High Energy Physics Programs

Asia

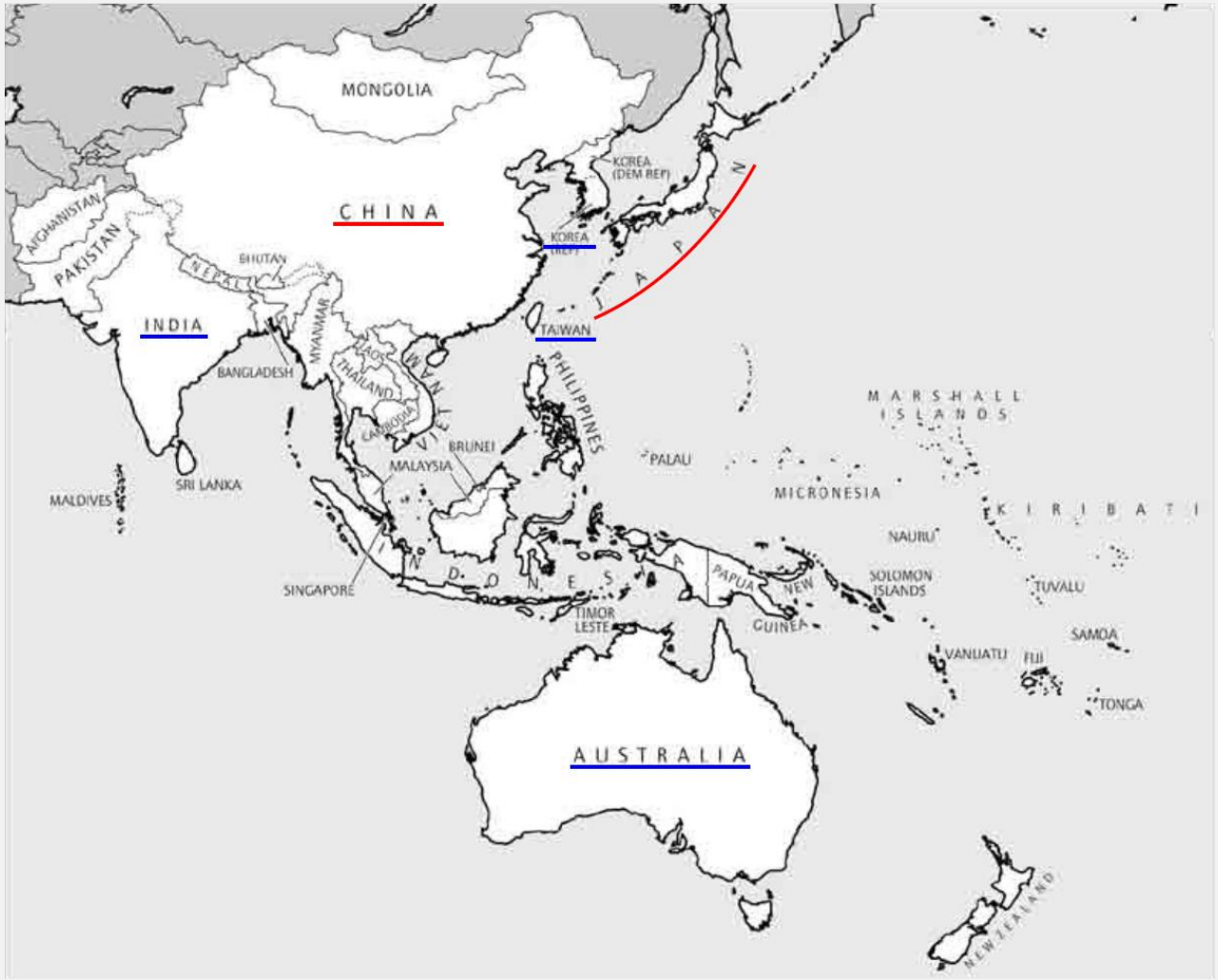
XinChou Lou
Institute of High Energy Physics, Beijing

Special thanks to
Geoffrey Taylor (U Melbourne &CoEPP),Tao Han (U Pittsburg)
Yasuhiro Okada (KEK), Yifang Wang (IHEP),Miao He (IHEP)
Liangjian Wen (IHEP)

Outline

- A brief survey of HEP experiments pursued in Asia
- Experiments planned & under development
- Large colliders: status and prospects of the ILC and CEPC
- Summary

HEP projects pursued in Asia



HEP Projects in Asia - Japan

- *SuperKEKB/Belle II: e+e- B-factory*
- *Super Kamiokande: atmospheric neutrinos/p decay*
- *J-Parc/T2K: Accelerator neutrino oscillation/CP*
- *Muon g-2/*
- *XMASS: W*
- *ALPACA: C*
- *KAGRA: Ka*
- *ILC: Higgs factory / Future collider*
- *Hyper-K: atmospheric neutrinos/proton decay*

- SuperKEKB/Belle II has started the physics experiment
- Various HEP programs are ongoing at J-PARC
- Participations in the LHC at CERN
- Efforts for promotion and preparation of the ILC project are intensified in Japan

Geoffrey Taylor, Workshop for Future Particle Accelerators, KAIST, July 9, 2019
Tao Han, HKUST Gordon Research Conference, 2019

HEP Projects in Asia - Korea

- ***RENO: reactor neutrino oscillation***
- ***CAPP: underground lab at IBS***
  - axion search/proton EDM/muon g-2
  - COMET: mu2e
- ***CUP: underground lab at IBS***
  - COSINE: WIMP DM
  - AMoRE: Double Beta (0n2b) decay
  - NEOS: reactor sterile neutrinos
- ***LHC CMS/ALICE: collider expts***
- ***SHiP @ CERN: long-lived particles***
- ***KEK B/Belle II: e+e- B-factory***
- ***Super K, ICECUBE: neutrinos***

Listed in Blue → outside of Korea

Geoffrey Taylor, Workshop for Future Particle Accelerators, KAIST, July 9, 2019
Tao Han, HKUST Gordon Research Conference, 2019

HEP Projects in Asia – India, Hong Kong

India:

- ***LHC CMS, ALICE: collider expts***
  - Associate Member, CERN
- ***SuperKEKB/Belle II: e+e- B-factory***
- ***PLANCK: satellite CMB***
- ***LIGO-India: gravitational wave***
- ***India Neutrino Observatory: atmospheric neutrinos***

Hong Kong:

- ***LHC ATLAS: collider expt***
- ***Daya Bay reactor neutrino experiments***
- ***VLA, SMA, ALMA: radio/optical astrophysics***
- ***Fermi-LAT: gamma-ray astrophysics***

Geoffrey Taylor, Workshop for Future Particle Accelerators, KAIST, July 9, 2019
Tao Han, HKUST Gordon Research Conference, 2019

HEP Projects in Asia – Australia, Taiwan, …

Australia:

- *LHC ATLAS: collider expt*
- *SuperKEKB/Belle II: e+e- B-factory*
- *LIGO: gravitational wave*
- *Axion Search*
- *SUPL/SABRE: Underground direct dark matter*

Taiwan:

- *LHC CMS: collider expt*
- *SuperKEKB/Belle II: e+e- B-factory*

Several smaller efforts across a range of countries

Geoffrey Taylor, Workshop for Future Particle Accelerators, KAIST, July 9, 2019
Tao Han, HKUST Gordon Research Conference, 2019

HEP Projects in Asia - China

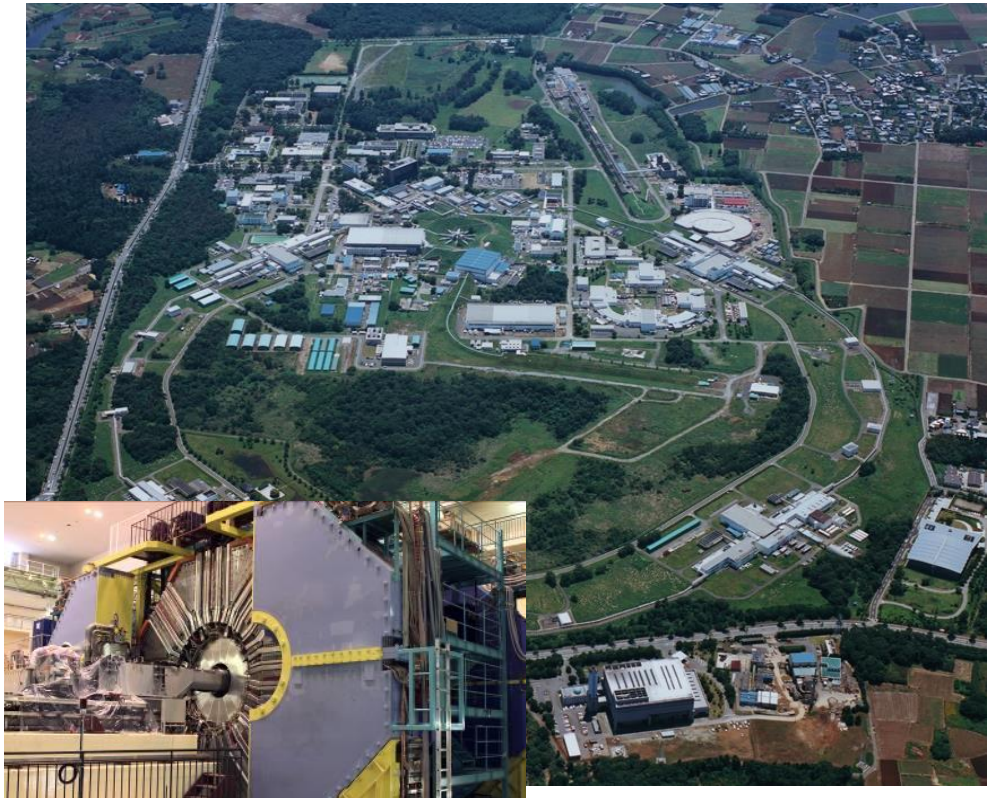
- *BEPCII/BESIII: e+e- collider program (tau/charm)*
- *Daya Bay/JUNO: reactor neutrino oscillation*
- *PANDAX, CEDEX: JinPing lab DM expts*
- *LHASSO: air shower cosmic rays*
- *DAMPE: satell*
- *AMS: space st*
- *Ali: CMB polar*
- *LHC ATLAS/CMS/LHCb/ALICE: collider expts*
- *SuperKEKB/Belle II: e+e- B-factory*
- *ILC: Higgs factory*
- *CEPC/SppC: Higgs factory, future colliders*

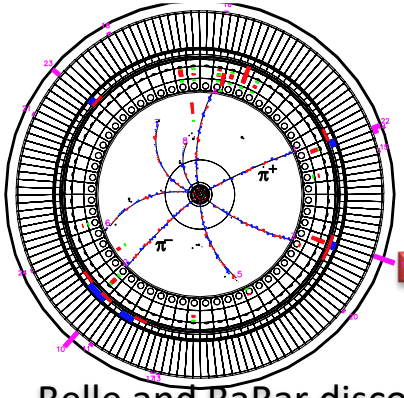
- **BEPCII/BESIII experiment half way – white paper coming**
- **Various HEP programs are ongoing or under development**
- **R&D and cultivation of the CEPC**

Listed in Blue → outside of China

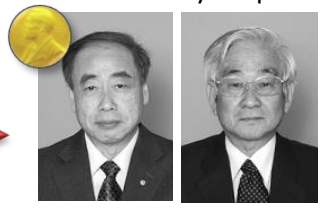
Geoffrey Taylor, Workshop for Future Particle Accelerators, KAIST, July 9, 2019
Tao Han, HKUST Gordon Research Conference, 2019

BELLE II





2008 Nobel Physics prize

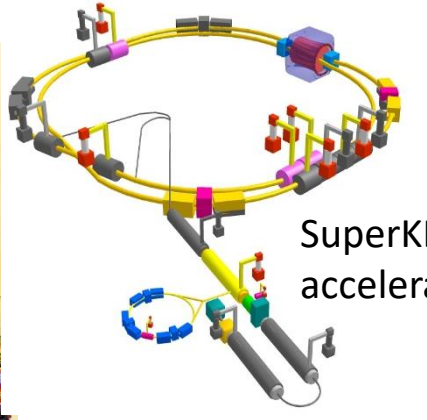


Dr.Kobayashi Dr.Maskawa

Belle and BaBar discovered CP violation in B mesons, and confirmed Kobayashi-Maskawa theory. The apparatus has been upgraded to search for new physics beyond this theory.

>900 scientists from 26 countries (Jul. 2019)

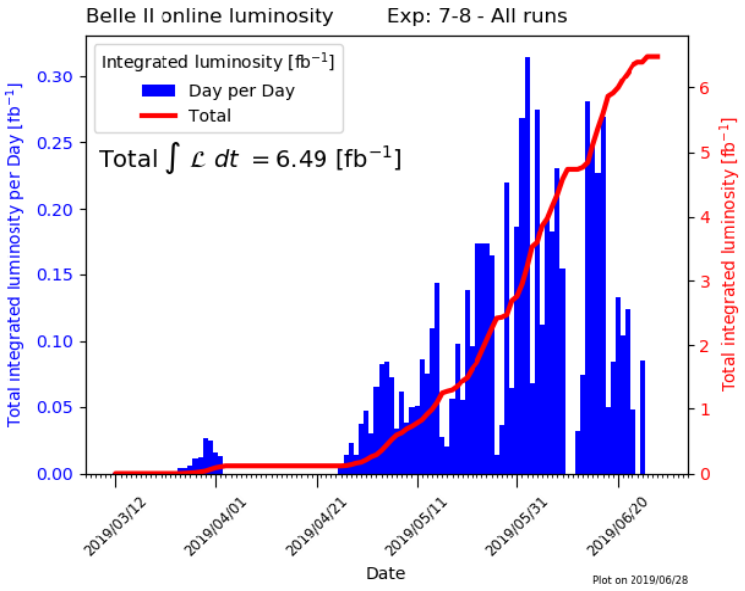
Belle II detector and members (Feb. 2017)

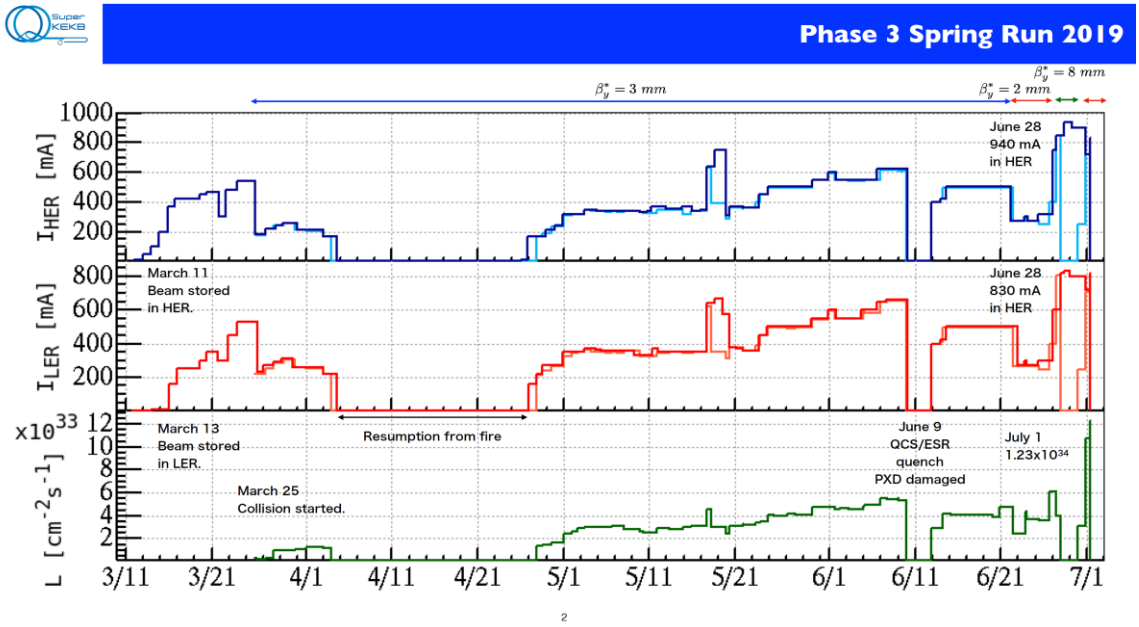


SuperKEKB accelerator

Operations

Integrated Luminosity

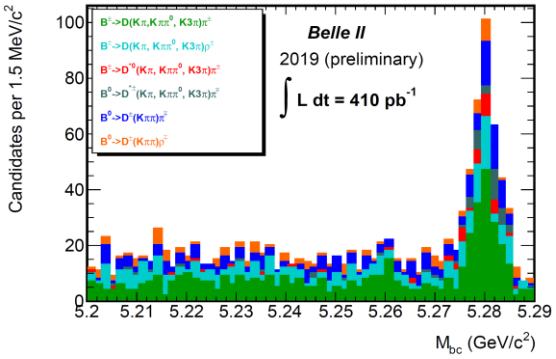




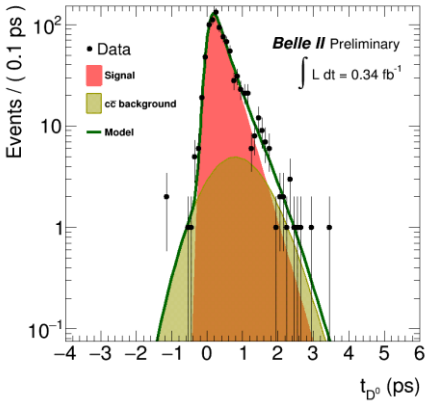
SuperKEKB/Belle II operation with full detector coverage started from March 11th 2019.
Instantaneous luminosity $> 1.2 \times 10^{34} cm^{-2} s^{-1}$
Integrated luminosity by July 1st $= 6.49 fb^{-1}$

Belle II performs well under harsh beam background in the initial stage, which already enables several measurements.

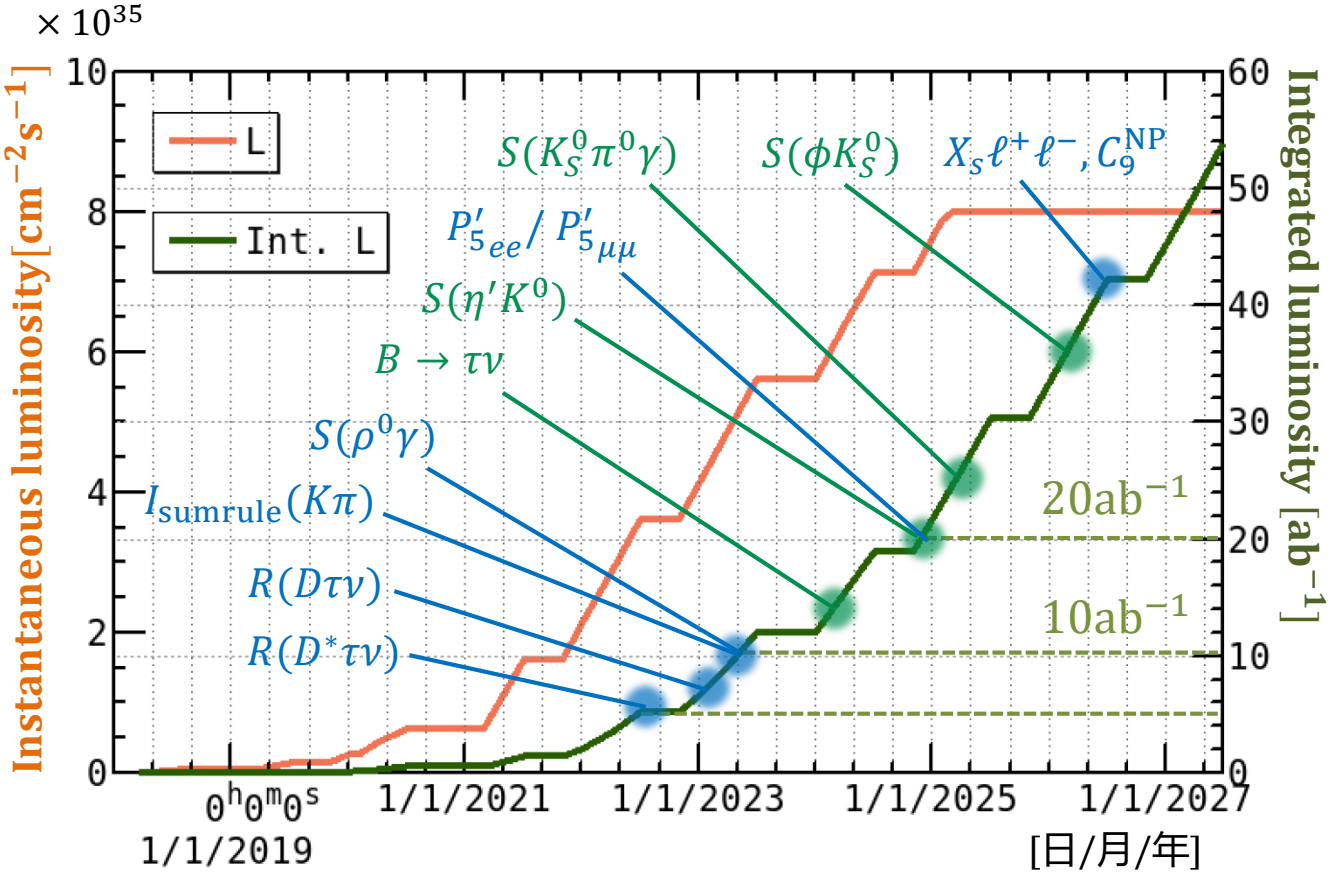
B→Dh reconstruction



D^0 lifetime measurement



Luminosity profile and potential discoveries



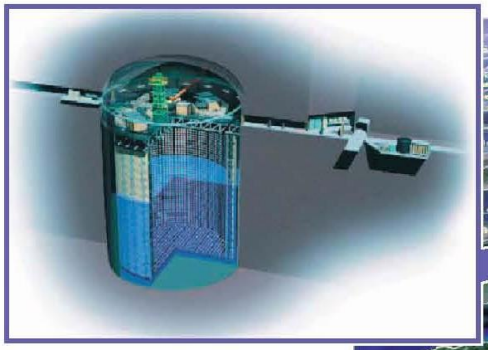
- 5σ (observation)
- 3σ (evidence)

Assuming:

- 8 months operation per year
- 4 years to achieve design luminosity
- “Current” central values

T2K (Tokai to Kamioka) experiment

2010~ (Running)



Super-Kamiokande
(ICRR, Univ. Tokyo)

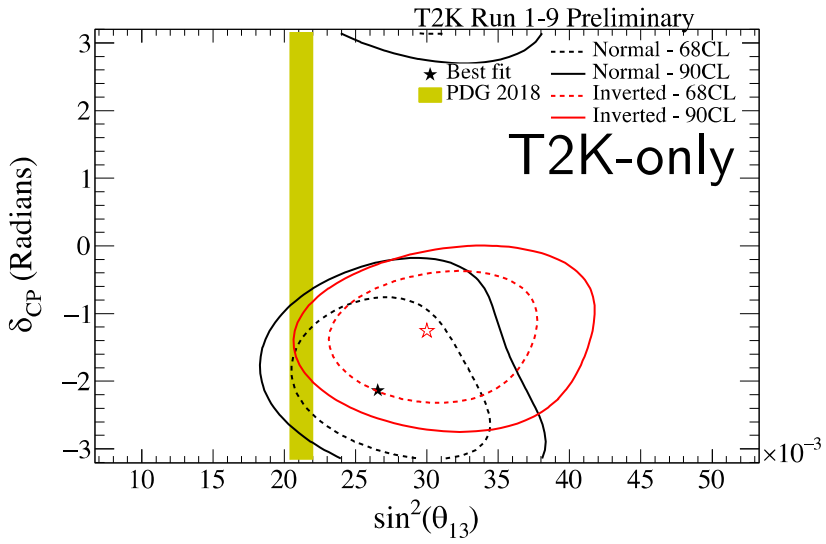
J-PARC Main Ring
(KEK-JAEA, Tokai)

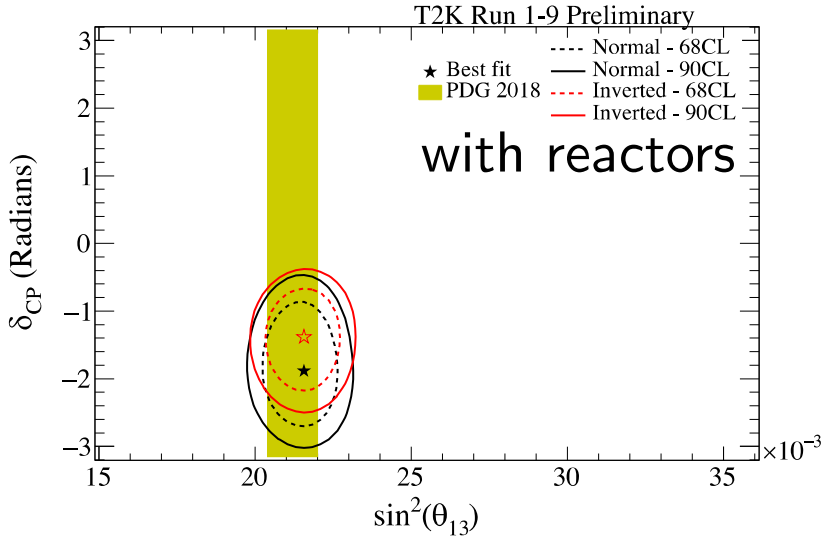
- High intensity ν_μ beam from J-PARC MR to Super-Kamiokande
- Observation of $\nu_\mu \rightarrow \nu_e$ (2013)
- Updated goals
  - Precise measurement of ν_e appearance
  - Precise meas. of ν_μ disappearance

➔ Measure CPV phase, contribution to mass hier. determ.

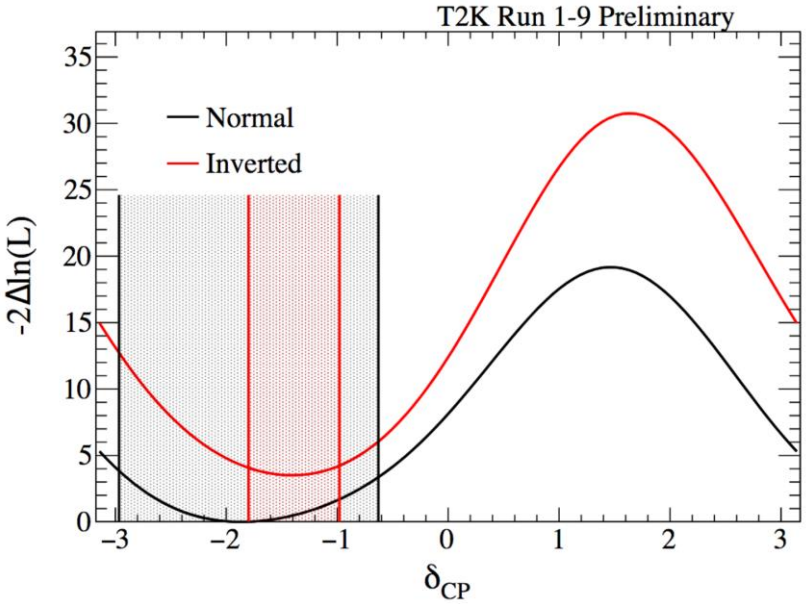
T2K (Tokai to Kamioka) experiment

Latest T2K CP Violation Search Result





T2K fit with reactor constraint

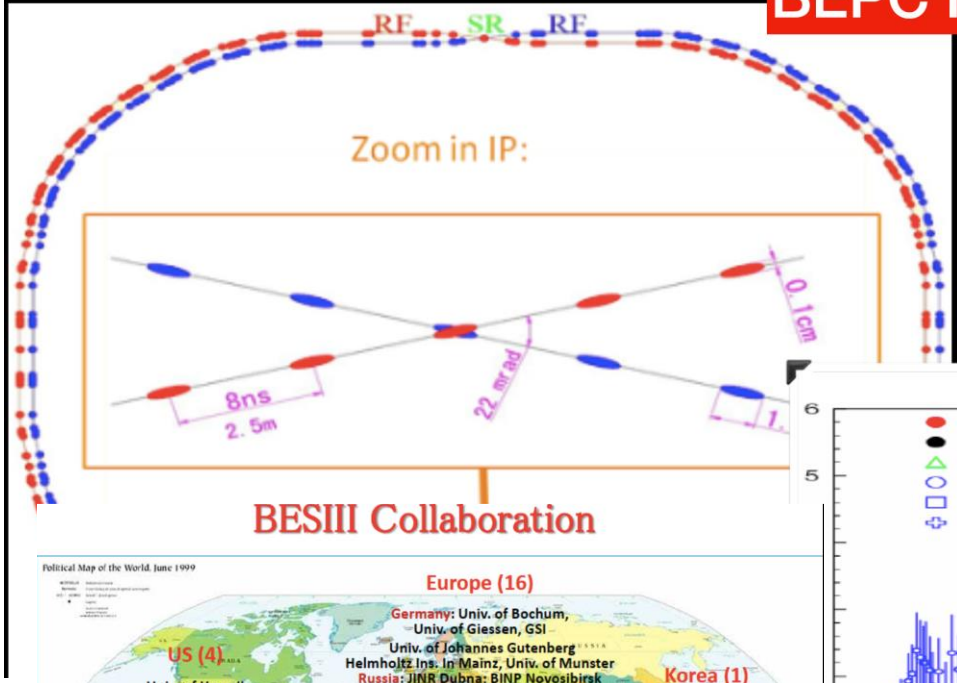


Best fit point : δ_{CP} = -1.885 rad in normal hierarchy.
CP conserving values (0,π) fall outside of 2σ CL intervals.
- Suggestive, but **need more data**.

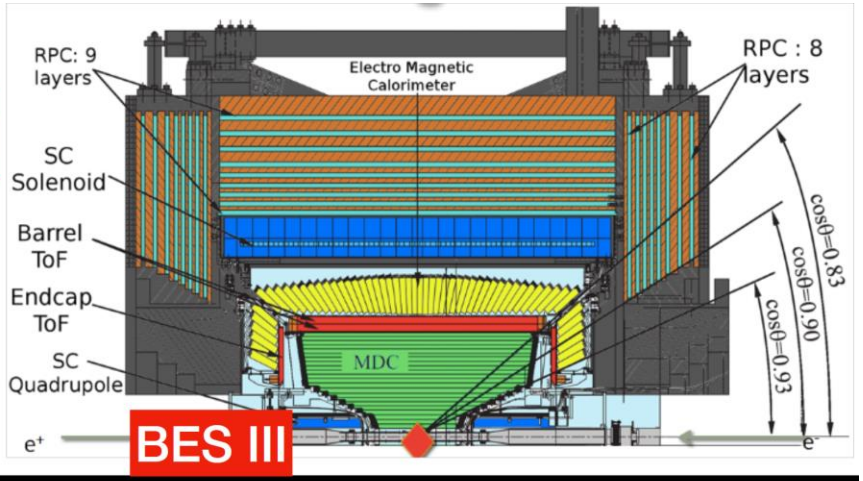
HEP Projects in Asia - China

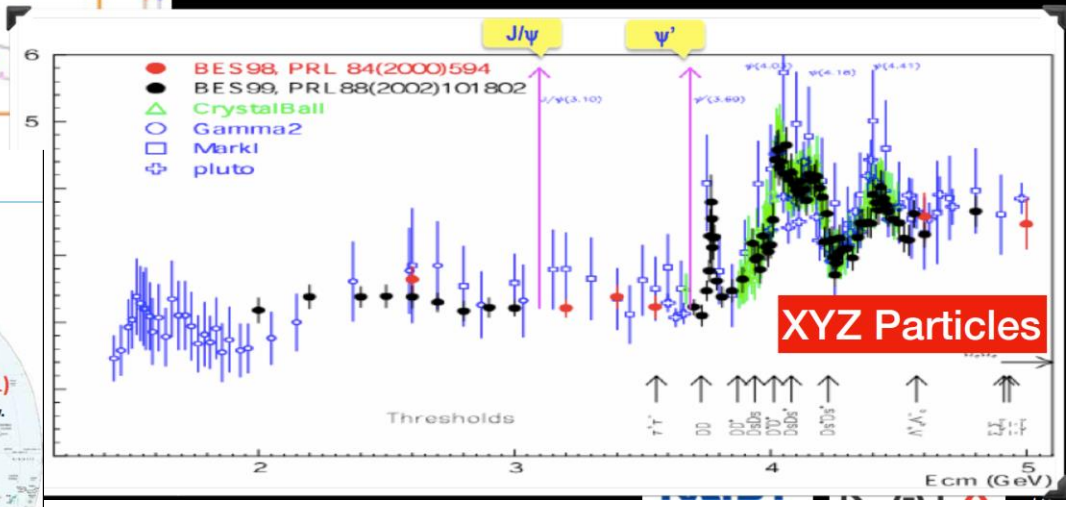
Postcards from China

BEPC II

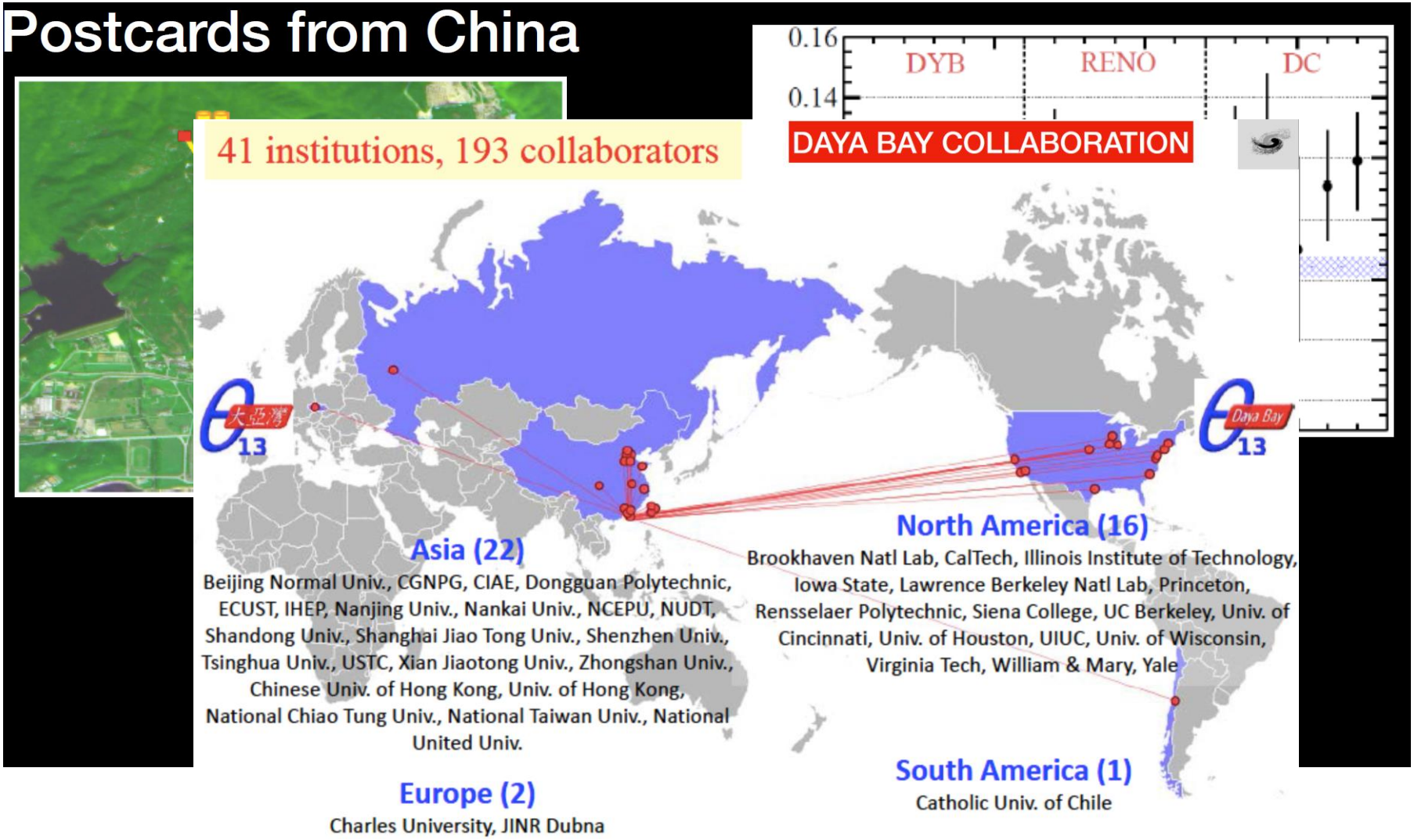


BESIII Collaboration

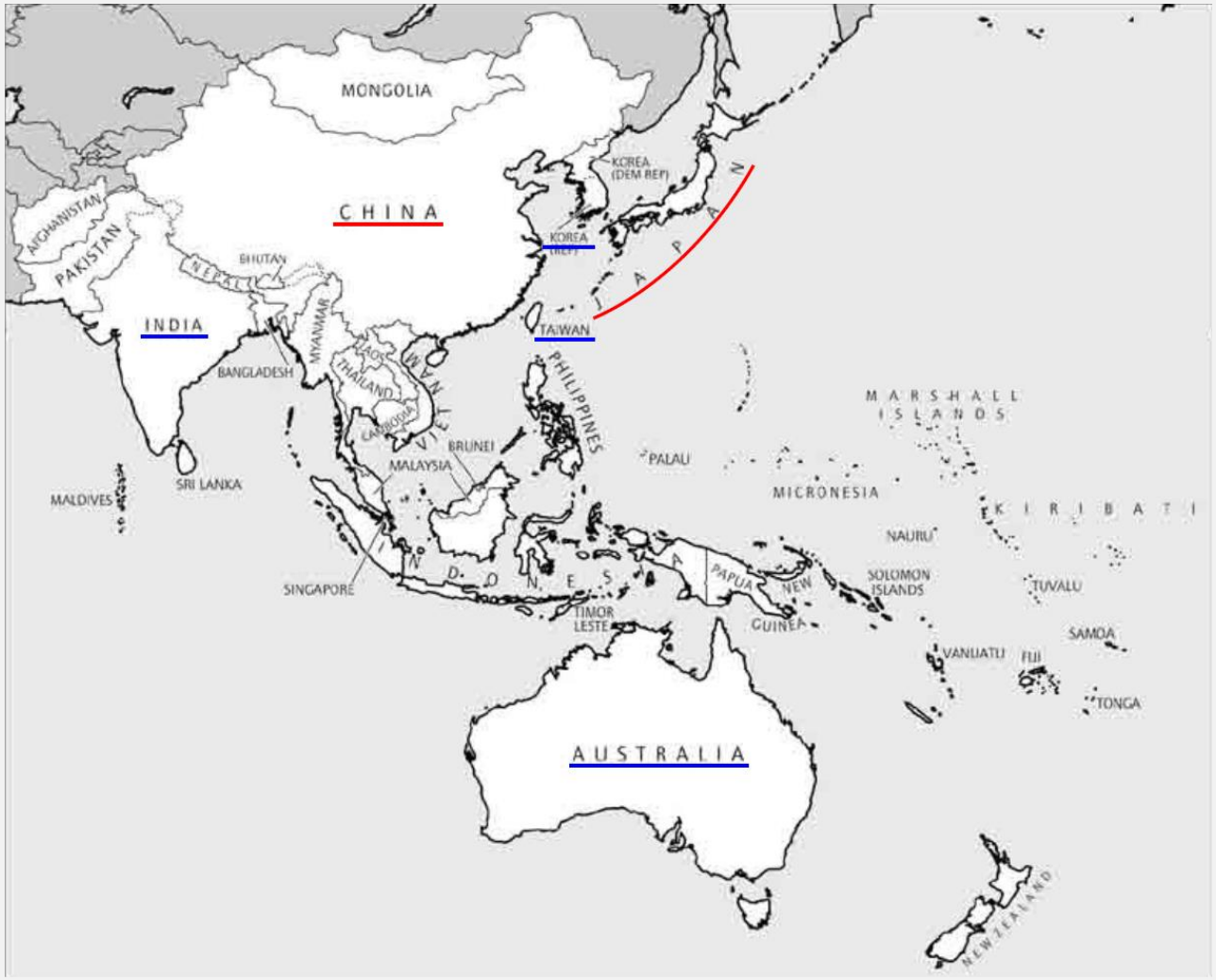




HEP Projects in Asia - China



HEP experiments in Asia
planned & under development



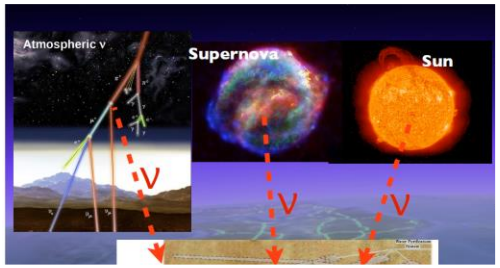
KEK
High Energy Accelerator Research Organization

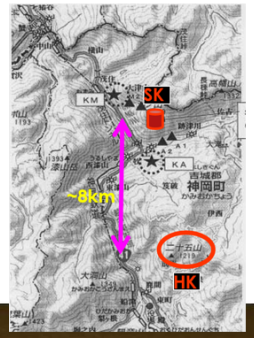
Hyper-Kamiokande

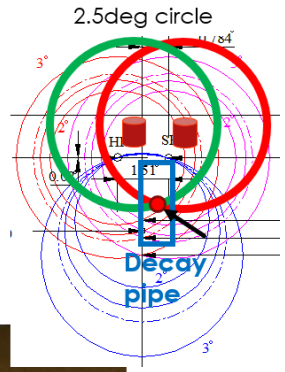
- Next-generation Water Cherenkov detector (ICRR/U. Tokyo)
  - 260kt (190kt fid. mass)
  - Location (candidate)
    - ✓ ~8km south of SK
    - ✓ 295km from J-PARC, @ same off-axis angle
  - 650m overburden (1755m W.E.)
- J-PARC ν-beam upgrade (KEK)
  - Beam power: 750kW → 1.3MW
  - New near neutrino detector

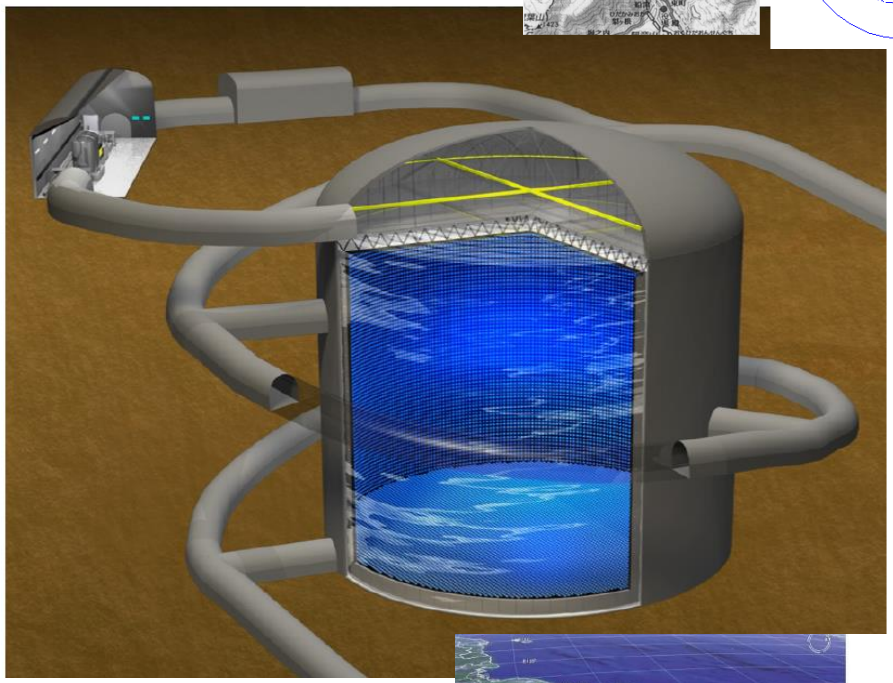
→ highest priority in KEK-PIP
Endorsed at 1st KEK SAC

- Physics goals
  - Accelerator neutrino
    - ✓ CPV in neutrino
  - Non-accelerator/Astroparticle
    - ✓ Discovery of proton decay
    - ✓ Atm-nu
    - ✓ Solar-nu
    - ✓ Supernova (relic) nu









- **Listed in the 2017 MEXT Roadmap of the Large Research Infrastructure**
- **A decision by MEXT to be made in 2019.**

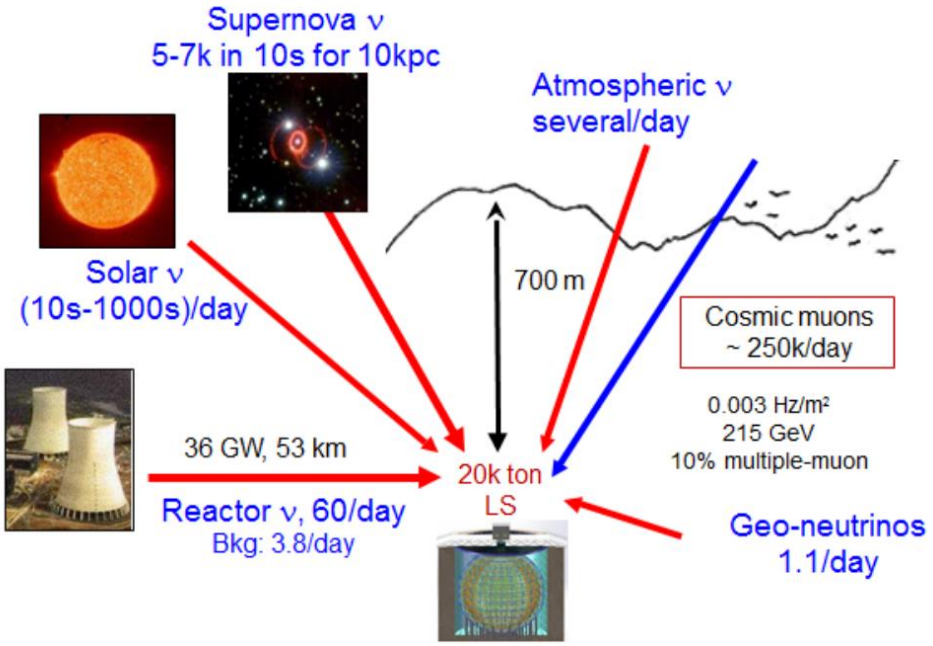
Jiangmen Underground Neutrino Observatory

Project

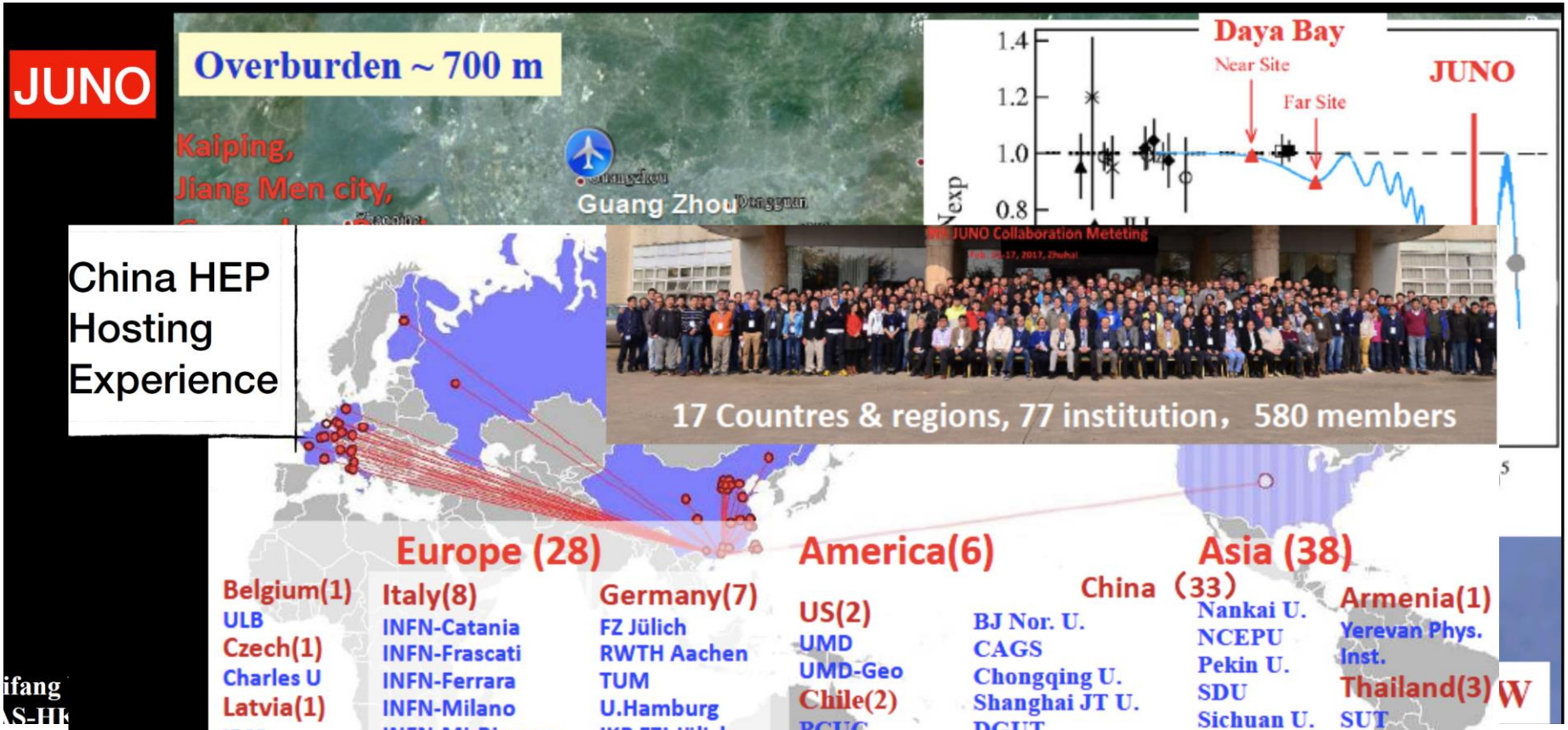
- 20 kton liquid scintillator, 3%@1MeV energy resolution, 700 m underground
- Approved in **2013**, construction started in **2015**, operation in **2021**

Physics

- Determine mass hierarchy
- Precision measurement of oscillation parameters
- Astronomical neutrinos
- Proton decay and exotics

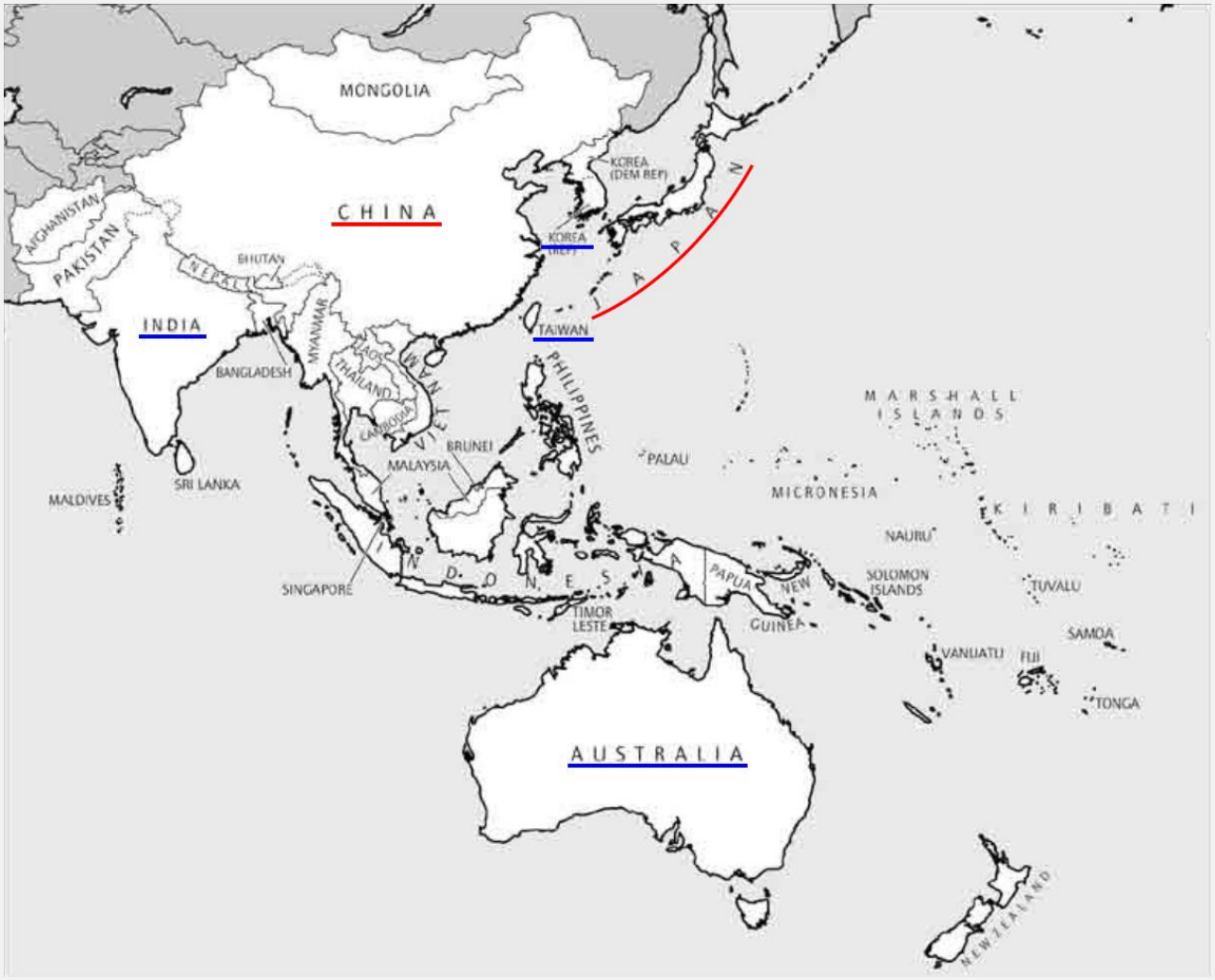


HEP Projects in Asia - China



Large colliders in Asia: ILC and CEPC

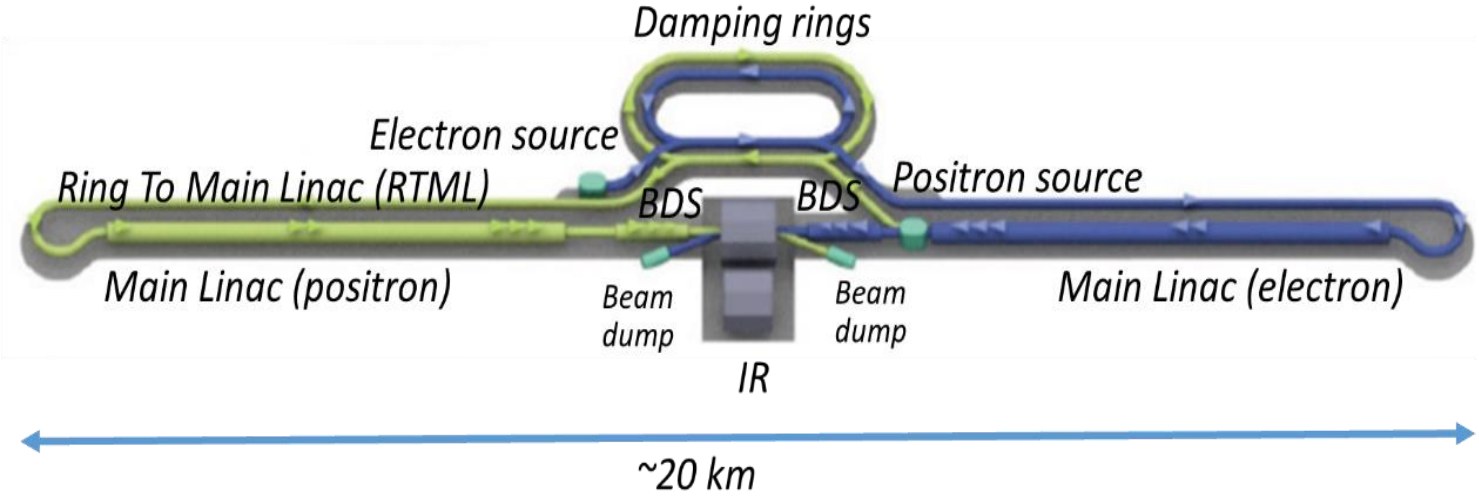
status, challenges and prospects



KEK
High Energy Accelerator Research Organization

International Linear Collider (ILC)

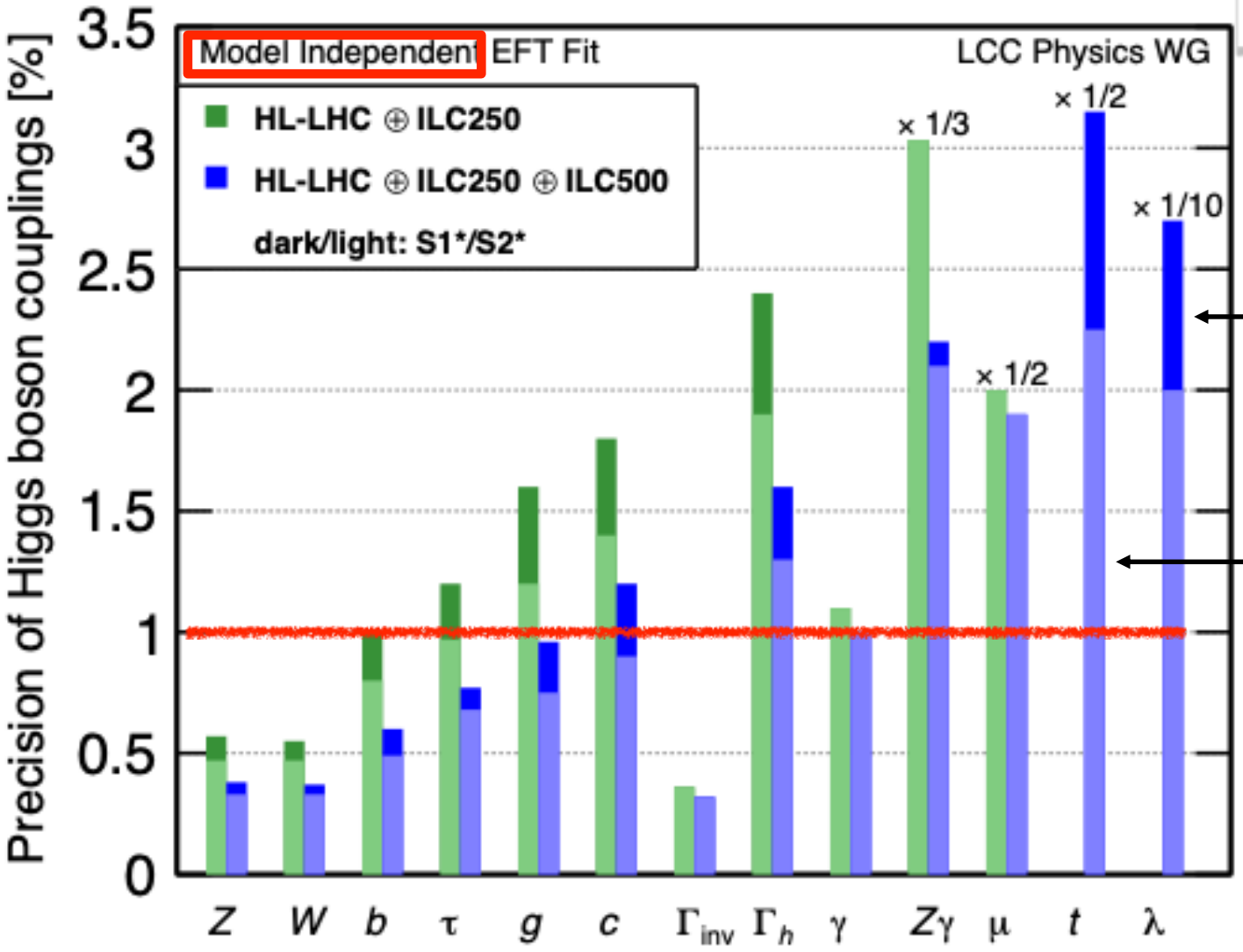
The next energy-frontier electron-positron collider to explore physics laws in the early Universe.



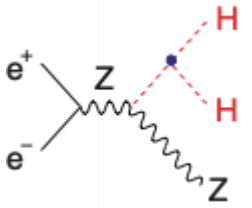
- Collisions of 125 GeV electrons and positrons in a 20 km tunnel. (250 GeV ILC), extendible to 1 TeV
- It can produce a large number of the Higgs particles (a Higgs factory).
- It has a good potential to discover new particles such as dark matter.

KEK
High Energy Accelerator Research Organization

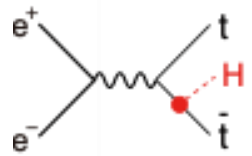
Higgs coupling mesurements at ILC



arXiv: 1901.09829



Self-coupling
Not accessible at 250 GeV.
Can reach 26% at 500 GeV.

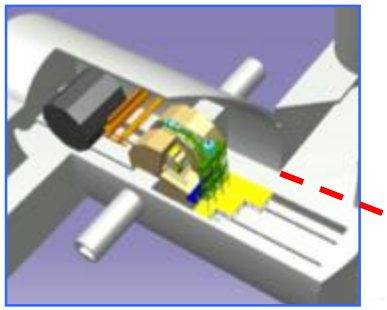


Top Yukawa
Not accessible at 250 GeV.
Can reach 3% at 550 GeV.

ILC allows model-independent fit to extract all the major Higgs couplings !

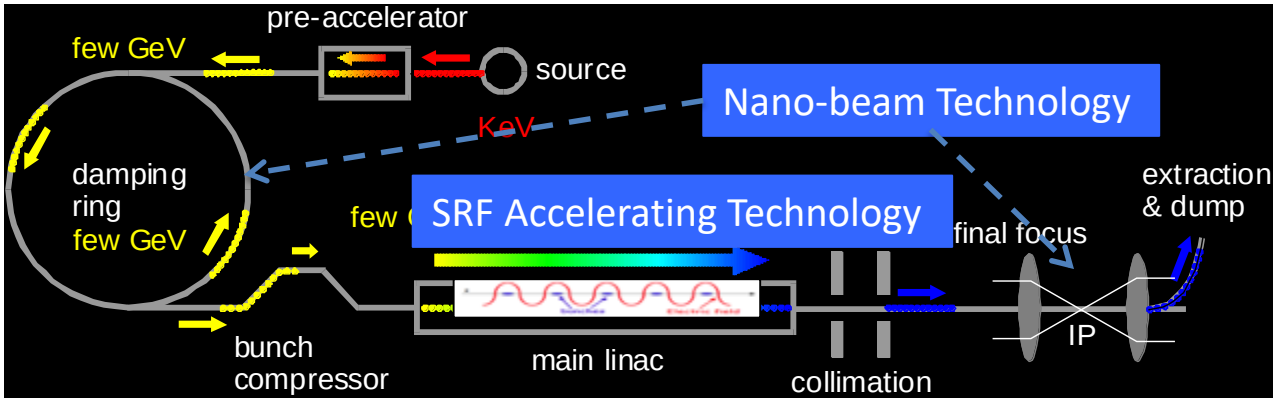
KEK
High Energy Accelerator Research Organization

ILC Design Overview



Physics Detectors

Key Technologies



Item	Parameters
C.M. Energy	250 GeV
Length	20km
Luminosity	1.35 x10^{34} $cm^{-2}s^{-1}$
Repetition	5 Hz
Beam Pulse Period	0.73 ms
Beam Current	5.8 mA (in pulse)
Beam size (y) at FF	**7.7** nm@250GeV
SRF Cavity G. Q_0	**31.5** MV/m (**35** MV/m) Q_0 = 1x10^{10}

KEK
High Energy Accelerator Research Organization

Recent developments of the ILC project in Japan

- MEXT explained it views on the ILC to ICFA on March 7, 2019

"MEXT has not yet reached declaration for hosting the ILC in Japan at this moment."
"MEXT will continue to discuss the ILC project with other governments while having an interest in the ILC project."

- The industrial sector, the local governments/communities released statements.

They took the MEXT statement positively.

- ICFA released a statement (March 21, 2019)

"ICFA responds to Japan's interest in the International Linear Collider and encourages its realisation"
https://www.interactions.org/press-release/icfa-responds-japans-interest-international-linear-collider

- KEK presented its plan for the ILC project

See KEK-DG Masa Yamauchi's presentation at the FNAL Colloquium on April 24, 2019
https://vms.fnal.gov/asset/detail?recid=1959841

MEXT= Ministry of Education, Culture, Sports, Science and Technology-Japan

KEK
High Energy Accelerator Research Organization

Current actions by KEK

- Organize the international working group with close consultation with MEXT.

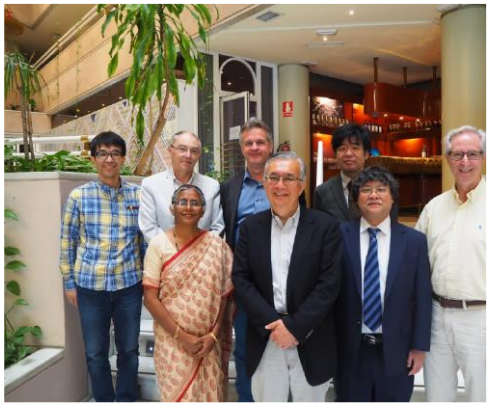
  Report on cost-sharing and governance issues by Sept.2019

- Promote activities to gain a better understanding of the broader academic community in Japan.
  - Propose the ILC project to the SCJ Master Plan
  - Organize a symposium
- Cooperate MEXT to establish the governmental level discussion groups with France and Germany. Also, we need to strengthen the discussion group with the US DOE.
- Conducts R&D program at ATF, STF and CFF facilities collaborating with the international teams.

  US-Japan ILC cost-reduction R&D
- … and so on.

KEK is making all efforts to realize the ILC as an international project.

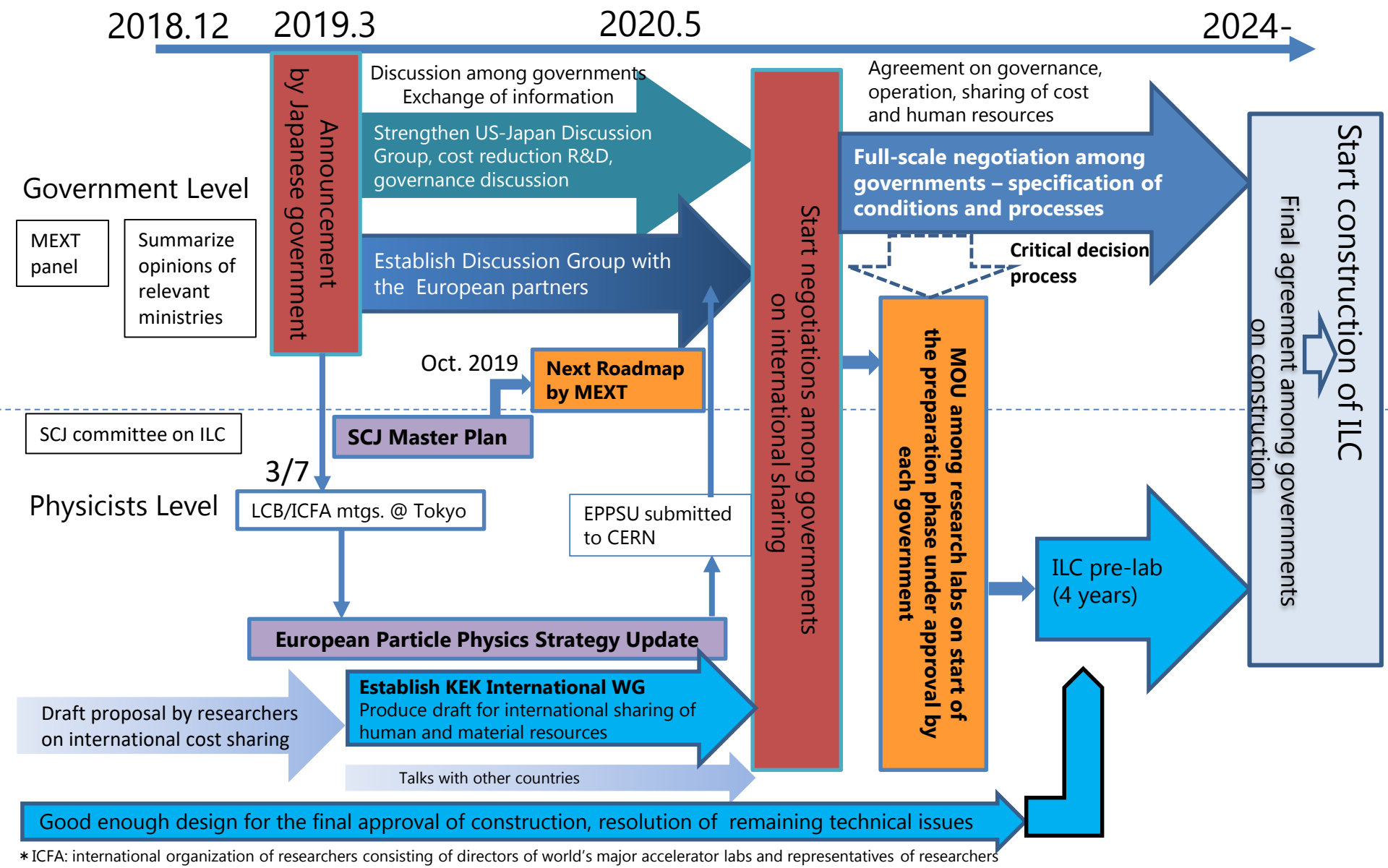
- 1st KEK international WG meeting in Granada on May 2019



- Japanese Diet members and MEXT officials visited Germany and France in July 2019
- US DOE official Dr. Paul Dabbar visited Japan and attended the Diet member's meeting for the ILC in October 2018

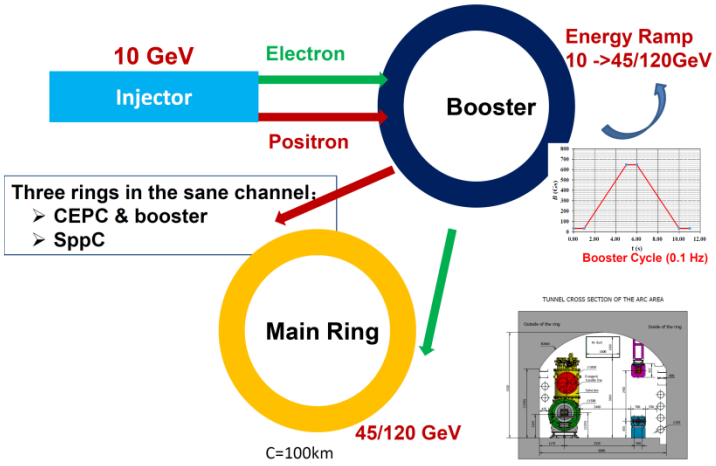
KEK
High Energy Accelerator Research Organization

Processes toward Realization of ILC



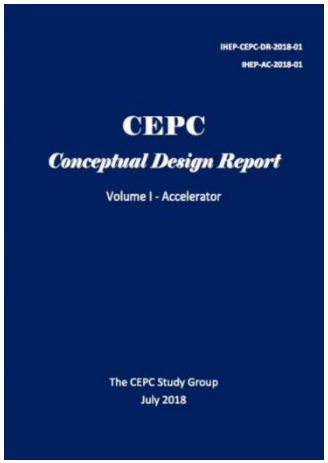
* ICFA: international organization of researchers consisting of directors of world's major accelerator labs and representatives of researchers
* ILC pre-lab: International research organization for the preparation of ILC based on agreements among world's major accelerator labs such as KEK, CERN, FNAL, DESY etc.

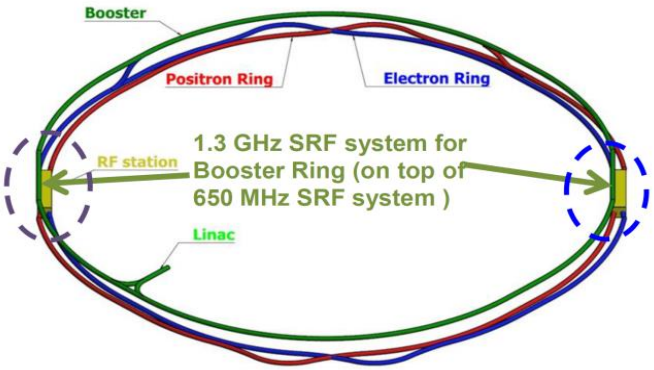
ILC/CLIC and CEPC/FCC(ee) - CEPC



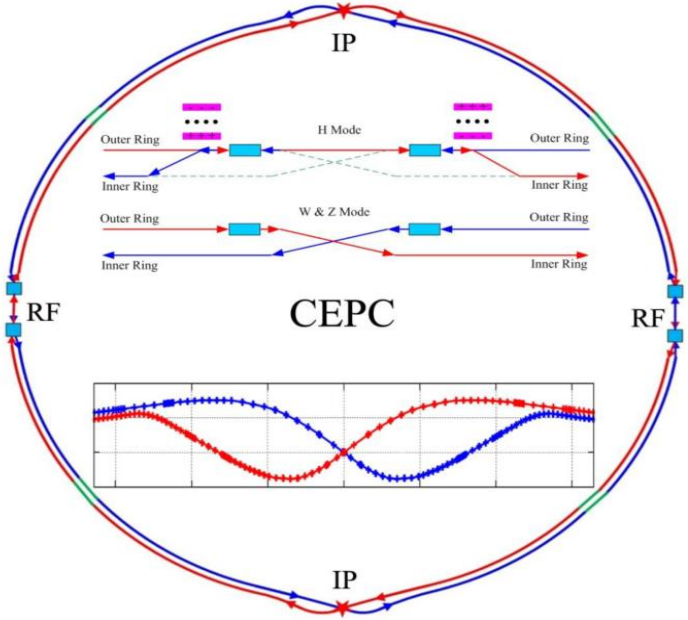
Lumi.	Higgs	W	Z	Z(2T)
$\times 10^{34}$	2.93	11.5	16.6	32.1

- 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





SRF system location of CEPC (two RF stations)



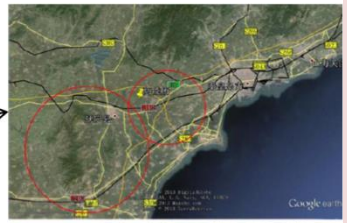
Layout of 650 MHz SRF system for Collider Ring

Conceptual Design Reports released on November 15, 2018

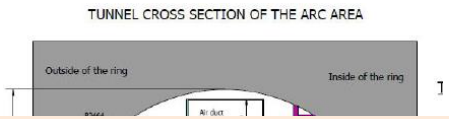
CDR Volumes 1 (Accelerator) and 2 (Physics-Detector) , are available at

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

ILC/CLIC and CEPC/FCC(ee) - CEPC



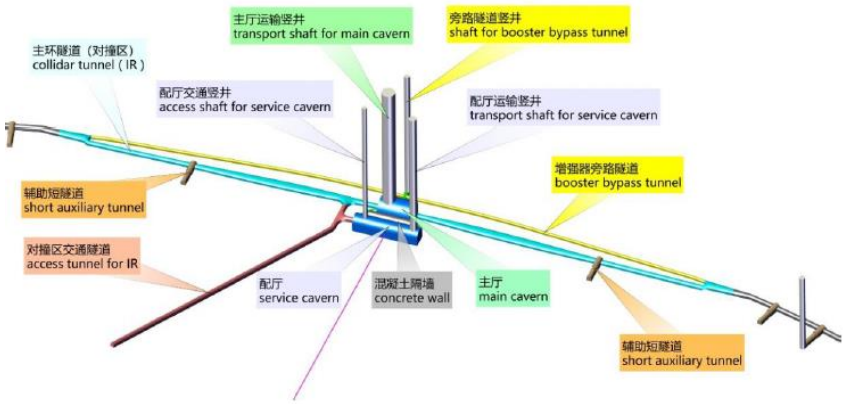
- ✓ site visits & study
- ✓ facility deign
- ✓ construction plan
- ....



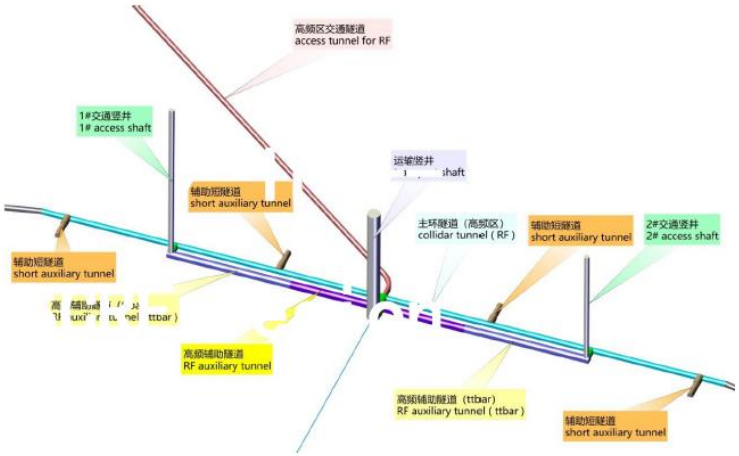
CEPC is conducting country wide site visits and study. Local government agencies are very receptive and supportive to CEPC. CDR study is based on site 1 (Qing Huang Dao).

.....

CEPC Interaction Region

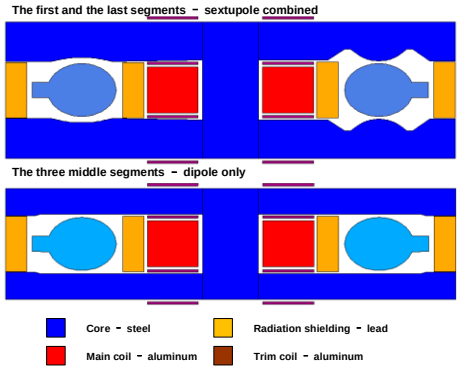


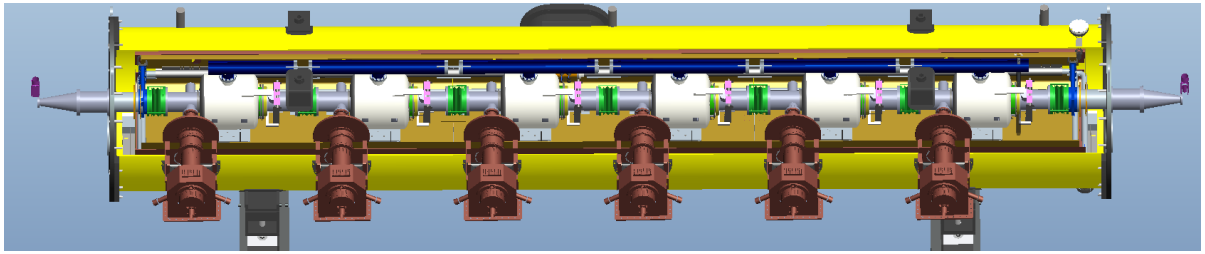
CEPC Injection Region

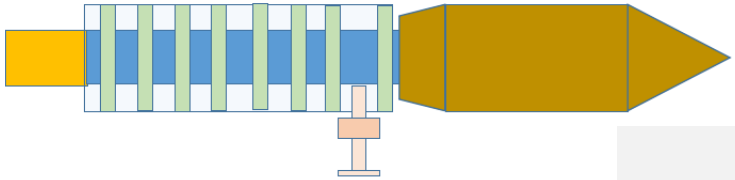


CEPC Industrial Promotion Consortium (CIPC)

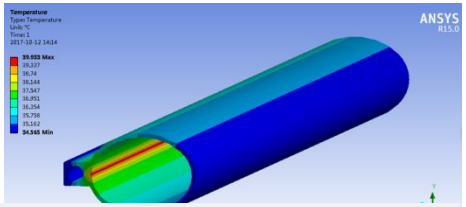
was established in 2017 to prepare for industrial production of CEPC components

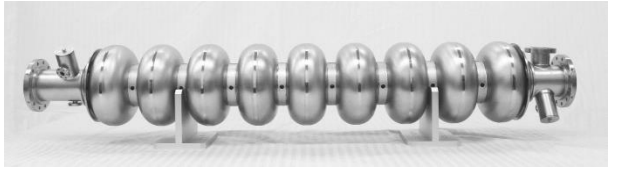






High Efficiency RF cavity section





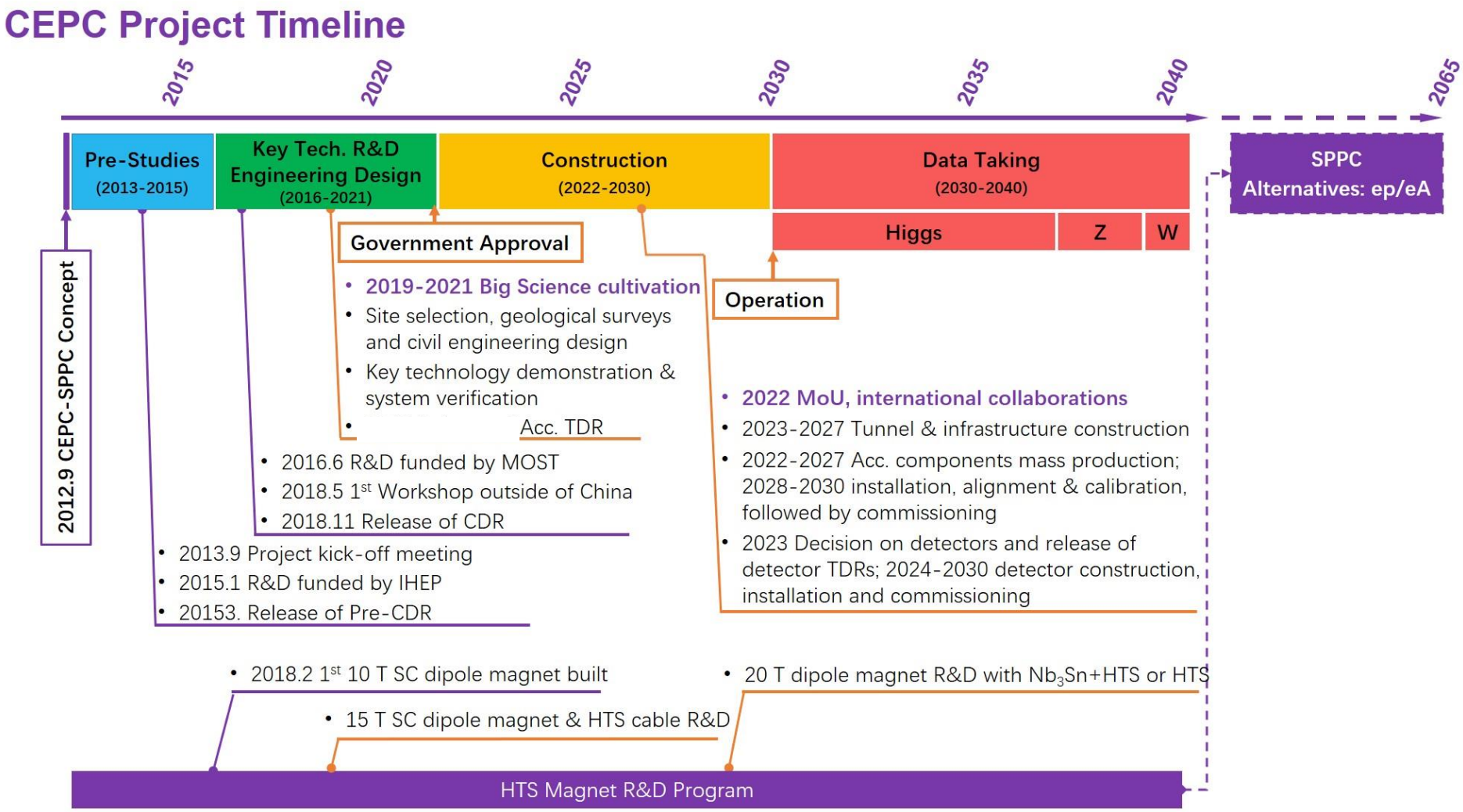
Path to realizing the CEPC

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**

CEPC team is actively cooperating with the Chinese Ministry of ST to seek to be included in the program

CEPC Schedule (ideal) – Goals and Plan

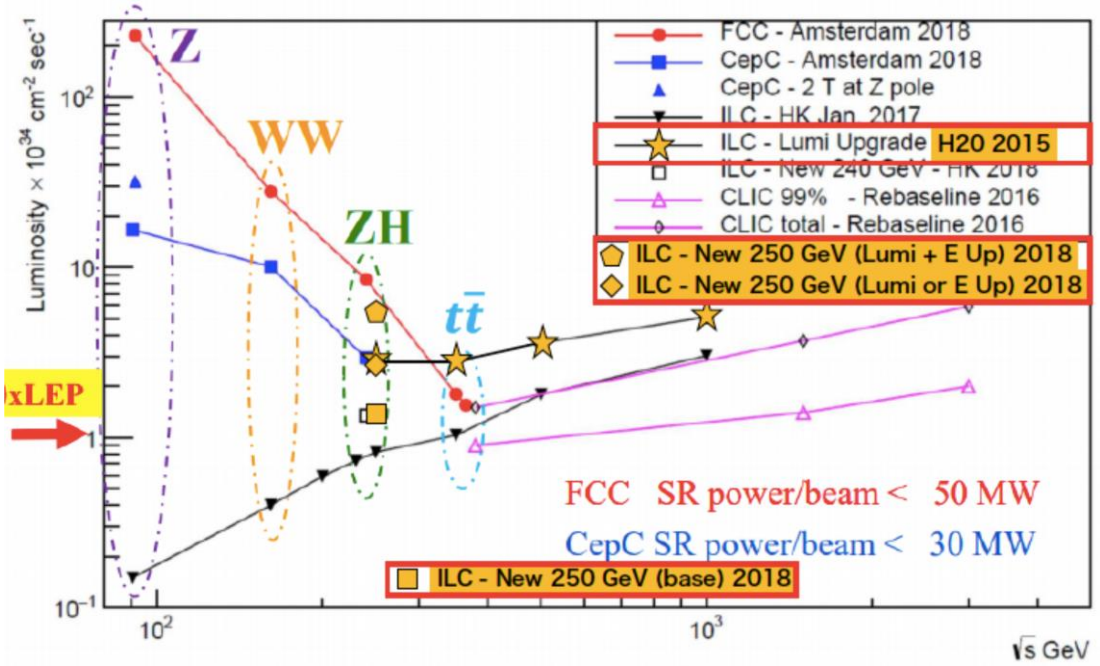


Circular Electron-Positron Collider

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



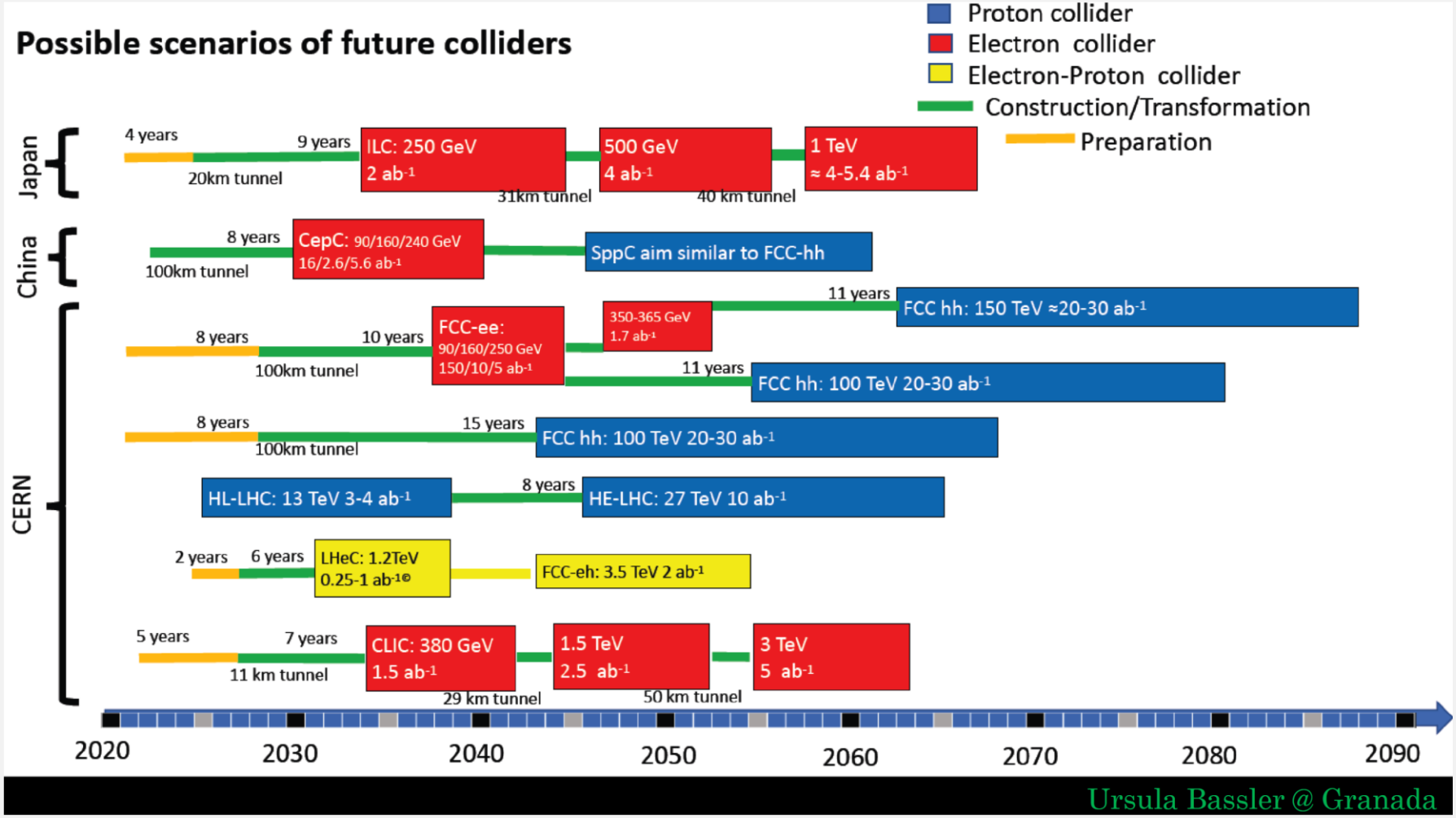
G. Taylor et al

Linear:

very impressive Higgs precision
best Lumi. at higher energies, or only option for VHE
(ILC lumi upgrade even better at the Higgs**)**

circular & linear colliders are ideally complementary to each other

Asia brings potentials to the world of HEP



Summary

- **Asia is a major contributor to the world of HEP**
  - HEP programs in Asia cover a wide range of scientific frontiers
  - Projects under development will bring exciting physics opportunities
  - Large e^+e^- colliders (ILC, CEPC) – options for the world
- **Many of the Asian HEP physicists are trained in the West and are global minded – good for international collaboration**
- **Continued effort, world-wide coordination, improved design and technological advance are crucial for realizing future high energy frontier e^+e^- collider(s)**
- **Asia by itself does not produce a single HEP strategy. It is very important that European ESPP and US P5 include Asia**

Acknowledgement

Special thanks to

Geoffrey Taylor (U Melbourne &CoEPP)
Tao Han (U Pittsburg),
Yasuhiro Okada (KEK),
Yifang Wang (IHEP)
Miao He (IHEP)
Liangjian Wen (IHEP)