2013 DPF UC SANTA CRUZ

Meeting of the American Physical Society(APS) Division of Particles and Fields(DPF)
August 13 - August 17, 2013
Hosted by the Santa Cruz Institute for Particle Physics (SCIPP)

Particle Physics Projects in Asia

Atsuto Suzuki

INTER-UNIVERSITY RESEARCH INSTITUTE CORPORATION
HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION

Outline

1. Projects in Japan
   - Particle Physics Strategy
   - Intensity Frontier
     SuperKEKB/BELLE-II, J-PARC/T2K, KOTO, COMET
   - Energy Frontier: ILC
   - Underground Physics at Kamioka

2. Projects in China
   - Accelerator-based
   - Reactor-based
   - Project-list outside China

3. Projects in Korea
   - Accelerators
   - Reactor-based
   - Underground Physics

4. Projects in India
   - Underground Physics
   - ILC Activity

5. Summary

1. Projects in Japan

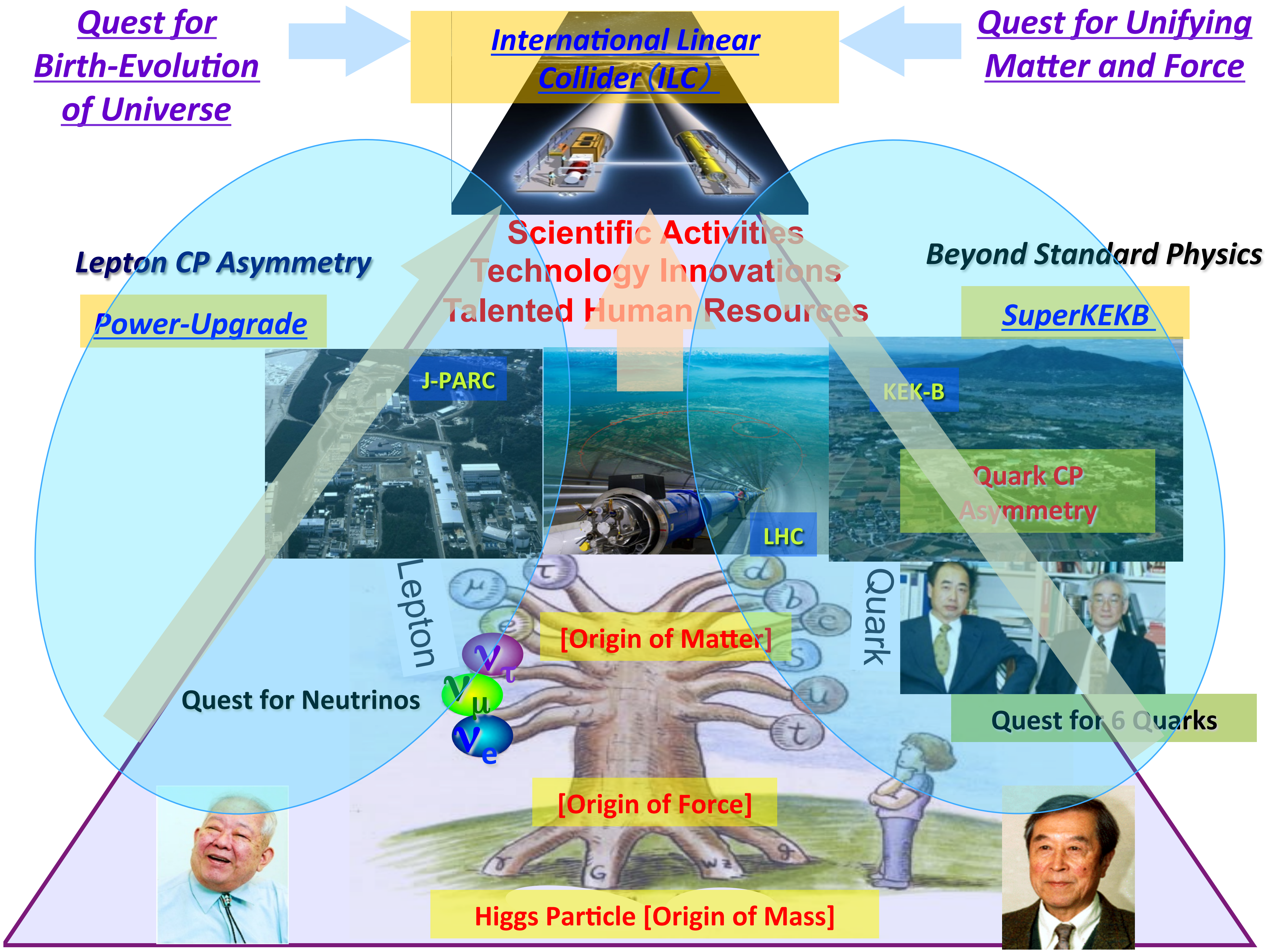
- Particle Physics Strategy

2008 - 2012 Roadmap

Dr. S. Ozaki
(BNL)

Dr. H. Weerts
(ANL)

After 2013 – 2017 Roadmap

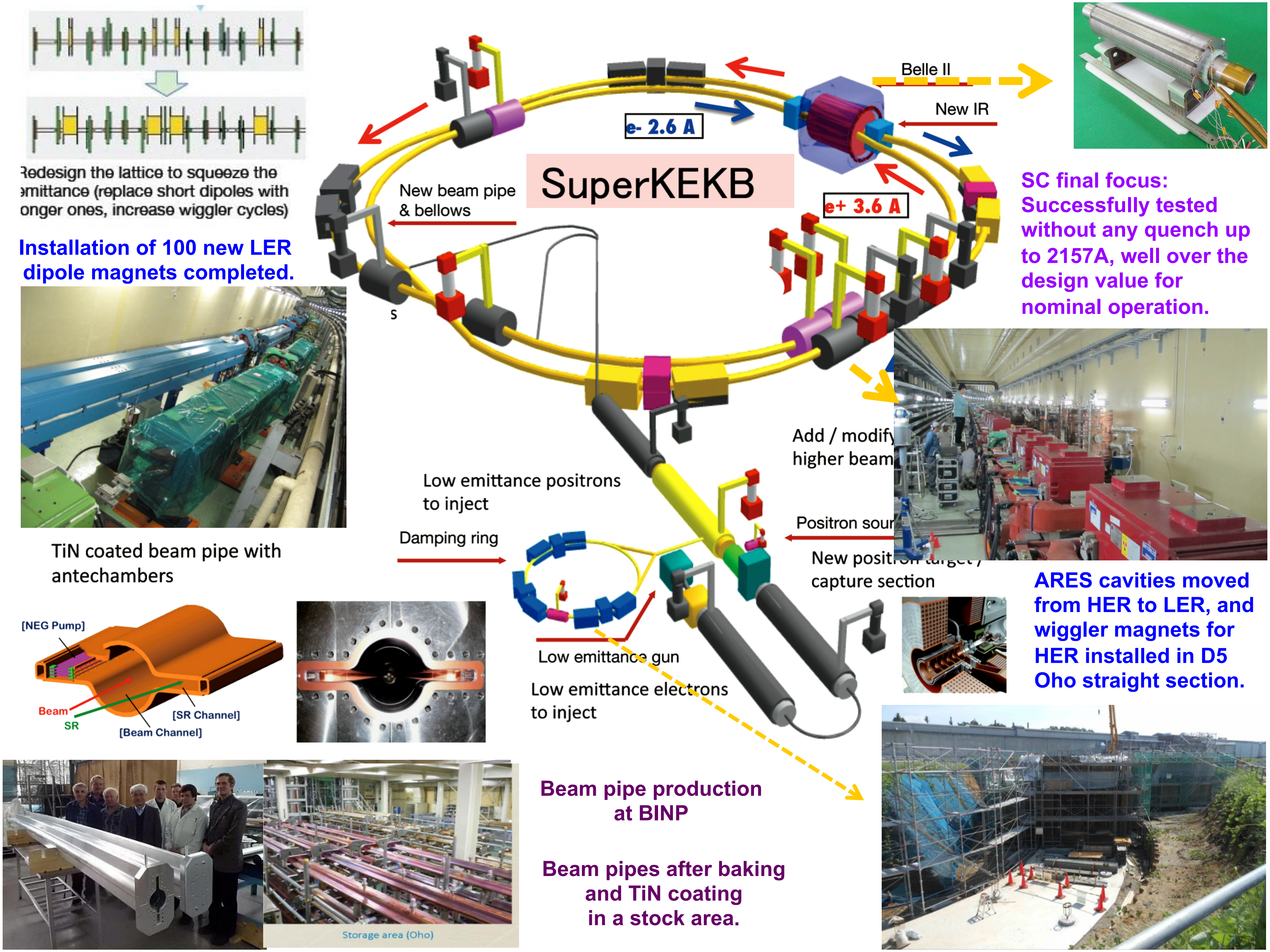


Quest for Birth-Evolution of Universe
International Linear Collider (ILC)
Quest for Unifying Matter and Force
Scientific Activities
Technology Innovations
Talented Human Resources
Lepton CP Asymmetry
Beyond Standard Physics
Power-Upgrade
SuperKEKB
J-PARC
KEK-B
LHC
Quark CP Asymmetry
Lepton
Quark
[Origin of Matter]
Quest for Neutrinos
Quest for 6 Quarks
[Origin of Force]
Higgs Particle [Origin of Mass]

1. Projects in Japan

- **Intensity Frontier**
  SuperKEKB/BELLE II

- **~500 collaborators from 76 institutions in 21 countries**



Redesign the lattice to squeeze the
mittance (replace short dipoles with
onger ones, increase wiggler cycles)
Installation of 100 new LER
dipole magnets completed.
Belle II
New IR
e- 2.6 A
e+ 3.6 A
SuperKEKB
New beam pipe
& bellows
SC final focus:
Successfully tested
without any quench up
to 2157A, well over the
design value for
nominal operation.
Add / modify
higher beam
Low emittance positrons
to inject
Positron sour
Damping ring
New positron target /
capture section
TiN coated beam pipe with
antechambers
[NEG Pump]
Beam
SR
[SR Channel]
[Beam Channel]
Low emittance gun
Low emittance electrons
to inject
ARES cavities moved
from HER to LER, and
wiggler magnets for
HER installed in D5
Oho straight section.
Storage area (Oho)
Beam pipe production
at BINP
Beam pipes after baking
and TiN coating
in a stock area.

Belle II Detector Upgrade

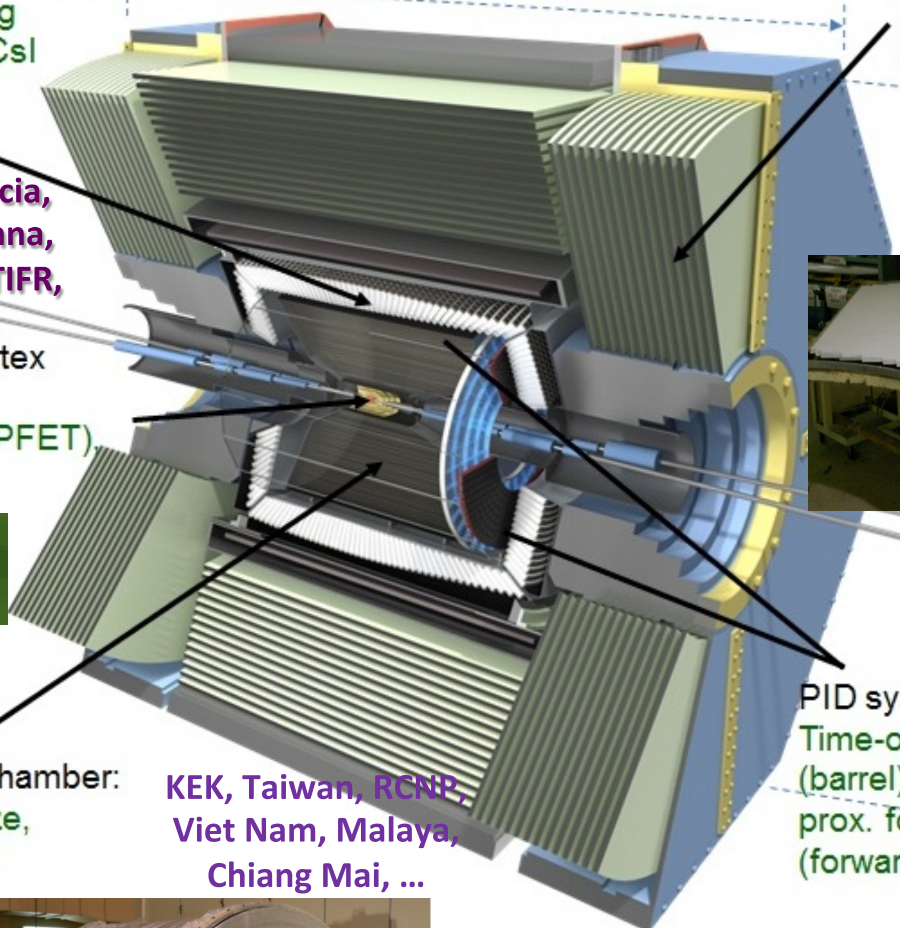
BINP, KEK, Nara
Taiwan, Hanyang, …

CsI(Tl) EM calorimeter:
waveform sampling electronics, pure CsI for end-caps

7.4 m

RPC μ & K_L counter:
scintillator + Si-PM for end-caps

ITEP, Virginia, KEK,
Hawaii, Indiana,
Wayne state, …



MPI, Bonn, Heidelberg, Valencia,
Karlsruhe, Charles, DESY, Vienna,
KEK, IPMU U-Tokyo, Tohoku, TIFR,
Melbourne, Krakow

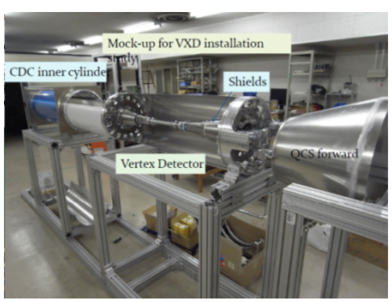
4 layers DS Si Vertex Detector →
2 layers PXD (DEPFET),
4 layers DSSD

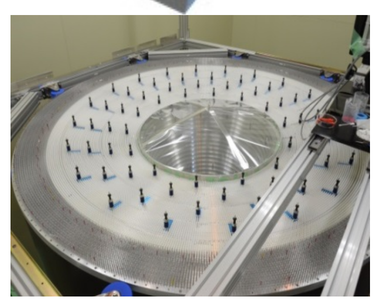
Nagoya, Toho, Chiba, Niigata,
Hawaii, Cincinnati, PNNL,KEK,
Tokyo metro, Ljubljana, …

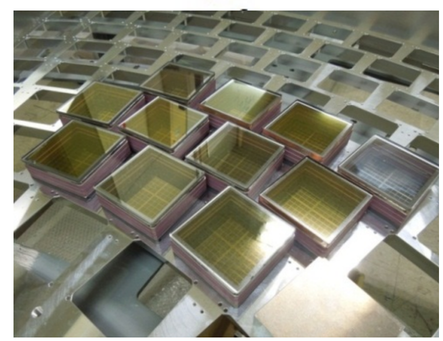
PID system
Time-of-Propagation counter (barrel),
prox. focusing Aerogel RICH (forward)

Central Drift Chamber:
smaller cell size,
long lever arm

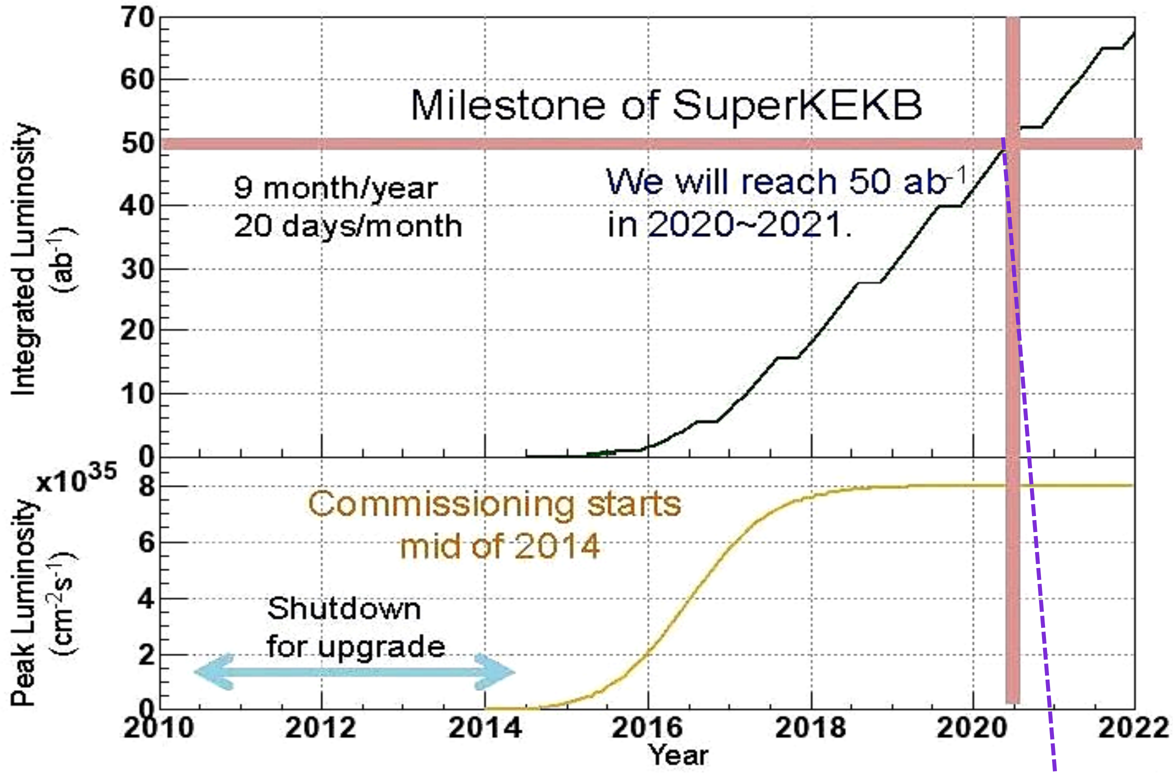
KEK, Taiwan, RCNP,
Viet Nam, Malaya,
Chiang Mai, …



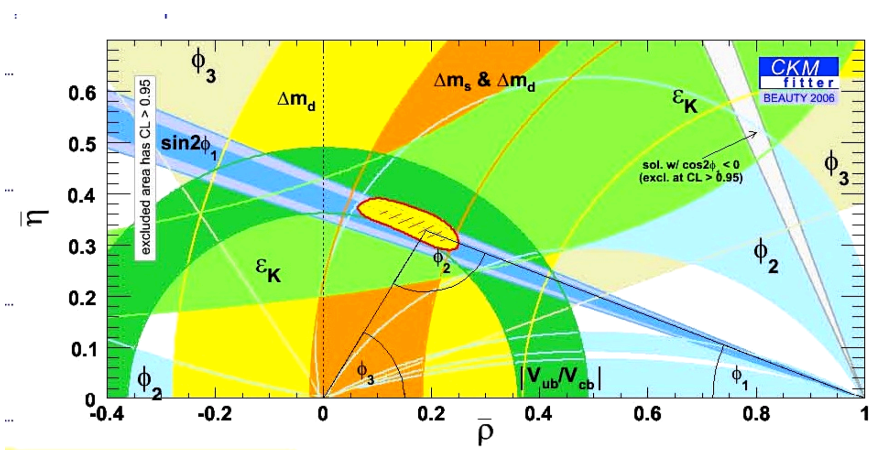


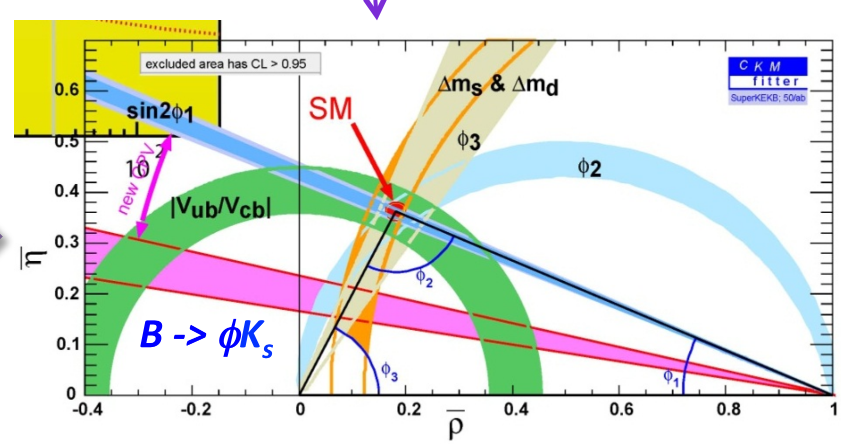


SuperKEKB luminosity projection



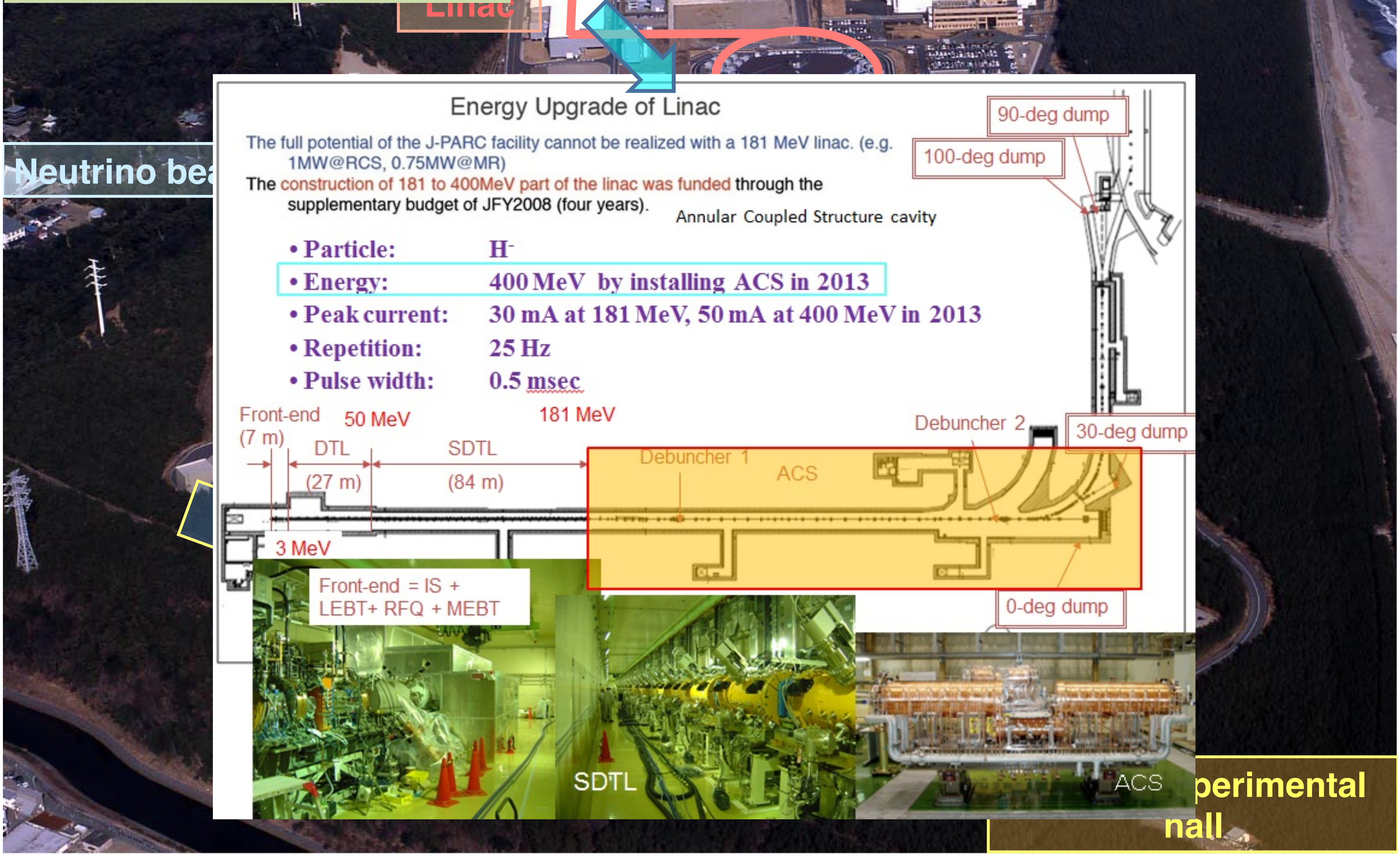
Inconsistency in unitarity triangle?



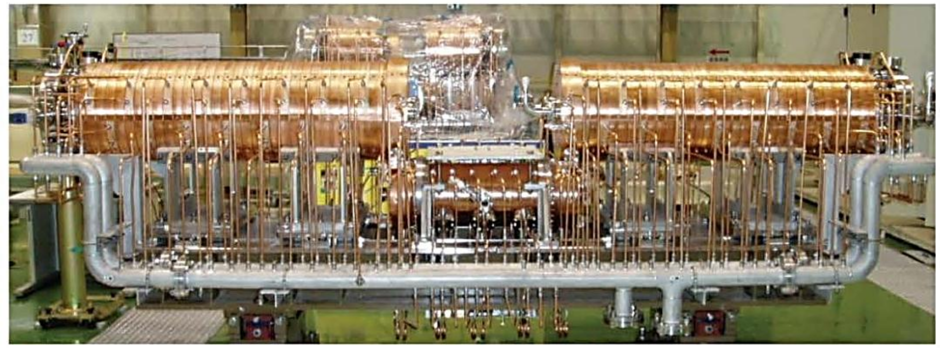


1. Projects in Japan

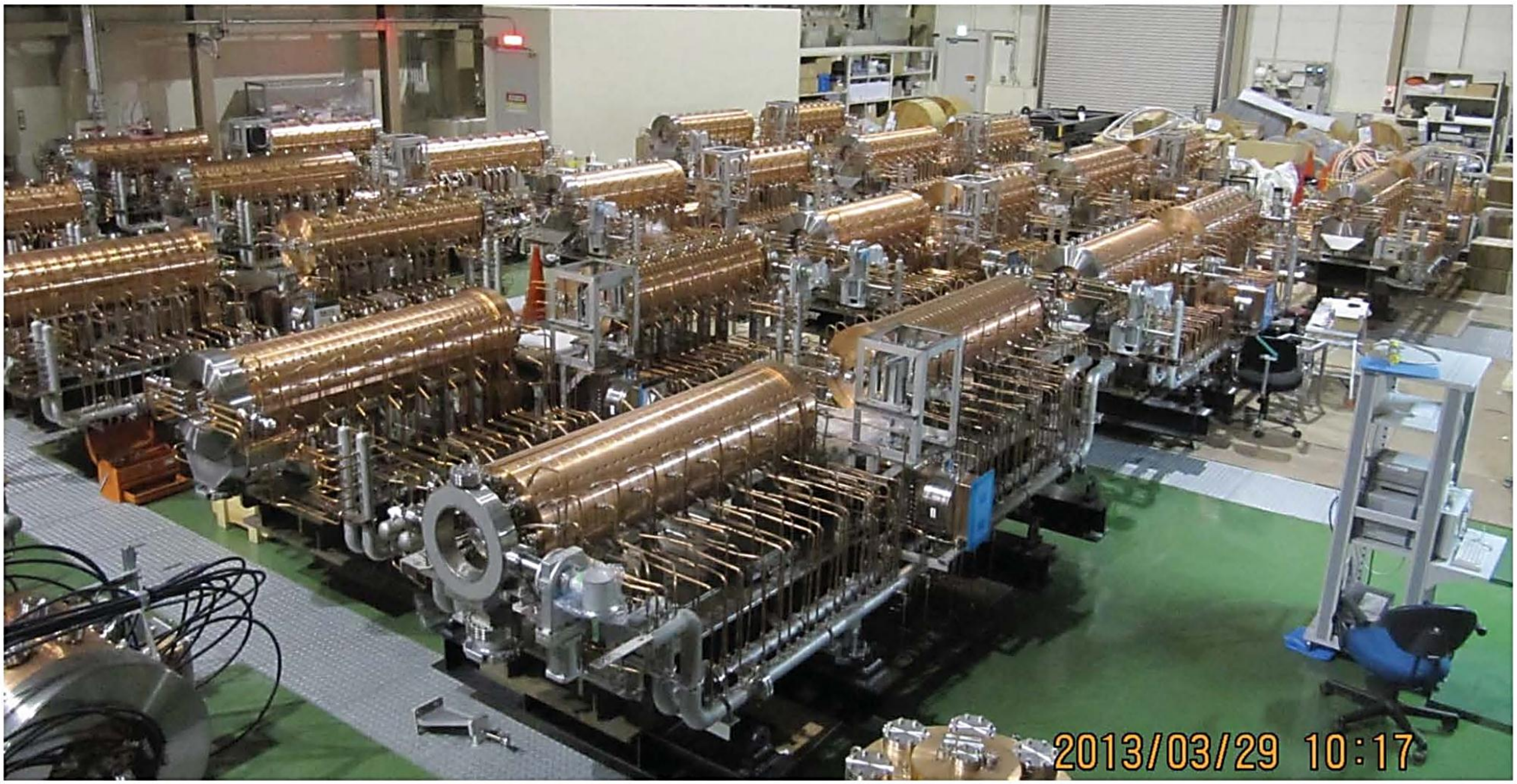
- Intensity Frontier
  J-PARC

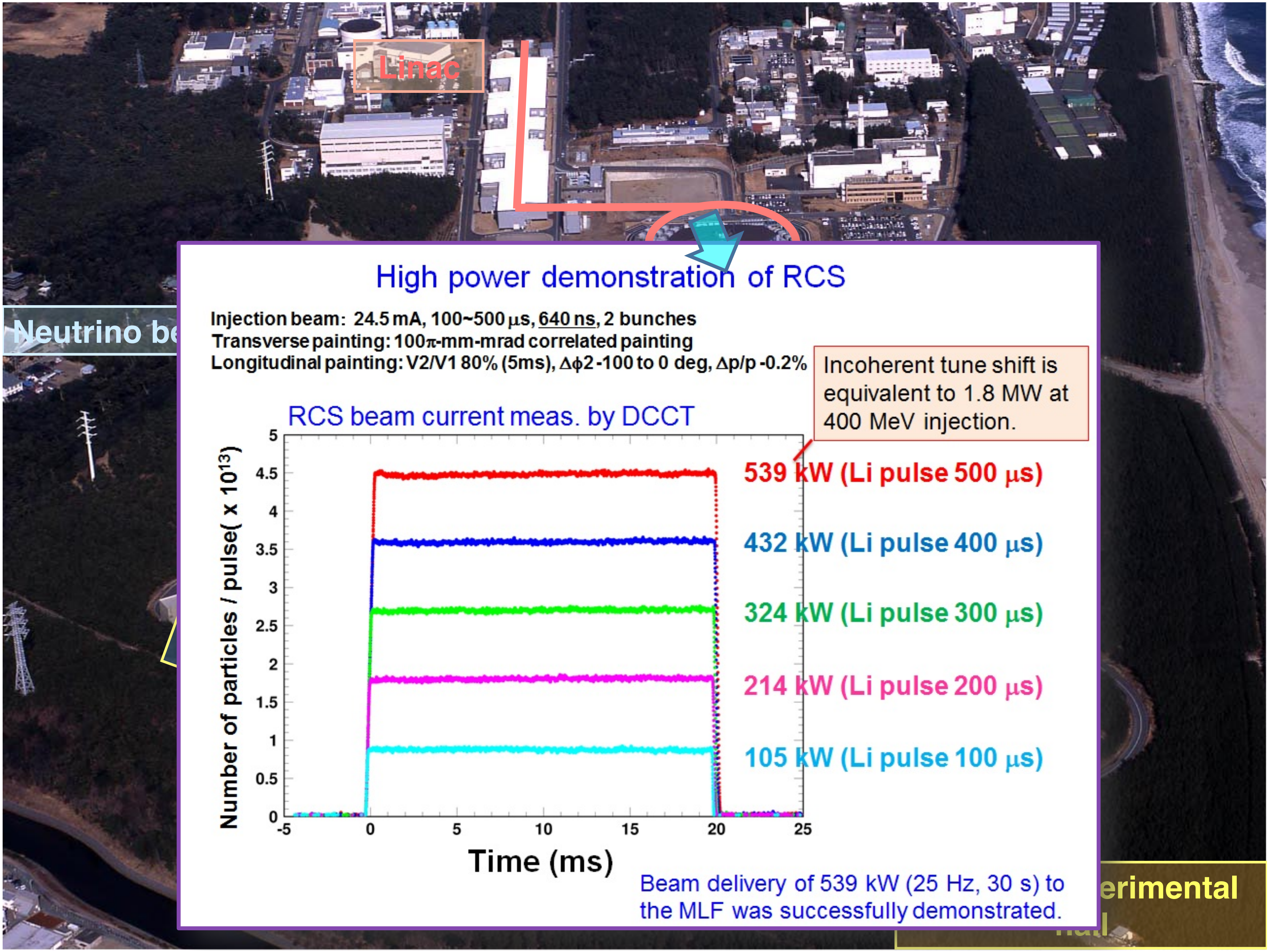


ACS modules for the energy upgrade of J-PARC Linac



Annular Couple Accelerator

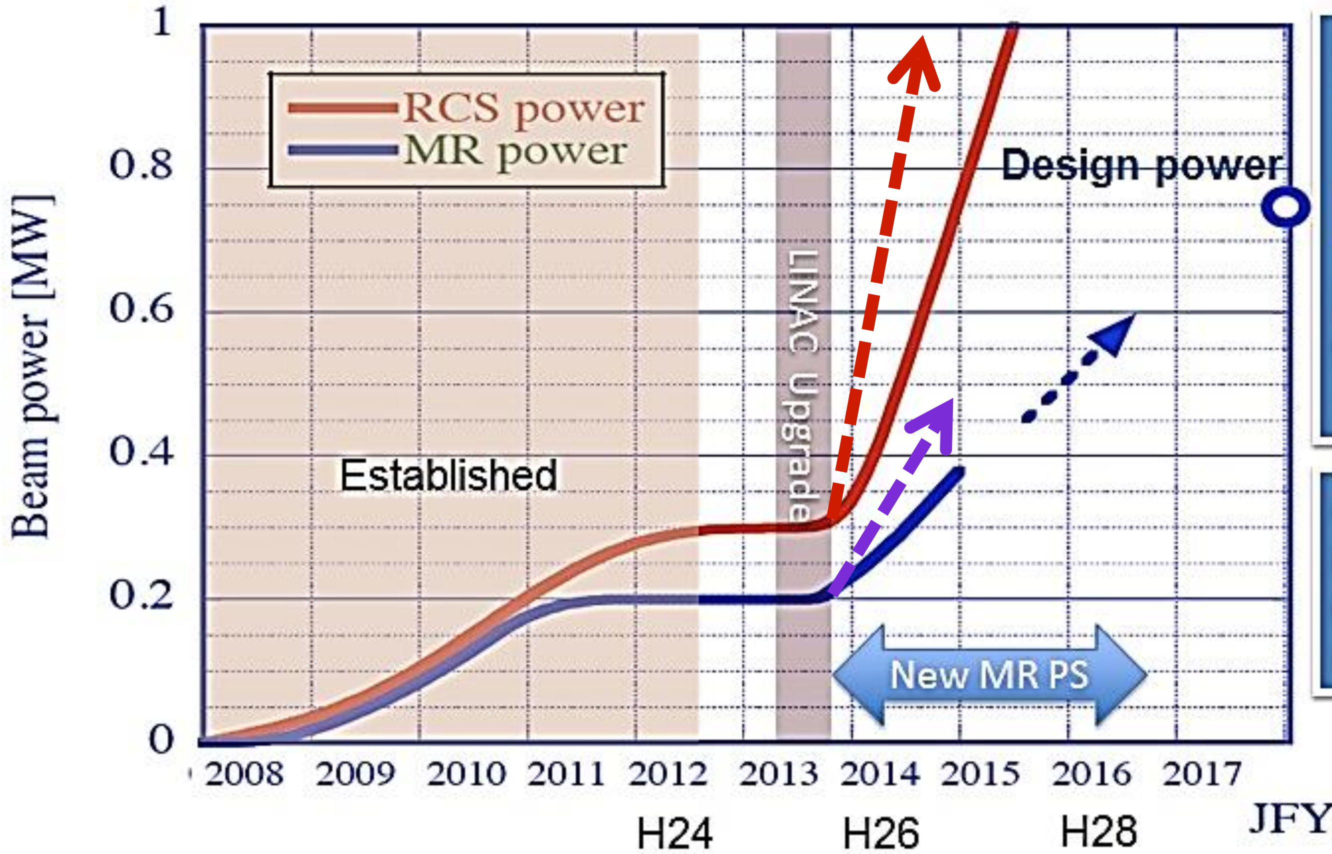




Linac
Neutrino be
High power demonstration of RCS
Injection beam: 24.5 mA, 100~500 μs, 640 ns, 2 bunches
Transverse painting: 100π-mm-mrad correlated painting
Longitudinal painting: V2/V1 80% (5ms), Δϕ2 -100 to 0 deg, Δp/p -0.2%
Incoherent tune shift is equivalent to 1.8 MW at 400 MeV injection.
RCS beam current meas. by DCCT
Number of particles / pulse(x 10^13)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
-5
0
5
10
15
20
25
Time (ms)
539 kW (Li pulse 500 μs)
432 kW (Li pulse 400 μs)
324 kW (Li pulse 300 μs)
214 kW (Li pulse 200 μs)
105 kW (Li pulse 100 μs)
Beam delivery of 539 kW (25 Hz, 30 s) to the MLF was successfully demonstrated.
erimental

Beam Power Improvement

RSC reaches 1 MW after LINAC upgrades summer 2013
MR requires new PS (hi-rep.rate) to reach 0.75 MW



MR requires
- New PS
- Hi-gradient RF cavity
- Injectn/Extractn for hi-rep. rate
- Better shielding

Aim for higher power after design power reached

1. Projects in Japan

- Intensity Frontier
  J-PARC/T2K

The T2K Collaboration

~500 members, 59 Institutes, 11 countries

Canada
TRIUMF
U. Alberta
U. B. Columbia
U. Regina
U. Toronto
U. Victoria
U. Winnipeg
York U.

France
CEA Saclay
IPN Lyon
LLR E. Poly.
LPNHE Paris

Germany
Aachen U.

Italy
INFN, U. Bari
INFN, U. Napoli
INFN, U. Padova
INFN, U. Roma

Japan
ICRR Kamioka
ICRR RCCN
Kavli IPMU
KEK
Kobe U.
Kyoto U.
Miyagi U. Edu.
Osaka City U.
Okayama U.
Tokyo Metropolitan U.
U. Tokyo

Poland
IFJ PAN, Cracow
NCBJ, Warsaw
U. Silesia, Katowice
U. Warsaw
Warsaw U. T.
Wroklaw U.

Russia
INR

Spain
IFAE, Barcelona
IFIC, Valencia

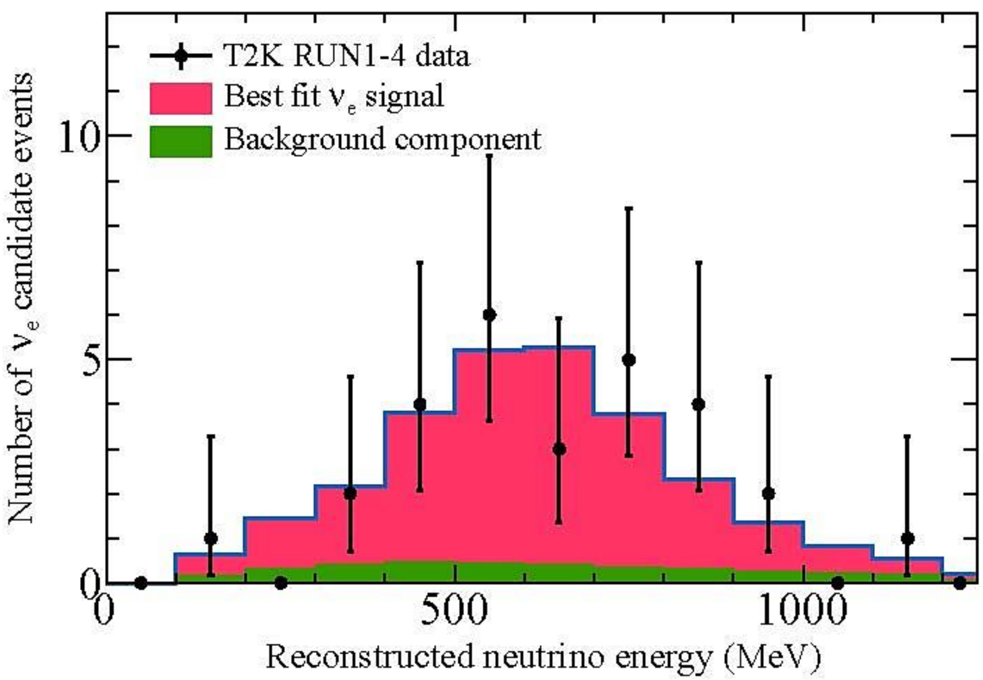
Switzerland
ETH Zurich
U. Bern
U. Geneva

United Kingdom
Imperial C. London
Lancaster U.
Oxford U.
Queen Mary U. L.
STFC/Daresbury
STFC/RAL
U. Liverpool
U. Sheffield
U. Warwick

USA
Boston U.
Colorado S. U.
Duke U.
Louisiana S. U.
Stony Brook U.
U. C. Irvine
U. Colorado
U. Pittsburgh
U. Rochester
U. Washington

- Stable operation at ~220kW achieved.
  - >1.2x10[14]ppp (1.5x10[13]x8b) is the *world record* of extracted protons per pulse for synchrotrons.
- Data for today's talk: *6.39x10[20]pot* (by Apr.12). 6.63x10[20] by May.8.
  - Statistics has been *doubled* successfully compared to the previous analysis (3.01x10[20]pot)

- **N_{exp}=20.4 at $\sin^2 2\theta_{13}$=0.1, while we observe 28 events**
- **ν_μ background significantly reduced by using new NCπ^0 fitter**
  - **~2.3 events expected with old (m_{π^0}-only) reduction**



best fit w/ 68% C.L. error:

$$\sin^2 2\theta_{13} = 0.152^{+0.041}_{-0.034}$$

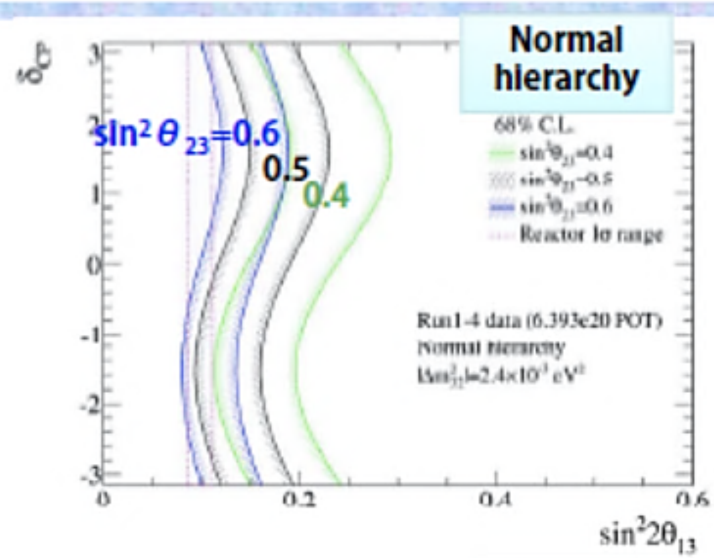
assuming
$|\Delta m^2_{32}|=2.4\times10^{-3}$ eV^2
$\delta_{CP}=0$, $\sin^2 2\theta_{23}=1$,
Normal hierarchy

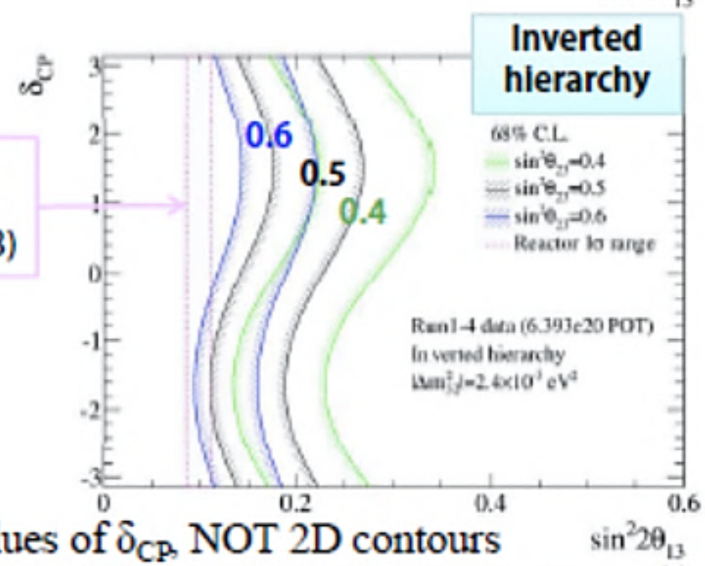
$\sqrt{-2\Delta \ln L}=\sqrt{56.27}$
$=7.5\sigma$
Our official value for the significance

δ_{CP} vs. $\sin^2 2\theta_{13}$ for different $\sin^2\theta_{23}$

$$P_{\nu_\mu \to \nu_e} \approx \sin^2\theta_{23} \sin^2 2\theta_{13} \sin^2 \frac{\Delta m^2_{32} L}{4E_\nu}$$

- Oscillation probability is largely dependent on $\sin^2\theta_{23}$ (octant)
  - PDG2012: $\sin^2(2\theta_{23}) > 0.95$
    - $\sin^2\theta_{23} = 0.50 \pm 0.11$
    - $\theta_{23} = 45 \pm 6.5°$
  - To reduce error on $\sin^2\theta_{23}$ is critical for further improvements





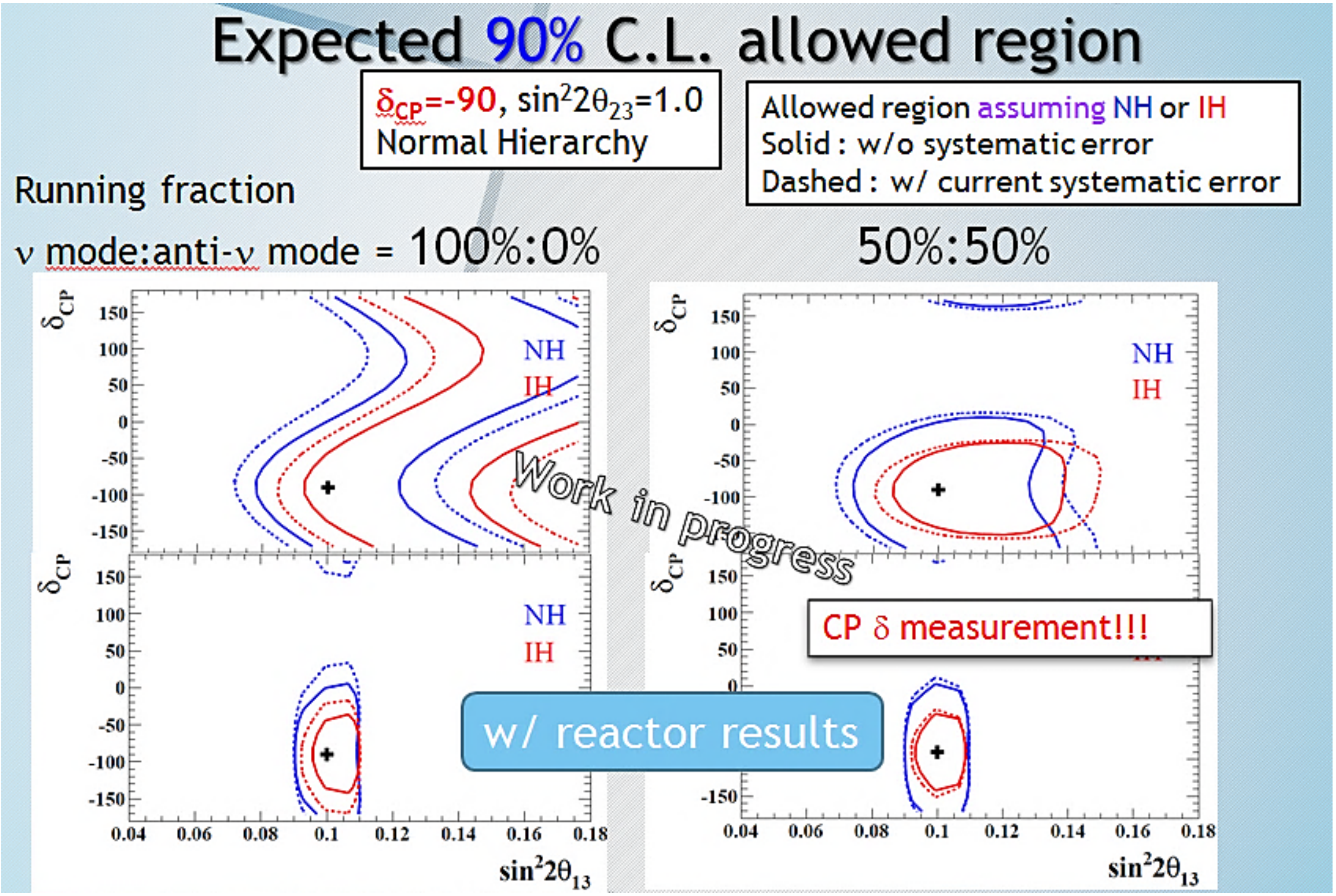
PDG2012 reactor average value (0.098±0.013)

T2K's ν_μ disappearance study will play a leading role.

NOTE: These are 1D contours for various values of δ_{CP}, NOT 2D contours

T2K sensitivity
@7.8E21 POT(750kW x 5e7sec @ 30GeV)

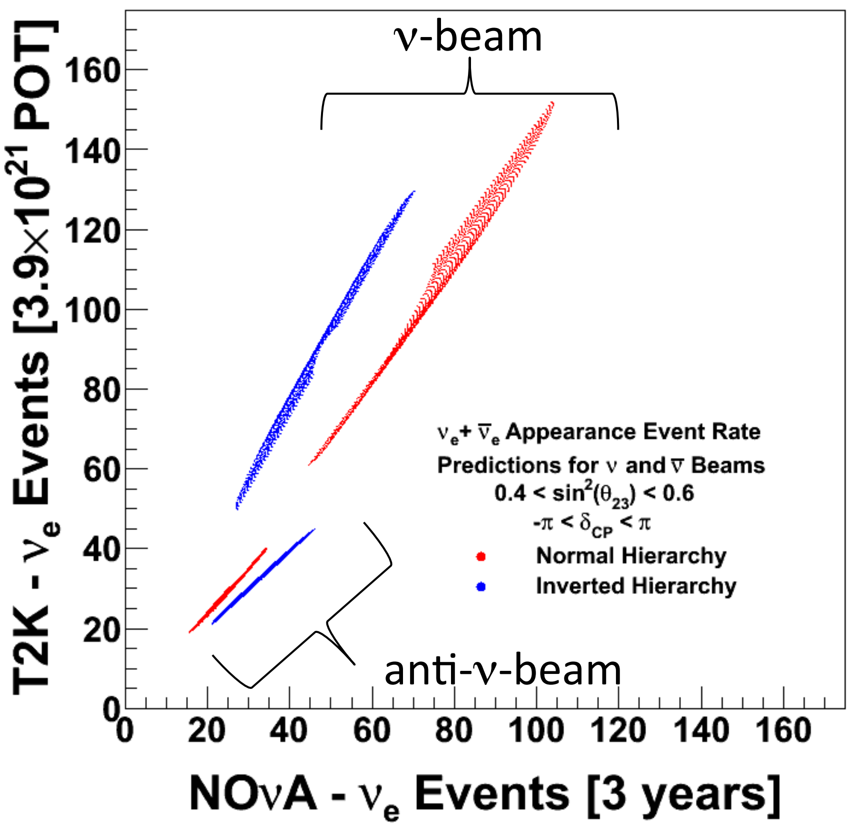
May 2012	2014	2018
190kW	300kW **500kW**	750kW

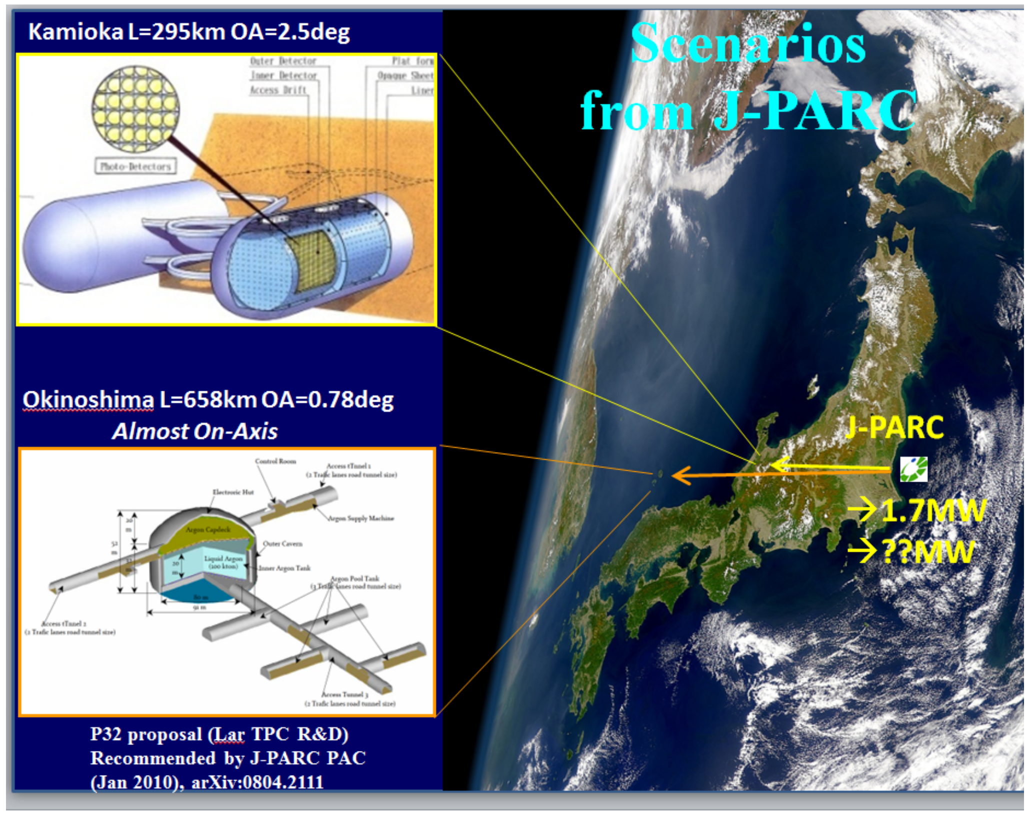


Assuming

ν beam and anti-ν beam = 1:1 for both experiment

Expected number of events distributed by unknown CP δ ($-\pi<\delta<\pi$) and θ_{23} ($0.4<\sin^2\theta_{23}<0.6$)





1. Projects in Japan

- Intensity Frontier

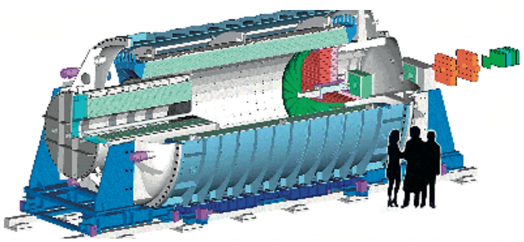
  J-PARC/ KOTO, COMET

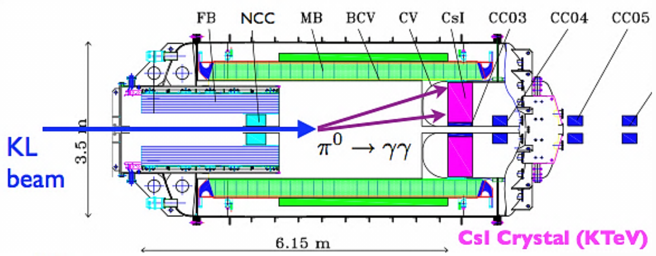
COMET: μ → e Conversion

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

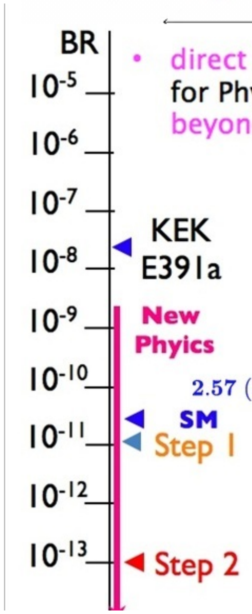
KOTO

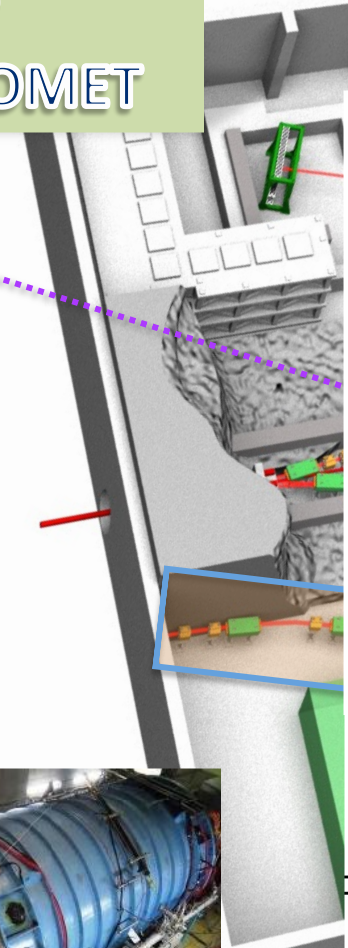
Rare Kaon Decay $K_L^0 \rightarrow \pi^0 \nu \bar{\nu}$

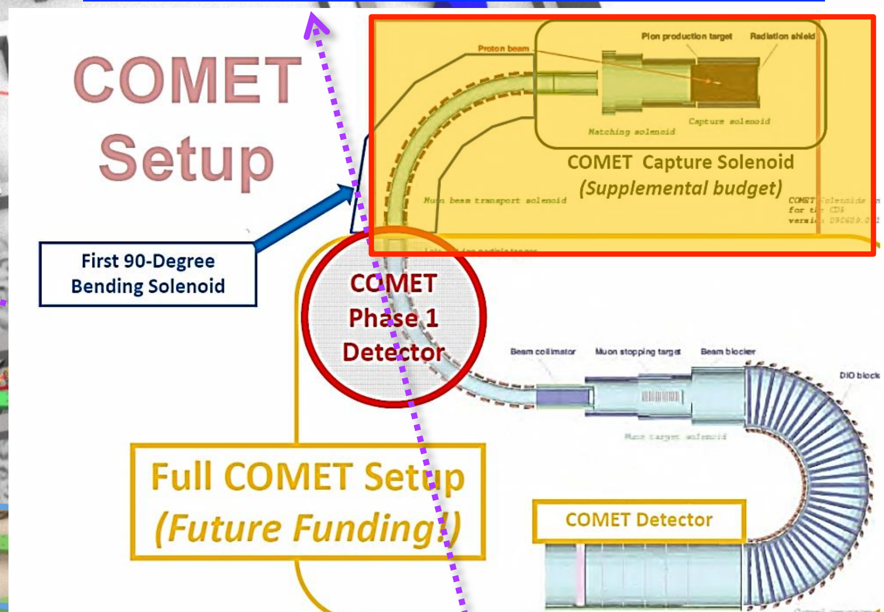


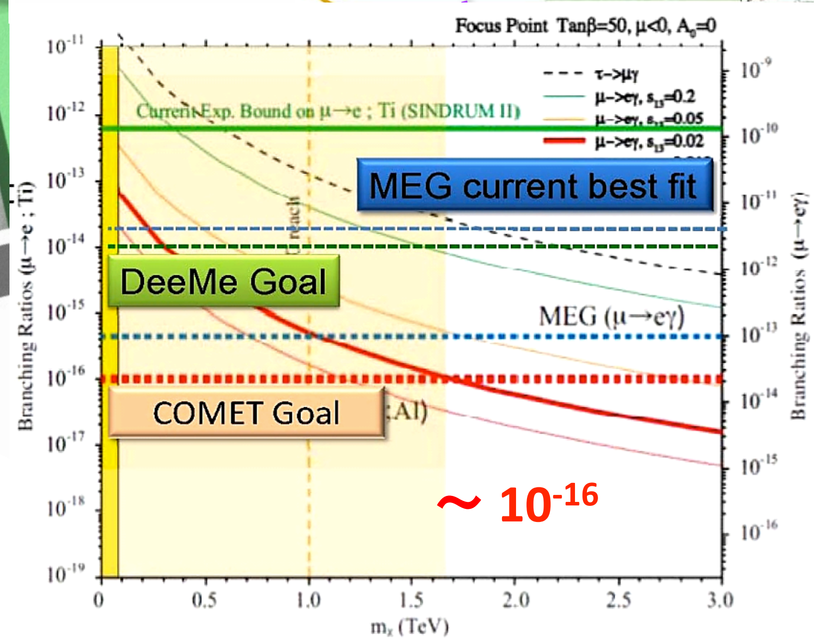


- direct CP-violating rare decay for Physics beyond the Standard Model









1. Projects in Japan

- Energy Frontier: ILC

ilc newsline

FEATURE

Press Release: International Linear Collider completes draft of its design report

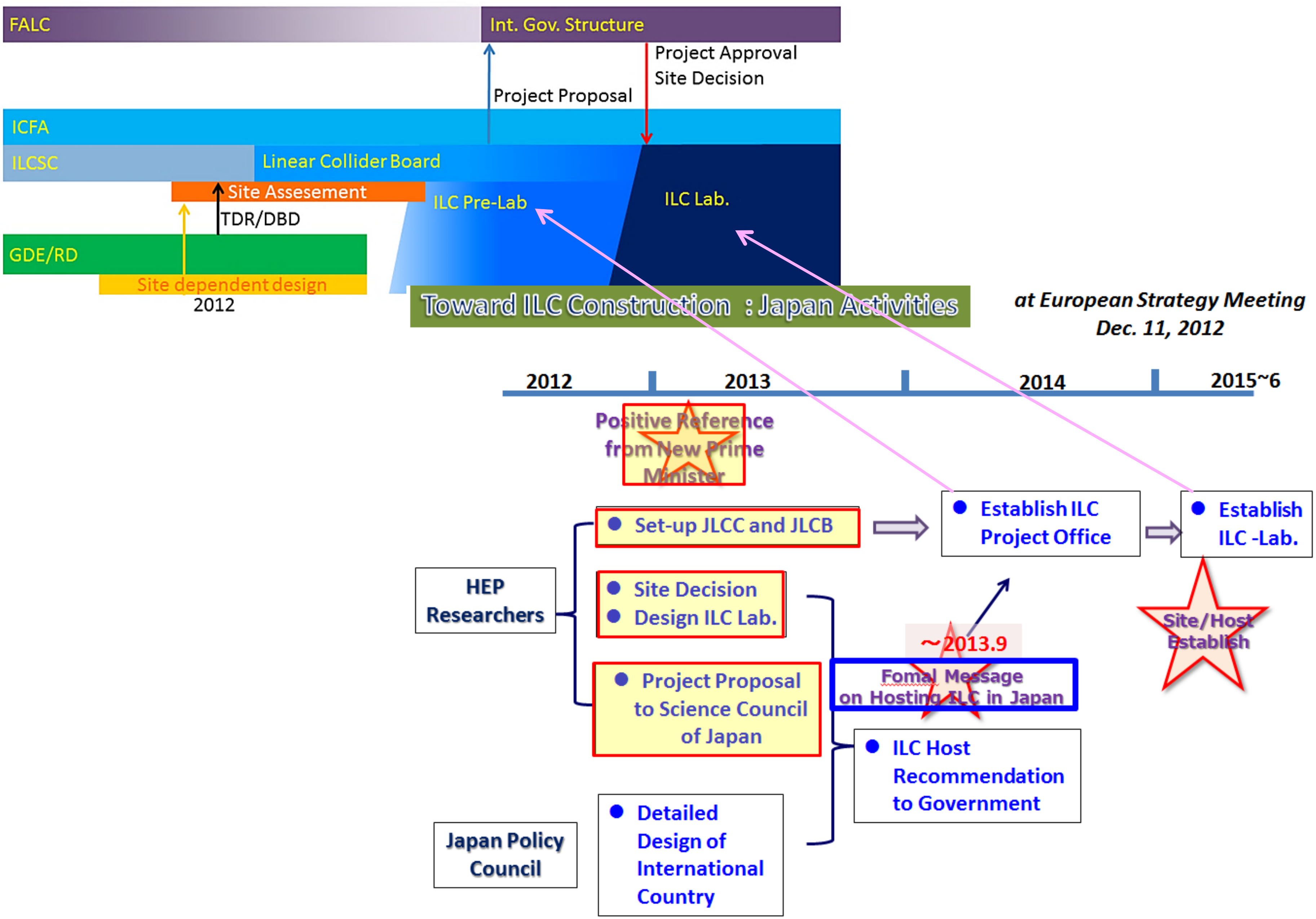
Handover ceremony on 15 December in Tokyo, Japan

20 December 2012

Barry Barish and Sakue Yamada handing over the TDR to ILCSC chair Jon Bagger. Image: Nobuko Kobayashi

The handover was followed by a panel discussion.

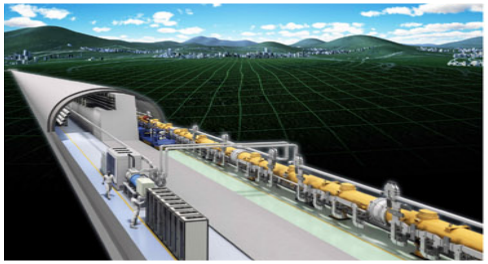
Possible Time-Sequence of Processes toward Realization



Geological Survey and Common-Subject Study, going on, in Japan

August

Reports to be available in ~~July~~, 2013



Federation of Diet Members for promotion of the ILC project

～150 menbers

日本成長戦略のビッグバン

リニアコライダー国際研究所
建設推進政策レポート
（案）

Big-Bang
of Japan Revitalization Strategy

Policy Report on Promotion
of
ILC Construction

August, 2013

2013年8月

リニアコライダー（先端線型加速器）
国際研究所建設推進議員連盟

Lyn Evans pays courtesy visit to Japan's prime minister Shinzo Abe

Share |

Images: Prime Minister of Japan and His Cabinet | 4 April 2013

On 27 March, LCC Director Lyn Evans paid a courtesy visit to Japan's Prime Minister Shinzo Abe. The Prime Minister acknowl significance of the linear collider project for the whole of humankind. Given that it is an international project, he said he needed t the development closely and would continue to investigate the role of Japan. The video of the visit is also available at the Cabine website.

Lyn Evans presented Prime Minister Abe with a book about the LHC.

Rolf Heuer, global ILC cities and the role of Japan

Rolf Heuer giving a talk at the ILC symposium held at University of Tokyo

April 30, 2013

Reviewing by Japan Science Council

Panel-chair's personal view ???

Japan Needs Years to Make Decision on ILC Building: Science Council Panel

There are uncertain elements to be removed.

He also concerns about possible cuts in outlays for other research field and difficulty securing more than 1,000 scientists and technicians for the project.

uncertain elements to be removed before the panel gives the green light.

No Clear Scientific Evaluation !

Clear Possitive Message for Scientific Value

about possible cuts in outlays for other research field and difficulty securing more than 1,000

It is essential to start investigating the reliability on hosting the ILC in Japan, taking 2~3 years.

asked to put up.

my understanding: "go-sign" of ILC pre-Jlab

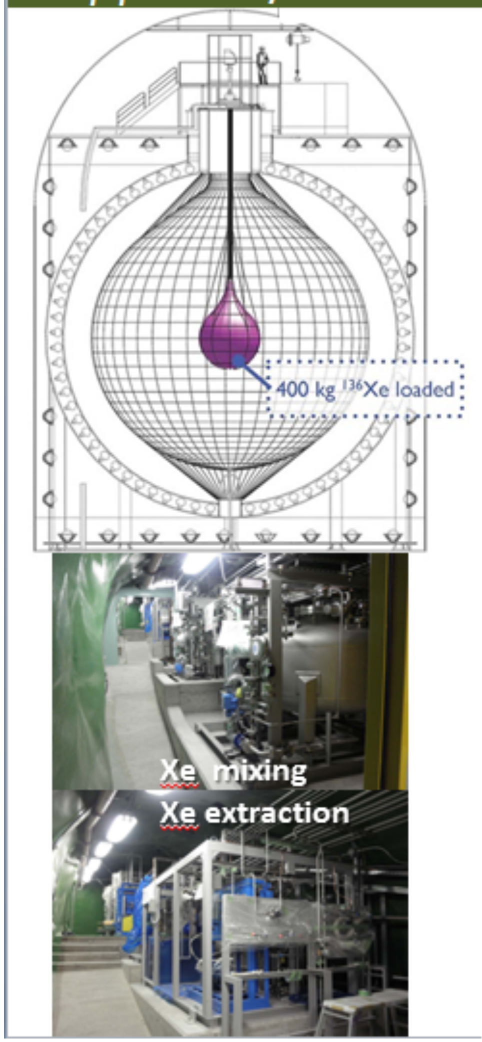
(2013/08/06-23:28)

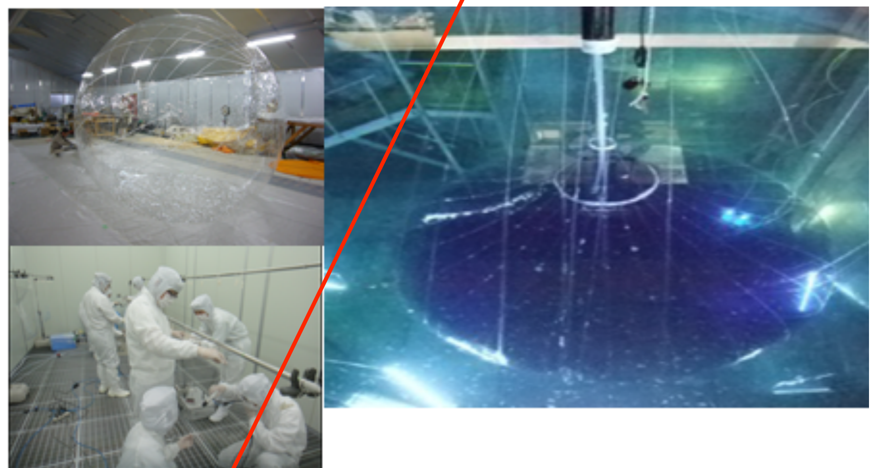
1. Projects in Japan

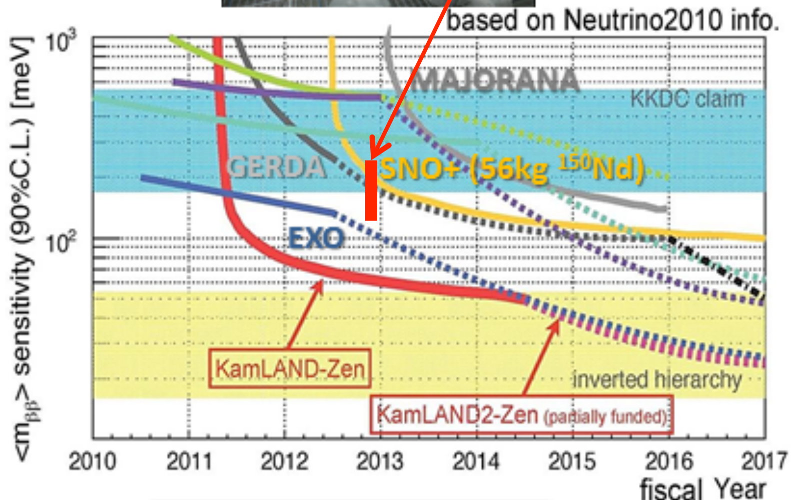
- Underground Physics at Kamioka

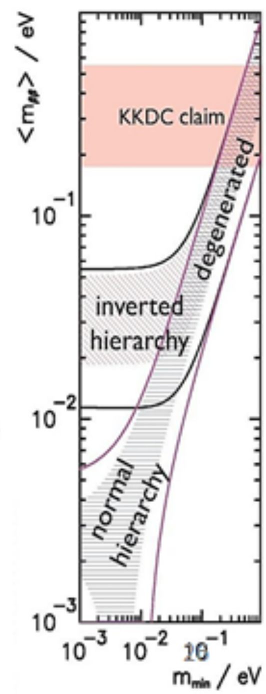
$m_{\beta\beta}$ < (120-250) meV at 90% C.L. (2013)

KamLAND-Zen
ββ-Decay Search









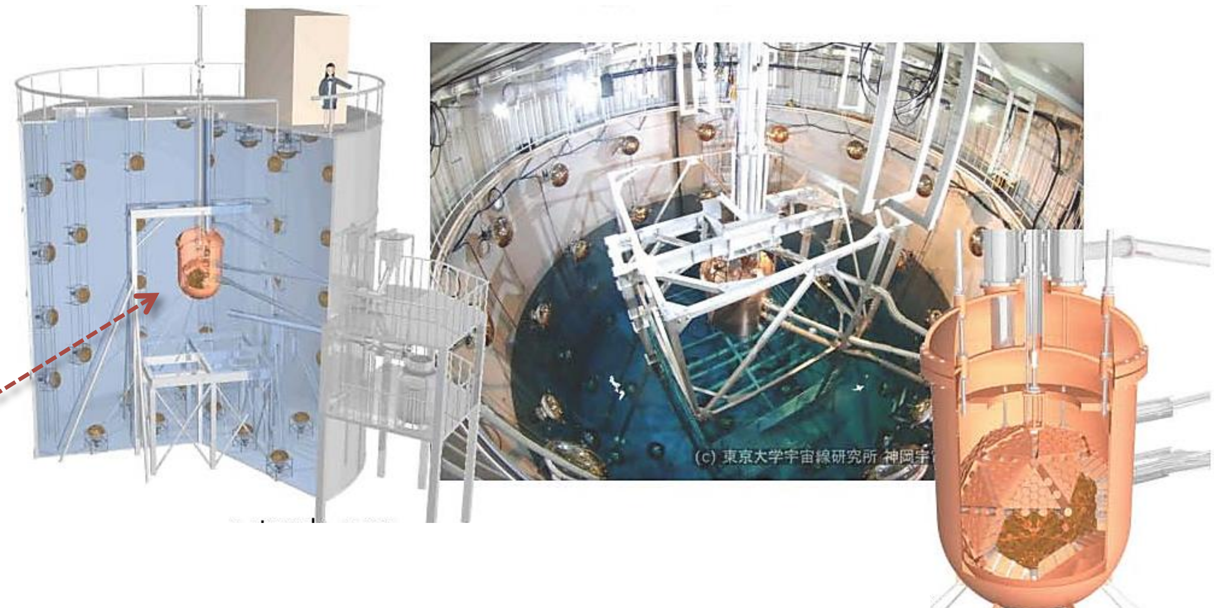
1st step : 400 kg ^{136}Xe

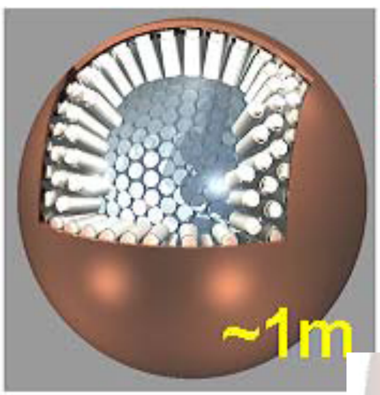
2nd step : 1 ton ^{136}Xe (possible to 10 ton)

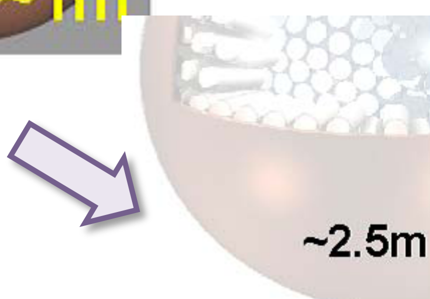
XMASS
Dark Matter Search: Xe-loaded Sci.

High Scalability

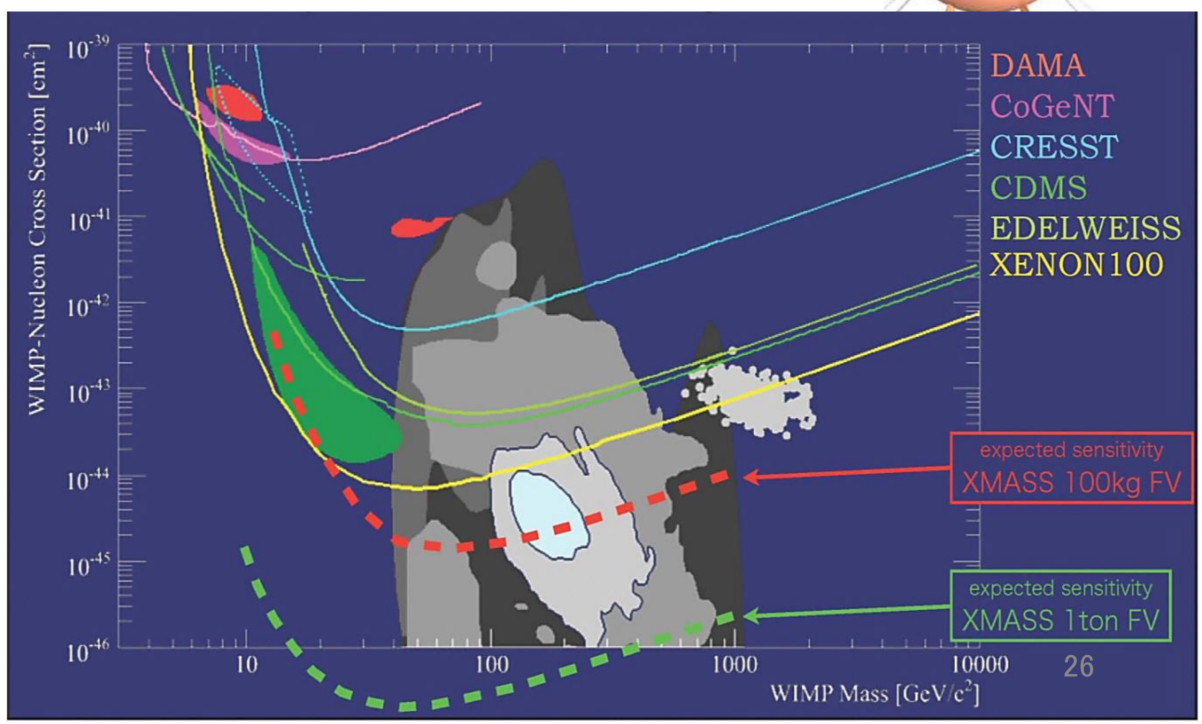
1st	→ 2nd	→ 3rd
100 kg	1 ton	10 ton

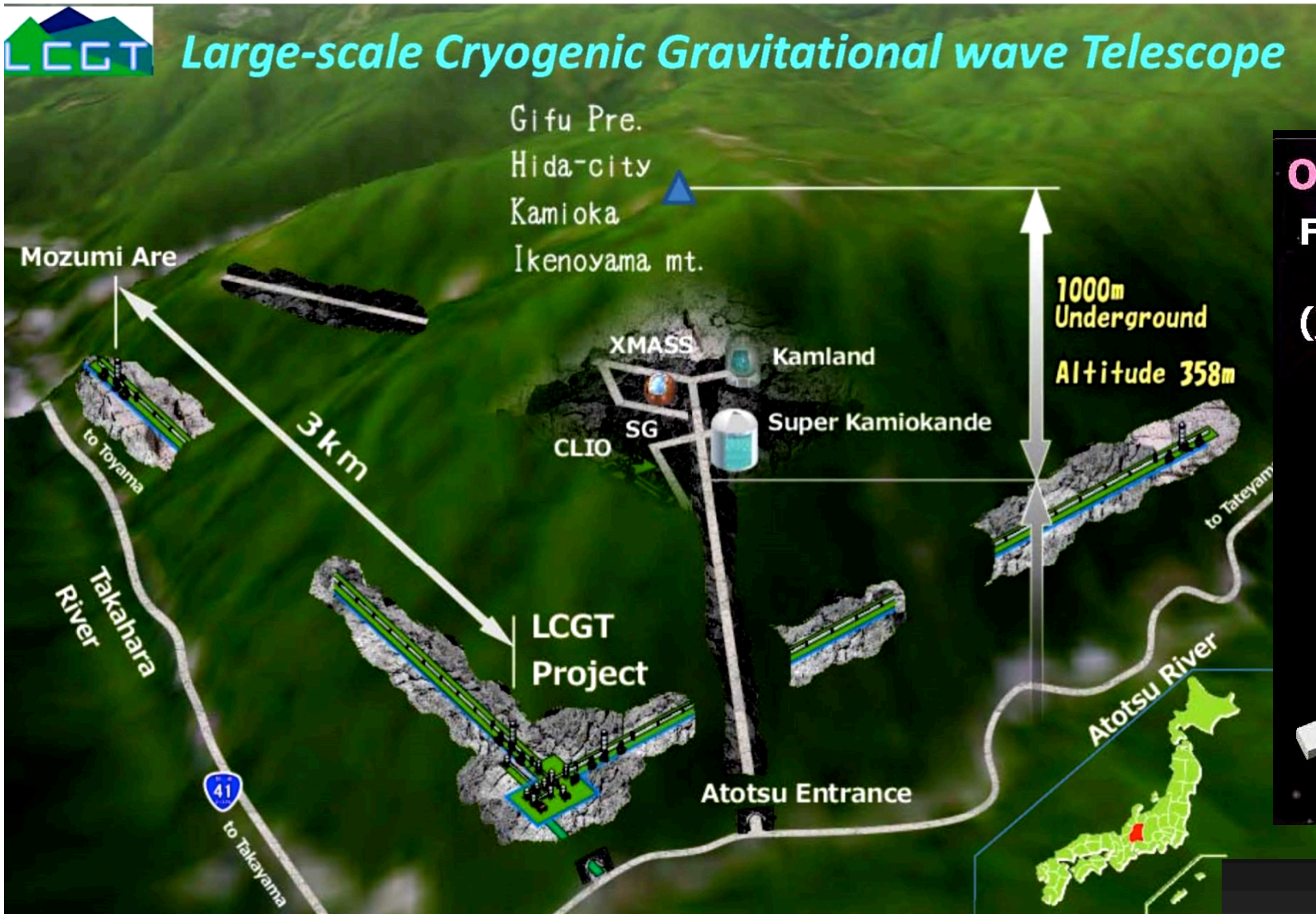


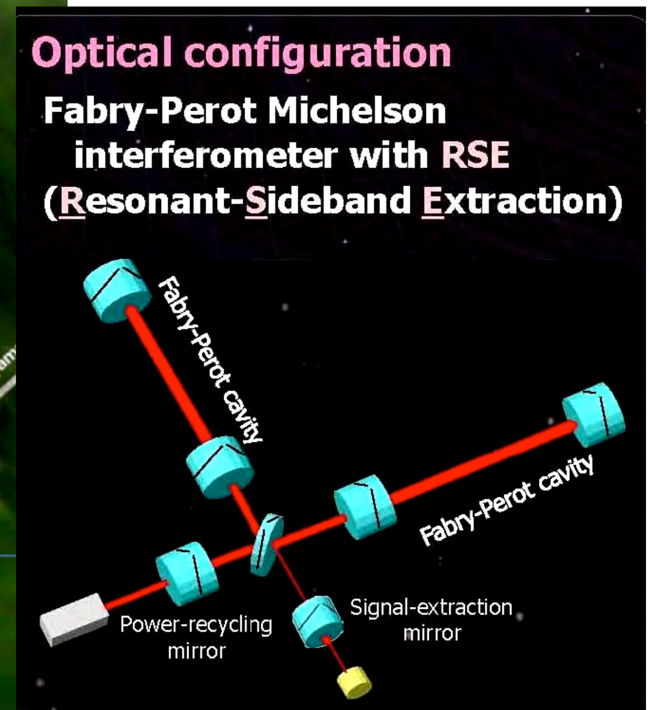


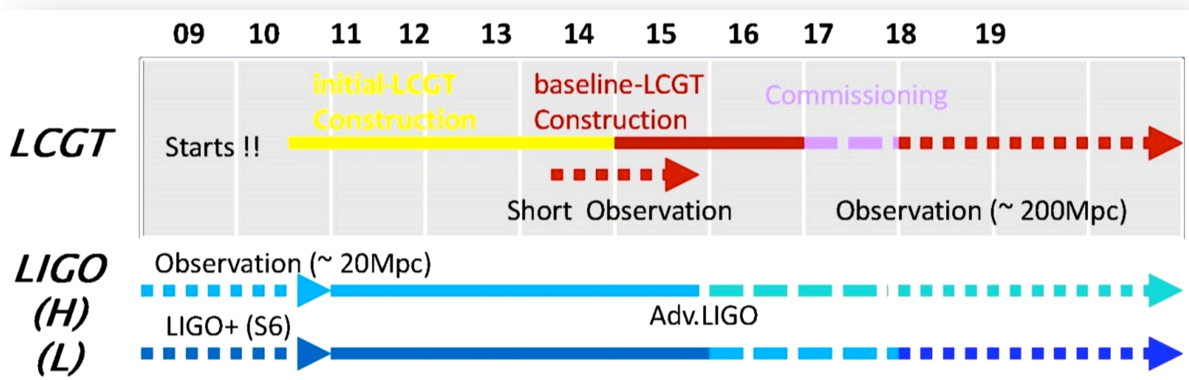


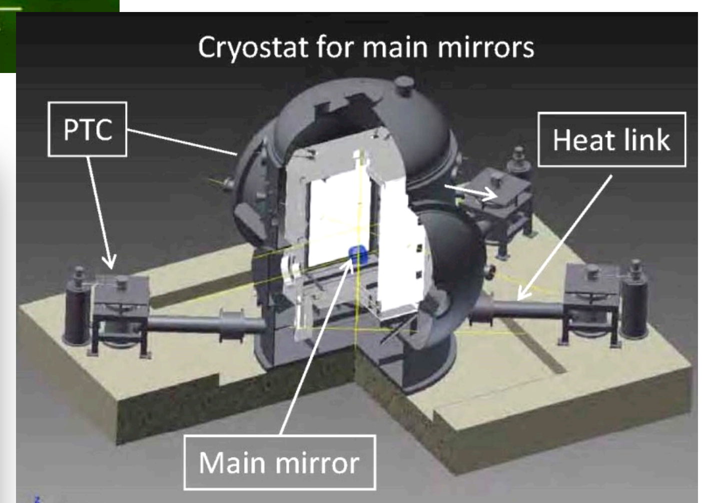
~20 ton detector
(FV 10ton)

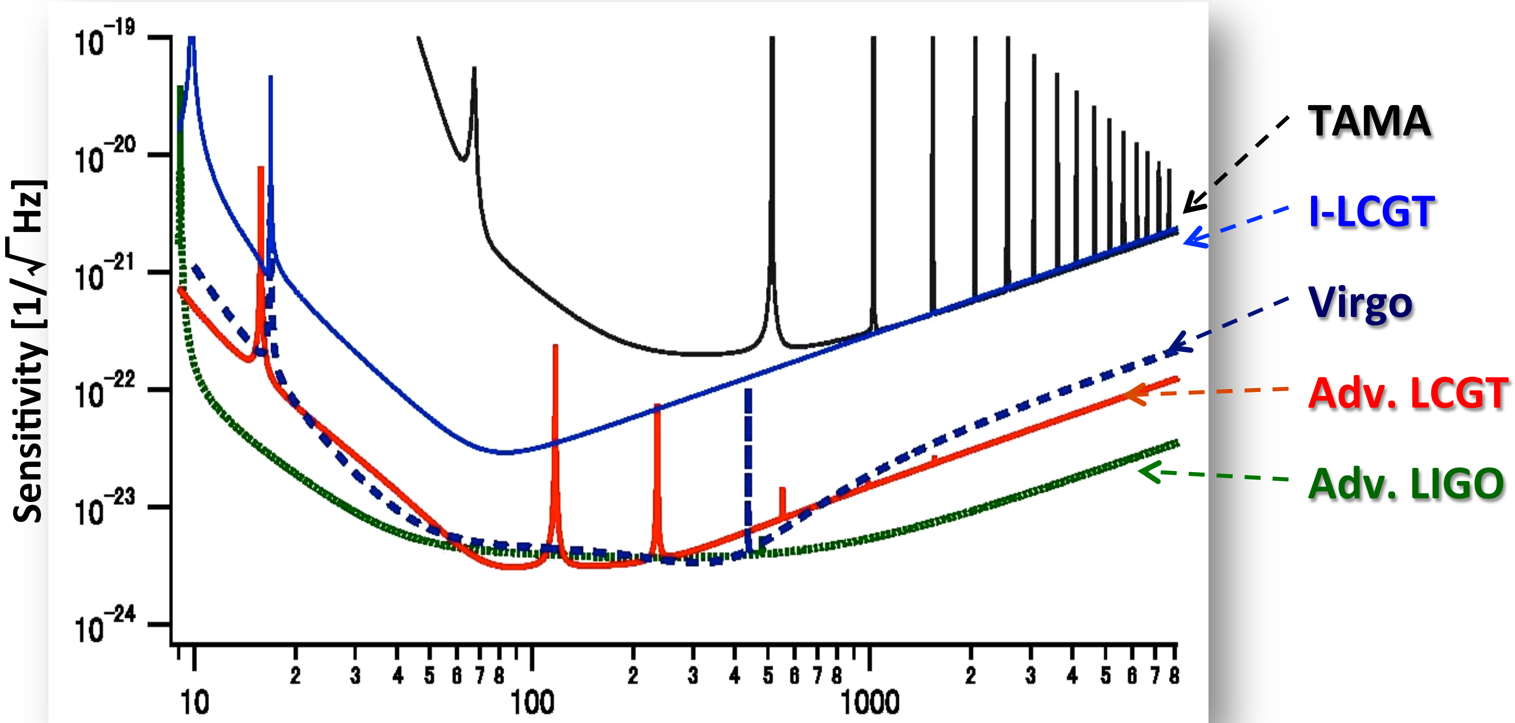


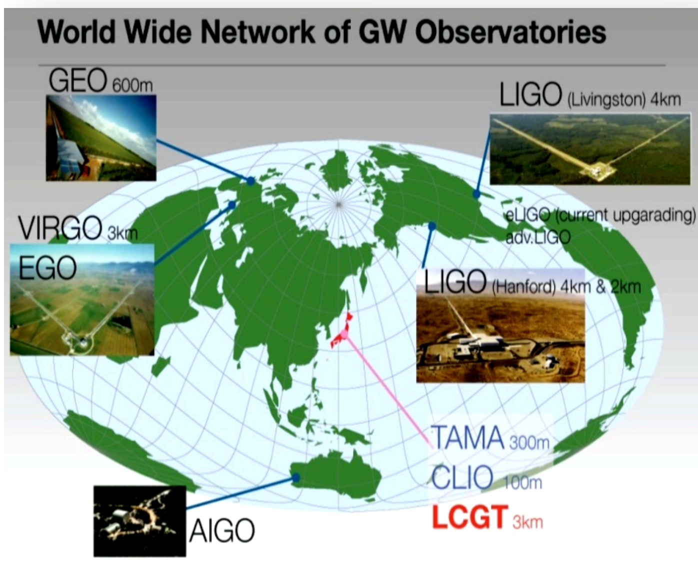

LCGT
Large-scale Cryogenic Gravitational wave Telescope
Gifu Pre.
Hida-city
Kamioka
Ikenoyama mt.
Mozumi Are
1000m Underground
Altitude 358m
XMASS
Kamland
Super Kamiokande
SG
CLIO
3km
LCGT Project
Atotsu Entrance
Atotsu River
Takahara River
to Toyama
to Takayama
to Tateyama
41

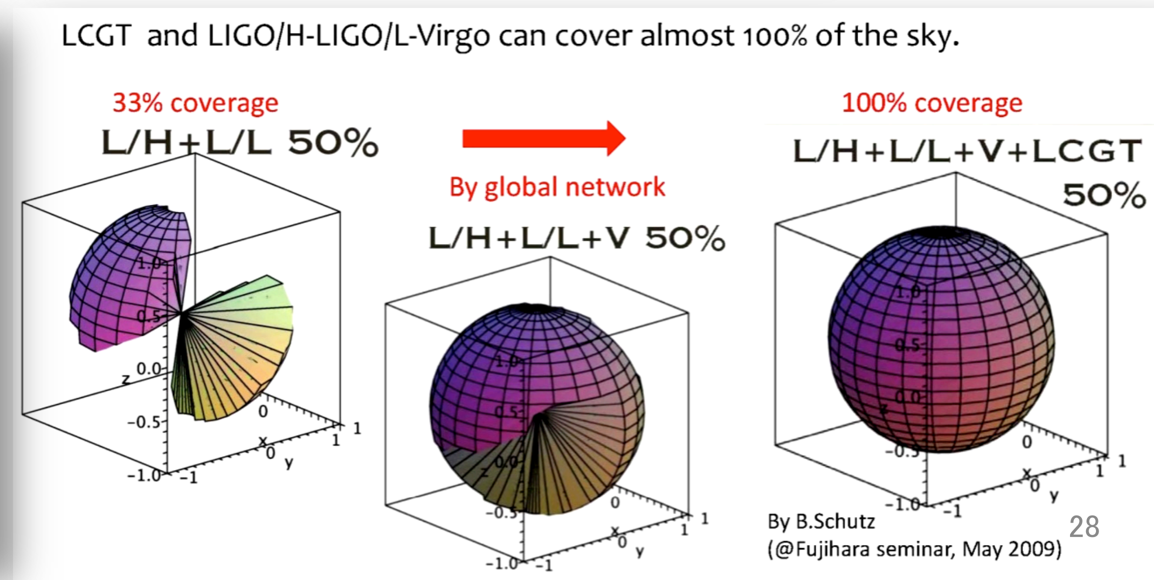

Optical configuration
Fabry-Perot Michelson interferometer with RSE
(Resonant-Sideband Extraction)
Fabry-Perot cavity
Fabry-Perot cavity
Power-recycling mirror
Signal-extraction mirror


09 10 11 12 13 14 15 16 17 18 19
LCGT
Starts !!
initial-LCGT Construction
baseline-LCGT Construction
Commissioning
Short Observation
Observation (~ 200Mpc)
LIGO (H) (L)
Observation (~ 20Mpc)
LIGO+ (S6)
Adv.LIGO


Cryostat for main mirrors
PTC
Heat link
Main mirror


Sensitivity [1/√Hz]
10^-19
10^-20
10^-21
10^-22
10^-23
10^-24
10
100
1000
TAMA
I-LCGT
Virgo
Adv. LCGT
Adv. LIGO


World Wide Network of GW Observatories
GEO 600m
LIGO (Livingston) 4km
VIRGO 3km
EGO
eLIGO (current upgarading)
adv.LIGO
LIGO (Hanford) 4km & 2km
TAMA 300m
CLIO 100m
LCGT 3km
AIGO

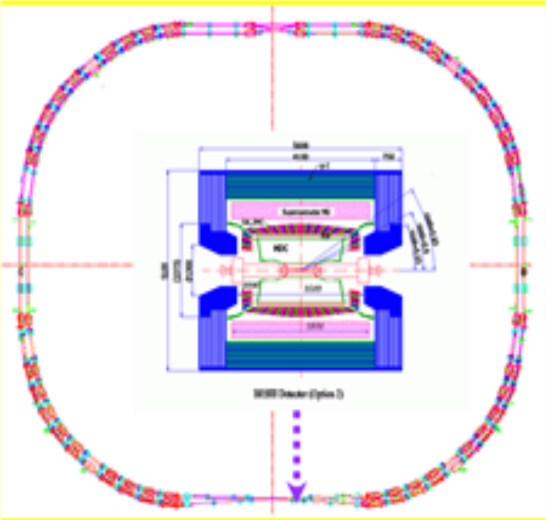

LCGT and LIGO/H-LIGO/L-Virgo can cover almost 100% of the sky.
33% coverage
L/H+L/L 50%
By global network
L/H+L/L+V 50%
100% coverage
L/H+L/L+V+LCGT
50%
By B.Schutz
(@Fujihara seminar, May 2009)
28

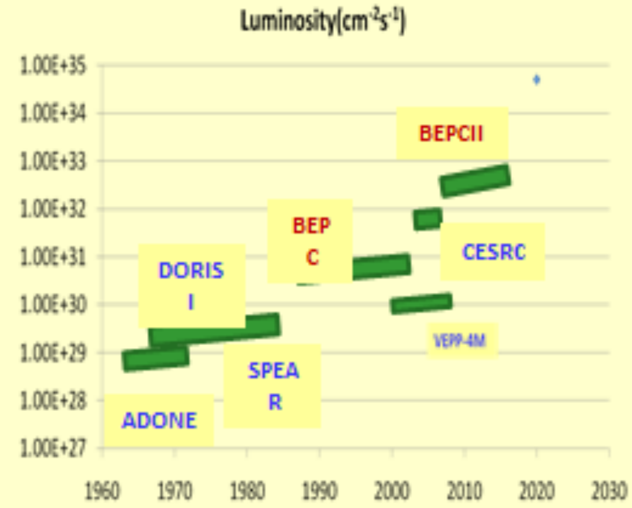
2. Projects in China

- Accelerator-based

BEPCII/BESIII: Operational since 2009

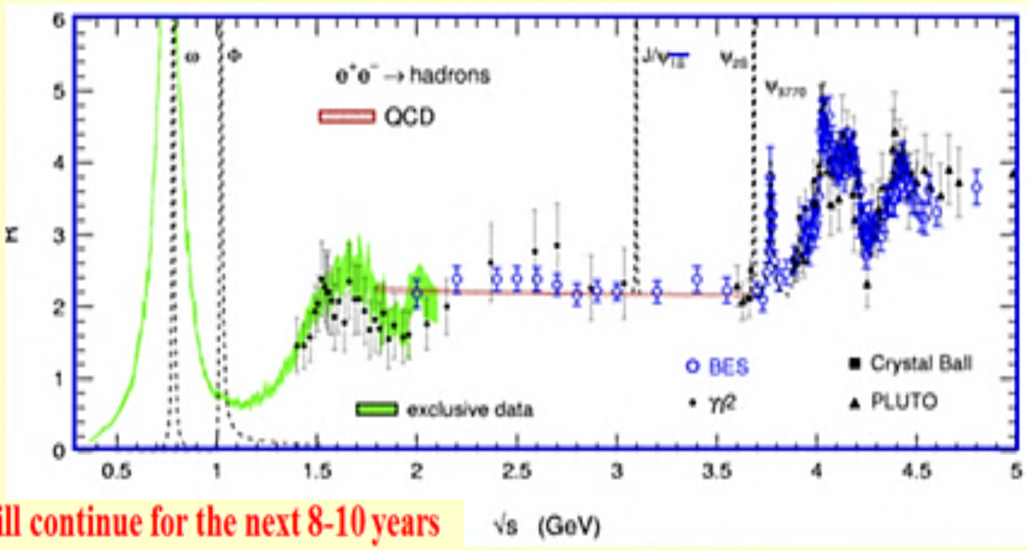
A high lumi. e^+e^- collider at the τ-c energy region





BESIII data taking status & plan

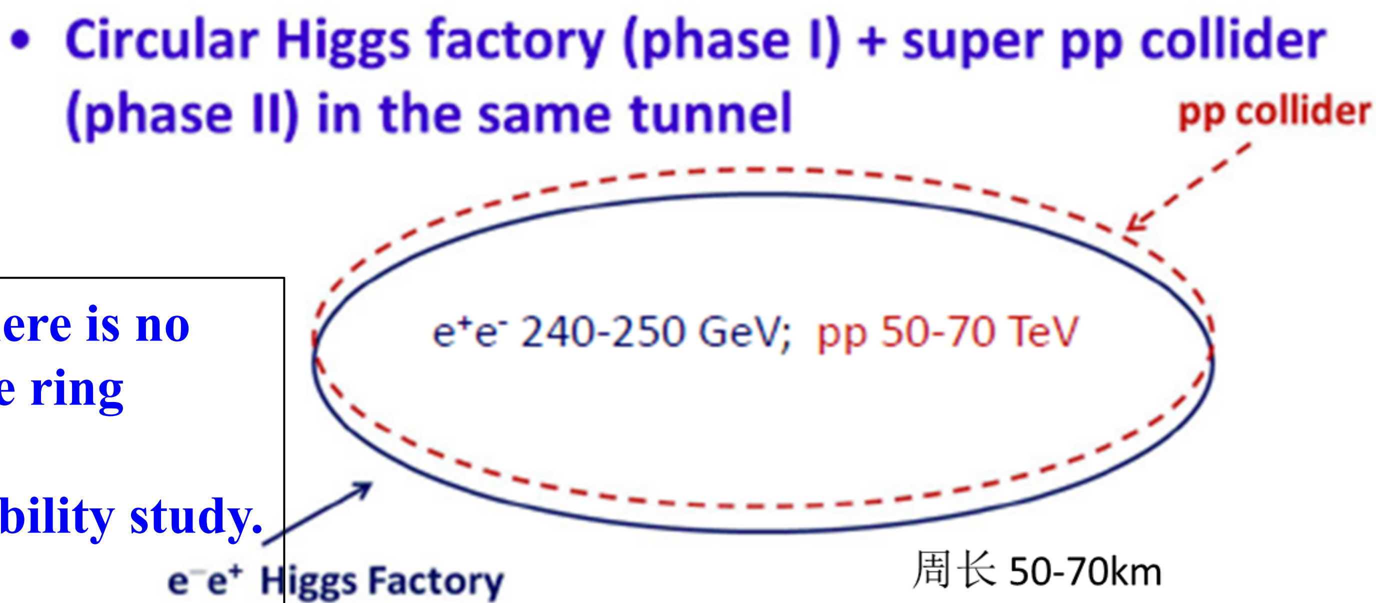
	Previous Data set	BESIII Near future
J/psi	BESII 58M	2009：200M，2012：1 B
Psi'	CLEO：28 M	2009：100M，2012：0.4 B
Psi"	CLEO：0.8 /fb	2010：0.9/fb，2011：2.6/fb
ψ(4040)/ψ(4160) & scan	CLEO：0.6/fb @ ψ(4160)	2011：0.4/fb @ ψ(4040) 2013：0.5/fb (4260), 0.5/fb (4360)
R scan & Tau	BESII	2013：1.5/fb (4260)



BESIII will continue for the next 8-10 years

Future

- Super tau-charm factory
- B factory
- Z factory
- Higgs factory ➔ upgradable to pp(AA, ep,eA)



Please note: There is no proposal for the ring Higgs factory.
It is just a feasibility study.

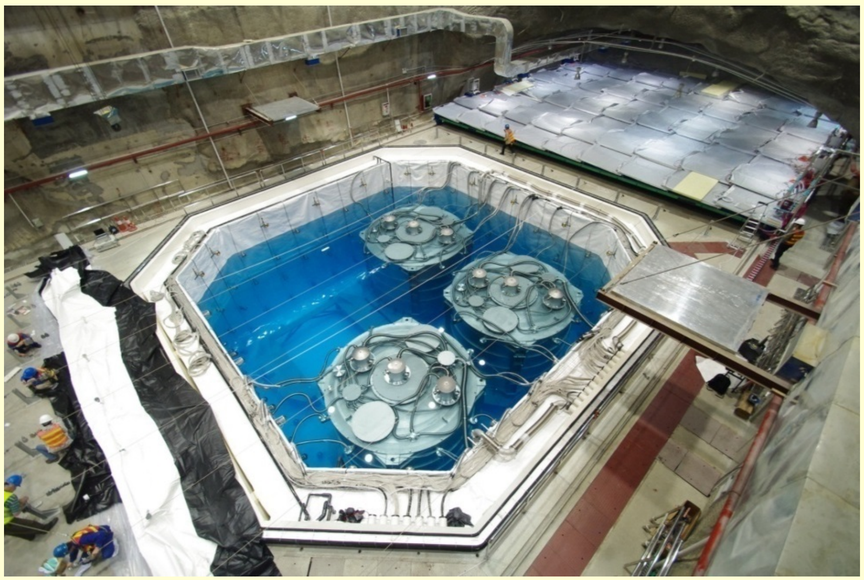
Yifang

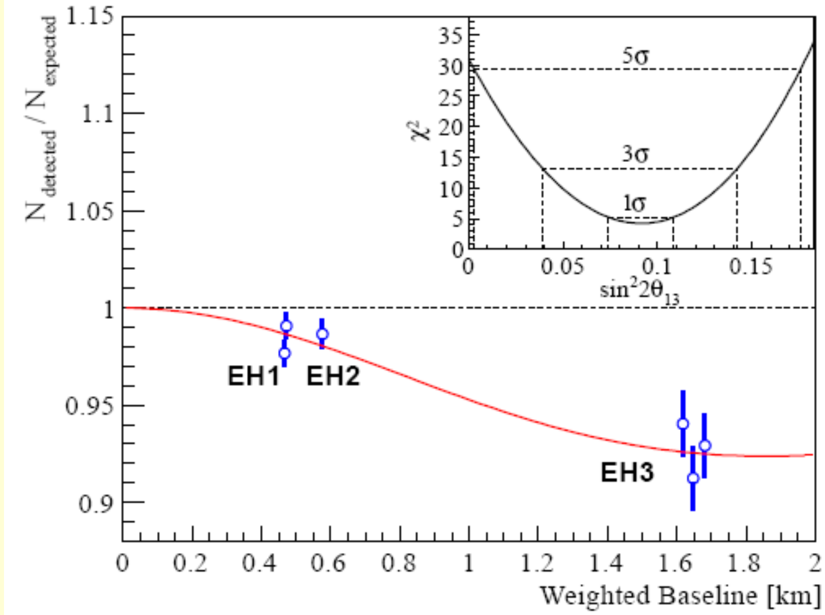
- **Energy frontier:**
  - **LHC: ~ 1% participation**
  - **ILC: hopefully (5-10)% participation if any**

2. Projects in China

- Reactor-based

Daya Bay: A new type of neutrino oscillation





$Sin^2 2\theta_{13} = 0.092 \pm 0.016(stat) \pm 0.005(syst)$

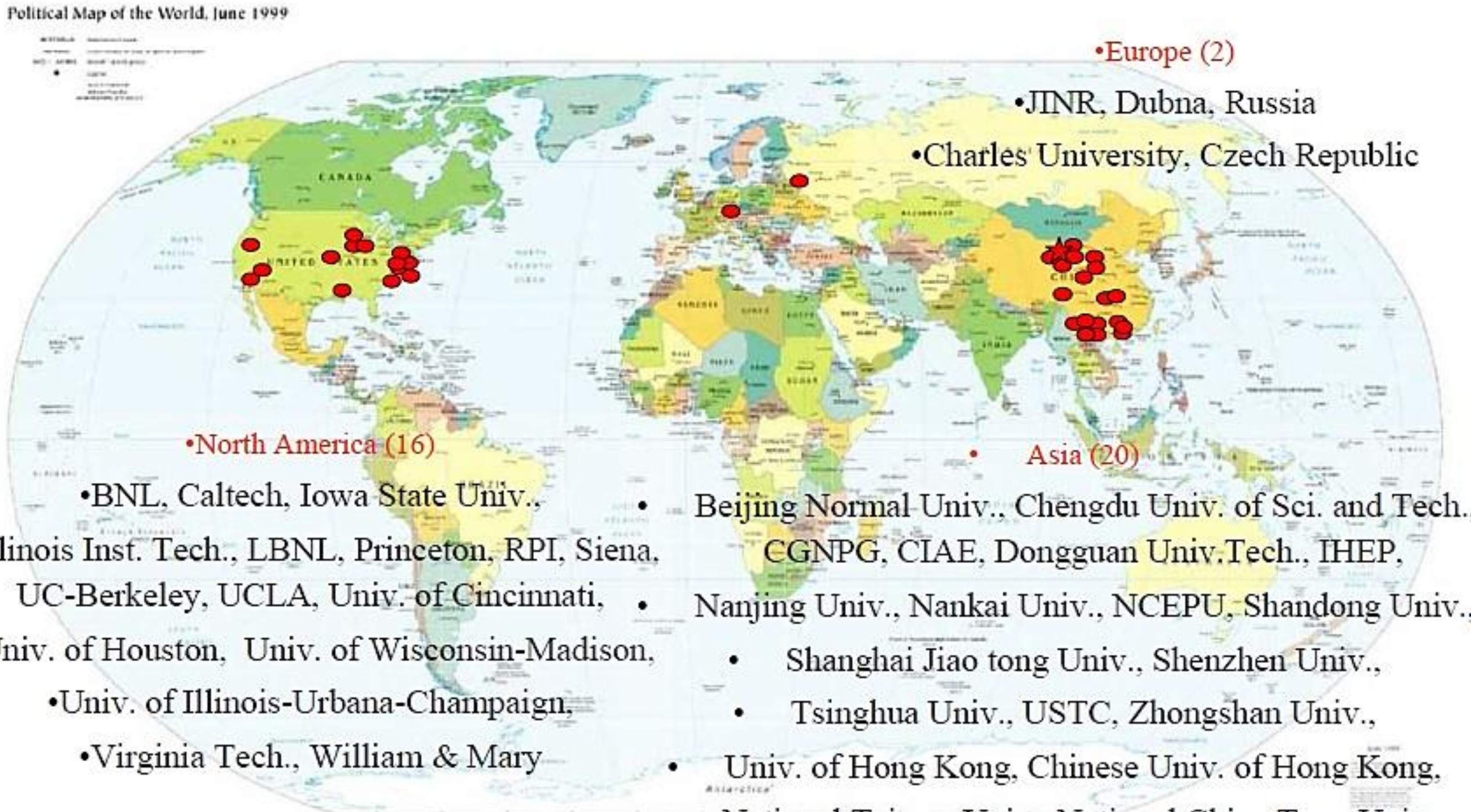
F.P. An et al., NIM. A 685(2012)78; Phys. Rev. Lett. 108, (2012) 171803

$Sin^2 2\theta_{13} = 0.089 \pm 0.010\ (stat) \pm 0.005(syst)$

$\chi^2/NDF = 3.4/4$, 7.7 σ for non-zero θ_{13}

F.P. An et al., Chin. Phys.C 37(2013) 011001

The Daya Bay Collaboration



•Europe (2)
- •JINR, Dubna, Russia
- •Charles University, Czech Republic

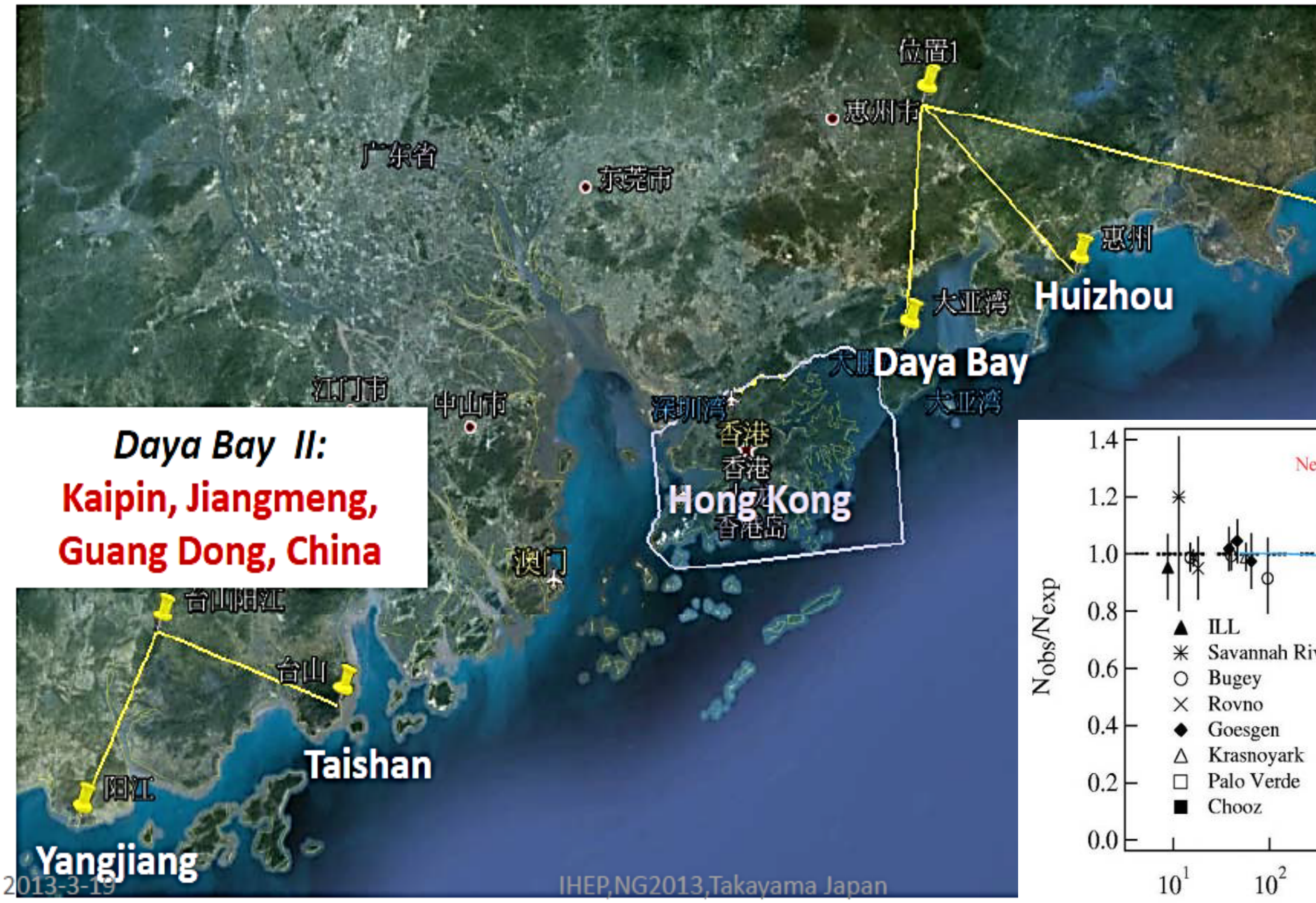
•North America (16)
- •BNL, Caltech, Iowa State Univ.,
- •Illinois Inst. Tech., LBNL, Princeton, RPI, Siena, UC-Berkeley, UCLA, Univ. of Cincinnati,
- •Univ. of Houston, Univ. of Wisconsin-Madison,
- •Univ. of Illinois-Urbana-Champaign,
- •Virginia Tech., William & Mary

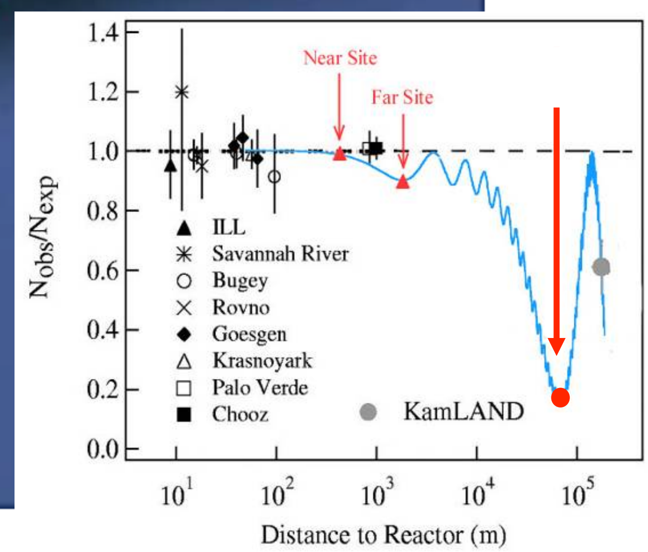
• Asia (20)
- Beijing Normal Univ., Chengdu Univ. of Sci. and Tech., CGNPG, CIAE, Dongguan Univ.Tech., IHEP,
- Nanjing Univ., Nankai Univ., NCEPU, Shandong Univ.,
- Shanghai Jiao tong Univ., Shenzhen Univ.,
- Tsinghua Univ., USTC, Zhongshan Univ.,
- Univ. of Hong Kong, Chinese Univ. of Hong Kong,
- National Taiwan Univ., National Chiao Tung Univ.,
- National United Univ.

~250 Collaborators

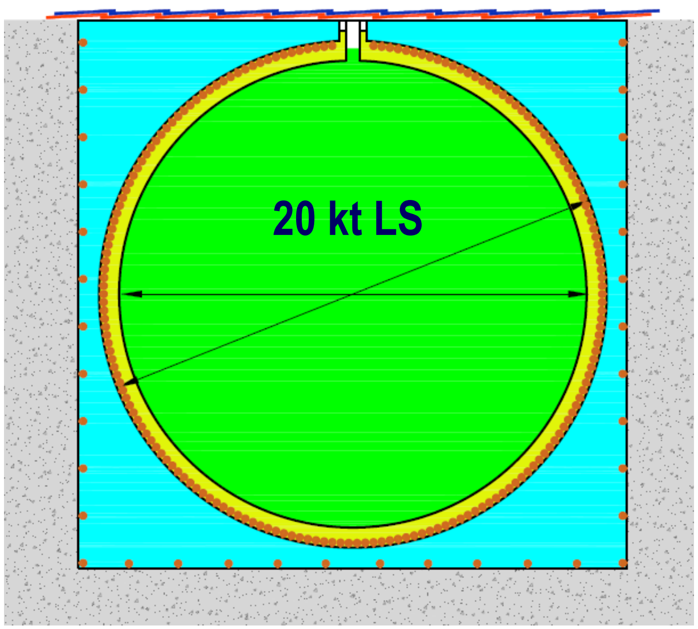
New site：Kaiping county, Jiangmen city

	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 (~2017)	18.4 GW(~2014,?)

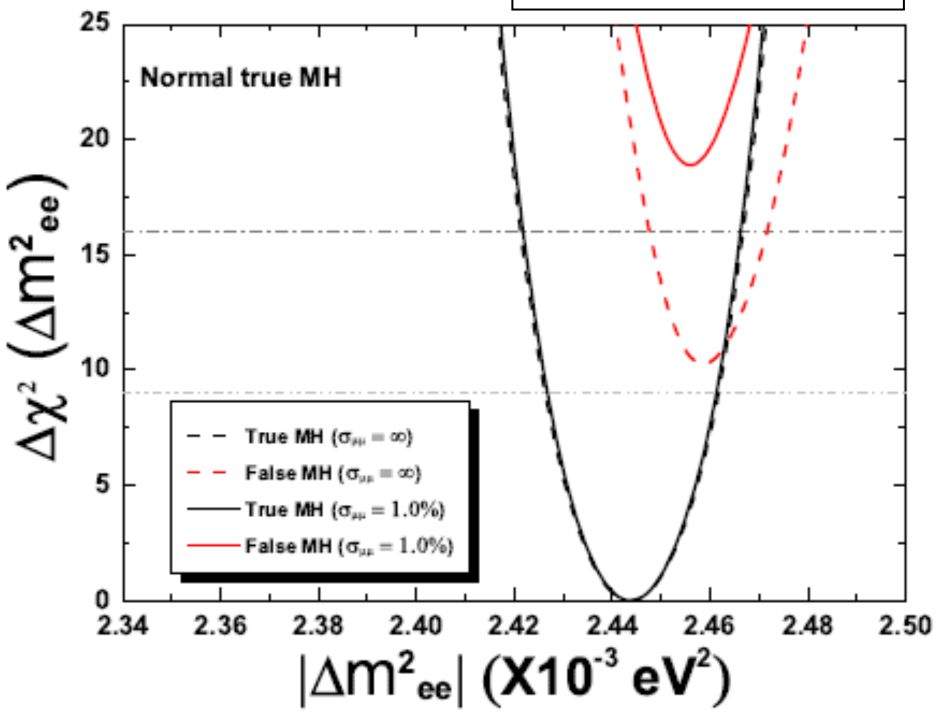




Physics reach of DYBII



arXiv:1303.6733



	Current	DYB II
Δm^2_{12}	3%	0.6%
Δm^2_{23}	5%	0.6%
$\sin^2\theta_{12}$	6%	0.7%
$\sin^2\theta_{23}$	20%	N/A
$\sin^2\theta_{13}$	14% ➔ 4%	~ 15%

- Mass Hierarchy
- Mixing parameters
- Supernova neutrinos
- Geoneutrinos
- Sterile neutrinos

3. Projects in Korea

- Accelerators

Current Accelerator Activities in Korea (2013)

PLS-II (3.0-GeV Light Source)

Full operation:
at the end of 2014

10-GeV
PAL-XFEL

Ground-breaking
Ceremony: May, 2013

RAON, Rare
Isotope Acc.

SC Cyclotron for
Carbon Therapy

KOMAC, 100-MeV
Proton Linac

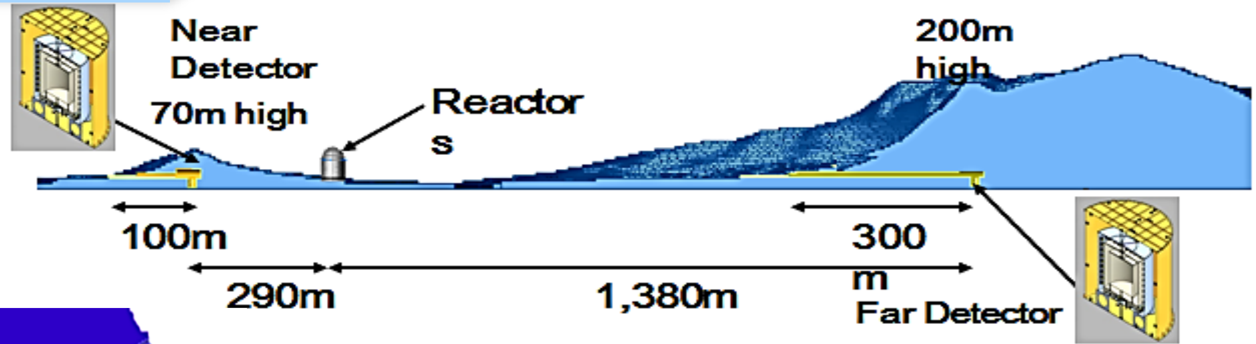
- Project period : 2011.12-2018.02
- Budget : 460BWon (1BWon~1M$)

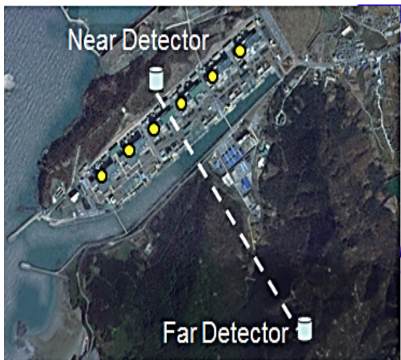
Commissioning
June, 2013

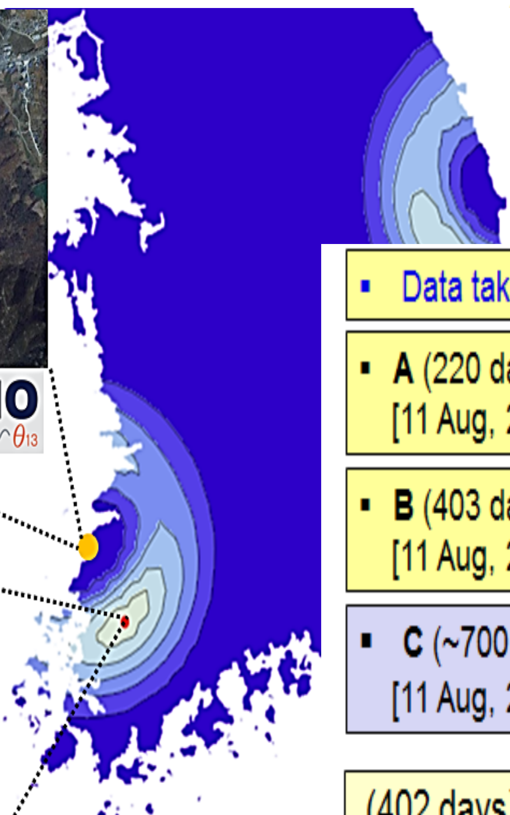
3. Projects in Korea

- Reactor-based

KNRC
Korea Neutrino Research Center







RENO

RENO Status

- Data taking began on Aug. 1, 2011 with both near and far detectors.
- **A** (220 days) : First θ_{13} result $\sin^2 2\theta_{13} = 0.113 \pm 0.013\,(stat) \pm 0.019\,(syst)$
  [11 Aug, 2011~26 Mar, 2012] PRL 108, 191802 (2012)
- **B** (403 days) : Improved θ_{13} result $\sin^2 2\theta_{13} = 0.100 \pm 0.010\,(stat) \pm 0.015\,(syst)$
  [11 Aug, 2011~13 Oct, 2012] NuTel 2013
- **C** (~700 days) : Shape+rate analysis (in progress) (expected total error: ~0.01)
  [11 Aug, 2011~31 Jul, 2013]

(402 days) 0.100 ± 0.018 (5.6 σ) ⇨ ± 0.007 (~ 14 σ) (5 years)

(7 % precision)

RENO-50

18 kton LS Detector
~47 km from YG reactors

Mt. Guemseong (450 m)
~900 m.w.e. overburden

Overview of RENO-50

- **RENO-50** : An underground detector consisting of 18 kton ultra-low-radioactivity liquid scintillator & 15,000 20" PMTs, at 50 km away from the Hanbit(Yonggwang) nuclear power plant

- **Goals** : - Determination of neutrino mass hierarchy
- High-precision measurement of θ_{12}, Δm^2_{21} and Δm^2_{31}
- Study neutrinos from reactors, the Sun, the Earth, Supernova, and any possible stellar objects

- **Budget** : \$ 100M for 6 year construction
(Civil engineering: \$ 15M, Detector: \$ 85M)

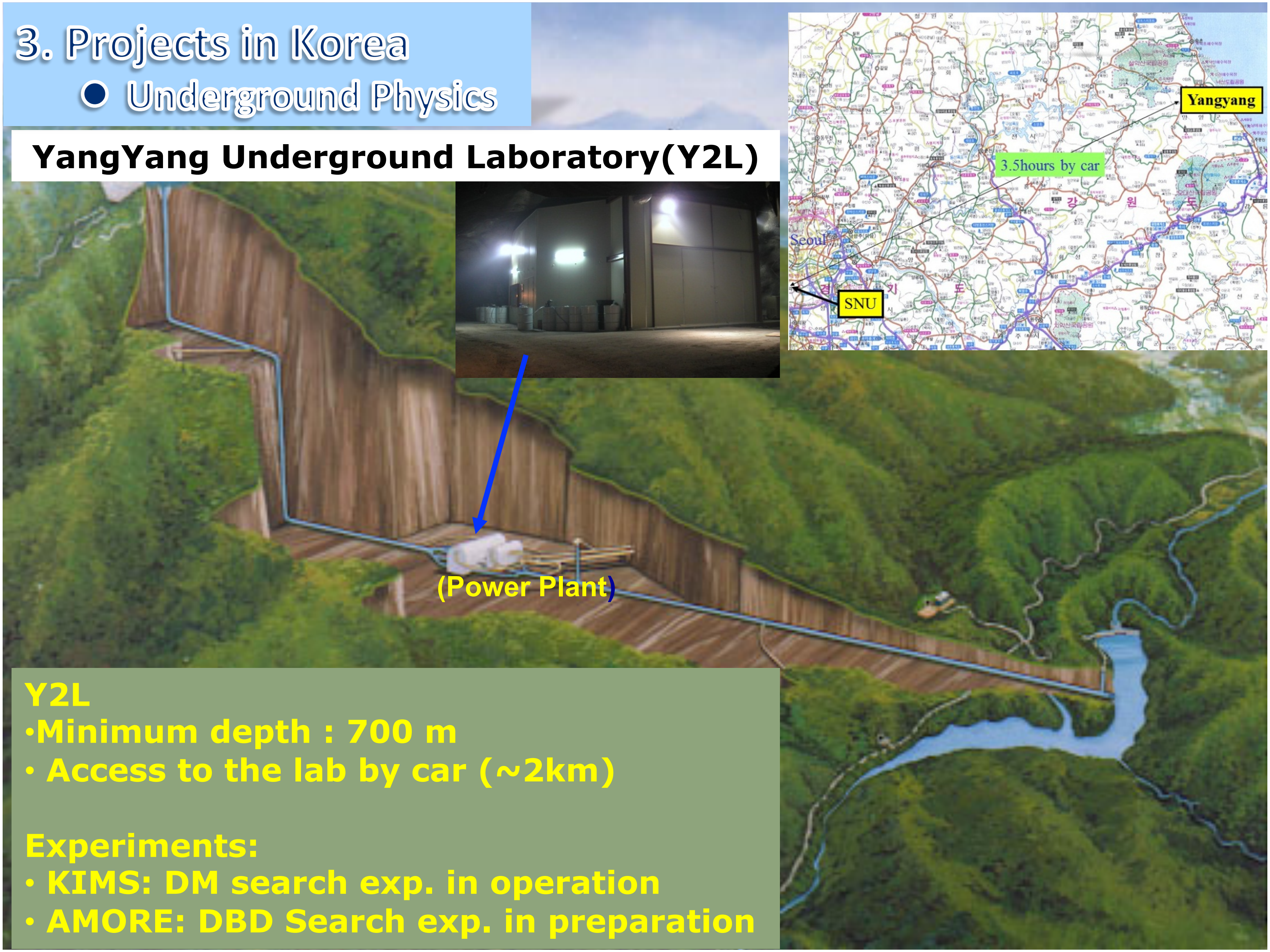
- **Schedule** : 2013 ~ 2018 : Facility and detector construction
2019 ~ : Operation and experiment

not yet approved

3. Projects in Korea

● Underground Physics

YangYang Underground Laboratory(Y2L)



Y2L
- Minimum depth : 700 m
- Access to the lab by car (~2km)

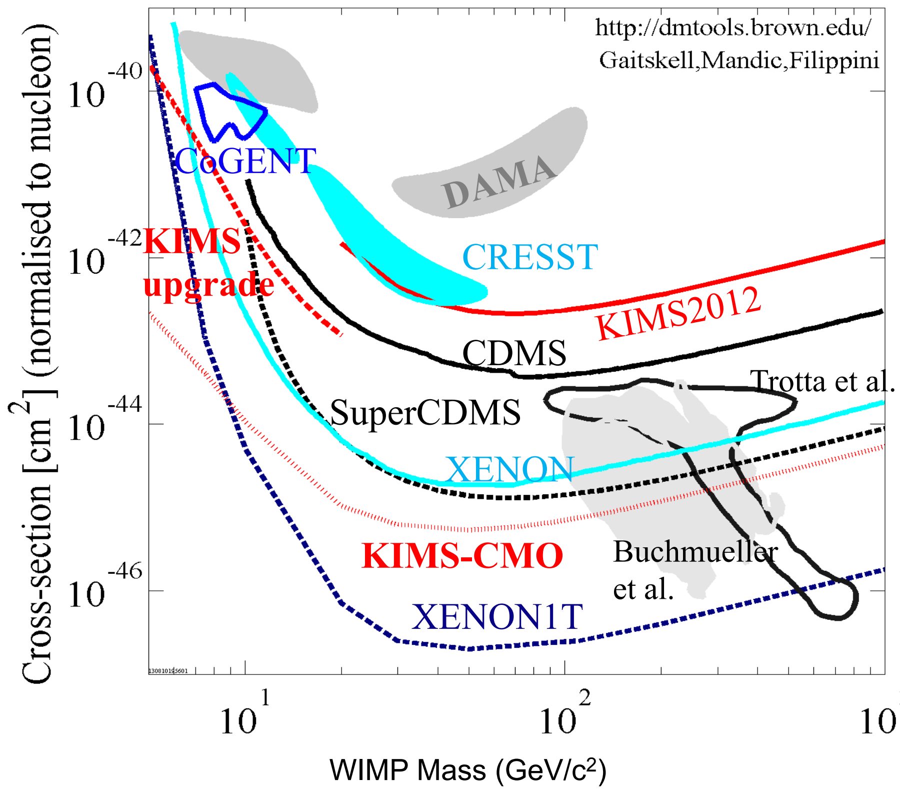
Experiments:
- KIMS: DM search exp. in operation
- AMORE: DBD Search exp. in preparation

KIMS+ Projects

I. **KIMS-CsI : Upgrade of CsI(Tl) crystal detector**
- Lower threshold ~ 1.5keV, <1dru, counts/(keV kg day).
- This will help to clear issues about the modulation signals of DAMA.

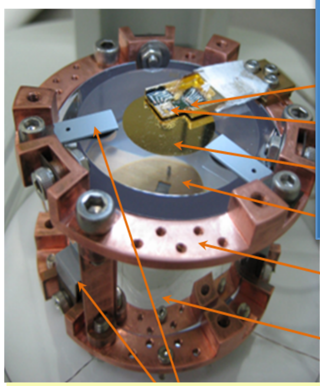
II. **KIMS-NaI : new NaI(Tl) detector**
- Duplicate DAMA experiment with ultra-low background NaI(Tl) crystals.
- 200kg run in 2015-2016

III. **KIMS-CMO**
- ${}^{nat}Ca^{nat}MoO_4$ crystals ~ 200 kg year.
- High sensitivity in low mass WIMP.
- 2019-2022

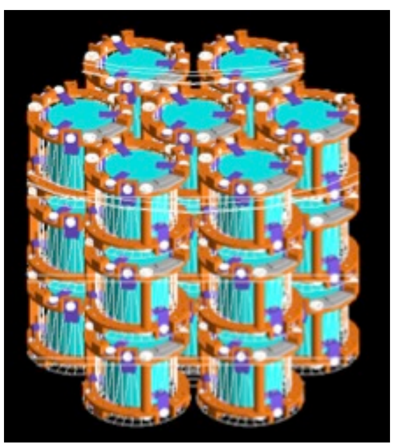


AMoRE – 0νββ experiment

- Detector : 200 kg of $^{40}Ca^{100}MoO_4$ scintillating bolometer.
- Reach "zero background" for 3 years data.
- $<m_{ee}> \sim$ 30-50 meV
- AMoRE-10kg (2016-2017) → 200kg (2019-2022)



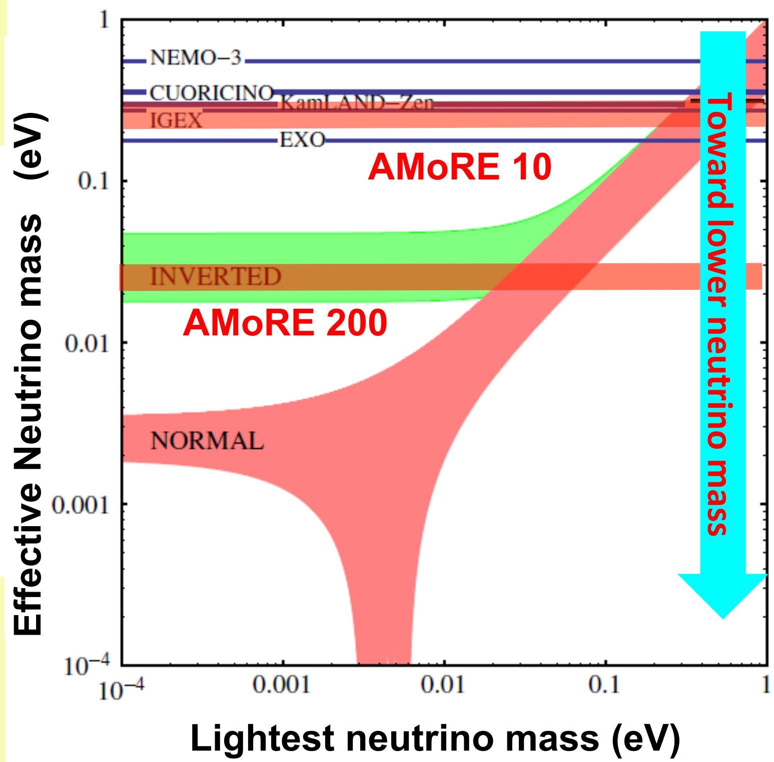
$CaMoO_4$ Bolometer
4cm(D)x4cm(L), 211g
Energy resolution
10 keV(2013) → 5 keV (2015)

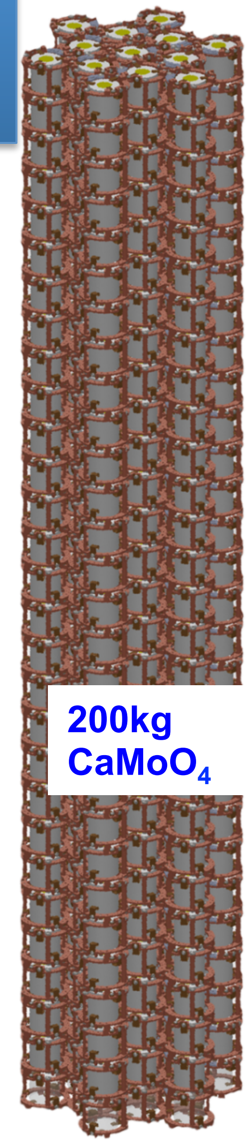


1^{st} phase
10 kg setup
AMoRE-10

2^{nd} phase
200 kg
setup

AMoRE -200

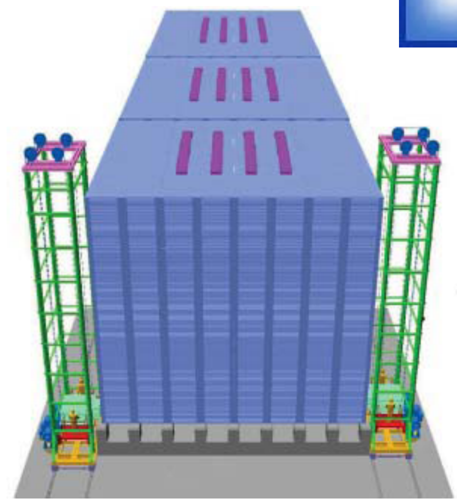


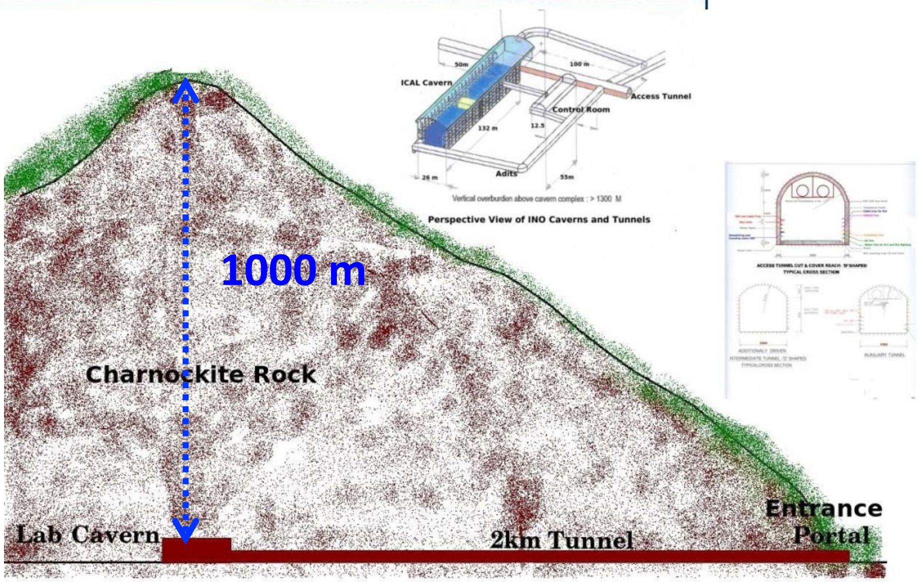


4. Projects in India

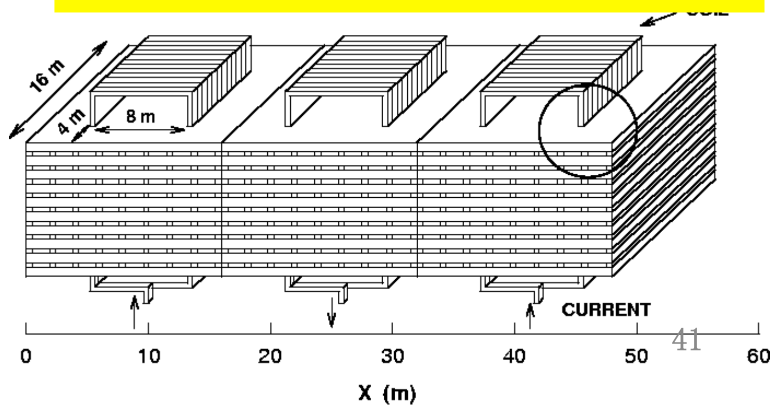
- Underground Physics

INO : India-based Neutrino Observatory





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



Digging deep for neutrinos

Delayed because its original site was on an elephant corridor, work on a giant underground neutrino observatory is now finally getting under way, as **Pallava Bagla** reports

India is embarking on an ambitious project to catch and detect the world's lightest subatomic particle: the neutrino. In an attempt to bag these elusive entities, the country is planning a giant experiment in a subterranean cavern in a site in southern India more than a kilometre beneath the Earth's surface. Called the India-based Neutrino Observatory (INO), it will be India's largest ever single investment towards an experiment in basic science. The Rs18.5bn ($350m) lab is expected to be operational – with the first of three detector modules in place – by 2017. When complete, it will also boast the world's largest magnet, made from some 50 000 tonnes of iron, and 30 000 particle detectors.

India hopes that the INO will help the country to reclaim its leading position in neutrino research – a field in which it was a pioneer back in the early 1960s. It was then that a team from the Tata Institute

India-based Neutrino Observatory

Going underground The India-based Neutrino Observatory, with project spokesperson Naba Mondal pictured left, will be built in a cavern under this mountain in the south-eastern state of Tamil Nadu.

PHYSICS WITH ATMOSPHERIC NEUTRINOS

- *Reconfirm neutrino oscillations from distortion in L/E*
- *Measure* $|\Delta m^2_{31}|$ *and* $\sin^2 2\theta_{23}$
- *Determine the neutrino mass hierarchy*
- *Determine the deviation of* θ_{23} *from* 45^o *and its octant*
- *Other (new) physics (sterile neutrinos, NSI, CPTV, LIV, Long range forces….)*
- *Very high energy neutrinos and muons*

LIGO

Laser Interferometer Gravitational wave Observatory

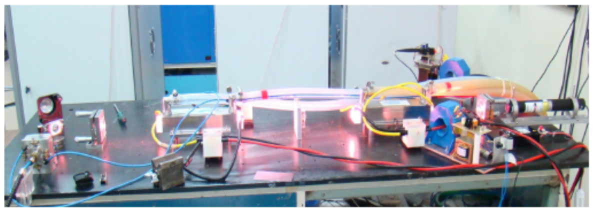
- Gravitational Wave (GW) science holds the potential to address some of the key questions in fundamental physics, astrophysics and cosmology - General Relativity
- Interferometric GW detectors have been built in the USA (LIGO), Europe (GEO600 and VIRGO) and Japan (TAMA300).
- Originally LIGO was an international collaboration involving the LIGO-USA and the Australian consortium for gravitational astronomy (ALIGO)
- The project has now been formally offered to India
- 16 Indian institutions are expected to participate in the project.
- NSF USA will contribute towards setting up the facility

4. Projects in India

● ILC Activity

RRCAT, Laser Welding Technology for SRF Cavity Fabrication

20 kW Nd:YAG fiber-coupled laser



Prototype 3.9 GHz SCRF Nb cavity

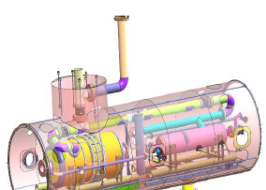
Prototype 1.3GHz cavity Nb half cells welded

9-cell copper cavity

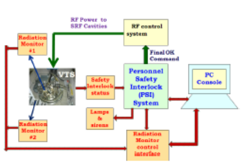
RRCAT, SCRF Cavity Test Setups

VTS Cryostat & Cavity Insert Assy

RF Supply for VTS



Internal Configuration of HTS (with cryogen piping)



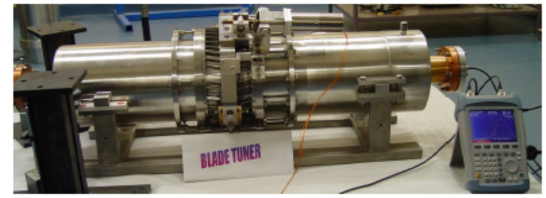
Block Diagram of VTS PSI System

VTS PSI Rack

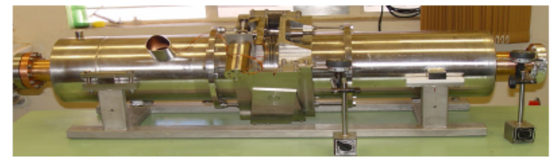
RRCAT, Development of 1.3 GHz tuner and testing

Development of two types of 1.3 GHz SCRF cavity tuners have been taken up.

- Blade tuner fabrication and testing.
- Scissor tuner design, analysis and fabrication.



1.3 GHz Prototype Dressed Cavity with Blade Tuner

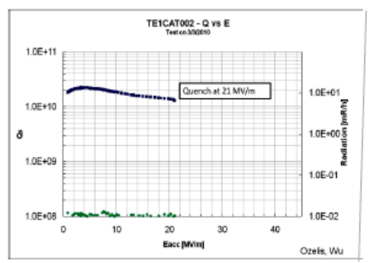


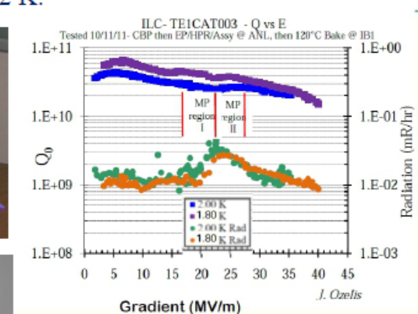
Development of Single Cell 1.3 GHz SCRF Cavities at RRCAT - IUAC Under Indian Institutions & Fermilab Collaboration

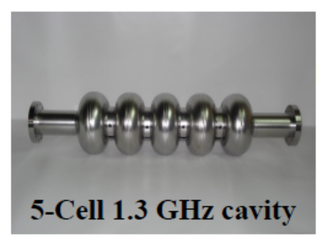
First Indian 1.3 GHz superconducting cavity performance measured at Fermilab. Maximum accelerating field of 21 MV/m at Q > 1 E+10 achieved at 2 K.

Subsequently, two more cavities have been fabricated and processed under IIFC to improve the performance.

These cavities have exhibited accelerating gradients up to 37.5MV/m with a Q > 1 E+10 at 2 K.







5-Cell 1.3 GHz cavity

5. Summary

Particle Physics Activity in Asia