Observation of Wakefield Effects with Wideband feedthrough-BPM at the Positron Capture Section of the SuperKEKB Injector LINAC

M. A. Rehman and T. Suwada*

*rehman@post.kek.jp *High Energy Accelerator Research Organization (KEK)*

MOPP10

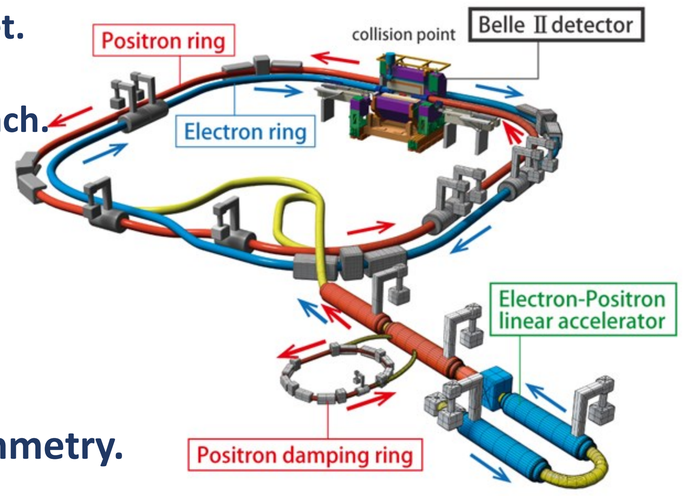
Abstract

At the SuperKEKB injector linac, e^+ are generated by striking electron beam at tungsten target. The secondary e^- are also produced during positron creation and accelerated in the positron capture section. A new wideband feedthrough beam position monitor (BPM) system was developed for synchronous detection of secondary produced e^- and e^+ beams with temporal separation of about 180 ps. When e^+/e^- bunches pass through the accelerating structure or vacuum duct of different radius, they generate wakefields. These wakefields can be directly observed with the feedthrough-BPM. A simulation study has also been carried to validate the observed wakefield effects with the feedthrough-BPM. The effects of wakefields on beam parameters will be reported in this poster.

Introduction

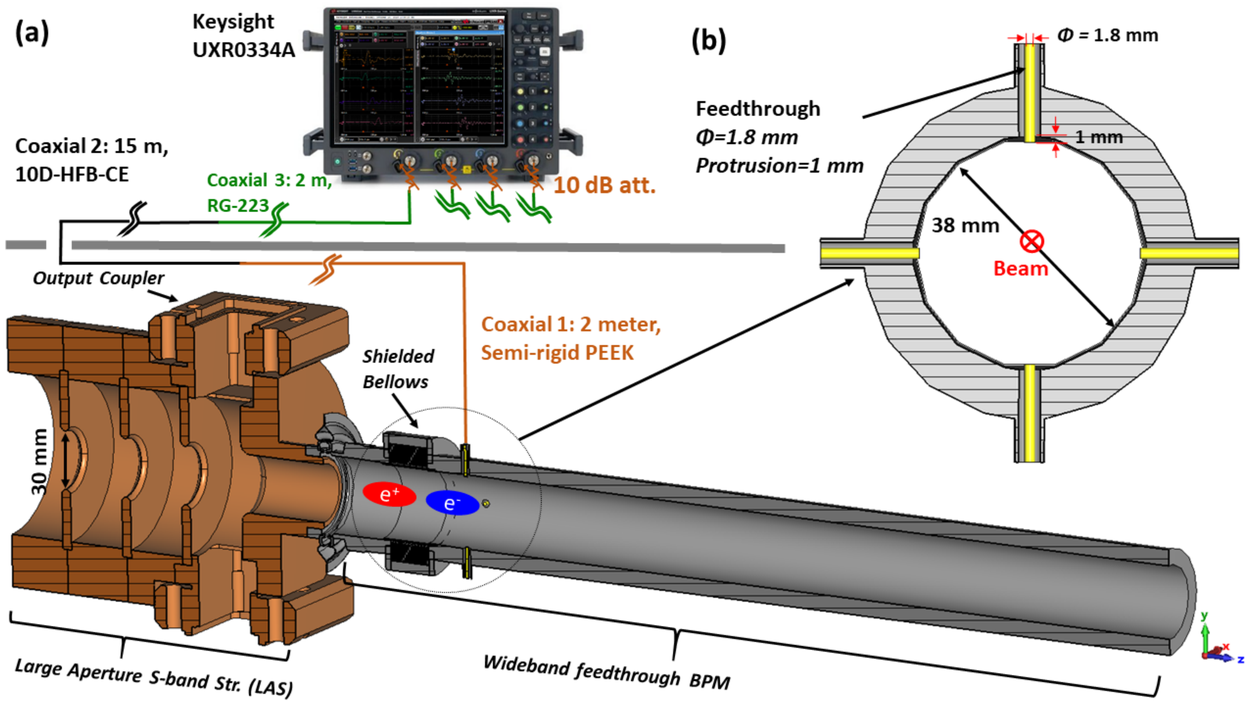
- The e^+ beam is produced by striking the e^- beam of energy 3.5 GeV and bunch charge of 10 nC at a tungsten target.
- The secondary e^- produced during the positron creation process and accelerated.
- Because of phase slipping in the capture section, the secondary e^- bunch is only **135-243** ps away from the e^+ bunch.
- **Conventional beam monitors cannot** detect such closely spaced and opposite polarity signals due to low frequency response and high cable losses.
- **New Wideband BPM** is needed for synchronous detection e^+/e^- and efficient transmission of e^+ beam

SuperKEKB Collider



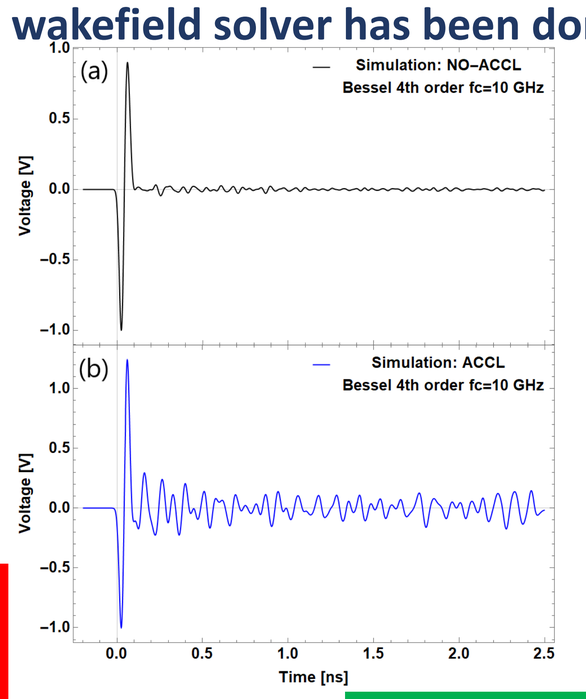
Wideband Feedthrough Beam Position Monitor

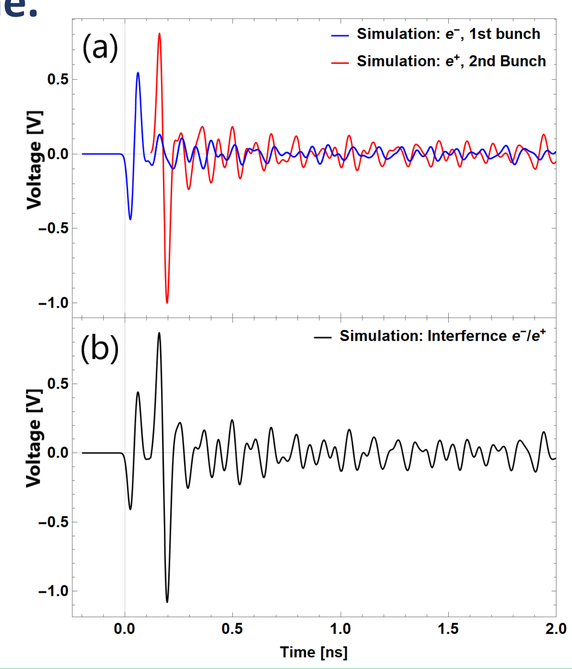
- The feedthrough-BPM consists of four SMA-type feedthroughs made of Kovar with $\frac{\pi}{2}$ rotational symmetry.
- The SMA connectors of the feedthroughs are first connected to serval kind of coaxial cables.
- The cable losses have been measured in advance by a VNA and have been de-embedded from the feedthrough-BPM signals.



Wakefield simulation of Wideband feedthrough-BPM

- When a charged particle travels through any obstacle electromagnetic fields generates, know as wakefield.
- In order to understand the wakefield field effect on the feedthrough-BPM signal, a time-domain simulation in CST-wakefield solver has been done.





Experimental Results

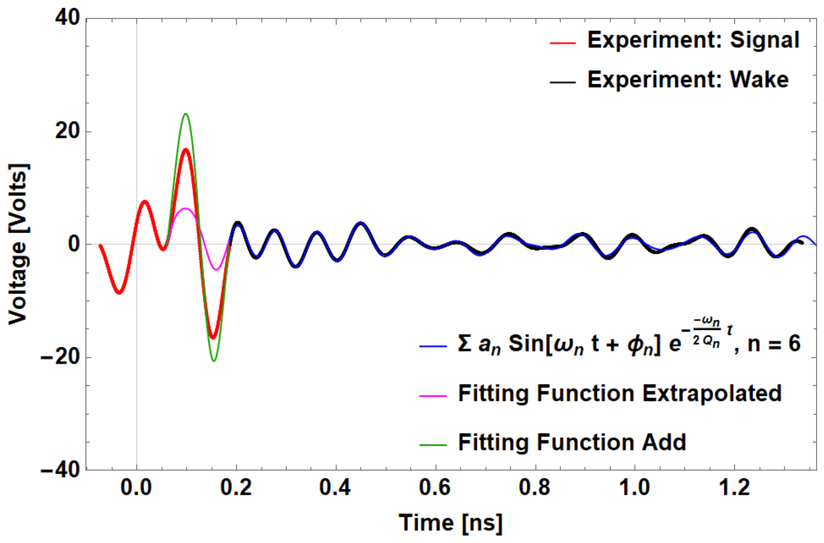
To estimate the effect of the wakefield on the experimental signal of the double bunch, it is assumed that the wakefields induced voltage oscillates and decays as follows:

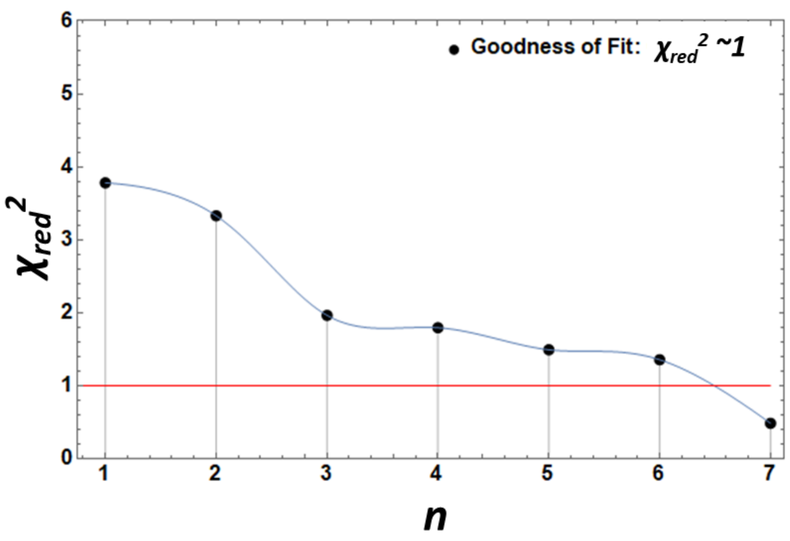
$$V(t) = \sum_n a_n \sin[\omega_n t + \phi_n] e^{\frac{-\omega_n}{2Q_n} t}$$

The model described in above is used to fit the experimental data and then extrapolated it on the bipolar signal to estimate the effect of the wakefields on the beam parameters.

Comparison between Experiment and Simulation

Wakefield errors		
Beam Parameters	**Experiment**	**Simulation**
Area	41%	38%
Bunch width	1.2 ps	0.72 ps
Time Interval	2.5 ps	2.4 ps





Summary

The short-range wakefield has been observed as a ringing signal after a double bipolar signal in synchronous measurements of the e^- and e^+ bunches with the wideband feedthrough-BPM system at the e^+ capture section of the SuperKEKB factory.

A simulation study and analytical function fitting on experimental data have been successfully carried out to estimate the effect of the wakefield on the beam parameters measured by the new beam monitor.

The estimated wakefield errors for the beam parameters are consistent in experiment and simulation.

References

Tsuyoshi Suwada, Muhammad Abdul Rehman, Fusashi Miyahara, "First Simultaneous Detection of Electron and Positron Bunches at the Positron Capture Section of the SuperKEKB Factory", Sci Rep 11, 12751 (2021), https://doi.org/10.1038/s41598-021-91707-0.