Control

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(On behalf of SuperKEKB Control Group)

SuperKEKB Control System Overview

Controlled apparatuses of the large-scale accelerators are installed in the large area. (Note, SuperKEKB circumference ~3km.)
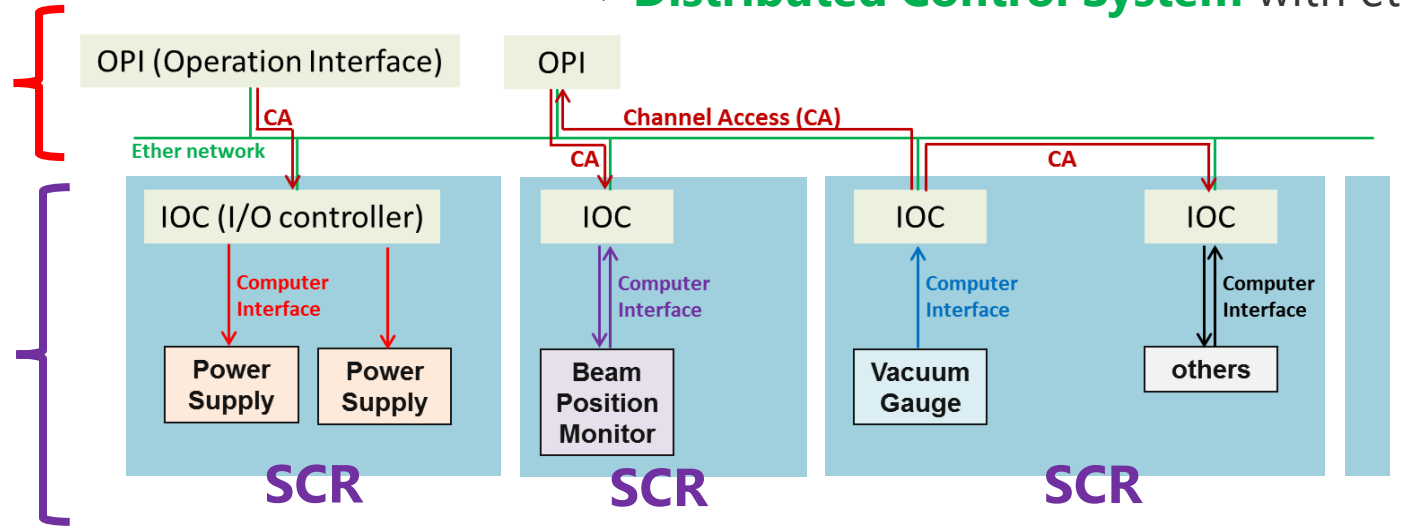⇒ **Distributed Control System** with ethernet

Central Control Room (CCR):
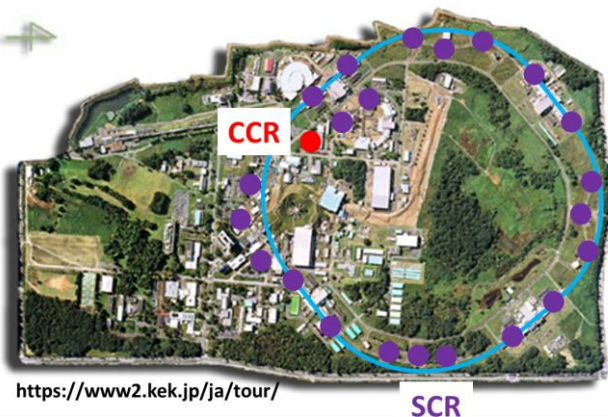Operators control all hardware via the network and IOCs.

Sub Control Rooms (SCRs):
I/O controllers (IOCs) are installed. IOC controls individual hardware.

EPICS(Experimental Physics and Industrial Control System) for Control System Software

- The network protocol among IOCs is unified. Channel Access.
⇒ Capability for improvement and extension of IOC
⇒ Adapting to new requests during the operation
- Software is developed and maintained with the worldwide collaboration of accelerator facilities
⇒ Possibility to employ sources developed by other institutes.

https://www2.kek.jp/ja/tour/

IOC at SuperKEKB

Number of Control info.
- Hardware   10,000
- control info.   200,000

- There are more than 300 IOCs at CCR and SCRs.
  Mostly, the industrial CPUs like **VME**, **PLC**, or **μTCA**-types are utilized.
  In addition, the development of **embedded-type** and the application
  of **PC**

Group	VME	PLC	μTCA	PC	Embedded	Other
Magnet	9	30	0	0	0	0
RF	7	24	65	0	0	9
Monitor	48	7	0	0	0	0
BT	14	23	0	0	10	0
Control	22	0	0	19	5	0
Vacuum	2	29	0	0	0	0
Safety	0	6	0	0	0	0

VME-type IOC

CPU   **I/O module**

PLC-type IOC
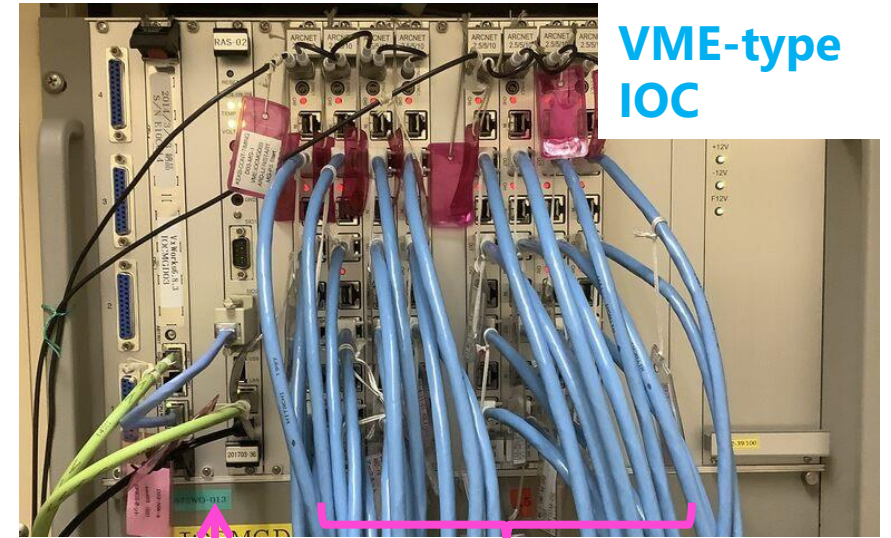
PC-type   **PClexpress I/O module**   **Embedded-type** (19inch rack, 1U height)

F3RP61   I/O modules

3

Sustainability

CPU of VME (MVME series) and PLC (f3rp61) are discontinued

- f3rp71, which is successor module, is already using in operation.

The feasibility of microTCA.4 architecture as a control system is being evaluated

- Start evaluation at test stand.
- As a first step, we are evaluating the feasibility of the timing system.

MVME5500

F3RP61

F3RP71

microTCA.4

2024/3/26

4

Bucket Selection for Bunch Current Equalization (BCE)

- Injection Bucket is decided from Bunch Current Monitor Value
- The value is transmitted with Shared Memory(RM)
- Calculate Timing according to decided bucket
- Timing Information is transmitted Main Timing Station, and generate Timing From EVG/EVR Timing modules
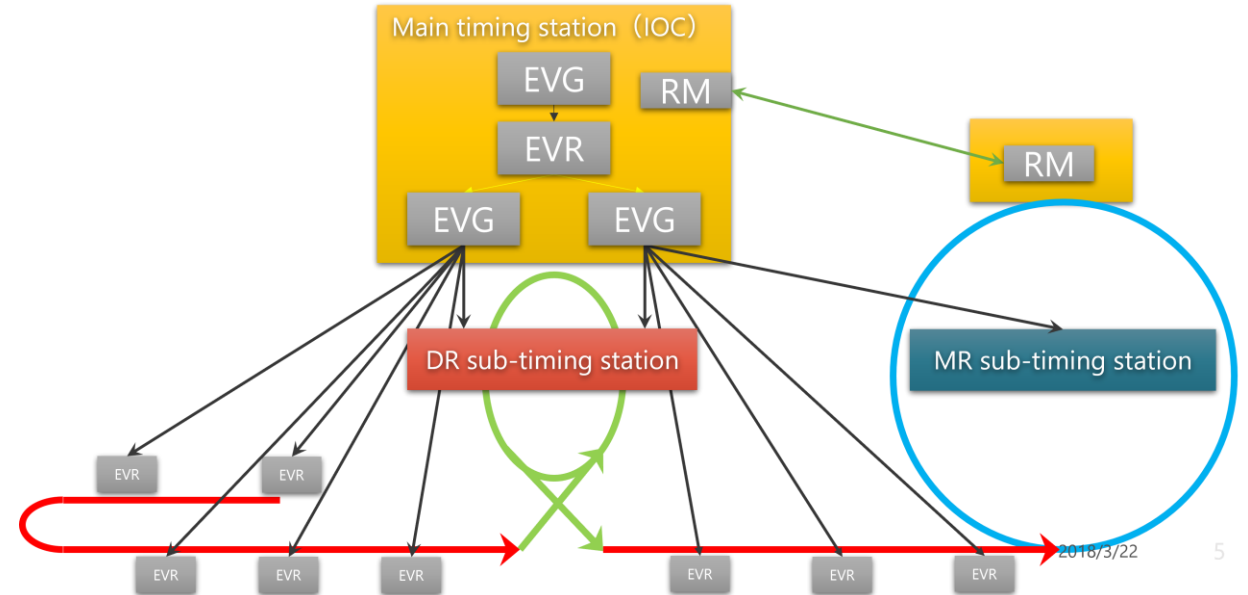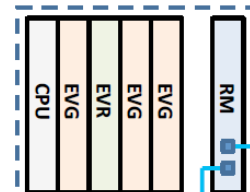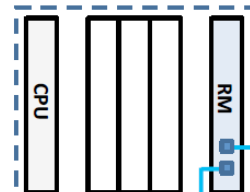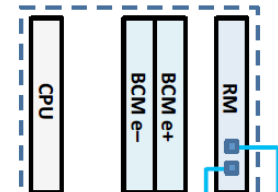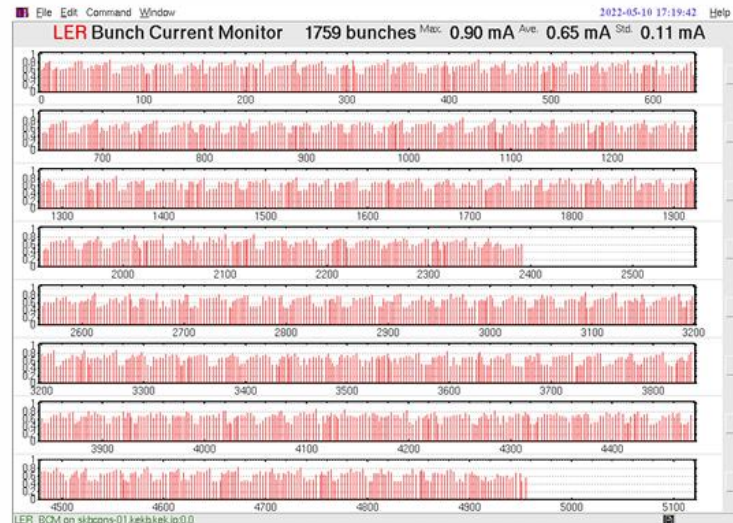
BCE in 2-bunch injection

- Bucket Selection Software is updated and BCE in 2-bunch injection is READY.
- We expect to increase luminosity in this period by BCE 2-bunch injection.

↑ Presented by Hiroshi Kaji in Previous MAC

Turn-by-turn BPM trigger

Trigger is upgraded.

- The new test trigger is developed.
- The vertical kicker and RF kick are available.
  => Now we can induce the oscillation to the x/y/z directions. **See Ohnishi-san's slides for more detail.**
  (Good collaborative works with BT, monitor, and optics groups have been done.)
- The injection to the other ring is possible during the study.

Many upgrade item can be considered.

- Synchronization between BPM and loss monitor (ex. CLAWS).
  => gives us the calibration of the beam loss monitor
  => gives us more detailed mechanism of the beam loss in both the injection and SBL.
- Include Belle II
  => makes capability for the beam background study
- Database development, maybe based on EPICS7
  => increases the potential users in the offline analysis. Even though oversea colleagues.
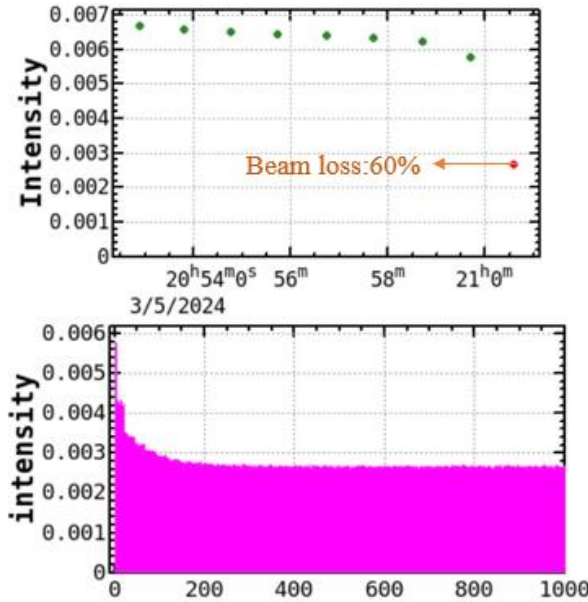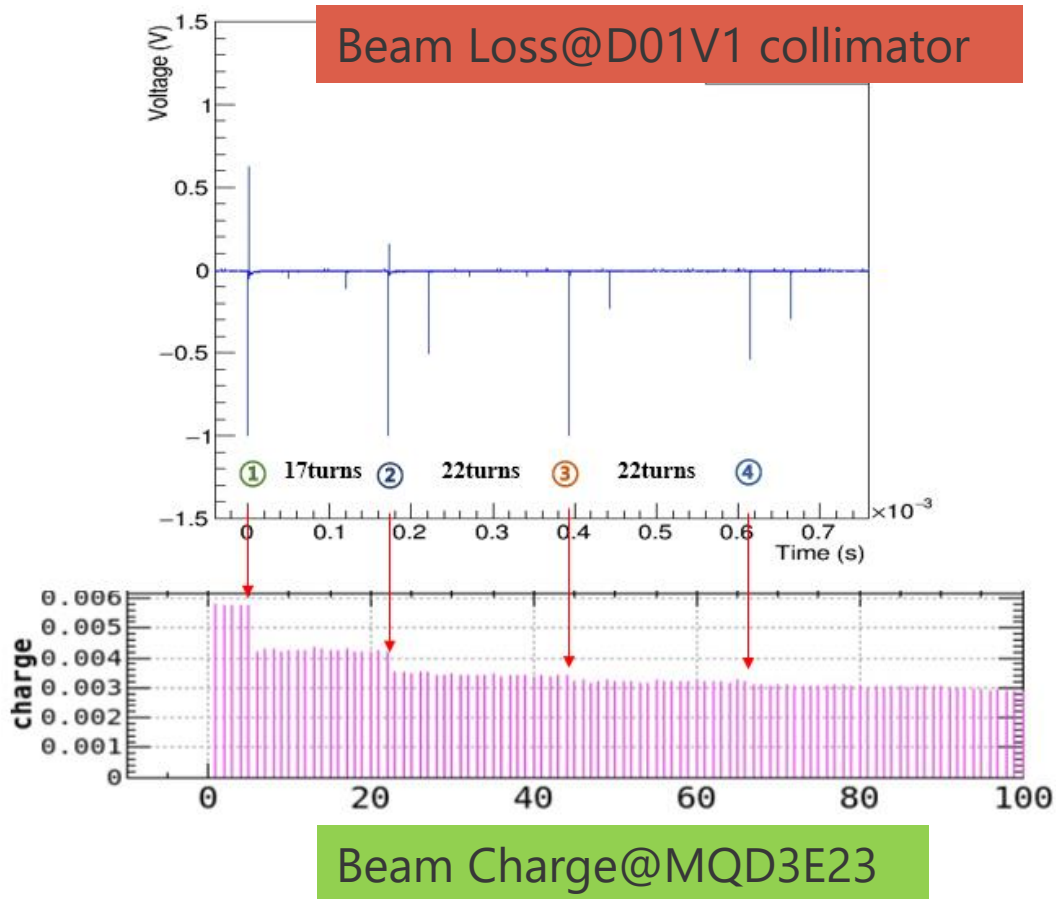
LER horizontal kick
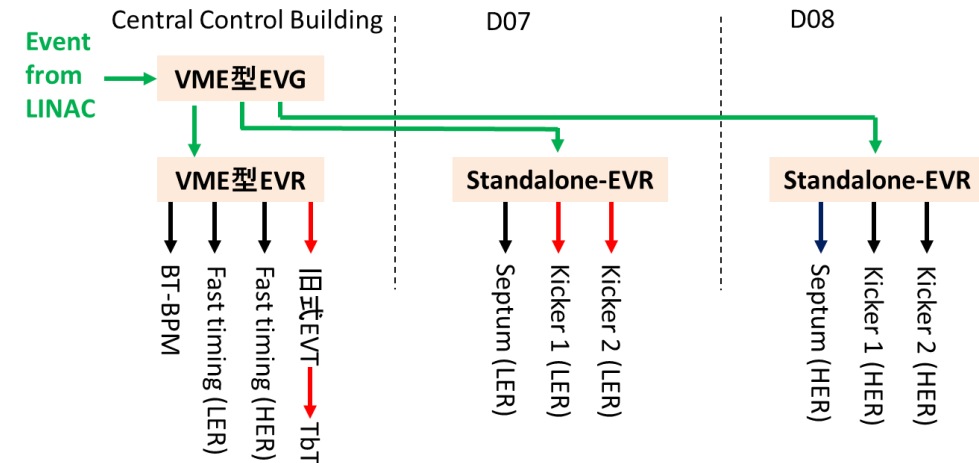
HER horizontal kick
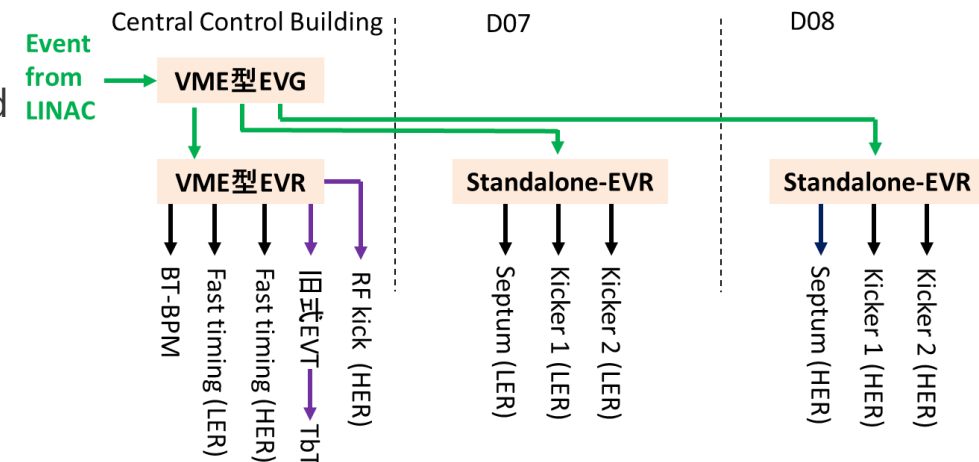
Short-term trial for the synchronization with loss monitor

HER Vertical kick study on March 5th.

Beam Loss@D01V1 collimator

Beam Charge@MQD3E23

Slide from Meng Li@IJCLab

Beam loss:60%

3/5/2024

➢ The beam loss mainly occurs in the first 20 turns and last up to 60 turns.
➢ In that case, the particles all lost on D01V1, and the loss patten is consist with signals from beam loss monitor.

We plan to upgrade this system to be regularly operated.

New abort diagnose system

The White Rabbit timestamp is put to all abort request signals.

- The accuracy of the timestamp becomes from ~100us to 8ns-100ns (depend on the condition).
- It will be stronger tool to understand the source of the beam abort.

Hardware development is finished during LS-1

- The 8ns-resolution-TDC based on "SPEC+FMC-DIO"
- Same as the loss monitor for the SBL diagnose.
- 8 slave node-station (D01/D02/D04/D05/D07/D08/D10/D11)
- Master-station (CCB)

Software development is on-going.

Abort Trigger System @ D07

White Rabbit EPICS IOC
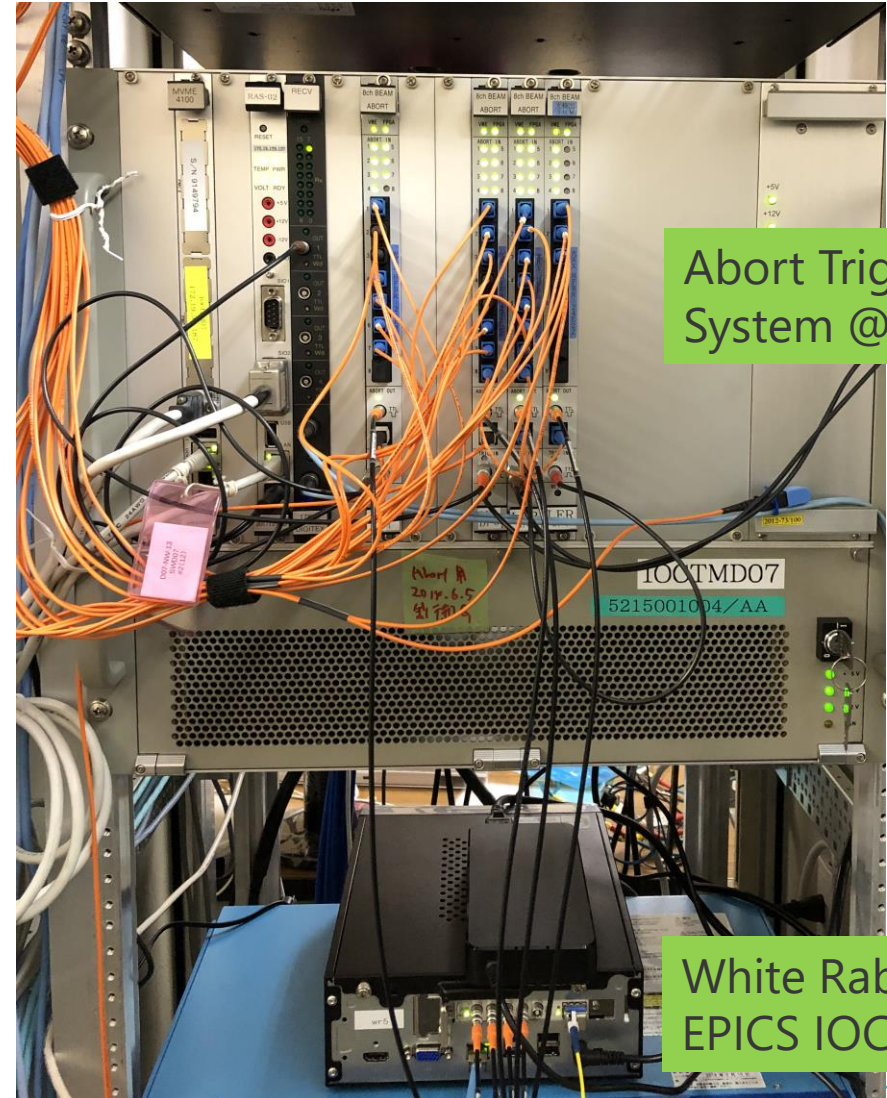
Computing System

Rackmount type of computers

- Operation was started from 2020
- 4 nodes are located at KEK network, and 9 nodes are located at SuperKEKB control network.

Each Service is Running on Virtual Machine

- We could migrate easily even if physical host computer fails.
- To reduce the impact of failures, VMs are setup for each service.
  - web, Postgres, epics softioc, working for user ... and so on
- System configuration is managed by CODE (Infrastructure as Code)
  - We adopt "Ansible" playbook.
  - The code is managed by version control system(git) and stored web-based remote repository (GitLab)

Upgrade of OS was done (CentOS7⇒AlmaLinux9) in 2023 Summer

- As the end of Life is approaching, almost all server which includes VMs were upgraded.

Network

Layer3 Core Switch connected to Layer 2 Edge Switch configuration

- 2 Core Switches and 39 Edge Switches.

10G/1G redundant configuration

- Spanning tree protocol

Each Network Component Replaced Every Year

- 2019, 2021, 2022 - Edge Switch was replaced
- 2020 - Core Switch was replaced
- 2023 – Firewall was replaced
- 2024 – Wireless LAN will be replaced

core switch

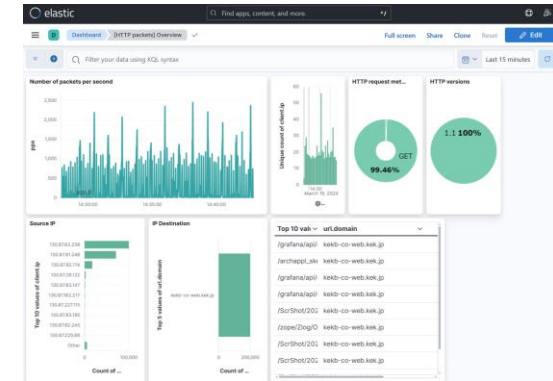# Software Development utilizing web technology

Many Web Tools

Grafana

- Monitors Computer and Network resource (storage, traffic, CPU load, memory and so on.)
- These information is retrieved in Zabbix

Kibana

- Views various Logs (web access log, computer process log ... etc.)
- Logs stored in Elastic Search

GitLab

- Version Control System with "git" for remote repository
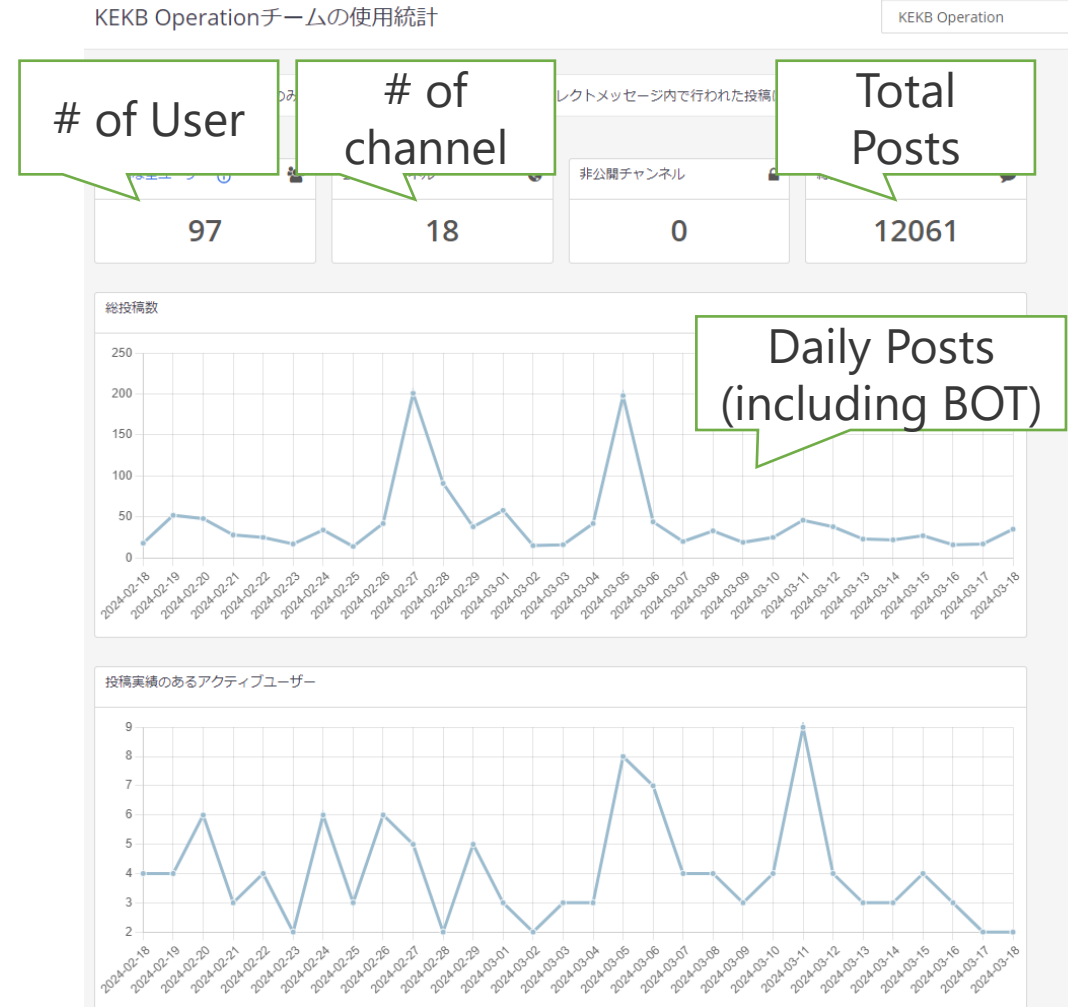- Easy to see diffs

Communication Tool

Mattermost

- Slack-like chat tool
- Began operating with an On-Premise Server from July. 2022
- Not only SuperKEKB but also PF, PF-AR, cERL project use our Mattermost.
- About 100 people participated in SuperKEKB Team
  - Roughly half of the people are always Online.
  - There is a lot of "Flank" communication taking place on the server.
  - Many discussions are stored in the server's internal storage and can be searched.
- SuperKEKB ITF teams is also working on another server.

KEKB Operationチームの使用統計

# of User · # of channel · Total Posts

97 · 18 · 0 · 12061

総投稿数

Daily Posts (including BOT)

投稿実績のあるアクティブユーザー

Auto generation of Shift Report

Shift Report had been made PowerPoint since KEKB era for each shift.

- It is difficult to find out when the events of the past occurred.
- It takes much time to make the report.

Auto generation system is developed

- Many kinds of trend graph is generated and automatically put the Shift Report website.
- Gather some events (Abort and Knob Scan etc.) from operation log with web scraping.

Shifter can write memo(note) on the GitLab wiki

- The notes are sent to Shift Report website.
- Both Trend graph and notes can be viewed on a single website

Shift Report page

Summary

SuperKEKB Control System is based on EPICS distributed system

- More than 300 IOCs, and 200,000 PVs

Sustainability of CPU is evaluating for next generation

BCE algorithm in 2-bunch injection is ready for operation

Trigger for Turn by Turn BPM was upgraded

New abort diagnose system with WR is developing

Computer and Network

- Upgraded OS
- Replace Network components every year

Web Tools

- Grafana, Kibana is monitored in computer health
- GitLab is introduced as not only version control but also shift report
- Mattermost for chat communication