Search for CP violation in $B^{0/\pm} \to D^{(*)} D^{\pm}$ decays in the Belle II experiment

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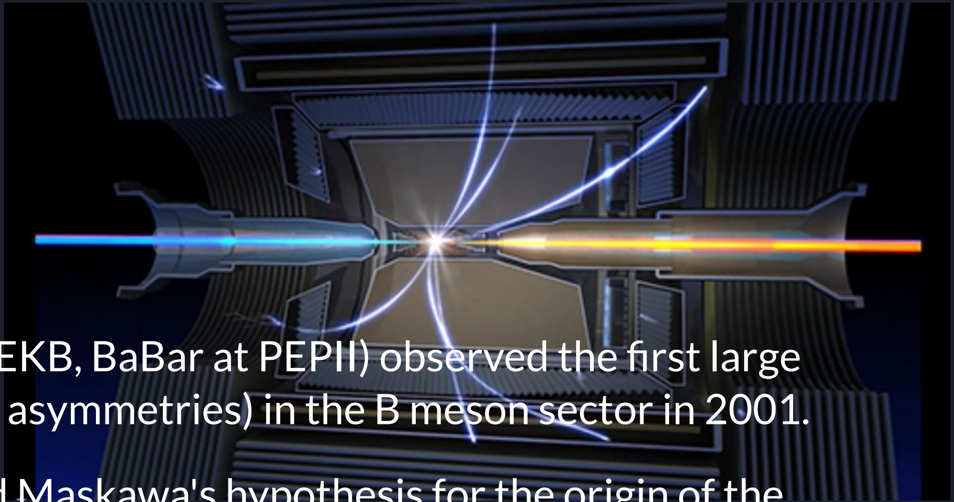
Introduction



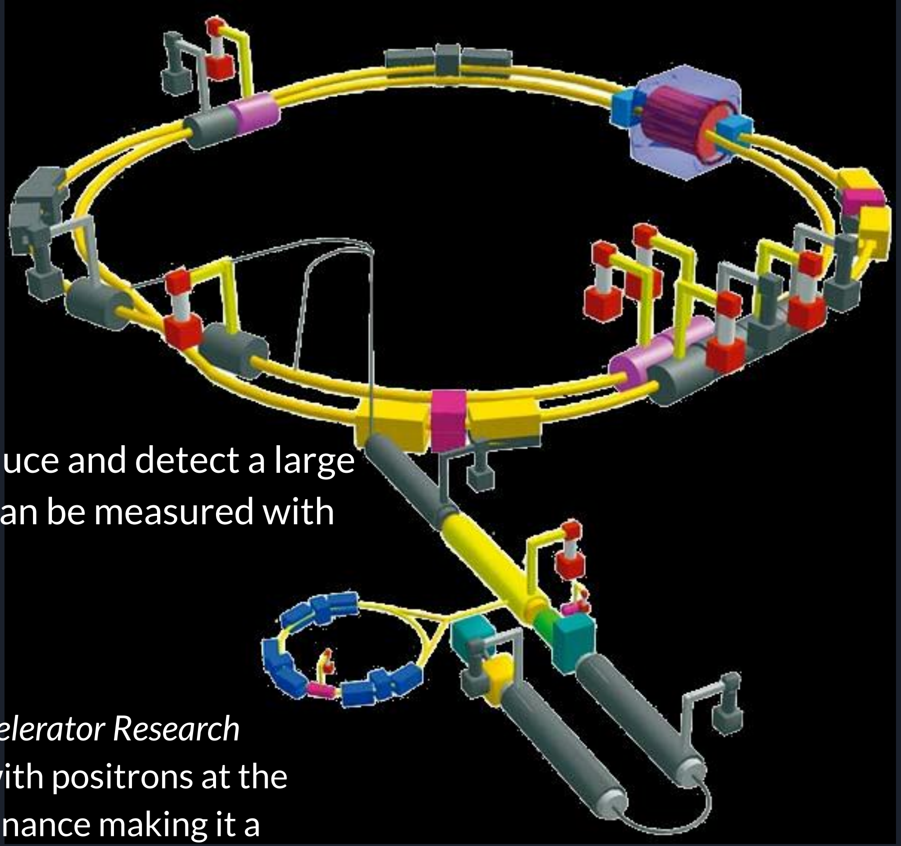
The two B-factory experiments (Belle at KEKB, BaBar at PEPII) observed the first large signals for CP violation (matter-antimatter asymmetries) in the B meson sector in 2001.

These results demonstrated Kobayashi and Maskawa's hypothesis for the origin of the CP violation is correct and provided the experimental foundation for their 2008 Nobel Prize in Physics.

Belle II, the first super B-Factory experiment, is designed to make precise measurements of weak interaction parameters and find NP (New Physics) beyond the Standard Model of particle physics.

In May 2021, SuperKEKB, the new e^+e^- collider, achieved a new instantaneous luminosity world record, 2.9×10^{34} $cm^{-2}s^{-1}$.

B factory - SuperKEKB



B-factory is a particle collider experiment designed to produce and detect a large number of B mesons so that their properties and behavior can be measured with small statistical uncertainty.

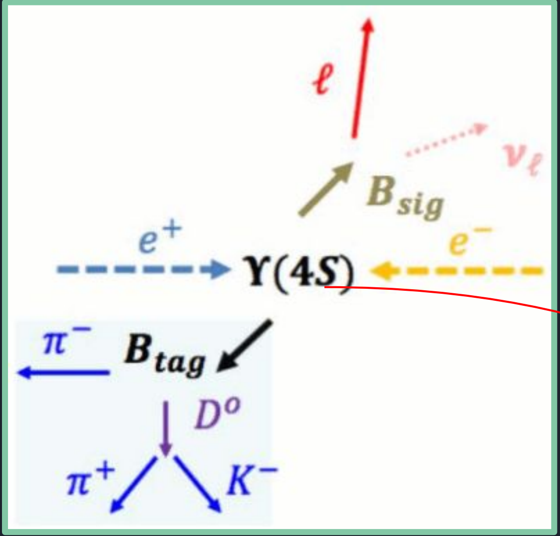
SuperKEKB is a particle collider located at KEK (*High Energy Accelerator Research Organisation*) in Tsukuba, Japan. SuperKEKB collides electrons with positrons at the centre-of-momentum energy close to the mass of the Y(4S) resonance making it a second-generation B-factory for the Belle II experiment. The accelerator is an upgrade to the KEKB accelerator, providing approximately 40 times higher luminosity.


Mt. Tsukuba
BELLE II
~ 1 km
KEKB Ring
~ 1.5 km
Damping Ring
Linac
KEK Tsukuba Campus

Belle II collaboration

> 1000 members
> 100 institutions

Why do we need B-factories?



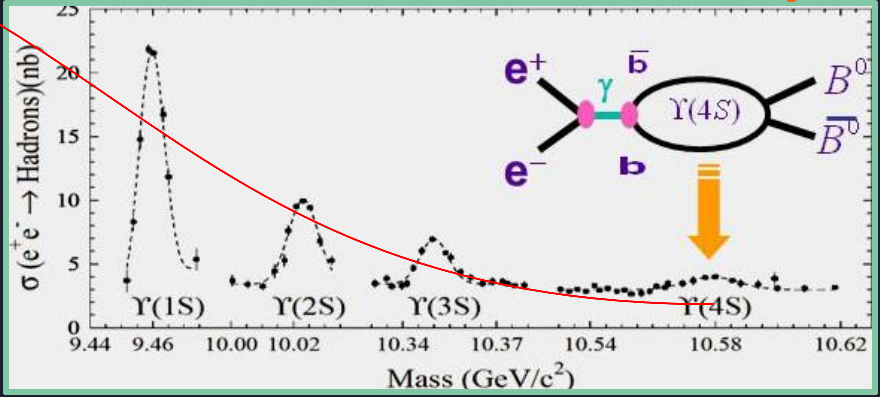
$$\mathcal{B}(\Upsilon(4S) \to B\bar{B}) > 96\%$$

⇒ nothing but BB-bar in the final state

We exploit the reaction process

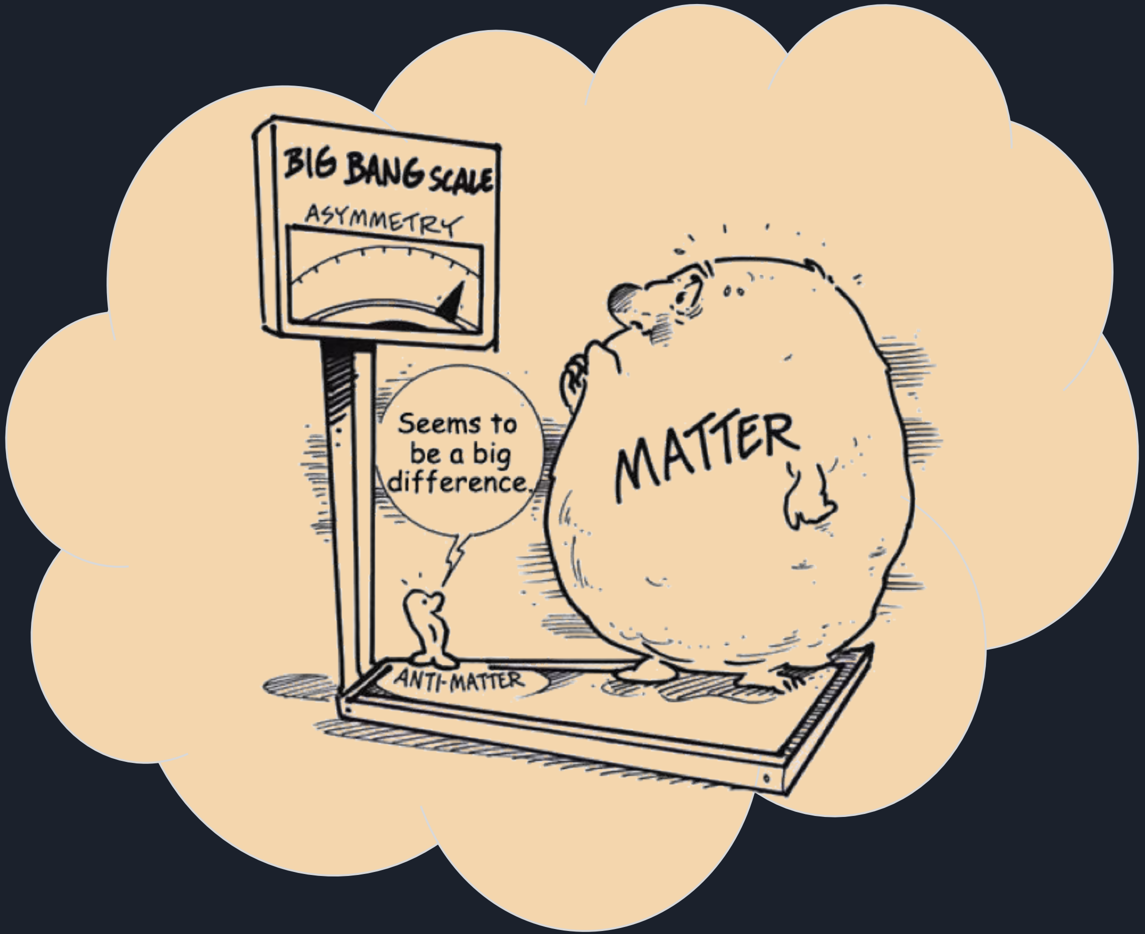
$$e^+e^- \to \Upsilon(4S) \to B_{tag}\bar{B}_{sig}$$

- ➔ full reconstruction of $\boldsymbol{B_{tag}}$ decay chain
- ➔ constrain the (E, p), charge, flavor, etc. of $\boldsymbol{B_{sig}}$

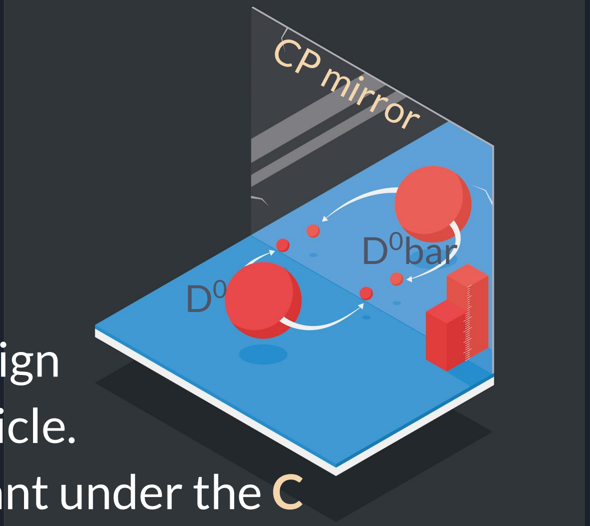


★ **Making B's at hadron colliders (e.g. LHCb)**
- huge number of B mesons are produced but
- no info. on p_B, unless you actually reconstruct the B meson

★ **Making B's at $e^+ e^-$ colliders with**
- a moderate number of B mesons are produced
- $E_B = \sqrt{s}/2 \sim 5.29$ GeV ; $|\vec{p}_B| \sim 0.35$ GeV/c


BIG BANG SCALE
ASYMMETRY
Seems to be a big difference.
MATTER
ANTI-MATTER

CP symmetry

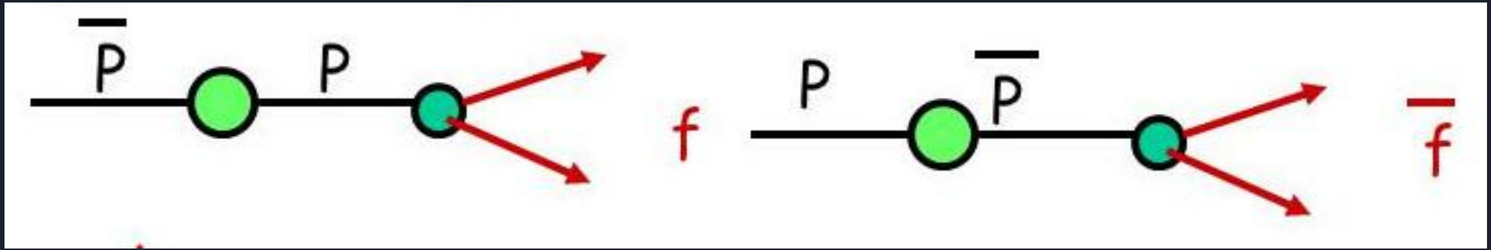


- ★ **CP symmetry** is the combined operation of **C** and **P**
- ★ **C** (Charge Conjugation): Charge Conjugation changes a particle to its antiparticle. In particular, it reverses the sign of the electric charge and magnetic moment of the particle.
  - Strong and e/m interactions are found to be invariant under the **C** operation
  - BUT in Weak interaction **C** invariance is broken
- ★ **P** (Parity): Parity operation reverses the direction of any spatial vector (Mirror reflection).
  - Under parity a left-handed particle transforms to a left-handed.
  - Parity is conserved in strong and e/m interactions
  - But not in weak

Types of CP Violation

★ Direct CPV

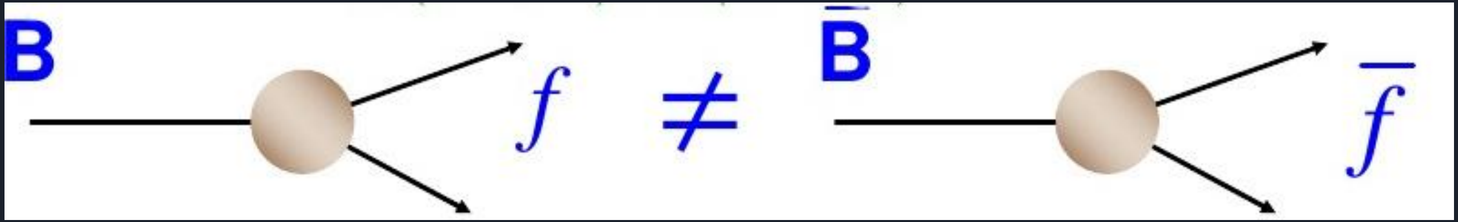
★ Indirect CPV



★ CP interference between mixing and decay

Direct CP Violation

- ★ CP violation arises from the difference between the magnitudes of a decay amplitude and its CP conjugate amplitude.
- ★ The measurement is to compare the decay rate of B meson and its CP conjugate.
- ★ Only possible source of CP asymmetry in charged meson decays



$$\left|\frac{\bar{A}}{A}\right| \neq 1, \quad A_{CP} = \frac{\Gamma(\bar{B} \to \bar{f}) - \Gamma(B \to f)}{\Gamma(\bar{B} \to \bar{f}) + \Gamma(B \to f)}$$

Thank you for attention!