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Current Status and Future Prospect of the PEFP Control Room

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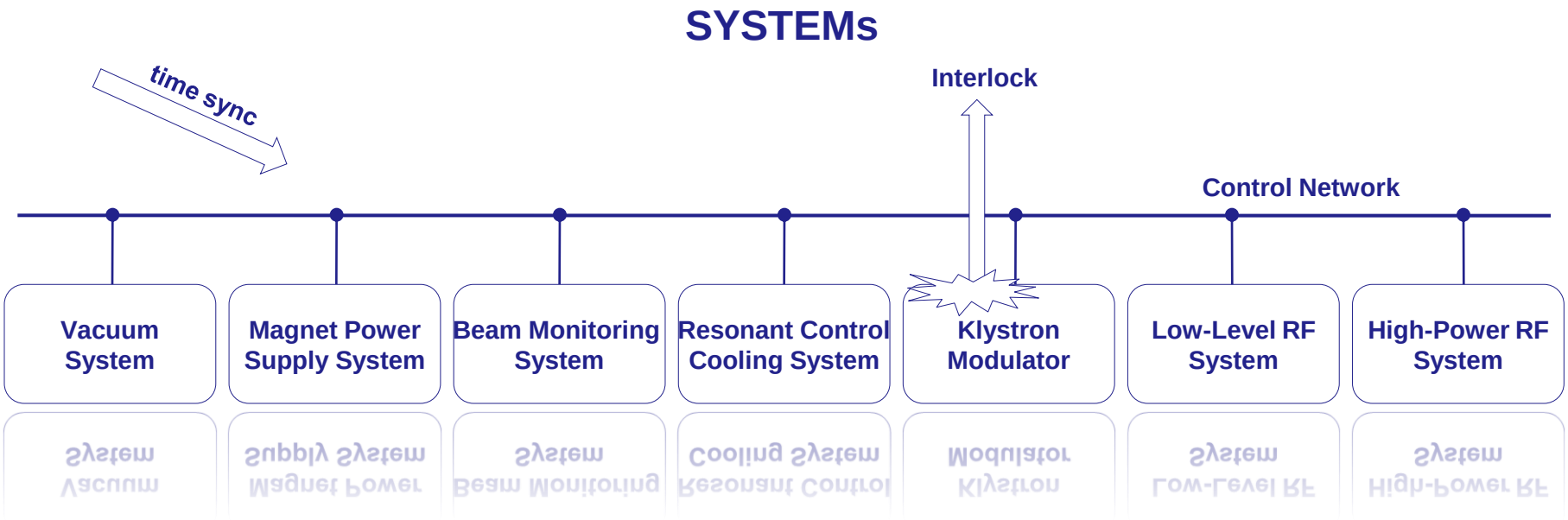
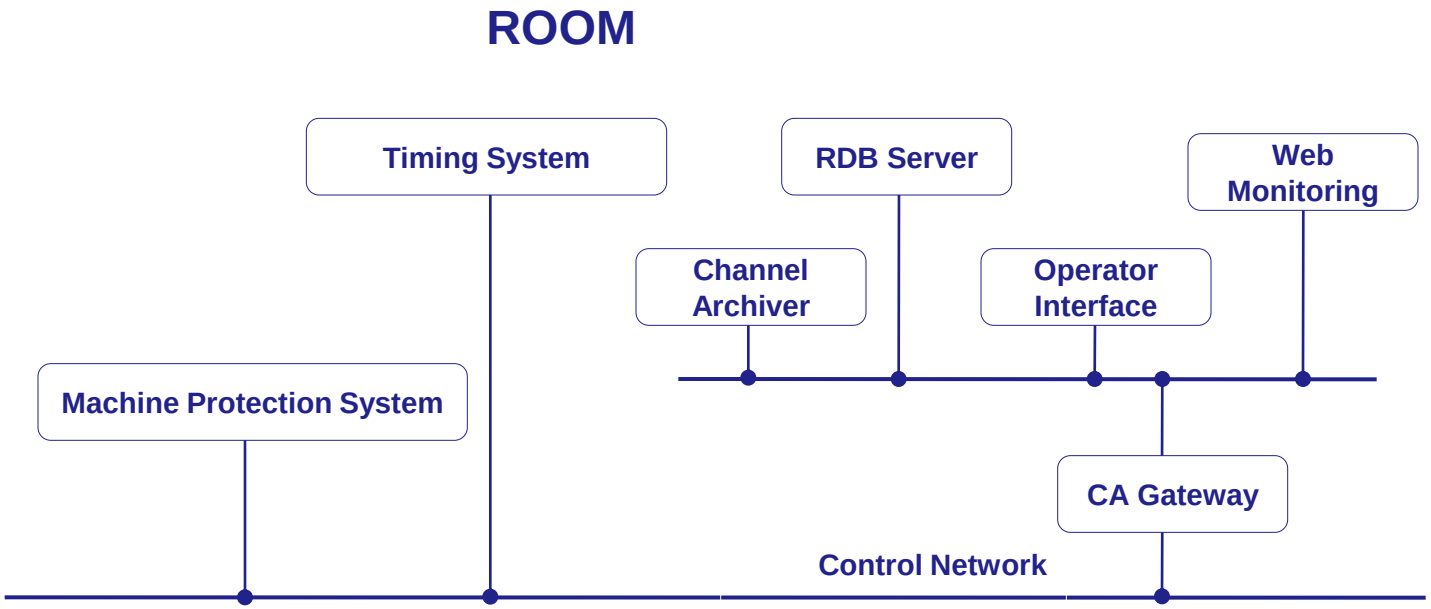
Contents

Distributed Control of the PEFP accelerator

- Network based Distributed Control System
- Integration of Subsystem Controllers
- EPICS Software Architecture



Centralized Control of the PEFP accelerator



- Control Room for the 20 MeV Proton Linac
- Control Room
  - Allowing Operators to Control Devices
  - Allowing Operators to Monitor Operation Parameters
- To give More Environmental Condition to Operators
- To design Main Control Room for the 100 MeV Proton Linac

Contents

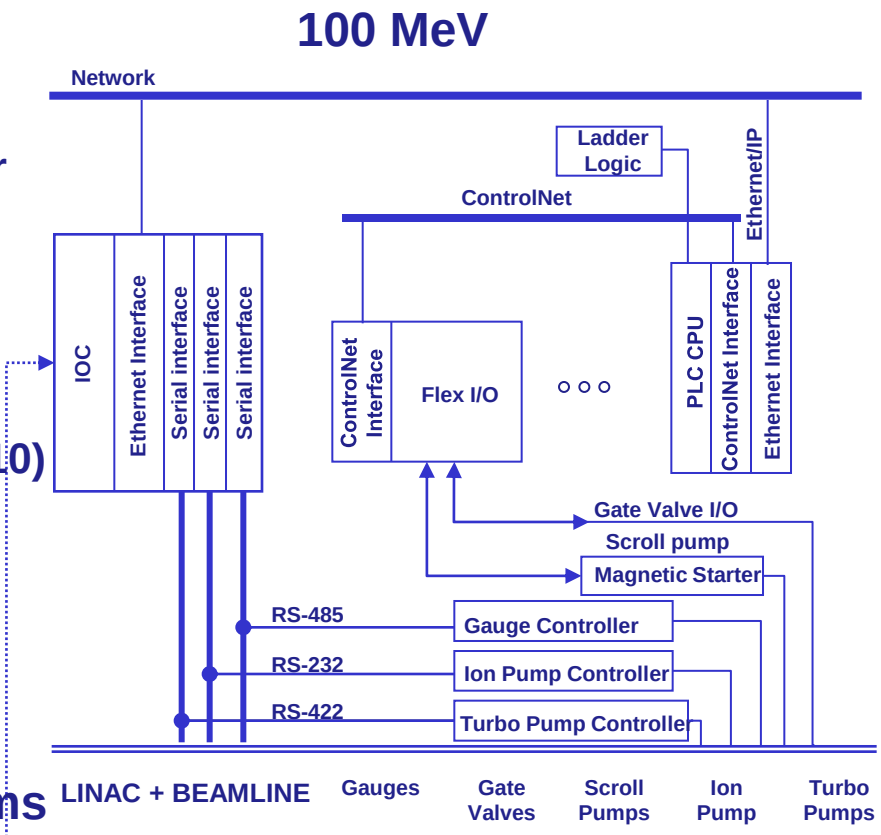
Control Infrastructure

PEFP Proton Engineering Frontier Project

- Red Hat Enterprise Linux (RHEL): Rack Mounted Server
  - Servers to support remote access (IBM, HP)
  - Servers to support network services and network management
  - EPICS file/boot servers
  - Application servers
- Application Installation: RHEL Servers
  - EPICS Base and Extensions, SUN java/jvm, SQL DB
  - ECLIPSE as an IDE for java/C++/C development
- Target IOC hardware, OS selection, IDE configuration
  - VME-SBC PowerPC architecture
    - MVME5110 is used for more demanding applications
  - VxWorks 5.5.1 is a production target OS
  - Development environment
    - To build a cross-compiler environment using Tornado and vxWorks in SunOS

Vacuum

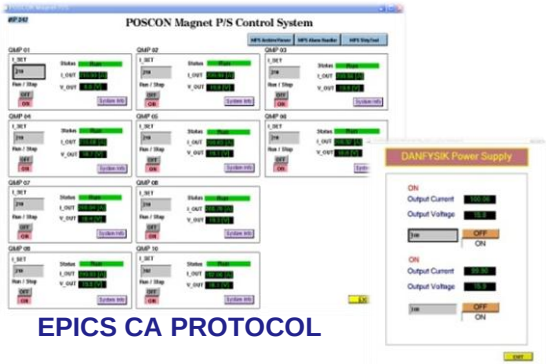
- First Control System using EPICS
  - Red Hat Linux OS
  - Industrial PC Rack-mounted Server
  - Limited Communication Interface
- Demonstration of the Capability of EPICS on the Control System
- Upgraded Vacuum Control System
  - MVME5110 VME-SBC (PowerPC7410)
  - VME Serial Board
  - VxWorks 5.5.1
  - EPICS 3.14.9
- Use PLC to Control Scroll-Pumps and Gate-Valves
- To Design State Transition Diagrams with Interlock Scenario
- Sequencer module



Magnet Power Supply

- Remote Control and Monitoring
- Protection of DT electroquadrupole magnet
- Operator Interface
- Controller
  - MVME5110 VME-SBC (PowerPC7410)
  - VME Serial Board
  - VxWorks 5.5.1
  - EPICS 3.14.9
  - Modbus/RTU protocol
- Functions
  - Monitoring: voltage, current, status(on/off, local/remote, normal/alarm)
  - Control : on/off, current setting permissible setting range
- EPICS sequencer module
  - To protect Draft Tubes (DT) from cooling trip and unstable current
- 100 MeV Magnet Power Supply
  - Need Discussion and Decision

Operator Interface



EPICS CA PROTOCOL

Input Output Controller (EPICS IOC)

Modbus/RTU PROTOCOL

Power Supply Controllers

Low-level RF (LLRF)

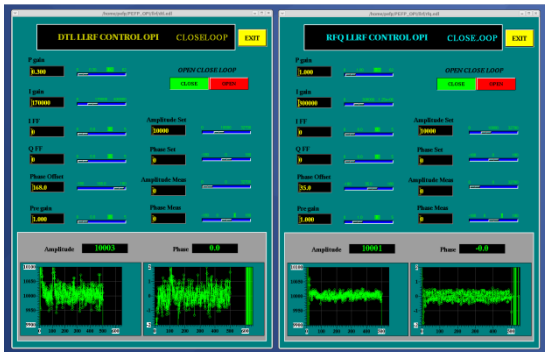
- RF amplitude and phase requirements of the accelerating field are within ±1% and ± 1˚
- RF digital feedback control system was developed and operated
- Digital RF feedback control system
  - MVME5110 VME-SBC (PowerPC7410)
  - ICS-572B FPGA board,
  - VxWorks 5.5.1
  - C programming with BSP, Text terminal

- LLRF control system configured to improve RF field control of the 100 MeV accelerator
  - Pentek 7142 FPGA PMC module
  - EPICS 3.14.9
- Fill the Requirements

	RF Control Frequency
RF	350 MHz
LO	300 MHz
IF	50 MHz
Sampling clock	40 MHz

- ADC : 125MHz max. sampling rate
  : 4 ch., 14bit resolution
- DAC : 320MHz max. converting rate
  : 1 ch., 16bit resolution
  : dc to 160MHz IF output
- FPGA : Xilinx Virtex4 XC4VSX55
- Memory : DDR2 SDRAM (64M×32)
- Clock : external (1 to 300MHz, 0 to +10dBm)
  : internal (125MHz max.)
- Gate : internal or external

100 MeV

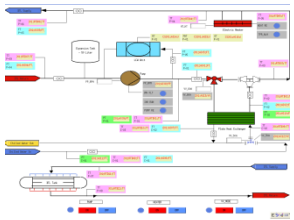


Resonance Control Cooling System (RCCS)

- Resonant frequency matched to the HPRF driving frequency
- RCCS IOC: temperature, flow rate, pressure, motor speed & control, valve status & control, alarm status screen, flow chart screen, AutoSave
- Resonance frequency error measured by LLRF system and fed in RCCS

Parts	Specification
Case/Slot	19”, 6U USB Backplane Type
CPU	Intel Pentium, 500 MHz
Memory	512 MB
HDD	4 GB Compact Flash Memory
Ethernet	10/100/1000 Mbps
OS	Linux (Fedora Core 8 and over)
Kernel	RT Kernel 2.6.23.1
Software Tool	EPICS base, sequencer, AutoSave
Signal I/O modules	Analog Input Board Analog Output Board Digital Input Board Digital Output Board RTD board

RCCS OPI



Transmission of Frequency Error Signal through EPICS CA

EPICS CA PROTOCOL

RCCS IOC

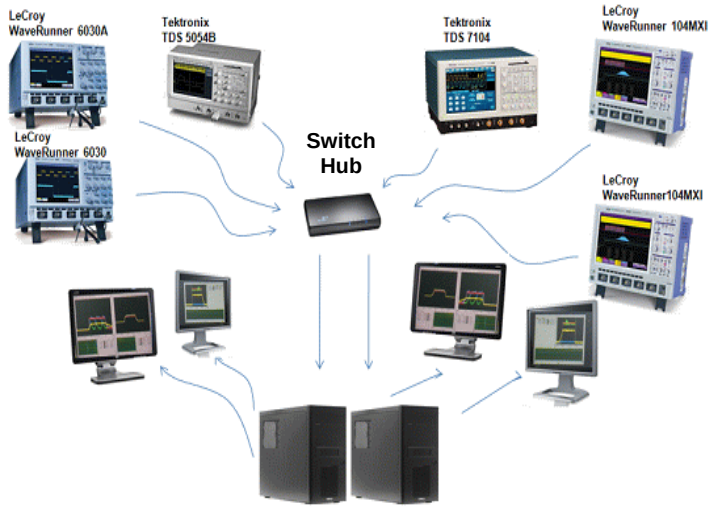
LLRF IOC

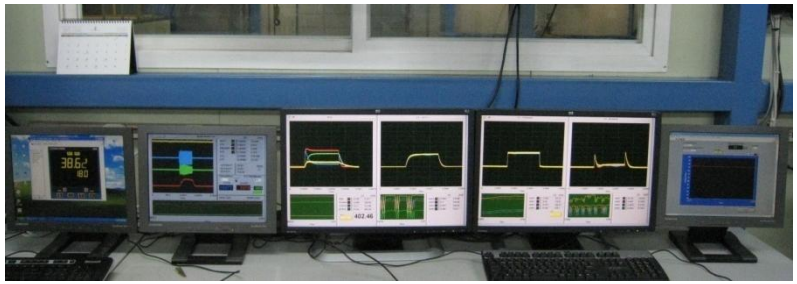
LLRF Control System

Fabricated water pumping skip

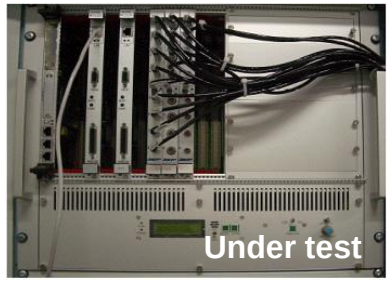
RF and Beam Current Monitoring System

- RF
  - SSA, cavity, forward, reverse
- Beam Current :
  - ACCT, TCT, FCT, BPM
- NI LabVIEW 8.6 TCP/IP VISA resource
- EPICS software: Not Used
- Modification
  - NI LabVIEW Client I/O Server
- For Beam Monitoring System
  - MVME5110 VME-SBC (PowerPC)
  - VxWorks 5.5.1, EPICS 3.14.9
  - VME VTR812 ADC board
    - 8 channel, 12 bit resolution, 10MHz sampling rate
    - Common external triggering/clock
  - Oscilloscope Embedded IOC
  - PXI IOC





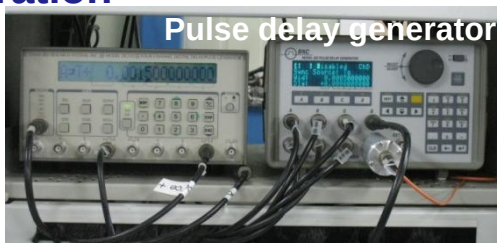
VTR812 Fast ADC Test Board

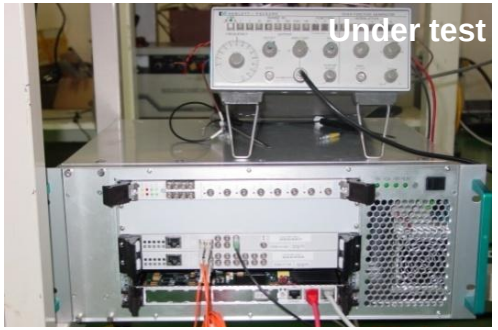


EPICS IOC

Timing System

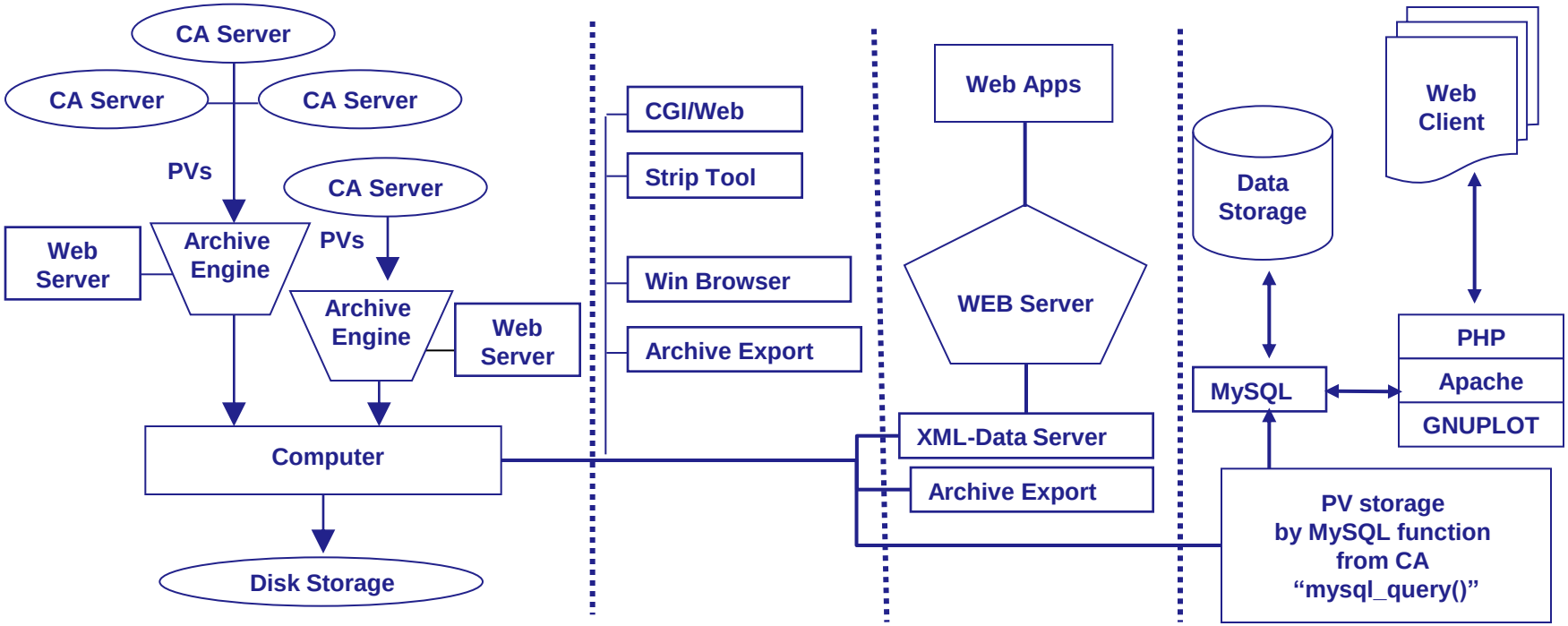
- Providing Accurate Trigger Signals for Synchronized Operation
  - RF gate generation
  - Beam gate generation
  - Low level RF control trigger
  - Klystron modulator control trigger
- Control System Synchronized and Operated with the Same Time Referenced to External Clock
- Event System





Data Management

- Data Storage Systems
  - EPICS channel-archiver : IOC real-time database to store real-time data
    - H/W: rack-mounted server (Intel-based)
    - S/W: RHEL 4, EPICS 3.14.9
  - SQL database to store a lot of information
    - Running on RHEL with Intel Xeon 2.4GHz and memory 2GB
- Web Report System



20 MeV Control System

PEFP Proton Engineering Frontier Project

- Install IOCs for the 20 MeV proton linac
  - HVCM, HPRF, and so on
- Standard for the 100 MeV Control System
  - To optimize EPICS programs
  - To improve the stability and reliability

Control Room

Display monitors | Magnet Power Supply | Vacuum | LLRF | RCCS | RF & Beam monitoring | Web browser | Alarm

EPICS Channel Access Protocol

Control System

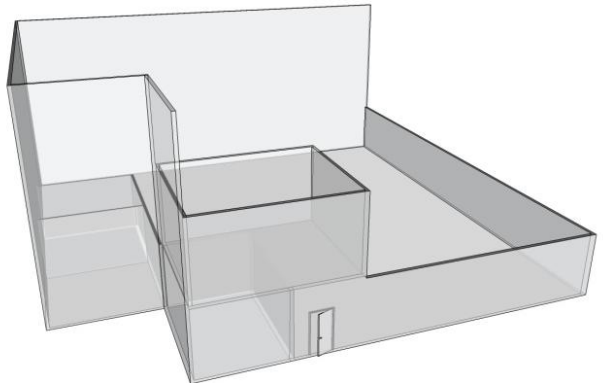
Data Storage & Web Server
Channel Access Gateway Server

Magnet Power Supply | Vacuum | RCCS | LLRF | RF & Beam Measurement

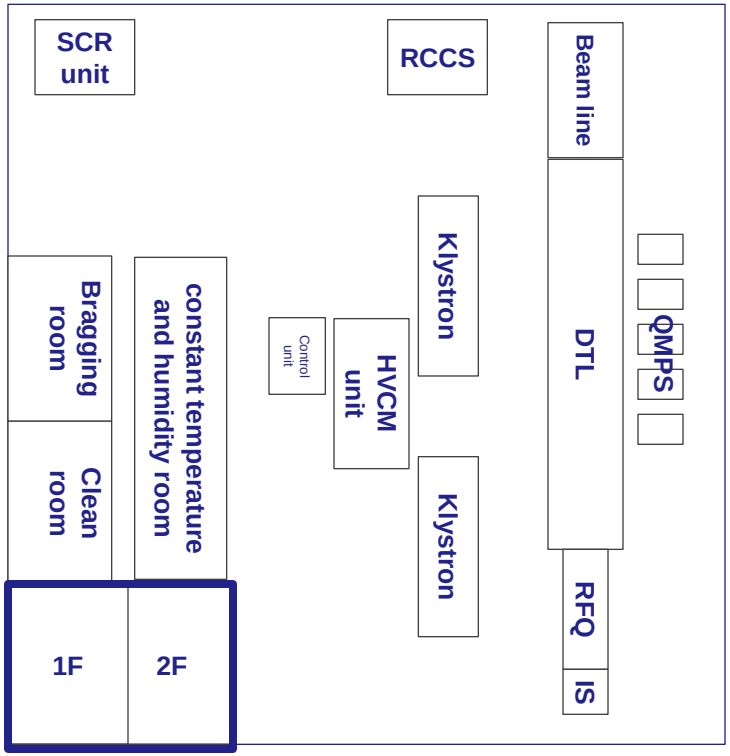
Contents

20 MeV Control Room

PEFP Proton Engineering Frontier Project



- **Facility Building**
  - Size : 35 m × 35 m
  - Accelerator components (ION, RFQ, DTL, beam line)
  - HPRF (High Power RF)
  - HVCM (HV Converter Modulator)
  - Bragging room
  - Clean room
  - 1st floor :
    - Size : 5m × 7 m
    - Control room → Experiment preparation room
  - 2nd floor :
    - Size : 9 m × 7 m
    - Office room → Control room

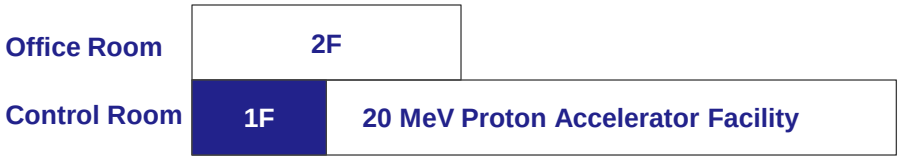


Facility Building Layout

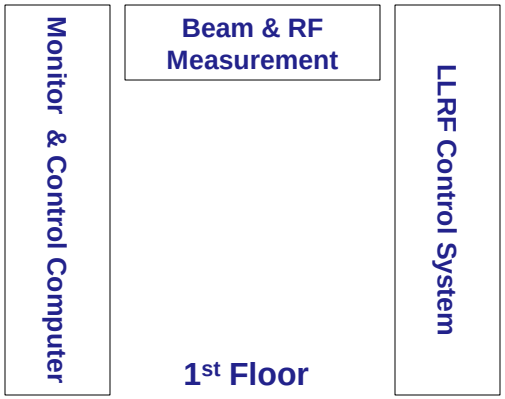
2007 ~ 2008

PEFP Proton Engineering Frontier Project

- **Use Control Room**
  - Remote control
  - Monitoring of operation parameters
- **Computer equipments**
  - Low level RF, vacuum control system
  - Beam, RF monitoring system
  - Sun, IOC, OPI server
  - 4 display monitors
- **Features**
  - Not enough space
  - Local panel display
  - No tables to hold keyboards and mice
  - No ventilation system



Side View of Facility Building



1st Floor Control Room

Motivation for Change

PEFP Proton Engineering Frontier Project

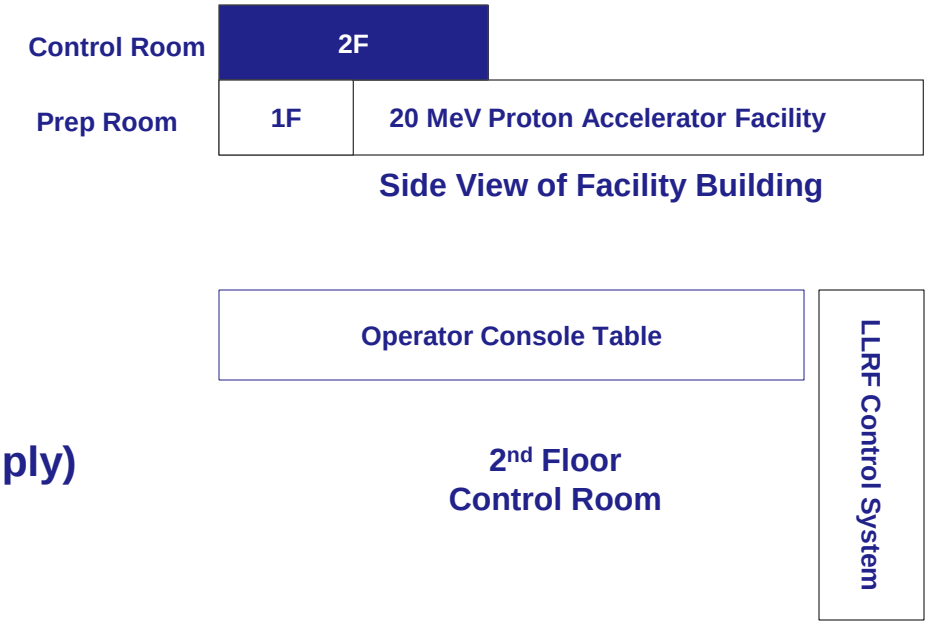
- 1st Control Room : Motivation for Change

- Minimum Requirements
  - Enough room for operator, scientific and engineering staffs
  - Console and seating
  - Increase display monitors
  - Ergonomic design
  - Air ventilation system
  - Dust trap

- Moving Plan
  - Size : 9 m × 7 m
  - UPS (Uninterruptable Power Supply)
  - Computer system
  - CCTV (Closed Circuit Television) camera and monitor
  - Cabling work

Since Feb 2009 ~

- Improved Factors
  - Air ventilation
  - Control parameters
  - Display monitors
  - Expanded console and setting
  - Installed CCTV camera
  - UPS (Uninterruptible Power Supply)

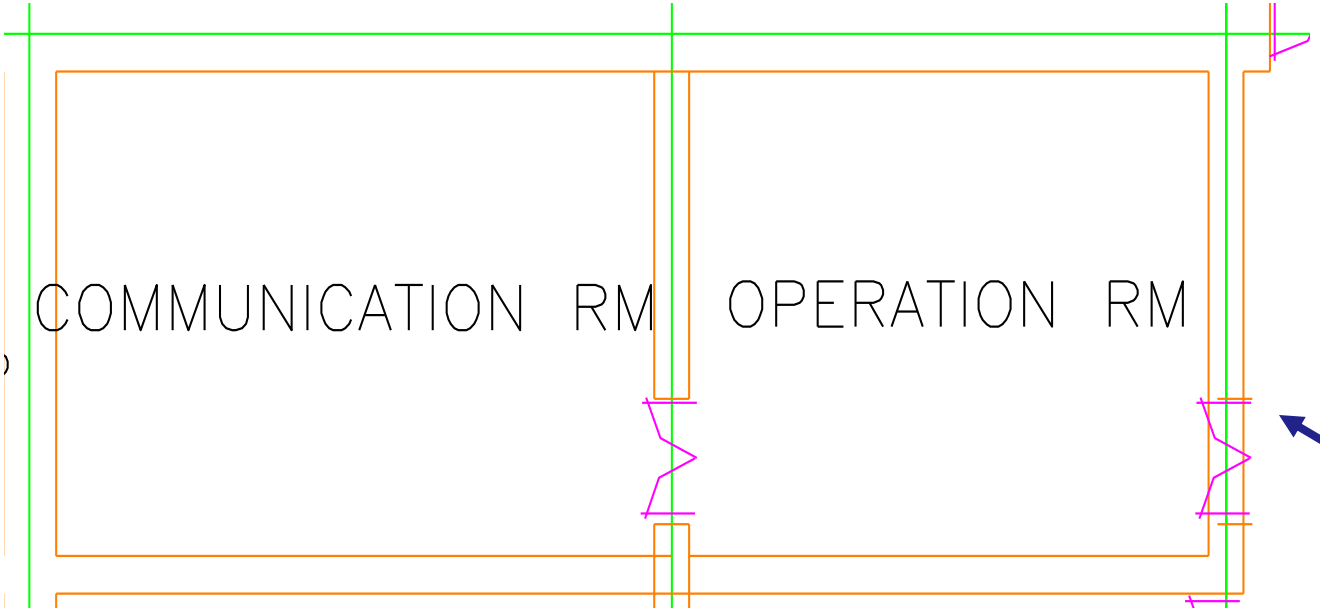


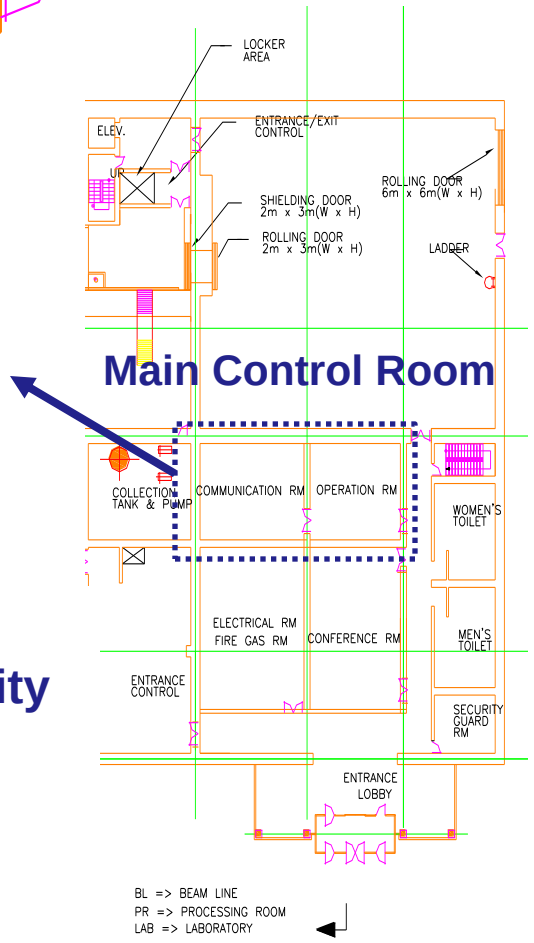
2F Control Room

2F LLRF racks (Control Room)

1F Measurement racks

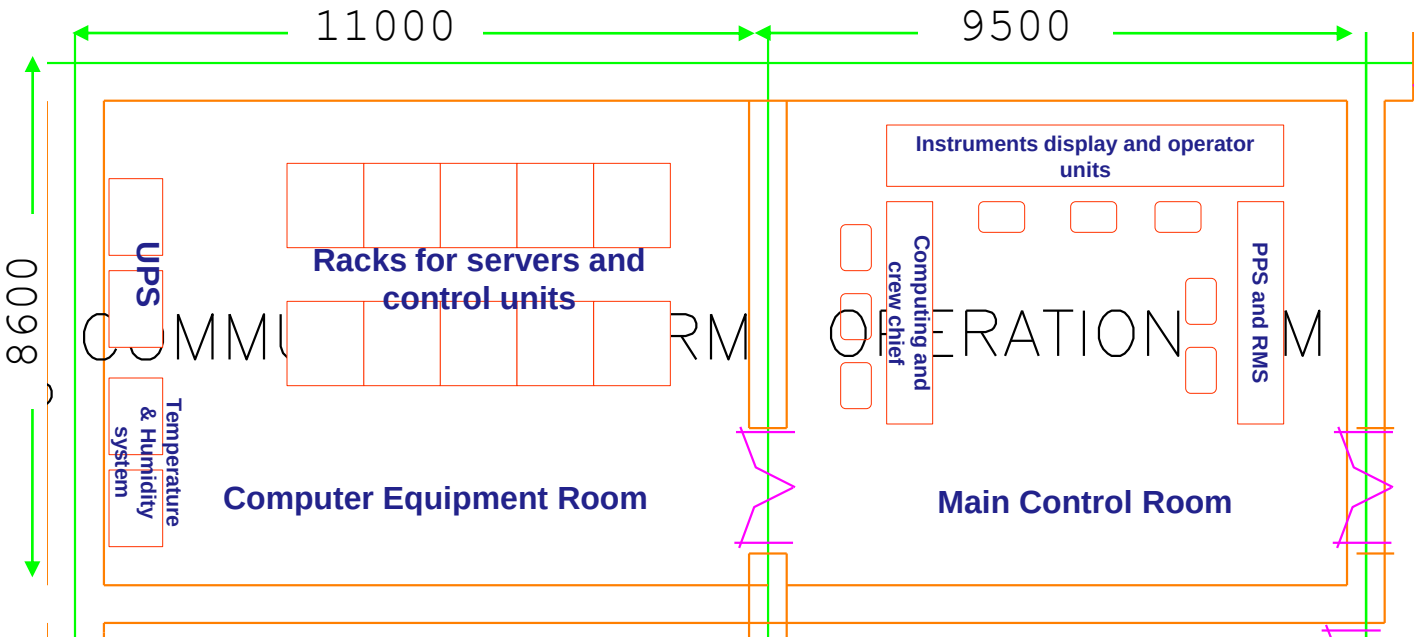
100 MeV Control Room at Gyeongju site





- MCR Located on the Ground Floor of the PEFP facility
- MCR of a Restricted Area
- Unauthorized Entry Prohibited
- Entry only by showing of access card

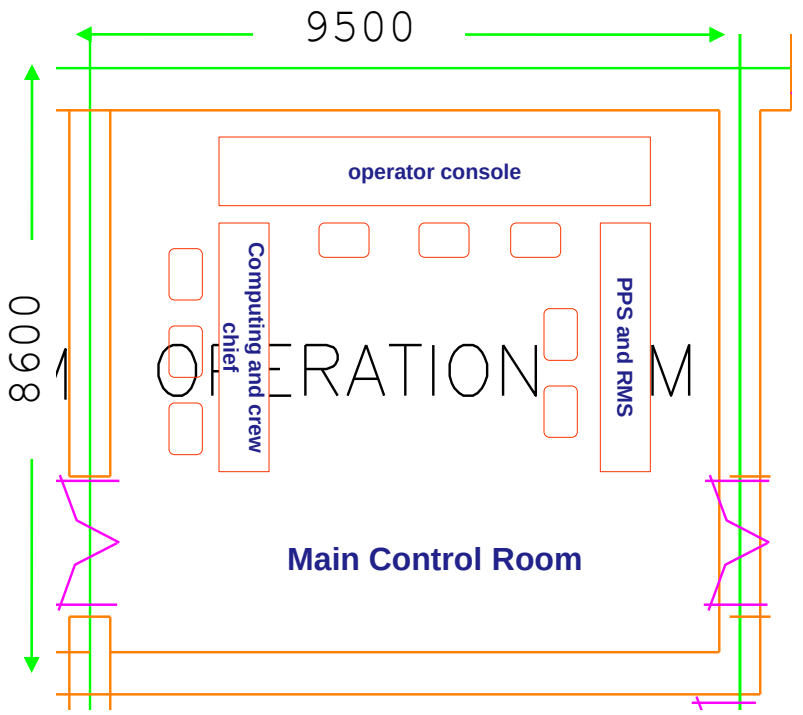
Basic Layout



- Size: 20 m × 8.6 m
  - Main control room : 9.5 m × 8.6 m, machine room : 11 m × 8.6 m
- Main Points
  - Access floor, Electric work, Computer equipments, Air conditioning
- Major Considerations
  - Constant temperature and humidity
  - Power cable, Signal cable, Network cable using duct of access-floor

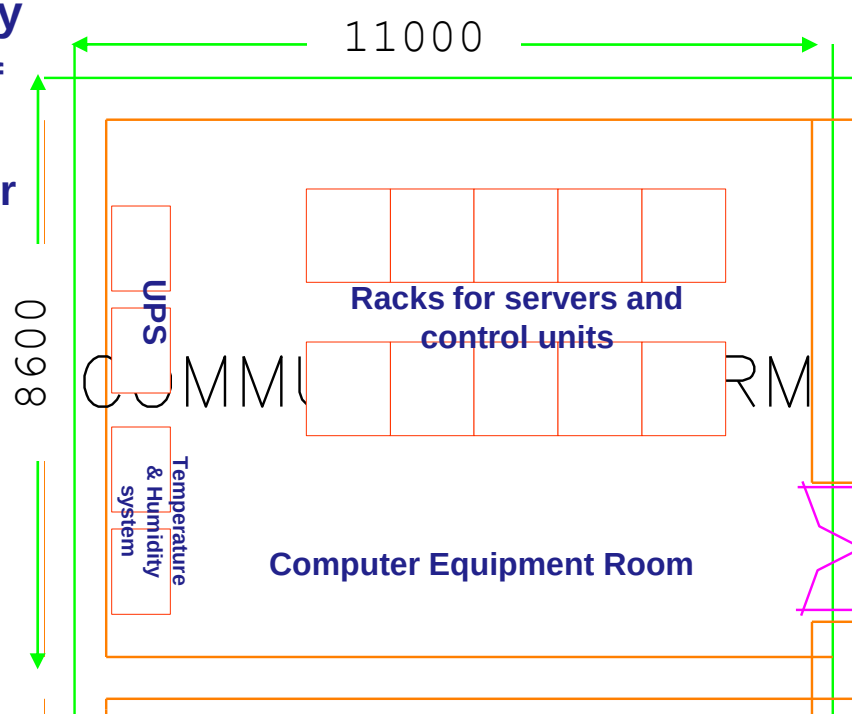
Control Room

- Design Factors :
  - Human traffic, Lighting effects, Temperature and humidity, Console layout
- Air conditioning
  - Temperature: 21 ~ 24°C
- Access Floor: Double Floor
- Display
  - OPI: 22" LCD 18 ea.
  - CCTV: 26" LCD 3 ea.
  - Display Wall : 26" LCD 4 ea.
  - LED : Safety Status
- Console Table
  - U-shaped array
  - House console and seating
    - Operator
    - PPS & RMS
    - Crew chief
- Console Layout
  - Decision of a console target
  - Accessibility among console targets
  - Classify the order of priority



Computer Equipment Room

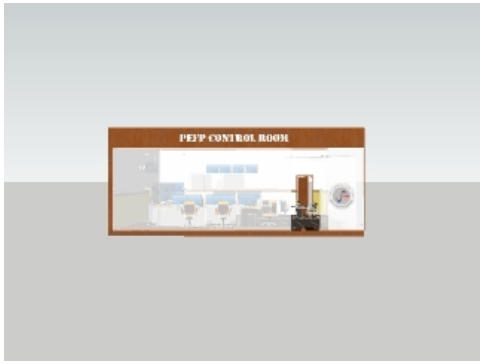
- Maintenance Consideration
- Constant Temperature and Humidity
  - 23°C ±2°C, 45 ~ 50% (a standard of machine room)
  - Down-flow type supplying air under access floor
- Automatic Fire Equipment
- Redundant UPS
- Access Floor : Double Floor
- Server: 10 ea.
  - OPI, Storage, Web, IOC
- Network System
  - Backbone
  - Workgroup switch
- 5 Racks: Computer Equipments

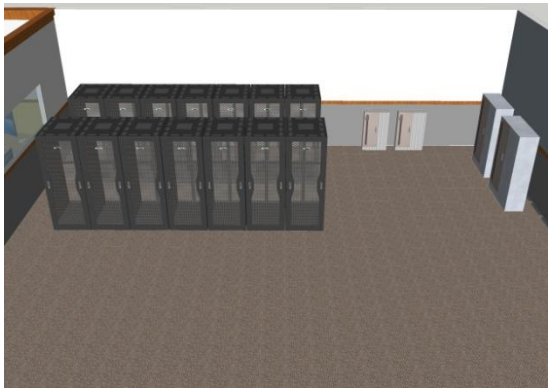


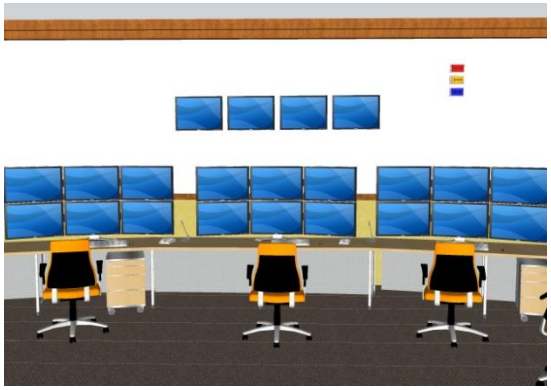
Main Control Room of the PEFP 100 MeV Accelerator

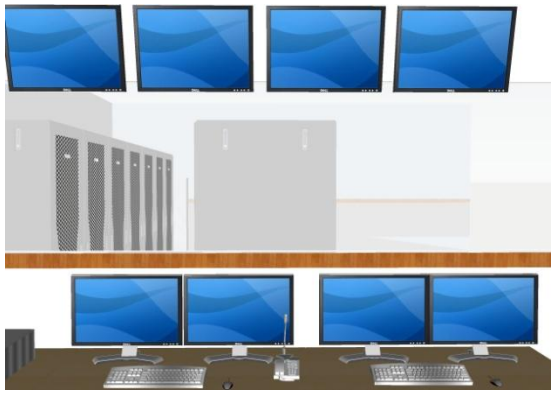
PEFP Proton Engineering Frontier Project

- U-shaped array
- Console and Seating
  - Operator
  - PPS & RMS
  - Crew chief
- Access Floor : Double Floor









Contents

Summary

PEFP Proton Engineering Frontier Project

- Network Distributed Control System using EPICS
- Integration Control Parameters using EPICS CA Protocol
- Cost-effective and high reliability
- Keep Optimization of EPICS IOC for the stability and reliability
- Main Control Room
  - Define target for control room design
  - Measure :use questionnaire to acquire operation information
  - Survey existing control system
  - Prepare draft design