Future Colliders in China and ep

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DIS 17

University of Birmingham
3 April 2017

Outline

The Future Collider Machines in China

Circular Electron Positron Collider (CEPC)

Super Proton Proton Collider (SPPC)

The electron-proton option

High Intensity heavy ion Accelerator Facility (HIAF)

Upgrade to an Electron Ion Collider (EIC)

Circular Colliders: CEPC and SPPC

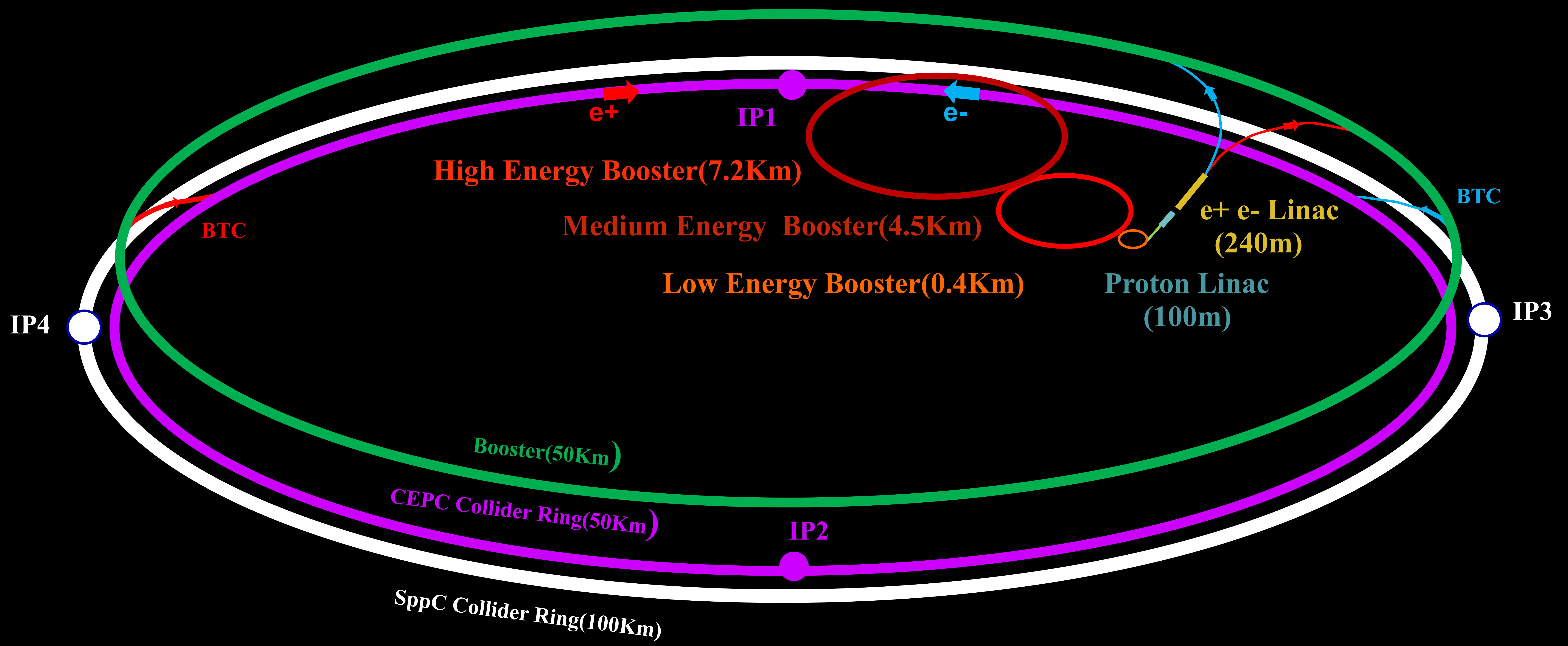
Given the Higgs Boson low mass ($m_H \sim 125$ GeV)

1. Build a Circular Higgs Factory (CEPC)

followed by

2. Proton Collider (SPPC) to explore energy frontier

C = 100 km

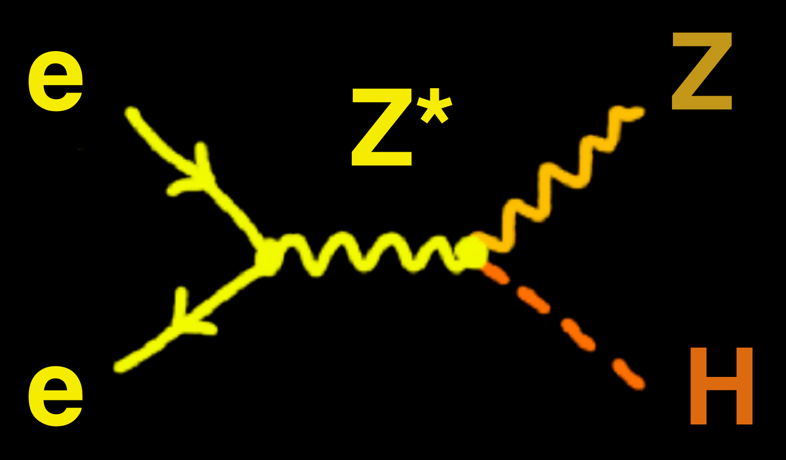


Science of CEPC-SPPC

CEPC: Electron-positron collider (90, 250 GeV)

Higgs factory （10^6 Higgs)

- precision study of Higgs (m_H, couplings)
- looking for hints of new physics
  - Higgs rare decays
- similar & complementary to ILC



Z and W factory （10^{11} Z^0)

- precision test of SM
- search for rare decays

Flavor factory: b, c, τ and QCD studies

SPPC: proton-proton collider at ~100 TeV

Directly search for new physics beyond SM

Precision test of SM

e.g., h^3 & h^4 couplings

Precision measurement + searches:

Complementary with each other !

IHEP-CEPC-DR-2015-01

IHEP-EP-2015-01

IHEP-TH-2015-01

Can be downloaded from

http://cepc.ihep.ac.cn/preCDR/volume.html

CEPC-SPPC

Preliminary Conceptual Design Report

Volume I - Physics & Detector

403 pages, 480 authors

Australia, Canada, China, France, Germany, Hong-Kong, Israel, Italy, Japan, Korea, Mexico, Morocco, Pakistan, Serbia, South Africa, Switzerland, Taipei, UK, USA

The CEPC-SPPC Study Group

March 2015

IHEP-CEPC-DR-2015-01

IHEP-AC-2015-01

CEPC-SPPC

Preliminary Conceptual Design Report

Volume II - Accelerator

328 pages, 300 authors

Australia, China, France, Germany, Hong-Kong, Italy, Japan, Russia, Taiwan, UK, USA

The CEPC-SPPC Study Group

March 2015

Current Status and the Plan

Pre-CDR completed

- No show-stoppers
- Technical challenges identified → R&D issues
- Preliminary cost estimate

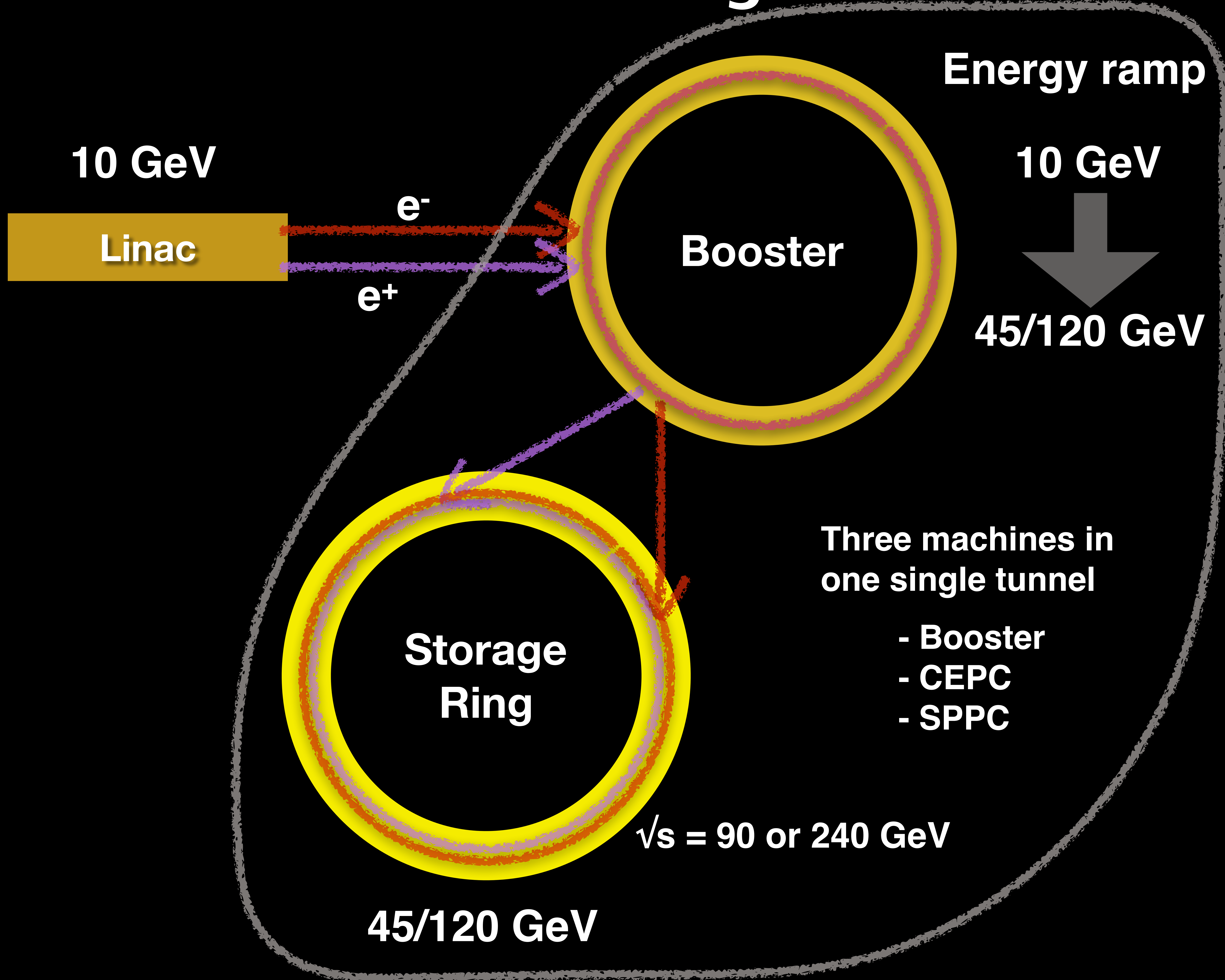
Working towards CDR (Accelerator and Detector)

- Goal: A working machine on paper by end of 2017
- Ready to be reviewed by government at any moment

R&D issues identified and funding request underway

- Seed money from IHEP: 12 M RMB/3 yrs
- MOST: 36 M RMB/5 yrs approved, +~40 M RMB expected next year
- NSFC: ~12M RMB/4 yrs approved → 6 M RMB/yr to be approved
- Beijing Municipality: 400M RMB
- NCDR: ~0.8 B RMB/5 yr, failed in a voting process
- CAS & NSFC: more than 10M/yr expected, hopefully ~50 M/yr (under discussion)

CEPC Accelerator Design



CEPC Design –Higgs Parameters

Parameter	Design Goal
Particles	e+, e-
Center of mass energy	2*120 GeV
Luminosity (peak)	>2*10^34/cm^2s
No. of IPs	2

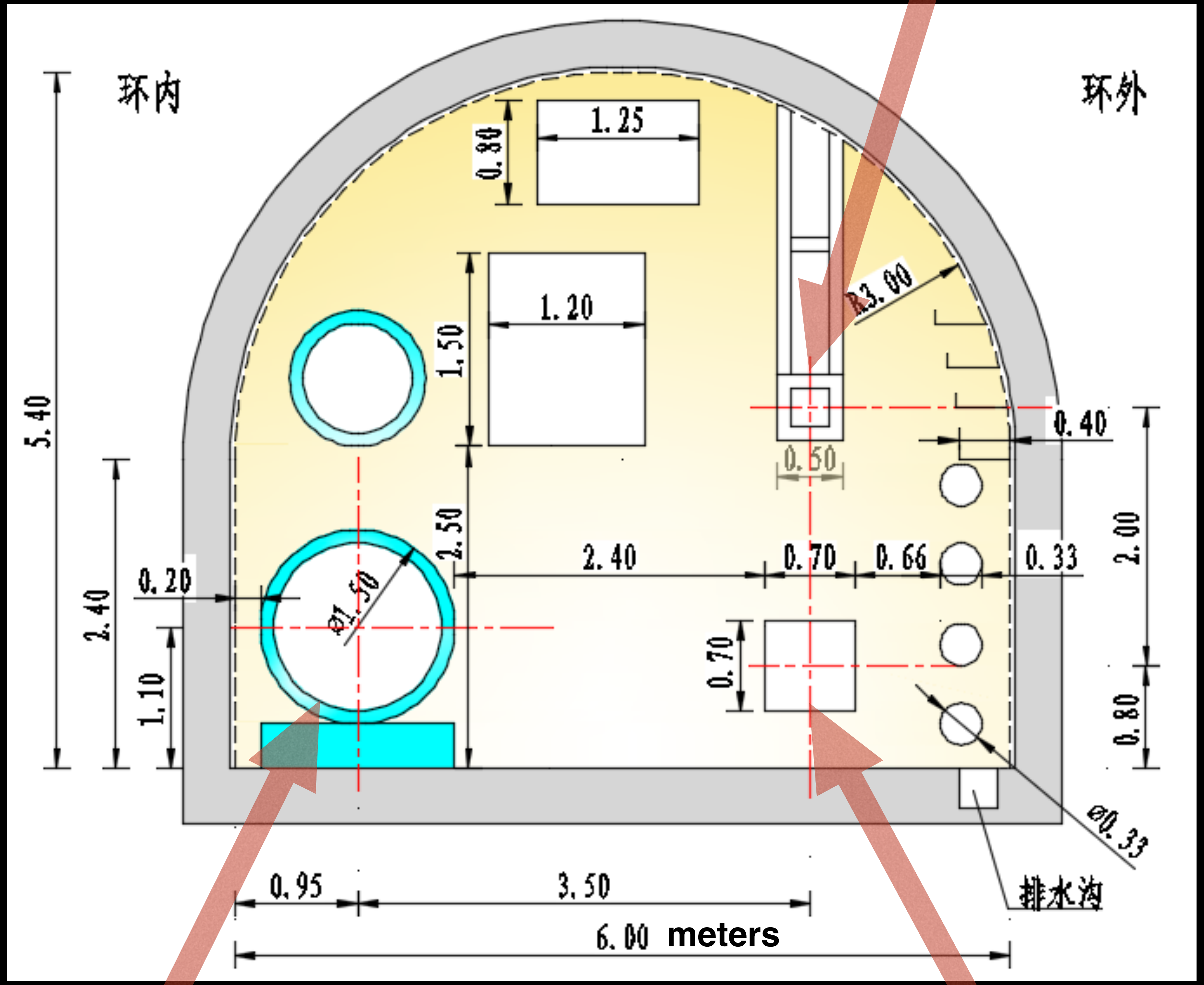
CEPC Design – Z-pole Parameters

Parameter	Design Goal
Particles	e+, e-
Center of mass energy	2*45.5 GeV
Integrated luminosity (peak)	>10^34/cm^2s
No. of IPs	2
Polarization	to be considered in the second round of design

Planning CDR by end of 2017 to give the detailed design for all systems

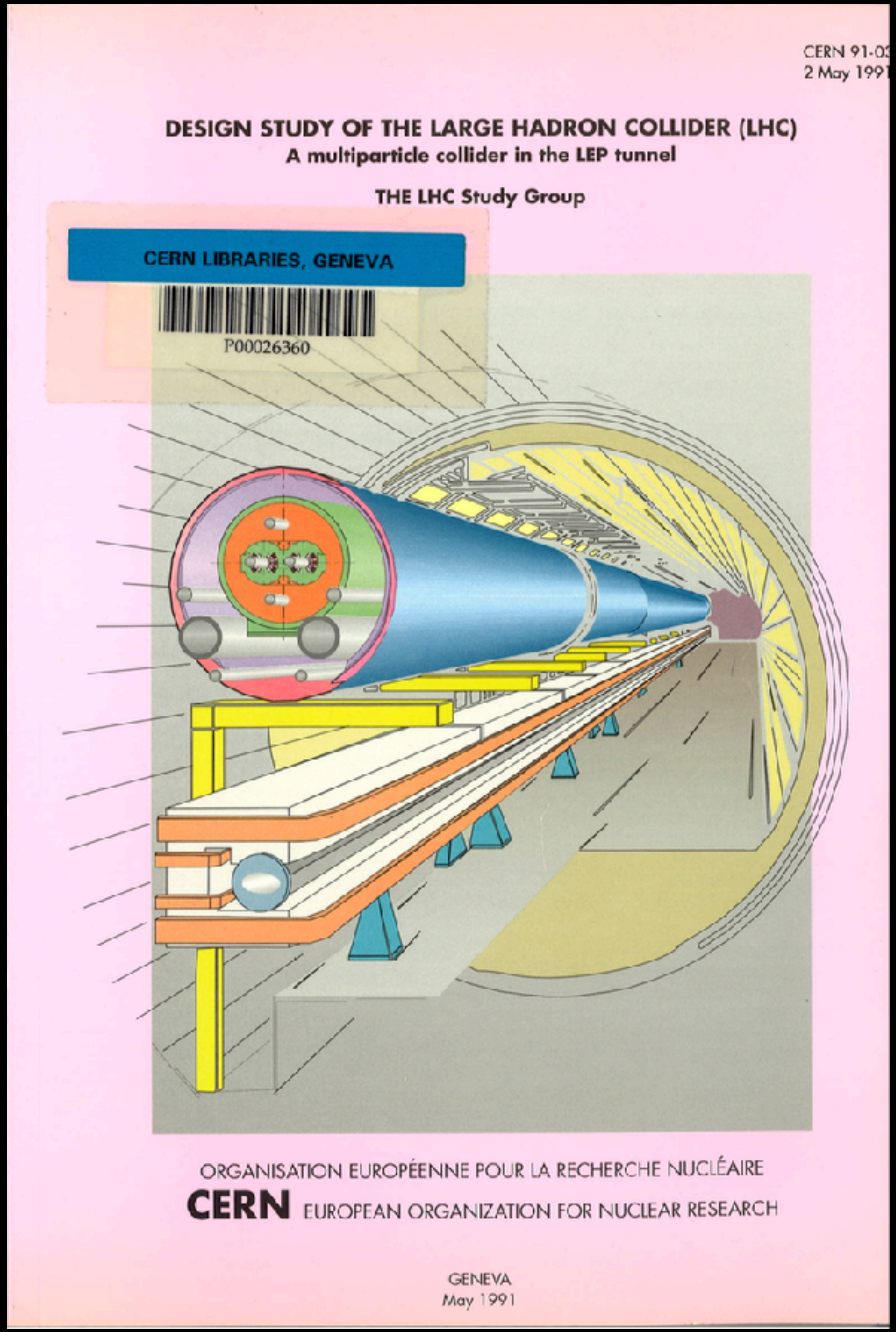
The 100k tunnel cross section

CEPC Booster



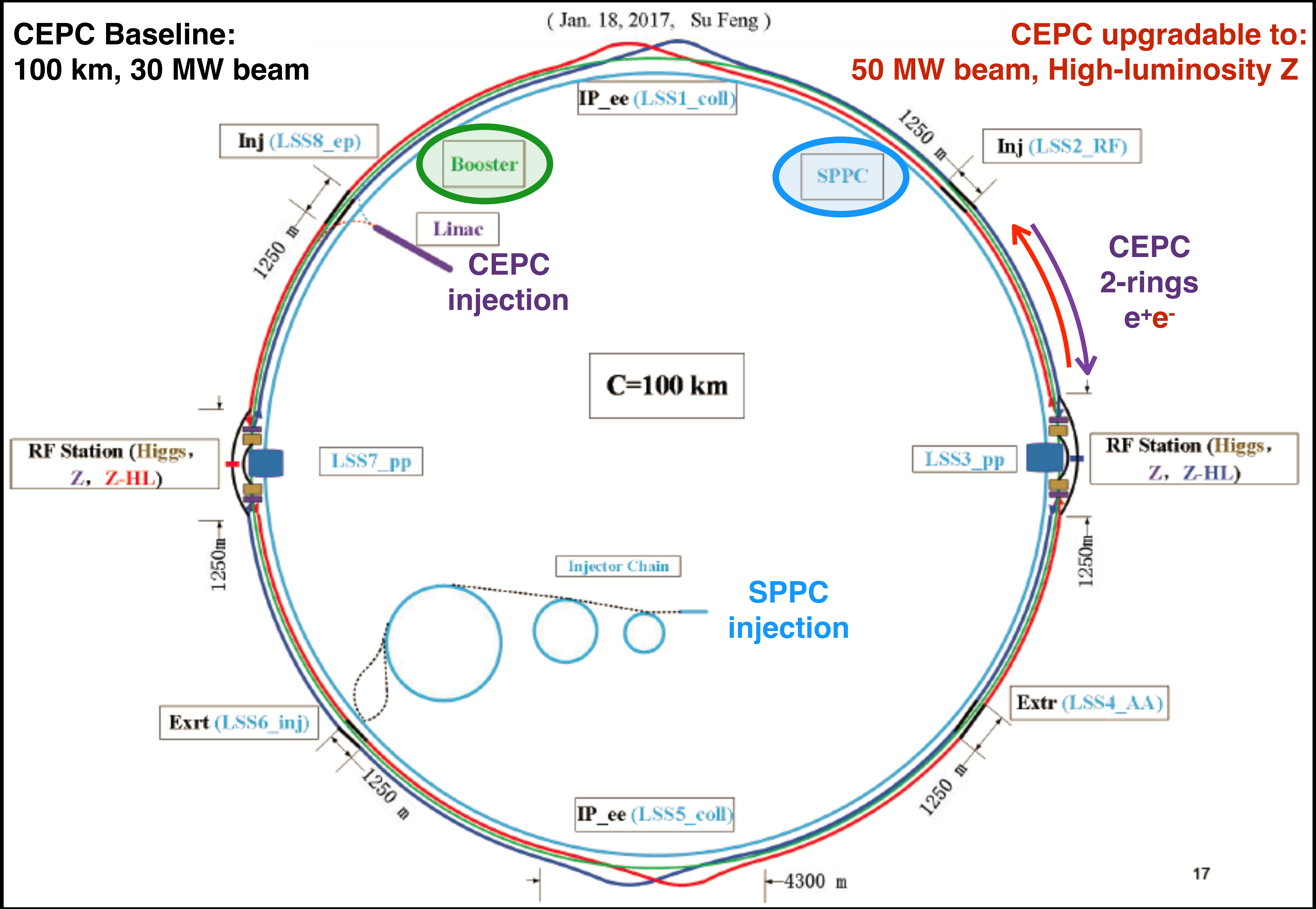
SPPC collider

CEPC collider

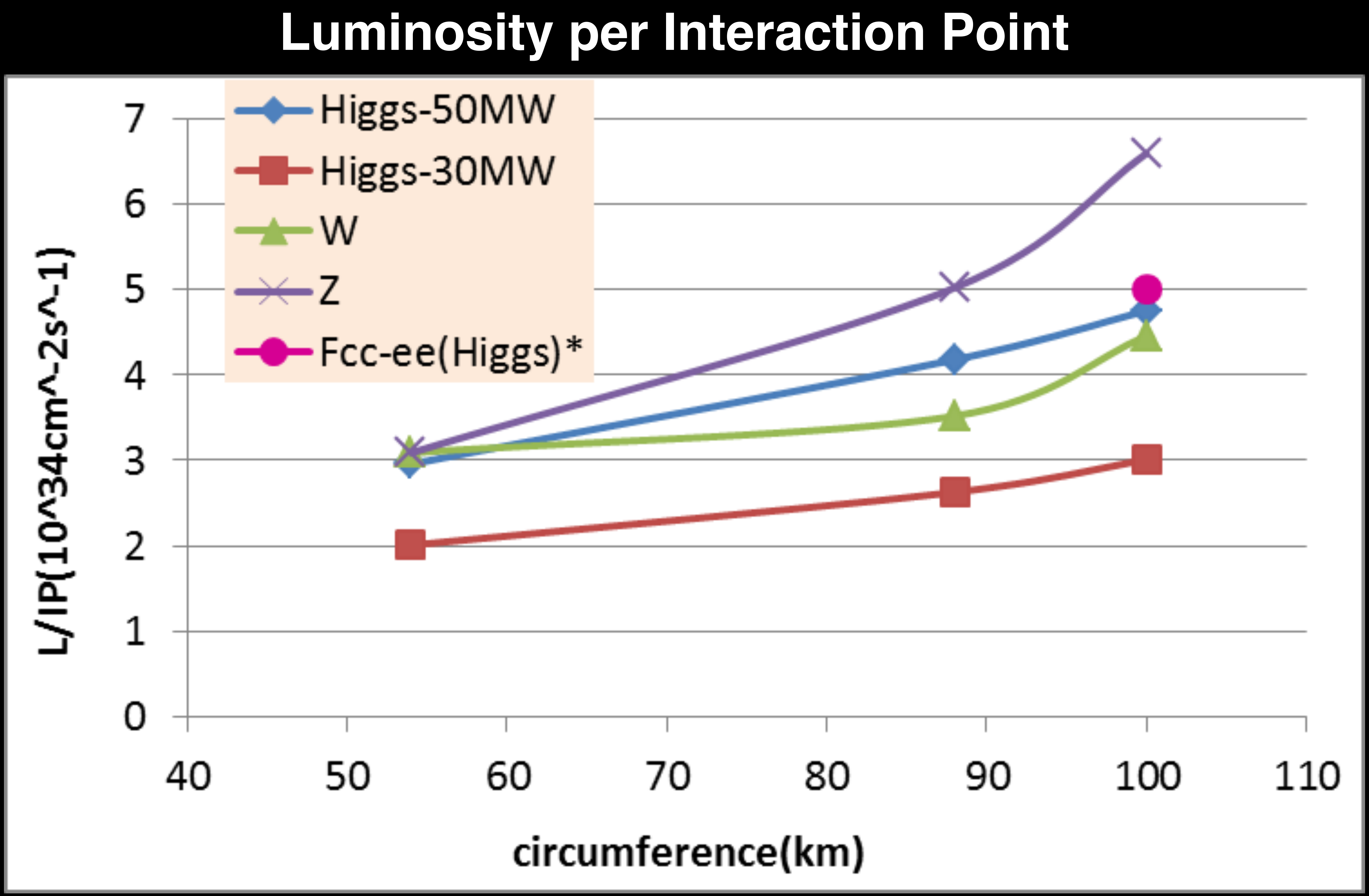


Proposed in Lausanne Workshop in 1984

Layout of CEPC-SPPC



CEPC luminosity versus ring size



* Fabiola Gianotti, Future Circular Collider Design Study, ICFA meeting, J-PARC, 25-2-2016

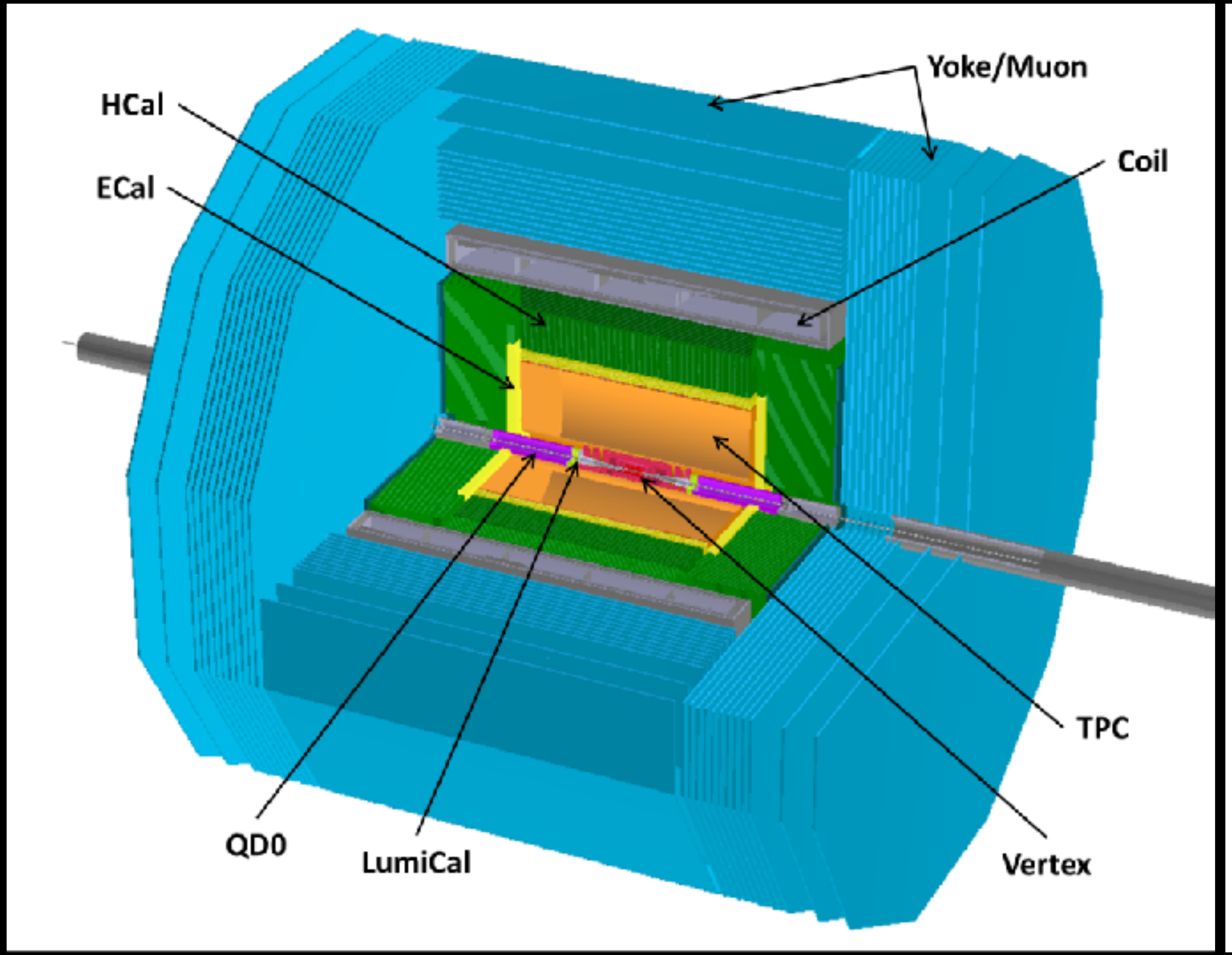
Parameters for CEPC Full Partial Double Ring

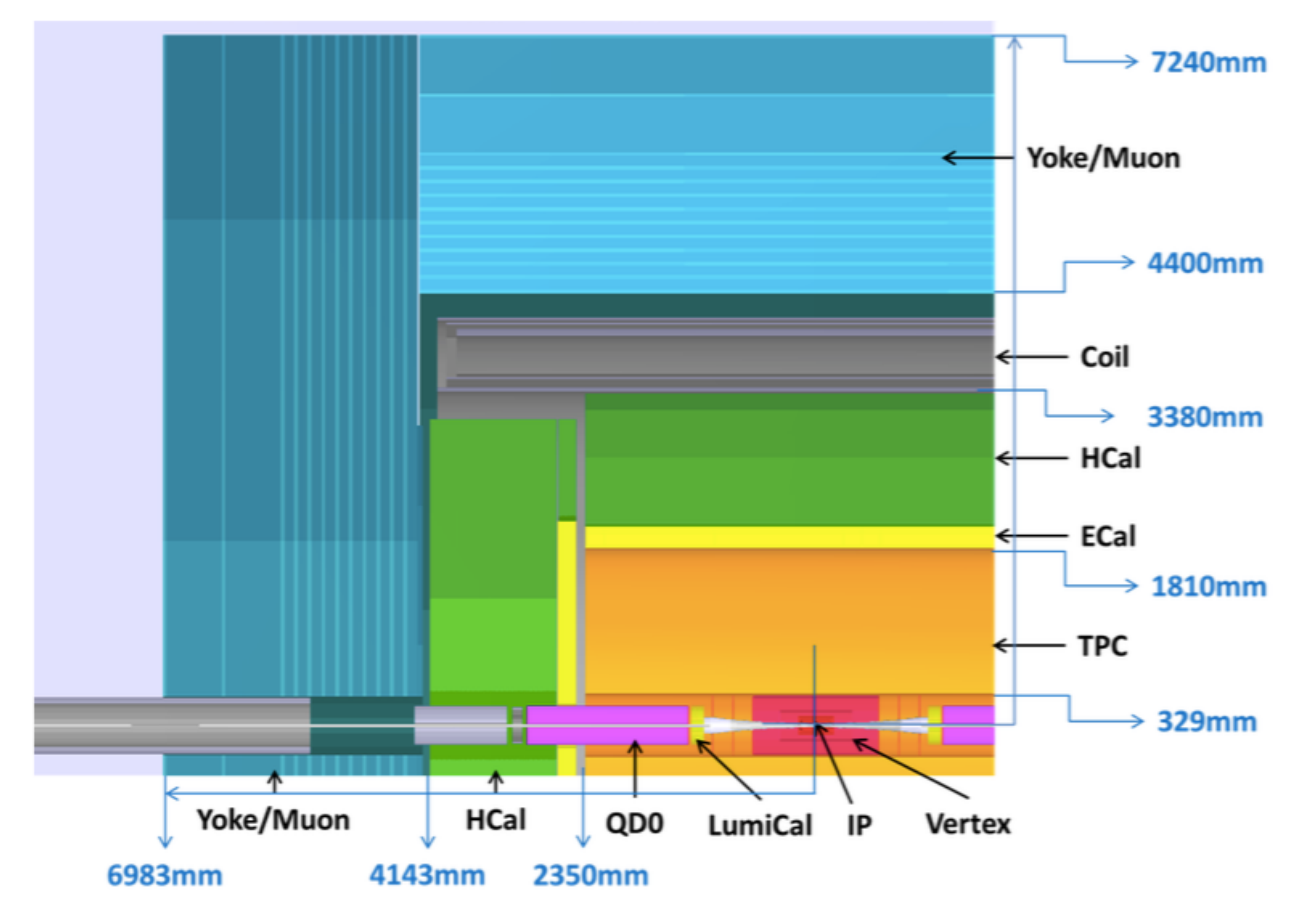
Preliminary

	Pre-CDR	H-high lumi.	H-low power	W	Z	
Energy (GeV)	120	120	120	80	45.5	45.5
Circumference (km)	54	100	100	100	100	100
SR loss/turn (GeV)	3.1	1.67	1.67	0.33	0.034	0.034
N_e/bunch (10^{11})	3.79	1.12	1.12	1.05	0.46	0.46
Bunch number	50	555	333	1000	16666	65716
SR power /beam (MW)	51.7	**50**	**30**	16.7	12.7	50
β_{IP} x/y (m)	0.8/0.0012	0.3/0.001	0.3/0.001	0.1 /0.001	0.12/0.001	0.12/0.001
Emittance x/y (nm)	6.12/0.018	1.01/0.0031	1.01/0.0031	2.68/0.008	0.93/0.0049	0.93/0.0049
ξ_x/ξ_y/IP	0.118/0.083	0.029	0.029	0.0082/0.055	0.0075/0.054	0.0075/0.054
RF Phase (degree)	153.0	0.083	0.083	149	160.8	160.8
V_{RF} (GV)	6.87	**2.0**	**2.0**	**0.63**	**0.11**	**0.11**
f_{RF} (MHz) (harmonic)	650	650	650	650 (217800)	650 (217800)	
Nature σ_z (mm)	2.14	**2.72**	**2.72**	**3.8**	**3.93**	**3.93**
Total σ_z (mm)	2.65	2.9	2.9	3.9	4.0	4.0
HOM power/cavity (kw)	3.6 (5cell)	0.75(2cell)	0.45(2cell)	1.0 (2cell)	1.6(1cell)	6.25(1cell)
Energy acceptance (%)	2	1.5	1.5			
Energy acceptance by RF (%)	6	1.8	1.8	1.5	1.1	1.1
Life time due to beamstrahlung_cal (minute)	47	52	52			
L_{max}/IP ($10^{34}cm^{-2}s^{-1}$)	2.04	5.42	3.25	4.08	18.0	70.97

CEPC Detector

ILD-like design with some modification for circular collider





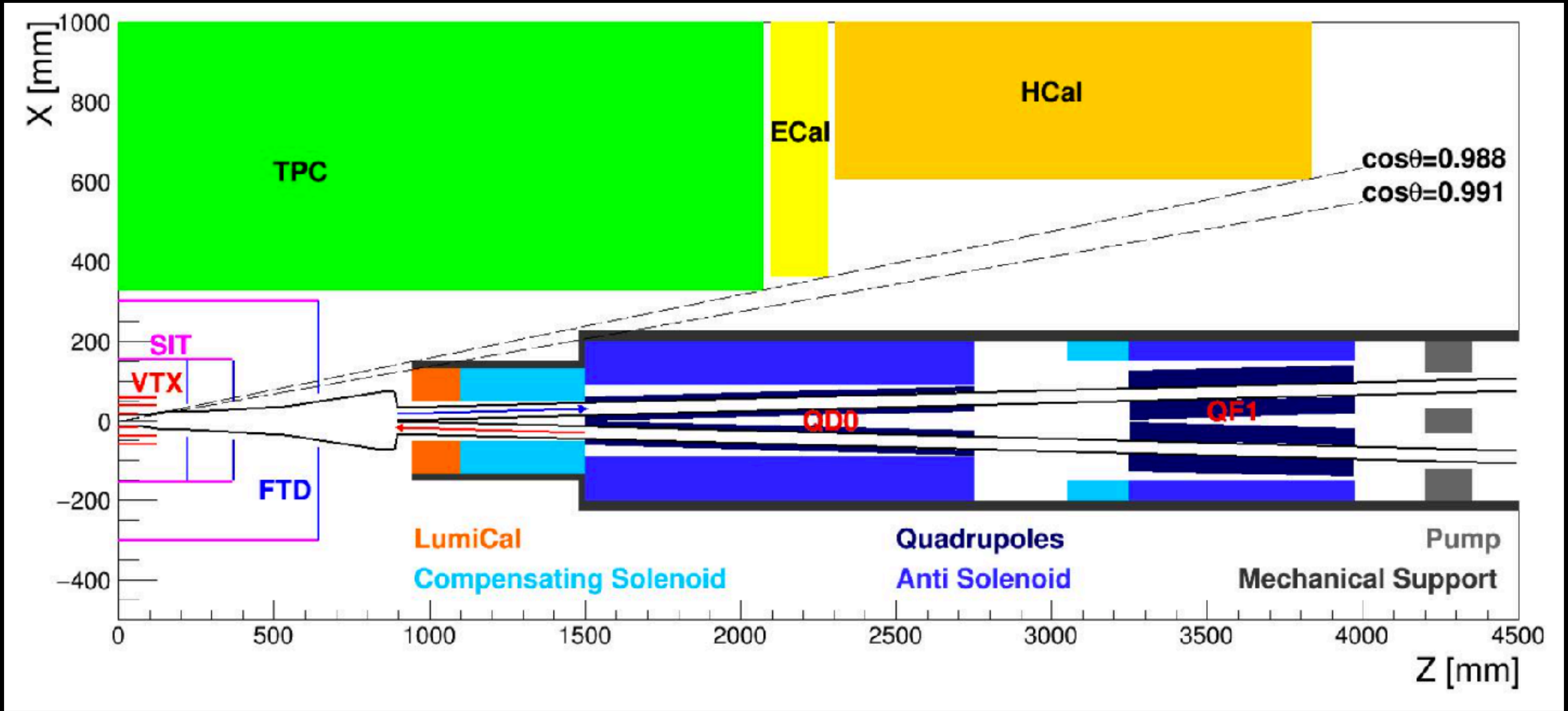
- Impact parameter resolution: less than 5μm
- Tracking resolution : $\delta(1/Pt) \sim 2*10^{-5}$ (GeV^{-1})
- Jet energy resolution : $\sigma_E/E \sim 0.3/\sqrt{E}$

Alternatives:

1. **Full silicon tracker SiD-style**
2. **Dual-readout calorimeter plus drift chamber**

Machine Detector Interface

Very challenging since focusing magnets are inside detector



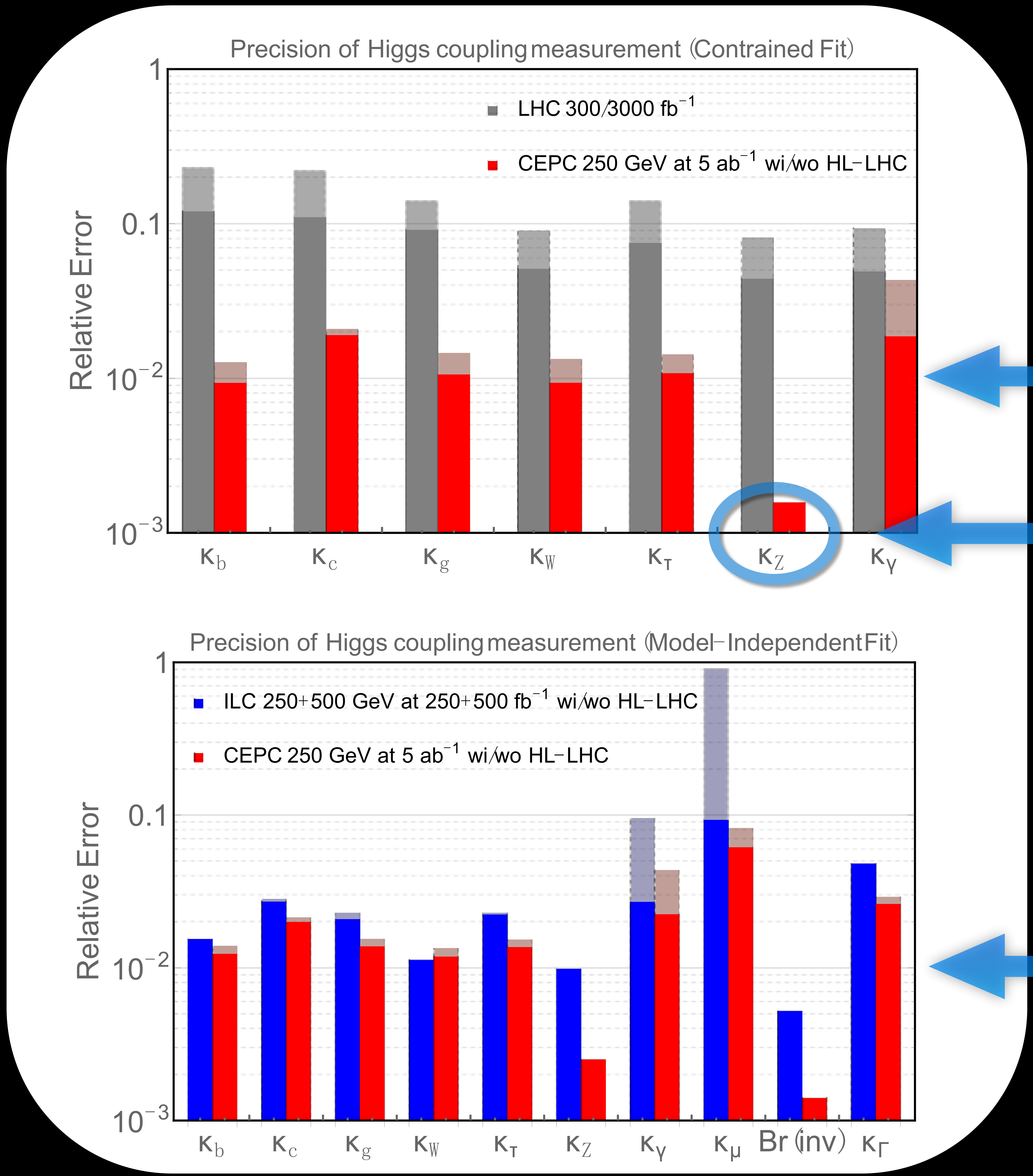
- $L^* = 1.5m$ @ $CEPC, (L^* \downarrow \rightarrow L \uparrow)$
- The crossing angle is 30 mrad in the double ring scheme
- Space are very tight for both the accelerator and the detector

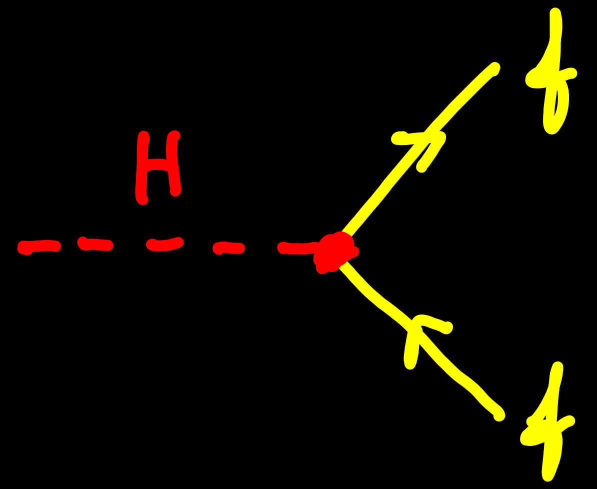
Higgs couplings at new colliders

CEPC

CEPC
vs
LHC

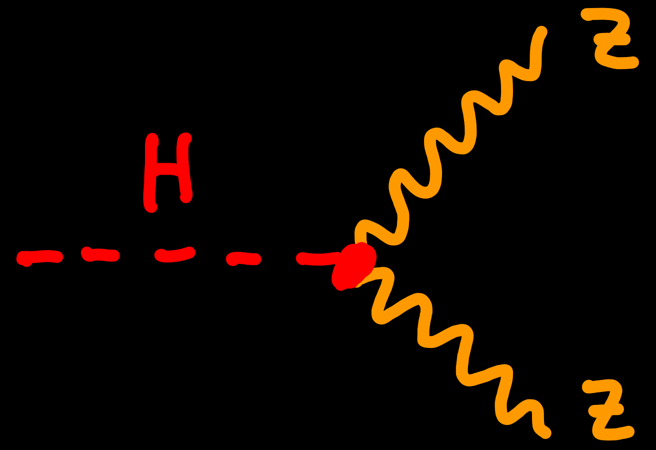
CEPC
vs
ILC





1%

K_Z (h-Z) ~ 0.2 %



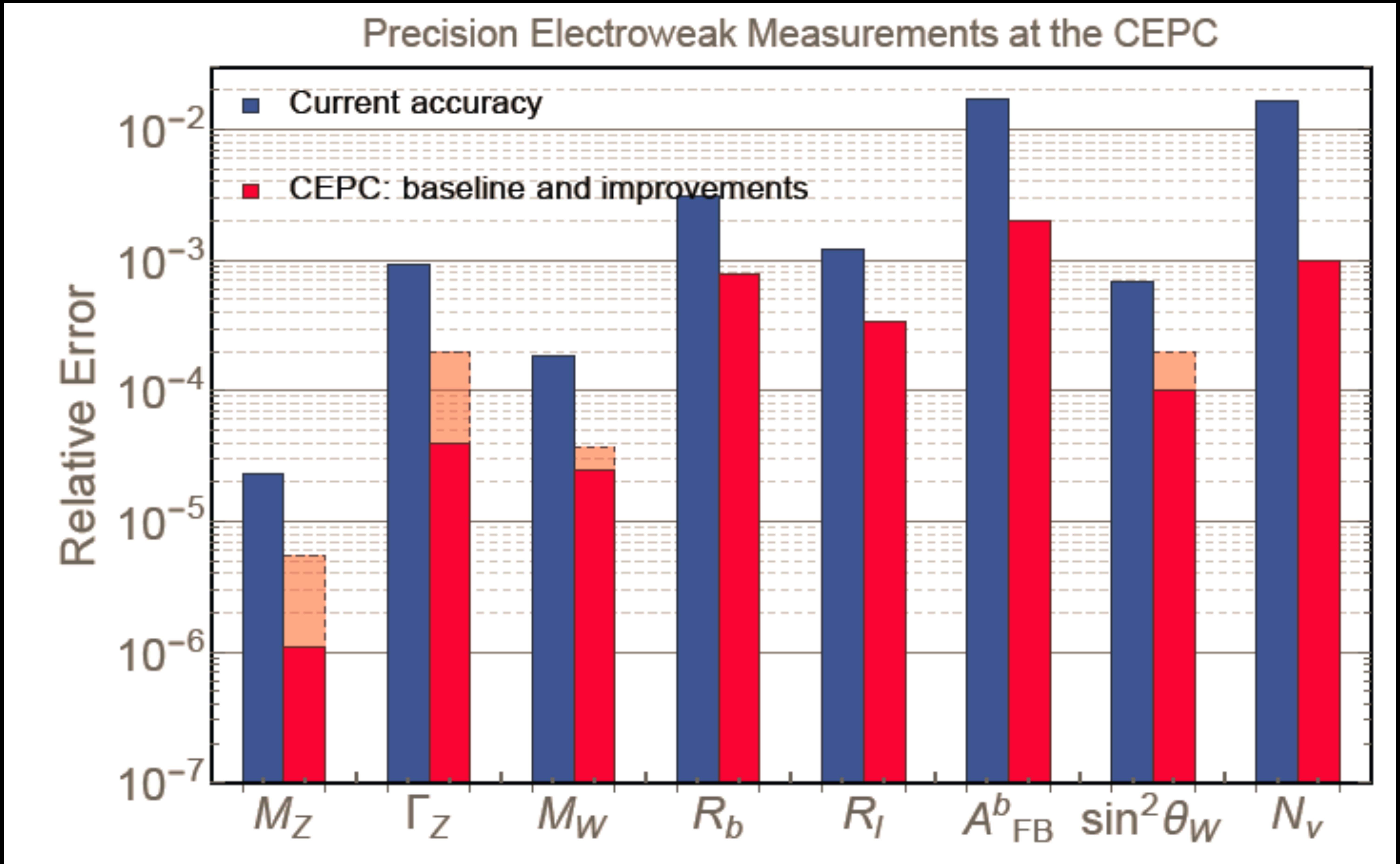
1%

Improvements in Electroweak Precision

Total of 10^{11} Z bosons

A detailed study of Z & W to look for deviations from the Standard Model

Can probe new physics up to ~ TeV, better than HL-LHC by a factor of 3



m_Z: 0.0001% m_W: 0.002%

CEPC goals

Framework for SPPC Conceptual Design Report

Baseline design

- **Tunnel circumference**: 100 km
- **Dipole magnet field**: 12 T, using iron-based HTS technology
- **Center of Mass energy**: >70 TeV
- Injector chain: 2.1 TeV
- Relatively lower luminosity for the first phase, higher for the second phase

Energy upgrading phase

- **Dipole magnet field:** 20 -24T, iron-based HTS technology
- **Center of Mass energy:** >125 TeV
- Injector chain: 4.2 TeV (adding a high-energy booster ring in the main tunnel in the place of the electron ring and booster)

Development of high-field superconducting magnet technology

Starting to develop required HTS magnet technology; before applicable iron-based HTS wire are available, models with YBCO and LTS wires can be used for specific studies

(magnet structure, coil winding, stress, quench protection method etc.)

SPPC main ring parameters (61 km, 100 km, 82 Km)

	SPPC (Pre-CDR)	SPPC 61Km	SPPC 100Km	SPPC 100Km	SPPC 82Km
Beam energy[E_0]/TeV	35.6	35.0	50.0	64.0	50.0
Circumference[C_0]/km	54.7	61.0	100.0	100.0	82.0
Dipole field[B]/T	20	19.81	15.62	19.98	19.74
Peak luminosity per IP[L]/ $cm^{-2}s^{-1}$	1.1×10^{35}	1.20×10^{35}	1.52×10^{35}	1.02×10^{36}	1.52×10^{35}
Beta function at collision[β^*]/m	0.75	0.85	0.99	0.22	1.06
Max beam-beam tune shift per IP[ξ_y]	0.006	0.0065	0.0068	0.0079	0.0073
Number of IPs contribut to ΔQ	2	2	2	2	2
Circulating beam current[I_b]/A	1.0	1.024	1.024	1.024	1.024
Number of bunches[n_b]	5835	6506	10667	10667	8747
Bunch population[N_p] (10^{11})	2.0	2.0	2.0	2.0	2.0
Normalized RMS transverse emittance[ε]/μm	4.10	3.72	3.59	3.11	3.35
RMS bunch length[σ_z]/mm	75.5	56.69	66.13	14.62	70.89
Full crossing angle[θ_c]/μrad	146	138.03	105.93	179.82	99.29
Energy loss per turn[U_0]/MeV	2.10	1.98	4.55	12.23	5.76
SR power per ring[P_0]/MW	2.1	2.03	4.66	12.52	5.90

CEPC-SPPC e-p design consideration

Assumption: NO upgrade of CEPC-SPPC required to realize e-p or e-A collisions

e-p performance is determined by beams from CEPC-SPPC

CEPC e+e- collisions and e-p collisions cannot run simultaneously

The CEPC lepton beam has only 300-500 bunches while the SPPC proton beam has 3000 to 6000 bunches

CEPC lepton beam is extremely flat (aspect ratio ~330) while a SPPC proton is basically flat
It is very difficult to have the spot sizes of two beams matched

Without the need to run e+e- and e-p collisions simultaneously, the CEPC electron beam can be reconditioned to match the proton beam to optimize the e-p collision luminosity

Increase electron bunches to 3000

Reduce the emittance aspect ratio to make it a round beam

Double the beam current (still under 100 MW SR power budget)

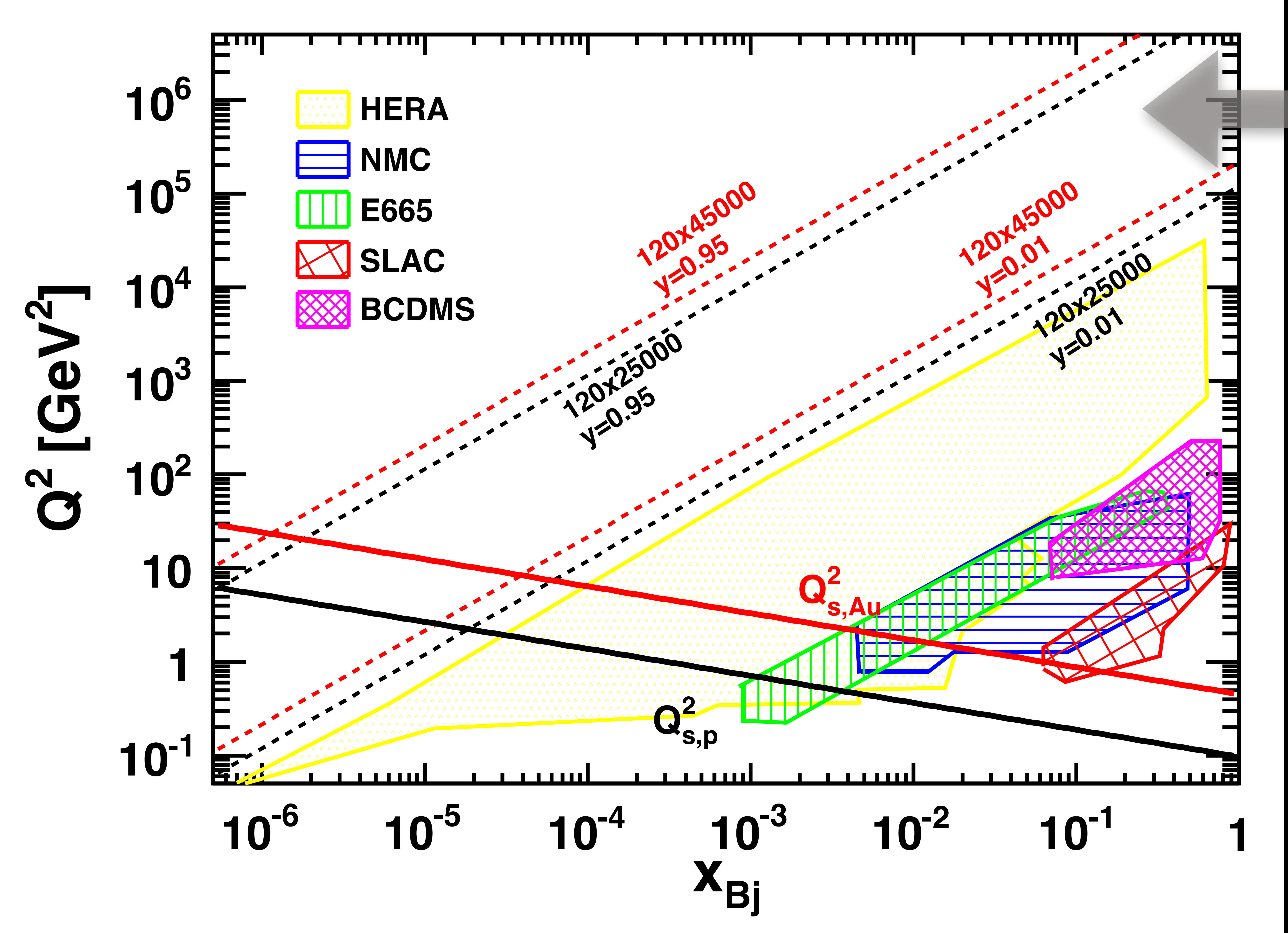
Early design has not been synchronized with the most recent developments in the machine design (100km ring, CEPC double-ring design)

CEPC-SPPC e-p parameters (Very Preliminary)

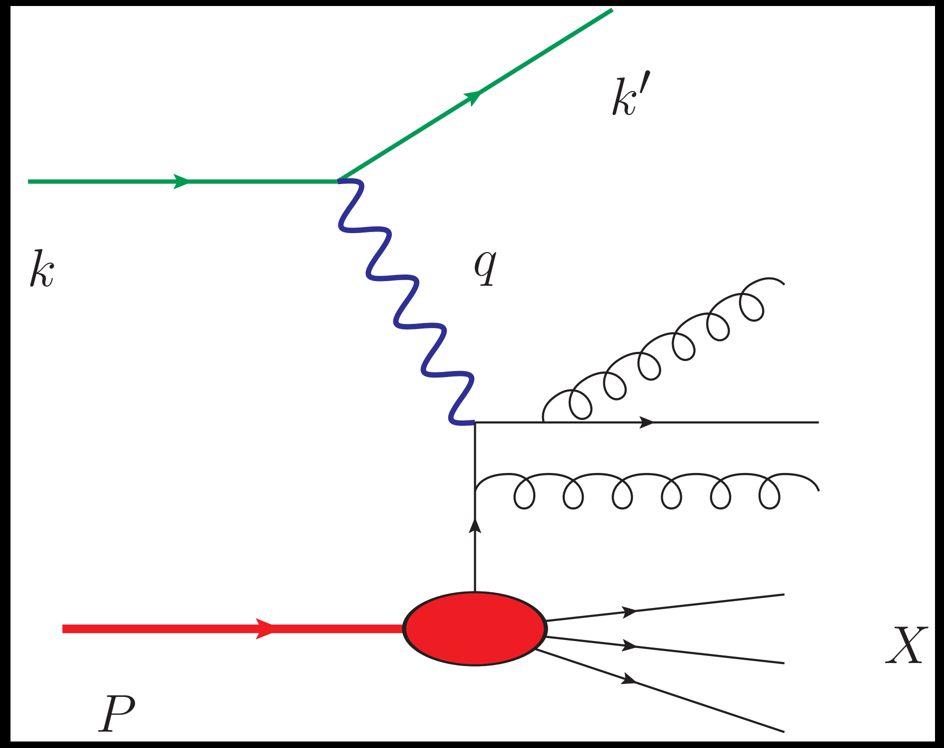
Operational scenario		*e-p* and *pp*		*e-p* only	
Particle		Proton	Electron	Proton	Electron
Beam energy	TeV	35.6	0.12	35.6	0.12
CM energy	TeV	4.1		4.1	
Beam current	mA	860	33.8	430	33.8
Particles per bunch	10^{10}	16.8	0.66	16.8	1.31
Number of bunch		5812	5812	2924	2924
Bunch spacing	ns	25	25	50	50
Bunch repetition rate	MHz	40	40	20	20
Normalized emittance, (x/y)	μm rad	**4.1**	250	**2.35**	250
Bunch length, RMS	cm	7.55	0.242	7.55	0.242
Beta-star (x/y)	cm	75	7.5	75	4.35
Beam spot size at IP (c/y)	μm	9.0	9.0	6.65	6.65
Beam-beam per IP(x/y)		0.0002	0.15	0.0007	0.15
Crossing angle	mrad	~0.8		~0.8	
Hour-glass (HG) reduction		0.904		0.794	
Lumi. per IP, w/ HG reduction	10^{33}/cm^2/s	3.2		4.8	

Early design has not been synchronized with the most recent developments in the machine design (100km ring, CEPC double-ring design)

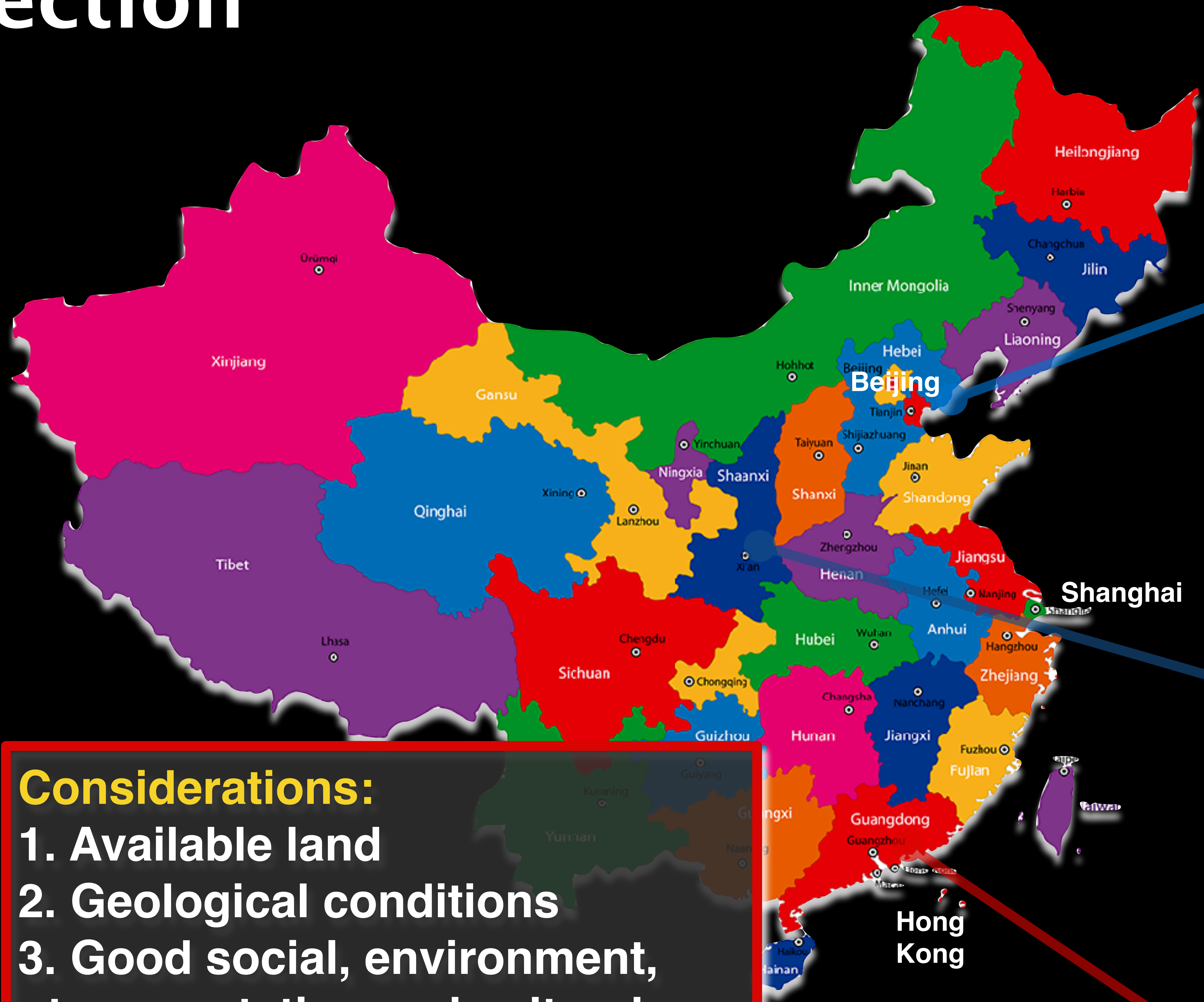
Deep Inelastic Scattering at CEPC-SPPC



Kinematical coverage of ep scattering at the CEPC



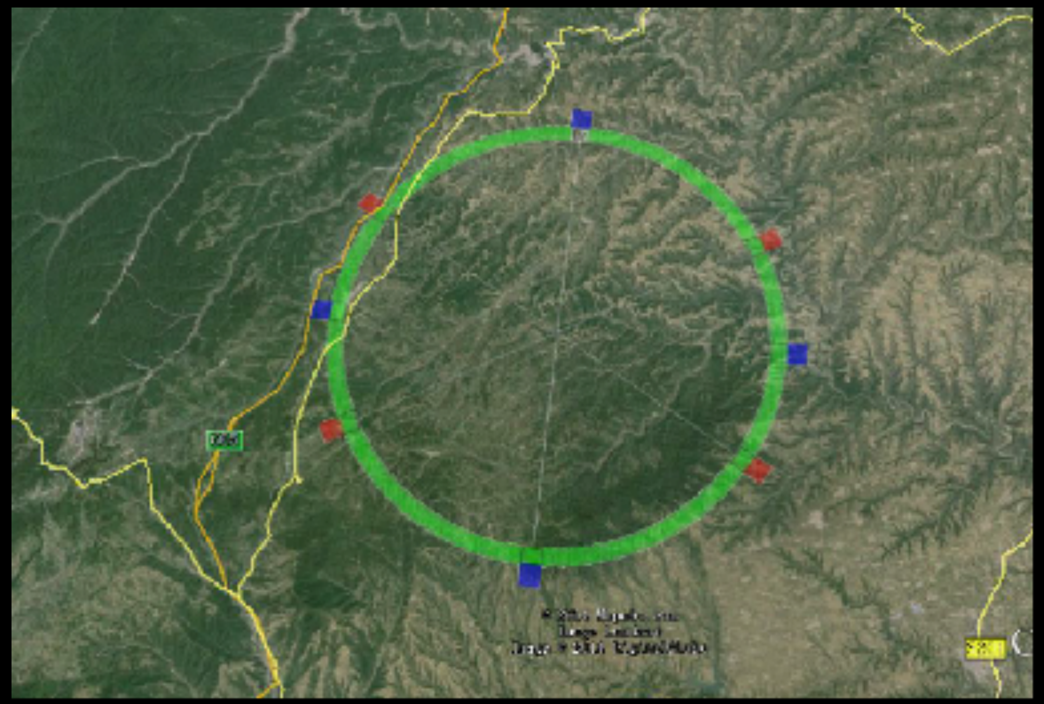
Site selection



Considerations:
1. Available land
2. Geological conditions
3. Good social, environment, transportation and cultural conditions
4. Fit local development plan: mid-size city → + science city

Qinhuangdao
秦皇岛

Shaanxi
陕西黄陵



Shenzhen
深汕合作区

Cost Estimation of CEPC (Preliminary)

No.	Equipment name	Total price (M¥) (50 km)	Total price (M¥) (100 km)
1	Total	25,498	36,051
2	Accelerator	15,973	23,132
3	Detector	2,502	2,502
4	Synchrotron radiation device	326	326
5	Civil Construction	6,697	10,091
5.1	Civil engineering (Drilling and blasting method, ⦸ 6 m...)	2,793	4,138
5.2	Installation of electrical equipment	2,210	3,429
5.3	Installation of metal structure equipment	177	261
5.4	Temporary works	287	422
5.5	Independent cost	473	698
5.6	Unforeseen expenses (10%)	594	895
5.7	Other cost	163	247

$1 US = 6.91 RMB(¥)

100 km CEPC cost:

< 40 Billion RMB(¥)

< 5.8 Billion $US

Perspective on the cost of future colliders

BEPC: Cost/4yrs/GDP of China 1984 ≈ 0.0001

SSC: Cost/10yrs/GDP of US 1992 ≈ 0.0001

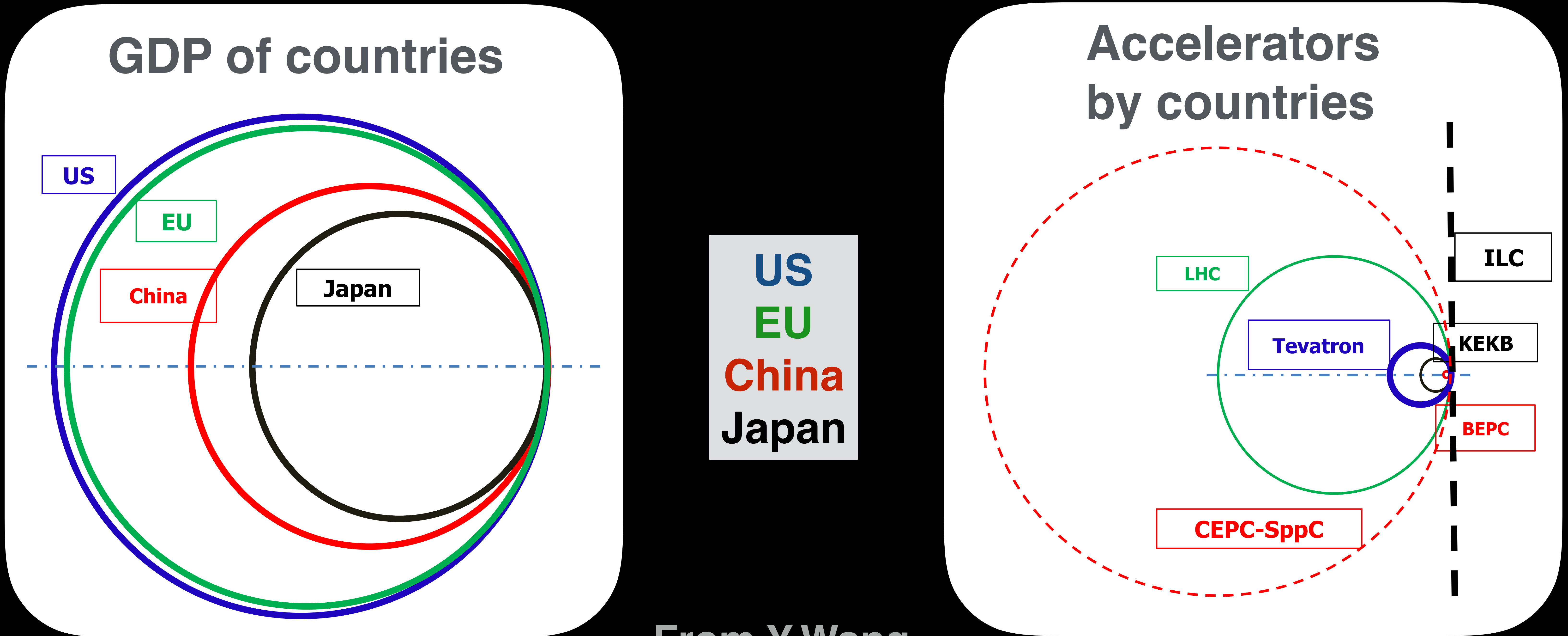
LEP: Cost/8yrs/GDP of EU 1984 ≈ 0.0002

LHC: Cost/10yrs/GDP of EU 2004 ≈ 0.0003

ILC: Cost/8yrs/GDP of JP 2018 ≈ 0.0002

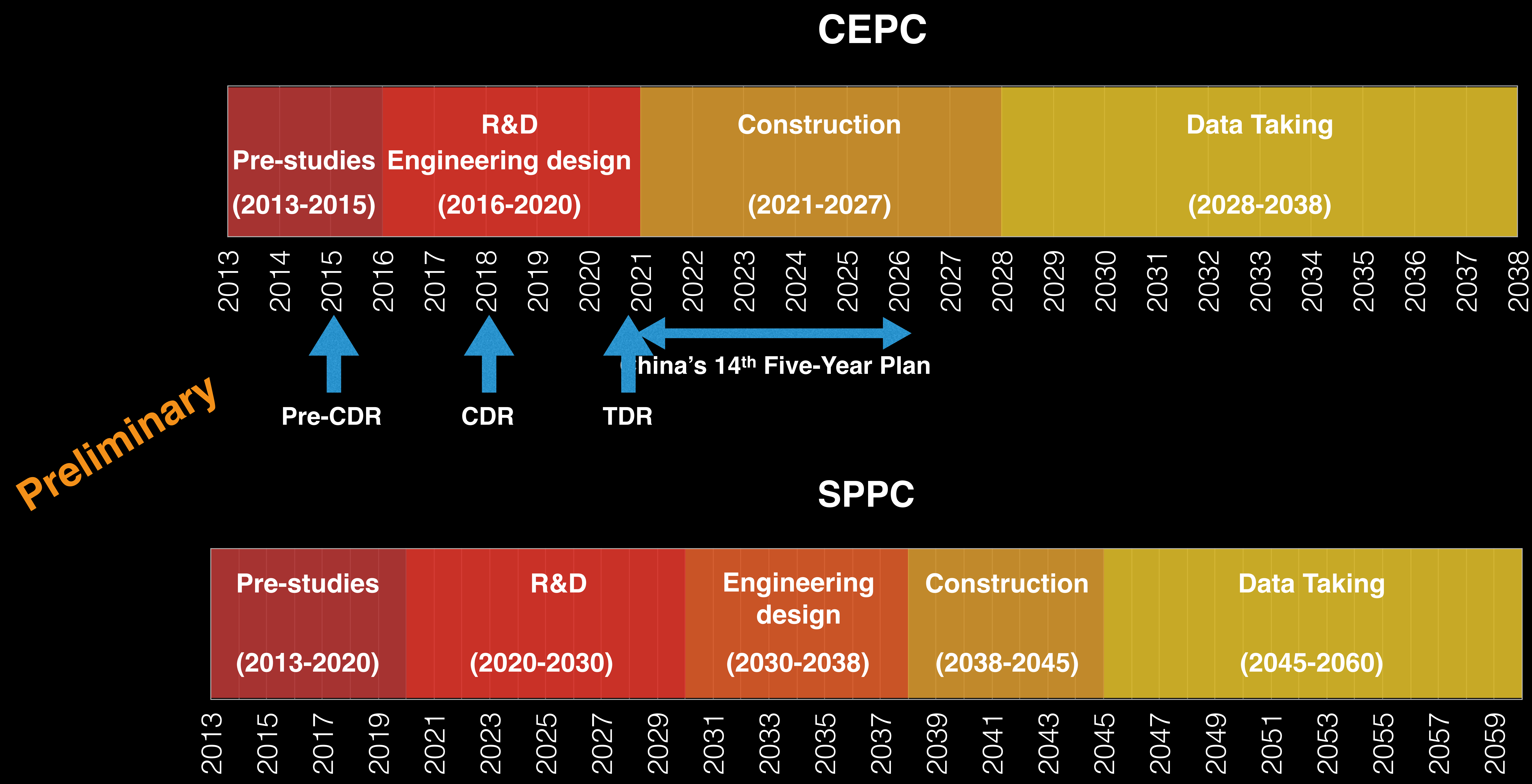
CEPC: Cost/8yrs/GDP of China 2020 ≈ 0.00005

SppC: Cost/8yrs/GDP of China 2036 ≈ 0.0001



From Y.Wang

CEPC and SppC Timeline (optimistic)



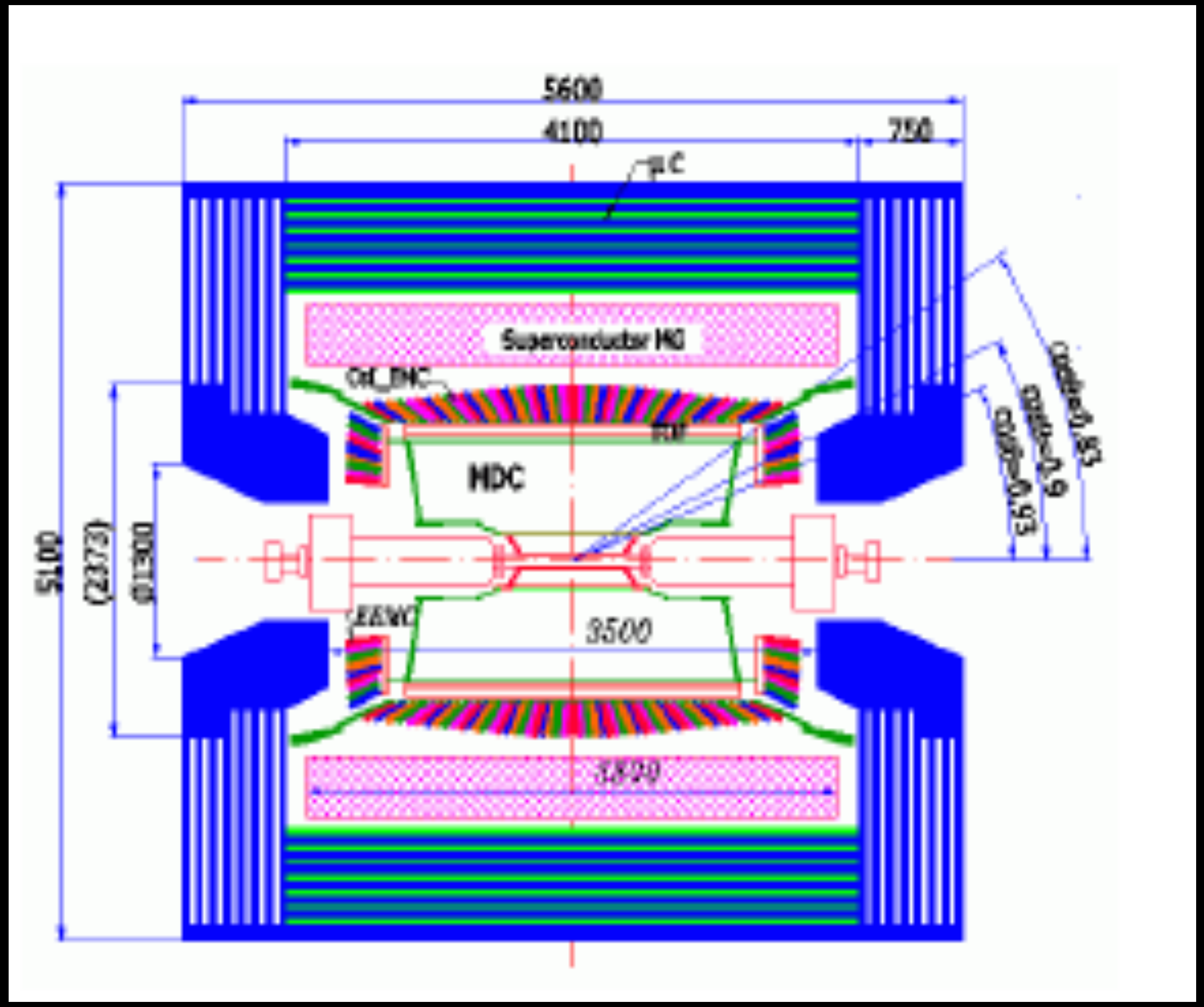
Can China do it?

International collaboration is a must for both accelerators and detector components, but….

China is experienced in e^+e^- colliders and detectors

BEPCII

BESIII

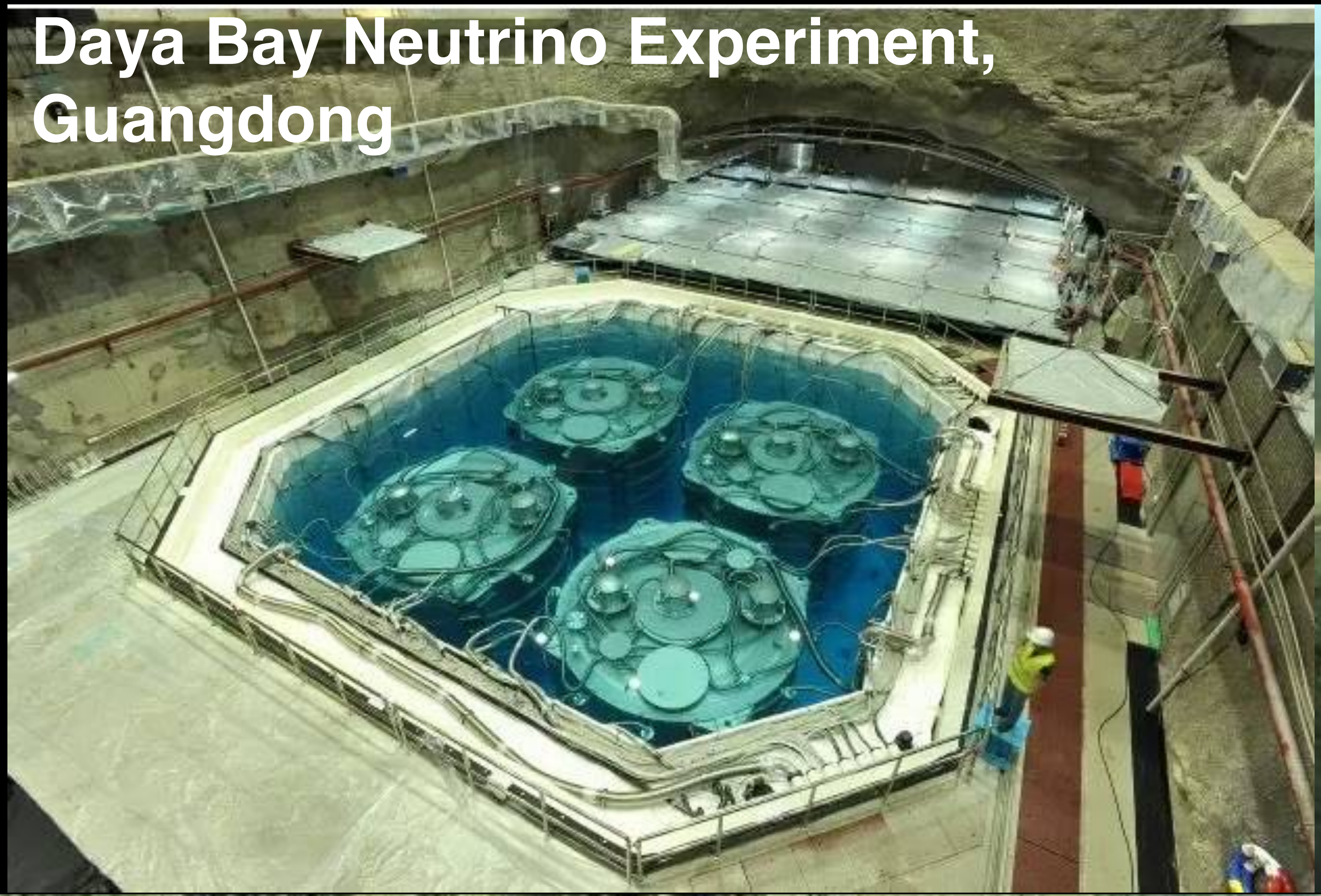


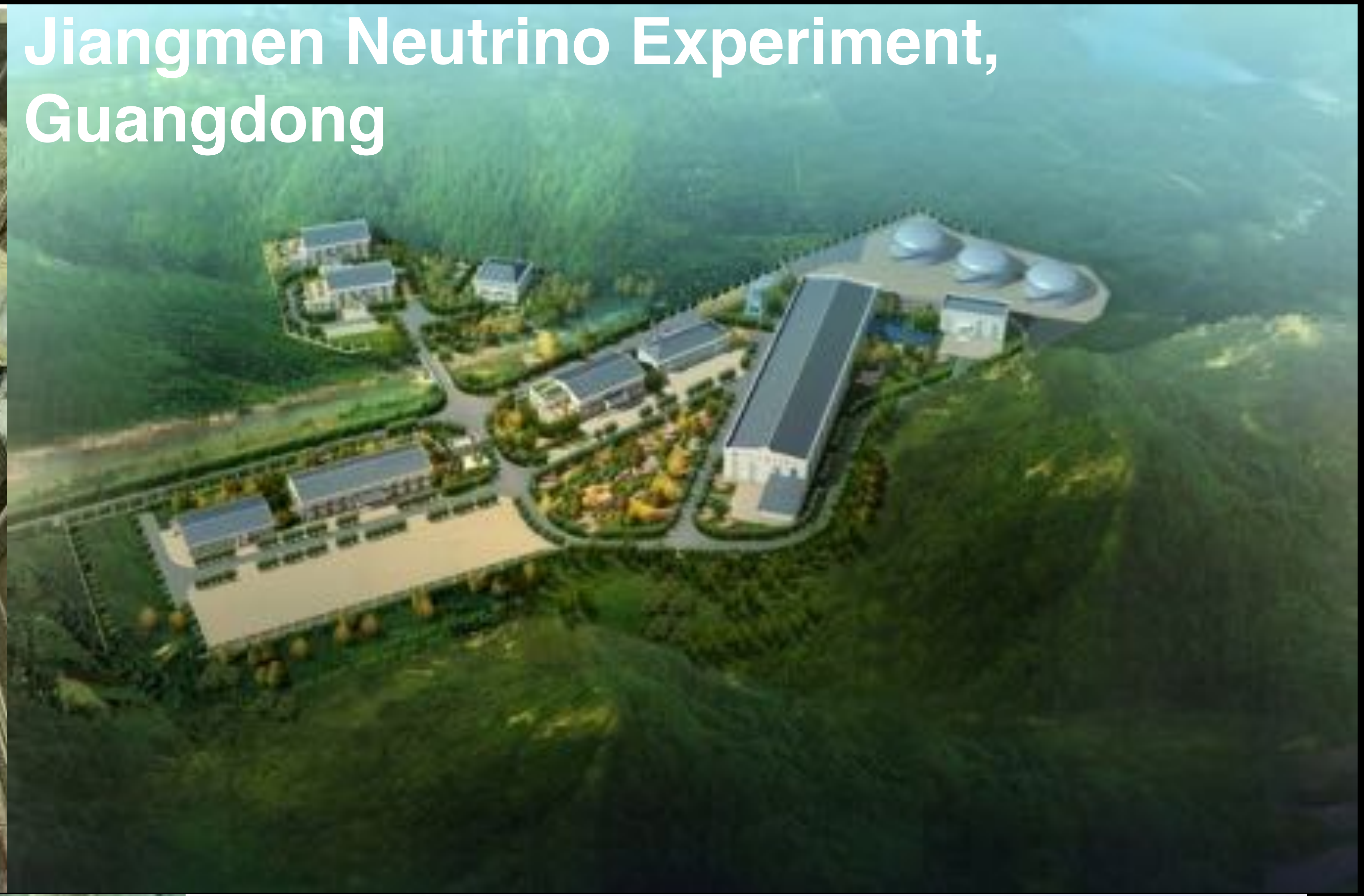
Big jump:
240 m ring → 100 km ring

A challenge smaller than 30 years ago when they started the BEPC

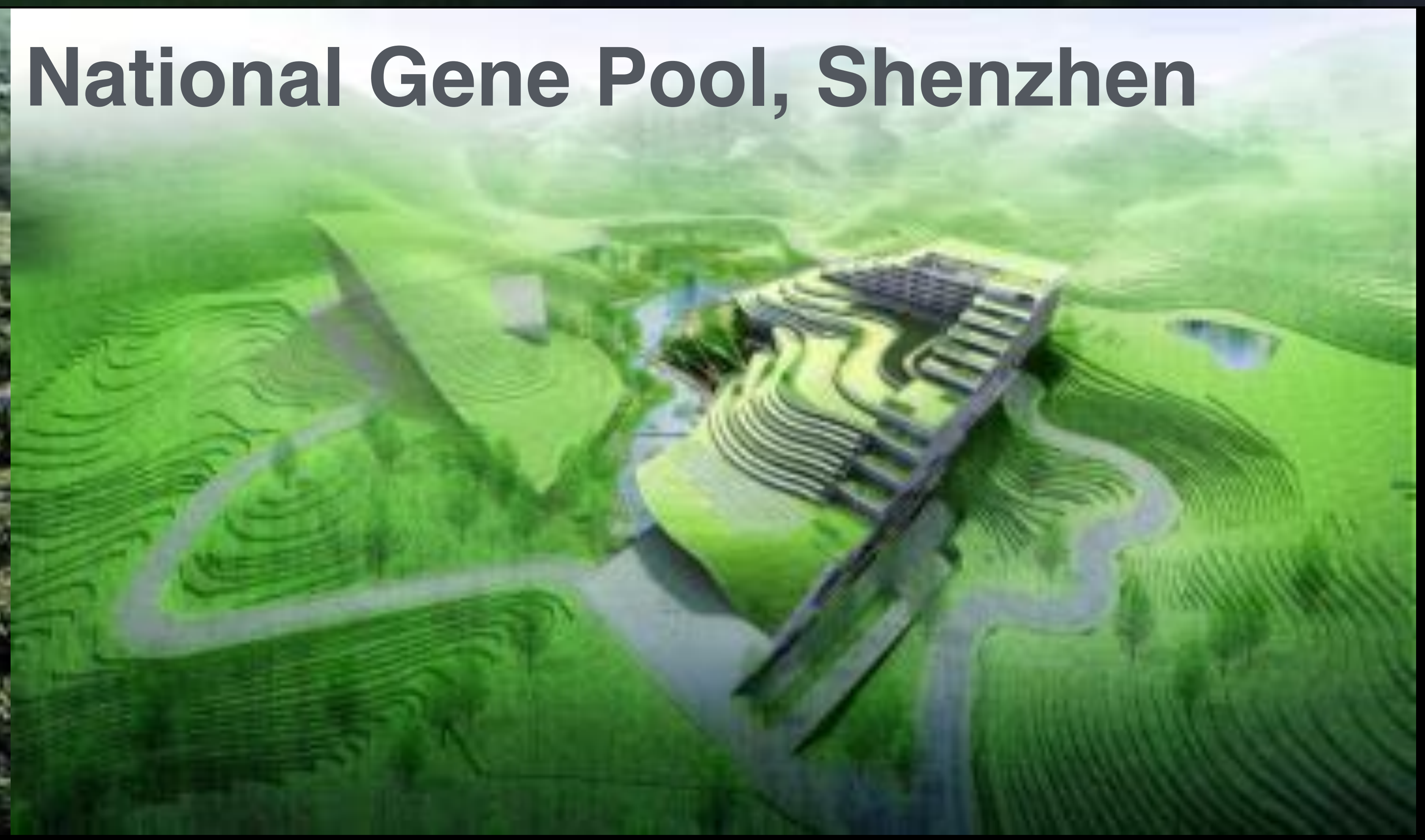
Many other large scientific research projects with big construction: Daya Bay, Juno, ….

Chinese team can take responsibilities proportional to China’s contributions


Daya Bay Neutrino Experiment, Guangdong

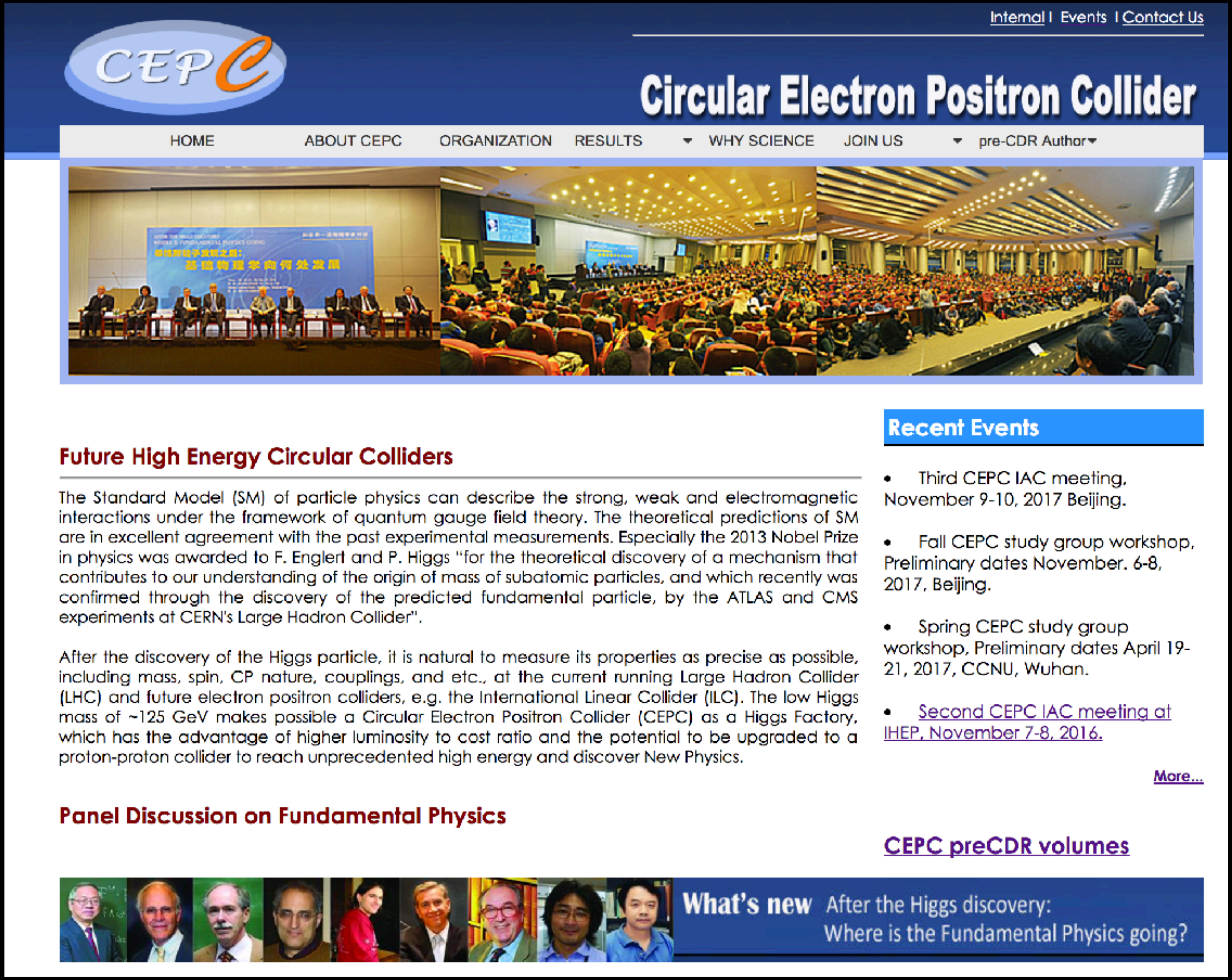

Jiangmen Neutrino Experiment, Guangdong


Spallation Neutron Source, Dongguan


National Gene Pool, Shenzhen

CEPC web site

http://cepc.ihep.ac.cn/



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CEPC

Circular Electron Positron Collider

HOME ABOUT CEPC ORGANIZATION RESULTS WHY SCIENCE JOIN US pre-CDR Author

Future High Energy Circular Colliders

The Standard Model (SM) of particle physics can describe the strong, weak and electromagnetic interactions under the framework of quantum gauge field theory. The theoretical predictions of SM are in excellent agreement with the past experimental measurements. Especially the 2013 Nobel Prize in physics was awarded to F. Englert and P. Higgs "for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider".

After the discovery of the Higgs particle, it is natural to measure its properties as precise as possible, including mass, spin, CP nature, couplings, and etc., at the current running Large Hadron Collider (LHC) and future electron positron colliders, e.g. the International Linear Collider (ILC). The low Higgs mass of ~125 GeV makes possible a Circular Electron Positron Collider (CEPC) as a Higgs Factory, which has the advantage of higher luminosity to cost ratio and the potential to be upgraded to a proton-proton collider to reach unprecedented high energy and discover New Physics.

Panel Discussion on Fundamental Physics

What's new After the Higgs discovery: Where is the Fundamental Physics going?

Recent Events

- Third CEPC IAC meeting, November 9-10, 2017 Beijing.
- Fall CEPC study group workshop, Preliminary dates November. 6-8, 2017, Beijing.
- Spring CEPC study group workshop, Preliminary dates April 19-21, 2017, CCNU, Wuhan.
- Second CEPC IAC meeting at IHEP, November 7-8, 2016.

More...

CEPC preCDR volumes

Upcoming CEPC events:

April 19-21, 2017:

Spring CEPC study group workshop,
CCNU, Wuhan
http://indico.ihep.ac.cn/event/6433/

November 6-8, 2017:

Fall CEPC study group workshop,
Beijing
http://cepcws17.ihep.ac.cn/

November 9-10, 2017:

Third CEPC IAC meeting,
Beijing

High Intensity Heavy Ion Accelerator Facility (HIAF)

Facility proposed by the Institute of Modern Physics (IMP) in Lanzhou, China

1957: **IMP founded, affiliated with the Chinese Academy of Sciences (CAS)**

- Research center for low-to-intermediate energy physics in China
- 800 scientists and engineers

1991: **Heavy Ion Research Facility in Lanzhou (HIRFL)**

Major national research facility focusing on **nuclear physics**, **atomic** physics, **heavy-ion** applications and interdisciplinary research

2007: **Cooler Storage Ring (HIRFL-CSR)**

~1 GeV/u for heavy ions up to Uranium

2009: New Proposal
High Intensity Heavy Ion Accelerator Facility (HIAF)

China prepares to spend billions (US Dollars) on science & technology

Physics Today, May 2013

Construction money comes from the:

National Development and Reform Commission (NDRC)

- **Up to CNY 2 billion/project**
- **Total of $US 3 billion up to 2015**

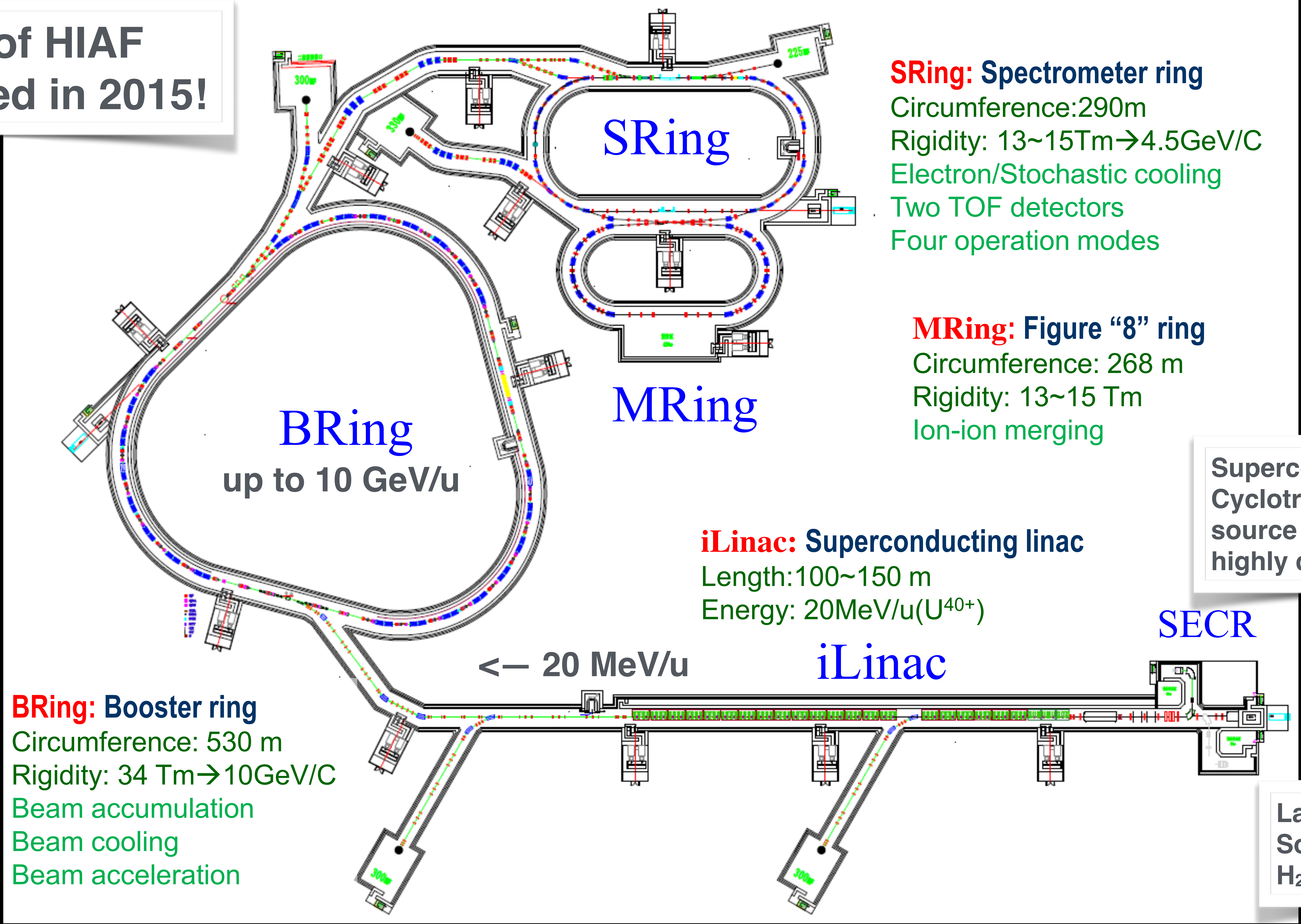
Science and technology infrastructure gets the nod in China's 12th five-year plan: Mid- to long-term projects ranked by priority

1. Ocean-floor scientific survey network
2. High-energy synchrotron test facility
3. Accelerator-driven subcritical reactor research facility
4. Synergetic Extreme Condition User Facility
5. High-flux heavy ion accelerator
6. High-efficiency, low-carbon gas turbine testing facility
7. Large High Altitude Air Shower Observatory
8. Future network experimental facility
9. Outer-space environment simulating facility
10. Translational medicine research facility
11. China Antarctic Observatory
12. Precision gravity measurement research facility
13. Large-scale low-speed wind tunnel
14. Shanghai Synchrotron Radiation Facility Phase-II Beamline Project
15. Model animal phenotype and heredity research facility
16. Earth system digital simulator

12th five-year plan: 2011-2015 → 13th five-year plan: 2016-2020

High Intensity Heavy Ion Accelerator Facility (HIAF)— Phase I — Main Parameters

First phase of HIAF was approved in 2015!



SRing: Spectrometer ring
Circumference:290m
Rigidity: 13~15Tm→4.5GeV/C
Electron/Stochastic cooling
Two TOF detectors
Four operation modes

MRing: Figure "8" ring
Circumference: 268 m
Rigidity: 13~15 Tm
Ion-ion merging

iLinac: Superconducting linac
Length:100~150 m
Energy: 20MeV/u(U^{40+})

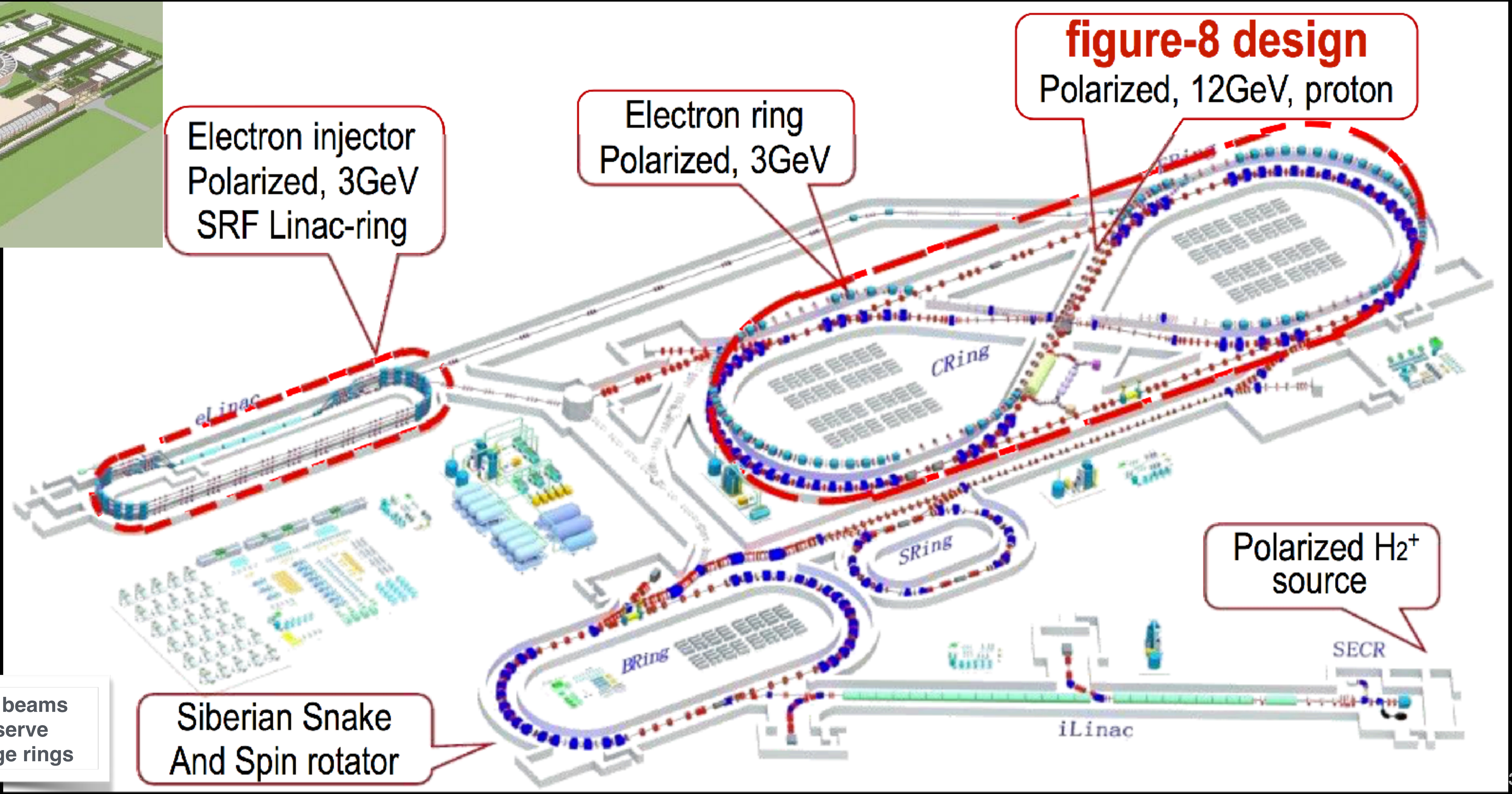
BRing: Booster ring
Circumference: 530 m
Rigidity: 34 Tm→10GeV/C
Beam accumulation
Beam cooling
Beam acceleration

Superconducting Electron-Cyclotron-Resonance ion source (SECR) provides highly charged ion beams

Lanzhou Intense Proton Source (LIPS) provides H_2^+ beam.

High Intensity Heavy Ion Accelerator Facility (HIAF)— Phase II — EIC

EIC@HIAF: e(3 GeV) +p(12-16 GeV), both polarized, L >= 10^{33} cm^{-2}/s^{-1}



Accelerate spin-polarized beams to high energy and to preserve their polarization in storage rings

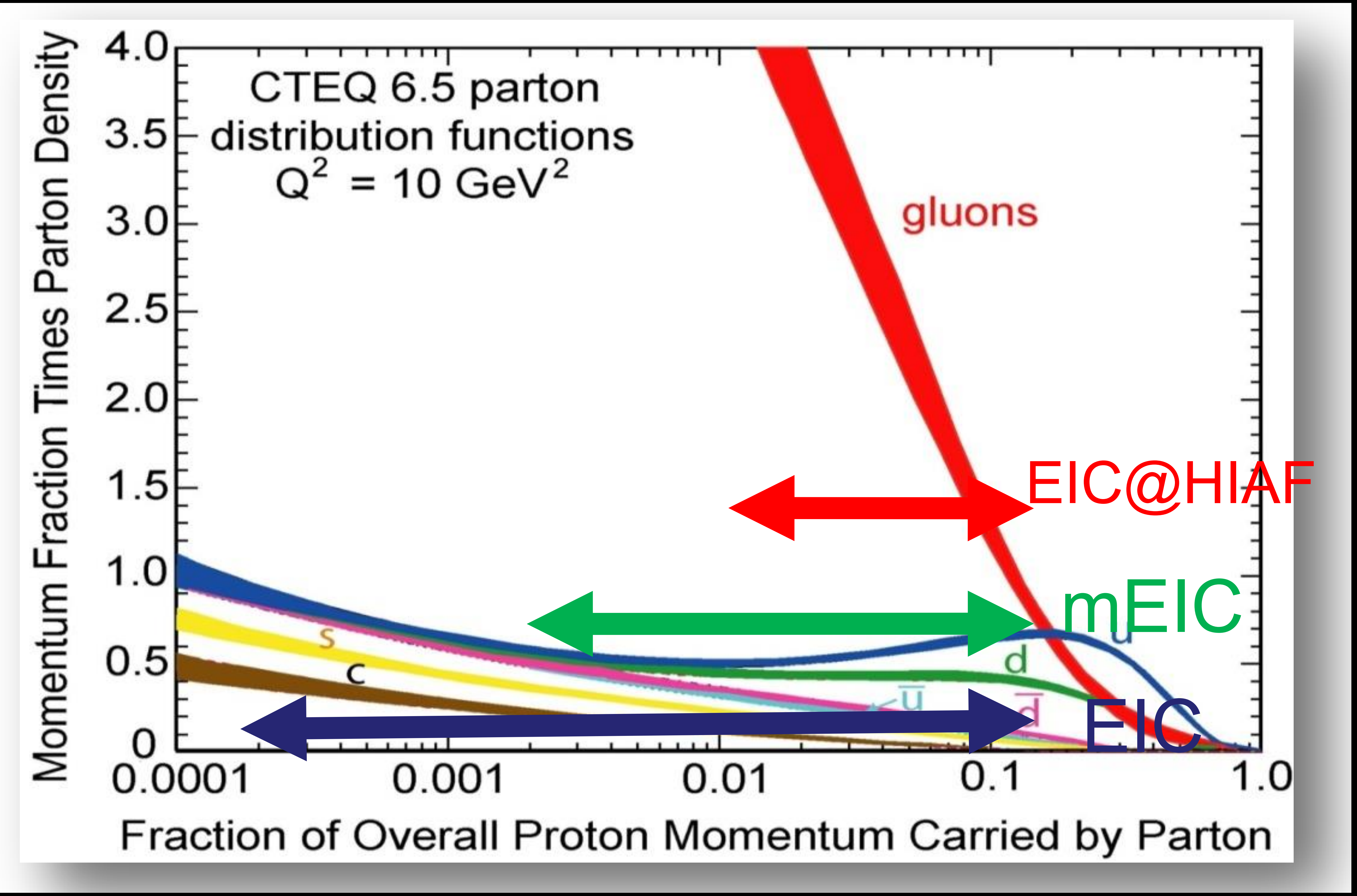
The physics of the EIC@HIAF

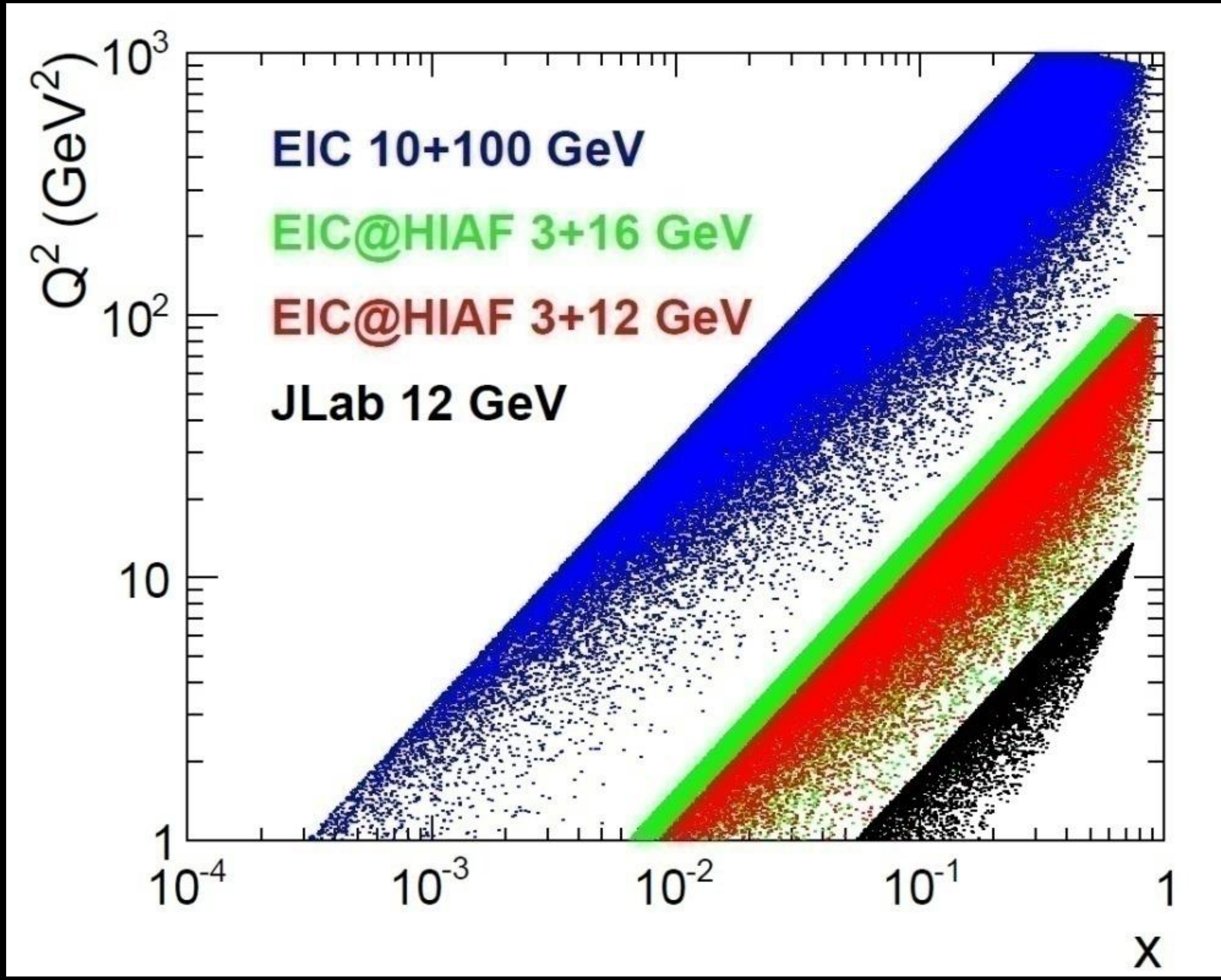
Main Goal:
Map the spin-flavor, multi-D spatial/momentum structure of valence & sea quarks

Six golden experiments

1. Nucleon spin-flavor structure (polarized sea, Δs)
2. GPDs (Deep-Virtual Meson Production, pion/Kaon)
3. TMD in “sea quark” region and significant increase in Q^2 / P_T range for valence region
4. Pion/Kaon structure functions in the high-x (valence) region
5. e-A to study hadronization
6. EMC-SRC in e-A

The physics of the EIC@HIAF





EIC@HIAF :

- Explore the spin and spatial structure of valence & sea quarks in nucleons

The best region for studying sea quarks (x > 0.01)

higher Q^2 in valence region

- Allows some studies of gluons

Facilities	Main goals
JLab 12 GeV	Valence quark
HIAF-EIC	Sea quark
US and Europe EIC	gluon

Final remarks

CEPC/SPPC is the first Chinese Science project at such a scale

Many challenges to overcome

International collaboration and international interest are essential

Tremendous progress up to now, but a long way to go

No need to wait for LHC

- If LHC finds nothing, a Higgs factory can give us a first indication
- If LHC finds something, it is a new era:
  1. Higgs need(s) to be understood anyway
  2. A higher energy pp collider is needed

(An Higgs factory give us time to develop SC cables and 16-20 T magnets)

Given the importance of the Higgs one of FCC-ee, ILC or CEPC should be built

CEPC-SPPC can be run in an ep configuration
Not much work done since the pre-CDR. It would benefit from enthusiastic newcomers

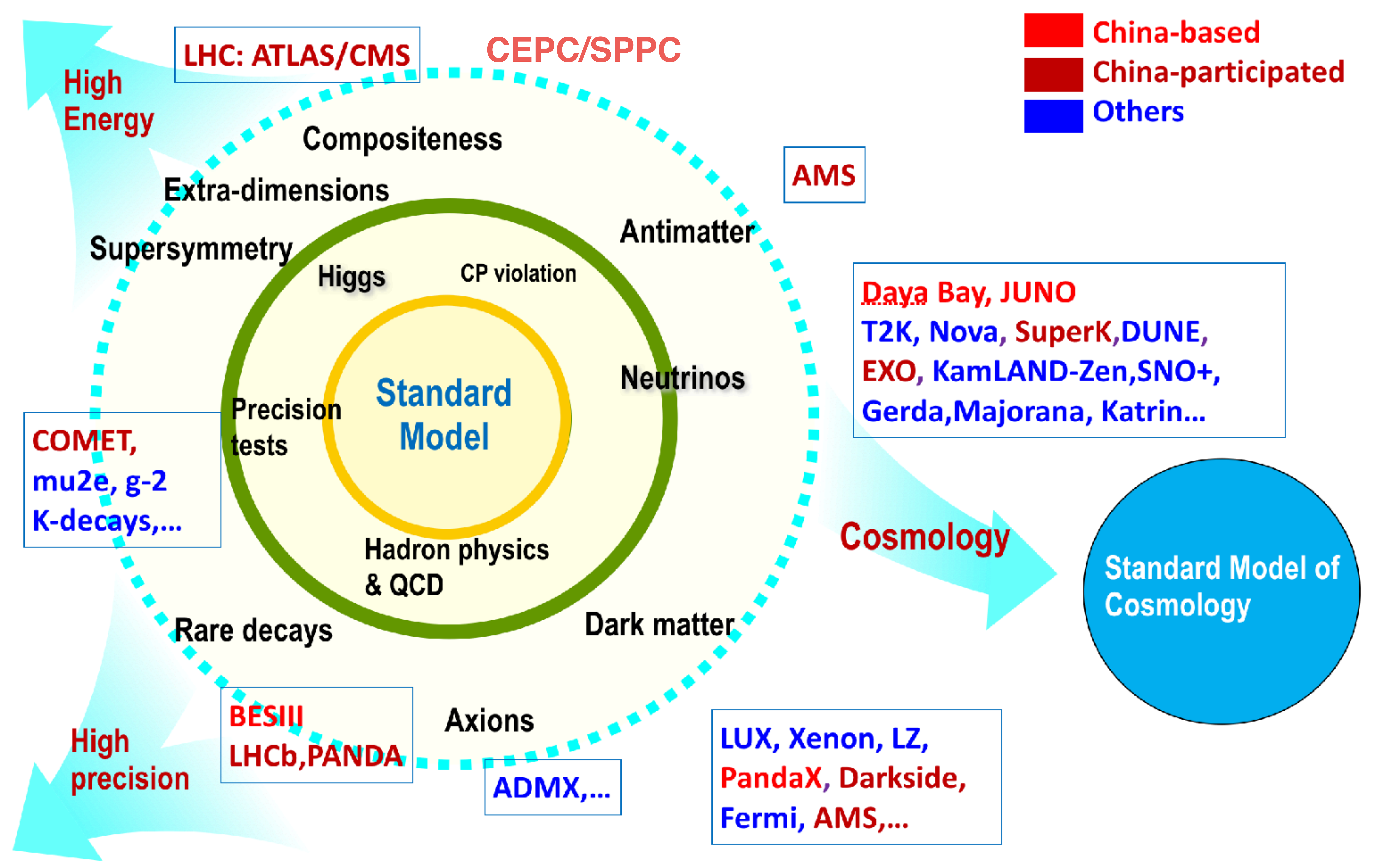
High Intensity Heavy Ion Accelerator Facility (HIAF) under construction in Lanzhou
EIC is considered for a 2nd phase of HIAF, to start after 2024. No design update since 2014

Extra Slides

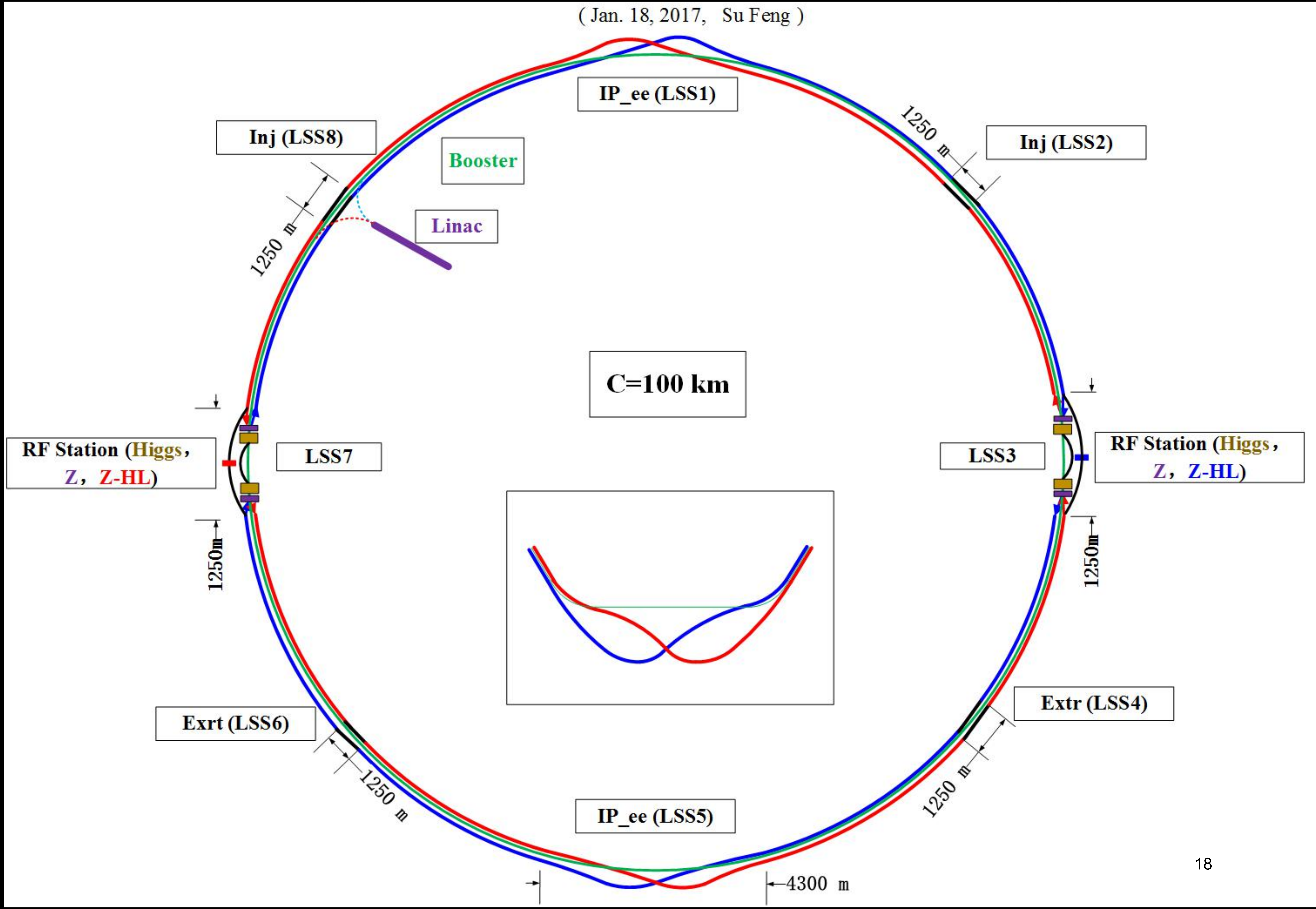
Main Future Colliders under discussion

Name	Location	Type	Particles	Size	Energy
CEPC	China	Circular	ee	100 km	90->240 GeV
SppC	China	Circular	pp	100 km	70-100 TeV
FCC-hh	CERN	Circular	pp	100 km	100 TeV
FCC-ee	CERN	Circular	ee	100 km	90->350 GeV
ILC	Japan	Linear	ee	30-50 km	250-500 GeV
CLIC	CERN	Linear	ee	50 km	0.5-5 TeV
CEPC/SPPC	China	Circular	ep	100 km	< 4.2 TeV
FCC-he	CERN	Circular	ep	?	60-175 GeV(e)

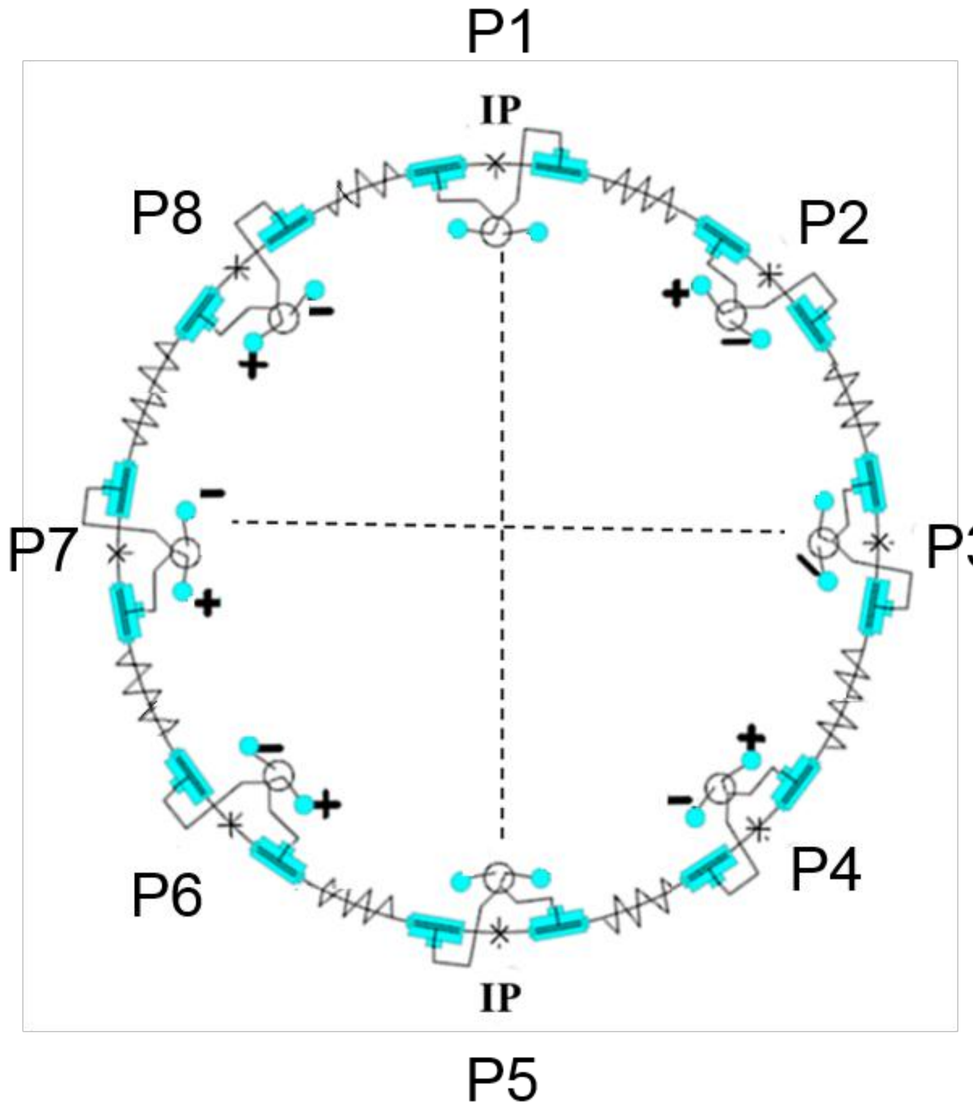
Snapshot of current experiments



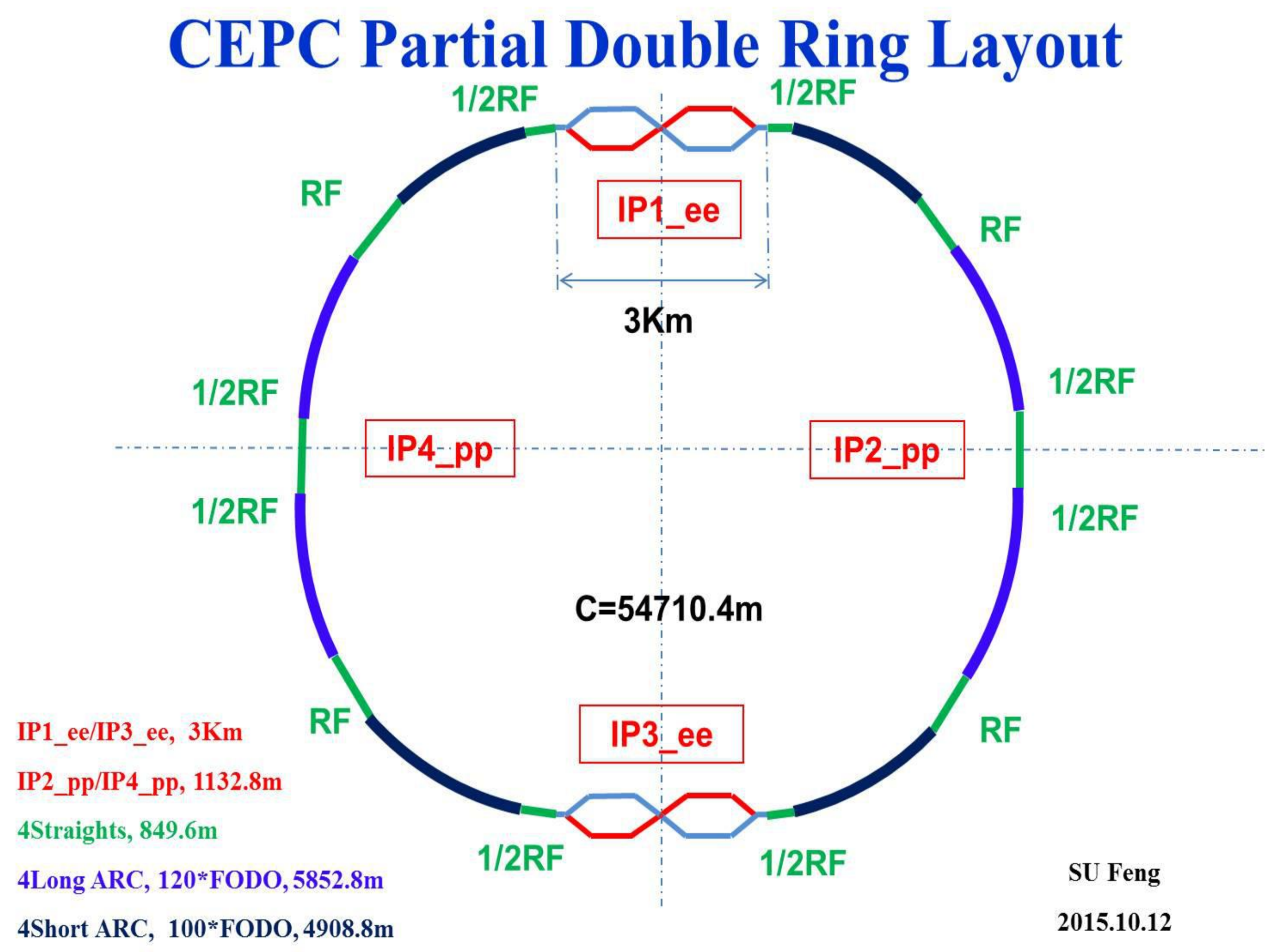
Layout of CEPC – Fully Partial Double Ring



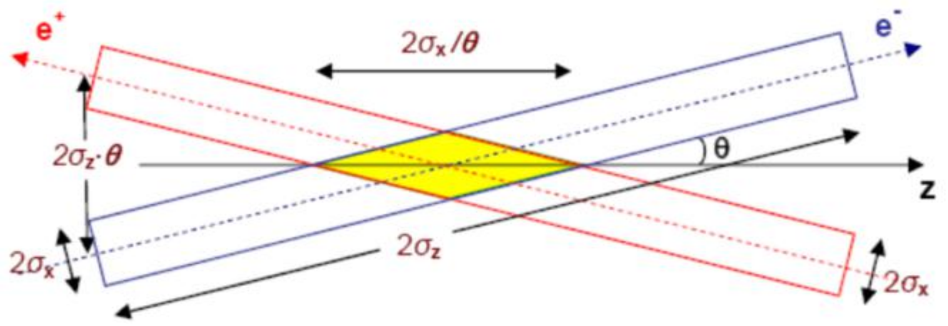
CEPC accelerator configurations options



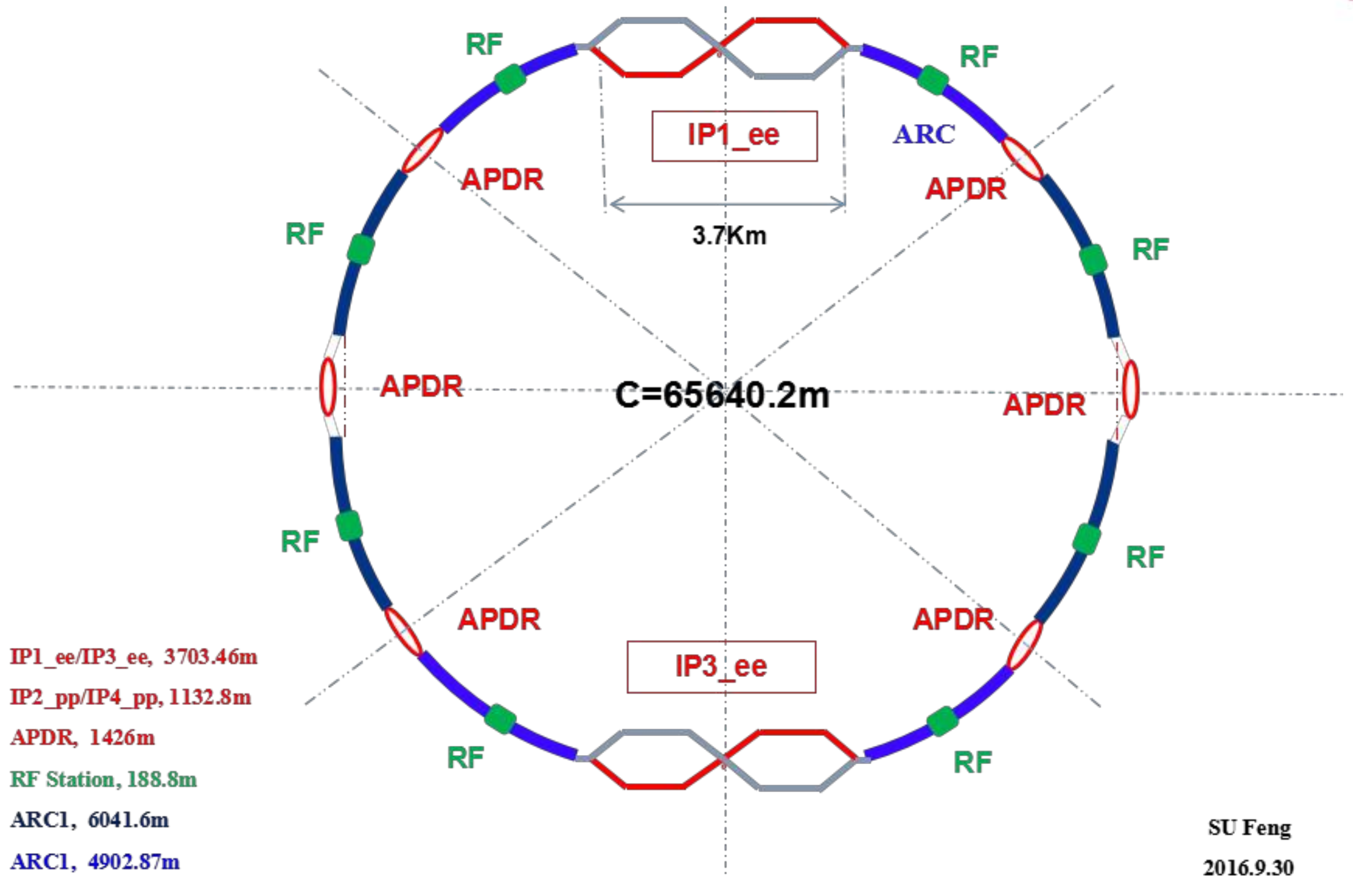
Since Oct 2012



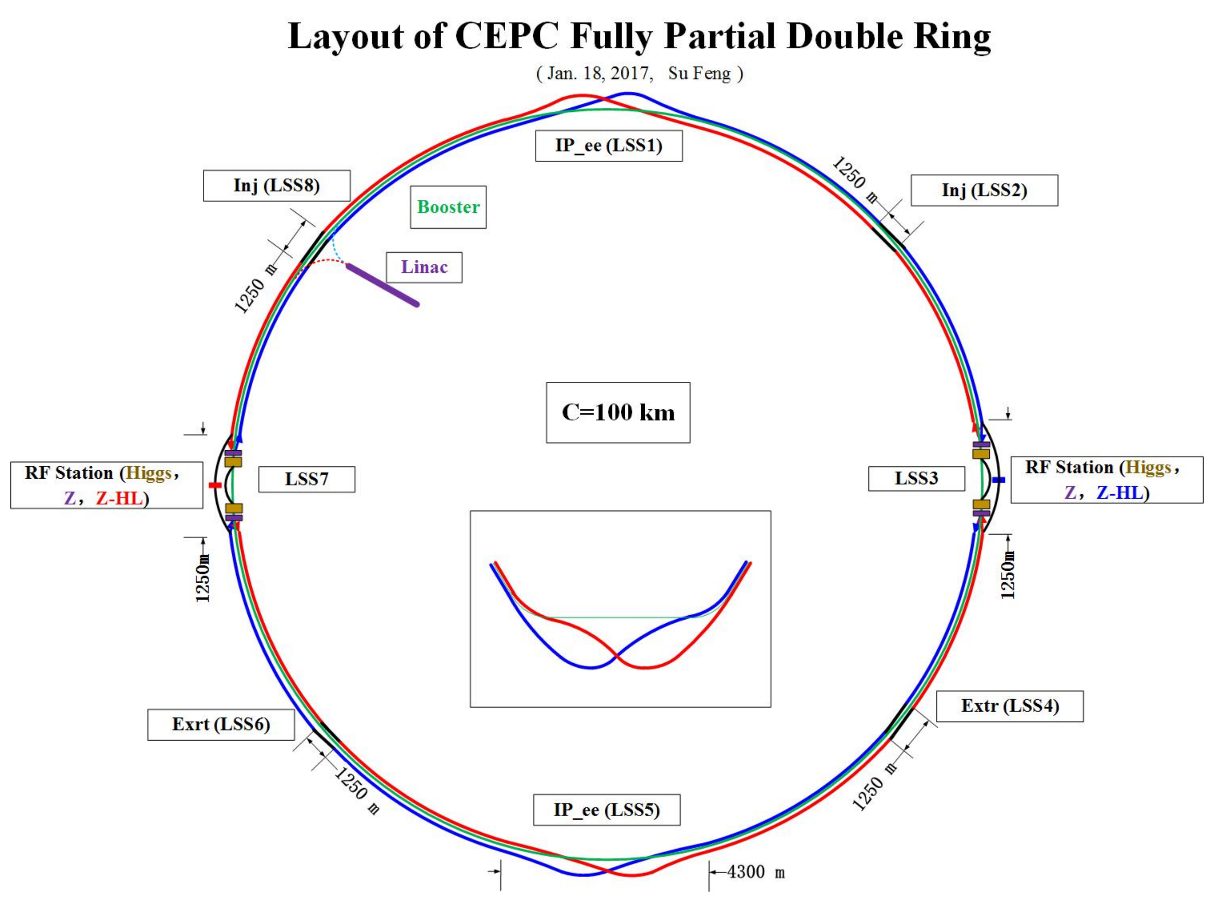
Since May 2015



CEPC Advanced Partial Double Ring Option II

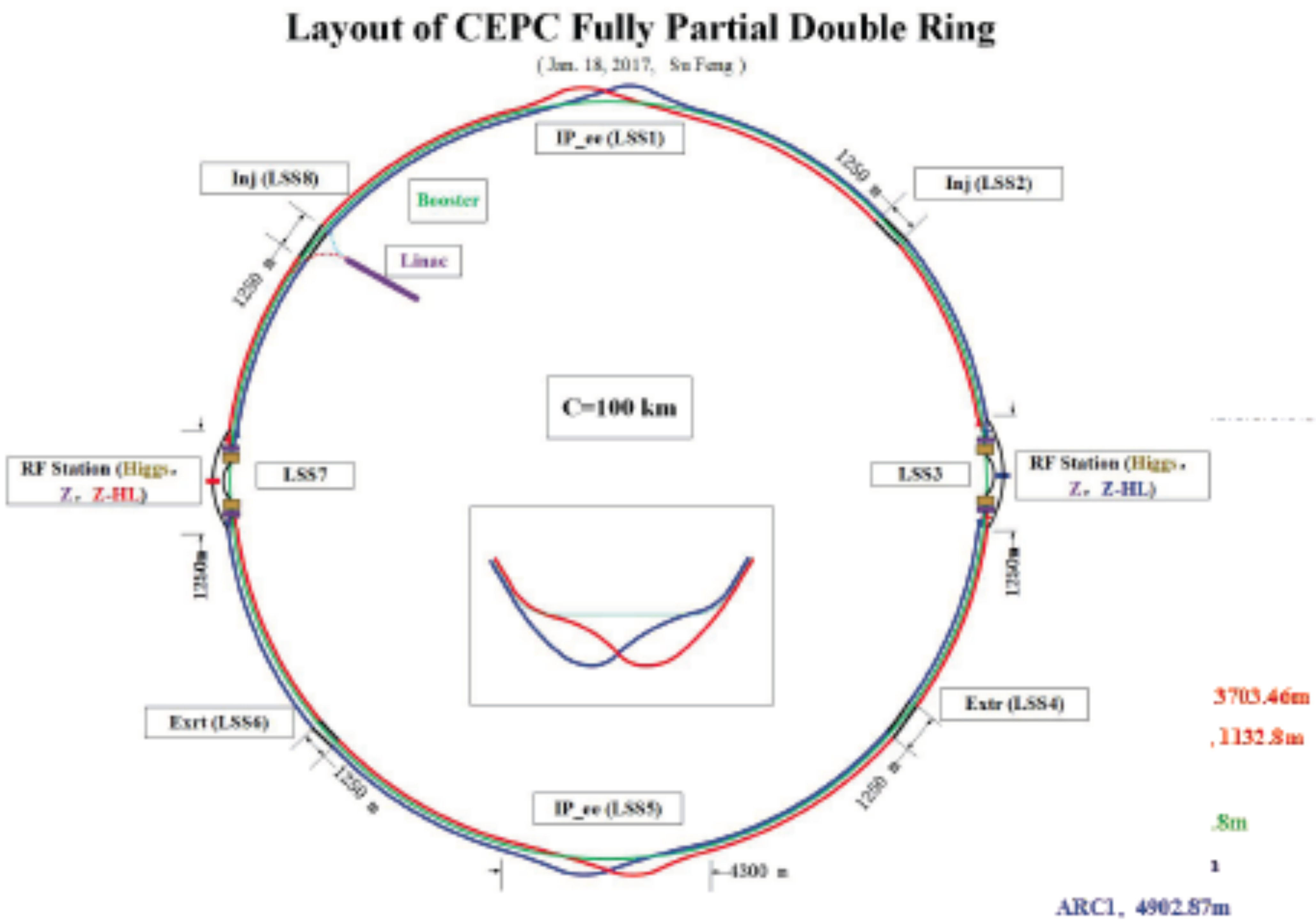


Since May 2016

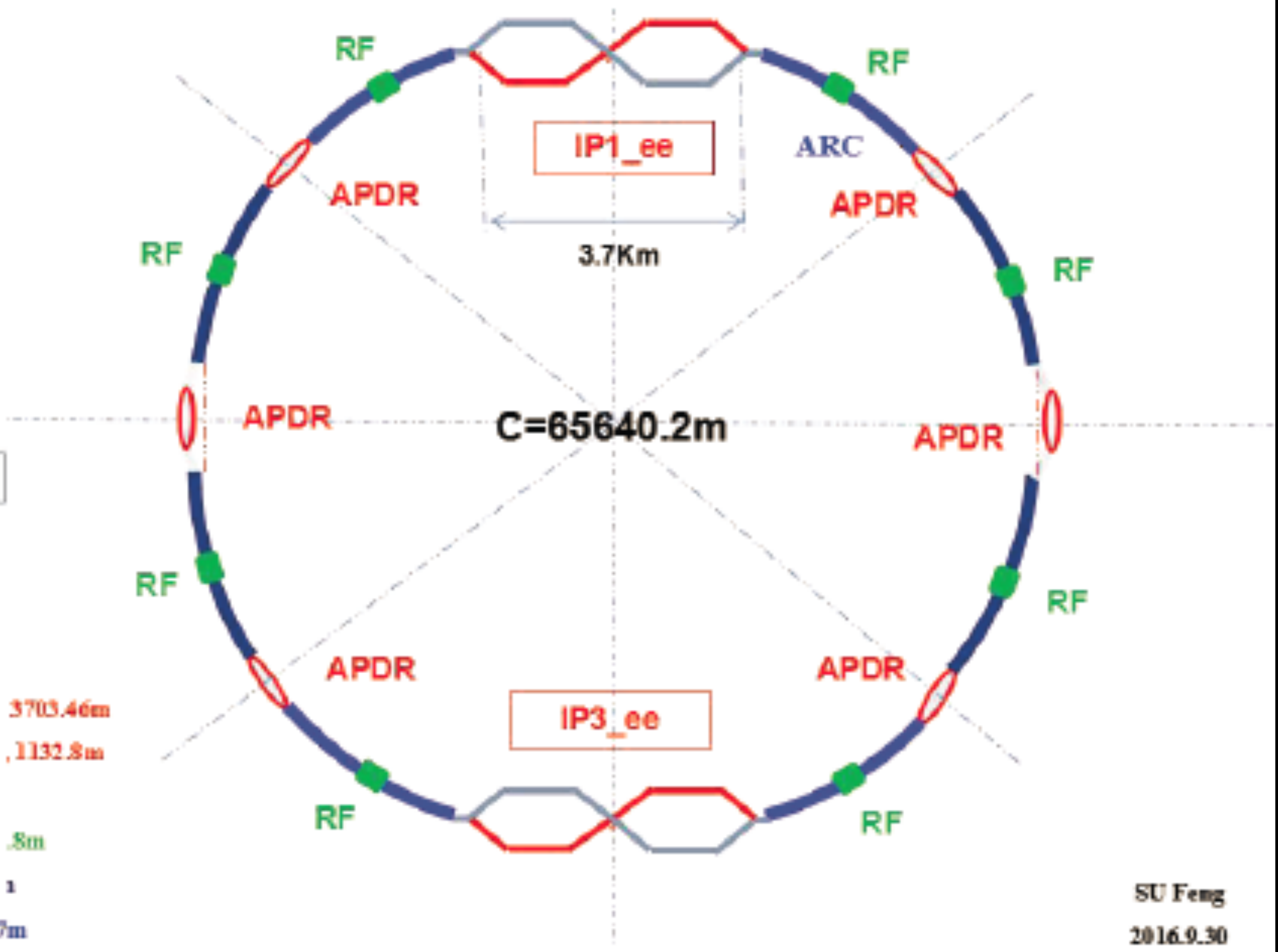


Since Nov 2016

CEPC: Two schemes towards the CDR



CEPC Advanced Partial Double Ring Option II



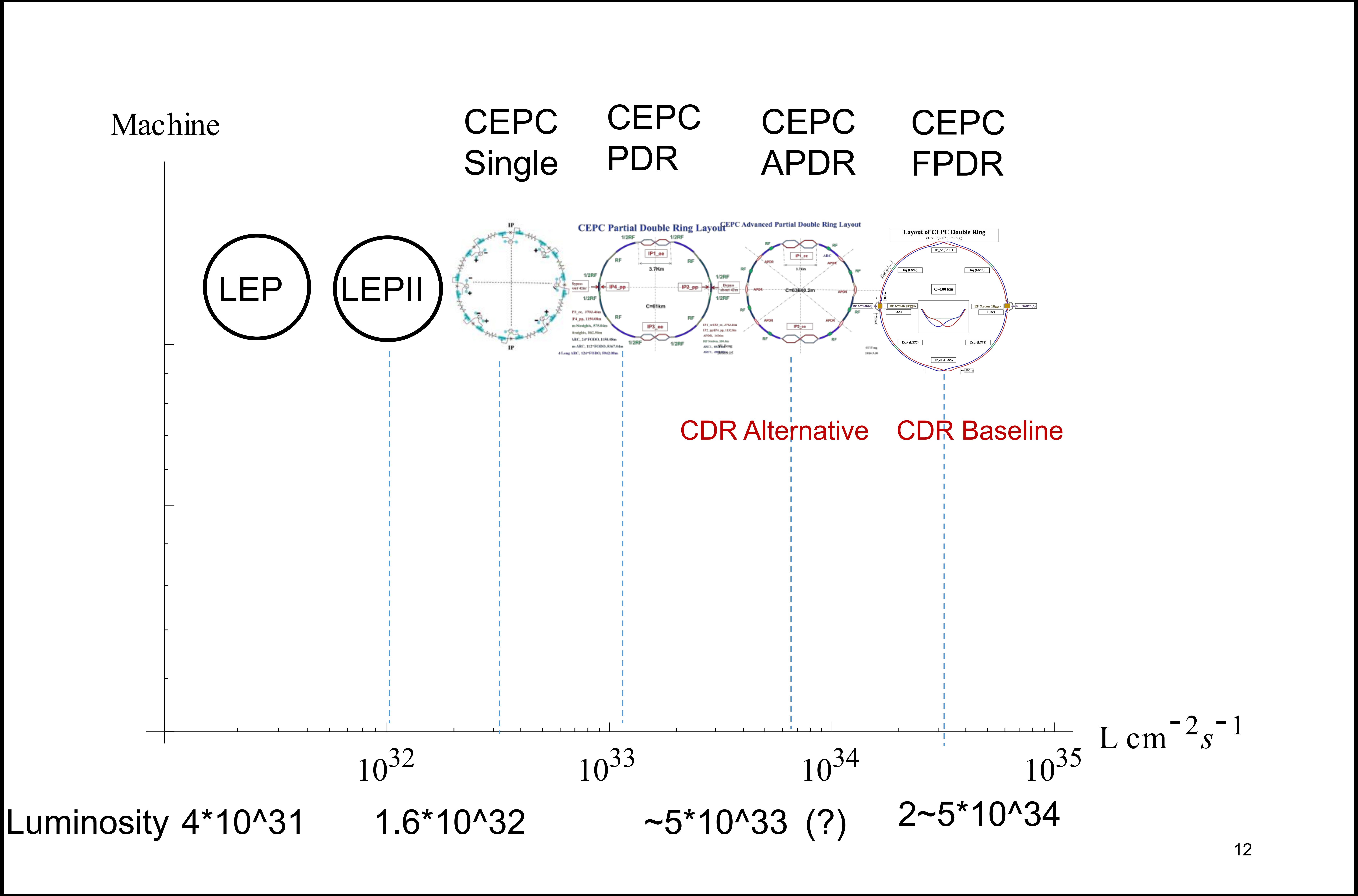
CEPC Baseline Design

Better performance for Higgs and Z compared with alternative scheme, without bottle neck problems, but with higher cost

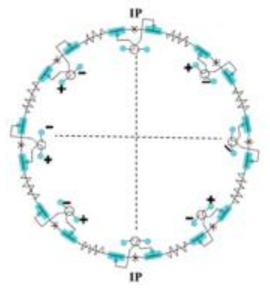
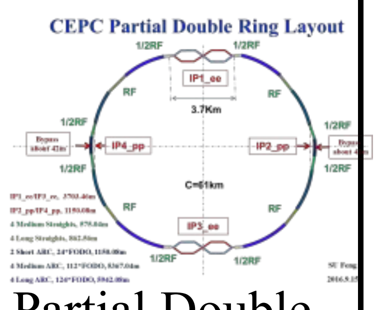
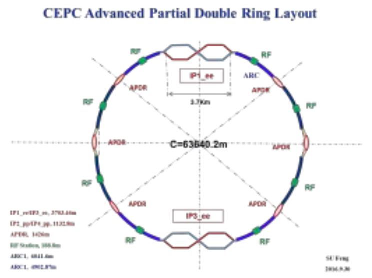
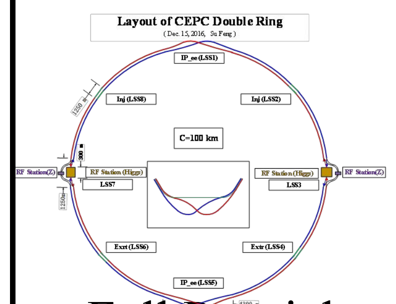
CEPC Alternative Design

Lower cost and reaching the fundamental requirement for Higgs and Z luminosities, under the condition that sawtooth and beam loading effects be solved

Machine options luminosity potentials



CEPC configuration options comparison

Option	Pretzel	Sawtooth effect	Beam loading	Dynamic Aperture	Orbit Correction	H luminosity	Z-pole luminosity	AC power	SRF syetem compatible for H and Z
 Single Ring (SR)	Yes ★	Very high ★	Low ★★★★★	Very small ★	Very hard ★	Low ★★★	Very low ★	High ★	Difficult ★★★
 Partial Double Ring（PDR）	No ★★★★★	High ★★	Very High ★	Medium ★★★	Hard ★★	Medium ★★★	Medium ★★★	Low ★★★★★	Difficult ★★★
 Advanced Partial Double Ring （APDR）	No ★★★★★	High ★★★	High ★★★	Medium ★★★	Medium ★★★	Medium ★★★	High ★★★★	Low ★★★★★	Difficult ★★★
 Full Parrtial Double Ring（FPDR）	No ★★★★★	Vey Low ★★★★★	Low ★★★★★	Large ★★★★★	Easy ★★★★★	High ★★★★★	Very High ★★★★★	Low ★★★★★	Very good ★★★★★ 11

Comparison with other machines

	Science	Upgrade	Technology	Cost	Schedule
CEPC	****	****	****	*****	*****
SppC	*****	*	**	***	***
ILC	****	*	***	****	*****
FCC-ee	****	****	****	****	?
FCC-pp	*****	*	**	**	***
CLIC	****	**	***	***	**
VLHC	*****	***	****	**	?
Muon collider	*****	****	*	*	?
New acceleration	*****	?	? ?	?	? ?

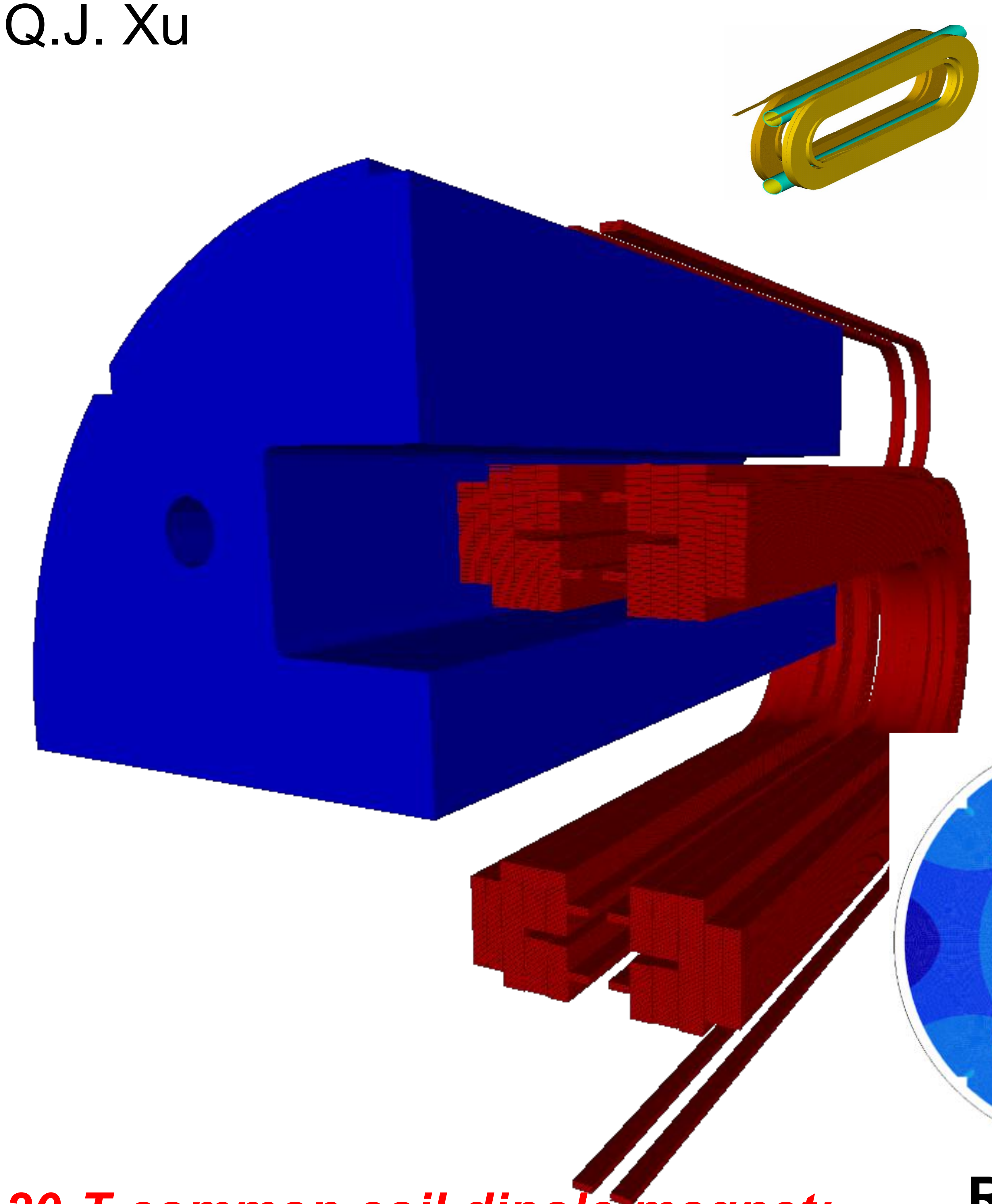
by Yifang Wang, IHEP director

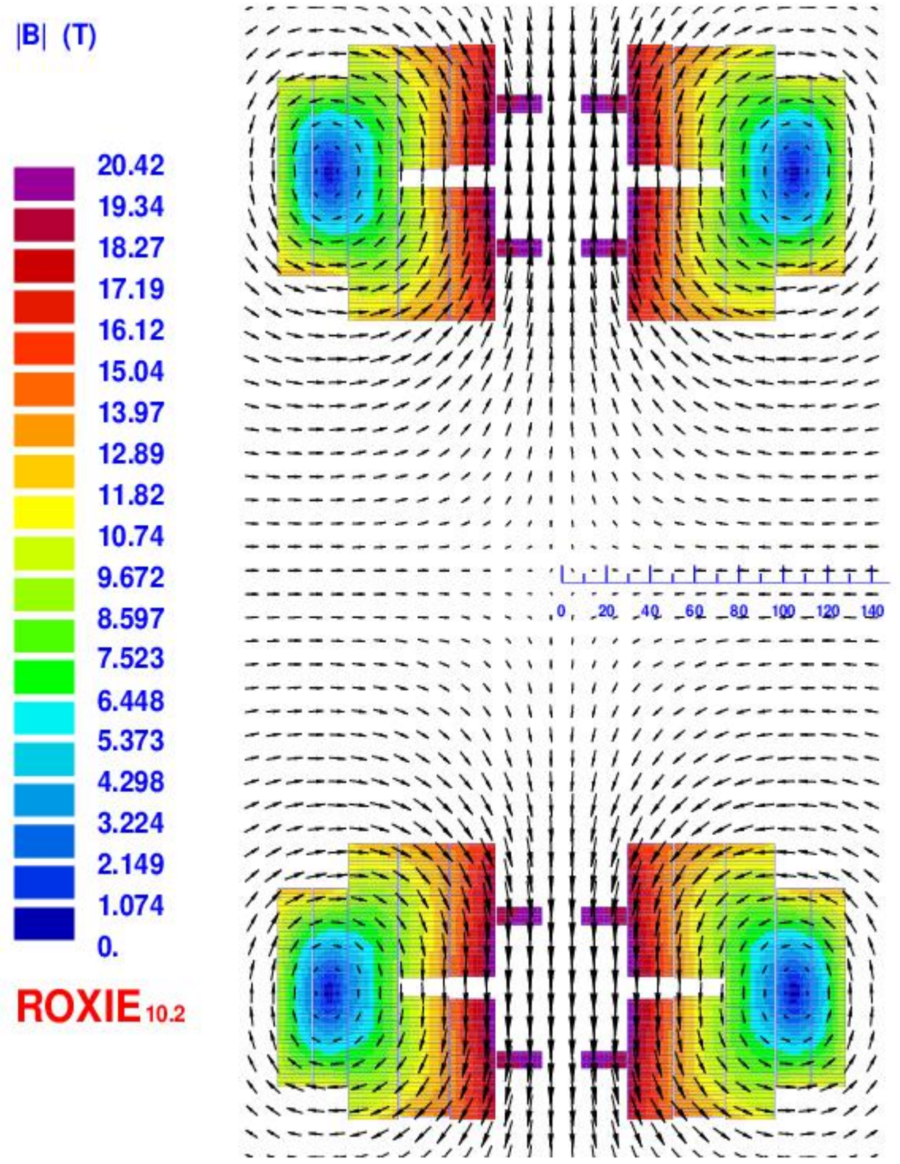
CEPC electroweak parameters for EWK fit

	Present data	CEPC fit
$\alpha_s(M_Z^2)$	0.1185 ± 0.0006 [23]	$\pm 1.0 \times 10^{-4}$ [24]
$\Delta\alpha_{\mathrm{had}}^{(5)}(M_Z^2)$	$(276.5 \pm 0.8) \times 10^{-4}$ [25]	$\pm 4.7 \times 10^{-5}$ [26]
m_Z [GeV]	91.1875 ± 0.0021 [27]	$\pm\mathbf{0.0005}$
m_t [GeV] (pole)	$173.34 \pm 0.76_{\mathrm{exp}}$ [28] $\pm 0.5_{\mathrm{th}}$ [26]	$\pm 0.2_{\mathrm{exp}} \pm 0.5_{\mathrm{th}}$ [29, 30]
m_h [GeV]	125.14 ± 0.24 [26]	$< \pm 0.1$ [26]
m_W [GeV]	$80.385 \pm 0.015_{\mathrm{exp}}$ [23] $\pm 0.004_{\mathrm{th}}$ [31]	$(\pm\mathbf{3}_{\mathrm{exp}} \pm 1_{\mathrm{th}}) \times 10^{-3}$ [31]
$\sin^2\theta_{\mathrm{eff}}^{\ell}$	$(23153 \pm 16) \times 10^{-5}$ [27]	$(\pm\mathbf{2.3}_{\mathrm{exp}} \pm 1.5_{\mathrm{th}}) \times 10^{-5}$ [32]
Γ_Z [GeV]	2.4952 ± 0.0023 [27]	$(\pm\mathbf{5}_{\mathrm{exp}} \pm 0.8_{\mathrm{th}}) \times 10^{-4}$ [33]
$R_b \equiv \Gamma_b/\Gamma_{\mathrm{had}}$	0.21629 ± 0.00066 [27]	$\pm\mathbf{1.7} \times 10^{-4}$
$R_\ell \equiv \Gamma_{\mathrm{had}}/\Gamma_\ell$	20.767 ± 0.025 [27]	$\pm\mathbf{0.007}$

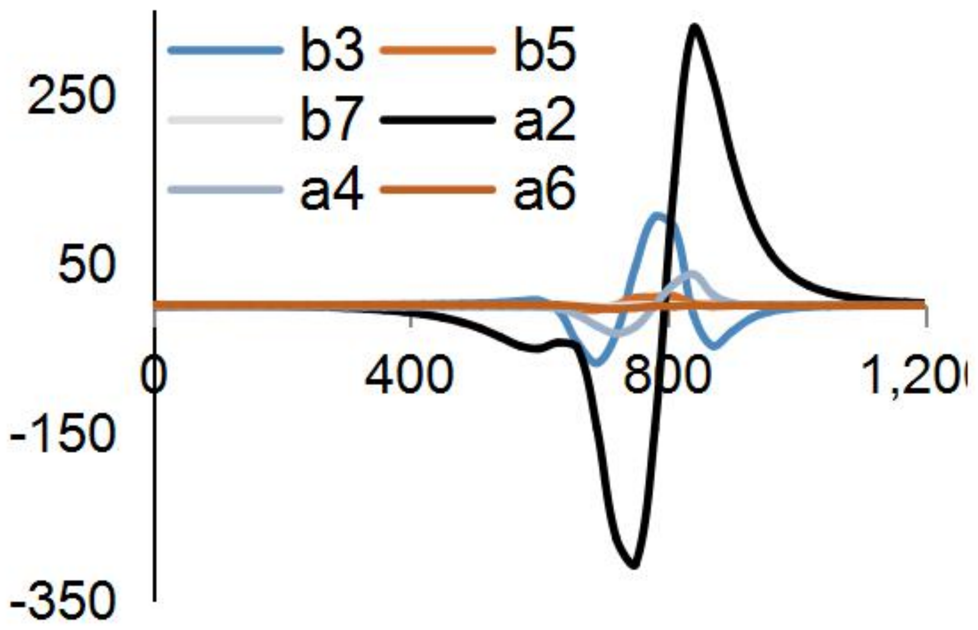
SPPC 20T Nb_3Sn+HTS SC Dipole Conceptual Design

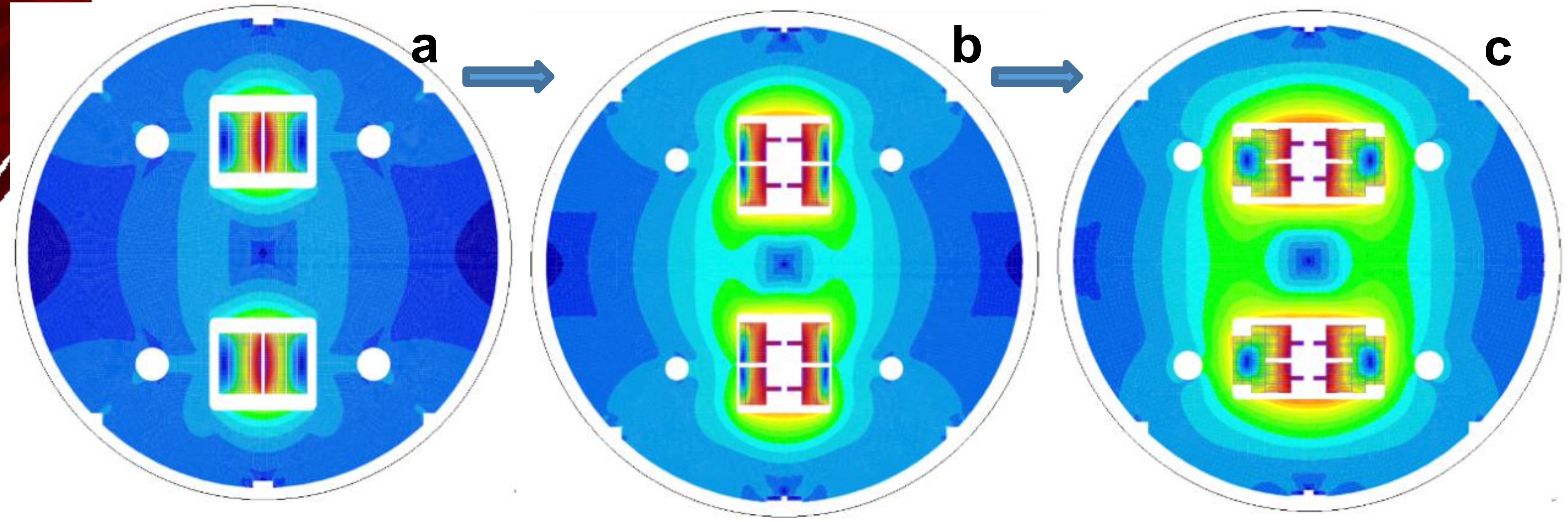
Q.J. Xu





High order multiples along axis





20-T common coil dipole magnet:
space for beam pipes: 2 * Φ50 mm, with the load line ratio of ~90% @ 4.2 K

R&D steps for fabrication of the 20-T dipole magnet with common coil configuration
a. a 15-T sub-scale magnet; **b.** a 15-T dipole magnet with 2 apertures; **c.** a 20-T dipole magnet with 2 apertures and 10^{-4} field quality

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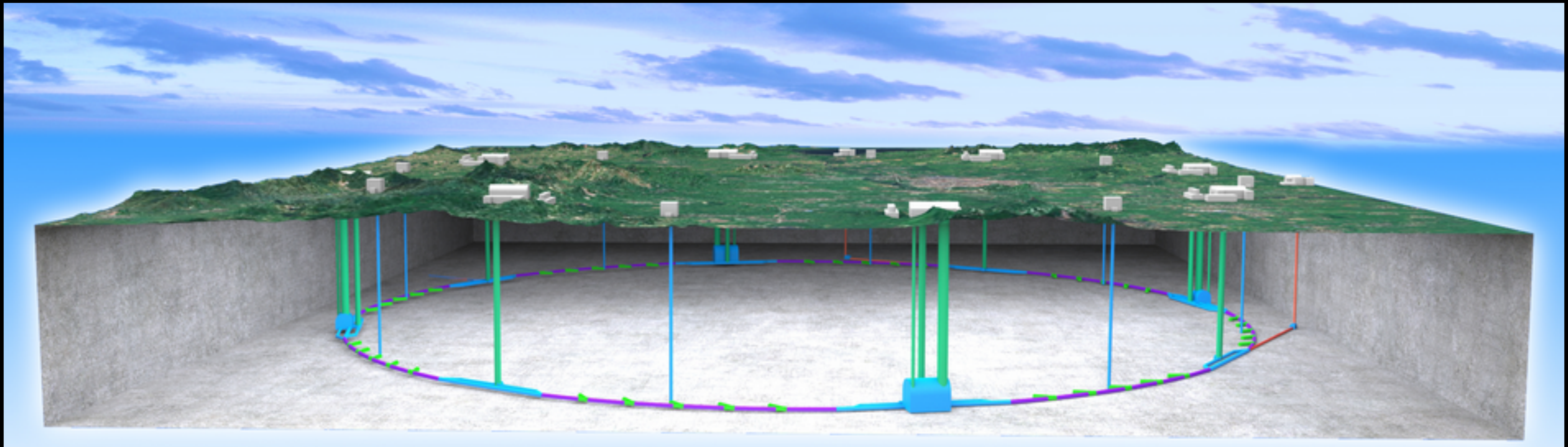
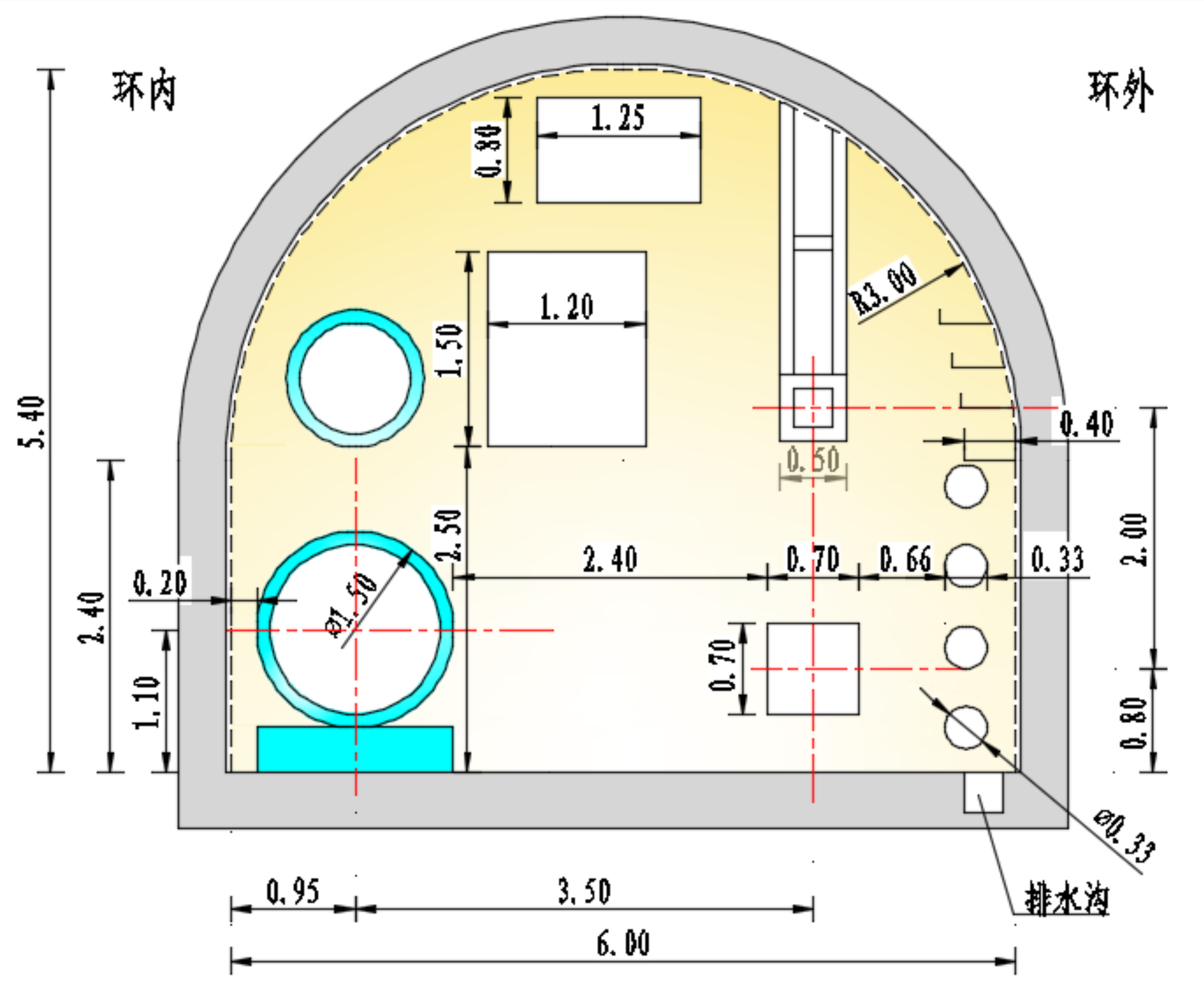
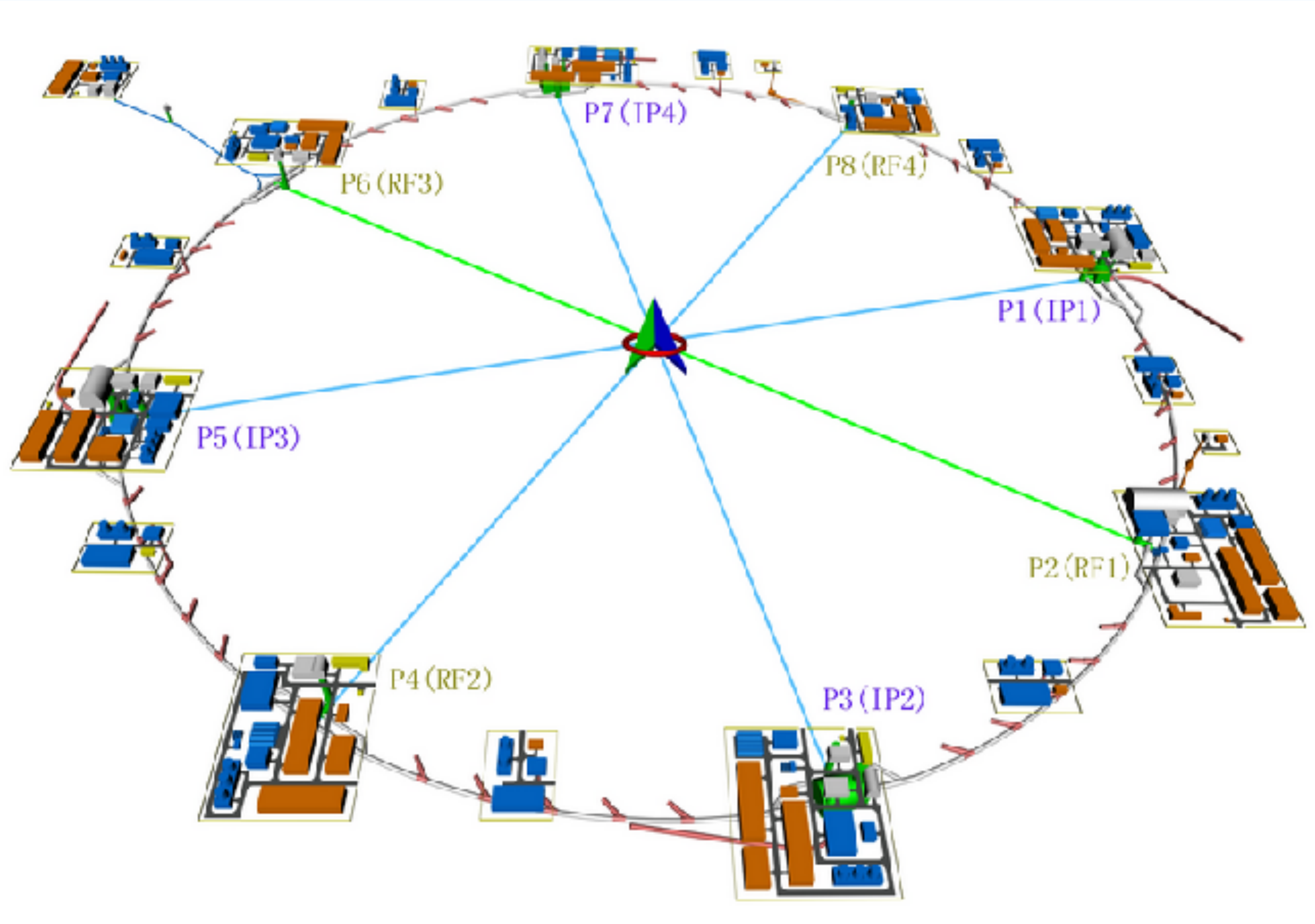
Civil Construction



Tunnel cross section



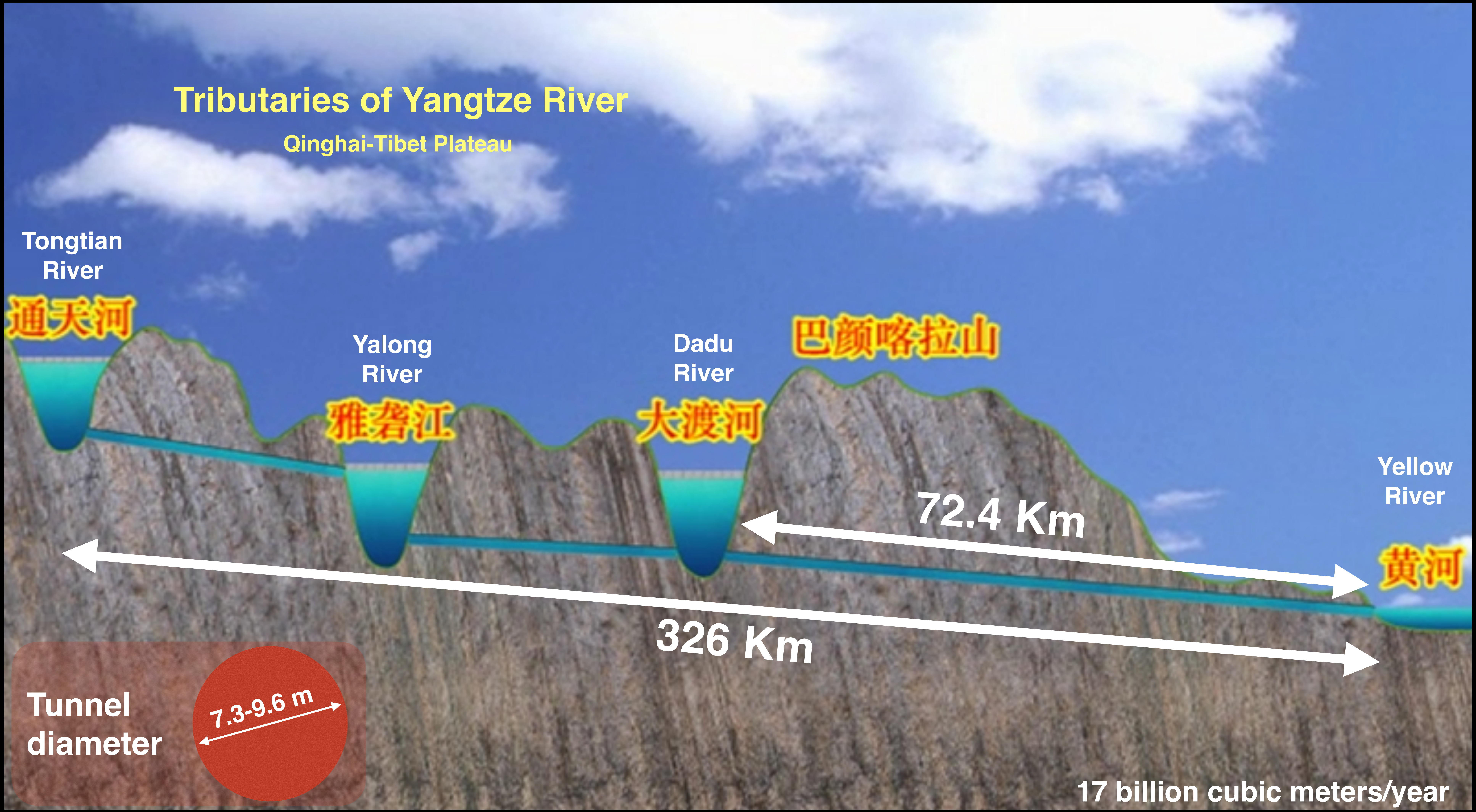
Surface buildings



How big is this project?

Similar tunneling projects…

South-to-North Water Diversion: West Line Project

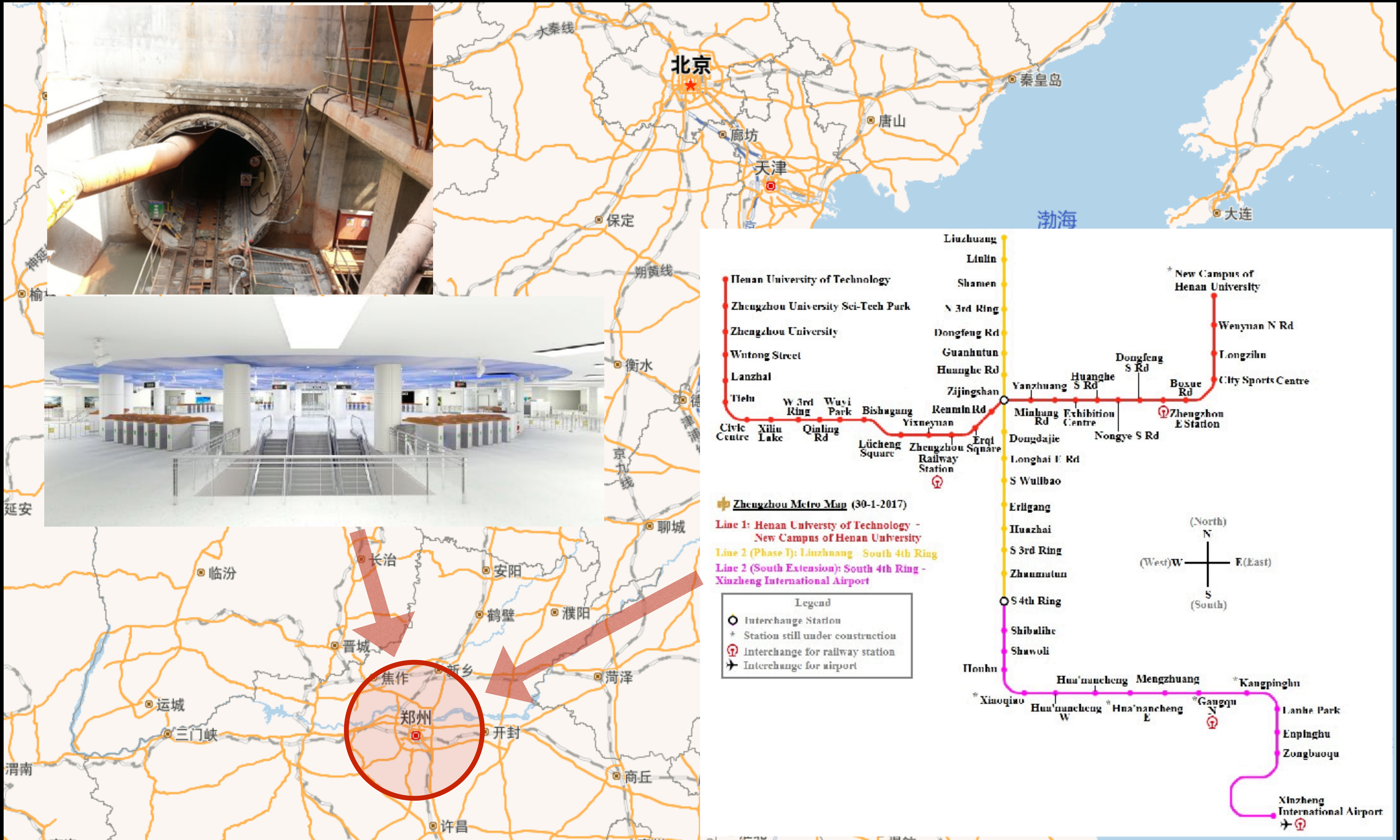


Similar tunneling projects…

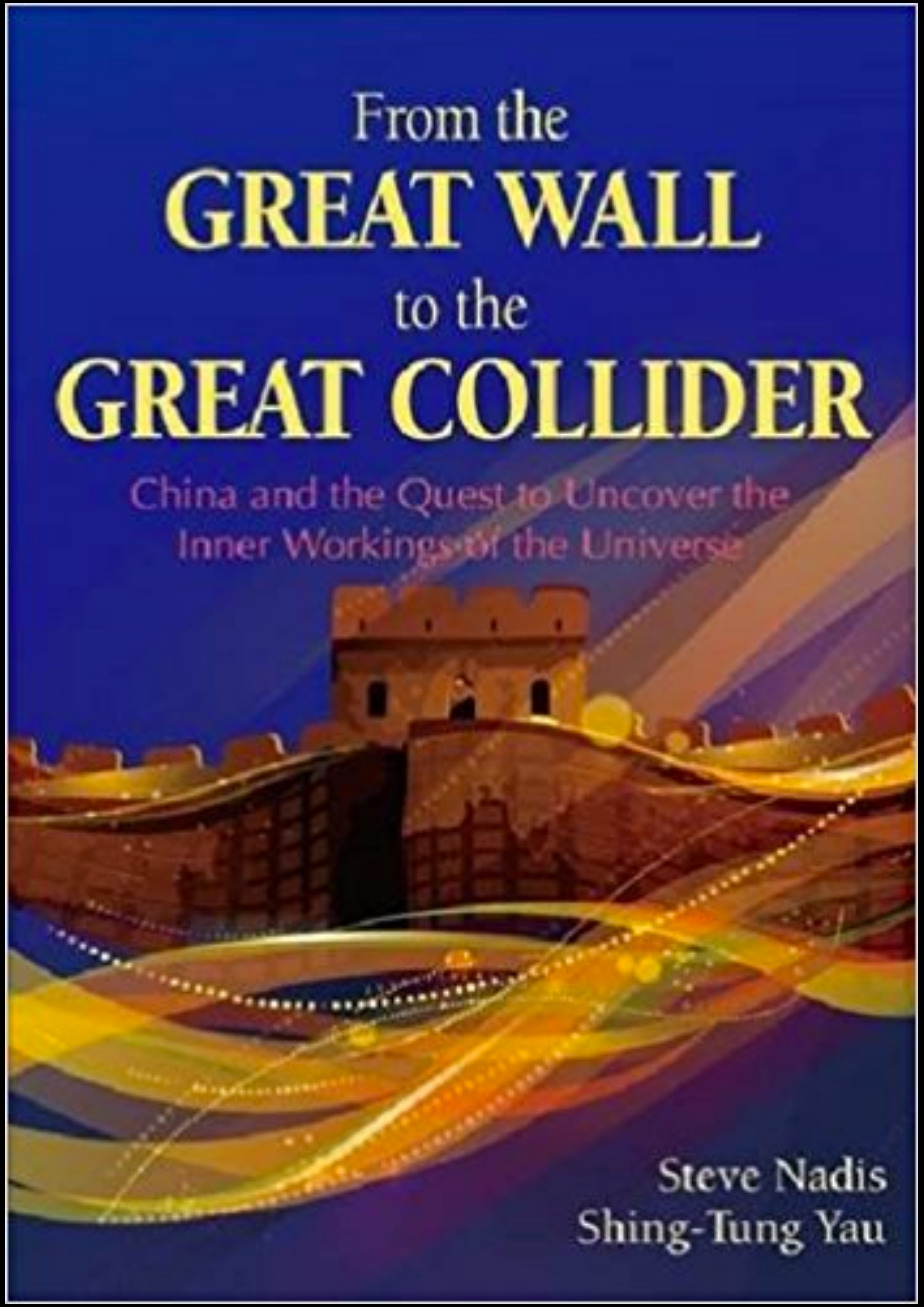
Similar tunneling projects…

Subway in Zhengzhou

Length: 94 km
Stations: 57



Public Debate in China



Prof. Shing-Tung Yau

Harvard Professor
Field Medalist
Cabbibo-Yau Manifolds

Published book on CEPC/SPPC in 2016

Followed by International Meeting in Beijing

“A Super Collider Is Not for Today’s China”

Prof. Chen-Ning Yang

Tsinghua University Professor
Nobel Prize Winner
Yang-Mills Theory (the basis of SM)

Published article on WeChat platform

Instant messaging application
> 1 billion accounts
> 860 million active users

estimates cost of CEPC to be at least $20 billion and possibly ending as “a bottomless pit”

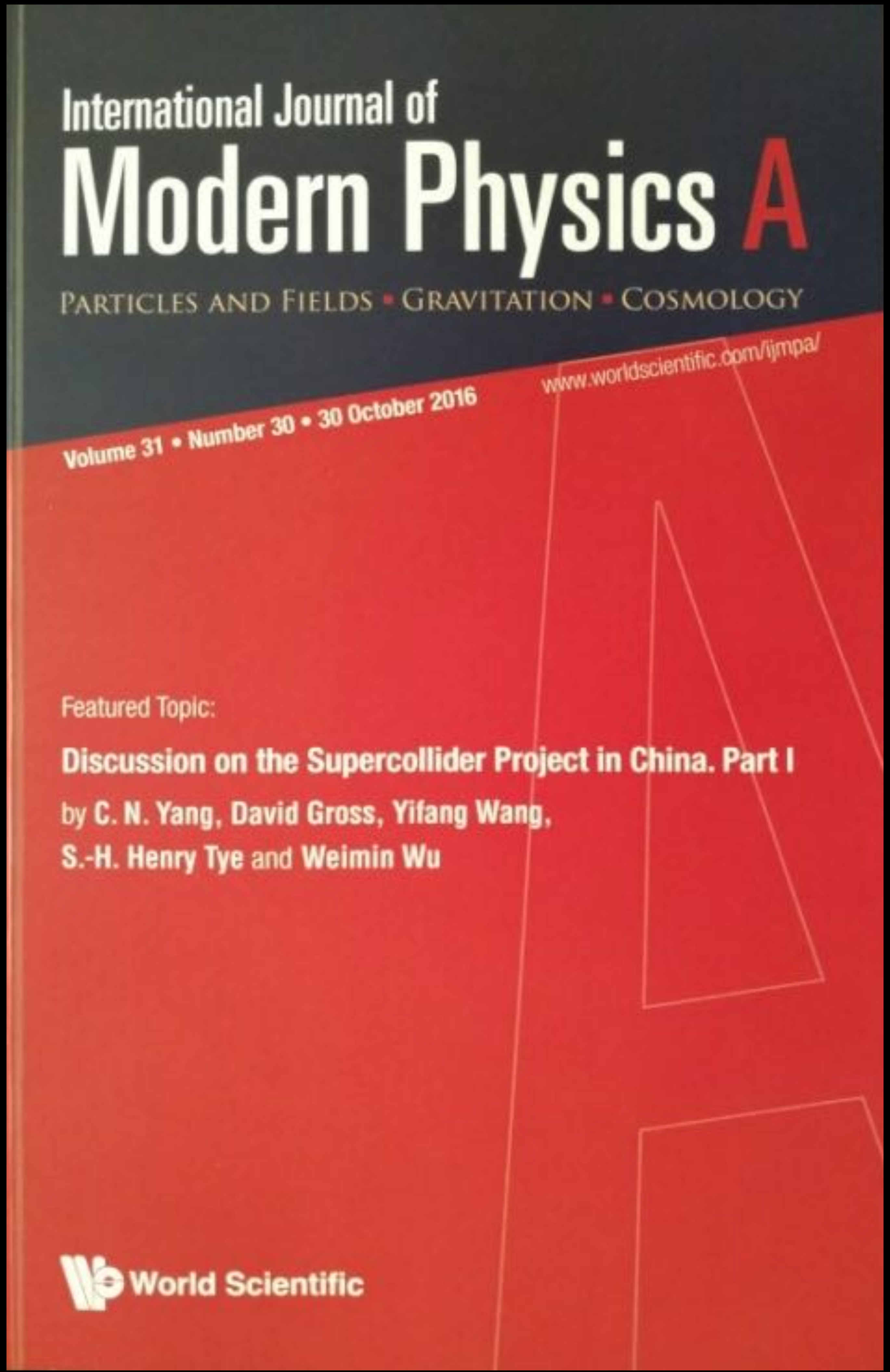
concerns over the science of CEPC as it is just out of “a guess of physicists”

“Even if they see something with the machine, it’s not going to benefit the life of Chinese people any sooner,”

the Chinese cannot do it

Public debate in China

Public Debate exploded in main media and social media



Prof. Wang was joined in the discussion by

Yau, Anderson, Gross, Glashow, Weinberg, t Hooft', Hawking, ….

articles published by World Scientific

Most discussion happened in Chinese, on main TV, WeChat, and other platforms

I was told that even taxi drivers would discuss the issue!

Why does China want to do it?

A Chinese contribution to the human civilization

Benefits for China

Technology:

Improve the existing technology to the world's leading level:

- Mechanics, vacuum, electronics, computer, …

Establish new technologies in China and lead the world, hopefully on a number of new enterprises:

- Cryogenics, RF power, SC cavities, ASIC chips, …

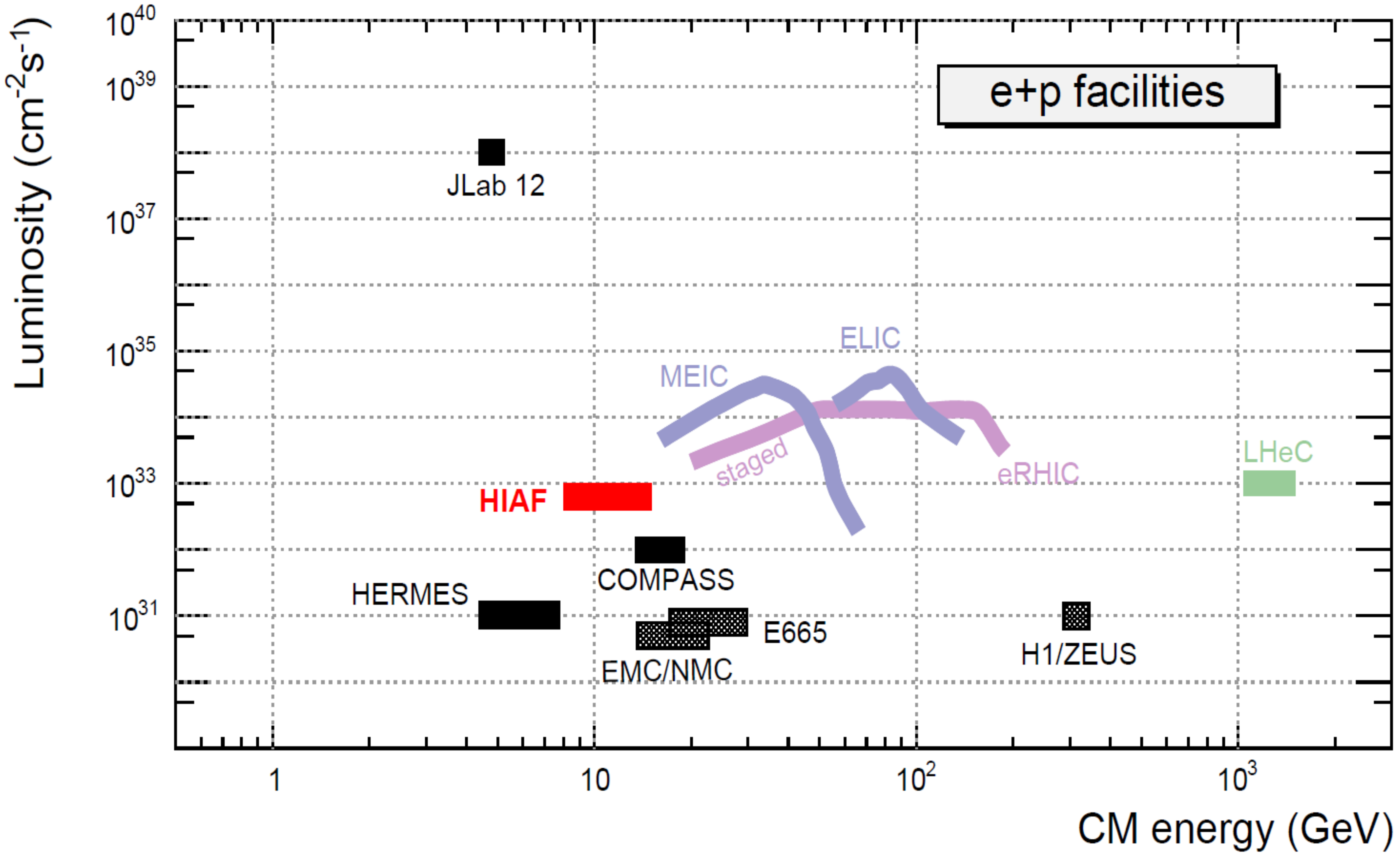
Push for revolutionary technologies:

- HTC superconducting cables

International science center:

Innovative personal training
Local economic development
New system of Science and Technology

Other lepton-nuclei facilities



●The energy reach of the EIC@HIAF is significantly higher than JLab12 but lower than the full EIC being considered in US

●COMPASS has similar (slightly higher) energy, but significantly lower polarized luminosity (about a factor of 200 lower, even though the unpolarized luminosity is only a factor of 4 lower)

●HERA only has electron and proton beams collision, but no light or heavy ion beams , no polarized beams and its luminosity is low (10^{31} $cm^{-2}s^{-1}$)