

## DIRECTOR'S CORNER

## Introducing a Global Linear Collider Vision

by Jenny List



At the LCWS2024, held at Tokyo University from 8 to 11 July, around 350 members of the linear collider community discussed for the first time a new global vision towards a linear collider facility, and how to make it happen somewhere in the world – in Japan or elsewhere. Ideas are concept-independent and everybody is invited to take part. This Director's Corner summarises the discussion and gives an outlook on the next steps.

## AROUND THE WORLD

## Prototype cryomodule toward ILC under development

by Rika Takahashi



KEK is developing a new cryomodule. The five-year project aims to build cryomodules identical to those designed for the ILC to demonstrate the high acceleration performance required for the project. Foreign research institutes also participate under the international framework of the ILC Technology Network.

FEATURE

## New ILC Artwork Release!

by Rika Takahashi



We're excited to announce the release of new images by artist Rey Hori. We invite the community to use these images in outreach and promotional efforts to help share the excitement and potential of the ILC with a wider audience.

## IN THE NEWS

### from *Physics World*

October 22 2024

#### How a next-generation particle collider could unravel the mysteries of the Higgs boson

There are two main designs on the table today – circular and linear. The motivation for linear colliders is due to the problem of sending electrons and positrons round in a circle – they radiate photons. So as you go to higher energies in a circular collider, electrons and positrons radiate that energy away in the form of synchrotron radiation.

### from *Deutsche Welle*

September 30 2024

#### Why CERN wants to build a giant particle collider

Meanwhile, the American Particle Physics Project Prioritization Panel (P5) chose to support upgrades at CERN over building a separate Higgs factory. There are also plans to build an International Linear Collider (ILC) in Japan.

### from *CERN Courier*

September 20 2024

#### A decider for CERN's next collider

There is also a clearer view of the international landscape. In December 2023 the US “P5” prioritisation process stated that the US would support a Higgs factory in the form of an FCC-ee at CERN or an International Linear Collider (ILC) in Japan, while also exploring the feasibility of a high-energy muon collider at Fermilab

### from *Iwate Nippo*

August 30 2024

#### ILC関連予算10.5億円要求 文科省来年度

文部科学省が29日公表した2025年度予算の概算要求で、国際リニアコライダー（ILC）関連は24年度当初予算と同額の10億5千万円が計上された。将来加速器の性能向上に向けた重要要素技術開発事業費として、24年度と同額の7億円を盛り込んだ。ILCテクノロジーネットワークの国際的な協力枠組みを活用して取り組みを推進する。(In the budget estimate for FY2025 announced by the Ministry of Education, Culture, Sports, Science and Technology on November 29, 1.05 billion yen has been allocated for the ILC. This amount matches the initial budget for FY24. The project aims to advance efforts through the international cooperation framework of the ILC Technology Network.)

### from *Symmetry Magazine*

August 24 2024

#### US physicists prioritize closer study of the Higgs

The head of the P5 panel, theorist Hitoshi Murayama, calls the ILC “shovel-ready and technologically mature.” But to move forward with construction, scientists still need to gain the approval of the Japanese Ministry of Education, Culture, Sports, Science and Technology, something they’ve been working on for a little over a decade.

### from *Kyodo news*

August 10 2024

#### 次世代大型加速器、日本が先導を 技術進展と欧州科学者

宙誕生の謎を探る次世代大型加速器について、欧州合同原子核研究所（CERN）のマキシム・ティトフ研究員が共同通信の取材に応じた。岩手・宮城両県の北上山地が候補地に挙がる国際リニアコライダー（ILC）を、技術面の準備や費用の国際分担を踏まえ「現実的で手が届く計画だ」と評価。日本政府は実現に向けて議論を先導すべきだと強調した。(Maxim Titov, a researcher at the European Laboratory for Nuclear Research (CERN), gave an interview to Kyodo News regarding the next generation of large accelerators that will probe the mysteries of the birth of space. He praised the International Linear Collider (ILC), for which the Kitakami Mountains in Iwate and Miyagi prefectures are a candidate site, as a ‘realistic and affordable plan’, based on technical preparations and the international sharing of costs. He stressed that the Japanese Government should lead discussions towards its realisation.)

### from *Iwate Nippo*

July 14 2024

#### ILCの優位性印象づけ 山本均氏（東北大名誉教授）LCWS総括

東京大で開かれた国際学会リニアコライダー・ワークショップ（LCWS、8～11日）について、山本均・東北大名誉教授（69）＝素粒子実験＝は「世界の研究者に国際リニアコライダー（ILC）の優位性を印象づけた」と総括した。欧州や中国で進められる大型円形加速器計画とILCが本格的に比較された初めての機会だとして「日本政府が誘致に向けて踏み出すなら今しかない」と強調した。東京都内で岩手日報社の取材に答えた。(The International Conference Linear Collider Workshop (LCWS) held at the University of Tokyo (8-11 August) was summed up by Hitoshi Yamamoto, 69, Professor Emeritus of Particle Physics at Tohoku University, who said that the workshop ‘impressed researchers around the world with the superiority of the International Linear Collider (ILC)’. He stressed that this was the first time that the ILC had been compared in earnest with the large circular accelerator programmes underway in Europe and China, and that ‘now is the time for the Japanese Government to step forward to invite the ILC’. He gave an interview to The Iwate Nippo in Tokyo.)

### from *Mainichi Shimbun*

July 11 2024

#### ILC確定なら「米は必ず協力」 米大教授

宇宙誕生の謎を探る次世代大型加速器に関する米政府諮問委員長を務める、村山斉・米カリフォルニア大バークリー校教授は1日、盛岡市内で講演し、日本に国際リニアコライダー（ILC）ができるとはっきりすれば「米国は必ず乗ってくる」と述べ、米側の協力が期待できると強調した。(Professor Hitoshi Murayama of the University of California, Berkley, who chairs the US government's advisory committee on the next-generation large accelerator that will probe the mysteries of the birth of the universe, gave a speech in Morioka City on 1 January, saying that if it is clear that Japan will build the International Linear Collider (ILC), 'the US will definitely come on board' and stressing that US cooperation is expected. The ILC will be a major project in the future.)

**from Iwate Nippo**

July 10 2024

**故駒宮幸男さんの功績しのぶ 東京大でILC実現推進に貢献**

国際学会リニアコライダー・ワークショップ（LCWS）を開催している東京大で9日、同大名誉教授で国際リニアコライダー（ILC）を推進する中心メンバーだった故駒宮幸男さんの追悼セッションが行われた。(On 9 September, a memorial session was held at the University of Tokyo, which is hosting the International Conference Linear Collider Workshop (LCWS), for the late Yukio Komamiya, a professor emeritus at the University and a key member in promoting the International Linear Collider (ILC))

**from Iwate Nippo**

July 09 2024

**ILC、世界の最新動向を共有 東京で国際学会開幕**

国際学会リニアコライダー・ワークショップ（LCWS）は8日、東京大で開幕した。国内開催は2019年の仙台市以来5年ぶりで、11日までの4日間。岩手県が建設候補地とされる国際リニアコライダー（ILC）の準備状況や科学的意義について研究者が共有する。欧州や中国でも建設が計画されている大型加速器の最新動向も示された。(The International Conference Linear Collider Workshop (LCWS) opened at the University of Tokyo on 8 August. It is the first time in five years that the conference has been held in Japan since Sendai in 2019, and will last for four days until 11 November. Researchers will share information on the preparation status and scientific significance of the International Linear Collider (ILC), for which Iwate Prefecture is considered a candidate construction site. The latest developments on large accelerators, which are also planned for construction in Europe and China, were also presented.)

**from Kyodo News**

July 01 2024

**大型加速器「建設なら米は参加」 米政府諮問委員長の村山氏**

宇宙誕生の謎を探る次世代大型加速器に関する米政府諮問委員長を務める、村山斉・米カリフォルニア大バークリー校教授は1日、盛岡市内で講演し、日本に国際リニアコライダー（ILC）ができるとはっきりすれば「米国は必ず乗ってくる」と述べ、誘致すれば米側の協力が期待できると強調した。(Professor Hitoshi Murayama of the University of California, Berkley, who chairs the US government's advisory committee on the next-generation large accelerator that will probe the mysteries of the birth of the universe, gave a speech in Morioka City on 1 January, saying that if it is clear that Japan will host the International Linear Collider (ILC), 'the US will definitely come on board' and stressed that if Japan invites the ILC, cooperation from the US can be expected. He stressed that if Japan invites the ILC to Japan, the cooperation of the US side can be expected.)

## PREPRINTS

### ARXIV

2411.09418

Simulation of the process  $e^+e^- \rightarrow W^+W^-$  with the heavy right-handed neutrino exchange at 1 TeV future lepton colliders

2411.08143

Investigating vector-like leptons decaying into an electron and missing transverse energy in  $e^+e^-$  collisions with  $s\sqrt{=500}$  GeV at the ILC

2411.01507

Higgs Self-coupling Strategy at Linear  $e^+e^-$  Colliders

2411.00872

Exploring vector dark matter via effective interactions

2410.18198

Lepton Collider as a window to Reheating: II

2410.17605

New Physics Off the Z-Pole:  $e^+e^- \rightarrow f\bar{f}$  at Future Lepton Colliders

2410.14622

$\tau$  searches at future  $e^+e^-$  colliders

2410.11322

Application of Particle Transformer to quark flavor tagging in the ILC project

2408.13952

Associated charged Higgs production within the 2HDM:  $e^-e^+$  versus  $\mu^-\mu^+$  colliders

2407.12111

Search for dark matter in the framework of Einstein-Cartan gravity at the International Linear Collider (ILC)

NULL

DIRECTOR'S CORNER

## Introducing a Global Linear Collider Vision

Jenny List | [29 November 2024](#)



Jenny List presenting a global vision for a Linear Collider at LCWS 2024, held at the University of Tokyo on July 8

For well over 20 years, there have been two major linear collider proposals: the International Linear Collider (ILC), based on klystron-driven superconducting radio frequency (SRF) cavities, and the Compact Linear Collider (CLIC), based on normal-conducting cavities powered by a drive beam. In the last couple of years, many more ideas have come up – from the Cool Copper Collider (C3) to concepts based on energy recovery, continuous-wave operation, or even plasma acceleration. Often, proposals have been discussed in the context of a specific technology mapped to a specific host location: ILC in Japan, CLIC at CERN, C3 at Fermilab, and so on. While this approach is very logical if the approval of a concrete project seems imminent, unfortunately, none of the linear colliders is at this stage at the moment. Thus why not take a step back and remind ourselves that across all the different technologies and siting options, all linear colliders share common physics goals and a common global vision for the future of particle physics?



A linear collider facility with polarised electron and positron beams, colliding at centre-of-mass energies of up to about 1 tera electron volt (TeV), would offer a rich programme to explore the Higgs boson and the top quark in a way highly complementary to a hadron collider. Above 1 TeV, the physics case, beyond pure exploration, is less clear *today* – but this could of course change with the high-luminosity LHC! While, e.g. the ILC's Technical Design Report presents a proposal on how to reach 1 TeV with existing technology, a key ingredient of the linear collider programme is upgradeability: many important measurements of the Higgs boson and the top quark can actually be done at lower energies.

Therefore, an initial facility with 250 giga electron volts (GeV) — or even 550 GeV — could deliver unprecedented new clues on the mysteries of our universe at a significantly lower price tag in terms of financial and environmental resources than the full 1TeV-machine. If designed appropriately, the initial facility could then be upgraded to higher energies – and/or higher luminosities – with whatever technology seems the most suitable when the decision needs to be taken.

Here, [the International Workshop on Future Linear Collider](#) (LCWS) presented a fresh and much wider view than ever before by exploring upgrades with *other* technologies – i.e. replacing the full original main linac with a technology allowing for much higher gradients in order to reach higher centre-of-mass energies, even beyond 1 TeV, without extending the tunnel! Improved SCRF with much higher gradients, cool copper cavities, a CLIC-like drive beam scheme or even plasma-acceleration-based accelerators are intriguing candidates. Should future physics results determine that much higher luminosities are more urgent than higher energies, upgrades with energy- and particle recovery would offer a promising path. It is too early to choose a concrete upgrade scenario today, but the flexibility to incorporate advanced accelerator technologies is a key feature of the linear collider approach.

In any case a linear collider facility can be augmented with a second interaction region, to host a second interaction point – for example, for photon collisions – as well as beam dump and beamlines for fixed-target experiments and detector and accelerator R&D. Thus it could host large-scale demonstrators for its own upgrade technologies! On the other hand, a linear collider facility does not restrict in any way the choices for eventually exploring the 10-TeV-parton energy scale, for which, as of today, we don't have the technology at hand – nor a very clear picture of what the required energy actually is. Whether in the end, a hadron collider, a muon collider, a plasma wakefield e+e-collider or any combination of those will be best can be chosen independently depending on R&D progress and physics developments.

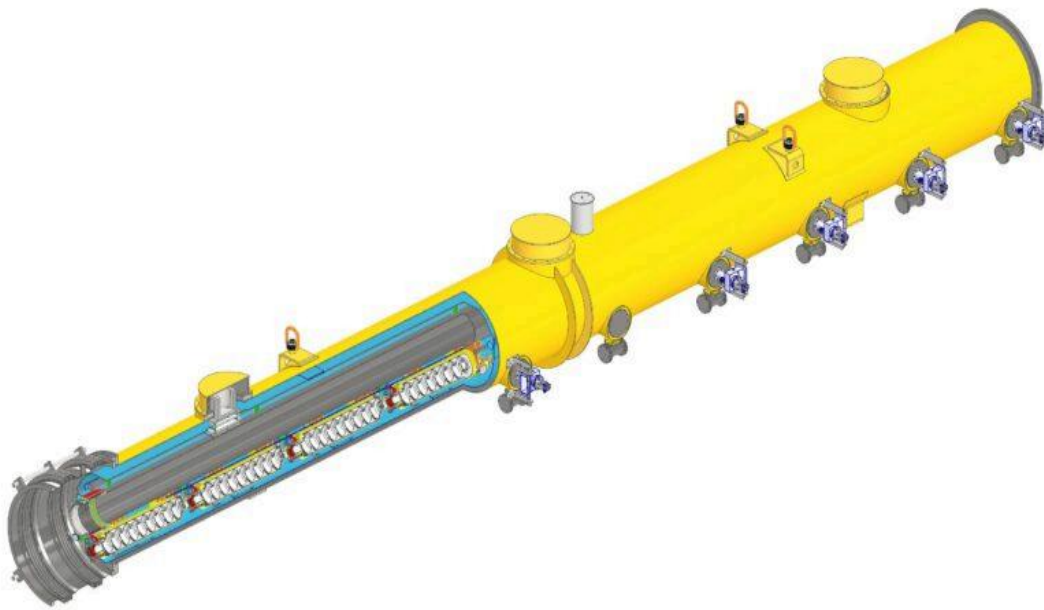
Under the nickname of "A Global Linear Collider Vision", or short LCVision, these ideas were discussed throughout LCWS2024, starting with a dedicated session in the afternoon of the very first day and culminating in a presentation in the closing plenary. As I perceived it, the topic also came up in numerous parallel sessions and coffee-break conversations, inspiring all participants. It became very clear that these ideas should be pursued and put into a coherent picture for the upcoming Update of the European Strategy for Particle Physics. Meanwhile, an LCVision organisation has been setup, and work towards substantiating the various upgrade ideas, as well as towards proposing such a linear collider facility as next project for CERN, has started. The results will be presented at an [LCVision workshop](#) to be held Jan 8-10, 2025 at CERN. Registration is open until December 15. Everybody interested to follow the developments is cordially invited to sign up at [LCVision-General](#) !

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AROUND THE WORLD

## Prototype cryomodule toward ILC under development

Rika Takahashi | [29 November 2024](#)



Cross-sectional image of a cryomodule being developed at KEK @KEK

A new Cryomodule is being developed at KEK to demonstrate high acceleration specification performance, as required for the International Linear Collider (ILC). This project, funded by a grant from the Ministry of Education, Culture, Sports, Science and Technology (MEXT), will last five years, starting in 2023. The cryomodule in development is built on the ILC design but has been updated to include the latest technology.

The cryomodule is equipped with superconducting radio frequency (SRF) cavities inside and keeps them extremely cold, allowing it to accelerate particles efficiently. These cavities need to be at  $-271^{\circ}\text{C}$  to become superconducting, which minimises energy loss during particle acceleration. The cryomodule achieves this by using liquid helium to cool the cavities inside an insulated tube.

KEK has been developing accelerators for the ILC, including the STF-2 accelerator, which comprises 14 L-band 9-cell superconducting cavities. However, the ILC requires that all countries develop accelerators according to standard specifications. For this reason, the cryomodule design specified in the Technical Design Report is now being developed in accordance with standard specifications worldwide.

The following technological developments are required in this project;

- Development of superconducting cavities with high acceleration gradients, in compliance with the Japanese High-Pressure Gas Safety Act
- Design and prototyping of high-performance cryomodules, incorporating the latest technology.

Research institutes outside Japan are also involved in this effort under an international framework called the ILC Technology Network (ITN). CERN and KEK agreed in July 2023 to collaborate under the ITN framework, and this work is being conducted under the ITN



framework. For instance, in collaboration with CERN and other organisations such as CEA (France) and INFN (Italy), efforts are being made to produce European superconducting cavities. Since superconducting accelerators require cooling with liquid helium, compliance with the High-Pressure Gas Safety Act is essential. This marks one of the initial efforts and a significant challenge to producing a superconducting cavity abroad that adheres to the High-Pressure Gas Safety Act in Japan, as well as to install into a cryomodule. Korea University in South Korea is also working on developing a cavity that meets ILC specifications.

The cryomodule features peripheral components like input couplers and frequency tuners. Notably, it incorporates cutting-edge technologies being adopted for the first time in Japan, such as cylindrical ceramics for couplers. We are collaborating on these advancements with researchers from DESY in Germany, the Irène Joliot-Curie Laboratory of Physics of the Two Infinities (IJCLab) in France, and the Fermi National Accelerator Laboratory (Fermilab) in the USA.

At present, young researchers from [KEK iCASA's](#) SRF Group are at the forefront of cryomodule development. Notably, this is their first experience with designing and manufacturing a cryomodule. They are engaging in active research, independent thinking, and deepening their understanding, providing an excellent chance for skill development and learning.

The cryomodule is expected to be finished and its performance assessed by the end of 2027. Scientists are united in these efforts, working together with researchers worldwide to achieve positive results.

FEATURE

## New ILC Artwork Release!

Rika Takahashi | [29 November 2024](#)

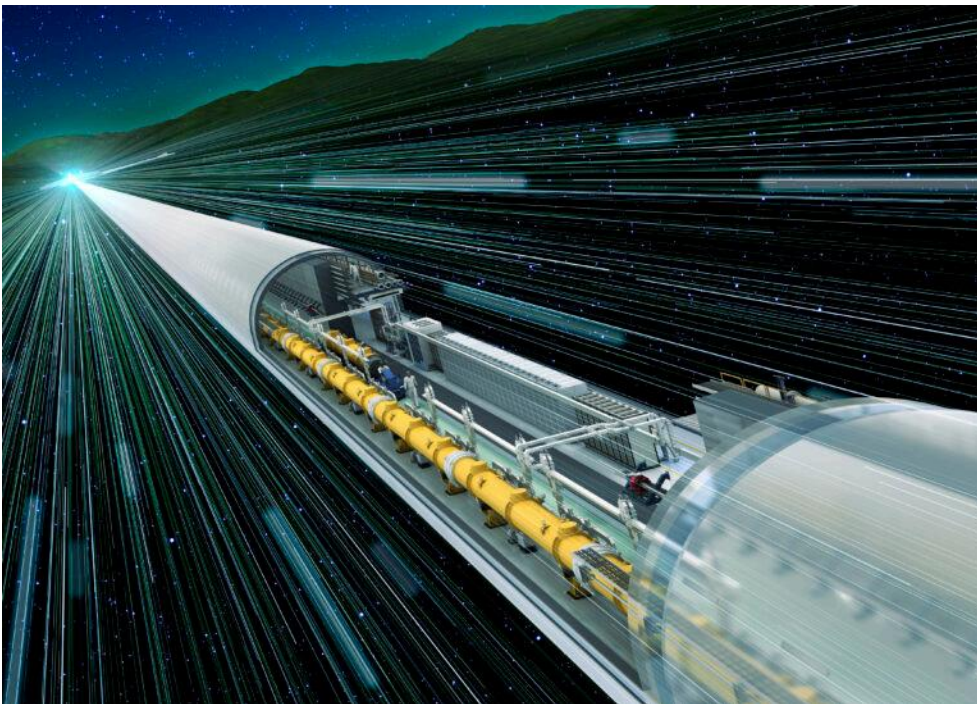
We're excited to announce the release of four new images by artist Rey Hori. Each piece captures a unique vision, showcasing intricate detail and vibrant color.

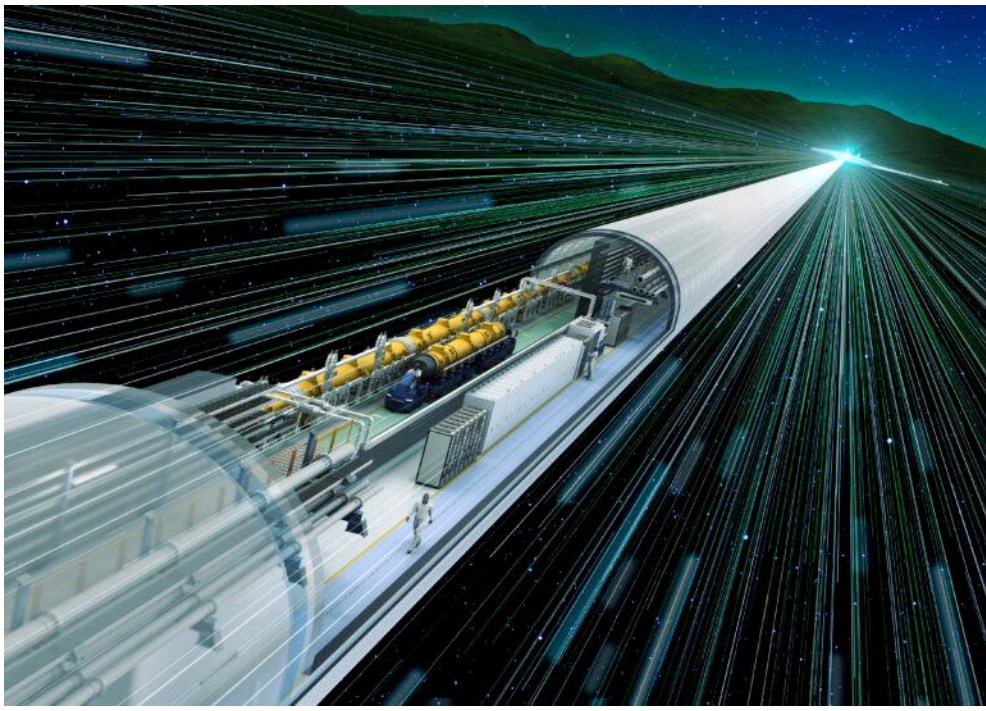
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