STATUS OF SSRF CONTROL SYSTEM

SSRF Control Group

Shen Iiren 2009/2/13

SINAP

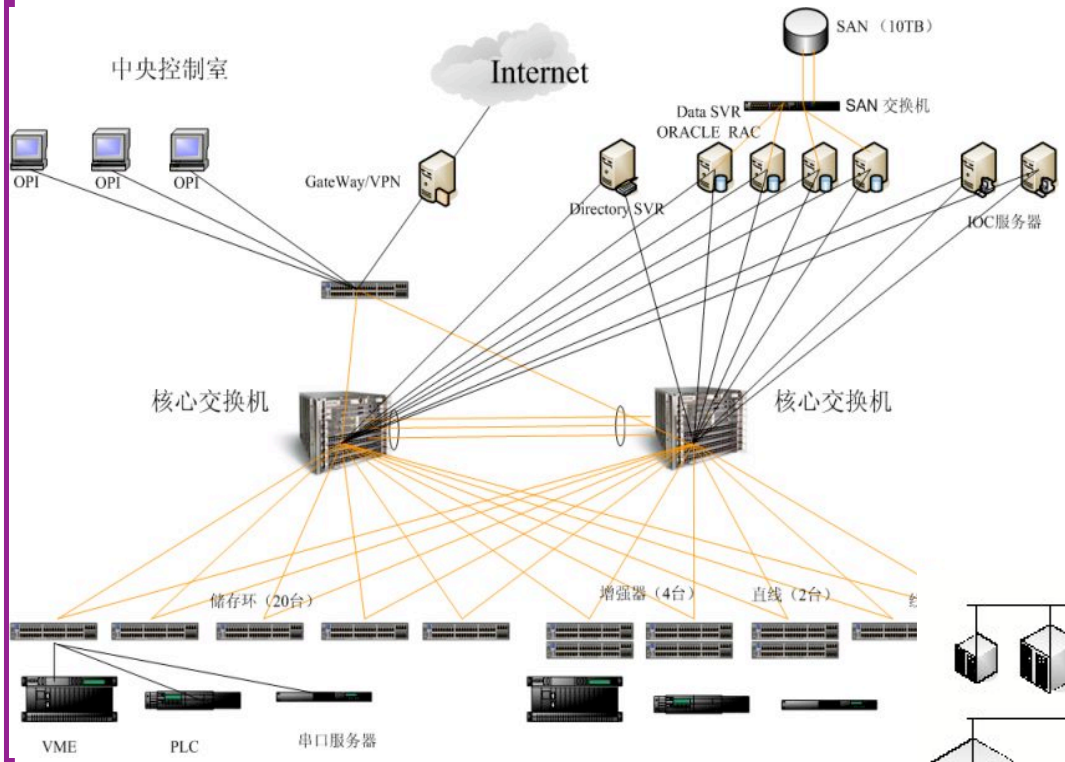
中国科学院上海应用物理研究所

Shanghai Institute of Applied Physics, Chinese Academy of Sci

Introduction

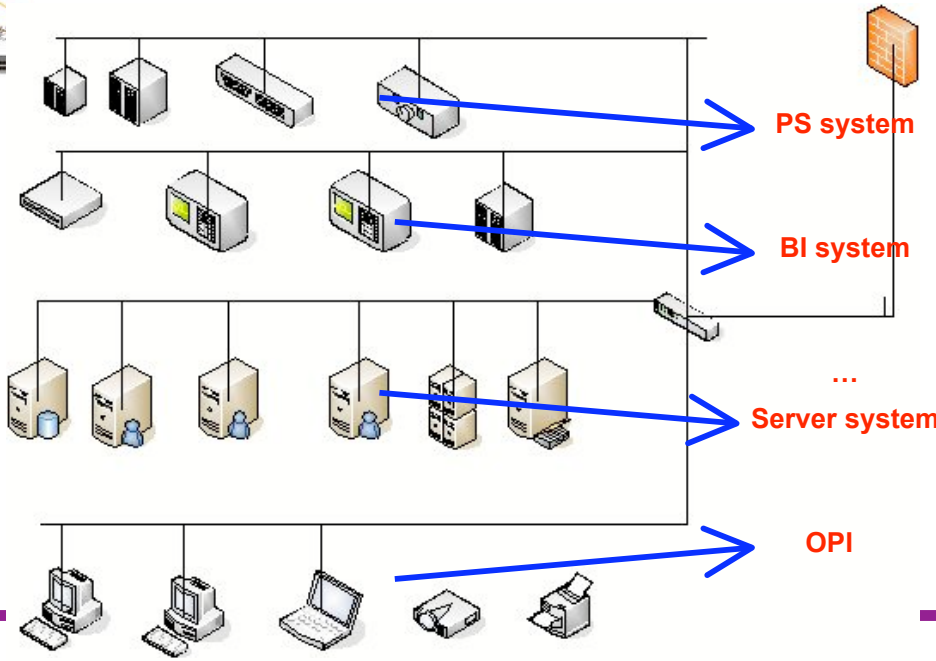
- Shanghai Synchrotron Radiation Facility (SSRF)
  - Third-generation of synchrotron radiation light source
  - SSRF consist of a 150MeV LINAC, a booster and a 3.5GeV electron storage ring.
  - Beam current 300mA
  - Minimum emittance 4 nmrad
  - Lifetime >10 hours.
  - By using advanced insertion device, photon energy range is from 0.1 to 40keV
- SSRF control system is EPICS based control system designed for light source
  - Hardware (including network)
  - Software
  - Subsystems
- Inserting devices

Control System Network



- 1G Ethernet with 3 layer switcher
- backbone reach 2G.
- Full Network manage ability
- Remote access and monitor
- Backbone redundancy design to ensure reliability
- Isolated from office network
- VPN access (Nokia hardware)

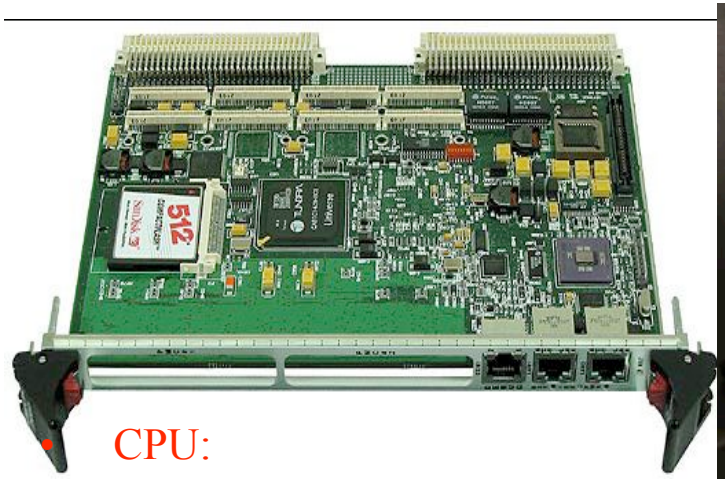
- Sub system division by VALN
  - 10.30.X.X/24
- Static 3 layer route table
- Access List table for access control
- Can be extended easily in future



Hardware

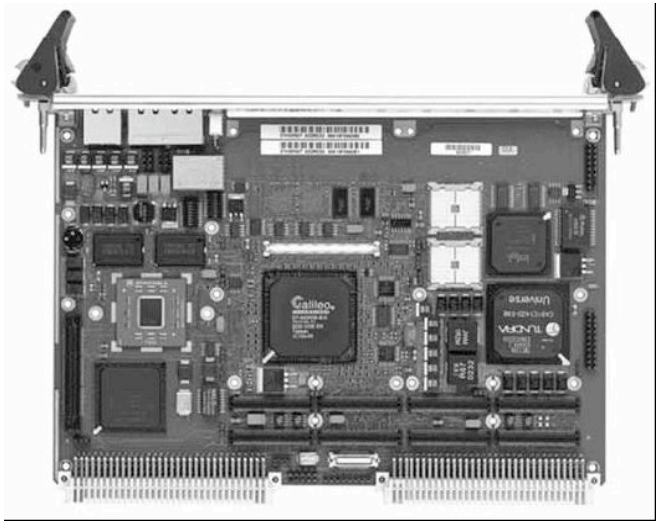
- Not so much VME devices are used in SSRF
  - GE VME7050
  - Motorola MV5500
- PLCs are widely used (Subsystems&PPS)
  - Yokogawa FM3
  - SIEMENS S7-300
- Various kinds of serial devices
  - Vacuum, Power supply, motor controller, etc.
- All of devices are connected via Ethernet
  - Serial/Ethernet converter box (Moxa Nport5610)
- These make our system clean and simple

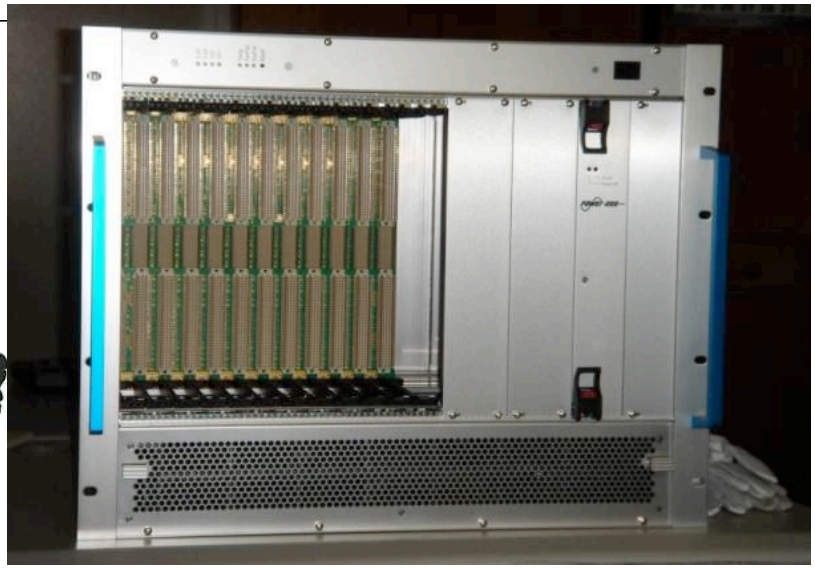
VME System



CPU:

- Motorola MV5500
- GE VMIVME-7050

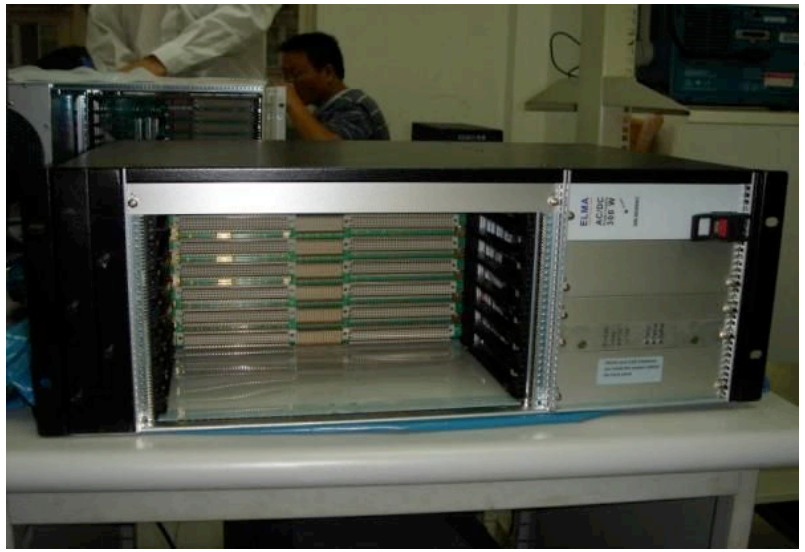




VME 64X crate by Elma

4U 7Slots
9U 12 Slots

Crate status can be monitored by Ethernet or serial port

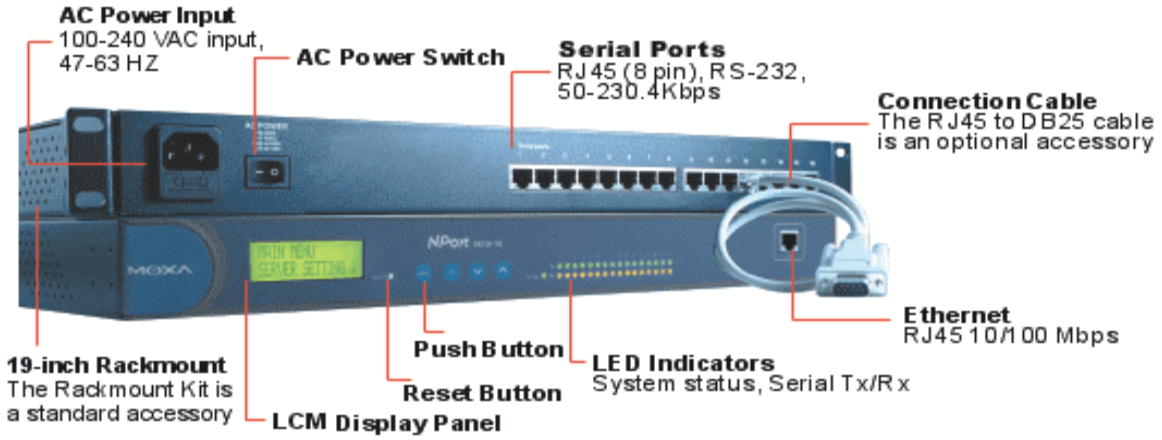


Can be monitored with PV names (NetDrv)

PLCs and Nport5610

- Serial to Ethernet converter

MOXA NPort 5610-16



Software

- The SSRF control system is composed of EPICS toolkits
  - base v3.14.8.2/3.14.8.10
  - extensions
  - Cross-compile environment
- OS
  - Fedora core 7 (mainly)
  - Ubuntu server 8.10/ CentOS5.2/ Scientific Linux
- OPI
  - EDM
- High level physics application
  - Matlab v2007a
  - MCA/LabCA
  - Accelerator Toolbox (AT) & middle layer was adopted

EPICS Development Platform

- Two servers
  - HP Rack PC Server 580GG4, Xeon 3.0G/8G RAM/300G SCSI HD
  - One Master, the other Slave
  - NIS/NTP/NFS
  - RSYNC backup
  - Local yum update/PXE server
- EPICS environment
  - OS
    - Linux FC7/Kernel 2.6x/GCC 4.xx
  - EPICS base
    - 3.13.9/3.14.7/**3.14.8.2**/3.14.10
  - Extensions
    - Edm/medm/SDDS/Archiver/Sequencer/etc.
  - Cross-compiler environment
    - Vxworks 5.5.1
    - Monta-vista linux gcc3.4

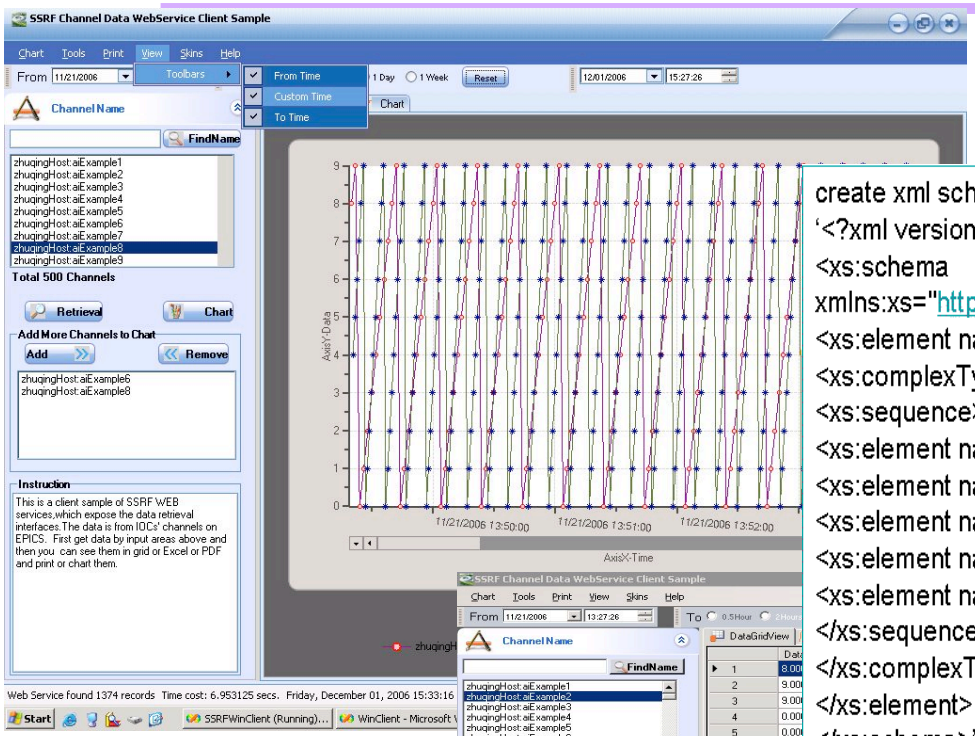
EPICS Drivers/Records

- EPICS Drivers
  - 5-10 types of new serial device drivers are modified based on netDev
  - Yokogawa Plcs uses netDev
  - Simens PLC uses driver from PSI
  - Stream device driver are used for several kinds of serial devices
  - Modbus driver from EPICS website
  - VME device drivers are copy from device manufactures or other labs
- Records
  - Bi/bo
  - ai/ao
  - Mbbi/mbbo
  - Subrutin/gensub
  - Waveform
  - Caculate
  - fanout

Data Archive and Analysis Tools

- Distributed archive engine with center relational database
- Native XML data type with xml schema for data storage
- Developed a data retrieval system based XML Web Services to access the archived data.
- The system included bottom layer interface and interface applicably for accelerator physics as well as client samples exemplifying how to use the interface.
- Tools for users that can browse, retrieve and plot data
- By the client samples, user can development their own application.
- Memo: not be used now, just in test progress

Data Archive and Analysis Tools



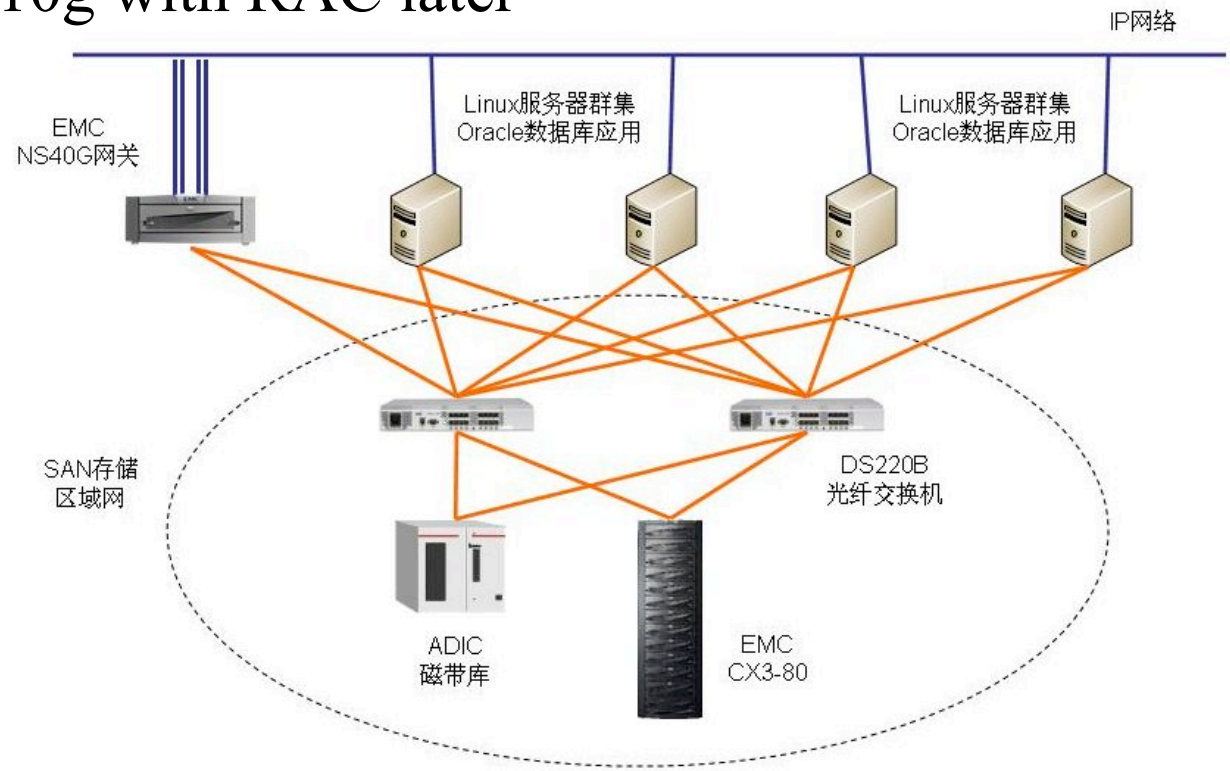

```
create xml schema collection archiverschema As
'<?xml version="1.0"?>
<xs:schema
xmlns:xs="http://www.w3.org/2001/XMLSchema">
<xs:element name="data">
<xs:complexType>
<xs:sequence>
<xs:element name="type" type="xs:string"/>
<xs:element name="value" type="xs:string" />
<xs:element name="time" type="xs:string" />
<xs:element name="stat" type="xs:string" />
<xs:element name="severity" type="xs:string" />
</xs:sequence>
</xs:complexType>
</xs:element>
</xs:schema>'
```

```
create table channel
(channelID int primary key,
channelname varchar(50) not null,
infoxcol xml not null)
```

```
create table data
(
        channelID int primary key,
        dataxcol xml(archiverschema) not null
)
```

Database

- The hardware platform using SAN & database server cluster
- Now we have tested on the MS SQL Server 2005 and will transfer to Oracle 10g with RAC later



e-Log

- Based on center database system
- Using Web2.0 Blog system
- Support RSS
- Integrated with uniform authentication system

Subsystems

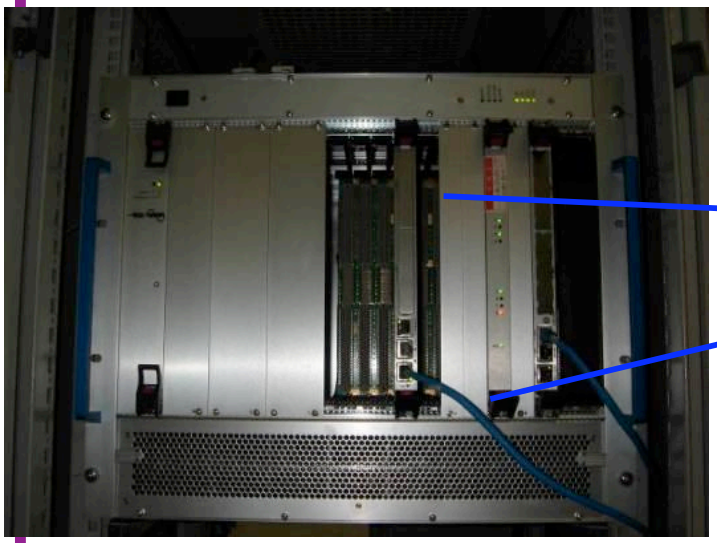
- Three part of control system:
  - Linac, Booster, Storage Ring
  - PS, Vacuum, Modulator, e-gun, Microwave, Transport Line (injector/extract), Timing, MPS, RF
- Some subsystems statistics

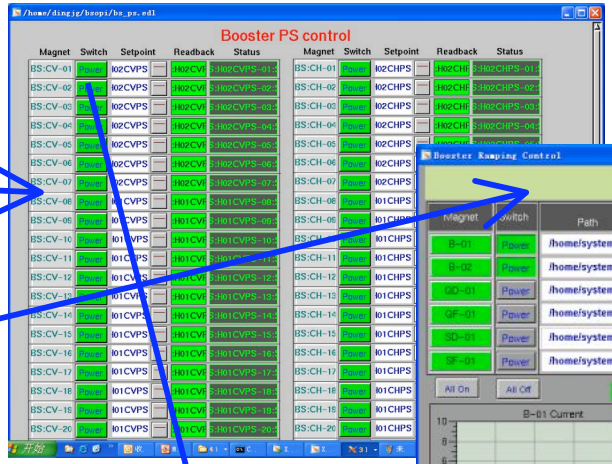
System	Devices	IOCs	PVs
PS	585	26	60000
Vacuum	730	25	23000
MPS	25	3	16000
Timing	16	16	540

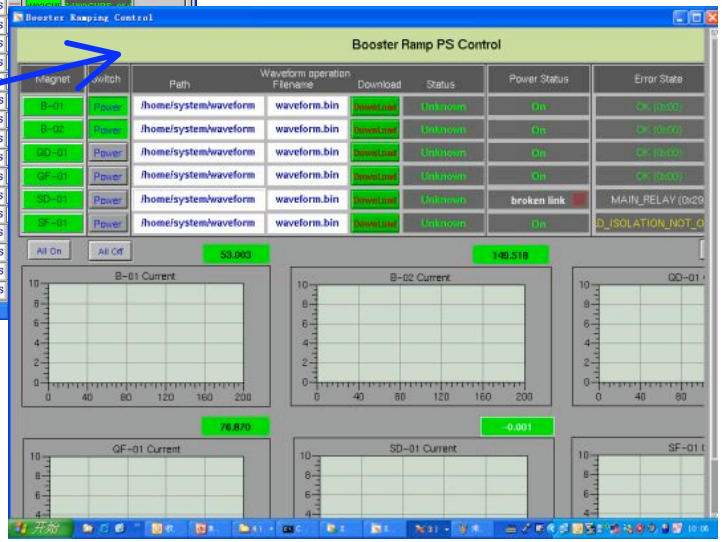
PS Control

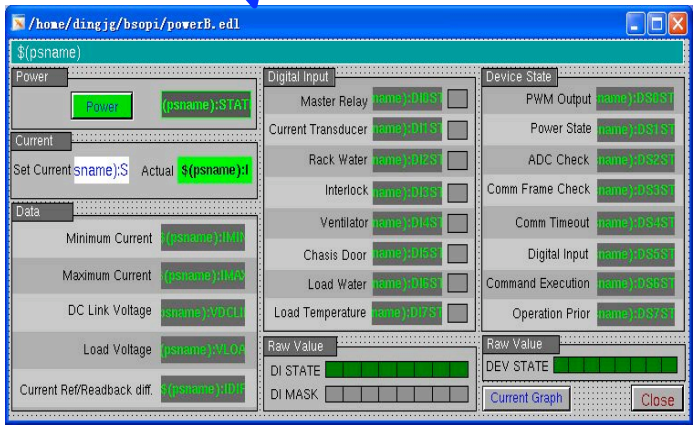
- Over 550 magnet power supplies are used at SSRF
- All PS are digital controlled
- 2 types of digital controllers
  - SINAP self-developed digital PS controller
    - LINAC, Booster and Transport Lines
  - PSI designed digital controller (Purchased from DLS Co., Ltd)
    - Storage Ring and the Booster Ramp PS
- Performance of stability and reliability has been proved since SSRF commission

Storage Ring PS Control

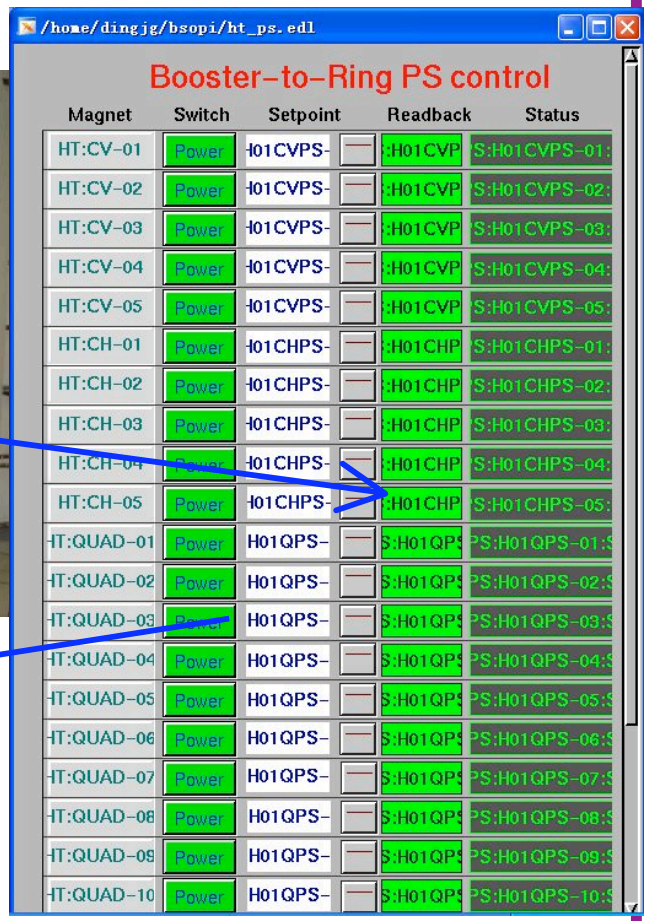


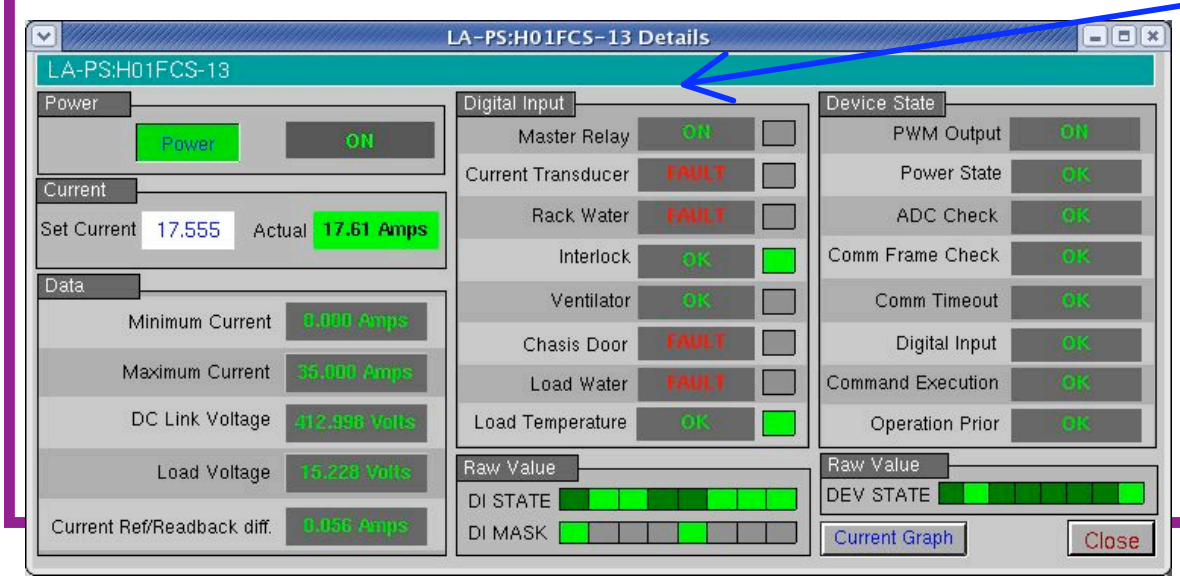






Booster PS Control





Vacuum Control

- Most devices are based on serial port
  - VARIAN Multi Gauge
  - JJJvac Sputter Ion Pump Power Supply
  - VAT valve
  - RGA (Residual Gas Analyzer)
  - Etc.

- PLCs
  - Yokogawa FAM3

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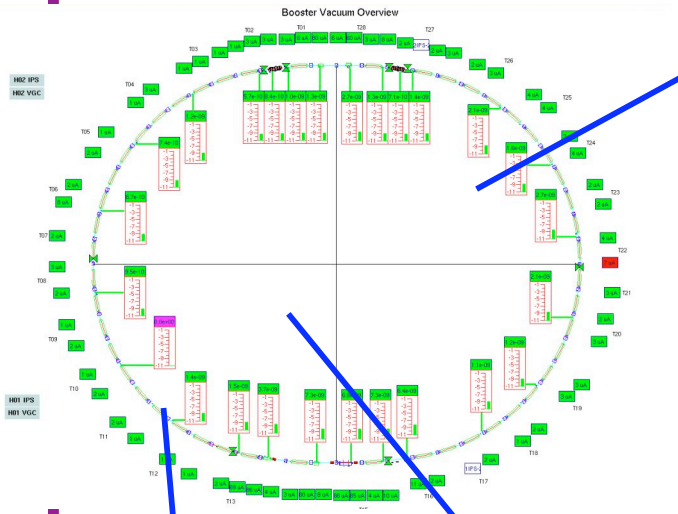
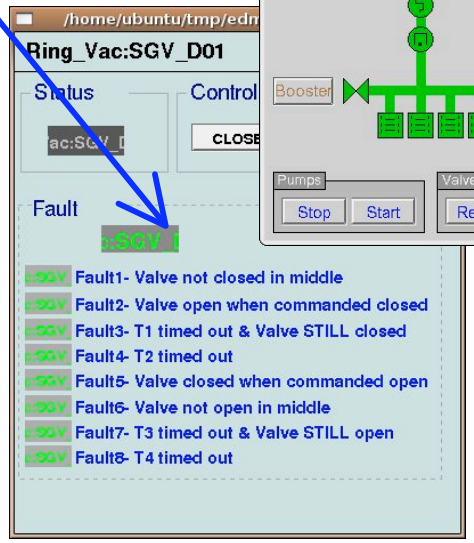
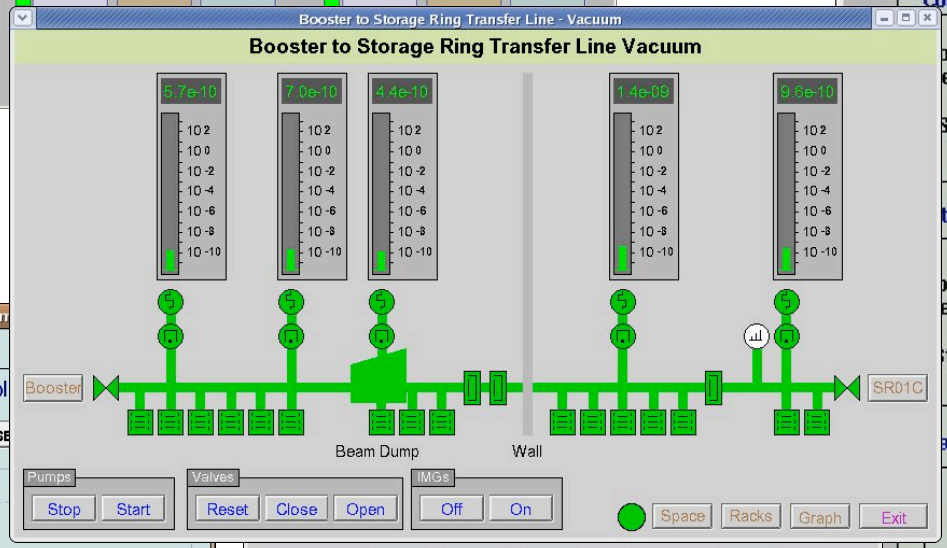
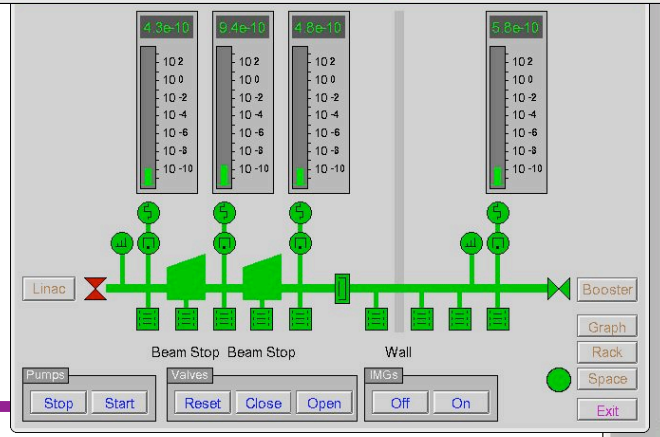
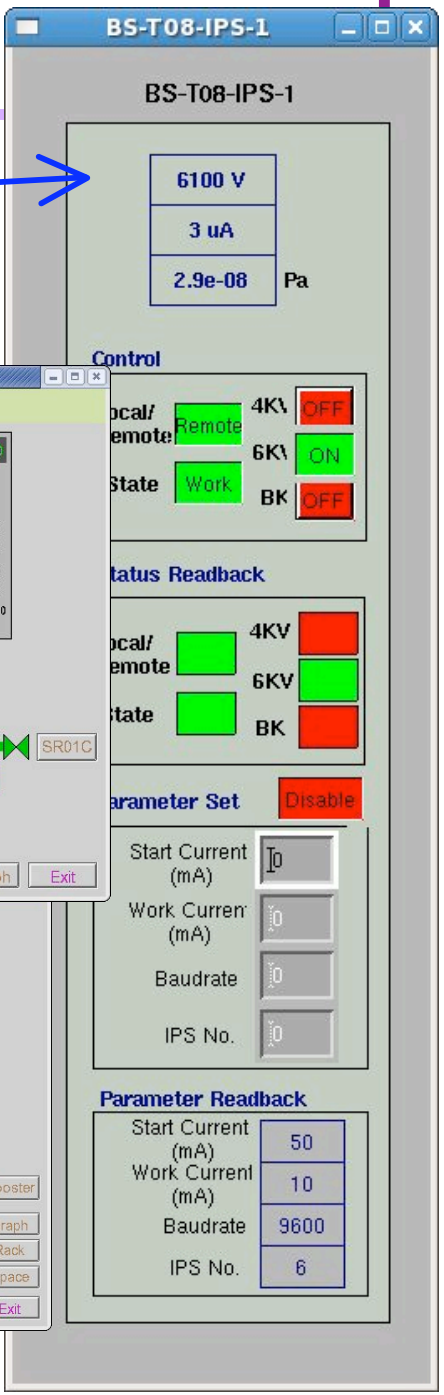
Vacuum Control GUI



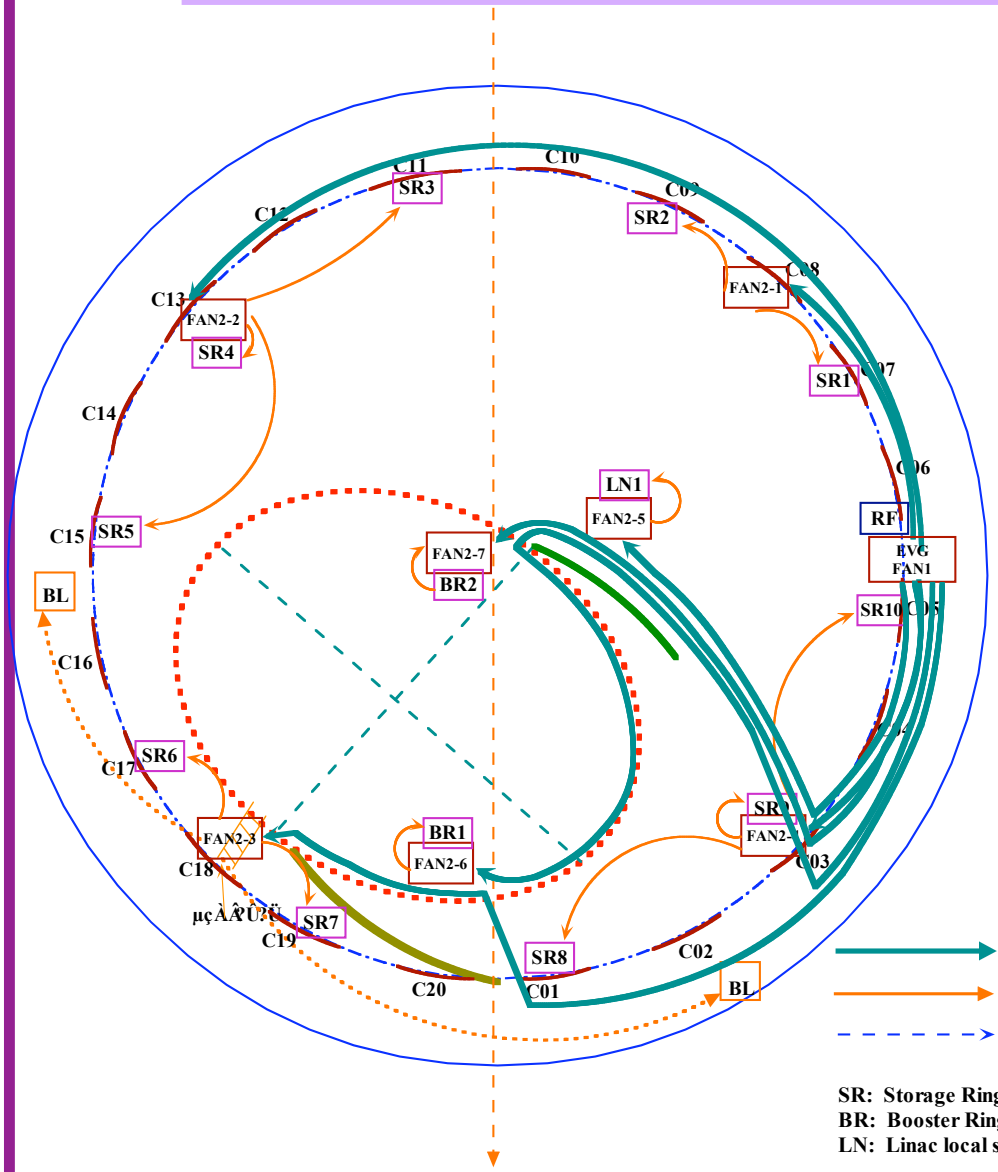








The Event Timing System



- New event timing system
  - Structure is simple used broadcasting method
  - Low Jitter with distributed RF clock
  - Run on the EPCIS environment, base 3.14.x
  - Easy to extend
- Compact network based on characteristic event system.
- All EVRs are placed on timing crates and BI local stations not being triggered devices
- All trigger outputs integrate with hardware interlocks

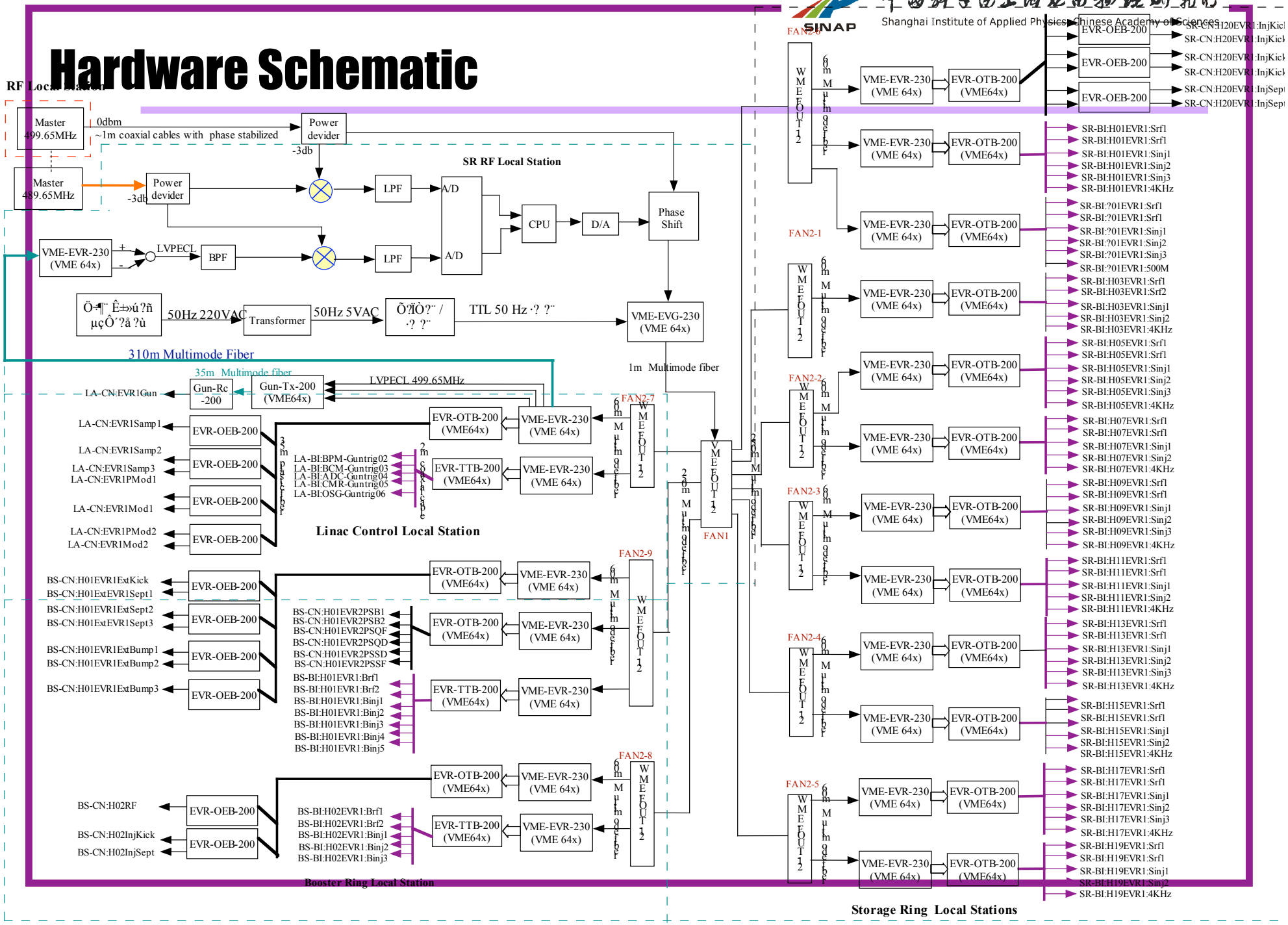
Second level brunches, ~ 250m

Third level brunches, ~ 60m

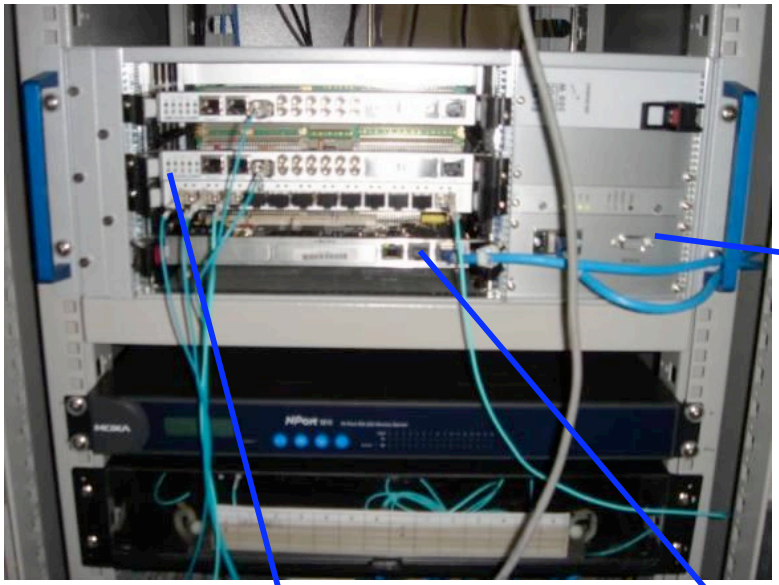
Fouth level brunches (plastic fibers), ~35m

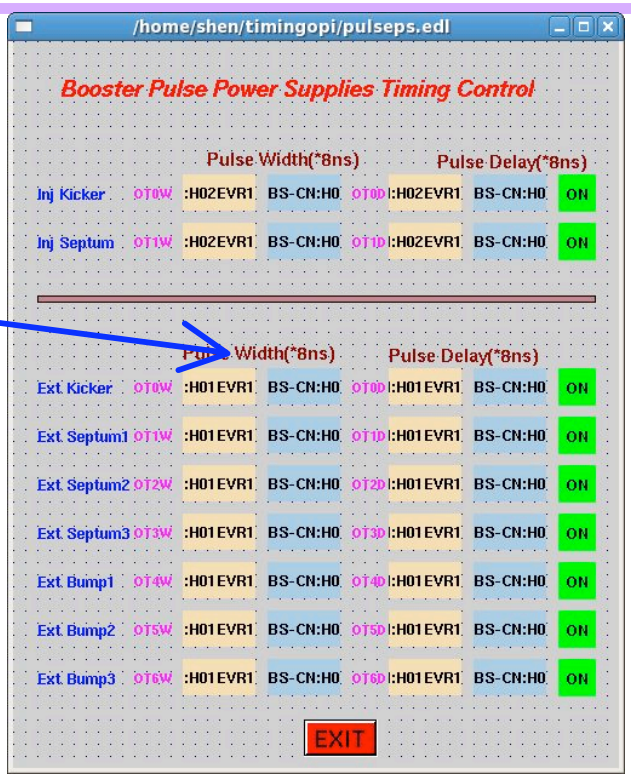
SR: Storage Ring local station ,assuming 10
BR: Booster Ring local station ,assuming 2
LN: Linac local station ,assuming 1

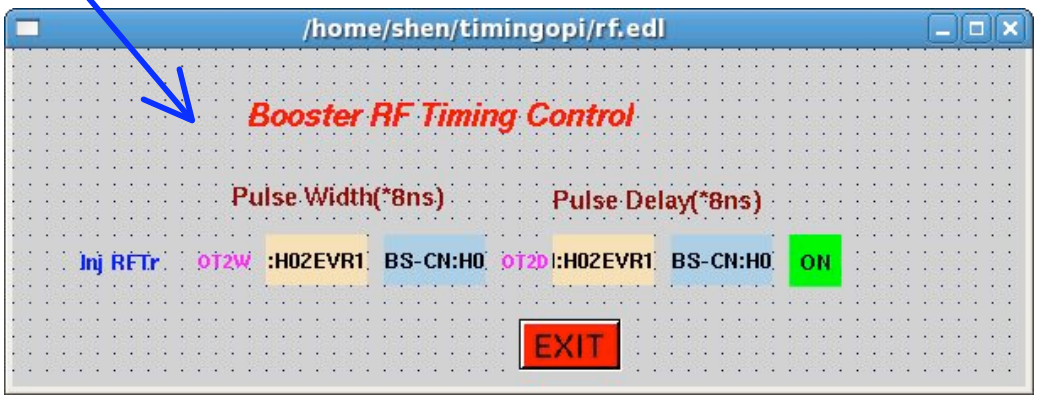
Hardware Schematic



Timing System





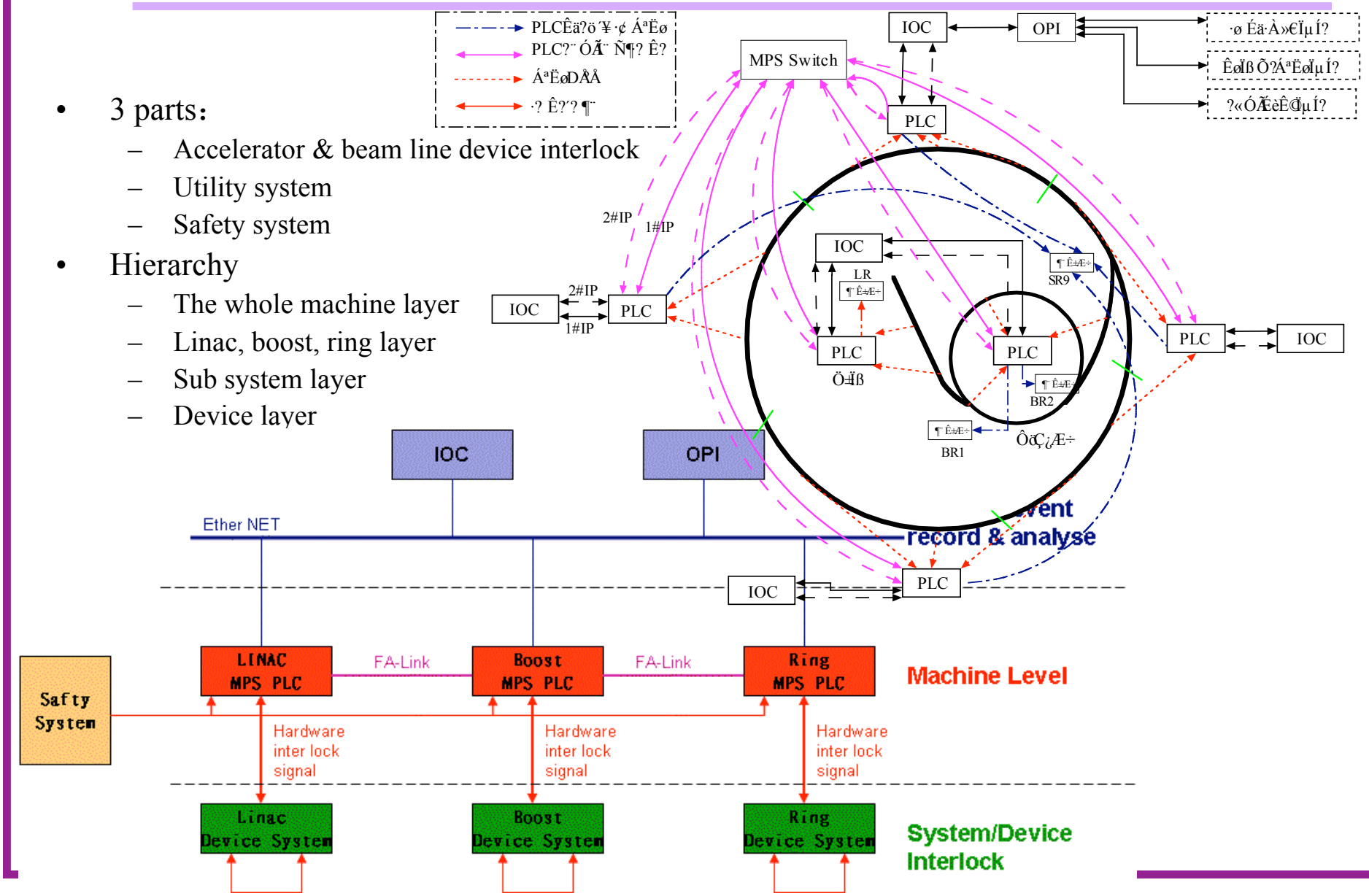


Performance

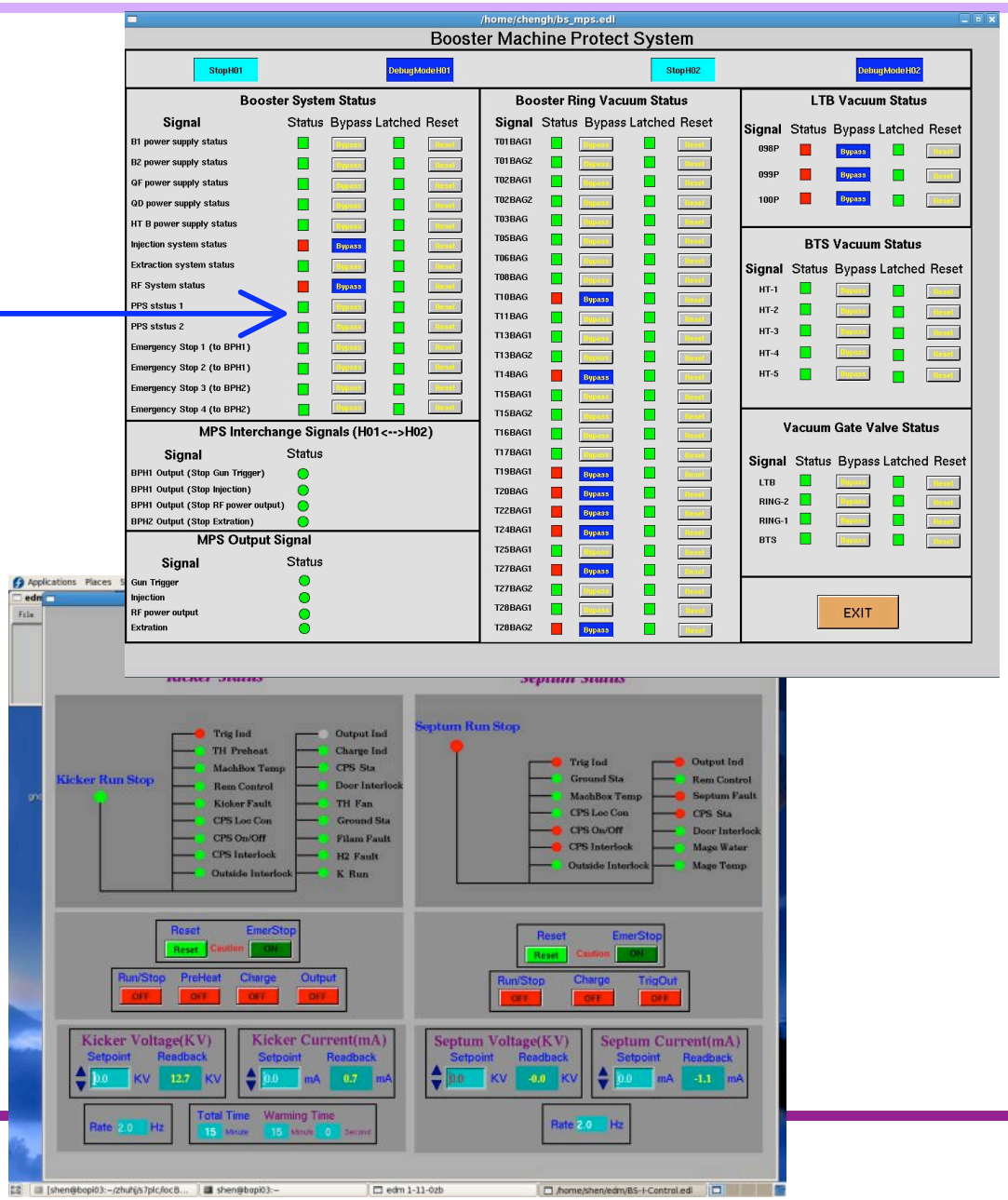
- The RMS jitter of gun trigger relative to RF reference is 10.72ps, which includes the jitter of e-gun and oscilloscope.
- The RMS jitters of other injection and extraction trigger are less the 30ps.
- Performance are satisfied with the requirements of physical design.

MPS

- 3 parts：
  - Accelerator & beam line device interlock
  - Utility system
  - Safety system
- Hierarchy
  - The whole machine layer
  - Linac, boost, ring layer
  - Sub system layer
  - Device layer



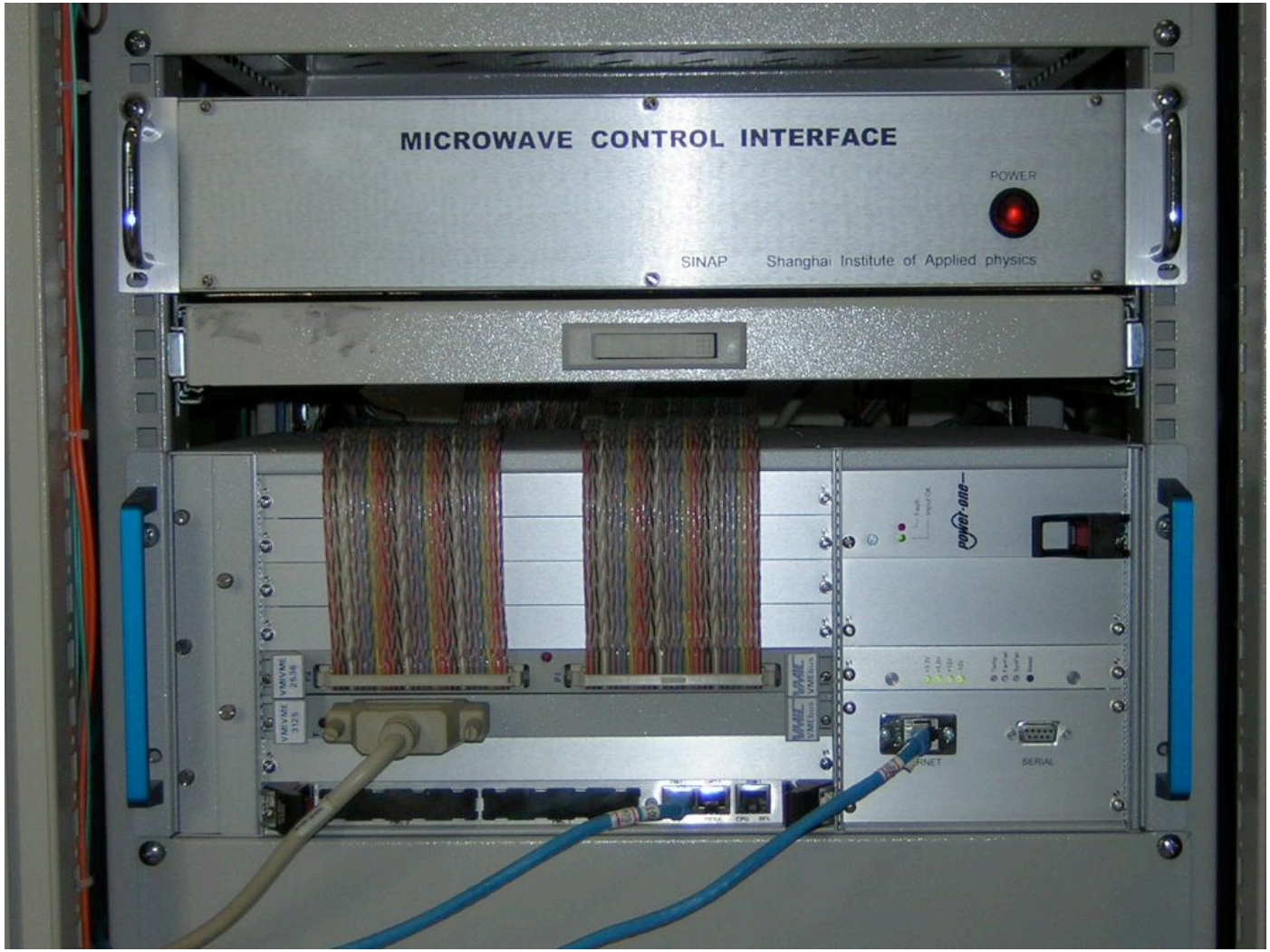
MPS GUI


/home/chengh/bs_mps.edl
Booster Machine Protect System
StopH01
DebugModeH01
StopH02
DebugModeH02
Booster System Status
Signal Status Bypass Latched Reset
B1 power supply status
B2 power supply status
QF power supply status
QD power supply status
HT B power supply status
Injection system status
Extraction system status
RF System status
PPS ststus 1
PPS ststus 2
Emergency Stop 1 (to BPH1)
Emergency Stop 2 (to BPH1)
Emergency Stop 3 (to BPH2)
Emergency Stop 4 (to BPH2)
MPS Interchange Signals (H01<-->H02)
Signal Status
BPH1 Output (Stop Gun Trigger)
BPH1 Output (Stop Injection)
BPH1 Output (Stop RF power output)
BPH2 Output (Stop Extration)
MPS Output Signal
Signal Status
Gun Trigger
Injection
RF power output
Extration
Booster Ring Vacuum Status
Signal Status Bypass Latched Reset
T01BAG1
T01BAG2
T02BAG1
T02BAG2
T03BAG
T05BAG
T06BAG
T08BAG
T10BAG
T11BAG
T13BAG1
T13BAG2
T14BAG
T15BAG1
T15BAG2
T16BAG1
T17BAG1
T19BAG1
T20BAG
T22BAG1
T24BAG1
T25BAG1
T27BAG1
T27BAG2
T28BAG1
T28BAG2
LTB Vacuum Status
Signal Status Bypass Latched Reset
098P
099P
100P
BTS Vacuum Status
Signal Status Bypass Latched Reset
HT-1
HT-2
HT-3
HT-4
HT-5
Vacuum Gate Valve Status
Signal Status Bypass Latched Reset
LTB
RING-2
RING-1
BTS
EXIT
Kicker Run Stop
Trig Ind
TH Preheat
MachBox Temp
Rem Control
Kicker Fault
CPS Loc Con
CPS On/Off
CPS Interlock
Outside Interlock
Output Ind
Charge Ind
CPS Sta
Door Interlock
TH Fan
Ground Sta
Filam Fault
H2 Fault
K Run
Septum Run Stop
Trig Ind
Ground Sta
MachBox Temp
CPS Loc Con
CPS On/Off
CPS Interlock
Outside Interlock
Output Ind
Rem Control
Septum Fault
CPS Sta
Door Interlock
Mags Water
Mags Temp
Reset
EmerStop
Caution
Run/Stop
PreHeat
Charge
Output
TrigOut
OFF
Kicker Voltage(KV)
Kicker Current(mA)
Septum Voltage(KV)
Septum Current(mA)
Setpoint
Readback
Rate
Total Time
Warming Time

RF System

- Linac microwave system is designed by SSRF
- Thales design RF system for SSRF
- Integrated with EPICS system and can be controlled at center control room

Linac RF Control



RF for Booster and Storage Ring

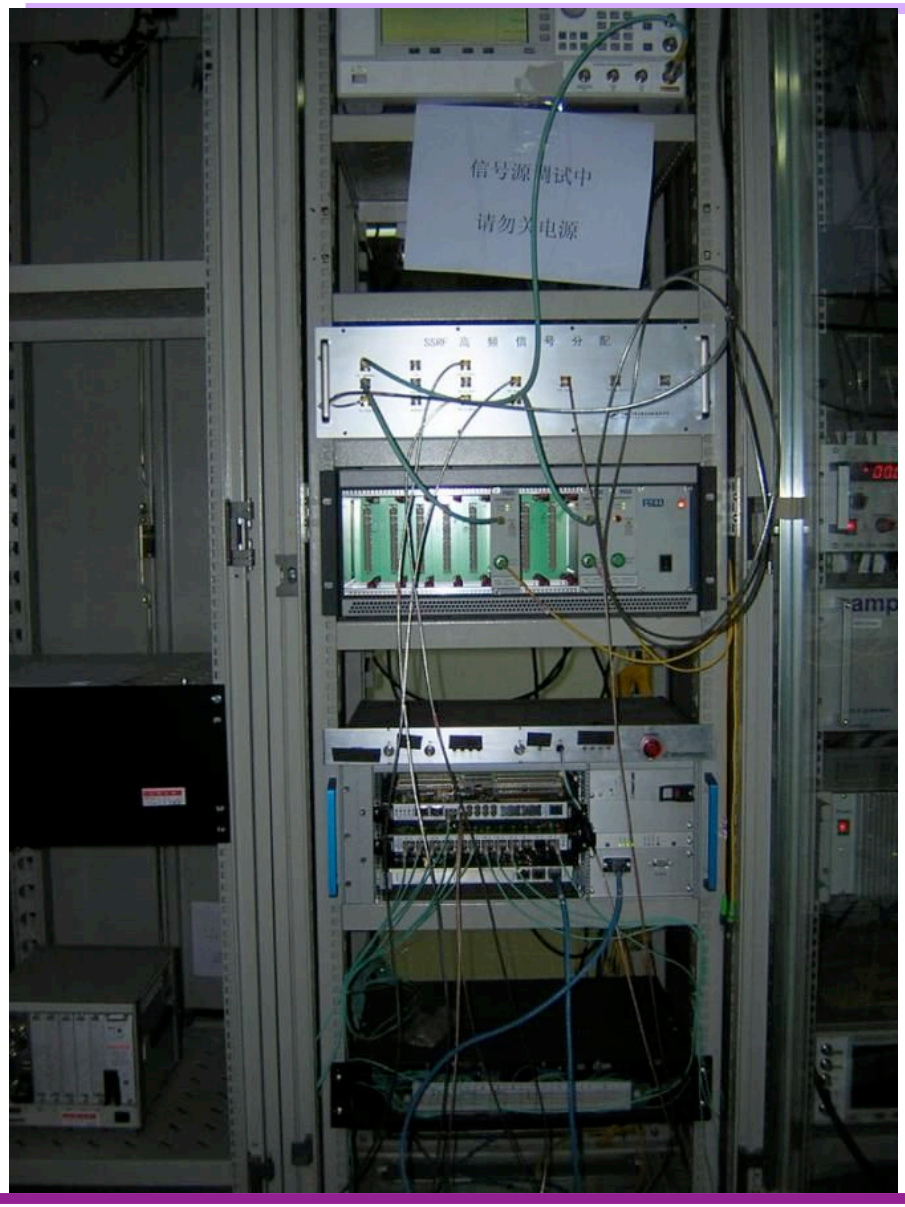
RF Amplifier &
Klystron

Booster 180Kw

Storage Ring
300Kw X 3

Epics IOC
MVME 5500
Hytec I/O boards
Fully Isolated -
Interface

RF and Timing Event Distribution



Master Signal Generater

RF Signal Distrubution Unit

Timing & Eent Signal Generator

Fiber (Om3) Distribution Unit

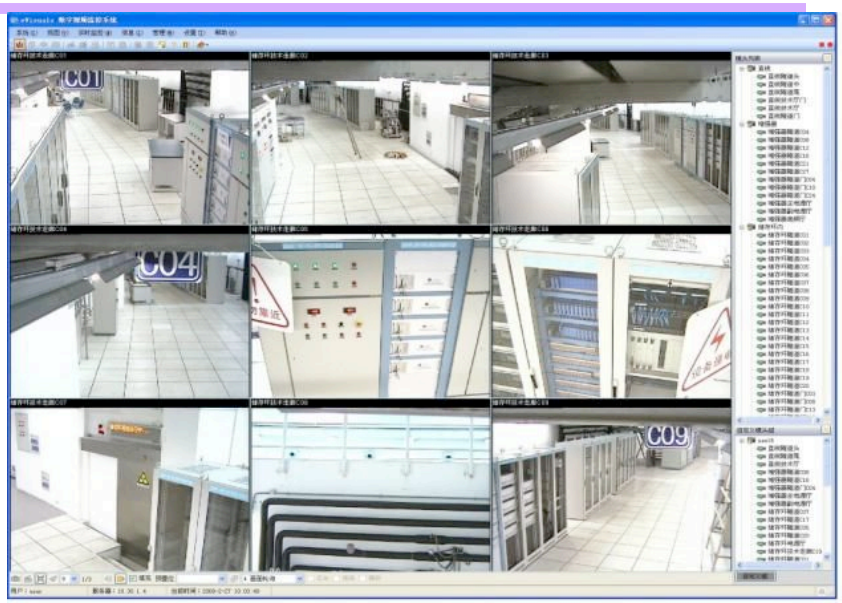
RF GUI

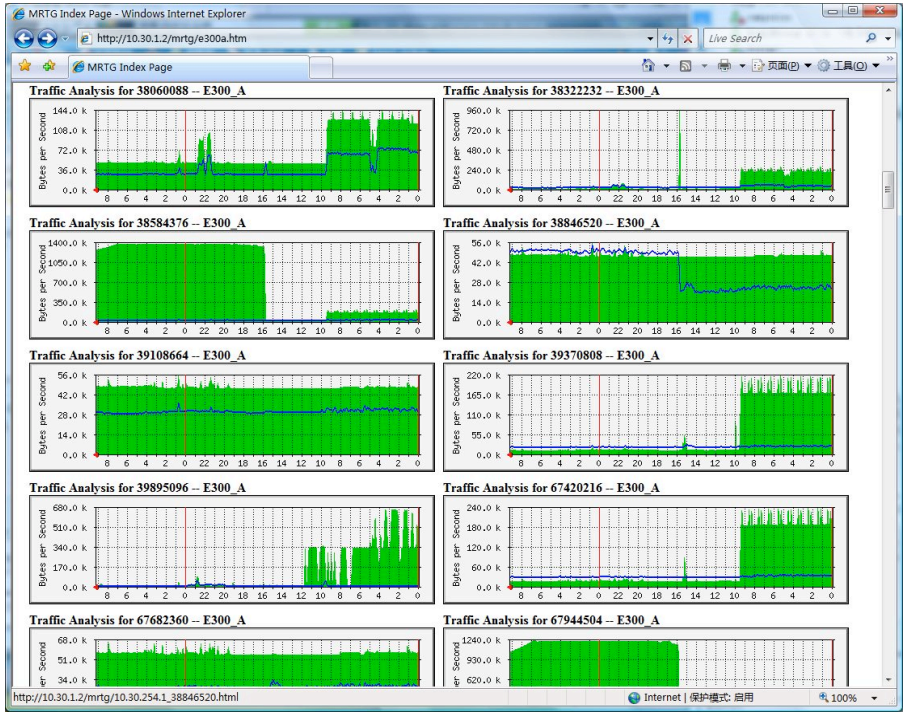
Storage Ring

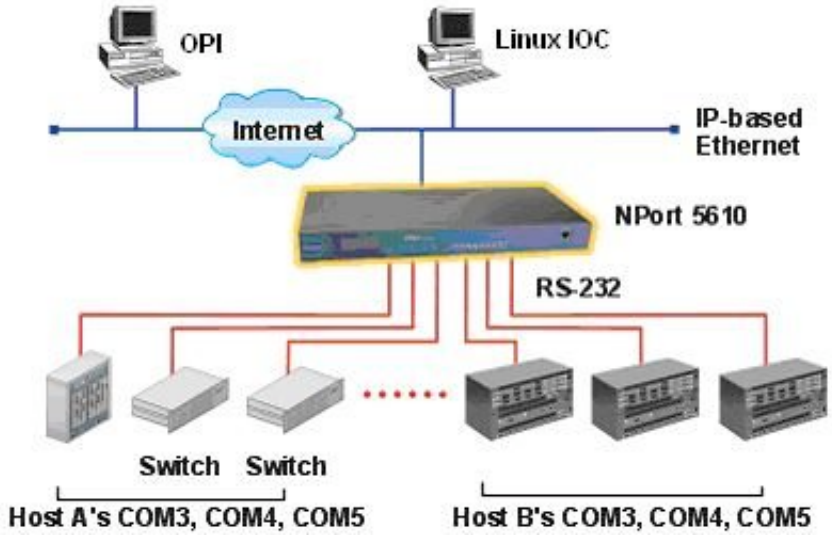
Booster

Remote Management

- Video & Audio system based on network
- Device management
- Remote monitor: VME ,Switch, UPS etc
- Network management system
  - Based on SNMP
- Email、SMS alarm system (Next)







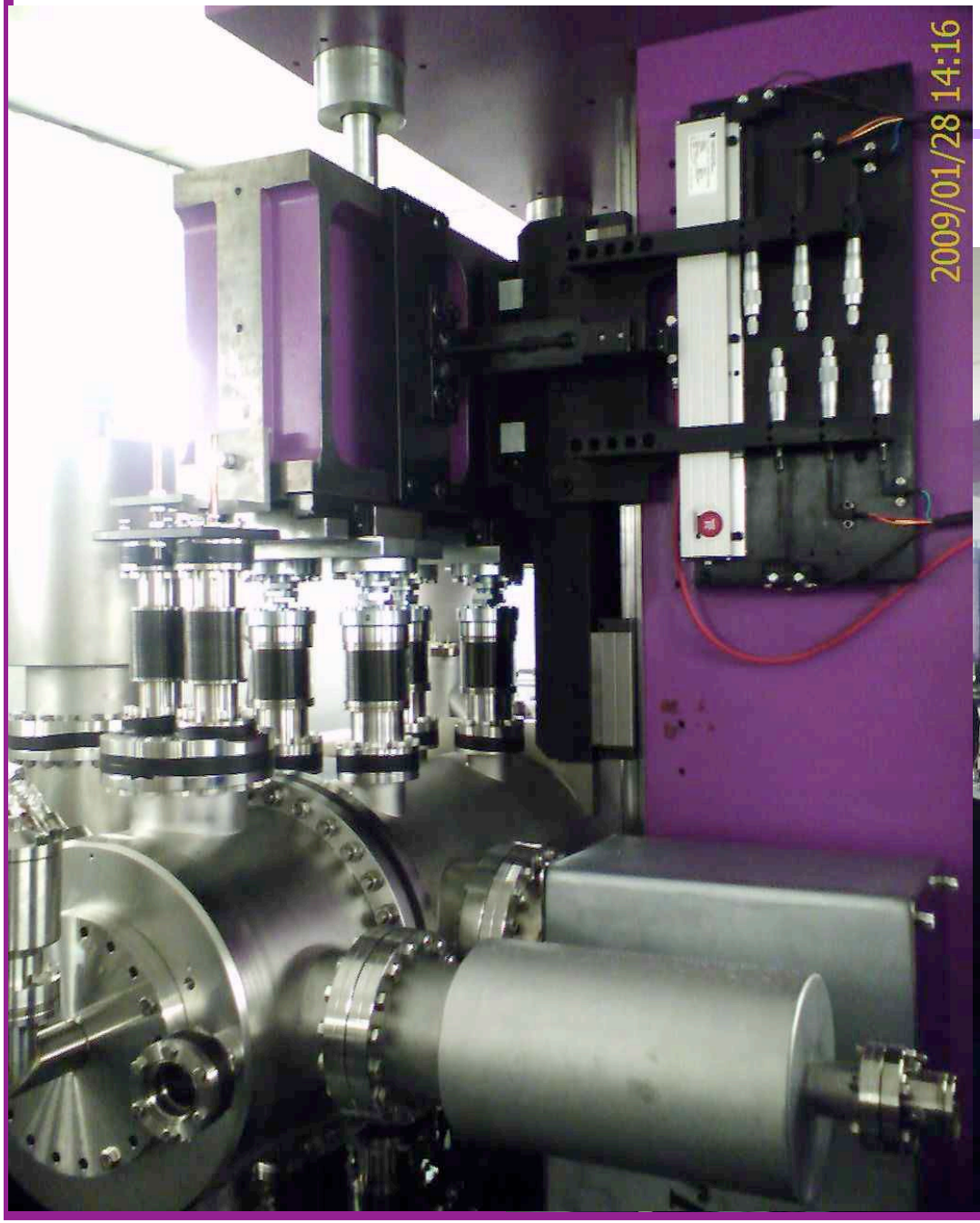
Center Control Room

- 18 HP7700 OPI PCs in the Control Room
- All the OPIs run on the Linux Fedora 7 and in ssrf.ac.cn domain.
- OPI system running at control system has uniform runtime environment.
- The edm GUI files are stored on NFS file server and all the client can access it by a start script.


SR-RF status
BS-RF status
2008/02/27

Inserting Device (ID)

- More than 60 beam lines could be installed in the ring
- 26 of them will be based on insertion devices
- First stage will also include 7 initial beam lines and experimental stations
  - macromolecular crystallography
  - XAFS
  - hard X-ray microfocus
  - X-ray imaging and biomedical application
  - soft X-ray spectromicroscopy
  - diffraction
  - small angle X-ray scattering respectively
- 5 beam lines are based on insertion devices, 2 are based on bending magnets
  - 2 wigglers, finished
  - 1 elliptically polarizing undulator (EPU) , finished
  - 2 in-vacuum undulators (1 finished, 1 will be finished in this month)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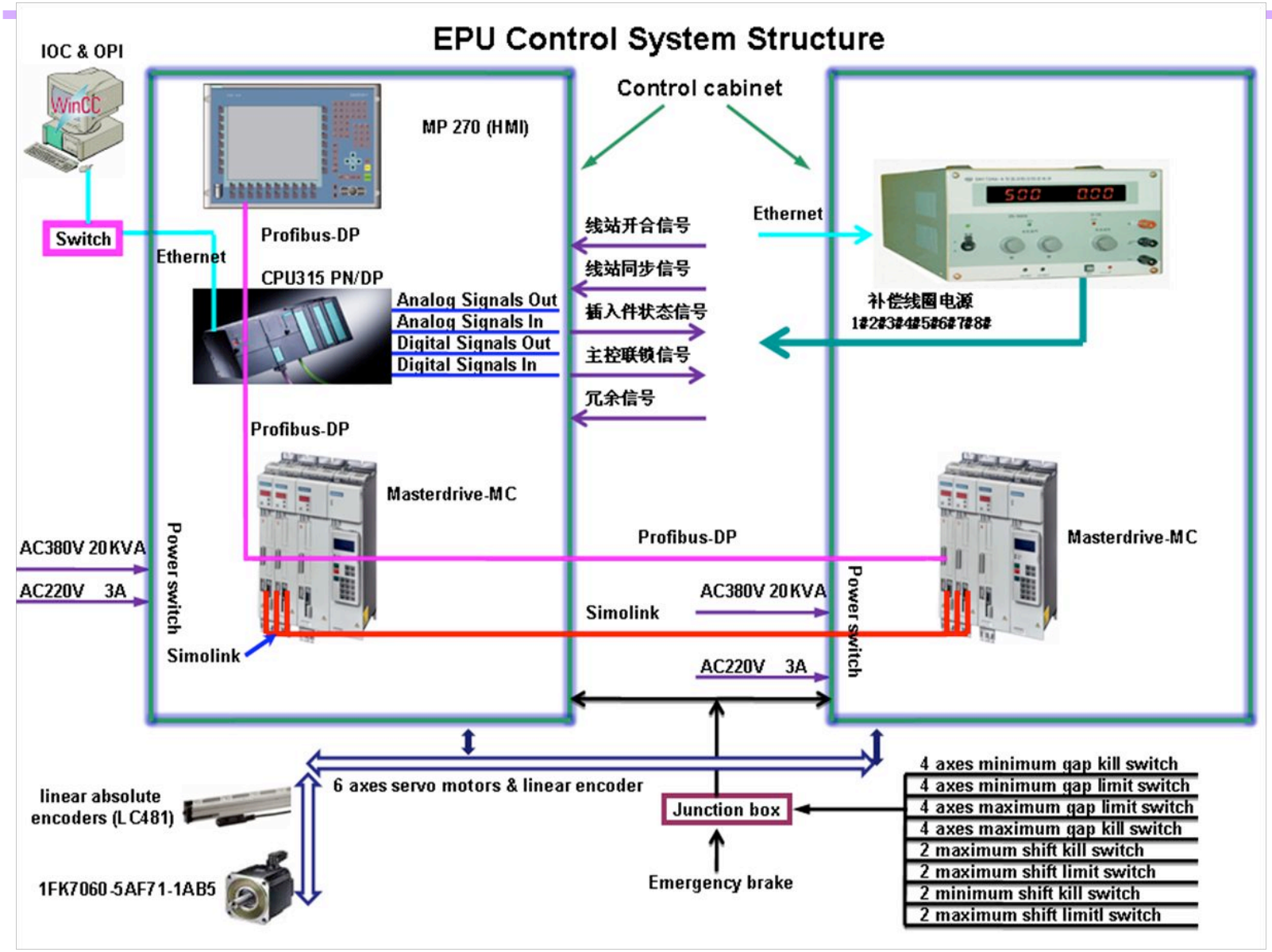
2009/02/03 17:11

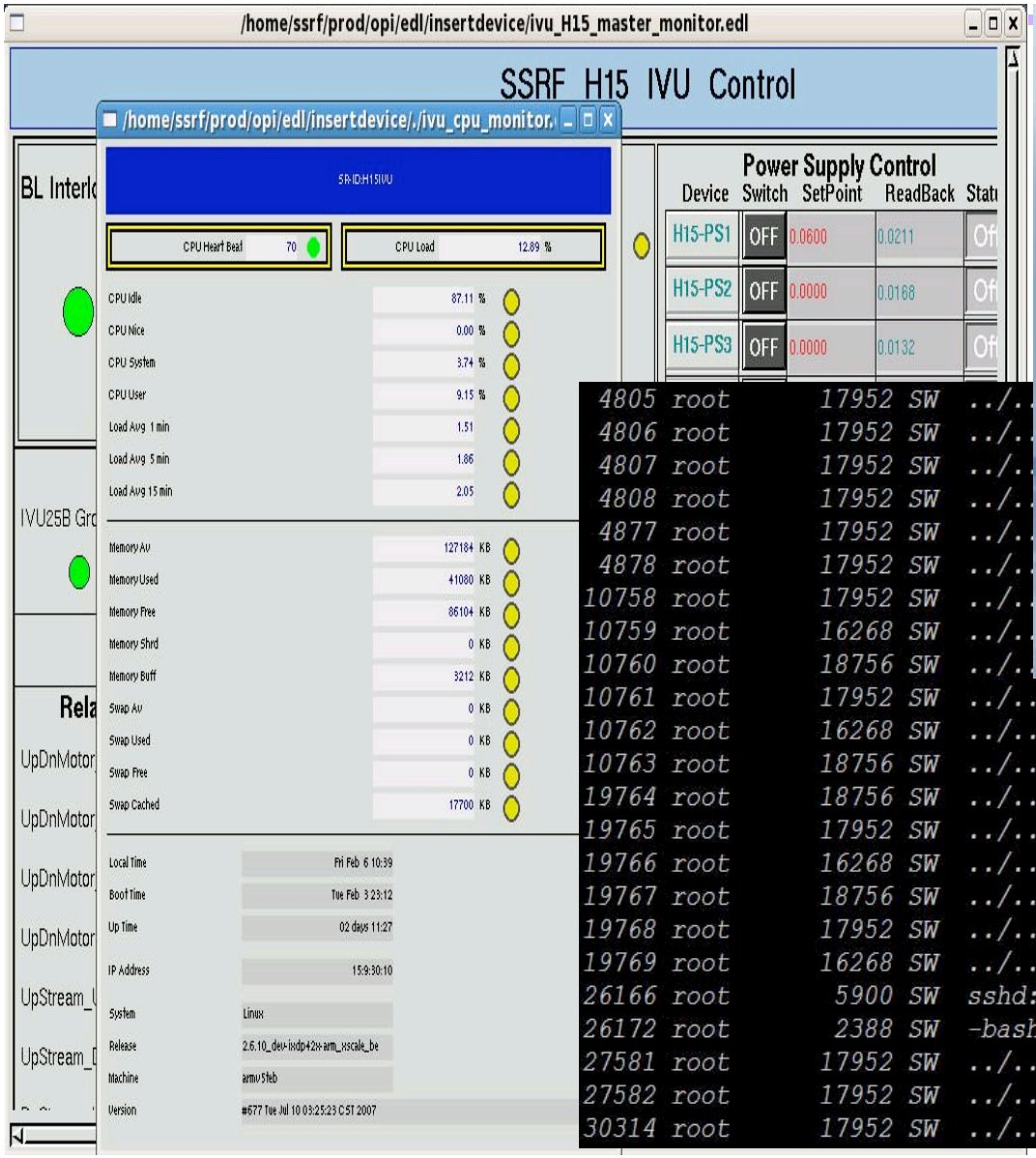
Wiggler and EPU control



Embedded EPICS Controller of IDs

- We use embedded EPICS controller to implement ID control
  - DI/DO interfaces
  - 2 Ethernet ports/ 1 RS232 debug ports/PCMCIA wireless card
  - Intel xscale CPU
  - CF card storage support
- Full IOC core
  - Base 3.14.10 cross compile, CF card storage
- Additional programming for converting Ethernet/serial (Full duplex)
- Three types of EPICS applications running on it
  - S7 PLC driver
  - Power supply driver
  - PC Monitor application
- Running stability
  - Kernel version 2.6
  - About 15% CPU loading, several tens of Mega storage
  - Full ioc core supported including sequencer
  - Startup ioc via /etc/inittab

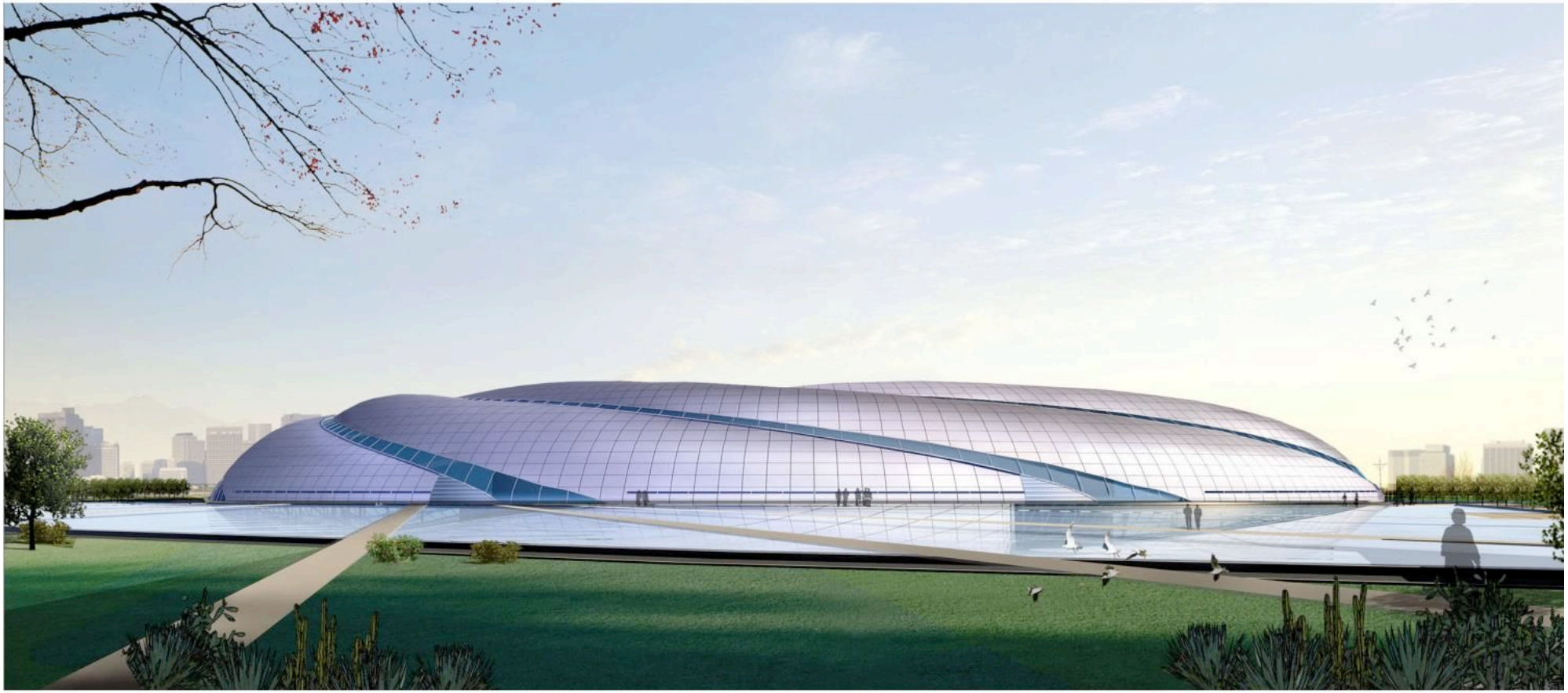
Embedded EPICS Controller



Conclusion

- SSRF control system is another successful application of EPICS
- We benefit greatly from other control groups, especially KEKB control group
- Ethernet and netDev (J.Odagiri) make our control architecture simple and clean
- The control system was successful during the machine commissioning, has reached design goal
- We hope can do some enhanced works in the future and contribute to EPICS collaboration

Thanks



主体建筑透视图

Design Parameters

Wiggler
最小磁隙 13（16）mm
最大使用磁隙 50 mm
最大可拉开磁隙 150mm
最大磁隙调节速度4 mm/sec
打开磁隙从最小到最大～67 sec
打开磁隙从最小到最大工作磁隙～19sec
磁隙最小间隙必须有限位开关
通过网络与加速器控制接口
.1 um 绝对值光栅尺
光电限位开关 & 机电刹车开关

- Controller Manages
  - 4 Gap Servo Motor
  - 2 Phase Shift Servo Motor
  - 6 Heidenhain linear absolute encoders
  - 24 Limit and Kill Switches
  - 联锁信号
  - 4 Correction Coils
  - Software Interface
- 2 in-vacuum undulator
  - Step motor
  - Diffirent encoders and so on

EPU：
6个伺服电机（4个磁隙控制，2个相位控制）
最小磁隙 ~30 mm
最大使用磁隙 85 mm
最大可拉开磁隙 100mm
最大磁隙调节速度4 mm/sec
≈10 sec Min to Max Gap Time
最小磁隙调节分辨率 ≤5μm
最大磁场极化相位调节速度 30s(从线极化调至圆极化)
相位移动范围±55mm
磁隙最小间隙必须有限位开关
通过网络与加速器控制接口
.1 um 绝对值光栅尺
光电限位开关 & 机电刹车开关