Present Status of Shanghai Light Source (SSRF)

Dekang LIU

2004/12/8

A. Status of SSRF

- **Overview of the project progress**
- **SSRF Design Optimization**
- **Project Budget and Schedule**

B. Status of I & C for SSRF

* Status of Control System
* Status of Instrumentation

The SSRF project proposal was officially approved by the Chinese central government in January 2004!

Overview of the Project Progress

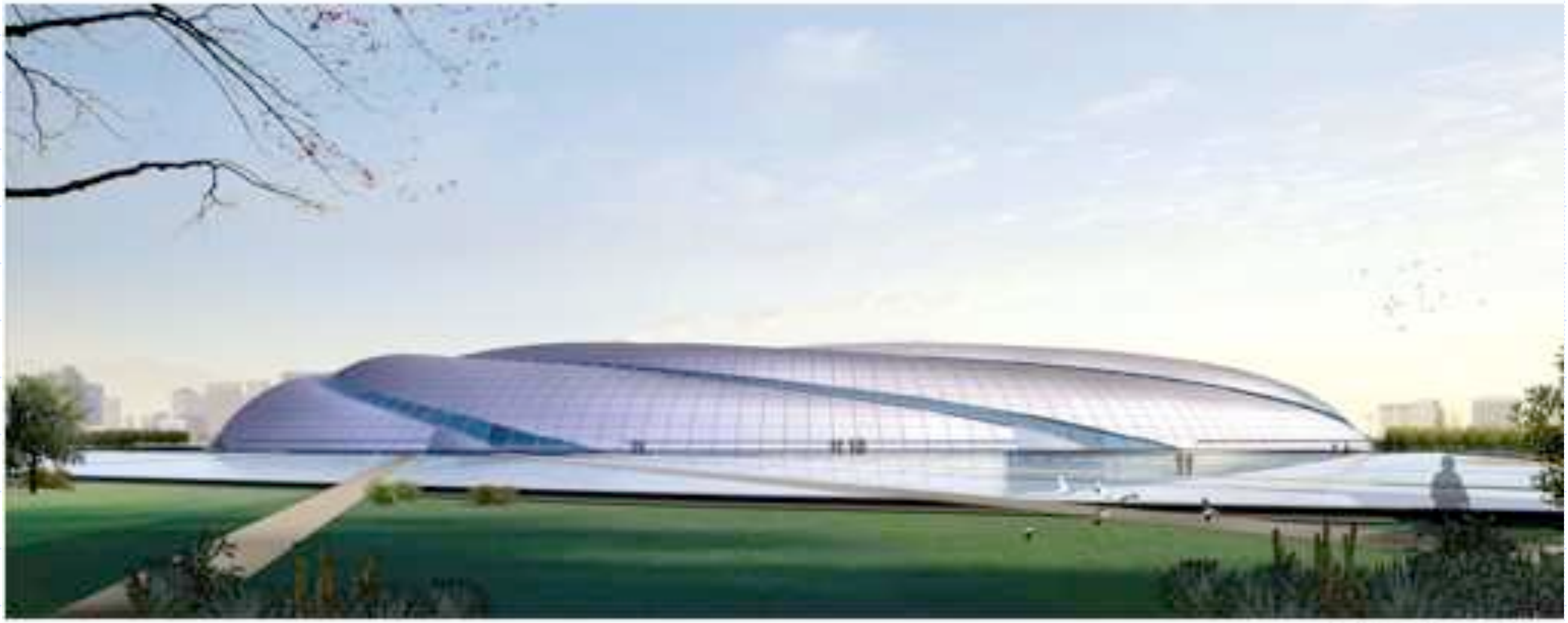
- SSRF (Shanghai Synchrotron Radiation Facility): An intermediate energy 3rd generation light source;
- The SSRF will be located in Shanghai Zhang-Jiang High Tech Park (Pudong new development district);
  - The SSRF site occupies a area of 600m×300m
  - About 25km from Pudong international airport
  - Close to Subway and magnetic leveled train line
  - Convenient to access the Shanghai down town area

BEPCII/IHEP
PLS
Spring-8
PF
Hefei LS
TLS
INDUSII
SSRF/SINAP
R U S S I A
KAZAKHSTAN
MONGOLIA
Caspian Sea
Aral Sea
Lake Balkhash
Lake Baikal
North Pacific
KYRGYZSTAN
TAJIKISTAN
IRAN
AFGHANISTAN
PAKISTAN
INDIA
Arabian Sea
Harbin
Shenyang
BEIJING
Tianjin
Ürümqi
Yellow Sea
Zhengzhou
Shanghai
Nanjing
Xi'an
Wuhan
Chengdu
Chongqing
Lhasa
Brahmaputra
East China Sea
Philippine Sea
Taipei
Taiwan
Guangzhou
Hong Kong S.A.R.
Macau S.A.R.
South China Sea
Mekong
BURMA
THAILAND
VIETNAM
LAOS
BHUTAN
NEPAL
PHILIPPINES
Hainan Dao

Site of SSRF

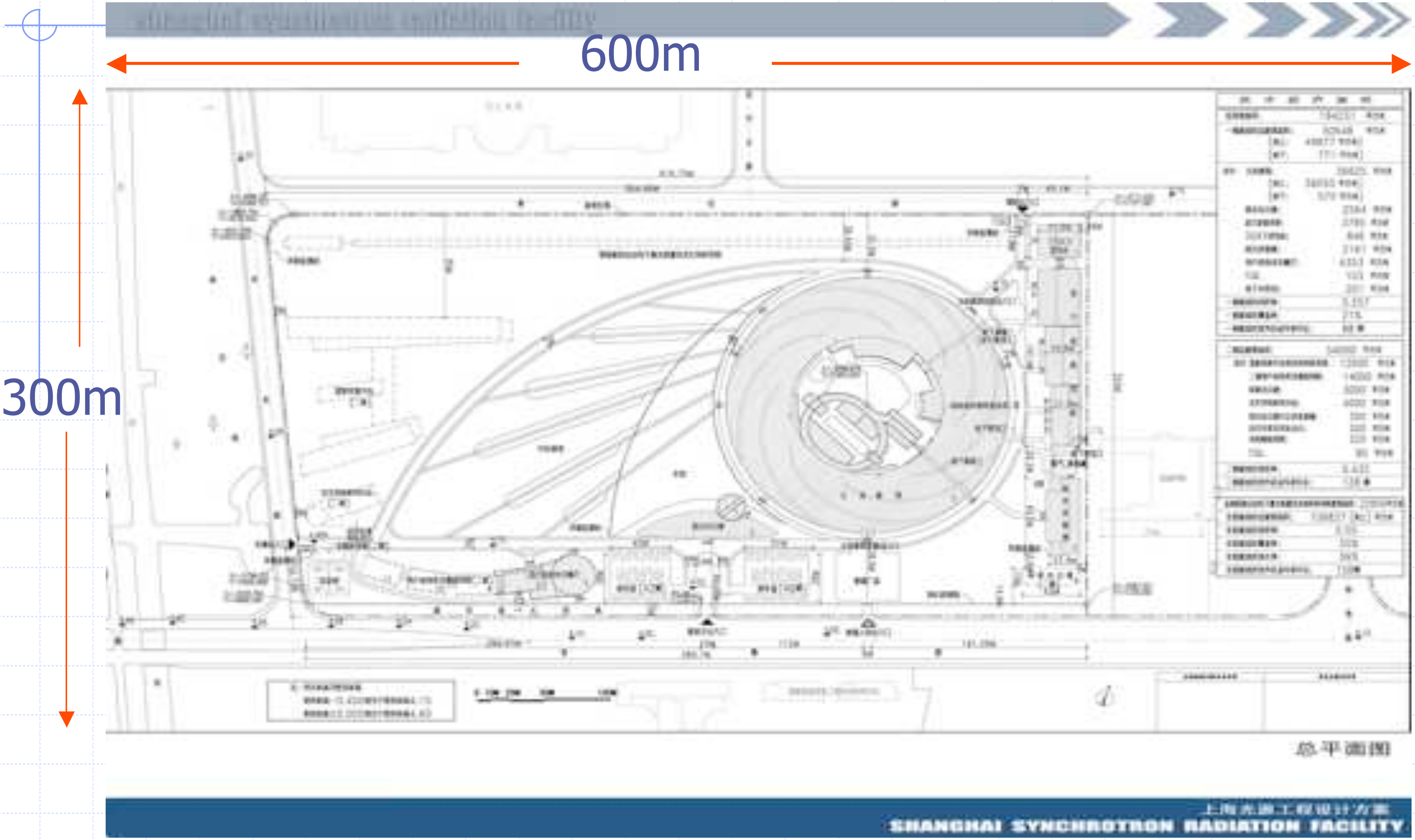
Yangtze River
Huangpu River
Planned Outer Ring Road
Inner Ring Road
Shanghai Municipal Government
Yang Pu Bridge
Nan Pu Bridge
Xu Pu Bridge
Pudong Avenue
Zhangjiang Road
Longdong Avenue
Shanghai (Z.J.) Hi-Tech Park
Planned Subway Route No. 2
Subway Route No. 1
Hong Qiao
SSRF
Pudong Airport
Hongjiao Airport
Magnetic leveled train
35Km/7minits 430km/h Max

An Architect's-eye of the SSRF Layout



主体建筑透视图

Layout of SSRF



Brief History of the SSRF Project

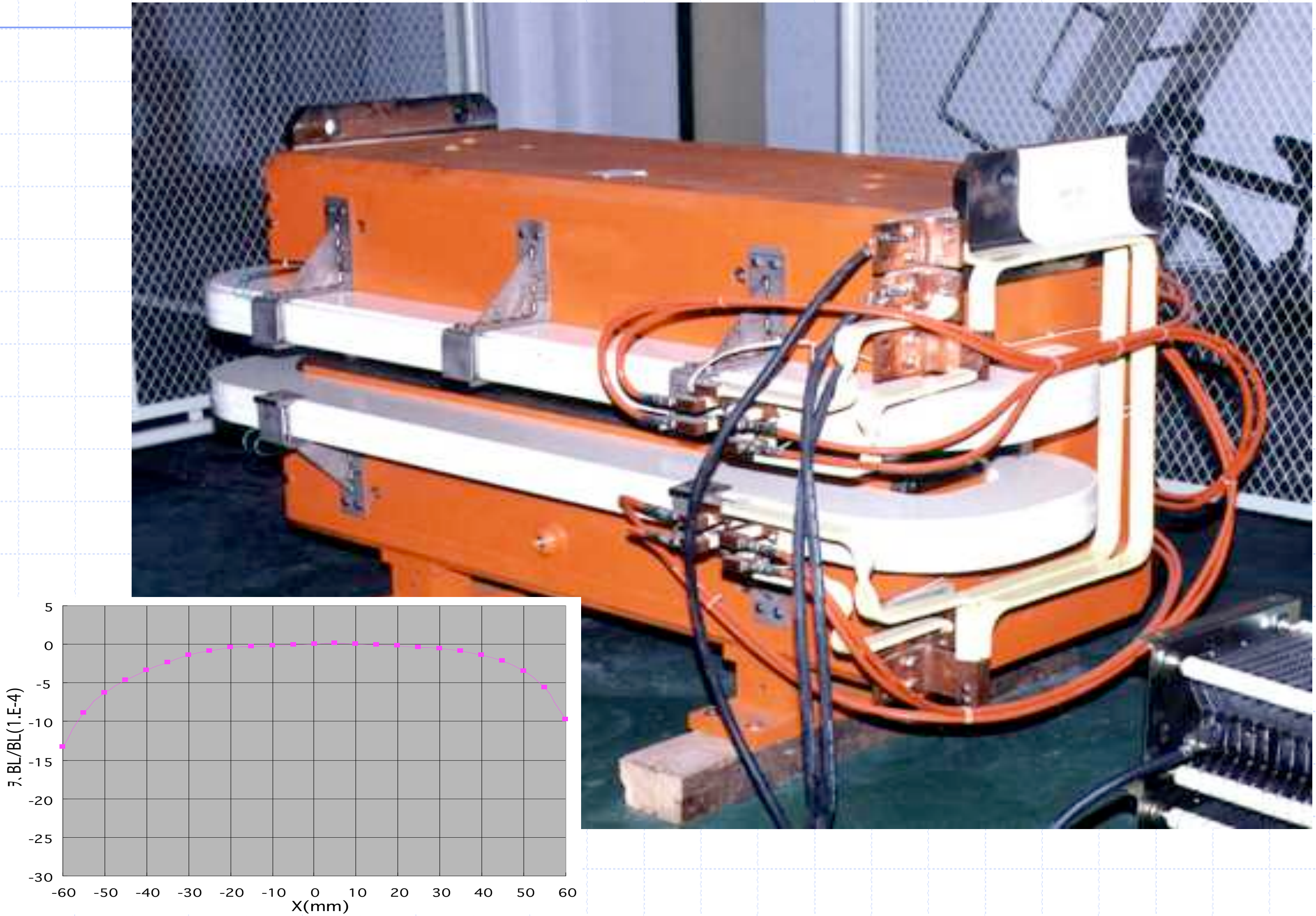
- Dec.1993: Three Chinese scientists proposed formally to central government to build a third generation light source;
- March 1995: The Chinese Academy of Sciences and the Shanghai municipal government made a joint proposal to construct the SSRF in Shanghai;
- June 1997 and March 1998:The state science and technology leading group and the state planning committee approved the SSRF R&D program;
- Jan.1999~March, 2001: The SSRF R&D with budget of 80M Yuan was being performed;
- Jan. 2004: The SSRF project was finally approved

- ❑About 10 year's efforts to get this light source project approved;
- ❑There are still one more project steps before performing the groundbreaking this year;
  - ■Project feasibility study report review approval

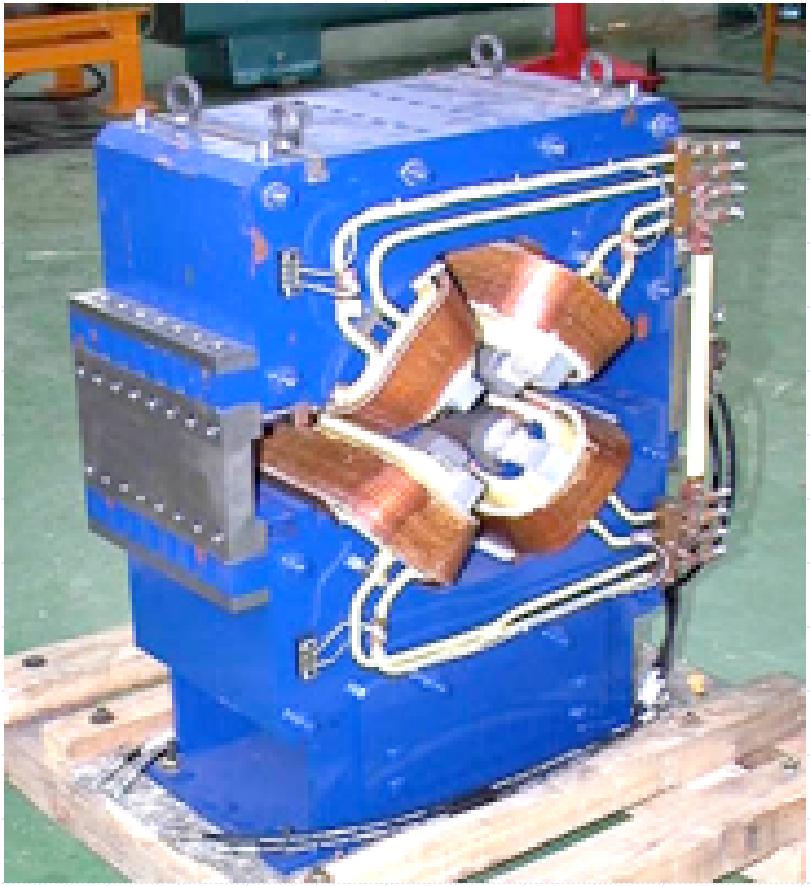
    At July of 2004
  - ■Project detailed design study report review and approval

Hardware Prototype in Pre-R/D (1999-2001)

Bending Magnet (made in IHEP, Beijing)

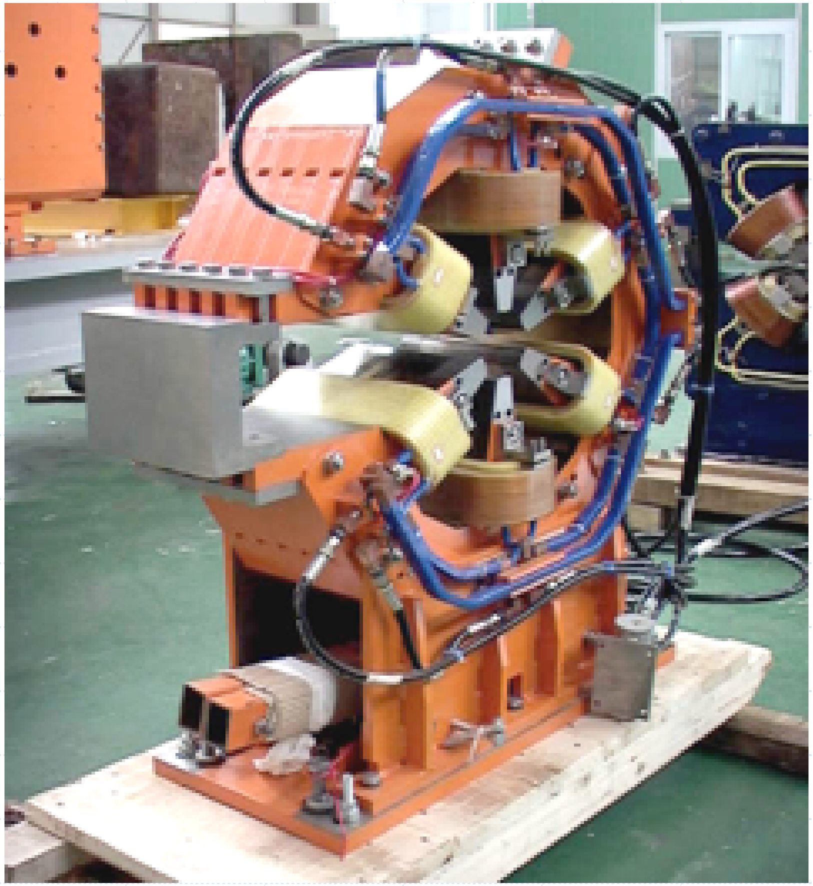


Quadrupole Magnet



(Made in Kelin, Shanghai)

Sextupole Magnet



Made in CUSTC, Hefei

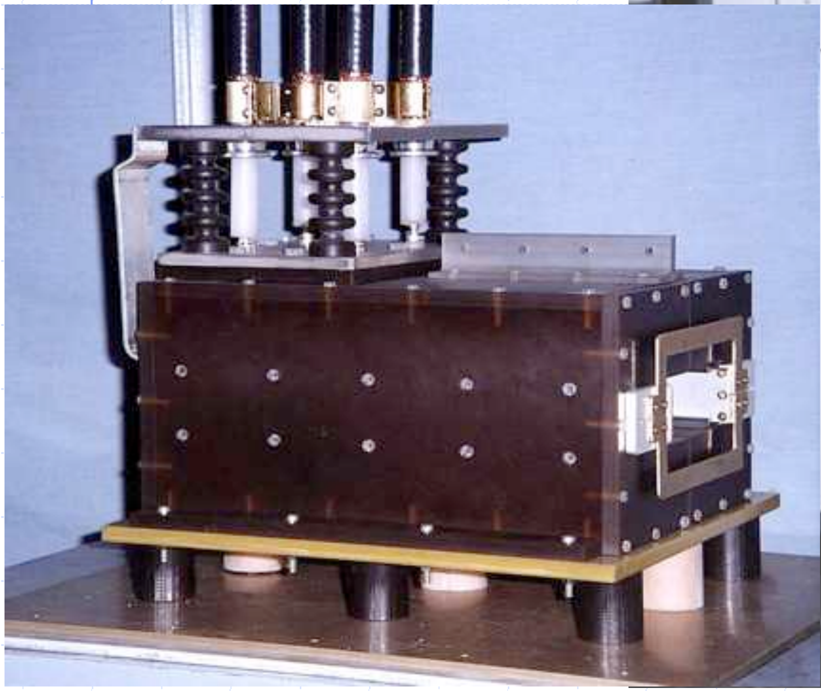
Bending Magnet Power Supply

500A/100V, $\pm 1\times10^{-5}$/24hrs

6m Antechamber Section

Kicker Magnet and Its Pulser

4μs half-sine-wave
0.12T peak field jitter time < ±6.5ns



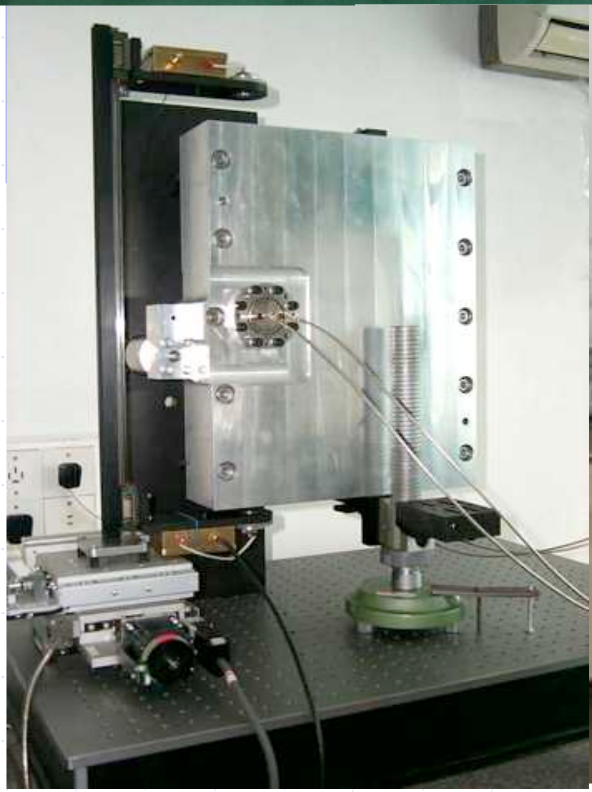
Low Level RF Control System

High Power RF System

- **500MHz, 180kW CW**

BPM And Its Mapping System

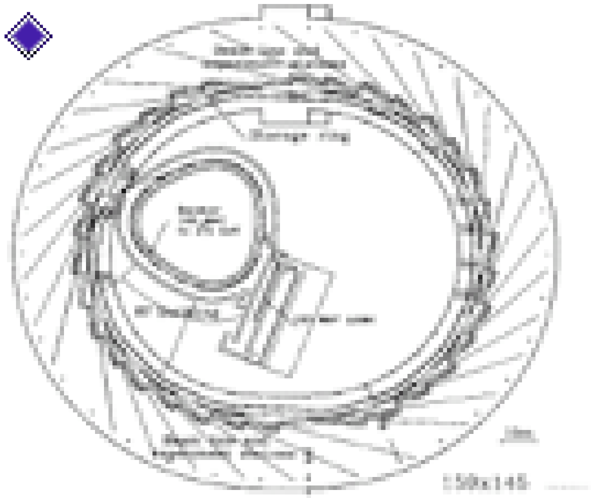
2μm resolution



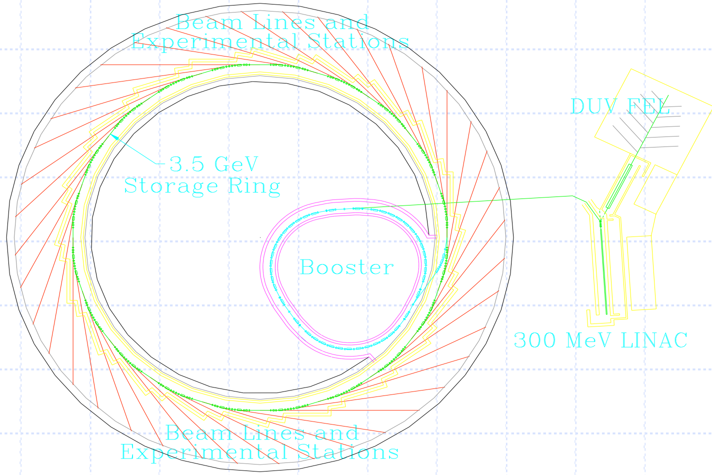
Evolution of the SSRF Designs

- There have been 4 main SSRF design versions since 1996, and the SSRF has been evolved to a high performance and cost-effective light source for the past 8 years, which includes:
  - Upgraded the SSRF storage ring energy from 2.2 GeV to 3.5 GeV;
  - Optimized the storage ring with high flexibility, low emittance and high beam orbit stability;
  - Optimized the SSRF complex operating with top-up injection modes;
  - …

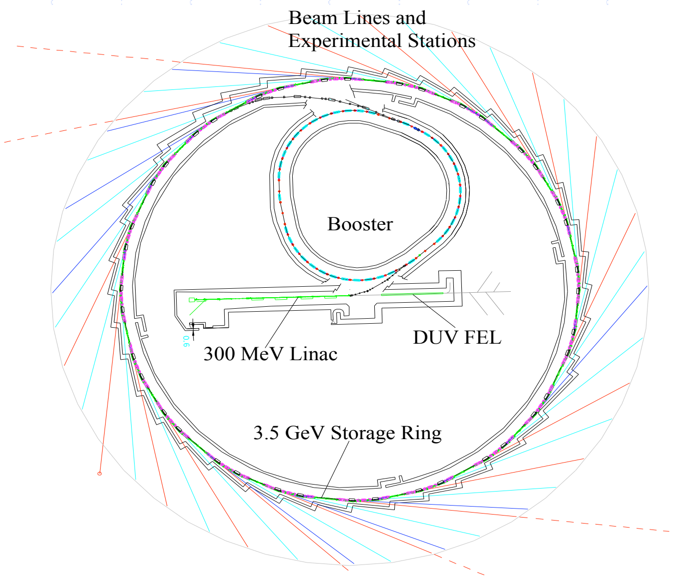
1996



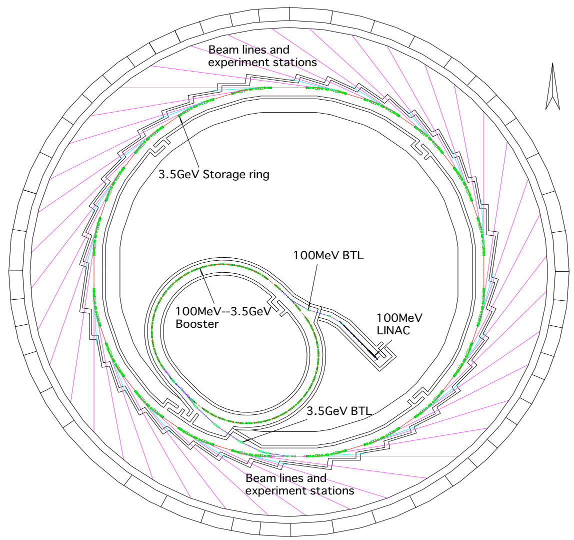
1998



2001

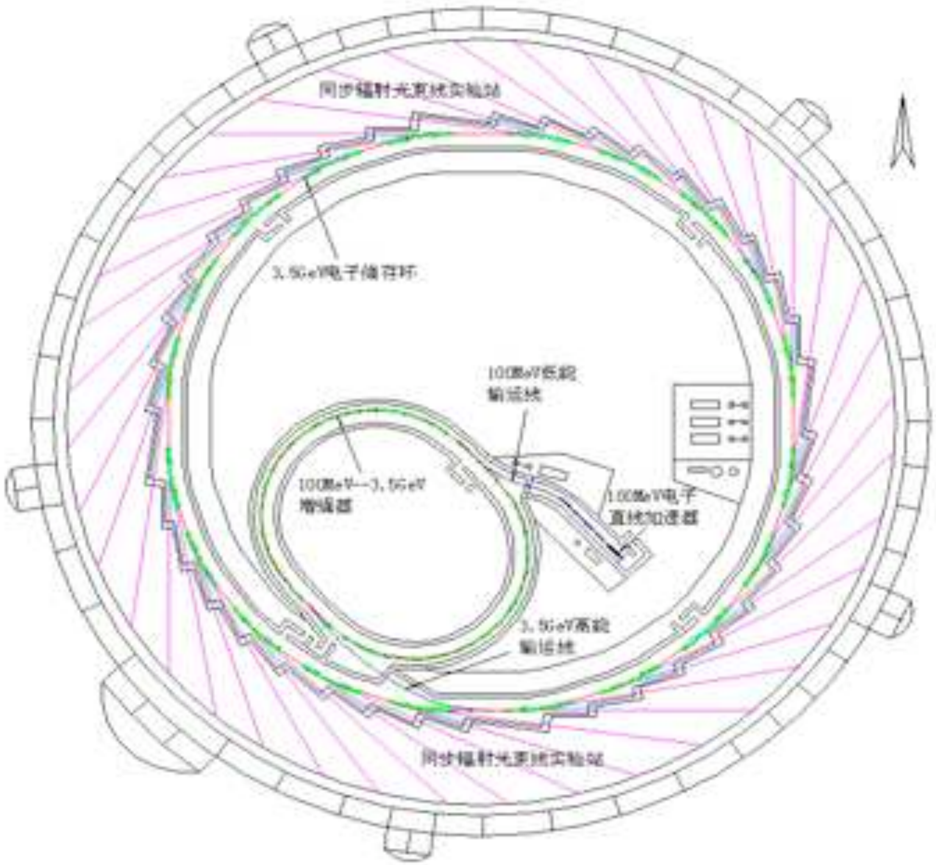


2003



SSRF Accelerator complex

- **100MeV Electron Linac**
- **3.5GeV Booster**
- **3.5GeV Storage Ring**
- **Beam Line and Experimental stations**



The SSRF Design Evolution

Design Version	1996	1998	2001	2003
Energy (GeV)	2.2 (2.5)	3.5	3.5	3.5
Circumference (m)	345.36	384	396	432
Emittance (nm*rad)	3.78 (4.88)	11.8	4.8 (11.8)	2.95
No. of cells/super-periods	16/2	20/10	20/10	20/4
Straight sections (number_length)	12_7m 2_8m 2_18m	10_6.6m 10_4.6m	10_7.24m 10_5m	4_12.0m 8_7.0m 8_5.0m

Latest SSRF Design Optimization

- Optimization to enhance the SSRF capability and cost-effectiveness
  - lower emittance and high brightness
  - Short, standard and long straight sections for IDs and accelerator demands
  - Top-up injection operation
- Optimization to improve beam stability
  - Effective control of various perturbation sources
  - Active feedbacks to stabilize beam orbit

Latest SSRF Design Optimization

- Adoption of advanced technologies
  - Superconducting RF system
  - Digital beam position monitor system (at BEPC)
  - Orbit feedbacks and transverse beam feed back
  - High stable Digital power supplies
  - In-vacuum mini-gap undulators

The Project Budget

❑ Project budget estimation

- Total project budget :　(1200M RMB)　~150M$

  Building and conventional facility　~43M$

  Accelerators and Beamlines　~79M$

  Contingency　~10M$

  R&D and other project items　~18M$

  (not including land fee and staff salary)

- Annual operation budget:　~12M$

  (not including staff salary)

Cost Estimate and Schedule

- Proposed Schedule

  Break-grounding would be completed before the end of this year.

Spring. 2005 ~ Nov. 2007 Procurement, Fabrication, Construction, Installation and injector commissioning

Dec. 2007 ~ Oct. 2008 Storage ring commissioning

Test operation for SR users

May .2009 light beam available

Status of I & C

The main requirements

*Whole machine can be run with safety and reliability.

*An easy to use.Ideally,this should be a GUI that is already familiar to scientists and engineers .

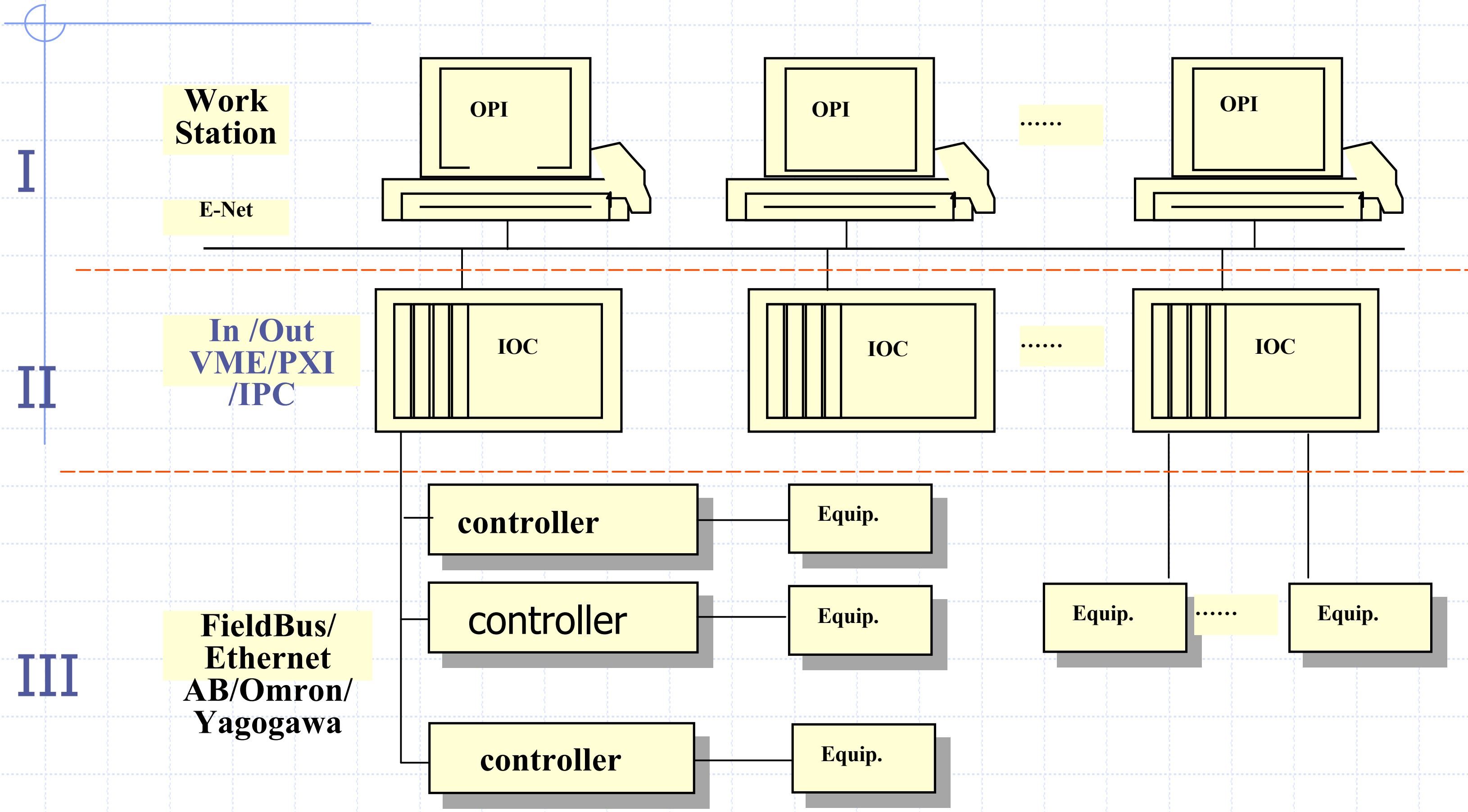
*Tight integration with standard software packages

*Access to control system via the WEB.

*Use standards.To reduce the time of design &build

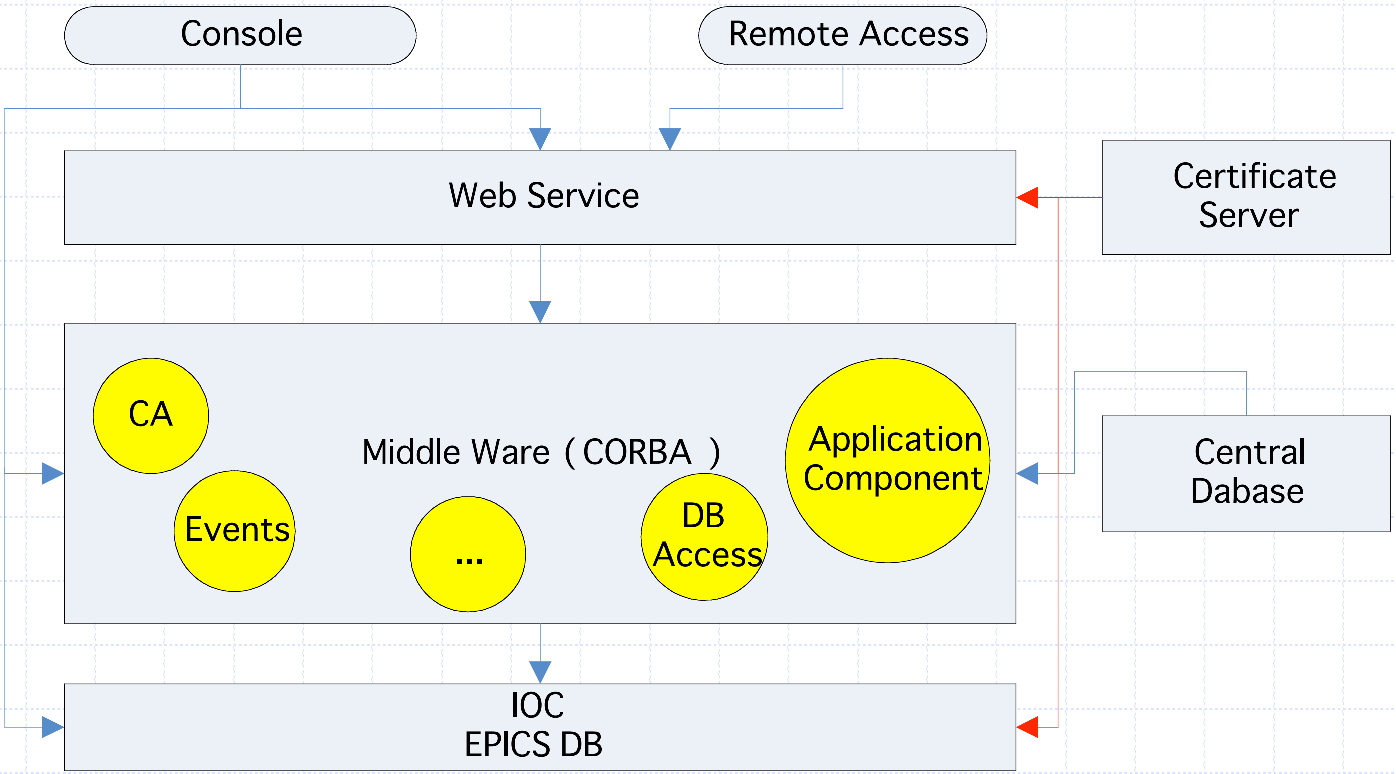
- **Use of a standard solution for protection system A clearly defined strategy used for handling machine protection and Human safety.**
- **EMI,EMC needs to be including in design.**
- **Use of modular I/O system for various subsystem**
- **Ease to extend**

Hardware Structure



Device controller

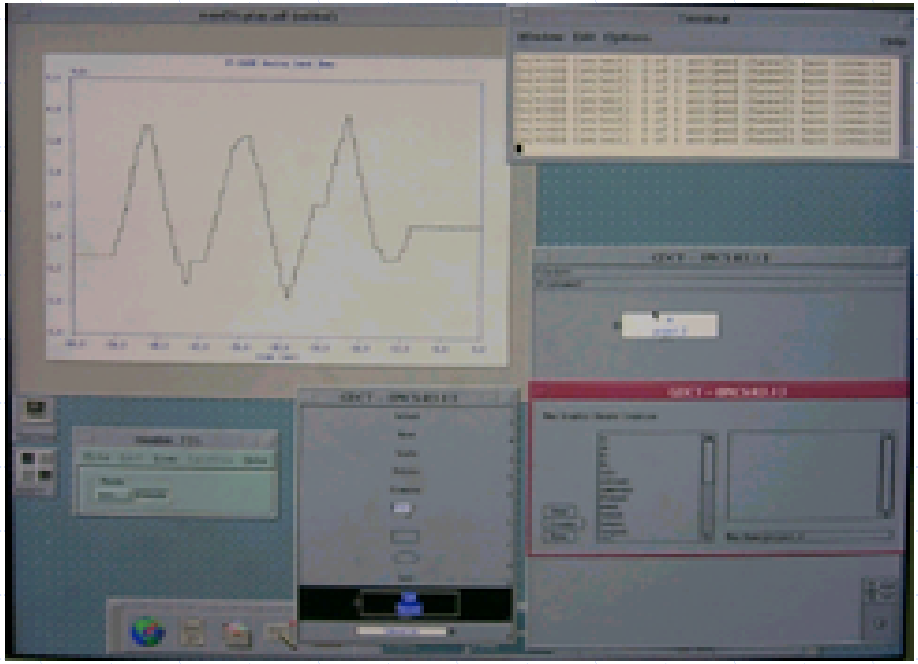
Software Structure Diagram



Middle Ware serve the EPICS getway;DB access;status control,system configuration,safety certification

EPICS Developing Environment

- Standard System Software
  - Sun Solaris
  - RedHat Linux Version 9
  - MS-Windows XP,2003
  - HP-UX 10.x
  - VxWorks
  - EPICS Version R3.14.6
  - Borland VisiBroker 6.0
- Standard Development Tools
  - Borland C++ Builder 6.0
  - gcc 3.x
  - Jbuilder X
  - Borland Together 6.2
  - MS-Visio 2003



Network Structure

1.Based on 1000M fast Ethernet

*Safety access certification
*Remote access *Wireless

2.Network Management

*Reconfiguration by VLAN *QOS
*Remote access

3.Reliability & Easy to use

*Dual fiber redundancy technique will be adopted
*Double protection for UPS *Industrial level E-Net will be used for special usage

Physical Application Consideration

*SSRF will use MathLAB as platform of physical application

*Mathlab application can be accessed through MCA linked with EPICS CA

*In SLAC, many software tools and application software have been developed for light source such as

- AT for accelerator and MCA,
- Linear Optic Correction Algorithm
- Various commissioning software for light source

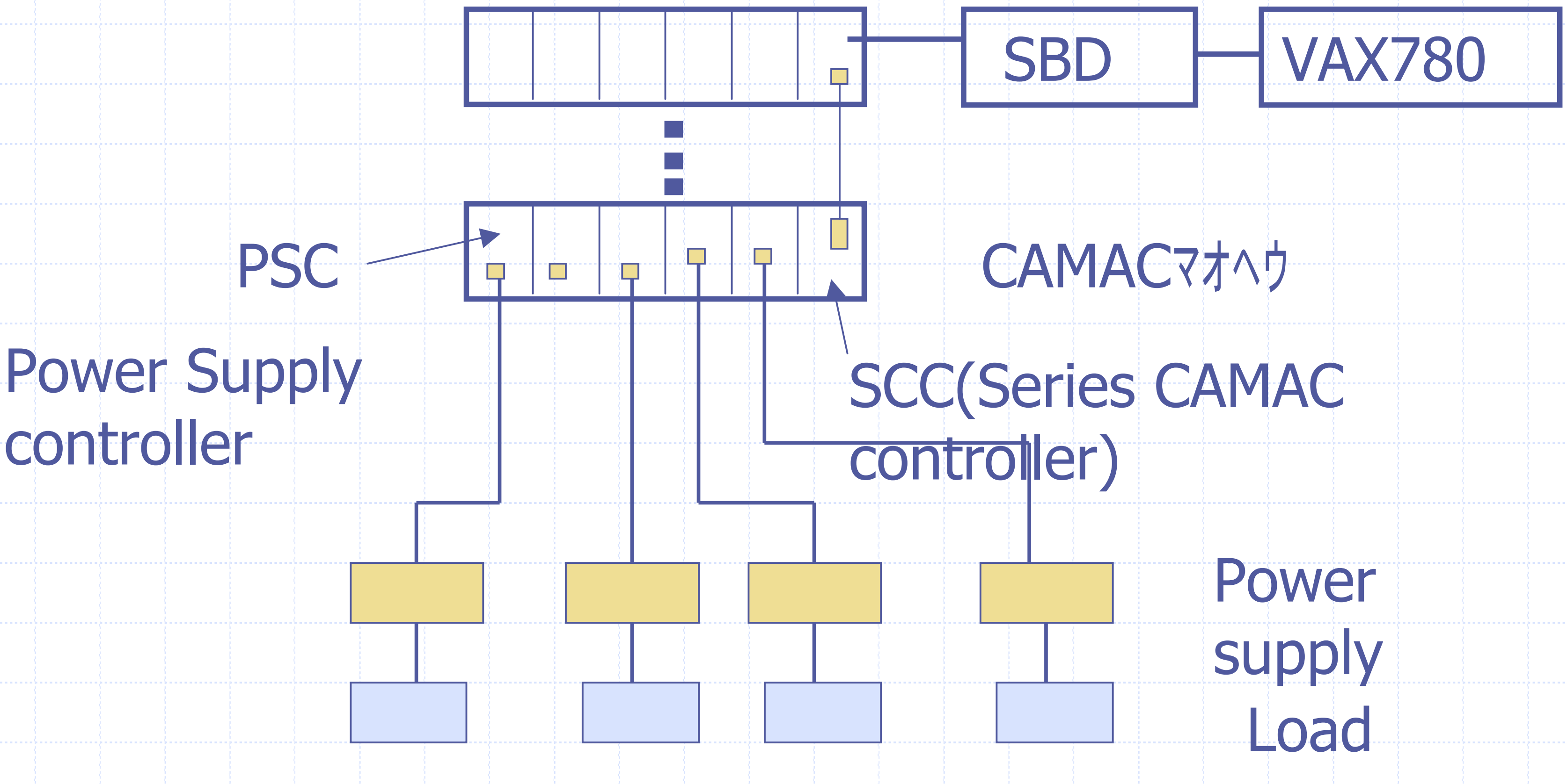
Main equipment to be controlled

1.Magnet Power supply

	LINAC	LL	Booster	HL	Ring	Note
B	1	1	1	1	1	+/-5E-5
Q	2	11	2	12	200	+/-5E-4
S			2		140	+/-5E-3
Other	3 7				80	
C	5	7	56	10	160	
Fast/C					80	
Total	45	19	61	23	661	809

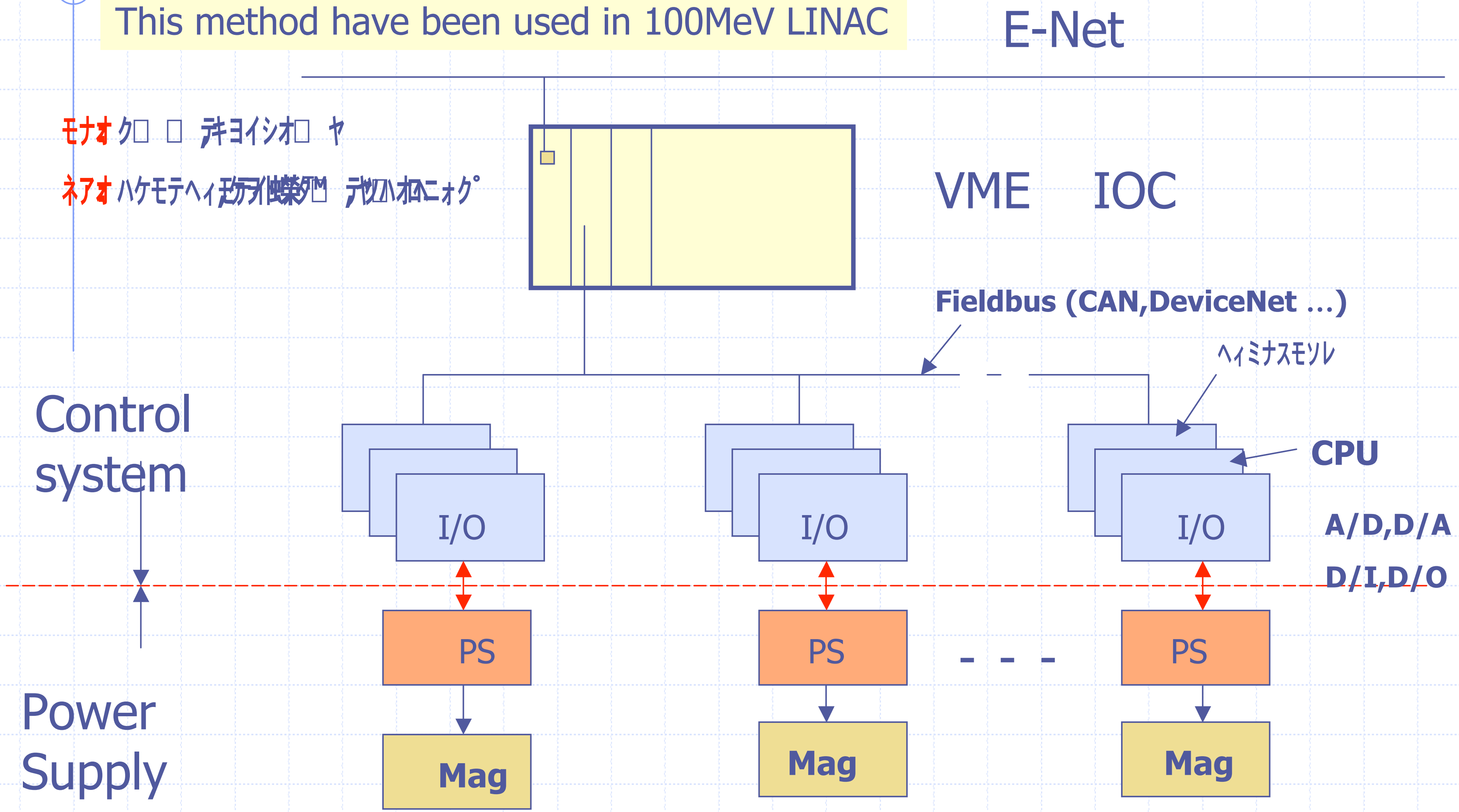
There are several options

1.)Analog to digital control mode (20years ago)



2.)Distributed control system for PS (before 10 years)

This method have been used in 100MeV LINAC



3.)SNS project PS control

Fiber

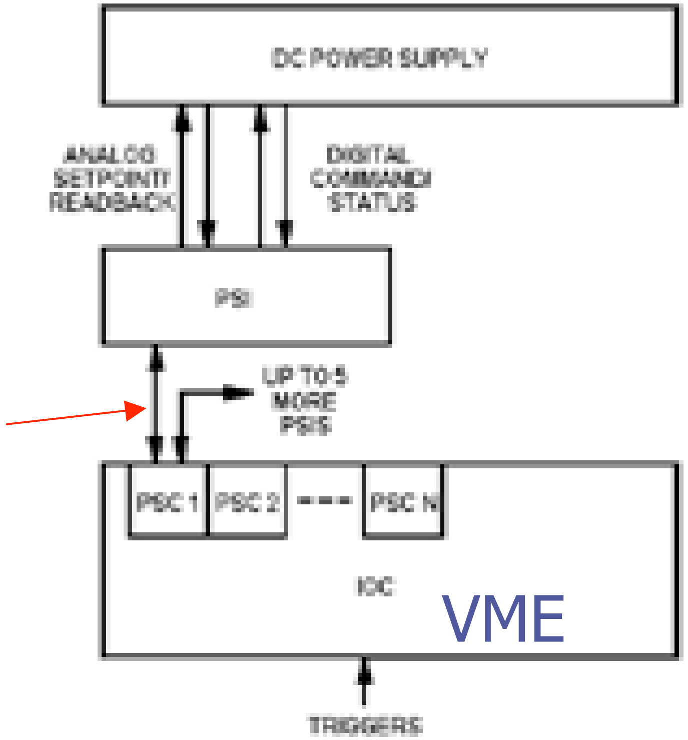


Figure 1: DC Power Supply Control Arrangement.

DC Power control

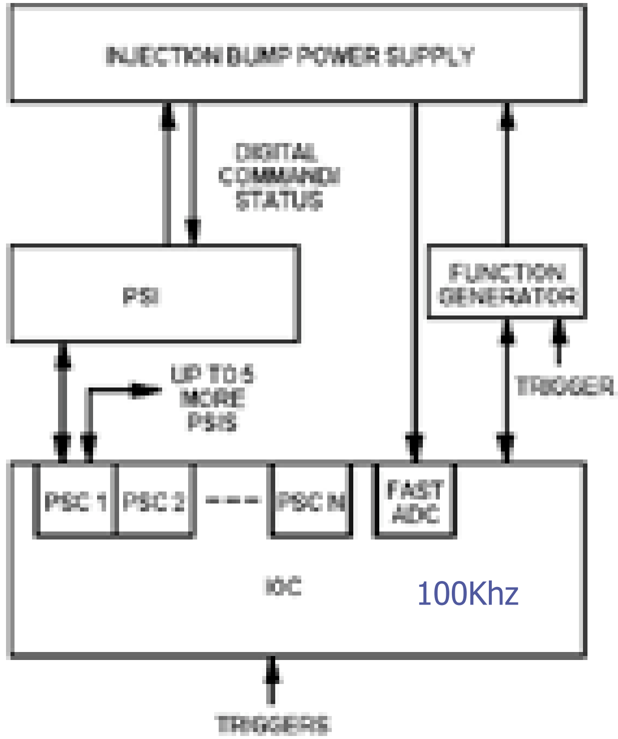


Figure 2: Injection Bump Supply Control Arrangement.

Inject BumpPS control

performance:

*One PSC link with 6 PSI

* each PSI with 16bit D/A,4X16bit A/D,15 D/O ,16 D/I

* Readback and setting on time

* Max sampling 10Khz data record, it can work on Burst mode.

* 5000 historydata can be recorded

* Fiber isolated

* PS can be tested through series channel or VME

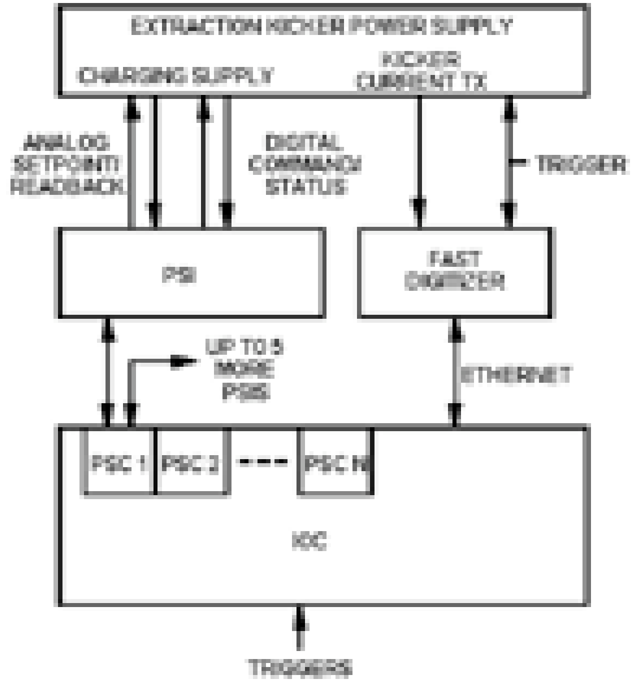
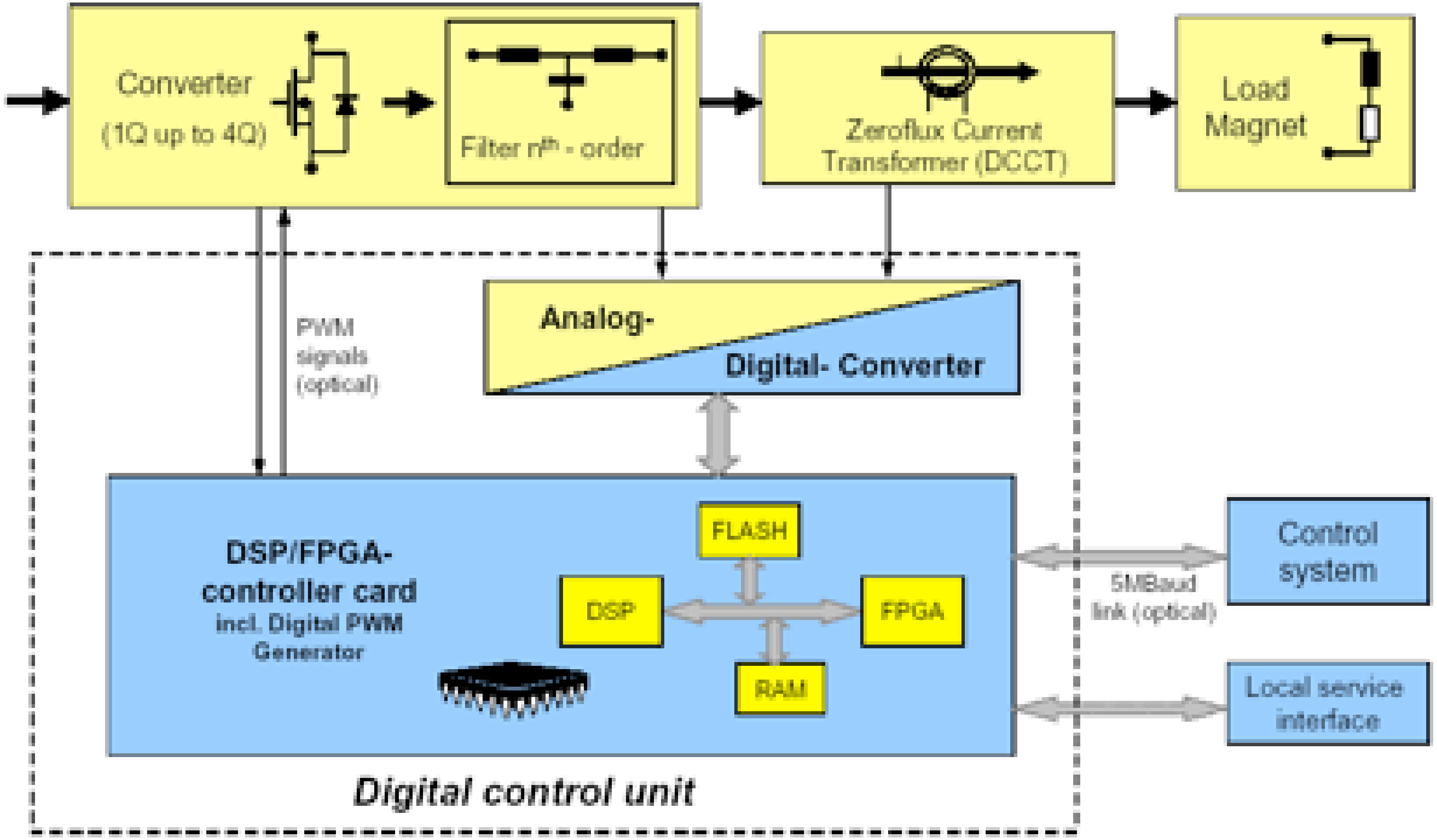


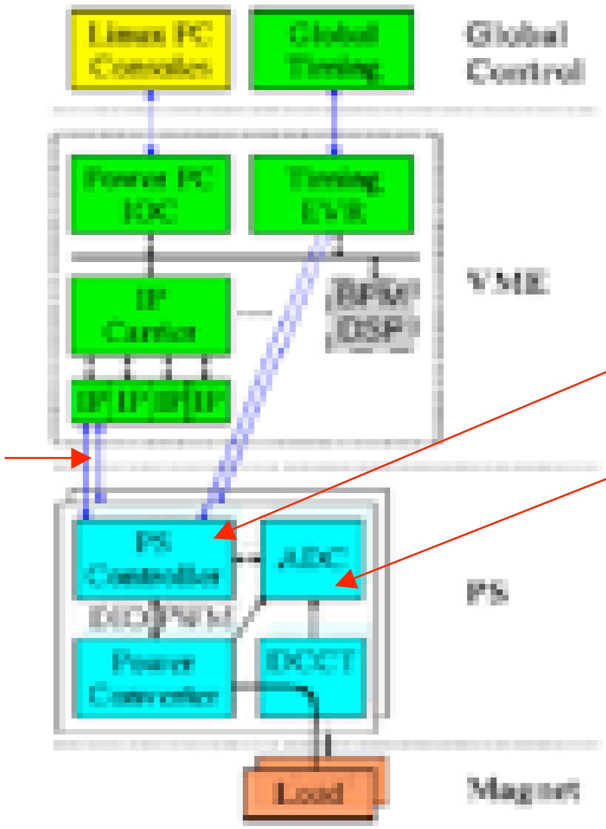
Figure 3: Extraction Kicker Control Arrangement.

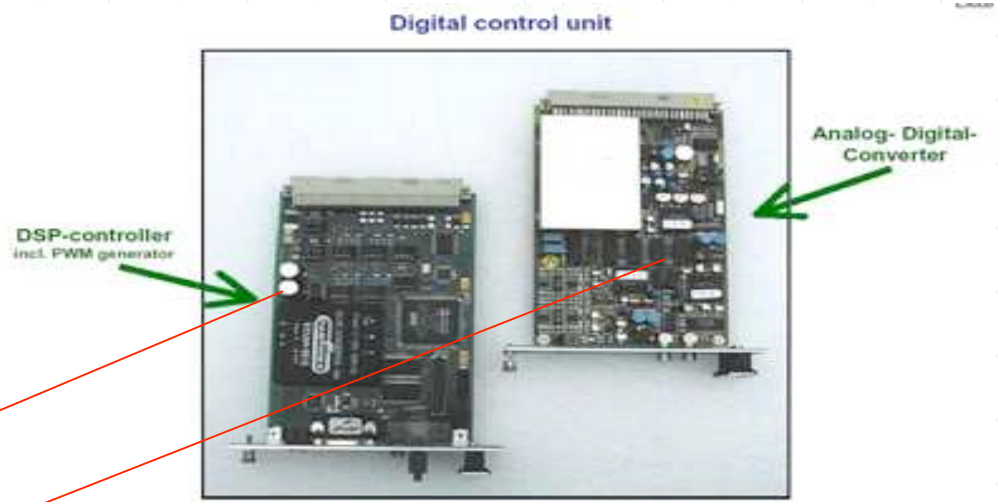
8bit/300M hz

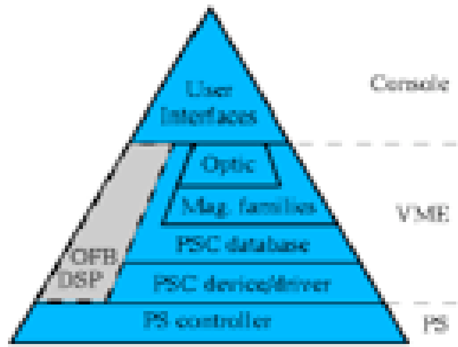
SLS Power supply control



Structure of SLS Power Supply







Software structure

Performance:

- * High dynamic rang up to 1000A
  * High accuracy (7ppm for corrector 1Khz)
  * High reliability & stability (<15ppm for bending
  * link with control system without loosing accuracy)
  * Module can be used for all kind of power supply
  * Without drift
  * High integration
  * Saving spare parts & easy to maintaining

Now we are discussing this issue & make decision soon based on its performance /cost.

2. RF system control

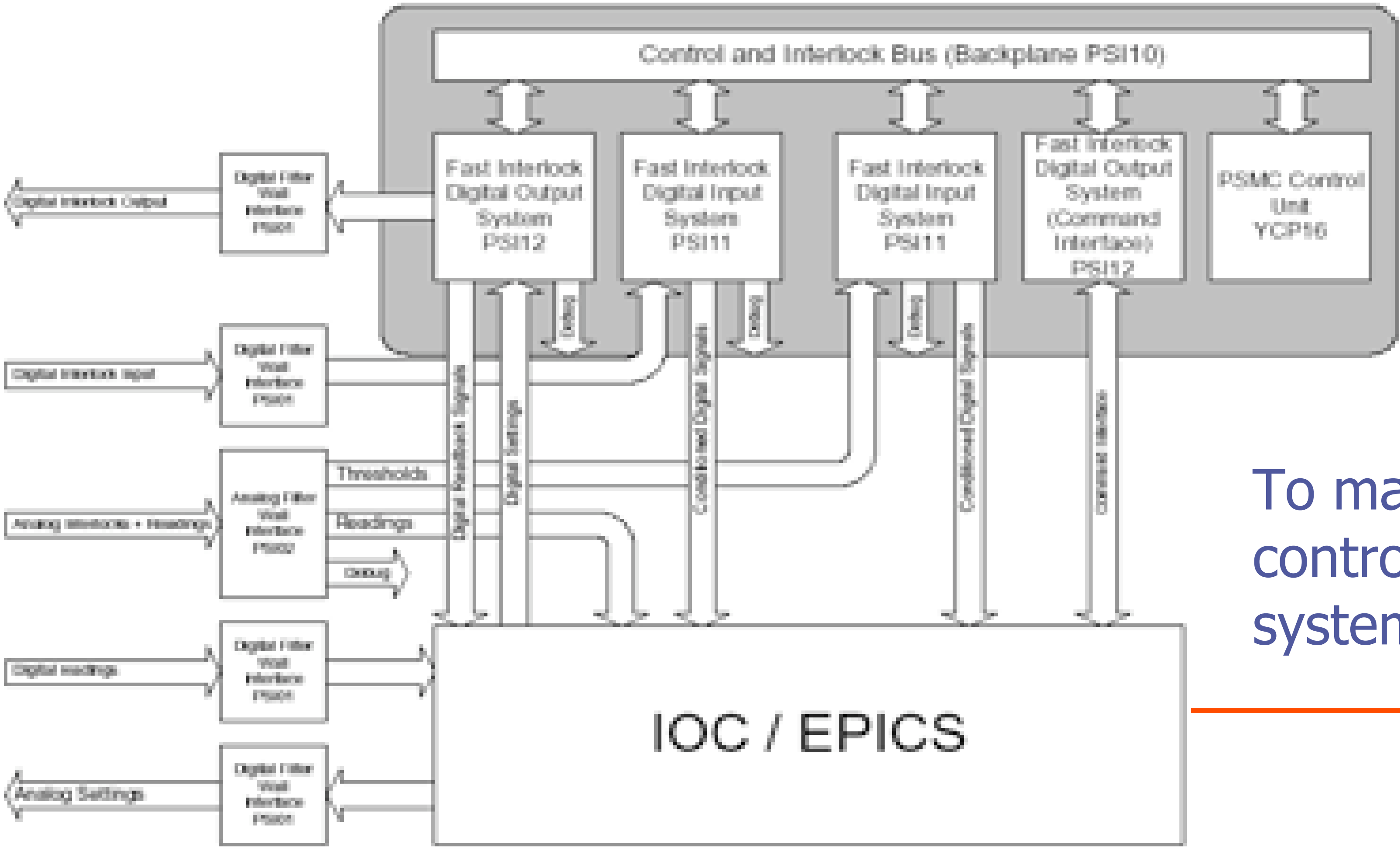
According to physical design, there are three set of RF station used for super conduct cavities in storage ring and one set RF station used for booster.

This RF station control is based on EPICS system , whole Rf control system(180Kw klystron+cavity+low level system) have been tested in Pre-R/D term. Hardware and software have been tested.

Question to be discussed:

How to deal with superconductor cavity control and cryogenic system?

Layout of RF control station



To main control system

Main-page of RF control

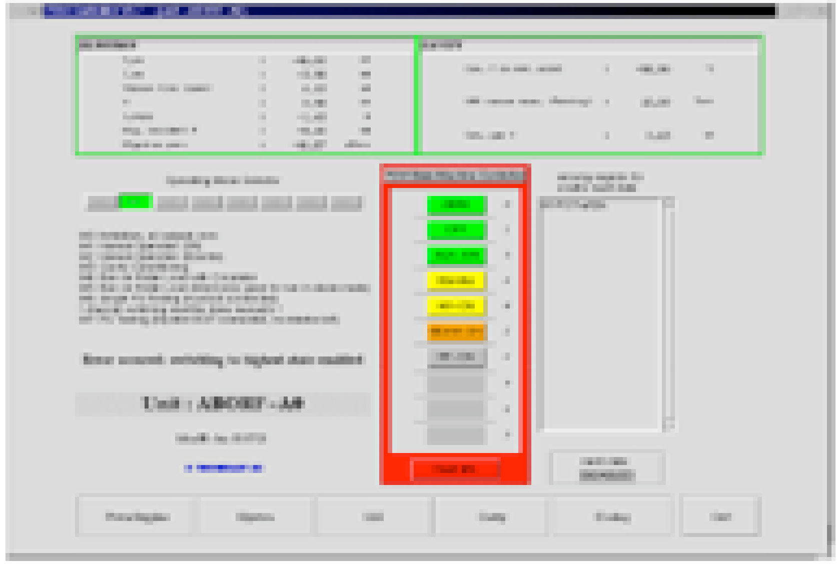
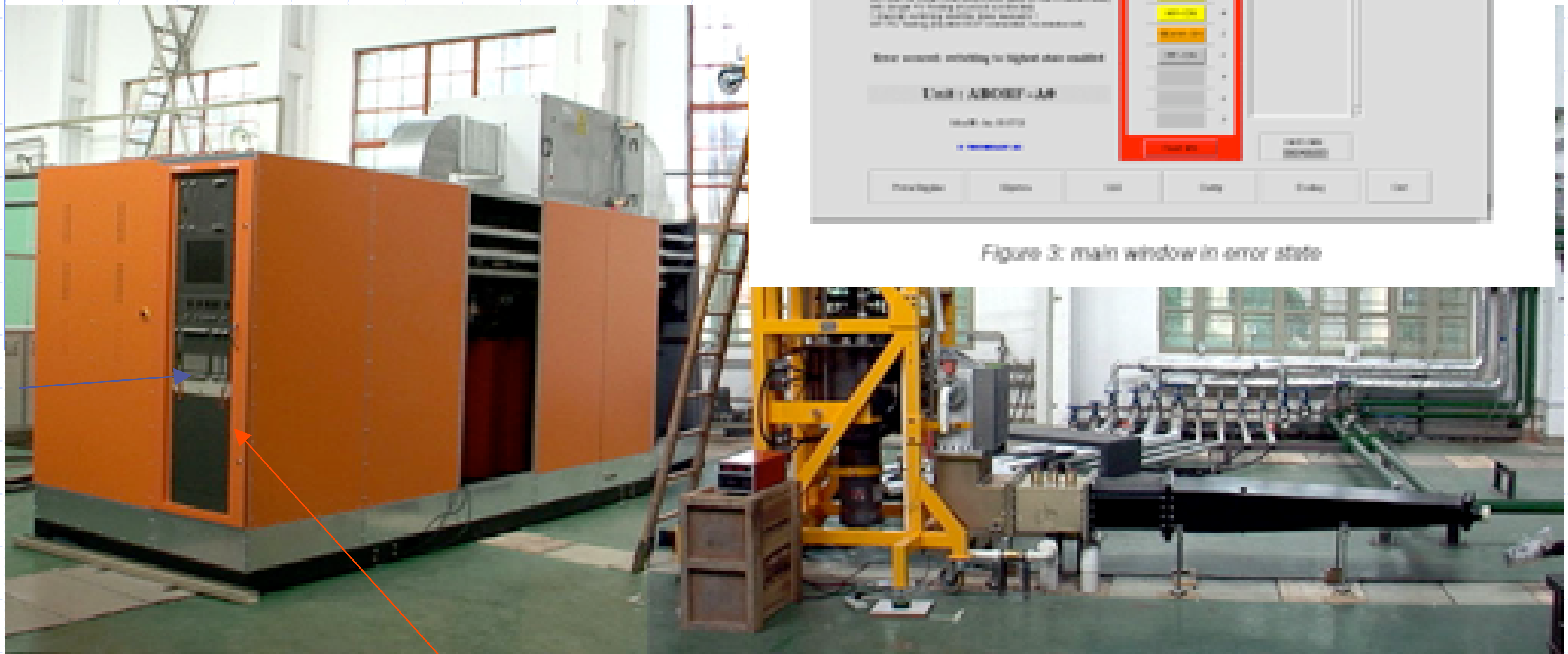


Figure 3: main window in error state



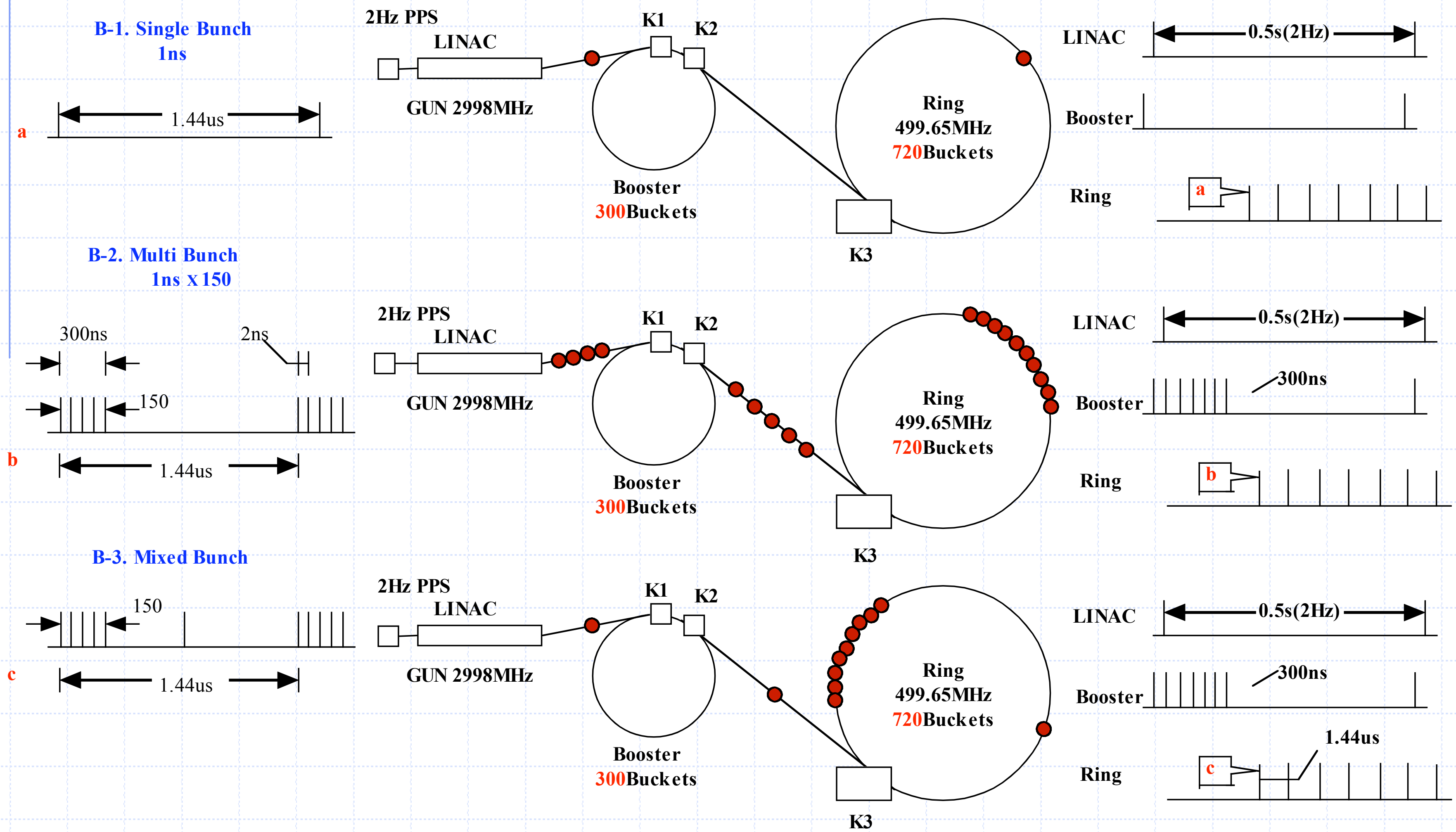
ICS

VME bin

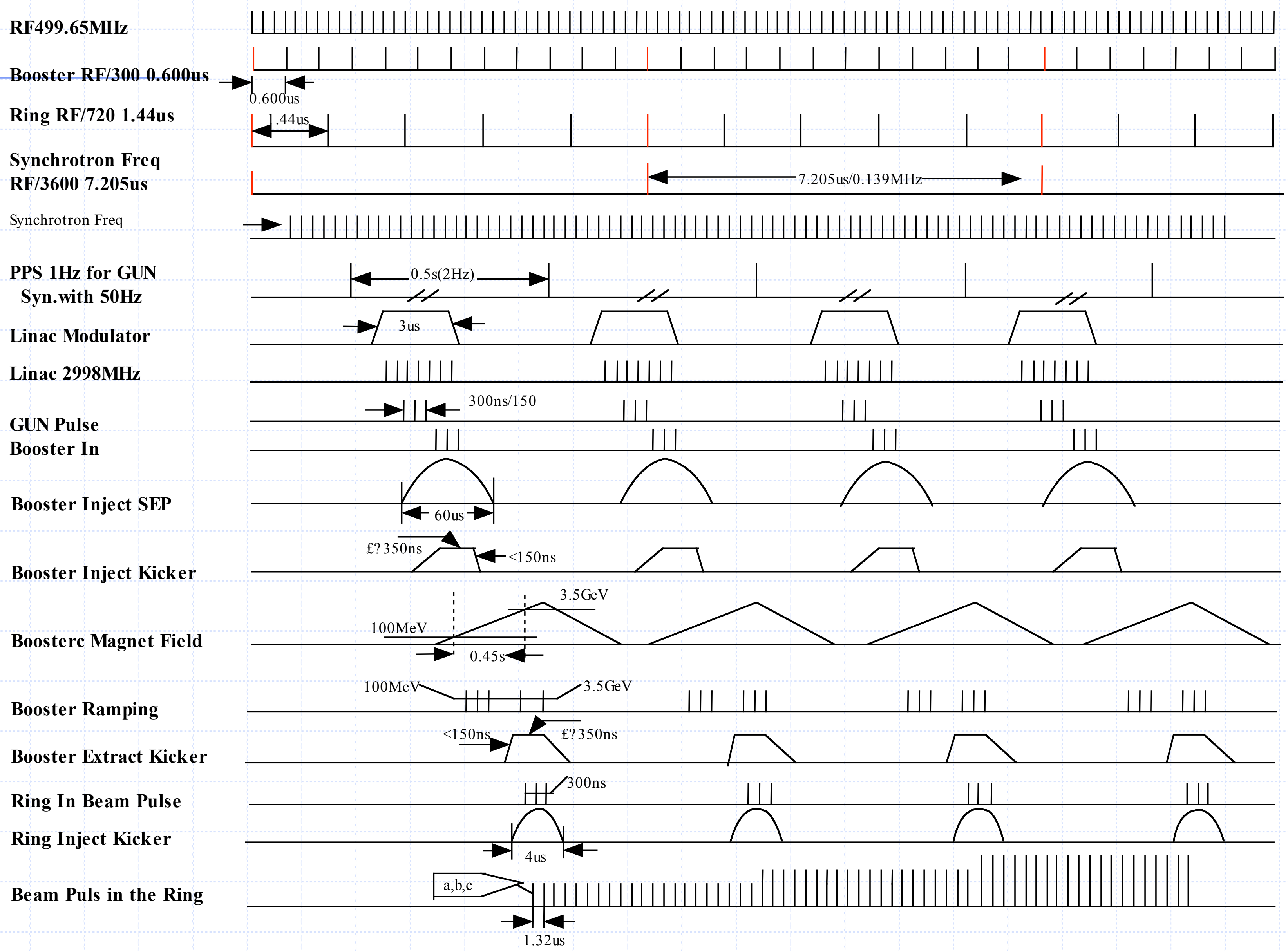
PVs of RF station are over 700

3.Tested result of timing system for SSRF

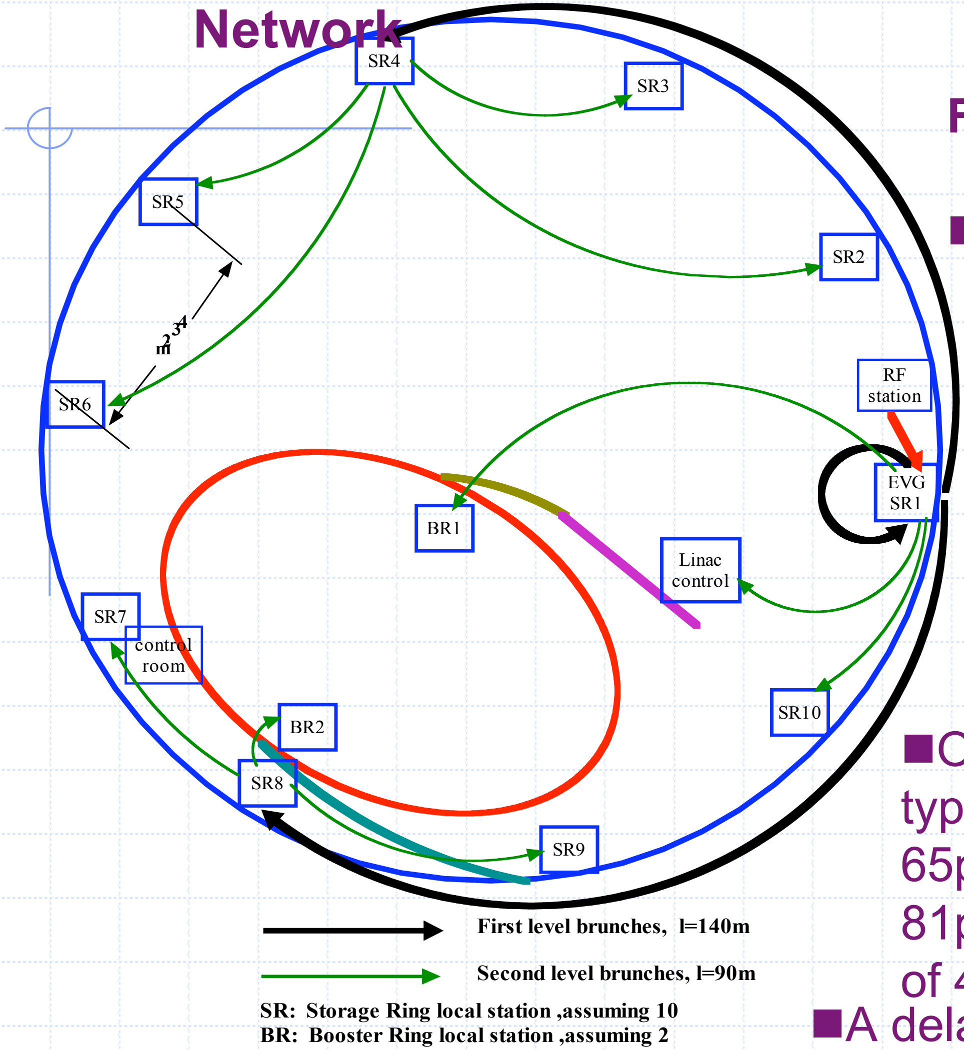
ÔËDDÄ£Ê?Running Mode



Logical Diagram of Timing Signals



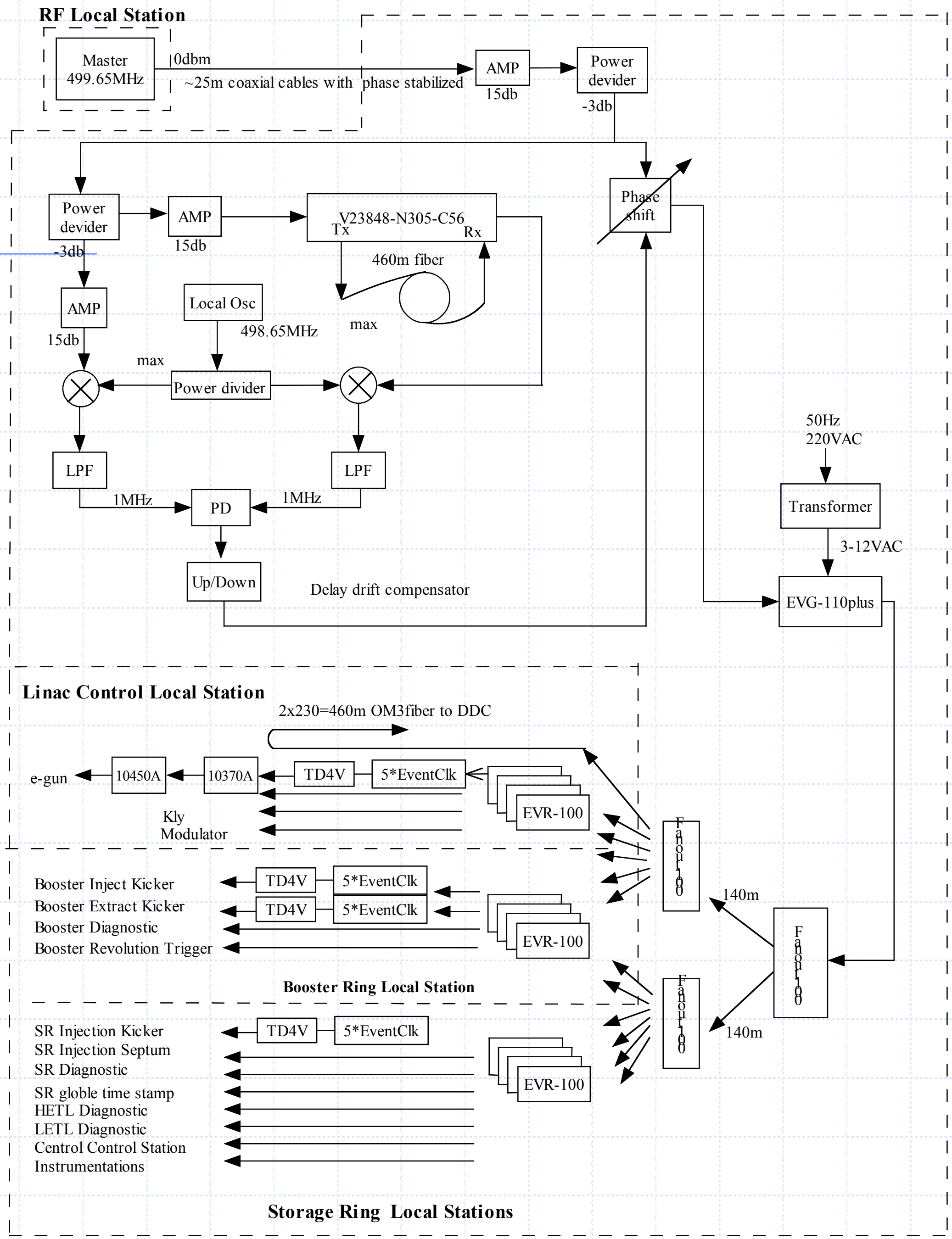
Timing System Network



Features」ː

- Event system complete all timing tasks
- A two level mutil star topology
- All fiber cables are equally long
- Single source fanout to multi receiver
- OM-3 multimode fiber has typical thermal delay drift of 65ps/km/。」300m will induced 81ps during temperature deviation of 4 。
- A delay drift system will correct the this error

Schematic Diagram Of Timing System



Only two reference source
3~12 VAC
499.65MHz RF Clock

Question to be discussed:

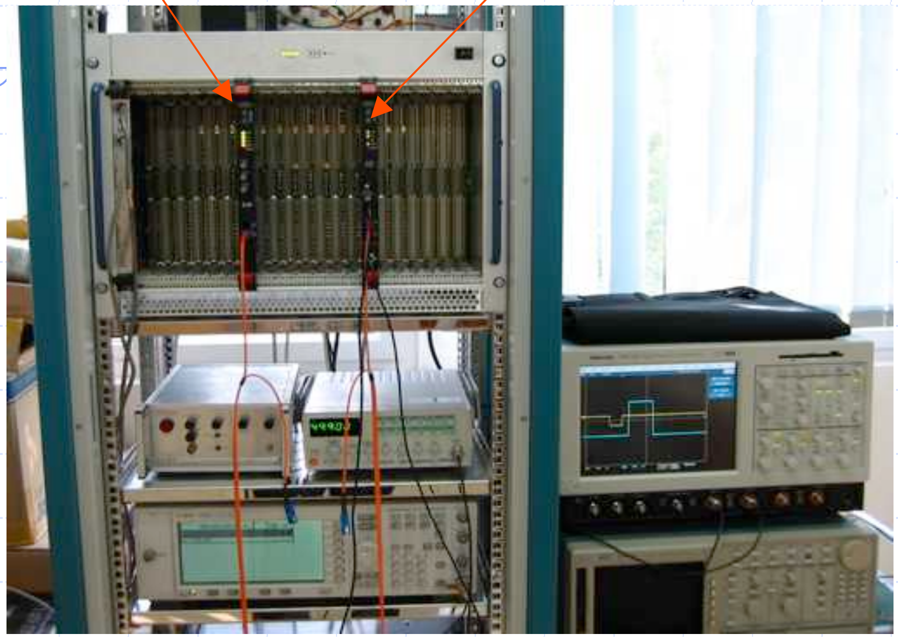
1. Whether fiber cable compensated phase is needed between Rf master and LINAC?

2. How to deal with long compensated fiber cable for installation round ring?

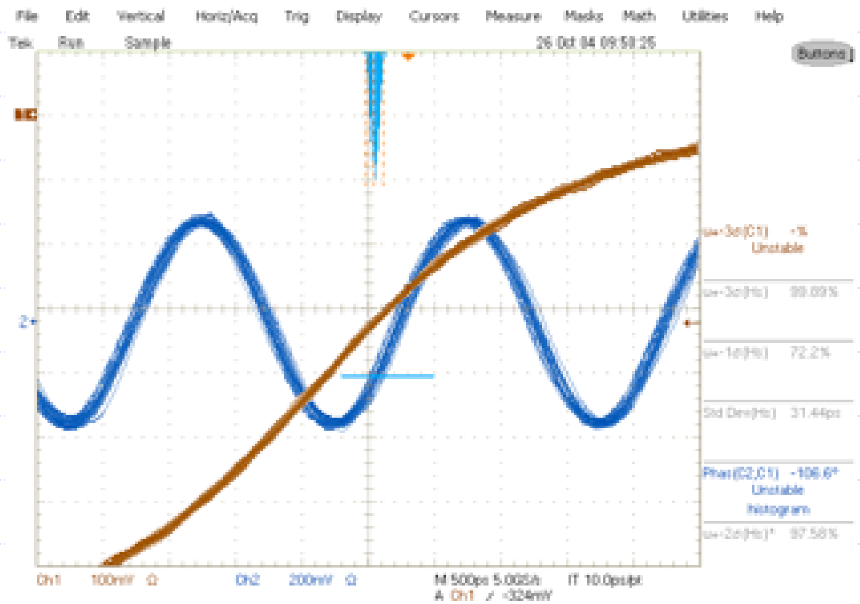
3. How to lock the phase between 496.654Mhz and RF of LINAC?

EVG

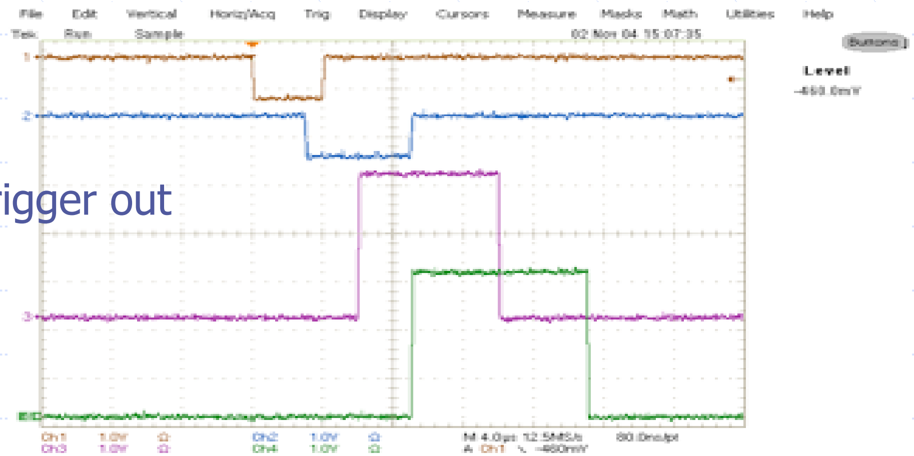
EVR

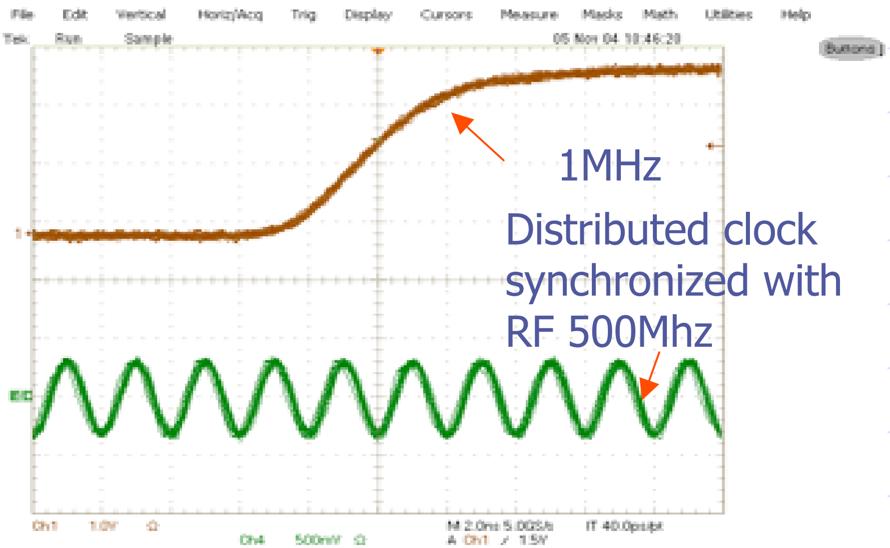


Jitter<31.4ps



Event trigger out





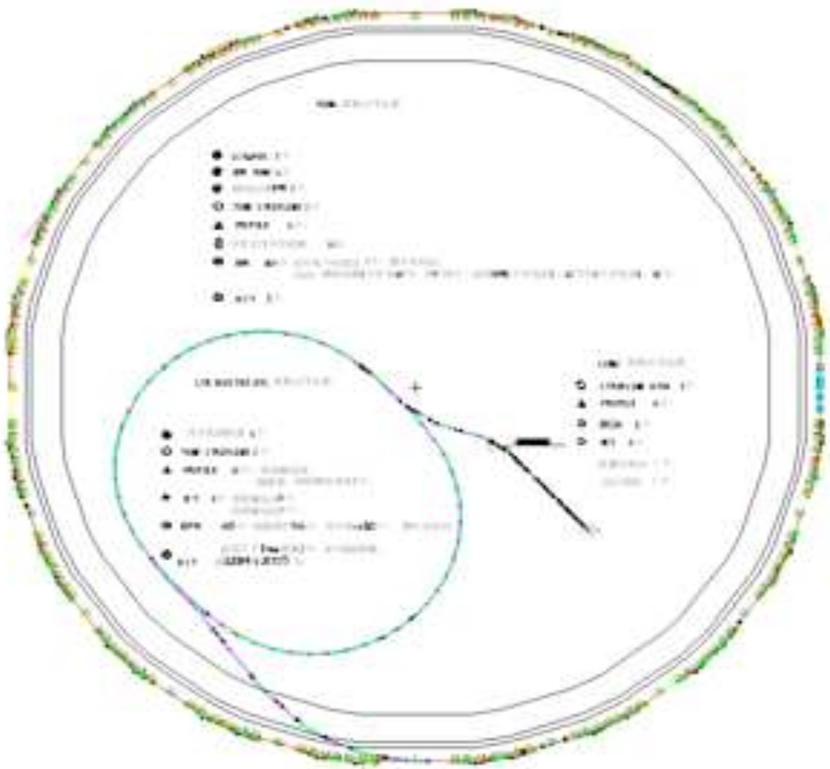
1MHz

Distributed clock synchronized with RF 500Mhz

Beam instrumentation

	LINAC	LEL	Booster	HEL	Ring	ｺﾏｼﾆ
Pulse current monitor ｣ｨWCM,BCM,FCT｣ｩ	3+1	3	1	4	1	13
Profile monitor	5+1	3	4	4	1	18
Energy spread	1					1
Farady Cup	1					1
Split		2		2	2	6
｣ｨDCCT｣ｩ			1		1	2
BPM	3	4	56	5	152	220
stripling			2		2	4
SLM			1		1	2
Xray pinhole					1	1
Total	15	12	65	15	161	268

Distributed beam monitor



LINAC	15
LEL	12
booster	65
HEL	15
Ring	161
Total	268

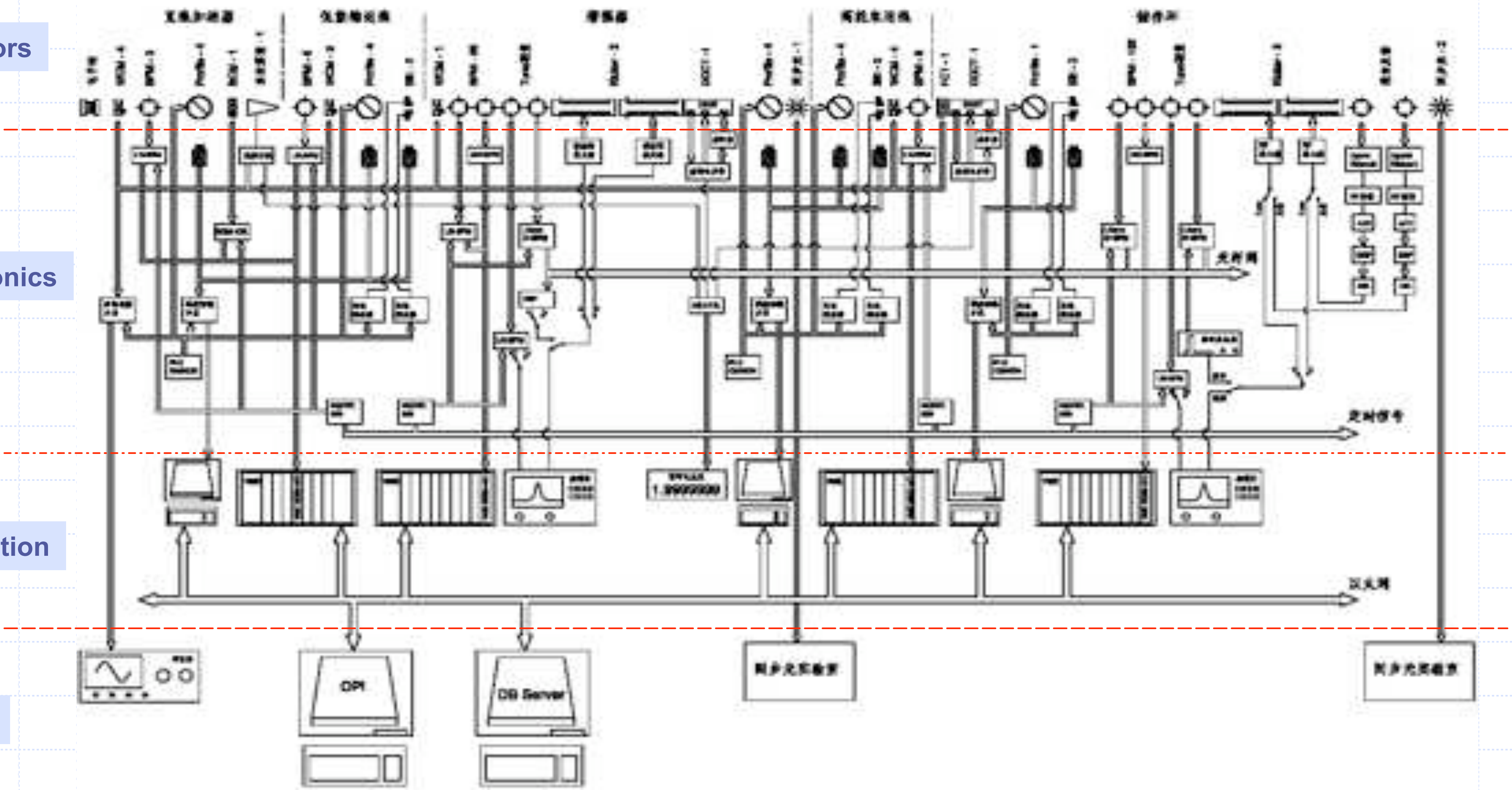
Beam instrumentation data acquisition

Monitors

Electronics

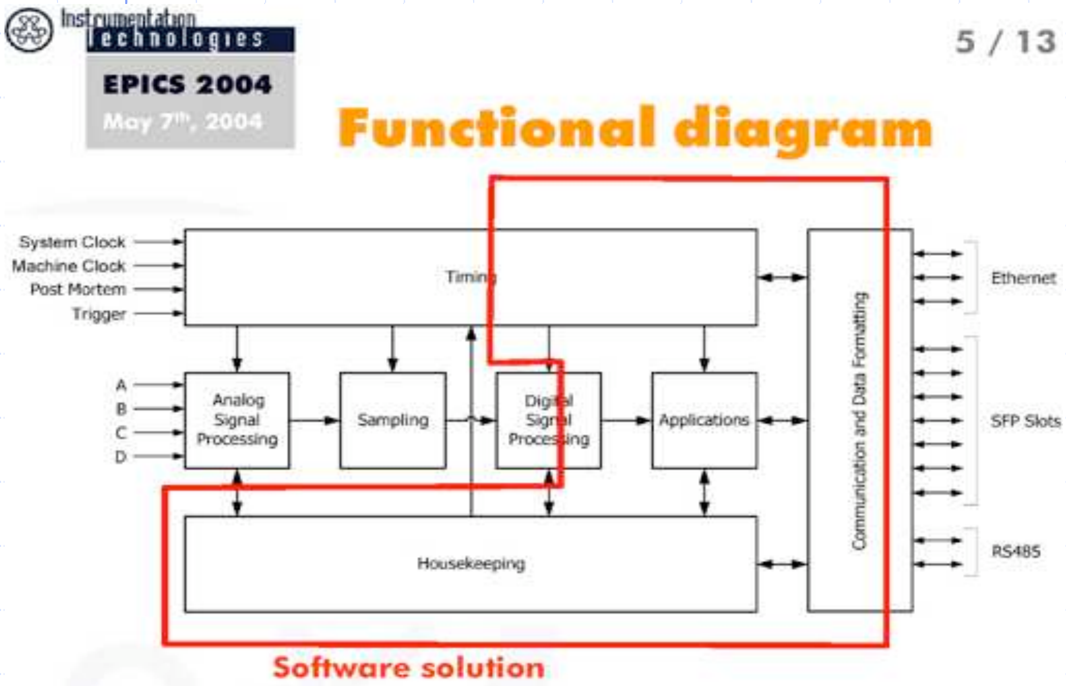
BM station

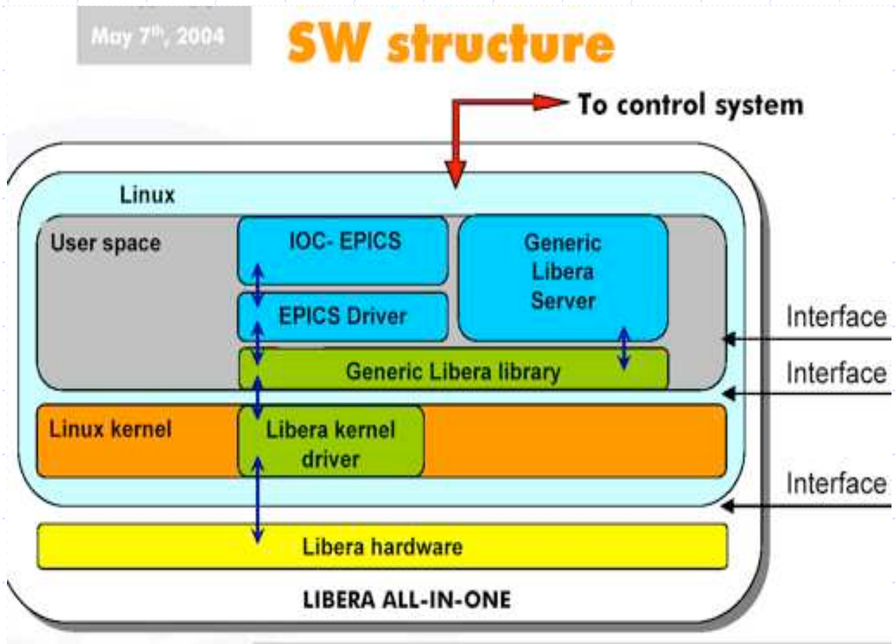
OPI



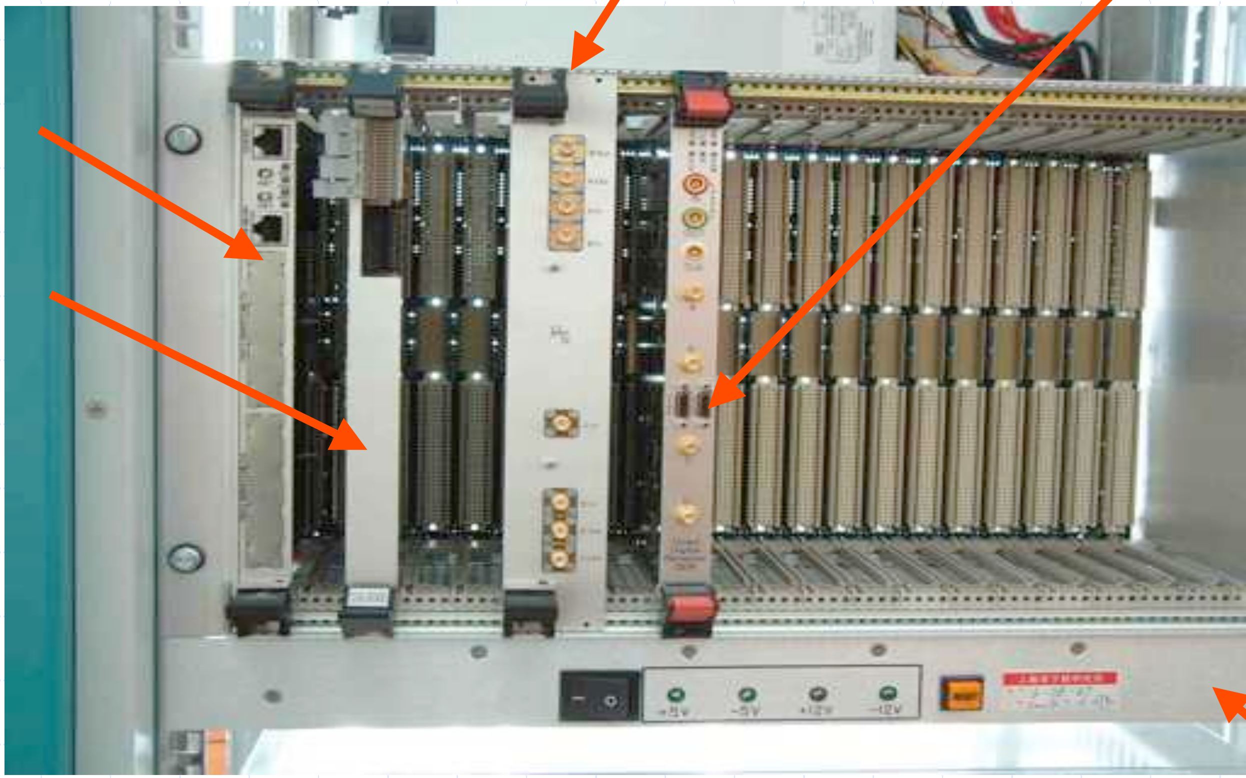
BPM Data processing diagram

New DBPM
Resolution <1um

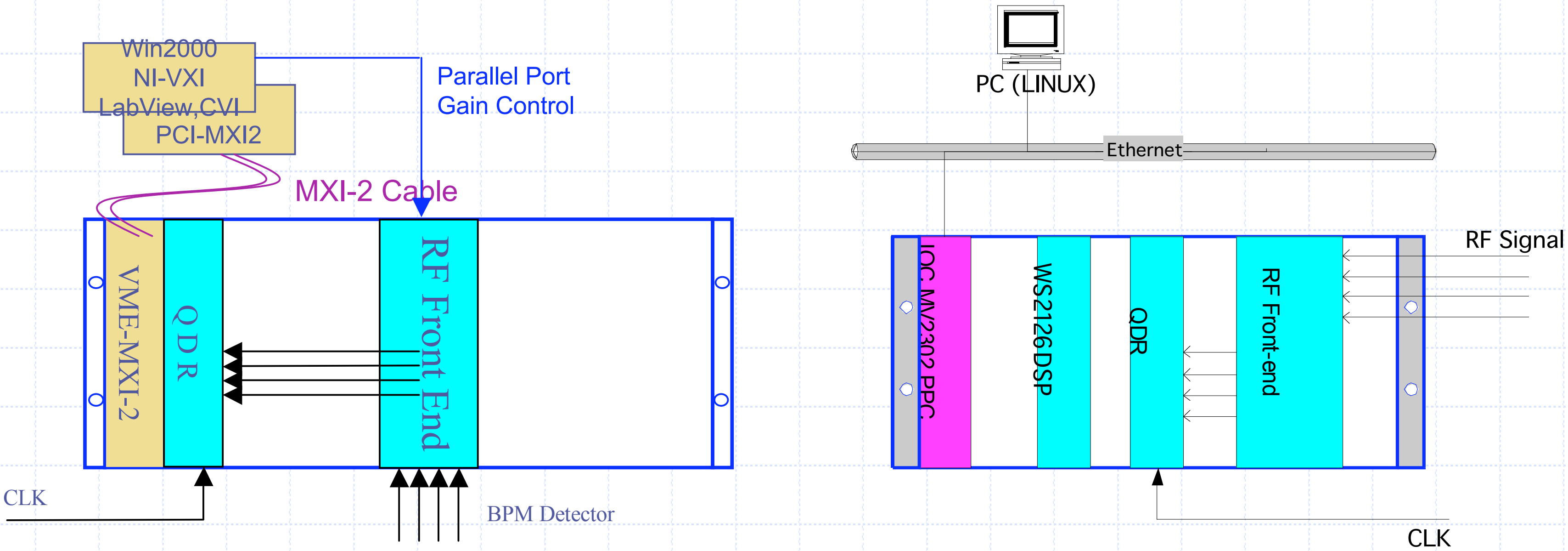




Test result of DBPM in BEPC machine



DBPM Hardware Architecture



VME-PCI8000, PCI-MXI2-VME
(Remote Controller)

(i)

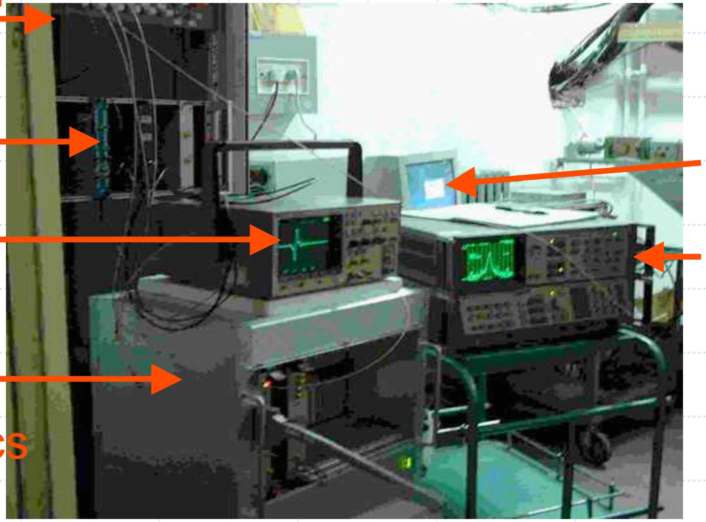
EPICS Based
(Embedded Controller)

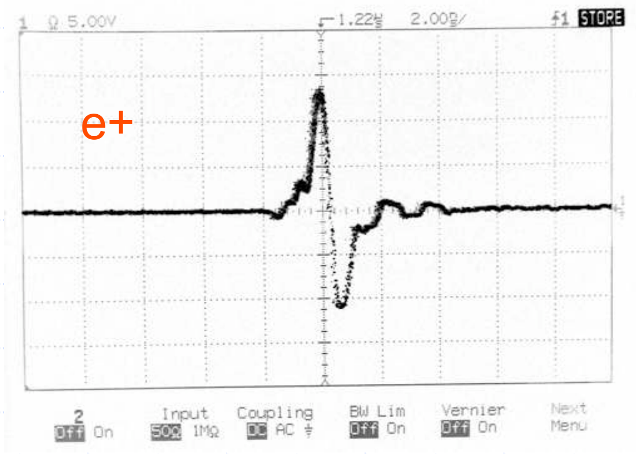
(ii)

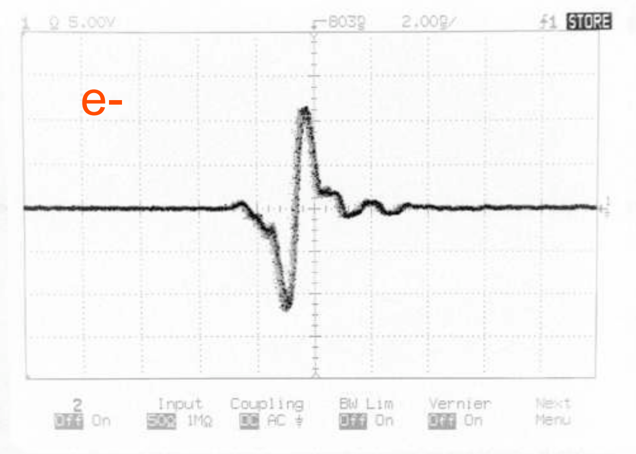
BEPC Test Photos

Electronics modes:

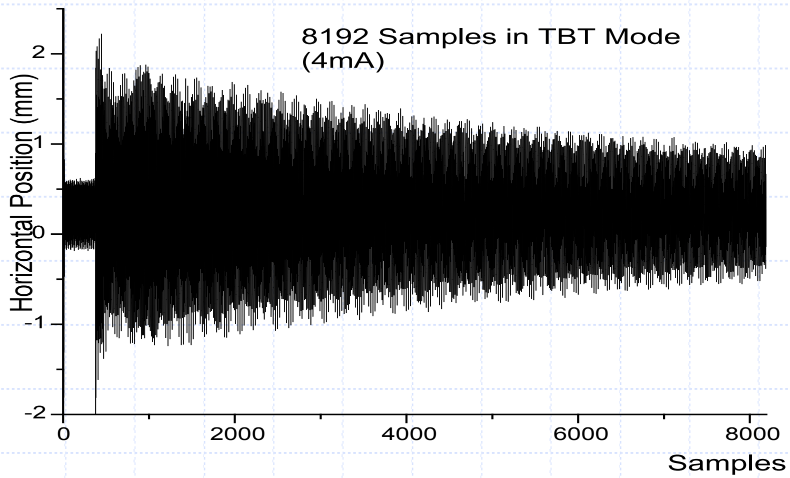
DBPM modes	Time Span of 8K samples	Turns per sample	Bandwidth
Turn-by-turn	6568.8 _s	1 turn	620 KHz
Ramp-26ms	26 ms	4 turns	155 KHz
COD	840 ms	128 turns	4.8 KHz

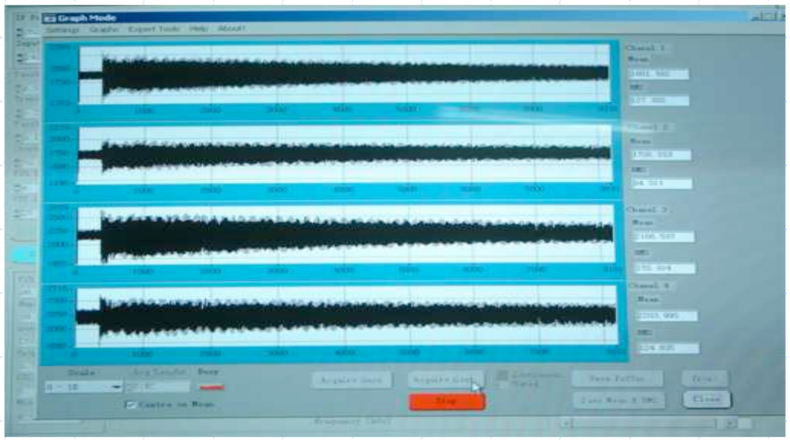






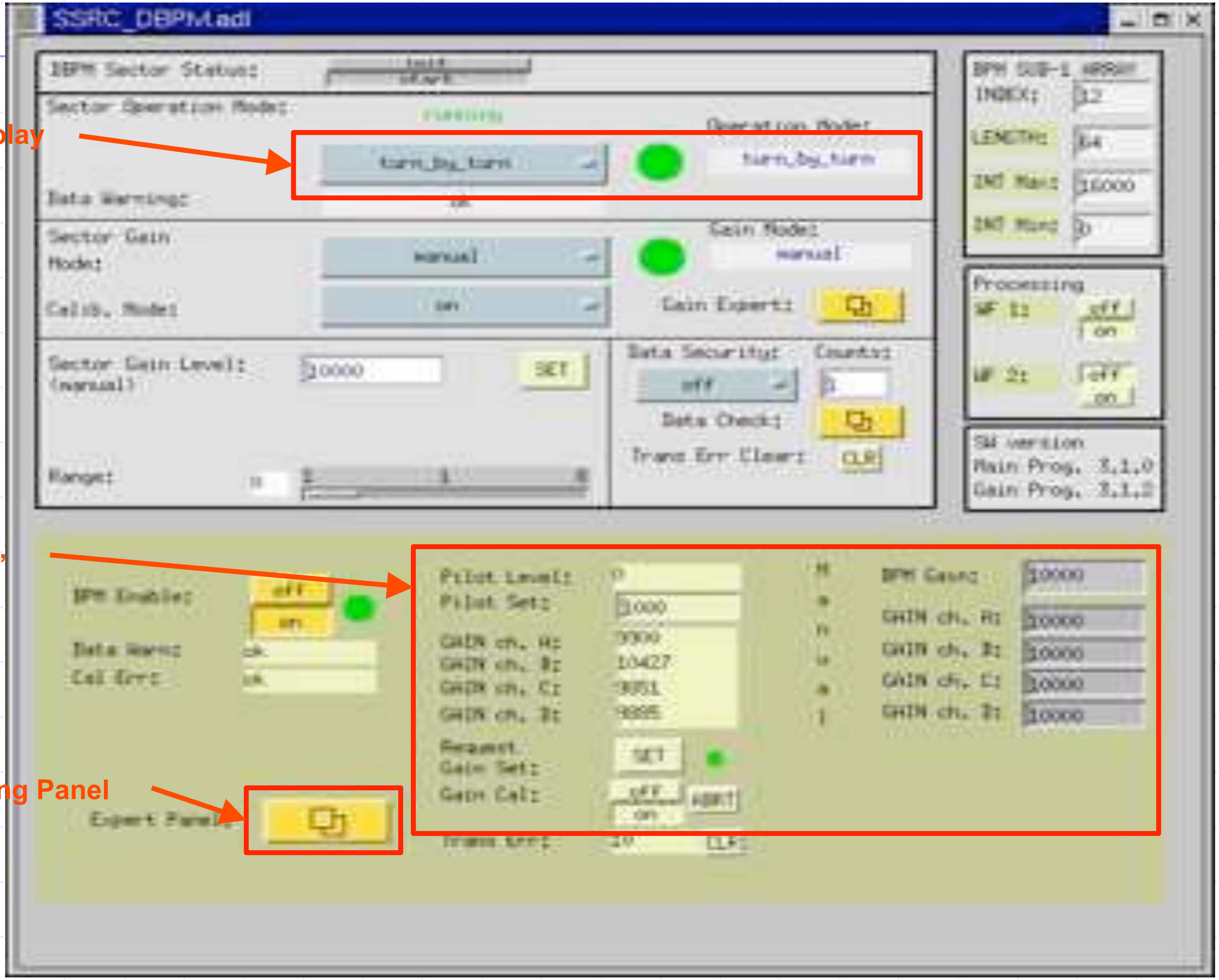
Damping Time of BEPCⅡ





DCCT	Damping Time
8mA	~ 6.34ms
6mA	~ 6.89ms
5mA	~ 7.05ms
4mA	~ 7.04ms
3mA	~ 12.27ms

MEDM Panel」]



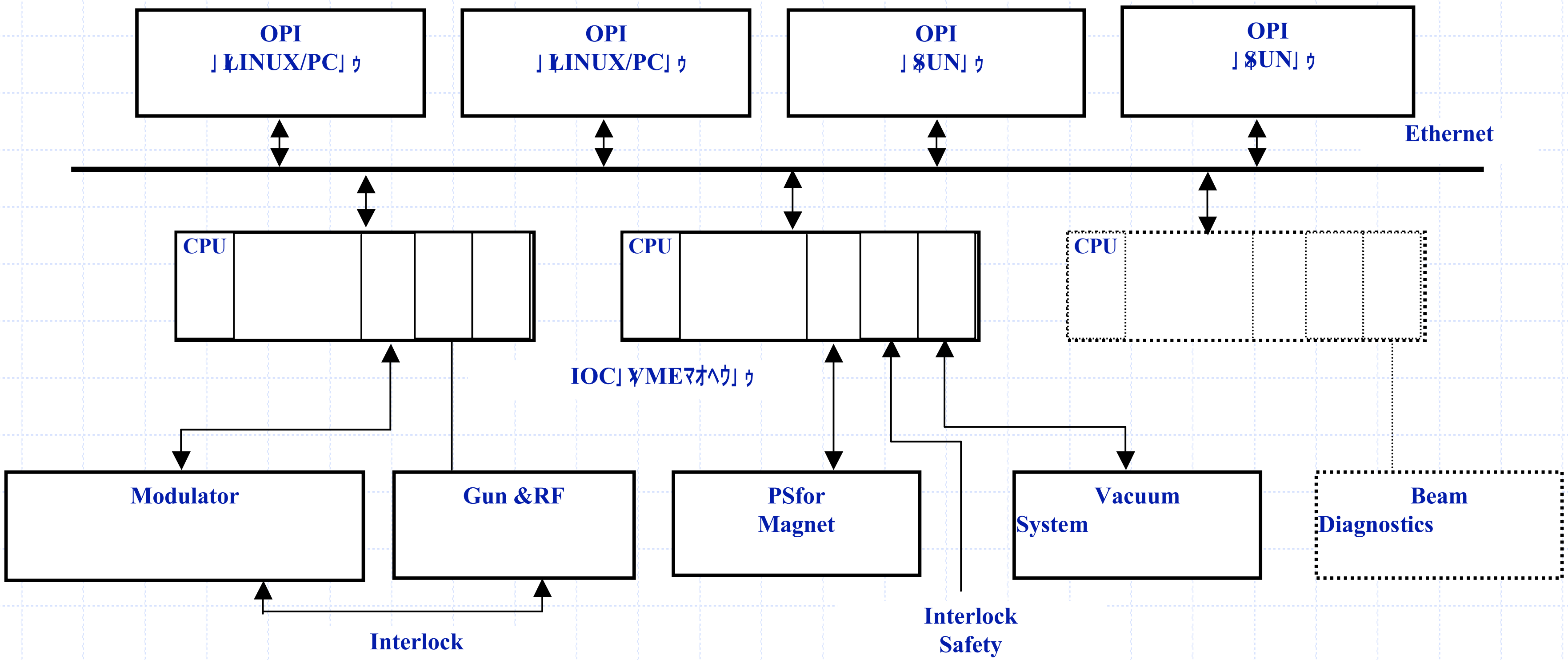
Mode Set&Display

Gain Setting, Calibration

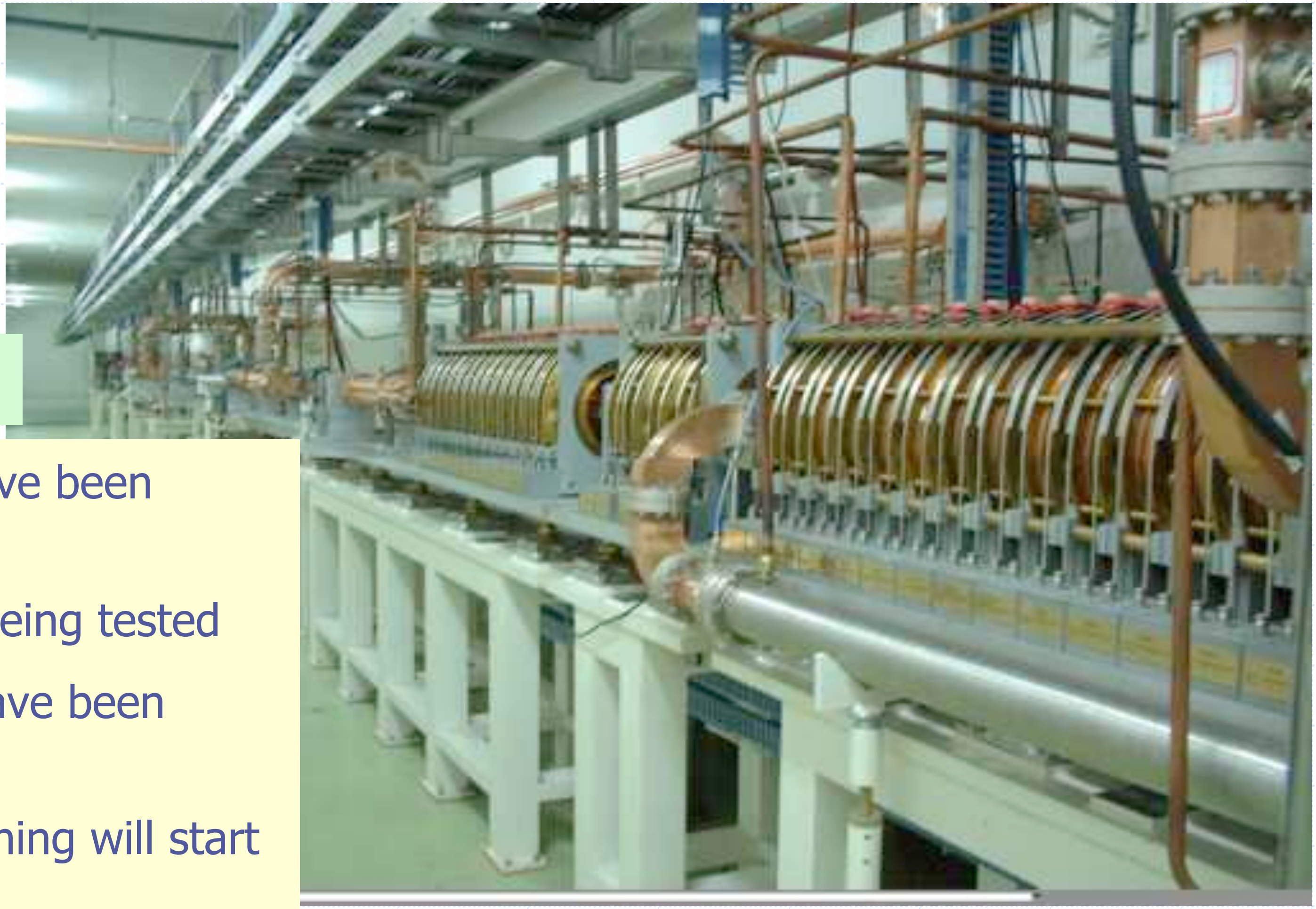
Data Sampling Panel

100MeV LINAC Control System Diagram

*Since 2002-up to now, it will be extended to 300MeV for DUV-FEL research



100MeV LINAC Tunnel



Present status

*All components have been installed

*Now,RF power is being tested

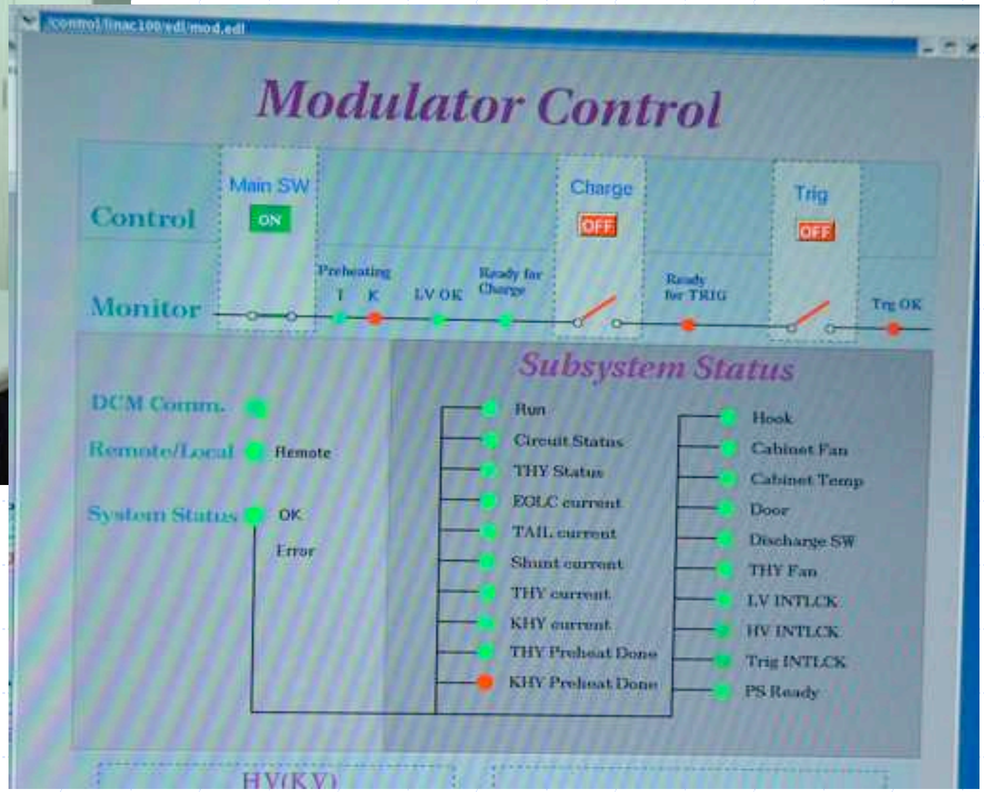
*Each subsystem have been tested.

*System commissioning will start soon

MEDM modulator page

VME/IOC

Modulator station



LINAC control room

LINAC Power Supply

MEDM PS page

Summery

1.During past few years , we accumulated some experience on the IOC level control such as RF local station, LINAC local control based on EPICS.

2.To set up some prototype(such as DBPM ,event system) and tested it with EPICS

3.We still have not experience for large scale accelerator such as Database management and physical application .

4.We still need to study some new technology such as digital PS, embedded IOC (Libera) etc.

5.Standard selection of HW & SW (such as VME/PXI;many kind of PLS,Field bus etc.)

Acknowledgement

We should appreciated many labs and friends to give us so kind of support when we start our project .

*During past few years KEK have held 3 times seminar of EPICS in China with success.

*Many experts from SLAC give us lot information about beam instrumentation and physical application on SPEAR III.

*Some new technique such as event system ,digital PS ,DBPM from SLS ,Diamond, PAL and IT Inc ….

Any comments and suggestion are welcome!!

Thank you for your attention and

please enjoy with us !!