# Status of the CSNS Control System


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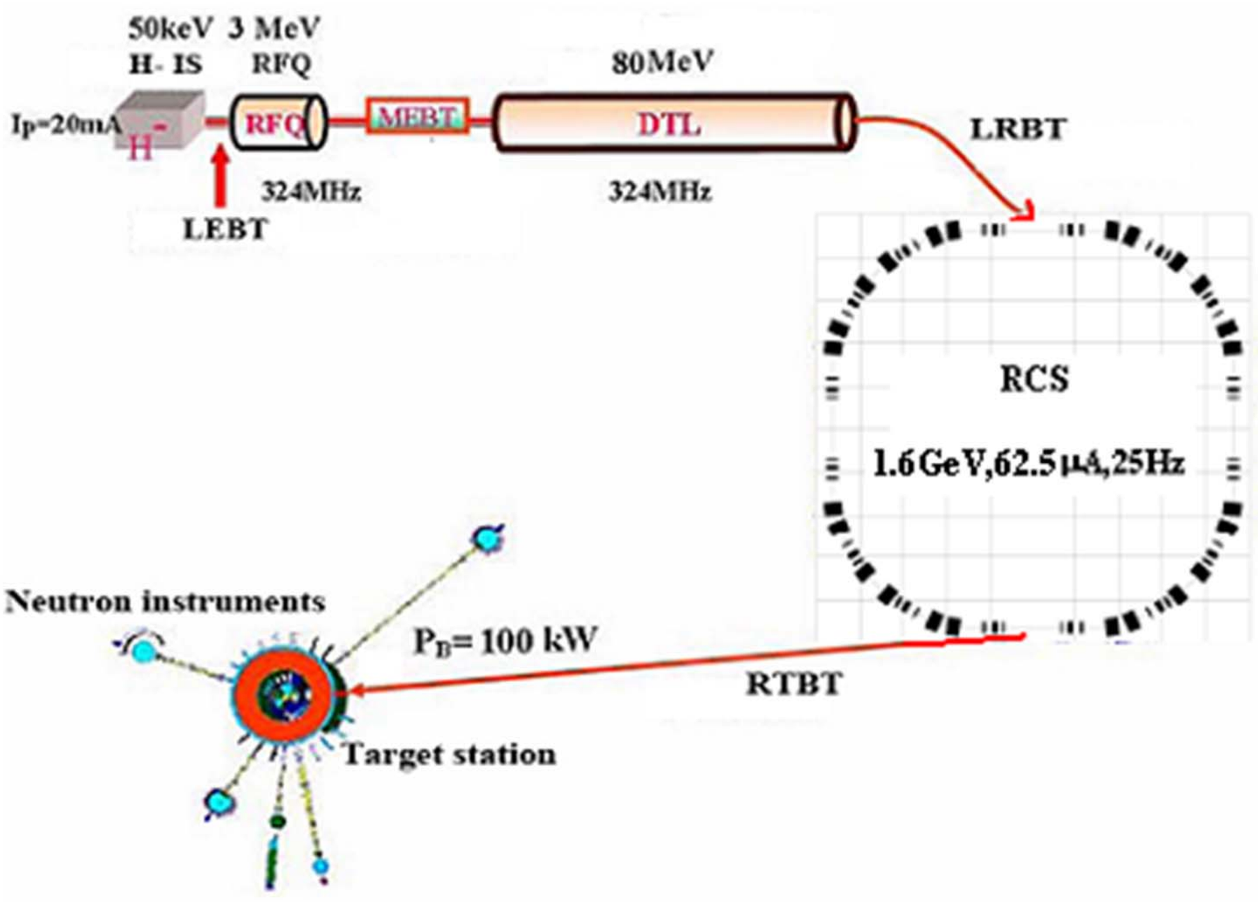
# Outline

- Project Overview
- Preliminary Design of the Control System
  - Control Task/Scope
  - System Architecture
  - Equipments Interface
  - Computers and Network
  - Consoles
- Prototype Progress
  - Ion Source Control System
  - Injection PS Control System
  - Timing System
- Time Schedule and Personnel Plan
- Summary

# CSNS Facility Layout

- The phase-I CSNS facility consists of an 80-MeV H- linac, a 1.6-GeV RCS, beam transport lines, a target station, and 3 instruments.

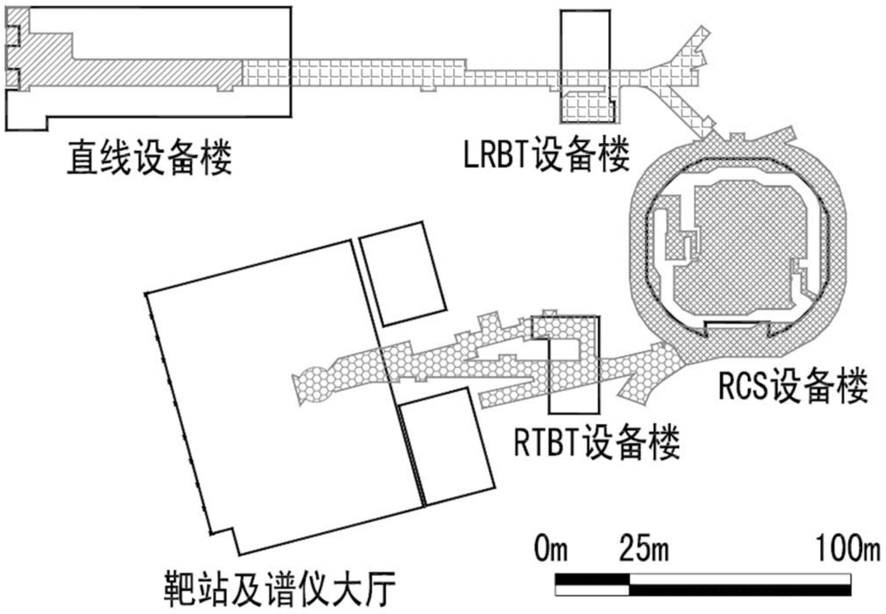


# Key Milestones

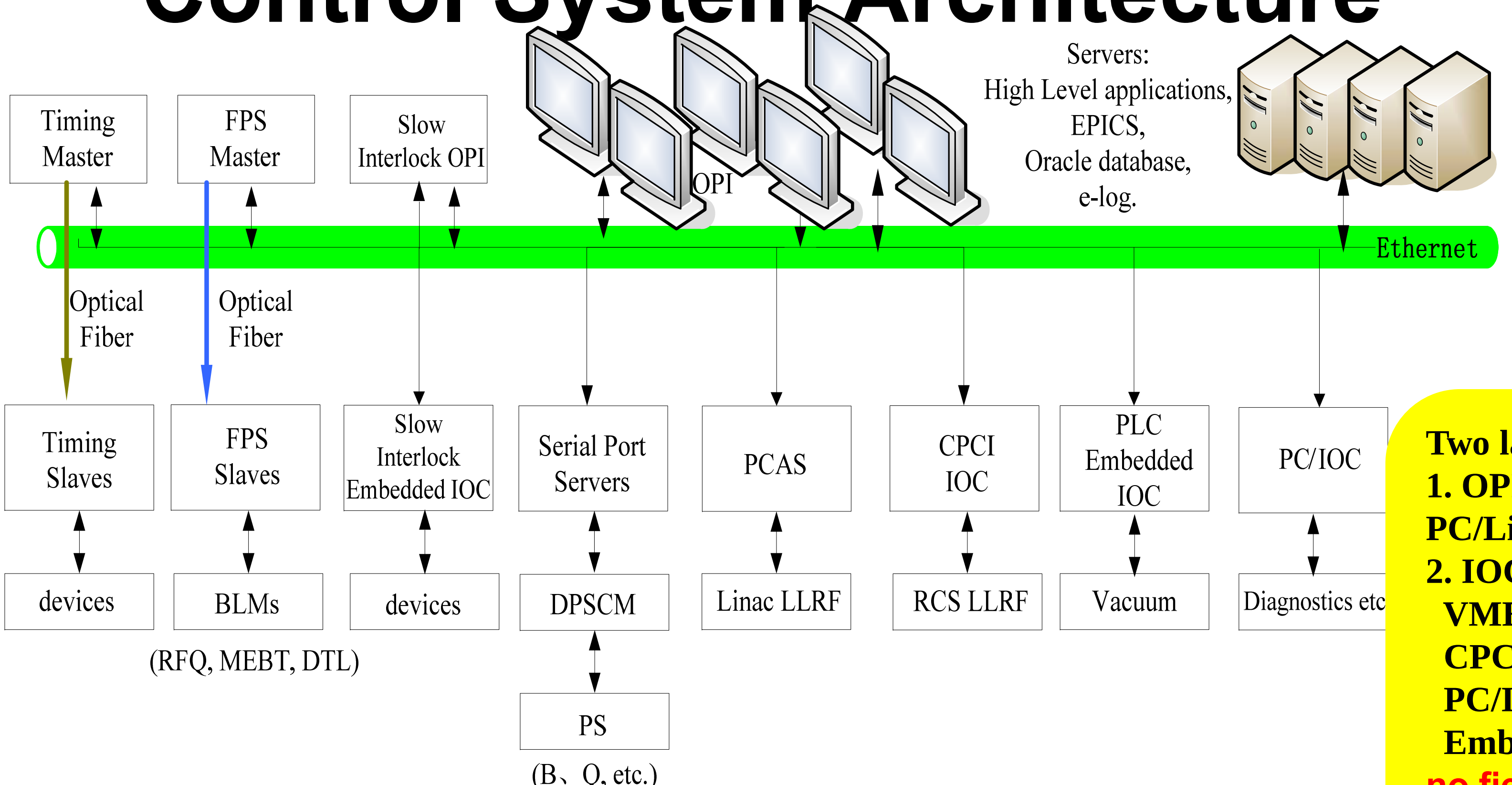
| | |
|---|---|
| February 2001 | idea of CSNS discussed |
| June 2005 | proposal approved in principle by the central government (CD-0) |
| January 2006 | CAS funded 30M CNY for R&D 1 |
| July 2007 | Guangdong funded 40M CNY for R&D 2 |
| December 2007 | proposal reviewed |
| September 2008 | proposal approved |
| October 2009 | feasibility study reviewed |
| April 2010 | site preparation start in Dongguan |
| February 2011 | feasibility study approved (CD-1) |
| May 2011 | preliminary design approved (CD-2) |
| September 2011 | construction start (CD-3) |

# Civil Engineering

- Total long-term construction site area is about 0.67km$^2$. 0.27km$^2$ has been planned for phase-I construction.
- Main buildings include Linac, RCS, transport line, target, with total area of 30,431m$^2$. Auxiliary buildings include administration, office, with total area of 36,258m$^2$.
- Detailed civil engineering design is in progress.



# Control System Architecture




**Two layer architecture**
**1. OPI:**
**PC/Linux/Windows**
**2. IOC**
**VME IOC**
**CPCI IOC**
**PC/IOC**
**Embedded IOC**
**no field bus to a third layer**

**extensive use:**

**serial interfaces from the lower layer to the equipments.**

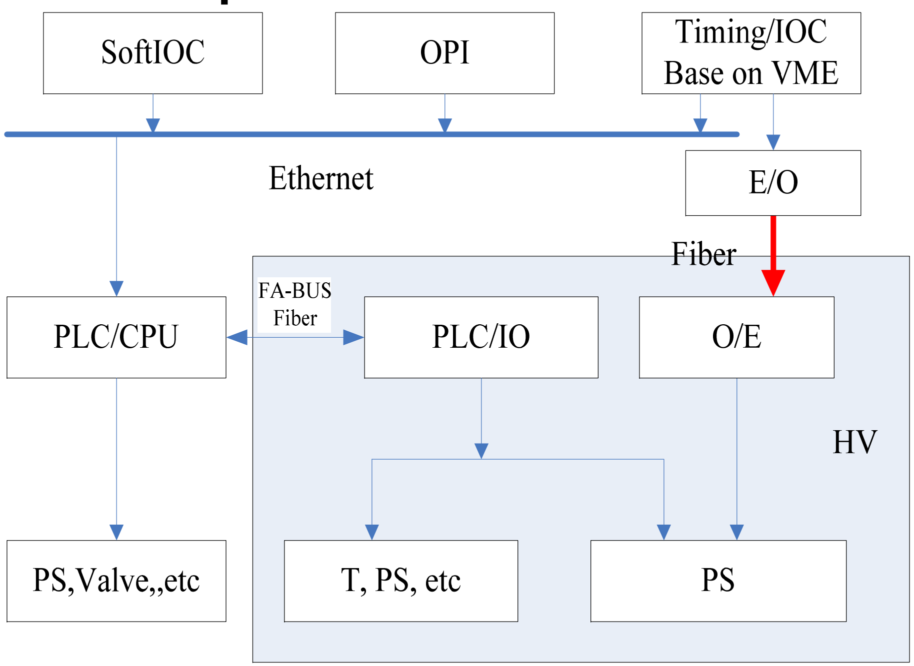
- **Control scope covers linac,LRBT,RCS,RTBT**
- **Overall task: thousands of equipments/devices**
- **IOCs :VMEIOC(MVME6100/VxWorks5.5),PC/IOC(Linux), Embedded I**
- **The preferred interfaces: analogue,digital and serial (RS232, RS485**
- **Software Version determined: EPICS 3.14.10/VxWorks5.5/Linux2.6**

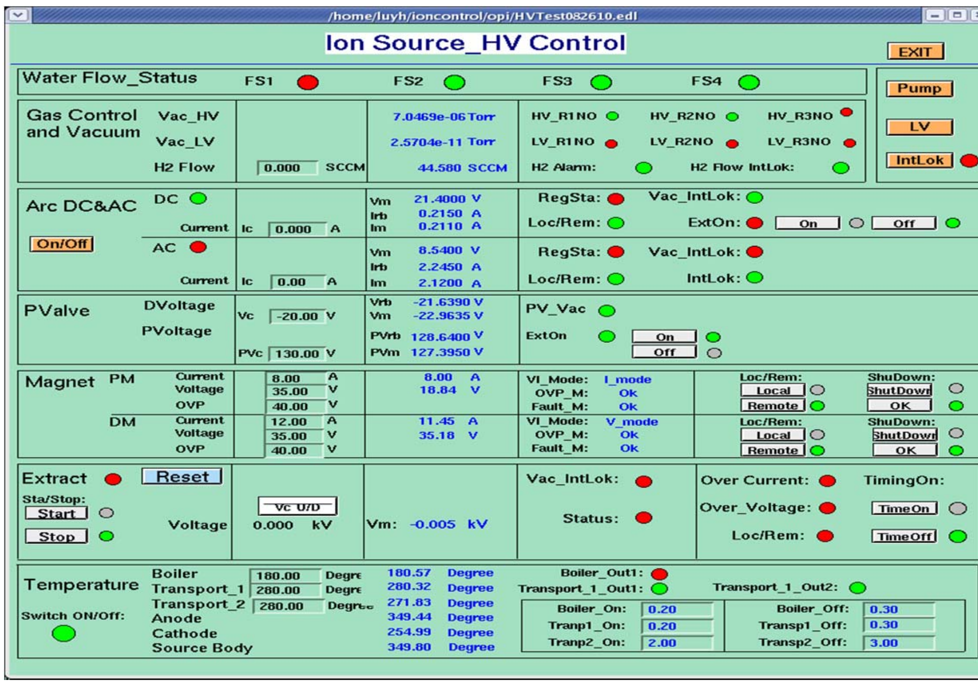
# Front-end Control Interface (determined)

- Front-end includes an Ion source,LEBT,RFQ and MEBT.
- The Ion source control system is typically a single component of the CSNS control system.
- It includes 5 parts:
  - power supplies, vacuum, temperature measurement, water cooling and timing.
- All are required to be controlled locally in the tunnel and remotely at the central control room.
- The power supplies work in the high voltage environment.
- Require the control system with high reliability and availability.

# Prototype of Ion Source Control

- A PC/Linux running softIOC exchanges the data with PLC/CPU via Ethernet.
- The PLC/CPU communicates with the PLC/IO (all inputs and outputs) modules through the FA-Bus Optical Fiber.
- No extra electrical isolation between the ground and high voltage platform.



# Prototype of Ion Source Control

- Some experience and lessons are learn by the prototype of H －ion source control system:
- “Ground” isolation
- temperature modulation (from relay switching on/off to PID control)
- more details specification of device interface
- processing control of high voltage ramping and so on.
- Next step, the embedded PLC/IOC will be used to replace the combination of the softIOC and the PLC/CPU.

# Prototype of Ion Source Control

- Some experience and lessons are learn by the prototype of H －ion source control system:
- “Gr
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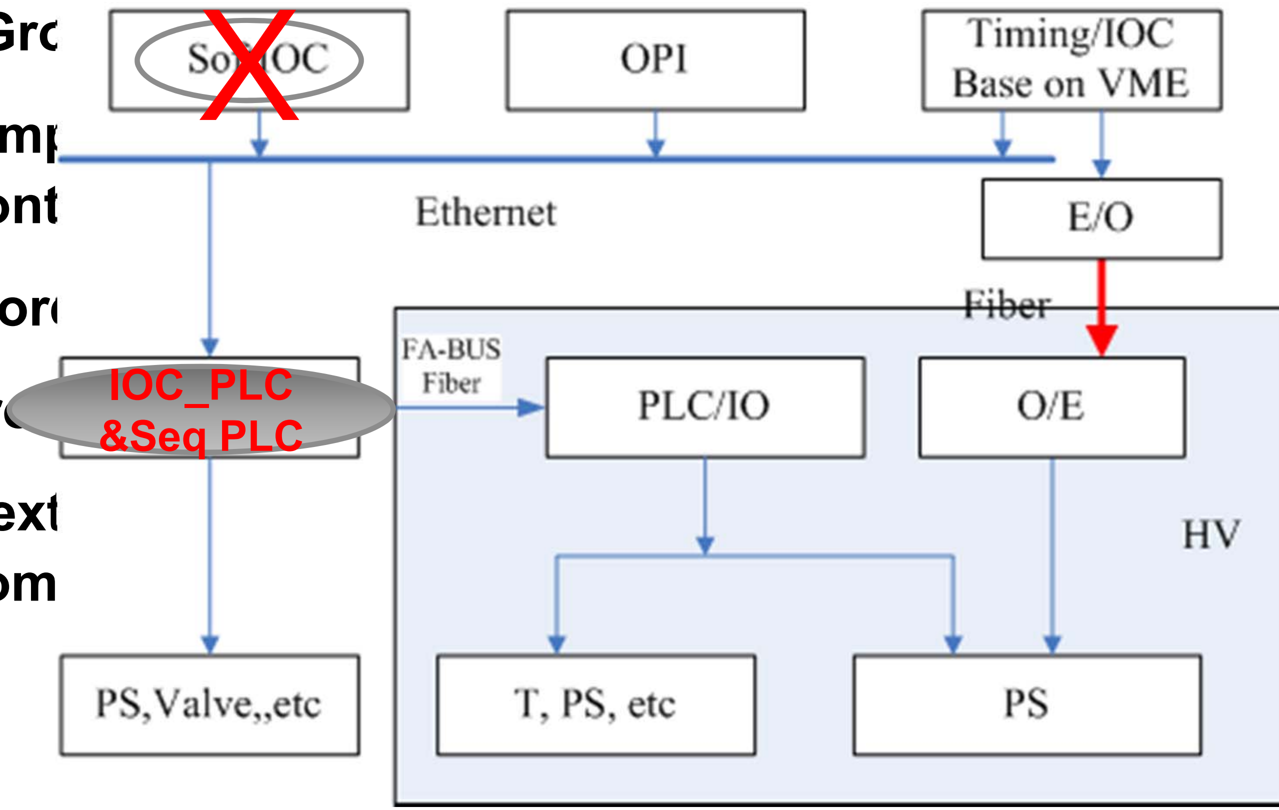
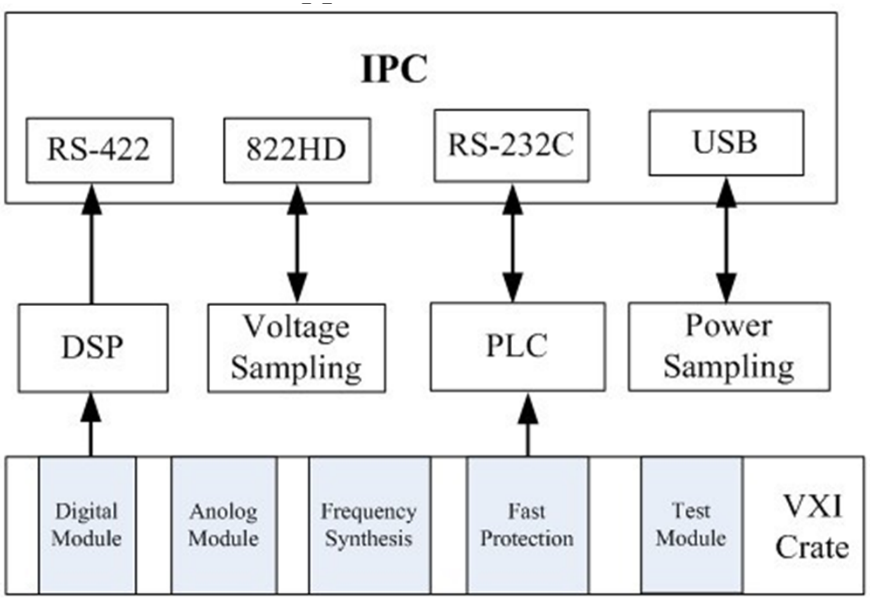
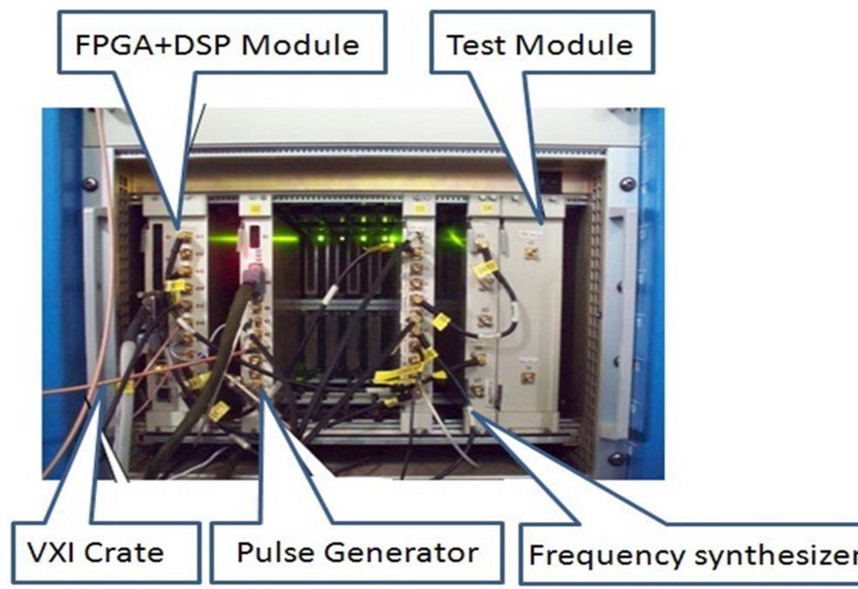


# Linac LLRF interface

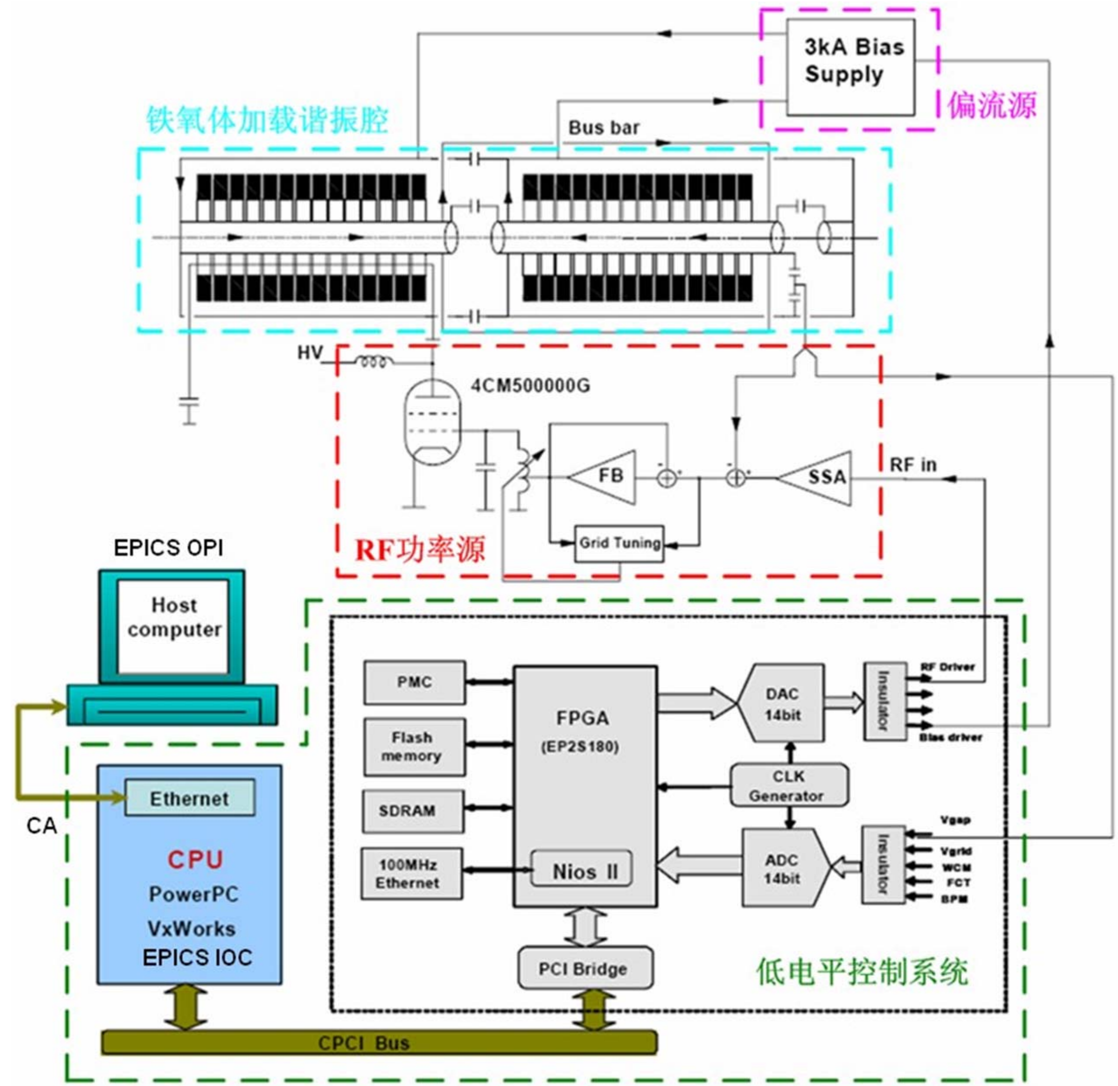
- **Linac LLRF consists of a VXI crate and customized I/O modules and a PC through RS422. It has been done by Linac RF group**
- **Use PCAS to communicate with the API of the LLRF change local variable into EPICS PVs**



# RCS LLRF Interface (determined)

- RCS LLRF will be implemented using customized CPCI I/O modules by RCS RF group.
- The control system needs to develop EPICS driver and database to interface with VxWorks driver supported by the company.



# Power Supply Control

- CSNS power supplies will use digital power supplies using the Digital Power Supply Control Module (DPSCM) developed by the Power Supply Group.
- The DPSCM is an intelligent power supply controller with serial port supporting Modbus RTU /RS232.
- The DPSCM implemented logic control to the digital power supplies. Most work can be done within the DPSCM and power supply.

# Power Supply Families

| Name | Type | Qt. (sets) |
|---|---|---|
| DTL-Q | DC | 98 |
| LEBT-S | DC | 3 |
| LEBT-B | DC | 4 |
| MEBT-Q | DC | 8 |
| MEBT-B | DC | 16 |
| LRBT-B | DC | 3 |
| LRBT-Q | DC | 22 |
| LRBT-C | DC | 21 |
| RTBT-B | DC | 4 |
| RTBT-Q | DC | 31 |
| RTBT-C | DC | 21 |
| RTBT-OCT | DC | 2 |
| RCS-S | DC | 2 |
| RCS-Corrector | DC (fast response, 25Hz, trigger) | 58 |
| RCS-B | DC+AC(25Hz, sine wave, trigger) | 1 |
| RCS-Q | DC+AC (25Hz, MW power) | 5 |
| TOTAL | | 303 |

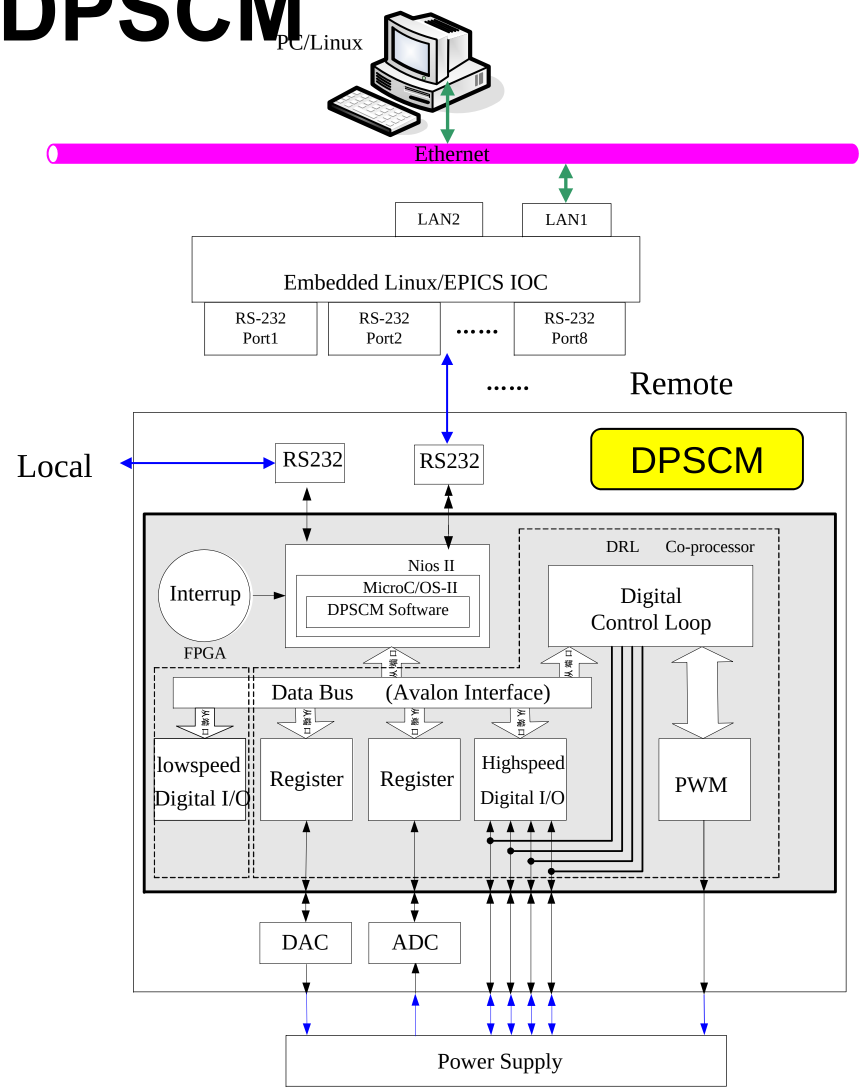
**PS in Linac,LRBT,RTBT almost same:**
**DC PS: regular**

**PS in RCS special:**
**AC 25Hz sine waveform**

**Although these PS are different, the control interface to the different PS will be standardized.**

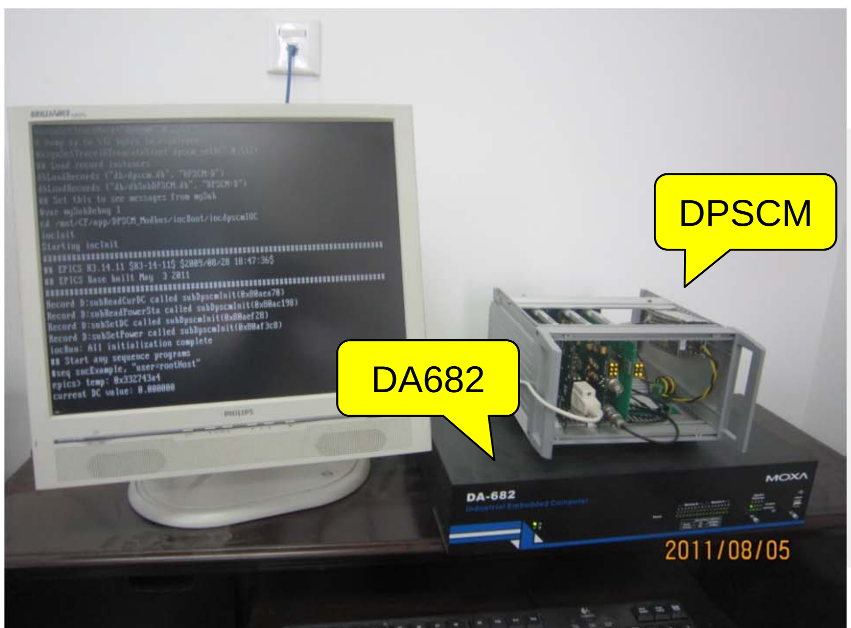
# The interface to the DPSCM

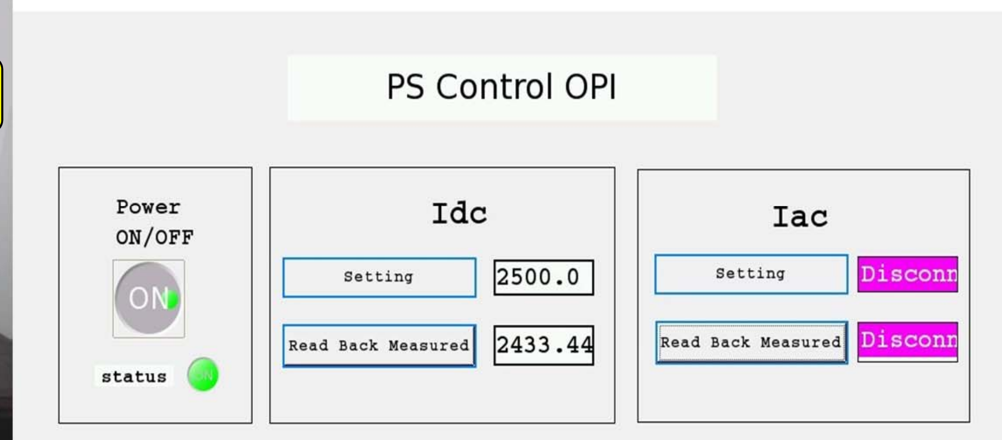
- Use MOXA embedded serial device communicate with the DPSCM
- MOXA DA682 has 2 ethernet ports and 8 serial ports
- MOXA DA682 running Linux as EPICS IOC, developing
- Modbus RTU driver
- Modbus RTU EPICS driver
- Modbus RTU EPICS device support



# Progress of the PS remote control

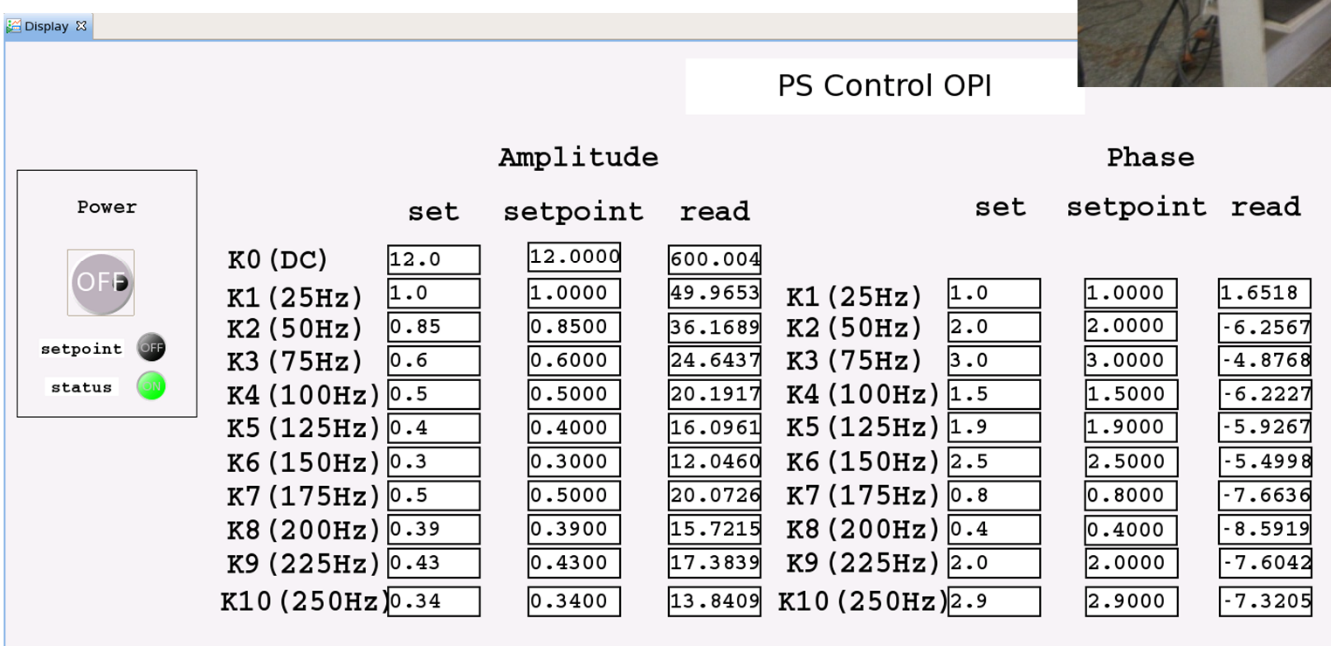
- **MOXA DA682/EPICS IOC has been tested with the DPSCM**
  - **Modbus RTU communication driver**
  - **Modbus RTU EPICS driver**
  - **Modbus RTU EPICS device support**
  - **Databse and OPI with CSS**



# Testing with the PS on site

- In August, the MOXA DA682/EPICS IOC has been tested with the DPSCM and a power supply
- It works fine now



Display

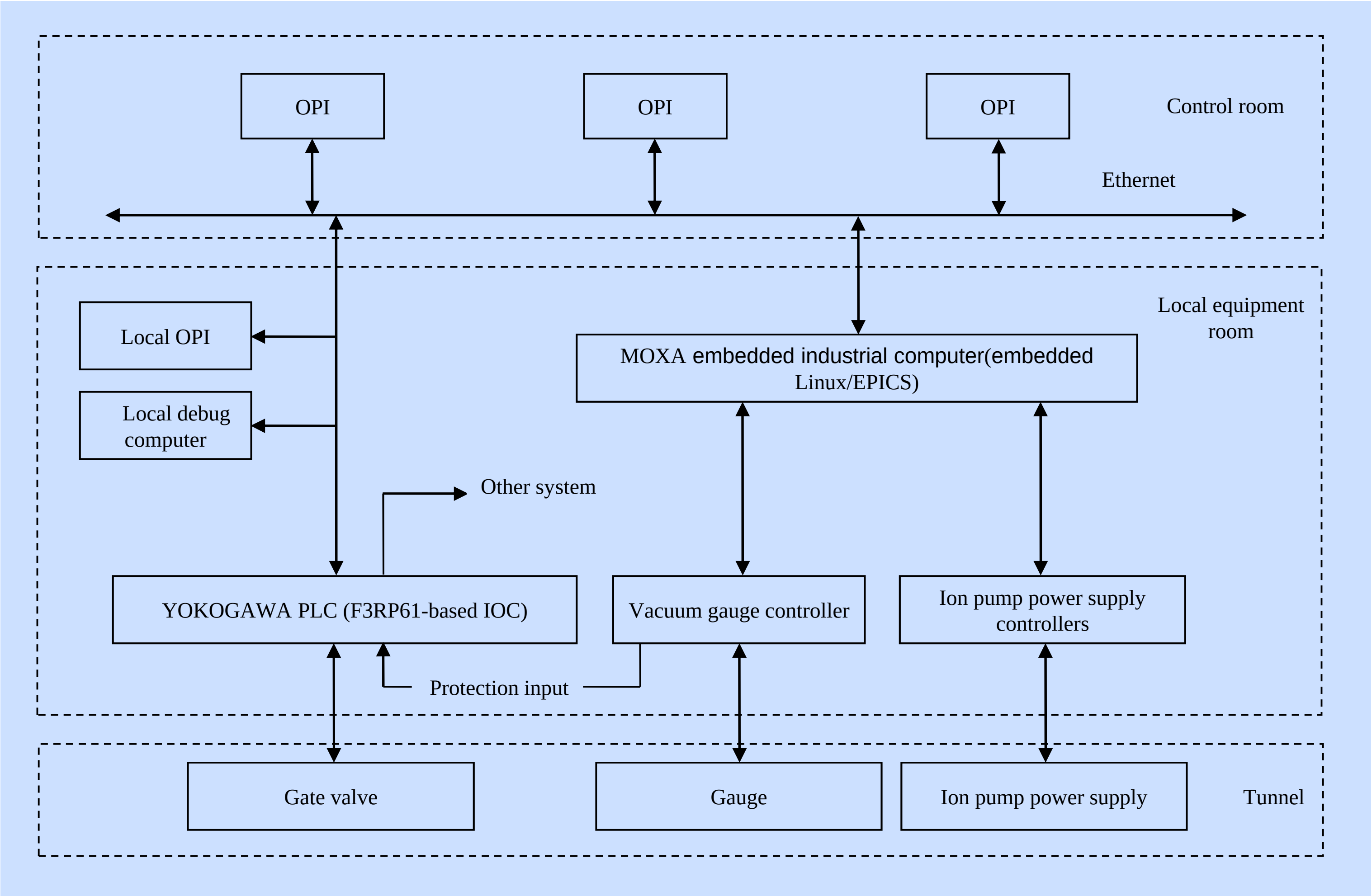
PS Control OPI

Power: OFF — setpoint: OFF — status: ON

| | Amplitude set | Amplitude setpoint | Amplitude read | | Phase set | Phase setpoint | Phase read |
|---|---|---|---|---|---|---|---|
| K0 (DC) | 12.0 | 12.0000 | 600.004 | | | | |
| K1 (25Hz) | 1.0 | 1.0000 | 49.9653 | K1 (25Hz) | 1.0 | 1.0000 | 1.6518 |
| K2 (50Hz) | 0.85 | 0.8500 | 36.1689 | K2 (50Hz) | 2.0 | 2.0000 | -6.2567 |
| K3 (75Hz) | 0.6 | 0.6000 | 24.6437 | K3 (75Hz) | 3.0 | 3.0000 | -4.8768 |
| K4 (100Hz) | 0.5 | 0.5000 | 20.1917 | K4 (100Hz) | 1.5 | 1.5000 | -6.2227 |
| K5 (125Hz) | 0.4 | 0.4000 | 16.0961 | K5 (125Hz) | 1.9 | 1.9000 | -5.9267 |
| K6 (150Hz) | 0.3 | 0.3000 | 12.0460 | K6 (150Hz) | 2.5 | 2.5000 | -5.4998 |
| K7 (175Hz) | 0.5 | 0.5000 | 20.0726 | K7 (175Hz) | 0.8 | 0.8000 | -7.6636 |
| K8 (200Hz) | 0.39 | 0.3900 | 15.7215 | K8 (200Hz) | 0.4 | 0.4000 | -8.5919 |
| K9 (225Hz) | 0.43 | 0.4300 | 17.3839 | K9 (225Hz) | 2.0 | 2.0000 | -7.6042 |
| K10 (250Hz) | 0.34 | 0.3400 | 13.8409 | K10 (250Hz) | 2.9 | 2.9000 | -7.3205 |

# Vacuum Control

- 128 ion pump power supply controllers, 45 vacuum gauge controllers and 27 gate valves in linac, LRBT and RCS,RTBT



# Injection/Extraction Control

- The RCS injection system includes 8 painting bump magnets
    - 4 are used for horizontal, powered by BHPS
    - 4 are used for vertical, powered by BVPS.
- 8 kicker magnets and 8 kicker pulse power supplies.
- The interface to these PS has been determined.
- The ON/OFF control of these PS will be implemented by YOKOGAWA PLC.
- The ZTEC oscilloscope (1GS/S, 300MHz, 12 bits, 2 Ch) with a built-in EPICS system is selected to get the charge voltage and pulse current of the extraction PS
- The YOGOKAWA WE7000 measurement system was used for Injection PS waveform setting and readback
    - Tested with the prototype of the bump PS in 2009.12

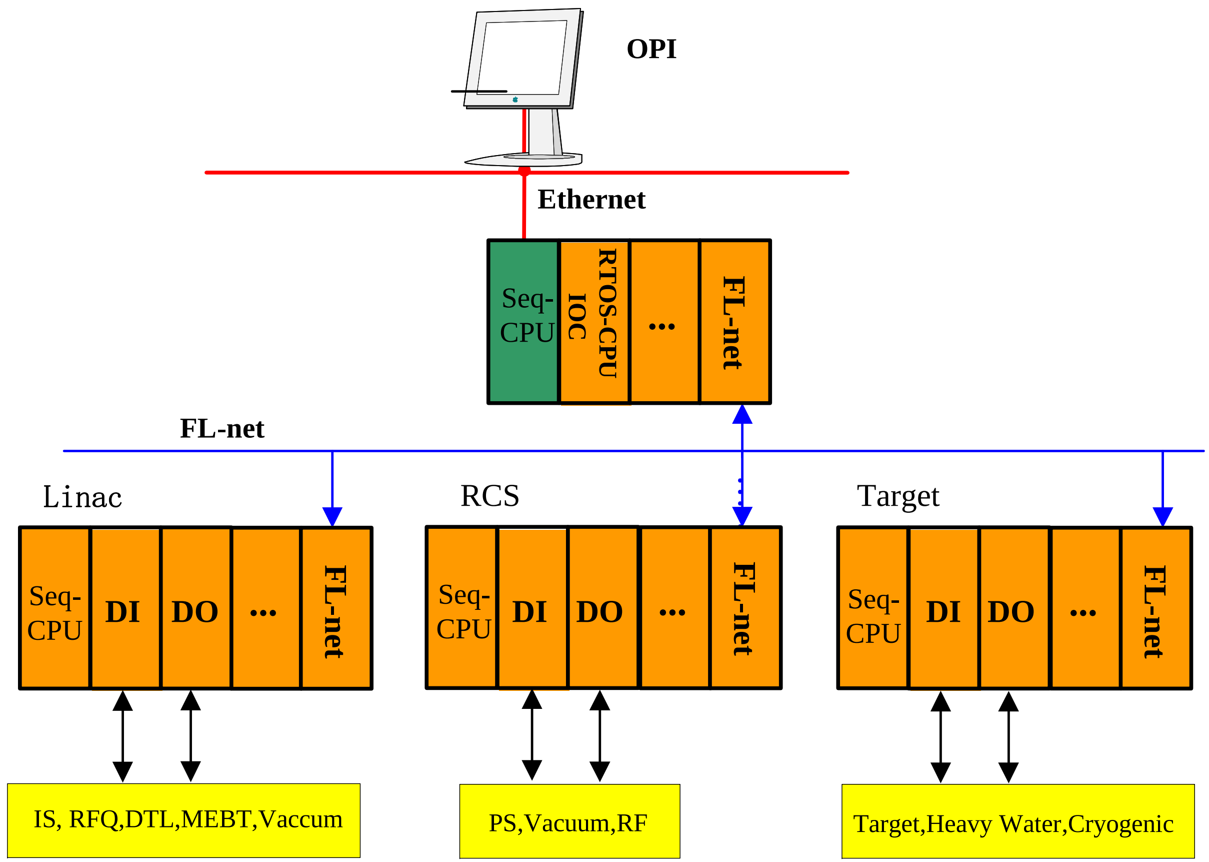
# Machine Protection System

- It consists of two parts
- Equipment Protection System
  - For collecting signals and detecting internal faults  from the equipments in Linac、RCS、Target、PPS . When any equipments fault occur，it performs alarm handler and stop beam to avoid damage due to thermal effects.
- Fast Protection System
  - Monitor BLM，once beam loss exceeds loss limit, shut down Ion source to avoid damage due to radiation and thermal effects.
- Besides，display status of the equipments
- Allow automatic recovery from beam faults.

# Equipment Protection System

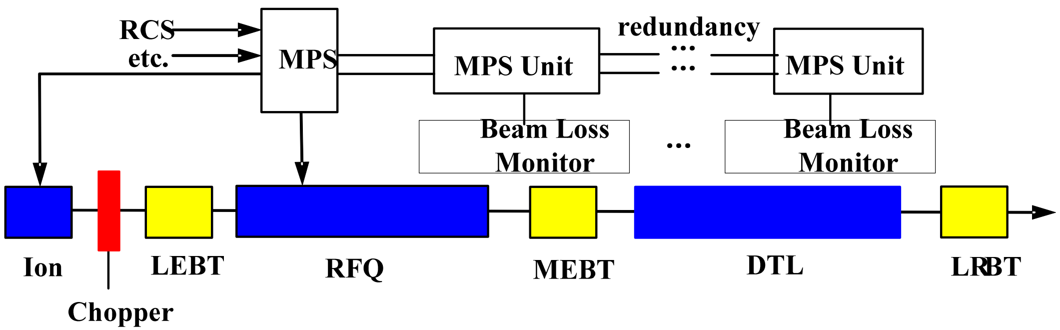
- Consists of one central PLC and several PLC stations
- Collect signals and propagate the state signals of Linac, RCS and Target through the FL_Net to the Master PLC.

- The FL_Net can accomplish data scanning within 200μs.
- The communication speed of FL_Net can be up to 10Mbps.
- The response time from a fault signal of the equipments to action within 20ms

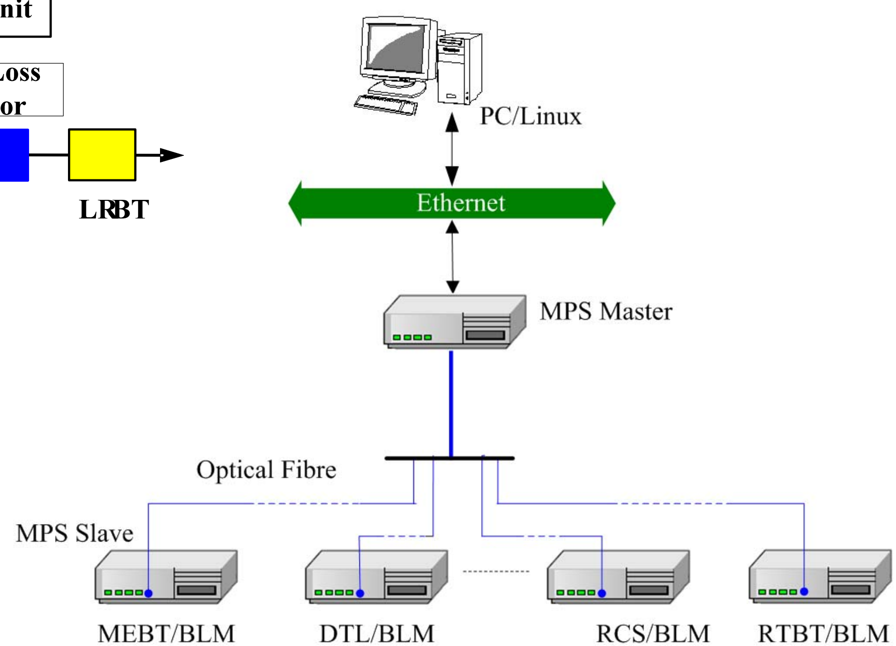


# Fast Protection System

- **FPS interface to BLM, once beam loss exceeds loss limit, shut down Ion source and drop RFQ Voltage to zero within 20 μs to avoid damage due to radiation and thermal effects**



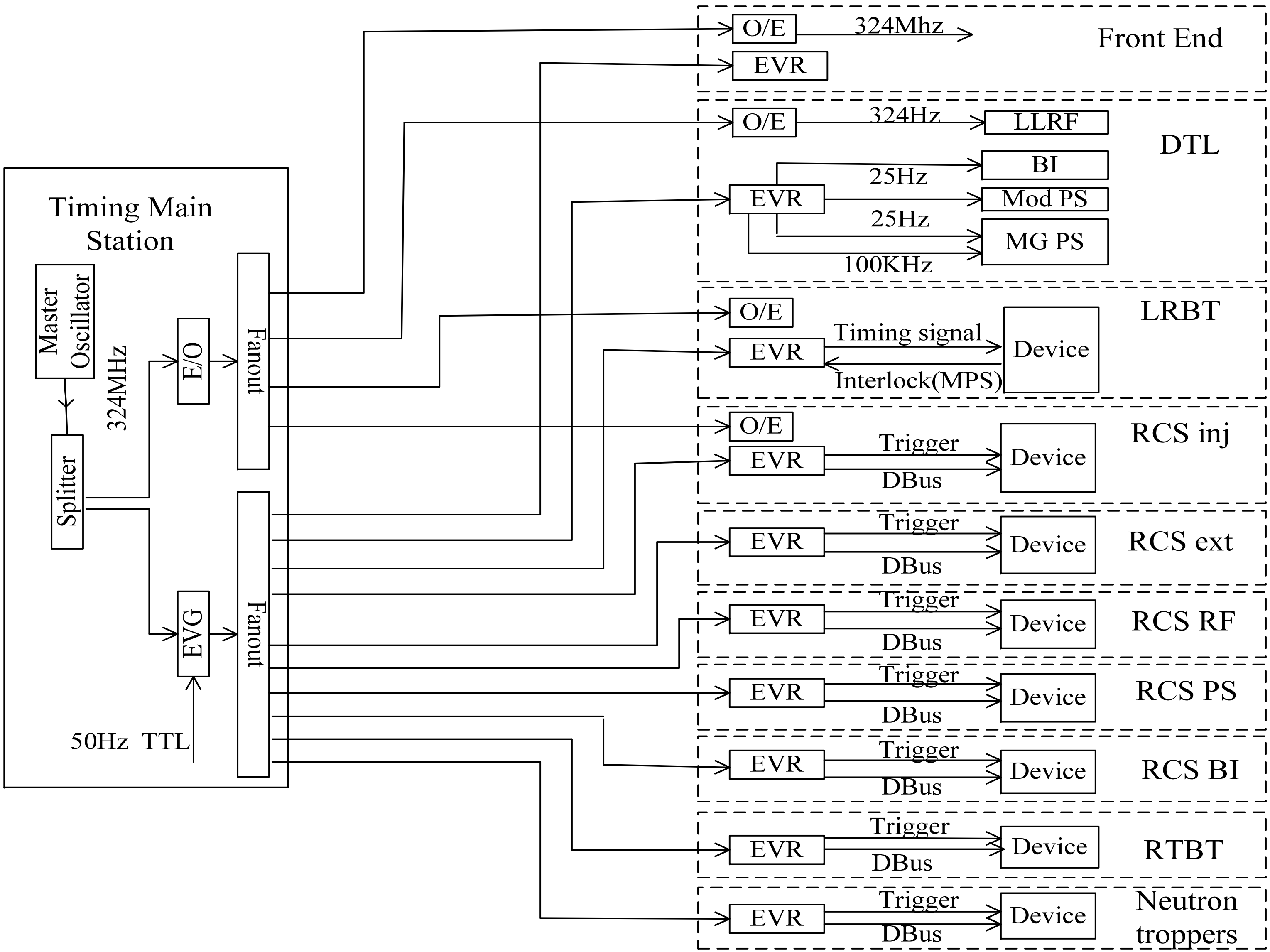

- **FPS Master communicates with FPS slave via optical link.**
- **Fast responses are handled in FPGA (Xilinx Spartan 6)**
- **Global response time: 20 μs**
- **Easily extend with new control points**



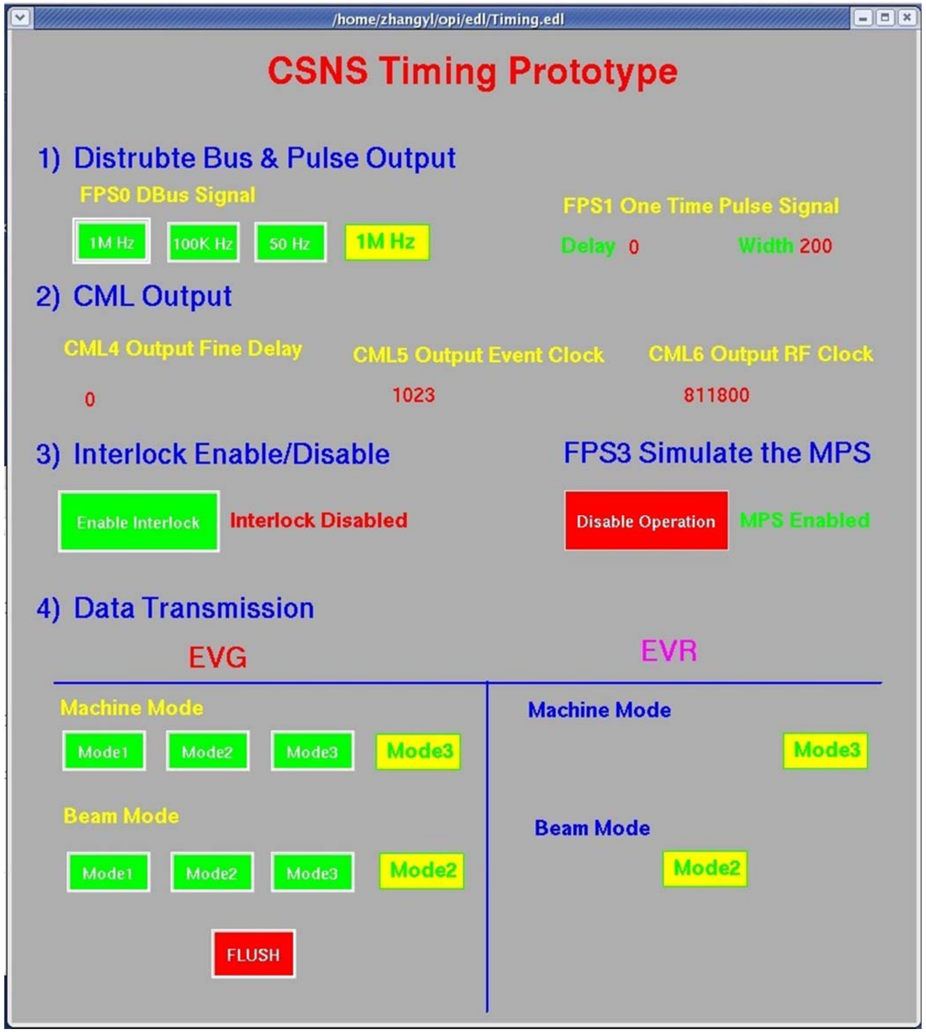
# Timing System

- Timing system is designed to provide triggers and clocks to the following systems
  - Front end, linac RF, injection, beam instrumentation, magnet power supply, RCS RF, extraction, spectrameter and target
- Detailed discussions with the above systems have been done, while there are still some points need to be studied further.
- Prototype using EVG/EVR has been setup.

# Timing System Structure



# Prototype using EVG/EVR



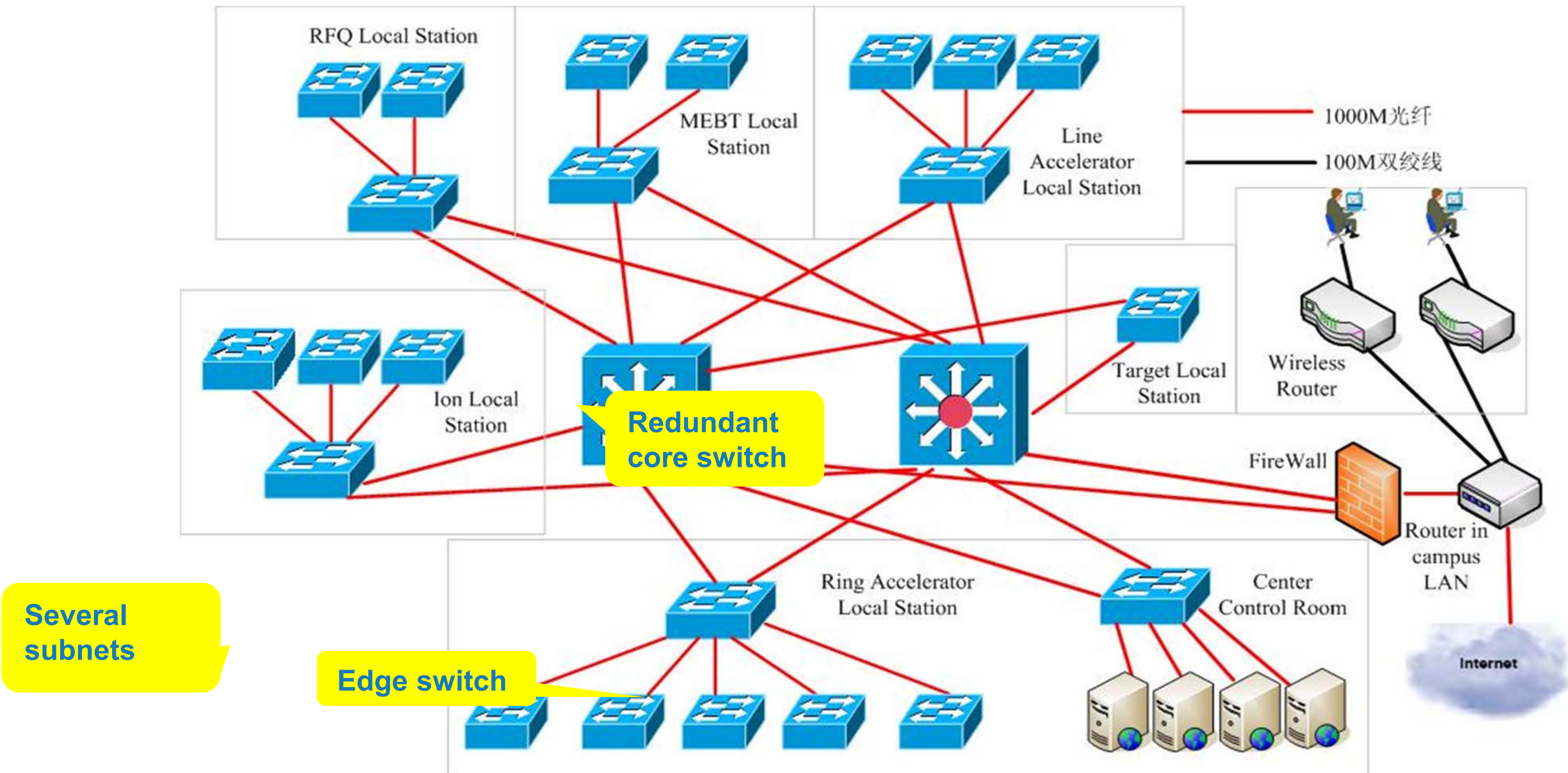

| Test Items | Specifications | Test Results |
|---|---|---|
| Trigger Signal Frequency | 25Hz | 25Hz |
| Trigger Signal Rise Time | <5ns | 490ps |
| Trigger Signal Delay Step | 5ns | 630ps（CML Output）<br>12.4ns（TTLOutput） |
| Trigger Signal Delay Scope | 1ms | 12.3ms |
| Trigger Signal Width | 1us ~ 1ms | 12.4ns~37ms |
| Trigger signal Jitter（Reference to 324MHz Agilent oscillator） | <1ns | <90ps（Pk-Pk）<br>（Jitter of oscilloscope is 40ps） |
| Dbus Signal Frequency | 100KHz | 100KHz |
| Dbus Signal Rise time | | 529ps |
| DBus signal Jitter Reference to 324MHz Agilent oscillator | | 84ps（Pk-Pk）<br>Jitter of oscilloscope is 40ps |

Acceptance test at lab in 2/09/2011

# Application Software

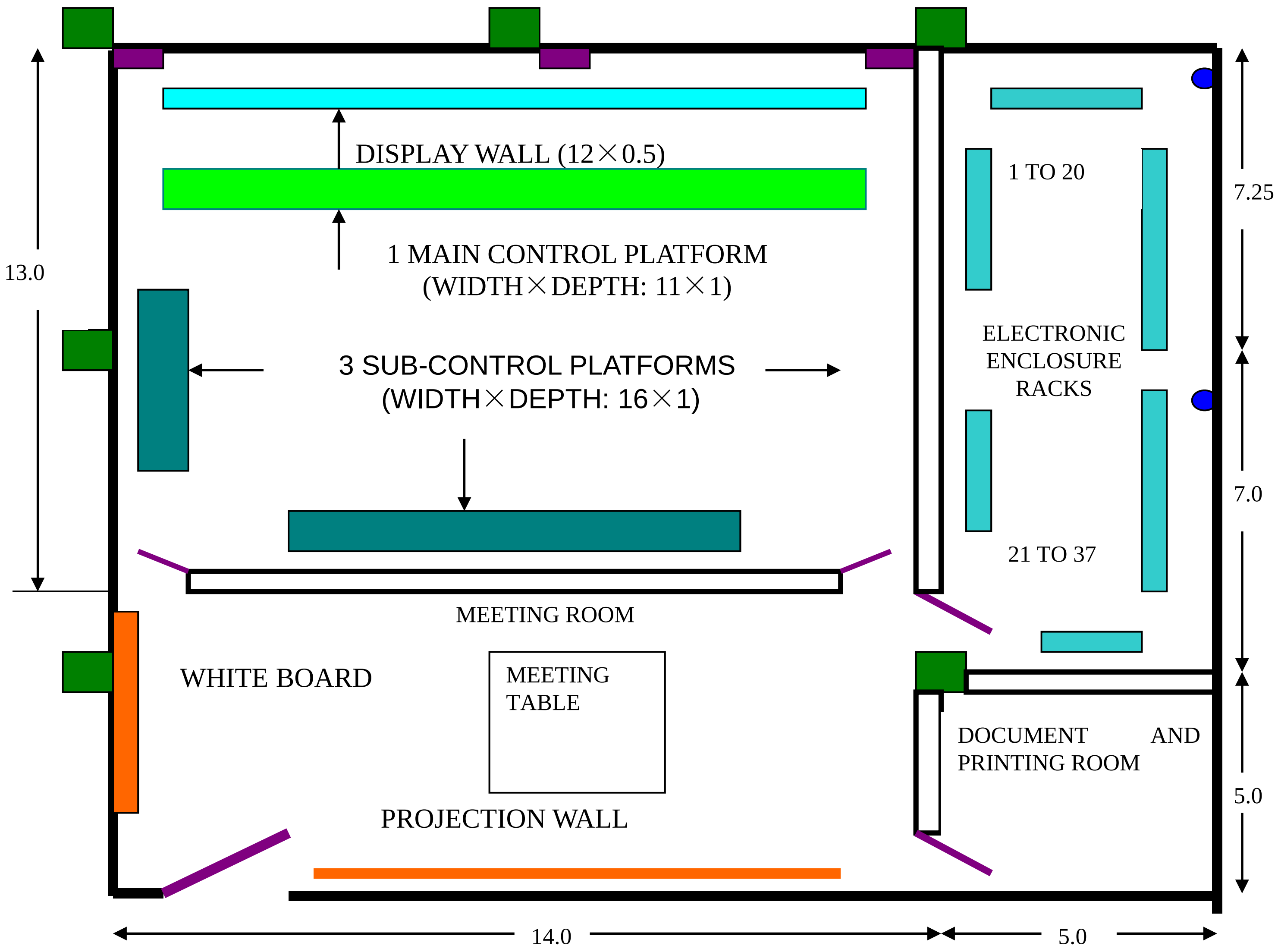
- Device application: EPICS tools
  - Control panels: EDM or CSS
  - Alarm management: Alarm Handler
  - Archiving: Channel Archiver together with Oracle database.
  - Web-based control panel is planned to be developed
    - Interface to IE
- High level application: XAL
  - Some XAL work in CSNS has been done
  - The control system provides platform
  - The AP group for coding development

# Topology of the control system network




- **100Mbit switched Ethernet with a Gigabit switched Ethernet backbone.**
- **A firewall inside the core switch for access from the campus network to the control network. EPICS CA gateway for the different IOC PV access and effective management of traffic and security.**

# Central Control Room Layout (the size in meter)



# Time Schedule

- System development: 2 years
- Some subsystem installation: from 12/2012
- Installation and testing: complete in 2/2016
- Online system commissioning: 3 months
- Expecting complete in 5/2016
- Put system into operation

# Personnel Plan

- The control group is not only responsible for the CSNS control system construction, but also for the BEPCII control system maintenance.
- Currently 12 persons in the group (part-time)
- 6 young persons for the CSNS (full-time)
- At the R&D stage: 12
- At the development and construction stage: 21
- At the maintenance stage: 15
- Some students: good help

# Summary

- Preliminary design: complete
- Device interface determined
- R&D prototype: complete
- Recent accomplishments
  - The remote interface to the digital power supply has been decided. The prototype is working fine.
  - Timing prototype has been accepted in early September
- Next step:
  - Start MPS, Vacuum Control, RFQ control, DTL control…
  - Setup Application Development Environment (ADE)
  - System Integration
  - …….

# Thanks for your attention!