# Overview of the CEPC Project

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# Outline

The CEPC-SppC Study Group – a brief reminder

Progress and Status

- **Preliminary CDR**
  - Volume 1: Physics, detector, simulation and physics reach
  - Volume 2: Accelerators: CEPC, SPPC
  - Volume 3: Civil engineering and site consideration
  - preCDR: Technical review & Completion
- Communication, outreach and education
- Training and professional development

Pre. R&D and funding requests

CDR

Project evaluation

Summary

# Reminder:

# CEPC-SppC Study Group

# CEPC-SppC

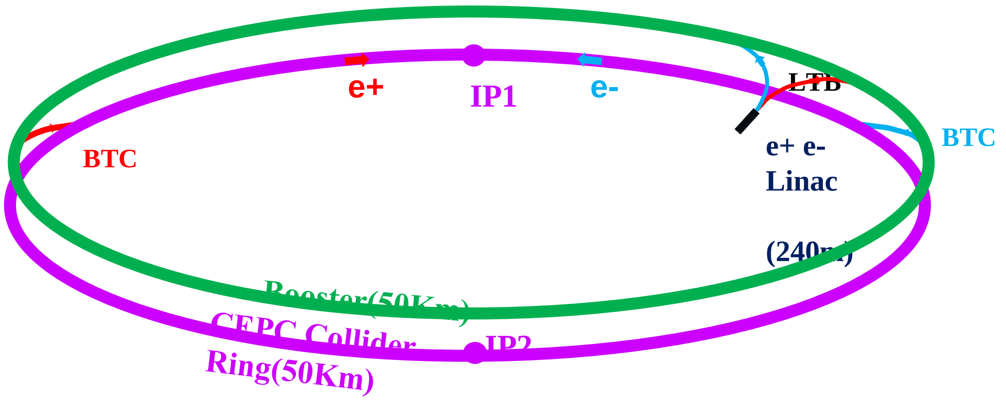
**Phase 1: $e^+e^-$ Higgs (Z) factory** **two detectors, 1M ZH events in 10yrs**

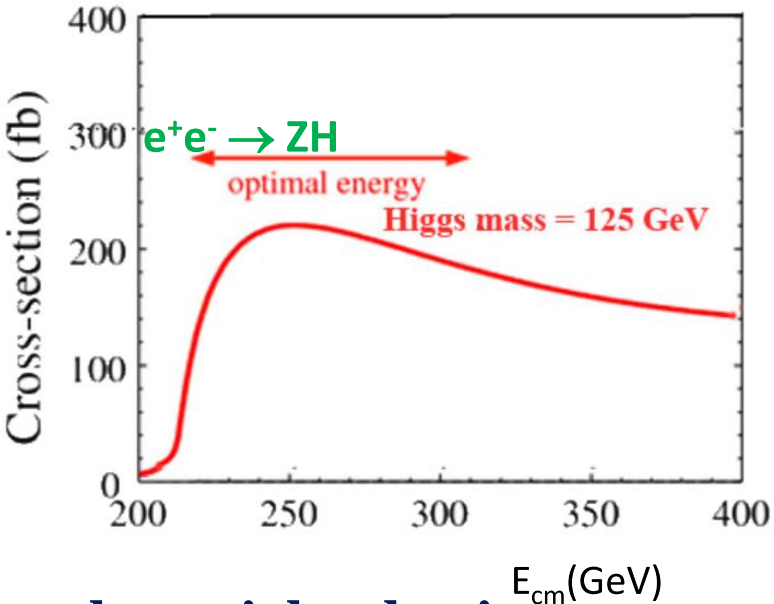
$E_{cm}$≈240GeV, luminosity ~$2\times10^{34}$ $cm^{-2}s^{-1}$, can also run at the Z-pole

**Precision measurement of the Higgs boson (and the Z boson)**

**Phase 2: a discovery machine**; pp collision with $E_{cm} \approx$ 50-100 TeV; ep,HI options

**Discovery machine for BSM**

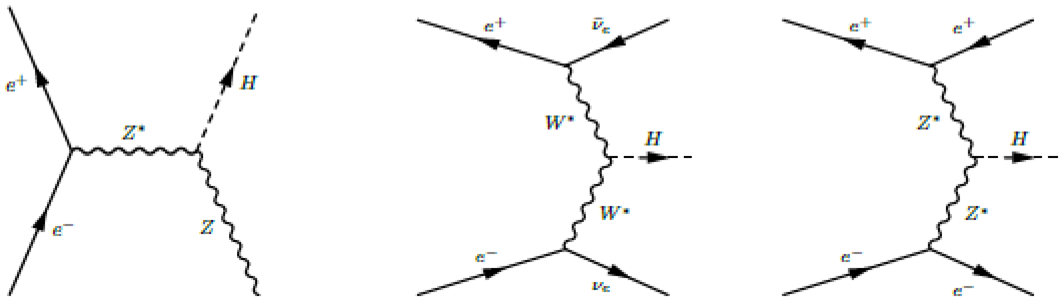


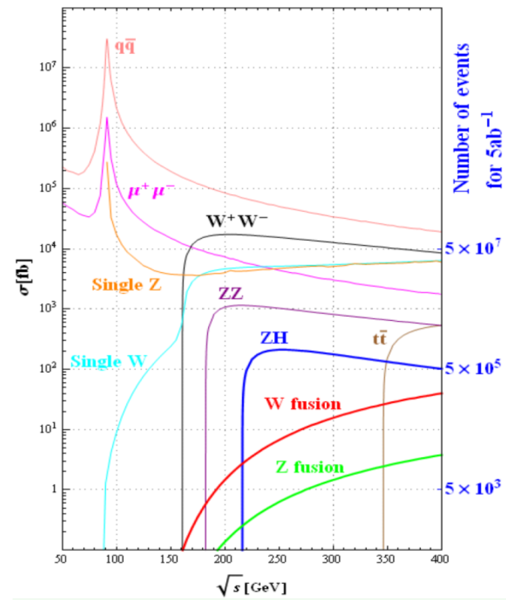

**favored post BEPCII accelerator based particle physics program in China**

# CEPC

- Precise measurements of the Higgs properties as a Higgs Factory (similar to ILC@250 GeV)
  - Mass, $J^{PC}$, couplings, etc. → reach (sub-) percentage accuracy

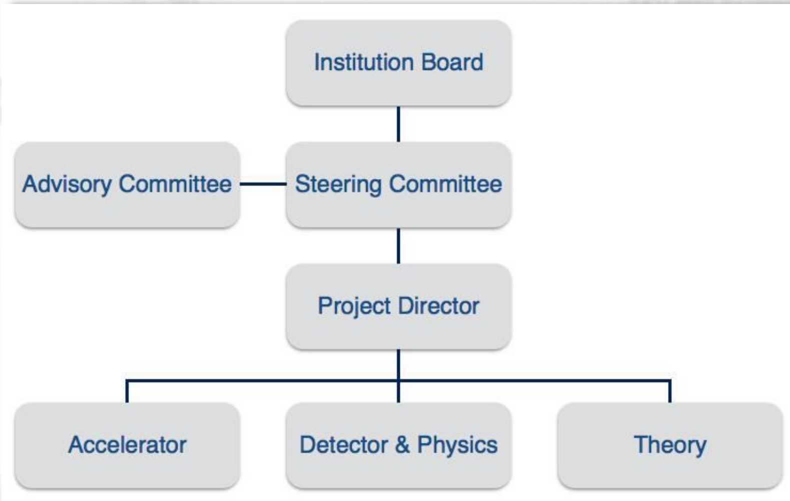



| Process | Cross section (fb) | Nevents in 5 ab$^{-1}$ |
|---|---|---|
| | Higgs boson production | |
| $e^+e^- \to ZH$ | 209 | $1 \times 10^6$ |
| $e^+e^- \to \nu\bar{\nu}H$ | 6.9 | $3.5 \times 10^4$ |
| $e^+e^- \to e^+e^-H$ | 0.6 | $3.0 \times 10^3$ |




- Precise measurements of Electroweak Symmetry-Breaking parameters at Z-pole and WW threshold
  - $m_Z, m_W, \Gamma_Z, \sin^2\theta_W^{\rm eff}, \alpha_S$, *etc. + searches for rare decays*

# CEPC Organization





- Institution Board and Steering Committee formed in the kick-off meeting in September 2013; conveners appointed for the three

## Office of Engineering and Support at IHEP

appointed by IHEP director Y. F. Wang on April 15, 2014

- ➢ The CEPC management was reorganized in May 2015, after the preCDR, to move forward with the CDR process;
- ➢ Int’l advisory committee formed; first meeting in September.

# Preliminary Conceptual Design Report (**preCDR**)

Volume 1: Physics, detector, simulation and physics reach
Volume 2: Accelerators: CEPC, SPPC
Volume 3: Civil engineering and site consideration

- **Getting preliminary answers to critical questions**
- **Identify critical physics, technologies & tools for R&D**
- **Develop estimates for R&D costs**
- **Formal review by int'l committees & completion**

**Document ready for 13$^{th}$ 5 Year Plan (2015)**

# Status and Progress

## ACCELERATORS

**Preliminary**

**For details please presentation by Qing Qin**

# CEPC-SppC Accelerators

- **$e^+e^-$ collider**

  Higgs produced above the $e^+e^- \rightarrow ZH$ threshold

  Collide $e^+e^-$ at $E_{cm}$~240GeV， σ~ 200 fb

  Need 250 $fb^{-1}$/y/IP —> 1M Higgs particles in 10 years

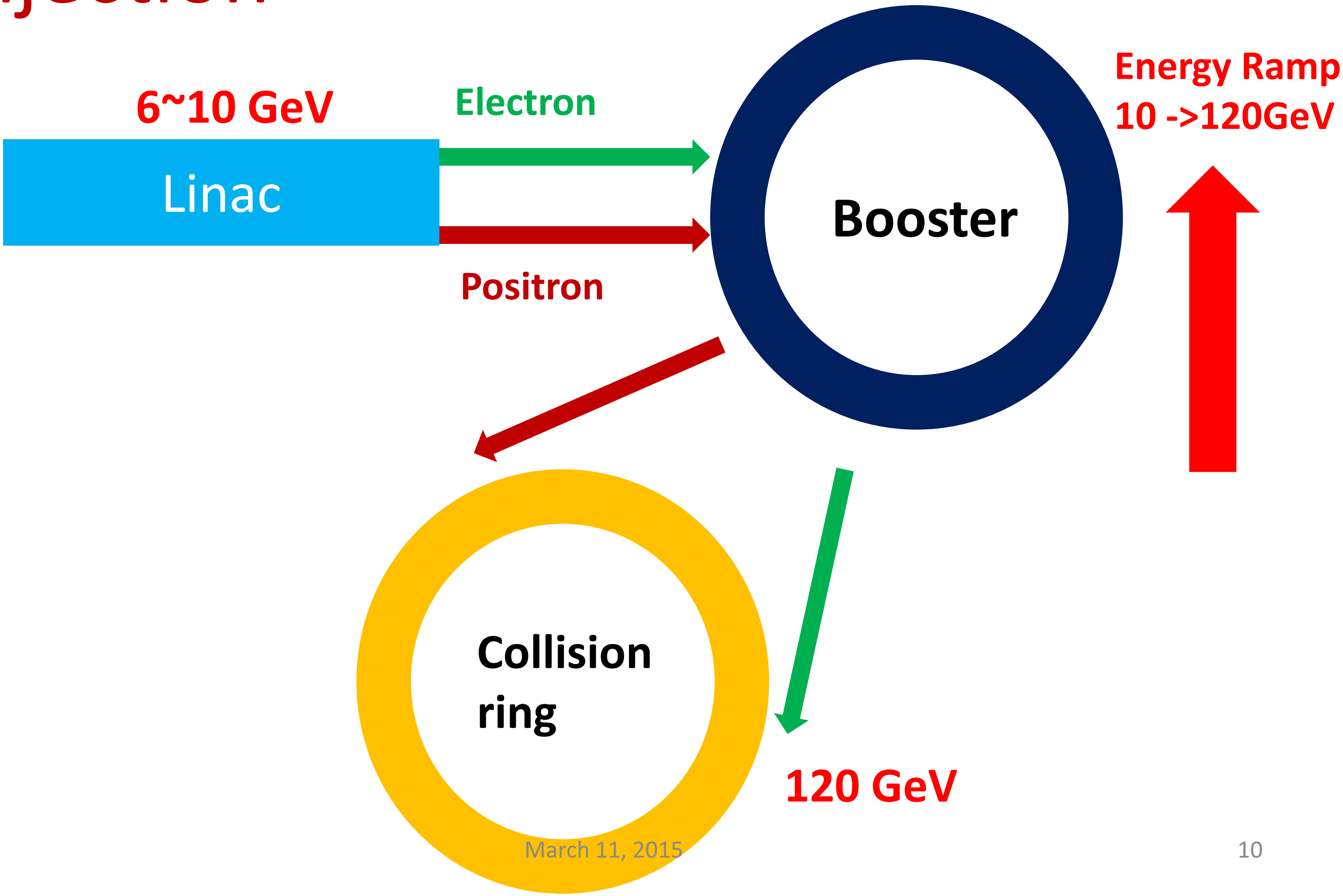
  **Goal**

- **pp collider**

  $E_{cm}$=70 TeV or higher

# CEPC Accelerator Baseline Design

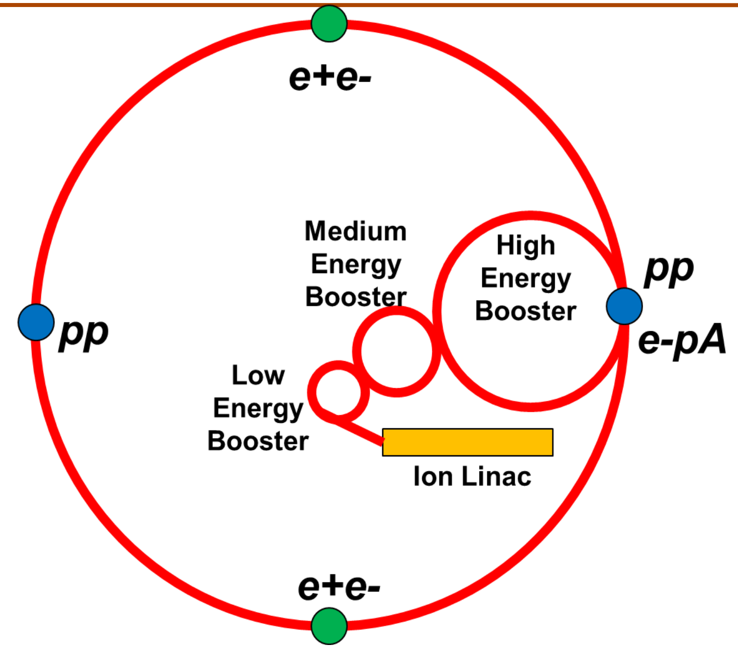
## Injection



# CEPC main parameters

| Parameter | | | Design Goal | | |
|---|---|---|---|---|---|
| Parameter | Unit | Value | Parameter | Unit | Value |
| Beam energy [E] | GeV | 120 | Circumference [C] | m | 54752 |
| Number of IP[$N_{IP}$] | | 2 | SR loss/turn [$U_0$] | GeV | 3.11 |
| Bunch number/beam[$n_B$] | | 50 (48) | Bunch population [Ne] | | 3.79E+11 |
| SR power/beam [P] | MW | 51.7 | Beam current [I] | mA | 16.6 |
| Bending radius [$\rho$] | m | 6094 | momentum compaction factor [$\alpha_p$] | | 3.36E-05 |
| Revolution period [$T_0$] | s | 1.83E-04 | Revolution frequency [$f_0$] | Hz | 5475.46 |
| emittance (x/y) | nm | 6.12/0.018 | $\beta_{IP}$(x/y) | mm | 800/1.2 (3) |
| Transverse size (x/y) | $\mu$m | 69.97/0.15 | $\xi_{x,y}$/IP | | 0.118/0.083 |
| Bunch length SR [$\sigma_{s.SR}$] | mm | 2.14 | Bunch length total [$\sigma_{s.tot}$] | mm | 2.65 |
| Lifetime due to Beamstrahlung | min | 47 | lifetime due to radiative Bhabha scattering [$\tau_L$] | min | 51 |
| RF voltage [$V_{rf}$] | GV | 6.87 | RF frequency [$f_{rf}$] | MHz | 650 |
| Harmonic number [h] | | 118800 | Synchrotron oscillation tune [$\nu_s$] | | 0.18 |
| Energy acceptance RF [h] | % | 5.99 | Damping partition number [$J\varepsilon$] | | 2 |
| Energy spread SR [$\sigma_{\delta.SR}$] | % | 0.132 | Energy spread BS [$\sigma_{\delta.BS}$] | % | 0.096 |
| Energy spread total [$\sigma_{\delta.tot}$] | % | 0.163 | $n_\gamma$ | | 0.23 |
| Transverse damping time [$n_x$] | turns | 78 | Longitudinal damping time [$n_\varepsilon$] | turns | 39 |
| Hourglass factor | Fh | 0.68 | Luminosity /IP[L] | $cm^{-2}s^{-1}$ | 2.04E+34 |

# SppC Accelerator Design considerations




- Proton-proton collider luminosity

$$L_0 = \frac{N_p^2 N_b f_{rep} \gamma}{4\pi \varepsilon_n \beta_{IP}} F \qquad \left(F = \sqrt{1 + \left(\frac{\theta_c \sigma_z}{2\sigma_{x,IP}}\right)^2}\right) \qquad \xi = \frac{N_p r_p}{4\pi \varepsilon_n} \le 0.004$$

- Main constraint: high-field superconducting dipole magnets
  - **50 km**: $B_{max}$ = 12 T, $E$ = 50 TeV
  - **50 km**: $B_{max}$ = 20 T, $E$ = 70 TeV
  - **70 km**: $B_{max}$ = 20 T, $E$ = 90 TeV

$$B_{\min} = \frac{2\pi (B\rho)}{C_0}$$

# R&D plan of the 20 T accelerator magnets

(Very Preliminary)

- **2015-2020**: Development of a 12 T operational field $Nb_3Sn$ twin-aperture dipole with common coil configuration and $10^{-4}$ field quality; Fabrication and test of 2~3 T HTS (Bi-2212 or YBCO) coils in a 12 T background field and basic research on tape superconductors for accelerator magnets (field quality, fabrication method, quench protection).
- **2020-2025**: Development of a 15 T $Nb_3Sn$ twin-aperture dipole and quadrupole with $10^{-4}$ field uniformity; Fabrication and test of 4~5 T HTS (Bi-2212 or YBCO) coils in a 15 T background field.
- **2025-2030**: 15 T $Nb_3Sn$ coils + HTS coils (or all-HTS) to realize the 20 T dipole and quadrupole with $10^{-4}$ field uniformity; Development of the prototype SppC dipoles and quadrupoles and infrastructure build-up.

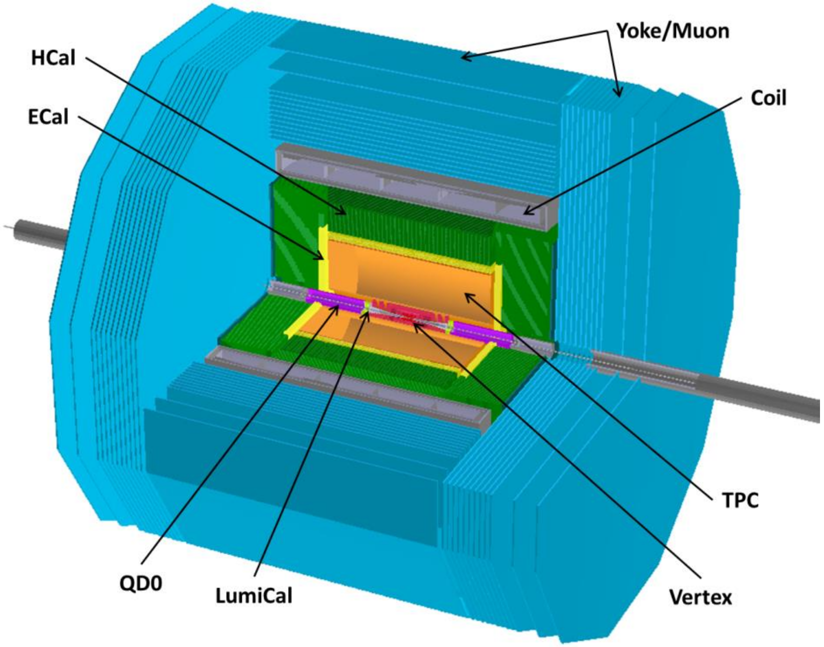
**a long term plan for SC 20T magnets is being developed**
**will be a world wide effort**

# Status and Progress

## DETECTOR

- aim at coming up with a credible prel. CDR
- identify “R&D” for CDR & TDR

# CEPC Detector considerations



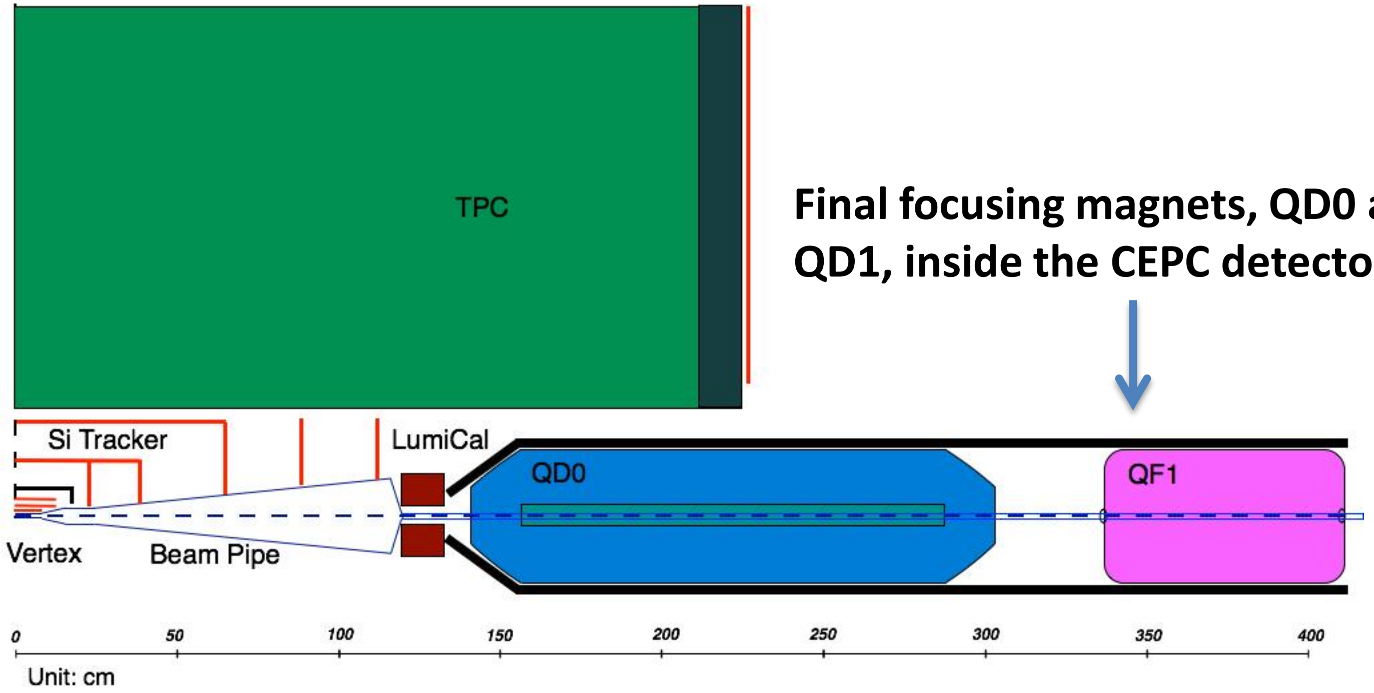

**ILD-like detector with additional considerations (*incomplete list*):**

- Shorter L* (**1.5**/2.5m) → constraints on space for the Si/TPC tracker
- No power-pulsing → lower granularity of vertex detector and calorimeter
- Limited CM (up to 250 GeV) → calorimeters of reduced size
- Lower radiation background → vertex detector closer to IP
- …

- **Similar performance requirements to ILC detectors**
  - Momentum: $\sigma_{1/p} < 5\times10^{-5}\ \text{GeV}^{-1}$ ← recoiled Higgs mass
  - Impact parameter: $\sigma_{r\phi} = 5 \oplus 10/(p\cdot\sin^{\frac{3}{2}}\theta)\ \mu\text{m}$ ← flavor tagging, BR
  - Jet energy: $\frac{\sigma_E}{E} \approx 3-4\%$ ← W/Z di-jet mass separation

**Sub-detector groups consider design options, identify challenges, plan R&D**

# CEPC Detector considerations

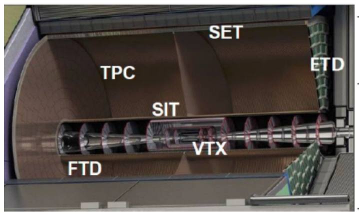



**Final focusing magnets, QD0 and QD1, inside the CEPC detector**

- Focal length (L*), the distance between QD0 and the interaction point, shortened to 1.5 m to allow realization of high luminosity without large chromaticity corrections
- Comprehensive understanding and optimization of both detector and collider performance are needed in future studies

# CEPC Detector considerations

## Vertex Detector




| Detector | | Geometric dimensions | | | Material budget $[X/X_0]$ |
|---|---|---|---|---|---|
| SIT | Layer 1: | | $r = 153$ mm, | $z = 371.3$ mm | 0.65% |
| | Layer 2: | | $r = 300$ mm, | $z = 664.9$ mm | 0.65% |
| SET | Layer 3: | | $r = 1811$ mm, | $z = 2350$ mm | 0.65% |
| FTD | Disk 1: | $r_{in} = 39$ mm, | $r_{out} = 164$ mm, | $z = 220$ mm | 0.50% |
| | Disk 2: | $r_{in} = 49.6$ mm, | $r_{out} = 164$ mm, | $z = 371.3$ mm | 0.50% |
| | Disk 3: | $r_{in} = 70.1$ mm, | $r_{out} = 308$ mm, | $z = 644.9$ mm | 0.65% |
| | Disk 4: | $r_{in} = 79.3$ mm, | $r_{out} = 309$ mm, | $z = 846$ mm | 0.65% |
| | Disk 5: | $r_{in} = 92.7$ mm, | $r_{out} = 309$ mm, | $z = 1057.5$ mm | 0.65% |
| ETD | Disk: | $r_{in} = 419.3$ mm, | $r_{out} = 1822.7$ mm, | $z = 2420$ mm | 0.65% |

**Silicon Internal Tracker (SIT)** – 2 inner layers Si strip detectors
**Forward Tracking Detector (FTD)** – 5 disks (2 with pixels and 3 with Si strip sensor) on each side, comparing 7 disks on ILD, due to smaller L*
**Silicon External Tracker (SET)** – 1 outer layer Si strip detector
**End-cap Tracking Detector (ETD)** – 1 end-cap Si strip detector on each side

- b/c-quark and tau lepton identification (*essential for the precision physics program*) requiring impact parameter resolution in the transverse plane better than:

$$\sigma_{r\phi} = 5 \oplus \frac{10}{(p \cdot \sin^{3/2}\theta)} \ \mu m$$

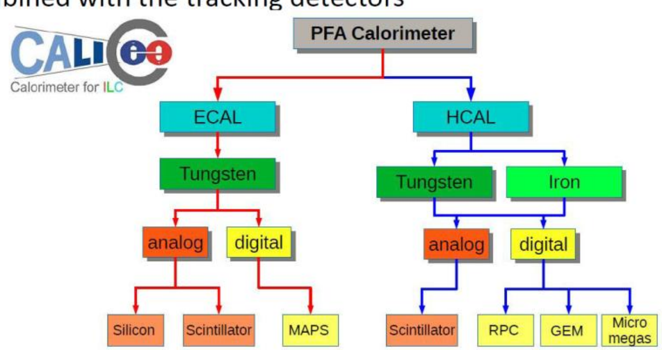
- The vertex detector should comply with:
  - Spatial resolution near the IP better than 3 μm
  - Material budget ≤0.15% radiation length (X0) per layer
  - 1st detector layer close to the IP (r = 16 mm)
  - Detector occupancy not exceeding 1%

Requirements on pixel sensor

**Single-point resolution <3 μm, power consumption < 50mW/cm$^2$ (air cooling), readout time < 20μs**
**radiation tolerance: annual TID~100 kRad and NIEL~3 ×10 $n_{eq}$/cm$^2$**

## Calorimeters

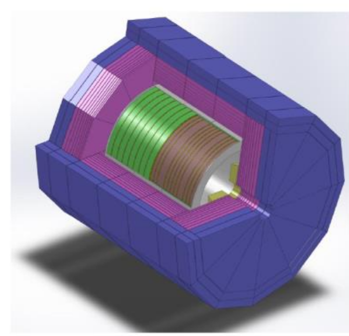
- Particle Flow Algorithm (PFA) oriented electromagnetic and hadronic calorimeters, expected jet energy resolution of 3-4% combined with the tracking detectors



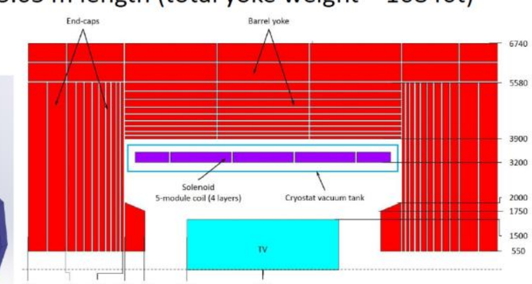

- Intensive detector R&D efforts in the CALICE collaboration, be selective on the technologies most suitable for CEPC

## Magnet

- 3.5 T central field of superconducting solenoid in a warm aperture of 6 m in diameter and 8.05 m length (total yoke weight ~ 10840t)



Structure of the coil/iron yoke




| | | | |
|---|---|---|---|
| The solenoid central field [T] | 3.5 | Nominal current [kA] | 17.82 |
| Maximum field on conductor [T] | 3.75 | Total ampere-turns of solenoid [MAt] | 22.24 |
| Coil inner radius [mm] | 3200 | Inductance [H] | 8.62 |
| Coil outer radius [mm] | 3500 | Stored energy [GJ] | 1.368 |
| Coil length [mm] | 7400 | Stored energy per unit of cold mass [KJ/kg] | 9.44 |

# CEPC Detector R&D considerations

## Critical R&D for pixel detector

- Pixel sensors with low power consumption and fast readout
  - Optional technologies: HR-CMOS, SOI, DEPFET, etc.
  - Novel readout architecture and enhanced in-pixel and sensor level electronics functionality
- Mechanical design and cooling
  - Light weight mechanical support structure and cables
  - Vibration under forced-air cooling: *impacts on position precision an consequentially the impact parameter resolution*
  - Air cooling or more aggressive CO2 cooling

## Critical R&D for strip detector

- Silicon microstrip sensor with high spatial resolution
  - Convectional p+-on-n sensor with small pitch size ~ 50um fabricated with large size wafer (6'' or even 8'')
  - Preferably to be thinned down to below 200 um (less material) and with slim-edge (maximal sensitive area)
  - Alternatively pixelated strip sensors based on CMOS technology as being pursued by the ATLAS experiment for HL-LHC
- Front-end electrons
  - Fabricated with 90/65 nm CMOS technology
  - Fast electronics with low noise and low power consumption
- Mechanics, powering and cooling

## Critical R&D for PTC

- Techniques and design to fully suppress the Ion backflow
- Understand the impacts of magnetic/electric field distortion on readout modules and track reconstruction and figure out possib solution
- Readout options (GEM or Micromegas) and front-end electronic (ASICs fabricated with 65 nm CMOS technology)
- Efficient cooling techniques: two-phase CO2 cooling or more efficient micro-channel CO2 cooling
- Alignment and calibration system

## DHCAL R&D

- Detector optimization including pad size, number of detector layers, gas recirculation system, HV distribution system
- Readout Electronics (PCB, low power ASIC FEE)
- Effective cooling together with power saving strategy
- Calibration
  - Energy, position and density calibration
  - Detailed shower measurement gives possibility to use track segments (from data itself) to calibrate calorimeter
- Mechanical: self-support and compact module

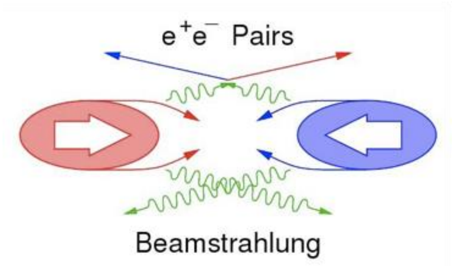
# CEPC Detector (pixel) considerations

Many technologies from ILC/CLIC R&D could be referred.
BUT, unlike the ILD, the CEPC detector will operate in continuous mode.

- **Pixel sensor**: power consumption < 50mW/cm$^2$ with air cooling, readout < 20μs
- **Front-end electronics**: low power consumption, low noise, 65nm CMOS technology, potential unified application with calorimeter readout
- **Power and cooling**: DC-DC powering, air cooling (or more aggressive cooling, eg. silicon micro-channel cooling)
- **Mechanics**: low mass supporting structure but with sufficient stiffness and stability, easy integration and replacement etc.

# Beam Related Backgrounds

- Backgrounds originating from beam-beam interactions
  - Beamstrahlung (negligible)
  - Electron-positron pair production (dominant)
  - Hadronic background (negligible)
  - Radiative Bhabha scattering (small)




On the inner most detector layer

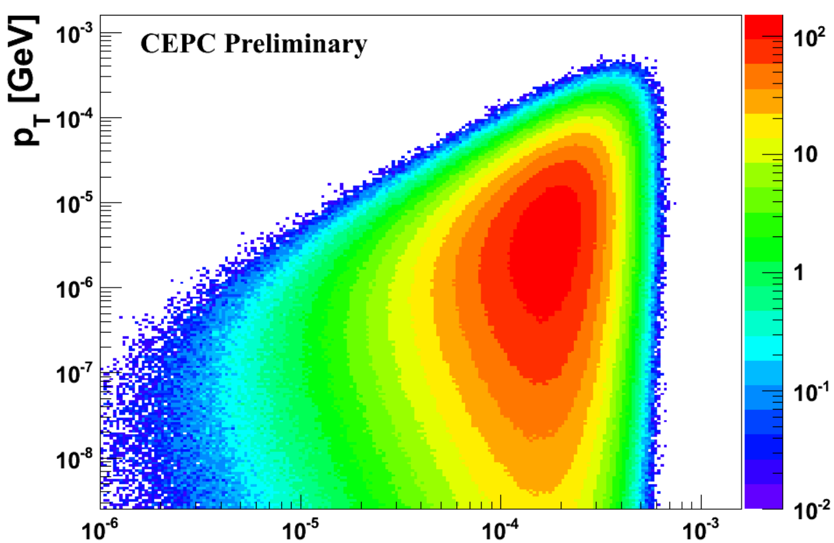
Hit density : 0.8 hits/cm$^2$/BX
Radiation levels: annual TID~100 kRad and NIEL~3 ×10 $n_{eq}$/cm$^2$

- Other backgrounds also studied
  - Synchrotron radiation (partially evaluated, detectors safe)
  - Beam-gas interactions (negligible)

# CEPC Detector considerations

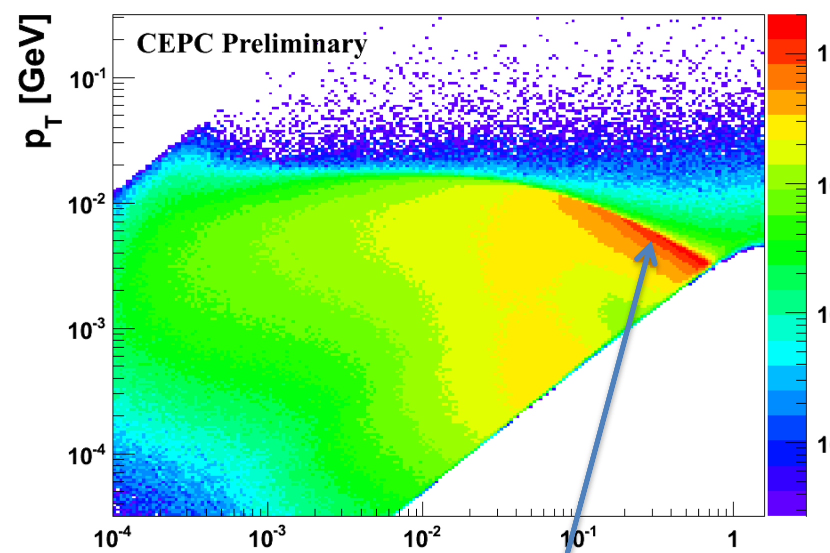
Noise near the IP

- Beam induced backgrounds (beam-gas, beam-beam, synchrotron radiation) imposes large impact on detector design (eg, occupancies, radiation damage)
- Beam-beam interactions simulated with Guinea-Pig, including
  Beamstrahlung, $e^+e^-$ pair production, hadronic backgrounds, etc.




Beamstrahlung photons

Low momentum and small polar angle → negligible, but should avoid directing any detector component




e+e- pair production

Dominant detector background with sharp kinematic edge → detector components (beampipe) to be placed away

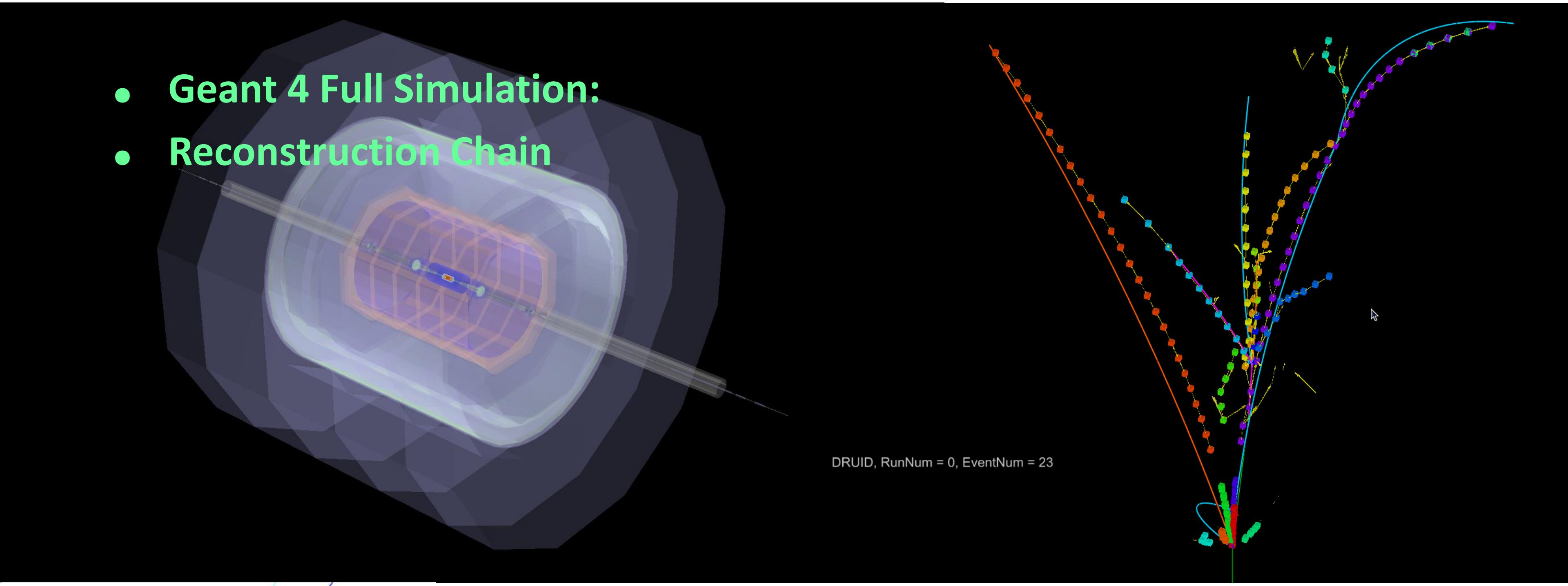
# Status and Progress

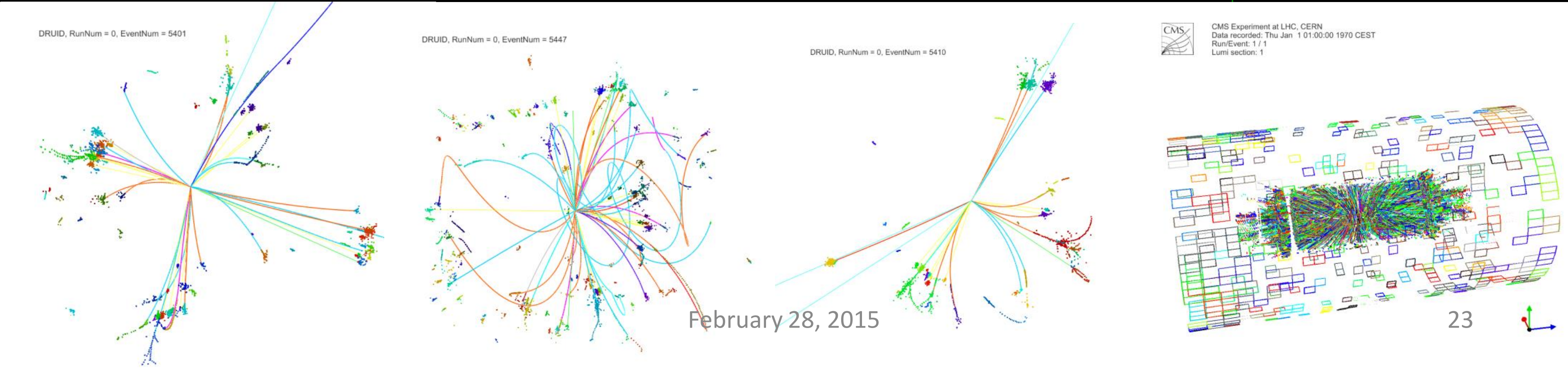
## SIMULATION & PHYSICS REACH

**Preliminary**

# CEPC simulation & physics

- Geant 4 Full Simulation:
- Reconstruction Chain

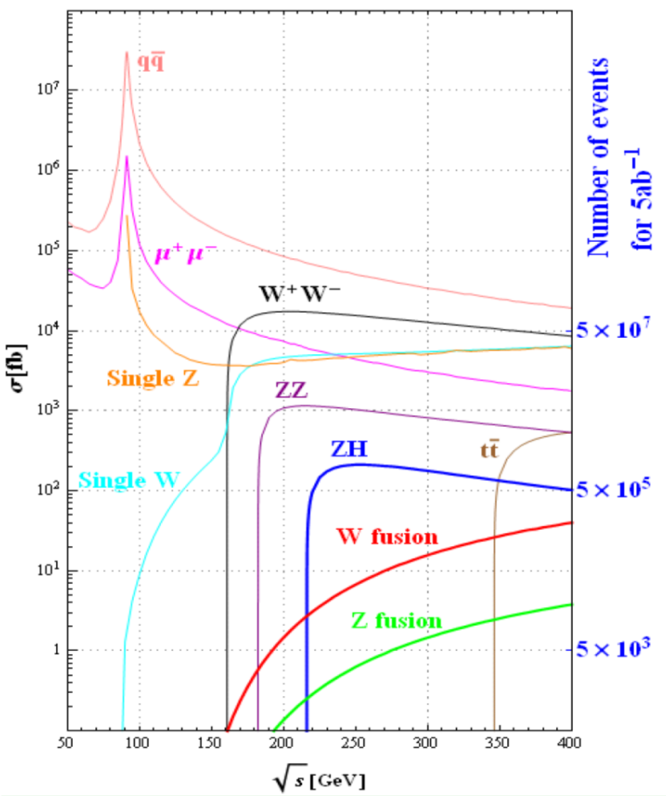


# CEPC simulation & physics

MC Samples

- Generators: Full SM sample + Several BSM Signals




**CEPC preCDR Higgs sensitivity study**

| | di-muon | di-electron | di-neutrino | di-jets |
|---|---|---|---|---|
| σ(ZH) | | | - | |
| $M_H$ | | | | |
| σ(ZH)*Br(H→bb) | | | | |
| σ(ZH)*Br(H→cc) | | | | |
| σ(ZH)*Br(H→gg) | | | | |
| σ(ZH)*Br(H→WW) | | | | |
| σ(ZH)*Br(H→ZZ) | | | | |
| σ(ZH)*Br(H→ττ) | | | | |
| σ(ZH)*Br(H→γγ) | | | | |
| σ(ZH)*Br(H→μμ) | | | | |
| σ(νvH)*Br(H→bb) | - | - | | - |
| Br(H→invisible) | | | - | |
| Br(H→exotic) | | | | |

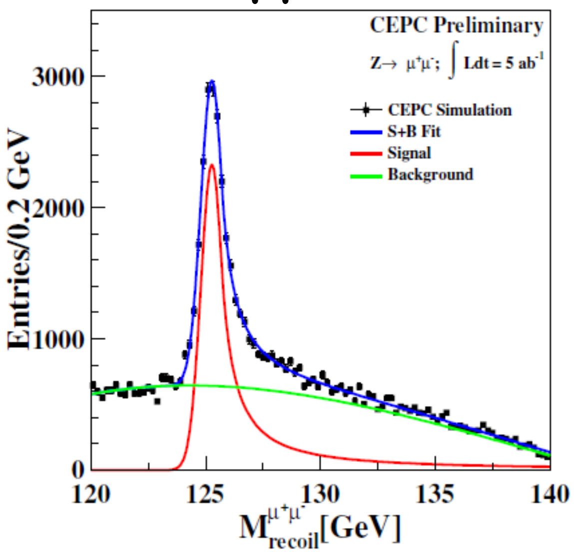
Signal with CEPC Full Simulation, Bkgrd with Fast Simulation

CEPC Fast Simulation

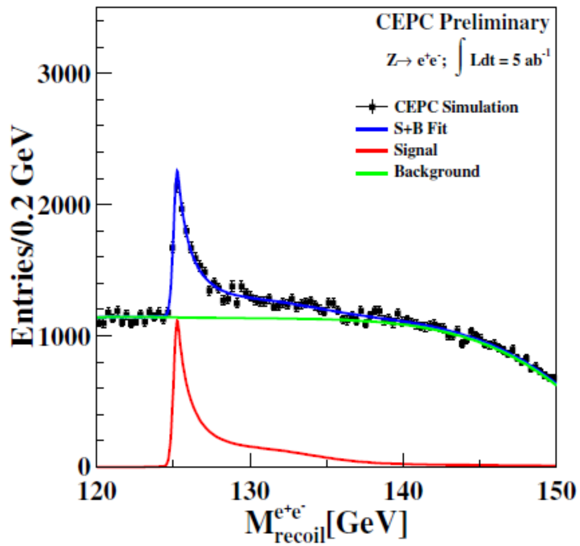
Extrapolated from ILC/FCC-ee results

# CEPC simulation & physics

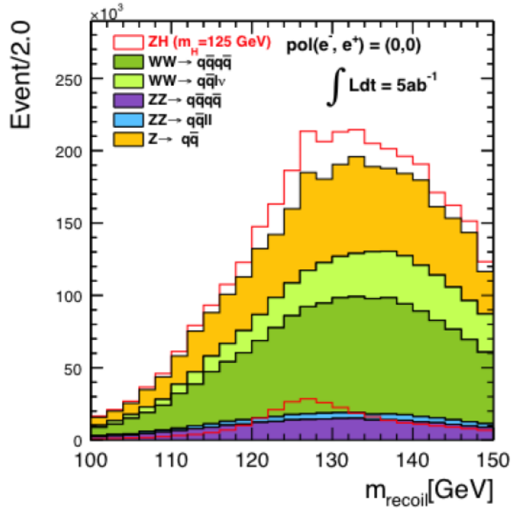
**Z→μμ recoil**




**Z→ee recoil**




**Z→qq recoil**




$$m_{\text{recoil}}^2 = (\sqrt{s} - E_{ff})^2 - p_{ff}^2$$

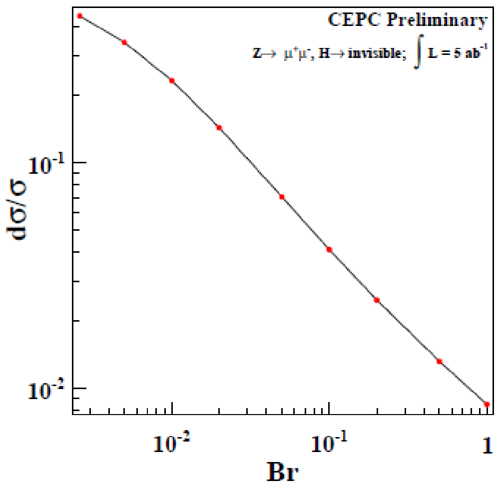
| $Z$ decay mode | $\Delta M_H$ (MeV) | $\Delta\sigma(ZH)/\sigma(ZH)$ | $\Delta g(HZZ)/g(HZZ)$ |
|---|---|---|---|
| $ee$ | 14 | 2.1% | |
| $\mu\mu$ | 6.5 | 0.9% | |
| $ee+\mu\mu$ | 5.9 | 0.8% | 0.4% |
| | | | |
| $q\bar{q}$ | | 0.65% | 0.32% |
| $ee+\mu\mu+q\bar{q}$ | | 0.51% | 0.25% |

**~0.5%** accuracy on σ(ZH), the **anchor** of absolute Higgs measurements

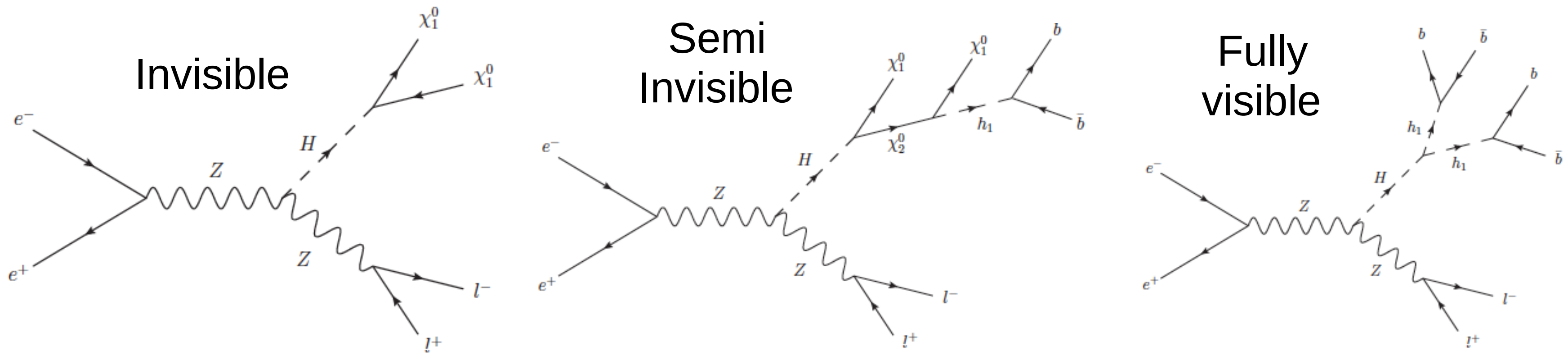
# CEPC simulation & physics

- **Model independent tagging of Higgs boson (via Z recoil mass)**
- **Make CEPC extremely sensitive to BSM Higgs decay**

| Channel | Accuracy | Methods |
|---|---|---|
| $Z \to \mu\mu, H \to invisible$ | 0.8% | CEPC Full Simulation |
| $Z \to ee, H \to invisible$ | 1.1% | Estimation |
| $Z \to qq, H \to invisible$ | 0.14% | Extrapolated from ILC result |
| Combined | 0.14% | |




- Br(H→inv): **0.14%** accuracy with Br = 100%
- Br(H→bb + MET): 9.4σ deviation with Br = 0.2%
- Br(H→bbbb): 8.4σ sigma deviation with Br = 0.04%



# CEPC simulation & physics

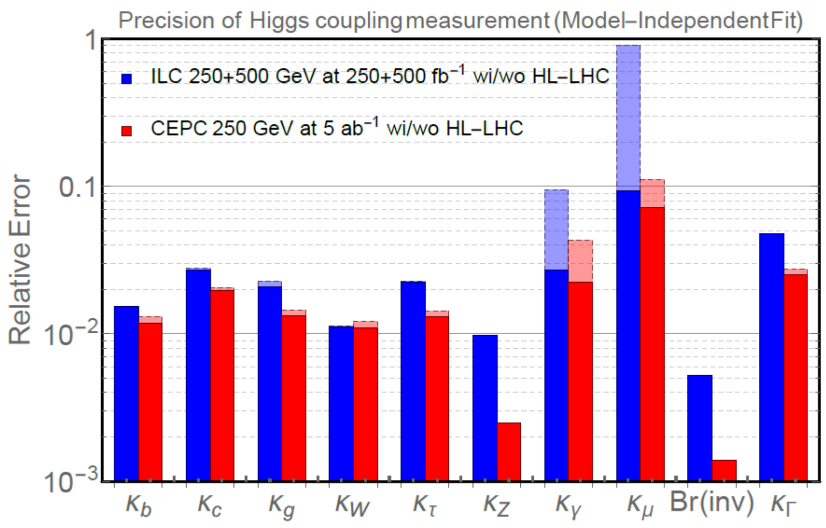
| $\Delta M_H$ | $\Gamma_H$ | $\sigma(ZH)$ | $\sigma(\nu\bar{\nu}H) \times \mathrm{BR}(H \to b\bar{b})$ |
|---|---|---|---|
| 5.9 MeV | 2.8% | 0.51% | 2.8% |

| Decay mode | $\sigma(ZH) \times \mathrm{BR}$ | BR |
|---|---|---|
| $H \to b\bar{b}$ | 0.28% | 0.57% |
| $H \to c\bar{c}$ | 2.2% | 2.3% |
| $H \to gg$ | 1.6% | 1.7% |
| $H \to \tau\tau$ | 1.2% | 1.3% |
| $H \to WW$ | 1.5% | 1.6% |
| $H \to ZZ$ | 4.3% | 4.3% |
| $H \to \gamma\gamma$ | 9.0% | 9.0% |
| $H \to \mu\mu$ | 17% | 17% |
| $H \to \mathrm{inv}$ | – | 0.28% |

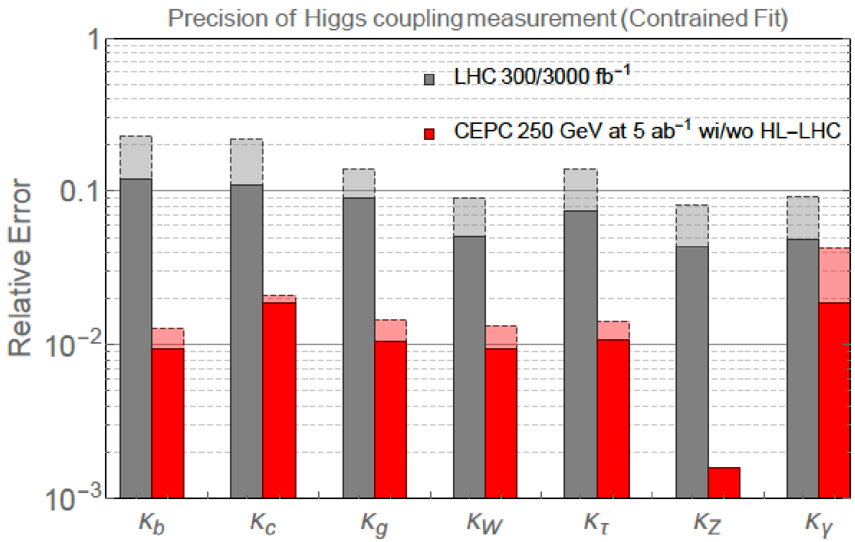
CEPC Combination group:

Model independent result compared to ILC

Model dependent result compared to LHC
*(LHC: very limited access to model Independent measurement)*




preliminary




preliminary

# Status and Progress

## CIVIL ENGINEERING & SUPPORT

# Office of Engineering and Support at IHEP

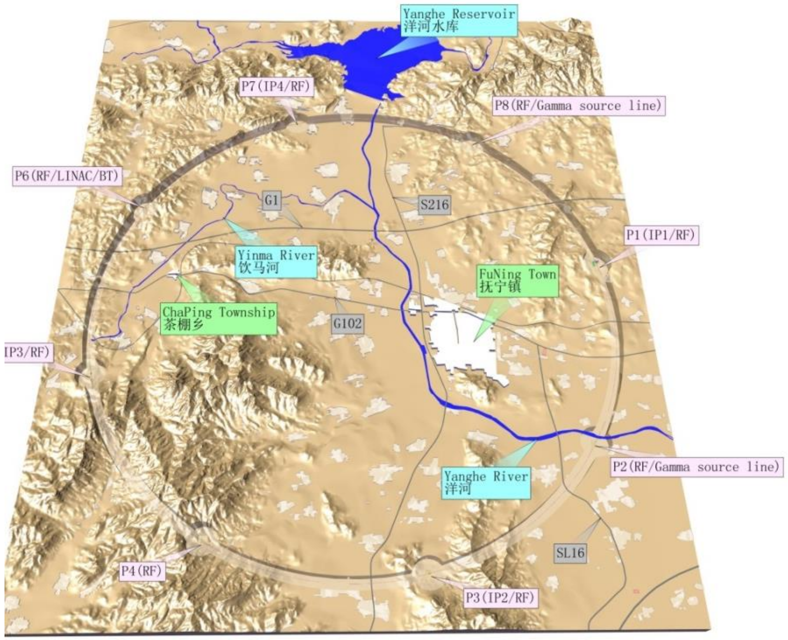
- appointed by IHEP director Y. F. Wang on April 15, 2014
- veterans and very experienced professionals

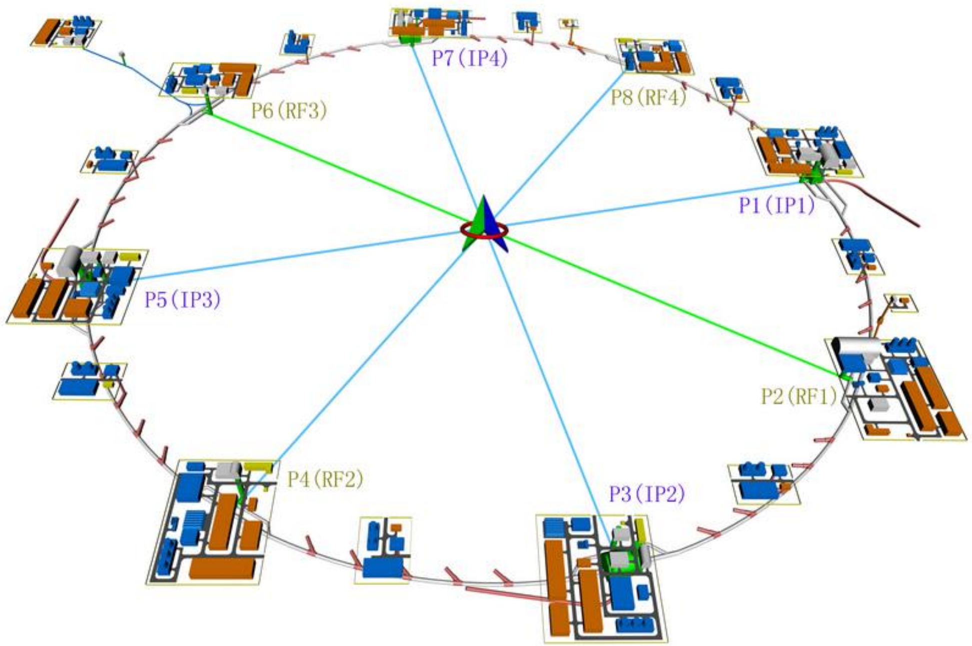
"enormous amount of effort & progress"

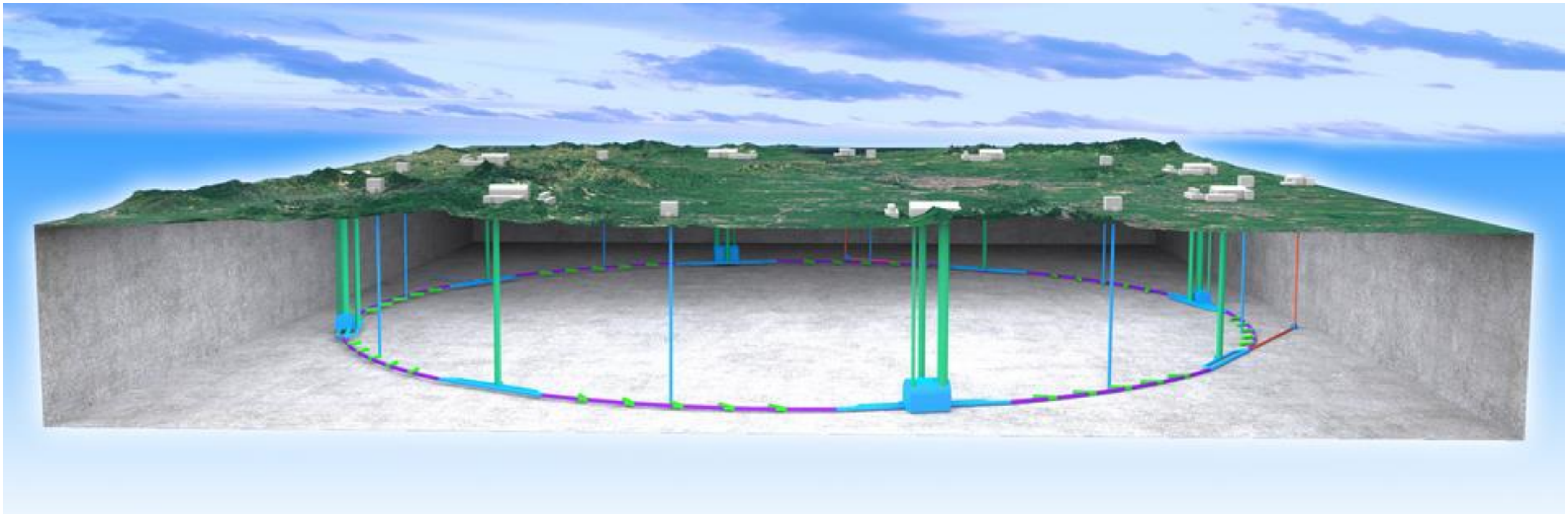

## QingHuangDao site Investigation

- ➢ 300km from Beijing
- ➢ Geo well suited
- ➢ Great environment

# CEPC "Qinghuandao Site" Investigation



# Preli. CDR

Reviews and completion

# CEPC Pre-CDR：初步概念设计

http://cepc.ihep.ac.cn/preCDR/volume.html

- ## The preliminary CDR volumes

  Volume I: Physics and the Detector
  Volume II: The CEPC-SppC Accelerators
  Volume III: Civil Engineering (in Chinese)

- ## The reviews

- ## Revisions and Chinese edition

**CEPC-SPPC**

***Preliminary Conceptual Design Report***

Volume II - Accelerator

**Contents**



**CEPC-SPPC**

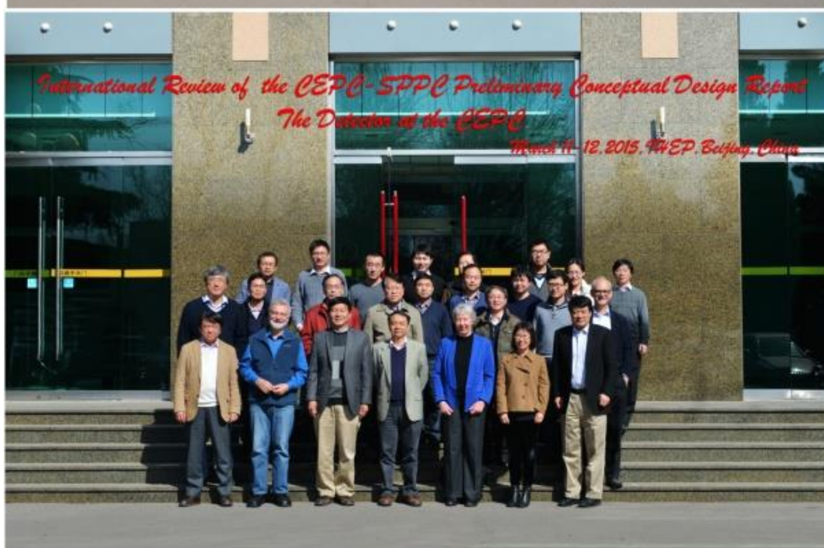
***Preliminary Conceptual Design Report***

**Volume I - Physics & Detector**

CONTENTS

# CEPC preCDR 初步概念设计 - Reviews






# CEPC preCDR 初步概念设计 - Reviews

"The committee considers the CEPC-SPPC to be well aligned with the future of China's HEP program, and in fact the future of the global HEP program."

"The committee strongly endorses the physics case of the CEPC, as outlined in the preCDR, recognizing it as an essential step in the understanding of Nature"

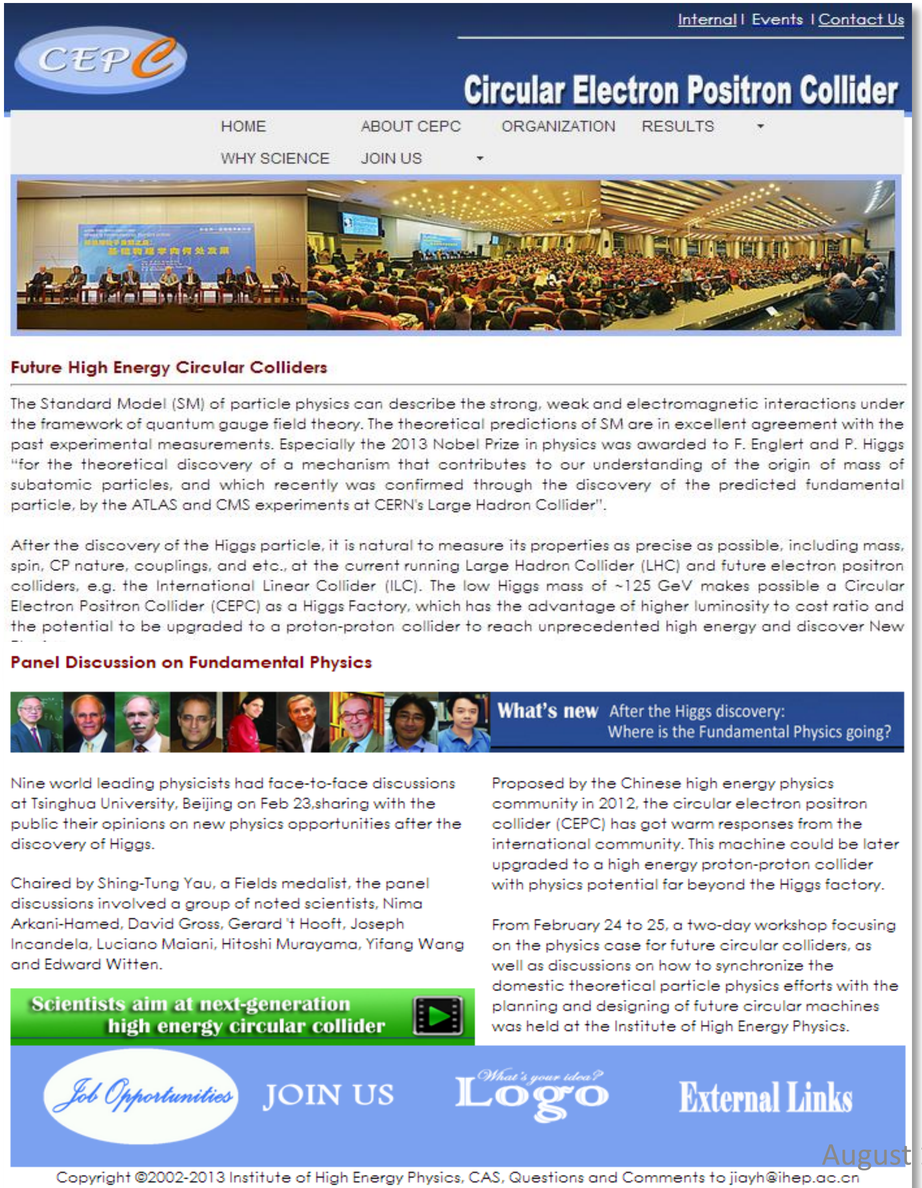
"The Committee has been very impressed with the progress during such a short period of time, as well as the work and presentations shown, mostly done by the young generation, who are the ones that can devote their carriers to this project through the coming decades"

- Physics goals and precision reachable（preliminary）
- No technological obstacles that can not be overcome
- Specification of R&D items
- Initial cost estimate
- Complete preCDR (implement reviewers comments),

# Status and Progress

## COMMUNICATION, OUTREACH & EDUCATION

# Communication: CEPC Web site (English, Chinese)



Internal | Events | Contact Us

CEPC

Circular Electron Positron Collider

HOME ABOUT CEPC ORGANIZATION RESULTS WHY SCIENCE JOIN US

**Future High Energy Circular Colliders**

The Standard Model (SM) of particle physics can describe the strong, weak and electromagnetic interactions under the framework of quantum gauge field theory. The theoretical predictions of SM are in excellent agreement with the past experimental measurements. Especially the 2013 Nobel Prize in physics was awarded to F. Englert and P. Higgs "for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider".

After the discovery of the Higgs particle, it is natural to measure its properties as precise as possible, including mass, spin, CP nature, couplings, and etc., at the current running Large Hadron Collider (LHC) and future electron positron colliders, e.g. the International Linear Collider (ILC). The low Higgs mass of ~125 GeV makes possible a Circular Electron Positron Collider (CEPC) as a Higgs Factory, which has the advantage of higher luminosity to cost ratio and the potential to be upgraded to a proton-proton collider to reach unprecedented high energy and discover New

**Panel Discussion on Fundamental Physics**

What's new After the Higgs discovery: Where is the Fundamental Physics going?

Nine world leading physicists had face-to-face discussions at Tsinghua University, Beijing on Feb 23,sharing with the public their opinions on new physics opportunities after the discovery of Higgs.

Chaired by Shing-Tung Yau, a Fields medalist, the panel discussions involved a group of noted scientists, Nima Arkani-Hamed, David Gross, Gerard 't Hooft, Joseph Incandela, Luciano Maiani, Hitoshi Murayama, Yifang Wang and Edward Witten.

Scientists aim at next-generation high energy circular collider

Proposed by the Chinese high energy physics community in 2012, the circular electron positron collider (CEPC) has got warm responses from the international community. This machine could be later upgraded to a high energy proton-proton collider with physics potential far beyond the Higgs factory.

From February 24 to 25, a two-day workshop focusing on the physics case for future circular colliders, as well as discussions on how to synchronize the domestic theoretical particle physics efforts with the planning and designing of future circular machines was held at the Institute of High Energy Physics.

Job Opportunities JOIN US What's your idea? Logo External Links

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CEPC 环形正负电子对撞机 Circular Electron Positron Collider

首 页 组织机构 建设背景 建设方案 科学目标 进展动态 科普园地 传媒扫描

**基于加速器的高能物理发展战略研讨会在高能所召开**

3月20日至21日，基于加速器的高能物理发展战略研讨会在高能所召开，会议由中国物理学会高能物理分会主办、高能所承办。来自国内外26个单位的115名从事高能物理实验与理论研究、粒子加速器与探测器技术方面的专家和科学院前沿科学... 【详细内容】

- 下一代环形正负电子对撞机项目引热评
- 未来高能物理环形对撞机国际研讨会召开
- 高能物理前沿研究中心揭牌成立
- 高能所举办CEPC物理分析及探测器优化培训
- CEPC-SPPC启动会顺利召开

更多新闻 >>

招聘信息 更多>>
- 实验物理中心博士后招聘启事

建设背景 更多>>

希格斯粒子是粒子物理"标准模型"预言的解释物质质量起源的粒子。2012年欧洲核子中心宣布在大型强子对撞机上的实验发现了希格斯粒子，标志着"标准模型"的完成，也标志着新时代的开始。对于中国的高能物理研究，乃至整个科技的发展，这是一个难得的重要机遇。我们建议在我国建设一个以超高能环形加速器为核心的世界级大型加速器基地，寻找超出"标准模型"的新物理，寻找未来发展的突破口。

科学目标 更多>>
- 环形正负电子对撞机（CEPC）的主要科学目标
- 超级质子-质子对撞机(SppC)的主要科学目标

学术交流 更多>>

| | |
|---|---|
| The 5th International Particle Accelerator Conference | 13-11-21 |
| 27th Linear Accelerator Conference, LINAC14 | 14-02-01 |
| ICHEP 2014 | 14-02-01 |
| 1st CFHEP Symposium on circular collider physics | 14-01-16 |
| 中国物理学会高能物理分会第九届全国会员代表大会暨学术年会 | 13-12-10 |

科普园地 更多>>

| | |
|---|---|
| 希格斯粒子及其发现 | 14-06-16 |
| 为什么要深入研究希格斯粒子的性质？ | 14-06-16 |
| 研究希格斯粒子为什么要建造超高能正负电子对撞机？ | 14-06-16 |
| 什么是"CEPC+SppC"方案？ | 14-06-16 |
| CEPC和SppC的物理目标是什么？ | 14-06-16 |

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| | |
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| 【fnal】ICFA Statement on the ILC, on Regional Planning, and on Stu... | 14-08-25 |
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| 【Nature】China plans super collider | 14-07-23 |
| 【文汇报】相信中国科学家能发现新粒子 | 14-06-05 |
| 【中国科学报】顶尖"大咖"中国行 | 14-03-07 |
| 【新华网】Chinese scientists plan better machine to hunt "God parti... | 14-02-27 |

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- After the discovery of Higg...
- Introduction of CEPC-SppC
- World HEP Program – Today
- Why We Must Pursue Basic Sc...

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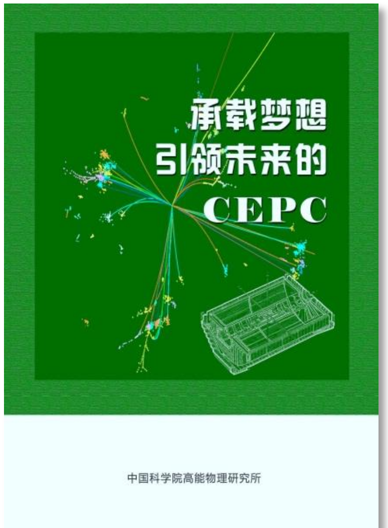
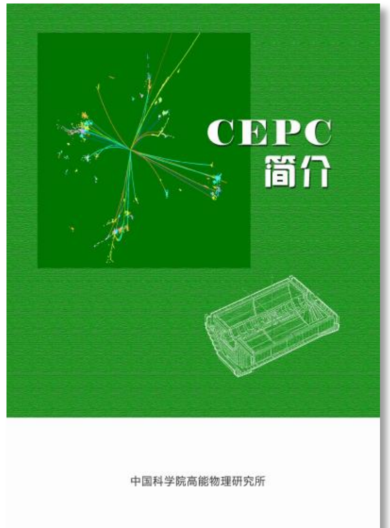
# Outreach & education

## CEPC Outreach




～ 30000字




～ 6700字


～ 27000字


～ 5600字

CEPC建议
引起巨大国际反响

～10000字

CEPC
大事记

高能物理的
社会效益

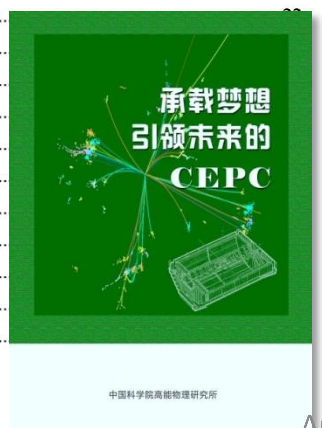
进行中

未来的
希格斯工厂

进行中

# 目 录






# 目 录



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# 公众宣传

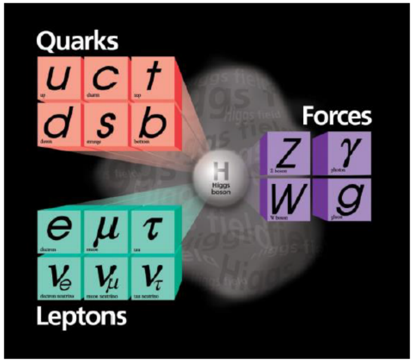
## 十问“希格斯粒子”与“环形正负电子对撞机”

希格斯粒子究竟是什么？为什么全球数千位科学家，花费数十亿美元，坚持50年在寻找它？它被喻为粒子物理标准模型“最后的一块拼图”，可是为什么当它终于被发现，科学家们却说这是人类探索基本粒子的新开端？中国科学家为什么想要建造下一代环形正负电子对撞机来“批量生产”它？为什么这是我国高能物理研究，甚至国家发展的难得机遇？

关于“希格斯粒子”与“环形正负电子对撞机”，太多网友表示“不明觉厉”，小编这就联合高能所的粒子物理学家为你解开疑惑。

### 1、什么是粒子物理的“标准模型”？

粒子物理的“标准模型”是一个描述物质世界的基本构成（基本粒子）及其相互作用的理论，于20世纪60至70年代在弱电统一理论以及量子色动力学的基础上逐步完善起来。物理学家温伯格(Steven Weinberg)、萨拉姆(Abdus Salam)和格拉肖（Sheldom Lee Glaschow）等是标准模型的奠基人。



粒子物理标准模型示意图

该模型把基本粒子分为夸克、轻子和玻色子三大类别，共62种，这些粒子后来陆续被高能物理实验所证实。

标准模型预言的希格斯粒子是自旋为零的玻色子。与之相关的希格斯机制为基本粒子的质量起源提供了动力学解释，因此是整个标准模型的基石之一。假如希格斯粒子不存在，那将成为标准模型的重大缺陷。

### 2、什么是希格斯粒子？它为什么被称作“上帝粒子”？

希格斯粒子是粒子物理标准模型预言的一种自旋为零的玻色子，以英国理论物理学家彼得·希格斯（Peter Higgs）的名字命名。标准模型中的一些其他基本粒子受希格斯场的作用产生惯性，最终形成质量。因此可以说，希格斯机制为物质世界的形成奠定了质量基础。基本粒子有了质量才能产生引力，才会形成宇宙和生命。在过去几十年中，寻找希格斯粒子是许多大型高能粒子物理实验的最重要目标。

### 3、什么是希格斯场和希格斯机制？

简单来说，希格斯场是一种不可见的、遍及整个宇宙的能量场；希格斯机制是基本粒子的质量产生机制。在希格斯机制中，希格斯场引起弱电规范对称性的自发破缺，将质量赋予传递弱相互作用的规范玻色子以及费米子。希格斯粒子是希格斯场的量子激发，它通过自相互作用而获得质量。

根据粒子物理标准模型和宇宙大爆炸理论，宇宙起源于一次大爆炸，无数的正反粒子同时产生，轻子和夸克通过与希格斯场的相互作用获得了质量。这些粒子构成物质，通过长时间的演化形成了星系，最终形成今天的物质世界。


用漫画来解释希格斯机制。作者：David J. Miller

1993年，英国科技大臣曾向科学家们发出挑战，让他们用一页纸的篇幅向他解释清楚希格斯机制。他共收到117份作品，其中英国伦敦大学学院的物理学家戴维·米勒（David J. Miller）的解释被评为最优。米勒把希格斯场比作在一个均匀分散着的一大群政客的房间，把一个没有质量的基本粒子比作前英国首相撒切尔夫人（Margaret Hilda Thatcher）。普通人可以任意穿过房间，就像光子一样。但是撒切尔夫人的到场，一定会吸引大量的关注：人们会围拢在她周围，减慢她穿行的速度，使她获得“质量”。这个类比形象地说明了没有质量的基本粒子是如何通过与希格斯场的相互作用而获得质量的。

### 4、希格斯粒子为什么如此难以捕获？

希格斯粒子作为质量之源，在137亿年前的宇宙大爆炸初始就已经完成了它的使命。现在，物理学家要再次捕获希格斯粒子的踪迹，就只有建造高能对撞机，通过高能粒子的对撞，来模拟宇宙起源的时刻，“复活”希格斯粒子。

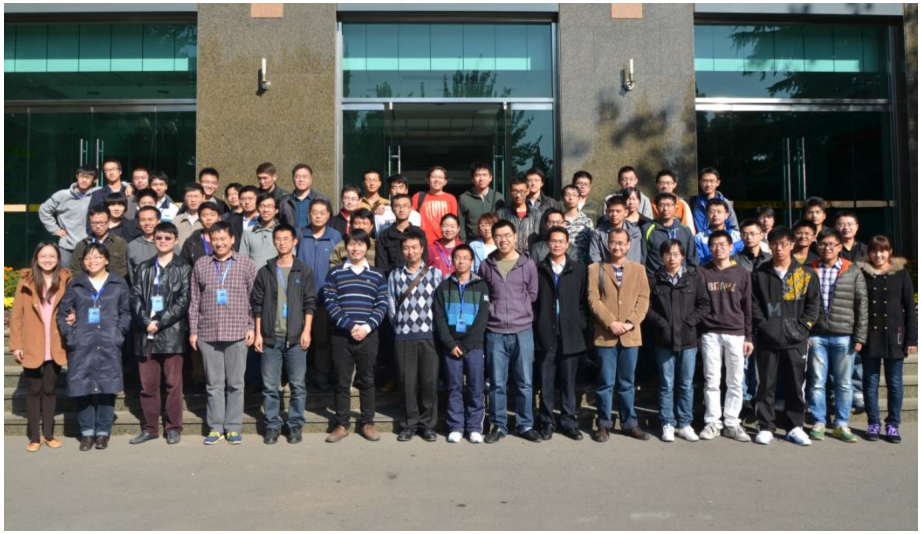
# Status and Progress

## TRAINING & PROFESSIONAL DEVELOPMENT

# Training and Professional development for CEPC

**We need more professionals to undertake the CEPC-SppC project to good completion**

- Training young people to address manpower shortage



- Professional development for current staff and faculty
- Recruitment: postdocs and staff at IHEP
- Increase size of HEP graduate students (quality, too)
- ……

## Training

August 2014

11 Aug - 15 Aug Detector Simulation and Geometry editing

October 2013

19 Oct - 20 Oct CEPC Training: Physics Analysis, Detector Optimization and Software tools

International Summer school on TeV Experimental Physics (iSTEP)

20-29 August 2014
IHEP
Asia/Shanghai timezone

Overview

# CEPC Study Group
# Pre. R&D and funding requests

1. **IHEP internal investment ~10M RMB**

   organize teams, initialize preliminary R&D

2. **Seek funding from Chinese Ministry of Sci. & Tech.**

   kick-off R&D

3. **Seek Chinese 13$^{th}$ 5 year plan approval for R&D and validation**

   CDR, TDR and preparation for construction

# CEPC Study Group
# CDR and IAC

In May 2015, the CEPC Study Group decided to begin the CDR process, with a preliminary target date of completion: end of 2016

An International Advisory Committee has been formed to advise the CEPC SG on int'l collaboration, organizational structures, governance, Science & Technology issues, etc.

# CEPC Study Group
# Project evaluation

- The Ministry of Science and Technology (MOST) has been asked to lead the evaluation of the CEPC-SppC project, with several other central government agencies joining in the process
- In May MOST held a discussion session on CEPC-SppC
- We anticipate more actions by MOST, including possibly a formal project evaluation, later this year

# SUMMARY

- Tremendous efforts have been made, real progress in all fronts on the CEPC-SppC study
- preCDR volumes have been reviewed and finalized; no technological show stoppers
- CEPC-SppC study group will make the case to the government
- Much work ahead: funding requests, project evaluation, CDR, ...;
- More internationalization expected for CEPC