Report from the 5th Meeting of the KEK Science Advisory Committee

April 17, 2024 *

1 Executive Summary

The 5th meeting of the KEK Science Advisory Committee took place at KEK from February 29 to March 2, 2024. The agenda of the meeting, the membership of the SAC and its charge are provided in the Appendices.

The KEK DG provided the following mandate to the SAC for this meeting:

> The KEK Roadmap and KEK-PIP, which play an important role in guiding KEK's research, have been completed with recommendations by the SAC in the previous years, and discussions with MEXT are currently underway to make this a reality. Therefore, we do not ask for recommendations on any particularly important issues at this SAC meeting. The purpose of this meeting is to report to the SAC on the progress of the research program in general, discussions with MEXT, and on KEK's activities other than research, and to ask for your opinion from a broad perspective.

KEK enables unique scientific opportunities for researchers from academia and industry in Japan and abroad, covering accelerator science, particle physics, nuclear physics, cosmology, materials science, and the life sciences. KEK operates and develops world-leading electron-based and proton-based accelerator facilities on its Tsukuba and Tokai campuses, respectively. Using various types of beams from these facilities, KEK investigates the fundamental laws of nature and the origins of the functional properties of materials.

The SAC is impressed with the very large array of activities currently underway at KEK. The level of these activities is very high and generally internationally competitive.

SuperKEKB and Belle II are poised for an excellent start in luminosity and in detector performance in 2024 data-taking. After the SuperKEKB long shutdown, LS1, collisions restarted in February, 2024. The high luminosity already achieved before the shutdown is very encouraging and puts the medium-term goal of $10^{35}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$ well within reach. With such continued improvement, Belle II will remain at the leading edge of flavour physics, the goal of a luminosity of $2 \times 10^{35}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$ before LS2 also being in sight. Its success in remaining competitive with CERN's LHCb will depend upon significant beam-time being provided. The longer term goal of a luminosity of $6 \times 10^{35}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$ remains a major challenge. The SAC looks forward to the progress expected in 2024. With SuperKEKB having the highest power requirement amongst KEK facilities, achieving this will require considerable effort by management.

The Hyper-Kamiokande project is awaited with excitement by the international community. Progress in the fast extraction proton beam is very impressive, having shown stable 763kW operation. The goal of proton beam power of 1.2MW by 2027 for the commencement of Hyper-Kamiokande looks within reach. The SAC also looks forward to a progress report on the near detector development, the development of which must be in step with the beam development.

With encouragement from ICFA's International Development Team (IDT) and the Japanese HEP community, KEK has secured from MEXT five years of funding for the ILC Technology Network (ITN), resulting in a doubling of ILC development funding. Already this has resulted in additional support for ILC in Europe.

*Minor edits, June/July, 2024

The agreement between KEK and the various European countries is managed through CERN. Following the successful P5 report, the US DoE is expected to contribute to the ITN program as well.

The Institute for Materials Structure Science consolidation of the Center for Integrative Quantum Beam Science (CIQus) and the Structural Biology Research Center (SBRC) shows unique possibilities. The SAC encourages the joint usage of photon (SR), neutron and muon probes to build upon this uniqueness.

KEK strengthens and broadens its portfolio of activities by partnering with other world-leading research laboratories and facilities, including LHC and ATLAS at CERN, KISS at RIKEN, TUCAN at TRIUMF, KAGRA at Kamioka, and the future space-based LiteBIRD. SAC is happy to learn that KISS 1.5 is now expected to be realized through the acquisition of a Grant in Aid for Specially Promoted Research.

KEK is universally regarded as a valued and trusted collaborator in these partnerships.

KEK develops the next generation of accelerator technologies for a wide range of sciences and collaborates with industry on research aimed at developing useful products for society. One of the most notable achievements in this area is the initiation of a clinical trial of BNCT, an accelerator-based next-generation therapy for refractory brain tumors.

The establishment of the Alliance Promotion Department (APD) to carry out the URA activities with the aim of increasing external funding is seen as positive by the SAC. The SAC also views positively the pursuit of activities in iCASA with commercial potential, whilst remaining firmly within the expertise and activities of KEK.

Of note are delays, due to funding shortages and technical issues, in two internationally important and significant projects at J-PARC: the muon g-2 experiment and the COMET experiment. Management is encouraged to find ways to maintain momentum in these important experiments.

The expansion of the J-PARC hadron hall was recognized as a top priority in the 2022 PIP following a fourth place in priority in 2016. However, insufficient funding has not allowed the project to be realized. The SAC is concerned that such delays in realization might lead to a weakening of the community as well as the loss of many scientific opportunities. The SAC encourages KEK to seek solutions with reduced cost, such as de-scoping the building dimensions and facility staging, or by seeking resource-sharing opportunities.

Although there has been a moderation of electricity prices in late 2023, the cost to the budget remains a major issue for KEK operations. Planned shutdowns reduced the impact to some extent, and the MEXT supplement to (partially) compensate for electricity costs this FY and next is very important. The emphasis on energy efficiency improvements is applauded by the SAC. The dual benefits of replacing ageing equipment with current, more energy-efficient and reliable power supplies and other items should be continued.

The SAC applauds KEK for focusing on the implementation of last year's recommendations, in line with the PIP2022 report. Comments on all the 2023 recommendations are found in the Appendix.

Important amongst these recommendations, the "Additional contribution to HL-LHC at CERN" has been secured, partially in 2023 and with a larger contribution to be made in FY2024. Being such an important part of the Japanese particle physics program, its success is of the utmost importance.

The issue of staff recruitment has been demonstrated to remain problematic, with permanent staff age profiles showing an alarming distribution. The SAC supports activities underway to secure and increase staff numbers in the future, including: the transfer of some expenditure on outside companies to additional KEK staff; programs to attract more women into STEM (Science, Technology, Engineering and Mathematics) ; and programs supporting graduate students and post-docs.

The SAC notes that the staff age-profile will impact upon the long-term projects with many retirements expected in the next 5–10 years. The SAC encourages management to focus on staff renewal and suggests that the SAC be provided with reports of the evolution of the staff profile in coming years. It is requested that plans for dealing with the forthcoming retirement "bulge" be reported at the next SAC meeting.

Significant efforts have been made to increase the numbers of female students and researchers joining KEK. These have been reinforced by a significantly enhanced flextime policy and a childcare-leave/family-care-leave system. Gender balances at KEK have been improved in all categories in the last 5 years. At the dissemination level the high school camps seem to be very successful and a high number of female students are attending them. We hope that these efforts will enhance the fraction of female students in STEM, and look forward to receiving a progress report at our next meeting.

1.1 *Recommendations*

1. *Maintain a laboratory-wide focus on staff renewal;*
2. *Continue to seek effective ways of replacing company hired staff with new KEK positions;*
3. *Further develop programs to enhance female participation in STEM generally, and more specifically in KEK;*
4. *Seek an extension of the electricity power subsidy currently provided by MEXT;*
5. *Continue to monitor the progress of high-priority projects in the KEK-PIP 2022;*

Recommendations specific to the various KEK projects and programs are to be found in the approporaite sections below.

The SAC greatly appreciates the efforts of many people who participated in thoughtful presentations and candid conversations during this meeting, as well as the facility tours on both the Tsukuba and Tokai campuses.

2 Accelerators

2.1 *Observations*

Impressive progress has been achieved at J-PARC, where performance has improved significantly while the energy efficiency of both the RCS and the Main Ring has also also increased greatly. As a significant milestone, the J-PARC Main Ring has now demonstrated a fast-extraction (FX) beam power for T2K of 763 kW, which exceeds the design value of 750 kW defined at the project start.

Ongoing upgrades to the J-PARC Main Ring (MR) aim at increasing the beam power from about 500 (50) kW in fast (slow) extraction in 2020 to more than 1.2 (0.1) MW in 2027, at the start of HyperK, and 1.3 MW in 2028. An essential ingredient is new power supplies with a large capacitor bank for faster cycle operation, which have reduced the cycle time from 2.48 s already to 1.36 s (and in the future to 1.16 s), while reducing the energy consumption (normalized to beam power) by about 30%. The J-PARC team is following closely the 10-year power ramp-up plan from 2018 to 2028 with annual increases of about 100 kW.

In the RCS, the RF cavities will be progressively replaced by more efficient ones through 2028. Three out of twelve cavities have already been exchanged. The new cavities have 40% lower electric power consumption.

At the MR, in addition to the main power supplies, the RF system, collimators, injection and fast extraction systems are being upgraded. The beam loss power at the highest FX beam power was 1.2 kW, well below the present collimator limit of 3 kW. In slow extraction (SX) mode, the MR has achieved an efficiency of 99.5%, which is the world's highest slow-extraction efficiency.

In 2023, there were two fire incidents, at the MR and at the HEF. The incident of greater impact was a fire in the pre-charger transformer for the QDN power supply, which resulted in a stop of MR beam operation of about 1.5 months. In response, the design of the pre-charger was replaced by a circuit without a transformer. The second fire occurred at a mechanical polarity switching device that had been in service for many years.

At the end of January 2024, SuperKEKB resumed operation after a 1.5 year stop (so-called LS1) for upgrades of the detector and the accelerator. The LS1 accelerator work included various improvements, such as a QCS (final quadrupole) front panel replacement, the installation of a nonlinear collimation system in the LER, HER aperture modifications to increase injection efficiency, an upgraded abort system, installation of more robust collimators, replacement of damaged collimators, modified collimator locations, and other mitigation measures for the sudden beam loss. The commissioning so far is smooth. Beam currents above 500 mA have been reached and about 160 Ah accumulated in both rings after only 3 weeks of operation. The plan is to double the record luminosity and approach $10^{35}\mathrm{cm}^{-2}\mathrm{s}^{-1}$ before the 2024 summer shutdown, with a β_y^* of 1.0 or 0.8 mm. The International Task Force for the SuperKEKB accelerator comprises more than 60 researchers, 40% of whom are from foreign institutes

The next long shutdown (LS2) is expected around 2028. Larger modifications are considered for LS2, such as further improvement of the injection complex and beam transport, a strengthening of the RF system needed for higher stored beam current, and, most importantly, a more compact final quadrupole, QC1P, closer to the IP with an additional super thin solenoid coil in between IP and QC1P, for fully local coupling correction. The QC1P Nb_3Sn filament size should be less than 5 μm (10 times smaller than for the HL-LHC magnets), which shall be achieved in collaboration with FNAL and Furukawa Electric Co., Ltd.

The e^- /e^+ linac serves as a top-up injector to four rings, at 5 different beam energies, requiring pulse-to-pulse changes in RF phases, gradients, and some quadrupole strengths. The linac was constructed in the 1980s and aging issues lead to the risk of water leaks. A total of 16 S-band structures have already been replaced by new ones. Ten aged structures are still to be replaced. The production of 12 new structures is scheduled from this year. In addition, 11 pulsed quadrupoles were installed for improved optics matching, in the J-ARC and the positron capture section. Machine learning control is used to maximize the linac transmission, and resulted in a 5 nC positron bunch charge at the injection line entrance into the damping ring.

The PF has been leading the development of nonlinear kickers for injection since 2004, starting with the development of pulsed quadrupoles, then moving to pulsed sextupoles. Development of a pulsed octupole magnet is on-going, with the promise of further reducing injection disturbances. The original low-level RF system occupied a large number of racks connected by hundreds of cables. This has been replaced by a compact digital system, which has been operating stably since Fall 2023. In support of the PF-HLS concept, a new HOM-damped cavity is under development, along with a fast feedback system and a chamber coating that provides ultra-low photon-stimulated desorption.

KEK is constructing seven large-aperture 5.6-T Nb-Ti separation dipoles (D1) for the HL-LHC project. The first series-production magnet has been completed. Another three are under construction. A prototype is being tested at CERN. KEK will also build 630 quench-protection-heater power supplies for the whole chain of HL-LHC magnets, which will comprise the “Additional Contributiuon to the HL-LHC at CERN”. Prototyping has just started.

Based on the experience with the compact Energy Recovery Linac (cERL) and using ILC RF technology, an application for lithography is being explored with industry, namely an EUV-FEL. For this application the energy needs to be raised from 17.6 to 800 MeV and the average beam current from 0.9 to 10 mA to produce light of less than 13.5 nm wavelength. An intermediate step is the cERL 10 mA plan, which aims at developing component studies for EUV-FEL prototypes such as the main-linac, gun and undulators, and allow a feasibility study for 10-mA ERL operation, in preparation for the EUV-FEL. The cost of a real 800 MeV EUV-FEL prototype, whose construction could start around 2029, is beyond KEK’s budget, so that additional funding from government or industry will be essential.

The Ibaraki Boron Neutron Capture Therapy project (iBNCT) has been developed in collaboration with the University of Tsukuba. It consists of a high power proton accelerator based on the J-PARC linac design and a neutron production target. Clinical tests have started recently and the “First Patient In” (FPI) is scheduled for March 2024.

The age structure of the Accelerator Laboratory staff presented to the SAC remains a concern. In the coming 7–10 years almost half of the accelerator engineers will retire. For the accelerator researchers the situation looks marginally better, with a second peak in the 46-50 year age group, further away from retirement. About 100 contract workers support the accelerator activities, in particular accelerator operation, at J-PARC and on the Tsukuba campus.

2.2 *Comments*

The SAC congratulates the J-PARC team on the MR exceeding the design beam power of 750 kW in fast extraction, closely following the 10-year power upgrade plan, and for significant progress in improving the energy efficiency of the RCS and MR with new RF systems and faster power supplies. Congratulations also for the successful upgrades of the Belle II experiment and SuperKEKB accelerator complex, and the successful restart of the collider operation after a long stop.

The J-PARC accelerators have entered a phase when the need for upgrades and end-of-life equipment replacements must be continuously evaluated, and upgrades put in place to maintain high availability. Supply chain issues remain for some rather simple components (e.g., fuses, IGBTs), which may require larger spare part inventories. With these issues and the available funding it is very difficult to maintain both sufficient operating time and high availability.

Ultra-fast beam losses occurring over 1–2 turns in both SuperKEKB rings limited the luminosity increase prior to LS1. The cause of these sudden beam losses is not fully understood. There is no beam blow up associated with the loss and only a small change in the orbit has been seen. One proposed explanation is the "fireball" hypothesis. Other possible explanations involve the collimators. Whatever the precise cause, the mitigation measures implemented during LS1 might help to suppresses these events. Additional diagnostics has also been installed, e.g., more loss monitors around collimators for timing analysis, and acoustic monitors at collimators and the QCS beam pipe.

The planned QC1P based on Nb_3Sn superconductor with filament sizes below 5 μm may be challenging to develop and construct within the time span available. The required conductor appears well beyond the present state of the art defined by the HL-LHC magnets. An HTS-based quadrupole could be an alternative, perhaps more promising approach, and might profit from the currently advancing developments in HTS-based magnets world-wide.

The ILC technical design has basically not changed over the past one or two decades. More aggressive cavity parameters, taking advantage of the ongoing progress in SRF technology, could lead to a shorter tunnel length, fewer cavities, etc., and to a reduced cost for the ILC.

The planned lithography ERL with an average beam current of 10 mA and 800 MeV beam energy will compete with other similar efforts in the world, and timely progress will be important.

KEK has successfully overcome a difficult period with high electricity cost, although the cost of electricity still remains elevated compared with a few years ago. The SAC applauds the additional MEXT contribution to help offset the cost. In all areas KEK is taking adequate and impressive steps to improve energy efficiency by replacing old components with more energy efficient ones, and developing technologies of high intrinsic energy efficiency, such as ERLs.

The KEK staffing levels and age profile are concerning. The important need for knowledge transfer to the next generation must be addressed. The staffing trend appears to have a positive direction.

2.3 *Recommendations*

1. *When end-of-life equipment needs to be replaced, continue to use these opportunities to upgrade to more energy efficient equipment wherever possible.*

2. *Install more and especially faster beam instrumentation (∼1 turn), including turn-by-turn, bunch-by-bunch beam-position monitors at several places around the SuperKEKB rings, distributed fast beam loss monitors, and fast beam-size measurements, to determine the origin of the very fast beam losses.*

3. *Review and refine the plan for SuperKEKB LS2 in light of the challenges for constructing the QC1P.*

4. *The SAC encourages KEK to continue to expend major efforts to prepare appealing future career options, in order to attract a talented and diverse generation of researchers and engineers in a timely way, so as to assure that unique knowledge is transferred to the next generation.*

3 Particle and Nuclear Physics

3.1 ILC

The International Linear Collider (ILC) remains one of the prominent candidates for a Higgs factory. A Higgs factory has been identified as the next large collider project by the world high energy physics community. The Japanese community has been promoting the ILC to be hosted in Japan as a global project. Together with the ILC international Development Team, a sub-panel of ICFA, KEK has successfully launched the ILC Technology Network (ITN) in August 2023, which will ensure further technical development and engineering studies in collaboration with other accelerator laboratories worldwide. KEK and CERN concluded an agreement on "Support for the European International Linear Collider (ILC) Technology Network". CERN will cooperate in specific ITN studies and will act as a coordinating and facilitating hub for ITN-specific technology developments and studies in Europe. Achievements by the ITN will be useful for other accelerator projects including outside particle physics. KEK physicists are also participating in physics and detector studies at the ILC in the framework of an international Higgs factory working group.

3.2 SuperKEKB and Belle II

A long shutdown (LS1) has just been completed, and much consolidation and many improvements were made for Belle II detector and the accelerator complex. The vertex detector is now fully equipped with two pixel layers and some of the photon detectors of the barrel particle identification system that had been affected by gain losses were replaced. With all the improvements being implemented, the committee believes that the detector will be able to take data at $\sim 2 \times 10^{35}$ cm^{-2}s^{-1} in the coming run period.

3.3 LHC and the ATLAS Experiment

Coordinated by KEK, the community of Japanese physicists has made important contributions to the upgrade of the ATLAS detector at the LHC (new small wheels), together with a new muon trigger that will be important for the discovery of $H \to \mu^+\mu^-$ during Run 3 of the LHC. The "Additional Contribution to HL-LHC at CERN" has been secured, partially in 2023 and with a larger contribution in FY2024. This contribution will be used to construct new beam separation magnets and major upgrades to the ATLAS detector.

3.4 Hyper-Kamiokande

As one of only a small number of flagship neutrino experiments, T2K has been producing exciting results, including a combined analysis with the atmospheric neutrino data of Super-K and the first results of a combined analysis with NOvA. T2K has a good chance to detect neutrino CP violation. However, the high electricity cost and the fire accidents resulted in an unsatisfactorily short data-taking period in 2023. It is hoped that T2K will operate for the entirety of the planned data-taking period in 2024. Reaching the expected beam-time in coming years will require concerted effort.

Hyper-K is a next-generation flagship neutrino experiment that has great discovery potential. Data taking is scheduled for 2027. J-PARC is expected to provide a 1.3 MW neutrino beam for Hyper-K. Remarkably, stable continuous operation at 763 kW was achieved already in 2023.

Upgrade of the near detectors progress very well. New sub-detectors (SuperFGD, HA-TPC, ToF) were partially installed in 2023, and have successfully detected neutrino interaction events. The upgrade is expected to be complete in 2024. The important transition of detectors and staff from T2K to Hyper-K is under discussion.

The SAC commends the KEK Hyper-K team for their efforts in securing the site for the new near detector IWCD.

3.5 $g_\mu - 2$ and EDM Experiment

This experiment is of fundamental interest in view of recent theoretical and experimental results on the hadron vacuum polarization contribution to $g_\mu - 2$. These new results are in tension with previous results, but do not remove entirely the discrepancy between theoretical predictions and experimental measurements of $g_\mu - 2$. The J-PARC $g_\mu - 2$ experiment is of particular interest because it uses a novel technique. The team plans to demonstrate this year muon cooling and acceleration, steps that are crucial for the realization of the experiment.

3.6 Theory Center

The Center plays valuable roles supporting young theorists in the development of their careers, linking different areas of particle and nuclear physics with astrophysics and cosmology, connecting theory with experiment, and acting as a gateway between the Japanese and international communities.

3.7 COMET

The COMET experiment dedicated to muon-electron conversion search at J-PARC is an excellent probe to search for new physics beyond the SM and is key to understanding the origin of neutrino masses. During the first engineering run in 2023, muons were observed to pass through the muon transport solenoid, and the detector commissioning proceeded on-site. COMET is now getting ready for the capture solenoid installation.

3.8 WAKO Nuclear Science Center

Low-energy nuclear physics is studied at the Radioactive Beam Facility (RIBF) at RIKEN where KEK runs the WAKO Nuclear Science Center. This Center leads comprehensive studies of rare isotopes with different devices such as the KEK Isotope Separation System (KISS) dedicated to high-precision mass measurements. They has realized excellent work in recent years, and a summary of the masses determined recently was presented.

During 2023, six experiments performed at RIBF were first-time measurements of the masses of very neutron-rich isotopes produced in multineutron transfer. The number of publications in recent years is outstanding. Among the highlights it is important to mention the discovery of a new isotope ^{241}U at KISS [PRL130(2023)132502]. In the quest towards characterizing superheavy nuclei, the α-MR-TOF method has been used to determine the mass of the superheavy nucleus ^{257}Db.

Last year it was recommended to continue the efforts to realize KISS-II. This year we see in the planning that funding for KISS 1.5 has already been received. This is very important and timely. The RIBF facility is in full swing, but other facilities are coming on the horizon, like FRIB, so upgrades should realized as soon as possible due to future competition.

3.9 Hadron Experimental Facility (HEF)

High- and medium-energy nuclear physics is studied at J-PARC by exploiting the high energy, 30 GeV, of the proton beam. This facility explores the origin of matter through experiments in nuclear hadron and flavor physics by different experiments.

3.9.1 The KOTO experiment

This experiment studies the CP-violating rare decay of $K_L \longrightarrow \pi^0\nu\overline{\nu}$. The event signature is 2γ from the π^0 and nothing else. Data taken in 2021 gave the lowest branching ratio limit of less than 2×10^{-9}. Upgrades of beam line, detector and data acquisition are needed to reduce and better understand the background. A review panel was formed with the mandate to assess the current achievements and review KOTO's capability for background rejection and the reach of the experiment in the coming years. They considered that KOTO was approved under optimistic hypotheses. They recommended extending the run as long as progress on assessing the background sources is being achieved. With respect to KOTO II, they considered that it would require a large investment of personnel and funds, and should be considered only once the results from KOTO are well understood.

3.9.2 Hypernuclei Studies

The precise lifetime measurement via the reaction $^4He(K^-, \pi^0)^4_\Lambda H$ demonstrated that this low-probability channel could be observed. It showed that the kaon could swap its strange-quark with an up-quark in the proton. The precise measurement was published in May 2023 [Phys Lett 845 (2023) 138128]. These results open the door to measure in 2024 (E73) the lifetime of $^3_\Lambda H$ using the equivalent reaction to solve the present puzzle in the value of the $^3_\Lambda H$ half-life.

3.9.3 Extension of the HEF hall

There are plans to expand the research program of the HEF to study the origin of matter more deeply. The extension of the hall was prioritised in the PIP 2022. It is an ambitious program including a new production target, 4 new beam lines and two updated beam lines. The project requires a considerable extension of the hall, which make it rather costly. One should study the possibility of making the extension in stages prioritizing the beamlines that will host more urgent physics cases.

3.10 QUP

The SAC commends QUP on assembling an outstanding team of experts to push the envelope of quantum measurement systems to study the physics of fundamental particles at the smallest scales where quantum physics prevails, as well as their influence on our world at the largest scales, the Universe. Established in December 2021, QUP has made great progress in identifying and hiring diverse area experts with a strong focus on detector development and deployment that has the potential to open new views into our Universe.

The program is well-aligned to bring KEK into the future via a high-impact program with a long-term vision of providing new ways of looking at our Universe. A physics program around the CMB presents a rich opportunity for new physics, while developing SpaceTES for LiteBIRD provides a concrete and realistic short-term target in the first five to ten years of QUP. The physics programs centered on the low-temperature and quantum detector clusters offer potential for rapid advancement in new areas of fundamental physics and publications in high-impact journals. The rad-hard device cluster is critical for the development of space-ready astrophysics detectors and will play a crucial role world-wide. The data acquisition and analysis clusters will help KEK develop the capacity to use modern DAQ and analysis techniques that also use the burgeoning field of quantum computing.

QUP has managed well the initial start-up period typical for new low-temperature laboratories. The initial papers are already rolling in and the SAC is happy to see the expected number of papers in the next several years. These are exciting papers from a diverse set of areas spanning quantum technologies and fundamental physics as demonstrated by 'best and first' publications: 32 papers of new ideas from the theory group is quite impressive.

Lastly, the societal engagement via the QUP Synergy Summit and Internship Program (QUPIP) are innovative and will help in recruiting the best and brightest. A successful scientific program is critical for the program as well as retention and recruitment of the brightest and diverse group of people. The ability to offer competitive salaries also helps in this regard and should be supported.

3.11 *Recommendations*

3.11.1 *Recommendations for Particle Physics*

1. *The SAC acknowledges the KEK's leading role in the realisation of a Higgs factory and supports continuation of its effort. The Committee also encourages KEK, together with the Japanese community, to pursue a solution for realising the ILC.*

2. *In order to stay competitive with the LHCb experiment, it is essential that sufficient beam time will be allocated to SuperKEKB/Belle II. In parallel, investigations must continue to achieve the full design luminosity.*

3. *Being such an important part of the Japanese particle physics program the success of the contribution to HL-LHC is of the utmost importance.*

4. *As KEK is taking the lead responsibility for new Hyper-K near detector, IWCD, it should provide strong oversight for the coherent construction of the detector and its timely completion.*

5. *It is important for the Theory Center to be able to recruit new young staff. Opportunities for interchanges and joint appointments with universities should be pursued, as well as international exchange visits.*

6. *KEK should develop a strategy for the future of the KOTO experiment.*

3.11.2 *Recommendations for Nuclear Physics*

1. *The planned upgrade of KISS towards KISS-II should not be delayed. For the next meeting a detailed plan of the upgrade should be presented.*

2. *The planned upgrade of KISS 1.5 should be realised without any delay.*

3. *The unique hypernuclei research program should continue. The expected beamtime in 2024 should be realised in its entirety. This is very important as it should enable the puzzle of the $^{3}_{\Lambda}H$ half-life to be resolved.*

4. *KEK should seek solutions to realise the extension of the J-PARC Hadron Hall with reduced cost, such as de-scoping the building dimensions or facility staging, or by seeking resource-sharing opportunities.*

3.11.3 *Recommendations for QUP*

1. *The SAC recommends continuation of the successful program at QUP to push the frontier of its high-impact scientific program, taking advantage of its ability to make rapid progress to publish in new areas of detector development and fundamental science.*

2. *We also recommend that QUP develops a cohesive story that ties together the components of its program.*

3. *We also recommend that QUP continues its effort to recruit a diverse cohort of successful researchers.*

4 Material and Life Science

The activities of KEK in material science can be summarized into three equally important roles:

1. Development of beamlines and instruments for synchrotron radiation (Section 4.2), neutron (Section 4.3), muon (Section 4.4), and positron facilities.

2. Operation of user programs.

3. Research in condensed matter and material sciences using the facilities.

4.1 Institute of Materials Structure Science (IMSS)

The IMSS continues to consolidate its activities under the Center for Integrative Quantum Beam Science (CIQus) and the Structural Biology Research Center (SBRC).

The long-term goal of offering seamless materials analysis using a combination of multibeam probes has shown some encouraging uptake by users. CIQuS trains users in utilizing several quantum beam techniques and cultivates joint usage. Out of about 2000 experiments over the last three years, about 100 have made use of the multi-probe center.

Addressing the physical difficulties associated with sample transfer/preparation between photon, neutron, slow positron and muon sources appears (albeit slowly) to being overcome. The combination of SR (photon) neutron and muon probes in many areas of research activities particularly has shown an increase in users numbers. It would be interesting to understand if lack of familiarity with the benefits of multibeam analysis is a major hurdle to the adoption of this approach. A case in point, for example, is in the international SR community where multi-beamline requests within most SR facilities are still not commonplace.

How the center is dealing with this aspect in terms of potential user education would be interesting to hear at the next meeting. Some good examples of the power of the multiprobe approach is evident in the recent topics section with the successful projects using neutron/photon and positron/photon combinations.

The benefits of the new Cryo EM facilities are also clear.The "snapshot" summary of multiprobe experiments conducted at the SBRC in 2022 is a good start but should also be extended to, for example, combined photon/neutron analyses.

4.1.1 Recommendations

1. *In order to see more easily quantifiable progress the CIQuS usage, the SAC asks for the summary table in the presentation outlining "Multi-probe Experiments conducted with CIQuS" to be updated annually for review.*

2. *In order to encourage multi-probe usage, the SAC recommends providing single-beam users to obtain beam time at other beam facilities (using photon, neutron, muon and positron techniques). This could take the form of dedicated multiprobe beam time or assistance in proposal writing for PF and J-PARC.*

4.2 PF status and development of a new lightsource

The Photon Factory (PF) holds a unique position in being the first (1982) dedicated synchrotron light source in Japan supplying X-rays. While other light sources of that era have been decommissioned or replaced, the PF has evolved through innovative upgrades and additions stretching over the past 42 years. The operational availability of PF and PF-AR average about 99%, with the exception of 2020, which was impacted by the pandemic. Operational hours in recent years have been in excess of 3000 hours/year for PF and about 2400 hours for PF-AR.

The PF and PF-AR facilities are serving about 3000 users, including many PhD students and postdocs. More than 6000 PhD and Masters theses have been produced at the PF over the past four decades. The SAC commends the excellent operation efficiency, achieved with only about 0.5 staff members per PF/PF-AR beamline, thanks to the strong involvement of the beamline users, which is unusual for the photon science community.

Two new multi-functional R&D beamlines are under construction in preparation for a future facility with simultaneous use of two photon beams. This is expected to begin operation in 2025, with completion of R&D by 2027; there has been a delay of about six months due to budget constraints.

Continuing the tradition of innovation, the PF has now proposed a novel Hybrid Lightsource (HLS) design which incorporates two beam probes for simultaneous multi-beam experiments. This unique concept, if successfully implemented, will open up many new lines of research and also create many technical innovations along the way.

A conceptual design of PF-HLS with switchable beam energy (2.5 and 5 GeV) and multi-beam wave lengths, spot sizes, and pulse lengths has been completed. The switchable beam energy permits a wide photon energy range, from 10 eV to 100 keV, to be covered. In addition to two beam energies, three operating modes are envisioned: low-emittance operation with stored beam, operation with one-pass beam from a superconducting linac, and hybrid operation with both types of beams.

The proposed lattice design is a modified Double Double-Bend Achromat (DDBA), with a circumference of 749.5 m. The lattice design includes isochronous cells, which will preserve the linac beam pulse length between the injection and extraction points and aid in energy recovery in the superconducting linac. The natural emittance at 2.5 (5.0) GeV would be 0.208 (0.832) nm. Compared to the PF, the X-ray brightness is expected to increase by more than 2.5 orders of magnitude. The power requirements to operate the new source are estimated to be 30% lower than for simultaneous operation of PF and PF-AR.

4.2.1 Comments

A carefully managed plan is important to ensure progress on this radical new program. It would be interesting to hear from the PF on its plans going forward. Priorities would include assessing progress on

1. *Completing two new beamlines at the PF designed to demonstrate the multibeam beam concept.*

   This stage is vital to establishing the potential scientific applications of the two-beam system. This build is underway but is already 6 months behind schedule. Its completion is an absolute priority as it impacts the viability of the PF-HLS project.

2. *Managing the impact of this on the present PF operations*

   The current staffing level of 0.5 scientific staff/beamline is remarkably low by common standards of typically at least 2 scientific staff. There would therefore seem to be little flexibility in redirecting staff to the new light source project. However, the success of the facility has been its unique bond with its users which appears to have grown stronger over time. These strong academic roots are a reflection of the position the PF holds in the scientific community. It would be of interest to the SAC to understand how this new program would impact this balance of support. For instance, in the longer term what would be the backup plan if future funding remained limited during operations/development? Has rationalisation of existing beamlines been examined? For example, closing down some low-performing beamlines and redirection of staff to the new lightsource project?

3. *Engagement with the broader Japanese user community beyond the PF user groups.*

The PF user community has expressed its support for the PF-HLS project. Given the unique relationship it has with the PF this would be expected, but could this enthusiasm distort the perceived national interest in the program? For a project of this size to receive funding, users of other Japanese light sources would also need to be convinced of its importance.

4. *Positioning of this proposed facility and its capabilities within the broader Japanese light source context.*

   Japan has the largest concentration of synchrotron light sources (10) in a single country worldwide. More recent investments in both Spring-8 upgrades and the new Nano Terasu light sources over the past decade were presumably targeted at addressing the needs of the broader Japanese user community. There would no doubt also be other similar facilities that are also seeking to renew their infrastructure. Are there partnerships for example to be made with such light sources?

The strong involvement of the PF/PF-AR beamline users is unusual for the photon science community and offers excellent hands-on experience to PhD students and postdocs. The two new beamlines and the proposed PF-HLS design testify that the PF/PF-AR is continuing to drive innovation in the field of photon science, particularly with the (possibly) unique multi-functional beamline. The high availability of PF and PF-AR are remarkable, particularly given the age of the facilities. This is a testimony to the expertise and dedication of those responsible for their operation and maintenance.

There is a great deal of on-going work around the world on the design of 4^{th}-generation storage rings for synchrotron radiation production, which almost without exception emphasizes ultra-high X-ray brightness through ultra-low electron beam emittance and optimized lattice functions in the insertion devices. The proposed PF-HLS light source targets emittance somewhere between the 3^{rd}- and 4^{th}-generation sources, but adds some genuinely unique and intriguing features, namely operation at two significantly different energies and provision of X-rays from both stored and single-pass beams. This suggests that the proposed source would provide capabilities not available at other light sources. However, it is unclear to the SAC how wide the appeal would be among X-ray users compared to a more conventional approach.

The SAC notes that in conventional synchrotron radiation sources insertion devices and beamlines are optimized for photon energy ranges that are much less than the proposed 10 eV to 100 keV range for PF-HLS. This suggests that many beamlines in PF-HLS will operate with 2.5 GeV or 5.0 GeV electron beams, but not both, so that the research productivity per beamline may be about half of what could be achieved from single-energy operation.

Although the PF-HLS provides a several order-of-magnitude increase in X-ray brightness compared to the PF, in absolute terms between 1 and 10 keV it would be half an order of magnitude *below* the 3-GeV NSLS-II ring, which has been in operation since 2014. The circumference—a primary driver of emittance—is relatively large and very similar to that of NSLS-II.

An innovative concept for insertion devices with very short periods was presented, but appears impractical for storage rings due to the small gap. The SAC encourages thinking about how this technique might be adapted to create practical applications in storage rings and FELs.

4.2.2 *Recommendations*

1. *The new twin beamline construction program should be funded adequately as a matter of priority, to assure timely completion.*

2. *Approval of the PF-HLS should await completion of the PF multibeam project and R&D studies;*

3. *The laboratory should outline a contingency plan should the PF-HLS project not progress.*

4. *The SAC requests a report on the strategy for engaging users beyond the PF.*

5. *The laboratory should outline the strategy to establish the importance of the HLS project within overall Japanese synchrotron science.*

6. *The laboratory should consider carefully how the proposed dual-energy and multi-beam approaches are optimal to position PF for scientific relevance and impact for the long-term.*

4.3 Neutron Beam Science

4.3.1 *Observations*

The beam power at MLF has been stable for a number of years and is close to what was originally designed. The neutron instruments at J-PARC are world-class in performance, though several of them still have significant scope for upgrade, such as in completing detector coverage. The instruments are oversubscribed with a strong participation of international users. The 8 KEK neutron beamlines at J-PARC are supported by 14 scientists. The scientist work descriptions were broadened a few years ago to strengthen the emphasis on independent science, in an effort to attract more diverse staff. A number of highlights of recent high-impact science were reported, showcasing the capabilities of the J-PARC instrument suite.

4.3.2 *Comments*

KEK has a solid science program at KEK beam lines with outstanding results and a high demand for beam time. Further progress to accommodate more users and maintain science programs, along with efforts to continue the program of improving instrumentation, will be challenging with the current staffing level, which is far behind other spallation neutron sources. We welcome the suggestion to increase automation on the instruments, which can be an effective means to increase experiment throughput.

The instrument and target systems hardware represent major investments which have delivered a world-class instrument suite and would benefit from increases in staffing levels to provide the best possible return on this investment. The KEK instruments are close to completion as originally envisioned. Further projects to complete capabilities such as detector coverage on selected instruments would further enhance the return on investment.

Broadening the scope of the instrument scientist positions to strengthen in-house science helps to make the positions more attractive to the best quality scientists, in addition to the original intent of attracting more women and early-career scientists. These efforts would be significantly enhanced by increases in the number of scientific staff, allowing them to expand their activities outside their current focus on user support.

The SAC fully supports the intent to leverage the situation of operating multiple quantum beam facilities within the same organization to expand the range and impact of science at all facilities. While many neutron users have experience of X-ray experiments, there is scope for management to help existing PF and MLF users to overcome the hurdles involved in obtaining beamtime at multiple facilities. This could take the form of creating a dedicated channel for multi-probe beamtime or assistance in proposal writing. Such an approach may deliver a quicker and broader impact than the current effort to develop a sample transfer system across the different quantum beam techniques. More detail on how the sample transfer project will concretely help users bridge the technique divide will help the SAC to understand better this effort. The number and breadth of multi-probe experiments reported by CIQuS appears encouraging, A breakdown by year would help to understand how this effort is trending.

4.3.3 *Recommendations*

1. *Prepare a strategy to increase the staffing level at the KEK instruments to a level on a par with other world-class neutron facilities.*

2. *The SAC suggests consideration be given to establishing alliances with universities or pursuing international cooperation to have a permanent presence of scientists and technicians.*

4.4 Muon Beam Science

The muon facility operated by KEK at J-PARC (Muon Science Establishment, MUSE) consists of four beam lines: decay muon line (D-line), slow muon line (S-line), high-momentum beam line (H-line) and the ultra-slow muon line (U-line) with seven instruments in total for μSR research.

While improvements are continuously being implemented and issues resolved, the stable operation of the D- and S-lines has allowed achieving important results in basic as well as applied science with publications in high-impact journals, utilizing positive and negative muons. We are very pleased about this and congratulate the team on their achievements.

The U-line with its source of ultra-slow muons (USM) obtained by laser ionization of muonium is the flagship line designed for materials and life science studies at the nanometer scale.

An efficient and reliable USM source is required for the very demanding new materials science tools such as the USM microscope and the Transmission Muon Microscope (TμM) (selected in the 2022 PIP as a category II project), but is also of crucial importance for particle physics experiments such as the high precision g-2/EDM measurement (e.g., to achieve its statistical accuracy), listed in the KEK Project Implementation Plan (PIP) 2016.

The final version of the TμM instrument will be installed at the H-Line and would allow unprecedented depth- and position-resolved studies of nanomaterials, including biological samples, using the μSR method. A very compact cyclotron for accelerating USM to 5 MeV has been procured and installed as a first step towards the realization of the TμM. The SAC congratulates KEK on this unique achievement. While challenges remain, the SAC is pleased with the progress that has been made in various directions of the laser systems utilized for the ionization of thermal muonium in the USM production scheme and congratulate the team on its concentrated effort.

4.4.1 *Recommendations*

1. *Considering the limited manpower and resources available at the MUSE facility, the SAC encourages KEK to maintain an efficient balance between new developments, user support, and research.*
2. *Recognising the central role played by the USM source for the TμM and the g-2/EDM experiment, the SAC calls for strengthening and focusing the efforts to meet its design parameters.*
3. *The SAC recommends a regular review of the overall progress.*

5 Social Issues

5.1 Research Ethics

The new Code of Conduct (CoC) plan was reported, focusing on research ethics. Public trust is essential to sustaining the scientific enterprise. Strong adherence to research ethics is of paramount importance in this regard. The SAC is pleased with KEK's efforts to raise awareness of ethical behaviour within the organization, starting with the current CoC, and encourages further activities to prevent scientific misconduct.

5.2 Diversity and Gender Equality

The definition of diversity corresponds to the acknowledgement, respect, and appreciation of the fact that people differ in many ways. Diversity is also to be considered in terms of scientific background, culture, and perspective. In addition to diversity, progress requires a commitment to equity, justice, and fairness.

Diversity of people doing research is recognized at KEK as an important factor for boosting productivity and innovation. Monitoring diversity is the basis for understanding where the laboratory stands and how to proceed to enlarge diversity. Women's Day, March 8th, was created a century ago, but it is still needed. It is a good moment to celebrate and reflect on the situation.

Women outnumber men in university degrees but they are biased towards Arts and Humanities. We recommend strong science and engineering programs for young women in schools and for their teachers and parents to reduce the social pressure against women choosing science and engineering careers. Universities and research centers hold a unique position in society that makes them critical actors to make a change. KEK can do little by itself to change long-standing societal patterns that affect gender balance in the scientific and engineering fields. However, KEK can take steps to ensure a welcoming environment for women employees and should strive to beat government and industry norms in this regard, which will provide a competitive advantage in attracting such employees. We welcome KEK's steps seeking to beat government norms for parental leave.

Another such step would be ensuring that complaints of harassment or unfair treatment are impartially investigated and addressed.

SAC commends the efforts of KEK in gathering year-by-year statistics on gender proportionality in promotions to higher positions, which showed a significant gain in the number of female scientists in managerial positions. The gender proportion of engineers and administrators is expected to follow suit over the years, but needs to be followed up.

5.3 *Recommendations*

1. *The laboratory should develop a comprehensive program and policy to prevent workplace harassment, which could include training for new hires and existing staff as well as investigation of all complaints by a group that is independent of line management.*

2. *SAC recommends that KEK keep track of improvements and complaints over time and address repeat offenders.*

3. *SAC commends KEK for developing a comprehensive Code of Conduct for its user base. The laboratory should make the Code of Conduct public and accessible to signal its commitment to safety and a welcoming working environment for all.*
   The SAC welcomes a report from the point of contact in future SAC meetings.

4. *The laboratory should continue reporting statistics on gender proportionality at all levels of management and devise steps to encourage women into managerial positions.*

5. *The laboratory should work with experts in the area to develop programs to improve the professional climate. This will help in recruiting and retaining the best and the brightest while helping to recruit and retain more women at KEK.*

6. *The laboratory should continue to develop public outreach and education programs to help develop a pipeline of future researchers and engineers. The KEK should also make careful survey on the needs of female researchers, young researchers, and other minority groups for career development to find out plan to improve the diversity of KEK.*

6 Appendices

Appendix A: Agenda of the Fifth KEK Scientific Advisory Committee Meeting

Day 1 Thursday, February 29, 2024

9:00 - 9:05 (5) Executive session(closed)

9:05 - 9:20 (15) Introduction to KEK and mandate of the committee
(M. Yamauchi, KEK D.G.)

9:20 - 9:40 (20) Status of the KEK Roadmap 2021 and KEK PIP2022
(Y. Okada, Executive director)

9:40 - 10:20 (40) Progress report on particle and nuclear physics
(N. Saito, Director, IPNS)

10:20 - 10:35 (15) (Break)

10:35 - 11:15 (40) Progress report on material structure science
(N. Kosugi, Director, IMSS)

11:15 - 11:55 (40) Progress report from the Accelerator Lab.
(T. Koseki, Director, ACCL)

11:55 - 12:40 (45) Progress report from the Applied Research Lab.
(Y. Namito, Director, ARL etc.)

11:55 – 12:10 (15) Overview (Y. Namito, Director, ARL)

12:10 – 12:25 (15) Computing Research Center (A.Manabe, Head, CRC)

12:25 – 12:40 (15) Cryogenics Science Center (T.Ogitsu, Head, CSC)

12:40 - 13:20 (40) (Lunch)

13:20 - 13:40 (20) Progress report from the J-PARC Center
(T. Kobayashi, Director, J-PARC Center)

<u>Status reports of the selected topics</u>

13:40 - 14:00 (20) ILC (S. Asai, KEK D.G. designate)

14:00 - 14:20 (20) HyperKamiokande (T. Nakadaira, Prof., IPNS)

14:20 - 14:40 (20) iCASA (S. Michizono, Prof., ACCL)

14:40 - 14:55 (15) (Break)

14:55 - 15:15 (20) LHC and ATLAS upgrade (K. Hanagaki, Prof., IPNS)

16:30 - 18:00 (90) Facility tour at Tsukuba campus

18:00 - 19:00 (60) Transportation to Hotel

19:00 - 21:00 (120) (Welcome dinner)

Day 2 Friday, March 1, 2024

<u>Status reports of the selected topics</u>

9:00 - 9:25 (25) QUP and LiteBIRD (M. Hazumi, Director, QUP)

9:25 - 9:45 (20) Development of new light source (N. Funamori, Prof., IMSS)

9:45 - 10:00 (15) International cooperation programs (Y. Okada, Executive director)

10:00 - 10:15 (15) (Break)

<u>Issues outside scientific program</u>

10:15 - 10:30 (15) Code of conduct (J. Haba, Executive director)

10:30 - 10:45 (15) Education of Graduate Students at KEK

(Y. Okada, Executive director)

10:45 - 11:00 (15) Soaring electricity price and procurement issues

(J. Haba, Executive director)

11:00 - 11:15 (15) URA system (S. Adachi, Executive director)

11:15 - 11:45 (30) Executive session

11:45 - 12:30 (45) (Lunch)

12:30 - 13:50 (80) Transportation to J-PARC

14:00 - 16:30 (150) J-PARC Facility tour

16:30 - 18:00 (90) Transportation to Hotel in Tsukuba

Day 3 Saturday, March 2, 2024

9:00 - 10:30 (90) Executive session

10:30 - 11:00 (30) (Break)

11:00 - 12:00 (60) Discussion with KEK members

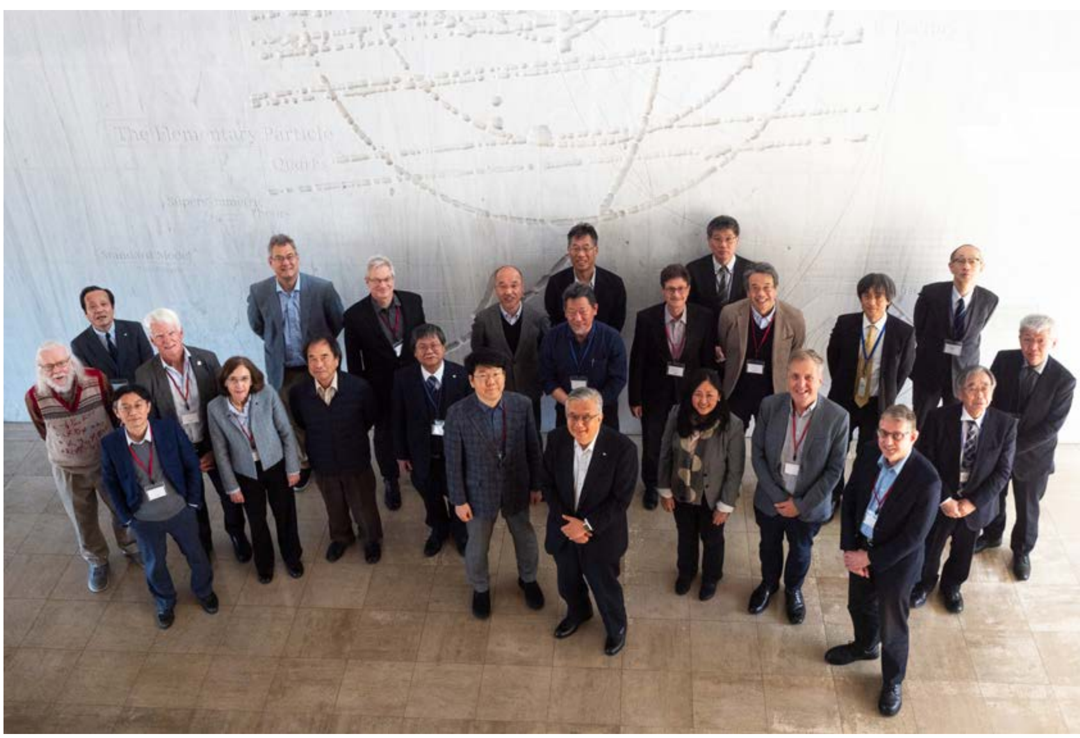
12:00 - 13:00 (60) (Lunch)

13:00 - 15:00 (120) Executive session and drafting

15:00 Adjourn

Appendix B: Members of the KEK Scientific Advisory Committee

Field	Name	Affiliation
HEP	Reina Maruyama	Yale University
	Jun Cao	Institute of High Energy Physics, Chinese Academy of Science
	Geoffrey Taylor(Chair)	The University of Melbourne
	Tatsuya Nakada	EPFL, Ecole polytechnique fédérale de Lausanne
Theory	John Ellis	King's College, London
Nuclear	Takashi Nakano	Osaka University
	Maria Jose-Borge	Consejo Superior de Investigaciones Científicas, Spain
Accelerator	Frank Zimmermann	CERN, European Organization for Nuclear Research
	Wolfram Fischer	Brookhaven National Laboratory(BNL)
PF (Synchrotron Radiation)	Michael David Borland	Argonne National Laboratory
	Robert Norman Lamb	The University of Melbourne
Neutron	Ken Andersen	The Institut Laue-Langevin (ILL)
	Sungil Park	Korea Atomic Energy Research Institute (KAERI)
Muon	Elvezio Morenzoni	PSI, Paul Scherrer Institute



Appendix C: Charge to the Science Advisory Committee

The KEK Roadmap and KEK-PIP, which play an important role in guiding KEK's research, have been completed with recommendations by the SAC in the previous years, and discussions with MEXT are currently underway to make this a reality. Therefore, we do not ask for recommendations on any particularly important issues at this SAC meeting. The purpose of this meeting is to report to the SAC on the progress of the research program in general, discussions with MEXT, and on KEK's activities other than research, and to ask for your opinion from a broad perspective.

7 Progress on KEK-SAC Recommendations, 2023

7.1 2023 KEK-SAC Recommendations - Executive Summary

1. *Perform planning exercises by considering various scenarios to prepare for high electricity costs in the future. In these exercises, consider the different energy consumption of the facilities, their maintenance and renovation plans, which may also depend on possible delays in delivering essential components.*

   Response: Electricity subsidy received from MEXT. Focus on energy savings is clear.

2. *Develop ways to bring early-career staff to get trained (e.g., SuperKEKB commissioning) to mitigate staffing issues (both quantity and expertise).*

   Response: training and mentoring programs are supported.

3. *Continue to monitor progress of high-priority projects in the KEK-PIP 2022.*

   Response: The KEK-SAC continues this role. Presentations were provided to KEK-SAC 2024

4. *Consider upgrading legacy network infrastructure and systems that may be vulnerable to cyber security and digital hygiene issues.*

   Response: Report provided.

5. *Present at the next SAC meeting how various Centers and Research Labs fit in the KEK organization and how their activities are coordinated with those from KEK's divisions and departments.*

   Response: Senior KEK staff provided KEK-SAC 2024 comprehensive presentations.

6. *Assess gender balances in leadership roles at KEK.*

   Response: Presentations and discussion with KEK-SAC 2024

7.2 2023 KEK-SAC Recommendations - Accelerator Facilities

1. *Secure funding both for improving and upgrading aging and obsolete accelerator equipment and systems, and for stocking up adequate critical operational spares.*

   Response: Countermeasures to aging are urgent issues and should be given high priority. Efforts of improvements and upgrades of aging hardware have been promoted by the MEXT's annual budget and supplementary budget in JFY2023

2. *Pursue accelerator sub-system upgrades that may lead to significant reduction in electrical power consumption, including J-PARC RF cavities and old power supplies.*

   Response: Pursuing sub-system upgrades adopting the latest technologies to reduce power consumption, including RCS cavity replacement, power supply replacement and pulse quads in electron linac

3. *Consider upgrading legacy network infrastructure and systems that may be vulnerable to cyber security and digital hygiene issues.*

4. *Develop a long-term succession plan for the many contributing rehired retired staff, which would preserve their often-unique expertise, and pursue the recruitment of new young staff members. Consider mechanisms to engage more PhD students and postdocs with the Accelerator Laboratory, which would also create a pool of candidates for KEK posts.*

   Response: posts of retired researchers at ACCL are being used to hire new researchers in ACCL; graduate student programs.

5. *Further advance the design of the future hybrid-ring light source, including parameter lists and a siting study for the Tsukuba campus, and present it at the next SAC meeting.*

   Response: Conceptual Design Report was published in January 2024.

7.3 2023 KEK-SAC Recommendations - Particle Physics

1. *Give full support to the running of the Belle II experiment in order to remain competitive against the LHCb experiment at CERN and to exploit the unique feature of an e+e- experiment.*

   Response: Following LS1, focus on data-taking is clear.

2. *Provide further contribution to the LHC luminosity upgrade, which has been requiring further resources for completing timely this important worldwide project.*

   Response: Successful

3. *Discuss the next step for KOTO and COMET in the international context.*

   Response: COMET is getting ready for the capture solenoid installation; report on KOTO status provided.

4. *Keep the prominent role in the ILC related technology development by ensuring sustained support by MEXT.*

   Response: The ILC Technology Network (ITN) has been approved.

7.4 2023 KEK-SAC Recommendations - Nuclear Physics

1. *Continue the efforts to realize KISS-II in order to maintain the leading position in the field, closely cooperating with RIKEN and strengthening the international collaboration.*

2. *Secure funding to provide sufficient beamtime at J-PARC in a planned manner in order to ensure that experiments conducted by research groups can be carried out efficiently and systematically.*

   Response: KEK management shows great focus on this recommendation

3. *Begin discussions with MEXT to proceed with the Hadron Hall extension according to the currently defined time-line with a feasible and realistic plan developed in collaboration with universities.*

   Response: This project remains unfunded. Recommendation from KEK-SAC 2024 provided

7.5 2023 KEK-SAC Recommendations - Materials and Life Science

1. *Further strengthen the quantum beam instrument capacity by providing CIQuS with adequate resources, with special emphasis on staffing, for increasing the already existing developments of common tools, in order to provide full packages of instruments able to solve complex problems.*

   Response: A new center (Scientific Innovation Center with additional 4 permanent professors and budgets) will collaborate with CIQuS.

2. *Detail the critical path in the transition to initially combining 2 quantum beams for user access. This should address for example the experimental set-up, like sample environment, common sample holders (where appropriate), and the software and data analysis level required. How will user engagement in this process be assessed?*

   Response: The long-term goal of offering seamless materials analysis using a combination of multibeam probes has shown some encouraging uptake by users. CIQuS trains users in utilizing several quantum beam techniques and cultivates joint usage. Addressing the physical difficulties associated with sample transfer/preparation between photon, neutron, slow positron and muon sources appears (albeit slowly) to being overcome.