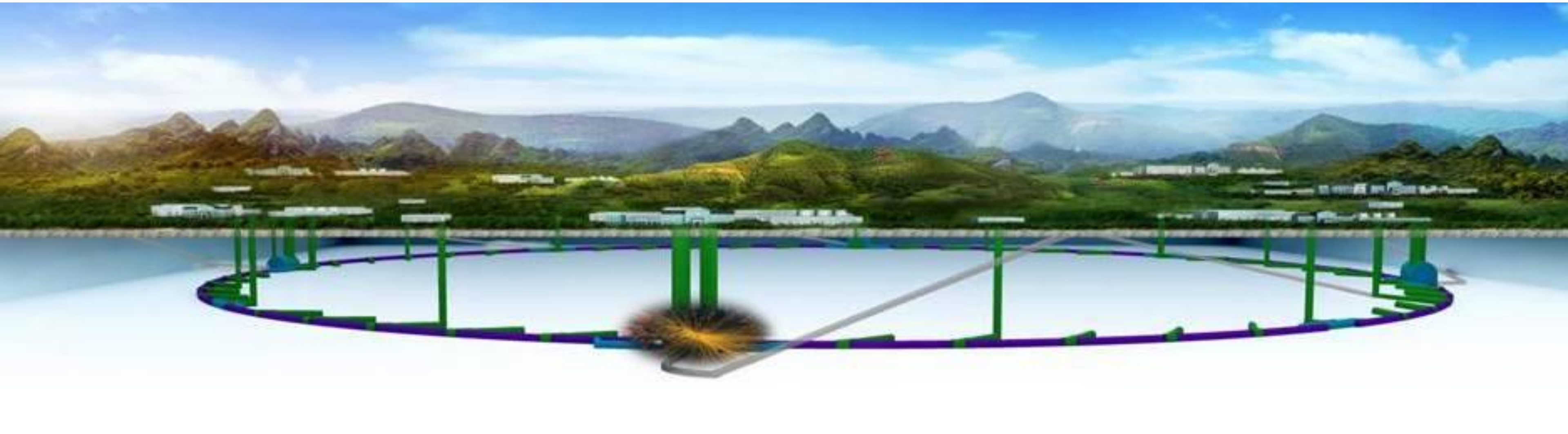
CEPC Status and Perspective

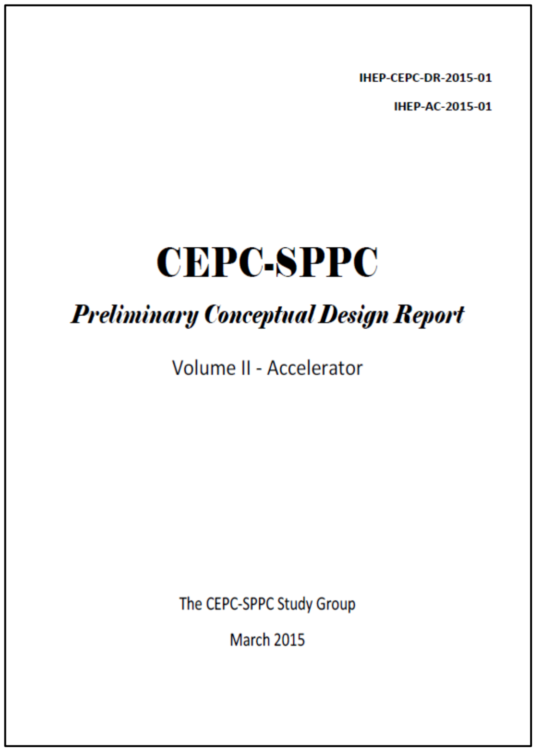
Yifang Wang

Institute of High Energy Physics, Beijing



CEPC-SppC from Pre-CDR towards CDR

http://cepc.ihep.ac.cn


IHEP-CEPC-DR-2015-01

IHEP-AC-2015-01

CEPC-SPPC

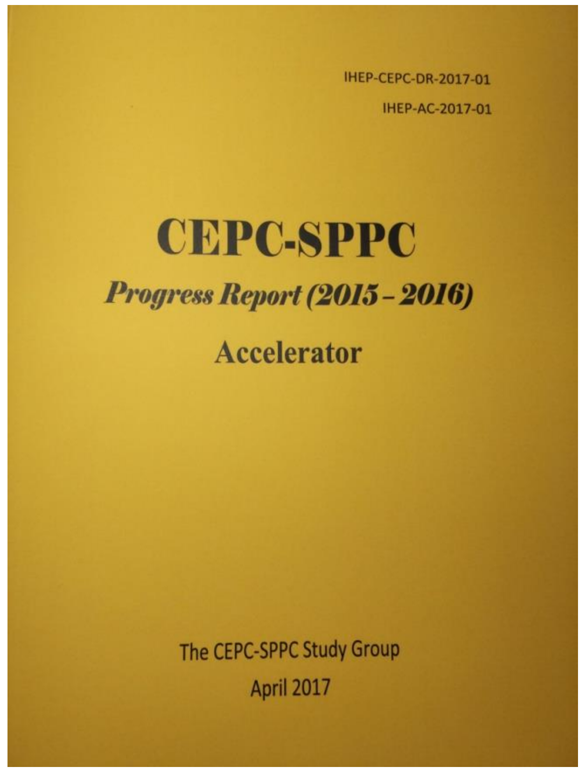
Preliminary Conceptual Design Report

Volume II - Accelerator

The CEPC-SPPC Study Group

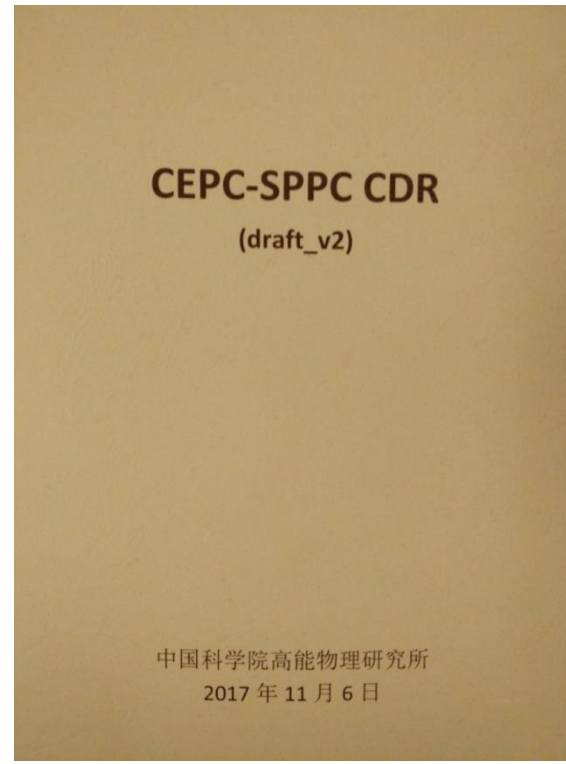
March 2015

March 2015



April 2017

CEPCSppC baseline and alternative decision processe recorded



Nov 2017

CEPC-SppC CDR Preliminary Draft during CEPC-SppC Mini review

CEPC-SppC CDR will be available by May 2018

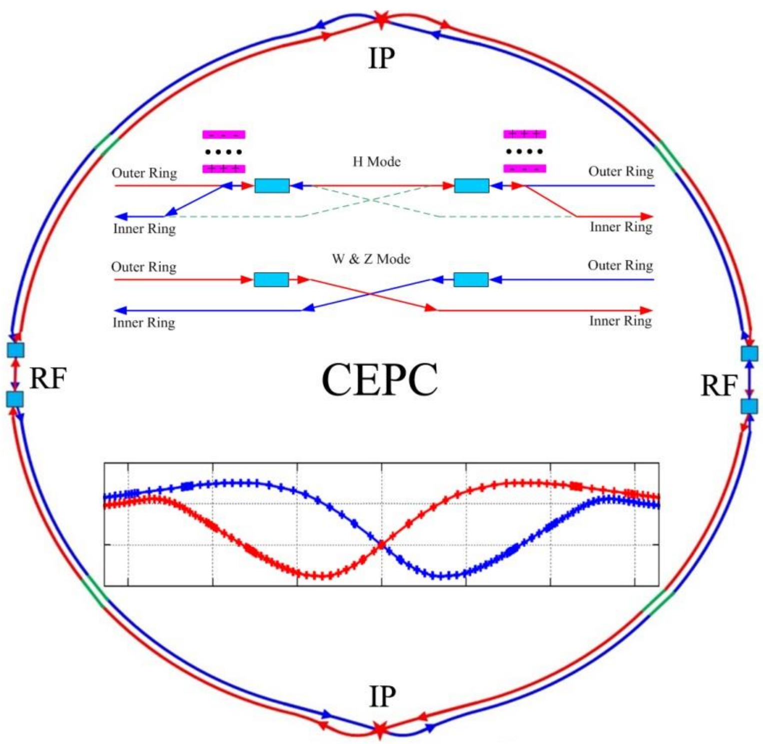
Current Status of CDR

- A first draft at the end of last year. More international participation than pre-CDR
- A mini-international review was organized soon after and a lot of inputs was taken
- International review will be taken in June-July
- The final version is almost ready, to be published in summer
- TDR will start next year, hopefully more international participation

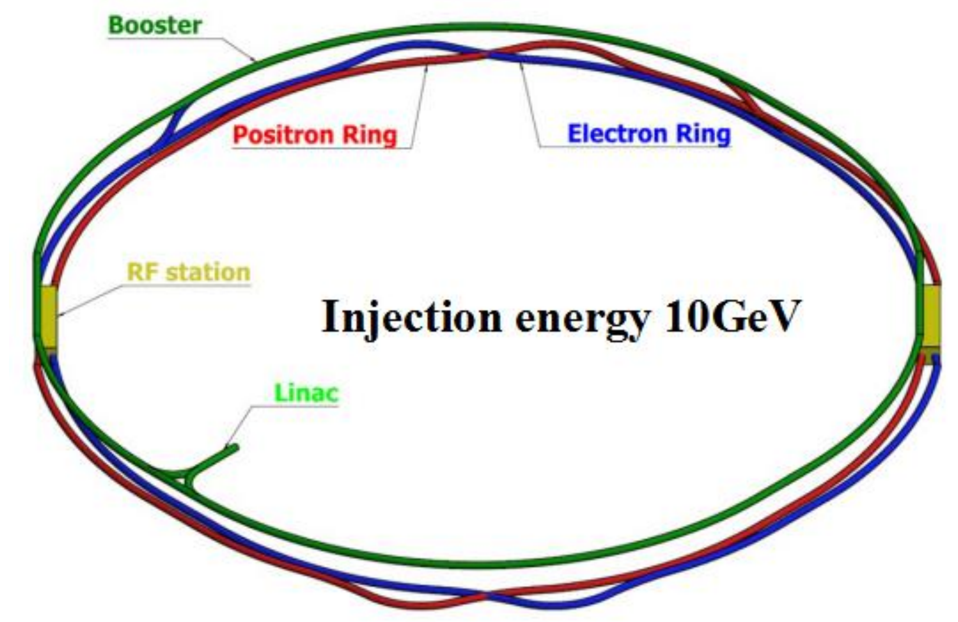
Motivation, physics case

- Capability of precision measurement, Higgs and Z factories (overview).
- Physics goals
  - Electroweak symmetry breaking: naturalness, nature of electroweak physics transition.
  - Dark sector searches through Higgs and Z exotic decays.
  - Connection to neutrino physics.
  - Connection to baryogenesis
  - Flavor physics at Z-factory
  - Precision QCD measurements

CEPC CDR Basseline Layout

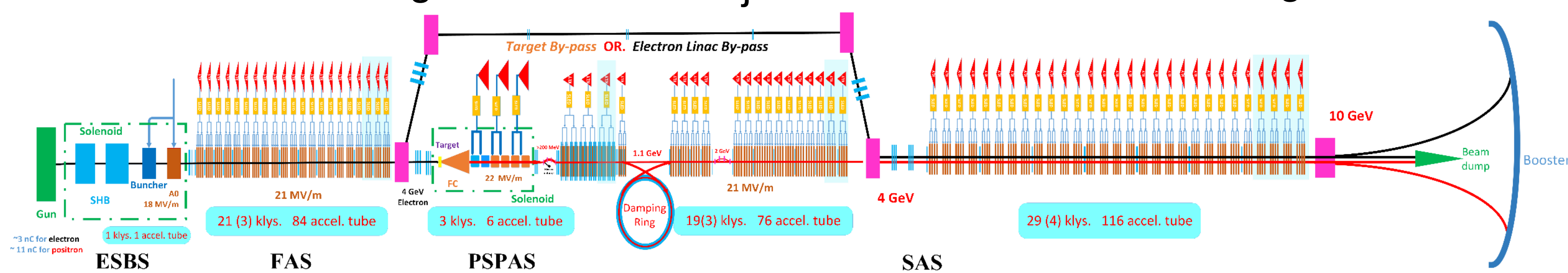


Collider ring



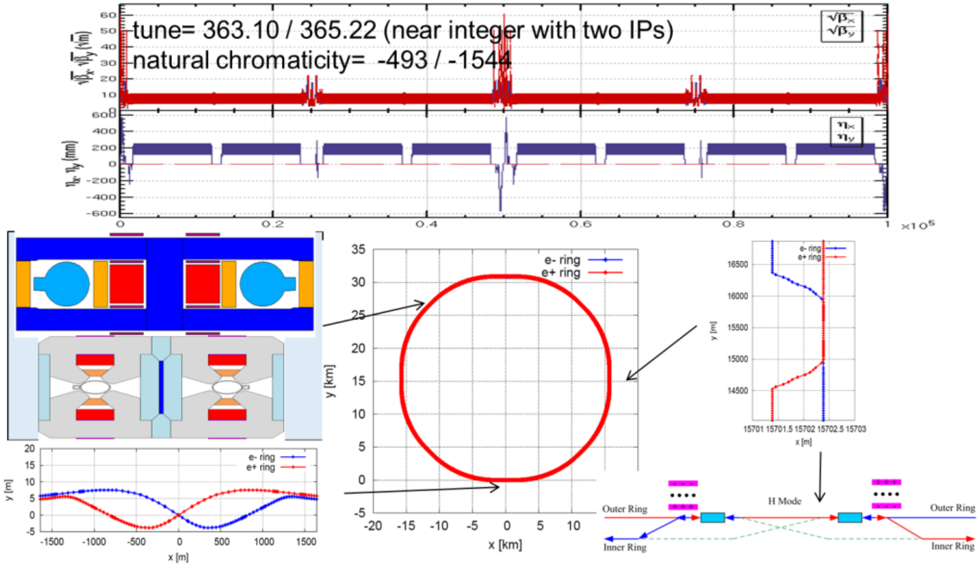
Booster ring

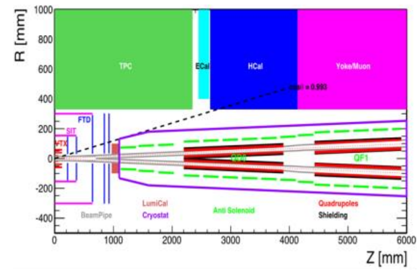
Linac injector

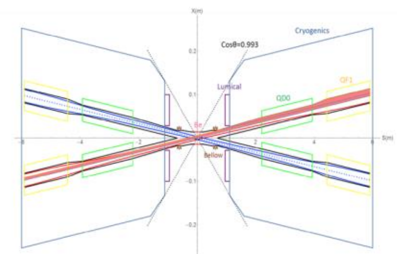


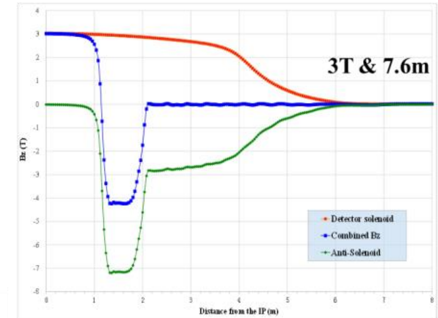
Baseline: 100 km, 30 MW; Upgradable to 50 MW, High Lumi Z
Try all means to cut cost down

CEPC Collider CDR Design





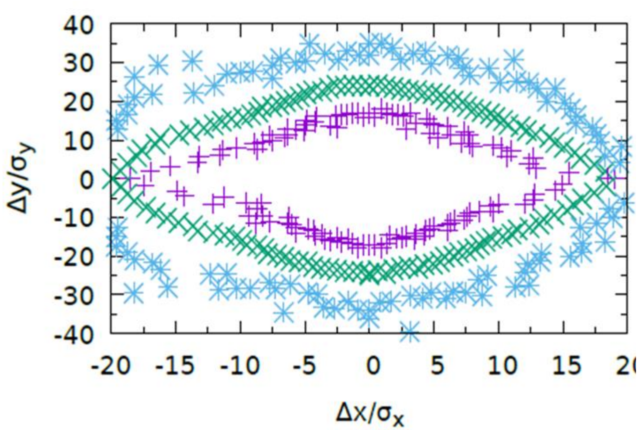


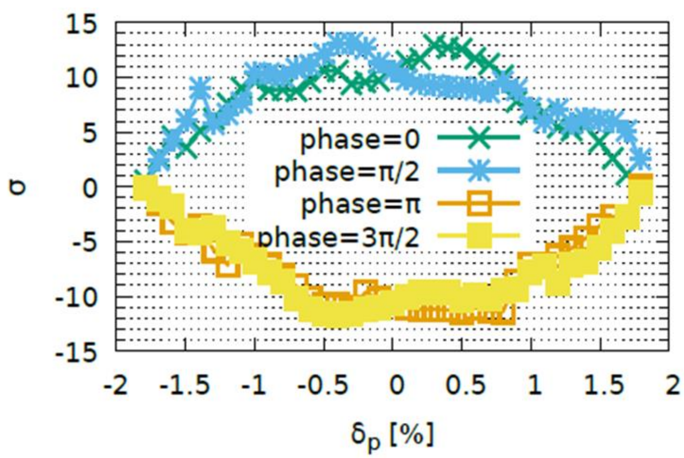


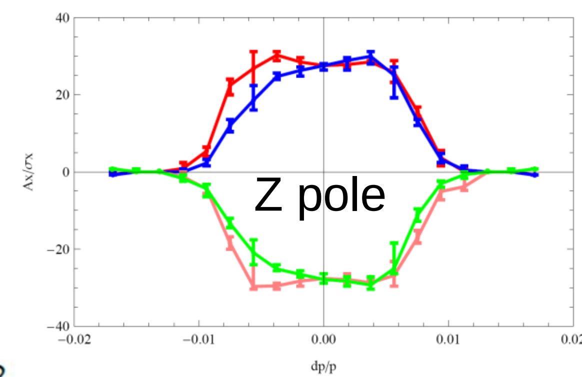
22 anti-Solenoid **sections with different inner coil diameters**

$\int B_z ds$ within 0~2.12m. Bz < 300Gauss away from 2.12m with local cancellation structure

The skew quadrupole coils are designed to make fine tuning of Bz over the QF&QD region instead of the mechanical rotation.







DAs of Higgs energy

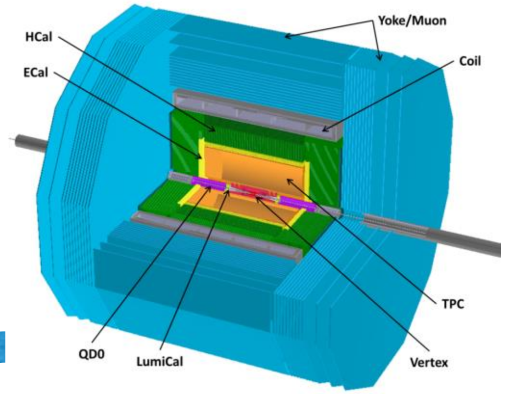
DA of Z-Pole energy

Main Parameters

	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	2.58	7.0	23.8	
Number of particles/bunch N_e (10^{10})	15.0	12.0	8.0	
Bunch number (bunch spacing)	242 (0.68μs)	1524 (0.21μs)	12000 (25ns+10%gap)	
Beam current (mA)	17.4	87.9	461.0	
Synchrotron radiation power /beam (MW)	30	30	16.5	
Bending radius (km)	10.7			
Momentum compact (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 $\varepsilon_x/\varepsilon_y$ (nm)	1.21/0.0031	0.54/0.0016	0.18/0.004	0.18/0.0016
Beam size at IP σ_x/σ_y (μm)	20.9/0.068	13.9/0.049	6.0/0.078	6.0/0.04
Beam-beam parameters ξ_x/ξ_y	0.031/0.109	0.013/0.106	0.0041/0.056	0.0041/0.072
RF voltage V_{RF} (GV)	2.17	0.47	0.10	
RF frequency f_{RF} (MHz) (harmonic)	650 (216816)			
Natural bunch length σ_z (mm)	2.72	2.98	2.42	
Bunch length σ_z (mm)	3.26	5.9	8.5	
Betatron tune ν_x/ν_y	363.10 / 365.22			
Synchrotron tune ν_s	0.065	0.0395	0.028	
HOM power/cavity (2 cell) (kw)	0.54	0.75	1.94	
Natural energy spread (%)	0.1	0.066	0.038	
Energy acceptance requirement (%)	1.35	0.4	0.23	
Energy acceptance by RF (%)	2.06	1.47	1.7	
Photon number due to beamstrahlung	0.29	0.35	0.55	
Lifetime _simulation (min)	100			
Lifetime (hour)	0.67	1.4	4.0	2.1
F (hour glass)	0.89	0.94	0.99	
Luminosity/IP *L* (10^{34}cm^{-2}s^{-1})	2.93	10.1	16.6	32.1

CDR Conceptual Designs

Baseline detector for CDR
ILD-like
(similar to pre-CDR)



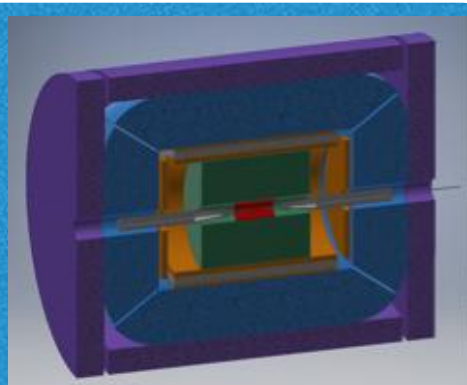
Impact parameter resolution
less than 5 μm

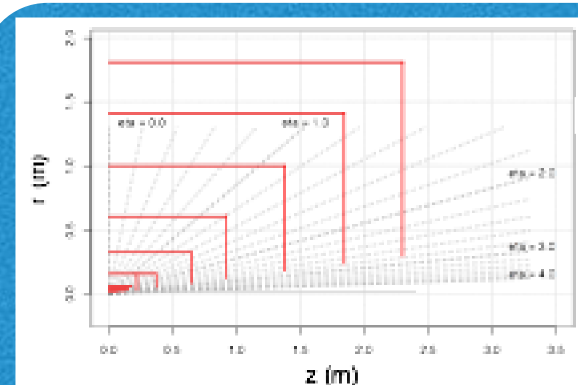
Tracking resolution
$\delta(1/P_t) \sim 2\times10^{-5}\,(GeV^{-1})$

Jet energy resolution
$\sigma_E/E \sim 30\%/\sqrt{E}$

Two alternative detector concepts

Low magnetic field concept



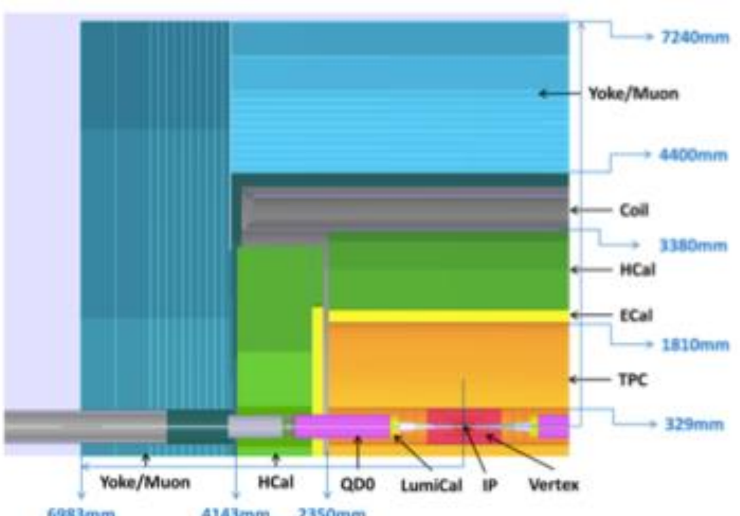


Full silicon tracker concept

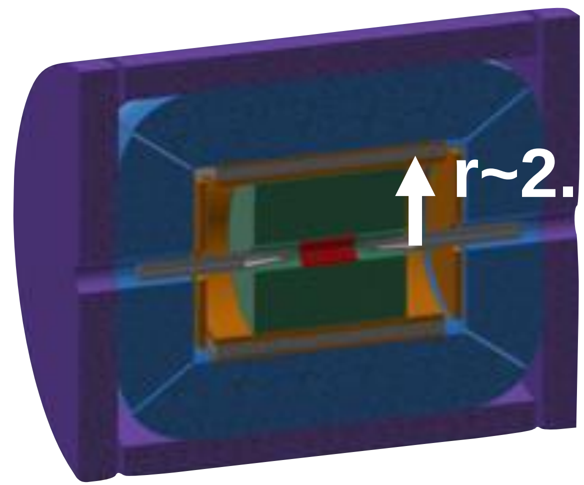
Final two detectors likely to be a mix and match of different options

CEPC major detector concepts

Baseline Concept



Alternative Concept



	3 Tesla	2 Tesla
	6 layers of pixel sensors	Same
	TPC + Silicon tracker	Drift Chamber
	Particle flow inside solenoid	Dual readout outside solenoid
	3.4 m	2.1 m
	RPC or MPGD	RPC or MPGD

Physics results in CDR mostly estimated with *full simulation* of baseline concept

CEPC Funding

HEP seed money

11 M RMB/3 years (2015-2017)

国家重点研发计划
项目预申报书

FY 2016

Ministry of Science and Technology
Requested 45M RMB; **36M RMB approved**

项目名称：	高能环形正负电子对撞机相关的物理和关键技术预研研究
所属专项：	大科学装置前沿研究
指南方向：	新一代粒子加速器和探测器关键技术和方法的预先研究
推荐单位：	教育部
申报单位：（公章）	清华大学
项目负责人：	高原宁

R&D Funding - NSFC

Increasing support for CEPC D+RDby NSFC
5 projects (2015); 7 projects(2016)

CEPC相关基金名称（2015-2016）	基金类型	负责人	承担单位	
高精度气体径迹探测器及激光校正的研究 (2015)	重点基金	李玉兰/陈元柏	清华大学/高能物理研究所	Tsinghua IHEP
成像型电磁量能器关键技术研究(2016)	重点基金	刘树彬	中国科技大学	USTC
CEPC局部双环对撞区挡板系统设计及螺线管场补偿(2016)	面上基金	白莎	高能物理研究所	IHEP
用于顶点探测器的高分辨、低功耗SOI像素芯片的若干关键问题的研究(2015)	面上基金	卢云鹏	高能物理研究所	IHEP
基于粒子流算法的电磁量能器性能研究 (2016)	面上基金	王志刚	高能物理研究所	IHEP
基于THGEM探测器的数字量能器的研究(2015)	面上基金	俞伯祥	高能物理研究所	IHEP
高粒度量能器上的通用粒子流算法开发(2016)	面上基金	阮曼奇	高能物理研究所	IHEP
正离子反馈连续抑制型气体探测器的实验研究(2016)	面上基金	祁辉荣	高能物理研究所	IHEP
CEPC对撞区最终聚焦系统的设计研究(2015)	青年基金	王逗	高能物理研究所	IHEP
利用耗尽型CPS提高顶点探测器空间分辨精度的研究 (2016)	青年基金	周扬	高能物理研究所	IHEP
关于CEPC动力学孔径研究(2016)	青年基金	王毅伟	高能物理研究所	IHEP

Funding to MOST (~40M) in process

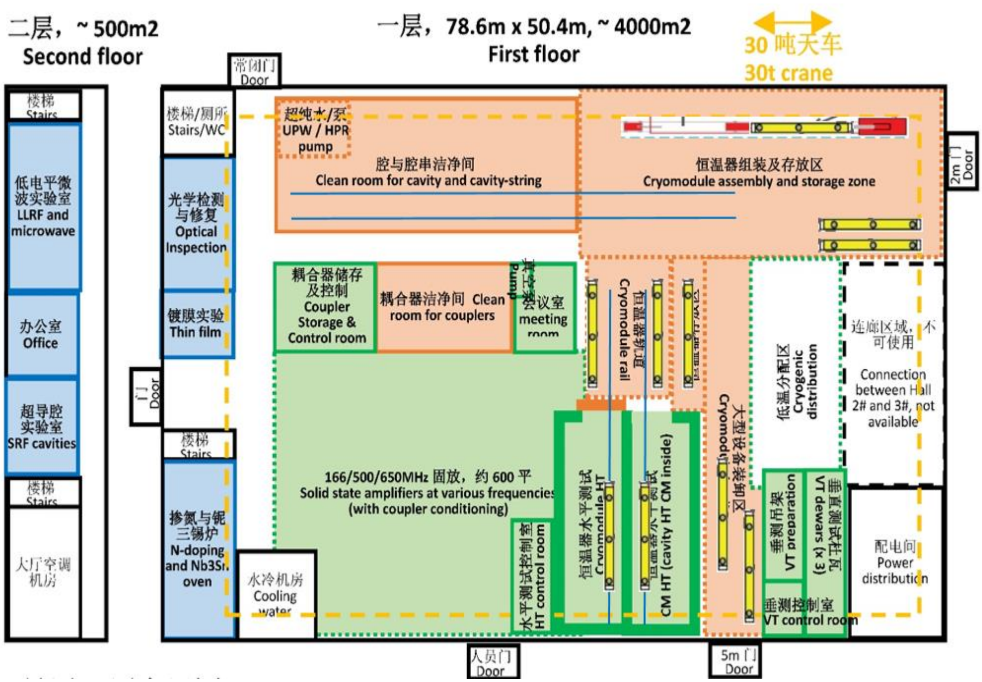
- **40M RMB** CAS talent program
- **10M-100 RMB** CAS fund for HTc
- **~500M RMB** Beijing fund (for light source)
- **~100M RMB** other agencies

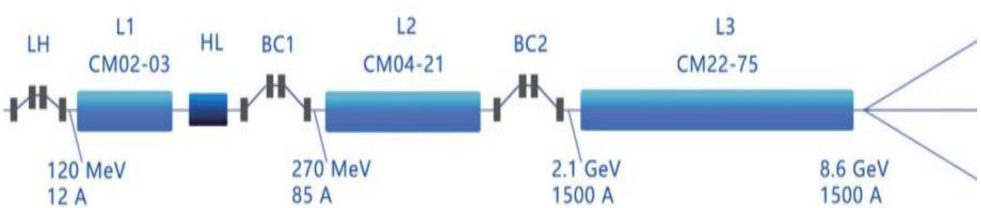
funding needs for carrying out CEPC design and R&D should be mostly met by end of 2018

SRF Cavities

- A new SRF testing facility is under construction, thanks to Beijing municipal government
- Shanghai municipal government decided to support significantly the Shanghai Coherent Light Facility(SCLF).
  - 432 1.3 GHz cavities
  - 54 Cryomodules
- IHEP plans to collaborate with SINAP and provide > 1/3 of cavities and cryomodules, an excellent exercise for us.

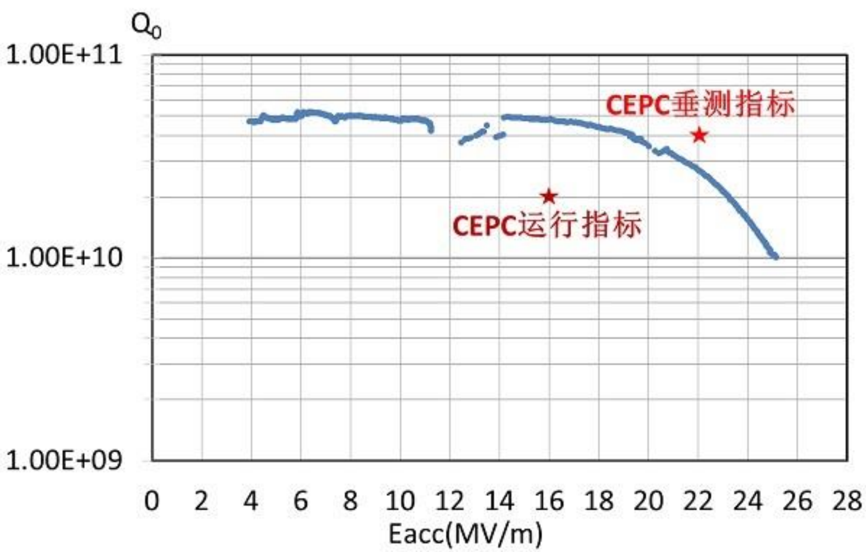
New SRF test facility under construction

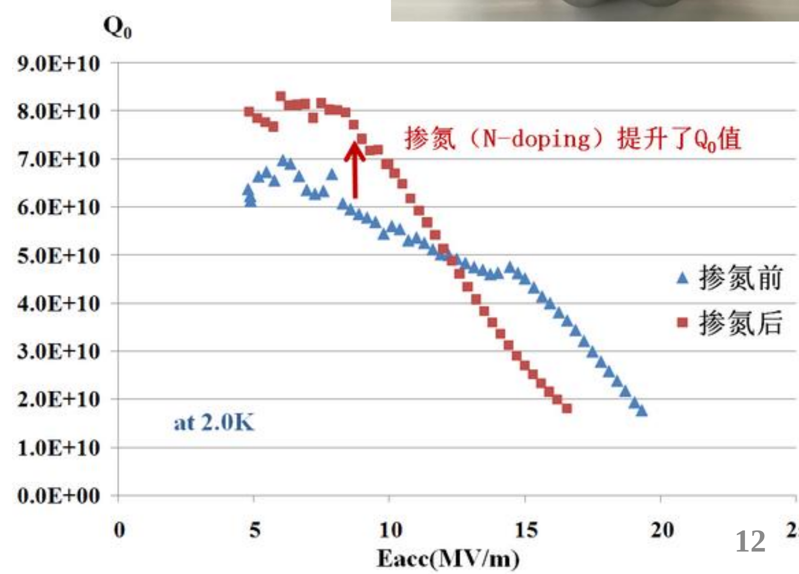




Current R&D results

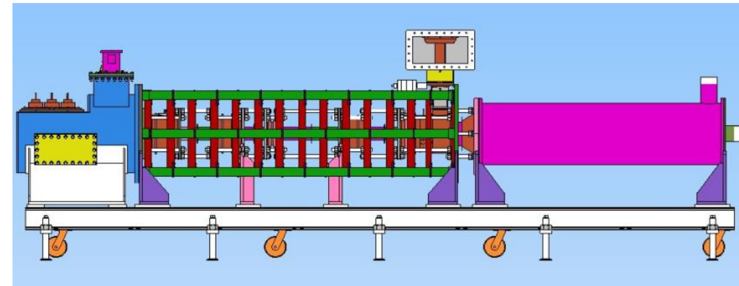
- A CEPC 650MHz 1-cell cavity completed the vertical test.
- A CEPC 650MHz 2-cell cavity completed, to be test soon
- EP facility is under construction(ADS funding and others), ready this summer
- Two CEPC 650MHz 1-cell cavities tried N-doping, Q_0 increase is seen.

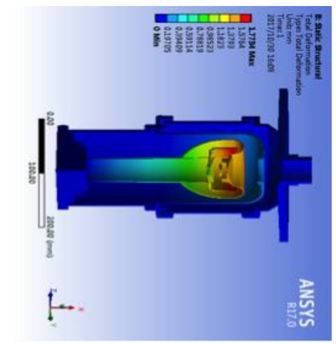


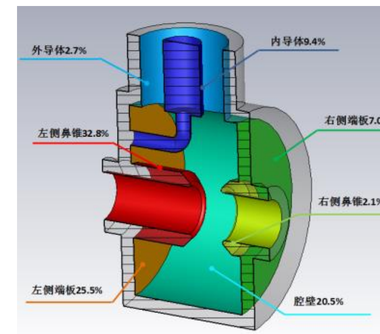


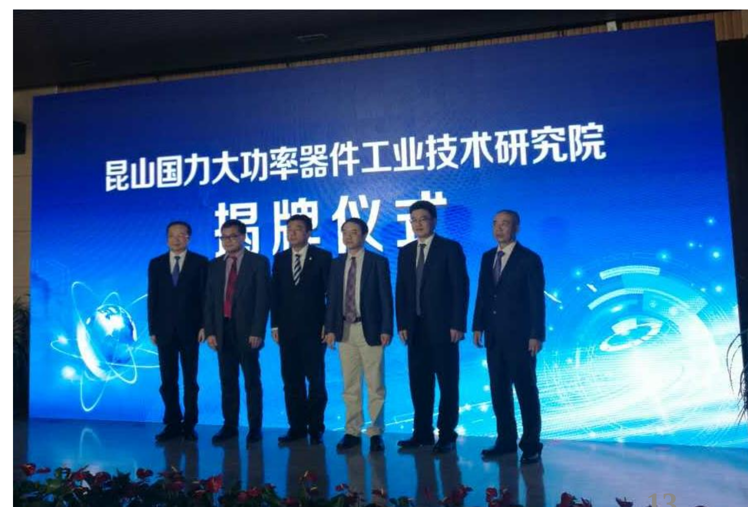
High Efficiency Klystrons

- Goal: CW Power > 800 kW, Efficiency > 80%, Lifetime > 100 k hrs
- A collaboration with the institute of electronics of CAS, and Kunshan Guoli
- Design of the first klystron with an efficiency of 65% has completed. Manufacturing contract signed. Available this year.
- Design of the second higher efficiency (70%) klystron will be finished soon. Production next year.
- Based on the test results, the high efficiency klystron (80%) will be built in 2020-2021

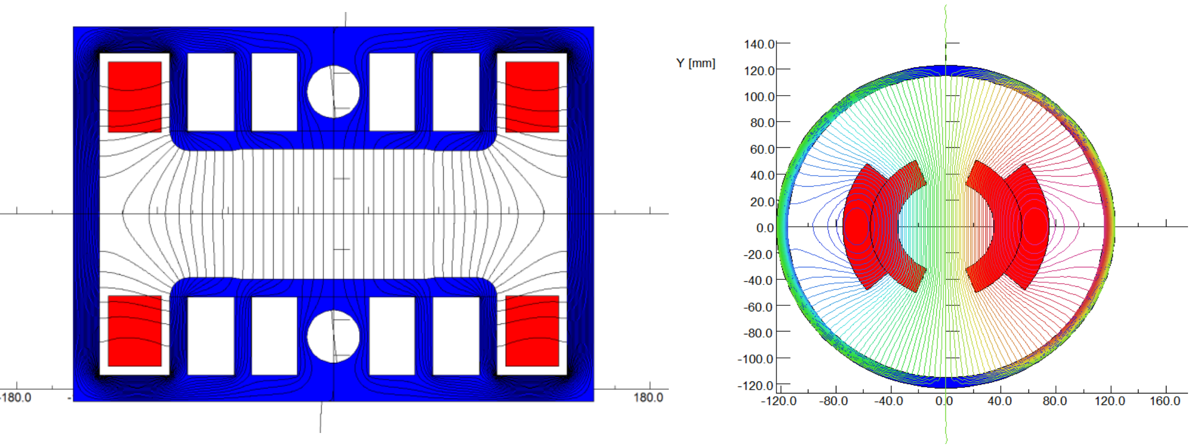




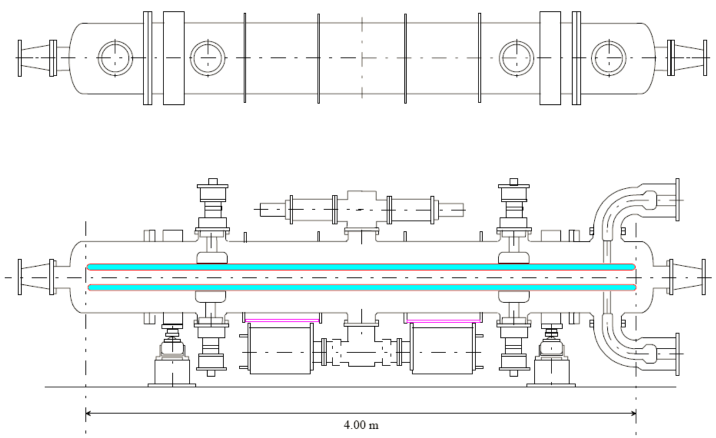




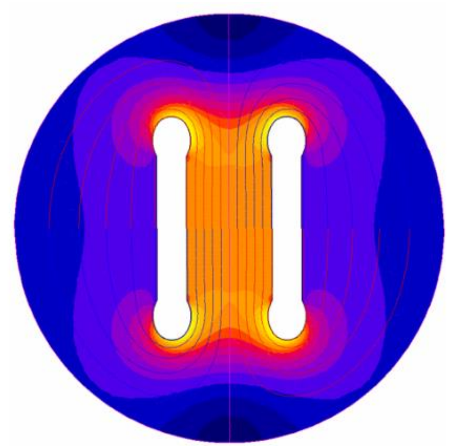
Other prototypes

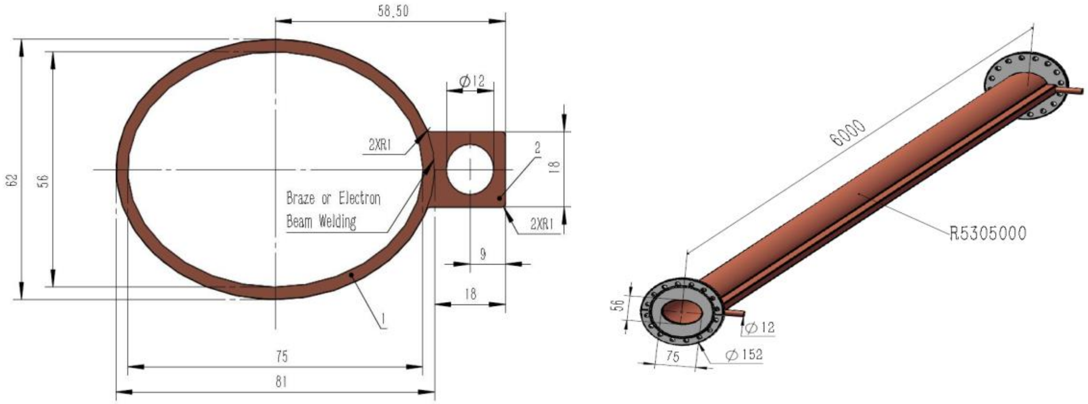


High precision, low field dipole magnet



Electrostatic separator





6m long vacuum pipes(Al & Cu)

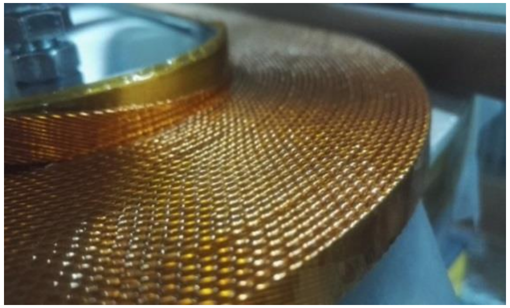
High Field Magnet based on HTC Cable

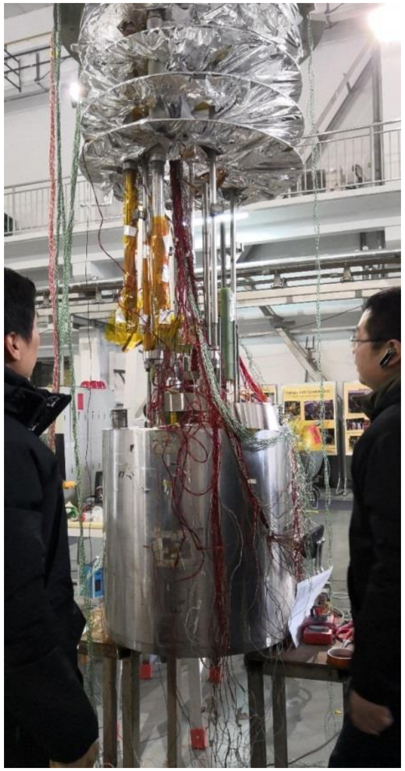
- Huge impact If HTC cable can be used for 10-20T magnets
  - Huge cost reduction
  - Huge applications in other area and industry
- Fe-based HTC cable
  - Advantages: Metal, easy to process; Isotropic; Cheap in principle
  - Good start at CAS
    - World highest Tc Fe-based materials
    - World first ~ 115 m Fe-based SC cables: 12000 A/cm^2 @ 10 T
- A collaboration on “HTC SC materials” established
  - IOP, USTC, IOEE, SC cable companies
  - Two approaches:
    - Fe-based HTC cables
    - ReBCO & Bi-2212
- A workshop in Hong Kong this Jan. Next one in KEK

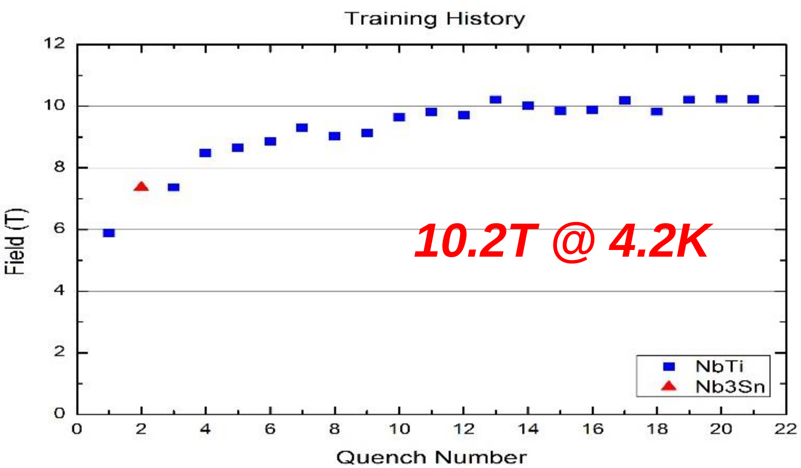
High Field Magnet R&D

- CCT magnet for LHC
- exercise of the Dipole magnet

NbTi+Nb_3Sn, 2*ф10 aperture → **All Nb_3Sn, 2*ф20 aperture** → **Nb_3Sn+HTS, 2*ф30 aperture** → **All HTS**





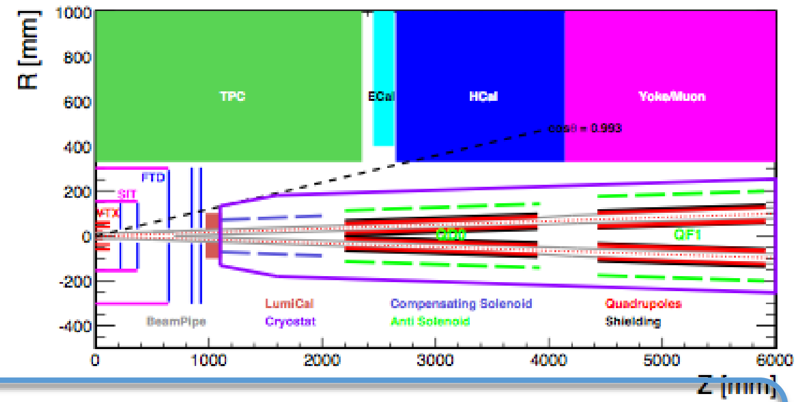


First (NbTi+Nb_3Sn) test successful

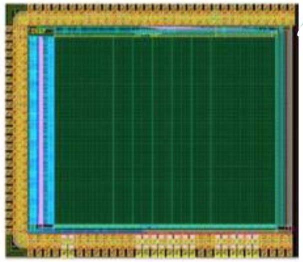
Most active research items

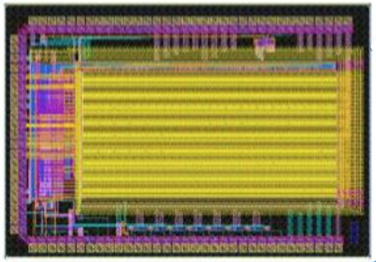
No show-stoppers so far

Technical challenges identified → R&D issues



- **Machine Detector Interface**
  - Major redesign to accommodate changes in accelerator
  - Includes 7 Tesla compensating magnet
- **Vertex detector**
  - R&D on low-mass integrated sensors: pixel CMOS and SOI
  - Test sensors being studied. Preliminary results in CDR.
  - Prototype to be produced in next few years





- **TPC**
  - Operation at high-luminosity, Z pole rates studied and preliminarily confirmed
- **Calorimeters**
  - Several high-granularity calorimeter technologies explored
  - Will produce small prototypes based on SiPM technology

Mini CDR international review in November 2017

Final version expected around Summer 2018

International Collaboration

- Limited international participation for the CDR
  - Not in any roadmap
  - No funding support
- Hopefully it will be included in the roadmap of Europe, Japan and the US
- The international advisory board worked very well
  - A lot of suggestions
- MOUs have been signed with many institutions
- Welcome recommendation/suggestions

1/3 international participation

CEPC-SppC Industrial Promotion Consortium (CIPC)

1) Superconduting materials (for cavity and for magnets)
2) Superconductiong cavities
3) Cryomodules
4) Cryogenics
5) Klystrons
6) Vacuum technologies
7) Electronics
8) SRF
9) Power sources
10) Civil engineering
11) Precise machinary.....

Established in Nov. 7 , 2017

More than 40 companies joined in first phase of CIPC，
and more will join later....

CEPC Schedule (ideal)

design issues
R&D items
preCDR

design, funding
R&D program
Intl. collablration
site study

seek approval, site decision
construction during 14th 5-year plan
commissioning

Latest Politics

- Science & Technology is strongly supported by this government ➔ also a "requirement" to local governments (difference seen at Beijing & Shanghai since 2016)
- Not difficult to find local support for the site
- State Council announced in March "Implementation method to support China-initiated large international science projects and plans"
  - Science of Matter, Evolution of the Universe, life science, earth, energy, …
  - Goal:
    - up to 2020, 3-5 preparatory projects; 1-2 construction projects
    - up to 2035, 6-10 preparatory projects; ? construction projects
  - Possible competitors: ~ 50 ideas collected, Fusion reactor, space program, brain program, Investigation of the Qinghai Tibet Plateau, CEPC, …
- We are working with the MOST to be included in the roadmap planning, project selection, etc.