

Magnet Information Management System Based on Web Application for the KEK e-/e+ Injector Linac

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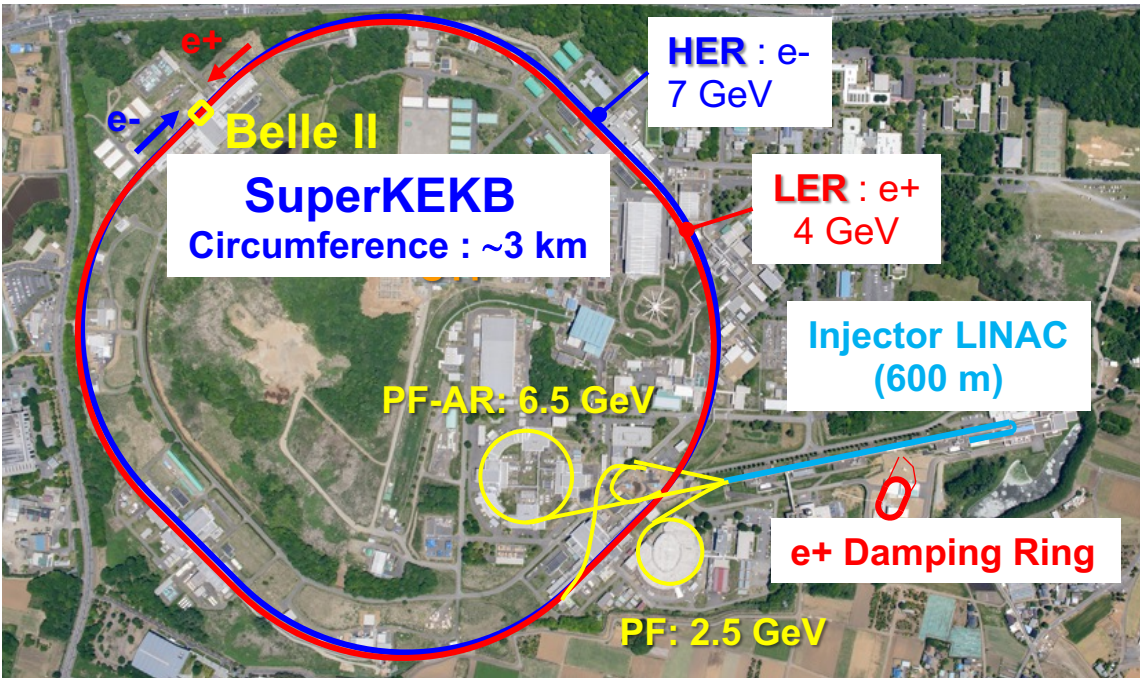
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Outline

- Lepton Accelerator Complex in KEK Tsukuba Campus
- Device information database system
- New Magnet information management system based on Web application
- Summary

Lepton Accelerator Complex in KEK Tsukuba Campus

--- e-/e+ injector, four rings and e+ DR ---
Simultaneous top-up injection since 2019



Each ring requires much different beam quality

Injector linac beam up-to 50 Hz
Bunch charge: 0.1 nC – 4 nC (10 nC for e+ production)
Beam energy: 2.5 GeV – 7 GeV
Emittance: 15 – 150 mm·mrad (normalized)

Injector Linac provides the beams to 4 (+1) different rings up to 50 Hz

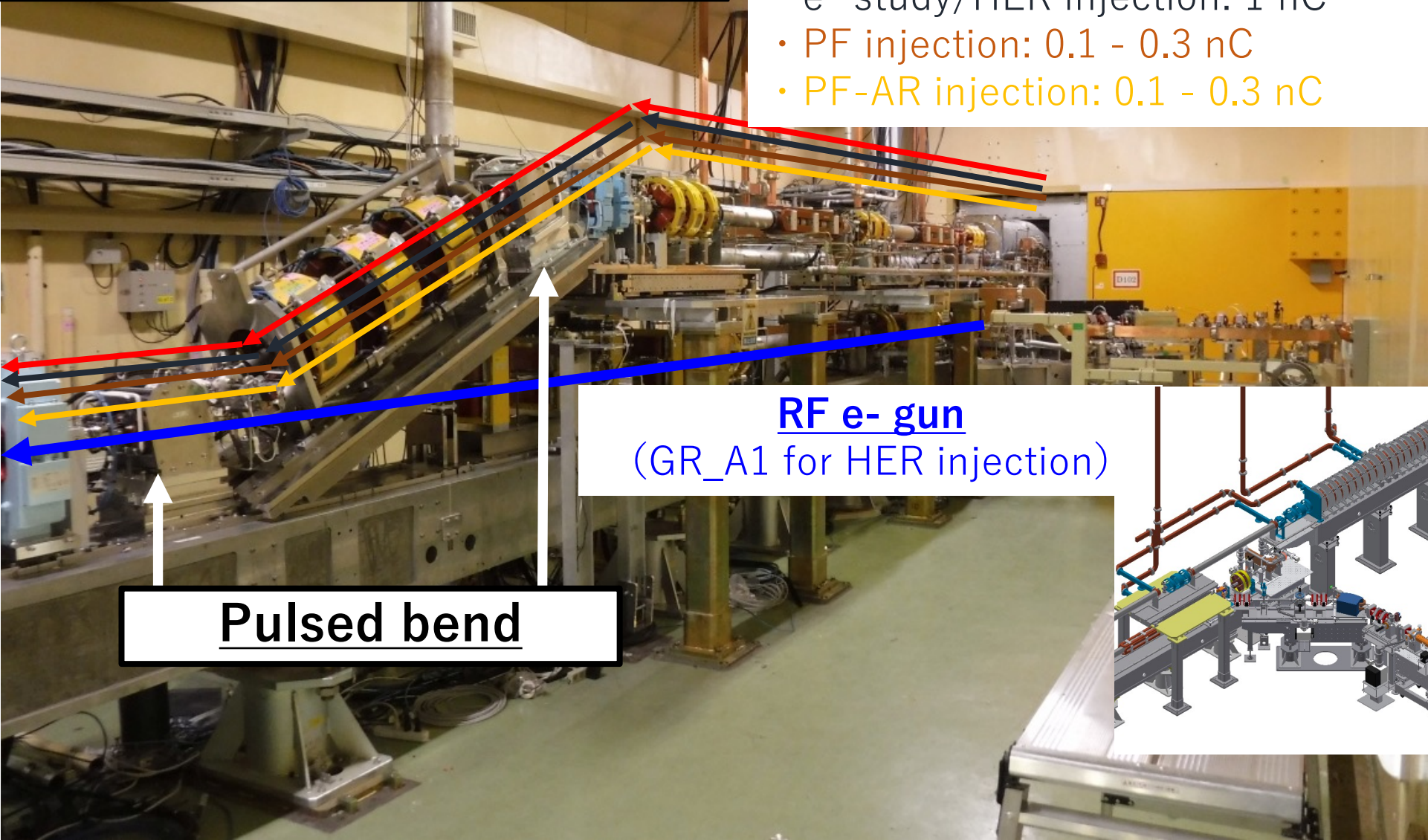
- Photon Factory } Light Source
- PF-AR }
- SuperKEKB High Energy Ring (HER)
- SuperKEKB Low Energy Ring (LER) + Damping Ring } Belle II experiment

Pulse to pulse beam switching: rf e- gun/thermionic e- gun In injector section

Thermionic DC e- gun (GU_AT)

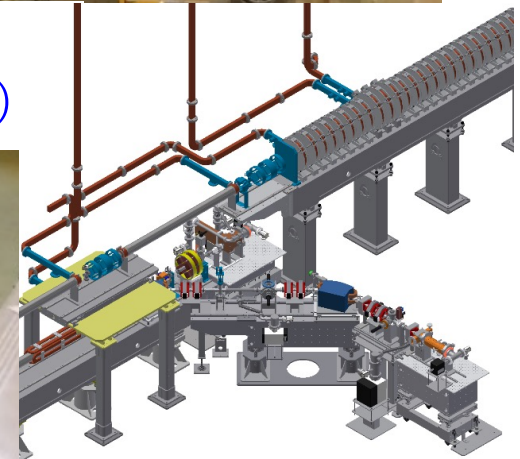
w/ 2 subharmonic bunchers (114 MHz, 571 MHz)
and 2 bunchers.

- e+ production e-: 10 nC (for LER injection)
- e- study/HER injection: 1 nC
- PF injection: 0.1 - 0.3 nC
- PF-AR injection: 0.1 - 0.3 nC

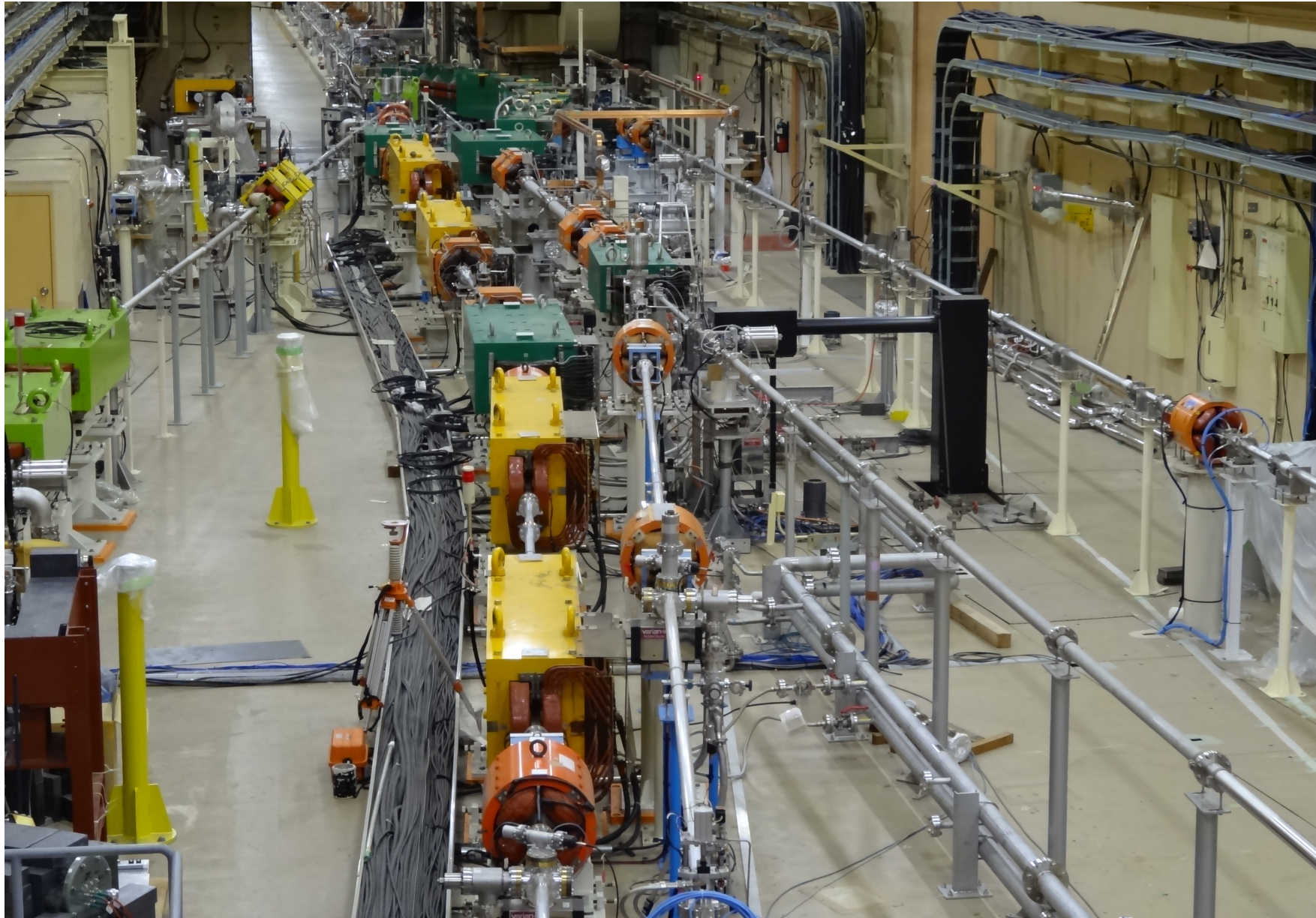


RF e- gun (GR_A1 for HER injection)

Pulsed bend



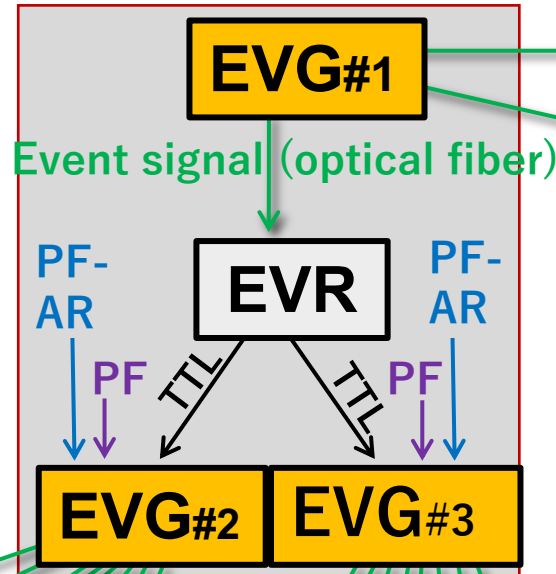
Beam switching yard from injector to each ring beam transport line



Event Based Timing System

Frequency	Ratio	Purpose
10.385 MHz	-	RF Gun
EVG clock 114.24 MHz	x11	Linac SHB1 & RF Gun
571.2 MHz	x55	Linac SHB2
2856 MHz	x275	Linac Main RF & RF Gun
508.89 MHz	x49	DR & MR RF

Central timing station

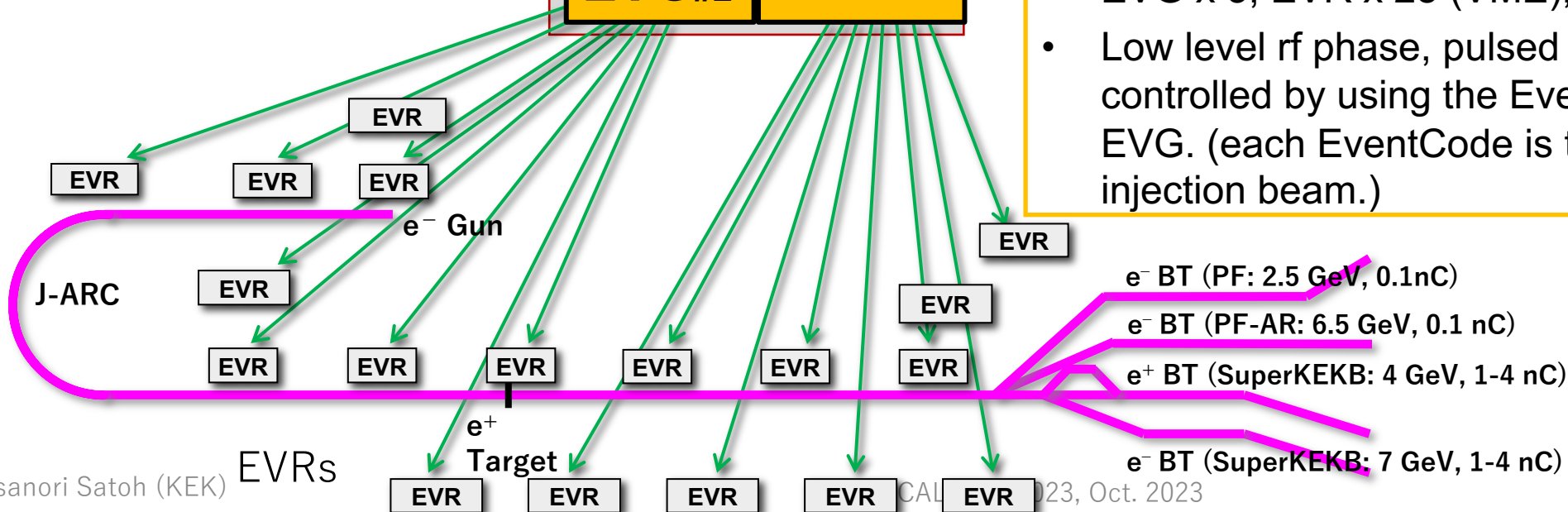
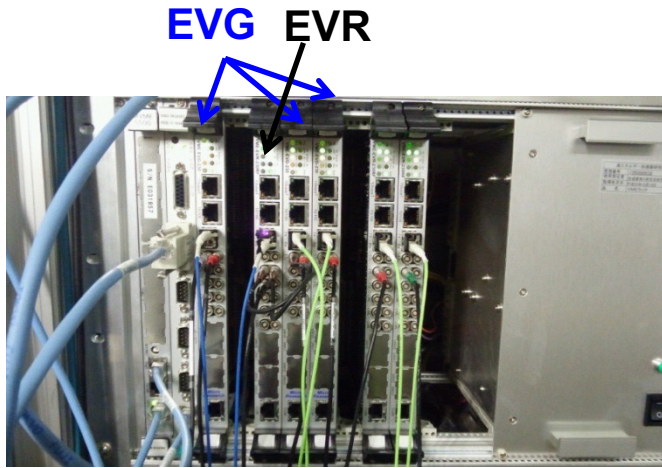


Main Rings

Damping Ring

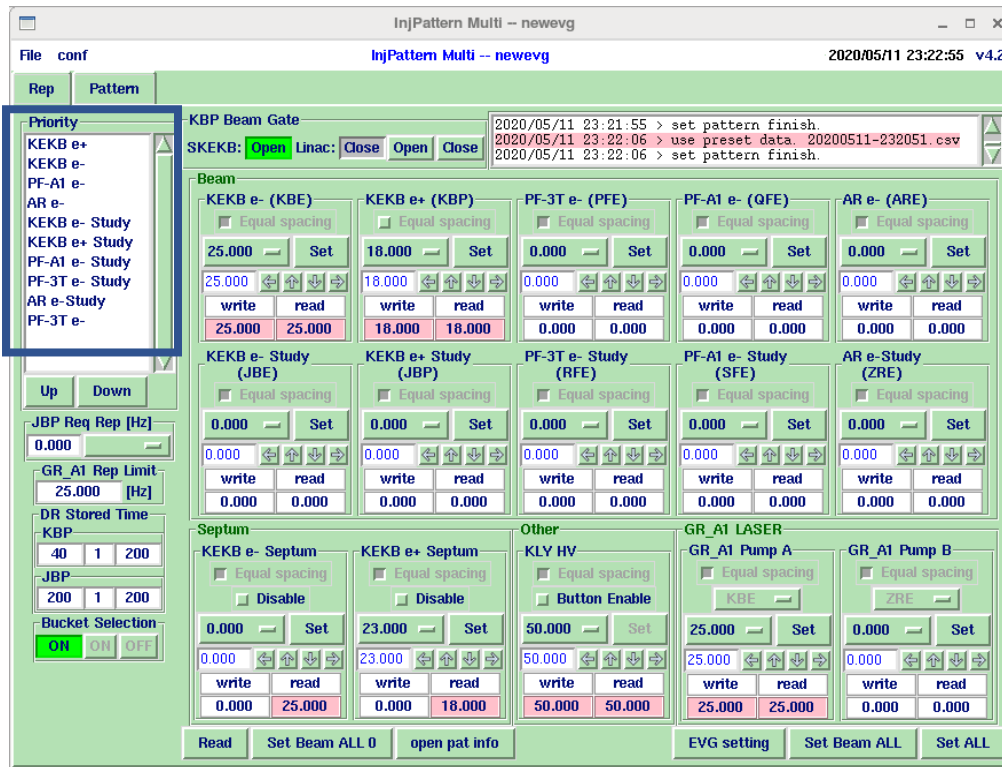
Micro-Research Finland Oy: event generator (EVG), event receiver (EVR)

- Based on VME system (VxWorks6.8 (RTOS), MVME6100 (CPU))
- PXIe EVR for pulsed magnet control
- EVG x 3, EVR x 28 (VME), x17 (PXIe)
- Low level rf phase, pulsed magnet, etc are controlled by using the EventCode distributed from EVG. (each EventCode is tagged to each ring injection beam.)

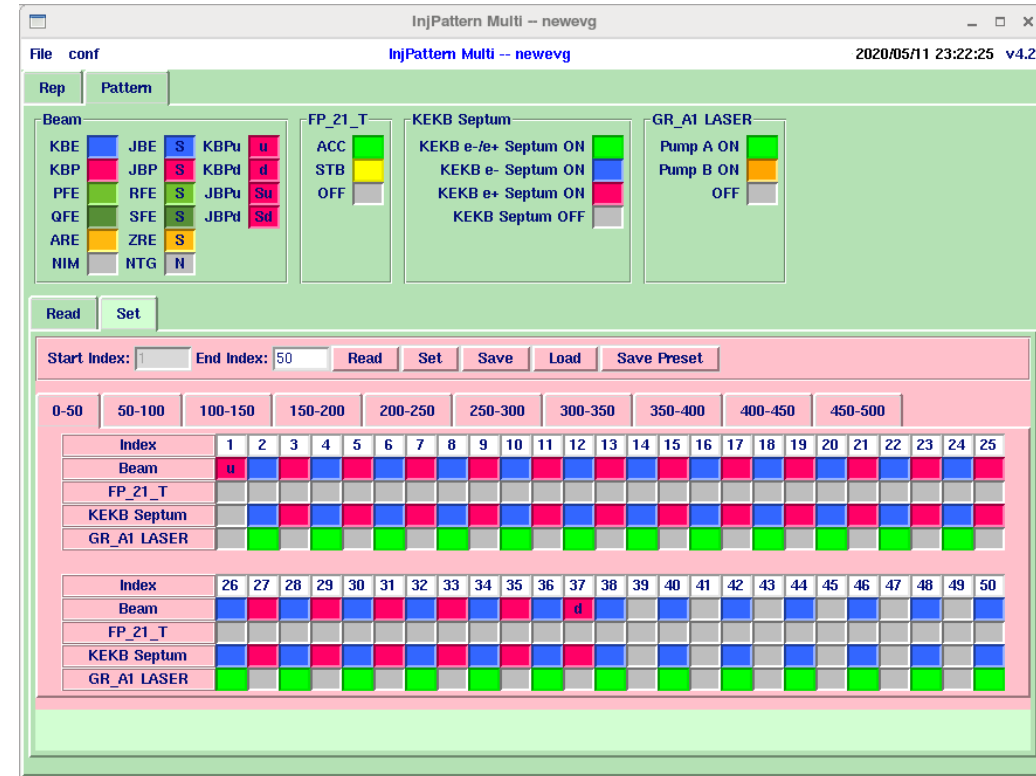


Beam Injection Pattern Generation

- Beam repetition rate is determined by demand from each ring.
- Priority can be defined.



Beam repetition rate management for each beam injection mode.



Beam mode

KBE: SuperKEKB e- (HER)

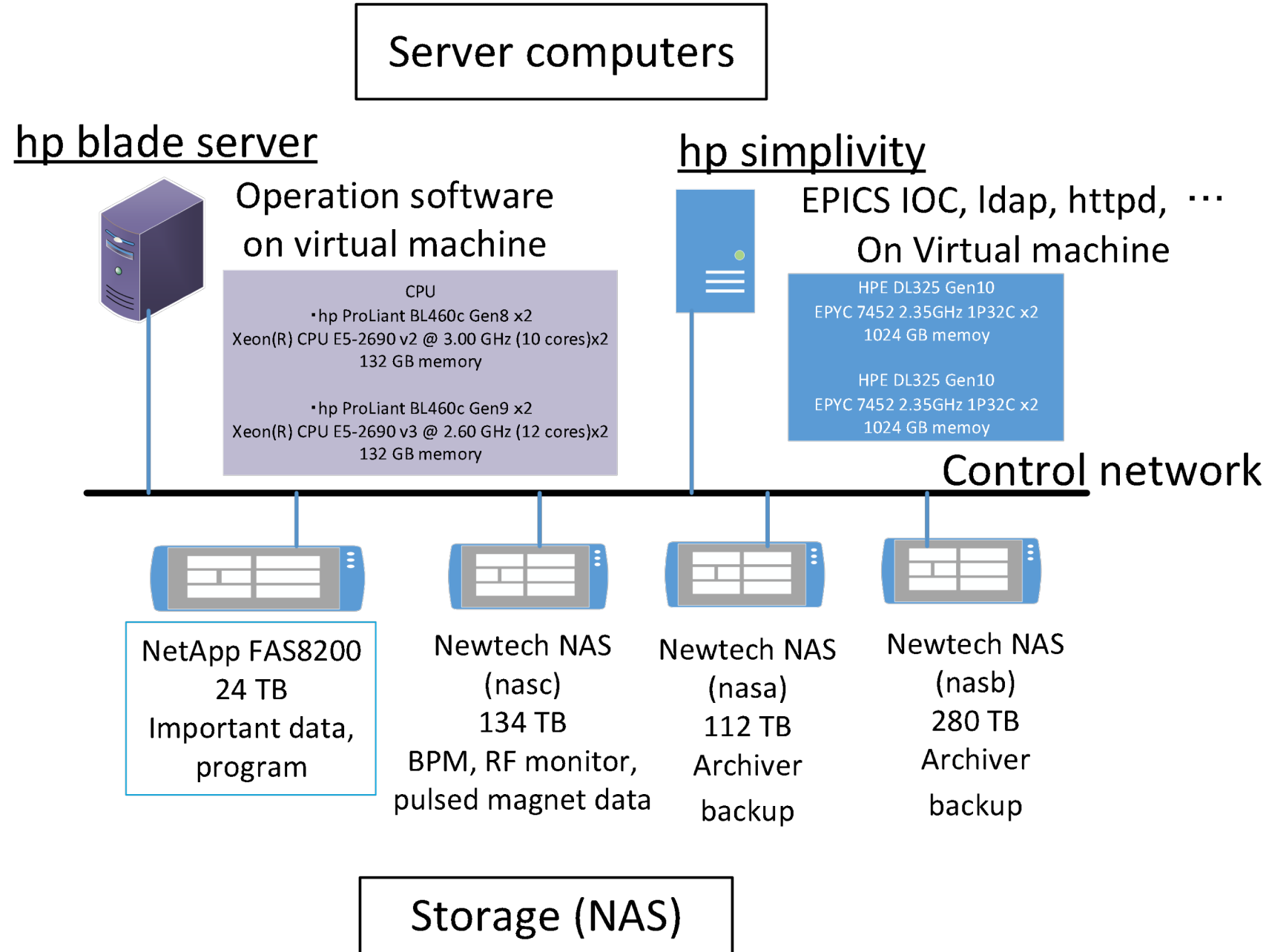
KBP: SuperKEKB e+ (LER)

QFE: PF

ARE: PF-AR

Injector Linac Control System

- **EPICS based control system with HA server computers.**
- **500 IOCs are running on virtual machine.**
- **Local controller**
 - **VME**
 - **PLC**
 - **Embedded system**
 - **PXIe**



Device information system

- **The text-based database files have long been used for the device information management.**
- **They are master information for generating EPICS database files and other configuration files of LINAC control software programs.**
- **In this management scheme, it is not easy for common users except a control software expert to access and update any information.**
- **Database files: `/usr/users/control/*tbl.tbl`**

Screen monitor (profile monitor) related database file

file name: scrn2tbl.tbl

- Using this database file, EPICS database can be generated with shell or Python scripts.

```
@(#) scrn2tbl.tbl dec.01.2018. version 1
-----
NAME : screen name
SECT : sector
TYPE : device type
      = 'PLC type1 (mikawa)'      1:YES, 0:NO      0000 0000 0000 0001      0001
      = 'PLC type2 (toyotomi)'    1:YES, 0:NO      0000 0000 0000 0010      0002
      = 'not insert/remove'       1:YES, 0:NO      0000 0000 0000 0100      0004
      = 'TWO SCREENS'             1:YES, 0:NO      0000 0000 0000 1000      0008
      = 'GC Camera (GC650)'       1:YES, 0:NO      0000 0000 0001 0000      0010
      = 'GC Camera (GC1020)'      1:YES, 0:NO      0000 0000 0010 0000      0020
BMODE : Beam Mode
      = 'KBE'                     1:YES, 0:NO      0000 0000 0000 0001      0001
      = 'KBP'                     1:YES, 0:NO      0000 0000 0000 0010      0002
      = 'PFE'                     1:YES, 0:NO      0000 0000 0000 0100      0004
      = 'QFE'                     1:YES, 0:NO      0000 0000 0000 1000      0008
      = 'ARE'                     1:YES, 0:NO      0000 0000 0001 0000      0010
      = 'JBE'                     1:YES, 0:NO      0000 0000 0010 0000      0020
      = 'JBP'                     1:YES, 0:NO      0000 0000 0100 0000      0040
      = 'RFE'                     1:YES, 0:NO      0000 0000 1000 0000      0080
      = 'SFE'                     1:YES, 0:NO      0000 0001 0000 0000      0100
      = 'ZRE'                     1:YES, 0:NO      0000 0010 0000 0000      0200
      = 'NIM'                     1:YES, 0:NO      0000 0100 0000 0000      0400
      = 'NTG'                     1:YES, 0:NO      0000 1000 0000 0000      0800
      ALL MODE                      ffff
-----
!separator = ' '
!keyword   = "NAME SECT TYPE BMODE"
!format    = "%s %s %x %x"
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
SC_AT_G1   A      0001   Offe
SC_AT_G5   A      0001   Offe
SC_AT_O    A      0001   Offe
SC_A1_G    A      0001   0001
SC_A1_O    A      0001   0001
SC_AS_1    A      0012   0000
SC_A1_1    A      0012   0001
SC_A1_C2_0 A      0012   0001
```

Previous database files of magnet system

Database file name	contentes
mgtbl.tbl	DC magnet controller (PLC) information
mgbasetbl.tbl	Pulsed magnet controller (PXI) information
mgpvtbl.tbl	Magnet name/EPICS PV name table
mgbtbl.tbl	DC magnet excitation curve (magnetic field)
mgktbl.tbl	DC magnet excitation curve (k value)
mgbptbl.tbl	Pulsed magnet excitation curve (magnetic field)
mgbftbl.tbl	DC magnet fudge factor
mgbfptbl.tbl	Pulsed magnet fudge factor

Contents of magnet relater database files

Excitation curve (coefficients of fitting polynomial)

!↓
!separator
!keyword
!format

= "%s %lf %d %lf %lf %lf %lf %lf %lf %lf %lf %lf %lf %lf"↓

!↓
BM_AT_J1 0. 7461977 7 2. 0648E-03 5. 5384E-03 4. 0852E-05 -1. 3193E-06 1. 9443E-08 -1. 4039E-10 4. 7789E-13 -6
BM_AT_J5 0. 7440547 7 1. 46581E-03 5. 47120E-03 3. 63971E-05 -1. 05224E-06 1. 44002E-08 -9. 72086E-11 3. 06191
BX_AT_0 0. 008407342 1 0 0. 001681468 0 0 0 0 0 0 0 0↓
BY_AT_0 0. 008407342 1 0 0. 001681468 0 0 0 0 0 0 0 0↓
BM_16_C1 0. 338602 7 1. 194185E-03 5. 559374E-03 1. 291535E-05 -1. 304585E-06 7. 828253E-08 -2. 346886E-
BM_16_C2 0. 338113 7 1. 067642E-03 5. 533907E-03 2. 635390E-05 -3. 009850E-06 1. 676876E-07 -4. 626279E-
BM_16_C3 0. 338711 7 1. 192142E-03 5. 565421E-03 1. 407860E-05 -1. 831112E-06 1. 190518E-07 -3. 622459E-
BM_16_C4 0. 337909 7 1. 196444E-03 5. 484598E-03 3. 062452E-05 -2. 999390E-06 1. 579246E-07 -4. 299464E-

Pulsed magnet information

!separator = ' '
!keyword = "NAME NODE CASE CH OPE"
!format = "%s %s %s %d %x"
!NAME NODE CASE CH OPE

NAME	NODE	CASE	CH	OPE
PF_13_5	ACC-PM-PC-1	1EB	0	1
PD_13_5	ACC-PM-PC-1	1EB	1	1
PX_13_5	ACC-PM-PC-1	1EB	2	1
PY_13_5	ACC-PM-PC-1	1EB	3	1
PY_12_2	ACC-PM-PC-1	1EB	4	1
PX_13_2	ACC-PM-PC-1	1EB	5	1

06.2019 modified MAX Cur

PX_13_5 5.5 -> 8.0, PY_13_5 1.5
PX_13_2 5.5 -> 8.0, PX_17_4 1.5
PX_18_4 2.0 -> 6.0, PY_18_4 2.0 -> 8.0, PX_21_4 2.0 -> 6.0,
PY_21_4 1.5 -> 6.0, PY_24_4 2.0 -> 8.0, PX_24_4 2.0 -> 8.0
t.k, Sep.10.2019 BM_RO_1/6 MAX 265 -> 349
t.k, Jan.10.2020 modify pulsemagnet READ_W IWRITE -> READ_W
t.k, Jan.22.2020 FB 0 -> 1
BM_RO_1/6, BM_RO_2/3/4/5,
SL_15_T, SL_15_11, SL_16_11, SL_16_22, SL_16_33,
BM_61_1/6, BM_61_2/5, BM_61_3/4, BM_61_A1, BM_61_A2/3
t.k, Feb.27.2020 comment out BM_61_AS, BS_61_AS
t.k, Jul.07.2020 QD_AT_J2,J3,J4 MAX 35 -> 100
t.k, Sep.02.2020 QD_AT_J2, QF_AT_J3, QD_AT_J4 OFF 00FE -> 0076
remove QF_13_5, QD_13_5, QF_23_44
add BY_A1_C4, PX_13_52, SX_15_15, SX_15_25, SY_16_15, SX_16_25
t.k, Sep.14.2020 BY_A1_C4,SX_15_15,SX_15_25,SY_16_15,SX_16_25 ON 0001 -> 00FF

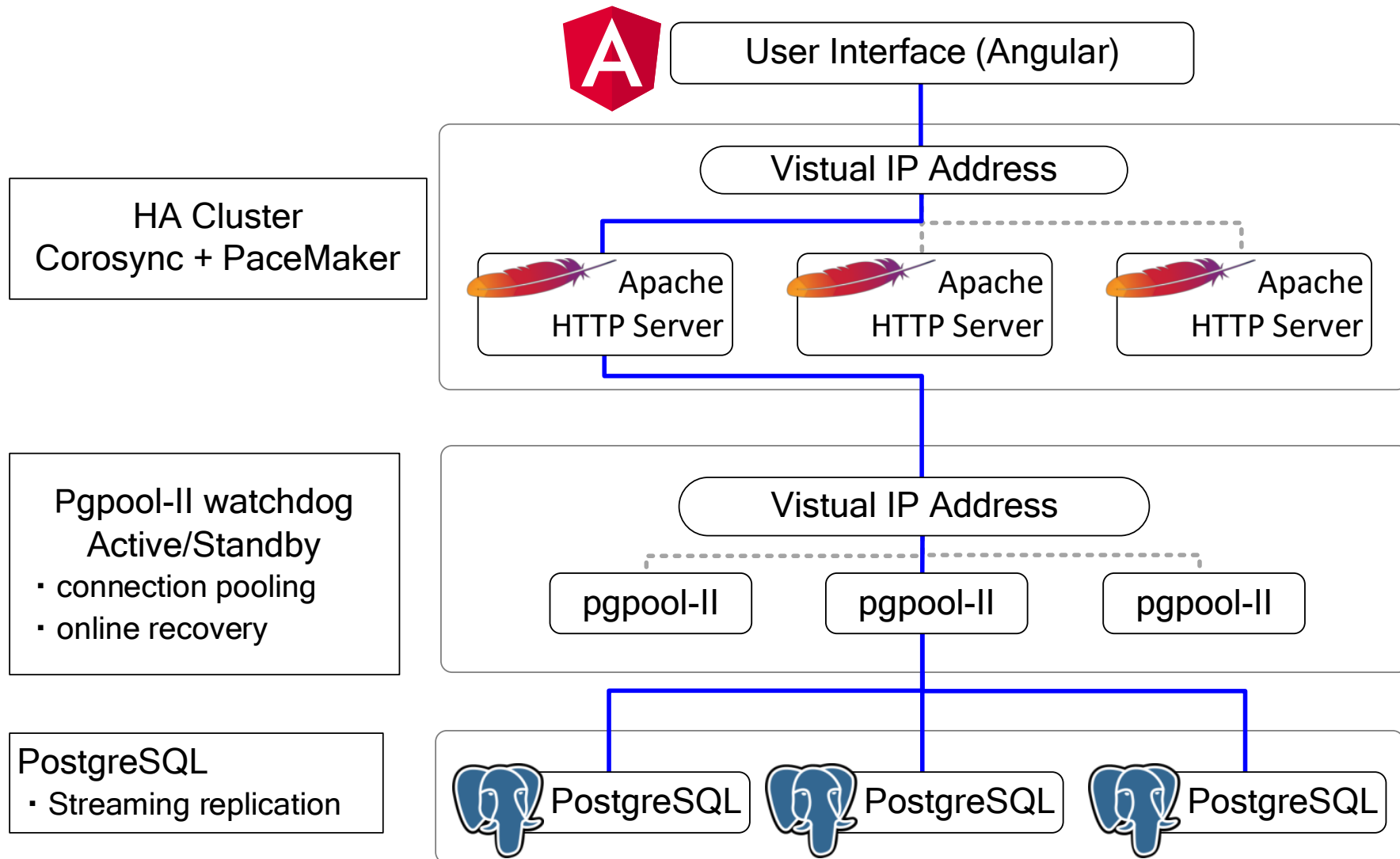
File header (Changelog)

New magnet information management system

- **To improve the usability of magnet database, a web-base application was developed.**
- **For non-software experts, it is not easy to update the database and check the present status.**
- **Multiple database files are consolidated into PostgreSQL.**
- **By using web application GUI, non experts can easily operate the database.**

System diagram

- Angular (UI), PostgreSQL (database), HA cluster (Corosync, PaceMaker)



Functionality

- **The access control of the database can be managed using the already existing Lightweight Directory Access Protocol (LDAP) server at LINAC. (read only or read-and-edit access)**
- **Data can be easily edited (modify, add, delete data) directly within the web browser by the allowed user.**
- **The bulk import/export data with the CSV file format. (all data or the selected data)**
- **600 magnet information are registered. Each magnet information has 100 data column components. (magnet name, power supply specification,)**

Web application main page (after authentication with ID/password)

The screenshot displays the MgTblEditor web application. The browser address bar shows the URL: `www.linac2.kek.jp/~kudou/Angular-cont/MgTblEditor/dist/MgTblEditor/#/home`. The page title is "Magnet Table Editor".

The main content area features a table with 11 rows of magnet data. The columns are: 電磁石名称 (Magnet Name), 電源名称 (Power Name), 情報更新日 (Last Update), 情報更新者 (Last Updated By), 磁場有効長 [m] (Magnet Effective Length), 磁場近似デー... (Magnet Approximation Date), 磁場近似デー... (Magnet Approximation Date), 磁場近似デー... (Magnet Approximation Date), and 磁場近似式 (Magnet Approximation Formula). The table includes a small graph icon for each row, which is highlighted by a blue arrow pointing to the graph on the right.

The graph on the right is titled "SX_AT_G0 (2021/10/07 21:23:40)". The y-axis is labeled "B [Tesla or Tesla/m for Q]" and ranges from -0.0015 to 0.0015. The x-axis is labeled "I [A]" and ranges from -3 to 3. The graph shows a linear relationship between current and magnetic field.

Annotations on the table highlight key fields:

- magnet name**: Points to the "電磁石名称" column.
- PS name**: Points to the "電源名称" column.
- last update**: Points to the "情報更新日" column.
- username**: Points to the "情報更新者" column.
- manet effective length**: Points to the "磁場有効長 [m]" column.
- excitation curve coefficients**: Points to the "磁場近似式" column.

	電磁石名称	電源名称	情報更新日	情報更新者	磁場有効長 [m]	磁場近似デー...	磁場近似デー...	磁場近似デー...	磁場近似式
1	ML_AT_G0	ML_AT_G0	2021-09-24 12...	TPさん	0.024731	2021-09-24 12...	http://www-lina...		区間[A]:0~3, 多項式係数: [0.00000000E+00,1.70884
2	SX_AT_G0	SX_AT_G0	2021-09-27 22...	TPさん	0.05796	2021-09-27 22...	http://www-lina...		区間[A]:-3~3, 多項式係数: [0.00000000E+00,2.7588! 区間[A]:3~6, 多項式係数: [0.00000000E+00,2.75889
3	SY_AT_G0	SY_AT_G0	2021-09-10 00...	紙谷	0.05796	2021-09-24 11...	http://www-lina...		区間[A]:-3~3, 多項式係数: [0.00000000E+00,2.7588!
4	ML_AT_G1	ML_AT_G1	2021-09-10 00...	紙谷	0.02473	2021-09-24 11...	http://www-lina...		区間[A]:0~3, 多項式係数: [0.00000000E+00,1.70884
5	SX_AT_G1	SX_AT_G1	2021-09-10 00...	紙谷	0.04196	2021-09-24 11...	http://www-lina...		区間[A]:-3~3, 多項式係数: [0.00000000E+00,4.7554!
6	SY_AT_G1	PS name	2021-09-10 00...	紙谷	0.04196	2021-09-24 11...	http://www-lina...		区間[A]:-3~3, 多項式係数: [0.00000000E+00,4.7554!
7	SL_AT_G1	PS name	2021-09-10 00...	username	290267	2021-09-24 11...	http://www-lina...		区間[A]:0~35, 多項式係数: [0.00000000E+00,7.7925
8	SL_AT_G2	PS name	2021-09-10 00...	username	290267	2021-09-24 11...	http://www-lina...		区間[A] 925
9	SL_AT_G3	SL_AT_G3/4	2021-09-10 00...	紙谷	0.290267	2021-09-24 11...	http://www-lina...		区間[A] 925
10	SL_AT_G4	SL_AT_G3/4	2021-09-10 00...	紙谷	0.290267	2021-09-24 11...	http://www-lina...		区間[A]:0~35, 多項式係数: [0.00000000E+00,7.7925
11	SX_AT_G4	SX_AT_G4	2021-09-10 00...	紙谷	0.290267	2021-09-24 11...	http://www-lina...		区間[A]:-5~5, 多項式係数: [0.00000000E+00,8.6366!

Edit page

- Modify/Add/Delete items directly within the web browser
- Bulk import/export feature via CSV file

The screenshot displays the Magnet Table Editor web application. The browser's address bar shows the URL `http://magnet.jp/~magnet/magnet/manager/setting/magnet/setting/magnet/...`. The page title is "Magnet Table Editor" and the user is logged in as "tp".

The main content area is titled "Edit" and contains the following form fields:

- 電磁石名称*: SX_AT_G0
- 電源名称: SX_AT_G0
- 磁場有効長 [m]: 0.05796
- 磁場近似式: (Contains a table with buttons "Edit", "Add", "Copy", and "Remove")

The table in the "磁場近似式" field is as follows:

最小電流 [A]	-3	3
最大電流 [A]	3	6
BL0	0.00000000E+00	0.00000000E+00
BL1	2.75889600E-05	2.75889600E-05
BL2	0.00000000E+00	0.00000000E+00
BL3	0.00000000E+00	0.00000000E+00
BL4	0.00000000E+00	0.00000000E+00
BL5	0.00000000E+00	0.00000000E+00
BL6	0.00000000E+00	0.00000000E+00
BL7	0.00000000E+00	0.00000000E+00
BL8	0.00000000E+00	0.00000000E+00
BL9	0.00000000E+00	0.00000000E+00

On the left side, there is a table listing magnet names and their IDs:

電磁石名称	ID
ML_AT_G0	1
SX_AT_G0	2
SY_AT_G0	3
ML_AT_G1	4
SX_AT_G1	5
SY_AT_G1	6
SL_AT_G1	7
SL_AT_G2	8
SL_AT_G3	9
SL_AT_G4	10
SX_AT_G4	11
SY_AT_G4	12
SL_AT_G5	13
SL_AT_G6	14

On the right side, there is a vertical list of numerical values in scientific notation, such as `00E+00,1.70884`, `00E+00,2.7588!`, `00E+00,2.75889`, `00E+00,2.7588!`, `00E+00,1.70884`, `00E+00,4.7554!`, `00E+00,4.7554!`, `00E+00,7.7925`, `00E+00,7.7925`, `00E+00,7.7925`, `00E+00,7.7925`, `00E+00,8.6366!`, `00E+00,8.6366!`, `00E+00,7.7925`, and `00E+00,7.7925`.

Filtering setting

The screenshot shows the MgTblEditor web application interface. A 'Filter Setting' dialog box is open in the foreground, allowing users to filter the data in the background table. The dialog has a title 'Filter Setting' and a dropdown menu set to '次の条件のすべてが該当' (All of the following conditions are met). A 'Clear ALL' button is located in the top right of the dialog. Below the dropdown, there is a search bar with the text '電磁石名称' (Magnet name) and a filter condition 'が次を含む' (contains the following). The value '61' is entered in the search bar. Below the search bar is a table with three columns: '電磁石名称' (Magnet name), 'が次を含む' (contains the following), and 'BM'. The table contains two entries: '電磁石名称' with 'が次を含む' and 'BM', and '電磁石名称' with 'が次を含む' and '61'. At the bottom of the dialog are 'Ok' and 'Cancel' buttons.

Magnet Table Editor

Login user : tp

Show / Edit Log

電磁石名称	電源名称	情報更新日	情報更新者	磁場有効長 [m]	磁場近似デー...	磁場近似デー...	磁場近似デー...	磁場近似式
1 ML_AT_G0	ML_AT_G0	20...						0~3, 多項式係数: [0.00000000E+00,1.70884
2 SX_AT_G0	SX_AT_G0	20...						3~3, 多項式係数: [0.00000000E+00,2.7588!
3 SY_AT_G0	SY_AT_G0	20...						3~6, 多項式係数: [0.00000000E+00,2.75889
4 ML_AT_G1	ML_AT_G1	20...						3~3, 多項式係数: [0.00000000E+00,2.7588!
5 SX_AT_G1	SX_AT_G1	20...						3~3, 多項式係数: [0.00000000E+00,1.70884
6 SY_AT_G1	SY_AT_G1	20...						3~3, 多項式係数: [0.00000000E+00,4.7554!
7 SL_AT_G1	SL_AT_G1	20...						0~35, 多項式係数: [0.00000000E+00,7.7925
8 SL_AT_G2	SL_AT_G2	20...						0~35, 多項式係数: [0.00000000E+00,7.7925
9 SL_AT_G3	SL_AT_G3/4	20...						0~35, 多項式係数: [0.00000000E+00,7.7925
10 SL_AT_G4	SL_AT_G3/4	20...						0~35, 多項式係数: [0.00000000E+00,7.7925
11 SX_AT_G4	SX_AT_G4	20...						5~5, 多項式係数: [0.00000000E+00,8.6366
12 SY_AT_G4	SY_AT_G4	20...						5~5, 多項式係数: [0.00000000E+00,8.6366
13 SL_AT_G5	SL_AT_G5/6	2021-09-10 00...	紙谷	0.290267	2021-09-24 11...	http://www-lina...		区間[A]0~35, 多項式係数: [0.00000000E+00,7.7925
14 SL_AT_G6	SL_AT_G5/6	2021-09-10 00...	紙谷	0.290267	2021-09-24 11...	http://www-lina...		区間[A]0~35, 多項式係数: [0.00000000E+00,7.7925

Summary

- **The text-based database files have long been used for the device information management. (generating EPICS database files and other files required for control software programs)**
- **In the new magnet information management system, the multiple database files are consolidated using PostgreSQL. The complexity of managing these database files is markedly reduced.**
- **Non-software experts can easily modify the data-base using the operational interface of the web application developed by Angular.**
- **We will expand this system to other device information management (accelerating structure, klystron, and a beam monitor).**

Thank you for your attention!