Circular Electron Positron Collider

Overview of the Project

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IHEP, Beijing

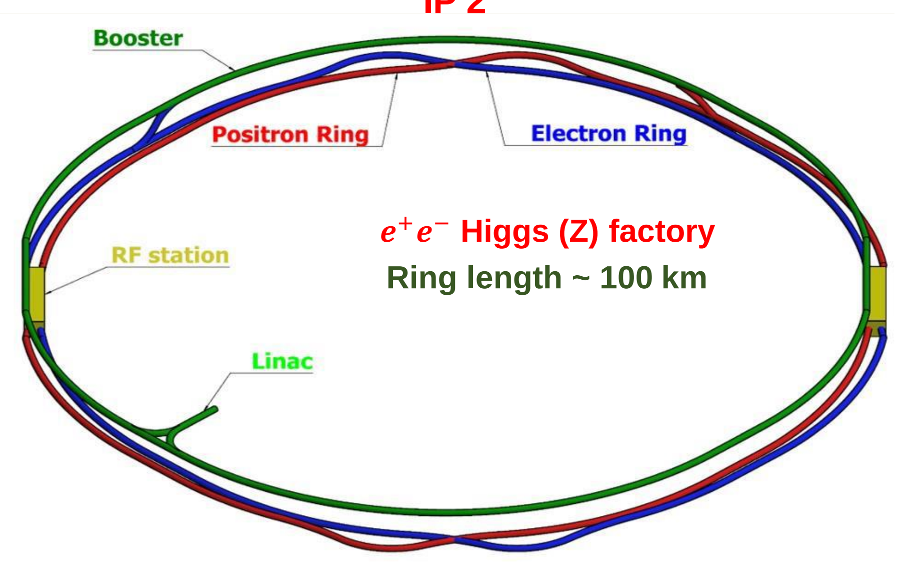
Outline

- CEPC - introduction and reminder
- Progress and focuses in 2022-23
- Implementation of 2022 IAC recommendations
- Plan for the future
- Q&A + discussion

Introduction

The idea of CEPC followed by a possible Super proton-proton collider(SPPC) was proposed in Sep. 2012, and quickly gained the momentum in IHEP and in the world.

- **Looking for Hints@e^+e^- Collider ➔ If yes, direct search at pp collider**
- **The tunnel can be re-used for pp, AA, ep colliders up to ~ 100 TeV**



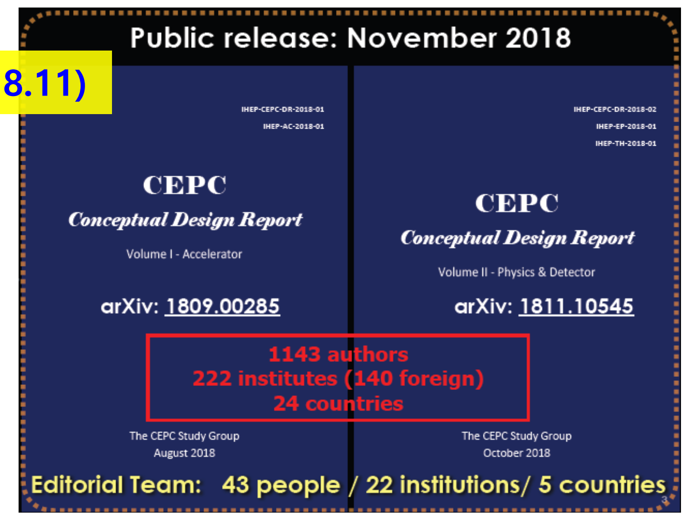
- A Higgs factory - to run at $\sqrt{s}$ ~ 240 GeV, above the **ZH** production threshold for ≥1 M Higgs; at the **Z** pole for ~Tera Z; at the **W^+W^-** pair and then $t\bar{t}$ pair production thresholds. Probes of physics BSM.
- The CEPC aims to start operation in 2030's, as a Higgs (Z / W) factory in China.

Introduction

CEPC-SPPC Kickoff (2013.9)

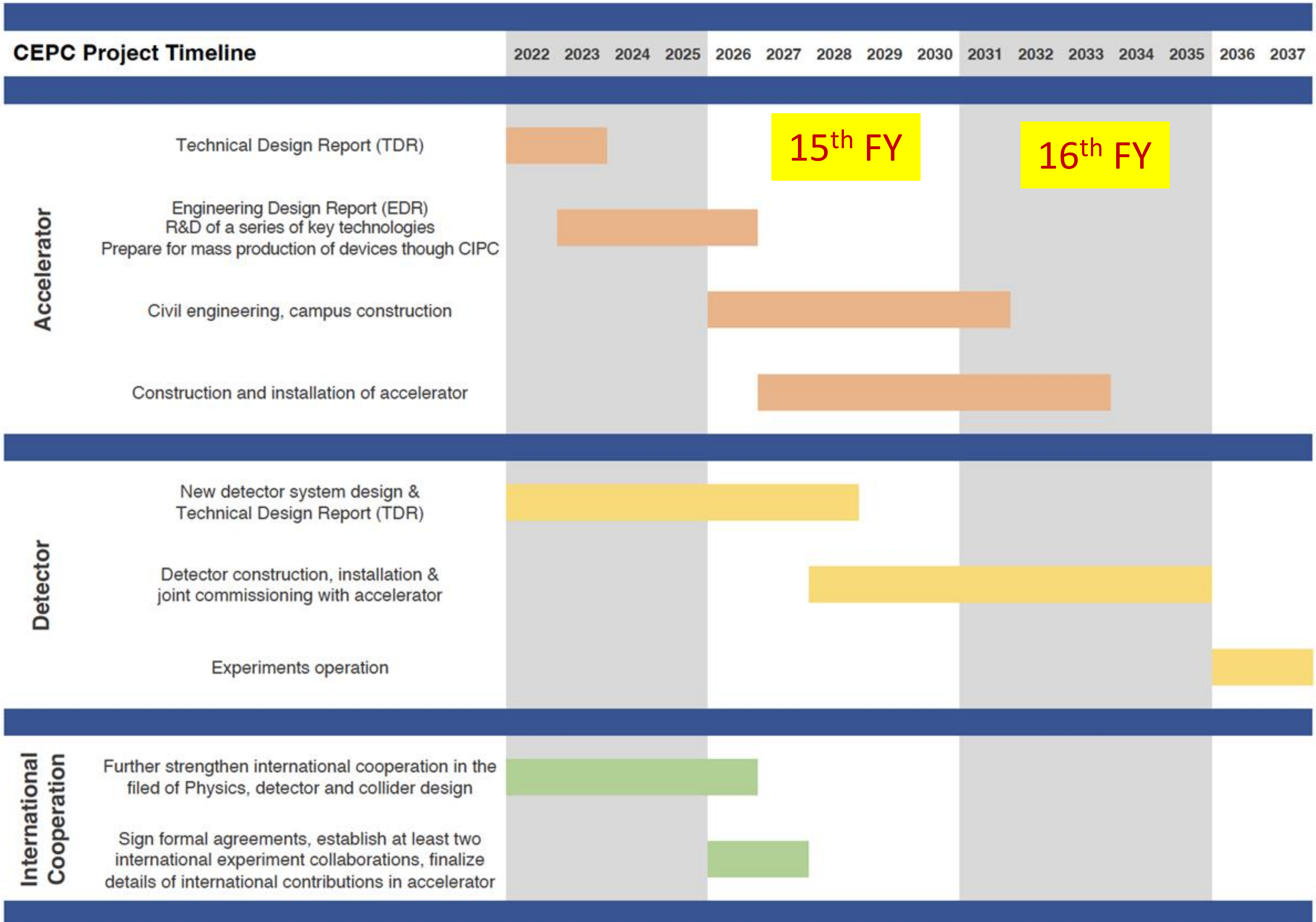
First CEPC IAC Meeting (2015.9)

CEPC CDR Released (2018.11)



Introduction planning & schedule

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



CEPC progress and focuses in 2022-23

The main thrusts in the last ~12 months:

- CEPC accelerator technical design report (TDR)
- Positioning CEPC with CAS planning for the 15th FYP (2026-2030)
- A new initiative – Plasma Wakefield Acceleration project Yuhui LI
- HTS magnet program
- Detector R&D + prototypes Joao Guimaraes da Costa
- Funding preparation CAS, MOST, ….

CEPC Accelerator TDR

CEPC Accelerator Technical Design Report (TDR) (2023)

The CEPC Accelerator TDR 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 costs

Three phases of reviews completed

Phase 1: This review on the technical aspects of CEPC accelerator June 12-16, HKUST

Phase 2: Review on the civil cost aspects by a domestic committee June 26, 2023

committee report was presented to an international panel July 17, 2023, online

Phase 3: Cost review by an international committee September 11-15, 2023, HKUST

brief from the July 17 international panel

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.

CEPC Accelerator TDR

Phase-I TDR technical review

...Design Report (TDR). The International Review Committee, chaired by Dr. Frank Zimmermann (CERN) is asked to 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

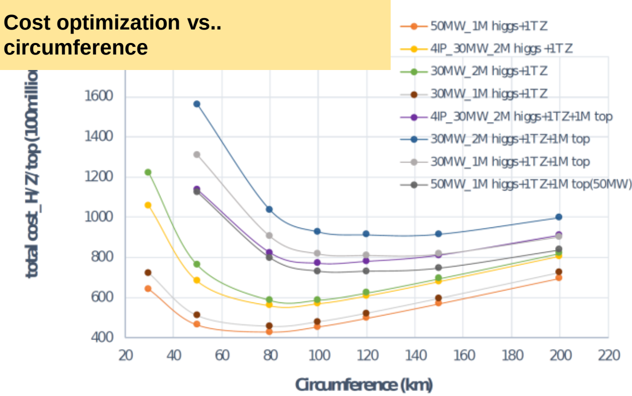
Phase-I TDR technical review concluded with positive outcome (more to follow)

CEPC Status: Layout and Design Essentials

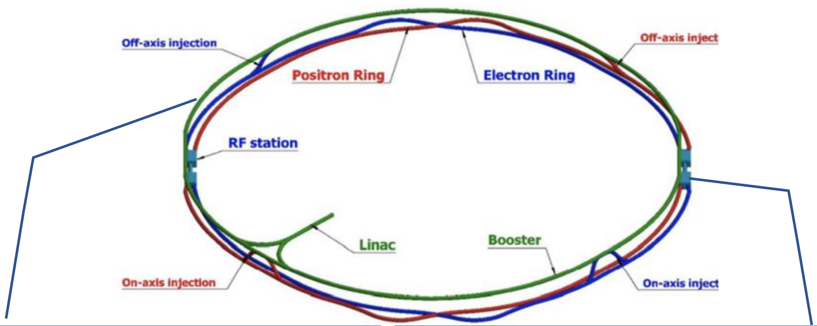
Design of experimental facility and technical requirements

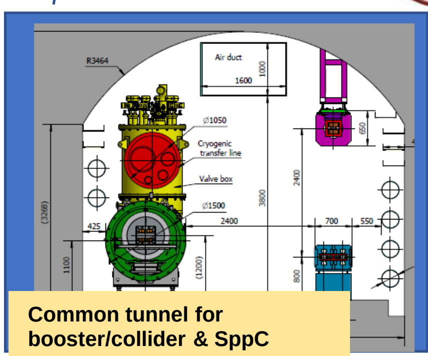
- **Circular collider**: **Higher luminosity** than a linear collider
- **100km circumference**: Optimum **total cost**, good also for **SppC**
- **Shared tunnel**: Accommodate **CEPC** booster &collider and **SppC**
- **Switchable operation**: Higgs, W/Z, top

Cost optimization vs.. circumference

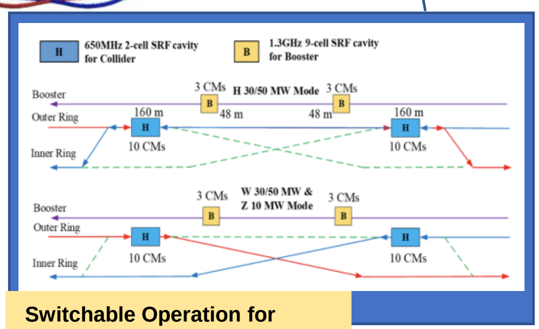


D. Wang *et al* 2022 *JINST* **17** P10018





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}/cm^2/s]	**8.3**	**27**	**192**	**0.83**

CEPC Status: Overall Quality

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

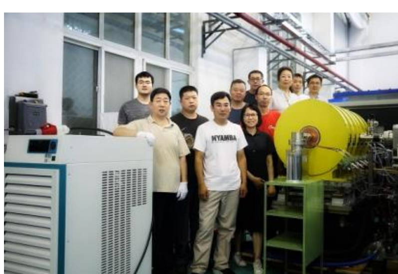
- 100km circular collider
- Partial/Full double ring
- Switchable energies H/W/Z
- One tunnel for booster/collider and SppC

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

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

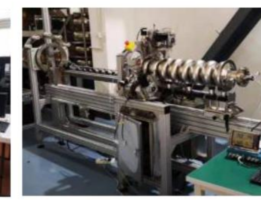
Crygenic system hall

Vacuum furnace (doping & annealing)

Nb3Sn furnace

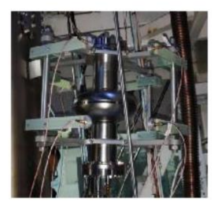
Nb/Cu sputtering device

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

CEPC Status: R&D and Prototypes

R&D: Other Prototypes

Experience at HEPS & BEPCII

Summary of Key Technology R&D

- CEPC received ~ 260 Million CNY from MOST, CAS, NSFC for key technology R&D
- Large amount of key technology validated in other project by IHEP: BEPCII, HEPS, …

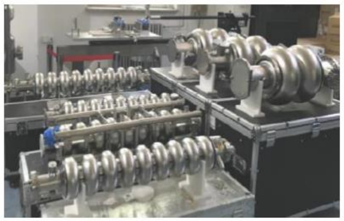
CEPC R&D ~ 40% cost of acc. components	➢ High efficiency klystron ➢ SRF cavities ➢ Positron source ➢ High performance accelerator	➢ Novel magnets: Weak field dipole, dual aperture magnets ➢ Extremely fast injection/extraction ➢ Electrostatic deflector ➢ MDI
BEPCII / HEPS ~ 50% cost of acc. components	➢ High precision magnet ➢ Stable magnet power source ➢ Vacuum chamber with NEG coating ➢ Instrumentation, Feedback system	➢ Survey & Alignment ➢ Ultra stable mechanics ➢ Radiation protection ➢ Cryogenic system ➢ MDI

October 30, 2023

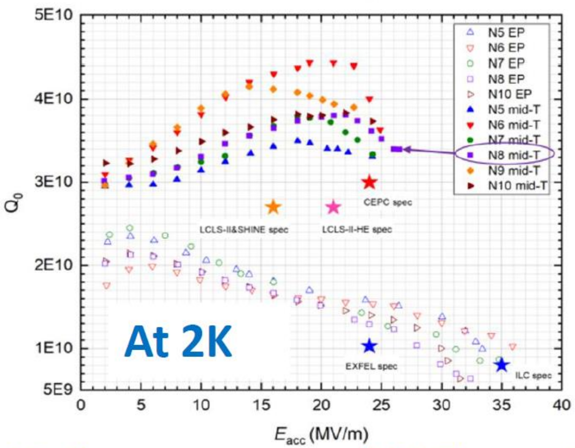
- **~10% remaining (the machine integration, commissioning etc.) to be completed by 2026.**
- **International contribution/collaboration important**

- **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 !

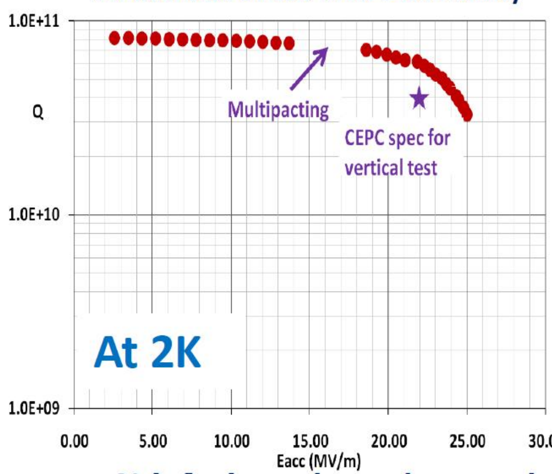


IHEP 1.3 GHz 9-cell Cavity Vertical Test



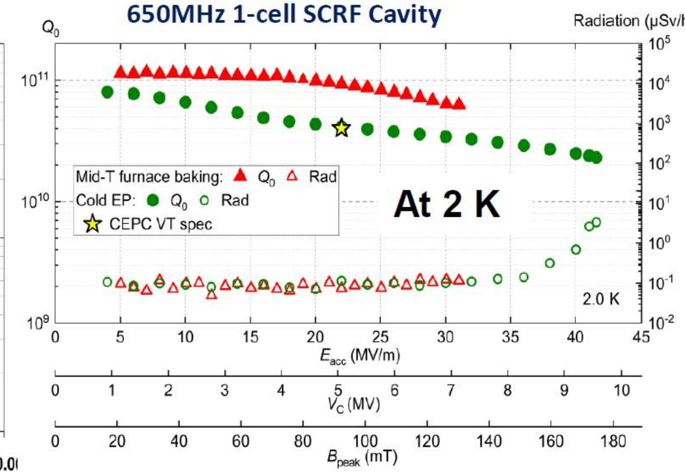
Medium-temperature (Mid-T) annealing adopted to reach Q_0 = 3.4E10 @ 26.5 MV/m

Vertical test of 650 MHz 2-cell cavity



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

650MHz 1-cell SCRF Cavity



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

TDR Reviews

Phase-II TDR accelerator costing review

The CEPC accelerator TDR International Cost Review Committee (ICRC), chaired by Professor Leonid Rivkin (EPFL, PSI) will review the cost of the CEPC TDR accelerator systems (Phase-II, excluding the civil engineering cost). The Committee is specifically asked to review and comment on the following aspects:

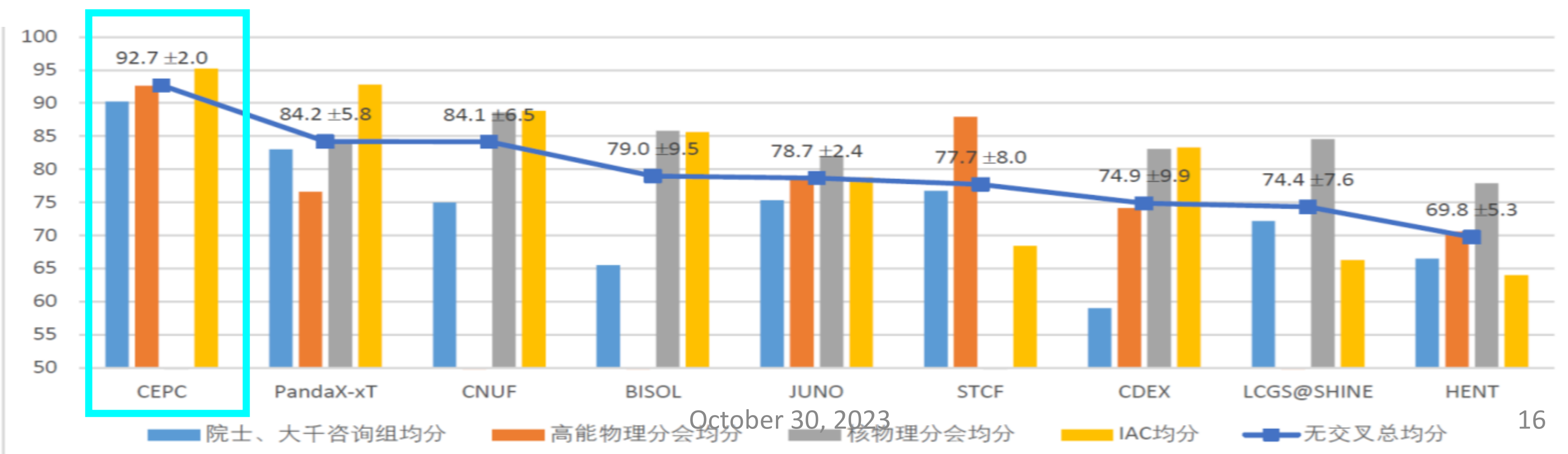
Based on the TDR document and the presentations,

1. are the CEPC team and the presenters professionally competent and possessing the technical proficiency to perform the cost evaluation?
2. are there any missing subsystem or components in the consideration that will affect the accuracy of the cost calculation of the CEPC accelerator?
3. are the basic considerations, pricing information on the material, manufacturing cost and

Phase-II TDR costing review concluded with confirmation of understanding, may need 20% contingency & will reach improved uncertainty with EDR study

Positioning CEPC for the 15th FYP

- **China's Economic & Dev. follow a 5-year cycle: 14th FYP(2021-5), 15th FYP(2026-30)**
- Chinese Academy of Sciences (CAS) is planning for the 15th 5-years plan for large science projects, and a steering committee has been established, chaired by the president of CAS
- **High energy physics**, as one of the 8 groups, has been working on this for a year:
  - Setting up rules and the standard(based on scientific and technological merits, strategic value and feasibility, R&D status, team and capabilities, etc.), established domestic and international advisory committees
  - Collected 15 proposals and selected 9, based on the above-mentioned standard
  - Evaluations and ranking by committees after oral presentations by each project
- **CEPC is ranked No. 1, with the smallest uncertainties, by every committee**
- A final report has been submitted to CAS for consideration



Positioning CEPC for the 15th FYP

Project Selection Results

- “After synthesizing the evaluations from various expert panels, the projects in the high-energy accelerator domain "Circular Electron Positron Collider" (CEPC), nuclear physics accelerator domain "China Advanced Nuclear Physics Facility" (CNUF), and non-accelerator neutrino physics project "Tens of Tons Liquid Xenon Detection Plan PandaX-xT" (PandaX-xT) respectively hold the highest priority in their three domains. “
- “Among them, **CEPC consistently ranked first in all scoring schemes and is the only project with an average score exceeding 90 across all panels,** with the smallest variance, indicating a high level of consensus from both international and domestic experts, meeting the world-leading standards in various aspects. In all scoring schemes' rankings, the top 6 projects belong to the first two rankings of the three directions (high-energy accelerator, nuclear physics accelerator, non-accelerator neutrino physics).”

Report by the HEP and NP Strategic Development Group

Positioning CEPC for the 15th FYP

Development Focus and Steps

- ***1. High-Energy Accelerator Physics***
  - (1) **CEPC,** focusing on the high-energy frontier for research on the properties of the Higgs boson and the search for new physics, reflects the highest priority in the international high-energy physics domain. It is the flagship facility in the particle physics field. Once completed, it will become the world's highest energy electron-positron collider, leading the high-energy frontier physics research for decades. It represents a significant opportunity to achieve "world leadership". CEPC aligns with the nation's positioning, requirements, and goals for major scientific infrastructure, holds significant strategic value, and has vast potential for upgrades and scientific discoveries in the future. Its scientific lifespan is expected to last two to three decades, and it will also drive a series of technological innovations. The technical design report and key technology preliminary research for CEPC have been essentially completed, the team is basically in place, meeting the requirements for initiation, and possesses the capacity for international collaboration, scientific research, and achieving scientific objectives. **It's strongly recommended that the country support it and launch it during the "15th Five-Year Plan".**

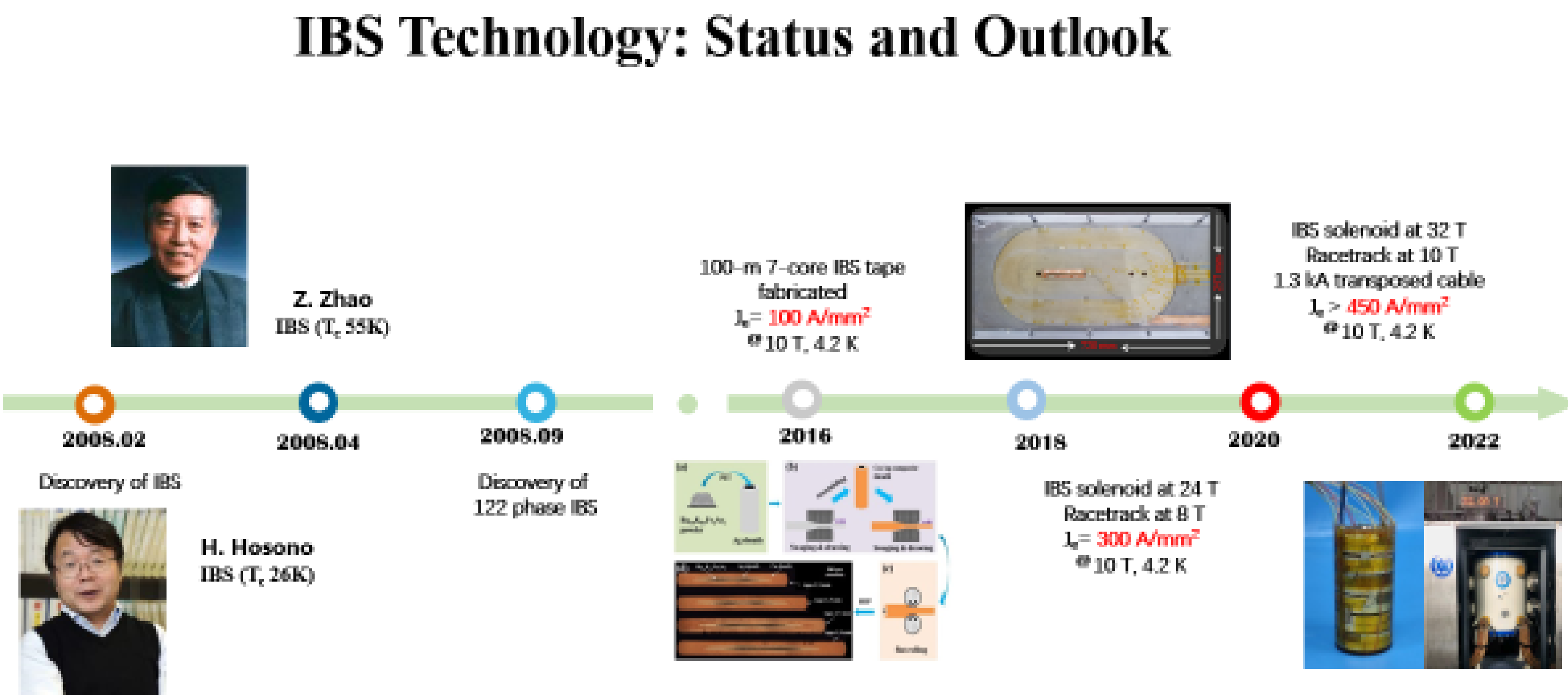
Report by the HEP and NP Strategic Development Group

October 30, 2023

CEPC Status

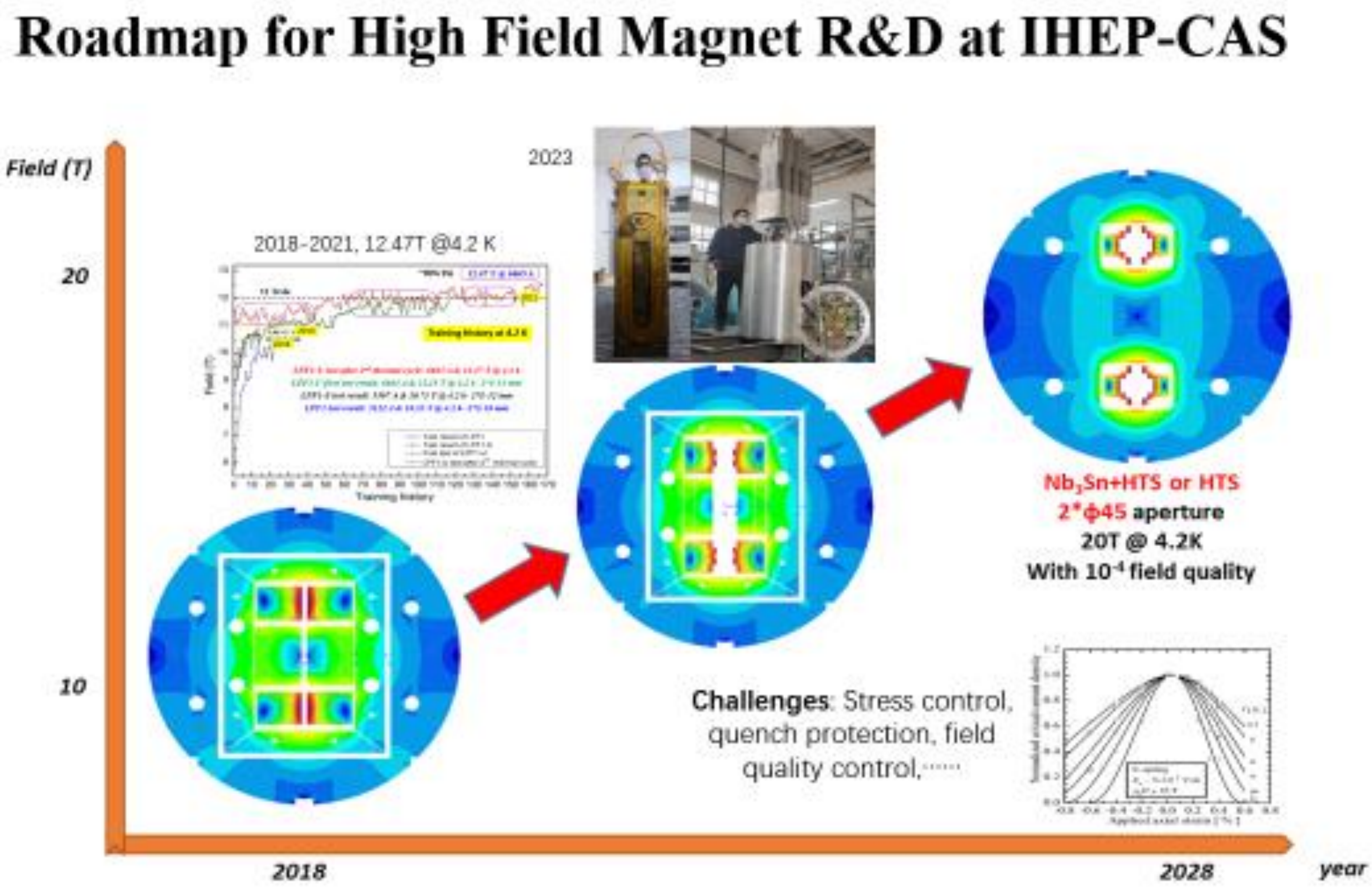
Yuhui LI
will present the overview of the CEPC accelerator TDR

HTS Magnet Program



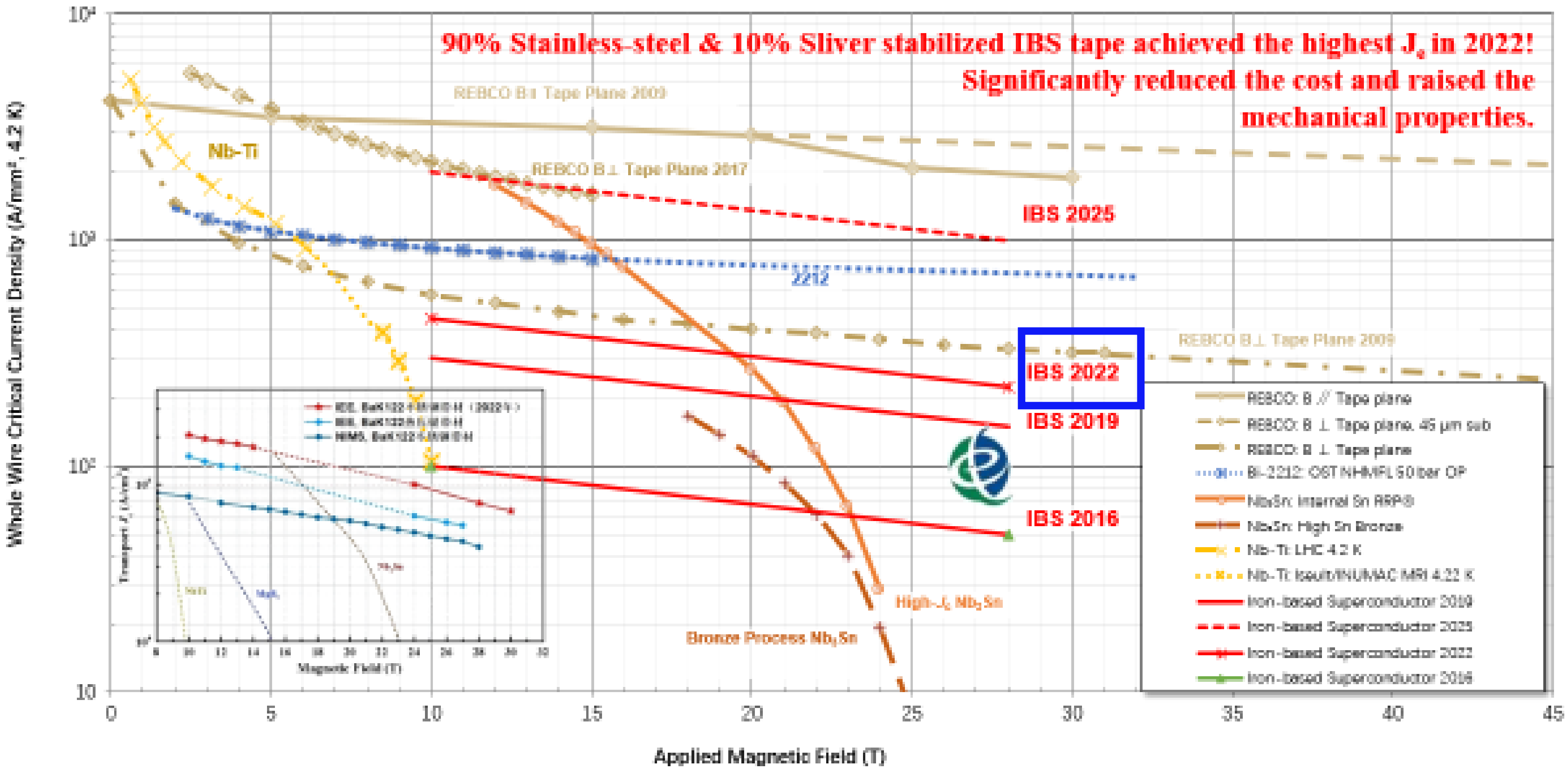
J_e of IBS expected to be similar as ReBCO in 2020s with better mechanical properties and lower cost, ready for mass applications in ultra high field magnets

HTS Magnet Program



HTS Magnet Program

J_e of IBS conductor: Status and Outlook



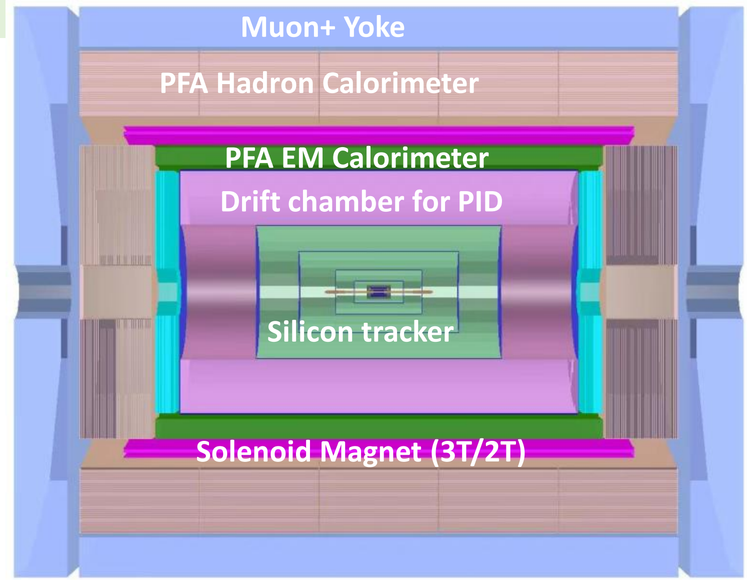
Detector R&D + prototypes

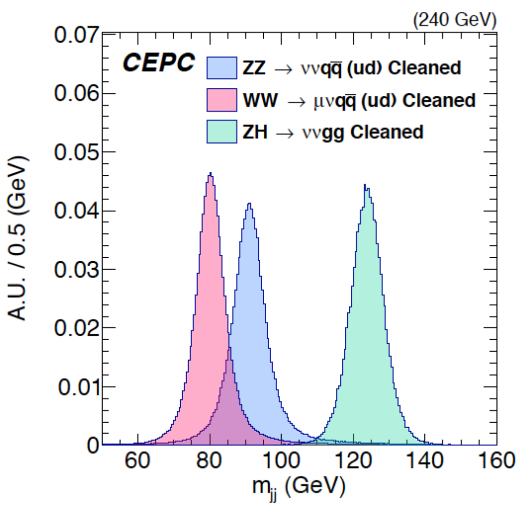
Detector

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

See Joao's presentation

Detector R&D + prototypes

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

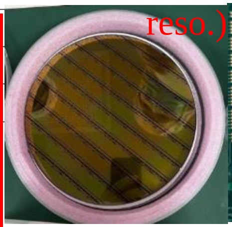
- **With international partners, all sub-detector covered**
  - PFA calorimeter: with CALICE Collaboration
  - TPC: with LCTPC Collaboration
  - Drift cham: with Italian colleague
  - Silicon tracker: with UK/Germany/Italian colleague
  - Silicon vertex: with French/Spain colleague

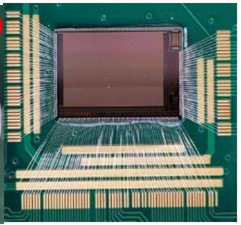
Prototypes under evaluation

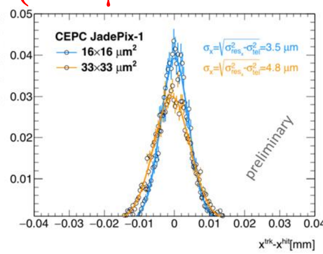
PFA calorimeter

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 T – 3 T < 150 mm	1 T – 4 T [27–29] > 270 mm	Prototyping

Vertex detector R & D (3- 5 μm reso.)

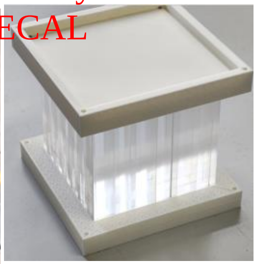






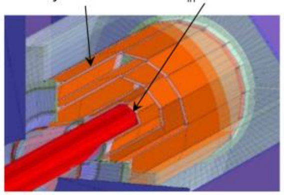
PFA scintillator-W ECAL

4D crystal ECAL



See Joao's presentation

Detector R&D + prototypes



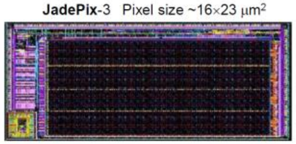
Goal: σ(IP) ~ 5 μm for high P track

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

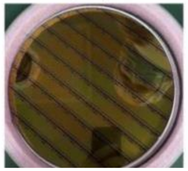
Develop **CEPCPix** for a CEPC tracke basing on **ATLASPix3** CN/IT/UK/DE TSI 180 nm HV-CMOS process

JadePix-3 Pixel size ~16×23 μm²

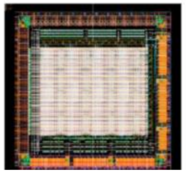


Tower-Jazz 180nm CiS process
Resolution 5 microns, 53mW/cm²

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

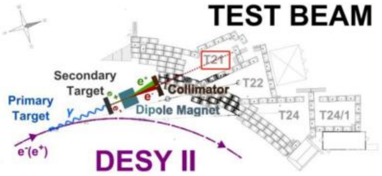


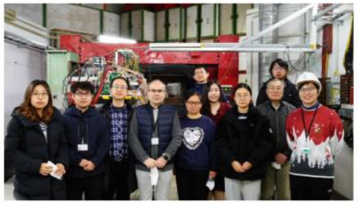
CPV4 (SOI-3D), 64×64 array ~21×17 μm² pixel size

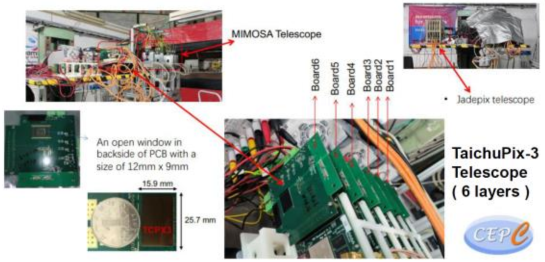


Arcadia by Italian groups for IDEA vertex detector LFoundry 110 nm CMOS

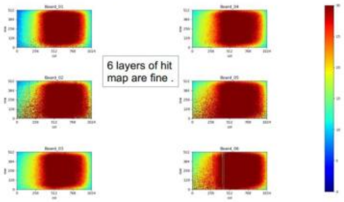
Full vertex detector prototype (TaichuPix-3, JadePix-3) has TB at DESY in Dec. 2022.



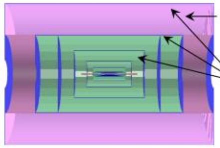


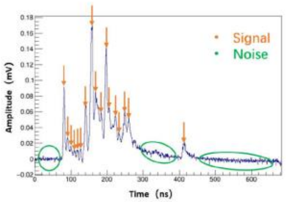


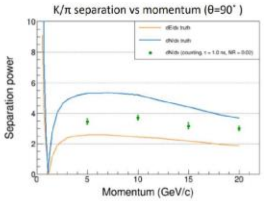
Hitmap of 4 GeV e⁺/e⁻ beam



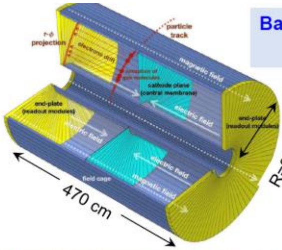
- **Goal: 3σ π/K separation up to ~20 GeV/c.**
- Cluster counting method, or **dN/dx**, measures the number of primary ionization
- **Can be optimized specifically for PID**: larger cell size, no stereo layers, different gas mixture.
- Garfield++ for simulation, realistic electronics, peak finding algorithm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



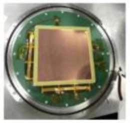




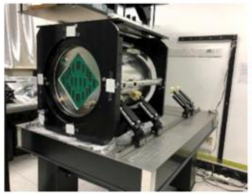
IHEP and Italian INFN groups have close collaboration and regular meetings.
IHEP joined the TB (led by INFN group) in 2021 and 2022



Baseline main tracker
σ(r-ϕ) ~100 μm

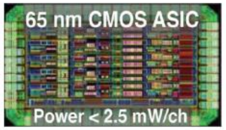


GEM-MM cathode

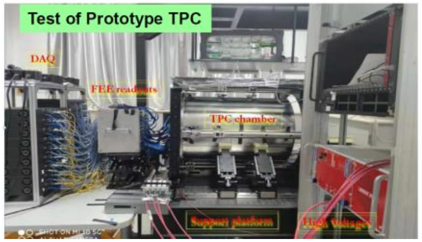


TPC Prototype + UV laser beams

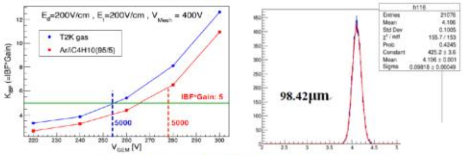
MOST 1 (IHEP+THU)



Low power FEE ASIC



- **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.**

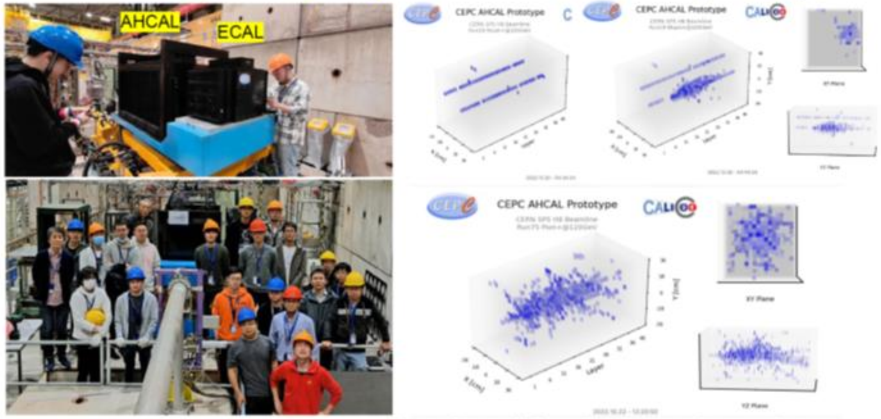


σ_r < 100 μm for drift length of 27cm

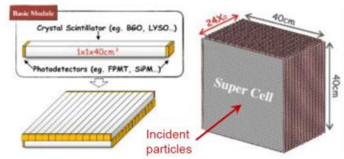
See Joao's presentation

Detector R&D + prototypes

➤ PFA ScW-ECAL & AHCAL prototypes: Test Beam at CERN SPS H8 (Oct. 2022)



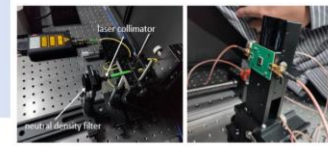
USTC, IHEP, SJTU, Japanese & Israel groups have close collaboration and regular meetings



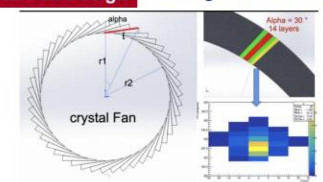
- Long bars: 1 x 40 cm, super-cell: 40x40 cm²
- Timing at both ends for positioning along bar.
- Significant reduction of number of channels.

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

Bench Test

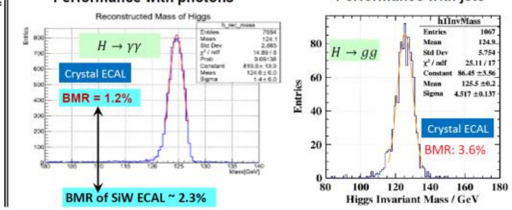


Crystal Fan Design Fine segmentation in Z, ϕ, r

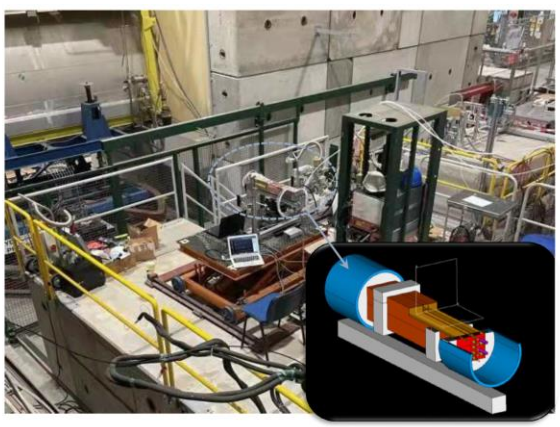


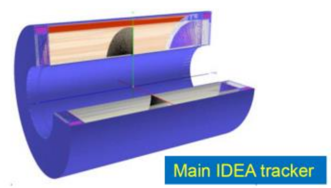
Full Simulation Studies + Optimizing PFA for crystals

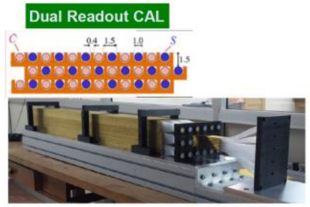
Performance with photons — Performance with jets



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







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

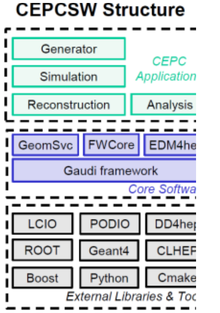
Key4hep: an international collaboration with CEPC participation
CEPCSW: a first application of Kep4hep – Tracking software
CEPCSW is already included in Key4hep software stack

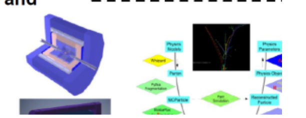
https://github.com/cepc/CEPCSW

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





See Joao's presentation

Implementation of 2022 IAC recommendations

For the next IAC meeting in 2023, arrange some form of person-to-person meetings with more detailed materials at whatever location promises the largest attendance

We are meeting at IHEP + Zoom in 2023.

At its next meeting in 2023, the IAC would like to receive a report on the CAS selection process for large facilities and would appreciate an update from the Project Management whenever there is news from this process, or indeed any other important aspect of the project.

Pages 16-18.

Implementation of 2022 IAC recommendations

International involvement should be maximised. However, it is vital to ensure that the project can be proposed to the authorities on the currently envisaged timescales, even if international commitment is initially small.

See Jianchun WANG's presentation on detector

"We managed to invite a few international software experts to come to China. For example, we invited Andreas Salzburger, who is a tracking software expert working at CERN. During his short visit to IHEP and Shandong University, lots of discussions took place. As the result of these discussions, a plan has been worked out to strengthen the cooperation between the CEPC experiment and the ACTS group."

See Weidong LI's talk

Implementation of 2022 IAC recommendations

The report of the Institute of Science and Technology Strategic Consulting, CAS, on the societal cost-benefit analysis of the CEPC project should be presented at the next IAC meeting and sent to IAC members as soon as it is available.

A report in Chinese is ready.

Excerpts in English are attached in the backup slides (not verified)

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Implementation of 2022 IAC recommendations

A path to site selection, necessary for many aspects of the Engineering Design (ED) Phase, should be presented at the next IAC meeting.

CEPC team will work (and is working) closely with local government, CAS, and MOST towards this goal, with the accumulated site selection experiences in the last 10 years.

A CEPC site WG will likely make recommendation of two sites. The central government will make a final decision.

Implementation of 2022 IAC recommendations

A plan for the EDR phase should be presented to the IARC, IDRDC and subsequently to the IAC, at their next meetings.

An EDR plan has been prepared in 2023 together with the progress of TDR, it contains the EDR general goal, plan and scope of about 20 pages, and Jie Gao will give a dedicated talk on EDR plan and scope in this IAC meeting on Oct. 31, 2023.

Implementation of 2022 IAC recommendations

Collaboration with industry on klystron development should be explored.

The collaboration with industry on klystron has been strengthened, for example with Kunshan Guoli (company) on 650MHz 800kW CW multi-beam towards a ~80.5% efficiency klystron and C-band 80MW klystron development.

A plan for the required testing of components should be provided at the next IAC meeting.

In the EDR plan and scope to-do-list breaks down to 35 working groups. A 20 page preliminary working plan has been established, which will be reported in the Jie Gao's talk on EDR plan and scope.

Implementation of 2022 IAC recommendations

Iron-based superconductor (IBS) should continue to be developed as a promising, cost-effective approach to reach 16 T and higher.

Page 20-22.

The costing exercise should include the total number of persons required to build the facility from the moment of approval (when significant ED activities will still be ongoing) to completion.

Estimation of the human resource required to build the facility from the moment of approval has been estimated preliminarily, which will be reflected in Jie Gao's talk on EDR plan and scope.

Implementation of 2022 IAC recommendations

A plan for the EDR phase should be presented to the IARC, IDRDC and subsequently to the IAC, at their next meetings.

An EDR plan has been prepared in 2023 together with the progress of TDR, it contains the EDR general goal, plan and scope of about 20 pages, and Jie Gao will give a dedicated talk on EDR plan and scope in this IAC meeting on Oct. 31, 2023.

Implementation of 2022 IAC recommendations

The costing exercise should include the total number of persons required to build the facility from the moment of approval (when significant ED activities will still be ongoing) to completion.

Appropriate comparisons to the ILC and CLIC costings and personnel requirements, including methodology used, etc. should be used.

The costing exercise should be based as far as possible on actual quotes from relevant companies. The HEPS spending profile should be used as an example.

Comparison with ILC and HEPS will be briefly given in Jie Gao's talk on EDR plan and scope. CEPC TDR costing is based on both prototypes and also on the relevant companies such as IHEP Ruixin company for magnets, SRF cavities, and Kunshan Guoli companies for klystrons, etc. HEPS spending profile is considered.

Implementation of 2022 IAC recommendations

The IARC should organise the review of the TDR, in conjunction with the project management, augmenting itself with appropriate experts for particular areas of activity.

The IARC should organise the review of the costing, in conjunction with the project management. The information supplied to the review should include a detailed costing-process description. This should take place after the review of the TDR mentioned above has reported.

Independent international review committees have been established for TDR review and TDR cost review both with appropriate experts. A dedicated international TDR cost review has been down after the international TDR review.

Implementation of 2022 IAC recommendations

Site selection should be done as quickly as possible, within the constraints of the political approval process.

Continuous efforts have been taken in site selection.

A proposal for synchrotron-radiation beamlines should be integrated properly with the construction and machine designs at as early a stage as possible

A proposal for synchrotron-radiation beamlines should be integrated properly with the construction and machine designs at as early a stage as possible.

Yuhui LI's talk

Implementation of 2022 IAC recommendations

Reduce the detector solenoid field for the fourth detector concept down to closer to 2 T in order to meet the requirement for the transparency of the magnet and also for the minimum thickness envelope, while optimizing the general detector performance. Prioritize the magnet design parameter optimization, balancing the detector performance with the fundamental requirement for extremely reliable magnet operation.

Resume the Al-stabilized superconducting technology research in China.

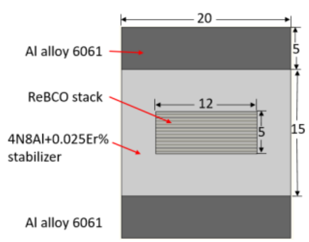
Implementation of 2022 IAC recommendations

Solenoid Magnet From 3T to 2T

The solenoid magnet is designed at 3T. Some new designs and materials will be used to meet the physics requirements.

- Transparency: HTS (High Temperature Superconducting) conductor is adopted instead of LTS (Low Temperature Superconducting)conductor to meet the transparency requirements.
- Thickness: Through the new HTS conductor design, coil structure optimization, new coil support structure design, optimized coil cooling structure, removing the thermal shield, the ultra-thin structure can be realized.
- We have also been optimizing the magnet design, considering the detector performance and extremely reliable magnet operation.

HTS conductor and coil layout



The solenoid magnet can also work at 2T if needed. Reducing the magnetic field from 3T to 2T can indeed reduce the thickness of the cold mass and increase the transparency. If physics need, we can also carry out the 2T magnet design.

Implementation of 2022 IAC recommendations

By Feipeng Ning/Ling Zhao

Resume the Al-stabilized superconducting technology research in China

- Coextrusion line has been established at Wuxi Toly Co.
- Al-stabilized NbTi superconductor with lengths greater than 1 kilometer has been produced(4.7mm*15mm) , and samples by a second coextrusion are in the process of testing(56mm*22mm).
- Al-stabilized HTS cable have been successfully developed, and the critical current of the cable has a degradation of less than 10%.
- R&D of High Strength and High RRR Aluminum- Stabilizer for Superconducting Cable get a good results: Yield strength > 74 MPa at room temperature, RRR value > 400.

TOLY ELECTRIC

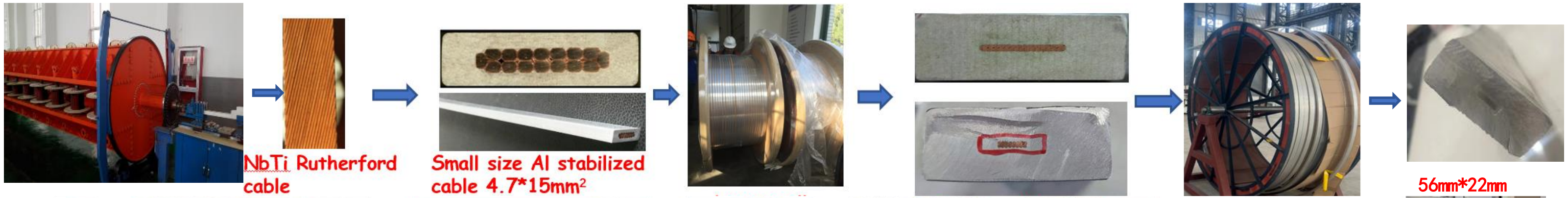
Al-stabilized superconductor

Pre-processing equipment

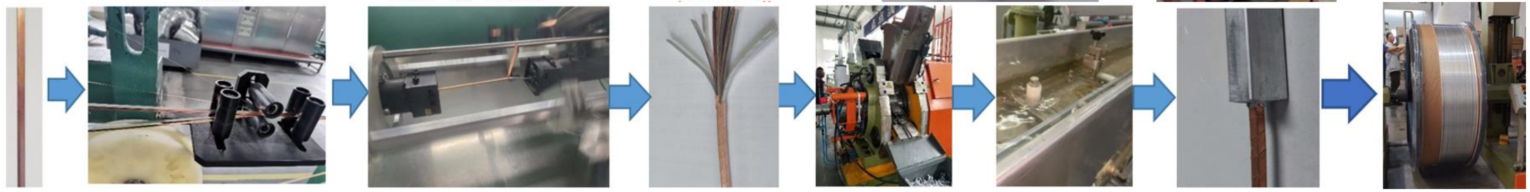
Extrusion machine

Parameter	Extrusion wheel diameter/mm	Rod diameter/mm	Cable thickness/mm	Cable width/mm
Value	400	2*9.5~12	3.0~30.0	10.0~70.0

LTS



HTS



Implementation of 2022 IAC recommendations

Strengthen the collaboration with the recently formed working groups under the ECFA Detector R&D roadmap. A particular area for collaboration is the use of test beams.

See Jianchuan WANG's talk

Develop plans for the construction of adequate domestic test beam facilities.

The CNSS plans to construct new beam line (proton + muon), which can be used for test beam.

Test beam at HEPS and BEPC II linac (in synergy with Plasma Weak Field project) is also under discussion..

Implementation of 2022 IAC recommendations

Engage more strongly mechanical engineering, especially addressing system aspects and MDI.

Conceptual study has been conducted, including the MDI & Muon System Mechanical Design.

Provide a sharper focus for the detector R&D program, concentrating on the baseline technologies for the concept detectors..

R&D on components almost done, detector system design optimized to be more intensifying.

Implementation of 2022 IAC recommendations

Continue outreach to the international community, in particular, continue the strong engagement with the US particle physics community and the P5 process. At the same time, an inward-looking outreach effort is encouraged to gain the support and participation of as large a segment of the particle physics community in China as possible. **Jianchun WANG's talk**

Engage theorists, especially experts in QCD and BSM physics, more strongly in efforts to bolster the physics program, particularly from colleagues in Chinese universities. The necessary funding to enable this should be given a high priority.

2023 CEPC workshop in Nanjing was well attended by people from within China. First time to be in-person since 2020. More effort to engage with the domestic community.

Implementation of 2022 IAC recommendations

Aim at having a stronger involvement of Chinese universities to strengthen the simulation effort. Explore avenues to engage international software experts for short-term, targeted visits.

Strengthen the physics case as much as possible through targeted, full simulations of the key physics processes and complete the set of whitepapers, addressing the five science areas, well before the CEPC proposal is due.

Articulate the unique features of the CEPC physics program in the context of the global high-energy physics program and consider submission of a separate whitepaper on this topic.

The flow-down of the physics requirements should be based on the detector performance as a whole and the detector treated as an integrated system rather than a set of subdetectors.

A meeting of the IDRDC should take place urgently. The mandate of the IDRDC should change to: advise on the Detector R&D, including the Machine Detector Interface, optimize the strength of the overall Physics program and maximize its discovery potential. Cross-members between the

Many will be covered by talks, and discussions on these will take place at this meeting

advance the level of maturity of the most promising candidate baseline technologies for the various subdetectors, maximising the complementarity between the two detectors.

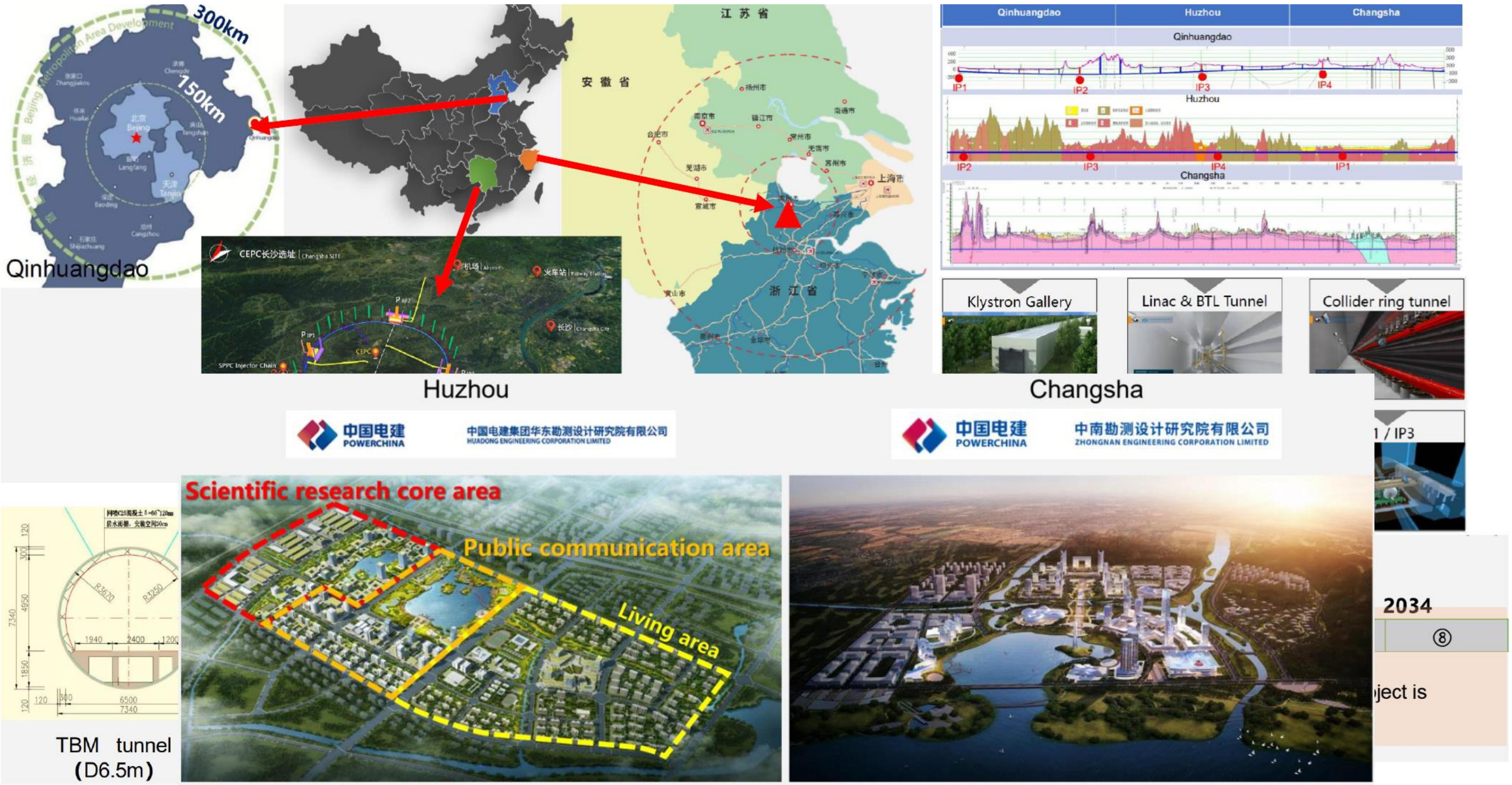
Plan for the future

- EDR – roadmap, execution, …. Jie Gao's talk
  get ready for CEPC construction
- Detector reference TDR Joao's talk
  compatible with accelerator schedule
  costing, required for CEPC approval
- Address weak areas Y. LI's talk
  alignment, MDI, costing, green+low carbon
- International collaboration Jianchun Wang's talk

……

Backup Slides

CEPC Status: Site Investigation



CEPC Status

Core team, the host institution and the existing support

- 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).

Implementation of 2022 IAC recommendations

The report of the Institute of Science and Technology Strategic Consulting, CAS, on the societal cost-benefit analysis of the CEPC project should be presented at the next IAC meeting and sent to IAC members as soon as it is available.

The CEPC technology, as a major scientific and technological infrastructure, brings enormous integrated benefits. Apart from its significant role in advancing physics and the exploration of universal laws through scientific output benefits, CEPC also positively impacts in areas such as economic stimulation, technological spillover, talent cultivation, enhancement of international scientific influence, and public good value. Thus, the construction and operation of CEPC have profound strategic importance for China's technological innovation capabilities and societal development.

Regarding scientific output benefits, CEPC can provide higher energy, more precise particle collision experiments, aiding the study of fundamental particle properties and interaction rules, and exploring the basic composition of matter and the evolution of the universe. CEPC can also serve as a platform for discovering new particles, offering possibilities for groundbreaking findings in physics. This is crucial in expanding the frontier of science and achieving theoretical breakthroughs.

Implementation of 2022 IAC recommendations

From an economic drive benefit perspective, the construction and operation of large-scale scientific facilities directly spur the growth of related industries. Moreover, the technological innovations and research outcomes generated by the scientific apparatus can be translated into commercial applications, stimulating the development of innovative industries and fostering economic growth and societal progression. Opening up the facility's construction to enterprises and collaborating with them is highly conducive to promoting technological innovation and boosting corporate enthusiasm. Such collaboration ensures an organic amalgamation of scientific research and industrial application, thus advancing the commercialization and conversion of technological results. Concurrently, the construction of CEPC also necessitates an abundance of human resources and service support, thereby generating employment opportunities and promoting job market development.

In terms of technological spillover benefits, the construction and operation of CEPC require addressing many cutting-edge technological challenges, which will propel the technological advancement in related domains. Technological innovations and breakthroughs will enhance China's R&D capabilities in accelerator science and its affiliated fields, further promoting the nation's technological progression in high-tech areas.

Implementation of 2022 IAC recommendations

Regarding the value in student and talent cultivation, a significant number of researchers, engineers, and students will be drawn to participate, engaging in pertinent research and tasks. This offers China a valuable opportunity to cultivate elite scientific talent. Students, through their research involvement with CEPC, will encounter pioneering scientific issues and intricate experimental techniques, enhancing their research and innovation capacities. Concurrently, CEPC will also provide ample developmental prospects and a conducive research environment for top-tier researchers, enticing them to return and contribute to China, thereby augmenting China's talent pool and research strength in the field of high-energy physics.

In the aspect of elevating international scientific influence, CEPC will attract research personnel and institutions from around the world to partake in its endeavors. This will foster international scientific collaboration and exchanges, stimulating innovative vigor between countries and research institutions, and driving technological development and advancement. It encourages knowledge sharing, resource complementarity, collaborative innovation, collectively addressing challenges in the scientific realm, and advancing global scientific progress.

From the perspective of public good value, firstly, CEPC will provide opportunities for science popularization and education, enabling more individuals to understand and pay attention to the progression of science. Secondly, the construction and operation of CEPC will promote the advancement and application of pertinent technologies, propelling technological innovation and industrial upgradation, hence contributing to socio-economic development. Moreover, CEPC will also attract tourists and audiences for visits and understanding, stimulating the growth of the tourism and cultural sectors, and enhancing the city's image and prominence.