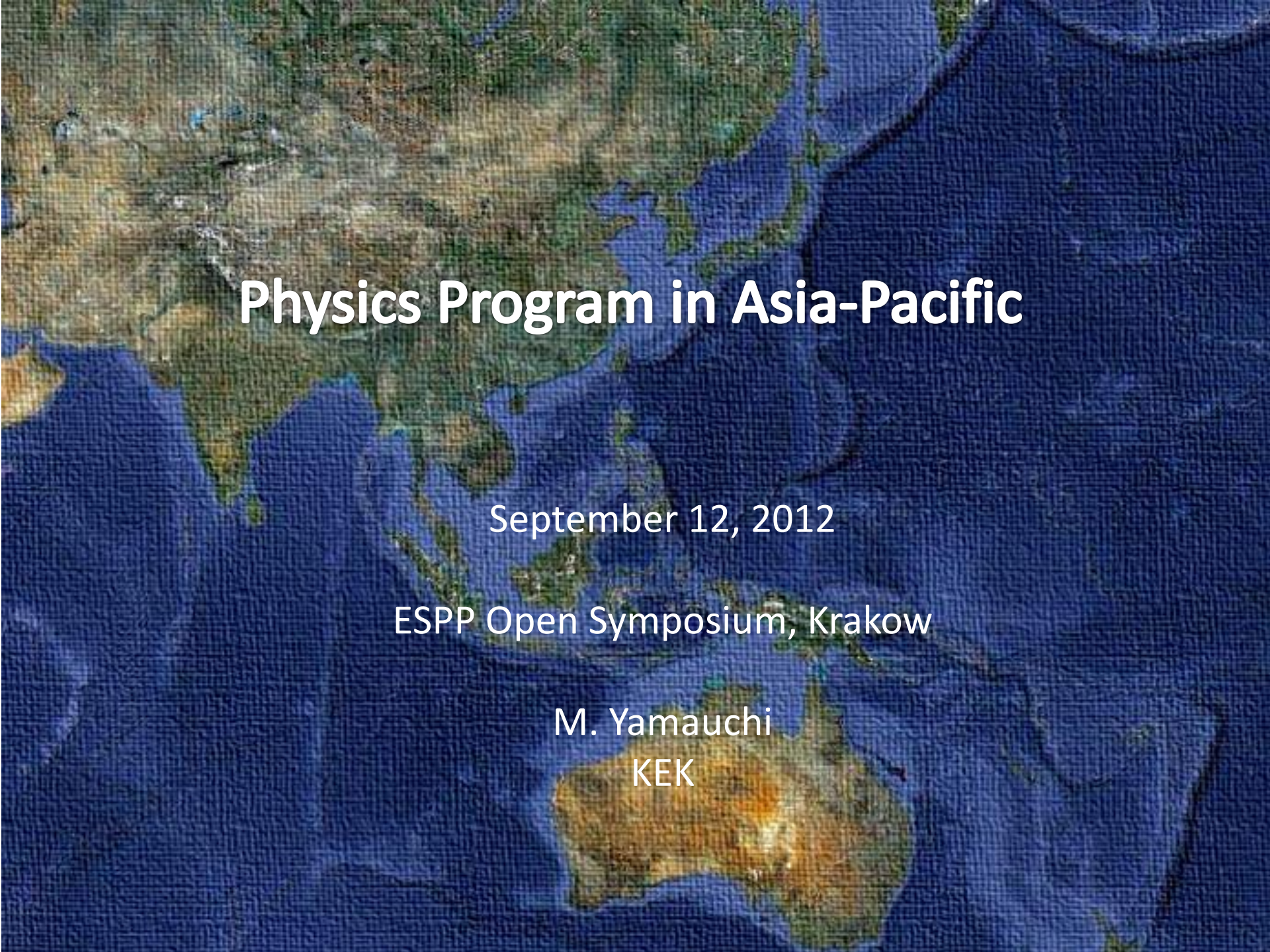


Physics Program in Asia-Pacific

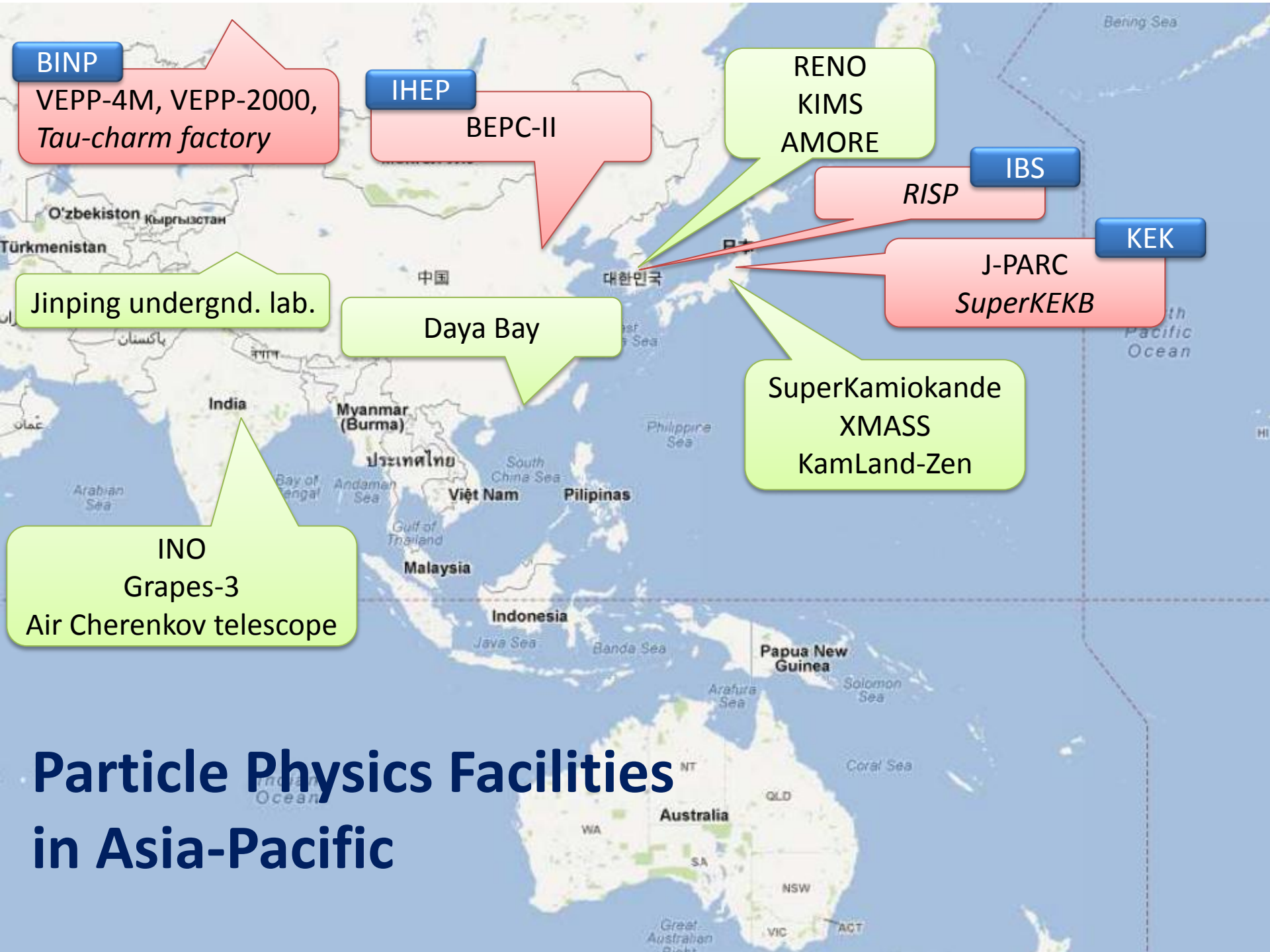
September 12, 2012

ESPP Open Symposium, Krakow

M. Yamauchi
KEK

Outline

- Introduction
- High energy accelerators in Asia-Pacific and their future plan
- Non-accelerator physics facilities in Asia-Pacific and their future plan
  - Reactor neutrino experiments
  - Deep underground observatories
- ILC – Plan in Japan
- Summary



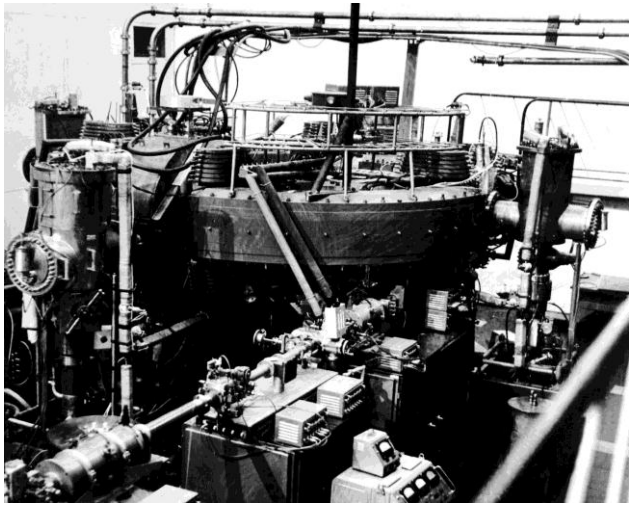
Particle Physics Facilities in Asia-Pacific

From VEP-1 to Tau-charm factory

BINP

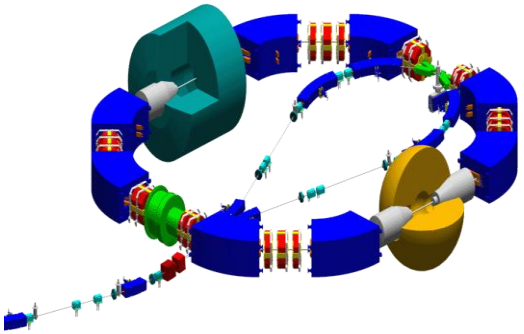
VEP-1

VEPP-2



VEPP-3

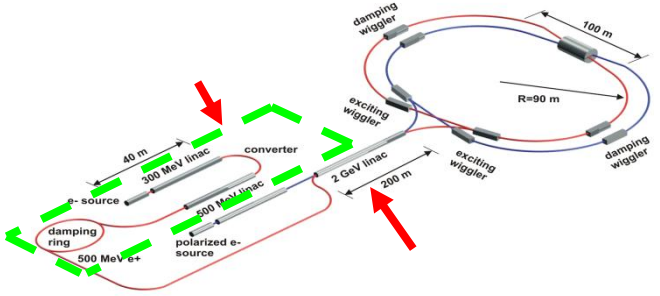
VEPP-2000



VEPP-4M

VEPP-4

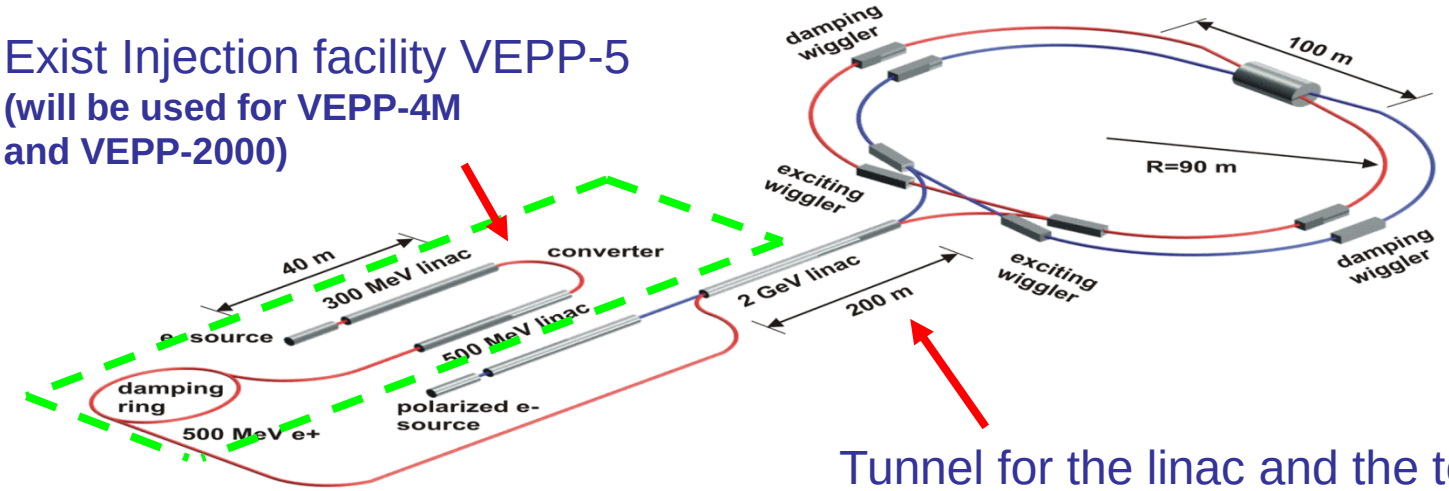
Tau-charm



Novosibirsk Super Tau-Charm factory

BINP

Exist Injection facility VEPP-5
(will be used for VEPP-4M and VEPP-2000)



Tunnel for the linac and the technical straight section of the factory is ready

L = 1035 cm-2s-1, Variable energy Ecm= 2 – 5 GeV**

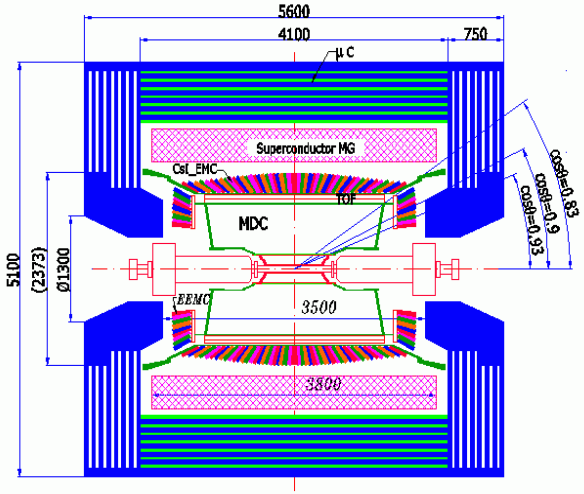
- D-Dbar mixing
- CP violation searches in charm decays
- Rare and forbidden charm decays
- Standard Model tests in τ leptons decays
- Searches for lepton flavor violation $\tau \rightarrow \mu\gamma$
- CP/T violation searches in τ leptons decays

Waiting for green light from the Russian Government. Project evaluation by the new government will start soon.

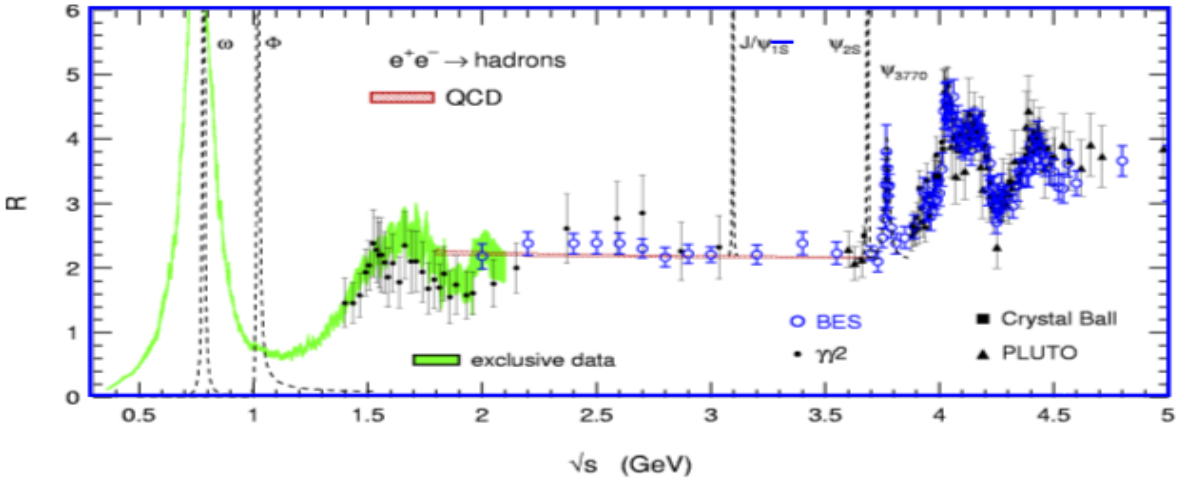
BEPCII/BESIII: Status and Plan

IHEP

	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) 2013：4/fb
R scan & Tau	BESII	2014



BESIII Detector (Option 2)



BESIII will continue for the next 8-10 years

Science Business Belt &
Rare Isotope Science Project (RISP)

Fully funded by Korean Government
First beam expected in 2017

R&D시설

첨단산업시설

정주시설

	Driver Linac				Post Acc.	Cyclotron
Particle	H^{+}	O^{+8}	Xe^{+54}	U^{+79}	RI beam	proton
Beam energy(MeV/u)	600	320	251	200	18.5	70
Beam current(pμA)	660	78	11	8.3	-	1000
Power on target(kW)	400	400	400	400	-	70

Electron machines in Tsukuba and proton machines in Tokai

KEK

Tokai

Tsukuba

Sapporo

Honshu

Nagoya

Kobe

Osaka

Chiba

Fukuoka

Shikoku

Kyushu

Tanega-shima

© 2010 ZENRIN
© 2010 Europa Technologies
© 2010 Geocentre Consulting
Data © 2010 MIRC/JHA
38°24'54.24" N 139°30'09.59" E elev 42 m

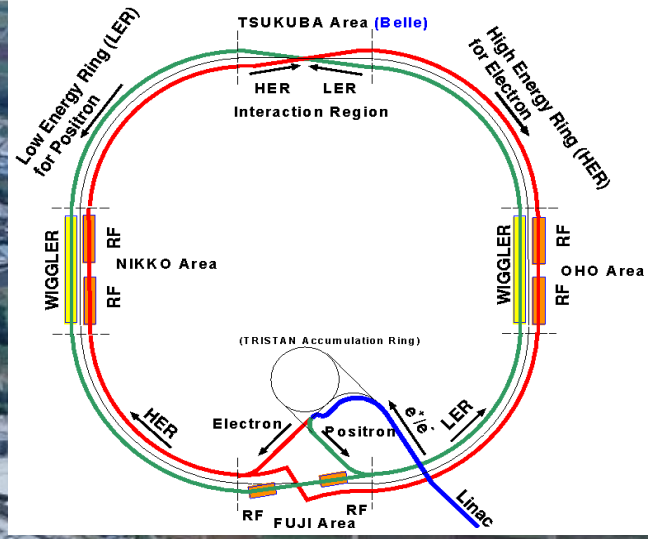
©2010 Google

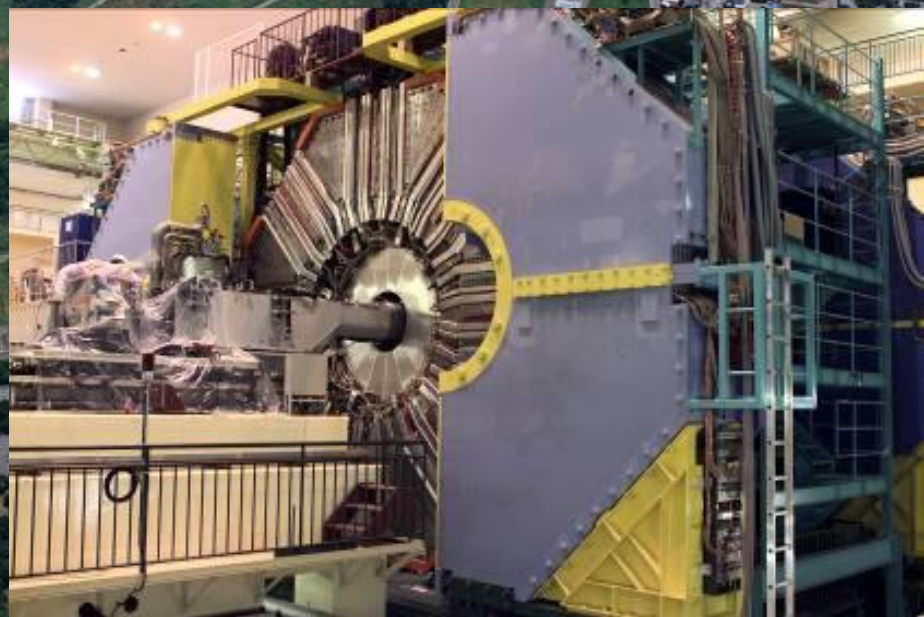
Eye alt 2182.40 km

KEKB and Belle

KEK

SuperKEKB and Belle II

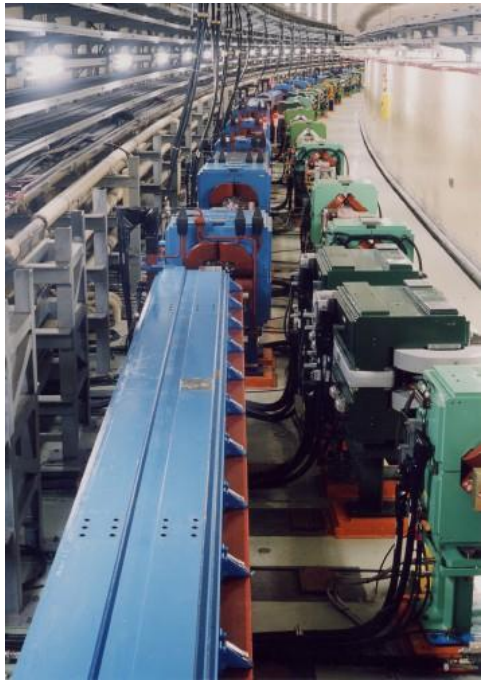


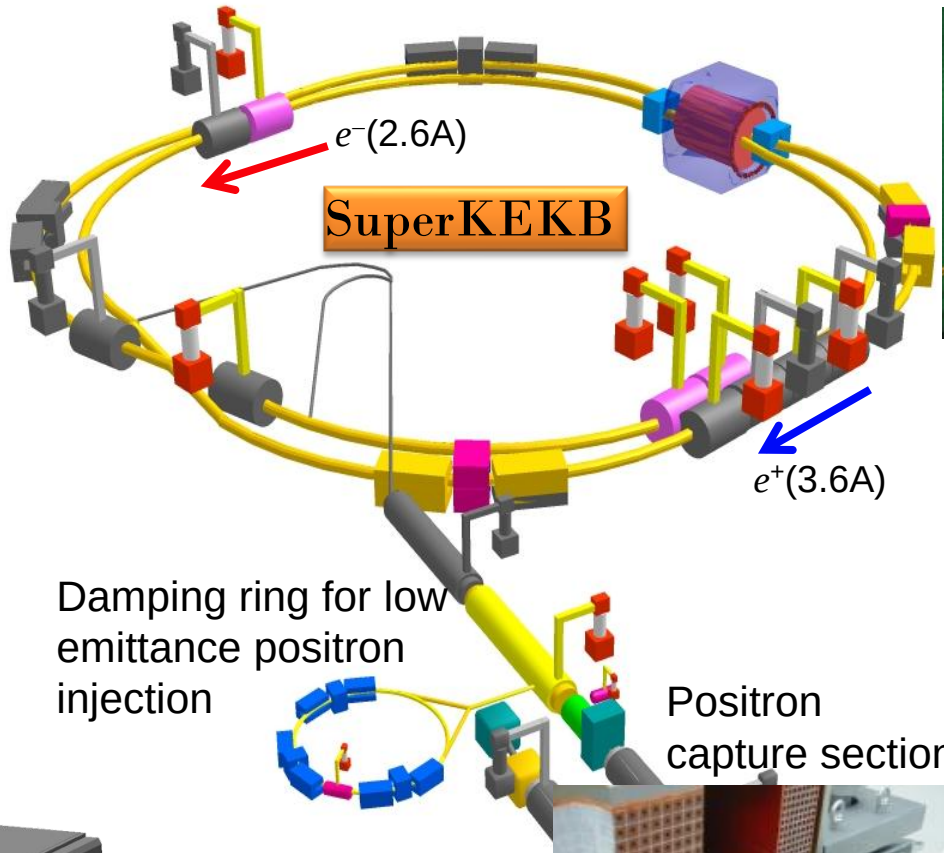


KEKB upgrade to SuperKEKB

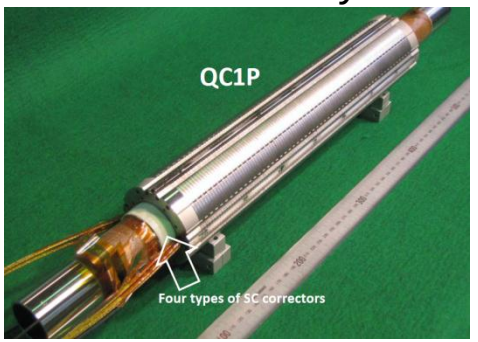
Beam commissioning scheduled in 2015

Low emittance lattice





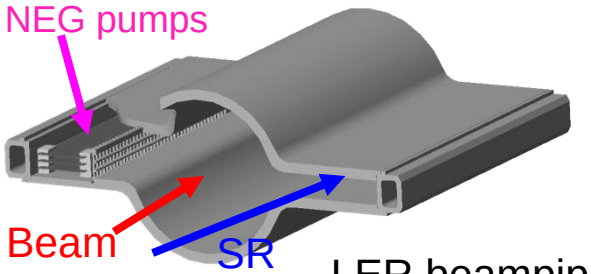
IR with β_y*=0.3mm
SC final focus system



Add RF systems for higher beam current

Damping ring for low emittance positron injection

Positron capture section

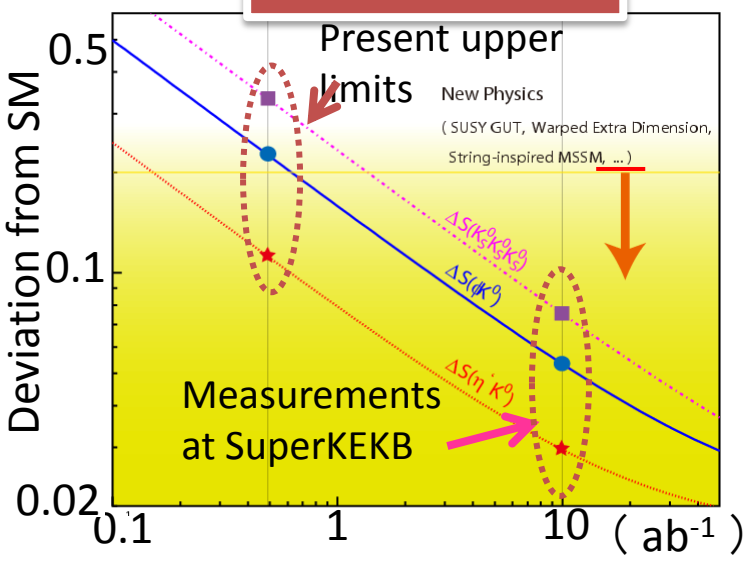


LER beampipe to suppress photoelectron instability

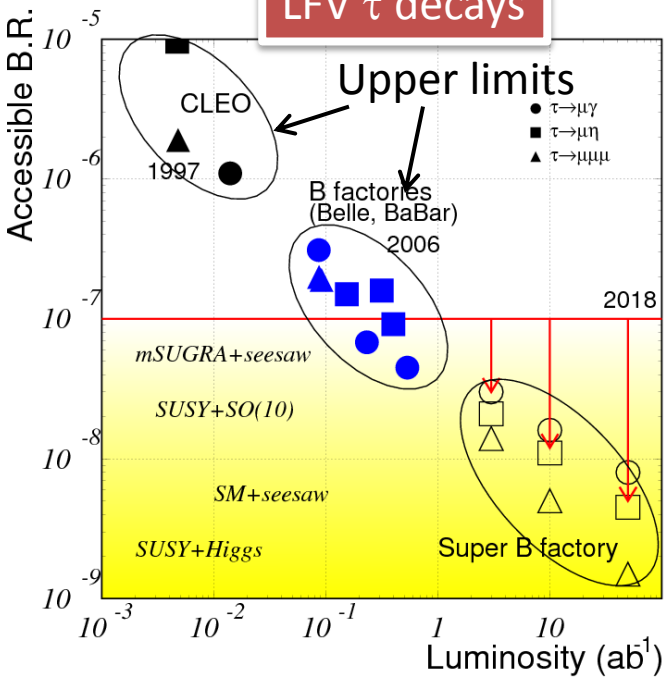
Physics at SuperKEKB

- If New Physics scale is at TeV region,
  - It is natural to assume that the NP effects are seen in $B/D/\tau$ decays.
  - Flavor structure of new physics?
  - CP violation in new physics?
- Otherwise…
  - Search for deviations from SM in flavor physics will be one of the best ways to find new physics.

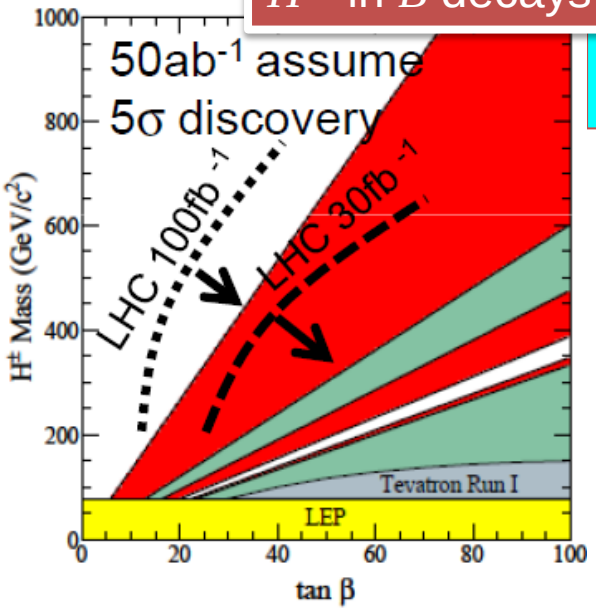
CPV in new FCNC



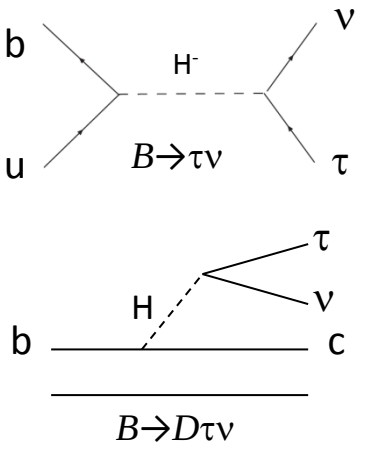
LFV τ decays



$H^{\pm}$ in B decays



B->τν: H-b-u coupling
B->Dτν : H-b-c coupling



European Physicists at Belle-II

~150 physicists from 20 institutions in 9 European countries

cf. 400 physicists from 67 institutions in 20 countries in total

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


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

DAQ and computing

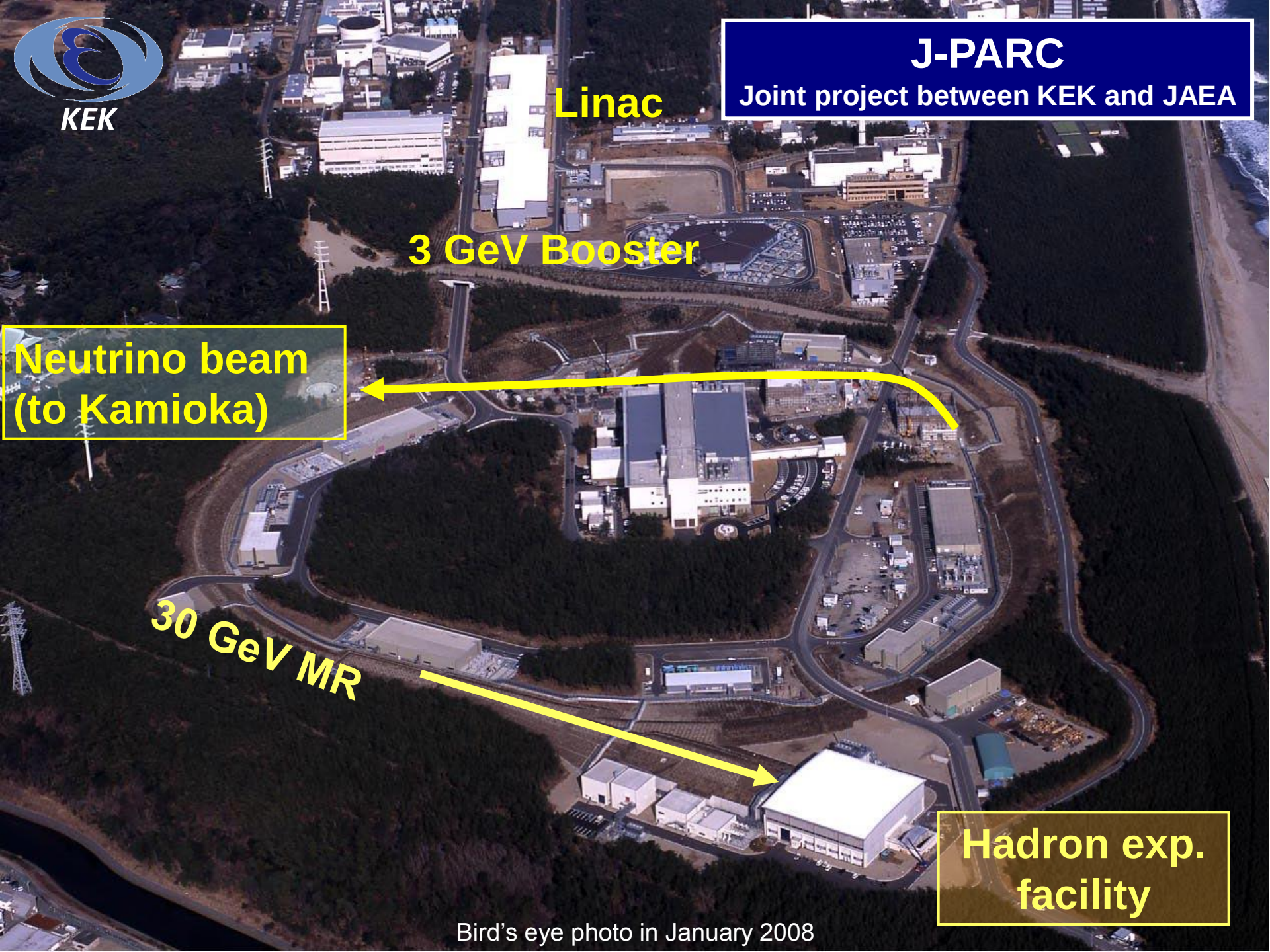
4 layers DS Si Vertex Detector →
2 layers PXD (DEPFET),
4 layers DSSD





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

Central Drift Chamber:
smaller cell size,
long lever arm



Bird's eye photo in January 2008

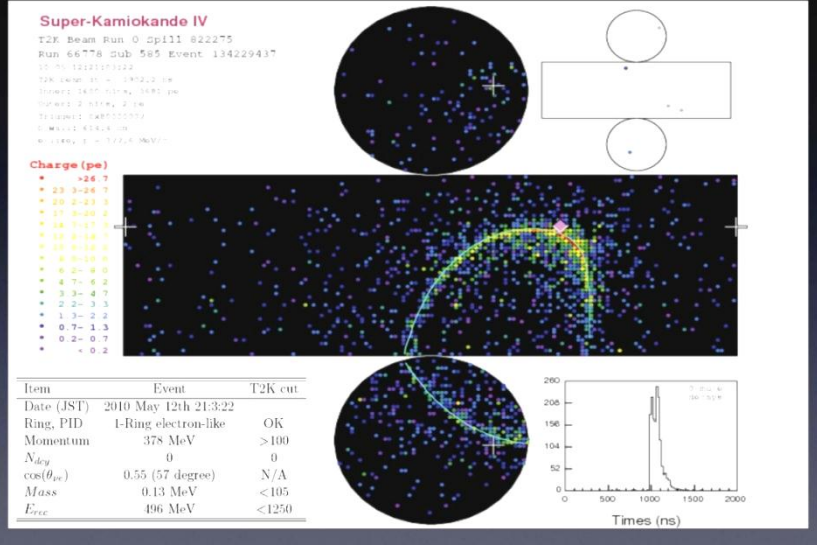
T2K : Long Baseline Neutrino Experiment

Super-Kamiokande
(ICRR, Univ. Tokyo)

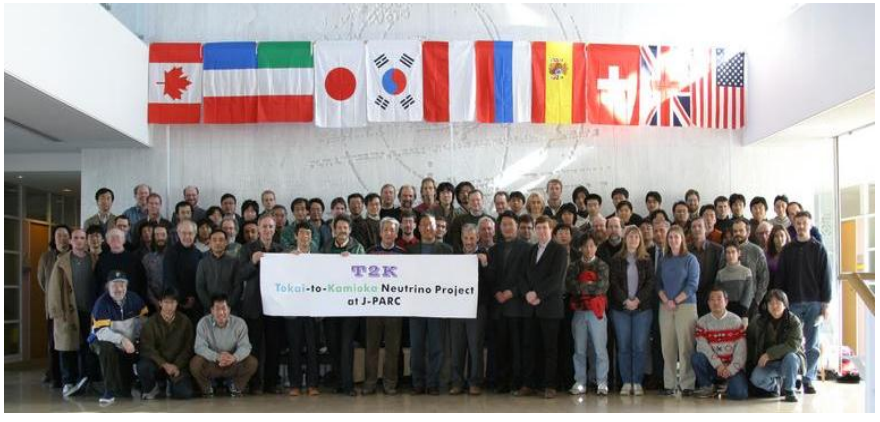
J-PARC Main Ring
(KEK-JAEA, Tokai)

T2K ν_e CC signal candidate (2010a)

Signal candidate event passing all cuts



Item	Event	T2K cut
Date (JST)	2010 May 12th 21:3:22	
Ring, PID	1-Ring electron-like	OK
Momentum	378 MeV	>100
N_{decy}	0	0
$\cos(\theta_{rec})$	0.55 (57 degree)	N/A
Mass	0.13 MeV	<105
E_{rec}	496 MeV	<1250

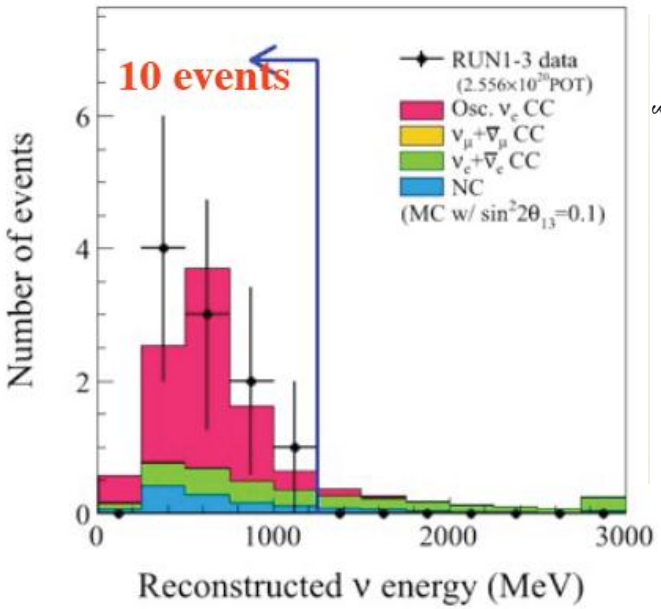


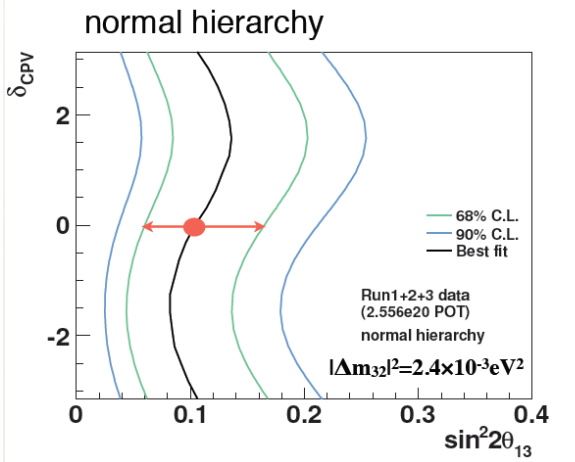
~500 members from 12 Countries:
Japan, US, Canada, France, UK, Switzerland, Poland, Korea, Russia, Spain, Italy, Germany

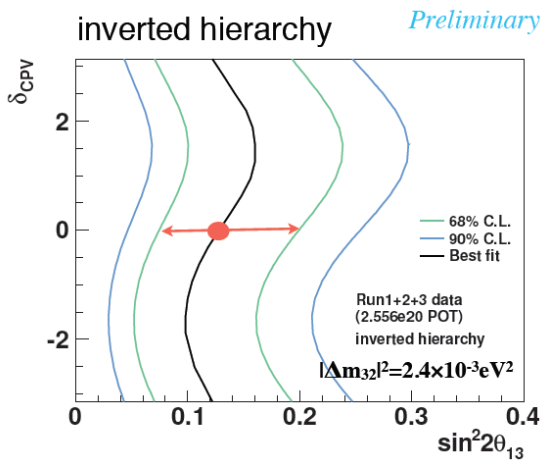
Latest Result of $\nu_\mu \rightarrow \nu_e$ from T2K

All the plots here are preliminary.

2.5x10^{20} POT



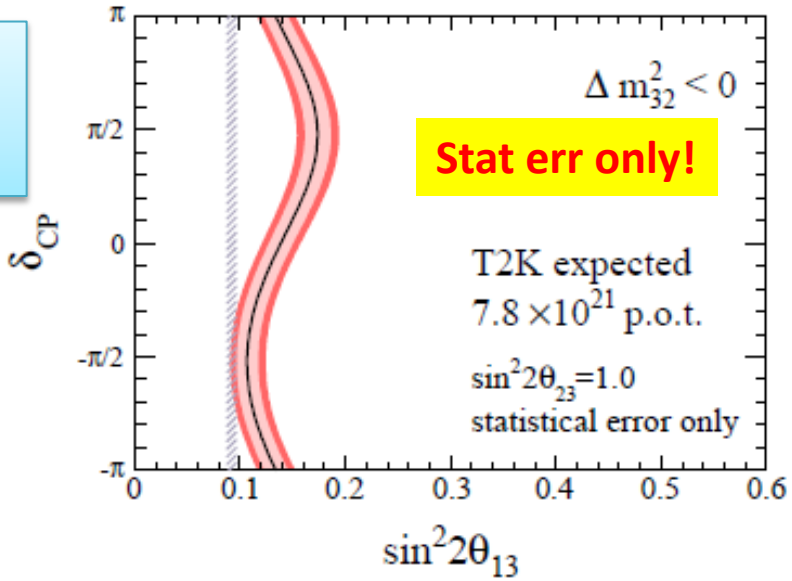




$\sin^2 2\theta_{13}=0.104\ ^{+0.060}_{-0.045}\ @\delta_{CP}=0$ $\sin^2 2\theta_{13}=0.128\ ^{+0.070}_{-0.055}\ @\delta_{CP}=0$

Improvement of both reactor and accelerator experiments will provide first handle on the CP violating complex phase δ_{CP}.

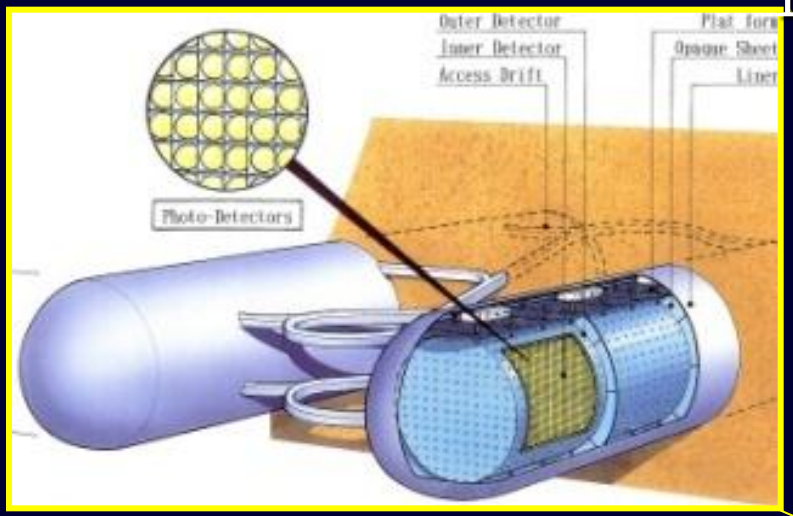
Expectation with ~50 times more data (750kWx 5x10^{7}s)

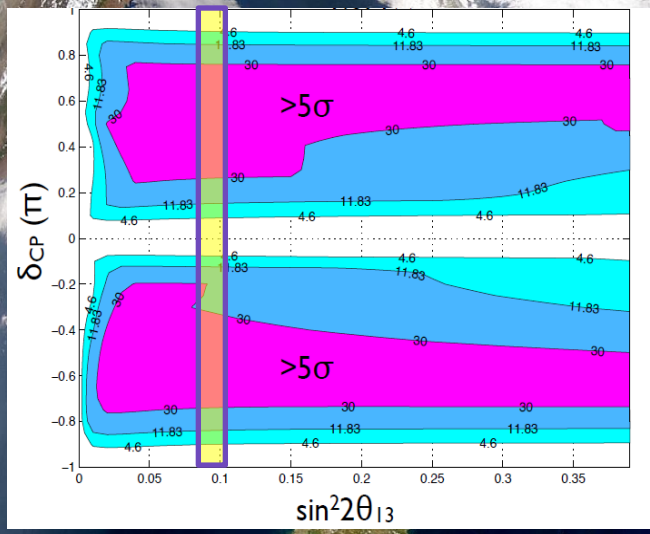


Expected beam power	May 2012	2014	2018
	190kW	300kW	750kW

Next ν program at J-PARC

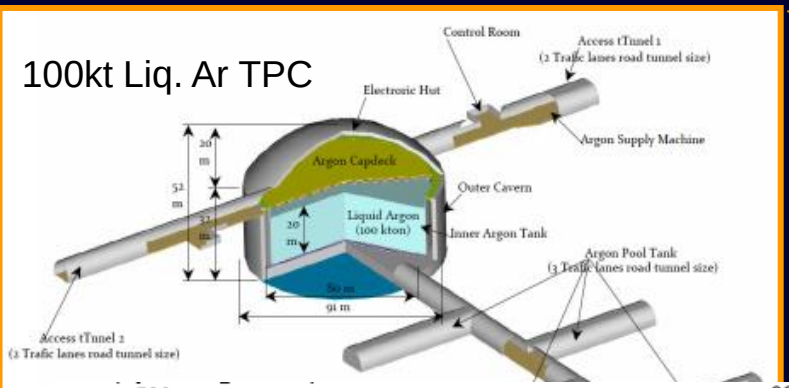
Kamioka L=295km OA=2.5deg

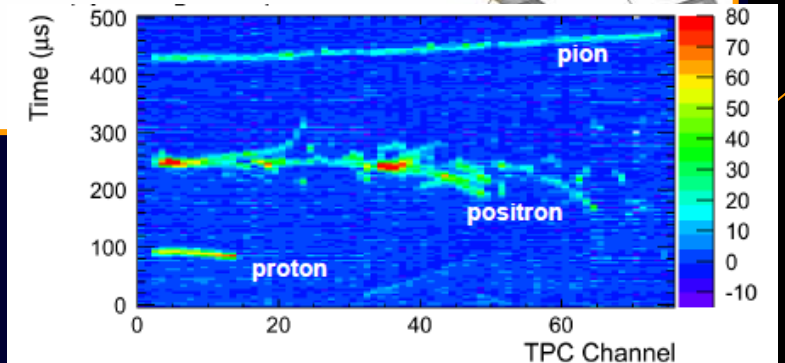




Okinoshima L=658km OA=0.78deg

100kt Liq. Ar TPC





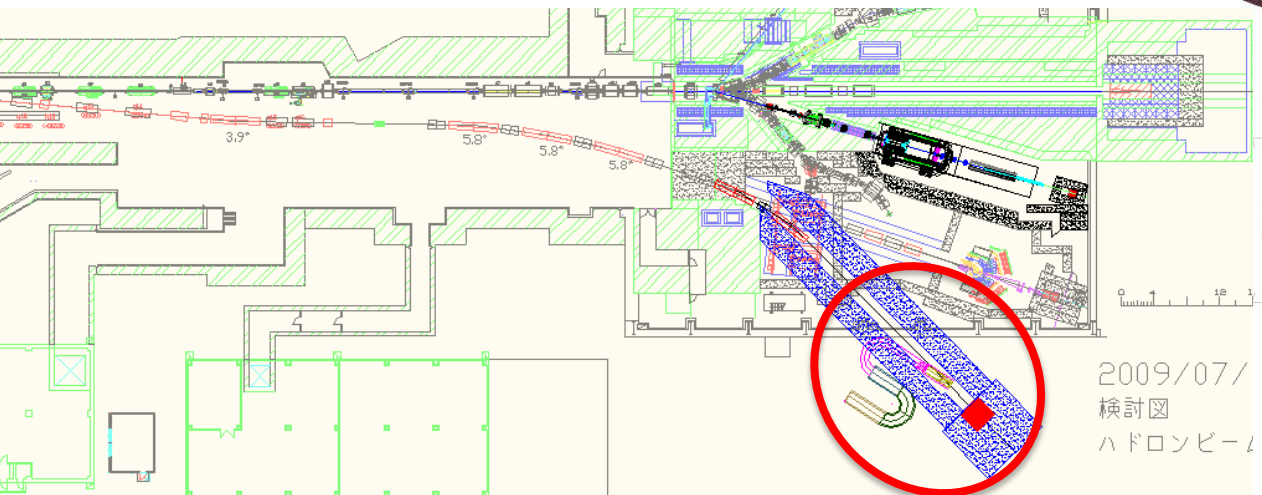
J-PARC
→1.7MW

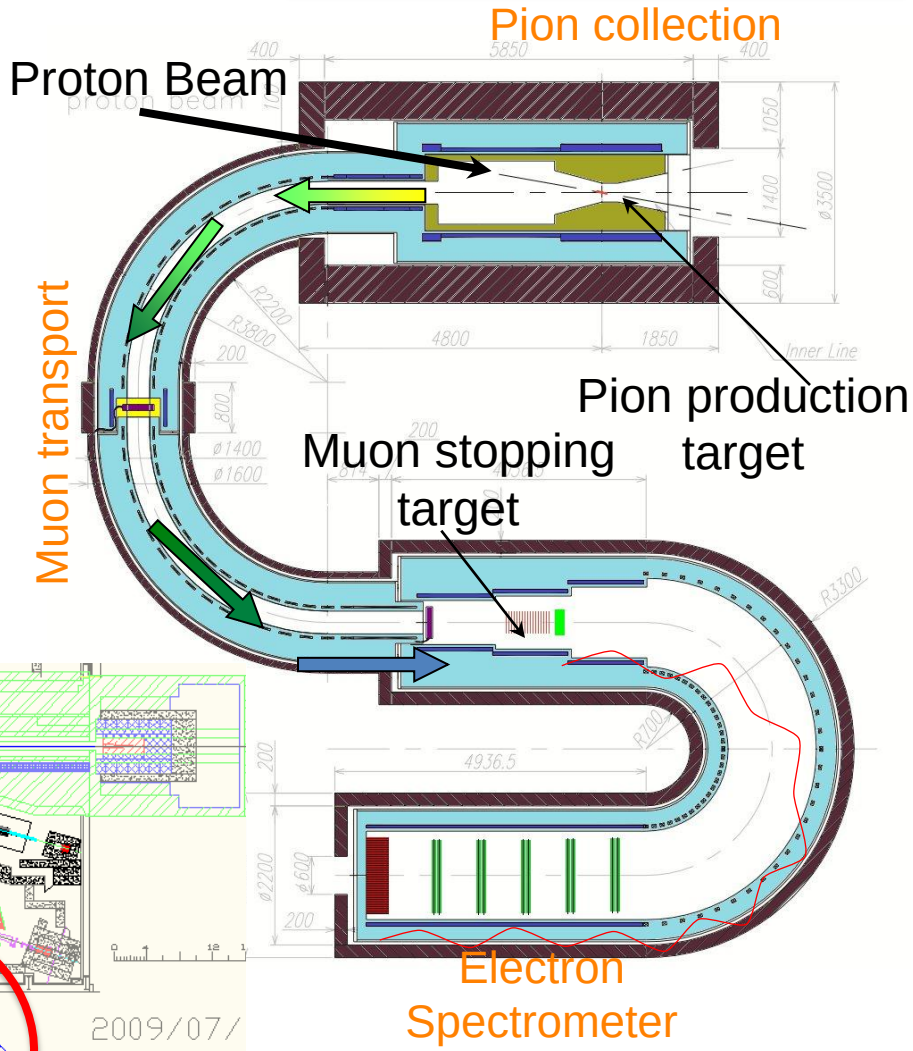
Hope to start construction ~2018

COMET μ-e conv. search

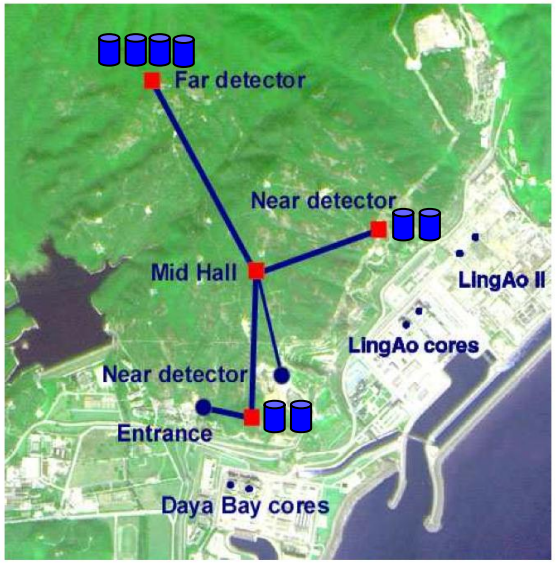
Phase-I phys run in 2017
Full COMET run in 2021-2022

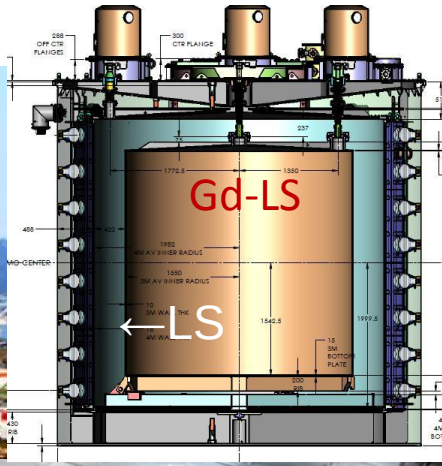
- Search for cLFV mu-e conv.
  - **10^{-16}** sensitivity (Target S.E.S. 2.6×10^{-17})
  - Improve **O(10^4)** than present upper bound such as SINDRUM-II BR[$\mu^- + Au \rightarrow e^- + Au$] < 7×10^{-13}
- Signature: 105MeV monochromatic electron
- Beam requirement
  - 8GeV bunched slow extraction
  - 1.6×10^{21} pot needed to reach goal
  - 7 uA (56kW) x 4 SN year (4×10^7sec)
  - Extinction <10^{-9}

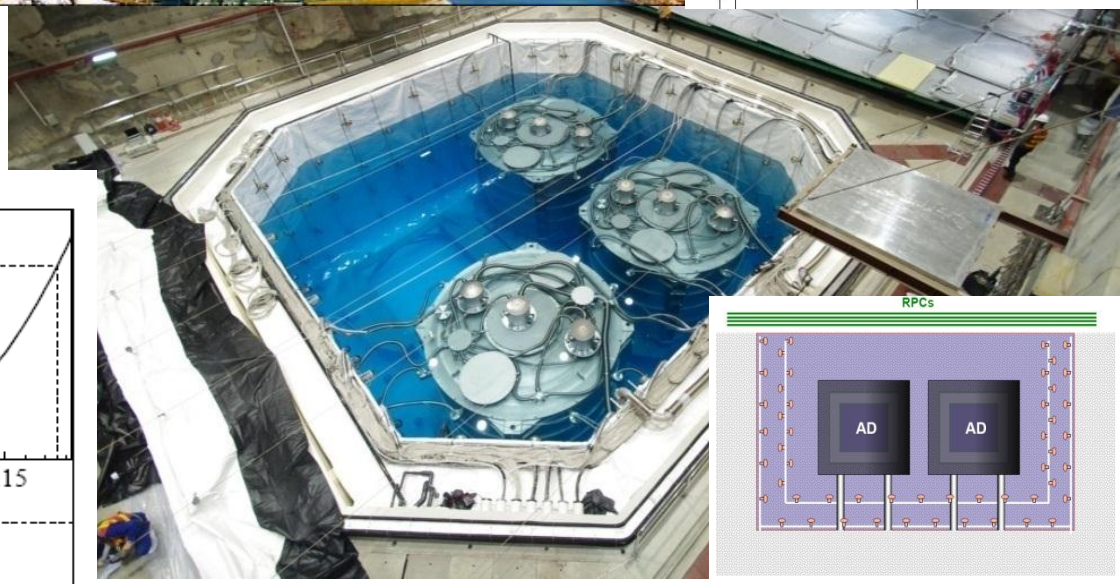


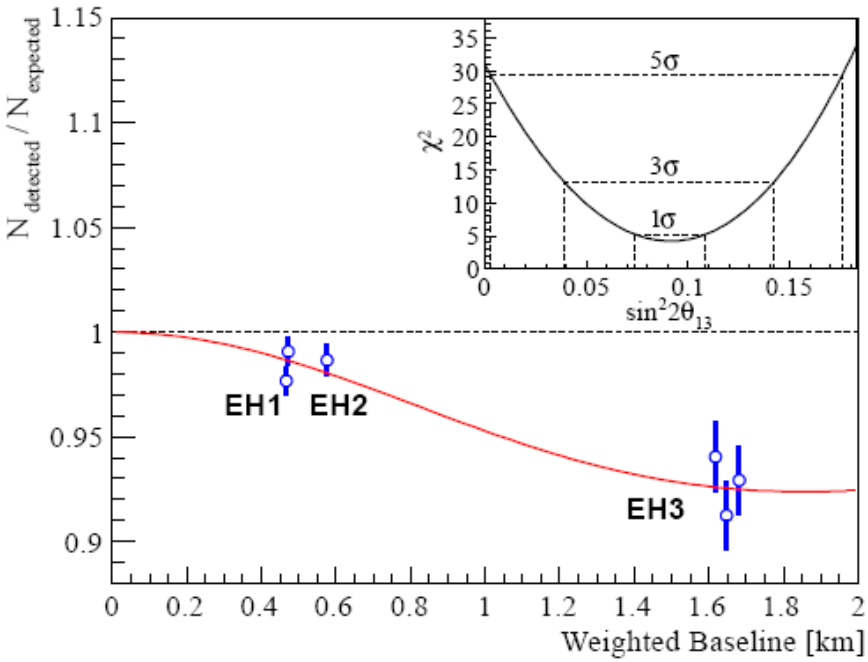


Daya Bay experiment









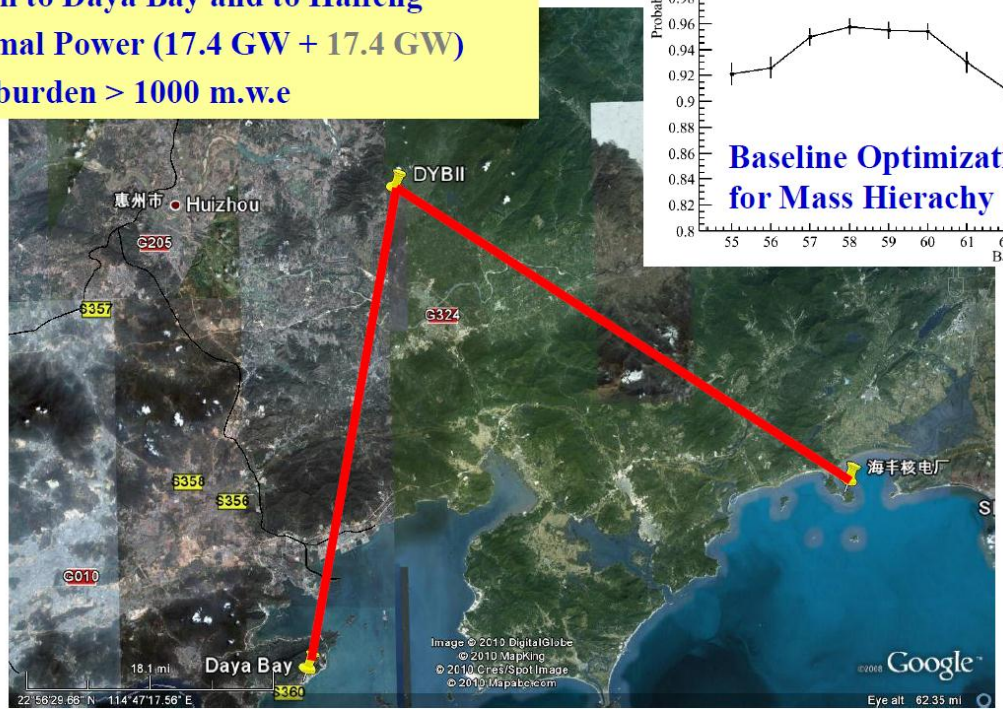
$\sin^2 2\theta_{13} = 0.092 \pm 0.016(\text{stat}) \pm 0.005(\text{syst})$

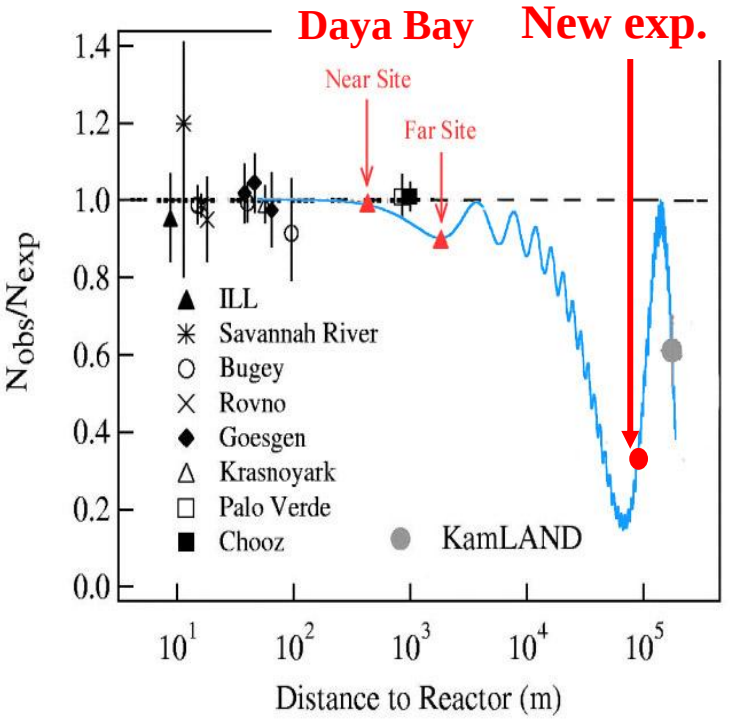
$\chi^2/\text{NDF} = 4.26/4$

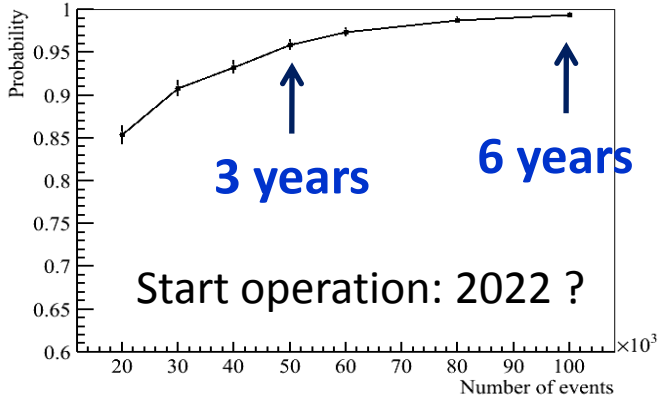
5.2 σ for non-zero θ_{13}

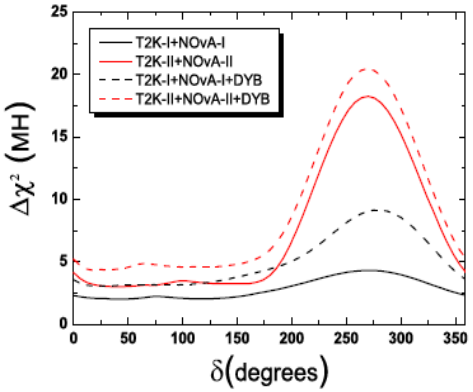
Future Reactor Neutrino Experiment at Daya Bay

~60km to Daya Bay and to Haifeng
Thermal Power (17.4 GW + 17.4 GW)
Overburden > 1000 m.w.e



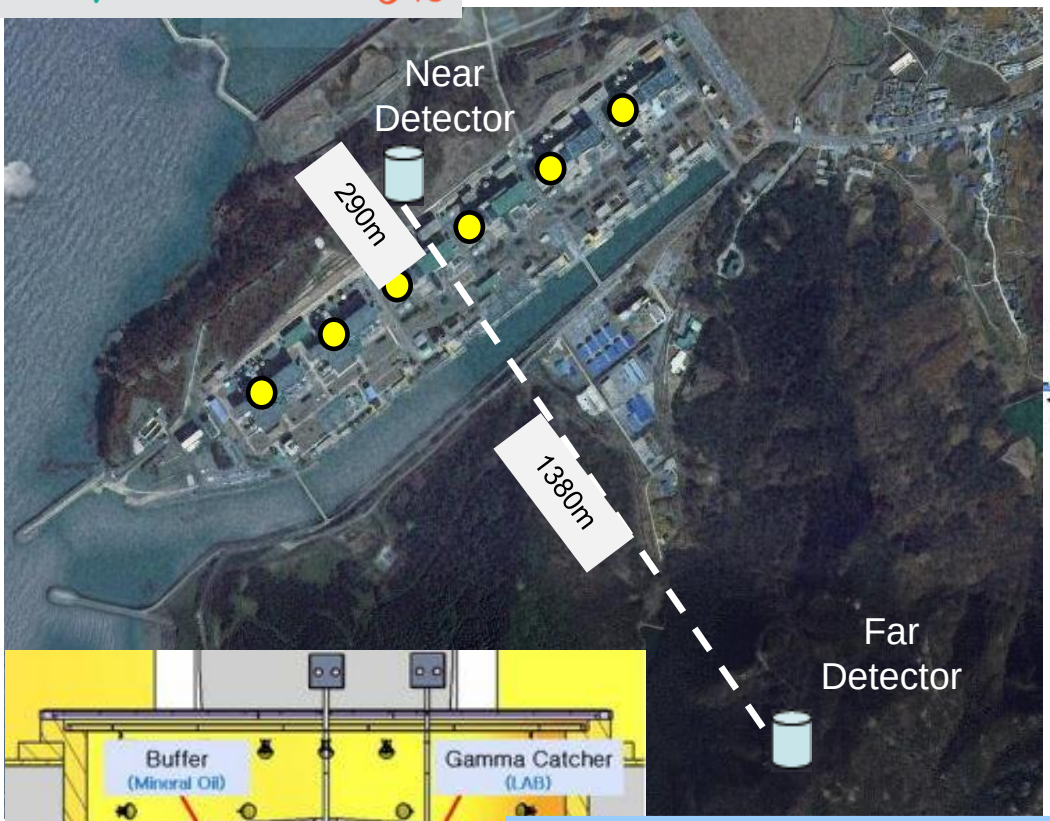


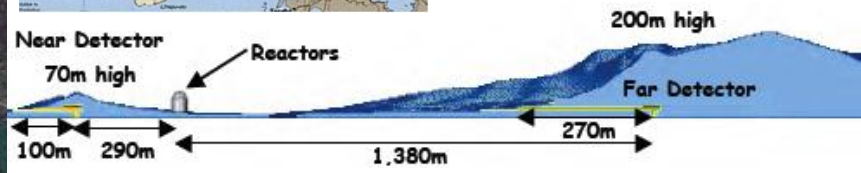


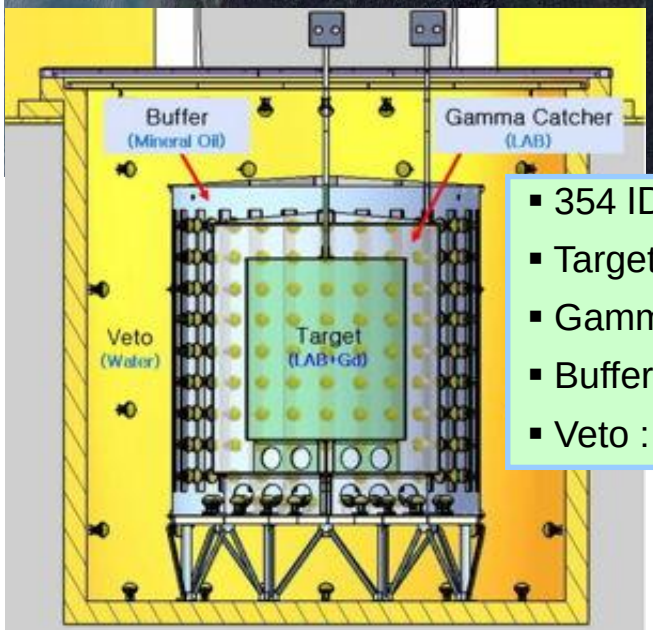


- Detector: 20kt liquid scintillator
- Energy reso.: 2-3%
- Scientific goal
  - ⇨ Mass hierarchy
  - ⇨ Precision meas. of mixing matrix elements
  - ⇨ Supernovae
  - ⇨ Geo-neutrino
  - ⇨ Atmospheric neutrinos
  - ⇨ Sterile neutrinos, etc.

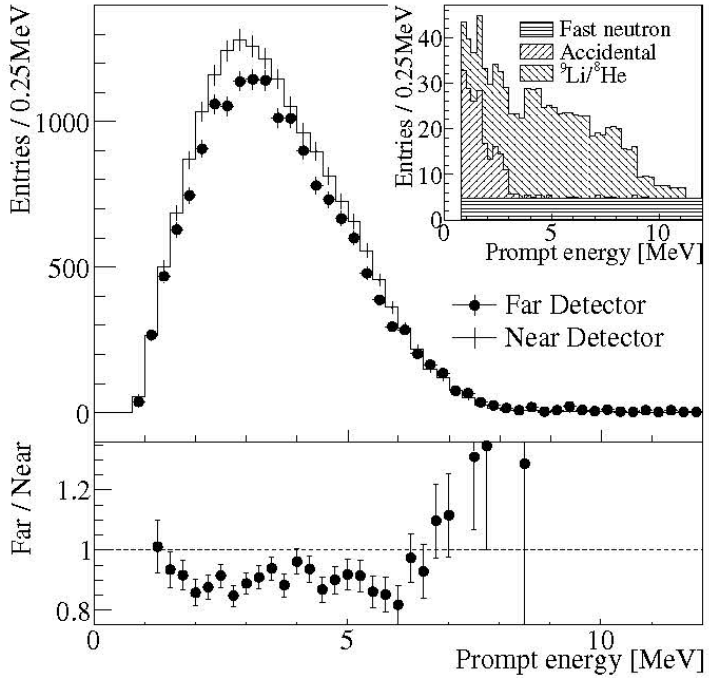
RENO Experiment







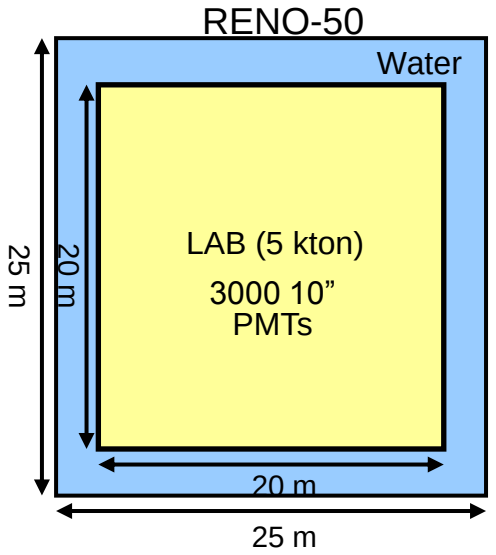
- 354 ID +67 OD 10” PMTs
- Target : 16.5 ton Gd-LS
- Gamma Catcher : 30 ton LS
- Buffer : 65 ton mineral oil
- Veto : 350 ton water



$$\sin^2 2\theta_{13} = 0.113 \pm 0.013(stat.) \pm 0.019(syst.)$$

RENO-50

- **Measure large θ_{12} neutrino oscillation with 5kton liquid scintillator at L~50 km**
- **RENO can be used as near detectors.**
- **2018 ~**



Physics goal of RENO-50

- Precise measurement of θ_{12}

  $\frac{\delta \sin^2\theta_{12}}{\sin^2\theta_{12}} \sim 1.0\%(1\sigma)$ in a year ← current accuracy : 5.4%

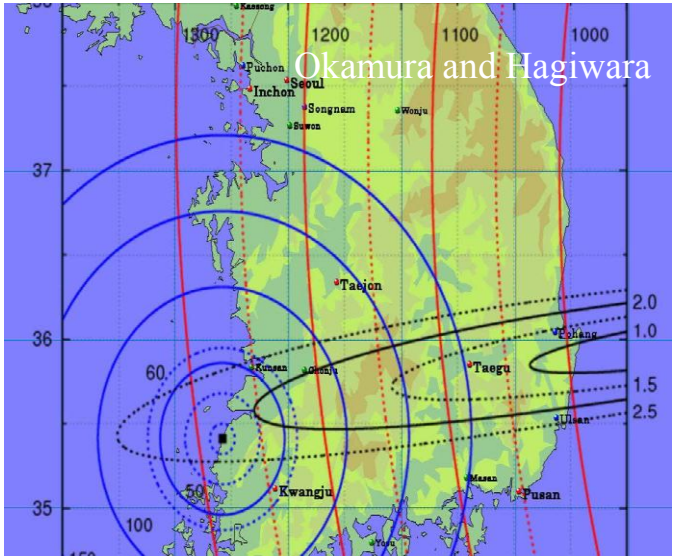
- Determination of mass hierarchy Δm^2_{13}
- Neutrino burst from a Supernova in our Galaxy :

  ~1500 events (@8 kpc)

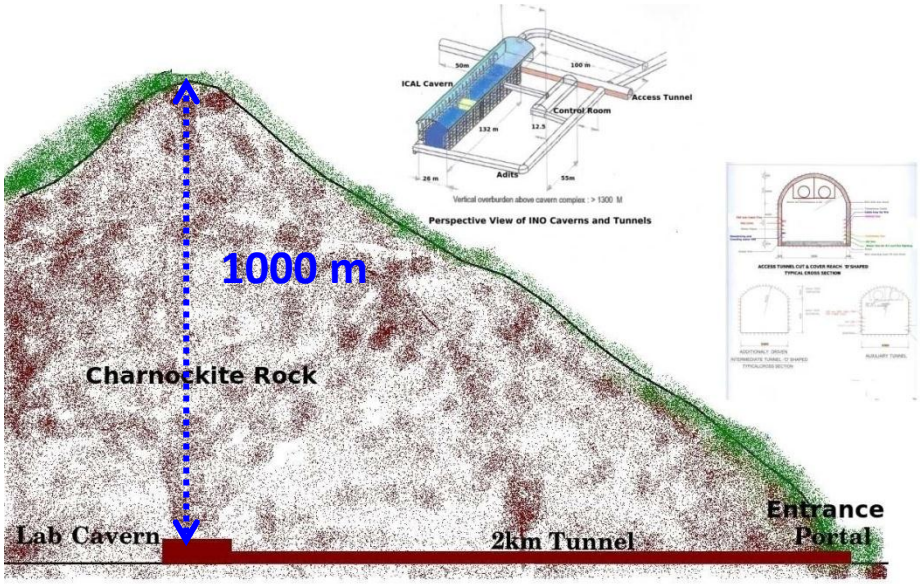
- Detection of T2K beam : ~120 events/year
- Test of non-standard physics :

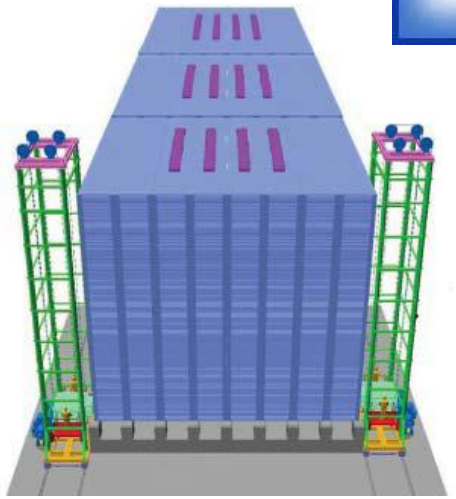
  sterile/mass varying neutrinos

J-PARC neutrino beam direction



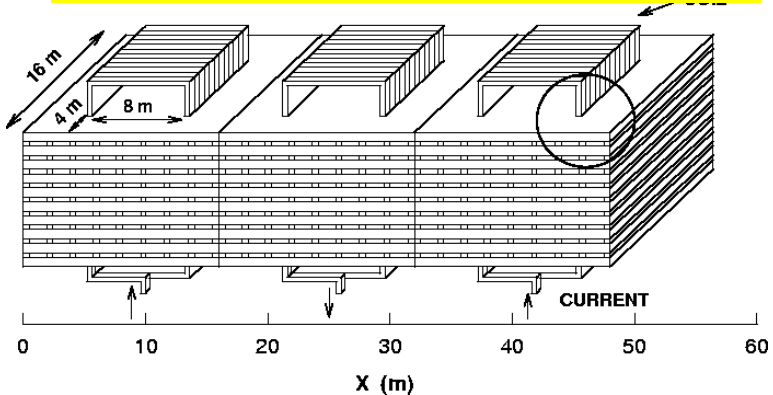
INO : India-based Neutrino Observatory





- 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



YangYang Underground Laboratory(Y2L)

(Upper Dam)

Y2L
- **Located in a tunnel of Yangyang Pumped Storage Power Plant Korea Middleland Power Co.**
- **Minimum depth : 700 m**
- **Access to the lab by car (~2km)**

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

(Power Plant)

(Lower Dam)

양양양수발전소

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

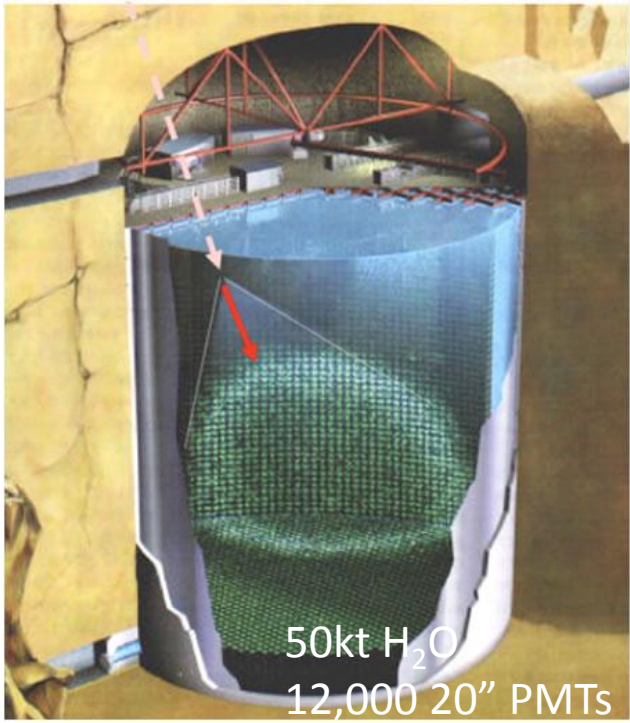
China Dark Matter Experiment

CDEX-TEXONO 1kg scale HPGe detector run!

- 20g HPGe test running now!
- 1000g PCGe detector in CJPL!

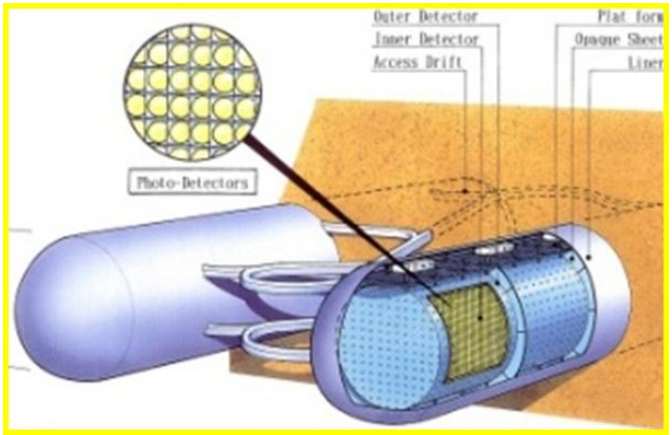
Super-Kamiokande

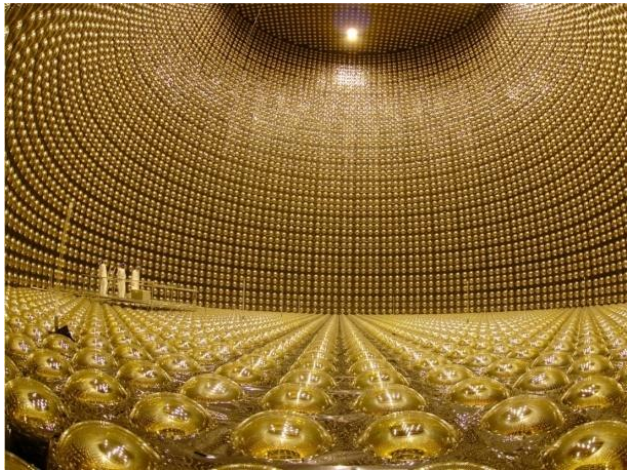
- SK have obtained many important results
  - Discovery of ν oscillation: atmospheric (1998), solar(2001 w/SNO), K2K (2004)
  - Discovery of $\nu_\mu \rightarrow \nu_e$(2011, T2K)
- Remaining tasks
  - Determine Mass hierachy, CP Violation
    - T2K and Hyper-Kamiokande
  - Supernova
    - 8,000 neutrino events from a SN at 10 kpc
  - Supernova Relic Neutrinos search (with Gd)
    $\rightarrow$ ~33 SRN signals for E =10~30 MeV (> 4σ)
    - Will start in a few years
  - Solar
    - Observe 'upturn' (to confirm oscillation or exotics?)



SuperKamiokande
$\rightarrow$HyperKamiokande

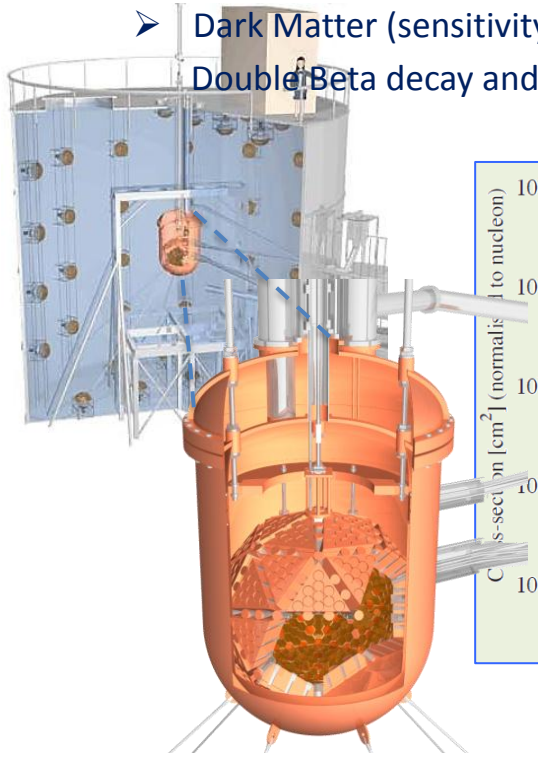
1Mt H_2O
99,000 20" PMTs

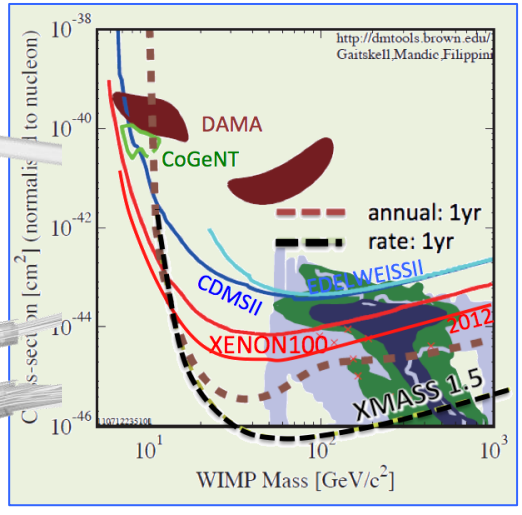




XMASS

- Phase-1: 100kg liq. Xe for dark matter search → now running
- XMASS1.5 : upgrade to 5t for better sensitivity $\sigma_{SI} < 10^{-46}$ cm^2 (at m_χ~100 GeV)
  - To be launched in 2015
- Final Goal: 10t fiducial mass
  - Dark Matter (sensitivity $\sigma_{SI} < 10^{-47}$ cm^2), Double Beta decay and pp-^{7}Be solar neutrinos

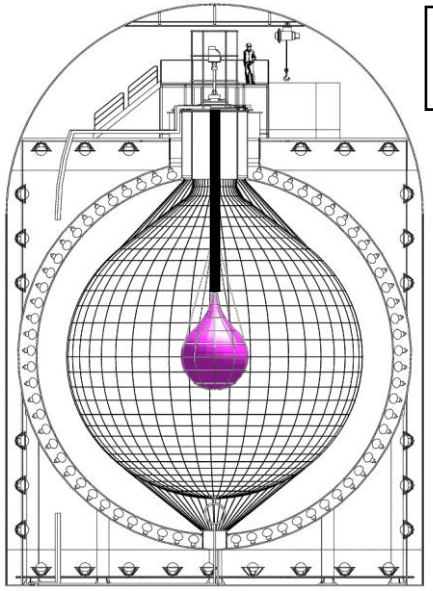




KamLAND-Zen

Zero Neutrino double beta decay search

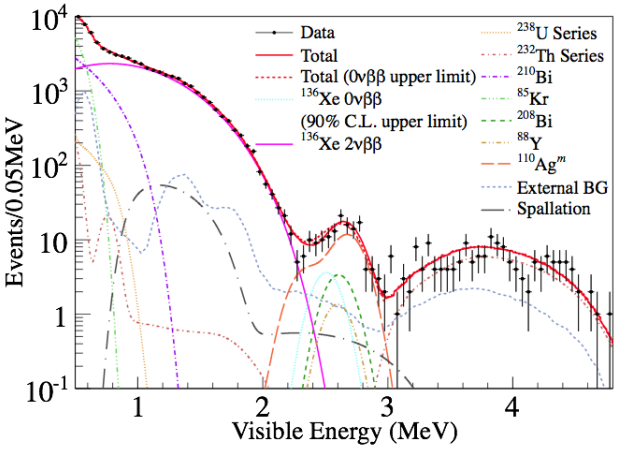
1st run with ~320kg
90% enriched ^{136}Xe



Planned improvement (2013)
~40mV sensitivity with 700kg Xe

Proposed upgrade (2016~)
~20mV sensitivity with winstone cone, higher yield LS and 1000kg Xe

Results from initial 38.5kg-yr data



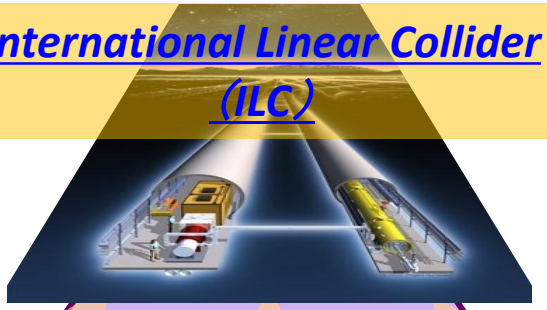
$\langle m_{\beta\beta} \rangle$
<0.26~0.54 eV
@90% C.L.

Time line of particle physics program in Japan

Quest for Birth-Evolution of Universe

International Linear Collider (ILC)

Quest for Unifying Matter and Force



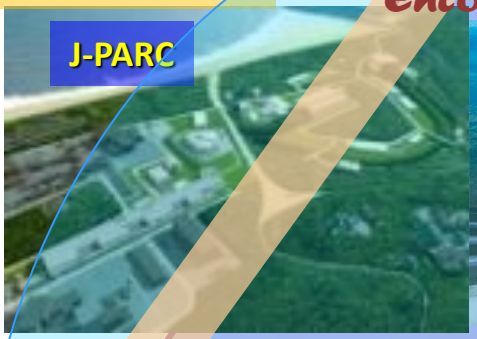
Lepton CP Asymmetry

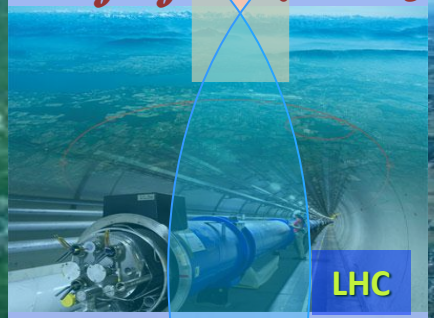
Scientific Activities
Technology Innovation
Encouraging Human Resources

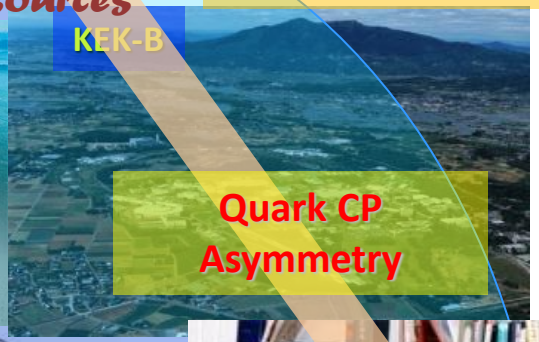
Beyond Standard Physics

Power-Upgrade

Super-KEKB







Quark CP Asymmetry

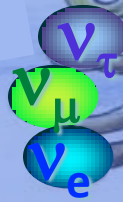
Quest for 6 Quarks

Lepton

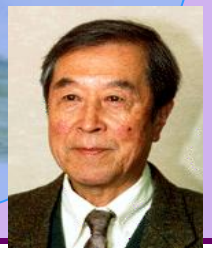
Quark

[Origin of Matter]

Quest for Neutrinos

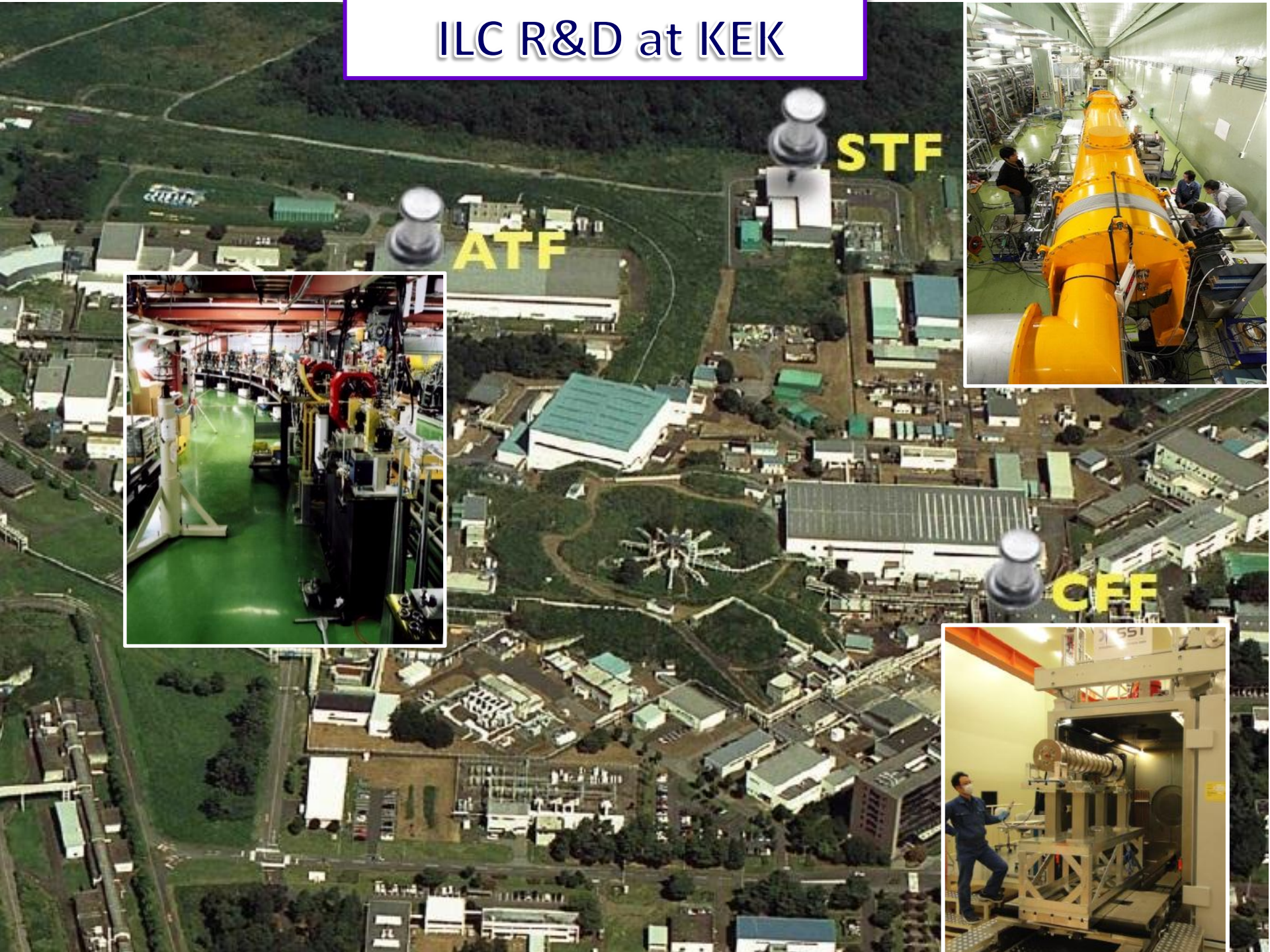


[Origin of Force]



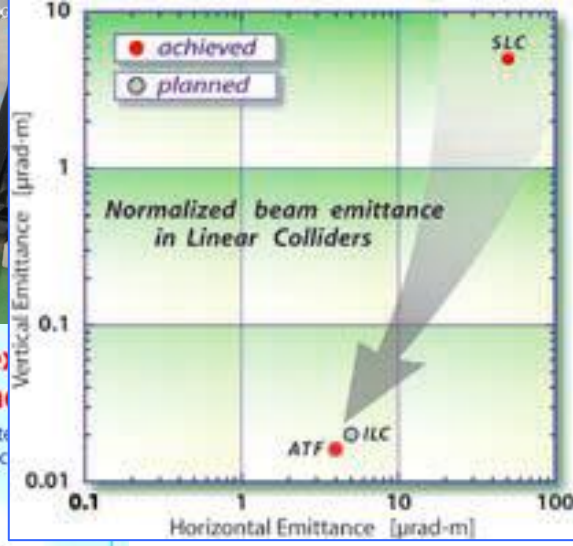
Higgs Particle [Origin of Mass]

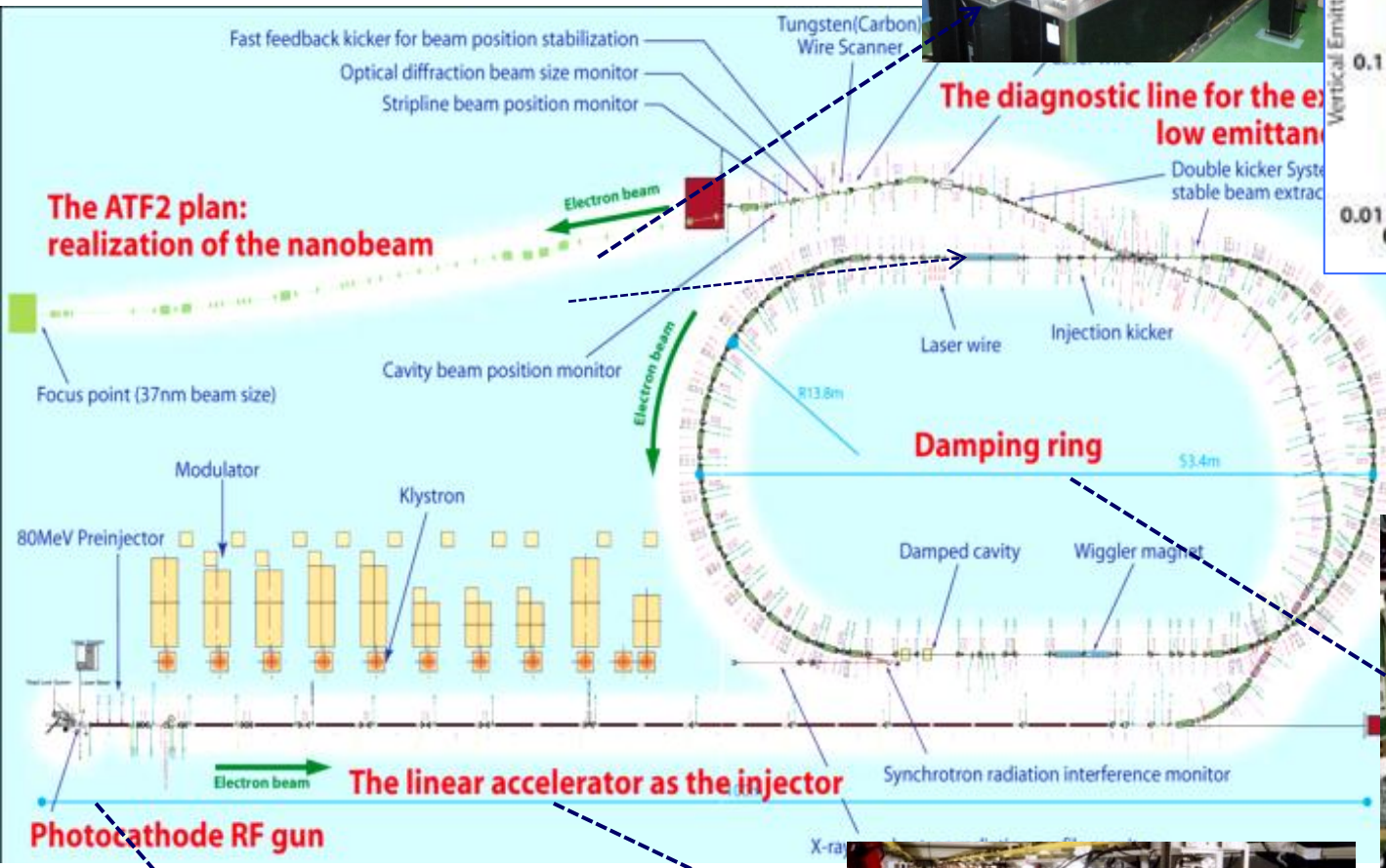
ILC R&D at KEK

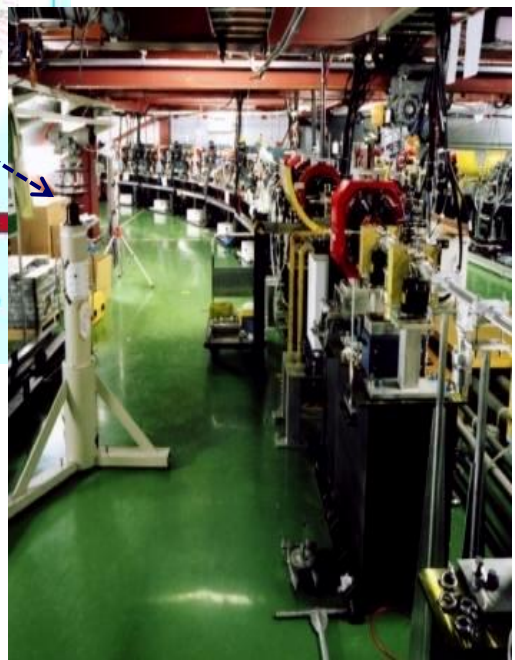


ATF: Accelerator Test Facility for ILC

- Generate Low Emittance Beams
- Handle Nano-Size Beams



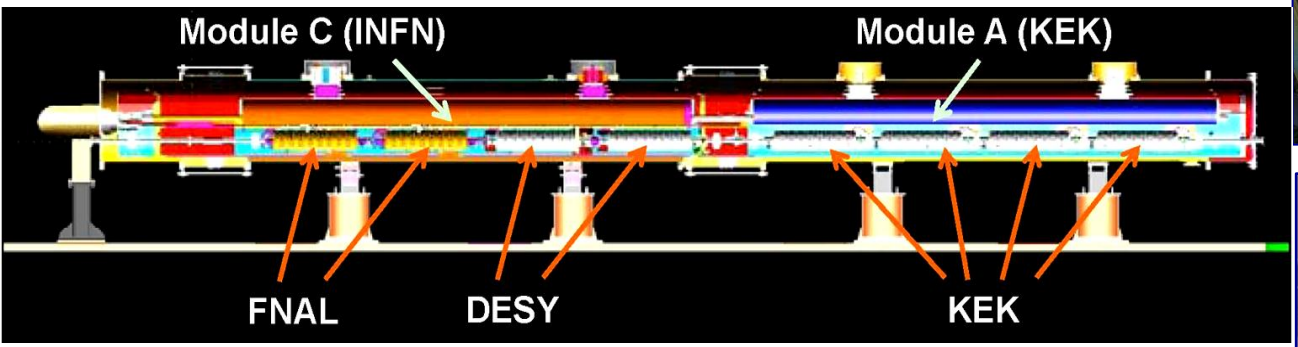


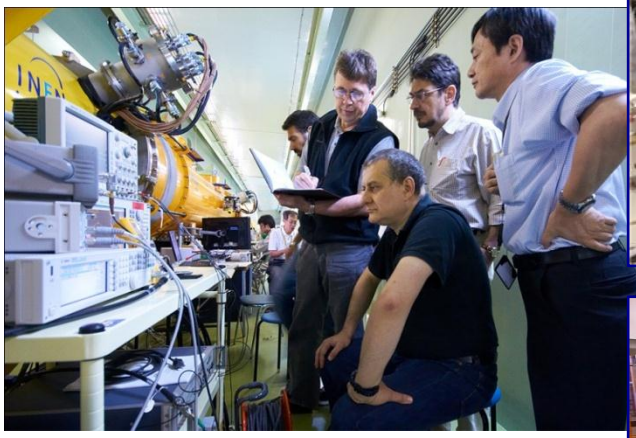


S1-Global

The first step of ILC

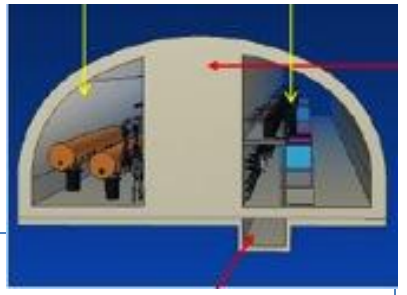
2009 ~ 2011.2.25



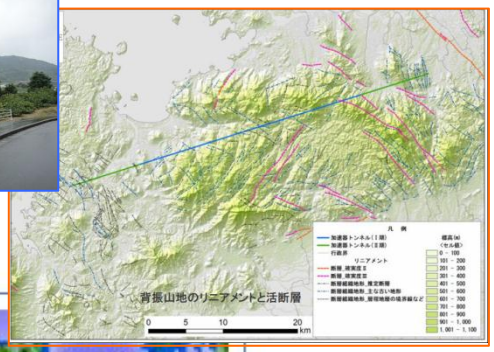


Plug compatibility of SCRF system was successfully demonstrated by international collaboration.

Two Candidate Sites in Japanese mountainous locations



- Japanese Mountainous Sites -



SEFURI

KYUSHU district

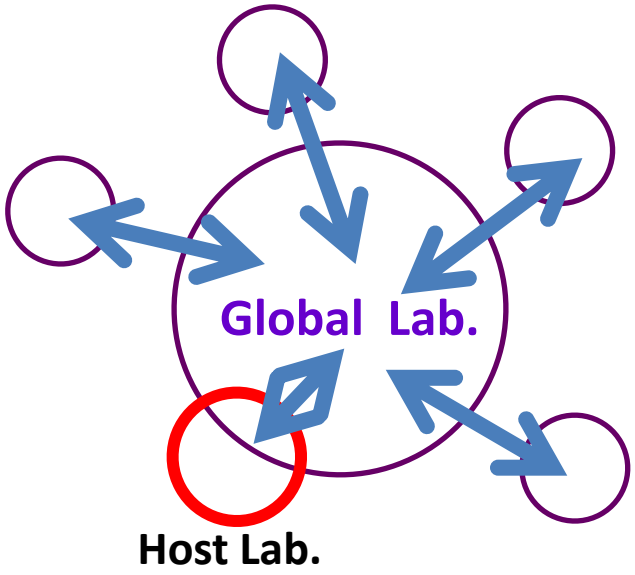
Site-A KITAKAMI

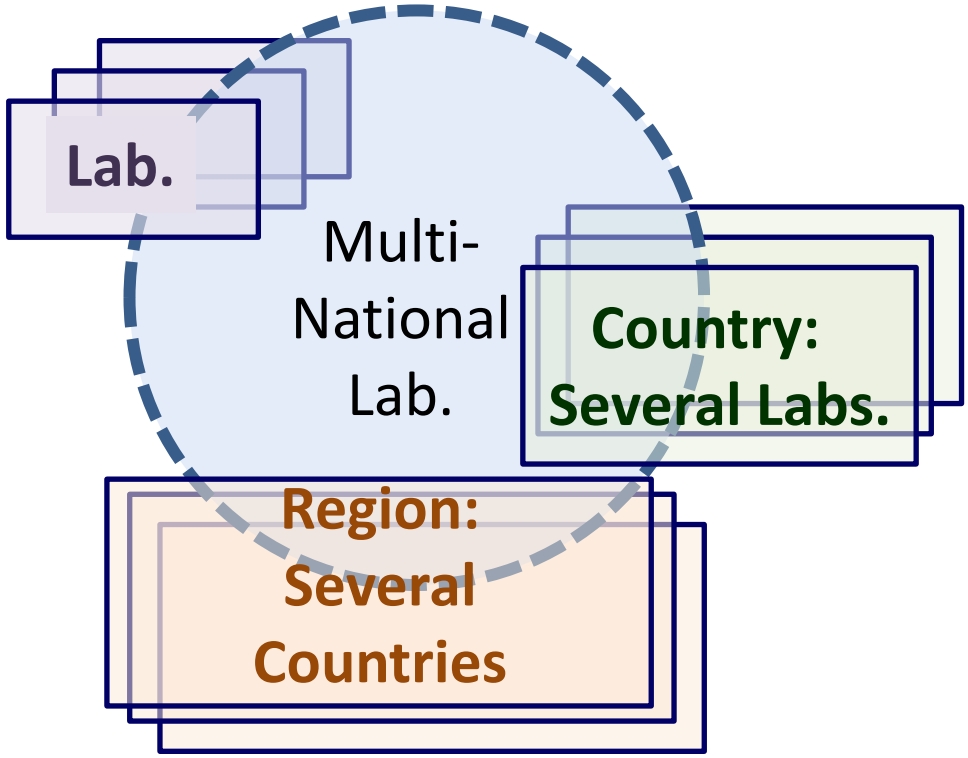
Tokyo

TOH

- GDE-CFS group visited two candidates sites, Oct. 14 and 15, 2011

Possibility 2 : Multi-National Lab.





◆ Brief Concept:

※ World HEP-labs, countries and regions which wish to participate, set up their branch within Multi-national-Lab. These participating units are called a member-unit.

※ The member-units contribute in sharing the human and financial resources with in-kind and common fund issues.

※ This Multi-national-Lab is virtually built first in ICFA or a representative unit, and then, inside the host laboratory after the host-site selection.

ILC Plan in Japan

- Japanese HEP community proposes to host ILC based on the "staging scenario" to the Japanese Government.
  - ILC starts as a 250GeV Higgs factory, and will evolve to a 500GeV machine.
  - Technical extendability to 1TeV is to be preserved.

- It is assumed that one half of the cost of the 500GeV machine is to be covered by Japanese Government. However, the share has to be referred to inter-governmental negotiation.

Answers to Tatsuya's questions

Concerning the Japanese LC initiative

- What is the baseline scope?
  - ✓ – Fast realisation of starting with ~250 GeV?
  - – Up to t-$\bar{t}$ from the beginning?
  - ✓ – Already 500 GeV from the beginning?
    (NB: LHC was approved to start with less number of magnets first)
- What is the baseline framework?
  - ✓ – Full global project: 50% host 50% elsewhere including cash contribution?
  - – Full global project with larger host country contribution?
  - – A la HERA & LHC, i.e. very strong host laboratory with some "work packages" contributions? (KEK as the host laboratory?)
- What is the baseline for timescale?
  - ✓ – data taking starts ~~≲2025~~ < 2030 (significant overlap with LHC)?
  - – data taking starts ≳2030 (no real overlap with LHC)?

Summary –Physics landscape in Asia-Pacific in 2020's

- Future accelerators in Asia-Pacific
  - Super tau-charm factory at BINP
  - BEPCII continues to run at IHEP
  - SuperKEKB: high luminosity B factory at KEK
  - J-PARC: K, μ and ν program
  - RISP at IBS will join the particle physics research.
- Future non-accelerator facilities in Asia-Pacific
  - Daya Bay II and Jinping lab. in China
  - RENO-50 and Y2L in Korea
  - INO in India
  - SuperKamiokande and its upgrade, XMASS, KamLand-Zen, and many more in Japan
- Japanese HEP community strongly hopes to host ILC, and making all the possible efforts: intensive R&D on machine and detector, site investigation, organizational issues and actions to get understandings of general public and government.

Acknowledgement and apologies

- I am grateful to the following people for their help to collect informations.

  SunKee Kim, Eunil Won, Tariq Aziz, Yifang Wang, Paoti Chan, Martin Savior, Yoichiro Suzuki, Kunio Inoue, Akira Yamamoto, Kaoru Yokoya, Atsuto Suzuki, Takashi Kobayashi, Naohito Saito, and many more.

- There are many more interesting and important experiments in Asia-Pacific which I could not cover because of limitation of my skill and time.
- Off-shore programs were not described.