



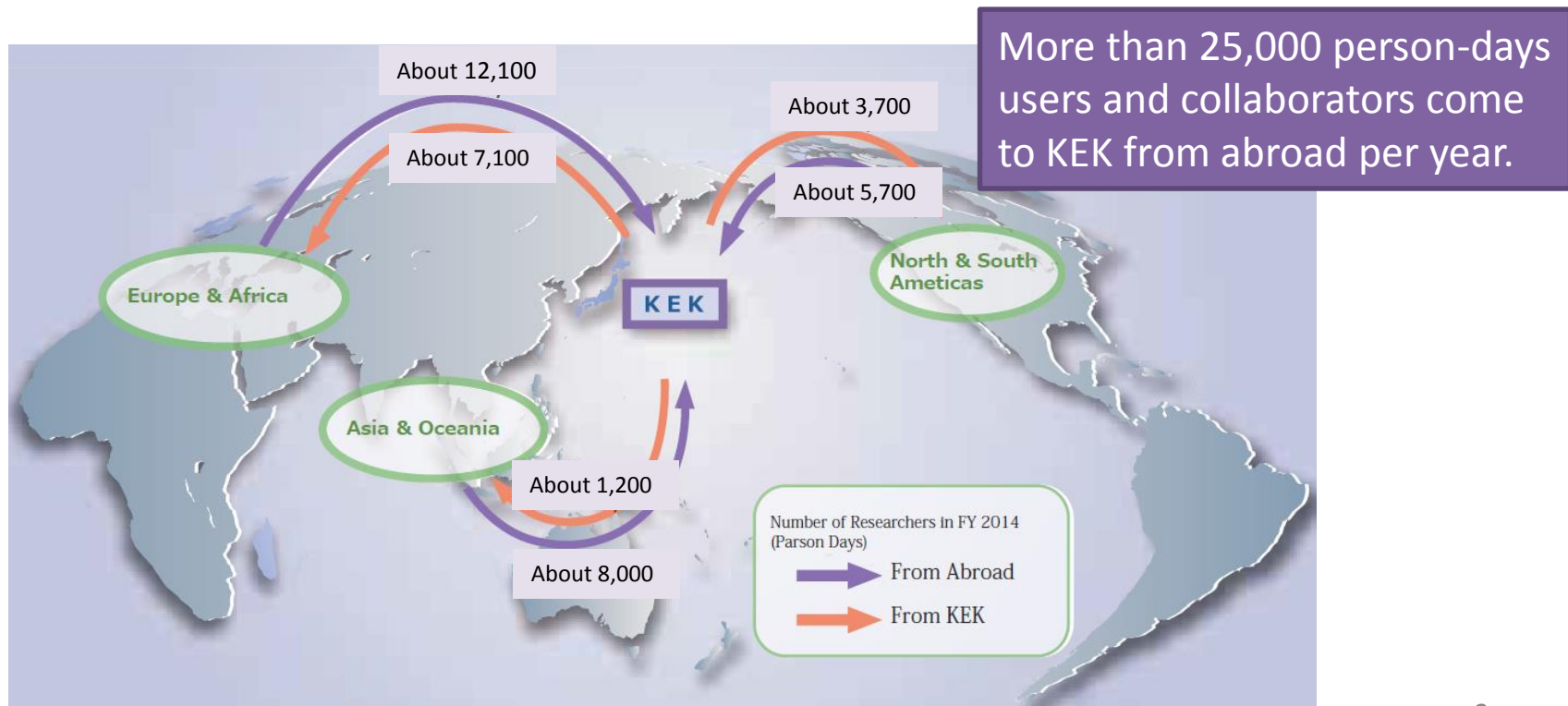
KEK, High Energy Accelerator
Research Organization

Welcome to KEK

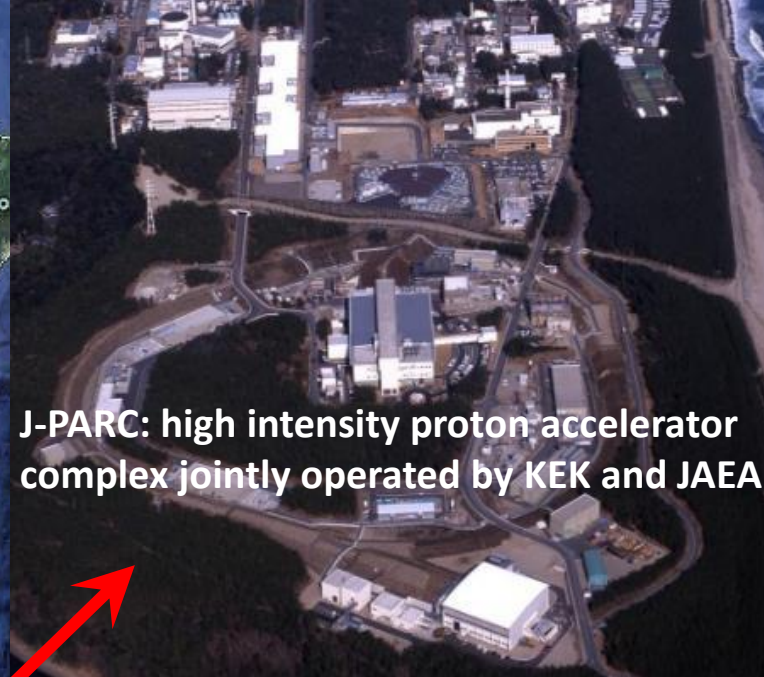
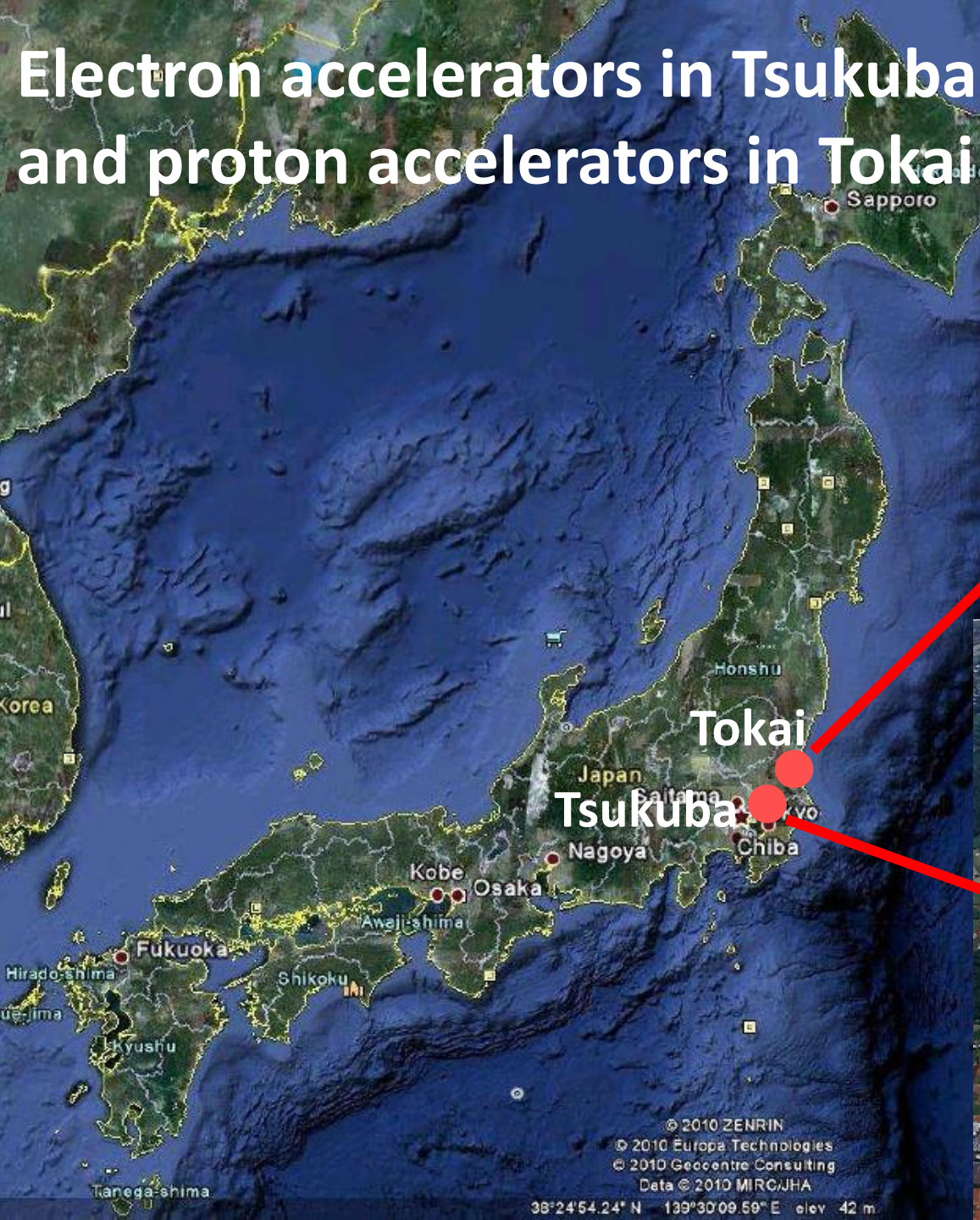
Yasuhiro Okada

HEPiX Fall/Autumn 2017 workshop
LHCOPN-LHCONE meeting/HUF2017
October 16, 2017

- KEK is an Inter-University Research Institute Corporation, first established in 1971 as National Laboratory for High Energy Physics.
- Now, KEK covers a wide area of scientific fields from particle and nuclear physics to materials and life sciences by constructing and operating large accelerator facilities.
- We have about 700 permanent staff, 100 students, and 8,000 users/year.
- KEK is one of leading accelerator science centers worldwide.

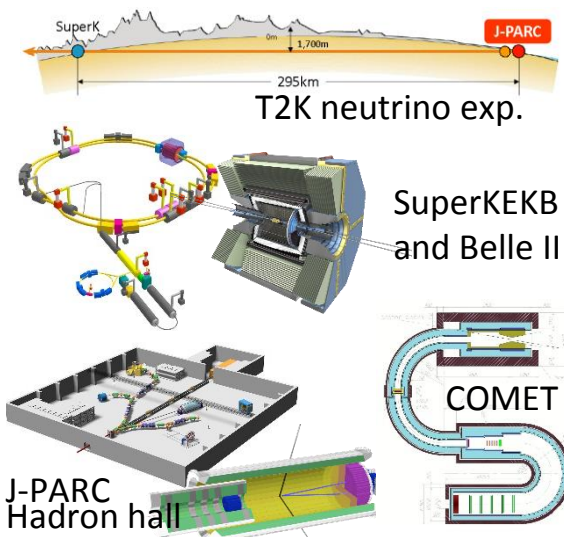
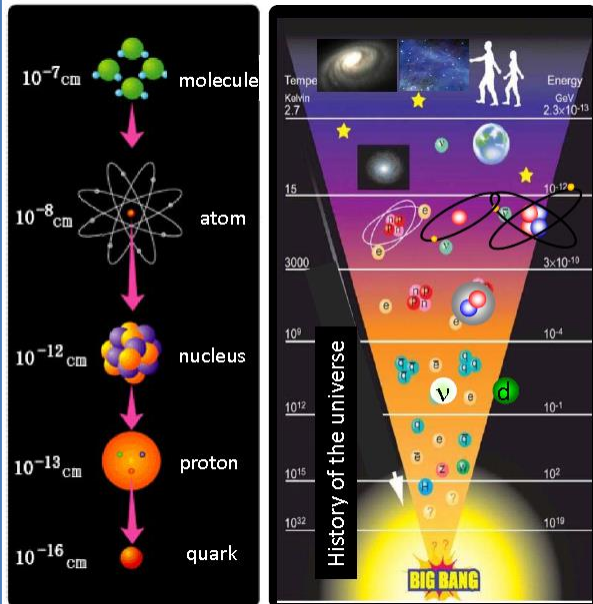


Electron accelerators in Tsukuba and proton accelerators in Tokai



Diversity in accelerator based sciences

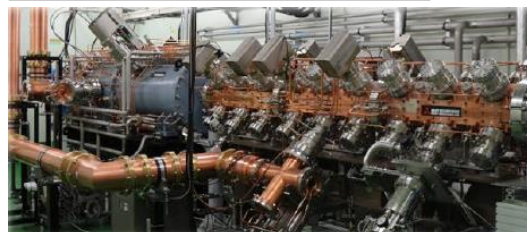
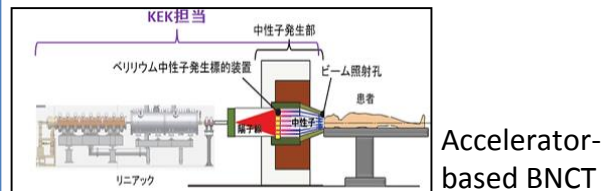
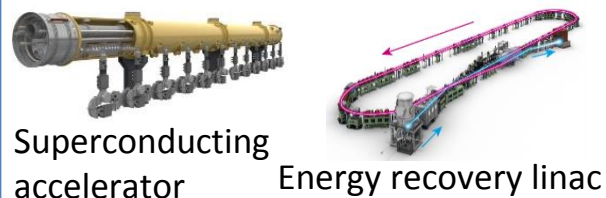
Pursuing fundamental laws of nature



Basic science Material science
and its applications

KEK

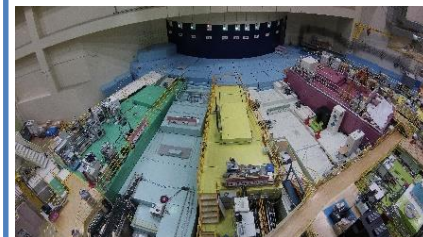
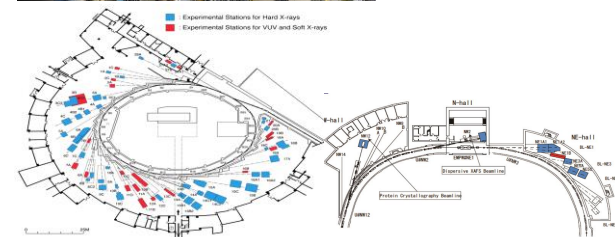
Technical development
and its applications



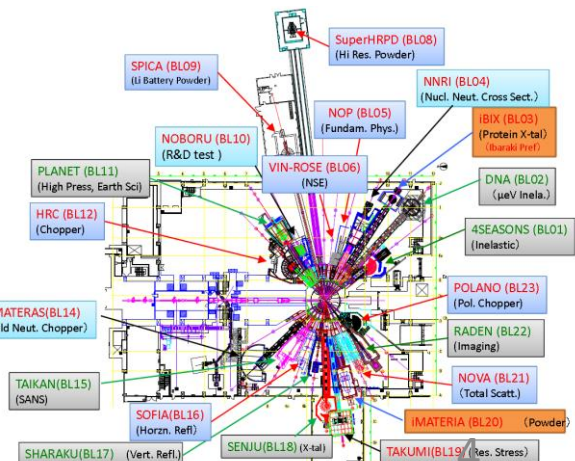
Pursuing origin of function in materials



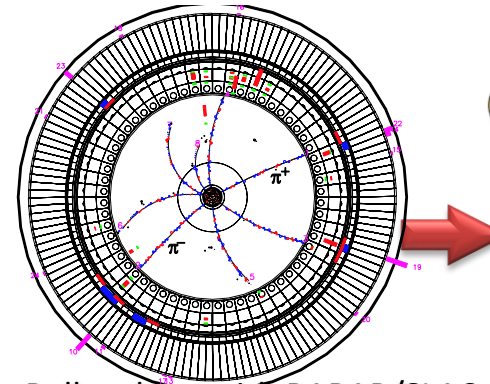
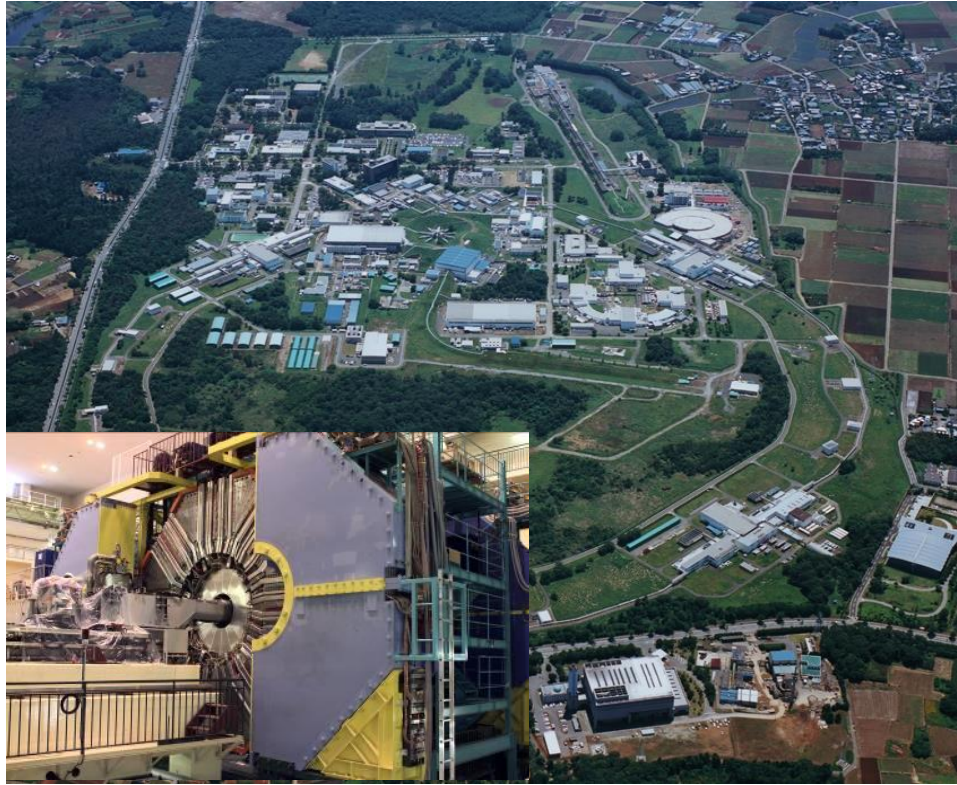
Photon factory
X-ray as a probe



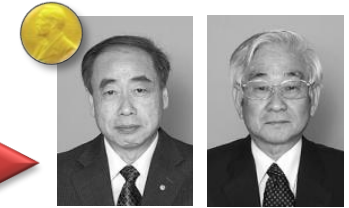
J-PARC MLF
neutron and μ
as a probe



SuperKEKB and Belle II



2008 Nobel Physics prize

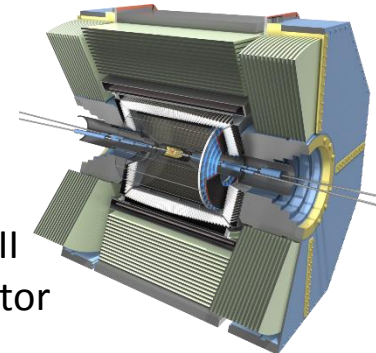


Dr.Kobayashi Dr.Maskawa

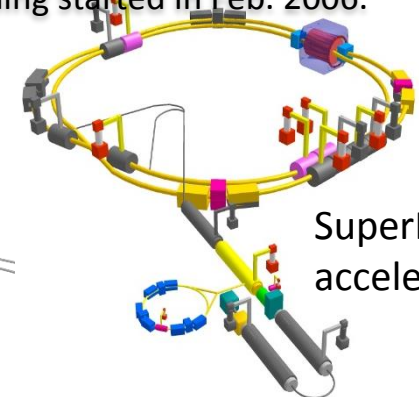
Belle, along with BABAR/SLAC, discovered CP violation in *B* mesons, and confirmed Kobayashi-Maskawa theory.

The apparatus is now being upgraded to search for new physics beyond this theory.

Accelerator commissioning started in Feb. 2006.



Belle II
detector



SuperKEKB
accelerator



~750 scientists from 25 countries



Belle II is now at IP

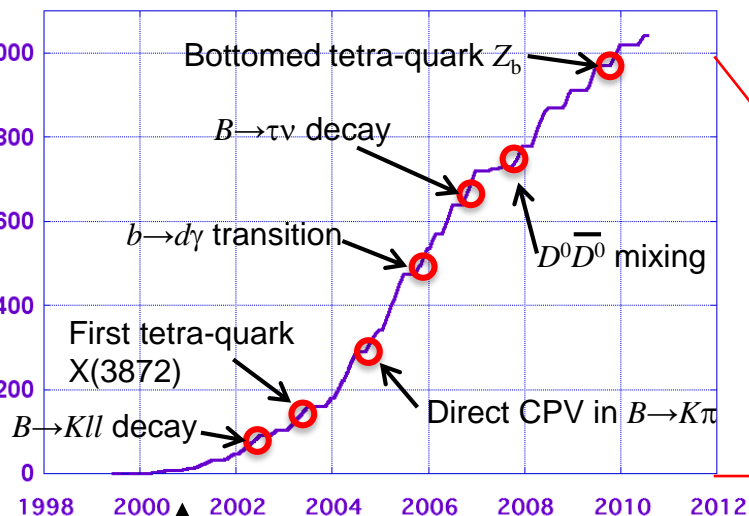
April 11, 2017



SuperKEKB/Belle II is 40 times more powerful machine compared to the previous B factory experiment, KEKB/Belle.

Belle

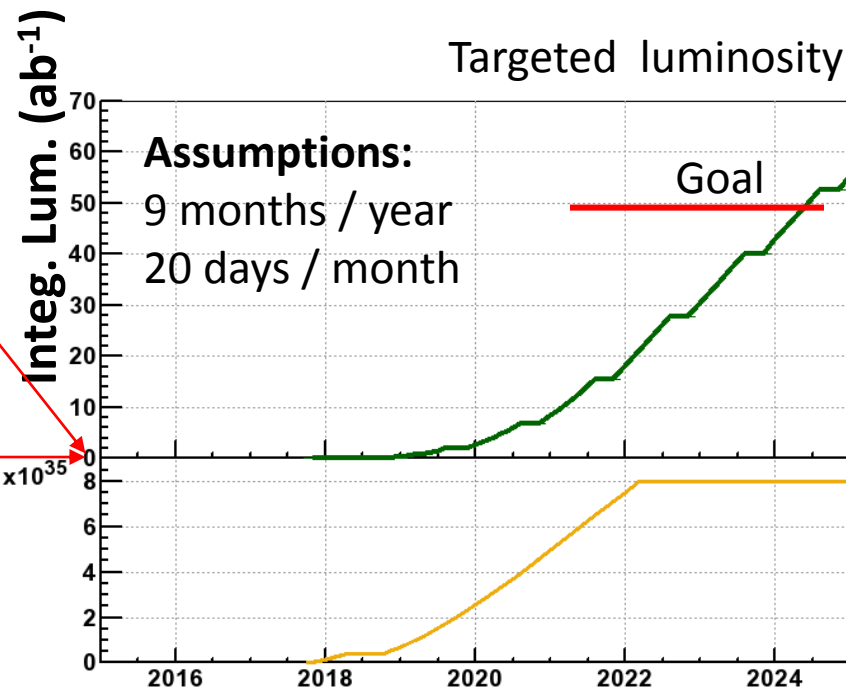
fb^{-1}



Discovery of
CP violation in B decays

Belle II

$\text{ab}^{-1} = 1000\text{fb}^{-1}$

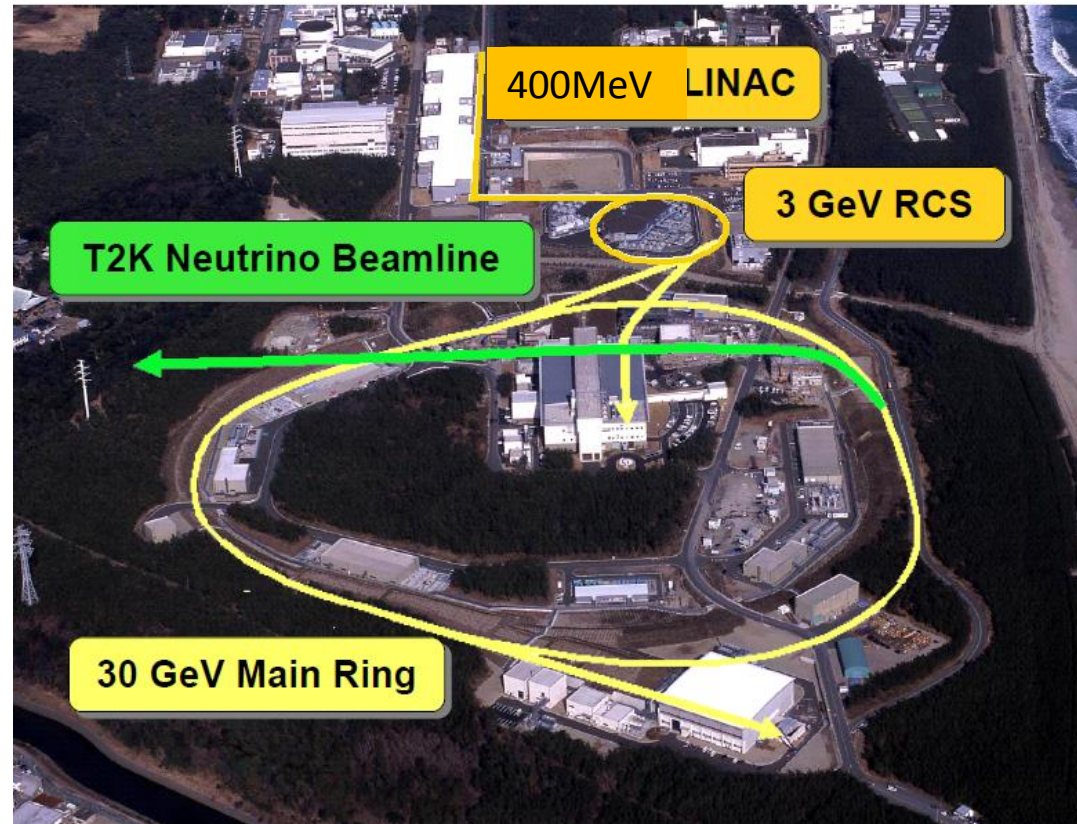
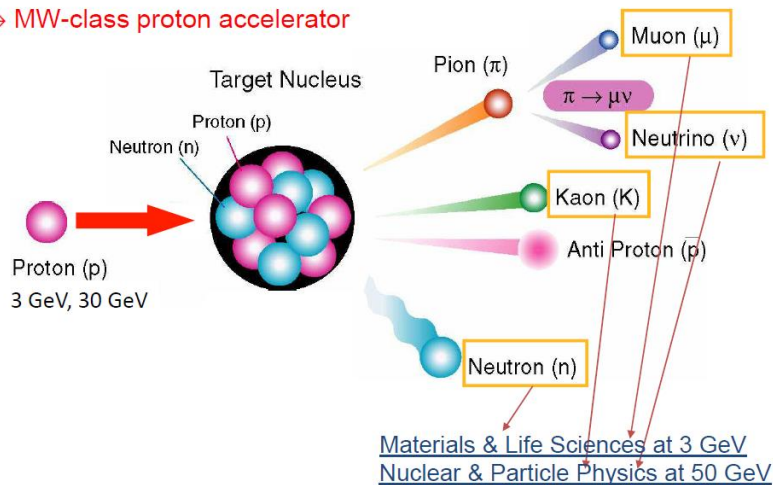


Luminosity ($/\text{cm}^2/\text{s}$)

- Located in Tokai, 60km N.E. of the KEK Tsukuba campus
- Completed in 2009
- Design goal
 - ▶ RCS: 1MW
 - ▶ MR: 750kW

Goal

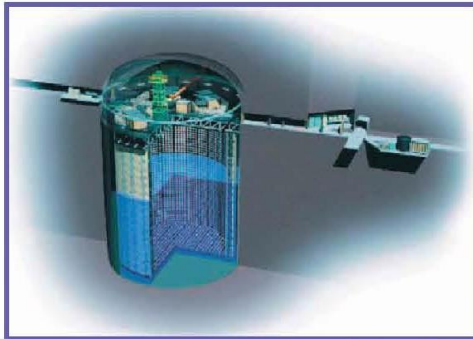
→ MW-class proton accelerator



Joint project of KEK & Japan Atomic Energy Agency (JAEA)

T2K (Tokai to Kamioka) experiment

2010~ (Running)



Super-Kamiokande
(ICRR, Univ. Tokyo)



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



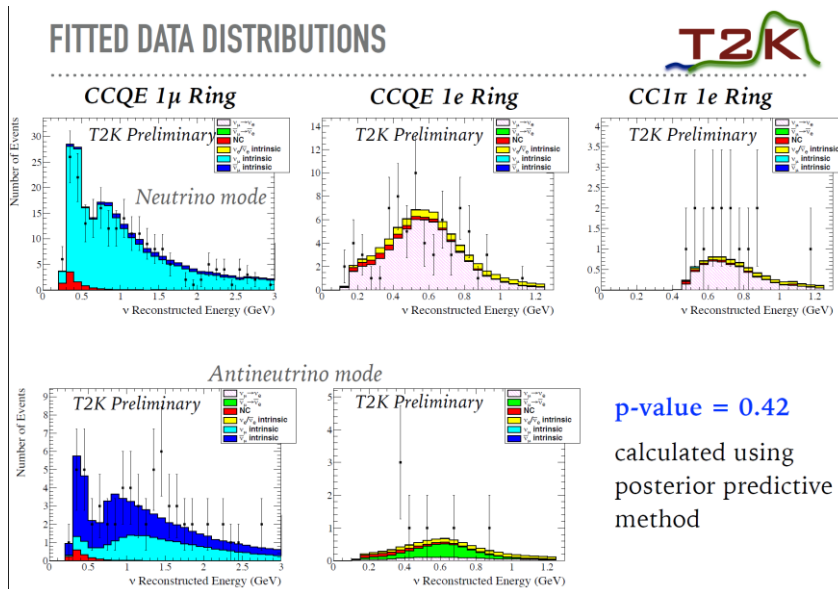
- High intensity ν_μ beam from J-PARC MR to Super-Kamiokande
- Observation of $\nu_\mu \rightarrow \nu_e$ (2013)
- Updated goals
 - ▶ Precise measurement of ν_e appearance
 - ▶ Precise measurement of ν_μ disappearance
 - ➔ CPV phase, contribution to mass hierarchy determination

T2K collaboration

~500members from 63 institutes
in 11 countries



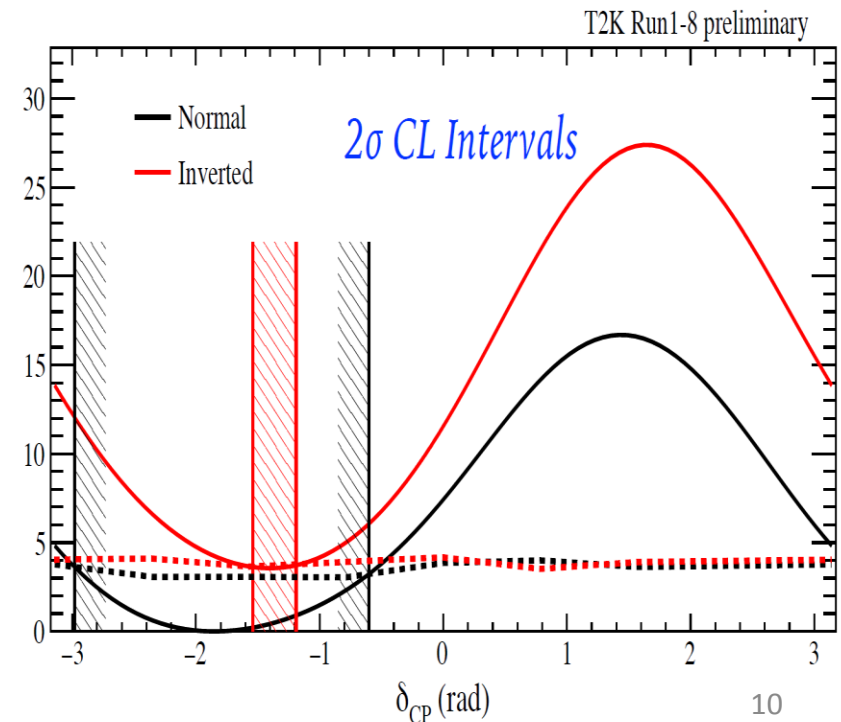
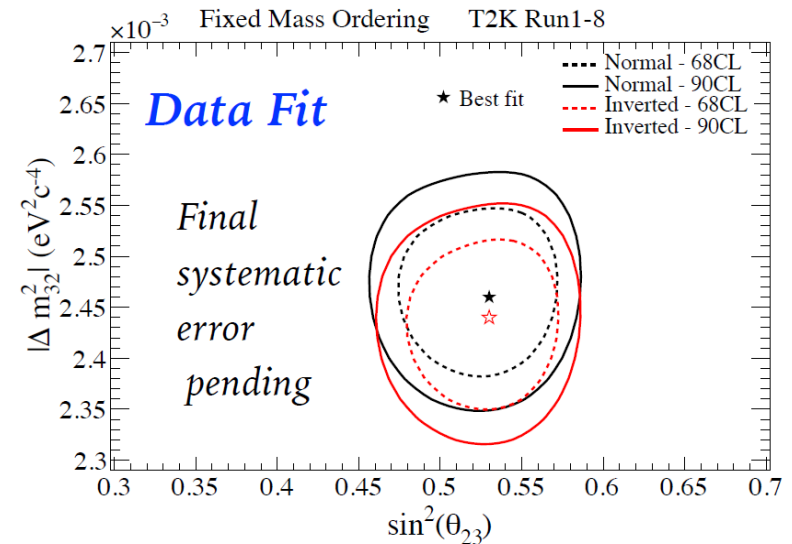
Latest Results from T2K



Posterior probabilities (with reactor constraint)

	$\sin^2\theta_{23} < 0.5$	$\sin^2\theta_{23} > 0.5$	Sum
NH ($\Delta m_{32}^2 > 0$)	0.193	0.674	0.868
IH ($\Delta m_{32}^2 < 0$)	0.026	0.106	0.132
Sum	0.219	0.781	

- 470kW stable operation achieved
- Twice larger statistics than 2016 release
 - ▶ x1.5 POT than 2016
 - ✓ ν-beam: 14.9×10^{20} (~doubled)
 - ✓ $\bar{\nu}$ -beam: 7.6×10^{20}
 - ▶ +33% higher efficiency (new sample, enlarged F.V.)
- Still consistent with maximum 23 mixing
- **CPC excluded at 95% !**
- Weak preference on NH (~87%)



A variety of nuclear and particle physics experiments are carried out at the hadron experimental facility.

Hadron Physics

K1.8

Strangeness Nuclear Physics

K1.8BR

KL

Rare Kaon Decay

Hadron Mass

High Momentum BL

μ -e conversion

COMET BL

International Collaboration Experiments

KOTO

Search for CPV in $KL \rightarrow \pi \nu \nu$
(Physics Run started)

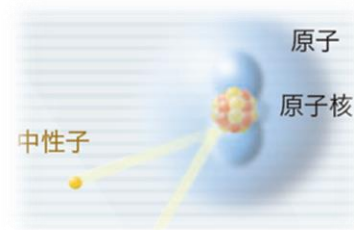
COMET (Phase I)

Search for Lepton Flavor Violation
(Under construction)

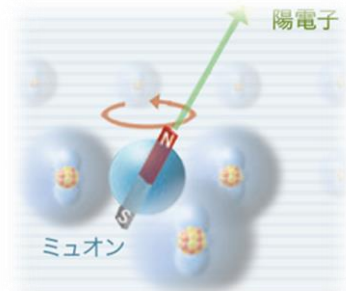
Muon g-2/EDM
(R&D phase)

Material and Life Science facility at J-PARC

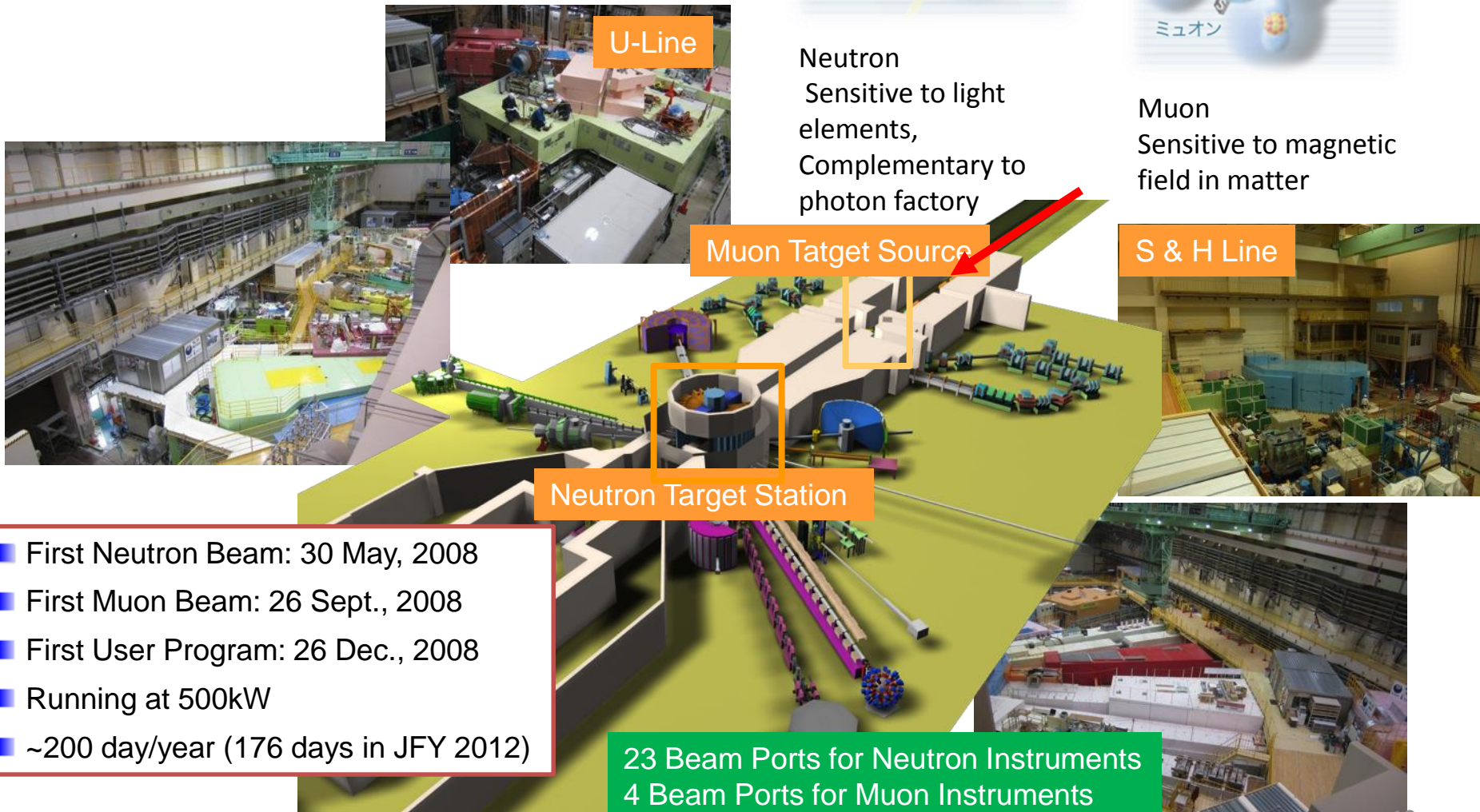
Materials and Life science using world top –
class pulse neutron and muon beams



Neutron
Sensitive to light
elements,
Complementary to
photon factory



Muon
Sensitive to magnetic
field in matter



23 Beam Ports for Neutron Instruments
4 Beam Ports for Muon Instruments

- First Neutron Beam: 30 May, 2008
- First Muon Beam: 26 Sept., 2008
- First User Program: 26 Dec., 2008
- Running at 500kW
- ~200 day/year (176 days in JFY 2012)

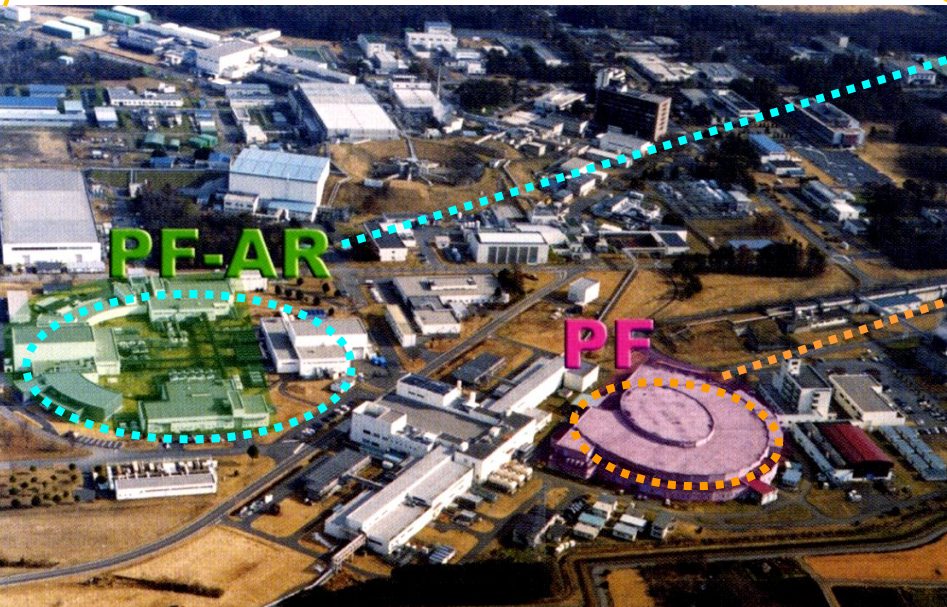
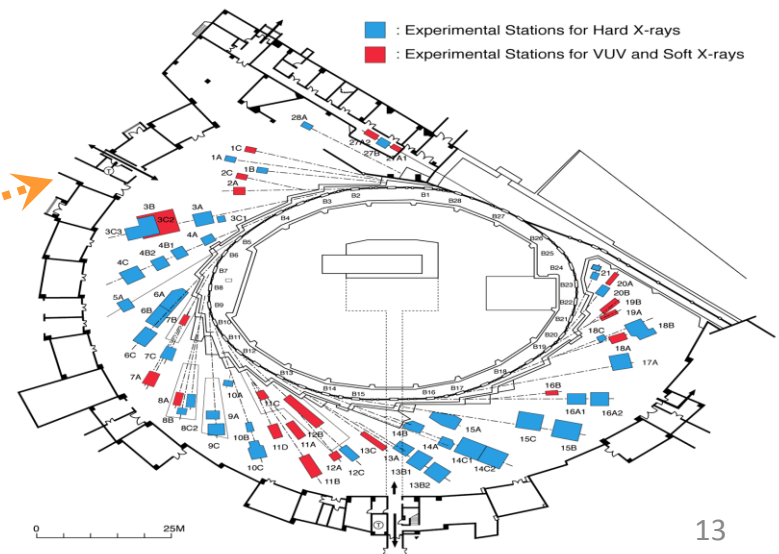
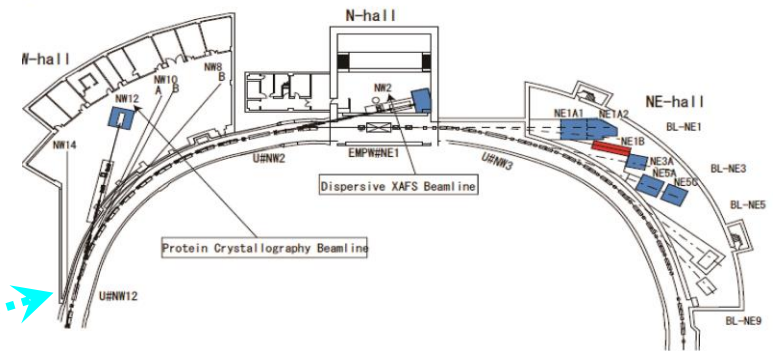
Light source facilities at KEK



PF: 2.5 GeV, 450mA e^- (since 1982)

PF-AR : 6.5 GeV, 60mA e^- (since 1997)

Exp station: ~50, Users: >3000/year



Photon Neutron

Muon Positron

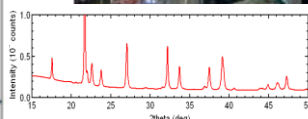
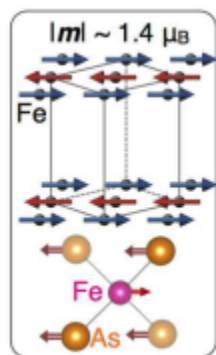
Tsukuba Campus

**Photon &
slow positron
at PF and PF-AR**

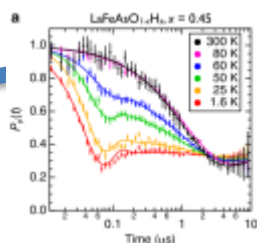
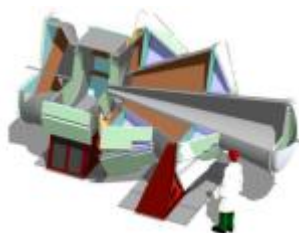


Tokai Campus

**Neutron & muon
at J-PARC**



Local magnetic moment



Muon

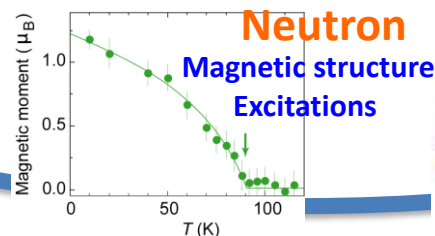
**Comprehensive understanding
of materials structure**

**Slow positron
Surface structure**



Synchrotron

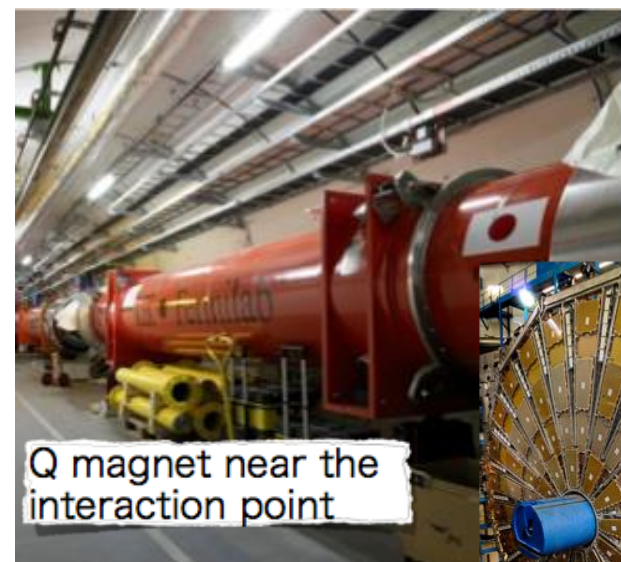
**Crystal structure
Electronic structure**



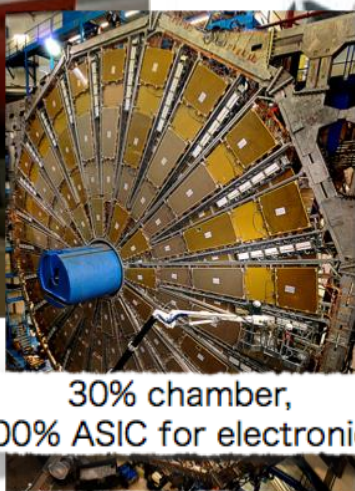
Neutron

**Magnetic structure
Excitations**

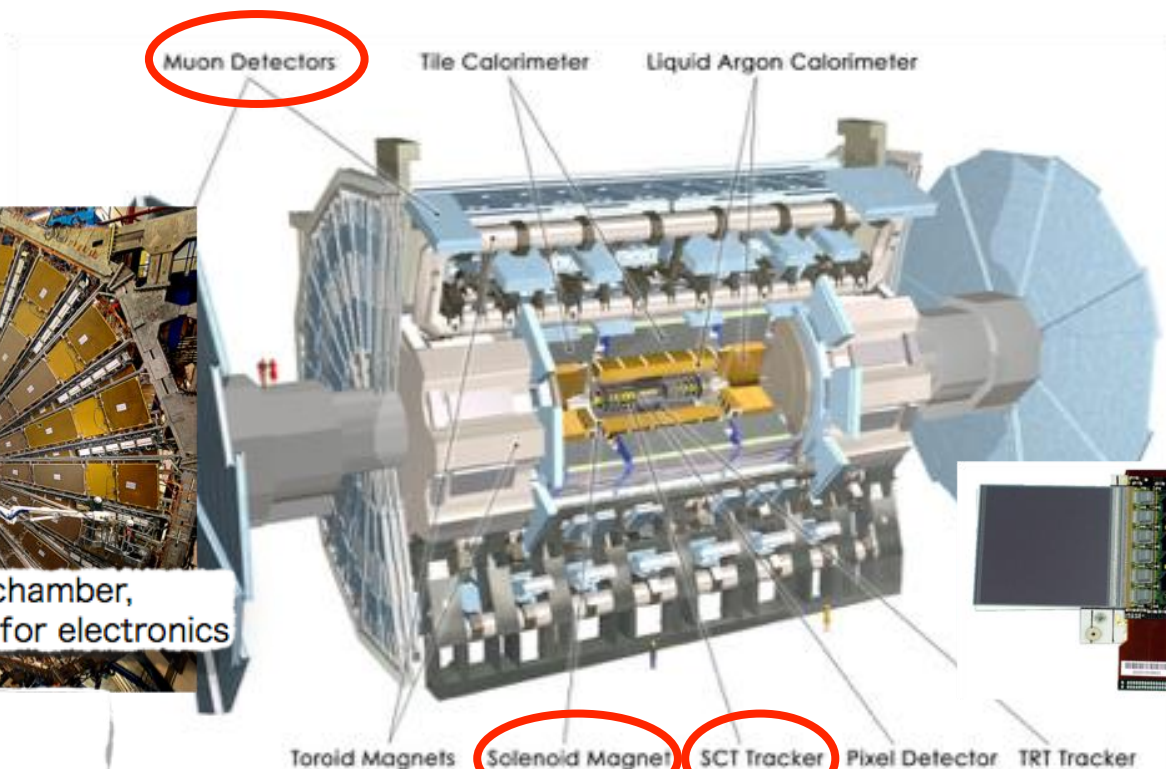




Q magnet near the
interaction point

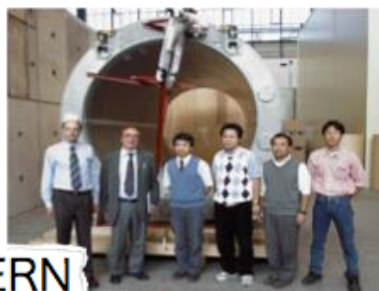


30% chamber,
100% ASIC for electronics



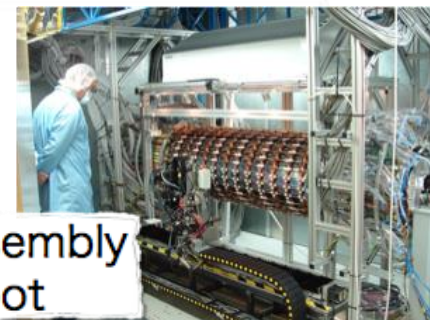
Critical contributions

- pixel/SCT operation
- muon trigger responsibility
- computing
- physics analysis
- trigger coordinator
- collaboration board chair



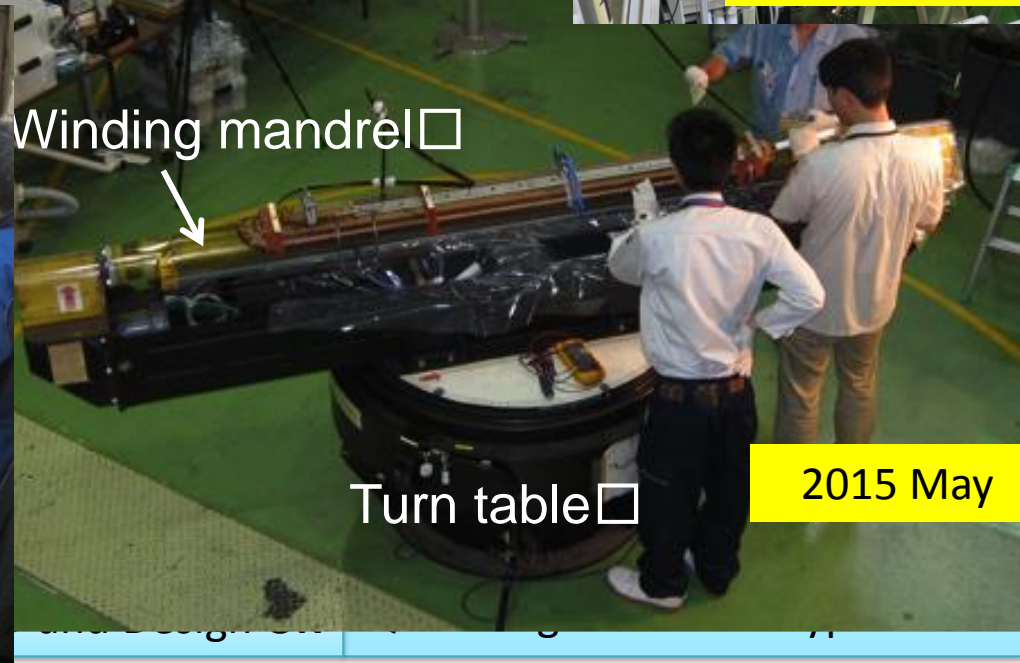
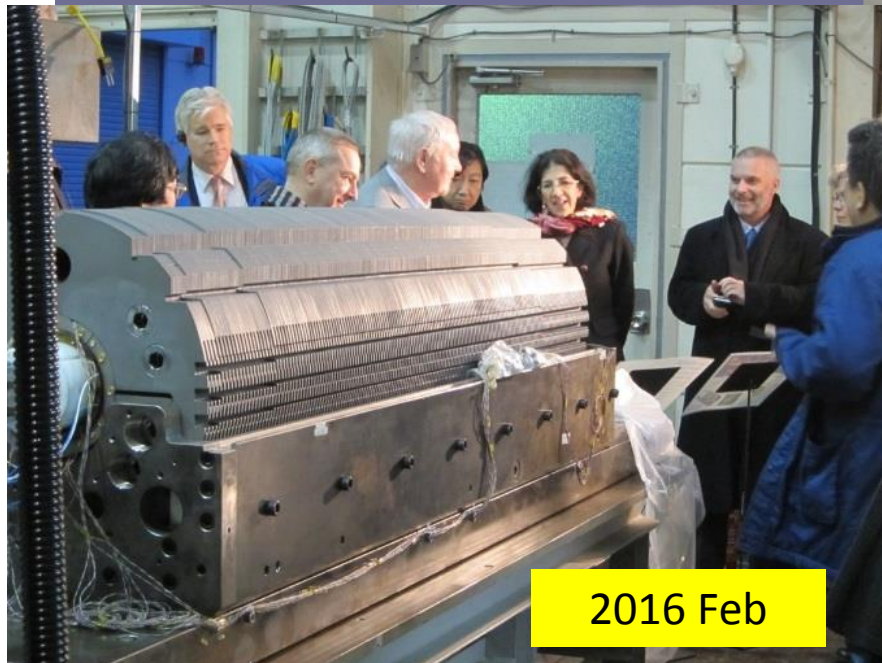
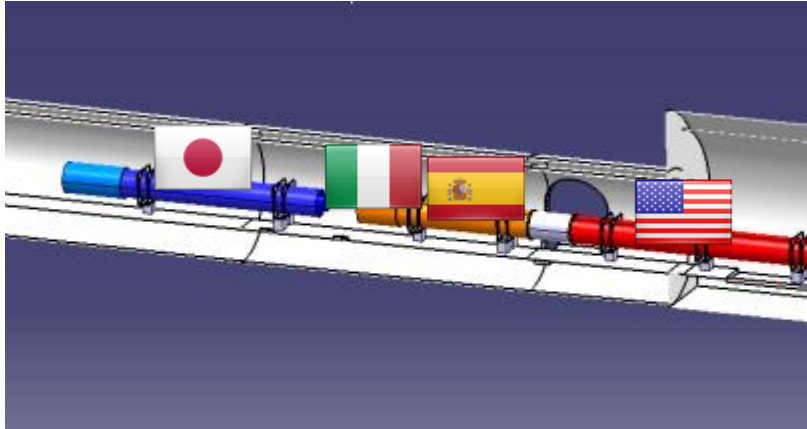
Solenoid at CERN
before installation

100% 20%



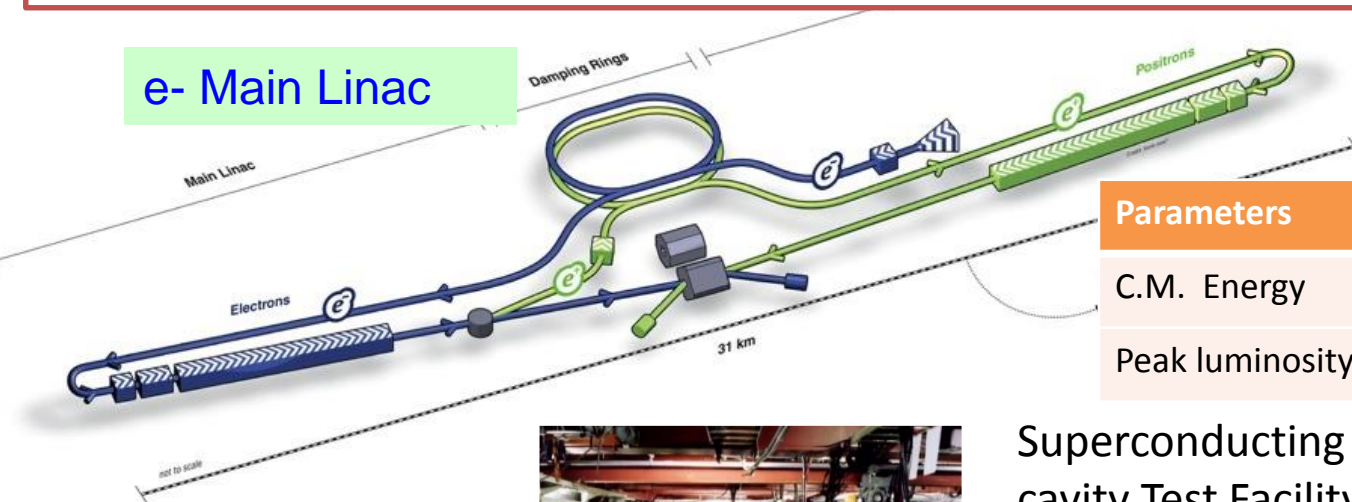
module assembly
by KEK robot

2m Model coil production and test at KEK



International Linear Collider

- There is a consensus among the world high energy physics community that an e^+e^- linear collider should be the next collider. The rationale is even stronger after the discovery of the Higgs particle at CERN.
- The Japanese HEP community proposed to host ILC in Japan, and this proposal was welcomed by the worldwide HEP community, ex. in Update of the European Strategy for Particle Physics, May 2013.
- MEXT, Japanese Government is investigating issues to judge hosting the ILC in Japan.
- Discussions on 250GeV ILC as a Higgs Factory are ongoing in Japan and the worldwide HEP community.



e- Main Linac

e+ Main Linac

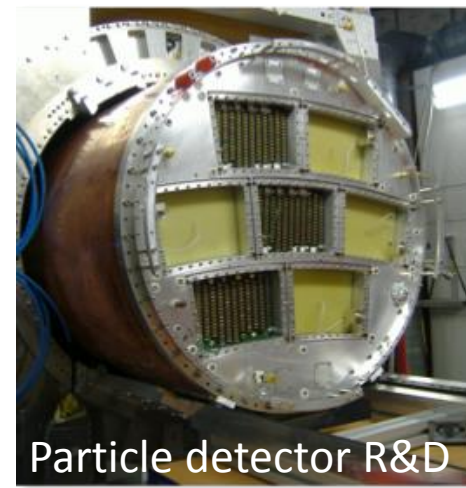
Parameters	Value
C.M. Energy	500 GeV
Peak luminosity	$1.8 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$

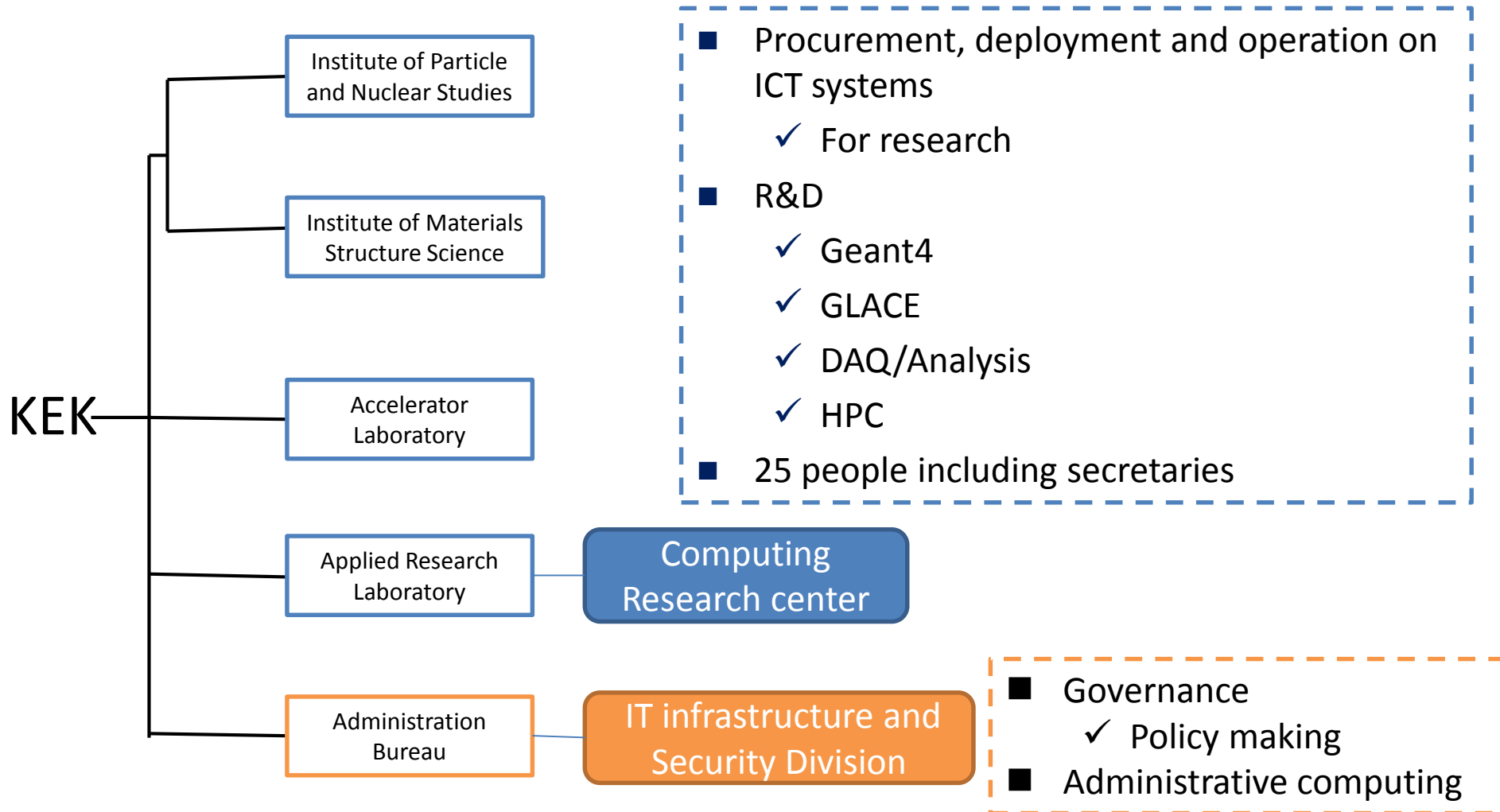
ILC Scheme | © www.form-one.de

Various R&D for ILC has been conducted at KEK as an international endeavor.



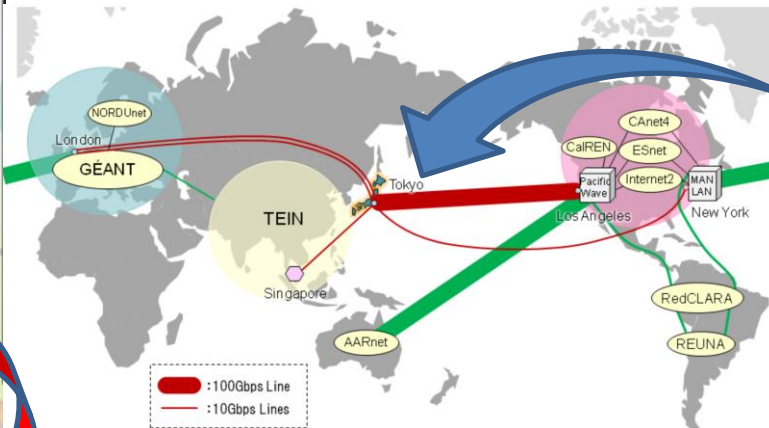
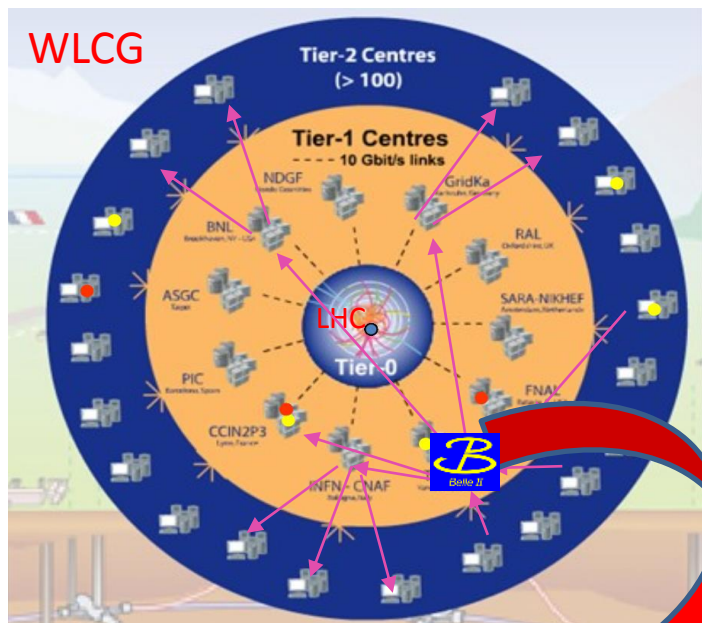
Superconducting cavity Test Facility



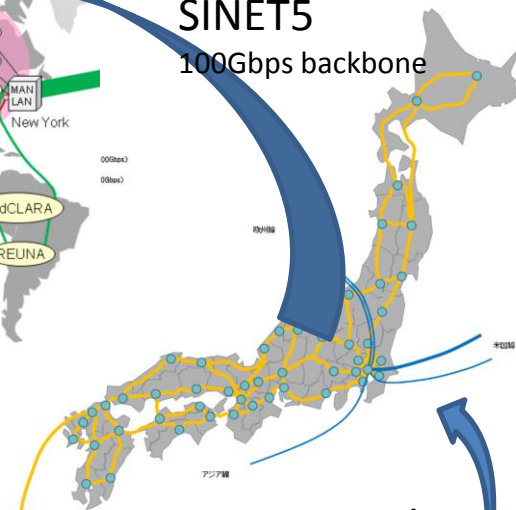


- Services, not just hardware and software
 - ▶ 4-5 years contact
 - ▶ The provider is chosen in competitive tenders
 - ✓ The procedure takes 1.5 years period according to the government regulations
 - ▶ Staffs necessary for the operation are sent to KEK from the companies
- The next procurement for Central Computer System will take place in 2020

KEK in Global Computing



SINET5
100Gbps backbone



BelleII Grid over WLCG(KEK and BelleII are observers)



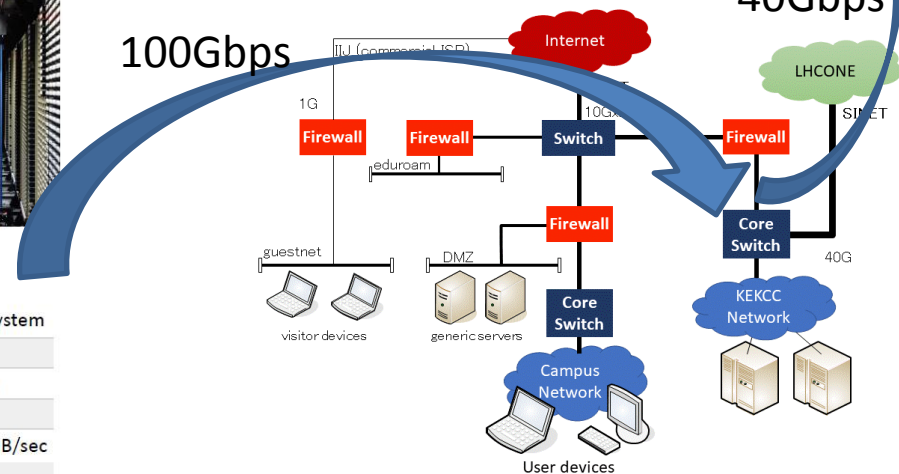
Linux Cluster

CPU Server	Lenovo NextScale
CPU Cores	10,024
Memory	54 TB
OS	Scientific Linux 6
Batch Job Scheduler	LSF

Data Storage (GPFS/HPSS)

Disk Storage	IBM Elastic Storage System
HSM Disk Storage	DDN SFA 12K
Disk Capacity	13 PB (3 PB for HSM)
Tape Drive	IBM TS1150
Tape Speed	10 TB/volume, 360 MB/sec
Tape Max Capacity	70 PB

100Gbps



40Gbps

Central Computer System 2016

I hope you have fruitful meetings this week
and enjoy fall/autumn in Japan.