Control of KURRI FFAG

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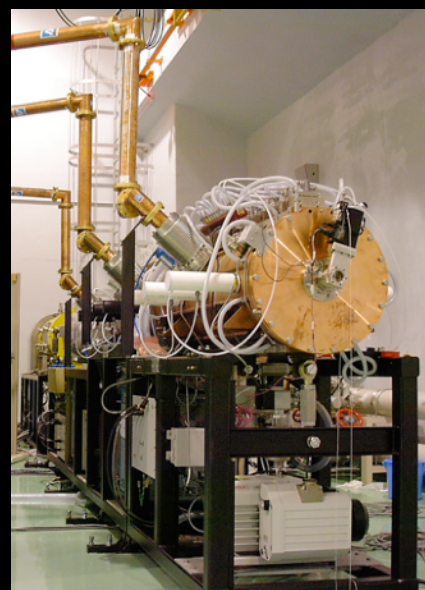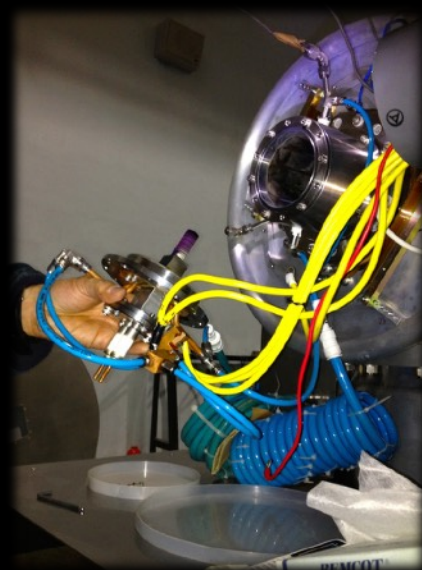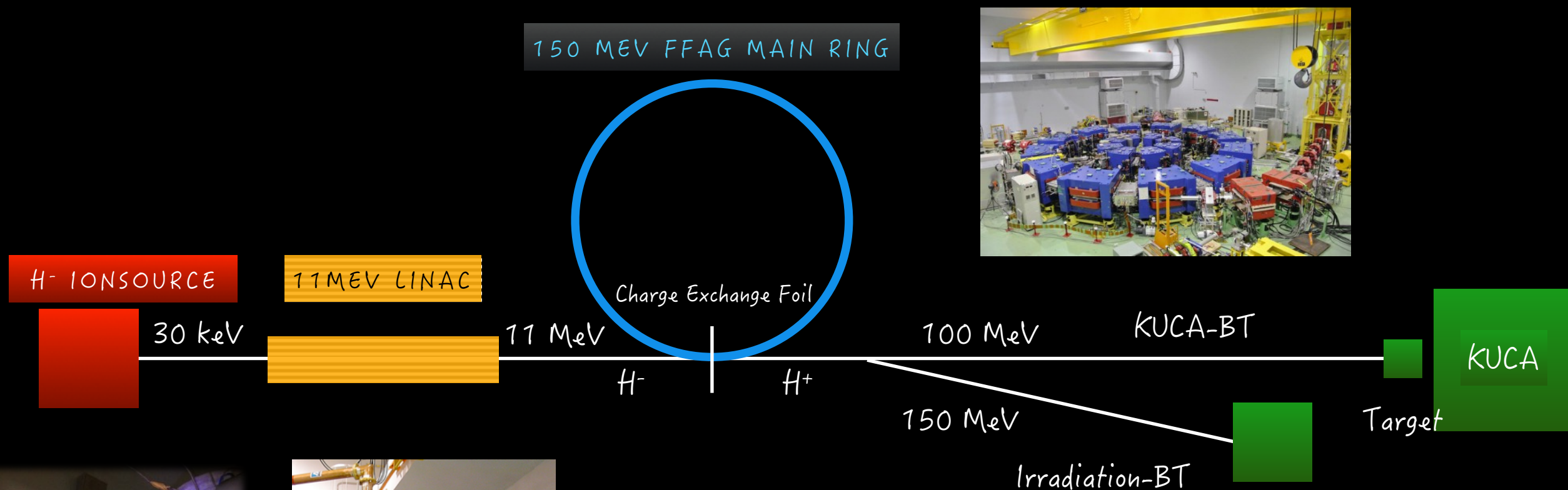 - Next Plan

FFAG Construction

FY2002	KART (ADS) Project started
FY2005	Construction of Accelerator complex started
FY2009	First ADS Experiment (100MeV - 2pA@Neutron Production target)
FY2011	Injector to the MR was changed to Linac
FY2012	Energy upgraded 100 MeV to 150 MeV Beam current upgraded to 10 nA with 20 Hz Rep.
FY2015	RFQ Trouble (Beam Stop)
FY2017	Re-Start Beam Commissioning

KUCA

Innovation Research Lab.

KURRI-FFAG Complex

150 MEV FFAG MAIN RING

Charge Exchange Foil

H⁻ IONSOURCE

11MEV LINAC

30 keV

11 MeV

H^- H^+

100 MeV   KUCA-BT

150 MeV

Irradiation-BT

Target

KUCA

- Injector : 11 MeV H⁻ Linac
- 1μA ave., ~ 200 Hz Repetition
- MR : 150 MeV FFAG
- 10 nA, ~ 60 Hz Repetition

History of KURRI-FFAG Controls

- PLC with LabVIEW (2006~)
  - LabVIEW was running on Windows laptop
    *NIMA "Control system for the FFAG complex at KURRI", M.Tanigaki, et al.

- PLC with {LabVIEW or EPICS} & GPIB (2009~)
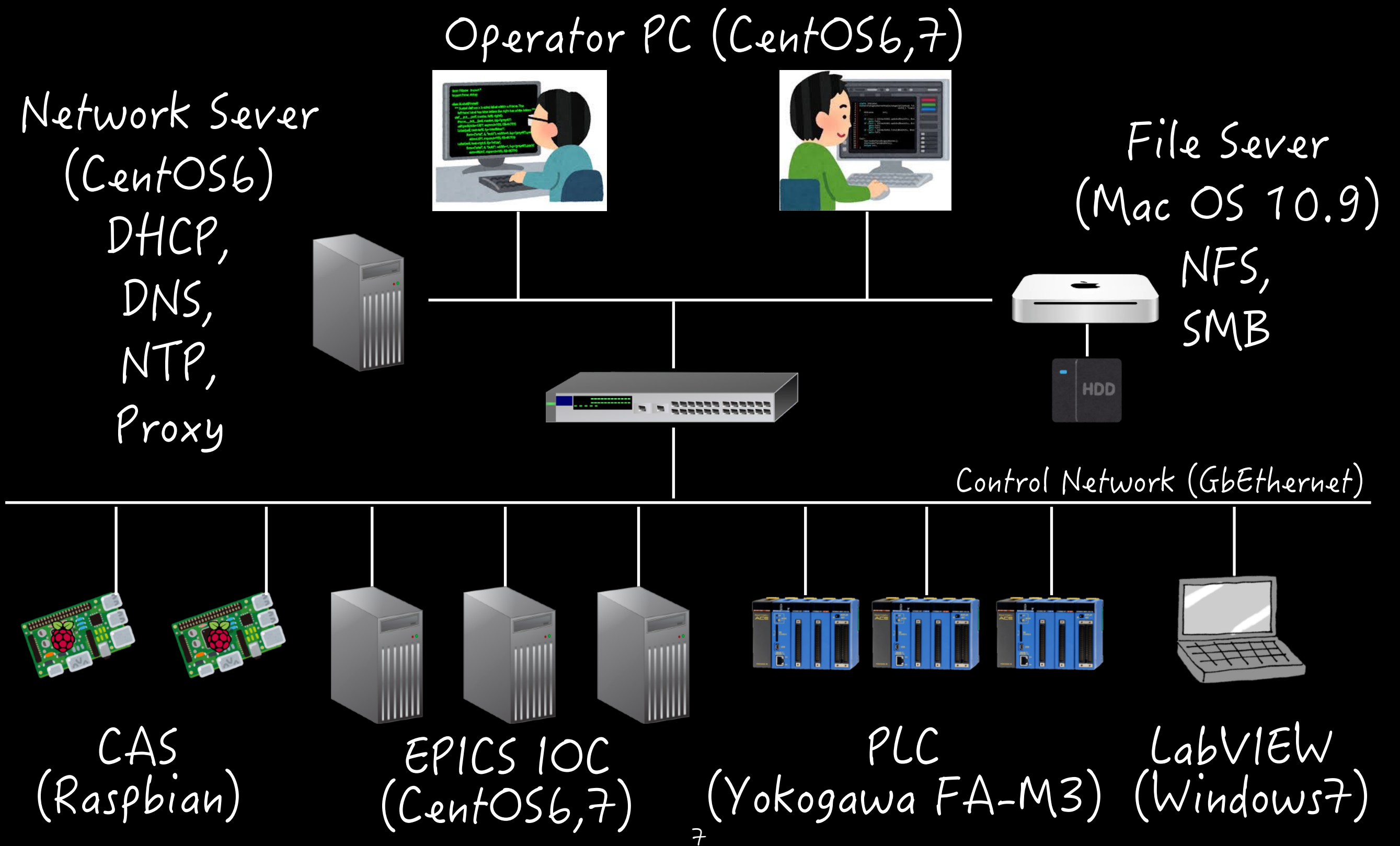 - Introduction of EPICS had started

- PLC with {EPICS or LabVIEW} & GPIB (2016~)
  - LabVIEW is used for Interlock System & Linac Control
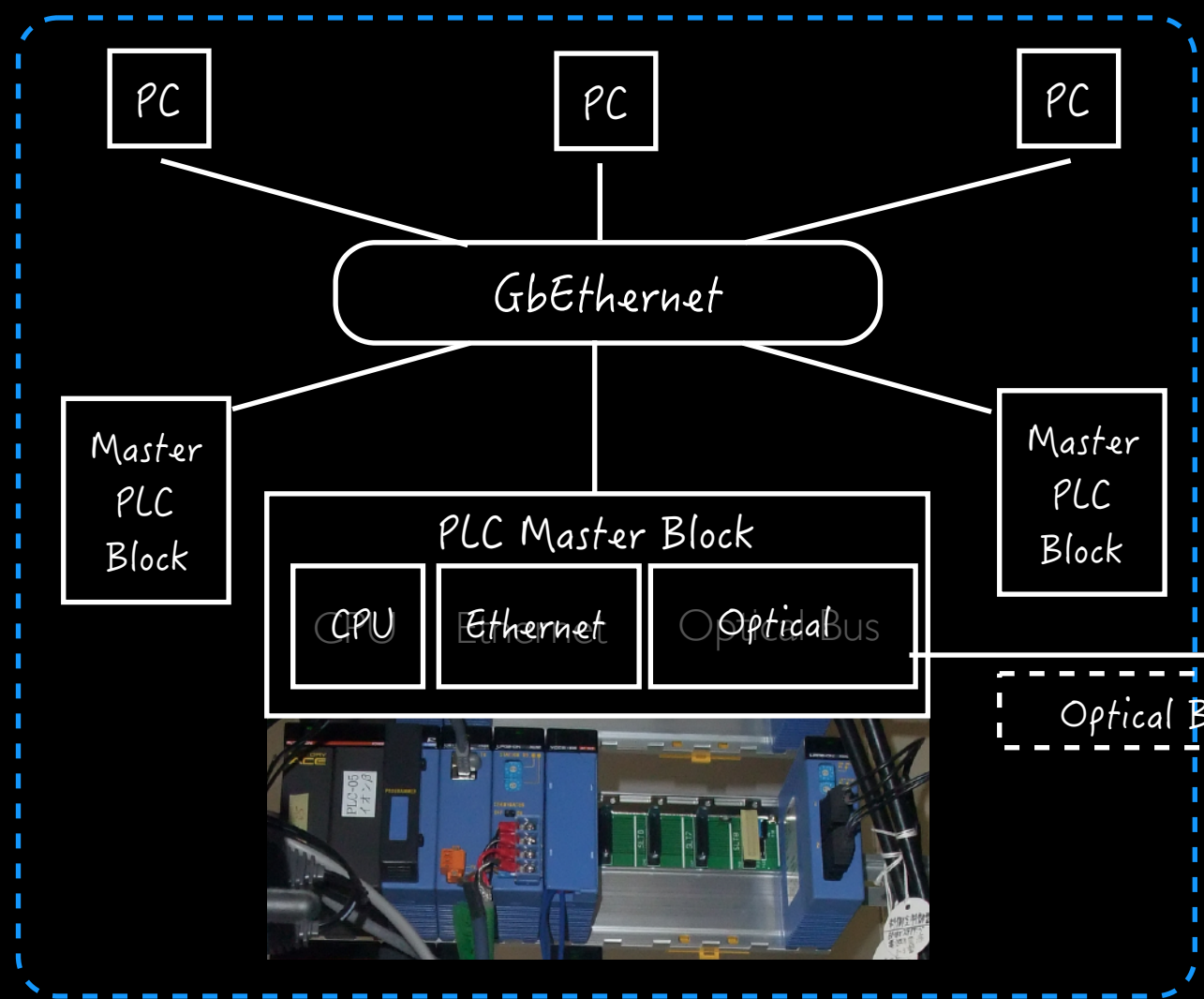
KURRI-FFAG Controls

- EPICS as basic environment

- Scripting language for operation tools
  - Shell script (bash), Python

- GPIB is still used for
  - Power Supply of MR D magnet
  - Stepping motor controller for Robot
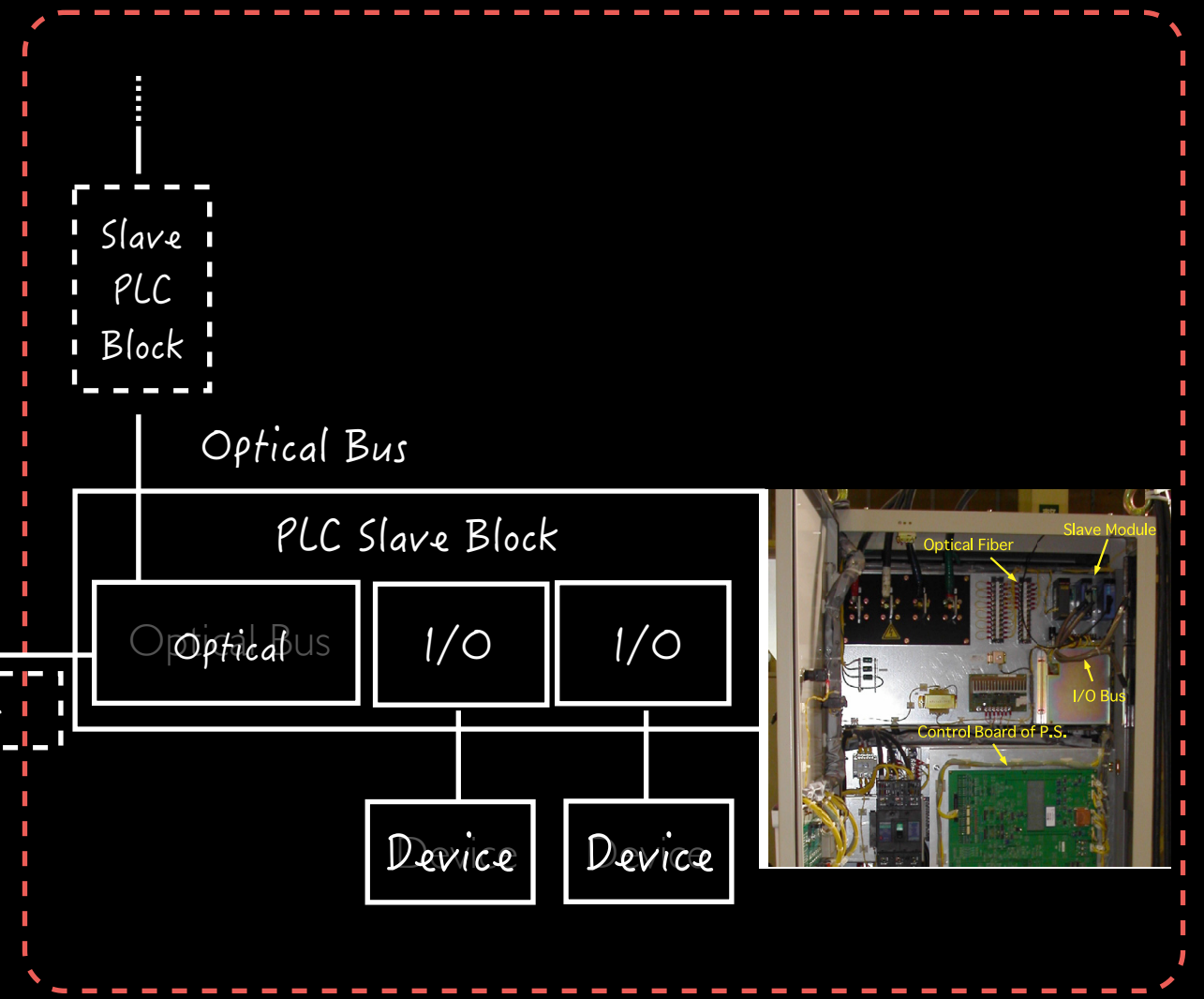 - Arbitrary waveform generator for LLRF

PCs & Network

Operator PC (CentOS6,7)

Network Sever
(CentOS6)
DHCP,
DNS,
NTP,
Proxy

File Sever
(Mac OS 10.9)
NFS,
SMB

Control Network (GbEthernet)

CAS
(Raspbian)

EPICS IOC
(CentOS6,7)

PLC
(Yokogawa FA-M3)

LabVIEW
(Windows7)
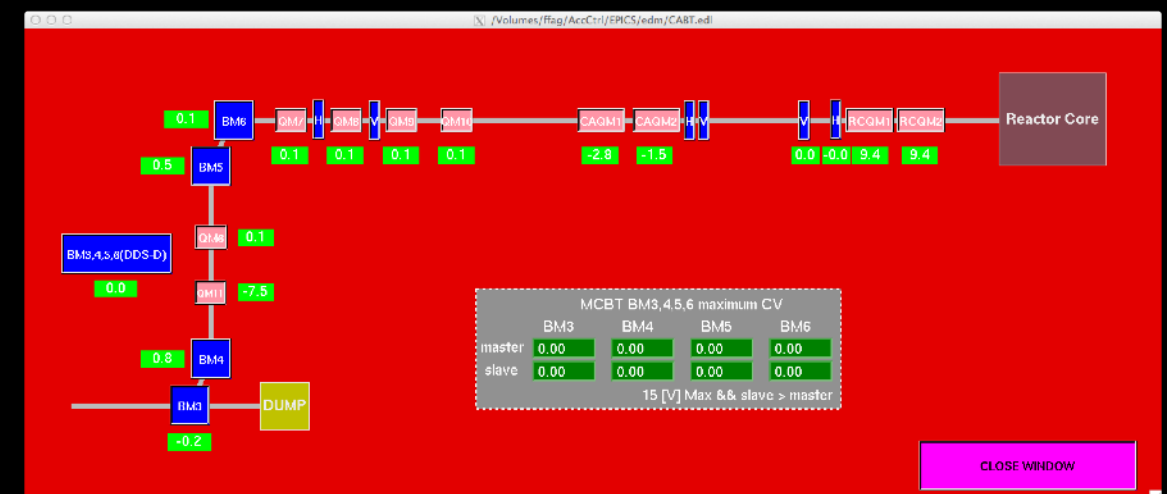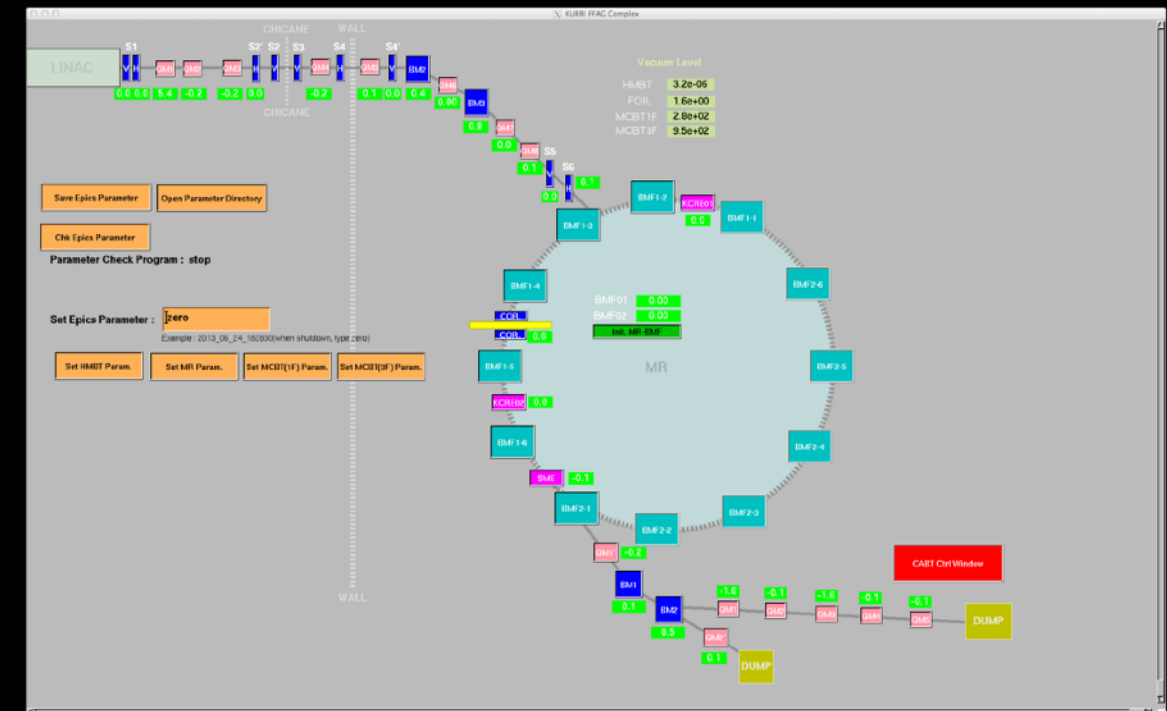
PLC System

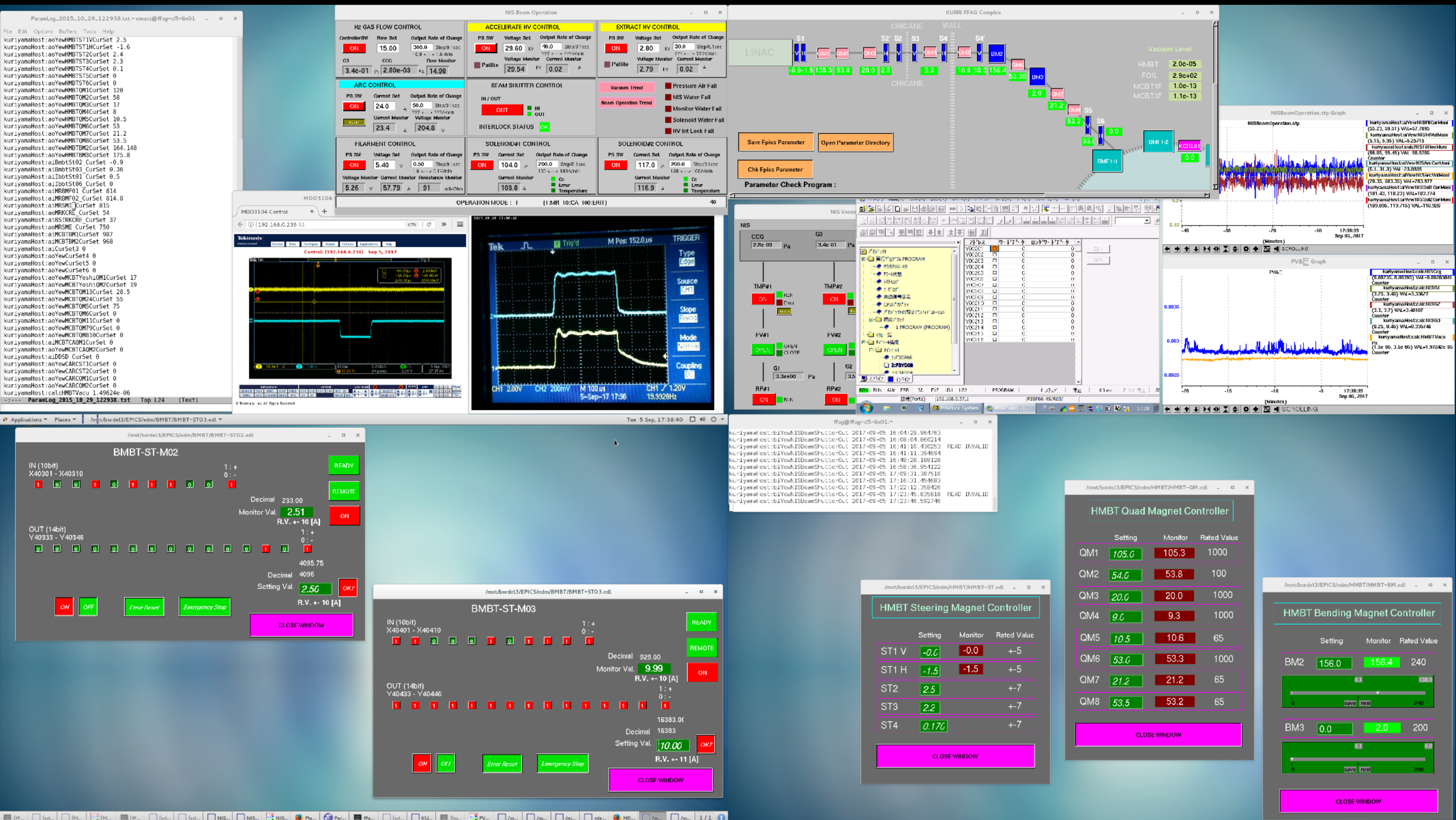## Control Room

Accelerator & Power supply Room

EPICS based Control

- EPICS Base R3.14
  - Released at 2002
- Development of OPIs using EDM/MEDM
- netDev
  - EPICS Module
  - Communicate with PLC
  - Developed by Odagiri (KEK)

Screenshot of OPI @ 5th Sept. 2017
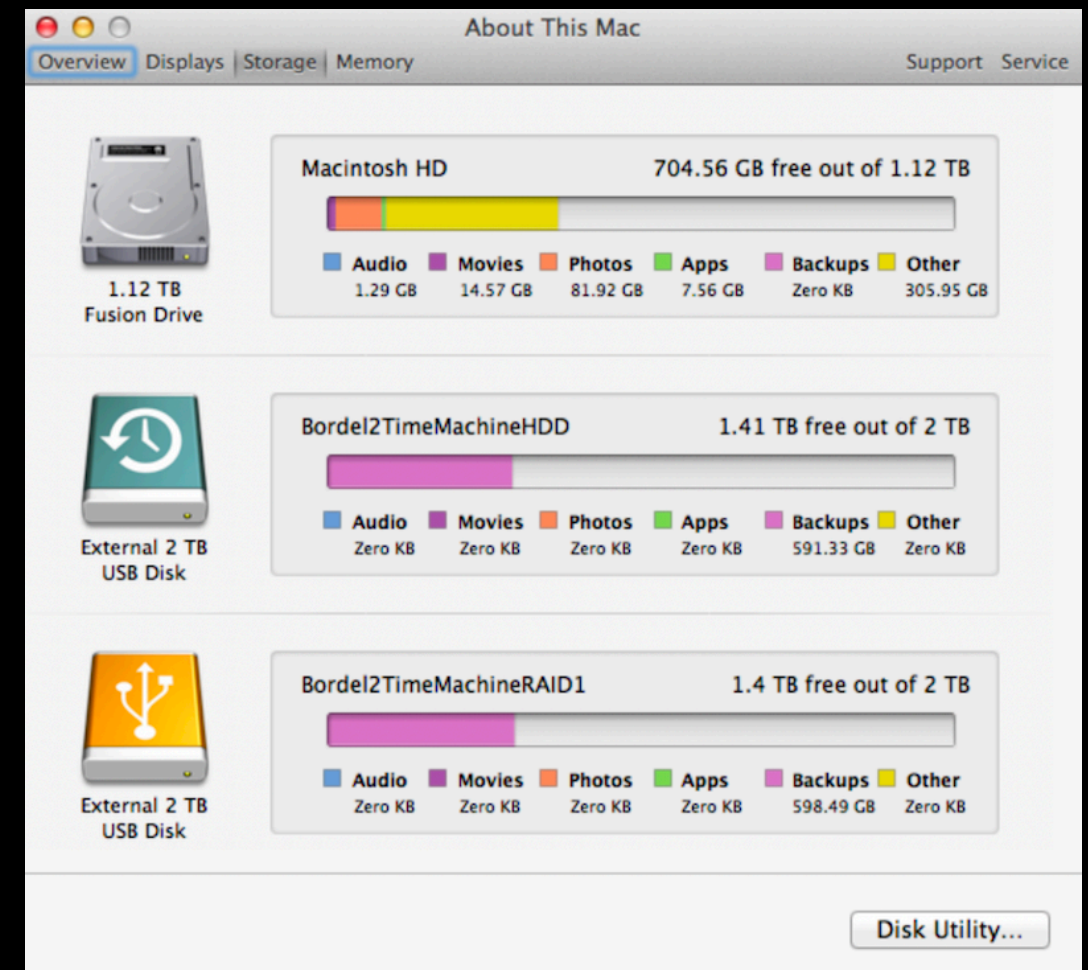
Data Storage

Reliably we have to keep

- Control Program
  - EPICS database, edm, medm, strip tool ⋯
  - LabVIEW VI
- Parameter & Vacuum Log
- LLRF Pattern for MR
- Beam diagnosis data
  - Beam Profile Pics, Bunch monitor CSVs, Neutron monitor Meas. data, ⋯
- All data is saved on File Sever "Bordel3"

File Sever "Bordel3"

- Requirements for the file server
  - Small storage size is enough
    - 1 TB or so (at this point)
  - Fast Access
    - More than 20 Clients
  - Easy Data Recovering from machine trouble

- Mac mini with "SSD+HDD"
- For the data protection
  - Time Machine is the best!!

EPICS IOC PC's Storage

- Important data is not stored in local storage

Mount file server
Storage using NFS

```
[kuriyama@ffag-cel-lin01 ~ $ df -h
Filesystem              Size  Used Avail Use% Mounted on
/dev/mapper/vg_ffagcellin01-lv_root
                         50G  4.1G   43G   9% /
tmpfs                   918M     0  918M   0% /dev/shm
/dev/sda1               477M   71M  381M  16% /boot
/dev/mapper/vg_ffagcellin01-lv_home
                        176G   92M  167G   1% /home
192.168.0.252:/Users/ffag/AccCtrl
                        1.1T  382G  657G  37% /mnt/bordel3
```
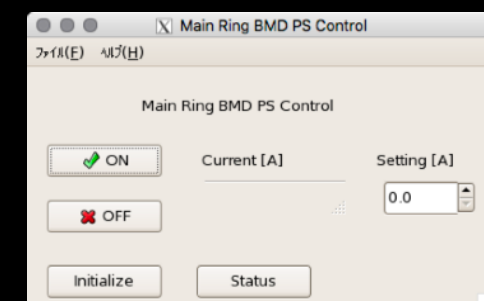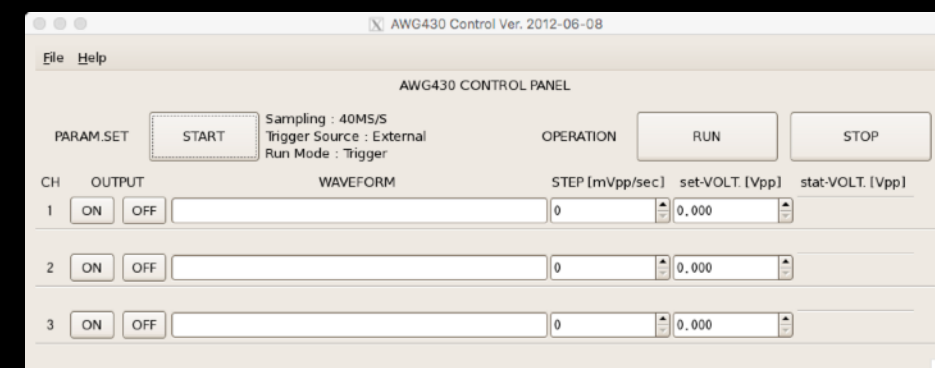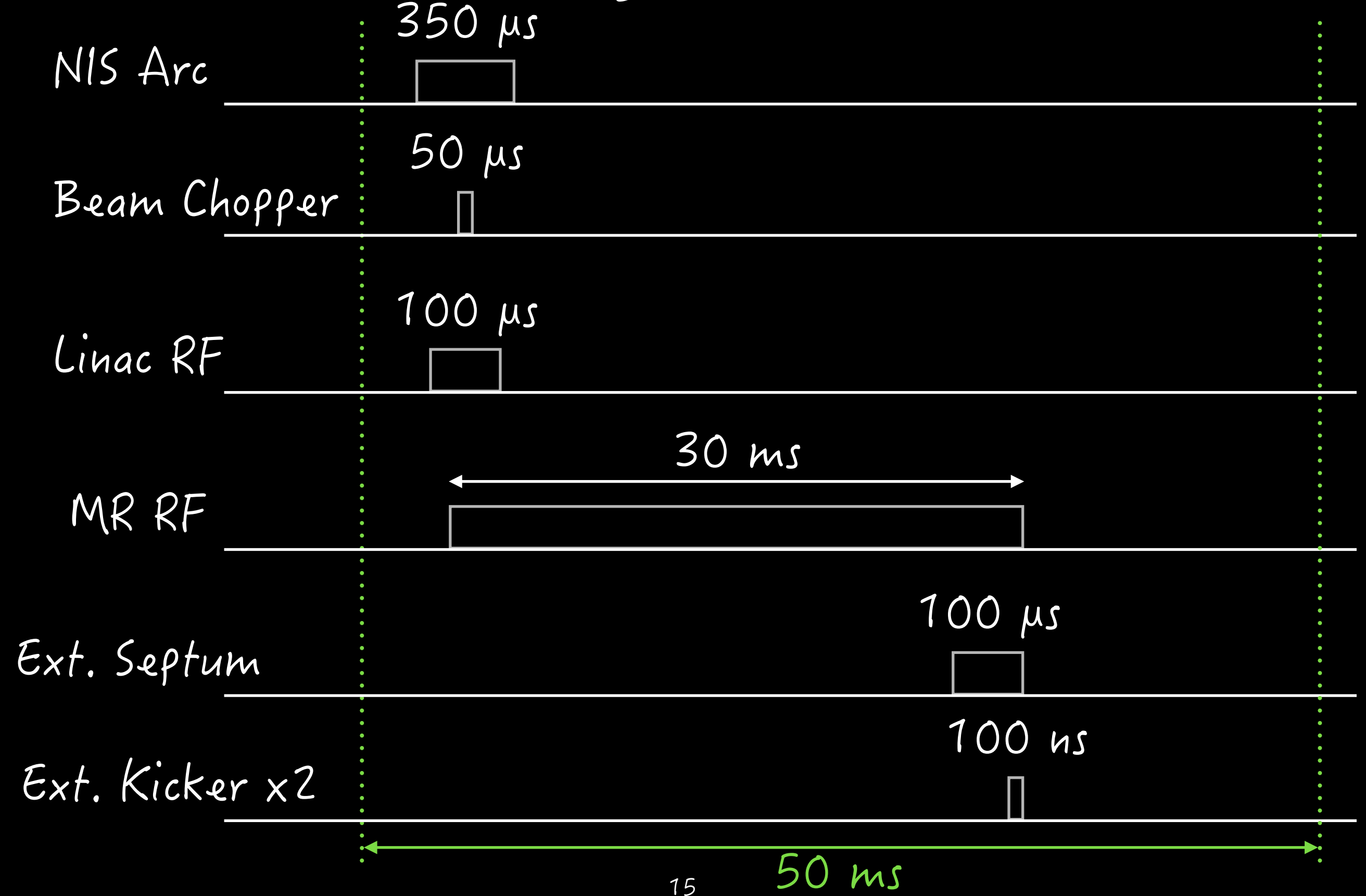
EPICS
Related
Files

```
kuriyama@ffag-cel-lin01 EpicsADE $ pwd
/home/kuriyama/EpicsADE
[kuriyama@ffag-cel-lin01 EpicsADE $ ls -lh
合計 56K
[-rw-rw-r--   1 502 games 467  7月 21 16:48 2016 Makefile
drwxrwxr-x   5 502 games 170  7月 21 16:48 2016 SampleApp
lrwxrwxrwx   1 502 games  29  7月 21 18:25 2016 StripTool -> /mnt/bordel3/EPICS/StripTool/
drwxrwxr-x   3 502 games 102  7月 21 16:51 2016 bin
drwxrwxr-x  12 502 games 408  7月 21 16:50 2016 configure
lrwxrwxrwx   1 502 games  21  7月 21 18:36 2016 db -> /mnt/bordel3/EPICS/db
drwxrwxr-x   7 502 games 238  7月 21 16:51 2016 db.bak
drwxrwxr-x   5 502 games 170  7月 21 16:50 2016 dbd
lrwxrwxrwx   1 502 games  22  7月 21 18:25 2016 edm -> /mnt/bordel3/EPICS/edm
drwxrwxr-x   3 502 games 102  7月 21 16:50 2016 include
drwxrwxr-x   4 502 games 136  7月 21 16:48 2016 iocBoot
drwxrwxr-x   3 502 games 102  7月 21 16:50 2016 lib
lrwxrwxrwx   1 502 games  24  7月 21 18:25 2016 medm -> /mnt/bordel3/EPICS/medm/
drwxrwxr-x   3 502 games 102  7月 21 18:37 2016 userHost.substitutions
```

Control with GPIB

- GPIB devices :
  - MR-D Power Supply (IDX)
  - Stepping Motor Controller (Tsuji-denshi PM4C)
  - Arbitrary waveform Generator (Tektronix AWG430)
- Control System Consists with
  - Linux (CentOS 5) PC
  - NI GPIB-USB-HS
  - Device driver "NI-488.2" developed by NI
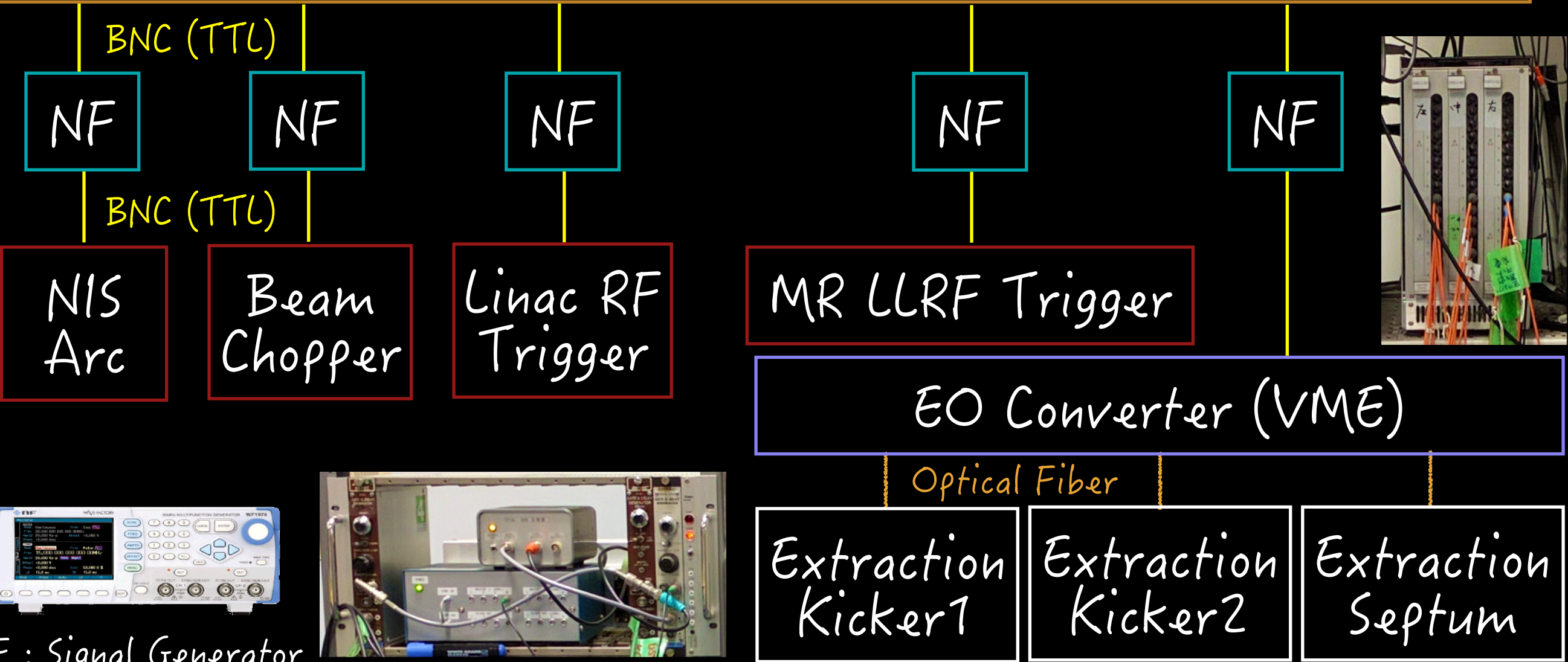- GTK based OPIs were developed using Glade2

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Yasutoshi KURIYAMA, KURRI, Sep. 2017

Timing Control

NIS Arc — 350 μs

Beam Chopper — 50 μs

Linac RF — 100 μs

MR RF — 30 ms

Ext. Septum — 100 μs

Ext. Kicker x2 — 100 ns

50 ms

Timing Control

Access Control to the Accelerator Room

- In 2016, Update to Raspberry Pi from Windows + VB6 based system
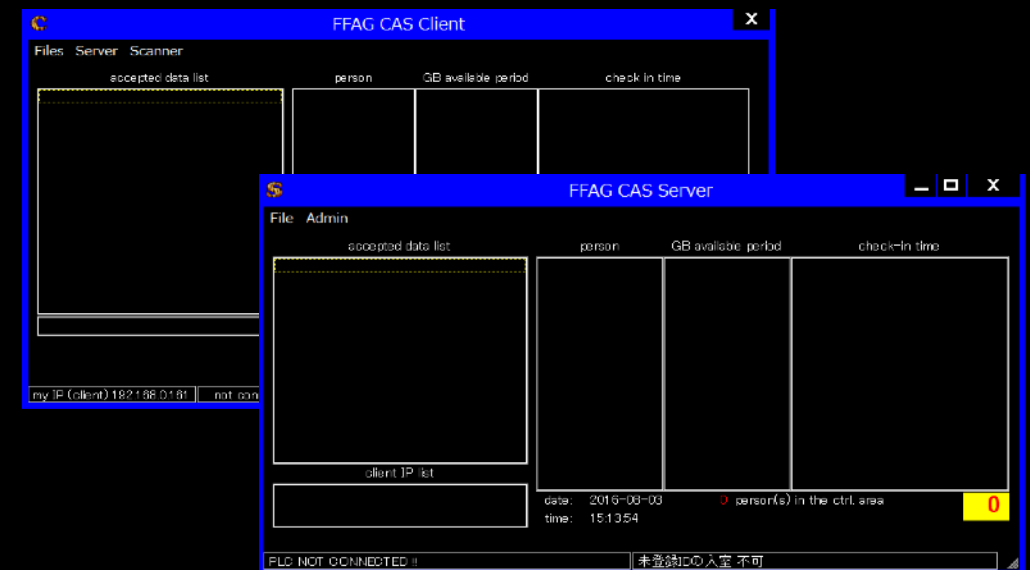 - Used for Beam Interlock

- Raspberry pi + PLC (with Ladder)
  - QR code reader : usb-cam
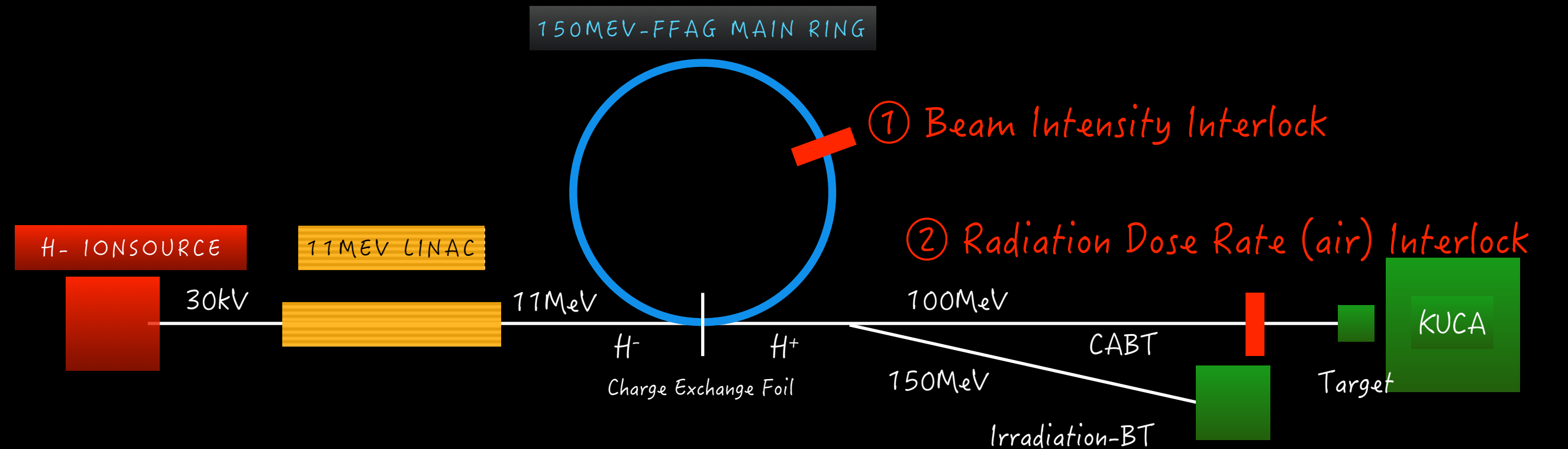 - Software : ZBar + Python
  - All critical information is stored in PLC.
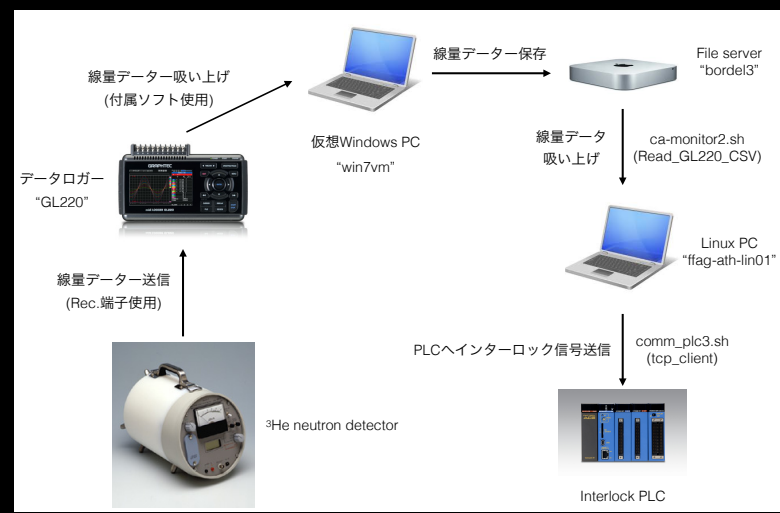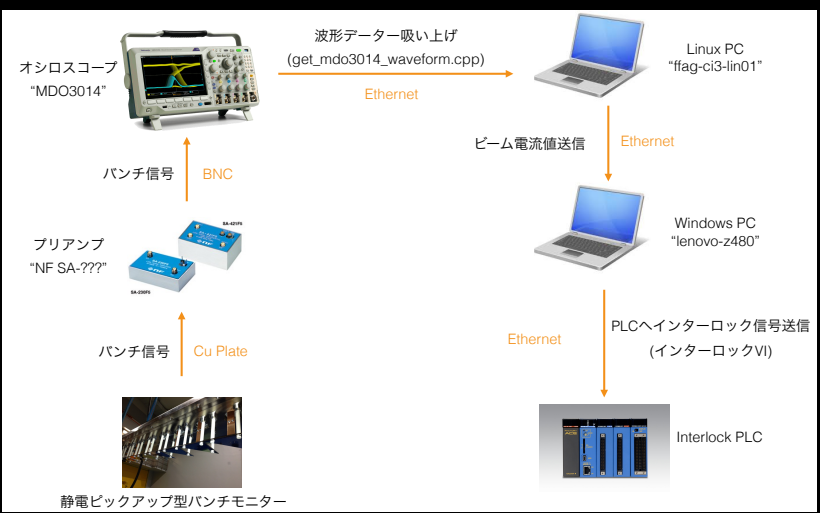
Updated

Developed by Yuya HORITA

Beam Interlock

Two Interlock System related with Beam Intensity are prepared

150MEV-FFAG MAIN RING

① Beam Intensity Interlock

② Radiation Dose Rate (air) Interlock

H- IONSOURCE   11MEV LINAC   KUCA

30kV   11MeV   100MeV

H-   H+   CABT

Charge Exchange Foil

150MeV   Target

Irradiation-BT
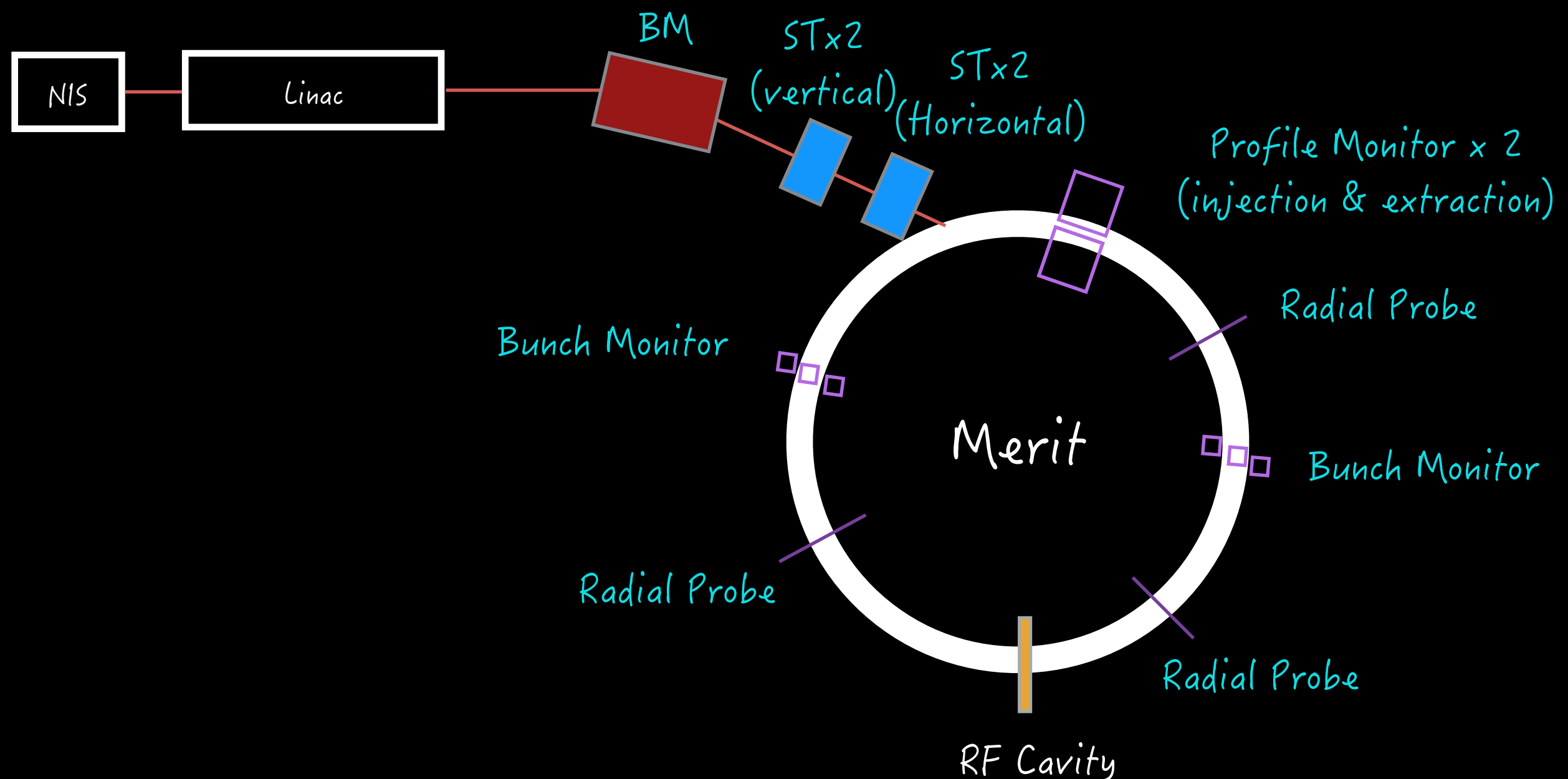
① Beam Intensity Interlock

② Radiation Dose Rate (air) Interlock

2015/09/04更新

Comunicate
w/ interlock-PLC
(EPICS IOC)

Control System of MERIT

## Newly, we have to prepare control system below

Control System of MERIT

- MERIT Control system should control
  - 8 Power Supplies
    - BMx1 & STx4 magnets at BT
    - F & D FFAG Magnet
  - Radial Probes for the Injection, profile monitor & scraper
  - Bunch monitor
  - LLRF for the MERIT ring
  - Vacuum System
    - TMPx2 & RPx2 & Vacuum Gauge
- All devices will be controlled with PLC & EPICS (under construction···)
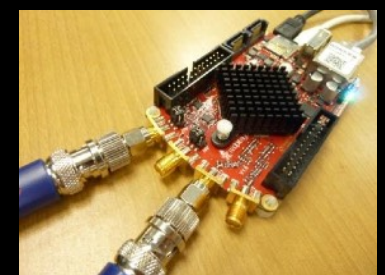

Power Supply
for the MERIT Injection BT

NIS — 30 keV H⁻ — 11MEV LINAC — 11 MeV H⁻ / H⁺ — Charge Exchange Foil

MERIT
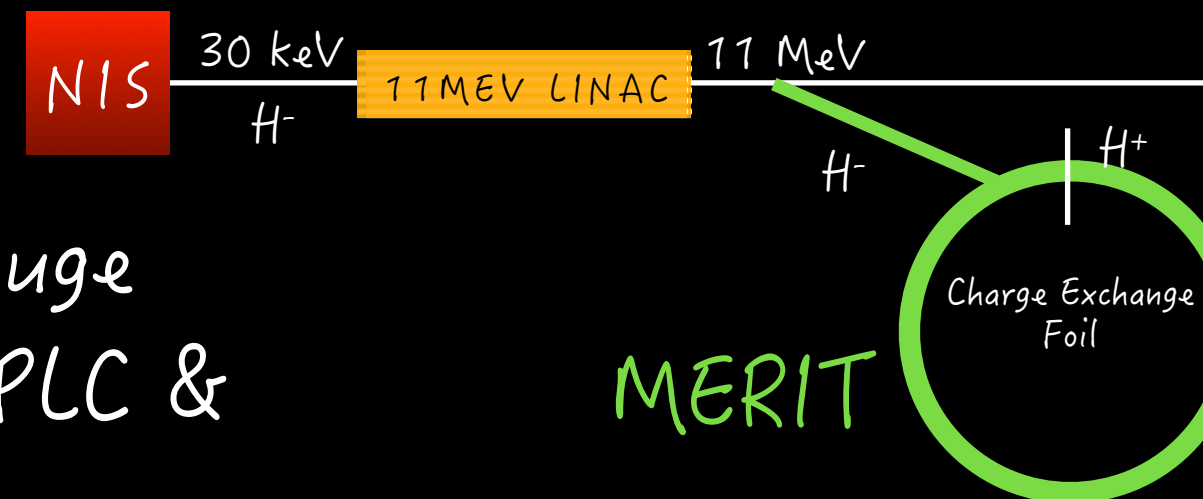
Next Task

- **Integration of GPIB control program to EPICS**
  - Bridge program is already developed
- **Preparation of parameter archiving system**
  - Now, Shell script is used for saving and loading parameter value
  - Archiver Appliance (CSS) is one of the candidate
- **Integration of beam diagnosis with EPICS**
  - Beam Diagnosis Devices are operating independently

Summary

- KURRI FFAG Complex is now controlled using EPICS
  - Migration from LabVIEW is almost finished
- GPIB Control system still remains
  - Integration with EPICS is in progress
- Merit Control System is under construction
- EPICS Archiving System & Integration of Beam Diagnosis devices with EPICS is planning

Thank you