

# Correlation between vibrations, luminosity and IP beam position measurements at SuperKEKB

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TYL/FJPPN workshop, May 2024

*Contact:*

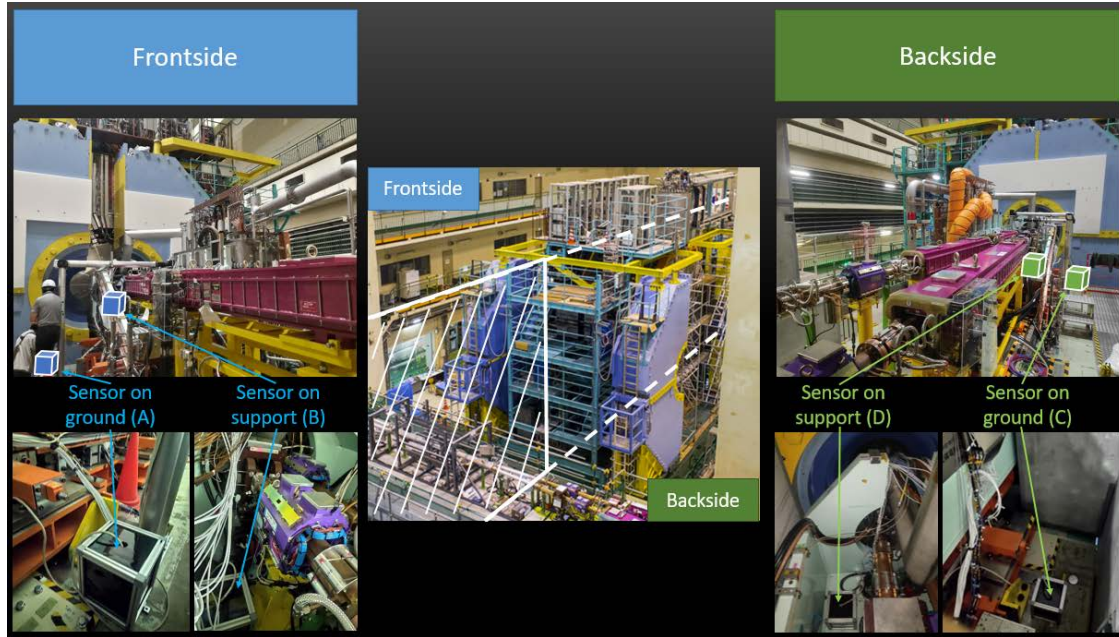
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## RD23 is a new development proposition following the RD14 conclusions (Vibrations influence on the SuperKEKB beam)

- Long-term monitoring with continuous available data for the collaboration:

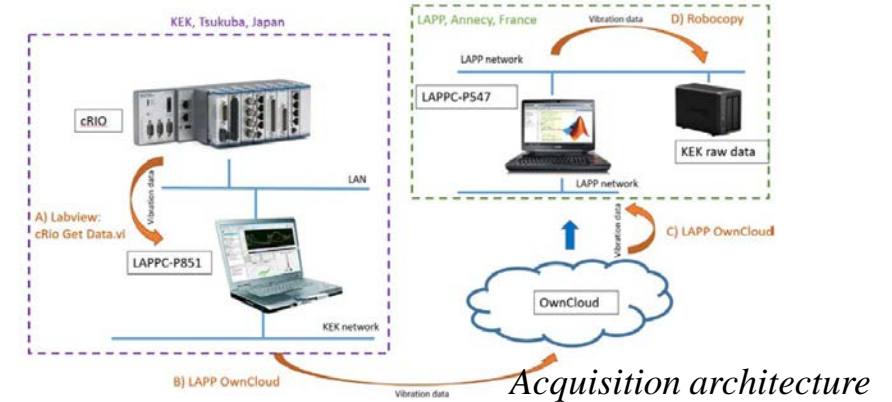
*4 seismic sensors - 2 at each side of the BELLE II detector*



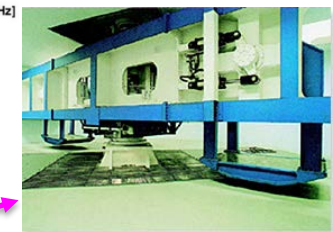
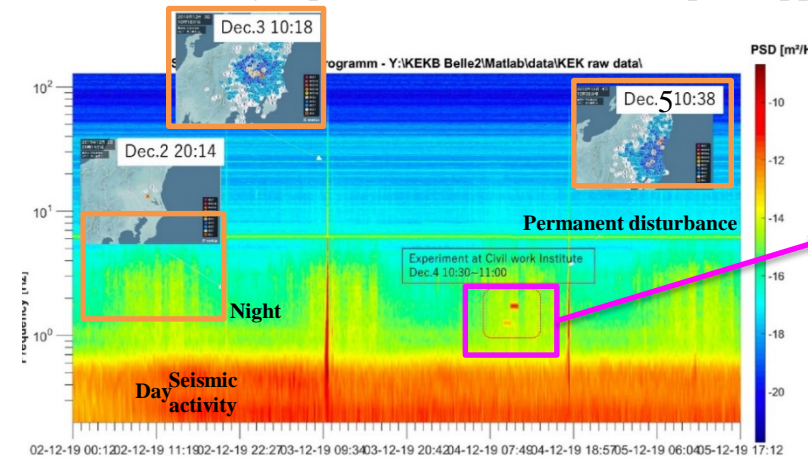
Monitoring 10'/hour to limit the data



Guralp 6T



- Weekly reports are available at : <https://lappweb.in2p3.fr/SuperKEKB/>



Experiment of accelerate centrifugal force close to KEK

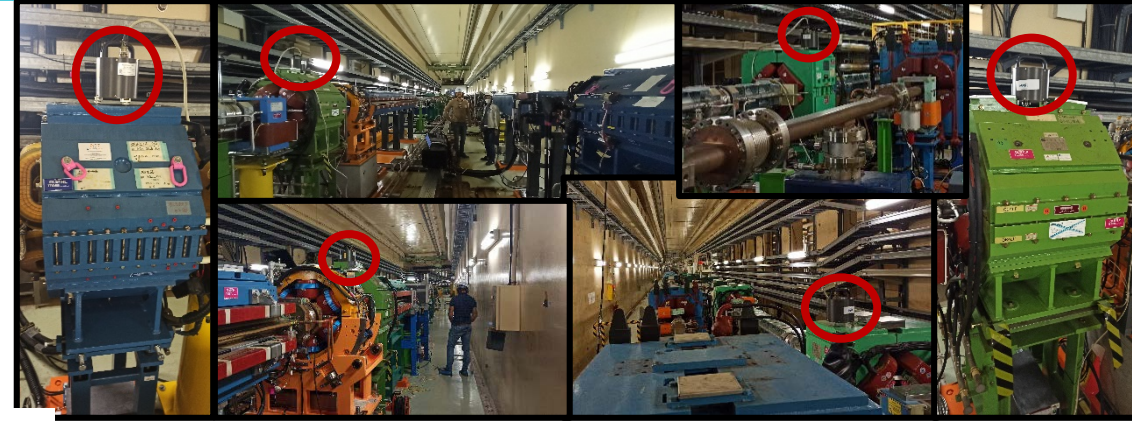
- Objective 1: Identification of disturbances or specific events:

- Comparison day – night
- Seismic events
- External disturbances
- Drift in time...

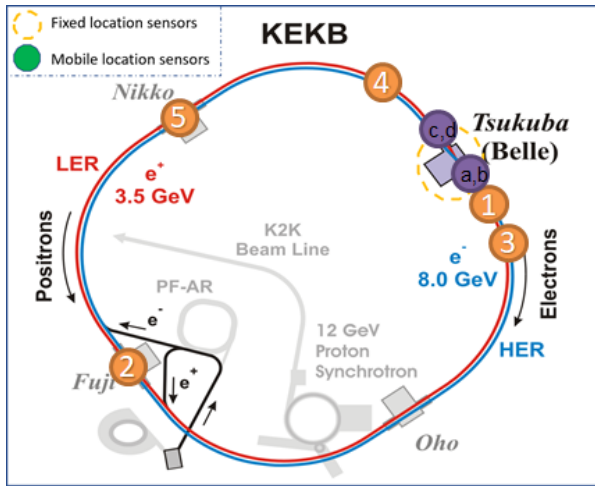
Vibration analysis: *earthquake* and *external perturbations*

## Objectives:

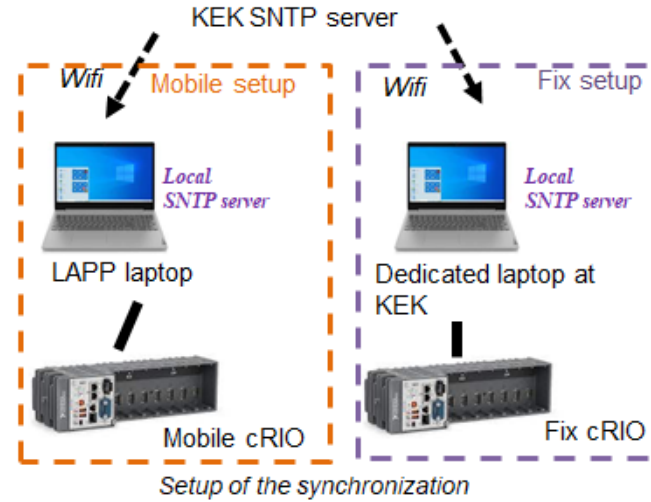
- Coherences measurements: vibrations effects analysis (SuperKEKB) and behavior of the tunnel (FCC-ee uniform waves studies and GND generator) with two synchronized ADC setups
- Evaluation of the behavior of the main impacting magnets (QLC7RE, QLC3RP, QX3RE, QLB1RE, QLB1RP, QLB1LE, QLB1LP, QW7NRP)



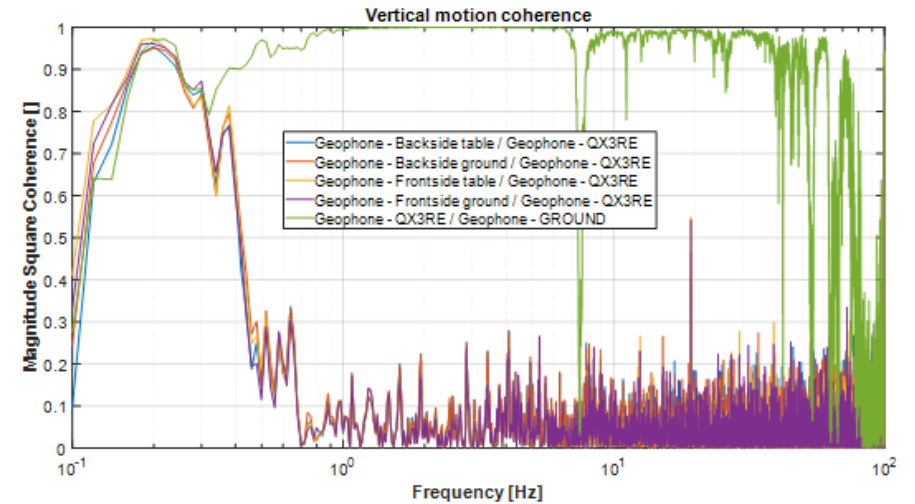
Sensors locations of the various measurements



Various sensors locations in the tunnel



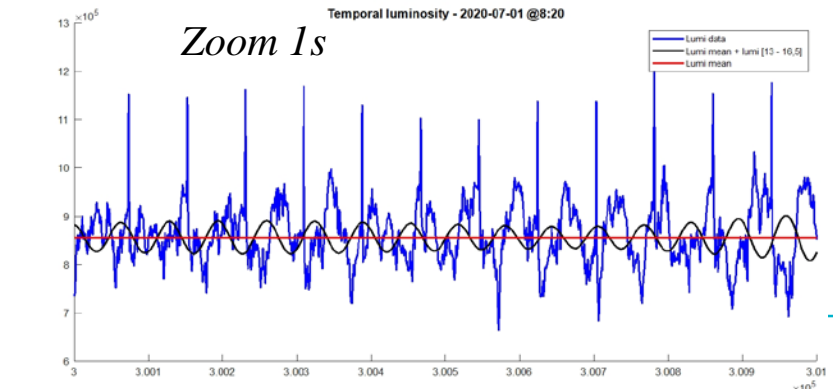
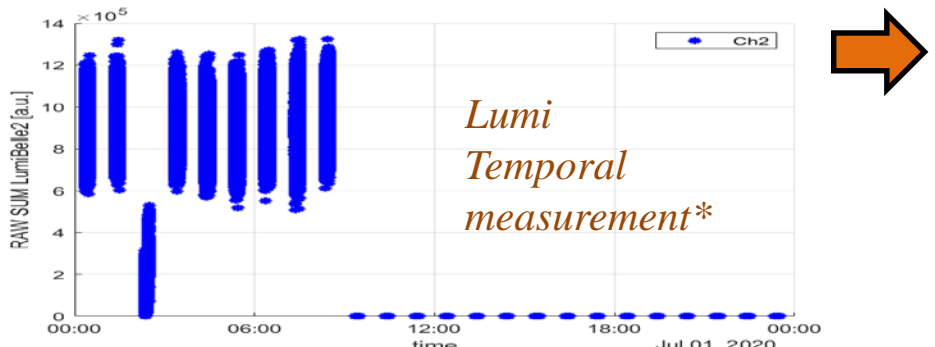
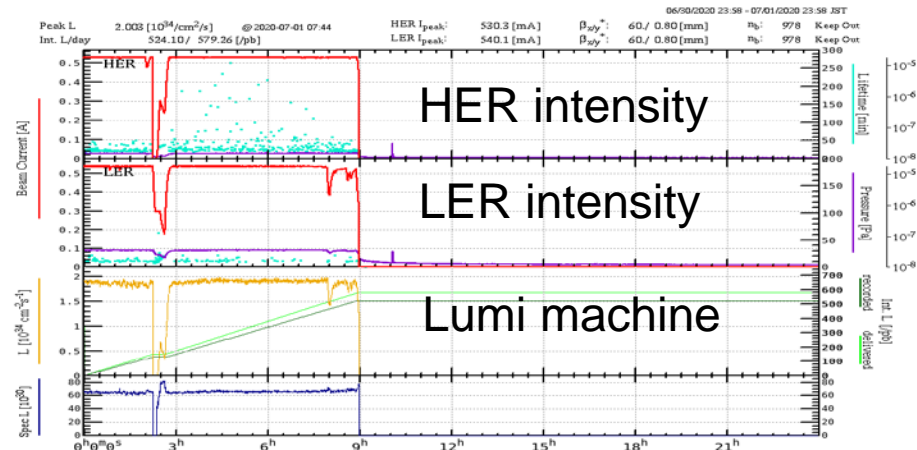
Setup of the synchronization



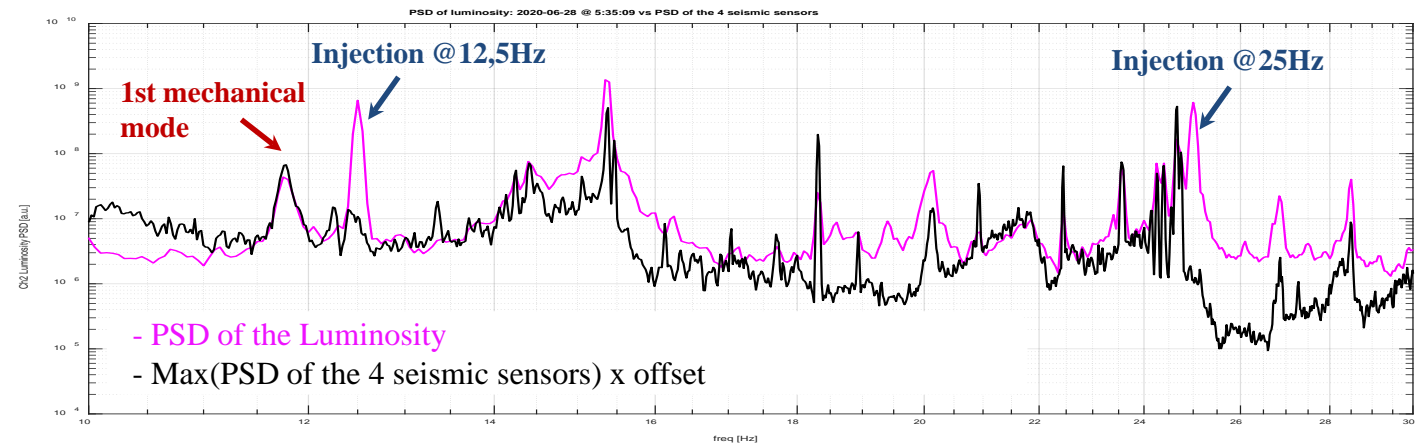
Example of results : coherence measurement at the opposite locations in the tunnel

➤ **Analysis in progress**

## Comparison vibrations vs Luminosity monitoring via Bhabha scattering (IJCLab & KEK)



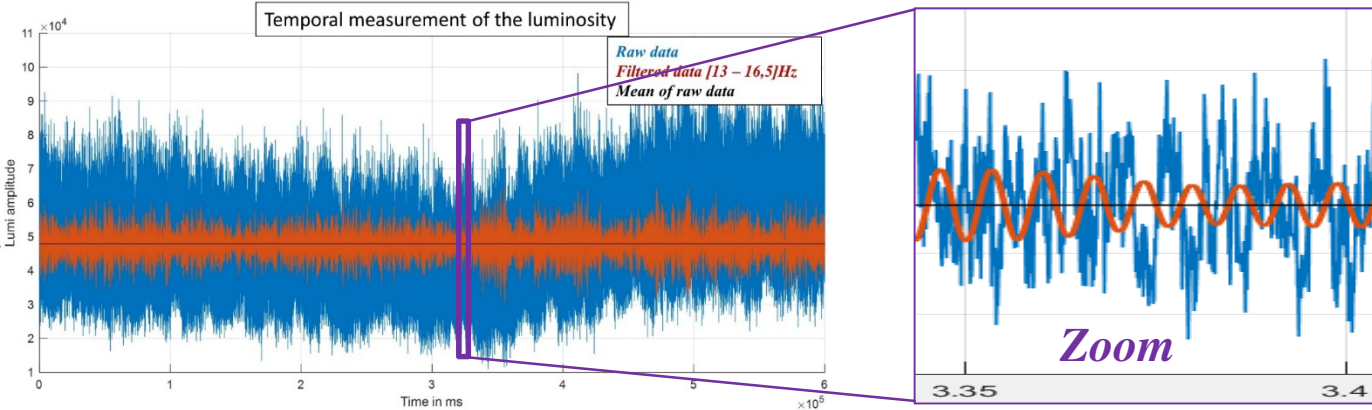
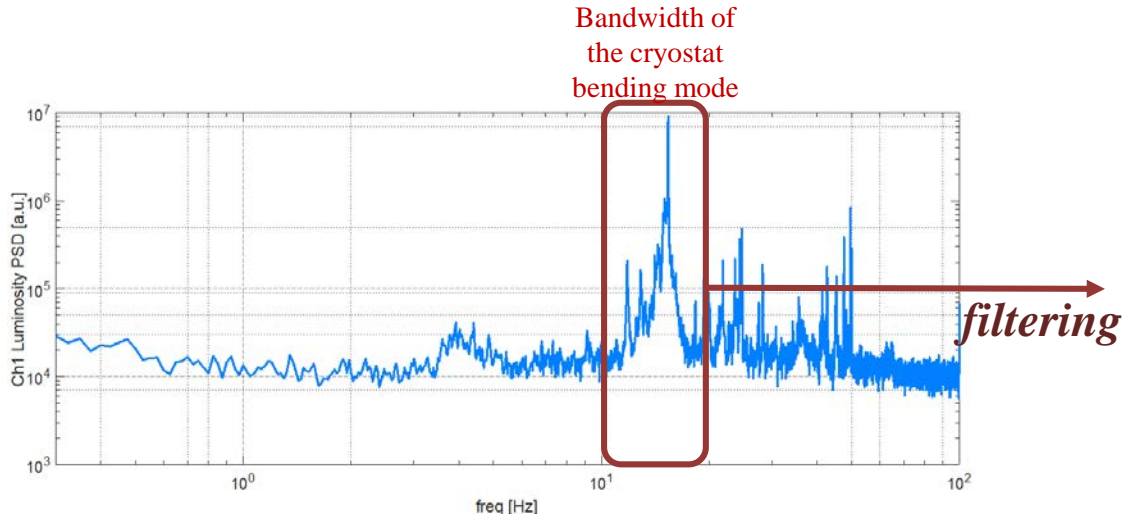
\*: The 4 permanent luminosity measurements are managed by the IJCLab team:  
*C. G. Pang et al., “A fast luminosity monitor based on diamond detectors for the SuperKEKB collider”, Nucl. Instrum. Methods Phys. Res., Sect. A, vol. 931, pp. 225–235, Jul. 2019.*



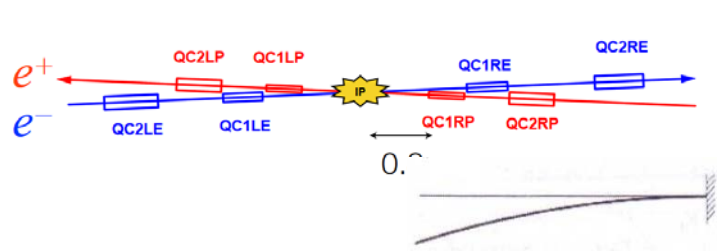
- Except the peaks at 12,5 Hz & 25 Hz due to the injection, all the luminosity peaks are mainly due to vibrations amplified by asymmetrical mechanical structures
- **Publication:** *M. Serluca, G. Balik, L. Brunetti, B. Aimard, A. Dominjon, P. Bambade, S. Wallon, S. Di Carlo, M. Masukawa, S. Uehara, Vibration and luminosity frequency analysis of the SuperKEKB collider, NIMA (2021).*

➤ **This study highlights the effects of the dynamic of the cryostat on the beam**

- Comparison of the measured and theoretical ratio of luminosity disturbance due to the cryostat vibrations (vs beam energies, HER or LER, beam size...)



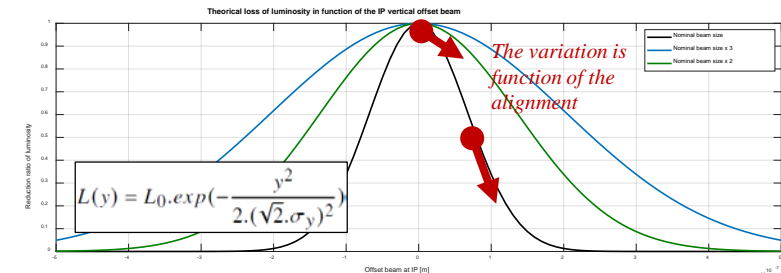
➤ **Measured ratio of luminosity disturbance** due to the cryostat bending mode, [2 : 20]% of amplitude compared to the luminosity average



Differential motions between QC1RP, QC1RE, QC2RP, QC2RE

Optics simulation (SAD) with magnet movement amplitudes as maximum misalignments

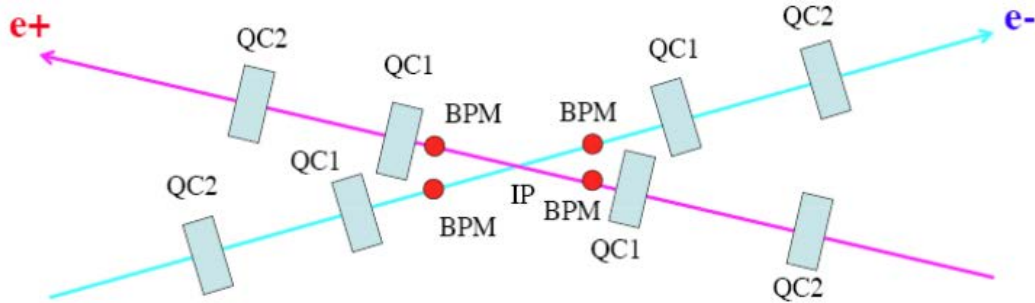
➔ Induced residual offset between the two beams at IP



➔ **Theoretical ratio of luminosity disturbance**

- RD14 has allowed to highlight the vibration effects on the beam parameters, especially in the luminosity measurements. To evaluate and to quantify more into details these effects, it is necessary to know the position of the beam at the IP with a similar frequency rate.

➤ **Correlation vibration, luminosity and beam position at the IP -> RD23**



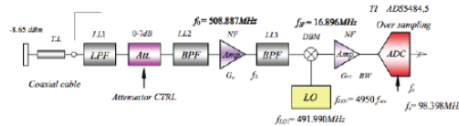
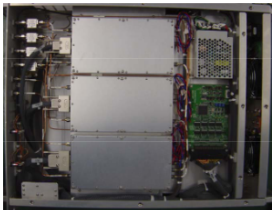
Makoto Tobiya, "IP feedback for SuperKEKB"

- ❑ **Need:** to have a data logger of the 4 IP BPM (2 axes) at a frequency rate similar to the vibration measurements (250 Hz) or to the luminosity measurements (evaluated at 1 KHz).

■ **IP BPM acquisition status:**

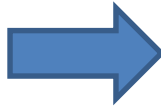
- Down convert 508.8MHz component to IF of 16.9MHz with analog mixer (with level FB).
- Convert IF signal with 16 bit ADCs (99.4MHz=4950 freq).
- Digitally down convert to DC (I & Q ch) through CIC and FIR filters.

- **Only very fast measurements**
- **Used for IP BPM**
- **Only evaluation of the differential beam positions is logged: slow control at 1 Hz (can't be used for this analysis)**



Makoto Tobiya, "IP feedback for SuperKEKB"

- To study the feasibility of an interface between the  $\mu$ TCA (fast acquisition) to a slower acquisition similar to the vibration acquisition (CRio National Instruments at 1 KHz with analog ADC cards for example) with the SuperKEKB BPM experts



*Setup of the vibration acquisition on site*

- Benefits to have the knowledge of the beam positions at the IP in real time:
  - To quantify the vibration influence on the beam parameters which depend to the beam alignment
  - Singular coupling for a leptonic collider (vibration, luminosity and alignment)
  - Could be very valuable for the IP feedback studies
  - Very important for FCC-ee studies

*$\mu$ TCA performs calculation on each channel of each BPM*

- **Collaboration:**

- IJCLab, KEK and LAPP

- **Possible milestones**

- Definition of the setup : Summer 2024
- Development and first tests on site : end of 2024

- **Next mission on site**

- To carry out the required setup to have the analysis of the correlation between the beam position (KEK - BPMs), the vibrations level (LAPP - seismic sensors) and the luminosity (KEK&LAL - in the transverse and in the vertical directions)

- **Communication**

- FCC-ee collaboration (FCC week)

- **LAPP request:**

- ☐ Travels on site (2 persons)      ➤ **Total 3 Keuros**