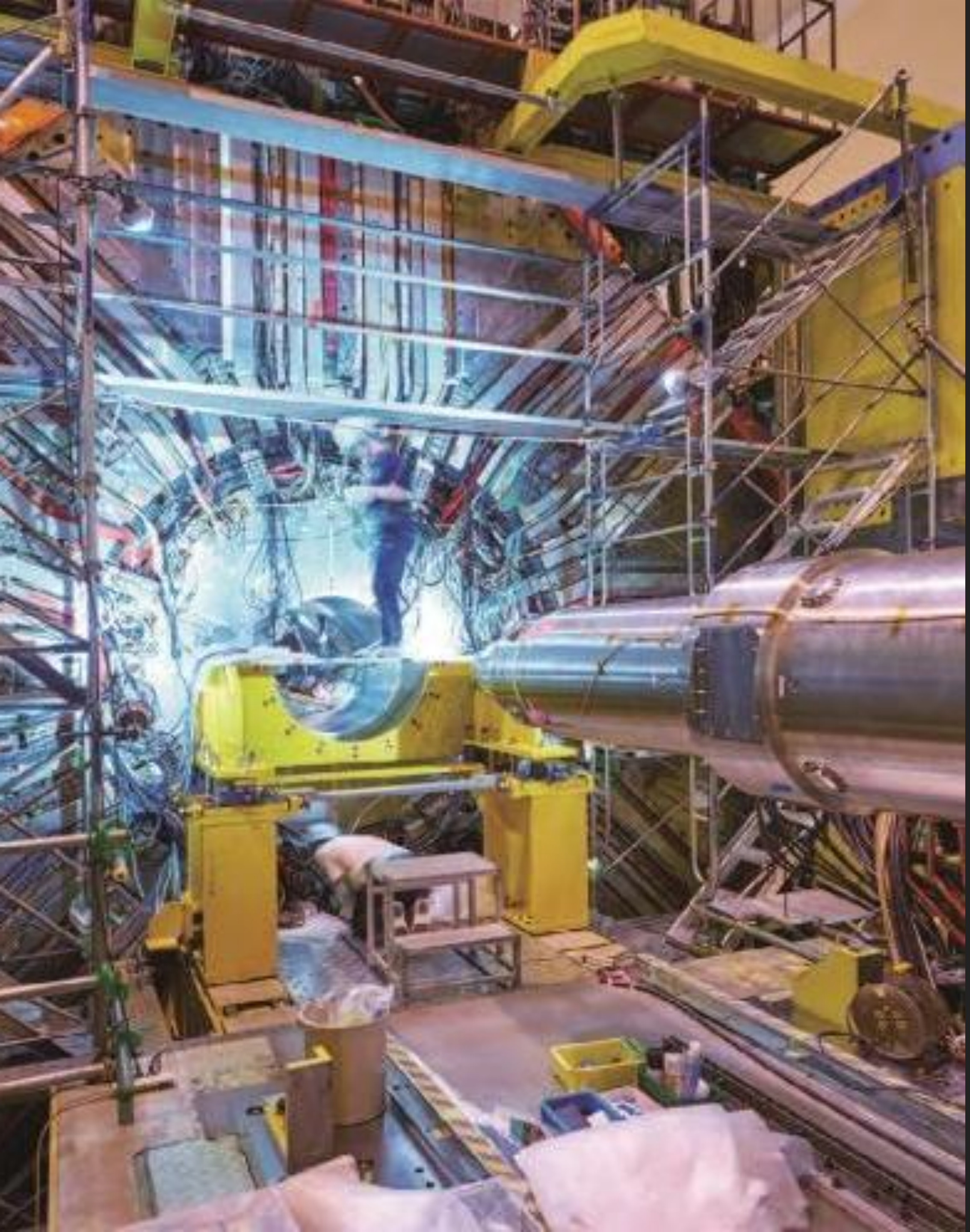

Investigation of The Correlation between SuperKEKB Luminosity and Environments.

Supervisor: Prof. Hiroyuki Nakayama

Nauroh Salsabila

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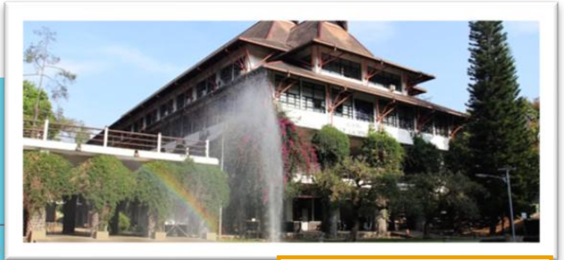
About Me

Nauroh Salsabila (Nara)

Undergrad's student (3rd year)

- Department of Physics, Institut Teknologi Bandung (ITB) 🇮🇩



My Campus ☺

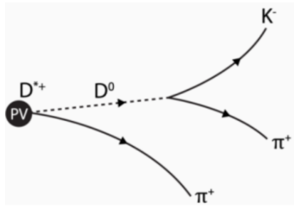
<u>Hobbies:</u> cooking, listen to music

<u>Interest:</u> Experimental-HEP

- Physics analysis
- Accelerator science

<u>Future Undergraduate Thesis:</u>

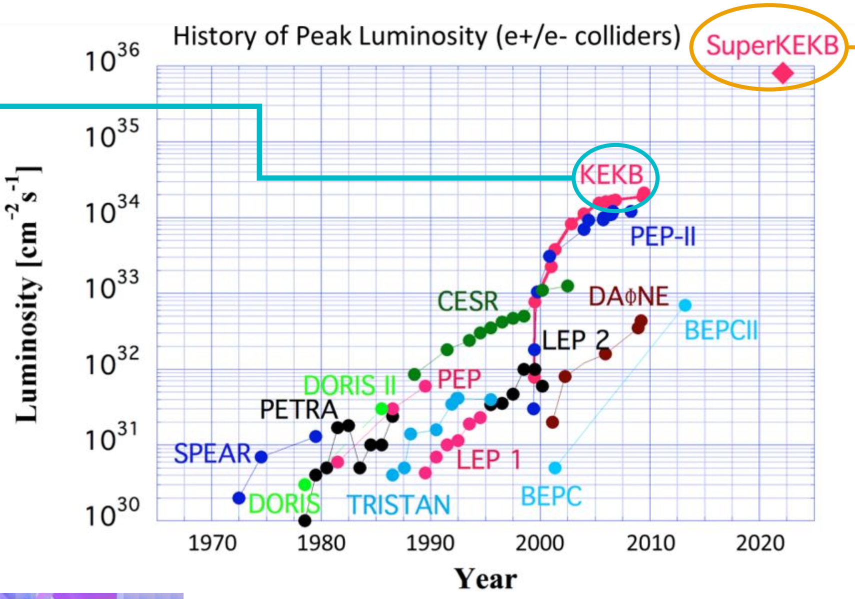
- "D* meson production in the ALICE Experiment at CERN"



Introduction

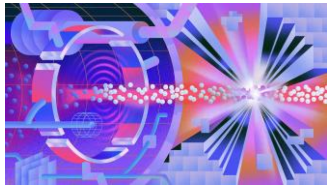
SuperKEKB Accelerator & Luminosity

Previously on the **Belle experiment** through the **KEKB accelerator**, they achieved **"the world highest peak luminosity"** : $2.1 \times 10^{34}/cm^2/s$



Now we have upgraded the accelerator to **SuperKEKB** for the **Belle II experiment**. The goal is to achieve **40x higher luminosity.**
$L_{peak} = 80 \times 10^{34}\ /cm^2/s$

What is luminosity?



Luminosity describes how effectively an accelerator produces particle collisions. The higher the luminosity, the more collision events are available for physics analysis.

Belle II Experiment

Studies CP Violation & BSM

Need a large amount of collision data

Which requires

High luminosity

Therefore

SuperKEKB

My Project
during KEK-SSP

Project Background & Motivation

SuperKEKB 24-Hour Operation Summary

Accumulation of the world's largest Y(4S) dataset June 5, 2026.

New peak luminosity 5.319 x 10^34 (cm-2s-1), June 30, 2026.

Still a long way to go!

Source: https://www-linac.kek.jp/skekb/snapshot/dailysnap.html

There is still room for performance improvement…

Achieving high luminosity requires **stable accelerator operation**

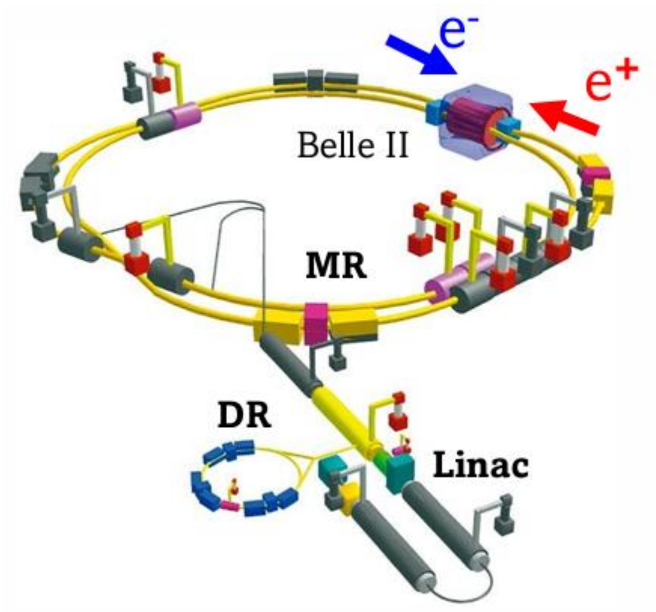
Accelerator performance is influenced by various **machine parameters** and **environmental conditions**.

Understanding the relationship between machine parameters helps **characterize accelerator behavior** and **provides insight for future machine optimization**.

Current Task

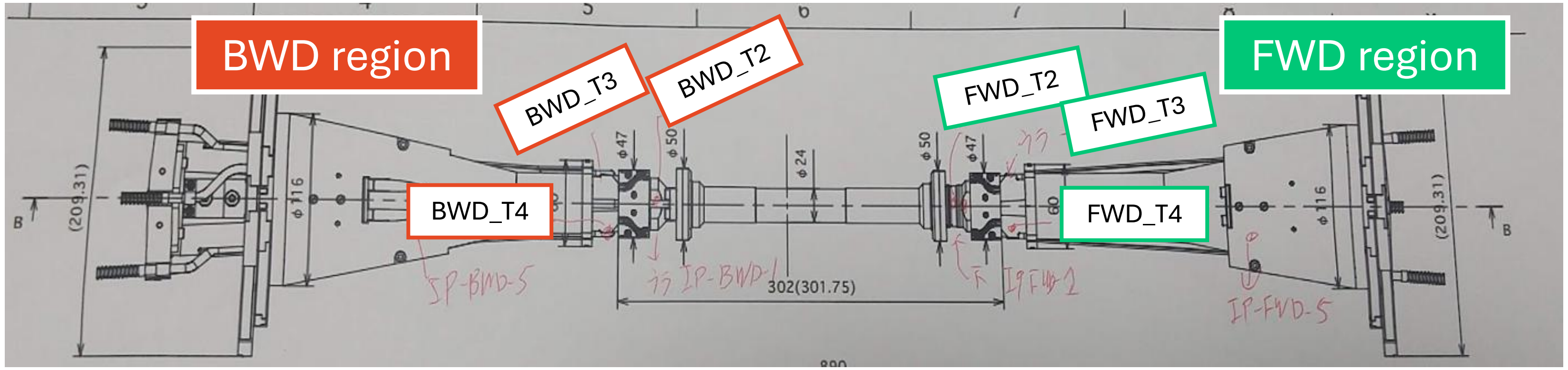
As the first step of this project, **I investigate the relationship between HER & LER beam current and beam pipe temperature** using SuperKEKB machine data.

Beam current: HER & LER



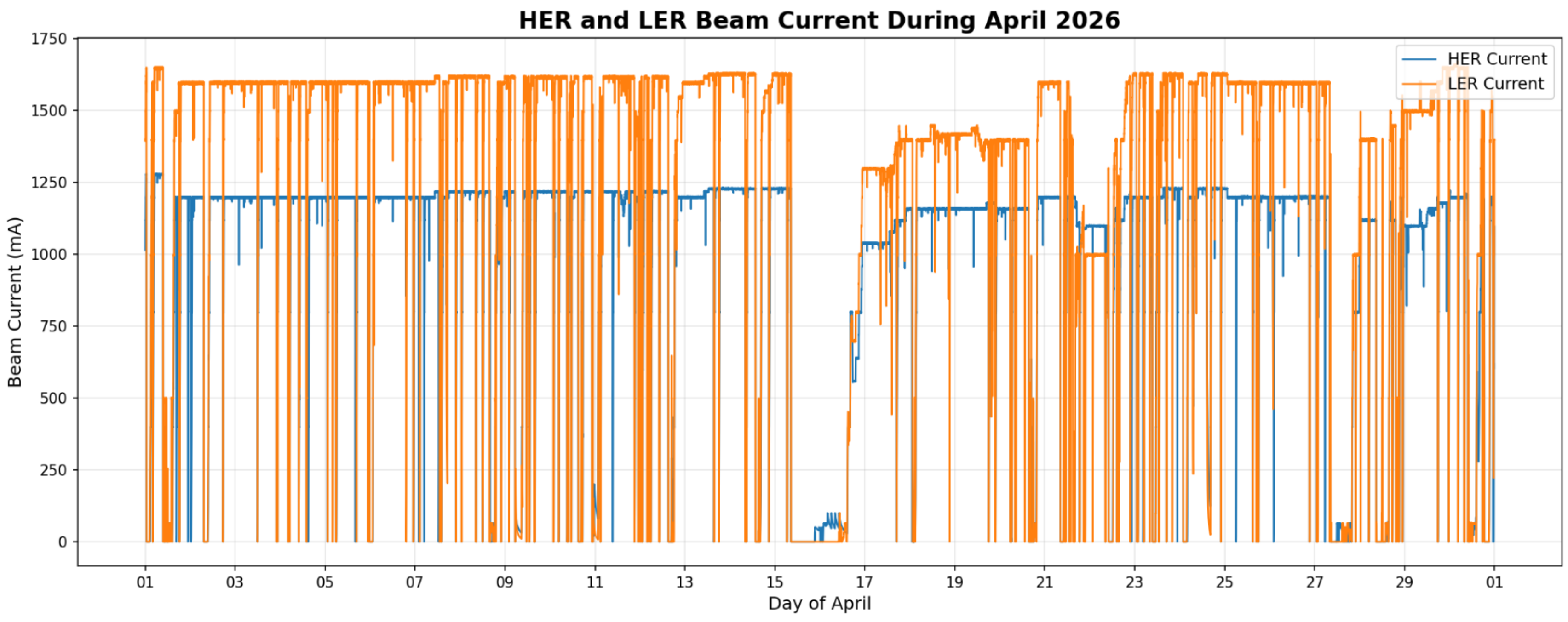
- **Main Ring (MR)**
  - Circumference: ~3016 m
  - High Energy Ring (HER, 7 GeV) for electrons
  - Low Energy Ring (LER, 4 GeV) for positrons

Beam Pipe Temperature: 6 points



1st Week Progress

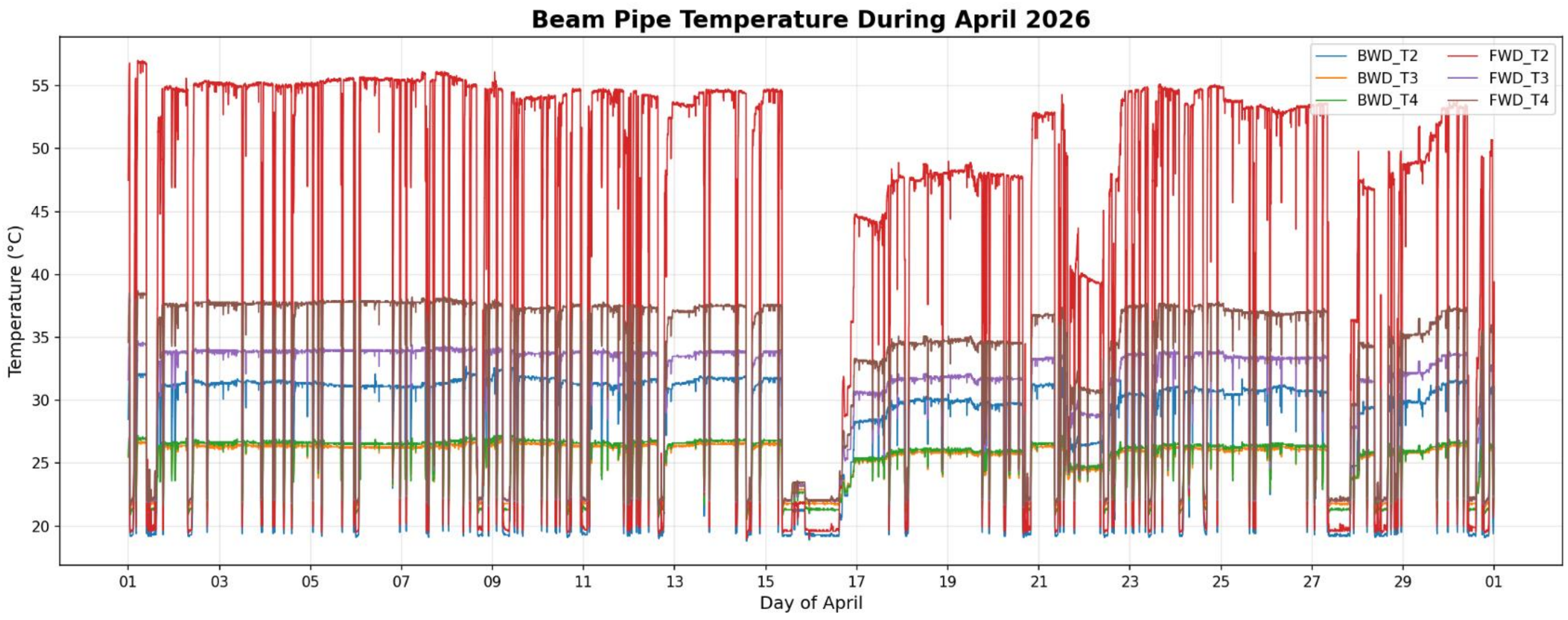
Plot 1: Beam Current vs Time



- LER current always higher than HER current
- The ratio of LER and HER current generally constant (5:4)
- Periodic current drops correspond to machine operation cycles.

1st Week Progress

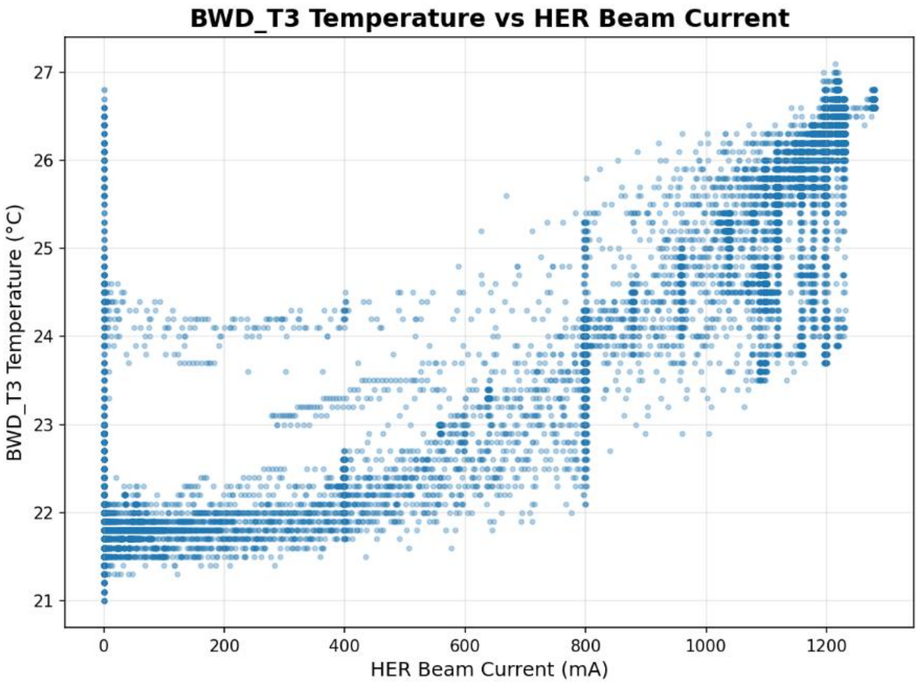
Plot 2: Beam Pipe Temperature vs Time

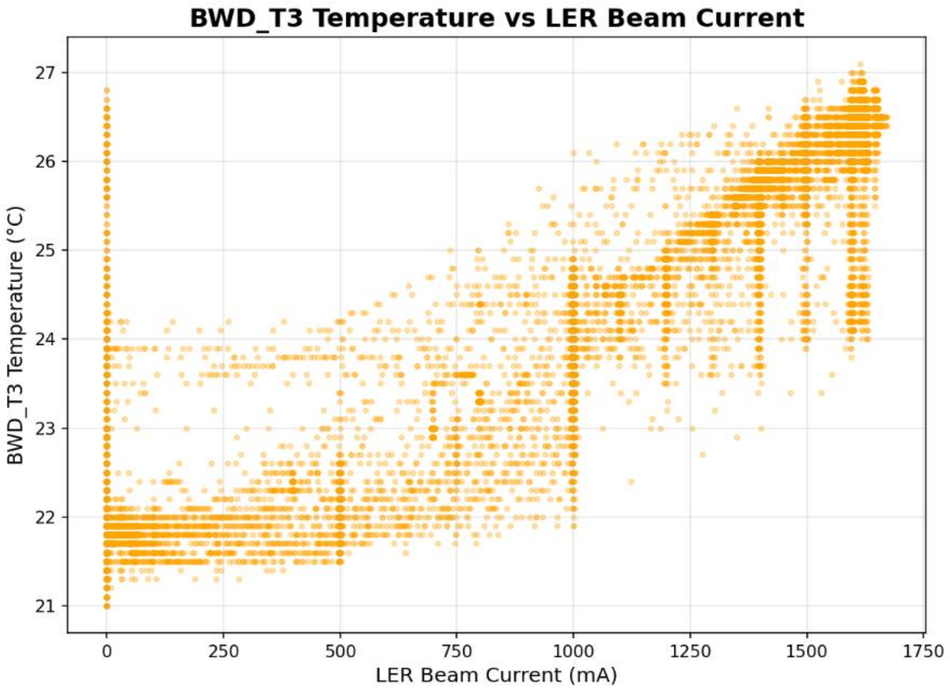


- FWD temperatures are consistently higher than BWD temperatures.
- Temperature variations appear to follow changes in beam current

1st Week Progress

Plot 3&4: Temperature vs HER & LER Beam Current



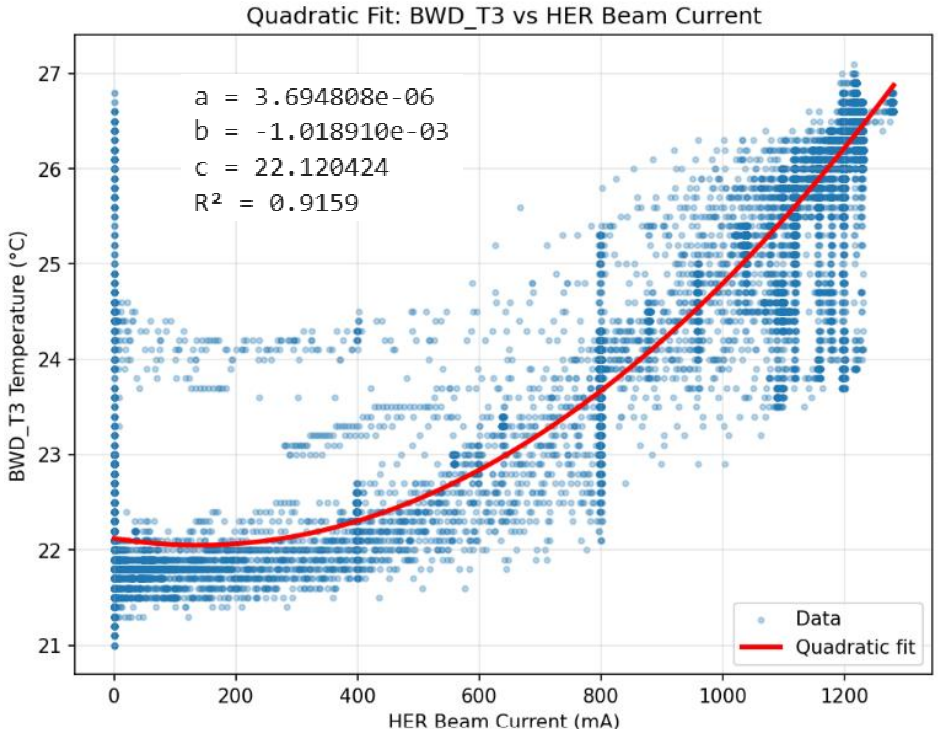


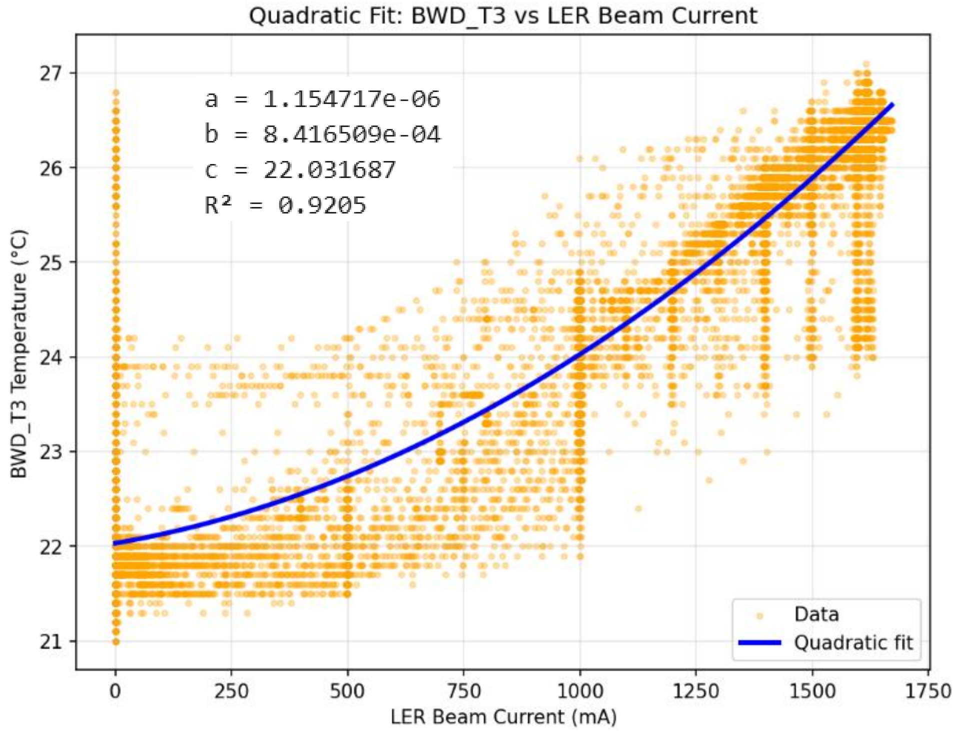
- Vertical bands correspond to periods where the beam current was intentionally held constant to monitor beam conditions
- The spread at zero beam current reflects the beam-off period, during which the beam pipe gradually cools down.

1st Week Progress

Fitting

Quadratic fitting:
$$T = aI^2 + bI + c$$





1st Week Progress

Fitting

	Temperature	Beam	a (I^2)	b (I)	c	R^2
0	BWD_T2	HER	9.282e-06	-2.194e-03	20.168	0.9210
1	BWD_T2	LER	2.909e-06	2.393e-03	19.935	0.9306
2	BWD_T3	HER	3.695e-06	-1.019e-03	22.120	0.9159
3	BWD_T3	LER	1.155e-06	8.417e-04	22.032	0.9205
4	BWD_T4	HER	4.201e-06	-1.072e-03	21.703	0.9287
5	BWD_T4	LER	1.233e-06	1.118e-03	21.634	0.9105
6	FWD_T2	HER	2.680e-05	-6.802e-03	22.356	0.8836
7	FWD_T2	LER	9.701e-06	5.067e-03	21.111	0.9558
8	FWD_T3	HER	8.718e-06	-1.899e-03	22.970	0.8852
9	FWD_T3	LER	3.037e-06	2.071e-03	22.561	0.9517
10	FWD_T4	HER	1.166e-05	-2.797e-03	23.308	0.8783
11	FWD_T4	LER	4.230e-06	2.340e-03	22.732	0.9560

- The quadratic model provides good fits for all sensors (R^2 = 0.88–0.96).
- LER generally exhibits higher R^2 values than HER, particularly for the forward sensors.
- BWD_T4 is an exception, where the HER fit performs slightly better than the LER fit.
- The linear coefficient b is negative for all HER fits but positive for all LER fits, an interesting feature that is currently under investigation.
- The contribution of aI^2 is larger than the bI.

- If $\Delta T \propto I$, it could be caused by
  - Synchrotron radiation heating
- If $\Delta T \propto$ I^2, it could be caused by
  - Resistive-wall heating
  - RF heating due to HOM or wake-field
  - Beam loss

Future Work

1. Improve the regression model
   - Investigate separate HER and LER contributions in a combined fitting model:
   $$T = aI_{HER}^2 + bI_{HER} + cI_{LER}^2 + dI_{LER} + e$$
2. Extend the parameter analysis
   - Include additional machine parameters (e.g., beam size, number of bunches, beam lifetime, etc.)
   $$T = f(I_{HER}, I_{LER}, beam\ size, number\ of\ bunches, \dots)$$
3. Explore advanced data analysis methods
   - Investigate correlation, regression, and forecasting tools available in the provided PV Analysis framework.
4. Correlate machine parameters with luminosity
   - Extend the analysis to include luminosity
   - Investigate which machine parameters are most strongly related

Arigatou Ghozaimasu for this amazing experience!