CEPC Status

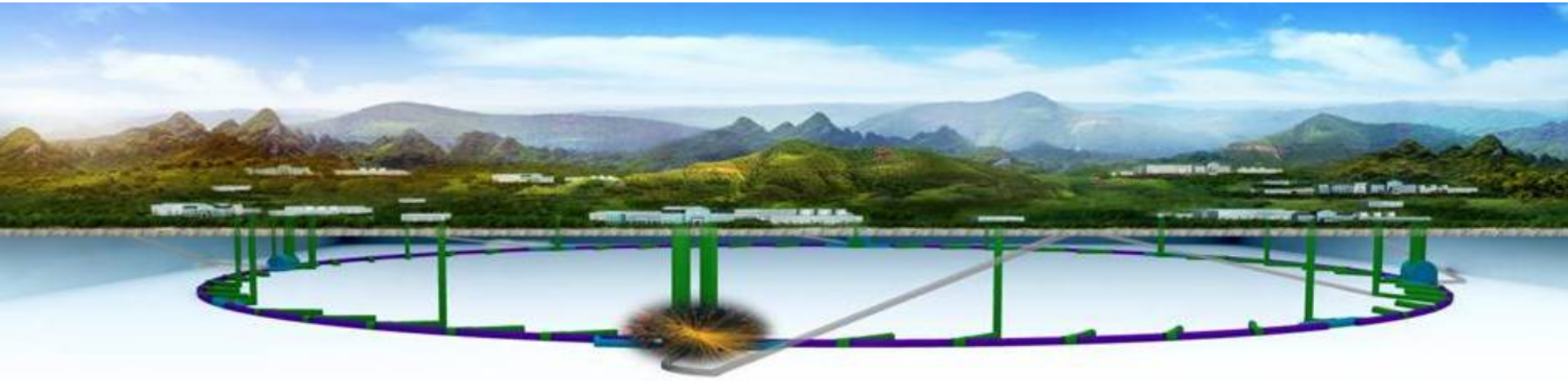
Qing-Hong Cao

Institute of Theoretical Physics, PKU
Center of High Energy Physics, PKU

CEPC Overview

XinChou Lou
Institute of High Energy Physics, Beijing

International Workshop on the Circular Electron-Positron Collider



Why CEPC?

Precision = Discovery

m_W m_Z $\sin\theta_W$	EW symmetry breaking Global symmetry of scalar potential
A_{FB}	Parity violation; weak isospin
Γ_Z	3 active neutrinos
m_t	Fermion mass origin (the only natural quark)
Γ_t	Equivalence theorem
m_H	Vacuum stability
Γ_H	fundamental or composite, or ……

We, bump hunters, are also excellent painters of Nature's details.

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… consistent with the SM …

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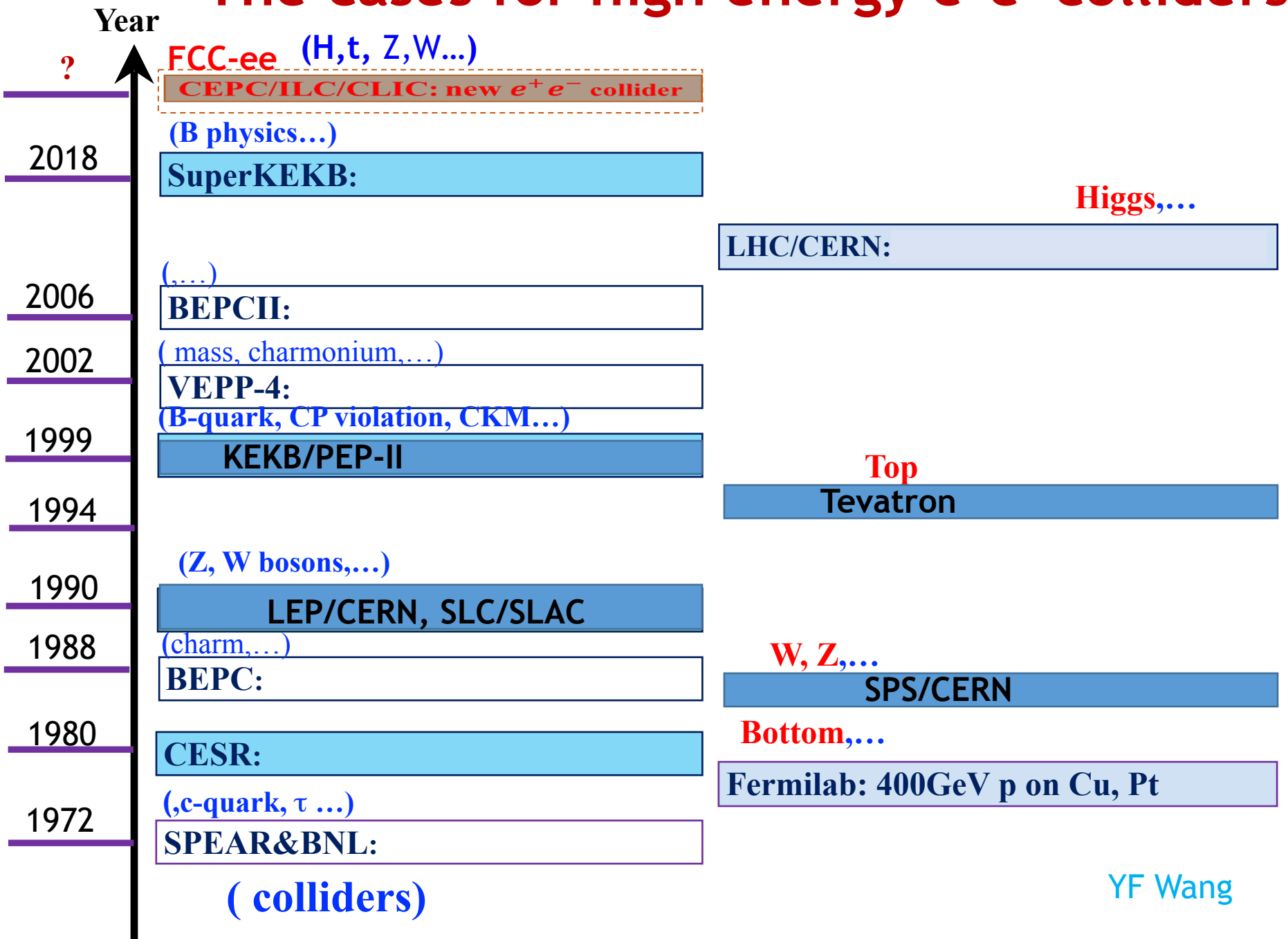
… excluded (ruled out) …

… consistent with the SM …

We discover … is not supported at 95% CL

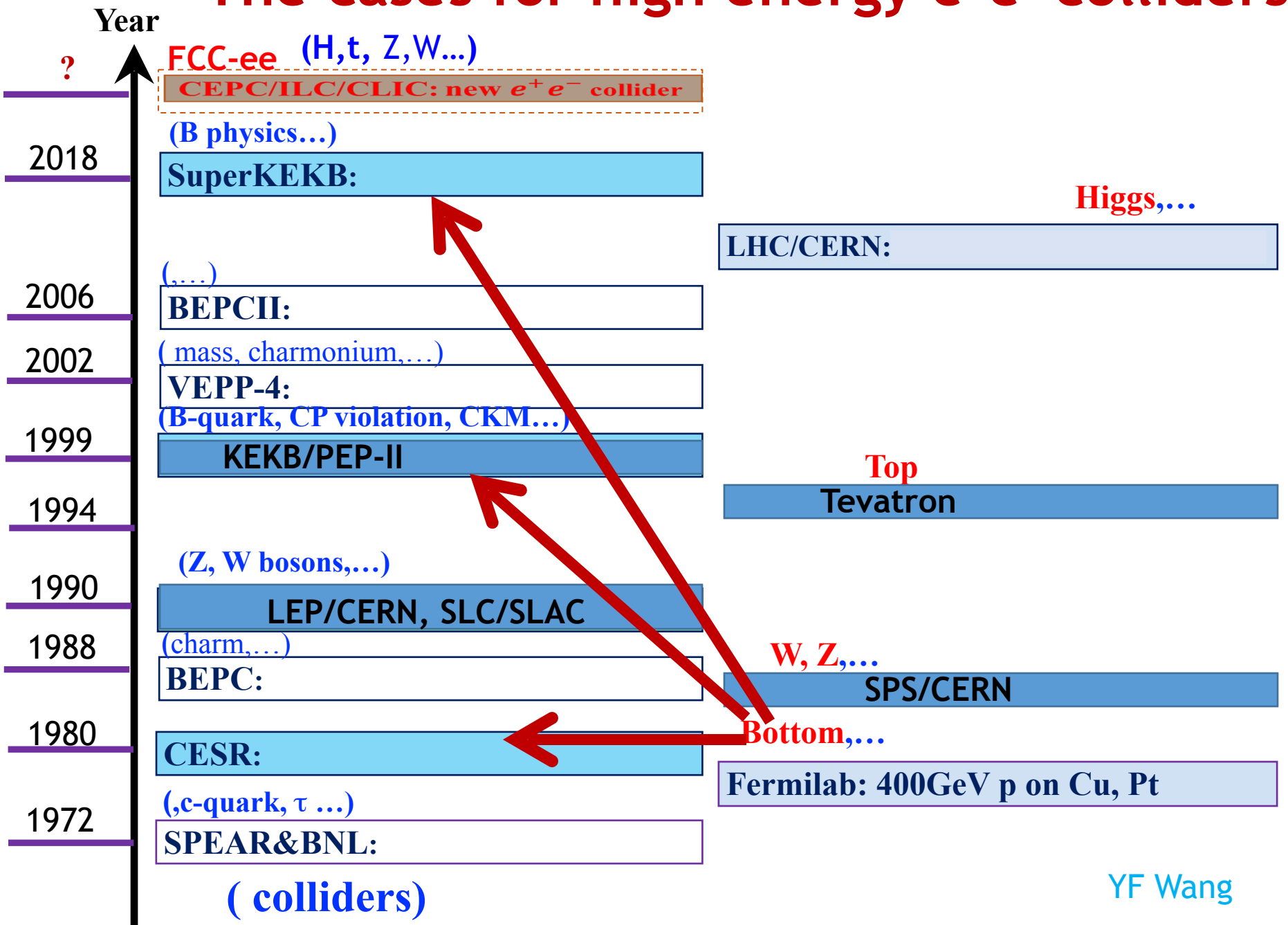
We discover a tight constraint on NP …

The cases for high energy e^+e^- colliders



YF Wang

The cases for high energy e^+e^- colliders



YF Wang

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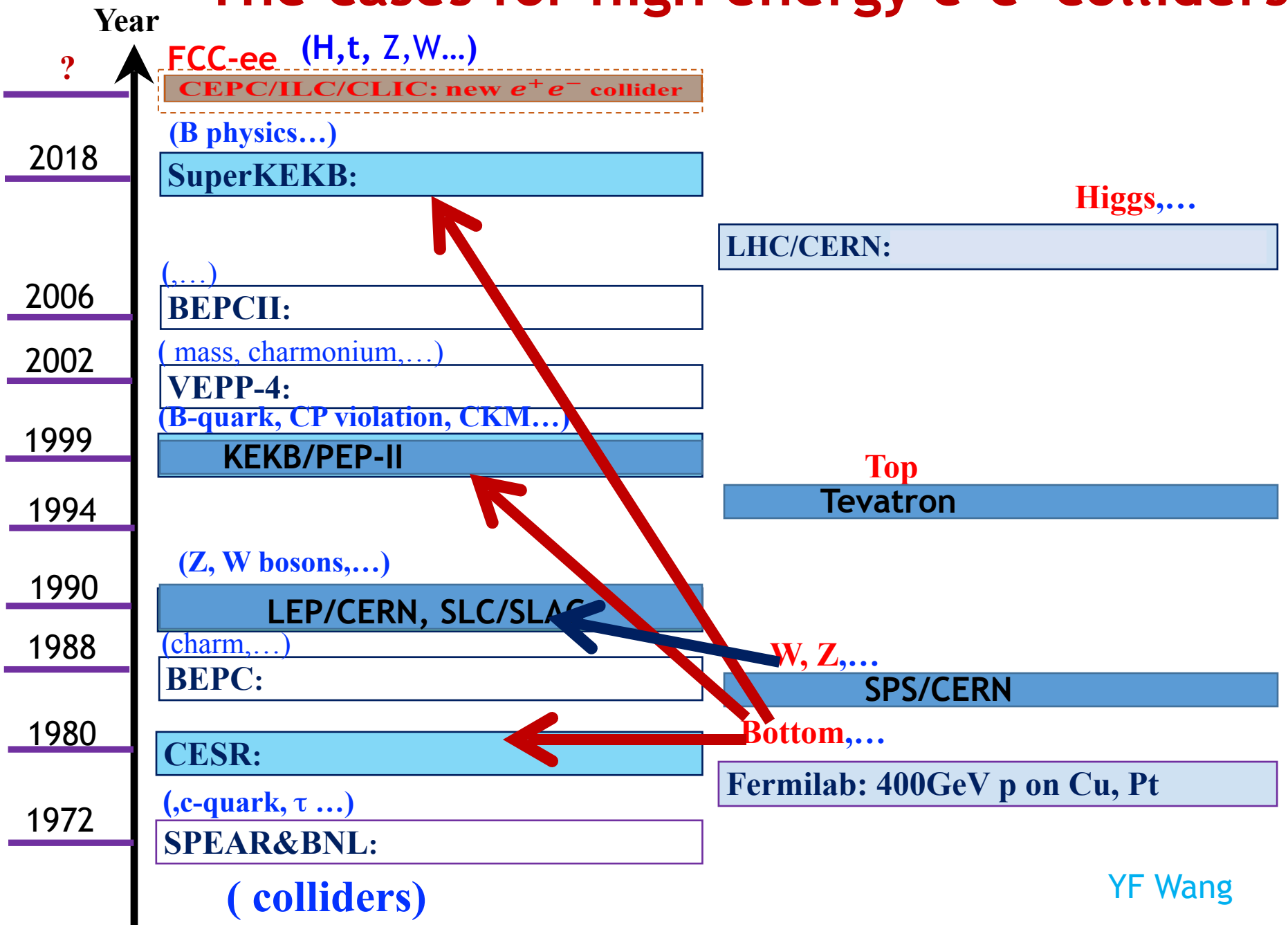
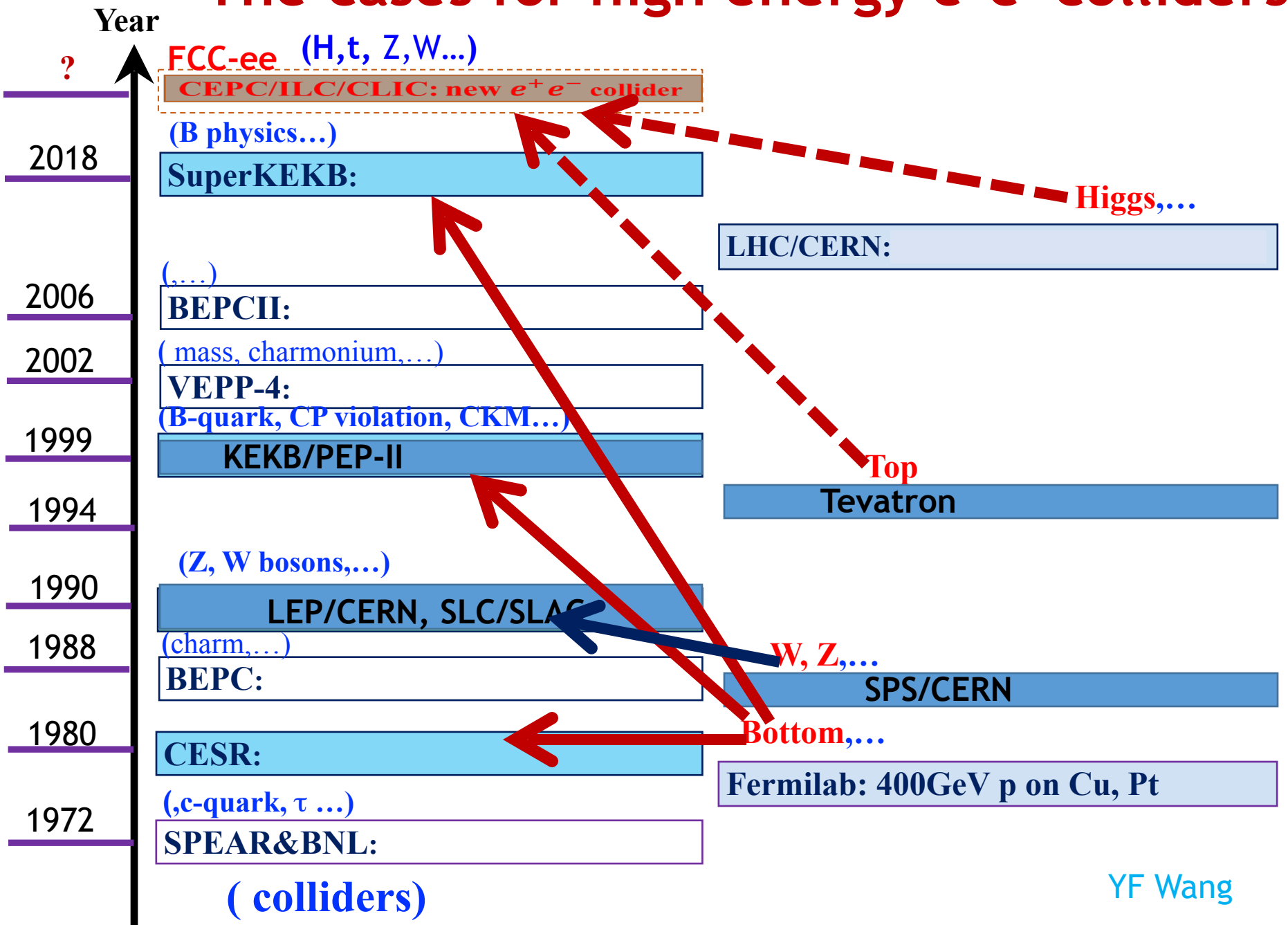


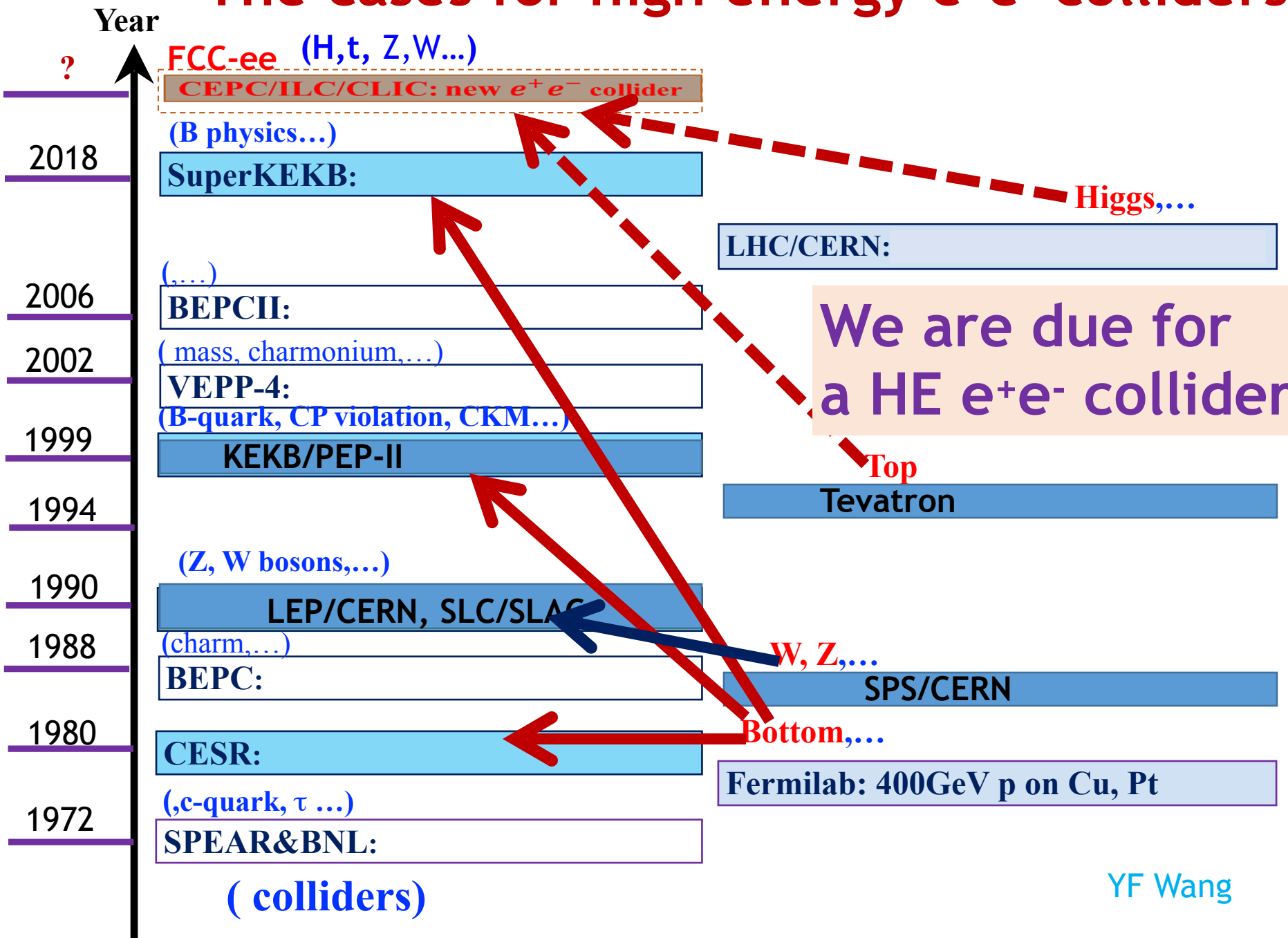
YF Wang

The cases for high energy e^+e^- colliders



YF Wang

The cases for high energy e+e- colliders



YF Wang

Reminder about the CEPC-SppC

e^+e^- Higgs (Z) factory

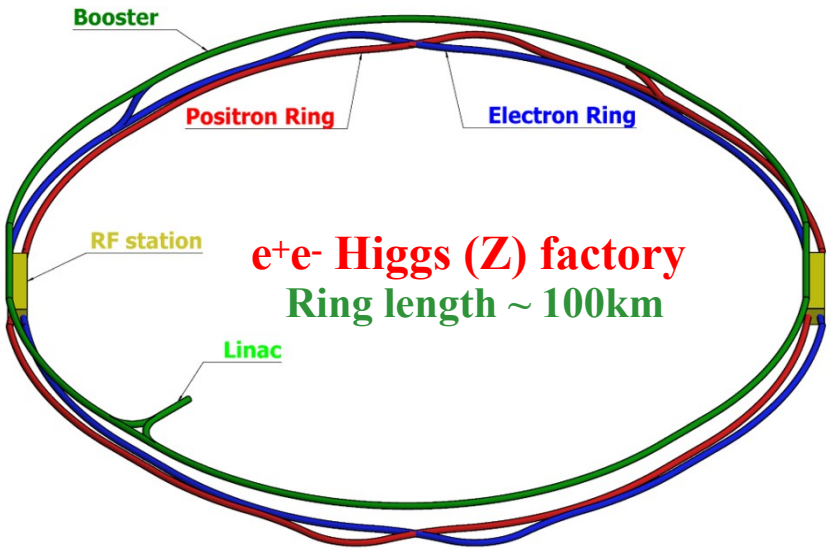
E_{cm}≈240GeV, luminosity ~2×10^{34} $cm^{-2}s^{-1}$, 2IP, 1M H in 10 years
at the Z-pole 10^{10}Z bosons/yr

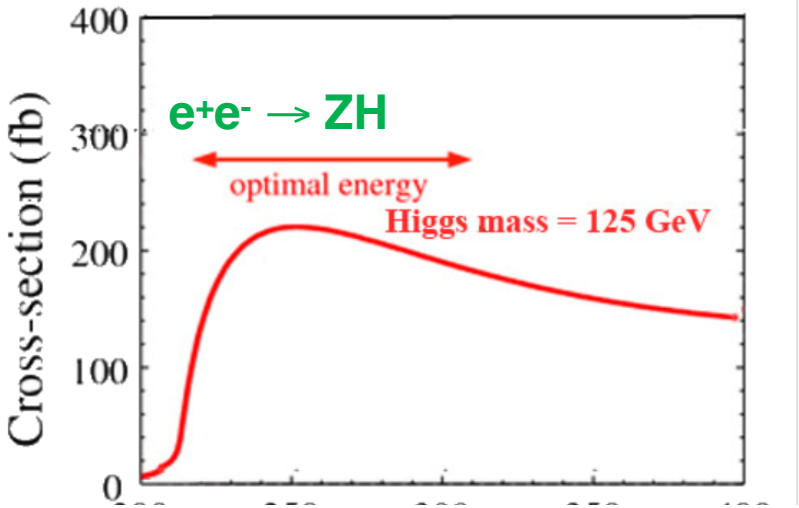
Precision measurement of the Higgs boson (and the Z boson)

Upgradable to pp collision with E_{cm} ≈ 50-100 TeV (with ep, HI options)

A discovery machine for BSM new physics

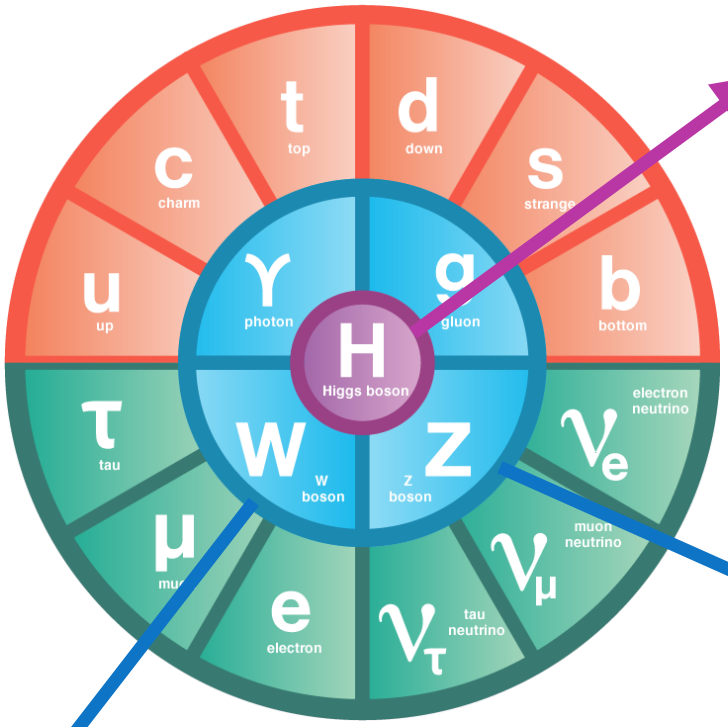
Higgs precision
1% or better





BEPCII will likely complete its mission ~2020s;
CEPC – possible accelerator based particle physics program in China after BII

CEPC运行的计划



10^6 希格斯粒子

10^{12} Z 玻色子

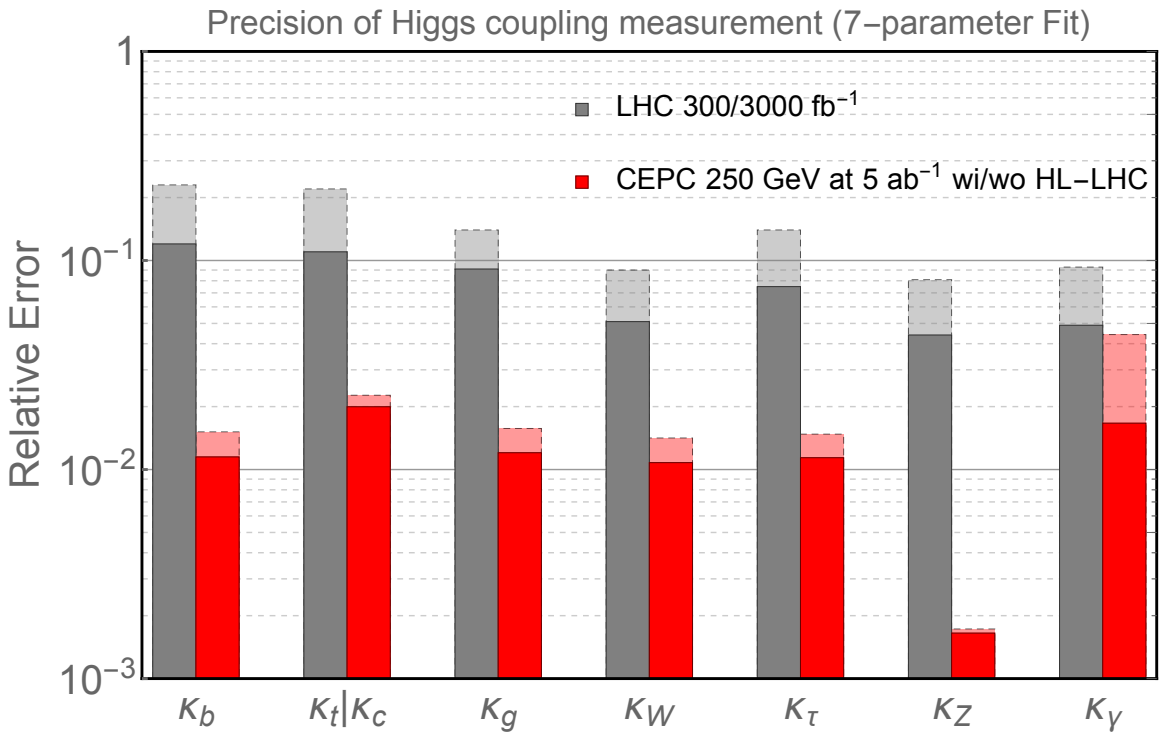
10^7 W玻色子

产生大量的粒子是为了更仔细地研究它们的性质

数量越多，精度越高

L.-T. Wang's talk

CEPC 的主要物理目标:
精确测量希格斯粒子的性质

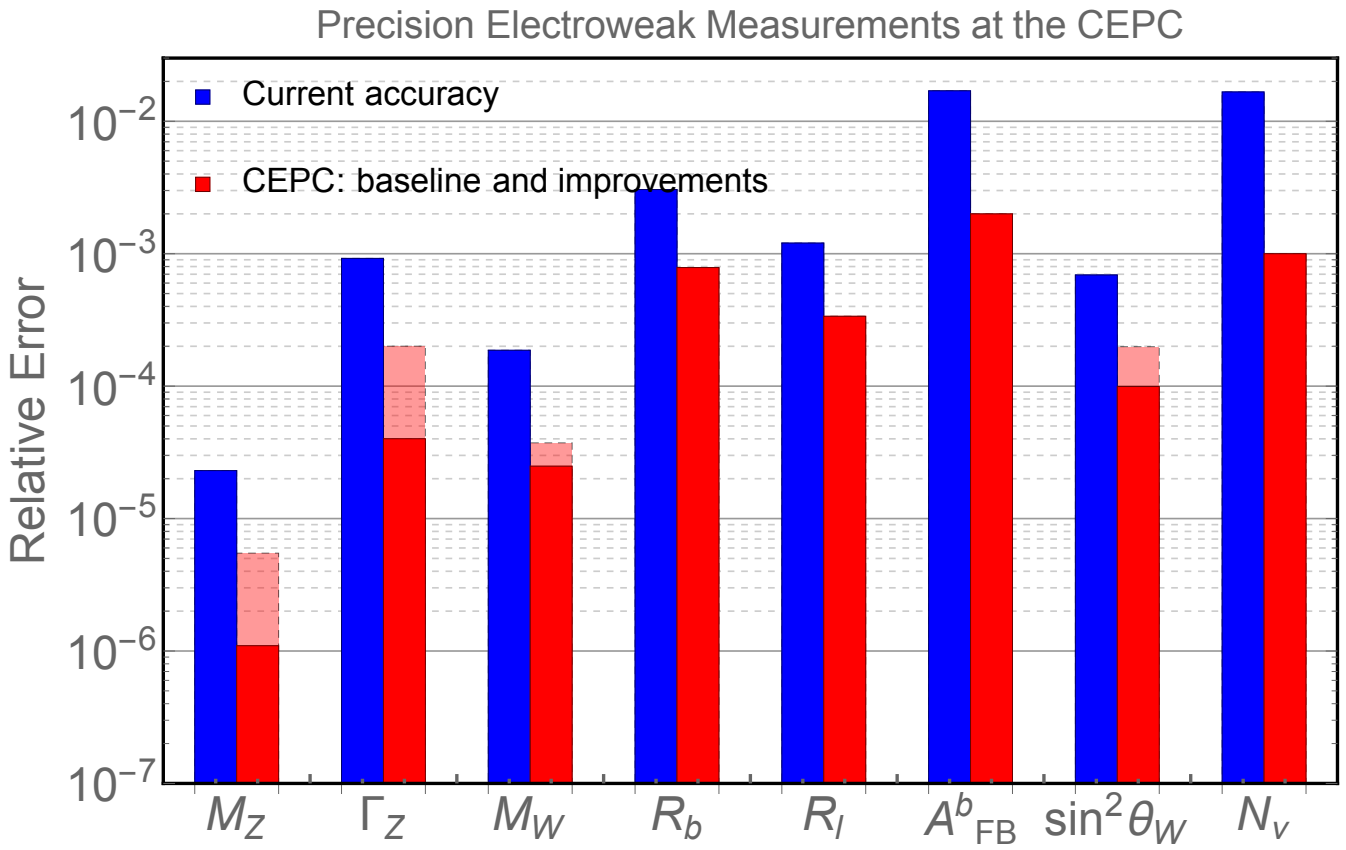


这也是欧洲核子中心(CERN)大型强子对撞机(LHC)
今后15-20年首要物理目标之一

CEPC 精度超过大型强子对撞机10到几十倍

L.-T. Wang's talk

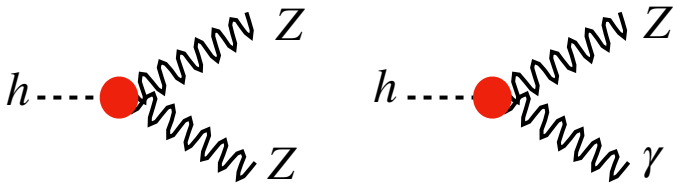
CEPC 的主要物理目标:
精确的测量W和Z玻色子的性质



精度提高10倍以上

L.-T. Wang's talk

What can we learn from those CEPC precision?

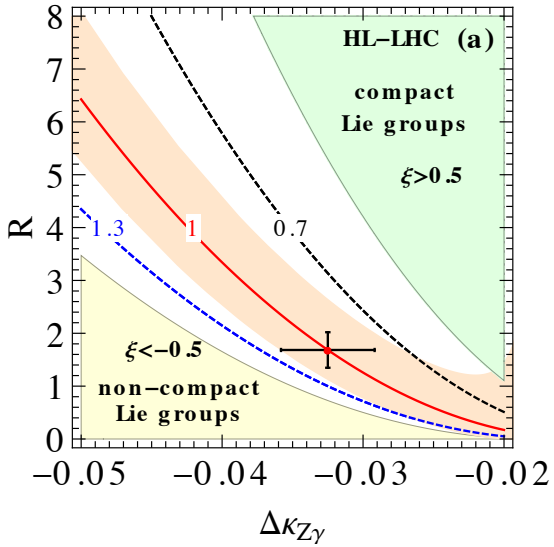


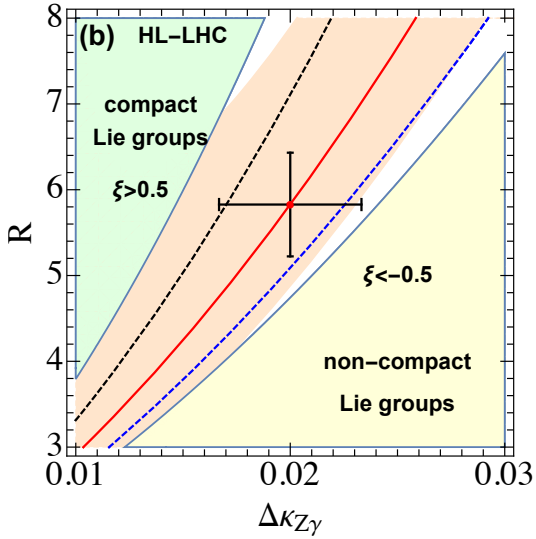
$$R \equiv \frac{\mu(h \to Z\gamma)}{\mu(h \to Z^*Z)}$$

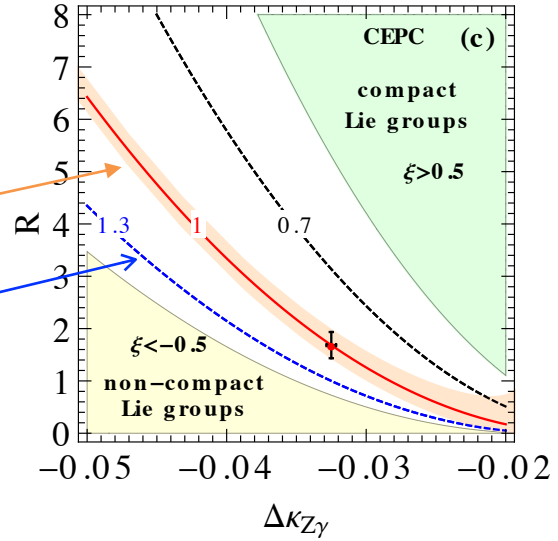
$$\mu(h \to Z^*Z) = \frac{\mathrm{BR}(\mathrm{h} \to \mathrm{Z}^*\mathrm{Z})}{\mathrm{BR}(\mathrm{h} \to \mathrm{Z}^*\mathrm{Z})_{\mathrm{SM}}}$$

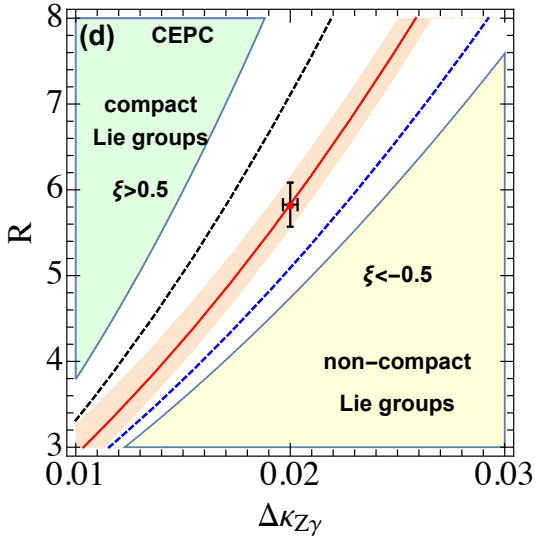
$$\mu(h \to Z\gamma) = \frac{\mathrm{BR}(h \to Z\gamma)}{\mathrm{BR}(h \to Z\gamma)_{\mathrm{SM}}}$$

QHC, Yan, Xu, Zhu, 1810.07661









Fundamental

Composite

Precision = Discovery

Reminder about the CEPC-SppC

Kick-off on Sept. 13, 2013 - inspired by the discovery of the Higgs boson at the LHC

CEPC study group formed in Beijing

PreCDR, March 2015 – initial investigations; no-show stoppers, identified issues & R&D

Funding, R&D, international collaboration, … – continued effort since 2013

CDR, August-October 2018 – scientific goals well justified & aligned with intl priorities; endorsement for moving towards TDR, and …

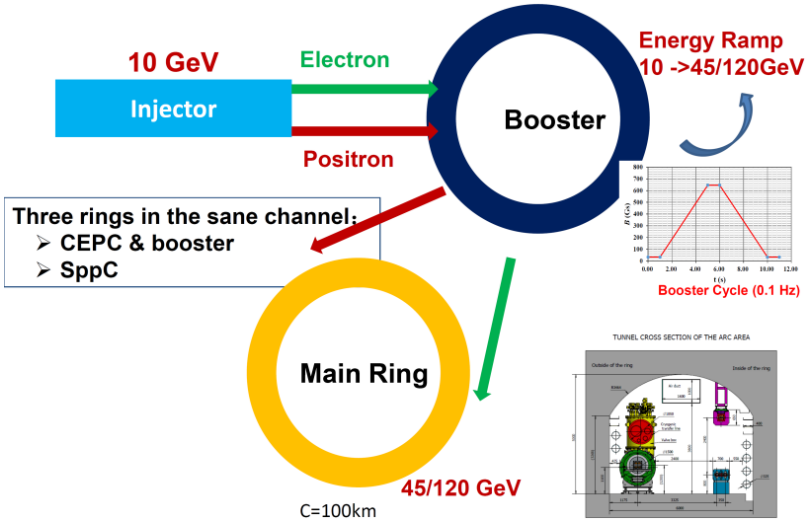
CEPC Schedule (ideal)

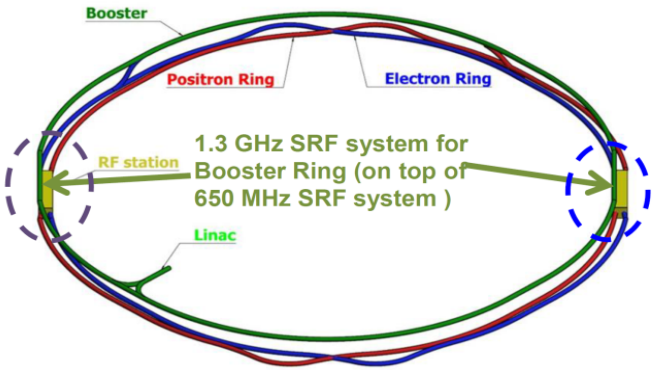
design issues R&D items preCDR	CDR, funding R&D program Intl. collaboration site study	seek approval, site decision construction during 14th 5-year plan commissioning

- CEPC data-taking starts before the LHC program ends around 2035
- possibly con-current, and complimentary to the ILC

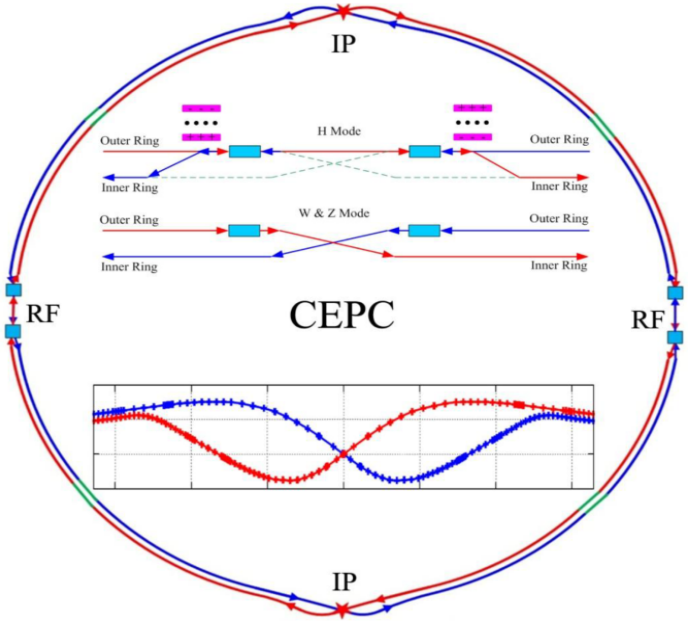
Progress and Updates

Progress and updates - CEPC CDR





SRF system location of CEPC (two RF stations)



Layout of 650 MHz SRF system for Collider Ring

Progress and updates - CEPC CDR

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

Luminosities exceeded those in the preCDR

- double ring baseline design (30MW/beam)
- 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

International Review of CEPC CDR (June 28-30, 2018, IHEP)

International Review of CEPC CDR

June 28 – 30, 2018, IHEP, Main Building, Room A415

Agenda

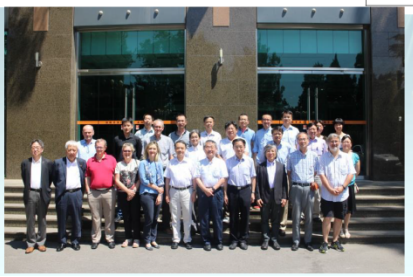
Thursday, June 28

8:30-9:00	Chair: K. Oide Committee Executive Session	
9:00-9:05	Chair: Qing Qin Welcome	Yifang Wang
9:05-9:20	Overview of CEPC	Jie Gao
9:20-9:35	Overview of beam dynamics	Chenghui Yu
9:35-10:05	CEPC collider lattice design	Yiwei Wang
10:05-10:35	CEPC beam-beam and DA	Yuan Zhang
	Coffee break(30')	
	Chair: K. Oide	
11:05-11:35	Instabilities	Na Wang
11:35-12:05	Machine-detector interface	Shu Bai
12:05 – 14:00	Lunch break	
	Chair: K. Oide	
14:00-14:30	Booster	Dou Wang
14:30-15:00	Injection and extraction	Xiaohan Cui
15:30-16:00	Linac injector	Cai Meng
	Coffee break(30')	
16:30-18:30	Committee Executive Session	
19:00	Dinner of Committee	

	Chair: K. Oide	
8:30-9:00	SRF system	
9:00-9:30	RF power source	
9:30-10:00	Cryogenic system	
10:00-10:20	CEPC collider ring Magnet	
10:20-10:40	CEPC booster ring magnet	
	Coffee break(30')	
11:10-11:30	SC magnet for CEPC IR	
11:30-12:00	Power supplies	
12:00-12:30	Vacuum	
12:30 – 14:00		
	Chair: K. Oide	
14:00-14:30	Instrumentation	
14:30-15:00	Control	
15:00-15:30	Synchrotron radiation	
15:30-16:00	Radiation shielding	
	Coffee break(30')	
16:30-18:30	Committee Executive Sessio	
	Dinn	

Saturday, June 30

	Chair: K. Oide	
8:30-9:00	Survey and alignment	Xiaolong Wang
9:00-9:30	Mechanics	Haijing Wang
9:30-10:00	Conventional facilities	Guoping Lin
10:00-10:30	Site investigation	Yu Xiao
	Coffee break (30')	
11:00-12:00	Discussion with CEPC team	
12:00 – 14:00	Lunch break	
14:00-16:00	Committee Executive Session	
	Coffee break (30')	
16:30-17:30	Close out	
	Banquet	

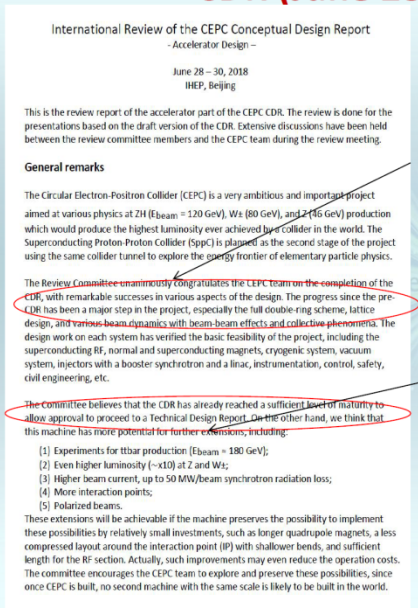


Review Committee Members:

Brian Foster	Oxford U./DESY
Eugene Levichev	BINP
Katsunobu Oide (chair)	CERN/KEK
Kazuro Furukawa	KEK
Manuela Boscolo	INFN
Marica Biagini	INFN
Masakazu Yoshioka	KEK/Tohoku University
Norihito Ohuchi	KEK
Paolo Pierini	ESS
Steinar Stapnes	CERN
Yoshihiro Funakoshi	KEK
Zhengtang Zhao (absent)	SINAP

J Gao

International Review Report (draft) of CEPC CDR (June 28-30, 2018, IHEP)



International Review of the CEPC Conceptual Design Report

- Accelerator Design –

June 28 – 30, 2018

IHEP, Beijing

This is the review report of the accelerator part of the CEPC CDR. The review is done for the presentations based on the draft version of the CDR. Extensive discussions have been held between the review committee members and the CEPC team during the review meeting.

General remarks

The Circular Electron-Positron Collider (CEPC) is a very ambitious and important project aimed at various physics at ZH (E_{beam} = 120 GeV), W± (80 GeV), and Z (46 GeV) production which would produce the highest luminosity ever achieved by a collider in the world. The Superconducting Proton-Proton Collider (SppC) is planned as the second stage of the project using the same collider tunnel to explore the energy frontier of elementary particle physics.

The Review Committee unanimously congratulates the CEPC team on the completion of the CDR, with remarkable successes in various aspects of the design. The progress since the pre-CDR has been a major step in the project, especially the full double-ring scheme, lattice design, and various beam dynamics with beam-beam effects and collective phenomena. The design work on each system has verified the basic feasibility of the project, including the superconducting RF, normal and superconducting magnets, cryogenic system, vacuum system, injectors with a booster synchrotron and a linac, instrumentation, control, safety, civil engineering, etc.

The committee believes that the CDR has already reached a sufficient level of maturity to allow approval to proceed to a Technical Design Report. On the other hand, we think that this machine has more potential for further extensions, including:

(1) Experiments for ttbar production (E_{beam} = 180 GeV);
(2) Even higher luminosity (~x10) at Z and W±;
(3) Higher beam current, up to 50 MW/beam synchrotron radiation loss;
(4) More interaction points;
(5) Polarized beams.

These extensions will be achievable if the machine preserves the possibility to implement these possibilities by relatively small investments, such as longer quadrupole magnets, a less compressed layout around the interaction point (IP) with shallower bends, and sufficient length for the RF section. Actually, such improvements may even reduce the operation costs. The committee encourages the CEPC team to explore and preserve these possibilities, since once CEPC is built, no second machine with the same scale is likely to be built in the world.

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J Gao

Progress and updates - CEPC CDR

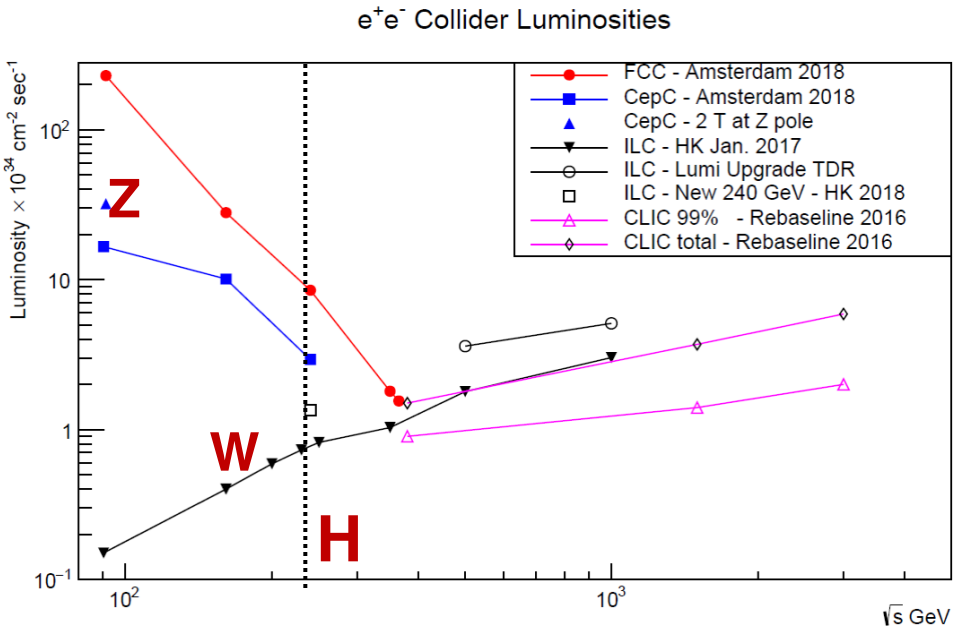
Luminosity vs. CM energy

Circular:

offers higher lumi. @ LE
⇒unprecedented Z,W,+H program
mature technology
HE synchrotron light source (?)
very long term: pp upgrade path

Linear:

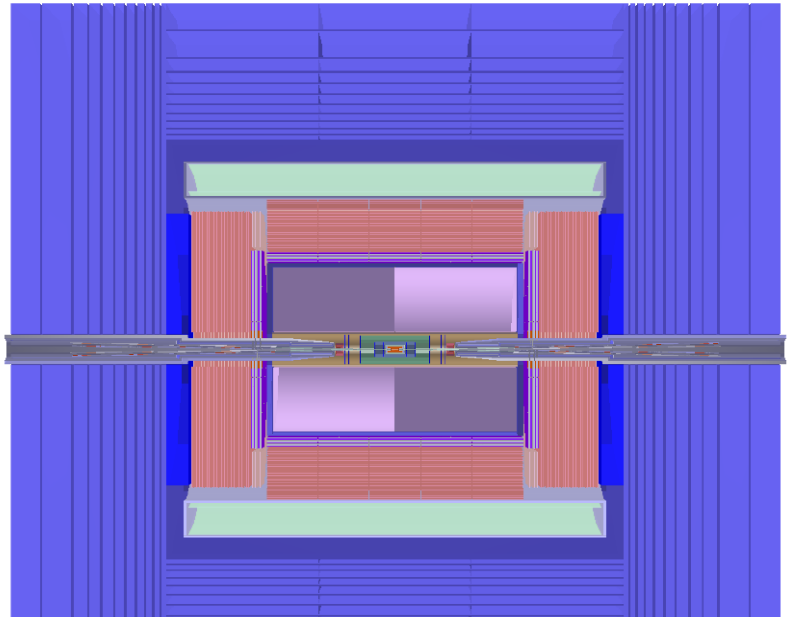
very impressive Higgs precision
best Lumi. at higher energies, or only option for VHE



F. Bedeschi, INFN-Pisa

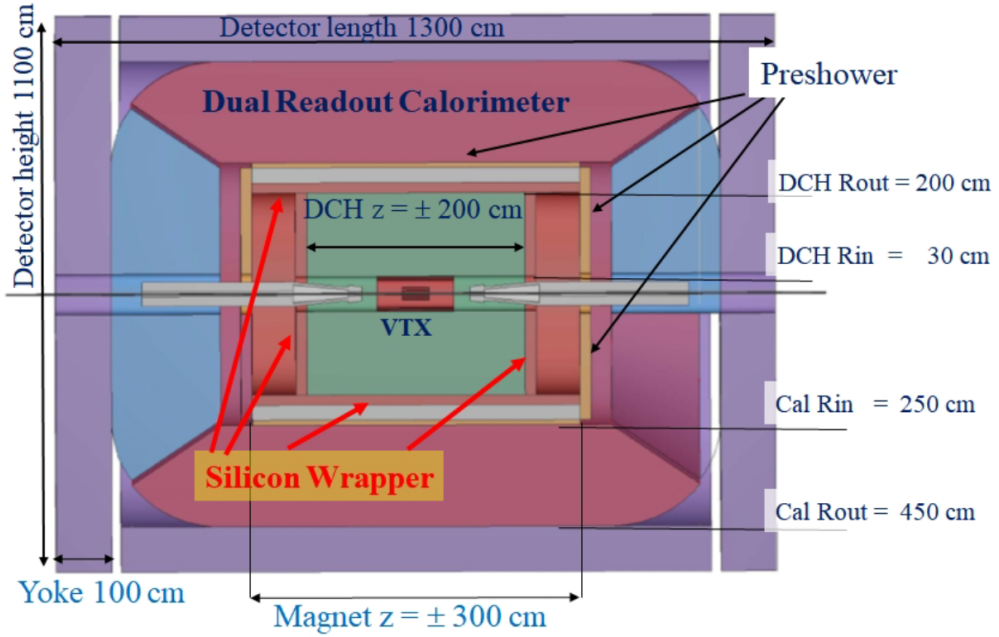
circular & linear colliders are ideally complementary to each other

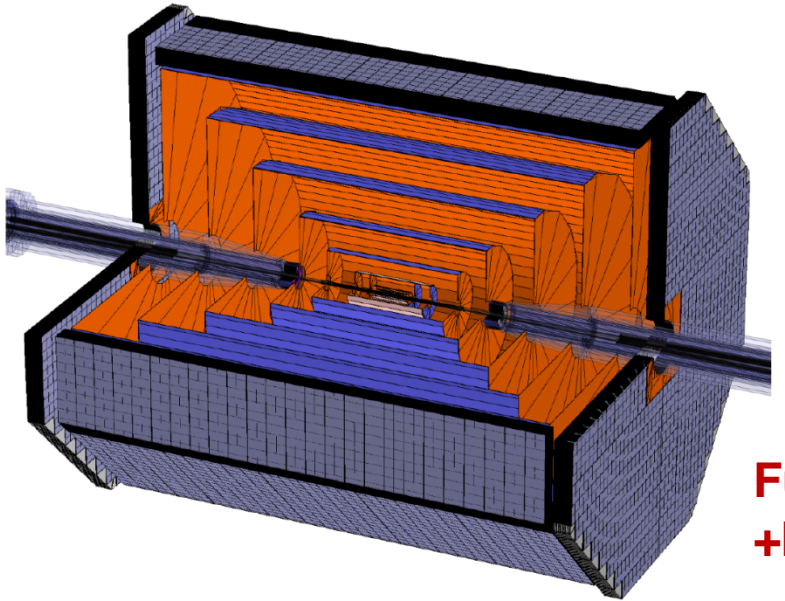
Progress and updates - Detector-Physics



Baseline detector: pixel vertex detector, silicon inner tracker, a TPC, Si external tracker, ECAL, HCAL, 3 T B-field, embedded muondetector

Alternative detector

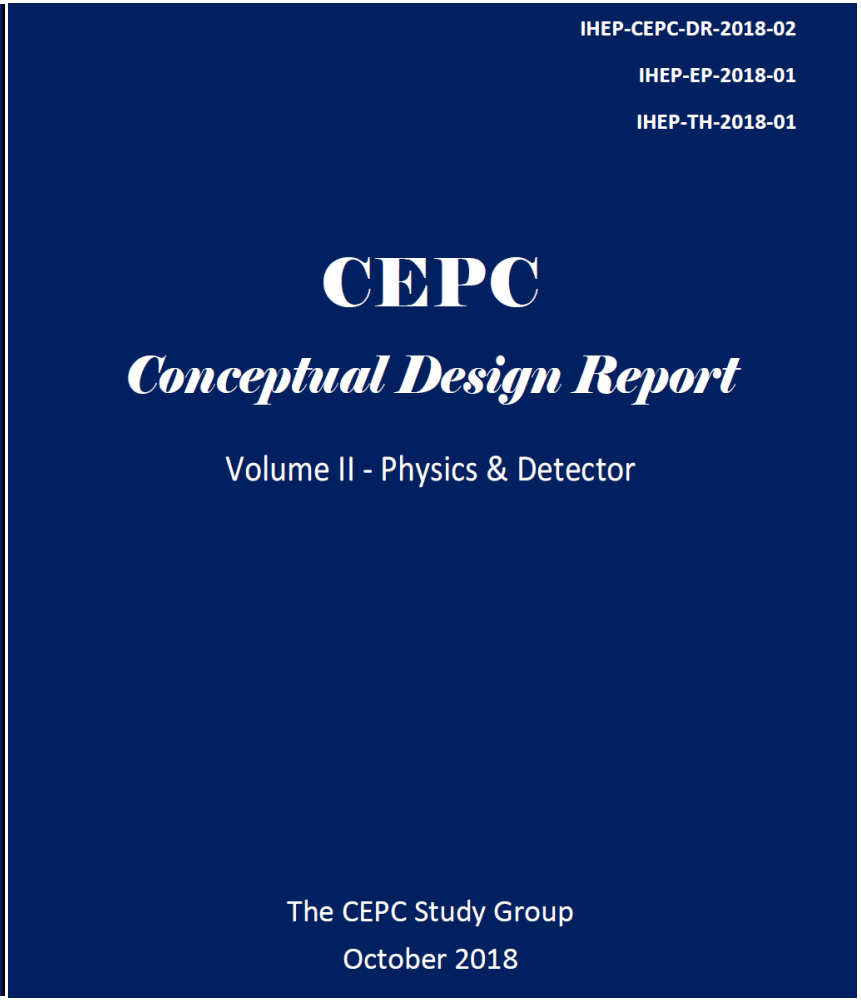




Full silicon tracker +baseline detector

CDR Volumes 1 (Accelerator) and 2 (Physics-Detector) , are available at

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



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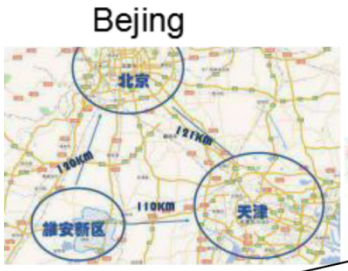
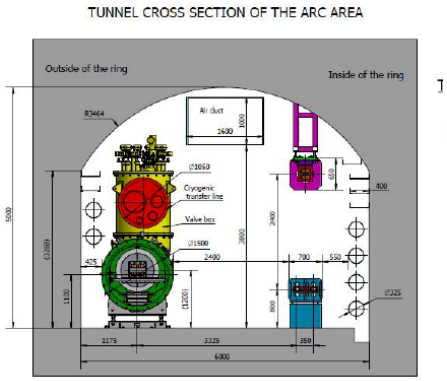
Progress and updates - CEPC CDR



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)

- ✓ site visits & study
- ✓ facility deign
- ✓ construction plan
- ....



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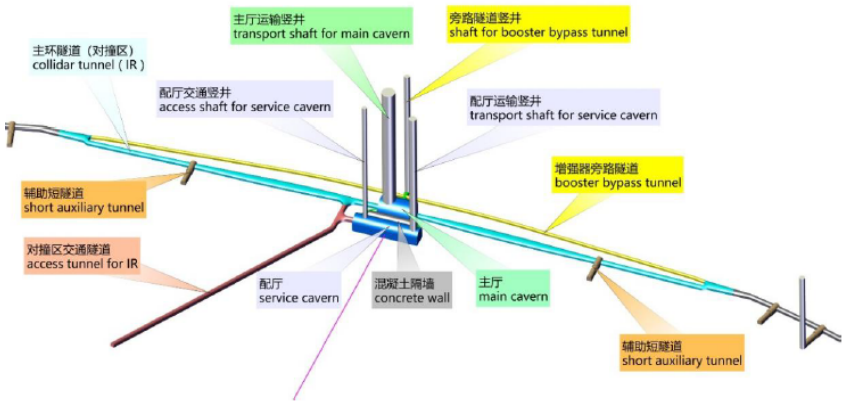
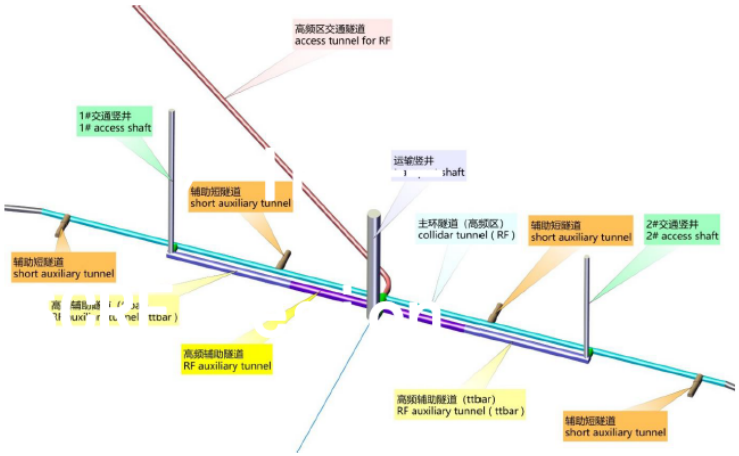
CEPC Interaction Region



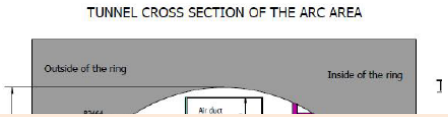
CEPC Injection Region



Progress and updates - CEPC CDR

- ✓ site visits & study
- ✓ facility deign
- ✓ construction plan

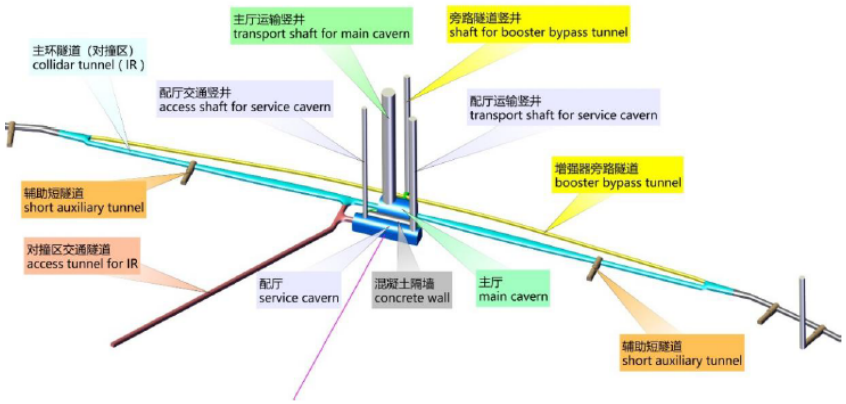
....



CEPC is conducting country wide site visits and study. Local government agencies are very receptive and supportive to CEPC.

CDR study is based on site 1 (Qing Huang Dao).

CEPC Interaction Region



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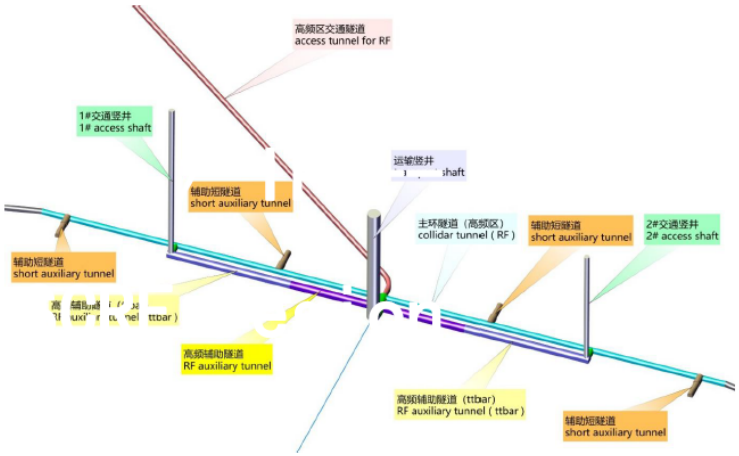


Progress and updates - Funding

2017 workshop

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 RMB CAS-Beijing fund, talent program

~500M RMB Beijing fund (light source)

year 2017 funding request (45M) to MOST and other agencies under preparation

Present day

- **funding request (31M) to MOST approved**
- **funding needs for carrying out CEPC design and R&D basically met**

Progress and updates – Intl Collaboration

- Strengthen cooperation with CERN
- Joined CALICE collab., ILD TPC collab., RD collab.s

- First international workshop on CEPC in Europe – Rome 2017

- Next one will in Oxford, UK, April 15-17, 2019

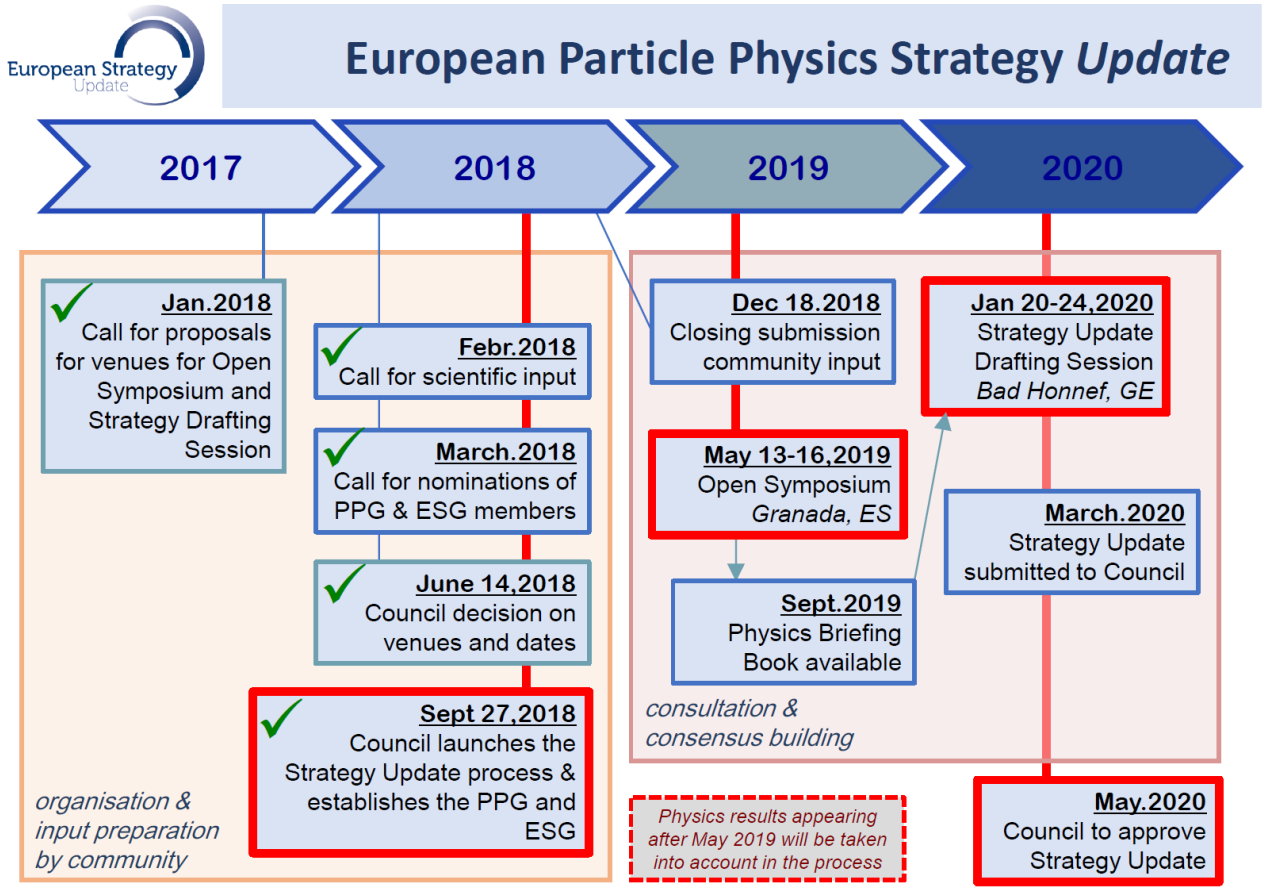
…

- Fourth CEPC IAC meeting (Nov. 14-16, 2018)
  to focus on international collaboration and other aspects

Progress and updates – Intl Collaboration

Preparation for European Strategy for Particle Physics update

Inputs (CEPC accelerator, physics-detector) have been drafted, under review-revision, will be submitted around November 26, 2018



Progress and updates – Path to realization

Chinese Government：”actively initiating major-international science project…”

国发〔2018〕5号 （2018.3.14）

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

- focuses on “**frontier science, large-fundamental science, global focus, international collaboration, …**”
- by year 2020，3-5 projects will be chosen to go into “preparatory stage”, among which 1-2 projects will be selected. More projects will be selected in later years.
- The task of selecting the projects, and develop them further falls on the Ministry of Science and Technology (MOST)
- MOST committees formed, are writing the guidelines
- **This is a likely path to realize CEPC.**
  We are paying close attention to this opportunity

Goals and Plan

CEPC Schedule (ideal) – Goals and Plan

design issues	CDR, funding	seek approval, site decision
R&D items	R&D program	construction
preCDR	Intl. collaboration	during 14th 5-year plan
	site study	commissioning

- R&D, validation, and industrial preparation
- Global collaboration and strategy
- Best positioning CEPC for national government's positive decision
- Realization of the CEPC project

International Workshop on CEPC 2018

Summary

- CEPC CDR volumes (accelerator, detector-physics) completed
- Design + R&D funding needs are largely met with various sources; people are hard working on DRD
- Move towards the TDR, and build a stronger CEPC team w. intl. collab. & participation
- Infrastructure, experience and engineering proficiency gained through current projects (light source, CSNS, etc.) helpful for the CEPC
- Upon successfully completing the DRD program, we expect to make the case to the national government for building CEPC (in ~4-5 years)

北京大学高能物理研究中心
Center for High Energy Physics, PKU

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