



# Asian Linear Collider Workshop 2018

May 28 - June 1, 2018 Fukuoka International Congress Center Fukuoka, JAPAN



## Particle Physics Programme in Asia incl. Oceania



George W.S. Hou (侯維恕)  
National Taiwan University



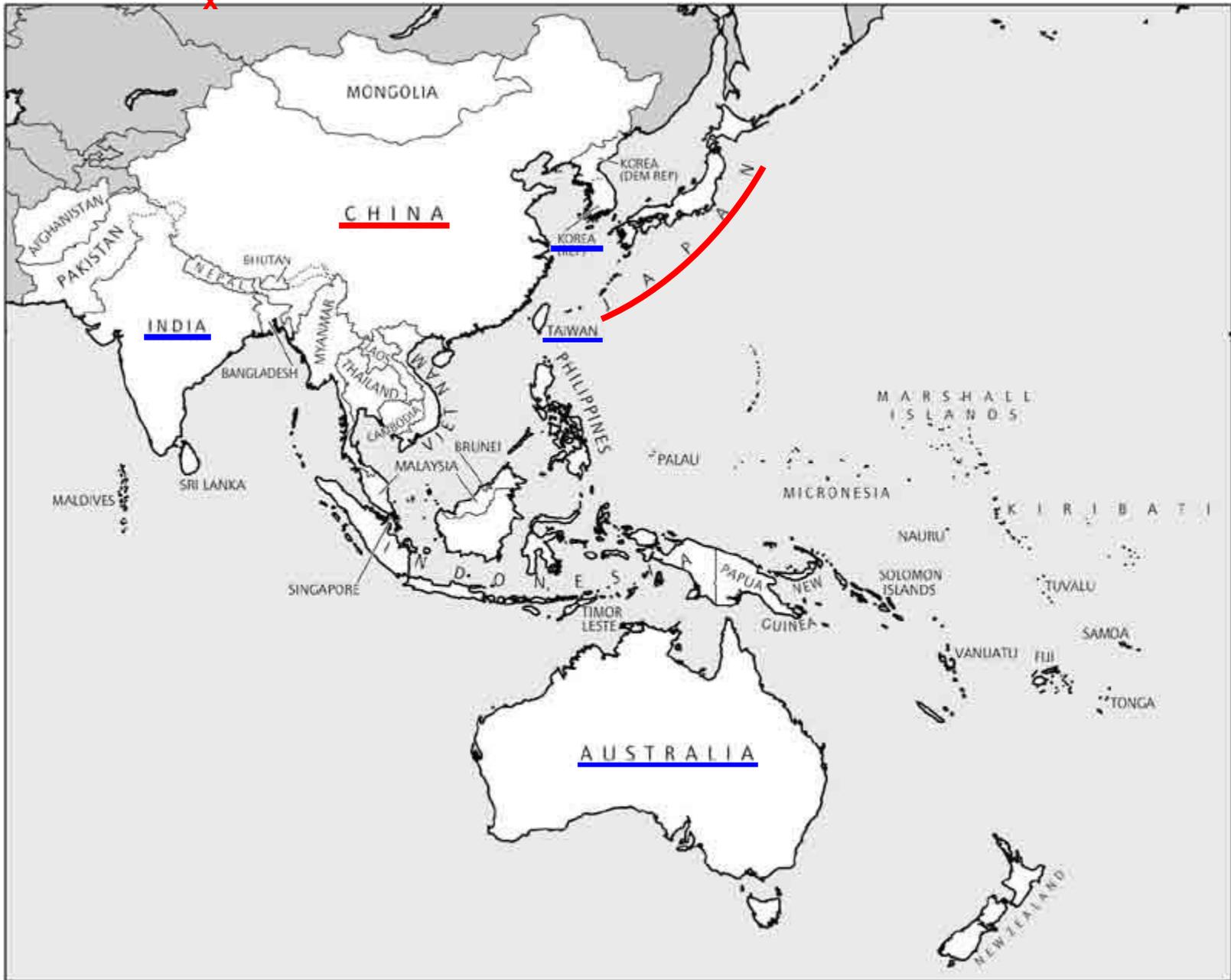
## Outline

1. Asia-in-World →to→ Asia
2. Success to Successor
3. J-PARC and Non-Accelerator
4. **The Hopefuls: ILC & CEPC(-SppC)** → Yasuhiro Okada/ Yifang Wang  
(next talk)
5. Amalgamation of **ACFA/AsiaHEP**

## ICFA Mission

- To promote international collaboration in all phases ... of very high energy accelerators.
- To organize regularly world-inclusive meetings for the exchange of information on future plans for regional facilities and for the formulation of advice.
- To organize workshops for the study of problems related to super high-energy accelerator complexes and their international exploitation and to foster research and development of necessary technology.

# AsiaHEP Member States



## AsiaHEP/ACFA Statement on ILC + CEPC/SPPC

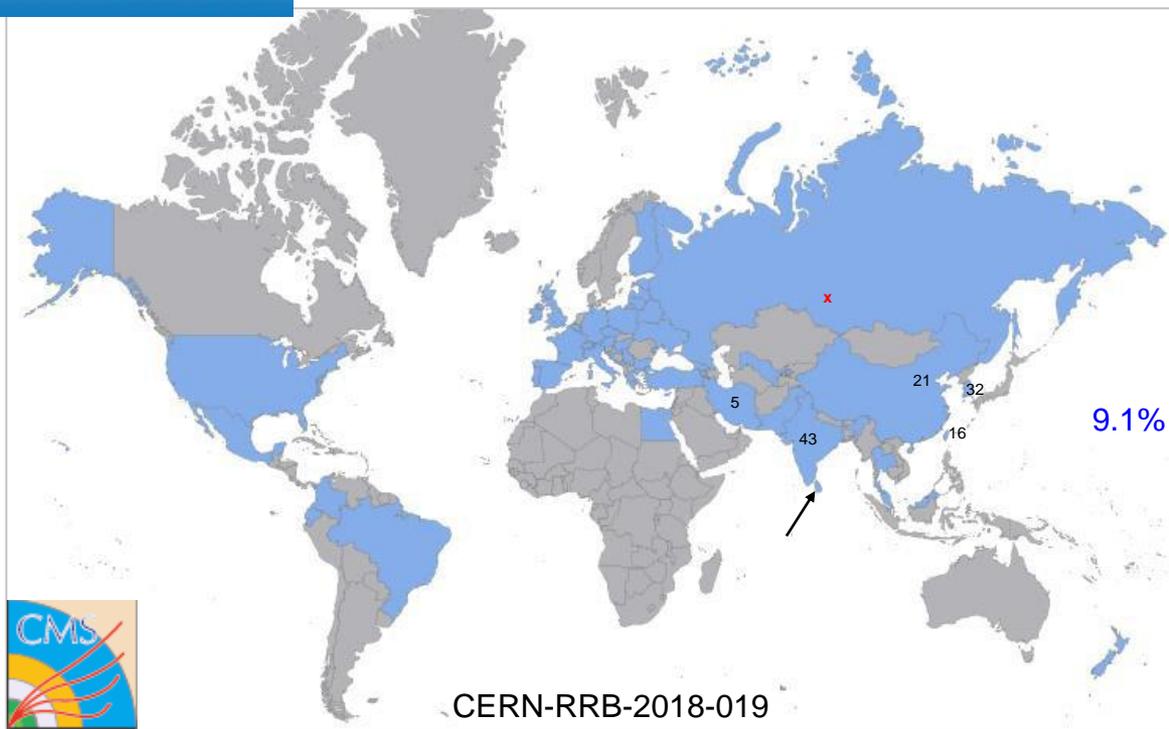
AsiaHEP and ACFA reassert their strong endorsement of the ILC, which is in a mature state of technical development. The aim of ILC is to explore physics beyond the Standard Model by unprecedented precision measurements of the Higgs boson and top quark, as well as searching for new particles which are 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.

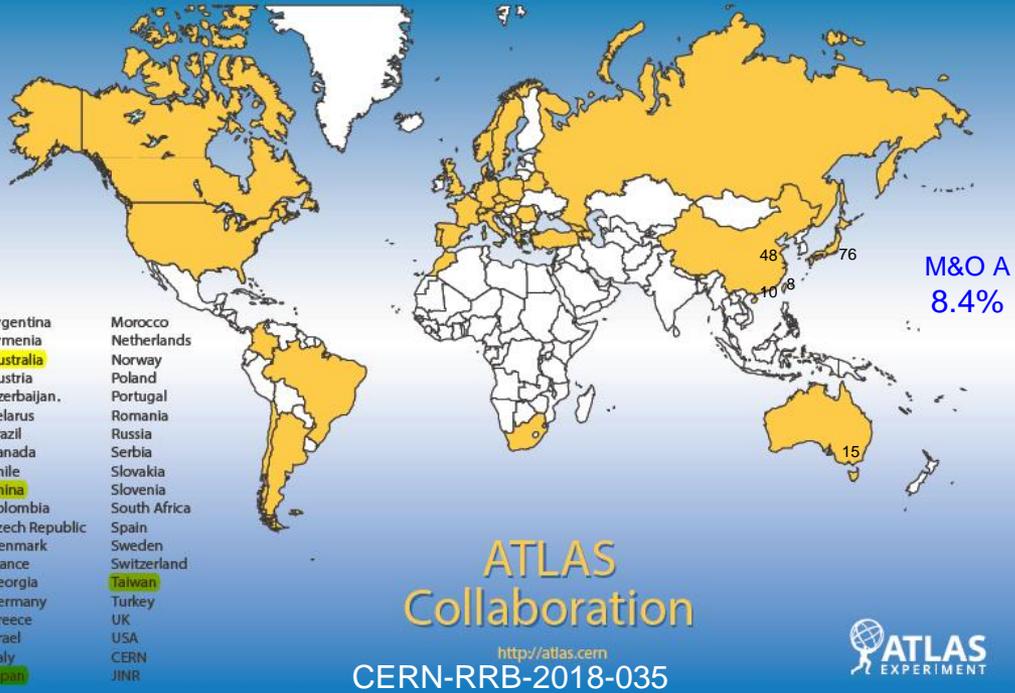
ILC

CEPC



LHC is current World HEP Focus

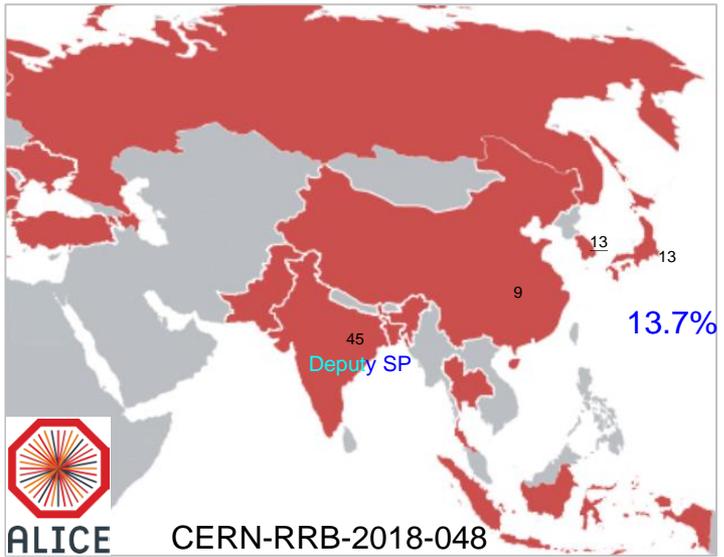




LHC is current World HEP Focus

Phase-2 > 21 MCHF

LHCb: 21 (China) 4.1%



PPP Asia



# The High-Granularity Calorimeter HGCal for CMS Phase II Upgrade

Stathes Paganis  
(5/28 para.)

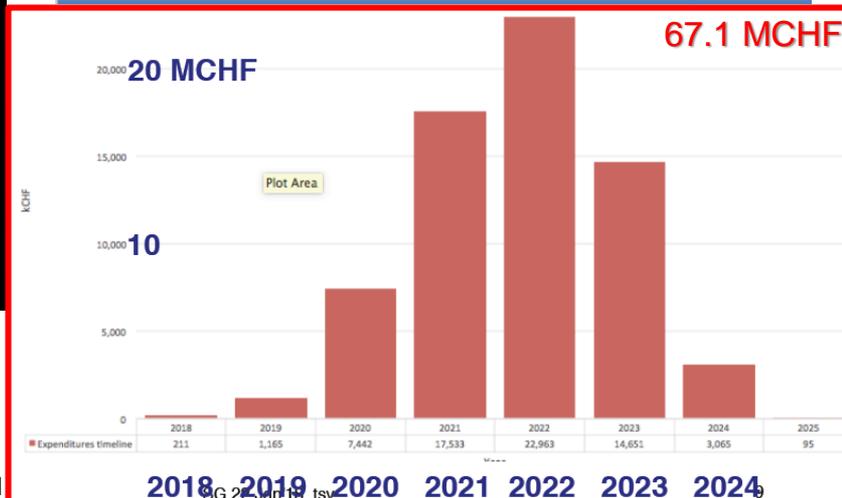
*Challenging !!*

**Taiwan: 2.87 MCHF**

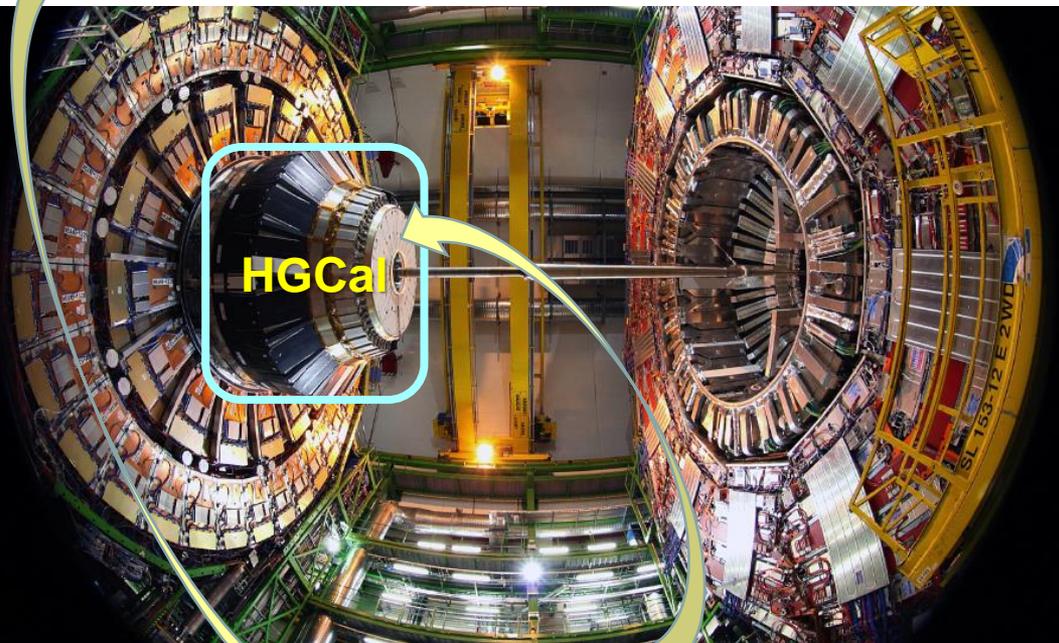
**Module Assembly Center (MAC)**  
in new **Si-Lab @ NTU**

Lead: UCSB  
Also: IHEP (China)  
BARC (India)  
CMU  
TexasTech

Sum of Cost kCHF	
CBS	Total
1.1 - Mechanical Systems	11'441
1.10 - Installation and Commissioning	226
1.2 - Cassettes	3'027
1.3-1.4 Sensors and Modules	25'992
1.5 - Scintillator/SiPM Modules	2'945
1.6 - Electronics and Electrical Systems	15'762
1.7 - Backend System (Trigger and DAQ)	6'226
1.8 - Slow control	598
1.9 - Detector Assembly (on surface)	910
<b>Grand Total</b>	<b>67'127</b>



Preshower ('02-'08)



**HGCal**



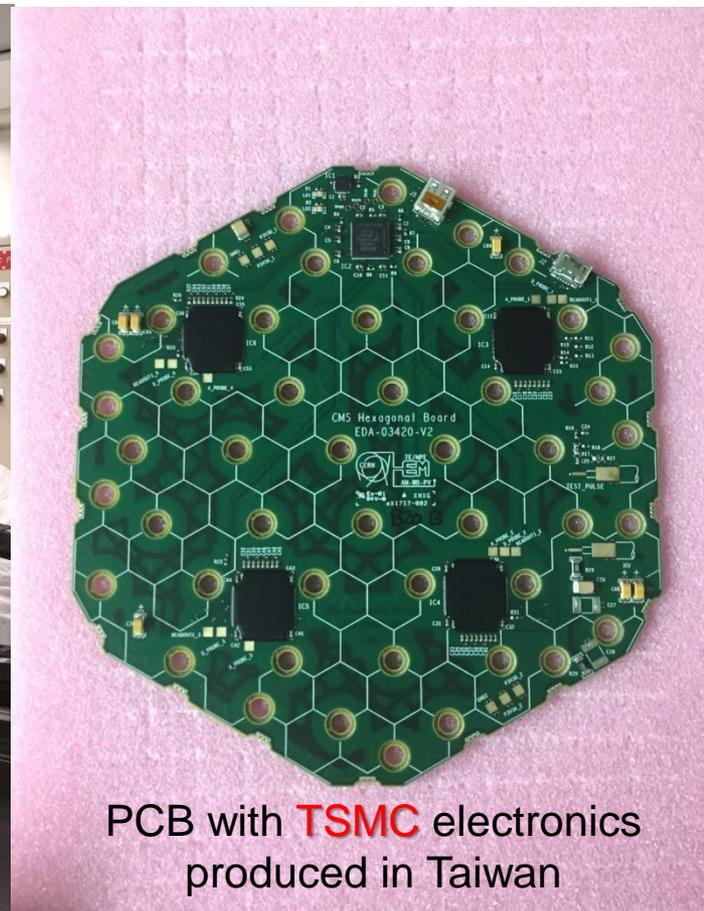
Pixel 1 ('10-'16)

George W.S. Hou

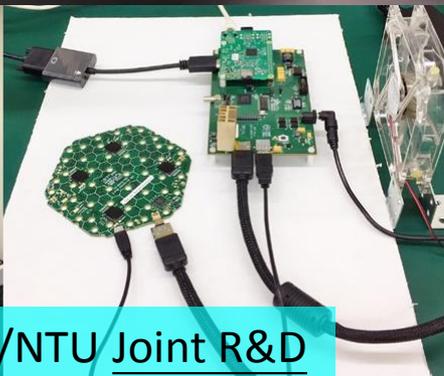
# CMS HGCal MAC in Taiwan



NTU AstroMath Building



PCB with **TSMC** electronics produced in Taiwan



Training young talents

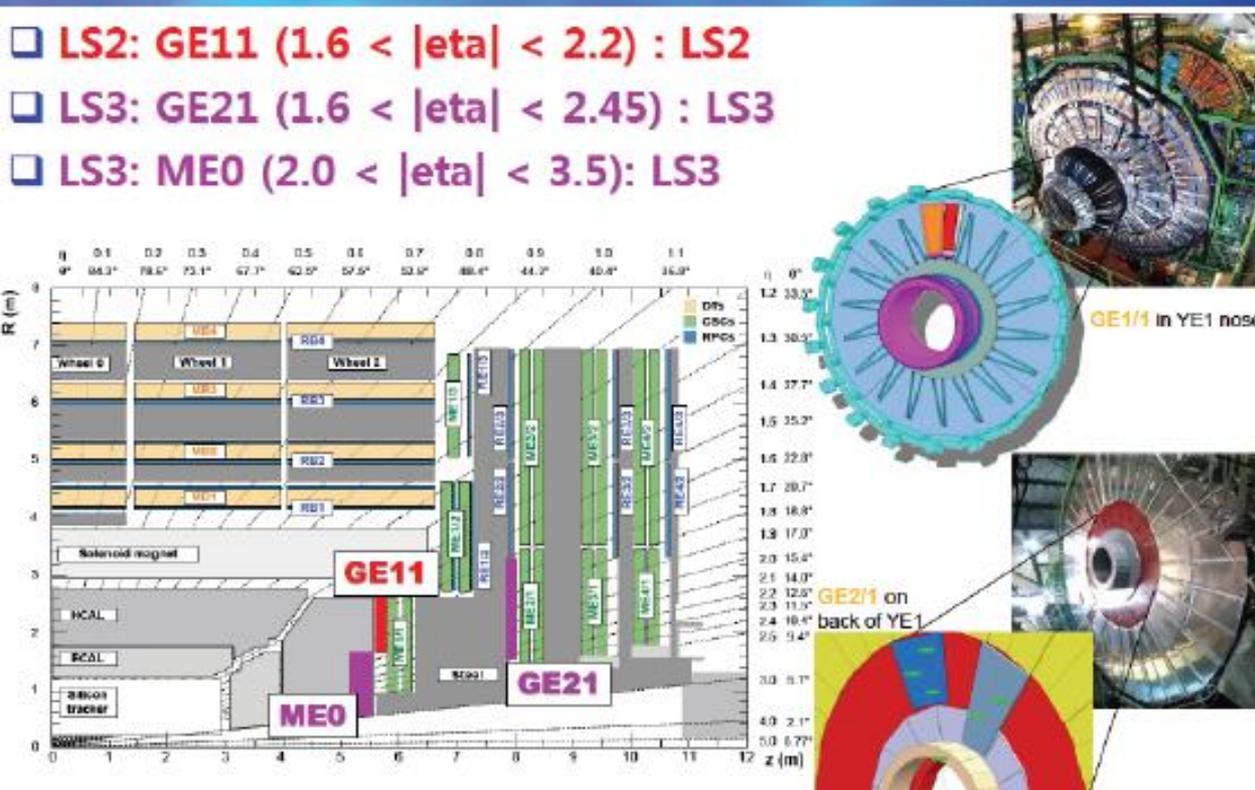
AS/NCU/NTHU/NTU Joint R&D



# CMS Phase II Upgrade

- Total cost for Phase II (LS2+LS3) : 265MCHF
  - 2.25% share by KCMS: 6MCHF (~70억)

- ❑ LS2: GE11 (1.6 < |eta| < 2.2) : LS2
- ❑ LS3: GE21 (1.6 < |eta| < 2.45) : LS3
- ❑ LS3: ME0 (2.0 < |eta| < 3.5): LS3



- LS2 : Muon-GEM (GE11)
  - KCMS share: 650kCHF
- LS3 (2023~2024)
  - GEM & RPC: ~2.5MCHF
  - Common fund: ~0.5MCHF
  - Tier 1 (option)
  - Backup project: L1 Trigger & calorimeter



GE11 in YE1 nose



GE21 on back of YE1



# CMS →to→ Asia



**CMS** **CMS WEEK**  

**14 – 18 November, 2016**  
**Tata Institute of Fundamental Research**  
**Mumbai, India**

The banner features the CMS logo on the left, followed by the text 'CMS WEEK' in large, bold, red letters. To the right of 'CMS WEEK' are the logos for 'tif' and 'BARC'. Below this, the dates '14 – 18 November, 2016' and the location 'Tata Institute of Fundamental Research, Mumbai, India' are written in bold black text.

# Growing Attraction of Asia

Toru Iijima @ ICFA Seminar 2017

## Belle II Collaboration



25 countries/regions  
105 institutions  
~750 researchers

Europe	300
Austria	13
Czechia	6
France	14
Germany	110
Israel	3
Italy	76
Poland	13
Russia	42
Slovenia	16
Spain	4
Ukraine	3

Asia			346
Saudi Arabia	1	Korea	43
Australia	33	Malaysia	6
China	33	Vietnam	3
India	44	Taiwan	28
Japan	150	Thailand	2
		Turkey	3

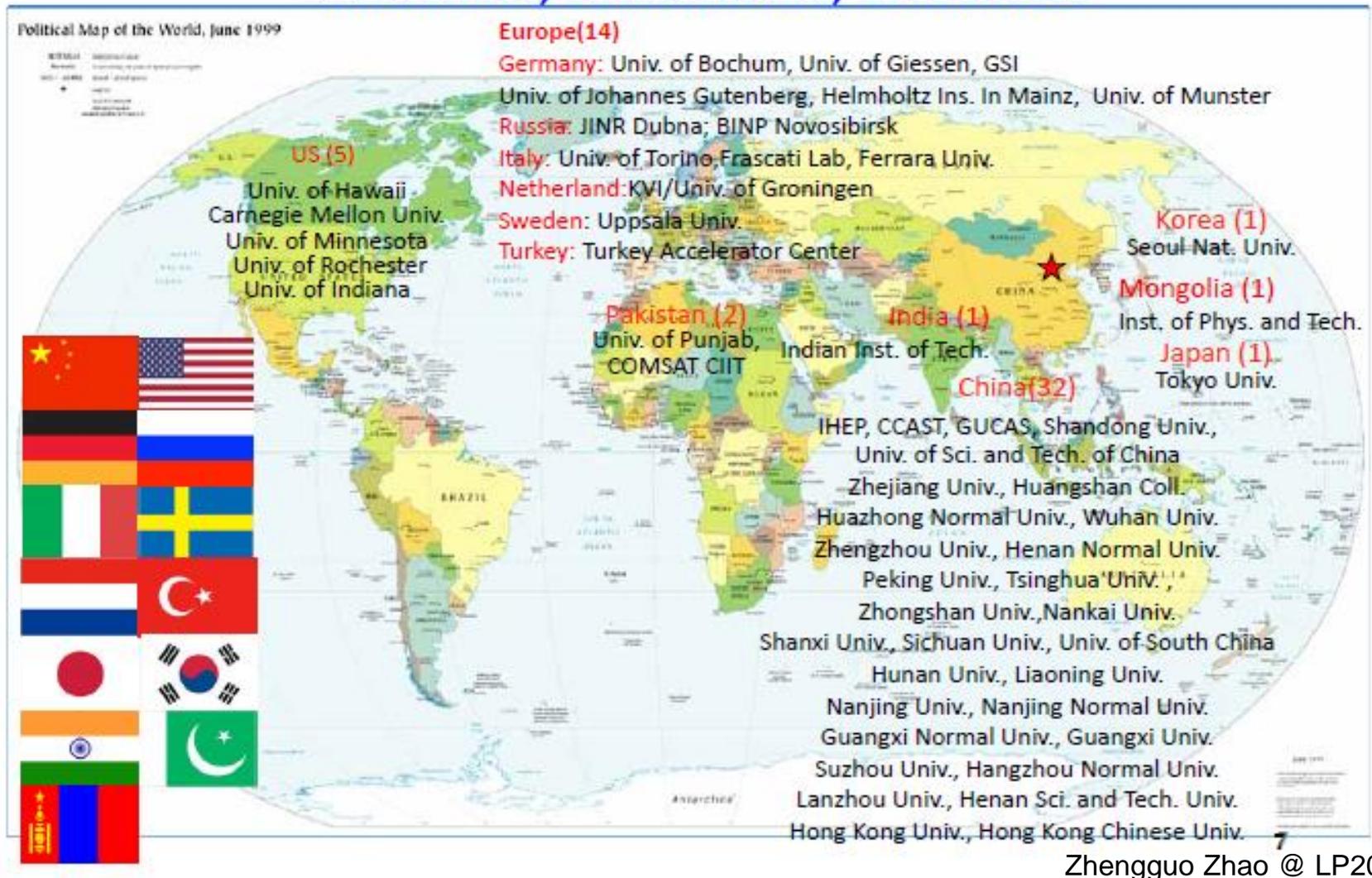
America	129
Canada	28
Mexico	12
USA	89

# Growing Attraction of Asia

## BESIII Collaboration



~400 authors, 60 institutions, 13 countries



Zhengguo Zhao @ LP2017

# Growing Attraction of Asia



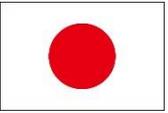
## JUNO Collaboration



Country	Institute	Country	Institute	Country	Institute
Armenia	Yerevan Physics Institute	China	IMP-CAS	Germany	U. Mainz
Belgium	Universite libre de Bruxelles	China	SYSU	Germany	U. Tuebingen
Brazil	PUC	China	Tsinghua U.	Italy	INFN Catania
Brazil	UEL	China	UCAS	Italy	INFN di Frascati
Chile	PCUC	China	USTC	Italy	INFN-Ferrara
Chile	UTFSM	China	U. of South China	Italy	INFN-Milano
China	BISEE	China	Wu Yi U.	Italy	INFN-Milano Bicocca
China	Beijing Normal U.	China	Wuhan U.	Italy	INFN-Padova
China	CAGS	China	Xi'an JT U.	Italy	INFN-Perugia
China	ChongQing University	China	Xiamen University	Italy	INFN-Roma 3
China	CIAE	China	NUDT	Latvia	IECS
China	DGUT	Czech Rep.	Charles U.	Pakistan	PINSTECH (PAEC)
China	ECUST	Finland	University of Oulu	Russia	INR Moscow
China	Guangxi U.	France	APC Paris	Russia	JINR
China	Harbin Institute of Technology	France	CENBG	Russia	MSU
China	IHEP	France	CPPM Marseille	Slovakia	FMPICU
China	Jilin U.	France	IPHC Strasbourg	Taiwan	National Chiao-Tung U.
China	Jinan U.	France	Subatech Nantes	Taiwan	National Taiwan U.
China	Nanjing U.	Germany	Forschungszentrum Julich ZEA2	Taiwan	National United U.
China	Nankai U.	Germany	RWTH Aachen U.	Thailand	NARIT
China	NCEPU	Germany	TUM	Thailand	PPRLCU
China	Pekin U.	Germany	U. Hamburg	Thailand	SUT
China	Shandong U.	Germany	IKP FZJ	USA	UMD1
China	Shanghai JT U.			USA	UMD2

**550 collaborators from 71 institutions in 17 countries and regions**

Yifang Wang, Pub. Lect. @ LP2017



## COMET

160 researchers from 32 institutes in 13 countries + 1 international institute

Major contributions from Asian countries



Japan – (host) Facility, Detector & Analysis,  
 China – Tracker Electronics & Physics analysis  
 India – Beam monitor, Vietnam – Analysis,  
 Malaysia - Analysis

... and of course many from other countries !



## J-PARC

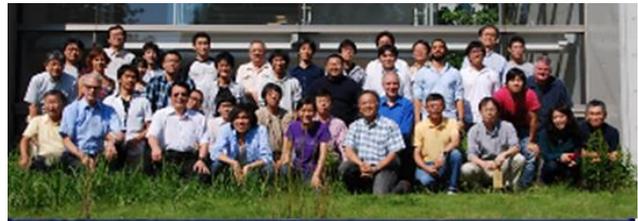
### g-2 @ KEK

98 members from 21 institutes in 8 countries



~500 members, 61 Institutes, 12 countries

## Hyper-K



Cheju 2	KEK 7	JINR 4	Nat. Taiwan 5	Arizona State 2	
Chonbuk 1	Kyoto 9			Chicago 5	
Kyungpook 2	Osaka 11	<b>KOTO</b>			
Pusan 3	Saga 6				Michigan State 4
Soul 2	Yamagata 2				

## 2. Success to Successor



The Nobel Prize in Physics 2008



"for the discovery of the mechanism of spontaneous broken symmetry in subatomic physics"



Photo: University of Chicago

**Yoichiro Nambu**

🏆 1/2 of the prize

USA

Enrico Fermi Institute,  
University of Chicago  
Chicago, IL, USA

b. 1921  
(in Tokyo, Japan)

"for the **discovery** of the **origin** of the broken symmetry which **predicts** the existence of **at least three families of quarks in nature**"



Photo: KEK

**Makoto Kobayashi**

🏆 1/4 of the prize

Japan

High Energy Accelerator  
Research Organization  
(KEK)  
Tsukuba, Japan

b. 1944



Photo: Kyoto University

**Toshihide Maskawa**

🏆 1/4 of the prize

Japan

Kyoto Sangyo University;  
Yukawa Institute for  
Theoretical Physics (YITP),  
Kyoto University  
Kyoto, Japan

b. 1940

### CP Violation in SM



**naturenews**  
7 October 2008



The Belle detector in Japan helped to confirm the symmetry breaking effects predicted by theoretical physicists.

KEK

### B Factories (BaBar & Belle)

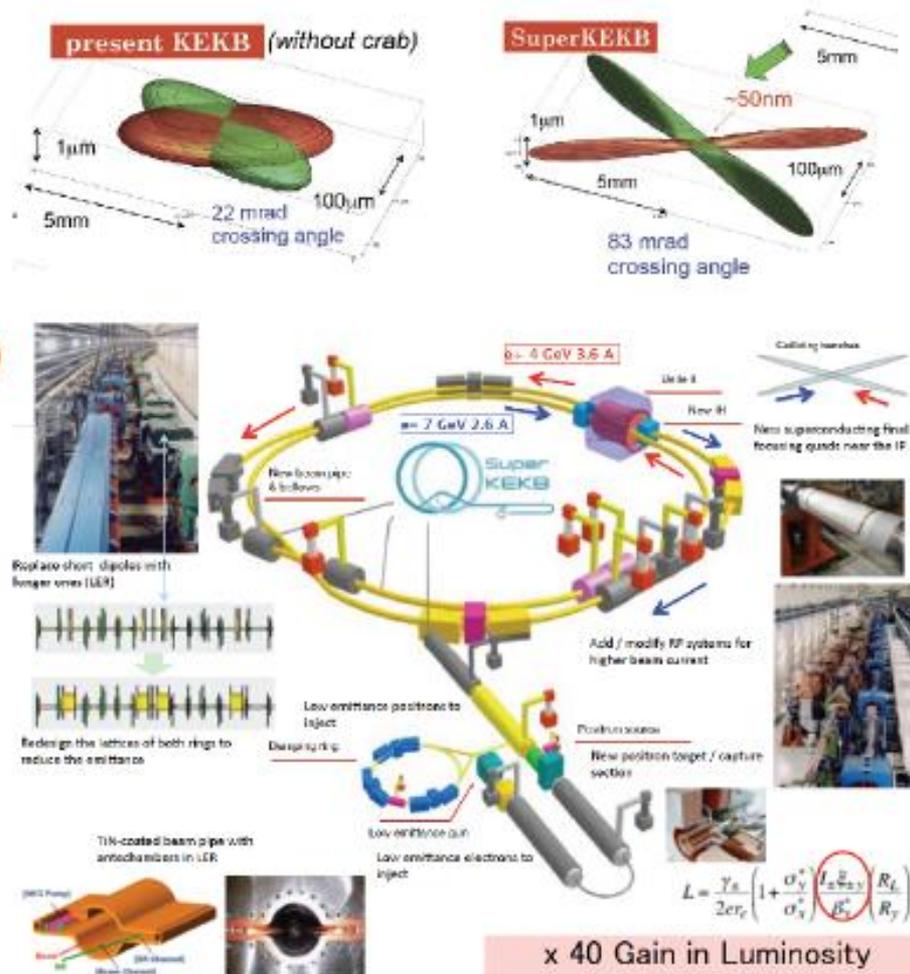


## SuperKEKB Accelerator

- Low emittance (“nano-beam”) scheme employed (originally proposed by P. Raimondi)

### Machine parameters

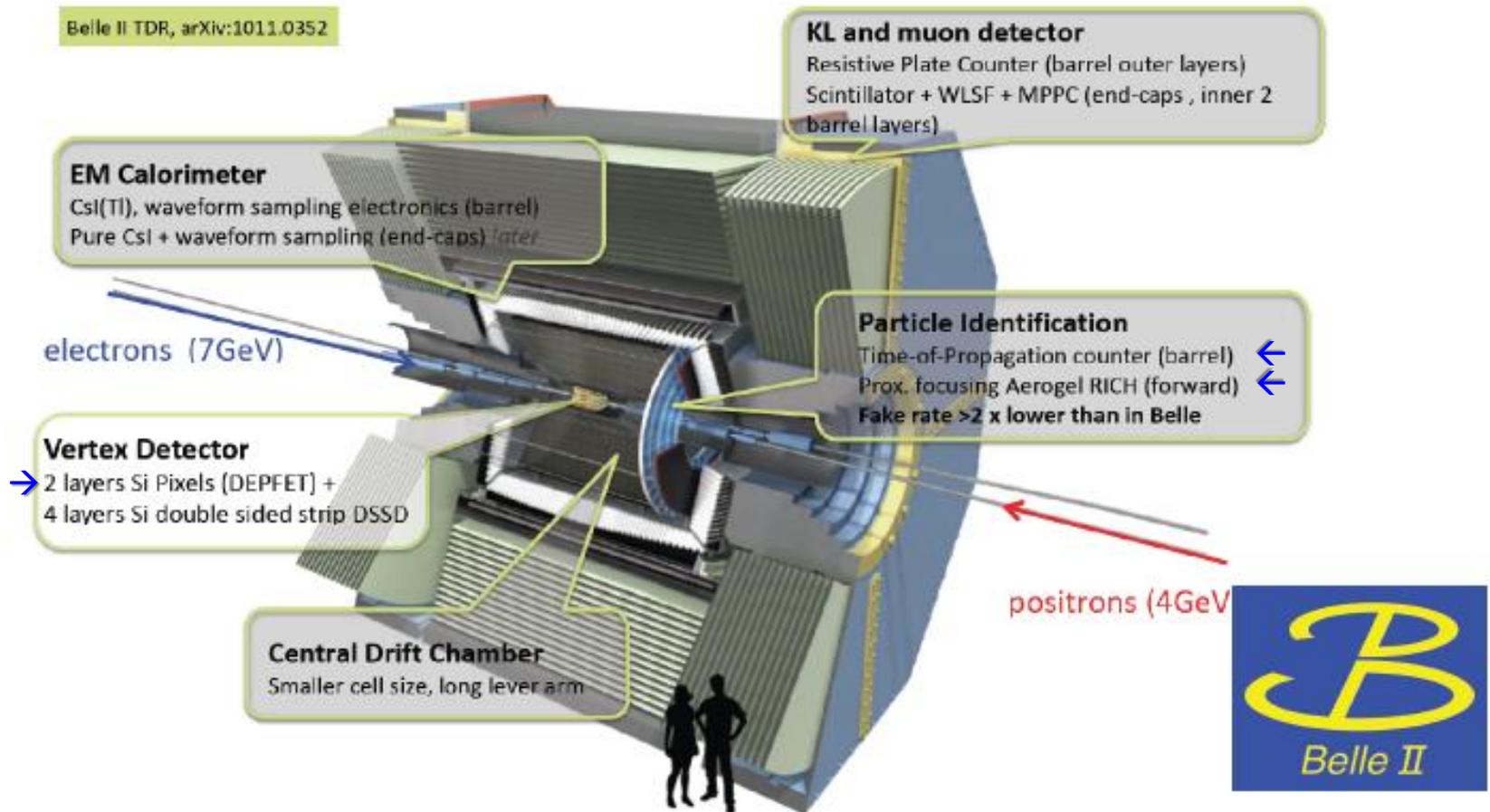
	SuperKEKB LER/HER	KEKB LER/HER
E(GeV)	4.0/7.0	3.5/8.0
$\epsilon_x$ (nm)	3.2/4.6	18/24
$\beta_y$ at IP(mm)	0.27/0.30	5.9/5.9
$\beta_x$ at IP(mm)	32/25	120/120
Half crossing angle(mrad)	41.5	11
I(A)	3.6/2.6	1.6/1.2
Lifetime	~10min	130min/200min
L(cm <sup>-2</sup> s <sup>-1</sup> )	80 × 10 <sup>34</sup>	2.1 × 10 <sup>34</sup>



# Belle II Detector

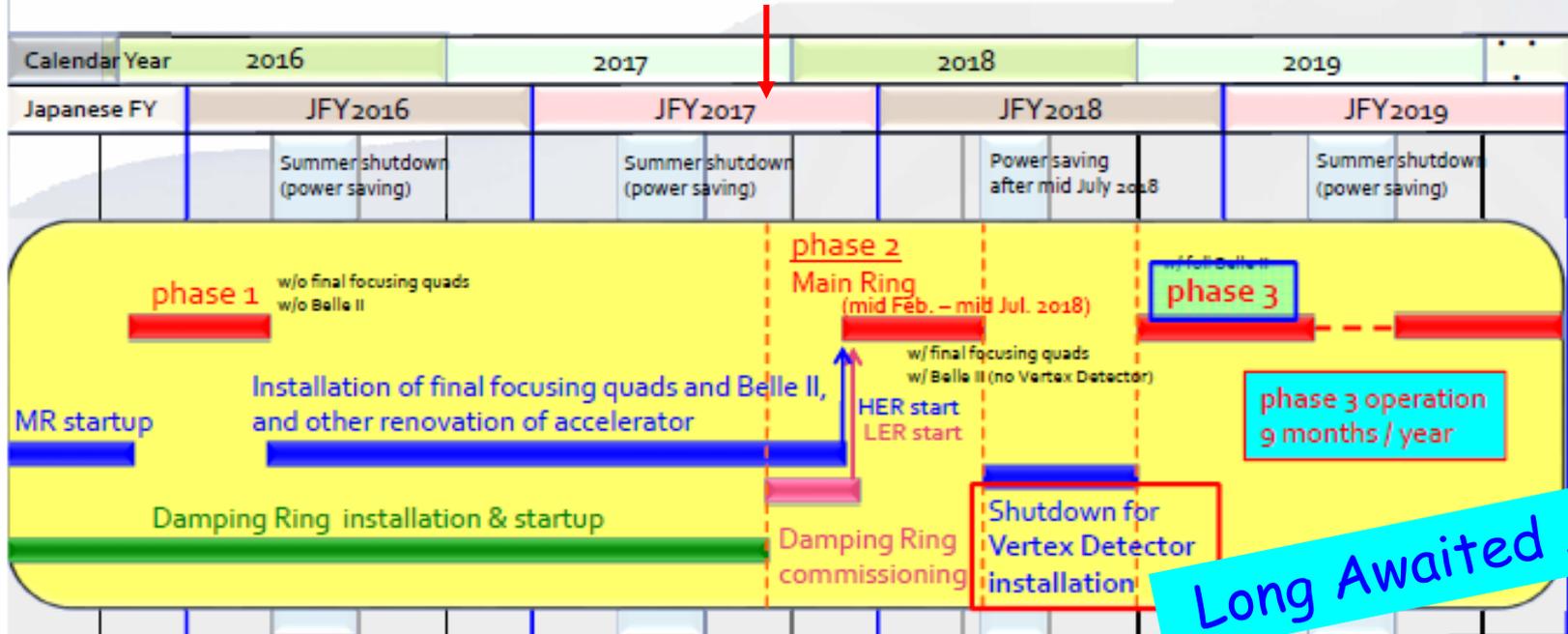
- Deal with higher background (10-20 $\times$ ), radiation damage, higher occupancy, higher event rates (LI trigg. 0.5 $\rightarrow$ 30 kHz)  $\leftarrow$
- Improved performance and hermeticity

Belle II TDR, arXiv:1011.0352



## 2. Success to Successor

### SuperKEKB/Belle II schedule



Phase 1 (w/o final focusing Q, w/o Belle II):

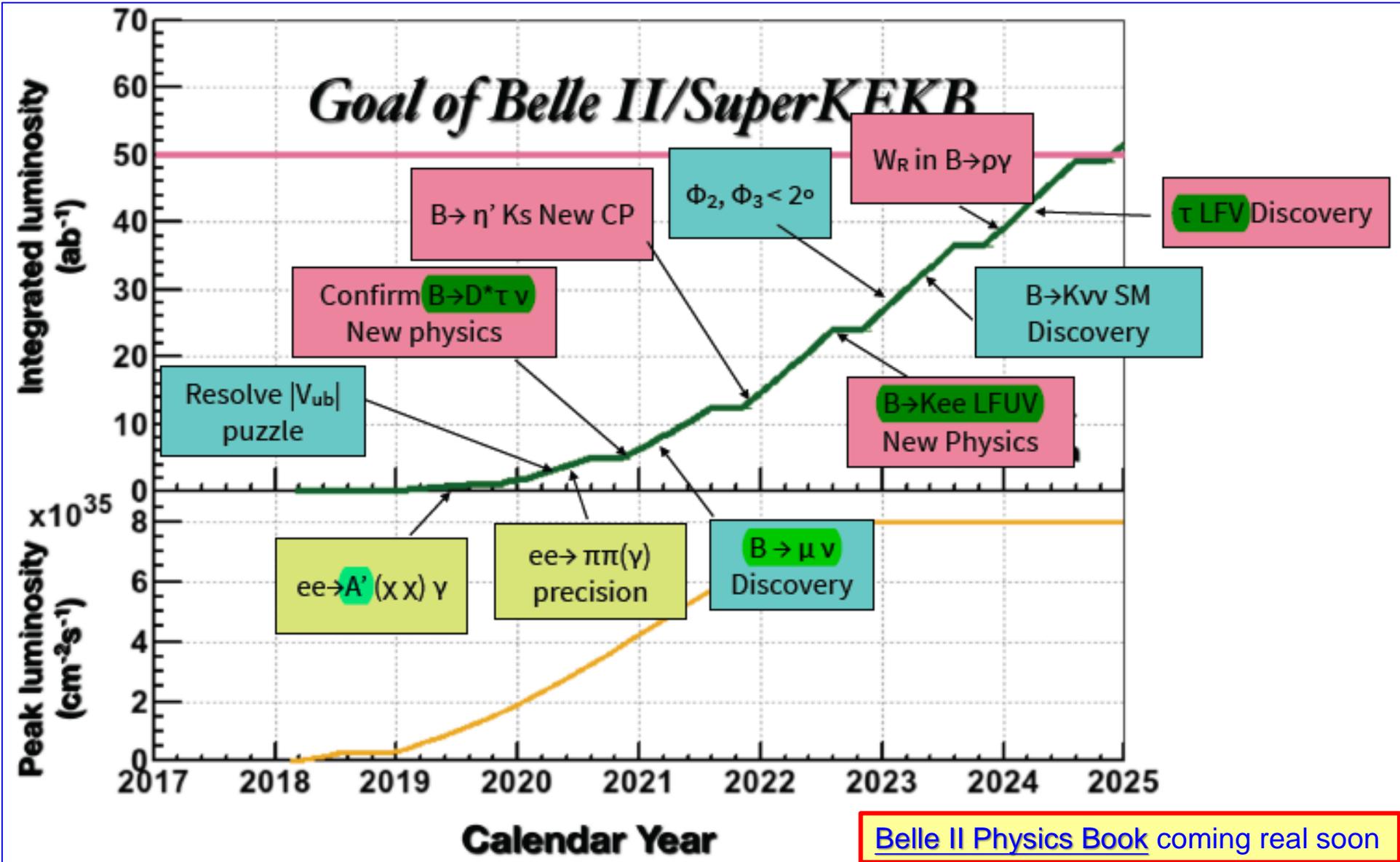
- Accelerator system test and basic tuning,
- Vacuum scrubbing,
- Low emittance tuning, and
- Beam background studies

**Phase 2** (w/ final focusing Q, w/Belle II but background monitors instead of vertex detectors)

- Verification of nano-beam scheme  
target:  $L > 10^{34} \text{ cm}^{-2}\text{s}^{-1}$
- Understand beam background especially in **vertex detector** volume

## 2. Success to Successor

Phil Urquijo @ LIO 4/2018

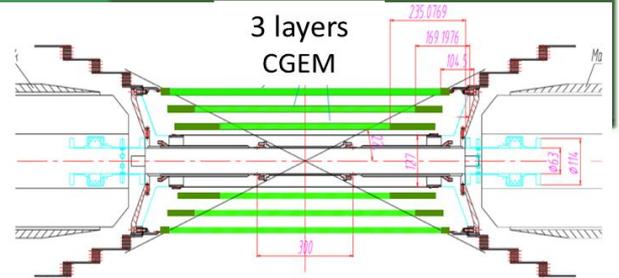
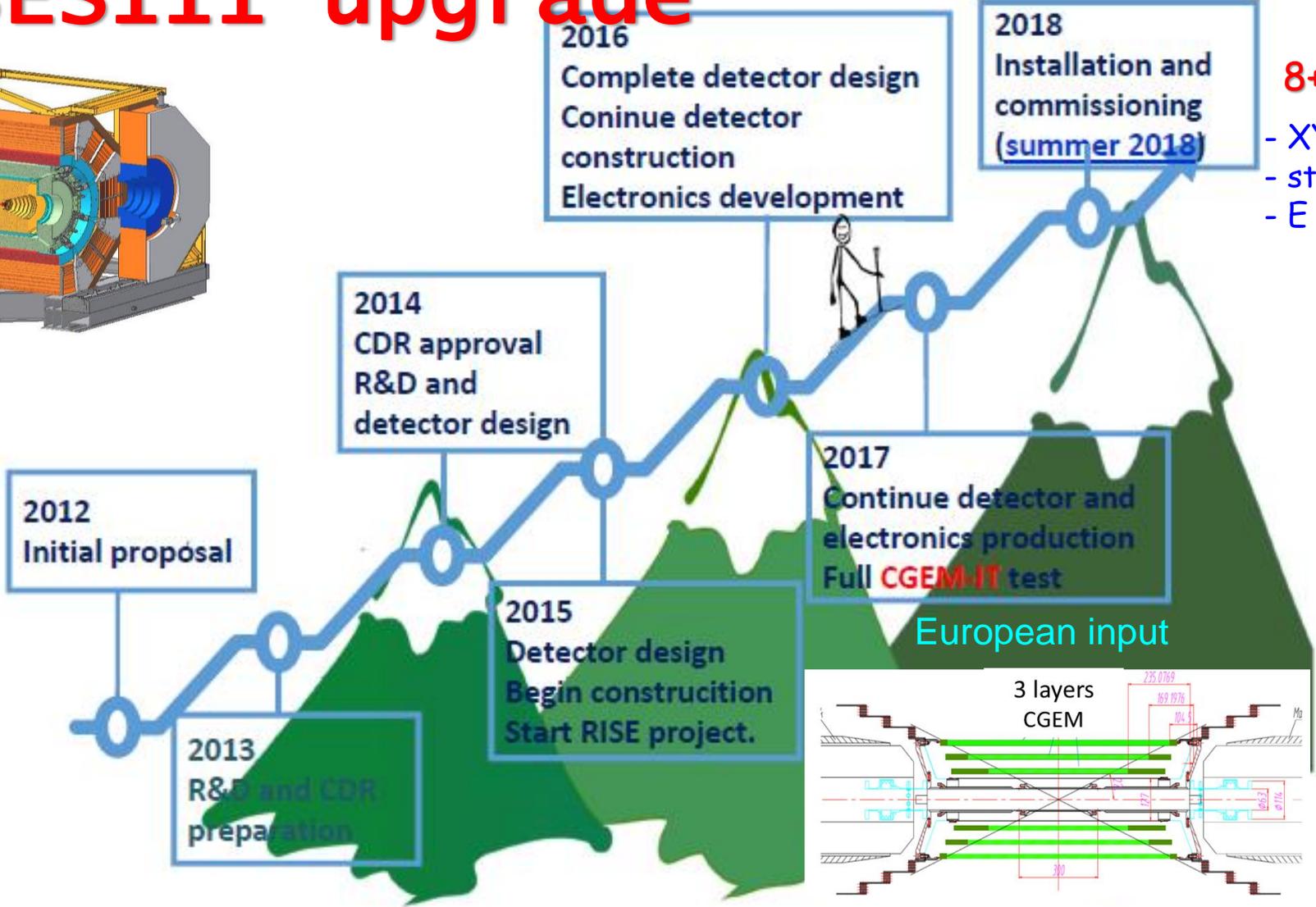
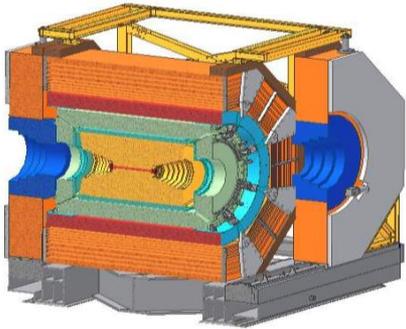


→ Masako Iwasaki



## 2. Success to Successor

# BESIII upgrade





# 2. Success to Successor

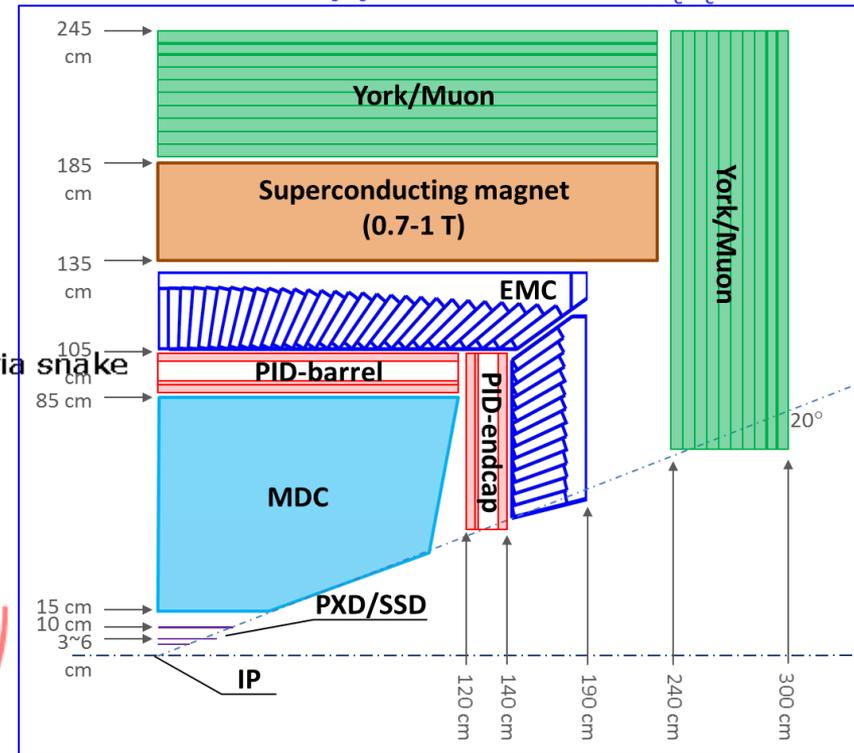
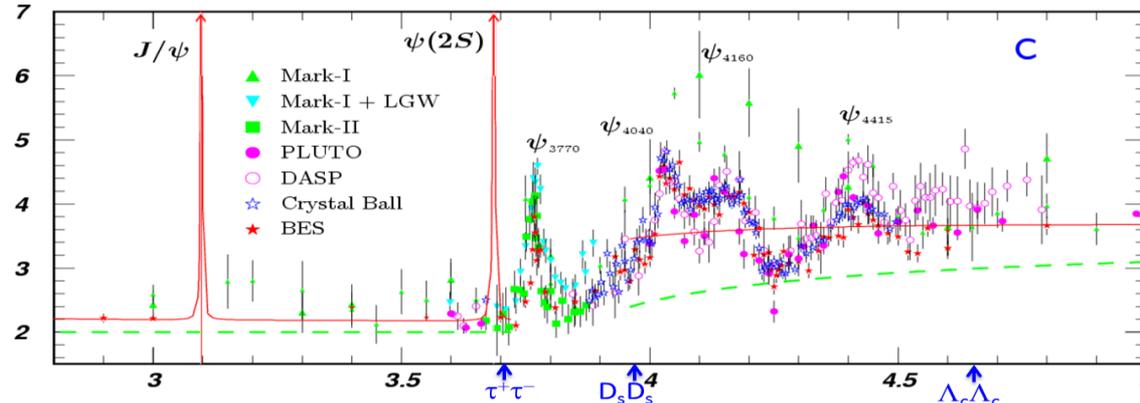
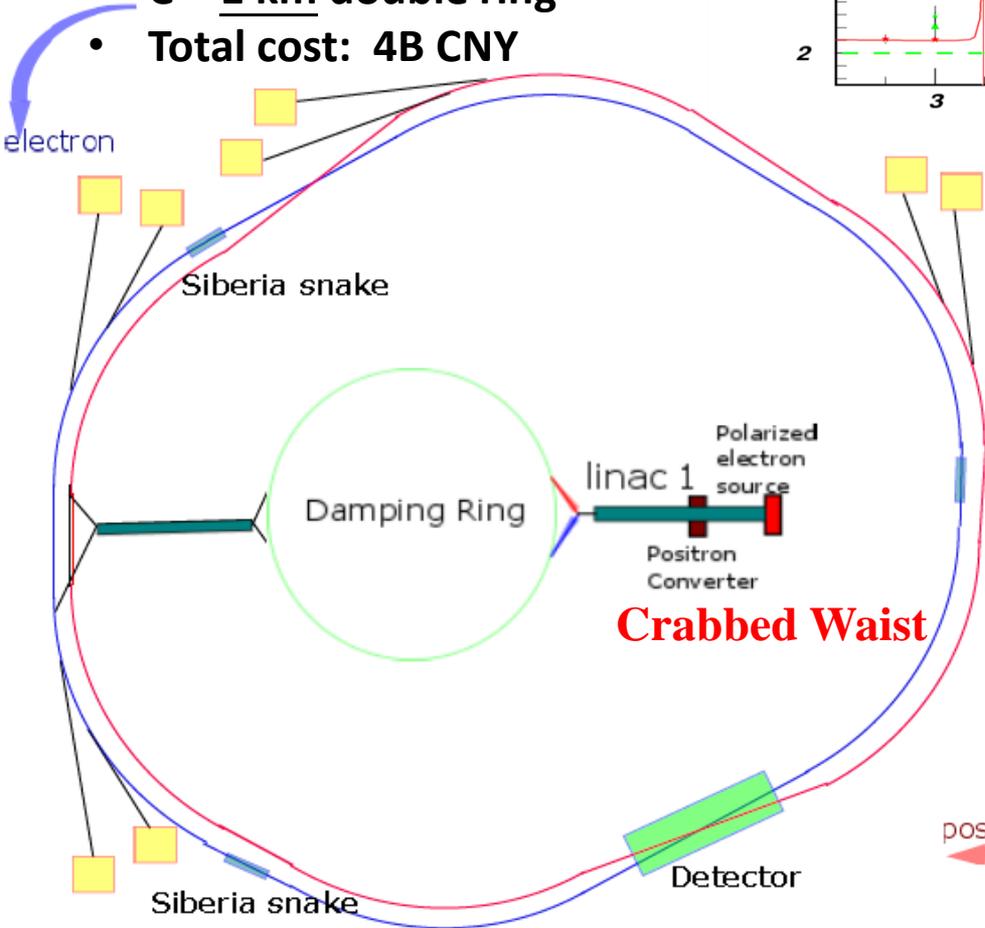
in planning

also: BINP@Novosibirsk

## Super Tau-Charm Facility (STCF)

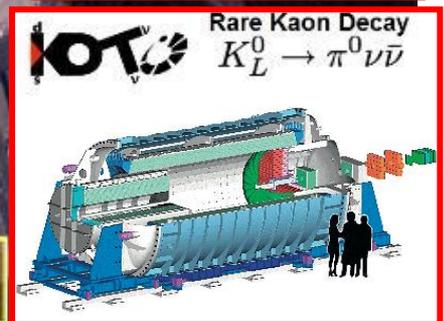
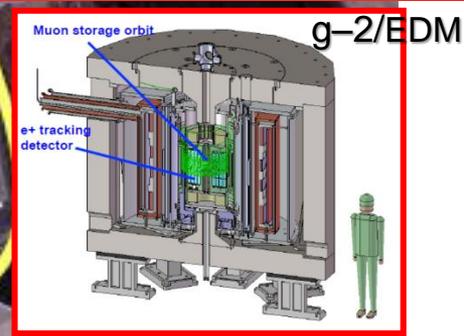
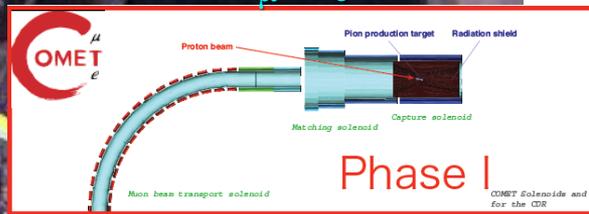
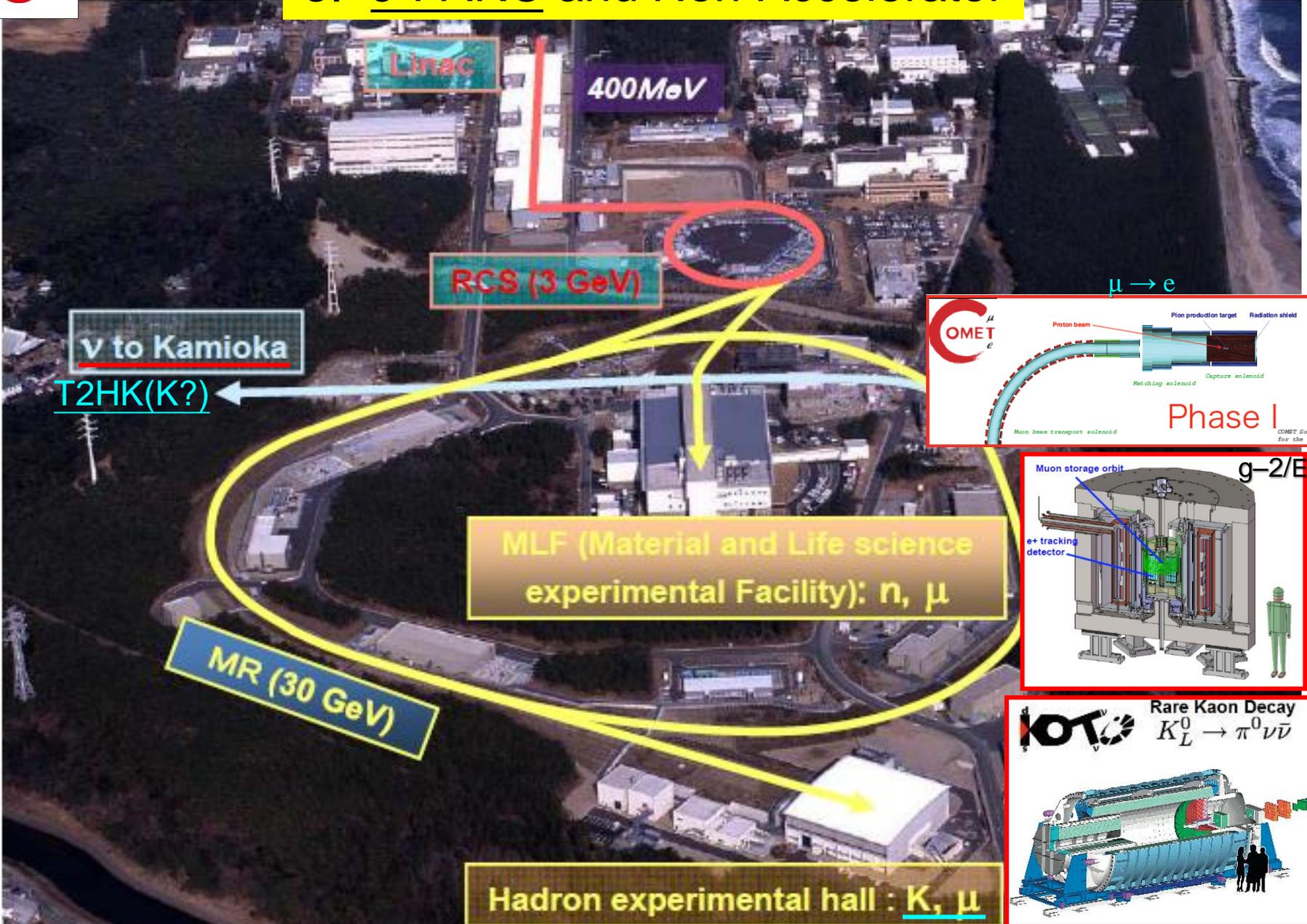
- $E_{cm} = 2-7 \text{ GeV}$
- $L = 1 \times 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$  at 4 GeV
- $C = 1 \text{ km}$  double ring
- Total cost: 4B CNY

R



Zhengguo Zhao @ HIEPA2018 (target: USTC, Hefei)

# 3. J-PARC and Non-Accelerator

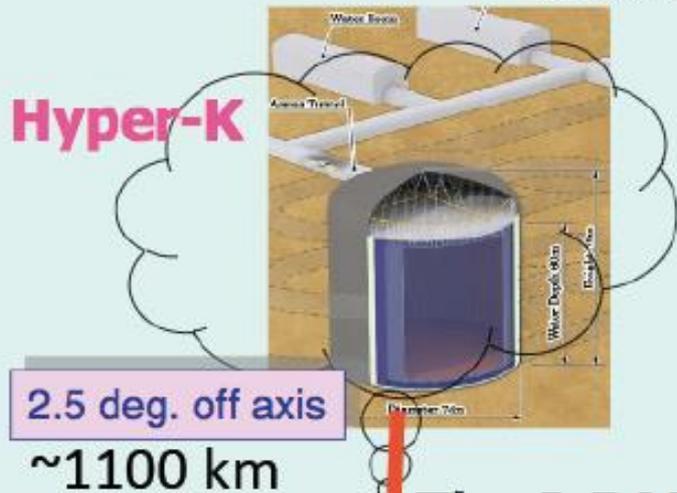


### 3. J-PARC and Non-Accelerator

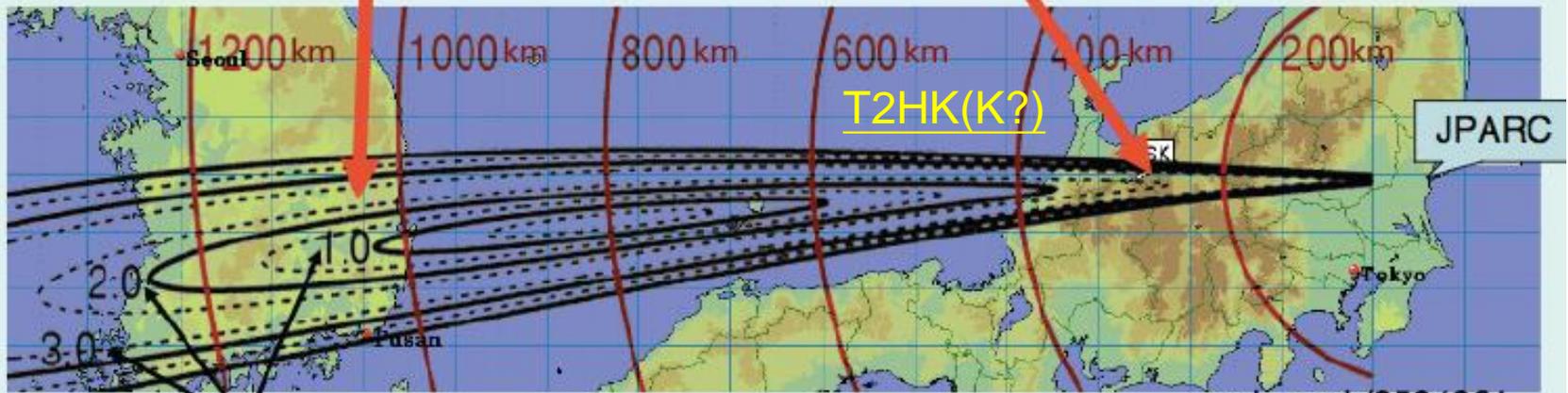
## The 2<sup>nd</sup> Hyper-K Detector in Korea

arXiv:1611.06118

MO &  $\delta_{CP}$



The J-PARC  $\nu$  beam comes to Korea.



see hep-ph/0504061

By K. Hagiwara, N. Okamura, K. Senda

Off-axis angle

### 3. J-PARC and Non-Accelerator



## Neutrino Mixing Angles

Atmospheric Neutrino Oscillation

$\theta_{23}$



$\sim 45^\circ$  (1998)  
Super-K; K2K



Solar Neutrino Oscillation

$\theta_{12}$



$34^\circ$  (2001)  
SNO, Super-K;  
KamLAND



Reactor Neutrino Oscillation

$\theta_{13}$



$9^\circ$  (2012)  
Yifang Wang  
Daya Bay, RENO  
Soo-Bong Kim  
Double Chooz  
+ T2K (2011)  
Koichiro Nishikawa



2015  
Nobel  
Prize

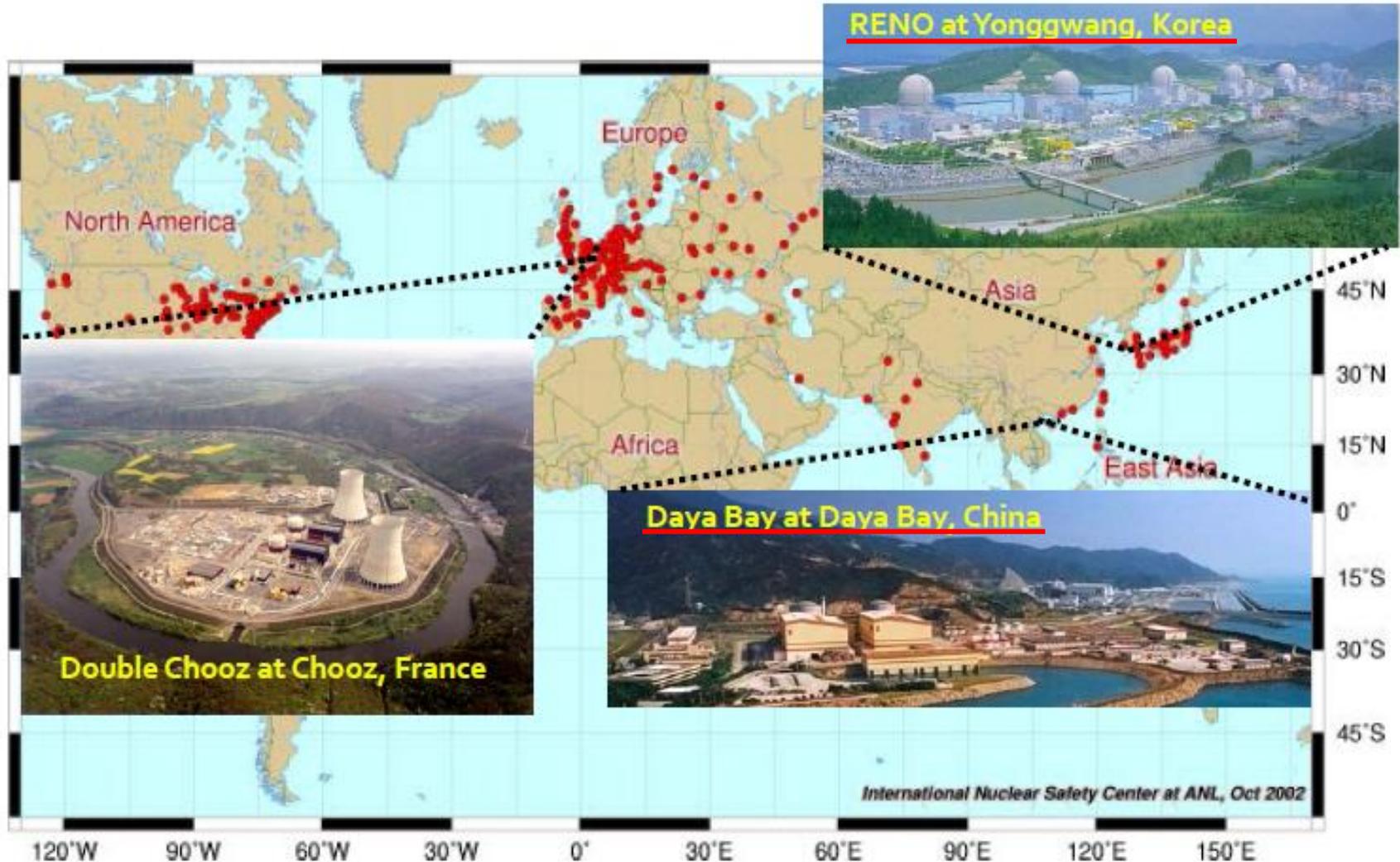


2017  
Pontecorvo  
Prize

“Neutrino has mass”

“Established three-flavor mixing framework”

### 3. J-PARC and Non-Accelerator Reactor $\theta_{13}$ Experiments



### 3. J-PARC and Non-Accelerator

## $\theta_{13}$ Impacts for Future Experiments

Success to Successor

Accelerator

Reactor



MO



RENO-50

$\theta_{13} \approx 9^\circ$

MO &  $\delta_{CP}$



MO = Mass Ordering

MO

MO &  $\delta_{CP}$

Success to Successor

INO



PINGU



ORCA

Atmosphere

Japan really strong in v



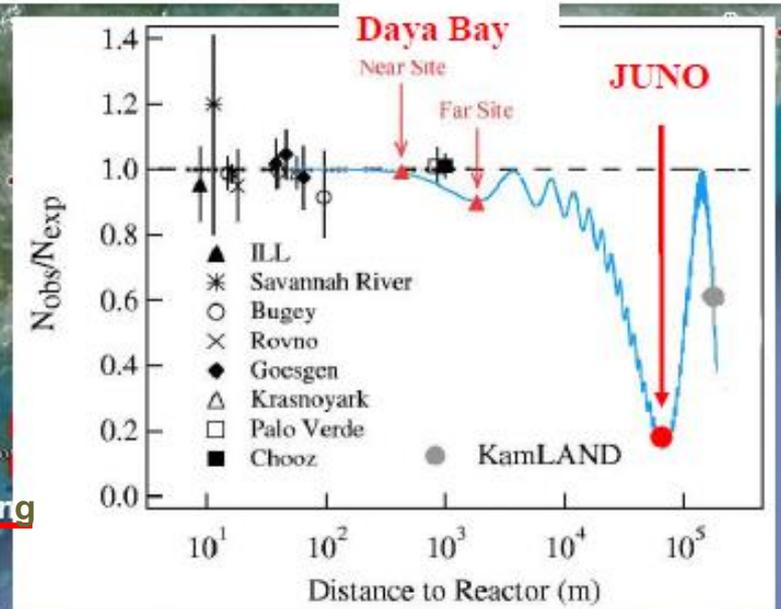
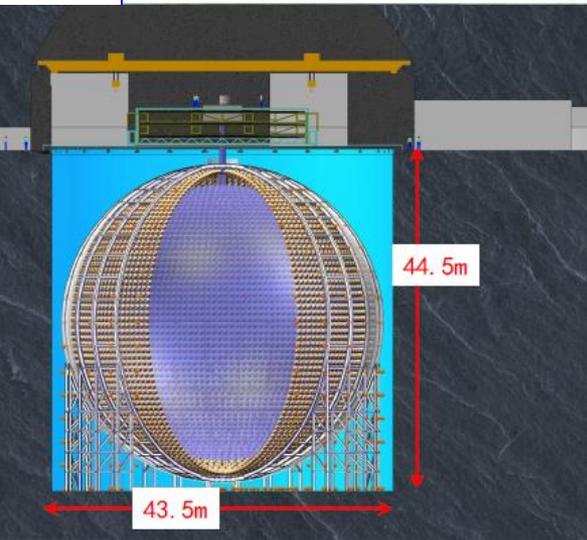
# 3. J-PARC and Non-Accelerator

Mass Ordering

## The JUNO Experiment

Success to Successor

NPP	Daya Bay	Huizhou	Lufeng	Yangjiang	Taishan
Status	Operational	Planned	Planned	Under construction	Under construction
Power	17.4 GW	17.4 GW	17.4 GW	17.4 GW	18.4 GW



by 2020: 26.6 GW

# 3. J-PARC and Non-Accelerator

Courtesy: Youngjoon Kwon

## Center for Axions and Precision Physics (IBS)

Institute for Basic Science

Korea



Yannis Semertzidis

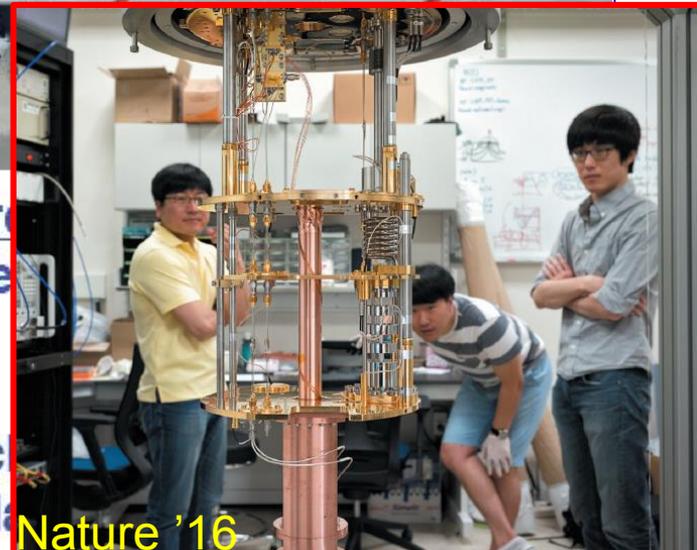
### Physics

- Axion Search
- Proton EDM
- Muon g-2 experiment
- mu2e experiment
- Precision Physics

Proposal  
Fermilab  
COMET

### Human Resources

- 25 research fellows
- 20 students
- 5 staffs
- Engineers/technicians
- Visiting scholars

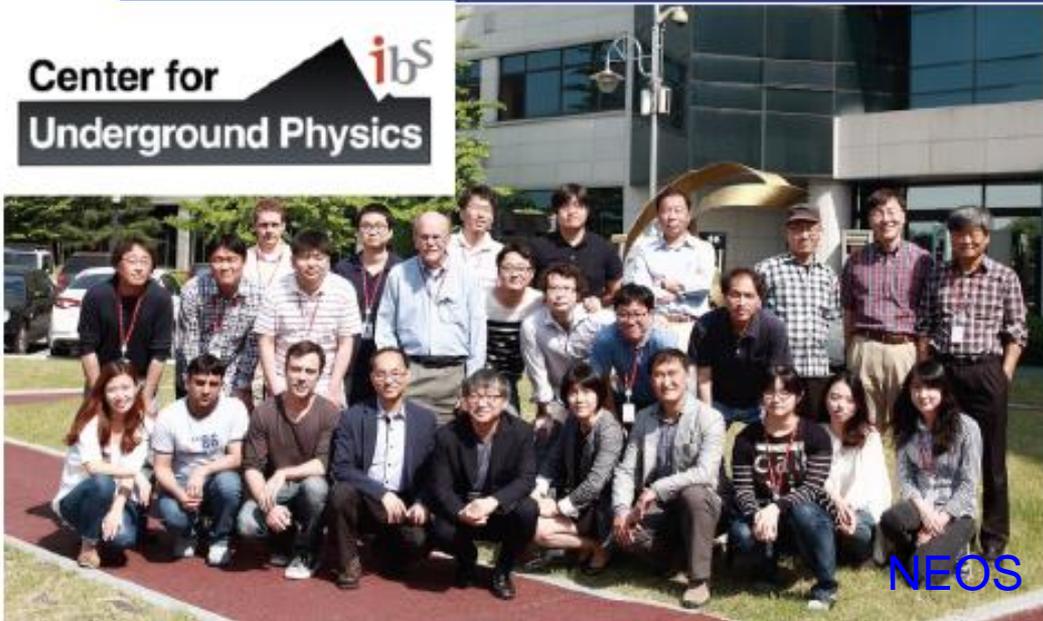


Nature '16

# 3. J-PARC and Non-Accelerator

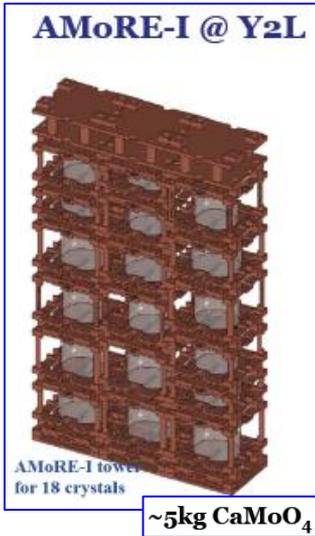
Korea

Courtesy: Youngjoon Kwon



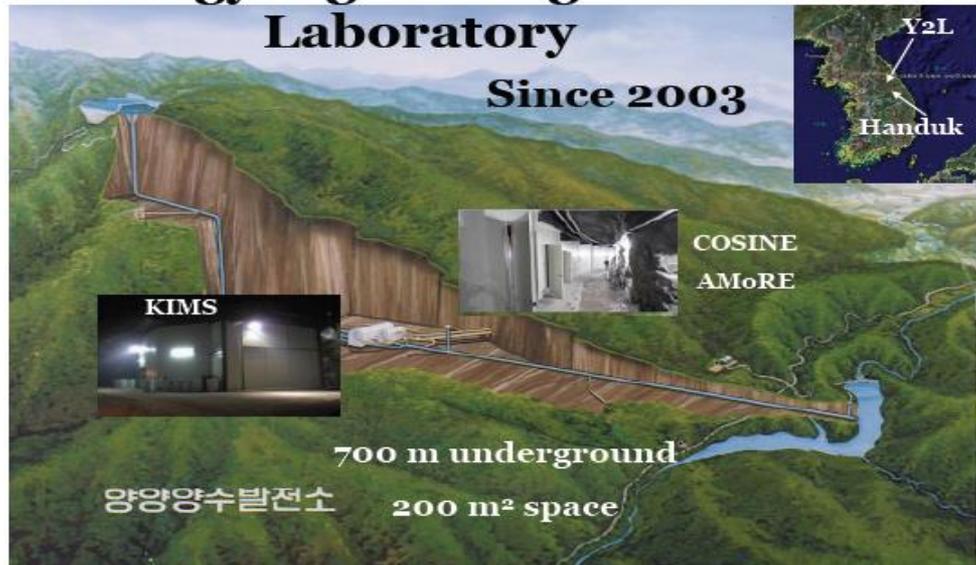
**COSINE-100**  
**COSINE-200**  
 (NaI / DAMA)  
**NEOS (SBL)**

AMoRE-II @ Handuk mine  
 ~200 kg X-MoO<sub>4</sub> crystals

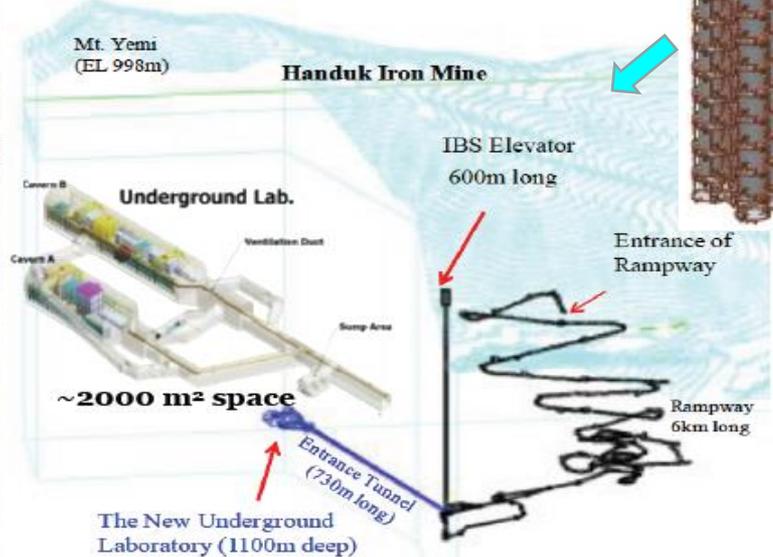


## Yangyang Underground Laboratory

Since 2003

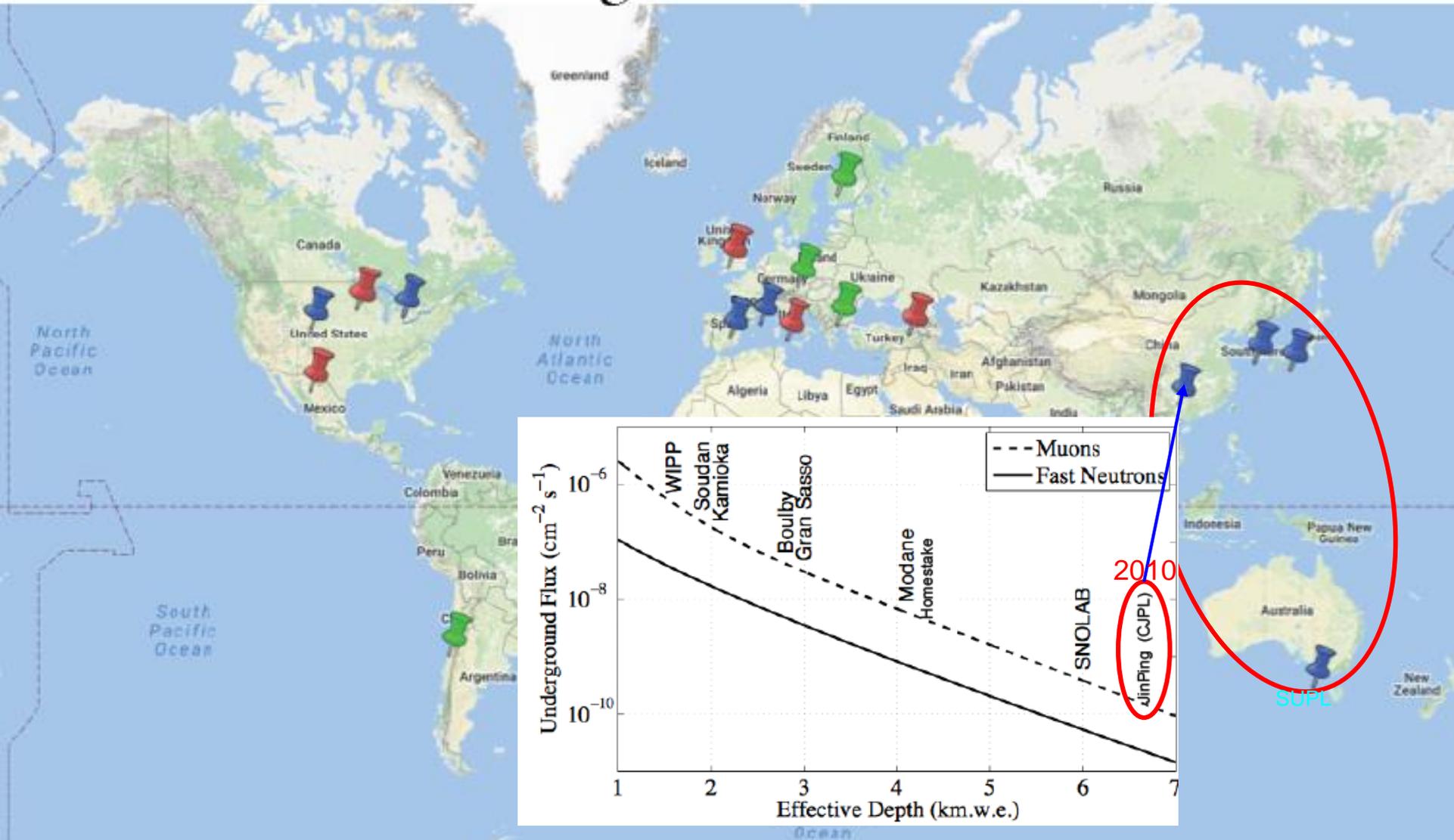


## Handuk Iron mine



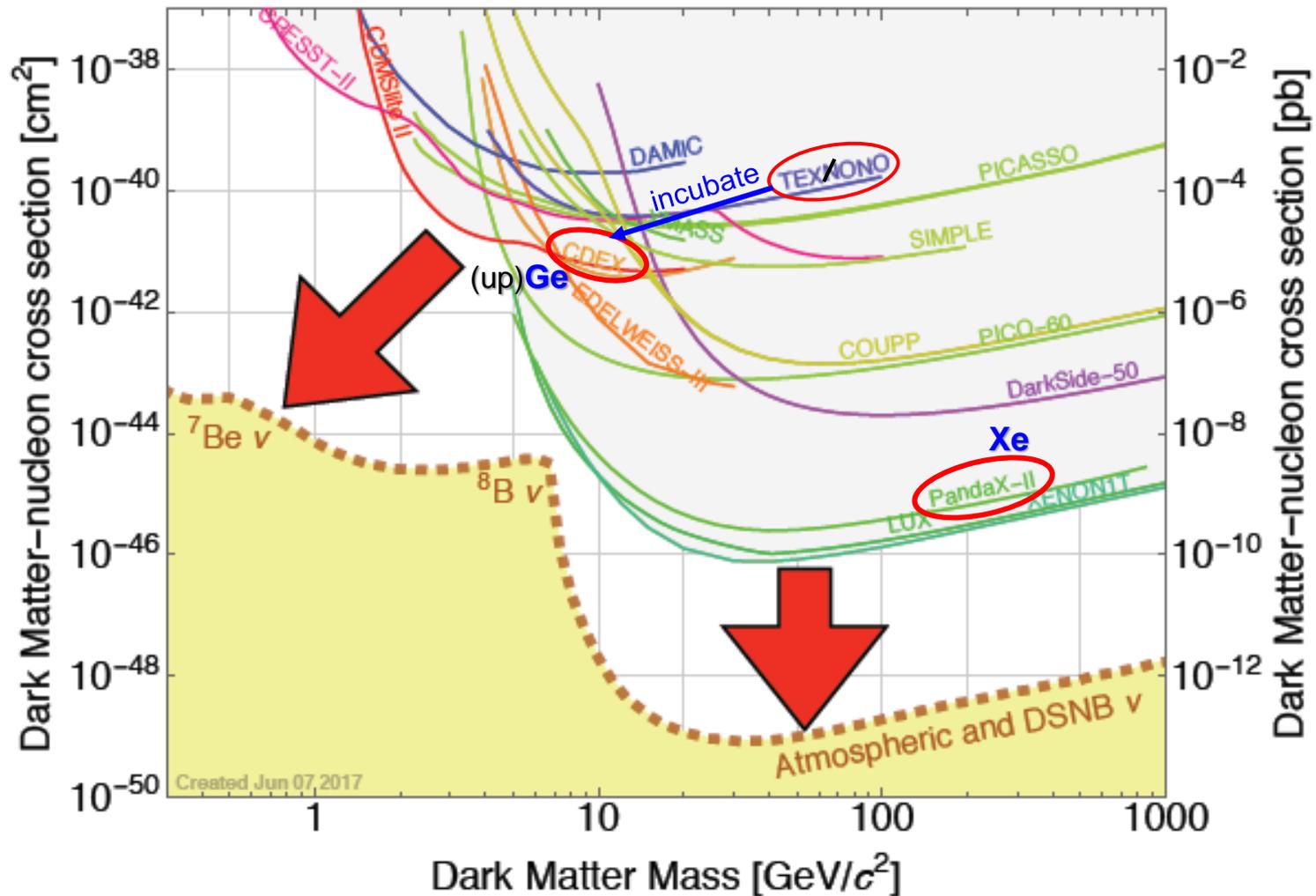
### 3. J-PARC and Non-Accelerator

## World Underground Facilities



### 3. J-PARC and Non-Accelerator

# Current Landscape



CJPL-I

Also:  $0\nu\text{DBD}$

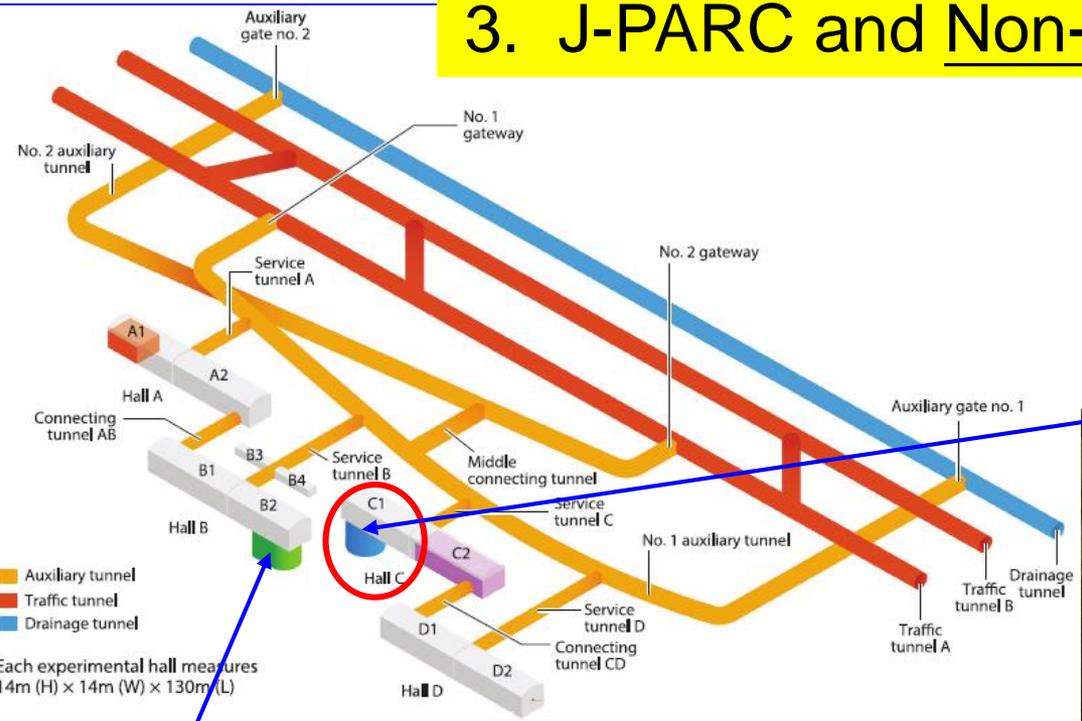
Jodi Cooley @ ICFA Seminar 2017

George W.S. Hou (NTU)

ALCW, Fukuoka, 30 May '18 31



# 3. J-PARC and Non-Accelerator



CDEX Hall @ [CJPL-II](#)

PandaX



N.B. Leave out Particle  
Astro and Space ...

1801.00587  
(ARNPS '17)

## 4.1. The Hopefuls: ILC

# ILC (International Linear Collider)



Advantages of linear colliders

- (1) No energy loss due to synchrotron radiation  
(c.f. Circular Colliders  
 $-\Delta E/\text{turn} \propto (E/m)^4 R^{-1}$ )
- (2) **Energy extendability:**  
length, (gradient)  $\Rightarrow$  energy
- (3) Beam Polarization

Discovery of the 125 GeV Higgs Boson at LHC in 2012

$\Rightarrow$  obvious physics target (Higgs is a portal of physics beyond the Standard Model)

$\Rightarrow$  triggered early construction of the ILC

**ILC Site Candidate Location in Japan:**  
**Kitakami**

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



Sachio Komamiya @ DPF2017

# ILC R&D at KEK

Superconducting RF Test Facility

STF

Accelerator Test Facility

ATF



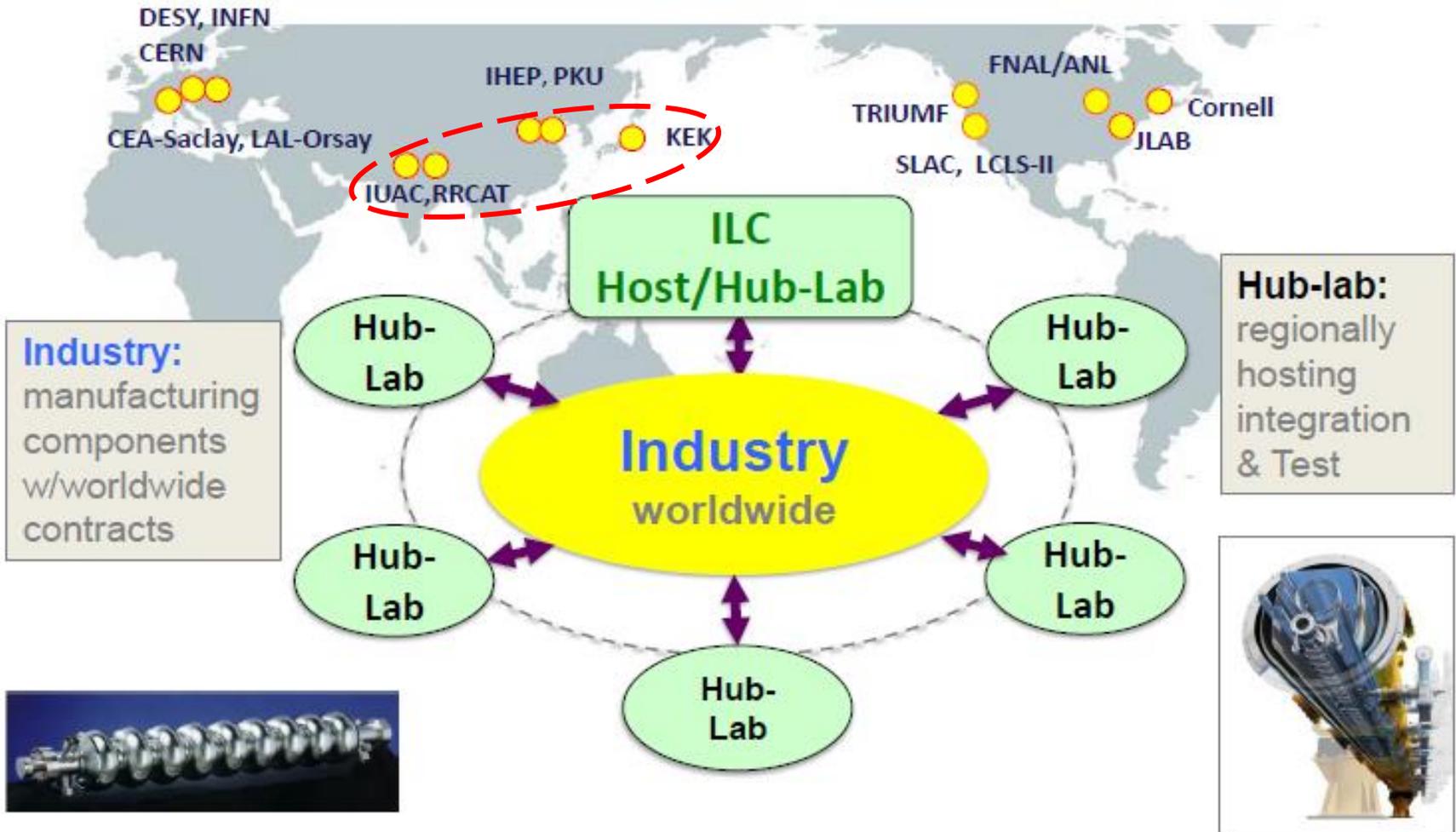
Cavity Fabrication Facility

CFF



→ [Yasuhiro Okada, next talk](#)

# ILC SRF Global Integration Model



## 4.2. The Hopefuls: CEPC(-SppC)

# CEPC: A Higgs Factory

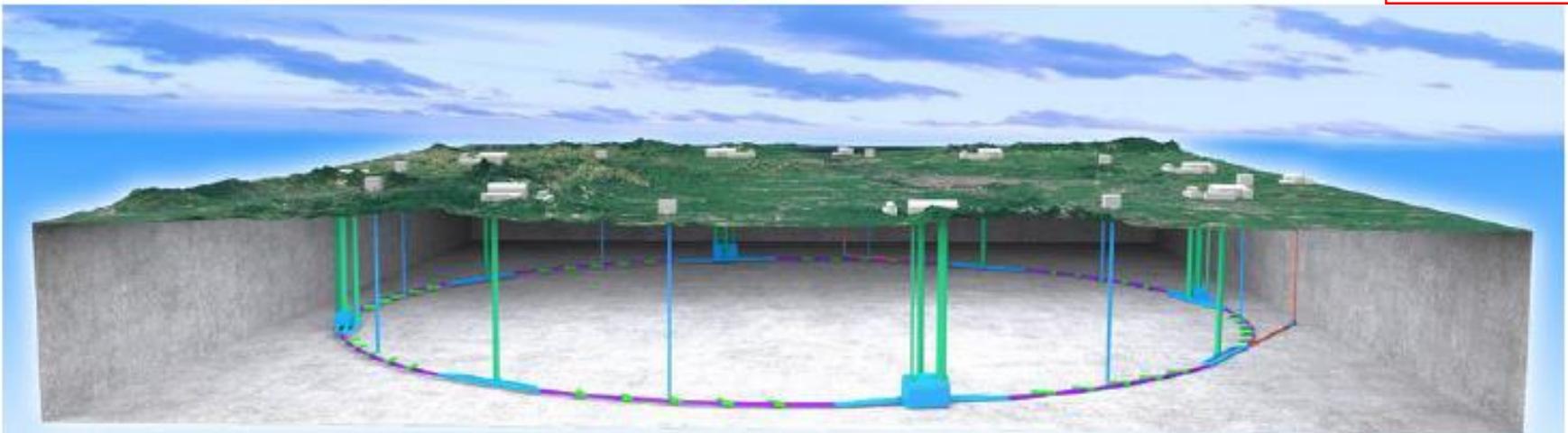
→ Yifang Wang, Monday

- Since 2005, we were discussing the next machine after BEPC/BEPCII
- Thanks to the low mass Higgs, there is the possibility to build a Higgs Factory: **Circular e+e- Collider(CEPC)**
  - Looking for Hints (from Higgs) → direct searches
  - The tunnel can allow us to build pp, AA, ep colliders in the far future:  
**Super proton-proton Collider(SppC)**

LEP100

↓ FCC

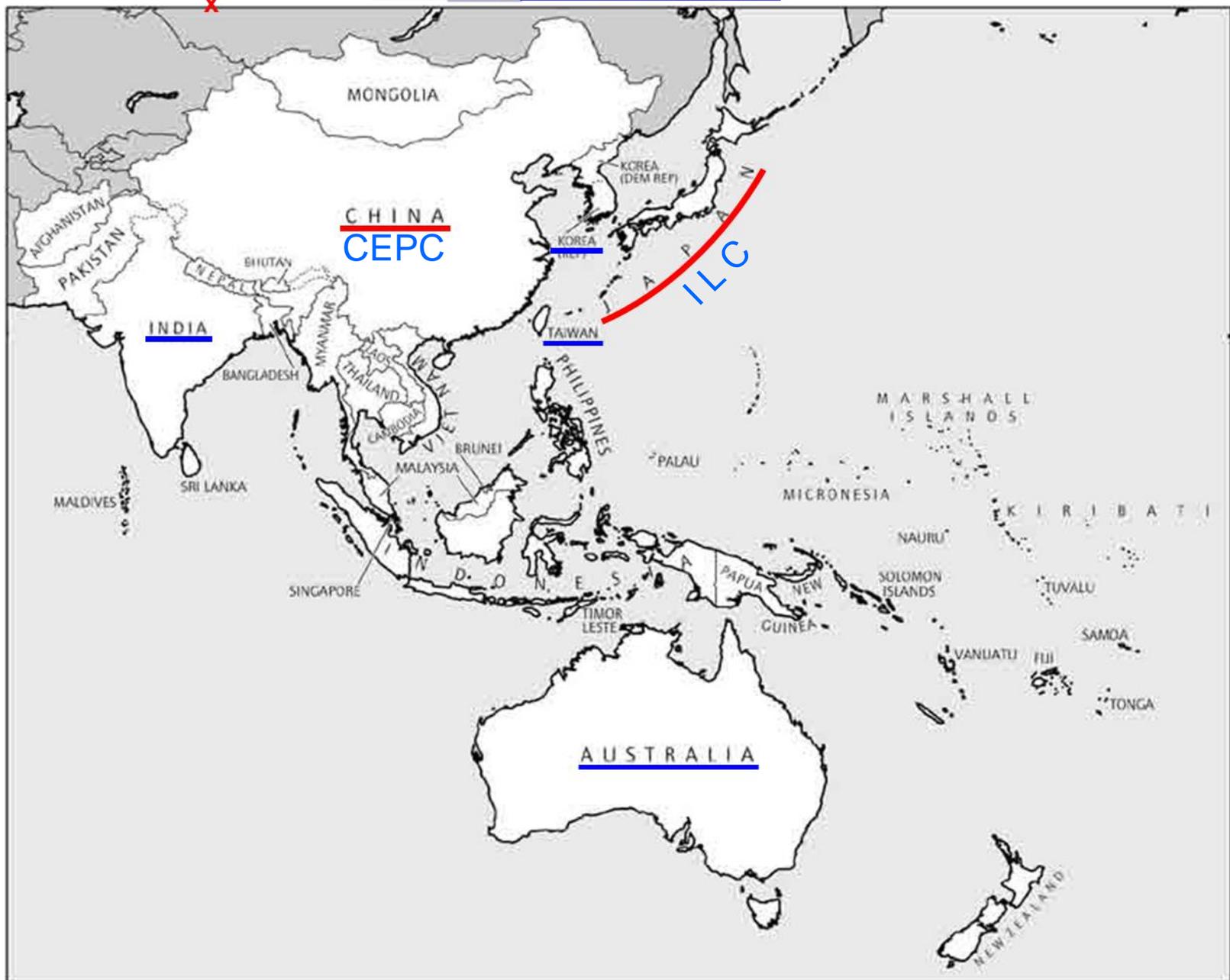
LHC100



We had B-factories, c-factories,  $\phi$ -factories, Z-factories in the past. It is very natural to think about Higgs factories

Yifang Wang, Pub. Lect. @ LP2017

# AsiaHEP Member States



# 5. Amalgamation of ACFA/AsiaHEP

## Timeline of xCFA's:

- 1963 (or 67): **ECFA** (Weisskopf as CERN DG)
- 1976: **ICFA**
- 1996: **ACFA** (Sugawara + ZP Zheng, i.e. KEK + IHEP)
- 2012: - **AsiaHEP** (before h(125))

CERN LIBRARIES, GENEVA



CM-P00100105

7 January, 1963

**ECFA**

EUROPEAN COMMITTEE FOR FUTURE ACCELERATORS

REPORT 1967

### ACCELERATOR MEETING

Geneva - 20 December, 1962

a larger machine

begin with a rather large diameter

### MINUTES

<u>Chairman:</u>	Prof. V.F. Weisskopf
	Dr. J.B. Adams
	Prof. E. Amaldi
	Mr. J.H. Bannier
	Prof. W. Gentner
	Prof. C. Möller
	Prof. F. Perrin
	Prof. C.F. Powell
	Mr. F. de Rose
<u>CERN Officials:</u>	Prof. G. Bernardini
	Mr. S.A. ff Dakin
	Dr. P. Germain
	Dr. M.G.N. Hine
	Dr. K. Johnsen
	Prof. G. Puppi

5318/e

# 5. Amalgamation of **ACFA/AsiaHEP**

## Timeline of xCFA's:

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*put ACFA back in line  
w/ "xCFA" namesake*

a step forward  
on 2/2018  
(together w/  
Geoff Taylor)

→ **AsiaAC?**

Accelerator Consortium  
[Light**S**ource & Neutron**S**ource]  
(for mutual benefit)

## Timing & Vision

**Timeframe: European Strategy Update**



amalgamation: the action or process of uniting or merging two or more things

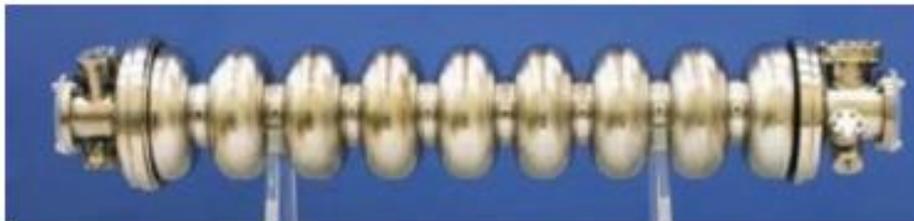
# Summary

- Asia's Economic footprint looms large
- Asia HEP expanding rapidly
- Let's HELP realize ILC in Japan
- Let's HELP realize CEPC(-SppC) in China
- **ACFA** needs to restore to xCFA namesake,  
but maintain LS/NS base, for mutual benefit



# US-Japan cost reduction

Shin Michizono @ LCWS2017



*Cost reduction by technological innovation*

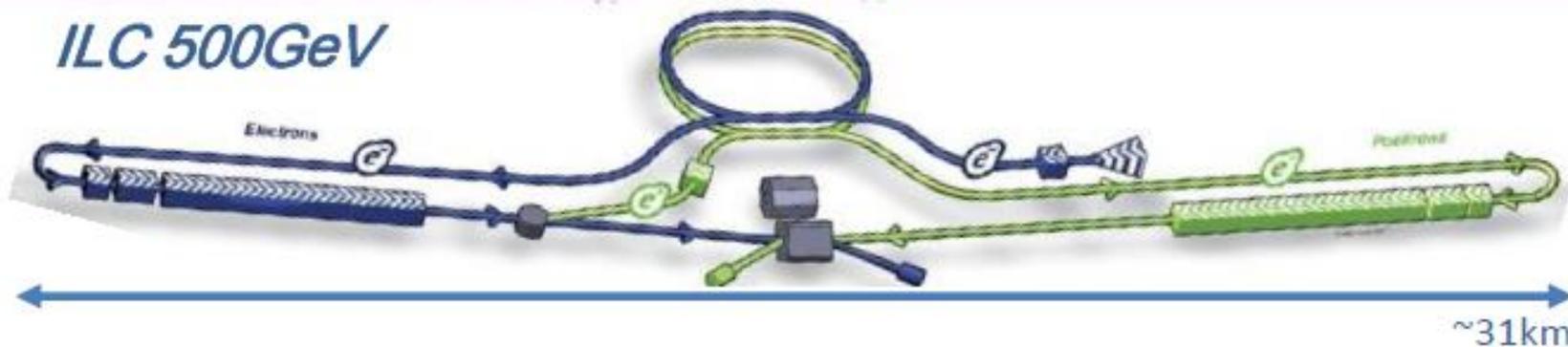
SCRF improvements:  $O(10\%)$

*Innovation of Nb (superconducting) material process: decrease in material cost*

*Innovative surface processing for high efficiency cavity by FNAL: decrease in number of cavities*

## Staging

*ILC 500GeV*



*ILC 250GeV*



*Cost reduction by compact ILC*

Init. Energy:  
 $O(30\%)$

# World wide Labs for SRF system



**European XFEL**



**ILC-SRF technology**



**Americas LCLS-II**



**Project:**  
 1.3 km / 2.5 km  
 1000 RF cavities  
 2014 April/2016  
 2018 1.3 km, 2020 2.5 km  
 2021 1.3 km, 2023 2.5 km



**PAPS@IHEP**

**CFF/STF@KEK**

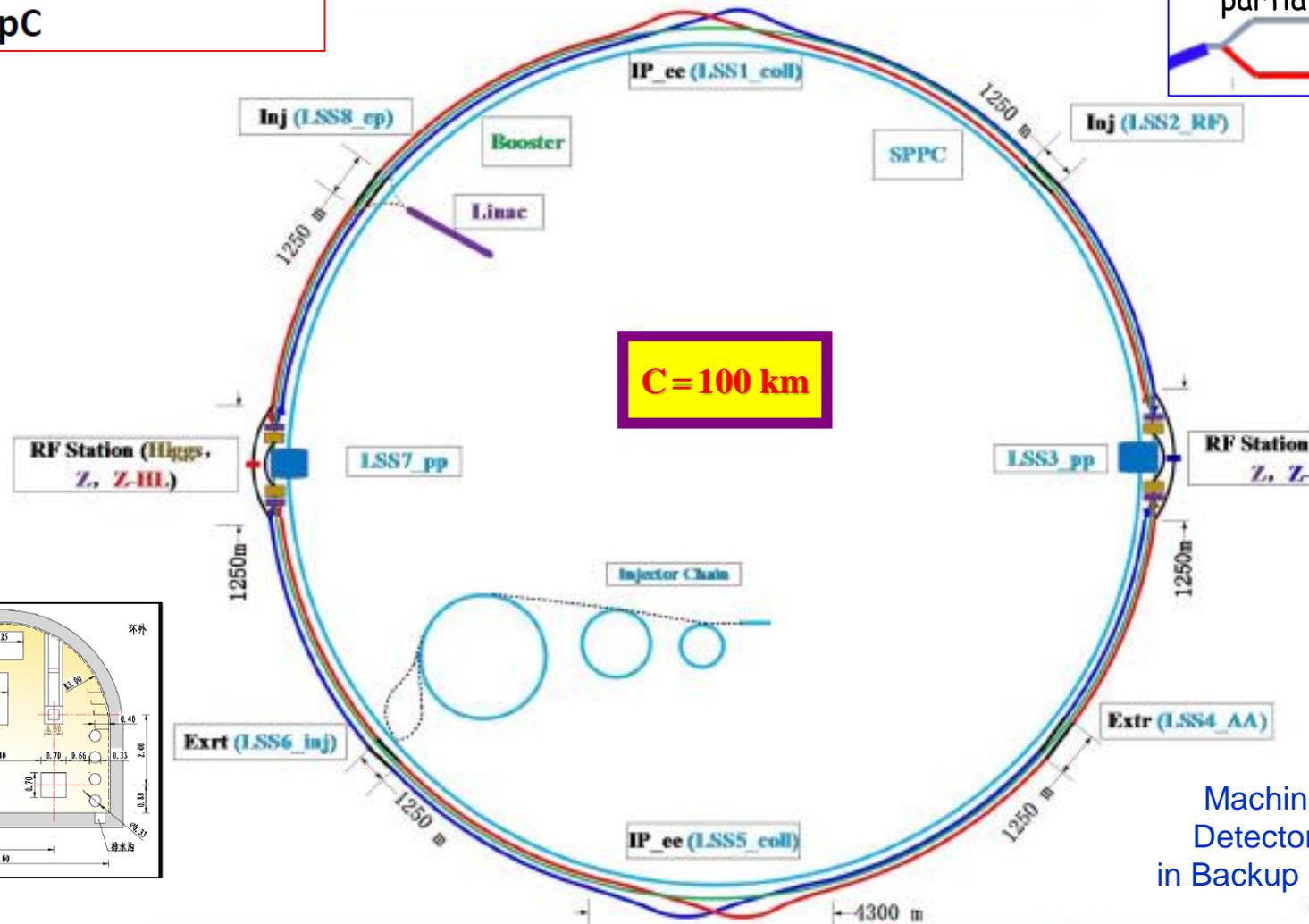
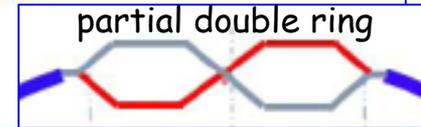
**Asia**

### 3 machines in one tunnel:

- CEPC & booster
- SppC

## Layout of CEPC-SPPC

CDR 2017



Machine params.,  
Detector & params.  
in Backup (➔ Qing QIN)

Layout and hardware satisfying both the **Z** and the **H** programs

$$L = 2 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1} \text{ (at } E_{\text{cm}} = 240 \text{ GeV)}$$

$$L = 1 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1} \text{ (at } E_{\text{cm}} = 91 \text{ GeV)}$$

# It's the Economy ...

+ Technology/Manpower

in backup: Yifang Wang's percentage of GDP

