

The operator-developed useful tools at SuperKEKB accelerator

Workshop on Accelerator Operations 2018

Takuya Nakamura

Mitsubishi Electric System & Service Co. Ltd.

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 - Vacuum status monitoring
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Overview



- SuperKEKB operation stages:
- Phase 1: Feb 2016 – Jun 2016
 - Phase 2: Jan 2018 – Jul 2018
 - Phase 3: Mar 2019 –

We have 3 operational shifts every day:

- from 9 a.m. to 5 p.m.
- from 5 p.m. to 1 a.m.
- from 1 a.m. to 9 a.m.

Overview (2)

SuperKEKB control room



SuperKEKB operator



Introduction

SuperKEKB operator's tasks:

- Beam injection, tuning
- Machine status monitoring
- Operation logging
- Safety management
- Hardware maintenance (during shutdown term)

Operators need to act quickly according to the situation.

Why does the operator make operation tools?

1. To respond to the accelerator operation changes.

Tasks of the accelerator operation are changing day by day.
Operators must respond to such tasks.

2. To optimize the operator's efficiency.

Routine tasks should be efficiently performed →

To automate, to save the labor, and to simplify operator's tasks is very urgent.

To match these requests, operator needs to create some new tools by himself/herself.

SuperKEKB software environment

GUI Environment:

- Python
- Control System Studio (CSS), BOY
- SAD script

(Mathematica-like language, developed in KEK)

Usually operators are developing the tools with python and CSS BOY.

Control System Studio

CSS is a collection of tools:

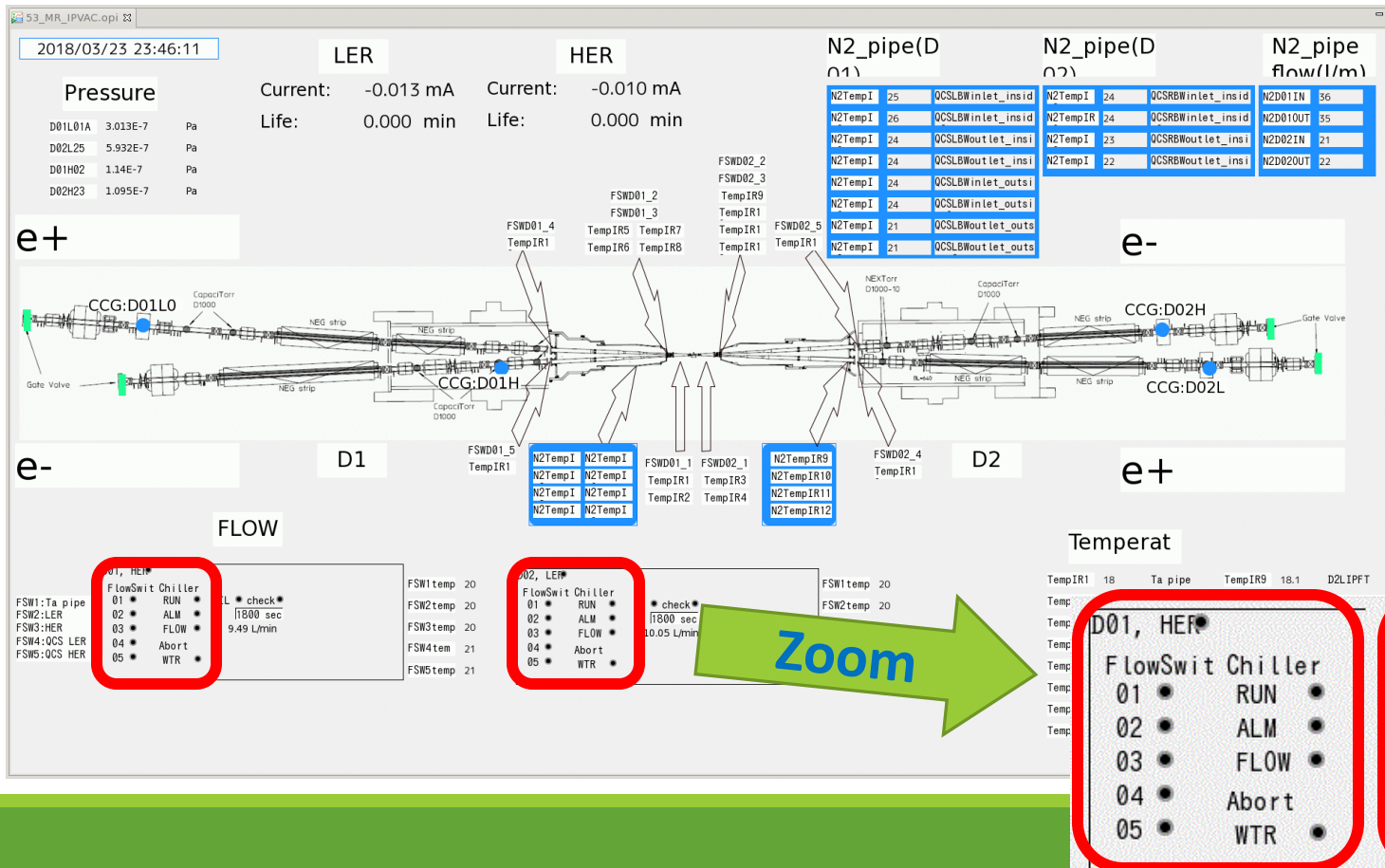
- Alarm Management
- Archive Engine
- Operator interface : The Best OPI Yet (CSS BOY)

CSS BOY is an operator interface editor and runtime.

CSS BOY became very popular among operators. The reason is the simplicity of its utilization.

Vacuum status monitoring (1)

Vacuum Status Panel for Interaction Region



Operator has to check cooling system condition. (Red square area)

If trouble is happened, operator must call for an expert as soon as possible.

Vacuum status monitoring (2)

Console for Vacuum Group



Many GUI panels are opened.

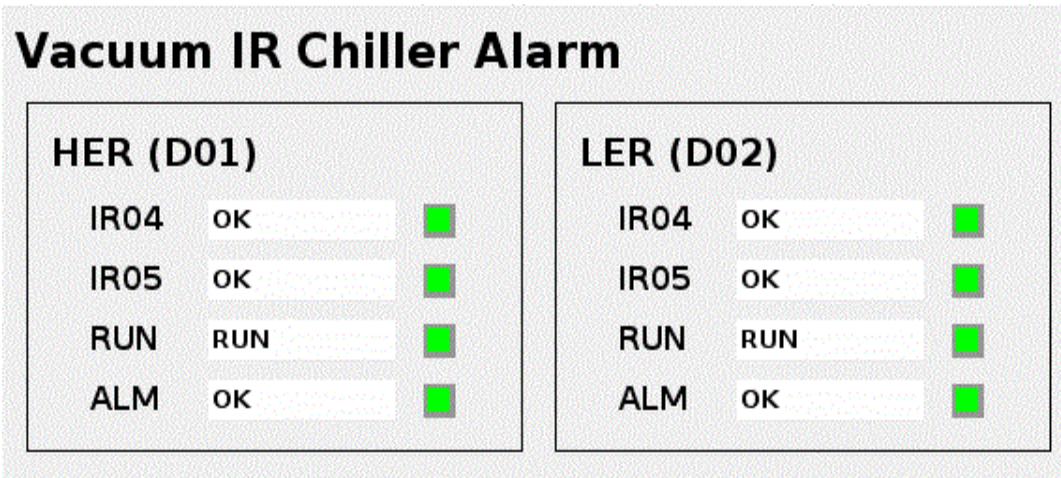
Where is the status monitor panel ?!

Operator has to find the target panel.

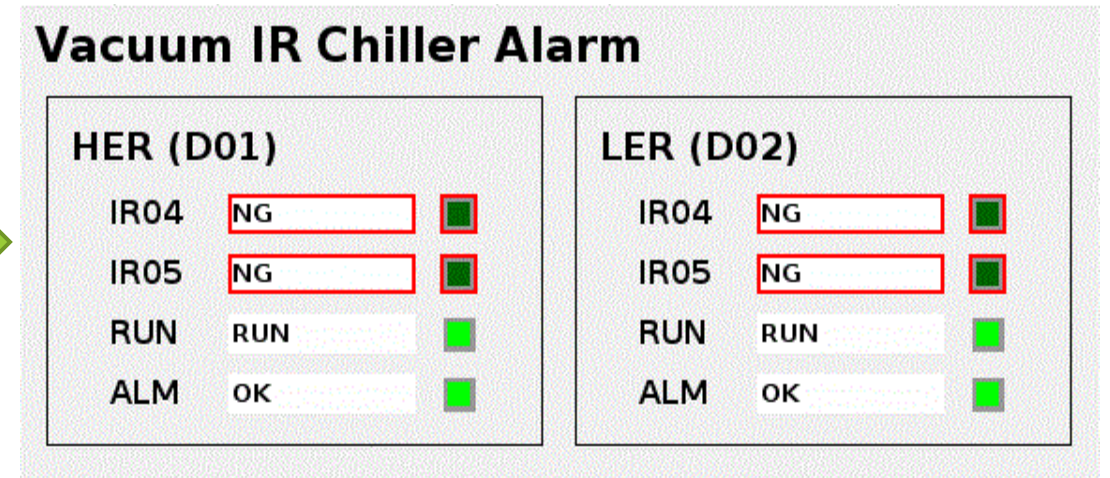
Sometimes, this panel is on the background, or minimized, or just closed down.

Vacuum status monitoring (3)

Normal status (Good)



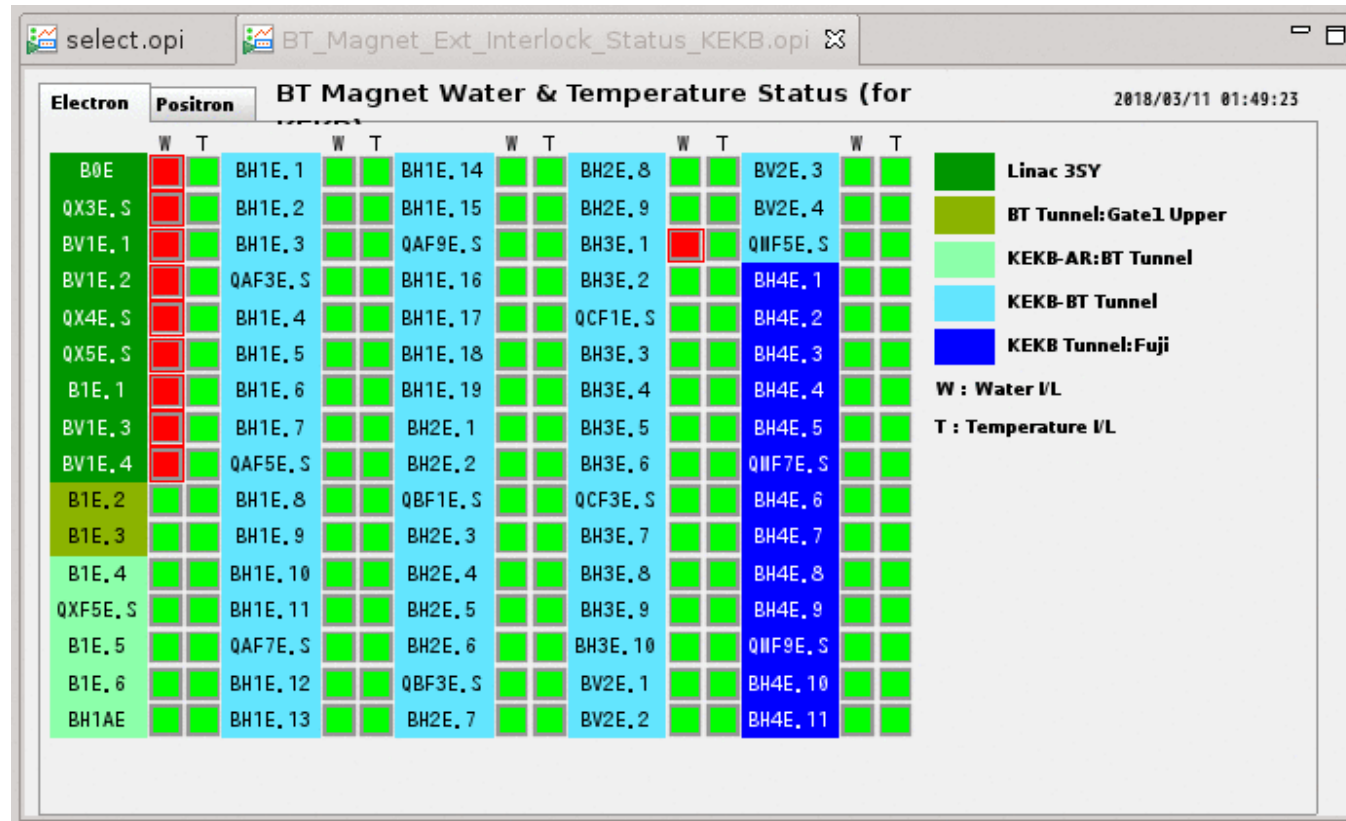
Alarm status



Operator creates a simple panel for vacuum status monitoring.
It can be judged immediately whether it is normal or abnormal.

Magnet interlock status monitoring

Magnet interlock status panel for Beam Transport



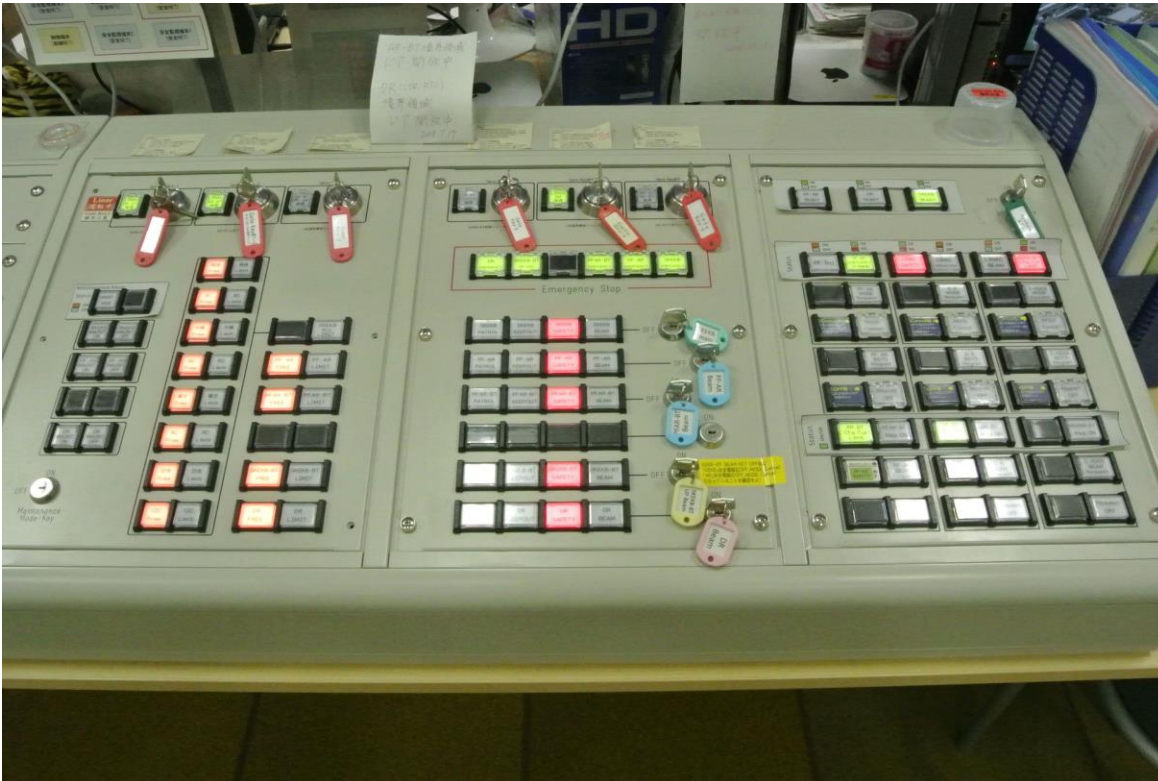
Magnet Interlock status display panel includes:

- Cooling water flow status
- Thermal status

The operator can easily identify the location of the magnet by the color indication.

Safety management

Safety management console



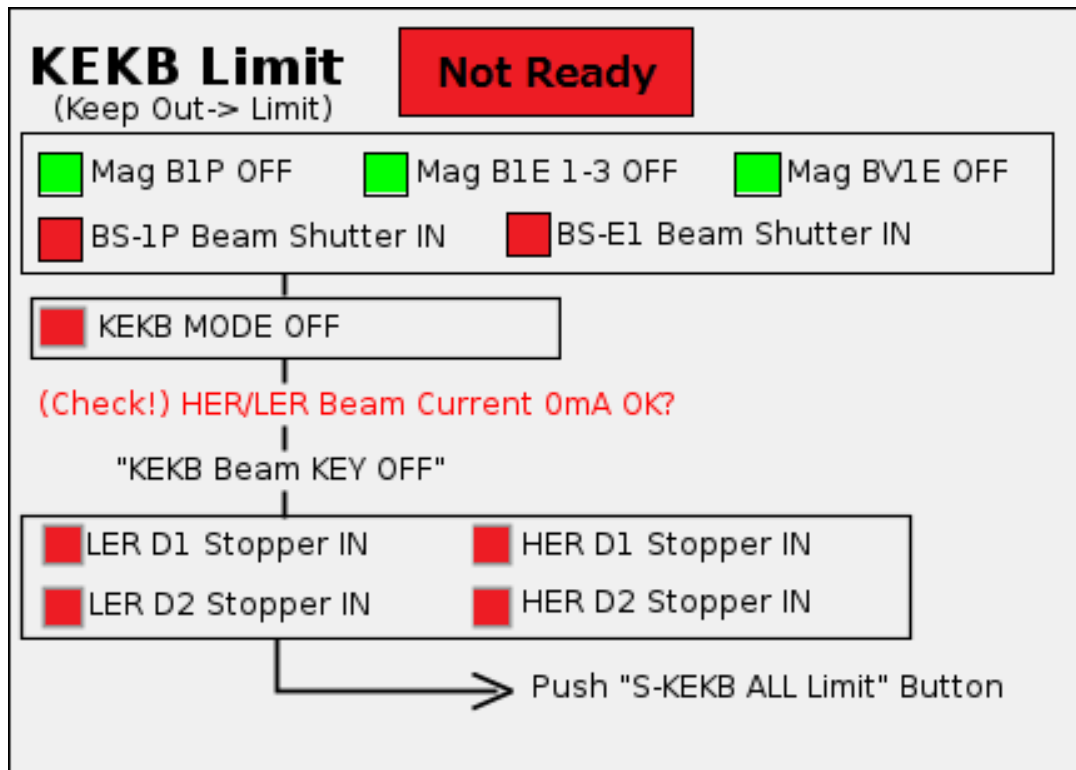
Operate when changing the operation state of the accelerator. (For example, when accessing a tunnel)

There are many buttons and keys. Complex manipulations are necessary.

After a manipulation mistake occurred, it takes from 15 to 20 minutes for operation recovery.

Safety management (2)

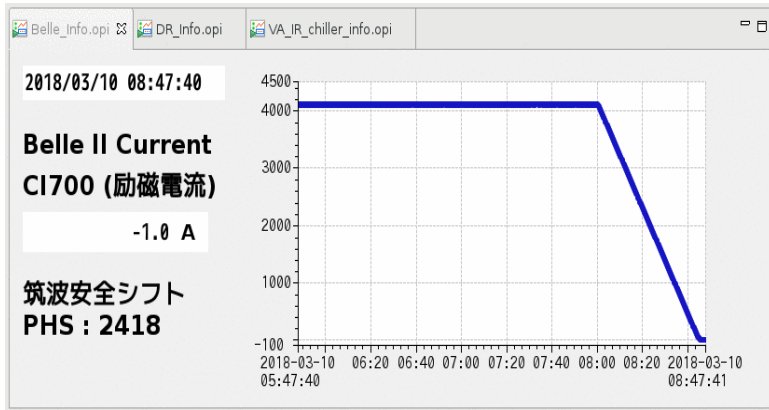
Status panel for safety management console



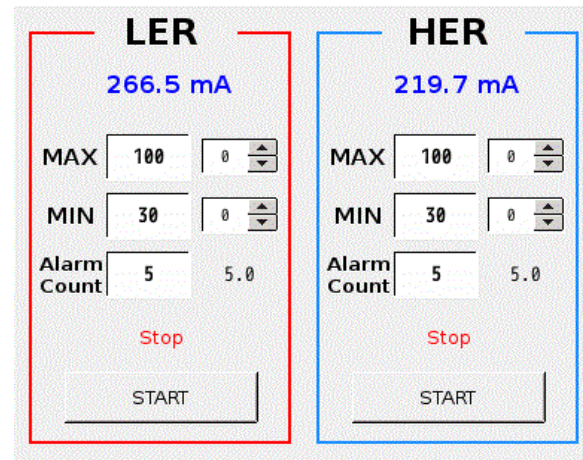
This panel shows the order of manipulations of the safety management console. Operator can confirm what to do now to proceed to the next stage.

Other panels

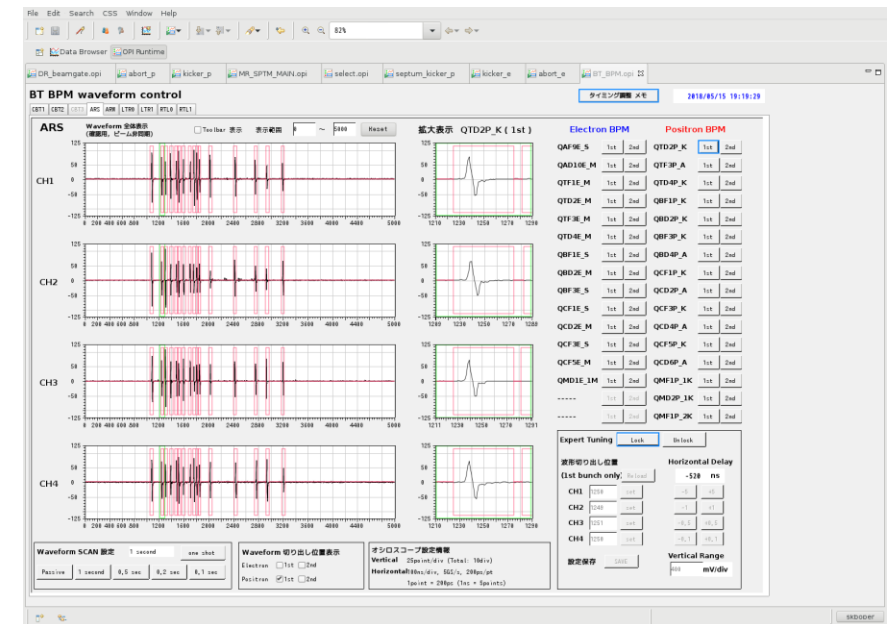
Current monitor for Belle 2



Injection status monitor



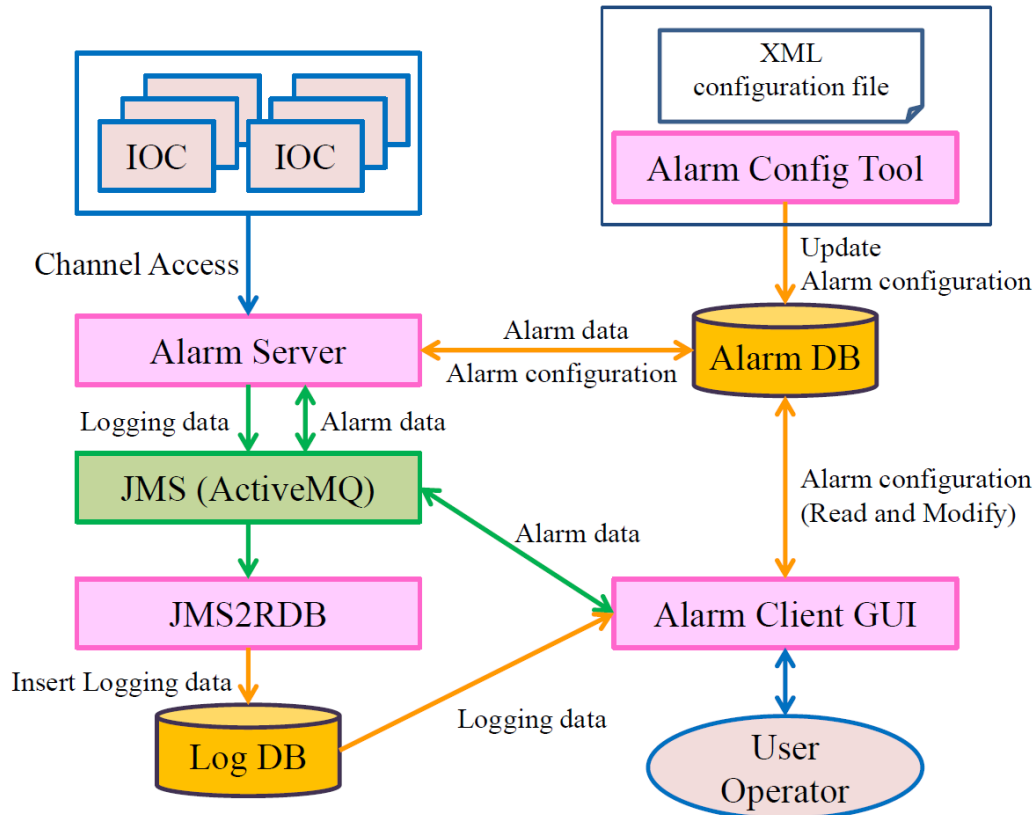
Beam Position Monitor



The operator creates several useful tools for accelerator operation.

CSS alarm display panel

Structure of CSS Alarm System



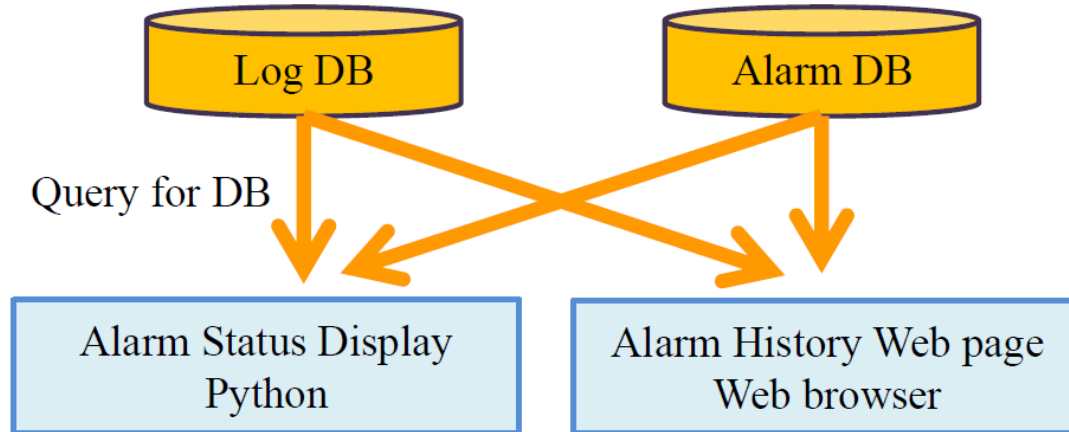
SuperKEKB uses the CSS Alarm System.

In addition to the standard tools, we adopted our own tool.

We have prepared our own client panel so that operators and staff members can use it easily.

CSS alarm display panel (2)

Structure of Alarm Client Tools



Alarm client tool queries the database and displays an alarm information.

I implemented the function which allows to display the alarm information on the Web as well as on the program's panel.

| Linac | | Safety | |
|-----------|----------|---------------|---------------|
| BT (p) | BT (e) | MG (LER) | MG (HER) |
| RF (LER) | RF (HER) | VAC (LERp) | VAC (HERe) |
| Operation | BM | Abt Trg (LER) | Abt Trg (HER) |

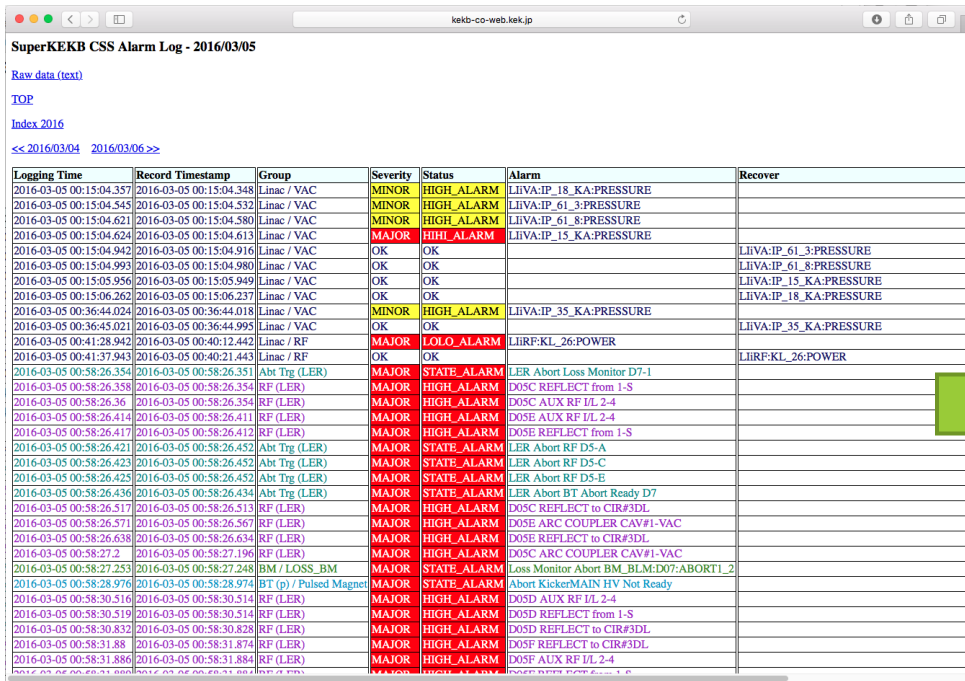
Current Alarm: 00 Latest Changes: 2016-05-10 03:56:05

| Alarm Time | Group | Severity | Alarm Message |
|---------------------|----------|----------|-----------------------|
| 2016-05-10 08:37:58 | RF (LER) | MAJOR | DOZE SAFETY INTERLOCK |
| 2016-05-10 08:37:58 | RF (LER) | MAJOR | DOZE SAFETY INTERLOCK |
| 2016-05-10 08:37:58 | RF (LER) | MAJOR | DOZE SAFETY INTERLOCK |
| 2016-05-10 08:37:58 | RF (LER) | MAJOR | DOZE SAFETY INTERLOCK |
| 2016-05-10 08:37:58 | RF (LER) | MAJOR | DOZE SAFETY INTERLOCK |
| 2016-05-10 08:37:58 | RF (LER) | MAJOR | DOZE SAFETY INTERLOCK |

| Alarm Time | Group | Severity | Alarm Message |
|---------------------|----------|----------|-----------------------|
| 2016-05-10 08:37:58 | RF (LER) | MAJOR | DOZE SAFETY INTERLOCK |
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| 2016-05-10 08:37:58 | RF (LER) | MAJOR | DOZE SAFETY INTERLOCK |
| 2016-05-10 08:37:58 | RF (LER) | MAJOR | DOZE SAFETY INTERLOCK |

CSS alarm display panel (3)

Alarm History web page

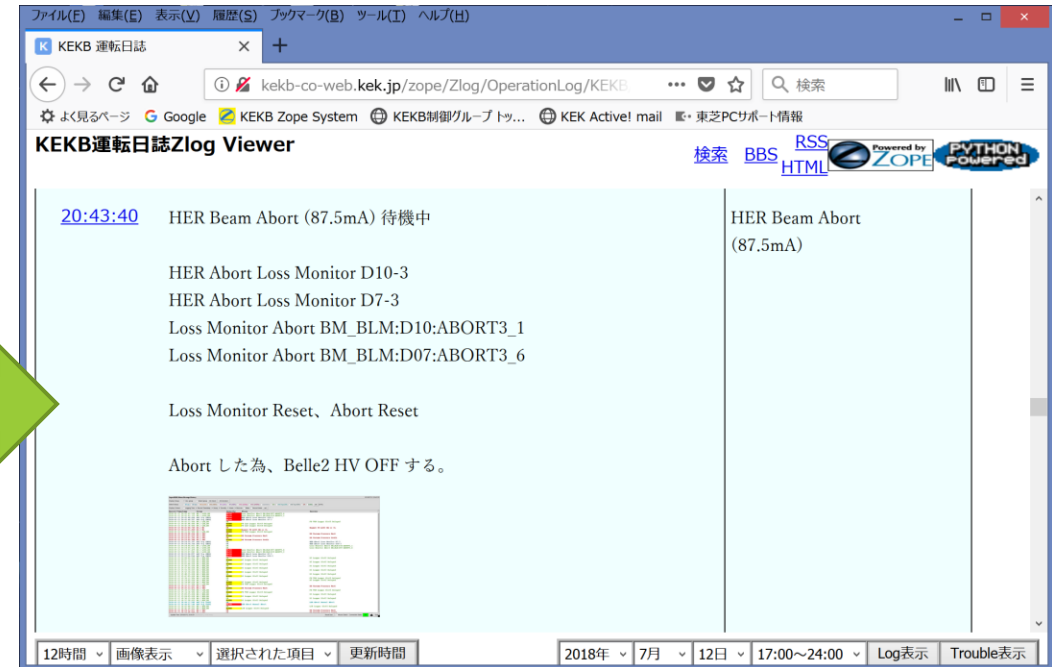


SuperKEKB CSS Alarm Log - 2016/03/05

Raw data (text)
TOP
Index 2016
<< 2016/03/04 2016/03/06 >>

| Logging Time | Record Timestamp | Group | Severity | Status | Alarm | Recover |
|-------------------------|-------------------------|------------------------|----------|-------------|----------------------------------------|-------------------------|
| 2016-03-05 00:15:04.357 | 2016-03-05 00:15:04.348 | Linac / VAC | MINOR | HIGH_ALARM | LIIVA:IP_18_KA:PRESSURE | |
| 2016-03-05 00:15:04.545 | 2016-03-05 00:15:04.532 | Linac / VAC | MINOR | HIGH_ALARM | LIIVA:IP_61_3:PRESSURE | |
| 2016-03-05 00:15:04.621 | 2016-03-05 00:15:04.580 | Linac / VAC | MINOR | HIGH_ALARM | LIIVA:IP_61_8:PRESSURE | |
| 2016-03-05 00:15:04.624 | 2016-03-05 00:15:04.613 | Linac / VAC | MAJOR | HIGH_ALARM | LIIVA:IP_15_KA:PRESSURE | |
| 2016-03-05 00:15:04.942 | 2016-03-05 00:15:04.916 | Linac / VAC | OK | OK | | LIIVA:IP_61_3:PRESSURE |
| 2016-03-05 00:15:04.993 | 2016-03-05 00:15:04.980 | Linac / VAC | OK | OK | | LIIVA:IP_61_8:PRESSURE |
| 2016-03-05 00:15:05.956 | 2016-03-05 00:15:05.949 | Linac / VAC | OK | OK | | LIIVA:IP_15_KA:PRESSURE |
| 2016-03-05 00:15:06.262 | 2016-03-05 00:15:06.237 | Linac / VAC | OK | OK | | LIIVA:IP_18_KA:PRESSURE |
| 2016-03-05 00:36:44.024 | 2016-03-05 00:36:44.018 | Linac / VAC | MINOR | HIGH_ALARM | LIIVA:IP_35_KA:PRESSURE | |
| 2016-03-05 00:36:45.021 | 2016-03-05 00:36:44.995 | Linac / VAC | OK | OK | | LIIVA:IP_35_KA:PRESSURE |
| 2016-03-05 00:41:28.942 | 2016-03-05 00:40:12.442 | Linac / RF | MAJOR | LOLO_ALARM | LIIRF:KL_26:POWER | |
| 2016-03-05 00:41:37.943 | 2016-03-05 00:40:21.443 | Linac / RF | OK | OK | | LIIRF:KL_26:POWER |
| 2016-03-05 00:58:26.354 | 2016-03-05 00:58:26.351 | Abt Ttg (LER) | MAJOR | STATE_ALARM | LER Abort Loss Monitor D7-1 | |
| 2016-03-05 00:58:26.358 | 2016-03-05 00:58:26.354 | RF (LER) | MAJOR | HIGH_ALARM | D05C REFLECT from 1-S | |
| 2016-03-05 00:58:26.36 | 2016-03-05 00:58:26.354 | RF (LER) | MAJOR | HIGH_ALARM | D05C AUX RF I/L 2-4 | |
| 2016-03-05 00:58:26.414 | 2016-03-05 00:58:26.411 | RF (LER) | MAJOR | HIGH_ALARM | D05E AUX RF I/L 2-4 | |
| 2016-03-05 00:58:26.417 | 2016-03-05 00:58:26.412 | RF (LER) | MAJOR | HIGH_ALARM | D05E REFLECT from 1-S | |
| 2016-03-05 00:58:26.421 | 2016-03-05 00:58:26.452 | Abt Ttg (LER) | MAJOR | STATE_ALARM | LER Abort RF D5-A | |
| 2016-03-05 00:58:26.423 | 2016-03-05 00:58:26.452 | Abt Ttg (LER) | MAJOR | STATE_ALARM | LER Abort RF D5-C | |
| 2016-03-05 00:58:26.425 | 2016-03-05 00:58:26.452 | Abt Ttg (LER) | MAJOR | STATE_ALARM | LER Abort RF D5-E | |
| 2016-03-05 00:58:26.436 | 2016-03-05 00:58:26.434 | Abt Ttg (LER) | MAJOR | STATE_ALARM | LER Abort BT Abort Ready D7 | |
| 2016-03-05 00:58:26.517 | 2016-03-05 00:58:26.513 | RF (LER) | MAJOR | HIGH_ALARM | D05C REFLECT to CIR#3DL | |
| 2016-03-05 00:58:26.571 | 2016-03-05 00:58:26.567 | RF (LER) | MAJOR | HIGH_ALARM | D05E ARC COUPLER CAV#1-VAC | |
| 2016-03-05 00:58:26.638 | 2016-03-05 00:58:26.634 | RF (LER) | MAJOR | HIGH_ALARM | D05E REFLECT to CIR#3DL | |
| 2016-03-05 00:58:27.2 | 2016-03-05 00:58:27.196 | RF (LER) | MAJOR | HIGH_ALARM | D05C ARC COUPLER CAV#1-VAC | |
| 2016-03-05 00:58:27.253 | 2016-03-05 00:58:27.248 | BM / LOSS_BM | MAJOR | STATE_ALARM | Loss Monitor Abort BM_BLM:D07:ABORT1_2 | |
| 2016-03-05 00:58:28.976 | 2016-03-05 00:58:28.974 | BT (p) / Pulsed Magnet | MAJOR | STATE_ALARM | Abort KickerMAIN HV Not Ready | |
| 2016-03-05 00:58:30.516 | 2016-03-05 00:58:30.514 | RF (LER) | MAJOR | HIGH_ALARM | D05D AUX RF I/L 2-4 | |
| 2016-03-05 00:58:30.519 | 2016-03-05 00:58:30.514 | RF (LER) | MAJOR | HIGH_ALARM | D05D REFLECT from 1-S | |
| 2016-03-05 00:58:30.832 | 2016-03-05 00:58:30.828 | RF (LER) | MAJOR | HIGH_ALARM | D05D REFLECT to CIR#3DL | |
| 2016-03-05 00:58:31.88 | 2016-03-05 00:58:31.874 | RF (LER) | MAJOR | HIGH_ALARM | D05F REFLECT to CIR#3DL | |
| 2016-03-05 00:58:31.886 | 2016-03-05 00:58:31.884 | RF (LER) | MAJOR | HIGH_ALARM | D05F AUX RF I/L 2-4 | |

Electric Operation log (Zlog)



KEKB 運転日誌

kek-b-co-web.kek.jp/zope/Zlog/OperationLog/KEKB

KEKB運転日誌Zlog Viewer

20:43:40 HER Beam Abort (87.5mA) 待機中

HER Beam Abort (87.5mA)

HER Abort Loss Monitor D10-3
HER Abort Loss Monitor D7-3
Loss Monitor Abort BM_BLM:D10:ABORT3_1
Loss Monitor Abort BM_BLM:D07:ABORT3_6

Loss Monitor Reset、Abort Reset

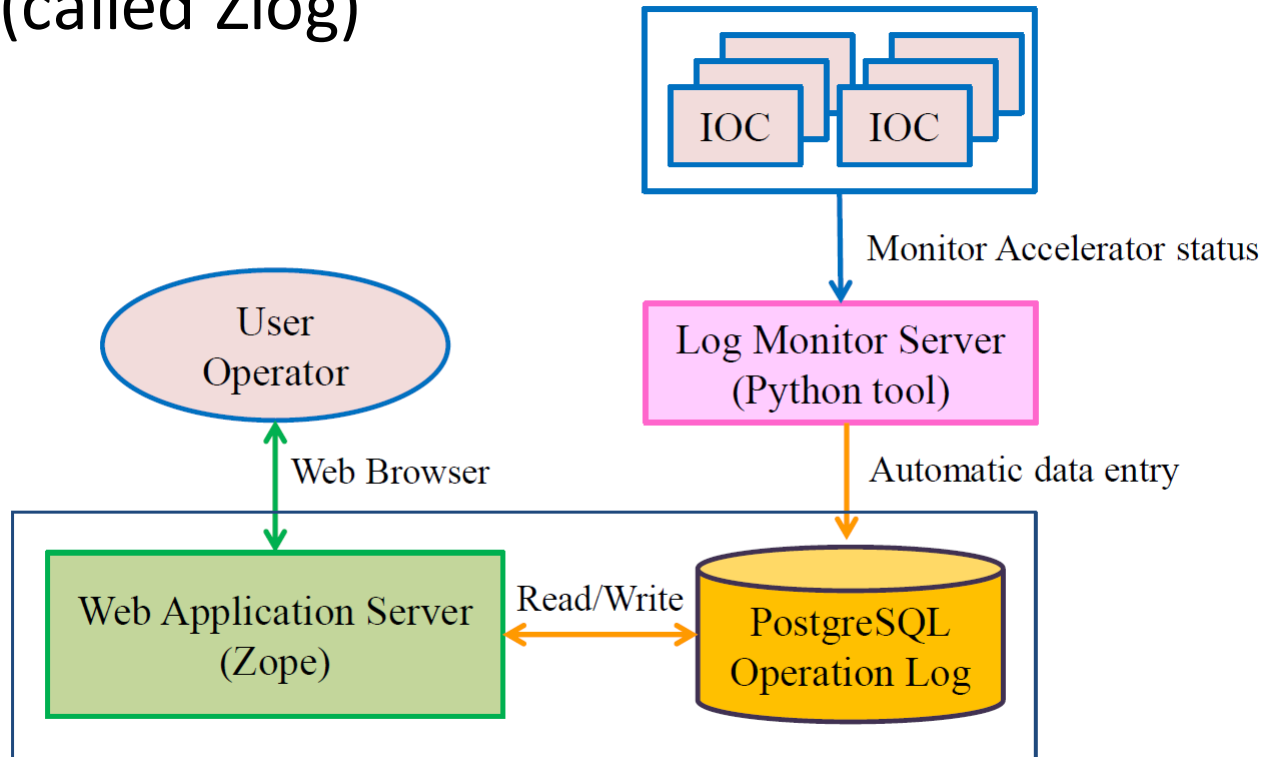
Abort した為、Belle2 HV OFF する。

12時間 画像表示 選択された項目 更新時間 2018年 7月 12日 17:00~24:00 Log表示 Trouble表示

Operator can simply copy & paste the alarm information to the operation log.

Automatic operation logging

Structure of Electric Operation Log system (called Zlog)



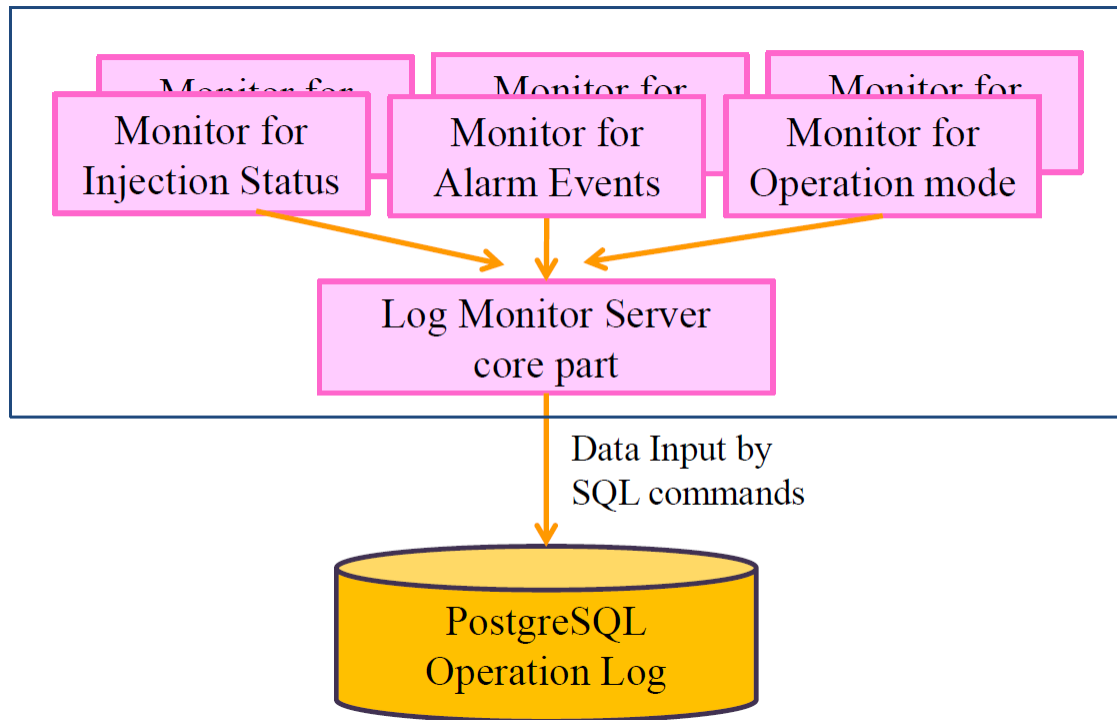
Zlog is an electric operation log system in SuperKEKB.

Some data is automatically entered by log monitor server.

- Start/stop of the injection
- Operation mode changes
- Alarm events
- Start of beam tuning
- etc ...

Automatic operation logging (2)

Structure of Log Monitor Server



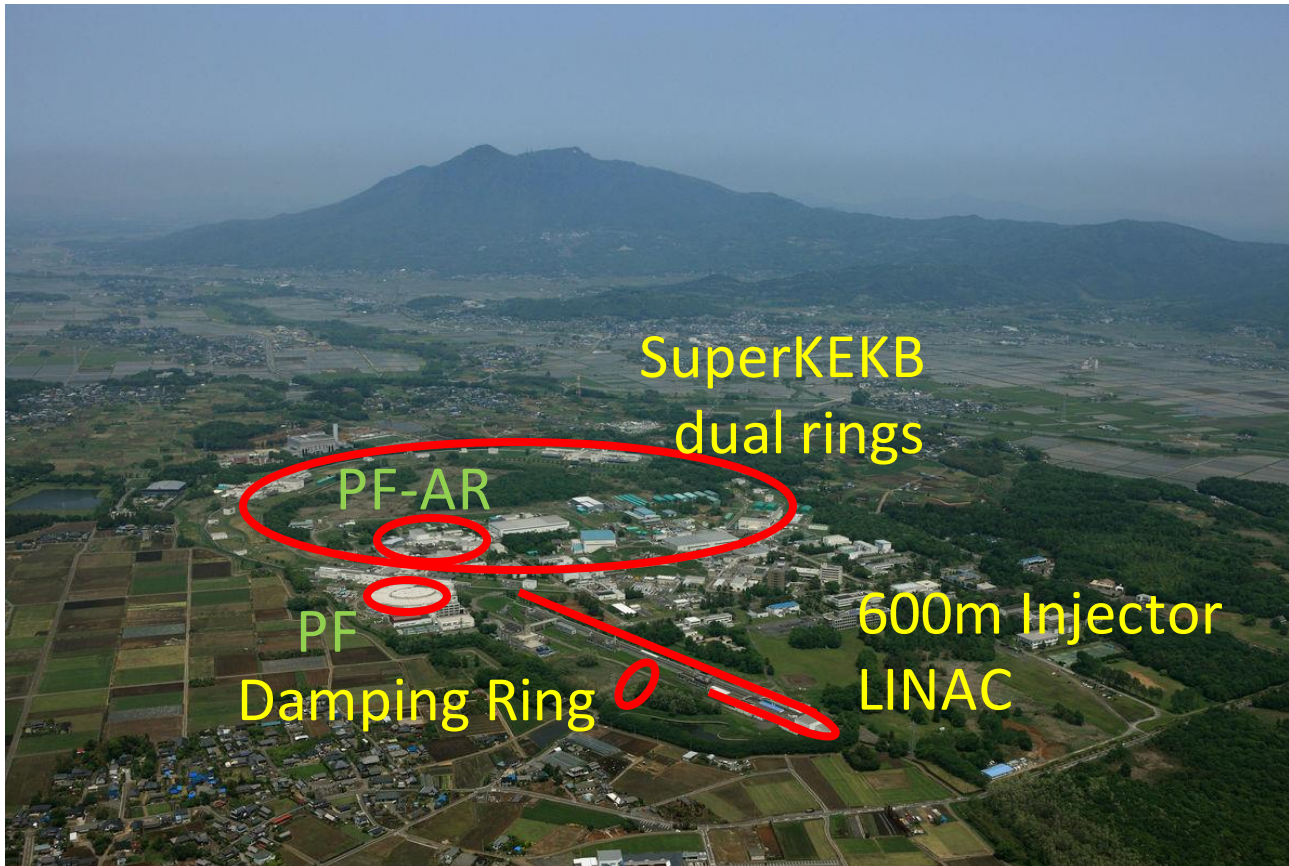
Automatic log entry is indispensable to save the operator's labor.

Operation state changes day by day, so the operator needs to adjust the monitor settings accordingly.

This tool allows to focus on the main task, without being distracted by the operation logging.

Cooperation with LINAC operator

SuperKEKB and LINAC

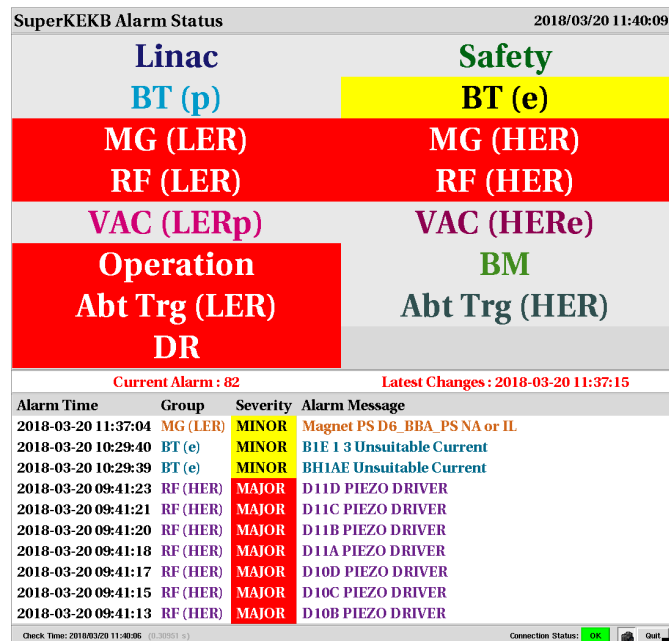


SuperKEKB operator and LINAC operator are members of the same company.

Therefore, SuperKEKB operators and LINAC operators are collaborating on tool development.

Cooperation with LINAC operator (2)

SuperKEKB version



SuperKEKB Alarm Status 2018/03/20 11:40:09

| | |
|-----------------------------------------|-----------------------------|
| Linac BT (p) | Safety BT (e) |
| MG (LER) RF (LER) | MG (HER) RF (HER) |
| VAC (LERp) | VAC (HERe) |
| Operation Abt Trg (LER) DR | BM Abt Trg (HER) |

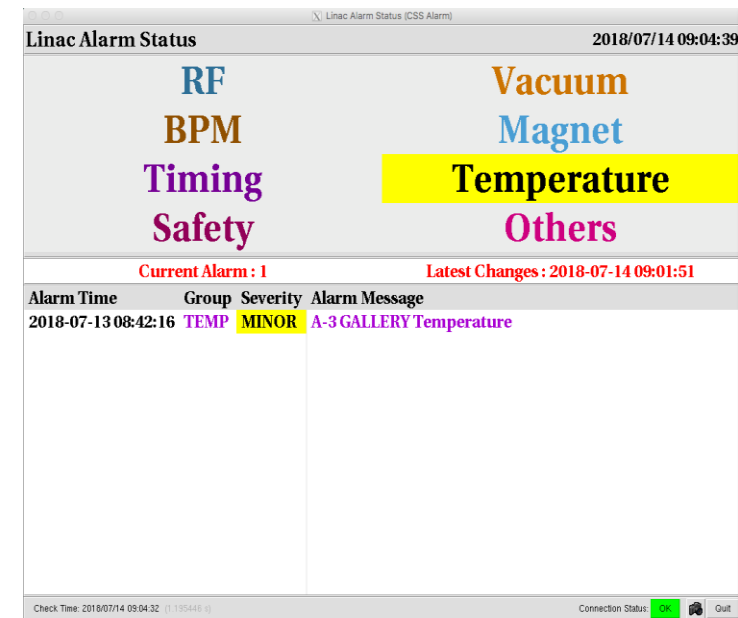
Current Alarm : 82 Latest Changes : 2018-03-20 11:37:15

| Alarm Time | Group | Severity | Alarm Message |
|---------------------|----------|----------|------------------------------|
| 2018-03-20 11:37:04 | MG (LER) | MINOR | Magnet PS D6_BBA_PS NA or IL |
| 2018-03-20 10:29:40 | BT (e) | MINOR | B1E 1 3 Unsuitable Current |
| 2018-03-20 10:29:39 | BT (e) | MINOR | BH1AE Unsuitable Current |
| 2018-03-20 09:41:23 | RF (HER) | MAJOR | D11D PIEZO DRIVER |
| 2018-03-20 09:41:21 | RF (HER) | MAJOR | D11C PIEZO DRIVER |
| 2018-03-20 09:41:20 | RF (HER) | MAJOR | D11B PIEZO DRIVER |
| 2018-03-20 09:41:18 | RF (HER) | MAJOR | D11A PIEZO DRIVER |
| 2018-03-20 09:41:17 | RF (HER) | MAJOR | D10D PIEZO DRIVER |
| 2018-03-20 09:41:15 | RF (HER) | MAJOR | D10C PIEZO DRIVER |
| 2018-03-20 09:41:13 | RF (HER) | MAJOR | D10B PIEZO DRIVER |

Check Time: 2018/03/20 11:40:06 (1/30/05) s) Connection Status: OK



LINAC version



Linac Alarm Status 2018/07/14 09:04:39

| | |
|--------------------------------------|---------------------------------------------------------|
| RF BPM Timing Safety | Vacuum Magnet Temperature Others |
|--------------------------------------|---------------------------------------------------------|

Current Alarm : 1 Latest Changes : 2018-07-14 09:01:51

| Alarm Time | Group | Severity | Alarm Message |
|---------------------|-------|----------|-------------------------|
| 2018-07-13 08:42:16 | TEMP | MINOR | A-3 GALLERY Temperature |

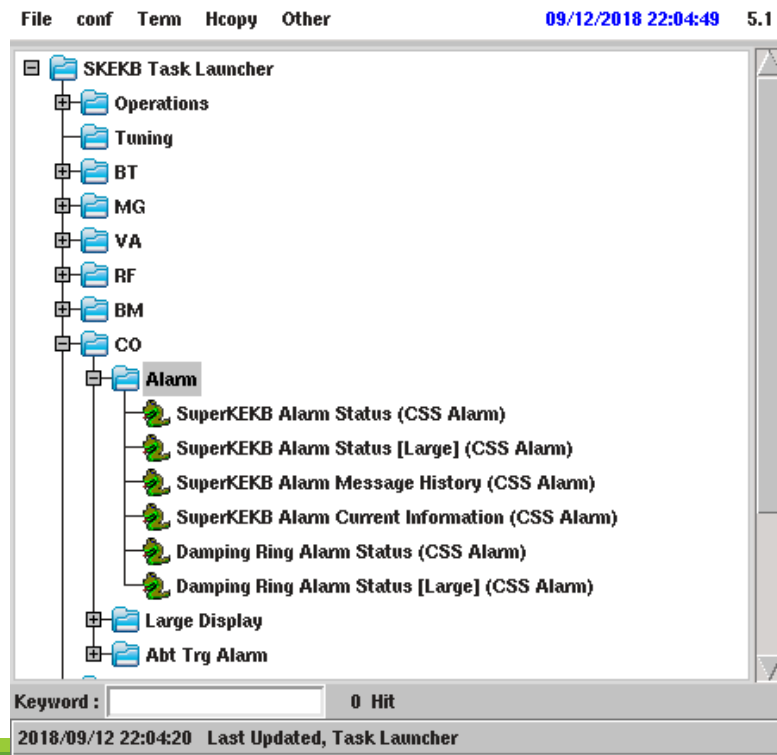
Check Time: 2018/07/14 09:04:32 (1/1/54/05) s) Connection Status: OK

CSS Alarm Tools are also used at LINAC.

Could be used immediately after the slight adjustment of the parameters.

Cooperation with LINAC operator (3)

Program launcher panel for SuperKEKB



Program launcher panel was originally developed at LINAC, and then adopted to SuperKEKB.

We have modified the panel by adding the specific features of SuperKEKB.

So, we are able to realize any request of the accelerator staff quickly by collaborating to each other rather than creating the panel from scratch.

Conclusion

In order to operate the accelerator efficiently, the operators need to develop new useful tools.

If the operator succeed to create a useful tools, that would allow to perform many tasks more efficiently.

Next year, SuperKEKB operation will resume with Phase III.

Once the collision experiments will begin, we expect more sophisticated tasks and more busy operation time.

Thus, we would like to create more effective tools for reliable and stable operations.

Thank you.

backup slides

Our company at KEK

KEK 常駐部門には4つのグループがある

- LINAC
- SuperKEKB
- PF
- PF Beam line

運転員業務や開発業務を行っている

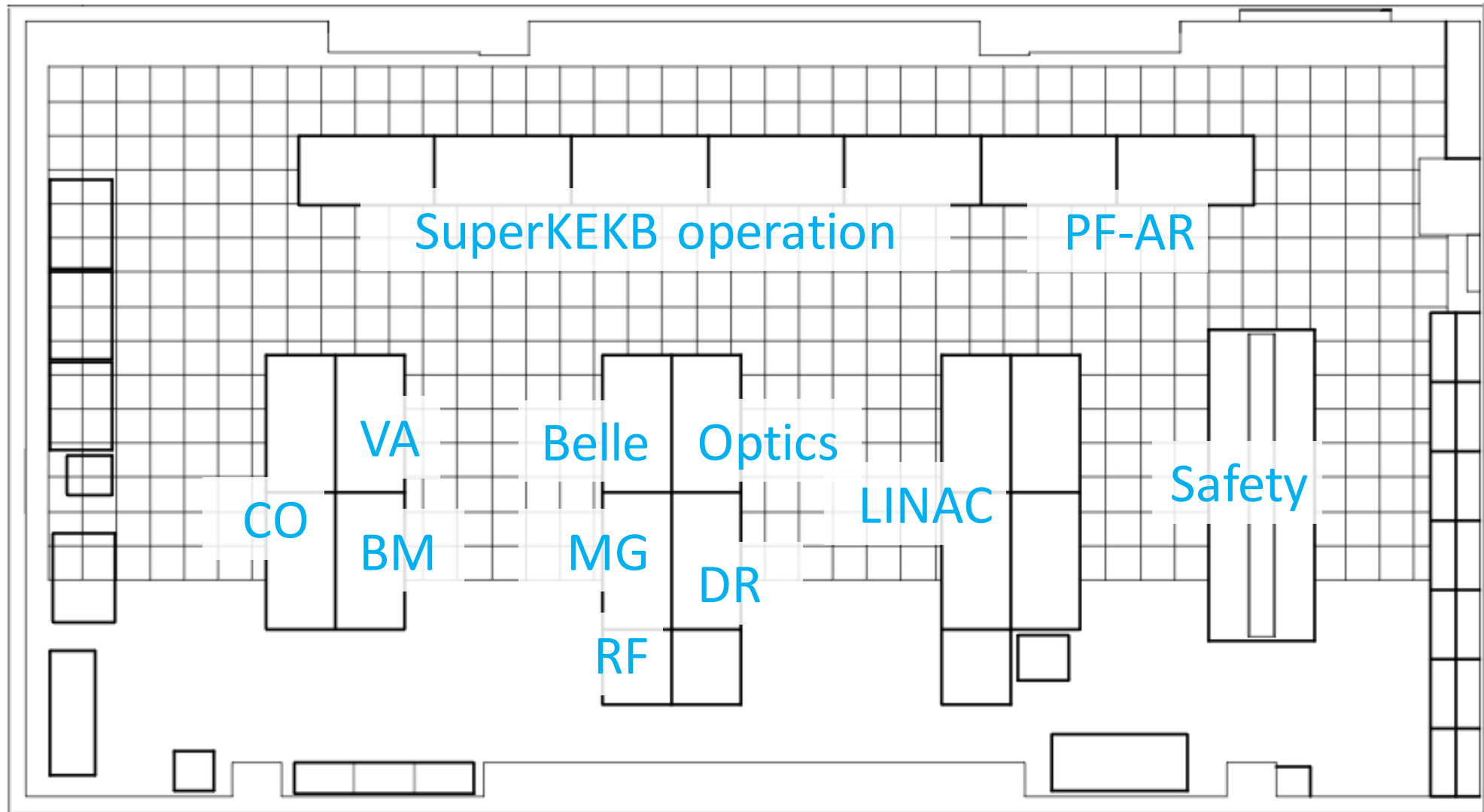
SuperKEKB control room



7 Large Displays (55-inch)



SuperKEKB control room



Safety management panels

The screenshot displays the CS-Studio interface with several safety management panels and a radiation emergency status panel.

Limit Ready Panels:

- KEKB Limit (Keep Out -> Limit):**
 - not Keep Out
 - Mag B1P OFF, Mag B1E 1-3 OFF, Mag BV1E OFF
 - BS-1P Beam Shutter IN, BS-E1 Beam Shutter IN
 - KEKB MODE OFF
 - (Check!) HER/LER Beam Current 0mA OK?
 - *KEKB Beam KEY OFF*
 - LER D1 Stopper IN, HER D1 Stopper IN
 - LER D2 Stopper IN, HER D2 Stopper IN
 - Push "S-KEKB ALL Limit" Button
- AR Limit (Keep Out -> Limit):**
 - not Keep Out
 - Mag BA3 OFF, Mag BA2 OFF
 - Beam Shutter1 IN, Beam Shutter2 IN
 - AR MODE OFF
 - RF SW OFF, AR Stopper 1 IN, AR Stopper 2 IN
 - AR Beam Current 0mA OK?
 - AR Beam Key OFF push "AR Limit"
- KEKB-BT Limit (Keep Out -> Limit):**
 - not Keep Out
 - Mag B1P OFF, Mag B1E 1-3 OFF, Mag BV1E OFF
 - BS-1P Beam Shutter IN, BS-E1 Beam Shutter IN
 - KEKB MODE OFF
 - AR MODE OFF (Cation!)
 - KEKB-BT Beam KEY OFF Push "KEKB-BT Limit"
- AR-BT Limit (Keep Out -> Limit):**
 - not Keep Out
 - Mag BA3 OFF, Mag BA2 OFF
 - Beam Shutter1 IN, Beam Shutter2 IN
 - AR MODE OFF
 - AR-BT Beam Key OFF push "AR-BT Limit"
- DR Limit (Keep Out -> Limit):**
 - not Keep Out
 - Mag BL1N.1_4 OFF, LTR Beam Shutter IN
 - Mag BRS.1_3 OFF
 - DR MODE Request OFF
 - DR Ring RF OFF
 - *DR Beam Key OFF*
 - DR Beam Stopper IN
 - Push "DR Limit"

Beam Key [ON -> OFF] Operation:

| | |
|----------|--------|
| SKEKB | OFF |
| PF-AR | OFF |
| AR-BT | OFF |
| | no use |
| SKEKB-BT | OFF |
| DR | OFF |

Radiation Emergency Status Panel:

- 2018/09/10 08:55:34
- from Abort System: Abort LER, Abort HER
- SAFETY System: Abort LER, Abort HER, BSWFLP, BSWFRE
- Emergency: 3M, 6M, 9M, 12M (not included in Ope)
- Door, UPS, Stopper, Radiation, Key
- Locations: TSUKUBA, OHO, D1-D12, 3SM1-3SM4, 6SM3-6SM4, 9C, 6C, 5, 6, 7, 8, 9, 10, 11, 12

Safety management devices



Safety management devices & consoles (PCs)



Surveillance camera & access control

