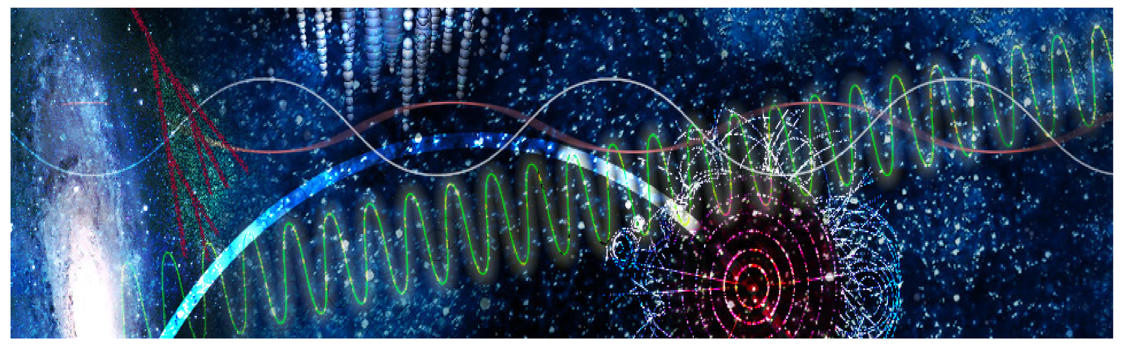

CP VIOLATION IN τ DECAYS

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ABSTRACT

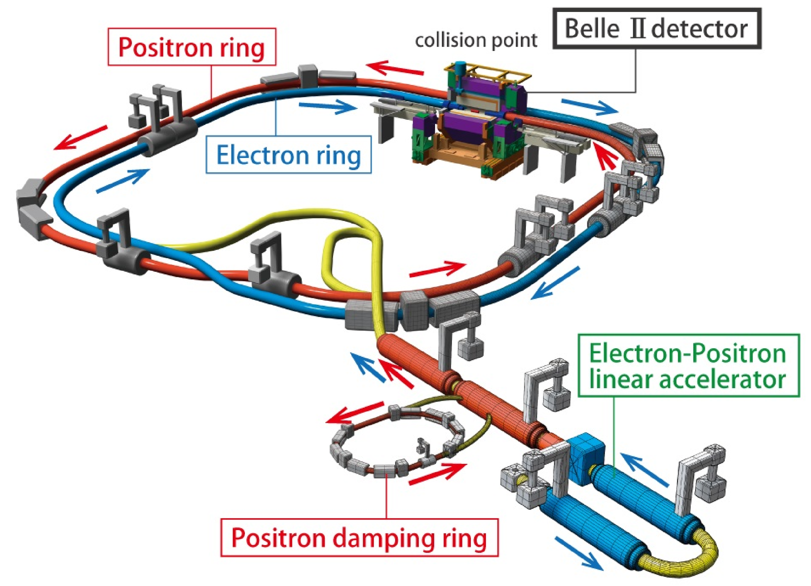
The τ lepton is the only lepton heavy enough to decay to hadrons. Though the CP violation is well established in neutral kaons and in D and B mesons, the CP violation of the charged leptons is not expected within the Standard Model. We are searching for direct CP violation in the decay $\tau^- \to \pi^- K_S^0 (\geq 0\pi^0)\nu_\tau$ using a data sample corresponding to an integrated luminosity of 362 fb^1.

INTRODUCTION

The data is collected with the Belle II detector at the SuperKEKB e^+e collider at a center-of-mass energy of 10.58 GeV [1]. In this decays, the Standard Model predicts CP violation coming from the kaon mixing, and a value for the charge asymmetry of $(0.33 \pm 0.01)\%$ [2]. Any deviation from the Standard Model value would be an evidence for physics beyond the Standar Model.

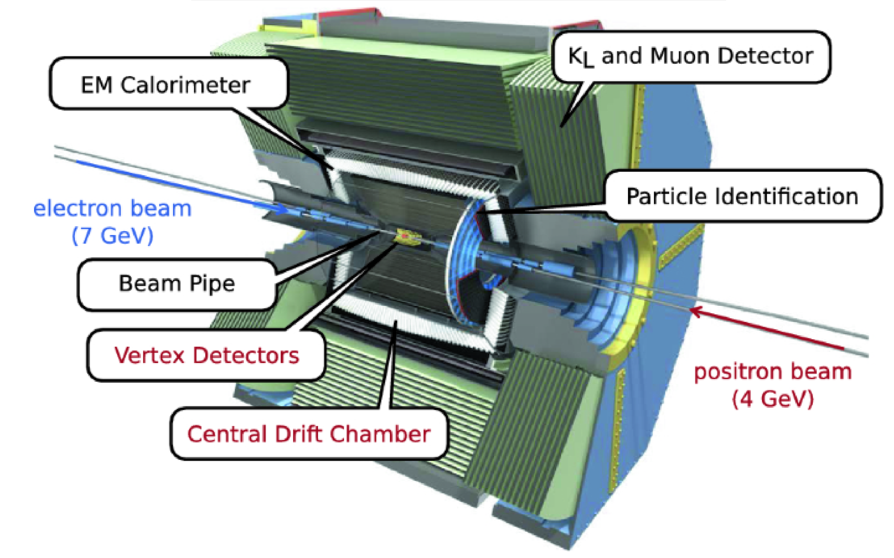
BELLE II EXPERIMENT

The SUPERKEKB accelerator



- Asymmetric beam energy
  - e^-(7 [GeV]) and e^+(4 [GeV])
- Holds world record instantaneous luminosity of 4.7·10^{34} cm^{-2} s^{-1}
- $\sigma(e^+e^- \Rightarrow \Upsilon(4S) \Rightarrow B\bar{B})$ = 1.05 nb.
  $\sigma(e^+e^- \Rightarrow \tau^+\tau^-)$ = 0.919 nb.
  - Not only a B but also τ factory.

The Belle II Detector



- Composed of 7 major subdetectors arranged around the interaction point.
- Data collected since 2019: 428 fb^{-1}.
- Currently in long shutdown.
- Expected to restart by the end 2023

ANALYSIS STRATEGY

The decays of tau leptons to final states containing a K_S^0 predicted to have a non-zero decay rate asymmetry in SM due to CP violation in kaon sector.

$$A_1 = \frac{\Gamma(\tau^+ \to \pi^+ K_S^0 \bar{\nu}_\tau) - \Gamma(\tau^- \to \pi^- K_S^0 \nu_\tau)}{\Gamma(\tau^+ \to \pi^+ K_S^0 \bar{\nu}_\tau) + \Gamma(\tau^- \to \pi^- K_S^0 \nu_\tau)}$$

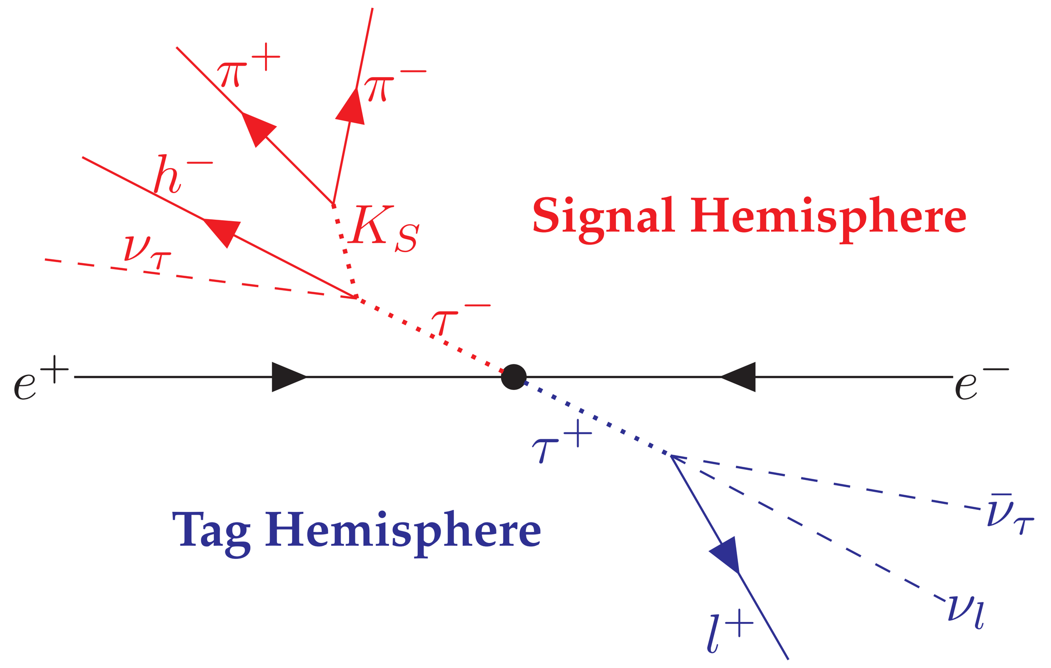
The SM asymmetry is identical for decays with any number of π^0 mesons.
After the background subtraction, the final sample will contain the following decay modes:

1) $\tau^- \to \pi^- K^0 \nu_\tau (\geq 0\pi^0)$
2) $\tau^- \to K^- \bar{K}^0 \nu_\tau (\geq 0\pi^0)$
3) $\tau^- \to \pi^- K^0 \bar{K}^0 \nu_\tau (\geq 0\pi^0)$

With their respectively decay rate asymmetries A_1, A_2 and A_3 and fractions f_1, f_2 and f_3. From SM assumptions, the total asymmetry A is related to the signal asymmetry A_1 (from $\tau^- \to \pi^- K_S^0 \nu_\tau$) A2 and A3, as:

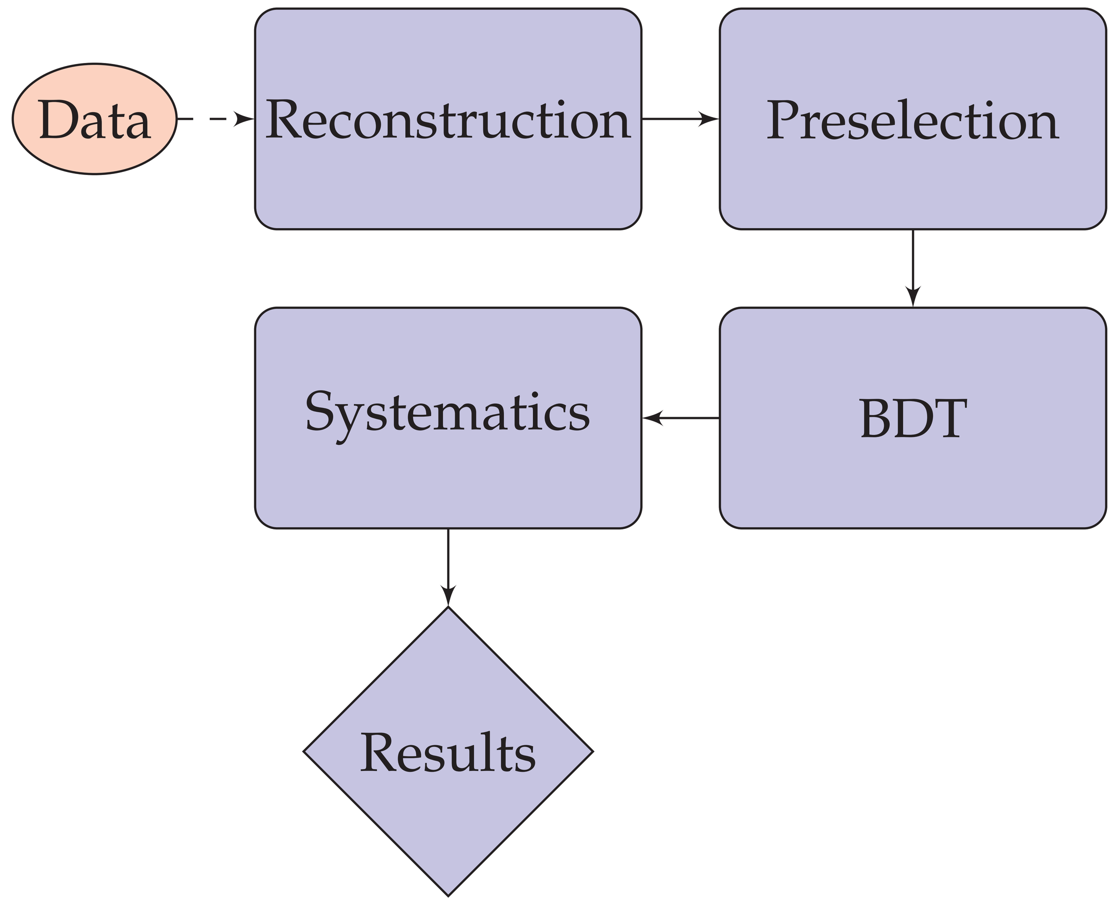
$$A = \left(\frac{f_1 - f_2}{f_1 + f_2 + f_3}\right) A_1 \tag{1}$$

RECONSTRUCTION



- Tau pairs in $e^+e^- \to \tau^+\tau^-$ events produced back-to-back in center-of-mass system
- Possible to separate them in two opposite hemispheres defined by the plane perpendicular to the thrust axis.
- Signal side
  - 1 K_S^0 reconstructed from the two pions
  - 1 charged track (not identified as kaon)
  - Any number of π^0
- Tag side
  - Electron or muon

METHODS



- After the reconstruction, some preselection cuts are applied in order to remove the obvious non-τ pair background.
- To obtain an high purity sample without affecting the efficiency, we use a 2-step BDT to remove $q\bar{q}$ background and select good K_S^0.
- Then we study all the possible systematics that could affect our measurement. The main systematics comes from:
  - Asymmetry of charged pion detection
  - Asymmetry in the K^0 and $\bar{K}^0$ interaction with the material
- We compute the final measurement using Equation (1).

REFERENCES

[1] T. Abe and I. Adachi et al. *"Belle II Technical Design Report"*, 2010.

[2] I. I. Bigi and A. I. Sanda. *"A 'known' CP asymmetry in τ decays"*. *Phys. Lett. B*, 625(47), 2005.

CURRENT STATUS

We are currently studying the two main systematic effects that affects our analysis. The asymmetry of charged pion detection is being studied using the decay mode $\tau^- \to \pi^-\pi^-\pi^+\nu_\tau$ as a control sample. The asymmetry in the K^0 and $\bar{K}^0$ nuclear interaction is being computed through a theory model simulation.

CONTACT INFORMATION

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