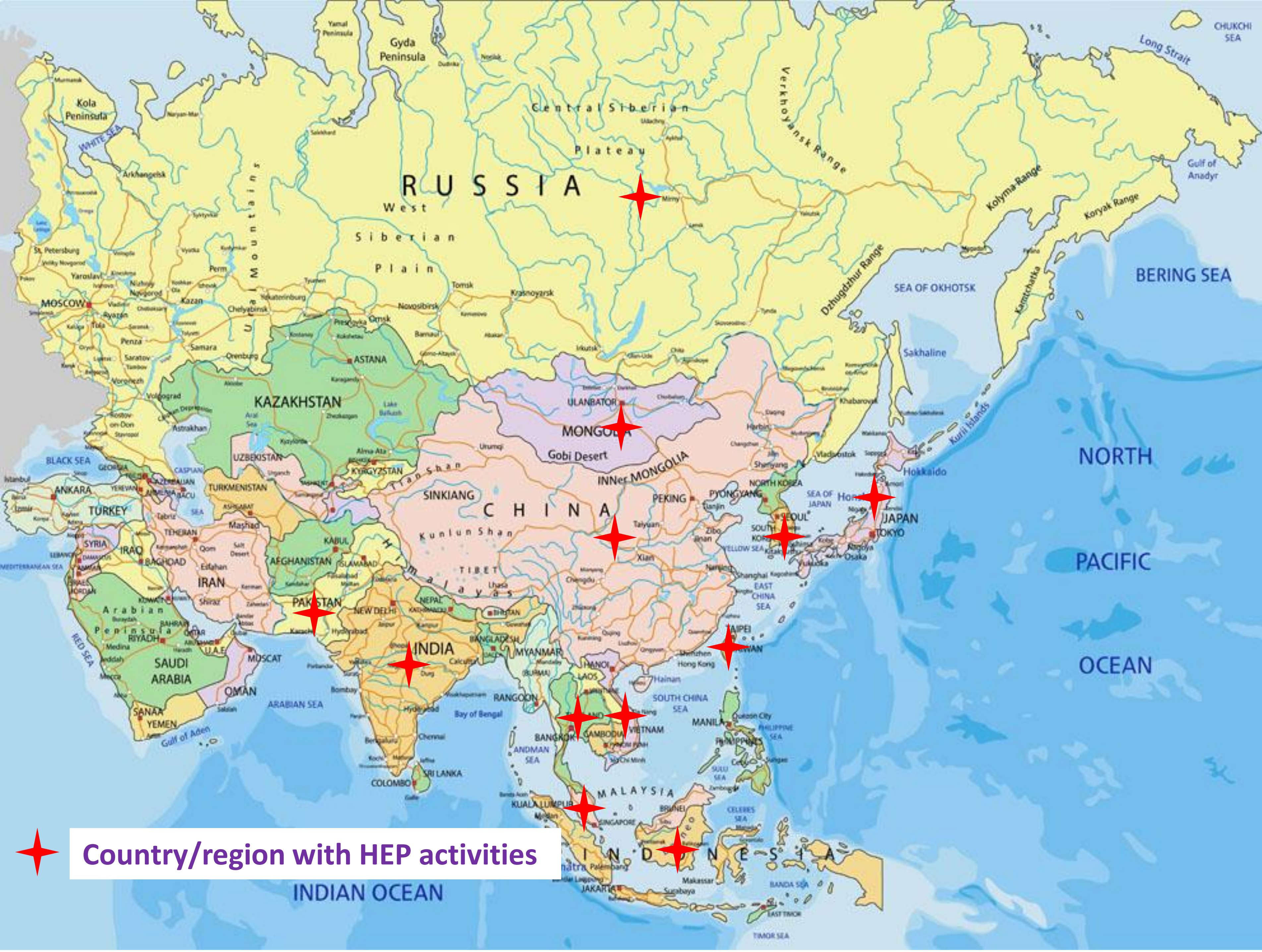
ACFA View and Asia Activities on Future Colliders

Yifang Wang
Institute of High Energy Physics, Beijing

FCC week, April 11, 2016


Country/region with HEP activities
RUSSIA
West Siberian Plain
Central Siberian Plateau
Verkhoyansk Range
Kolyma Range
Koryak Range
Dzhugdzhur Range
Ural Mountains
Kola Peninsula
Gyda Peninsula
Yamal Peninsula
WHITE SEA
CHUKCHI SEA
Long Strait
Gulf of Anadyr
BERING SEA
SEA OF OKHOTSK
Sakhaline
Kamtchatka
Kurils Islands
Hokkaido
NORTH PACIFIC OCEAN
MOSCOW
St. Petersburg
Yaroslavl
Kazan
Perm
Samara
Saratov
Penza
Volgograd
Rostov-on-Don
Astrakhan
Orenburg
Omsk
Tomsk
Novosibirsk
Krasnoyarsk
Barnaul
Irkutsk
Khabarovsk
Vladivostok
Yekaterinburg
Chelyabinsk
ASTANA
KAZAKHSTAN
UZBEKISTAN
TURKMENISTAN
KYRGYZSTAN
Alma-Ata
Tashkent
ULANBATOR
MONGOLIA
Gobi Desert
INNer MONGOLIA
SINKIANG
CHINA
Tian Shan
Kunlun Shan
TIBET
Himalayas
Urumqi
PEKING
Tianjin
Taiyuan
Xian
Chengdu
Nanjing
Shanghai
Harbin
Shenyang
Changchun
Hong Kong
Shenzhen
Hainan
TAIPEI
TAIWAN
NORTH KOREA
PYONGYANG
SEOUL
SOUTH KOREA
SEA OF JAPAN
YELLOW SEA
EAST CHINA SEA
JAPAN
TOKYO
Nagoya
Osaka
Kobe
BLACK SEA
CASPIAN SEA
MEDITERRANEAN SEA
RED SEA
ARABIAN SEA
Gulf of Aden
Bay of Bengal
ANDMAN SEA
SOUTH CHINA SEA
PHILIPPINE SEA
SULU SEA
CELEBES SEA
BANDA SEA
TIMOR SEA
INDIAN OCEAN
Istanbul
ANKARA
TURKEY
GEORGIA
SYRIA
IRAQ
BAGHDAD
TEHERAN
IRAN
Mashad
KABUL
AFGHANISTAN
ISLAMABAD
PAKISTAN
Karachi
NEW DELHI
INDIA
NEPAL
KATHMANDU
BHUTAN
BANGLADESH
Calcutta
Bombay
Hyderabad
Chennai
Bengaluru
SRI LANKA
COLOMBO
MYANMAR (BURMA)
RANGOON
HANOI
LAOS
BANGKOK
CAMBODIA
VIETNAM
MANILA
Quezon City
PHILIPPINES
MALAYSIA
KUALA LUMPUR
SINGAPORE
BRUNEI
INDONESIA
JAKARTA
Surabaya
Makassar
EAST TIMOR
Arabian Peninsula
RIYADH
SAUDI ARABIA
QATAR
U.A.E.
MUSCAT
OMAN
SANAA
YEMEN
KUWAIT
BAHRAIN
Medina
Mecca

Major Facilities(Planned) in Asia

- China
  - CEPC-SPPC
  - Daya Bay → JUNO
  - BEPCII-BESIII
- Korea
  - RENO → RENO-50
- Japan
  - ILC
  - SuperK → HyperK
  - SuperKEKB-BELLE II
- India
  - INO
- Russia
  - Super Tau-Charm factory

On April 5, 2016, BEPCII reached the target luminosity of $1 \times 10^{33} cm^2 s^{-1}$

AsiaHEP/ACFA Statement on ILC + CEPC/SPPC

Feb., 2016

AsiaHEP and ACFA reassert their strong endorsement of the ILC, which is in a mature state of technical development. The aim of ILC is to explore physics beyond the Standard Model by unprecedented precision measurements of the Higgs boson and top quark, as well as searching for new particles which are difficult to discover at LHC. The Higgs studies at higher energies are especially important for measurement of WW fusion process, to fix the full Higgs decay width, and to measure the Higgs self-coupling. In continuation of decades of world-wide coordination, we encourage redoubled international efforts at this critical time to make the ILC a reality in Japan. The past few years have seen growing interest in a large radius circular collider, first focused as a "Higgs factory", and ultimately for proton-proton collisions at the high energy frontier. We encourage the effort lead by China in this direction, and look forward to the completion of the technical design in a timely manner.

ACFA: Asia Committee for Future Accelerators
AsiaHEP: Asia-Pasific High Energy Physics Panel

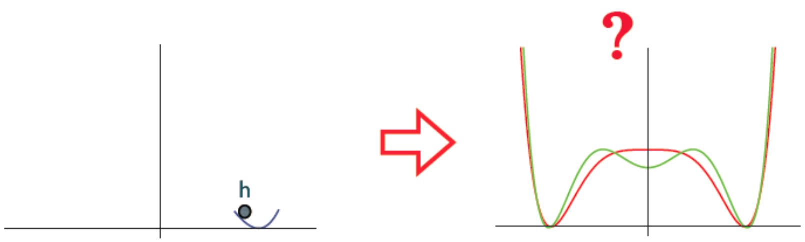
International Linear Collider(ILC)

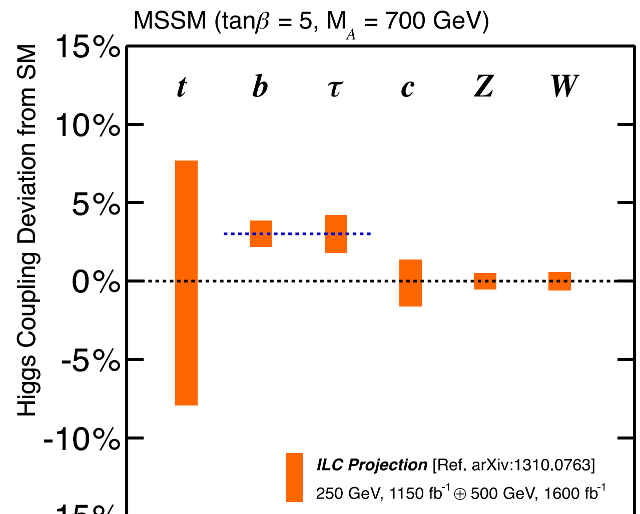
Slides mainly from
Sachio Komamiya

Main Science Goals

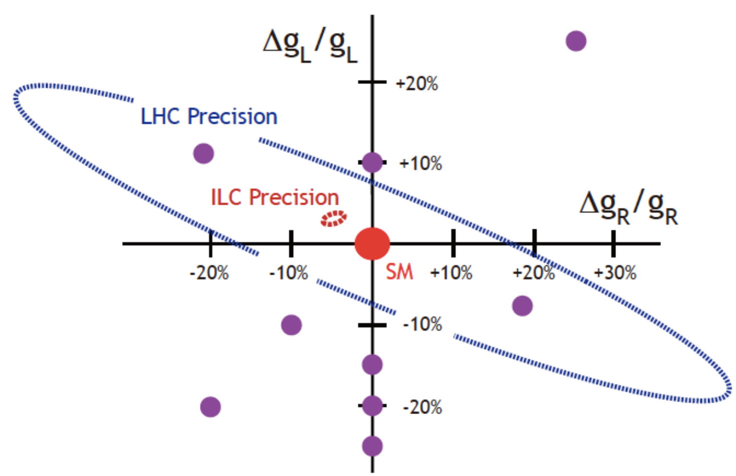
C.M. Energy	500 GeV
Length	31 km
Luminosity	1.8 x10^{34} $cm^{-2}s^{-1}$

- Precise measurement of Higgs couplings, to determine Higgs boson "elementary or composite" and to distinguish models
- Measure Higgs self-couplings to 30%, to determine EW phase transition: first or second order



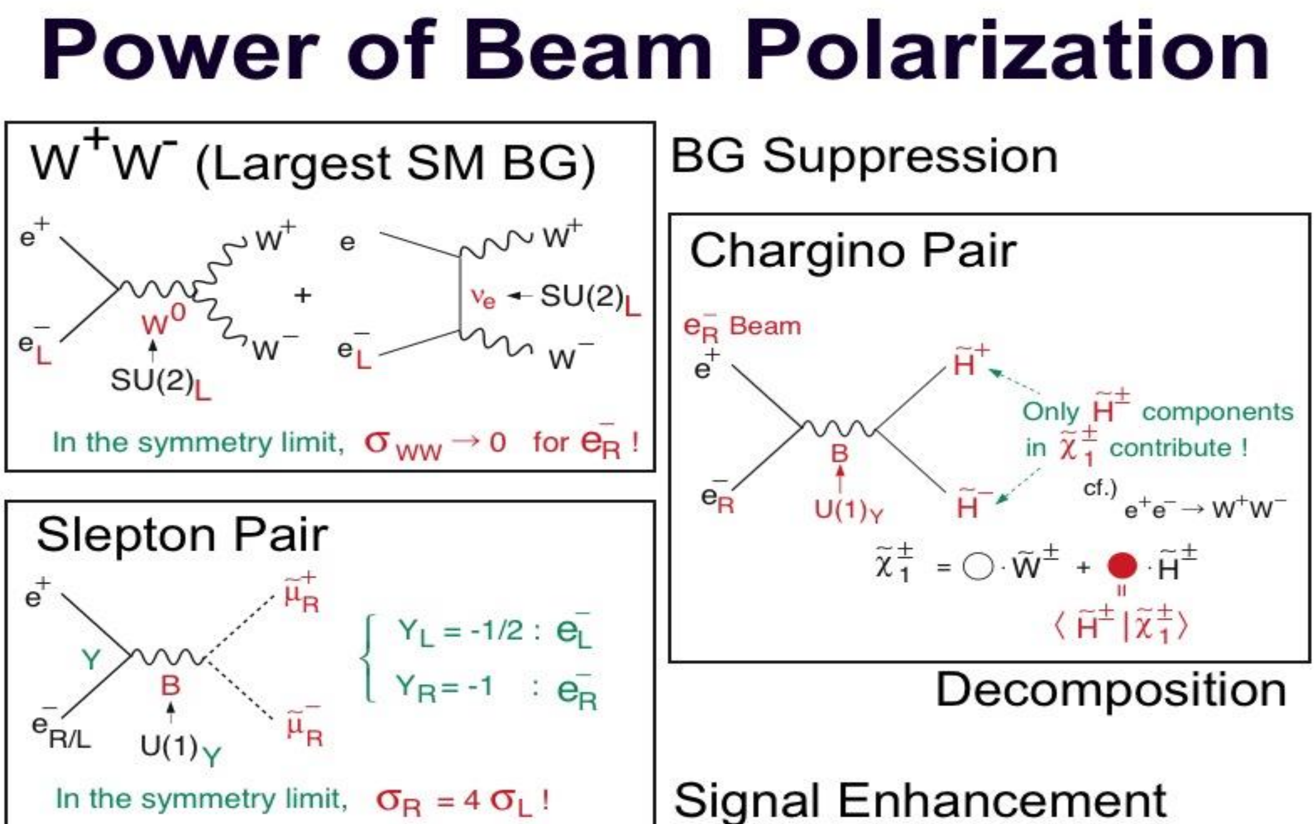


- Precision Top quark measurement
- Direct search for light SUSY particles



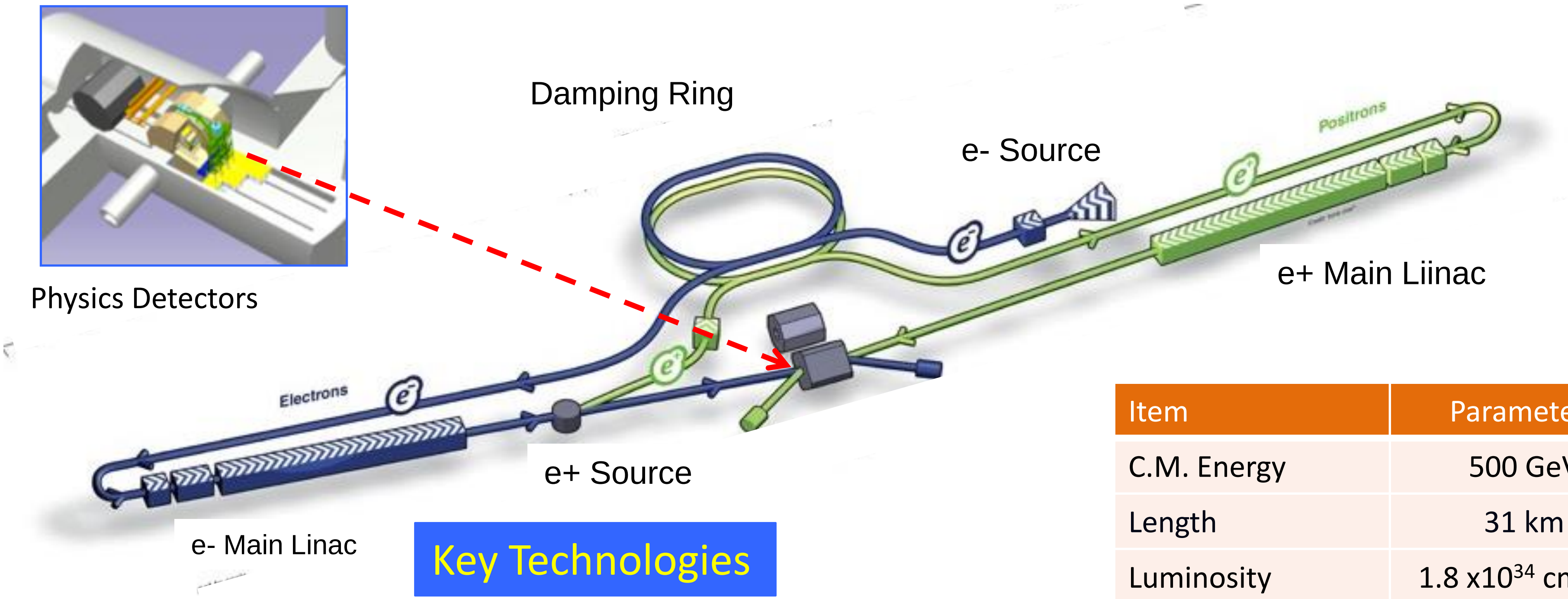
Advantages of Linear Collider

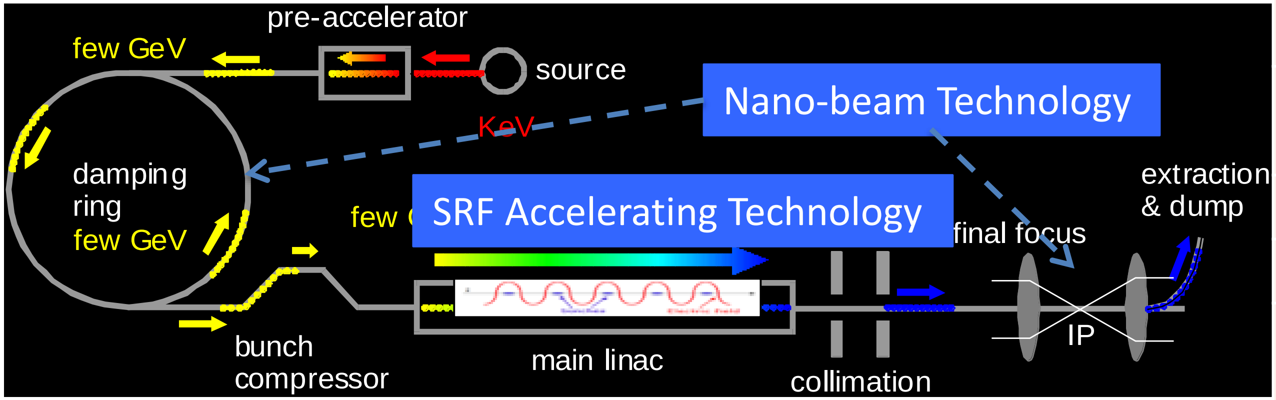
- No energy loss due to synchrotron radiation
- Extendability (length ⇒ energy)
- Beam Polarization
- Energy Scanning



[Fujii]

ILC Acc. Design Overview (in TDR)



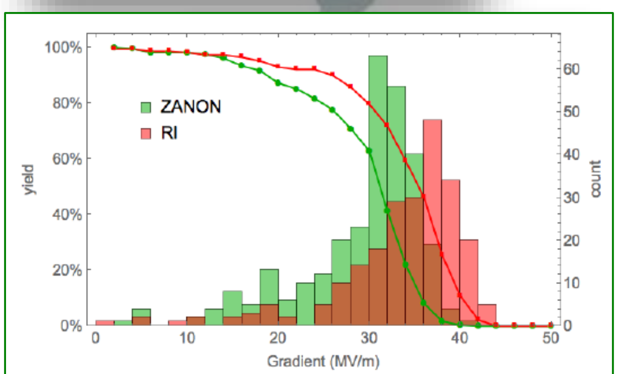


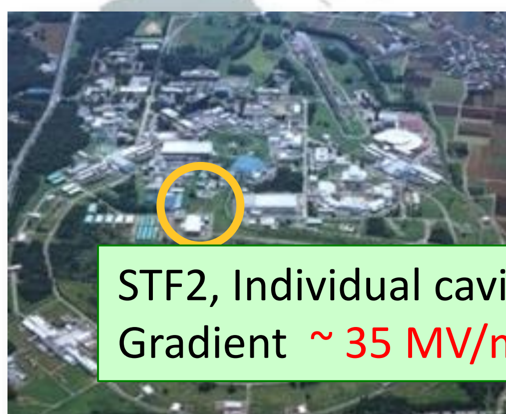
Item	Parameters
C.M. Energy	500 GeV
Length	31 km
Luminosity	1.8 x10^{34} $cm^{-2}s^{-1}$
Repetition	5 Hz
Beam Pulse Period	0.73 ms
Beam Current	5.8 mA (in pulse)
Beam size (y) at FF	5.9 nm
SRF Cavity G. Q_0	31.5 MV/m Q_0 = 1x10 ^{10}

Many accelerator slides are stolen from Akira Yamamoto (KEK)

SRF Facilities anticipated for ILC Hubs. and SRF Progress in 2014 – 2015

Technology globally matured to realize ILC





STF2, Individual cavity
Gradient ~ 35 MV/m

*AMTF @DESY/**E-XFEL**, CM*

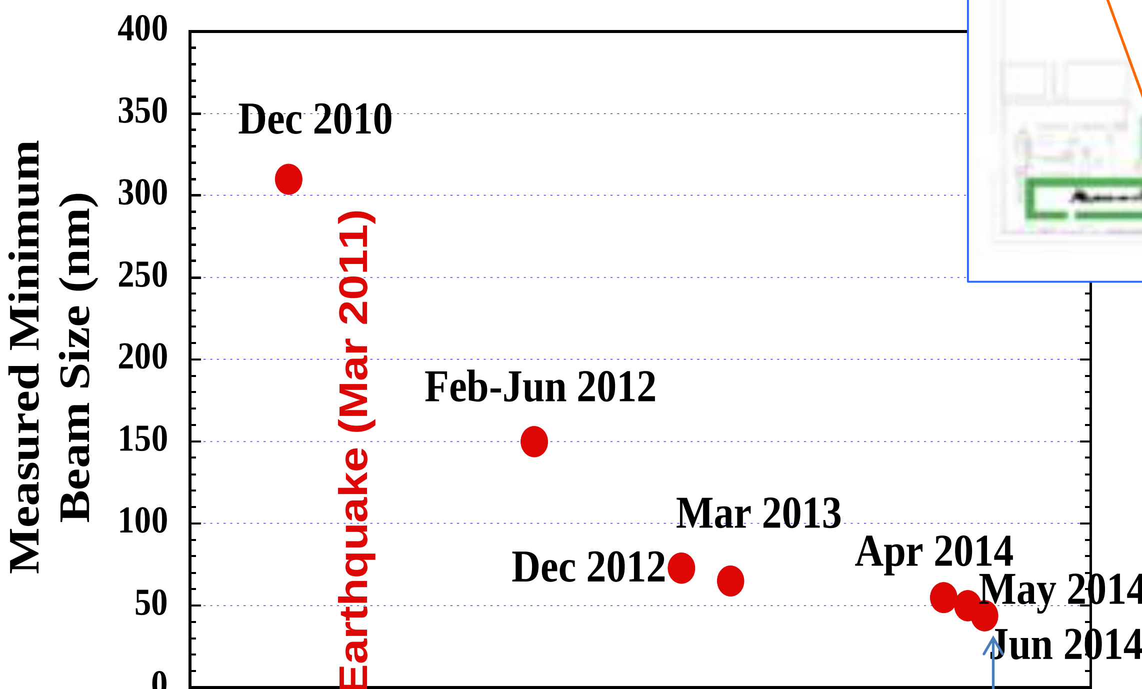
STF-CFF @ KEK

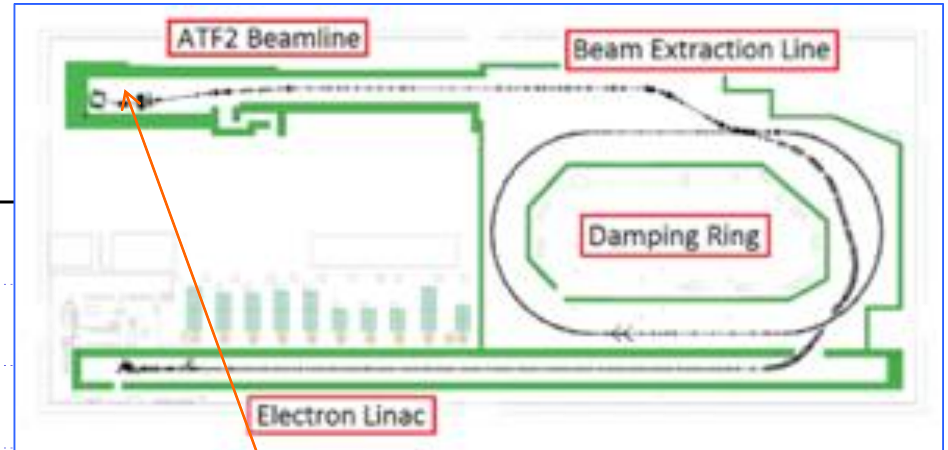
ASTA @ FNAL, TEDF @ JLab

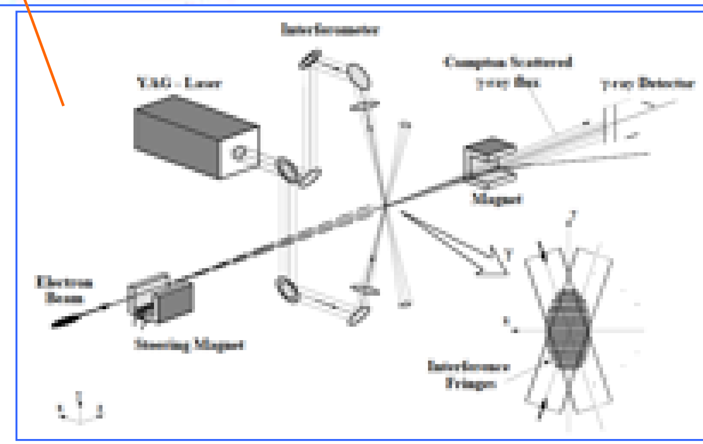
- 800 cavities are completed, w/ < 30 MV/m >

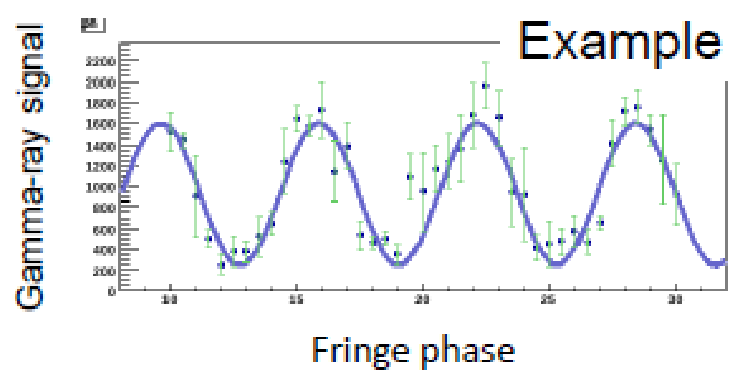
Cryomodule test at Fermilab reached < **31.5** > MV/m, exceeding ILC specification

Local chromatic correction at final focus progress at ATF2





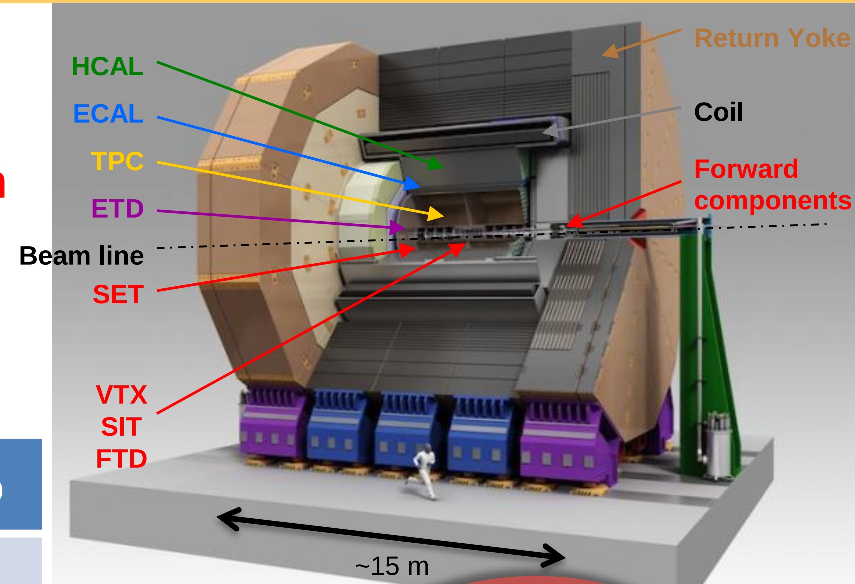




Average Beam Size 44 nm observed,
corresponding to 7 nm at ILC
(Goal : 37 nm,
corresponding to 6 nm at ILC)

ILC Detector R&D (ILD, SiD)

- **Vertex Detector: pixel detectors & low material budget**
- **(Time Projection Chamber: high resolution & low material budget, MPGD readout)**
- **Calorimeters: high granularity sensors, 5x5mm^2 (ECAL)、3x3cm^2 (HCAL)**



Sensor Size	ILC	ATLAS	Ratio
Vertex	5×5 mm^2	400×50 mm^2	x800
Tracker	1×6 mm^2	13 mm^2	x2.2
ECAL	5×5 mm^2 (Si)	39×39 mm^2	x61

Particle Flow Algorithm

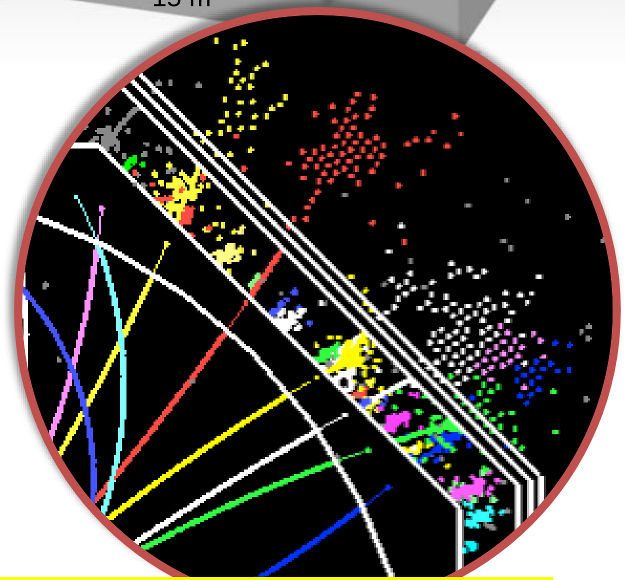
Charged particles → Tracker,

Photons → ECAL, Neutral Hadrons → HCAL

Separate calorimeter clusters at particle level

→use *best* energy measurement for *each* particle.

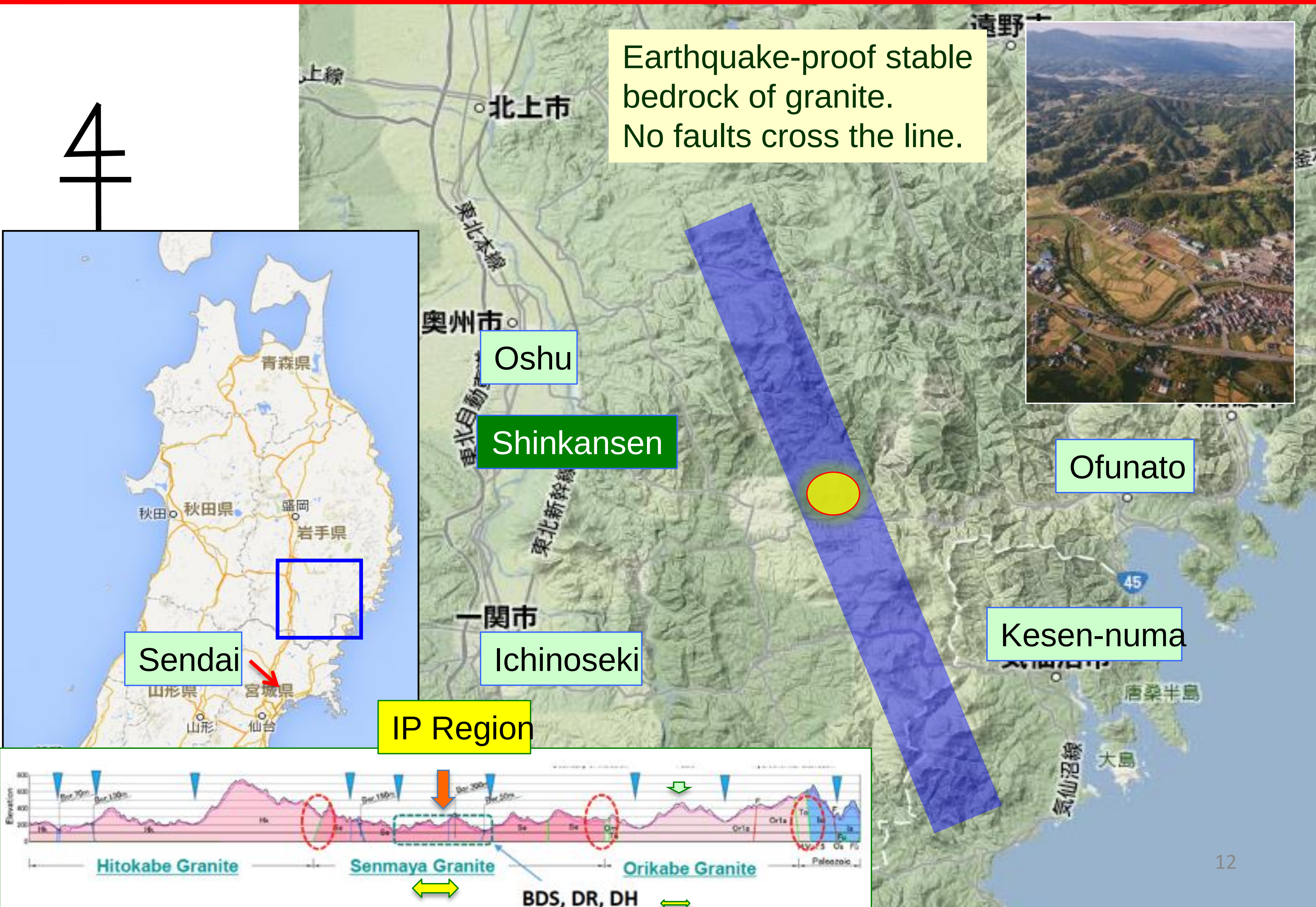
→offers unprecedented **jet energy resolution**



State-of-the-art detectors can be designed for ILC

ILC Site Candidate Location in Japan: Kitakami

Earthquake-proof stable bedrock of granite.
No faults cross the line.



International Organization after TDR

ICFA
Chair: J. Mnich

FALC
Chair: J. Womersley

Program Adv. Committee
PAC – Chair: N. Holtkamp

Linear Collider Board
LCB – Chair: S. Komamiya

KEK
Planning Office
for the ILC

Regional Directors
- B. Foster (EU)
- H. Weerts (AMs)
- A. Yamamoto (AS)

Linear Collider Collab.
LCC
- Director: L. Evans

Deputy (Physics)
– H. Murayama

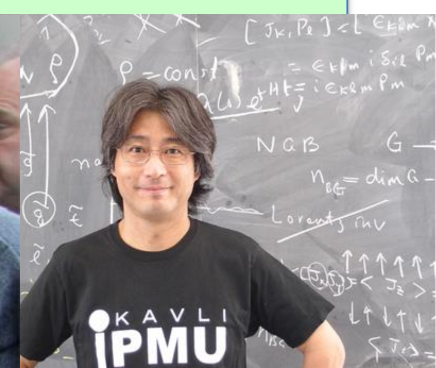
Assoc. Directors

ILC
– M. Harrison
(Deputy)
H. Hayano, N. Walker

CLIC
– S. Stapnes

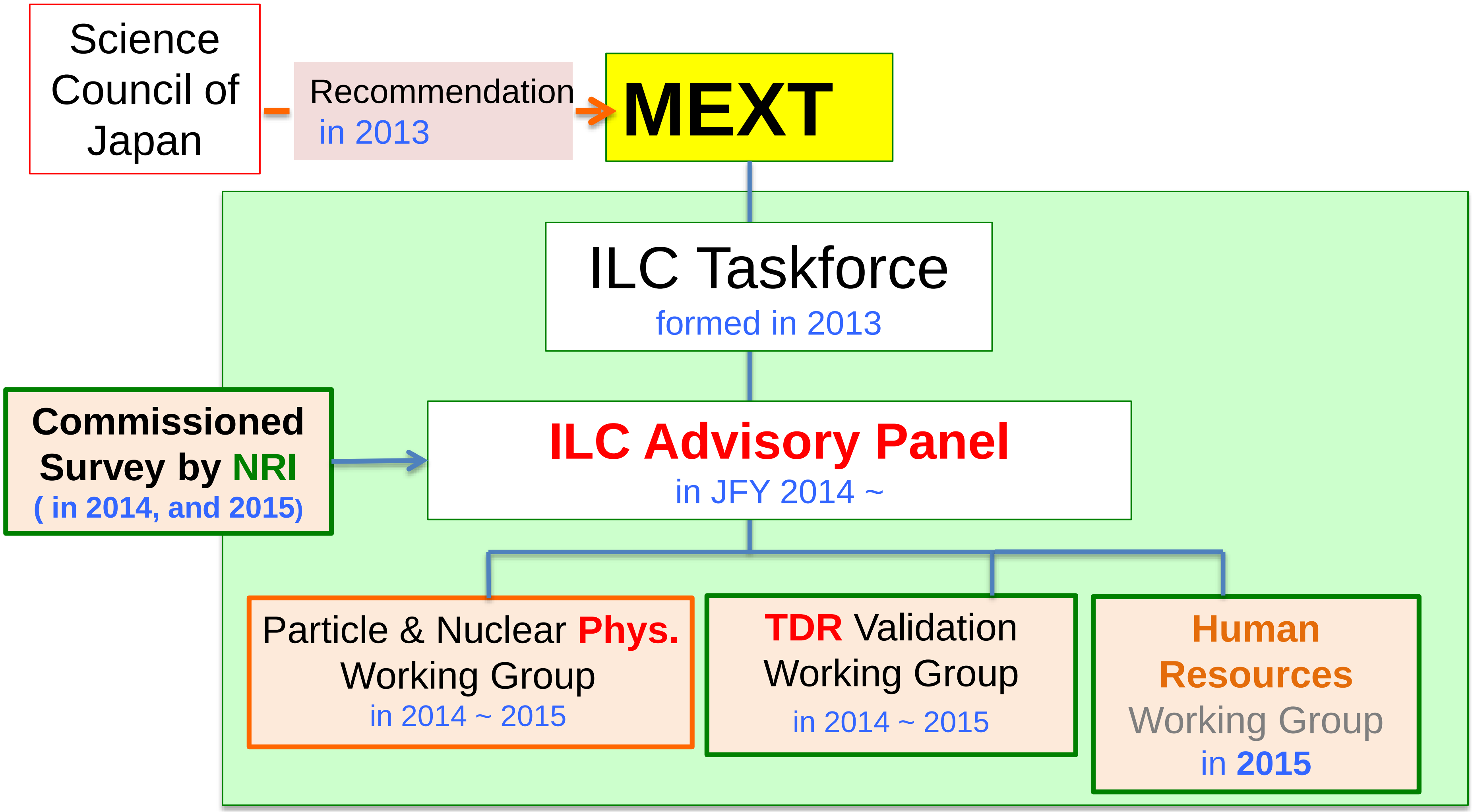
Physics & Detectors
– H. Yamamoto

ILC Project Unit,
Coordination Unit



The Position of MEXT and the Japanese Government towards the ILC

ILC being studied officially by the MEXT Japan



Necessary steps towards the approval

1. Technology Choice (2003)

2. R&D and design of the machine/detectors by the international team
   ⇒ Technical Design Report (2013)

3. Official investigation and reviews of the ILC project by MEXT (now)
4. Clarify the scientific and technical issues in the report of the ILC Advisory Panel (done)

5. To facilitate / prepare intergovernmental discussions for sharing of cost human resources and the schedule without commitment (starting).

6. MEXT green signal
7. Endorsement of CSTP (Council of Science, Technology and Innovation; chair: Prime Minister)
8. Cabinet decision

9. International agreement with commitment ⇒ Establishment of ILC Lab

Time line for the ILC project

Years need

2 Preparation period Continuation of high-tech R&D (now)

4 Preparation for the ILC construction (with real budget)

9 Construction

6th year - Start Installation

7th year- Start of step-by-step accelerator test

1 Beam Commissioning

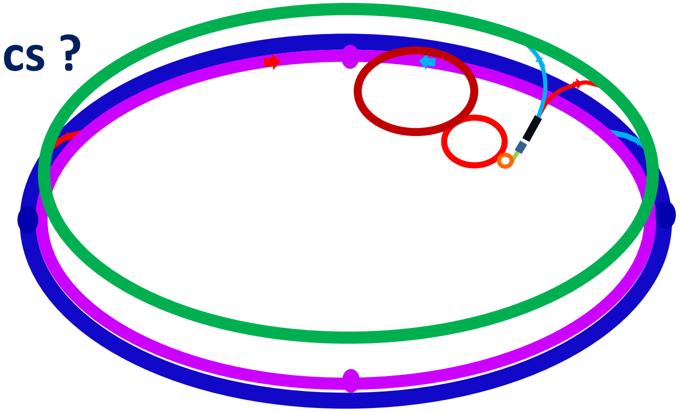
~8 Physics Run (500 GeV, 350 GeV, 250 GeV)

~ Run with Luminosity upgrade (500 GeV, 250 GeV)

TBD Energy upgrade (~ 1TeV)

CEPC-SPPC

- **Electron-positron collider(90, 250 GeV)**
  - Higgs Factory: Precision study of Higgs
    - Higgs mass, width, couplings, J^{PC}, etc.
    - Looking for deviation from SM, new physics ?
  - Z & W factory: precision test of SM
    - Deviation from SM ?
  - Flavor factory: b, c, τ and QCD studies



- **Proton-proton collider(~100 TeV)**
  - Directly search for new physics beyond SM
  - Precision test of SM
    - e.g., h^3 & h^4 couplings

Precision measurement + searches:
Complementary with each other !

IHEP-CEPC-DR-2015-01

IHEP-EP-2015-01

IHEP-TH-2015-01

IHEP-CEPC-DR-2015-01

IHEP-AC-2015-01

Can be downloaded from

http://cepc.ihep.ac.cn/preCDR/volume.html

CEPC-SPPC

Preliminary Conceptual Design Report

Volume I - Physics & Detector

403 pages, 480 authors

The CEPC-SPPC Study Group

March 2015

CEPC-SPPC

Preliminary Conceptual Design Report

Volume II - Accelerator

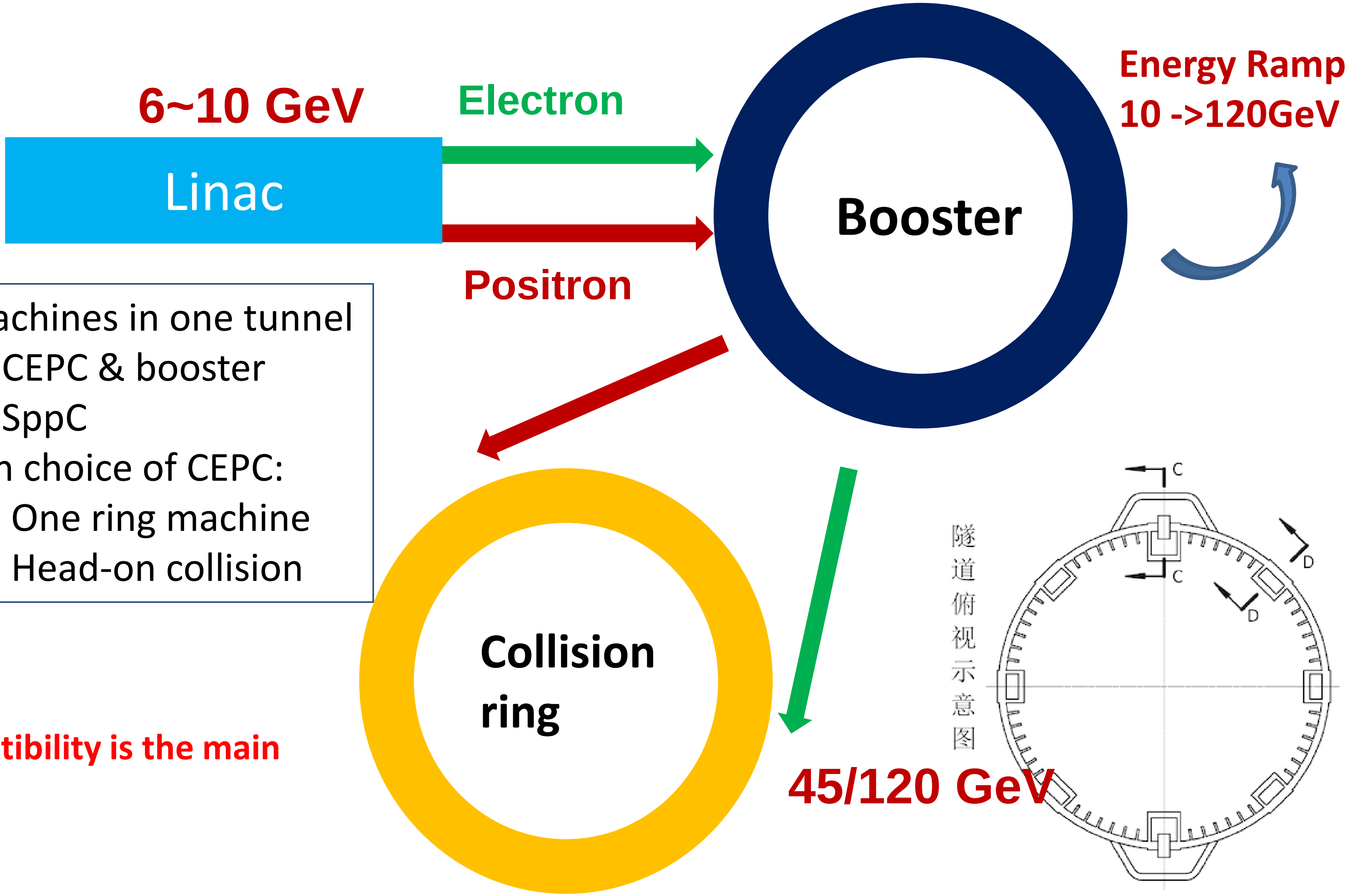
328 pages, 300 authors

The CEPC-SPPC Study Group

March 2015

0, 2015

CEPC Accelerator

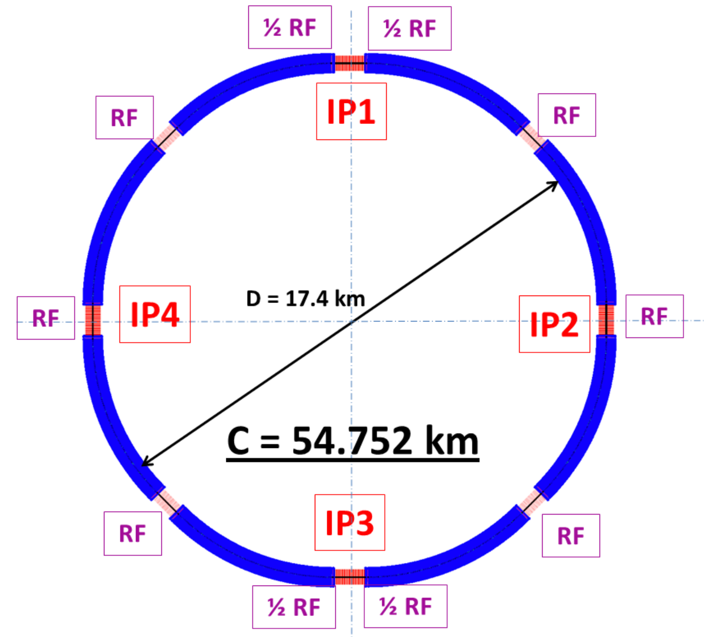


- 3 machines in one tunnel
  - CEPC & booster
  - SppC
- Main choice of CEPC:
  - One ring machine
  - Head-on collision

Compatibility is the main Issue

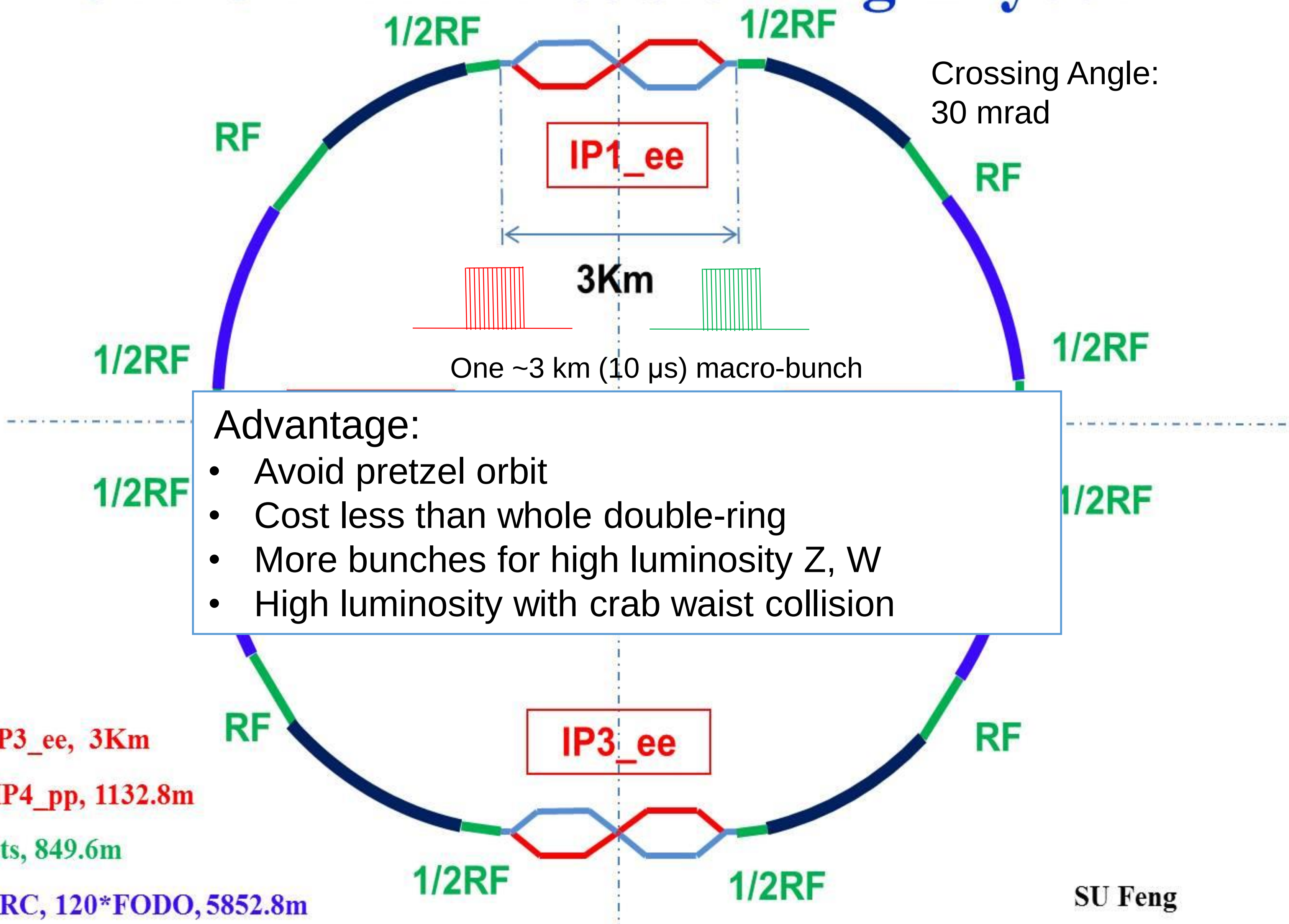
CEPC Design

- Beam physics: dynamic aperture, momentum acceptance, electron cloud, pretzel scheme, …
- SRF system: High-Q cavity, power loading, HOM dumping, …
- Total power consumption



Parameter	Unit	Value	Parameter	Unit	Value
Beam energy [E]	GeV	120	**Circumference [C]**	m	54752
Number of IP[N_{IP}]		2	**SR loss/turn [U_0]**	GeV	3.11
Bunch number/beam[n_B]		50	**Energy acceptance RF [h]**	%	5.99
SR power/beam [P]	MW	51.7	**Beam current [I]**	mA	16.6
emittance (x/y)	nm	6.12/0.018	**β_{IP}(x/y)**	mm	800/1.2
Transverse size (x/y)	μm	69.97/0.15	**Luminosity /IP[L]**	$cm^{-2}s^{-1}$	2.04E+34

CEPC Partial Double Ring Layout



Advantage:

- Avoid pretzel orbit
- Cost less than whole double-ring
- More bunches for high luminosity Z, W
- High luminosity with crab waist collision

IP1_ee/IP3_ee, 3Km

IP2_pp/IP4_pp, 1132.8m

4Straights, 849.6m

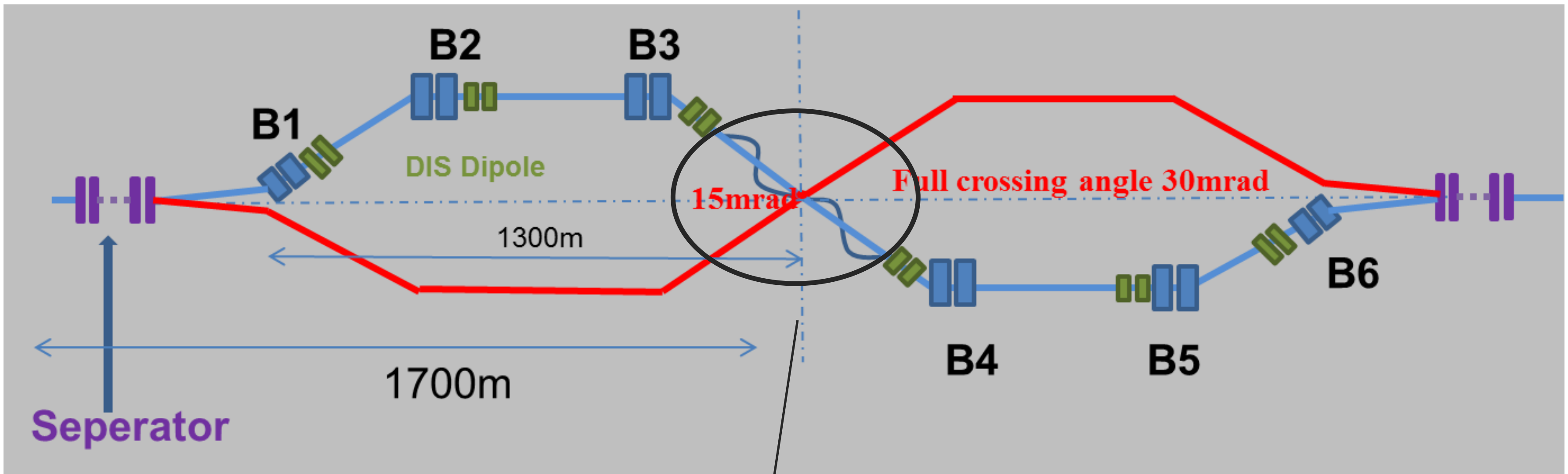
4Long ARC, 120*FODO, 5852.8m

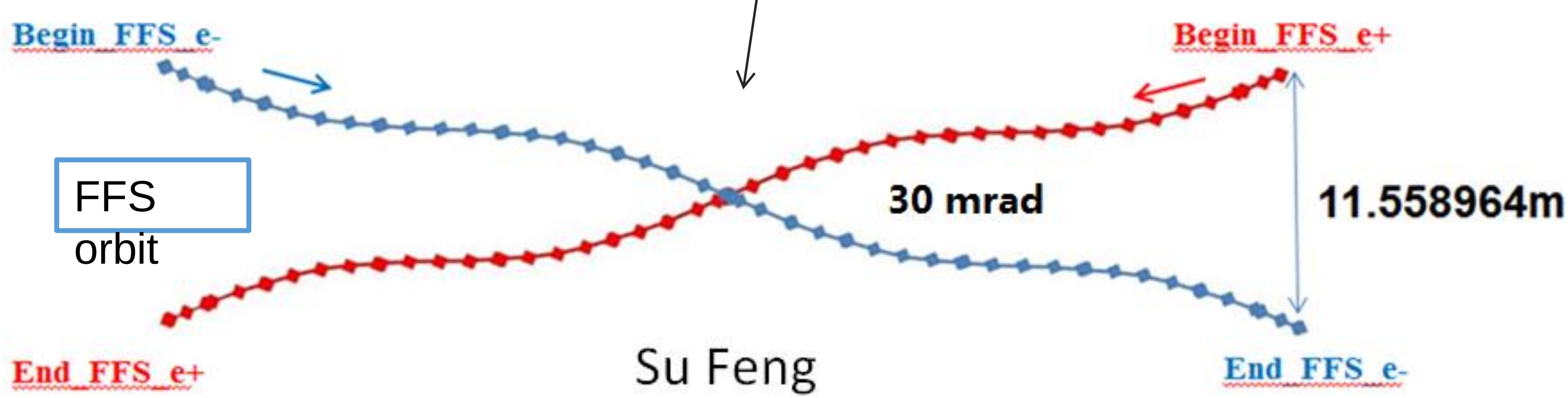
4Short ARC, 100*FODO, 4908.8m

SU Feng

2015.10.12

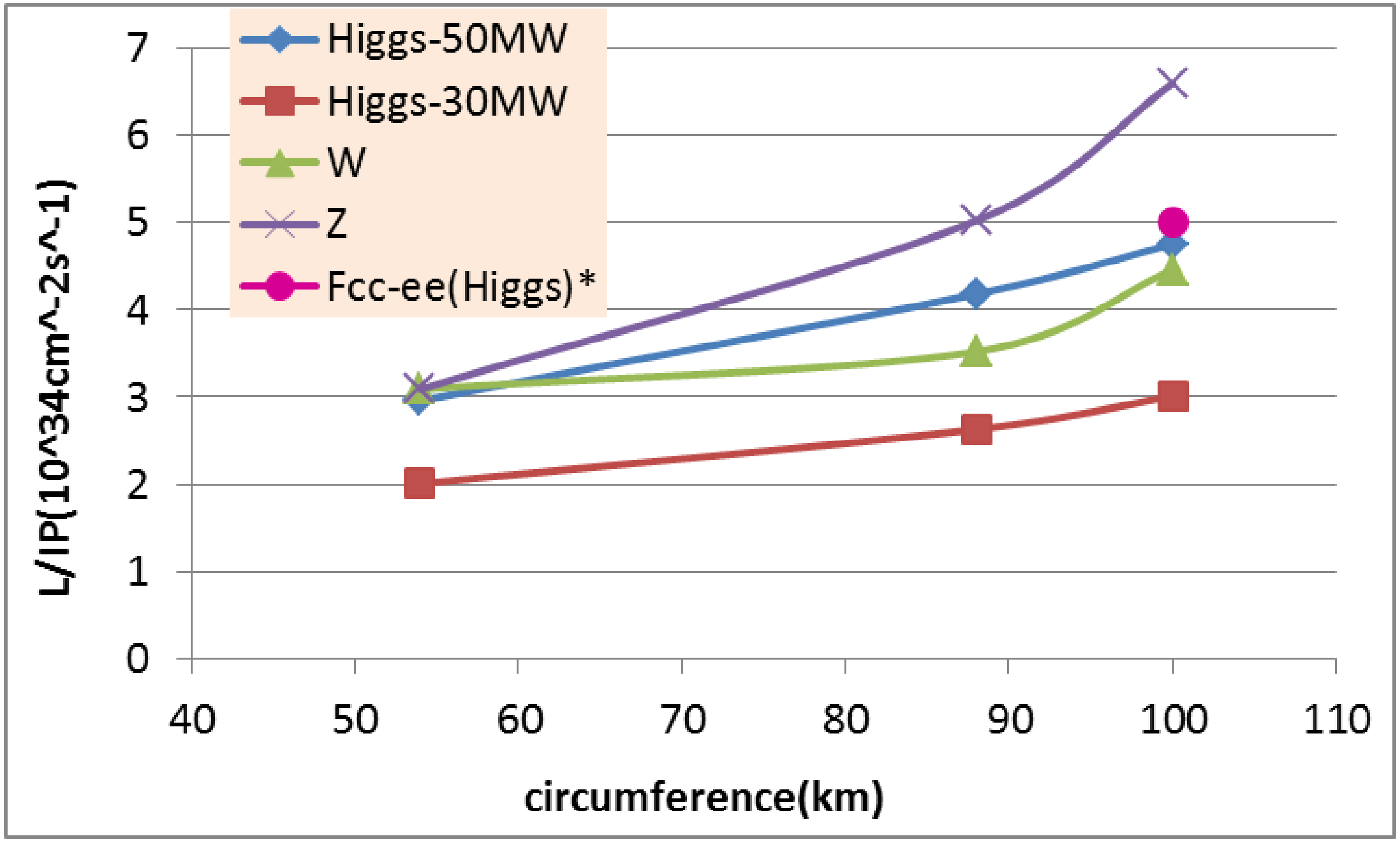
Partial Double Ring Lattice





Su Feng

CEPC PDR Luminosity vs circumference

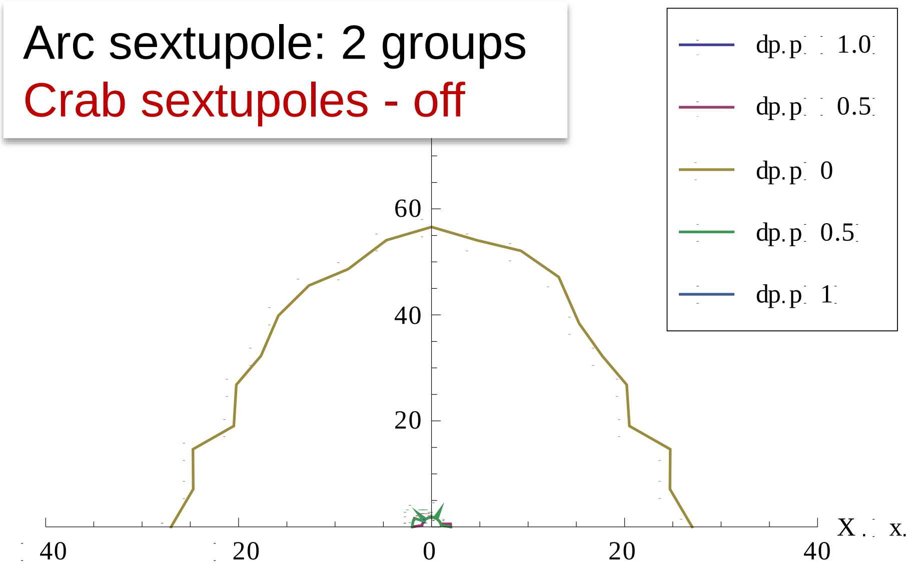


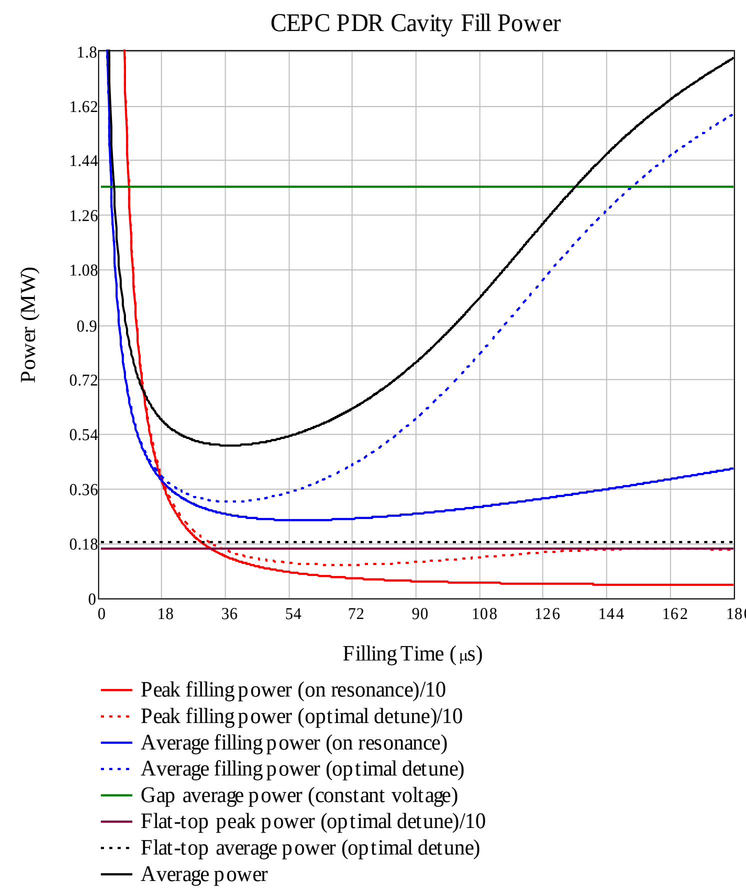
* Fabiola Gianotti, Future Circular ColliderDesign Study, ICFA meeting, J-PARC, 25-2-2016.

Many Remaining Issues

- Single ring or partial double are clearly more difficult
- Beam physics: Dynamic aperture, …
- SRF: total & transient beam loading, RF-to-beam efficiency,…

Arc sextupole: 2 groups
Crab sextupoles - off



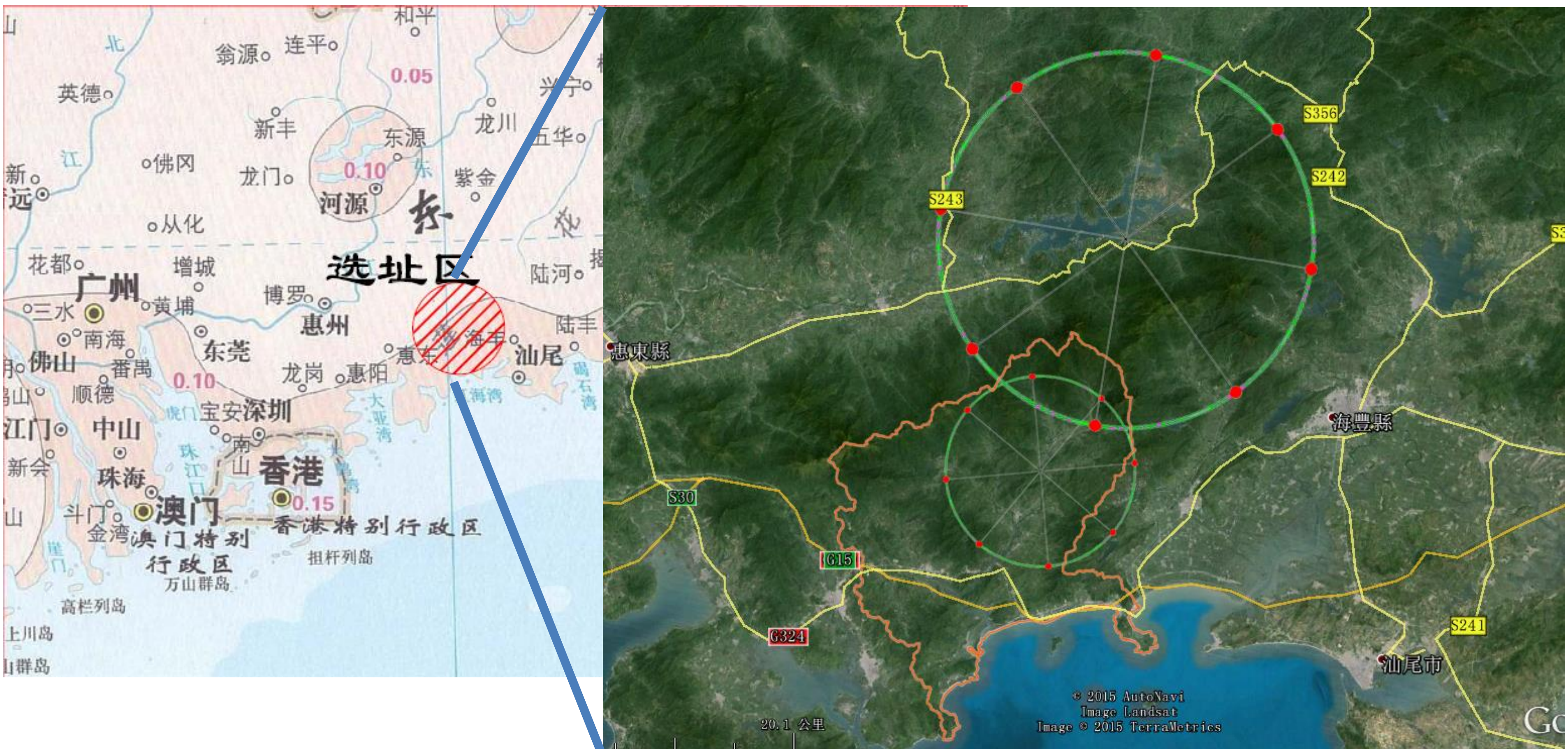


After chromaticity correction

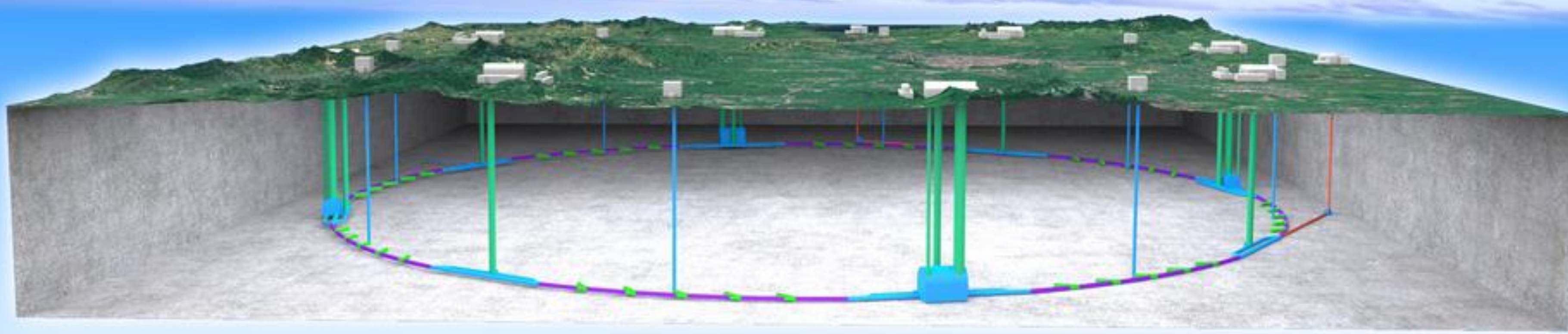
- DA (on-momentum): $27\sigma_x \times 57\sigma_y$
- DA (±0.5%): $2\sigma_x \times 2\sigma_y$

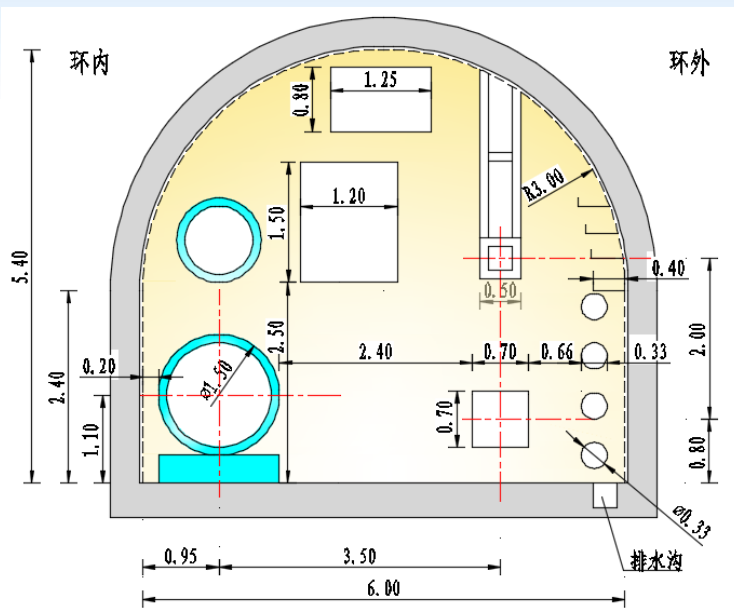
Site Selection

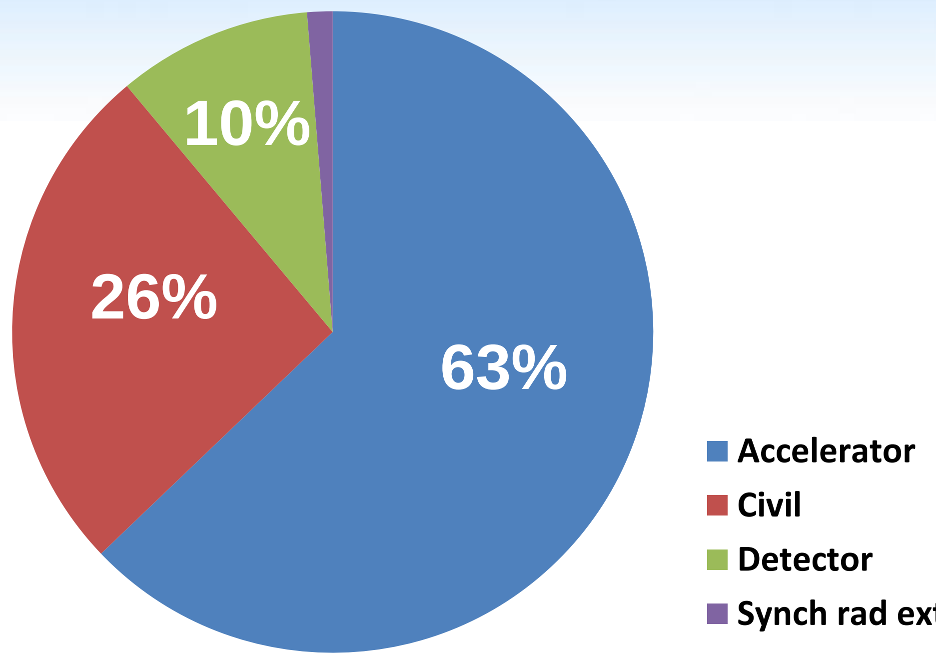
- Continue to work on site selection
- A new possibility, invited by the local government



Civil Construction







International Collaboration

- **Limited international participation for the pre-CDR**
  - **An excise for us**
  - **Build confidence for the Chinese HEP community**
- **Chinese government welcomes international collaboration**
  - **to integrate China better into the international community**
  - **to modernize China's research system("open door" policy)**
  - **to obtain needed help on funding, technology, etc.**
- **This machine will be built and owned by the international community, but a new scheme of collaboration and management need to be explored**
- **An international advisory board is formed last Sep. to consult on this issue, in addition to scientific and technological discussions**

Timeline (dream)

- **CPEC**
  - Pre-study, R&D and preparation work
    - Pre-study: 2013-15
      - **Pre-CDR for R&D funding request**
    - R&D: 2016-2020
    - Engineering Design: 2015-2020
  - Construction: 2022-2028
  - Data taking: 2029-2035
- **SppC**
  - Pre-study, R&D and preparation work
    - Pre-study: 2013-2020
    - R&D: 2020-2030
    - Engineering Design: 2030-2035
  - Construction: 2035-2042
  - Data taking: 2042 -

US | EUROPE | AFRICA | ASIA | 中文 April 10,

HOME | CHINA | WORLD | BUSINESS | LIFESTYLE | CULTURE | TRAVEL | SPORTS | OPINION | R

China / Innovation

Hot Issues | Government | Society | Innovation | Education | Co
Photos

China plans world's most powerful particle collider

By Cheng Yingqi (China Daily)

Updated: 2015-10-29 07:49

Comments | Print | Mail | Large | Medium | Small

The first phase of the project's construction is scheduled to begin between 2020 and 2025

Media is media
Chinese media is also media
Don't get too excited, nor panic
CEPC will not be easy and quick
R&D will come gradually

Five-year plan boosts basic research funding

Blueprint gives few details, but scientists foresee more generous grants and new facilities

By **Hao Xin**, *in Beijing*

Science, vol. 351, no. 6280, pp. 1382, 2016

C... a windfall for basic science. Cosmic evolution, the structure of matter, the origins of life, and understanding how the brain works all deserve strengthened support, according to China's latest 5-year development plan, which could triple funding for basic research by 2020.

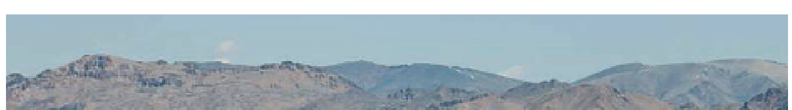
An outline of the plan, which covers 2016 through 2020, received pro forma approval by the National People's Congress (NPC) on 16 March at its closing session. The plan signals that top leaders are looking to researchers, even those doing fundamental work, for innovations that will drive the economy as it

of Science and Technology (MOST), which ...ed research, can ...s under the new 5-year plan. CAS is holding expert meetings to help it decide which programs to support, according to its website. MOST has already called for proposals in nine areas, including precision medicine, reproductive health, biomedical materials, global change, and cloud computing and big data mining.

New big science projects, too, are vying for a share of the increased funding. After the U.S.-based Advanced Laser Interferometer Gravitational-Wave Observatory an-

at the South Pole and made a premature detection claim 2 years ago. Some in the Chinese scientific community have suggested that the Ngari project should enlist international collaborators.

For one high-profile project the news is not as good. China plans to hold off on construction of the Circular Electron Positron Collider (CEPC), intended to generate large numbers of Higgs bosons to precisely measure the particle's mass. The project would cost somewhere between \$3.8 billion and \$5.4 billion, depending on its circumference. Wang Yifang, director of CAS's Institute of High Energy Physics in Beijing, the chief sponsor of the CEPC, says the project continues to get R&D funding.



Current Status and the Plan

- Pre-CDR completed
  - No show-stoppers
  - Technical challenges identified → R&D issues
  - Preliminary cost estimate
- Working towards CDR
  - A working machine on paper
  - Ready to be reviewed by government
- R&D issues identified and funding request underway
  - Seed money from IHEP available: 12 M RMB/3 years
  - MOST: ~ 45 M + 45 M / 5 yr, proposal submitted, approval this year ?
  - NCDR: ~1 B RMB / 5 yr, process may start this year
- Start international collaboration once funding is available

Summary

- Asia is catching up on Science, thanks to its economic growth. New initiatives from Asia are opportunities to the community
- ILC is now under review by the Japanese government, while CEPC is still in its early stage
- Given the importance of Higgs, we hope that at least one of them, FCC-ee, ILC, or CEPC, can be realized.