中国散裂中子源

Introduction of CSNS Control

Control Group

Feb.13 , 2009

CSNS
CHINESE ACADEMY OF SCIENCES

Outline

- **Overview**
  - Primary design parameters/Milestones
  - Site and effective drawing
  - Control Architecture Based on EPICS
  - Standardization
- **CSNS Control System**
  - Globle control: Computer, Network, MPS, PPS…
  - Front End control: PS, VA, LLRF, Ion, Injection/Extraction…
  - Commissioning Software: XAL…
  - Other interface control: CF, target, spectrometer…
- **WBS and Manpower**

Primary design parameters

Phase	I	II	ultimate
Beam power on target [kW]	120	240	500
Beam energy on target [GeV]	1.6	1.6	1.6
Ave. beam current [μA]	76	151	315
Pulse repetition rate [Hz]	25	25	25
Protons per pulse [10^{13}]	1.9	3.8	7.8
Linac energy [MeV]	81	130	230
Linac type	DTL	DTL	DTL+SCL
Target number	1	1	2
Target material	Tungsten		
Moderators	H_2O (300K), L-H_2(20K) coupled & decoupled		
Number of spectrometers	3	18	>18

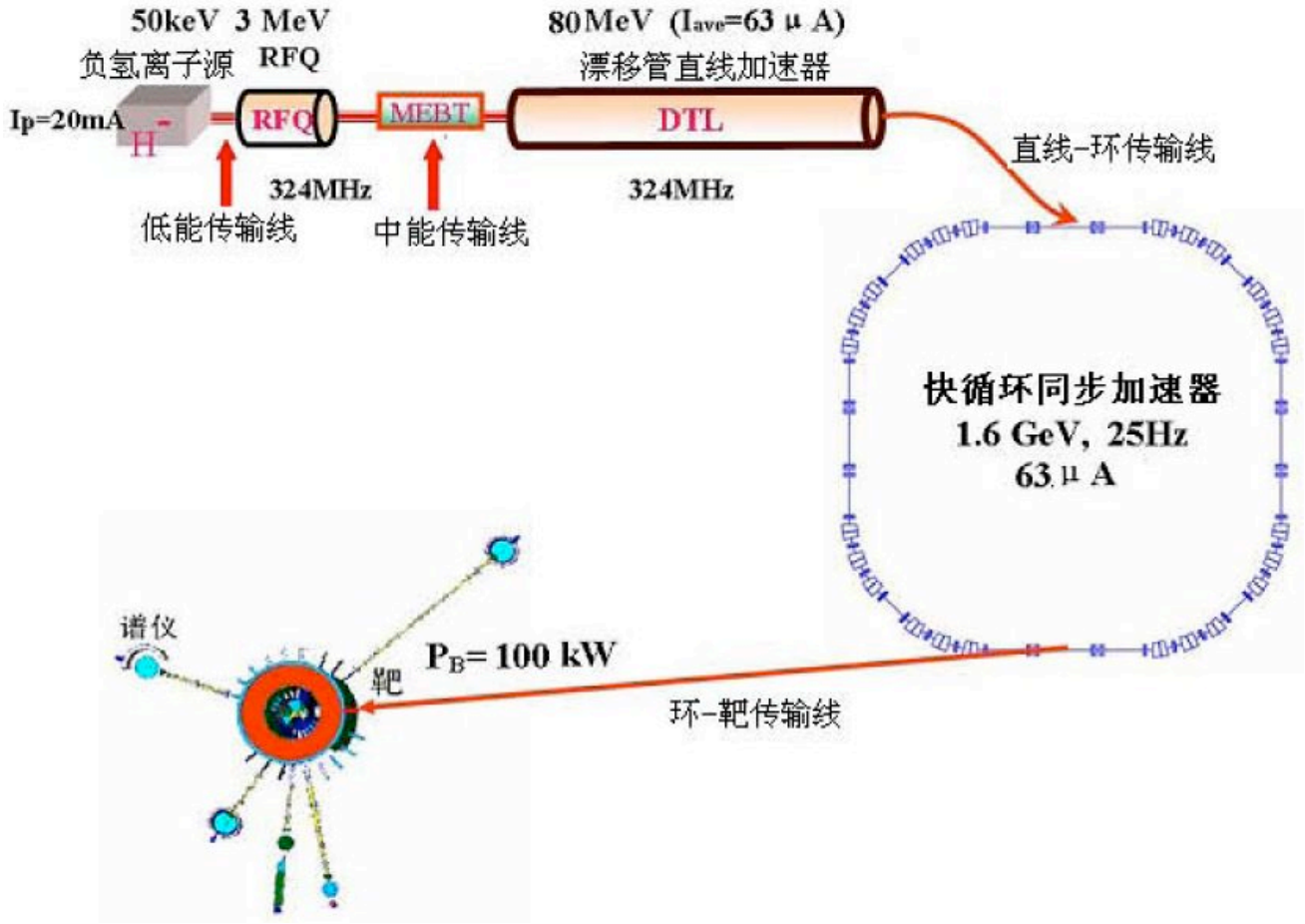
Milestones

- 2005. 6: “political approval”
  - central government approval & fund allocation
- 2006.1 -: CAS funded R&D 1 (35 M CNY)
- 2007.7 -: Guangdong funded R&D 2 (40 M CNY)
- 2007.12 -: “project establishment review”
  - Budget baseline: 1.4 B CNY + 0.5 B CNY (Guangdong) + land
- 2008.6: environmental impact assessment completed
- 2008.9: Approved by the Government
- 2010.3: ground breaking expected
  - Need to pass feasibility review and preliminary design reviews

Dang Lang Town, Dong Guan City, Guang Dong Province

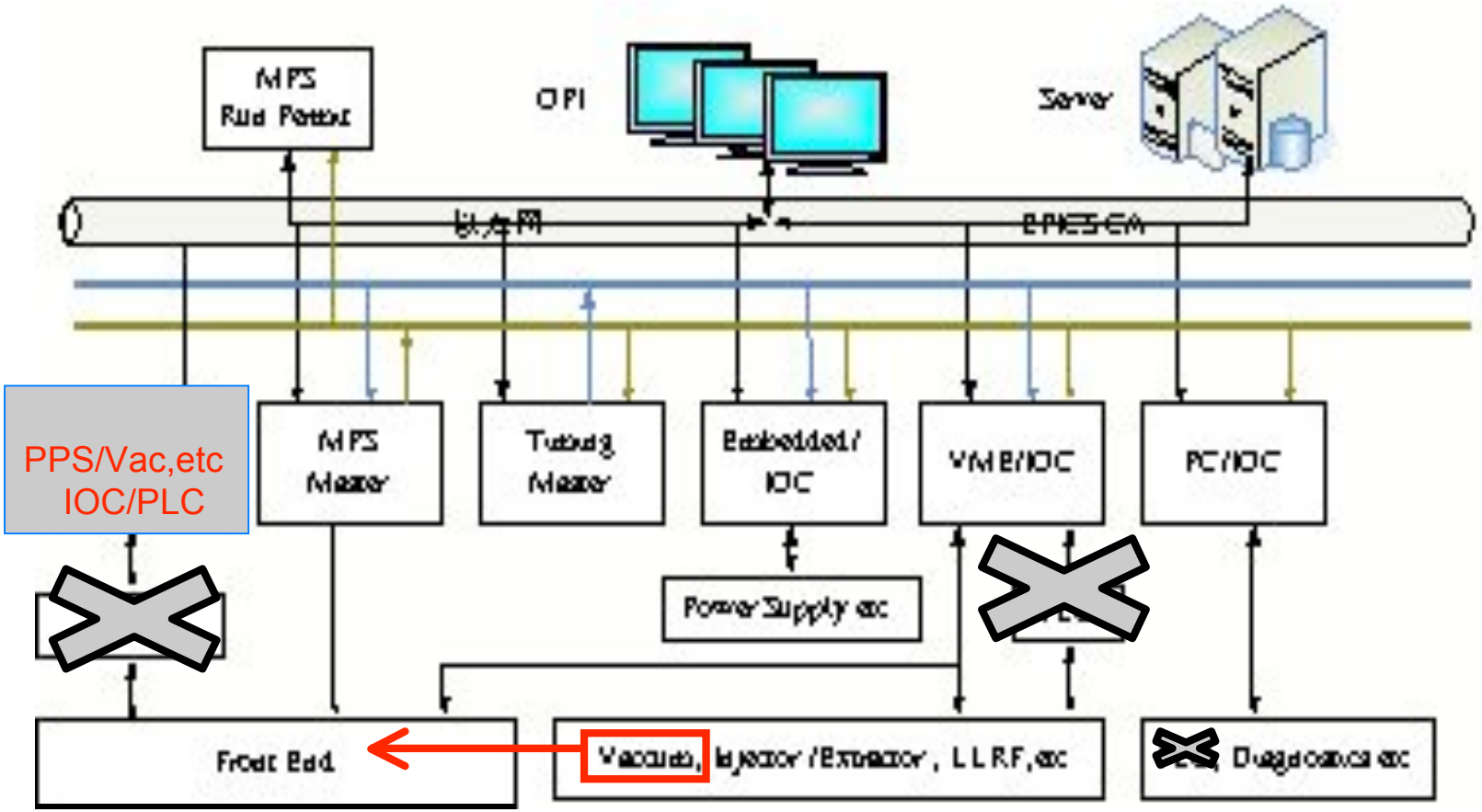
Layout of CSNS

CSNS: 80 MeV Injector, two Transport Lines, 1.6 GeV RCS, one Target, Three Spectrometers, etc.



Overview

Distributed Control System



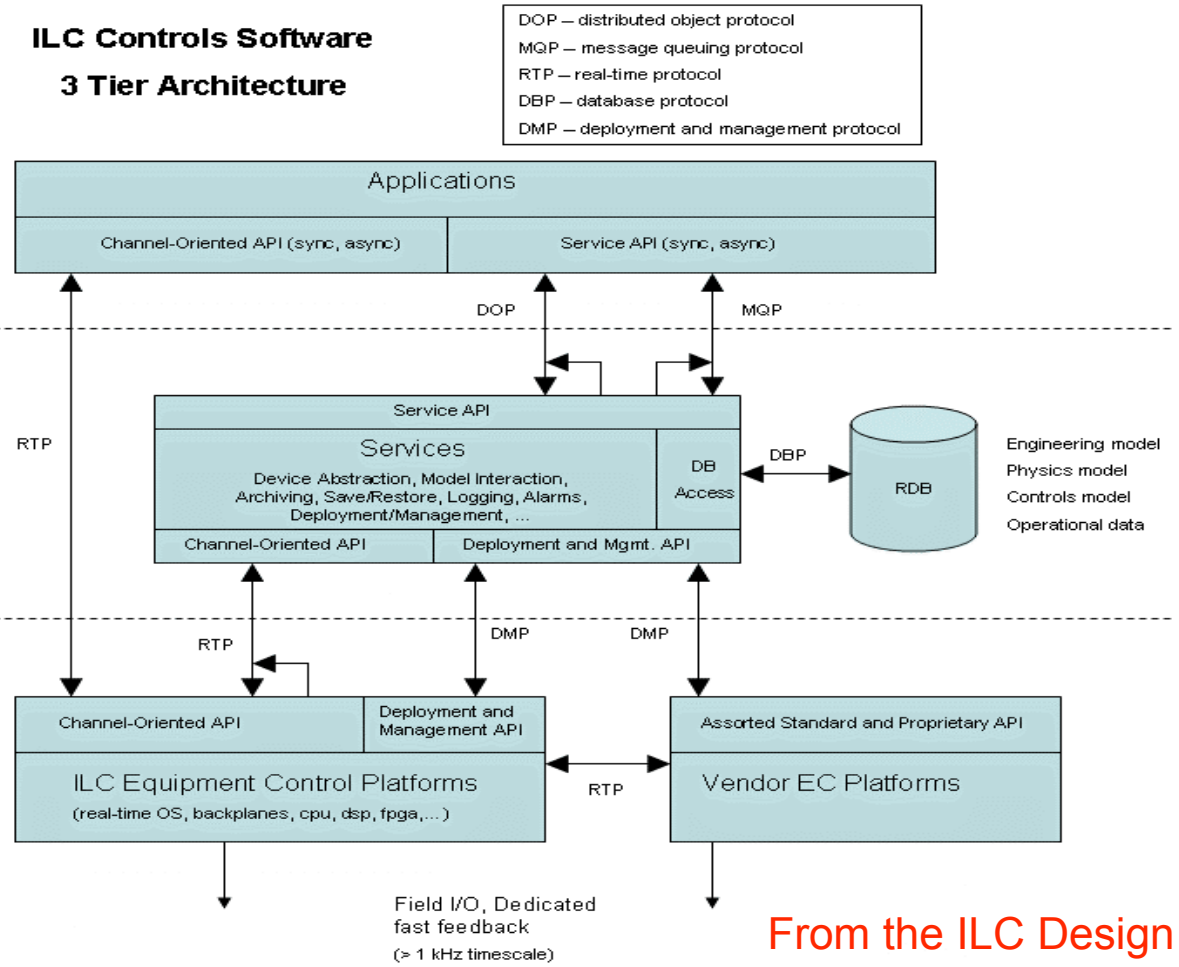
Overview

Software： Client, Service, Front-End.

Client Tier
- 人机界面
- 运行管理

Services Tier
- RDBMS
- 调束软件
- 数据归档
- 故障管理
- 高层反馈控制
- 在线计算作业
- 控制应用
- 应用软件开发

Front-End Tier
- 实时OS
- 实时DB
- 设备驱动
- 现场控制
- 快速反馈系统



From the ILC Design report

Overview-Standardization

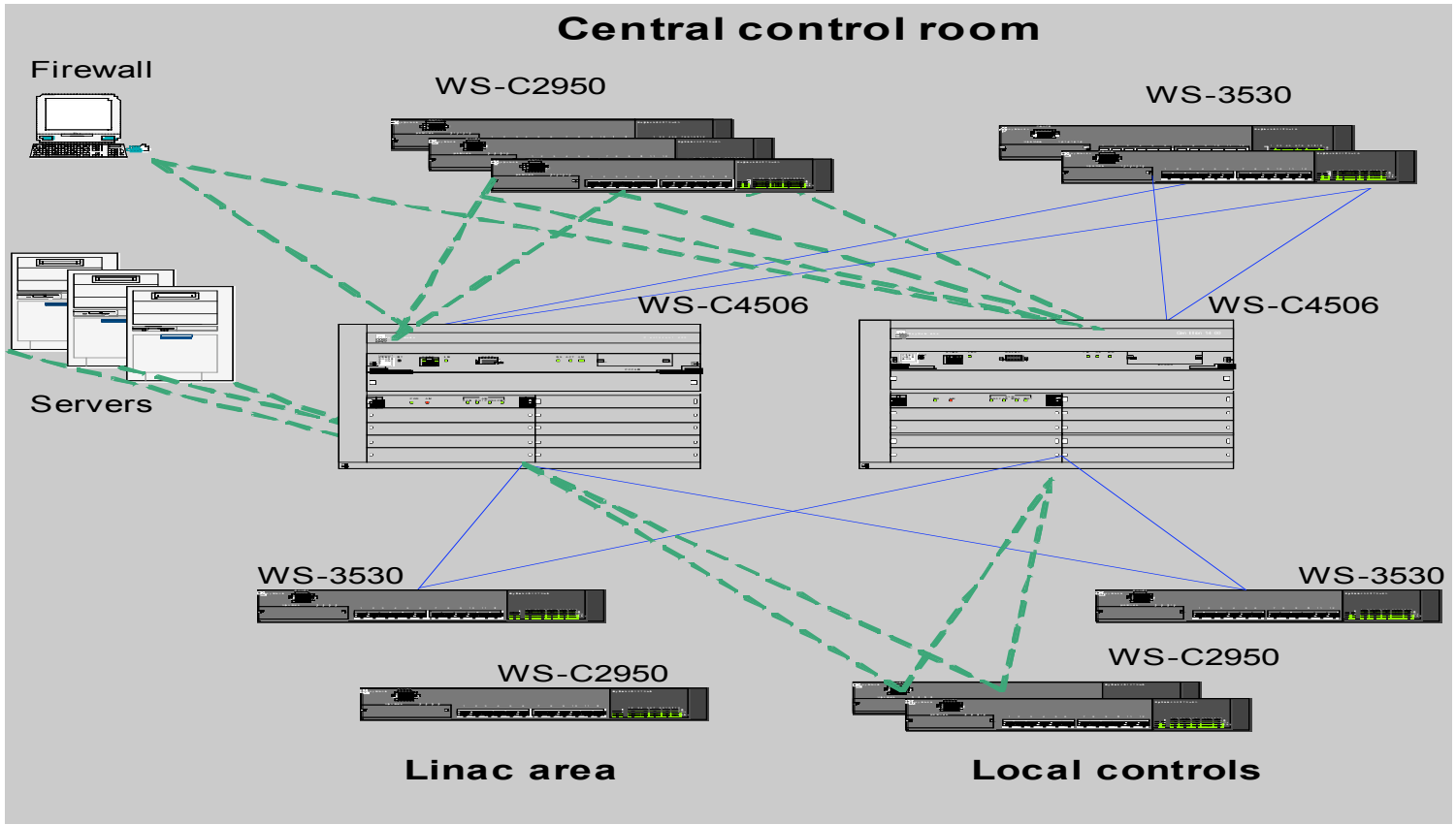
- **Software: EPICS and other Standard software Components**
  - Linux, VxWorks, Windows, RTEMS
  - GNU C,CVS, C/C++,Java, LabView, Eclips
  - Oracle
- **Hardware: Standard Commercial Product**
  - VME(VME64X Crate, MVME5500 or MVME6000 Processor)
  - PLC will adopt Yogokawa PLC
  - IPC (Industrial PC)
  - Intelligence Controller: RS232 to Ethernet, etc
  - Oscillograph

CSNS control System

- **Global System**
  - Computer
    - Server (HP linux, Sun Solaris)
      - EPICS Server
      - Archiver Server
      - Oracle Server
      - Other Server: NFS, NIS, NTP, etc
    - Operator Console (Linux,sunRay)
    - etc

CSNS control System-Global system

- **Control Network(IPV4 and IPV6)**



Control Network Structure

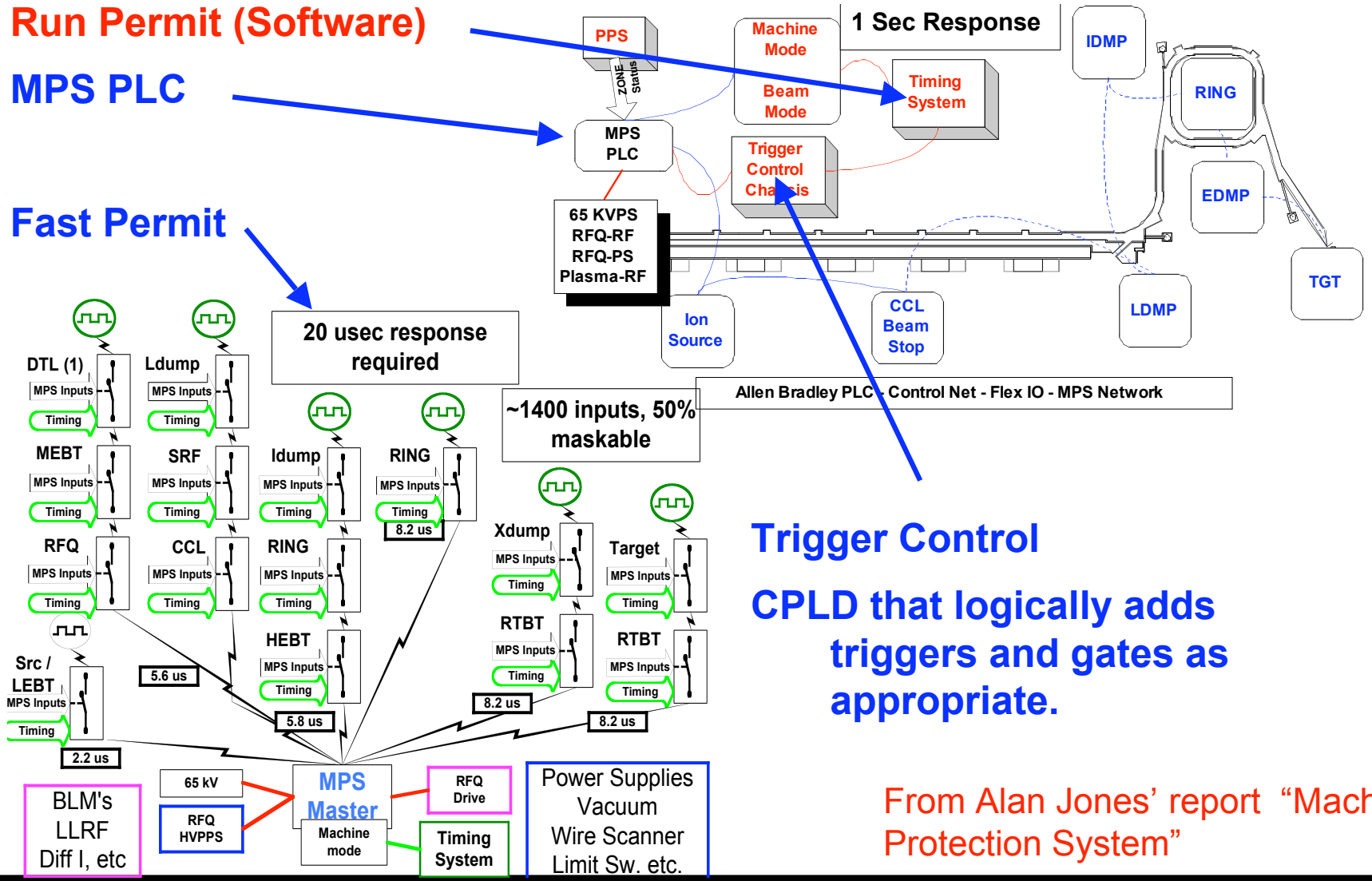
CSNS control System-Global system

- **MPS(Machine Protection System)**
  - MPS to protect the accelerator from beam induced damage.
  - MPS to ensure that Beam Loss <1W/m,10^{-4}
  - MPS will terminate beam in less than 20usec from receiving a fault.
  - MPS only controls Source and RFQ enables and timing gates
- **MPS consists of Run permit, Fast permit and PLC**
- **MPS is not a personnel protection system (PPS)**
- **MPS is not an alarm handler**

CSNS control System-Global system

- **MPS is new, challenging system**
- **We will learn more experience from J-PARC and SNS(U.S,A)**
  - Noise immunity (Fiber Optic instead of copper cable)
  - Improve Availability (>99%)
- **Next Step**
  - Build up the prototype of MPS
  - Do some R&D to evaluate the response time of Fast protection system and noise immunity of MPS

CSNS control System-Global system

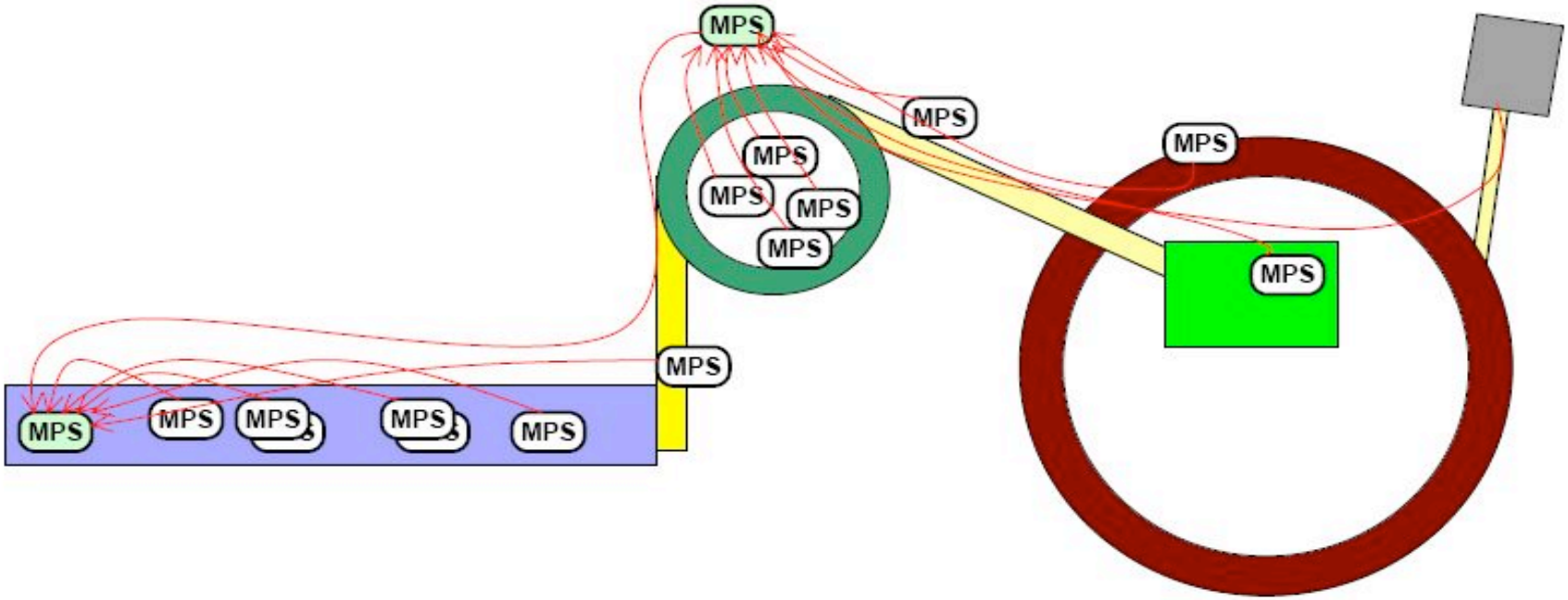


Trigger Control

CPLD that logically adds triggers and gates as appropriate.

From Alan Jones' report "Machine Protection System"

CSNS control System-Global system



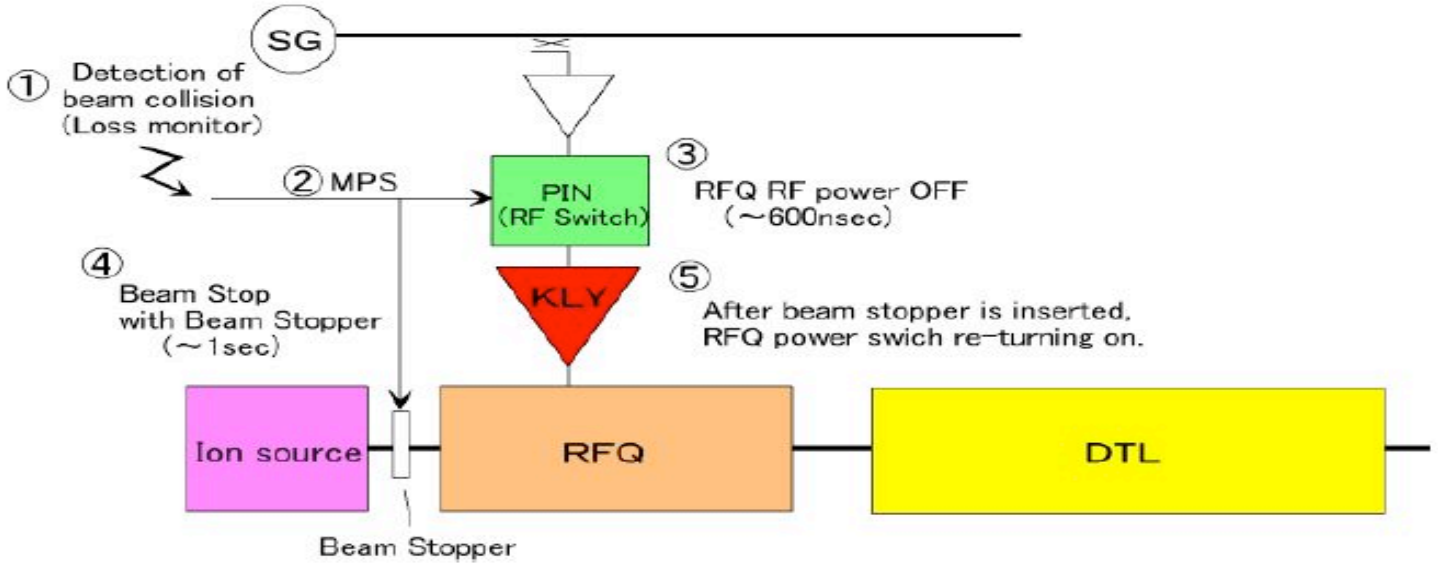
Many MPS units are distributed in the facility, and MPS events are transported to “Stopping the beam” circuit through the independent MPS line.

From the report “Machine Protection System for J-PARC”

CSNS control System-Global system

- "Stopping the beam" means the procedure as follows;
  1. Cut off the input of low level RF to RFQ immediately. (for fast response)
  2. Beam Stopper just before RFQ is inserted into the beam line. (block the beam)
  3. Faraday Cup just before RFQ is inserted into the beam line. (redundancy for Beam Stopper)
  4. RF power to RFQ inputs again as soon as possible. (stabilize the thermal state of RFQ)

  - Procedure-1 should be modified to combined action with setting the offset of RF phase.
  - Fundamentally, MPS assumes that the beam output returns immediately. In the case it takes long time to check the reason of MPS action, Ion source is stopped as operation.



From the report "Machine Protection System for J-PARC"

CSNS control System-Global system

- **PPS(Personnel Protection System)**
  - Prevent human from damage in case of unexpected incident
  - High Reliability (almost 100%)
  - Gate permission(Redundant is necessary)
  - Radiation dose Monitor
  - Fire warning
  - Industrial Monitor System at the pivotal place and device
  - Isolation from Control System

CSNS control System-Frond End control

- **Ion Source control**
  - Power supplies: arc ,extract , deflexion magnet, accelerating, discharging
  - Temperature measure & control : 6
  - Local Trigger Generator : 7 triggers
  - Vacuum system: pump , valves, mass flow meters
  - Hydrogen gas : Piezoelectricity valve
  - Cesium gas : Power supplies (2)
  - Water cooling: pump ,valve
- **All devices are on – 50 kv HV platform except accelerating powers supply and vacuum devices**

CSNS control System-Frond End control

- **Ion Source control**

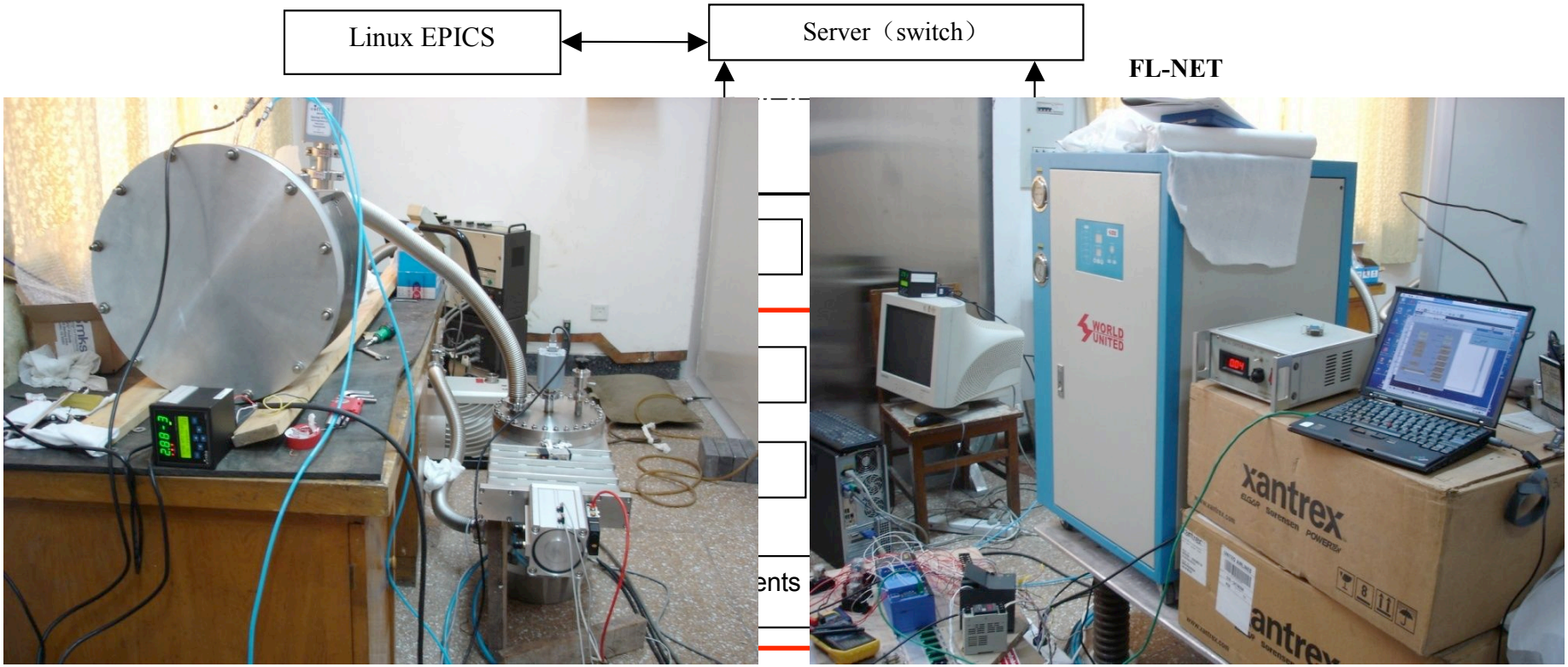
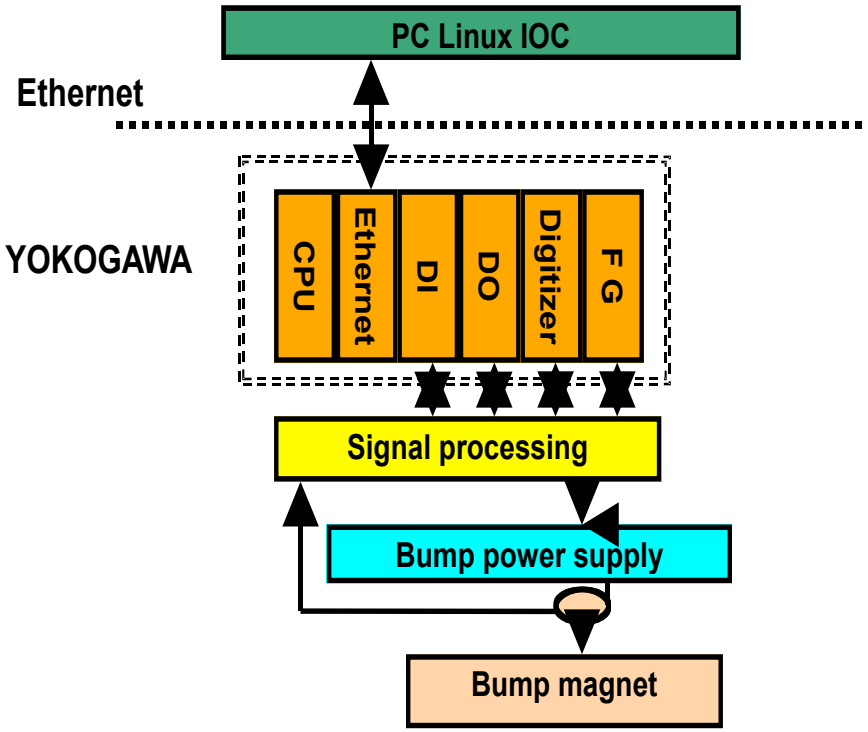


图3 潘宁型离子源控制系统硬件结构

CSNS control System-Frond End control

- **Injection/Extraction Control**
  - 4/4 horizontal/ vertical painting magnets, 2 Pulsed power supplies
  - 10 kicker magnets, 10 pulsed power supplies



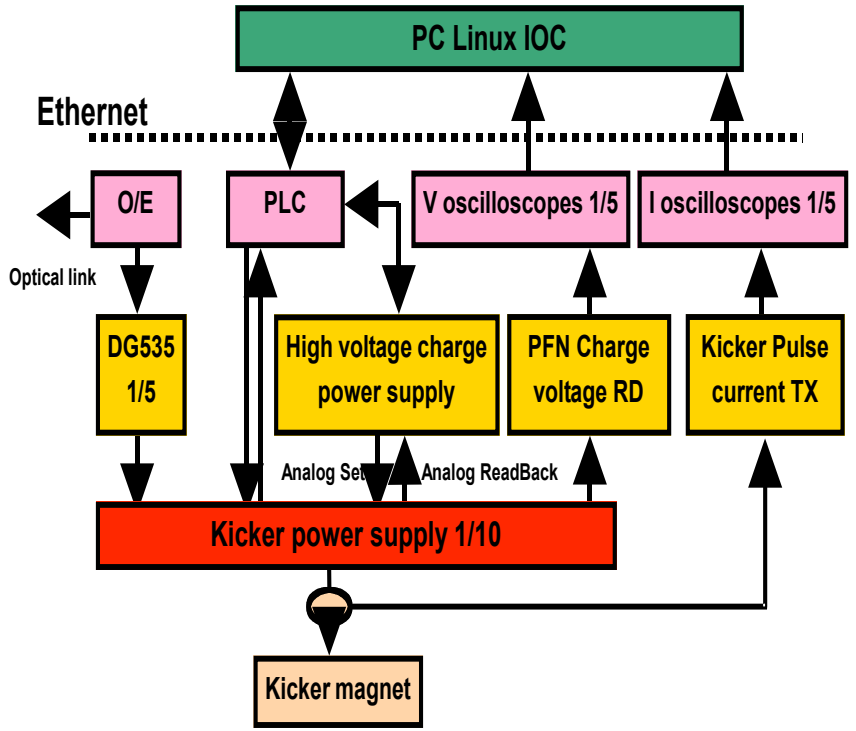


Figure1 Injector control Structure Fiugre2 Extract coontrol Structure

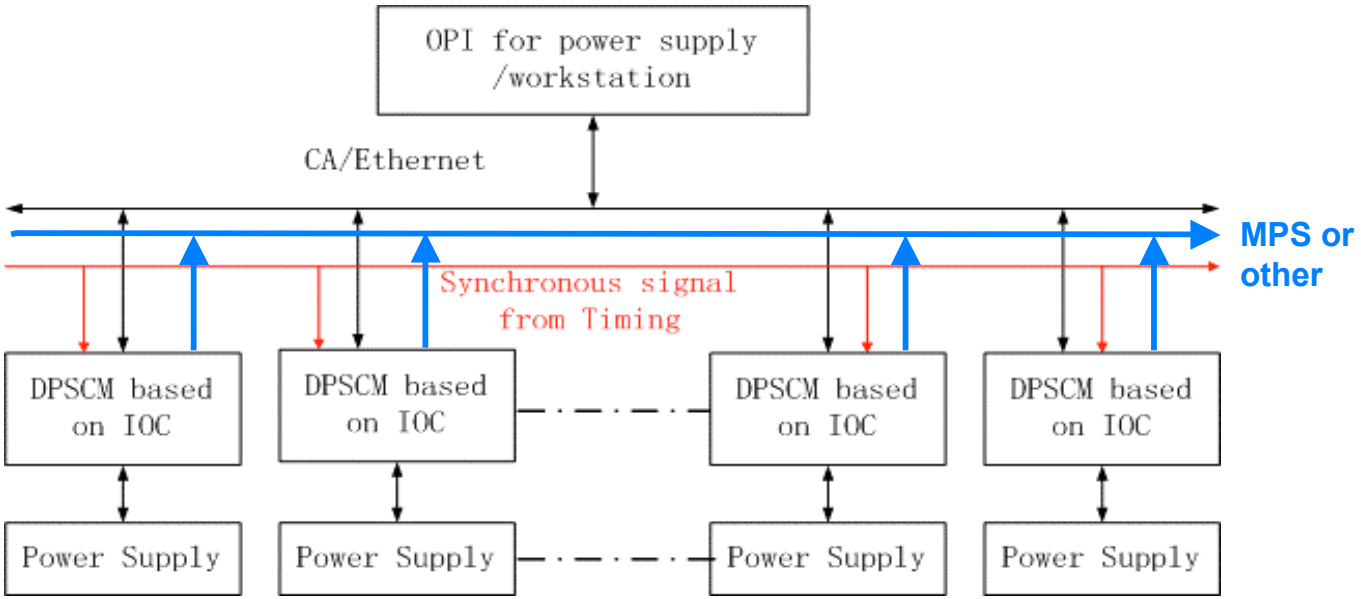
CSNS control System-Frond End control

- ## Power Supply Control

被控设备名	台数	每台设备引出信号数				本型设备引出信号总数			
		AI	AO	DI	DO	AI	AO	DI	DO
直线DTL磁铁主电源	76	2	2	6	8	152	152	456	608
直线LEBT磁铁主电源	9	2	2	6	7	18	18	54	63
直线MEBT磁铁主电源	20	2	2	6	7	40	40	120	140
LRBT磁铁主电源	32	2	2	6	7	64	64	192	224
RTBT磁铁主电源	22	2	2	6	7	44	44	132	154
RCS环磁铁主电源	8	4	4	6	8	32	32	48	64
RCS环磁S铁电源	4	4	4	6	8	16	16	24	32
RCS环磁铁校正电源	72	4	4	6	8	288	288	432	576
注入系统直流电源	4	2	2	6	7	8	8	24	28
小计	247					662	662	1482	1889
信号总数	4695								

CSNS control System-Frond End control

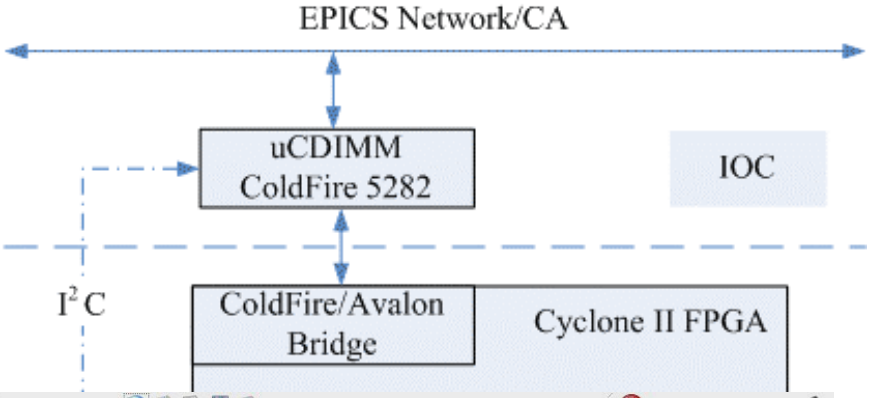
- **Power Supply Control**
  - **Embedded IOC based on FPGA+ColdFire**

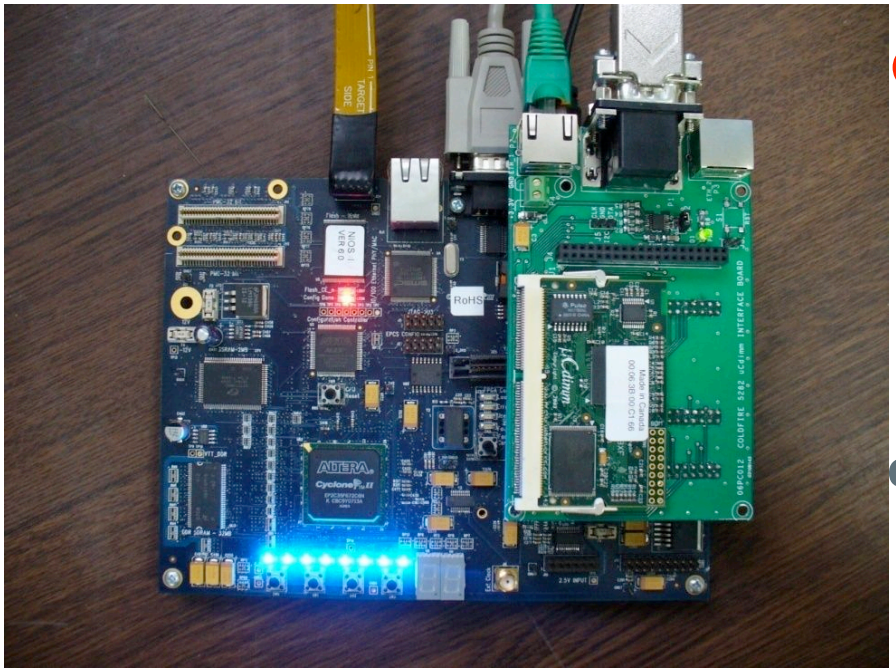


CSNS电源控制系统结构图

CSNS control System-Frond End control

- **Power Supply Control**
  - Embedded IOC R&D
  - Build up RTEMS/EPICS
  - Create an example IOC /RTEMS





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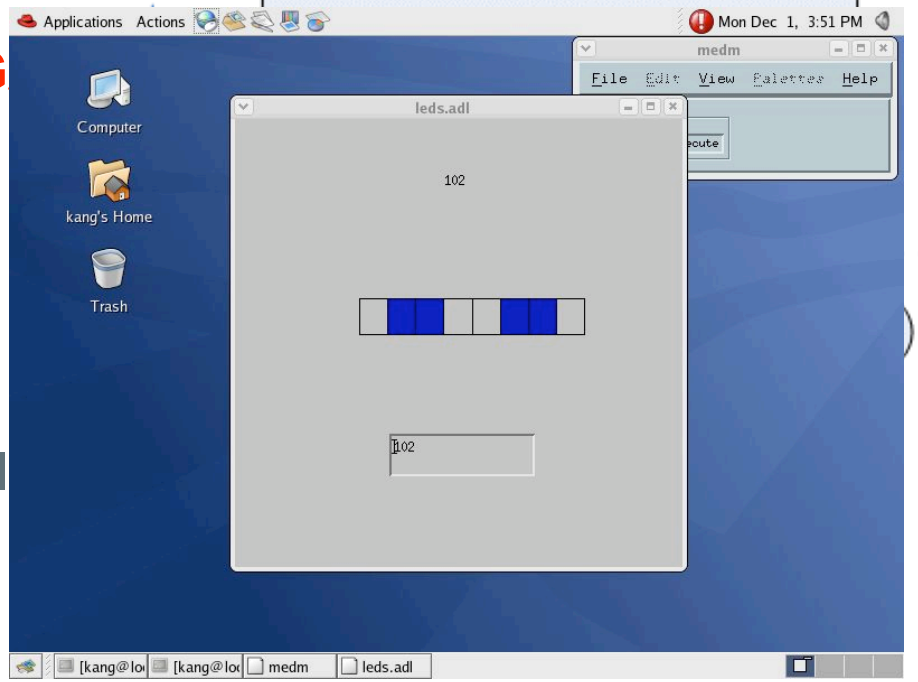
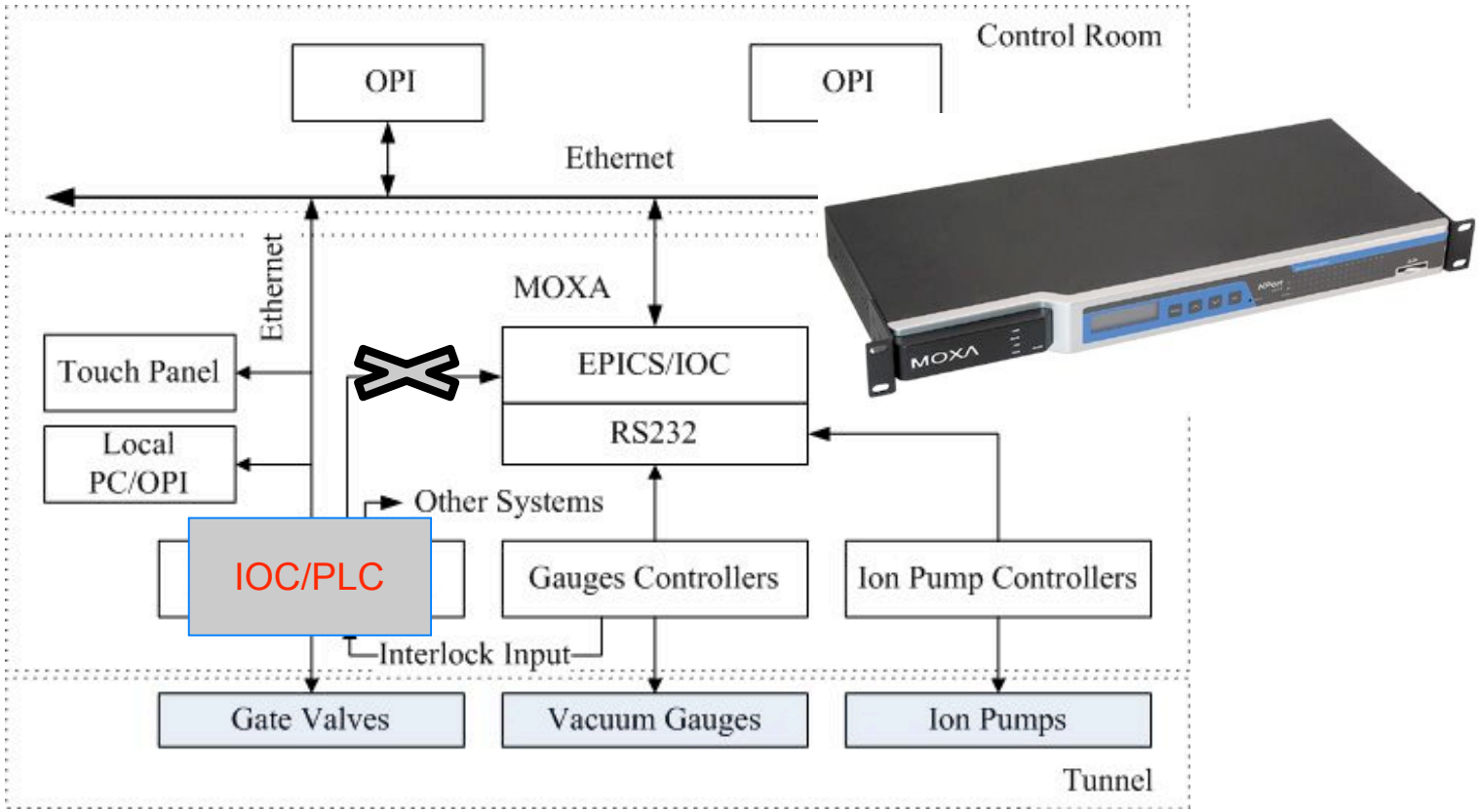


CSNS control System-Frond End control

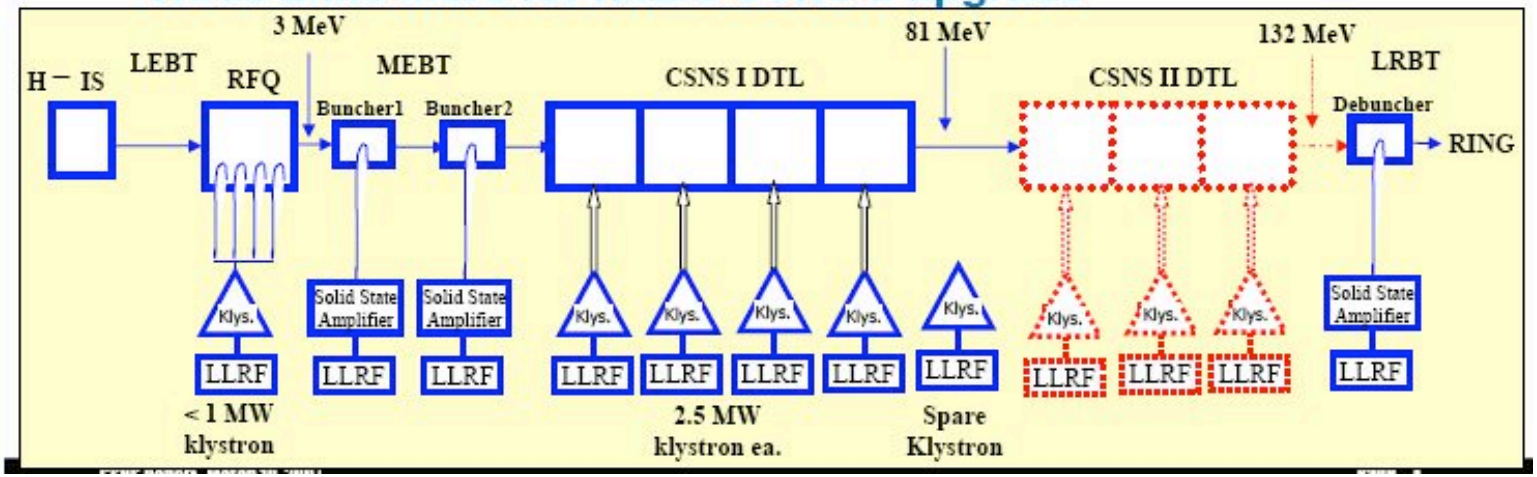
- **Vacuum control**
  - 40 Ion Pump Controller,33 Vacuum Gauge and 26 Valves



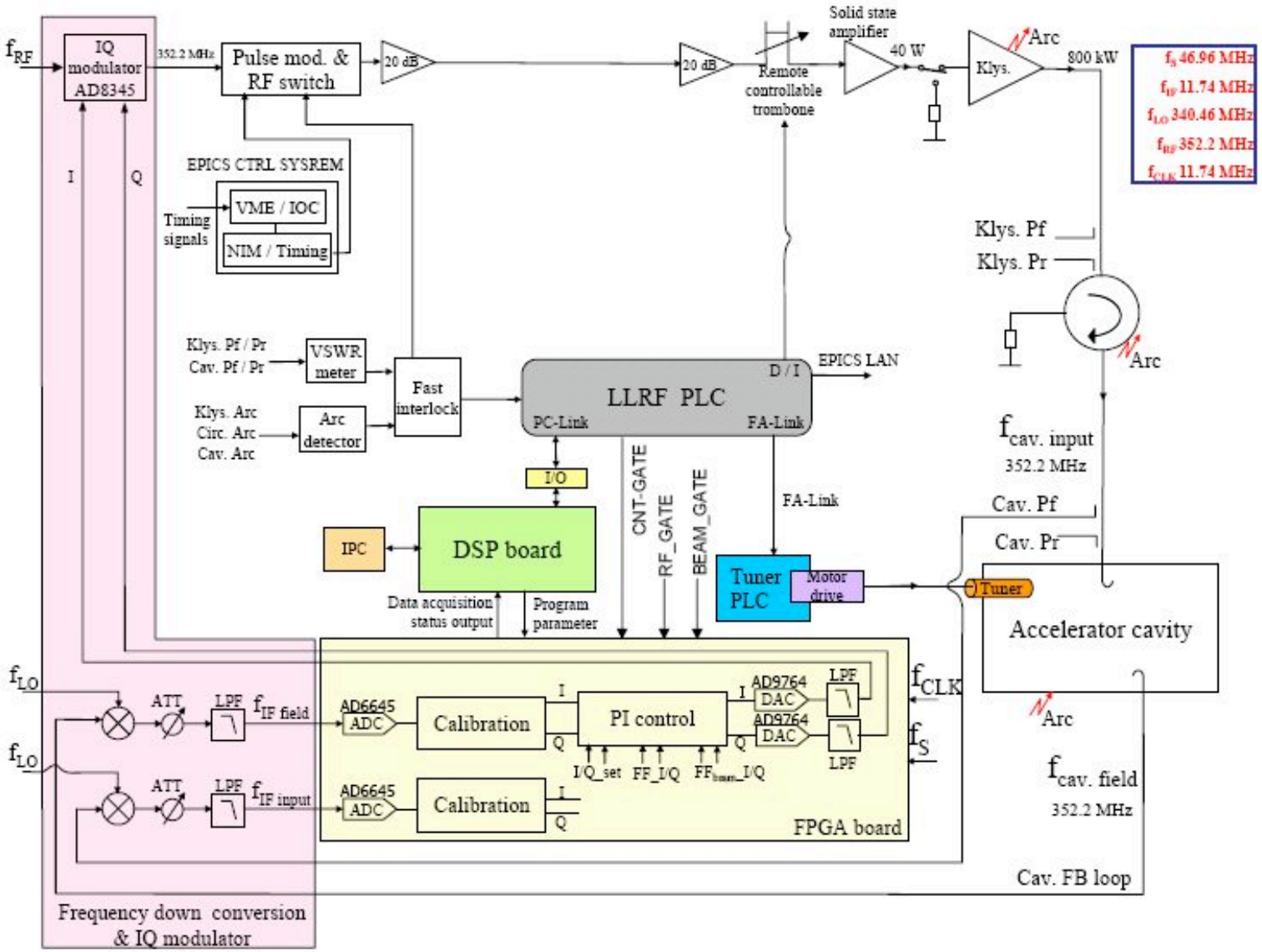
CSNS control System-Linac LLRF

- Number of CSNS I klystron RF power sources:

  one for RFQ + four for DTL + one spare
- One-klystron-per-cavity independent RF control
- Nine units of LLRF for CSNS I
- Three units more for future CSNS II upgrade

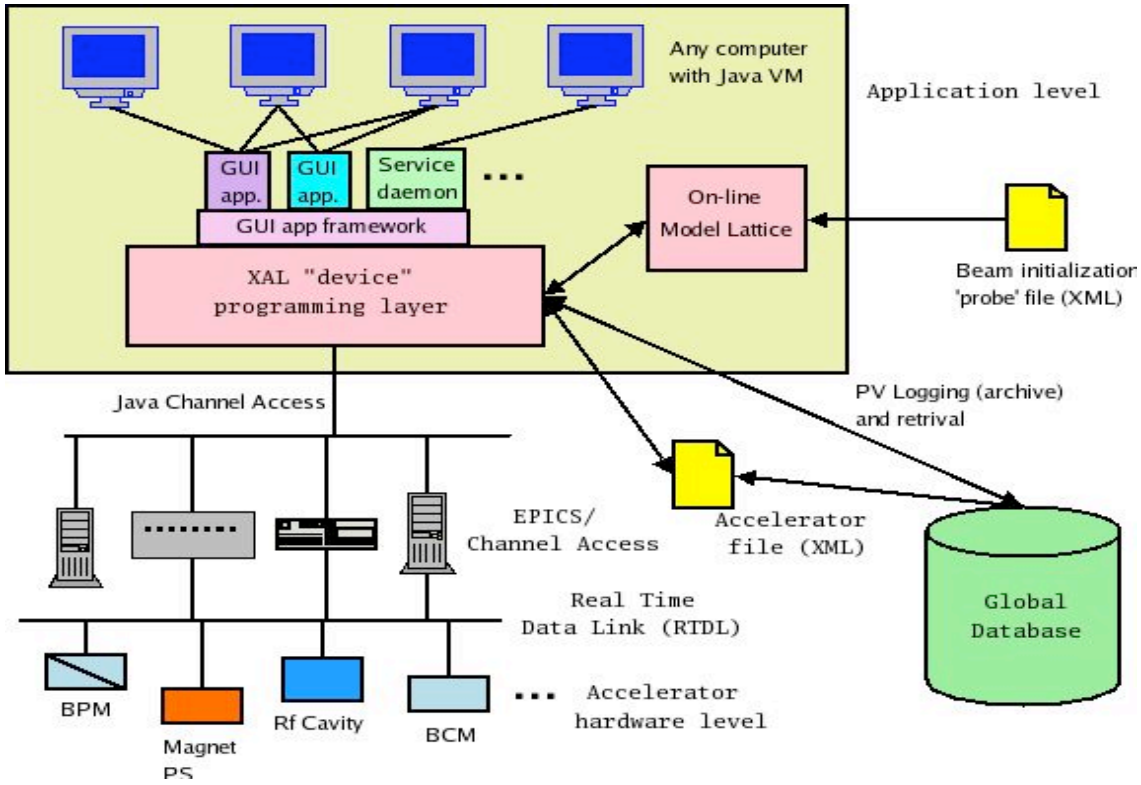


CSNS control System-Linac LLRF



CSNS control System-High Level Applicaton

- **XAL**
  - One student cooperator with SLAC(Paul Chu)
  - One young guy from Physics Group visit SLAC on XAL



CSNS control System- CF, target, spectrometer

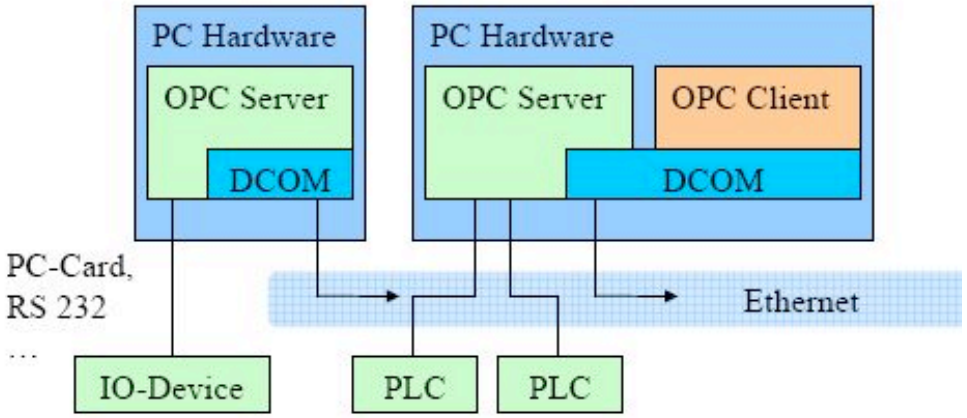
- **Interface between control and CF, target, spectrometer**
  - **SCADA, OPC, OPC Gateway**

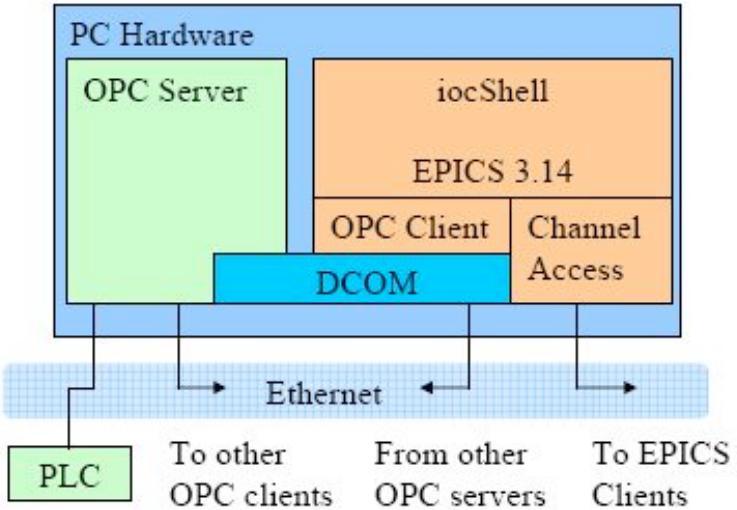
OPC Client Libraries
Available for Windows, Unixes (see http://www.opcconnect.com)
Binary distribution of the client library by Softing is royalty-free

OPC Client – OPC Server Communication
via DCOM (available by Microsoft and others – also for Linux)

OPC Server Application
Always available from the PLC vendor
For wide-spread PLC series there are alternatives offered by third party vendors (see link list at http://www.opcconnect.com or e.g. http://www.matrik

OPC Server – PLC C
Proprietary, vendc





WBS and Manpower

- **WBS**
  - 52.10M RMB(6.5%), less than 8％-10％ of accelerator
- **Manpower**
  - 20 People

Thank you for your attention!

Welcome any advice and comment on CSNS control system.

Whatever, thank you again!