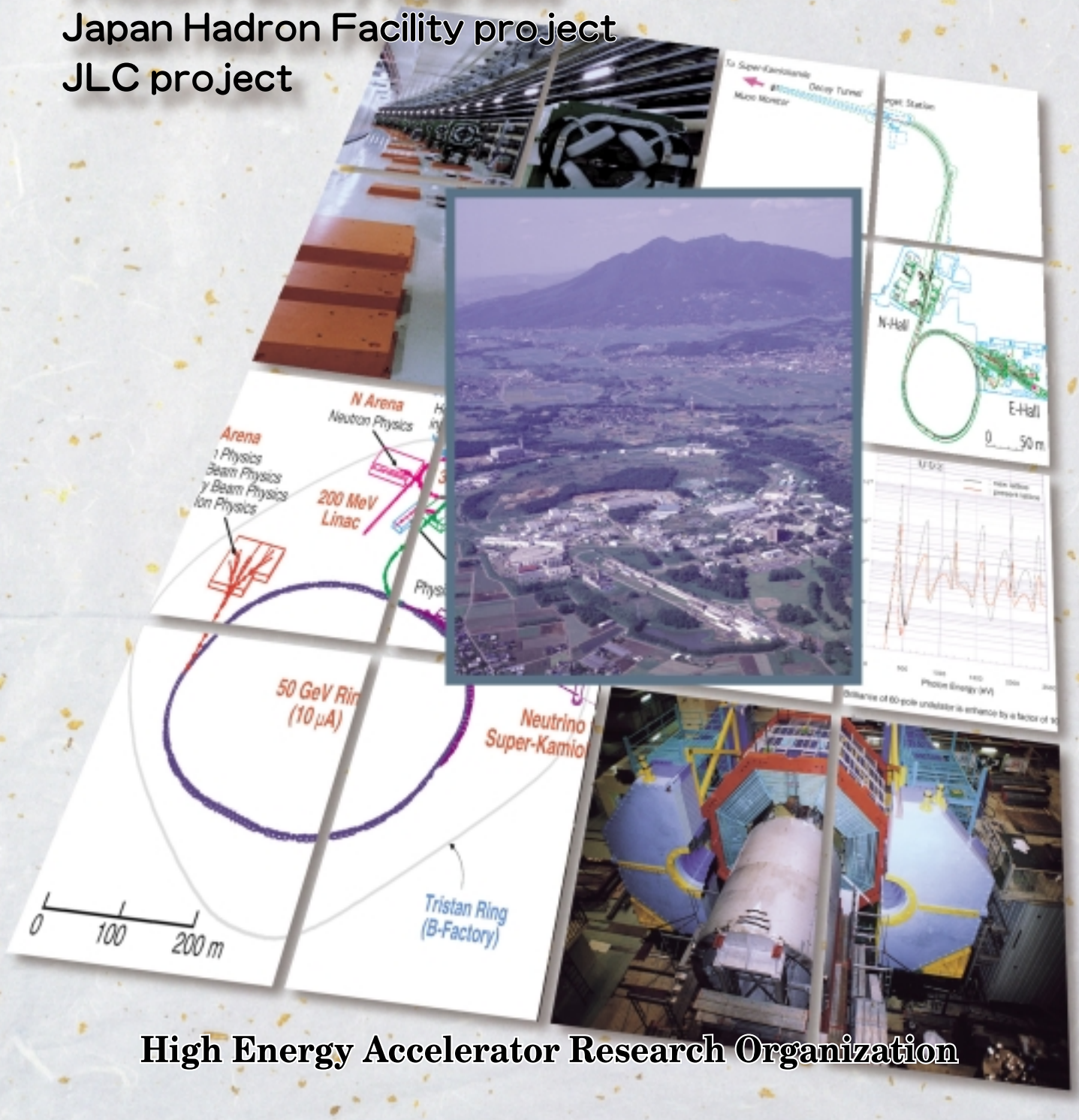
Vol. 1, No. 1

KEK News

New organization

Present and Future plans at KEK

- KEK B - Factory
- Long - Baseline Neutrino Oscillation
- Photon Factory Upgrades
- Japan Hadron Facility project
- JLC project



High Energy Accelerator Research Organization

Thanks to the supports from many people, the High Energy Accelerator Research Organization (new KEK) started with full enthusiasm from researchers. The foundation of this organization was formed from the Institute of Nuclear Study and the Meson Science Laboratory (both of University of Tokyo) and the National Laboratory for High Energy Physics (former KEK).

This newly founded organization consists of Institute of Particle and Nuclear Studies, Institute of Materials Structure Science, Accelerator Laboratory and Applied Research Laboratory.

With this new organization, we are geared up for the next step of our research activities. Following pages show the future plans of KEK. Some of them are already into construction phase and some of them are in R&D stages. I hope we will see even greater number of people from outside of Japan participating in future activities at KEK and make this organization one of the truly international facilities.

This "KEK News" (both Japanese and English versions) replaces the KEK Monthly Report (Japanese version only) of the former KEK days, as the new organization starts. With its English version, we hope we can reach more people outside of Japan and attract many young physicists to participate in KEK activities. We will appreciate your continuing interest and support on future issues.

September 15, 1997

Director General

Hirotaka SUGAWARA

Institute of Particle and Nuclear Studies

Director *Sakue YAMADA*

The Institute of Particle and Nuclear Studies is working on the B-factory project and the Long-baseline neutrino oscillation project along with all other project INS and/or former KEK has been working on. This includes studies with 12 GeV proton synchrotron as well as collaboration on experiments or R&D efforts in the USA, Europe and Asia. R&D efforts concerning the research programs at the JHF and the JLC projects are also done in here.

Institute of Materials Structure Science

Director *Yoshitaka KIMURA*

The Institute of Materials Structure Science was founded on former Photon Factory and former Neutron Facility, both of KEK, and former Meson Science Laboratory of University of Tokyo. With the new organization this institute will be challenging wide varieties of activities in materials structure science field by fully utilizing accelerator generated research probes such as synchrotron radiation, neutrons, muons, slow positrons, etc.

Accelerator Laboratory

Director *Motohiro KIHARA*

Accelerator Laboratory specializes in all aspects of particle accelerators, fully utilizing wide range of experiences obtained from KEK accelerators as well as other R&D studies done at the former KEK accelerator division.
It will lead the designing of future accelerators as well.

Applied Research Laboratory

Director *Kenjiro KONDO*

Applied Research Laboratory consists of four research support centers. Along with its activities, this Laboratory supports various research activities at KEK with the advanced technology on computing, cryogenics, mechanical engineering, radiation physics and environmental protection.

Engineering Department

Director *Akira MIKUNI*

Engineering Department represents engineers and technicians of this organization to provide most effective professional assistance to physicists.

Administration Bureau

Secretary General *Michiaki TAKAISHI*

Administration Bureau is also reorganized to accommodate the new organization : General Management, International Research Cooperation and Plant & Facilities.

Present and Future Plans at KEK

KEK has been operating for many years the 12 GeV Proton Synchrotron, the 0.5 GeV Booster Synchrotron Utilization Facility and the 2.5 GeV synchrotoron radiation source, Photon Factory, to be used for a variety of scientific research, while successfully completeing the 9-year high-energy-physics program in 1995 with the 60 GeV electron-positron collider (TRISTAN).

As you will see in the following pages, new KEK offers even richer advanced research programs with new projects which are all at final stages of construction ;

- B-Factory project challenging to solve a mysterious, subtle imbalance between particles and their antiparticles.
- Long-baseline neutrino-oscillation experiment aiming to probe very tiny masses of neutrinos.
- Upgraded Photon Factory providing very high quality light beams for materials science.

In parallel with these ongoing efforts, KEK is conducting intense studies and is preparing for the next-generation research facilities that again would lead the world.

Significant progresses have been made and an early start is anticipated for the following projects ;

- JHF (Japan Hadron Facility) project, construction of a high-intensity proton accelerator complex, for nuclear physics, particle physics, and materials science.
- Conversion of the 6.5 GeV Accumulation Ring to a dedicated synchrotron x-ray source.
- JLC (Japan Linear Collider) project, construction of a 500 GeV electron-positron collider, for particle physics at energy frontier.

While these new projects are well under way, research activities at the present KEK facilities are already going strong, having over 500 visiting researchers from abroad every year. It is our intention to open all the research facilities to the world scientific community and, by having many more researchers from abroad involved in these new projects, to make KEK one of the truly international centers for accelerator science.

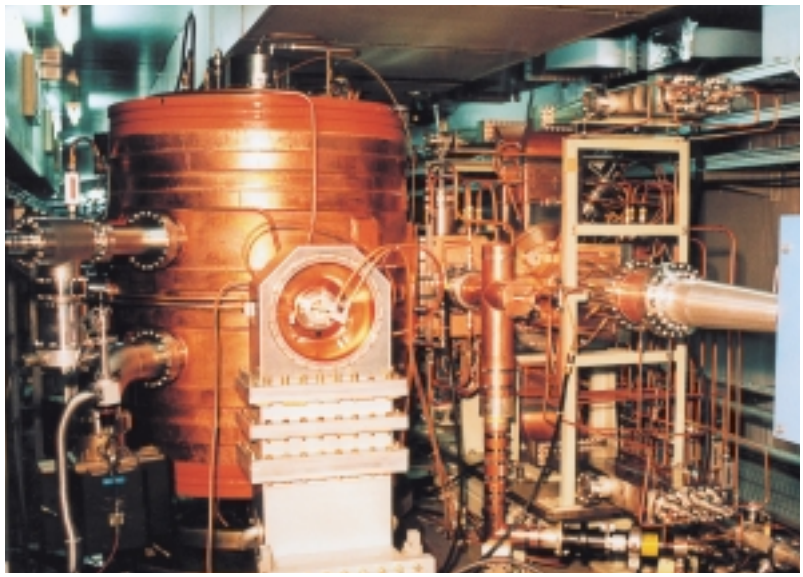
(for job openings, please see http://www.kek.jp/personnel.html)

KEK B-Factory Project

KEK B-Factory Project aims at solving the long-standing puzzle of elementary particles ; there is a subtle imbalance in physics law between particles and their antiparticles (CP violation). On the other hand, there is a huge imbalance between matter and antimatter in the universe ; an antimatter world does not seem to exist. The B-Factory project is expected to give a clue to answer such questions, too.

An experimental key to the CP problem lies in the third-generation quark, the bottom quark. An asymmetric electron-positron collider (KEKB) is under construction as a means to selectively mass-produce high-energy B-antiB meson pairs, where a B is a meson made of a b-quark and a lighter quark. To measure such final states, a general-purpose detector (BELLE) is being built. It is used to quantify differences between decays of B and antiB mesons and also to study all aspects of b-quarks at unprecedentedly deep levels.

The new collider, KEKB, is built in the TRISTAN tunnel which is 3 km in circumference. A 3.5 GeV positron beam crosses with an 8 GeV electron beam at a shallow angle of 11 mrad. In order to achieve an ultimate collision luminosity of $10^{34}/cm^2/sec$, very high beam currents are distributed over 5,000 bunches going around the collider rings. The beams are stably accelerated with newly developed superconducting as well as normal conducting RF cavities and are further stabilized with a feedback system.

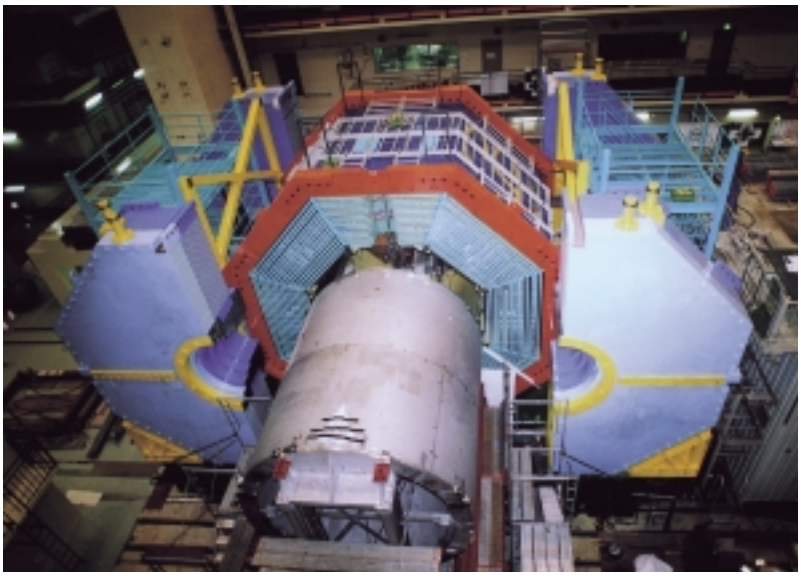


ARES Normal conducting accelerating cavity with energy storage. Large tank at left is the energy storage cell.

Quadrupole magnets for LER placed in the TRISTAN tunnel

The new detector, BELLE, is being constructed by a large collaboration of physicists from 10 countries/regions. It can perform accurate particle tracking in 1.5 Tesla magnetic field and is equipped with fine-grained calorimeter for high precision gamma-ray measurement.

Good particle identification capability is provided by advanced Time-of-Flight counters as well as new aerogel Cherenkov counters. Data acquisition system allows a very high-rate data collection with parallel processing.



BELLE detector structure under construction
Cryostat of superconducting magnet is about to be installed.

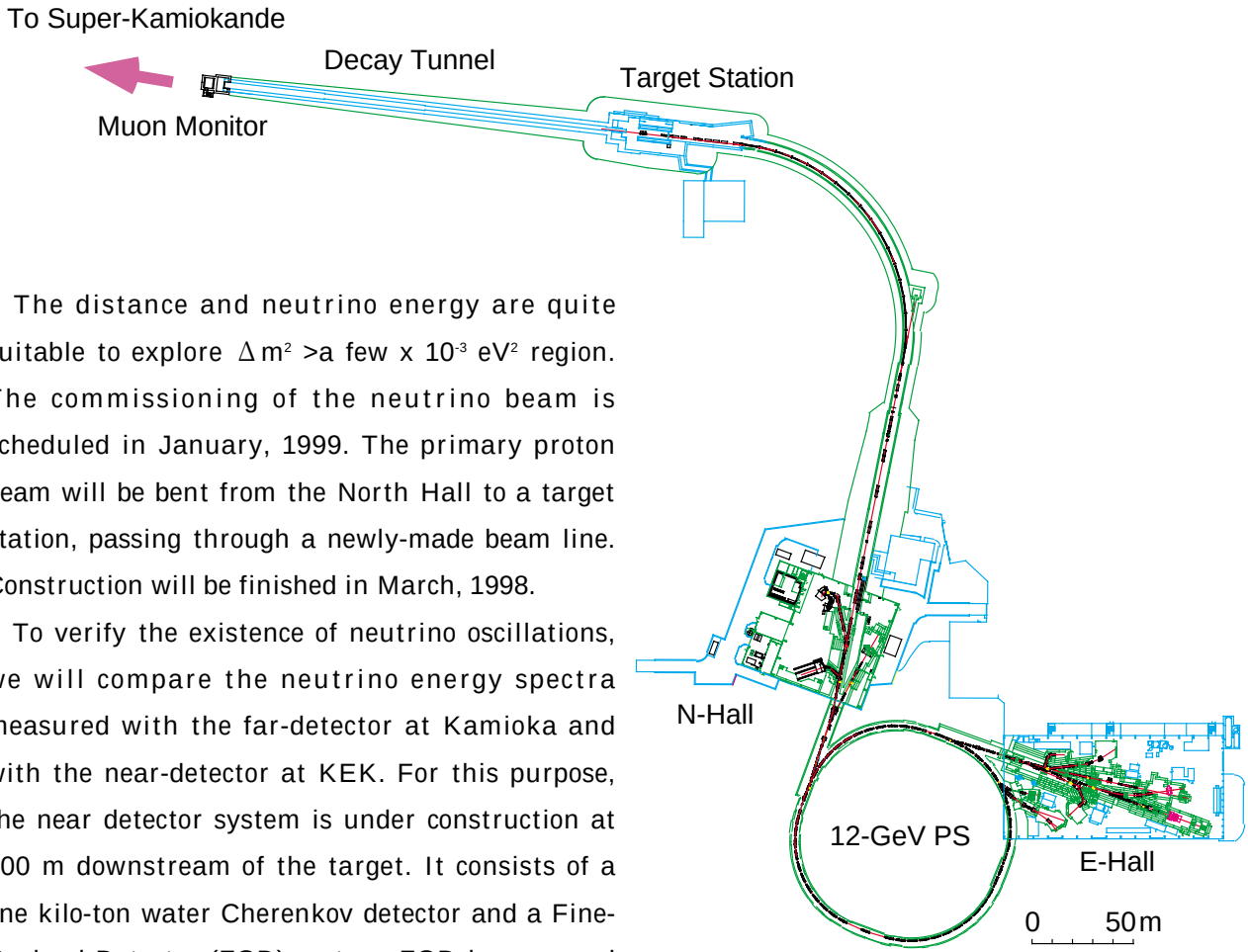
Central Drift Chamber

Commissioning of the project is scheduled to be in the fall of 1998, both for KEKB and BELLE. The experiment will start by the beginning of 1999.

Long-Baseline Neutrino Oscillation Experiment

KEK is presently preparing for a long-baseline neutrino oscillation experiment linking KEK to Kamioka.

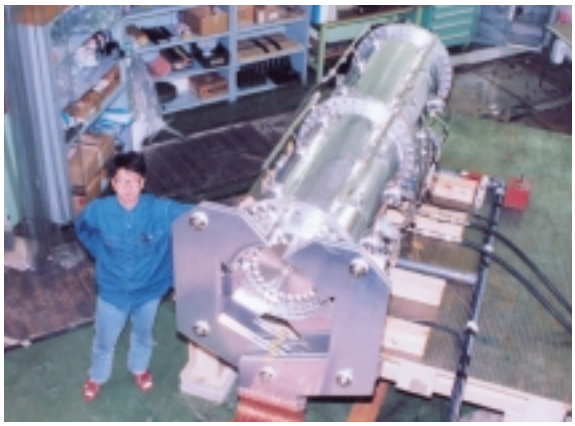
In this plan, a high-intensity muon neutrino beam (average energy of 1.5GeV) produced at the KEK-PS will be injected to the Super-Kamiokande located 250km west of KEK



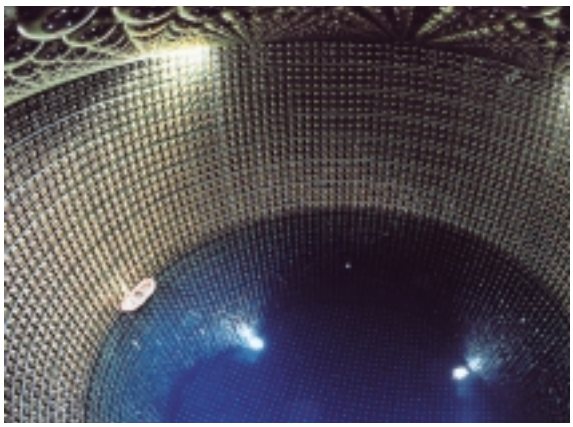
The distance and neutrino energy are quite suitable to explore Δm^2 >a few x 10^{-3} eV^2 region. The commissioning of the neutrino beam is scheduled in January, 1999. The primary proton beam will be bent from the North Hall to a target station, passing through a newly-made beam line. Construction will be finished in March, 1998.

To verify the existence of neutrino oscillations, we will compare the neutrino energy spectra measured with the far-detector at Kamioka and with the near-detector at KEK. For this purpose, the near detector system is under construction at 300 m downstream of the target. It consists of a one kilo-ton water Cherenkov detector and a Fine-Grained Detector (FGD) system. FGD is composed of (i) water target with 4-ton fiducial volume interleaved every 6 cm by scintillating fiber sheets, (ii) EM shower calorimeter of 600 lead-glass blocks, and (iii) muon range detector with 12 pairs of iron plates and chamber layers. The muon neutrino energy spectrum is reconstructed by detecting each charged current quasi-elastic interaction (CCQE). Electron neutrino contamination rate in the original beam, estimated to be about 1%, is obtained from (i) and (ii). The expected event rate is 4 x 10^4 CCQE interactions for the 4-ton fiducial volume of FGD in 3 years of running, which should be compared to what we will obtain in the Super-Kamiokande (200 CCQE and 400 total charged current events without oscillation). Any overall deficit in the number of muon neutrino, distortion of their spectra, and/or appearance of electron neutrino events is the signature for the neutrino oscillation.

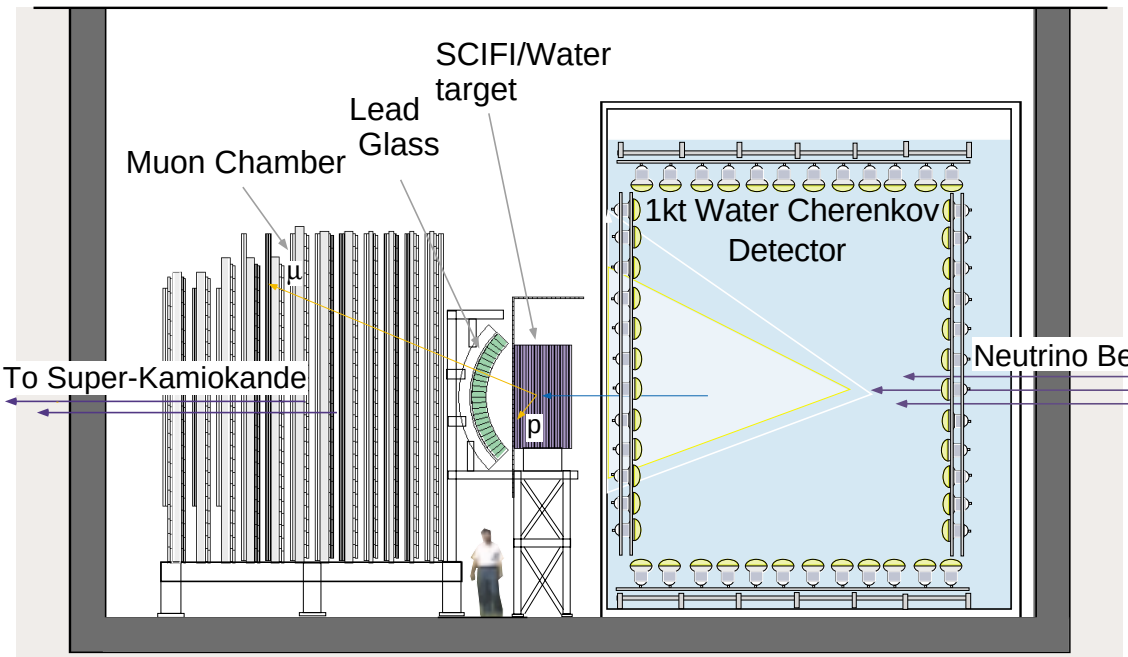
The HORN magnet system consists of a target and the surrounding cylindrical conductors both made of aluminum. A large pulsed current is applied to generate a strong magnetic field, focusing secondary pions to the detector direction. A series of tests were performed. A long-term operation test with the nominal current have been taking place since July, 1997.



HORN magnet system



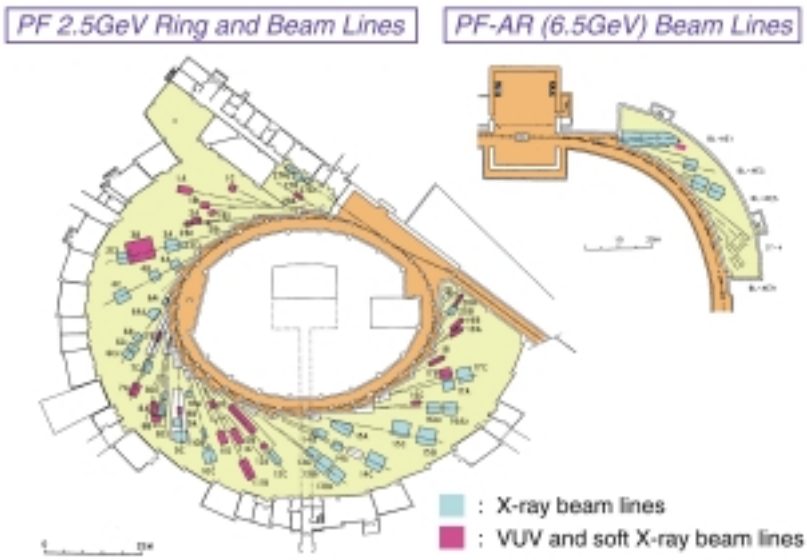
Super Kamiokande (ICRR, University of Tokyo)



Front Detector System at KEK site

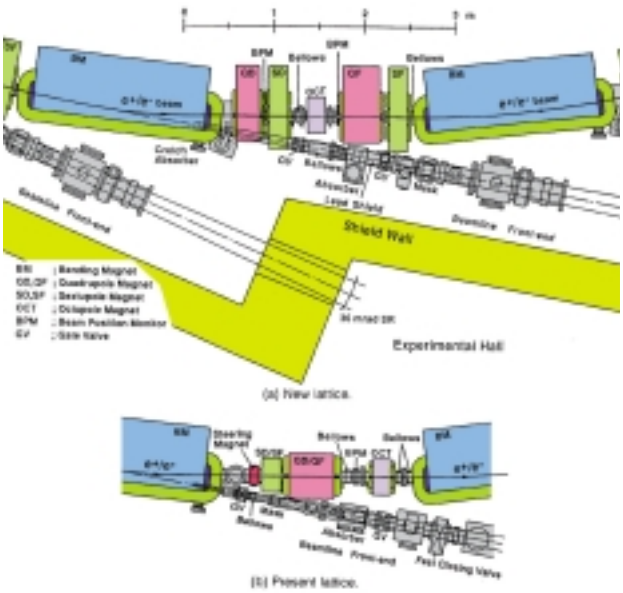
Photon Factory

The Photon Factory has two storage rings for synchrotron radiation research. One is a dedicated 2.5 GeV positron (electron) storage ring (I=400mA,τ=60hrs) which has been operational since 1982. The other is the 6.5 GeV Tristan Accumulation Ring (I=40mA,τ=3hrs) which has been used parasitically for synchrotron radiation research since 1986. About 700 experimental proposals are active now covering a variety of scientific fields.

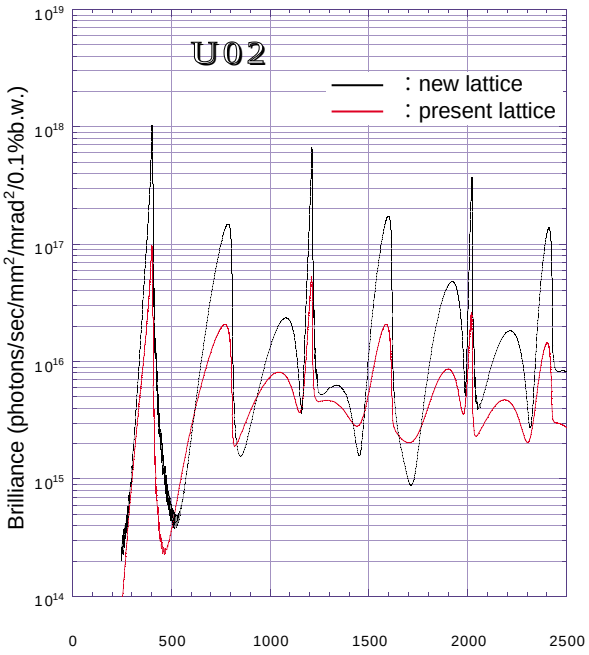


Upgrade program of 2.5 GeV ring

In 1997 the lattice of the 2.5 GeV ring is being modified to reduce the emittance of the electron beam from the present value of 130 nmrad to 27 nmrad (Commissioning of the ring is being scheduled in Oct. 1997). With this modification, the brilliance of the SR source will be enhanced by a factor of 5 to 10.



Modification of the lattice of 2.5Gev ring for emittance upgrade



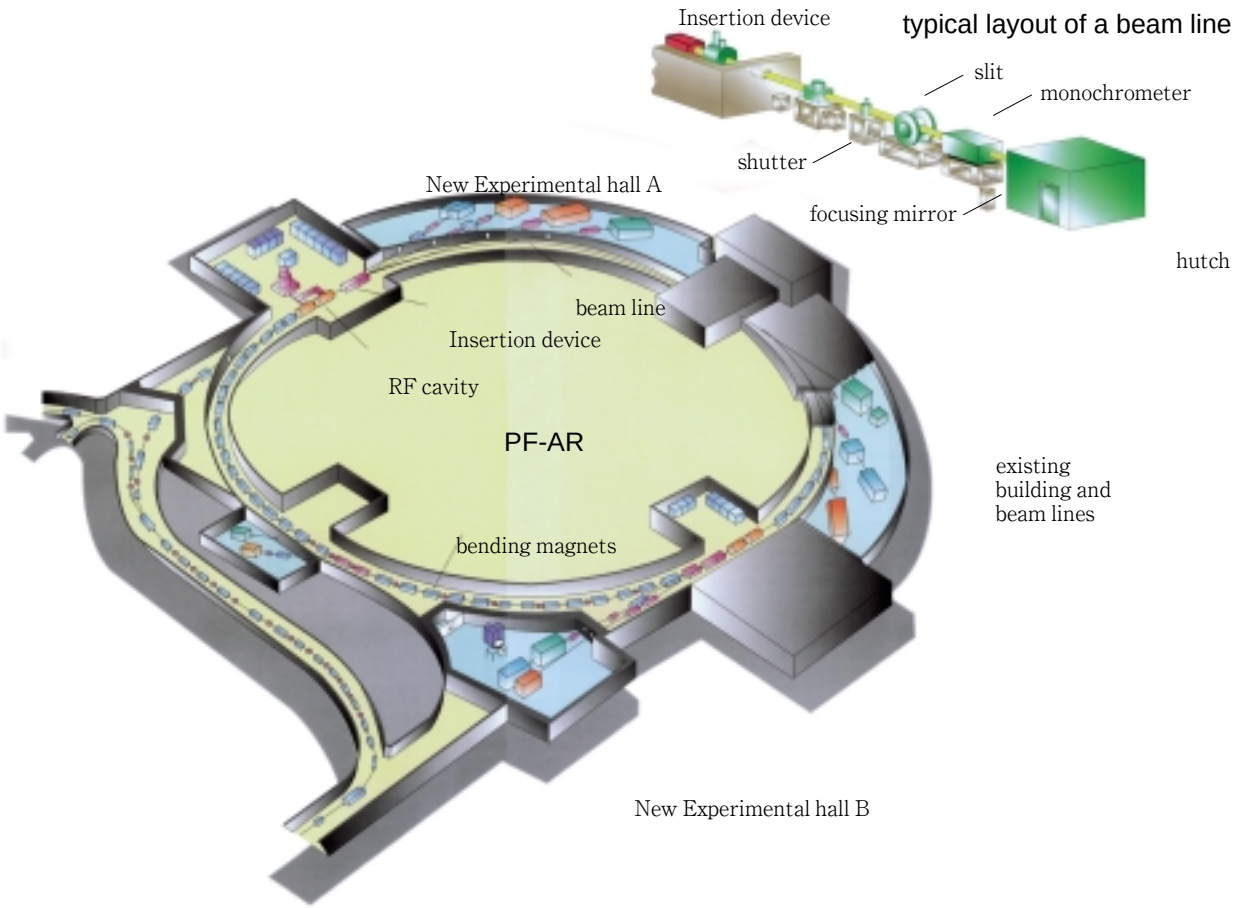
Brilliance of 60-pole undulator is enhanced by a factor of 5 to 10.

Conversion of 6.5 GeV Tristan Accumulation Ring to a dedicated synchrotron radiation source for production of intense pulse X-rays

The parameters of the proposed ring is given in the table. With this new machine, pulse X-rays having a pulse width of 100ps and repetition interval of 1.25 μs will be produced. Time-resolved diffraction and spectroscopy experiments will be carried out for studies of intermediate structures of reacting biological systems, chemical catalysis and condensed matters. By building new experimental halls, 5 new insertion device beamlines and 3 bending magnet beamlines will be constructed in addition to the existing beamlines (2 insertion devices and 2 bending magnets).

PF-AR : New Ring for the production of Intense Pulse X-Rays

Energy	6.0 GeV
current	200 mA
emittance	159 nmrad
life time	10 hrs
mode of operation	single bunch
circumference	377.26 m
Bending radius	17.825 m
number of insertion device	6



Present building and beam lines

Japan Hadron Facility Project at KEK

The main goal of the Japan Hadron Facility (JHF) is to advance sciences with accelerator complex that provides high intensity beams.

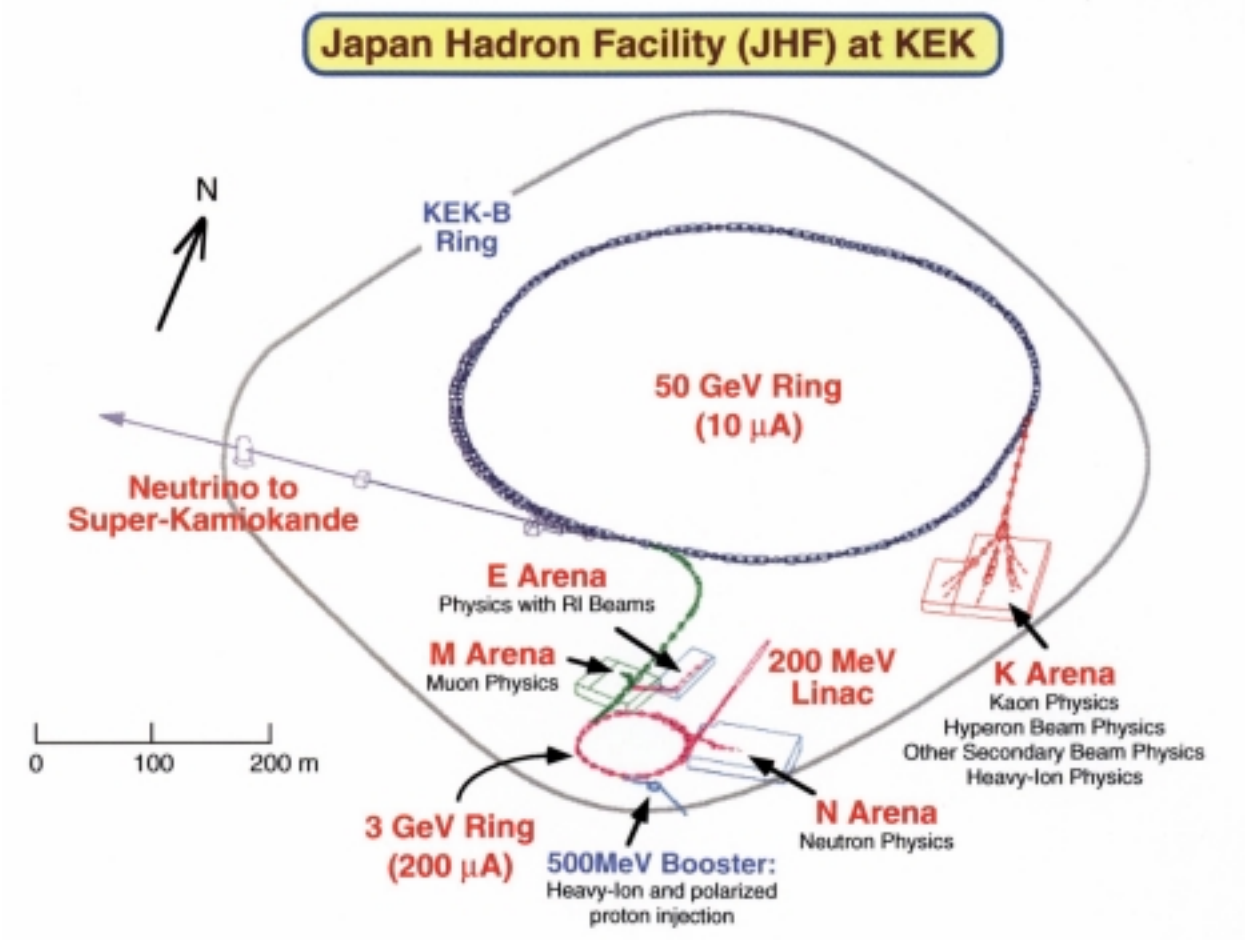
The accelerator complex consists of :

(1) 200 MeV Linac

(2) 3 GeV Ring which provides proton beams at 200 μA, and

(3) 50 GeV Ring which provides proton beams at 10 μA.

At the 50 GeV Proton Synchrotron (PS) nuclear physics experiments using kaon beams, anti-proton beams, pions beams, hyperon beams and primary beams including heavy ions are planned. In addition, experiments on kaon rare decays, other symmetry tests, and an advanced neutrino oscillation experiment using Super-Kamiokande as a detector will be carried out. This area of research which utilizes the 50 GeV PS is called the K Arena in JHF. The 3 GeV ring will be used as a booster synchrotron for the 50 GeV main ring. In addition, it is designed to provide beam current of 200 μA, which corresponds to 0.6 MW.



Main Ring

	Energy (GeV)	Particle per pulse	Repetition (Hz)	Current (μA)
This 50GeV PS	50	2×10^{14}	0.3	10.0
BNL AGS	30	6×10^{13}	0.3	3.0
FNAL MI	120	3×10^{13}	0.3	1.3
CERN PS	26	2×10^{13}	0.5	1.6
KEK 12GeV PS	12	0.4×10^{13}	0.3	0.16
Serpukhov	70	1.7×10^{13}	0.1	0.27

Booster

	Energy (GeV)	Particle per pulse	Repetition (Hz)	Current (μA)
This 3GeV BS	3.0	5.0×10^{13}	25	200
Rutherford ISIS	0.8	2.5×10^{13}	50	200
LAMPF PSR	0.8			100
PSI	0.6		DC	1500
KEK Booster	0.5	0.2×10^{13}	20	6

Three areas in physics research will be pursued. The first one is the neutron physics with a spallation neutron source. This area, called the N Arena, will concentrate on condensed matter physics, material sciences and life sciences. In the second area, called the M Arena, muon sciences will be carried out, such as μSR (muon spin rotation/relaxation), muon catalyzed fusion, and other material sciences. Also, particle physics experiments such as a μe conversion experiment are planned. In the third, the E Arena will devote on nuclear physics research using the ISOL-type radioactive beams.

Arena	*Where*	*Beam*	*Physics*
K	*50 GeV*	*K*	*Kaon and muon rare decays*
		ν	*Long Baseline neutrino oscillation*
		K	*Strangeness Nuclear Physics*
		p, HI	*Primary beam*
N	*3 GeV*	*n*	*Pulsed neutron science*
M	*3 GeV*	*μ*	*Pulsed muon science*
E	*3 GeV*	*RI*	*Nuclei far from stability line*

Once this facility is constructed, it will be open to the entire international science community. It is rather inconvenient for non-Japanese users to travel to KEK to initiate and perform experiments. Thus, one of the major tasks presently in progress at KEK is to try to improve infrastructure of KEK so that it would be easier to work at KEK for non-Japanese physicists.

The JHF proposal was sent to the Government in 1997. The project is under the review of the Government. We anticipate, if the project is approved, to have the first beam in 2004.

Heavy ion lineac constructed at the Tanashi Branch of KEK.
This lineac will be used for acceleration of unstable nuclear beams at JHF.

JLC Project

The JLC project consists of the construction of an electron-positron linear collider and the experiment therewith at an initial center of mass energy around 250 - 500 GeV. The energy will be increased to around 1 TeV in the second phase. The JLC will allow us to study elementary processes that could happen only in the early very hot universe.

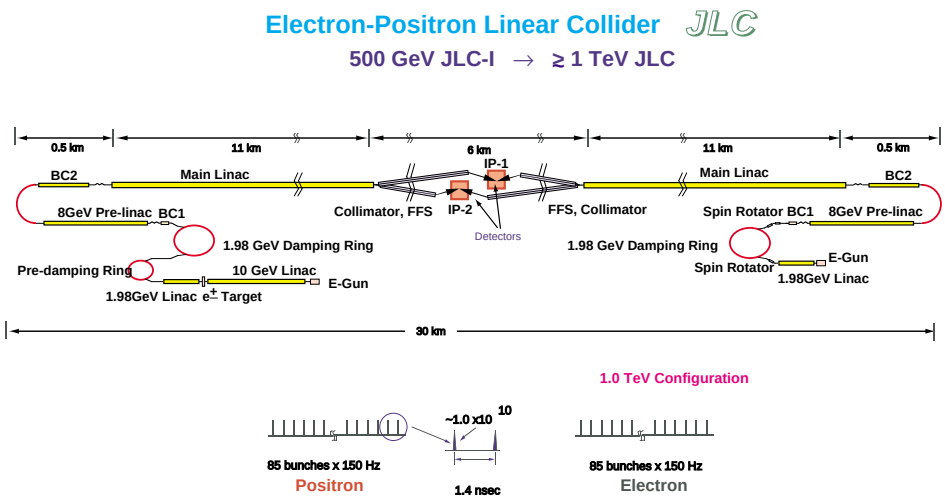
Initiated by the recommendation of the Japanese High Energy Physics committee in 1986, thorough R&D works have been performed at KEK, which include the developments of particle sources, RF systems, beam delivery and final focusing system, and the studies at ATF (Accelerator Test Facility) as well as the developments of the state-of-the-art detector technologies.

ATF Damping Ring Wiggler Section

The ATF is a prototype for the linear collider. It consists of a 1.54 GeV injector linac and a damping ring. Started the construction in 1993, the successful high gradient acceleration, as high as 33 MeV/m, and control of multi-bunch beam of 20 bunches had been demonstrated in 1994 to 1996 period. The construction of the damping ring was completed in 1996. The picture at left shows the wiggler section of the ATF. In January 1997, the first beam was circulated through the damping ring, and further studies to achieve extremely low emittance are now in progress under the world wide collaboration from more than 10 countries. The preliminary results are promising to achieve the design goal.

To allow immediate startup and adiabatic energy upgrade, X-band technology with the realistic RF peak power specification has been chosen for the main linac design, while keeping the C-band technology as a backup scheme.

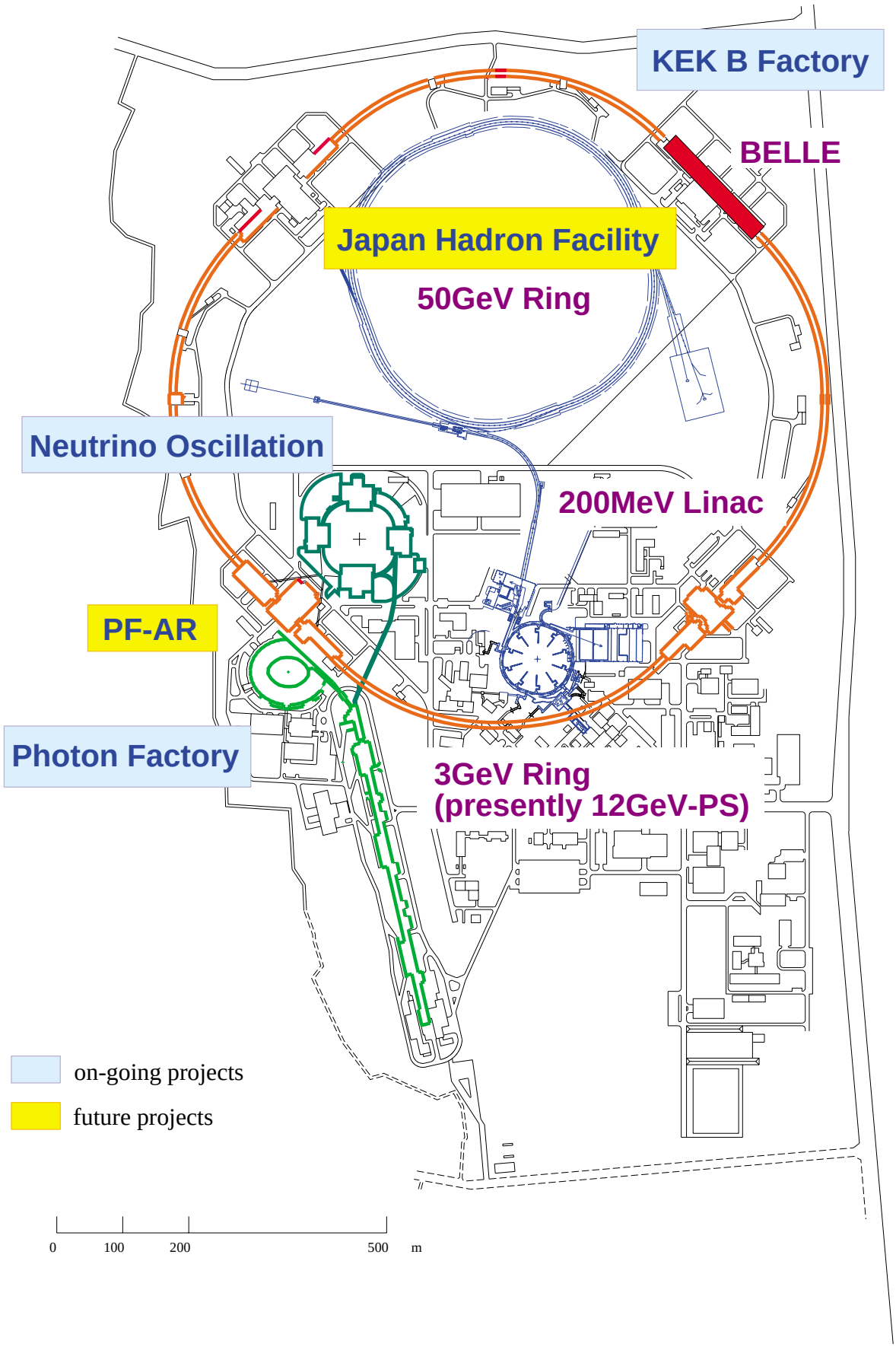
The figure shows the schematic layout of the JLC. The optimization of the design and the R&D in engineering aspects are now in progress.



We are aiming at starting the construction of the phase-one accelerator in the early next century . The LC Project office has been established at KEK this year. The project is open to the international high energy society and it will be carried out by an international organization.

(for more information, see http://www-jlc.kek.jp/)

KEK FUTURE PLANS



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