



BEPCII Control System

Jijiu Zhao

BEPCII Control Group

13 Feb. 2009, KEK



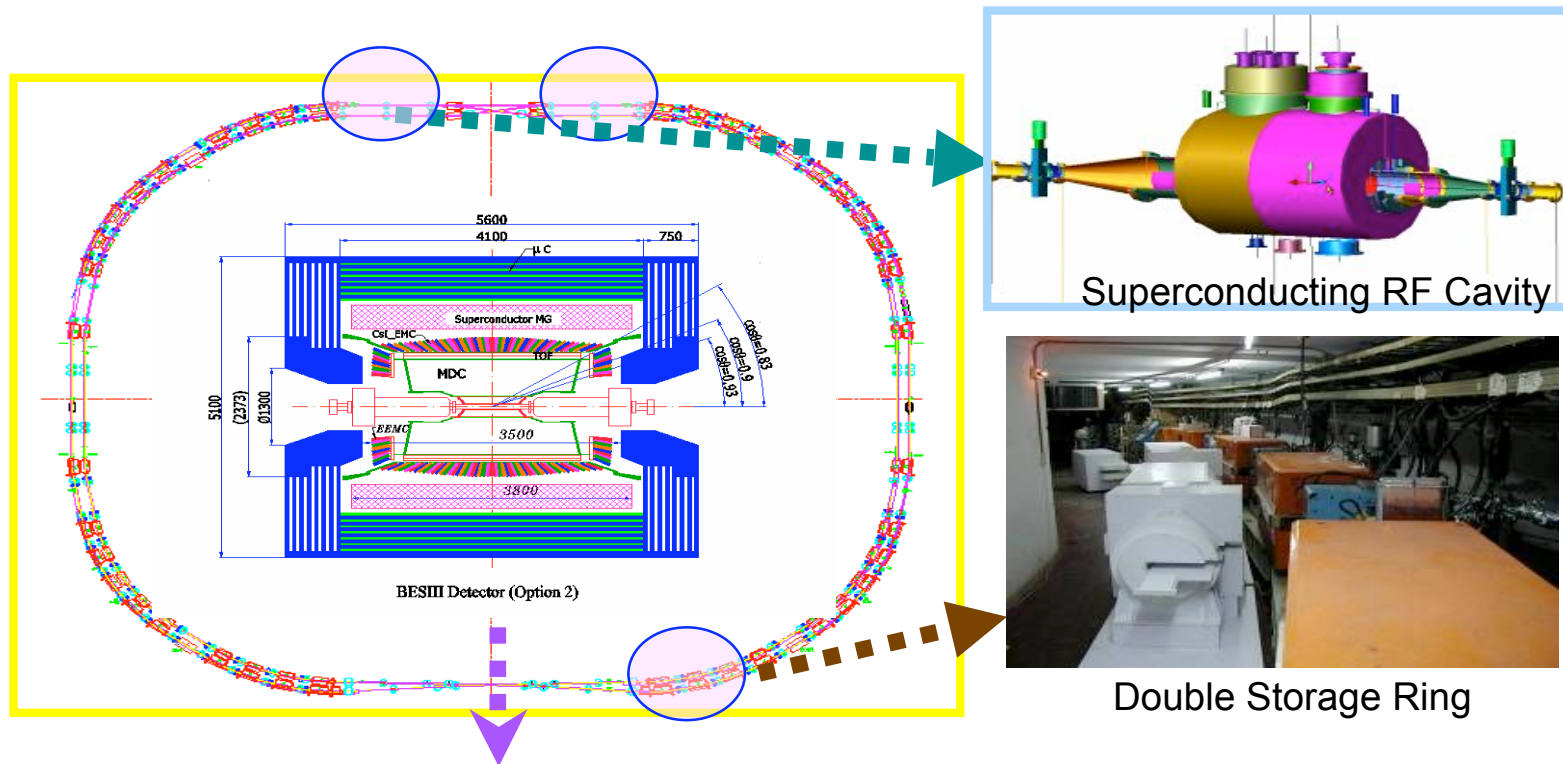
BEPCII Project

- The project BEPCII is for upgrading the BEPC to reach a higher luminosity, $1 \times 10^{33} \text{cm}^{-2} \text{s}^{-1}$, 100 times to the BEPC.
- BEPCII still serves high energy physics experiments and synchrotron radiation research. (total budget 650M CNY)
 - Energy 1.89GeV at Collision mode (\rightarrow 1.85Gev)
 - Energy 2.5GeV at Synchrotron radiation mode
- The project was started in August 2001
 - Project proposal
 - Conceptual design
- R&D started in October 2002
- System development started in Jan. 2004
- First beam into storage ring in November 2006



BEPCII

BEPCII consists of the Linac, Transport line and Storage Ring

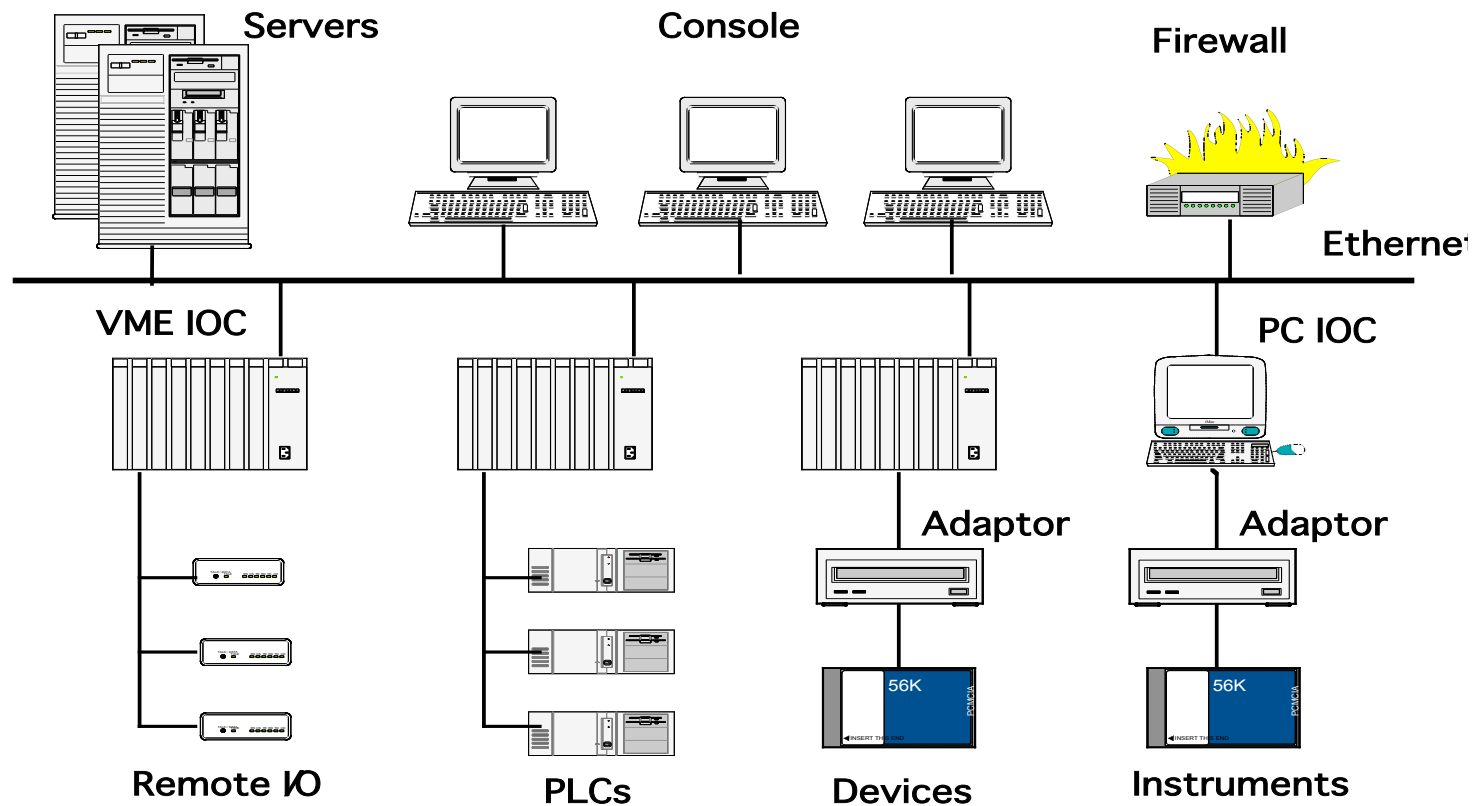


- BEPCII adopted Double ring schema and super-conducting devices
- The old control system has been removed. We have to build a new control system and there are 20,000 channels in the control system



System architecture

Adopt “Standard mode” and EPICS system
It’s the first time that EPICS was adopted officially





Systems Components

- Host computer system
- Control network
- Sub-systems
 - Power supply control
 - Vacuum control
 - RF control
 - Cryogenic control
 - Linac control
- Timing system
- High level applications
- Oracle database
- Central console



Host Computer system

Host computer system in MCC building

- SUN Cluster system (v3.0)
 - 2 SUN V880 servers
 - 8 CPU each (1.2GHz Ultra SPARCIII)
 - 32GB memory each
 - 6*73GB disks each
 - 12*73 shared disk array: RAID 5 + 1 hot spare, NFS
 - Used as EPICS server and for HLA Calculations
- EPICS/ChannelArchiver data server
- Oracle server
- 28 Console computers – SUN Blade2000 and Linux PCs



SUN cluster installing and testing





Computers in main control room





Hardware

- More than 30 VME IOCs (MVME 5100 / 2431)
- And about 25 PC IOCs
- Device control and interface
 - Remote I/O: Power supply and linac control
 - Intelligent controller: Vacuum pumps, gauges
 - VME I/O modules: RF control
 - AB-PLC for cryogenic and Vacuum control
 - Omron PLC for machine protection system
- 1G/100M Ethernet
 - using Cisco C4506 switch, redundancy
- Field Buses
 - ControlNet, CANbus, RS232, RS485



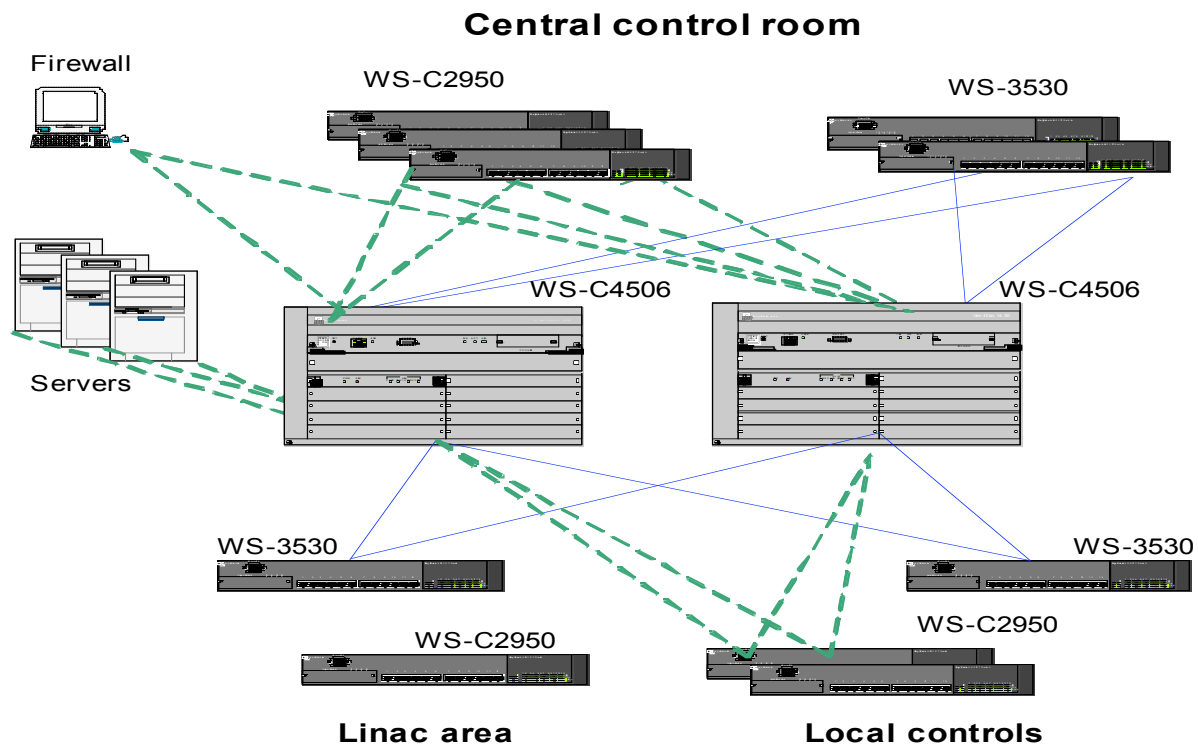
Software

- EPICS Base R3.13.8 for VME IOC
- EPICS Base R3.14.7 for PC IOC
- Host
 - SUN Solaris 8 and PC Linux red hat 9
 - EPICS host tools:
MEDM, EDM, VDCT, SNL, Tcl / Tk, ALH, Channel Archiver, Probe, StripTool, SAD, etc.
 - Third party software
 - CVS for software management
 - File server with NFS
- IOC
 - VxWorks 5.4
 - Tornado 2.0 development environment
- HLA
 - developed and transferred from KEKB with SAD environment, after evaluation of HLA for SNS, PEP-II, APS and KEKB
- Oracle database store history data



Control Network

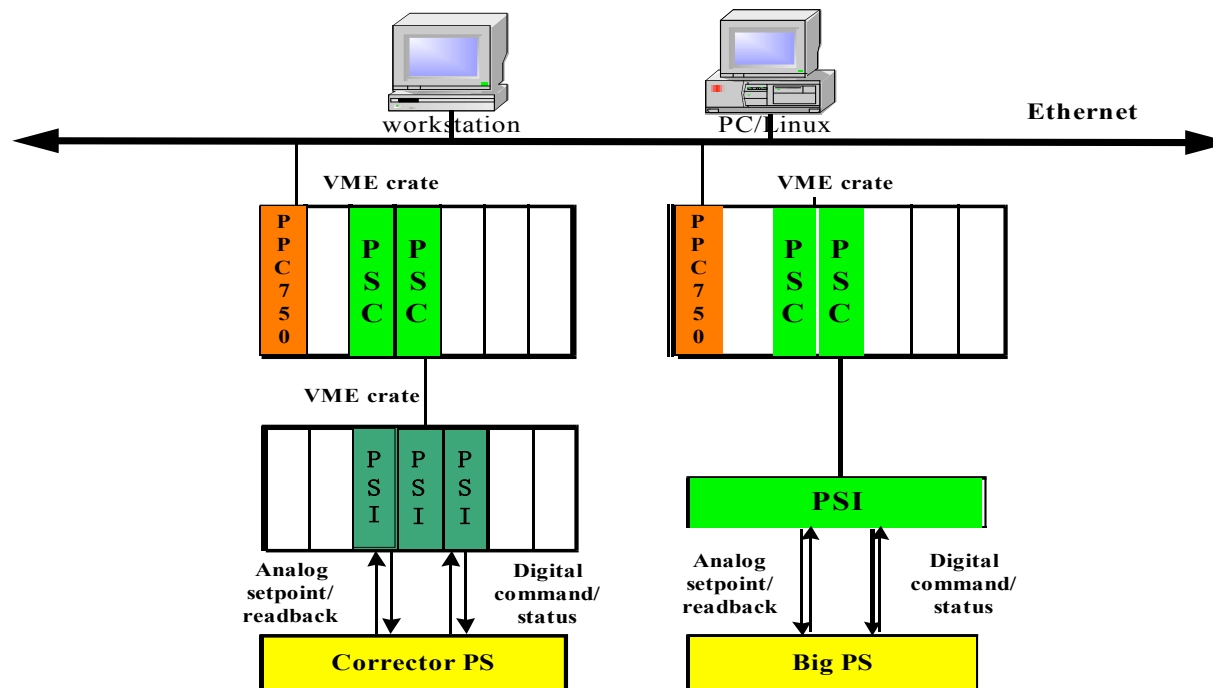
- Cisco 4506 series products, redundant system
- 200 nodes in the network, 2 VLANs
- Ethernet and Star Topology with 1G/100M Ethernet





PS Control

- About 420 PS on Storage ring and TL
 - including SC magnets PS in IR regin
- 13 VME IOCs
- Remote I/O module PSC-PSI for PS on Storage Ring
- PSC and PSI were designed by BNL





PS Local Control Station





PS Control panels

TPS_Check_ON_End
TPS_Check_OFF_End

TEQ POWER SUPPLY

RampUp_TEQ

NAME	ON/OFF Command			
TEQ1&3&9&11	ONAux	ON	OFF	OFFAux
TEQ2&10	ONAux	ON	OFF	OFFAux
TEQ4	ONAux	ON	OFF	OFFAux
TEQ5	ONAux	ON	OFF	OFFAux
TEQ6	ONAux	ON	OFF	OFFAux
TEQ7	ONAux	ON	OFF	OFFAux
TEQ8	ONAux	ON	OFF	OFFAux
TEQ12	ONAux	ON	OFF	OFFAux
TEQ13	ONAux	ON	OFF	OFFAux
TEQ14	ONAux	ON	OFF	OFFAux
TEQ15	ONAux	ON	OFF	OFFAux
TEQ16	ONAux	ON	OFF	OFFAux
TEQ17	ONAux	ON	OFF	OFFAux

RAMP DELTA: 0.5 A STEP DURATION: slow

TPS_Check_Alarm_End

BSR Ring Corrector Power Supply Monitor

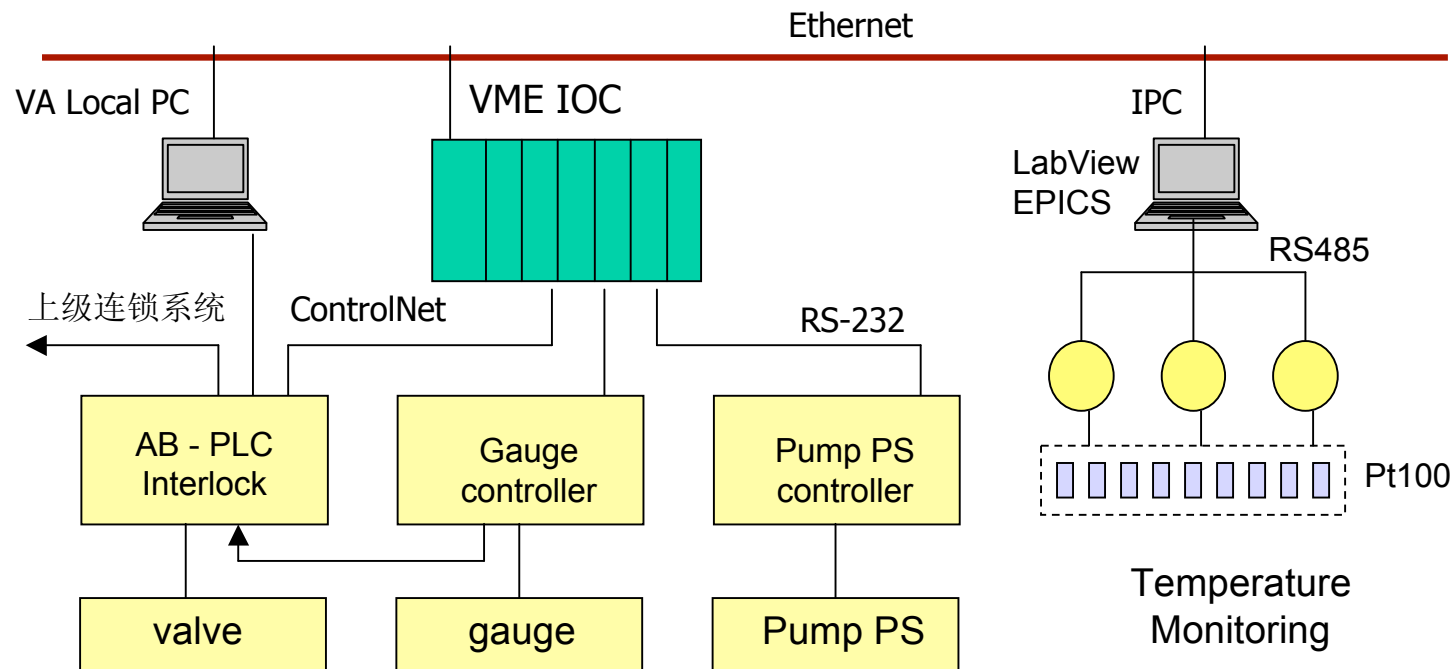
DONE

NAME	DESIMON	SETPOINT	CURRENT	NAME	DESIMON	SETPOINT	CURRENT
R2OBV02	ON	-11.419	-11.590	R1OBV02	OFF	0.018	0.021
R2OBV05	OFF	1.675	0.012	R1OBV05	OFF	-24.636	0.001
R2OBV07	OFF	-2.385	0.009	R1OBV07	OFF	17.220	0.011
R2OBV09	OFF	3.622	-0.002	R1OBV09	OFF	-25.427	-0.004
R2OBV11	OFF	-13.367	0.003	R1OBV11	OFF	0.000	-0.013
R2OBV13	OFF	1.669	-0.015	R1OBV13	OFF	0.000	0.005
R2OBV15	OFF	-1.456	0.006	R1OBV16	OFF	0.000	-0.010
R2OBV17	OFF	0.643	0.031	R1OBV17	OFF	0.000	0.011
R3OBV15	OFF	2.660	0.005	R4OBV15	OFF	0.000	-0.027
R3OBV13	OFF	-5.678	0.033	R4OBV13	OFF	0.000	-0.004
R3OBV11	OFF	0.000	0.011	R4OBV11	OFF	0.000	0.012
R3OBV09	OFF	0.000	0.005	R4OBV09	OFF	0.000	0.016
R3OBV07	OFF	0.000	-0.009	R4OBV07	OFF	0.000	-0.007
R3OBV05	OFF	0.000	0.004	R4OBV05	OFF	0.000	-0.023
R3OBV04	OFF	0.000	-0.023	R4OBV04	OFF	0.446	0.010
R3OBV02	ON	0.000	-0.134	R4OBV02	OFF	5.963	0.003
R2OWBT2	OFF	0.000	-0.005	R1OWBT2	OFF	0.000	0.003
R2OBT01	OFF	0.000	-0.017	R1OBT01	OFF	0.000	0.000
R2OBT03	OFF	0.000	-0.001	R1OBT03	OFF	0.000	0.018
R2OBT04	OFF	0.000	-0.004	R1OBT04	OFF	0.000	-0.005
R2OBT05	OFF	0.000	-0.013	R1OBT05	OFF	0.000	0.016
R2OBT07	OFF	0.000	0.027	R1OBT07	OFF	0.000	-0.012
R2OBT09	OFF	0.000	-0.008	R1OBT09	ON	0.000	0.041
R2OBT10	OFF	0.000	0.005	R1OBT10	OFF	0.000	0.030
R2OBH17	OFF	0.000	-0.023	R1OBH17	OFF	-0.000	0.010
R3OBT10	OFF	0.000	-0.005	R4OBT10	OFF	0.000	-0.006
R3OBT09	OFF	0.000	0.011	R4OBT09	OFF	0.000	0.001



Vacuum Control

- 48 point for vacuum pressures
- 360 pump ,18 valves interlock with vacuum pressure,
- 1000 channel for temperature monitor of vacuum chamber



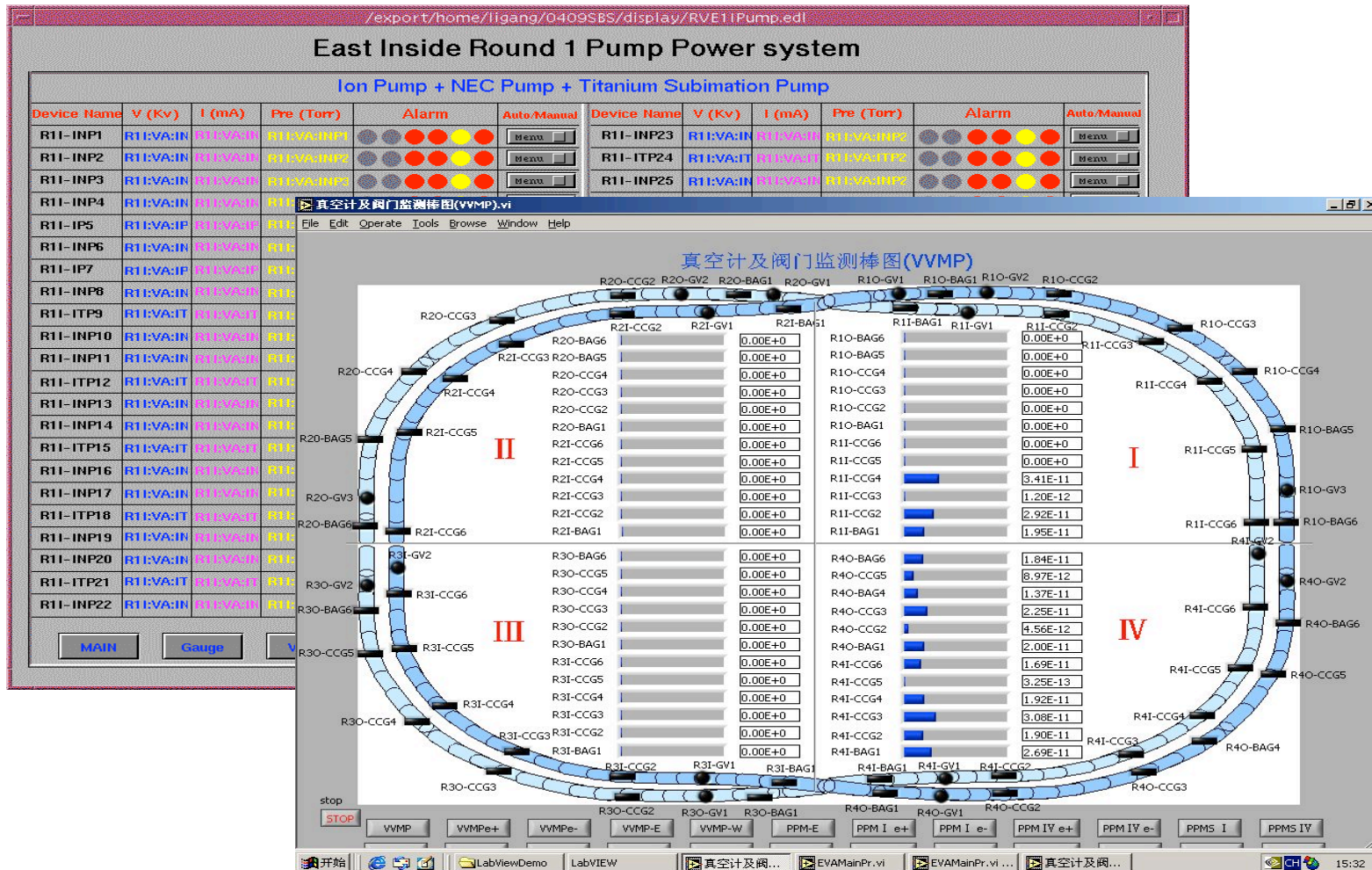


Vacuum control

- 2 VME IOCs
- Vacuum interlock system with AB-PLC and ControlNet
 - ControlLogix 5555 and AB-1756 I/O modules
 - VME-ControlNet adaptor SST-5136CN-VME
- An IPC for temperature monitoring of vacuum chamber
 - An IPC as EPICS IOC
 - Remote controller communication with IPC by RS-485
 - Developed with LabView
 - Installed LabView-EPICS interface “shared memory”

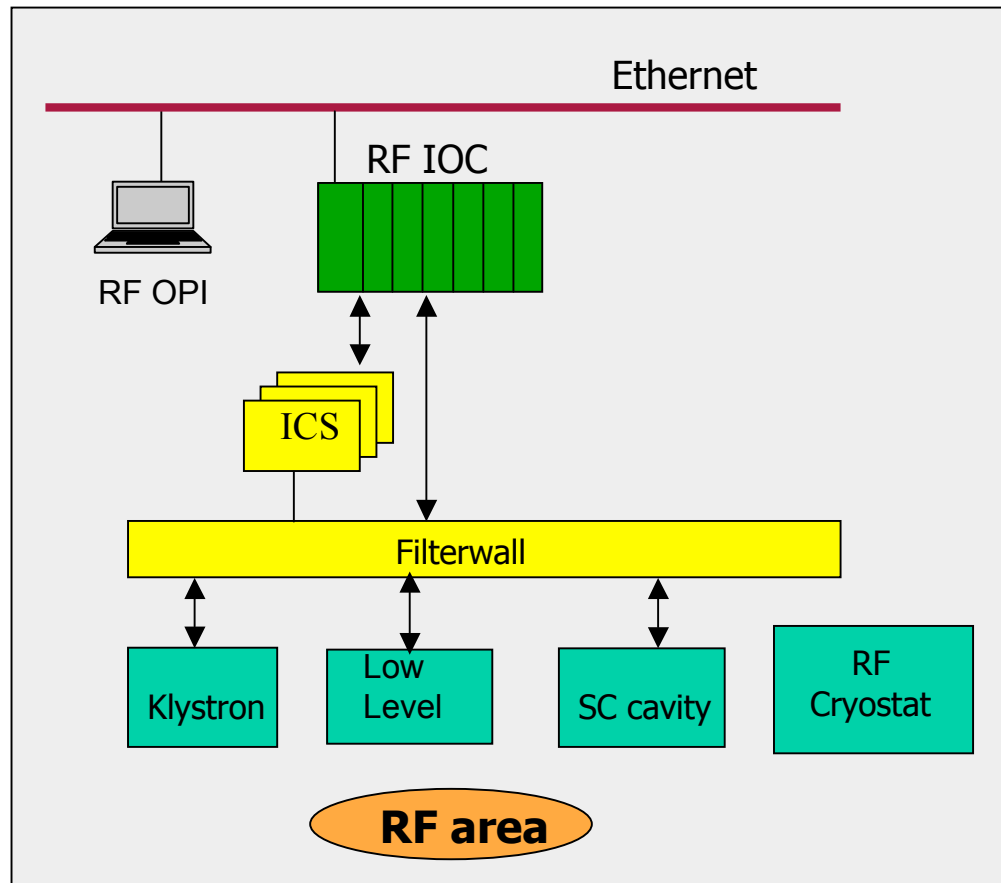


Vacuum panel





RF Control

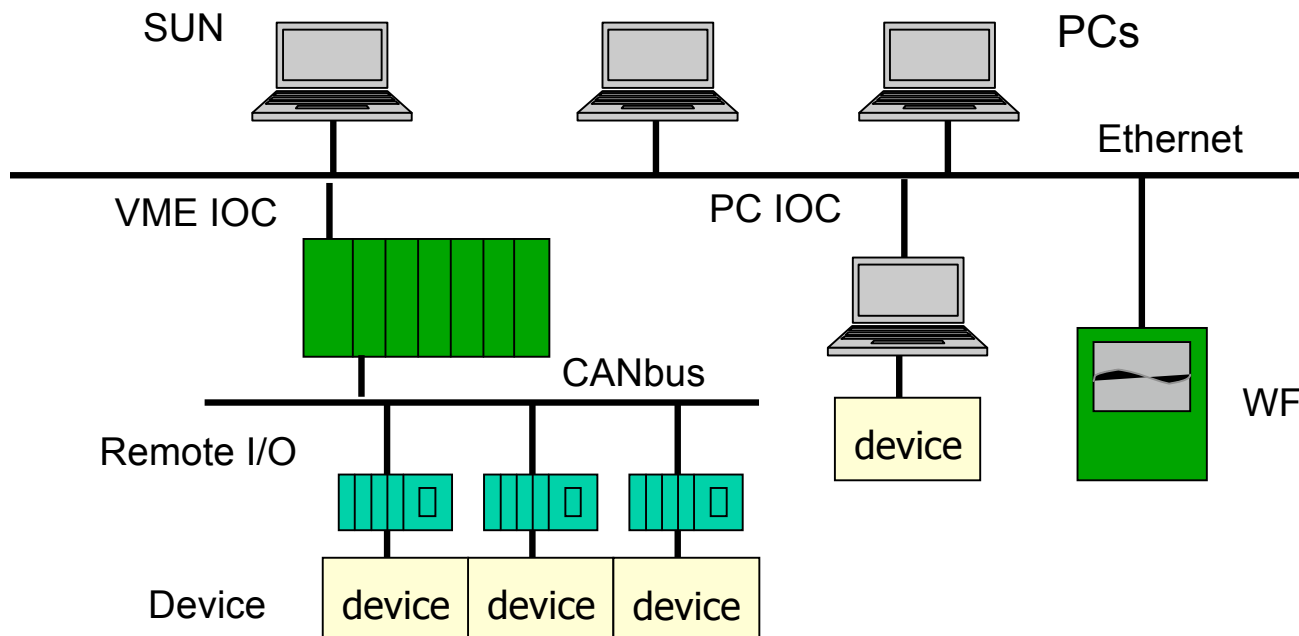


- The RF control system is developed by company Thomcast based on EPICS
- 2 Klystrons, 2 SC RF Cavities
- 2 VME IOCs , VME I/O modules, and interlock system with ICS modules
- LLRF system developed by IHEP



Linac Control

- EPICS based system
 - IOC: MVME2431 and Vxworks5.4
 - Remote I/O modules made in China
 - CANbus connect VME IOC and the remote I/O modules
- Linac control system was put into use in Nov. 2003. It's the first EPICS-based control system in IHEP.





Cryogenic Control

- Cryogenic control is made by IHEP
 - valve boxes, tanks, dewars, coils, cooling pipes
 - 2 local stations for SCQ ,SSM and 2 SCRF cavities
 - **Using AB-PLC, ControlNet, VME IOCs**
 - **VME-ControlNet adapter SST-5136-CN-VME used for data exchange between IOC and PLCs**

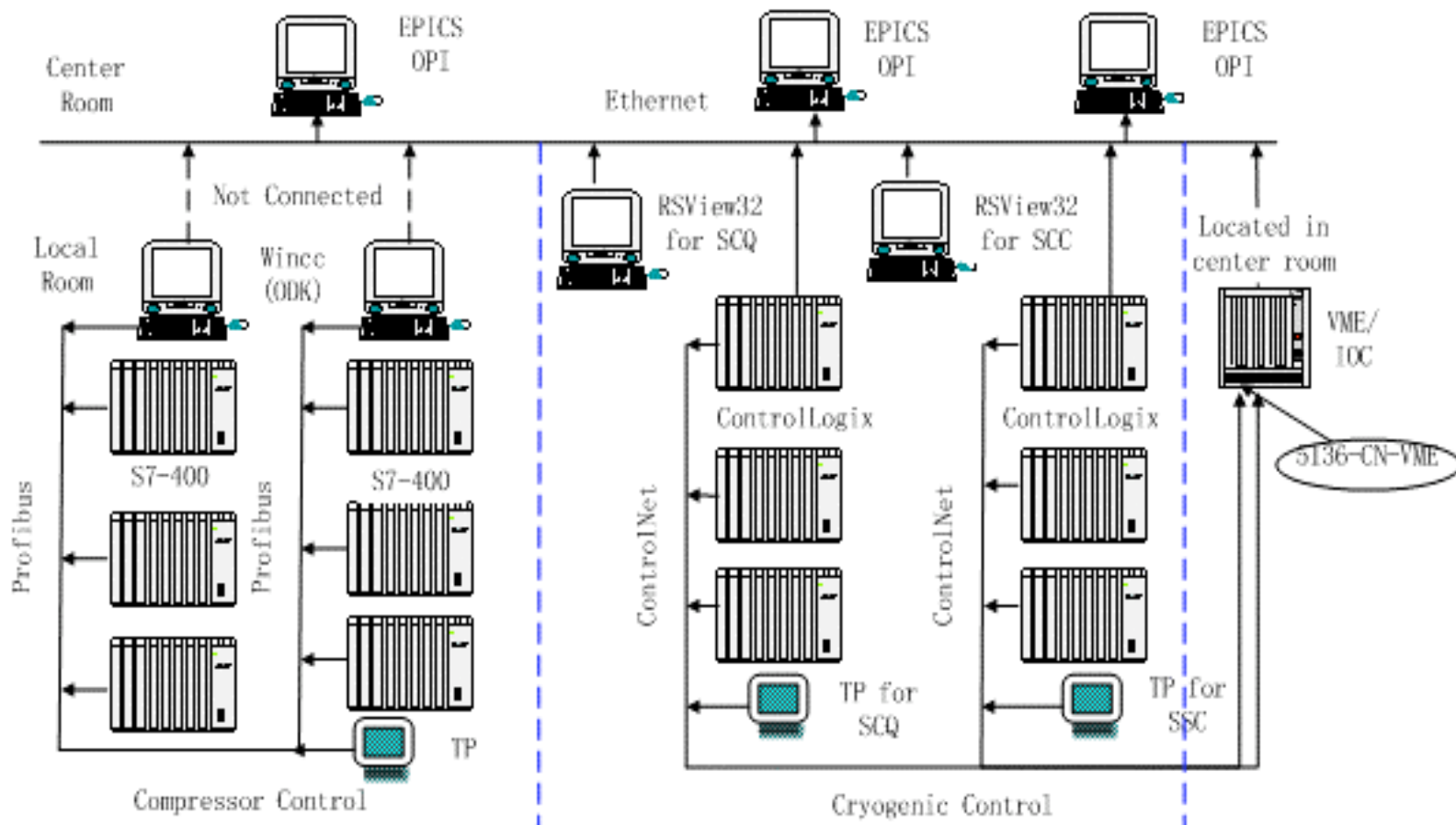
- Compressor control is made by Linde company
 - Using Siemens PLC S7, Profibus

- Data communication program has been developed between the two systems with Wincc/ODK and EPICS/CA



Cryogenic control

CR control system was put into operation in Jan. 2005





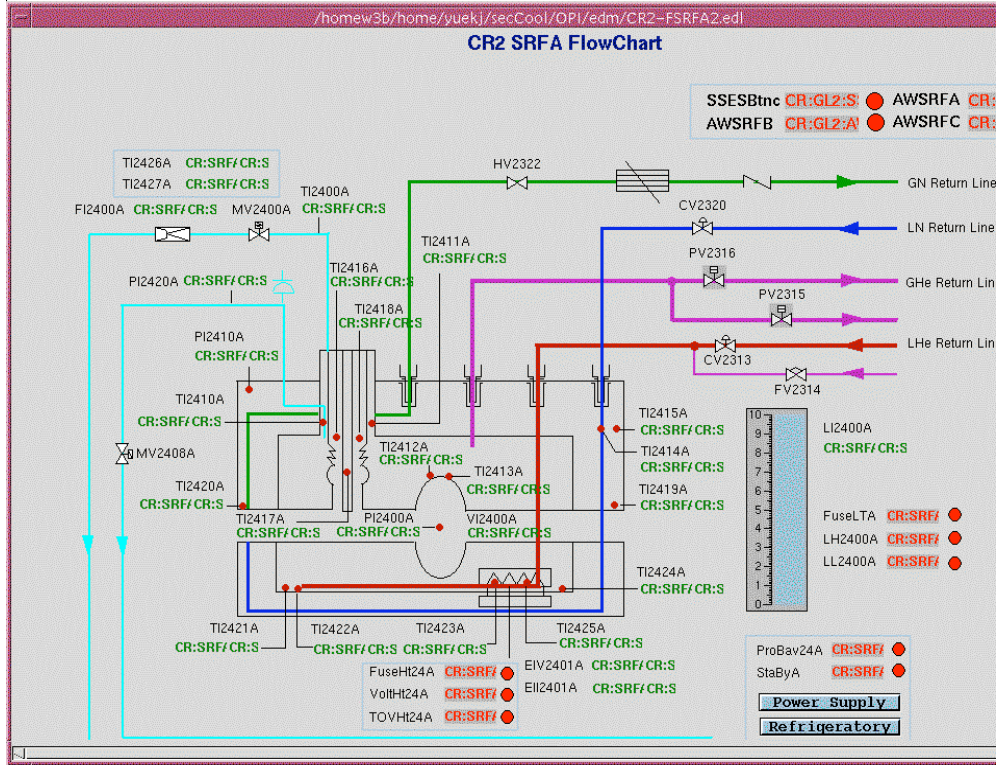
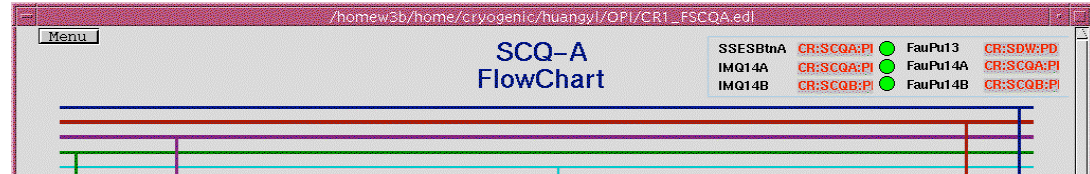
CR local control



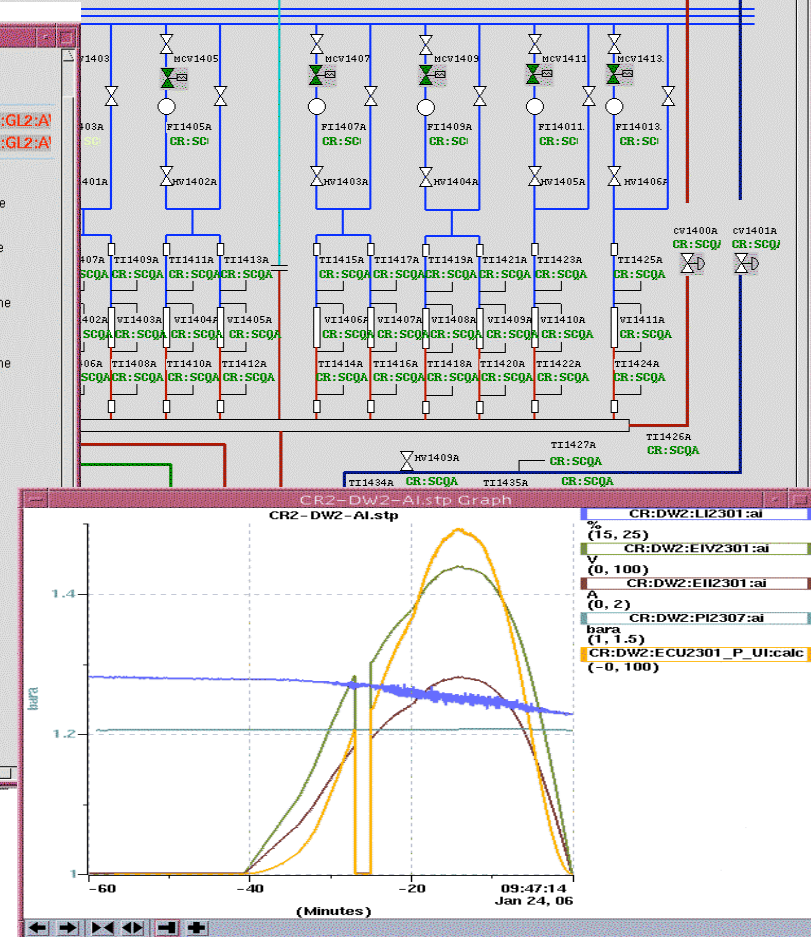


Control Panel

SCQ/SSM control



SCRF Cavity control





High level applications

- Most high level applications transferred from KEKB
- Using SAD development environment
- Main components
 - Optics
 - Closed orbit correction
 - IP commissioning
 - Slow orbit feedback control
 - BBA, Respons matrix
 - Injection timing



Panels of Optics and COD applications

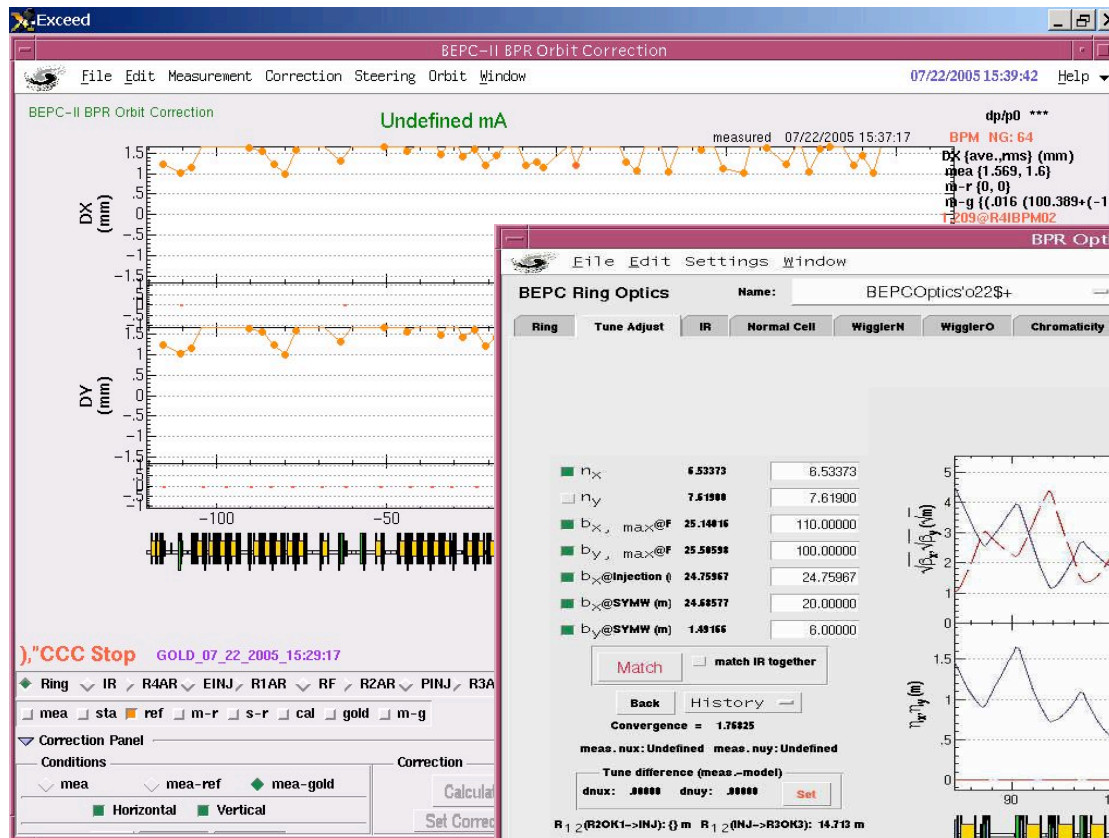


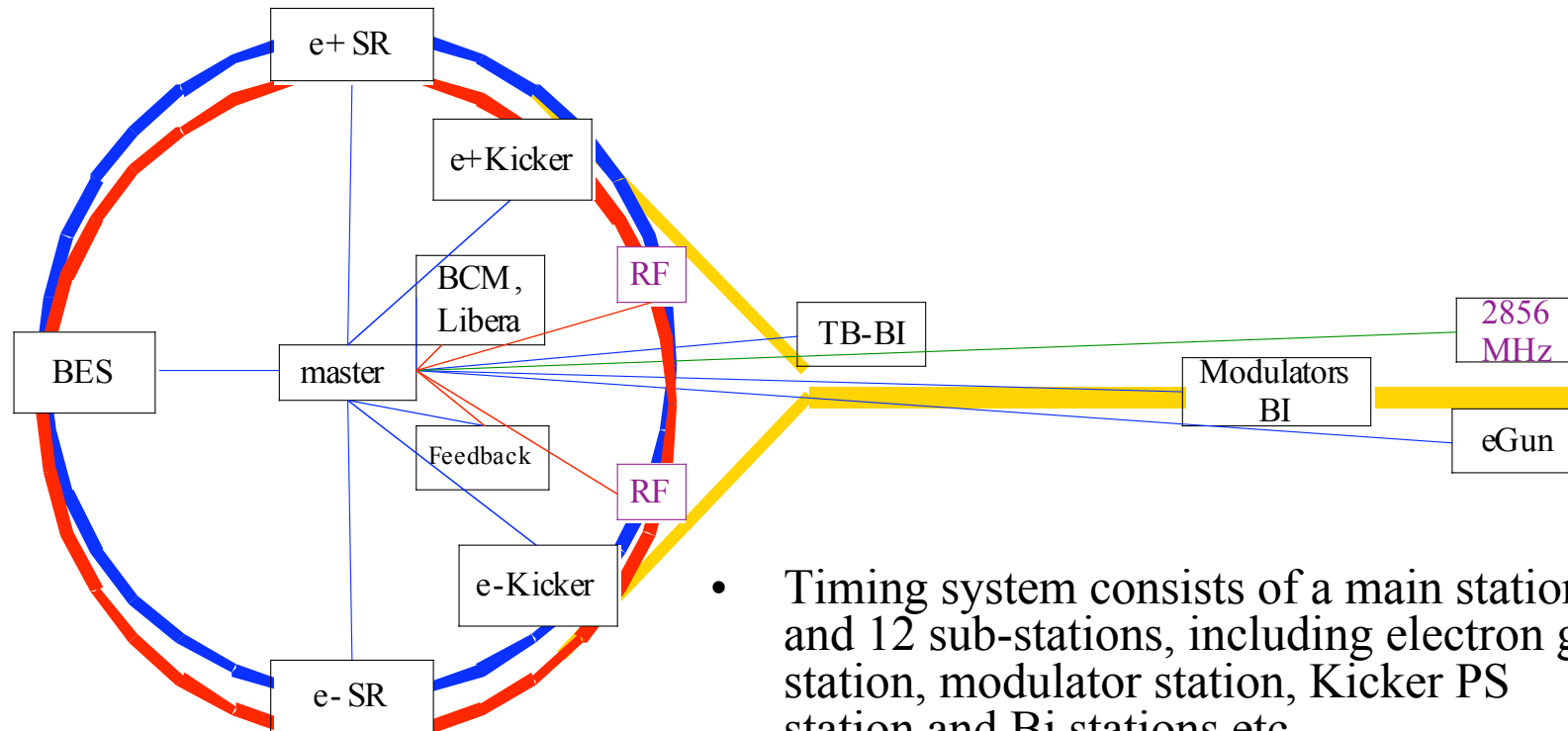
Fig1. COD



Fig2. Optics



BEPCII timing system layout



- Timing system consists of a main station and 12 sub-stations, including electron gun station, modulator station, Kicker PS station and Bi stations etc.
- Blue lines: event system optical cables
Red lines: 499.8MHz signals
Green line: 10MHz time base synchronized with Linac 2856MHz signal generator

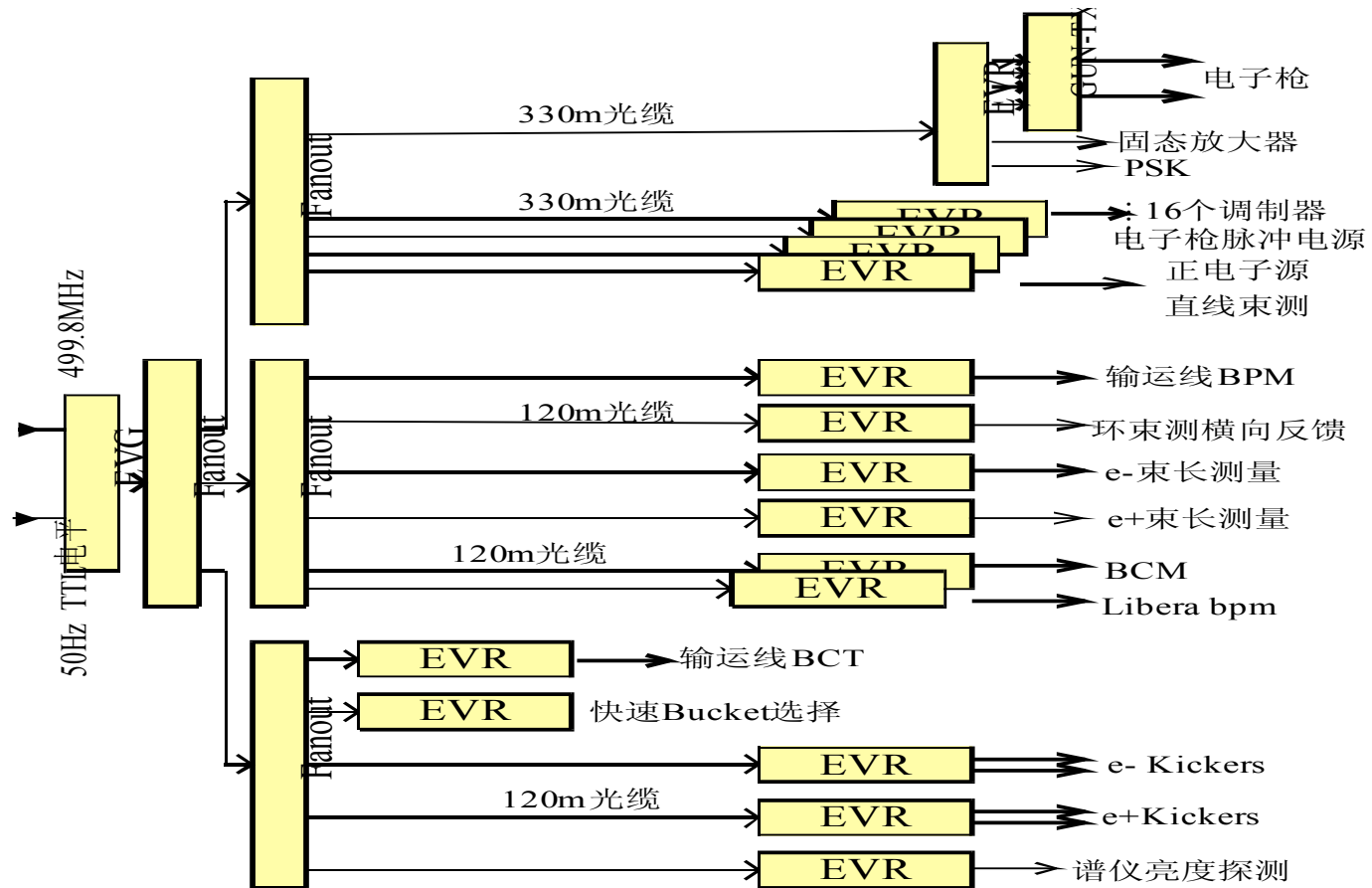


BEPCII timing system hardware

- 2 EVGs, 19 EVRs
- 13 VME crates and controllers,
- 2 levels of fanout, 5 Fout-7 modules in total.
- GUN-TX and Gun-Rx for e-gun pulser timing
- 4 TD-4Vs for Kickers
- 18 sets of home-made E/O and O/E for linac

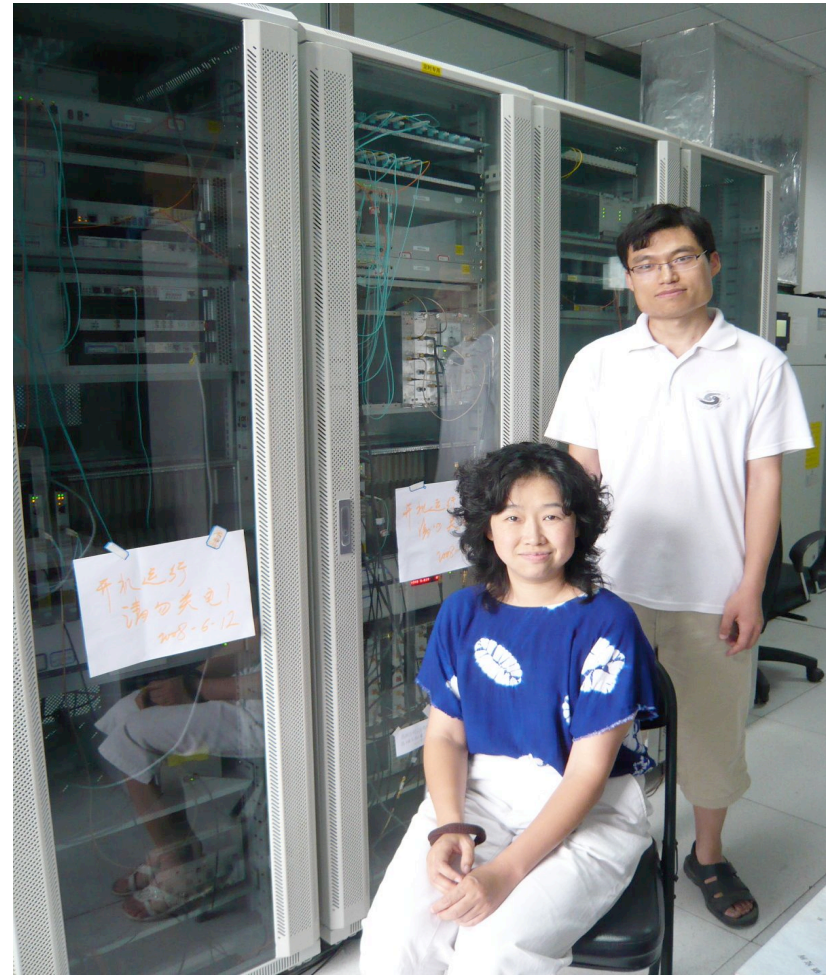
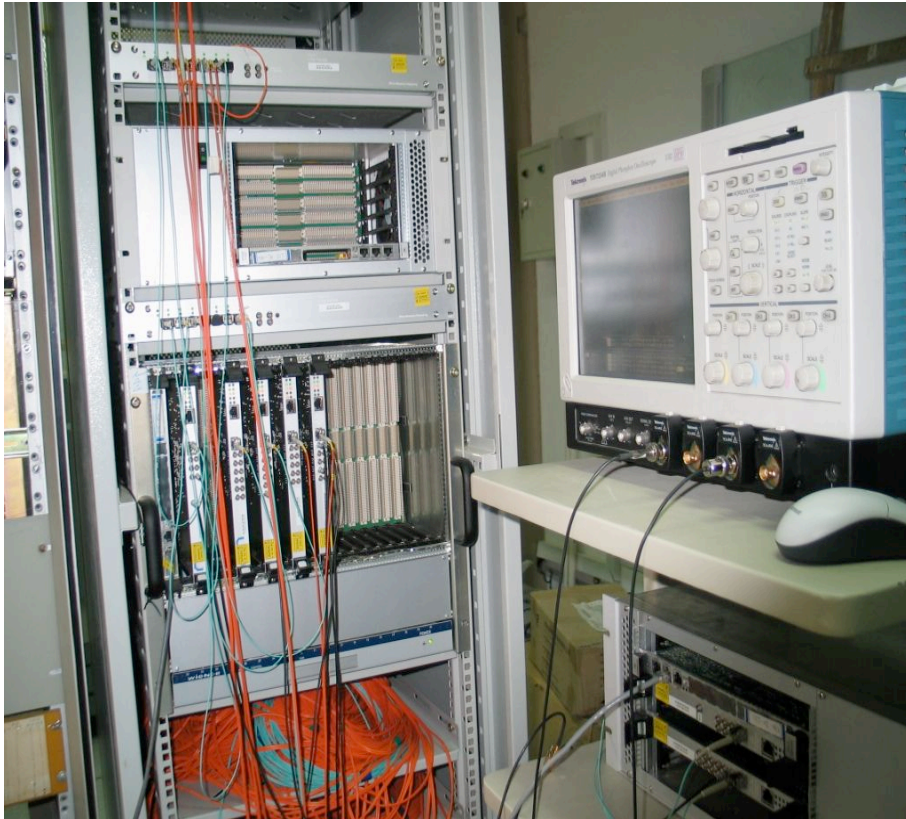


Event Timing System





Timing system crates





Control Panels

/tmphome21/home/leige/epicsApp/timing200App

BEPCII Kicker Timing Control

EXIT

Trigger Status

To stop e- trig To start e- trig e- trig is OFF

To stop e+ trig To start e+ trig e+ trig is OFF

DelaySettings **DelayReadback**

	DelaySet nanoSecond	Evr Delay step=10ns	TD4 Delay step=2ns	
e-K1	8660	866	0	Disable
e-K2	8700	870	0	Disable
e+K1	8200	820	0	Disable
e+K2	8780	878	0	Disable

e-TriggerCount: 42819 e+TriggerCount: 91208

Linac Repetition Frequency Control

To stop all timing triggers
in case of emergency, press
the Pause button here

/tmphome21/home/leige/epicsApp/timing

Libera timing for e+

EXIT

Libera trigger enable control

Enable manual control **manual**

Go with kicker trigger **auto**

Manually enable or disable libera trigger

MultiBunch Inj BSR & e+ v1.3 2006/11/28

File Edit Window 04/05/2007 23:25:42 Help

Multi Bunch Inj Control

Start Multi Bunch Inj

Pause Multi Bunch Inj

Set Bucket Pattern

Exit

Bucket Change Period in second: 3

Vacuum Restriction: 4.5E-8

Beam Current High Restriction: 30

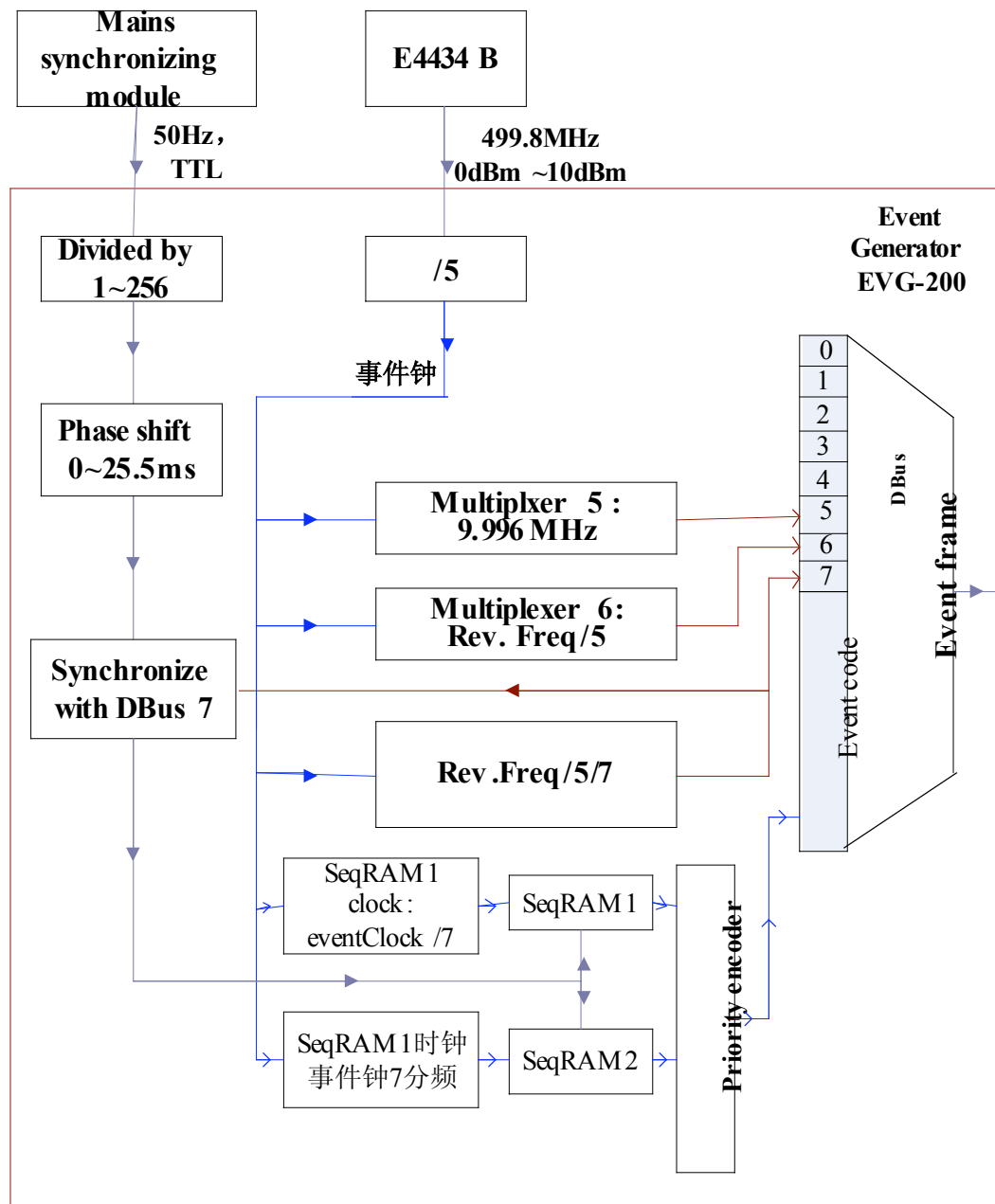
Beam Current Low Restriction: 20

Bucket Pattern File at: /home21/operator/bucket/bktPatternBSR

Set Harmonic Number: 396 for Colliding 402 for SR

injBSRp on 192.168.20.235:0.0

BEPCII event timing clock



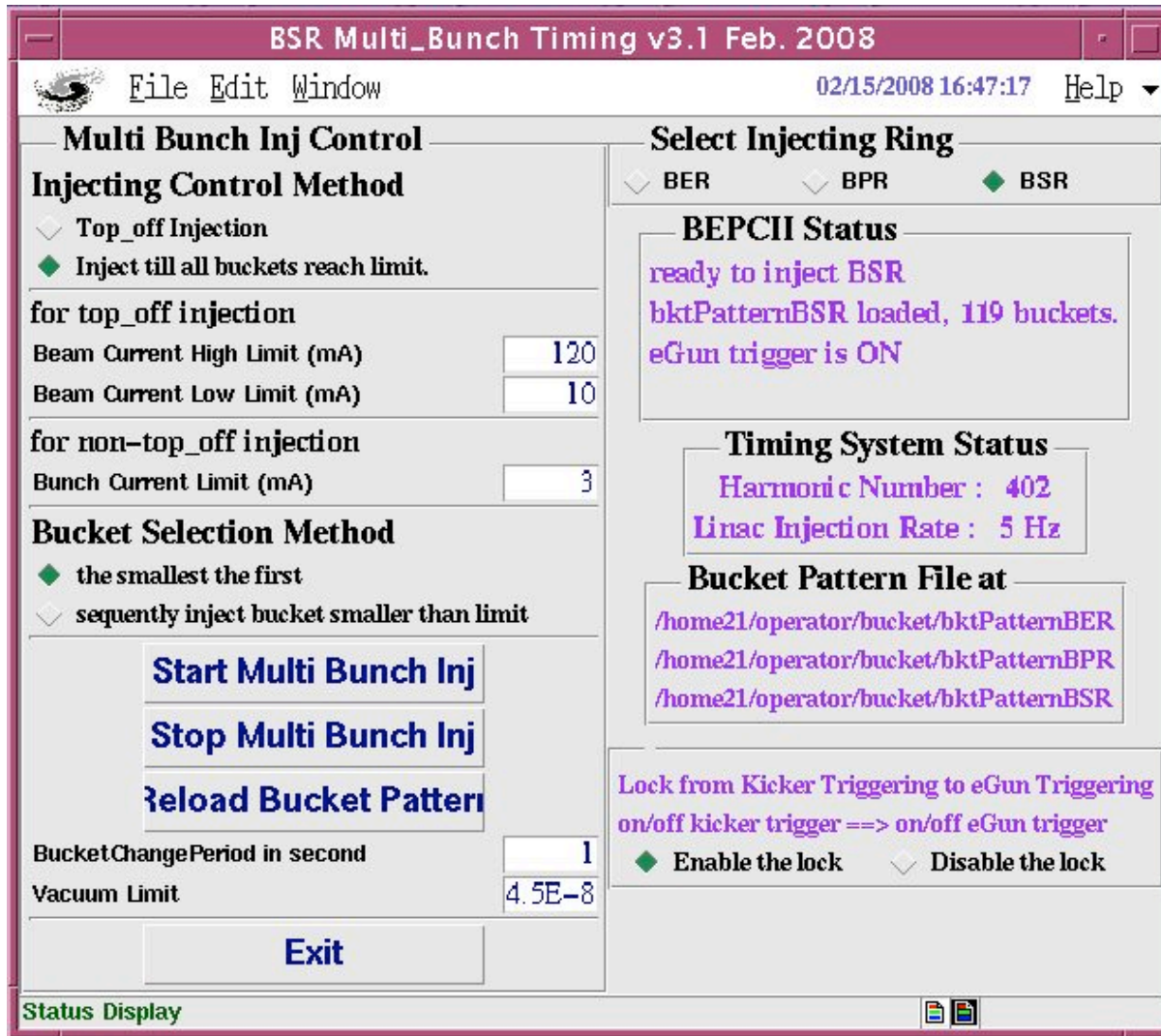
To select any bucket

- The event clock is set to $499.8\text{MHz}/5$.
 - Reason: In EVG-200, the event clock can be generated from RF divided by 4,5,6,8,10 and 12, among which only 5 is a prime number.
- event-clock/7 is set to be the sequencer clock
 - Reason: 7 is a common factor of BEPCII ring RF and linac RF frequency.

To select any bucket

- $B_n = \text{MOD}(R_n * 35, 396)$, for BEPCII colliding mode
 - R_n is the SequenceRAM unit number, B_n is the bucket number.
 - Using the above formula, any unit from 0 to 395 in SeqRAM can be mapped to one and only one bucket in the ring, which has 396 buckets in total.
- The above formula can generate a table, SeqRAM unit to bucket number. Transform it to a table mapping bucket number to SeqRAM unit number.

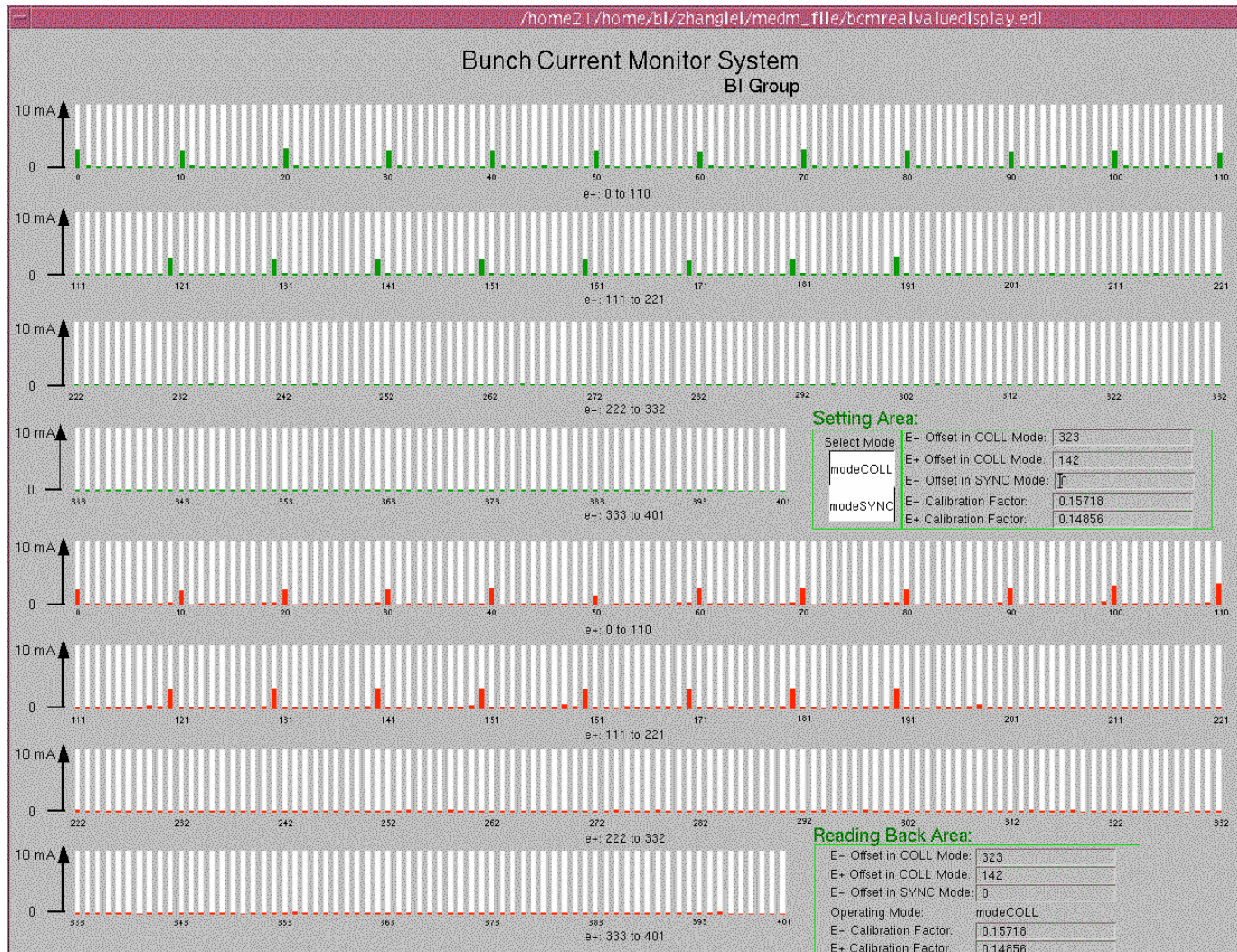
Multi bunch injection control



Multi-bunch injection control

- Control when to inject and when to stop
 - Top-off injection, a control loop
 - Stop injection when all buckets reach the bunch current limit
- Bucket select method
 - The smallest the first
 - Next smaller than the bunch limit, according to the sequence in the injection pattern definition file
- Criterion
 - Beam current from DCCT, or bunch current from BCM
- Injection pattern definition file: ASCII files

BCM display of 20 * 20 buckets colliding





Performance

Performance: jitter of transport line beam signal to 499.8MHz RF signal is less then 16 pico seconds





Oracle Database

- The Oracle database used to store the machine parameters and control data
- It has a Web interface
- Including
 - Static parameters
 - History data from IOCs
 - Manager information
- We have developed the communication programs
 - Between IOC and Oracle
 - Between ChannelAchiver and Oracle
- e-logbook based on Oracle database



Static Data

- Magnet measurement data
- Drawings

The screenshot shows a Microsoft Internet Explorer browser window with the address bar displaying `http://bepc2as.ihep.ac.cn:8080/bepc2app/load_data_dba_index.html`. The page title is "二极磁测数据导入 - Microsoft Internet Explorer". The main content area is titled "磁铁测量数据导入" (Magnet Measurement Data Import) and "二维激磁征数据导入" (2D Excitation Data Import). It prompts the user to "请输入要导入的数据文件" (Please enter the data file to be imported) and provides four input fields for file paths, each with a "浏览..." (Browse...) button. The first two fields contain the path `C:\tomcat\webapps\bepc2app\mt_data\B2D_Magnet\`. Below the input fields are "数据导入" (Data Import) and "退出" (Exit) buttons. On the left side, there is a sidebar with radio buttons for selecting data types: "二极磁测数据", "激磁特性数据" (selected), "积分激磁数据", "四极磁测数据", "六极磁测数据", and "校正磁测数据". Below this, there are radio buttons for data import methods: "本地数据文件" (selected) and "服务器数据文件". A "确认提交" (Confirm Submit) button is at the bottom of the sidebar.



Drawings

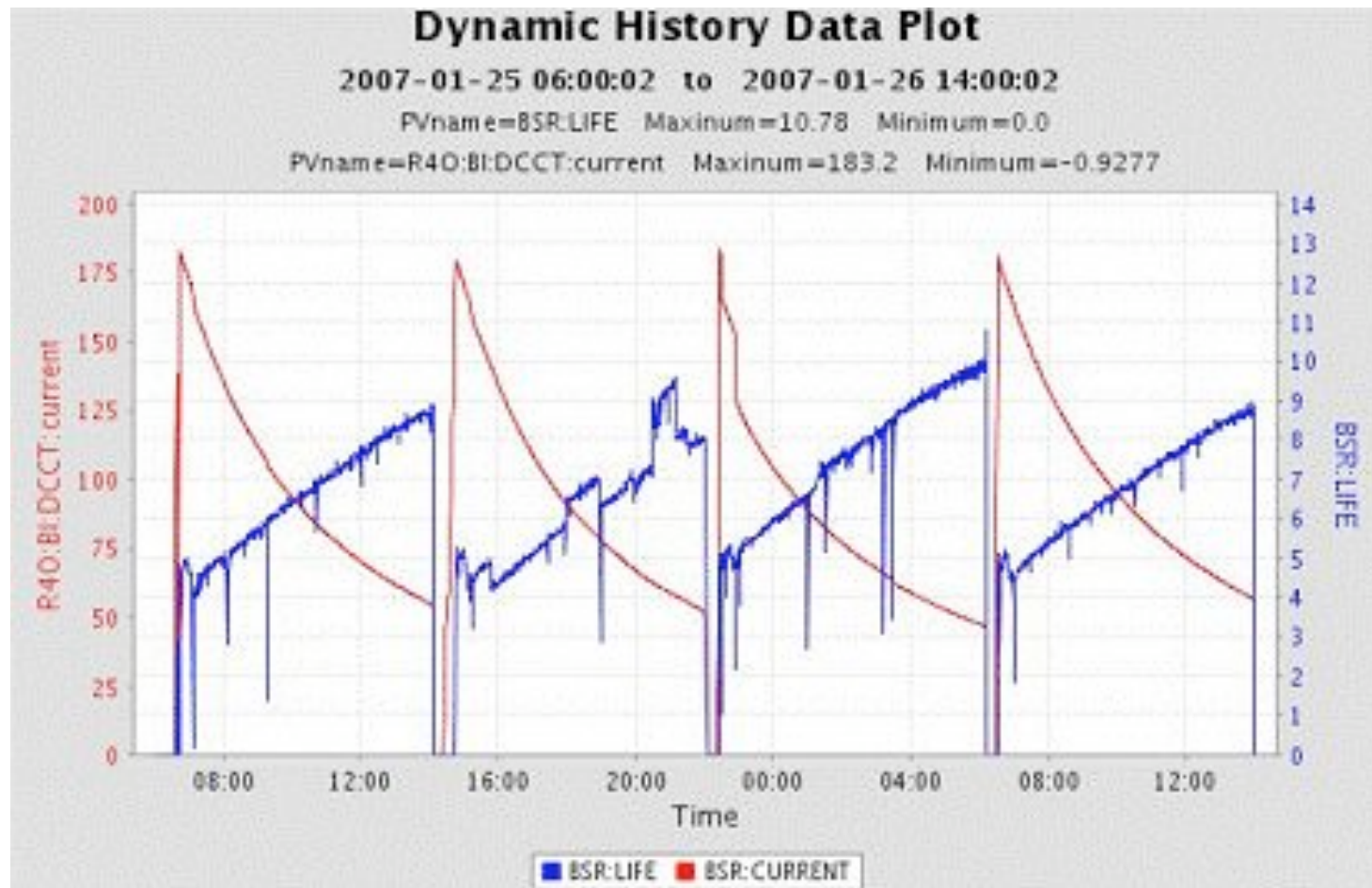
序号	项目名称	安装位置	分系统	项目负责人	校核人	设计人
1	四桥梳齿架			设计主管	王站	王站

查看项目基本内容, 图8

添加新项目 图9

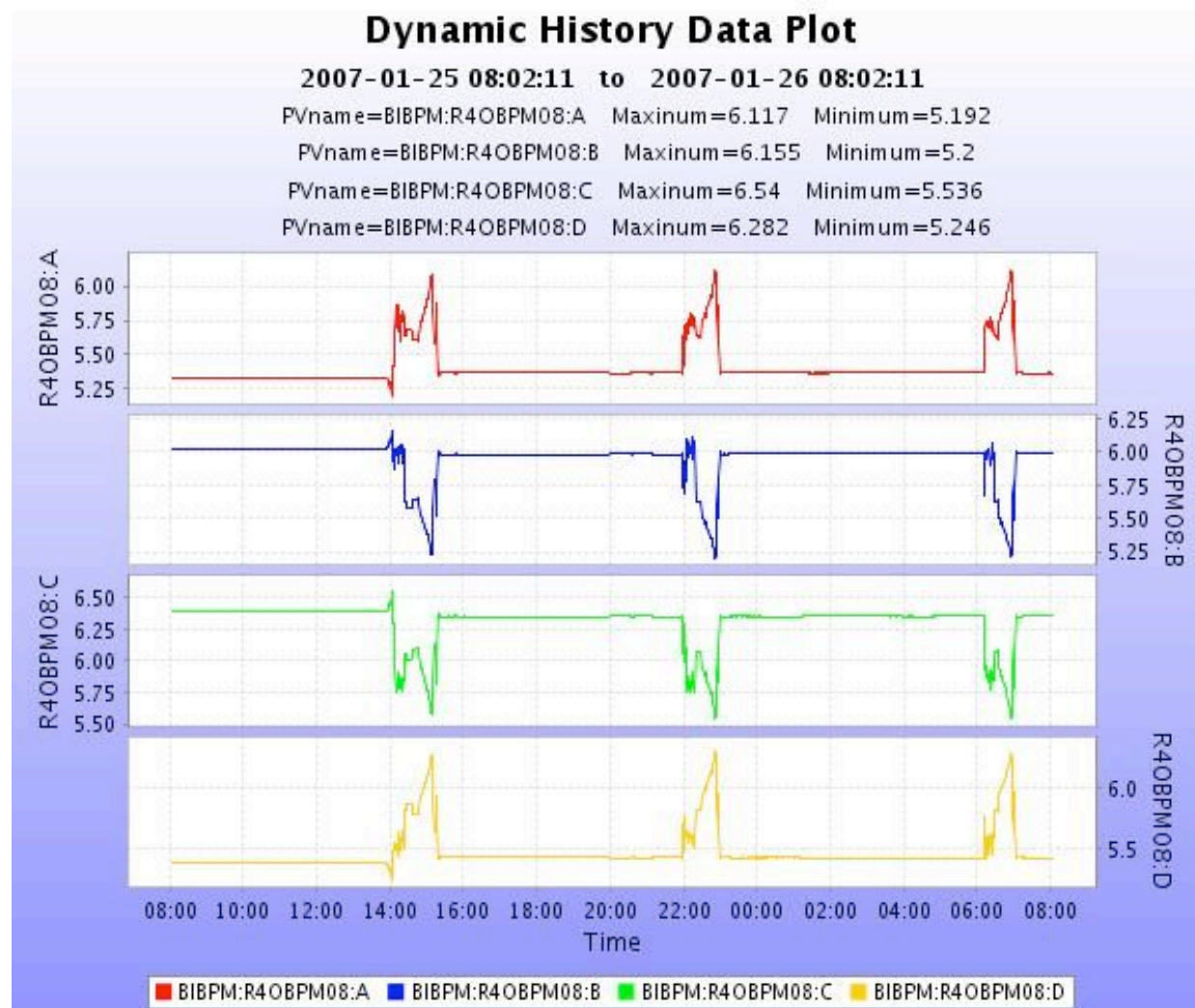


History data





History data





e-logbook

- Developed BEPCII e-logbook in Chinese
- E-logbook saved in Oracle database
- Based on DESY's version

The screenshot displays the BEPC II Elog Book interface. At the top right, it says "BEPC II Elog Book 电子日志系统". The main content area shows search results for "xugl" from 2006-07-17 to 2006-11-17. A specific entry is highlighted with a detailed view:

Logbook里查找: BEPCII, TIMING | 添加信息: BEPCII - 查找: xugl
从: 17-07-06 17:55:33 到: 17-11-06 17:55:33

升序排列 行模式 语言: Chinese
排序: 时间 意义 主题 作者 更新

newref newrefcd
TIMING: 28-九月-2006 11:17:11 Ref: TODO list
xugl Changed on: 28-九月-2006 11:25:22
熔接光纤
一束测
机箱就位
--直线4号位
11号厅
机箱采购
--正负同步光

帮助
设置默认日志
应用概览

本主页由高能物理研究所加速器中心控制组制作维护
IE6.0浏览器,1024X768分辨率



Machine Protection system

- Adopt Omron PLC and PC-link
- Central interlock system
 - Interlock of BEPCII machine start up
 - Interlock between systems, such as the accelerator and Detector
 - Publish the BEPCII running information in IHEP campus
- Low level interlock system
 - Vacuum, PS and Magnet cooling water, RF interlock.....

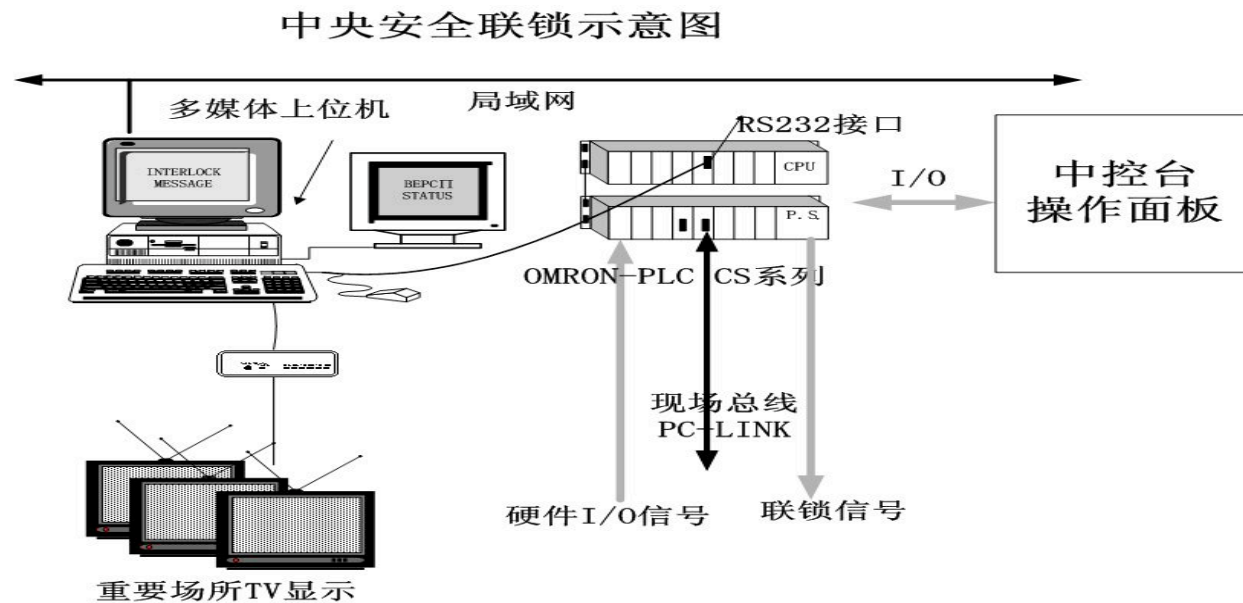


图 8-4-17 中央安全连锁系统示意图

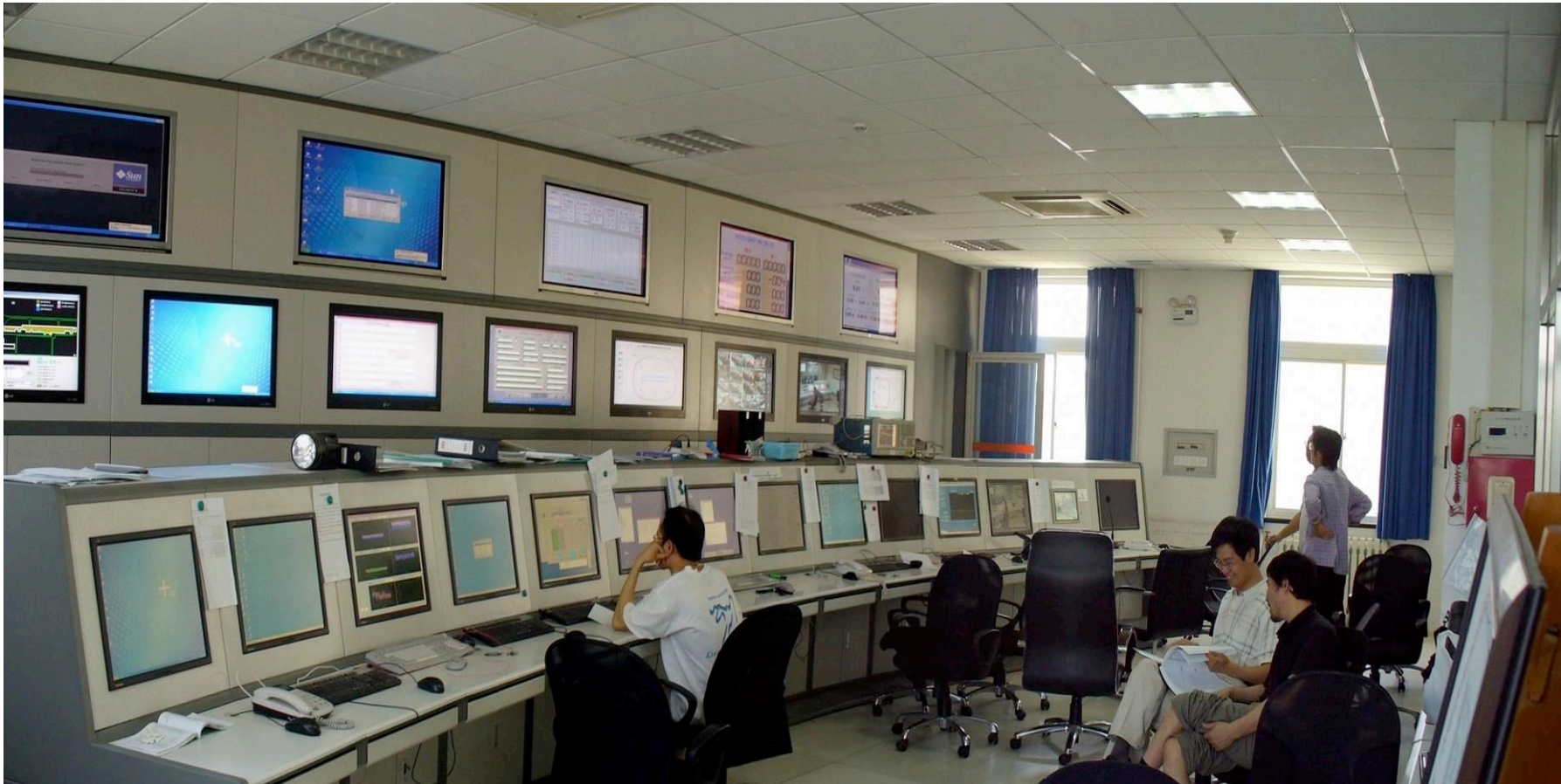


New console installation





New Control Room





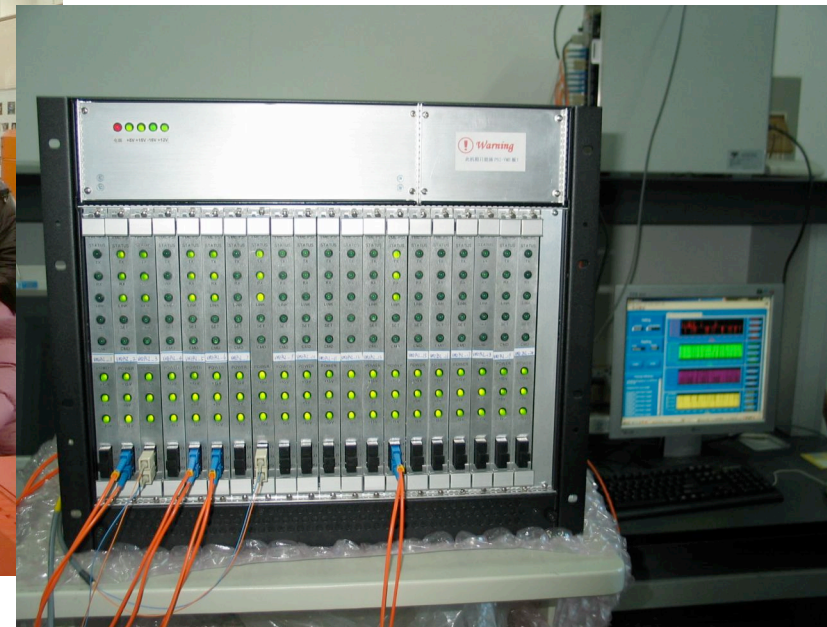
R&D

- From Oct.2002 to Nov. 2003 is the R&D stage
- We built EPICS and Power supply prototype system
- Developing all of I/O driver and communication drivers that we needed
- Transferring SAD environment from KEKB to BEPCII Solaris 8



On line test of prototype for chopper PS

Prototype of Corrector PS





System Development

- We spent 2 years to developing the system in laboratory (Jan.2004 to Dec. 2005)
- Make off-line and on-line test at Lab
- We have built both of hardware and software of the
 - Host computer system and EPICS environment
 - Redundant network system
 - Power supply control system
 - Vacuum control system
 - RF control system
 - Cryogenic control system
 - Event timing system
 - Oracle database
 - Commissioning applications
 - Machine protection system
 - A new console



Installations

In 2006 we spent 8 months to install control system on BEPCII site





System Test

- The system test on site BEPCII from Summer to Oct. 2006





First beam accumulated at Storage Ring



- BEPCII Control system was put into operation in 12 Nov. 2006



BEP-II commissioning

Stages

- Oct.10, 06 - Aug.24, 07 Commissioning backup scheme
- Oct.24, 07 – Mar.28,08 Commissioning with SCQ without detector
- Jun.22, 08 - Dec.18, 08 Commissioning and HEP operation with detector

Milestone

- Nov.12, 06 Start ring commissioning from transport lines
- Nov.14, 06 First turn in the ring
- **Nov.18, 06 First e⁻ beam storage in outer ring (SR ring)**
- Nov.25, 06 Start SR beam line commissioning and user operation
- Mar. 25 2007 Collision backup scheme
 - Single bunch collision: 9mA*9mA
 - Multi-bunch collision: 7*7, ~20mA/ring
- Jan.29 2008 Collision with 500mA * 500mA with SCQ
- Jul.19 2008 Collision with detector

Current Result

- **Lum record: $1.3 \times 10^{32} \text{m}^{-2} \text{s}^{-1}$ @ 489mA x 530mA with 90 bunches**
- Max. beam current : 600mA of both of e⁻ and e⁺ beam, Max. 93 bunches
- SR mode: 2.5GeV, 250mA with full energy injection, beam life time is 10 hours



Collaborations

- Collaboration with KEKB went through 10 years, KEKB provided us most of their HLA, which speeded development of BEPCII
- We have sent 12 young people to go to KEKB and learn EPICS system and control technology
- We have hosted two Asia EPICS Seminar and EPICS training course in Beijing in 2001 and 2002
- DESY cryogenic control group gave us valuable advices and transferred some source code, which is very helpful for developing BEPCII cryogenic control system
- SSRF Lab. lent us EVG/EVR modules to build the timing prototype at that time our device have not delivered



EPICS Web Page at IHEP

We join the EPICS collaboration and have got a lot of help from EPICS world

主页 - 傲游(MyIE2) Beta

文件(F) 编辑(E) 查看(V) 收藏(A) 快捷组(G) 选项(O) 工具(T) 窗口(W) 帮助(H)

地址 http://acc-center.ihep.ac.cn/epics/index.htm

Welcome EPICS系统研究

旨在为加速器中心和高能所用户学习使用EPICS提供必要的资料

主页 Epics培训 Epics会议 Epics文档 研究论文

您现在的位置: 主页

加速器中心Epics培训 (2003.2.27—3.4)

系统简介:

EPICS系统(Experiment Physics and Industrial Control System)是1987年由美国LANL和ANL实验室联合开发的实验物理和工业控制软件包,是构建分布式的控制系统的系统集成工具,用于分布式的实时数据库的建立、图形人机界面的开发、故障报警系统的建立和管理、历史数据存档管理和各种图形显示等。使用EPICS进行系统集成可以减少软件开发和维护的工作量,延长软件的生命周期,提高系统的可靠性;使用EPICS控制系统可以实现网络数据共享,建立开放的、标准化的系统。

目前国际上有100多家实验室、大学、研究机构的项目使用EPICS系统,包括加速器控制系统高能实验物理数据获取系统、射电天文望远镜和工业过程控制系统,如美国的LANL、ANL、SLAC、BNL、FNAL(DO)、JLAB、SNS、LBL、加拿大的TRIUMF、欧洲的SLS、BESSYII、DESY、日本的KEKB和韩国的PAL等。中科院高能物理研究所、合肥同步辐射光源、上海原子核所于1997年与EPICS国际合作组织签订协议,参加EPICS的合作研究。2001年5月BEPCII工程指挥部决定使用EPICS开发BEPCII控制系统。本网页旨在为加速器中心和高能所用户学习使用EPICS提供必要的资料。

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Links

<http://www.aps.anl.gov/epics/>

<http://lansce.lanl.gov/lansce8/Epics/>

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Summary

- Since September 2001, the BEPCII control system has gone a long road for system design and construction
- The project is successful with good quality and reliability
- It has been done on schedule and within the budget
- Thanks all of people who have gave us a lot of help in the past few years!



Control People





**Thank you for your
attention!**