Construction of Shanghai Synchrotron Radiation Facility

Zhentang Zhao
Shanghai Institute of Applied Physics, CAS, China
APAC2007, RRCAT, Indore, Feb. 1, 2007

Outline

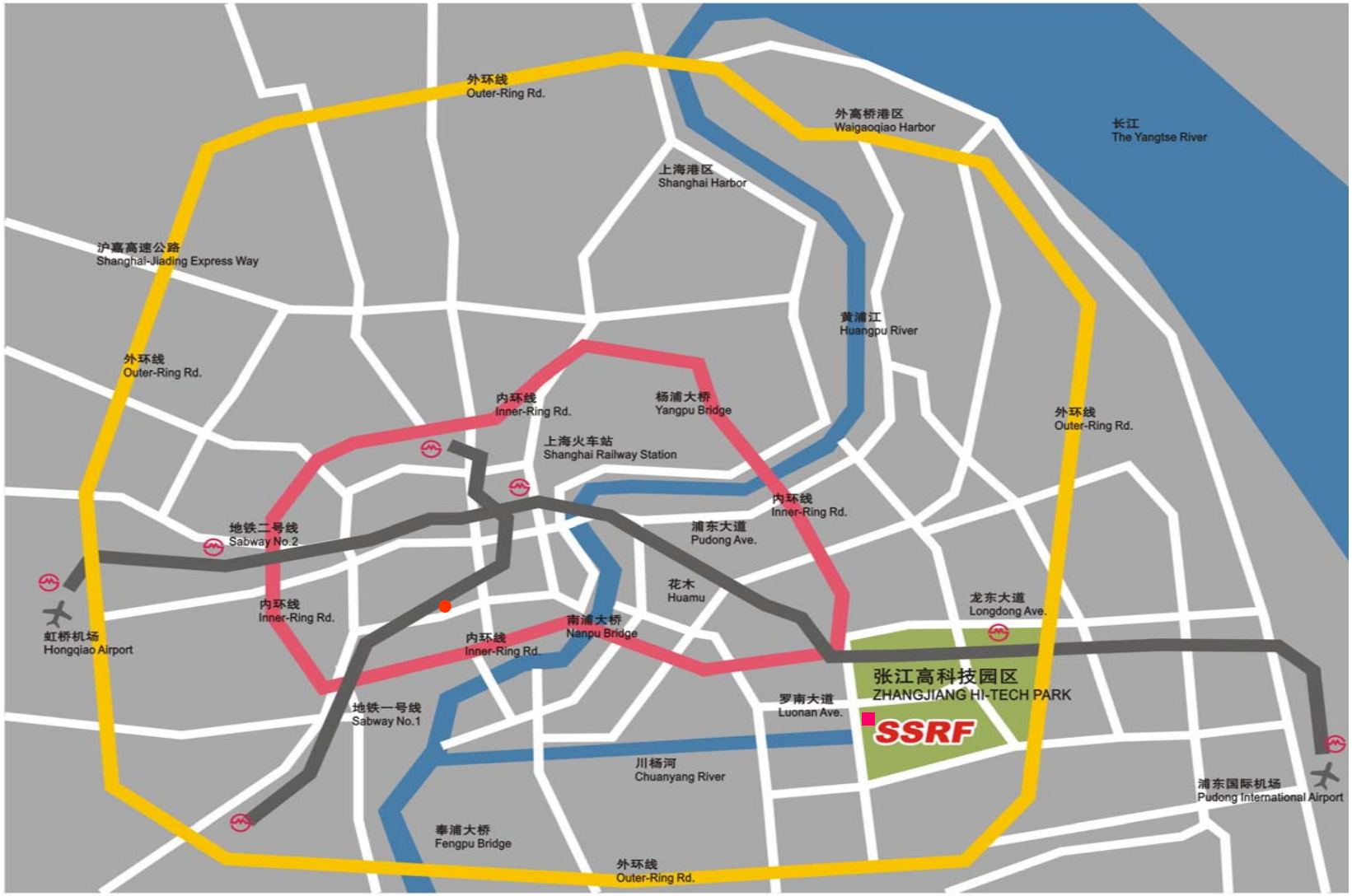
- Shanghai Synchrotron Radiation Facility
- Construction of SSRF Buildings;
- Commissioning of SSRF utilities;
- Status of the SSRF Machine;
- Summary

Overview of the SSRF Project

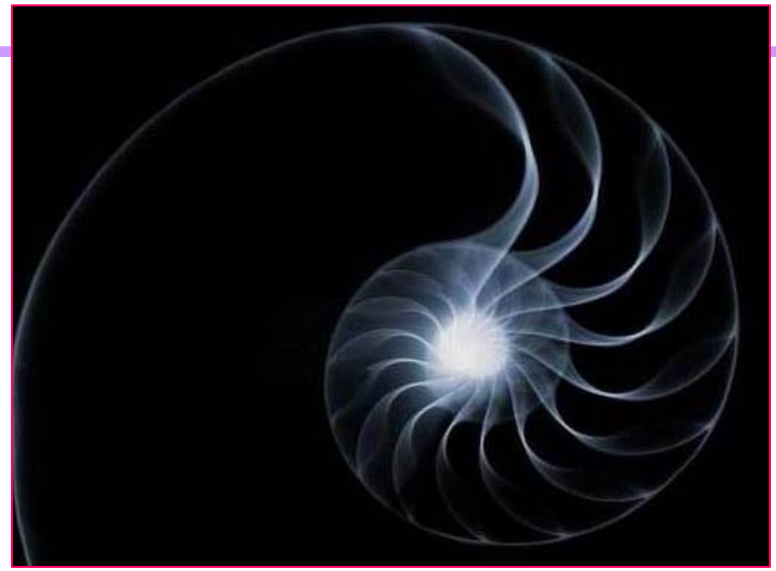
- The Shanghai Synchrotron Radiation Facility (SSRF): is a 3rd generation SR light source based on a 3.5GeV and 432m circumference electron storage ring;
- The SSRF site is located in Zhang-Jiang High Tech Park, Shanghai Pudong new development district;
- The SSRF project is founded by Central Government, Shanghai Local Government and Chinese Academy of Sciences; The total project budget is about 150M USD, which not including land and man power costs;
- The project groundbreaking was made on December 25 2004, and the user operation is scheduled to start in April 2009;

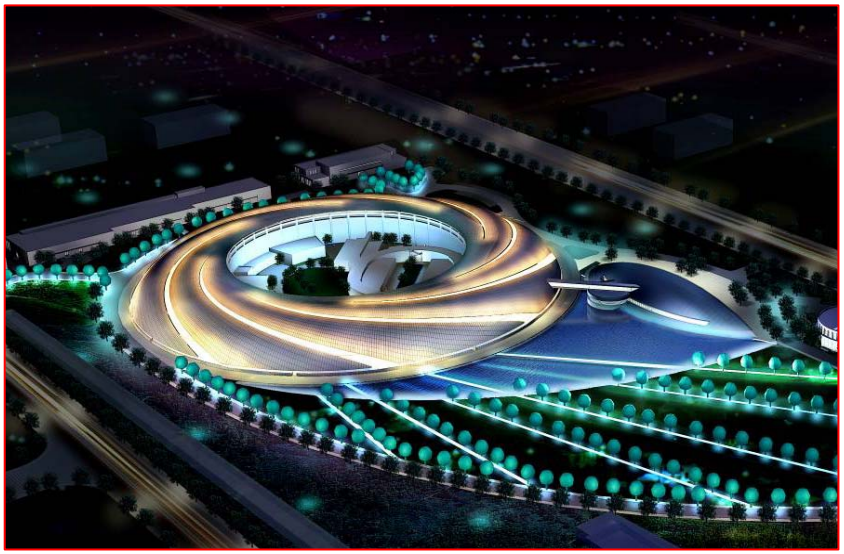

Caspian Sea
KAZAKHSTAN
Aral Sea
Lake Balkhash
Ob'
Yenisey
RUSSIA
Lake Baikal
Amur
Harbin
Shenyang
MONGOLIA
NORTH KOREA
SOUTH KOREA
JAP
UZBEKISTAN
KYRGYZSTAN
TURKMENISTAN
Ürümqi
BEIJING
Tianjin
Yellow Sea
TAJIKISTAN
AFGHANISTAN
Indian claim
Lanzhou
Huang He
Zhengzhou
Shanghai
Nanjing
Xi'an
East China Sea
Wuhan
Indus
Chengdu
Chongqing
Chinese line of control
Brahmaputra
Jiang
Chang
Taipei
PAKISTAN
Lhasa
NEPAL
Ganges
Taiwan
Guangzhou
INDIA
BHUTAN
Mekong
Hong Kong S.A.R.
Macau S.A.R.
BANGLADESH
VIETNAM
South China Sea
BURMA
LAOS
Hainan Dao
PHILIPPINES
THAILAND
0 300
0 300
SSRF

The SSRF Site Location



Layout of the SSRF Campus





Status of the SSRF Buildings

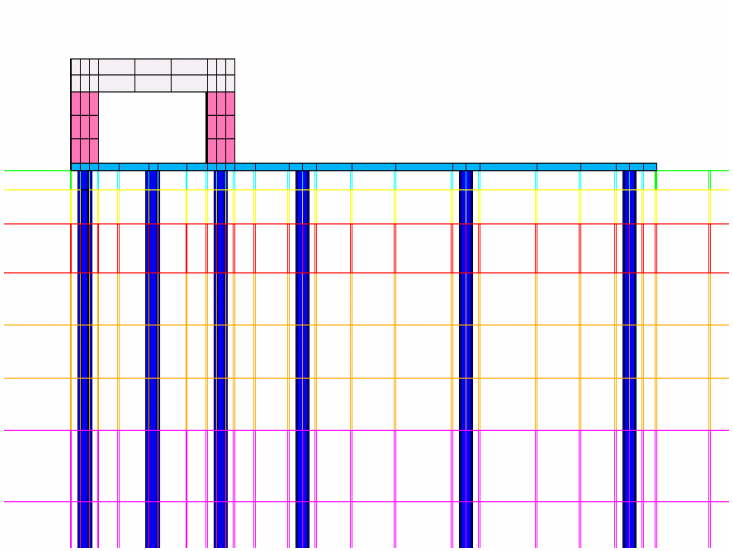
- The SSRF main building's construction is basically completed, which has been opened for machine installation since November 2006;
- The construction of utility buildings and the technical building have been completed and they are already in use;
- The constructions of the SSRF administration building, cafeteria and guesthouse have been completed and they are all in use or operation;

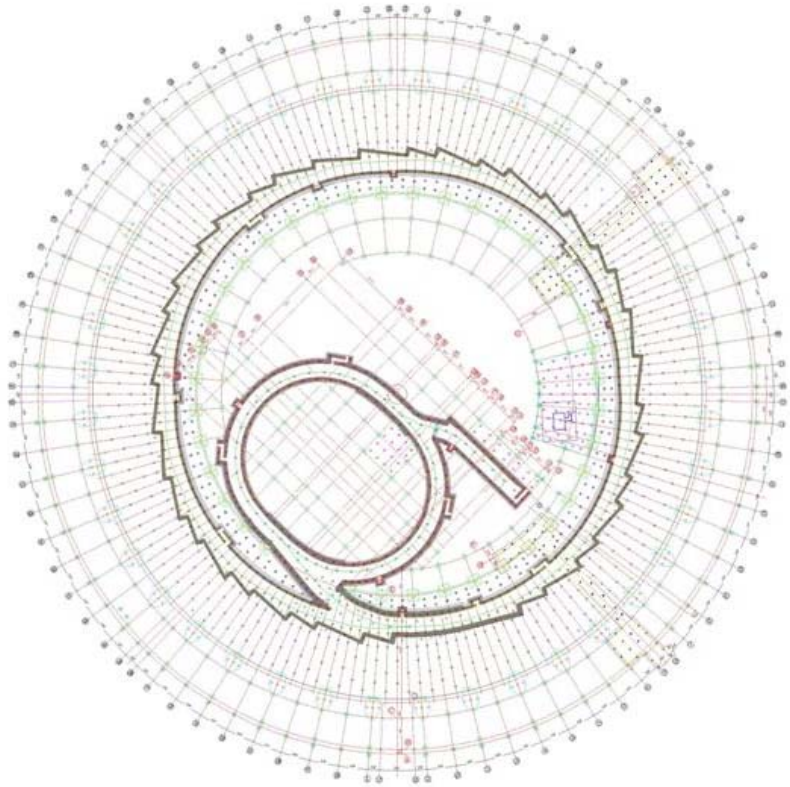
From green field to light source lab

The SSRF Main Building Jan.24, 2007

Solid Foundations

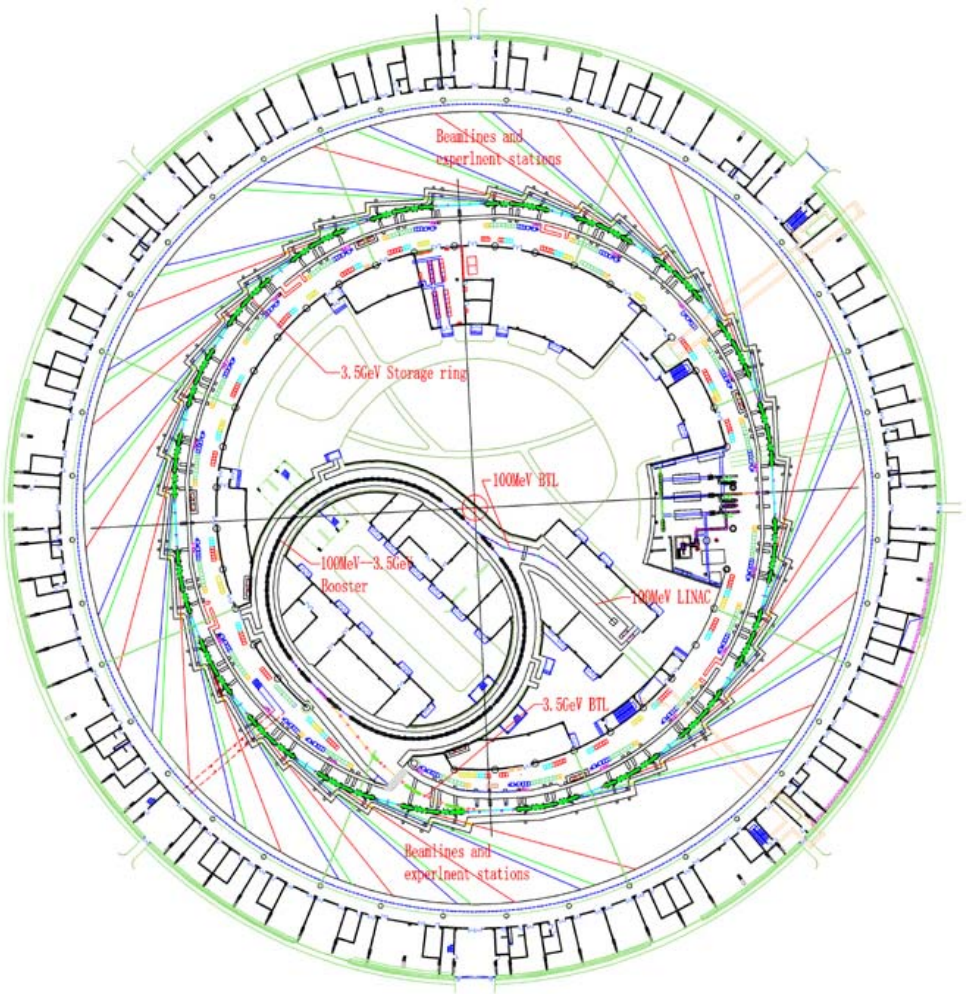
- 1000 piles in 0.6m diameter down to 48m underground
- Slab of 1.45m thick for the storage ring tunnel and SR experiment hall;






动平台

Layout of the SSRF complex



- 150MeV Electron Linac
- 3.5GeV Booster
- 3.5GeV Storage Ring
- Beam Line and Experimental Stations

The SSRF Accelerator Complex

- The SSRF accelerator complex consists of a 150MeV Linac, a full energy booster and 3.5GeV storage ring
- The energy selected higher than 3GeV for getting higher photon energy;
- High brightness and high flux optimized for photon energy range of 0.1 - 40keV;
- High beam stability @ the long, medium and short term ;
- Top-up injection considered as one of the normal operation mode;

SSRF Design Criteria

- **Optimization goal**
  - **Storage ring energy: 3.5GeV**
  - **Natural emittance: <4nm-rad**
  - **Circumference: <450m**
  - **Beam current: 200 ~ 300mA,**
  - **Beam lifetime: >10hrs**
  - **Beam size at ID source point: ~ 150 μm x 30 μrad**
  - **Orbit stability: 10% of beam size**
  - **Total straight length: >1/3 Circumference (with long and standard)**

The SSRF Storage Ring

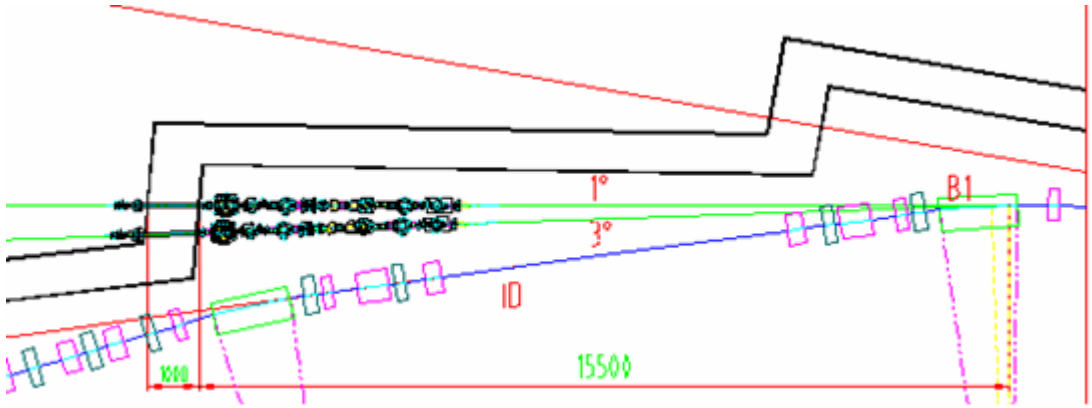
- A 20-cell double bend ring lattice structure with a circumference of 432 m and a natural emittance of 3.9nm-rad;
- 4 fold configuration with two types of straight sections (16x6.5m and 4x12m);
- One 12m straight for accommodating all injection elements, another one for RF cavities and other 18 for various IDs;
- Reasonable dispersion, beta functions and beam sizes at straight sections;

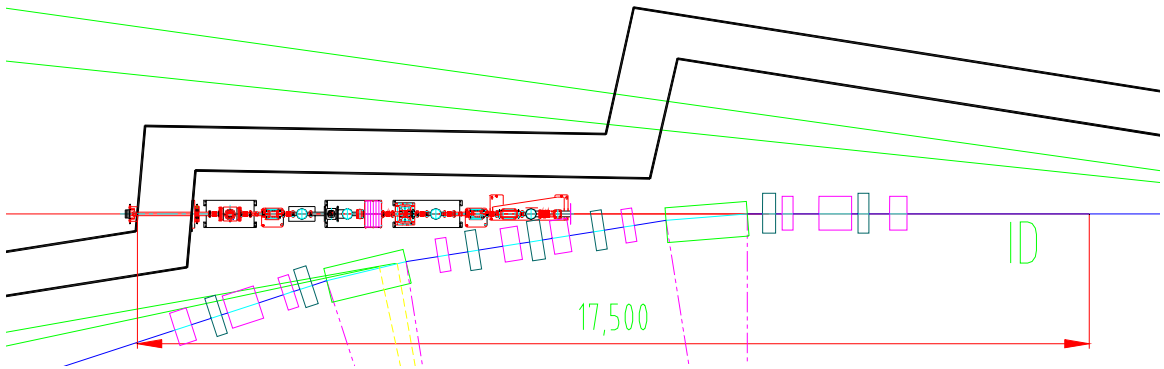
Main Parameters of the SSRF Storage Ring

	DBA	Low-emittance mode	Normal Mode
Enenrgy	GeV	3.5	3.5
Circonference	m	432	432
Natural Emittance	nm· rad	3.9	11. 2
Current：Multi-bunch（Single）	mA	200~300(5)	200~300(5)
Number of Cells		20/4	20/4
Straights: Length×Number	m	12×4、6.5×16	12×4、6.5×16
$\beta_x/\beta_y/\eta_x$ in middle of 12m straight	m	10.0/6.0/0.15	10.0/6.0/0.0*
$\beta_x/\beta_y/\eta_x$ in middle of 6.5m straight	m	3.6/2.5/0.10	3.6/2.5/0.0*
Betatron Tune Q_x/Q_y		22.22/11.32	22.22/11.32
Chromaticity ξ_x/ξ_y		-56/-19	-56/-19
RF Voltage	MV	4.0~6.0	4.0~6.0
Energy Loss Per Turn (Dipole only)	MeV	1.448	1.448
Max beam power	kW	~600	~600

Source Points

BM beamlines:
Separate front-ends



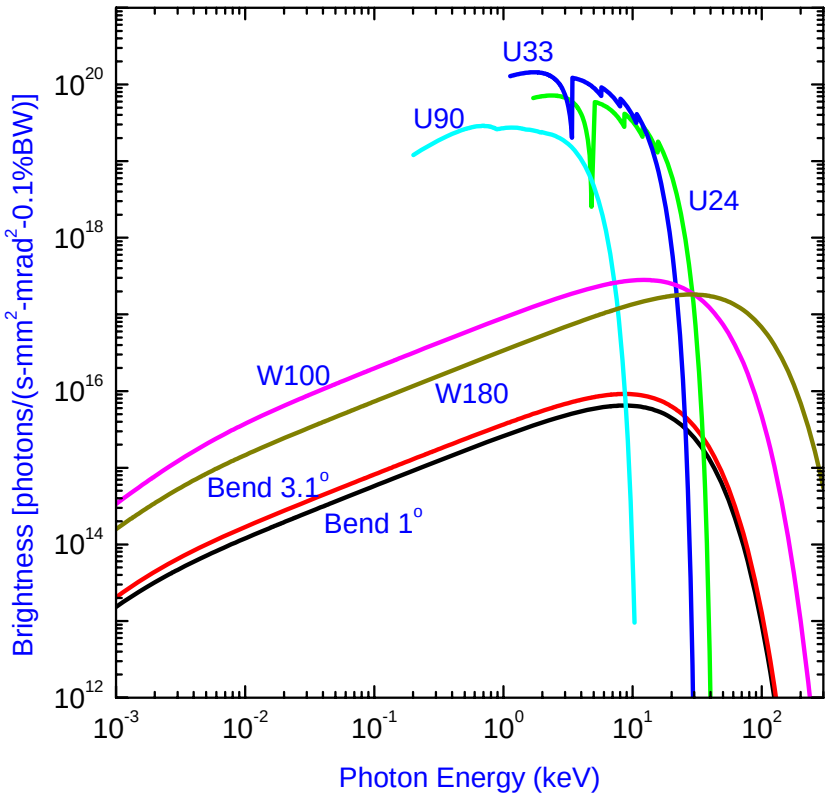


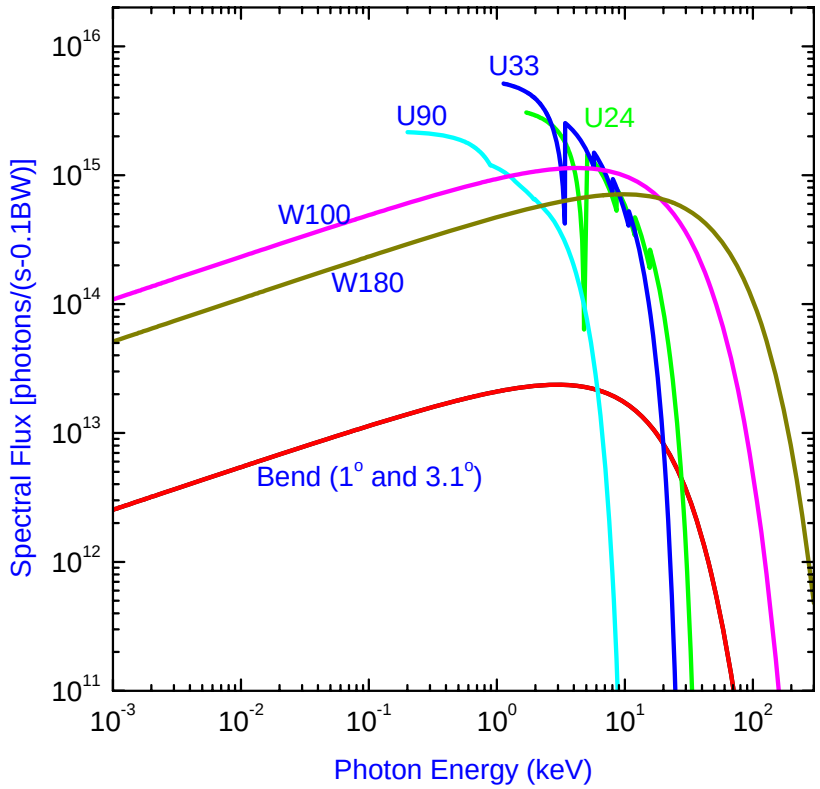
ID beamlines:
share the front-end

SSRF Beam Sizes at Source Points

Source Point	σ_x (μm)	σ_x' (μrad)	σ_y (μm)	σ_y' (μrad)
Standard Straight (6.5m)	158	33	9.9	3.95
Long Straight (12.0m)	247	20	15	2.55
1°@upstream of SS	70	114	22	1.97
3.1°@upstream of SS	53	94	22	1.97
1°@upstream of LS	77	116	23	1.79
3.1°@upstream of LS	56	96	23	1.79

SSRF Spectral Brightness and Flux

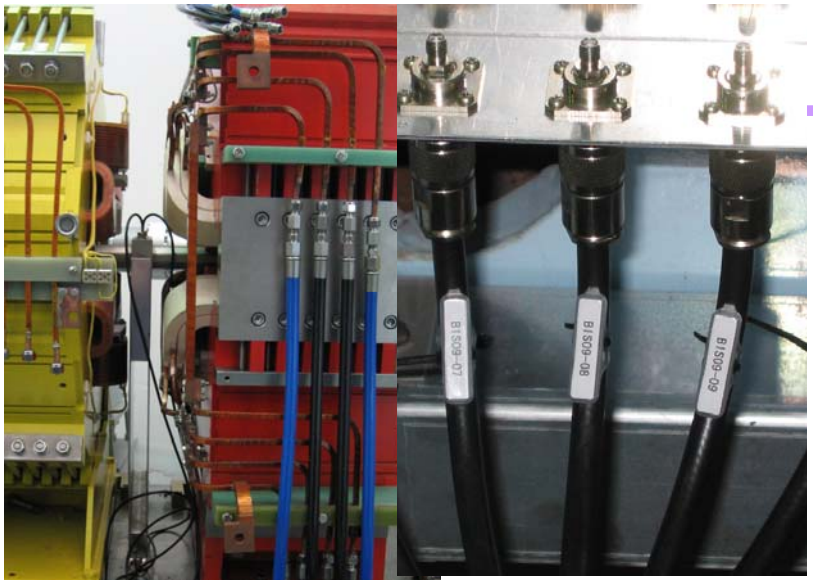


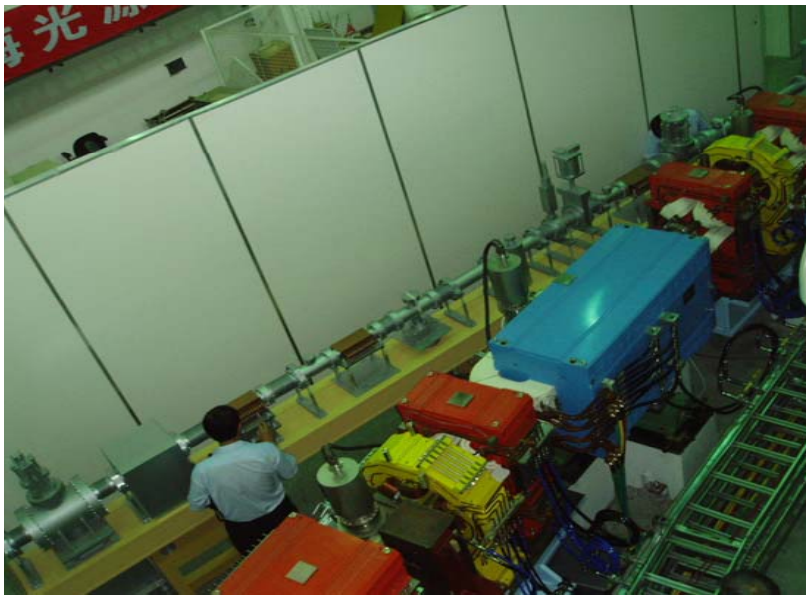


E=3.5 GeV， I=300 mA, ε=3.9 nm·rad, Emittance coupling = 1%

Status of the SSRF Storage Ring

- **Equipment manufacture**
  - Prototypes and first products have been manufactured and tested up to their specifications;
  - Main equipment, such as a magnets, vacuum chamber, RF transmitters, liquid helium refrigerator, girders, power supplies and etc., are delivered to the SSRF site or constructed on schedule;
- **Installation and integration**
  - A lab test installation of a storage ring cell has been carried out to validate the engineering design;
  - A on site test installation of a complete ring cell in the tunnel has been carried out to check the installations;

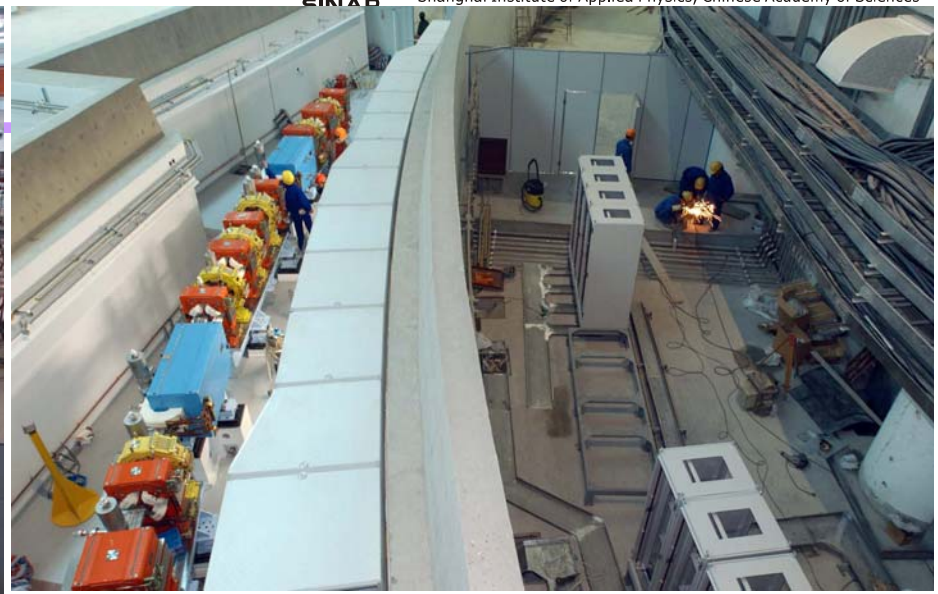

BIS09-07
BIS09-08
BIS09-09



Status of the SSRF Storage Ring

- **First Installation of a ring cell**

- First installation of a mechanical ring cell in the tunnel has been carried out last week to validate installation procedures, techniques, man power and schedule;
- First installation of a utility sector in the ring tunnel is being carried out to verify the piping and the cabling;
- First installation of a electrical sector in the ring inner technical corridor is being carried out to finalize the engineering design and electrical installation tech;




2007/01/25

Status of the SSRF Storage Ring

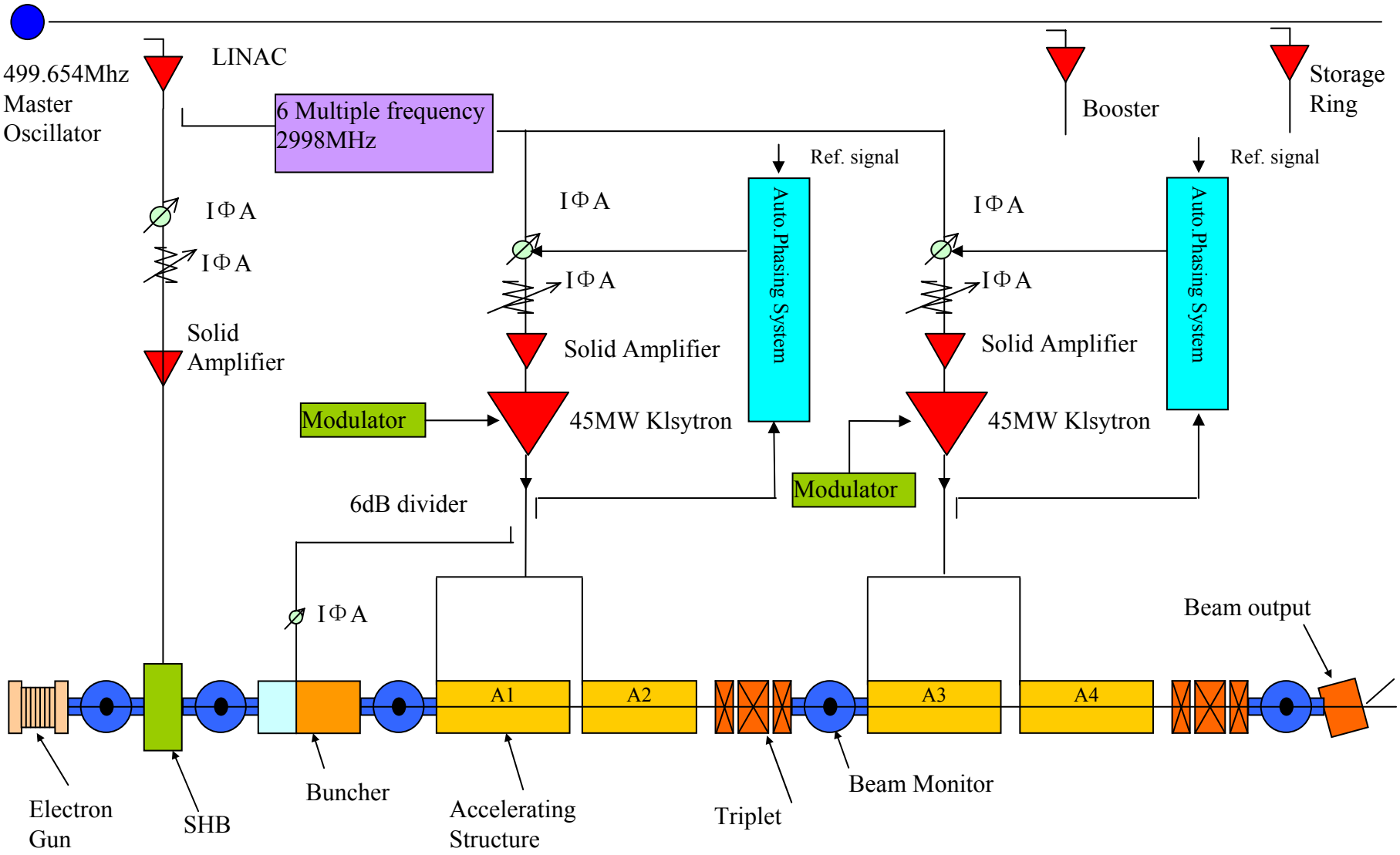
Installation of system equipment

- Refrigerator, RF transmitters, waveguide system are being installed and tested in the RF hall of the SSRF main Building;
- Power supplies will be installed from August 2007;
- Control and beam instrumentation equipment, PPS and MPS systems, are prepared for installations;
- The installation in Central control room and computer server room will start in May 2007;

The SSRF Linac

- A dedicated 150MeV Linac for top-up operation, consisting of four 2998MHz/3m long accelerating sections, a fundamental buncher and a sub-harmonic buncher;
- Frequency of 2998MHz chosen to have harmonic relation with the storage ring RF frequency;
- With Single and multi bunch operation modes;

Layout of the SSRF Linac



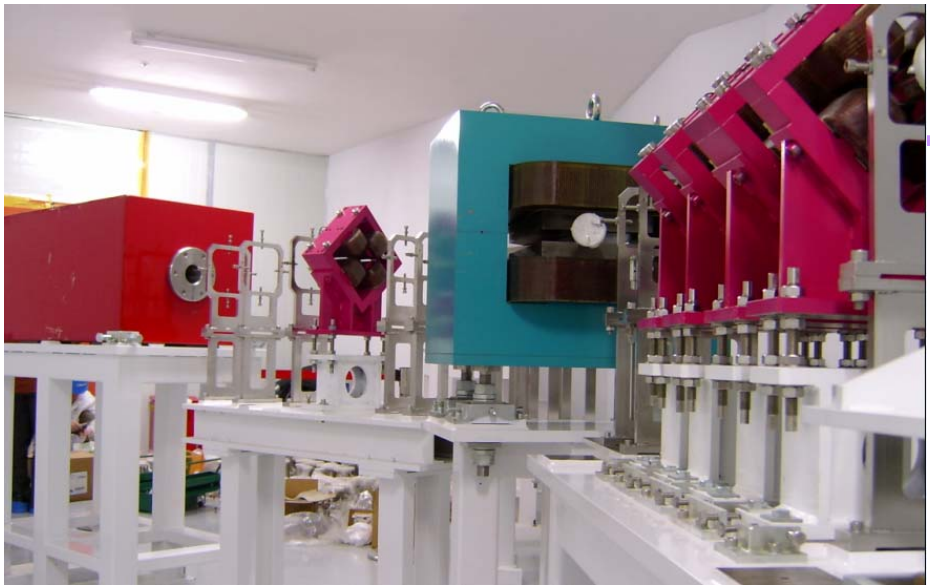
Main Parameters of the SSRF Linac

Nominal energy(MeV)	150
Pulse length: Single/multi-bunch (ns)	1/ 200
Beam charge Single/multi-bunch (nC)	1/3
Pulse to pulse energy stability (rms)	0.5%
Relative energy spread (rms)	0.5%
Normalized Emittance (mm·mrad)	< 50
Frequency (MHz)	2997.924
Repetition Rate (Hz)	1~10

Status of the SSRF Linac

- Almost all of the linac components have be delivered to the SSRF site for acceptance and installation;
- The linac installation started in Nov. 2006 and will be finished at end of March;
- The four accelerating sections, two triplets and one bending magnet, two Farady beam dumps and etc. have been installed and aligned; two modulators and two klystrons have been integrated and being tested;
- The linac commissioning is expected to start in the coming April;


2007/01/22




2007/01/25


2007/01/25

The SSRF Booster

- A full energy booster optimized for top-up injection;
- Two fold Lattice configuration to accommodating 28 FODO cells with 8 missing dipole magnets;
- Extraction beam emittance designed at about 100 nm-rad for getting a clean top-up operation;
- A circumference of 180m and a injection energy of 150MeV;
- Repeat rates up to 2Hz;

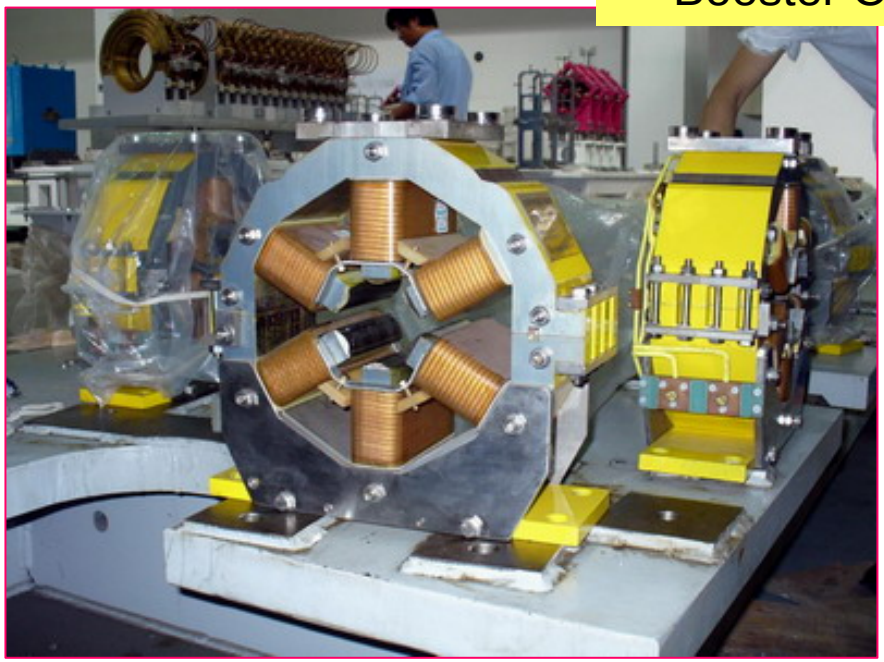
Main Parameters of the SSRF Booster

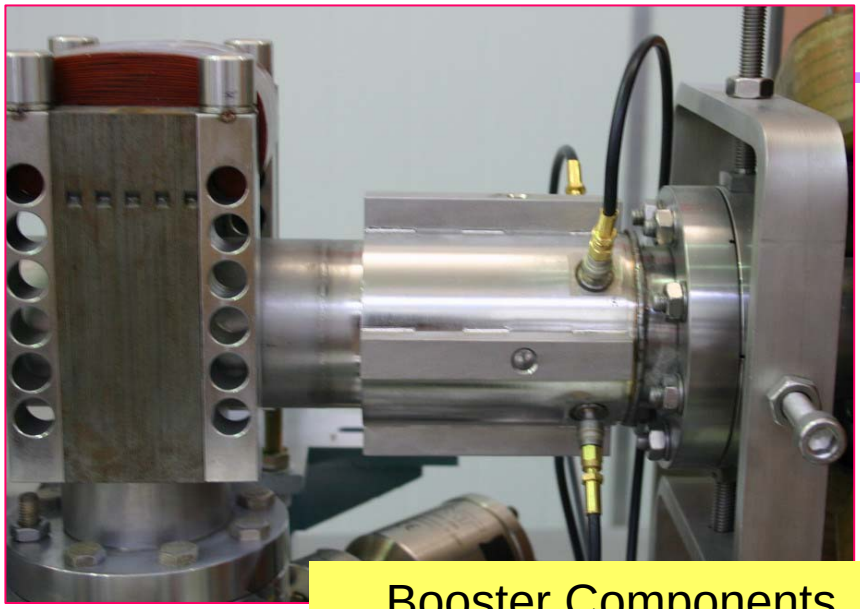
Injection energy	GeV	0.15	
Extraction energy	GeV	3.5	
Beam Current Single/Multi bunch	mA	1.6/15	
Circumference	m	180	
Cell number/Super periods		28/2	
Energy loss per turn at 3.5 GeV	MeV	0.915	
Natural emittance at 3.5 GeV		104	94.6
Betatron tune, ν_H /ν_V		8.181/5.229	8.416/5.389
Nature Momentum spread		7.799×10^{-4}	7.802×10^{-4}
Momentum compaction, α_P		0.01849	0.0176
Damping time, $\tau_{H,V,L}$	mS	4.8/4.6/2.3	4.8/4.6/2.3
RF Frequency	MHz	499.65	
Required RF voltage V_{RF}	MV	1.8	

Status of the SSRF Booster

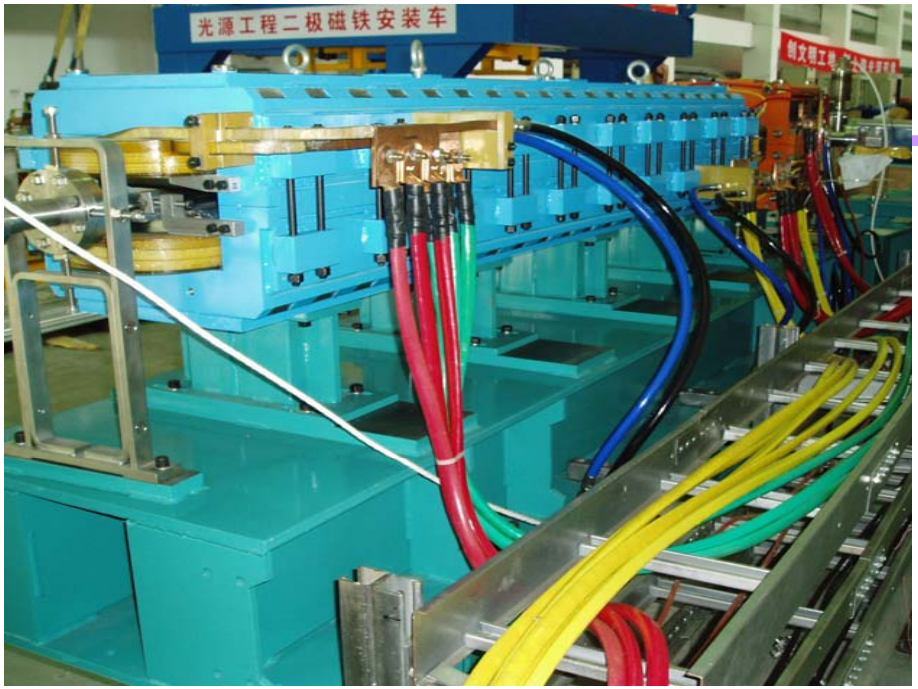
- Most of the booster components are under fabrication on schedule, part of them have been delivered to the SSRF site for acceptance testing;
- A lab test installation of a booster cell has been carried out to verify the engineering design, cabling and piping as well as installation techniques;
- The pre-assembly and pre-align of the booster magnet cell are being performed, which is expected to be installed from May 2007;
- The booster commissioning is scheduled in the coming October;

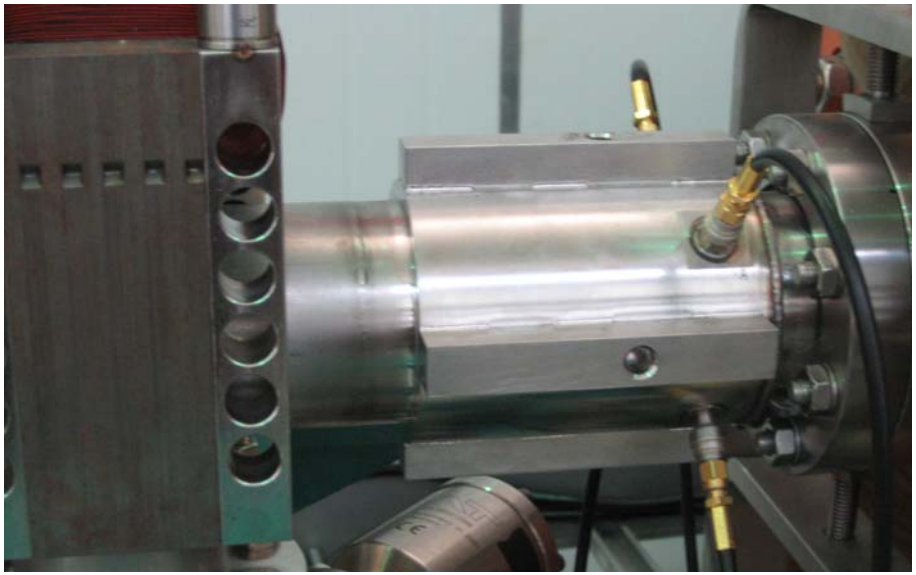
Booster Components





Booster Components


光源工程二极磁铁安装车




请勿触摸


2007/01/22


2007/01/25

The First SSRF Beamlines

- Macromolecular Crystallography (In-Vac Und.)
- High-Resolution Diffraction
- X-ray Absorption Fine Structure Spectroscopy (W.)
- Hard X-ray Micro-focus and Application (In-Vac Und)
- X-ray Imaging and Biomedical Application (W)
- X-ray Scattering
- Soft X-ray Microscopy (Und.)
- X-ray Interference Lithography – (SINAP)

The SSRF Construction Schedule

- Dec. 2004 ~ Sept. 2006: Building construction
- Jun. 2005 ~ Mar. 2008: Accelerator equipment and components manufacture and assembly
- Dec. 2005 ~Dec. 2008: Beamline construction and assembly
- Apr. 2007 ~ Jul. 2007: Linac commissioning
- Oct. 2007 ~ Mar. 2008: Booster commissioning
- Apr. 2008 ~ Oct. 2008: Storage ring commissioning
- Nov. 2008 ~ Mar. 2009: Beamline commissioning
- Apr. 2009: The SSRF operation begins

Summary

- Construction of the SSRF project is progressing on schedule towards the machine commissioning;
- The SSRF equipment and components are still being manufactured at industries;
- The accelerator installation started with the SSRF linac in November 2006 is going well;
- It is expected to start the linac commissiong in April 2007, the booster commissioning in October 2007 and the storage ring commissioning in April 2008;
- The user operation is scheduled to start in April 2009.


Thank you for your attention
谢谢！