BEPC/BSRF & HEPS

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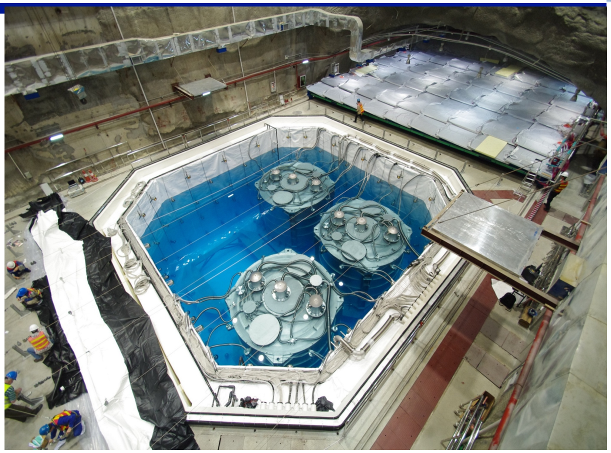
13/01/2016

Outlines

- Introduction to BEPC/BSRF
- Future plan --- HEPS
- R&D project of HEPS
- Summary

1. Introduction

BEPC



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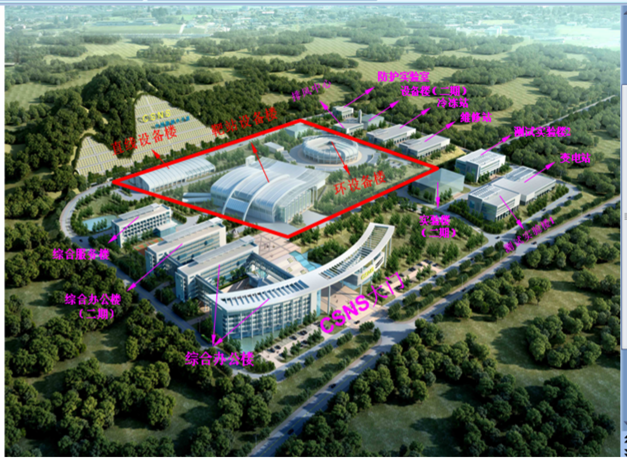

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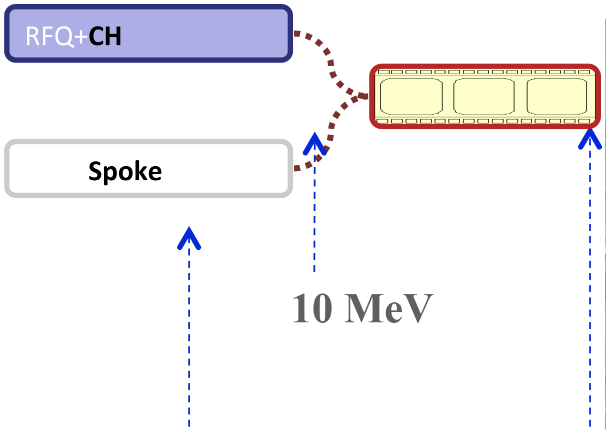
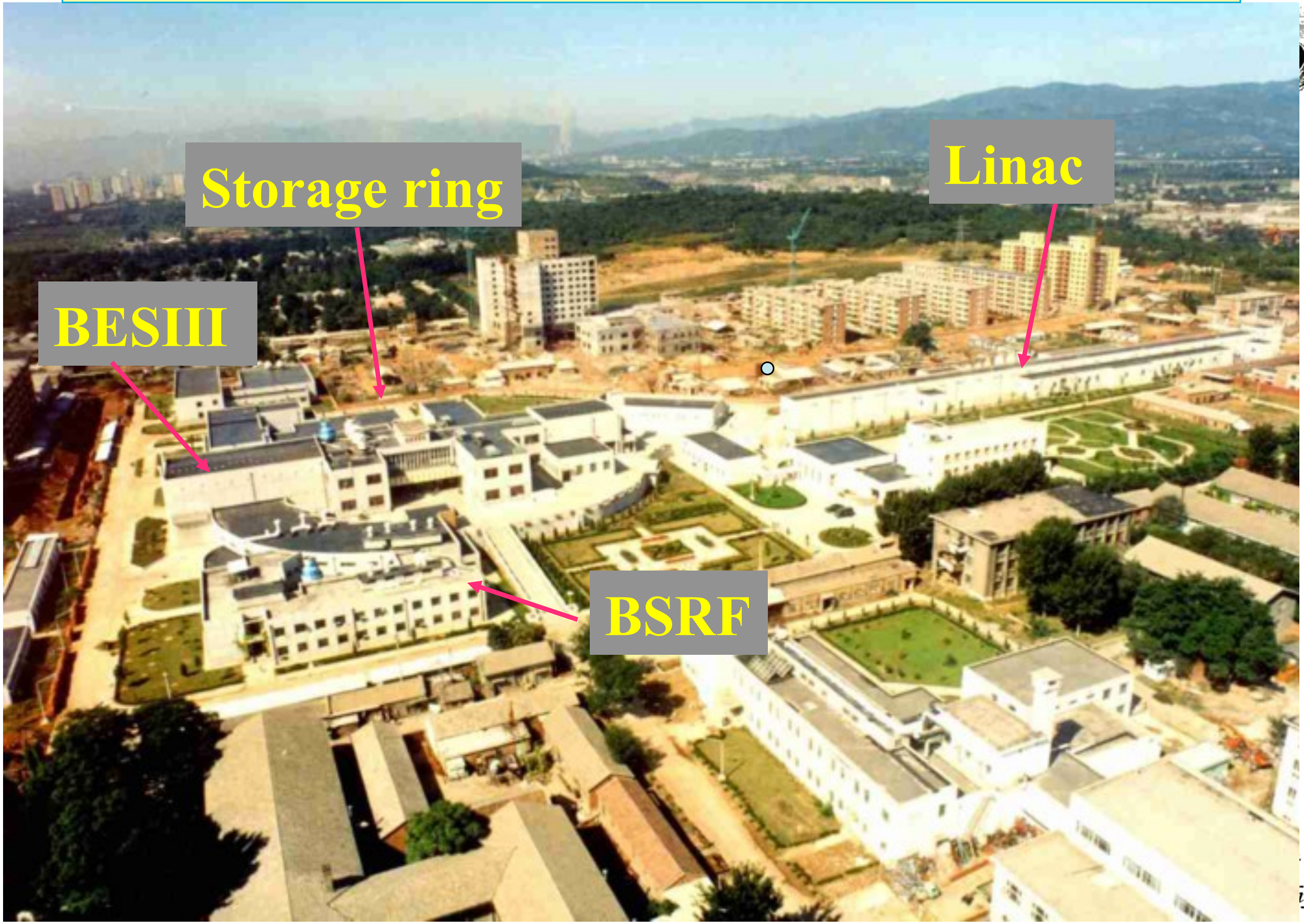


ADS

Yangbajing

HEPS

Beijing Electron Positron Collider (BEPC)



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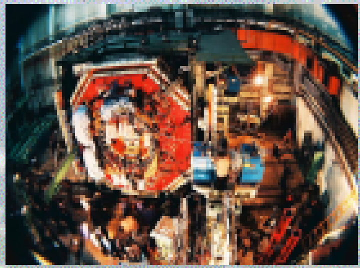
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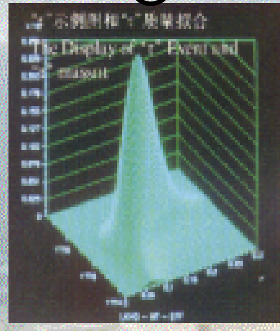

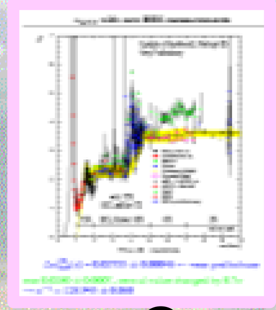
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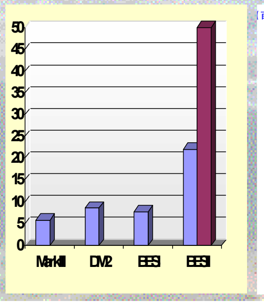

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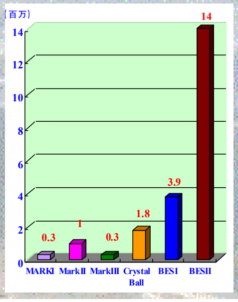

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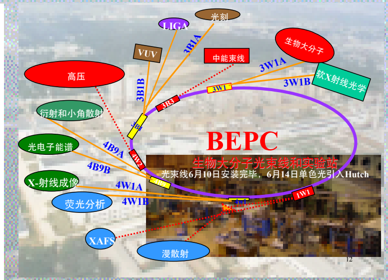

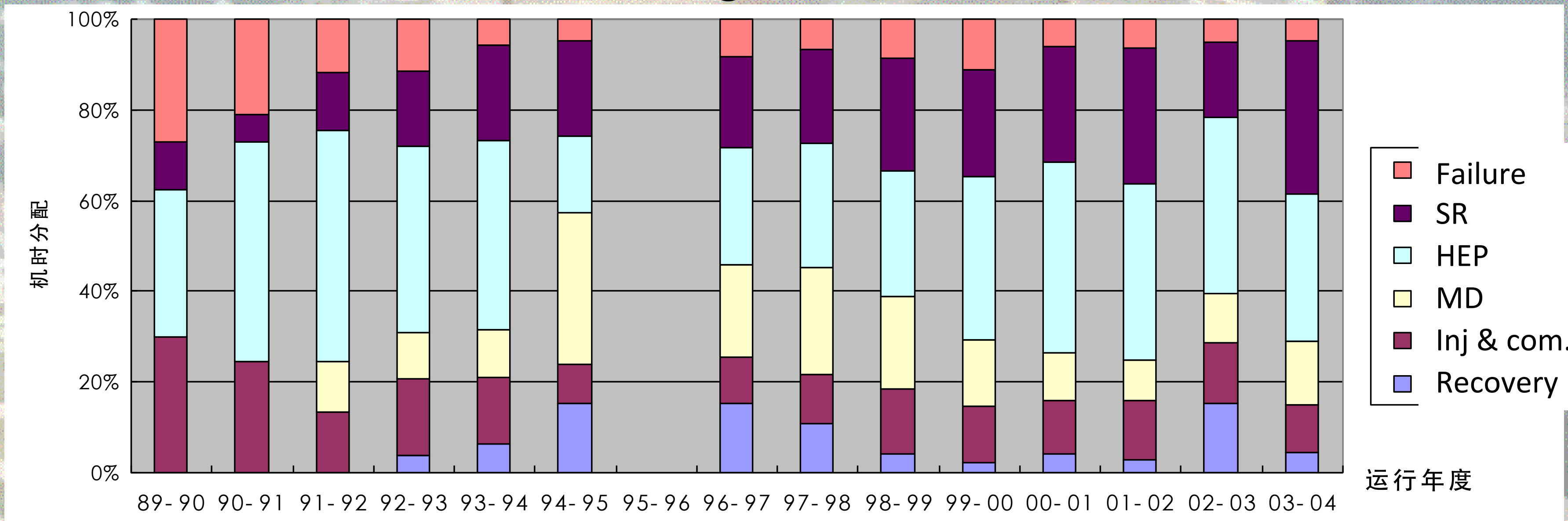

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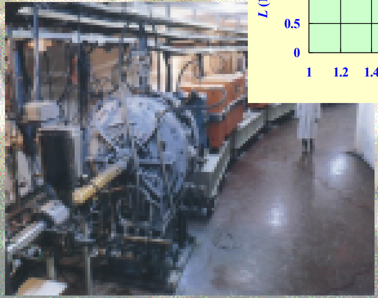
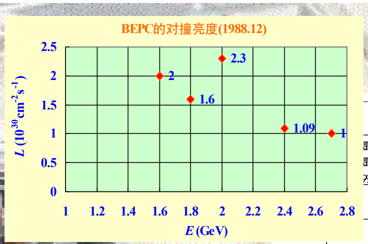

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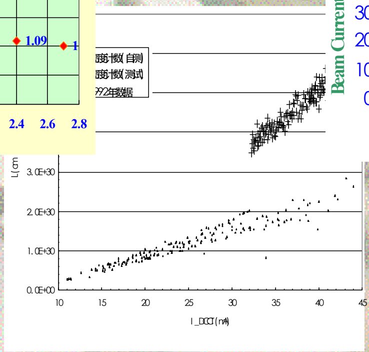

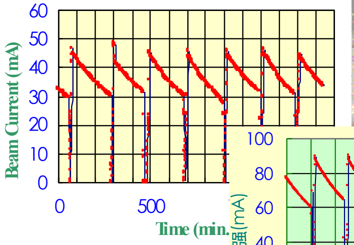

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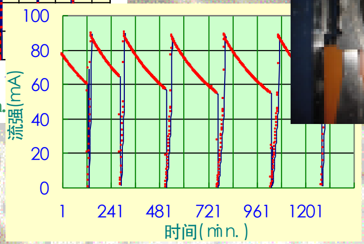

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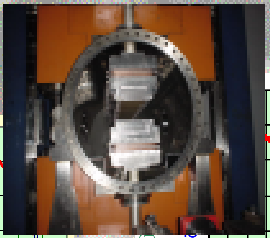
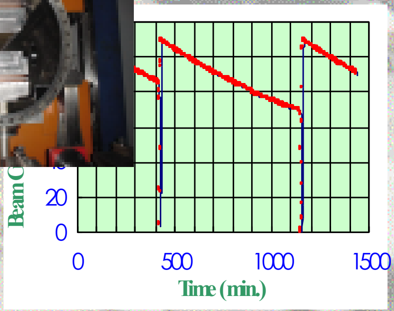



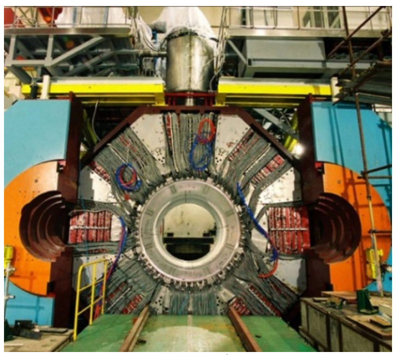
⑭

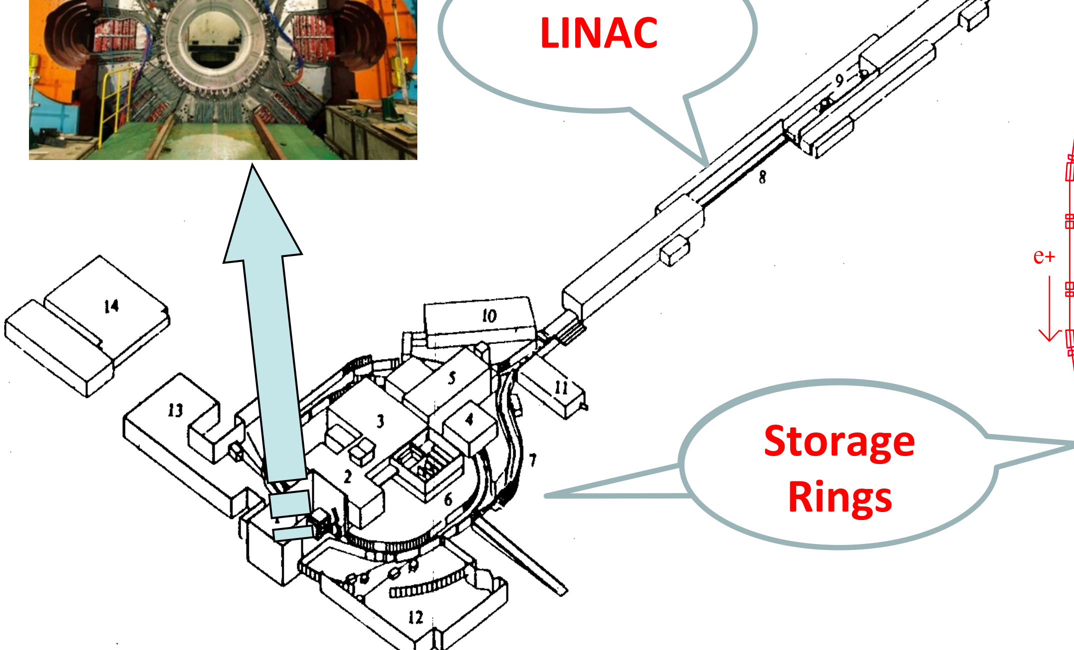
BEPCII/BSRF

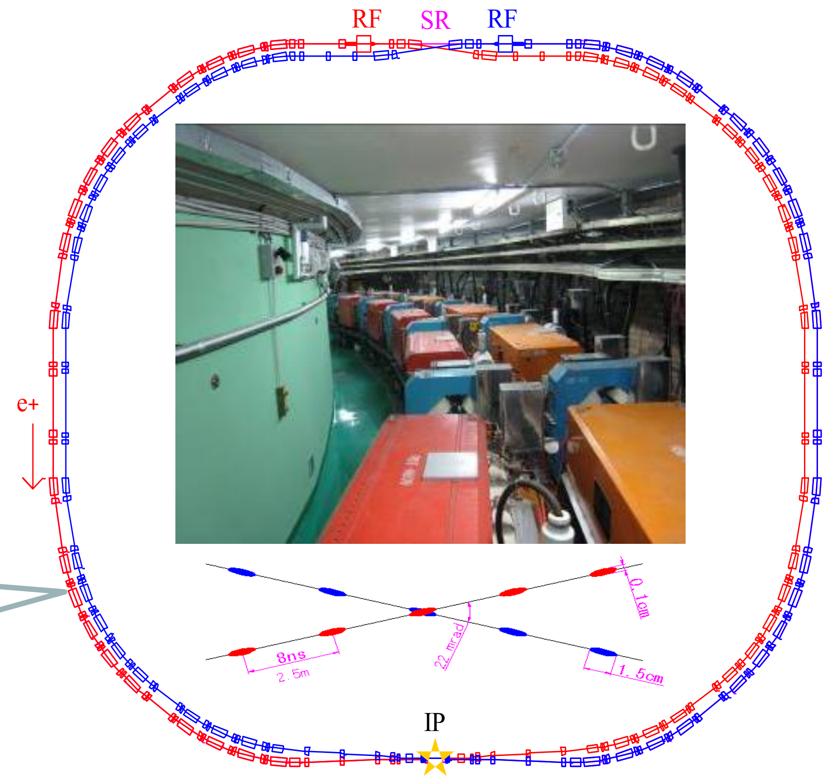
BEPCII — An upgrade project of BEPC

— A double-ring factory-like machine

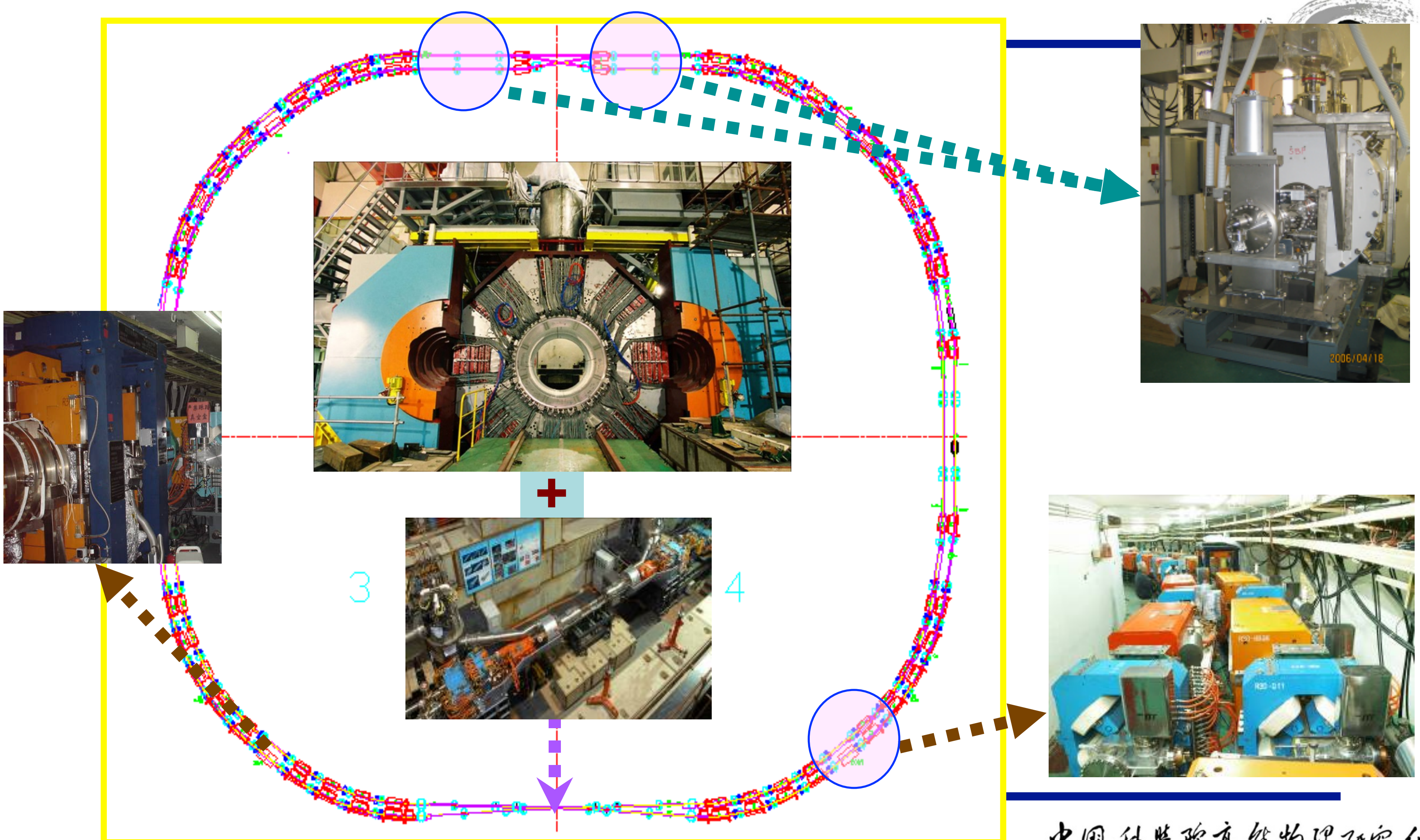
— Deliver beams to both HEP & SR







3-ring structure



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Design Goals of BEPCII

❑ Collision

- Beam energy range — 1-2.1 GeV
- Optimized beam energy — 1.89 GeV
- Luminosity — 1×10^{33} $cm^{-2}s^{-1}$ @1.89 GeV
- Full energy injection — 1-1.89 GeV

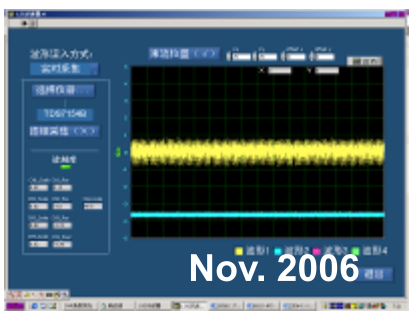
❑ Synchrotron radiation

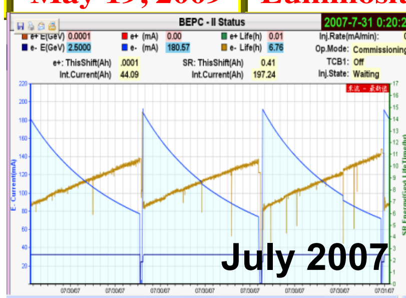
- Beam energy — 2.5 GeV
- Beam current — 250 mA
- Keep the existing beam lines unchanged

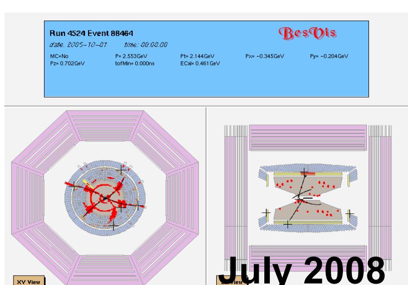
BEPCII: One-machine, Two-purpose (HEP, SR)

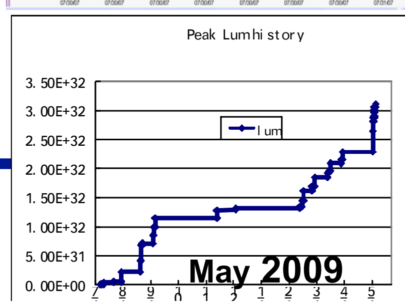
The Milestones

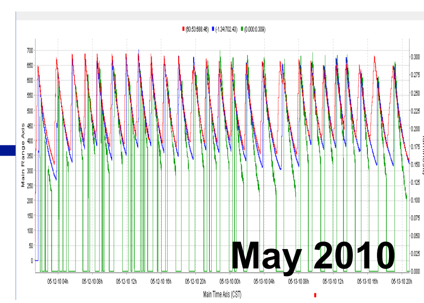
January 2004	Construction started
May. 4, 2004	Dismount of 8 linac sections started
Dec. 1, 2004	Linac delivered e^- beams for BEPC
July 4, 2005	BEPC ring dismount started
Mar. 2, 2006	BEPCII ring installation started
Nov. 13, 2006	Phase 1 commissioning started
Aug. 3, 2007	Shutdown for installation of IR-SCQ's
Oct. 24, 2007	Phase 2 commissioning started
Mar.28, 2008	Shutdown for installation of detector
June 24, 2008	Phase 3 commissioning started
July 19, 2008	First hadron event observed
May 19, 2009	Luminosity reached $3.3\times10^{32}cm^{-2}s^{-1}$

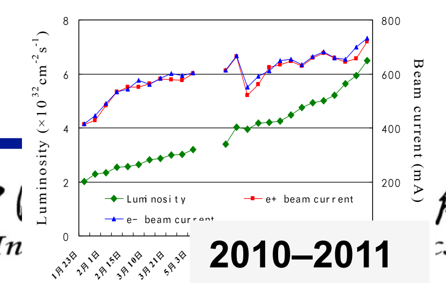










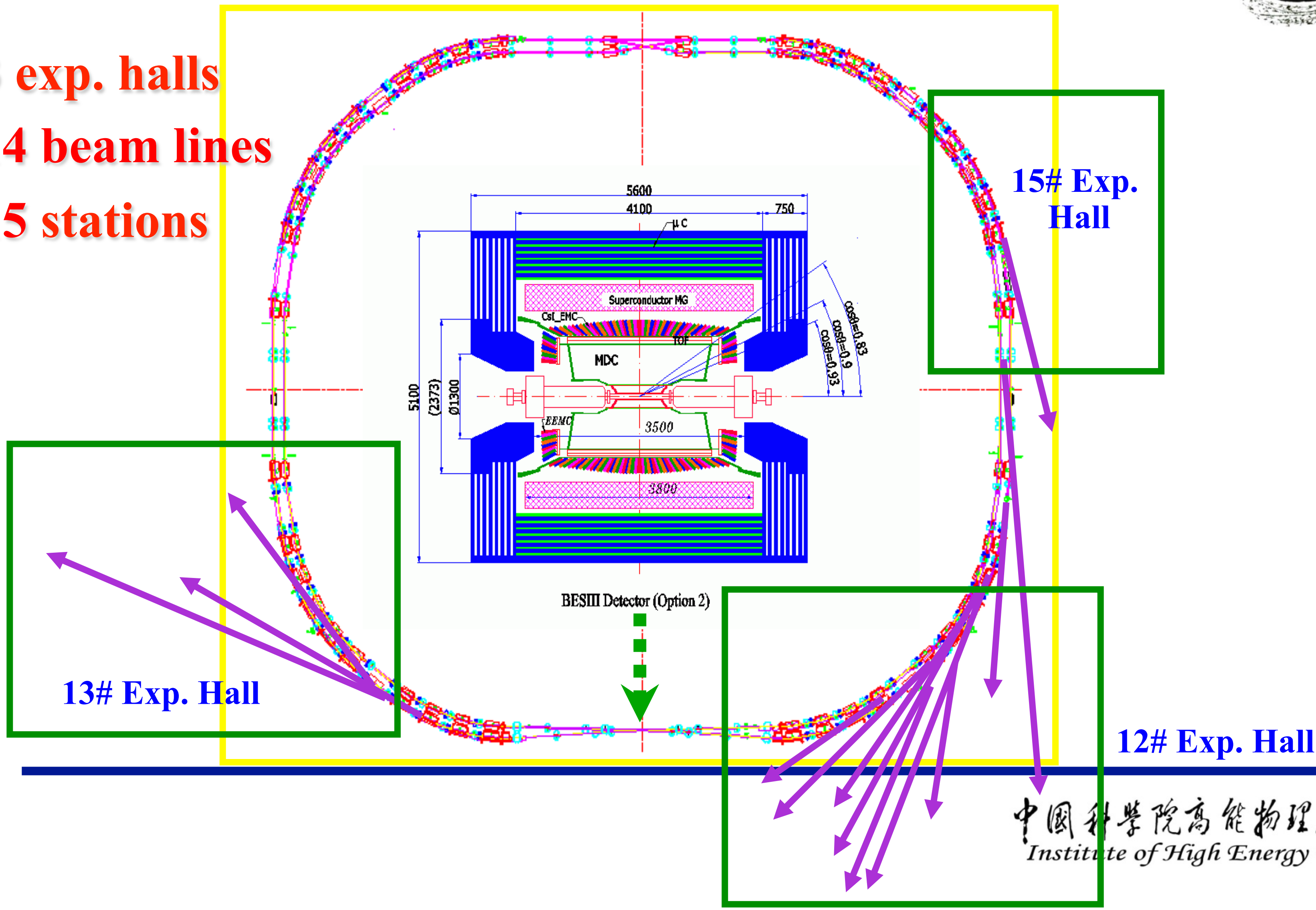


BSRF upgrade — 15# Experiment Hall

3 exp. halls

14 beam lines

15 stations



Design Parameters of Storage Rings (Dedicated SR Mode)

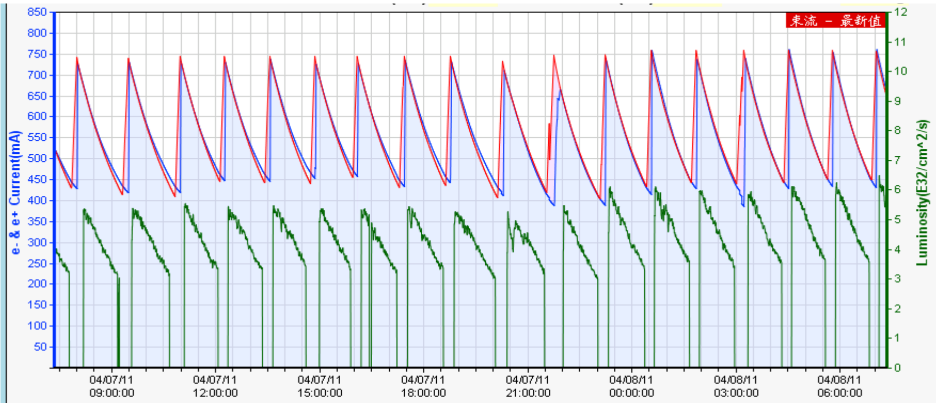
Energy	GeV	2.5
Circumference	m	241.13
Beam current	A	0.25
Bunch number		100 – 200
Bunch current	mA	1.2 – 2.5
Bunch spacing	m	1.2
Bunch length	cm	1.3
RF frequency	MHz	499.80
Harmonic number		402
Emittance (x/y)	nm·rad	100/1
No. of wiggler		5
Beam lifetime	hrs	10@2.5GeV, w/ 5 wig.

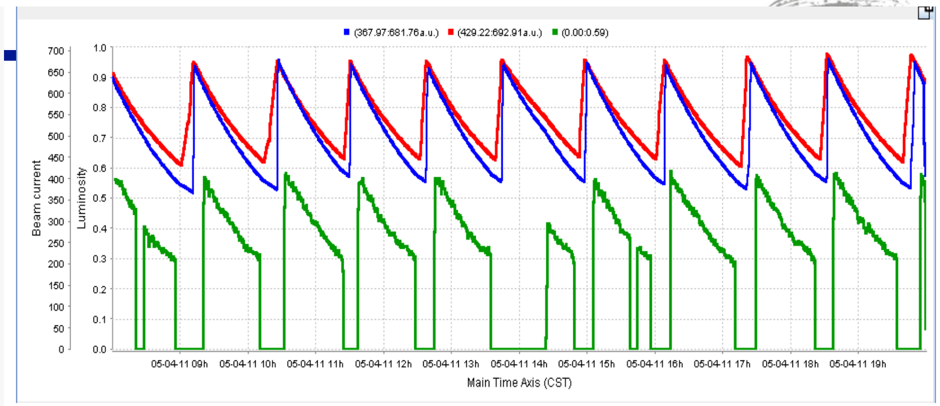
Routine operation of BEPCII

- 6 months running with collision mode for HEP experiments
- 3 months running with dedicated SR mode for users
- 1 month for recovery and machine development
- 2 months for maintenance during summer shutdown.

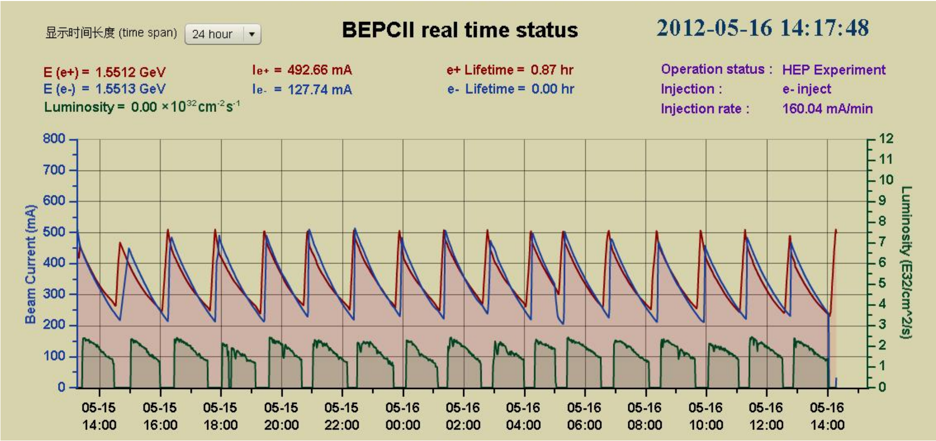
- Some of SR users can use beam with the parasitic SR mode during collision. 9 beam lines can be used.

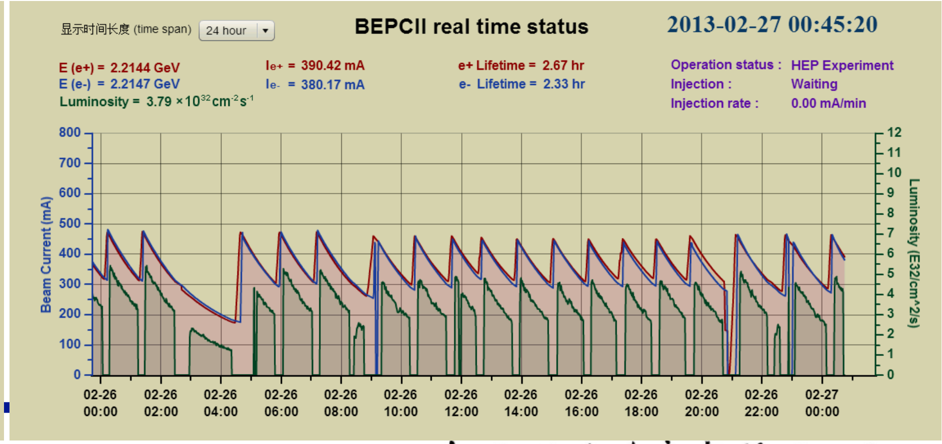
- **Data taking @ ψ(3770) and Ds in 2011**





- **Data taking @ J/ψ in 2012, and Y(4260) in 2013**





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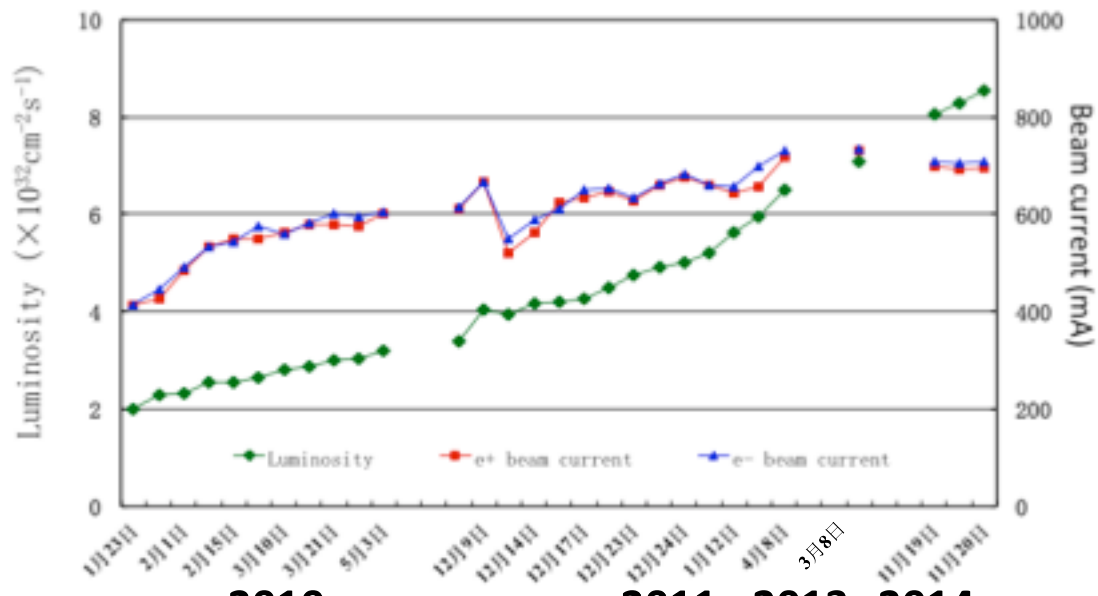
Luminosity at different beam energy (summary)

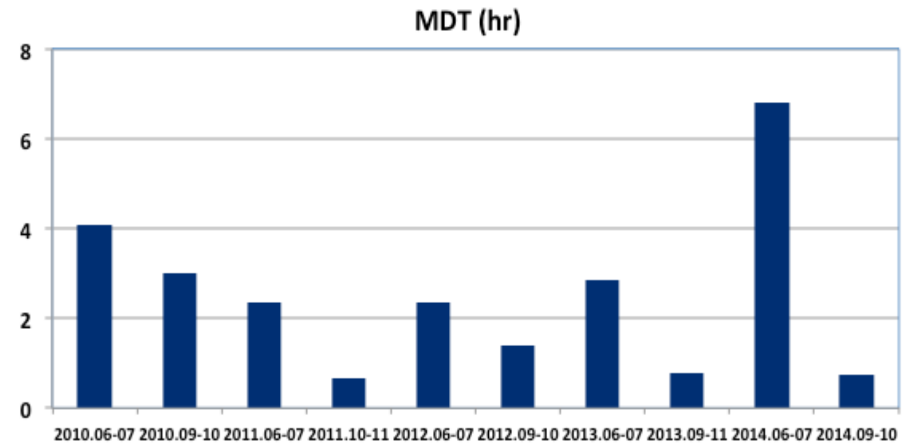
Beam energy	Peak luminosity	Max. beam-beam para.
1.89 GeV	8.53 E32 /cm^2/s	0.040
1.55 GeV	2.92 E32 /cm^2/s	0.028
1.84 GeV	5.07 E32 /cm^2/s	0.031
2.01 GeV	6.50 E32 /cm^2/s	0.032
2.13 GeV	6.28 E32 /cm^2/s	0.035, 0.04@450mA
2.18 GeV	5.37 E32/cm^2/s	0.037
2.21 GeV	5.30 E32/cm^2/s	0.037
2.30 GeV	3.0 E32/cm^2/s	0.023

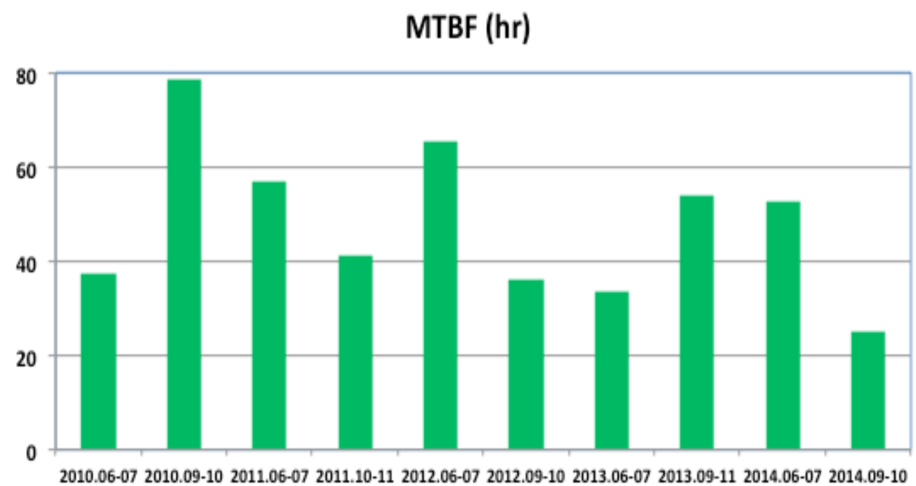
Luminosity & Beam current @ 1.89 GeV



Dedicated SR mode operation

Running as a 2nd generation synchrotron radiation facility
--- deliver beam to users for 3 months every year
--- 500 – 600 experiments done among 2000 applications

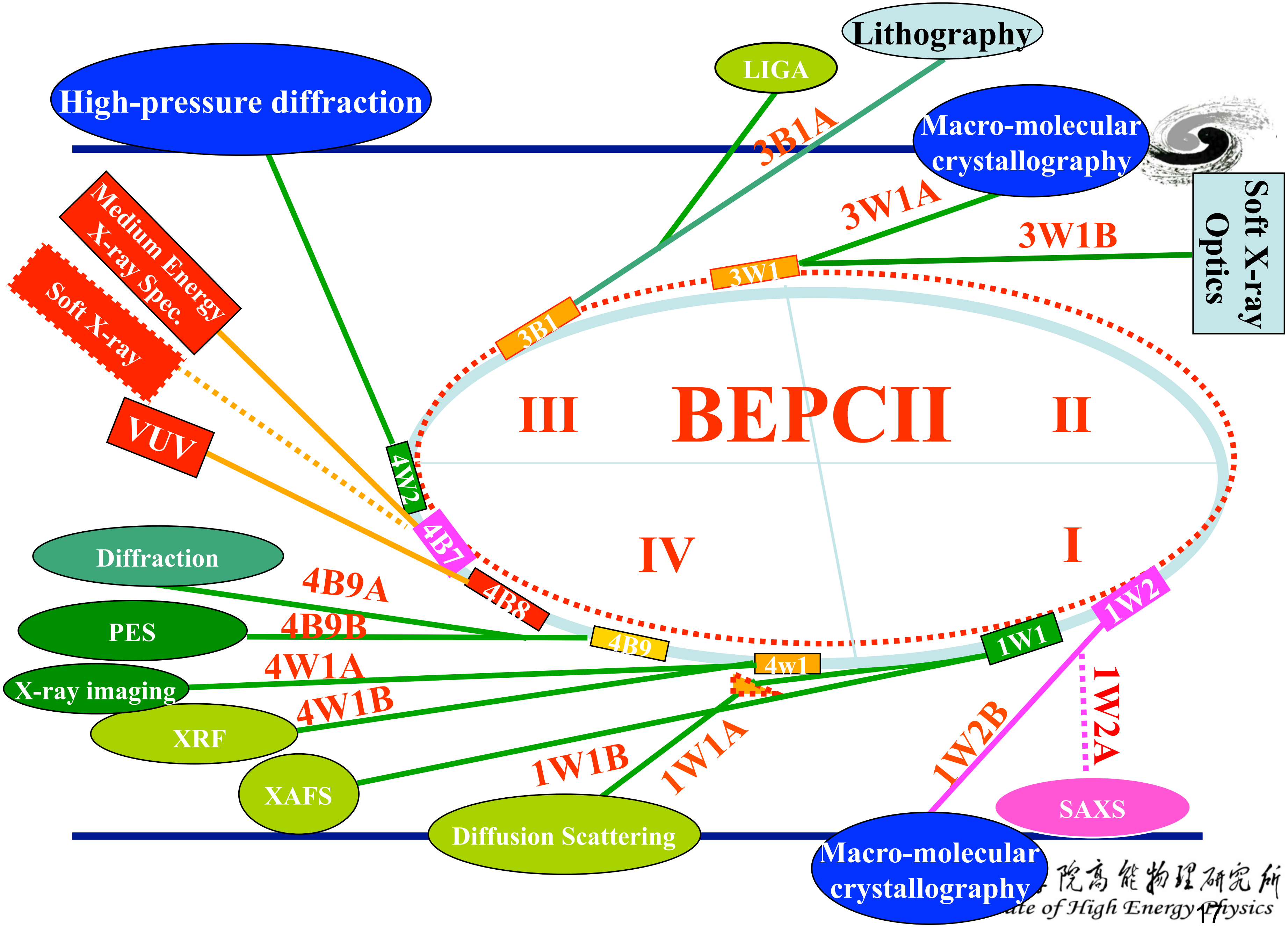




BSRF today

- **9 front areas: 5 from IDs, 4 from BMs.**
- **14 beamlines and 14 stations.**
- **2000 hours/year beam time in dedicated SR mode.**

- **9 beamlines can be operated in parasitic SR mode, in which 2 wigglers are used.**
- **~ 2^{nd} (parasitic/dedicated) generation machine.**


High-pressure diffraction
LIGA
Lithography
Macro-molecular crystallography
3B1A
3W1A
3W1B
Soft X-ray Optics
Medium Energy X-ray Spec.
Soft X-ray
VUV
3W1
3B1
4W2
4B7
4B8
4B9
4w1
1W1
1W2
BEPCII
III
II
IV
I
Diffraction
PES
X-ray imaging
XRF
XAFS
Diffusion Scattering
4B9A
4B9B
4W1A
4W1B
1W1B
1W1A
1W2B
1W2A
SAXS
Macro-molecular crystallography
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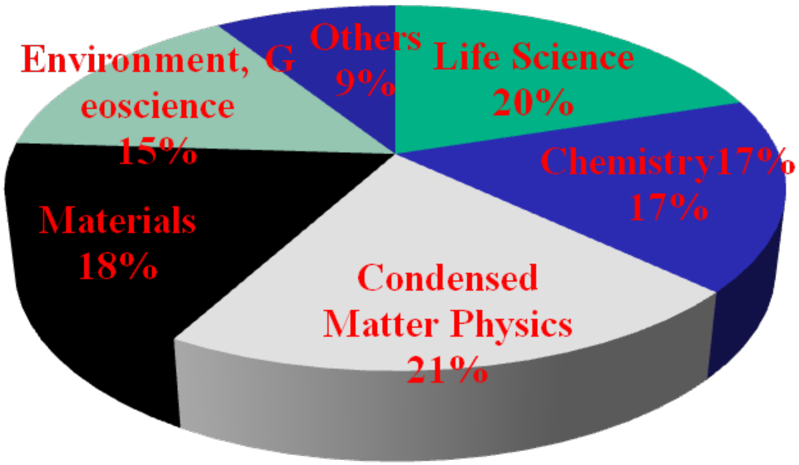
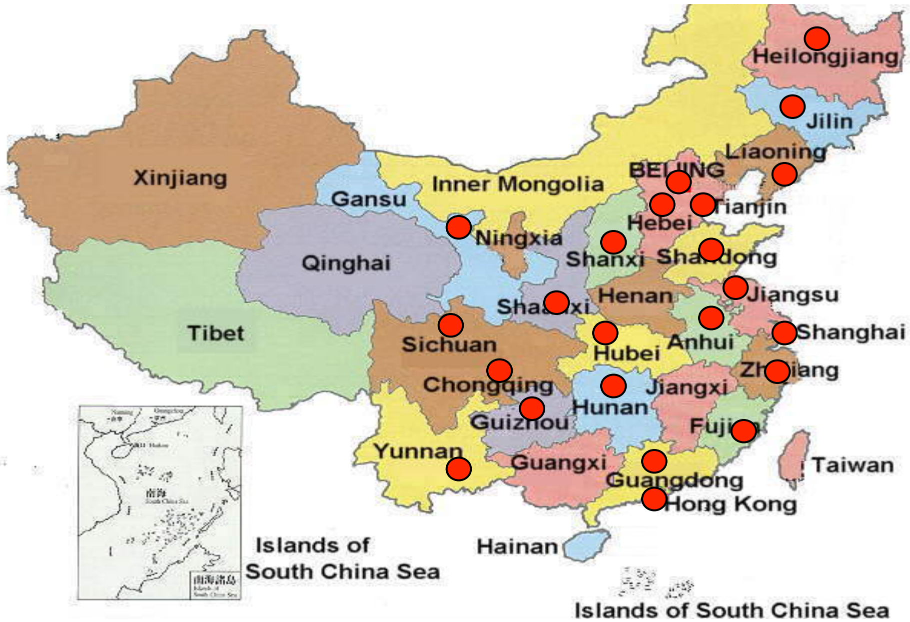
Proposals Distribution



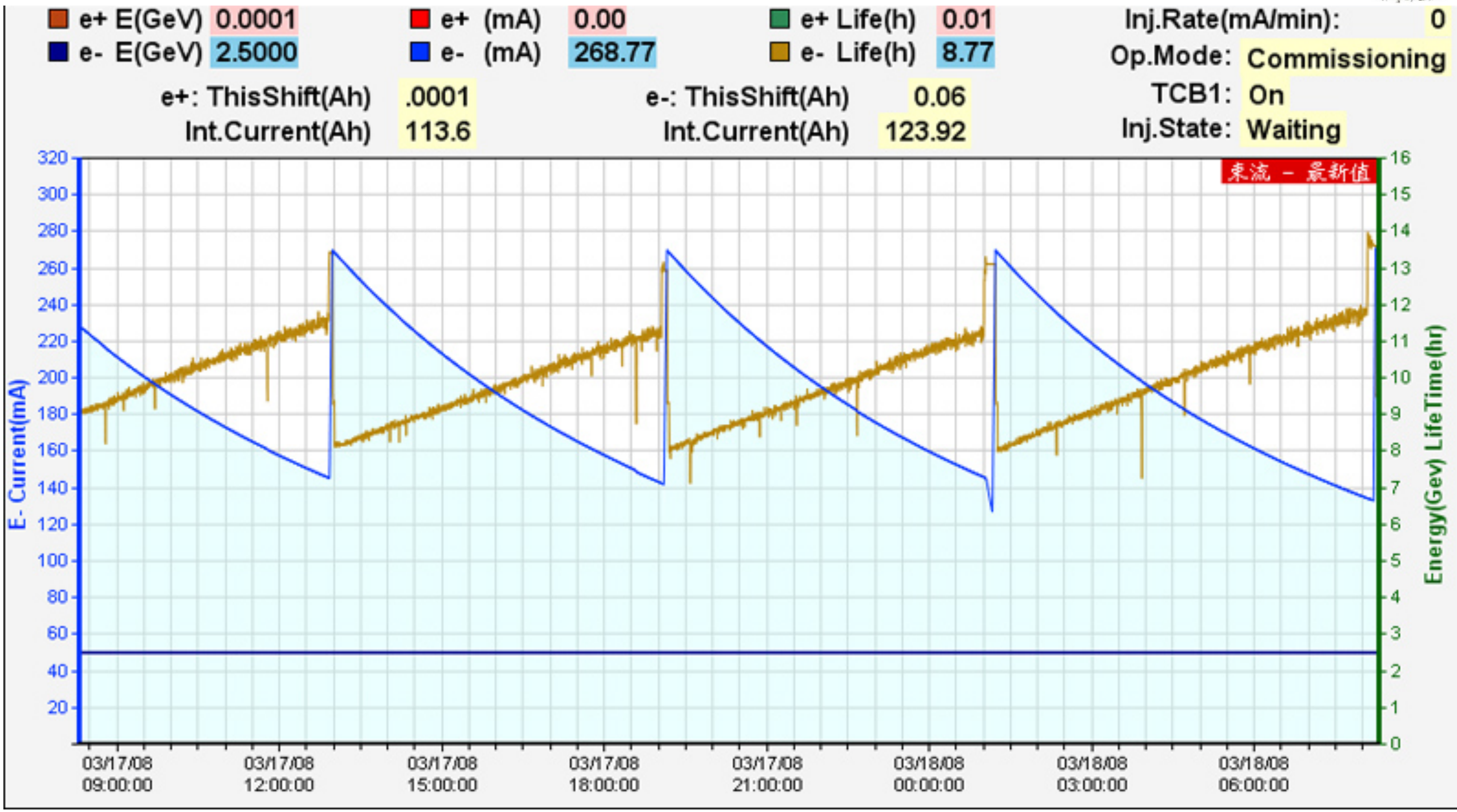
Users Distribution



- **Providing beamtime**
  - **For basic scientific researches**
  - **For national and social needs(Health, environment, etc.)**

Average about 1000 users, and 150 publicaitons/year

Dedicated synchrotron radiation operation



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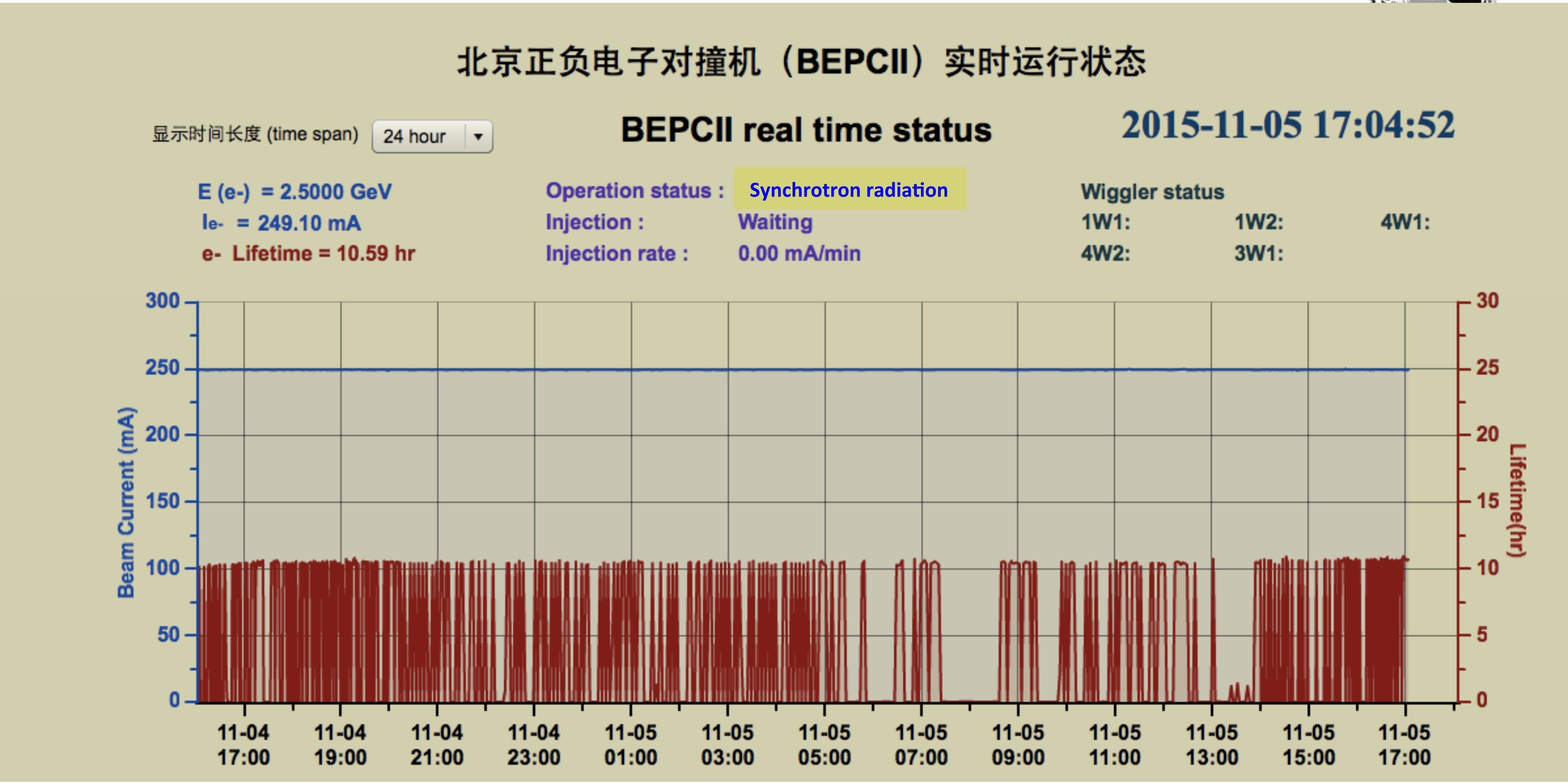
Top-up injection @ dedicated SR mode



http://202.38.128.208/RealTimeLineChart/syn.html

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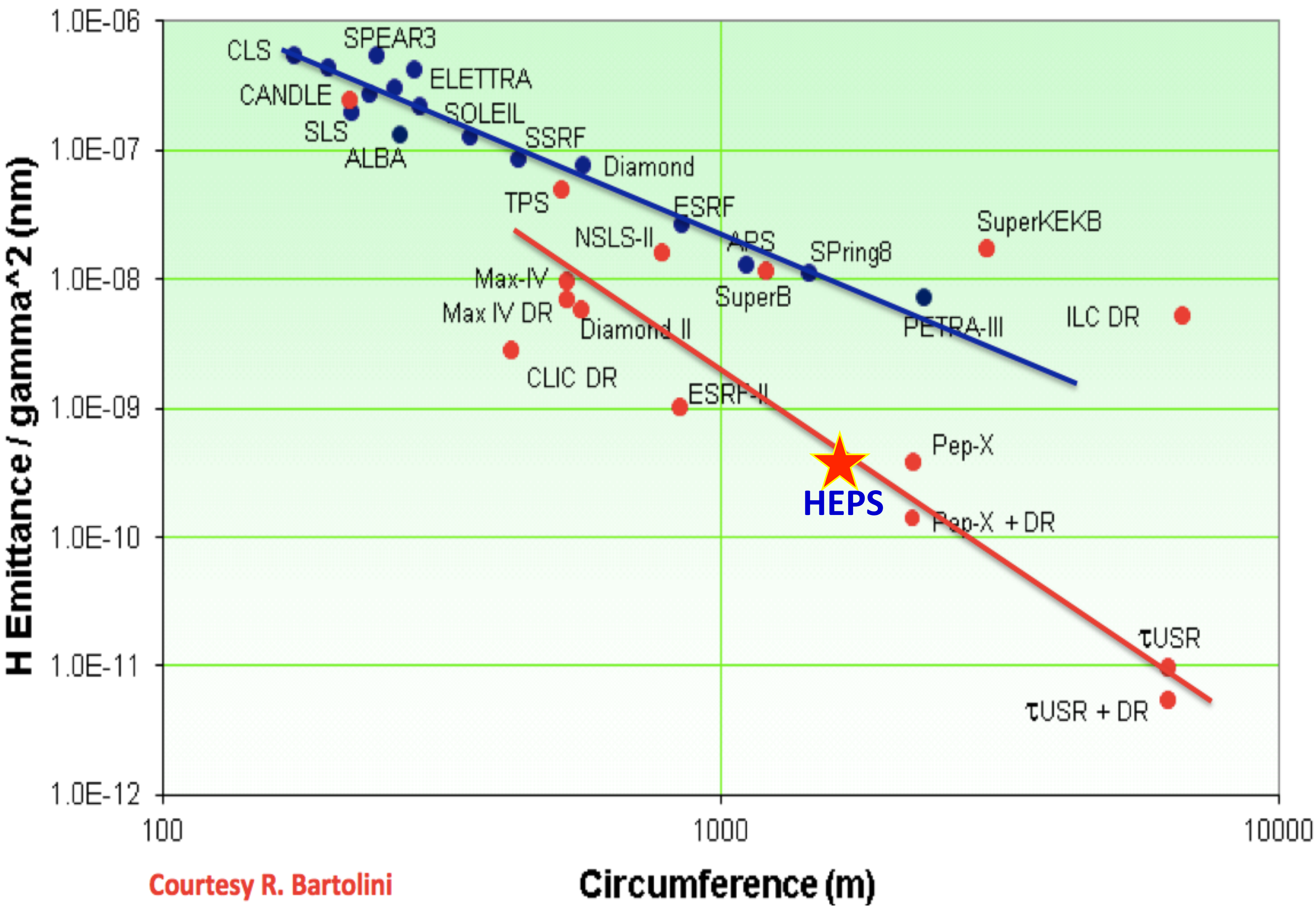
2. Future plan --- HEPS

High energy: 6GeV
Low emmitance: <0.1nm·rad, can be improved to 0.01nm·rad
48-7BA cell lattice
Brilliance: >10^{22}phs/s/mm^2/mrad^2/0.1%BW
The site has the possibility to build XFEL

Comparing with other facilities

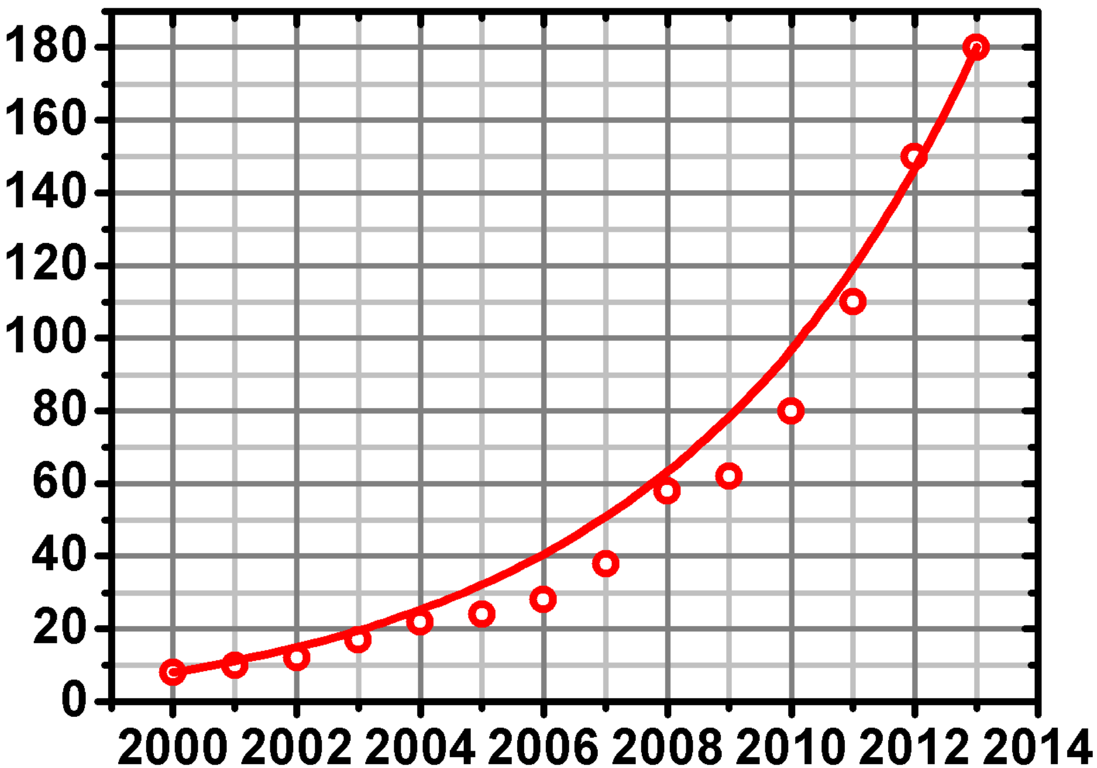


Courtesy R. Bartolini

研究所 Physics

The increase of SR users of China

Structure biology users



The users in SRF from 2000 to 2014:

✓Structure biology: from 8 to more than 180;

✓High pressure: from 5 to more than 40;

✓Geo-science: from few to more than 600 samples for a single proposal

New SR facility is required!

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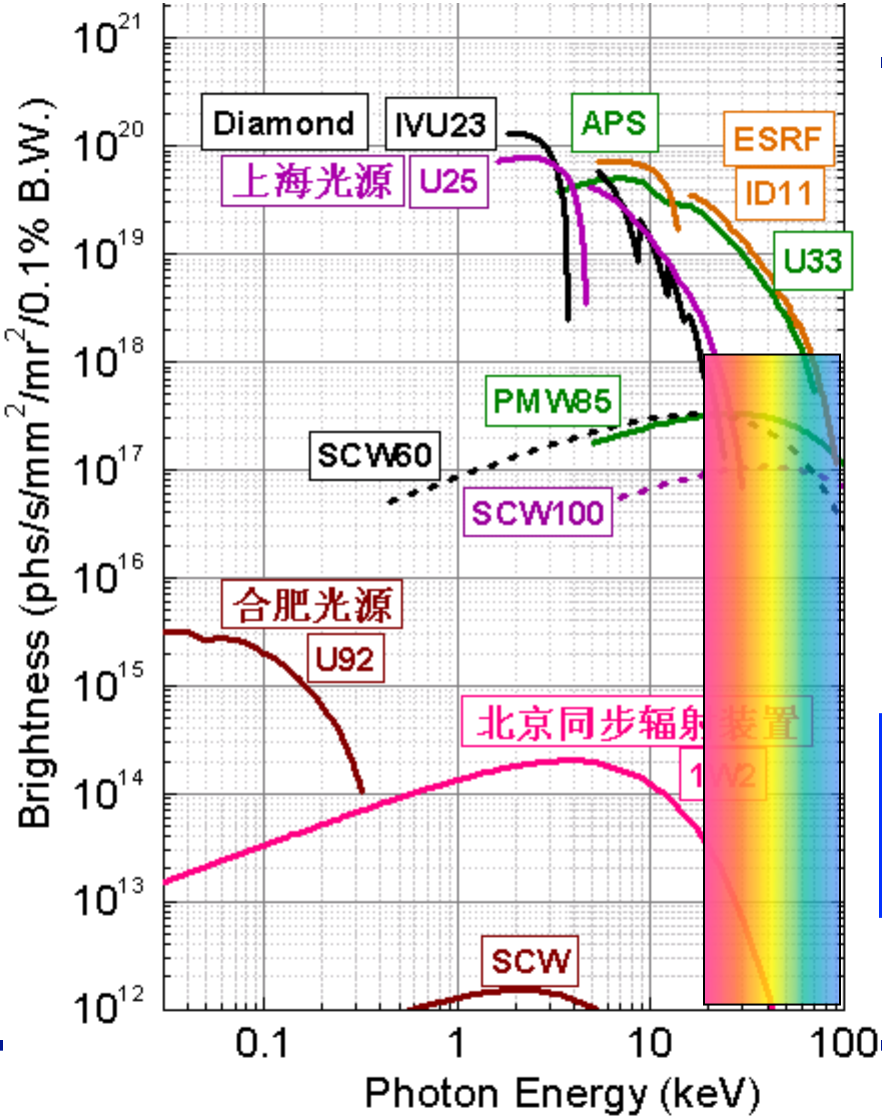
The SR facilities in mainland China

BSRF (2.5GeV, 1GLS)

HLS (0.8GeV, 2GLS)



SSRF (3.5GeV, 3GLS)

Hard X-ray is required !

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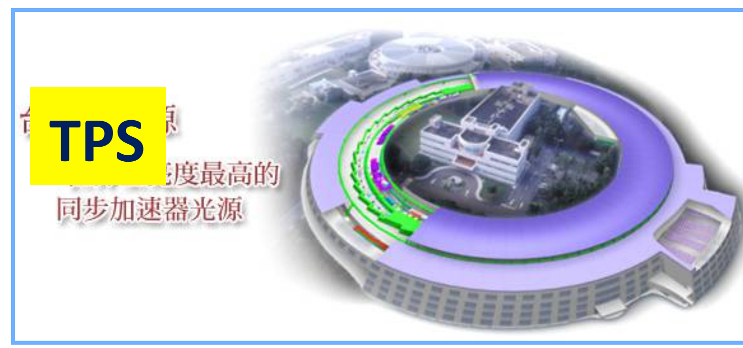
The trends of SR sources



- ✓ **Lower emittances (4 ↘ ≤ 0.1 nm·rad)**
- ✓ **Higher brilliances (↗2~3 orders)**
- ✓ **More advanced beam lines and end-stations (Better resolutions, higher speeds, etc.)**
- ✓ **SR-based research centers**

Scientific requirements for HEPS

- **Excellent performance**
  - ✓ **Brightness： 10^{21}**
  - ✓ **Hard X-ray： 300keV**
  - ✓ **Short pulse： 7 ps**
- **More ability on the support of scientific platform**

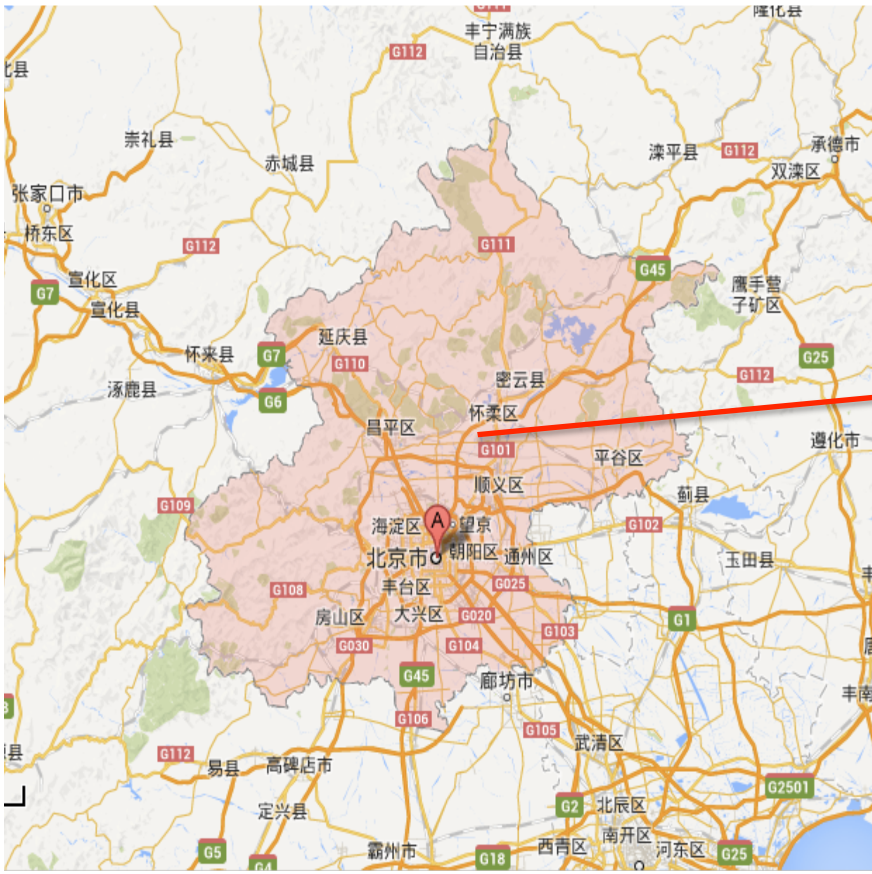
Promotion on

- ✓ **nm level high brightness focusing spot**
- ✓ **enrgy resolution at sub-meV**
- ✓ **Time resolution at ps**
- ✓ **Capacity on penetrating power**
- ✓ **Combination on multi-purpose**

Requirements in beamlines and stations

- Spatial resolution: Nano-focusing for X-ray
- Energy resolution: 10^{-7} (meV@10keV)
- Hard X-ray: 100keV X-ray for material research *in situ* and *in operando*
- Time-resolved experiments: High repetition data acquisition
- In situ experiment setup for synergic techniques
- High heat loads
- ……

Site



丰宁满族自治县
崇礼县
赤城县
张家口市
桥东区
宣化区
宣化县
怀来县
涿鹿县
延庆县
滦平县
承德市
双滦区
鹰手营子矿区
密云县
怀柔区
昌平区
平谷区
顺义区
遵化市
蓟县
海淀区
望京
北京市
朝阳区
通州区
丰台区
房山区
大兴区
玉田县
廊坊市
武清区
易县
高碑店市
定兴县
霸州市
北辰区
西青区
南开区
河东区

北京雁栖经济开发区
一区四园规划及周边关系图
中科院研究生院
雁栖湖
新能源新材料产业园
顶秀美泉小镇
万方研发服务中心
生命科学产业园
雁栖经济开发区
青龙小镇
中关村雁栖高新技术创新基地
怀柔城区
怀丰路
京密路
怀柔水库
怀柔东区
文化创意产业园
庙城组团
中影基地
京承高速路

The schedule of HEPS construction

- **High Energy Photon Source Test Facility (HEPS-TF): R&D of HEPS**
- **HEPS-TF project was approved in Feb. 2015 (323.5M RMB)**
- **The preliminary research was supported by IHEP.**

- **HEPS**
- **Construction will start in 2018.**
- **Commissioning in 2023.**

3. R&D project on HEPS (HEPS-TF)

- In 2010, HEPS R&D project was proposed to the National Development and Reform Committee for the next 5-year Plan. It was approved by Scientific Review Committee. Waiting to be approved by National Council.
- On 18 March, 2011, CAS and Beijing government signed an agreement to establish jointly the Beijing Multi-disciplinary Research Center (later BASIC), in Huairou.
- In Sept. 2011, a Xiangshan Science Conference has been held on the demands in China for high energy Synchrotron source. Users expressed strong interests in HEPS。
- The geographic survey and vibration measurements had been carried out preliminary in 2012 and 2013.
- Formal proposal on HEPS R&D project submitted March 2014.
- Got approval from government on Feb. 12, 2015

R&D issues of accelerator

- **Accelerator physics**
  - M-BA lattice design, other AP issues, booster design
- **Magnets**
  - High-gradient quadrupole and sextupole magnets
  - Combined magnets: dipole+quadrupole, quadrupole+ sextupole
  - Longitudinal gradient dipole
- **Magnet power supply**
  - High precision in magnet power supplies: 10ppm
  - Fast corrector power supplies: bandwidth 5-10kHz
- **Alignment**
  - High-precision and stability girder
  - Alignment of magnets

R&D issues of accelerator

- **Vacuum**
  - **NEG coating, heating on vacuum chambers due to SR, higher harmonic mode, beam wake field, etc.**
  - **Photon absorbers**
- **Beam measurement**
  - **High precision in beam positions and profiles**
  - **feedback**
- **Injection**
  - **swap-out**
  - **Strip-line kicker, short-pulse kicker power supply**
- **Stability & robustness**
  - **Temperature, ground vibration, power supply ripple, alignment and magnetic field errors, etc.**

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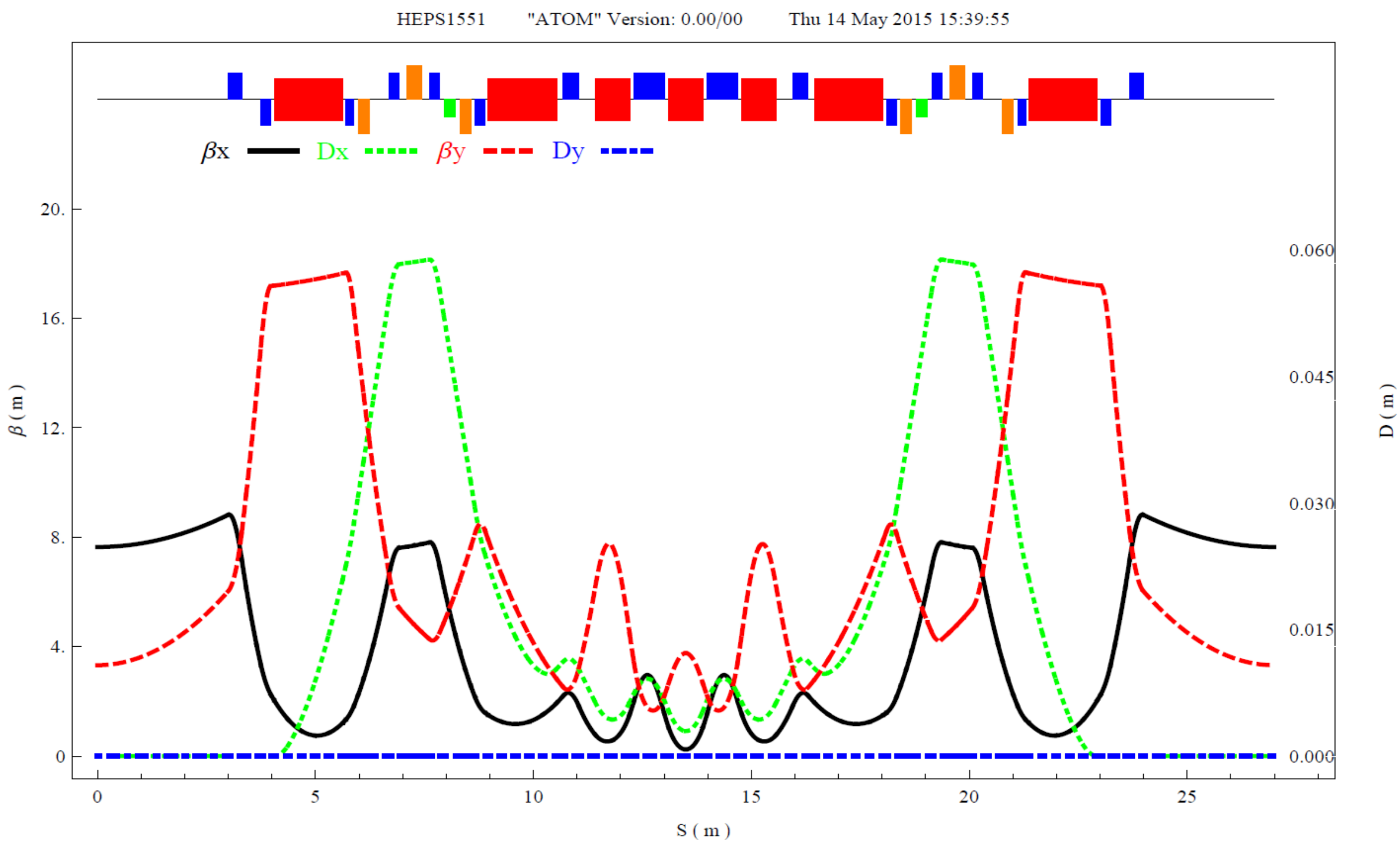
Accelerator physics design

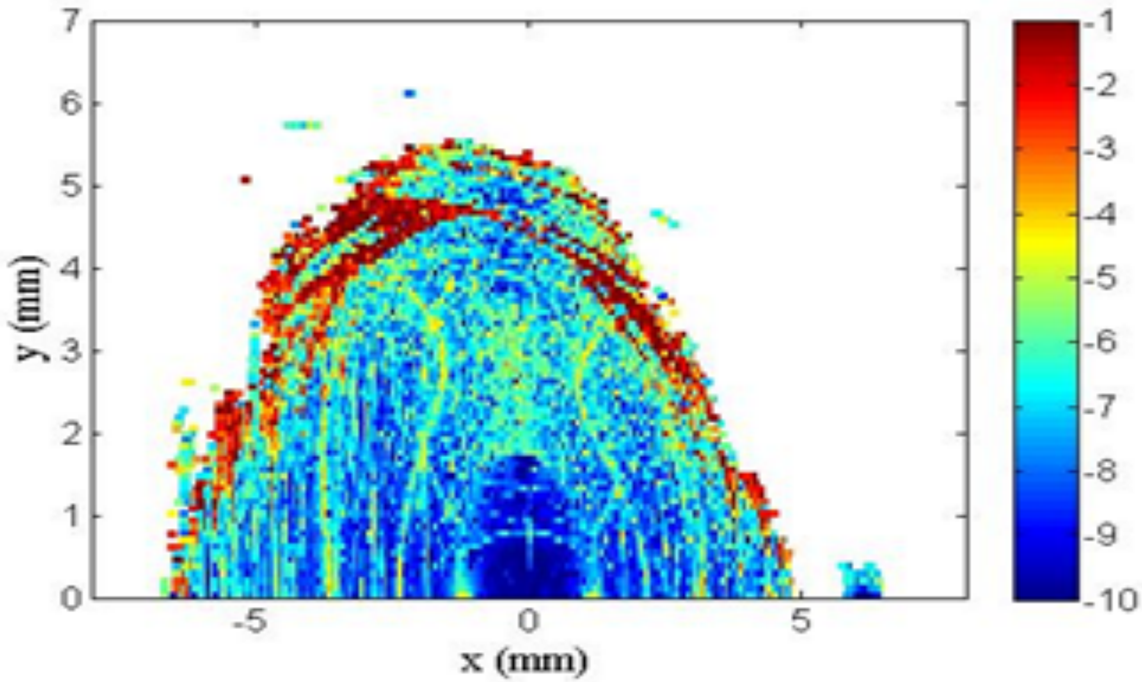
- **7-BA lattice**



研究所
Physics

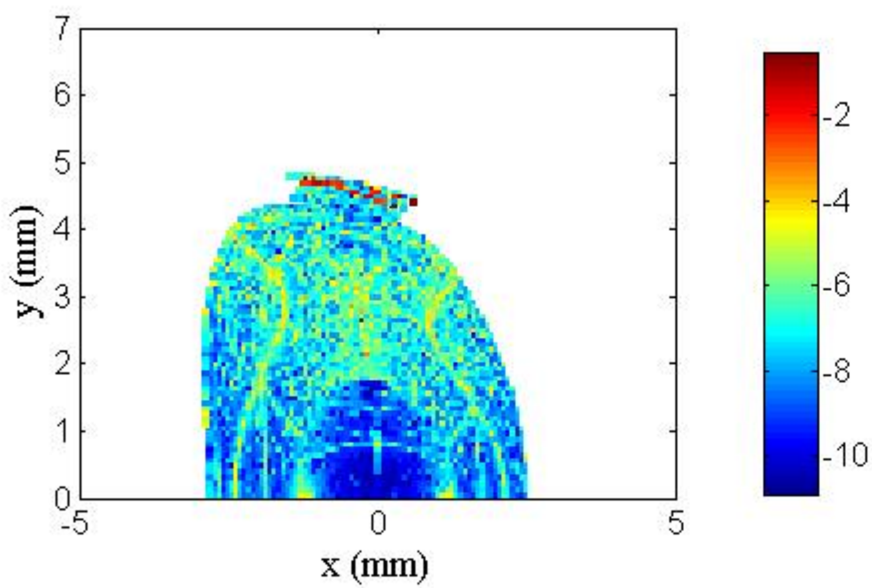
Main parameters of HEPS ring

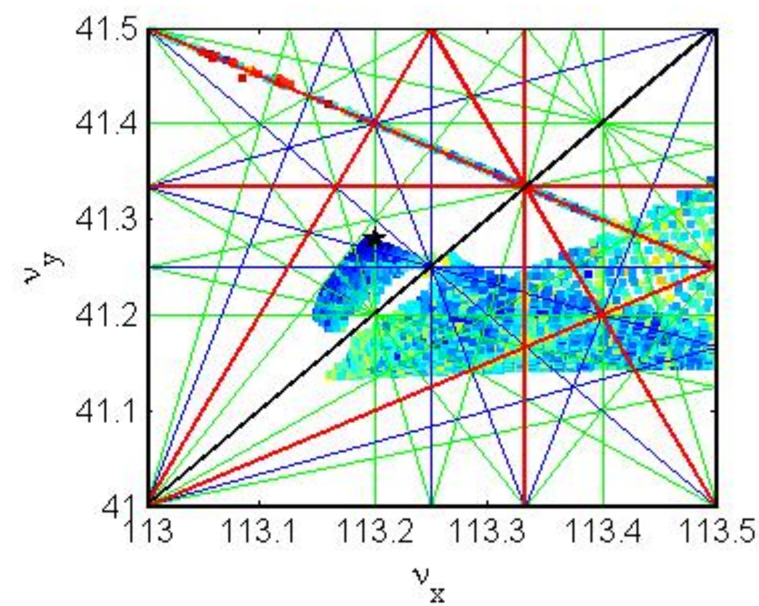
Beam current I_0	200	mA
Bunch number n_B	1296/2160	
Circumference	**1295.6**	**m**
Horizontal damping partition number $J_x/J_y/J_z$	1.38/1./1.62	
Emittance	**55/5**	**pm**
Working point (x/y/z)	113.196/41.227/0.0029	
Natural chromaticity (x/y)	-149/-128.2	
Number of 7BA achromats	**48**	
Damping time (x/y/z)	18.8/26.0/16	ms
Energy loss per turn, U_0	1.995	MeV
Energy spread σ_δ	0.000799	
Momentum compaction	3.67×10^{-5}	
RF voltage, V_{rf}	**6**	**MV**
RF frequency, f_{rf}	499.8	MHz
Harmonic number	2160	
Natural bunch length σ_z	2.07	mm



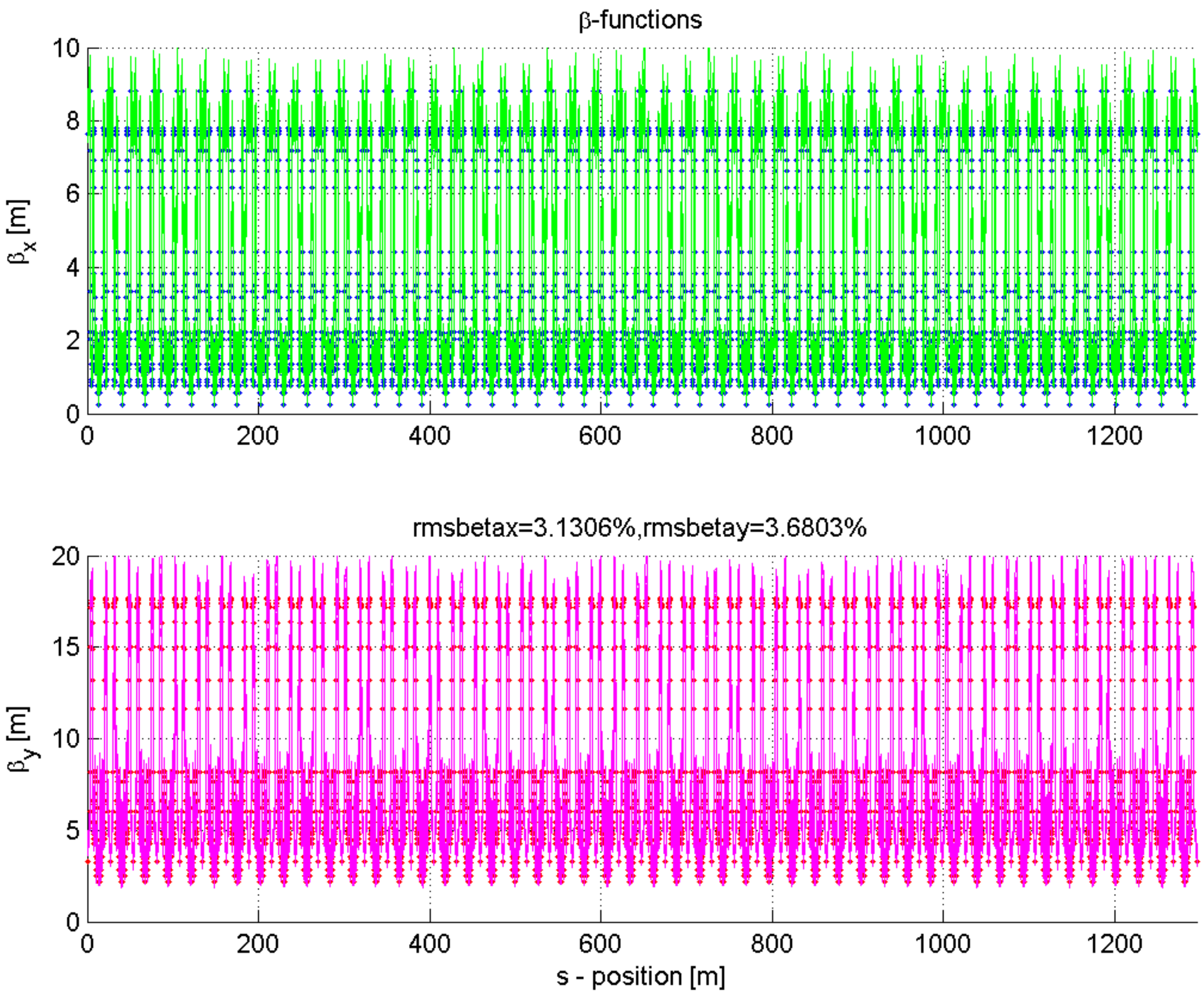
Optimizing for vertical injection
DA_max in vertical ~5.4mm(bare lattice)

FMA: foot print of tunes for many particles cross to half integer
DA in vertical： ~ 4.7mm

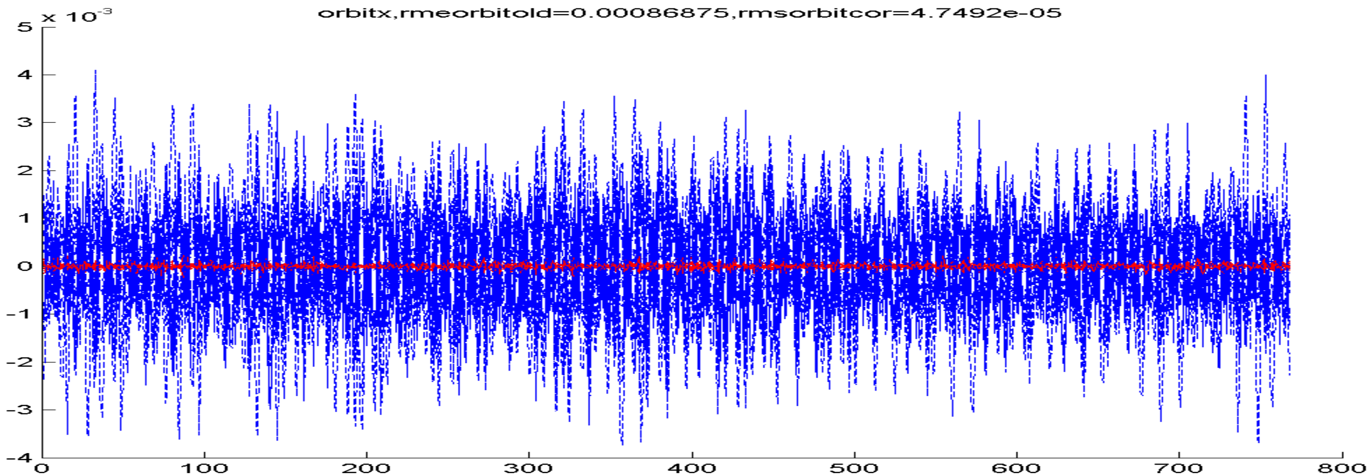


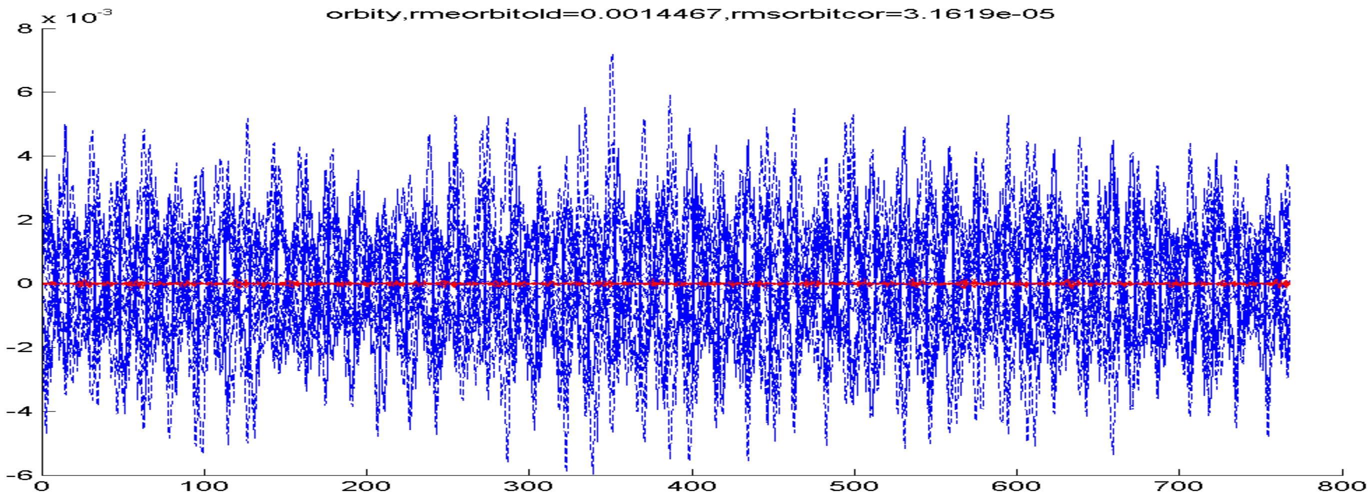


Misalignment: with 20μm,100 μr(tilt) (1)



misalignment(2)





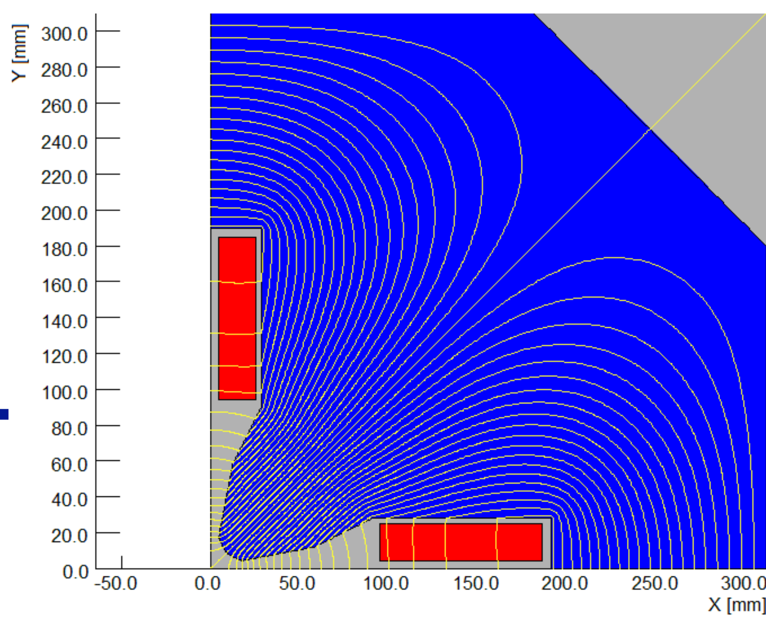
研究所
Physics

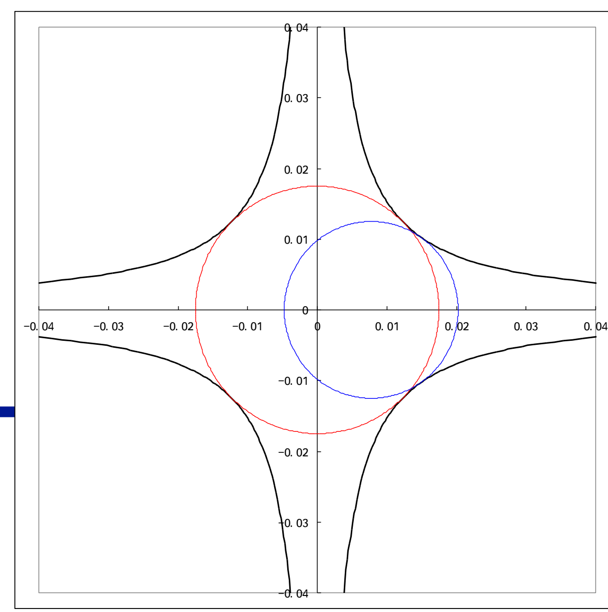
Technical systems of HEPS-TF

- Magnet (high gradient quad, combined function magnets)
- Power supplies
- Injection system
- Beam instrumentation
- Mechanics and alignment
- Insertion device
- RF system
- Vacuum system
- Test environment

• Magnet

- **High gradient quad and high gradient dipole/quad combined function magnet**
  - 2D design finished
  - Pure iron is used as the yoke and pole material.
  - FeCo or FeCoV alloy will be considered to reduce the power consumption.



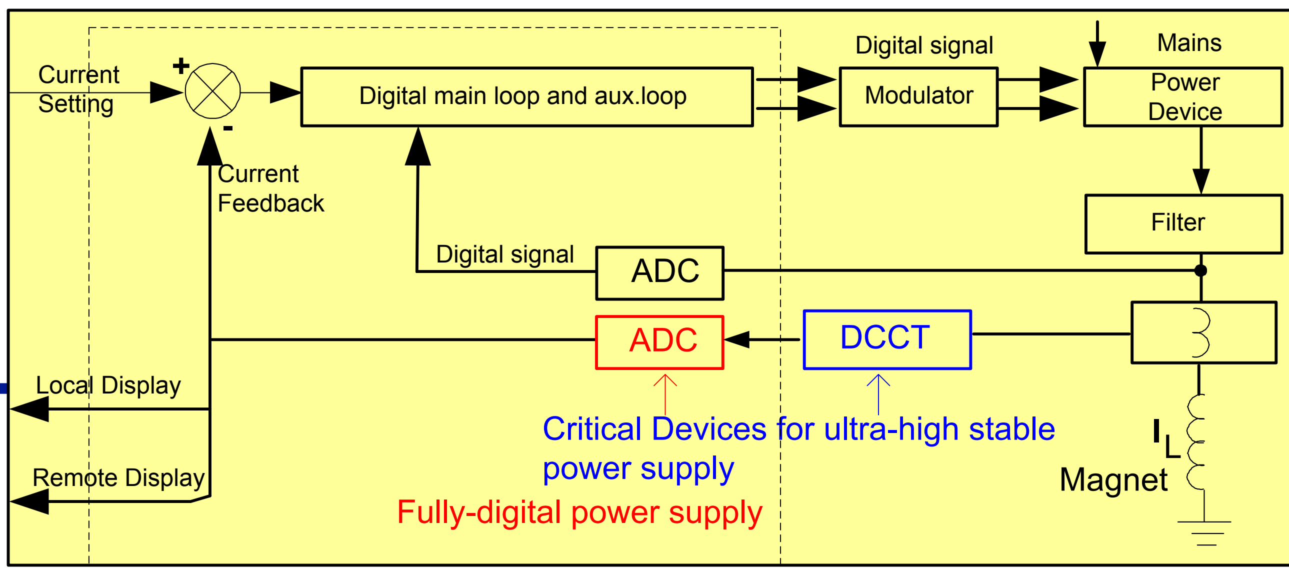


- **Design parameters of the high gradient magnets**

	High gradient quadrupole	High gradient dipole/ quadrupole combined function magnet
Magnetic length [mm]	690	760
Aperture [mm]	25	35
Dipole [T]	—	0.488
Quadrupole [T/m]	100	62.9
Good field region [mm]	±5	±5
High order field [B_n/B_2]	1×10^{-4}	1×10^{-4}
Material	Pure iron	
Ampere turns [AT]	8963	8982
Power consumption [kW]	13.2	14.7

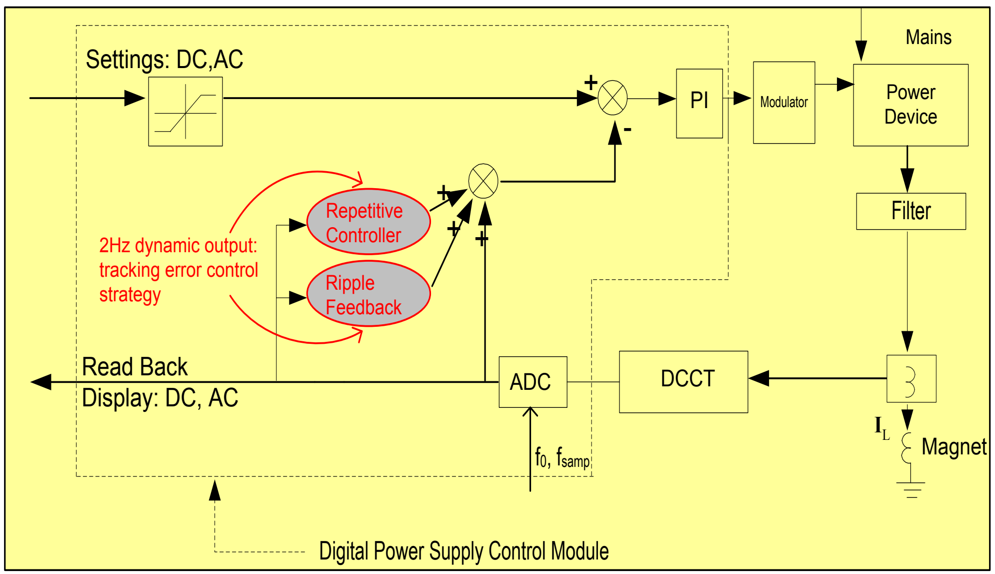
- **Power supply**

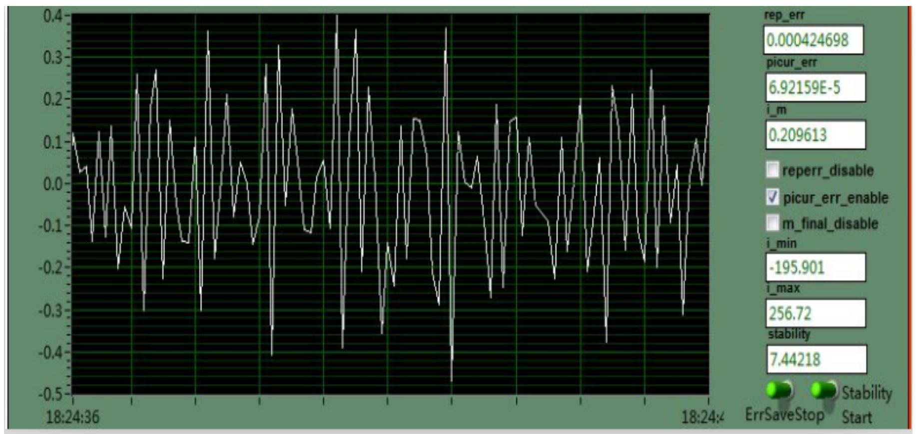
- **10ppm ultra-high stable power supply**
  - **Stability requirements: an order of magnitude higher than BEPCII power supplies.**
  - **For fully-digital power supply, application of highly precious and stable ADC is most important.**
  - **Research on the water-cooling, air-cooling and power room temperature control to ensure 10ppm stability.**



2Hz dynamic output power supply

- **Tracking error control: 0.1% current tracking error**
  - Special design for digital control strategy
  - Special considerations on mains topology for stabilization and EMI

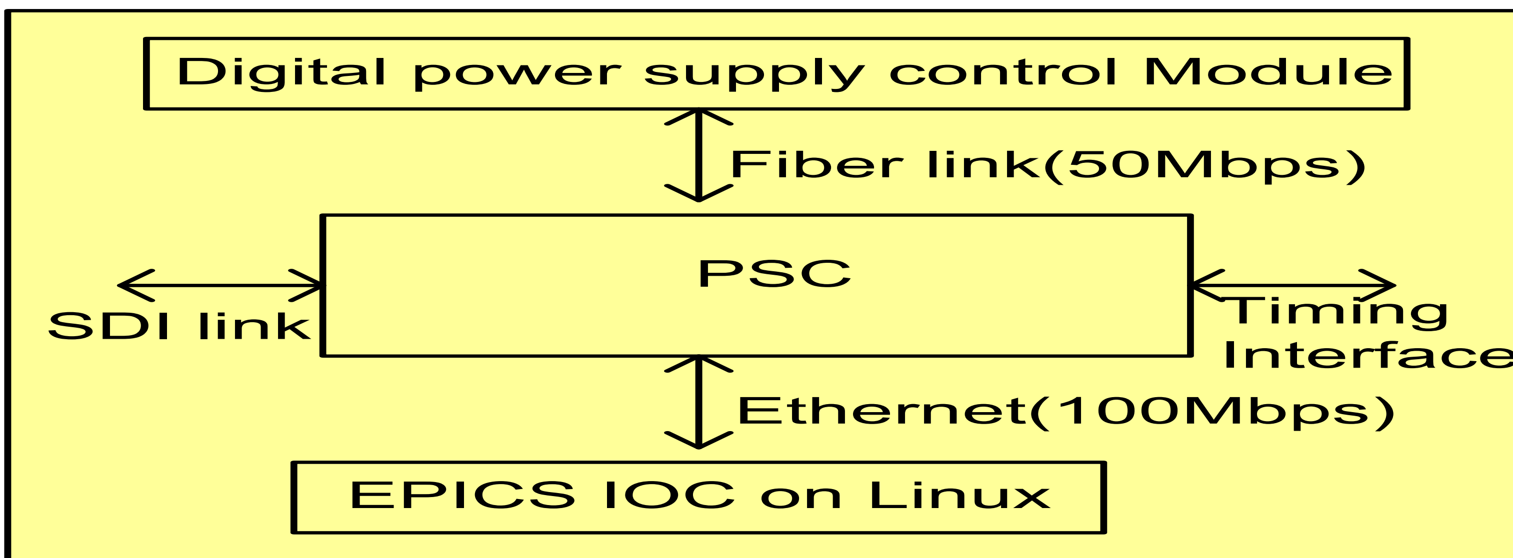




- **A prototype: 180A/30V**
  - **With the self-designed digital controller**
  - **Adding the repetitive controller:**
    - **100 + 50 sin(wt)**
    - **output shows: tracking error better than 0.5 ‰**

Fast power supply for corretor

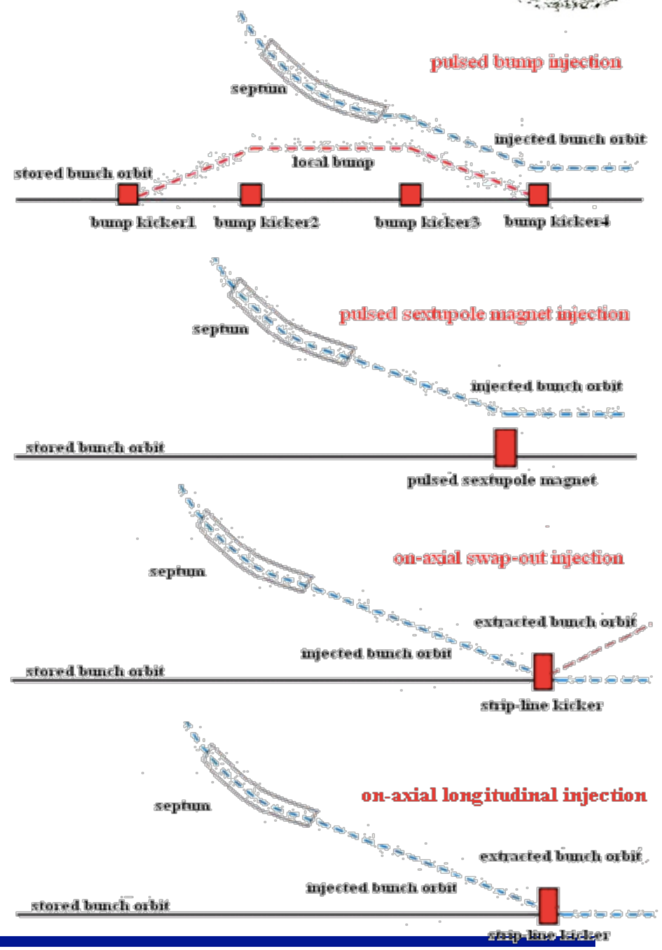
- **Fast correction magnet power supply**
  - **Remote interface has become a part of digital power supply control module.**
  - **The current setting should be updated greater than 100KHz.**
  - **Fast link interface (fiber link, 50Mbps) will be developed for BAPS digital power supply.**



Injection

- **Top-up Injection Schemes**

Potential top-up injection schemes for low emittance ring:



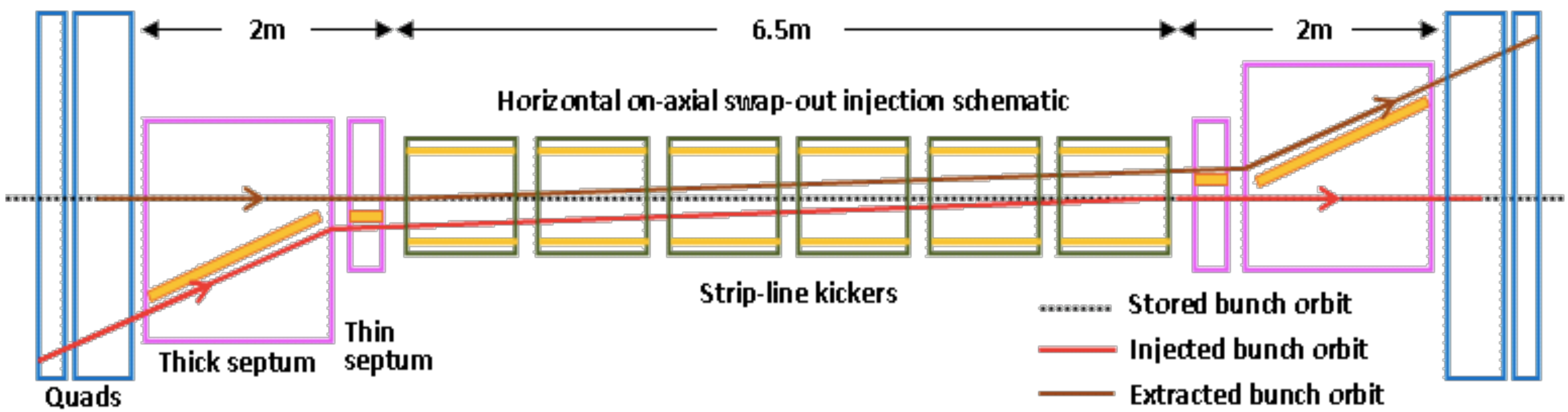
- **Off-axial injection (need larger DA)**
  - **Pulsed bump injection**
  - **Pulsed multi-pole injection**
- **On-axial injection (need faster kicker)**
  - **Swap-out injection (transverse, Tw<2τ)**
  - **Accumulate injection (longitudinal, Tw<τ)**

(Tw-Pulse width of kicker, τ- time spacing between bunches)

HEPS Top-up Injection System

On-axial swap-out injection system:

- Injection/ejection direction: Horizontal
- Bunch is swapped-out within a single 10.5m long straight section.
- Fast kickers： strip-line kicker； Septa： Lambertson magnet

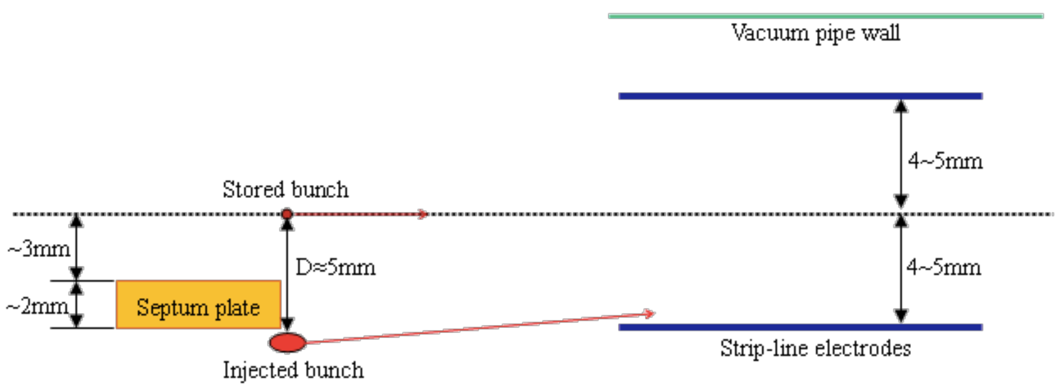


Horizontal On-axial Swap-out Injection Scheme

Requirements on Injection System

Distance between injected bunch and stored bunch orbit=5mm and distance between the septa on the both ends of straight section= 6.5m

- kick angle: θ > 0.8mrad -> θ ≥ 3mrad
- Distance between electrodes > 8~10mm, provide aperture clearance to injected beam
- Both end of kickers are allowed horizontal position offset 1 ~2mm



Strength Requirement for Strip-line Kicker

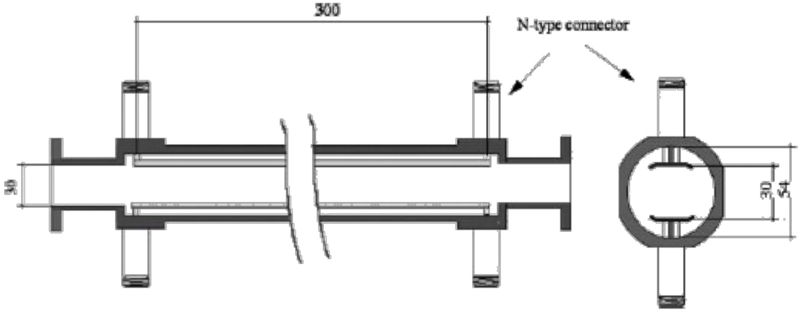
- Injection beam Energy: E=5GeV, kick Angle θ=3mrad, distance between electrodes : d=10mm, Geometrical factor of electrode: g=1

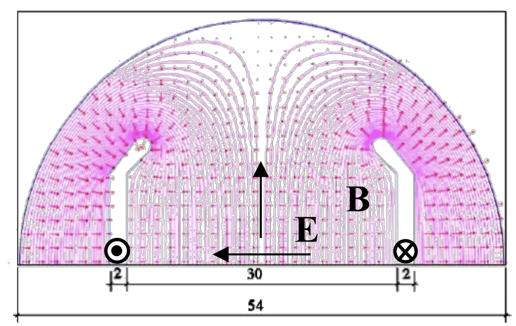
  =>$U*l$ > 75kV·m

- Six strip-line kickers: 6×l=6×0.75m => U > ±8.4kV (Bipolar pulser)

$$F_{E+B} = 2\frac{Uq}{d} \qquad \theta = \theta_E + \theta_B = 2\theta_E = 2g\frac{eU}{E}\frac{l}{d}$$

$$g = \tanh(\frac{\pi w}{2d}) \qquad \tanh(x) = \frac{e^{2x}-1}{e^{2x}+1}$$





Typical Strip-line Kicker and EM Filed Distribution

Design Parameter of kicker system

Need further detailed design consideration

Parameters	Unit	HEPS	APS-U
Injected/ejected beam energy	GeV	5~6	6
Minimum spacing of stored bunches	ns	10	11.36
Length of straight section for injection/ejection	m	10.5	5.8×2
Integrate kick angle	mrad	3	2.88
Injection /ejection direction	-	Horizontal	Vertical
Effective length of strip-line kicker	m	0.75	0.72
Distance of strip-line electrodes	mm	10	9
Strip-line kicker quantity	-	6	4
Pulsed voltage of bipolar pulser	kV	±8.4	±15
Rise time of pulser（10%-90%）	ns	4	4.5
Flat-top of pulser	ns	5	5.9
Fall time of pulser（90%-10%）	ns	4	4.5

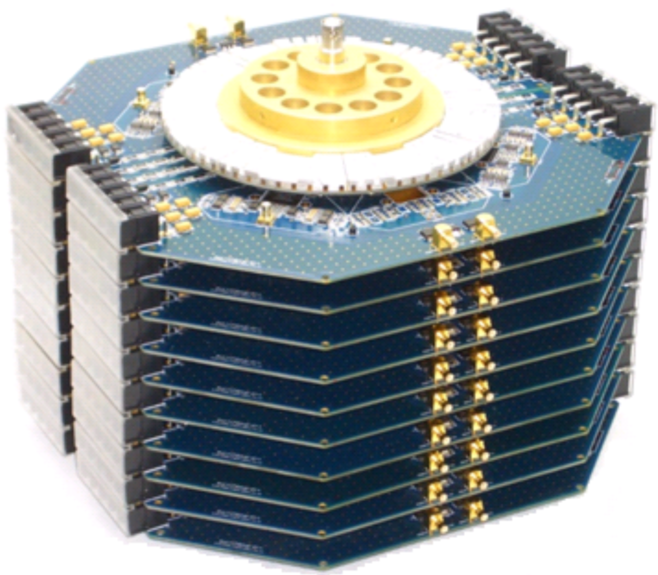
Fast Pulsed Power Supply R&D

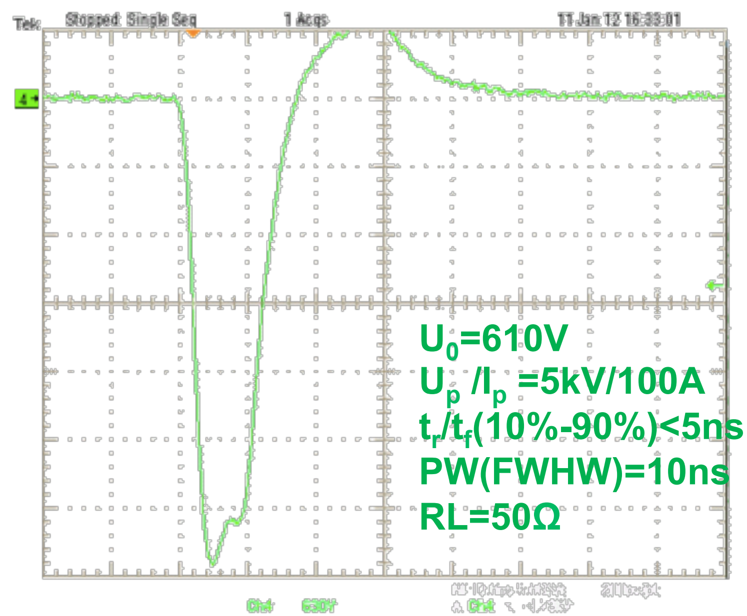
Potential solutions is to be considered:

- ☐ **RF-MOSFET based pulse power superposition technology**
  - **Inductive Adder**
  - **Transmission Line Transformer Adder**
  - **Marx Generator**
  - **Hybrid Adder**
- ☐ **DSRD(Drift Step Recovery Diode) based PFL(Pulse Form Line) modulator**

Inductive Adder R&D experience

The prototype was special designed for ILC DR strip-line kicker in IHEP, 2011.





10-stage inductive adder assembly and test result

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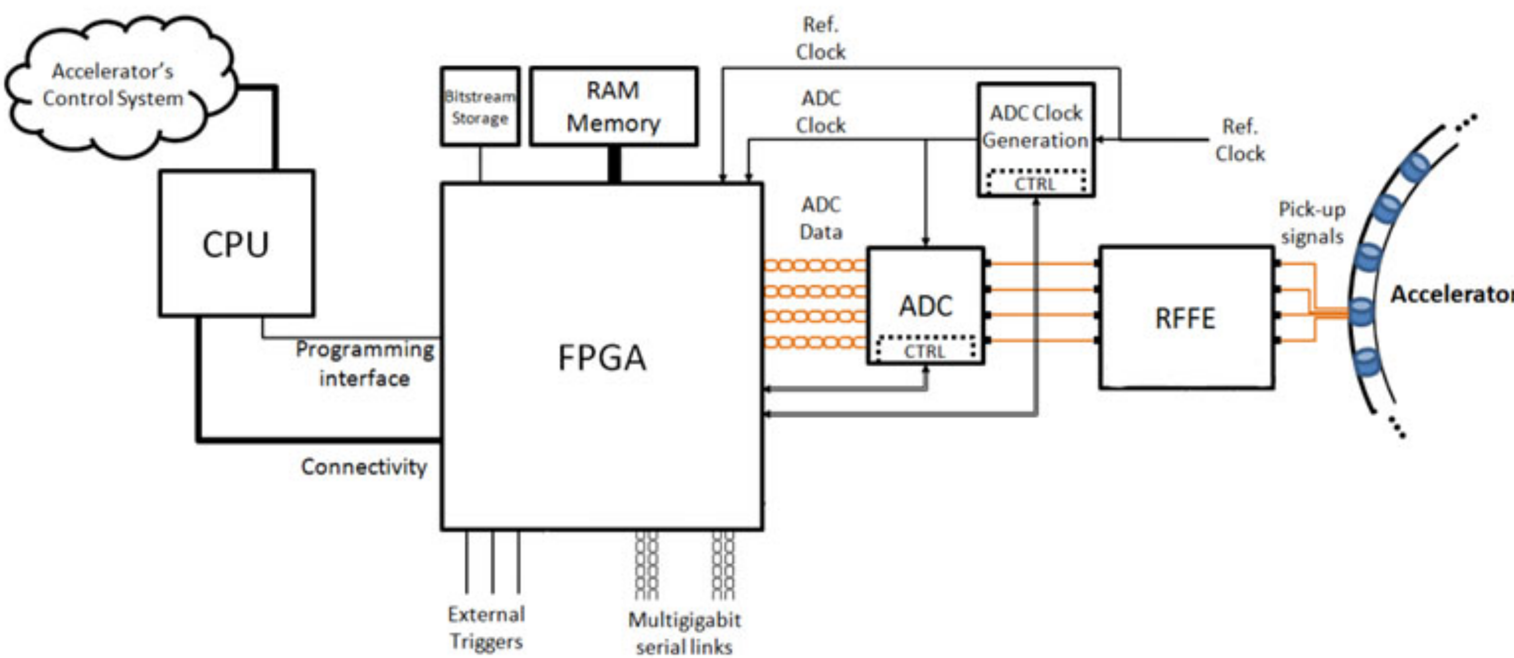
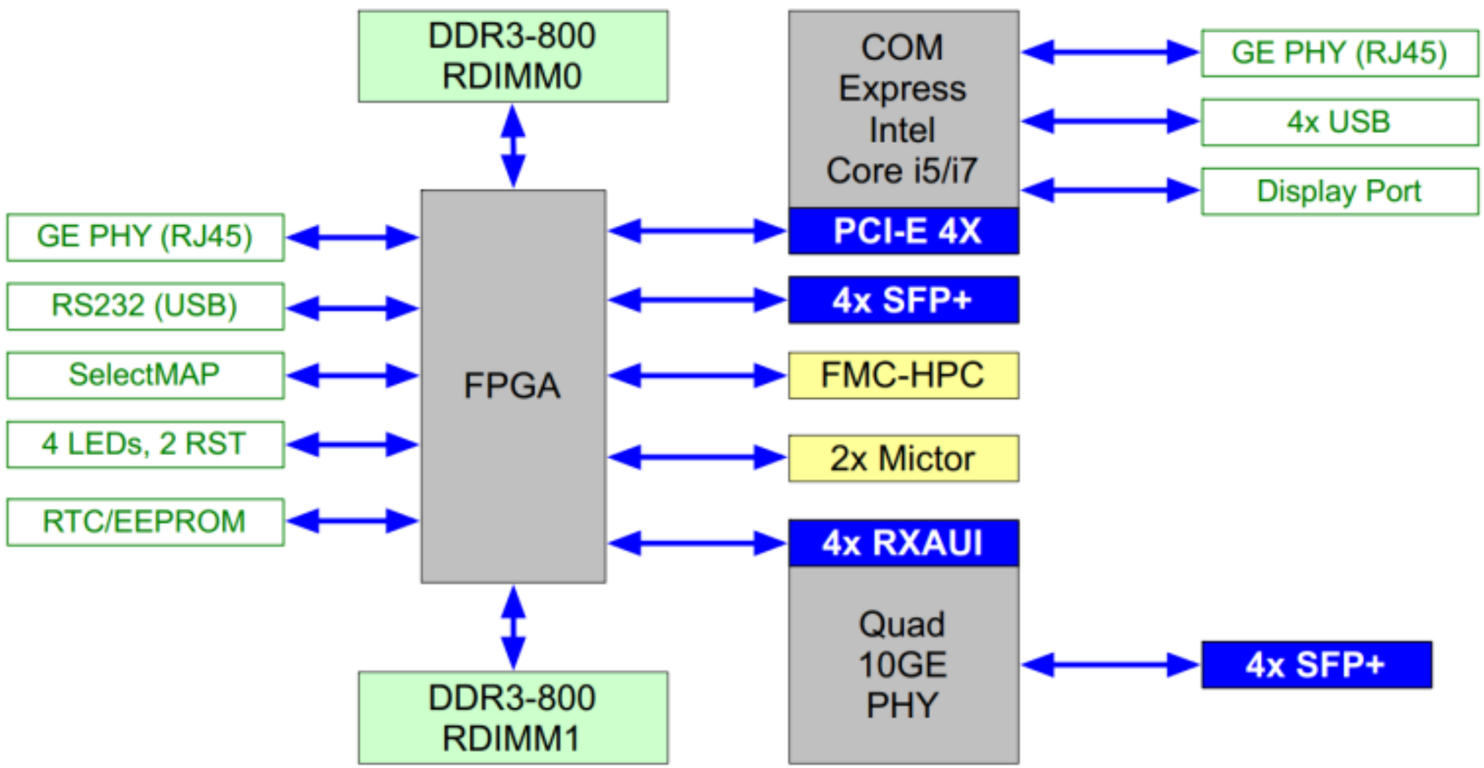
Beam instrumentation

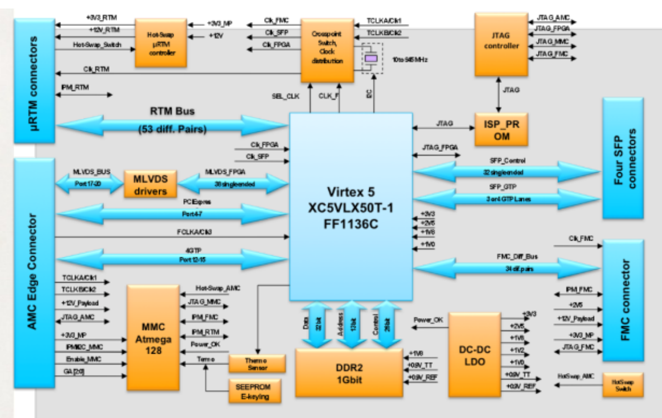
- **Digital Beam Position Monitor electronics**
  - RFFE (Radio frequency front end electronics)
  - Fast ADCs
  - High performance FPGA



- **Have developed software on the commercial data acquiring system in the lab.**
- **DAQ system in the lab have 4 tunnels, sampling frequency is 500MHz, and the resolution of ADC is 14 bit.**



- **Hardware**
  - Based on microTCA.4, which is specific to high energy physics, including RTM(Rear transition module) and AMC(advanced meggazineae card).
  - MicroTCA.4 is highly integrated and has advantages of flexibility and reliability, easy to development and cooperation with international labs and companies.



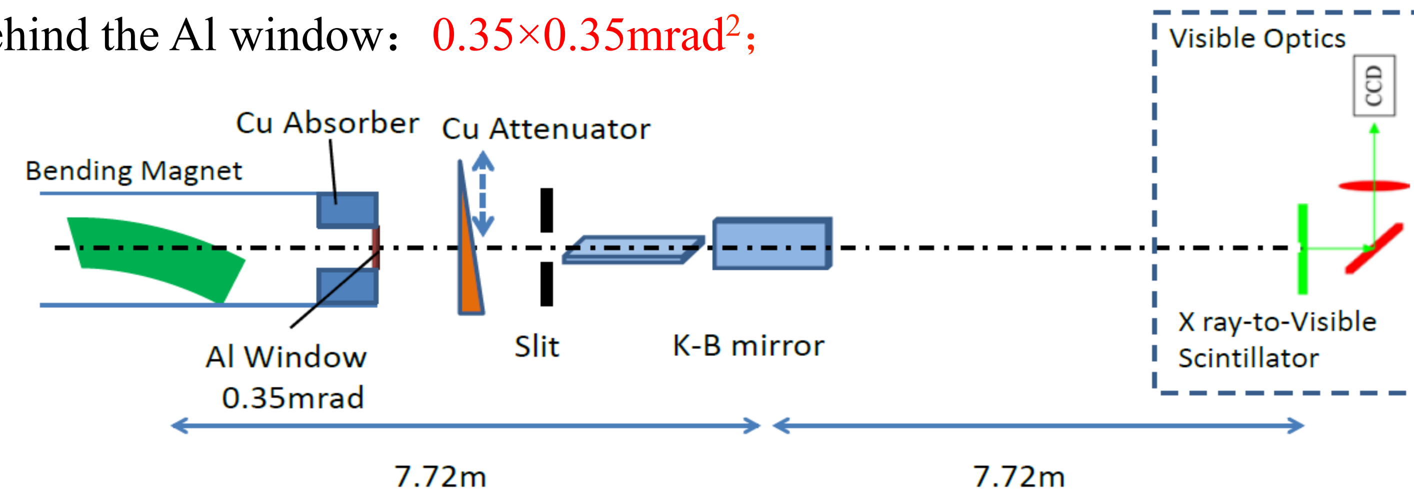
• X ray imaging system based on KB mirrors

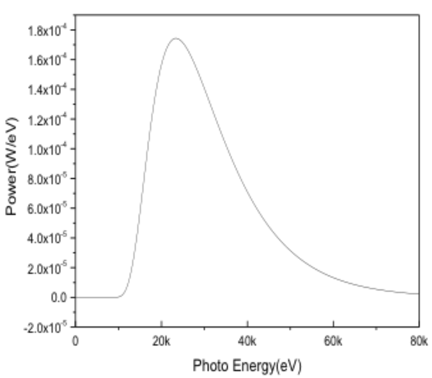
Beam energy of x ray: >10keV，characteristic energy：23keV；

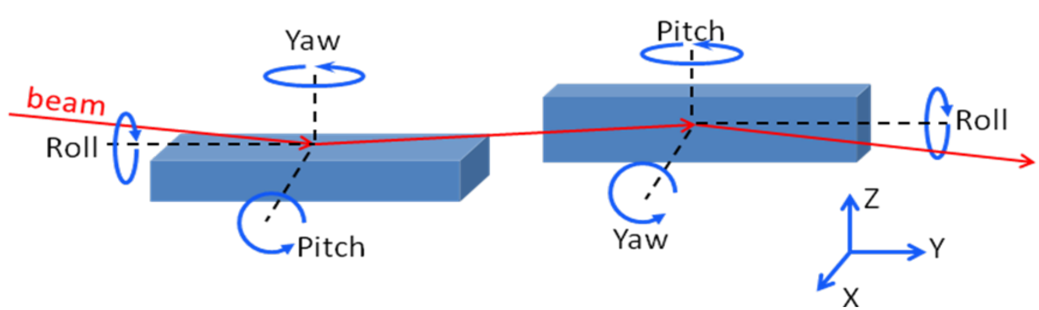
Beam size at the exit of bendingmagnet：70（vertical）×20（horizontal）μm^2；

Al window size：diameter：2mm，thickness：1mm；

Divergence angle behind the Al window：$0.35\times0.35 mrad^2$；







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- **Mechanics and alignment**
  - Vibrating-wire alignment technique --- to meet the tolerance ±0.03mm between magnet to magnet .
  - Precision-tuning magnet girder --- be manipulated through control system with the position monitored by sensors, to meet the tolerance ±0.05mm between girder to girder, and would be capable of beam-based alignment in the future.

Tolerances	Magnet to Magnet	Girder to Girder
Horizontal	±0.03mm	±0.05mm
Vertical	±0.03mm	±0.05mm
Roll angle	±0.2mrad	±0.2mrad

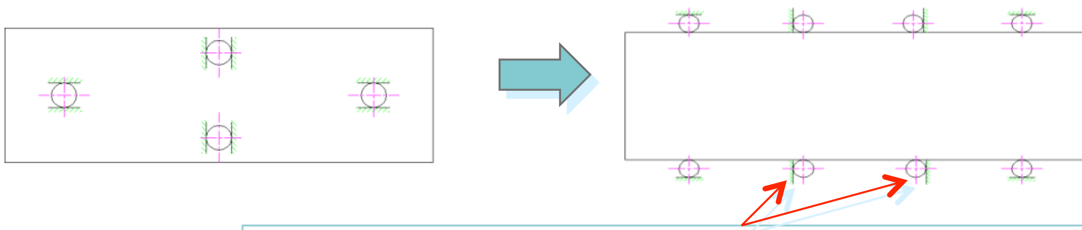
Girder Requirements

Specifications		Design value	Acceptance value
Adjusting Range	Horizontal	±8 mm	±4 mm
	Vertical	10 mm	±10 mm
Adjusting Resolution		0.002mm	0.005mm
Eigen Frequency		>30Hz	>24 Hz

- **Finished**
  - **Design of supporting scheme and selection of adjusting mechanism.**
  - **Derivation of adjusting matrix.**
  - **Study on motion way and range of the adjusting mechanism.**
  - **Design of control process of the girder motion.**

Supporting scheme

- Four V-grooves set perpendicular two by two。

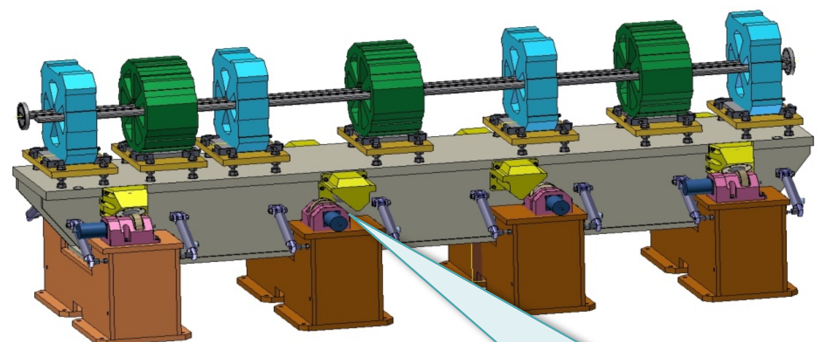


Two of eight contact points are for supplement.

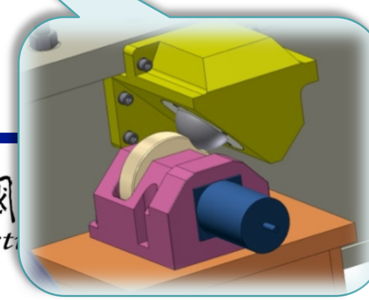
Adjusting mechanism

- Motor driving Cam mover

Specifications	Values
Size(L X W)	3.8m X 0.8m
Cam Load	2.5T
Cam center offset	7mm
Adjusting range	X(-8.7mm~9.4mm)
	Y(-11.8mm~10.4mm)

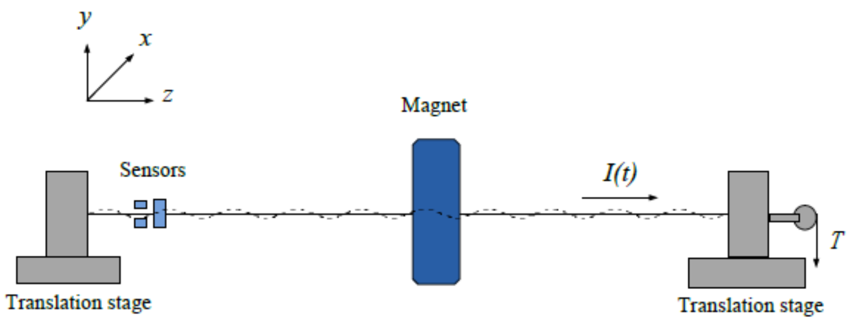


Girder model & Cam mover



- Vibrating wire technique --- based on the measurement of magnetic axis to meet the tolerance ±0.03mm between magnet

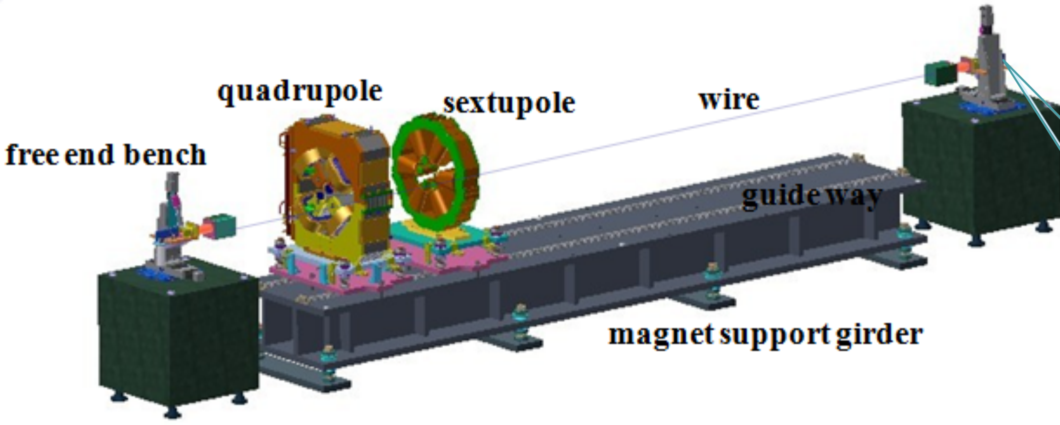
  to magnet on one girder.

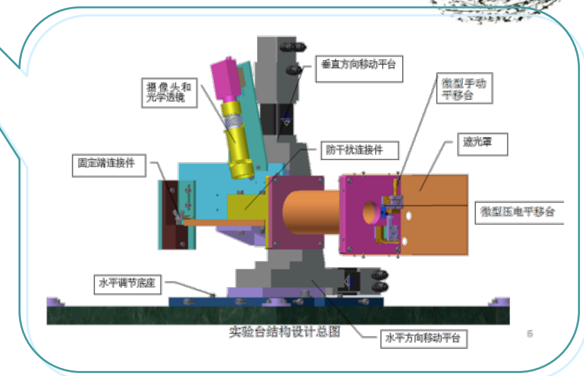


Scheme of vibrating wire experiments

Finished

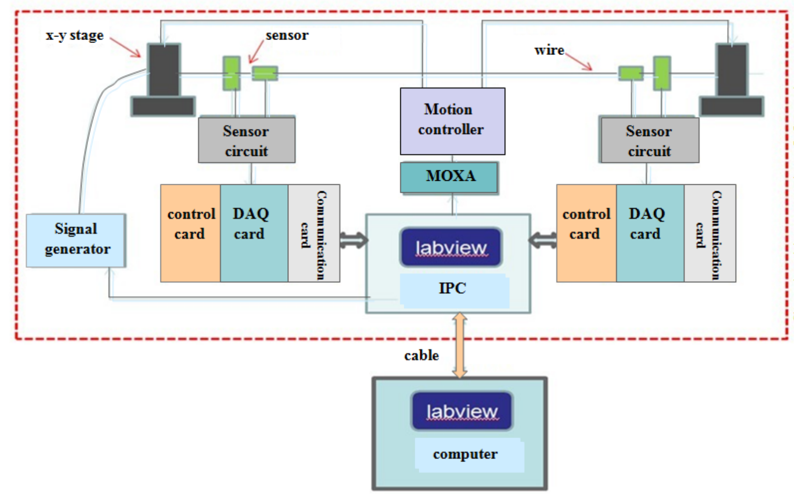
- Derivation of basic theory
- Design of test bench model
- Design of data acquisition and control system
- Design of sag measurement scheme
- Calculation of vibrating amplitudes
- Design of the sensor circuit and sensor calibration





Test bench model

- System setup
  - Wire
  - magnets& girder
  - translation stages on both ends
  - sensors & monitor
  - data acquisition and control system.
- BEPCII magnets will be used.

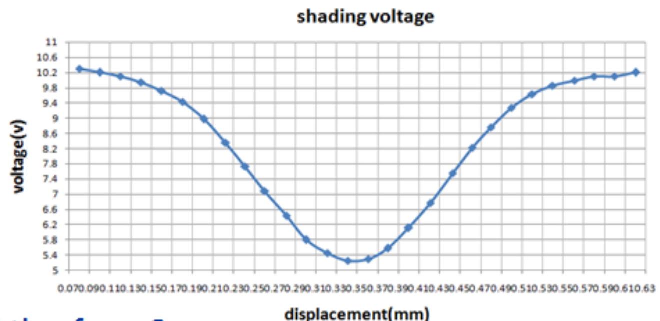


Data acquisition and Control system

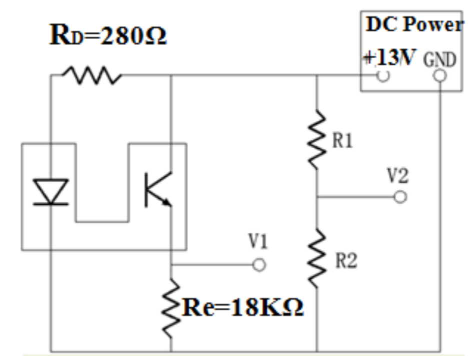
Linear output range and sensitivity of sensors

Linear range: ~0.12mm
Sensitivity : 30mV/μm

shading voltage				
	Left linear region		Right linear region	
Voltage(V)	9.45	5.8	5.58	9.27
Voltage difference(V)	3.65		3.69	
Displacement(mm)	0.18	0.3	0.38	0.50
Displacement difference(mm)	0.12		0.12	
voltage/displacement(mV/μm)	30.42		30.75	

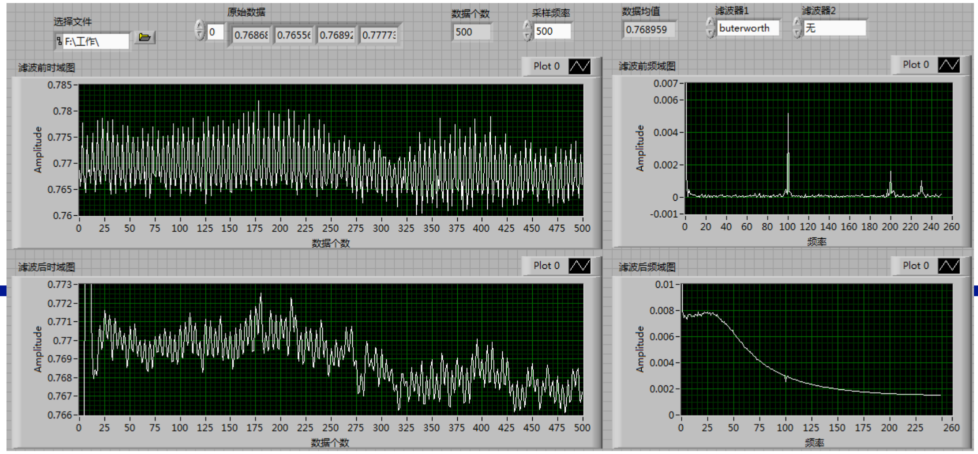


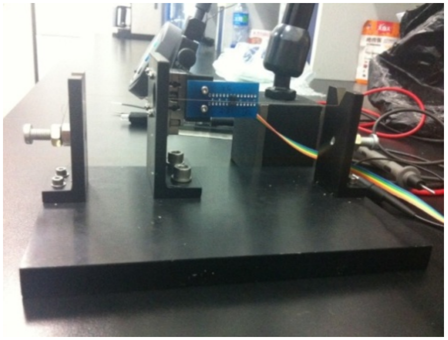
outputs of one of the four Sensors



Sensor circuit

- **Signal stability testing**
  - **After filtering, the voltage variation reduced significantly from 20mV to 6mV.**





Sensor output test bench

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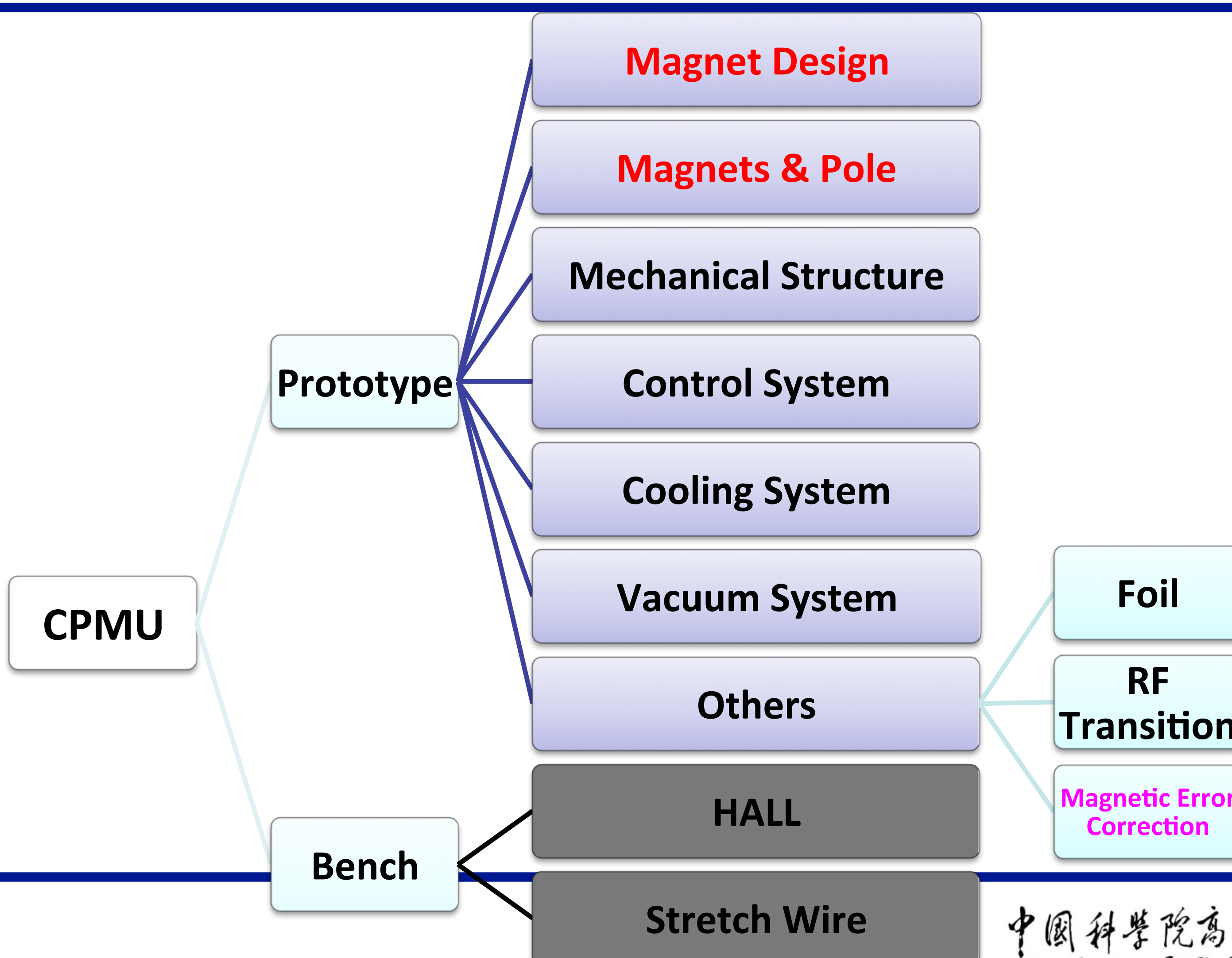
- Insertion device
  - Low temperature undulator
  - Small period SC wiggler → One SC wiggler on BEPCII

Low temp. undulator	
Length of period	12mm
Effective period No.	160
Length of magnet	～2m
Gap tuning range	g=5~100mm
Gap working range	g=5~9mm
Peak field	>0.7T @ g=5mm
Peak field error	< 0.1 % @ g=5-9mm
K	～0.8
Working temperature	80K

Small period SC damping wiggler	
Length of period	31mm
Minimum gap	10mm
Peak field	1.95T
K	～5.6
Pole No.	20
Total length	～0.3m

Preliminary Design was done



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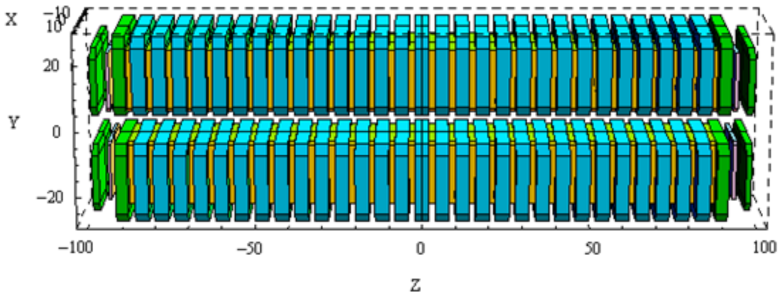
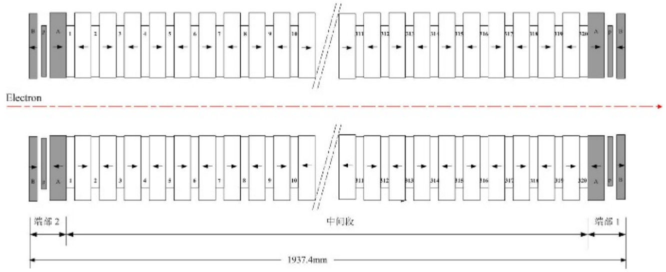
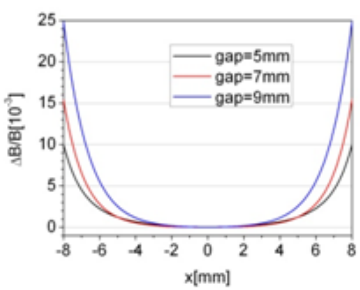
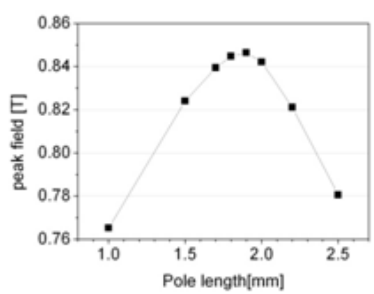
Magnet Design

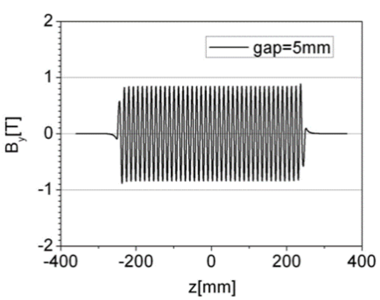


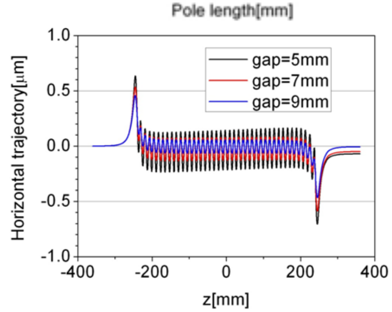
CPMU侧视图







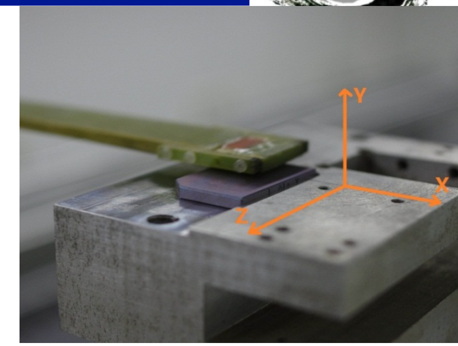


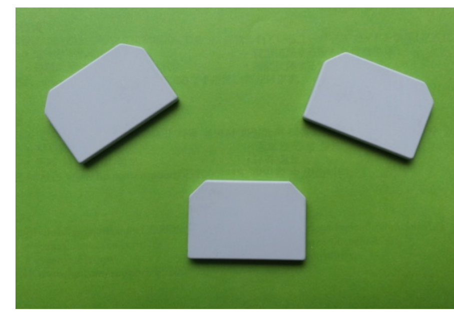


Type	Hybrid
Period Length	12 mm
Working Gap	5～9 mm
Peak Field	0.84 T
Magnet Size	36×24×4.1 mm^3
Pole Size	24×19×1.9 mm^3
End Magnet A	36×24×3.6mm^3
End Magnet B	36×21×1.9mm^3
End Pole p	24×18×1.15mm^3
Air Gap A-p	1.7mm
Air Gap B-p	2.4mm
Phase Error (RMS)	< 6° @ g=5-9mm
First Field Integral (x,y)	<50Gscm
Second Field Integral(x,y)	<20000$Gscm^2$
Quadrupole Normal/Skew	<50Gs
Sextupole Normal/Skew	<100Gs/cm
Octupole Normal/Skew	<100Gs/cm^2

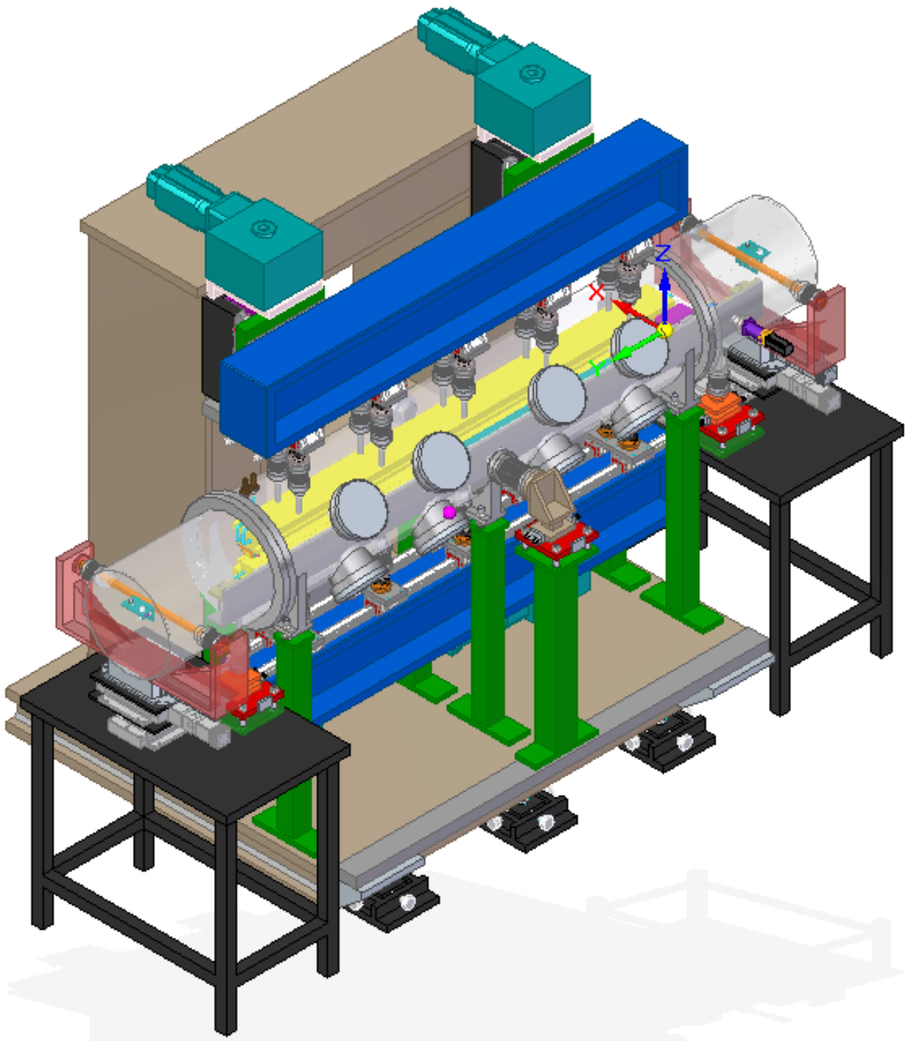
Cryogenic Property Research on PrFeB

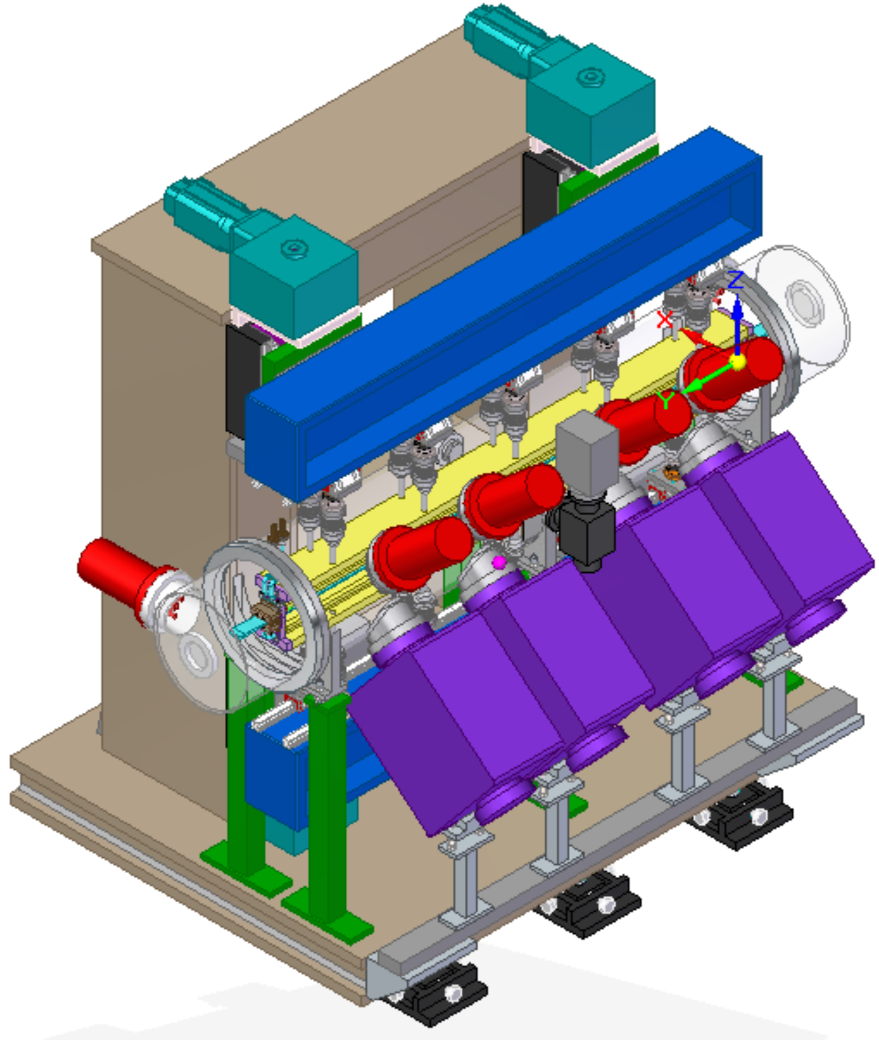
- **PrFeB**
  - **Magnetic**
    - Remanence Br
    - Intrinsic Coercivity Hcj
    - Susceptibility μ
  - **Thermal**
    - Thermal Conductivity
    - Heat Capacity
    - Thermal Diffusivity
    - Density
  - **Electrical**
    - Electrical Conductivity
  - **Mechanical**
    - Young's Modulus
    - Poisson Ratio
    - Compression Strength



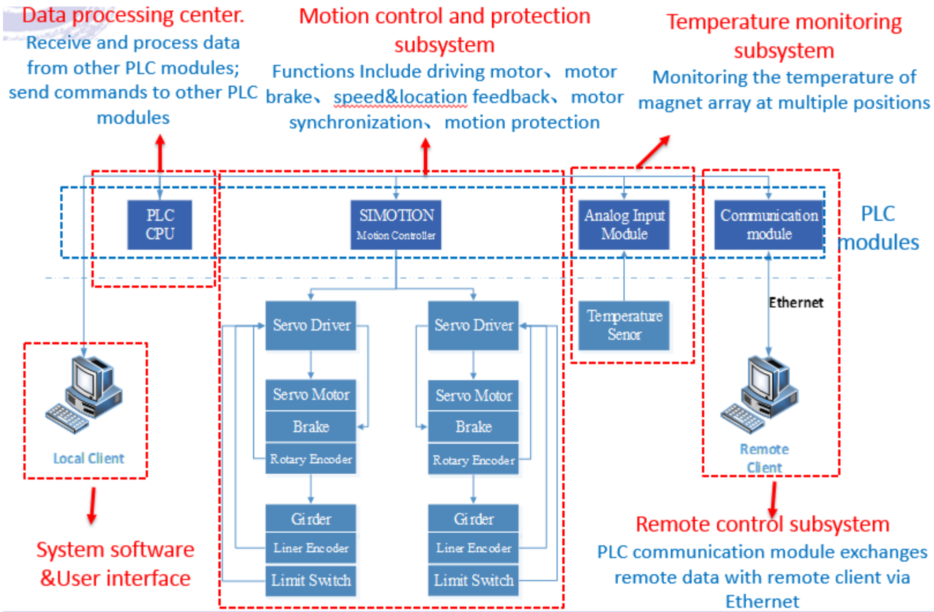


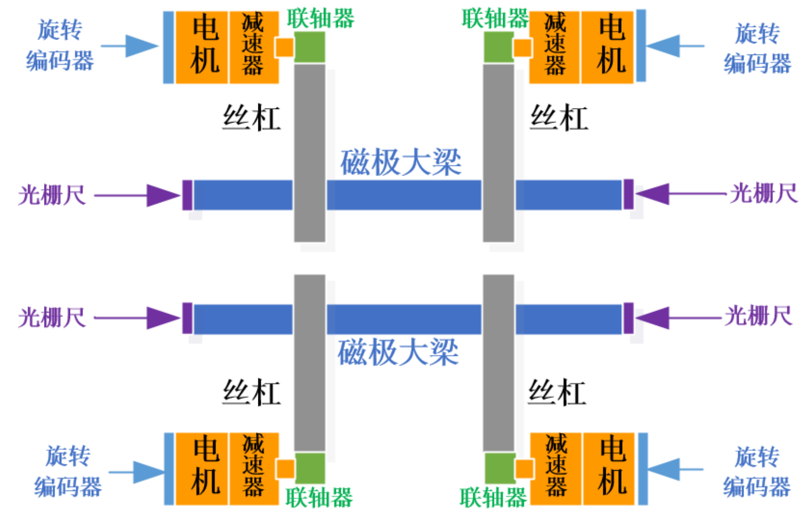
Mechanical Structure

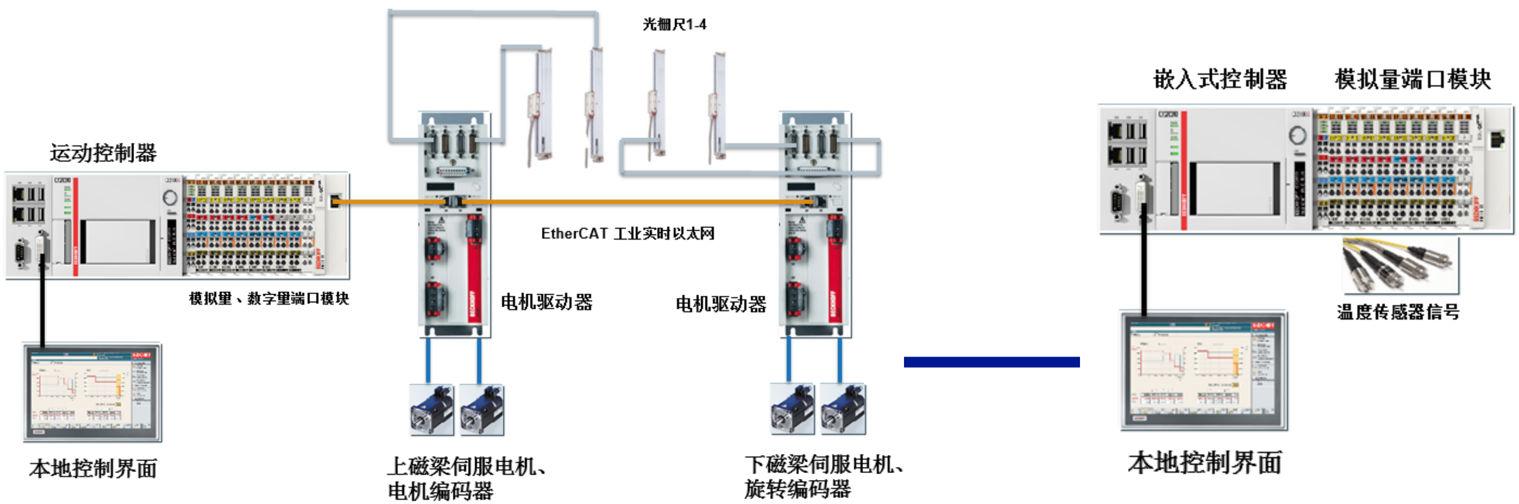




Control System

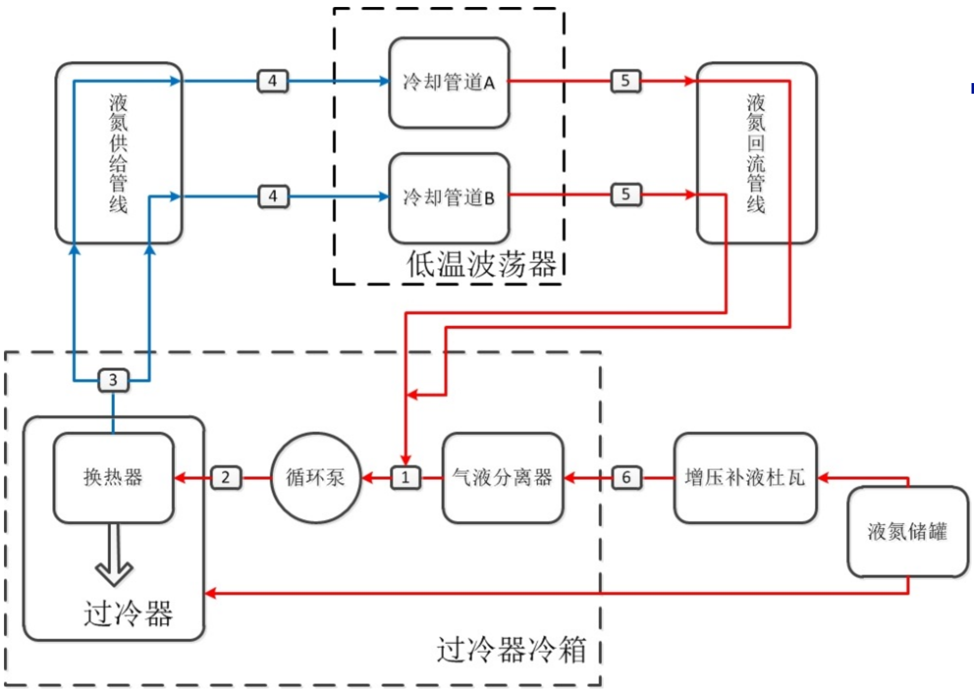


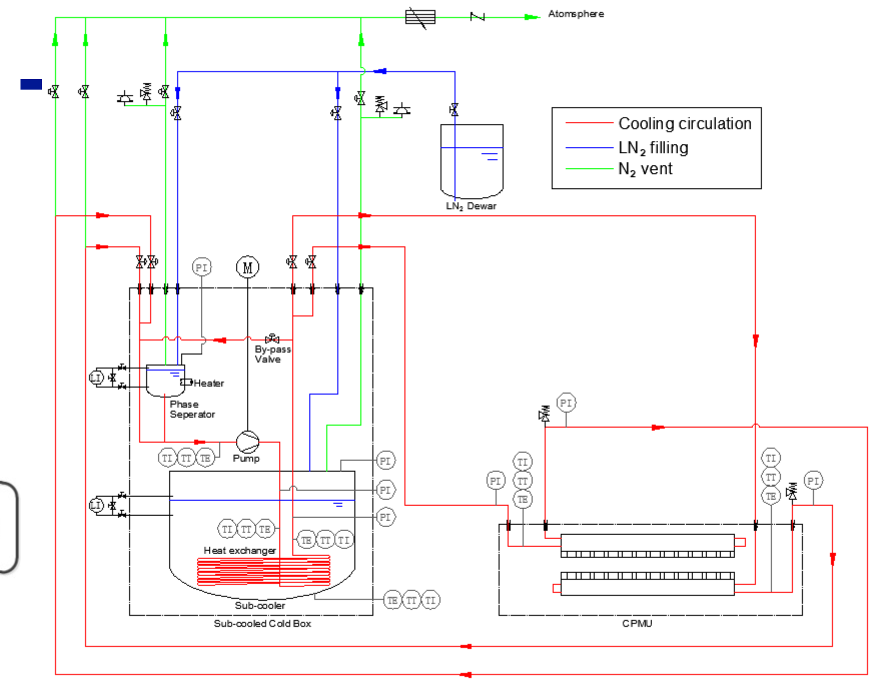


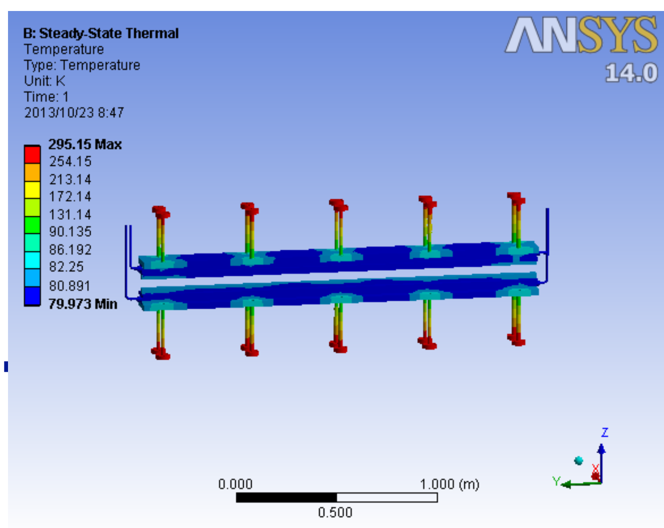


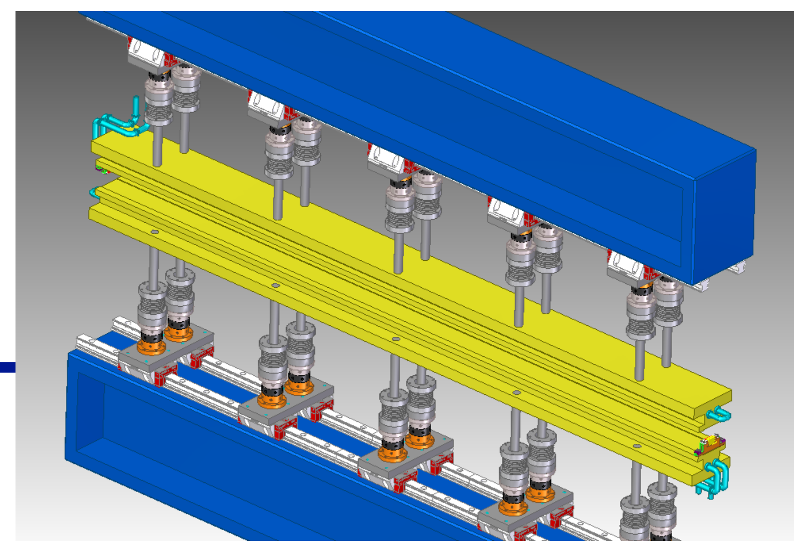
物理研究所
ergy Physics

Cooling System









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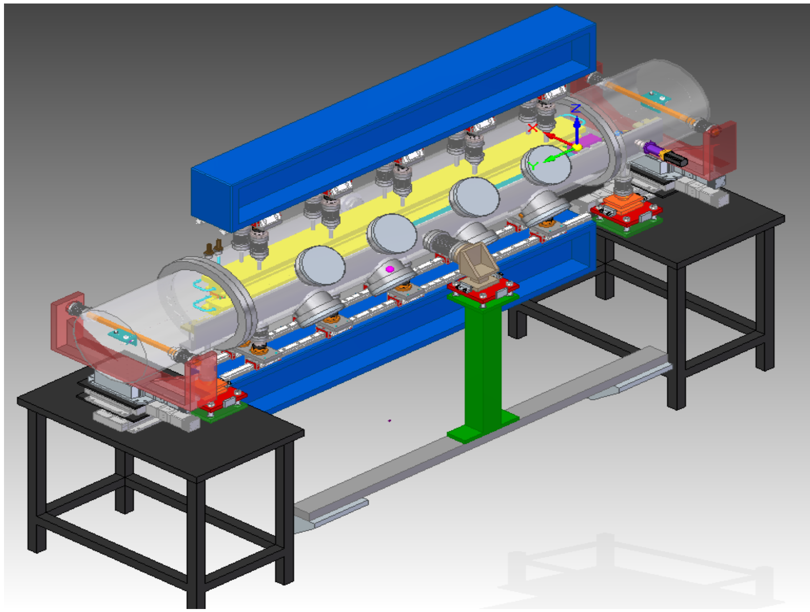
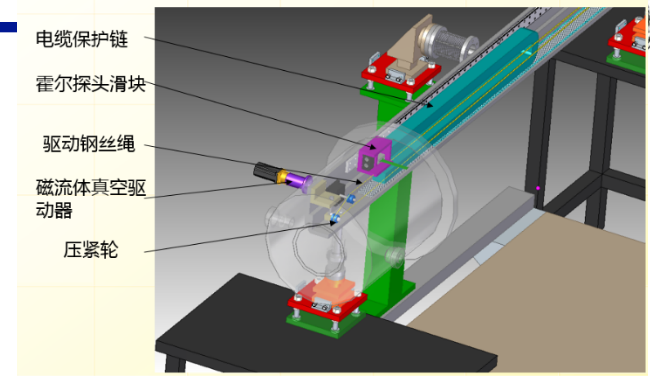
Physics

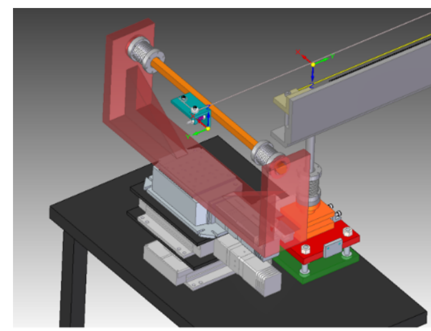
Magnetic Measurement Bench

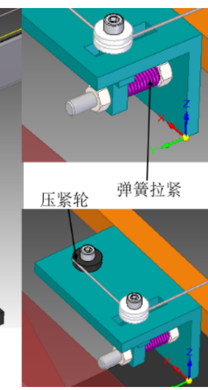


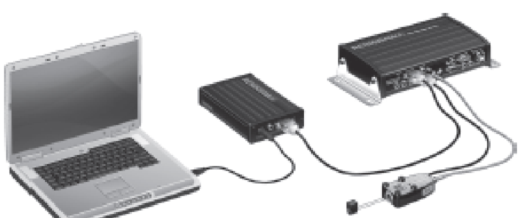
Hall

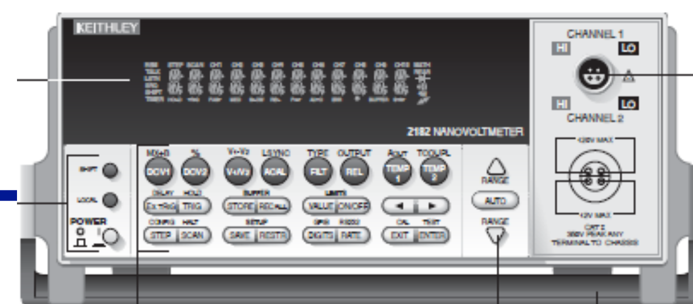


Stretch Wire

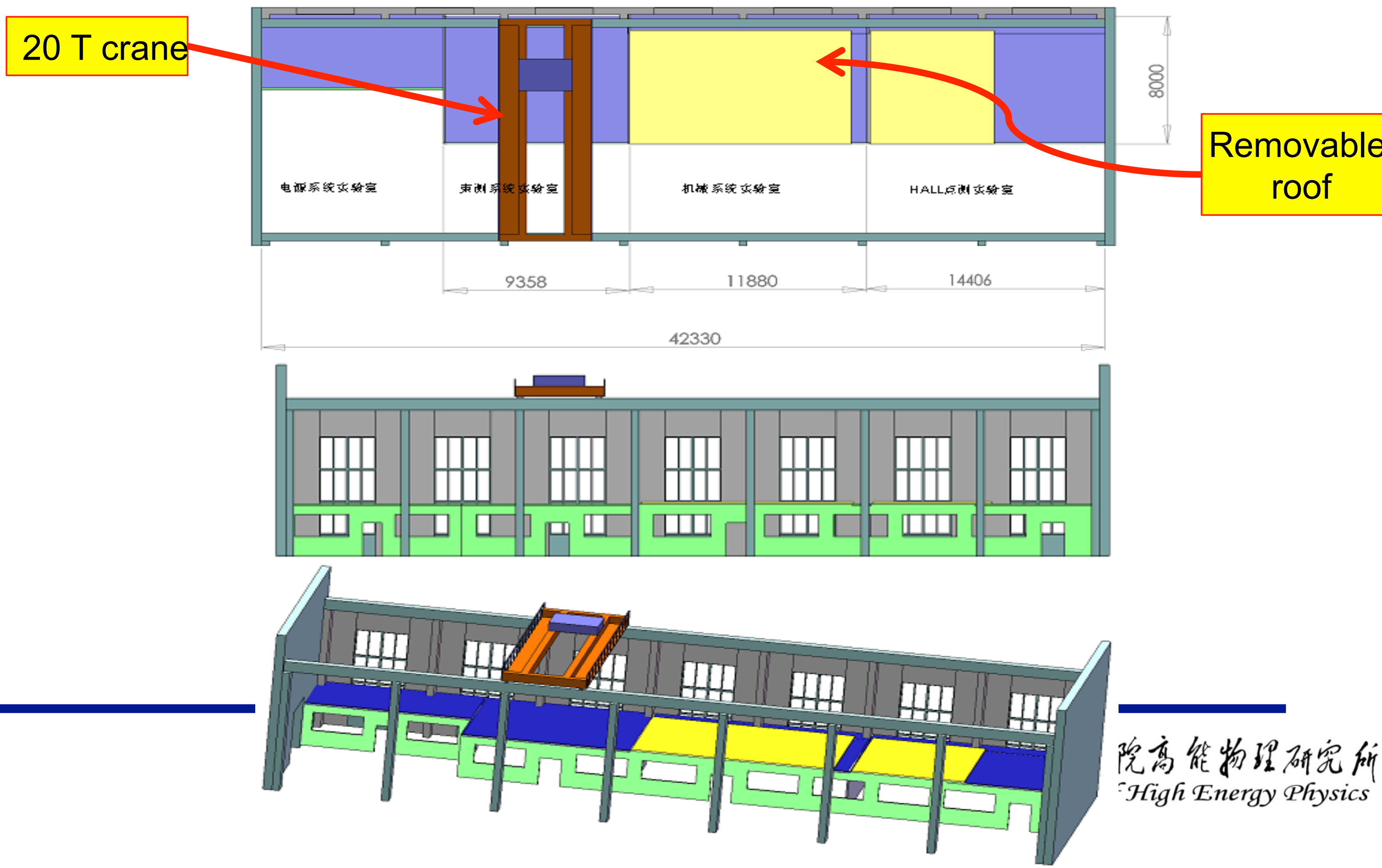








- **Test environment**
  - **Simulate the real environment for magnets on girder, etc.**



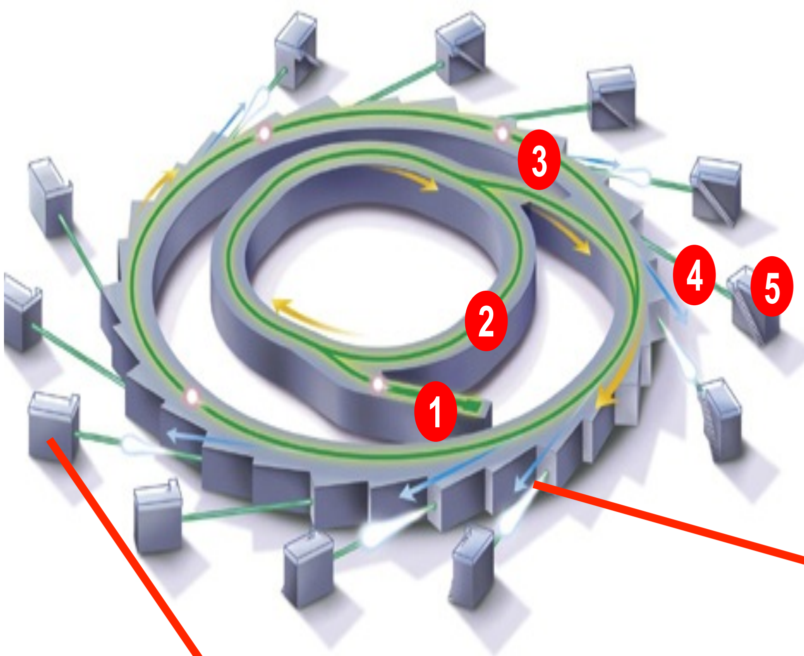
- **RF system**
  - Digital low level control system
  - Integrate solid state amplifier and cavity system
- **Vacuum system**
  - NEG coating
  - Vacuum system design for USR machine

R&D issues of beamlines and stations

- **Material research in situ and in operando**
  - **Smelting: SAXS, XAFS, Imaging @high-T**
  - **Machining: XRD, SAXS, Imaging, *in situ***
  - **In service: XRD, XAFS, Imaging, *in operando*, time-resolved**

- **Cooperation with University of Science & Technology Beijing, USTB**

R&D in BLs and stations

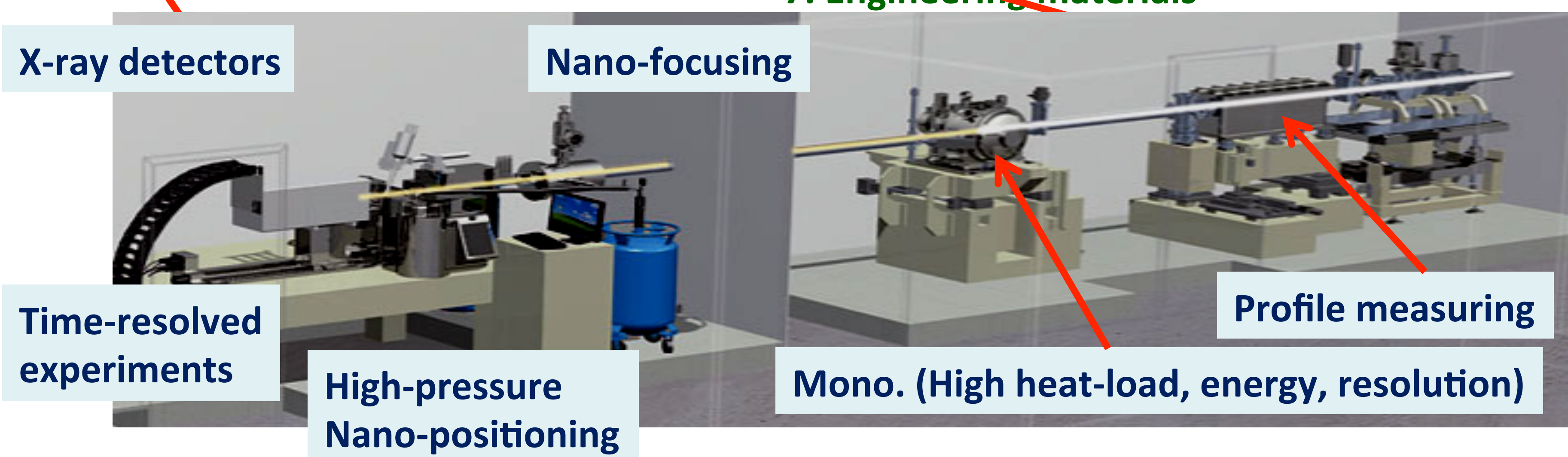


BLs

1. Mono. (High heat-load, energy, resolution)
2. Nano-focusing and positioning
3. Profile measuring

Stations

4. X-ray detectors
5. Time-resolved
6. High-pressure
7. Engineering materials



4. Summary

- HEPS will be a high-energy, low-emmitance SR facility.
- The high-brilliance and hard X-ray provided by HEPS should support the *in situ* and *in operando* research, which are essential for many fields.
- The R&D project, HEPS-TF, has been approved recently. The future project, HEPS, is scheduled to start at 2018.
- We hope to cooperate to overcome the challenges in accelerator, beamlines and stations.

Thanks for your attention！