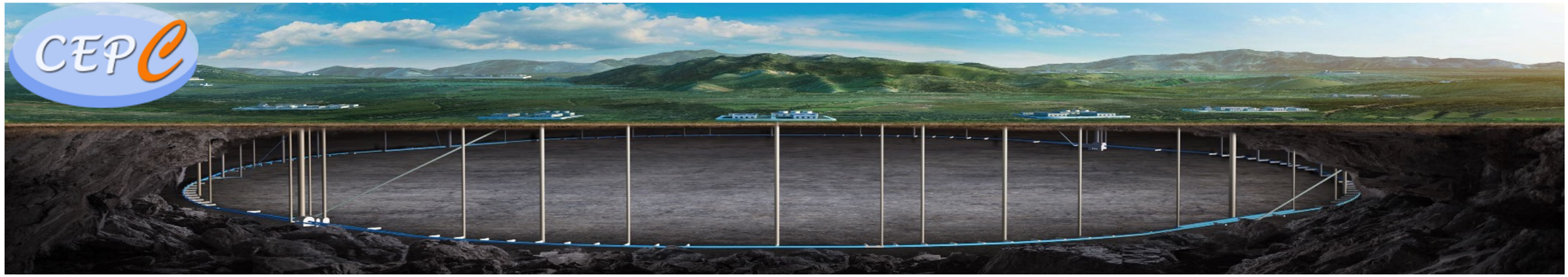
News from the Circular Electron Positron Collider (CEPC) project

Higgs factory from China



Yanyan Gao

University of Edinburgh

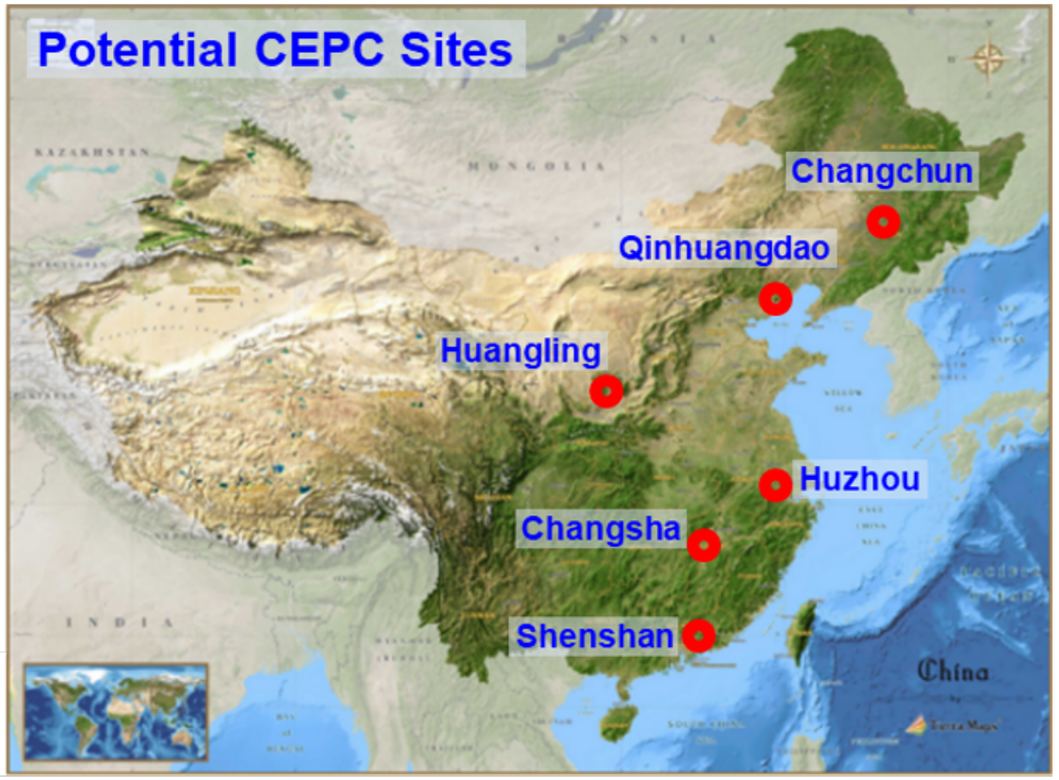
Particle Physics Advisory Panel Meeting, Birmingham, 7-July 2023

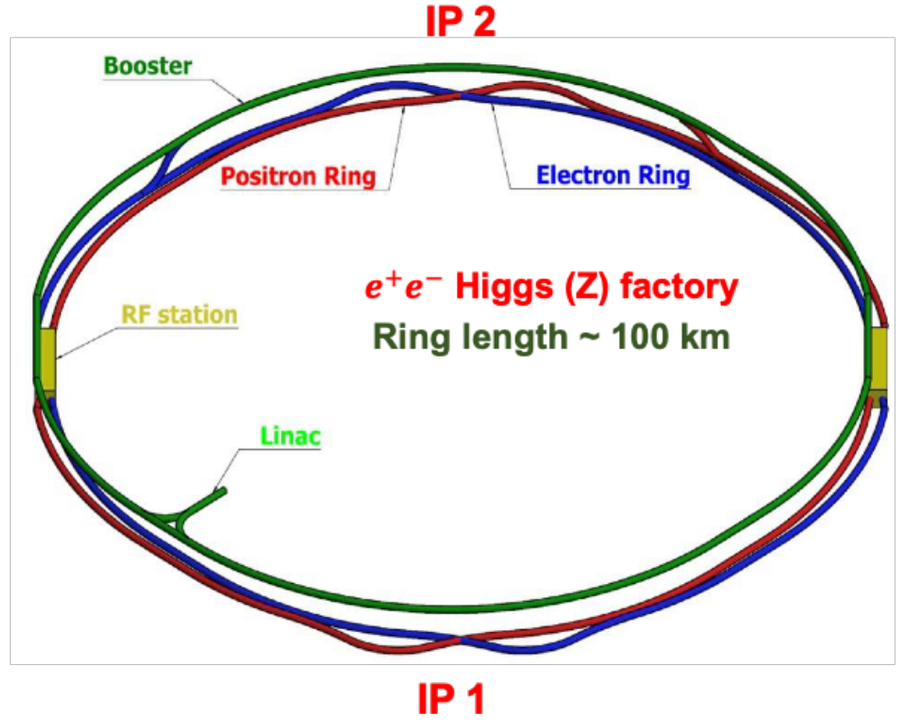
The 2023 CEPC workshop in Edinburgh 3-6 July

https://indico.ph.ed.ac.uk/event/259/

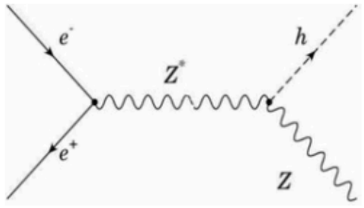
Lightening introduction

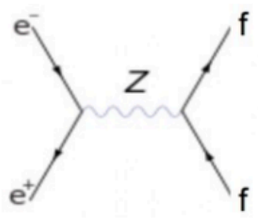
- The CEPC was proposed around 2012 as a Higgs factory in China
  - pre-CDR released in 2015
  - Accelerator and detector CDR released in 2018
  - Accelerator TDR has completed
    - Successful international review: June 2023
    - Costing review scheduled in Sep 2023
- Latest operation plan includes *Higgs/Z/WW/ ttbar* running to maximise physics sensitivity
  - 10 years Higgs, 2 years Z, 1 year WW, 5 years ttbar
- Possible pp collider (SppC) of $\sqrt{s}$ ~ 50–100 TeV in the far future

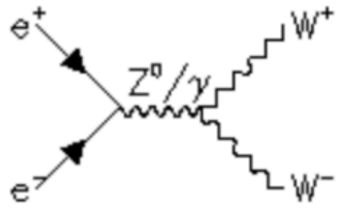


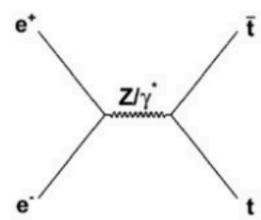


CEPC physics program









Operation mode		ZH	Z	W^+W^-	$t\bar{t}$
$\sqrt{s}$ [GeV]		240	91	160	360
Run time [years]		7	2	1	-
CDR (30 MW)	L / IP [$\times 10^{34}$ cm^{-2}s^{-1}]	**3**	**32**	**10**	-
	$\int L\,dt$ [ab^{-1}, 2 IPs]	5.6	16	2.6	-
	Event yields [2 IPs]	1×10^6	7×10^{11}	2×10^7	-
Run Time [years]		10	2	1	5
TDR (Latest) 30 MW	L / IP [$\times 10^{34}$ cm^{-2}s^{-1}]	**5.0**	**115**	**16**	0.5
	$\int L\,dt$ [ab^{-1}, 2 IPs]	13	60	4.2	0.65
	Event yields [2 IPs]	2.6×10^6	2.5×10^{12}	1.3×10^8	4×10^5
TDR (Latest) 50 MW	L / IP [$\times 10^{34}$ cm^{-2}s^{-1}]	**8.3**	**192**	**26.7**	**0.8**
	$\int L\,dt$ [ab^{-1}, 2 IPs]	21.6	100	6.9	1.0
	Event yields [2 IPs]	4.3×10^6	4.1×10^{12}	2.1×10^8	6×10^5

- **The centerpiece: precise measurement of the Higgs boson properties (width, couplings, mass …)**
- **huge measurement potential for precision tests of SM: electroweak physics, flavor physics, QCD**
- **Searching for exotic or rare decays of H, Z, B and τ, and new physics**
- **Top quark physics**

An extremely versatile machine with a broad spectrum of physics opportunities
→ Far beyond a Higgs factory

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From Jianbei Liu's talk

CEPC current plan and schedule

From Yuhui Li's CEPC overview talk

A CAS committee currently evaluates major accelerator options in China

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

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

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

Input from director of IHEP Yifang Wang

- *CEPC projects welcomes and values international collaboration*
- *International collaboration is considered key to the success of the fund application*
- *China has, and will continue to, contribute to other global particle physics projects*

Scope of UK involvement

- Scope of UK involvement is challenging especially the interplay with FCC
  - The scientific potential and timescale makes CEPC an important project for the UK PP community
    - *Personal opinion: we can not afford to only get involved after the project is committed and funded*
- The level of international funding depends on the machine/detector parameters
  - China is pursuing very ambitious R&D programme in nearly all areas of accelerator/detector R&D
  - *International contribution has always been identified crucial and essential*. This is an area also UK can in principle make a huge contribution with modest input
- Several groups have expressed interests and started in collaboration work on generic detector R&D that can be used for both CEPC and FCC-ee
  - There is an opportunity to get also involved with accelerator R&D

Initial input submitted to PPAP in Nov 2020

The CEPC Input to the Particle Physics Advisory Panel[1]

Adrian Bevan[a], Véronique Boisvert[b], Daniela Bortoletto[c], Jens Dopke[d], Brian Foster[c], Harald Fox[e], Yanyan Gao[f], Tim Jones[g], Roy Lemmon[h], Bill Murray[i], Fabrizio Salvatore[j], Craig Sawyer[d], Ian Shipsey[c], Jaap Velhuis[k], Trevor Vickey[l], Iacopo Vivarelli[j]

a) contact person representing Queen Mary University London
b) contact person representing Royal Holloway University of London
c) contact person representing University of Oxford
d) contact person representing STFC RAL and STFC Particle Physics Division
e) contact person representing University of Lancaster
f) contact person representing University of Edinburgh
g) contact person representing University of Liverpool
h) contact person representing STFC Daresbury Lab
i) contact person representing University of Warwick
j) contact person representing University of Sussex
k) contact person representing University of Bristol
l) contact person representing University of Sheffield

Additional material

CEPC operation plan

Particle	$E_{c.m.}$ (GeV)	Years	SR Power (MW)	Lumi. per IP ($10^{34}cm^{-2}s^{-1}$)	Integrated Lumi. per year (ab^{-1}, 2 IPs)	Total Integrated L (ab^{-1}, 2 IPs)	Total no. of events
H*	240	10	50	8.3	2.2	21.6	4.3×10^6
			30	5	1.3	13	2.6×10^6
Z	91	2	50	192**	50	100	4.1×10^{12}
			30	115**	30	60	2.5×10^{12}
W	160	1	50	26.7	6.9	6.9	2.1×10^8
			30	16	4.2	4.2	1.3×10^8
$t\bar{t}$	360	5	50	0.8	0.2	1.0	0.6×10^6
			30	0.5	0.13	0.65	0.4×10^6

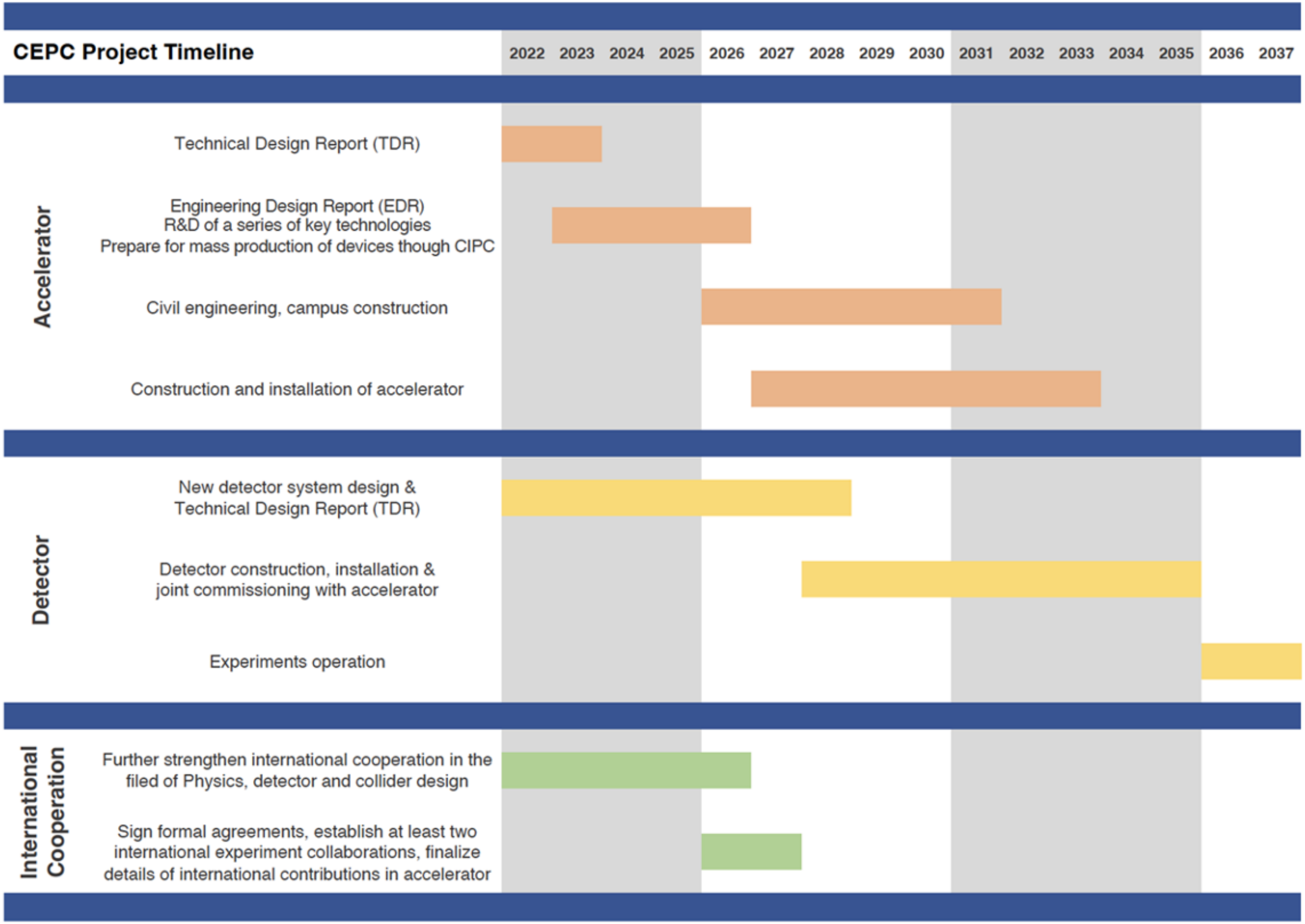
* Higgs is the top priority. The CEPC will commence its operation with a focus on Higgs.

** Detector solenoid field is 2 Tesla during Z operation, 3Tesla for all other energies.

*** Calculated using 3,600 hours per year for data collection.

From: Jie Gao's accelerator talk in the CEPC Edinburgh workshop

CEPC Projected timeline

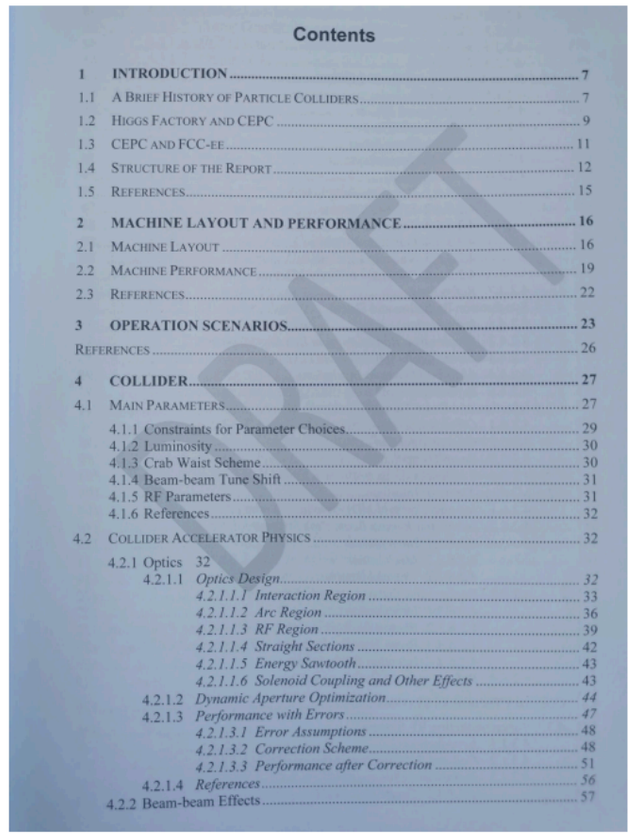


From Yuhui Li's CEPC overview talk

Milestone: accelerator TDR international review

CEPC Accelerator International TDR Review June 12-16, 2023 in HKUST-IAS, Hong Kong, China

https://indico.ihep.ac.cn/event/19262/timetable/



CEPC Accelerator International TDR Cost Review Sept. 11-15, 2023 in HKUST-IAS

2023-July-03 J. Gao | The 2023 International Workshop on CEPC (EU Edition) | 6

From: Jie Gao's accelerator talk in the CEPC Edinburgh workshop

Key accelerator parameters

The Evolution: from CDR to TDR

Main Parameters (30MW)

CDR（2018）

	Higgs	*W*	*Z（3T）*	*Z（2T）*
Number of IPs	2			
Circumference (km)	100			
Bunch number	242	1524	12000	
β function at IP β_x^* / β_y^* (m/mm)	0.36/1.5	0.36/1.5	0.2/1.5	0.2/1.0
Emittance $\varepsilon_x/\varepsilon_y$ (nm/pm)	1.21/3.1	0.54/1.6	0.18/4.0	0.18/1.6
Energy acceptance (%)	1.35	0.4	0.23	
Luminosity per IP ($10^{34}cm^{-2}s^{-1}$)	**2.93**	**10.1**	**16.6**	**32.1**

TDR（2023）

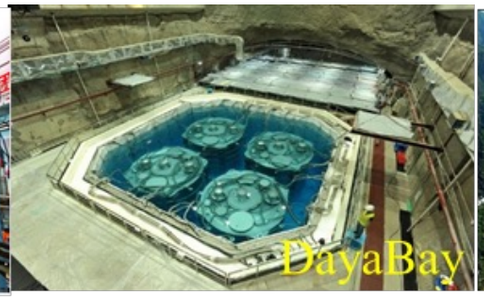
	Higgs	*W*	*Z (2T)*	*ttbar*
Number of IPs	2			
Circumference (km)	100.0			
Bunch number	268	1297	11934	35
β functions at IP β_x^*/β_y^* (m/mm)	0.3/1	0.21/1	0.13/0.9	1.04/2.7
Emittance $\varepsilon_x/\varepsilon_y$ (nm/pm)	0.64/1.3	0.87/1.7	0.27/1.4	1.4/4.7
Energy acceptance (%)	1.6	1.0	1.0	2.0
Luminosity per IP ($10^{34}cm^{-2}s^{-1}$)	**5.0**	**16**	**115**	**0.5**

Key technology R&D in TDR phase

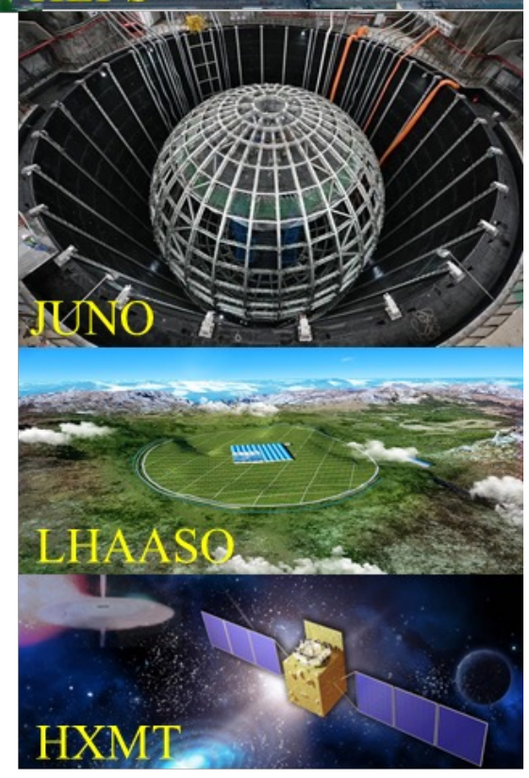
- **RF power supply and high efficiency klystron**
- **SRF cavities & modules (1.3G & 650MHz)**
- **Key components of the positron source**
- **High performance accelerator (S&C-band)**
- **Novel magnets: Weak field dipole, dual aperture magnets**
- **Injection/extraction**
- **Electrostatic deflector**
- **Vacuum chamber with NEG coating**
- **Instrumentation, Feedback system**
- **Cryogenic system**
- **Magnet power supply**

From: Jie Gao's accelerator talk in the CEPC Edinburgh workshop

Experiences for large-scaled facilities



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



From Yuhui Li's CEPC overview talk

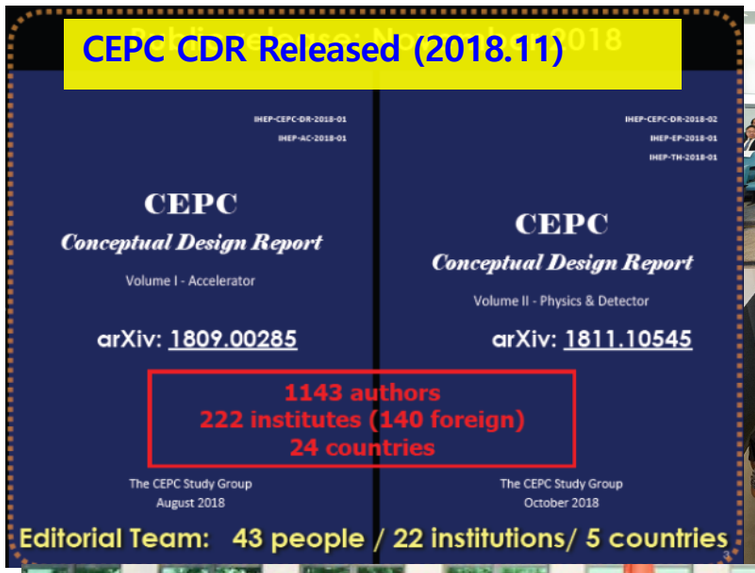
International collaborations

CEPC attracts significant International participation

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

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

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



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