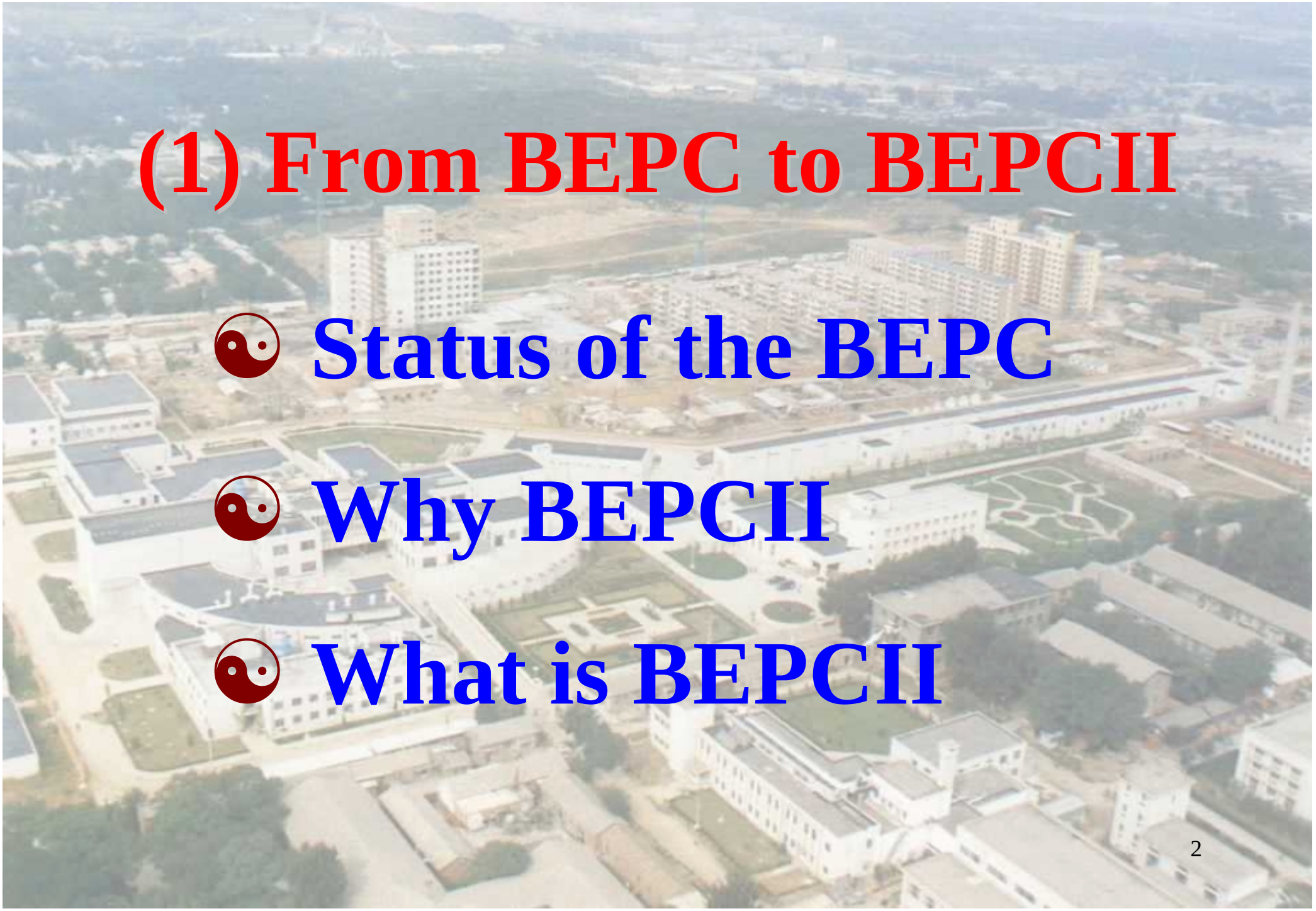
BEPCII :

Status and Progress

C. Zhang for BEPC Team

September 10, 2003, Workshop on e^+e^- in 1-2 GeV Range, Alghero, Italy

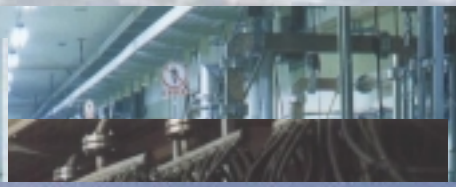
- **From BEPC to BEPCII**
- **Basic Design**
- **Key Technologies**
- **Budget and schedule**
- **Summary**

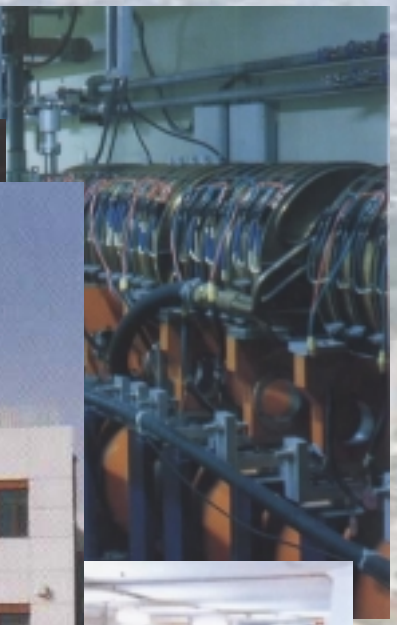


(1) From BEPC to BEPCII

- Status of the BEPC
- Why BEPCII
- What is BEPCII

1.1 The Status of the BEPC

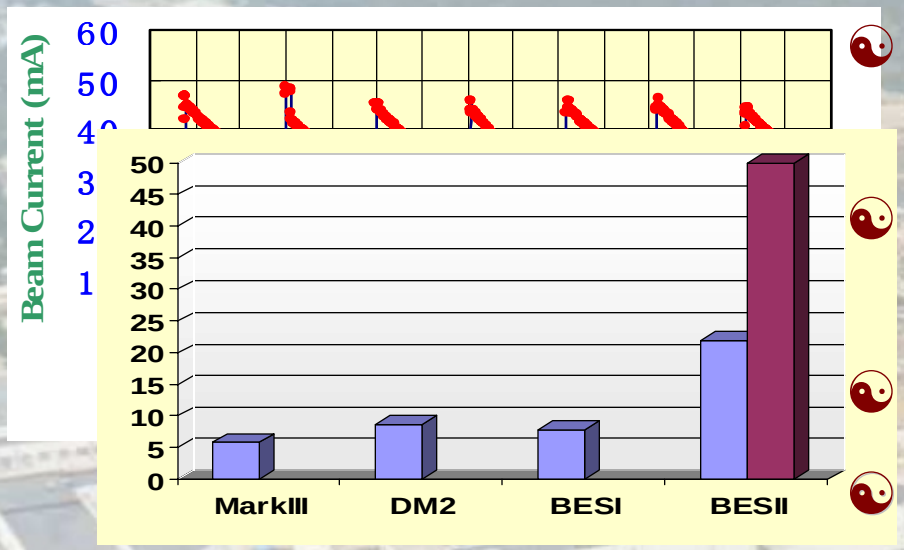


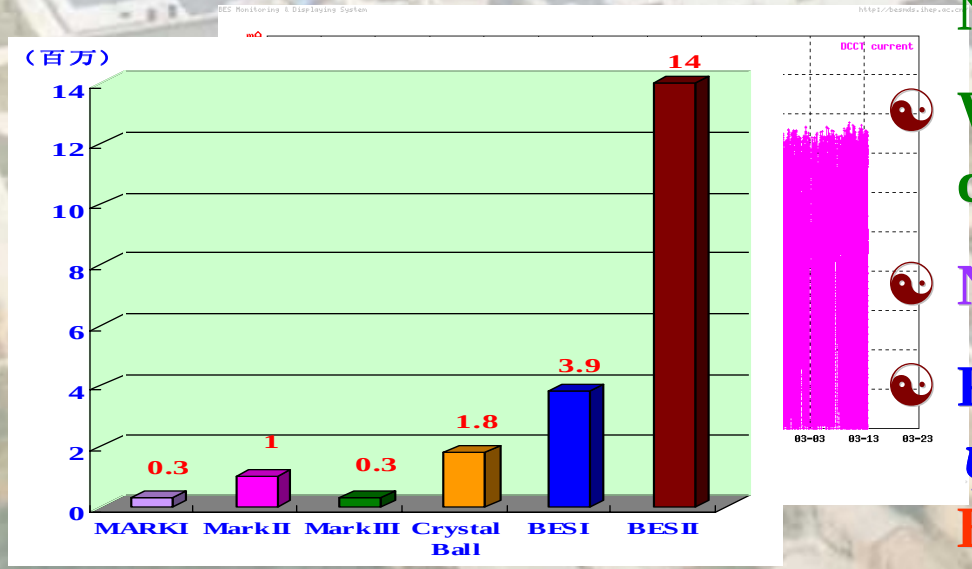


Main Parameters

Beam Energy (E)	1.0 ~ 2.5 GeV
Revolution frequency (f_r)	1.247 MHz
Lattice Type	FODO + Low-β Insertions
β^*_x -function at IP (β^*_x/ β^*_y)	1.3/0.05 m
Transverse Tune (ν_x/ν_y)	5.8/6.8 (Col. Mode) 8.72/4.75 (SR Mode)
Natural Energy Spread (σ_e)	$2.64E \times 10^{-4}$
Momentum Com. Factor (α_p)	0.042 (Col. Mode) 0.016 (SR Mode)
Hor. Natural Emittance (ε_{x0})	0.4@1.55 GeV, 0.076@2.2GeV(SR) mm·mr
RF Frequency (f_{rf})	199.533 MHz
Harmonic Number (h)	160
RF Voltage (V_{rf})	0.6~1.6 MV
Bunch Number (N_b)	1*1 (Col.), 60~80 (SR)
Maximum Beam Current	50mA@1.55 GeV (Col.,) 130mA (SR)
Luminosity	5×10^{30} cm^{-2} s^{-1} @1.55 GeV, 1×10^{31} cm^{-2} s^{-1} @1.89GeV

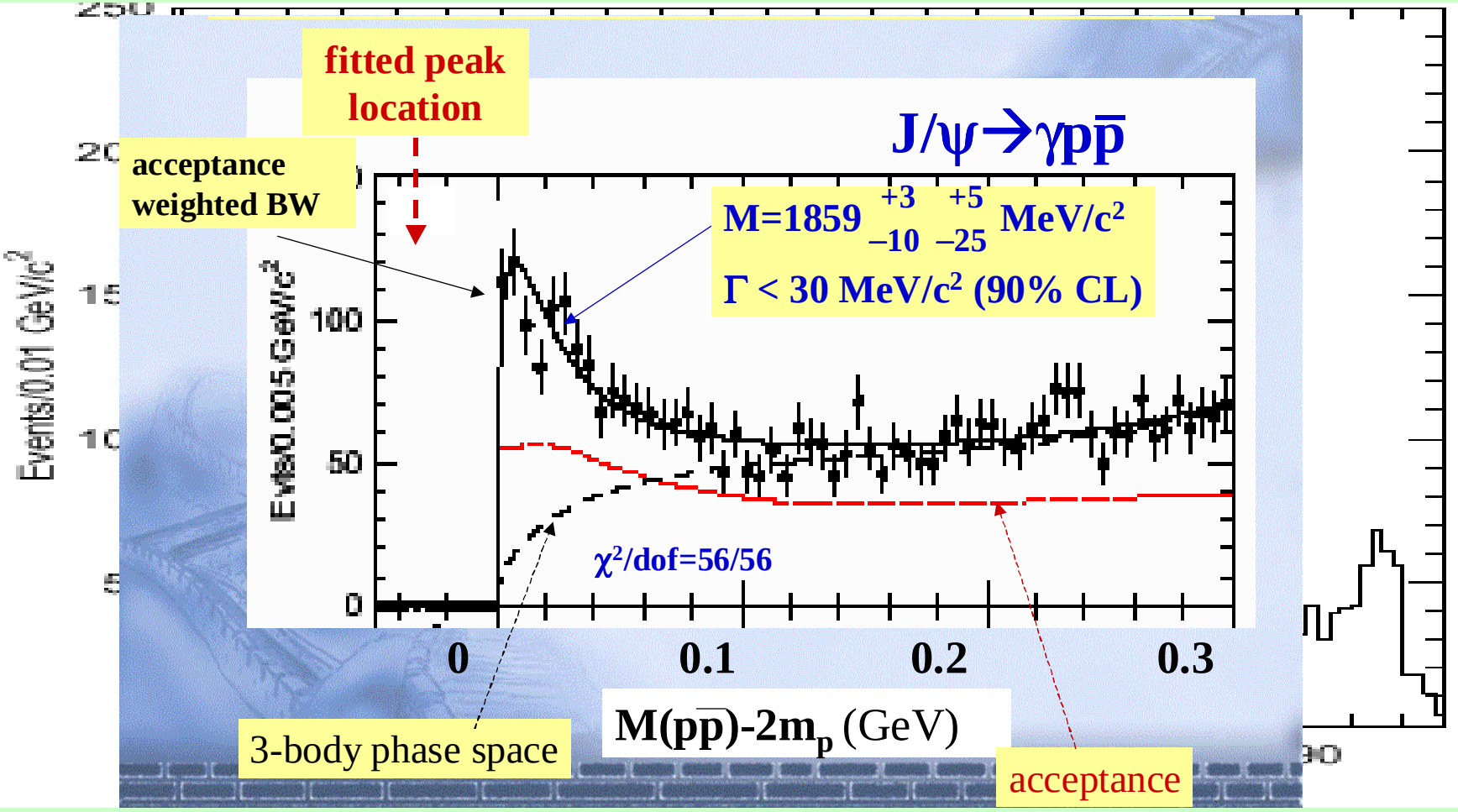
2.1 *Why BEPCII*



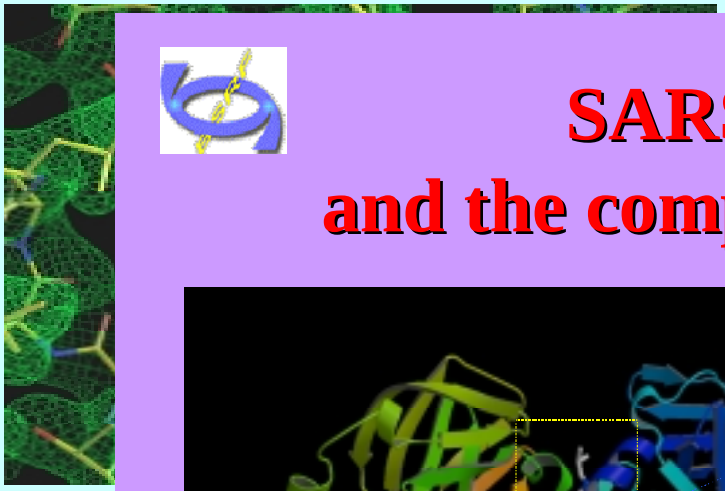


- **BEPC/BESI collected 9 ×10^6 J/ψ events in about two years;**
- **Upgraded BEPC/BESII obtained 5×10^7 J/ψ events in two years;**
- **BEPC/BESI collected 4 ×10^6 ψ' events;**
- **BEPC /BESII operated for ψ' from Nov. 23, 2001 to March 13, 2002;**
- **With 1 ×10^6 a week, 1.4×10^7 ψ' was collected in 100 days;**
- **Nice physics results are expected;**
- **For our physics goal, 6 ×10^9 J/ψ 2×10^9 ψ' per year are expected → → → BEPCII/BESIII!**

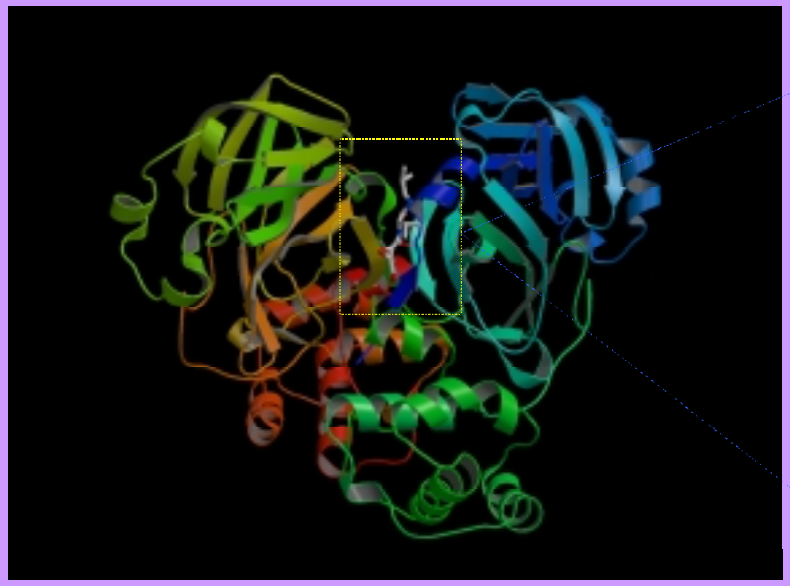
Proton-antiproton bond state?
Multiple quark state?

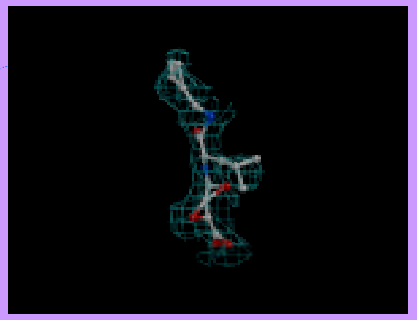


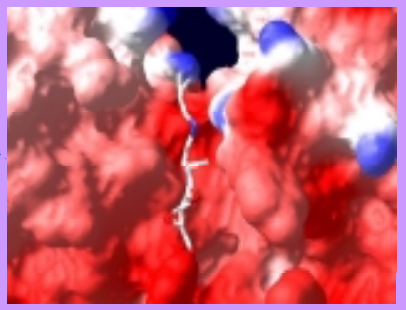
Structure of phenol sulfotranferese (PST)



SARS-CoV M^{pro} and the complex with inhibitor



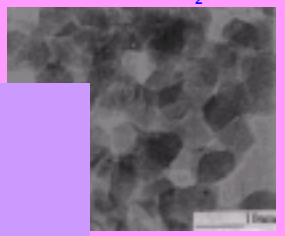




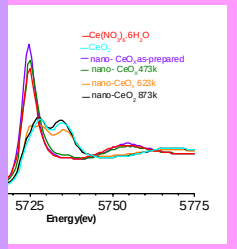
SARS-CoV M^{pro} and inhibitor

Ce N-edge NEXAFS

Nano-CeO_2



3-edge NEXAFS



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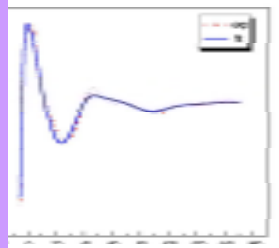
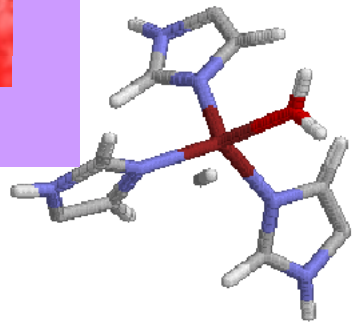
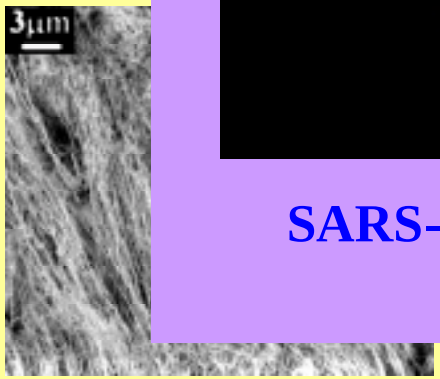
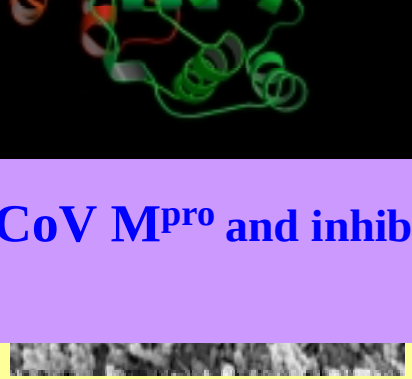




Samples





Sample 1

Sample 2

Scientific Goal of the BEPCII

Remains a dual-purpose facility

- **Charm and τ physics**
  - Light hadron spectroscopy, charmed mesons and τ at the thresholds;
  - Hadron production mechanism, low energy QCD;
  - Precision R values, ambiguous' structures in 3.8-4.2 GeV.
  - Searches for glueball, hybrids and exotic states;
  - New physics: probing rare decay, CP violation from the decays of J/ψ and ψ(2S);
  - ……
- **Synchrotron radiation research**

  Serve as a platform of multi-discipline researches with improved performance.

1.3 What is BEPCII

DR: multy-bunch k_{bmax}~400, k_b=1 → 93

Choose large ε_x & optimum param.: I_b=9.75mA, ξ_y=0.04

$$L(\mathrm{cm}^{-2}\mathrm{s}^{-1}) = 2.17\times10^{34}(1+R)\xi_y \frac{E(GeV)k_b I_b(A)}{\beta_y^*(cm)}$$

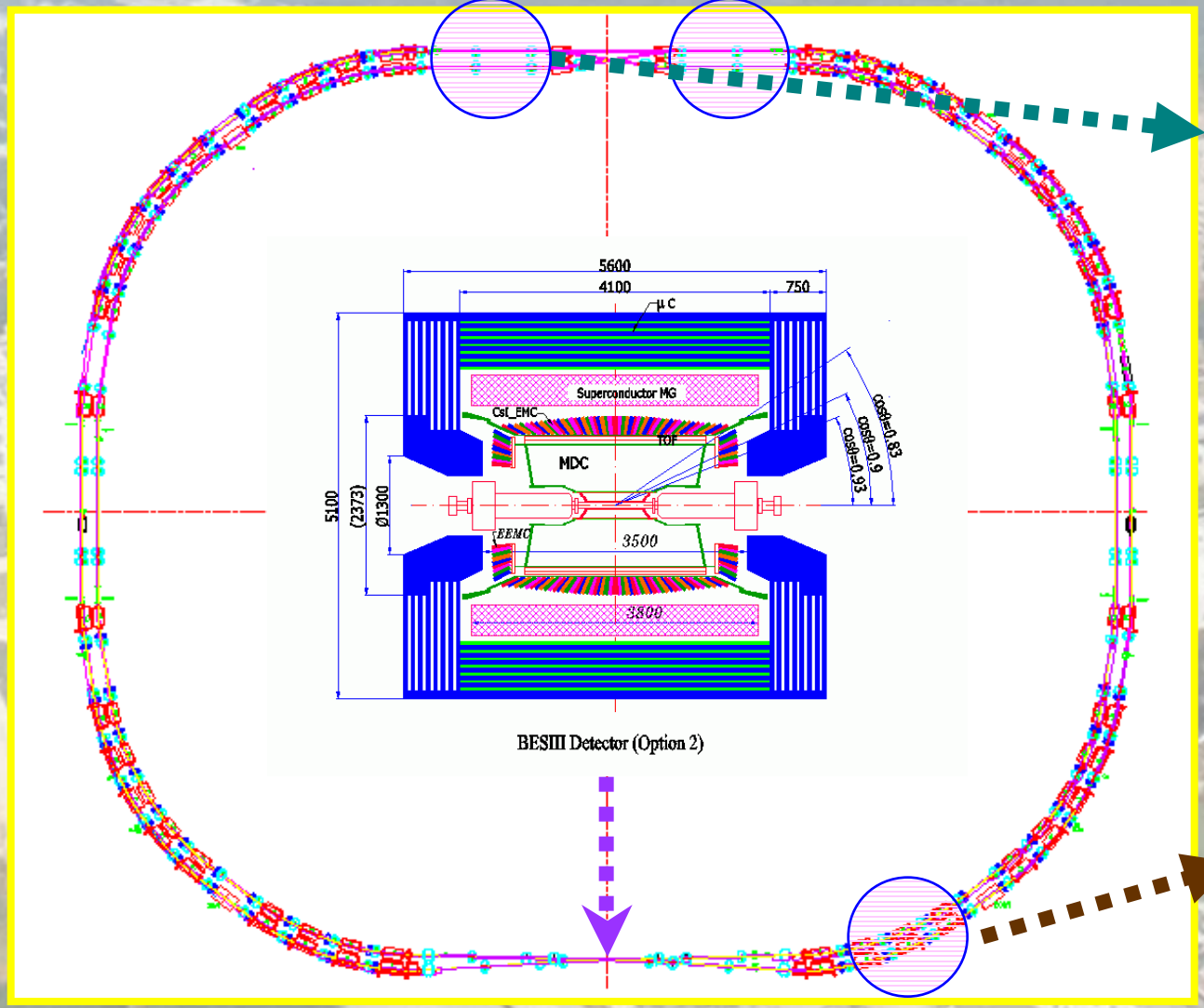
Micro-β: β_y^* =5cm → 1.5 cm
SC insertion quads

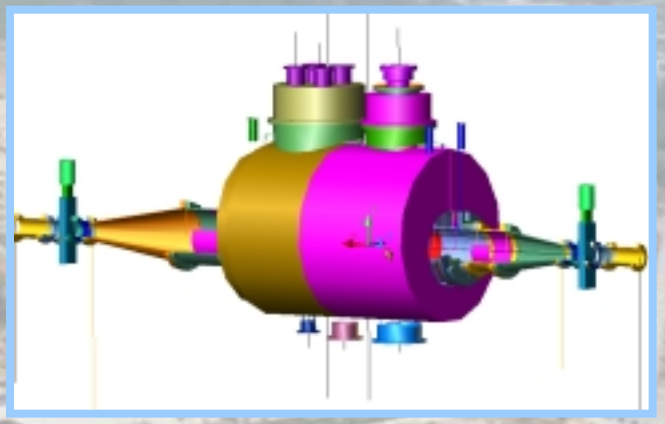
Reduce impedance +SC RF
σ_z =5cm → <1.5cm

$(L_{BEPCII}/ L_{BEPC})_{D.R.}$ =(5.5/1.5) ×93 × 9.8/35=96

L_{BEPC}=1.0×10 ^{31} cm^{-2}s^{-1} → L_{BEPCII} =1×10 ^{33} cm^{-2}s^{-1}

BEPCII: *a high luminosity double–ring collider*



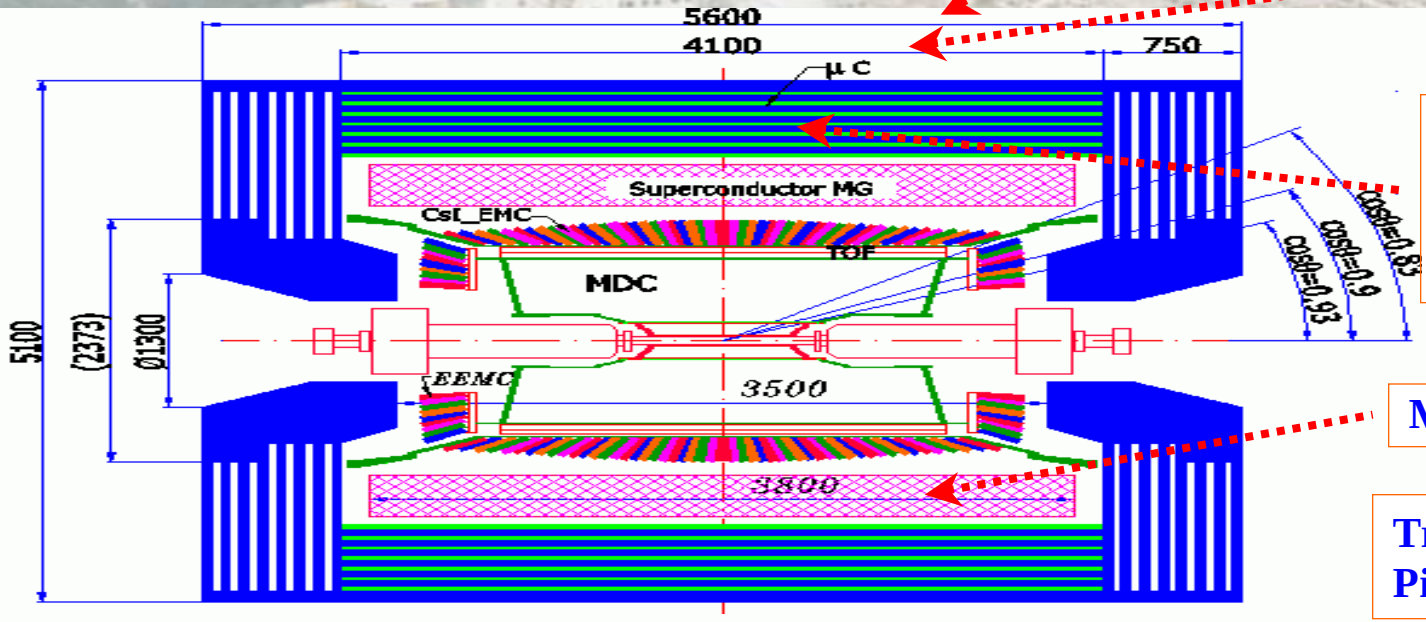


BESIII Detector

Magnet: 1 T Super conducting

EMCAL: CsI crystal
$\Delta E/E$ = 2.2% @1 GeV
σz = 0.5 cm/$\sqrt{E}$

TOF:
σT = 100 ps Barrel
110 ps Endcap



MDC: small cell & He gas
σ_{xy}=130 μm
s_p/p = 0.5% @1GeV
dE/dx=6%

Muon ID: 9 layer RPC

Trigger: Tracks & Showers
Pipelined; Latency = 2.4 ms

- Adapt to high event rate of BEPCII:
  $10^{33}cm^{-2}s^{-1}$ and bunch spacing 8ns
- Reduce sys. errors to match high statistics
  Photon measurement, PID…
- Increase acceptance

Data Acquisition:
Event rate = 3 kHz
Thruput ~ 50 MB/s

(2) The Basic Design

Detailed in the Working Group talk:
Accelerator Physics Issues of BEPCII

- **Design Goals and Main Parameters**
- **The Lattice and Dynamic Aperture**
- **Single Beam Effects**
- **Beam-Beam Effects**
- **Beam Lifetime & Average Luminosity**

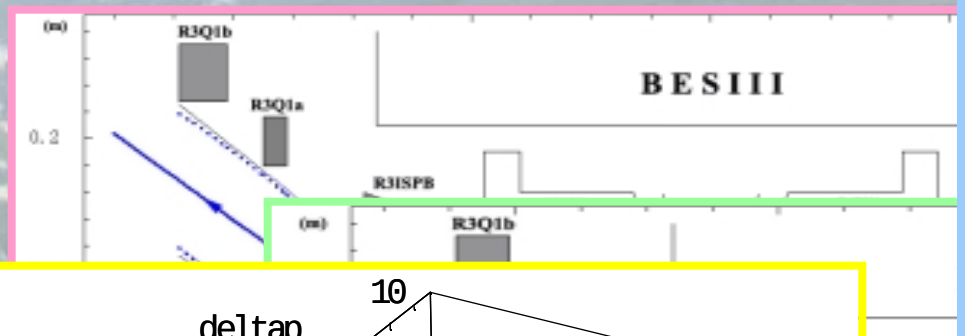
2.1 Design Goals and Main Parameters

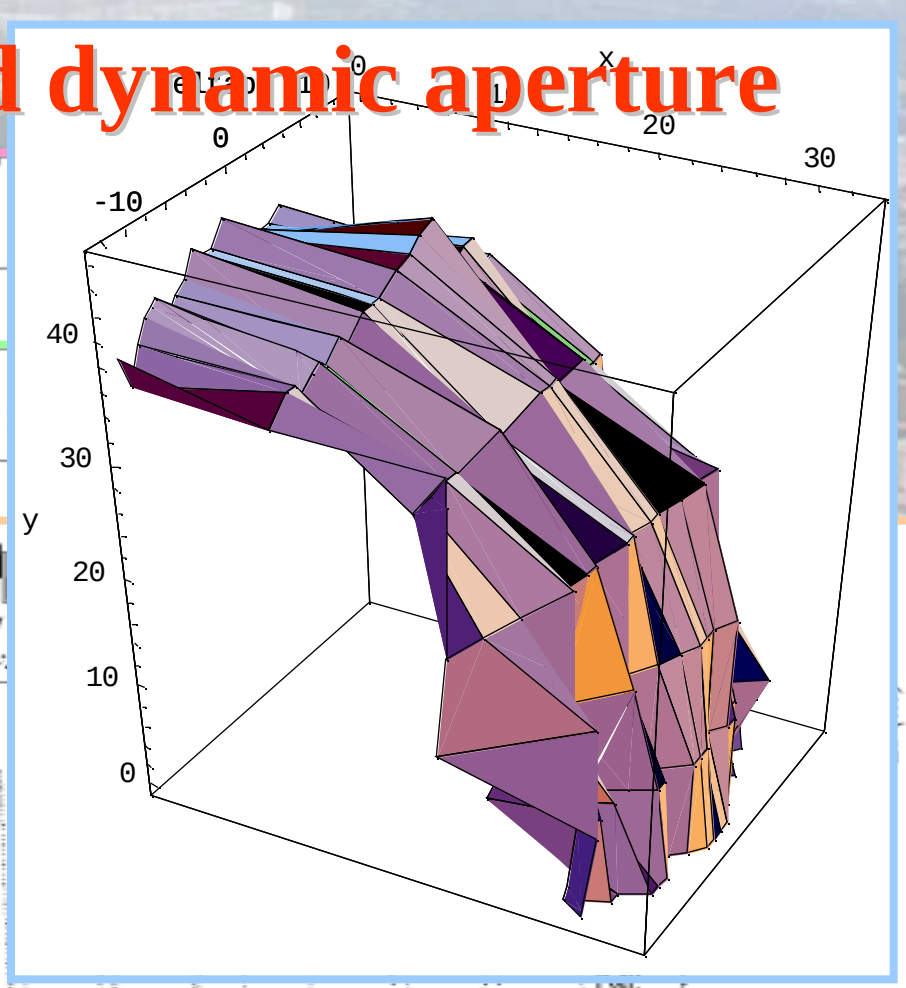
Beam energy range	1–2 GeV
Optimized beam energy region	1.89GeV
Luminosity @ 1.89 GeV	1×10^{33} $cm^{-2}s^{-1}$
Injection from linac	Full energy injection: E_{inj}=1.55–1.89GeV
Dedicated SR operation	250 mA @ 2.5 GeV

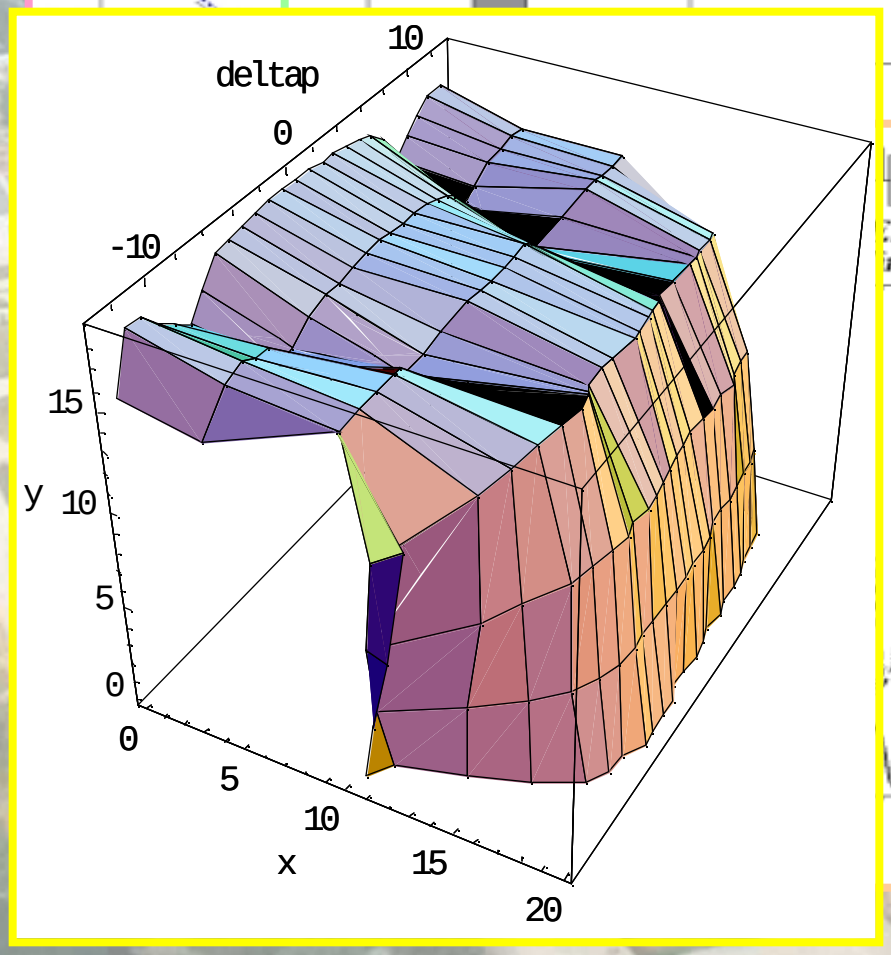
Main Parameters

Parameters		Unit	BEPCII	BEPC
Operation energy (E)		GeV	1.0–2.0	1.0–2.5
Injection energy (E_{inj})		GeV	1.55–1.89	1.3
Circumference (C)		m	237.5	240.4
β^*-function at IP (β_x^* / β_y^*)		cm	100/1.5	120/5
Tunes ($\nu_x/\nu_y/\nu_s$)			6.57/7.61/0.034	5.8/6.7/0.02
Hor. natural emittance (ε_{x0})		mm·mr	0.14 @1.89 GeV	0.39 @1.89 GeV
Damping time ($\tau_x/\tau_y/\tau_e$)			25/25/12.5 @1.89 GeV	28/28/14@1.89 GeV
RF frequency (f_{rf})		MHz	499.8	199.533
RF voltage per ring (V_{rf})		MV	1.5	0.6–1.6
Bunch number (N_b)			93	2×1
Bunch spacing		m	2.4	240.4
Beam current	Colliding	mA	910 @1.89 GeV	~2×35 @1.89 GeV
	SR		250@2.5GeV	130
Bunch length (cm) σ_l		cm	~1.5	~5
Impedance $\lvert Z/n\rvert_0$		Ω	~ 0.2	~4
Crossing angle		mrad	±11	0
Vert. beam-beam param. ξ_y			0.04	0.04
Beam lifetime		hrs.	2.7	6–8
luminosity@1.89 GeV		$10^{31}cm^{-2}s^{-1}$	100	1

2.2 The lattice and dynamic aperture







2.3 Single beam collective effects

- **Bunch length and impedance**

  V_{rf} = 1.5MV, $Z/n|_{eff}$~0.2Ω, I_{th} = 37mA → I_b = 9.8mA, σ_l ~ 1.3 cm

- **Beam-cavity interaction** (with KEKB SC cavities)

	a	τ (ms)	a	τ (ms)
Longitudinal	0	12.8	1	304
Transverse	1	26.6	2	1076

- **Resistive wall**

  ν_x/ν_y = 6.6/7.6, N_b = 99, I_b = 9.8mA, τ = 4.3ms;

- **Ion effects:** N_b = 93 , τ_{FII}=3ms;
- **Electron cloud instability:**

  Antechamber with TiN coating for e^+ ring

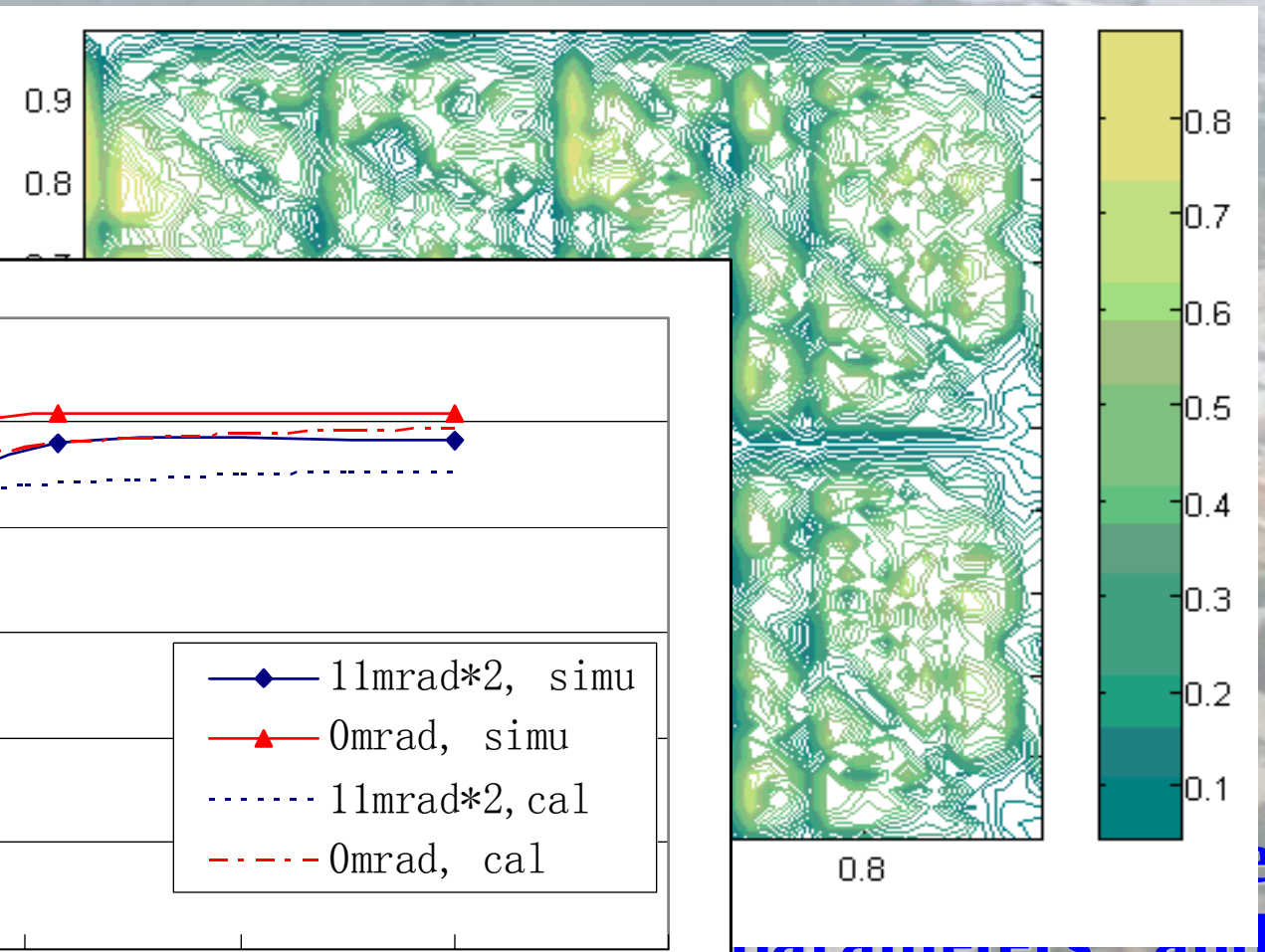
- **Bunch feedback:** τ_L=5 ms, τ_T =1 ms →→

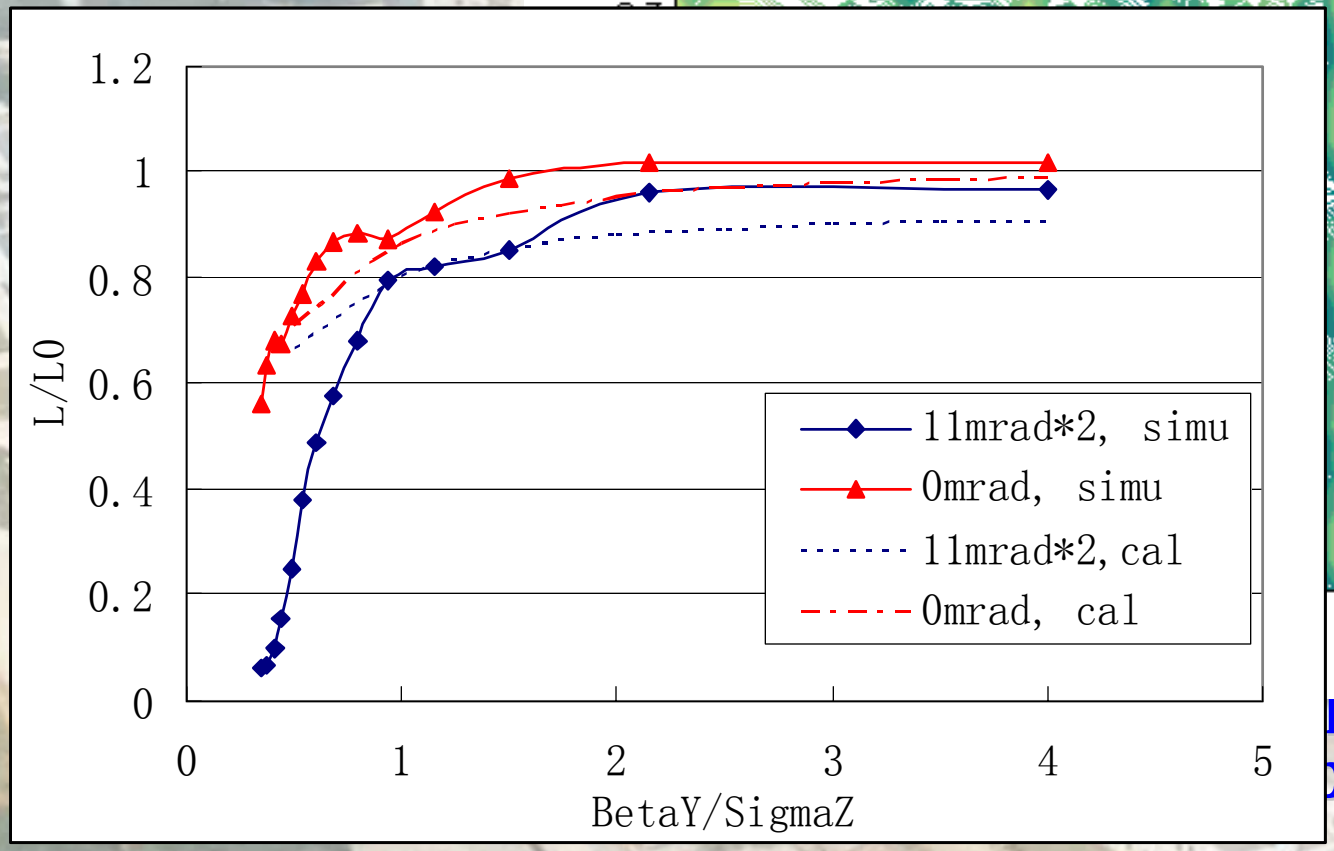
  Single beam instabilities can be damped !

2.4 Beam-beam effects

- **Head-on b**

➔➔ **ξ=0**





parameters" and

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2.5 Beam Lifetime and Average Luminosity

Effect	Condition	Lifetime (hrs.)
Beam-gas interaction	$P = 5\times10^{-9}$ Torr; 80% H_2, 20% CO	26
Quantum effect	$A_x \sim 10\ \sigma_x$	$>10^5$
Beam-beam bremsstrahlung	$\xi_{x,y}=0.04$, $\beta_y^* = 1.5$ cm	5.1
Touschek effects	$I_b = 16$ mA, $V_{rf} = 3$ MV	7.1
Overall lifetime	$\tau^{-1}=\Sigma\tau_i^{-1}$	3.0

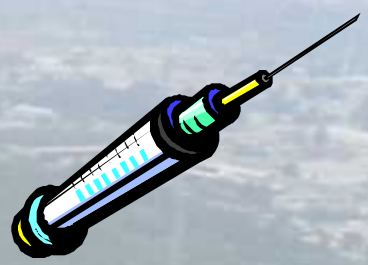
$$\langle L\rangle = \frac{\int_0^{t_c} L(t)dt}{t_c + t_f} = L_0\tau_L \frac{1-e^{-t_c/\tau_L}}{t_c + t_f}$$

Taking τ =1.5 hrs., t_f= 0.4 hr. and $L_0=1\times10^{33}$ $cm^{-2}s^{-1}$, the optimized collision time is calculated as 1.0 hrs. and the maximum average luminosity is calculated as $<L>_{max} \sim 0.5\times10^{33}$ $cm^{-2}s^{-1}$. The top-off injection will further improve the average luminosity to $<L>_{max} > 0.6\times10^{33}$.

(3) Key Technologies

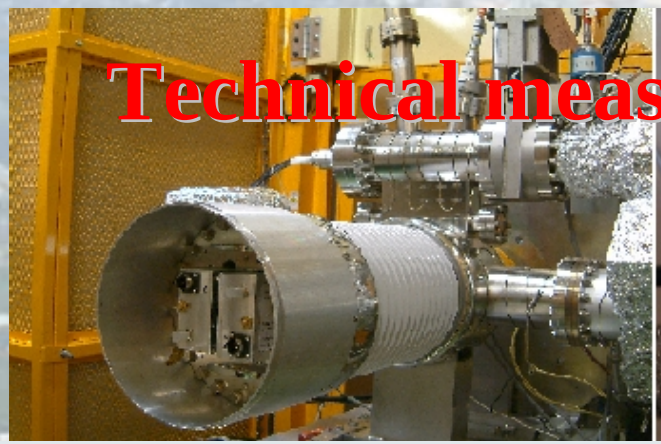
- Injector Upgrades
- RF System
- Injection system
- Magnet System
- Power Supply System
- Vacuum System
- Beam diagnosis
- Control Upgrade
- Cryogenics
- Interaction Region

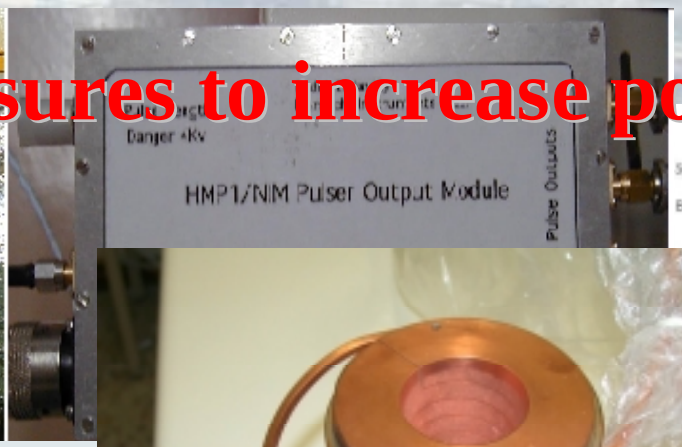
3.1 Injector upgrading

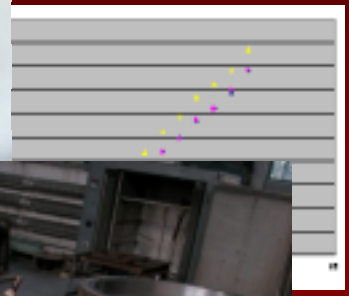


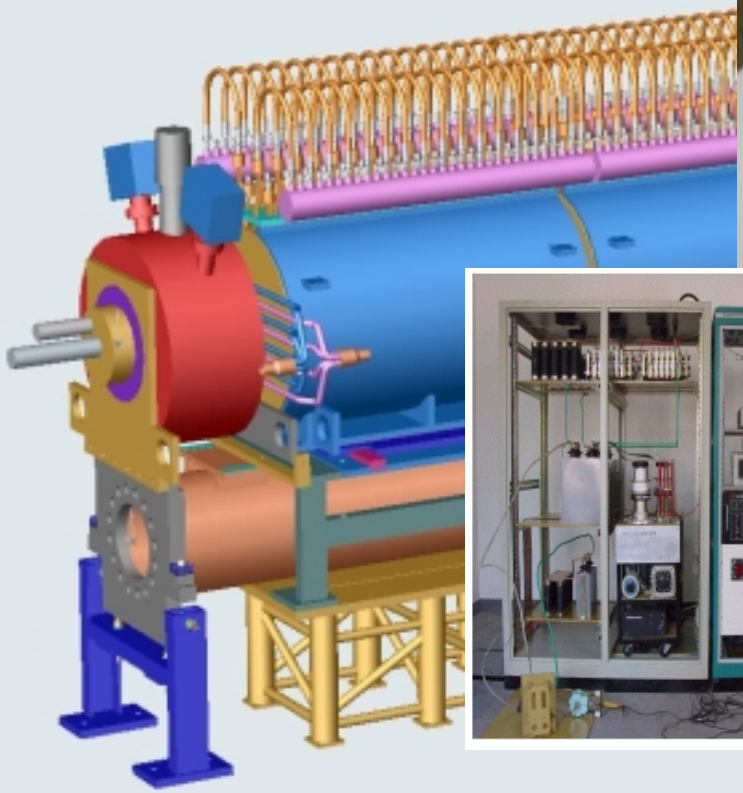
- **Basic requirement:**
  - **Higher intensity: positron injection rate ≥ 50 mA/min.;**
  - **Full energy injection with E=1.55 ~ 1.89 GeV;**
- **To enhance the current and energy of the electron beam bombarding the target and to reduce the beam spot;**
- **To design and produce a new positron source and to improve its focusing;**
- **To increase the repetition rate from present 12.5 Hz to 50 Hz.**
- **To consider multi-bunch injection (f_{RF}/f_{Linac}=7/40);**

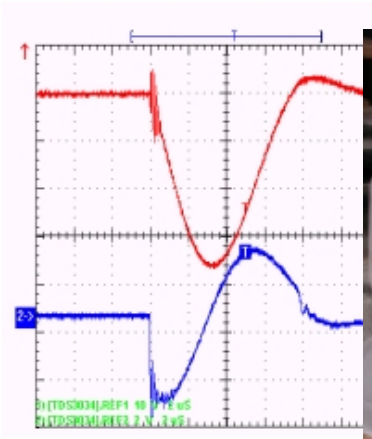
Technical measures to increase positron intensity





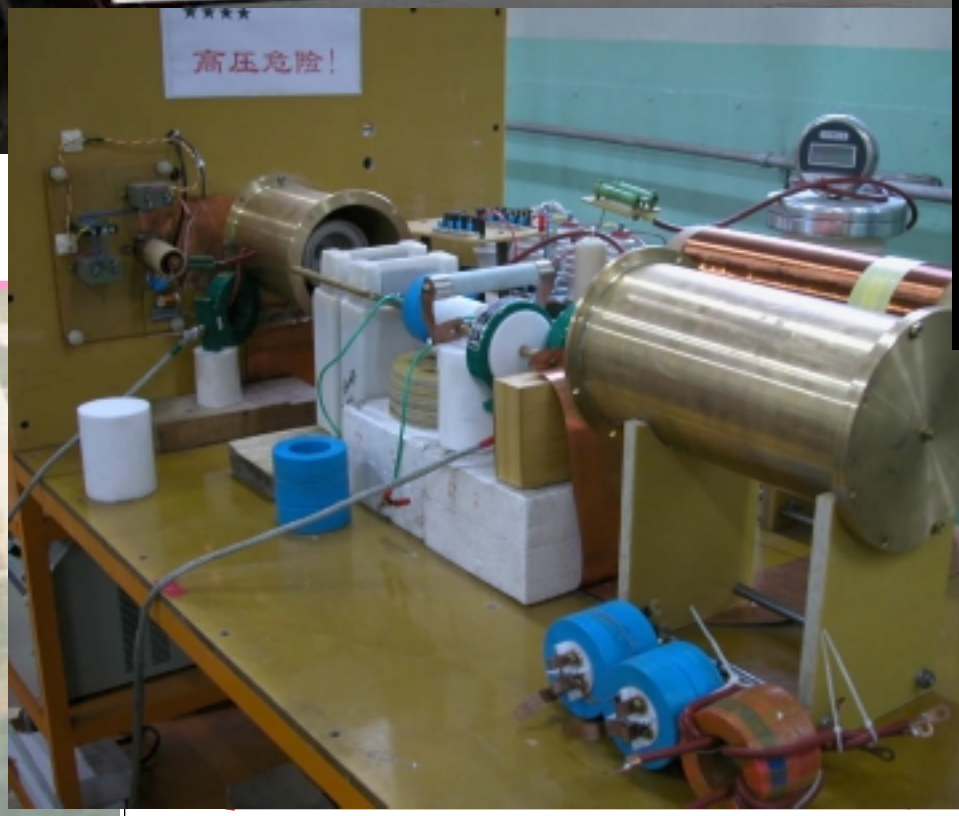


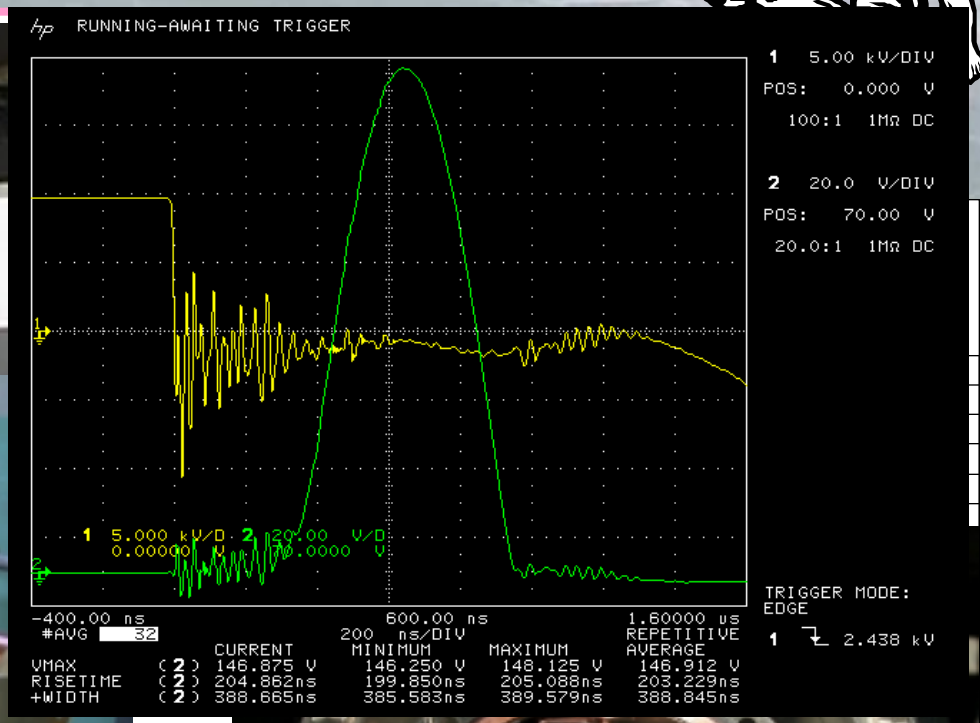


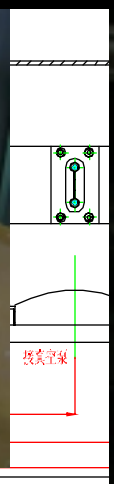


3.2 RF System

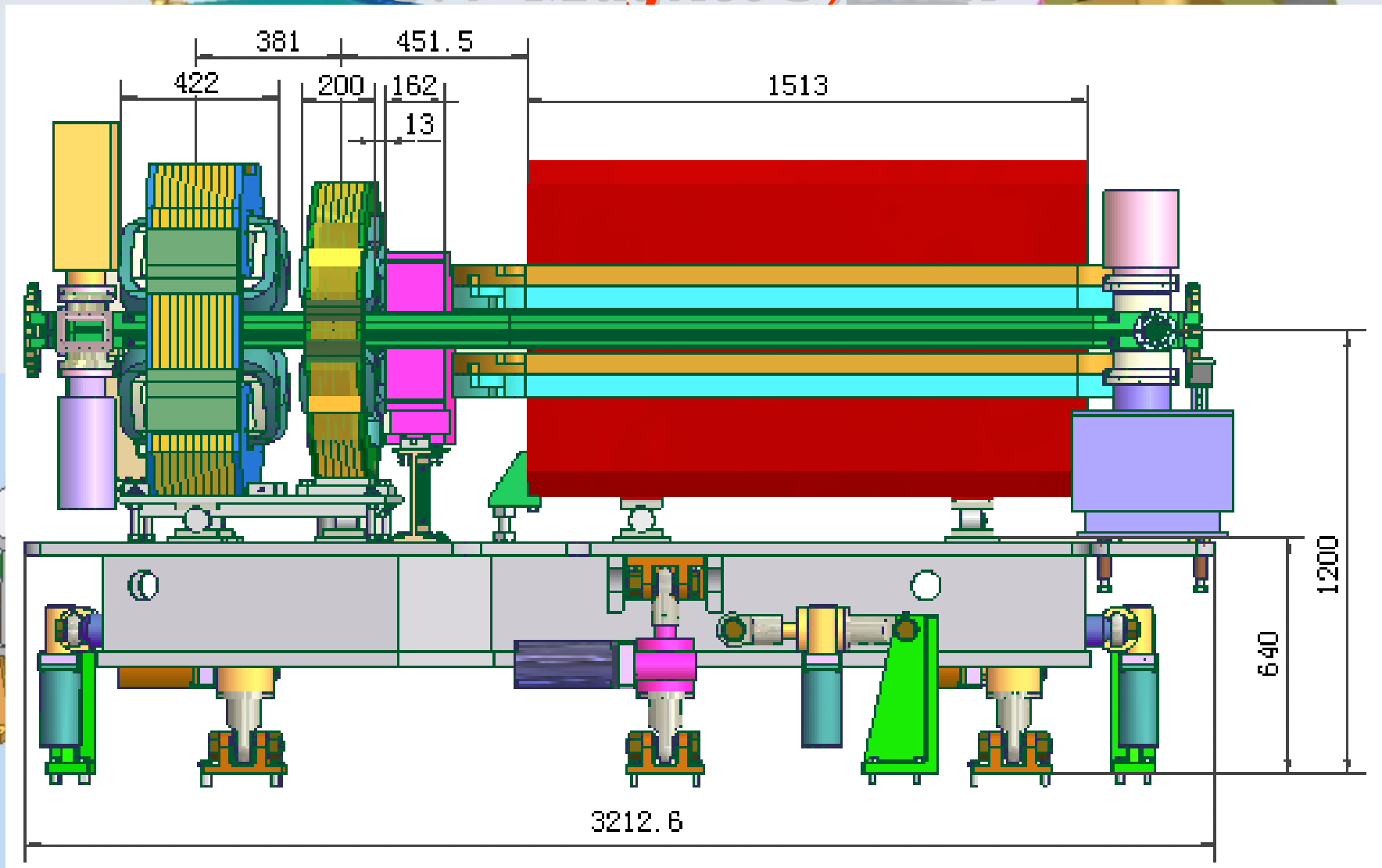
3.3 Injection System



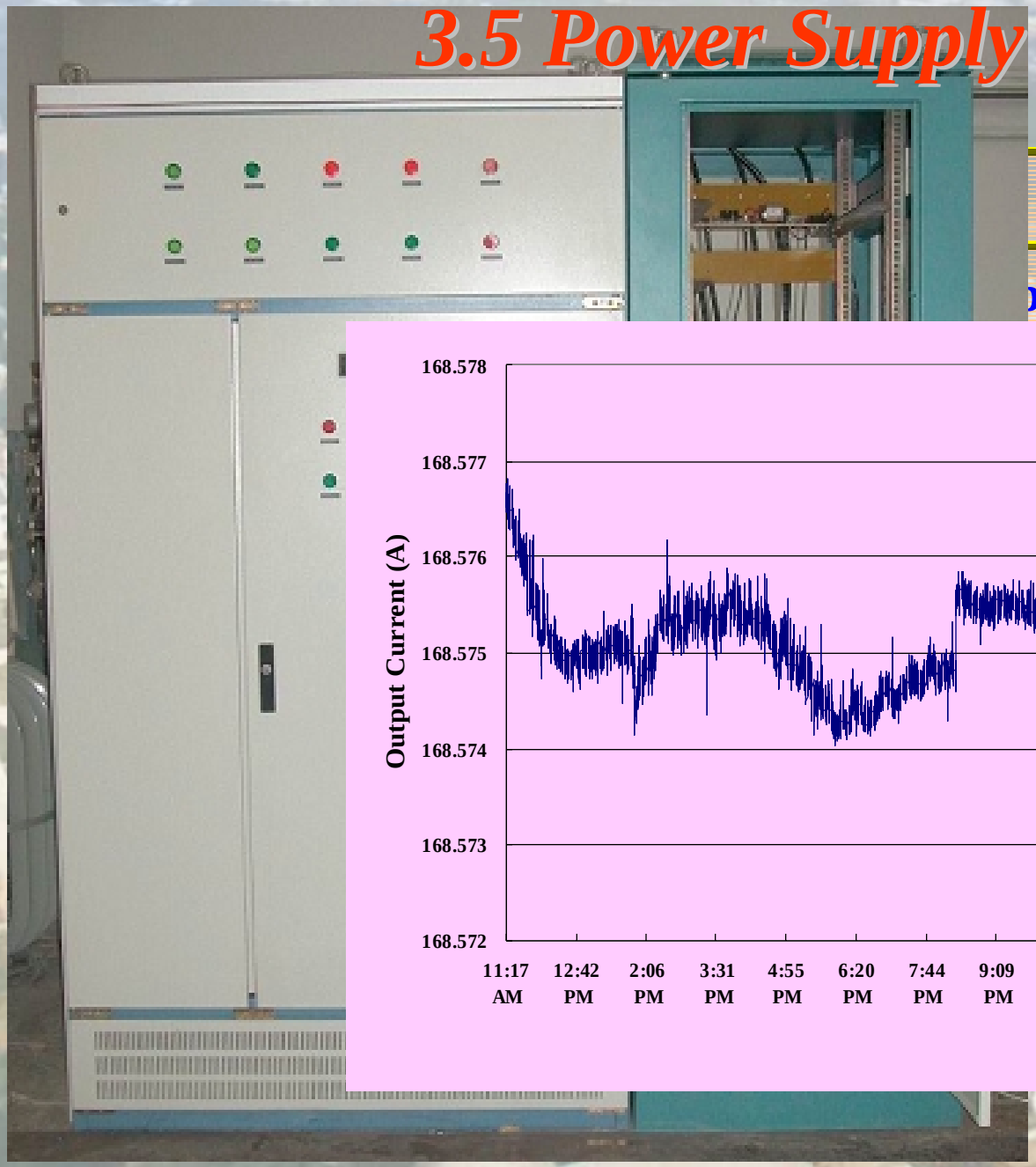




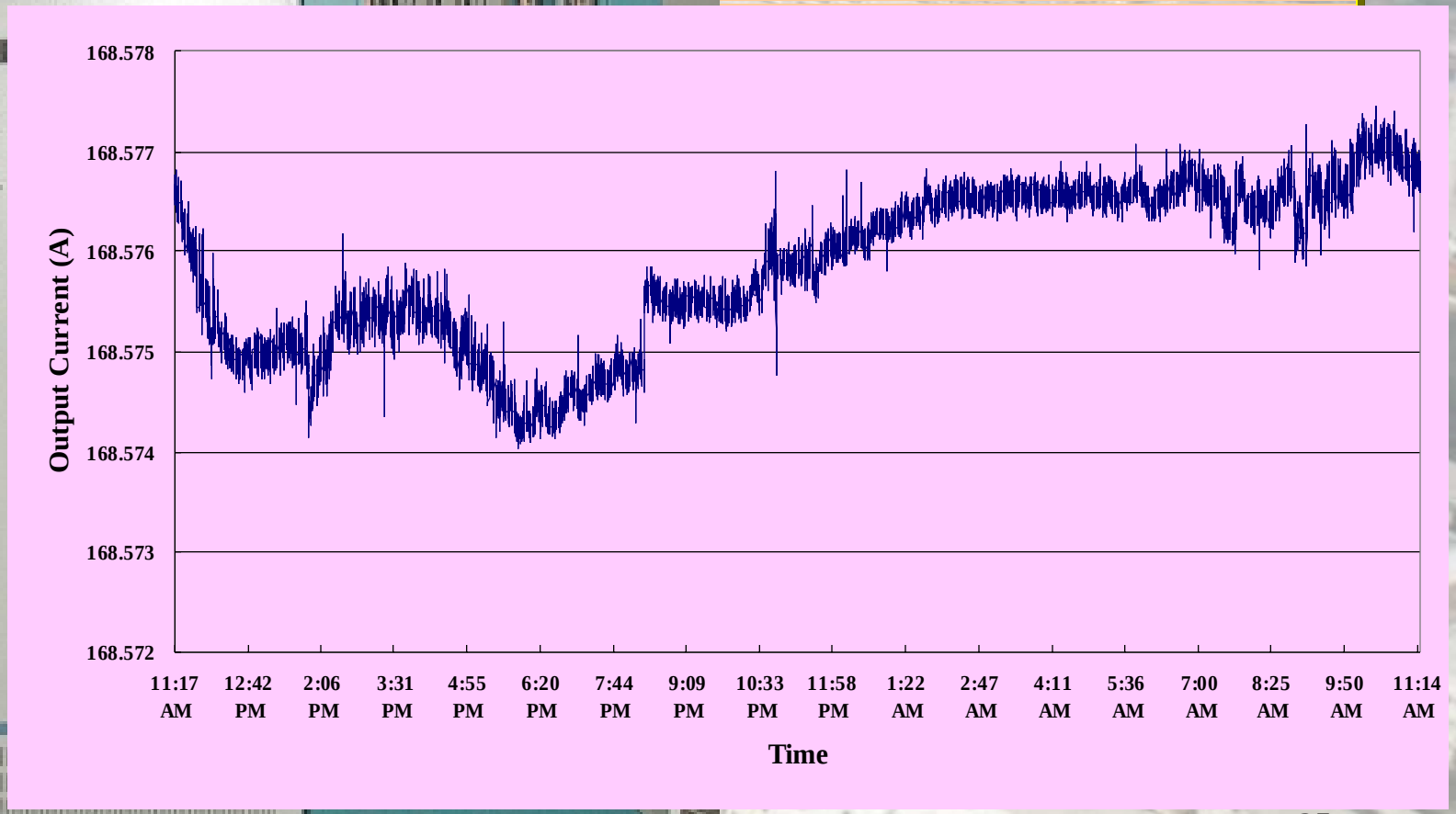
3.4 Magnet System



3.5 Power Supply System

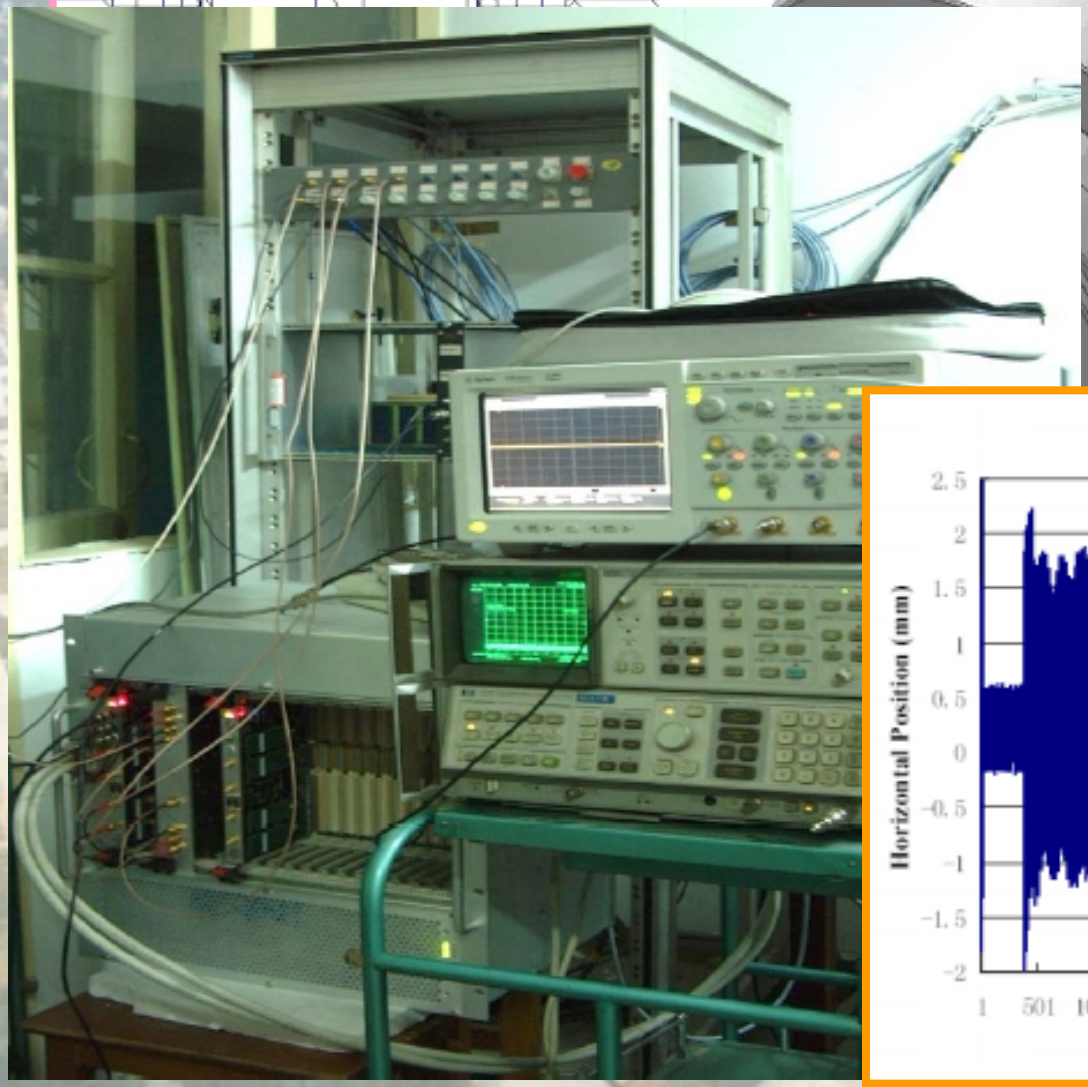


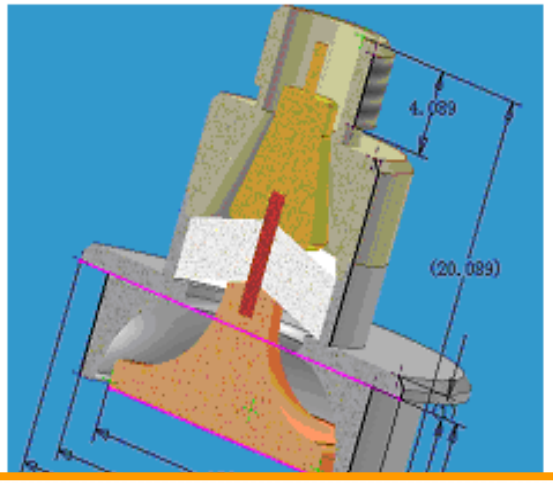
Type
hase-controlled converter

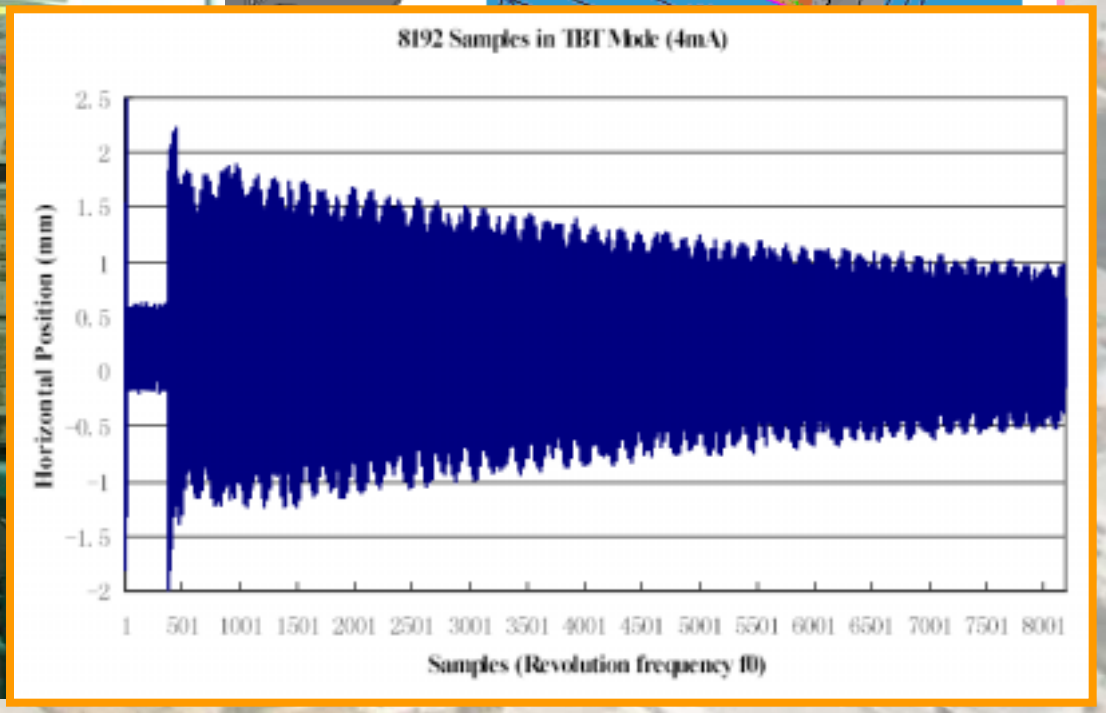


3.6 Vacuum System

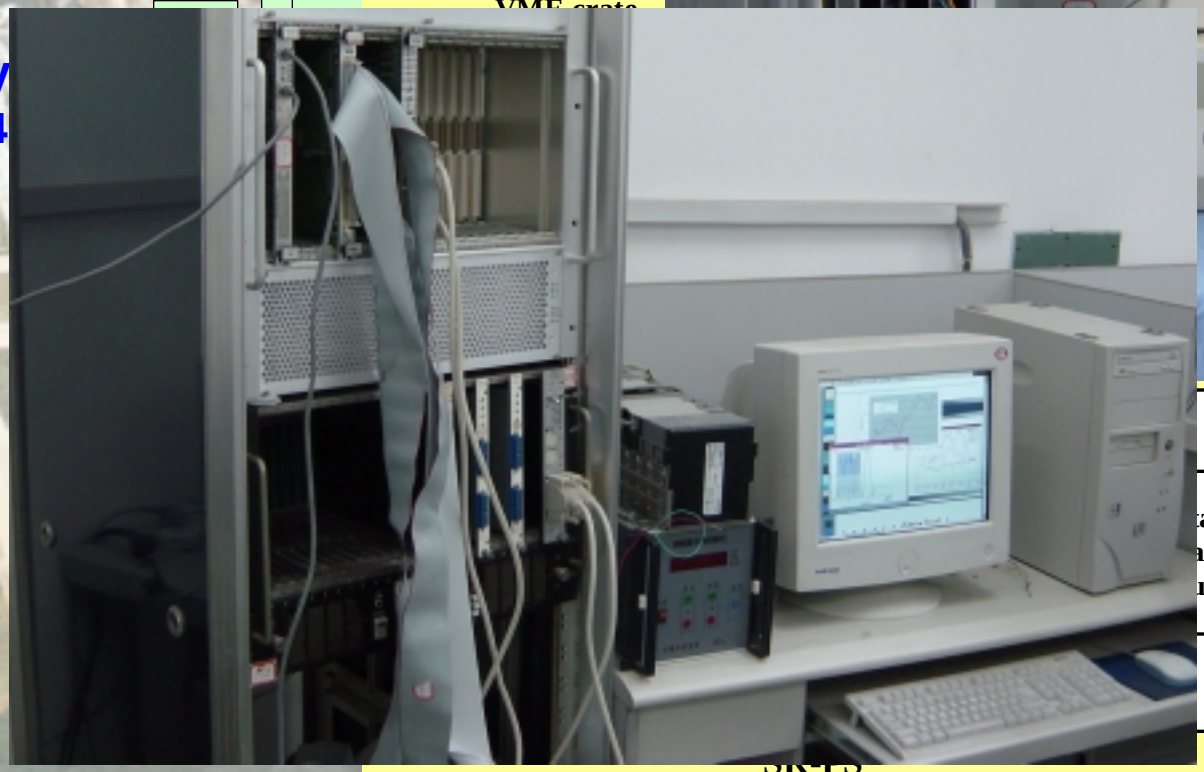
3.7 Beam Diagnosis







3.8 Control System: switch from BEPCI to BEPCII



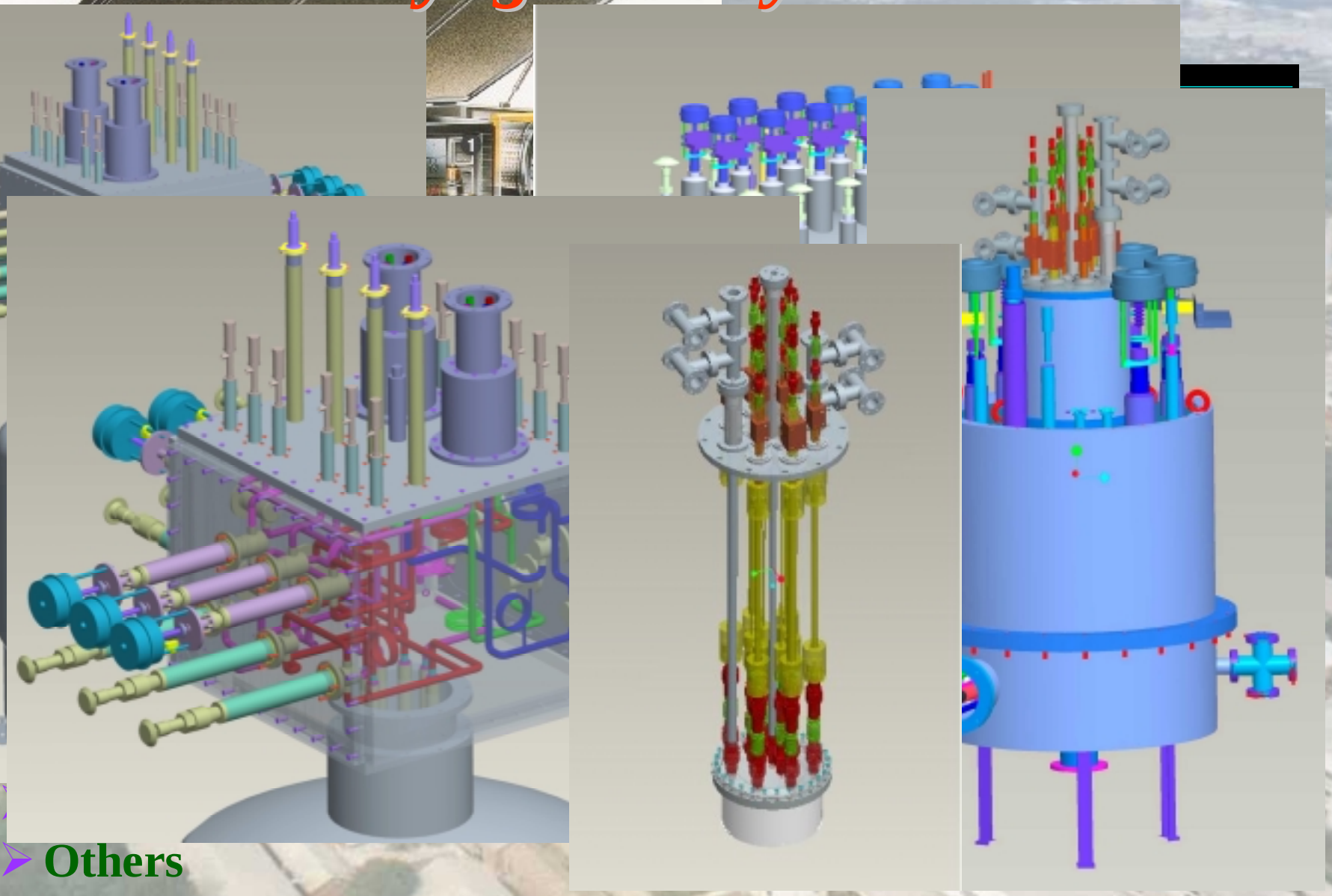
WS console

CC2401

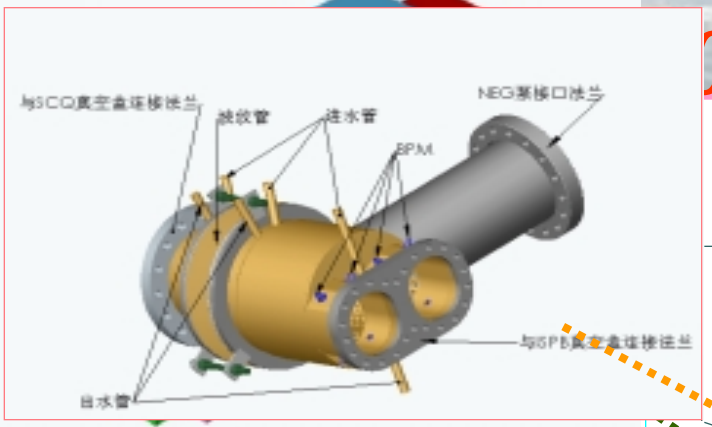
CC2401

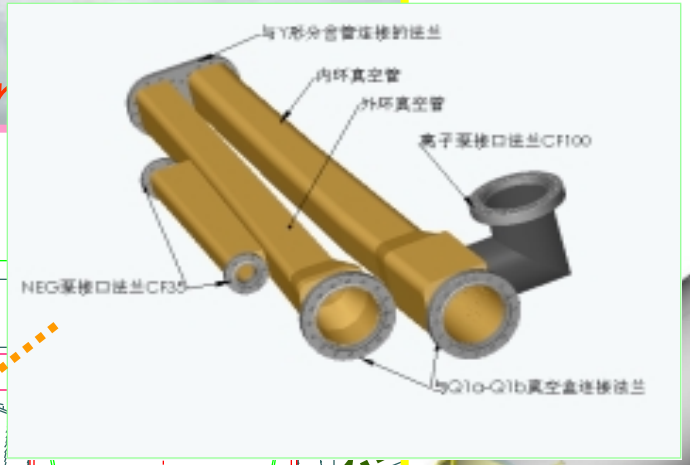
TP-PS

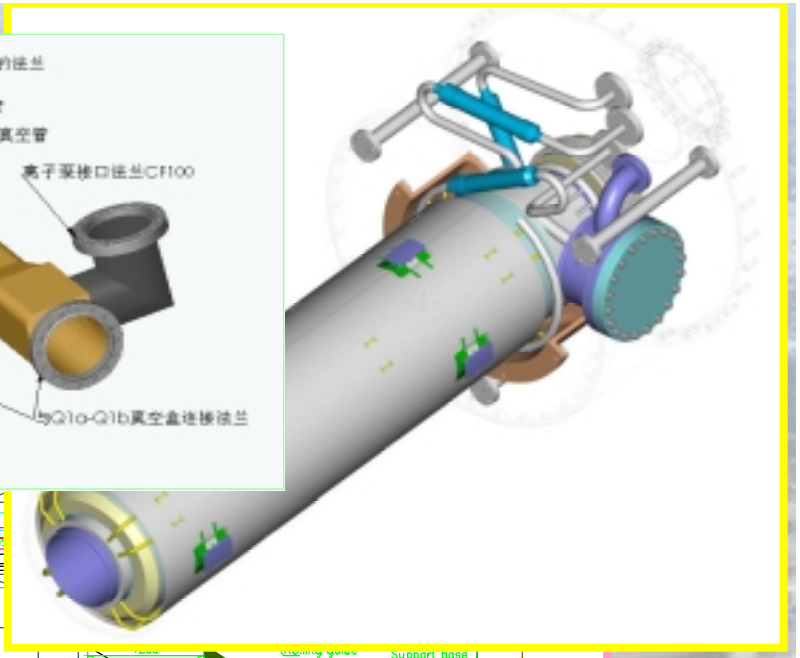
3.9 Cryogenics System

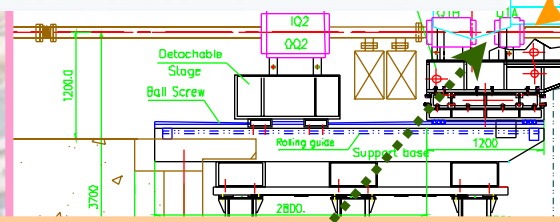


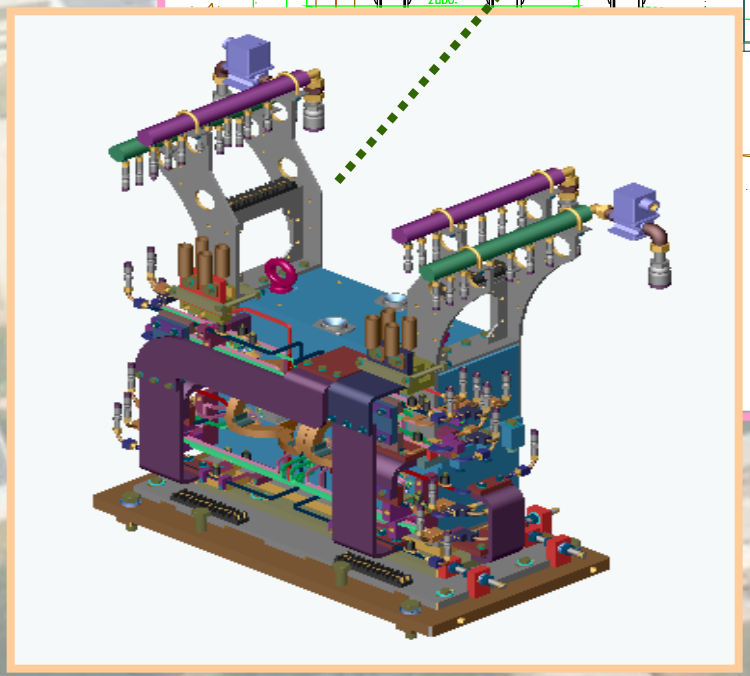
- Others


与SCQ真空盒连接法兰
波纹管
进水管
NEG泵接口法兰
BPM
与SPB真空盒连接法兰
出水管

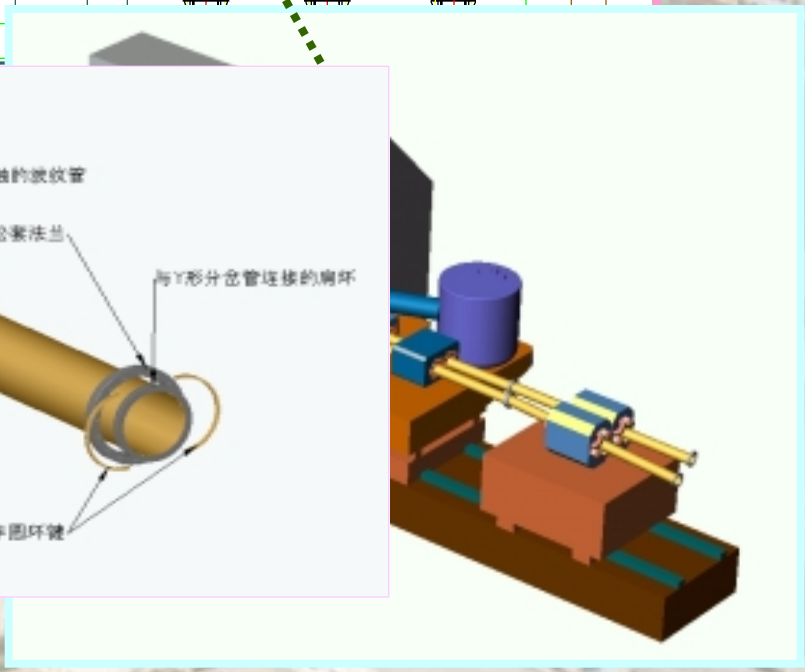

与Y形分仓管连接的法兰
内环真空管
外环真空管
离子泵接口法兰CF100
NEG泵接口法兰CF35
与Q1a-Q1b真空盒连接法兰




Q2
Detachable Stage
Ball Screw
Rolling guide
Support base
1200
2800
562

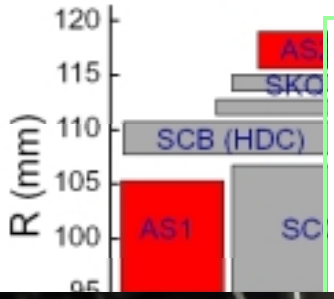



与IP真空盒连接的法兰
与BPM
与球面接触的波纹管
检查法兰
与Y形分仓管连接的肩环
半圆环键



SC Micro-β Magnets

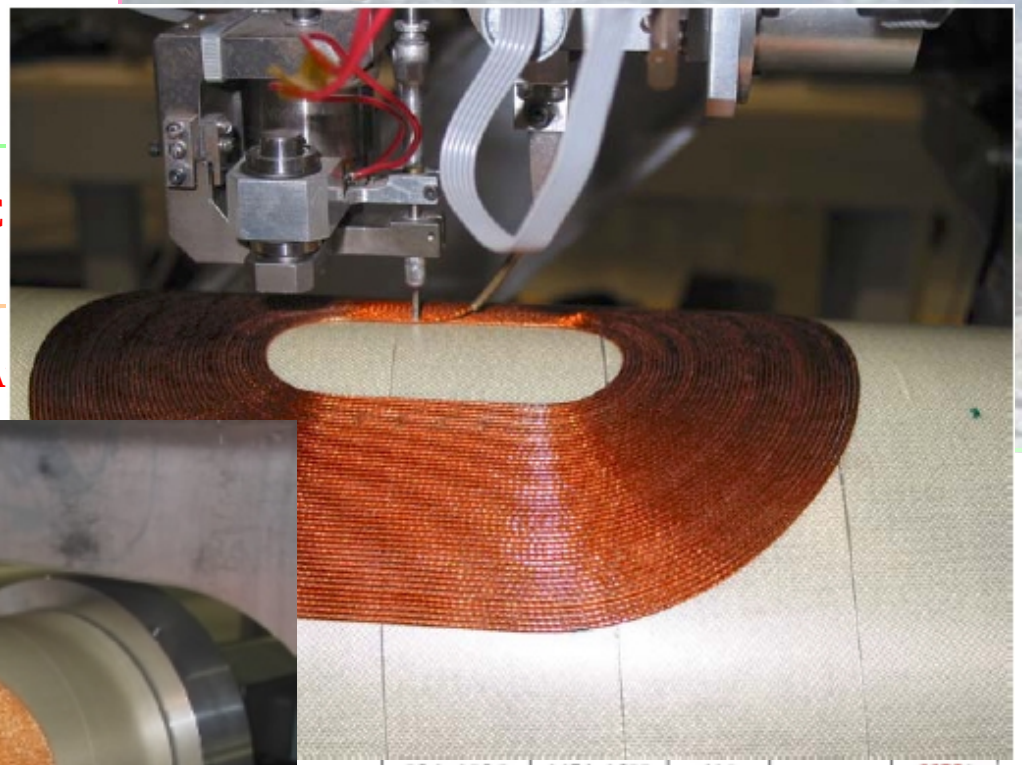
Coil Layout of SC IR Magnet

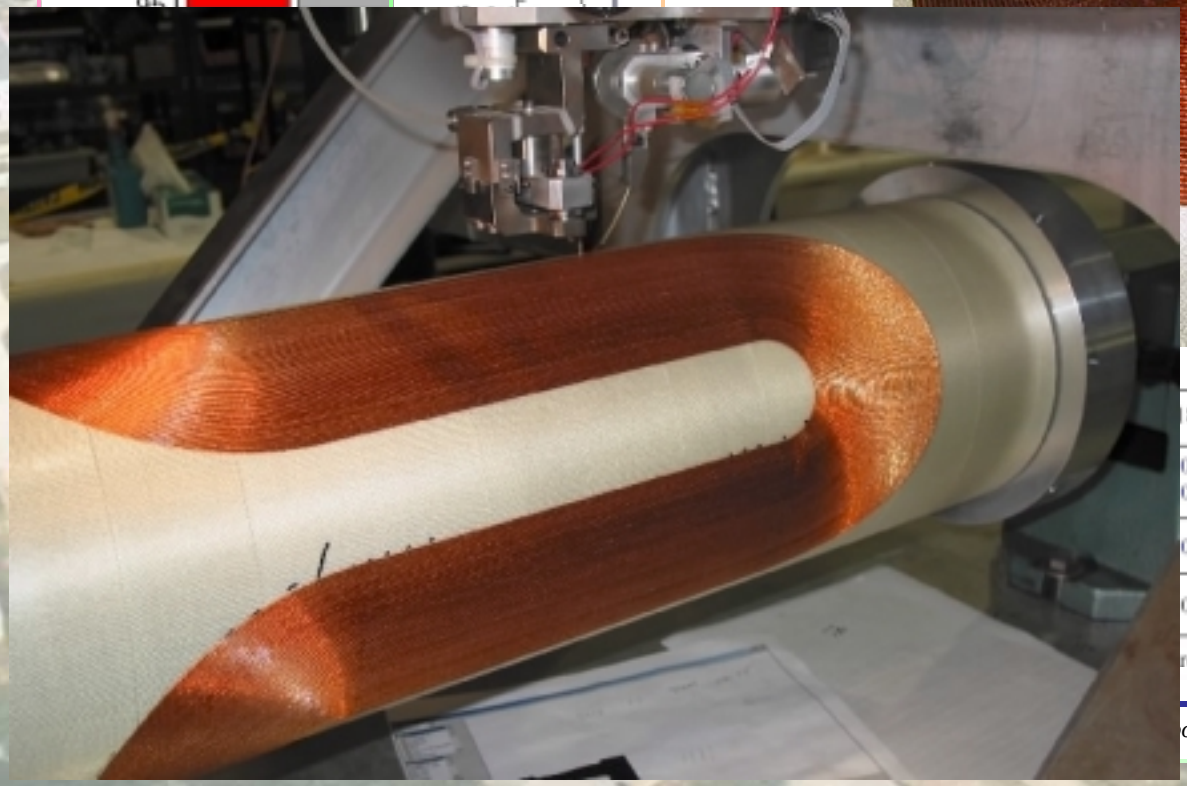


Three Anti-Solenoid C

AS1-3 are cor

A





-	95.1~105.9	1474~1590	116	-	**1120***
18.744	95.1~108.1	961~1457	496	400	460
0.543 0.056	108.5~111.8	633~1307	674	400	495 (580)
0.059	111.9~113.5	904~1514	610	380	24
0.937	113.6~115.2	954~1464	510	400	45

re in series with AS1 but can have their own independent trim currents.

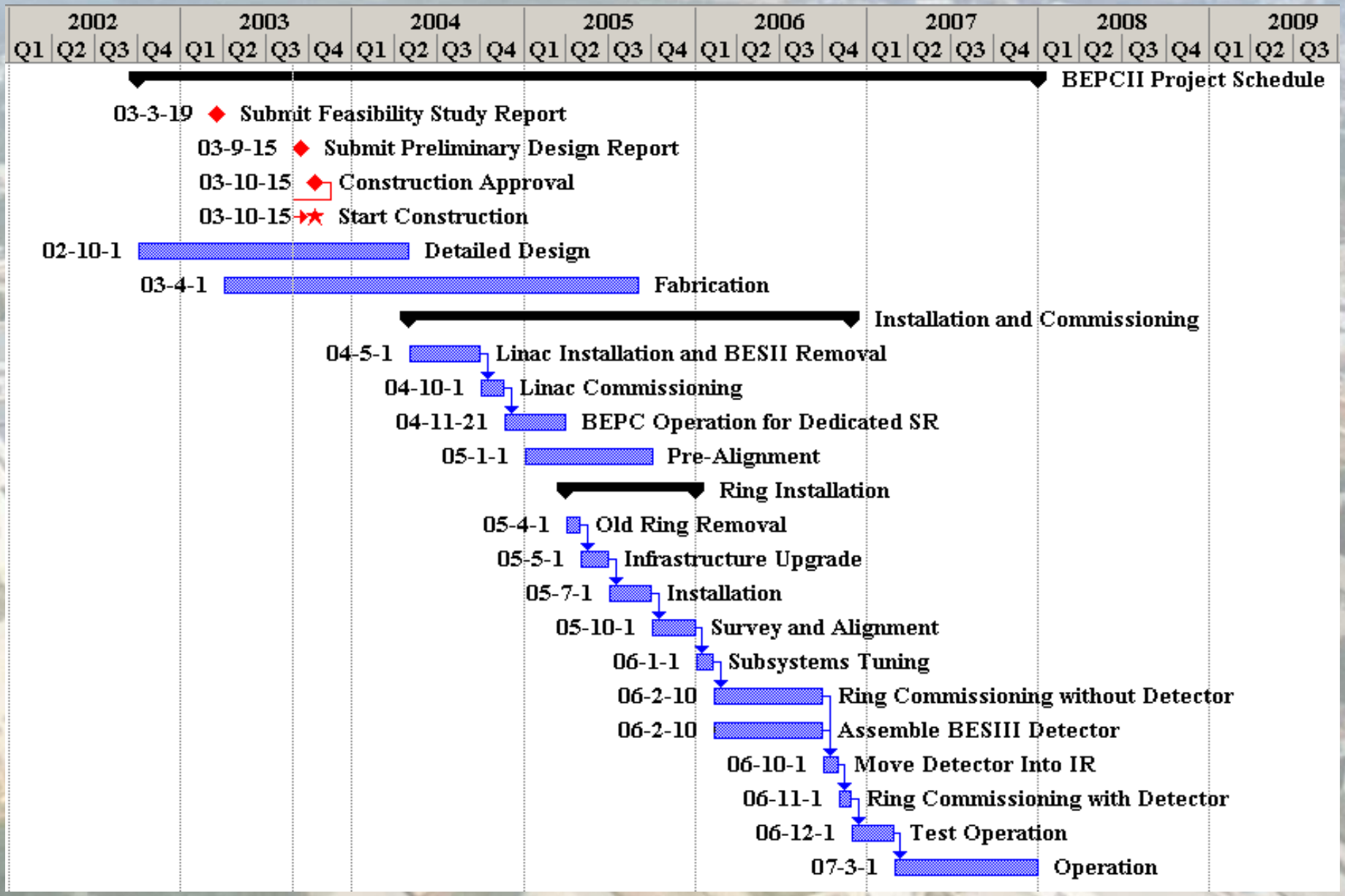
Collaboration on BEPCII

- **Linac: SLAC, KEK, INFN …**
- **Multiple bunches with Pretzel: Cornell …**
- **SC Micro-β quadruples: BNL, KEK …**
- **Interaction Ragion: KEK, SLAC, INFN…**
- **Superconducting RF cavities: KEK, Cornell, PU…**
- **Impedance study: LBNL, Tsinghua U., …**
- **Beam Instrumentation: CERN, SLAC, KEK…**
- **PC farm and Data management system: FNAL …**
- **BES III shower counters: Cornell …**
- **BES MDC IV: Cornell, USTC …**
- **BES III VC: FNAL D0 …**
- **BES III electronics: Tsinghua U.,… …**
- **……**

(4) Budget and Schedule

Linac Upgrading	44
Storage Rings	240
Detector	230
Utilities	80
Others	14
Contingency	32
Grand total	640M (77M$)

The project is expected to be finished in 4 years after its approval



(5) Summary

- The BEPC has been well operated with many exciting HEP and SR results for 14 years since it was put into operation in 1989.
- The BEPCII is designed as micro-β plus multibunches with two rings and its design luminosity is two order of magnitude higher than the present BEPC in energy range of charm and τ.
- Some key technologies is being developed in order to achieve the scientific goal of the BEPCII.
- The international collaboration and contribution will be promoted in order to accomplish this challenging and exciting project on schedule and budget.

ICHEP'04

Welcome to Beijing


Thank You
for Attention
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