Status Report from KEK

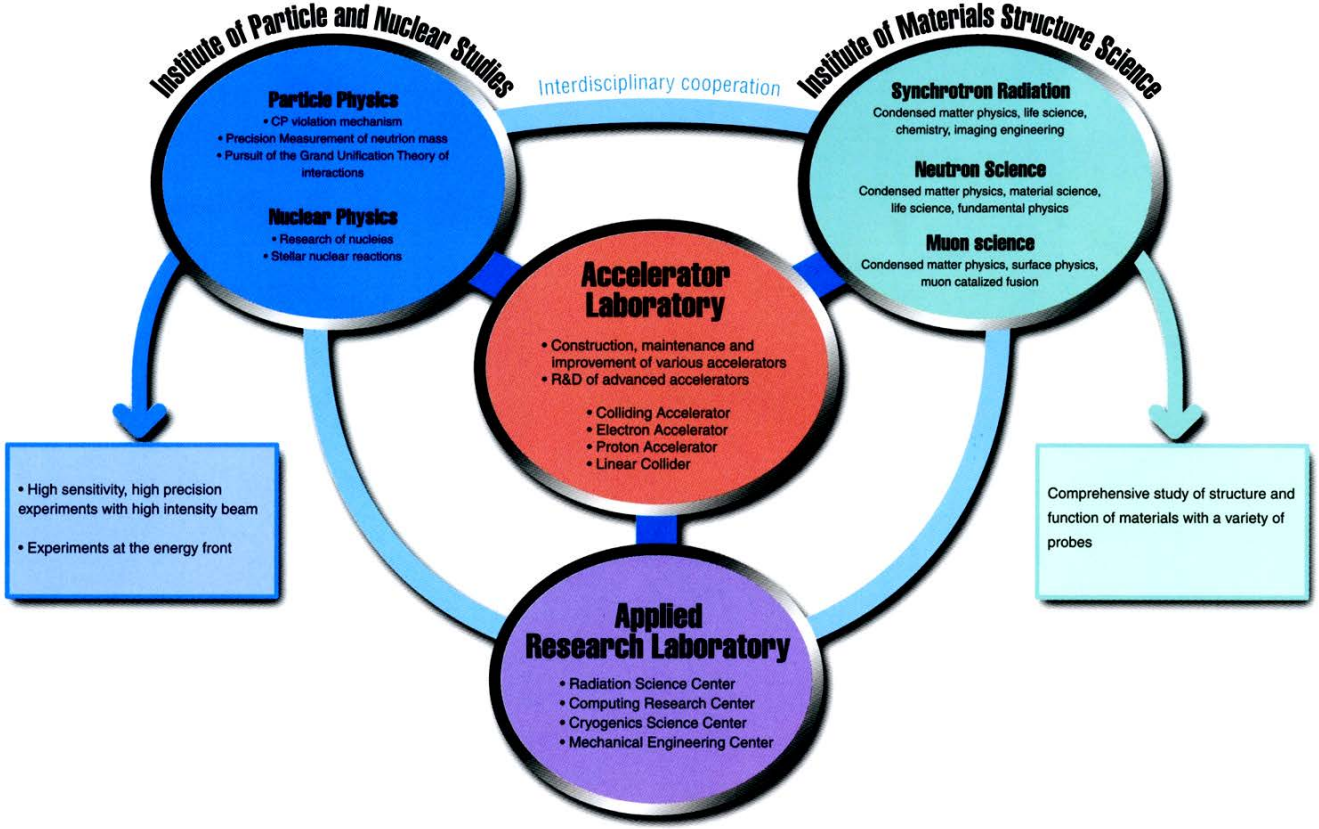
Yasuhiro Okada, Executive Director, KEK

2014 Joint Workshop of the TYL/FJPPL & FKPPL
Particle Physics Laboratories

May 27, 2014, Bordeaux, France

High Energy Accelerator Research Organization (KEK)

- Inter-University Research Institute Organization, first established in 1971 as National Laboratory for High Energy Physics
- International Accelerator Science Facilities
- Cover wide range of scientific fields

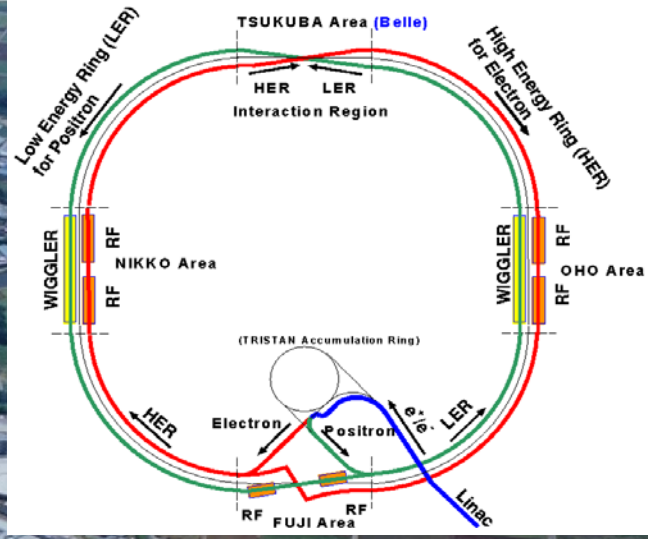


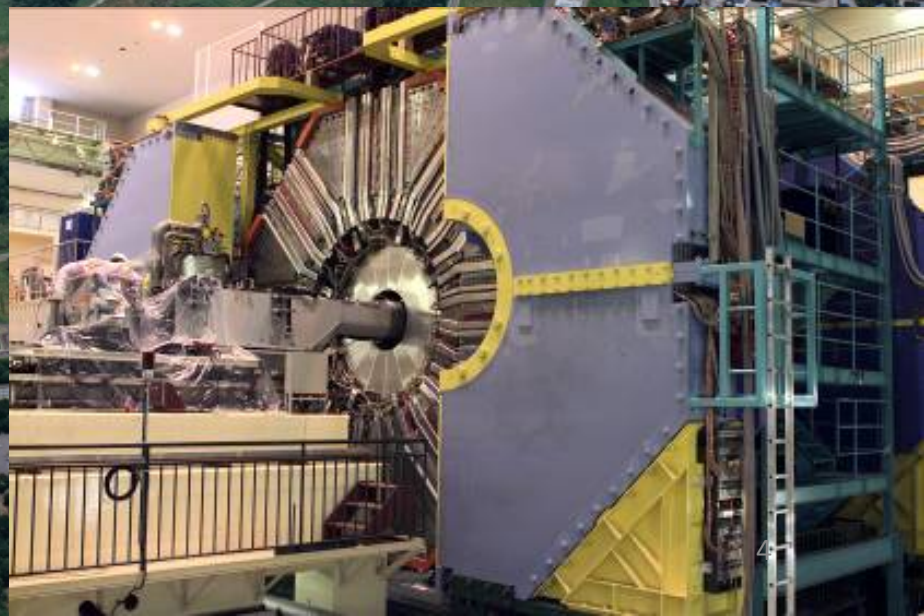
J-PARC: Joint Project between KEK and Japan Atomic Energy Agency (JAEA)

Electron machines in Tsukuba and proton machines in Tokai

KEKB and Belle

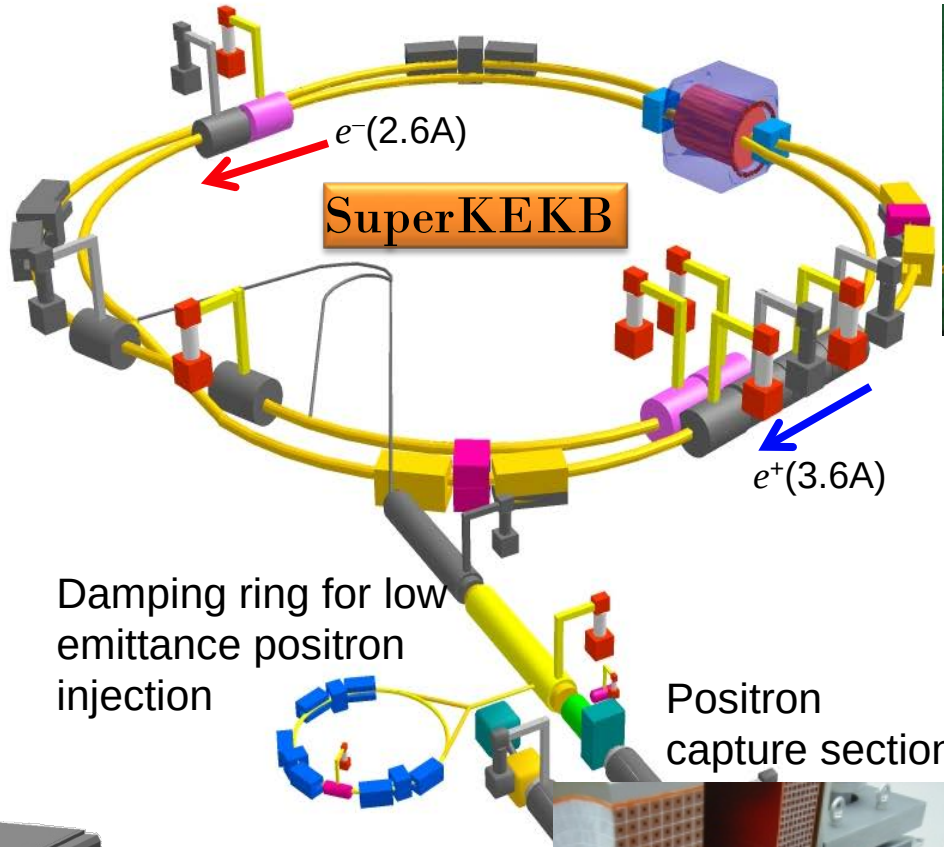
SuperKEKB and Belle II



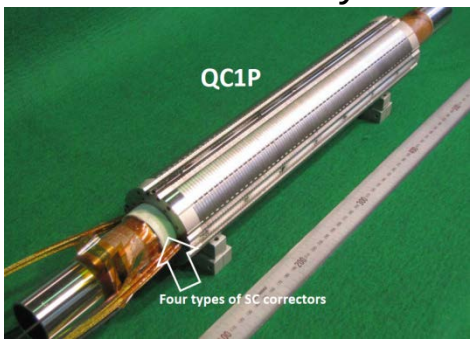


Accelerator upgrade

Low emittance lattice



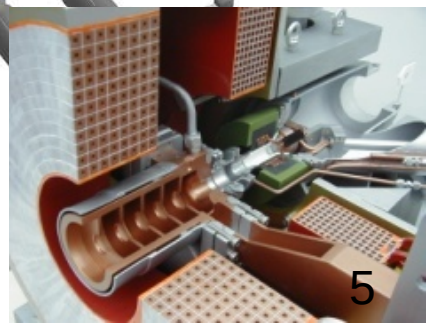
IR with β_y*=0.3mm
SC final focus system

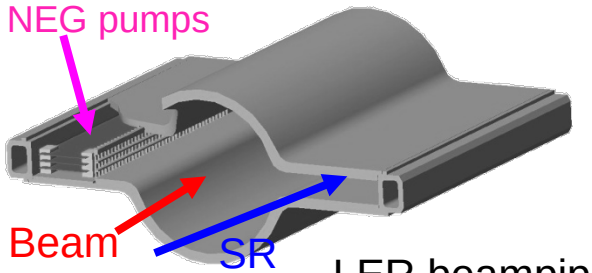


Add RF systems for higher beam current

Damping ring for low emittance positron injection

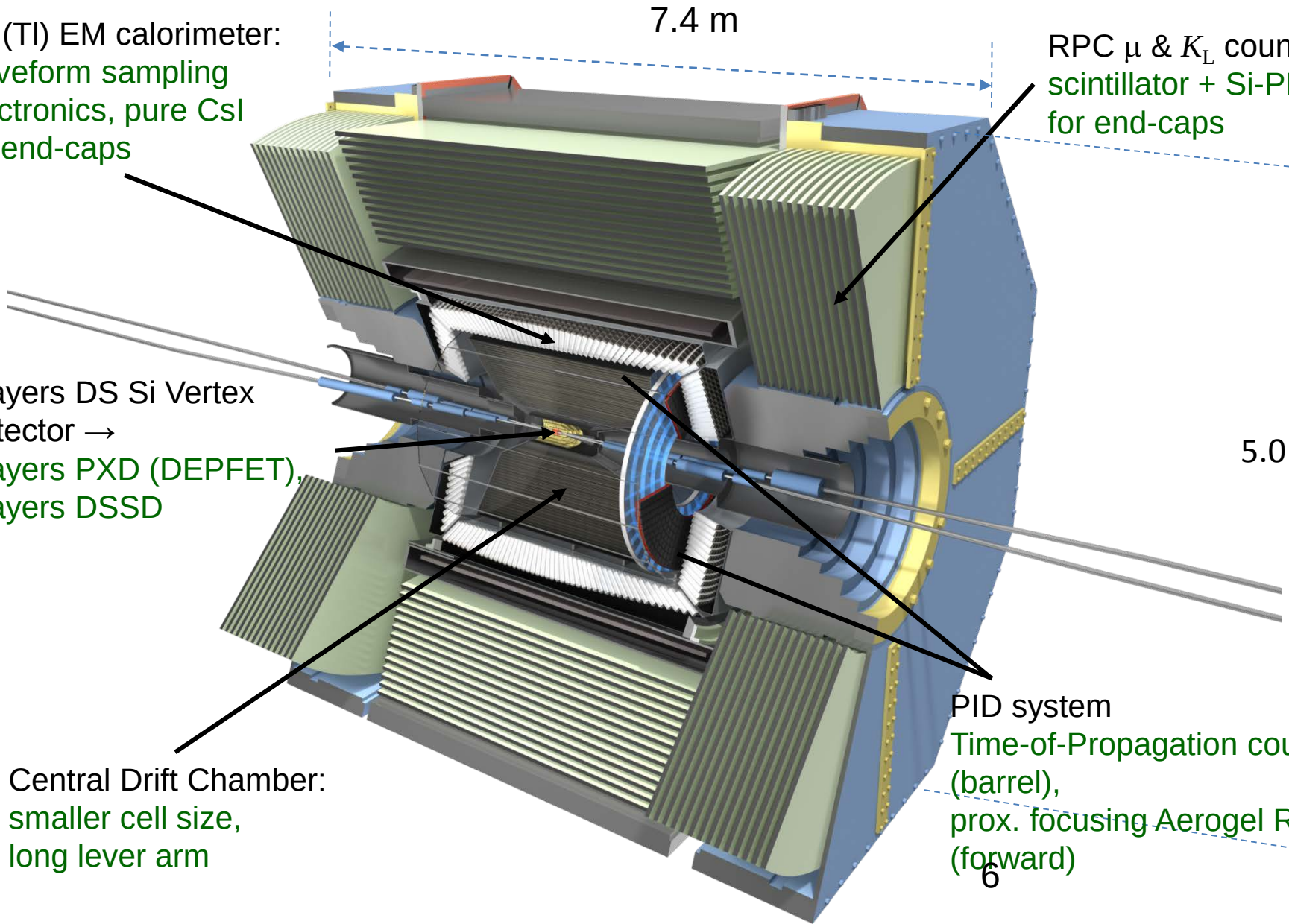
Positron capture section





LER beampipe to suppress photoelectron instability

Belle II Detector Upgrade



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

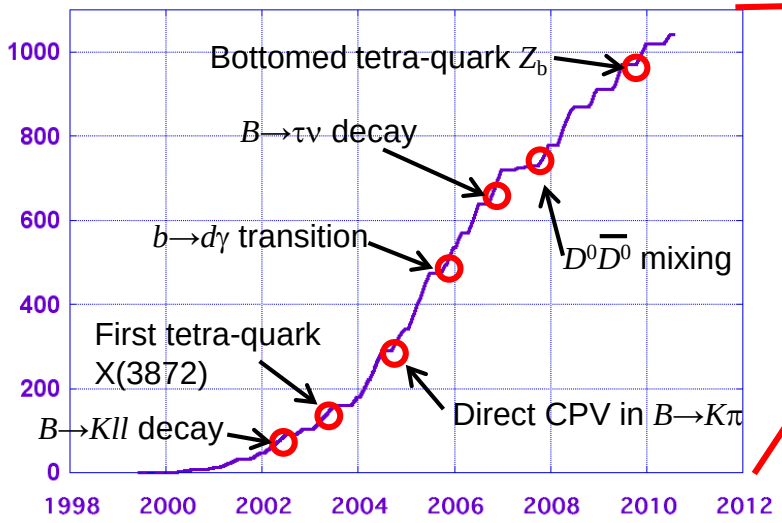
RPC μ & K_L counter:
scintillator + Si-PM for end-caps

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

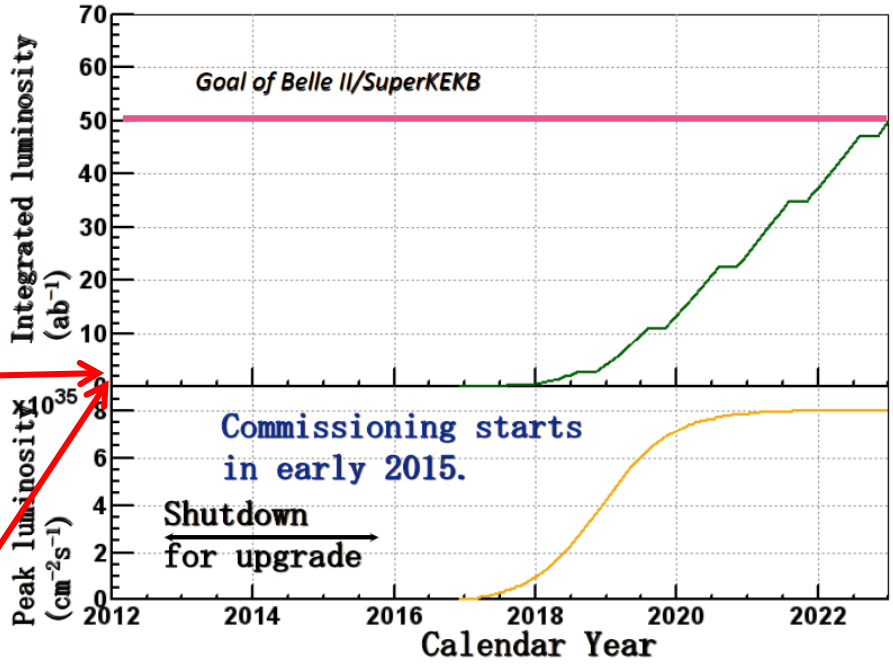
Central Drift Chamber:
smaller cell size,
long lever arm

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

Belle



Belle II



Golden modes

- **Key observables:**
  - Sensitive to different NP
  - Measurements to improve by order of magnitude
  - Not limited by hadronic uncertainties

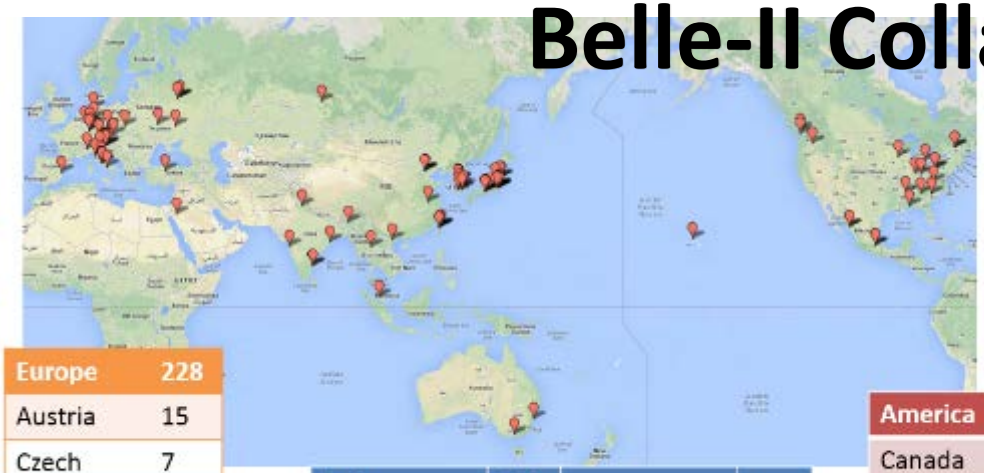
  e.g.

- **Unique capabilities of Belle II:**
  - Exactly two B mesons produced (at Y(4S))
  - High flavour tagging efficiency, with low trigger bias
  - Detection of photons, π^0, $\rho^{\pm}$, $\eta^{(\prime)}$, K_L: complete strong phase surveys of decay types.
  - Very clean(observe decays with several neutrinos)

- Difference of CP asymmetries, $S_{\psi K_S}$-$S_{\phi K_S}$, $S_{\psi K_S}$-$S_{\eta' K_S}$
- γ from CP asym. in tree level decays Vs. γ from penguins and boxes
- Charged lepton flavour violation, $\tau \to \mu\gamma$, $\tau \to eee$
- CPV in D^0 mixing
- A_{CP} in radiative decays, $S_{K_S\pi^0\gamma}$
- Rare searches and refinements, $b \to s\nu\nu$, $b \to s l^+ l^-$, $B \to \tau\nu$
- Improved CKM elements with full "Wilson Coefficient" analyses
- + Dark matter, new QCD states, Light Higgs.

List derived from Z. Ligeti KEKFF2013

Belle-II Collaboration



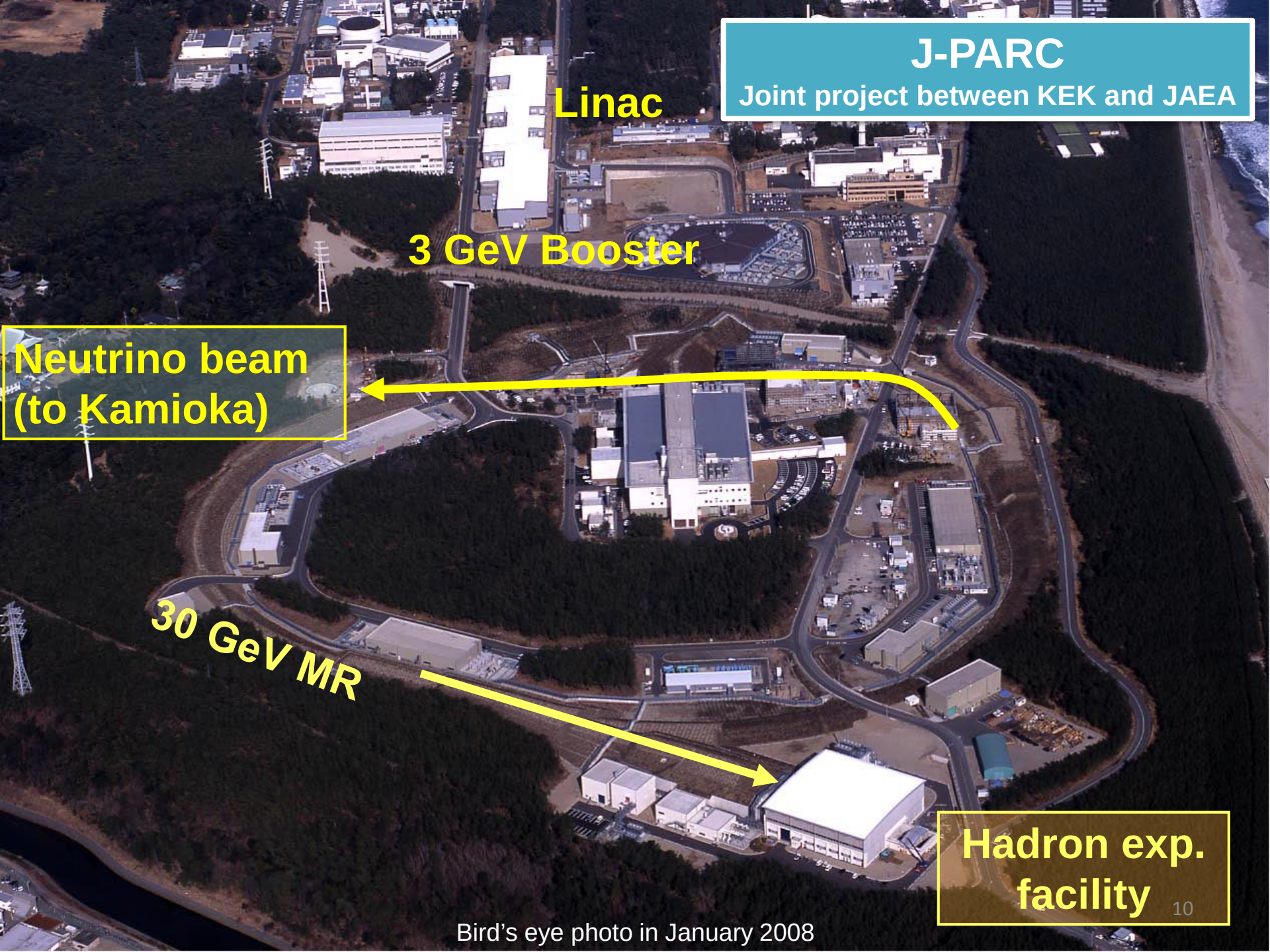
Europe	228
Austria	15
Czech	7
Germany	83
Italy	48
Poland	11
Russia	38
Slovenia	16
Spain	4
Ukraine	6

Asia	283		
Saudi Arabia	4	Korea	38
Australia	16	Malaysia	6
China	18	Viet Nam	3
India	22	Taiwan	24
Japan	145	Thailand	4
		Turkey	3

America	92
Canada	17
Mexico	6
U.S.A	69

- 603 collaborators from 97 institutions in 23 countries
- Spokesperson:

  Tom Browder (Hawaii)
- Series of open collaboration meetings in 2008.03 ~2014.2

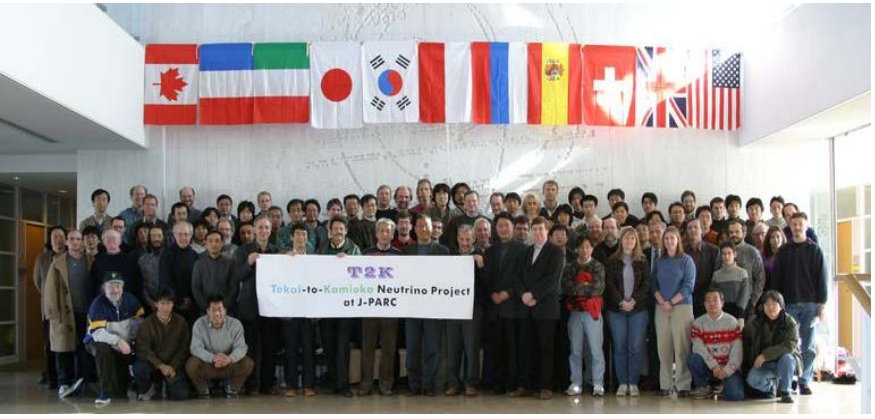


Bird's eye photo in January 2008

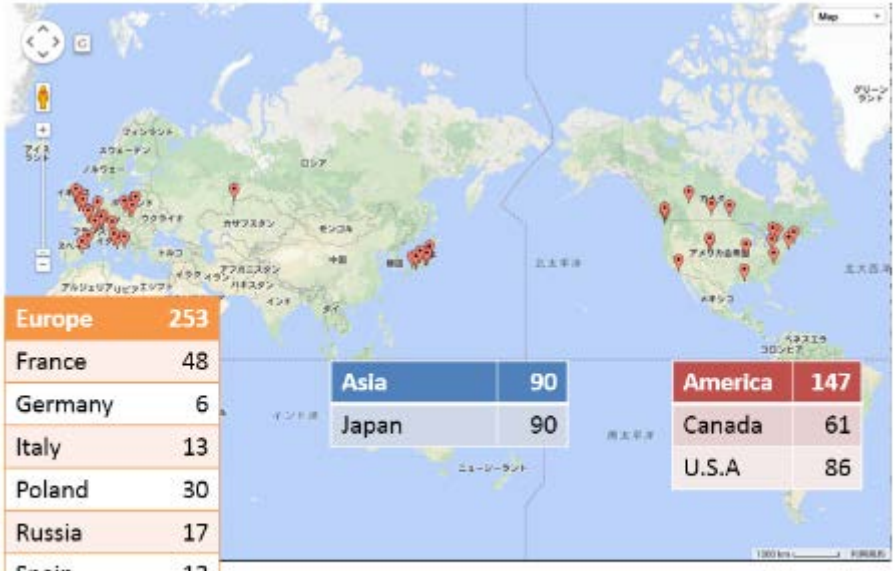
T2K : Long Baseline Neutrino Experiment

Super-Kamiokande
(ICRR, Univ. Tokyo)

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



~500 members from 59 institutions in 11 countries



Europe	253
France	48
Germany	6
Italy	13
Poland	30
Russia	17
Spain	13
Switzerland	26
UK	100

Asia	90
Japan	90

America	147
Canada	61
U.S.A	86

Recent results from T2K: ν_e appearance

Observed 28 ν_e candidate events (expected 4.64±0.53 events for $\sin^2 2\theta_{13}=0$)

- π^0 background rejection cut is improved using a new SK reconstruction algorithm.
- Near detector measurement is improved by using new event categories.

Fitting electron (p,θ) distribution:

7.5σ significance for non-zero θ_{13}

Best fit & 1σ error (@ $\delta_{CP}=0$)

normal hierarchy:

$$\sin^2 2\theta_{13} = 0.150^{+0.039}_{-0.034}$$

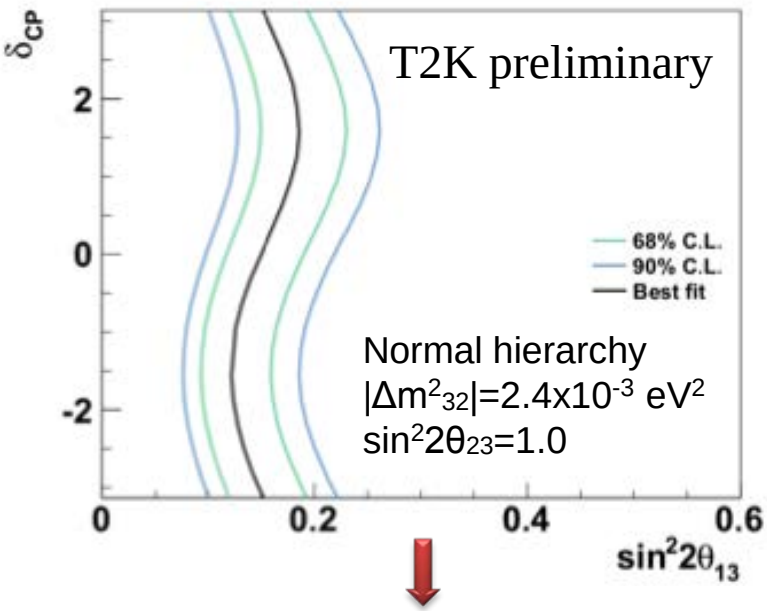
inverted hierarchy:

$$\sin^2 2\theta_{13} = 0.182^{+0.046}_{-0.040}$$

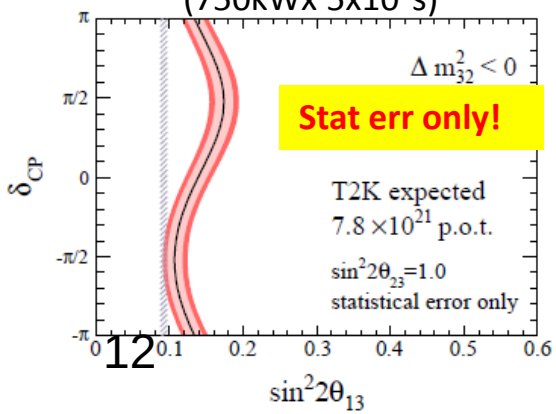
c.f. reactor results (PDG '12)

$$\sin^2 2\theta_{13} = 0.098 \pm 0.013$$

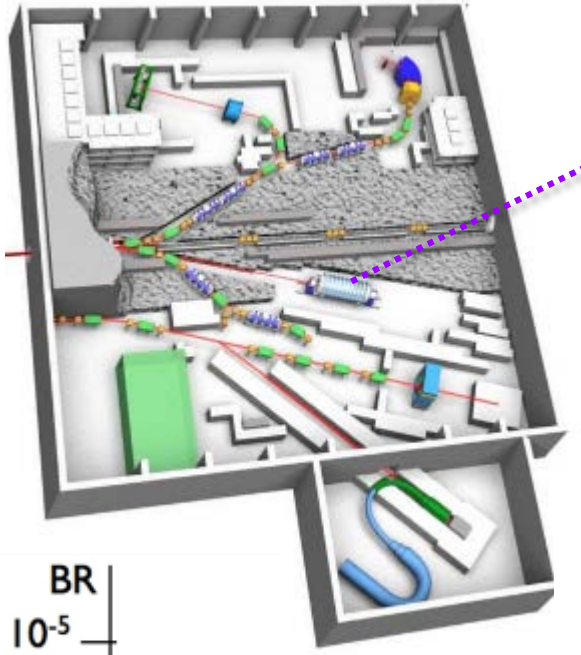
Based on 6.39 x 10^{20} p.o.t. (data until April 12th 2013)

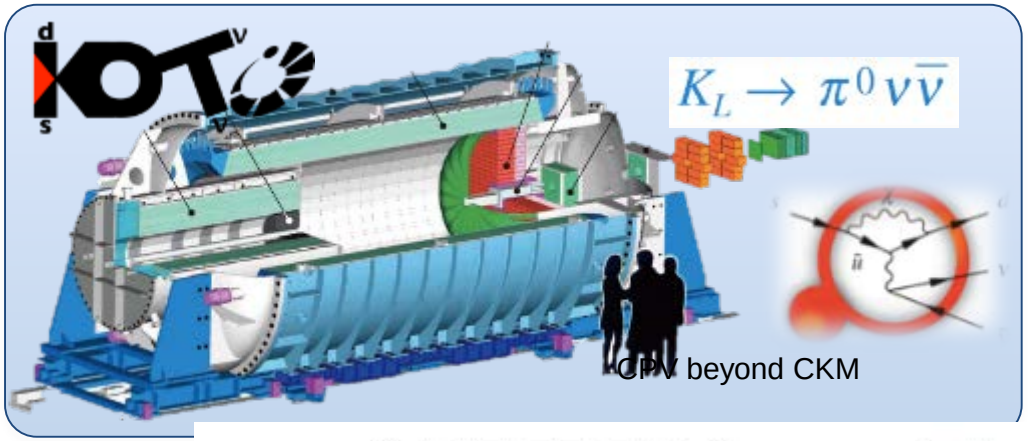


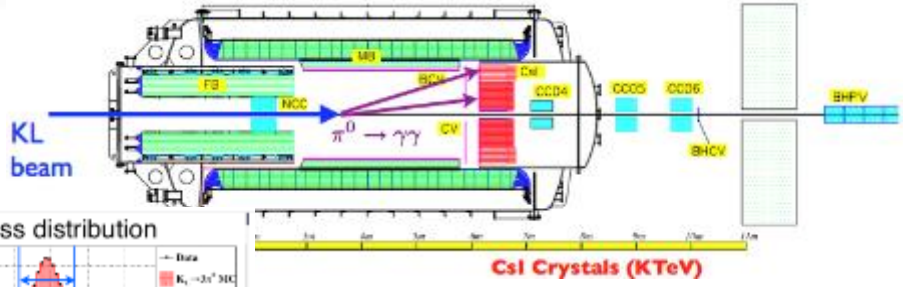
Expectation with ~50 times more data (750kWx 5x10^7s)

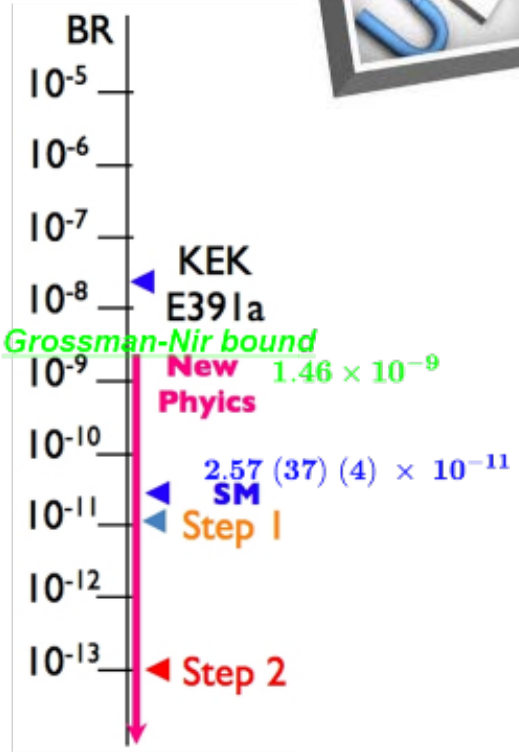


J-PARC Hadron Facility





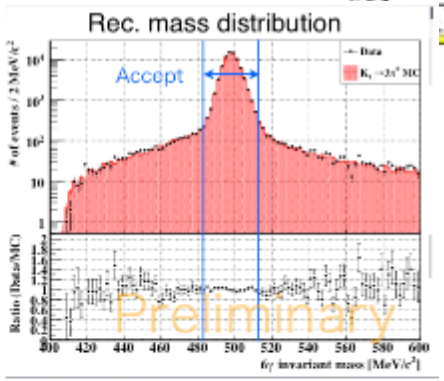




$K_L \to 3\pi^0$

分岐比

20%

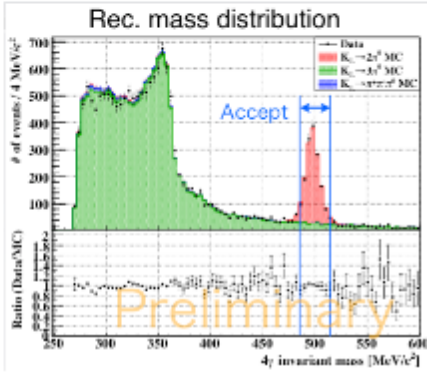


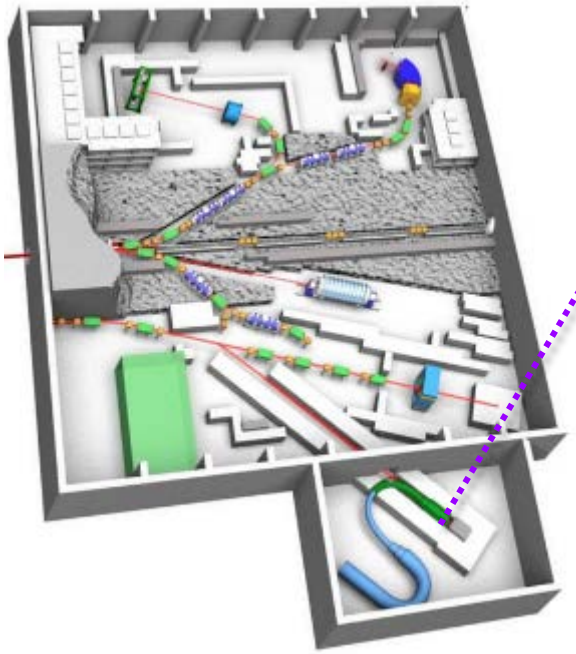
$K_L \to 2\pi^0$

w/ loose veto

分岐比

0.09%

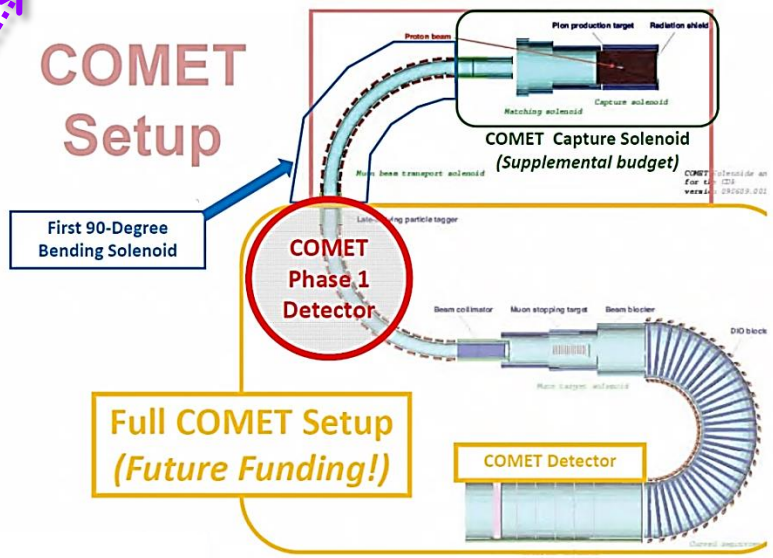




COMET: μ → e Conversion

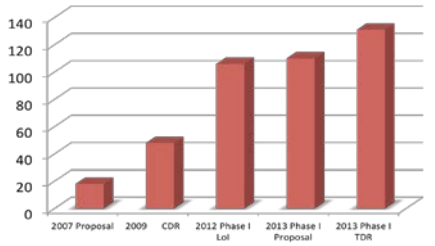
Signal : μ- + (A,Z) → *e*- + (A,Z)

COMET Setup

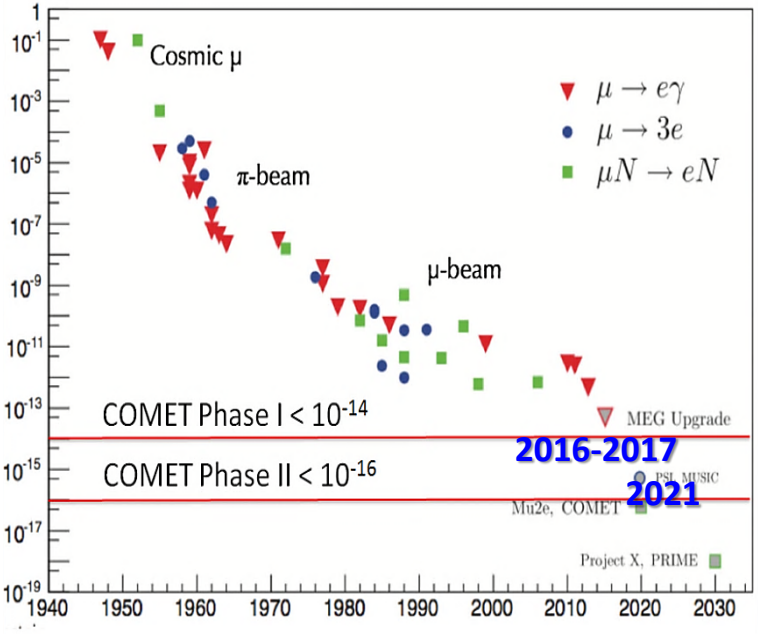


131 members from 12 countries

Collaboration growth



90% C.L. Upper Limit



Muon g-2@J-PARC

Intended Schedule

Improve Precision by 5 (0.1 ppm)

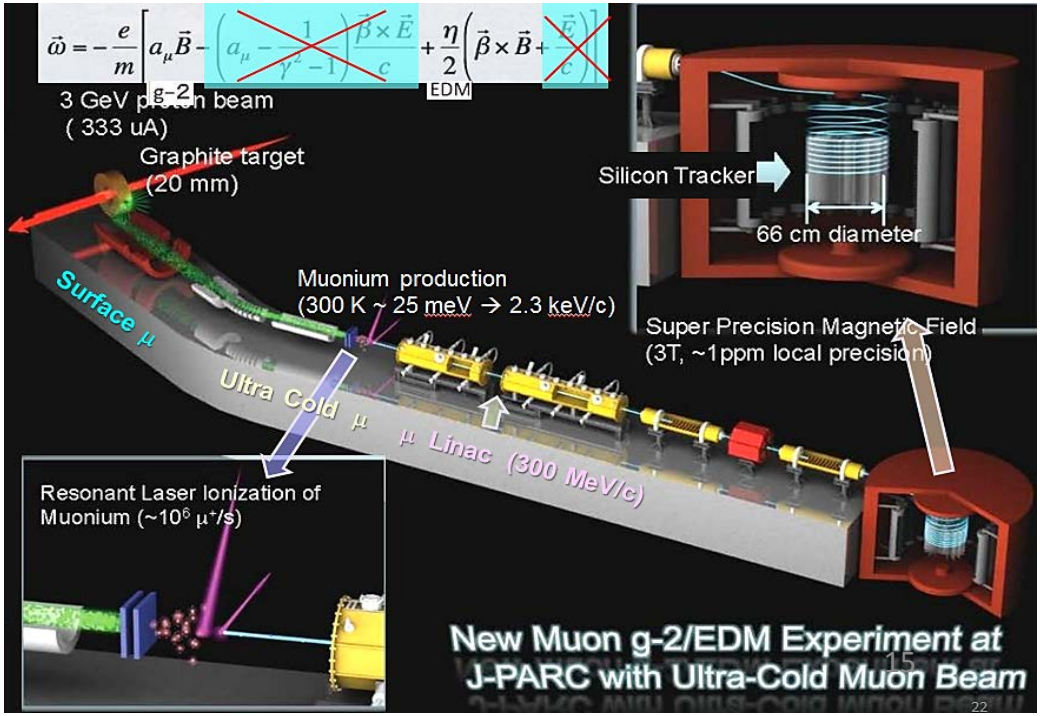
	2013	2014	2015	2016	2017	2018
Muon Sournce	R&D / Design			Construction		
Muon LINAC	R&D / Design			Construction		
Ultra-Precision Magnet	R&D / Design			Construction		
Detector	R&D / Design			Construction		

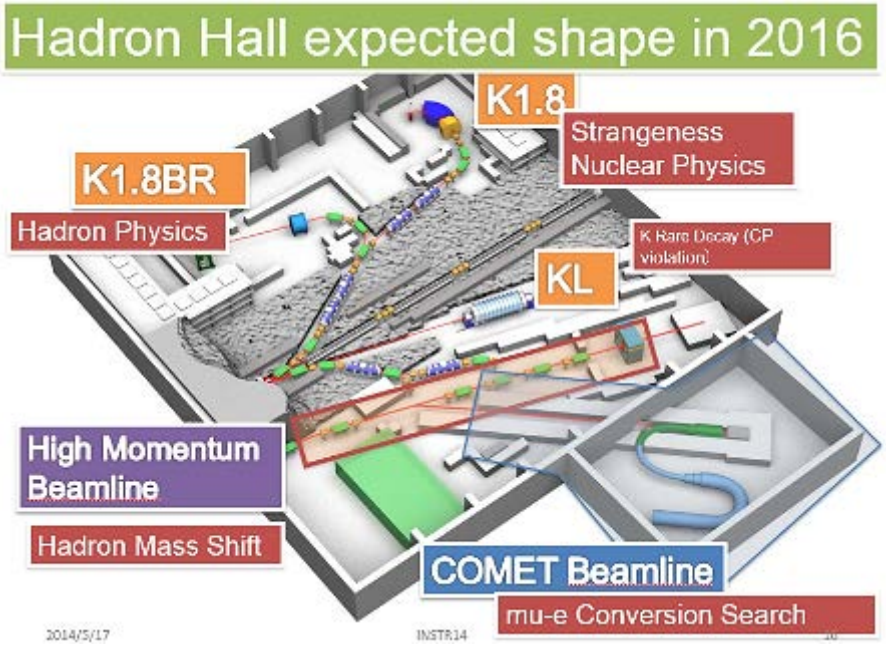
Experiment

Improve Precision by 100

EDM

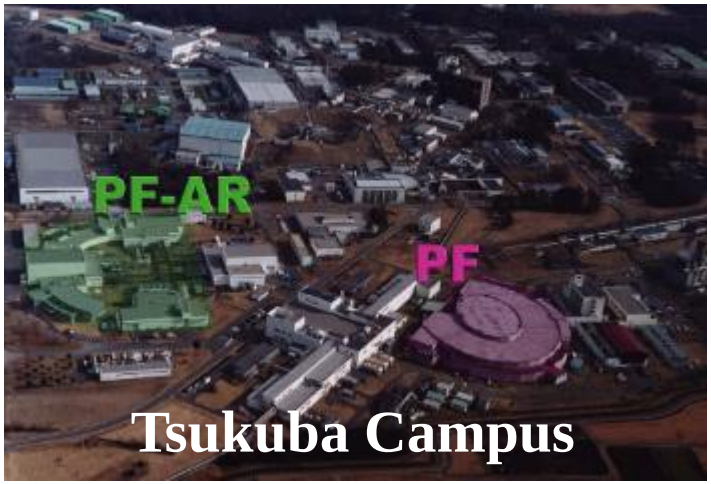
98 members (…still evolving) ,
21 Institutions , 9 countries

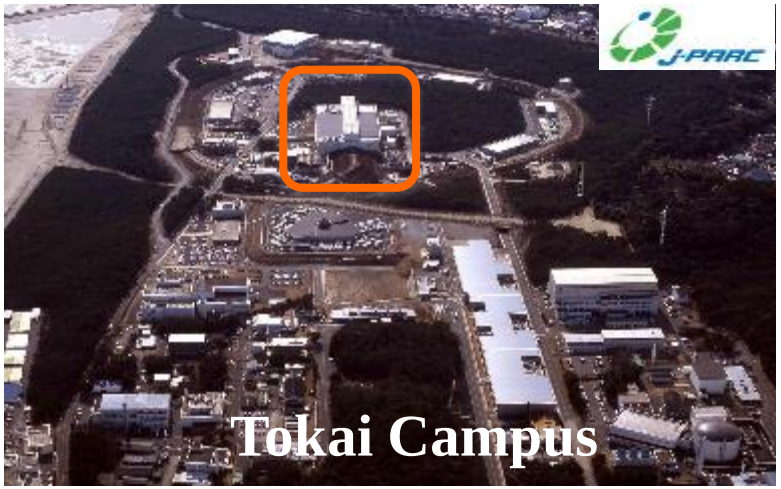




年次計画	H24 (2012)	H25 (2013)	H26 (2014)	H27 (2015)	H28 (2016)	H29 (2017)	H30 (2018)	H31 (2019)	H32 (2020)	H33 (2021)	H34 (2022)
Accelerator (Main Ring)		Beam Intensity Upgrades					Further Intensity Improvements				
Neutrino Exp.		Neutrino Oscillation and a hint of CPV									
					Next Generation Neutrino Experiment						
Hadron Exp.		Hi-momentum beamline					Hadron Hall Extension				
Muon Particle Physics Exp.		COMET phase-I				COMET phase-II g_μ-2/μEDM					
						(※)Accelerate to compete with US projects					
Neutron and Muon at MLF		Polarized neutron /muon S&H lines					Advance beamlines				

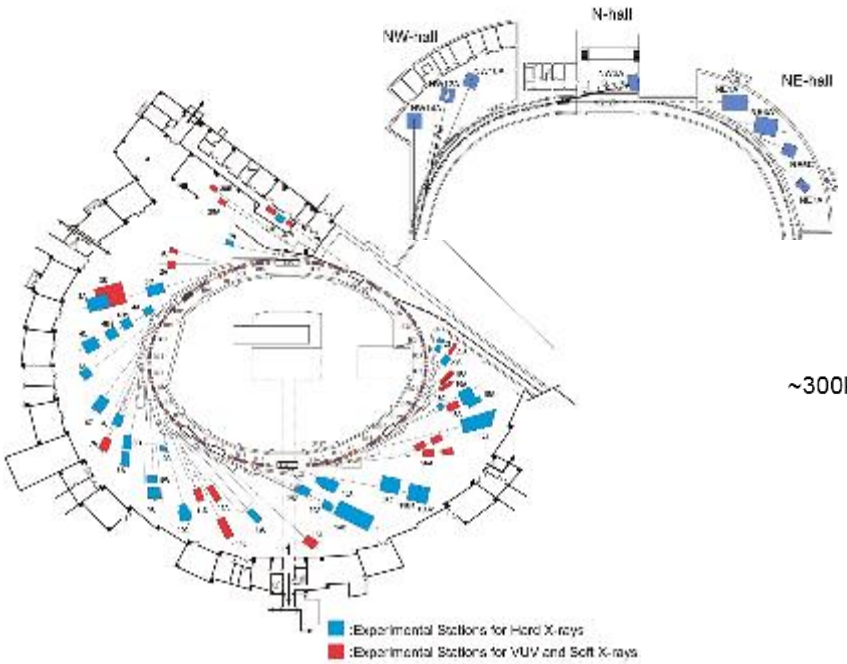
Progress in Material and Life Sciences

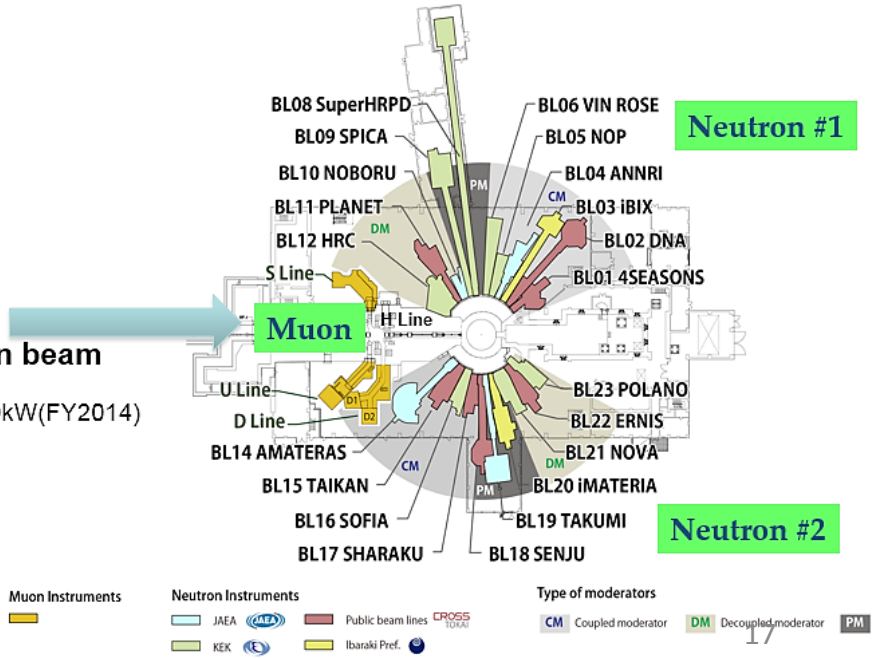




Synchrotron Radiation & Slow Positron

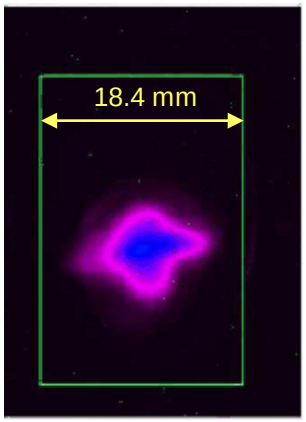
Neutron & Muon



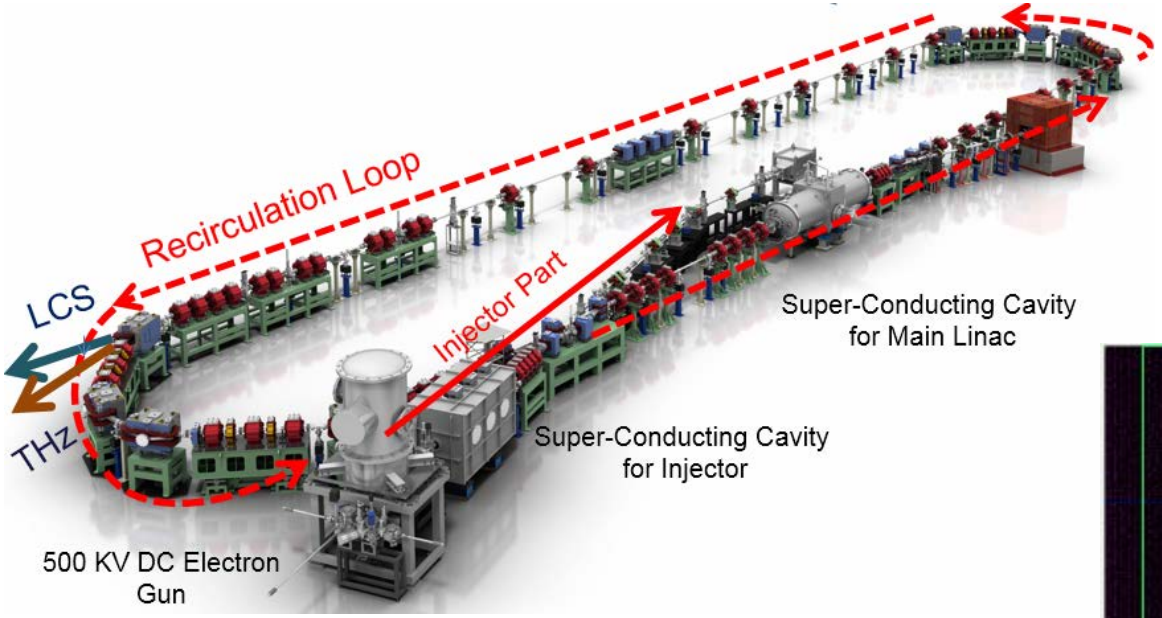


Achievement at the cERL in FY 2013

- Complete the construction of the hardware
- Commissioning of the beam operation
  - Injector part from April to June
  - Recirculation loop from Dec. to now

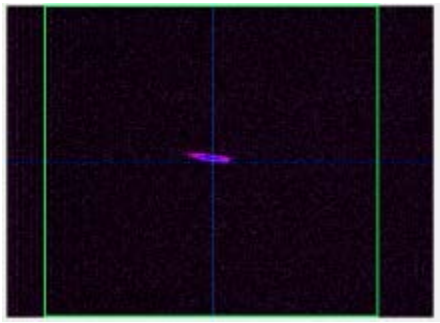


Beam profile at screen monitor (7.7pC/bunch)



- **Injector part (April to June)**

Confirm the electron beam emittance as 0.17 mm mrad at 10fC/bunch and ~0.8 mm mrad at 7.7 pC/bunch



Beam profile of decelerated beam in dump line

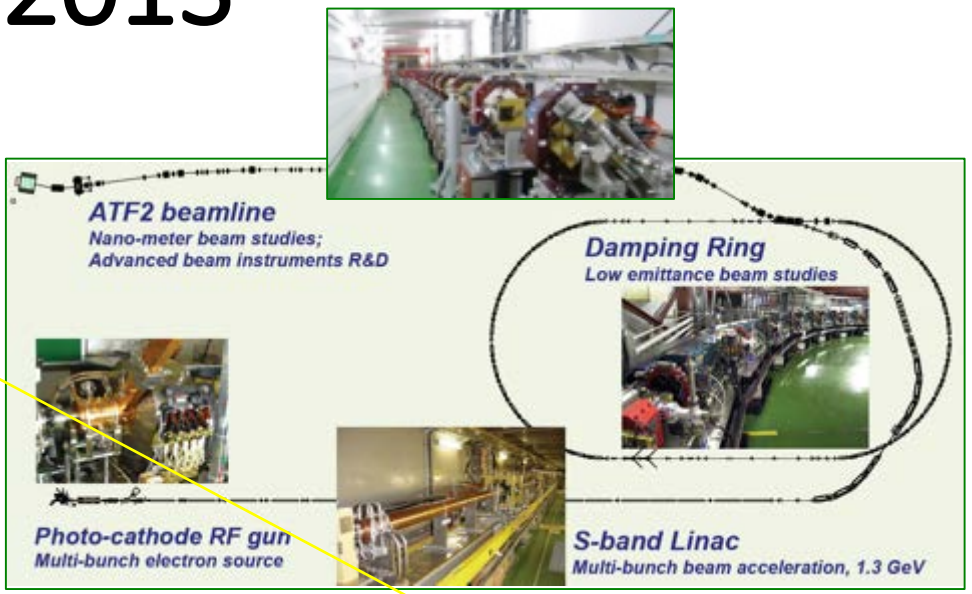
Fiscal Year 2014-2015(Application of cERL)
•Commissioning of LCS beamline
•Commissioning of THz beamline

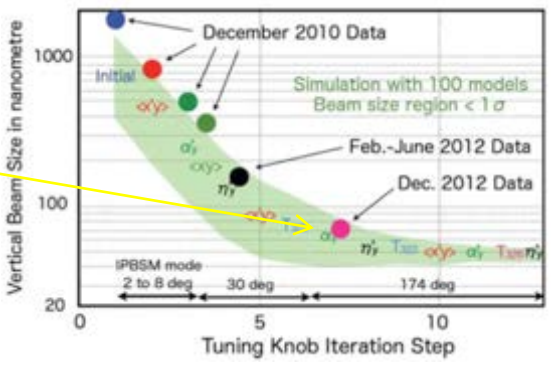
- **Recirculation Loop (December to Now)**
  - **confirm the accelerated electron beam up to 20 MeV by main linac and the decelerate electron beam at the beam dump line.**

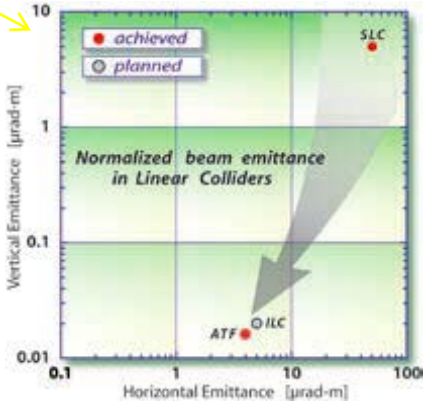
ATF2 Progress by 2013

Ultra-small beam

- Low emittance : KEK-ATF
  - Achieved the ILC goal (2004).
- Small vertical beam size : KEK ATF2
  - Goal = 37 nm,
    - 160 nm (spring, 2012)
    - 65 nm (April, 2013) at low beam current



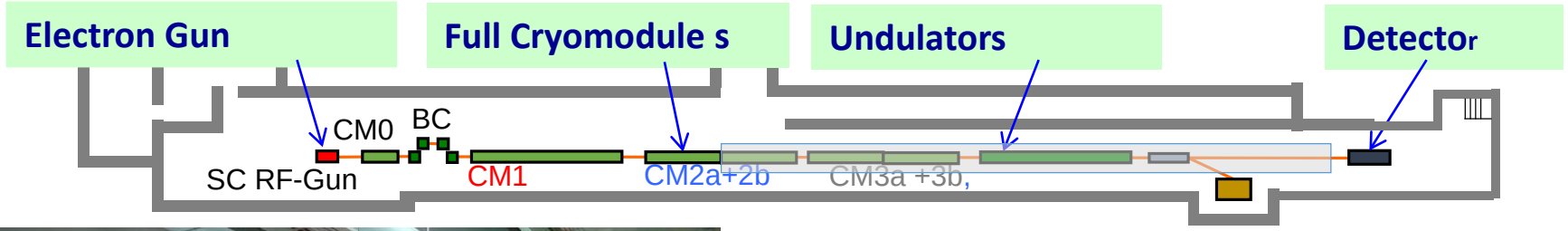




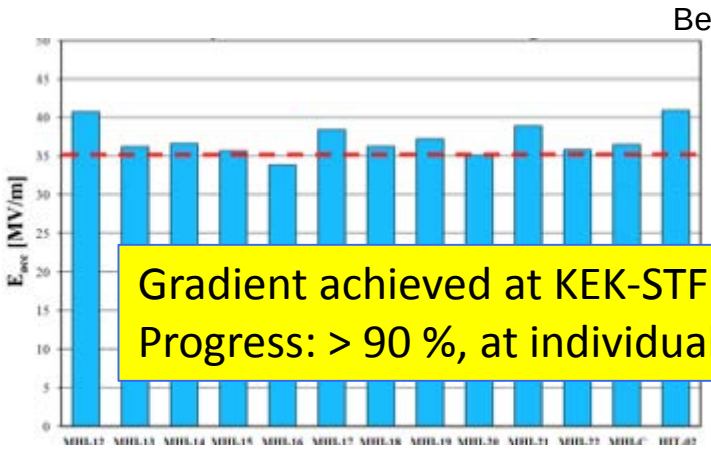
STF2; SCRF ACCELERATOR PLAN AT KEK

■ Objective
- High Gradient (31.5 MV/m)
  ＝＞Demonstration of full cryomodule
  - Pulse and CW operation
- Training for next generations

Plan:
- Multiple CM for system study
- In-house Cavity to be installed in cooperation with industry
- Wide range application including Photon Science



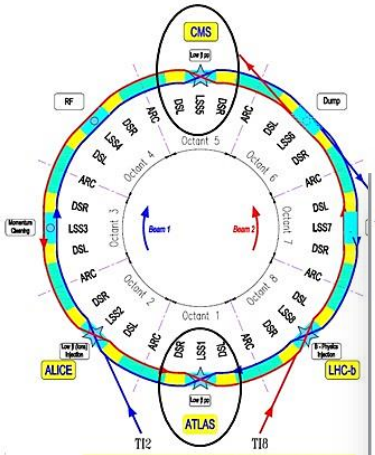
Beam Acceleration to be in 2015



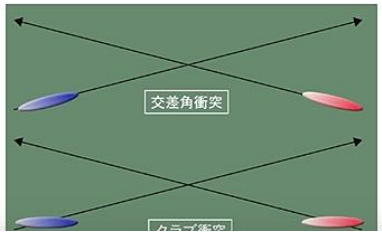
Gradient achieved at KEK-STF: > ~ 35 MV/m
Progress: > 90 %, at individual vertical test

LHC/ATLAS Upgrade

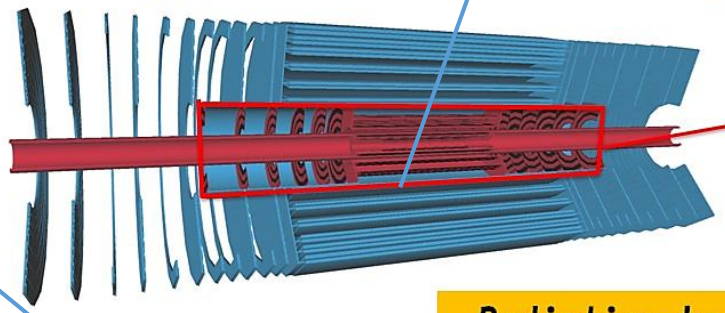
HL-LHC



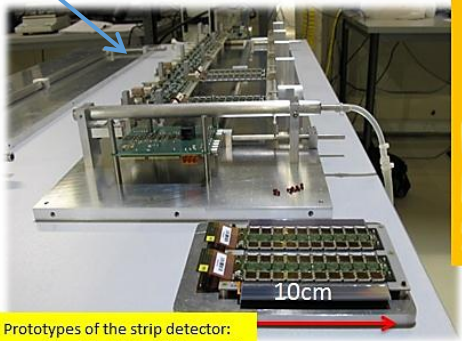
Replace the forcusing magnets around ATLAS and CMS.



ATLAS upgrade (1) Inner tracker replacement



A new inner tracker design



Prototypes of the strip detector: produced by KEK and Geneva U.

Radiation hard trackers are already in reality!

We need a huge investiment.

Pixel 8.2 m² 600 M ch.

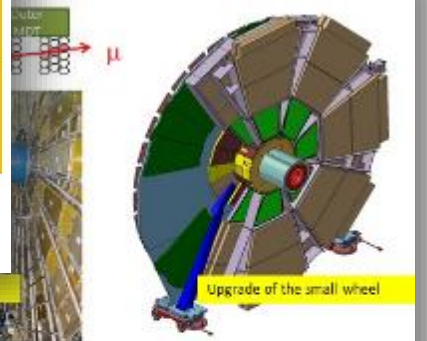
Strip 193 m² 70 M ch.

1

International collaboration has s
the design work of the magne

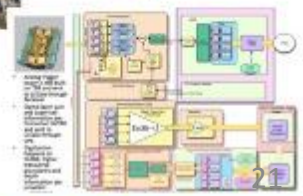
Challenges:
Large aperture (φ130~150mm) 6 Tesla magnet: saturation, flux leakage
High radiation dose: selections of rad-hard materials

r upgrade



Large wheels equipped with the TGCs

Track trigger (Waseda University)



CAL trigger upgrade (U. of Tokyo)

International collaboration

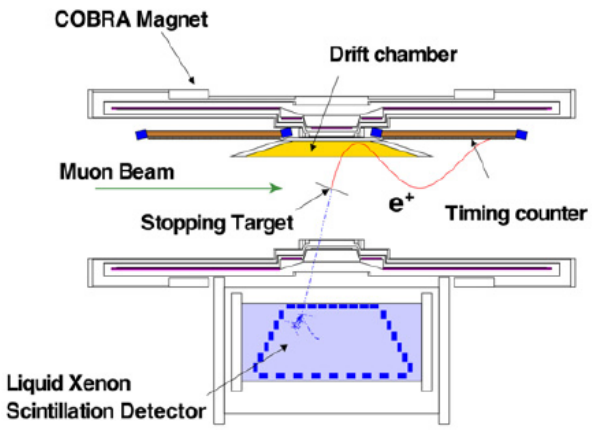
CMB B mode observation

QUIET

PolarBeaR

Atacama, Chile

MEG (μ->e γ search PSI)

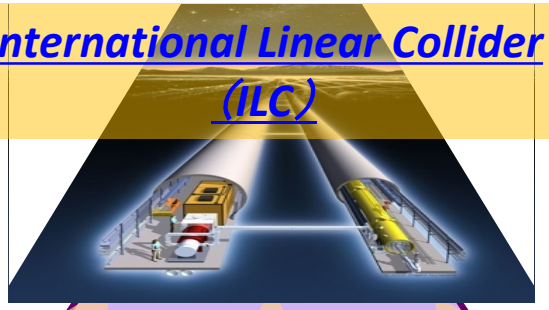


Ultra Cold Neutron (RCNP)

Quest for Birth-Evolution of Universe

International Linear Collider (ILC)

Quest for Unifying Matter and Force



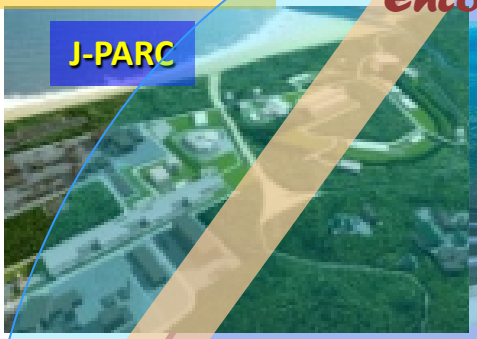
Lepton CP Asymmetry

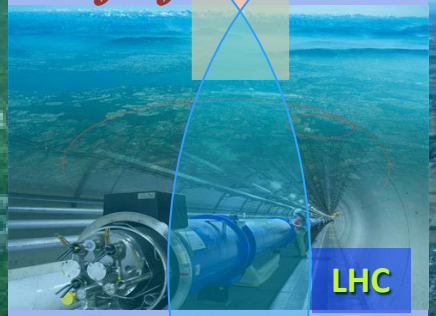
Scientific Activities
Technology Innovation
Encouraging Human Resources

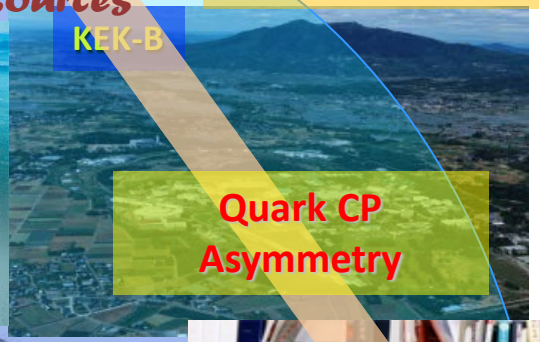
Beyond Standard Physics

Power-Upgrade

Super-KEKB







Quark CP Asymmetry

Lepton

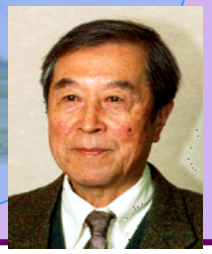
Quark

[Origin of Matter]

Quest for Neutrinos

Quest for 6 Quarks

[Origin of Force]



Higgs Particle [Origin of Mass]