Achievements and physics prospects in Asia

Junji Haba,

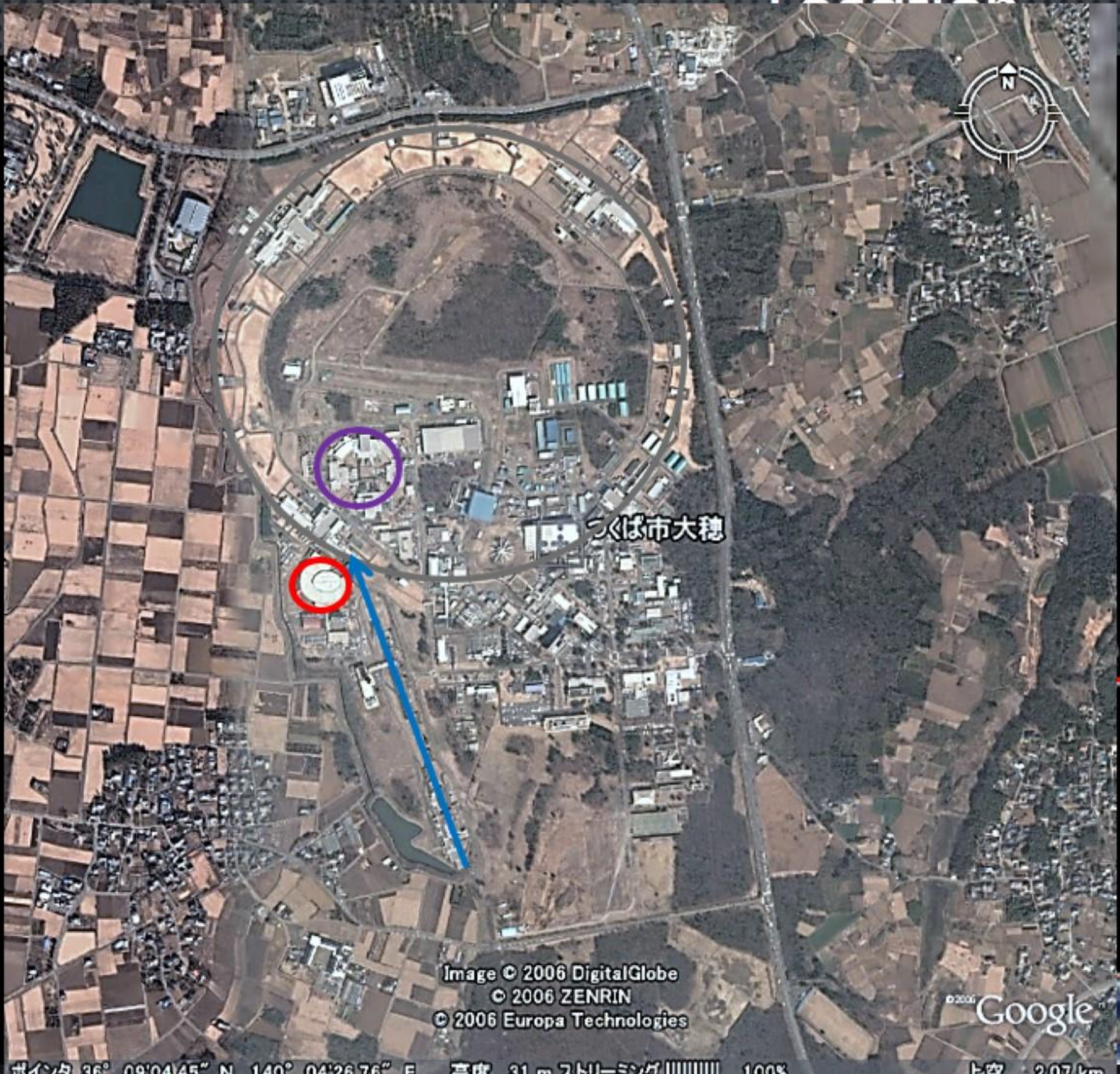
IPNS/KEK

Japan

WHO ARE WORKING IN ASIA?

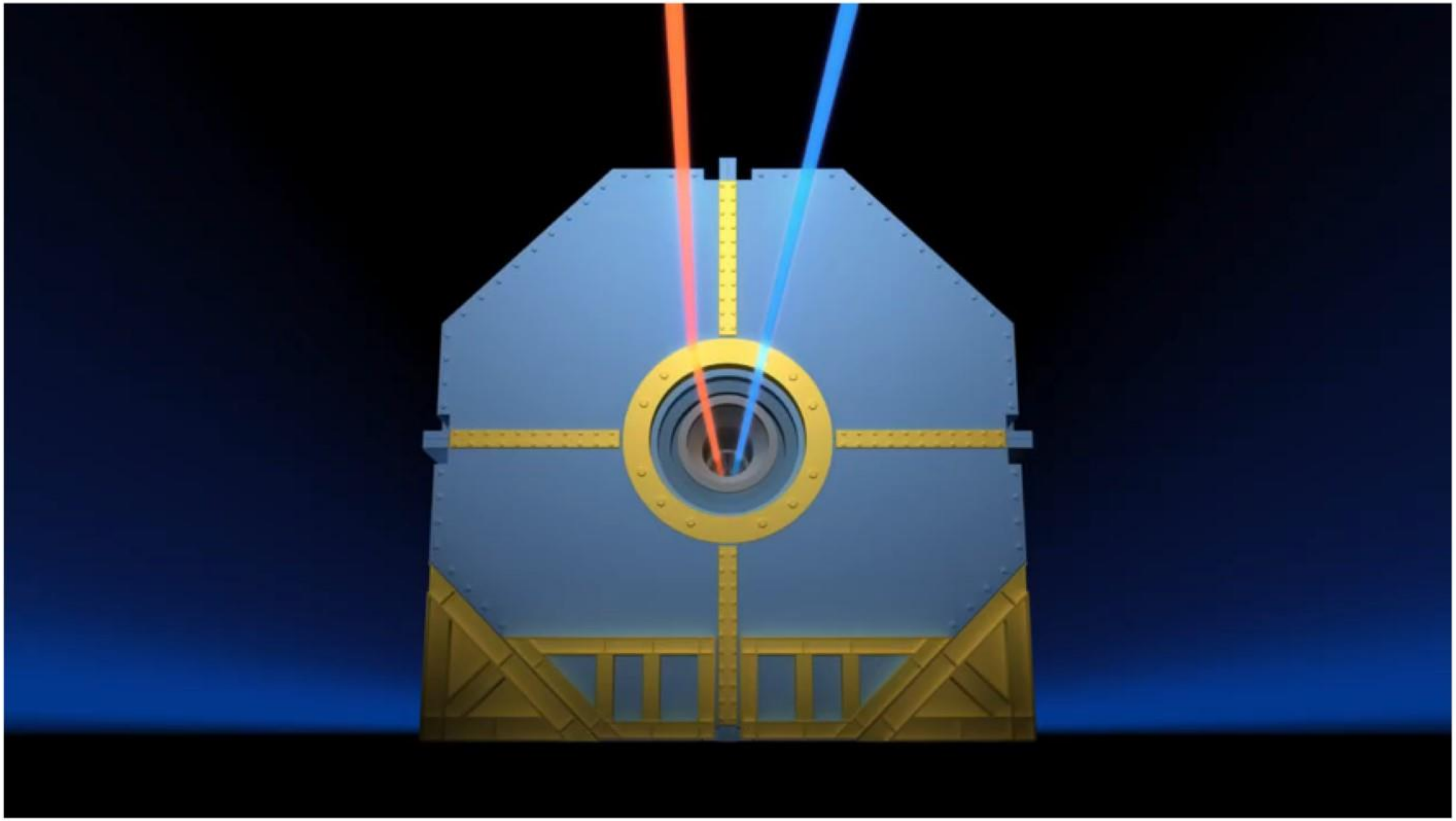
Accelerator labs in Asia

Location

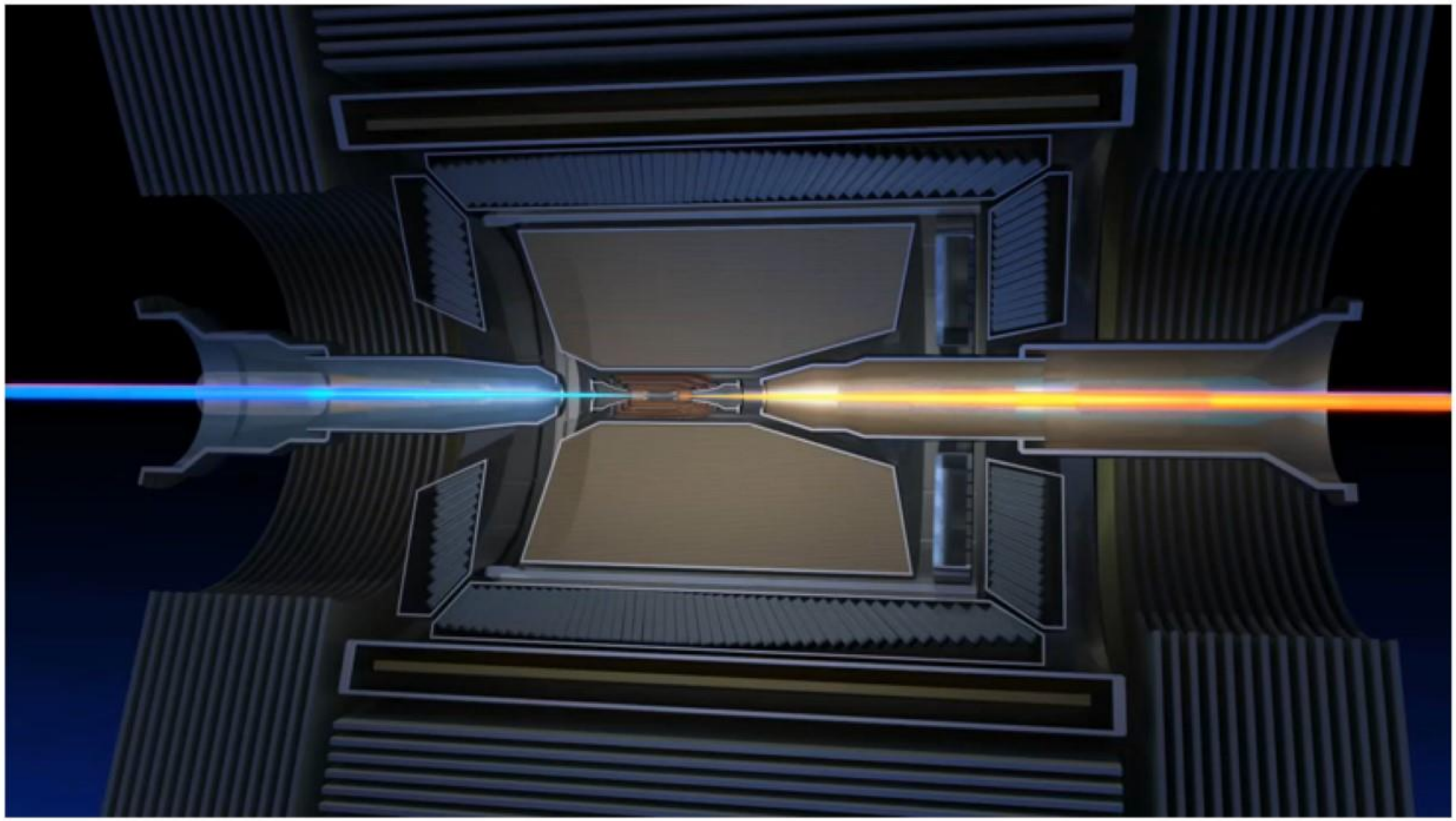


N
つくば市大穂
Image © 2006 DigitalGlobe
© 2006 ZENRIN
© 2006 Europa Technologies
Google
ポインタ 36° 09'04.45" N 140° 04'26.76" E 高度 31 m ストリーミング 100%
上空 2.07 km

ELECTRON POSITRON COLLIDERS FOR FLAVOUR PHYSICS



ELECTRON POSITRON COLLIDERS FOR FLAVOUR PHYSICS



$$e^+ e^- \rightarrow c\,\bar{c}\,, \tau^+\tau^-, b\bar{b}$$

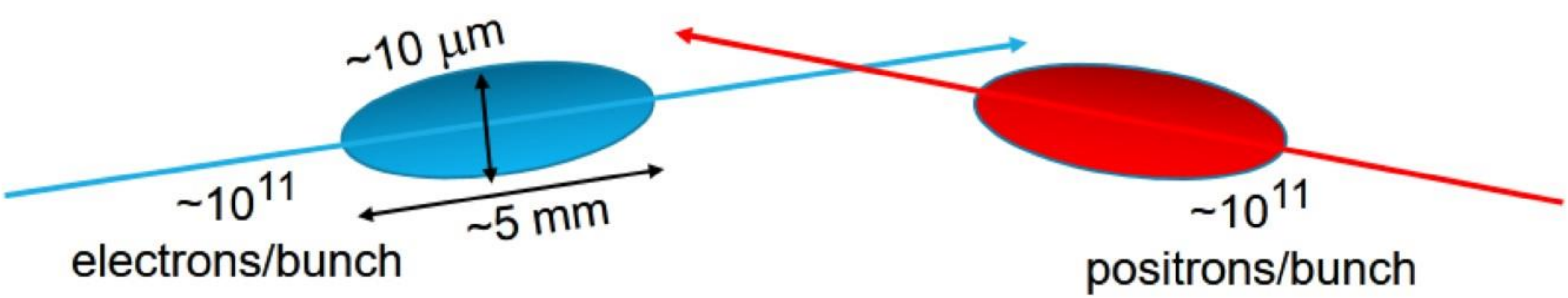
ELECTRON POSITRON COLLIDERS FOR FLAVOUR PHYSICS

KEKB/SuperKEKB, Tsukuba in Japan

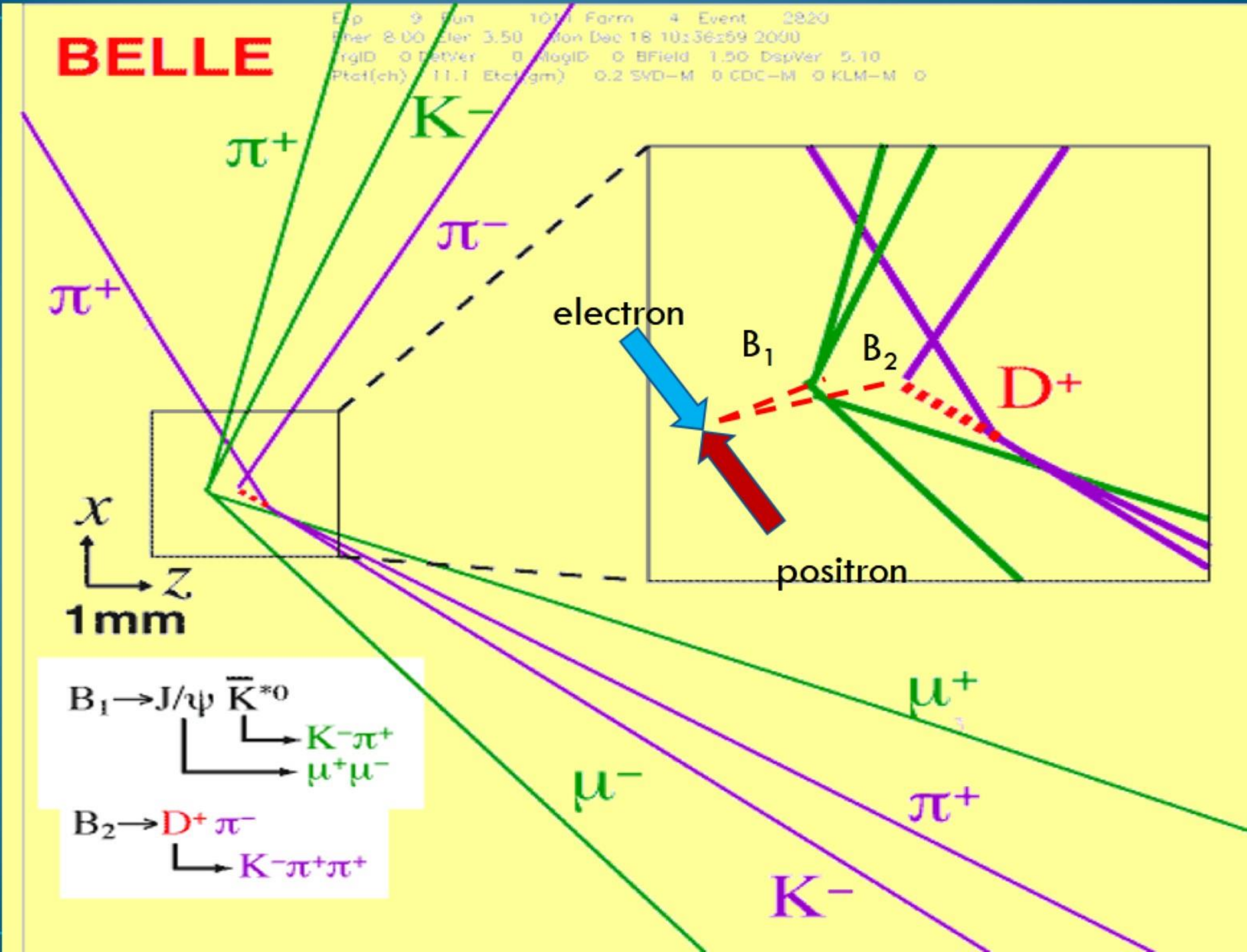
- B Physics at High Luminosity B-factory

CEPC/CEPC II, Beijing in China

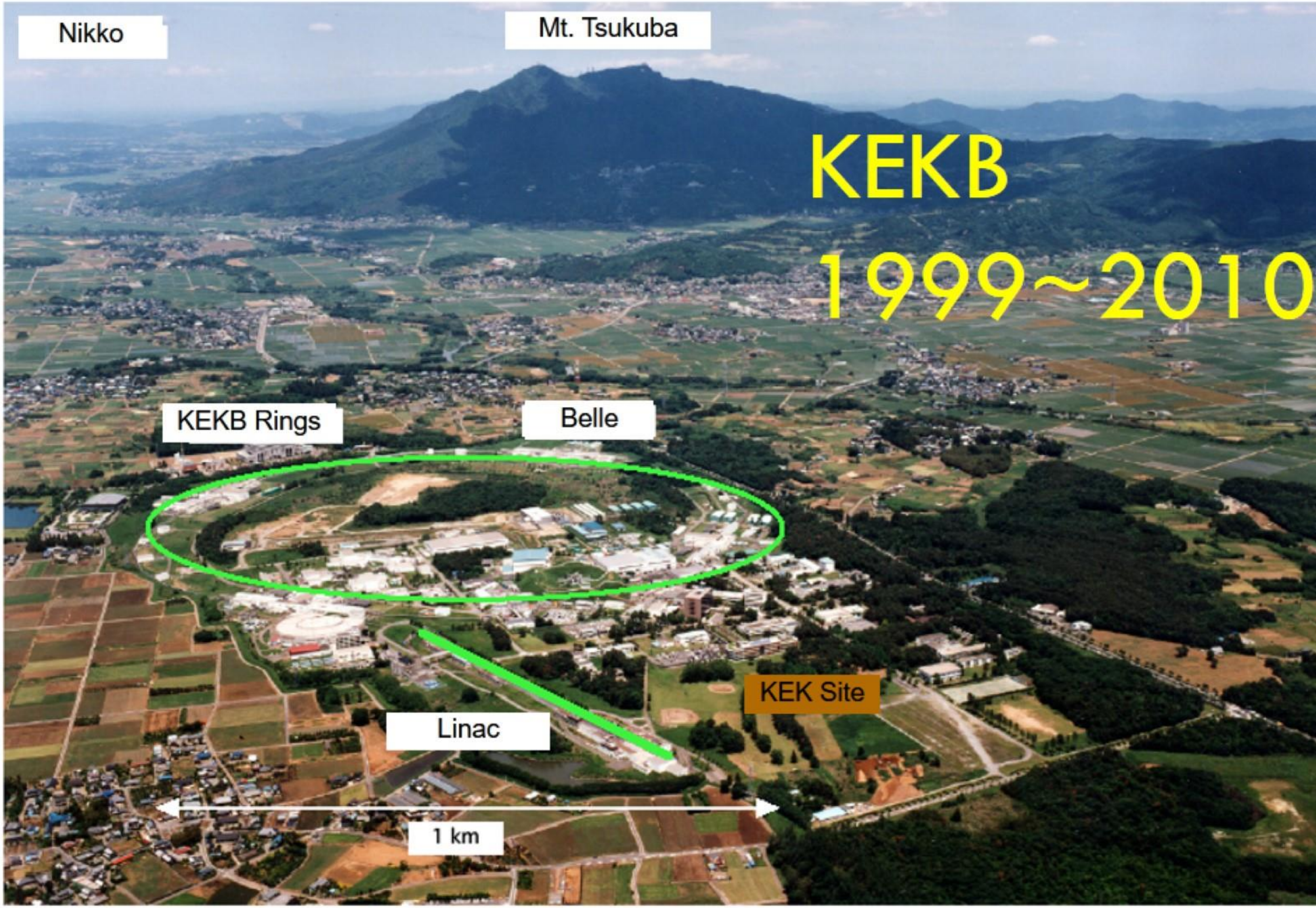
- Charm and tau Physics at High Luminosity c-τ factory



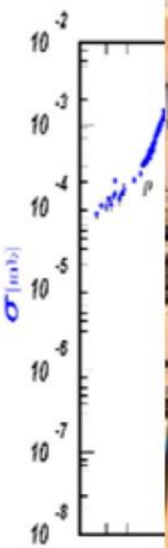
$$Interaction \cdot Rate = L \times \sigma \quad L\text{: luminosity}$$

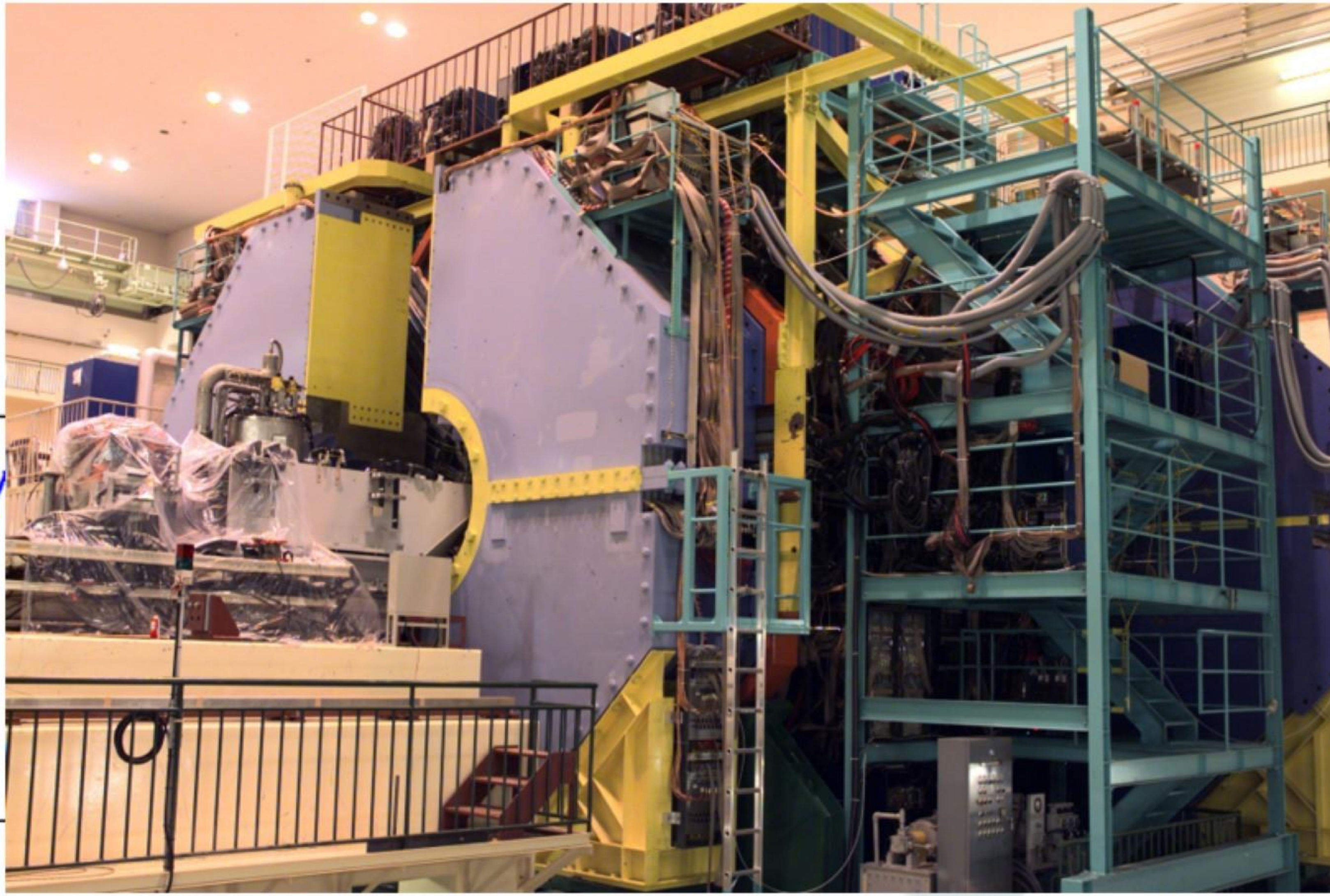


BELLE
Farm 4 Event 2820
8.00 3.50 Dec 18 10:36:59 2000
BField 1.50 DspVer 5.10
11.1 0.2 SVD-M 0 CDC-M 0 KLM-M 0
K⁻
π⁺
π⁻
π⁺
electron
positron
B1
B2
D⁺
x
z
1mm
μ⁺
μ⁻
π⁺
K⁻
B1→J/ψ K̄*0
K⁻π⁺
μ⁺μ⁻
B2→D⁺ π⁻
K⁻π⁺π⁺

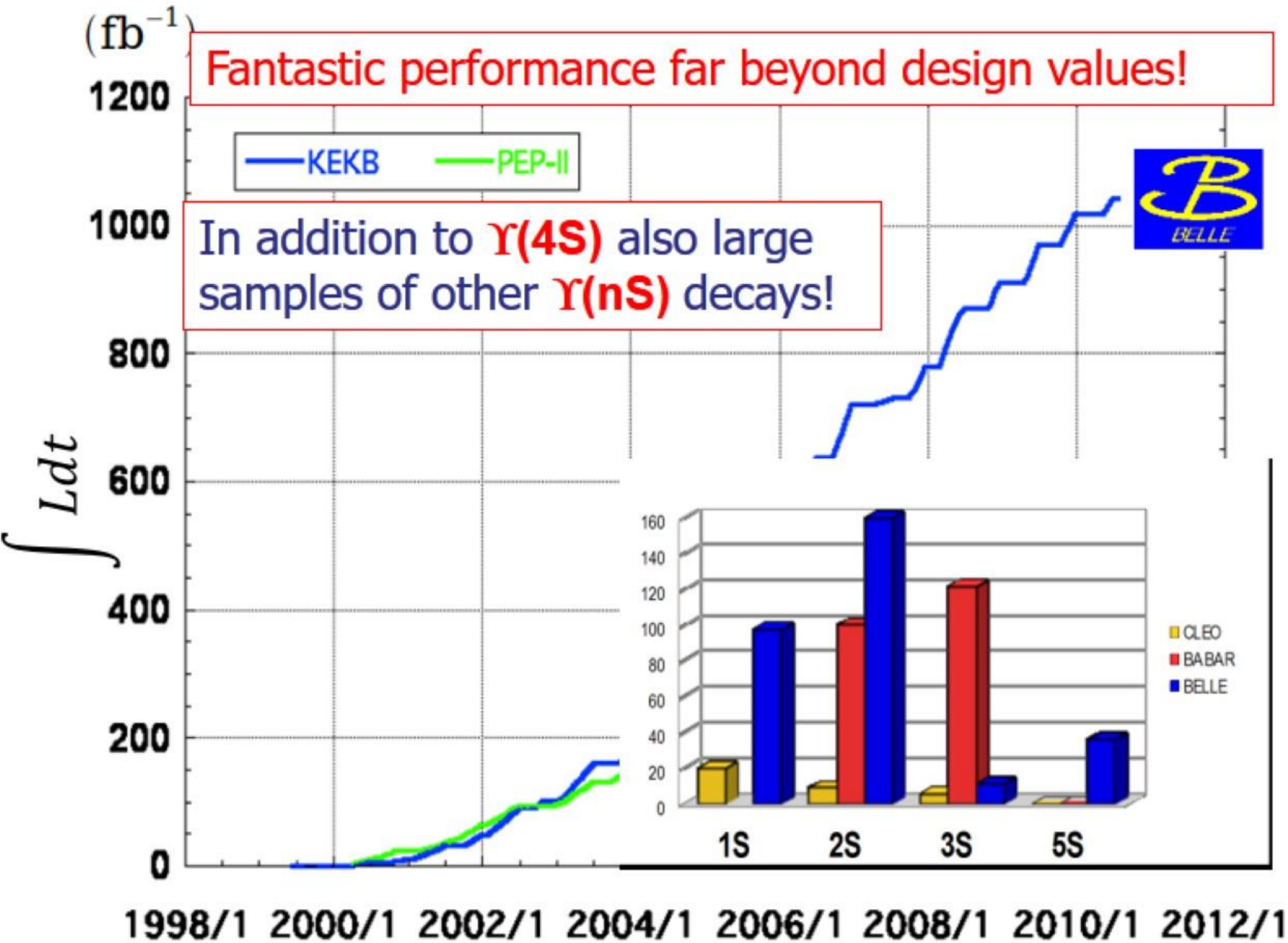

Nikko
Mt. Tsukuba
KEKB
1999~2010
KEKB Rings
Belle
KEK Site
Linac
1 km

The Belle detector





INTEGRATED LUMINOSITY AT B FACTORIES



$\mathrm{ab}=10^{-39}\,\mathrm{cm}^2$

$> 1\ \mathrm{ab}^{-1}$

On resonance:

$\Upsilon(5S)$: 121 fb^{-1}

$\Upsilon(4S)$: 711 fb^{-1}

$\Upsilon(3S)$: 3 fb^{-1}

$\Upsilon(2S)$: 25 fb^{-1}

$\Upsilon(1S)$: 6 fb^{-1}

Off reson./scan:

$\sim 100\ \mathrm{fb}^{-1}$

$\sim 550\ \mathrm{fb}^{-1}$

On resonance:

$\Upsilon(4S)$: 433 fb^{-1}

$\Upsilon(3S)$: 30 fb^{-1}

$\Upsilon(2S)$: 14 fb^{-1}

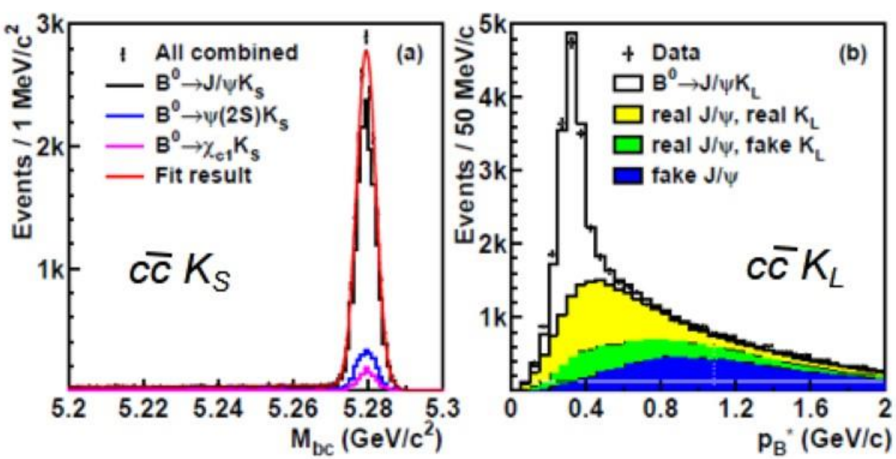
Off resonance:

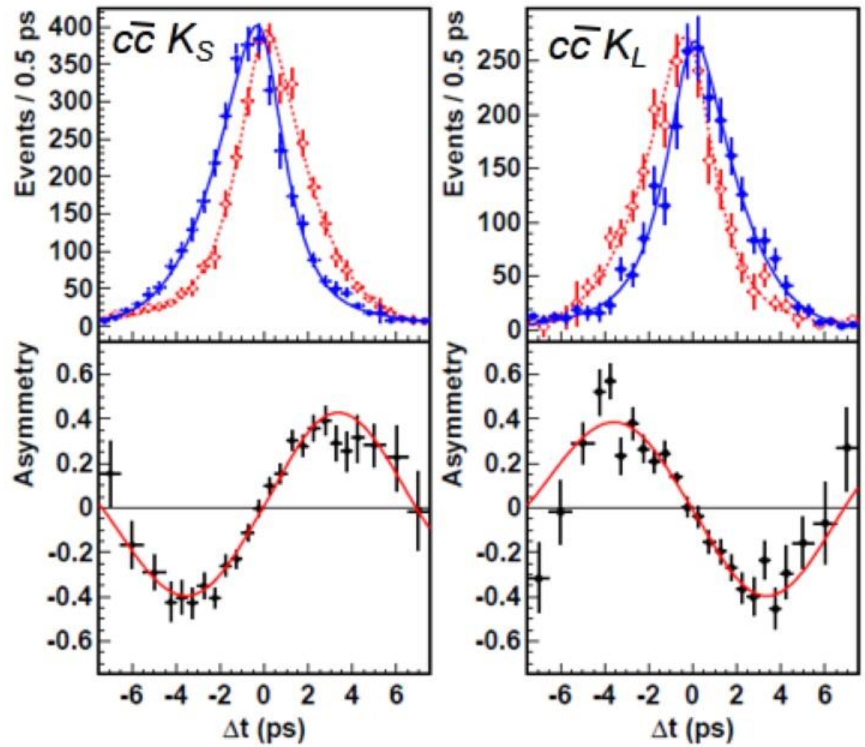
$\sim 54\ \mathrm{fb}^{-1}$

$$Toal\ number\ of\ event = \int (interation\ rate)dt = \sigma \int Ldt$$

Large CP (matter-antimatter symmetry) violation predicted in B^0 by KM theory has been confirmed experimentally.

Final measurement: with improved tracking, more data, improved systematics (50% more statistics than last result with 492 fb^{-1});
$cc = J/\psi,\ \psi(2S),\ \chi_{c1}$ → 25k events





Belle, final, 710 fb^{-1}, PRL 108, 171802 (2012)

naturenews

Published online 7 October 2008 | Nature | doi:10.1038/news.2008.1155

News

Nobel Prize in Physics for symmetry breakdown

Japanese-born theorists rewarded for work on fundamental symmetries in particle physics.

Geoff Brumfiel

A trio of Japanese-born physicists has been awarded the 2008 Nobel Prize in Physics for their work on understanding how the fundamental symmetries of nature are broken.

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

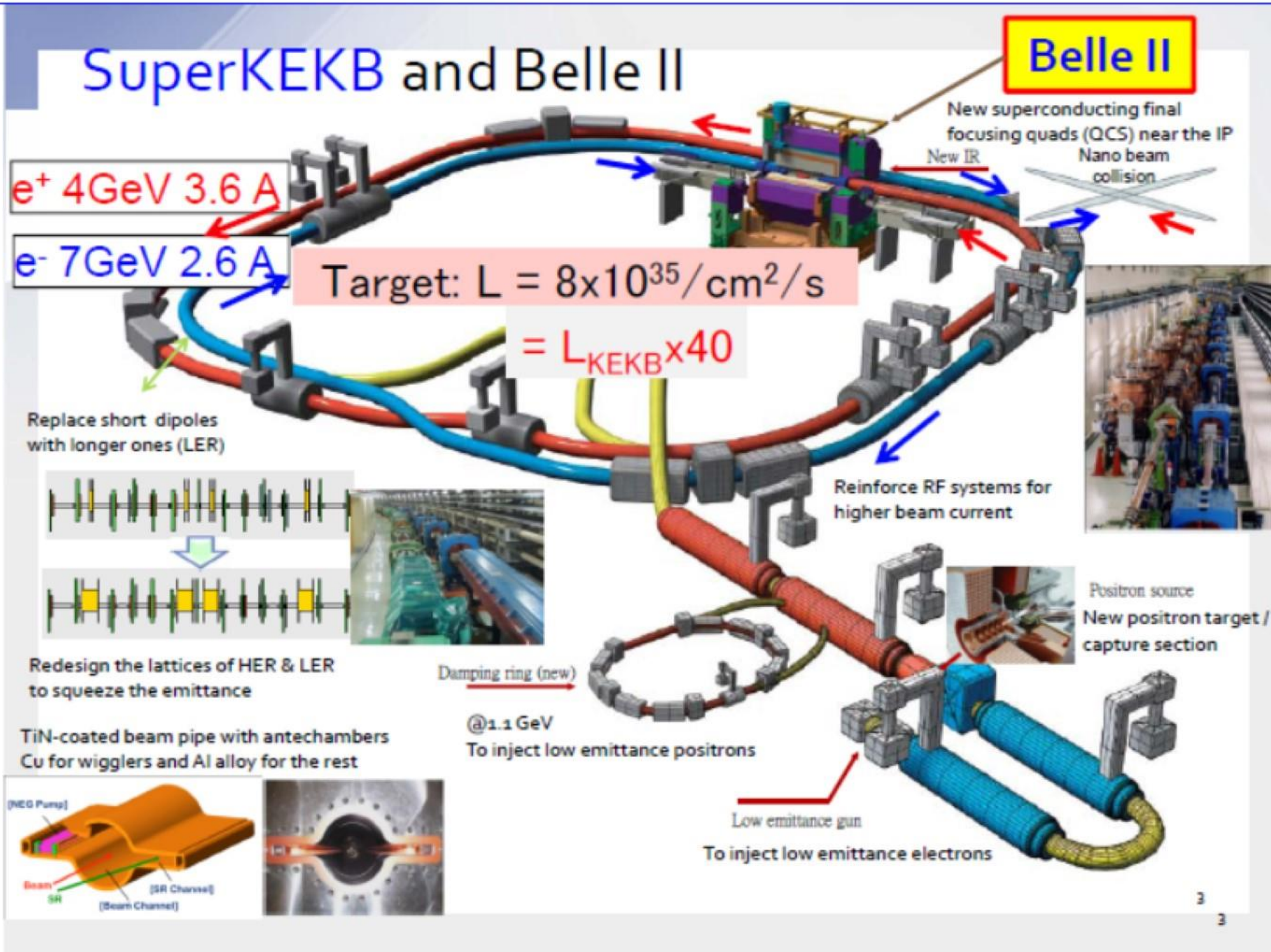
Makoto Kobayashi of Japan's High Energy Accelerator Research Organization (KEK) in Tsukuba and Toshihide Maskawa of the Yukawa Institute for Theoretical Physics (YITP) at Kyoto University were awarded a quarter of the prize each for discovering the origin of the 'broken symmetry' that contributed to a preponderance of matter over antimatter in the Universe.

Makoto Kobayashi

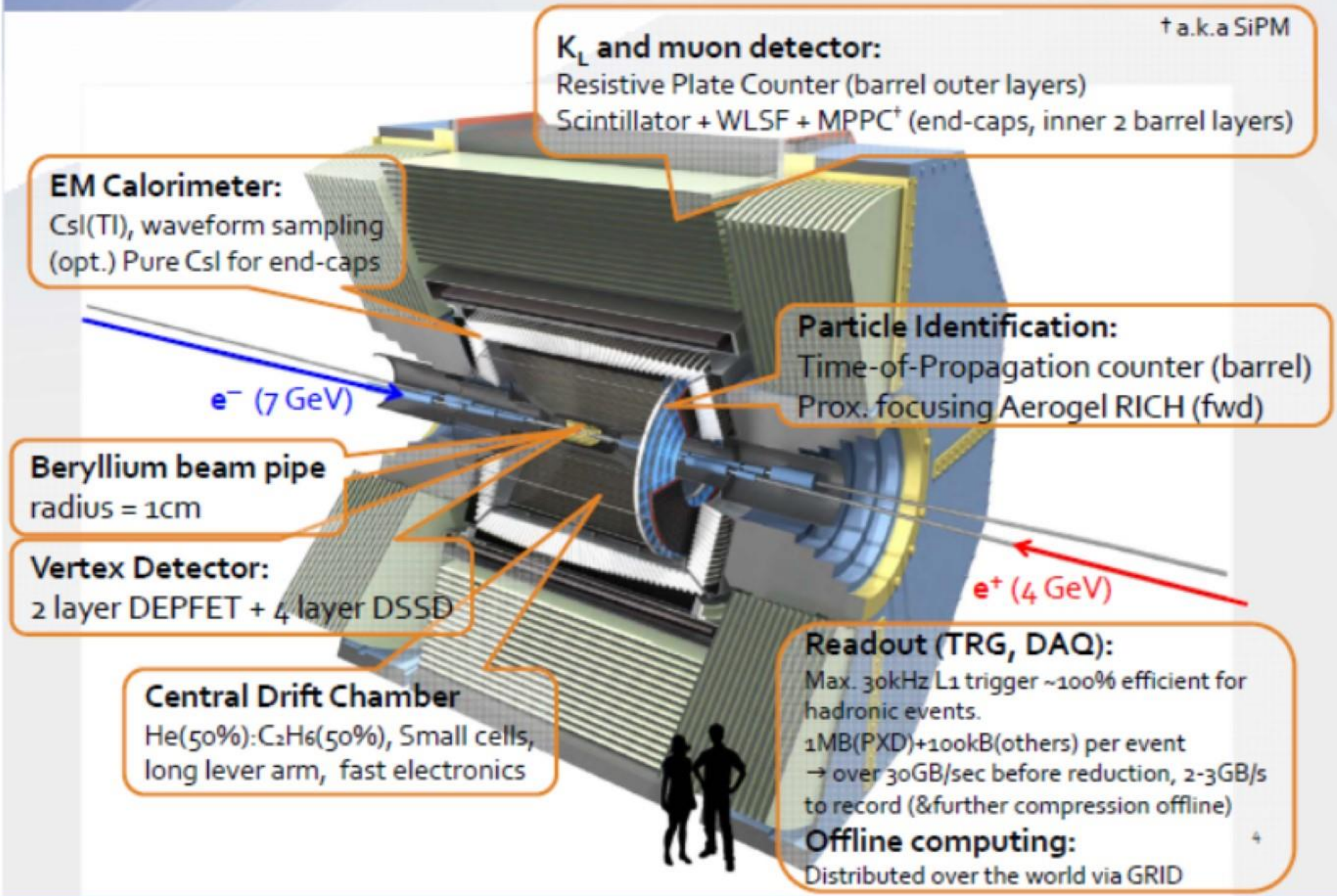
Toshihide Maskawa

It was later considered that CP violation found in quark system could not be sufficient for matter anit-matter asummetery in Universe .

From Success to Successor for Physics BSM



Cut view of **Belle II** Detector



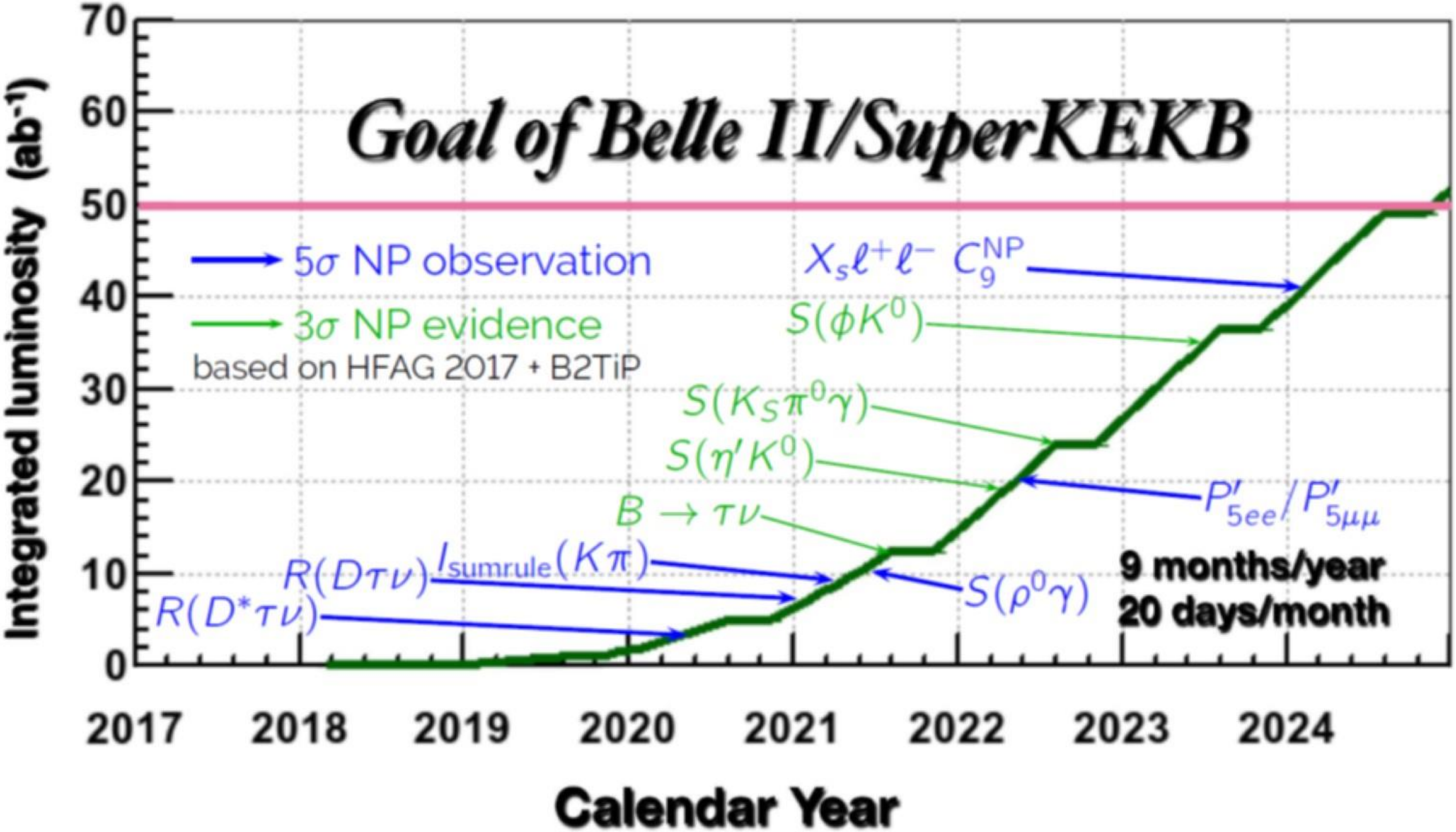
Growing Attraction of Asia

Europe	285
Austria	14
Czechia	7
Germany	110
Italy	73
Poland	11
Russia	46
Slovenia	17
Spain	4
Ukraine	3

Asia			345
Saudi Arabia	3	Korea	44
Australia	36	Malaysia	5
China	29	Vietnam	2
India	40	Taiwan	22
Japan	161	Thailand	2
		Turkey	1

America	119
Canada	23
Mexico	11
USA	85

Yutaka Ushiroda @ LP2017



Using "current" central values, and extrapolated stat+syst errors

Another story in China

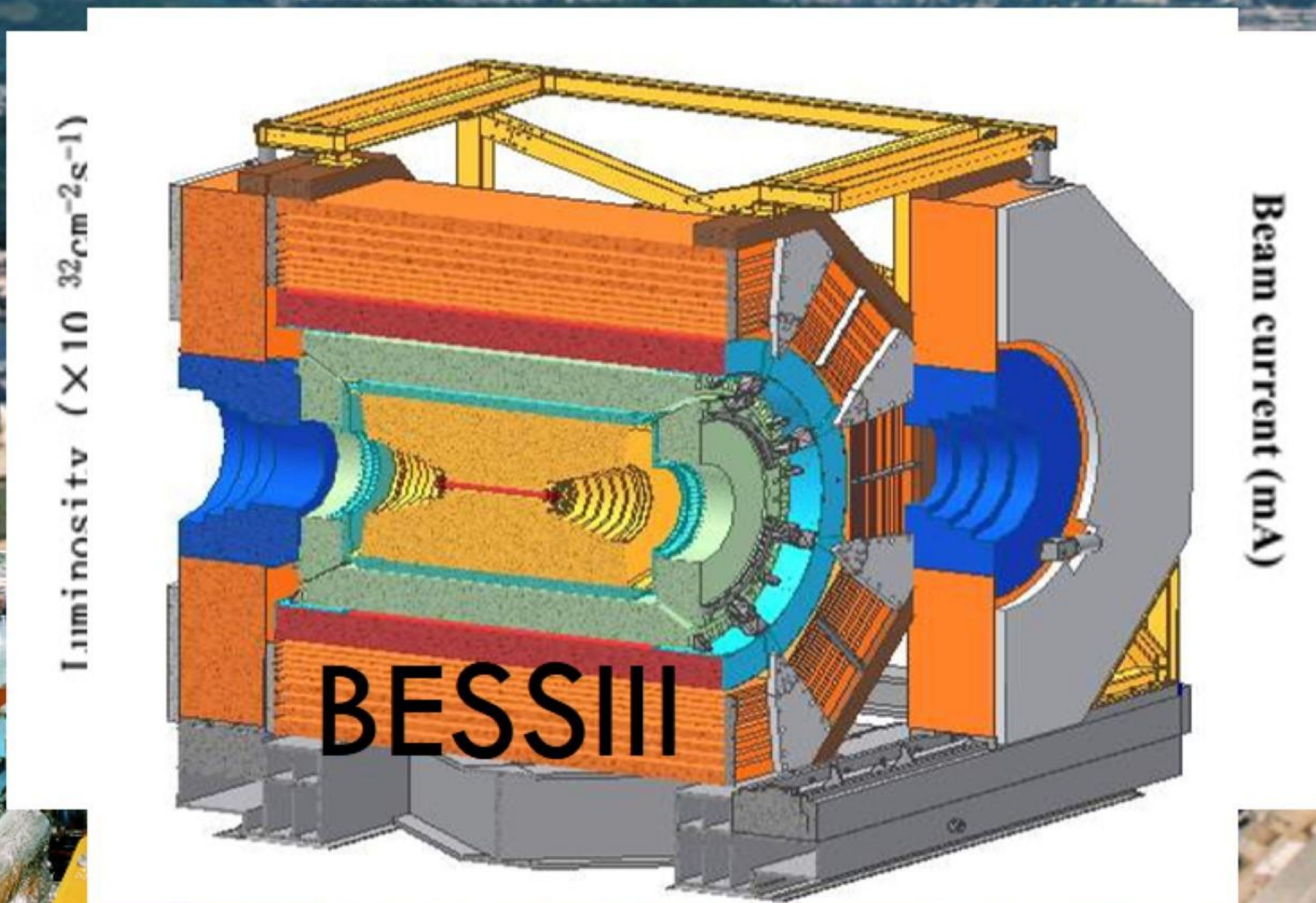
Symmetric double ring

E_{cm}: 2.0-4.6 GeV

σ_E: 5.16×10^{-4}

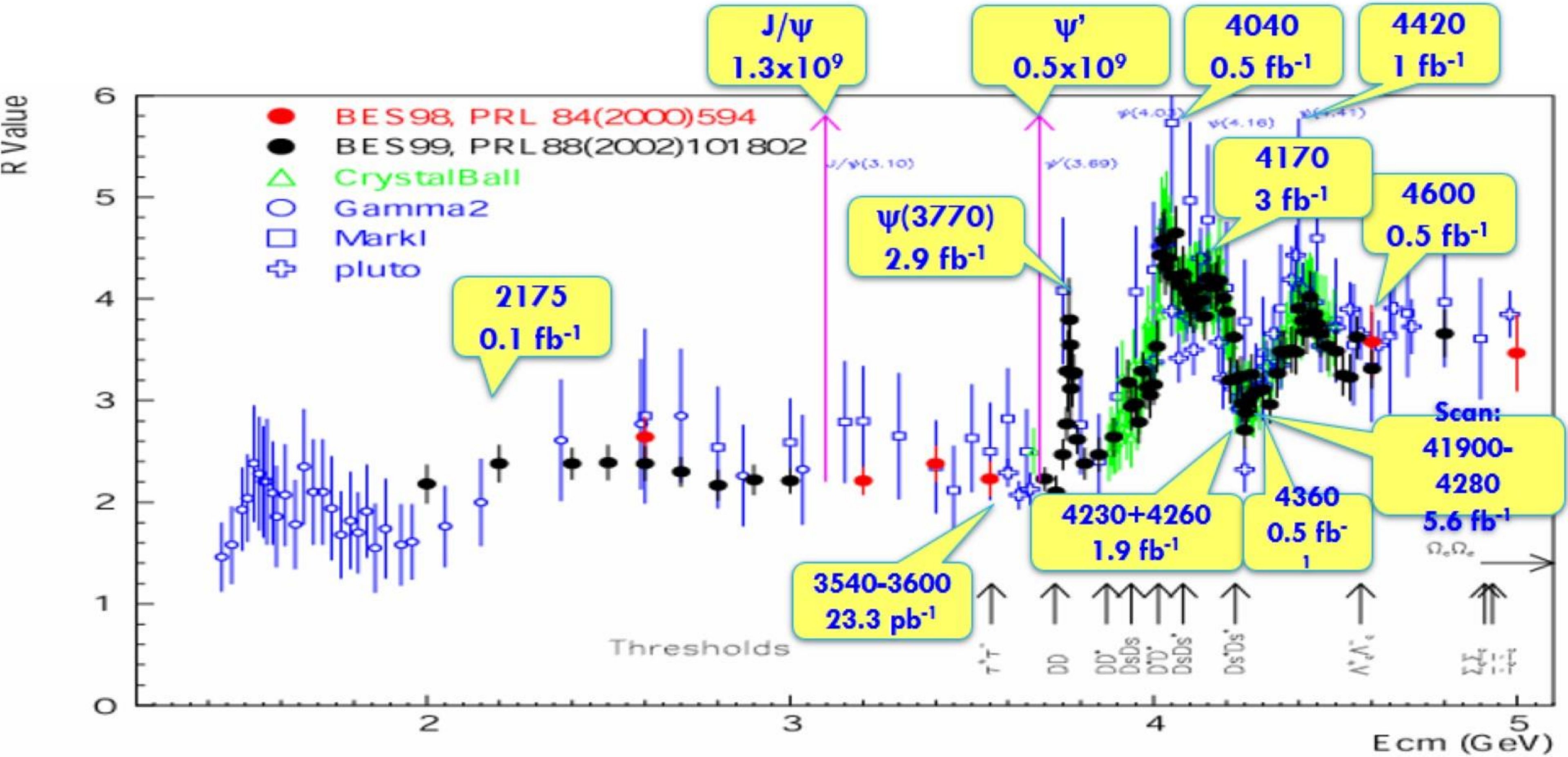
L: 1×10^{33} cm^{-2}s^{-1}@3770

Beijing, China



Data samples at BESIII

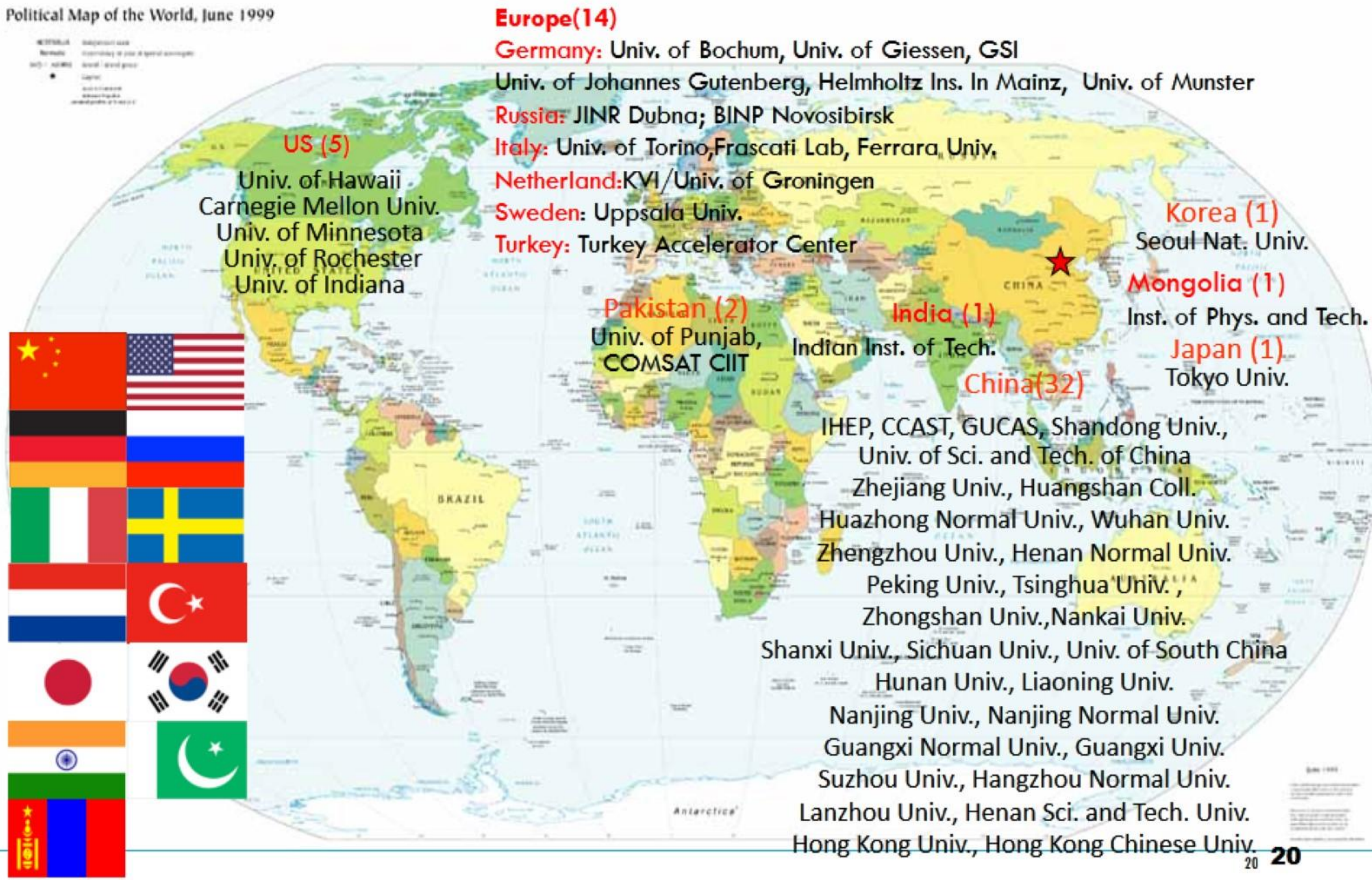
World larges data samples directly produced from e^+e^- collision at J/ψ, $\psi(2S)$, $\psi(3770)$, $\psi(4170)$ $Y(4260)$…



R scan at 130 energy points in 2-4.6 GeV (1.3 fb^{-1})

BESIII Collaboration

~400 authros, 60 institutions, 13 countries



Europe(14)

Germany: Univ. of Bochum, Univ. of Giessen, GSI
Univ. of Johannes Gutenberg, Helmholtz Ins. In Mainz, Univ. of Munster

Russia: JINR Dubna; BINP Novosibirsk

Italy: Univ. of Torino,Frascati Lab, Ferrara Univ.

Netherland:KVI/Univ. of Groningen

Sweden: Uppsala Univ.

Turkey: Turkey Accelerator Center

US (5)

Univ. of Hawaii
Carnegie Mellon Univ.
Univ. of Minnesota
Univ. of Rochester
Univ. of Indiana

Pakistan (2)

Univ. of Punjab,
COMSAT CIIT

India (1)

Indian Inst. of Tech.

Korea (1)

Seoul Nat. Univ.

Mongolia (1)

Inst. of Phys. and Tech.

Japan (1)

Tokyo Univ.

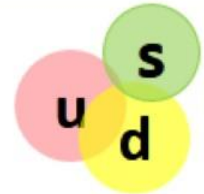
China(32)

IHEP, CCAST, GUCAS, Shandong Univ.,
Univ. of Sci. and Tech. of China
Zhejiang Univ., Huangshan Coll.
Huazhong Normal Univ., Wuhan Univ.
Zhengzhou Univ., Henan Normal Univ.
Peking Univ., Tsinghua Univ. ,
Zhongshan Univ.,Nankai Univ.
Shanxi Univ., Sichuan Univ., Univ. of South China
Hunan Univ., Liaoning Univ.
Nanjing Univ., Nanjing Normal Univ.
Guangxi Normal Univ., Guangxi Univ.
Suzhou Univ., Hangzhou Normal Univ.
Lanzhou Univ., Henan Sci. and Tech. Univ.
Hong Kong Univ., Hong Kong Chinese Univ.

Another Important Outcome from e+e- factories

Conclusive discovery of new states of matter

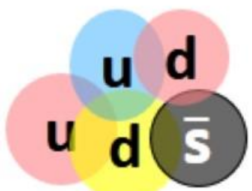
other than



Baryon(nucleon)

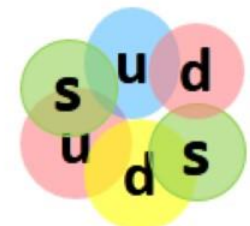
meson

Non-qq mesons or non-qqq baryons predicted by `QCD-motivated' models



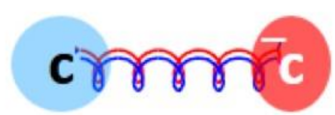
pentaquarks

glueballs

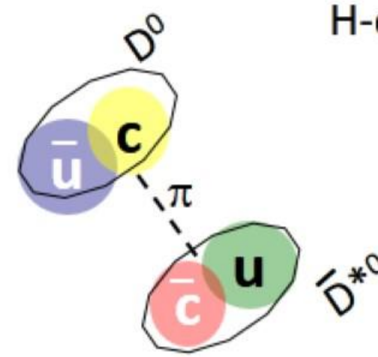


H-dibaryon

diquark-diantiquarks

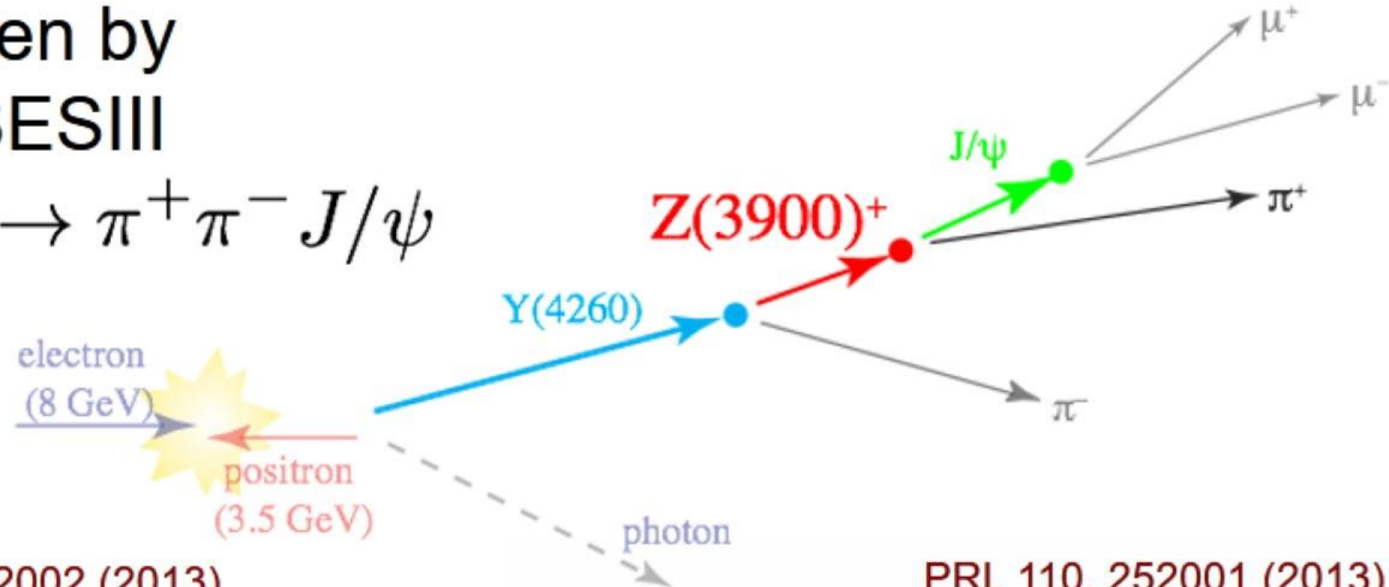


hybrids

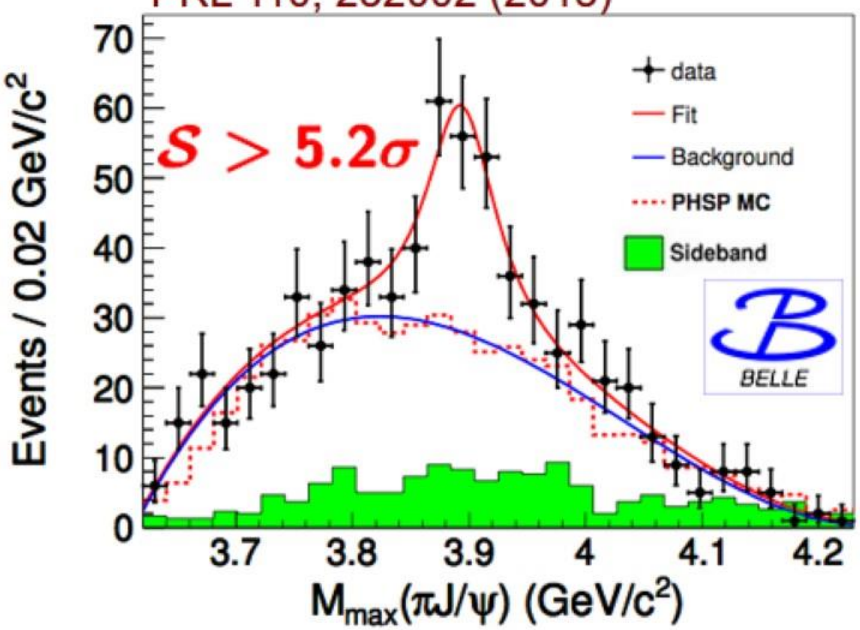


molecules

$Z(3900)^+$ seen by Belle and BESIII in $Y(4260) \to \pi^+\pi^- J/\psi$

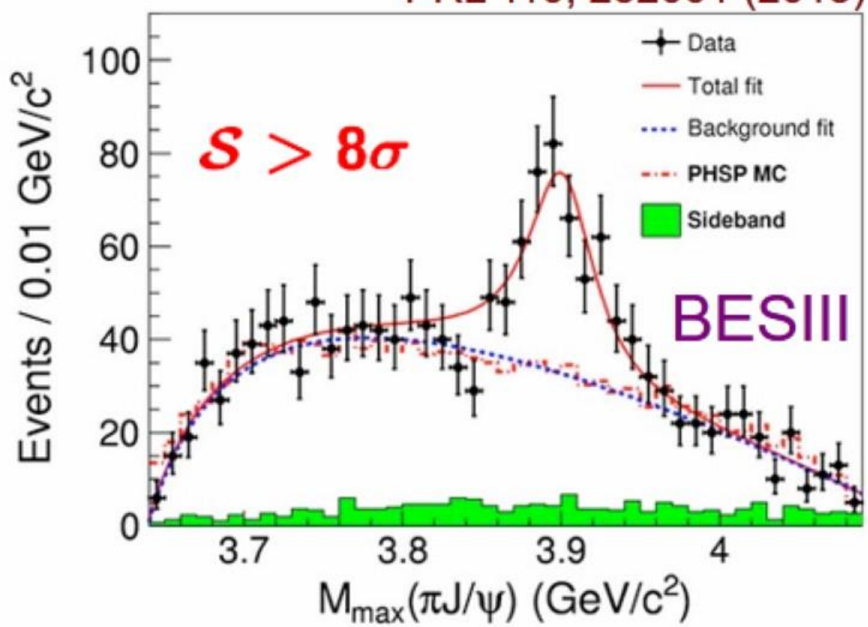


PRL 110, 252002 (2013)



$M = (3894.5 \pm 6.6 \pm 4.5)$ MeV
$\Gamma = (63 \pm 24 \pm 26)$ MeV

PRL 110, 252001 (2013)



$M = (3899.0 \pm 3.6 \pm 4.9)$ MeV
$\Gamma = (46 \pm 10 \pm 20)$ MeV

Proposal for the next **: ILC & CEPC(-SppC)**
Higgs factory using an e+e- collider

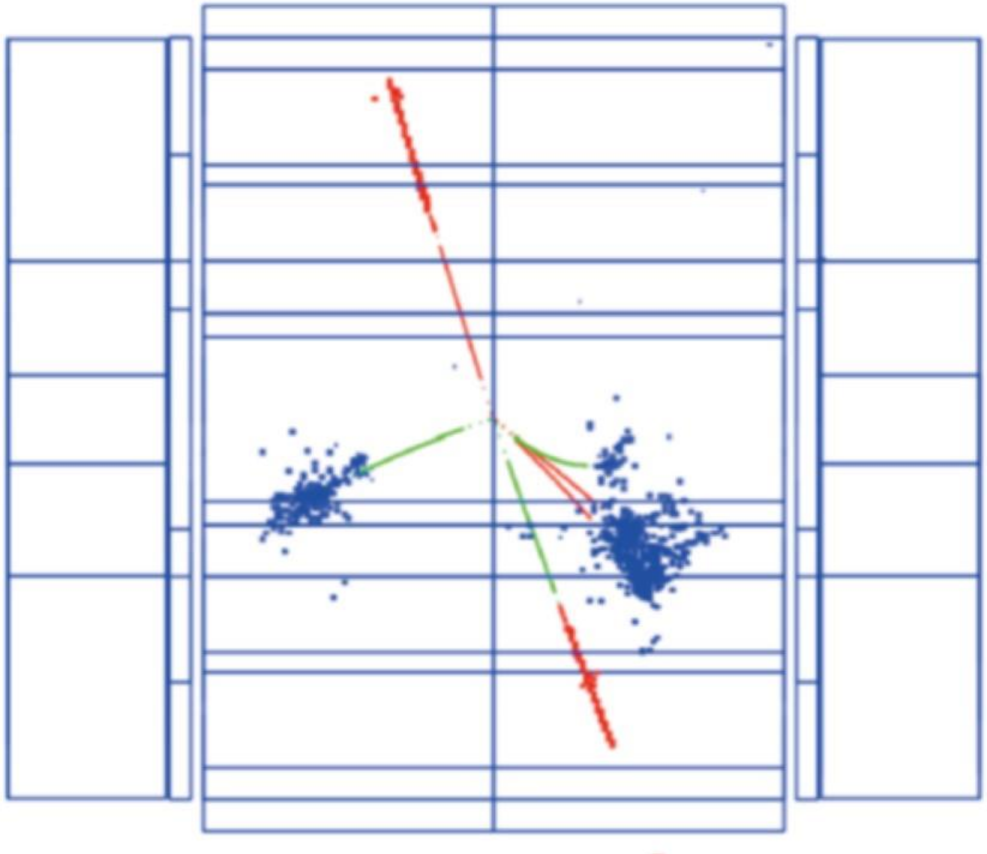
Why do
difficul

Higgs e
All star

Measur
measur

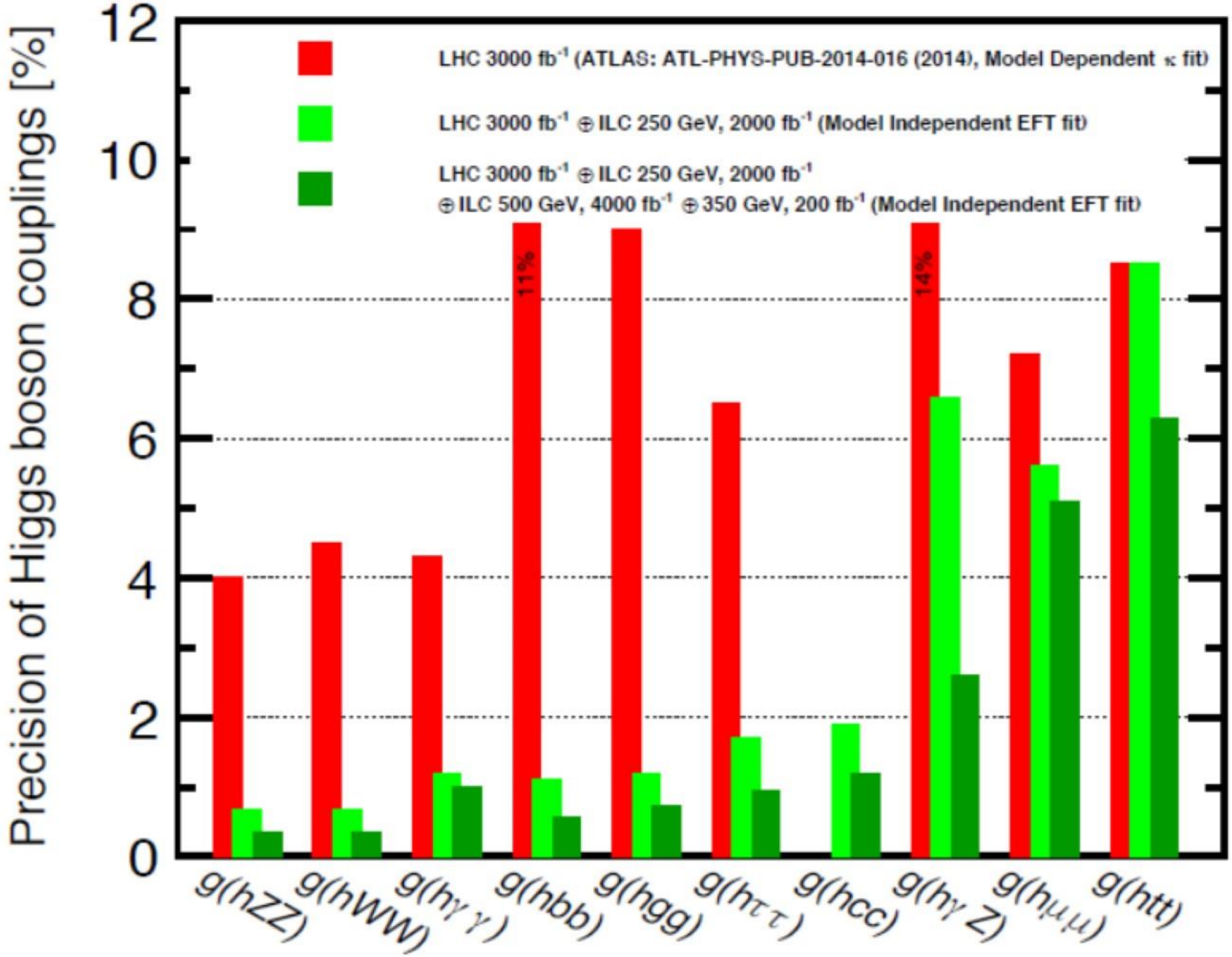
The ab
measur

At 250
$E_{lab} =$



(thanks to Manqi Ruan)

From M. Peskin in ICFA seminar 2017



Precision of Higgs boson couplings [%]
0
2
4
6
8
10
12
LHC 3000 fb-1 (ATLAS: ATL-PHYS-PUB-2014-016 (2014), Model Dependent κ fit)
LHC 3000 fb-1 ⊕ ILC 250 GeV, 2000 fb-1 (Model Independent EFT fit)
LHC 3000 fb-1 ⊕ ILC 250 GeV, 2000 fb-1
⊕ ILC 500 GeV, 4000 fb-1 ⊕ 350 GeV, 200 fb-1 (Model Independent EFT fit)
11%
14%
g(hZZ)
g(hWW)
g(hγγ)
g(hbb)
g(hgg)
g(hττ)
g(hcc)
g(hγZ)
g(hμμ)
g(htt)

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) ⇒ energy

(3) Beam Polarization

<u>**Discovery of the 125 GeV Higgs Boson at LHC in 2012**</u>

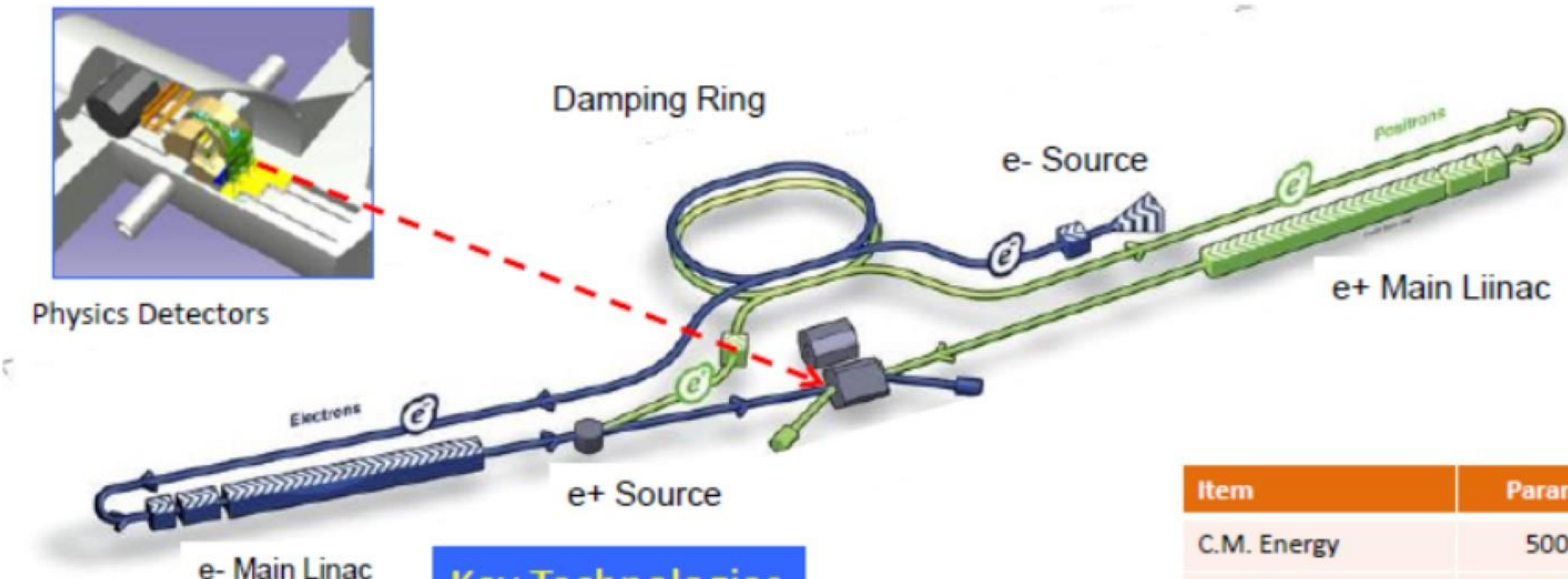
⇒ obvious physics target (Higgs is a portal of physics beyond the Standard Model)

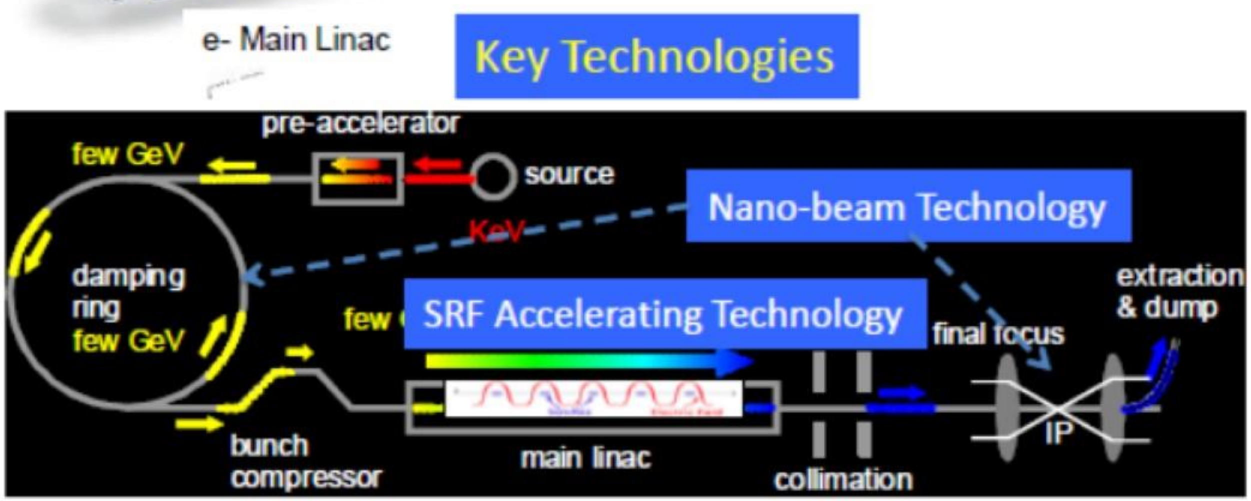
⇒ triggered early construction of the ILC

ILC Site Candidate Location in Japan:
Kitakami

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

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 $Q_0 = 1x10^{10}$

US-Japan cost reduction

Shin Michizono @ LCWS2017

Cost reduction by technological innovation

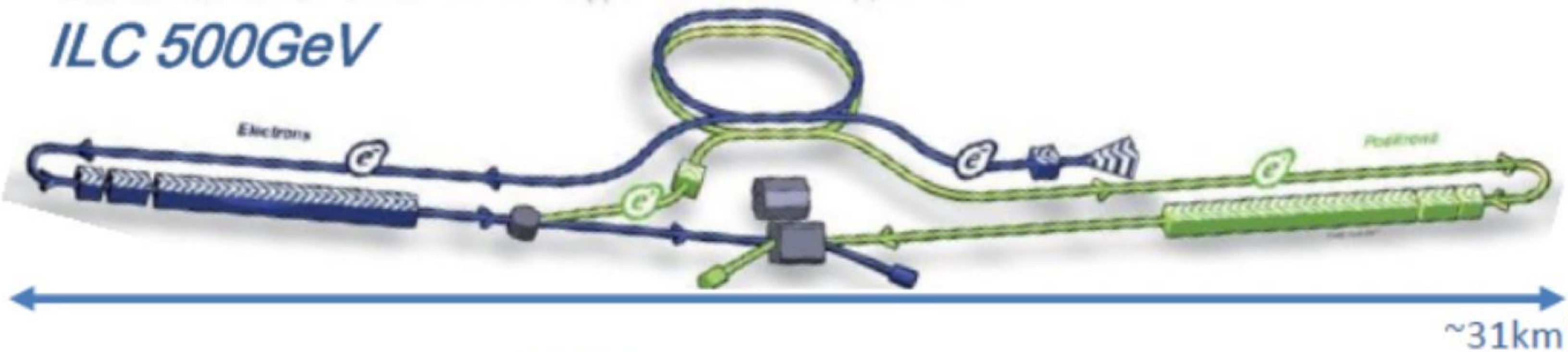
SCRF improvements: O(10%)

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

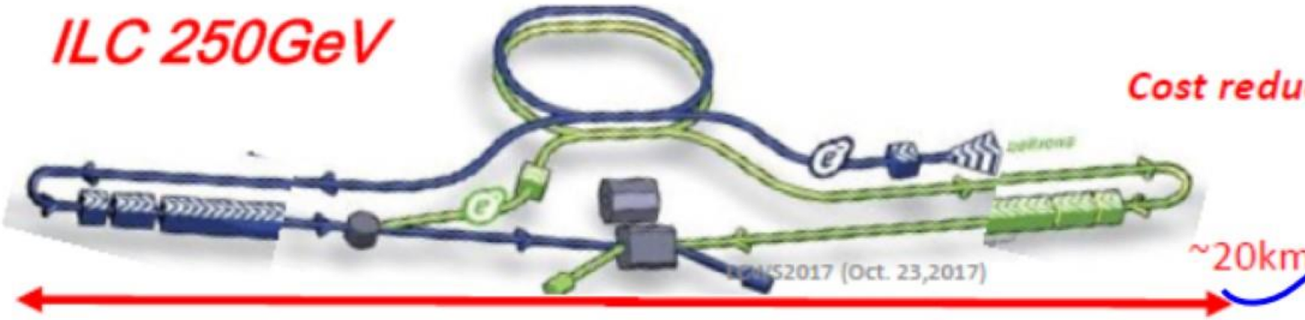
Innovative surface processing for high efficiency cavity by FNAL: decrease in number of cavities

Staging

ILC 500GeV



ILC 250GeV



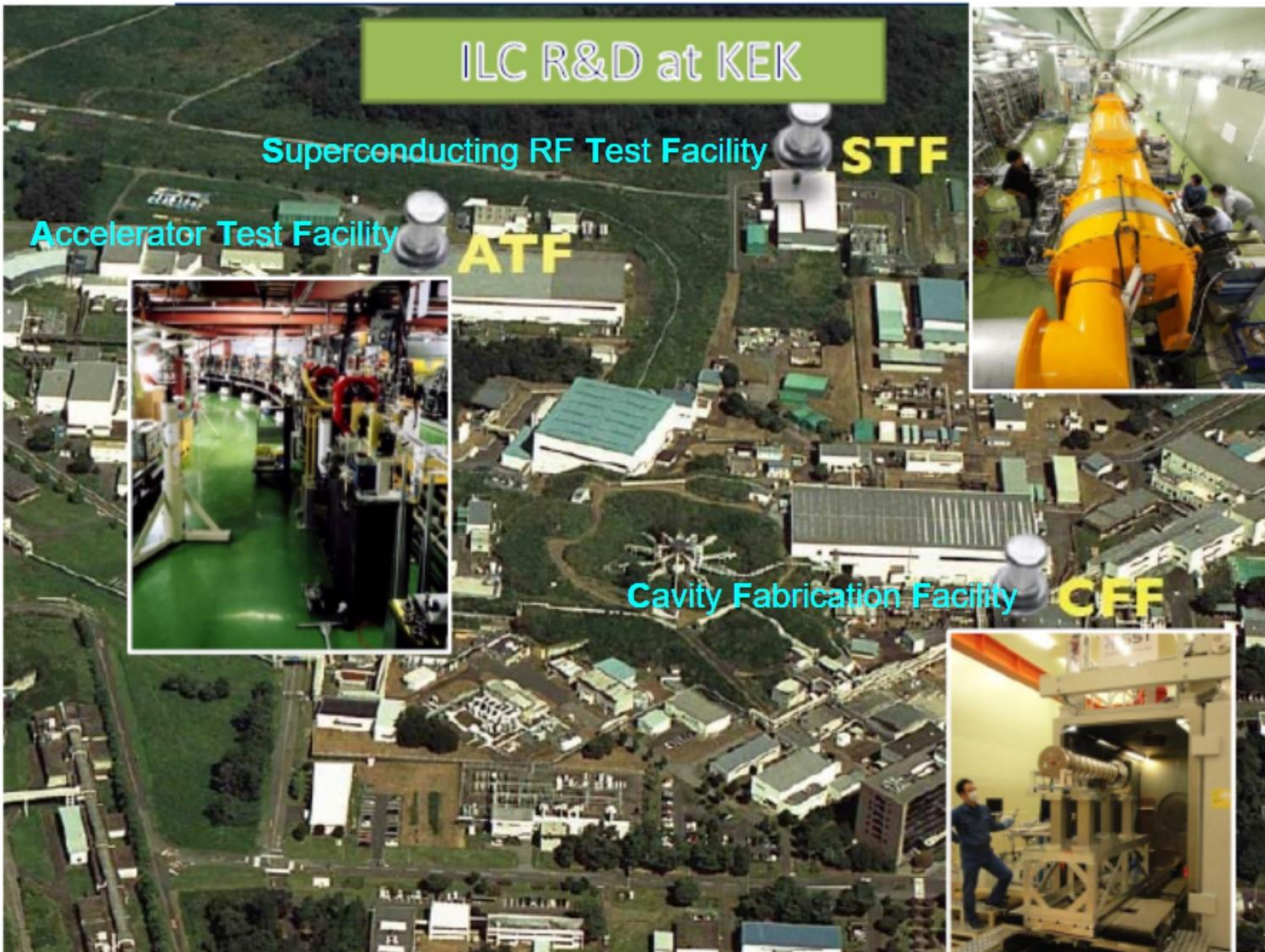
Cost reduction by compact ILC

Init. Energy:
O(30%)

Shin Michizono @ LCWS2017

World wide Labs for SRF system

ILC R&D at KEK

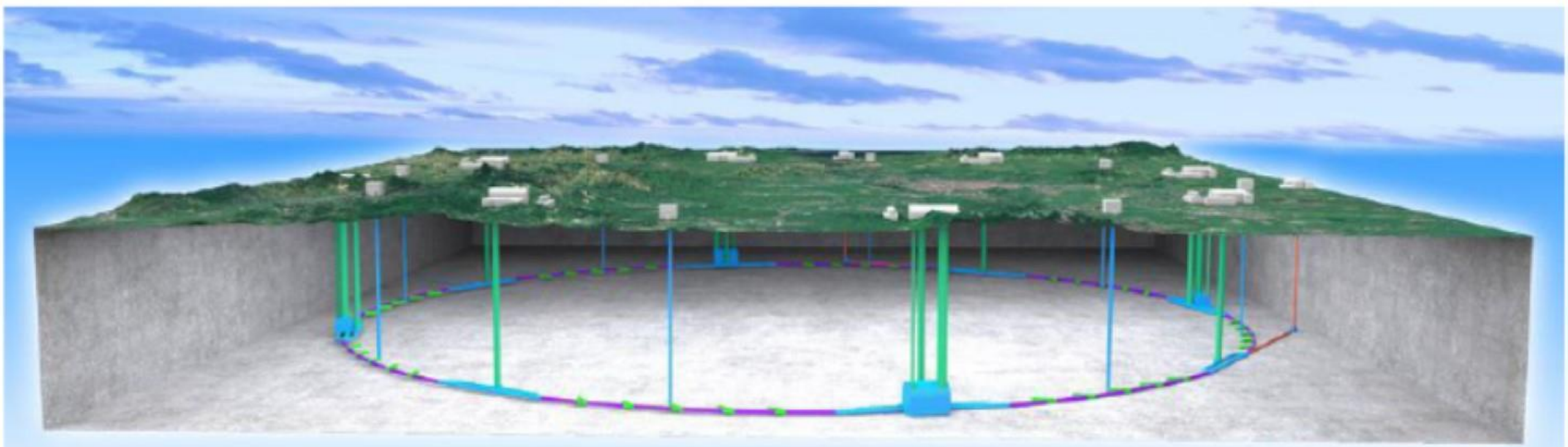


➔ Shin Michizono, this Wednesday

Chinese proposal for the future

CEPC：A Higgs Factory

- 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)



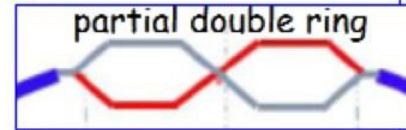
We had B-factories, c-factories, ϕ-factories, Z-factories in the past. It is very natural to think about Higgs factories

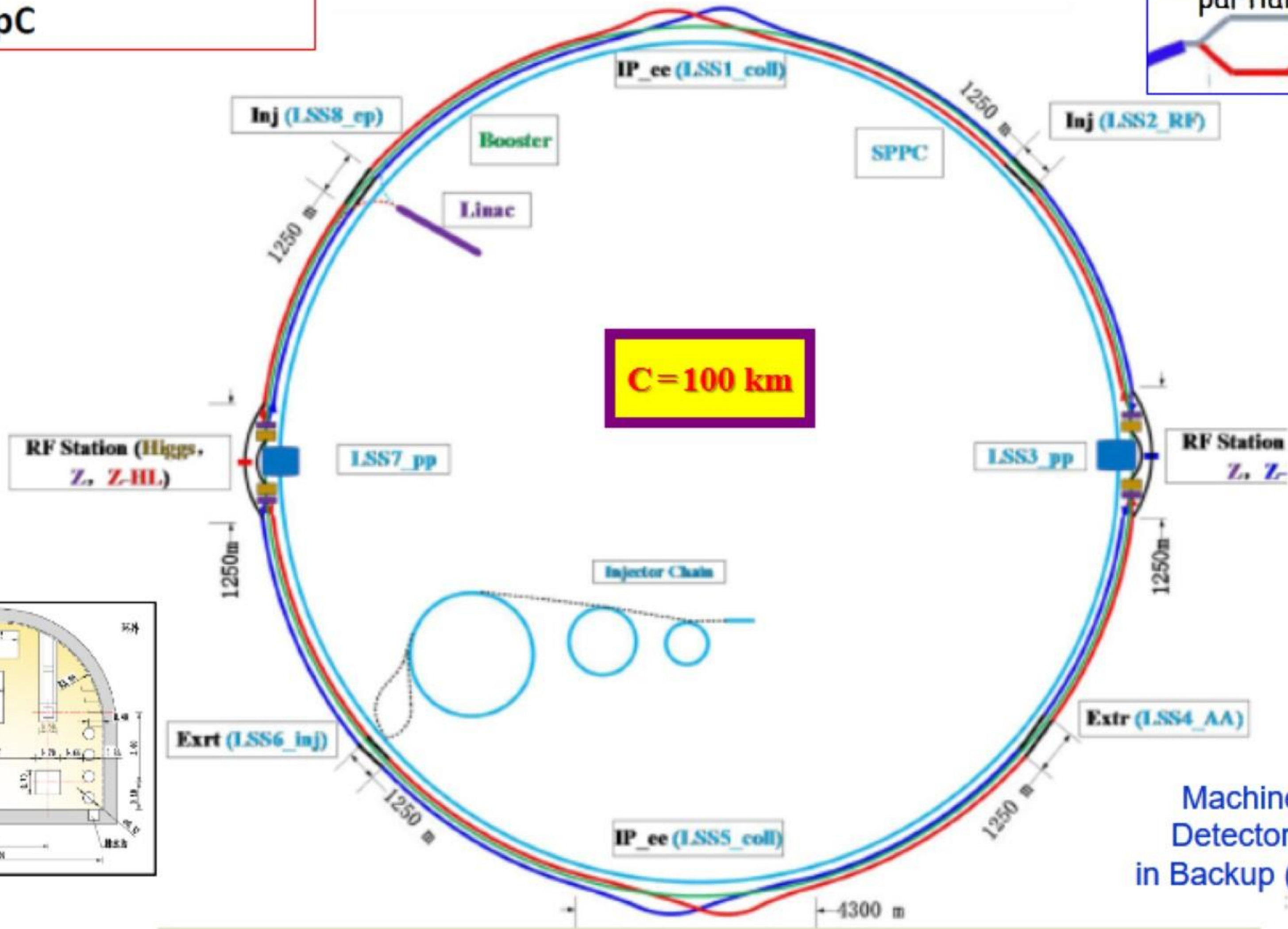
Yifang Wang, Pub. Lect. @ LP2017

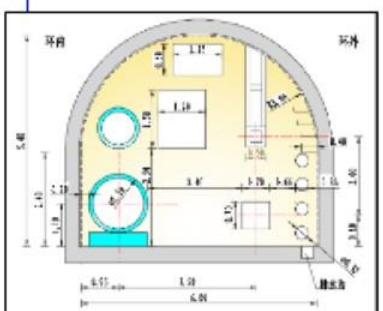
3 machines in one tunnel:
- CEPC & booster
- SppC

Layout of CEPC-SPPC

CDR 2017







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

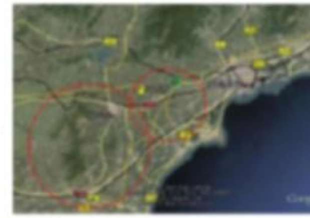
Layout and hardware satisfying both the Z and the H programs

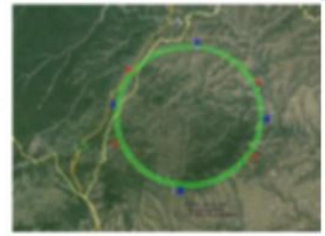
$L = 2\times10^{34} cm^{-2}s^{-1}$ (at E_{cm}=240 GeV)

$L = 1\times10^{34} cm^{-2}s^{-1}$ (at E_{cm}=91 GeV)

CEPC Site Exploration

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





1) QingHuangDao, Hebei（completed preCDR）

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

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

Xinchou Lou @ LP2017

Schedule (ideal)

seek approval, site decision
construction during 14th 5-year plan
commissioning

Missed 13-5 (HEPS) ➔ 14-5

SppC Design Scope (201701 version)

- **Baseline design**
  - Tunnel circumference: 100 km
  - Dipole magnet field: 12 T, iron-based HTS technology (IBS)

Top priority: reducing cost!
Instead of increasing field

Collaboration on HTS

"Applied High Temperature Superconductor Collaboration (AHTSC)" was formed in Oct. 2016. with >13 related institutes & companies and 50 scientists & engineers to advance HTS R&D and Industrialization.

HADRON ACCELERATOR

J-PARC in Japan

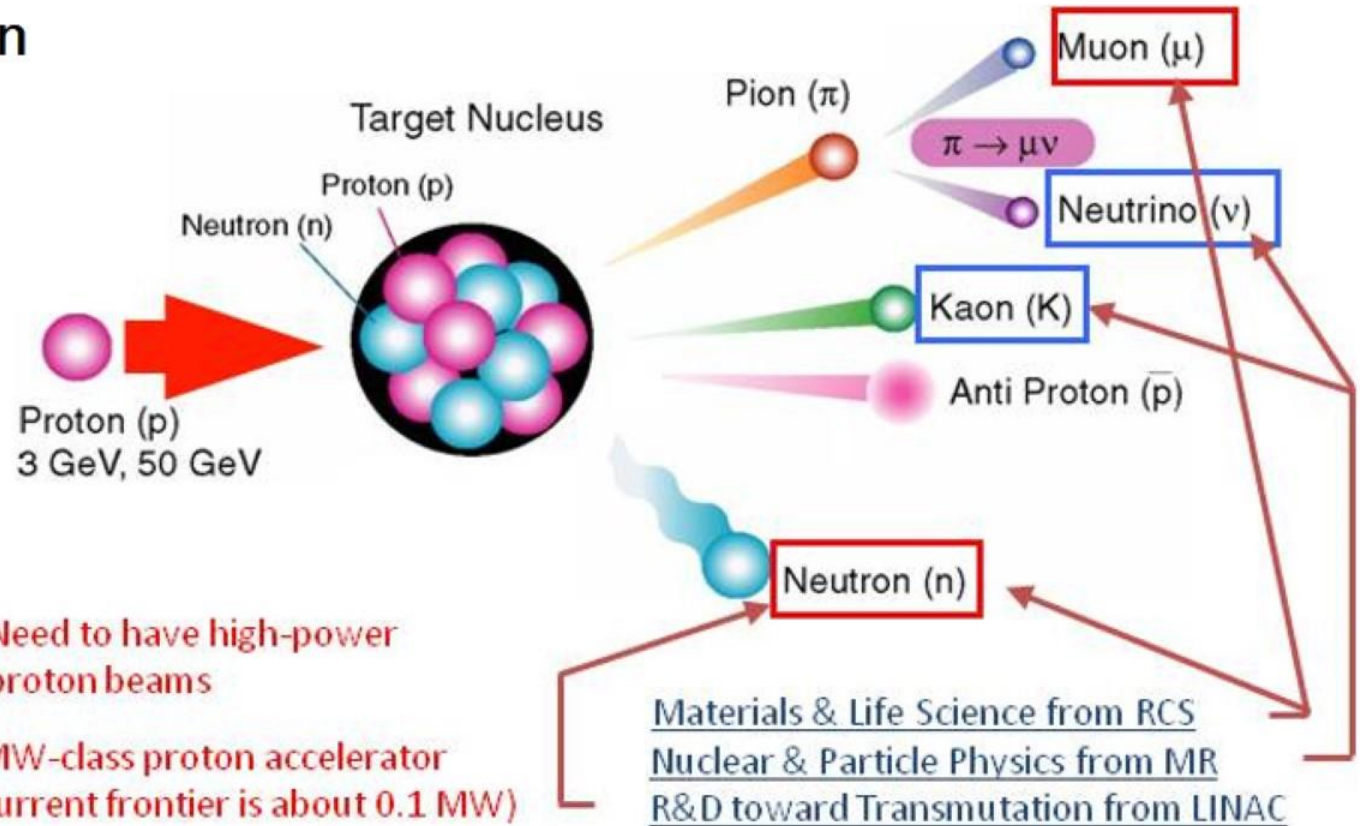
CSNS, Dongguan

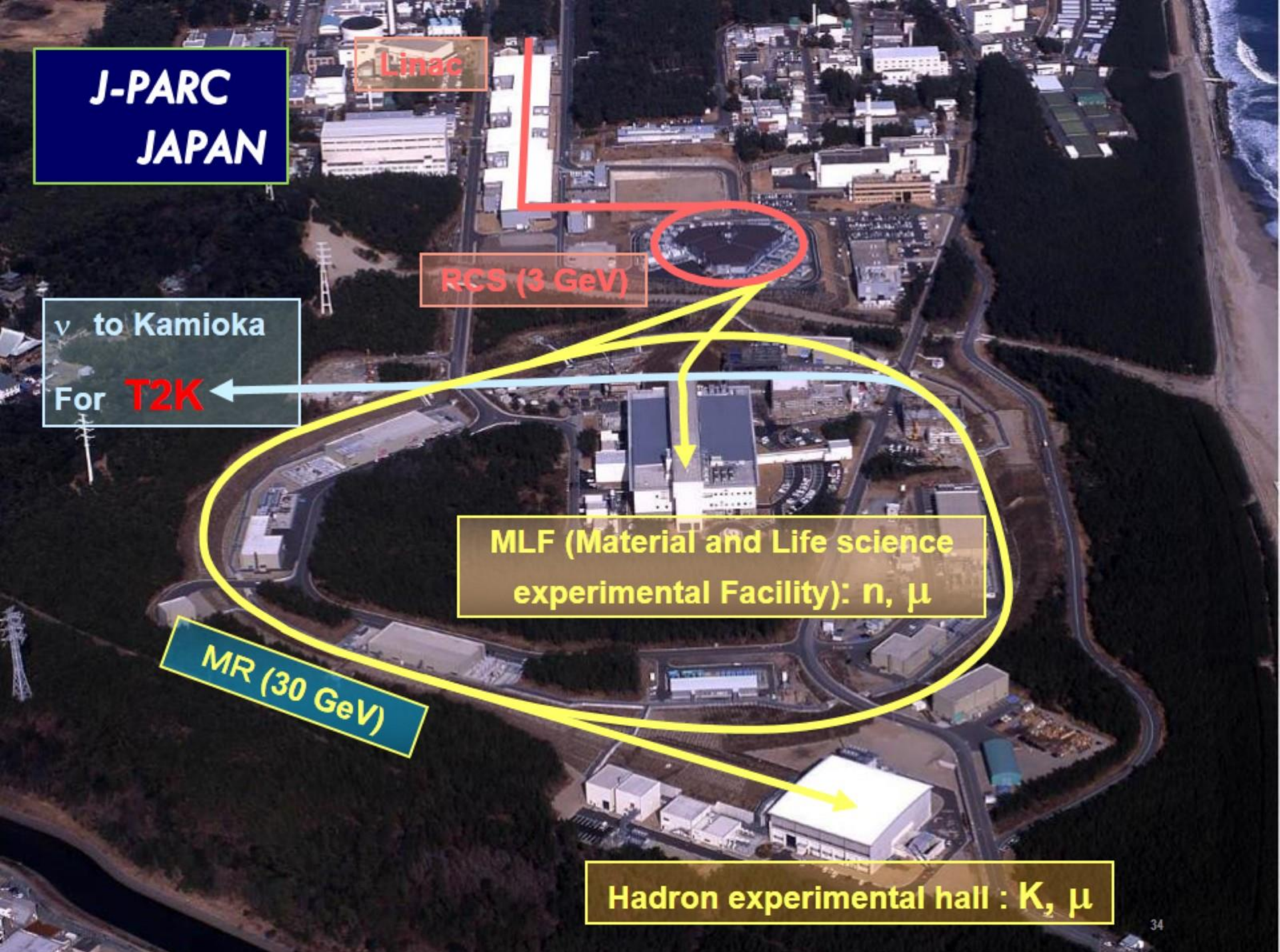
HIRFL, Lanzhou

in China

RISP, Daejeon

in Korea




J-PARC
JAPAN
Linac
RCS (3 GeV)
ν to Kamioka
For T2K
MLF (Material and Life science
experimental Facility): n, μ
MR (30 GeV)
Hadron experimental hall : K, μ

NEUTRINO PHYSICS AND KAMIOKA OBSERVATORY

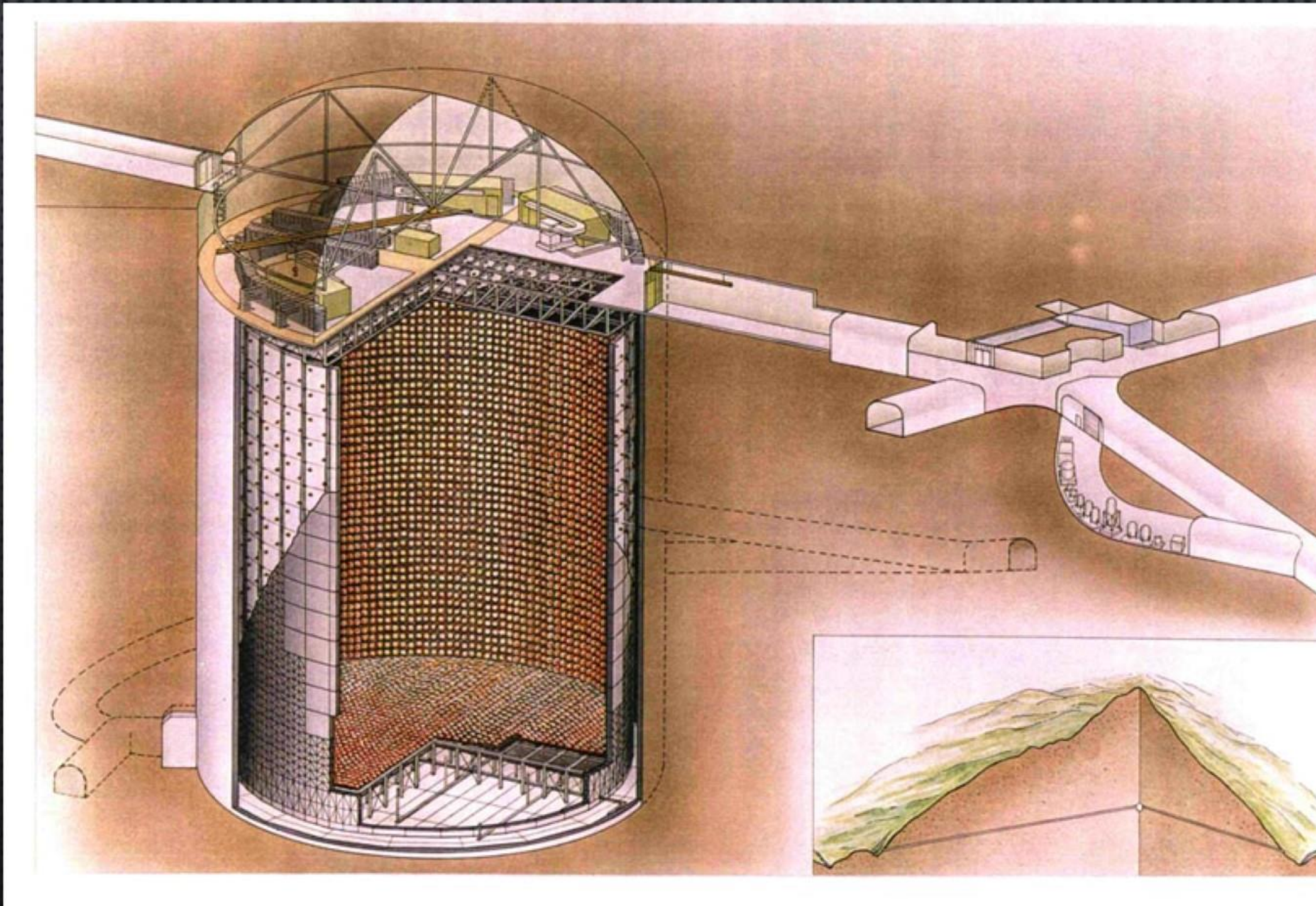
Opening ν astronomy, 2002,
M. Koshiba
<u>KAMIOKANDE</u>

Discovery of ν oscillation, 2015,
T. Kajita
<u>Super KAMIOKANDE</u>

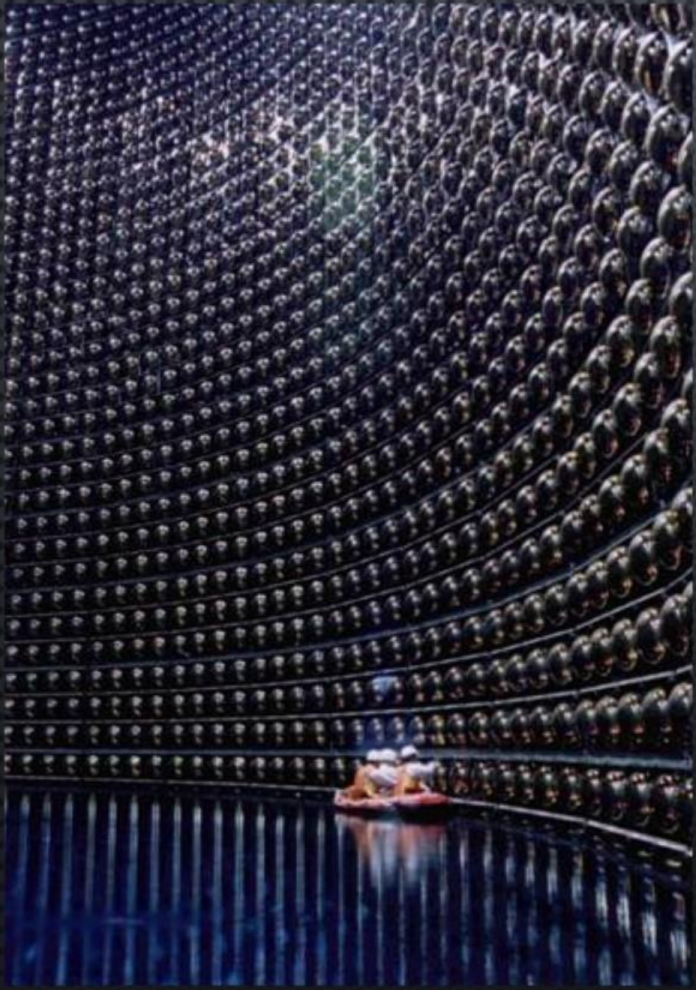
- Great progress in the past decades
- Still full of mysteries
  - First particle which exhibits property (non-zero mass) violating the expectation of Standard SM
  - Very small UNKNOWN mass for UNKNOWN reason
  - CP symmetry Unproven
  - Mixing btw generations is very large compared to quark mixing for UNKNOWN reason
  - Etc.

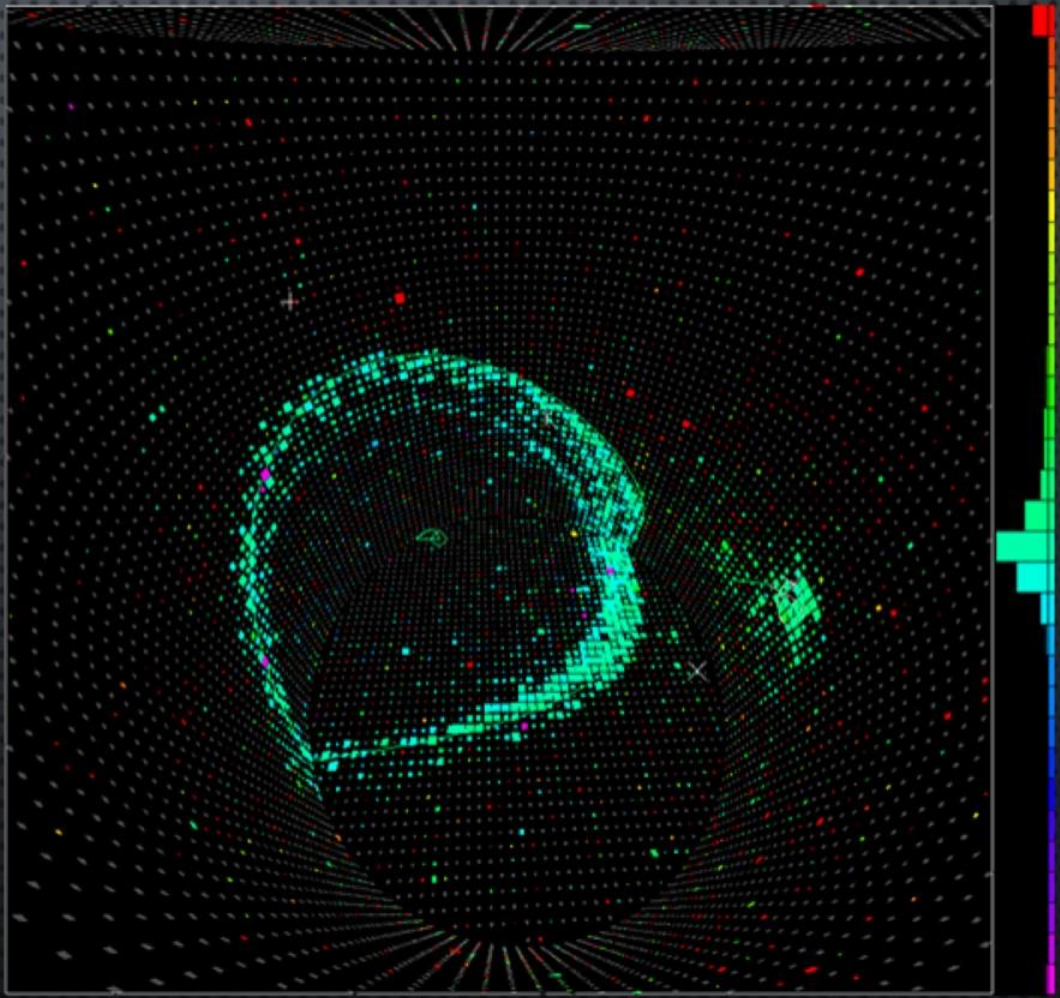
Lecture to be given for details by Oyama in the School

NEUTRINO DETECTION IN KAMIOKANDE



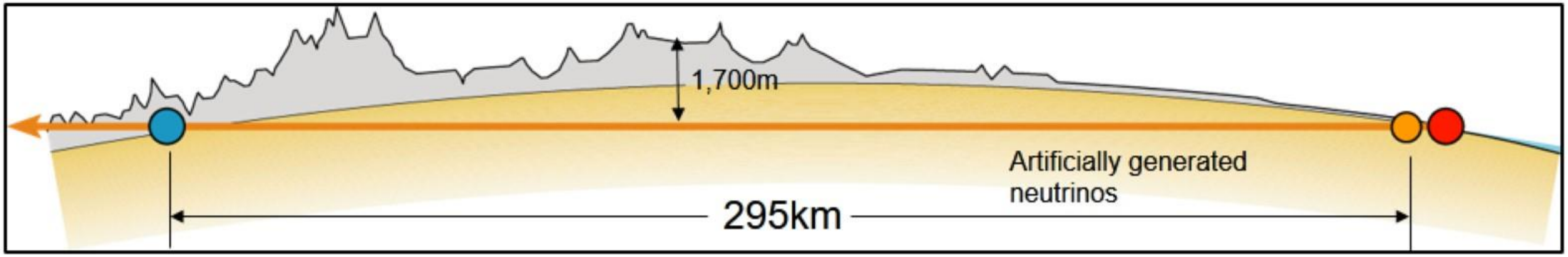
WATER CHERENKOV DETECTOR



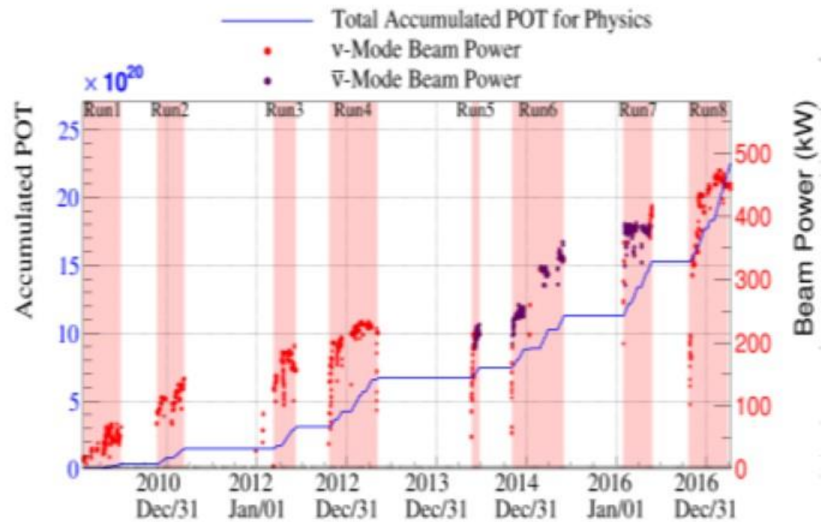


T2K (2010~)

0 m above sea level



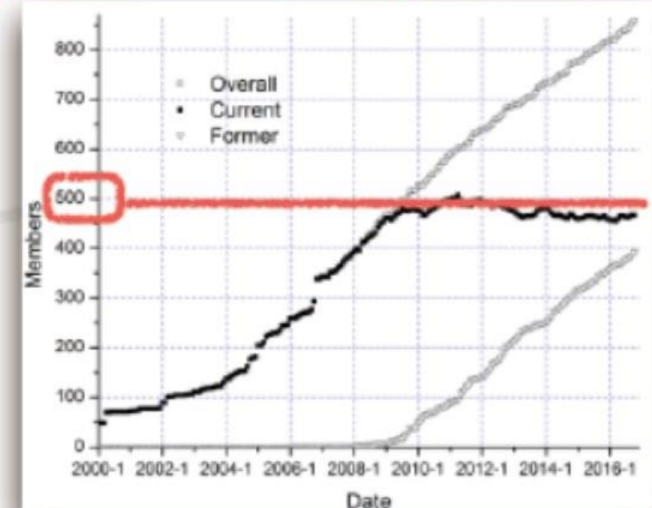
- High intensity ν_μ beam from J-PARC MR to Super-Kamiokande
- Evidence → Observation of $\nu_\mu \rightarrow \nu_e$ (2011-2013)
- Updated goals
  - Precise measurement of ν_e appearance
  - Precise meas. of ν_μ disappearance
  - → Measure CPV phase, contribution to mass hier. determ.



- 470kW stable operation achieved
- Accumulated POT: 22.5×10^{20}
  - ν-beam: 14.9×10^{20}
  - $\bar{\nu}$-beam: 7.6×10^{20}

The T2K Collaboration

~500 members, 63 Institutes, 11 countries

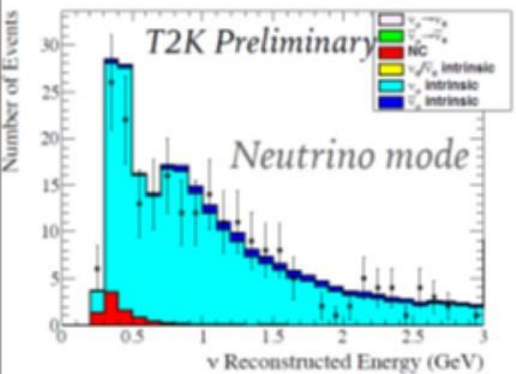


- Number of collaboration members: ~500, and steady
  - Two NEW institutions joined recently
    - Tokyo Institute of Technology
    - Tokyo University of Science
- Very active collaboration
  - 160 collaboration members at May 2017 Collaboration Meeting in Tokai, ~60 PhD students

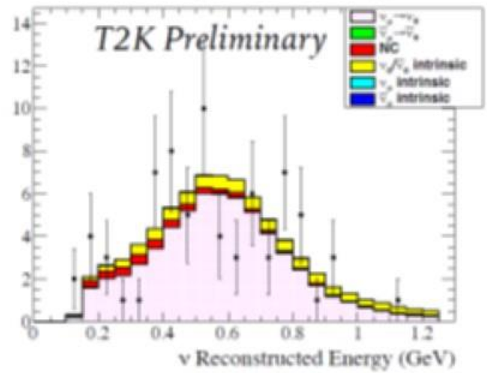
COMPLETED THESES		
	MSc/MSci	PhD
2008	6	0
2009	3	3
2010	12	7
2011	7	7
2012	9	18
2013	6	6
2014	4	11
2015		14
2016	9	16
2017 (SO FAR)	4	4

FITTED DATA DISTRIBUTIONS

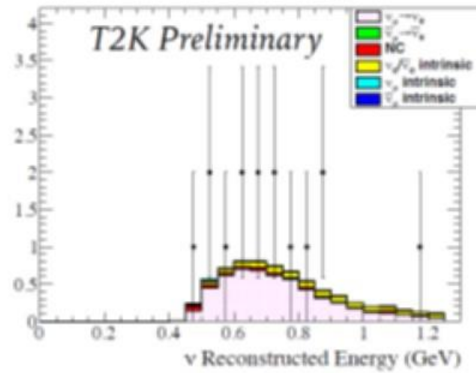
CCQE 1μ Ring



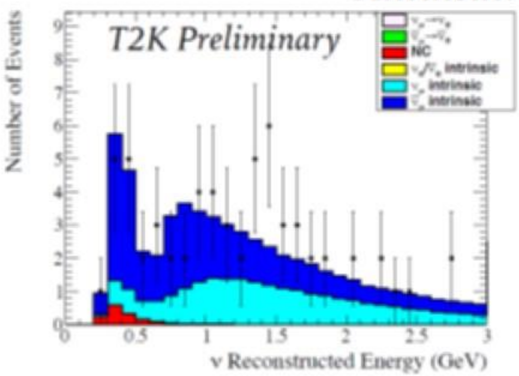
CCQE 1e Ring

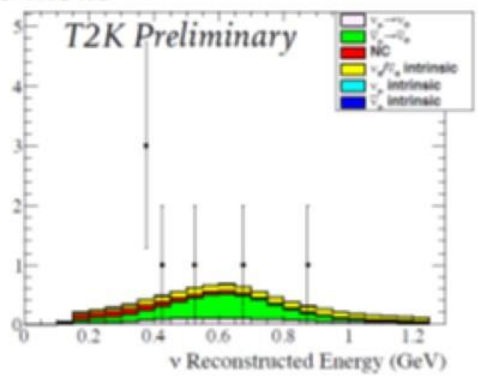


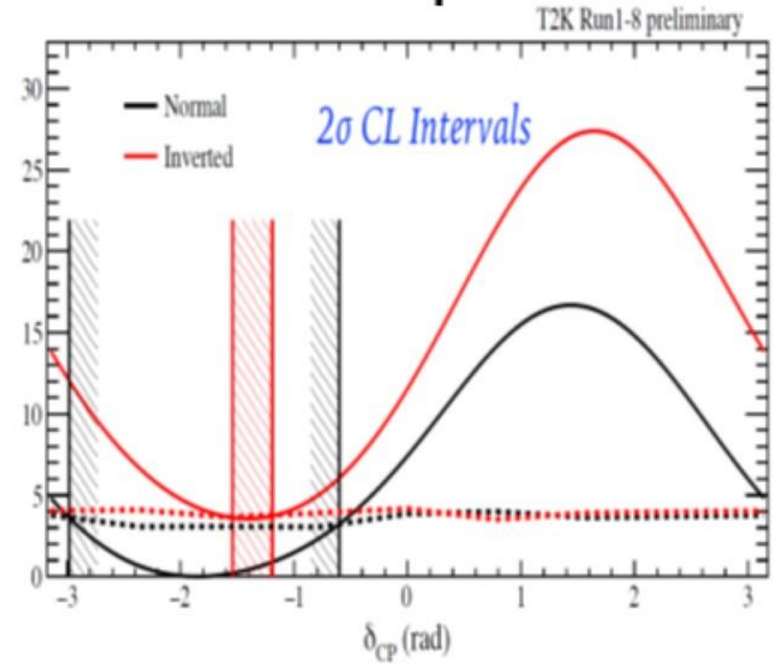
CC1π 1e Ring



Antineutrino mode

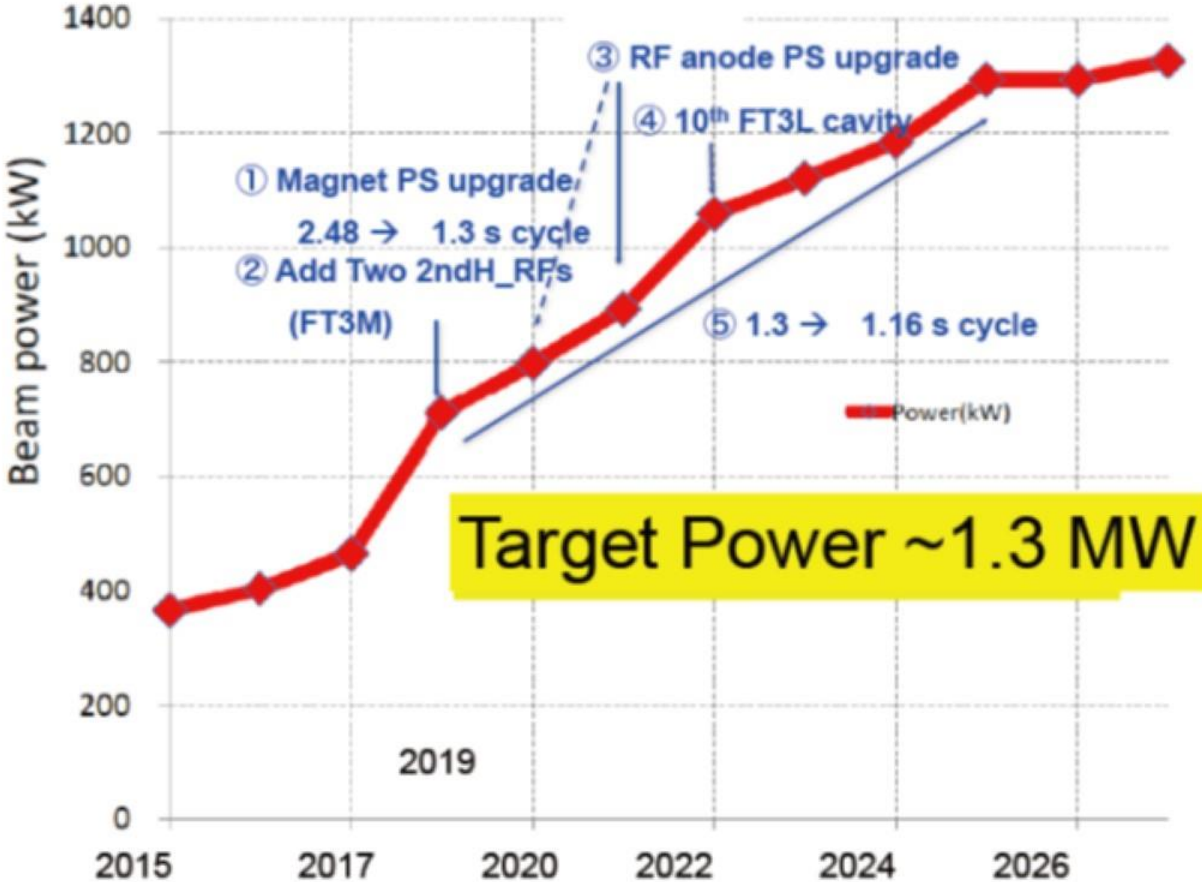






J-PARC MR POWER PROSPECT

Mid-term plan of MR upgrade for Neutrino



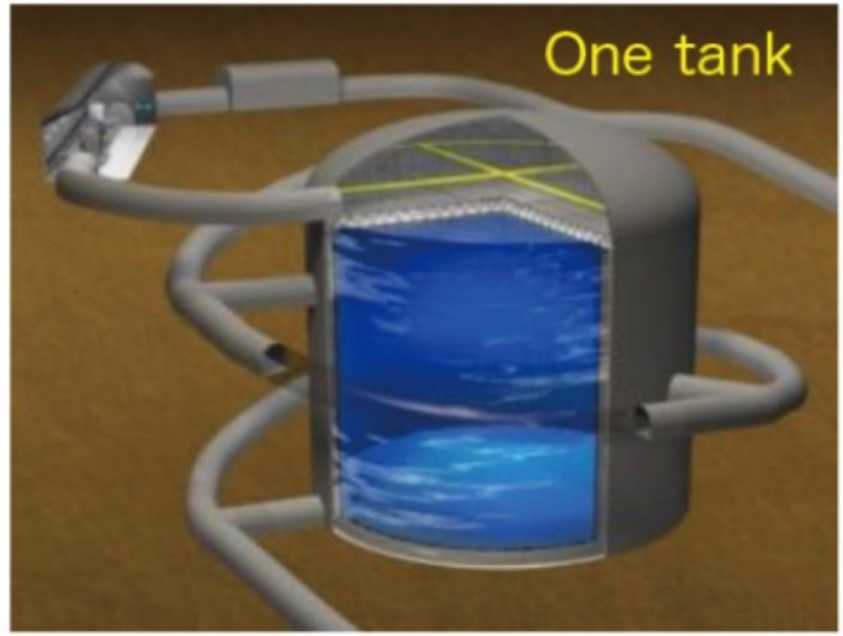
Hyper-Kamiokande (New Design)

http://www.hyperk.org


KEK Preprint 2016-21
ICRR-Report-701-2016-1

Hyper-Kamiokande

Design Report
(February 7, 2016)



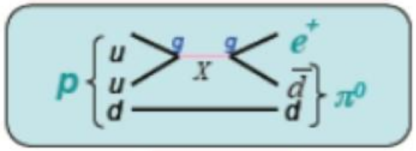
- 60m (high) × 74m (diameter)
- Total Volume: 260 kton.
- Fiducial Volume: 190 kton (∼ 10× Super-K).
- 40% PMT coverage.
- 40,000 50cm ID PMTs, 6,700 20cm OD PMTs.

- Improving the performance
  - A new PMT has x2 better Photon sensitivity
  - ~10 x Fiducial volume of Super-K
- A new design was reviewed and endorsed by the international advisory committee.

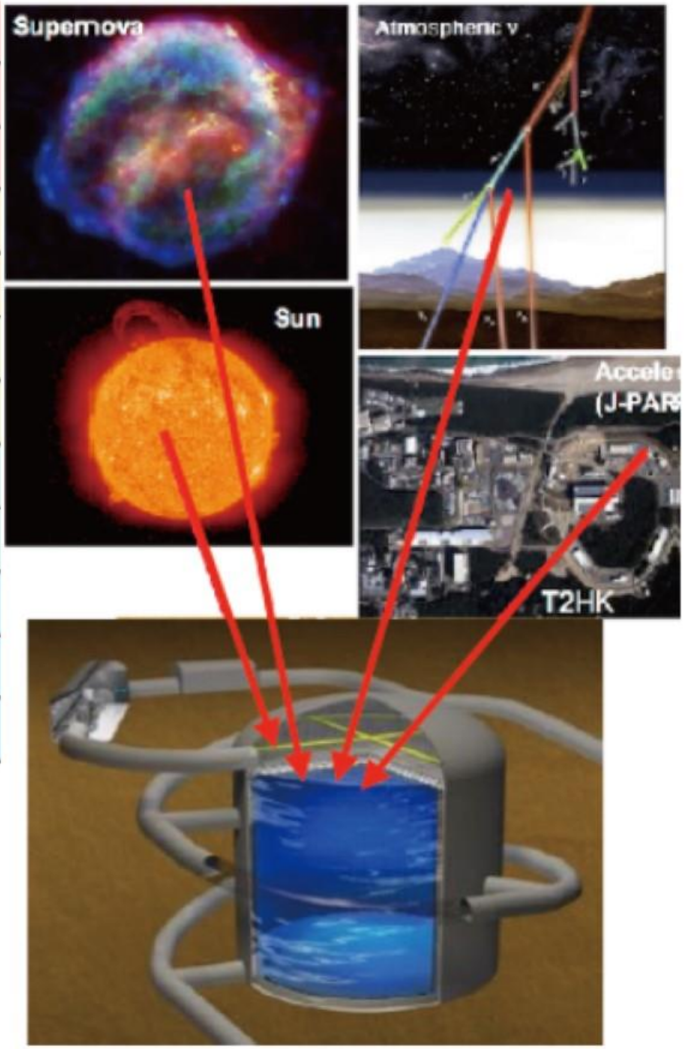
28

Rich Physics Program

LBL (13.5MWyr)	δ precision	7°-21°
	CPV coverage (3/5σ)	78%/62%
	$\sin^2\theta_{23}$ error (for 0.5)	±0.017
ATM+LBL (10 years)	MH determination	>5.3σ
	Octant ($\sin^2\theta_{23}$=0.45)	5.8σ
Proton Decay (10 years)	$e^+\pi^0$ 90%CL	1.2×10^{35}
	νK 90%CL	2.8×10^{34}
Solar (10 years)	Day/Night (from 0/from KL)	6σ/12σ
	Upturn	4.9σ
Supernova	Burst (10kpc)	104k-158k
	Nearby	2-20 events
	Relic (10 yrs)	98evt/4.8σ



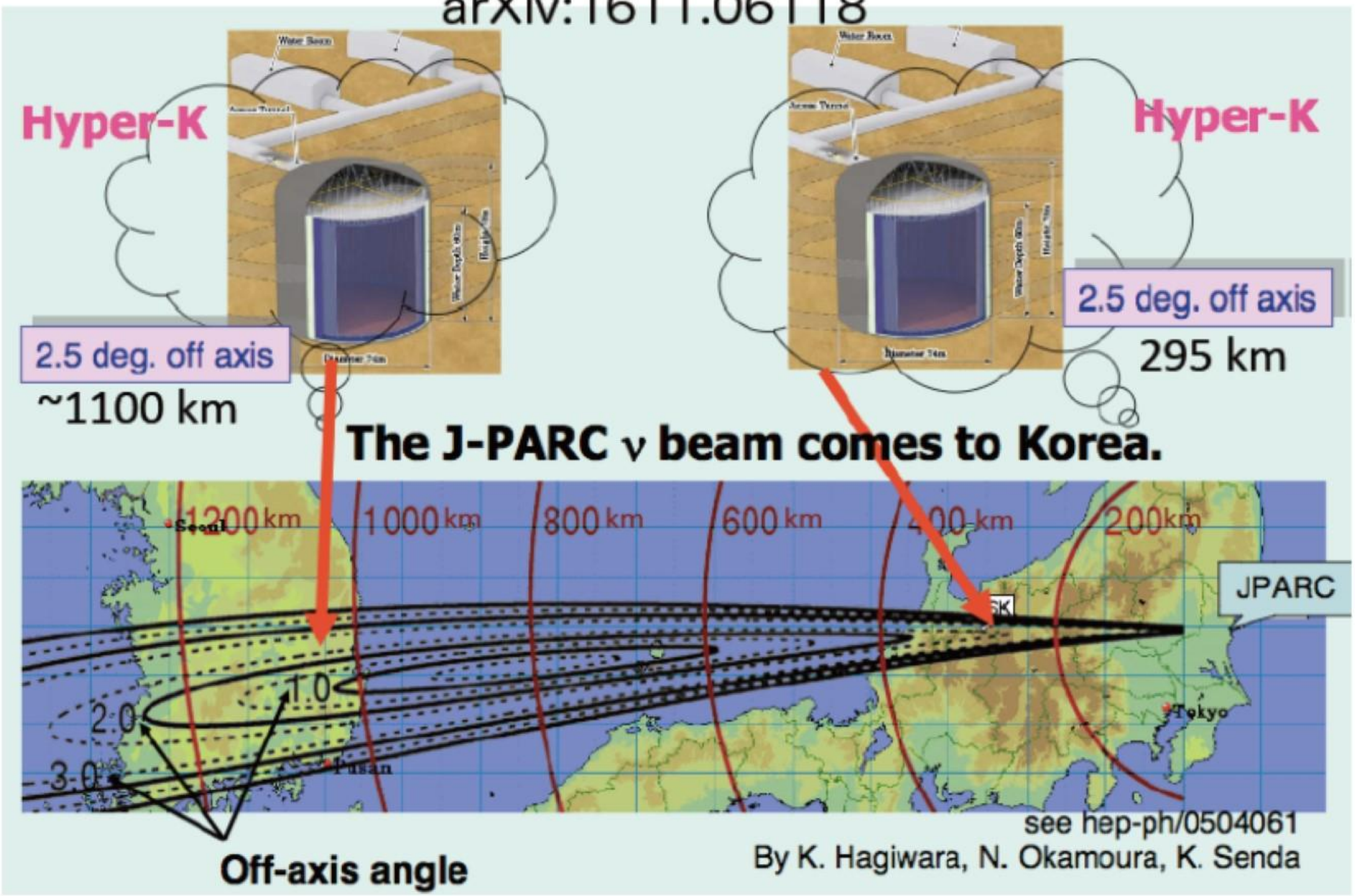
$p\rightarrow e^+\pi^0$



A beautiful option

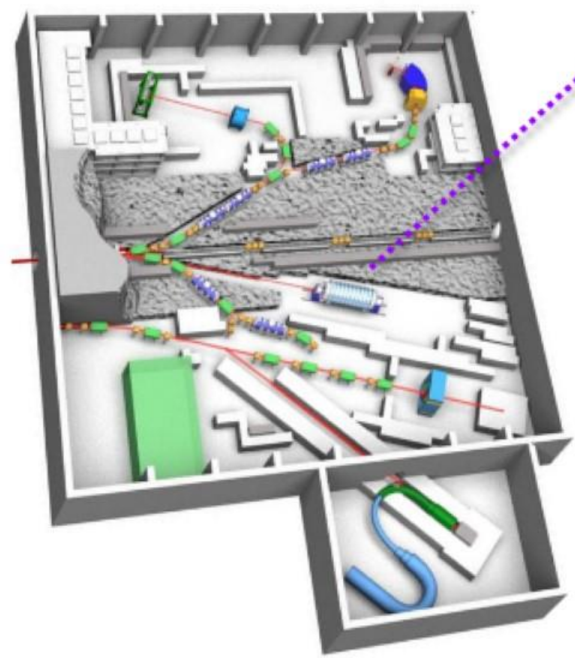
The 2nd Hyper-K Detector in Korea

arXiv:1611.06118

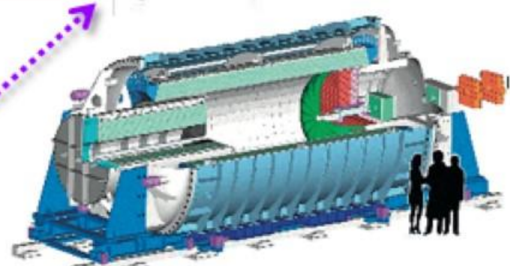


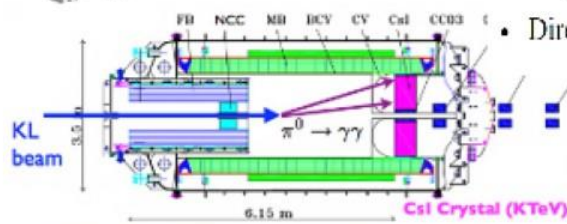
see hep-ph/0504061
By K. Hagiwara, N. Okamoura, K. Senda

J-PARC Hadron Facility

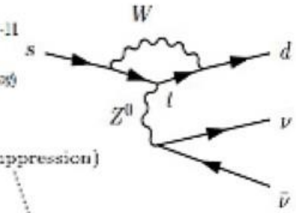


Rare Kaon Decay $K_L^0 \to \pi^0 \nu \bar{\nu}$



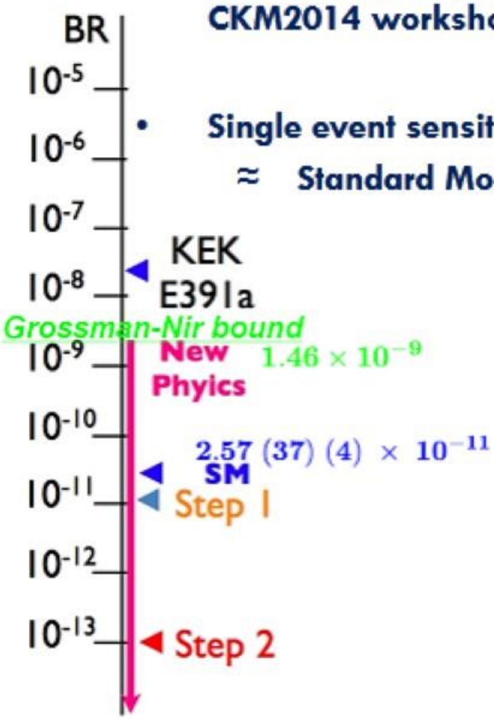


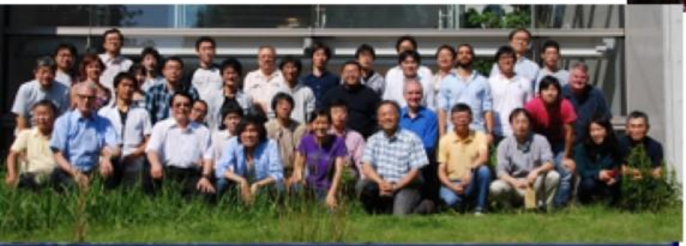
- Rare FCNC process Br(SM)=(2.4±0.4)x10-11
  - GIM suppression for u, c
  - Hierarchical structure of CKM for t quark
- Small theoretical uncertainty (~2%)
  - Short distance (W,Z,t)
  - Ke3 hadron matrix element from data
- Direct CP violation



Sensitive to new physics which break flavor structure and add new CP-violation

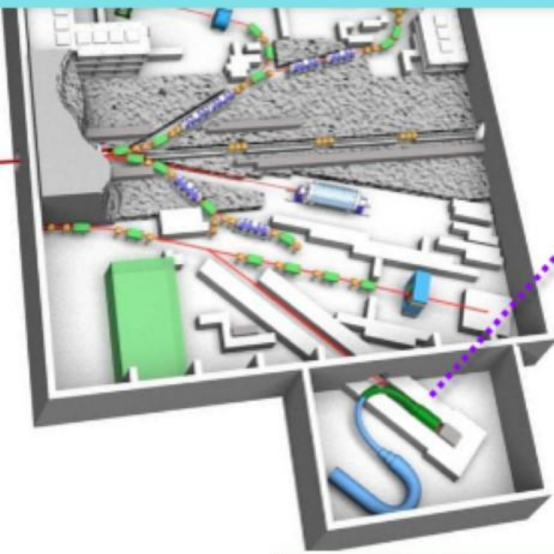
- **Started running in 2013, first results (preliminary) reported at the CKM2014 workshop in September.**
- **Single event sensitivity**
  ≈ Standard Model by 2018 run.

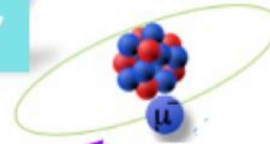




Korea	Japan	Russia	Taiwan	USA
Cheju 2	KEK 7	JINR 4	Nat. Taiwan 5	Arizona State 2
Chonbuk 1	Kyoto 9			Chicago 5
Kyungpook 2	Osaka 11			Michigan State 4
Pusan 3	Saga 6			
Soul 2	Yamagata 2			

J-PARC Hadron Facility





COMET:
COherent Muon to Electron Transition

- Lepton Flavour Violation
  - Forbidden in SM
    - Muon number +1 → 0
    - Electron number 0 → +1
  - Stunning Evidence BSM once observed (No SM background)

μ-e conversion

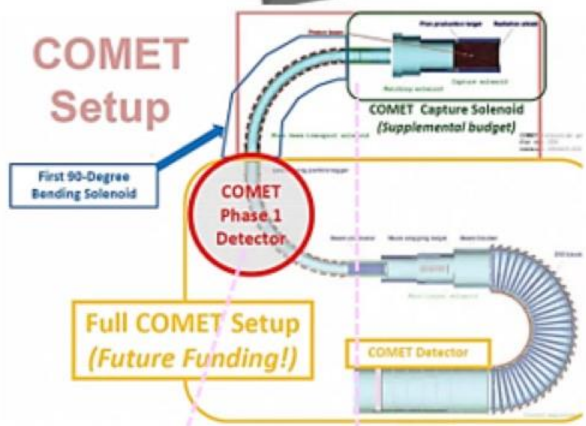
$$\mu^- + (A,Z) \rightarrow e^- + (A,Z)$$

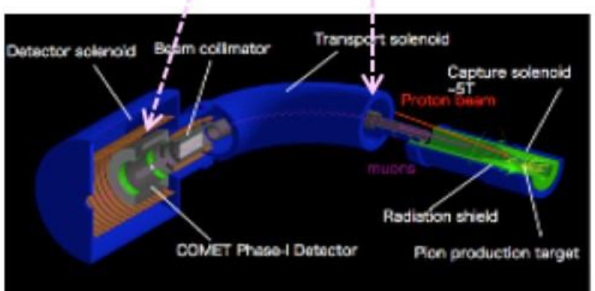
160 researchers from 32 institutes in 13 countries + 1 international institute

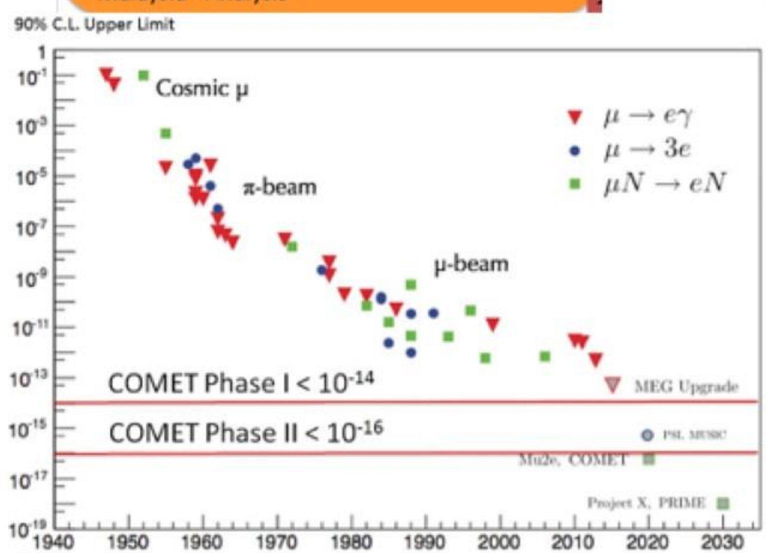
Major contributions from Asian countries

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

... and of course many from other countries !





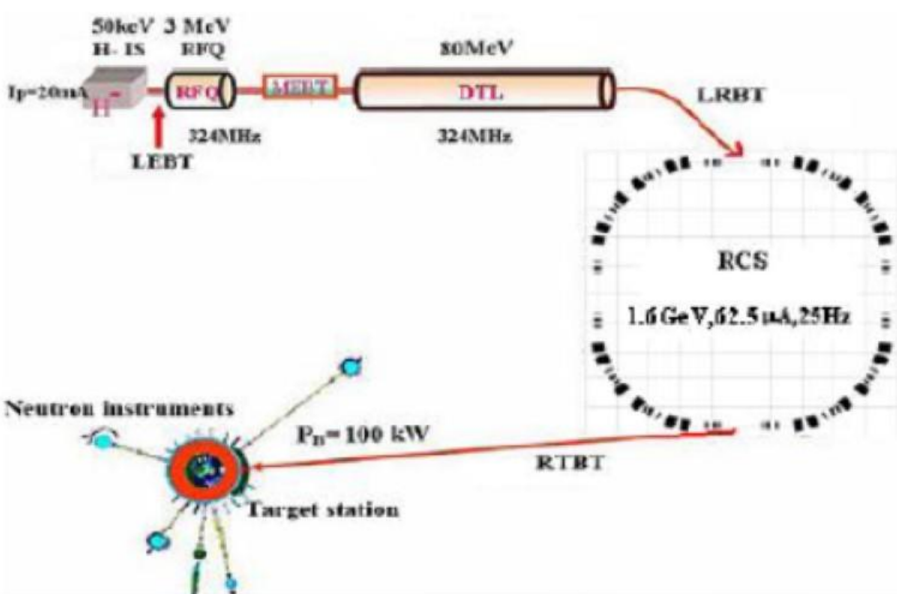


Facility construction

2016-2017

2021

China Spallation Neutron Source



Phase I: 100 kW Phase II: 500 kW

Start time: 2011

Completion time: 2017

Guangdong province

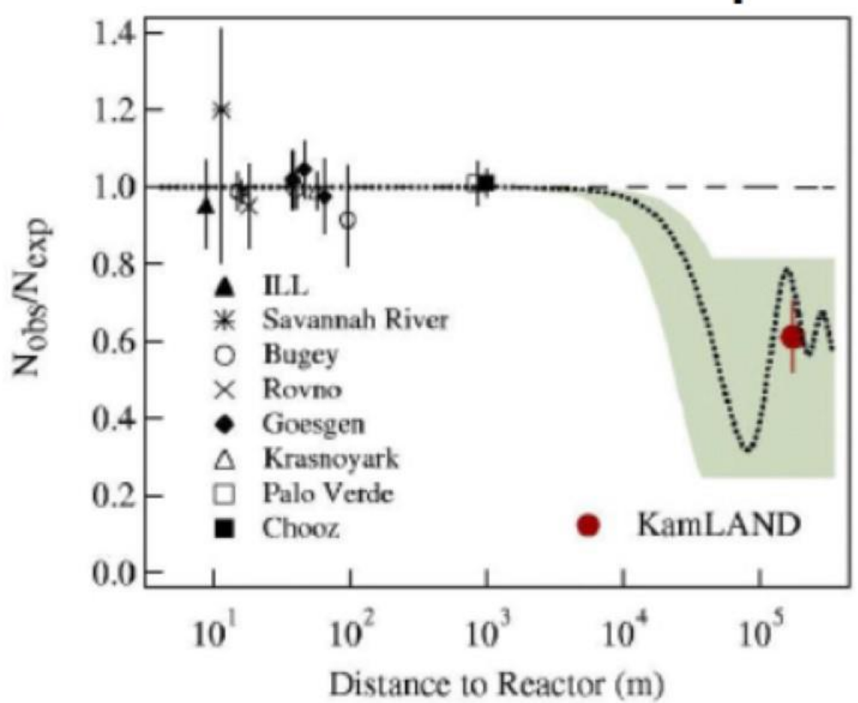
- Construction finished
- LINAC tested
- First neutron beam this week

NON ACEELERATOR PHYSICS

Another big success in Asia: Reactor Neutrino experiments

- Discovery of neutrino in 1956
- Small θ_{13} in 1990s
- limit on neutrino magnetic moment
- Observation of reactor $\overline{\nu_e}$ disappearance in 2003
- Discovery of non-zero θ_{13} in 2012
- Mass hierarchy and precision measurements
- Sterile neutrinos

KamLAND Japan



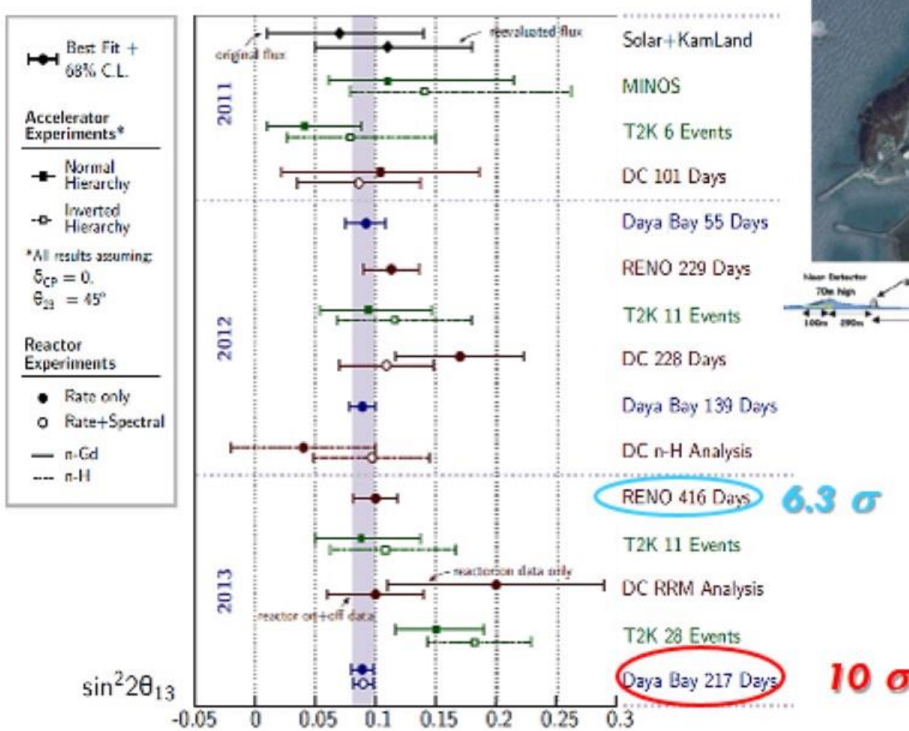
China

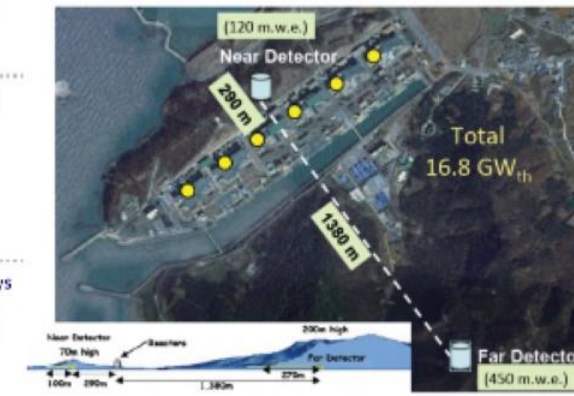
Korea

Daya Bay experiment

RENO

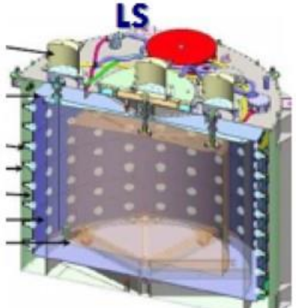
Global Comparison of θ_{13} Measurements

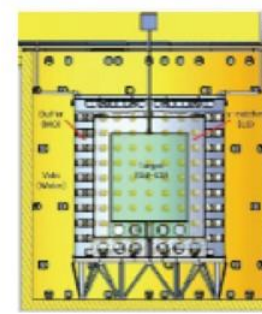




16.5 ton Gd-loaded LS

20 ton Gd-loaded LS

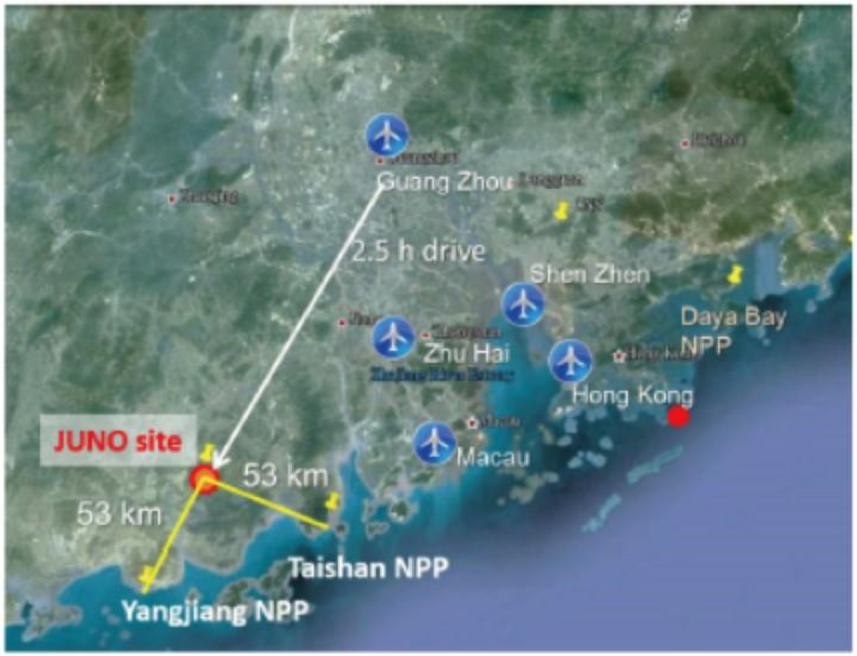


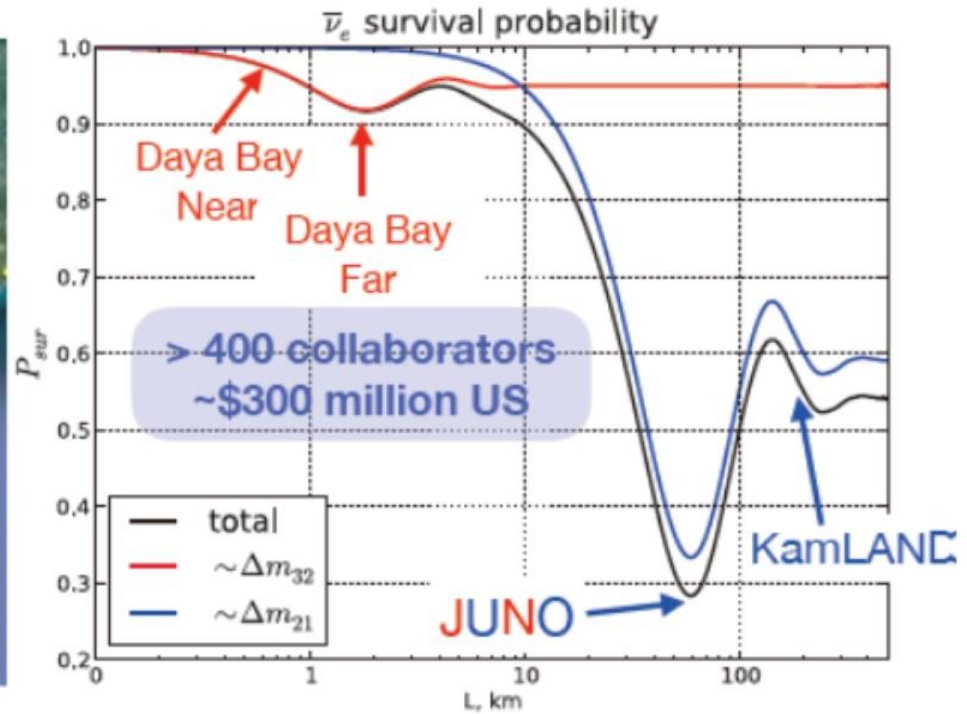


Next Chinese attempt

The JUNO Experiment

- There is also a major multipurpose reactor neutrino experiment being constructed in China: the Jiangmen Underground Neutrino Observatory (JUNO)
  - Baseline of 53km from two major power plants (10 reactors)





  - Given the larger baseline, the detector will have to be **MUCH** larger than the Daya Bay ones (roughly a factor of 100).

(Note: a similar proposal in Korea, RENO-50, has now been abandoned)

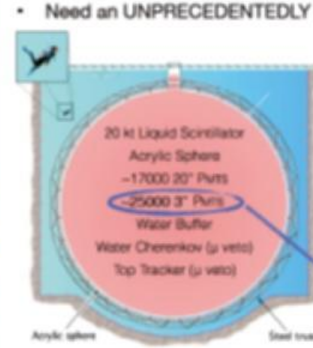
JUNO Schedule

2013	Complete conceptual design. Complete civil design and bidding
2014	Start civil construction. Complete prototyping (PMT & detector). International collaboration established
2015	PMT production line manufacturing
2016	Start PMT production. Start detector production or bidding
2017	Complete civil construction. Start detector construction and assembly
2018	Start LS production
2019	Complete detector assembly, installation and LS filling
2020	Start data taking

expect to run for over two decades

JUNO Detector

- Need an UNPRECEDENTEDLY LARGE & PRECISE detector:



	DETECTOR TARGET MASS	RESOLUTION
KamLAND	1000 t	$6\%/\sqrt{E}$
Double Chooz	8 t	$8\%/\sqrt{E}$
RENO	16 t	
Daya Bay	20 t	
Borexino	300 t	$5\%/\sqrt{E}$
JUNO	20000 t	$3\%/\sqrt{E}$

complementary to the large PMTs!

- Will also need highly transparent LS (> 22m attenuation length @ 430nm), photocathode coverage of > 75%, and a PMT quantum efficiency >35%.

0. 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

UNDERGROUND LABORATORY ASTROPARTICLE OBSERVATORY

ν INO

Grav. KAGRA

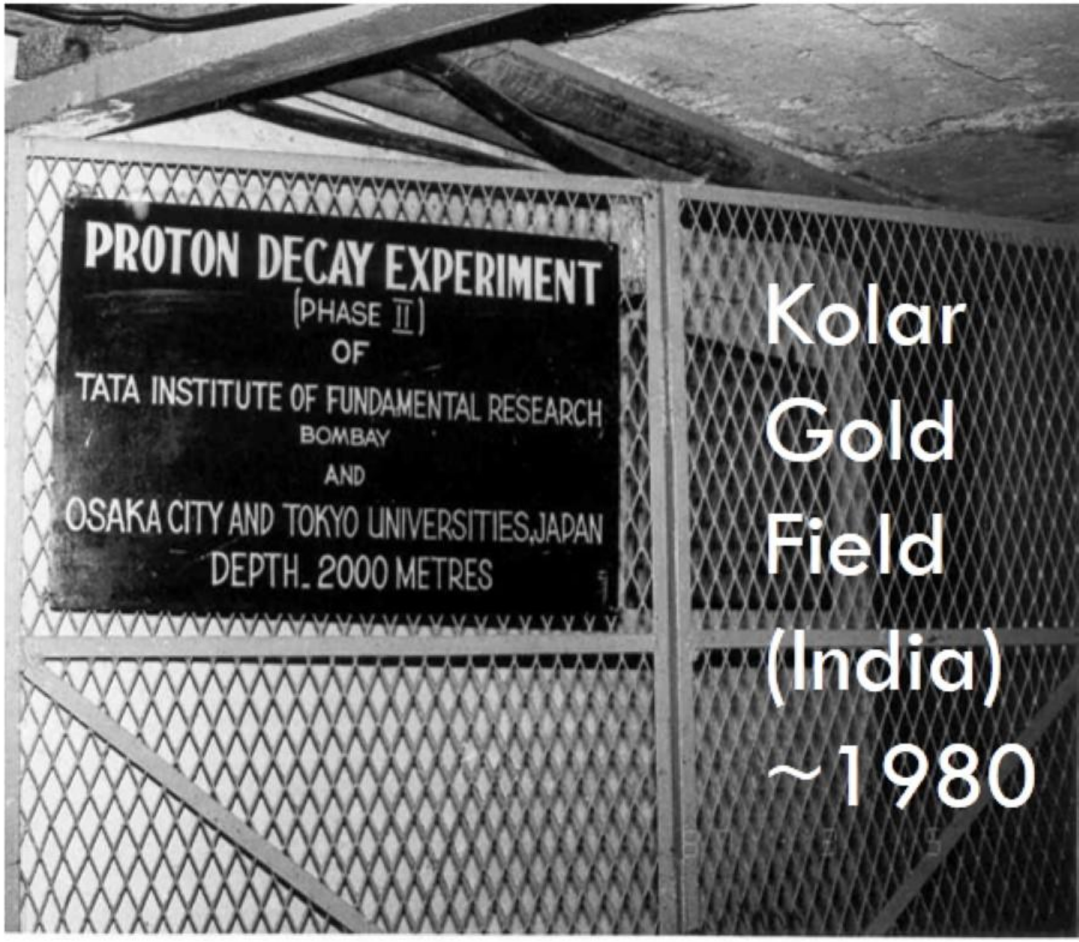
Indigo

DM PandaX

HE CR LHAASO

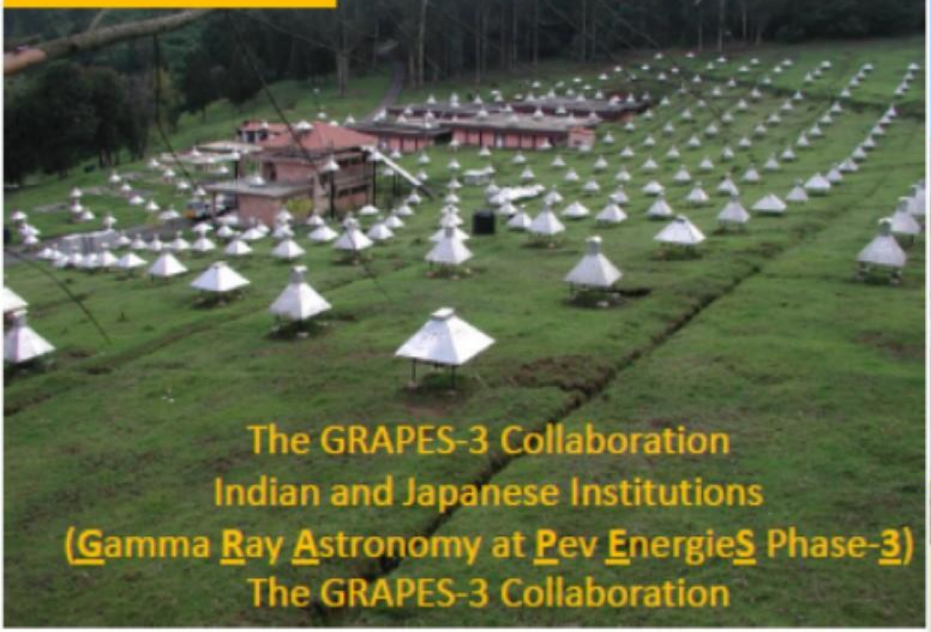
GRAPES-3

HAGAR



India

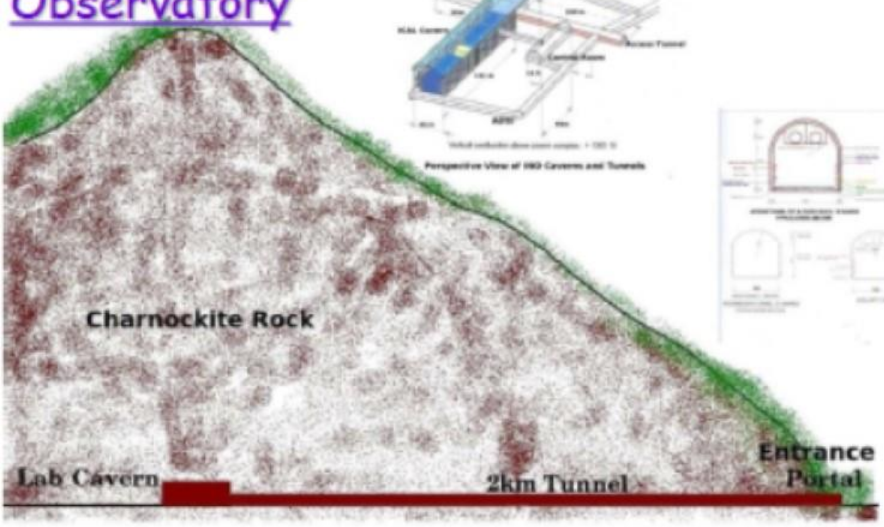
Non-accelerator based astro-particle physics



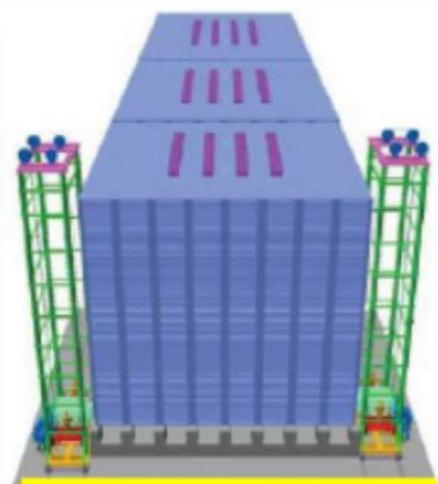
The GRAPES-3 Collaboration
Indian and Japanese Institutions
(**G**amma **R**ay **A**stronomy at **P**ev **E**nergie**S** Phase-**3**)
The GRAPES-3 Collaboration

High Altitude GAmma Ray (HAGAR) Telescope Array at 4250 m Altitude in Hanle, Ladakh
One of seven Telescopes (GeV-TeV-PeV γ ray)

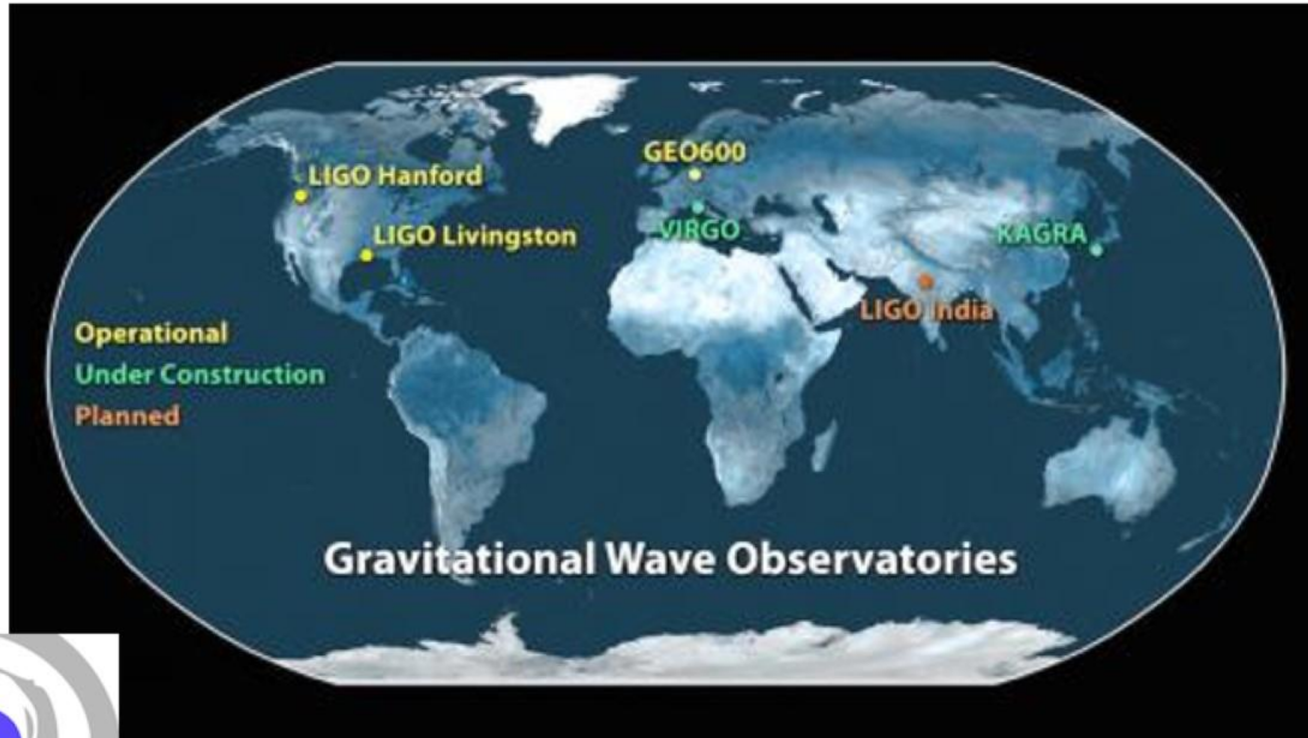
INO : India-based Neutrino Observatory



- Sanctioned by the Indian government.
- Total cost is a few hundred M€.
- Construction is about to begin.
- International collaboration are welcome.
- Other non-accelerator particle physics experiments are planned in the same cavern.



50 kton magnetized iron module(s) with 30,000 channel RPC



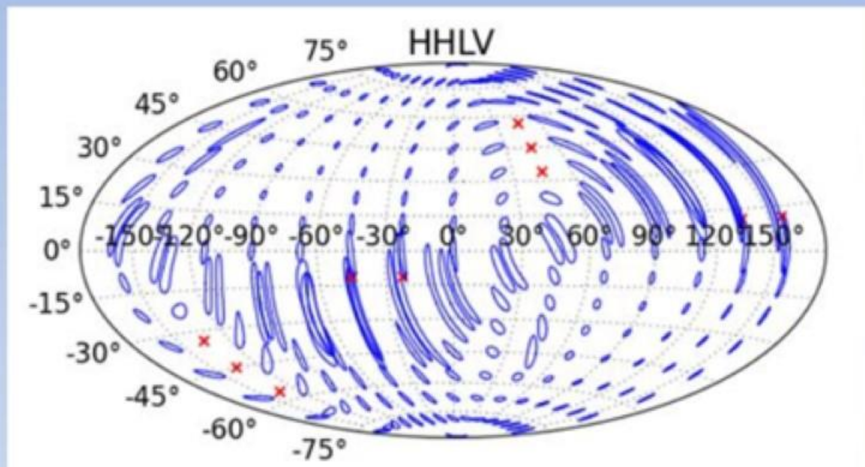
indigo

LIGO-India

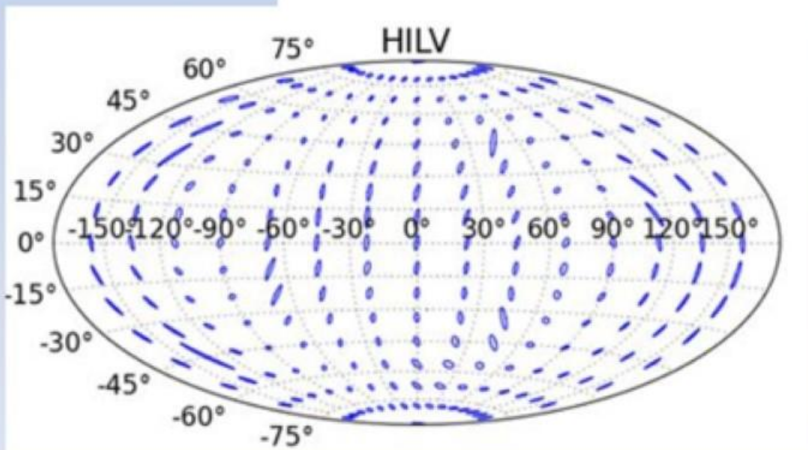
LIGO-India is a planned advanced gravitational-wave observatory to be located in India as part of the worldwide network. The project recently received the in-principle approval from the Indian government. LIGO-India is planned as a collaborative project between a consortium of Indian research institutions and the LIGO Laboratory in the USA, along with its international partners Australia, Germany and the UK.

Strategic Geographical relocation: science gain

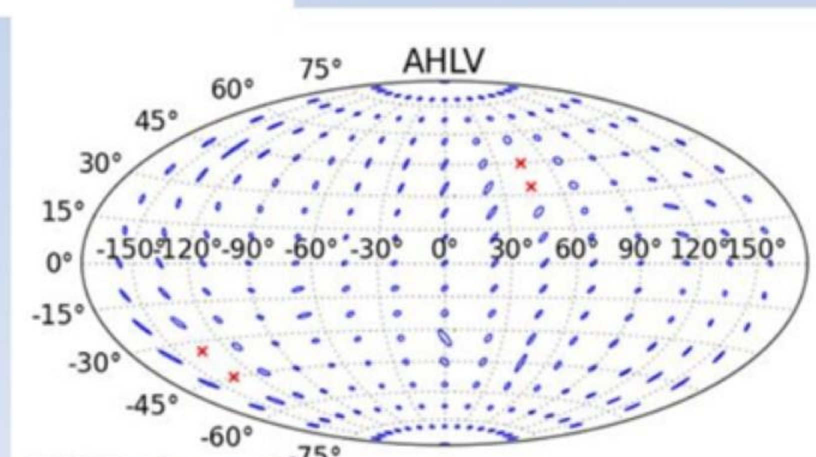
Source localization error



Original plan
2 +1 LIGO USA+ Virgo



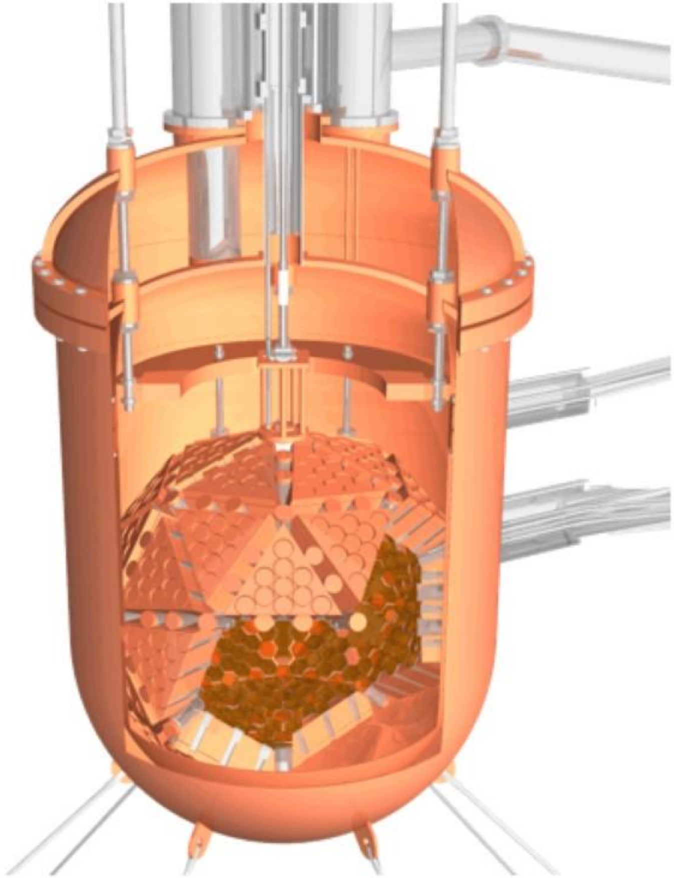
LIGO-India plan
1+1 LIGO USA+ Virgo+ LIGO India



LIGO-Aus plan
1+1 LIGO USA+ Virgo+ LIGO Aus

Underground Project in Japan

Kamioka Underground Facility



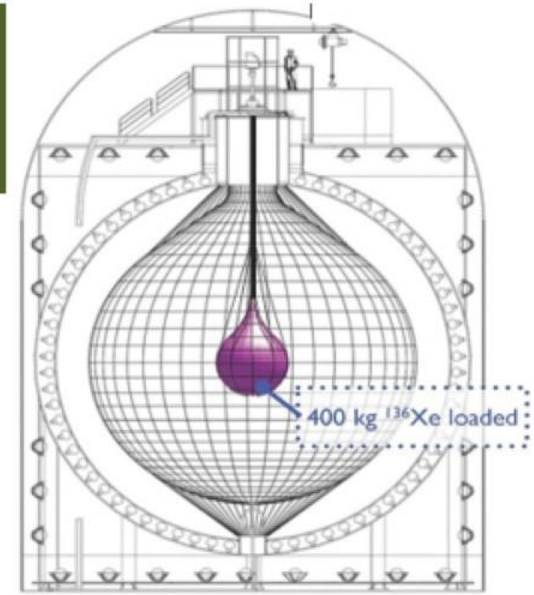
XMASS

Single phase liq. Xe detector

Dark Matter Search

KamLAND-Zen

ββ-Decay Search

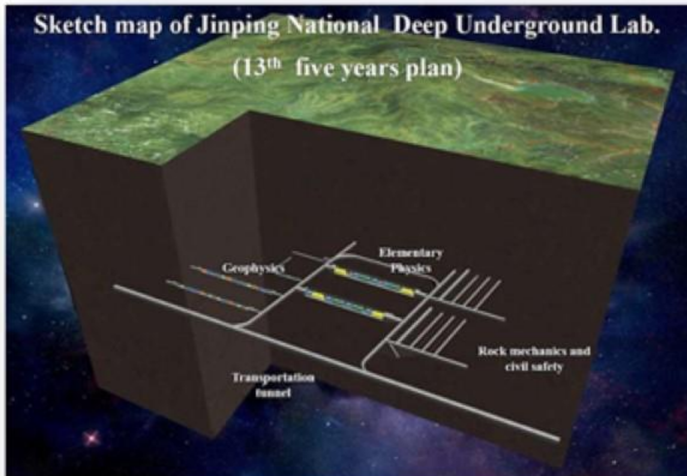


KAGRA

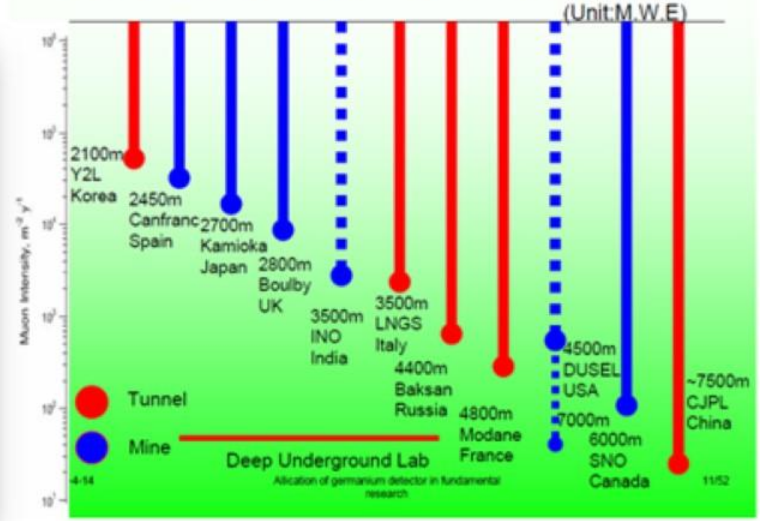
Gravitational wave

Underground Project in China

Jinping underground lab. of Tsinghua Univ. (2500m rock overburden)



Comparison of main ULs in the world



The main hall of CJPL in June 2010

Internal space use

PandaX : Particle AND Astrophysical Xenon TPC

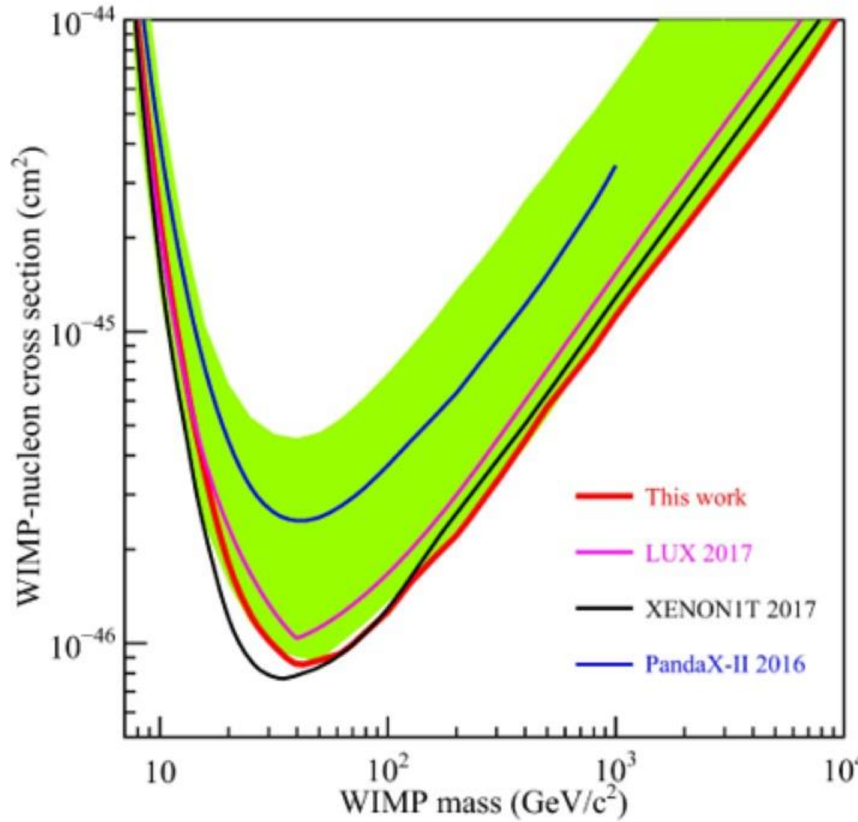
CDEX : China Dark matter EXperiment

PandaX = Particle and Astrophysical Xenon Experiments

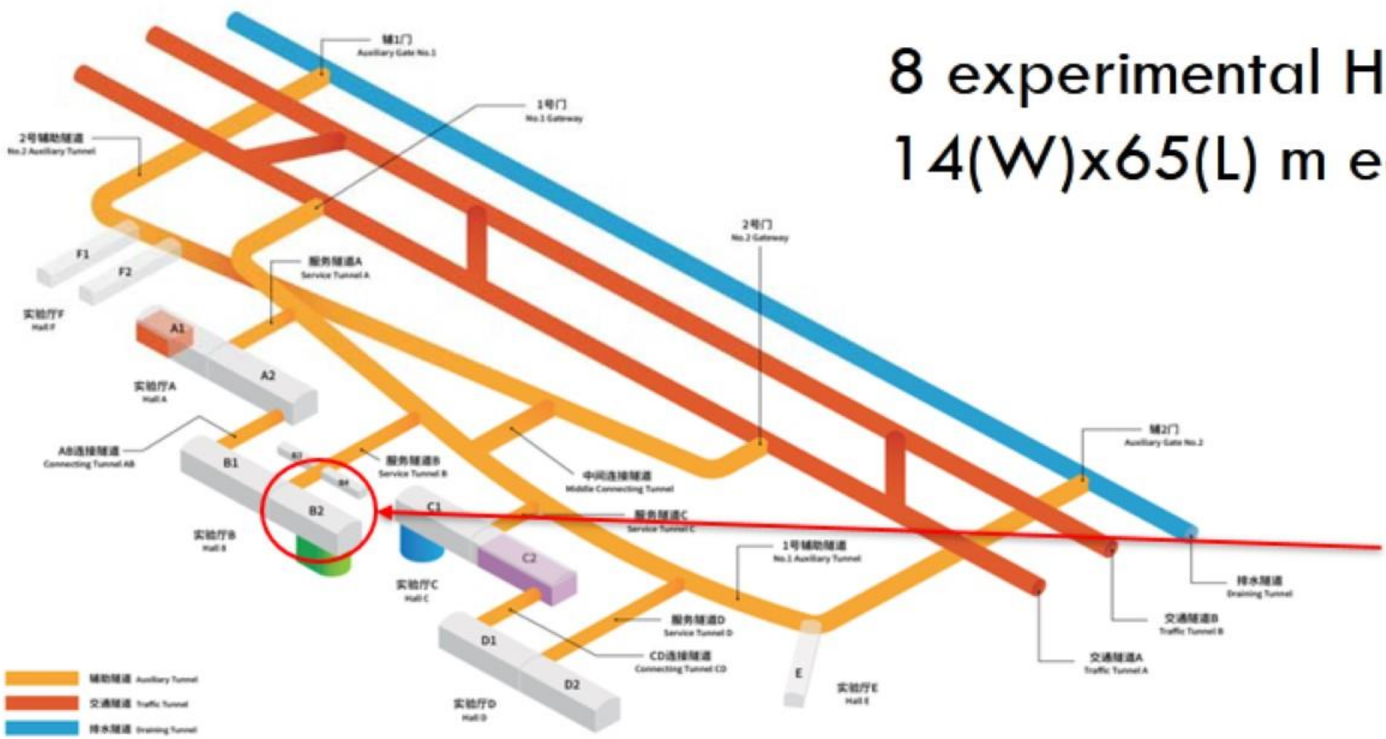
arXiv:1708.06917, submitted to PRL

Phase I:
120 kg DM
2009-2014

Phase II:
500 kg DM
2014-2018



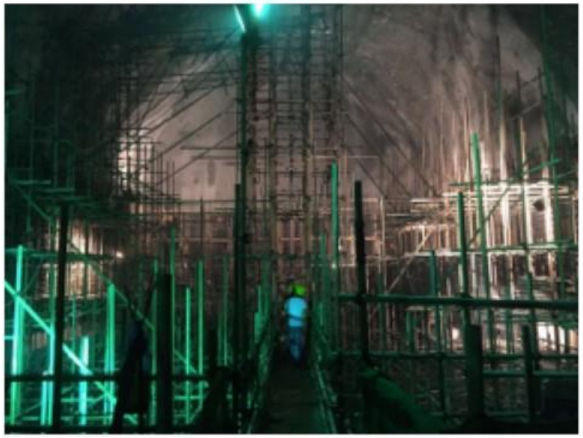
PANDAX NEW HOME: CJPL-II



8 experimental Halls, 14(H)x 14(W)x65(L) m each.

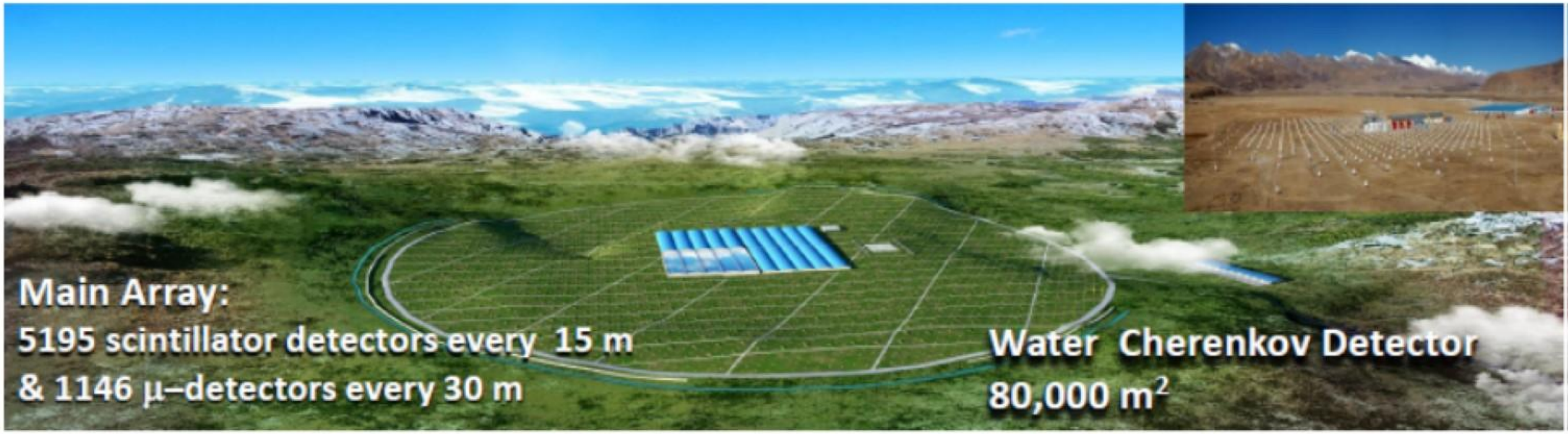
B2, PandaX site!

EXPERIMENTAL HALL



China

From ASγ/ARGO to LHAASO



Summary

- Particle Physics in Asia is very 

and exciting.
- Rich physics projects are going forward.
- Go west (beyond Pacific ocean) and join us.