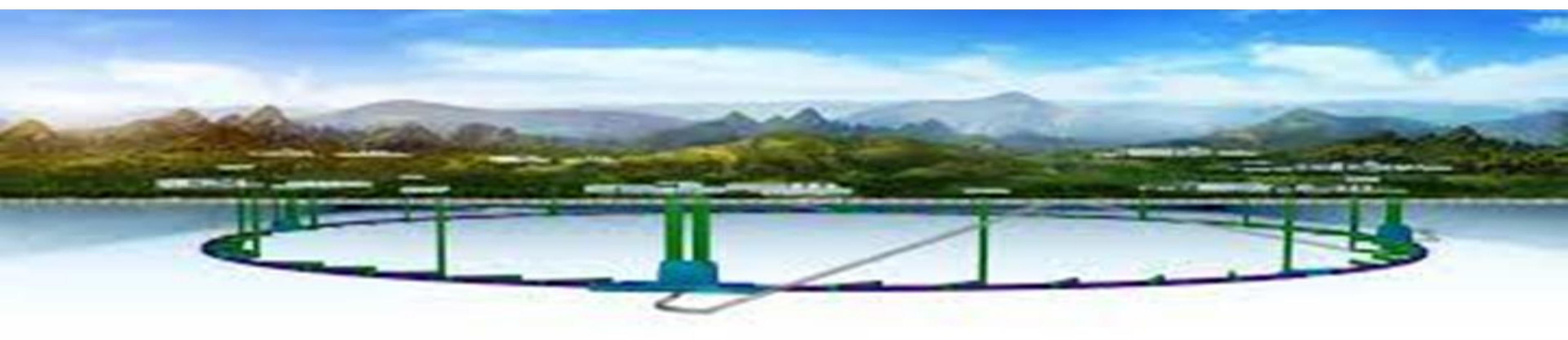
TDR Phase-1 Review, HKUST

Circular Electron Positron Collider

Report on the General Status

XinChou Lou

IHEP, Beijing

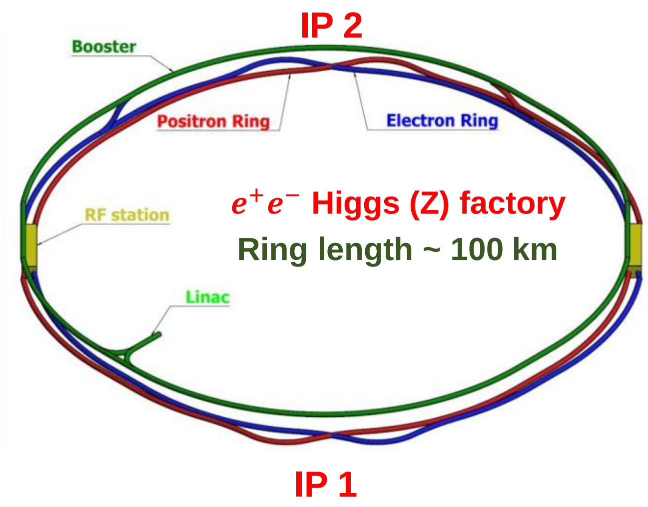


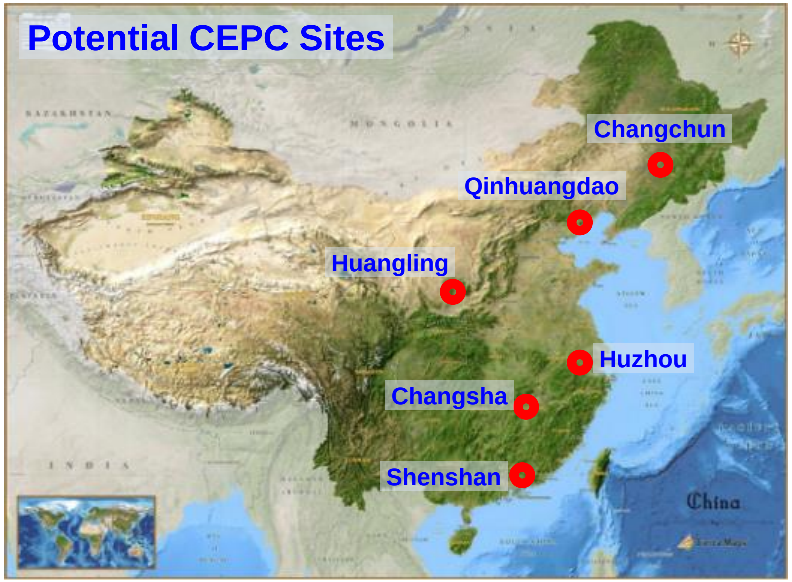
Outline

- Status of the CEPC
- Planning and Schedule
- TDR and Reviews
- Summary

CEPC Status

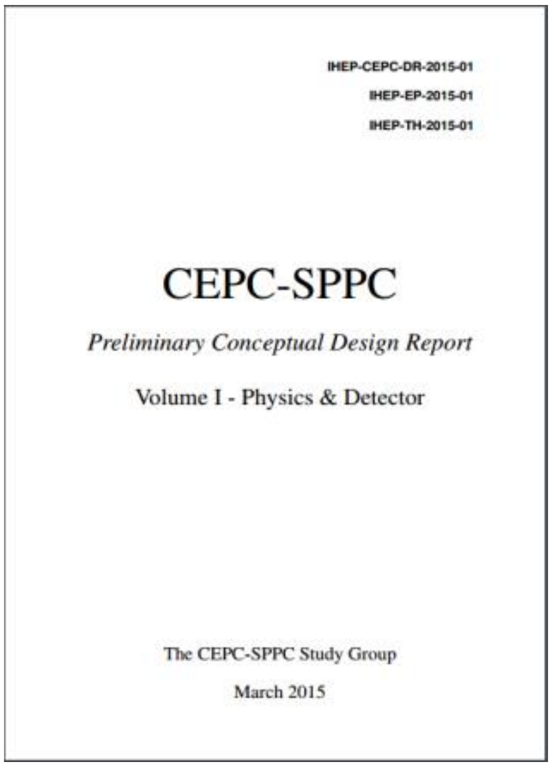
- The CEPC aims to start operation in 2030's, as a Higgs (Z / W) factory in China.
- To run at $\sqrt{s}$ ~ 240 GeV, above the **ZH** production threshold for ≥1 M Higgs; at the **Z** pole for ~Tera Z; at the **W^+W^-** pair and then $t\bar{t}$ pair production thresholds.
- Higgs, EW, flavor physics & QCD, probes of physics BSM.
- Possible *pp* collider (SppC) of $\sqrt{s}$ ~ 50–100 TeV in the far future.





CEPC Status

CEPC team took steps to advance


IHEP-CEPC-DR-2015-01
IHEP-EP-2015-01
IHEP-TH-2015-01

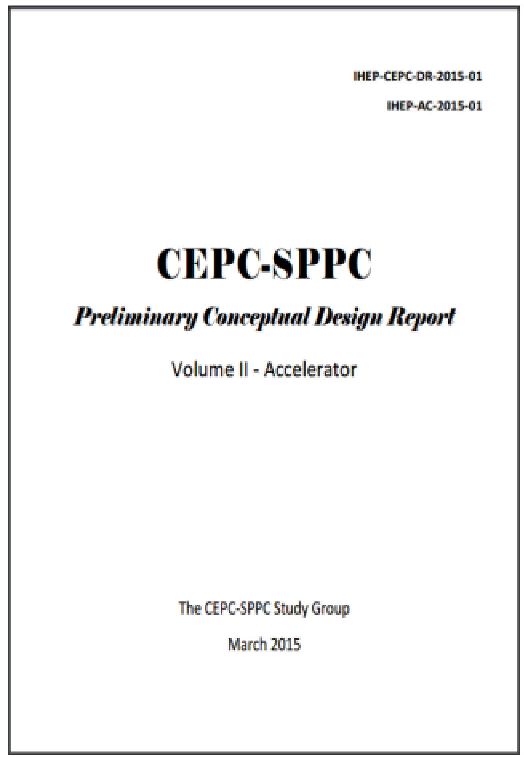
CEPC-SPPC

Preliminary Conceptual Design Report

Volume I - Physics & Detector

The CEPC-SPPC Study Group

March 2015


IHEP-CEPC-DR-2015-01
IHEP-AC-2015-01

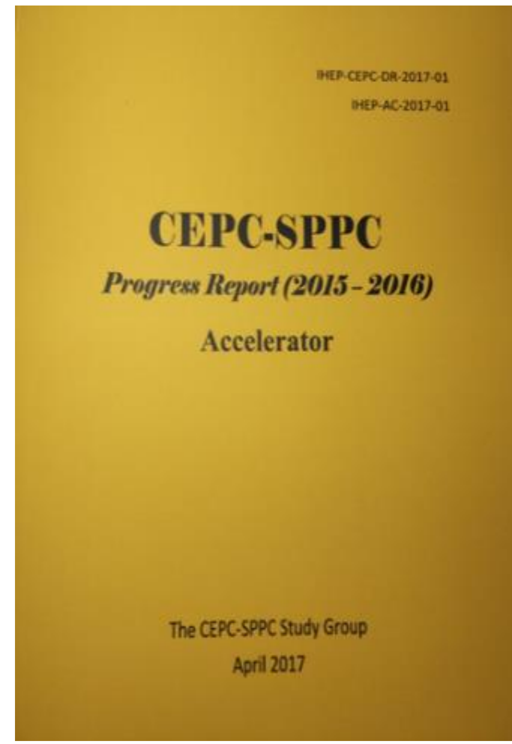
CEPC-SPPC

Preliminary Conceptual Design Report

Volume II - Accelerator

The CEPC-SPPC Study Group

March 2015


IHEP-CEPC-DR-2017-01
IHEP-AC-2017-01

CEPC-SPPC

Progress Report (2015 – 2016)

Accelerator

The CEPC-SPPC Study Group

April 2017

CEPC Status

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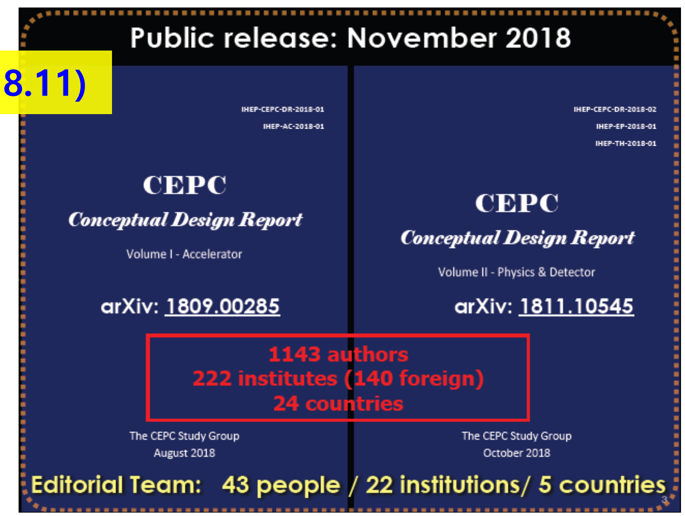
CEPC-SPPC Kickoff (2013.9)

First CEPC IAC Meeting (2015.9)

CEPC CDR Released (2018.11)



Scientific objectives, significance, and strategic value

The scientific importance and strategical value of an electron positron Higgs factory is clearly identified.

clear consensus in HEP community

*2013, 2016: **the CEPC is the best approach** and a major historical opportunity for the national development of accelerator-based high-energy physics program.*

2020 European Strategy Update

An electron-positron Higgs factory is the highest-priority next collider. For the longer term, the European particle physics community has the ambition to operate a proton-proton collider at the highest achievable energy. Accomplishing these compelling goals will require innovation and cutting-edge technology:

Conclusion from Executive Summary

Given the **strong motivation** and existence of proven technology to build an e^+e^- **Higgs Factory in the next decade**, the **US should participate** in the construction of **any facility that has firm commitment** to go forward.

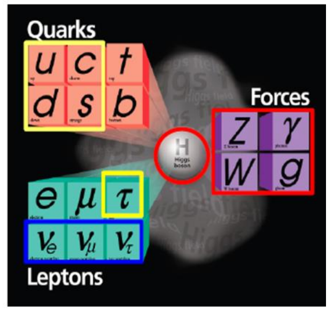
Sridhara Dasu (Wisconsin)

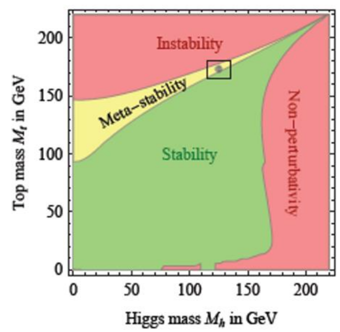
ICFA

*In April 2022, the International Committee for Future Accelerators (ICFA) "reconfirmed the international consensus on the importance of **a Higgs factory as the highest priority for realizing the scientific goals of particle physics**", and expressed support for the above-mentioned Higgs factory proposals. Recently, the United States also proposed a new linear collider concept based on the cool copper collider (C3) technology [31].*

CEPC Status

- We have a very successful Standard Model
- But we still have a lot of issues and questions:
  - Anything fundamentals behind the flavor symmetry ?
  - Mass hierarchy of elementary particles normal ?
  - Fine tuning of Higgs mass natural ?
  - Why a meta-stable vacuum ?
  - What are dark matter particles ?
  - No CP in the SM to explain Matter-antimatter asymmetry
  - Dirac or Majorana Neutrino mass ?
  - Unification of interactions at a high energy ?
- We are at a turning point:
  - a new, much deeper theory ?
  - Choices of experimental approaches ?
    - e^+e^-, pp, ep, $\mu^+\mu^-$ or no machine ?





- "Small cost" to look for hints. If yes, go for direct searches

$$\mathcal{L} = \mathcal{L}_{SM} + \sum_i \frac{c_i}{M^2}\mathcal{O}_{6,i} \qquad \delta \sim c_i \frac{v^2}{M^2}$$

No signal at LHC:

Direct searches: M ~ 1 TeV

10% precision: M ~ 1 TeV

Look for signals at CEPC/FCC-ee:

Precisions exceed HL-LHC ~ 1 order of magnitude (1% precision) ➔ M ~10 TeV

Naturalness will be at ~10^{-4} up to 10 TeV
If no New Physics up to 10 TeV, there will be no naturalness ➔ even bigger discovery ?

Pressing science questions, best addressed by an e^+e^- Higgs factory (~1% precision)

Scientific objective

CEPC Status

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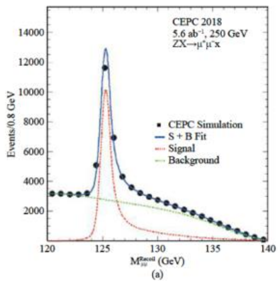
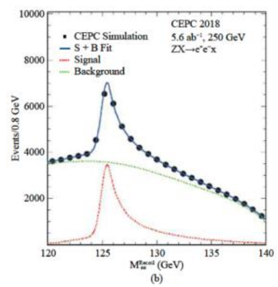
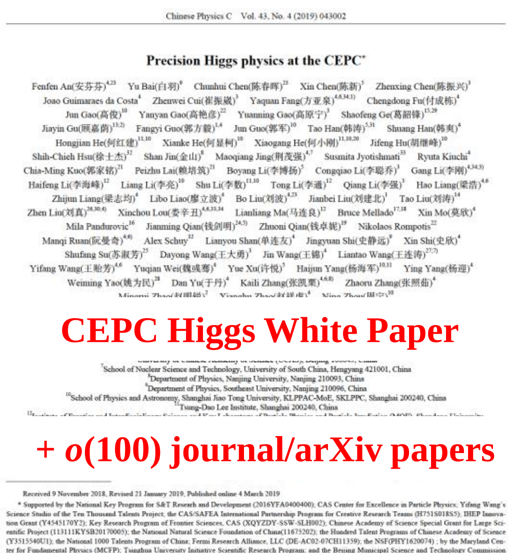
Scientific objectives, significance, and strategic value





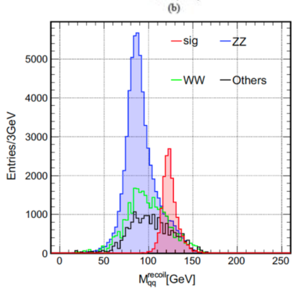


CEPC Higgs White Paper

+ $o(100)$ journal/arXiv papers

Table 2.1: Precision of the main parameters of interests and observables at the CEPC, from Ref. [1] and the references therein, where the results of Higgs are estimated with a data sample of 20 ab^{-1}. The HL-LHC projections of 3000 fb^{-1} data are used for comparison. [2]

Higgs			W, Z and top		
Observable	HL-LHC projections	CEPC precision	Observable	Current precision	CEPC precision
M_H	20 MeV	3 MeV	M_W	9 MeV	0.5 MeV
Γ_H	20%	1.7%	Γ_W	49 MeV	2 MeV
$\sigma(ZH)$	4.2%	0.26%	M_{top}	760 MeV	$\mathcal{O}(10)$ MeV
$B(H \to bb)$	4.4%	0.14%	M_Z	2.1 MeV	0.1 MeV
$B(H \to cc)$	-	2.0%	Γ_Z	2.3 MeV	0.025 MeV
$B(H \to gg)$	-	0.81%	R_b	3×10^{-3}	2×10^{-4}
$B(H \to WW^*)$	2.8%	0.53%	R_c	1.7×10^{-2}	1×10^{-3}
$B(H \to ZZ^*)$	2.9%	4.2%	R_μ	2×10^{-3}	1×10^{-4}
$B(H \to \tau^+\tau^-)$	2.9%	0.42%	R_τ	1.7×10^{-2}	1×10^{-4}
$B(H \to \gamma\gamma)$	2.6%	3.0%	A_μ	1.5×10^{-2}	3.5×10^{-5}
$B(H \to \mu^+\mu^-)$	8.2%	6.4%	A_τ	4.3×10^{-3}	7×10^{-5}
$B(H \to Z\gamma)$	20%	8.5%	A_b	2×10^{-2}	2×10^{-4}
$B\mathrm{upper}(H \to \mathrm{inv.})$	2.5%	0.07%	N_ν	2.5×10^{-3}	2×10^{-4}



Scientific Significance quantified by **CEPC physics** studies, via full simulation/phenomenology studies:

- Higgs: Precisions exceed HL-LHC ~ 1 order of magnitude.
- EW: Precision improved from current limit by 1-2 orders.
- Flavor Physics, sensitive to NP of 10 TeV or even higher.
- Sensitive to varies of NP signal.
- …

CEPC Status

Scientific objectives, significance, and strategic value

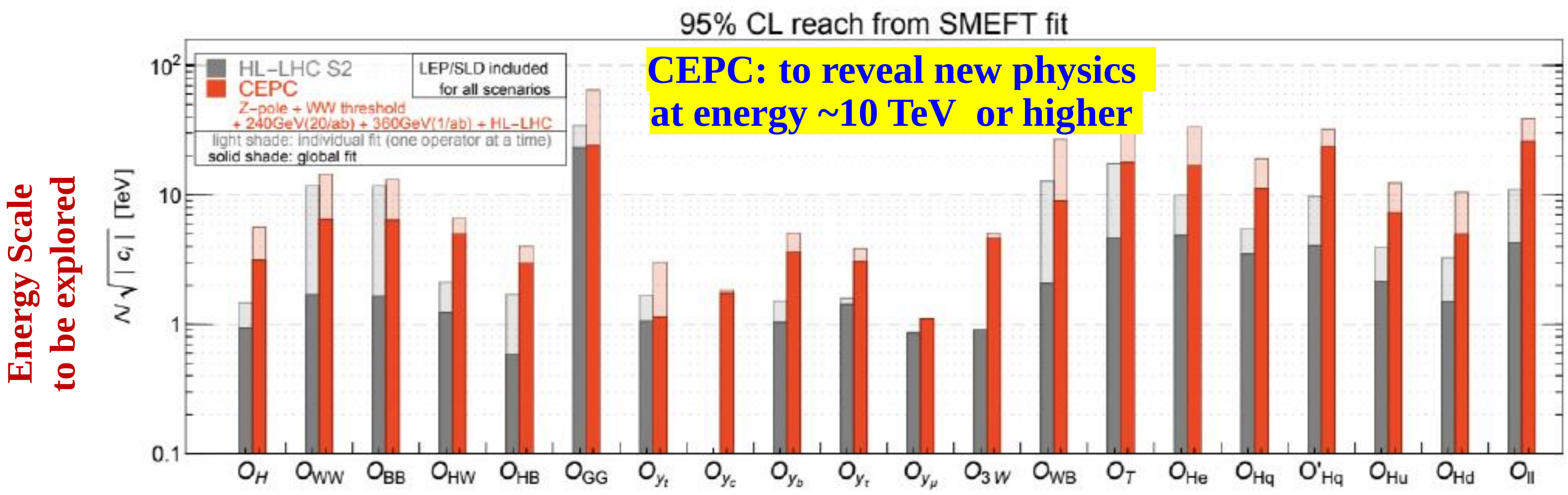
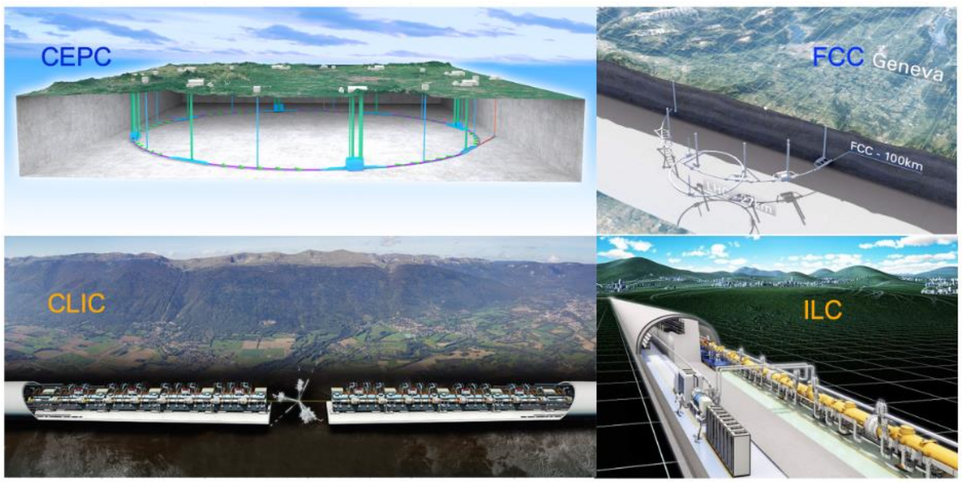
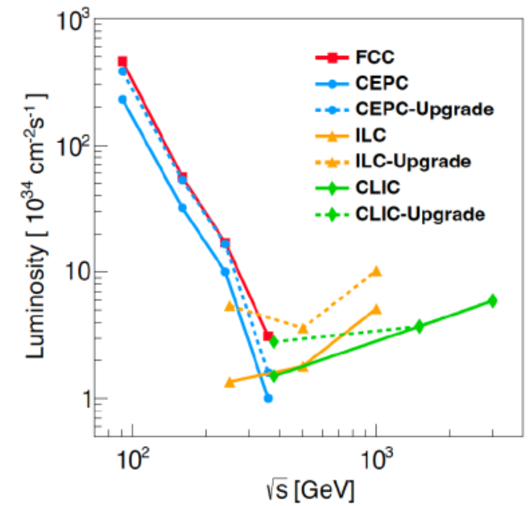


Figure 2.1: Covered energy scales of new physics from CPEC and HL-LHC, based on measurements of operators in the framework of the Standard Model Effective Field Theory (SMEFT). [1]

CEPC targets a major breakthrough in basic research, will greatly expand our understanding of the world.

CEPC Status





CEPC is well recognized in particle physics world, as a major choice for the future flagship facility.

advantages of CEPC

Versus FCC-ee

- Earlier data: collisions expected in 2030s (vs. ~ 2040s)
- Large tunnel cross section (ee & pp coexistence)
- Lower cost: ~ ½ the construction cost with similar luminosity up to 240 GeV

Versus Linear Colliders

- Higher luminosity for Higgs and Z runs
- Potential upgrade for pp collider

competitiveness of the project

CEPC Status

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New Physics
~10 TeV

- ✓ Dark Matter
- ✓ Extended Higgs
- ✓ Composite Higgs
- ✓ Supersymmetry
- ......

High Precision
~1%

- ✓ Higgs: 1%-0.1%
- ✓ EW : O(10^2-10^3) vs current
- ✓ Flavor
- ......

Detector
Particle Flow

- ✓ High Granularity
- ✓ Good Resolution
- ✓ Reliable PID
- ......

Design & Implementation
Detector & Accelerator

- ✓ Multi-purposed Acc.
- ✓ New concept Detector
- ✓ Cost, added values
- ✓ Spill-over
- ......

- ✓ Management
- ✓ Collaboration
- ......

High Lumi.
~$10^{34\text{-}36}$cm^{-2}s^{-1}

- ✓ Higgs: 20 ab^{-1}
- ✓ Z: 100 ab^{-1}
- ✓ W: 6 ab^{-1}
- ✓ Top: 1 ab^{-1}

Accelerator
2 IPs/100 km

- ✓ Switchable Operations
- ✓ Upgradability
- ✓ Large Piwinski angle with Crab-waist
- ......

Operation mode	Z	W	Higgs
Center-of-mass energy (GeV)	91	160	240
Operation time (year)	2	1	10
Instantaneous luminosity/IP (10^{34}cm$^{-2}s^{-1}$)	115	16.0	5.0
Integrated luminosity (ab^{-1}, 2 IPs)	60	3.6	12
Event yield (30 MW)	2.5×10^{12}	1.0×10^{8}	2.5×10^{6}
Event yield (50 MW)	4.0×10^{12}	1.6×10^{8}	4.0×10^{6}

key scientific issues & technological route

CEPC Status

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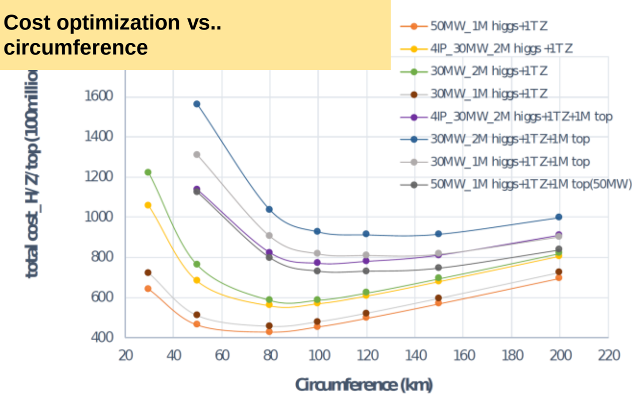
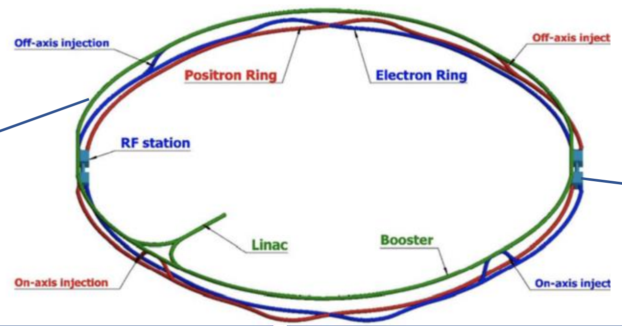
Design of experimental facility and technical requirements

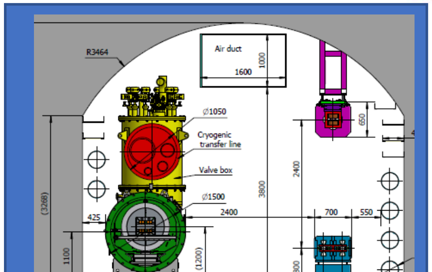
- **Circular collider**: **Higher luminosity** than a linear collider
- **100km circumference**: Optimum **total cost**, good also for **SppC**
- **Shared tunnel**: Accommodate **CEPC** booster &collider and **SppC**
- **Switchable operation**: Higgs, W/Z, top

Cost optimization vs.. circumference

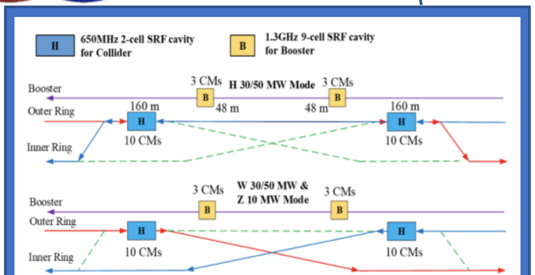


D. Wang *et al* 2022 *JINST* **17** P10018





Common tunnel for booster/collider & SppC



Switchable Operation for Higgs W and Z

Main Parameters: High luminosity as a Higgs Factory

	Higgs	W	Z	ttbar
Number of IPs	2			
Circumference [km]	100.0			
SR power per beam [MW]	**50**			
Energy [GeV]	**120**	**80**	**45.5**	**180**
Bunch number	415	2161	19918	59
Emittance (εx/εy) [nm/pm]	0.64/1.3	0.87/1.7	0.27/1.4	1.4/4.7
Beam size at IP (σx/σy) [um/nm]	15/36	13/42	6/35	39/113
Bunch length (SR/total) [mm]	2.3/3.9	2.5/4.9	2.5/8.7	2.2/2.9
Beam-beam parameters (ξx/ξy)	0.015/0.11	0.012/0.113	0.004/0.127	0.071/0.1
RF frequency [MHz]	650			
Luminosity per IP[10^{34}/cm²/s]	**8.3**	**27**	**192**	**0.83**

Originality and innovation

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CEPC: aims at innovative design, key technologies R&D, & to be among leading future colliders.

Conceptual Innovation	Upgradable Capability	State-of-the-art Tech.	Green & Cost Saving	Revolutionary Principle	Spillover

- 100km circular collider
- Partial/Full double ring
- Switchable energies H/W/Z
- One tunnel for booster/collider and SppC

- High efficiency Klystron
- SRF cavities
- Weak field dipole
- Dual aperture magnets
- PWFA Injector
- Iron based HTS Mag
- Innovative PFA Detector

impact of the project, technical performance requirements

CEPC Status

Yuhui Li will present the overview of the CEPC accelerator

CEPC Status

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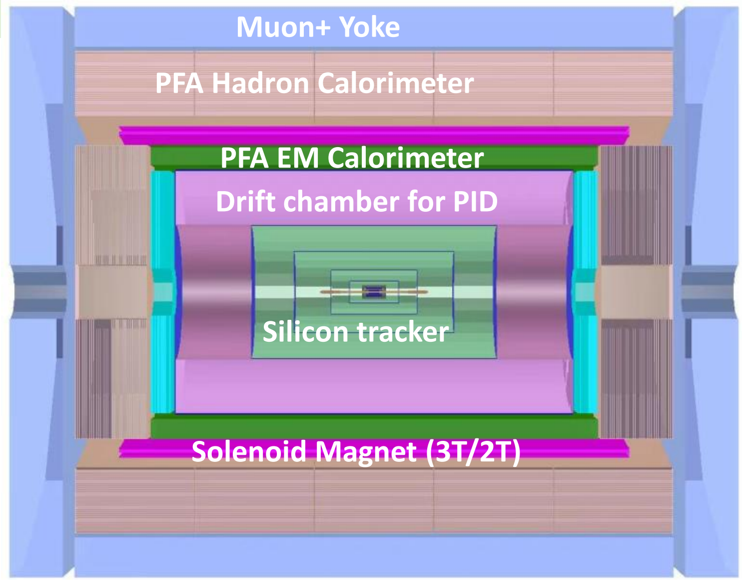
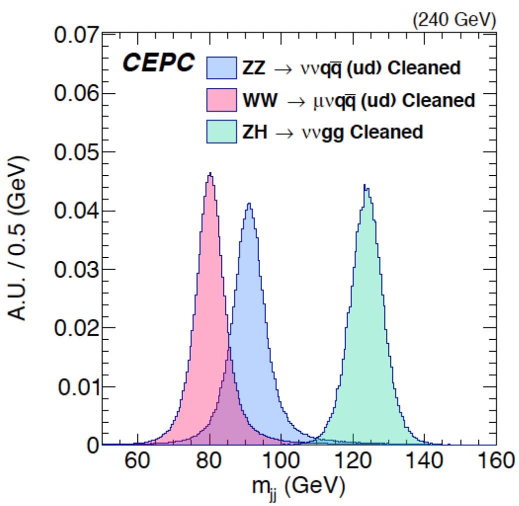
Detector

Requirements
boson mass resolution (BMR ~3%)

Challenges
- Support Particle flow with
  - High granularity
  - High precision





Novel detector design based on PFA calorimeter. Aim at improving BMR from 4% to 3%

Detector	Key parameter	World-class level	CEPC design
PFA based EM calorimeter	EM shower E resolution	~20%/√E	<3%/√E
PFA based Hadron calorimeter	Single hadron E resolution	~50%/√E	~40%/√E

Technical performance requirements for the facility

CEPC Status

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Status and maturities of the CEPC detector technologies

- **Extensive detector R&D benefitted from experience**
  - Silicon strip : Experience from ATLAS upgrade
  - MDI, Drift chamber & SC magnet : Experience from BESIII
- **CEPC R&D on key technologies**
  - Silicon pixel, silicon tracker and TPC
  - PFA calorimeter

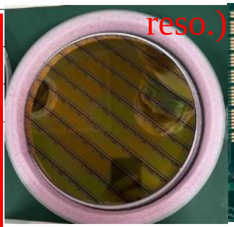
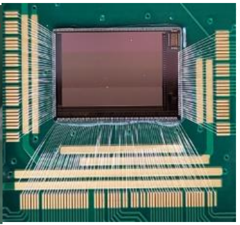
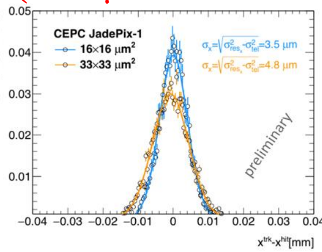
- **With international partners, all sub-detector covered**
  - PFA calorimeter: with CALICE Collaboration
  - TPC: with LCTPC Collaboration
  - Drift cham: with Italian colleague
  - Silicon tracker: with UK/Germany/Italian colleague
  - Silicon vertex: with French/Spain colleague

Prototypes under evaluation

PFA calorimeter

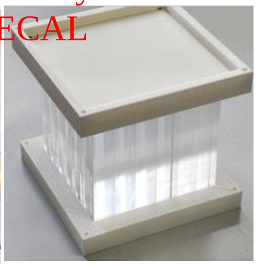
Sub-detector	Specification	Requirement	World-class level	CEPC prototype
Pixel detector	Spatial resolution	$\sim 3\ \mu m$	$3-5\ \mu m$ [12, 13]	$3-5\ \mu m$ [14–16]
TPC/drift chamber	dE/dx (dN/dx) resolution	$\sim 2\%$	$\sim 4\%$ [17, 18]	$\sim 4\%$ [19–21]
Scintillator-W ECal	Energy resolution Granularity	$< 15\%/\sqrt{E(\mathrm{GeV})}$ $\sim 2\times 2\ \mathrm{cm}^2$	12.5% [22]	Prototype built to be measured $0.5\times 0.5\ \mathrm{cm}^2$
4D crystal ECal	EM energy resolution 3D Granularity	$\sim 3\%/\sqrt{E(\mathrm{GeV})}$ $\sim 2\times 2\times 2\ \mathrm{cm}^3$	$2\%/\sqrt{E(\mathrm{GeV})}$ [23, 24] N/A	Prototyping [25] $\sim 3\%/\sqrt{E(\mathrm{GeV})}$ $\sim 2\times 2\times 2\ \mathrm{cm}^3$
Scintillator-Steel HCal	Support PFA, Single hadron σ_E^{had}	$< 60\%/\sqrt{E(\mathrm{GeV})}$	$57.6/\sqrt{E(\mathrm{GeV})}\%$ [26]	Prototyping
Scintillating glass HCal	Support PFA Single hadron σ_E^{had}	$\sim 40\%/\sqrt{E(\mathrm{GeV})}$	N/A	Prototyping $\sim 40\%/\sqrt{E(\mathrm{GeV})}$
Low-mass Solenoid magnet	Magnet field strength Thickness	$2\ \mathrm{T}-3\ \mathrm{T}$ < 150 mm	$1\ \mathrm{T}-4\ \mathrm{T}$ [27–29] > 270 mm	Prototyping

Vertex detector R & D (3- 5 μm reso.)

PFA scintillator-W ECAL

4D crystal ECAL



CEPC Status

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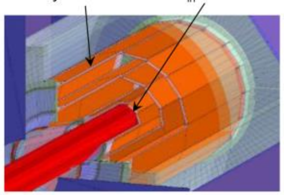
2 layers / ladder R_{in}~16 mm



Goal: σ(IP) ~ 5 μm for high P track

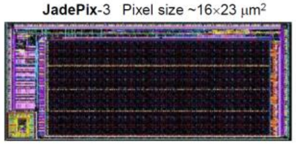
CDR design specifications

- Single point resolution ~ 3μm
- Low material (0.15% X_0 / layer)
- Low power (< 50 mW/cm²)
- Radiation hard (1 Mrad/year)

Silicon pixel sensor develops in 5 series: JadePix, TaichuPix, CPV, Arcadia, CEPCPix

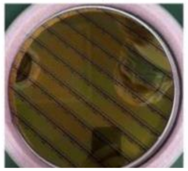
Develop **CEPCPix** for a CEPC tracke basing on **ATLASPix3** CN/IT/UK/DE TSI 180 nm HV-CMOS process

JadePix-3 Pixel size ~16×23 μm²

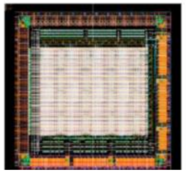


Tower-Jazz 180nm CiS process
Resolution 5 microns, 53mW/cm²

TaichuPix-3, FS 2.5x1.5 cm²
25×25 μm² pixel size

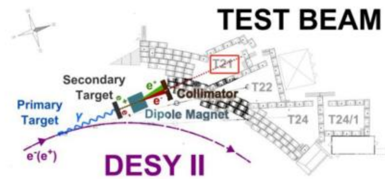


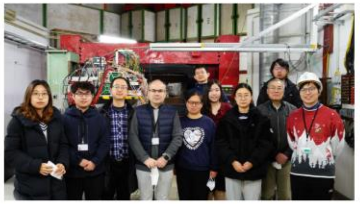
CPV4 (SOI-3D), 64×64 array
~21×17 μm² pixel size

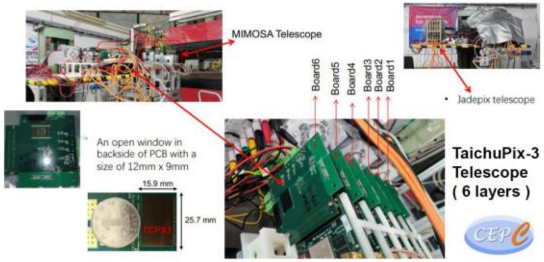


Arcadia by Italian groups for IDEA vertex detector
LFoundry 110 nm CMOS

Full vertex detector prototype (TaichuPix-3, JadePix-3) has TB at DESY in Dec. 2022.

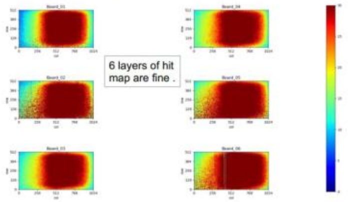




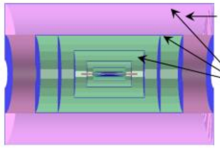


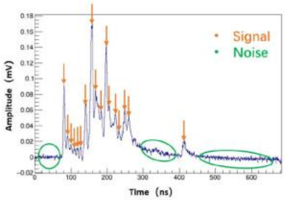
TaichuPix-3 Telescope (6 layers)

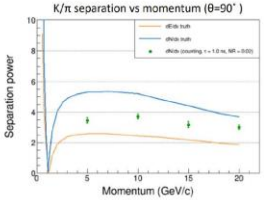
Hitmap of 4 GeV e⁺/e⁻ beam



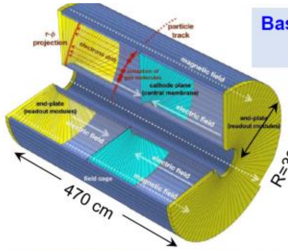
- **Goal: 3σ π/K separation up to ~20 GeV/c.**
- Cluster counting method, or **dN/dx**, measures the number of primary ionization
- **Can be optimized specifically for PID**: larger cell size, no stereo layers, different gas mixture.
- Garfield++ for simulation, realistic electronics, peak finding algorithm development.



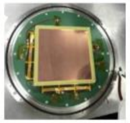


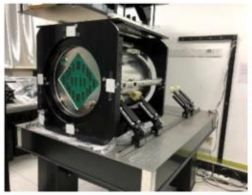


IHEP and Italian INFN groups have close collaboration and regular meetings.
IHEP joined the TB (led by INFN group) in 2021 and 2022

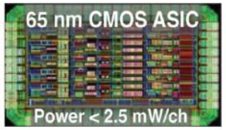


Baseline main tracker
σ(r-ϕ) ~100 μm



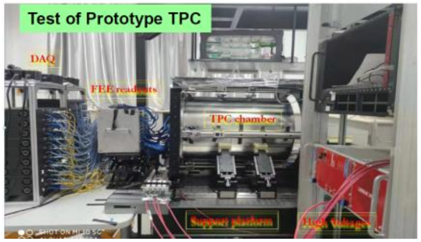


MOST 1 (IHEP+THU)

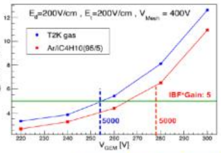


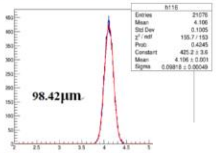
GEM-MM cathode TPC Prototype + UV laser beams Low power FEE ASIC

Test of Prototype TPC



- Challenge: Ion backflow (IBF) affects the resolution. It can be corrected by a laser calibration at low luminosity, but difficult at high luminosity Z-pole.





σ_x < 100 μm for drift length of 27cm

CEPC Status

TDR Phase-1 Review
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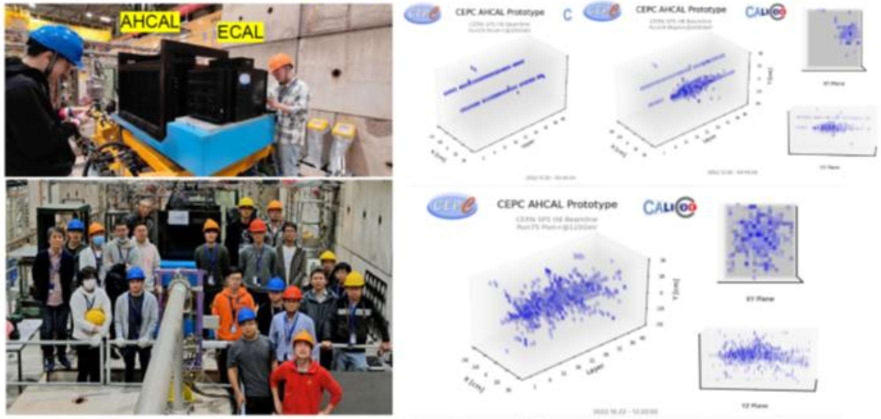
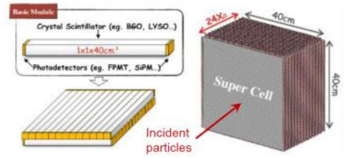
➢ PFA ScW-ECAL & AHCAL prototypes: Test Beam at CERN SPS H8 (Oct. 2022)



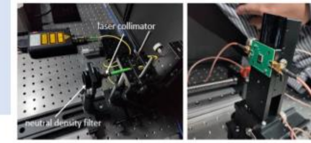
USTC, IHEP, SJTU, Japanese & Israel groups have close collaboration and regular meetings



- Long bars: 1 x 40 cm, super-cell: 40x40 cm^2
- Timing at both ends for positioning along bar.
- Significant reduction of number of channels.

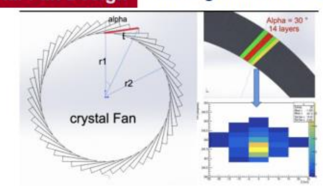
Goal

- Boson Mass Resolution < 4%
- Better BMR than ScW-ECAL
- Much better sensitivity to γ/e, especially at low energy.



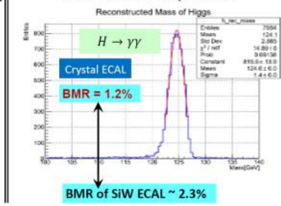
Bench Test

Crystal Fan Design Fine segmentation in Z, ϕ, r

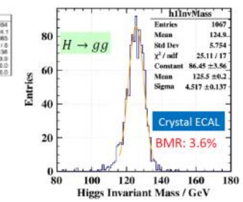


Full Simulation Studies + Optimizing PFA for crystals

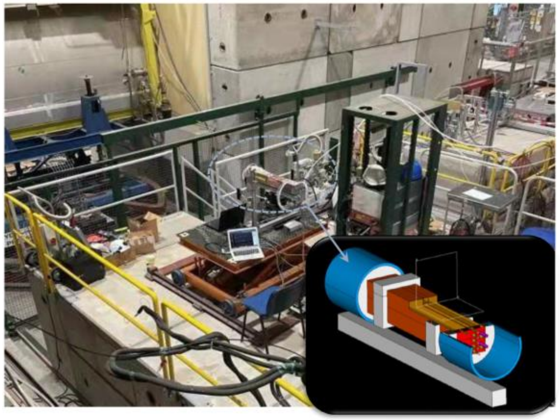
Performance with photons

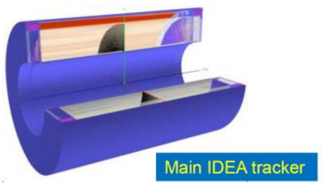


Performance with jets



Dual readout crystal calorimeter also being considered by USA and Italian colleagues





Italian groups and IHEP colleagues participated the test beam at CERN.

Key4hep: an international collaboration with CEPC participation
CEPCSW: a first application of Kep4hep – Tracking software
CEPCSW is already included in Key4hep software stack

https://github.com/cepc/CEPCSW

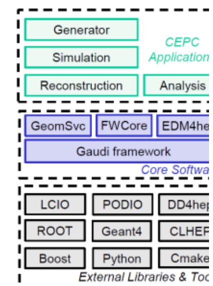
Architecture of CEPCSW

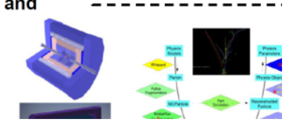
- External libraries
- Core software
- CEPC applications for simulation, reconstruction and analysis

Core Software

- Gaudi framework: defines interfaces of all software components and controls the event loop
- EDM4hep: generic event data model
- FWCore: manages the event data
- GeomSvc: DD4hep-based geometry management service

CEPCSW Structure





CEPC Status

TDR Phase-1 Review
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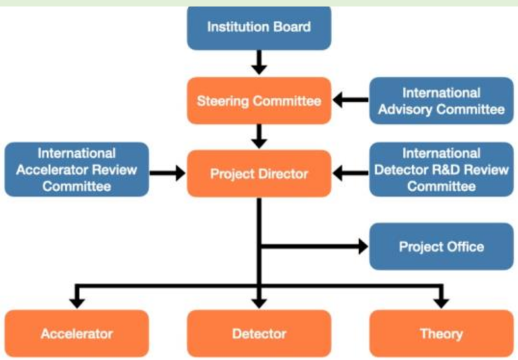
Core team, the host institution and the existing support



- Institution Board: 32 institutes, top universities/institutes in China
- Management team: comprehensive management experience at construction projects of BEPCII/CSNS/HEPS, and international projects of BESIII/Daya Bay/JUNO/…
- Accelerator team: fully over all disciplines with rich experiences at BEPCII, HEPS…
- Physics and Detector team: fully over all disciplines with rich experiences at BESIII, Daya Bay, JUNO, ATLAS, CMS, …

Table 7.2: Team of Leading and core scientists of the CEPC

Name	Brief introduction	Role in the CEPC team
Yifang Wang	Academician of the CAS, director of IHEP	The leader of CEPC, chair of the SC
Xinchou Lou	Professor of IHEP	Project manager, member of the SC
Yuanning Gao	Academician of the CAS, head of physics school of PKU	Chair of the IB, member of the SC
Jie Gao	Professor of IHEP	Convener of accelerator group, vice chair of the IB, member of the SC
Haijun Yang	Professor of SJTU	Deputy project manager, member of the SC
Jianbei Liu	Professor of USTC	Convener of detector group, member of the SC
Hongjian He	Professor of USTC	Convener of theory group, member of the SC
Shan Jin	Professor of NJU	Member of the SC
Nu Xu	Professor of IMP	Member of the SC
Meng Wang	Professor of SDU	Member of the SC
Qinghong Cao	Professor of PKU	Member of the SC
Wei Lu	Professor of THU	Member of the SC
Joao Guimaraes da Costa	Professor of IHEP	Convener of detector group
Jianchun Wang	Professor of IHEP	Convener of detector group
Yuhui Li	Professor of IHEP	Convener of accelerator group
Chenghui Yu	Professor of IHEP	Convener of accelerator group
Jingyu Tang	Professor of IHEP	Convener of accelerator group
Xiaogang He	Professor of SJTU	Convener of theory group
Jianping Ma	Professor of ITP	Convener of theory group

Management team, world-class leading scientists

Table 7.3: Team of the CEPC accelerator system

Number	Sub-system	Convener	Team (senior staff)
1	Accelerator physics	Chenghui Yu, Yuan Zhang	18
2	Magnets	Wen Kang, Fusan Chen	12
3	Cryogenic system	Rui Ge, Ruixiong Han	11
4	SC RF system	Jiyuan Zhai, Peng Sha	12
5	Beam Instrumentation	Yanfeng Sui, Junhui Yue	7
6	SC magnets	Qingjin Xu	10
7	Power supply	[illegible]	9
8	Injection & extraction	Jinhui Chen	7
9	Mechanical system	[illegible]	4
10	Vacuum system	Haiyi Dong, Yongsheng Ma	5
11	Control system	Ge lei, Gang Li	6
12	Linac injector	Jingyi Li, Jingru Zhang	13
13	Radiation protection	Zhongjian Ma	3
Sum			117

Table 7.4: Team of the CEPC detector system

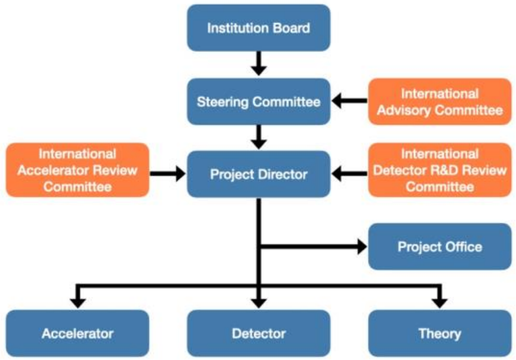
Number	Sub-system	Conveners	Institutions	Team (senior staff)
1	Pixel Vertex Detector	Zhijun Liang, Qun Ouyang, Xiangming Sun , Wei Wei	CCNU, IFAE, IHEP, NJU, NWPU, SDU, Strasbourg, ...	~ 40
2	Silicon Tracker	Harald Fox, Meng Wang, Hongbo Zhu	IHEP, INFN, KIT, Lancaster, Oxford, Queen Mary, RAL, SDU, Tsinghua, Bristol, Edinburgh, Livepool, USTC, Warwick, Sheffield, ZJU, ...	~ 60
3	Gaseous detector	Franco Bedeschi, Zhi Deng, Mingyi Dong, Huirong Qi	CEA-Saclay, DESY, LCTPC Collab., IHEP, INFN, NIKHEF, THU, ...	~ 30
4	Magnet	[illegible]	IHEP	~ 10
5	Calorimetry	Roberto Ferrari, Jianbei Liu, Haijun Yang, Yong Liu	CALICE Collab., IHEP, INFN, SJTU, USTC	~ 40
6	Muon	[illegible], Liang Li, Xiaolong Wang	[illegible]	~ 20
7	Physics	Manqi Ruan, Yaquan Fang, Liantao Wang, Mingshui Chen	IHEP, FDU, SJTU, ...	~ 80
8	Software	Shengseng Sun, Weidong Li, Xingtao Huang	IHEP, SDU, FDU, ...	~ 20
Sum				~ 300

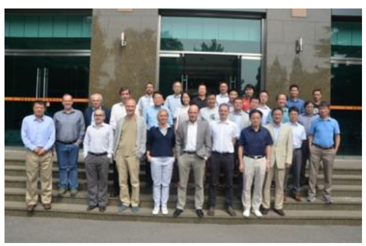
117 accelerator + ~300 detector staffs currently, + ~ 400 from BEPC/BESIII/JUNO/HEPS...once CEPC approved

integrity and professional competitiveness of the scientific and technical team

Core team, the host institution and the existing support

International Committees





Name	Affiliation	Country
Tatsuya Nakada	EPFL	Japan
Steinar Stapnes	CERN	Norway
Rohini Godbole	CHEP, Bangalore	India
Michelangelo Mangano	CERN	Switzerland
Michael Davier	LAL	France
Lucie Linssen	CERN	Holland
Luciano Maiani	U. Rome	San Marino
Joe Lykken	Fermilab	U.S.
Ian Shipsey	Oxford/DESY	U.K.
Hitoshi Murayama	IPMU/UC Berkeley	Japan
Geoffrey Taylor	U. Melbourne	Australia
Eugene Levichev	BINP	Russia
David Gross	UC Santa Barbara	U.S.
Brian Foster	Oxford	U.K
Marcel Demarteau	ORNL	USA
Barry Barish	Caltech	USA
Maria Enrica Biagini	INFN Frascati	Italy
Yuan-Hann Chang	IPAS	Taiwan, China
Akira Yamamoto	KEK	Japan
Hongwei Zhao	Institute of Modern Physics, CAS	China
Andrew Cohen	University of Science and Techbnology	Hong Kong, China
Karl Jakobs	University of Freiburg/CERN	Germany
Beate Heinemann	DESY	Germany

International Accelerator Review Committee

- Phillip Bambade, LAL
- Marica Enrica Biagini (Chair), INFN
- Brian Foster, DESY/University of Hamburg & Oxford University
- In-Soo Ko, POSTTECH
- Eugene Levichev, BINP
- Katsunobu Oide, CERN & KEK
- Anatolii Sidorin, JINR
- Steinar Stapnes, CERN
- Makoto Tobiyama, KEK
- Zhentang Zhao, SINAP
- Norihito Ohuchi, KEK
- Carlo Pagani, INFN-Milano

International Detector R&D Review Committee

- Jim Brau, USA, Oregon
- Valter Bonvicini, Italy, Trieste
- Ariella Cattai, CERN, CERN
- Cristinel Diaconu, France, Marseille
- Brian Foster, UK, Oxford
- Liang Han, China, USTC
- Dave Newbold, UK, RAL (chair)
- Andreas Schopper, CERN, CERN
- Abe Seiden, USA, UCSC
- Laurent Serin, France, LAL
- Steinar Stapnes, CERN, CERN
- Roberto Tenchini, Italy, INFN
- Ivan Villa Alvarez, Spain, Santader
- Hitoshi Yamamoto, Japan, Tohoku

IAC: global renowned scientists and top laboratory or project leaders who have ample experience in project management, planning, and execution of strategies, **operating since 2015**

IARC & IDRC: leading experts of this field, provide guide to the project director

integrity and professional competitiveness of the scientific and technical team
Experiences in international cooperation

CEPC Status

TDR Phase-1 Review
HKUST

Core team, the host institution and the existing support

- IHEP is one of the few institution in the world that
  - has rich management experience and successful constructed many large scientific facilities
  - has a full coverage of all technical disciplines for accelerators and detectors, **in particular for the design and construction and continuous operation of a circular e+e- collider (BEPCII) and the detector(BESIII)**
  - has all needed infrastructure for the construction of large facilities
  - has successfully hosted international projects such as BESIII, Daya Bay, JUNO, LHAASO, etc.
- **CEPC is committed by IHEP and workplan endorsed by CAS**

High Energy Light Source under construction

beam energy 6 GeV, 1.36KM, ≤ 0.06nm·rad, 14 beam lines

Carried out by IHEP, to be completed in 2025, great training and preparation for CEPC

CEPC SCRF Test Facility is located at IHEP Huairou Area ($4500m^2$)

New SC Lab Design ($4500m^2$)

SC New Lab (PAPS) has been put to operation in June 2021

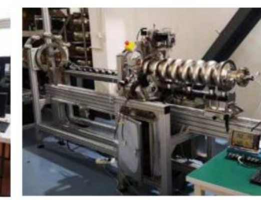
Crygenic system hall

Vacuum furnace (doping & annealing)

Nb3Sn furnace

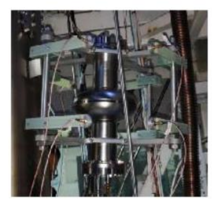
Nb/Cu sputtering device

Cavity inspection camera and grinder



9-cell cavity pre-tuning machine

Temperature & X-ray mapping system



Second sound cavity quench detection system

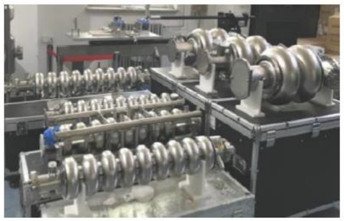
Helmholtz coil for cavity vertical test

Vertical test dewars

Horizontal test cryostat

- 1.3 GHz 9-cell SCRF cavity for booster: Q_0 = 3.4E10 @ 26.5 MV/m
- 650 MHz 2-cell SCRF cavity for collider ring: Q_0 = 6.0E10 @ 22.0 MV/m
- 650 MHz 1-cell SCRF cavity for collider ring: Q_0 = 6.0E10 @ 31.0 MV/m

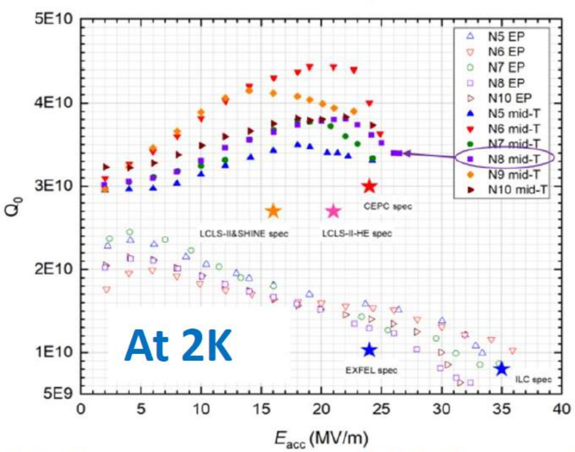
All SCRF satisfied CEPC design specifications !

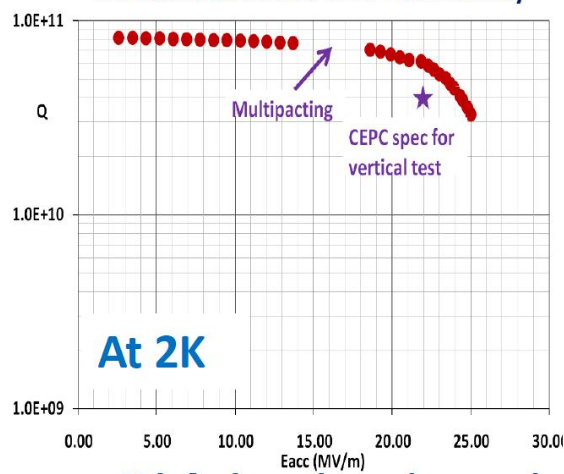


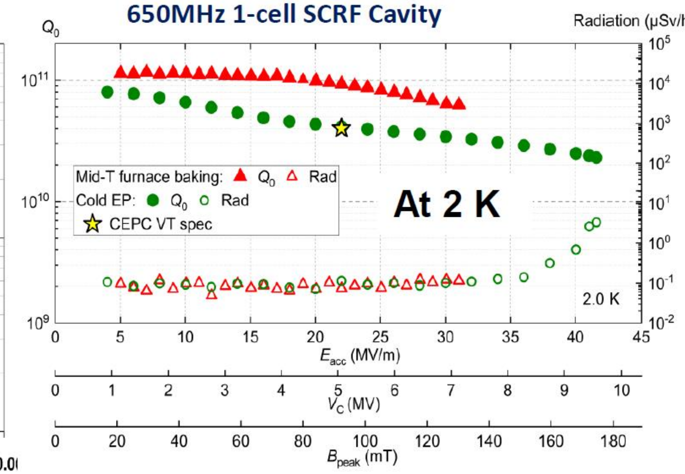
Vertical test of 650 MHz 2-cell cavity

650MHz 1-cell SCRF Cavity

IHEP 1.3 GHz 9-cell Cavity Vertical Test







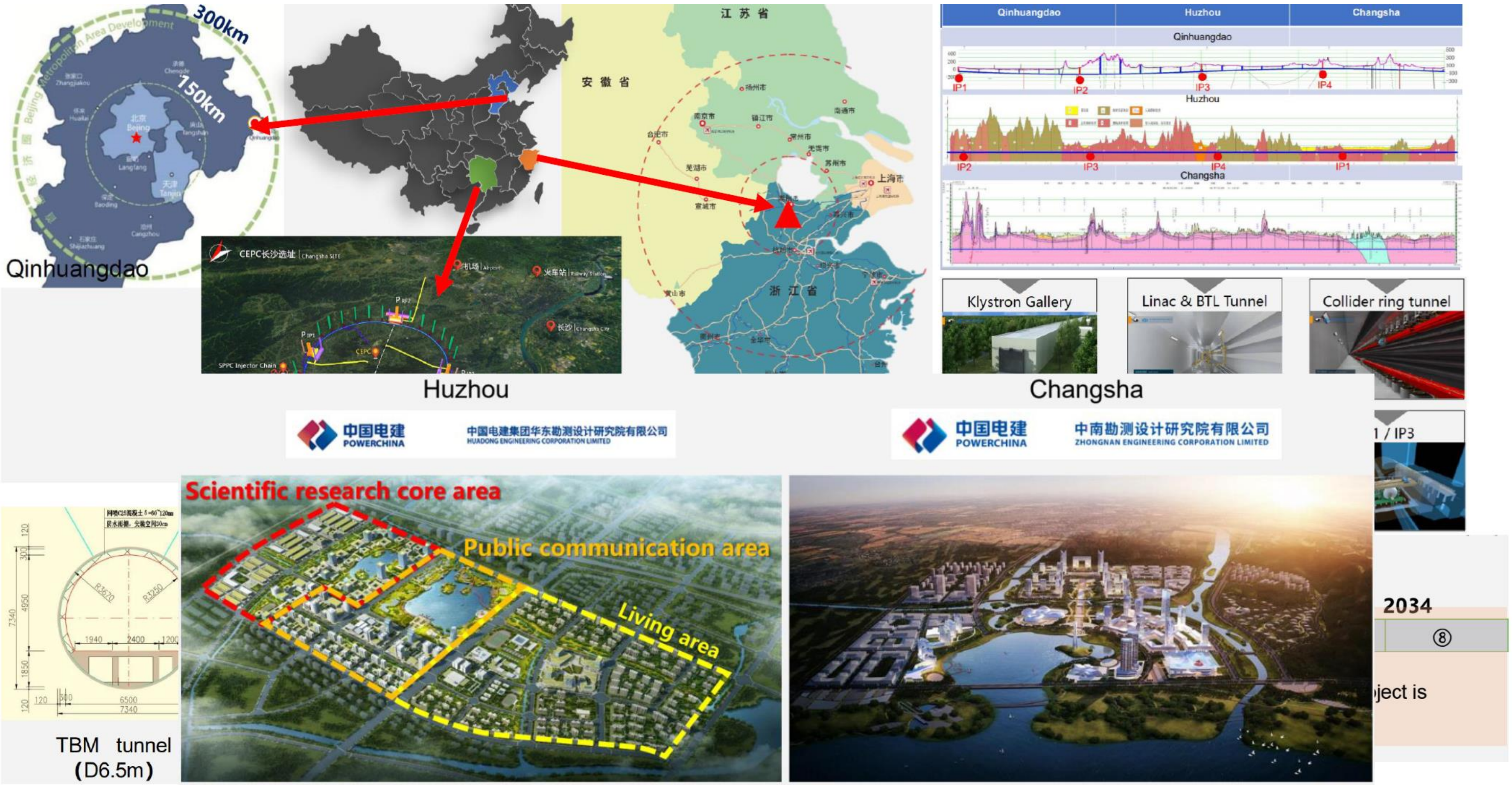
Medium-temperature (Mid-T) annealing adopted to reach Q_0 = 3.4E10 @ 26.5 MV/m

N-infusion adopted to reach Q_0 = 6.0E10 @ 22.0 MV/m

Q_0 = 6.0E10 @ 31 MV/m
Q_0 = 2.1E10 @ 42 MV/m

CEPC Status

TDR Phase-1 Review
HKUST



CEPC Status

TDR Phase-1 Review
HKUST

Core team, the host institution and the existing support

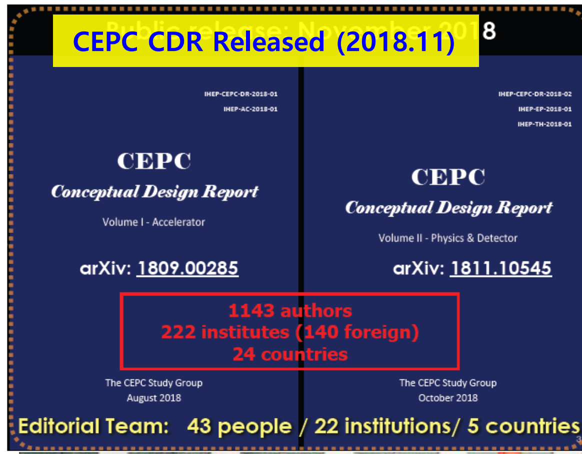
International collaboration

CEPC attracts significant International participation

- Conceptual design report: 1143 authors from 221 institutes (including 140 International Institutes)
- More than 20 MoUs signed and executed

- Intensive collaboration on Physics studies
- Oversea scientists made substantial contributions to the R&D, especially the detector system

- CEPC International Workshop since 2014
- EU-US versions of CEPC WS: Next one at Marseille
- Annual working month at HKIAS (since 2015)



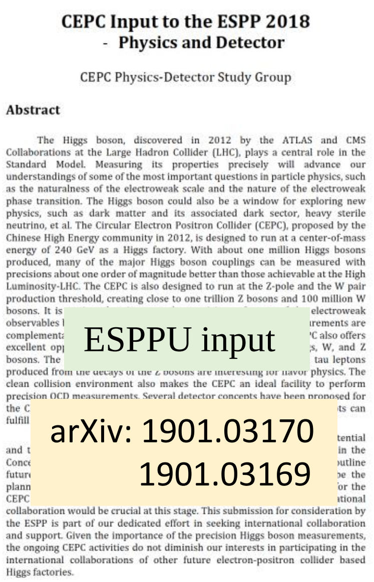
international cooperation

CEPC Status

TDR Phase-1 Review
HKUST

Core team, the host institution and the existing support

International influence

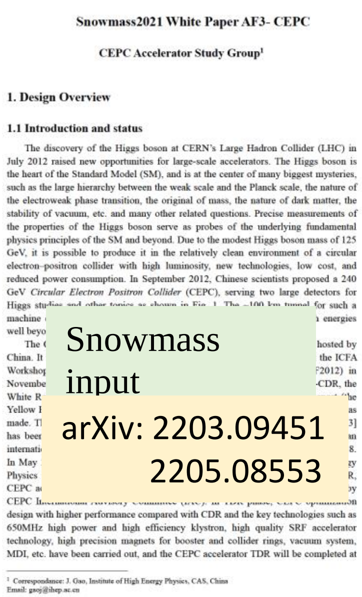

CEPC Input to the ESPP 2018
- Physics and Detector

CEPC Physics-Detector Study Group

Abstract

ESPPU input

arXiv: 1901.03170
1901.03169


Snowmass2021 White Paper AF3- CEPC

CEPC Accelerator Study Group[1]

1. Design Overview

1.1 Introduction and status

Snowmass input

arXiv: 2203.09451
2205.08553

- CEPC provides critical input to ESPPU & Snowmass as a **major player**
- Team member actively participated International study(ESPPU and Snowmass committees) and Panel discussions

CEPC attracts intensive international collaboration, ensuring that the CEPC design and technology are among the most advanced in the world. once approved, CEPC is expected to be substantially supported by international community.

international cooperation

Core team, the host institution and the existing support

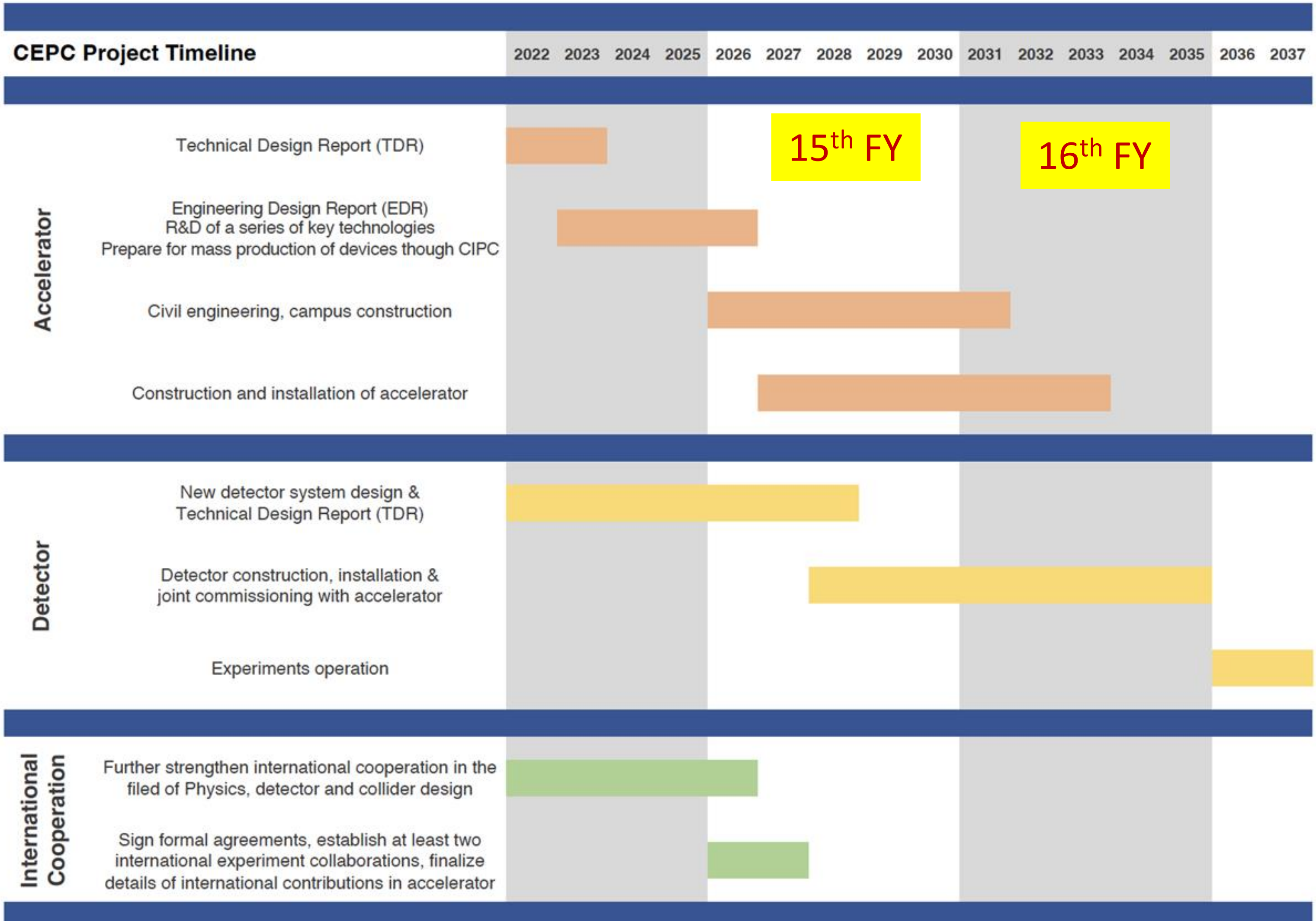
Industrial engagement

- CIPC, established in 2017, composed of ~ 70 high tech. enterprises, covers Superconducting materials, Superconducting cavities, cryomodules, cryogenics, Klystrons, electronics, power source, vacuum, civil engineering, etc. CIPC actively joins the Key technology R&D and **prepares for the mass production** for the CEPC construction.
- CEPC study group is **surveying main international suppliers**.
- CEPC strongly promote these relevant technology development (cost-benefit).

cost-benefit evaluation of the project

Planning & Schedule

TDR (2023), EDR(2026), start of construction (2027-8)



Planning & Schedule

A CAS committee currently evaluates major accelerator options in China

CEPC is ranked top based on a list of criteria that includes scientific significance, strategic values and the readiness of design, R&D and engineering capabilities.

A final report will be submitted to CAS for consideration for the 15th 5-year-plan (2026-2030).

CEPC will propose to the government to begin construction around 2027-8 during the 15th 5-year-plan period.

CEPC Accelerator TDR

The CEPC Accelerator Technical Design Report covers

- The design and the knowledge and progress gained by the CEPC
- The advancement of the technologies the CEPC depends upon, delivered through the comprehensive R&D program, HEPS experience and international contributions and cooperation
- New, innovative ideas and future upgrades to make the CEPC start-of-art as times moves forward

The CEPC TDR will be an important document to demonstrate to the Chinese government that CEPC will be ready to begin construction in 2027-8.

TDR Reviews

Three phases of reviews have been planned for the TDR

- **Phase 1**: This review on the technical aspects of CEPC June 12-16, HKUST
- **Phase 2**: Review on the site+civil cost aspects by a domestic committee
  June 26, 2023, IHEP

  committee report will be presented to an international panel
  July 17, 2023, online
- **Phase 3**: Cost review by an international committee
  September 11-15, 2023, HKUST

  will hear brief from the July 17 international panel

The CEPC team will implement the recommended changes and revisions, and aims at competing the TDR document by end of 2023

TDR Reviews

Phase 1 Review of the CEPC Technical Design Report
June 12-16, 2023, HKUST, Hong Kong

Charge

The CEPC Study Group, hosted by the Institute of High Energy Physics (IHEP), has been working on the design and development of a forefront e^+e^- collider as a Higgs factory that can extend to energies corresponding to the Z, WW and the top quark pairs, with the upgrade potential to a high energy pp collider. The CEPC represents a grand plan proposed, studied, and to be constructed by Chinese scientists in close collaboration with international partners. Since the release of the CEPC Conceptual Design Report in 2018, the CEPC Study Group has devoted significant effort to the design optimization, the R&D of key technologies and the study of the technical systems of the CEPC.

TDR Reviews

It is requested that a Committee report responding to this charge be forwarded to the IHEP Director, Professor Yifang Wang by July 15 2023.

conduct the first phase review* of this TDR draft. This first phase review shall cover all but the cost and site aspects of the CEPC. The Committee is specifically asked to review and comment on the following aspects:

1. Are the accelerator system design goals well defined? Have the goals been reached in the TDR?
2. Are the accelerator physics issues adequately addressed?
3. Are the accelerator complex design, the key technologies adopted, and the conventional facilities effective for achieving the performance goals?
4. Are the CEPC operation modes and upgrade plans well defined?
5. Is the CEPC design compatible with the future upgrade to the SppC?
6. Regarding the key technology research and development, are critical technologies and components of the CEPC accelerator ready or will they be ready before 2026, through the R&D program being carried out, or achieved with the Light Source project undertaken by IHEP, for the eventual realization of the CEPC?
7. What are the primary technical risks and their potential impacts on the CEPC? What are the mitigation measures that should be taken?
8. Will the CEPC accelerator be ready for construction, after the completion of the outlined R&D program, and industrial and engineering preparation, as well as issues identified in item 7 above be properly addressed in due time?
9. Any other issues you notice or any improvements you may suggest.

Summary

CEPC

- **addresses many most pressing & critical science problems in particle physics**
- **design and technologies are reaching maturity;**
- **has a strong-experienced team, backed by IHEP support and international cooperation, which are keys to bring CEPC to fruition**
- **schedule follows China's 5-year planning; expects to complete the R&D and the preparation to build the facility and carry out the science program**
- **This TDR review will examine the readiness of the CEPC accelerator and provide very valuable advice and input to the report**