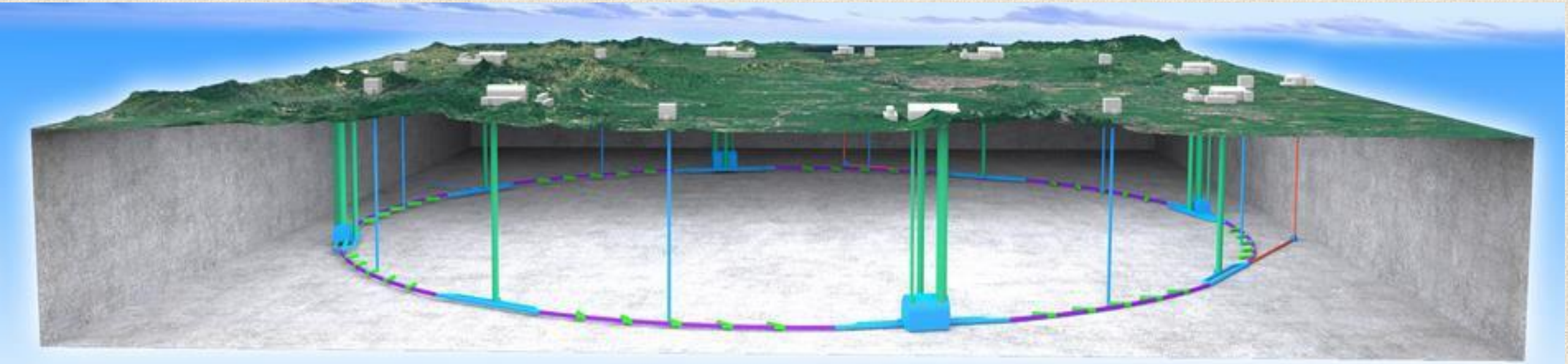
Status and Perspective of The CEPC

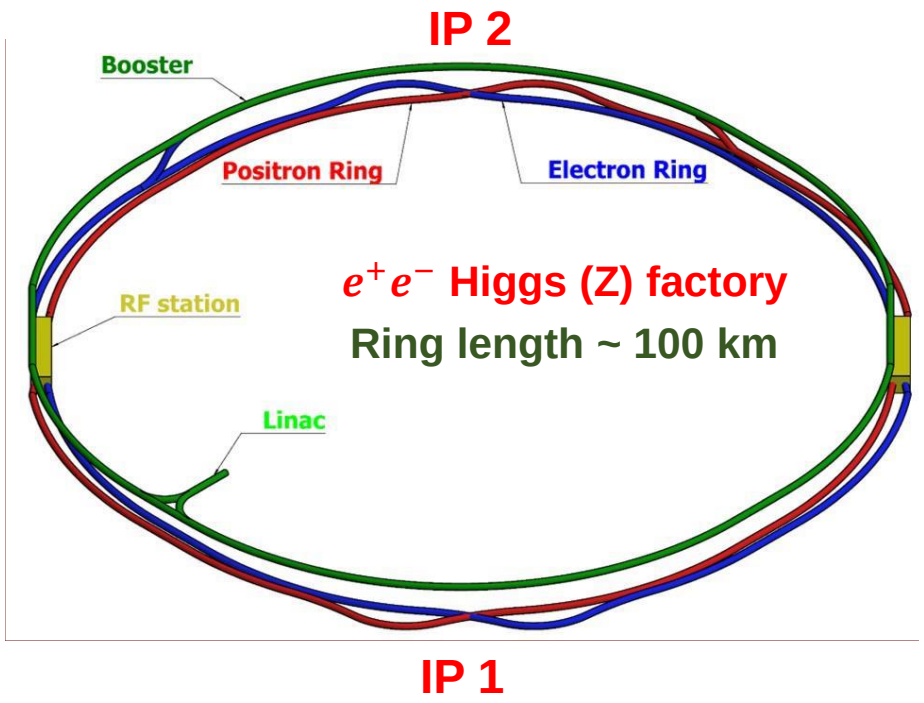
Jianchun Wang (IHEP, CAS)
For the CEPC Study Group

Mini-Workshop on HEP Collaboration
2024.10.24, Hangzhou

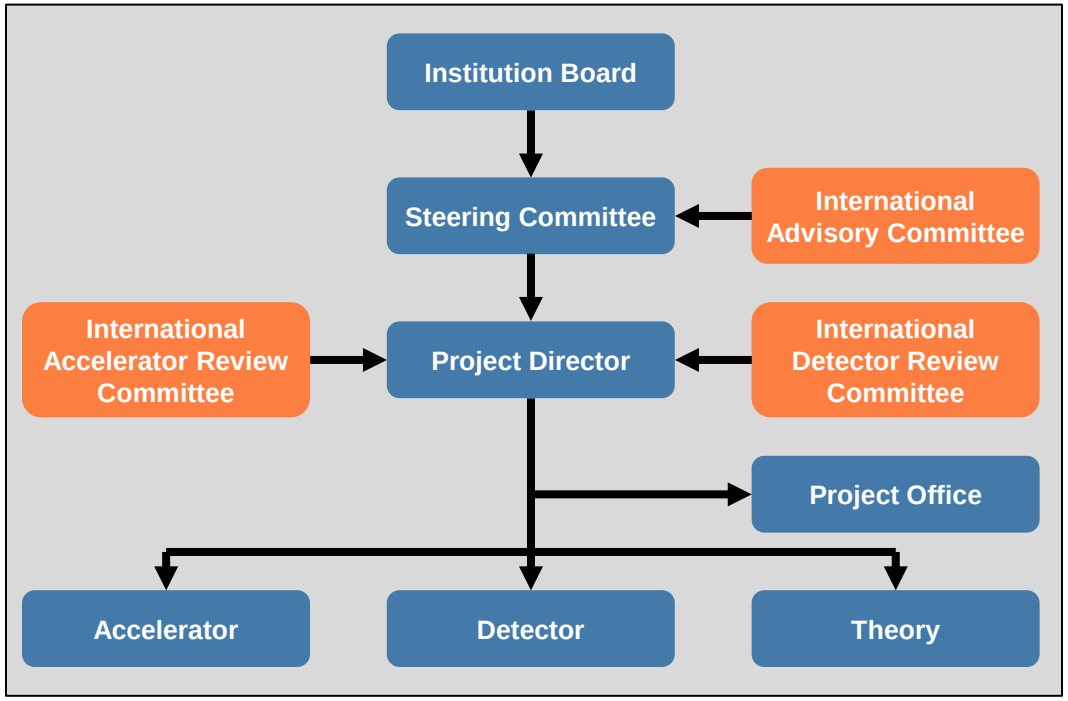


The Circular Electron Positron Collider (CEPC)

- The CEPC was proposed by the Chinese HEP community in 2012 right after the Higgs discovery. It aims to start operation in 2030s, as a Higgs / Z / W factory in China.
- To produce Higgs / W / Z / top for high precision Higgs, EW measurements, studies of flavor physics & QCD, and probes of physics BSM.
- It is possible to upgrade to a *pp* collider (SppC) of $\sqrt{s}$ ~ 100 TeV in the future.



International Efforts Towards Collaborative Experiments

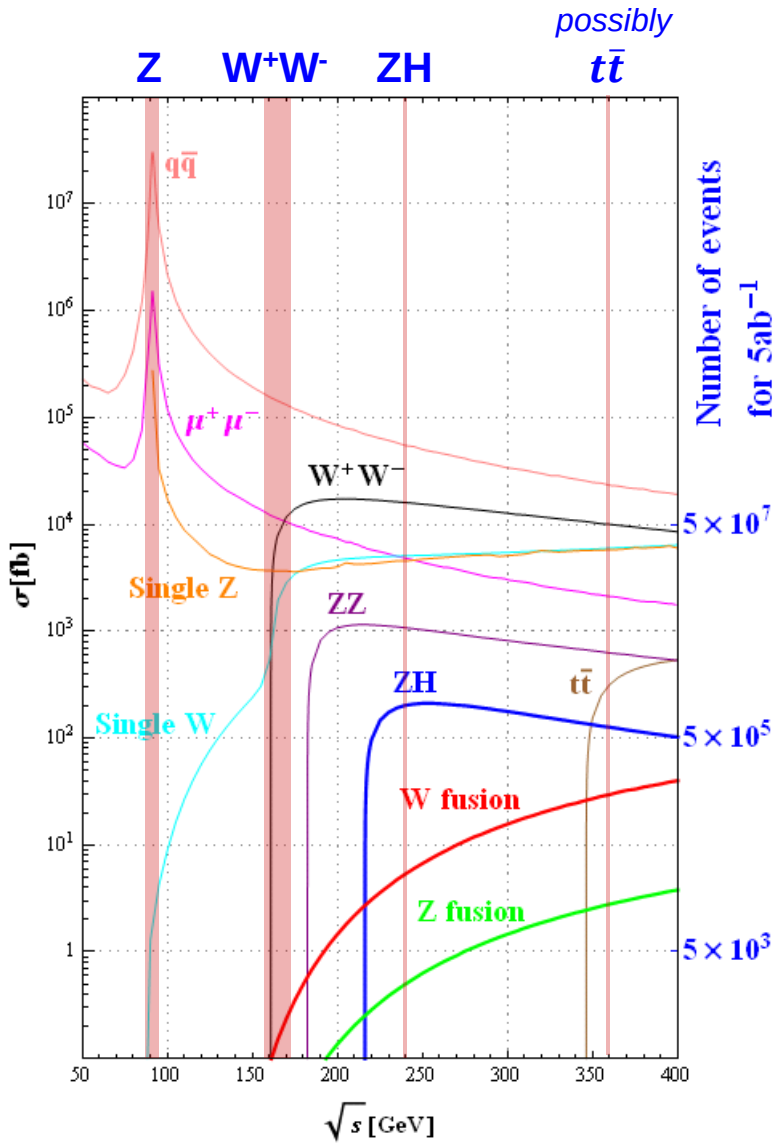


- Institution Board: 32 top domestic universities/institutes
- The International Advisory Committee (IAC) started in 2015, and held meeting yearly.
- Two international review committees for R&D: IARC and IDRC started in 2019.
- The CEPC study group consists of ~1/4 international members. We hope to boost up the rate.

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

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

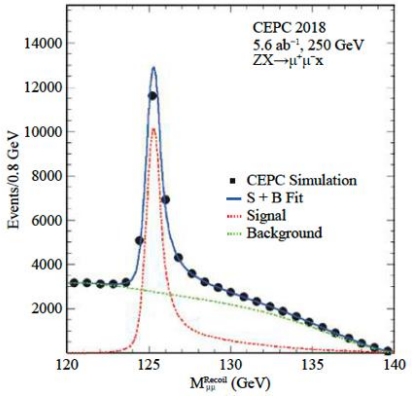
CEPC Operation Plan

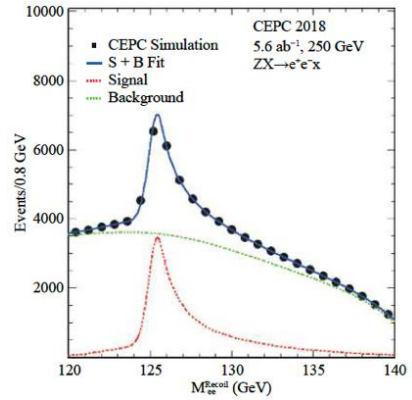


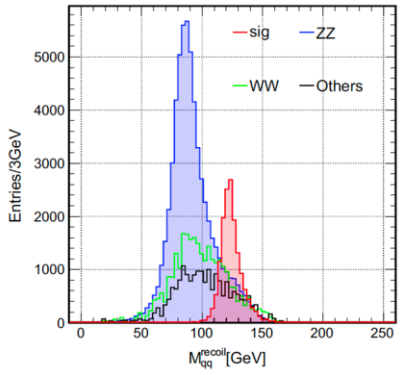
Operation mode		ZH	Z	W⁺W⁻	$t\bar{t}$
$\sqrt{s}$ [GeV]		~240	~91	~160	~360
Run Time [years]		10	2	1	~5
30 MW	L / IP [$\times 10^{34}$ cm^{-2}s^{-1}]	**5.0**	**115**	**16**	**0.5**
	$\int L\,dt$ [ab^{-1}, 2 IPs]	13	60	4.2	0.6
	Event yields [2 IPs]	2.6×10^{6}	2.5×10^{12}	1.3×10^{8}	4×10^{5}
50 MW	L / IP [$\times 10^{34}$ cm^{-2}s^{-1}]	**8.3**	**192**	**26.7**	**0.8**
	$\int L\,dt$ [ab^{-1}, 2 IPs]	22	100	6.9	1
	Event yields [2 IPs]	4.3×10^{6}	4.1×10^{12}	2.1×10^{8}	6×10^{5}

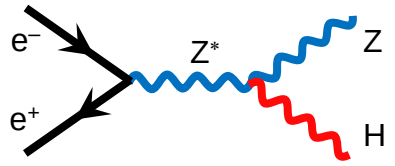
Both 50 MW and $t\bar{t}$ modes are currently considered as upgrades

Physics Opportunities @ CEPC









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Precision Higgs physics at the CEPC*

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CEPC Higgs White Paper

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+ *o*(100) journal/arXiv papers

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

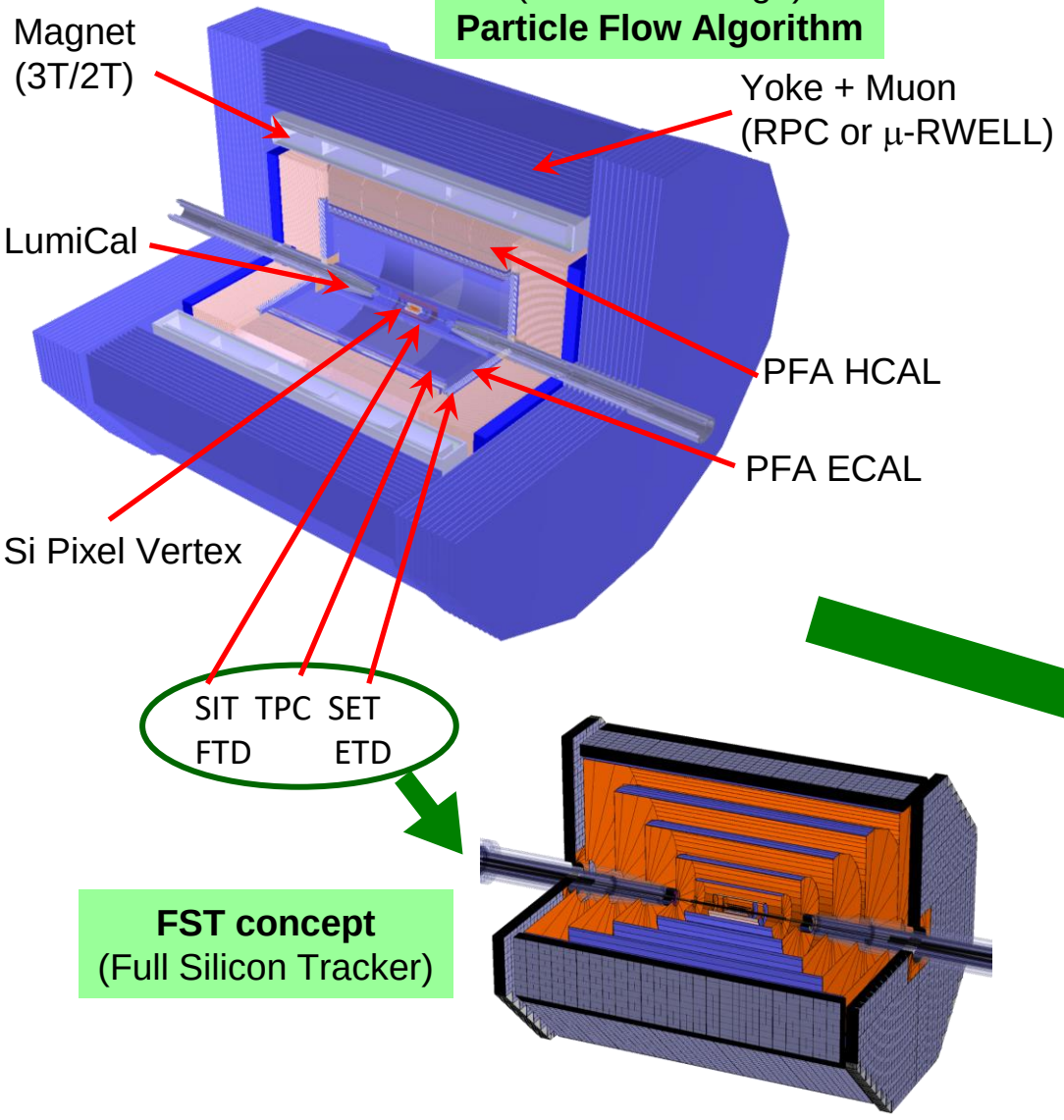
Higgs			W, Z and top		
Observable	HL-LHC projections	CEPC precision	Observable	Current precision	CEPC precision
M_H	20 MeV	3 MeV	M_W	9 MeV	0.5 MeV
Γ_H	20%	1.7%	Γ_W	49 MeV	2 MeV
$\sigma(ZH)$	4.2%	0.26%	M_{top}	760 MeV	$\mathcal{O}(10)$ MeV
$B(H \to bb)$	4.4%	0.14%	M_Z	2.1 MeV	0.1 MeV
$B(H \to cc)$	-	2.0%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

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

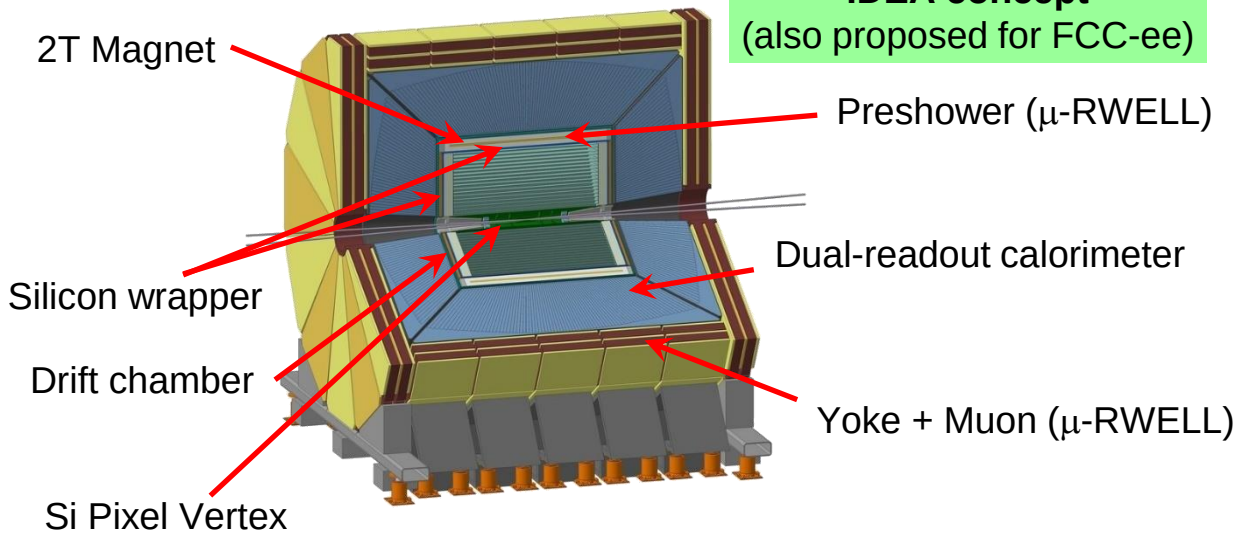
- Higgs: Precisions exceed HL-LHC ~ 1 order of magnitude
- EW: Precision improved from current limit by 1-2 orders
- Flavor Physics, sensitive to NP of 10 TeV or even higher
- Sensitive to varies of NP signal
- ...

Conceptual Detector Designs

(Baseline Design)
Particle Flow Algorithm

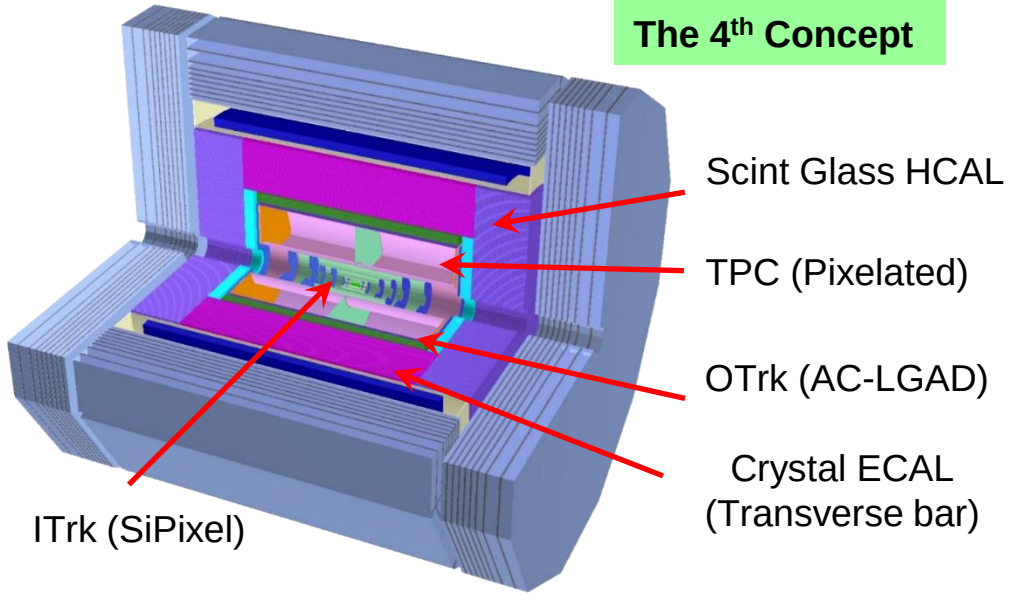


IDEA concept
(also proposed for FCC-ee)



FST concept
(Full Silicon Tracker)

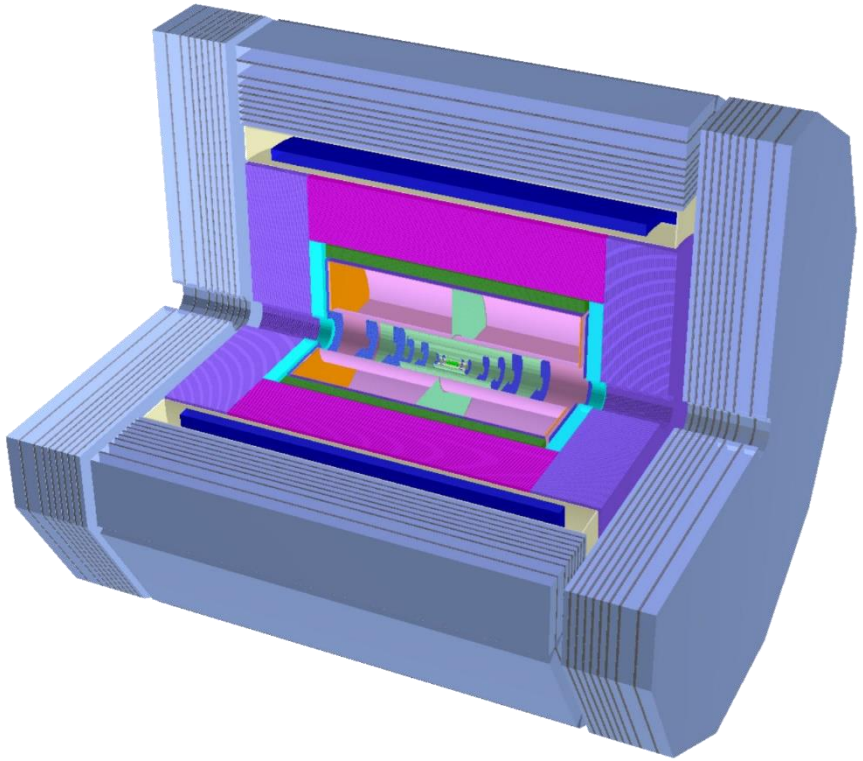
The 4th Concept



Technologies for Ref-TDR

System	Technologies		
Beam pipe	Φ20 mm		
LumiCal	SiTrk+Crystal		
Vertex	CMOS+Stitching	CMOS Pixel	
Tracker	SPD ITrk	CMOS Pixel	
	Pixelated TPC	PID Drift Chamber	
	AC-LGAD OTrk	SSD OTrk	SPD OTrk
		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
Magnet	LTS	HTS	
Muon	PS Bar+SiPM	RPC	
TDAQ	Conventional	Software Trigger	
BE electr.	Common	Independent	

R



- Prepare TDR of a reference detector, aiming for domestic endorsement, as recommended by the CEPC IAC
- Will continue to seek for better technologies, and decide the final detectors within the CEPC international collaborations

Baseline

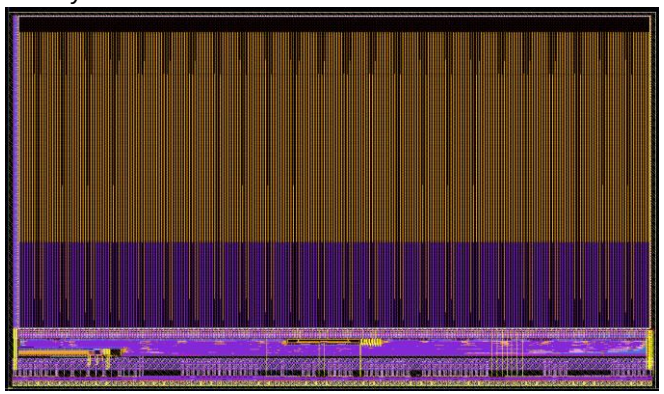
For Comparison

Silicon Pixel Vertex Detector

JadePix4

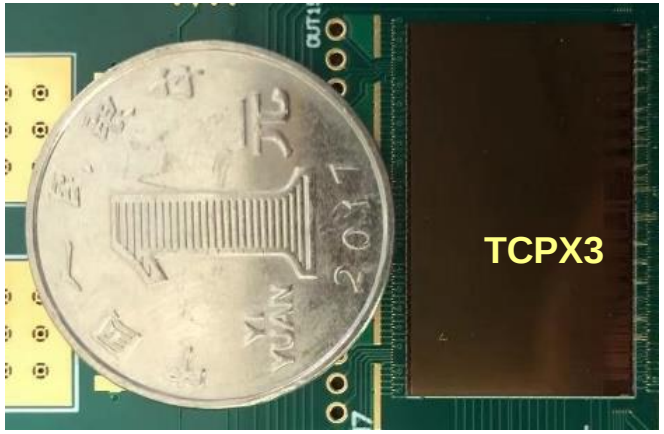
356×498 array of 20×29 μm^2

$\sigma_{x/y}$ ~ 3-4 μm, σ_t ~ 1 μs, ~100 mW/cm^2

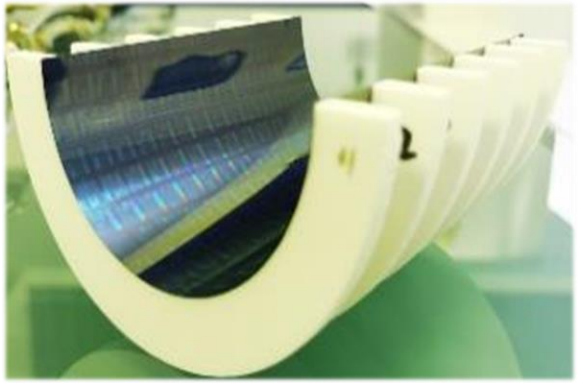


TaichuPix3

1024×512 array of 25×25 μm^2

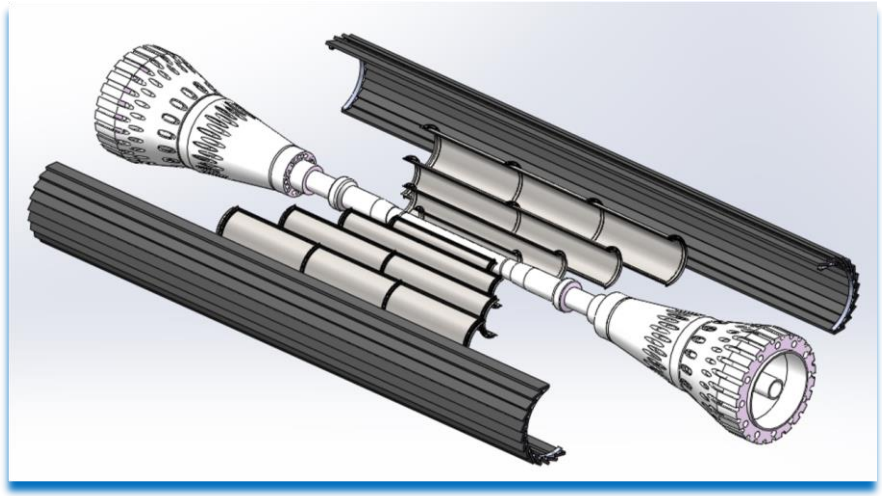


TowerJazz 180nm CIS process

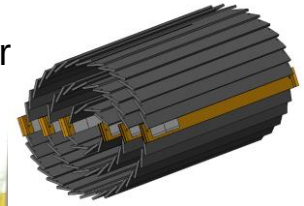


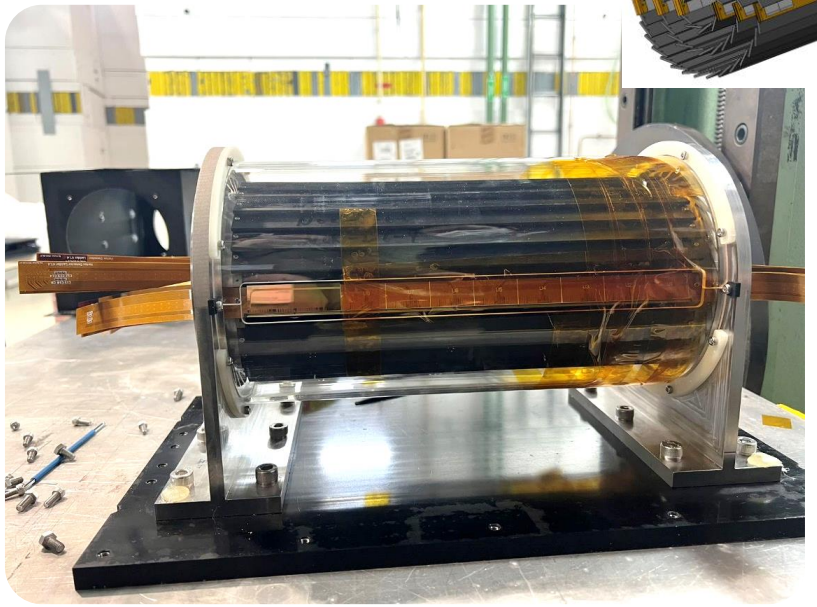
Looking into a stitching + curved MAPS technology.

This is similar to the ALICE ITS3, and could be a starting project for SUT.



A TaichuPix-based prototype detector was tested at DESY in April 2023





Goal: σ(IP) ~ 5 μm for high P

Key specifications:

- Single point resolution ~ 3 μm
- Low material (0.15% X_0 / layer)
- Low power (< 50 mW/cm^2)
- Radiation hard (1 Mrad/year)

International Workshops

- International workshops (with emphasis on the CEPC):
  - In China: Beijing (2017.11, 2018.11, 2019.11), Shanghai (2020.10 / hybrid), Nanjing (2021.11 / online, 2022.11 / online, 2023.10), **Hangzhou (2024.10)**
  - In Europe: Rome (2018.05), Oxford (2019.04), Edinburgh (2023.07), Marseille (2024.04), **Barcelona (2025.05)**
  - In USA: Chicago (2019.09), DC (2020.04 / online)
  - Annual IAS program on HEP (HKUST) since 2015. The upcoming one is between **January 13-17, 2025**
- Many topic-specific workshops at various sites. If the SUT group would like to host a workshop. Maybe it is better to start with a topic-specific workshop, and choose the topic of their expertise.