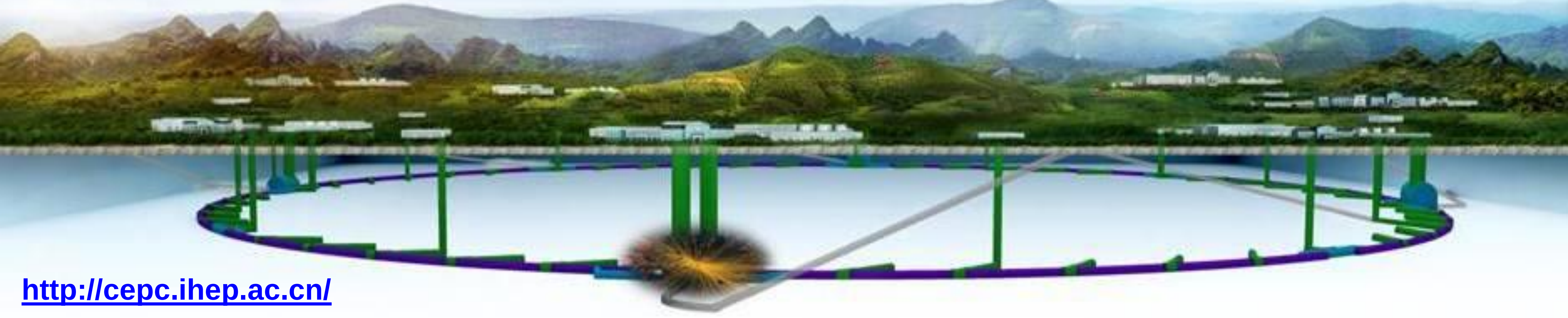
Status of CEPC Physics and Detector

Haijun Yang
Shanghai Jiao Tong University
(for the CEPC Working Group)

The 2021 Workshop on CEPC Detector & MDI Mechanical Design
IHEP Dongguan Campus, October 22-23, 2021



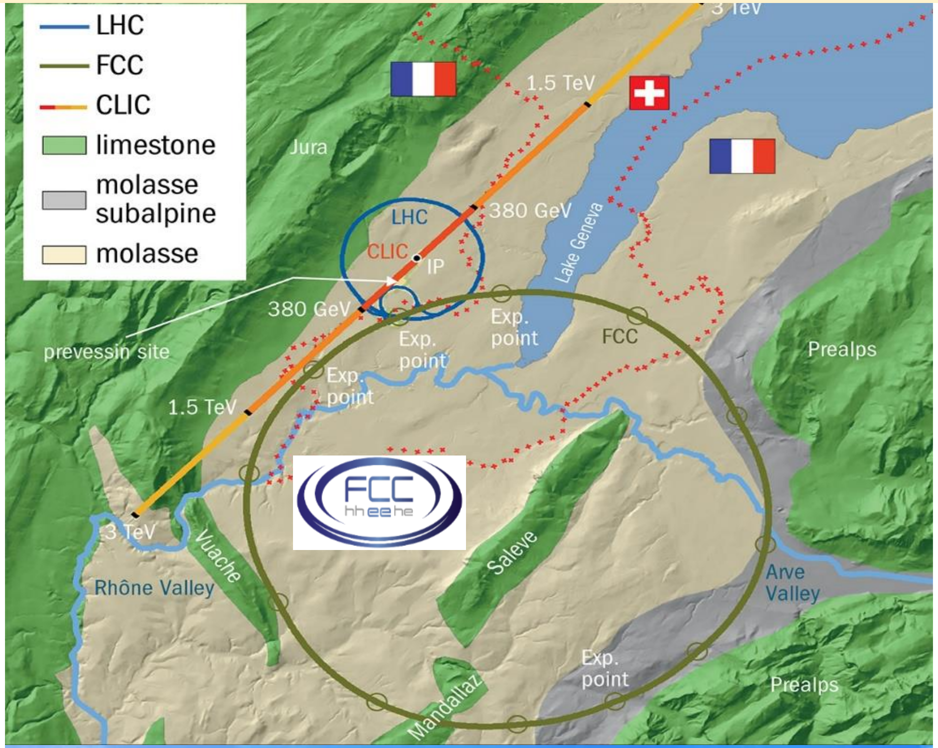
http://cepc.ihep.ac.cn/

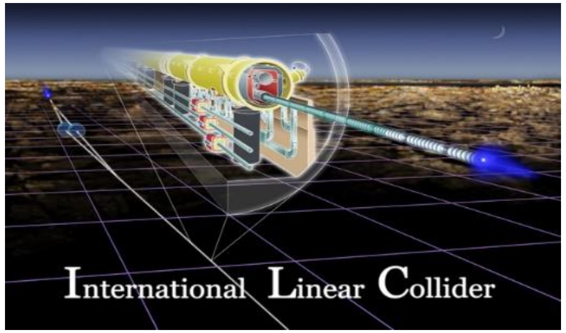
Outline

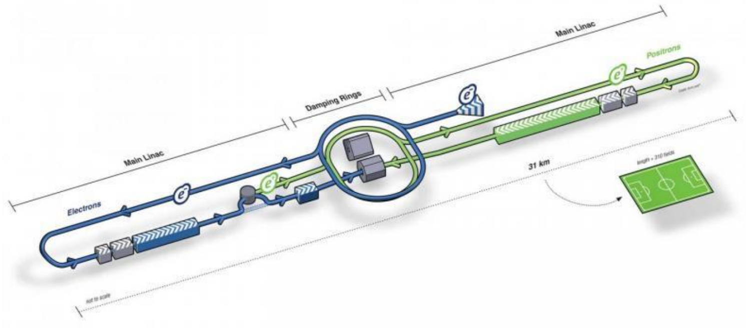
- Introduction of the CEPC
- CEPC Physics Potential
- CEPC New Detector Concept and R&D
- CEPC Sites and Timeline
- Summary

Worldwide Lepton Colliders

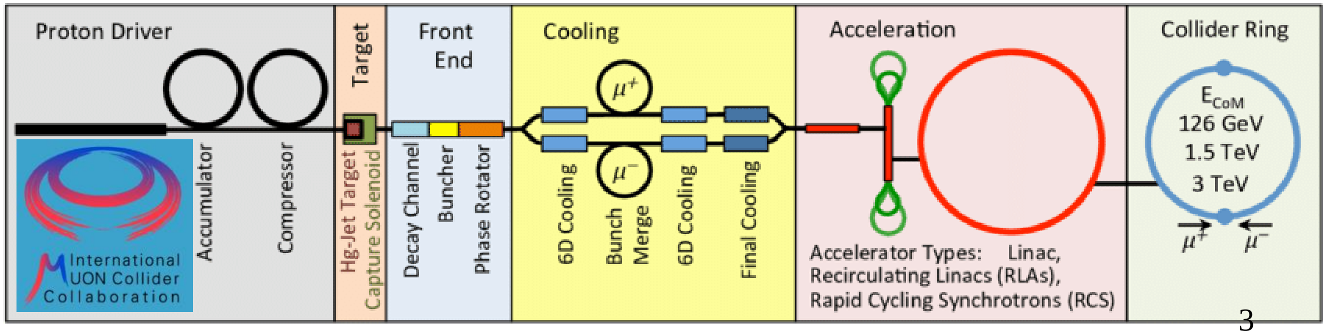
- 欧洲粒子物理战略规划提出：正负电子希格斯工厂是优先级最高的下一代对撞机。
- An electron-positron Higgs factory is the highest-priority next collider.







IDT	ILC Pre-Lab				ILC Lab.										
PP	P1	P2	P3	P4	1	2	3	4	5	6	7	8	9	10	Phys. Exp.

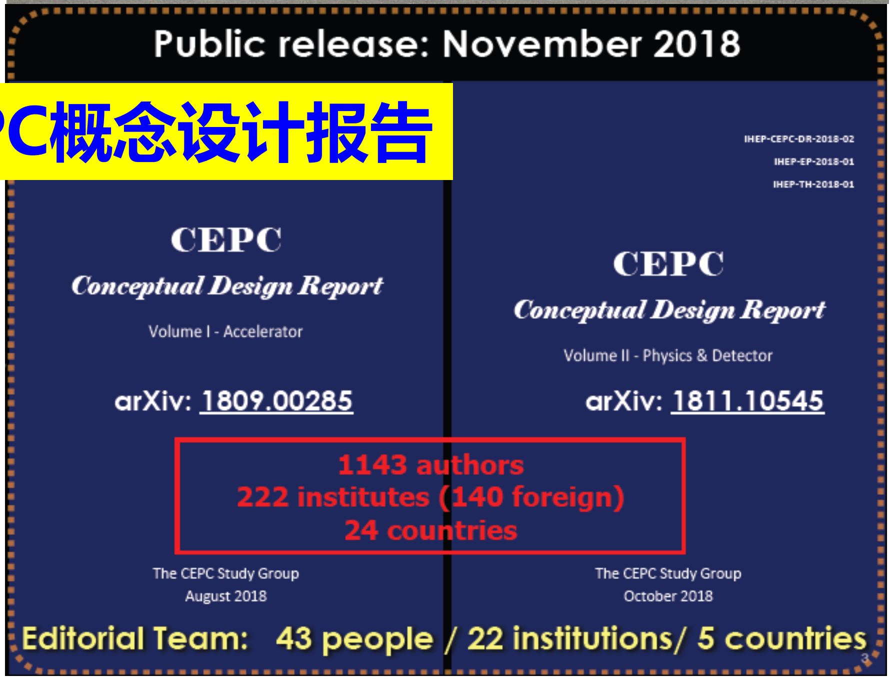


CEPC Major Milestones

2013年9月CEPC-SPPC启动会

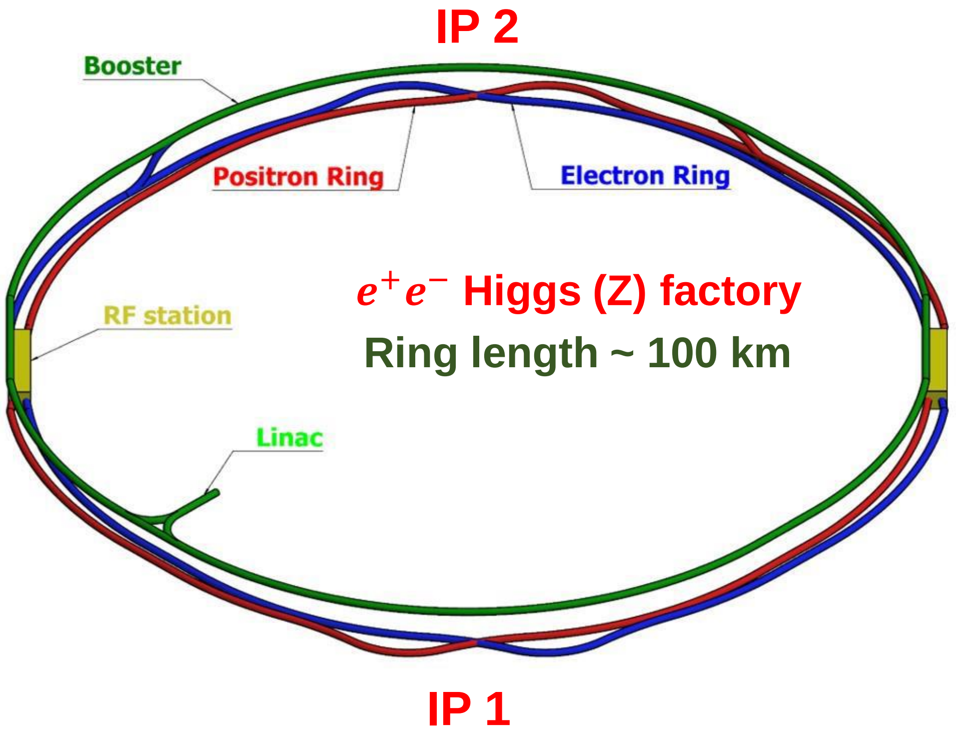
2015, CEPC IAC Meeting

2018年11月发布CEPC概念设计报告

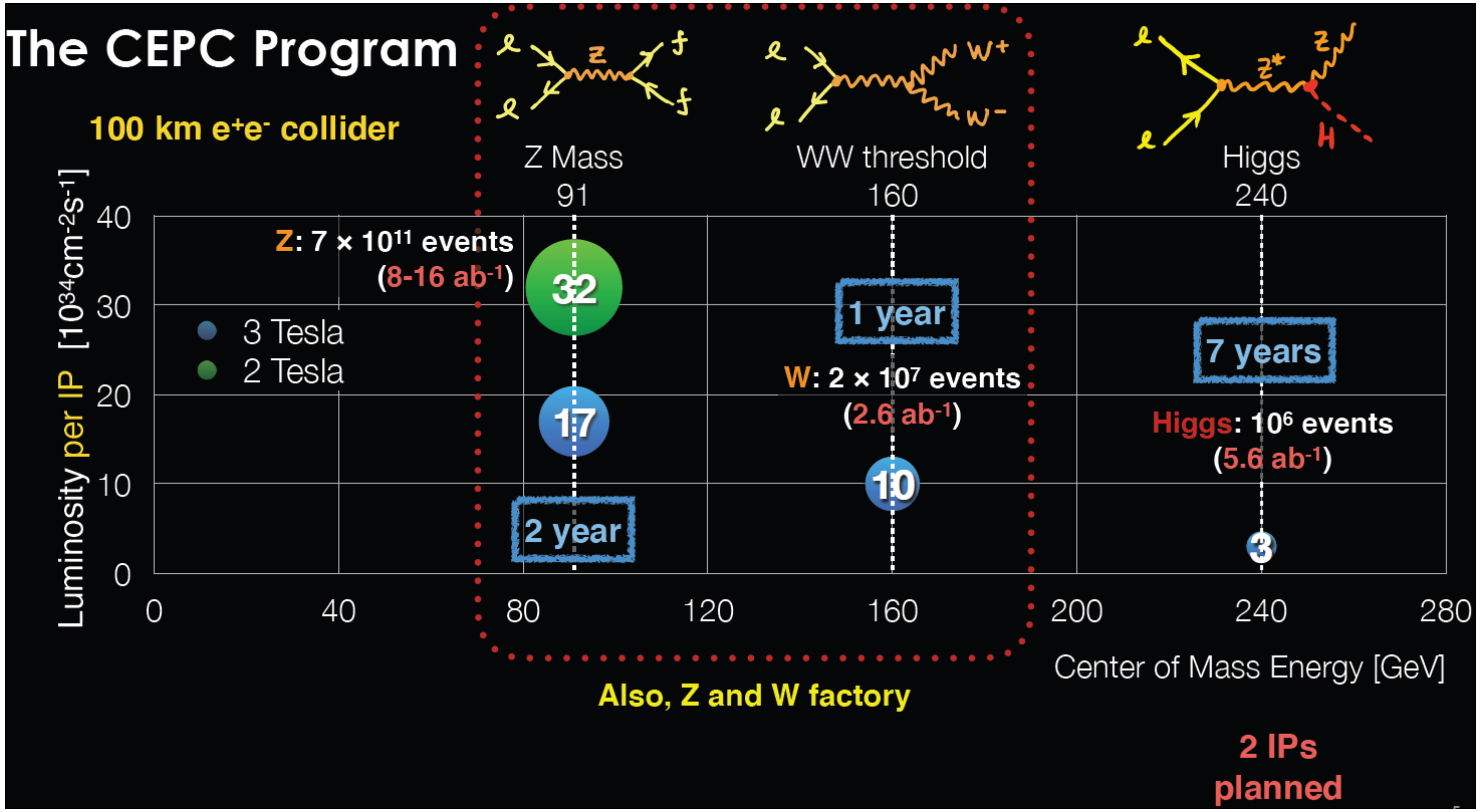


Circular Electron Positron Collider (CEPC)

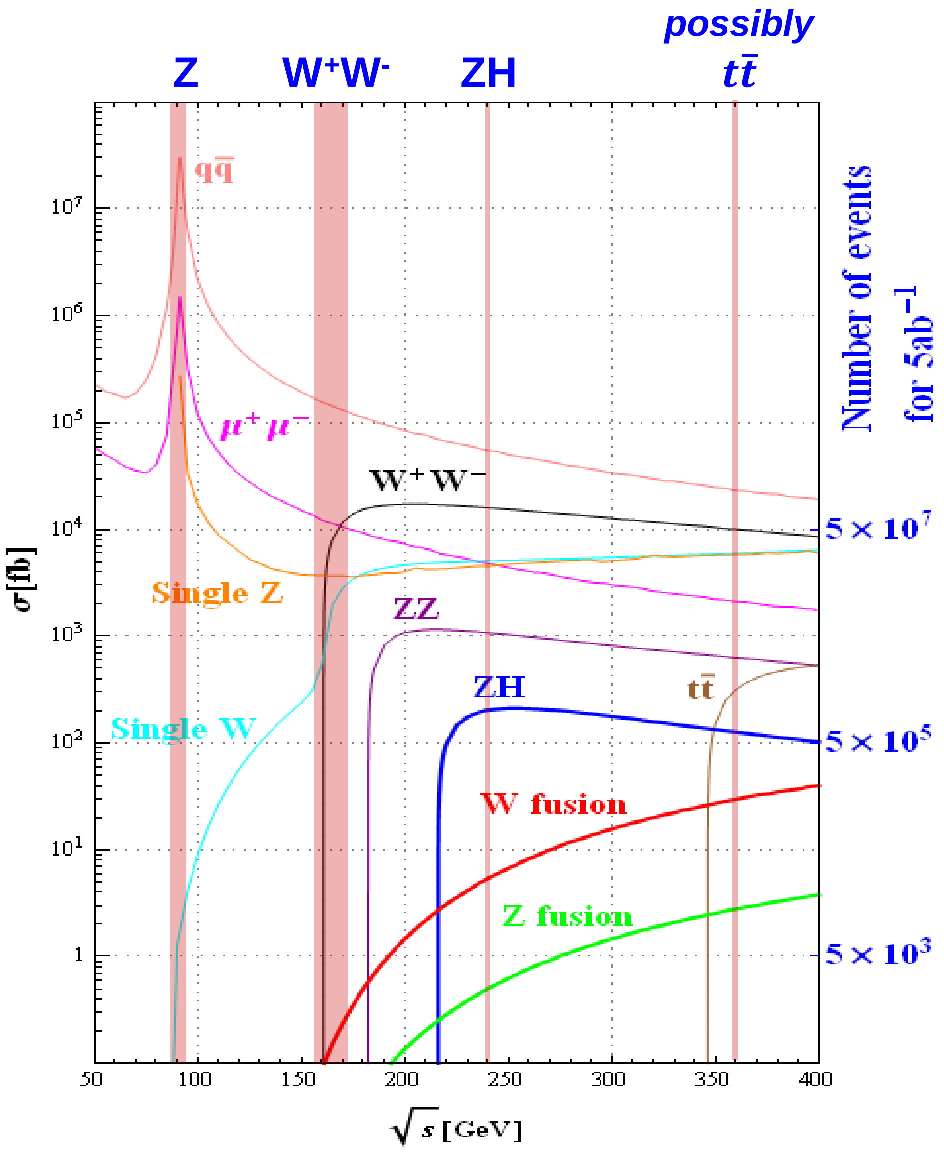
- The CEPC was initially proposed in 2012, as a Higgs (Z/W) factory in China.
- To run at $\sqrt{s}$ ~ 240 GeV, above the **ZH** production threshold for ~1M Higgs; at the **Z** pole for ~Tera Z, at the **W^+W^-** pair (possible $t\bar{t}$ pair) production threshold.
- Higgs, EW, flavor physics & QCD, BSM physics (eg. dark matter, EW phase transition, SUSY, LLP, ….)
- Possible Super *pp* Collider (SppC) of $\sqrt{s}$ ~ 50–100 TeV in the future.



CEPC Accelerator：Yuhui Li



The CEPC Physics Program



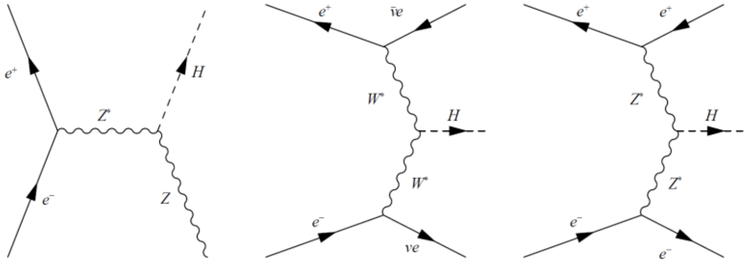
Operation mode		ZH	Z	W^+W^-
$\sqrt{s}$ [GeV]		~240	~91.2	158-172
Run time [years]		7	2	1
CDR	***L*** **/ IP [×10^{34} cm^{-2}s^{-1}]**	3	32	10
	$\int L\,dt$ [ab^{-1}, 2 IPs]	5.6	16	2.6
	Event yields [2 IPs]	**1×10^6**	**7×10^{11}**	**2×10^7**
Latest	***L*** **/ IP [×10^{34} cm^{-2}s^{-1}]**	5.0	115	15.4
	Event yields [2 Ips]	**1.7×10^6**	**2.5×10^{12}**	**3×10^7**

The large samples from 2 IPs:
~**10^6** Higgs, **~2x10^7** W, **~7x10^{11}** Z bosons

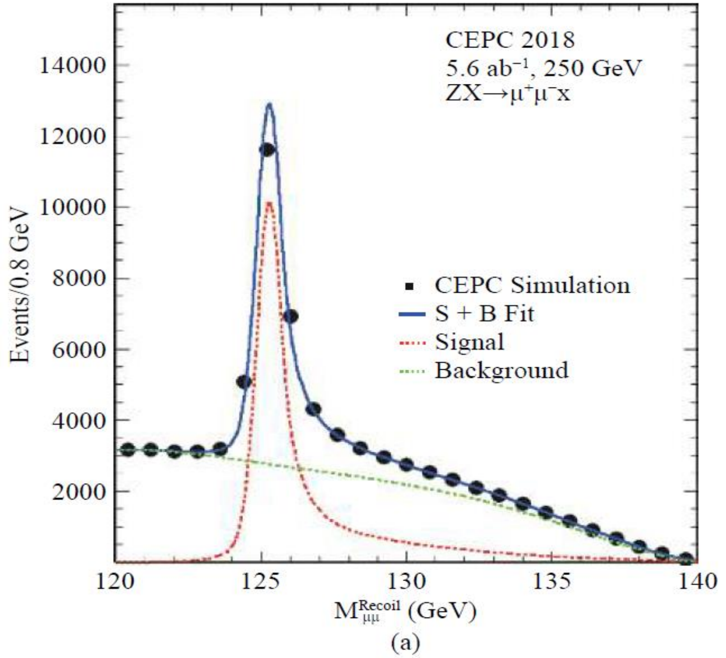
- **CEPC Conceptual Design Report:**
  Volume 1 – Accelerator, arXiv:1809.00285
  Volume 2 – Physics & Detector, arXiv:1811.10545

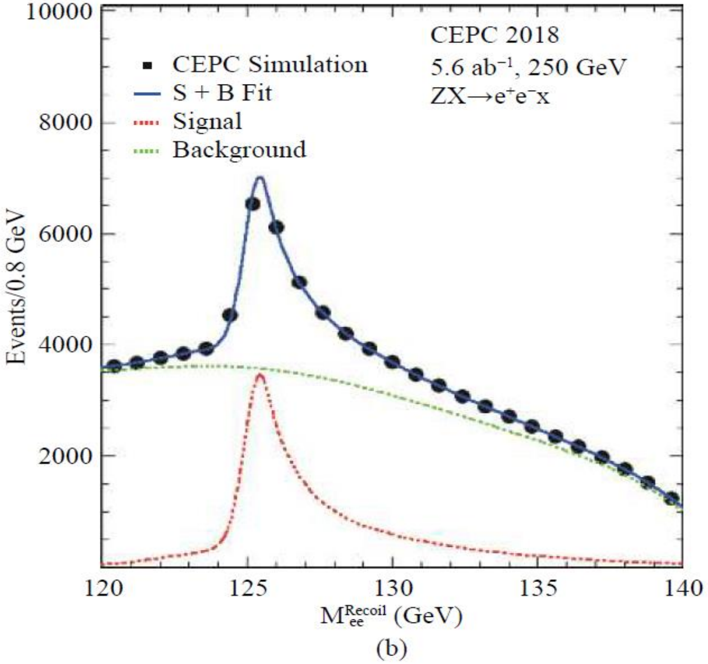
CEPC Physics Performance (CDR)

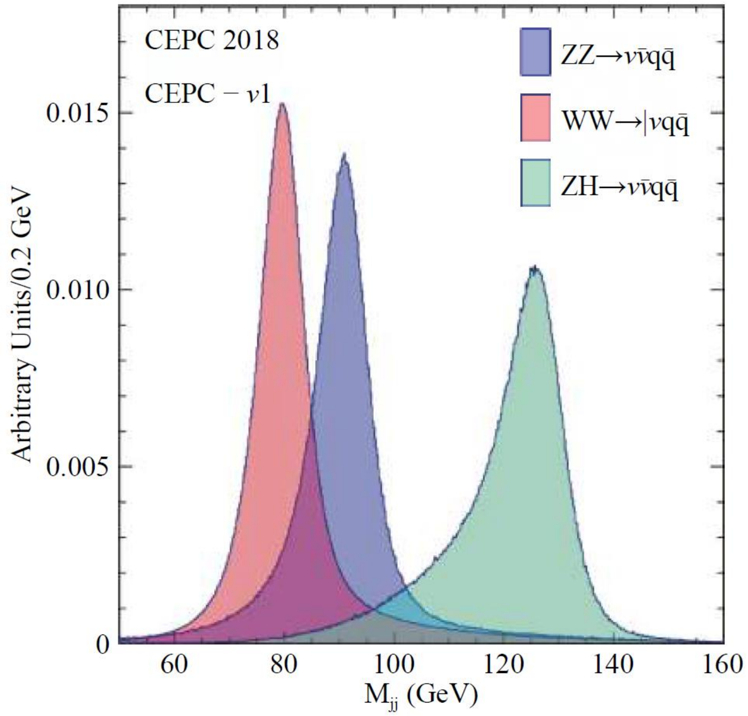
e⁺e⁻ annihilations at the CEPC



- **CEPC can make detailed study of various physics processes**
- **Higgs bosons are detected via recoil mass of the reconstructed Z, allowing for model independent & full investigation of the Higgs and any new physics that Higgs may reveal**
- **Very challenging events with missing neutrinos and jets are well reconstructed and identified**





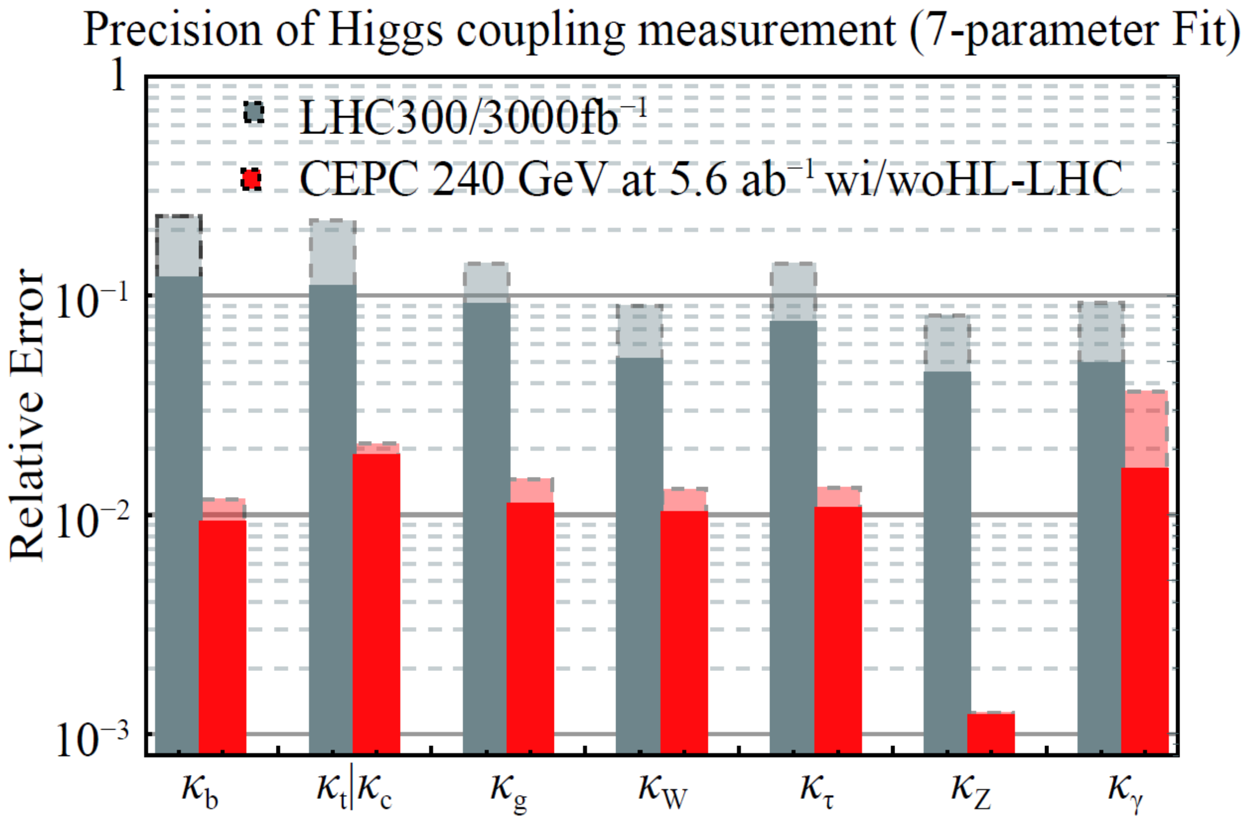


Chinese Physics C Vol. 43, No. 4 (2019) 043002

CEPC Physics Performance (CDR)

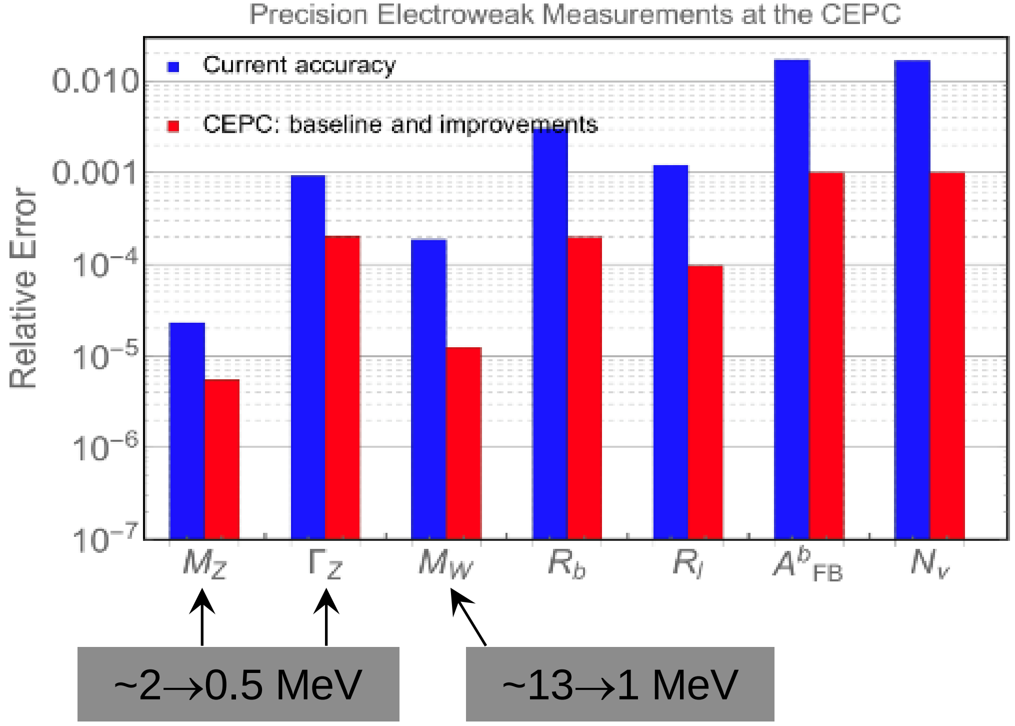
Order of magnitude improvement in precision ⇒ Unknown / discoveries

CEPC 使希格斯耦合参数测量精度比HL-LHC实验提高 5-10 倍



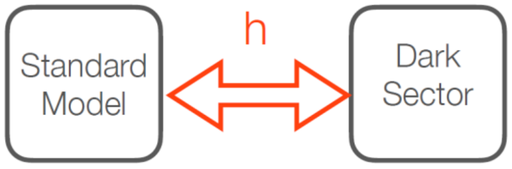
《Precision Higgs Physics at CEPC》
荣获中国物理学会2020年度最有影响论文奖
Chinese Physics C, 43 （2019）043002

CEPC 对电弱参数测量精度比当前实验精度提高约5-10倍



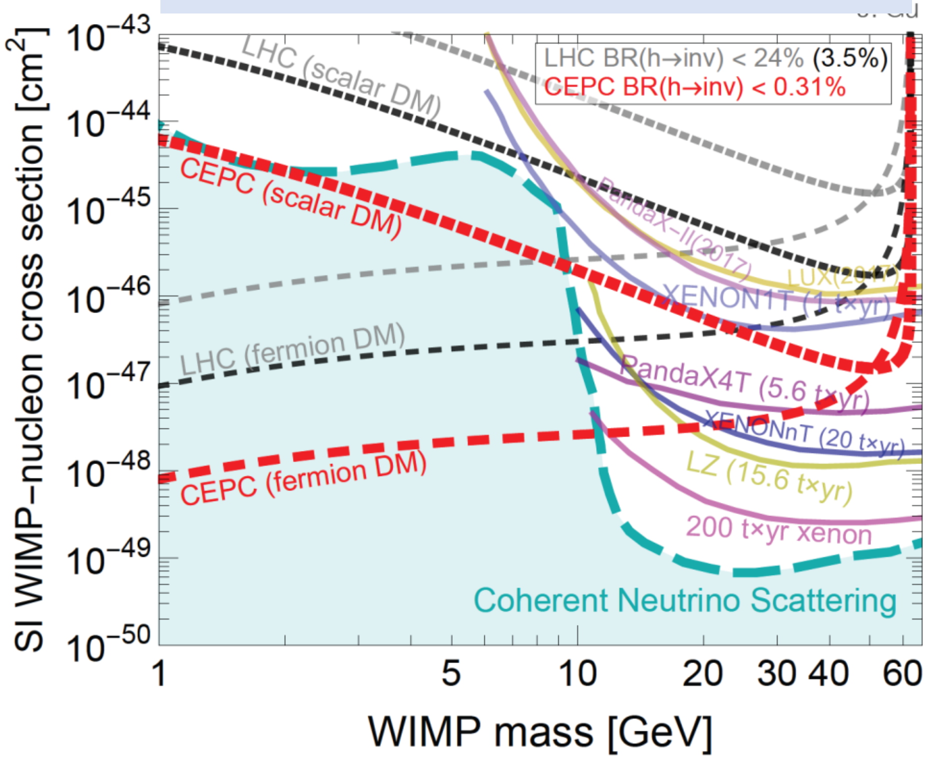
- ❑ **Precision EW measurements,**
- ❑ **Flavor physics (b, c, tau),**
- ❑ **Study of QCD,**
- ❑ **Probe physics BSM.**

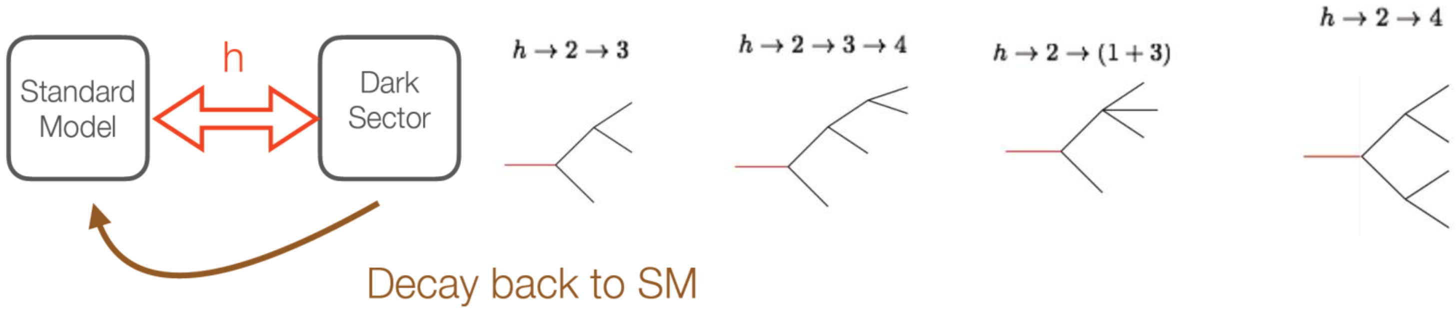
Discovery Potential for New Physics



$$h \rightarrow X_{dm} X_{dm}$$

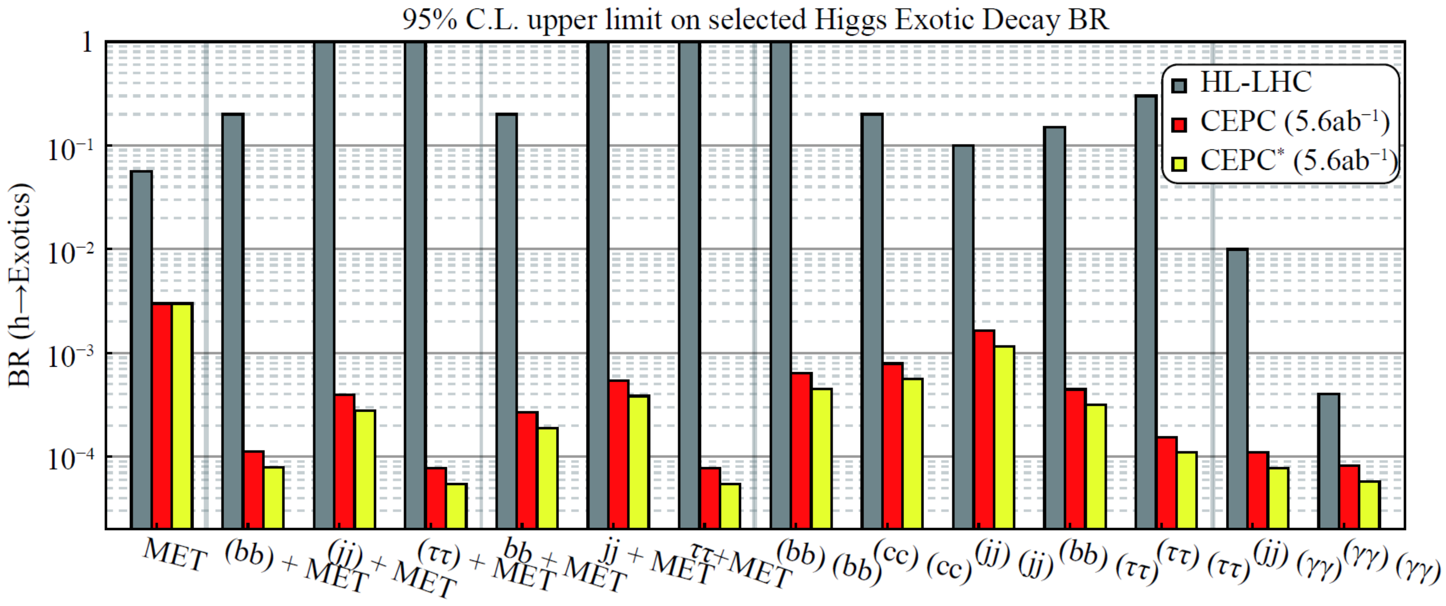
CEPC 对暗物质的探测灵敏度比LHC实验提高约一个数量级



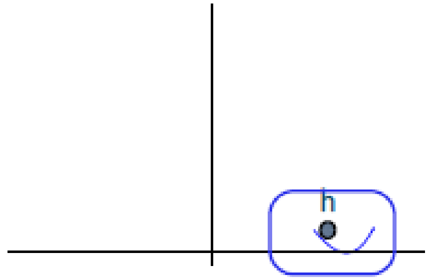


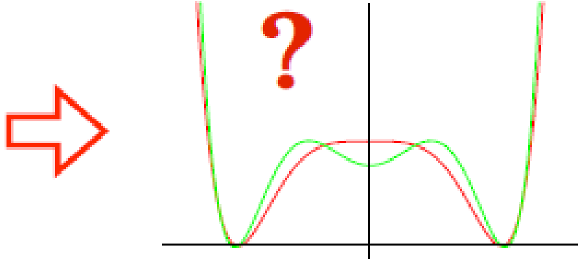
Higgs decays into BSM particles, H→ X_1X_2

CEPC 对新物理探测灵敏度比LHC实验提高约2-3个数量级

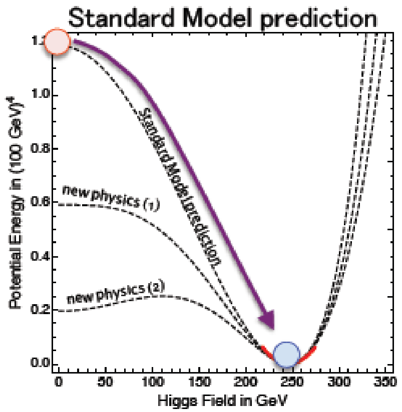


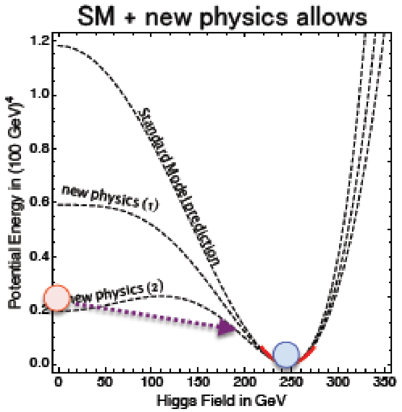
EWPT & Matter-AntiMatter Asymmetry

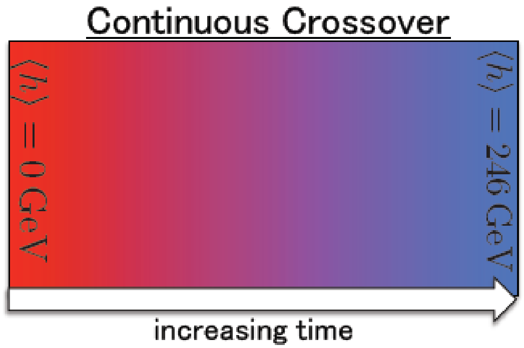


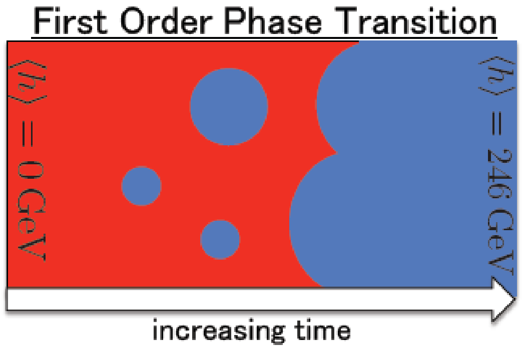


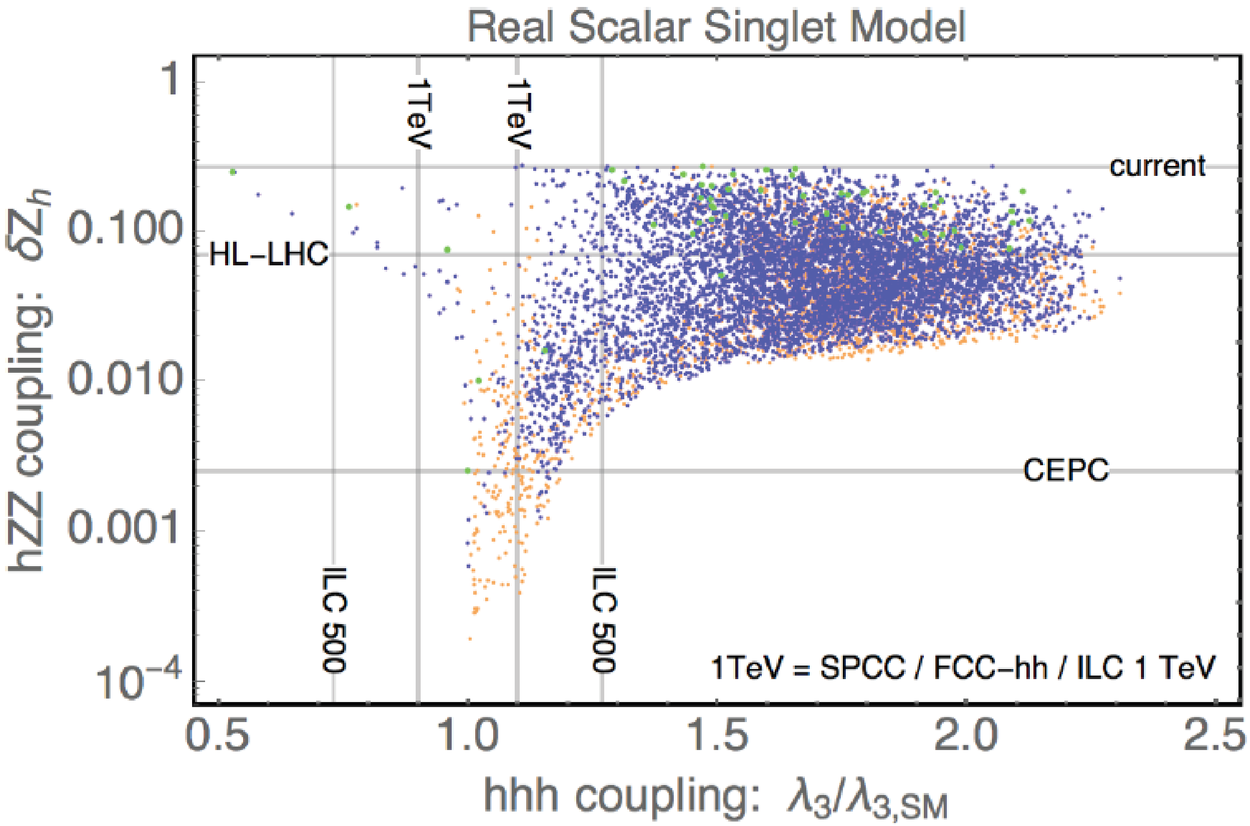
What we know from LHC
LHC upgrades won't go much further











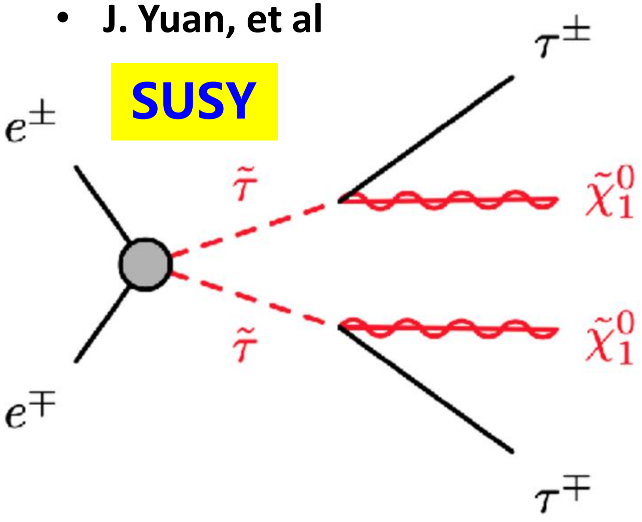
Orange = first order phase transition, $v(T_c)/T_c > 0$
Blue = "strongly" first order phase transition, $v(T_c)/T_c > 1.3$
Green = very strongly 1PT, could detect GWs at eLISA

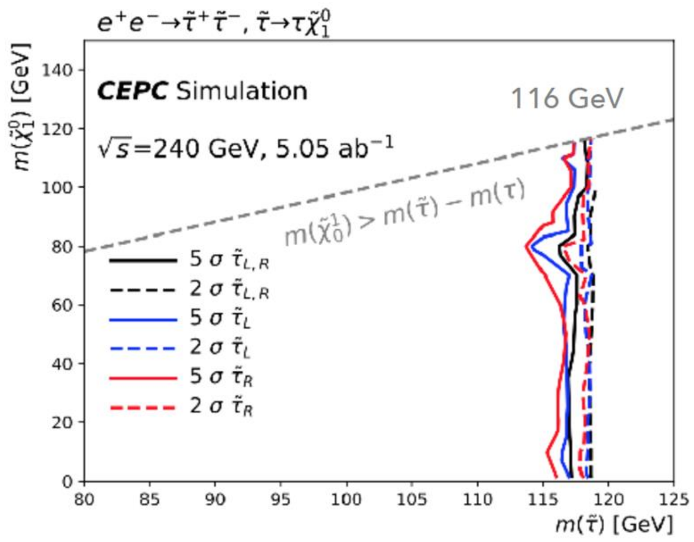
Huang, Long, LTW, 1608.06619

Beyond Standard Model

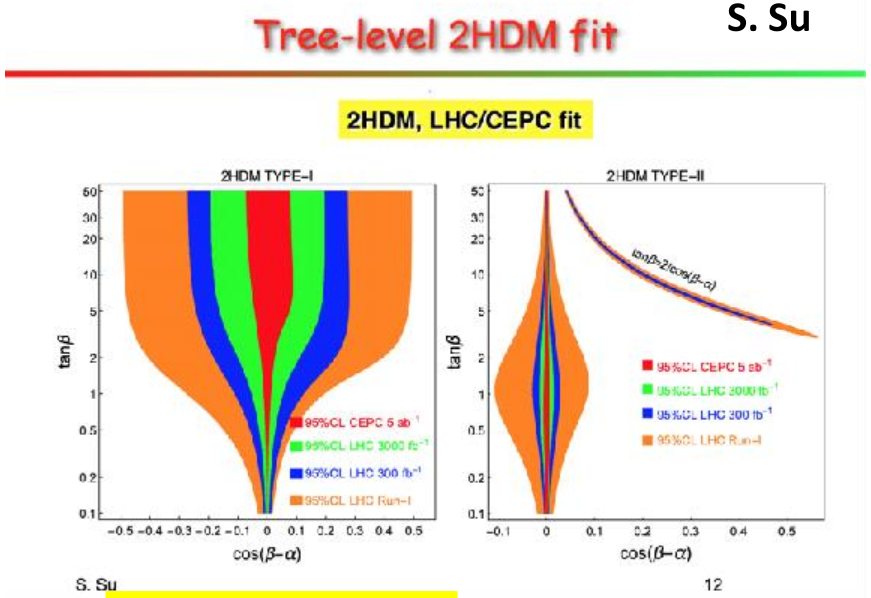
- **J. Yuan, et al**

SUSY

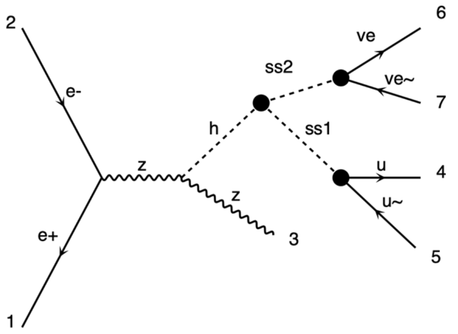


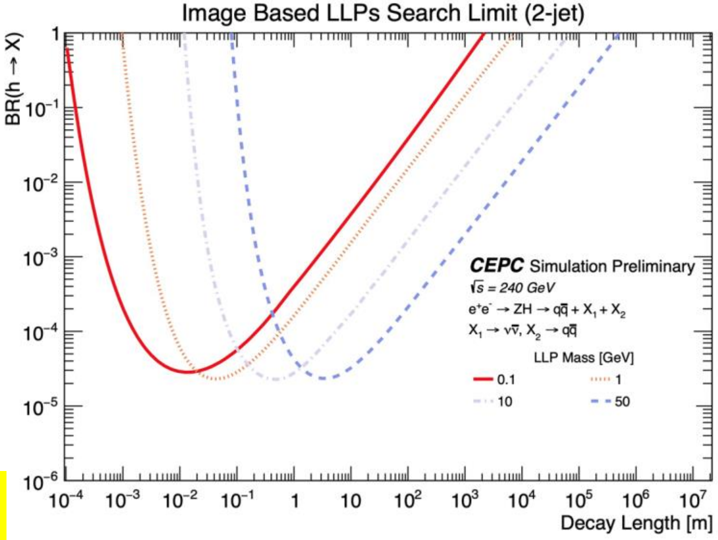


S. Su



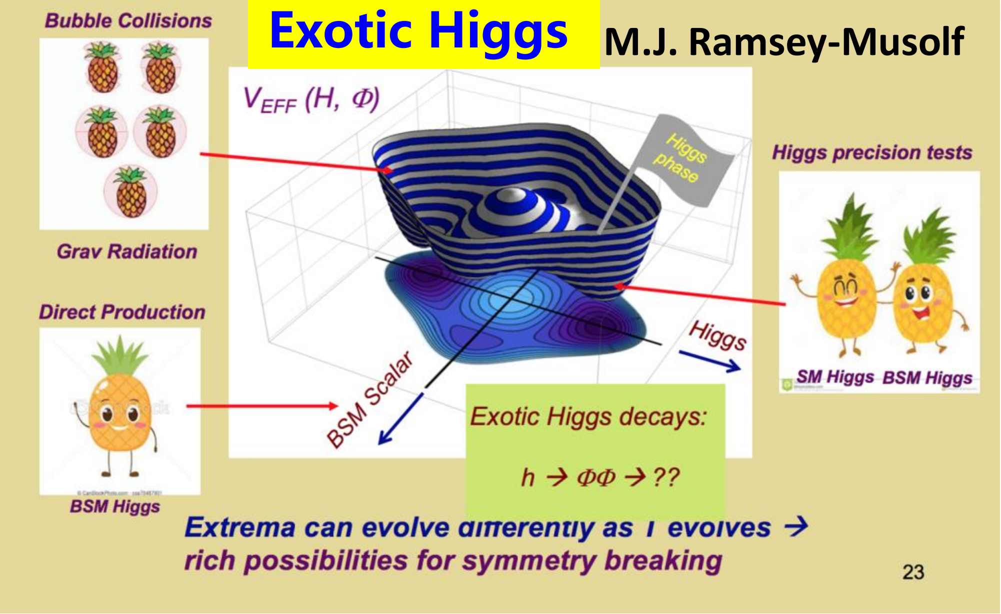
- **Y. Zhang, et al**





Long-lived Particle

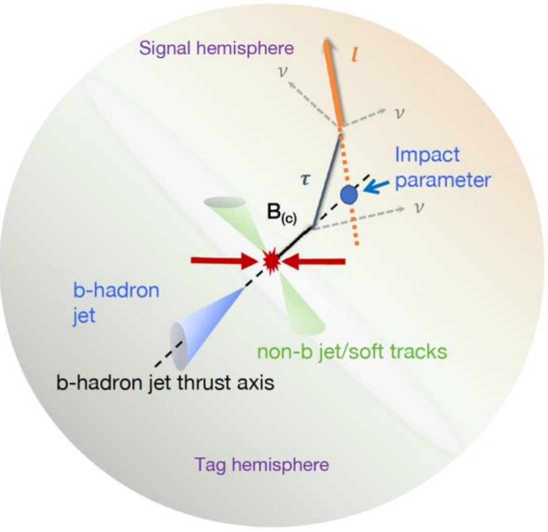
Exotic Higgs **M.J. Ramsey-Musolf**

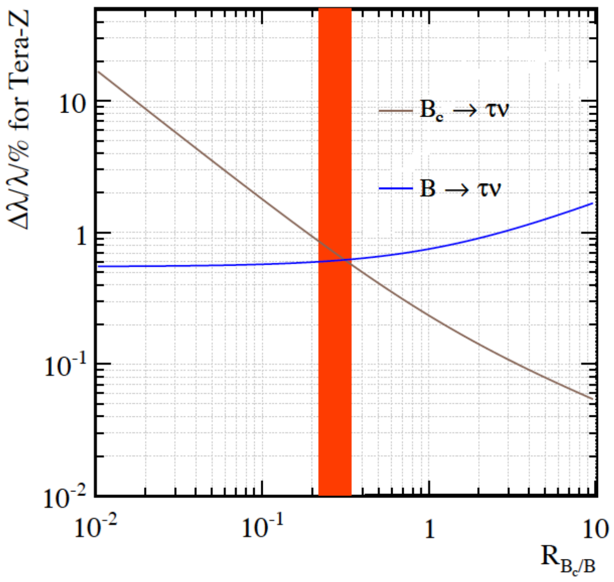


https://indico.ihep.ac.cn/event/13888/session/15

Flavor Physics

Analysis of $B_c \to \tau\nu_\tau$ at CEPC → |Vcb|~O(1%)
T. Zheng et.al., CPC 45, No. 2 (2021)





Chinese Physics C Vol. 45, No. 2 (2021)

Analysis of $B_c \to \tau\nu_\tau$ at CEPC*

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Yeuk-Kwan E. Cheung(张若筠)[1] Manqi Ruan(阮曼奇)[4†]

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[2]INPAC, SKLPPC, MOE KLPPC, School of Physics and Astronomy, Shanghai Jiao Tong University, Shanghai 200240, China
[3]Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn, 53115 Bonn, Germany
[4]Institute of High Energy Physics, Beijing 100049, China
[5]Department of Physics and Astronomy, Iowa State University, Ames, IA, USA

Abstract: Precise determination of the $B_c \to \tau\nu_\tau$ branching ratio provides an advantageous opportunity for understanding the electroweak structure of the Standard Model, measuring the CKM matrix element $|V_{cb}|$, and probing new physics models. In this paper, we discuss the potential of measuring the process $B_c \to \tau\nu_\tau$ with τ decaying leptonically at the proposed Circular Electron Positron Collider (CEPC). We conclude that during the Z pole operation, the channel signal can achieve five-σ significance with $\sim 10^9$ Z decays, and the signal strength accuracies for $B_c \to \tau\nu_\tau$ can reach around 1% level at the nominal CEPC Z pole statistics of one trillion Z decays, assuming the total $B_c \to \tau\nu_\tau$ yield is 3.6×10^6. Our theoretical analysis indicates the accuracy could provide a strong constraint on the general effective Hamiltonian for the $b \to c\tau\nu$ transition. If the total B_c yield can be determined to $O(1\%)$ level of accuracy in the future, these results also imply $|V_{cb}|$ could be measured up to $O(1\%)$ level of accuracy.

Test of Lepton-Flavor-Universality (LFU)
L.F. Li, T. Liu, JHEP 06 (2021) 064

	Experimental	SM Prediction
R_K	$0.745^{+0.090}_{-0.074} \pm 0.036$	1.00 ± 0.01 [4]
R_{K^*}	$0.69^{+0.12}_{-0.09}$	0.996 ± 0.002 [5]
R_D	0.340 ± 0.030	0.299 ± 0.003
R_{D^*}	0.295 ± 0.014	0.258 ± 0.005

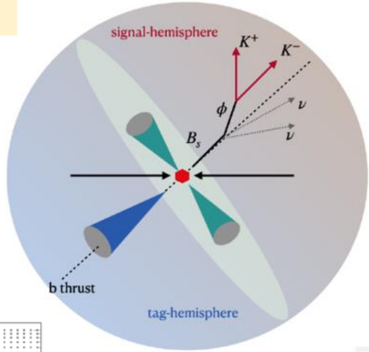
R_{K^*} & R_{D^*} anomalies at level of 2-3σ.

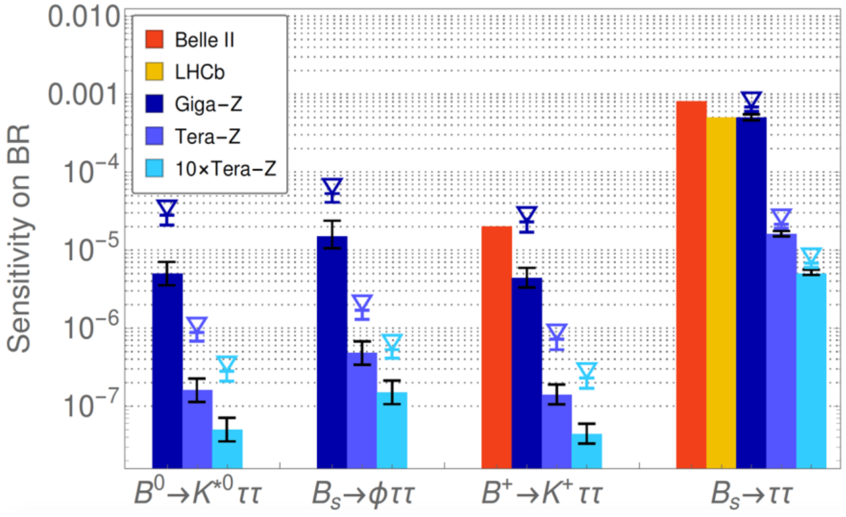
$$R_{K^{(*)}} \equiv \frac{\mathrm{BR}(B \to K^{(*)}\mu^+\mu^-)}{\mathrm{BR}(B \to K^{(*)}e^+e^-)}$$

$$R_{D^{(*)}} \equiv \frac{\mathrm{BR}(B \to D^{(*)}\tau\nu)}{\mathrm{BR}(B \to D^{(*)}\ell\nu)}$$

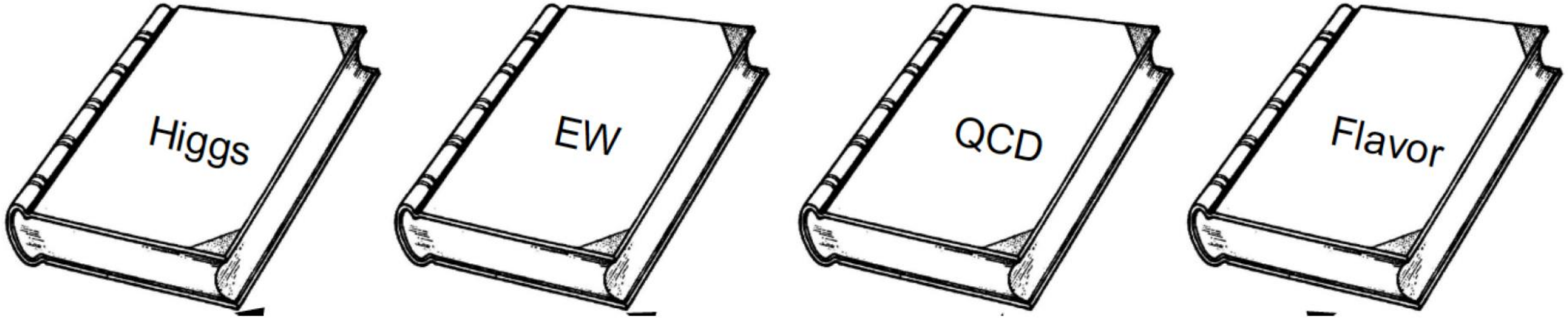
$b \to s\,\tau^+\tau^-$ is motivated to address LFU violating puzzle involving 3rd generation lepton directly.

Channel	SM prediction for BR
$B^0 \to K^{*0}\tau^+\tau^-$	$(0.98 \pm 0.10) \times 10^{-7}$ [11]
$B_s \to \phi\tau^+\tau^-$	$(0.86 \pm 0.06) \times 10^{-7}$ [11]
$B^+ \to K^+\tau^+\tau^-$	$(1.20 \pm 0.12) \times 10^{-7}$ [11]
$B_s \to \tau^+\tau^-$	$(7.73 \pm 0.49) \times 10^{-7}$ [12]



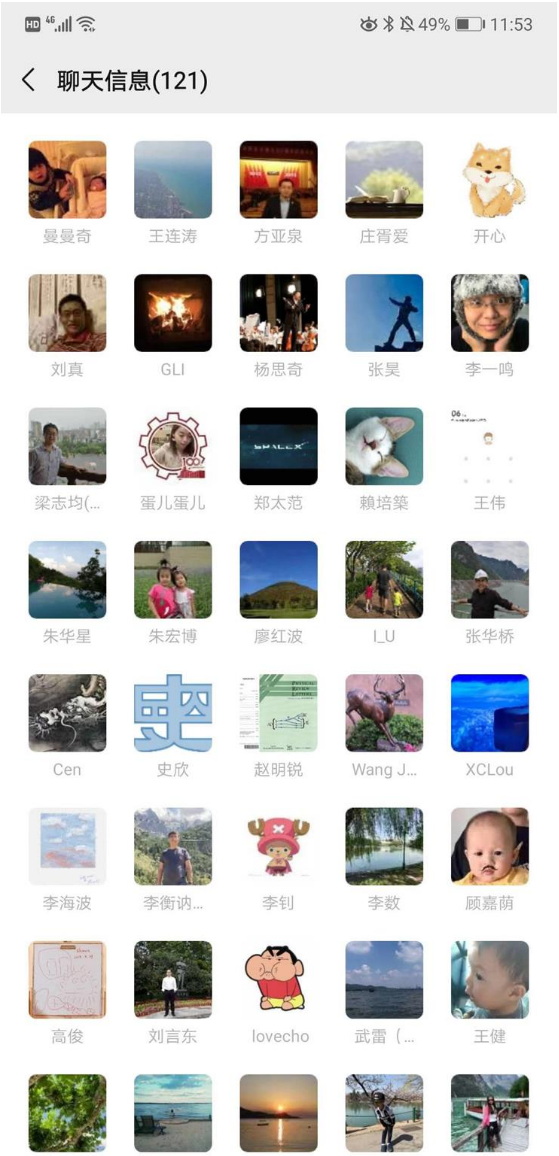


White papers



- To promote the physics study at TDR & to converge to the Physics White Papers
- Physics white papers:
  - Physics handbooks for new comers: PostDoc/Student
  - Official references for the physics potential
  - Guideline for future detector design/optimization
- Higgs white paper published in 2019

CEPC Study for Snowmass: Physics (17 LoI)



WG	LoI
EF01	Higgs boson CP properties at CEPC
	Measurement of branching fractions of Higgs hadronic decays
EF02	Study of Electroweak Phase Transition in Exotic Higgs Decays with CEPC Detector Simulation
	Complementary Heavy neutrino search in Rare Higgs Decays
EF03	Feasibility study of CP-violating Phase ϕs measurement via Bs → J/Ψϕ channel at CEPC
	Probing top quark FCNC couplings tq\gamma, tqZ at future e+e- collider
	Searching for Bs → ϕ νν and other b → sνν processes at CEPC
EF04	Measurement of the leptonic effective weak mixing angle at CEPC
	Probing new physics with the measurements of e+e- → W+W- at CEPC with optimal observables
	NNLO electroweak correction to Higgs and Z associated production at future Higgs factory
EF05-07	Exlusive Z decays
EF08	SUSY global fits with future colliders using GAMBIT
	Probing Supersymmetry and Dark Matter at the CEPC, FCCee, and ILC
EF09-10	Search for t + j + MET signals from dark matter models at future e+e- collider
	Search for Asymmetric Dark Matter model at CEPC by displaced lepton jets
	Dark Matter via Higgs portal at CEPC
	Lepton portal dark matter, gravitational waves and collider phenomenology

Snowmass — Letters of Intent

14 CEPC-Related Detector LoI submitted

https://indico.ihep.ac.cn/event/12410/

Detector R&D

Conveners: Joao Guimaraes Costa, WANG Jianchun, Mr. Manqi Ruan (IHEP)

15:00 **CEPC Detectors Overview LoI** *1'*
CEPC Detector Overview LOI
SNOWMASS21-EF1_EF4-IF9_IF0-260.pdf
Speakers: Joao Guimaraes Costa, Mr. Manqi Ruan (IHEP), WANG Jianchun
Material: Paper Slides

15:02 **IDEA Concept** *1'*
Speaker: Franco Bedeschi (INFN-Pisa)
Material: Paper

15:03 **Dual Readout Calorimeter** *1'*
Speaker: Roberto Ferrari (INFN)
Material: Paper

15:04 **Drift Chamber** *1'*
Speaker: Franco Grancagnolo
Material: Paper

15:06 **mu-RWELL (muons, preshower)** *1'*
Speaker: Paolo Giacomelli (INFN-Bo)
Material: Paper

15:08 **Time Detector LoI** *1'*
Speaker: Prof. Zhijun Liang (IHEP)
Material: Slides

15:09 **Key4hep** *1'*
Speakers: Dr. Weidong Li (高能所), Dr. Tao LIN (高能所), Prof. Xingtao Huang (Shandong University), Wenxing Fang (Beihang University)
Material: Slides

15:10 **PFA Calorimeter** *1'*
Speakers: Haijun Yang (Shanghai Jiao Tong University), Dr. Jianbei Liu (University of Science and Technology of China), Dr. Yong Liu (Institute of High Energy Physics)
Material: Slides

15:11 **High Granularity Crystal Calorimeter** *1'*
Speaker: Dr. Yong Liu (Institute of High Energy Physics)
Material: Paper Slides

15:12 **Muon Scintillator Detector** *1'*
Speaker: Dr. Xiaolong Wang (Institute of Modern Physics, Fudan University)
Material: document

15:13 **Vertex LoI** *1'*
Speaker: Prof. Zhijun Liang (IHEP)
Material: Slides

15:15 **MDI LoI** *1'*
Speaker: Dr. Hongbo ZHU (IHEP)
Material: Slides

15:16 **TPC LoI** *1'*
Speaker: Dr. Huirong Qi (Institute of High Energy Physics, CAS)
Material: Slides

15:17 **Solenoid R&D LoI** *1'*
Speaker: Dr. Feipeng NING (IHEP)
Material: Slides

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Requirements of CEPC Detector

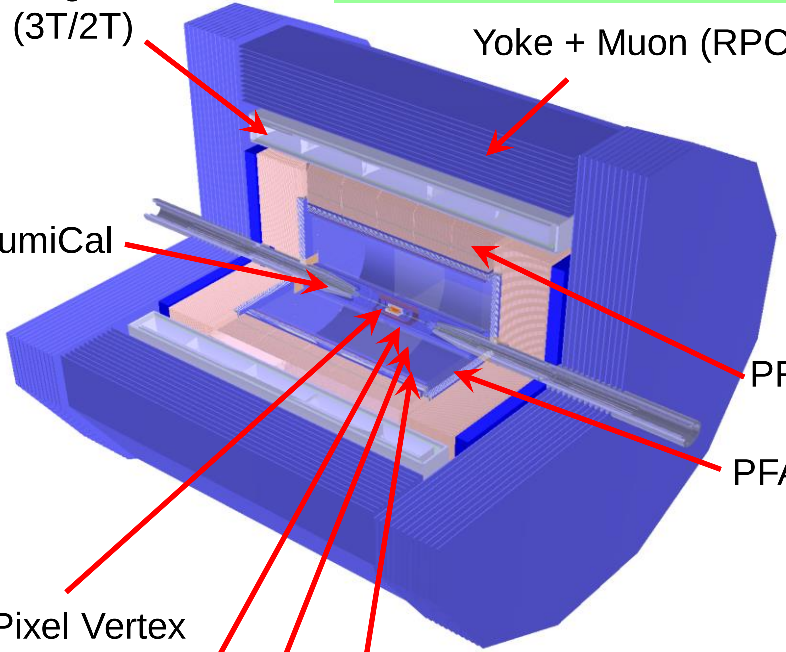
The physics motivations dictate our selection of detector technologies

Physics process	Measurands	Detector subsystem	Performance requirement
$ZH, Z \to e^+e^-, \mu^+\mu^-$ $H \to \mu^+\mu^-$	$m_H, \sigma(ZH)$ $\mathrm{BR}(H \to \mu^+\mu^-)$	Tracker	$\Delta(1/p_T) = 2 \times 10^{-5} \oplus \frac{0.001}{p(\mathrm{GeV}) \sin^{3/2}\theta}$
$H \to b\bar{b}/c\bar{c}/gg$	$\mathrm{BR}(H \to b\bar{b}/c\bar{c}/gg)$	Vertex	$\sigma_{r\phi} = 5 \oplus \frac{10}{p(\mathrm{GeV}) \times \sin^{3/2}\theta} (\mu\mathrm{m})$
$H \to q\bar{q}, WW^*, ZZ^*$	$\mathrm{BR}(H \to q\bar{q}, WW^*, ZZ^*)$	ECAL HCAL	$\sigma_E^{\mathrm{jet}}/E = 3 \sim 4\%$ at 100 GeV
$H \to \gamma\gamma$	$\mathrm{BR}(H \to \gamma\gamma)$	ECAL	$\Delta E/E = \frac{0.20}{\sqrt{E(\mathrm{GeV})}} \oplus 0.01$

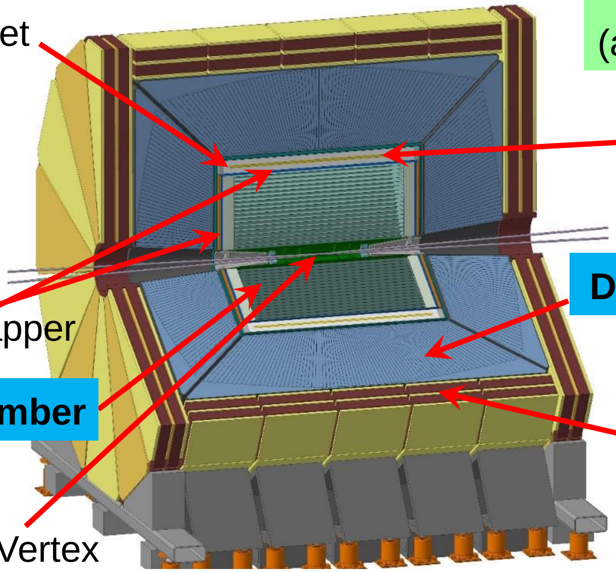
- **Flavor physics ⇒ Excellent PID, better than 2σ separation of π/K at momentum up to ~20 GeV.**
- **EW measurements ⇒ High precision luminosity measurement, δL / L ~ 10^{-4}.**

Conceptual Detector Designs

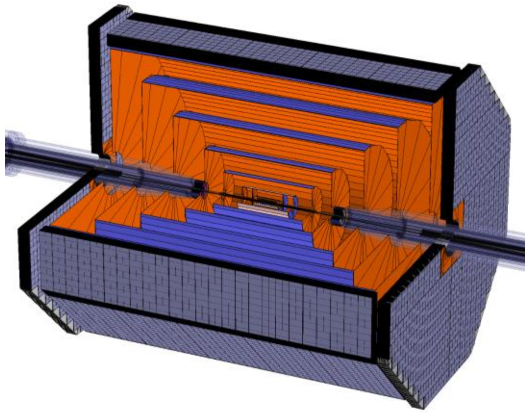
(Baseline Design)
Particle Flow Approach



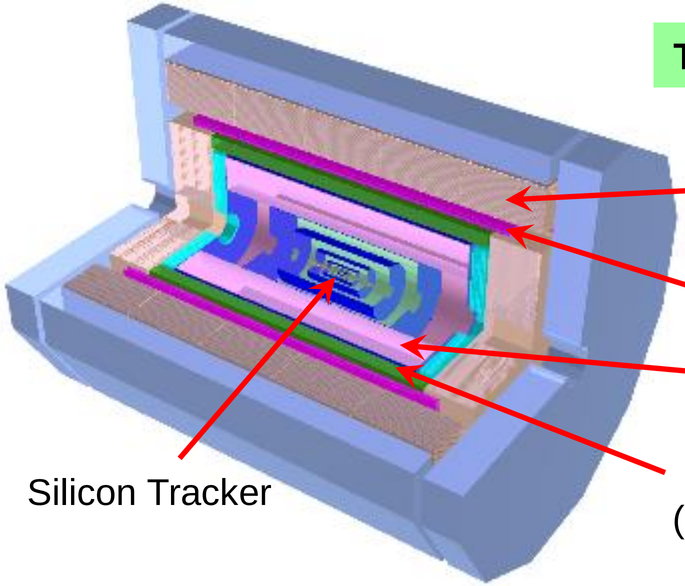
IDEA concept
(also proposed for FCC-ee)



FST concept
(Full Silicon Tracker)

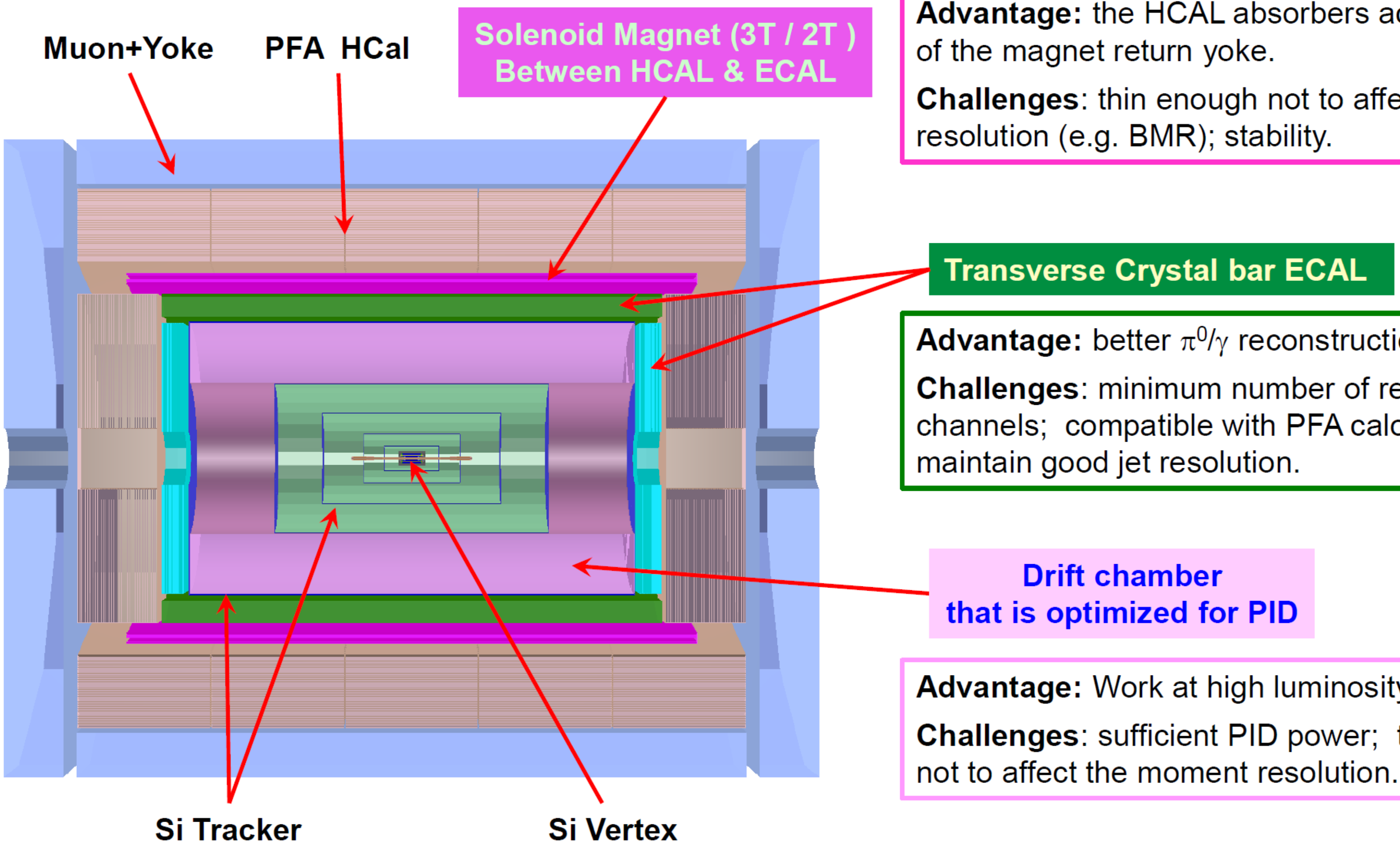


The 4th Concept



The 4th Conceptual Detector Design

➤ **提出新的CEPC探测器方案: 基于硅径迹探测器 + 漂移室PID + 晶体电磁量能器 + 薄螺线管磁铁介于电磁量能器和强子量能器之间**



Advantage: the HCAL absorbers act as part of the magnet return yoke.

Challenges: thin enough not to affect the jet resolution (e.g. BMR); stability.

Advantage: better π^0/γ reconstruction.

Challenges: minimum number of readout channels; compatible with PFA calorimeter; maintain good jet resolution.

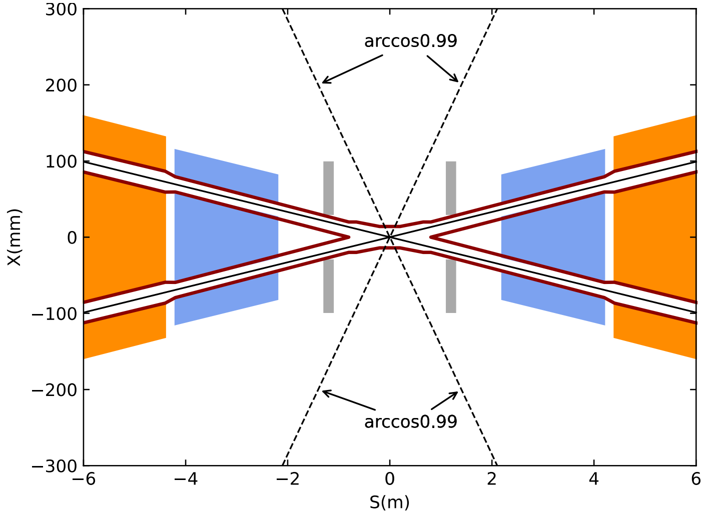
Advantage: Work at high luminosity Z runs

Challenges: sufficient PID power; thin enough not to affect the moment resolution.

CEPC R&D: Machine Detector Interface (MDI)

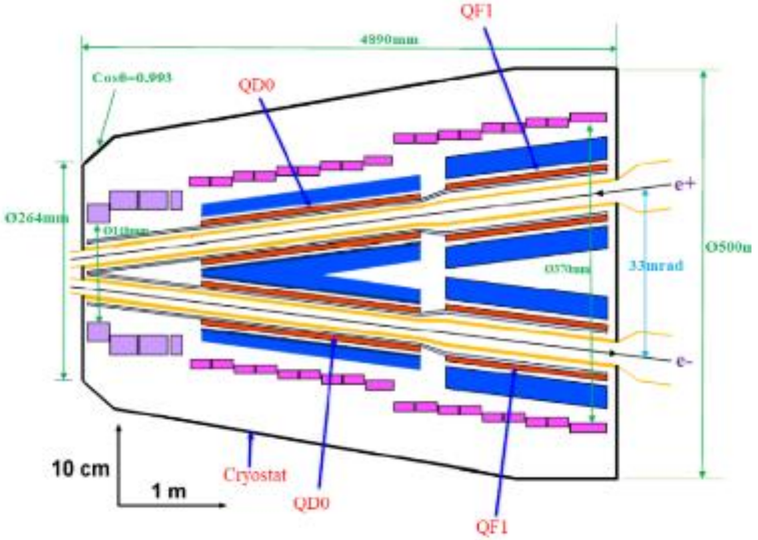
Crossing angle: 33 mrad,

Focal length: 2.2 m



Final focusing magnets (QD0, QF1) with

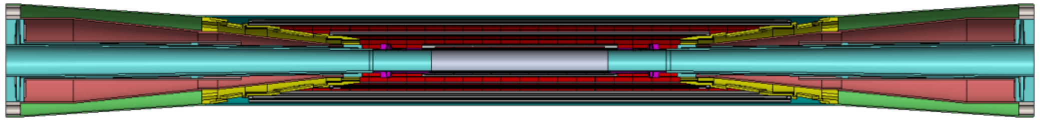
Segmented Anti-Solenoidal Magnets



MDI: Haoyu Shi & many more

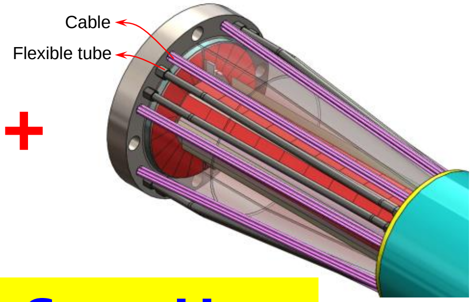
Beam Pipe

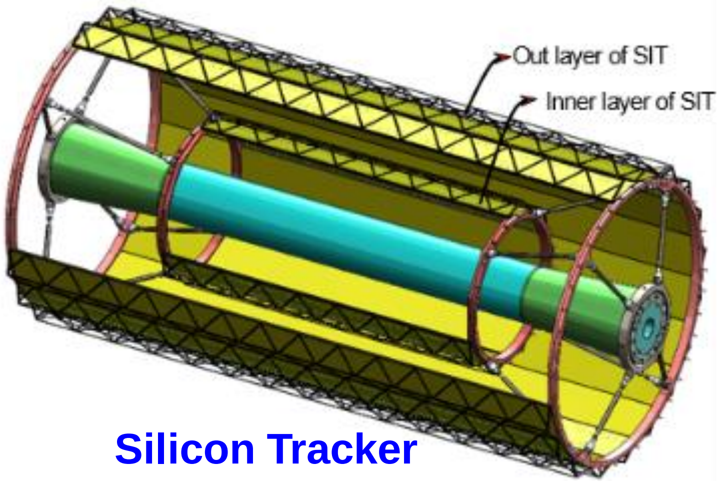
ϕ 28→20 mm, Be thickness: 0.85→0.35 mm



Vertex

LumiCal Tracker





Silicon Tracker

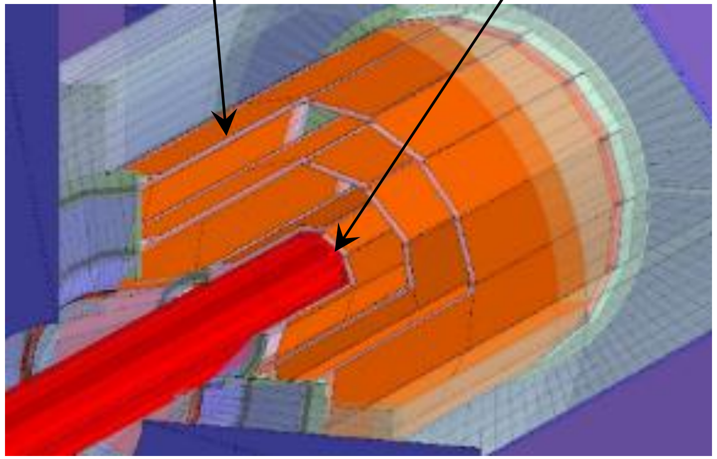
Vertex: Zhijun Liang

LumiCal: Suen Hou

Vertex: Yiming Li

CEPC R&D: Silicon Pixel Chips

2 layers / ladder R_{in}~16 mm



Goal: σ(IP) ~ 5 μm for high P track

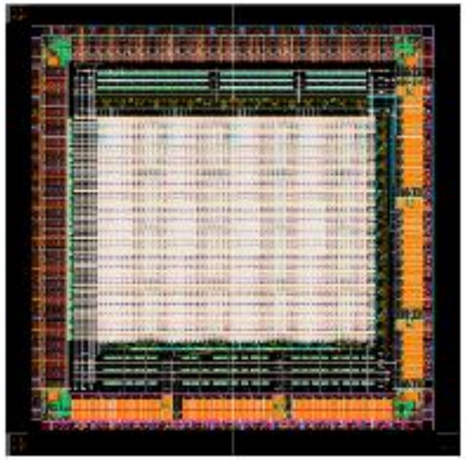
CDR design specifications

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

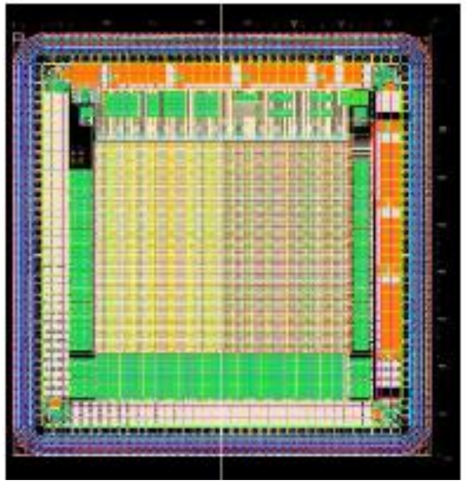
Silicon pixel sensor develops in 3 series:
JadePix / MIC, **TaichuPix**, **CPV**

CPV4 (SOI-3D), 64×64 array
~21×17 μm^2 pixel size

Upper chip



Lower chip

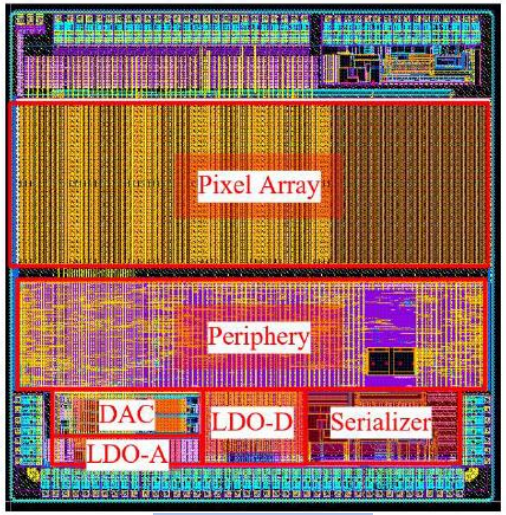


JadePix-3 Pixel size ~16×23 μm^2

Tower-Jazz CiS process
~5μm, power 52.8mW/cm^2

MOST 1

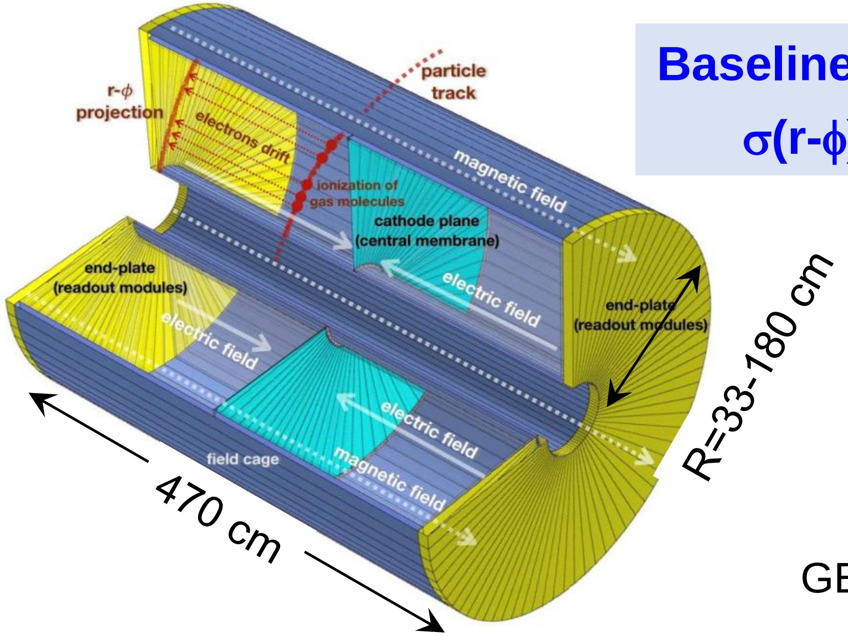
TaichuPix-2, 64×192 array
25×24 μm^2 pixel size



Full size TaichuPix-3 to be used for prototyping ladder

MOST 2

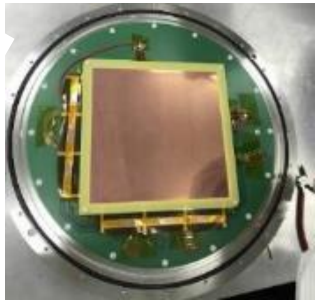
CEPC R&D: Time Projection Chamber



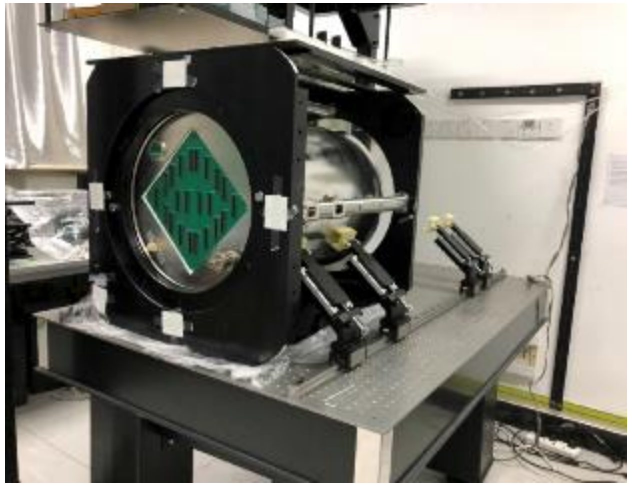
Baseline main tracker

$\sigma(r\text{-}\phi) \sim 100\ \mu m$

MOST 1

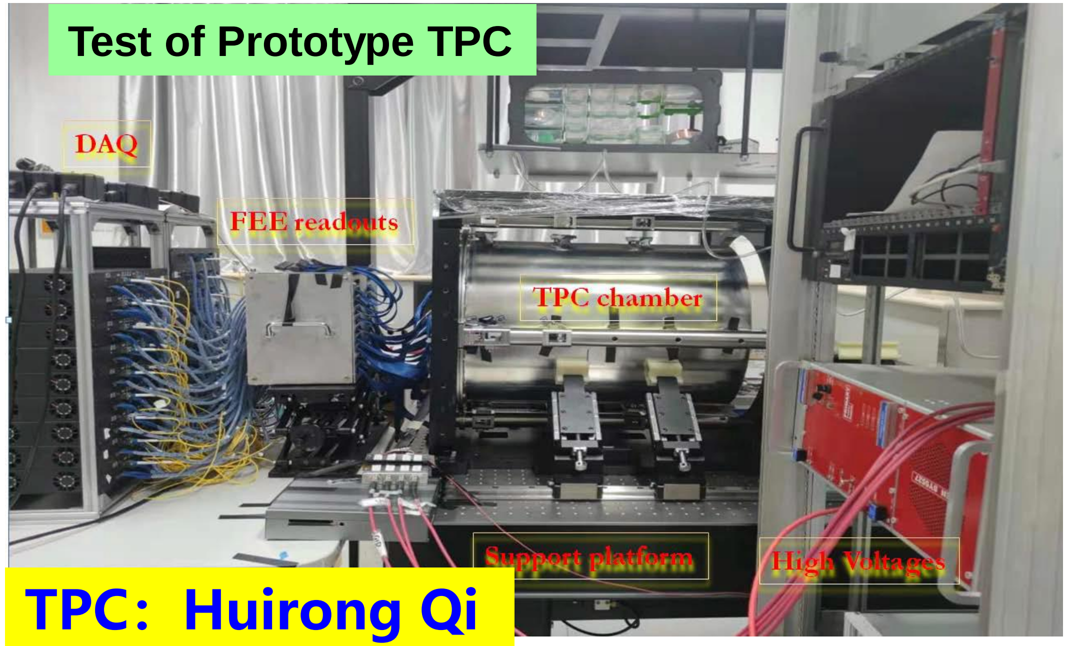


GEM-MM cathode



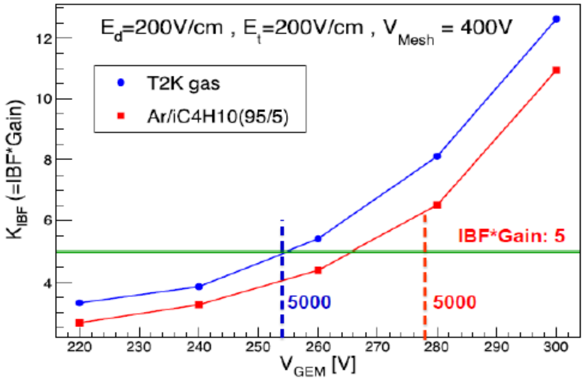
TPC Prototype + UV laser beams

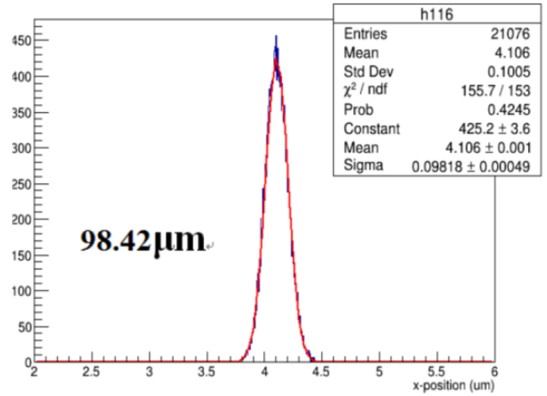
Low power FEE ASIC



TPC: Huirong Qi

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.





$\sigma_x < 100\ \mu m$ for drift length of 27cm

CEPC: Drift Chamber for Particle ID

◆ **Both TPC & DC in the two designs have good PID, with dE/dX or dN/dX (cluster counting).**

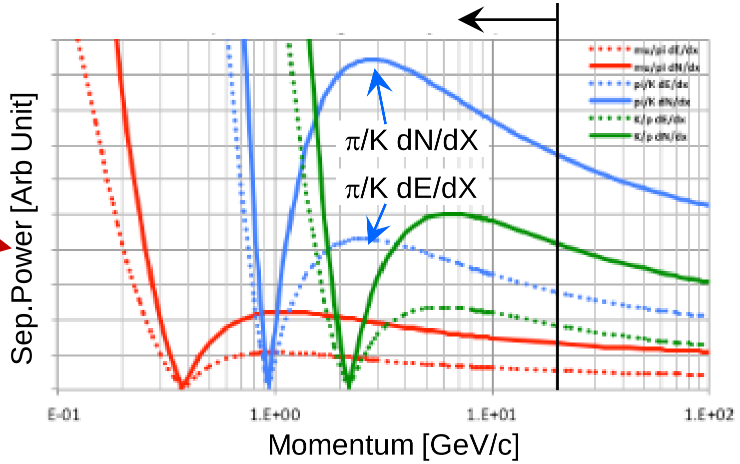
◆ **The FST solution needs a supplement PID. A combination of different PID detectors is also possible.**

◆ **Aim is to for have 2σ π/K separation for P<~20 GeV/c.**

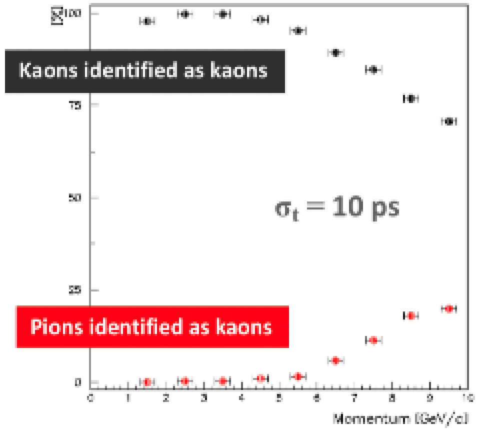
① **Drift chamber** between the outer layers of FST. The dN/dX method is more efficient. It is a joint R&D effort with the IDEA DC. But the DC can be optimized for PID only, not its tracking capability.

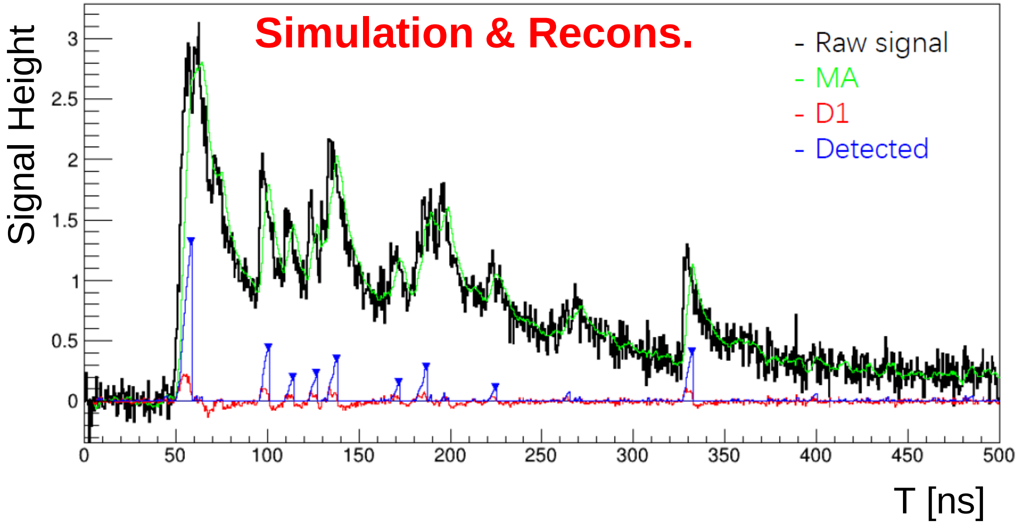
② **Time of flight** detector, e.g. LGAD. The time resolution ~20-30 ps today. Resolution of 10 ps is possible by the time of CEPC.

◆ Other options, e.g. an aerogel **RICH**, will also be considered.



IHEP-NDL LGAD-V2
Pixel size 1.3×1.3 mm²





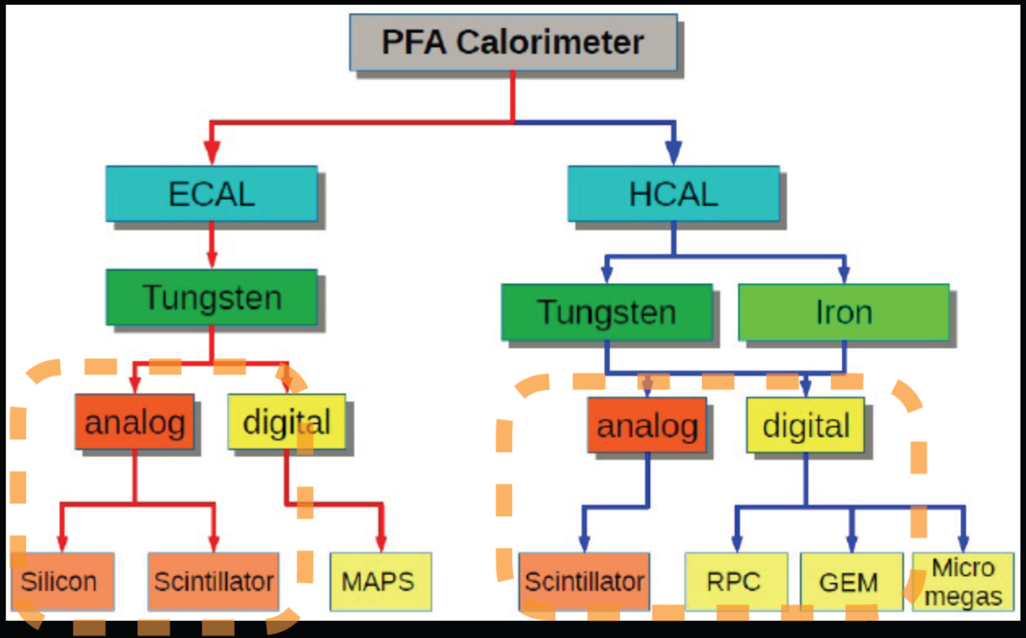
Drift Chamber: Mingyi Dong

CEPC R&D: PFA Calorimeters

Calorimeter options

Chinese institutions have been focusing on Particle Flow calorimeters

R&D supported by MOST, NSFC and IHEP seed funding



High Granularity

Electromagnetic	ECAL with Silicon and Tungsten (LLR, France) ECAL with Scintillator+SiPM and Tungsten (IHEP + USTC)
Hadronic	SDHCAL with RPC and Stainless Steel (SJTU + IPNL, France) SDHCAL with ThGEM/GEM and Stainless Steel (IHEP + UCAS + USTC) HCAL with Scintillator+SiPM and Stainless Steel (IHEP + USTC + SJTU)

Newer Options

Some longitudinal granularity	Crystal Calorimeter (LYSO:Ce + PbWO) Dual readout calorimeters (INFN, Italy + Iowa, USA) — RD52

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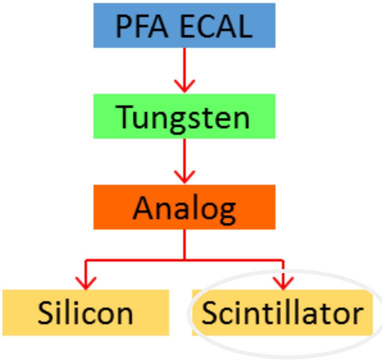
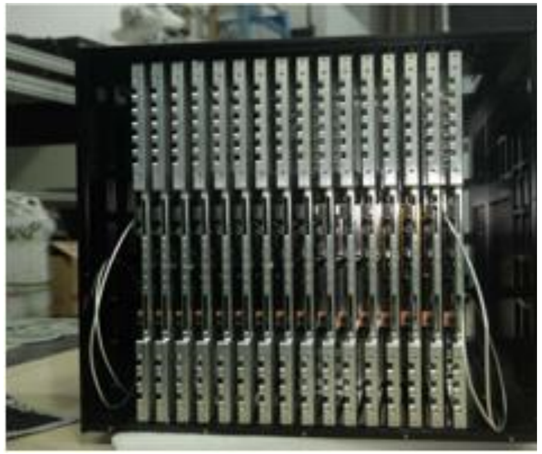
CEPC R&D: ScW-ECAL Prototype

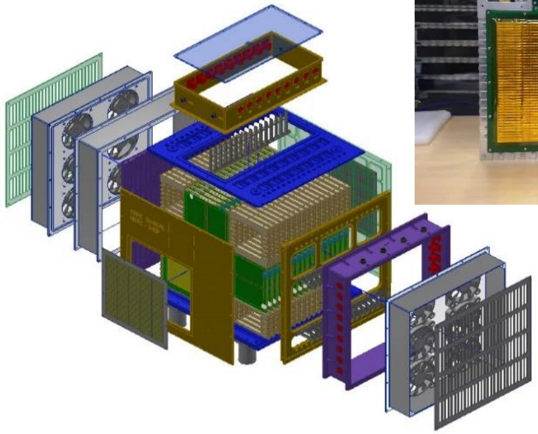


MOST 1

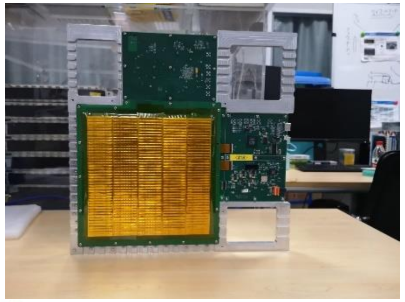
Goal of ECAL+HCAL+…

4% BMR, e.g. in (Z→νν) (H→gg)





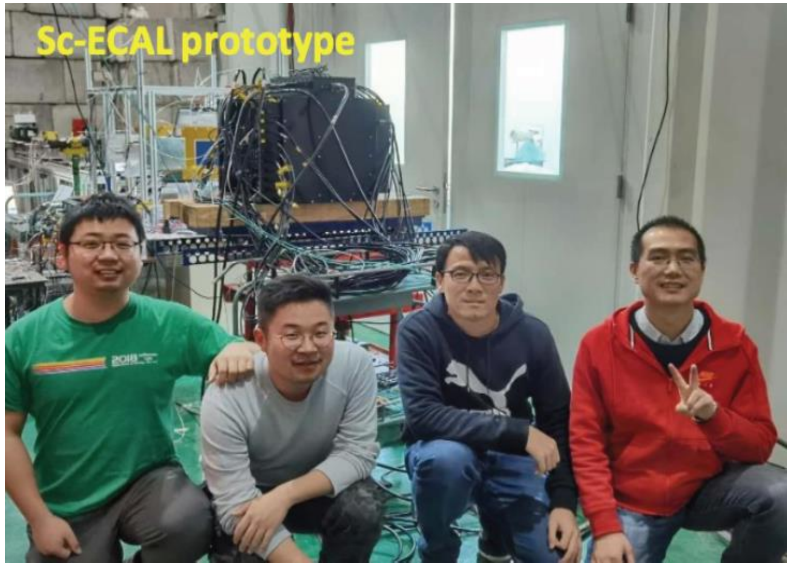
ScW-ECAL Prototype

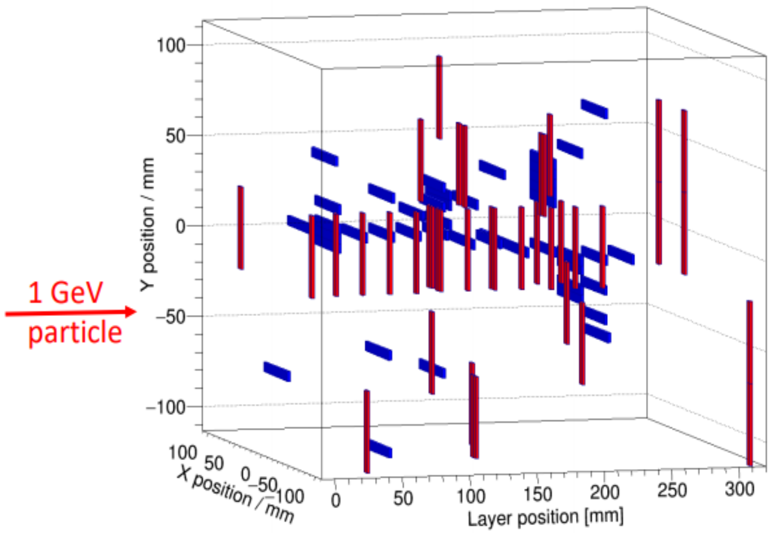


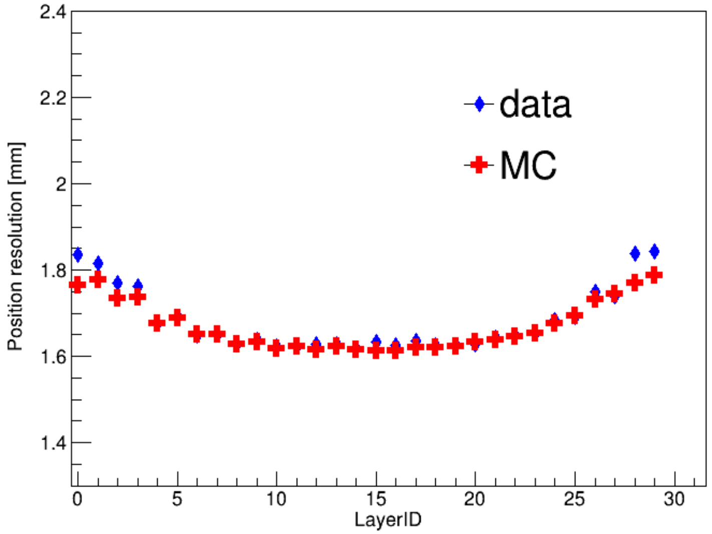
➔ **ScECAL prototype with 6700 channels**

- **32 active layer (EBU), 22 x 22 cm^2, ~22X$_0$**
- **Scintillator (2x5×45mm^3) + MPPC S12571**
- **Embedded FEE (192 SPIROC2E ASICs)**
- **It has been tested with cosmic rays & an electron beam at IHEP (Nov. 2020).**

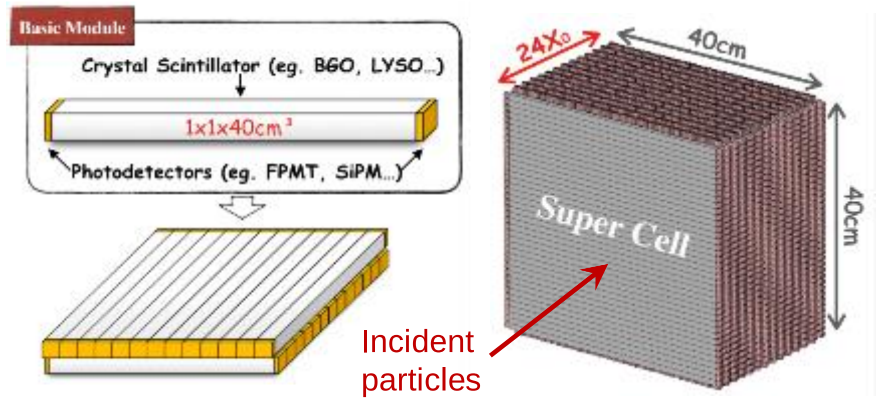
Granularity: 5mm × 5mm
Position resolution: 1.6-1.8mm







CEPC R&D: High Granularity Crystal ECAL



- Timing at two ends for positioning along bar.
- Significant reduction of number of channels.

Design Idea

Goal

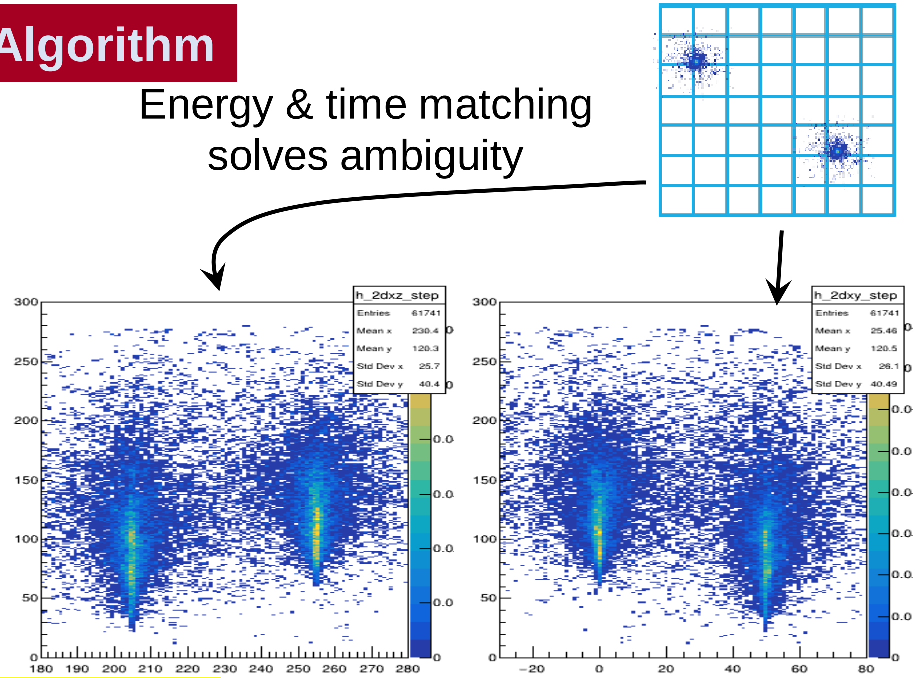
- Comparable BMR resolution as with the Sci+W ECAL.
- Much better sensitivity to γ/e, especially at low energy.

Test board for KLauS-5 in BGA package

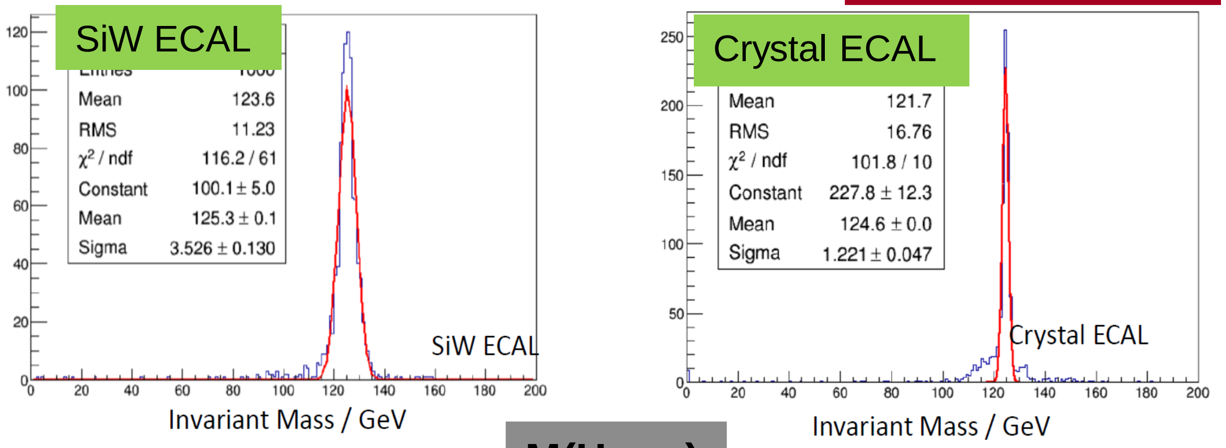
Bench Test

Recon. Algorithm

Energy & time matching solves ambiguity



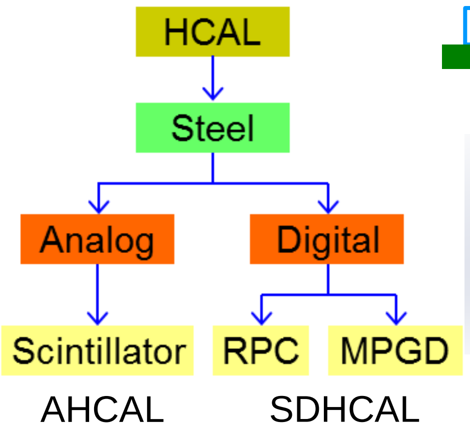
MC Simulation

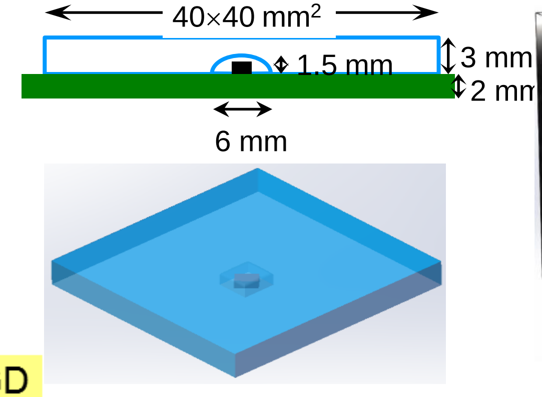


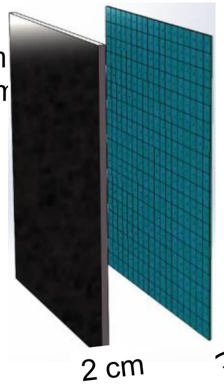
M(H→γγ)

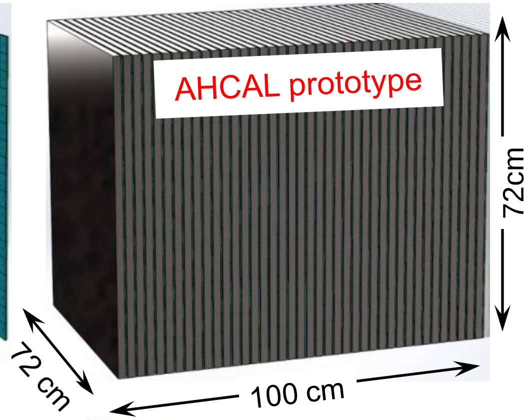
Calorimeter: Yong Liu

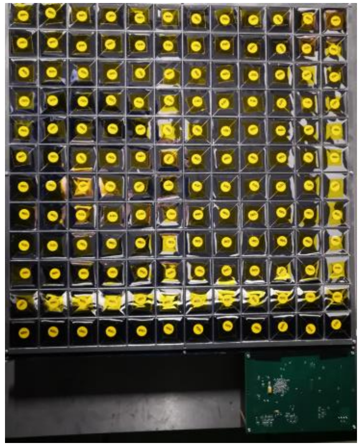
CEPC R&D: PFA HCAL

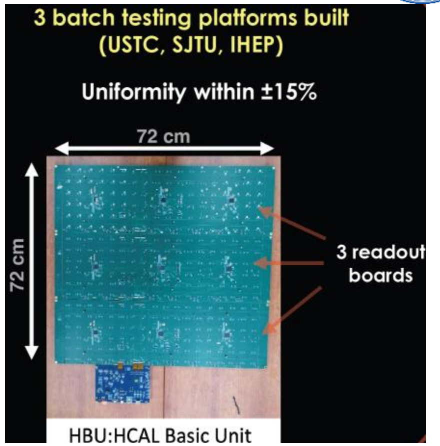




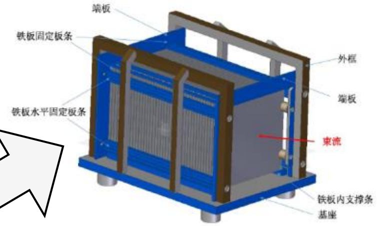


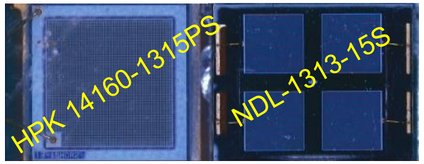






- **AHCAL with Scint.+SiPM (USTC, IHEP, SJTU)**
  - Prototype in production, size 72×72×100 cm^3,
  - 40 layers, Fe+Sct+SiPM+PCB=20+3+2=25mm,
  - 12960 Scintillators, cell size 40×40 mm^2
  - SiPM: HPK 14160-1315PS and NDL-1313-15S

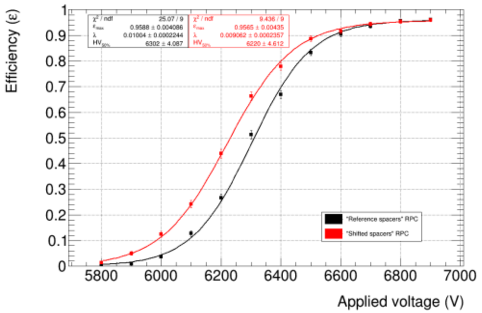




Tested ~ 15k Scintillators
Light Yield: ~ 13 ± 0.66

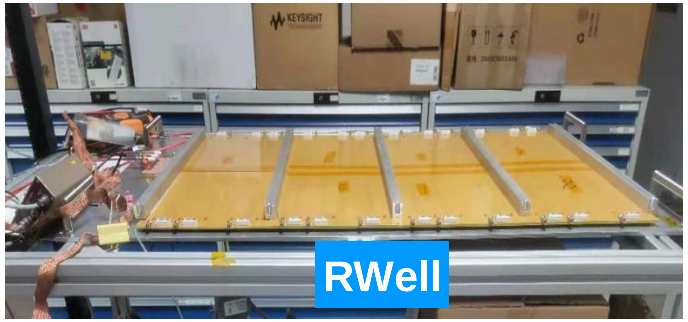
- **SDHCAL based on GRPC (SJTU)**

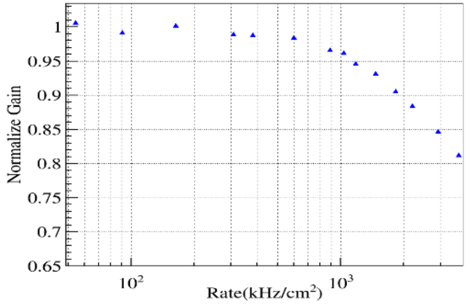
  Constructed 1×1 m^2 GRPCs, MIP Efficiency ~ 95.7%



- **SDHCAL based on MPGD (USTC, IHEP)**

  Constructed 1×0.5 m^2 RWell detector, MIP Efficiency ~ 95.9%, count rate ~ 1.8 MHz/cm^2

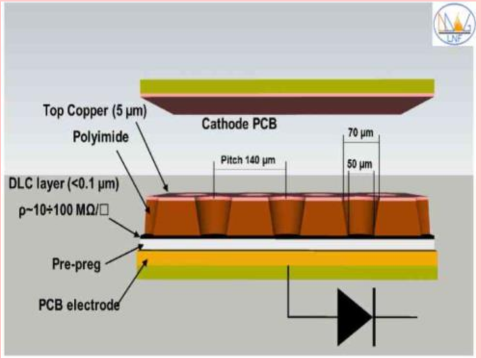


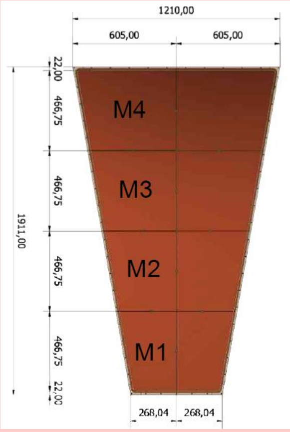


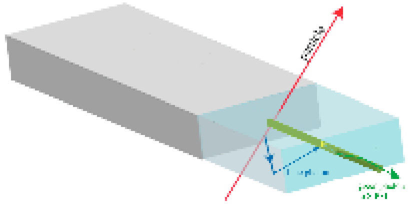
CEPC R&D: Muon Detector

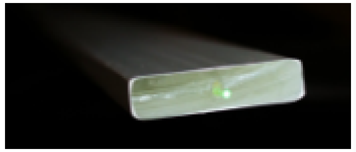
- **RPC R&D applies to both SDHCAL & Muon.**
- An alternative is **μ-RWELL** technology. The concept was proved. Currently focus mainly on industrialization and cost reduction.
- **Scintillator Muon detector. R&D overlaps with Belle II**
  - Building a prototype detector
  - Scintillator strips, improving quality & cost-reduction.
  - WLS fiber: purchased Kuraray, focusing on optical couplings.
  - SiPM Hamamatsu S13360-13**CS, and MPPC option.

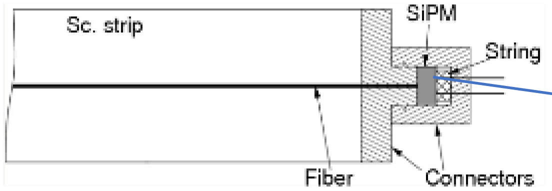
μRWELL for PS & Muon

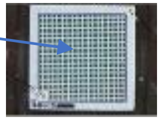


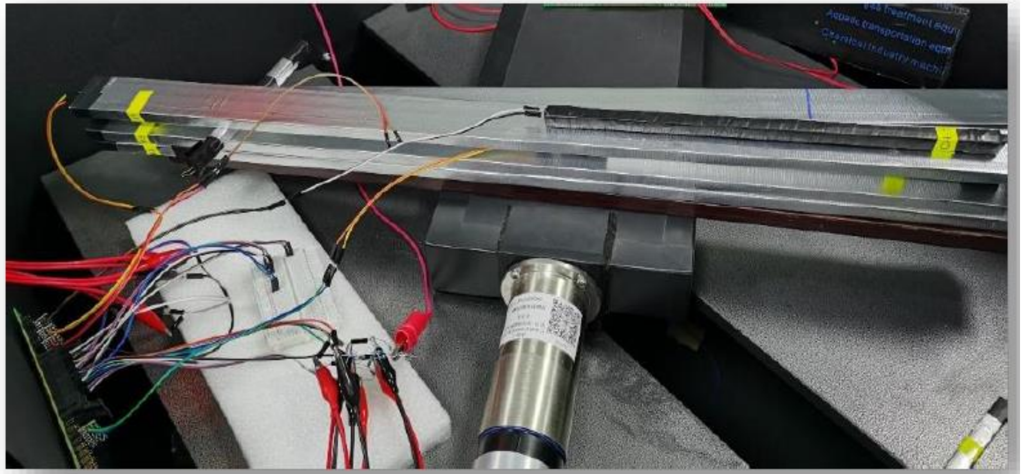


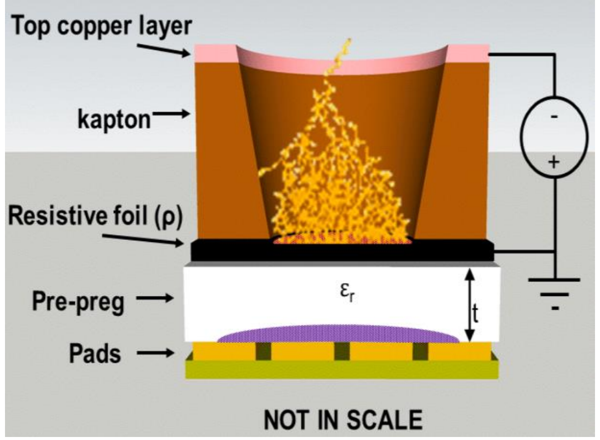












Achieved σ_t~2ns,

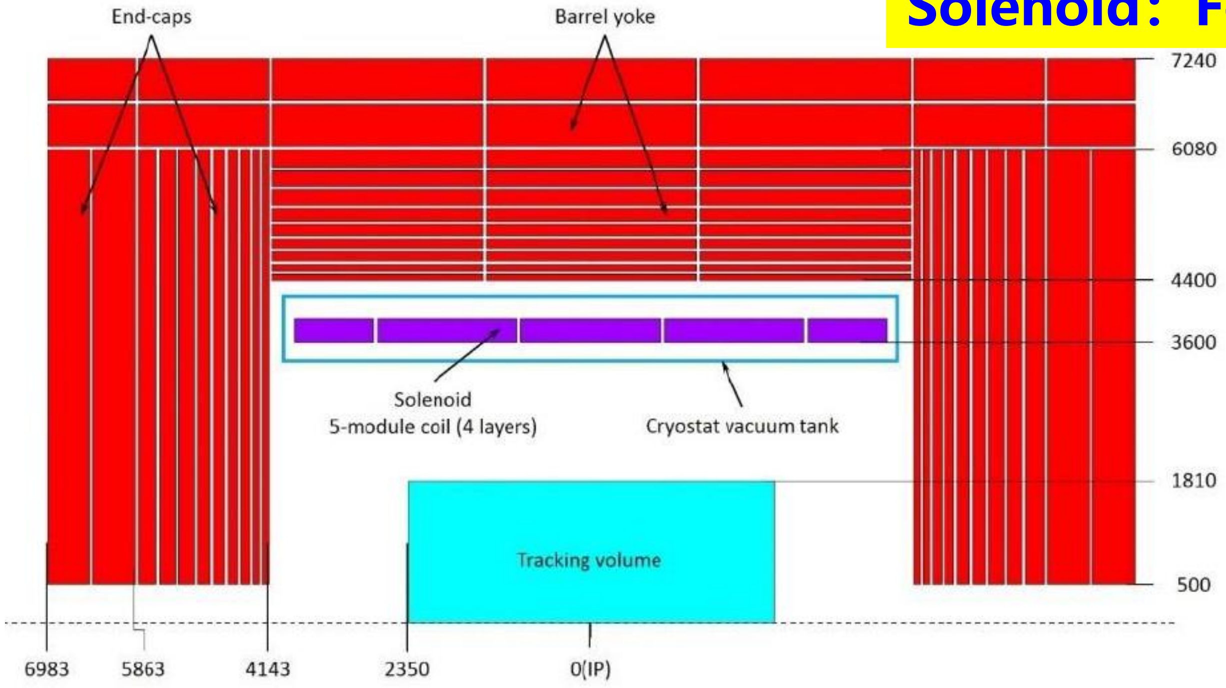
Aim for 100-200 ps.

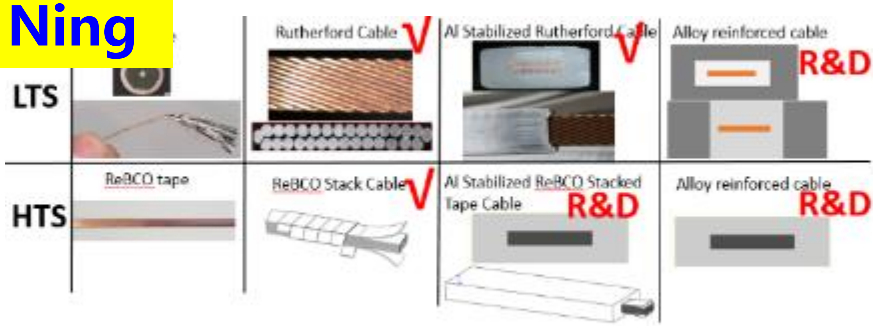
Fudan U.

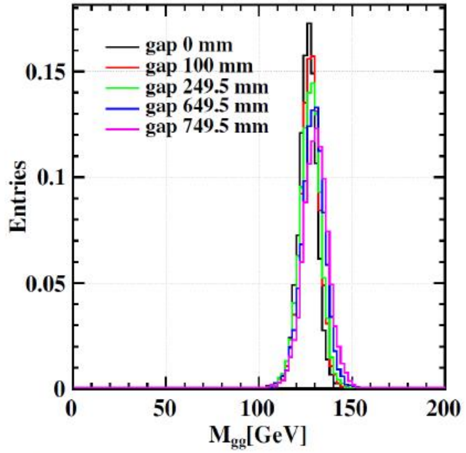
Muon: Xiaolong Wang

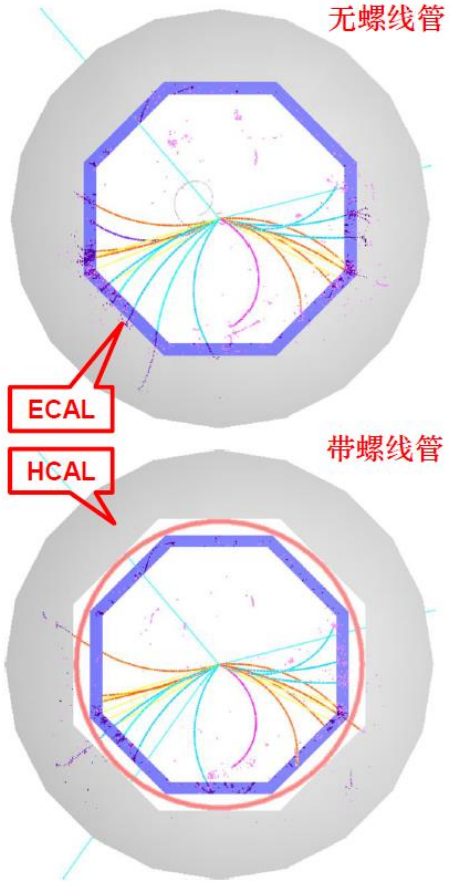
CEPC R&D: Solenoid Magnet

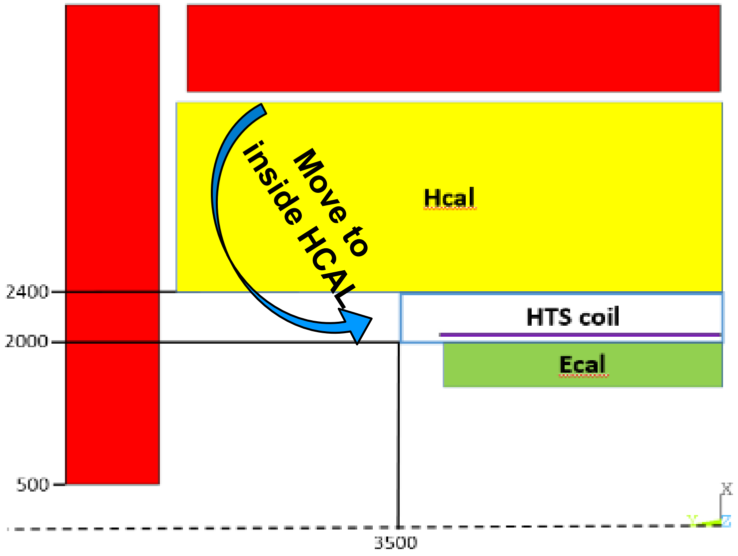
Solenoid: Feipeng Ning











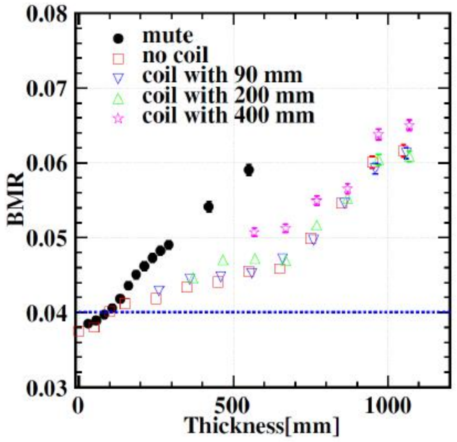
Main Challenges

Low mass

Ultra-thin

High strength cable

Keep BMR ~4%

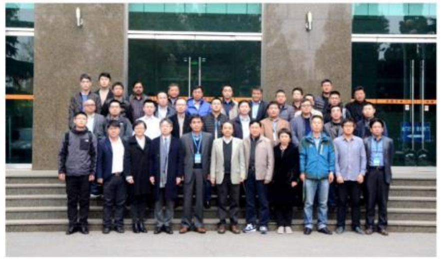


Collaboration with Industry (CIPC)

The CEPC Industrial Promotion Consortium (CICP) is established in Nov 2017. Till now, More than 60 companies joined CICP, with expertise on superconductor, superconducting cavities, cryogenics, vacuum, klystron, electronics, power supply, civil engineering, precise machinery, etc. The CIPC serves as a communication forum for the industrial and the HEP community.

1) Superconduting materials (for cavity and for magnets)
2) Superconducting cavities
3) Cryomodules
4) Cryogenics
5) Klystrons
6) Magnet technology
7)Vacuum technologies
8) Mechanical technologies
9)Electronics
10) SRF
11) Power sources
12) Civil engineering
13) Precise machinery
.....

More than **40 companies** first phase of CIPC，**and 70 companies now.**



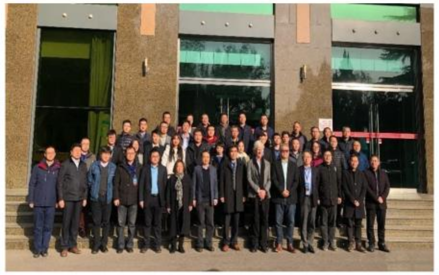
CEPC产业促进会2018年会
企业代表与高能所合影
Representatives of enterprises in the annual meeting, in July. 26 , 2018
40余家企业，80余人参会

CEPC产业促进会第二次全体会议
企业代表与高能所合影
Representatives of enterprises in the plenary meeting, in Nov. 13 , 2018
30余家企业代表

Review of CIPC annual meeting

Cryogenics workshop on TDR of CEPC
Nov 27, 2018, IHEP, Beijing, China

CIPC working group meeting On June 4,2019



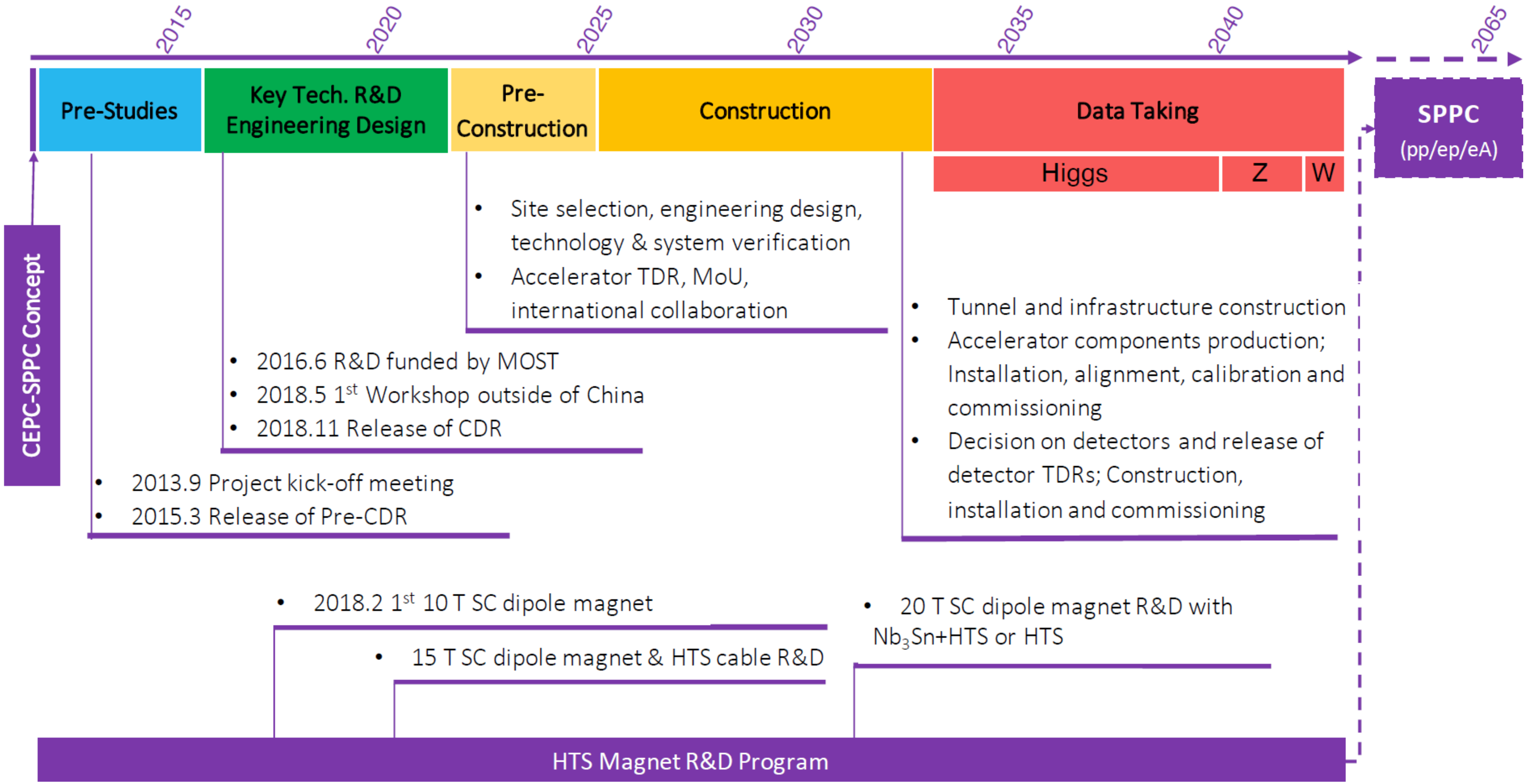
CEPC产业促进会-基金会
企业代表与高能所合影
Representatives of CIPC Foundations in the plenary meeting, in Nov. 21 , 2019

CEPC产业促进会第三次全体会议
企业代表与高能所合影
Representatives of enterprises in the plenary meeting, in Nov. 19 , 2019
64位代表，52个报告

CEPC Project Timeline

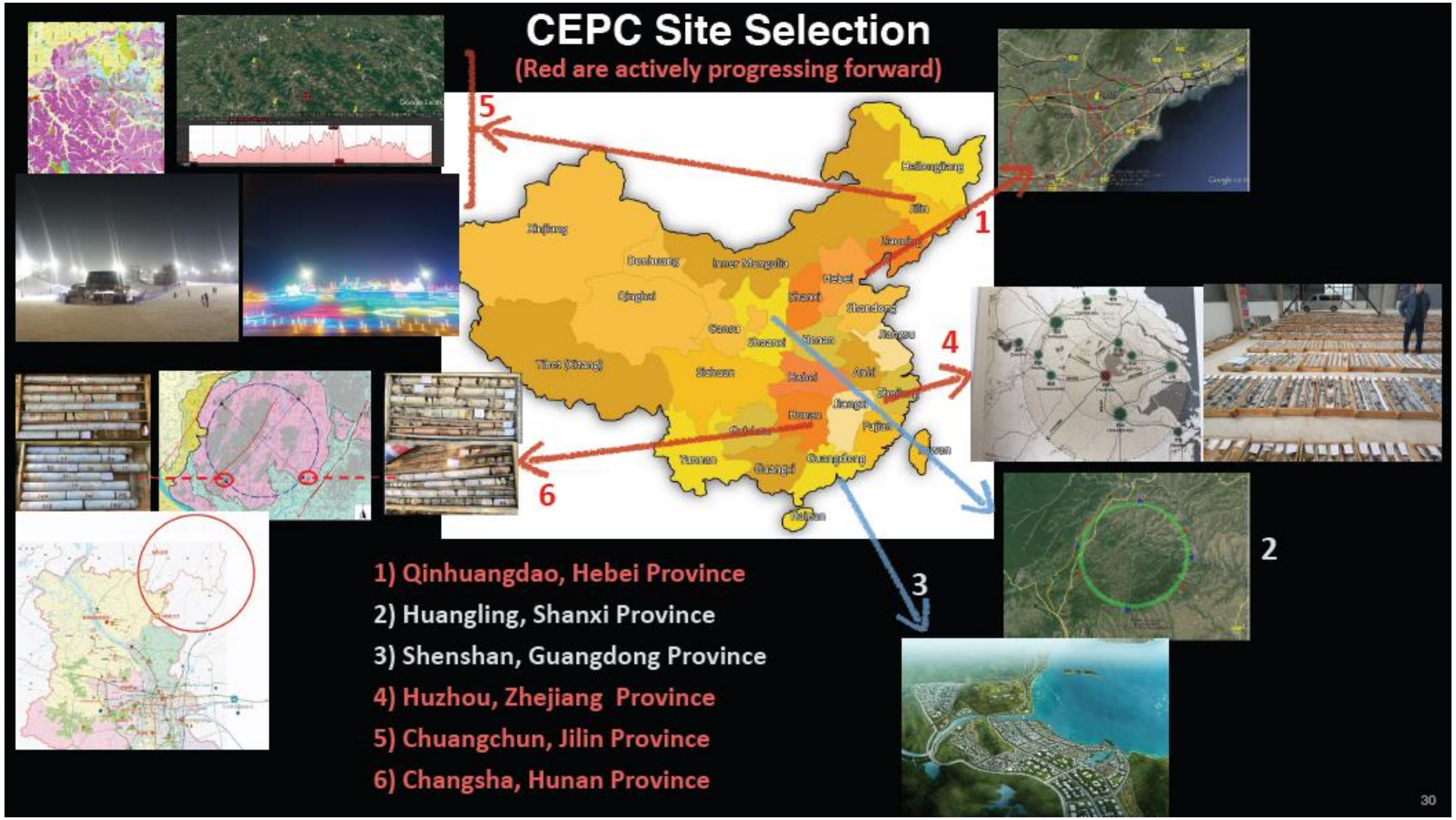
- **2013-2025：Key technology R&D，from CDR to TDR, Site selection**
- **Ideal situation: Approval in the 15th Five-Year Plan (2026-2030)**

CEPC Project Timeline



CEPC Site Selection

- 候选地址：秦皇岛、陕西、深圳、湖州、长春、长沙等

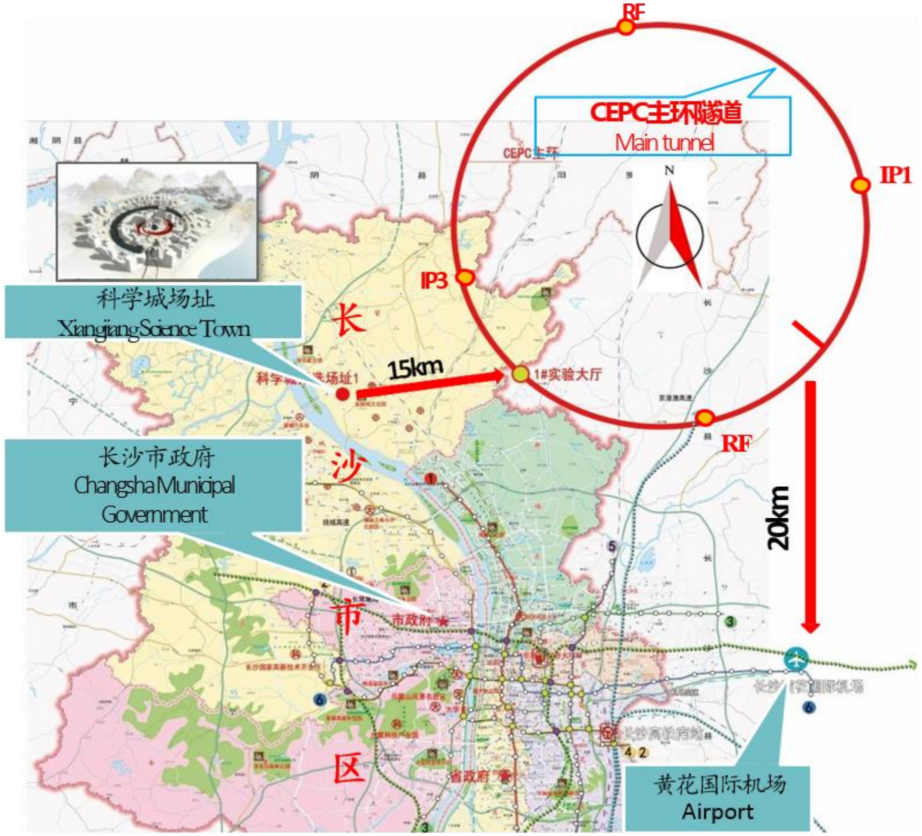


- Site selection is based on geology, electricity supply, transportation, environment, Local support & economy, …
- Initial CDR study is based on Qing-Huang-Dao site

- More invitations from local governments: Changsha, Changchun, …
- 团队调研长沙和长春:具有良好的地质条件和便利的交通（近大城市和国际机场~20公里)
- 长沙市政府非常积极，5月访问高能所；委托湖南大学在9月4日组织召开《中国(长沙)环形正负电子对撞机暨国际科学新城项目论证报告》专家论证会，对项目及国际科学城定位及规划的系统性、技术及投资的可行性等方面给予正面评价；当地政府非常支持项目落地建设。

CEPC Site Selection

- One of the best international image city of China (mainland), the UNESCO Creative City of Media Arts and the Culture City of East Asia.
- Changsha site and its surroundings have slight seismic activity in history, and are free of active faults. The peak ground acceleration is 50 Gal (0.5m/s^2) and the seismic intensity is VI. The tectonic structure is stable.
- Site located in the north of Changsha City,
  - 15 km from Xiangjiang science town
  - 20 km from downtown & international airport
- Accessibility and transport conditions: The existing transport and road network is sound and complete, with convenient access to downtown and airport. The site has open landform, pleasant environment with mountain and river, and complete supporting facilities around.

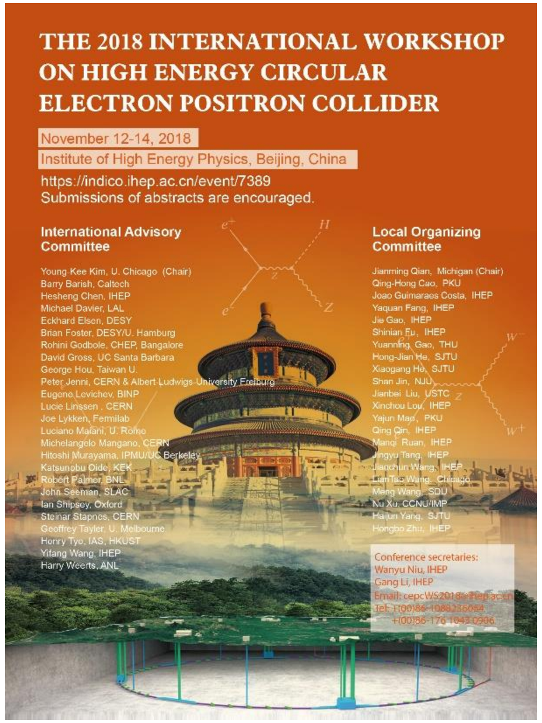


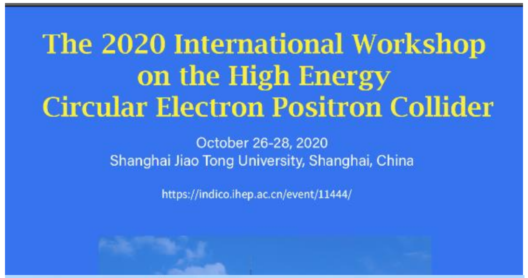
Summary

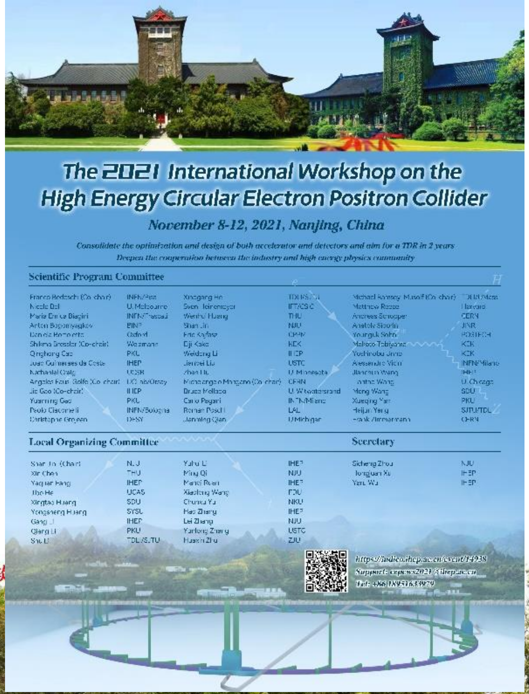
- CEPC 是希格斯工厂 + Z工厂 + W工厂，具有丰富的物理和探索新物理的巨大潜力
- 积极准备CEPC白皮书：希格斯物理（已发表），电弱物理，味物理，QCD物理及新物理等
- 提出了新的探测器概念设计，积极开展探测器关键技术预研
- 探测器关键技术预研取得了多项重要进展：
  - 成功研制硅像素芯片，空间分辨率达到5微米，功耗为53mW/cm^2；
  - 成功研制TPC原理样机，空间分辨好于100微米；低功耗，高集成度的读出电子学ASIC芯片，~2mW/ch
  - 成功研制国际首个基于闪烁体和硅光电倍增管的高颗粒度电磁量能器技术样机，单层位置分辨好于2毫米
- 召开了一系列CEPC国际研讨会:
  - 中国：　北京 (2017.11, 2018.11, 2019.11)，上海 (2020.10)，扬州 (2021.4), 南京 (2021.11)
    香港科技大学（2015起-）
  - 欧洲：　罗马 (2018.05), 牛津 (2019.04)，　马赛 (2022.05 ?)
  - 美国：　芝加哥(2019.09), 华盛顿特区 (2020.04, online)

- 经费资助：科技部，基金委，中科院，地方政府
- CEPC关键技术预研工作稳步推进，并取得了一系列重要进展，感谢大家的积极参与！

Recent CEPC Workshops







Next CEPC International Workshop

at Nanjing University, Nov. 8-12, 2021

You are very welcome to participate

https://indico.ihep.ac.cn/event/14938/

谢谢大家的关注和支持！


The 2021 Workshop on CEPC Detector & MDI Mechanical Design
IHEP Dongguan Campus, October 22-23, 2021

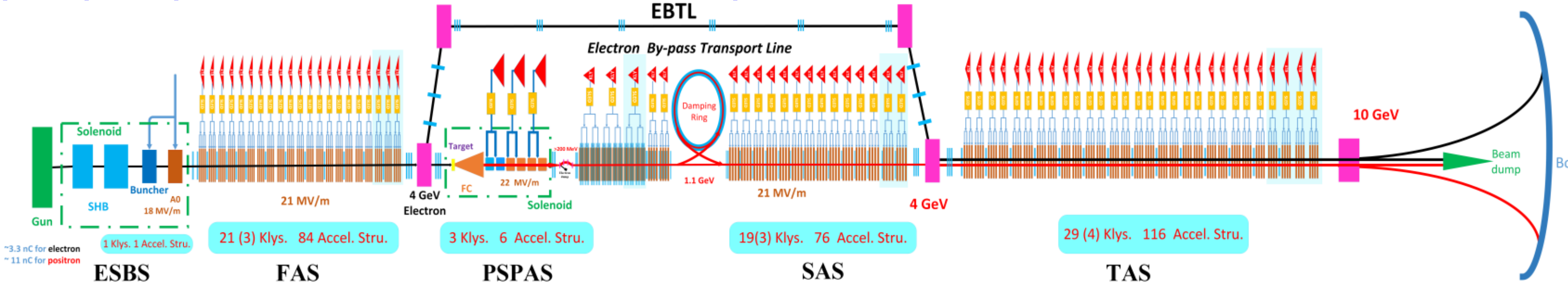
CEPC Accelerator Baseline (CDR)

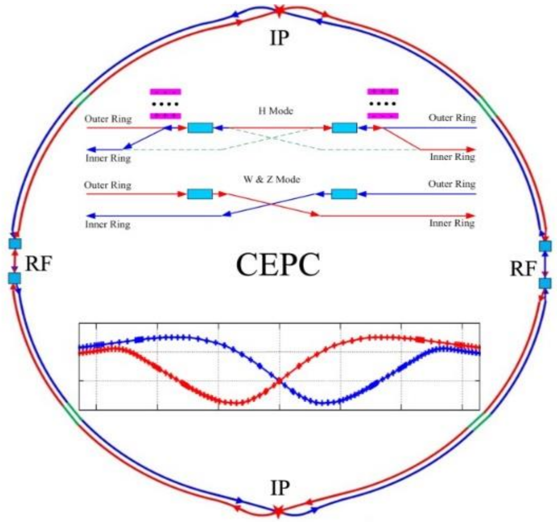
CEPC Accelerator: Yuhui Li

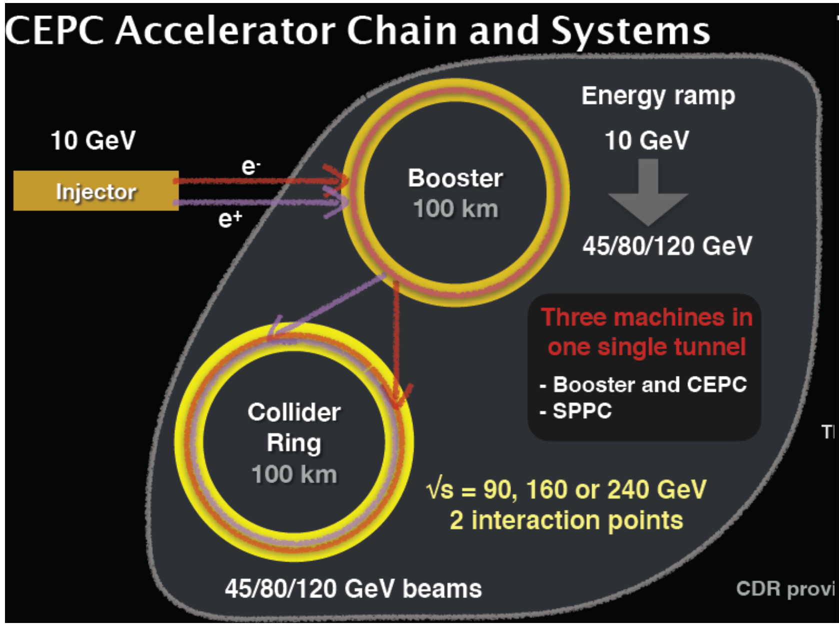
Baseline: 100 km, 30 MW; Upgradable to 50 MW, High Lumi Z, ttbar

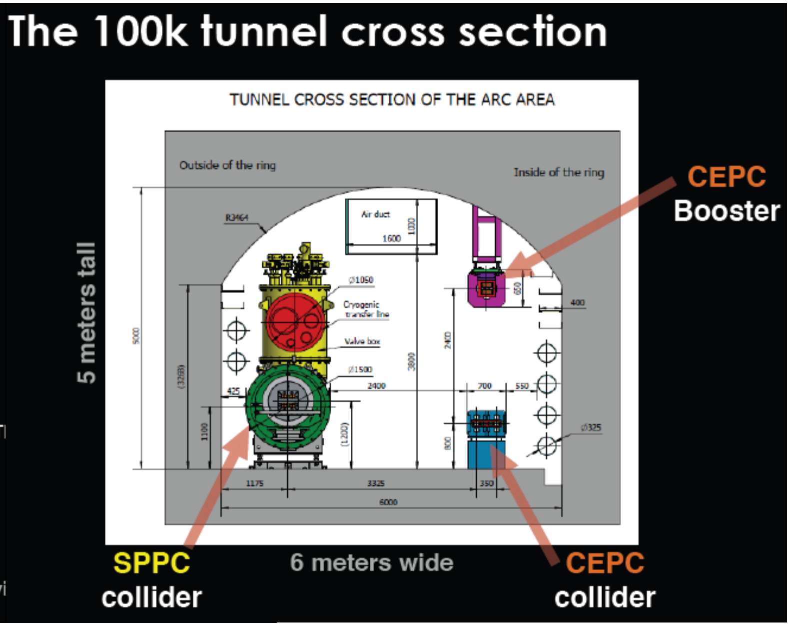
A very active **accelerator** R&D program towards a **TDR ~** the end of 2022

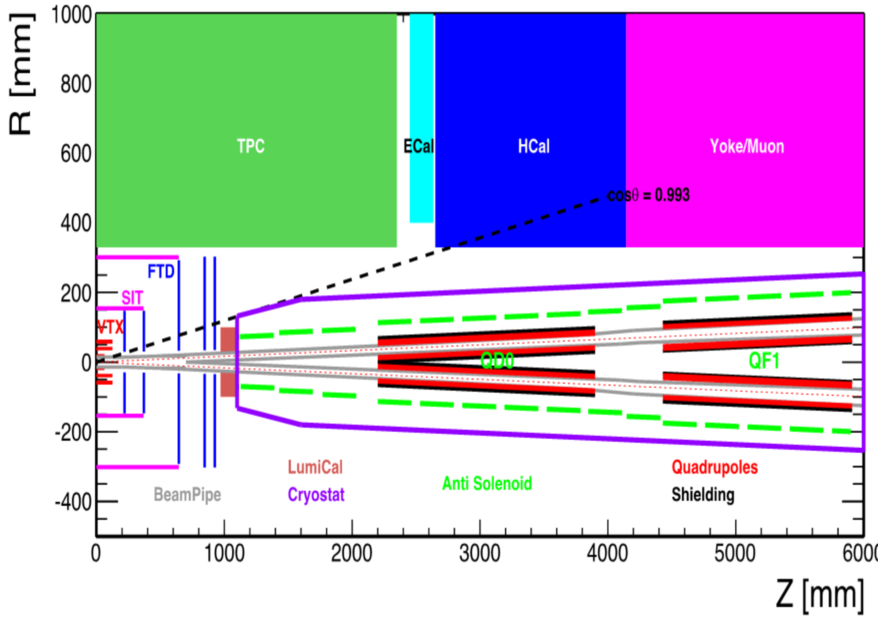
http://cepc.ihep.ac.cn/CEPC_CDR_Vol1_Accelerator.pdf











CEPC Accelerator Design Improvement

	Higgs	W	Z (3T)	Z (2T)
Number of IPs	2			
Beam energy (GeV)	120	80	45.5	
Circumference (km)	100			
Synchrotron radiation loss/turn (GeV)	1.73	0.34	0.036	
Crossing angle at IP (mrad)	16.5 × 2			
Piwinski angle	3.48	7.0	23.8	
Particles /bunch N_e (10^{10})	15.0	12.0	8.0	
Bunch number	242	1524	12000 (10% gap)	
Bunch spacing (ns)	680	210	25	
Beam current (mA)	17.4	87.9	461.0	
Synch. radiation power (MW)	30	30	16.5	
Bending radius (km)	10.7			
Momentum compaction (10^{-5})	1.11			
β function at IP β_x^*/β_y^* (m)	0.36/0.0015	0.36/0.0015	0.2/0.0015	0.2/0.001
Emittance x/y (nm)	1.21/0.0024	0.54/0.0016	0.18/0.004	0.18/0.0016
Beam size at IP σ_x/σ_y (μm)	20.9/0.06	13.9/0.049	6.0/0.078	6.0/0.04
Beam-beam parameters ξ_x/ξ_y	0.018/0.109	0.013/0.123	0.004/0.06	0.004/0.079
RF voltage V_{RF} (GV)	2.17	0.47	0.10	
RF frequency f_{RF} (MHz)	650			
Harmonic number	216816			
Natural bunch length σ_z (mm)	2.72	[illegible]	[illegible]	
Bunch length σ_z (mm)	4.4	[illegible]	[illegible]	
Damping time $\tau_x/\tau_y/\tau_E$ (ms)	[illegible]	[illegible]	849.5/849.5/425.0	
Natural Chromaticity	[illegible]	[illegible]1161	-491/-1161	-513/-1594
[illegible]	363.10 / 365.22			
[illegible]	0.065	0.040	0.028	
[illegible]ty (2 cell)	0.46	0.75	1.94	
Natural energy spread (%)	0.100	0.066	0.038	
Energy spread (%)	0.134	0.098	0.080	
Energy acceptance requirement (%)	1.35	0.90	0.49	
Energy acceptance by RF (%)	2.06	1.47	1.70	
Photon number due to beamstrahlung	0.082	0.050	0.023	
Beamstruhlung lifetime /quantum lifetime† (min)	80/80	>400		
Lifetime (hour)	0.43	1.4	4.6	2.5
F (hour glass)	0.89	0.94	0.99	
Luminosity/IP (10^{34} cm^{-2}s^{-1})	3	10	17	32

† include beam-beam simulation and real lattice

2018 CDR Baseline Design

	ttbar	Higgs	W	Z
Number of Ips	2			
Circumference [km]	100.0			
SR power per beam [MW]	30			
Half crossing angle at IP [mrad]	16.5			
Bending radius [km]	10.7			
Energy [GeV]	180	120	80	45.5
Energy loss per turn [GeV]	9.1	1.8	0.357	0.037
Piwinski angle	1.21	5.94	6.08	24.68
Bunch number	35	249	1297	11951
Bunch population [10^10]	20	14	13.5	14
Beam current [mA]	3.3	16.7	84.1	803.5
Momentum compaction [10^-5]	0.71	0.71	1.43	1.43
Beta functions at IP (bx/by) [m/mm]	1.04/2.7	0.33/1	0.21/1	0.13/0.9
Emittance (ex/ey) [nm/pm]	1.4/4.7	0.64/1.3	[illegible]	0.27/1.4
Beam size at IP (sigx/sigy) [um/nm]	39/113	15/[illegible]	[illegible]	6/35
Bunch length (SR/total) [mm]	2.2/2.9	[illegible]	[illegible]/4.9	2.5/8.7
Energy spread (SR/total) [%]	[illegible]	[illegible]/0.17	0.07/0.14	0.04/0.13
Energy acceptance (DA/RF) [%]	[illegible]	1.6/2.2	1.2/2.5	1.3/1.7
Beam-beam parameters (ksix/ksiy)	0.071/0.1	0.015/0.11	0.012/0.113	0.004/0.127
RF voltage [GV]	10	2.2	0.7	0.12
RF frequency [MHz]	650	650	650	650
HOM power per cavity (5/2/1cell)[kw]	0.4/0.2/0.1	1/0.4/0.2	-/1.8/0.9	-/-/5.8
Qx/Qy/Qs	0.12/0.22/0.078	0.12/0.22/0.049	0.12/0.22/	0.12/0.22/
Beam lifetime (bb/bs)[min]	81/23	39/18	60/717	80/182202
Beam lifetime [min]	18	12.3	55	80
Hour glass Factor	0.89	0.9	0.9	0.97
Luminosity per IP[1e34/cm^2/s]	0.5	5.0	16	115

2021 Improved Design

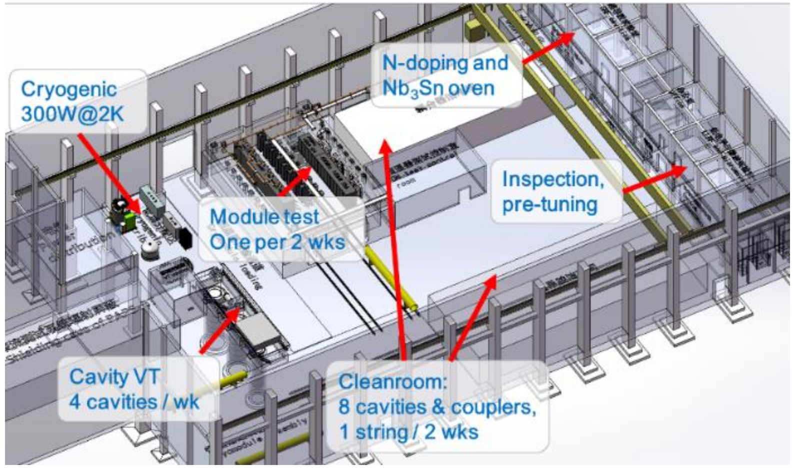
67%⇑

259%⇑

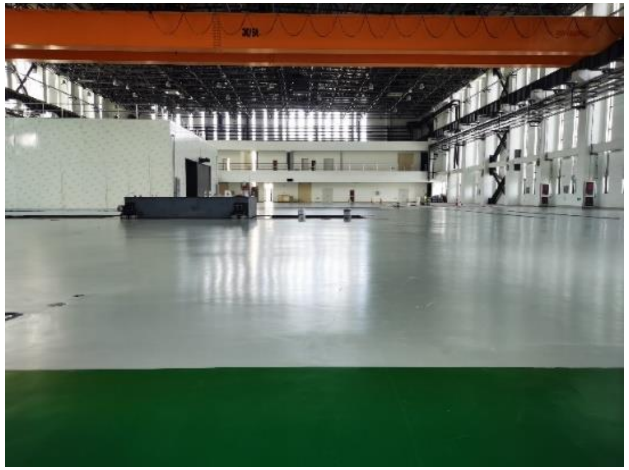
CEPC SCRF Test Facility

CEPC SCRF test facility (Lab)：Beijing Huairou ($4500m^2$)

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



SC New Lab will be available in 2021



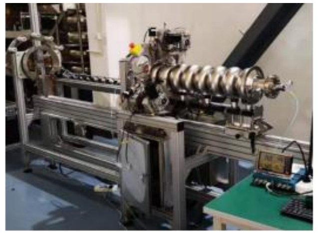
Crygenic system hall in Jan. 16, 2020

Vacuum furnace (doping & annealing)

Nb3Sn furnace

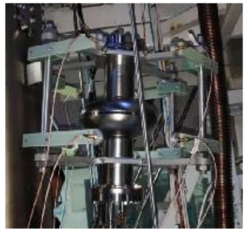
Nb/Cu sputtering device

Cavity inspection camera and grinder

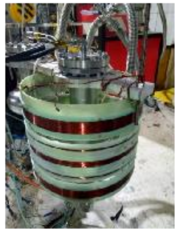


9-cell cavity pre-tuning machine

Temperature & X-ray mapping system



Second sound cavity quench detection system



Helmholtz coil for cavity vertical test

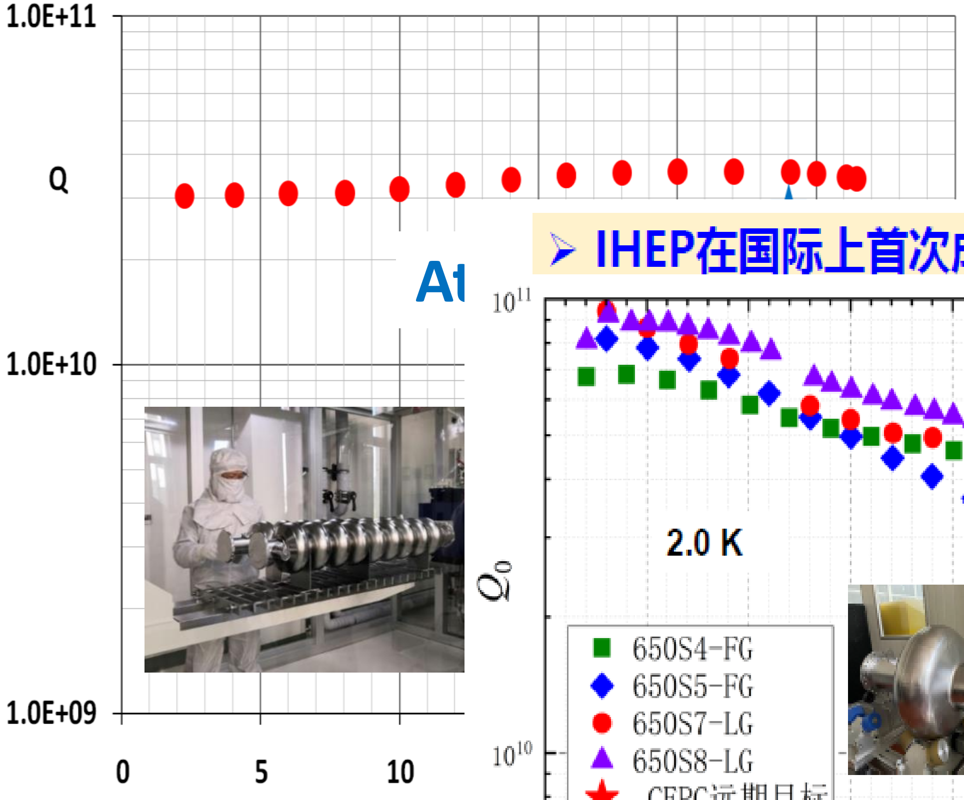
Vertical test dewars

Horizontal test cryostat

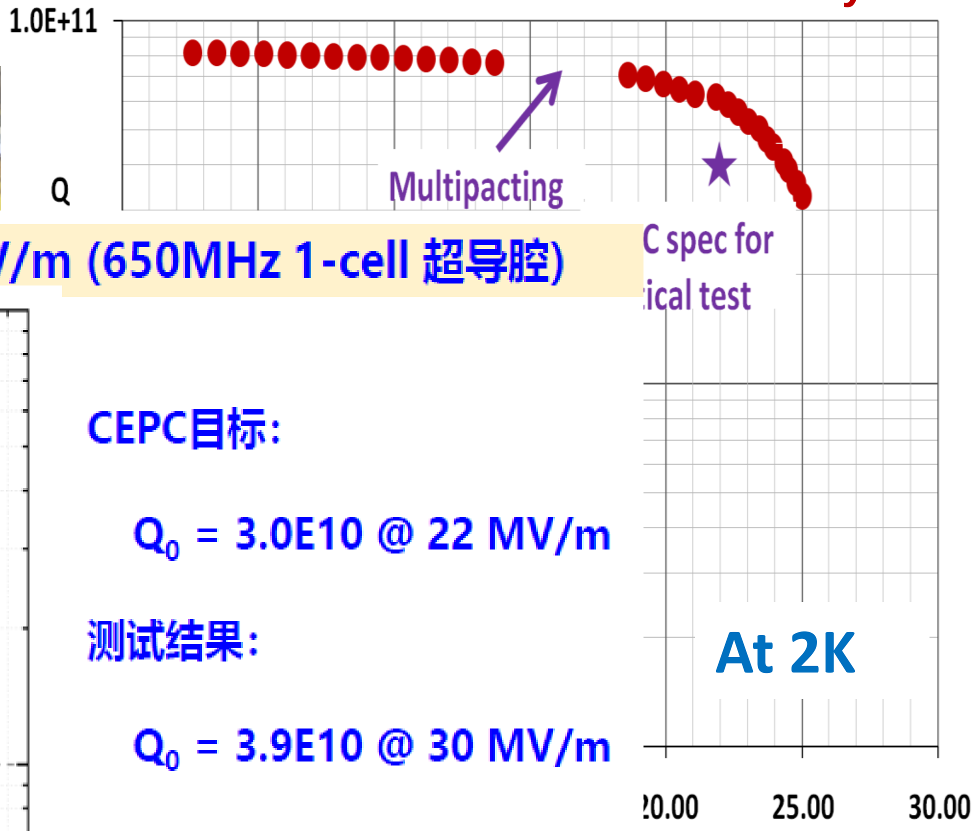
CEPC R&D: High Q SCRF Cavities

- ➢ Booster 1.3 GHz 9-cell SCRF cavity: Q = 3.4E10 @ 26.5 MV/m (中温退火)
- ➢ Collider ring 650 MHz 2-cell SCRF cavity: Q = 6.0E10 @ 22.0 MV/m (掺氮)
- ➢ IHEP研制的超导加速腔性能指标已经达到并超过了CEPC的设计指标 Q = 3 E10

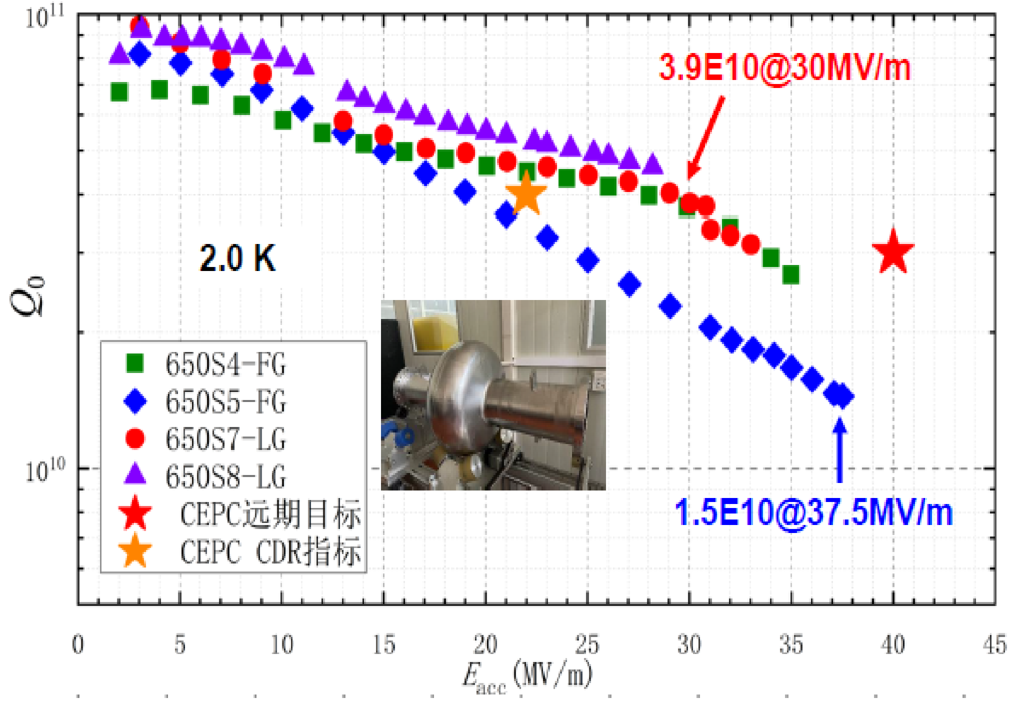
Vertical test of 1.3 GHz 9-cell cavity



Vertical test of 650 MHz 2-cell cavity



- ➢ IHEP在国际上首次成功实现3.9E10@30 MV/m (650MHz 1-cell 超导腔)



CEPC目标:

Q_0 = 3.0E10 @ 22 MV/m

测试结果:

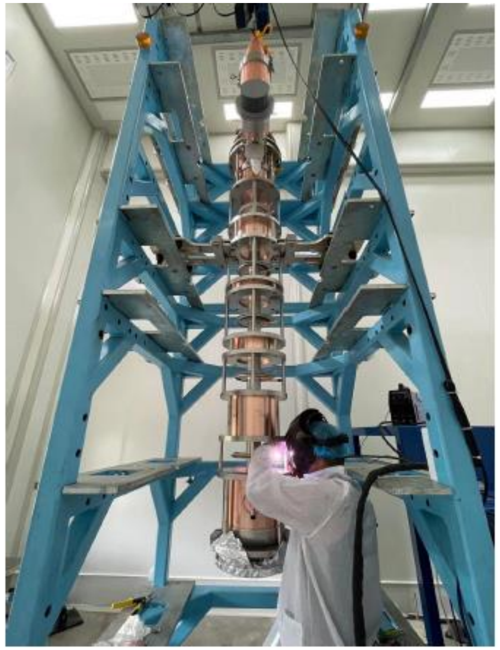
Q_0 = 3.9E10 @ 30 MV/m

Q_0 = 1.5E10 @ 37.5 MV/m

Medium-temperatur
adopted to reach Q :

CEPC R&D: High Efficiency Klystrons

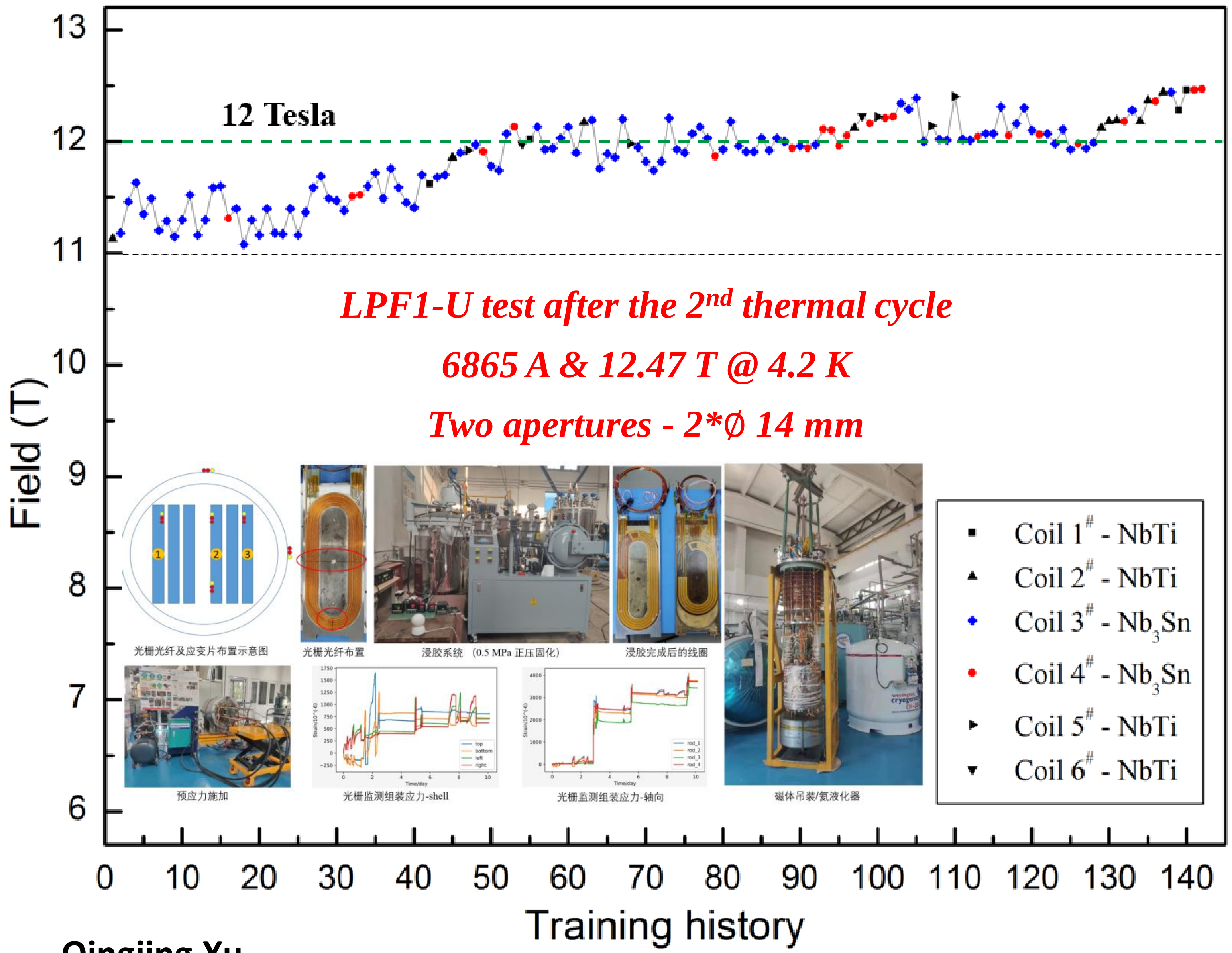
- 高效率束调管是CEPC加速器的关键核心技术之一
- 首个束调管样机通过测试，最大输出功率达到 700 kW (CW) 和 800 kW (Pulsed mode)，**转换效率达到 ~ 62%**
- 第二个束调管样机已经研制成功，将运送到怀柔先进光源研发与测试平台 （PAPS）进行测试，**设计效率：~77%**
- 多束流束调管设计已完成, **设计效率： ~80.5%**



第二个束调管组装

首个束调管功率测试

HTS SC Magnet (12T)



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Domestic Superconducting Dipole Magnet Reaches 12 Tesla

Contact

GUO Lijun

Editor: LIU Jia | Jun 17, 2021

The high-field superconducting magnet team of Institute of High Energy Physics (IHE Sciences has made progress in a new round of performance tests that ended on Jun magnet developed by the team exceeded 12 T (Tesla) in two apertures at 4.2 K, reach performance capacity of the superconducting wire. This magnet, including its design coils, and related equipment and platform, is based on domestic technologies.

At present, the magnetic field record for a dipole magnet without aperture is 16 T an for Nuclear Research (CERN). The record for a single-aperture dipole magnet is 14 T.

中国新闻网 WWW.CHINANEWS.COM

中国自主研制超导二极磁体磁场强度突破12特斯拉

中国新闻网

2021-06-16 21:26:21

中新社北京6月16日电 (记者 孙自法)中国科学院高能物理研究所(中科院高能所)16日发布消息，该所高场超导磁体团队自主研制的全国产超导二极磁体在最新结束的新一轮性能测试实验中取得突破性进展，该磁体在4.2K(零下269摄氏度)下两个孔径内实现超过12特斯拉(T，Tesla)磁场强度，达到超导线材临界性能的85%以上。

中科院高能所团队研制的该超导

中国科技网 stdaily.com

首页 研习 新闻 前沿 国际 访谈 专题

首页 > 科技新闻 > 正文

我国自主研制的超导二极

2021-06-16 21:07:11来

科技日报北京6月16日电（记者 陆成宽）16日，记者从导二极实验磁体，在新一轮性能测试实验中取得突破性进展斯拉（T）磁场强度，达到超导线材临界性能的85%以上。该的装备与测试平台，均基于国内自主技术路线。

高场超导磁体提供的强磁场可以实现高能量带电粒子束流的轨迹及尺寸控制，是基础物理研究、先进核聚变能源技术以及高能量粒子加速器建设的核心技术之一。欧洲及美国未来十年高能物理发展战略中均把高场超导磁体技术列为优先发展的关键核心技术之一；同时，正在开展的热核聚变实验堆计划也无一例外都依赖高场超导磁体技术。

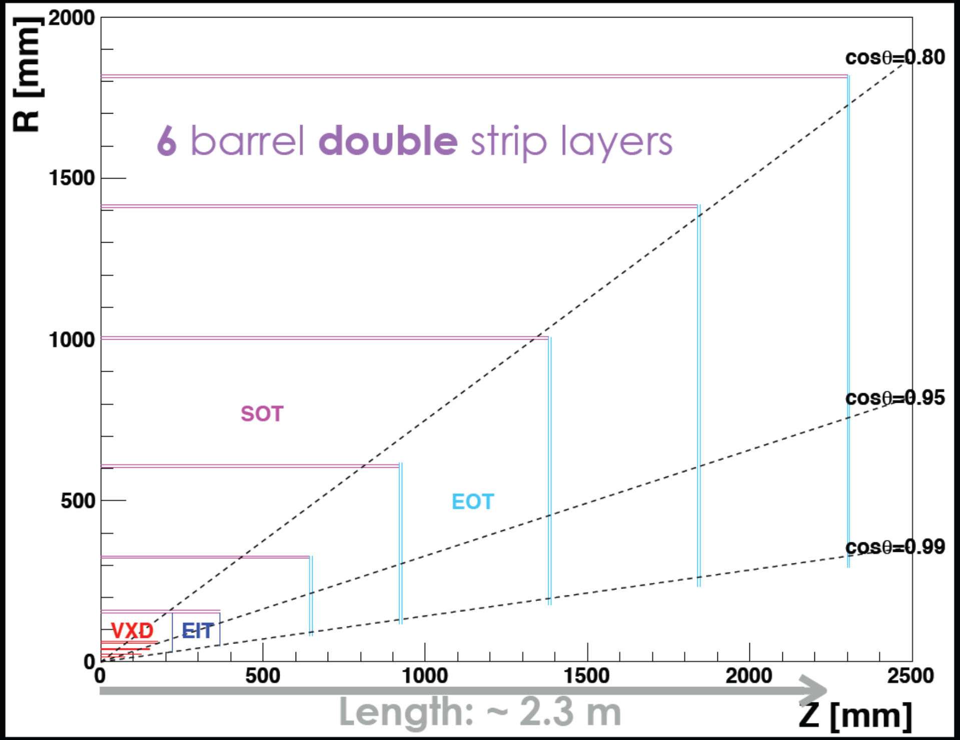
目前，加速器超导磁体的最高磁场强度记录为欧洲核子研究中心保持的16T无孔径二极实验磁体，以及美国费米

Qingjing Xu.

Full Silicon Tracker Concept

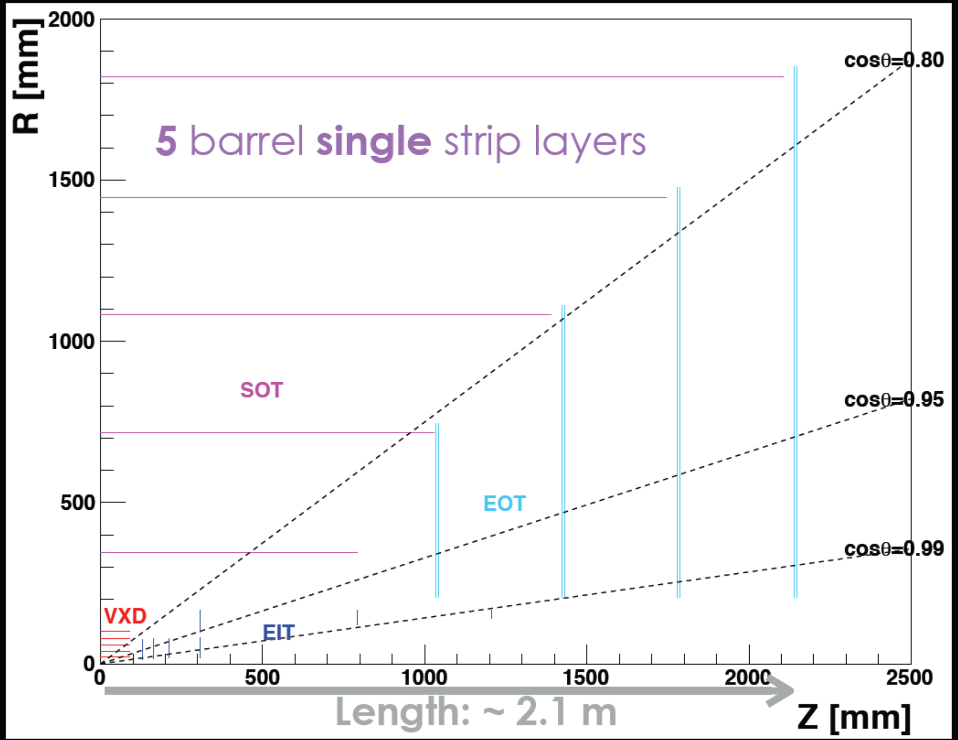
Replace TPC with additional silicon layers

FST layout: Rad length up to 7%



Radius ~ 1.8 m

FST2 layout: Rad length up to 10%



Proposed by Berkeley and Argonne

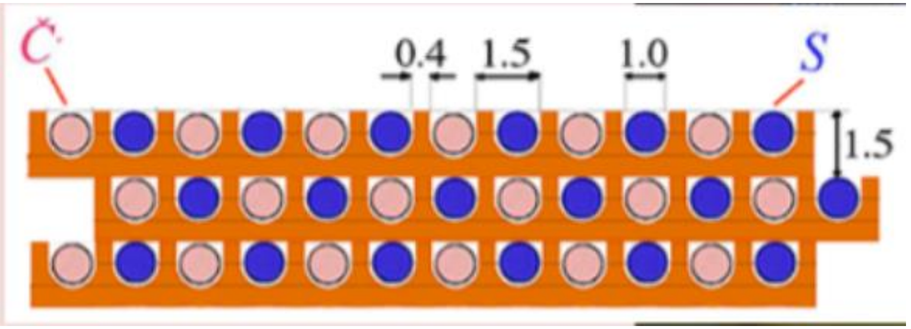
Drawbacks: higher material density and limited particle identification (dE/dx)

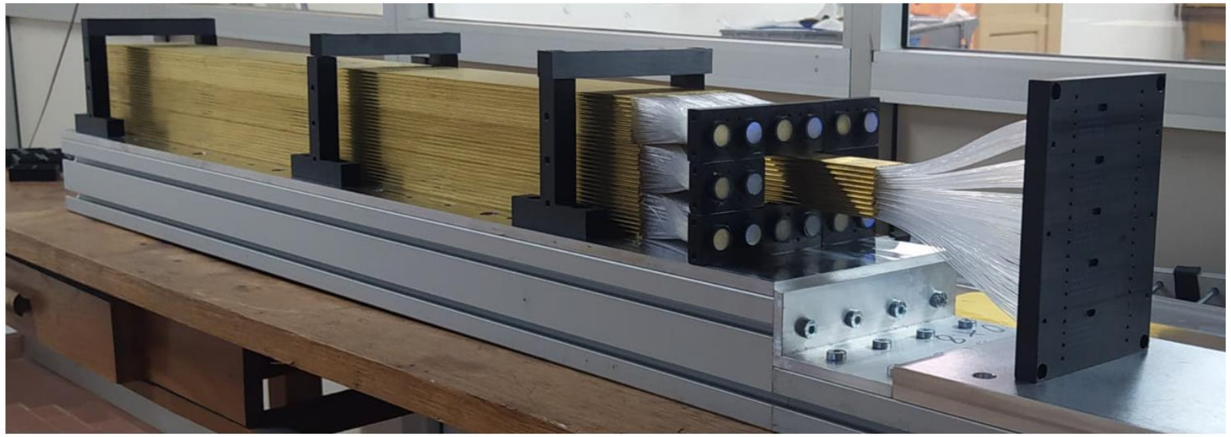
45

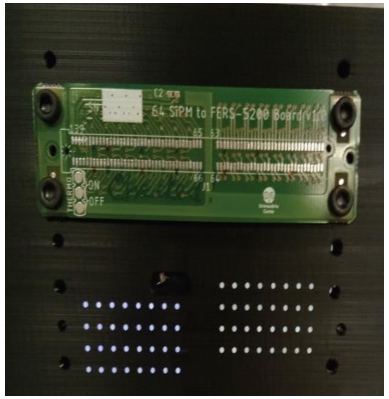
Dual Readout Calorimeter & SCEPCAL

A 3×3 towers ECal-size prototype has been built, waiting for testbeam.

Dual Readout calorimeter in the IDEA design







160 scint. fibers

160 Cherenkov fibers

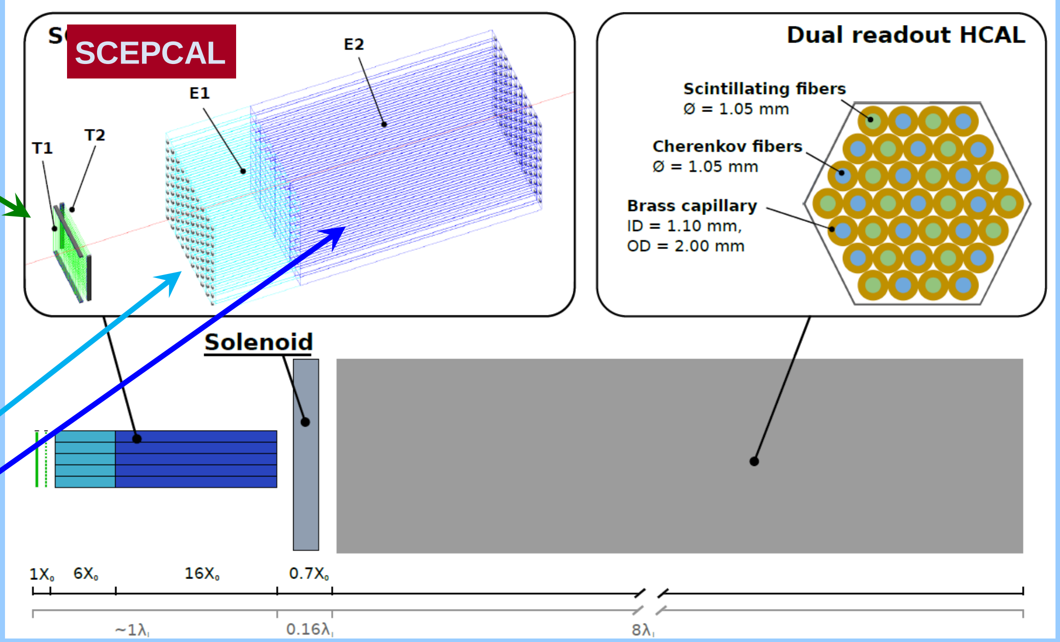
Tower: 20 rows × 16 columns

Combining Crystal ECal and DR Calorimeter

by Eno, Lucchini, and Tully et al. (arXiv:2008.00338)

Timing layer σ_t ~ 20 ps
- LYSO Ce crystal (~$1X_0$)
- $3\times3\times54$ mm^3 active cell
- 3×3 mm^2 SiPMs (15-20 μm)

ECAL layer σ_E/E~ $3\%/\sqrt{E}$
- PbWO crystals
- Front segment (~6 X_0)
- Read segment (~16 X_0)
- $10\times10\times200$ mm^3 Crystals
- 5×5 mm^2 SiPMs (10-15 μm)

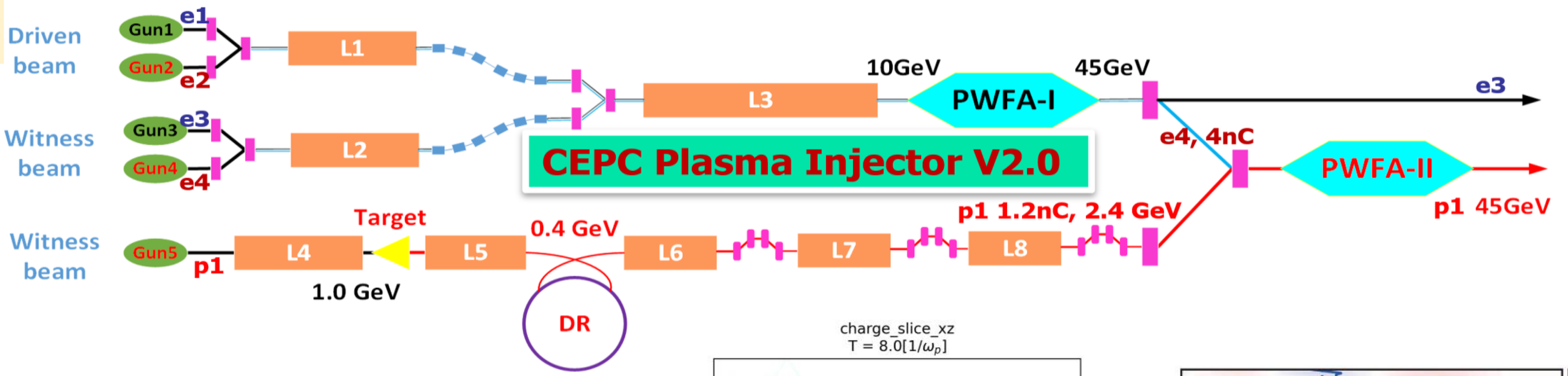


CEPC Accelerator: Plasma Injector

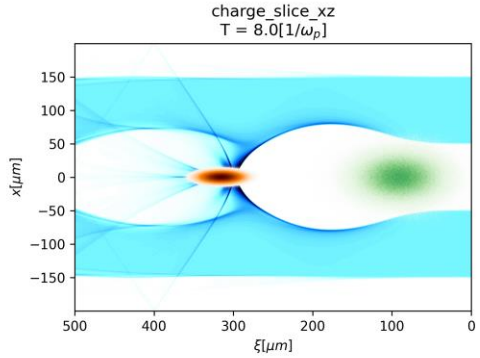
CEPC Plasma Injector V2.0

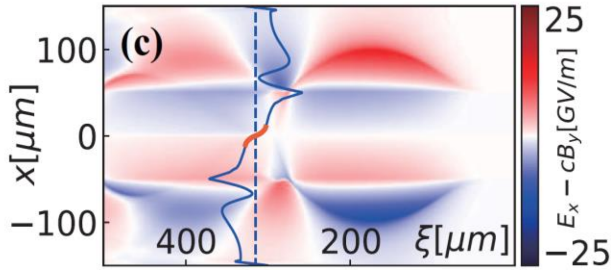
IHEP, THU, BNU

Booster Requirement	
Energy （GeV）	45.5
Bunch Charge （nC）	0.78
Bunch length (um)	<3000
Energy Spread (%)	0.2
ε_N (µm·rad)	<800
Bunch Size (um)	<2000

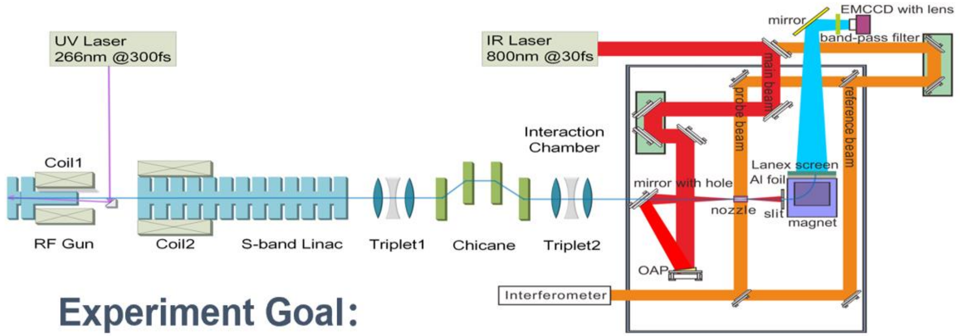


利用中空通道等离子体中稳定的非对称电子束，实现正电子束的高效率尾场加速，效率超过30%，能散约1.6%
W. Lu, et al., arXiv: 2012.06095v2



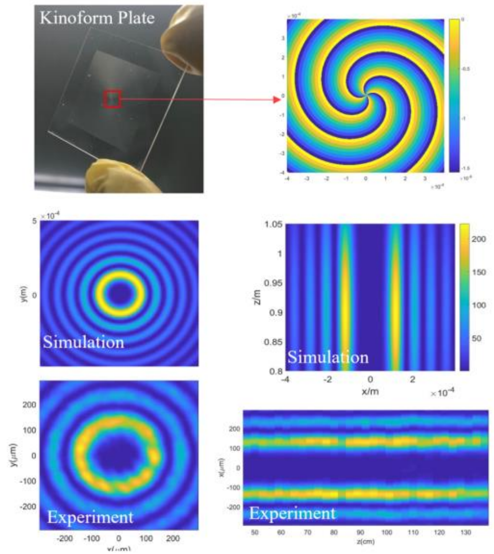


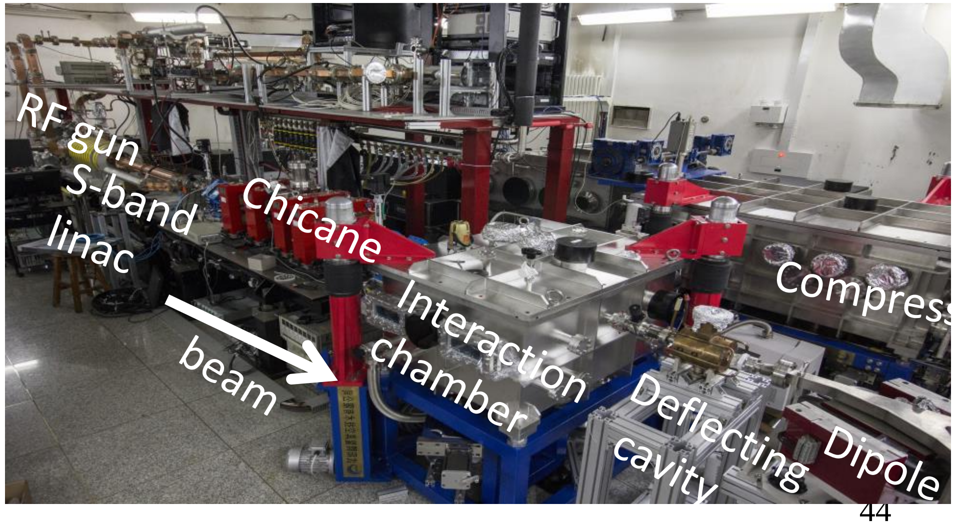
Plasma dechirper exp. at THU



Experiment Goal:

1. Decrease the energy spread from 1% to 0.1%
2. Study Hollow channel impact on beam quality





CEPC Accelerator Design Improvement

- **High luminosities at H and Z factories**
  - Optimization of parameters, improving dynamic aperture(DA) to include errors and more effects
  - New lattice for high luminosity at Higgs
  - New RF section layout
  - More detailed study of MDI
  - Optimization of the booster design and magnets
  - A new alternative design of the LINAC injector
  - A new plasma injector design
  - Injection design
  - ……
- **Accelerator Review Committee (ARC)**
  - Recommended by the IAC, established & met in November, 2019
  - Next ARC meeting will be held in Nov., 2021

CDR scheme (Higgs)

- ✓ **L*=2.2m, θc=33mrad, βx*=0.36m, βy*=1.5mm, Emittance=1.2nm**
  - Strength requirements of anti-solenoids (peak field B_z~7.2T)
  - Two-in-one type SC quadrupole coils (Peak field 3.8T & 136T/m)

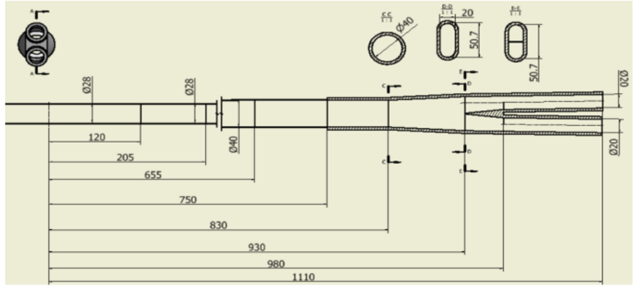
High luminosity scheme (Higgs)

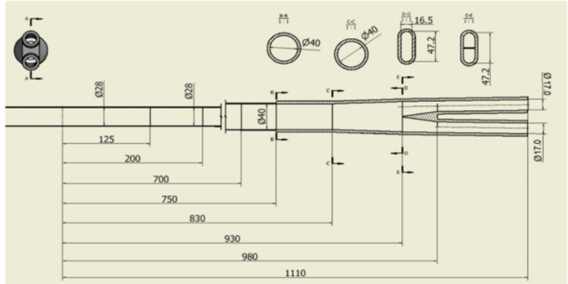
- ✓ **L*=1.9m, θc=33mrad, βx*=0.33m, βy*=1.0mm, Emittance=0.68nm**
  - Strength requirements of anti-solenoids (peak field B_z~7.2T)
  - Two-in-one type SC quadrupole coils (Peak field 3.8T & 141T/m) with room temperature vacuum chamber & Iron yoke

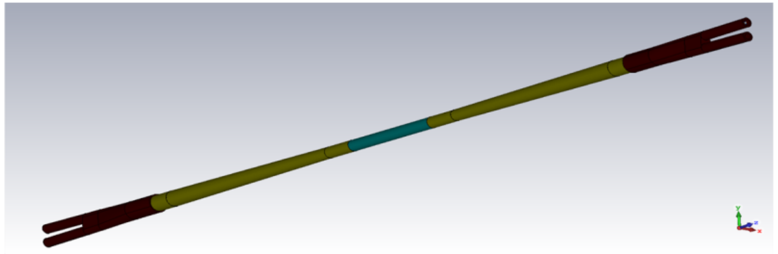
Change of IP chamber

CDR — Be pipe: 28mm, SCQ Beam pipe:20mm

High luminosity — Be pipe: 28mm, Beam pipe:17mm







CEPC Accelerator Design Improvement

2018 CDR Baseline Design

	Higgs	W	Z（3T）	Z（2T）
Number of IPs	2			
Beam energy (GeV)	120	80	45.5	
Circumference (km)	100			
Synchrotron radiation loss/turn (GeV)	1.73	0.34	0.036	
Crossing angle at IP (mrad)	16.5 × 2			
Piwinski angle	3.48	7.0	23.8	
Particles /bunch N_e (10^{10})	15.0	12.0	8.0	
Bunch number	242	1524	12000 (10% gap)	
Bunch spacing (ns)	680	210	25	
Beam current (mA)	17.4	87.9	461.0	
Synch. radiation power (MW)	30	30	16.5	
Bending radius (km)	10.7			
Momentum compaction (10^{-5})	1.11			
β function at IP β_x^* / β_y^* (m)	0.36/0.0015	0.36/0.0015	0.2/0.0015	0.2/0.001
Emittance x/y (nm)	1.21/0.0024	0.54/0.0016	0.18/0.004	0.18/0.0016
Beam size at IP σ_x/σ_y (μm)	20.9/0.06	13.9/0.049	6.0/0.078	6.0/0.04
Beam-beam parameters ξ_x/ξ_y	0.018/0.109	0.013/0.123	0.004/0.06	0.004/0.079
RF voltage V_{RF} (GV)	2.17	0.47	0.10	
RF frequency f_{RF} (MHz)	650			
Harmonic number	216816			
Natural bunch length σ_z (mm)	2.72	[illegible]	[illegible]	
Bunch length σ_z (mm)	4.4	[illegible]	[illegible]	
Damping time $\tau_x/\tau_y/\tau_E$ (ms)	[illegible]	[illegible]	849.5/849.5/425.0	
Natural Chrom[illegible]	[illegible]	[illegible]/-1161	-491/-1161	-513/-1594
[illegible]	363.10 / 365.22			
[illegible]	0.065	0.040	0.028	
[illegible]ity (2 cell)	0.46	0.75	1.94	
Natural energy spread (%)	0.100	0.066	0.038	
Energy spread (%)	0.134	0.098	0.080	
Energy acceptance requirement (%)	1.35	0.90	0.49	
Energy acceptance by RF (%)	2.06	1.47	1.70	
Photon number due to beamstrahlung	0.082	0.050	0.023	
Beamstruhlung lifetime /quantum lifetime† (min)	80/80	>400		
Lifetime (hour)	0.43	1.4	4.6	2.5
F (hour glass)	0.89	0.94	0.99	
Luminosity/IP (10^{34} cm^{-2}s^{-1})	3	10	17	32

† include beam-beam simulation and real lattice

2021 Improved Design

	ttbar	Higgs	W	Z
Number of Ips	2			
Circumference [km]	100.0			
SR power per beam [MW]	30			
Half crossing angle at IP [mrad]	16.5			
Bending radius [km]	10.7			
Energy [GeV]	180	120	80	45.5
Energy loss per turn [GeV]	9.1	1.8	0.357	0.037
Piwinski angle	1.21	5.94	6.08	24.68
Bunch number	35	249	1297	11951
Bunch population [10^10]	20	14	13.5	14
Beam current [mA]	3.3	16.7	84.1	803.5
Momentum compaction [10^-5]	0.71	0.71	1.43	1.43
Beta functions at IP (bx/by) [m/mm]	1.04/2.7	0.33/1	0.21/1	0.13/0.9
Emittance (ex/ey) [nm/pm]	1.4/4.7	0.64/1.3	[illegible]	0.27/1.4
Beam size at IP (sigx/sigy) [um/nm]	39/113	[illegible]	[illegible]	6/35
Bunch length (SR/total) [mm]	2.2/2.9	[illegible]	[illegible]/4.9	2.5/8.7
Energy spread (SR/total) [%]	[illegible]	[illegible]/0.17	0.07/0.14	0.04/0.13
Energy acceptance (DA/RF) [%]	[illegible]	1.6/2.2	1.2/2.5	1.3/1.7
Beam-beam parameters (ksix/ksiy)	0.071/0.1	0.015/0.11	0.012/0.113	0.004/0.127
RF voltage [GV]	10	2.2	0.7	0.12
RF frequency [MHz]	650	650	650	650
HOM power per cavity (5/2/1cell)[kw]	0.4/0.2/0.1	1/0.4/0.2	-/1.8/0.9	-/-/5.8
Qx/Qy/Qs	0.12/0.22/0.078	0.12/0.22/0.049	0.12/0.22/	0.12/0.22/
Beam lifetime (bb/bs)[min]	81/23	39/18	60/717	80/182202
Beam lifetime [min]	18	12.3	55	80
Hour glass Factor	0.89	0.9	0.9	0.97
Luminosity per IP[1e34/cm^2/s]	0.5	5.0	16	115

67%⇑

259%⇑

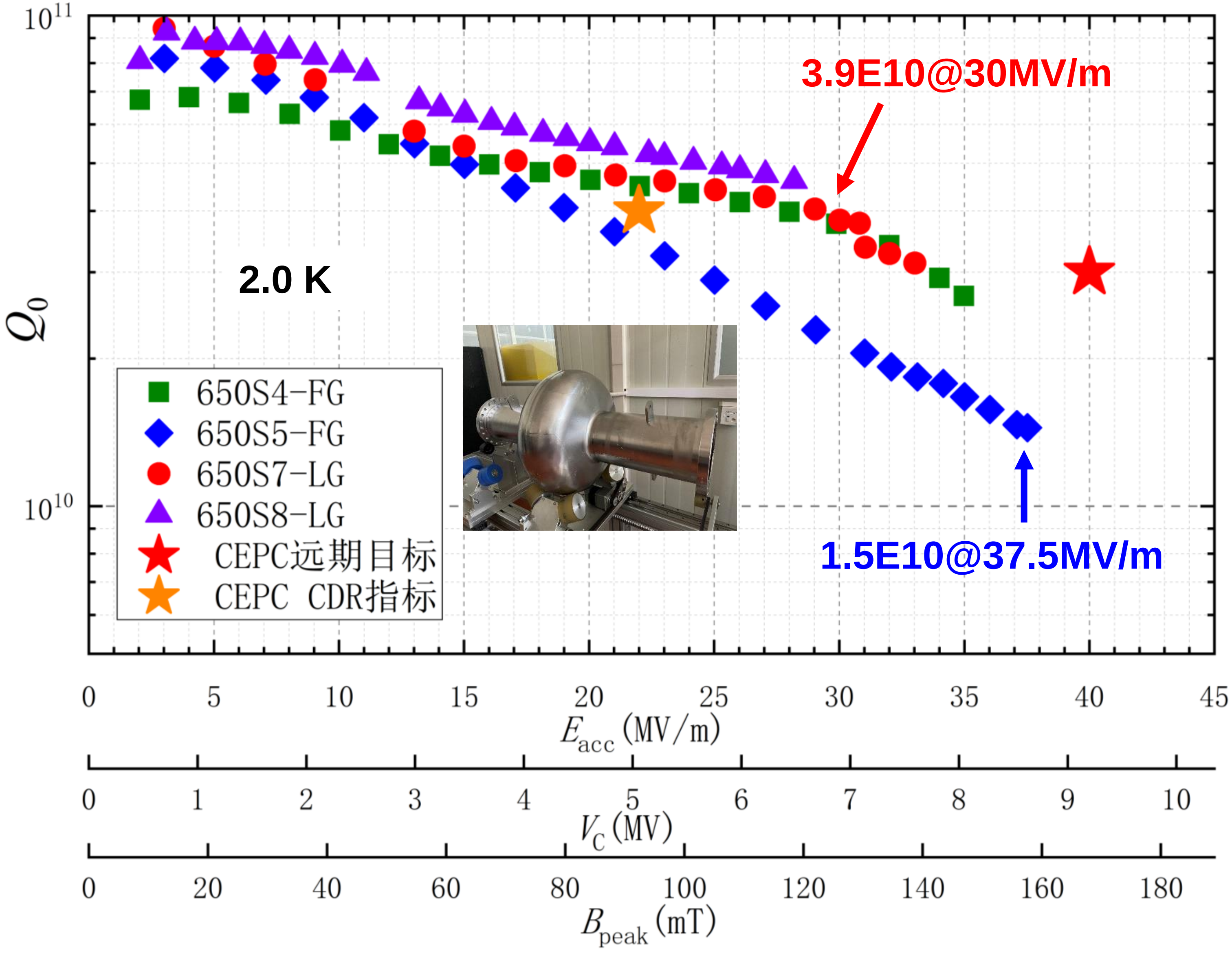
CEPC Accelerator R&D: Towards TDR

- CEPC 650MHz 800kW klystron: **high efficiency (80%), fabrication will be completed in 2021, test in 2022**
- CEPC 650MHz SC accelerator system (cavities and cryomodules): **to complete test cryomodule in 2022**
- High precision booster dipole magnets: **to complete full-size magnet model in 2021**
- Collider dual aperture dipole, quadrupoles and sextupole magnets: **t[illegible]plete full-size model in 2022**
- SC magnets including cryostats: **to complete shor[illegible] 2022**
- Vacuum chamber system: **to c[illegible]ion and costing test in 2022**
- MDI mechanic syste[illegible] **[illegible]uum connection removal to be tested in 2022**
- Collimator: **to complete model test in 2022**
- Linac components: **to complete key components test in 2022**
- Civil engineering design: **to complete reference implementation design in 2022**
- Plasma wakefield injector: **to complete the electron accelerator test in 2022**
- 18KW@4.5K cryoplant: **industrial partner**

Aiming for Accelerator TDR in 2022

CEPC R&D: High Q SCRF 650 MHz 1-Cell Cavity

➢ **IHEP在国际上首次成功实现3.9E10@30 MV/m (650MHz 1-cell 超导腔)**



CEPC目标:

Q_0 = 3.0E10 @ 22 MV/m

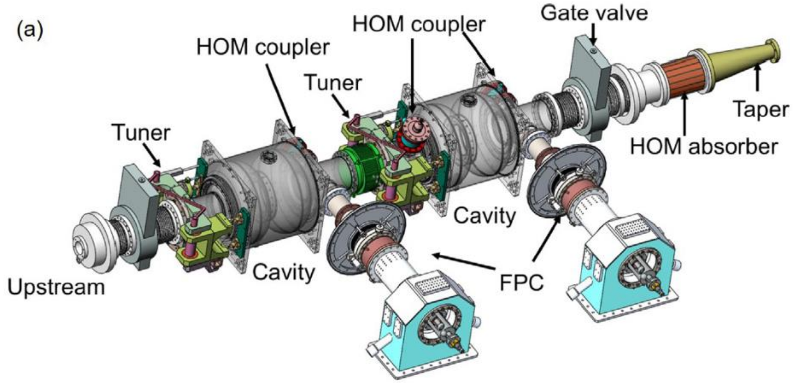
测试结果:

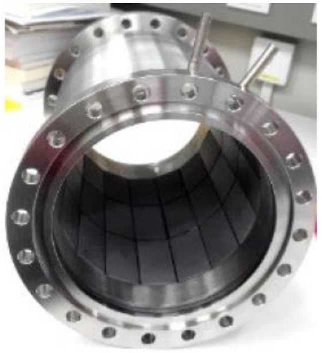
Q_0 = 3.9E10 @ 30 MV/m

Q_0 = 1.5E10 @ 37.5 MV/m

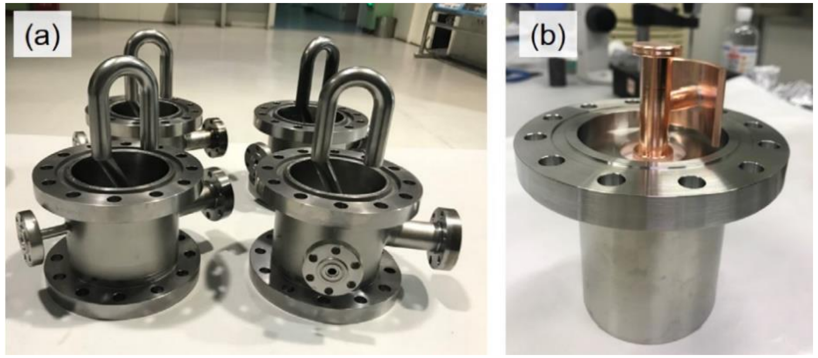
CEPC R&D: 650MHz SCRF Module

- 在先进光源研发与测试平台（PAPS）的支持下，正在研制一台包含2个650MHz 2-cell超导腔及其附件的650MHz模组，用于验证CEPC的关键技术。

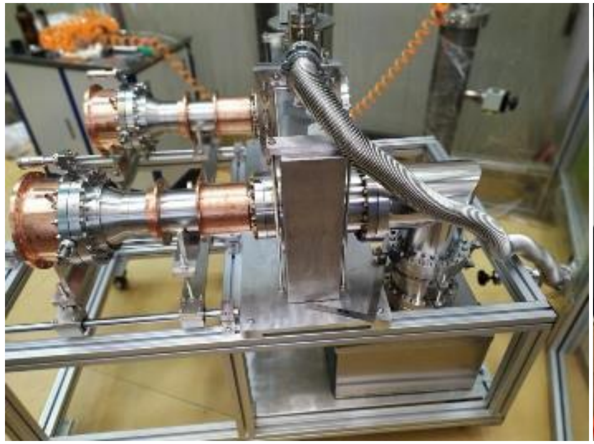




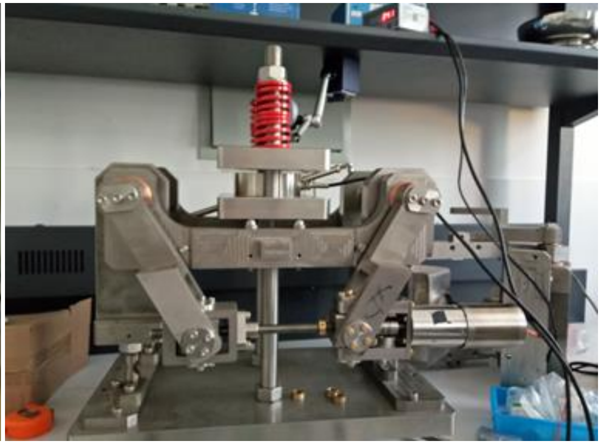
国内首个超导腔大功率
高阶模吸收器（5kW）



国内首个可拆卸大功率
高阶模耦合器（1kW）

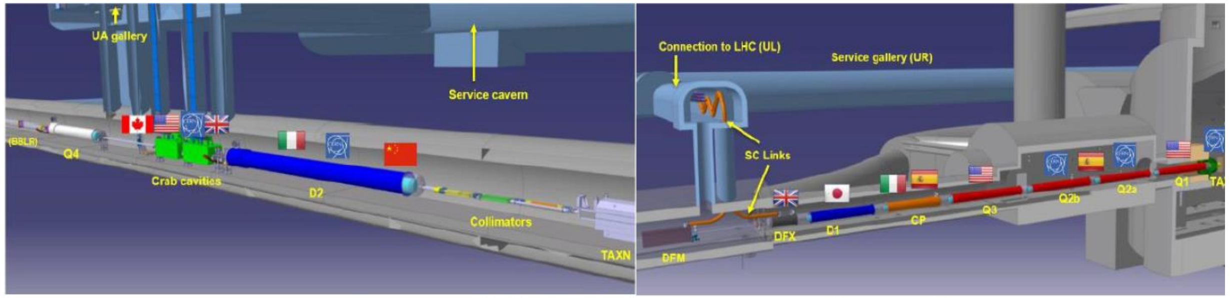


650MHz主耦合器 (400kW)
世界上最大的耦合器之一



超导腔调谐器

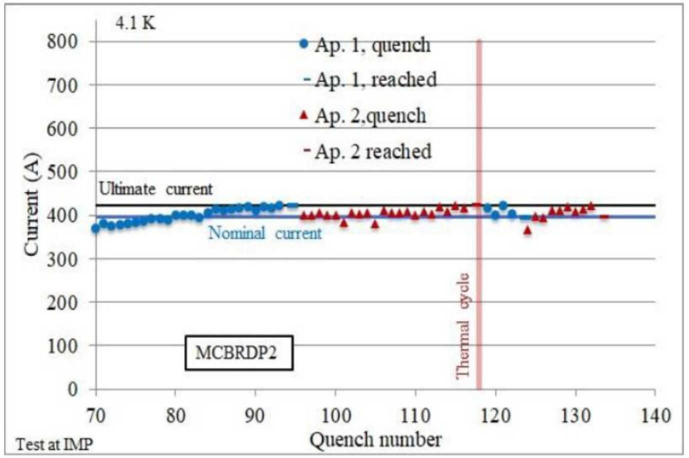
HL-LHC Magnet and HTS SC Magnet

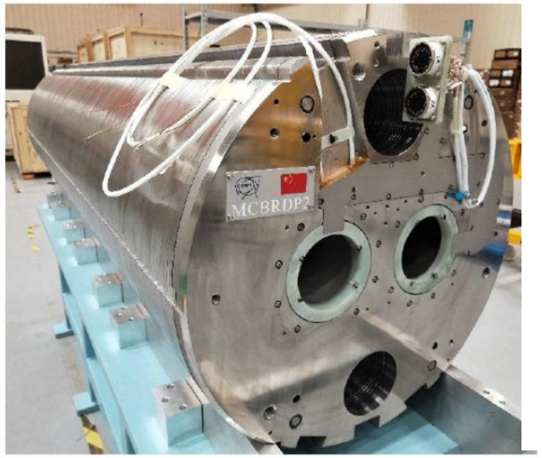


Layout of the HL-LHC Magnets and Contributors

China will provide 12+1 units CCT superconducting magnets for the HL-LHC project

After more than 1 month test and training at 4.2K, both apertures reached the design current ar ultimate current, and the field quality is within the limit.





Domestic Collaboration for HTS R&D

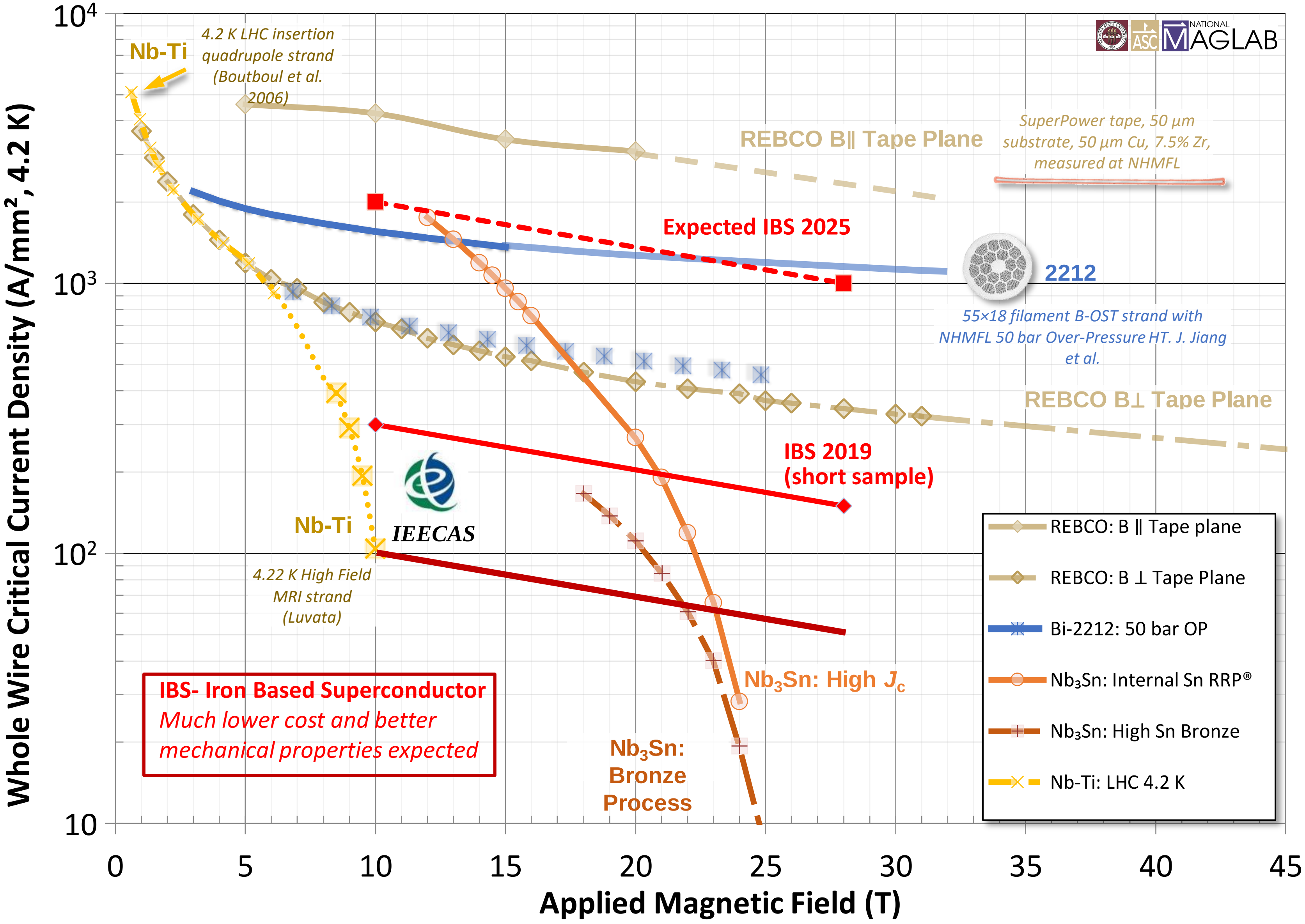
Applied High Temperature Superconductor Collaboration (AHTSC)

- ➢ R&D from **Fundamental sciences** of superconductivity, **advanced HTS superconductors** to **Magnet & SRF technology**.
- ➢ **Regular meetings every 3 months** from Oct. 2016
- ➢ **Goal：**
- **Increasing J_c** of iron-based superconductor **by 10 times**.
- **Reducing the cost** of HTS conductors to be **similar with "NbTi conductor"**
- Industrialization of the **advanced superconductors, magnets and cavities**

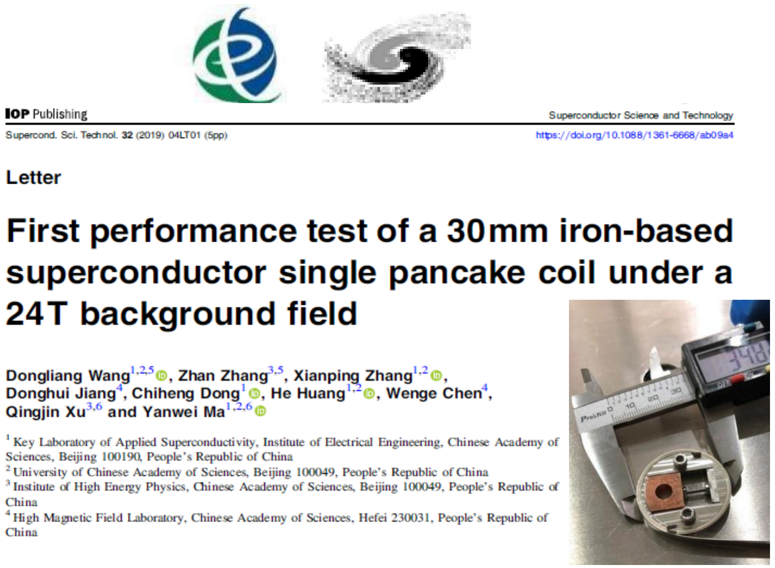
2020年国内首个HL-LHC超导磁铁样机(2*2.6T)运到CERN，通过了测试。目前正在批量试制中。

高能所与国内科研单位紧密合作，开展实用化高温超导磁铁研制，取得了重要进展。

HTS SC Magnet



Fabrication and test of IBS solenoid coil at 24T



IOP Publishing — Superconductor Science and Technology

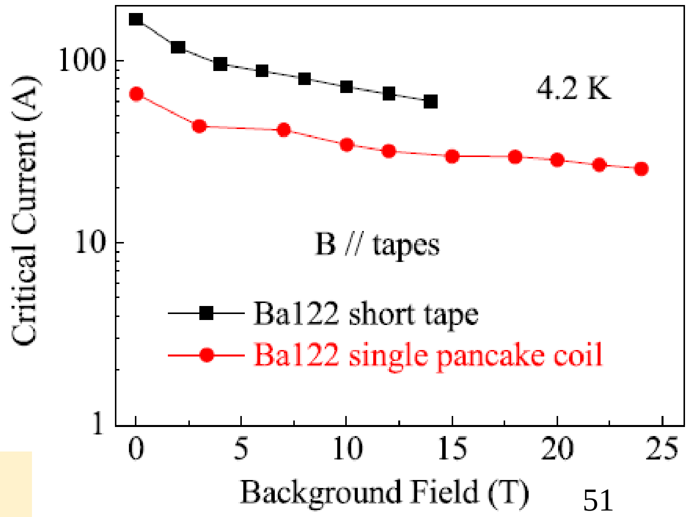
Supercond. Sci. Technol. 32 (2019) 04LT01 (5pp) — https://doi.org/10.1088/1361-6668/ab09a4

Letter

First performance test of a 30 mm iron-based superconductor single pancake coil under a 24 T background field

Dongliang Wang[1,2,5], Zhan Zhang[3,5], Xianping Zhang[1,2], Donghui Jiang[4], Chiheng Dong[1], He Huang[1,2], Wenge Chen[4], Qingjin Xu[3,6] and Yanwei Ma[1,2,6]

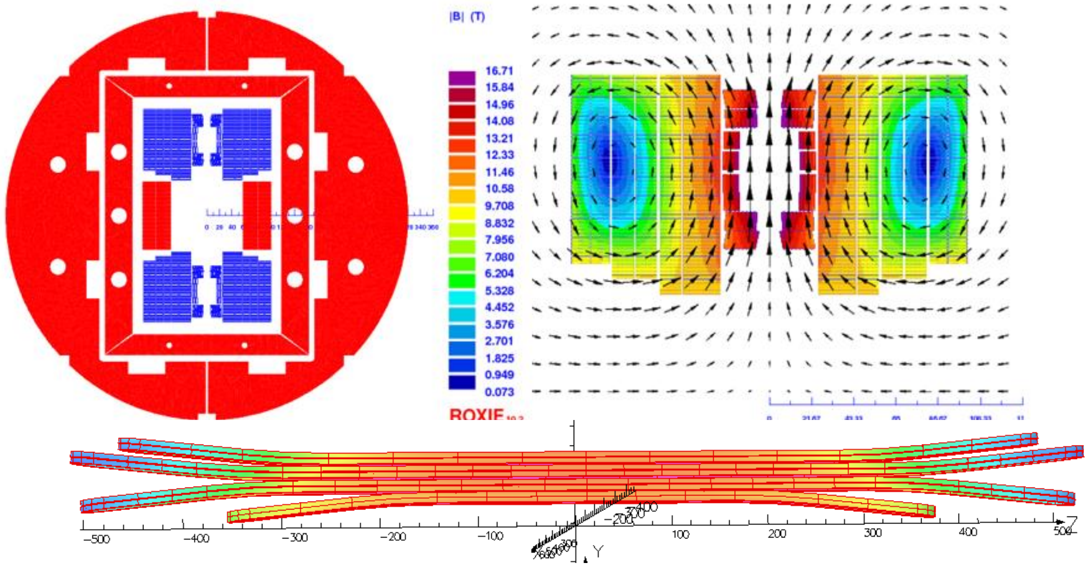
[1] Key Laboratory of Applied Superconductivity, Institute of Electrical Engineering, Chinese Academy of Sciences, Beijing 100190, People's Republic of China
[2] University of Chinese Academy of Sciences, Beijing 100049, People's Republic of China
[3] Institute of High Energy Physics, Chinese Academy of Sciences, Beijing 100049, People's Republic of China
[4] High Magnetic Field Laboratory, Chinese Academy of Sciences, Hefei 230031, People's Republic of China

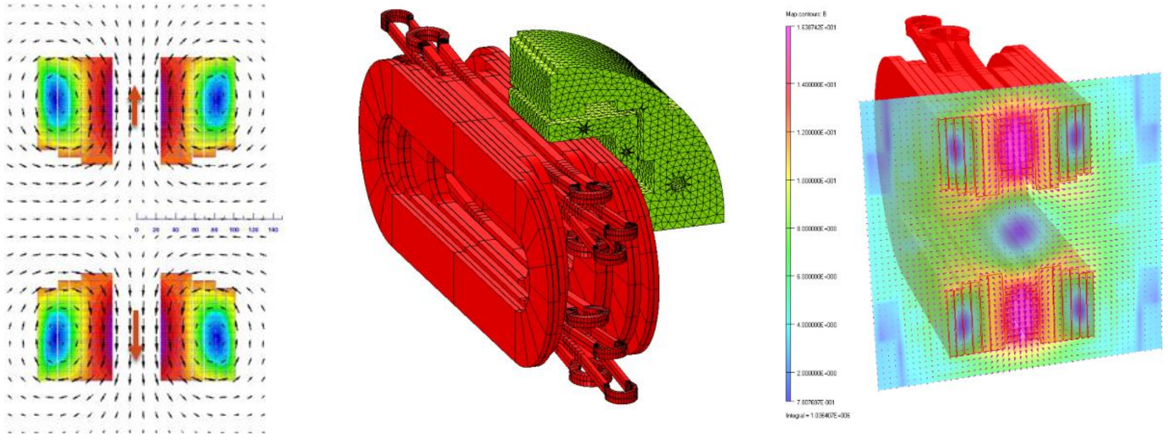


开展铁基超导研制，成功研制30mm IBS螺线圈磁铁，测试磁场达到24T

HTS SC Magnet (16T)

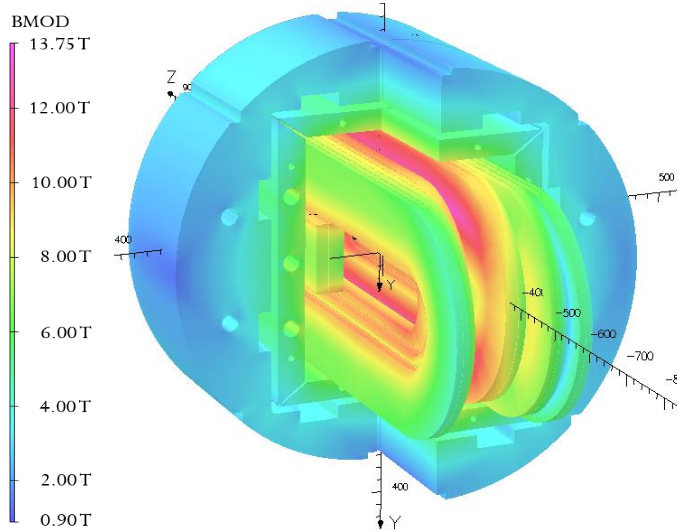
LPF3 16T二极磁体研制: Nb$_3$Sn 12~13 T + HTS 3~4 T

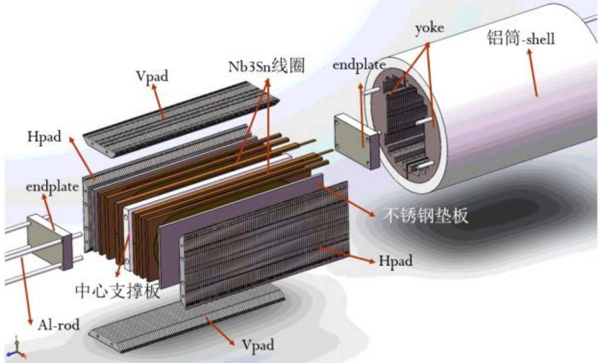


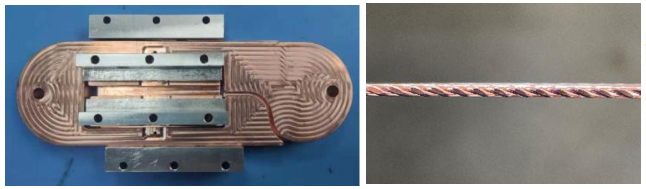


16-T 大孔径高场超导二极磁体 LPF3 (Nb$_3$Sn-13T+HTS-3T) 电磁设计

新型HTS换位电缆







13-T 及以上背场磁体正在研制过程中

LPF3 背场磁体研制计划表

CEPC R&D: Magnets etc.

➢ **Magnets, EM-separators, Vacuum Pipes, …**