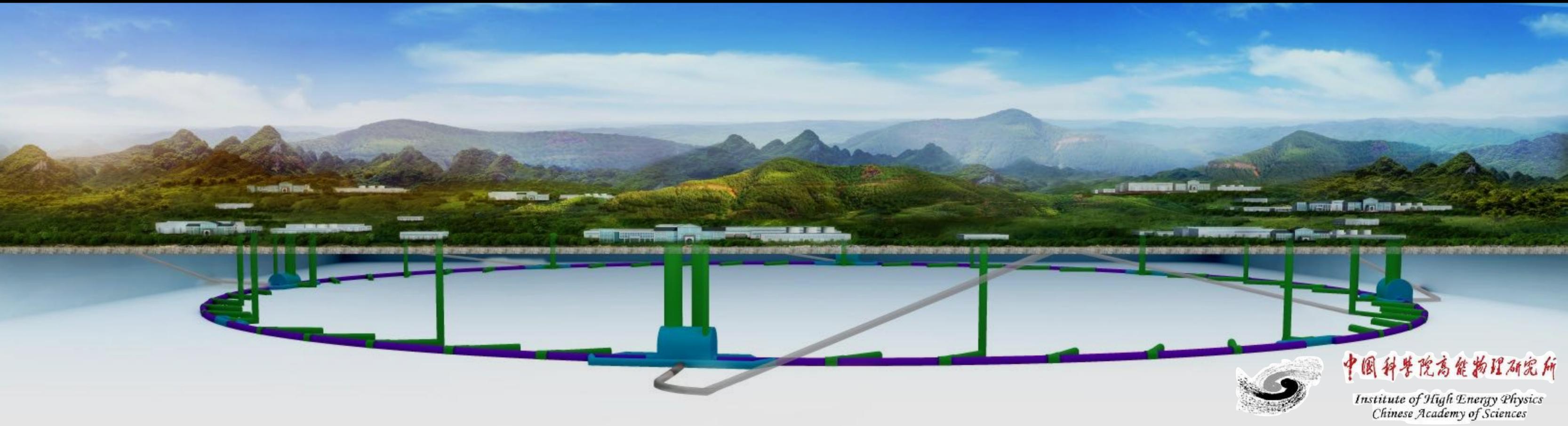


# Overview of CEPC Physics and Detector CDR

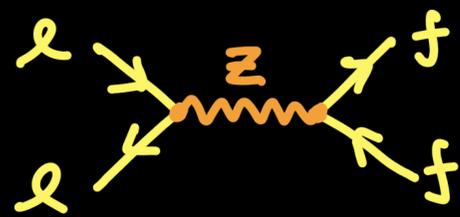


**João Guimarães da Costa**  
(IHEP, Chinese Academy of Sciences)

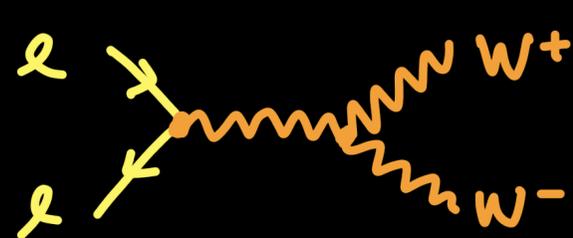
**CEPC Physics and Detector CDR International Review – Beijing**  
**13 September 2018**

# The CEPC Program

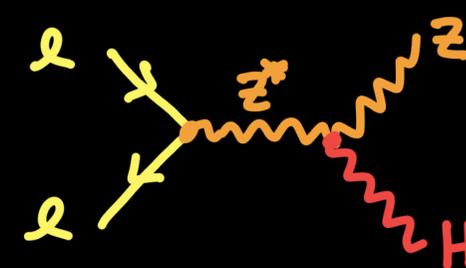
100 km  $e^+e^-$  collider



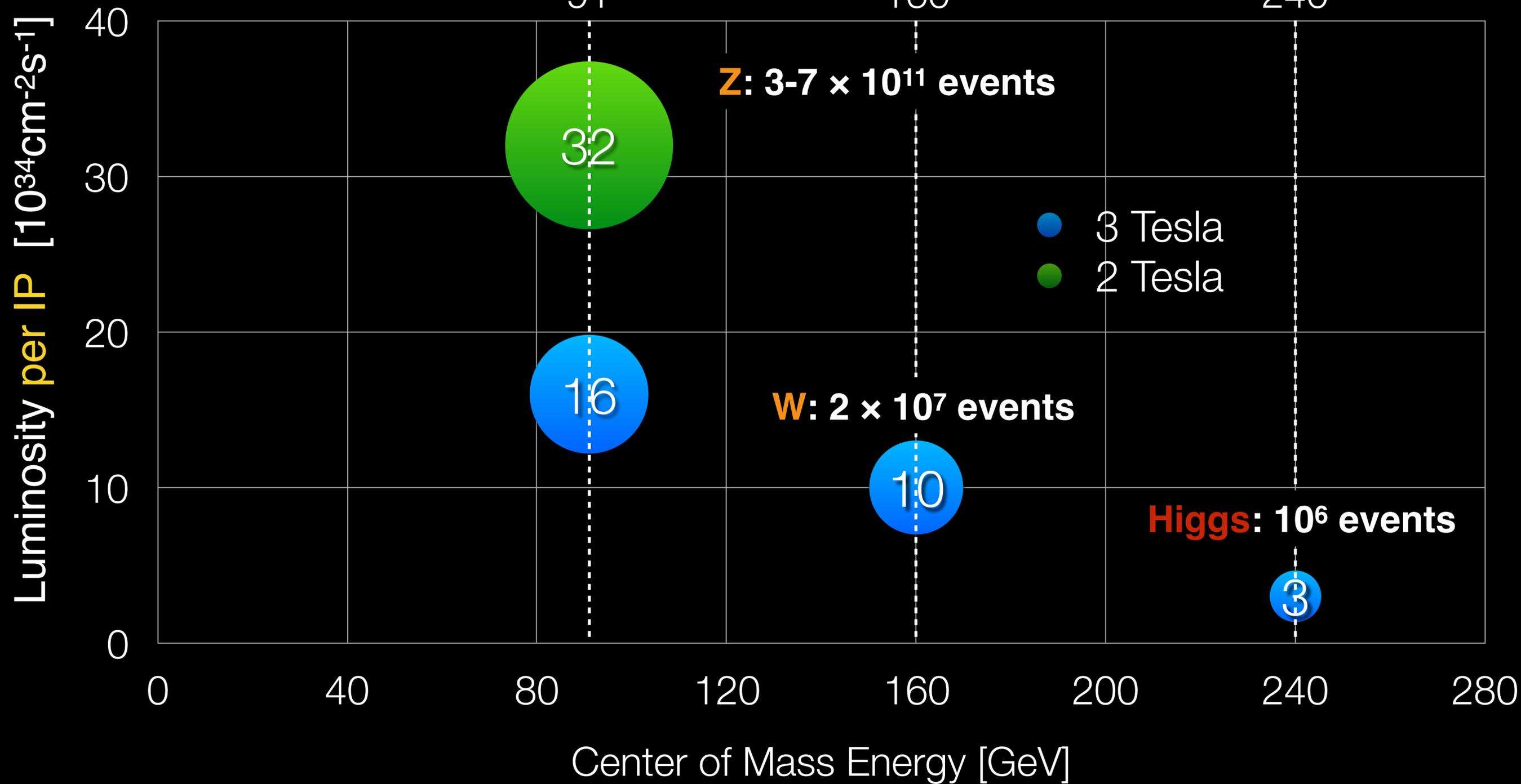
Z Mass  
91



WW threshold  
160



Higgs  
240



# Main Parameters of Collider Ring

	Higgs	W	Z (3T)	Z (2T)
Center-of-mass energy (GeV)	240	160	91	
Number of IPs	2			
Luminosity/IP ( $10^{34} \text{ cm}^{-2}\text{s}^{-1}$ )	3	10	16	32
Number of years	7	1	2	
Total Integrated Luminosity ( $\text{ab}^{-1}$ ) - 2 IP	5.6	2.6	8	16
Total number of particles	$1 \times 10^6$	$2 \times 10^7$	$3 \times 10^{11}$	$7 \times 10^{11}$

# Current CEPC Organization

Since Sept.  
2013



## Institutional Board

YN GAO  
J. GAO

## Steering Committee

Y.F. WANG (IHEP),....

## Project Director

XC LOU  
Q. QIN  
N. XU

## Theory

HJ HE(TH)  
JP MA(ITP)  
XG HE(SJTU)

## Accelerator

J. GAO (IHEP)  
CY Long (IHEP)  
SN FU (IHEP)

## Detector

Joao Costa (IHEP)  
S. JIN (NJU)  
YN GAO (TH)

## International Advisory Committee

Young-Kee Kim, U. Chicago (Chair)  
Barry Barish, Caltech  
Hesheng Chen, IHEP  
Michael Davier, LAL  
Brian Foster, Oxford  
Rohini Godbole, CHEP, Indian Institute of Science  
David Gross, UC Santa Barbara  
George Hou, Taiwan U.  
Peter Jenni, CERN  
Eugene Levichev, BINP  
Lucie Linssen, CERN  
Joe Lykken, Fermilab  
Luciano Maiani, Sapienza University of Rome  
Michelangelo Mangano, CERN  
Hitoshi Murayama, UC Berkeley/IPMU  
Katsunobu Oide, KEK  
Robert Palmer, BNL  
John Seeman, SLAC  
Ian Shipsey, Oxford  
Steinar Stapnes, CERN  
Geoffrey Taylor, U. Melbourne  
Henry Tye, IAS, HKUST  
Yifang Wang, IHEP  
Harry Weerts, ANL



# Organization of the **Physics and Detector** Working Group

## Conveners

Joao Barreiro Guimaraes Costa (IHEP)  
Yuanning Gao (Tsinghua Univ.)  
Shan Jin (Nanjing Univ.)

### Machine Detector Interface

Hongbo Zhu  
Sha Bai

### Vertex

Ouyang Qun  
Sun Xiangming  
Wang Meng

### Tracker

Qi Huirong  
Yulan Li

### Calorimeter

ECal

Hu Tao

HCal

Liu Jianbei  
Yang Haijun

Muons

Li Liang  
Zhu Chengguang

### Physics analysis and detector optimization

Ruan Manqi  
Li Gang  
Li Qiang  
Fang Yaquan

IHEP-CEPC-DR-2015-01

IHEP-EP-2015-01

IHEP-TH-2015-01

IHEP-CEPC-DR-2015-01

IHEP-AC-2015-01

**Can be downloaded from**

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

# CEPC-SPPC

*Preliminary Conceptual Design Report*

Volume I - Physics & Detector

**403 pages, 480 authors**

The CEPC-SPPC Study Group

2017-1-24

March 2015

# CEPC-SPPC

*Preliminary Conceptual Design Report*

Volume II - Accelerator

**328 pages, 300 authors**

The CEPC-SPPC Study Group

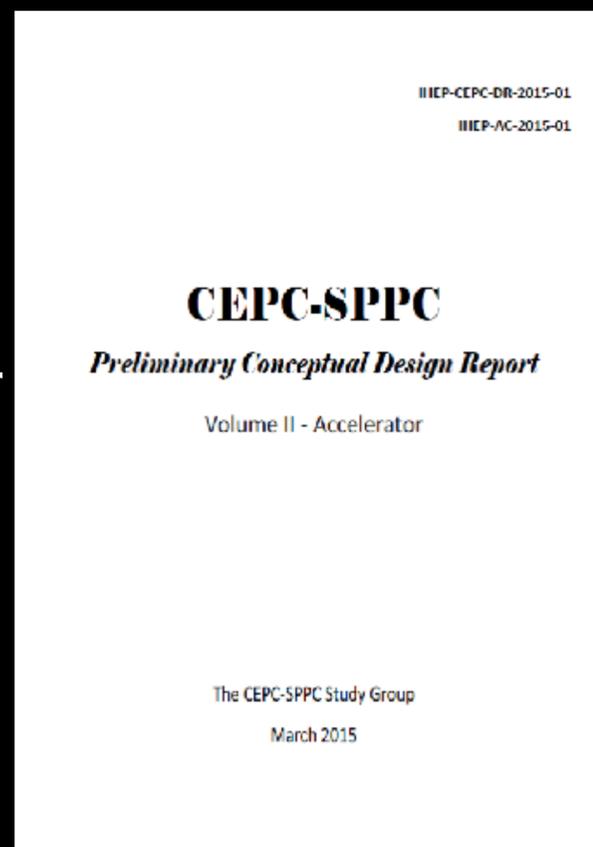
March 2015

# CEPC CDR – Volume I: Accelerator **Completed**

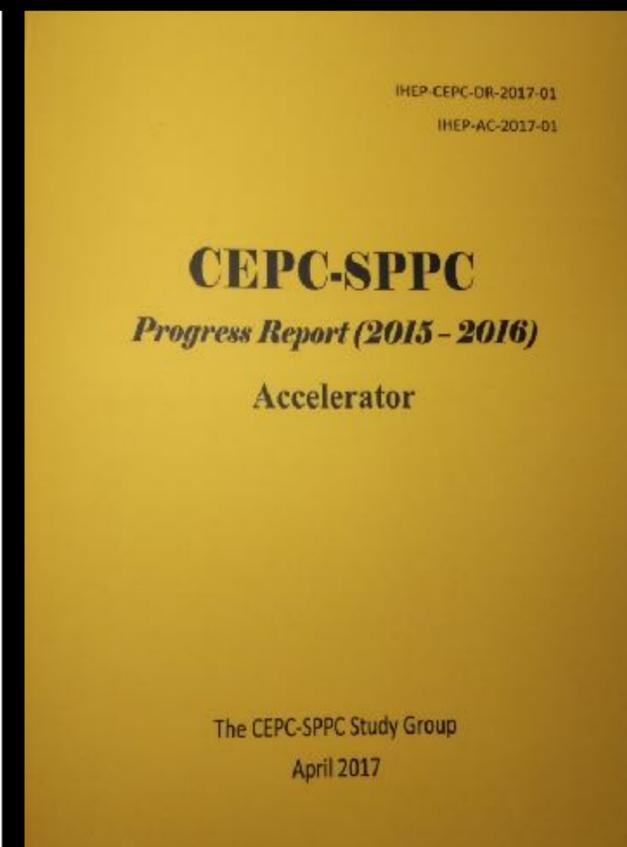
CEPC accelerator CDR **completed** in June 2018 (printed on **Sept. 2018**)

→ Executive Summary

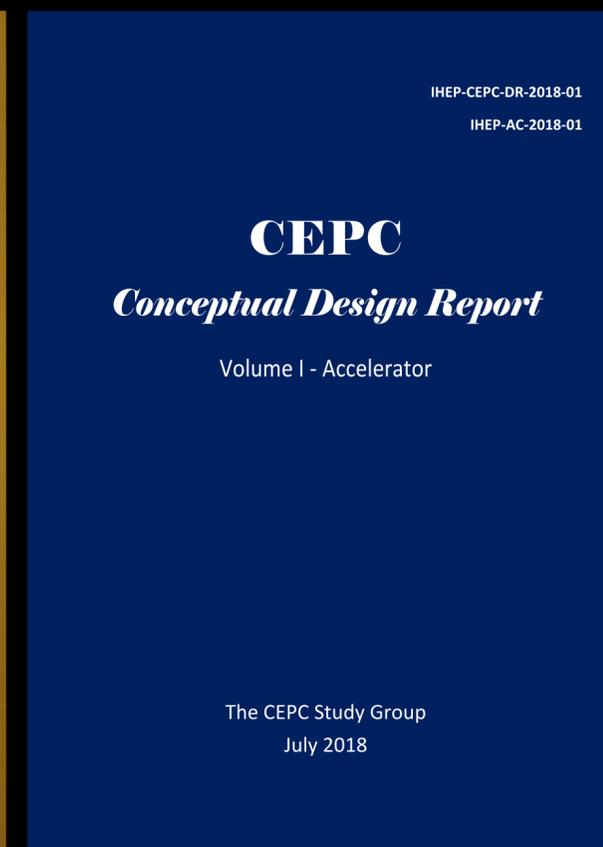
1. Introduction
  2. **Machine Layout and Performance**
  3. **Operation Scenarios**
  4. CEPC Booster
  5. CEPC Linac
  6. Systems Common to the CEPC Linac, Booster and Collider
  7. Super Proton Proton Collider
  8. **Conventional Facilities**
  9. Environment, Health and Safety
  10. R&D Program
  11. **Project Plan, Cost and Schedule**
- Appendix 1: CEPC Parameter List  
Appendix 2: CEPC Technical Component List  
Appendix 3: CEPC Electric Power Requirement  
Appendix 4: Operation for High Intensity  $\gamma$ -ray Source  
Appendix 5: Advanced Partial Double Ring  
Appendix 6: CEPC Injector Based on Plasma Wakefield Accelerator  
Appendix 7: Operation for e-p, e-A and Heavy Ion Collision  
**Appendix 8: Opportunities for Polarization in the CEPC**  
Appendix 9: International Review Report



**March 2015**



**April 2017**



**July 2018**

**CDR International Review June 28-30, 2018**

**Final CDR released on Sept. 2**

**arXiv:1809.00285**

# Mini-Review of Preliminary CDR

<https://indico.ihep.ac.cn/event/7384/>

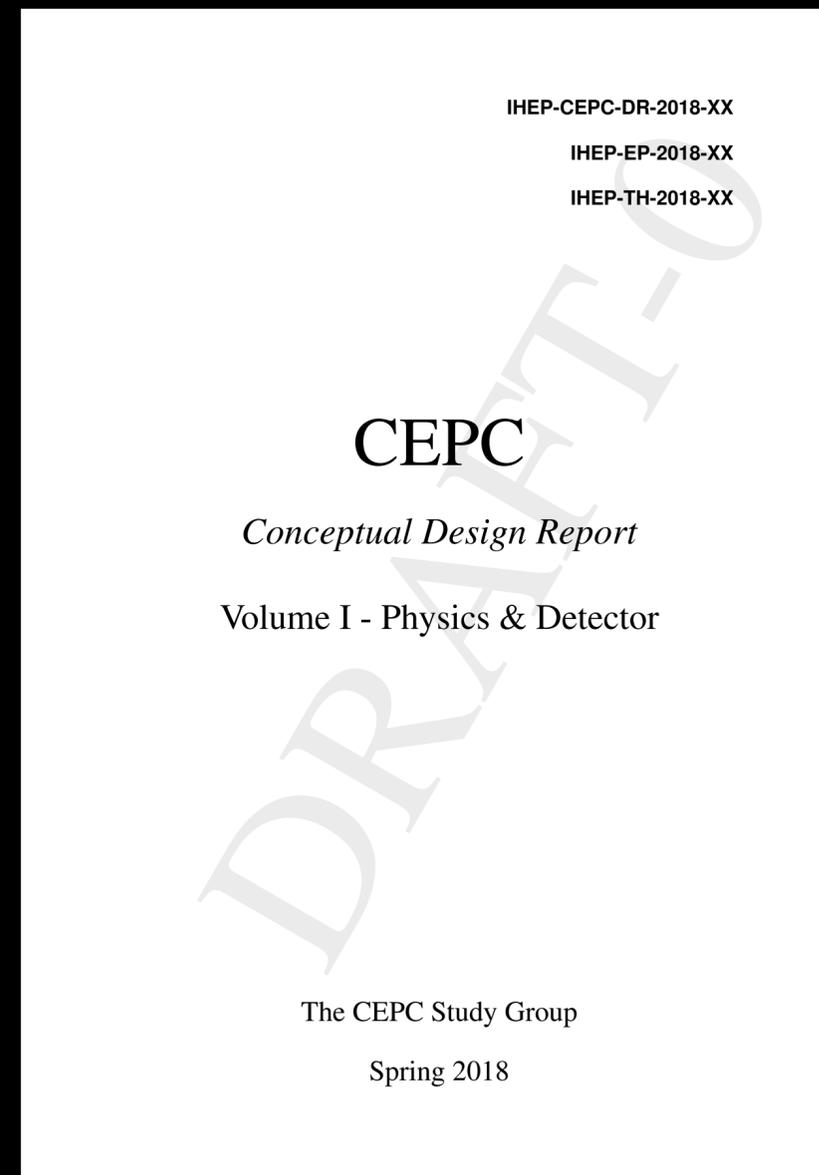
10-11 November, 2017

## Reviewers:

Alexandre Glazov (DESY),  
Charlie Young (SLAC),  
Sebastian Grinstein (Barcelona),  
Alberto Belloni (Maryland),  
Jianming Qian (Michigan),  
Walter Snoeys (CERN),  
Daniela Bortoletto (Oxford),  
Franco Grancagnolo (INFN)

### ○ Draft-0 preliminary chapters

- \* Chapter 3: Detector concepts (partial)
- \* Chapter 4: Vertex detector
- \* Chapter 5: Tracking system (TPC, silicon tracker, silicon-only concept, drift chamber)
- \* Chapter 6: Calorimeter (PFA and DR calorimeter options)
- \* Chapter 7: Magnet system
- \* Chapter 8: Muon system
- \* Chapter 10: MDI, beam background and luminosity measurement
- \* Chapter 11: Physics performance (partial)



Minutes and comments: <https://indico.ihep.ac.cn/event/7384/material/slides/1.pdf>

# Editors of CDR

## Liantao with many friends

### General Editors

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Joao Guimaraes da Costa,<sup>1</sup> [guimaraes@ihep.ac.cn](mailto:guimaraes@ihep.ac.cn),  
Yuanning Gao,<sup>2</sup> [gaoyin@mail.tsinghua.edu.cn](mailto:gaoyin@mail.tsinghua.edu.cn),  
Shan Jin,<sup>3</sup> [jins@ihep.ac.cn](mailto:jins@ihep.ac.cn)

### Chapter 1 Executive Summary

Joao Guimaraes da Costa,<sup>1</sup> [guimaraes@ihep.ac.cn](mailto:guimaraes@ihep.ac.cn)

### Chapter 2 Overview of the Physics Case for CEPC

Liantao Wang,<sup>11</sup> [liantaow@uchicago.edu](mailto:liantaow@uchicago.edu)

### Chapter 3 Experimental conditions, Physics requirements and Detector concepts

Joao Guimaraes da Costa,<sup>1</sup> [guimaraes@ihep.ac.cn](mailto:guimaraes@ihep.ac.cn),  
Manqi Ruan,<sup>1</sup> [ruanmq@ihep.ac.cn](mailto:ruanmq@ihep.ac.cn),  
Hongbo Zhu,<sup>1</sup> [ruanmq@ihep.ac.cn](mailto:ruanmq@ihep.ac.cn)

### Chapter 4 Tracking System

#### 4.1 Vertex tracker detector

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Yulan Li,<sup>2</sup> [qih@ihep.ac.cn](mailto:qih@ihep.ac.cn),  
Zhi Deng,<sup>2</sup> [dengz@mail.tsinghua.edu.cn](mailto:dengz@mail.tsinghua.edu.cn),

#### 4.2.2 Silicon Tracker

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#### 4.3 Full Silicon Tracker

Weimin Yao,<sup>12</sup> [dengz@mail.tsinghua.edu.cn](mailto:dengz@mail.tsinghua.edu.cn),  
Chengdong Fu,<sup>1</sup> [fucd@ihep.ac.cn](mailto:fucd@ihep.ac.cn),

#### 4.4 Drift Chamber

Franco Grancagnolo,<sup>14</sup> [franco.grancagnolo@le.infn.it](mailto:franco.grancagnolo@le.infn.it)

### Chapter 5 Calorimetry

#### 5.3 ECAL

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Tao Hu,<sup>1</sup> [hut@ihep.ac.cn](mailto:hut@ihep.ac.cn),

#### 5.4 HCAL

Haijun Yang,<sup>6,7</sup> [haijun.yang@sjtu.edu.cn](mailto:haijun.yang@sjtu.edu.cn),

#### 5.5 Dual-readout

Roberto Ferrari,<sup>15</sup> [roberto.ferrari@cern.ch](mailto:roberto.ferrari@cern.ch),  
Franco Bedeschi,<sup>16</sup> [bed@fnal.gov](mailto:bed@fnal.gov)

### Chapter 6 Magnet

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Xuyang Liu,<sup>1</sup> [liuxuyang@ihep.ac.cn](mailto:liuxuyang@ihep.ac.cn),

### Chapter 7 Muon System

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Paolo Giacomelli,<sup>17</sup> [paolo.giacomelli@cern.ch](mailto:paolo.giacomelli@cern.ch)

### Chapter 8 DAQ

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Fei Li,<sup>1</sup> [lifei@ihep.ac.cn](mailto:lifei@ihep.ac.cn)

### Chapter 9 MDI

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Suen Hou,<sup>18</sup> [suen@sinica.edu.tw](mailto:suen@sinica.edu.tw),  
Ivanka Bozovic-Jelisavcic,<sup>18</sup> [ibozovic@vinca.rs](mailto:ibozovic@vinca.rs)

### Chapter 10 and 11 Detector Optimization and Physics Analysis

Manqi Ruan,<sup>1</sup> [ruanmq@ihep.ac.cn](mailto:ruanmq@ihep.ac.cn),  
Yaquan Fang,<sup>1</sup> [fangyq@ihep.ac.cn](mailto:fangyq@ihep.ac.cn),  
Gang Li,<sup>1</sup> [li.gang@mail.ihep.ac.cn](mailto:li.gang@mail.ihep.ac.cn),  
Qiang Li,<sup>8</sup> [qliphy@gmail.com](mailto:qliphy@gmail.com),  
Zhijun Liang,<sup>1</sup> [zhijun.liang@cern.ch](mailto:zhijun.liang@cern.ch),  
Jianming Qian,<sup>13</sup> [qianj@umich.edu](mailto:qianj@umich.edu)

### Chapter 12

Xin Shi,<sup>1</sup> [shixin@ihep.ac.cn](mailto:shixin@ihep.ac.cn),  
Joao Guimaraes da Costa,<sup>1</sup> [guimaraes@ihep.ac.cn](mailto:guimaraes@ihep.ac.cn)

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2. Department of Engineering Physics Department, Tsinghua University, Beijing, China
3. Department of Physics, Nanjing University, Nanjing, China
4. Institute of Frontier and Interdisciplinary Science and Key Laboratory of Particle Physics and Particle Irradiation, Shandong University, Qingdao, China
5. University of Science and Technology of China, Hefei, China
6. Department of Physics and Astronomy, Shanghai Jiao Tong University, Shanghai, China
7. Tsung-Dao Lee Institute, Shanghai, China
8. Department of Physics, Peking University, Beijing, China
9. SLAC National Accelerator Laboratory, USA
10. Princeton University, USA
11. Department of Physics, University of Chicago, USA
12. Lawrence Berkeley National Lab(LBNL), USA
13. Department of Physics, University of Michigan
14. INFN - Sezione di Lecce and University of Lecce
15. INFN - Sezione di Pavia and University of Pavia
16. INFN - Sezione di Pisa, Universita' di Pisa and Scuola Normale Superiore
17. INFN - Sezione di Bologna and University of Bologna
18. Vinca Institute of Nuclear Sciences, University of Belgrade
19. Institute of Physics, Academia Sinica, Taiwan

# The Physics Goals

# CEPC Accelerator Chain and Systems

10 GeV

Injector

$e^-$

$e^+$

Booster  
100 km

Energy ramp

10 GeV

45/80/120 GeV

Collider  
Ring  
100 km

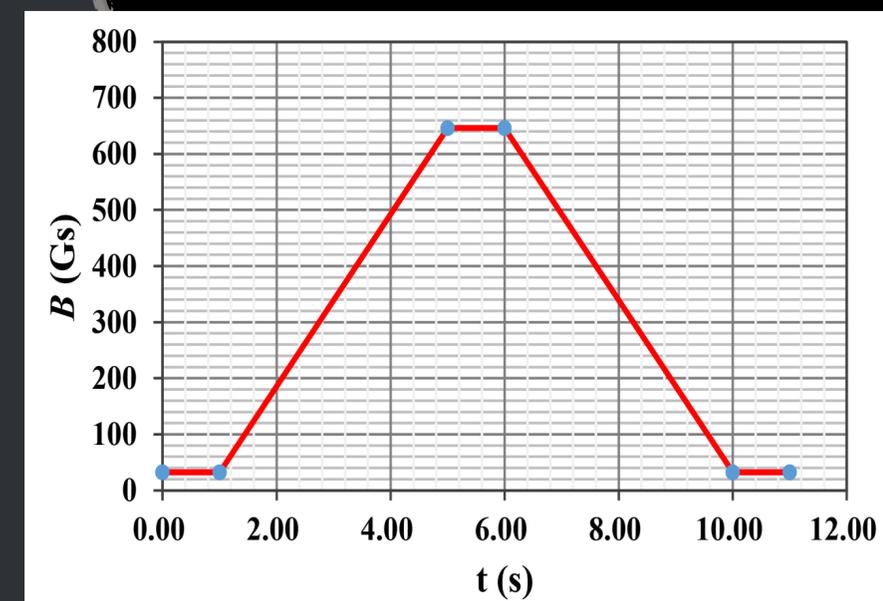
$\sqrt{s} = 90, 160 \text{ or } 240 \text{ GeV}$   
2 interaction points

45/80/120 GeV beams

Three machines in  
one single tunnel

- Booster and CEPC
- SPPC

Booster Cycle (0.1 Hz)



The key systems of CEPC:

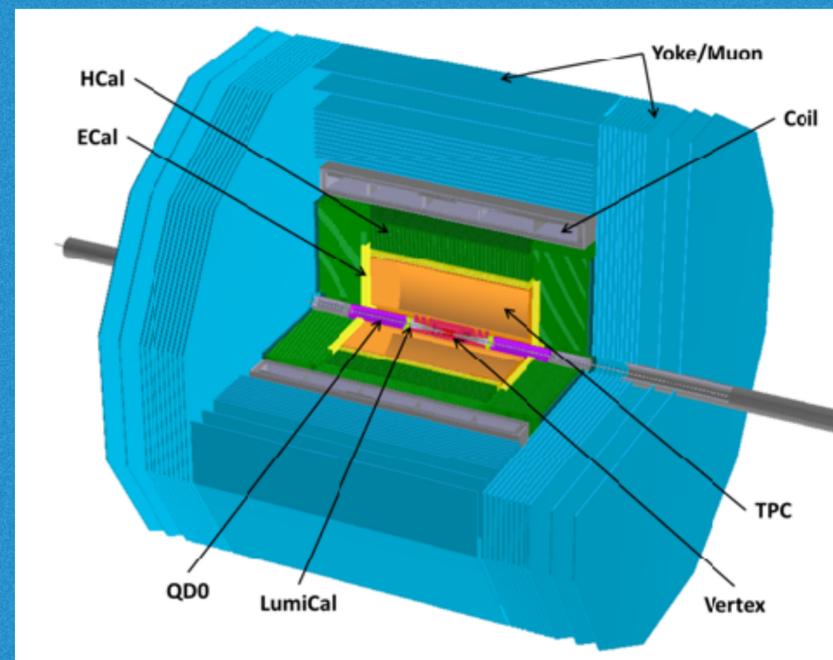
- 1) Linac Injector
- 2) Booster
- 3) Collider ring
- 4) Machine Detector Interface
- 5) Civil Engineering

Accelerator CDR provides  
details of all systems

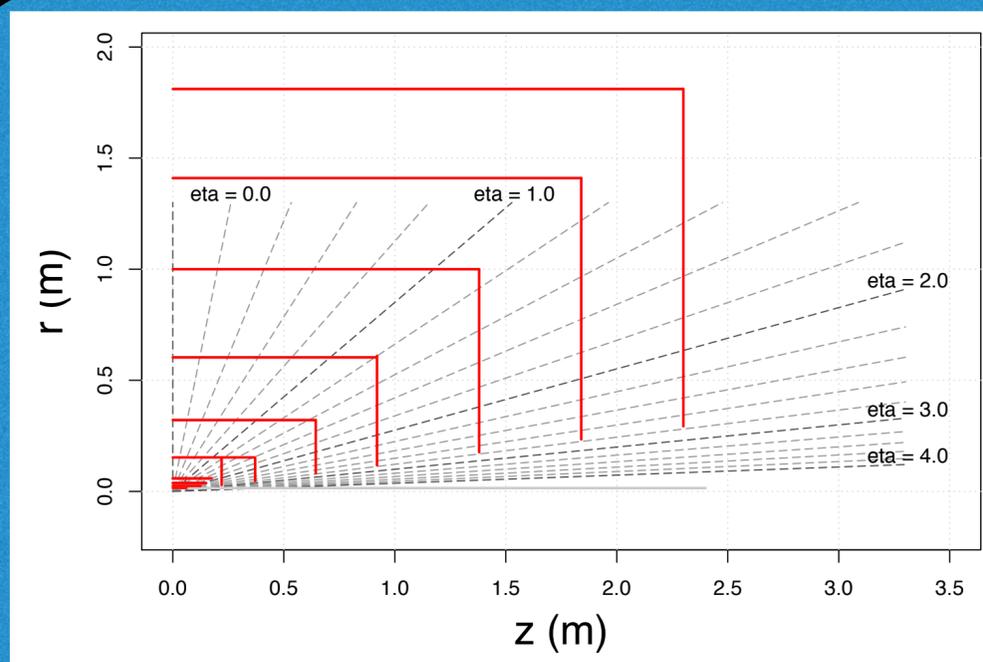
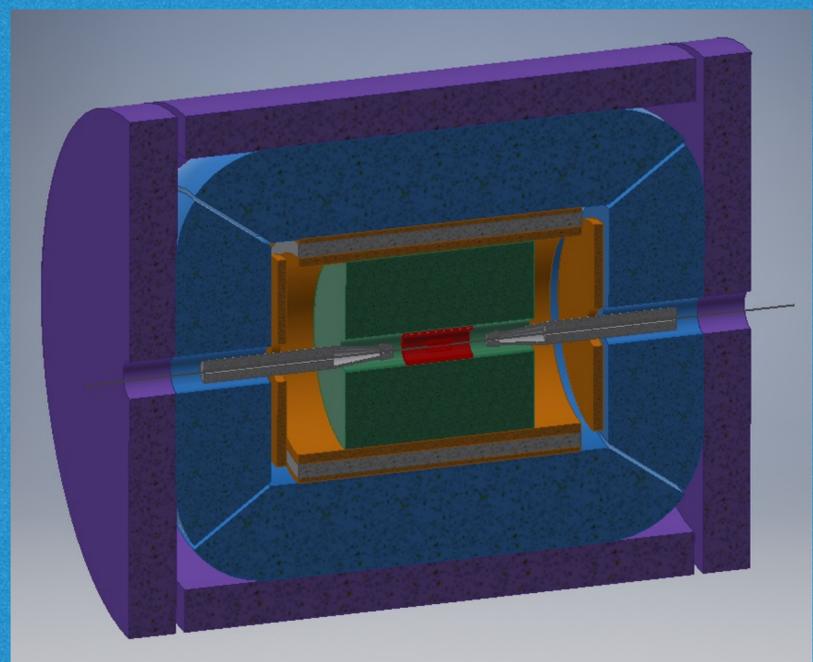
# Detector Conceptual Designs

CEPC plans for  
2 interaction points

Baseline detector (3 Tesla)  
ILD-like  
(similar to pre-CDR)



Low  
magnetic field  
concept  
(2 Tesla)



Full silicon  
tracker  
concept

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

# Committee Charge

**The International Review Committee of the CEPC Physics and Detector Conceptual Design Report (CDR) is to consider the physics program goals of the CEPC and the detector concepts presented.**

**The committee is asked to assess if the CEPC physics program is well motivated and aligned with the worldwide program for the future of High Energy Physics, and if the detector concepts presented in the CDR, as a whole, are adequate to carry out the physics program, and if there is a sufficient understanding of the detector subsystems to start working towards the TDR and produce detectors on the CEPC timescale. The Committee is requested to suggest mitigating measures in case of potential technological concerns on specific detector subsystems.**

**With regard to the site and cost no specific comments are solicited at this time.**

**The committee is invited to issue comments or suggestions on any aspect of this CDR draft beyond those specifically included in this charge.**

**It is requested that a committee report responsive to this charge be forwarded to the IHEP Director by September 27, 2018.**

# CEPC meetings and international impact

Many international events have been hosted to discuss CEPC physics and carry out collaboration on key-technology research

## INTERNATIONAL WORKSHOP ON HIGH ENERGY CIRCULAR ELECTRON POSITRON COLLIDER

November 6-8, 2017  
IHEP, Beijing

<http://indico.ihep.ac.cn/event/6618>

### International Advisory Committee

Young-Kee Kim, U. Chicago (Chair)  
Barry Barish, Caltech  
Hesheng Chen, IHEP  
Michael Davier, LAL  
Brian Foster, Oxford  
Rohini Godbole, CHEP, Indian Institute of Science  
David Gross, UC Santa Barbara  
George Hou, Taiwan U.  
Peter Jenni, CERN  
Eugene Levichev, BINP  
Lucie Linssen, CERN  
Joe Lykken, Fermilab  
Luciano Maiani, Sapienza University of Rome  
Michelangelo Mangano, CERN  
Hitoshi Murayama, UC Berkeley/IPMU  
Katsunobu Oide, KEK  
Robert Palmer, BNL  
John Seeman, SLAC  
Ian Shipsey, Oxford  
Steinar Stapnes, CERN  
Geoffrey Taylor, U. Melbourne  
Henry Tya, IAS, HKUST

### Local Organizing Committee

Xinchou Lou, IHEP (Chair)  
Qinghong Cao, PKU  
Joao Guimaraes Costa, IHEP  
Jie Gao, IHEP  
Yuanning Gao, THU  
Hongjian He, THU  
Shan Jin, IHEP  
Gang Li, IHEP  
Jianbei Liu, USTC  
Yajun Mao, PKU  
Qing Qin, IHEP  
Manqi Ruan, IHEP  
Meng Wang, SDU  
Nu Xu, CCNU  
Haijun Yang, SJTU  
Hongbo Zhu, IHEP

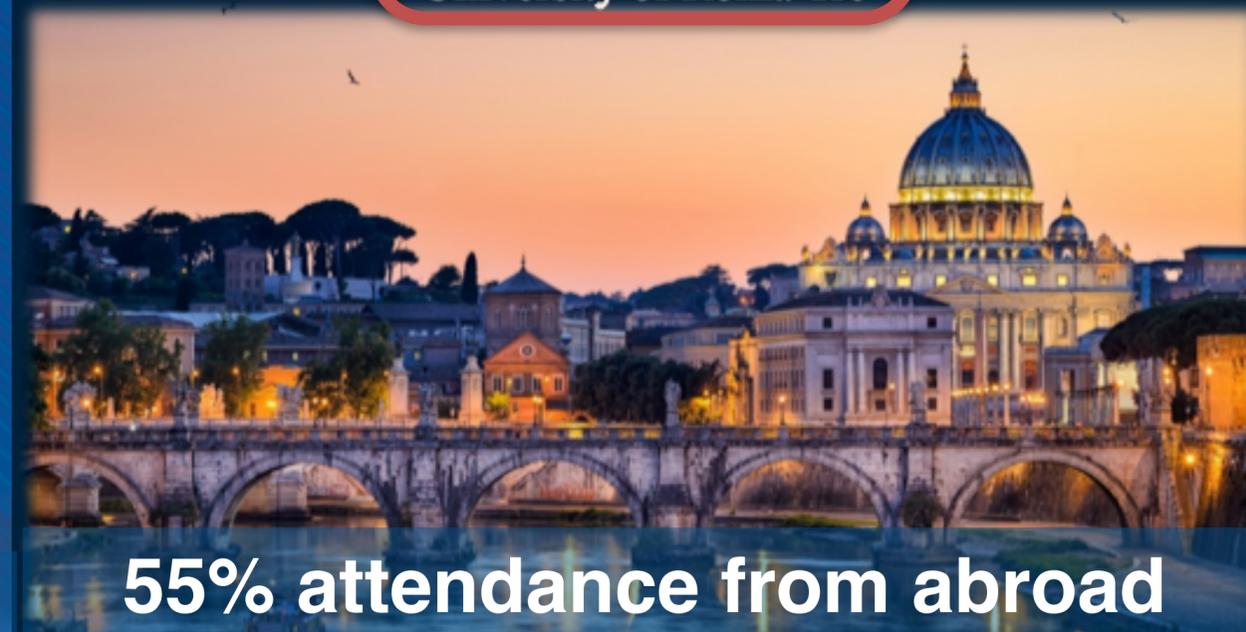
260 attendees  
30% from foreign institutions



## Workshop on the Circular Electron-Positron Collider

EU Edition

Roma, May 24-26 2018  
University of Roma Tre



55% attendance from abroad

<https://agenda.infn.it/conferenceDisplay.py?ovw=True&confId=14816>

### Scientific Committee

Franco Bedeschi - INFN, Italy  
Alain Blondel - Geneva Univ., Switzerland  
Daniela Bortoletto - Oxford Univ., UK  
Manuela Boscolo - INFN, Italy  
Biagio Di Micco - Roma Tre Univ. & INFN, Italy  
Yunlong Chi - IHEP, China  
Marcel Demarteau - ANL, USA  
Yuanning Gao - Tsinghua Univ., China  
Joao Guimaraes da Costa - IHEP, China  
Gao Jie - IHEP, China  
Gang Li - IHEP, China  
Jianbei Liu - USTC, China  
Xinchou Lou - IHEP, China  
Felix Sefkow - DESY, Germany  
Shan Jin - Nanjing Univ., China  
Marcel Vos - CSIC, Spain

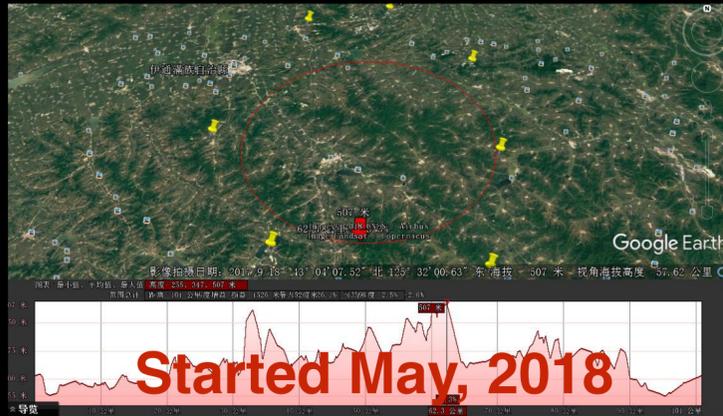
### Local Organizing Committee

Antonio Baroncelli - INFN, Italy  
Biagio Di Micco - Roma Tre Univ. & INFN, Italy  
Ada Farilla - INFN, Italy  
Francesca Paolucci - Roma Tre Univ. & INFN, Italy  
Domizia Orestano - Roma Tre Univ. & INFN, Italy  
Marco Sessa - Roma Tre Univ. & INFN, Italy  
Monica Verducci - Roma Tre Univ. & INFN, Italy



# Site selection

**Chuangchun, Jilin**  
吉林长春



**Huangling, Shanxi**  
陕西黄陵



**Shenshan, Guangdong**  
深汕合作区



**Qinhuangdao, Hebei**  
河北秦皇岛



**Xiong an, Hebei**  
河北雄安



**Huzhou, Zhejiang**  
浙江湖州



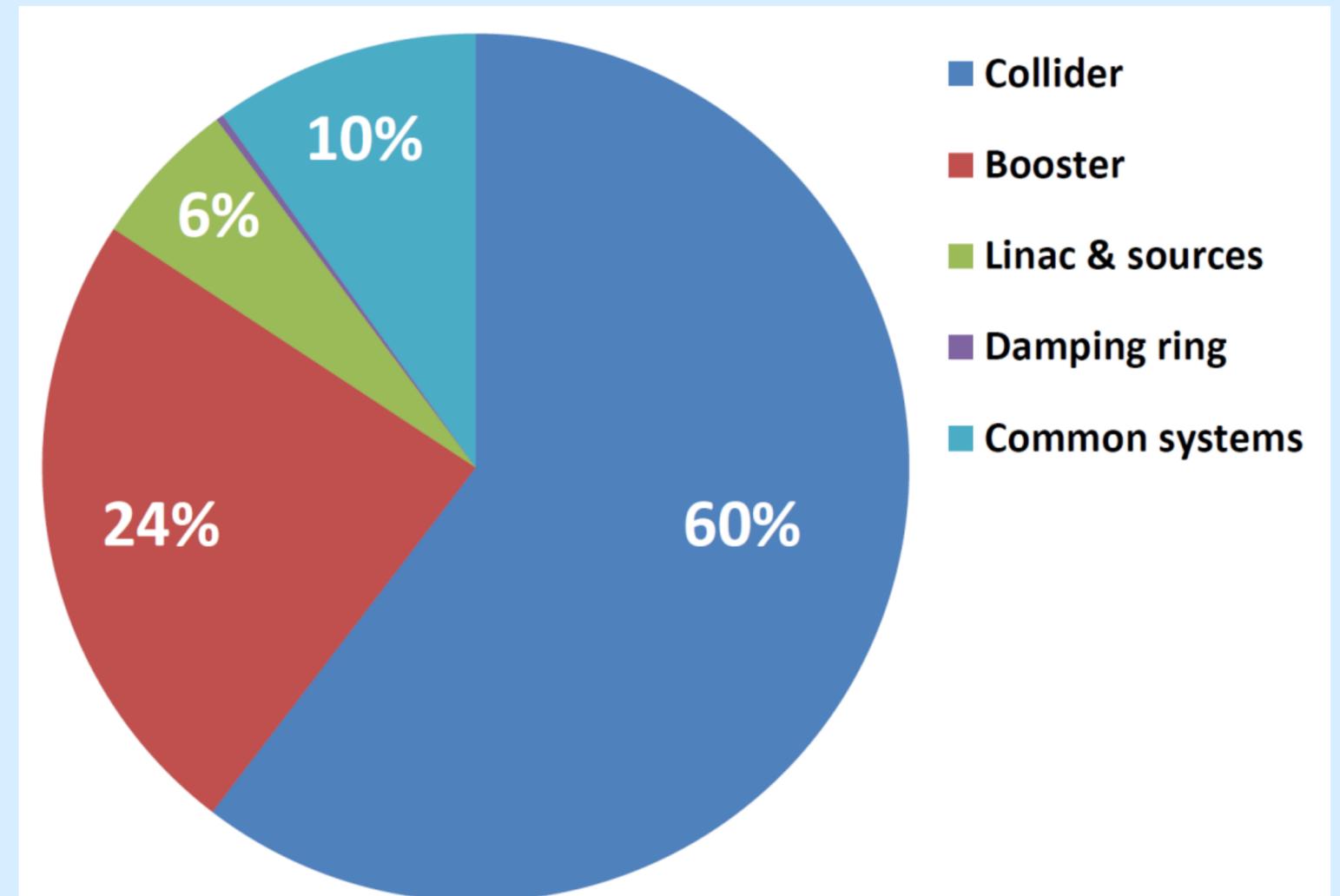
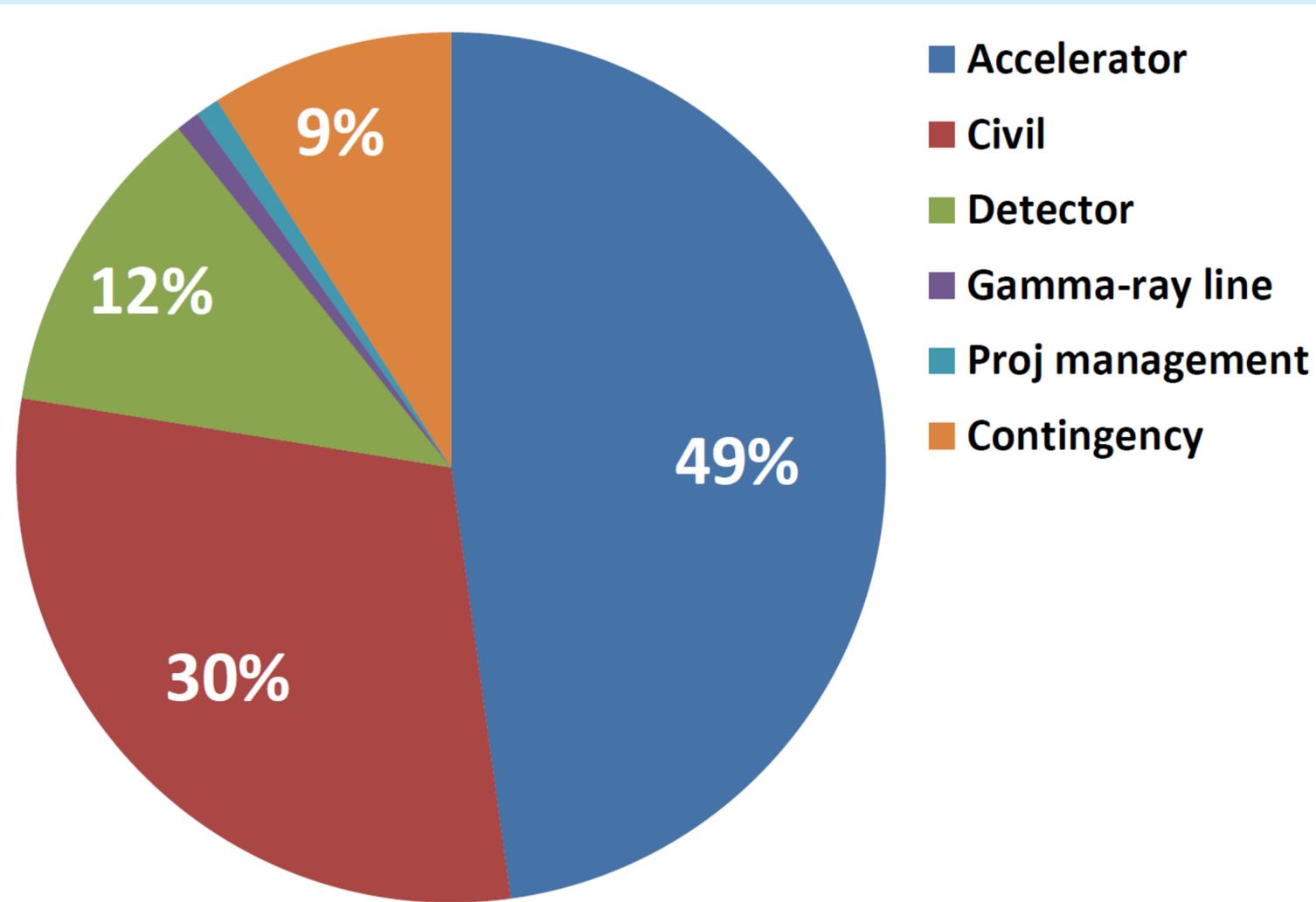
**Considerations:**

1. Available land
2. Geological conditions
3. Good social, environment, transportation and cultural conditions
4. Fit local development plan: mid-size city → + science city

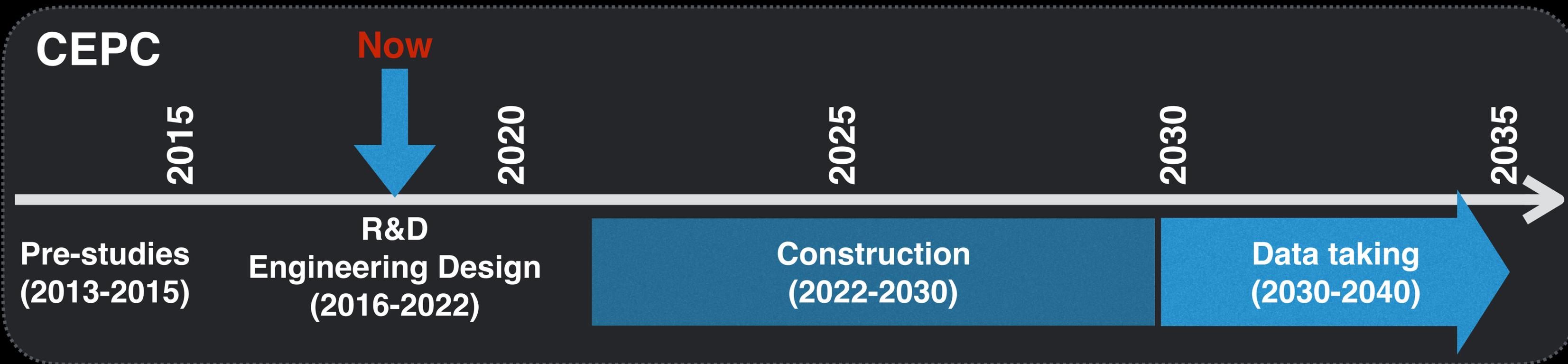
# Cost of project

**Cost of detectors not evaluated in detail and not part of the Conceptual Design Report**  
Careful costing estimates will be done moving forward towards the TDR

## General evaluation of the relative cost of the project provided in the accelerator CDR



# CEPC “optimistic” Schedule



- Design issues
- R&D items
- preCDR

- Design, funding
- R&D program
- Intl. collaboration
- Site study

- Seek approval, site decision
- Construction during 14<sup>th</sup> 5-year plan
- Commissioning

- **CEPC data-taking starts before the LHC program ends**
- **Possibly concurrent with the ILC program**

# CEPC Funding in recent years

**IHEP seed money**  
**11 M CNY/3 year (2015-2017)**

## R&D Funding - NSFC

Increasing support for CEPC D+RD by 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
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
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
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
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
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
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
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
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
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
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

## Ministry of Sciences and Technology

**2016: 36 M CNY**

国家重点研发计划  
项目申请书

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研究

所属专项: 大科学装置前沿研究

指南方向: 高能环形正负电子对撞机预先研究

专业机构: 科学技术部高技术研究发展中心

推荐单位: 教育部

申报单位: 清华大学 (公章)

项目负责人: 高原宁

中华人民共和国科学技术部  
 2016年05月06日

**2018: ~31 M CNY**

国家重点研发计划  
项目申请书

项目名称: 高能环形正负电子对撞机关键技术研发和验证

所属专项: 大科学装置前沿研究

指南方向: 3.1 高能环形正负电子对撞机关键技术验证

专业机构: 科学技术部高技术研究发展中心

推荐单位: 中国科学院

申报单位: 中国科学院高能物理研究所 (公章)

项目负责人: Joao Guimaraes da Costa

中华人民共和国科学技术部  
 2018年02月26日

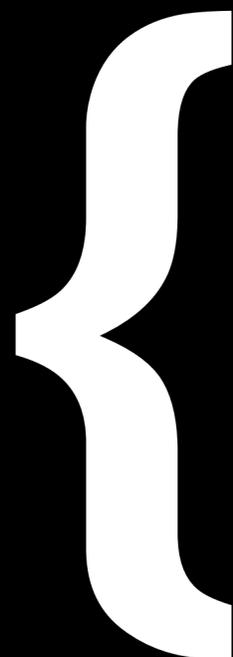
**~60 M CNY CAS-Beijing fund, talent program**

**~500 M CNY Beijing fund (light source)**

Thanks to many different funding sources, CEPC team can carry out CEPC design, key-technology research and site feasibility studies

# Funding Support for Detector R&D

**Multiple funding sources**



**Ministry of Sciences and Technology (MOST)  
National Science Foundation of China**

- Major project funds
- Individual funds

**Industry cooperation funds**

**IHEP Seed Funding**

**Others**

<b>Detector</b>	<b>Funding (M RMB)</b>
<b>Silicon</b>	<b>18.2</b>
<b>TPC</b>	<b>7.0</b>
<b>Calorimeter</b>	<b>21.3</b>
<b>Magnet</b>	<b>8.7</b>
<b>Total</b>	<b>55.2</b>

**Currently secured funding**