CEPC status and design study organization

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On behalf of the whole CEPC design group

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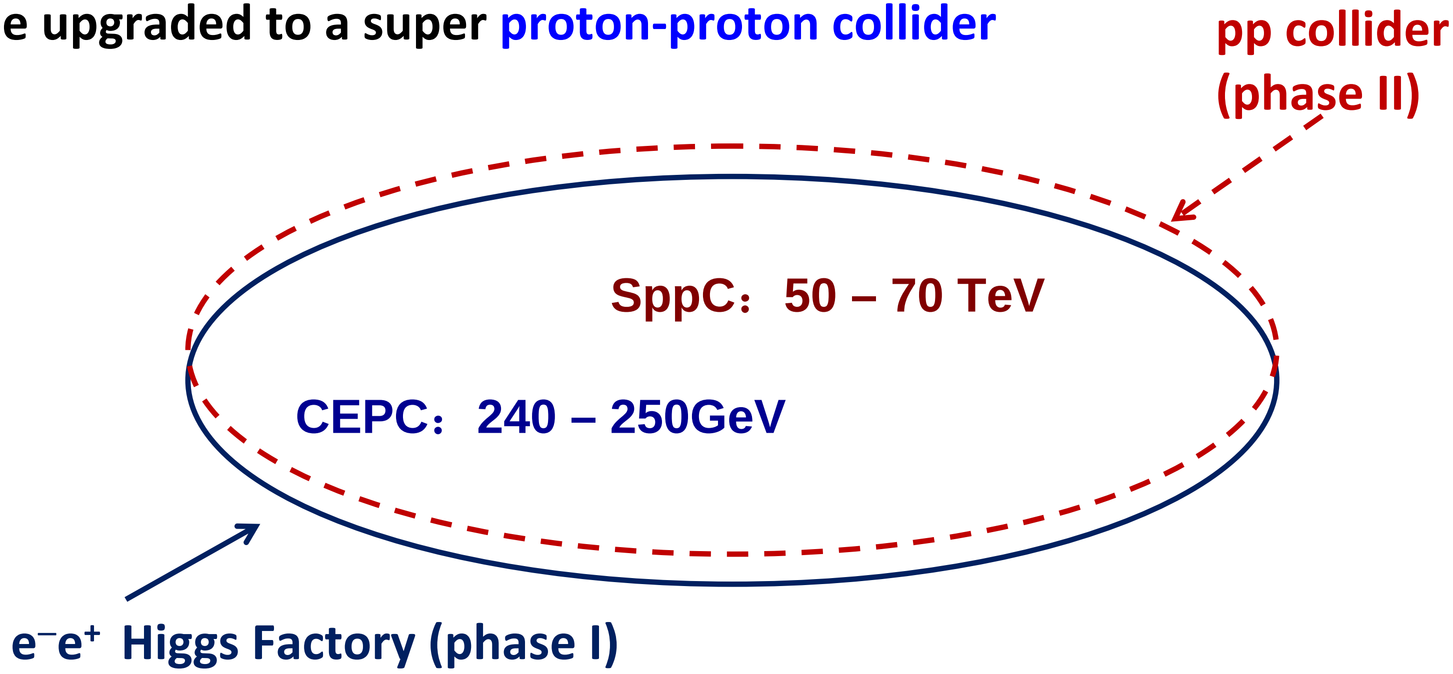
Outline

- Overview of CEPC
- Design study on accelerator
- Design study on CEPC detector
- CEPC design study organization
- Summary

1. Overview of CEPC

CEPC is

- an **C**ircular **E**lectron **P**ositron **C**ollider
- proposed to carry out high precision study on Higgs bosons
- to be upgraded to a super proton-proton collider



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CEPC basic parameter:

- Beam energy ~120 GeV.
- Synchrotron radiation power ~50 MW.
- 50/70 km in circumference.

SppC basic parameter:

- Beam energy ~50-70 TeV.
- 50/70 km in circumference.
- Needs B_{max} ~20T.

The circumference of CEPC is determined by that of the SppC, which is determined by the final energy of proton beam and the achievable dipole field strength.

2. Design study on accelerator

Circumference

- Currently the design effort are mostly focused on the C = 50km scenario and the CEPC machine

Empirical parameters taken

- Ring filling factor
  - ✓ κ = 0.78 (C=50km)
- Beam-beam tune shifts and β_y
  - ✓ ξ_y = 0.1 (e machine) & β_y = 1 mm

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Main beam parameters for CEPC at 50km

Parameter	Unit	Value	Parameter	Unit	Value
Energy	GeV	120	Circumference	km	50
Number of IP		1	SR loss	(GeV/turn)	2.96
N_e/bunch	1E11	3.52	N_b/beam		50
Beam current	mA	16.9	SR power/beam	MW	50
Partition Je		2	Long. damp. time	ms	6.7
Dipole field	Tesla	0.065	Bending radius	km	6.2
Dipole length	m	9.978	Bending angle	mrad	1.609
Emittance (x/y)	nm	6.69/0.033	β_{IP} (x/y)	mm	200/1
Trans. size (x/y)	μm	36.6/0.18	Mom. compaction	1E-4	0.4
$\xi_{x,y}$ /IP		0.1/0.1	Bunch length	mm	3

Parameters (cont.)

Parameter	Unit	Value	Parameter	Unit	Value
RF voltage V_{rf}	GV	4.2	RF frequency f_{rf}	GHz	0.7
Long. tune ν_s		0.13	Harmonic number		116747
Hourglass factor		0.6	n_γ		0.42
Energy spread SR		0.0013	Energy spread BS		0.00014
Energy acceptance	%	2.7	Lifetime BS	hr	1.6
L_0 /IP (10^{34})	$cm^{-2}s^{-1}$	2.65	L_{limit} /IP (10^{34})	$cm^{-2}s^{-1}$	1.26

CEPC main ring:

- A FODO lattice in arcs with 60 degree phase advances
- 16-folder symmetry
- RF sections distribute around the ring
- Pretzel scheme will be adopted for multi-bunch collision

Booster:

- In the same tunnel of the collider (6 – 120 GeV)

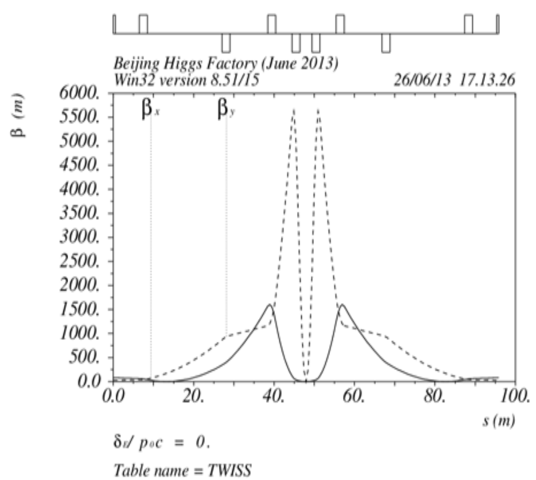
Linac:

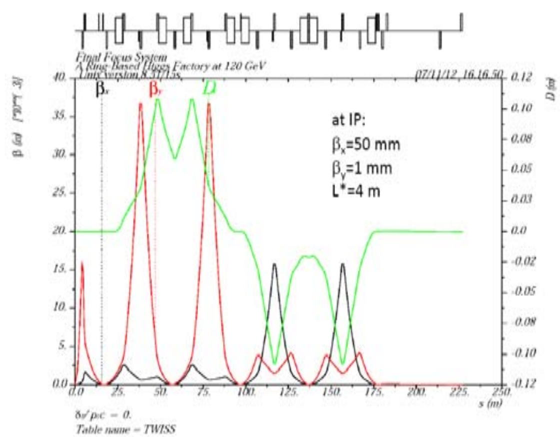
- 6GeV–Linac will be adopted.

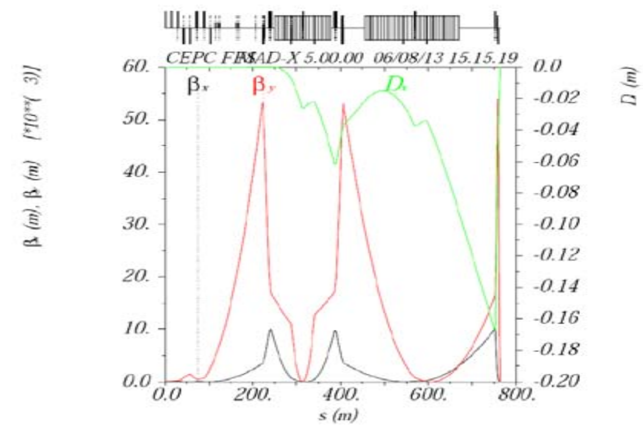
Final focus system

- **Simple FFS design had been tried, but the beam dynamic aperture is too small**
- **FFTB type and ILC type FFS designs are currently under study in parallel to achieve a reasonable dynamic aperture**

Please refer to Wang Dou's talk for details.







Possibility to lower the wall-plug power

- **High beam power due to SR will cause huge power consumption of the whole machine**
  - Arising heating of vacuum chamber
  - Increasing the cost of construction and operation
- **How can we save the power (beam, total)**
  - Reducing beam current → luminosity decreased dramatically.
  - Reducing beam current, and lower the β_y@IP – keep luminosity decreased not so much.
  - etc.

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Low-beta parameters for 50km CEPC

	β_{IP}(y) 1mm	β_{IP}(y) 0.48mm	β_{IP}(y) 0.35mm
SR power /beam (MW)	50	25	15
Beam current (mA)	16.9	8.45	5.07
N_e/bunch (10^{12})	0.79	0.38	0.28
Bunch number	22	23	19
$\beta_{IP\ x}$ (m)	0.2	0.071	0.041
Emittance x/y (nm)	14.6/0.073	9.5/0.035	8.9/0.026
σ_{IP} (um)	54/0.27	25.9/0.13	19.2/0.096
ξ_x	0.1	0.076	0.06
F (hour glass)	0.68	0.48	0.41
L_{max}/IP ($10^{34}cm^{-2}s^{-1}$)	3.1	2.31	1.58
L_{limit}/IP ($10^{34}cm^{-2}s^{-1}$)	1.5	0.9	0.8
Lifetime Bhabha (min)	35	17	12
Total AC power* (MW)	288	186	145

* including main ring, booster, injectors and detector etc.

Long. and tran. microwave instabilities

SR Power/beam(MW)	50	25	20	15	LEP3/50
Energy (GeV)	120	120	120	120	120
Circumference (km)	50	50	50	50	26.7
Beam current (mA)	16.9	8.45	6.76	5.07	7.2
Bunch number	50	23	21	19	3
Bunch current (μA)	338.0	367.4	321.9	266.8	2400
α_p (10^{-4})	0.4	0.38	0.38	0.38	0.81
σ_δ (10^{-3})	1.3	1.3	1.3	1.3	2.32
σz (mm)	3	2.2	2.2	2.2	3
νx/νy	172.3/171.3				70/100
ZL/nthreshold (Ω)	0.022	0.015	0.017	0.020	0.052
TMCI threshold I_{th} (μA)	656.5				1796.5
MWI threshold I_{th} (μA)	1045.2				4168.5

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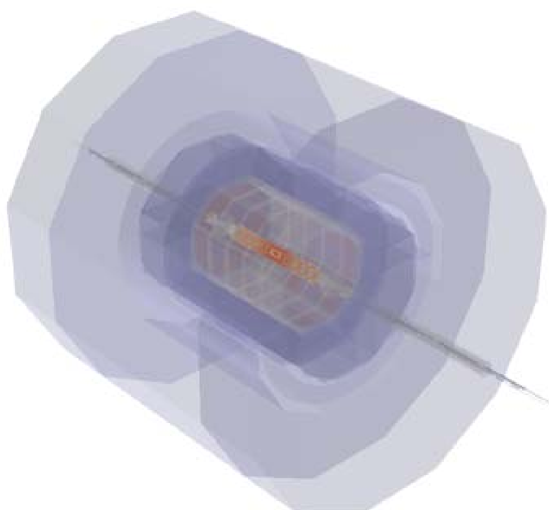
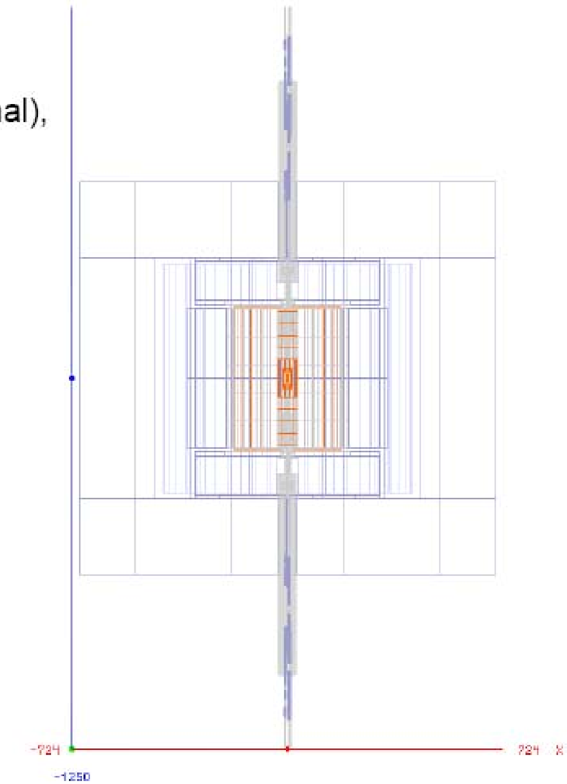
3. Design study on CEPC detector

Reference detector for CEPC: ILD

Scale: half_Z: 12.5/6.62 meter, radius 7.24 meter

Sub detectors: VTX, SIT, FTD, TPC, SET/ETD(optional), Ecal, Hcal, Coil, Muon





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ILD

- Massive usage of silicon pixel/strips in the tracking system & VTX: ensures good accuracy in Impact parameter & momentum measurement
- TPC as its main tracker
- PFA Oriented Calorimeter: Identify and measure each incident particles with sufficient energy
- Calorimeter R&D for ILD: Ultra high granularity: ~ 1 channel cm^{-3}. 3d, 4d or 5d image...

From ILD to CEPC detector

- **Many new designs**
  - **Changed granularity (no power pulsing)**
  - **Changed L***
  - **Changed VTX inner radius and TPC outer Radius**
  - **Changed Detector Half Z**
  - **Changed Yoke/Muon thickness**
  - **Changed Sub detector design**
  - **...**
- **All Changes need to be implemented into simulation, iterate with physics analysis and cost estimation**

4. CEPC design study organization

- **CEPC+SPPC kick-off on Sep. 13-14**
  - **100+ particle physicists from 20+ institutions (e.g. IHEP, Peking Univ., Shandong Univ., Tsinghua University, USTC, etc.) participated**
  - **Institutional Representatives elected**
  - **Organization committee determined**
  - **Steering Committee formed**
  - **Committee members chosen**
  - **3 working groups and convener decided**
  - **Work assigned (to specific person/institution)**

CEPC organization

- Organization committee:
  - chairman: YuanNing Gao (Tsinghua University)
  - One representative from each institution
- Steering committee:
  - chairman: Yifang Wang
- Project manager: Xinchou Lou, Qing Qin
- Working groups:
  - Theory (Convener: Hongjia He, Shouhua Zhu)
  - Accelerator (Convener: Qing Qin, Jie Gao)
  - Detector (Convener : Shan Jin, Yuanning Gao)

Summary

- A CEPC + SppC was proposed in IHEP for high precise probe of Higgs, and new discovery of physics as well.
- Main parameters and basic lattices are being studied and further iterations are required.
- Detector design are being investigated, optimization work is underway.
- CEPC+SPPC design work formally launched, more institutions are involved, man power and computing resources are being allocated to different topics.

Thank you for your attention !