

# Status of Activities Related to EPICS and Accelerator Control in China

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Presented by Guobao Shen

KEKB Control Group

EPICS Collaboration

RICOTTI Tokai, 8 Dec 2004

# Outline

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- Introduction
- EPICS Status in China
  - SSRF LINAC
  - BEPCII
  - HLS
  - CSNS
- References and Special Thanks

# Introduction

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- Started in the middle of 1990s
  - IHEP started EPICS research around 1995
  - HLS started from 1996
  - The first EPICS seminar was hold in IHEP at 1997
  - IHEP got the EPICS license at Jan. 1997
  - HLS got the EPICS license at Jan. 1997
  - SSRF got the EPICS license at 1998

# Outline

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- Introduction
- EPICS Status in China
  - SSRF LINAC (Materials are provided by Associate Prof. Jianguo Ding)
  - BEPCII
  - HLS
  - CSNS
- References and Special Thanks

# Status in SSRF LINAC

## -- Introduce

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### □ SSRF project

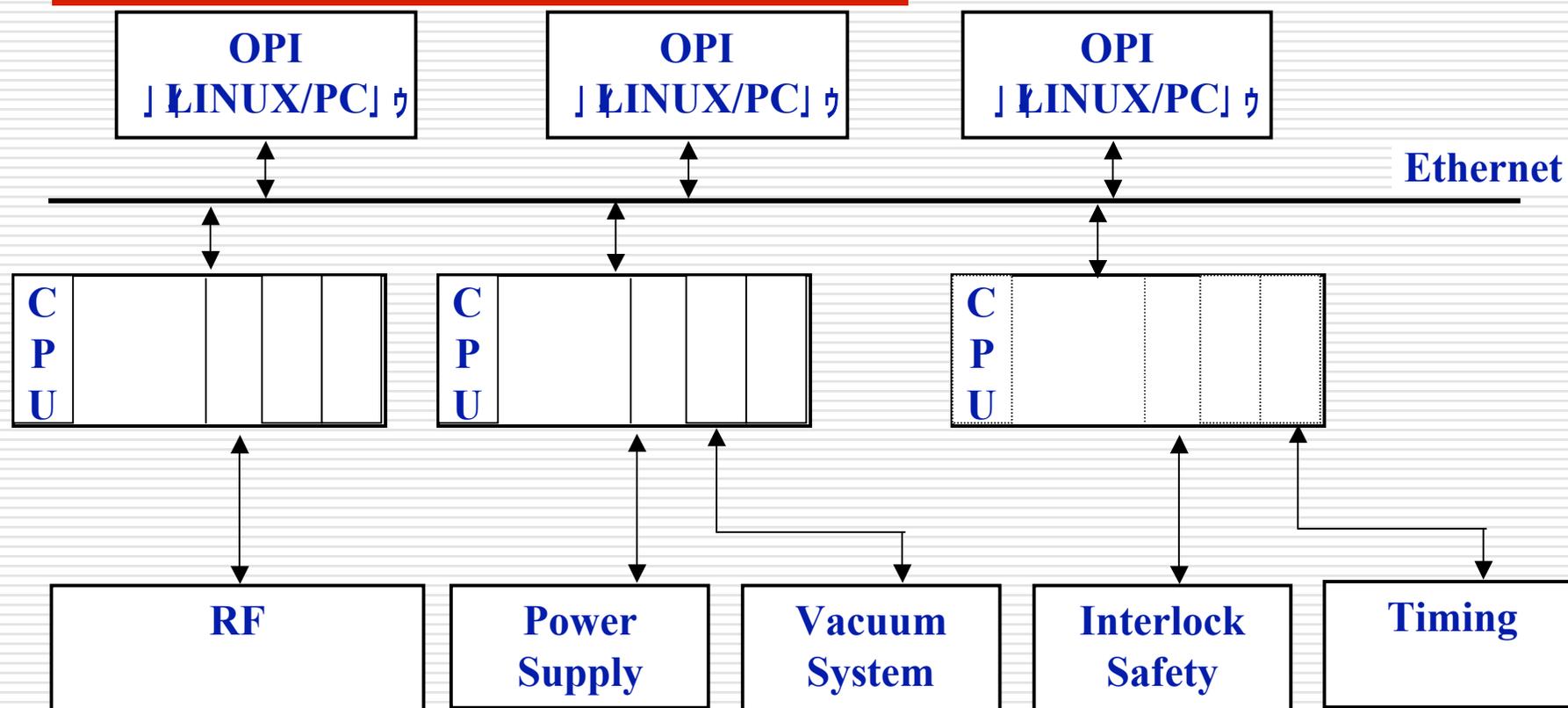
- Intermediate energy 3rd generation SR light source
- Suspended for almost 2 years from 2001
- Formal approval by Government at Jan. 2004
- Control System will be based on EPICS

### □ 100 MeV LINAC

- Approval in 2002
- Now under constructing
- Commissioning started at the beginning of Nov. 2004
- Will be upgraded to 300MeV for FEL (?)

# Status in SSRF LINAC

## -- Structure of Control System



# Status in SSRF LINAC

## -- Tools

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- EPICS Base: 3.13.10 upgrading from R3.13.1
- OPI OS: Linux
- IOC OS: Tornado1.0.1/vxWorks5.3.1
  - Development Platform
    - 3 SUN Ultra10 with Solaris2.6
    - 1 SUN Ultra60 with Solaris2.7
- EPICIS Tools:
  - BURT
  - ALH
  - StripTool
  - ChannelArchiver
  - EDM 1-10-0 /MEDM/DM2K
  - Capfast/VDCT

# Status in SSRF LINAC

## -- System Configuration

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- 5 subsystems
  - Power Supply, Vacuum, RF, Timing and interlock, Beam Diagnostics (Labview, non-EPICS)
- 3 OPIs
  - PC with Linux Redhat 9
- 3 IOCs
  - 2 Motorola MVME2302
  - 1 Motorola MVME162
- 12 Controllers
  - 2 A-B SLC 500, 1 A-B PLC 5, 6 A-B 1794 DeviceNet
  - 2 Industrial Pack (IP) Modules, directly VME I/O

# Status in SSRF LINAC

## -- Record Types

- Total: ~1,500 Records
  - Ai, Ao, Bi, Bo, Mbbi, Mbbo, Subroutine

Subsystem	Equip.	PVs					
		AI	AO	BI	BO	MBBI	MBBO
Gun	1	8	1	4	1	1	1
RF	9	41	16	12	5	1	1
Modulator	1	9	0	10	4	0	0
P.S.	46	45	45	90	45	0	0
Vacuum	20	52	16	92	82	8	8
Other	2	-	-	16	8	-	-
Total	79	157	86	216	1145	10	10

\*\*2 years old, see reference 1

# Status in SSRF LINAC

## -- Man Power

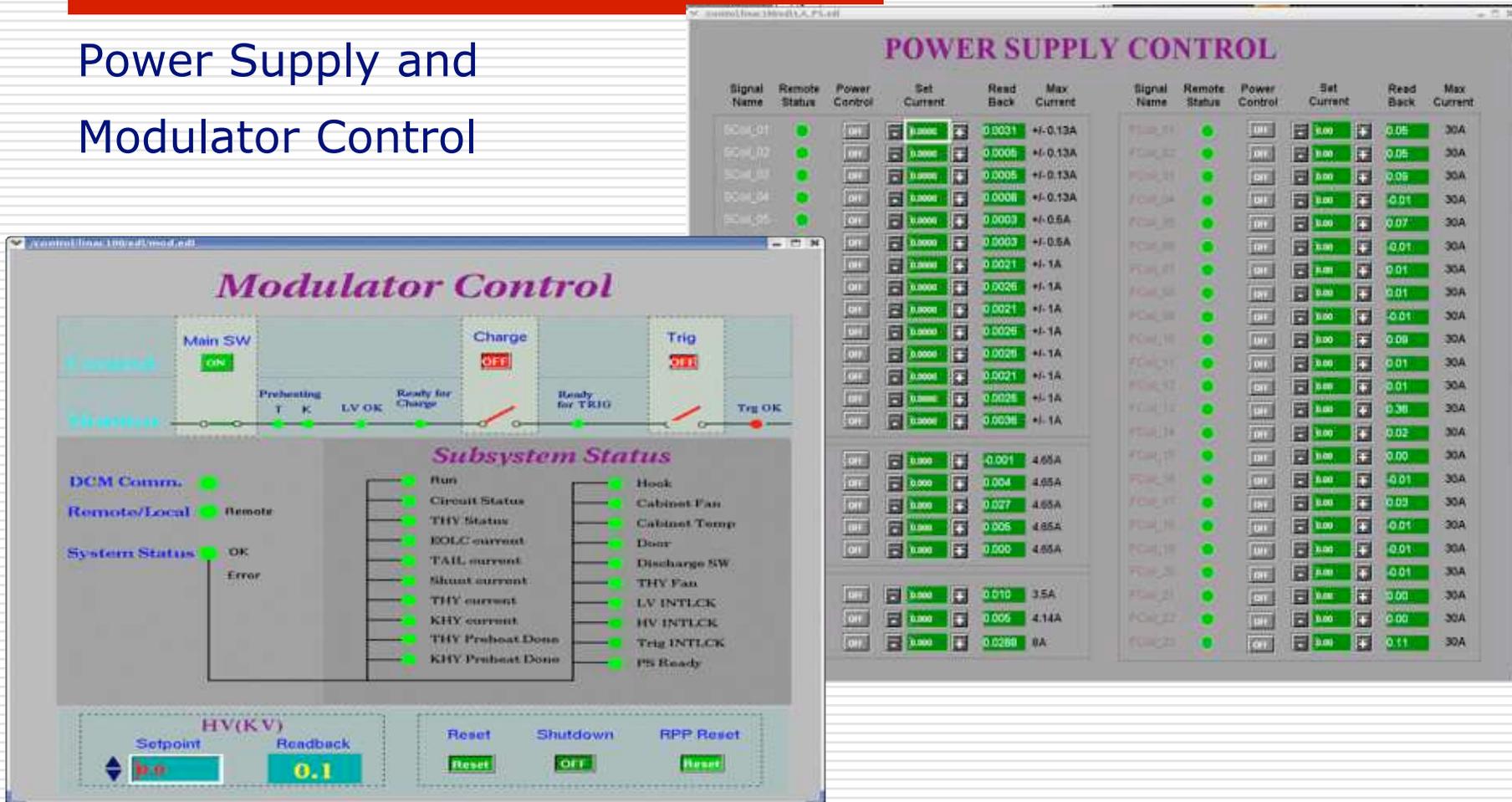
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- Total 7 persons
  - 5 persons related EPICS
- Others:
  - 2 students

# Status in SSRF LINAC

## -- OPI (1)

Power Supply and  
Modulator Control



# Status in SSRF LINAC

## -- OPI(2)

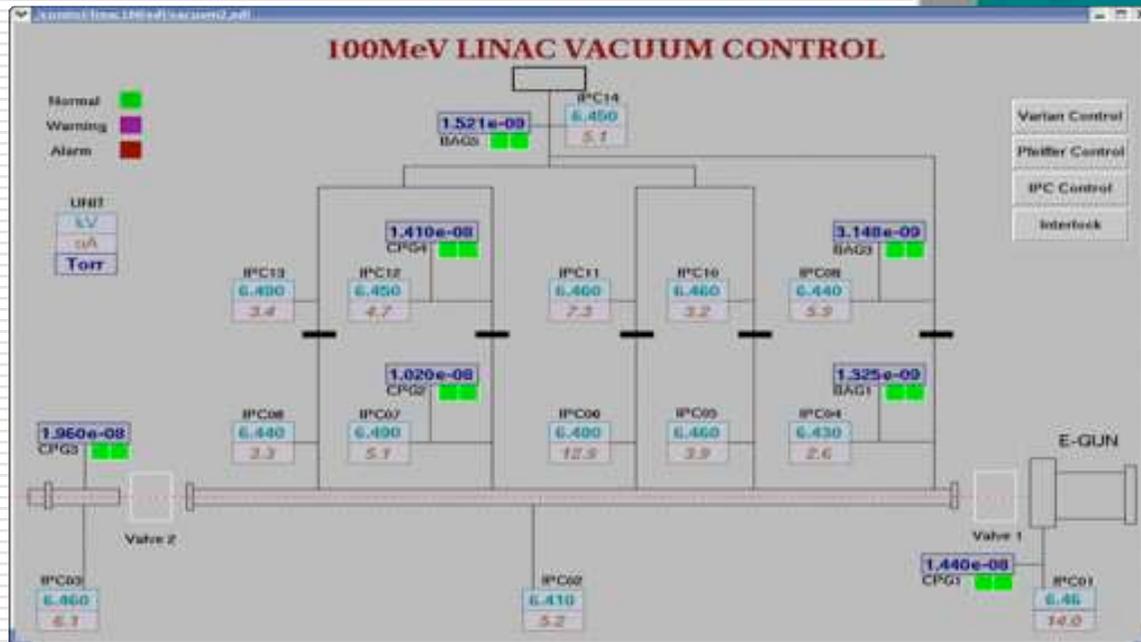
Phase Shifter and  
Amplifier Control

The image displays two overlapping OPI (Operator Interface) control panels. The background panel is titled "Control of the Shifter" and features a grid of controls for "preBenchSlt Control", "BenchSlt Control", and "tubeSlt Control". It includes buttons for "Run", "Stop", "Offline", "dwlLimit", and "upLimit", along with numerical readbacks for "Current Position" (all at 0.0000) and "readBack" (0). The foreground panel is titled "Micro Wave Amplifier" and shows a semi-circular "Attenuator" scale from 0 to 10, with a needle pointing to 6.601. It includes "Decrease" and "Increase" buttons, and status indicators for "Local/Remote" (Remote), "Normal/Fault" (Normal), "State" (ON), and "Power" (ON).

# Status in SSRF LINAC

## -- OPI(3)

Gun Monitor and  
Vacuum Control



# Status in SSRF LINAC -- OPI(4)

**PFEIFFER TPG262 CONTROL**

Pressure: CPG1 1.440e-08 Torr

Warning Set: Low 1.000e-07, High 5.000e-07

Alarm Set: Low 1.000e-04, High 1.100e-04

Setpoint Status: Warn Alarm (Green)

CPG2 1.040e-08 Torr

CPG3 1.960e-08 Torr

CPG4 1.420e-08 Torr

Vacuum Device Control

**VARIAN Multi-Gauge CONTROL**

Pressure: BAG1 1.318e-09 Torr

Warning Set: Low 1.000e-07, High 3.000e-07

Alarm Set: Low 1.000e-04, High 1.100e-04

Setpoint Status: Warning Alarm (Green)

BAG3 3.148e-09 Torr

BAG5 1.548e-09 Torr

**ION PUMP POWER SUPPLY CONTROL**

	HV(kV)	IC(uA)	Pressure(Torr)	IVL	Online	Overrange	Roast	8kV	4kV	DEV ON	DEV OFF
IPC01	6.460	15.2	1.14e-09	Green	Red	Red	Red	Green	Red	Green	Red
IPC02	6.410	5.5	4.14e-10	Green	Red	Red	Red	Green	Red	Green	Red
IPC03	6.470	6.2	4.66e-10	Green	Red	Red	Red	Green	Red	Green	Red
IPC04	6.430	2.6	1.95e-10	Green	Red	Red	Red	Green	Red	Green	Red
IPC05	6.460	3.9	2.78e-10	Green	Red	Red	Red	Green	Red	Green	Red
IPC06	6.480	12.5	9.40e-10	Green	Red	Red	Red	Green	Red	Green	Red
IPC07	6.490	4.9	3.68e-10	Green	Red	Red	Red	Green	Red	Green	Red
IPC08	6.440	3.1	2.33e-10	Green	Red	Red	Red	Green	Red	Green	Red
IPC09	6.440	6.1	4.59e-10	Green	Red	Red	Red	Green	Red	Green	Red
IPC10	6.460	3.4	2.56e-10	Green	Red	Red	Red	Green	Red	Green	Red
IPC11	6.460	7.1	5.34e-10	Green	Red	Red	Red	Green	Red	Green	Red
IPC12	6.460	4.7	3.53e-10	Green	Red	Red	Red	Green	Red	Green	Red
IPC13	6.490	3.2	2.41e-10	Green	Red	Red	Red	Green	Red	Green	Red
IPC14	6.450	5.5	4.14e-10	Green	Red	Red	Red	Green	Red	Green	Red

# Status in SSRF LINAC

## -- Central Control Room



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# Status in SSRF LINAC

## -- CRT Monitor

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# Status in SSRF LINAC

-- Rack of IOC, Trigger, Timing and B.M.



# Status in SSRF LINAC

## -- Power Supply Room



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# Status in SSRF LINAC

-- Work Hard

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# Outline

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- Introduction
- EPICS Status in China
  - SSRF LINAC
  - BEPCII ( Materials are provided by Prof. Jijiu Zhao)
  - HLS
  - CSNS
- References and Special Thanks

# Status in BEPCII

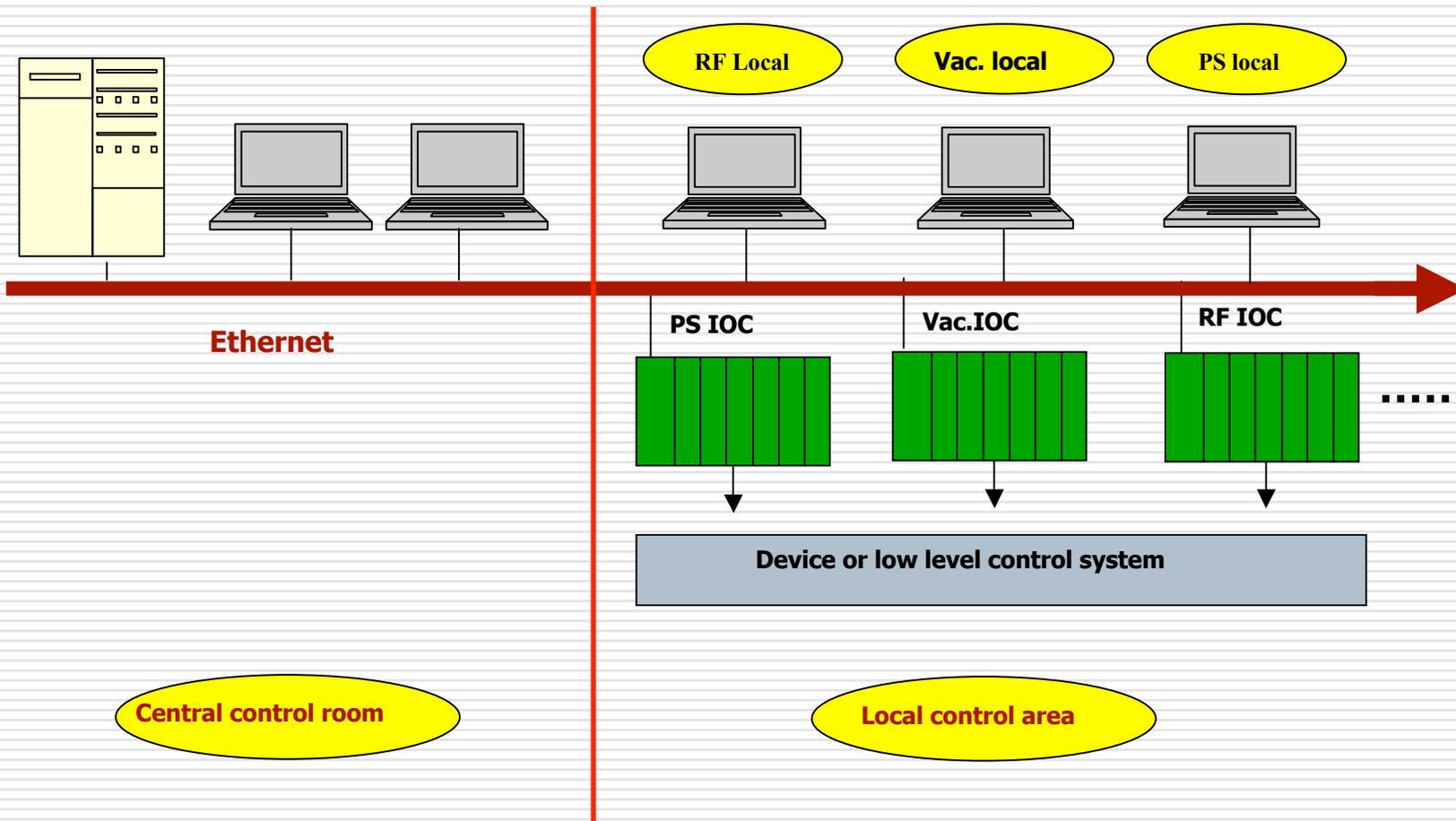
## -- Introduction

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- BEPCII Control System
  - Based on EPICS
  - R&D has been done in DEC. 2003
  - Development started in Spring of 2004
  - Under construction and in good progress
- System data of BEPCII
  - 1729 devices (930 at BEPC)
  - About 20,000 channels (4,500 at BEPC)

# Status in BEPCII

## -- Control System Structure



# Status in BEPCII

## -- Tools

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- EPICS BASE R3.13.8
- OPI OS: Solaris 2.8, Linux/PC
- IOC OS: Tornado2.0/vxWorks5.4
- Third Tools:
  - Labview, Tcl/tk, etc.
- EPICS Tools:
  - ALH
  - VDCT
  - SNL
  - Channel Archiver
  - MEDM/EDM
  - SAD

# Status in BEPCII

## -- System Configuration

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- 7 subsystems
  - Power Supply, RF, Vacuum, Beam Diagnostic, Injection, LINAC, Interlock
- OPI
  - SUN Solaris BLADE 2000, some Linux PCs
- 31 IOCs:
  - 22 MVME5100s for transport lines and storage rings
  - 7 MVME5100s for Timing Systems
  - 2 MVME2431s for LINAC
- Local Controller
  - Fieldbus: CANbus, ControlNet
  - RS-232
  - PLC: AB-PLC, S7-PLC(Siemens)

# Status in BEPCII

## -- Driver Development

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- PS control
  - PSC/PSI ( From SNS) interface for Chopper PS
  - VME - IP Carry board/IP modules for Corrector PS
  - VME-CAMAC for TL PS control
- Vacuum control
  - VME - ControlNet for Vacuum and Cryogenic control
  - VME - RS232
- Linac control
  - VME - CANbus
- RF Control
  - Developed by Thomcast company

# Status in BEPCII

-- Number of devices and channels

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Device	Num.	AI	AO	DI	DO	WF	othe	Sum
Power supply	399	399	399	1596	798		r	3192
Vacuum	517	957	398	814	994		488	3651
Injection kicker	8	8	16	40	4	4		72
Radio frequency	7	72	35	180	50	4		341
Beam diagnostic	459	864		80	80	6		1030
Injector Linac	325	559	198	228	198	36		1219
Summary	1715	2859	1046	2938	2124	50	488	9505

**\*\* 2 years old, See Reference 3**

# Status in BEPCII

## -- Present Status

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- Power Supply
  - prototype has been done in Dec. 2003
  - Supported Functions: On/off, settings/readings, status monitor
- Event timing system
  - New design finished in May 2004
  - Software design began in September
  - now software analysis is under way
- Vacuum
  - prototype has been done
  - collecting pressure and data of I.P. to IOC with RS-232
- Cryogenic control
  - Communication software between IOC and PLC has been done

# Status in BEPCII

## -- Present Status (Cont.)

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- RF
  - Klystron system is testing
- Injection control for Kicker Power Supply
  - Driver and application are developing
- Linac
  - Use SNL to carry out the ramping
  - Use EDM and TCL/TK to build OPI
  - Have been put into use in Nov. 2003
- High level application -- SAD
  - all of source and most of data file from KEKB  
In Jan. 2003
  - Built on SUN workstations
  - Main panel transfer from KEKB
  - Good collaboration between KEKB and IHEP

# Status in BEPCII

## -- Man Power

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- Total 16 persons
  - 12 persons related to EPICS
- Others:
  - 7 doctoral candidates

# Status in BEPCII

## -- OPI (1)

### Prototype of Power Supply Control



# Status in BEPCII

## -- OPI (2)

### LINAC Power Supply Control

**Quadruple Magnet PS Control**

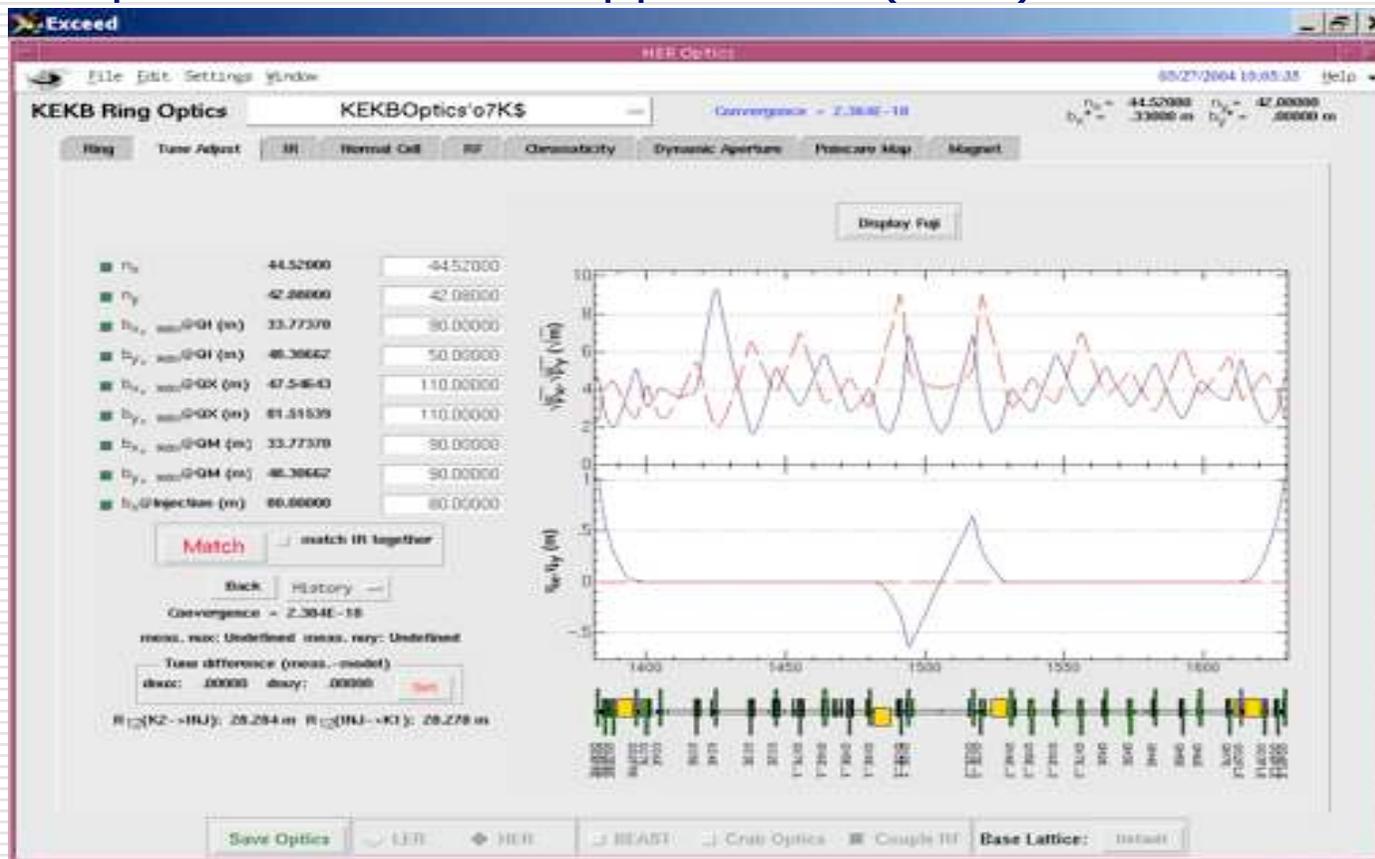
NAME	SAMPLE	SETTING	REF.	ON/OFF	ALARM	SET	NAME	SAMPLE	SETTING	REF.	ON/OFF	ALARM	SET
Q01	12.01	11.84	11.84	●		SET	Q16	11.88	11.74	11.74	●		SET
Q02	11.51	11.45	11.45	●		SET	Q17	9.33	9.34	9.34	●		SET
Q03	12.58	12.53	12.53	●		SET	Q18	9.02	8.96	8.96	●		SET
Q04	13.03	12.72	12.72	●		SET	Q19	9.31	9.30	9.30	●		SET
Q05	6.38	6.12	6.12	●		SET	Q20	8.68	8.90	8.90	●		SET
Q06	9.46	9.28	9.28	●		SET	Q21	7.32	6.86	6.86	●		SET
Q07	7.63	7.24	7.24	●		SET	Q22	7.67	7.44	7.44	●		SET
Q08	10.88	10.60	10.60	●		SET	Q23	10.59	10.22	10.22	●		SET
Q09	7.26	7.15	7.15	●		SET	Q24	10.21	10.12	10.12	●		SET
Q10	11.60	11.35	11.35	●		SET	Q25	11.73	11.58	11.58	●		SET
Q11	10.53	10.32	10.32	●		SET	Q26	10.91	10.73	10.73	●		SET
Q12	17.59	17.55	17.55	●		SET	Q27	20.02	19.77	19.77	●		SET
Q13	6.59	6.38	6.38	●		SET	Q28	12.48	12.73	12.73	●		SET
Q14	7.05	6.83	6.83	●		SET	Q29	13.66	13.41	13.41	●		SET
Q15	6.32	6.17	6.17	●		SET	Q30	13.84	13.79	13.79	●		SET

Control Panel: PS Control, Mode operation (Q Magnet, D Magnet, F Magnet, P Magnet, QG-B E Magnet), CAN BUS Status, Save Parameter, EXIT

# Status in BEPCII

## -- OPI (3)

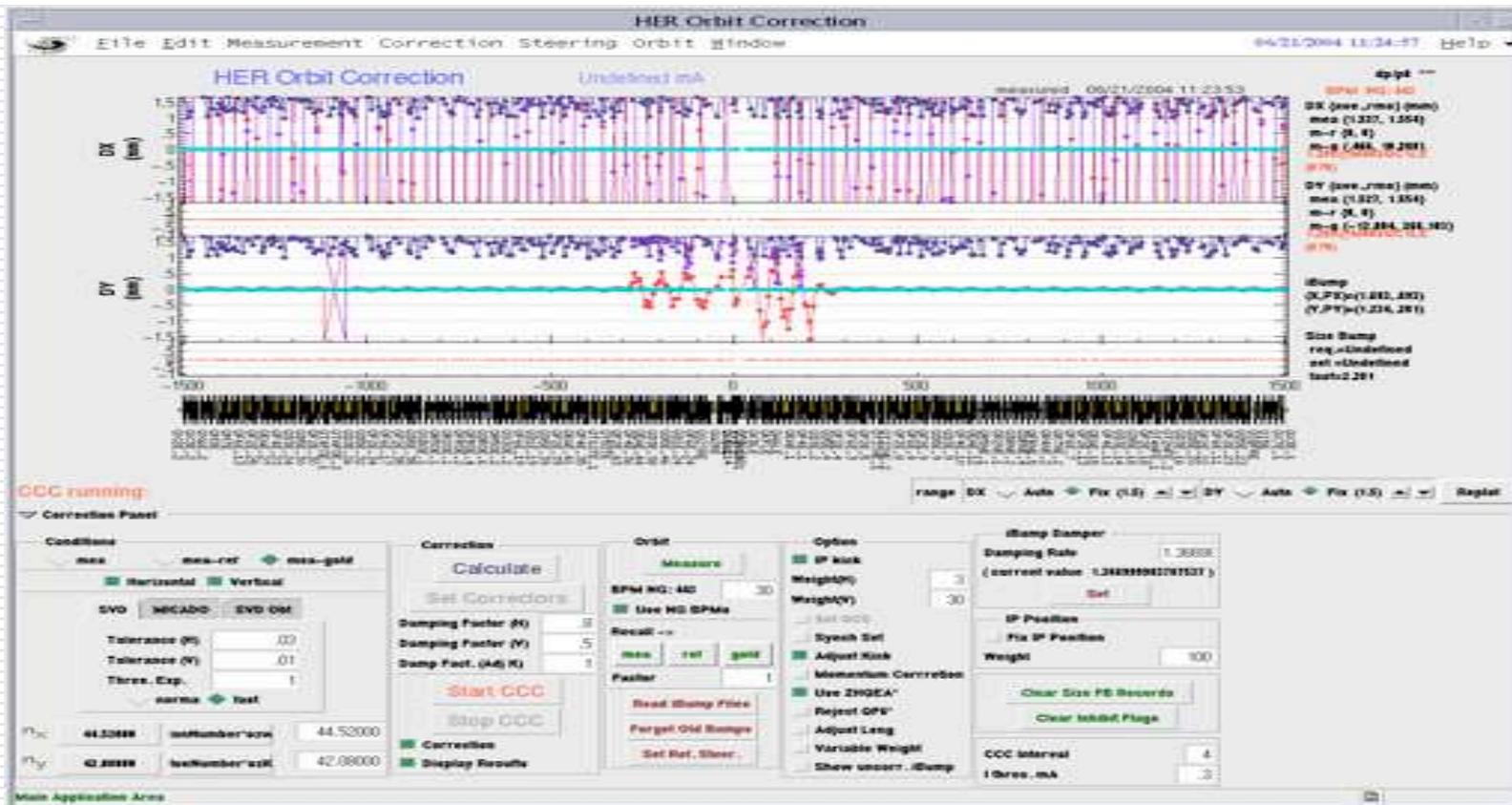
### Beam Optics Calculation Application (SAD)



# Status in BEPCII

## -- OPI (4)

### COD Correction Application (SAD)



# Status in BEPCII

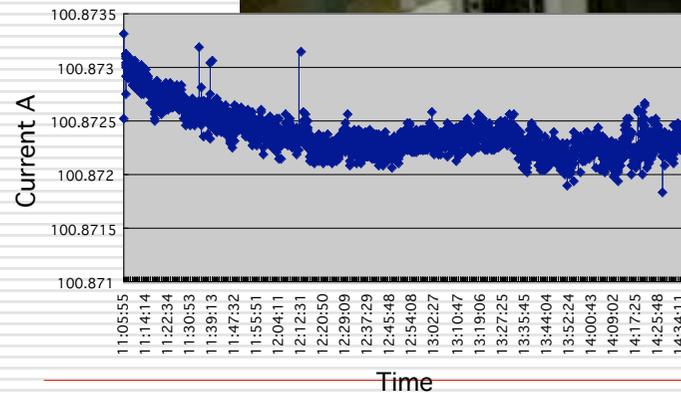
## -- MCC and New Console

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# Status in BEPCII

## -- Chopper on-line testing



Accuracy and Stability:  $5 \times 10^{-5}$

# Status in BEPCII

-- Prototype of PS control

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# Outline

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- Introduction
- EPICS Status in China
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  - BEPCII
  - HLS ( Materials are provided by Associate Prof. Gongfa Liu)
  - CSNS
- References and Special Thanks

# Status in HLS

## -- Instruction

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### HLS

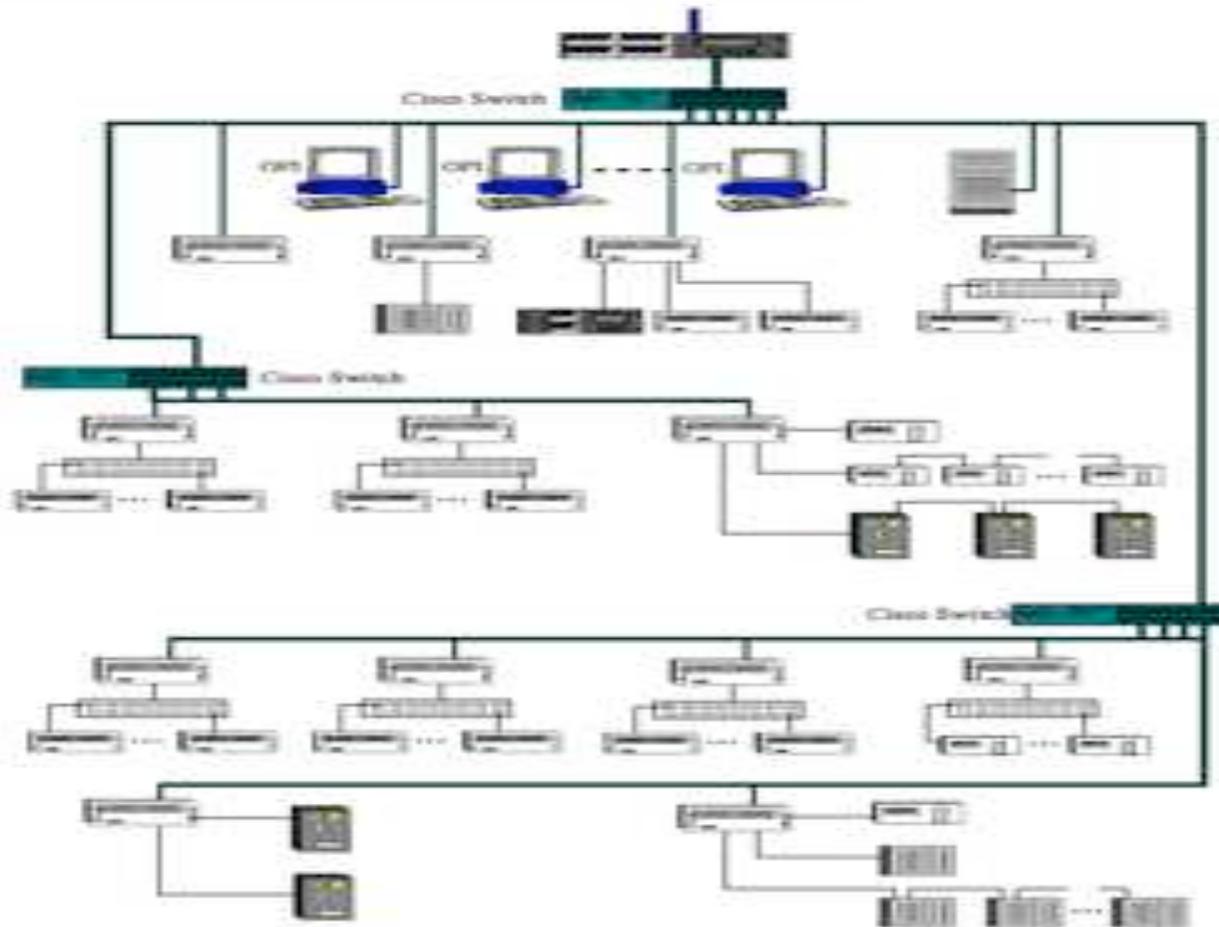
- 2nd generation dedicated synchrotron light source
- 200MeV electron LINAC and 800 MeV electron storage ring

### New Control System

- Phase II started from April 1999 formally
- Prototype system set up at May 1999
- First subsystem commissioning at June 2000
- Last subsystem commissioning at Oct. 2003

# Status in HLS

## -- New Control System Structure



# Status in HLS

## -- Tools

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- EPICS BASE R3.13.8, upgraded from R3.13.0.beta12 at June 2003
- OPI: Solaris7/8; Red Hat7/9; Windows98/2000
- IOC: Tornado1.0.1/vxWorks 5.3.1
  - Development Platform: SUN/Solaris
- Third tools: Tcl/tk, PHP, PLC Ladder Software Package, LabView/ActiveX
- EPICS tools:
  - DCT
  - MEDM
  - SDDS (Closed Orbit Correction)
  - SNL

# Status in HLS

## -- System Configuration

---

- 6 Subsystems
  - Power supply, RF, Vacuum, BPM, Interlock, Water
- 21 OPIs
  - 1 Sun Ultra 1, 3 Sun Ultra 10, 1 Sun E250, 2 PC (Linux), 14 PC (Windows)
- 17 IOCs
  - IPC (with Flash Disk)
- 107 Local Controllers
  - 56 IPC (with Flash Disk), 12 PLC, Others, 39

# Status in HLS

## -- Detail Lists of Subsystems

subsystem	IO	Local controller			OPI									
	C IPC	IPC	PL C	Other S	SUN Ultra	SUN Ultra	SUN	PC/Linux	PC/Windo					
Ring main mag. PS	3	12		2	1	30	E250	2	14					
Ring corr. Mag.PS	1	8												
Ring vacuum	1			6										
Ring Flag				1										
Injection system			3											
RF	2	1	2	1										
Water system	1													
RFKO	1			2										
Ring octupole mag. PS	1													
Transport line mag. PS	2	20												
Switch mag. PS	1			1										
Kly. focusing coil PS	1	6												
Analysis Mag. PS		1												
Linac vacuum	1			15										
Linac mag. PS	1	8												
Linac Flag	1			1										
interlock			1											
Linac Modu. pulse PS			6											
<b>sum</b>	17	56	12	39						1	3	1	2	14
	17	107								21				

# Status in HLS

## -- Record Statistics

Subsystems	Record Number
Ring main mag. PS	~400
Ring corrector mag. PS	~250
Transport line mag. PS	~800
Linac mag. PS	~300
RF	~150
Vacuum	~200
Injection system pulse PS	~50
Flag	~50
Others	~300
sum	~2500

# Status in HLS

## -- Record Type

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- Record type
  - Ai, Ao
  - Bi, Bo
  - Mbbi, Mbbo
  - MbbiDirect, MbboDirect
  - Subroutine,
  - subOut
  - maio
- Self development
  - subOut and maio

# Status in HLS

## -- Upgrade process

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- May 1999
  - set up a prototype system
- June 2000
  - First subsystem commissioning (Storage ring main magnet power supply control system)
- Oct. 2003
  - Last subsystem commissioning (Storage ring Octupole magnet power supply control system)
- June 2003
  - upgrade EPICS base R3.13.0.beta12 \_> R3.13.8

# Status in HLS

## -- Man Power

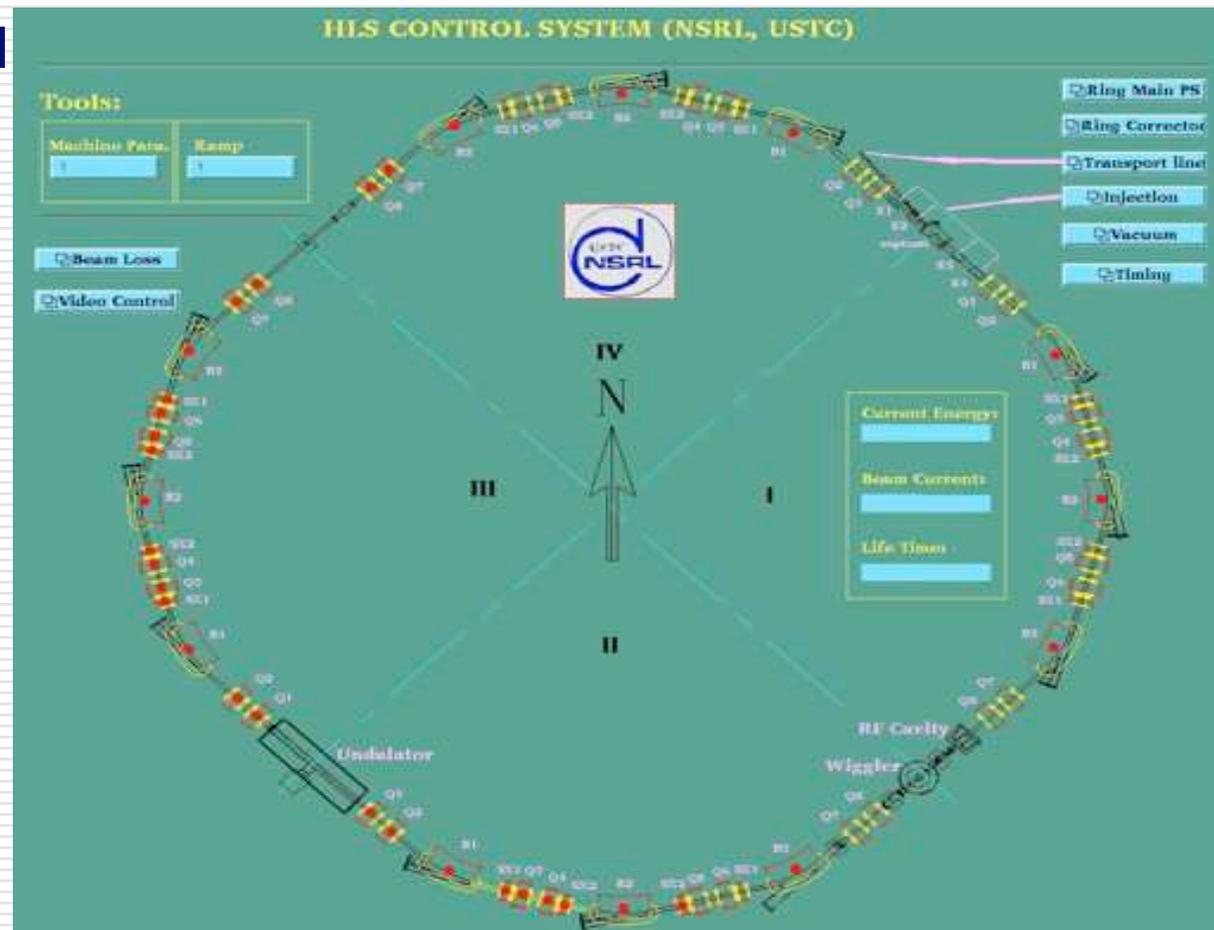
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- Total 5 persons
- 3 persons related to EPICS

# Status in HLS

## -- OPI (1)

Main Control Panel



# Status in HLS

## -- OPI (2)

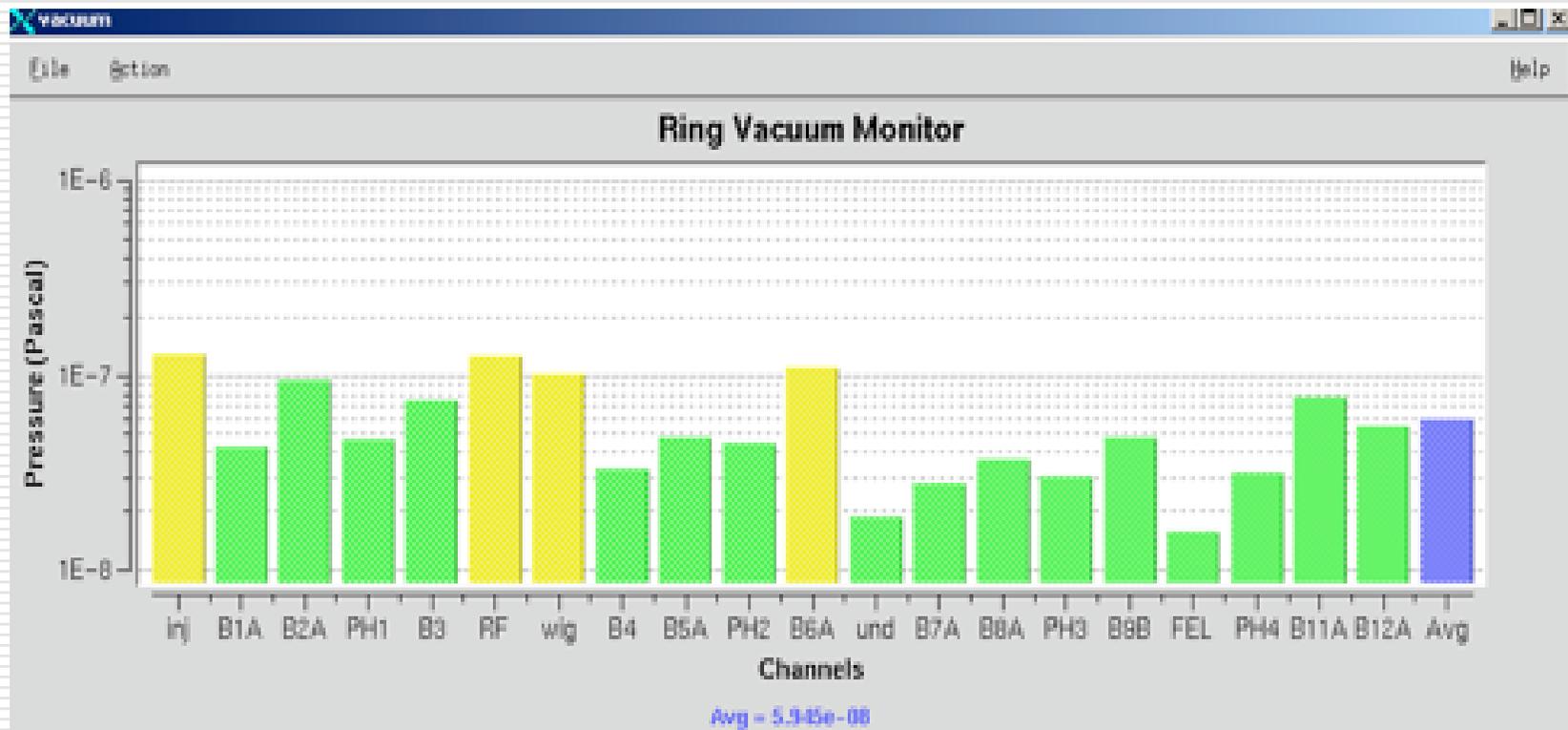
### Power Supply Control



# Status in HLS

## -- OPI (3)

### Ring Vacuum Monitor



# Status in HLS

## -- OPI (4)

Ramping Control

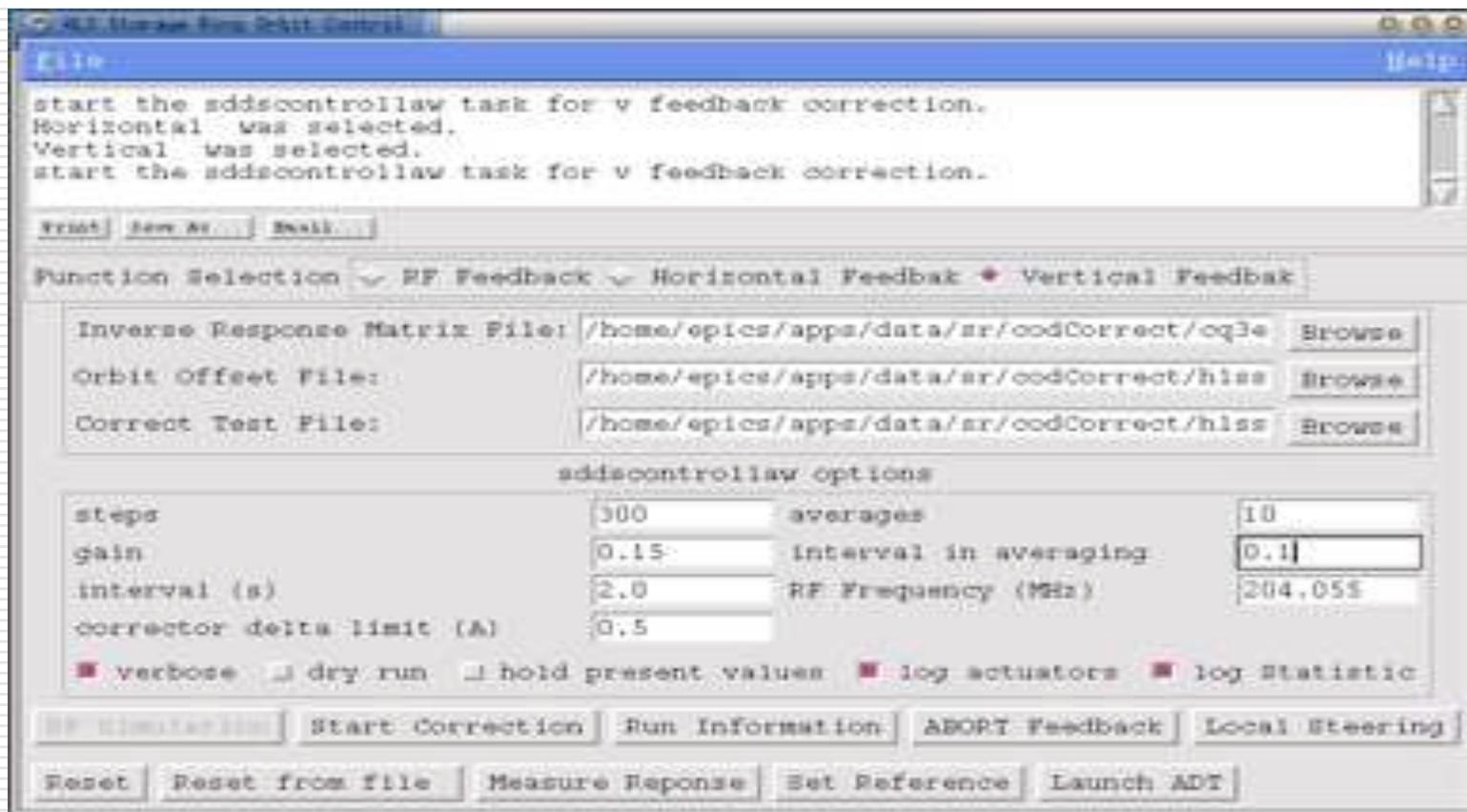
The screenshot shows the 'Ramping Control' software window. At the top, there is a menu bar with 'File', 'Edit', 'View', 'Tools', 'Options', 'Others', and 'Help'. Below the menu is a 'Lattice Layout' section with a green bar. The main part of the window is a table with columns for Energy (MeV) and five numerical columns. The rows are labeled BEND, Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8, SX1, SX2, and SX3. The 'Energy (MeV)' column is highlighted in red. Below the table is a 'Ramping Control' section with two input fields: 'Step Length(A):' with a value of 0.1 and 'Destination(A):' with a value of 851.55. To the right of these fields are two buttons: a green 'Start' button and a red 'Stop' button.

Energy(MeV)					
BEND	0.0	203.5034	405.7242	611.2989	851.5462
Q1	0.0024	30.3772	60.9362	91.277	122.733
Q2	0.0	19.4177	38.9309	58.7176	78.7318
Q3	0.0	44.7363	89.6327	134.7819	189.27
Q4	0.0032	60.3145	121.4791	182.6867	242.0721
Q5	0.0	60.6589	121.4747	183.0526	242.1078
Q6	0.0028	44.7586	89.6496	134.7975	189.2572
Q7	0.0	18.5054	36.2106	58.1888	78.7523
Q8	0.0	30.4631	60.9015	91.361	122.7814
SX1	1.3471	14.5001	30.4941	49.2057	78.9901
SX2	3.325	8.6312	17.2009	25.8495	34.9708
SX3	0.0	0.0	2.3684	2.3684	2.3684

# Status in HLS

## -- OPI (5)

### Ring Orbit Control (SDDS)



# Status in HLS

## -- Central Control Room

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# Status in HLS

## -- LINAC Control Room

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# Outline

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- Introduction
- EPICS Status in China
  - SSRF LINAC
  - BEPCII
  - HLS
  - CSNS (Materials are provided by Associate Prof. Chunhong Wang)
- References and Special Thanks

# Status in CSNS

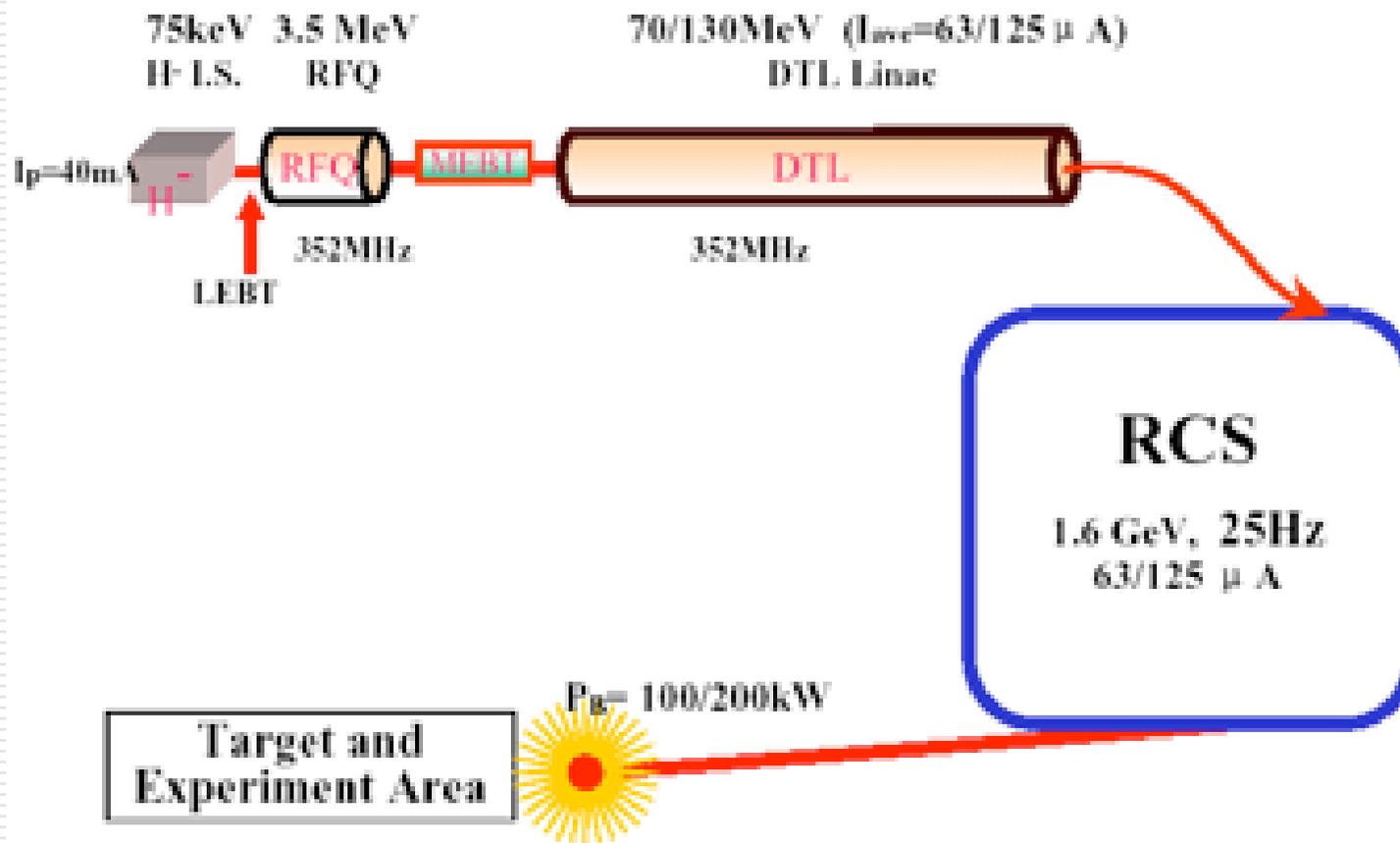
## -- Introduce

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- CSNS
  - China Spallation Neutron Source
  - 100KW, pulsed neutron source
  - 25 Hz repetition frequency
  - A LINAC with lower energy
  - A rapid cycle synchrotron ring with higher energy
- Jointly host by Institute of Physics, Institute of High Energy Physics and CAS
- IHEP response for building the facility
- In the process of R&D

# Status in CSNS

## -- CSNS Architecture



# Status in CSNS

## -- Control System

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- Include power supply control, vacuum control, RF control and machine safety protection
- EPICS based
  - Many people of CSNS have already accepted
- The preliminary design doesn't yet start.
- Power supply control prototype has started

# Outline

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- Introduction
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  - SSRF LINAC
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  - HLS
  - CSNS
- References and Special Thanks

# References

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## 1. Design Reports of SSRF 100 MEV LINAC

- Songqiang Liu, "CN-T33-100MeV LINAC Control System"
- Jitang Li, Lifang Zheng, Songqiang Liu, "CN-T38-LINAC P.S. Subsystem Control"
- Lifang Zheng, "CN-T51-LINAC Modulator Subsystem Control"
- Shouming Hu, "CN-T53 LINAC RF Subsystem Control"
- Shouming Hu, "CN-T55-LINAC Timing Subsystem Control"
- Jianguo Ding, "CN-T57-LINAC Phase Shifter Subsystem Control"
- Jianguo Ding, "CN-T58-LINAC GUN Subsystem Control"
- Haifeng Miao, Lifang Zheng, Jianguo Ding, "CN-T63-LINAC Vacuum Subsystem Control"

## 2. Jianguo Ding, Lifang Zheng, Shouming Hu, Haifeng Miao, Jitang Li, Songqiang Liu, "An EPICS-based LINAC Control System"

# References (Cont.)

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3. J. Zhao, "Progress of the Controls for BEPCII", EPICS Seminar In IHEP, 20 August, 2002
4. Gongfa Liu, "HLS new control system", EPICS Seminar in Hefei, 4 Mar. 2004
5. Materials of BEPCII are provided by Prof. Jijiu Zhao
6. Materials of CSNS are provided by Associate Prof. Chunhong Wang
7. All photos of SSRF 100MeV LINAC are provided by Associate Prof. Jianguo Ding
8. All photos of HLS are provided by Associate Prof. Gongfa Liu

# Special Thanks

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- SSRF
  - Prof. Songqiang Liu
  - Associate Prof. Jianguo Ding
  - Associate Prof. Lifang Zheng
  - Associate Prof. Shouming Hu
  - Associate Researcher Haifeng Miao
- BEPCII
  - Prof. ZHAO Jijiu
  - Associate Prof. Chunhong Wang
- HLS
  - Prof. Weimin Li
  - Associate Prof. Gongfa Liu

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*Thank You!*