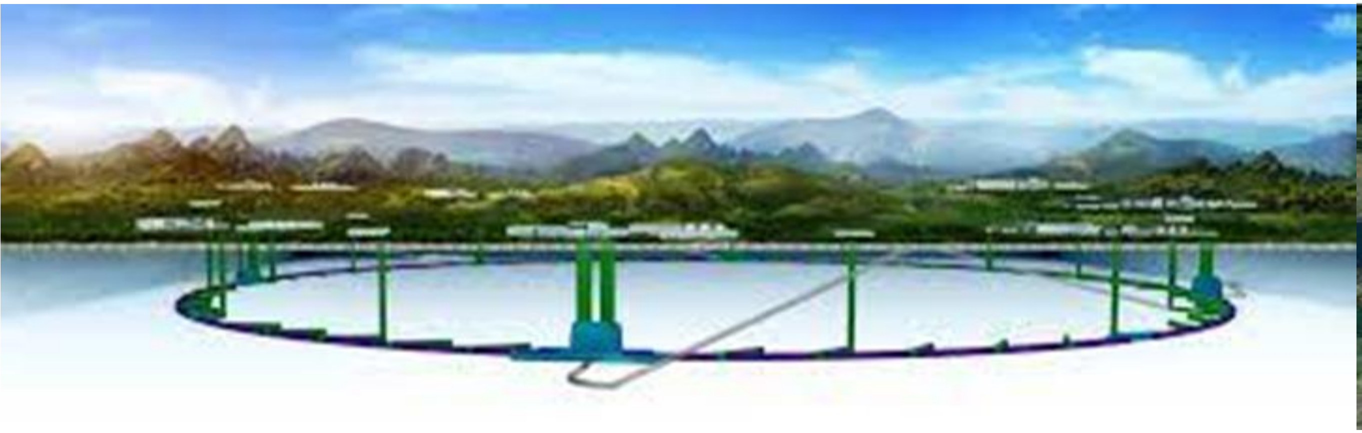
高能物理战略研讨会(2026), 广州

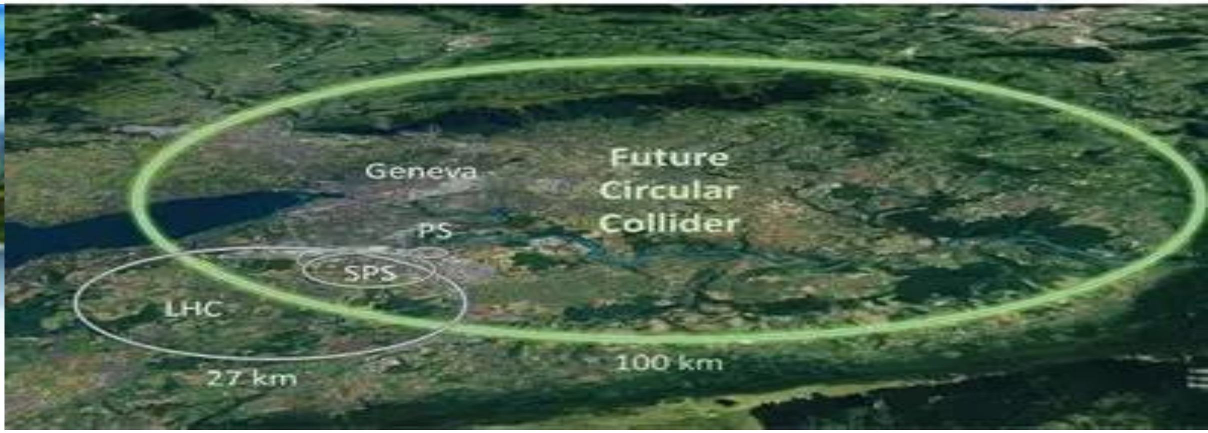
CEPC规划及与CERN-FCC合作态势

Xinchou LOU

IHEP, Beijing

with much help from Joao Guimaraes da Costa, Jie Gao, Jianchun Wang, Miao He, … and more people





Outline

- 介绍：CEPC 进展和状态
- CEPC 规划: 工程-技术设计加深，保持整体，争取国际领先, …
- CERN 战略更新, FCC 状态和计划
- 与CERN-FCC合作：计划，发展，未来, …
- 总结
- 讨论

Disclaimer
抱歉中英文混合（兼顾中外科学家）
内容巨大，不能全部-全面覆盖

介绍 - Introduction

CEPC 进展和状态

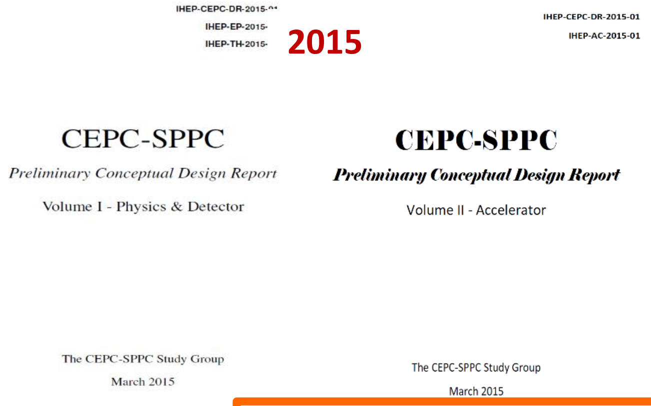
CEPC - progress & status

Introduction： CEPC - progress & status

The CEPC team takes steps to advance, and has been persistent in design and R&D

2013

2015



CEPC physics white papers:

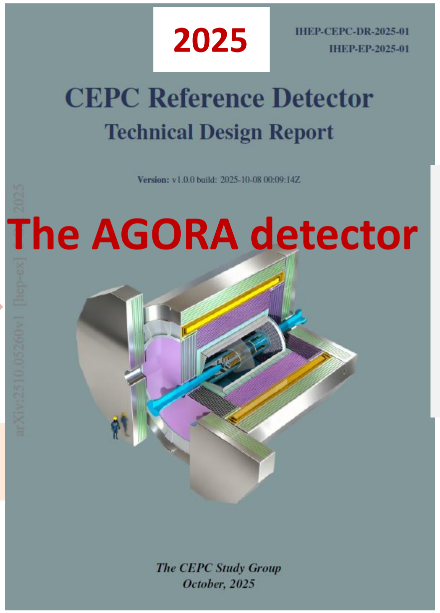
1. **Higgs physics,** arxiv:1810.09037
   Chin. Phys. C 43(2019) 043002
2. **Flavor physics,** Chin. Phys. C 49(2025) 10
3. **New Physics Search at the CEPC: a General Perspective**
   Chin. Phys. C 49(2025) 12
4. **Electroweak physics, to be published**
5. **QCD, to be published**

2018

2023

http://cepc.ihep.ac.cn

2025

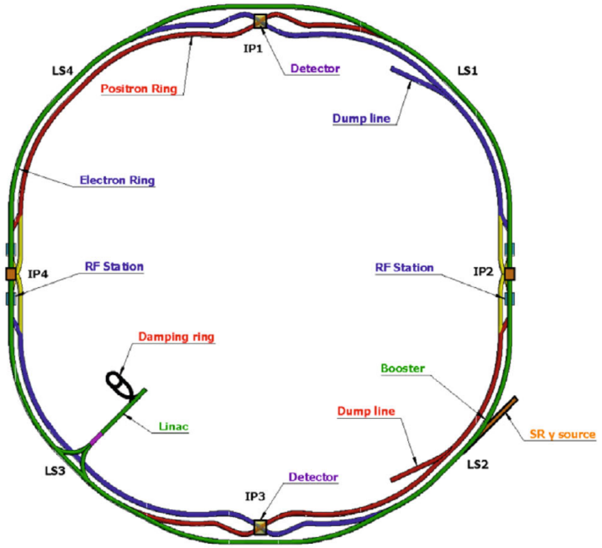


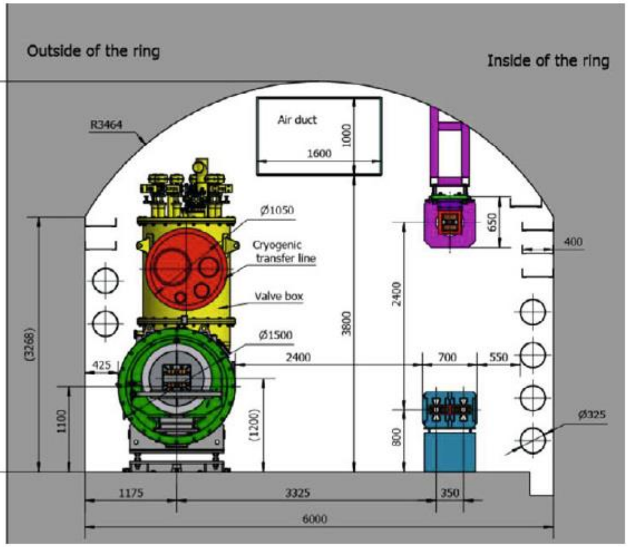
CEPC

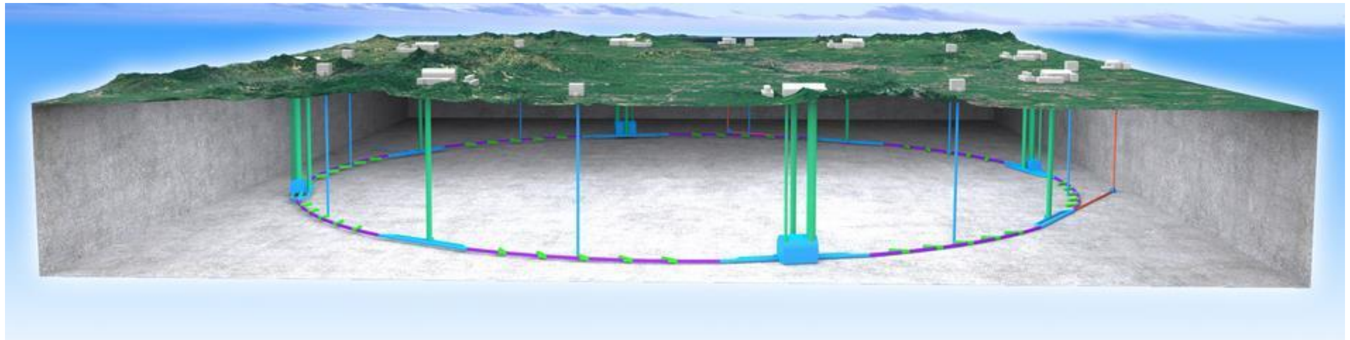
- compelling physics
- technologically feasible
- complete package

CEPC design and layout

- **2012年提出，正负电子对撞，质心能量91-240 GeV，可以产生海量的希格斯、Z和W粒子。升级到360 GeV后产生$t\bar{t}$。**
- **设计方案：** CEPC加速器主体由直线段、增强器、储存环组成；有两个对撞点容纳探测器
- **共享隧道:** CEPC增强器、对撞环及未来SppC共用同一隧道（早于FCC的概念）
- **100km周长:** 性价比最优的选择
- **能量灵活切换:** 原创性Higgs，W，Z 等多能量模式运行（被FCC采用）

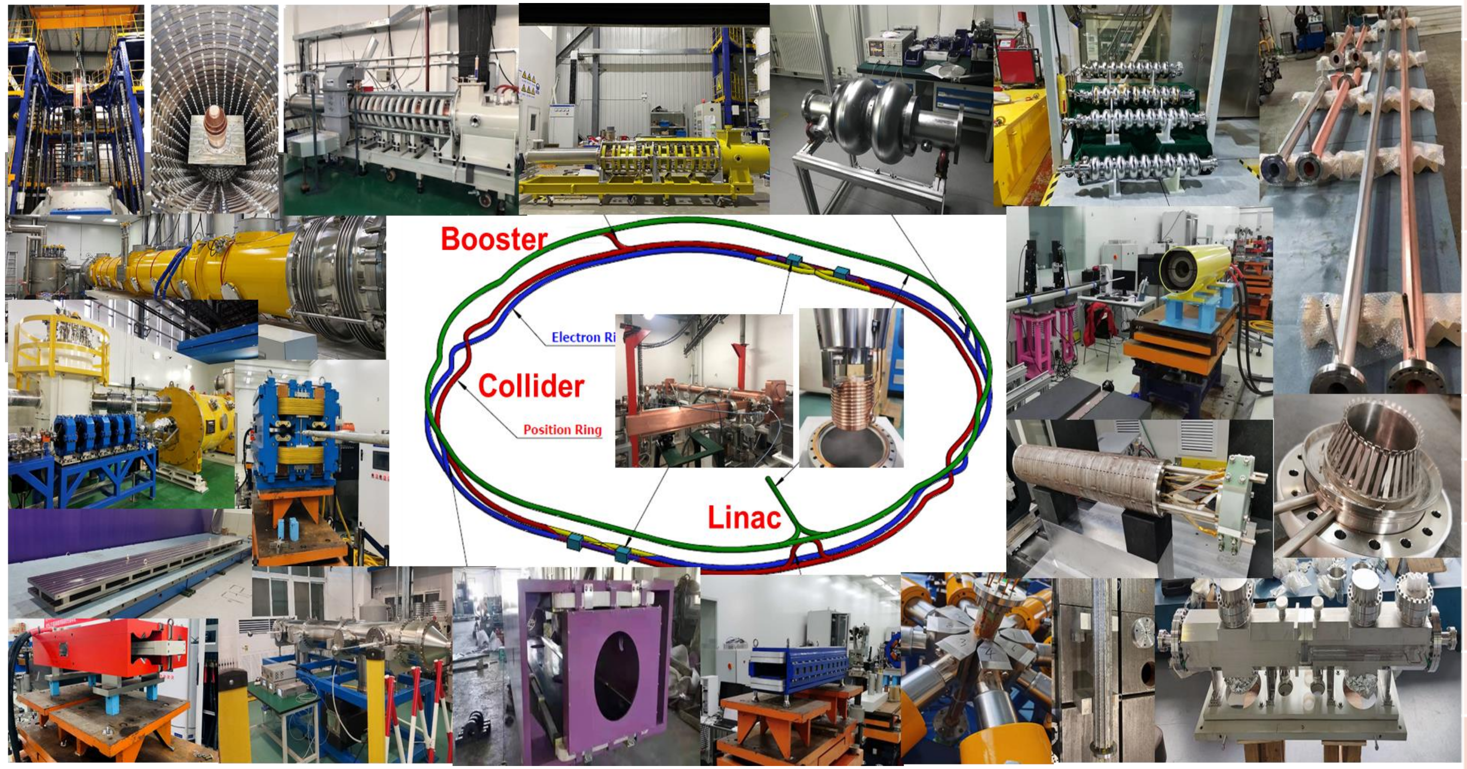






CEPC key accelerator technology readiness

- CEPC key components documented in TDR
- Remaining ~10% (eg. RF power source, control, alignment, SC magnets, machine integration) to be completed



The HEPS light source has been just completed by IHEP

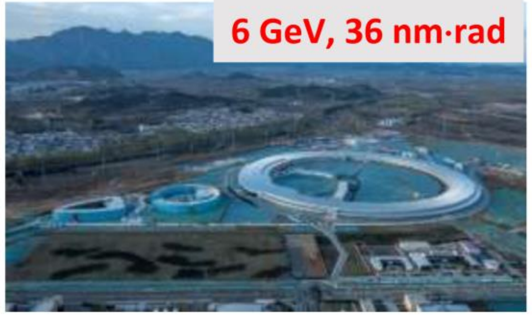
✔ Specification Met

✔ Prototype Manufactured

Accelerator	Fraction
✔ Magnets	27.3%
✔ Vacuum	18.3%
✔ RF power source	9.1%
✔ Mechanics	7.6%
✔ Magnet power supplies	7.0%
✔ SC RF	7.1%
✔ Cryogenics	6.5%
✔ Linac and sources	5.5%
✔ Instrumentation	5.3%
✔ Control	2.4%
✔ Survey and alignment	2.4%
✔ Radiation protection	1.0%
✔ SC magnets	0.4%
✔ Damping ring	0.2%

Gaining experience with electron accelerators

Learning & experimenting with a new light source (HEPS) and a working e+e- collider (BEPCII)



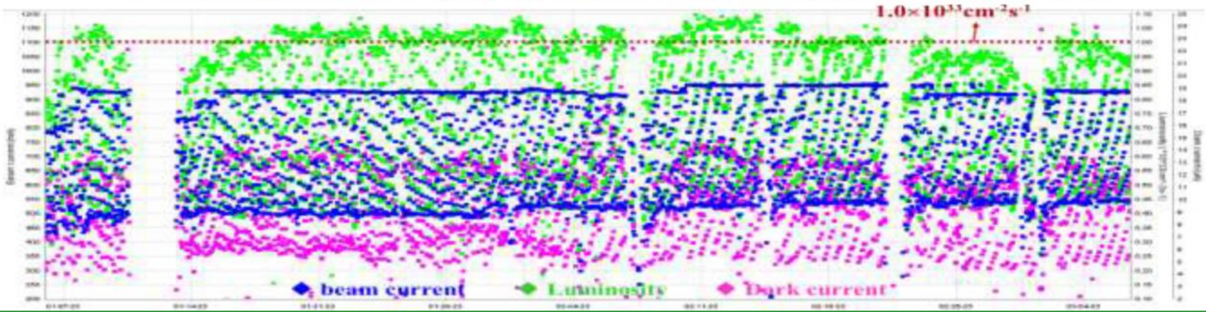
HEPS 6 GeV, 36 nm·rad, 4th generation light source, 1.3 km circumference construction completed in 2025

Magnets & alignment

Vacuum pipe and NEG coating

L. Feedback kicker

BEPCII high luminosity top-up injection physics data taking operation



Industrial partners and suppliers

	System
1	Magnet
2	Power supplier
3	Vacuum
4	Mechanics
5	RF Power
6	SRF/ RF
7	Cryogenics
8	Instrumentation
9	Control
10	Survey and alignment
11	Radiation protection
12	e-e+Sources

CEPC Industrial Promotion Consortium (CIPC, established in Nov. 2017)

Potential international collaborating suppliers and partners worldwide

CEPC the operation scenarios

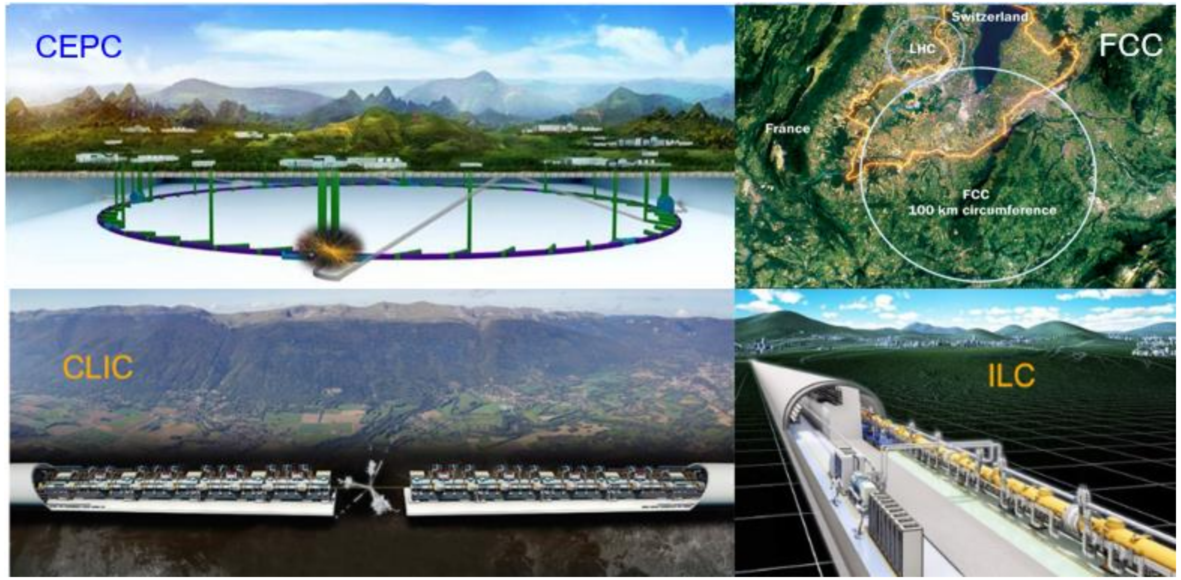
Baseline scenario

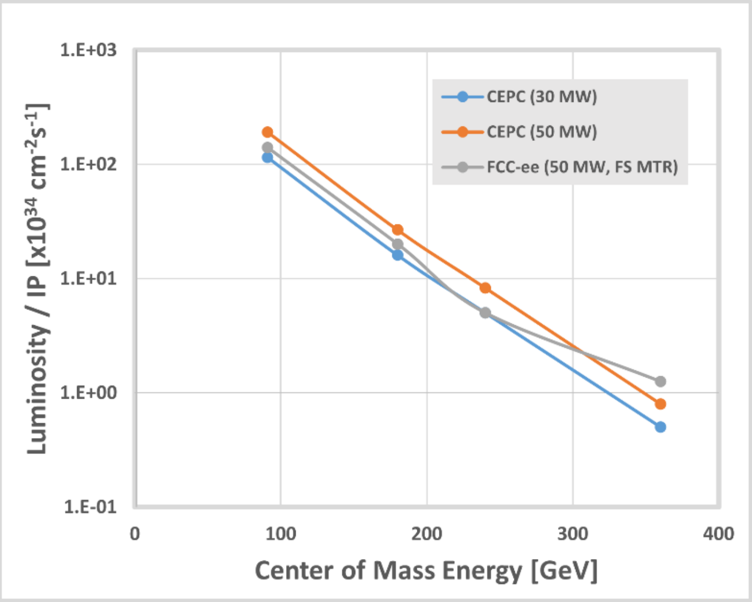
Operation mode	$\sqrt{s}$ (GeV)	SR power (MW)	$\mathcal{L}$ (10^{34} cm^{-2}s^{-1})	$\int\mathcal{L}$/year (ab^{-1})	Years	Total $\int\mathcal{L}$ (ab^{-1})	Event yields
H	240	30	5	0.65	15	10	2.0×10^6
Z	91	12.1	26(*)	3.2	4	13	5.6×10^{11}
W^+W^-	155-170	30	16	1.2	1	1.2	1.0×10^7(†)

Upgraded scenario: with international contribution

Operation mode	$\sqrt{s}$ (GeV)	SR power (MW)	$\mathcal{L}$ (10^{34} cm^{-2}s^{-1})	$\int\mathcal{L}$/year (ab^{-1}, 2 IPs)	Years	Total $\int\mathcal{L}$ (ab^{-1}, 2 IPs)	Event yields
H	240	50	8.3	2.2	10	21.6	4.3×10^6
Z	91	50	192(*)	50	2	100	4.1×10^{12}
W^+W^-	155-170	50	26.7	6.9	1	6.9	5.5×10^7
$t\bar{t}$	360	50	0.8	0.2	5	1.0	0.6×10^6

CEPC the comparison & advantages





直线希格斯工厂无优势，CEPC 在环形方案中有明显优势（共识：FCC/CEPC只建一个）

相比欧洲 FCC-ee

- 性能略好，使用灵活
- 建造成本低，时间短，性价比高

相比日本ILC和欧洲CLIC

- 性能好5-10倍
- 覆盖至90GeV能区（Z)
- 隧道可为质子对撞机复用

	CEPC	FCC	ILC	CLIC
计划开建时间	2032	2032	2030	2035
亮度($10^{34}cm^{-2}s^{-1}$)	5-8	5-8	~1	~1
造价(亿人民币)	380	1200	500	522

由于CAS没有支持十五五建设CEPC，丧失时间优势

AGORA: Advanced Glass Optimized Research Apparatus

从CEPC Reference Detector到AGORA

- AGORA面向下一代正负电子对撞机实验 (CEPC/FCC).
- 体现CEPC探测器的最大特色：基于闪烁玻璃的量能器
- AGORA在英文中是“聚集”的意思，体现国际和国内合作.
- AGORA基于CEPC基准探测器并不断发展

AGORA

ADVANCED GLASS OPTIMIZED RESEARCH APPARATUS

Introduction： TDR for the AGORA detector

International Committee composed of 19 experts in detector physics

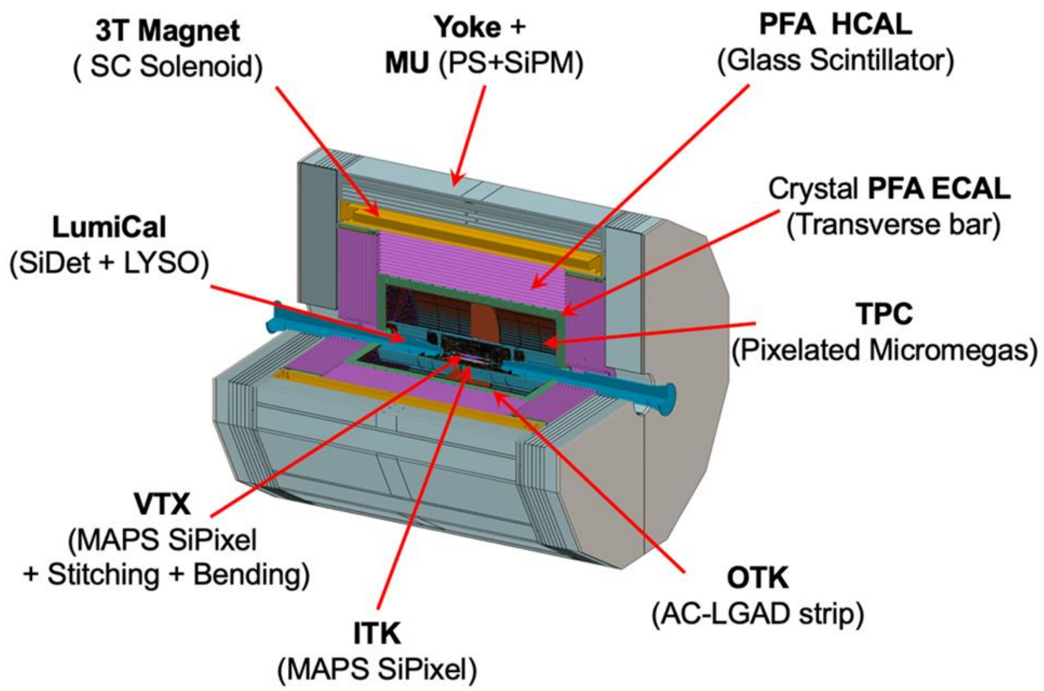
Name	Affiliation	Country/Region
Daniela Bortoletto (chair)	Oxford	UK
Colin Gay	UBC	Canada
Bob Kowalewski	U Victoria	Canada
Burkhard Schmidt	CERN	CERN
Liang Han	USTC	China
Paul Colas	Saclay	France
Christophe De La Taille	OMEGA, CNRS	France
Cristinel Diaconu	CPPM	France
Roman Poeschl	IJCLab	France
Maxim Titov	Saclay	France

Name	Affiliation	Country/Region
Frank Gaede	DESY	Germany
Anna Colaleo	INFN, Bari	Italy
Tommaso Tabarelli de Fatis	INFN Milano-Bicocca	Italy
Roberto Tenchini	INFN, Pisa	Italy
Akira Yamamoto	KEK	Japan
Hitoshi Yamamoto	Tohoku U., Valencia	Japan
Gregor Kramberger	IJS	Slovenia
Ivan Villa Alvarez	Santander	Spain
James Brau	Oregon	USA

Three review meetings were held from October 2024 to September 2025

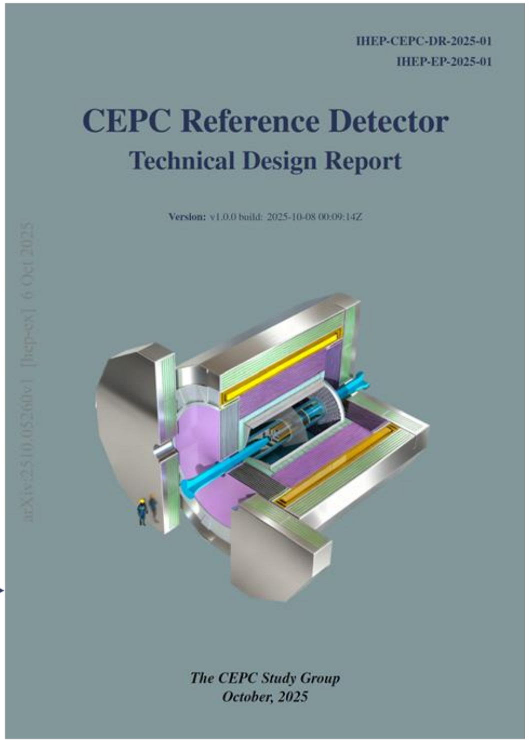
AGORA as a Reference Detector for CEPC - TDR

- **CEPC reference detector TDR:** Demonstrate readiness for construction of detector for baseline scenario. A detector that could be constructed and commissioned within a decade.
- **After CEPC project approval:** Two CEPC detectors will be selected among international proposals. International collaborations will lead those detector designs and produce corresponding TDRs adapted to the final operational scenarios.



$10\times10\times12$ m^3,
~5000 ton

19 chapters
669 pages
1474 authors
383 institutes
43 countries



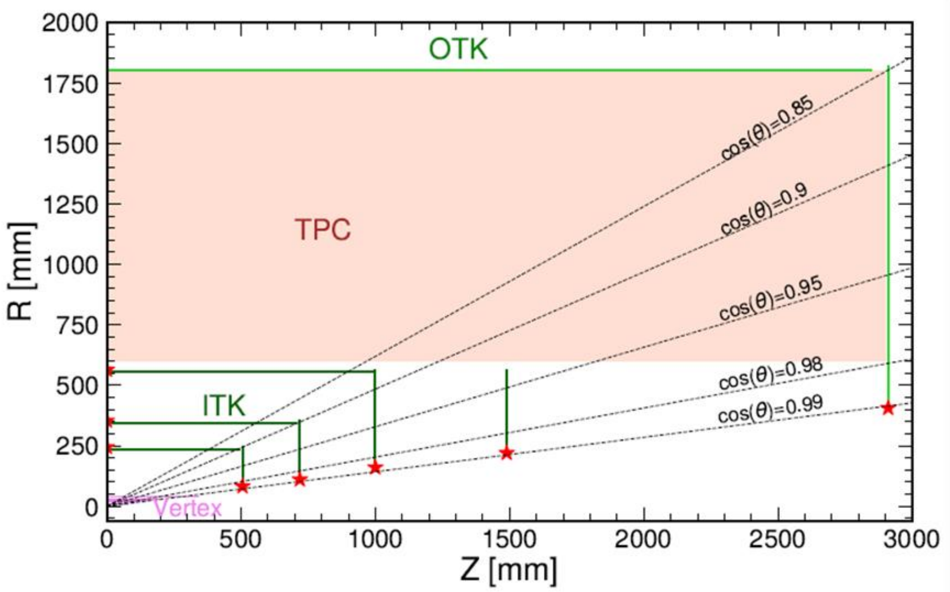
AGORA - the tracking system

Silicon detectors

- Vertex: MAPS silicon sensors bend to a tube, for σ of 5 μm
- 20 m^2 inner tracker using HV-CMOS pixel for σ ≈ 8 μm
- 85 m^2 outer tracker using AC-LGAD strips for σ ≈ 10 μm, σ_t ≈ 50 ps

Gaseous detector

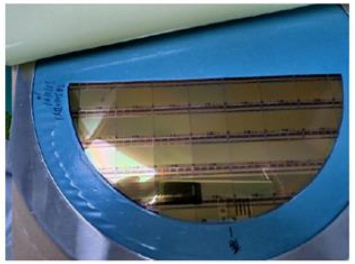
- TPC for tracking and PID for σ ≈ 100 μ m, dN/dx ≈ 3%

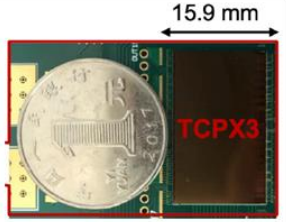


Measurands	Performance requirement
Coverage	$\lvert\cos\theta\rvert \le 0.99$
Recon. efficiency	$\ge 99\%$ ($p_T > 1$ GeV/c)
Resolution in barrel	$\sigma_{p_T}/p_T < 0.3\%$ ($\lvert\cos\theta\rvert \le 0.85$)
Resolution in endcap	$\sigma_{p_T}/p_T < 3\%$ ($\lvert\cos\theta\rvert > 0.85$)

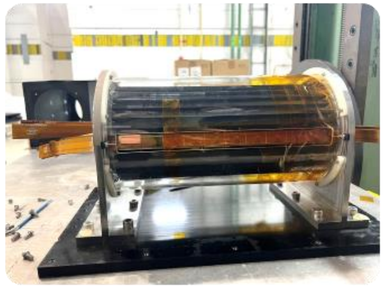
AGORA - key technologies in silicon detectors

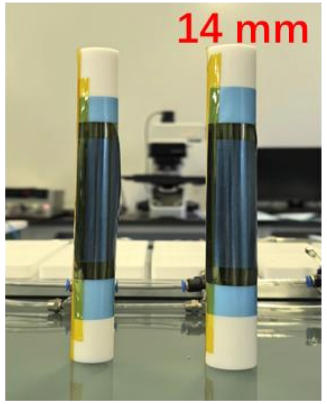
- **Vertex detector:** bending Monolithic Active Pixel CMOS (**MAPS**), for ultra-low material budget and low power



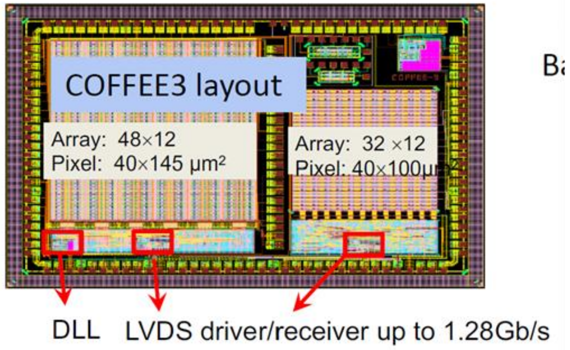


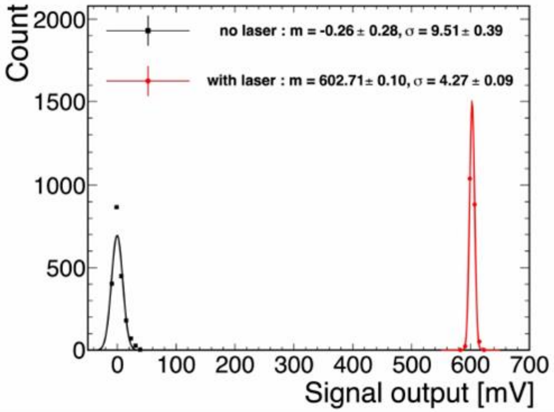
TaichuPix-3 chip vs. coin



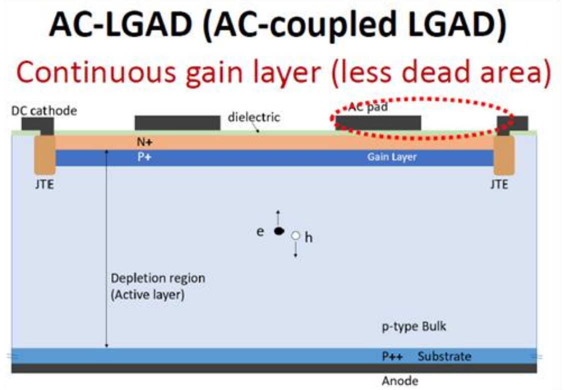


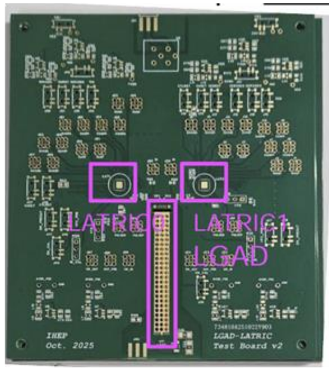
- **Inner tracker: HV-CMOS** MAPS fabricated using a **55 nm** CMOS process





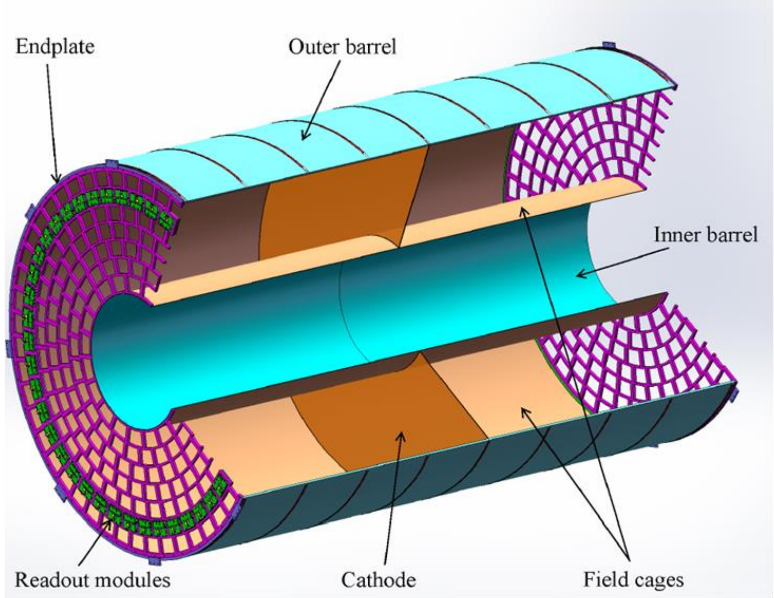
- **Outer tracker:** microstrip **AC-LGAD** with both good spatial and time resolution





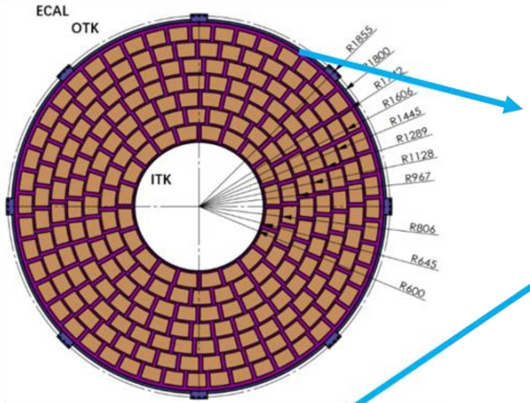
AGORA - the TPC outer tracker

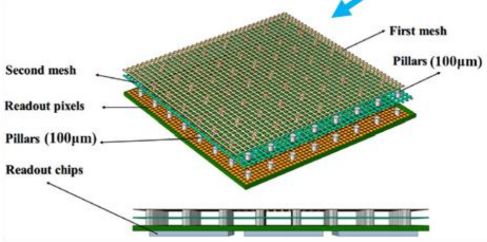
- A **chamber** (inner and outer cylinders, endplates) with gas mixture ($Ar/CF_4/iC_4H_{10}$ = 95/3/2), for low transverse diffusion and fast drift velocity.



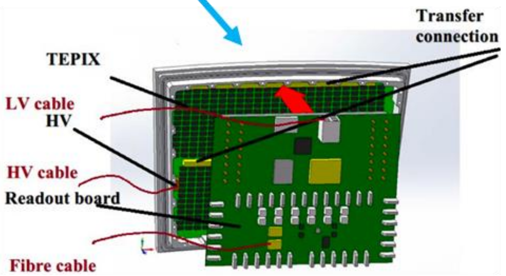
Length: 5.8 m, R extension: 0.6-1.8 m.

- High-granularity **readout** (500×500 μm²) of Micromegas for good tracking (σ~100 μm) and PID (dN/dx ~3%)





Double mesh micromegas readout board

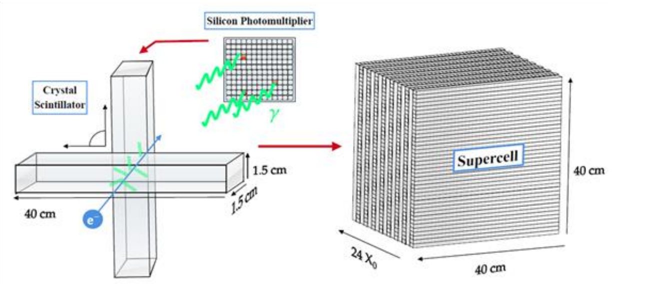


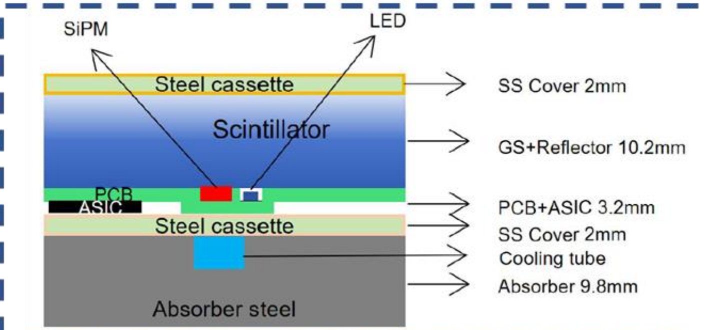
TEPIX: Low-power readout ASIC (<100 mW/cm²)

AGORA - Calorimeter Particle Flow Algorithm (PFA) oriented design

Electromagnetic Calorimeter (ECAL)

- 24 m^3 of BGO crystal bars ($1.5\times1.5\times40$ cm^3), arranged in the x-y direction alternatively, in perpendicular to the beam, to achieve fine 3D granularity. 570,000 SiPM readout channels.
- Energy resolution from 2025 beam test: $\boxed{1.96\,\%/\sqrt{E(\mathrm{GeV})}\oplus 0.54\,\%}$



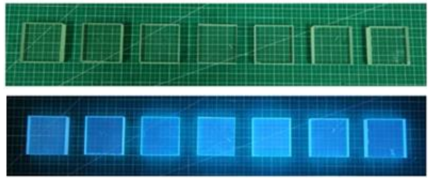


Hadron Calorimeter (HCAL)

- **85 m^3 glass scintillator** tiles ($4\times4\times1$ cm^3) interspersed with steel plates, $6\lambda_I$, 5.3 million SiPM readout channels, good 3D granularity
- High sampling ratio (~**30%**) and good energy resolution ~$\mathbf{30\%/\sqrt{E}}$

Key technologies

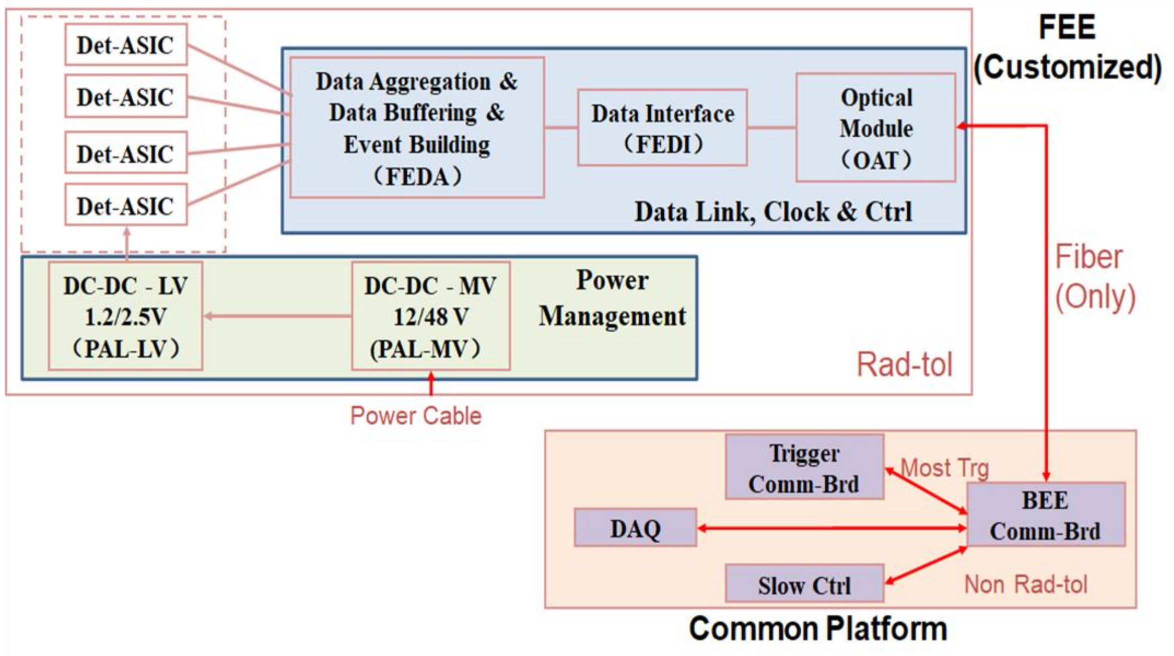
- **BGO crystal**: expensive, developing BSO as an alternative
- **Glass scintillator**: high-density and large-yield, technically challenging
- **SiPM+ASIC**: different requirements from ECAL and HCAL



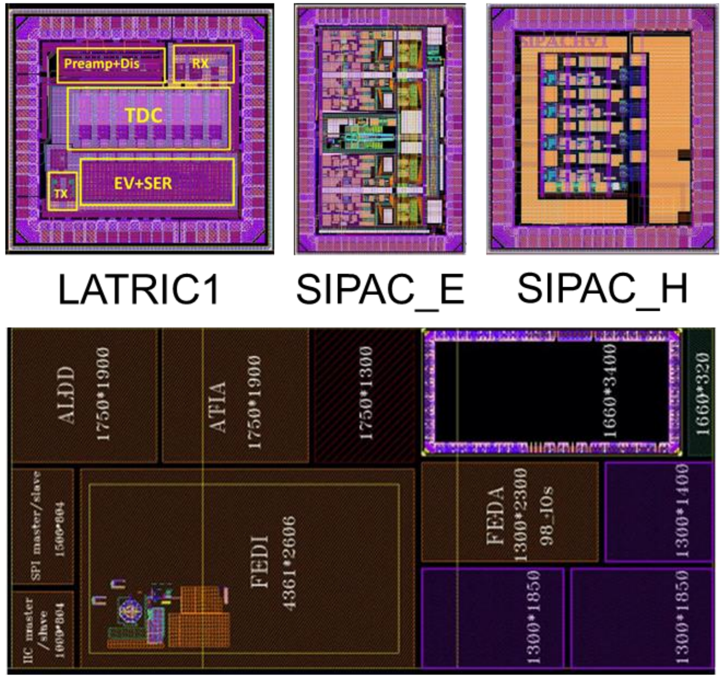
Glass scintillator under natural and ultraviolet light

AGORA - common electronics and data acquisition

- Customized on-det electronics, common data interface and backend electronics
- A serials of 55 nm ASICs
- Full data transmission is chosen as the primary strategy for electronics-trigger-DAQ
- Data storage rate 0.4/6.7 Gb/s for Higgs(50 MW)/Z(12.1 MW)

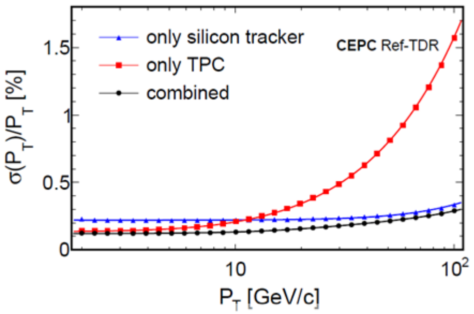


Framework of the common electronics

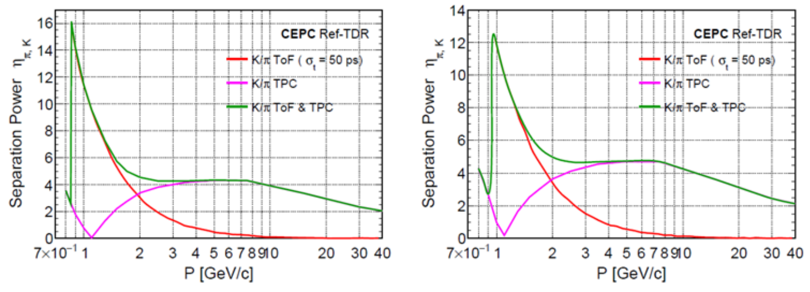


ASICs for the data interface

AGORA - Detector performance highlights

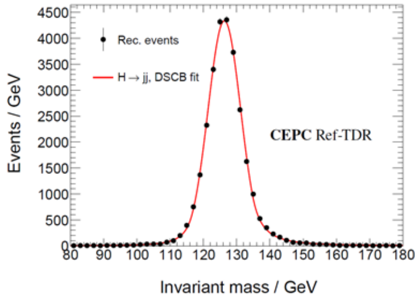


P_T resolution at 85°

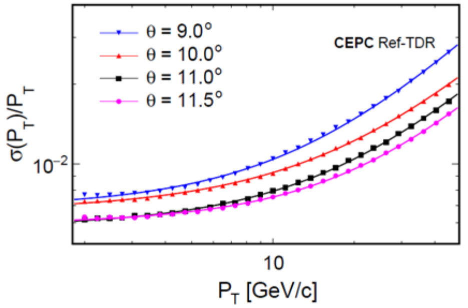


(a) $\theta = 85°$ (b) $\theta = 60°$

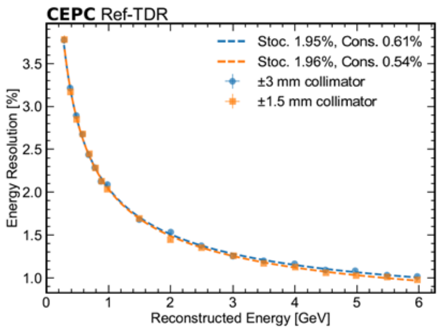
K/π separation power



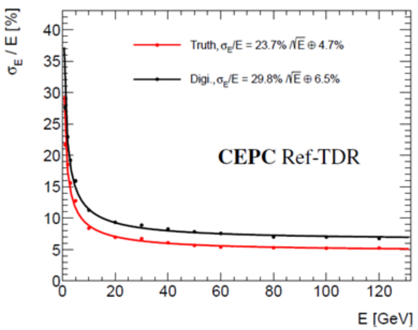
H→jj resolution



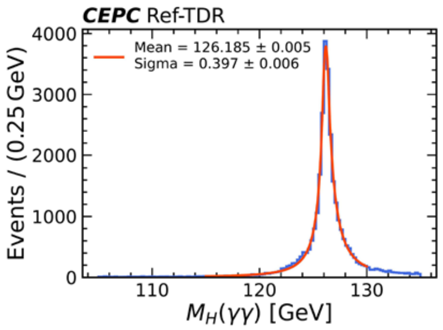
P_T resolution at different angles



EM resolution from beam test



Simulated Hadron resolution



H→γγ resolution

Tracking efficiency	Tracking σ_{pT}	Vertexing $\sigma_{x,y,z}$	π-k separation	EM resolution	BMR
>99.7% (for p>1 GeV)	~0.1% for majority	< 3.5 μm	3σ (1-20 GeV)	$2\%/\sqrt{E} \oplus 0.5\%$	3.87% (H->gg)

CEPC 规划 - Plan & Strategy

规划未来，工程-技术设计加深，保持整体，争取国际领先, …

planning, EDR-TDR enhancement, maintain integrated team, aiming at world class levels

CEPC Plan and Goals

CEPC intl. workshop
November 8, 2025

Representatives from Chinese institutes and universities unanimously agree:

- to continue to pursue CEPC in China
- to enhance cooperation with CERN on a future e^+e^- Higgs factory

CEPC Plan and Goals

2 days of reports, discussion and hearing advice from the IAC

Focused on the path for development, continuing R&D, enhancing international collaboration, and critically important areas to work on for the long term future

Strong encouragement from the IAC to move forward, to work with CERN (DRD, FCC,..), to be persistent with PWFA, HTS magnets, …

CEPC International Advisory Committee meeting
November 20-21, 2025

CEPC Plan and Goals

IHEP directorate group statement

“IHEP, as a leading high energy physics lab, will continue to pursue high energy frontier particle physics research, cutting edge technology development, and the CEPC. “

Consequently, IHEP is deploying its innovation funds to support CEPC and to strengthen the program.

CEPC Plan and Goals

Update to input to ESPP (#153, CEPC)

Letter from Jun Cao (IHEP director), Yifang Wang (CEPC), Xinchou Lou (CEPC）

We are writing this letter to provide **an update on the status of the CEPC project**, which was outlined in ESPP Input #153, The Circular Electron Positron Collider.

Regrettably, **the Chinese Academy of Sciences—the supervising body of the Institute of High Energy Physics (IHEP)—did not include the CEPC in the 15th Five-Year Plan (FYP).** In the past 13 years, the CEPC Study Group, hosted by IHEP, has been working intensively on the design and R&D of the CEPC, with the aim of delivering a Higgs factory before 2040 for the High Energy Physics community in the world. However, this goal is no longer achievable, and **the CEPC schedule has to be delayed.**

Institute of High Energy Physics

Chinese Academy of Sciences

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Tel: +86-10-88236076 Fax: +86-10-88233374 E-mail: yfwang@ihep.ac.cn Web: www.ihep.cas.cn

November 27, 2025

Dear Professor Jakobs,

We are writing this letter to provide an update on the status of the CEPC project, which was outlined in ESPP Input #153, The Circular Electron Positron Collider.

Regrettably, the Chinese Academy of Sciences—the supervising body of the Institute of High Energy Physics (IHEP)—did not include the CEPC in the 15th Five-Year Plan (FYP). In the past 13 years, the CEPC Study Group, hosted by IHEP, has been working intensively on the design and R&D of the CEPC, with the aim of delivering a Higgs factory before 2040 for the High Energy Physics community in the world. However, this goal is no longer achievable, and the CEPC schedule has to be delayed.

IHEP management reaffirmed that high-energy physics is our mission and the primary task. The CEPC Study Group will continue to work on the CEPC project, as endorsed by all IB members attending the CEPC annual meeting in Guangzhou this November. We will pursue and complete all the key accelerator and detector R&Ds identified by various review committees, such as silicon detectors and calorimeters, high efficiency klystrons, high performance SRF cavities and modules, automated production lines for magnets and NEG coating of vacuum pipes, etc. We believe that they are highly needed for the construction of any Higgs factory— CEPC or FCC-ee.

IHEP management approved also our strategy about CEPC and the collaboration with FCC-ee. While continuing to work on CEPC and maintaining the team, we will seek closer collaboration with DRD groups and discuss with CERN and FCC management regarding collaboration. If FCC-ee is approved for construction before 2030, we will abandon CEPC and join FCC-ee. Otherwise, we will submit a new CEPC proposal to the Chinese government in 2030.

We will continue our innovative studies for future colliders, including iron-based superconducting HTS cables and magnets for the SPPC/FCC-hh, and plasma wake field accelerators for future very-high-energy linear colliders. We are happy to collaborate with the international community on these topics.

I hope this letter will be useful for the ESG drafting session and the ESPP deliberations.

Director of IHEP	Chair of the CEPC Steering Committee	Project manager of CEPC
Jun Cao	Yifang Wang	Xinchou Lou

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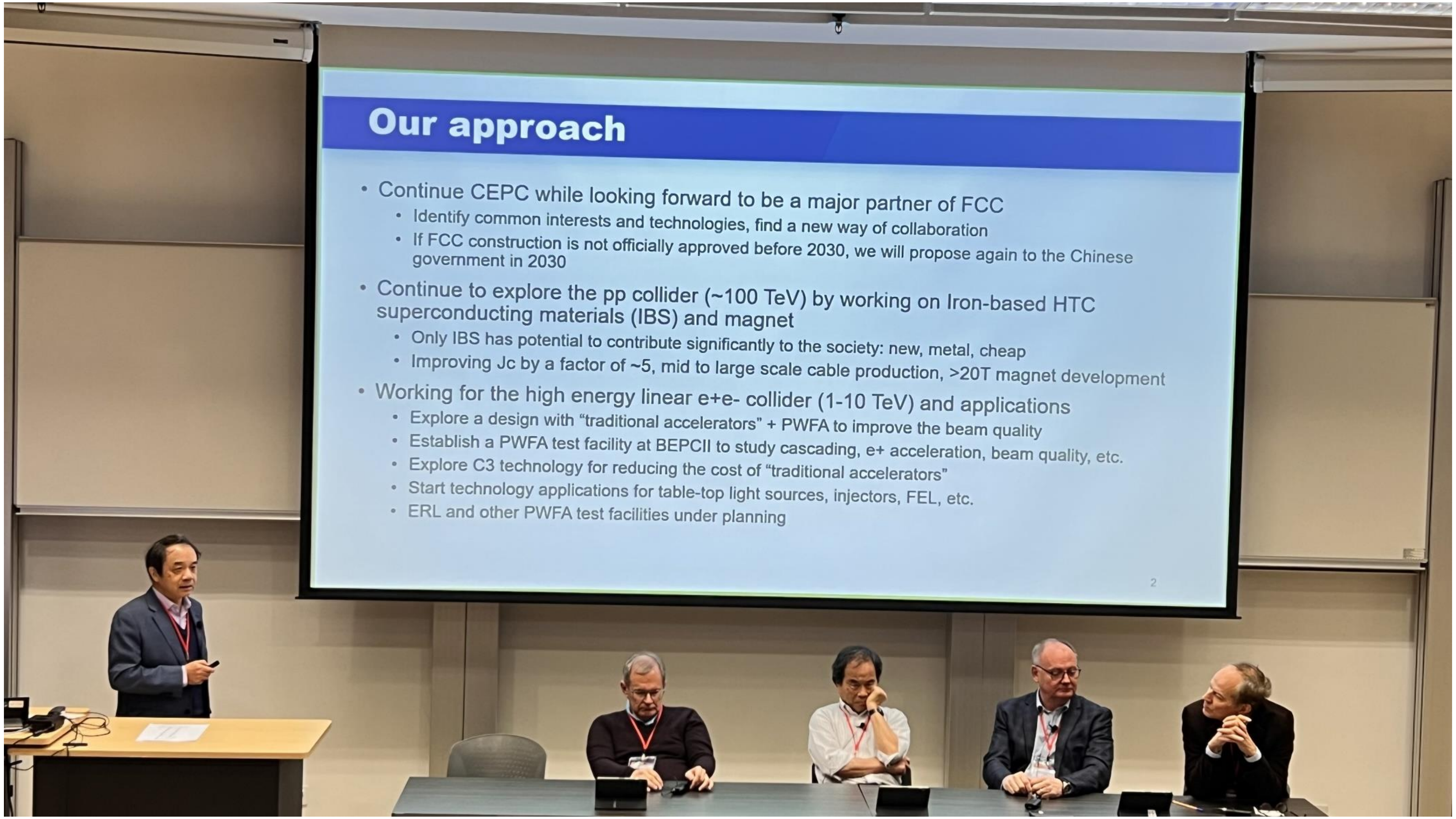
CEPC Plan and Goals

Yifang first presented the CEPC path forward at HKUST, January, 2026



CEPC Plan and Goals

Collaborate with international communities, especially with CERN, and prepare to join the FCC organization to contribute to the FCC accelerator and detector in significant ways.

Build synergetic scientific collaboration to ensure that a future Higgs+Z+W boson factory will be realized, and that Chinese HEP community will be at the forefront of the particle physics programs.

Prepare to propose CEPC to the Chinese government in 2030 if FCC has not been approved at around 2028

Build synergetic scientific collaboration to ensure that a future Higgs+Z+W boson factory will be realized, and that Chinese HEP community will be at theforefront of the particle physics programs.

Establish and carry through programs ranging from PWFA, C3, polarization at e-source etc.; to integrate applicable new advanced technologies in CEPC designs；

Leverage these technologies to explore high energy linear e+e- collider options and applications;

For long term high energy pp collider continue to pursue IBS magnets

Develop reliable, efficient and cost effective technical systems for CEPC/linear accelerator and the detector. Applications of technologies in other fields.

Build up and maintain a highly capable scientific and technical team in China as a driving force for CEPC-FCC

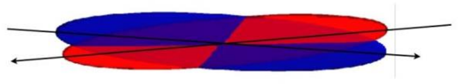
Build synergetic scientific collaboration to ensure that a future Higgs+Z+W boson factory will be realized, and that Chinese HEP community will be at the forefront of the particle physics programs.

CEPC Plan and Goals

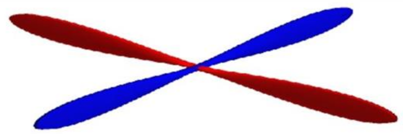
For example: Crab-waist scheme – test bed at BEPC-II

见高能所曹俊所长报告

BEPCII/U



BEPCII crab waist

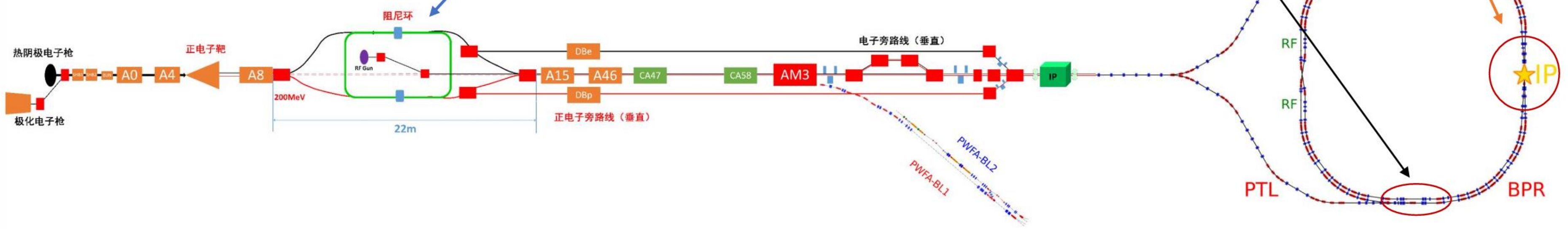


- Design study supported by IHEP Innovation funding since 2025.

1. IR: crab waist collision

2. Inner ring Inj. region: insert wigglers

3. Linac: Compact damping ring



Dou Wang

CEPC Plan and Goals

The TDR also documents future detector R&D plan details, many activities are with the DRD Collab.

prototyping with vital subsystems； continuing to improve the design
develop combined system to evaluate their performance

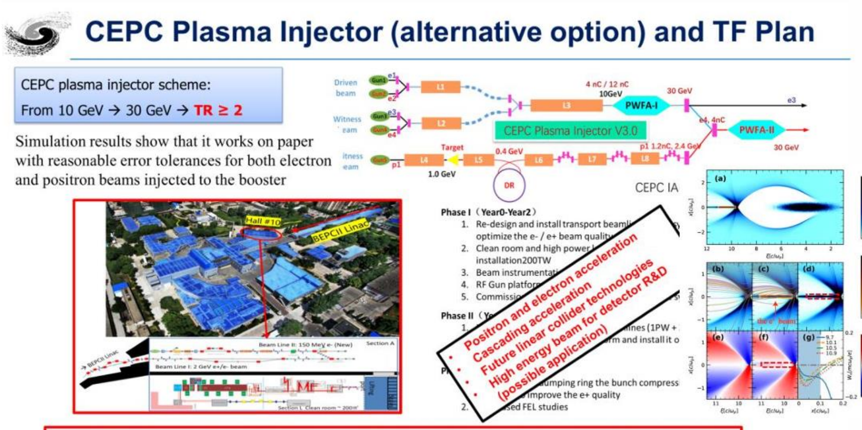
AGORA is designed for CEPC, and can be adapted for use at FCC-ee

MDI and Luminosity	• **MDI:** Optimization of collimato • **Luminosity measurement:** V • **Beam background:** improve
Silicon Detectors	• **Vertex:** Development of wafer- CIS stitching MAPSs with 65nı • **ITK:** HV-CMOS sensor R&D, I • **OTK:** larger size, higher perfor towards multi-channels readou
Gaseous Detector	• **TPC:** Test and validation of hig back-flow, and electron transm
Calorimeter and Muon Detectors	• **ECAL:** QA/QC specifications f • **HCAL:** Glass scintillator advar • **Muon:** Enhance light yield anc • R&D of **SiPM** and readout ASI

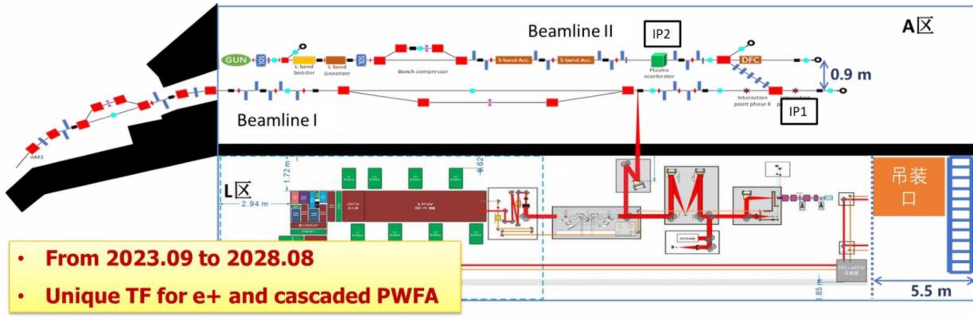
Detector Magnet	• Develop longer full-size aluminum-stabilized NbTi Rutherford cable • Enhance mechanical strength, achieving self-supporting structures, and ensuring bonding strength • Cryogenic system and mechanical design
Electronics and TDAQ	• Prototype verification, front-end chip development, and electronics common interface • Development of advanced trigger algorithms, high-speed transmission technology for trigger electronics, and high-bandwidth distributed parallel computing. • Small-scale experimental verification based on the new ATCA standard architecture
Mechanics and Integration	• Further design of yoke, sub-detectors, connection structure, and cooling • Service: cabling and piping, electrical & gas system, crane, forks … • Installation scheme optimization, design of the tooling and fixtures
Software and Computing	• Optimization of geometry coverage. • Study of standalone tracking for displayed vertex. • Simulation for physics impact and new physics.

CEPC Plan and Goals

For example: An IHEP PWFA lab in association with BEPC-II



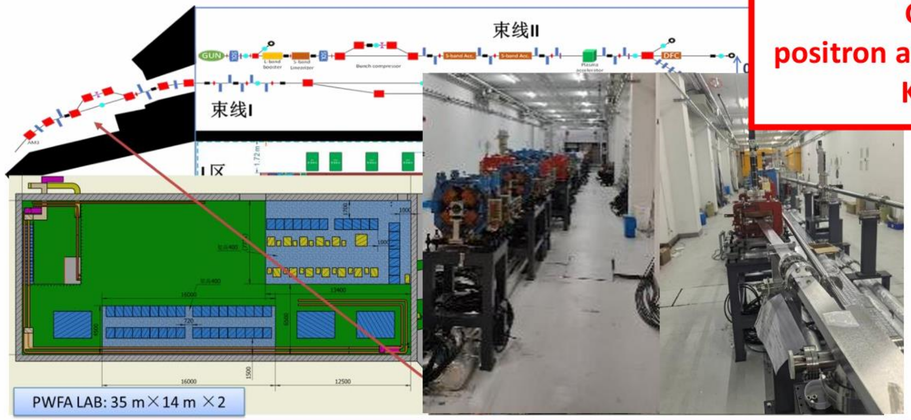
PWFA/LWFA TF based on BEPC-II Linac and HPL has been founded by CAS 90M RMB in Sept. 2023
Under development in the experimental hall #10 of BEPC-II



- From 2023.09 to 2028.08
- Unique TF for e+ and cascaded PWFA

Beam quality → Beamline I

Parameters	Unit	BL-I e- (AM3)	BL-I e- (IP1)	BL-I e+ (AM3)	BL-I e+ (IP1)	BL-I e- (IP1, block)	BL-I e+ (IP1, block)
Energy	GeV	2	2	2	2	2	2
Charge	pC	2000	2000	100	100	9.4	0.2
bunch length	ps	10	1	10	1	~1	~1
Geo. emittance	mm·mrad	0.1/0.1	0.1/0.1	0.4/0.4	0.4/0.4	0.011/0.005	0.04/0.02
RMS beam size	µm	-	150/150	-	300/300	30/40	54/76



PWFA LAB: 35 m×14 m ×2

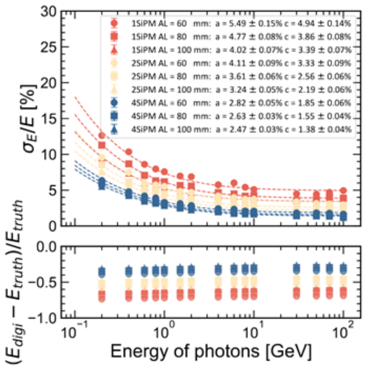
Goals: demonstration of acceleration of positron and electron beams with staging in next few years
Key technology for future linear colliders

Dazhang Li, Wei Lu and Jie Gao, Research highlights on plasma-based acceleration at IHEP, AAPPS Bulletin (2025) 35:3, https://doi.org/10.1007/s43673-025-00143-z

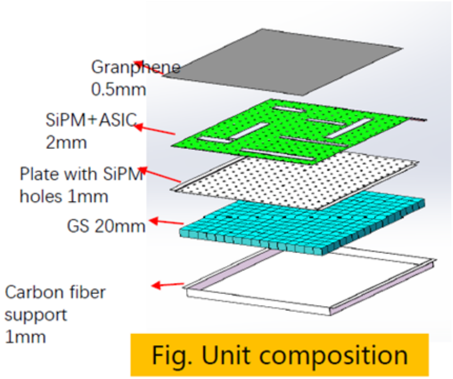
AGORA - new ideas to go beyond the TDR

An integrated design for ECAL and HCAL based on **glass scintillator (GS)**: trade-off between cost and physics

- GS-ECAL: 1/3-1/2 of BGO, channels × 7, better E/H ratio with hadronic shower
- GS-HCAL: optimization of sampling ratio to improve energy resolution



Energy solution of GS-ECAL can reach 3%-4%

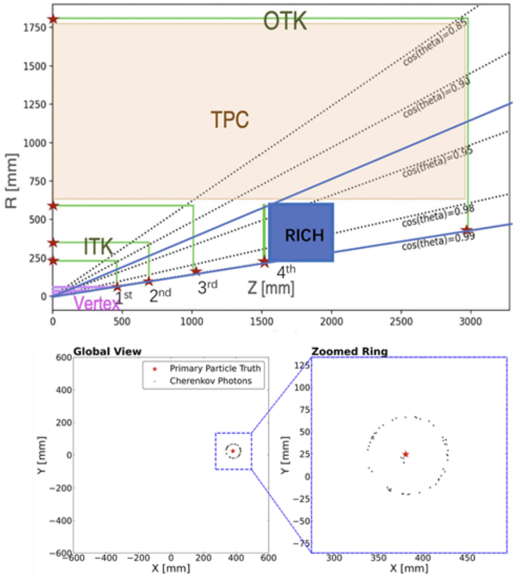


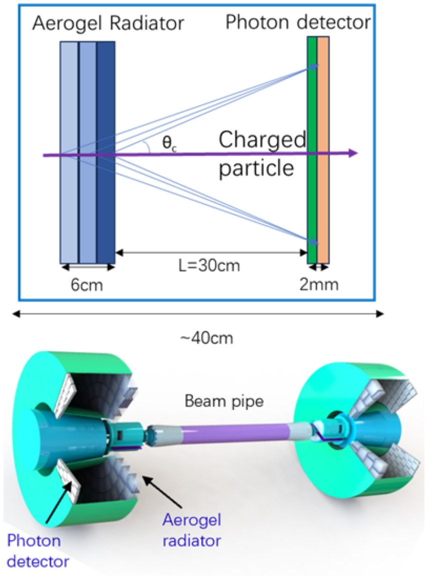
Preliminary design of a unit of GS-ECAL

Reference (talk at CEPC workshop in Lisbon, April 2026):
https://indico.cern.ch/event/1598929/contributions/7012849/

A Ring-Imaging Cherenkov (**RICH**) detector in the forward region

- To improve forward K/π separation
- Key technologies: aerogel radiators with low refractive index and radiation-hard SiPMs with low noise





Reference (talk at CEPC workshop in Lisbon, April 2026):
https://indico.cern.ch/event/1598929/contributions/7014479/

CEPC Plan and Goals

Presented at FCC Week 2026 in Helsinki, June 2026

"In light that the Chinese Academy of Sciences did not support the submission of the CEPC proposal for government approval in October 2025, **the study group intends to join the FCC accelerator and detector projects, and to contribute in a significant way.**

The CEPC Study Group intends to continue advancing the critical and innovative R&D projects identified by the various international review and advisory committees, while contributing to FCC. The AGORA detector will be modified to be a great one for the FCC.

If the FCC is not approved within the current schedule (2028-9), CEPC will be submitted for approval in 2030 within China's 16th Five-year Plan."

CERN

战略更新, FCC 状态和计划

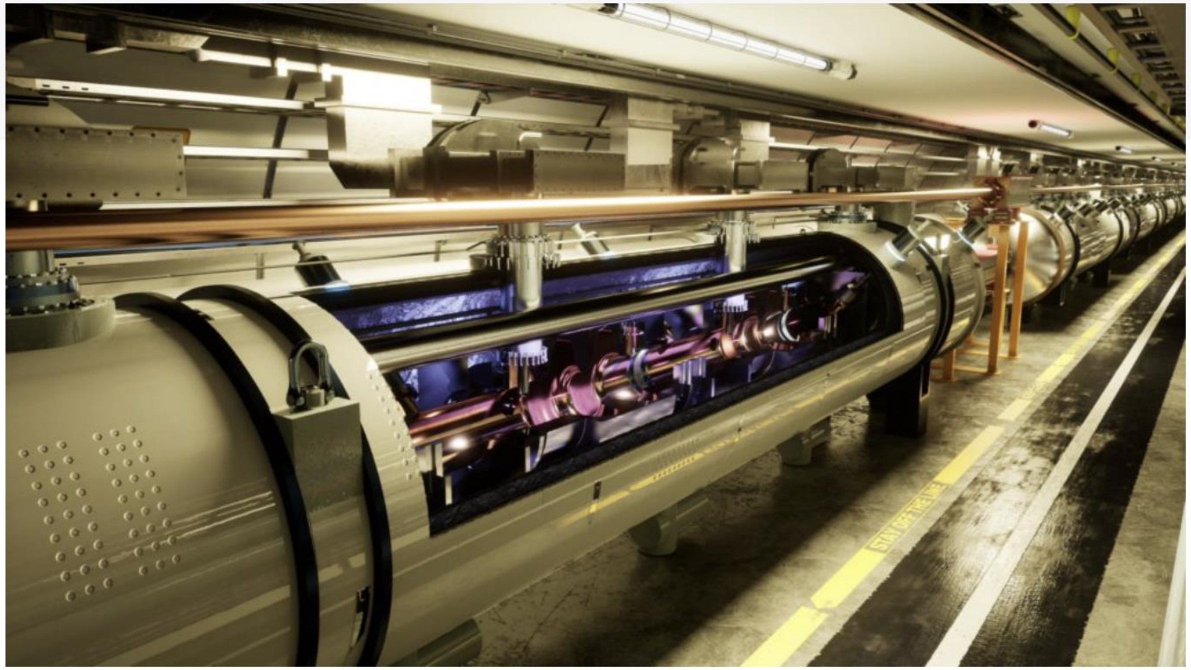
ESPP, FCC status & plan

CERN-EPPS, FCC: status & plan

2026年5月，CERN更新了《欧洲粒子物理战略》

The CERN Council decided to update the European Strategy for Particle Physics

22 May, 2026



Artistic representation of the Future Circular Collider (FCC-ee) (Image: CERN)

2024年3月启动，2025年12月提交CERN理事会

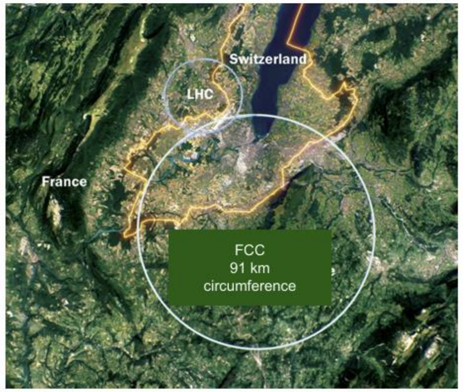
https://home.cern/the-cern-council-decided-to-update-the-european-strategy-for-particle-physics/

CERN-EPPS, FCC: status & plan

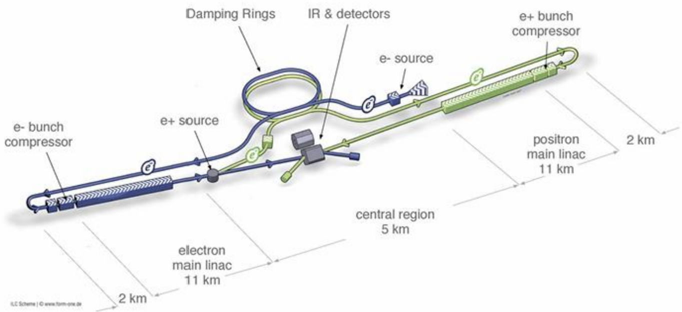
The choices for Europe

e$^+$e$^-$ colliders
("Higgs, Electroweak, Top and Flavor Factories factories")

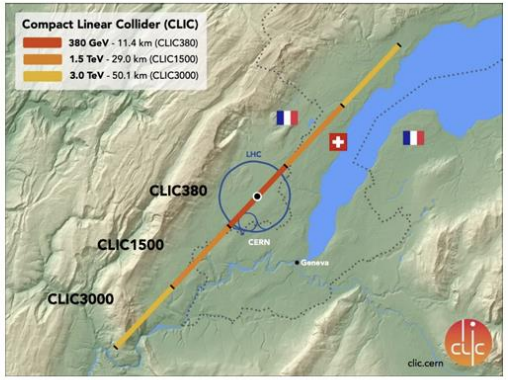
FCC-ee (e$^+$e$^-$, circular, 91 – 365 GeV)



LCF (e$^+$e$^-$, linear, 91 – 240, 550 GeV)



CLIC (e$^+$e$^-$, linear, 380 GeV, 1.5 TeV)

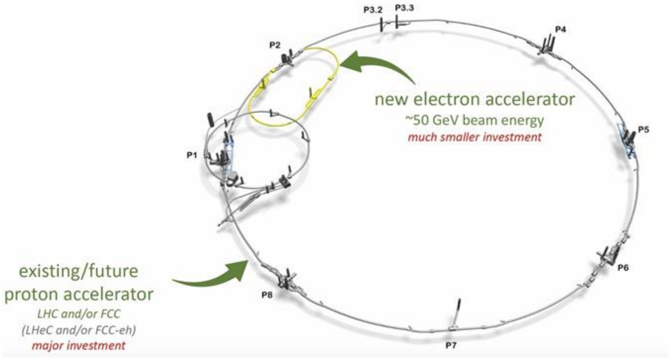


Intermediate projects

(Leave room (time, budget, resources) for further development of THE machine that can probe directly the energy frontier at the 10++ TeV parton center-of-mass scale)

LEP3 (e$^+$e$^-$, circular, 91 – 230 GeV)

LHeC (ep, circular, electron ERL, 50 GeV e$^-$, > 1 TeV ep collisions)



CERN-EPPS, FCC: status & plan

EPPS outcome

- 首选方案: **FCC-ee**
  (91公里，91-365 GeV，50 MW，4个探测器)
- 备选方案: **Descoped FCC-ee**
  (91-240 GeV，30 MW，2个探测器)

Paris Sphicas
chair of ECFA
Talk at FCC week in June, 2026

At this stage, without knowing the reasons for which the FCC-ee would not be feasible, the other alternative options are not ranked.

Machine	Precision Physics	BSM physics	Physics vs CEPC	Technical readiness	Constr. cost (BCHF)	Time scale	Path to ≥10 TeV
FCC-ee	22	23			15.3	2046-2060	
Descoped FCC-ee	15	17			12.9	2046-2055	
LCF550	15	17			14.8	2045-2065	
CLIC1500	14	18			14.6	2045-2066	
LCF250	10	16			9.4	2045-2053	
CLIC380	10	16			7.5	2045-2054	

Plan A

Plan B

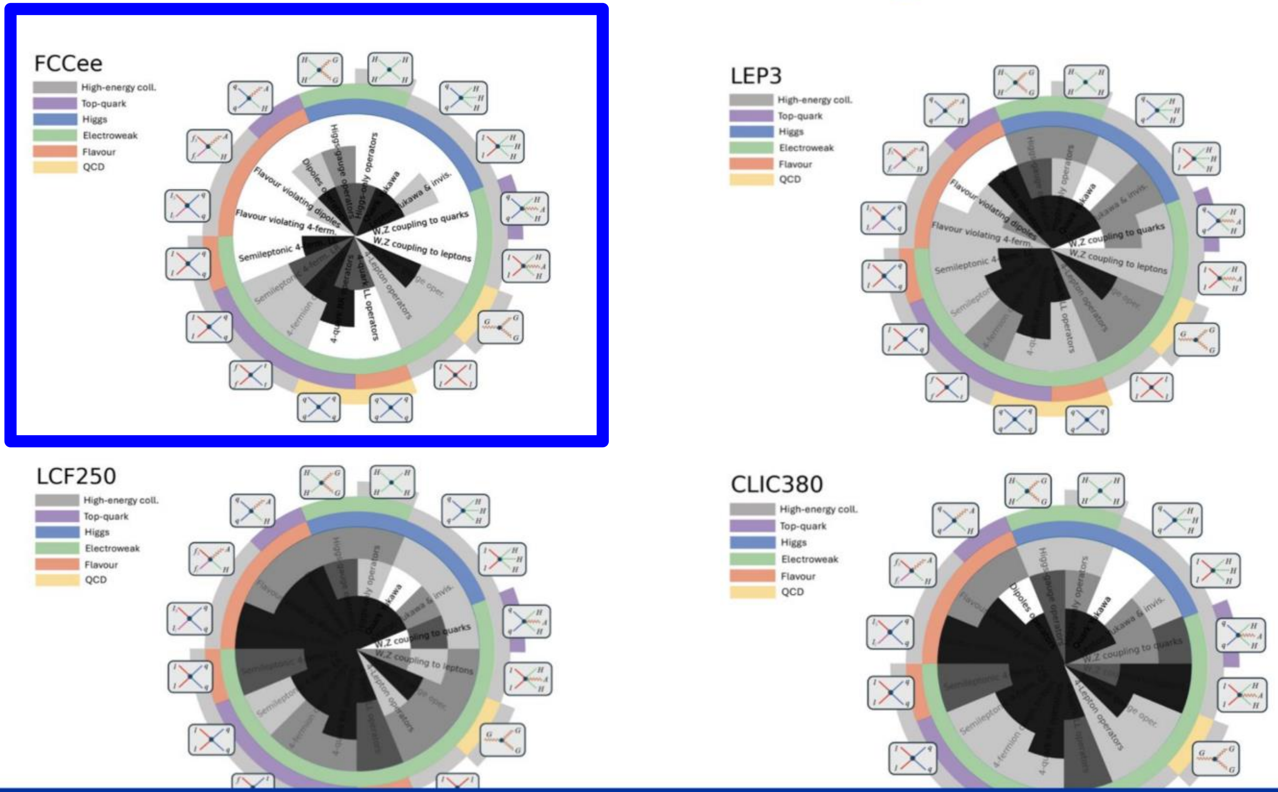
"The baton is now with CERN management and Council"

not iron clad (approved) yet

CERN-EPPS, FCC: status & plan

EPPS analysis of physics potentials

Coverage of FCC-ee with first stage e^+e^- colliders

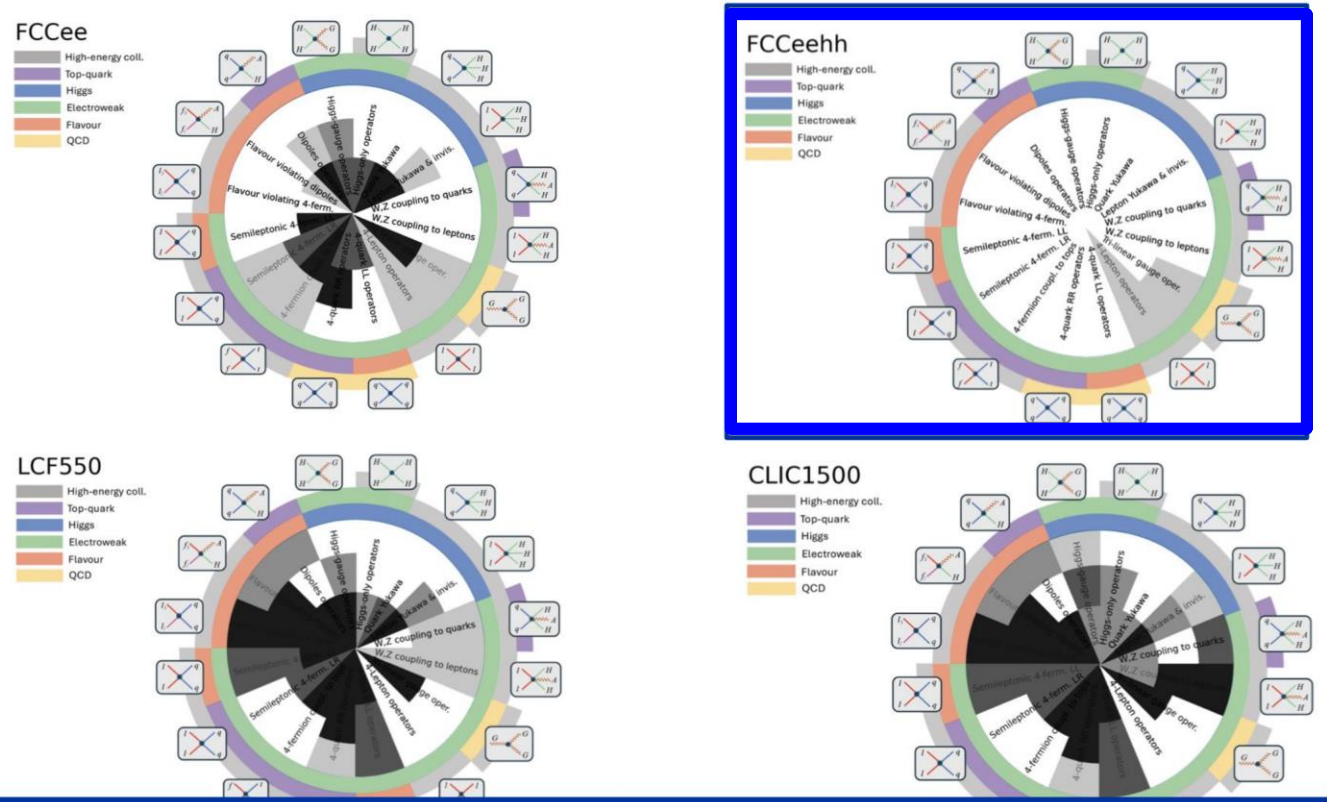


"Clear blue water" between FCC-ee and LEP3 and first-stage linear colliders

CERN-EPPS, FCC: status & plan

EPPS analysis of physics potentials

FCC-ee vs. second stage colliders



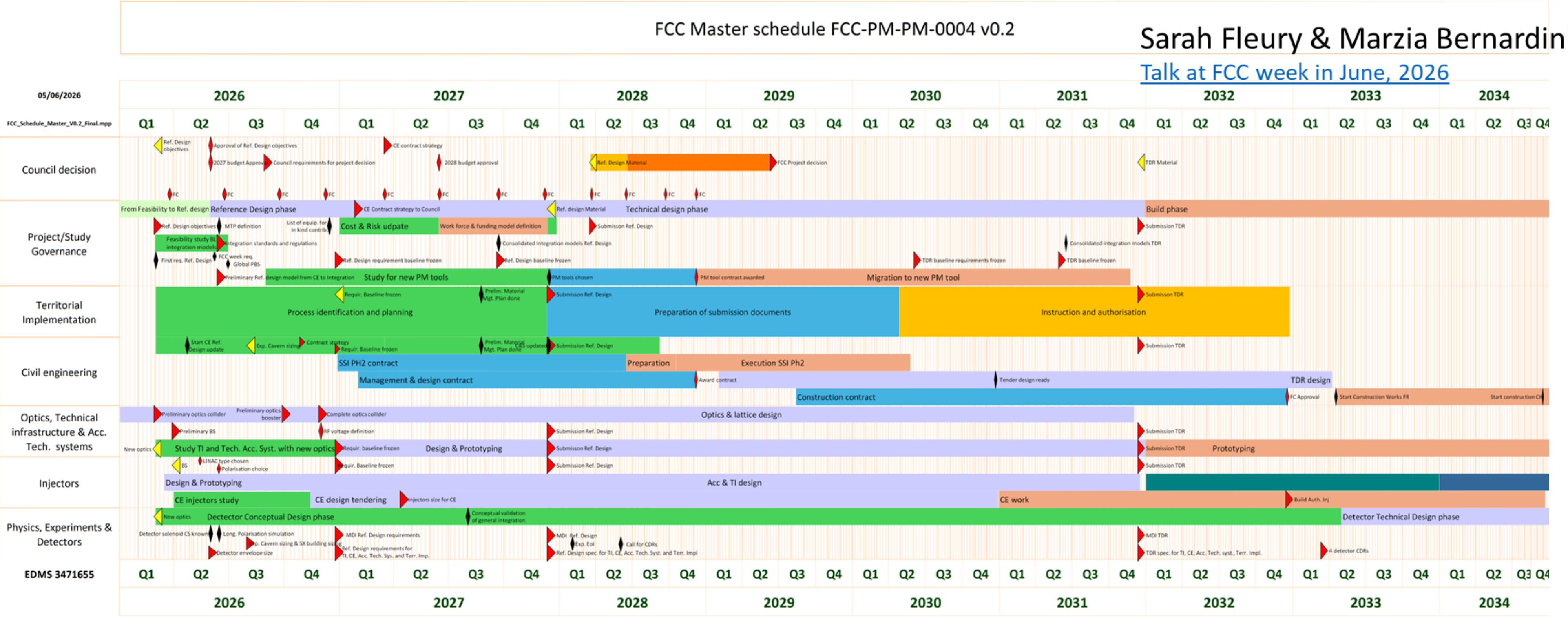
FCC-ee has wider physics coverage than higher energy linear options

CERN-EPPS, FCC: status & plan

EPPS timeline

Sarah Fleury & Marzia Bernardini

Talk at FCC week in June, 2026



- CERN管理层在未来两年提交年度报告。
- 理事会计划在2028-2029年做决定。
- 2032年开建，2046年运行。

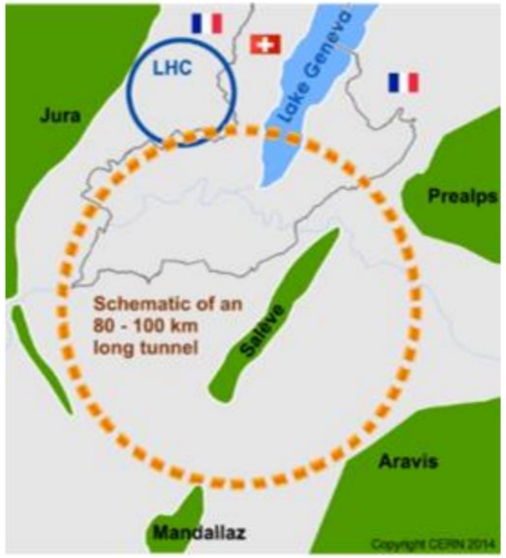
CERN-EPPS, FCC: status & plan

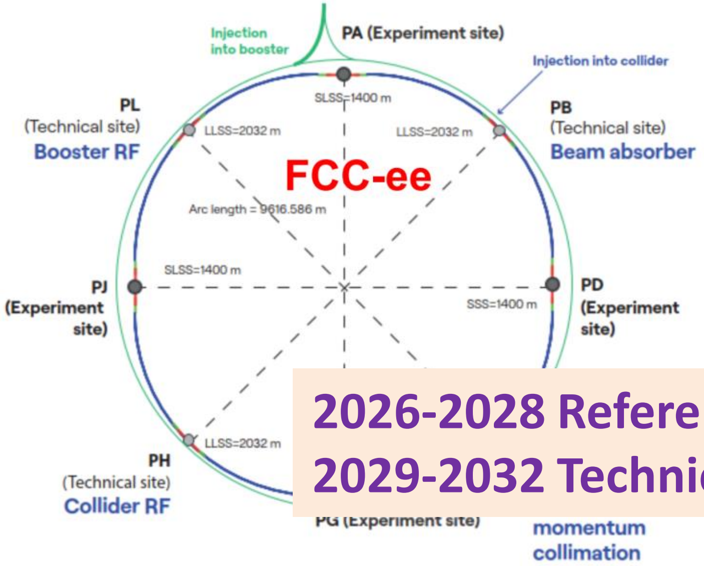
Future Circular Collider – scope

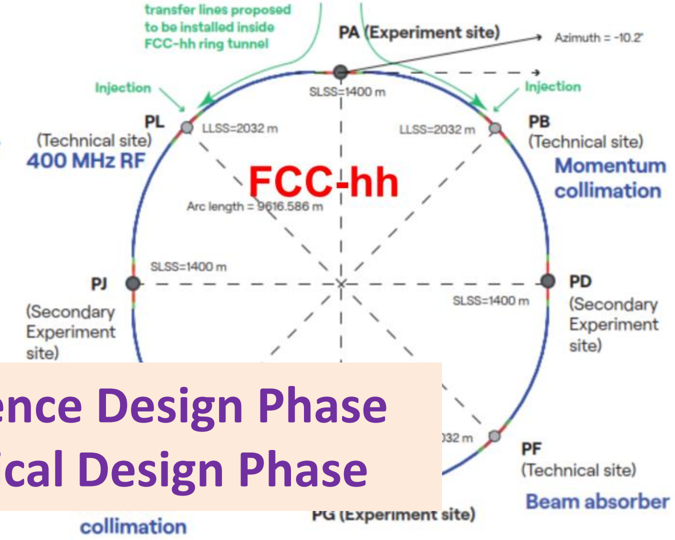
FCC-ee (Z, W, H, $t\bar{t}$): Higgs factory, electroweak & top factory at highest luminosities

FCC-hh (~100 TeV) as potential second step: energy frontier, pp & AA collisions; e-h option

- focus on implementation of FCC-ee as first step ; possible pathway to FCC-hh to be decided later
- Common civil engineering and technical infrastructures, building on and reusing CERN's existing infrastructure
- highly synergetic and complementary physics programme maximising the physics opportunities
- FCC-ee project would allow the start of a new, major facility at CERN within a few years of the end of HL-LHC







2026-2028 Reference Design Phase
2029-2032 Technical Design Phase

2020 - 2045 | 2048 - 2062 | ~2075 ?

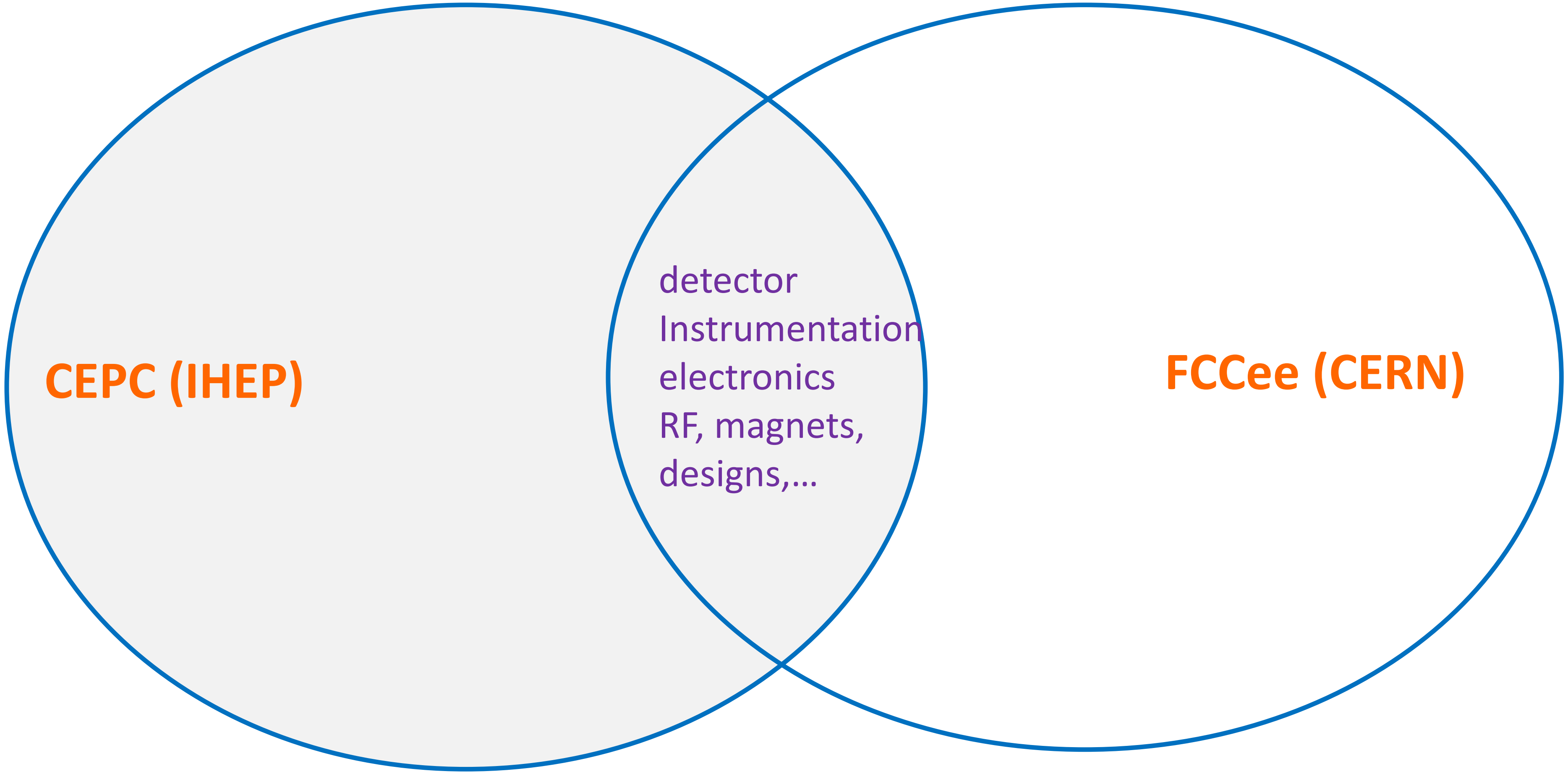
与CERN-FCC合作 - Collaboration with CERN-FCC

计划，发展，未来, …

plan and future development

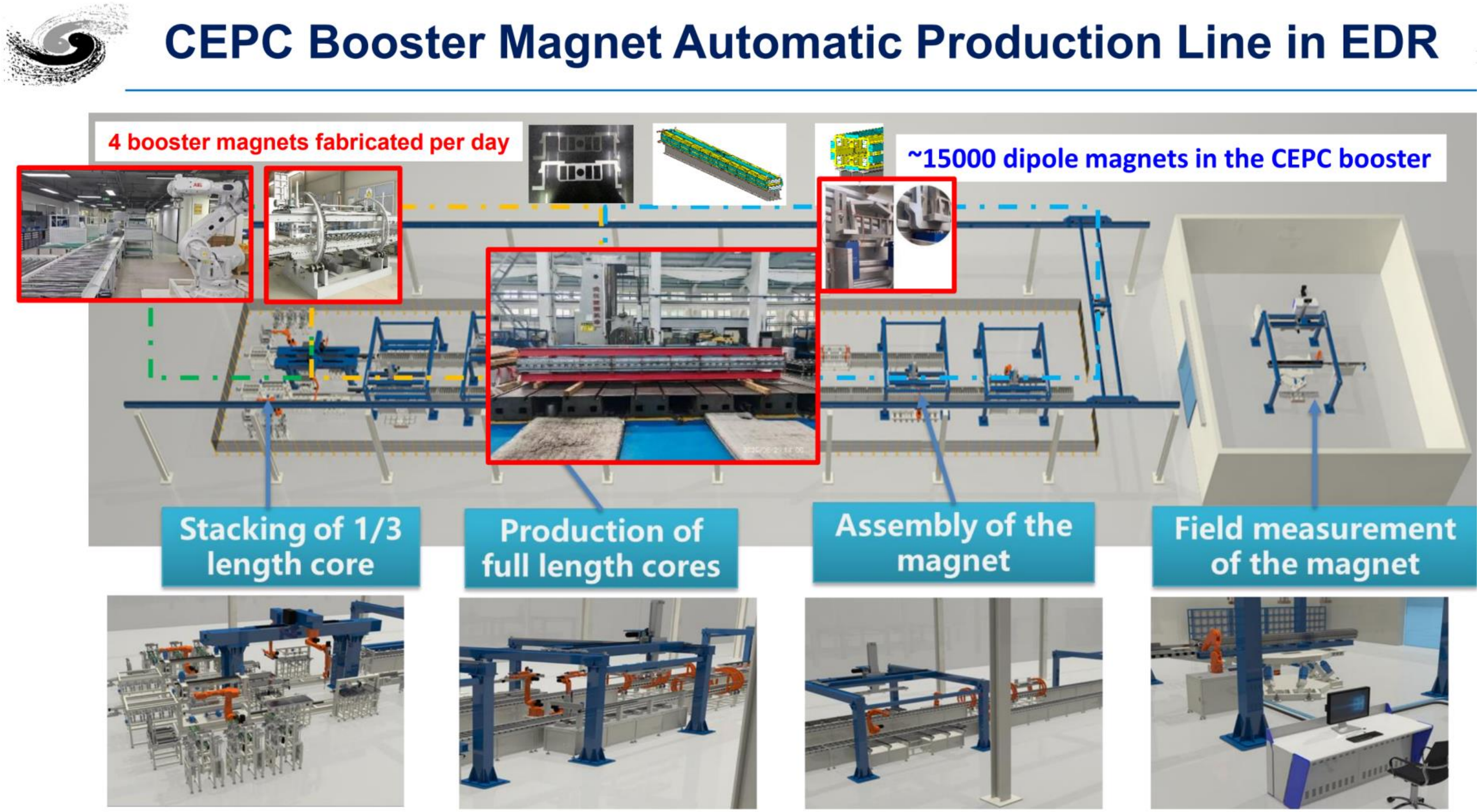
Collaboration with CERN-FCC

Two high energy circular e+e- colliders under-going design + R&D over the past ~14 years
Synergies and collaboration exist all along



Collaboration with CERN-FCC

Many accelerator-collider expertizes developed with CEPC are highly beneficial to FCCee



Collaboration with CERN-FCC

Many accelerator-collider expertizes developed with CEPC are highly beneficial to FCCee

The main components of vacuum oven for NEG coating have been manufactured and under are now being assembled.

Collaboration with CERN-FCC

Active R&D and collaborative efforts

- Active R&D continues in many fronts (not only on the detector elements mentioned in this talk)
  - International collaboration exists in most sub-detectors, but all activities have plenty of space and are eager for extra manpower
    - Vertex detector, Silicon trackers, TPC, Drift chamber, Calorimeters, Muon detector
  - One main goal is to adapt the concept to the challenges posed by the higher event rates
- Active member of the ECFA DRD program

Sub-system	DRD	Sub-system	DRD	Sub-system	DRD
Pixel Vertex Detector	3	Electromagnetic Calorimeter	6	Superconducting Solenoid	
Inner Silicon Tracker	3	Hadron Calorimeter	4, 6	Mechanical and Integration	8
Outer Silicon Tracker	3	Machine Detector Interface	8	General Electronics	**7**
Gas Tracker (TPC / DC)	1	Luminosity Calorimeter		Trigger and DAQ	**7**
Muon Detector	1 (RPC)	Fast Luminosity Monitor	3	Offline Software	Key4hep

不全面的统计

- Looking forward to extensive collaboration with FCC-ee Physics, Experiments, and Detector group, not only in AGORA but across the full program

21

Collaboration with CERN-FCC

A grass root meeting

DRD Round Table
7:00-9:00pm
Monday, July 13
Shenzhen Hall

Collaboration with CERN-FCC

AGORA at FCC-ee: From CEPC Baseline to High-Luminosity Operation

CEPC → FCC-ee: Key Differences

CEPC Baseline TDR	FCC-ee Plan A
12.1–30 MW SR 2 IPs, 100 km	50 MW SR power 4 IPs, 91 km

- FCC-ee operates at 50 MW SR power:
  - CEPC baseline: 12.1–30 MW, 50 MW only as upgrade goal)
  - Z pole luminosity:
    - 192×10^{34} cm^{-2}s^{-1} (FCC) vs 50×10^{34} (CEPC upgrade) — factor ~4 higher
  - Different MDI interface, beam parameters, civil engineering constraints

FCC-ee targets four EoIs for detectors by end 2028

AGORA aims to be one of the selected proposals

Critical R&D for FCC-ee Compatibility

- TPC at high rate: space-charge distortions, ion back-flow → double-mesh MicroMegas, graphene cathode
- MDI re-optimization: final focus, background simulations for FCC-ee conditions
- Electronics: clock and bunch crossing rate adaptation; COFFEE2/CHiR for ITK, LATRIC multi-channel scaling
- Glass scintillator: light yield ~1500 ph/MeV (vs BGO 7500), attenuation length ~6 cm — needs improvement
- BGO ECAL: 24 m³ crystals, 571k channels, SiPM mass production — engineering runs 2026–2028
- Software: CEPCSW (Gaudi) → FCC Key4HEP, Gaussino, adapt digitization and background mixing
- RICH: forward Cherenkov for PID, complementing TPC+OTK

AGORA's Advantages

- Only concept with complete TDR, engineering details, and validated cost estimate (333 MCHF)
- Unique glass scintillator HCAL + BGO crystal ECAL — highest BMR performance (3.87%)
- Advanced PID: dN/dx (TPC) + ToF (OTK, 50 ps) + RICH (forward) — K/π > 3σ to 20 GeV
- Active in ECFA DRD 1,3,4,6,7,8; ~50 domestic + ~40 international institutes; open to collaboration

Collaboration with CERN-FCC

FCC Week 2026 — Helsinki: Key Outcomes & AGORA Integration

CERN Council Decision (22 May 2026)

- FCC-ee adopted as next CERN flagship — 24/25 Member States support; integrated ee + hh programme as long-term vision
- Funding mandate: 860 M€ private donors secured; 3 B€ in EU MFF 2028–2034; ~4–5 BCHF needed outside CERN budget
- Target: final Council decision on FCC-ee by 2028-2029
- HL-LHC LS3 started 29 June 2026; HL-LHC operation ~2030–2041
  - FCC approval linked to success of HL-LHC upgrade
- Governance: informal Council retreat in Tallinn (Feb 2027) to discuss financial and governance models

- 6 key areas: technical maturity, civil engineering, risk reduction, international collaboration, cost, procurement
- Deliverables by Q1 2028: integrated baseline, master schedule, cost estimate, risk register
- Construction start ~2032/33, operations ~2045–48; new FCC Project Office established at CERN
- EoI call: at least 4 documented EoIs for FCC-ee experiments by end 2028
- LCC optics: 10% SR power reduction (45 MW), larger dynamic aperture, modular insertions

AGORA at FCC Week & Next Steps

- AGORA presented to FCC-ee community as new detector concept — 6 concepts now active (AGORA, IDEA, ILD, CLD, ALLEGRO, ALFA)
- Will be added to FCC-PED mailing lists, Indico pages, and working groups
- Re-baseline detector design for FCC-ee conditions: MDI, backgrounds, rates
- Consolidate designs within FCC framework, build international cooperation
- Join FCC-ee PED working groups: Tracker & PID, Calorimetry, Muon, Magnet, TDAQ, Luminometry

CEPC Study Group Plan & Funding

- CAS did not support CEPC submission for 15th Five-Year Plan
- IHEP will resubmit proposal for 16th Five-Year Plan (2030) unless FCC approved
- Funding support:
  - Multiple NSFC grant applications in 2026; new MOST5 project (2026–2031) on AC-LGAD, glass scintillator, SiPM, readout ASICs

- Next CEPC workshop: Shanghai, October 22–26, 2026

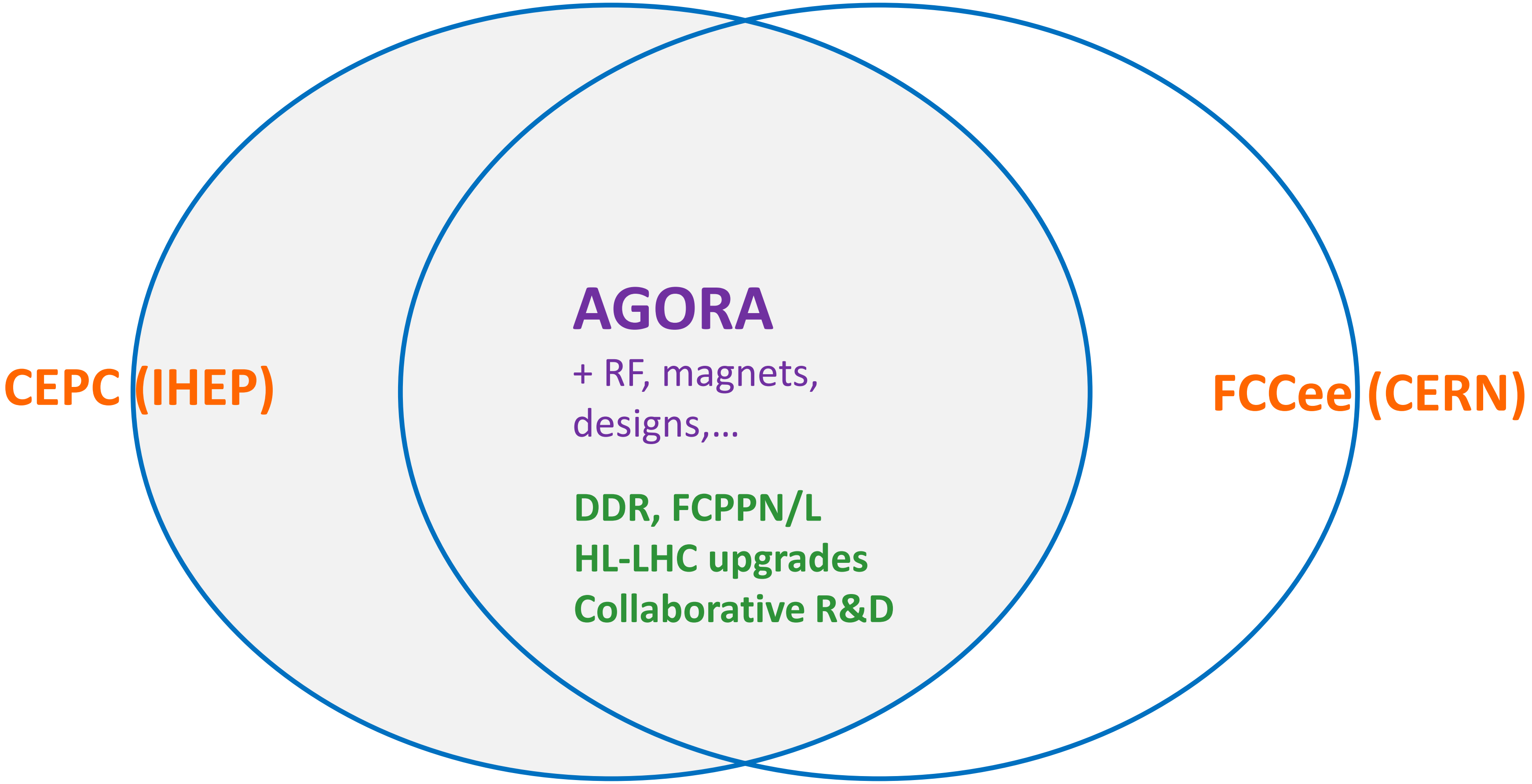
Collaboration with CERN-FCC

To forge collaboration at high level

Much work to be done

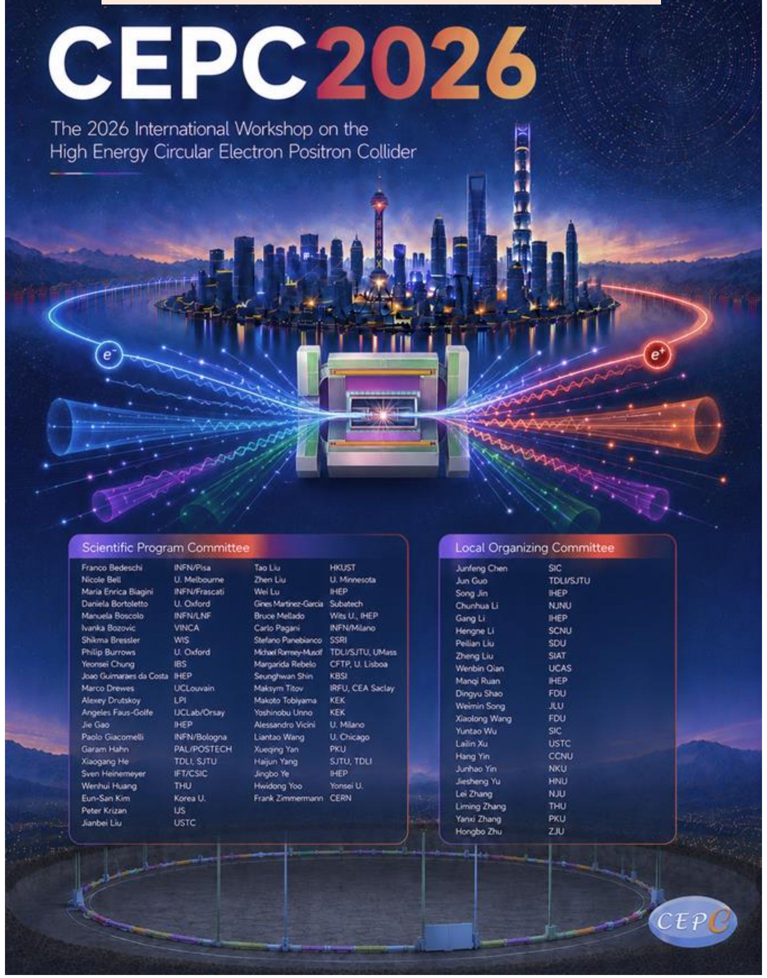
Collaborate with CERN-FCC

- **going forward, intensified collaboration with FCC will position the FCC project optimally for ultimate realization at CERN ;**
- **making AGORA a great detector for the FCC**



Future CEPC workshops

2026 intl. CEPC workshop
Shanghai, October 22-26



https://indico.ihep.ac.cn/event/28911/

2027 EU CEPC Workshop
Belgrade, Serbia
June 8-11, 2027

Please join us in person or online

Summary

- The CEPC team has made great effort to reach advanced design and technical levels in the last 12 years; though CEPC was not supported by CAS for 15th FYP; IHEP will continue to develop CEPC and advance the technology development
- will carry out technical validations, pursue new technologies, and enhance the AGORA design and international collaborations
- There is an updated roadmap and sets of goals; the CEPC team will collaborate actively with/in the FCC, making AGORA compatible and a great detector with the FCCee collider
- many wonderful opportunities for young scientists to work on frontier technologies and to become area experts-leaders.

谢谢！
Thank you!

Acknowledgements

- CEPC team's hard work, very fruitful international and CIPC collaborations have been critical to the CEPC program
- Special thanks to CEPC IB, SC, IAC, IARC and **IDRC** committees for their critical advices, suggestions and supports
- Funding agencies, local government, CAS and IHEP for their financial supports

AGORA - Detector performance highlights

Physics Briefing Book ESPP

Goals of many DRD Detector groups

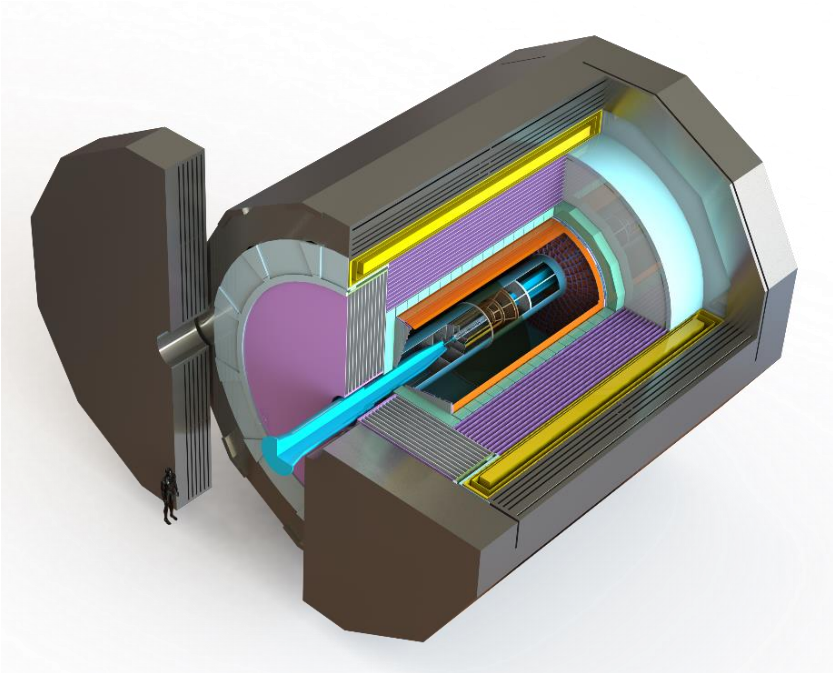
Performance indicator	Requirement	Physics motivation
Vertex hit resolution and material budget	$\approx 3\,\mu$m; $\approx 0.1\%\ X_0$ per layer	B-meson, Higgs-boson and τ lepton physics
Momentum resolution	$\sigma(p_T)/p_T \approx 2\times10^{-5}\cdot p_T(\mathrm{GeV})\oplus 0.2\%$	$\delta M_H = 4\,\mathrm{MeV};\ \delta M_Z = 15\,\mathrm{keV}$
ECAL	$\sigma(E)/E \approx \mathrm{few}\%/\sqrt{E(\mathrm{GeV})}$ and high granularity	B-meson, τ and EW physics, π^0 and γ reconstruction
Jet energy resolution	$\approx 30\%/\sqrt{E(\mathrm{GeV})}$	Higgs and multi-jet events
Magnetic field stability/mapping	better than 10^{-6}	Point-to-point energy uncertainty in $\delta\Gamma_Z$
Timing resolution	tens to 100 ps per track	Particle identification; δM_{HNL}
Particle identification	>3 standard deviation π–K separation 1 GeV to 30 GeV; standalone muon ID	$H\to s\bar{s}$; $b\to s\nu\bar{\nu}$; long-lived particle searches
Luminosity detector alignment	Position along beam line: $\delta z = 110\,\mu$m; Inner radius: $\delta R_{\min} = 1\,\mu$m	$\delta\mathscr{L} = 10^{-4}$ from Bhabha events at the Z pole energy
Data acquisition and trigger	50 MHz trigger rate and up to 25 $\mathrm{Gbit\,s^{-1}}$ module readout	Processing of beam-induced backgrounds at the Z pole

CEPC Ref. Detector TDR

Many achieved, to be enhancement

Tracking efficiency	Tracking σ_{pT}	Vertexing $\sigma_{x,y,z}$	π-k separation	EM resolution	BMR
>99.7% (for p>1 GeV)	~0.1% for majority	< 3.5 μm	3σ (1-20 GeV)	$2\%/\sqrt{E}\oplus 0.5\%$	3.87% (H->gg)

Post-TDR R&D Activities



- Prototyping individual detectors already started and will continue with all subsystems
- The prototypes will be integrated into a full-scale slice system to evaluate their performance under realistic and integrated operating conditions
- Detector in the Ref-TDR is not the final design. We will continue pursuing better technologies in the following years for the two final detectors

System	Technologies	
	Baseline (Ref-TDR)	Alternative
Beam pipe	Φ20 mm	
LumiCal	SiTrk + LYSO ECAL	SiTrk + SiW ECAL
Vertex	CMOS + Stitching	CMOS Si Pixel
Tracker	CMOS Si Pixel ITK	SSD + RO Chip, CMOS SSD
	Pixelated TPC	PID Drift Chamber
	AC-LGAD OTK	SSD / SPD OTK
		LGAD ToF
ECAL	4D Crystal Bar	Stereo Crystal Bar, GS+SiPM, PS+SiPM+W, SiDet+W
HCAL	GS+SiPM+Fe	PS+SiPM+Fe, RPC+Fe, MPGD+Fe
Magnet	LTS	HTS
Muon	PS bar+SiPM	RPC, μ-Rwell
TDAQ	Semi-Conventional	Software Trigger
BE electr.	Common	Independent

The AGORA detector – making it work at FCC and CEPC(Z)

Technical Challenges

- **CEPC → FCC-ee pivot**: MDI, final focus, background simulations must be re-optimised for FCC-ee conditions
- **Glass scintillator HCAL**: light yield only ~1500 ph/MeV (vs BGO 7500), attenuation length ~6 cm, slow decay (500 ns)
- **BGO ECAL scale-up**: 24 m^3 of crystals, 571k channels — mass production, quality control, SiPM cooling
- **TPC at Z pole**: ion back-flow from space charge; needs double-mesh Micromegas or graphene-coated cathode
- **Software migration**: CEPCSW (Gaudi) → full FCC Key4HEP; adapt digitisation and background

Project & Collaboration Challenges

- **Designed for CEPC, not FCC-ee** — the largest conceptual challenge
- Different MDI interface, beam parameters, civil engineering constraints
- Electronics clock, bunch crossing rate
- Re-baselining requires some effort
- Must pivot physics goals from CEPC to FCC-ee