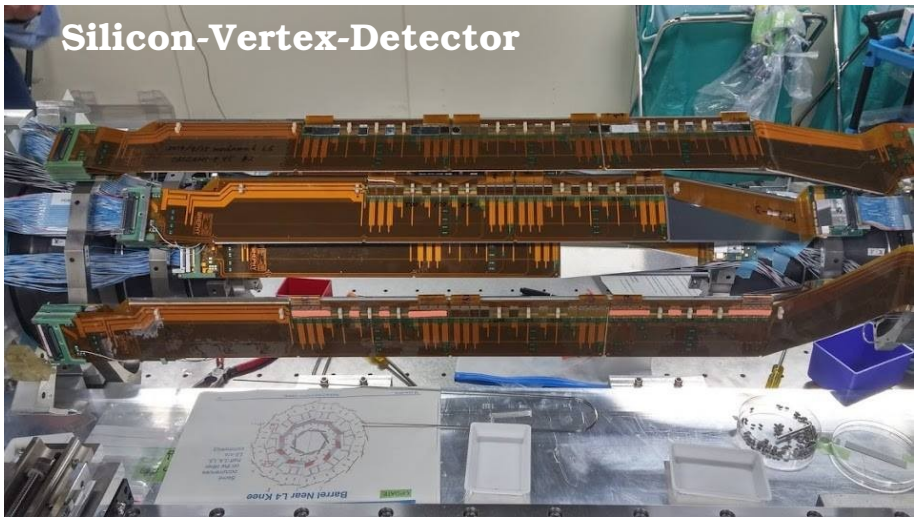
# Instead of summary

Belle II eagerly waiting for inner sub-systems installation… … which has just started!




**Very exciting time ahead! with lots of (new) physics to follow from 2018 - !**