2016-1-6

KEK-ILC Action Plan

KEK-ILC Action Plan Working Group

1. Introduction

The International Linear Collider (ILC) is a next-generation energy frontier electron–positron collider. It will reach a center-of-mass energy of 500 GeV in the first stage, and can be upgraded to an energy to 1 TeV in the future. It aims to precisely measure the properties of the Higgs particle and Top quark, discover new particles and phenomena, and search for new physics beyond the Standard Model of elementary particle physics.

The worldwide high-energy physics community has recognized importance of the ILC, and established the Global Design Effort (GDE) in 2005 under the supervision of the International Committee for Future Accelerators (ICFA). The GDE has advanced the design and technical development of the ILC within the international framework. In June 2013, GDE published its progress in the ILC Technical Design Report (ILC-TDR); this report included accelerator design, technology, construction costs, and the human-resource requirements necessary to realize the ILC. The ICFA established the Linear Collider Collaboration (LCC) under the supervision of the Linear Collider Board in February 2013 to oversee the detailed ILC accelerator design and engineering.

Based on discussions for its future plan, the Japan Association of High Energy Physicists proposed to host and to realize the ILC as a global project in October 2012. In May 2013, the Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT) asked the Science Council of Japan (SCJ) to study the ILC project from a scientific viewpoint. In September 2013, the SCJ produced a “Report on the International Linear Collider Project”. In May 2014, MEXT established the ILC Advisory Panel (ILC-AP), and has been studying issues pointed out by the SCJ. In June 2015, MEXT ILC-AP produced a report, “Summary of the International Linear Collider (ILC) Advisory Panel’s Discussions to Date”. Based on this report, further action has been taken to establish a new working group to verify the human resource and training plan necessary to realize the ILC.

The High Energy Accelerator Research Organization (KEK) has been promoting the development of linear collider accelerator technology for a long time and has greatly contributed to the ILC-TDR. KEK has conducted research and development through the Linear Collider Project Office of Department of Advanced Accelerator Technologies. Its activities are currently centered around three leading facilities: 1) the Superconducting RF Test Facility (STF), 2) the Accelerator Test Facility (ATF), and 3) the Cavity Fabrication Facility (CFF). The KEK Roadmap published in May 2013 considers the promotion of the ILC project to be a strategic part of its future. Thus, KEK established the Planning Office for the ILC in February 2014, to promote the ILC project and the technical development activities at KEK.

Based on the above progress, the KEK Director General (DG) proposed to develop a plan for KEK to start preparing the organization structure to align with its future vision (hereafter called “action plan”) and established a working group to draft the action plan in May, 2015. The intent of the working group is to prepare for when MEXT decides to initiate negotiations with foreign countries. The charge is attached as Appendix 1 and the working group member list is attached as Appendix 2. This report summarizes the study made by the working group, focusing on the human resources and actions necessary from starting the main preparation phase, to starting the ILC construction project under an international agreement. The study provides the basic information required to plan the technical actions, organization, human resources, and training to realize formal approval of the ILC project, and to ensure a smooth start of the construction phase through the preparation phase from the current status.

2. KEK-ILC Action Plan

2.1 Preparation for the ILC

The ILC project has three phases:

(a) Pre-preparation phase
(b) Main preparation phase (with the ILC pre-laboratory established)
(c) Construction phase (with ILC Laboratory realized)

(a) In the pre-preparation phase, which is the current phase, various R&D projects can be conducted on advanced accelerator R&D in general.

(b) The main preparation phase involves financial support dedicated to ILC preparations. The international collaboration framework for the ILC project promotion shall be transferred from the current LCC to the ILC pre-laboratory (tentatively noted as the "ILC pre-lab") based on a MOU with an inter-institution agreement (not yet inter-government agreement). The Headquarters hosted at KEK is a possible location for the ILC pre-lab. This lab is responsible for the engineering design, remaining technical R&D, construction preparations, and administrative assistance for inter-government negotiations toward the ILC project approval. In this phase, the functions of the current Planning Office for the ILC and the Linear Collider Project Office at KEK shall merge into the ILC pre-lab. The phase transition from (a) to (b) shall be quick and smooth once MEXT gives the green light (i.e., MEXT decides to start diplomatic negotiations with foreign countries with the assumption that the ILC project will be realized).

(c) The construction phase shall be based on an inter-government agreement for the project approval and based on an international laboratory for the ILC. Because the relationship between KEK and the ILC Laboratory should be determine during the international (inter-government) agreement process, it is beyond the scope of this report.

2.2 Human Resources and the Training Plan during the Preparation Phase

This section describes the human resource and the training plan during the main preparation phase. It focuses on the human resources required to complete necessary actions, including accelerator engineering design, technical verification, and administrative work, in case a dedicated human resources and a preparation budget become available. It assumes that work sharing with foreign institutions will be available based on an international agreement and that this phase will be four-year long to be started in 2016, 2017, or 2018. We are currently in the pre-preparation phase without dedicated financial support for the ILC project. Therefore, reducing the main preparation phase may be difficult even if the start is delayed. If we may start the main preparation phase in 2016 (2018), the ILC construction phase can begin in 2020 (2022), and the physics experiments would start in 2029 (2031). This assumes that the main preparation budgets for each subject are simultaneously available. On the other hand, some specific subjects could begin sooner, if the budget becomes partially available earlier. It should be noted that the main preparation phase for this human resource plan does not need to be fully matched with the formal negotiation phase for the inter-government agreement.

This plan provides a general guideline of how we may provide and train human resources estimated, in the ILC-TDR, for the ILC construction phase in Japan and abroad. Based on these general guidelines, the technical subjects and human resource required in the preparation phase are described.

2.2.1 Basic Considerations

- The transition from (a) the pre-preparation phase to (b) the main preparation phase (4 years assumed) must be quick and smooth once the green light is given by the government and a dedicated budget is available.

- The contribution from Japan is centered at KEK in collaboration with universities and other institutions in Japan. The preparation organization will be reinforced to conduct the accelerator, physics, common technical support, conventional facility and siting (CFS: civil engineering, building, and utilities), and administration tasks, including public relations. The functions of the current Linear Collider Project Office (belonging to the Department of Advanced Accelerator Technologies) and the Planning Office for the ILC (directly led by the KEK-DG) are to merge. After a transition phase, the preparation organization will be transferred to the ILC preparation organization (ILC pre-lab). Of the total human resources in Japan, 30–40% are sub-contractors necessary to build the facilities.

- The contributions from abroad include both members' activities based in Japan and at their home institutions. The ratio of human resources from abroad will gradually increase in a range of 20% to 40% during the preparation phase, which will provide a smooth transition to the construction phase where the contributions from abroad should exceed 50%.

- These contributions to the ILC pre-lab from Japan and abroad include full-time, part-time, and collaboration members, but the numbers herein are counted on a full time equivalent (FTE) basis.

- In the accelerator preparation phase, the following guidelines for the domestic and foreign contribution ratio are applied:
  - Accelerator Design and Integration (ADI): Globally shared with equal balance between qualified laboratories.
  - Superconducting RF (SRF) technology: Following the general guideline for the contributions from abroad, the ratio will gradually increase as described above so that the contribution to the construction phase is balanced in the three regions (Europe, the Americas, and Asia).
    - In Japan, new human resources and training will be necessary for SRF system engineering (assembly and performance verification) to mature as well as for industrialization and hub-laboratory functioning.
    - In Europe, the European XFEL (E-XFEL) project, which is 1/20 the scale of the ILC, is currently in progress. In the United States, the LCLS-II project, which is 1/60 the scale of ILC, is now beginning. Each hub-laboratory (such as DESY/INFN-LASA, CEA-Saclay/CNRS-LAL-Orsay, SLAC, Fermilab or JLab) already has 50–100 staff and/or collaboration workers involved in the system assembly and performance evaluation (quality control) program. The system engineering and human resources expected by the ILC are in the process of being integrated and matured. This study counts only the newly required number dedicated for ILC preparations, but does not count these already existing resources.
    - Common technical subjects will be settled with global collaboration.
  - Nanobeam technology: to be shared between Japan and foreign countries with a 1:1 ratio, reflecting the fact that the main R&D facility (ATF) is centered at KEK.

- CFS (civil engineering, building and utilities): Centered in Japan with expert's participation from abroad. Outsourcing should be made maximum use. Because special expertise is only temporarily required.

- Common technical support: Centered in Japan with expert's participation from abroad.

- Administration (e.g., general affairs, finance, international relations, public relations): Centered in Japan. In this study, the percentage of human resources for administration is assumed to be 10%. However, the exact composition of human resources to prepare for the ILC Laboratory has not been specifically studied. After the ILC project has been given the green light, it shall be studied and the human resources shall be adjusted accordingly. (It is generally understood that the administrative human resource fraction is about 20% in established laboratories.)

- It should be noted that existing experienced human resources, who are contributing to the on-going projects such as E-XFEL and LCLS-II programs possess skills that are globally matured. Laboratories such as DESY/INFN-LASA, CEA-Saclay/CNRS-LAL-Orsay, SLAC, Fermilab, and JLab have

50~100 such skilled experts respectively. This study does not count these numbers. Instead it counts the human resource required for the further preparations, development, and training to realize the ILC, especially more in Japan to possibly host the ILC, focusing the following subjects:

1) SRF hub-laboratory functions and human resource training, which are especially necessary in Japan, and increasing/boosting the human resource is necessary
2) Nanobeam technology and human resource training to be demonstrated
3) CFS design and preparation

- The human resources for the physics, detector construction, data analysis, and computing must be further studied by the wider physics community.

2.2.2 Technical Preparation and Human Resource expected

Table 1 summarizes the expected technical actions to prepare for the accelerator, CFS, common technical support, administration issues, and international collaborations. Appendix 3 summarizes the progress of accelerator design and technical development after TDR published, while Appendix 4 outlines a further detailed description for the technical subjects.

Table 1. ILC accelerator preparation tasks, international collaborations, and human resource sharing

Area	Tasks	International collaborations	Sharing JP : Abr.**
ADI	Design parameter optimization	LCC-ILC centered	~1 : 2
SRF	Mass-production and quality control Hub-lab functioning System performance stabilization (CM assembly and transportation)	Tesla Technology Collaboration (TTC) - KEK-STF (JP) - E-XFEL construction (EU) - LCLS-II construction (US)	~ 2 : 1
Nanobeam	Minimizing the beam size and demonstrating stability Beam handling (DR, RTML, BDS, BD)*	ATF Collaboration	~1 : 1
Positron source	Undulator-driven polarized positron source Electron beam–driven positron source (backup) Thermal balance, cooling and safety	Complementary cooperation between US and Japan	~1 : 1
CFS	Basic Plan by assuming a model site, engineering design, drawings, survey, assessment	JP-CFS centered Collaboration w/ local organizations	JP centered
Common technical support	Safety (radiation, high-pressure gas, etc.) Communication and network	International standard and harmonization Global networking	JP centered
Administration	General affairs, finace, int. relations, public relations Administrative support for ILC pre-lab	Share and cooperation between ILC pre-lab and participating institutions	JP centered

* Notes: DR: Damping Ring, RTML: Return to Main Linac (beam line), BDS: Beam Delivery System, BD: Beam Dump.
**JP: Japan, Abr.: Abroad

The major technical goals of the main preparation phase are described below. The necessary budget (for materials) is separately summarized.

☐ SRF-Japan:
- ➢ Fabricate multiple cryomodules (CMs) at KEK and confirm the performance reproducibility. Study electron beam acceleration using the multiple CMs and investigate dark-current (i.e., induced electrons from the cavity surface).
- ➢ Demonstrate a functioning SRF hub-laboratory (CM assembly in mass production, performance tests of CMs, inter-regional transportation, stability of the CM performance, etc.)

☐ SRF-abroad:
- ➢ Improve mass-production technology of SRF cryomodules, including performance stabilization (minimizing the acceleration gradient degradation after assembly and transportation)

☐ Nanobeam:
- ➢ Achieve the target final-focus beam size and stability (continuous beam experiment) at ATF2
- ➢ Understand and minimize the ground vibration effect on the beam stability and establish the feedback technology

☐ Positron sources:

- Establish the ILC-TDR baseline design (undulator-driven) positron source technology
- Prepare for a backup (electron beam–driven) positron source, technology, and demonstration of the prototype (full-scale prototype with radiation resistive rotational feed-through into the vacuum chamber, cooling, and the long-term stability in operation)

- Beam dump:
  - Conduct an engineering and safety study, including operations and maintenance
- CFS:
  - Implement a geological survey in each construction section, engineering design for civil-engineering work and for utilities and their drawings
  - Assess the environment and sustaining design with local regions
  - Prepare engineering specification drawings and an environmental safety assessment for large-scale construction and public bidding
- Common technical support and administration:
  - Thoroughly prepare EDMS (engineering data management system)
  - Develop a computing facility and communication network
  - Establish radiation safety, high-pressure-gas regulations and their safety guidelines, and feedback system for the accelerator design
  - Ensure that above items are compatible with global safety regulations
  - Prepare for the international laboratory

2.2.3. Annual Plan for human resource and training plan

Table 2 summarizes the technical issues during the pre-preparation and main preparation phases. Table 3 outlines an annual plan for the human resource in the FTE (full time equivalent) starting with the current status, while a more detailed breakdown is given in Appendix 5.

Table 2. Technical issues to be settled during the ILC accelerator preparation phase

	Pre-preparation Phase	Main Preparation Phase			
	Present	P1	P2	P3	P4
ADI	Establish main parameters	Verify parameters w/ simulations			
SRF	Accelerate beam with SRF cavity string and cryomodule	Demonstrate mass-production technology and stability Demonstrate Hub-lab functioning and global sharing			
Nanobeam	Achieve the ILC beam-size goal	Demonstrate the nanobeam size and stabilize the beam position			
Positron source	Demonstrate technological feasibility	Demonstrate both the undulator and e-driven e+ sources			
CFS	Pre-survey and basic design	Geology survey, engineering design, specification, and drawings			
Common technical support	Support engineering and safety	Common engineering supports (network, radiation safety, etc.)			
Administration	Project planning and promotion Preparation for the ILC pre-lab	General affairs, finance, international relations, public relations Establishing the ILC pre-lab and managing the ILC preparation			

Table 3. Human resources required during the ILC accelerator preparation (FTE) 1)

	Pre-P.2)	Main Preparation3)				Construction4)		Notes
	(present)	P1	P2	P3	P4	C1	C2	
Acc: JP : abroad	42 ≥ 20	54 28	74 41	98 65	122 89	172	530	JP: needs to mature SRF mass-prod. technology5) EU/US: already has experience6)
CFS: JP : abroad	3 1	11 3	11 5	13 5	17 5	52	53	JP: is primarily responsible, w/ outsourcing abroad: professional contribution
Comm: JP : abroad	2 1	7 3	10 4	13 6	14 7	109	109	JP: is primarily responsible abroad: professional contribution7)
Admin: JP : abroad	5 3	8 4	10 6	14 8	18 10	77	230	JP: is primarily responsible abroad: professional and regional contribution8)
Sum	≥ 77	118	161	222	282	410	922	

Additional comments

1) During the preparation phase, the contribution from abroad is to gradually increase to 20–40% (of total number) and to prepare for further contribution in the construction phase after reaching an international agreement for the ILC construction and work-sharing.

2) Pre-preparation Phase: Current status (based on general advanced accelerator R&D budget)

3) Preparation Phase: To be supported by a specific ILC construction preparation budget and human resources. This table excludes human resources already integrated and established with existing, ongoing accelerator construction projects in the world.
4) Construction Phase: Number of labor workers (hourly described in ILC-TDR converted to FTE).
5) Japan needs to integrate human resources and training to demonstrate SRF mass-production technology and a functioning Hub-lab (project management, quality control, and performance evaluation).
6) Europe and US will have integrated and experienced in their own projects (such as E-XFEL and LCLS-II) with human resources already trained with a level of 50–100 FTEs in each laboratory (DESY/INFN-LASA, CEA/CNRS-Saclay/CNRS-LAL-Orsay, SLAC, Fermilab, and JLab). These existing well-trained human sources are not included in this table.
7) Common technical supports need to be quickly increased in the construction phase, and to be further studied.
8) Human resource to prepare for the ILC Laboratory to be studied after the project judgment.

The numbers in Table 3 include the number to begin the ILC accelerator construction as described in the ILC-TDR, as this will help smoothly transit to the full number required during the ILC construction phase. They are expected to be core members for the construction phase after being trained and gaining experience in the preparation phase.

In the ILC construction phase, the human resource for the accelerator construction (including leaders, scientists, engineers, administrators, technician/workers, including sub-contractors) will be increased gradually and to reach a level of ~1,000 staff on average. About 1/4 of human resources will be trained during the preparation phase, and they will become core members during the ILC construction phase.

It is expected that the number of human resource for the accelerator preparation should be increased from ~ 40 to ~120 in Japan during the main preparation phase. Of this, 30–40% may be sub-contractors. According to this plan, KEK needs to increase the number of accelerator scientists and engineers for the ILC preparation by transferring human resource from current (on-going) projects, recycling human resource after retirements, and with additional members added using the new project budget.

Although some human resources from the on-going construction projects at KEK would be available since 2018 or later, new posts for the senior, junior, and post-doc positions for the ILC project need to be realized. These staff may be experienced and trained during the preparation phase, and are expected to be group leaders and core members during the ILC construction phase.

3. Summary

In this planning work, we studied the organization, technical issues, and human resources necessary in the ILC preparation phase. Herein we provide the KEK-ILC action plan, which may be useful for encouraging discussions on the required steps in Japan and abroad to realize the ILC.

We assume that the accelerator technical issues have been reasonably well studied, as reflected in our past experiences and ongoing accelerator projects. On the other hand, CFS, common technical support, and administration issues need to be further investigated. Physics experiments, detector systems, and computing for physics analyses remain as crucial issues and concepts yet to be investigated. The detailed design of the organization/management to promote the ILC project has yet to be established within the international framework during the ILC pre-lab period. The plan described here may be a good starting point for discussions with relevant organizations and individuals in order to develop a realistic plan.

Although this planning work has focused on the action plan in the main preparation phase, it is imperative to establish prioritized budget support to strengthen activities related to technical issues as well as to reinforce the human resources for the CFS, common technical support, and administration in the pre-preparation phase. Furthermore, it is important to strengthen the work to prepare for the ILC pre-lab by reinforcing the international cooperation framework.

Appendix

Appendix 1. Charges to the KEK-ILC Action Plan Working Group (WG)

(given by the KEK-DG, Masanori Yamauchi, on May 11, 2015)

Subject:

Assignment of the working group for the KEK-ILC action plan in case of the "Green Light" given by MEXT

- "Green Light" is defined as a formal announcement by MEXT to start negotiations with foreign countries with the assumption that ILC will be realized.
- The KEK organization will not be re-structured until the green light is given by MEXT.
- The WG is to provide a KEK-ILC action plan that includes how to re-structure KEK, how the executing organization can start up, and the timetable after the green light is given. (The WG mission is to report the work progress to KEK-DG by (approximately) the end of August 2015.
- The plan should:

  - ➢ Provide the plan at KEK serving the role for the domestic base, including its transition to the international organization.
  - ➢ Assume the necessary budget and human resources to be available.
  - ➢ Do not terminate existing, ongoing projects until intermediate stages still to reach clear progress/results.
  - ➢ Include the plan not only for the detailed accelerator design, but also various action plans to help MEXT, and extend the plan how the tasks can be executed in KEK and shared between institutions/universities in Japan and in the world. It is especially important to cooperate with LCC and to share the tasks.

- The plan should be realistic and should become a consensus reached at KEK. This action plan should effectively respond to the advices given by SCJ, and should be useful in preparing inputs to the Human Resource working group.

Appendix 2. Member List of the KEK-ILC Action Plan Working Group

Yasuhiro Okada (Chair)
Tomio Kobayashi
Keisuke Fujii
Shinichiro Michizono
Seiya Yamaguchi
Akira Yamamoto

Appendix 3. ILC Accelerator Design and Technical Development Progress after TDR

Summary of the active and expected change requests and management
(as of July 2015)

	Title	Contents	Proposed	Decision
CR-001	Add a return dogleg to target by-pass	Add additional lattices to bring ML and BDS beamline on axis, to prepare for future >1 TeV beam energies.		Rejected
CR-002	Adopt equal L* for both detectors	Single beam delivery optics for two detectors, ILD and SiD, with common L* for the final beam focusing parameter.		Approved
CR-003	Detector hall with vertical shaft access	Vertical access to the IR detector hall for efficient assembly and installation of the detectors.		Approved
CR-004	Extend the electron and positron ML tunnels	Lengthen ML tunnels by 1.5 km to (i) fulfill the global timing constraint and (ii) add a margin for the collision of beam energy of 500 GeV (center-of-mass energy).		Approved
CR-005	Update the top-level parameters	Correct errors in the reported luminosity for the 500 GeV baseline and the 1 TeV parameters.		Approved
CR-006	Add BPM downstream of QD0	Add BPMs immediately downstream of the QD0s to facilitate beam capture and construction of a "virtual IP BPM".		Approved
CR-007	Adopt the Asian design as the sole ILC baseline	Only the Asian version of the TDR designs will be the basis for further development.		Approved
CR-008	Formally release TDR-2015a lattice	Complete the set of matched lattices reflecting the TDR design.		Approved
CR-009	Cryogenics layout	Replacement of major components on the surface.	To be proposed	
CR-TBD-1	ML-tunnel central wall thickness	Optimizing (reduction) the wall thickness with the decision of no-human access to the utility tunnel side during beam acceleration.	To be proposed	
CR-TBD-2	BDS tunnel layout	Accommodation of e- beam–driven e+ source in parallel to the undulator driven e+ source.	Being discussed	
CR-TBD-3	Integrate the SRF cavity	Re-baseline design to integrate the SRF cavity, including input-couplers and tuners	Being discussed	

* Notes: ML; Main Linac, BDS: Beam Delivery System, IR: Interaction Region, BPM: Beam Position Monitor

In the above table, CR-003, CR-004, and CR-009 are the subjects of discussions and recommendations to be given by the ILC-AP of MEXT (and the TDR verification WG) in timely manner. These efforts may reliably satisfy the ILC specifications or provide the backup margins as well as the cost savings and safety improvements.

Further details are available in the report titled “ILC Progress Report 2015” provided by LCC, which is available online:

http://ilcdoc.linearcollider.org/record/62872/files/ILC-Progress%20Report.pdf

Appendix 4. Required Technical Preparations

1. Accelerator Design and Integration

- Detailed accelerator design and parameters must be established based on a model candidate site.

2. SRF Cavities and Cryomodules

- Mass production engineering and technology to manufacture SRF cavities and cryomodules must be demonstrated and matured.
- Multiple prototype productions and performance verifications must be integrated to prepare for mass production while inviting several manufacturers.
- KEK needs to lead the industrialization efforts in order to enable to provide timely and quick professional advice to manufacturers participating to the ILC project and help/train new manufacturers wishing to gain experience.

3. SRF Performance Verifications and "Hub-laboratory" Functions

- The SRF system construction must involve international collaborations and task sharing.
- A "hub-laboratory" function must be established in each region of Europe, the Americas, and Asia, to supervise cavity and cryomodule production as well as to conduct the performance verification program. KEK must serve as the hub-laboratory function in Asia
- It is essential to establish SRF cavity/cryomodule assembly and performance verification systems as well as prepare facilities and train engineers and technicians. It may be possible for a hub-laboratory to host the facility and to contract with companies to accept engineers and technicians.
- Cryomodule performance achieved at each region's hub-laboratory must be reproduced at the ILC Laboratory after inter-regional transportation. Such transportation, including the export/import and safety process, shall be demonstrated during the ILC preparation phase.
- Each hub-laboratory should provide training and experience for the beam acceleration using the SRF cavity system.

4. Nanobeam Technology

- The continuous effort for nanobeam handling and stability improvement at the final focusing point (IR) to meet the ILC requirements is crucial.
- Continuous research must be conducted to improve the beam quality using the KEK-ATF, which is an internationally unique facility.
- It is important to establish the ultimate control technology for stabilizing environmental conditions such as ground vibration and temperature variations, in addition to further improvement in the accelerator main-components, feedback control, as the next step in research and development to improve the beam performance.

5. Positron Source

- The ILC-TDR baseline design for the positron source, so-called "undulator-driven positron source", requires electron beams to reach the full beam energy of 250 GeV and to pass through undulators with a rotating magnetic field, to first produce polarized gamma-rays. They hit a metal target and produce positrons. It features highly polarized positron beams, but it is difficult to demonstrate the performance before completion of the full energy electron accelerator. This is a major issue.
- It is important to provide a backup solution, so-called "electron-driven positron source", that produces the positrons using low-energy electrons that directly hit the target. Because KEK has recognized the importance, the R&D effort has been integrated.
- KEK will continue its effort for the electron-driven positron source technology to be developed as a backup technology to the undulator-driven positrons source development led by the US team.

6. Other accelerator components

- Other accelerator component designs, including electron source, damping ring (DR), beam transport from returning to the main linac (RTML), beam delivery system (BDS), and beam dump (BD) are based on the Reference Design Report (RDR). A detailed design and technical demonstrations need to be extended.

7. CFS (civil engineering, building and utilities)

- It is important to proceed with a design study of civil engineering, building, and utilities from the framework of developing practical models with sufficient information on terrain, geology, and accessibility in order to improve the design accuracy and reliability of the accelerator design.
- Preparations for the construction must begin prior to the construction phase, with a half period to the construction phase. Preparations include basic design, engineering design, specification documents and drawings, as well as developing a bidding process for large-scale construction.
- Professional preparation must be managed by professional out-sourcing within a limited period. KEK needs to train supervisory staff in the fields of project management, civil engineering, building, electrical and mechanical utilities, environment, and geology.

Appendix 5. Breakdown of the Human Resource Plan (see: Table 3 in the main text)

Category	Subject		pp	P1	P2	P3	P4	Int.-FTE
Grand-Sum		Sum =JP+Abr.		118 = 80+38	161 = 105+56	222 = 138+84	282 = 171+111	783 = 494+289
Acc-Sum		Sum =JP+Abr.		82 = 54+ 28	115 = 74+41	163 = 98+65	211 = 122+89	571 = 348+223
Accelerator (FTE)	Tech. coordination	JP		1	1	1	1	4
		abroad		2	2	2	2	8
	ADI	JP		3	4	6	8	21
		abroad		6	8	12	16	42
	SRF (& ML)	JP		38	50	62	74	224
		abroad		8	12	22	32	74
	Nanobeam (& DR, BDS)	JP		6	9	15	21	51
		abroad		6	9	15	21	51
	Sources (e-, e+)	JP		3	4	5	6	18
		abroad		3	4	5	6	18
	Others (RTML, Dump etc.)	JP		3	6	9	12	30
		abroad		3	6	9	12	30
CFS-Sum		Sum =JP+Abr.		14 = 11+3	16 = 11+5	18 = 13+5	22 = 17+5	70 = 52+18
Conventional Facilities and Siting (CFS) (FTE)	Technical coordination	JP		1	1	1	1	4
		abroad		1	1	1	1	4
	Civil engineering	JP		2	2	3	4	11
		abroad		1	1	1	1	4
	Building	JP		2	2	3	4	11
		abroad		1	1	1	1	4
	Utility-Electrical	JP		2	2	2	3	9
		abroad		0	1	1	1	3
	Utility-Mechanical	JP		2	2	2	3	9
		abroad		0	1	1	1	3
	Environment	JP		2	2	2	2	8
		abroad		-	-	-	-	-
Common-Sum		Sum =JP+Abr.		10 = 7+3	14 = 10+4	19 = 13+6	21 = 14+7	64 = 44+20
Common Technical Support (FTE)	Technical coordination	JP		1	1	1	1	4
		abroad		-	-	-	-	-
	EDMS	JP		1	2	3	3	9
		abroad		1	1	2	2	6
	Computing, Networking	JP		2	3	4	4	13
		abroad		1	2	2	3	8
	Radiation safety	JP		1	2	3	4	10
		abroad		1	1	2	2	6
	General eng. support	JP		2	2	2	2	8
		abroad		-	-	-	-	-
Admin-Sum		Sum =JP+Abr.		12 = 8+4	16 = 10+6	22 =14+8	28 =18+10	78 = 50+26
Administration (FTE)	Adm. Management	JP		1	1	1	1	4
		abroad		-	-	-	-	-
	General affair	JP		2	3	4	5	14
		abroad		1	2	3	3	9
	Budget/Accounting	JP		3	3	5	6	17
		abroad		2	2	3	4	11
	Int. relationship	JP		2	3	4	6	15
		abroad		1	2	2	3	8