HF2014 Summary (Lattice design)

Bastian Harer

HF2014: 9-12 October in Beijing

10 Working Groups:

- Parameters
- Optics
- IR and MDI
- SR and Shielding
- Superconducting RF
- Injectors and Injection
- Orbit and Beam Stability
- Polarization
- Instrumentation and Control
- Green Accelerators

CEPC Overview

CEPC-SppC Project Timeline (dream)

CEPC

2015 | 2020 | 2025 | 2030 | 2035

- Pre-studies (2013-2015)
- R&D Engineering Design (2016-2020)
- Construction (2021-2027)
- Data taking (2028-2035)

1st Milestone: pre-CDR (by the end of 2014) → R&D funding request to Chinese government in 2015 (China's 13th Five-Year Plan 2016-2020)

SppC

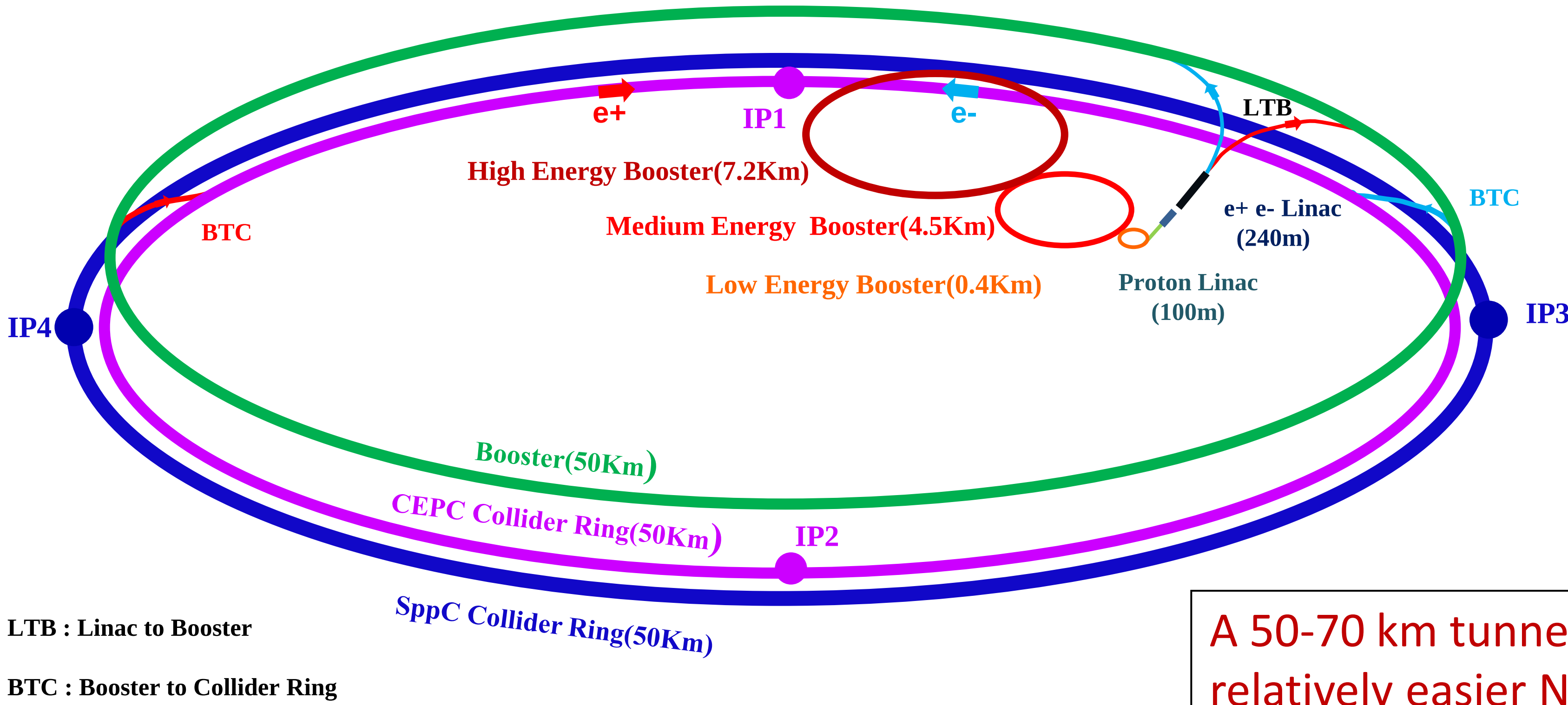
2020 | 2030 | 2040

- R&D (2014-2030)
- Engineering Design (2030-2035)
- Construction (3035-2042)
- Data taking (2042-2055)

Weiren Chou

Future: CEPC+SppC

- Thanks to the discovery of the low mass Higgs boson, and stimulated by ideas of Circular Higgs Factories in the world, CEPC+SppC configuration was proposed in Sep. 2012



A 50-70 km tunnel is relatively easier NOW in China

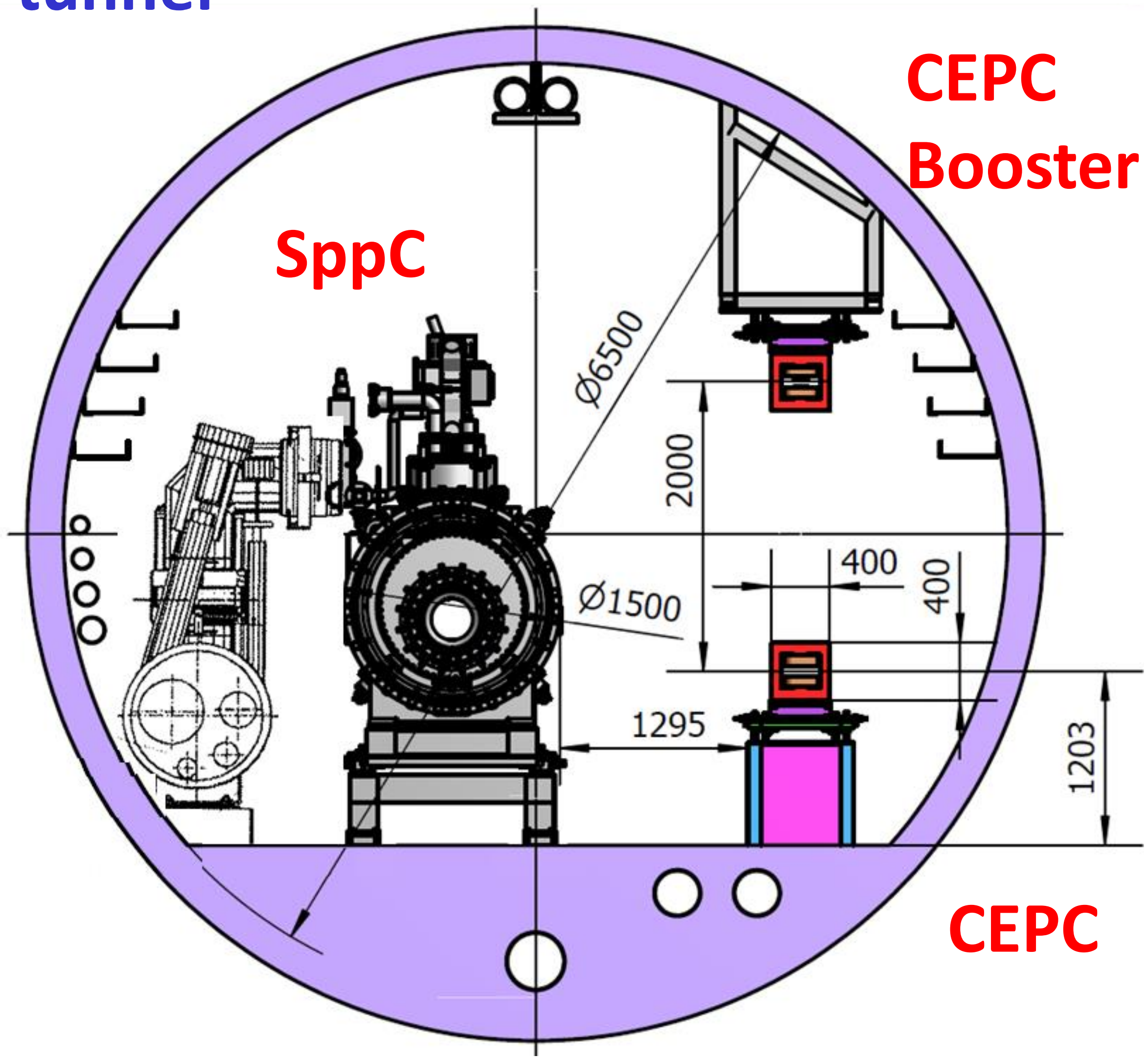
Yifang Wang

• Possible site: Qinhuangdao, Hebei province

Qing Qin

Qing Qin

- 3 machines in one tunnel
  - CEPC & booster
  - SppC
- Crosstalk of CEPC straights & SppC's detector
- Layout of CEPC determined by SppC layout

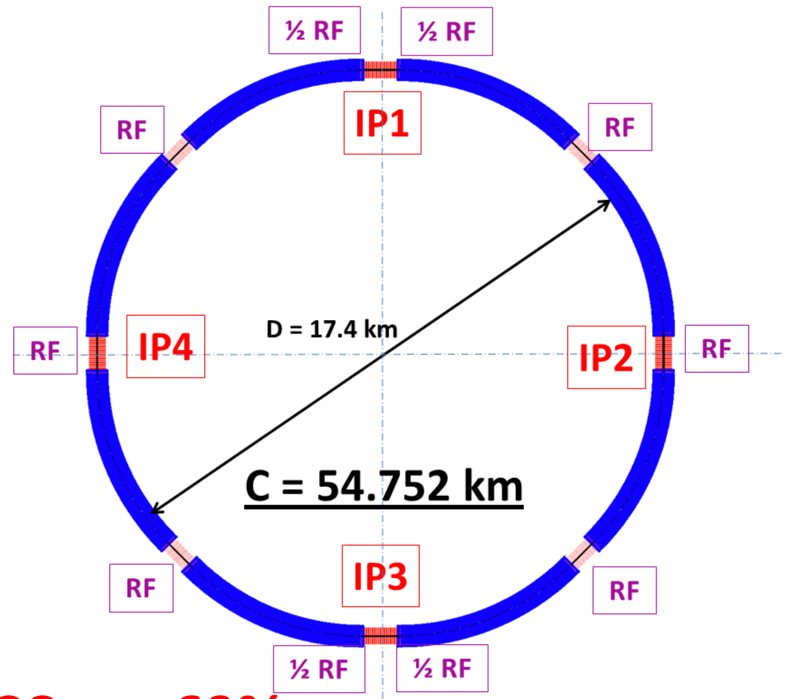


CEPC parameter list

Parameter	Unit	Value	Parameter	Unit	Value
Beam energy [E]	GeV	120	**Circumference [C]**	m	54752
Number of IP[N_{IP}]		2	**SR loss/turn [U_0]**	GeV	3.11
Bunch number/beam[n_B]		50	**Bunch population [Ne]**		3.79E+11
SR power/beam [P]	MW	51.7	**Beam current [I]**	mA	16.6
Bending radius [ρ]	m	6094	**momentum compaction factor [α_p]**		3.36E-05
Revolution period [T_0]	s	1.83E-04	**Revolution frequency [f_0]**	Hz	5475.46
emittance (x/y)	nm	6.12/0.018	**β_{IP}(x/y)**	mm	800/1.2
Transverse size (x/y)	μm	69.97/0.15	**$\xi_{x,y}$/IP**		0.118/0.083
Beam length SR [$\sigma_{s.SR}$]	mm	2.14	**Beam length total [$\sigma_{s.tot}$]**	mm	2.65
Lifetime due to Beamstrahlung (simulation)	min	47	**lifetime due to radiative Bhabha scattering [τ_L]**	min	52
RF voltage [V_{rf}]	GV	6.87	**RF frequency [f_{rf}]**	MHz	650
Harmonic number [h]		118800	**Synchrotron oscillation tune [ν_s]**		0.18
Energy acceptance RF [h]	%	5.99	**Damping partition number [$J\varepsilon$]**		2
Energy spread SR [$\sigma_{\delta.SR}$]	%	0.132	**Energy spread BS [$\sigma_{\delta.BS}$]**	%	0.119
Energy spread total [$\sigma_{\delta.tot}$]	%	0.163	**n_γ**		0.23
Transverse damping time [n_x]	turns	78	**Longitudinal damping time [n_ε]**	turns	39
Hourglass factor	Fh	0.658	**Luminosity /IP[L]**	$cm^{-2}s^{-1}$	2.04E+34

CEPC Layout

- CEPC is a Circular Electron Positron Collider to study the Higgs boson
- Critical parameters:
  - Beam energy: 120GeV
  - Circumference: 54 km
  - SR power: 51.7 MW/beam
  - 8*arcs
  - 2*IPs
  - 8 RF cavity sections (distributed)
  - Filling factor of the ring: ~70% **FCC-ee: 69%**



- Length of the straight sections are compatible with SppC requirement **??? → 850 m, 1130 m**

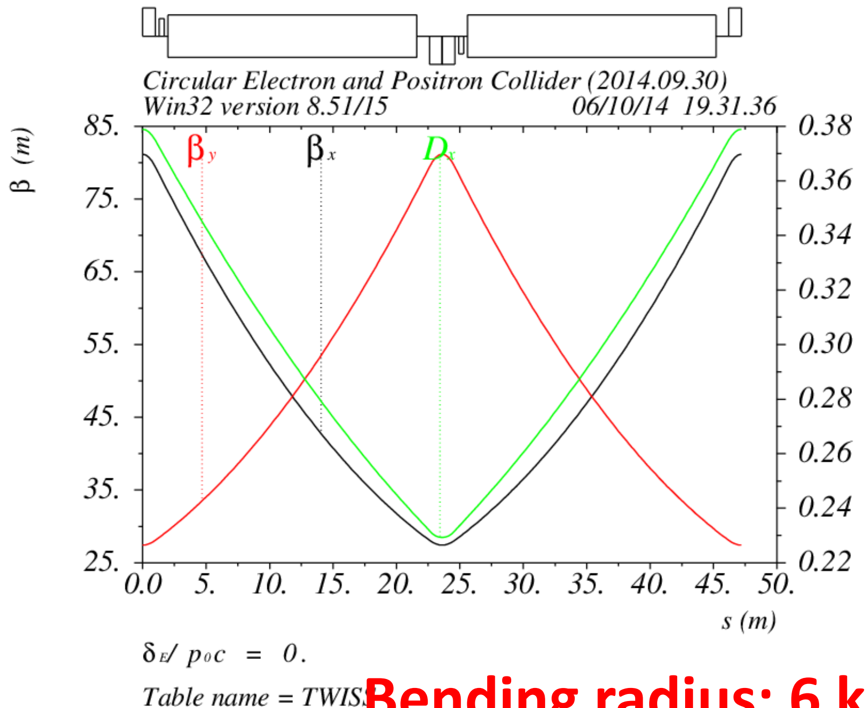
Huiping Geng

Lattice of arc sections

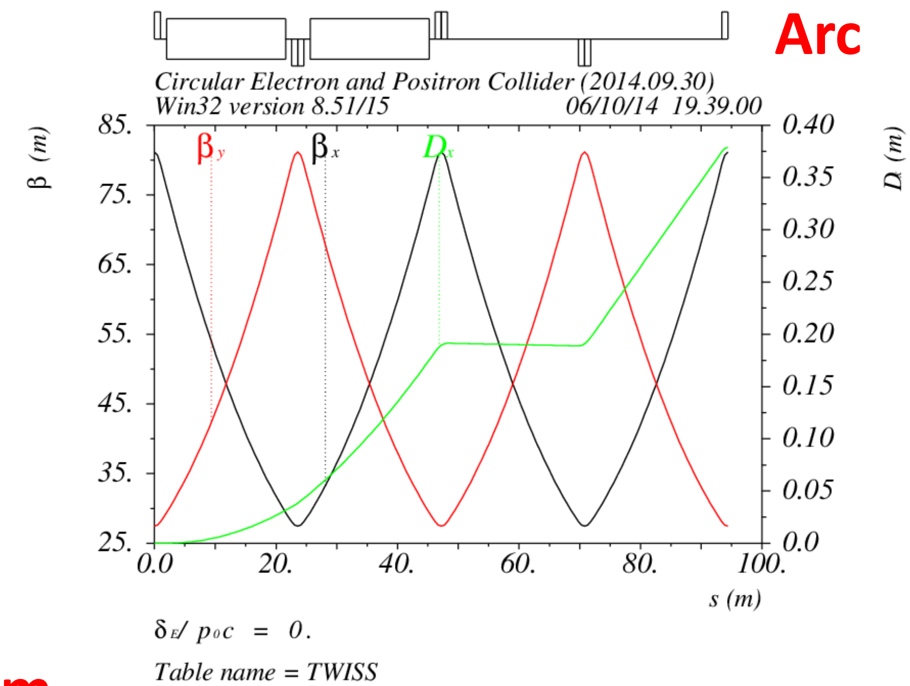
- Length of FODO cell: 47.2m
- Phase advance of FODO cells: 60/60 degrees

Missing-bend

- Dispersion suppressor on each side of every arc
- Length: 94.4m



Arc



Bending radius: 6 km
(FCC-ee: 10.6 km)

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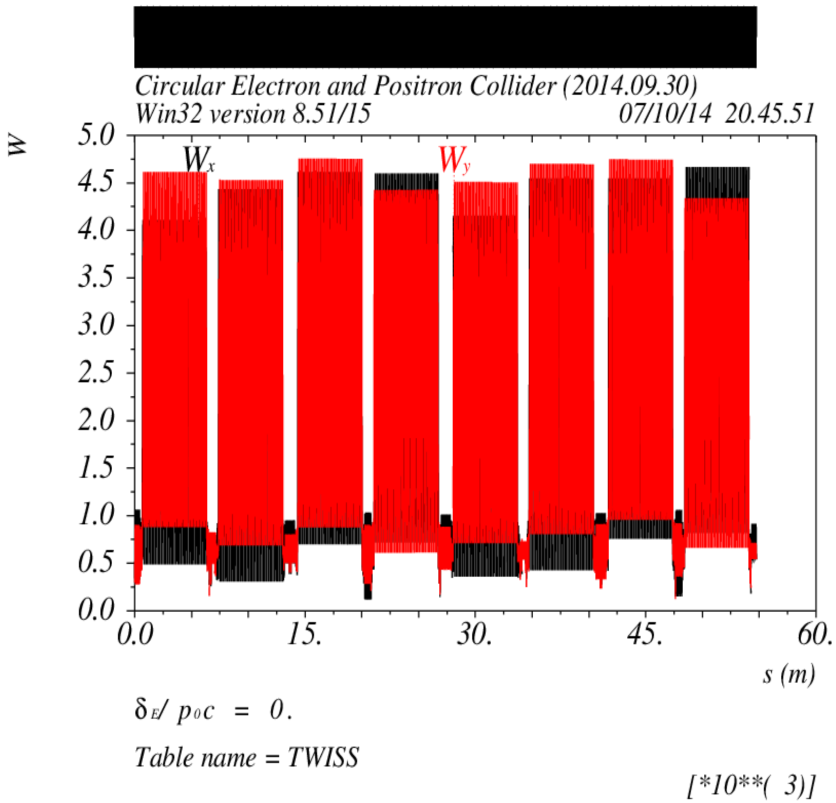
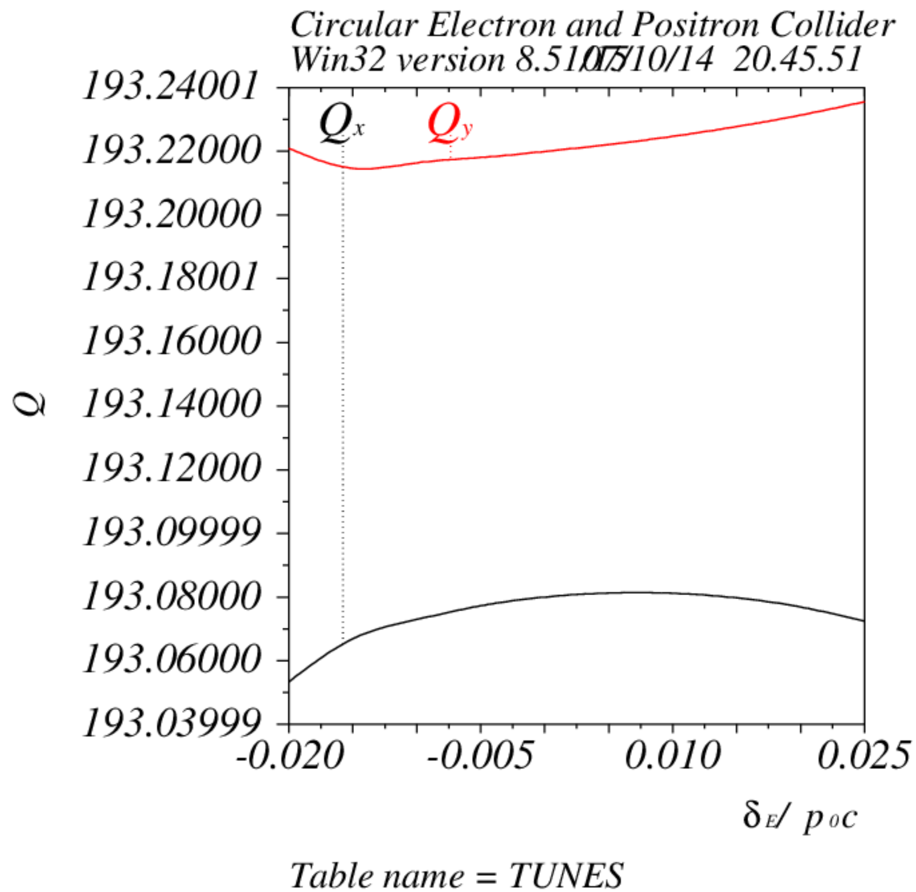
Chromatic correction

- Two families of sextupoles: one family for horizontal, one family for vertical plane next to each quadrupole in the arc section





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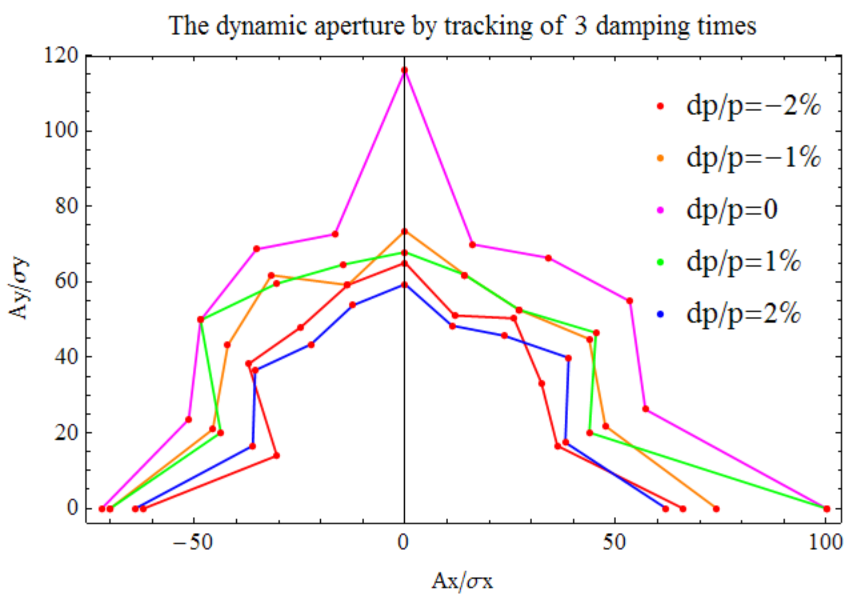
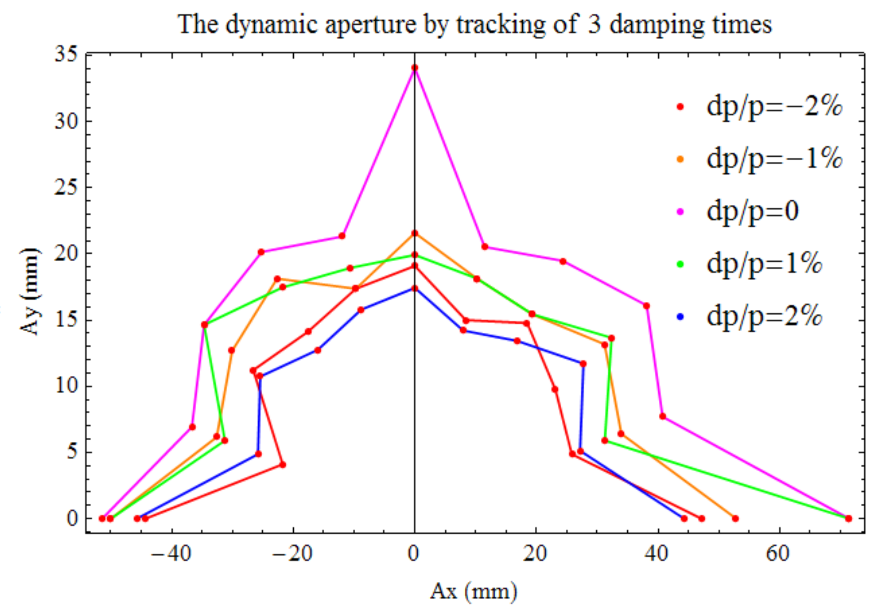
Dynamic aperture

- 240 turns is tracked for dynamic aperture
- Full coupling is assumed for vertical plane
- The dynamic aperture is: ~ $60\sigma_x/60\sigma_y$ or 40mm/16mm in x and y for ±2% momentum spread





Without low-beta insertions!

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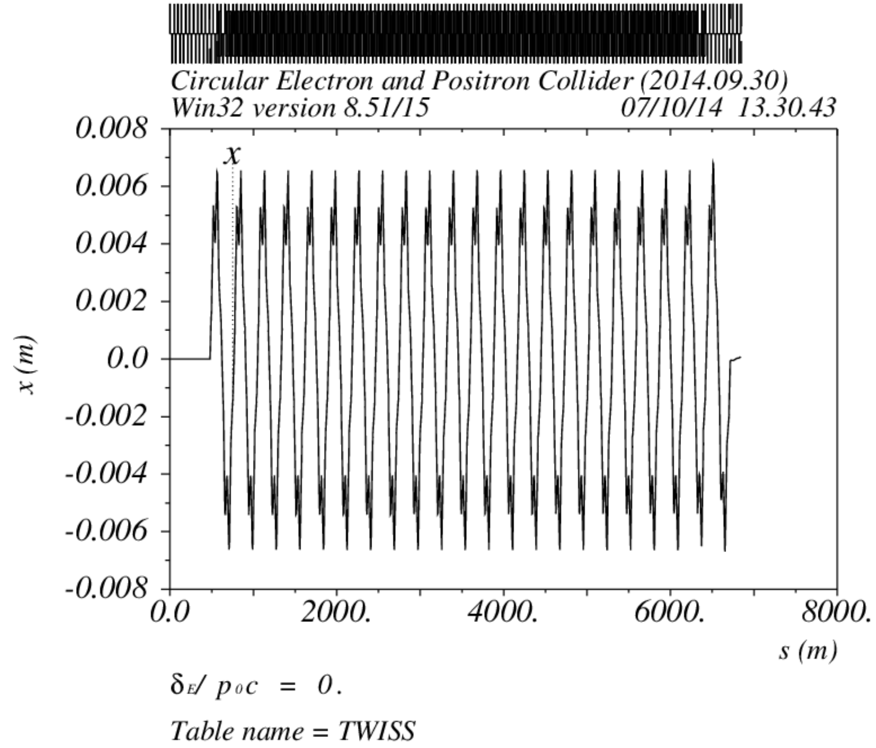
Pretzel scheme

- Horizontal separation is adopted to avoid big coupling
- No orbit in RF section to avoid beam instability and HOM in the cavity
- One pair of electrostatic separators for each arc



Orbit for the first 1/8 ring

- Separation distance: 5 σx for each beam
- Maximum separation distance is : 6.5 mm

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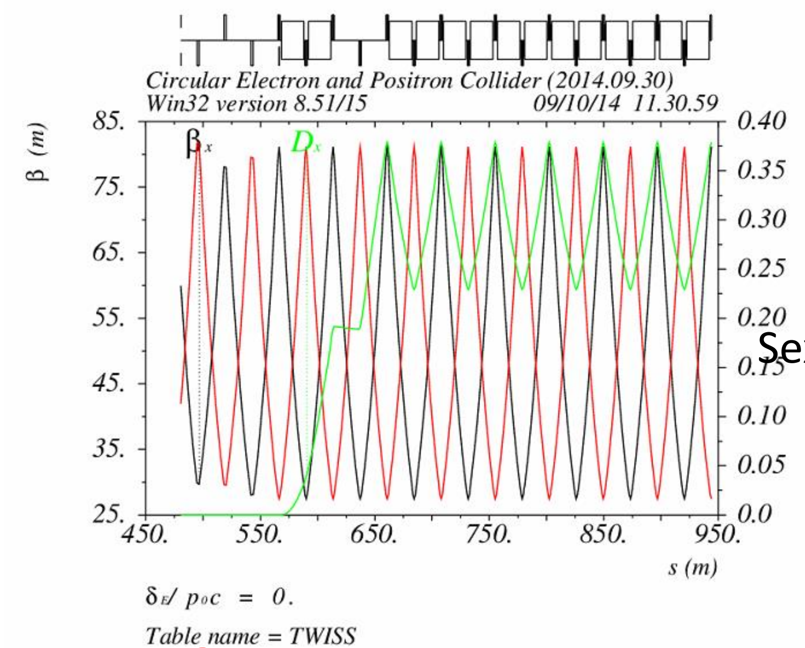
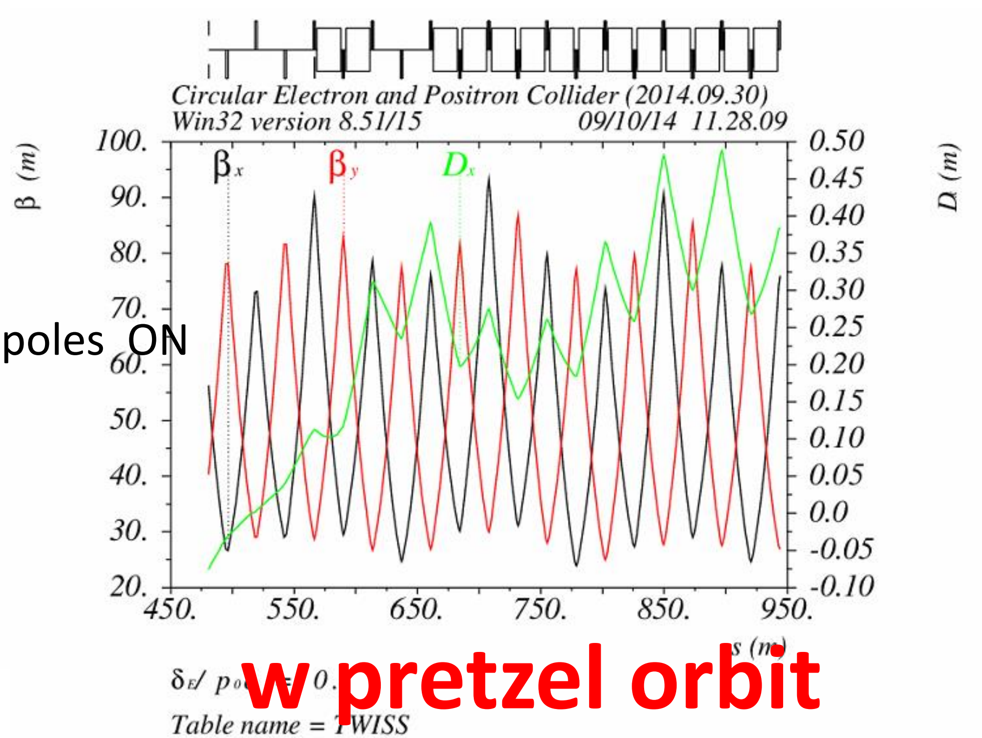
Effects of pretzel orbit

- Pretzel orbit has effects on:
  - Beta functions, thus tune
  - Dispersion function, thus emittance
  - Dynamic aperture



w/o pretzel orbit

Sextupoles ON



w pretzel orbit

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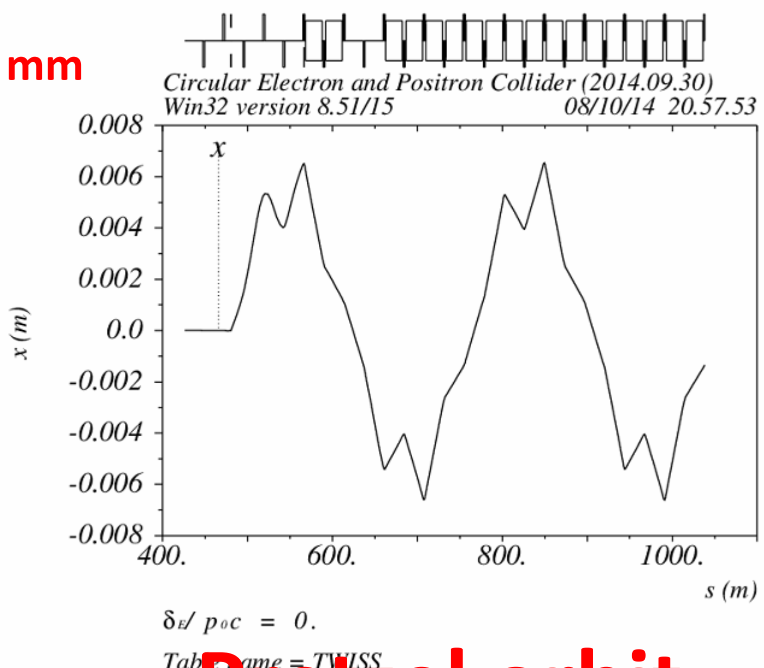
Sawtooth orbit

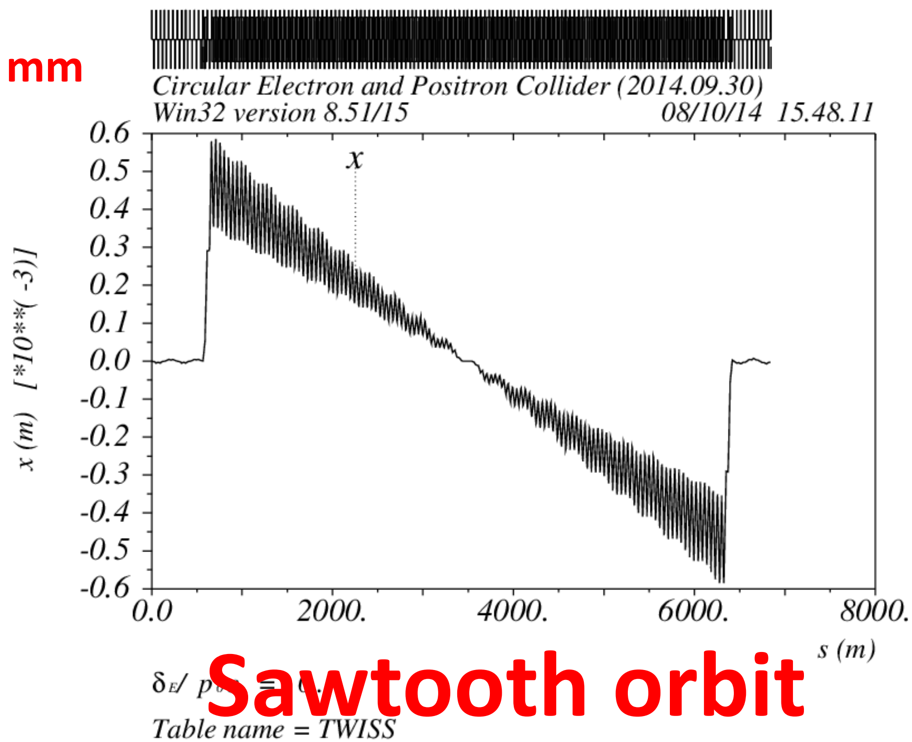
- Sawtooth orbit amplitude is one order smaller than pretzel orbit, how much will it affect DA ?
- How to correct sawtooth orbit if two beams stay in one ring ?

6 mm



Pretzel orbit

0.6 mm



Sawtooth orbit

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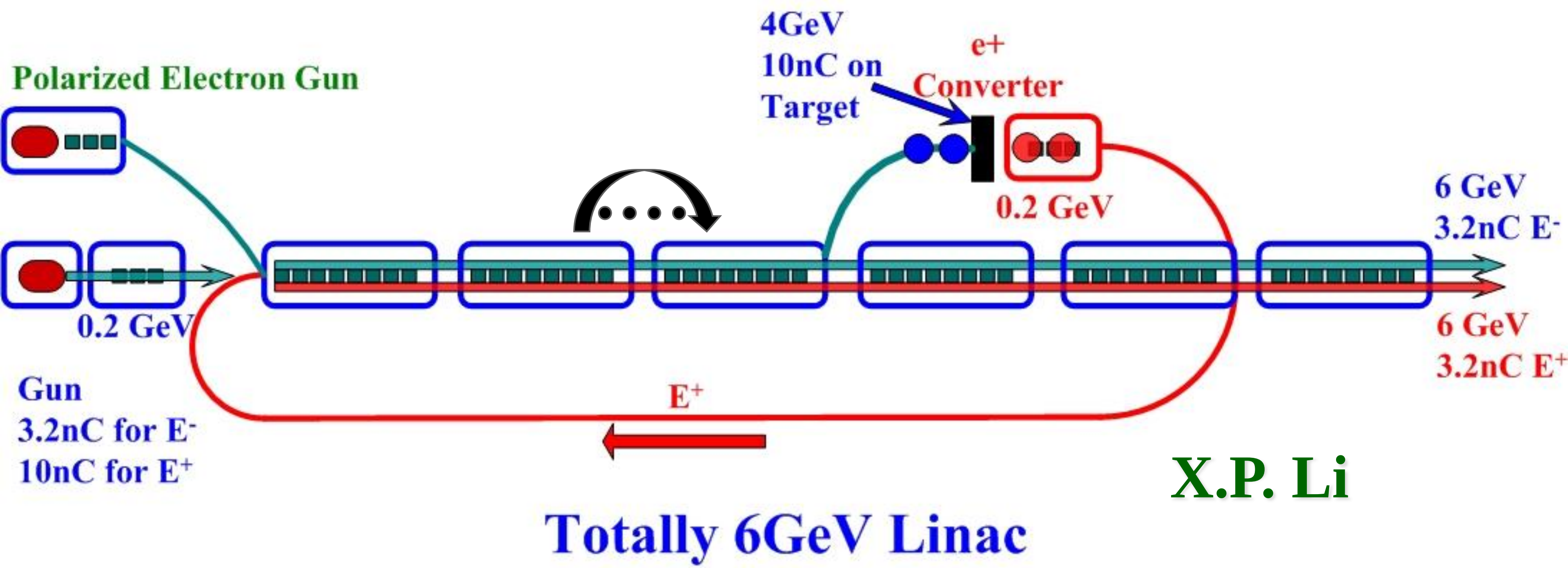
CEPC Injectors

CEPC Linac for booster injection



- Conventional S-band linac with frequency of 2856MHz;
- 4GeV 10nC electron beam on the positron converter;
- 0.2 GeV positron recycling line.

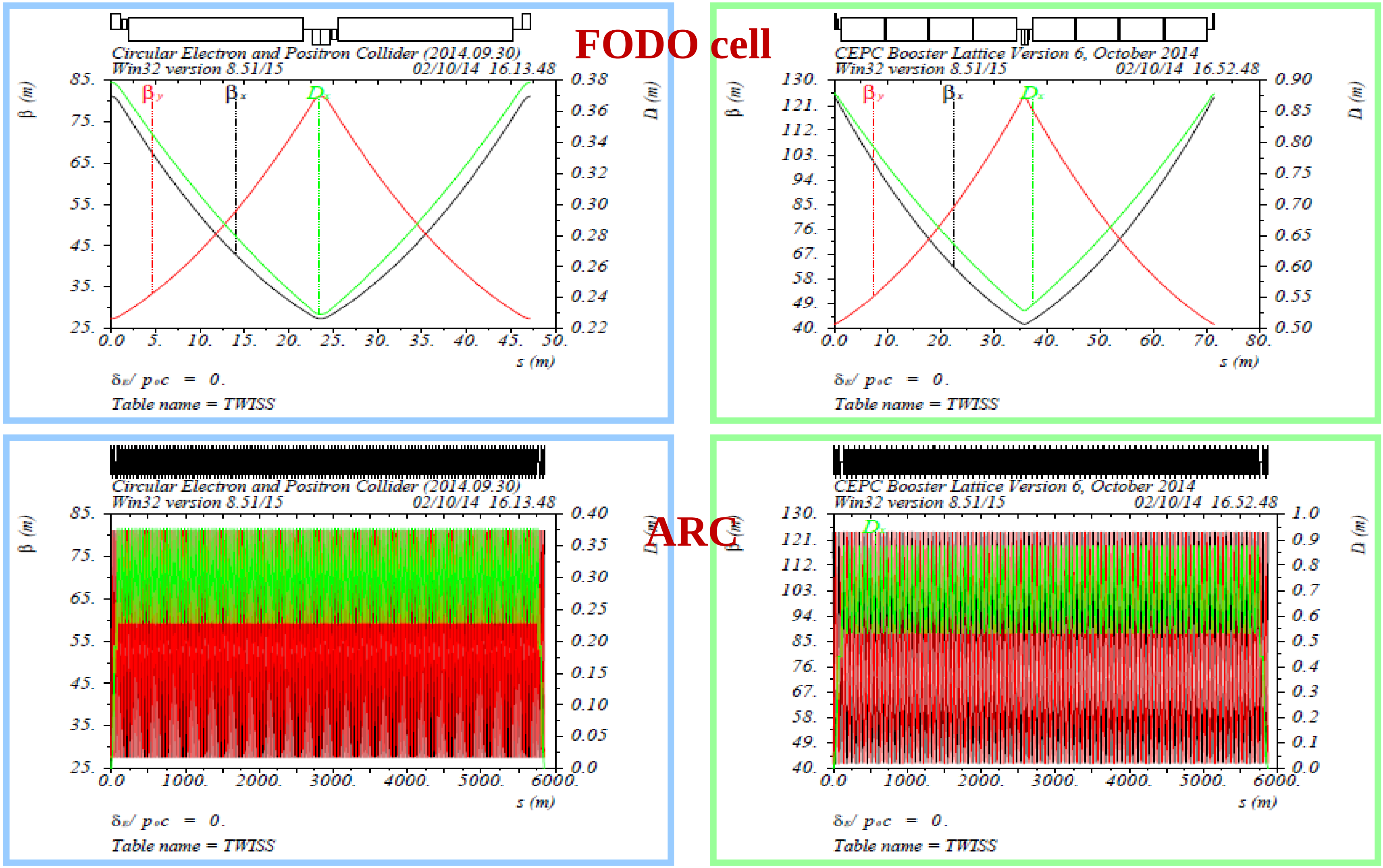
Chuang Zhang

Booster: General Description

Booster is in the same tunnel of the CEPC collider installed in its up-side with same circumference as the collider, while bypasses are arranged to keep away from detectors.

- **Provide beams for the collider with top-up frequency of 0.1 Hz.**
- **Use 1.3GHz RF system;**
- **Booster injection energy is 6 (10) GeV;**
- **Field is only 30 (50) Gs at injection.**

Lattice functions: booster vs. collider



- **Larger cell length to save costs: 71.3 m (instead of 47.2 m)**

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3. Injection energy and low field issue

The bending field of CEPC booster is 614Gs at 120 GeV; To reduce the cost of linac injector, the injection beam energy for booster is chosen as low as 6 GeV with the magnetic field of 30.7 Gs.

- **It needs to be tested if the magnetic field could be stable enough at such a low field against the earth field of 0.5-0.6 Gs and its variation?**
- **Try to find a way to increase the bending field at injection.**

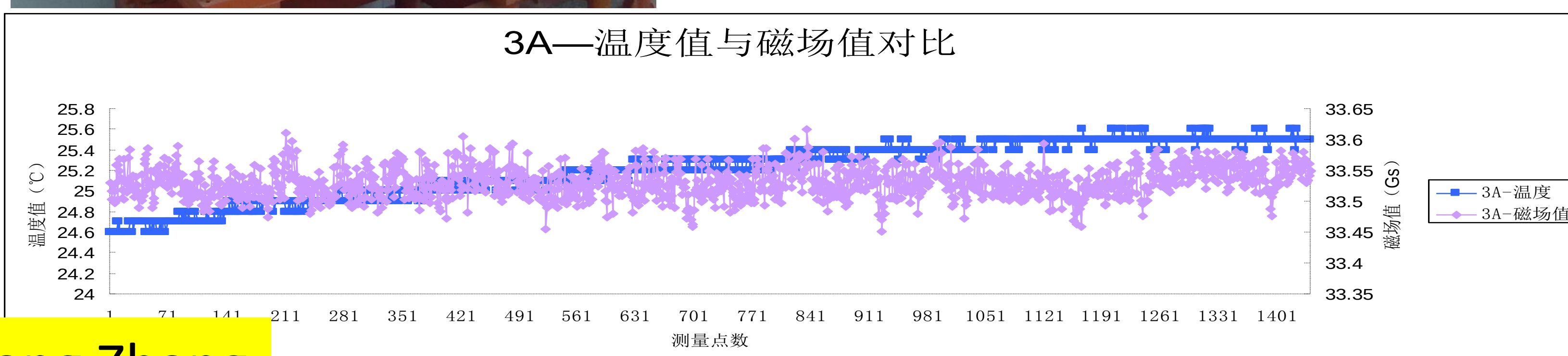
Chuang Zhang

3.1 Low field stability test

The bending field: 614Gs at 120 GeV;

Injection at 6 GeV: 30.7 Gs.

- **A BEPC bending magnet:**
- **B_0=30Gs @ I_B=3A 。**
- **The 24h field stability (σ_B) for 30 Gs-150 Gs is about (1-2)×10^{-3};**



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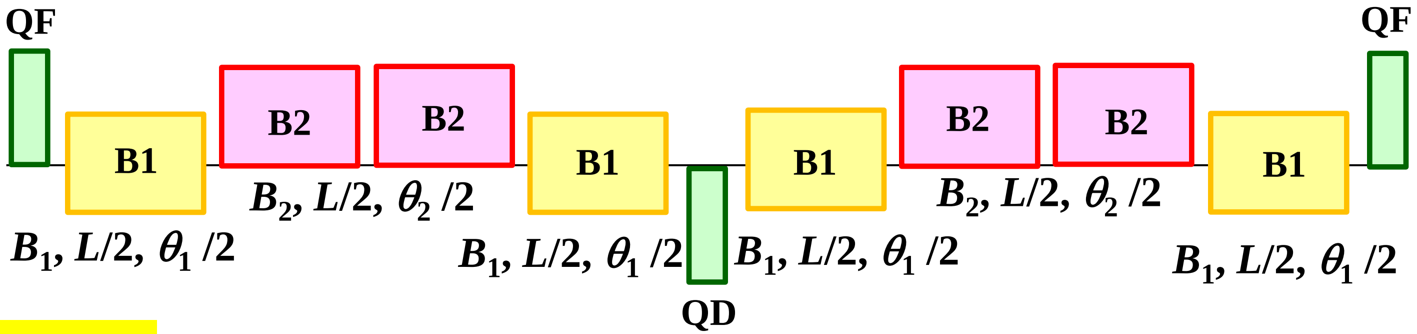
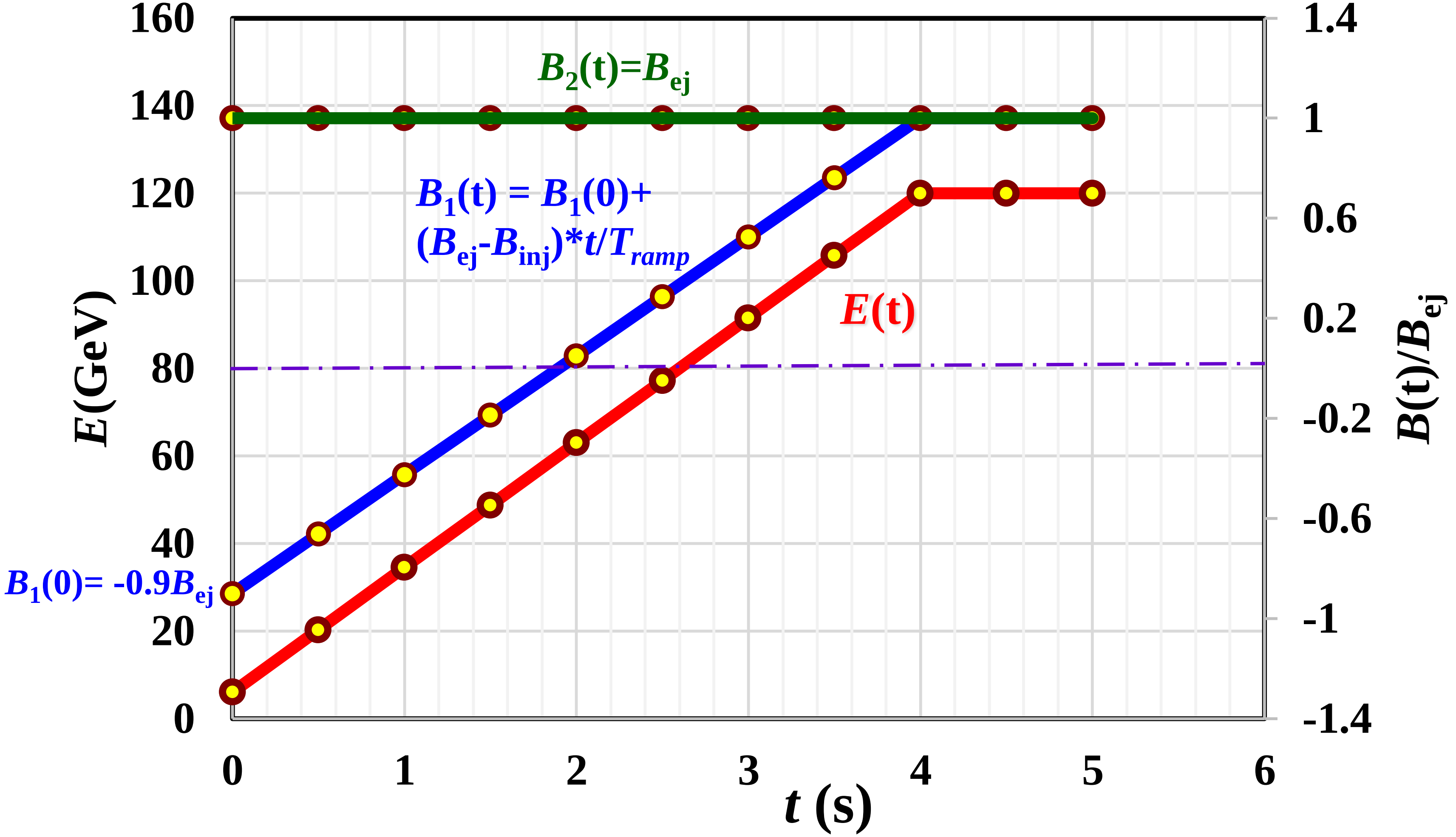
3.2 Wiggling-Bends

- **Four bending magnets with same length in a half cell, two outside bends are excited by a bipolar power supply;**
- **The magnetic field of the bends is properly set during the energy ramping to keep the total bending angle constant.**
- **Both "Wiggling-Bends", "Normal-Bends" and other combinations can be tested in operation.**



WB field vs. time during energy ramping



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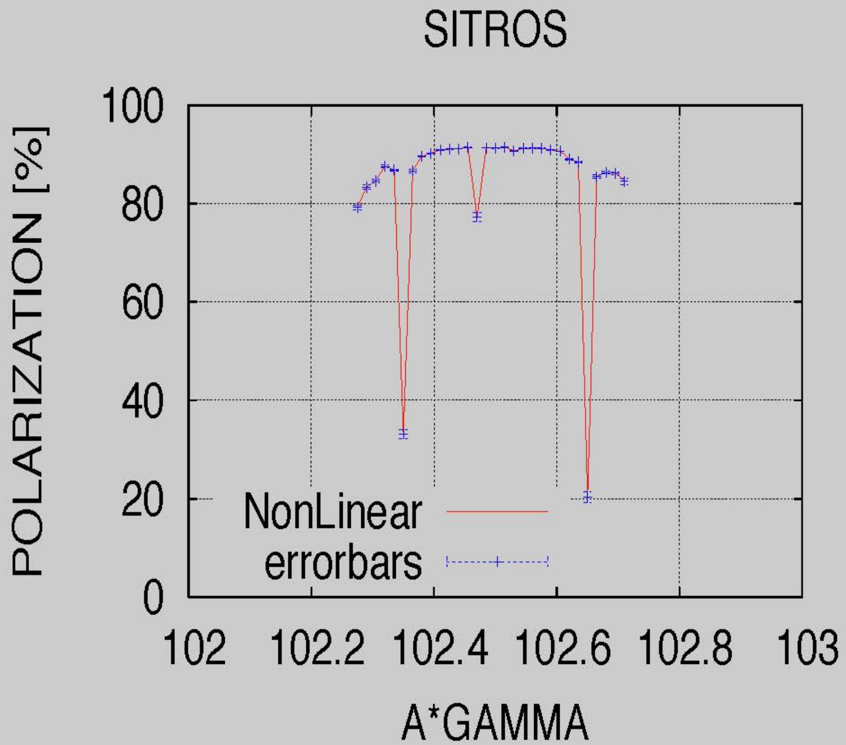
Different topics

Important Questions for Optics

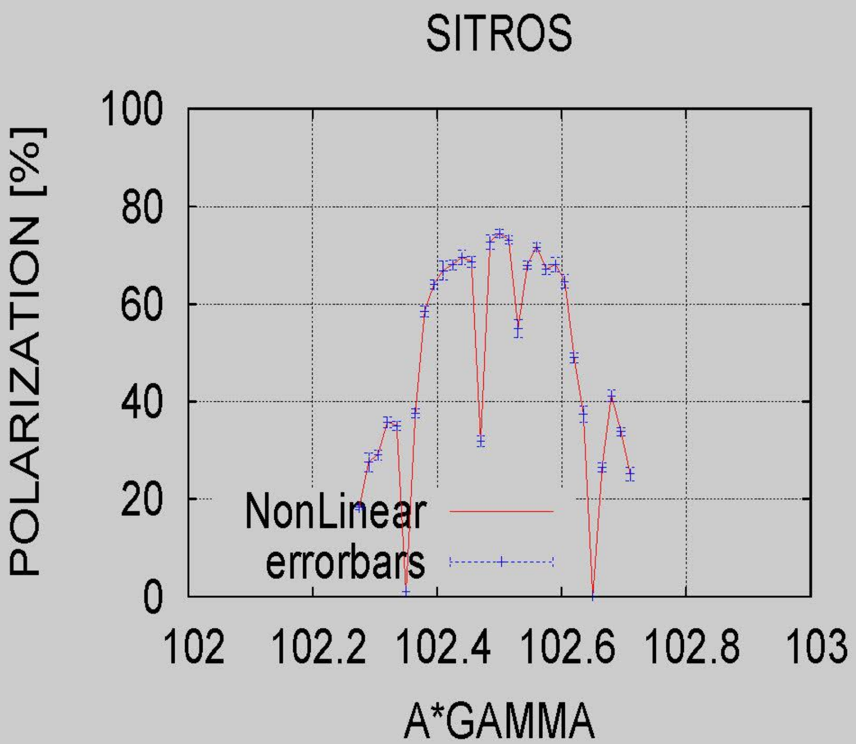
- Is FODO better for high packing factor, or any other possibility?
- Is the emittance hard to achieve in the reasonable sextupole strength?
- How is the degree of freedom in the design of final focus system?
- How is chromaticity correction well done mainly in IR design?
- Possibility for wider momentum acceptance and dynamic aperture.

SITROS: Polarization in presence of vertical misalignments w/o wigglers (no corrections!)

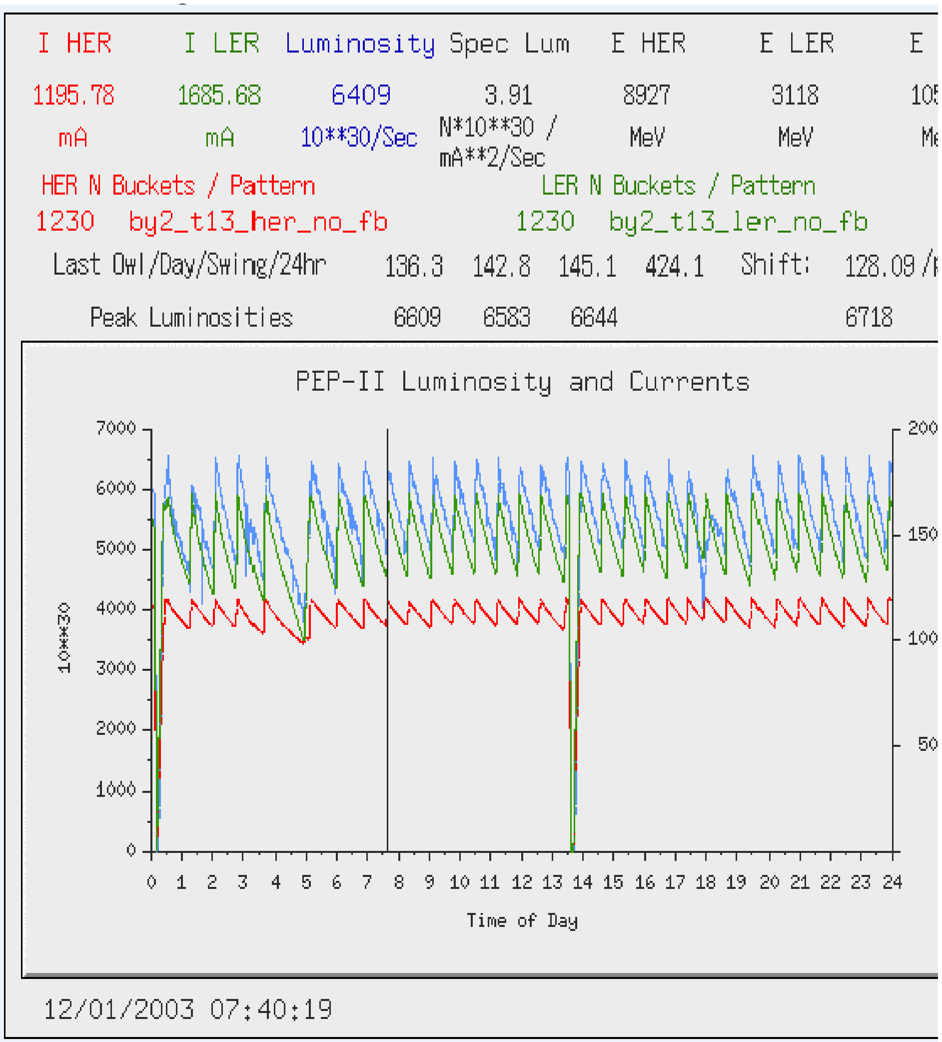
$B_+=0$, $\delta_y^Q=10\ \mu$m, y_{rms} 0.4 mm

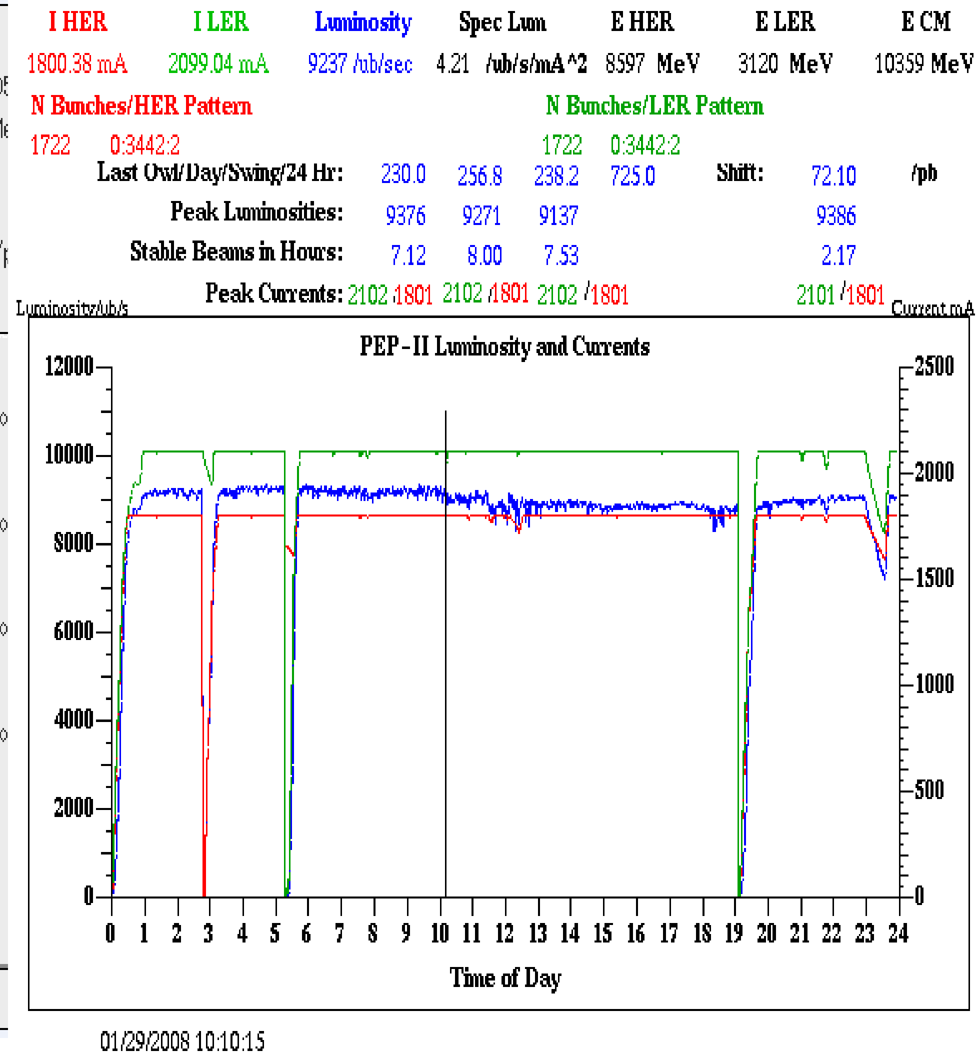


$B_+=0$, $\delta_y^Q=50\ \mu$m, y_{rms} 2 mm



Running with and without continuous injection at PEP-II





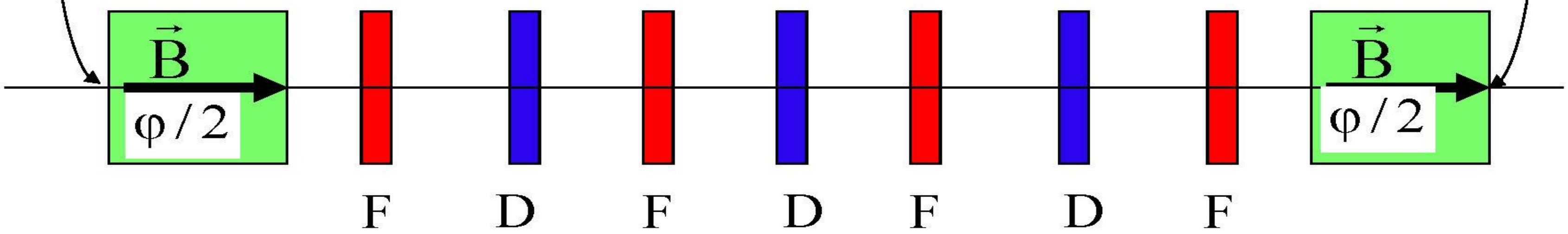
John Seeman

Spin transparent rotator for the solenoid type Snake

For decoupling should be $T_x = -T$ ← Litvinenko, Zholentz, 1980

$$T_x = \begin{pmatrix} -\cos\varphi & -2r\sin\varphi \\ (2r)^{-1}\sin\varphi & -\cos\varphi \end{pmatrix}$$ for the spin transparency!

$$r = pc/eB$$

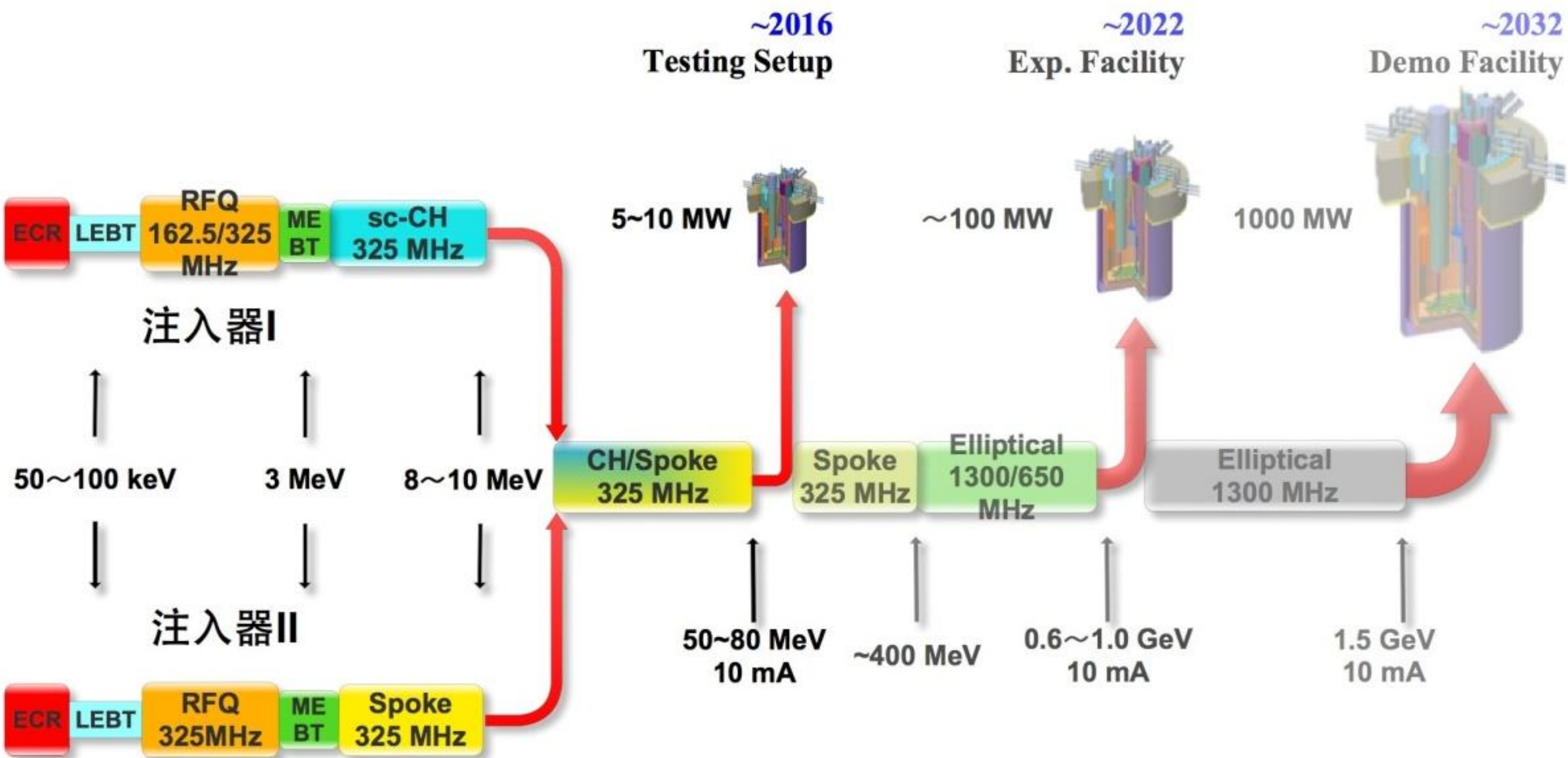


Two solenoids, each L=40 m B=5 T, provide spin rotation by $\varphi = 180^0$ at E=45.5 GeV. Extension to 120 GeV with B=10 T looks feasible.

- proposed scheme: use polarized e^- source, measure energy on every injection shot, for e^+ self polarization in 1-2 GeV intermediate ring
- several snakes in booster ring
- inject into collider with horizontal polarization vector
- measure modulation from Compton polarimetry over first 10,000 turns ; 1e-6 accuracy

Ivan Koop

ADS R&D



- High beam power （CW）
- Very high stability
- Very low beam loss：<1W/m .

Currently for injectors
- CW RFQ with a high intensity
- Very Low beta SC cavities

Yifang Wang

Summary

- Very interesting workshop

→ Many discussions, meeting a lot of people, …

- Link to Program/Slides:

http://indico.ihep.ac.cn/conferenceOtherViews.py?view=standard&confId=4221

- Proceedings will be published

Thank you for your attention!