The CEPC-SppC Study Group in China

Introduction, Status and Future Plans

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CFHEP Kick-off Meeting, Beijing

Feb. 24, 2014

Outline

- History: Accelerator Based HE Physics Programs in China
- Impact of HEP on China's Science & Technology
- Post BEPC-II options under study in China
- CEPC+SppC: a Higgs factory and a high energy pp collider
- Get organized to study the feasibility of CEPC+SPPC
- Current status
- Prospects

History: Accelerator Based HE Physics Programs in China

- **Beijing Spectrometer Experiment (BES, BES-II, BES-III)**
  at the BEPC (II) colliders (similar to the SPEAR collider)
  BEPC(1988), BEPC-II(2008)
- **International Collaborations**
  CERN: L3 at LEP, ATLAS-CMS at LHC
  KEK: Belle (-II)
  others

Established Chinese HEP experimental facilities

Trained several generations of physicists

Project (large scientific) management experience

Opened up international cooperation & visiting programs

Help establish and strengthen university HEP groups

Impact of Accelerator based HEP on China's Science & Tech.

- Scientific results
- Move on to build other major scientific apparatus

  Neutrino experiments, high energy astrophysics

  Synchrotron radiation facilities (Beijing, Shanghai, Northern China)

  Chinese Neutron Spallation Source in Southern China

- First internet connection in China to the outside world
- First Chinese Web site (IHEP)
- HP & Grid computing
- ……

Post BEPC-II options under consideration in China

Chinese Physical Society HEP Division is organizing the **feasibility study** of

HL Charm Factory E_{beam}=1-3 GeV, luminosity ≈$10^{35\text{-}36}$ $cm^{-1}s^{-1}$ at E=2 GeV

Z-factory (see Prof. Chao-Hsi Chang's talk)

EIC (see Prof. Xin-nian Wang's talk)

CEPC-SppC

- Physics potentials and objectives
- Accelerator design and critical technologies
- Detector technologies

Hope "to converge to a single accelerator facility in China that the HEP community will support"

CEPC-SppC
a circular e^+e^- Higgs factory + pp collider

- The idea of a circular e^+e^- collider as a Circular Electron Positron Collider (CEPC) as a Higgs Factory had been proposed for China at several of the "Accelerator Based HEP Program Workshops" during 2011-2012. Even though the evidences for the Higgs from ATLAS and CMS had not crossed the 5σ discovery threshold.

- At the September 13, 2012 workshop, an idea to upgrade CEPC to a 50-70 TeV pp collider adds life and physics potentials to the project

- On October 8th, 2012, a meeting was called by IHEP director Yifang Wang to discuss the CEPC + SPPC option. The effort intensified significantly since.

- XiangShan Science Forum (香山科学会议)
  - Consensus on the importance of Higgs physics
  - CEPC-SPPC Kick-off meeting was set for Sept. 13-14, 2013
  - Form CEPC-SppC Kick-off meeting Org. Committee（**Chair Y. F. Wang**）
  - Considered the organization structure of the CEPC-SppC study group
    - **IR committee， EB ， Advisory Committees,**
    - **Project Director， Conveners for study groups**

CEPC-SppC
Considerations

- A circular Higgs factory fits our strategic needs in terms of
  - Science (great & definite physics)
  - Timing (after BEPCII)
  - Technological feasibility (experience at BEPC/BEPCII and other machines in the world),
  - Manpower reality (our hands are free after ~2020)
  - Economical scale (although slightly too high)
- The risk of no-new-physics is complement by a pp collider in the same tunnel
  - A definite path to the future
- A unique position for China to contribute at this moment:
  - Economical growth ➔ new funding to the community
  - Large & young population ➔ new blood to the community
  - Affordable tunnel & infrastructure
  - If no new project, no new resources ➔ It is a pity if we miss it

Y. F. Wang

CEPC is broadly for

"**C**ircular **E**lectron **P**ositron **C**ollider"

"**C**ircular **E**lectron **P**roton **C**ollider"

"**C**ircular **E**lectron-positron or **P**roton-proton **C**ollider

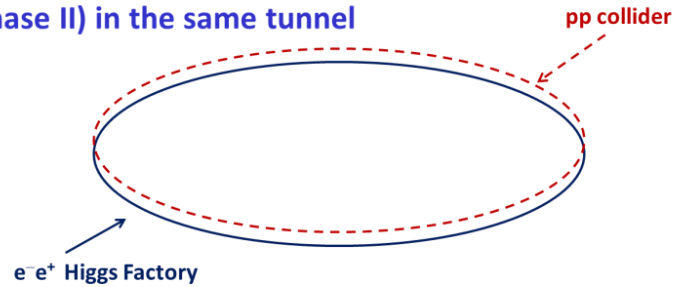
CEPC is an inclusive program

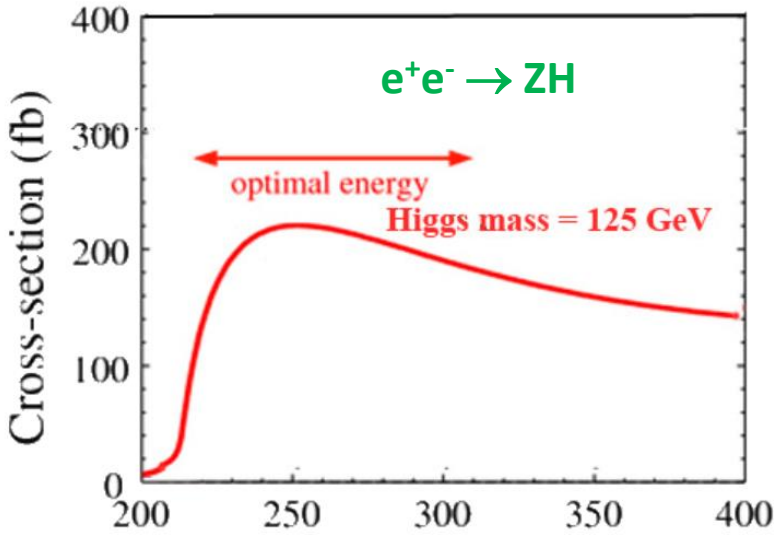
Phase 1: e^+e^- Higgs factory

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

Phase 2: a discovery machine; pp collision with $E_{cm} \approx$ 50-90 TeV

- Circular Higgs factory (phase I) + super pp collider (phase II) in the same tunnel





The CEPC-SppC Kick-off Meeting in Beijing

- The Chinese CEPC+SPPC Study Group kick-off meeting took place Sept. 13-14 in Beijing
- Participation by over 120 physicists from 19 domestic institutes
- Domestic accelerator, theoretical and experimental physicists were organized

The Circular Electron-Positron Collider as a Higgs Factory (CEPC)

CEPC-SppC Organization –

- Institutional Board:

  chairman: **GAO Yuanning** (Tsinghua U); 1 rep. per institution

  deputy chairman: **GAO Jie** (IHEP)

- Steering committee:

  chairman **WANG Yifang** (IHEP); 8 members

- Project directors: **LOU Xinchou (**IHEP), **QIN Qing** (IHEP)
- Working groups:
  - Theory (Convener: **Hongjia He, Shouhua Zhu**)
  - Accelerator (Convener: **QIN Qing, GAO Jie**)
  - Detector (Convener : **JIN Shan, GAO Yuanning**)
  - Established sub-groups

International Workshop Held in Beijing Dec. 16-17, 2013

The workshop will bring together people interested in circular high energy e^+e^- colliders as a Higgs factory as well as a future circular high energy pp collider beyond the Higgs factory, and will discuss critical issues in accelerator technology, detector design and in theory on the precision measurement of the Higgs and the physics with pp collision at 50-100 TeV.

Monday, December 16, 2013

09:00 - 10:35 Session I
Convener: Prof. Xinchou Lou (IHEP, Beijing)
09:00 Welcome and Introduction 15' Speaker: Prof. Yifang Wang (IHEP)
09:15 Physics Opportunities 40'
Speaker: Prof. Nima Arkani-Hamed (Princeton)
09:55 The HL-LHC Physics Program 40'
Speaker: Dr. Takanori Kono (KEK/Ochanomizu)

10:55 - 12:05 Session II
Convener: Dr. Frank Zimmermann (CERN)
10:55 First Look at the Physics Case of TLEP 35'
Speaker: Prof. Alain Blondel (DPNC UNiversity og Geneva)

11:30 CEPC Machine Optimization and Final Focus Design 35'
Speaker: Dr. Dou Wang (IHEP)

14:00 - 15:45 Session III
Convener: Prof. Qing QIN (Institute of High Energy Physics)
14:00 Beam-beam Study of TLEP and Super-KEKB 35'
Speaker: Dr. Demin Zhou (KEK)

…….

Get organized to study the feasibility of CEPC+SppC

- ✓ Kick-off meeting
- ✓ Organization
- ✓ Working group meetings
- ✓ Recruitment and training
- ✓ Regular Steering Committee meetings
- ✓ Regular CEPC-SppC group workshops & meetings

  3 times per year

- ✓ CFHEP – get theoretical guidance

CEPC – current status

Theoretical effort

Detector efforts

Accelerator effort

Pre-CDR, TDR

Site investigation – considerations, possible example sites,

IHEP program review

FCC cooperation

CEPC – theory effort

- Pre- and Post Kick-off Meeting theory effort led by **Hong-jian He** and **Shouhua Zhu**
  - Sub-groups formed
  - Meetings
  - Document " Higgs Physics at CEPC-SPPC " (90pages, v3) in progress

Higgs Physics at the CEPC-SPPC

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ABSTRACT: In this report, we survey Higgs physics in the SM and beyond, review the current measurements of Higgs physics at the LHC, and present the potential studies of Higgs physics at the CEPC-SPPC.

CEPC – theory effort

- Presentations at this workshop
  - Session: Physics Overview
  - Session: Working Group Activities I
  - Session: Working Group Activities II
  - Session: Working Group Activities III

http://indico.ihep.ac.cn/conferenceDisplay.py?ovw=True&confId=4068

CEPC – theory effort

CFHEP

- This is a machine for the world and by the world: not a Chinese one
- As a first step, “Center for Future High Energy Physics (CFHEP)” is established
  - Prof. Nima Arkani-Hamed is now the director
  - Many theorists (coordinated by Nima and Tao Han) and accelerator physicists(coordinated by Weiren Chou) from all the world have signed to work here from weeks to months.
  - More are welcome ➔ need support from the related management
  - Current work:
    - Workshops, seminars, public lectures, working sessions, …
    - Pre-CDR
  - Future works (with the expansion of CFHEP)
    - CDR & TDR
    - Engineer design and construction
  - A seed for an international lab ➔
    Organized and managed by the community

CEPC – current accelerator status

e+e- collider as a Higgs factory

- Beam energy ~ 120 GeV
- Synchrotron radiation power ~50 MW
- 50 or 70 km in circumference (two options)

Proton-proton collider

- Beam energy ~50-90 TeV
- 50 or 70 km in circumference
- Superconducting, high-field magnets (~20T)

The size of the ring will be decided later. The main consideration will be the Project cost. Preliminarily the total budget is capped at 20B RMB. ($3.3B)

CEPC – current accelerator status

Main ring:

- A FODO lattice in arcs with 60 degree phase advances
- 16-folder symmetry
- RF sections distribute around the ring

  f_{rf} = 700MHz is chosen
- Pretzel scheme is adopted for multi-bunch collision
- Double ring option is under-investigation
- ATF2 type and ILC type FFS designs are currently under study

Booster:

- In the same tunnel of the collider (6 – 120 GeV)

Linac:

- 6 GeV–Linac will be adopted

Main CEPC parameters with C=50km

Parameter	Unit	Value	Parameter	Unit	Value
Bean Energy	GeV	120	Circumference	km	50
Number of IP		2	L_0 /IP (10^{34})	$cm^{-2}s^{-1}$	2.62
No. of Higgs/year/IP		1E+05	Power(wall)	MW	200
e+ polarization		0	e- polarization		0
Bending radius	km	6.2	N_e/bunch	1E10	35.2
N_b/beam		50	Beam current	mA	16.9
SR loss	(GeV/turn)	2.96	SR power/beam	MW	50
Critical energy of SR	MeV	0.6	ε_x,n	mm-mrad	1.57E+06
ε_y,n	mm-mrad	7.75E+03	β_{IP} (x/y)	mm	200/1
Trans. size (x/y)	μm	36.6/0.18	Bunch length	mm	3
Energy spread SR	%	0.13	Full crossing angle	mrad	0
Lifetime due to Bhabha	sec	930	Damping part. No. (x/y/z)		1/1/2
b-b tune shift x/y		0.1/0.1	Syn. Osci. tune		0.13
RF voltage V_{rf}	GV	4.2	Mom. compaction	1E-4	0.4
Long. Damping time	turns	40.5	Ave. No. of photons		0.59
dB beam-beam	%	0.014			

Main Parameters of SppC

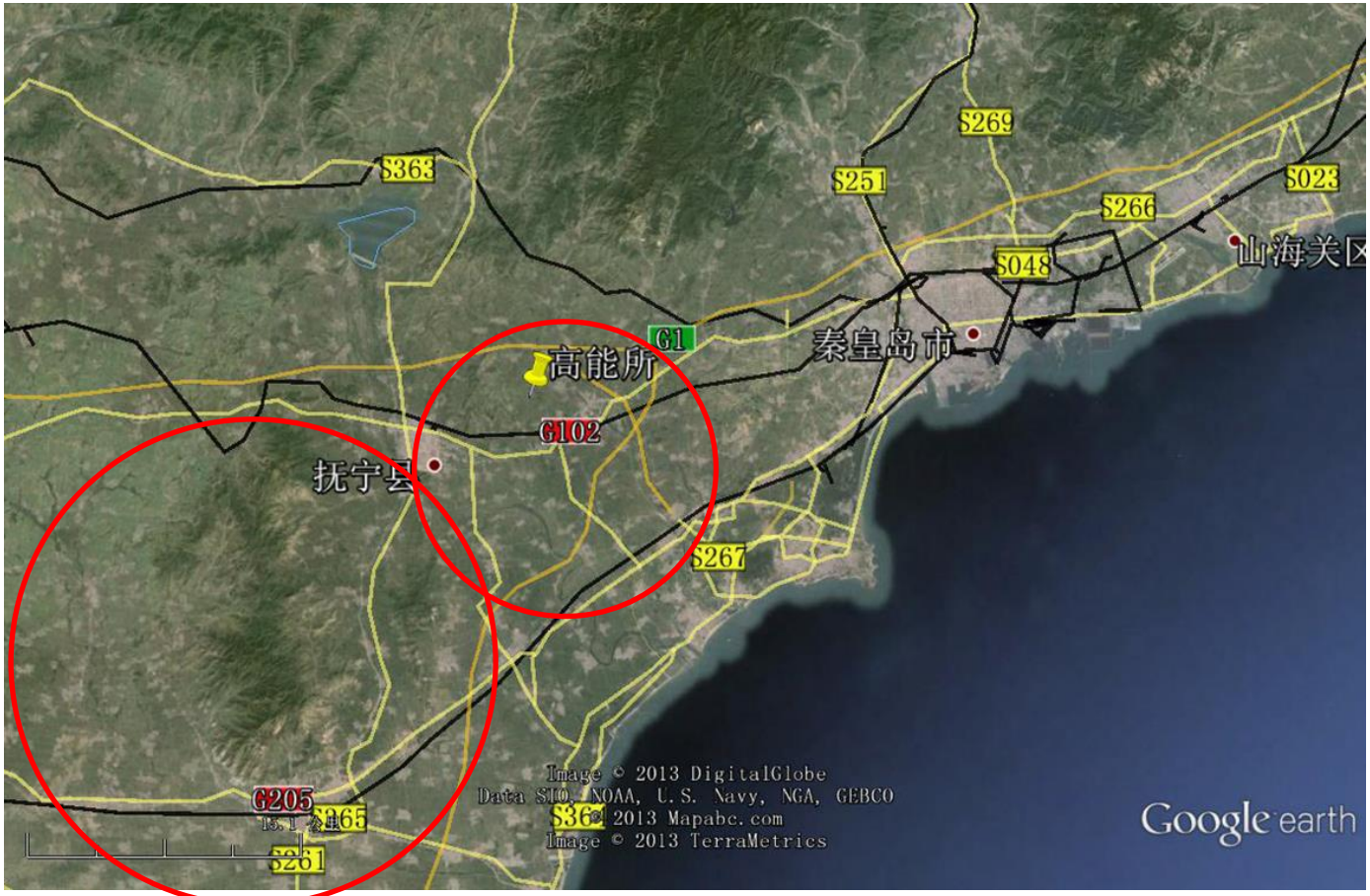
Parameter	SppC-1	SppC-2
Beam energy (TeV)	25	45
Circumference (km)	49.78	69.88
Number of IPs	2	2
SR loss/turn (keV)	440	4090
N_p/bunch (10^{11})	1.3	0.98
Bunch number	3000	6000
Beam current (mA)	0.5	0.405
SR power /ring (MW)	0.22	1.66
B_0 (T)	12	19.24
Bending radius (km)	6.9	7.8
Momentum compaction (10^{-4})	3.5	2.5
β_{IP} x/y (m)	0.1/0.1	0.1/0.1
Norm. trans. emit. x/y (μm·rad)	4	3
ξ_y/IP	0.004	0.004
Geo. luminosity reduction factor F	0.8	0.9
Luminosity /IP ($10^{35}cm^{-2}s^{-1}$)	2.15	2.85

CEPC – Site Investigation

Considerations: clean air, beautiful; geologically suitable, free land for campus, close to Beijing with easy access; local government support,…

Possible sites: visits to more than 14 sites, initial evaluations of geo. structure done

A good example is Qinghungdao (秦皇岛)



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CEPC – Site Investigation

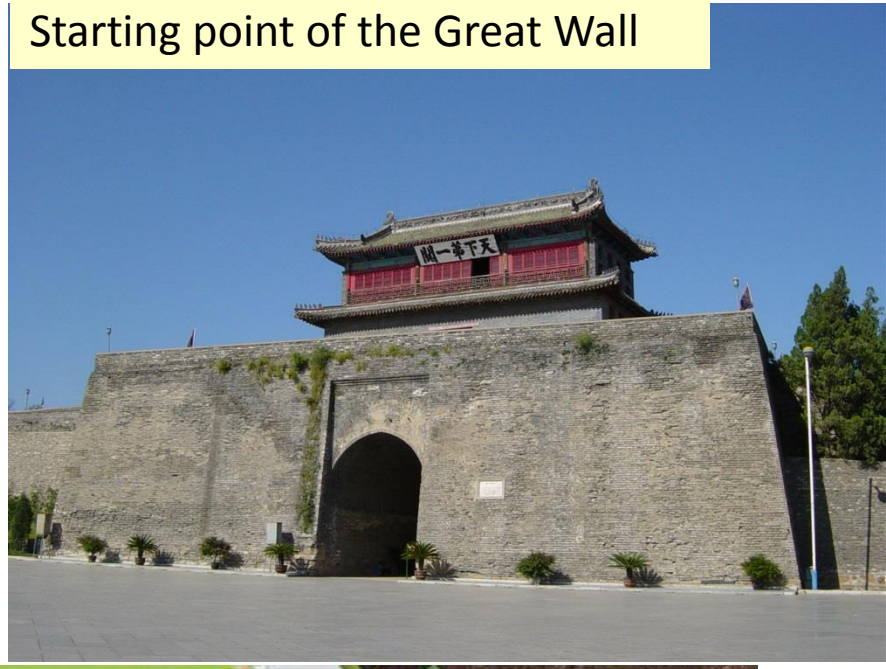
Qinghungdao (秦皇岛)

- 300 km from Beijing
- 3 hours by car
- 1 hours by high speed train

CEPC – Site Investigation Qinghungdao (秦皇岛)

Best beach & cleanest air
Summer capital of China

Starting point of the Great Wall



Wine yard

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CEPC – Site Investigation Qinghungdao (秦皇岛)

Good geological condition

- Base rock type: granite
- Base rock depth: 0.5 - 2 m
- Seismic intensity: no more than the level 7 (some damage to houses), 0.10g
- Earth vibration(RMS, nm):

	Zhangjiakou	Huailai	Qinhuangdao	Tianjing	Huairou
1~100hz	~12	~40	~1.9	~470	~60
4~100hz	~7	~14	~0.8	~24	

Building the tunnel in granite will have the lowest cost

Y. F. Wang

CEPC – Detector Considerations

Benefit greatly from the work done with the ILC

Start with the ILD

- ✓ Adopt the detector technologies and basic layout

- ➢ detector operates without the power pulsing
- ➢ vary detector geometries

- ➢ will implement simulation to evaluate the detector performance at the CEPC and do the cost estimates

CEPC – Detector Considerations

CEPC Detector: Institutes

Theory

VTX	TPC	Calo	Physics Requirement
ShanDong University (SDU) IHEP ...	Tsinghua University (THU), University of Chinese Academic of Science (UCAS), IHEP ...	University of Science and Technology of China (USTC), Shanghai Jiaotong University (SJTU), Wuhan University (WhU), Nanjing University IHEP ...	Nankai University, Pekin University (PKU), Beihang University, Center China Normal University (CCNU), IHEP ...

Machine

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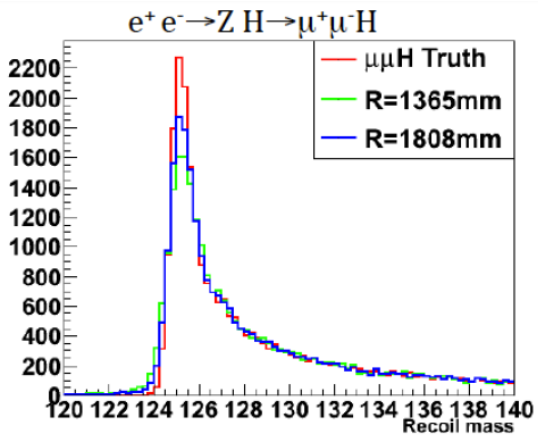
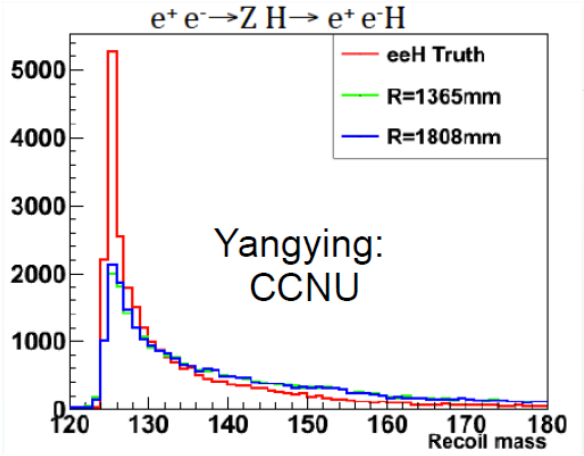
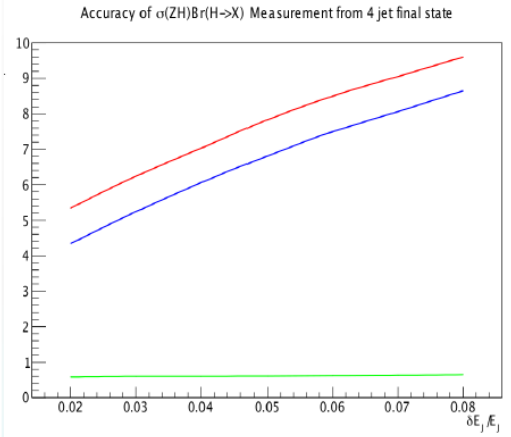
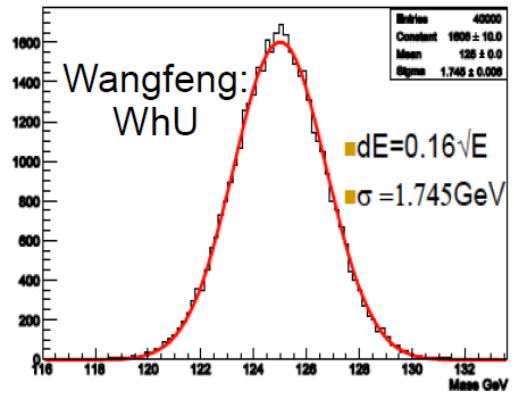
CEPC – Detector Considerations

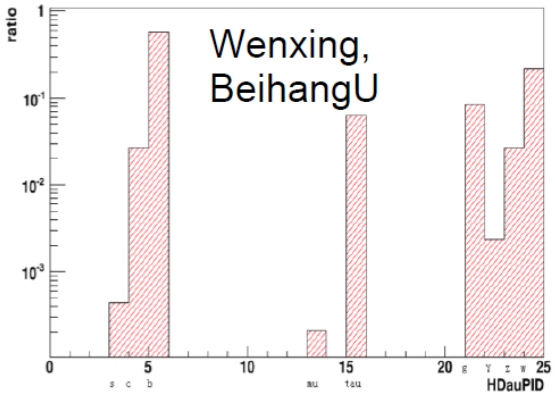
Ongoing Physics Analysis

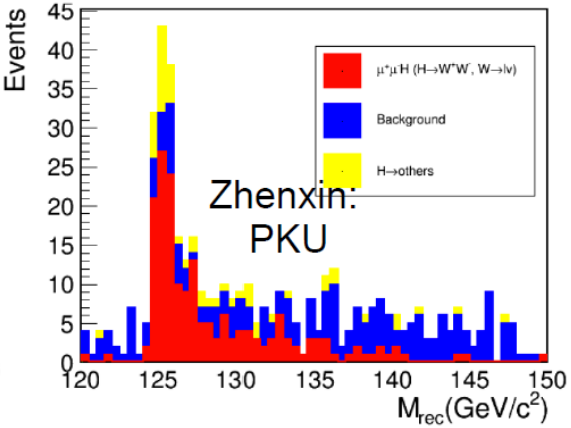












Duchun(IHEP): generator development/comparison

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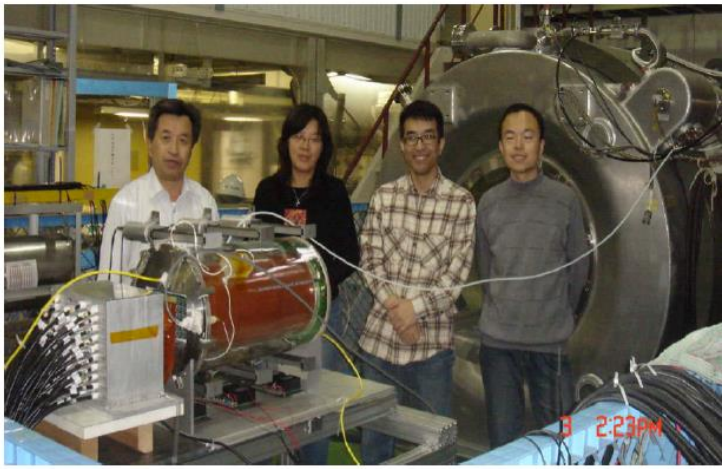
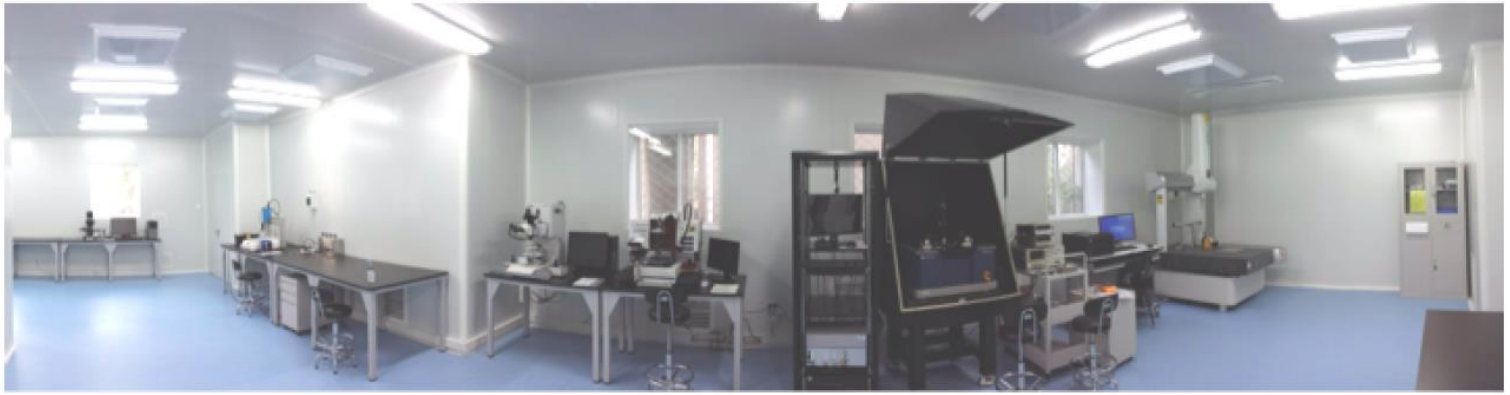
CEPC – Detector Considerations

Detector R&D

- Status:
  - TPC: Tsinghua & IHEP have participated in LCTPC
  - VTX: Investigating into the technology Market, lots of related projects
  - Calorimeter: cooperation with CALICE collaboration
- *Long termly: prototype design, construction, test, integration...*





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CEPC – Detector Considerations

Regular meetings, communications

Physics and Detector Meetings

November 2013

- 29 Nov CEPC Calorimeter Group Meeting 3rd New!
- 20 Nov CEPC Physics & Detector 5th New!
- 18 Nov - 19 Nov Franco-Chine Detector Discussing
- 15 Nov CEPC Tracking Group Meeting 2nd
- 07 Nov Simulation - Physics Analysis Meeting 1st
- 07 Nov CEPC Physics & Detector 4th
- 04 Nov CEPC Vertex Working Group Meeting 1st
- 01 Nov CEPC Tracking Group Meeting 1st
- 01 Nov CEPC Calorimeter Group Meeting 2nd

October 2013

- 23 Oct CEPC Physic & Detector 3rd
- 18 Oct CEPC Calorimeter Group Meeting 1st
- 09 Oct CEPC Physics & Detector 2nd

CEPC

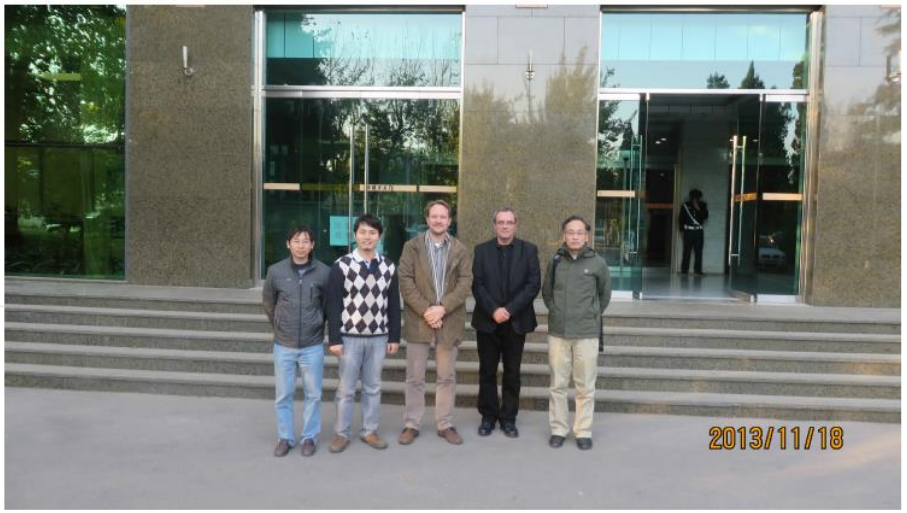
CEPC + SppC events

Managers: WEN, S.; Zhu, H.; Yang, H.; Hu, T.; Ruan, M.; QI, H.

General Meetings 2 events

Physics and Detector Meetings 13 events

Training 1 event



CEPC – Detector Considerations

- Training young people to address manpower shortage

- Recruitment: postdocs and staff at IHEP

CEPC Timeline (dream)

Pre-study, R&D and preparatory work

- Pre-CDR (by end of 2014) to be ready by China 13th 5-year plan
- Pre-study 2013-2015
- R&D 2016-2020
- Engineering Design 2015-2020

Construction: 2021-2027

Data taking: 2028-2035

CEPC Activities (incomplete)

- **Funding requests to Chinese Government in 2015 for R&D**
  - **Pre-CDR to be presented to government**
  - **Next 5-year planning – 2016-2020**
- **Consensus building and community support in China**
- **Be part of the global effort for (Higgs factory and energy frontier)**

  collaboration with the CERN FCC effort
- **Education**
- **Communication of the benefits to public**
- **Build a sizable HEP research manpower in China**

SppC Timeline (dream)

Pre-study, R&D and preparatory work

- Pre-study 2013-2020
- R&D 2020-2030
- Engineering Design 2030-2035

Construction: 2035-2042

Data taking: 2042 –

CEPC – Prospects

Theory

➔ fully explore physics with the Higgs boson & in the energy frontier

Detector: benefits from ILC, FCC, LHC experiments + own effort

➔ excellent design, cost effective, fully functional

Accelerator

➔ cost effective, expandability

International cooperation: LHC, ILC, FCC and CEPC and others

This is part of a global effort to make sure HEP's future is very bright

Detector: From ILD to CEPC

- Many new designs
  - Changed granularity (no power pulsing)
  - Changed L*
  - Changed VTX inner radius and TPC outer Radius
  - Changed Detector Half Z
  - Changed Yoke/Muon thickness
  - Changed Sub detector design
  - …
- All Changes need to be implemented into simulation, iterate with physics analysis and cost estimation