CEPC

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FLC retreat, Dec. 2017

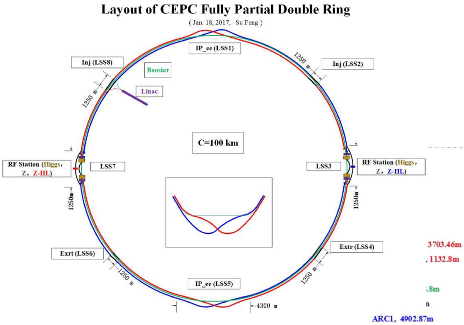
CEPC:

All material is from talks given at the “International Workshop on High Energy Circular Electron Positron Collider” at IHEP, Beijing, 6-8 Nov 2017 (indico).

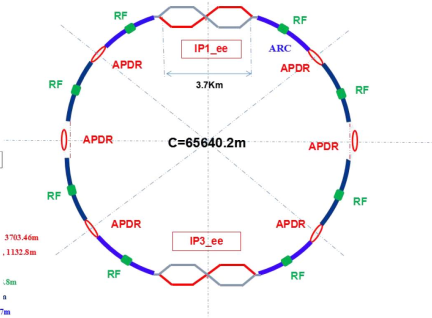
What is it?

- Baseline design & options for the Conceptual Design Report
  - circumference=100km,E_{cm} =240 GeV, power per beam $\leq$ 30MW
  - design luminosity :
    $\sim 2 \times 10^{34} cm^{-2} s^{-1}$ (240 GeV)
    $\sim 1 \times 10^{34} cm^{-2} s^{-1}$ (90 GeV)
  - two layouts:
    double ring as the default
    advanced local double ring as an option
- two independent detectors
- Benefits
  - mature technologies, Z+ZH program
  - high energy pp option beyond the Higgs(Z) factory
  - synchrotron light source (?)

What is it?



CEPC Advanced Partial Double Ring Option II



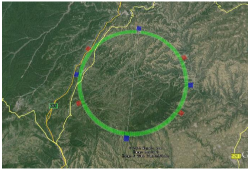
CEPC Baseline Design

Better performance for Higgs and Z compared with alternative scheme, without bottle neck problems, but with higher cost

CEPC Alternative Design

Lower cost and reaching the fundamental requirement for Higgs and Z luminosities, under the condition that sawtooth and beam loading effects be solved

Where is it?



1) QingHuangDao, Hebei（completed preCDR）

2) Huangling, Shaanxi（2017.1 signed contract to exp.）

3) ShenShan, Guangdong, （completed in August, 2016)

Who is it?

Statistics from November ’17 workshop:

- Total 260 participants
  - 160 from China
  - 50 from Europe (10 from Germany, Italy 19)
  - 30 from US
  - 10 from rest of Asia (4 from Japan)

$\Rightarrow$ Clearly a Chinese project !

Project cost comparison

ILC (250 GeV)

	ILC	
CoM. Energy	250	500
Site Length	~21	31
Luminosity	0.82	1.8
AC Power	129	163
Value Cost in TDR	TBD	7.98

($5 - 6B?)

CLIC (380 GeV)

380 GeV centre-of-mass energy.

	Value [MCHF of December 2010]
	1245
	974
	2038
	132
	2112
ure	216
	6690

CEPC (100 km)

总价（万元）100公里
3606984. 81
2323610. 85
250227. 56
32635. 00
1000511. 40

($5.5B)

- No cost available for FCC-ee at this moment

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On the table (1 RMB = 0.1 - 0.15 €)

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/ Tsinghua 高能物理研究所 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)

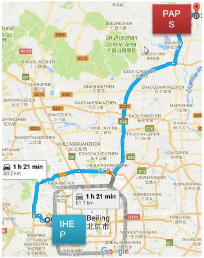
year 2017 funding request (45M) to MOST and other agencies under preparation

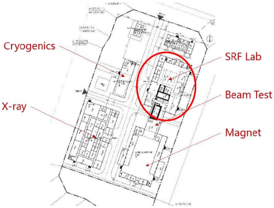
funding needs for carrying out CEPC design and R&D should be fully met by end of 2018

Money: The PAPS for RF R&D

Platform of **A**dvanced **P**hoton **S**ource Technology R&D, Huairou Science Park, Huairou, Beijing

Construction: 2017 - 2019
Ground Breaking: May 31, 2017





4500 m² SRF lab

- **500M RMB funded by city of Beijing**
- **Construction: May 2017 – June 2020**
- **Include RF system & cryogenic systems magnet technology, beam test, etc.**

Time-line

design issues
R&D items
preCDR

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**
- **Possibly con-current with the ILC program**

Time-line comparison

ILC (2030)

CEPC (2030)

CLIC (2035)

FCC-ee (2039)

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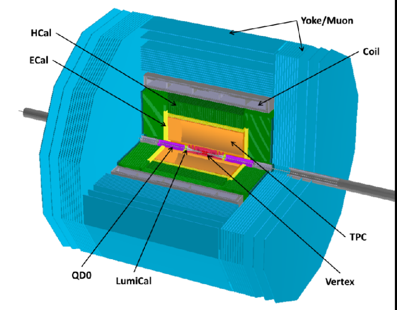
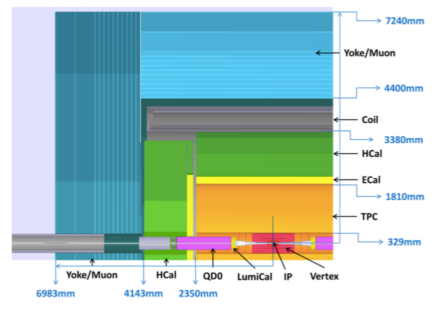
Detectors: ILD - the baseline

CEPC baseline detector: ILD-like





Magnetic Field: 3 Tesla — changed from preCDR

- **Impact parameter resolution**: less than 5 μm → **Flavor tagging**
- **Tracking resolution**: $\delta(1/Pt) \sim 2\times10^{-5}$ (GeV^{-1}) → **BR(Higgs → μμ)**
- **Jet energy resolution**: $\sigma_E/E \sim 0.3/\sqrt{E}$ → **W/Z dijet mass separation**

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Detectors: ILD - the updated baseline

Feasibility & Optimized Parameters

Feasibility analysis: TPC and Passive Cooling Calorimeter is valid for CEPC

	CEPC_v1 (~ ILD)	Optimized (Preliminary)	Comments
Track Radius	1.8 m	>= 1.8 m	Requested by Br(H->di muon) measurement
B Field	**3.5 T**	**3 T**	**Requested by MDI**
ToF	**-**	**50 ps**	**Requested by pi-Kaon separation at Z pole**
ECAL Thickness	84 mm	84(90) mm	84 mm is optimized on Br(H->di photon) at 250 GeV;
ECAL Cell Size	5 mm	10 – 20 mm	Passive cooling request ~ 20 mm. 10 mm should be highly appreciated for EW measurements – need further evaluation
ECAL NLayer	30	20 – 30	Depends on the Silicon Sensor thickness
HCAL Thickness	**1.3 m**	**1 m**	-
HCAL NLayer	**48**	**40**	Optimized on Higgs event at 250 GeV;

November 6, 2017 16

Alternative Detectors: SiD

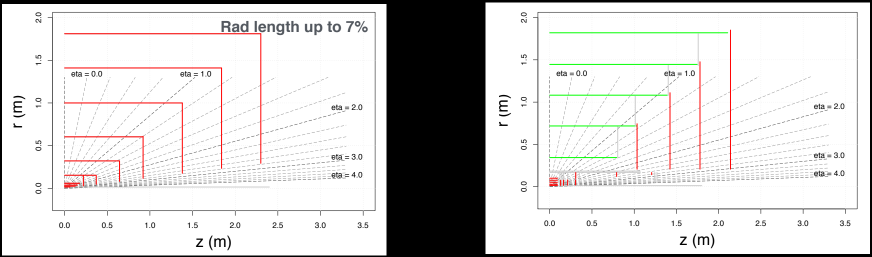
Full silicon tracker concept

Session I: Weiming Yao
CDR: Section 5.3

Replace TPC with additional silicon layers

CEPC-SID:
6 barrel double strip layers
5 endcap double strip layers

SIDB: SiD optimized
5 barrel single strip layers
5 endcap double strip layers



Drawbacks: higher material density, less redundancy and limited particle identification (dE/dx)

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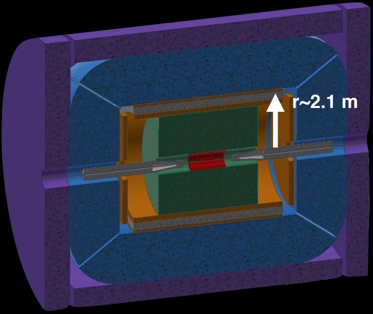
Alternative Detectors: Old friends ... (5th?)

Low magnetic field detector concept

Session I: Franco Bedeschi
CDR: Section 3.3

Proposed by INFN, Italy colleagues



Magnet: 2 Tesla, 2.1 m radius
Thin (~ 30 cm), low-mass (~0.8 X_0)

Beam pipe: radius 1.5 cm

Vertex: Similar to CEPC default

Drift chamber: 4 m long; Radius ~30-200 cm

Preshower: ~1 X_0

Dual-readout calorimeter: 2 m/8 λ_{int}

(yoke) muon chambers

Integrated into Conceptual Design Report
Dual readout calorimeter: Chapter 6
Talk: Session IV - Roberto Ferrari

Drift chamber: Chapter 5
Talk: Session II - Franco Gancagnolo

Muon detector (μRwell): Chapter 8
Talk: Session IV - Paolo Giacomelli

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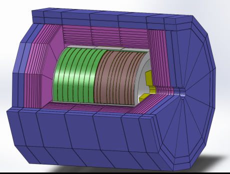
Alternative Detectors: ... twice ! (6th?)

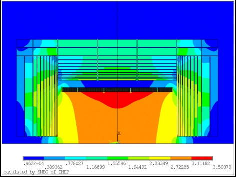
Superconductor solenoid development

Session I: Zian Zhu
CDR: Chapter 7

Updated design done for 3 Tesla field (down from 3.5 T)

Default: Iron Yoke



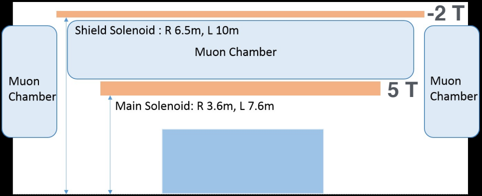


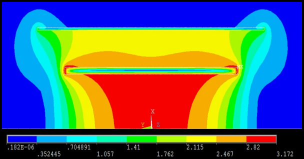
Non-uniformity 9.1%

Dual Solenoid Scenario

Lighter and more compact

Concept improved by FCC studies





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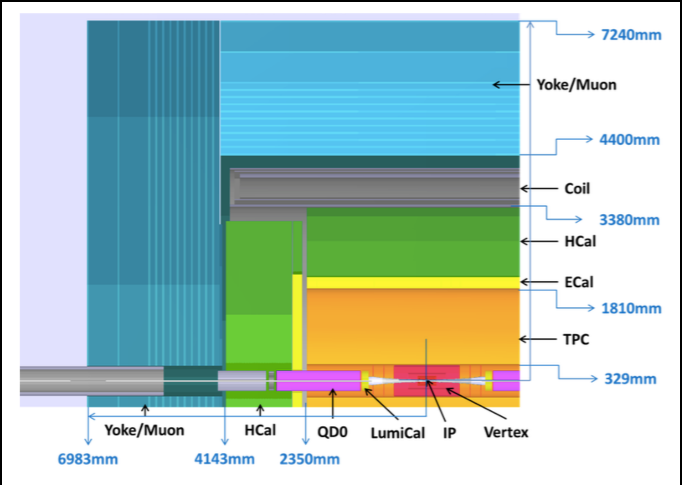
Detectors: QD0 !



Detectors: MDI

Interaction region: Machine Detector Interface

Session MDI: Chenghui Yu
CDR: Chapter 10

One of the most complicated issue in the CEPC detector design

Full partial double ring

Updated baseline parameters:

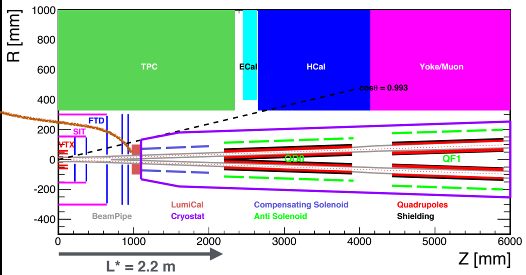
- Head-on collision changed to crossing angle of **33 mrad**
- Focal length (**L***) increased from 1.5 m to **2.2 m**
- Solenoid field reduced from 3.5 T to **3 T**

LumiCal

Lumi unc: 1 × 10^{-3}

Session MDI: Suen Hou
CDR: Chapter 10

(studies lead by Vinca and Academia Sinica)



Magnet	Field Strength	Length	Inner Radius
QD0	151 T/m	1.73m	19 mm

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Detectors: Backgrounds

Interaction region: Machine Detector Interface

Session MDI: Hongbo Zhu
CDR: Chapter 10

Machine induced backgrounds

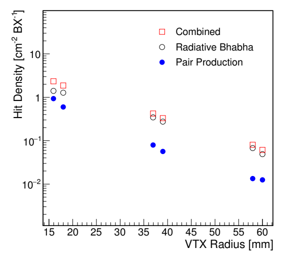
- Radiative Bhabha scattering
- Beam-beam interactions
- Synchrotron radiation
- Beam-gas interactions

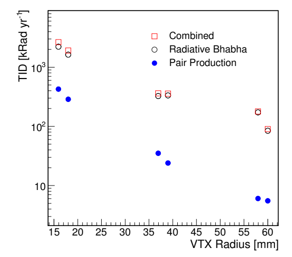
Studies for new configuration being finalized

Higgs operation
(E_{cm} = 240 GeV)

Rates at the inner layer (16 mm):
Hit density: ~2.5 hits/cm²/BX
TID: 2.5 MRad/year
NIEL: 10^{12} 1MeV n_{eq}/cm²

(Safety factors of 10 applied)





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Detectors: TPC - looks strangely familiar ...

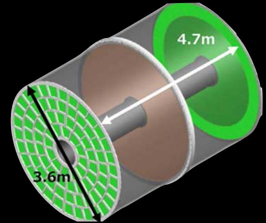
Time Projection Chamber (TPC)

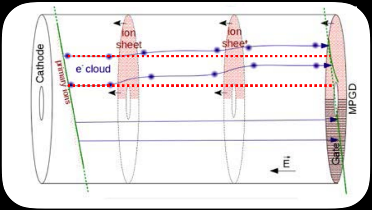
Session III: Huirong Qi
CDR: Chapter 5

TPC detector concept

- **Allows for particle identification**
- **Low material budget**
- **3 Tesla magnetic field —> reduces diffusion of drifting electrons**
- **Position resolution: ~100 μm in rϕ**
- **Systematics precision (<20 μm internal)**
- **GEM and Micromegas as readout**
- **Problem: Ion Back Flow —> track distortion**

Operation at $L > 2 \times 10^{34}$ cm^{-2} s^{-1} ?





Manpower and activities

- TPC detector R&D @IHEP (2016~2020)
  - Funding from MOST and NSFC (~3.5 Million RMB)
- Electronics R&D @Tsinghua (2016~2020)
  - Funding from NSFC (~2.0 Million RMB)
- Inhabitation of IBF using graphene @Shandong Univ. (2016~2019)

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Detectors: TPC Collaboration

International cooperation

- CEA-Saclay IRFU group (FCPPL)
  - Three vidyo meetings with Prof. Aleksan Roy/ Prof. Yuanning/ Manqi and some related persons (2016~2017)
  - Exchange PhD students: Haiyun Wang participates Saclay's R&D six months in 2017~2018
  - Bulk-Micromegas detector assembled and IBF test
  - IBF test using the new Micromegas module with more 590 LPI
- LCTPC collaboration group (LCTPC)
  - Singed MOA and joined in LC-TPC collaboration @Dec. 14,2016
  - As coordinator in ions test and the new module design work package
  - Regular meeting bi-weeks
  - Plan to beam test in DESY with our hybrid detector module in 2018

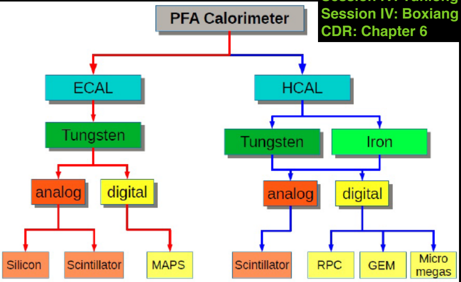
Detectors: Calorimeters - all options open

Calorimeter options

Session IV: Yunlong Zhang
Session IV: Boxiang Yu
CDR: Chapter 6

Chinese institutions have been focusing on Particle Flow calorimeters

R&D supported by MOST, NSFC and IHEP seed funding



Electromagnetic	ECAL with Silicon and Tungsten (LLR, France) ECAL with Scintillator+SiPM and Tungsten (IHEP + USTC)
Hadronic	SDHCAL with RPC and Stainless Steel (SJTU + IPNL, France) HCAL with ThGEM/GEM and Stainless Steel (IHEP + UCAS + USTC) HCAL with Scintillator+SiPM and Stainless Steel (IHEP)
New →	Dual readout calorimeters (INFN, Italy + Iowa, USA)

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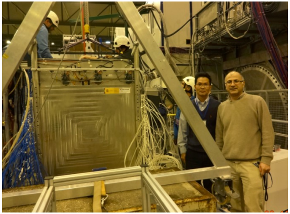
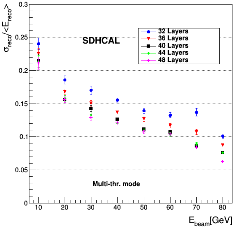
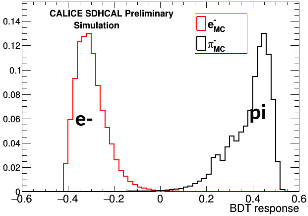
Detectors: CALICE

THU/SJTU/CALICE

- THU and SJTU joined the CALICE Collaboration
- Collaborating with Imad Laktineh (IPNL) on SDHCAL R&D.
- We have a joint Ph.D student via CSC program (2years). CAN-059 about using BDT to improve pi/e/mu separation is under review process.
- SJTU will host the CALICE collaboration meeting on Sept. 19-21, 2018. https://agenda.linearcollider.org/event/7799/





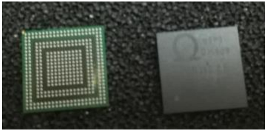


Detectors: AHCal

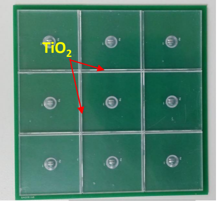
CEPC-AHCAL Next step

- ASCI chip readout research;
- Test Chinese (GNKD) plastic scintillator;
- Test the Chinese EQR-SiPM;
- Scintillator mega tiles test;

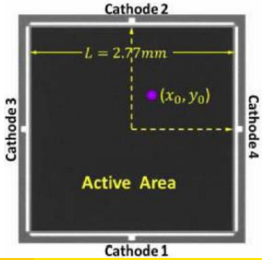
ASIC chip Spiroc2E



Mega tiles



Chinese SiPM



SW: Current framework

- Current CEPC software uses Marlin, adopted from ILC
- CEPC software group are built, including current CEPC software group, IHEPCC, SDU, SYSU, JINR……to work on future CEPC software
- Consider uncertain official support of Marlin, future CEPC software framework are investigated
  - Several existing framework are studied
- Gaudi is preferred with wider community, possible long-term official support, more experts available in hand, keep improved with parallel computing
- International review meeting is in consideration for final decision of framework

	Marlin	Gaudi	ROOT	ART	SNiPER
User Interface	XML	Python, TXT	Root script	FHiCL	Python
Community	ILC	Atlas, BES3, DYB,LHCb	Phenix, Alice	Mu2e, NOvA, LArSoft, LBNF	JUNO, LHAASO

SW: Current resources

- Active Site: 6 from England,Taiwan, China Universities(4)
  - QMUL from England and IPAS from Taiwan plays a great role
  - Cloud technology used to share free resource from other experiments in IHEP
- Resource: ~2500 CPU cores, shared resources with other experiments
- Resource types include Cluster, Grid ,Cloud
- Network: 10Gb/s to USA and Europe, to TaiWan and China University
  - Joining LHCONE is in plan to future improve international network connection

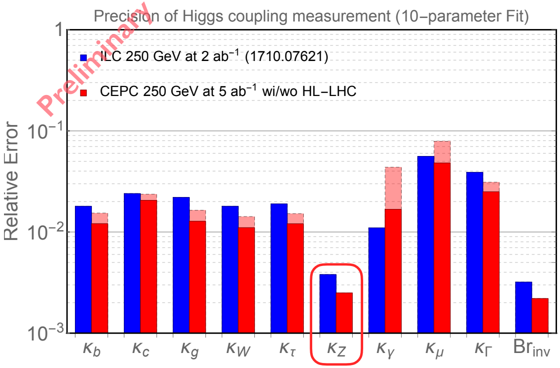
Site Name	CPU Cores
CLOUD.IHEP-OPENSTACK.cn	96
CLOUD.IHEP-OPENNEBULA.cn	24
CLOUD.IHEPCLOUD.cn	200
GRID.QMUL.uk	1600
CLUSTER.IPAS.tw	500
CLUSTER.SJTU.cn	100
Total (Active)	**2520**

QMUL: Queen Mary University of London
IPAS: Institute of Physics, Academia Sinica

Physics: Higgs

..... poor-man's ILC(250) @ H : Twice the lumi, but no polarisation. And short life-time (SppC!)

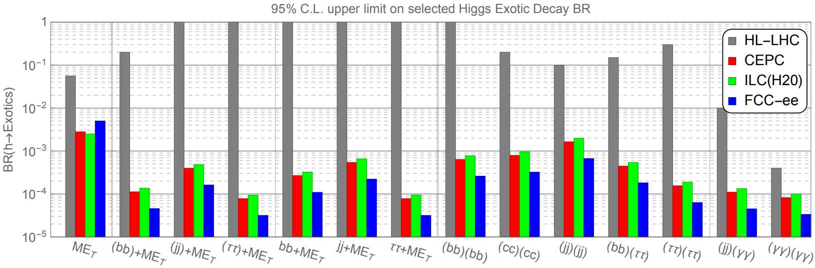
Zhen Liu, Jin Wang, Kaili Zhang



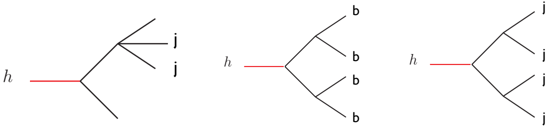
Physics: Exotic higgs decays

Higgs exotic decay

Zhen Liu, LTW, Hao Zhang

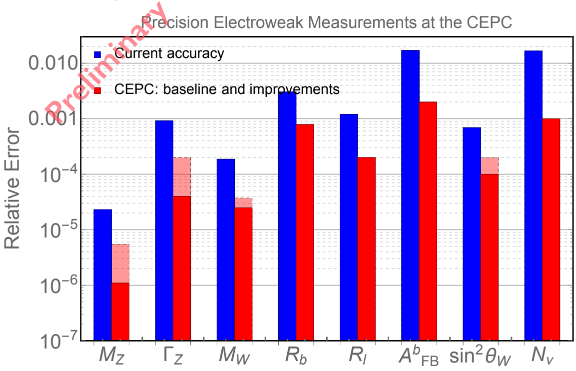


Examples:



Physics: ... but a great Z&W factory !

Z-factory



Based on Giga-Z. Large improvement.
Systematic dominated

projection: Zhijun Liang

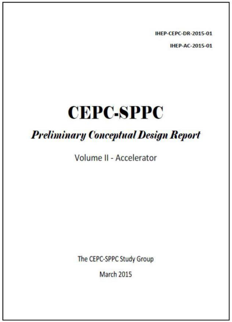
My Summary

- CEPC is quite similar to ILC@250 in
  - Cost
  - Physics potential
  - Time-line (It might seem optimistic, but remember that it is just a *very* big electron synchrotron - something one knows how to build !)
  - Both will upgrade after 10 years (Although only ILC will make an upgrade that makes sense ...)
- $\Rightarrow$ Unlikely that both would be built ...
- We *are* already collaborating, via LCTPC and CALICE
- Most effort (and funding) is on the machine, and on CEPC, not SppC.
- Much less on detector development and SW $\Rightarrow$ We would find our place in those fields.

All about it:

Progress report, along with the preCDR, is available at

http://cepc.ihep.ac.cn

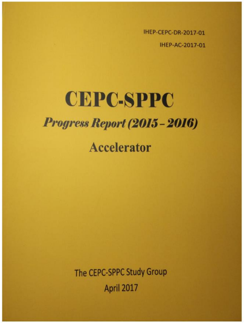

IHEP-CEPC-DR-2015-01
IHEP-AC-2015-01

CEPC-SPPC

Preliminary Conceptual Design Report

Volume II - Accelerator

The CEPC-SPPC Study Group
March 2015


IHEP-CEPC-DR-2017-01
IHEP-AC-2017-01

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Progress Report (2015 – 2016)

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CEPC CDR will be completed at the end of 2017

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