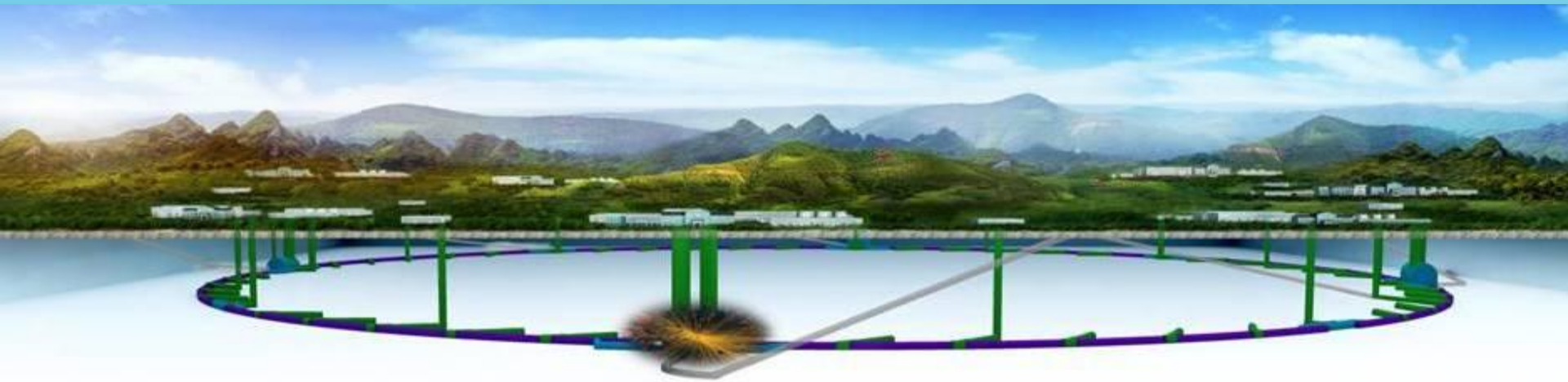
The Circular Electron Positron Collider
An Informal Report



XinChou Lou

The Institute of High Energy Physics

Seoul, July 6, 2018

High Energy Circular Electron Positron Collider

- Introduction
- CEPC status and progress
- Project development
- Discussion

MILESTONES

Nov. 2012
CEPC was firstly informal reported at HF2012.

Sept. 2012
The CEPC was proposed at the second High Energy Physics strategic workshop (China).

Jul. 2012
The Higgs boson was discovered.

Jun.2013
CEPC was suppo
the 464th Fragra
Meeting

Sept. 2013
Circular Electron-p
Collider (CEPC) K
Meeting

Dec. 2013
Center for Future
Energy Physics (C
was established

Jul. 2014
ICFA stated that ICFA continues to encourage international studies of circular collider

Feb. 2014
ICFA and Linear Collider Board meeting was hold. ICFA made the following statement: ICFA supports studies of energy frontier circular colliders and encourages global coordination.

Feb. 2014
Future Circular Collider (FCC) Study Kickoff Meeting was hold by CERN. A collaboration frame between CEPC and FCC was established

The first CEPC International Advisory Committee workshop was hold at IHEP

Oct. 2016
The 572th Fragrant Hill Meeting dedicated to CEPC has concluded that CEPC has a solid physics reason to be built with big physics potential in SppC.

Sept. 2016
Chinese High Energy Physics Physics Division of the Chinese Physics Society concluded that CEPC is the first option for future high energy accelerator project in China. It supports the strategy that aims at developing the CEPC towards a large international scientific project proposed by China.

Jul. 2016
Chinese Ministry of Science and Technology has allocated several tens of million RMB for the

Jan. 2017
CEPC-SppC baseline and alternative designs for Conceptual Design Report (CDR) have been decided by the Steering Committee of the CEPC-SppC

Apr. 2017
CEPC-SppC Progress Report on accelerator was published.

Nov. 2017
The first CEPC-SppC international workshop was held at IHEP.

Nov. 2017
CEPC Industrial Promotion Consortium (CIPC) was established at IHEP.

Dec. 2017
Draft CEPC CDR (accelerator) available.

- ✓ State Council on global science projects
- ✓ 2nd MOST grant awarded ~31M RMB
- ✓ CEPC accelerator CDR draft & review
- ✓ 1st CEPC workshop in Europe (Rome)
- ✓ Chinese DHEP reaffirms highest priority of CEPC
- ➢ Workshop on feasibility of CPEC at XiongAn
- ➢ CEPC detector CDR: draft, review, completion
- ➢ R&D and TDR
- ➢ European PP Strategy
- ➢ ……

CEPC CDR

http://cepc.ihep.ac.cn

April 2017 June 2018

Lumi.	Higgs	W	Z	Z(2T)
$\times 10^{34}$	2.93	11.5	16.6	32.1

- ✓ double ring baseline design
- ✓ switchable between H and Z/W w/o hardware change (magnet switch)
- ✓ use half SRF for Z and W
- ✓ can be optimized for Z with 2T detector (~3200× LEP luminosity)

Intl. review - June 28-30 at IHEP
Release of CDR: July (accelerator), September (detector)

CEPC Parameters

preliminary

	Higgs（3T）	*W（3T）*	*Z（3T）*	*Z（2T）*
Number of IPs	2			
Energy (GeV)	120	80	45.5	
Circumference (km)	100			
SR loss/turn (GeV)	1.73	0.34	0.036	
Half crossing angle (mrad)	16.5			
Piwinski angle	2.58	7.74	23.8	
N_e/bunch (10^{10})	15	15	8.0	
Bunch number (bunch spacing)	242 (0.68us)	1220 (0.27us)	12000 (25ns+10%gap)	
Beam current (mA)	17.4	87.9	461	
SR power /beam (MW)	30	30	16.5	
Bending radius (km)	10.6			
Momentum compaction (10^{-5})	1.11			
β_{IP} x/y (m)	0.36/0.0015	0.36/0.0015	0.2/0.0015	0.2/0.001
Emittance x/y (nm)	1.21/0.0031	0.54/0.0016	0.17/0.004	0.17/0.0016
Transverse σ_{IP} (um)	20.9/0.068	13.9/0.049	5.9/0.078	5.9/0.04
ξ_x/ξ_y/IP	0.031/0.109	0.013/0.12	0.0041/0.056	0.0041/0.072
V_{RF} (GV)	2.17	0.47	0.1	
f_{RF} (MHz) (harmonic)	650 (216816)			
Nature bunch length σ_z (mm)	2.72	2.98	2.42	
Bunch length σ_z (mm)	3.26	6.53	8.5	
HOM power/cavity (kw)	0.54 (2cell)	0.87(2cell)	1.94(2cell)	
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	0.44	0.55	
Lifetime _simulation (min)	100			
Lifetime (hour)	0.67 (40 min)	1.2	4	
F (hour glass)	0.89	0.94	0.99	
L_{max}/IP (10^{34}cm^{-2}s^{-1})	**2.93**	**11.5**	**16.6**	**32.1**

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 input was taken
- International review will be held in June-July
- The final version is almost ready, to be published in summer
- TDR will start next year, hopefully more international participation

Circular Electron-Positron Collider

- **Baseline design & options**

  E_{cm}=240 GeV, circumference=100 km, 30MW per beam, peak luminosity ~3×10^{34} $cm^{-2}s^{-1}$

  double ring; 2 detectors

- **Comparison with the ILC**

  ~same cost, 6× luminosity (ILC)

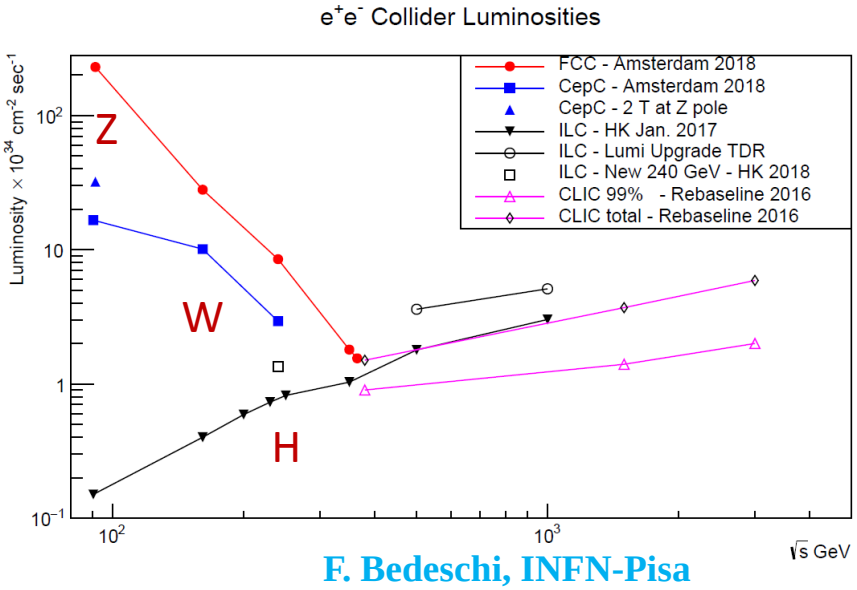
  unprecedented Z,W program

  mature technology

  high energy synchrotron light

  very long term: pp upgrade path

  ILC offers higher energy e^+e^- option

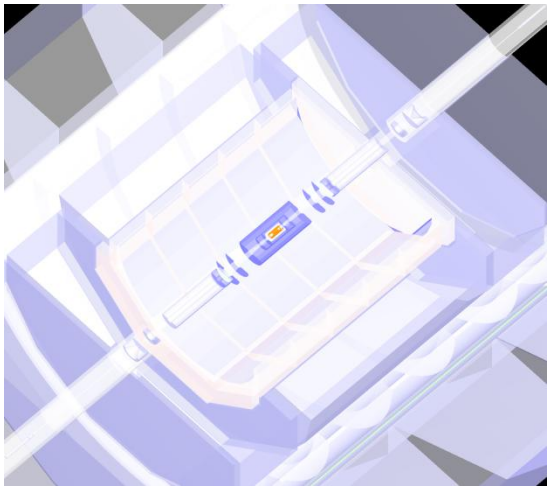


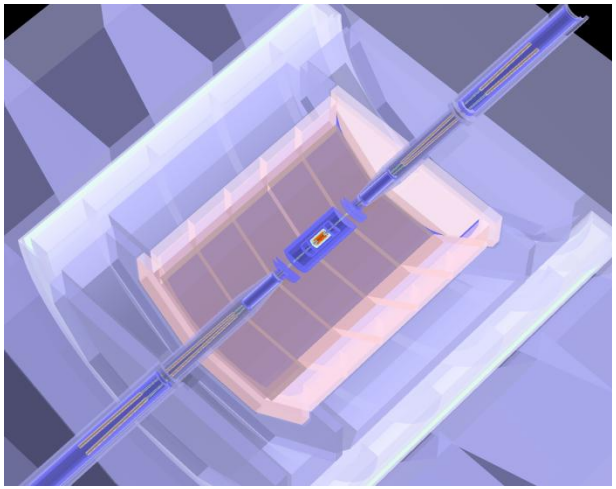
F. Bedeschi, INFN-Pisa

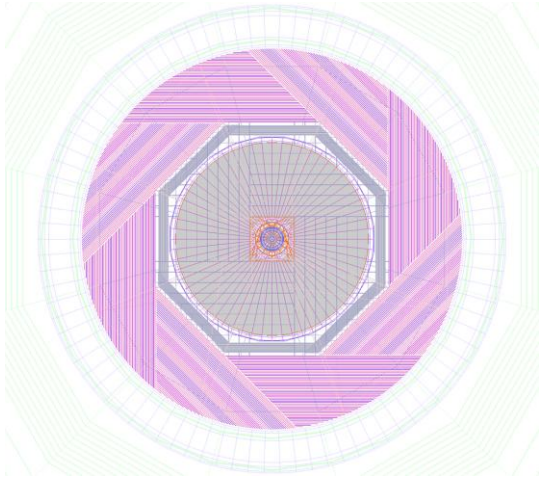
CEPC and ILC are ideally complementary to each other

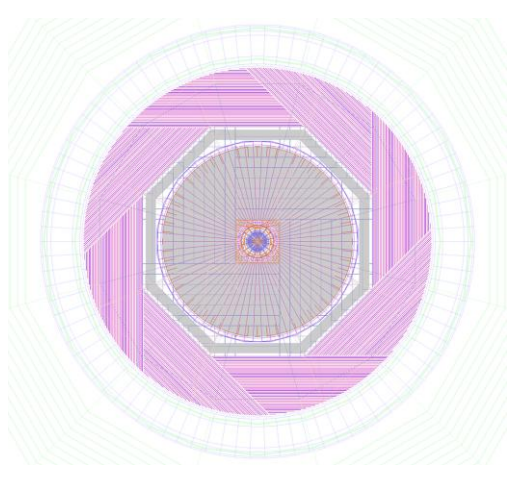
CEPC Detector: more compact & updated for CDR

preCDR (2015) → CDR (2017)

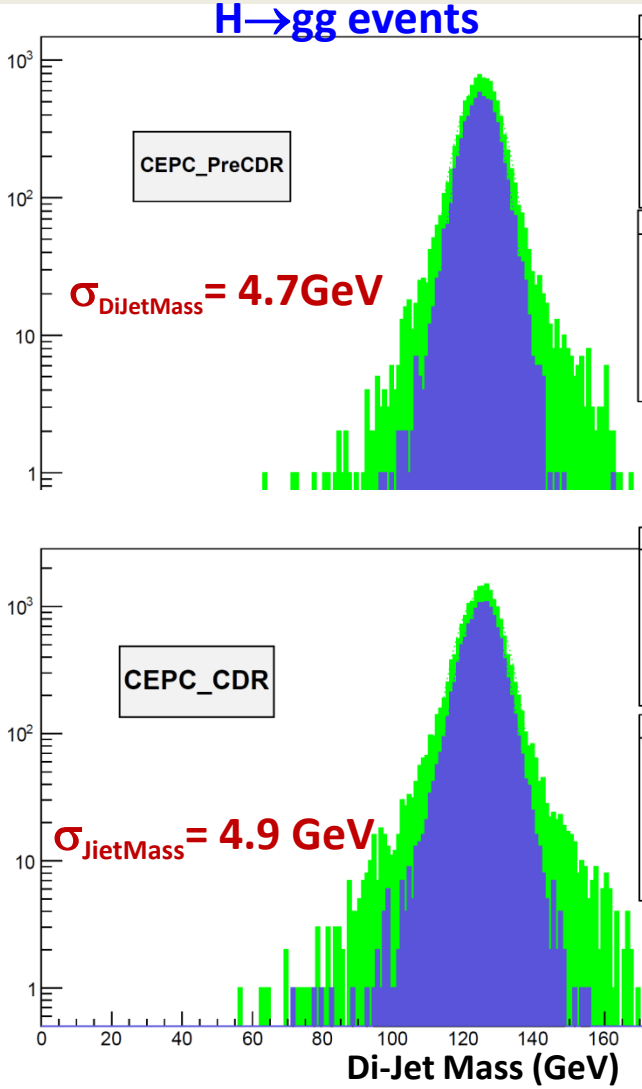








H→gg events



CDR CEPC detector:

Double ring geometry & MDI design implemented

HCAL reduced to 40 layers (from 48 in preCDR)

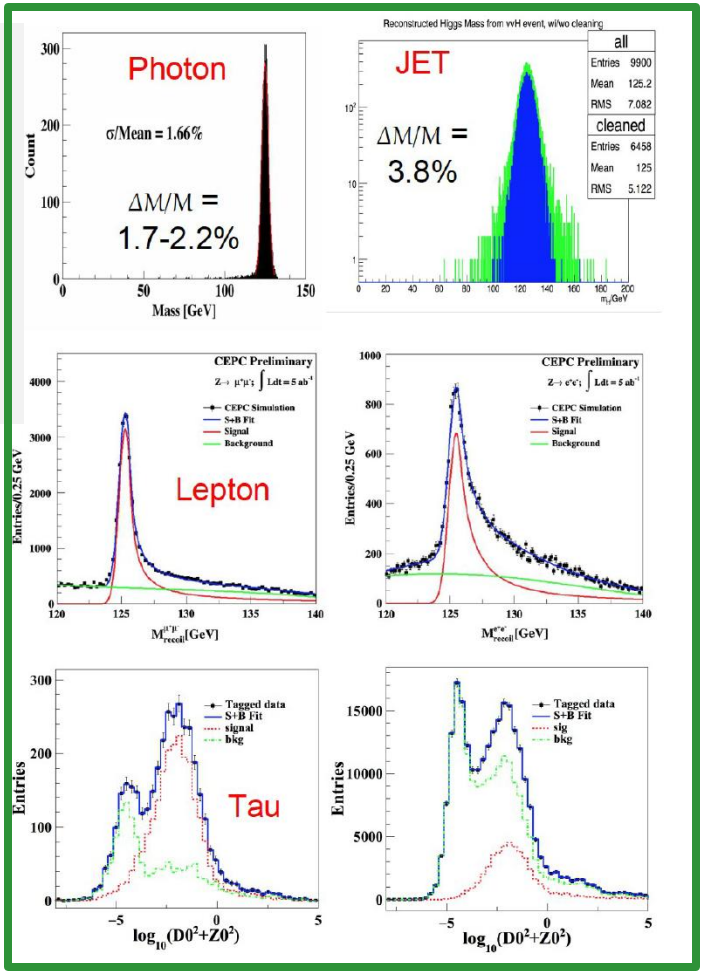
No visible impact on physics performance

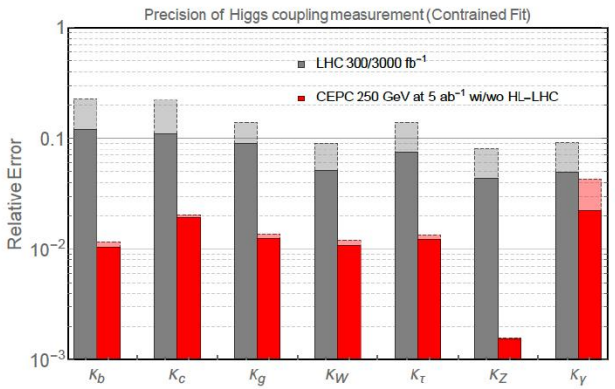
CEPC Detector Performance & Physics Measurement

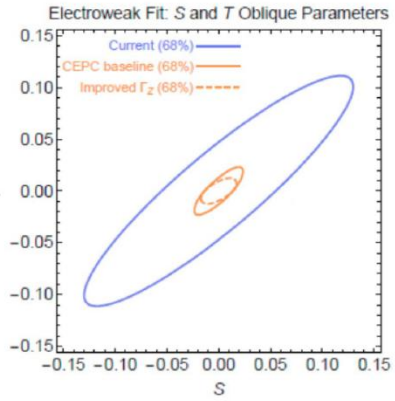
Based on the ILD framework, CEPC extends beyond the ILD and has developed several reconstruction-analysis software packages, which

correctly reconstruct physics objects, differentiating among the types, thus ensuring precision

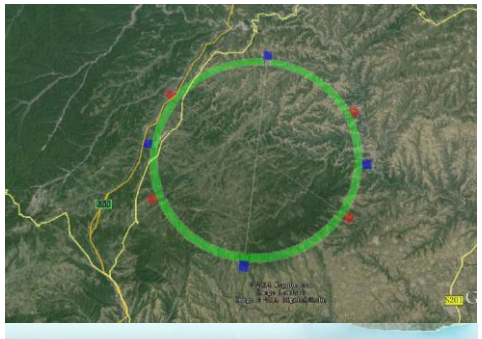
- Measurement of the Higgs boson: an order of magnitude better than at the HL-LHC
- EW precision is at least an order of magnitude better





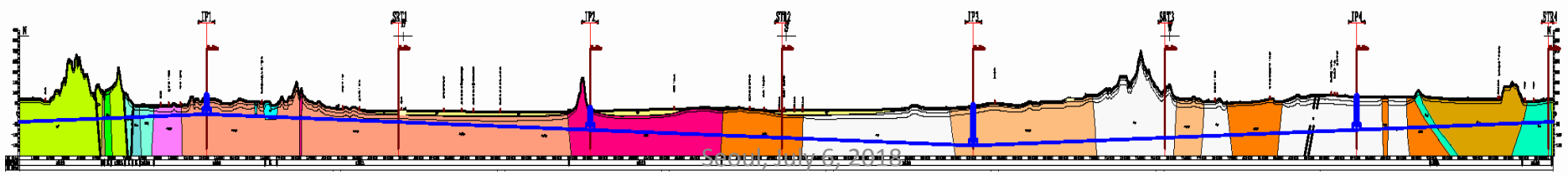


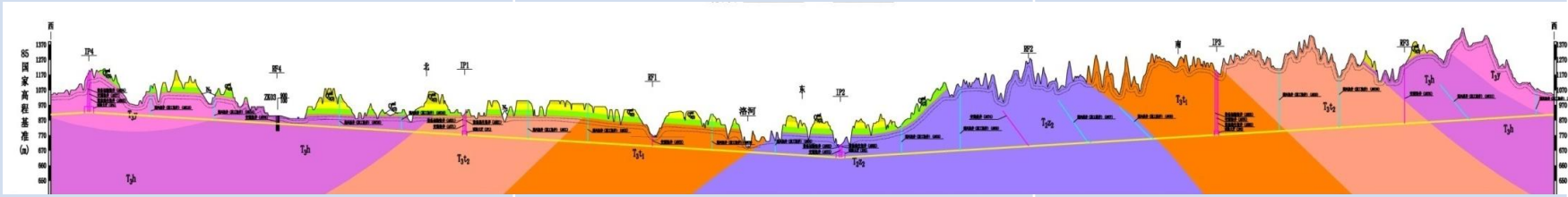
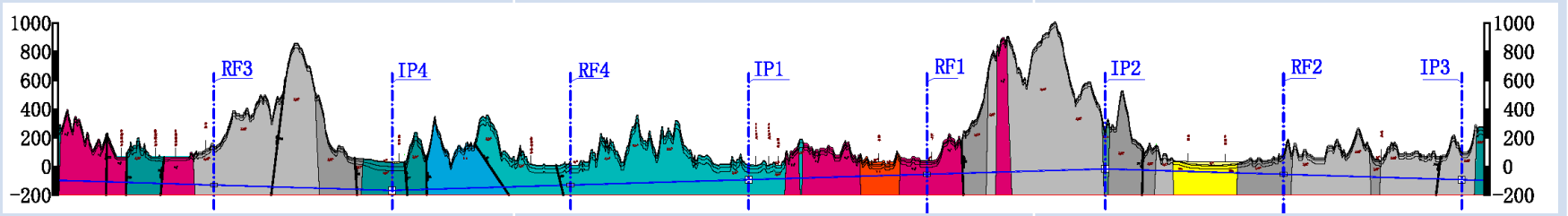
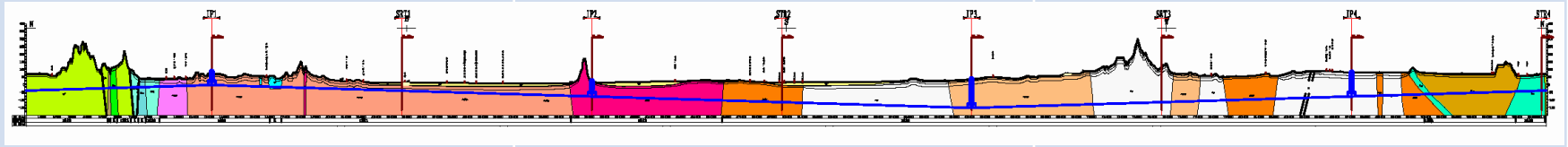
CEPC Site Exploration



1) Qinhuangdao, Heihe (Completed in 2014)
2) Huanging, Shanxi (Completed in 2017)
3)Shenshan, Guangdong (Completed in 2016)
4) Baoding (Xiong'an), Hebei (Started in August 2017, ~200 km south of Beijing)

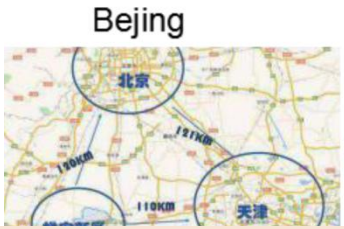
Longitudinal profile of tunnel (at Funing site, 1)



Item	Huangling	Shenshan	Funing
Project layout	Huangling (100 km) 	Shenshan (100 km) 	Funing (100 km) 
Construction difficulty	Moderate	Relatively difficult	Relatively easy

Seoul, July 6, 2018

高能环形正负对撞机（CEPC）



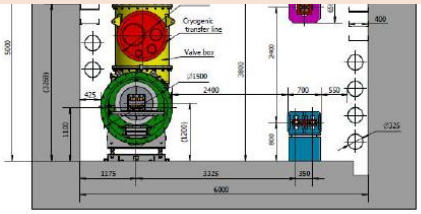
1

- ✓ site exploration
- ✓ construction plan
- ….

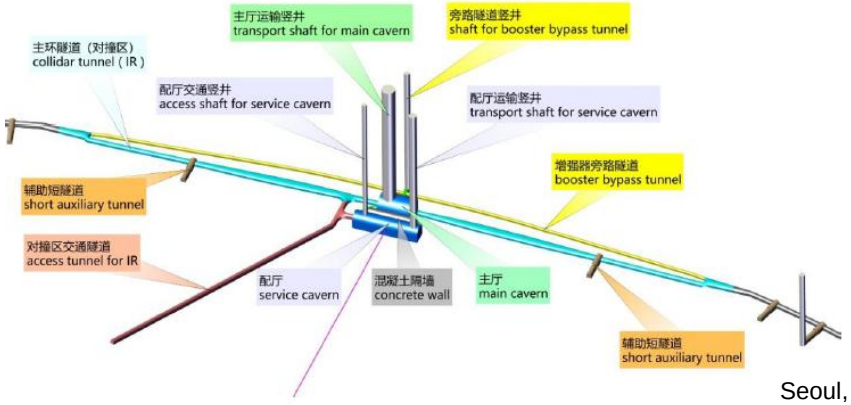
CEPC在多省市进行了实地选址勘探工作，获得了当地政府的欢迎和支持，获得了选址地的实际勘探一手资料。

1) Qin huang dao， Heihe （Completed in 2014）
2) Huanging， Shanxi（Completed in 2017)
3)Shen shan， Guangdong (Completed in 2016)
4) Baoding (Xiong an), Hebei (Started in August 2017, near Beijing
5) Zhejiang (under contact)
6) Jiangsu (under contact)

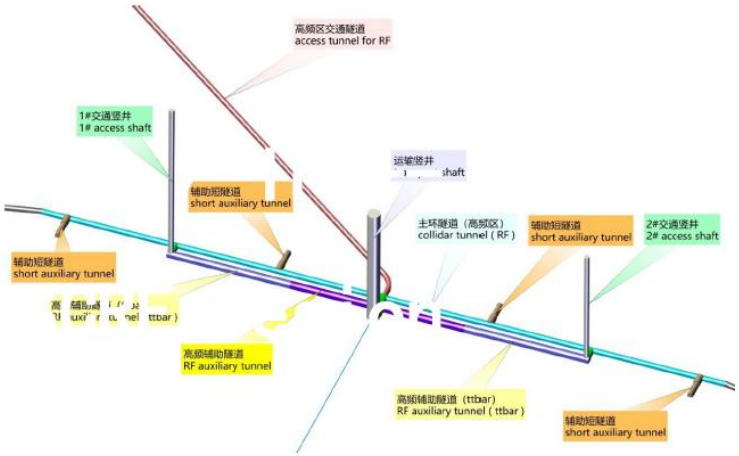
3



CEPC Interaction Region



CEPC Injection Region



CEPC: Domestic Support and Communications

Chinese DHEP reaffirms priority for CEPC

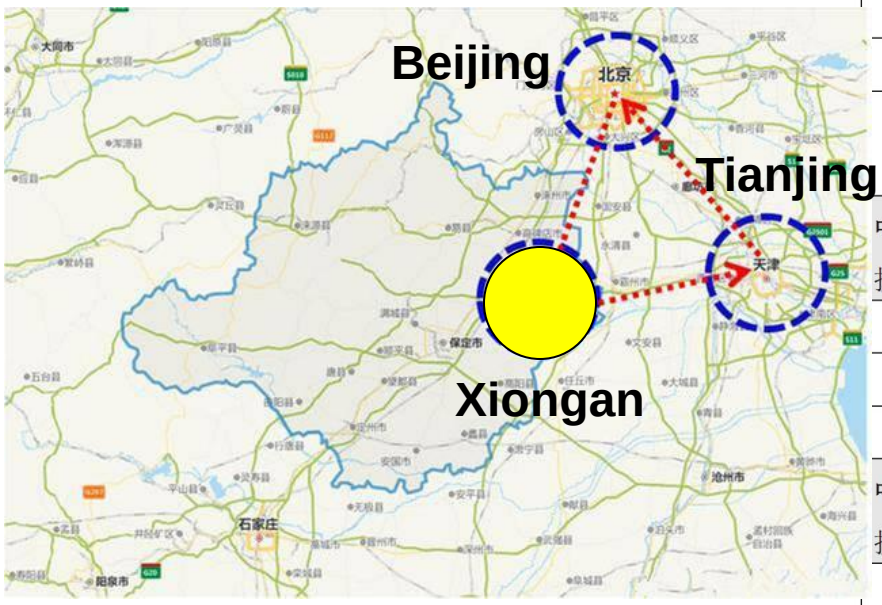
Shanghai, June 20-24, 2018

“与会人员充分讨论了我国基于加速器的高能物理发展战略，**一致同意 CEPC（包括Z工厂）是我国未来高能加速器物理高能量前沿发展的首选项目，应该积极争取使其成为我国发起的国际大科学工程之一**；同时针对tau-charm能区的高亮度前沿（HIEPA）及时组织开展可行性及预研。CEPC和HIEPA是我国基于加速器的高能物理在高能量前沿和高亮度前沿的重要布局，两者之间是相互融合、相互支持的关系。高能物理分会将继续开展战略研讨，并将尽快组织制定基于加速器的中国高能物理发展路线图，集我国高能物理学界的力量合理健康、有序有效地推进两个项目。”

Previous consensus on CEPC design and its R&D program

CEPC: Site Exploration and Feasibility Study

雄安 XiongAn
a new, modern city to be built in China



Feasibility of CEPC in XiongAn

高能环形正负电子对撞机落户雄安可行性研讨会

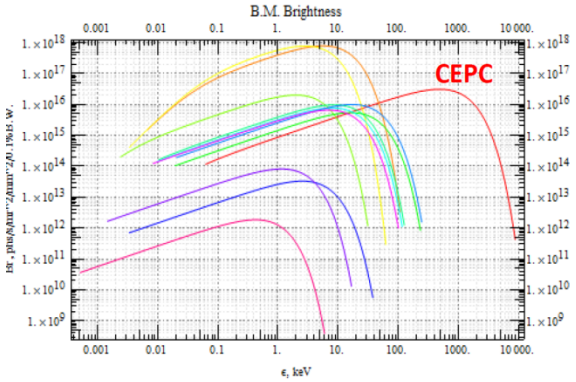
2018. 7. 12-13

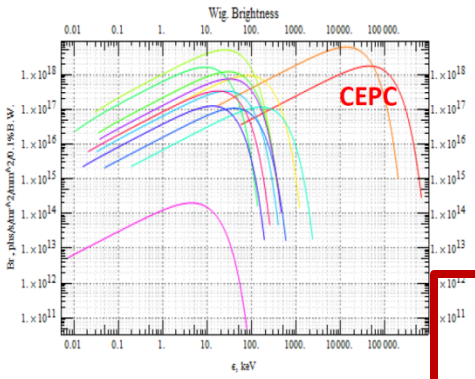
7 月 12 日上午		
执行主席：赵光达，陈和生，夏佳文，张焕乔，王乃彦，王贻芳，罗民兴		
时间	内　容	报告人
8：00－8：15	欢迎及院领导讲话	
8：15－8：20	执行主席讲话	执行主席
8：20－8：40	高能环形正负电子对撞机（CEPC）：进展和规划汇报	娄辛丑
中心议题 1：CEPC 物理目标、科学意义以及发展潜力		
执行主席：罗民兴，赵光达，陈和生，夏佳文，张焕乔，王乃彦，王贻芳		
8：40－9：10	CEPC 前沿物理和潜力	王连涛
9：10－9：40	讨论（自由问答与发言，≤5 分钟/人/次，可多次发言）	
9：40 - 10:10	休息，合影	
中心议题 2：CEPC 加速器：　设计、关键技术预研究及实施		
执行主席：夏佳文，罗民兴，赵光达，陈和生，王贻芳，王乃彦，张焕乔		
10：10－10：40	CEPC 对撞机概念设计，CEPC 加速器：　关键技术、预研究、建设及产业化	高杰
10：40－11：10	讨论（自由问答与发言，≤5 分钟/人/次，可多次发言）	
中心议题 3：围绕 CEPC 开展国际合作		
执行主席：张焕乔，王乃彦，夏佳文，罗民兴，赵光达，陈和生，王贻芳		

项目规划 Project Development： 高能伽马同步光源 γ light

CEPC也是高能同步辐射光源

- 从环上的二极铁引出的高能同步辐射光，能量可达628keV，超过目前所有正在运行和在建光源光子能量
- 使用扭摆磁铁或波荡器后，光子能量可以超过20MeV
- 前所未有的MeV级同步辐射光源，可能的应用
  - 核物理、国防、材料结构及缺陷、微加工、极端条件、高压、辐照改性、育种。。。





开辟新的科研手段

实验物理中心、加速器组织
BEPCII上研究γ光源探索

- 规划实验
- 申请经费
- 引进人才
- 理论-实验探索

第一次国内研讨会

第一届CEPC同步辐射光源应用研讨会
（6-8 Dec, 2017, IHEP, Beijing）
http://indico.ihep.ac.cn/event/7186/

CEPC Funding

IHEP seed money

11 M CNY/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

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
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

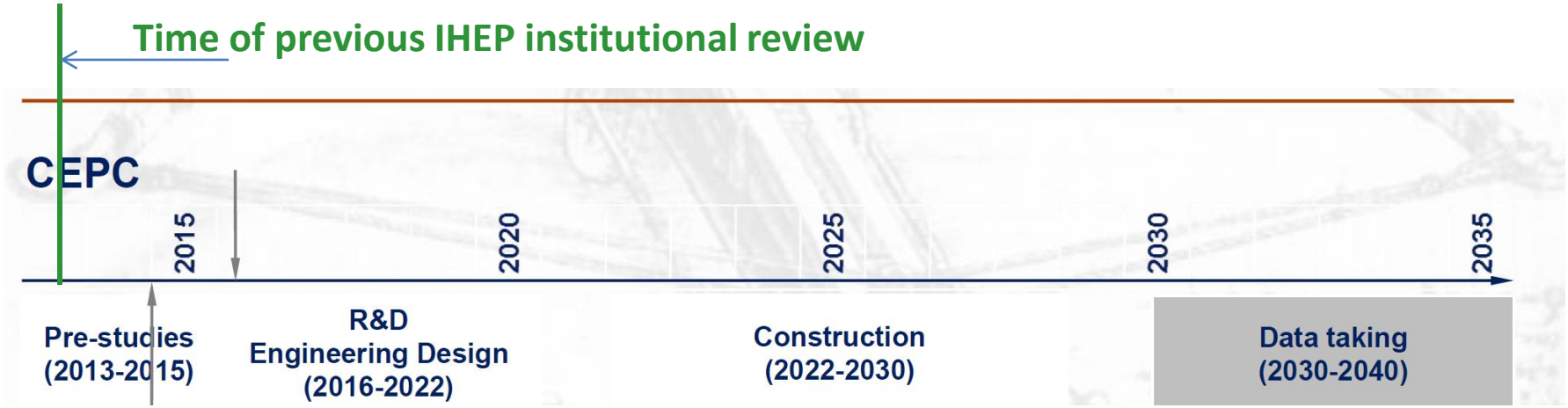
~60M CNY CAS-Beijing fund, talent program

~500M CNY Beijing fund (light source)

year 2017 funding request (32M) to MOST approved

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

CEPC Schedule (ideal)



design issues
R&D items
Pre-CDR

design, funding
R&D program
intl. collaboration
site study

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

- CEPC data-taking starts before the LHC program ends around 2035
- earlier than the FCC(hh, ee)
- possibly concurrent, but advantageous and complementary to the ILC

CEPC Path to Realization

- Science & Technology is strongly supported by this government ➔ also a "requirement" for local governments (difference seen in 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 MOST to be included in the roadmap planning, project selection, etc.

实现CEPC的路径？

国务院：“积极牵头组织国际大科学计划和大科学工程”

国发〔2018〕5号 （2018.3.14）

http://www.gov.cn/zhengce/content/2018-03/28/content_5278056.htm

“国际尖端，科学前沿。适应大科学计划基础性、战略性和前瞻性特点，聚焦国际科技界普遍关注、…”,“战略导向，提升能力。”,“中方主导，合作共赢。 ”,“创新机制”

“主要目标:

总体目标：通过牵头组织大科学计划，在世界科技前沿和驱动经济社会发展的关键领域，形成具有全球影响力的大科学计划布局，开展高水平科学研究，培养引进顶尖科技人才，增强凝聚国际共识和合作创新能力，提升我国科技创新和高端制造水平，推动科技创新合作再上新台阶，努力成为国际重大科技议题和规则的倡导者、推动者和制定者，提升在全球科技创新领域的核心竞争力和话语权。

近期目标：**到2020年，培育3—5个项目，研究遴选并启动1—2个我国牵头组织的大科学计划**，初步形成牵头组织大科学计划的机制做法，为后续工作探索积累有益经验。

中期目标：**到2035年，培育6—10个项目，启动培育成熟项目**，形成我国牵头组织的大科学计划初期布局，提升在全球若干科技领域的影响力。

远期目标：到本世纪中叶，培育若干项目，启动培育成熟项目，我国原始科技创新能力显著提高，在[illegible]重大科技议题作出贡献。”

实现CEPC的一个可能的通道

Discussion