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Description Scientifique

ACRONYME et titre du projet :

ACRONYME : DASKEB

Titre: Data analysis for anomaly detection and noise reduction in Turn by Turn BPMs signals of SuperKEKB main rings

Noms et coordonnées des porteurs :

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Laboratoires ou équipes :

Laboratoire LISN - CEA

Description (2 pages) :

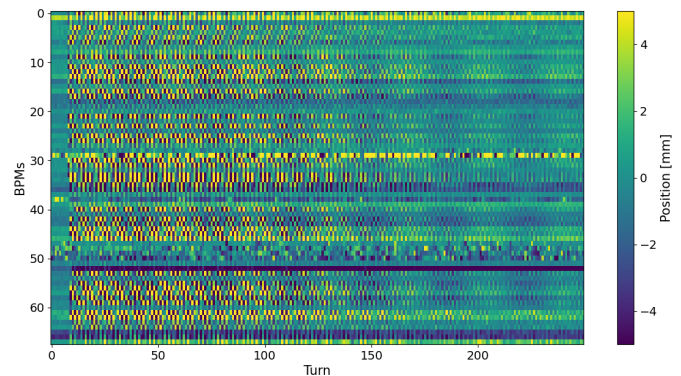
SuperKEKB[1] and the future circular colliders aim at luminosity as higher as of $10^{35} \text{ cm}^{-2}\text{s}^{-1}$. This requires very high beams current and very small beam sizes (nano-beams). In order to reach such beam sizes the accelerator physicist needs to control beam quality and accelerator optics. In particular, controlling even small linear and nonlinear effect that can perturb the optics is crucial. This is possible thanks to turn-by-turn Beam Position Monitors (BPM) signals. They allow the reconstruction of the optics parameters and the identification of the presence of imperfections that can limit the possibility of reaching the design accelerator parameters. Therefore, precise BPM signal processing becomes increasingly important for present and future colliders. Recent advancements in artificial intelligence (AI) and machine learning (ML) offer new methods to enhance the quality of BPM data, leading to better diagnostics and to results that are more accurate.

Optics measurements on existing machines can allow both to get important inputs for the simulation of the performance of the future accelerators and to test the proposed algorithms on data. In circular accelerators, the main parameters and performances of the circular accelerators are reconstructed by the analysis of turn-by-turn Beam Position Monitors (BPMs). The measured parameters values and the possibility to separate the contribution of linear and non-linear errors strongly depends on the measurement technique and BPM resolution. Furthermore, the peaks in the frequency spectrum of the turn-by-turn beam positions in the BPMs (Beam Position Monitors) identify the resonances that can induce instability of the beam. Therefore, we propose to analyze SuperKEKB BPM data and investigate possible denoising techniques to improve the TbT BPM data quality.

Objective

The aim of the project is to set up an automatic procedure to select high quality beam position monitors data to denoise the frequency spectrum, resulting from the FFT of the beam position signal of the SuperKEKB accelerator data.

Work Activities



BMP Data visualization

The student will work with BPMs data taken at SuperKEKB during the beam commissioning and the physics run in 2024. They contain the position of the centroid of the beam particle distribution at several positions around the main rings. The work will start with a preliminary analysis of the state of the art in the domain.

- First, the student will prepare the data for the data analysis and post-processing.
- The second step consists in data cleaning. Classical techniques (SVD for example) can be compared, or used in synergy, with Machine Learning based techniques (Isolation Forest for example [2]).
- The third step consists in the noise reduction of the FFT spectrum of the beam position. Commonly used techniques can be compared or mixed with Machine Learning algorithms.

The catalog of faulty BPMs and results of de-noised BPM signals will be shared with the SuperKEKB beam physicists.

The internship will take place at LISN, Lahdak team in collaboration with the DACM CEA Saclay. The collaboration will allow the synergy the strong knowledge in data integration and data analysis research with the technical expertise in the accelerators domain of LEDA laboratory (Laboratoire d' tudes et de d veloppements pour les acc l rateurs).

References

[1] Accelerator design at SuperKEKB, available: <https://doi.org/10.1093/ptep/pts083>

[2] fast.ai, "fast.ai—Making neural nets uncool again," Feb. 2024. Available: <https://www.fast.ai>

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Annexe financière

Récapitulatif

Titre du Projet	Noms des Porteurs	Montant du Financement demandé
Data analysis for anomaly detection and noise reduction in Turn by Turn BPMs signals of SuperKEKB main rings	Bugiotti Dalena Bruant	Indemnité de stage de 6 mois : 4200 €

Durée et dates envisagées du projet :

6 mois à partir du 31/3/2025

Etablissement en charge de la gestion des fonds :

LISN – Laboratoire interdisciplinaire de la science du numérique

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