Stony Brook University

Department of Physics & Astronomy
Stony Brook, New York 11794-3800
[redacted]

October 30, 2018

Professor Yasuhiro Iye
Chair, Committee on the revised ILC
Science Council of Japan

Dear Professor Iye,

I am taking this opportunity to write to you and the members of the Science Council of Japan committee on the ILC in support of Japan's expression of interest in hosting the ILC. My many colleagues worldwide and I are most appreciative of the exceptional effort that your committee has exerted to understand the issues related to such a decision.

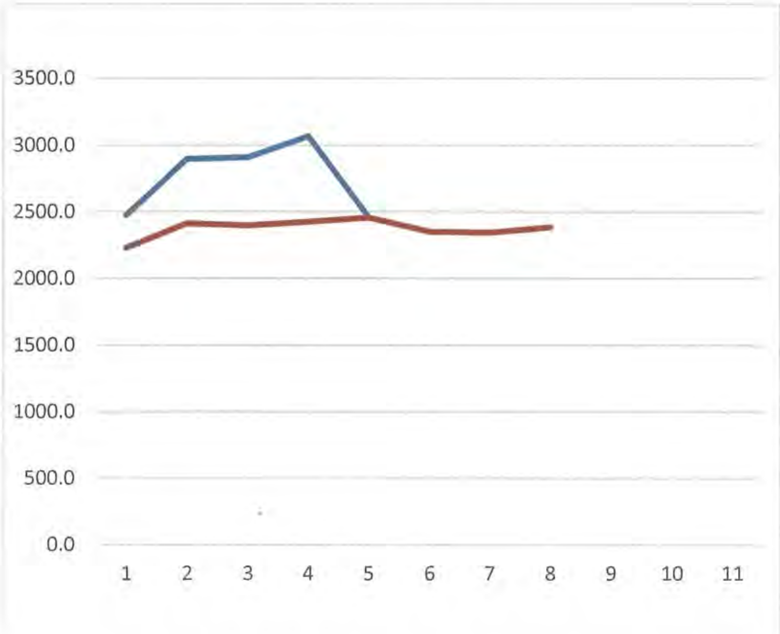
My own experience has primarily been on experimental studies using hadron collisions – at Fermilab, CERN and Brookhaven Lab. I was the leader of one of the two experiments that discovered the top quark in 1995. I served as Chair of the American Physical Society, Division of Particles and Fields. I received the APS W.K.H. Panofsky Prize in 2000. I am a foreign member of the Russian Academy of Sciences. Despite my past focus on hadron colliders, I am convinced that a lepton collider.is the next step needed to advance understanding of the fundamental constituents and forces of nature.

My support for the ILC is based on several factors:

1. As your committee has well understood, high precision measurements of the decay branching ratios of the Higgs boson into various final states has the unique potential to sense new physics beyond the Standard Model and discriminate among the ways this could arise.
2. The 250 GeV ILC already has the potential for new discoveries. Unlike the LHC, ILC measurements of the Higgs interactions with different quark flavors could help unravel the puzzle of why the quark generations have such different masses. Or ILC could find charged fermions below 100 GeV that are not visible in the LHC.
3. Long experience has shown that lepton colliders at lower energy complement measurements in a very clean and well-controlled environment. At present, the lack of clear direction coming from our experiments at hadron colliders indicates that it is time for enlightenment from electron positron colliders.
4. The ILC design is mature and the project is ready to be launched without need for major breakthroughs. In contrast to other electron positron colliders, the ILC has upgrade paths to enhance its energy reach or beam polarizations. Japan is a world leader in developing the superconducting RF technology.
5. Particle physics is truly international in scope and new facilities bring together researchers and their families from around the world. Hosting such facilities brings recognition to the host country as a technological leader. The economic payback from previous facilities is demonstrably large and there is every reason to expect this to be true for an ILC in Japan.
6. The worldwide program now has an opening for building the ILC. Funding for both the high luminosity LHC in Europe and the long baseline neutrino program in the

United States will roll off around 2025, enabling a fortuitous opening for world participation on the ILC.

7. In the US, we learned that failing to continue an ambitious project in one field (in our case, the cancellation of the Superconducting Supercollider project in fiscal year 1994) did not generate new opportunities in other fields. The red line in the plot below shows the sum of US Department of Energy funding for all science directorates excluding SSC funding, whereas the blue line shows the total for science directorates plus the SSC. The x-axis labels the fiscal years 1991 to 1998 and the y-axis is in millions of dollars. The SSC funding bump did not reappear in other directorates after SSC cancellation.



I thank you and the SCJ committee for undertaking this important study. I urge your support for an expression of interest for the ILC in Japan. I am confident that it will enable groundbreaking science and will further establish the very strong position of Japan in the global technological and scientific communities.

Sincerely,

Paul D. Grannis
Distinguished Research Professor

SLAC NATIONAL ACCELERATOR LABORATORY

FUNDAMENTAL PHYSICS DIRECTORATE

2575 Sand Hill Road, MS 96
Menlo Park, California 94025
[redacted]

October 31, 2018

Professor Yasuhiro Iye
Chair, the committee on the revised ILC
Science Council of Japan

Dear Professor Iye,

I am writing to support and encourage you regarding the importance of the ILC to Japan and to science. As an old particle physicist very unlikely to be active when the ILC turns on, I can take a rather long personal perspective. My graduate student dissertation was deep inelastic electron proton scattering at the Stanford Linear Accelerator Center. That was the discovery of point like constituents in the nucleon. In 1974, I was part of the team that discovered the ψ and ψ', which are made from Charmed quarks and put the quark model on indisputably solid ground. The recently discovered Higgs might sound like old news, and the precision measurements promised by the ILC may seem somewhat unexciting. I think the opposite is true – the Higgs is our first fundamental scalar particle, and we know almost nothing about it beyond the almost obvious. The fundamentally clean process producing the Higgs at the ILC will permit the discovery of all matter of interesting events that are lost in the horrible confusion and ill-defined initial state of the LHC. (Of course, the accomplishments of the LHC physicists are quite amazing, but the ILC is just a much simpler tool for exploring). Among the more interesting speculations is could there be a connection between the fundamental scalar particle and what appears to be a scalar field – dark energy?

I do not believe any more discoveries are needed from the LHC to totally justify the scientific case for the ILC. The ILC is also very likely to be sociologically and economically important for Japan, motivating younger people to take up careers in science, providing significant opportunities for industrial development during construction, and providing technical spinoffs for a very long time. I urge you to support it and help make a clear statement for the European Strategy Process in December.

Sincerely,

Professor Martin Breidenbach

UNIVERSITY OF OREGON

October 31, 2018

Professor Yasuhiro Iye
Chair, Committee on the revised ILC
Science Council of Japan

Dear Professor Iye,

I am writing to you and your colleagues of the SCJ committee on the ILC to express my reasons that I think Japan would be wise to host the International Linear Collider. I understand the significance of the decision you are asked to evaluate. To me it is clear a positive decision will be of great benefit to the people of Japan.

I am a senior member of the particle physics community in the United States. I began my career working as a graduate student at Fermilab on an experiment to study hadronic interactions that included collaboration with Japanese colleagues. I moved to the Stanford Linear Accelerator Center (SLAC) as a young postdoc, where I again collaborated with Japanese colleagues on an experiment that used a gamma ray beam produced by backscattered laser light to study charmed particles. Since then I have been involved in other experiments at Fermilab, SLAC and now CERN, where I work with my colleagues on the ATLAS experiment at the Large Hadron Collider. My work at SLAC included the first electron-positron linear collider, the SLC, which made an important measurement of the electroweak mixing parameter using a unique capability brought about with polarized electron beams. Throughout my career, I have been working closely with my Japanese colleagues and have developed a very strong relationship with them. Our work is truly international in nature and our science has benefited enormously through the years as a result of this aspect.

For nearly twenty years I have devoted a significant fraction of my effort to realizing the linear collider. I have understood over this period that advances in the science of elementary particles and forces demanded this facility. For many years I co-chaired the Worldwide Study of the Physics and Detectors for Future Linear Colliders. This group was recognized by the community as the coordinating effort to understand the scientific role of the linear collider and to develop the experimental capability. Recently I have been serving as the Associate Director for Physics and Detectors for the Linear Collider Collaboration. In this role I have continued my collaboration with Japanese, European, and other physicists, helping to coordinate the effort. We have been ready to move forward with the project for some time now (the Technical Design Report, which I played a lead role on, was finished in 2013).

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So, why does the world need the International Linear Collider? I know you are aware of the arguments, but please let me express this in my personal view.

We have known since the detailed studies of the gauge bosons of the weak interaction (W and Z) with LEP at CERN and with SLC at SLAC, and the top quark at Fermilab, that the Standard Model would very likely include a special particle, the Higgs boson. That particle was discovered at the LHC in 2012. Its special properties were specifically defined by the Standard Model once we knew its mass. For example, how often it decays to various elementary particles is a well-defined parameter once one knows the Higgs boson mass. These are the branching ratios.

With the discovery of the Higgs boson at a mass of 125 GeV, we knew the linear collider would provide essential measurements at a lower energy than we had assumed previously. Now, a center-of-mass collision energy of 250 GeV offers an excellent scientific program since the Higgs boson is produced in a simple reaction along with a Z boson. The presence of the Higgs boson can be tagged by identifying its accompanying Z boson. Even Higgs boson decays to invisible particles are detectable in this way. This is not possible at the LHC, but there are theoretical models that suggest this invisible decay mode could be present. If it were and we discovered it we would have found a very significant piece in the nature of physics beyond the Standard Model.

The major question confronting particle physics today is where does the Standard Model break down. It does not explain a number of fundamental issues confronting the field. For example, what is the explanation for the dark matter of the universe, that outweighs ordinary matter by about a five to one ratio. The behavior of the particles responsible for the dark matter are expected to alter the behavior of the Higgs boson; they would play a role in changing the Standard Model expectations for the branching ratios, for example. This comes through virtual processes, so it can affect the rates when the new particle masses are very high. The LHC has been searching for this and have so far failed to find the deviations or direct evidence of such new particles. However, due to the nature of the backgrounds inherent in the hadron collider they will not be able to achieve nearly the sensitivity in searching for the deviations that the International Linear Collider can reach. This is the nature of precision measurements that are possible in the much cleaner environment of the electron-positron collider.

Another important feature of the Standard Model that stands out as a theoretical mystery is that of the Higgs mass. All elementary particles are understood to be an active arena of many virtual processes. It was this aspect that led to the development of Quantum Electrodynamics more than fifty years ago. This feature has been a successful way to test the known particles and theories suggesting yet undiscovered additional particles. For example, such contributions to the measured properties of the W and Z bosons and the top quark led us to expect the Higgs boson should have a mass of roughly 100-150 GeV well before it was found there. Now that we know the Higgs boson exists at 125 GeV, we can ask how the virtual processes contribute to the Higgs boson mass. The conclusion suggests new particles are needed. This is known in the field as the "hierarchy problem." What it says is that without new, so far undiscovered particles, the mass of the Higgs boson should be many orders of magnitude heavier than it is. For this reason, and based on the past success of this analysis approach, we expect new particles to appear. They could be related to the dark matter.

The ILC has the potential to reveal light new particles that are very difficult, if at all possible, to find at the LHC. This comes from the extremely clean environment of the ILC and its advantage over the LHC. There are well-motivated theoretical models that suggest these particles should be there. If they are found at the ILC, it would not be the first time in the history of particle physics that higher energy experiments have been unable to find the particles eventually found in low energy electron-positron collisions. I point to the discovery of the tau lepton at SLAC as an example.

A final aspect of the value of the ILC in Japan that I would like to note is the role it will play in inspiring young students into science and technology. A project of this magnitude and significance can be a motivator, leading to increases in the interest of the young in a wide variety of technical pursuits. This is an aspect, as an educator, that I am quite aware and happy with.

I am grateful to you and your committee for the strong effort you are making to understand the importance of the ILC. I am certain that if Japan chooses to host the ILC through the strong international partnerships that overseas governments are prepared to discuss, including my own in the US, it will be a tremendously successful contributor to the benefit of the people of Japan and the world.

Sincerely,

James E. Brau

James E. Brau
Philip H. Knight Professor of Natural Science
and Principal Investigator, Oregon High Energy Physics

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October 31, 2018

Professor Yasuhiro Iye
Chair, the committee on the revised ILC, Science Council of Japan

Dear Professor Iye,

I am writing to strongly support the International Linear Collider (ILC) project in Japan.

The full exploration, with high precision, of the properties Of the Higgs Boson as a fundamentally new entity is a major imperative for science. The ILC is the essential tool to carry out this vital research. The detailed investigation of the Higgs has great potential for significantly advancing our understanding of the evolution and operation of the universe.

Japan has a tremendous opportunity to take the lead in fundamental science with the ILC. The technology developed for the ILC will contribute to advances in many areas of the physical sciences, health, and beyond.

The positive endorsement of the ILC by the Science Council of Japan will be recognized as a major step forward for global science.

Sincerely,

Dr. Andrew P. White
Professor of Physics
University of Texas at Arlington
[redacted]

STANFORD UNIVERSITY

SLAC National Accelerator Laboratory

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October 31, 2018

Professor Yasuhiro Iye
Chair, the Committee on the Revised ILC
Science Council of Japan

Dear Professor Iye,

I am writing to express my opinion that the Science Council of Japan should approve the International Linear Collider (ILC). This would be a globally-funded project with Japan as the host nation. The construction the ILC would be a tremendous opportunity for science. I hope very much that your committee will endorse this opportunity and allow the realization of its benefits.

In one of my roles, I am an educator on particle physics. Actually, I am an author of the leading textbook in the field, "An Introduction to Quantum Field Theory". I am a frequent invited lecturer at advanced schools in the US, Europe, and Asia. From this perspective, I can assure you that the nature of the Higgs boson is **the** central issue in elementary particle physics today, with all other questions depending in one way or another on the answer to this one. The ILC will provide concrete data, not available for any other source, that will advance our knowledge of the Higgs boson and make progress in understanding its mysteries. Thus, the ILC has a unique position among current proposals for high-energy physics experiments.

In another of my roles, I am a professor at the SLAC National Accelerator Laboratory, whose marquee project today is the operation of the LCLS X-ray laser for experiments in materials science, quantum chemistry, and structural biology. The driver for this laser is a linear electron accelerator. We are now constructing the LCLS-II, which will replace our existing accelerator driving the X-ray laser with, essentially, 1 km of ILC accelerating cavities. The history of the LCLS, and our prior history in the development of synchrotron radiation facilities, reflects close collaboration among our X-ray users, particle physicists, and accelerator experts.

While the focus of our home laboratory has turned increasingly to X-ray science, the laboratory has given strong support to our participation in particle physics experiments at global facilities such as the LHC. Our role in the ILC will follow this model.

It is recognized here that the interaction of X-ray science and particle physics does not have to be adversarial. In fact, our collaboration has been warm and mutually supportive. This collaboration is reflected in the advance of accelerators at SLAC for X-ray science, but it also extends to detectors and experimentation. Today, for example, we have a dedicated program in transition-edge sensors that will advance X-ray detection, particle physics, and astrophysical dark matter searches. We are also developing advanced linear acceleration technologies that, among other applications, promise a new generation of free-electron lasers capable of higher energy beams to access the K-shells of rare earth elements. The ILC laboratory will naturally become a world-leading center for these and similar technologies.

Science is not a zero-sum game. The fields of science move together in parallel, with advances in each field opening new frontiers for others. The ILC project, with its novel methods and ambitious goals, will create new technologies that will radiate out to all of science. It is an opportunity for physics, for Japan, and for you. Please move this project forward.

Sincerely,

Michael E. Peskin
Professor, Theoretical Physics

KU COLLEGE OF LIBERAL ARTS & SCIENCES
The University of Kansas

Dr. Graham W. Wilson
Department of Physics and Astronomy
University of Kansas
Lawrence, KS 66045, U.S.A.
31st October 2018

Professor Yasuhiro Iye
Chair, the committee on the revised ILC
Science Council of Japan

Dear Professor Iye,

I am writing this letter to express my very strong support for realizing the ILC. I have been working on the ILC project since 1995 and I am convinced that it is the right new experimental facility for advancing our understanding of particle physics.

I am an experimental particle physicist with leading contributions on the OPAL experiment at the CERN LEP electron-positron collider and the D0 experiment at the Fermilab Tevatron proton-anti-proton collider. Now I am participating in the CMS experiment at the CERN LHC. I am also deeply engaged in the design of a detector for the ILC in collaboration with many other scientists around the world including scientists from the US, Canada, Japan, UK, France, Germany, Spain, and in studies of the ILC physics potential.

I have extensive real experience of experiments with high energy electron-positron colliders. I'm originally from Glasgow, Scotland. In 2001 I moved from being based in Europe at CERN to an experiment at Fermilab in the US with the vision that we could continue our hunt for the Higgs, find it, and then build the next electron-positron collider in the US. One could say this was a little naive. But my initial premise that the Higgs would be well within the reach of a future linear collider, based on data prior to1995, has been borne out.

We have known with certainty since the experimental demonstration of the Higgs existence in 2012 that a relatively modest electron-positron collider such as the 250 GeV ILC would be sufficient to open up this new sub-field of precision Higgs physics. I really hope that you will help make such a long-standing goal a reality in the near future, and I will be delighted to come to Japan and help make it a great success. For decades the particle physics community has recognized the unique strengths of the electron-positron approach. Since soon after the top quark discovery in 1994, I realized that a linear collider has outstanding physics potential, and is well matched to understanding the mass-scales that we know exist in particle physics. After decades of work we now have mature and demonstrated accelerator technology that can make this vision a reality, and that enables advances in other fields of science.

KU COLLEGE OF LIBERAL ARTS & SCIENCES
The University of Kansas

Your committee has been deliberating on the ILC. What I'd like to convey to you is why I have dedicated a lot of my scientific career to furthering the opportunity for exploring the structure of our universe with such a machine. Electron-positron colliders simply put are beautiful scientific instruments. I consider my most important publication to be "*Measurement of Single-Photon Production in e+e- Collisions near the Z^0 Resonance*", (OPAL Collab.), Z. Phys. C 65 91995) 47 based on data from the CERN LEP e+e- collider. This work measures the invisible width of the Z, a quantity that is proportional to the number of generations of light neutrinos, and is of fundamental importance to understanding weak interactions and has inter-relations with cosmology. What is really fascinating is that this result rests on measuring the rate of events with one low energy photon and missing energy (carried away by a Z particle decaying to neutrinos that leave no detectable trace in the detector given that the neutrino interaction cross-section is so small).

This kind of experiment is simply not feasible with hadron colliders. In fact an ILC would allow a similar type of measurement this time being sensitive to dark matter particles. With the ILC, one has polarized beams, so can switch on and off particular production mechanisms, and an experimental situation where one does not need a "trigger". This is really the kind of experimental facility where one can truly experiment. Fundamentally a high energy electron-positron collider is a quantum mechanics machine that brings into existence the processes allowed by the underlying interactions, with a detector environment which makes their study straightforward and easily interpretable. It is a facility well within technological reach that is designed for doing science.

I'd like to urge you to seize this great opportunity that has been decades in the making and represents the work of thousands. There have been numerous "blue-ribbon" panels that have recognized the science case of the ILC. I participated in the 2013 process in the US, where the 2014 P5 report, "Building for Discovery" recognized that the physics case is extremely strong, and foresaw that Japan was well positioned to take the lead on this marvelous project.

Now that Japan has scrutinized the project, I would trust that your recommendations will be based on the scientific merit, which is indeed extremely compelling. I would think that other fields of science and society more broadly will welcome and should benefit from this opportunity for Japan to take the lead on this wonderful experimental facility.

Yours sincerely,

Graham W. Wilson

Dr. Graham W. Wilson, Professor of Physics at the University of Kansas

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Professor Yasuhiro Iye
Chair, the committee on the revised ILC
Science Council of Japan

Dear Professor Iye,

On behalf of the Spanish network for future accelerators and as member of the executive team of the International Linear Detector (ILD-ET) I would like to support warmly the ILC.

In a recent meeting of the Spanish community, we have prepared a draft to be sent to the European Strategy for particle physics. We prioritize ILC as the most important project beyond LHC. I send to you some extracts of the statements concerning the ILC. As you can see we are strongly supporting the ILC, and ILC250 in particular.

"The International Linear Collider (ILC) with center-of-mass energies between 250 GeV and 1000 GeV has a mature technical design that is ready for construction. The ILC will be a Higgs boson factory where the clean operating environment, low backgrounds, adjustable beam energies and polarizations will allow model-independent measurements of the Higgs-boson absolute couplings to SM fermions and gauge bosons, most of them to better than 1% precision, as well as determining their CP properties. ILC can make precision measurements of the Higgs boson self-coupling to an accuracy of typically 10-20%. The ILC will be also a precision top quark factory. The adjustable beam energy and clean operating environment will allow determining the top quark mass to a precision of 50 MeV or better. Also, the ILC will be able to produce new BSM particles up to half its centre-of-mass energy, and sensitive to new force particles Z' with masses ranging up to 7-12 TeV.

The ILC250 with its high luminosity and the possibility to polarize both beams offers great opportunities to measure with high precision the couplings of the Higgs and gauge bosons (where roughly similar precisions are expected at CLIC/FCC-ee). This will allow discriminating between the SM and many different BSM models, e.g. through exotic/invisible Higgs decays. This includes in particular Dark Matter discoveries. Going to lower energies, high-precision measurements of SM processes can be performed (GigaZ, WW threshold), offering a high potential for the indirect discovery of BSM physics. Extended to higher energies, the ILC will give access to the top quark properties and in particular to the Higgs self-coupling"

" ILC is well recognized as the only technologically ready machine that could be implemented if Japan offers its construction (with reasonable conditions financial and expertise wise). The physics potential of a program with different steps in center of mass energy, up to ~ 1TeV is well justified."

“The present ILC proposal, conceived as a Higgs factory at 250 GeV centre-of-mass energy with potential upgrades to higher energies is positively seen by the community. The scientific program is sound and the project is realistic and feasible. In general, the community prioritize an e+e- collider extendable in energy and capable to reach at least 550 GeV. At this level, both e+e- proposals, ILC and CLIC, are supported with a preference for the ILC as a more mature technology and for its faster implementation.

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If the Japanese government supports to construct and to host the ILC250, the Spanish community is eager to participate in this new endeavour. A possible future contribution from Spain to ILC250 should be negotiated in close collaboration with the rest of interested European countries. The participation of the CERN lab to this possible European contribution in technology and science as well as logistics is considered essential. “

Best regards

Alberto Ruiz Jimeno

(Chair of the Spanish Network for Future Accelerators)