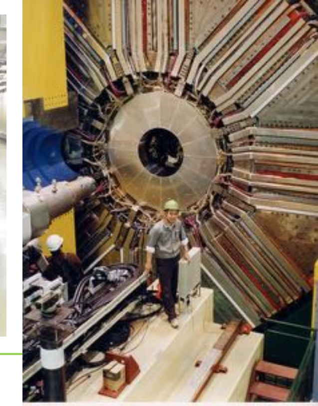
Overview of the ILC, its significance and impact on the region and sustainability considerations

Masakazu Yoshioka

Iwate University, Iwate Prefectural University — Visiting Professor

High Energy Accelerator Research Organization KEK — Professor Emeritus

400MeV Linac+3GeV RCS and 30GeV MR



- Let me begin by introducing myself.
- I am an accelerator scientist, born in 1946 (77 years old) and love sake beyond all else!
- I have been involved in the development, construction and operation of large-scale accelerators at KEK in Tsukuba/Tokai Campus for many years.
- After retiring from KEK in 2012, I moved to Tohoku and am now working to realize the ILC in Tohoku.

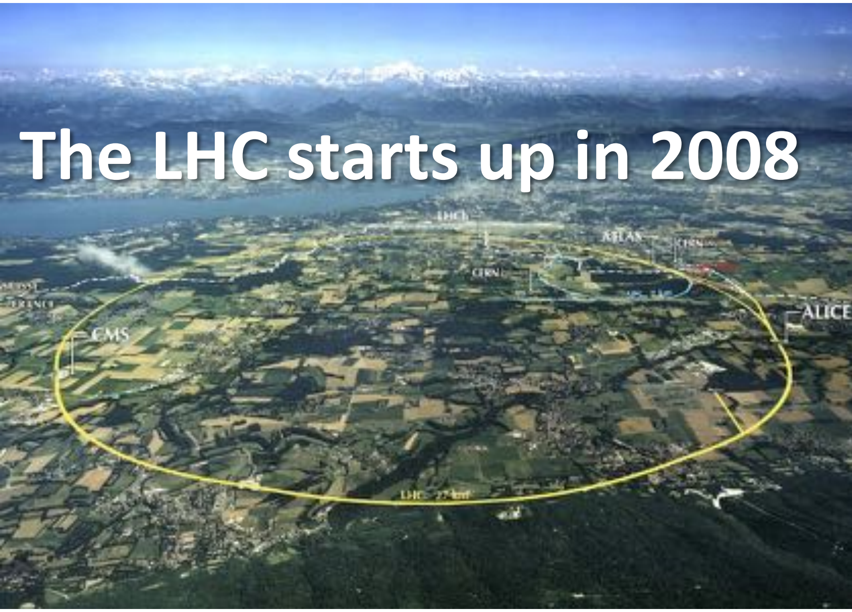
Major accelerator projects I have committed to are followings:

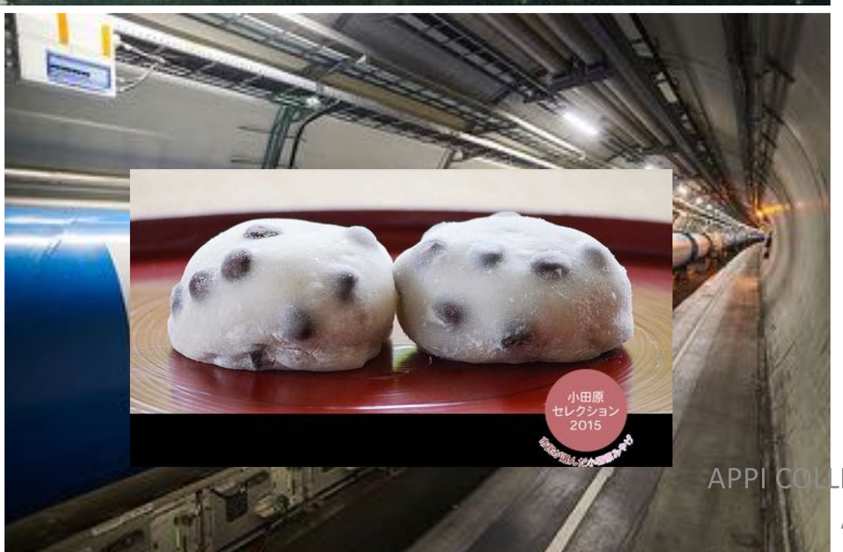
- 1980~1994 TRISTAN Energy frontier : E_{cm}=64GeV
- 1995~2004 KEKB Luminosity Frontier B-Factory: $\mathcal{L}=2\cdot 10^{34}/cm^2/s$ for BELLE experiment
- 2004~2010 J-PARC: High-Power Proton Accelerator Research Complex
  - 3GeV, 1MW proton beam for neutron and mu-on science,
  - 30GeV, 760kW fast extraction proton on the graphite target for long-baseline neutrino experiment T2K
  - 30GeV, 50kW slow extraction proton for hadron experiments

- Next, I need to know about you guys.
- Have you ever attended a lecture related to accelerators?
- Have you ever seen an accelerator?
- Accelerators accelerate charged particles such as electrons (leptons), protons (hadrons) and ions. What are the key elemental technologies?
- Vacuum
- High voltage
- Beam generation
- Beam orbit control
- etc.
- What accelerators are you familiar with?
- Now I know your level of knowledge!

Overview of the ILC, its significance and impact on the region and sustainability considerations

Q-1: As an energy-frontier accelerator why we need both hadron and lepton colliders?





Q-2: Why ILC is the next generation Lepton Collider after LEP (predecessor of LHC)?

- LEP, the predecessor of the LHC, began experiments at Z-pole energy in 1989, reached collision energy of 208 GeV in 2000, and was shut down
- Due to enormous synchrotron radiation loss, the energy only slightly reached the Higgs boson.

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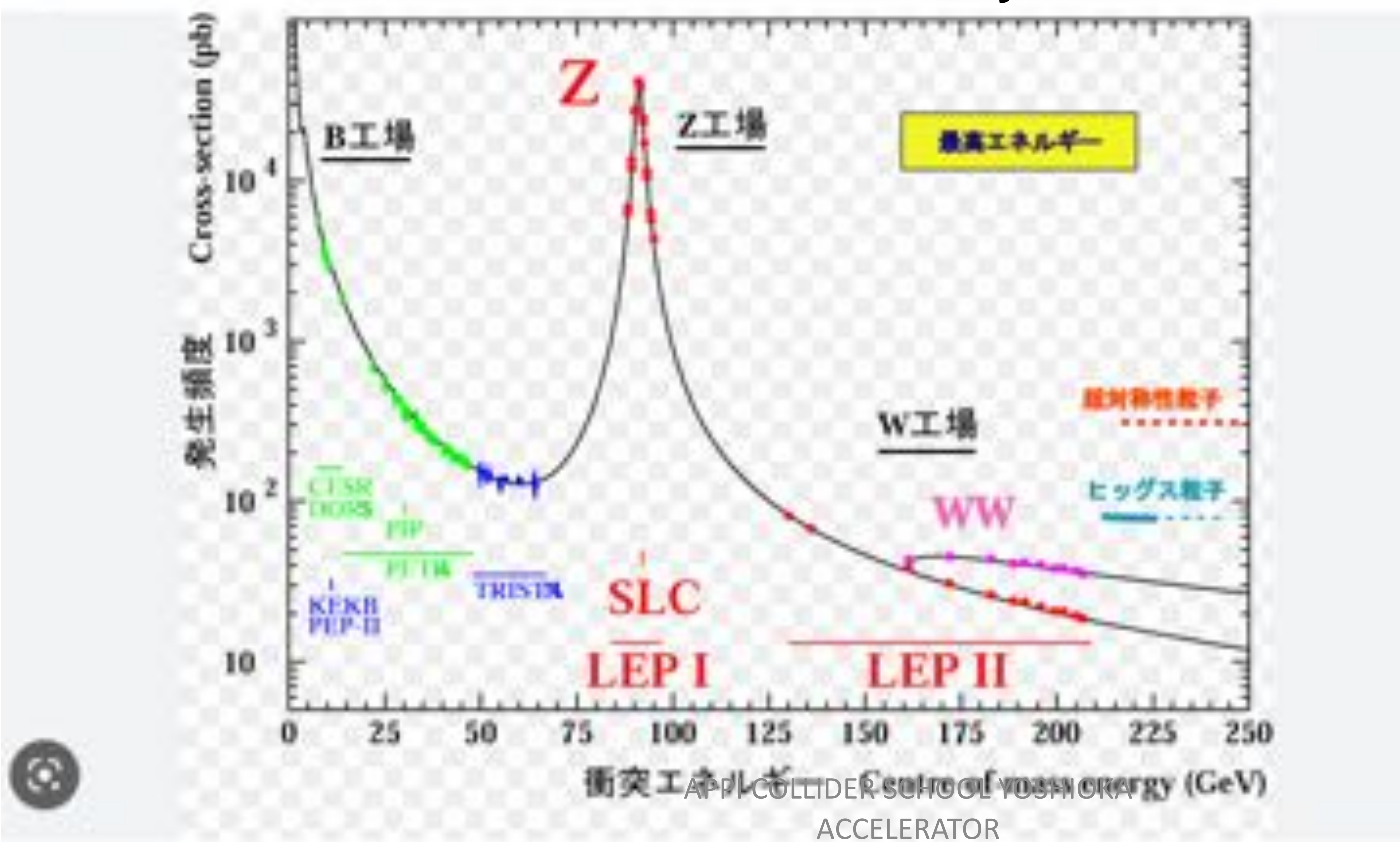
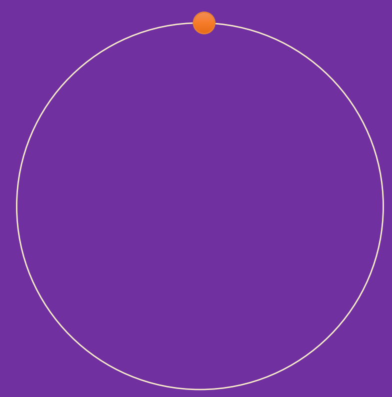


Why is ILC linear? (LHC is circular)

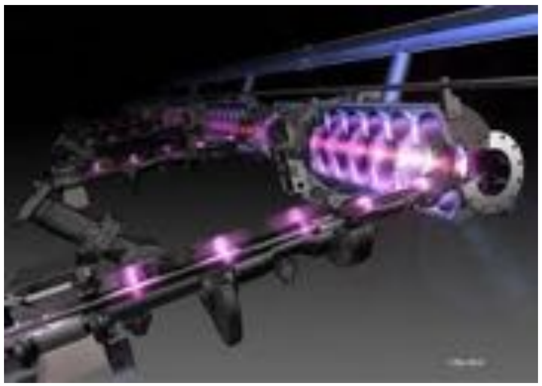
- If it's circular, the electrons emit a lot of synchrotron radiation and lose energy.
- Synchrotron radiation loss is inversely proportional to the fourth power of the particle mass.
- Since proton mass is 2000 times the electron mass, proton synchrotron radiation loss is not a problem
- If it's linear, it won't emit synchrotron radiation, so we're going to linearize the light electron-positron collider.
- However, there is a tradeoff. With a circular collider, the same particle has multiple opportunities to collide, but with a linear case, the collision of accelerated particles is a one-shot deal



Original slides by Professor Emeritus Hitoshi Yamamoto, Tohoku University

Q-3: Why the realization of the ILC will take more time than the LHC? (Not political but technical question)

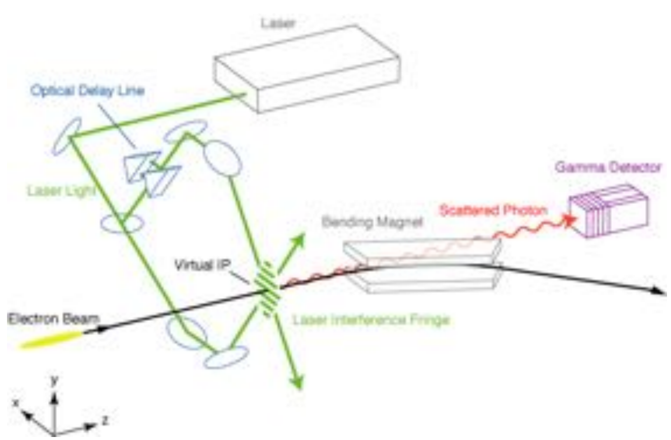
A-1: Issues are quality control, mass production and cost reduction of superconducting accelerators

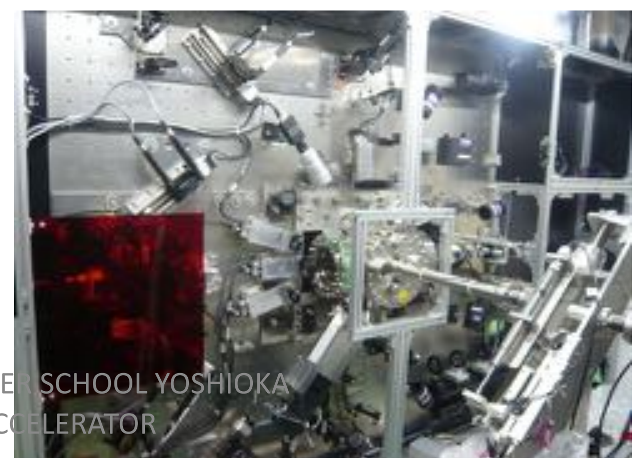


Yes, we can ! ➔ See next page (Euro-XFEL)

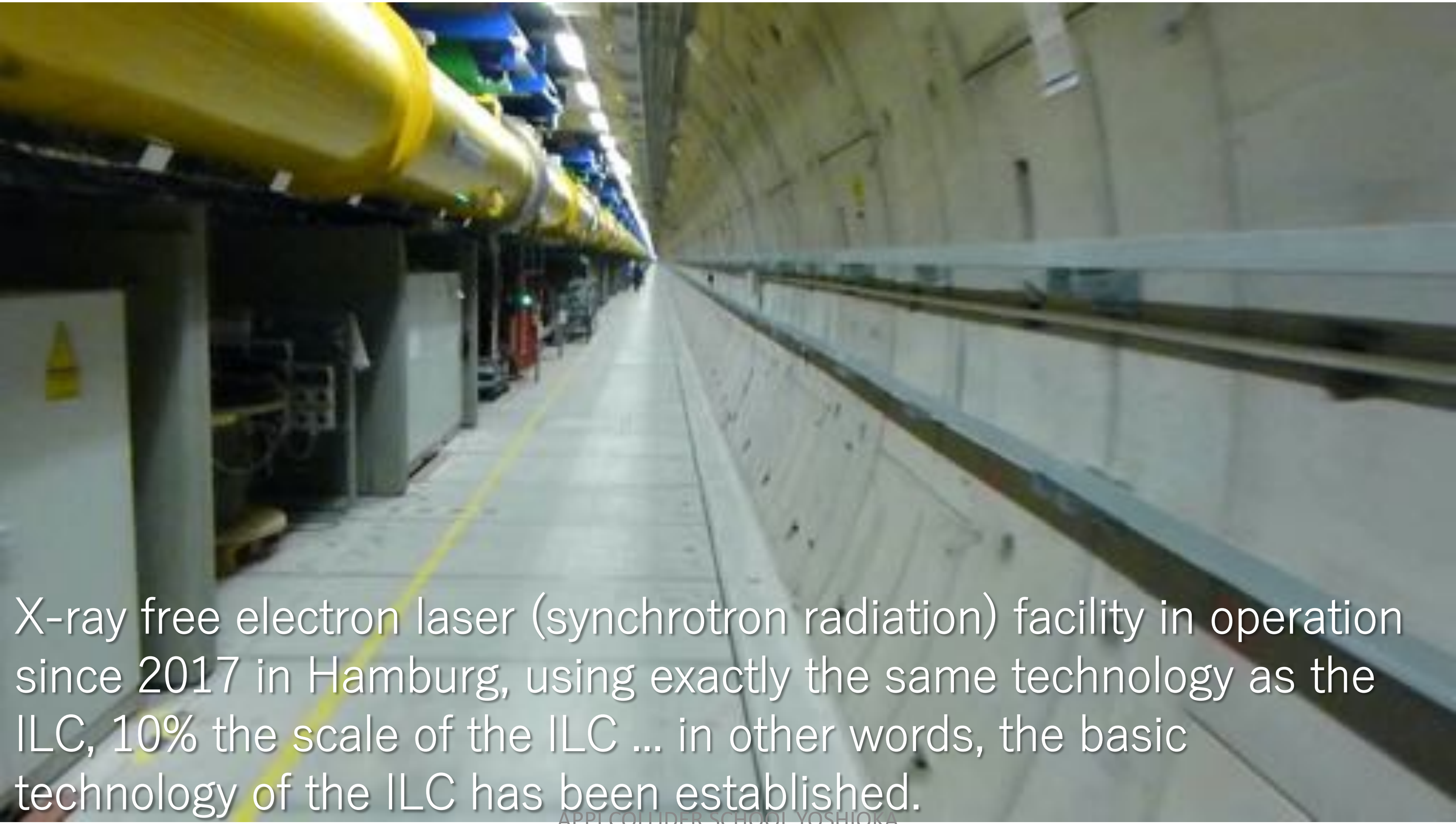
A-2: Beam control technology, especially collision control by narrowing the beam size to nanometer size

Yes, we can ! ➔See ATF-II@KEK





Euro XFEL in Hamburg



X-ray free electron laser (synchrotron radiation) facility in operation since 2017 in Hamburg, using exactly the same technology as the ILC, 10% the scale of the ILC … in other words, the basic technology of the ILC has been established.

Colliding particles in a single shot deal

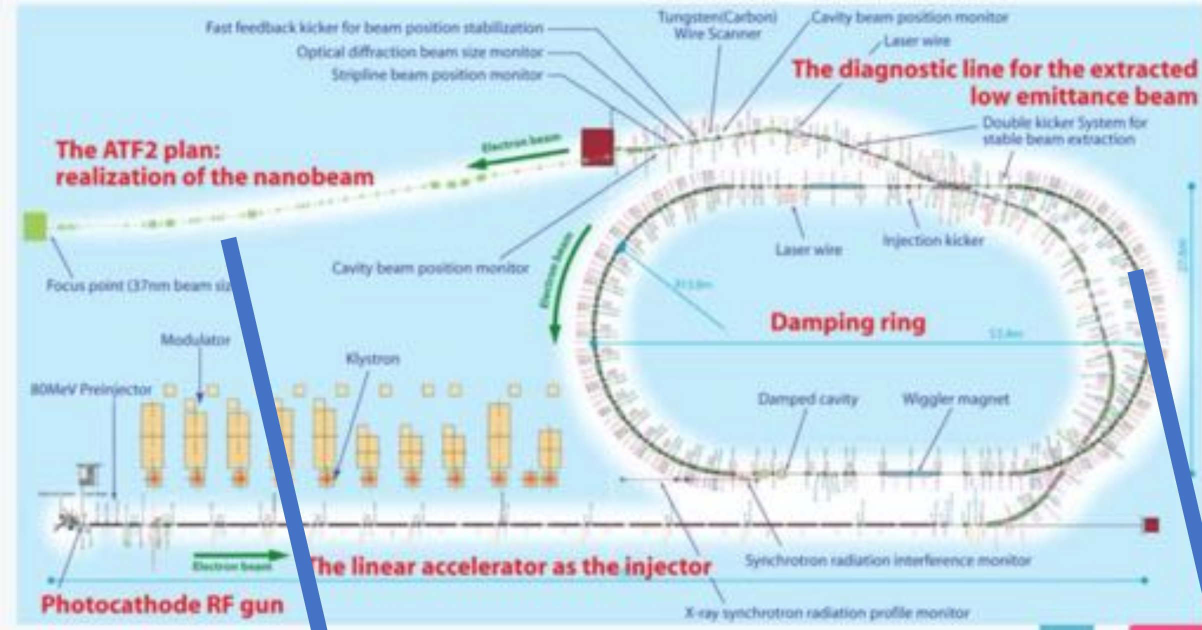
Beams of particles are bunched (swarmed).

Reducing the size of the bunch (narrowing the beam) makes collisions more likely.

Linear colliders especially need to narrow the beam size.

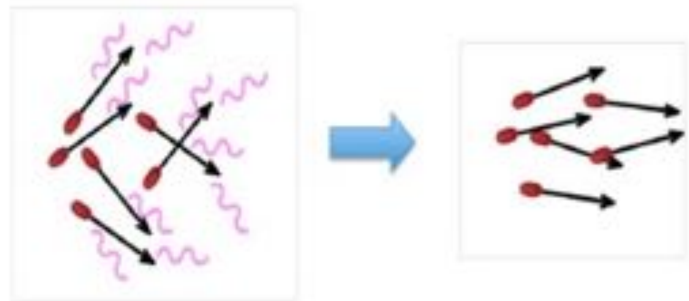
The role of the accelerator is all about accelerating and colliding well.

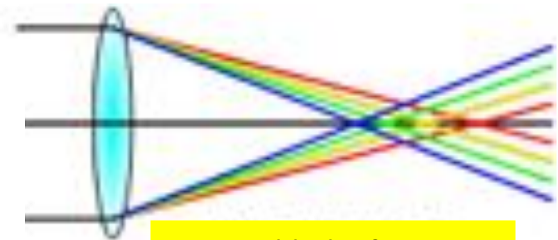
Original slides by Professor Emeritus Hitoshi Yamamoto, Tohoku University



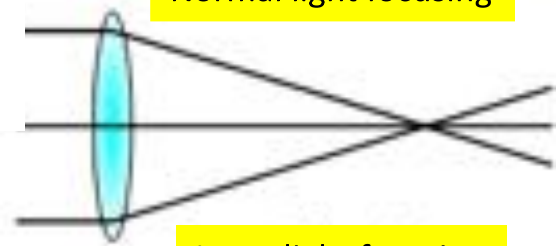
Fast feedback kicker for beam position stabilization
Optical diffraction beam size monitor
Stripline beam position monitor
Tungsten(Carbon) Wire Scanner
Cavity beam position monitor
Laser wire
The diagnostic line for the extracted low emittance beam
Double kicker System for stable beam extraction
The ATF2 plan: realization of the nanobeam
Electron beam
Focus point (37nm beam siz
Cavity beam position monitor
Laser wire
Injection kicker
Damping ring
Modulator
Klystron
80MeV Preinjector
Damped cavity
Wiggler magnet
Electron beam
The linear accelerator as the injector
Synchrotron radiation interference monitor
Photocathode RF gun
X-ray synchrotron radiation profile monitor

Let's understand the technology to focus beams to nanometer size and control collisions. (1) Realizing low beam emittance (radiation damping) and (2)good chromaticity correction.



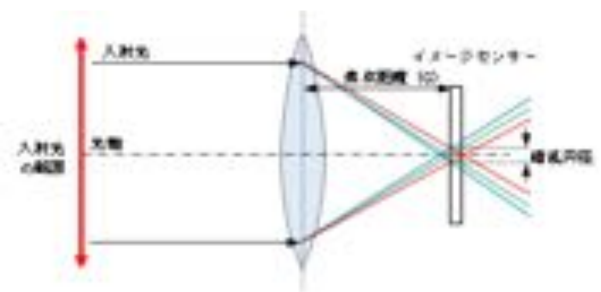


Normal light focusing

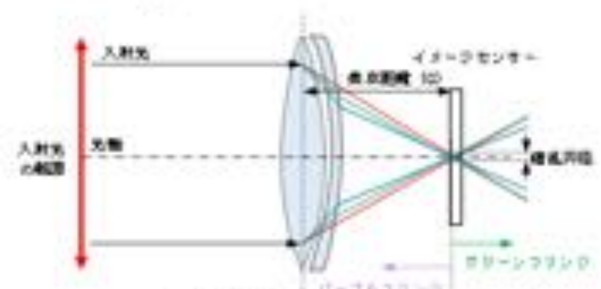


Laser light focusing

Minimize the beam emittance and realize strong focusing



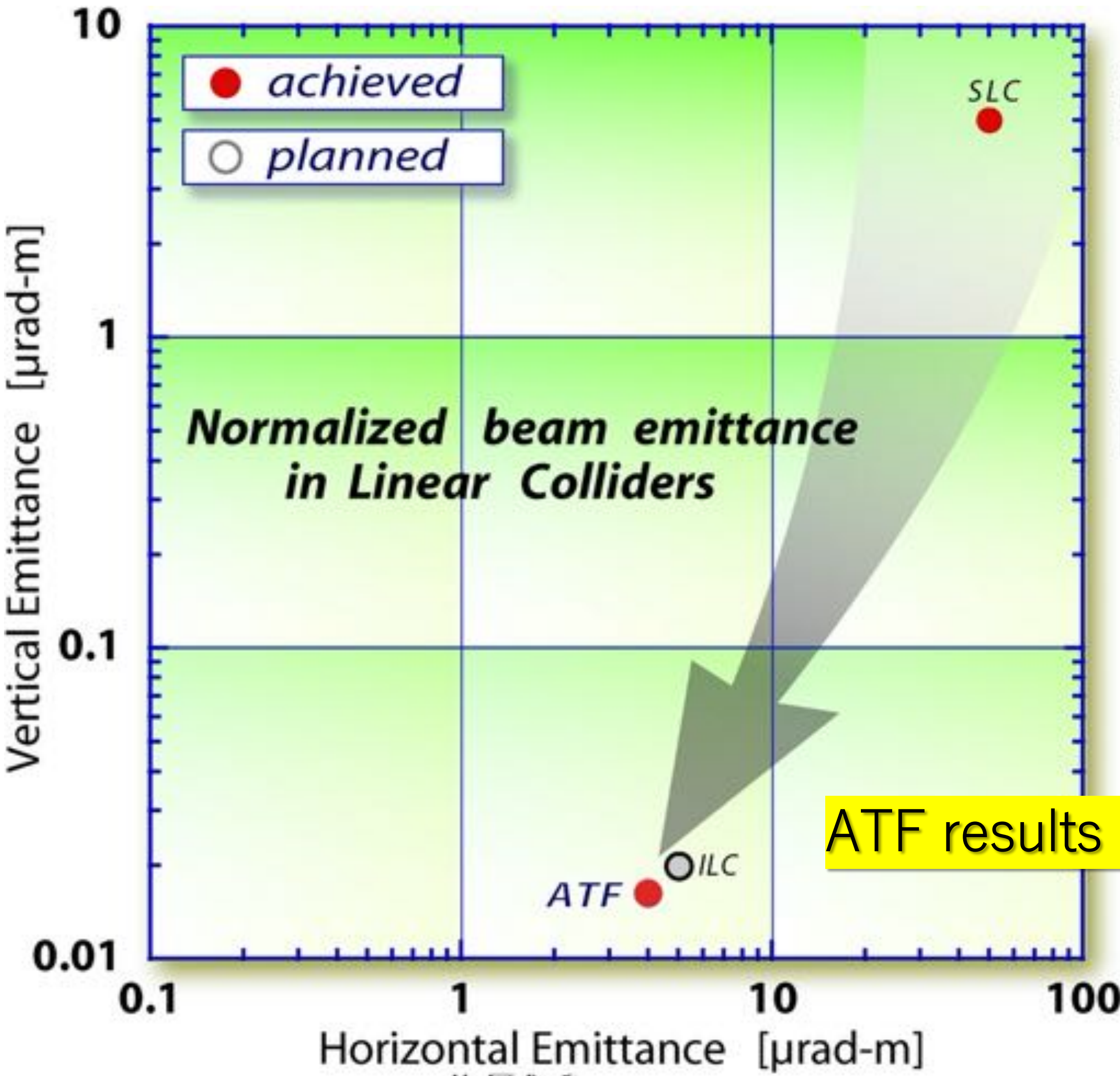
(a) レンズの軸上色収差



(b) 軸上色収差を補正したレンズ

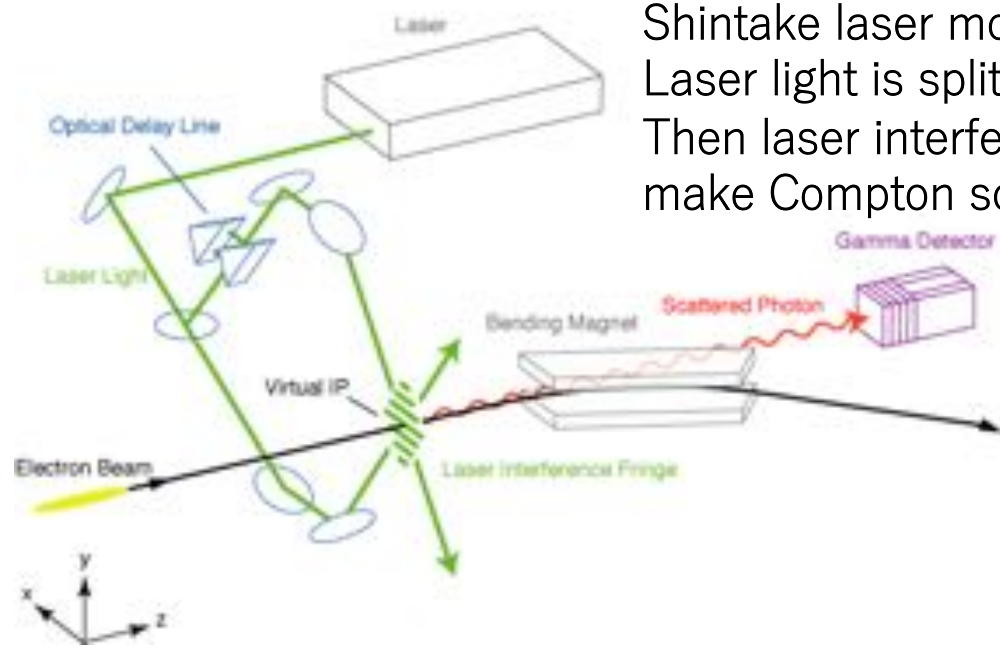
Accelerator beam is not completely monochromatic.

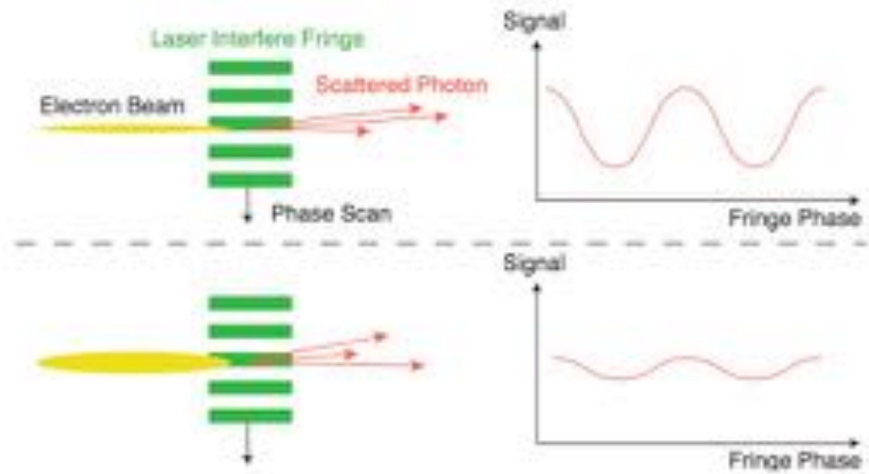
Need chromaticity correction



ATF results meet ILC's goals

Shintake laser monitor for beam size measurement
Laser light is splited and meet again.
Then laser interference fringe is made, which is a target to make Compton scattering.

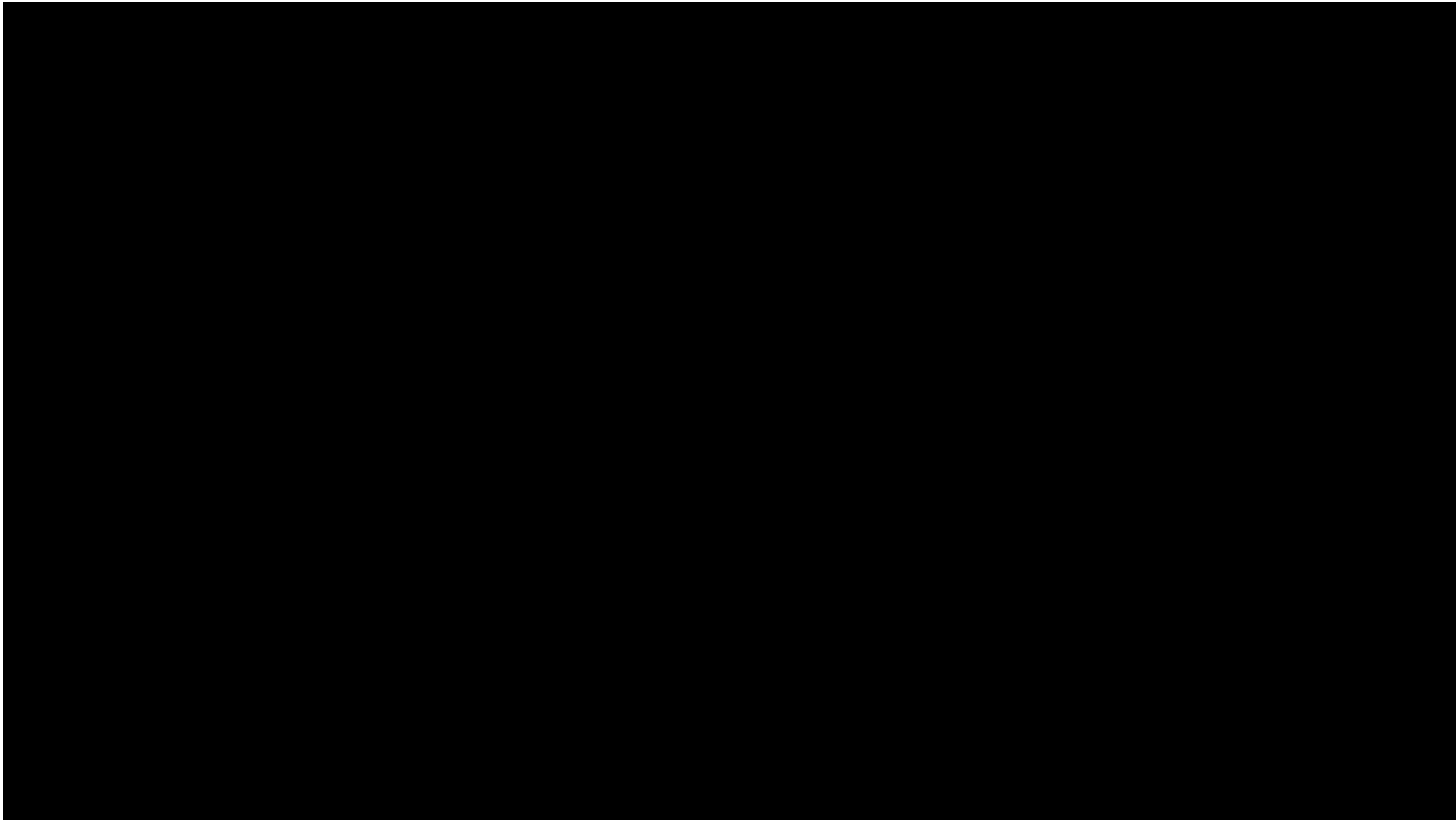




Beam Energy	ATF-II achieved	ILC design
1.3 GeV	41 nm	75.7 nm
125 GeV	4.2 nm	7.7 nm

Beam size is inversely proportional to the square root of energy.
ATF-II results meet ILC goals.

ILC video courtesy of Rey.HORI



Q-4: The core technology of the ILC has been achieved, so why we continue further development and research?

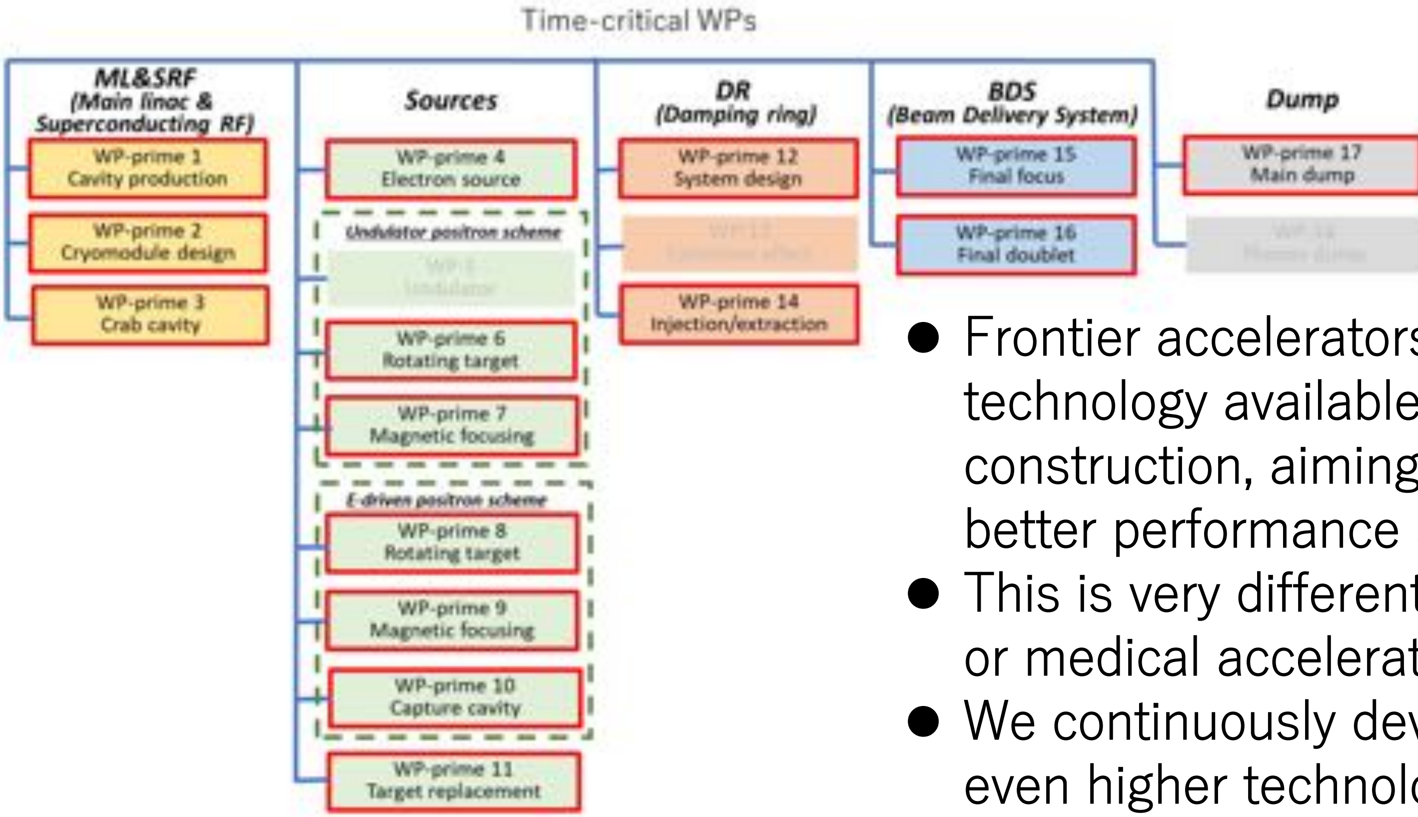


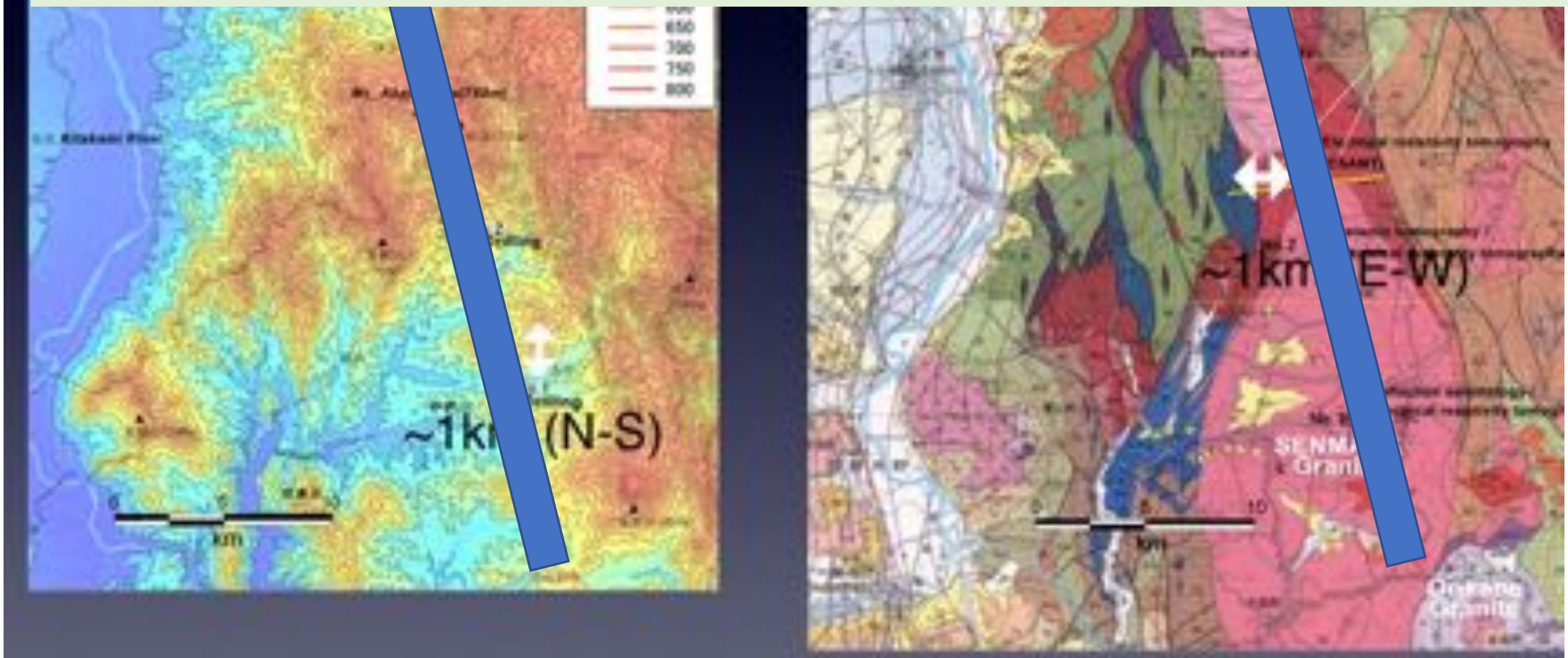
Figure 3: Time-critical WPs

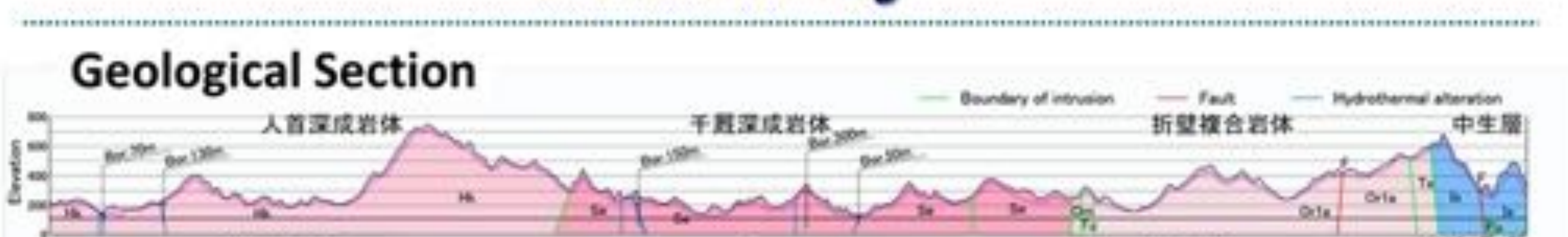
- Frontier accelerators use the best technology available at the start of construction, aiming to achieve better performance and lower cost.
- This is very different from industrial or medical accelerators.
- We continuously develop and adopt even higher technology after construction and operation begins, and upgrade its performance.
- Linear accelerators fit very well with this.

Q-5: Why was the Kitakami Highlands chosen as a candidate site for the ILC?

The terrain is gently rolling hills, suitable for tunneling.

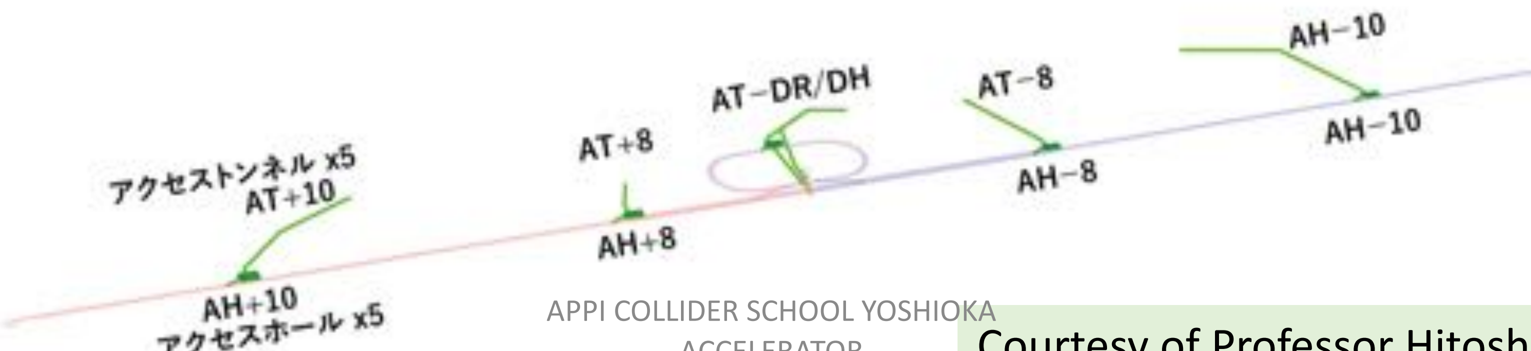
- Granite is a deep-bearing igneous rock.
- Magma solidified over a long period of time and surfaced on the ground surface due to its slightly lower specific gravity.
- Homogeneous granite zone is suitable for underground tunnelingTunnels can be excavated by blasting, with low construction risk and therefore relatively low cost





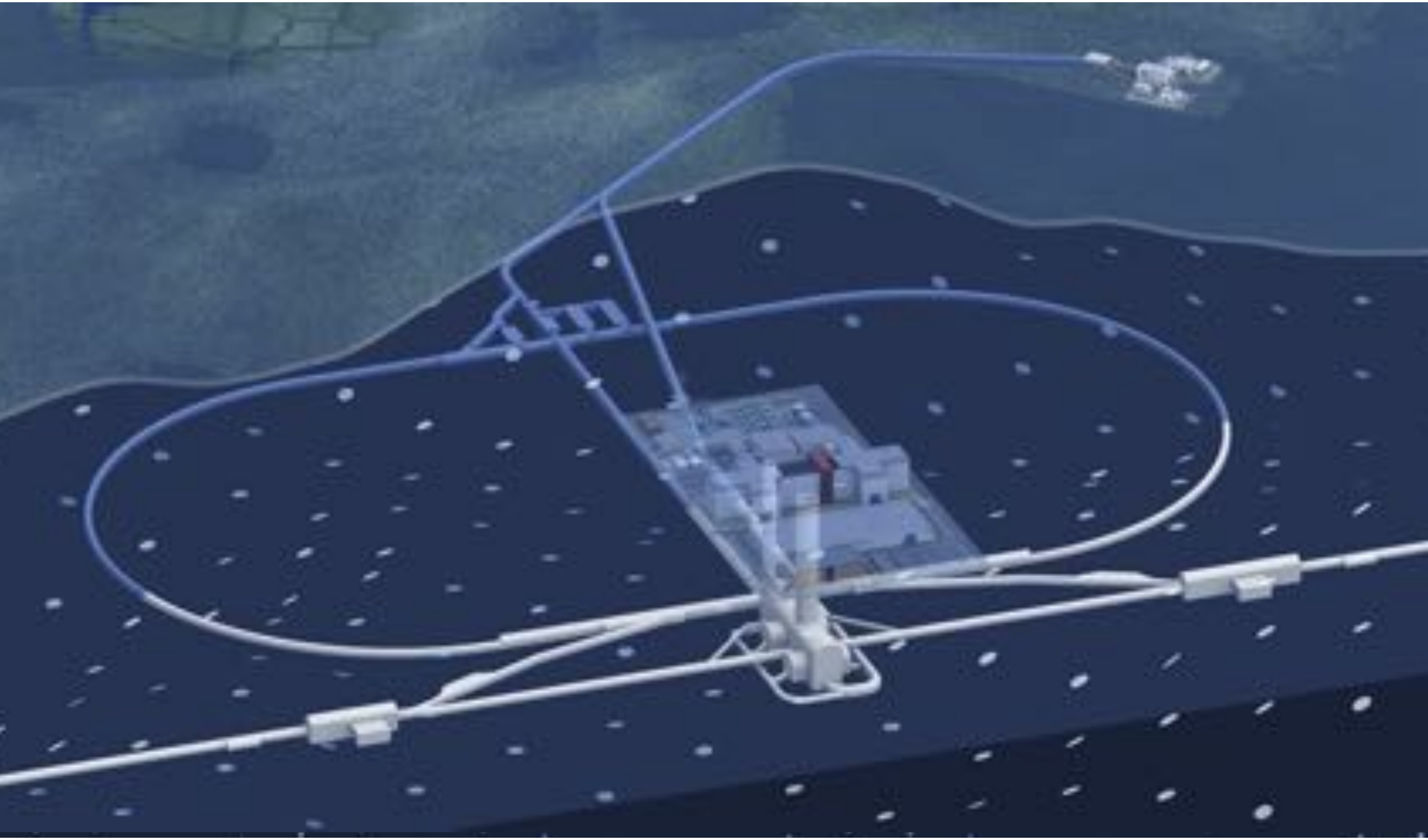
Accelerator tunnels are excavated along the geoid and the final focus tunnel is excavated in a laser-straight.

Excavate five access tunnels first, then proceed to the main tunnel



Courtesy of Professor Hitoshi Hayano

Bird's eye view of ILC Kitakami candidate site



Tunnel design for ILC Kitakami candidate site (ILC 250GeV 20.5km)

Courtesy of Professor Hitoshi Hayano

Monday, May 15, 2023

After the Corona disaster, the LCWS was held face-to-face last year for the first time in many years.

- Total number of participants: 220
- 7 participants from 3 companies in Tohoku area

Status and Activities of the International Development Team (IDT)

LCWS2023 at SLAC

Menlo Park, USA, 15-19 May 2023

Tatsuya Nakada

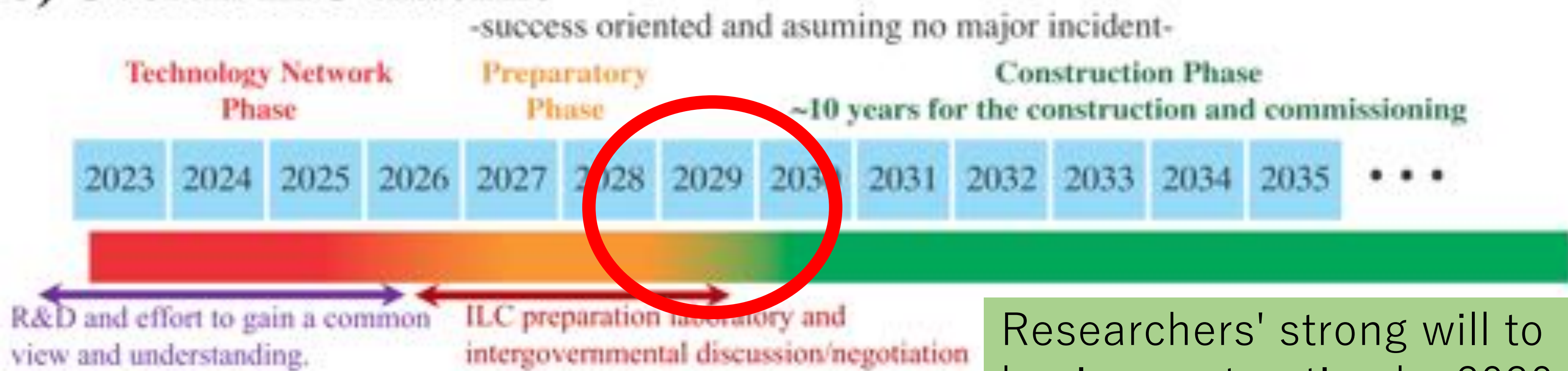
EPFL, Switzerland

Chair of the IDT Executive Board

Keynote speech by IDT Chair Nakata-san

- ILC is very attractive as a global Higgs factory;
  - Thanks to the GDE effort, ILC is technically mature and ready to proceed to construction.
  - As a global project, ILC cost is affordable.
  - ILC power consumption and environmental impact is modest.
  - ILC has a clear upgrade path to higher energies: to t.t-bar threshold, to ZHH, to ~1 TeV (and possibly beyond with technological advancement, when physics justifies).
  - ILC has been developed as a global project from its conception.

5) Overall ILC timeline

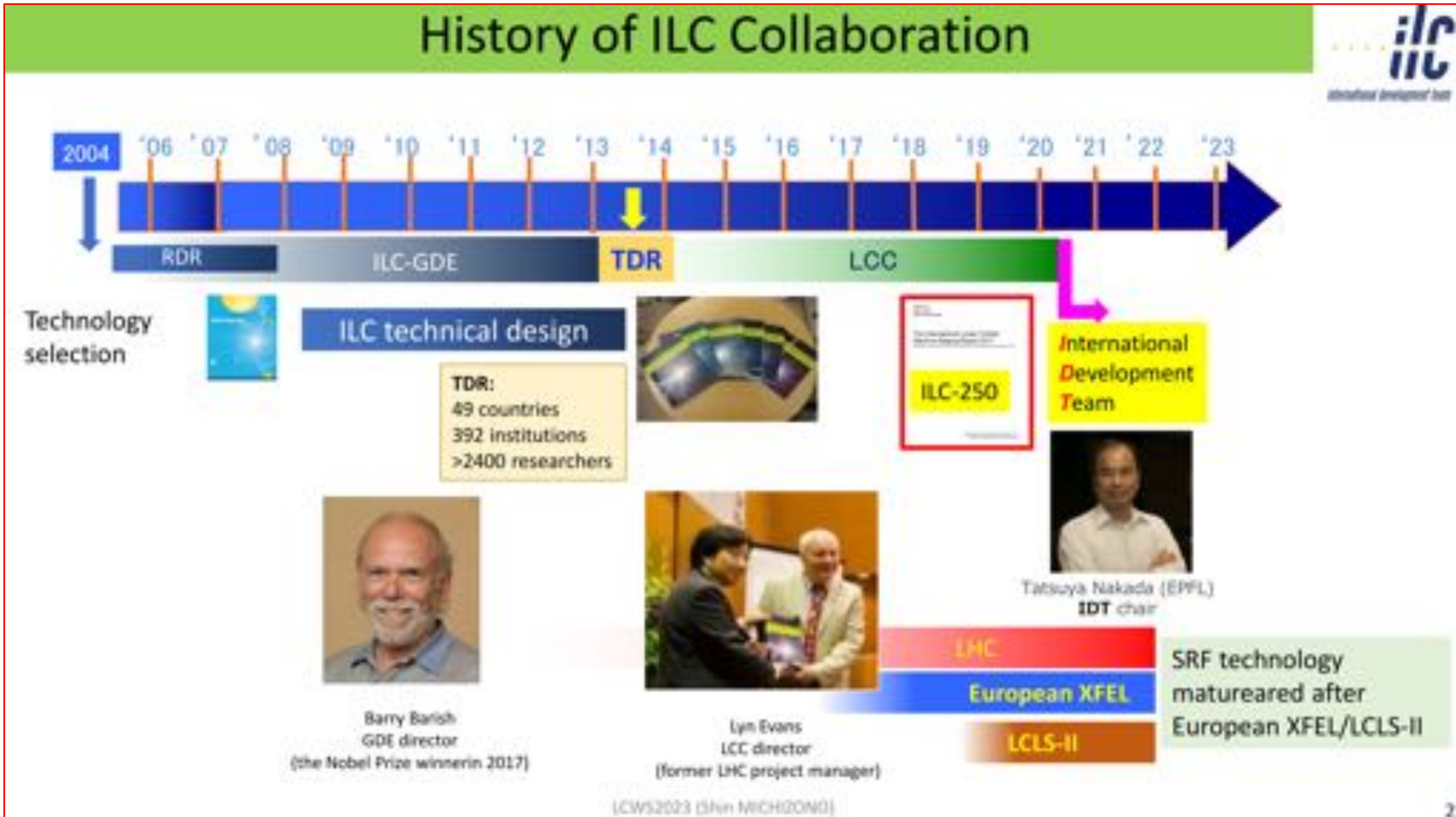


Researchers' strong will to begin construction by 2030

ILC Technology Network (ITN)

KEK / IDT-WG2
Shin MICHIZONO (KEK)

Shinichiro Michizono of KEK
Head of ICFA-IDT-WG2



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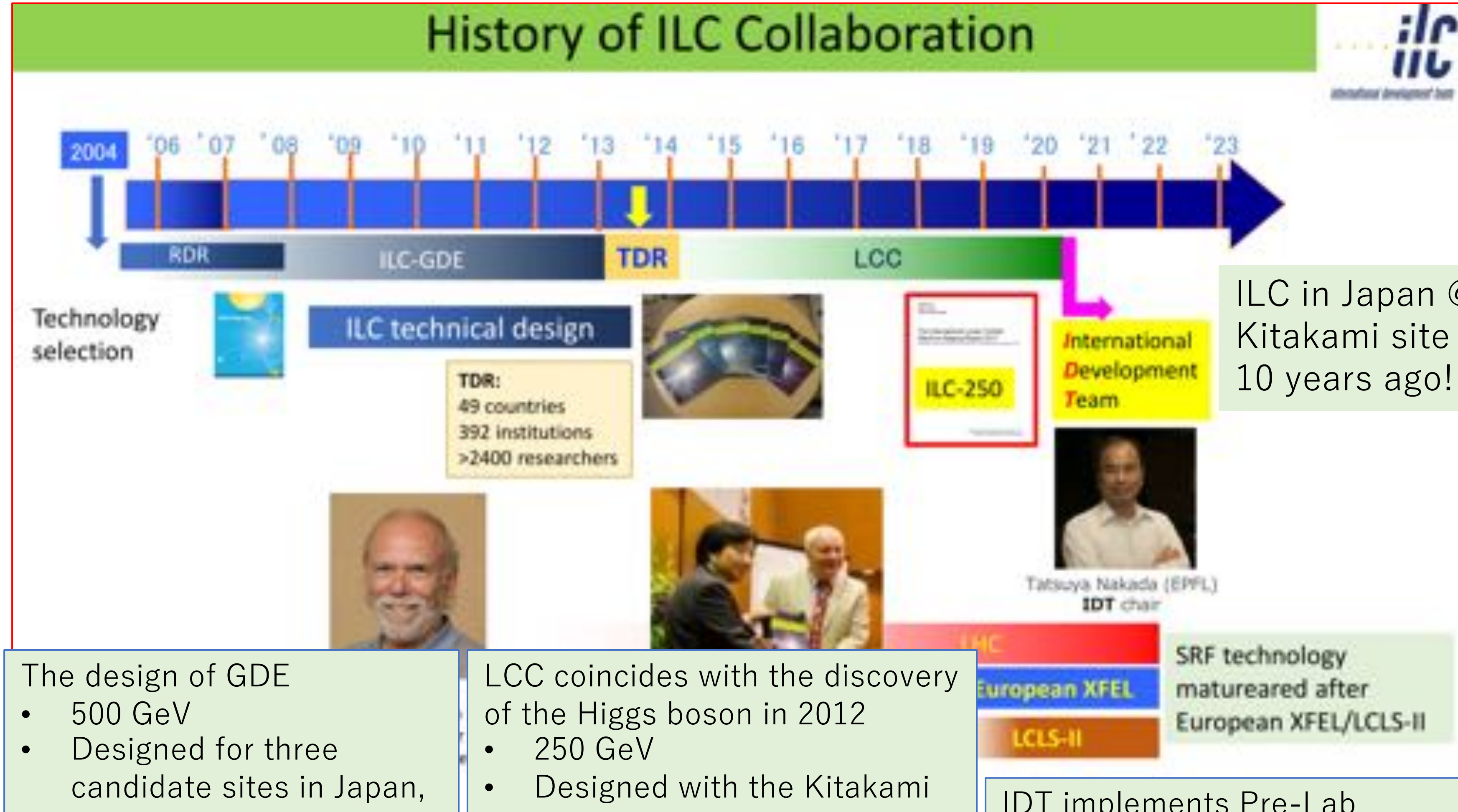


ILC in Japan @ Kitakami site was 10 years ago!

The design of GDE
- 500 GeV
- Designed for three candidate sites in Japan, the U.S., and Europe

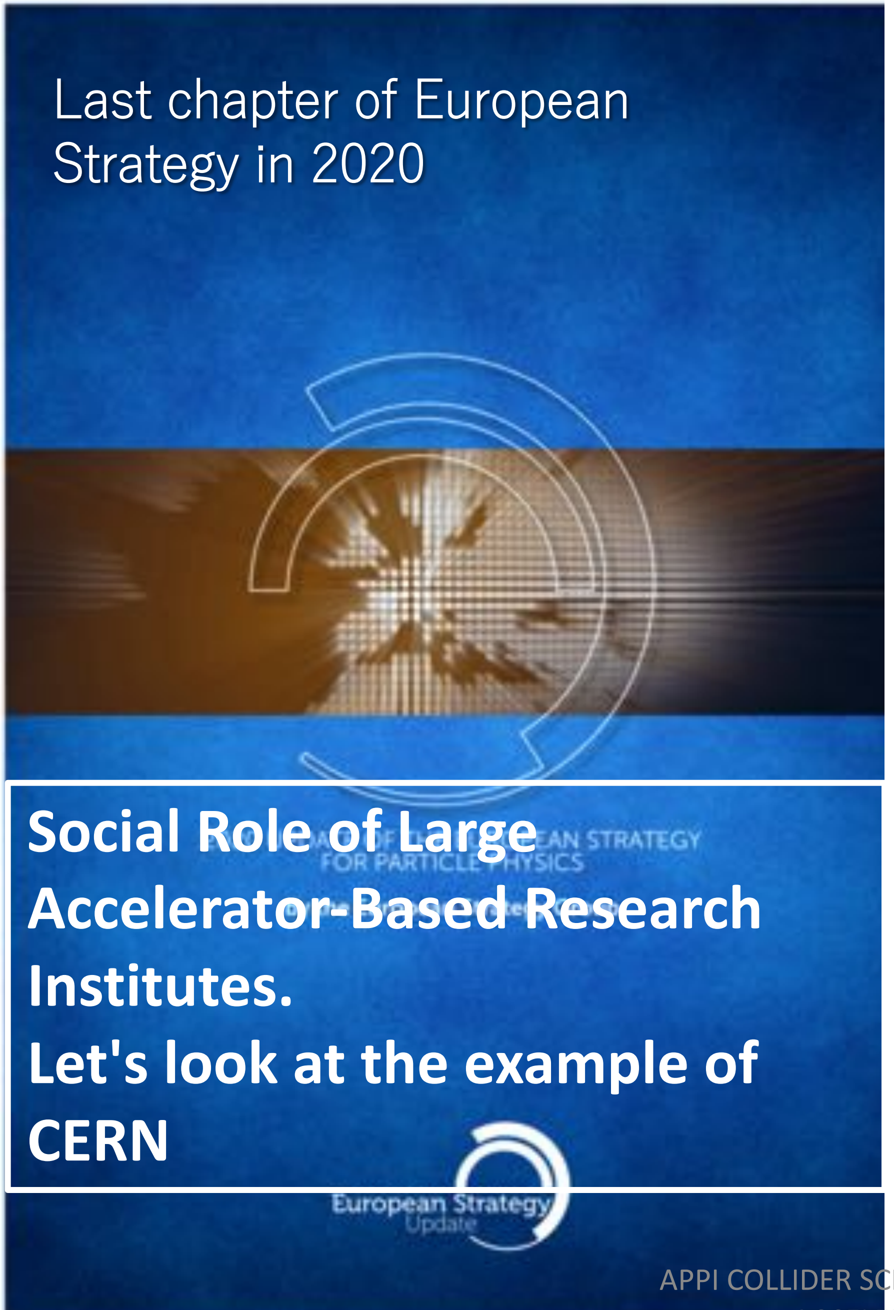
LCC coincides with the discovery of the Higgs boson in 2012
- 250 GeV
- Designed with the Kitakami Highlands as a candidate site

IDT implements Pre-Lab institutional design

Overview of the ILC, **its significance and impact on the region** and sustainability considerations

Learning from CERN about the significance of realizing a large international research institution

Last chapter of European Strategy in 2020



Social Role of Large Accelerator-Based Research Institutes.

Let's look at the example of CERN

7 Environmental and societal impact

A. The energy efficiency of present and future accelerators, and of computing facilities, is and should remain an area requiring constant attention. Travel also represents an environmental challenge, due to the international nature of the field. ***The environmental impact of particle physics activities should continue to be carefully studied and minimised. A detailed plan for the minimisation of environmental impact and for the saving and re-use of energy should be part of the approval process for any major project. Alternatives to travel should be explored and encouraged.***

B. Particle physics, with its fundamental questions and technological innovations, attracts bright young minds. Their education and training are crucial for the needs of the field and of society at large. ***For early-career researchers to thrive, the particle physics community should place strong emphasis on their supervision and training. Additional measures should be taken in large collaborations to increase the recognition of individuals developing and maintaining experiments, computing and software. The particle physics community commits to placing the principles of equality, diversity and inclusion at the heart of all its activities.***

C. Particle physics has contributed to advances in many fields that have brought great benefits to society. Awareness of knowledge and technology transfer and the associated societal impact is important at all phases of particle physics projects. ***Particle physics research centres should promote knowledge and technology transfer and support their researchers in enabling it. The particle physics community should engage with industry to facilitate knowledge transfer and technological development.***

D. Exploring the fundamental properties of nature inspires and excites. It is part of the duty of researchers to share the excitement of scientific achievements with all stakeholders and the public. The concepts of the Standard Model, a well-established theory for elementary particles, are an integral part of culture. ***Public engagement, education and communication in particle physics should continue to be recognised as important components of the scientific activity and receive adequate support. Particle physicists should work with the broad community of scientists to intensify engagement between scientific disciplines. The particle physics community should work with educators and relevant authorities to explore the adoption of basic knowledge of elementary particles and their interactions in the regular school curriculum.***

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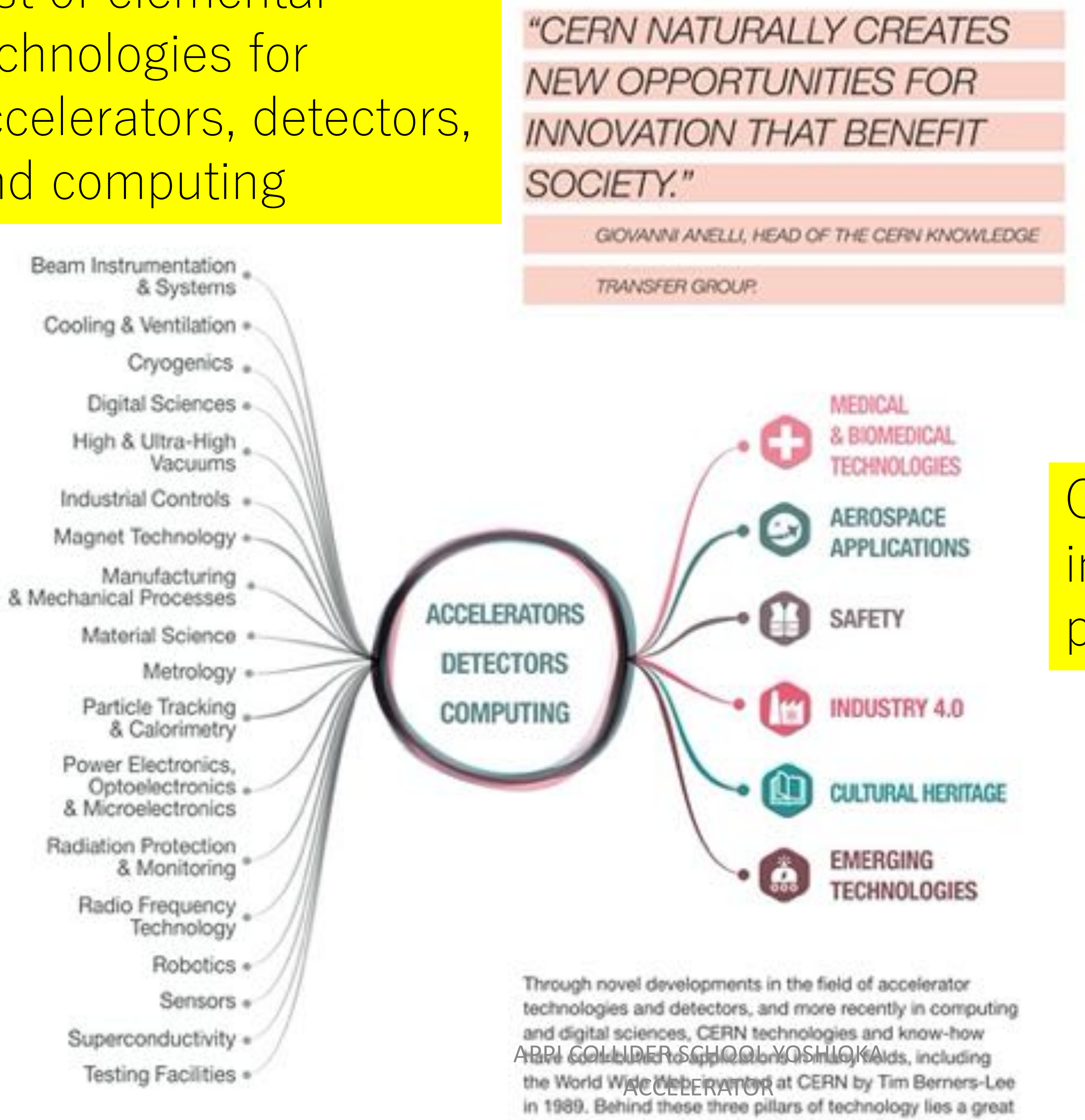
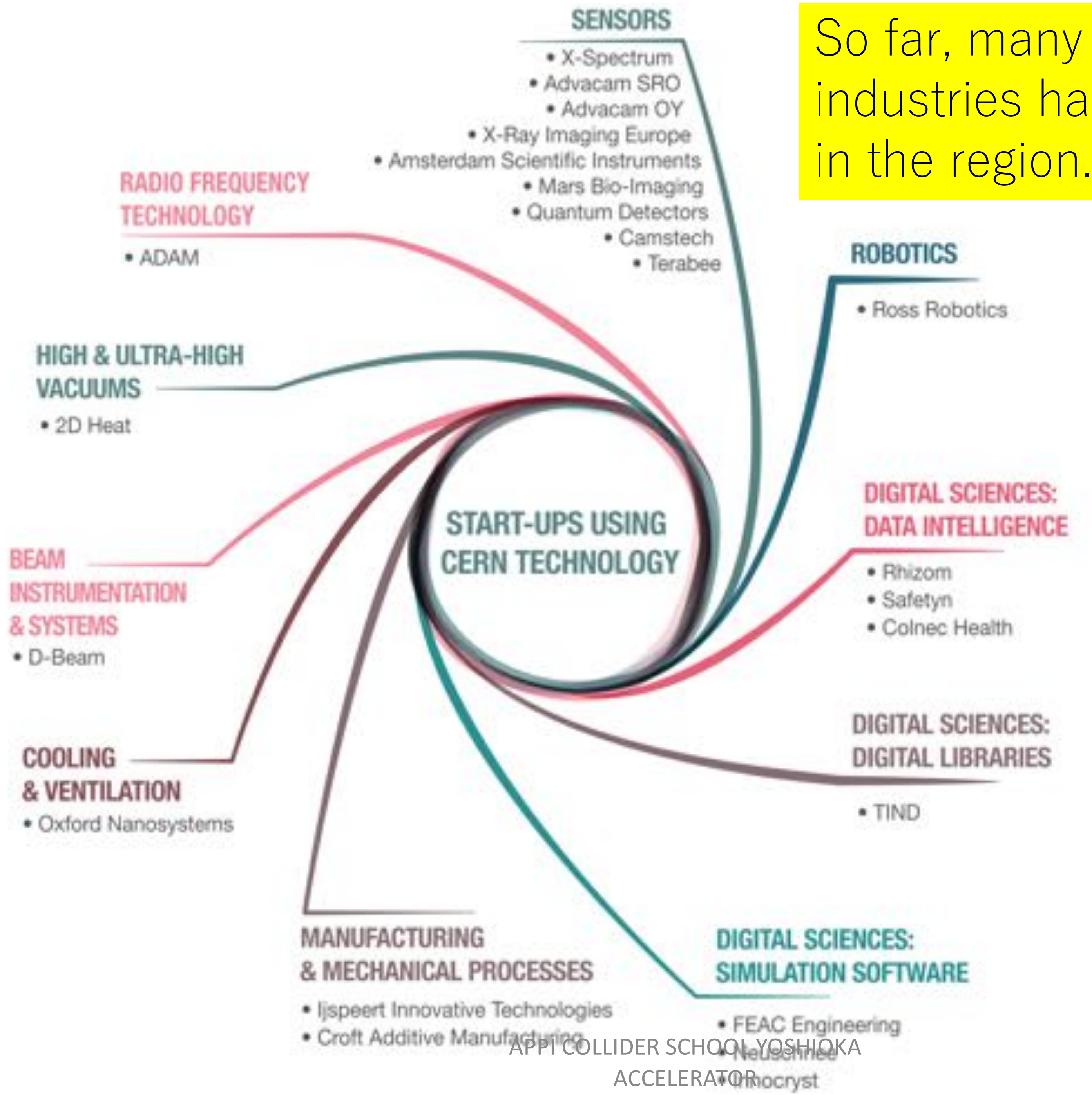
The ILC should also base its policy on this strategy

List of elemental technologies for accelerators, detectors, and computing



Create a new industry in the private sector

So far, many new industries have sprung up in the region.



- The next topic is about town planning/development triggered by the ILC.
- We need wide-area planning with Sendai and Morioka as the dipoles
- Ecosystem already under construction in Sendai, triggered by the construction of a synchrotron radiation facility
- As a community of researchers and engineers, it should be designed as a community of 200-300 units, each with its own local characteristics.

ILCを契機とした広域エコシステム構築

NTTファシリティーズ・
平井さん作成

Figure3: Community-driven town planning triggered by the construction of the ILC.

Summary

- ILC is the most sustainable and economical accelerator as Higgs Factory, which is based on the superconducting technologies.
- ILC is the most advanced Higgs Factory in terms of technology development, and I personally believe that we are at the point where construction can begin as soon as the green light is given.
- ILC is the most energy extendible accelerator in future.
- We hope that the IDT/Pre-Lab process will lead to international discussions on the structure and cost burden of the ILC, and that construction will begin as soon as possible.
- The ILC's relationship with society can be learned from the CERN’s experience.
- We are considering town planning together with the local community in the Tohoku region, using the ILC as a trigger.
- Establishment of Asia's first large-scale international research institute is a symbol of “Science for Peace”.

Learn from the History of CERN

French physicist Louis de Broglie put forward the first official proposal for the creation of a European laboratory at the European Cultural Conference, which opened in Lausanne on 9 December 1949.

First proposal was only 4 years after the end of WW-II

In the present era of war and infectious diseases, we must realize the ILC in Japan, the first large-scale international research institute in Asia, and use it as a symbol of Science for peace and world wide brain exchange.

Overview of the ILC, its significance and impact on the region and **sustainability considerations**

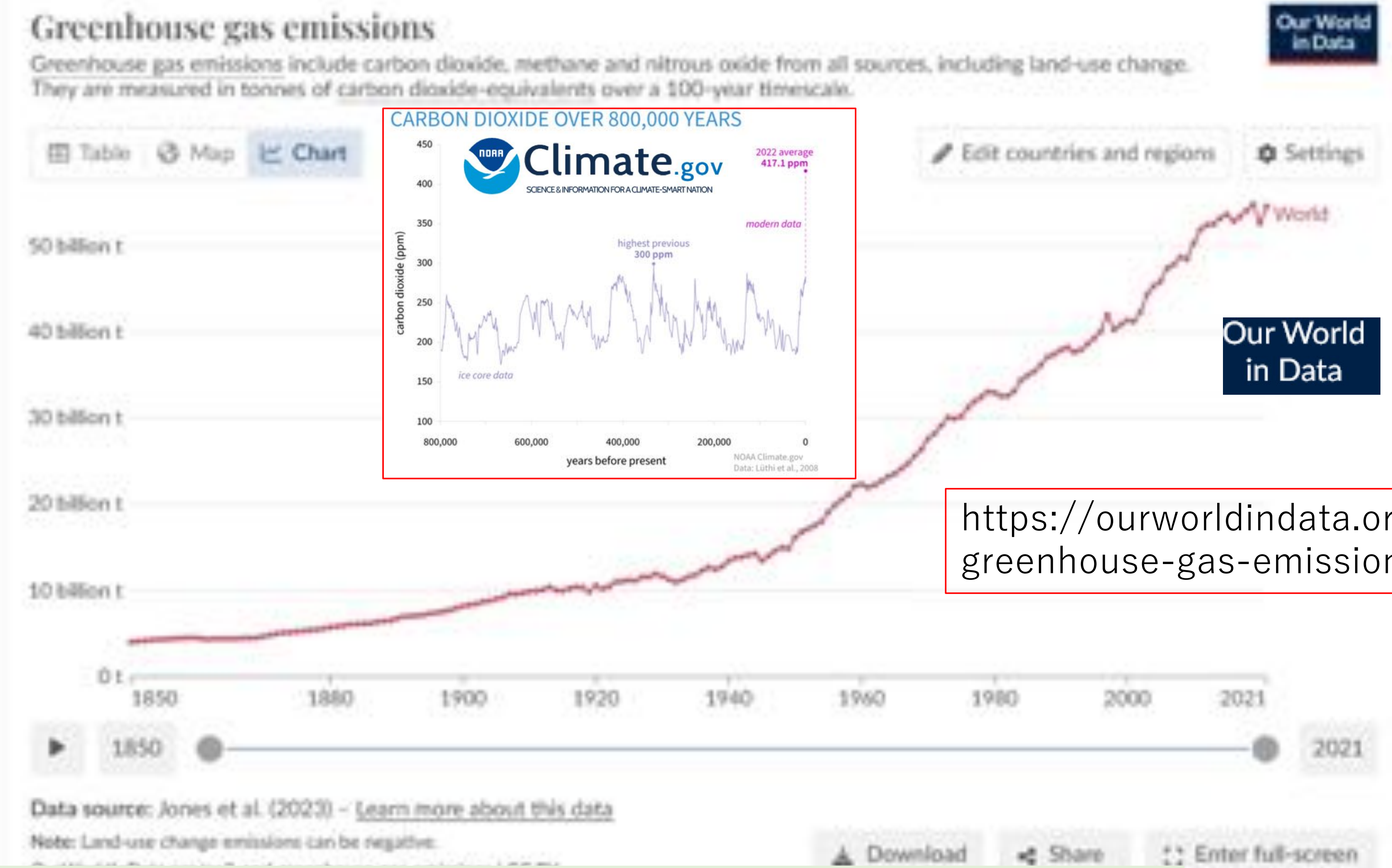
Th-AP02	10:30 - 11:00	Break	
		Chair: Maxim TITOV (CEA Saclay, Irfu)	
		Title	Speaker
	11:00	Green ILC [Zoom]	Masakazu YOSHIOKA (KEK)
	11:30 11:45	CO_2 Reduction Optimization with Future Colliders Design, Construction and Operation	Dou WANG (IHEP)
	12:00	Energy Recover and Reuse Technology Studies for Large Green Accelerators	Rui GE (IHEP)

Green ILC

KEK (Professor Emeritus)

Iwate University/Iwate Prefectural University (Visiting Professor)

1. Prologue: Global Warming, ILC Timeline & Features, Sustainable Accelerator Facility
2. The International Workshop on Sustainability in Future Accelerators in Morioka, Iwate
3. Epilogue: ILC and GX create new technologies and give back to society

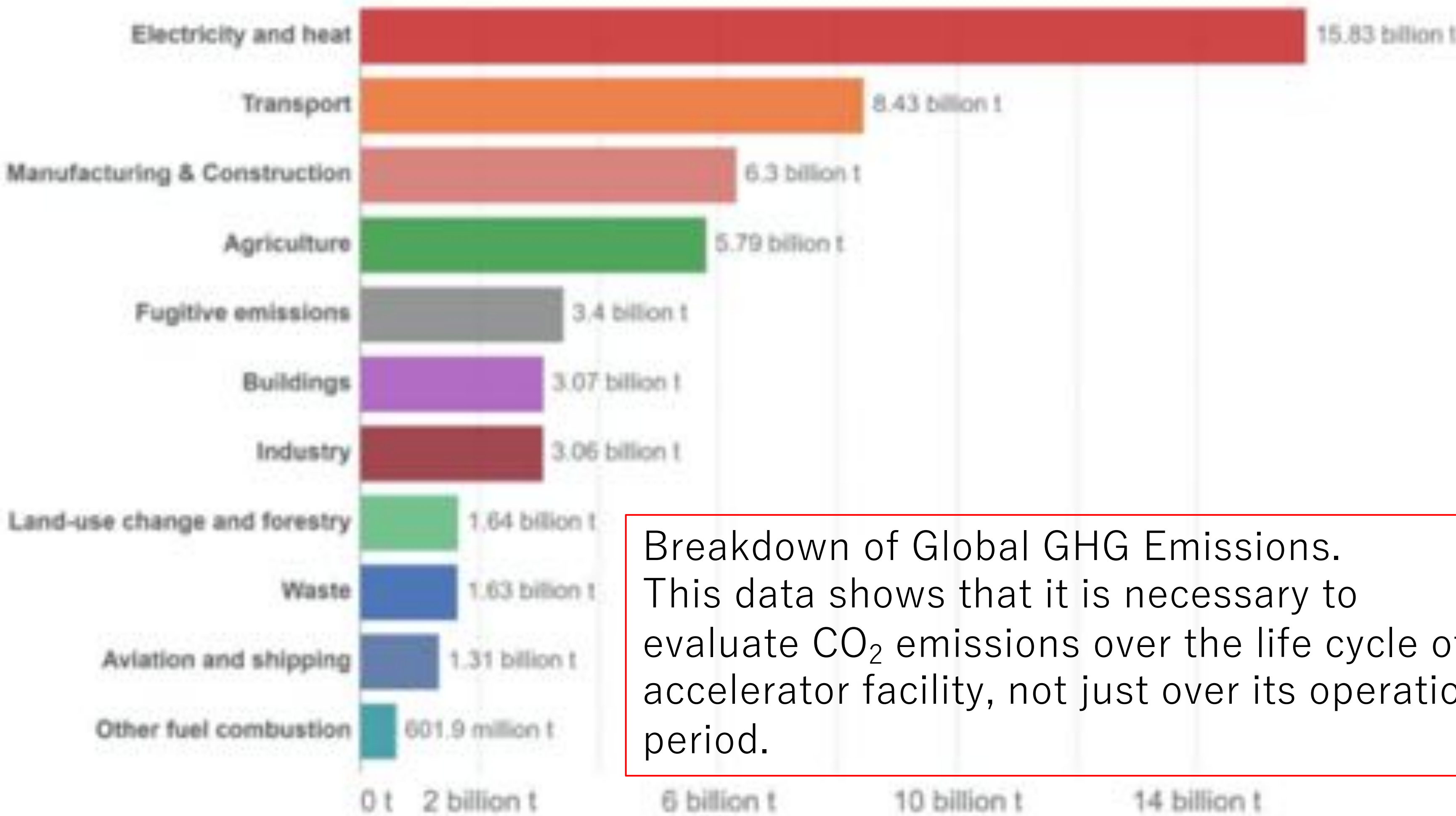


Our World in Data

https://ourworldindata.org/greenhouse-gas-emissions

Let me clarify my understandings.

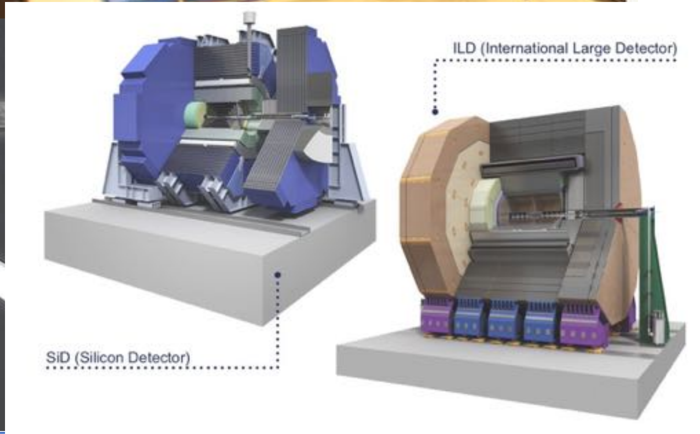
1. The earth is currently warming due to natural cycles (Milankovitch cycle).
2. Global greenhouse gases are accelerating this trend.
3. Scientists must work to stop it.
4. Accelerator facilities are no exception.



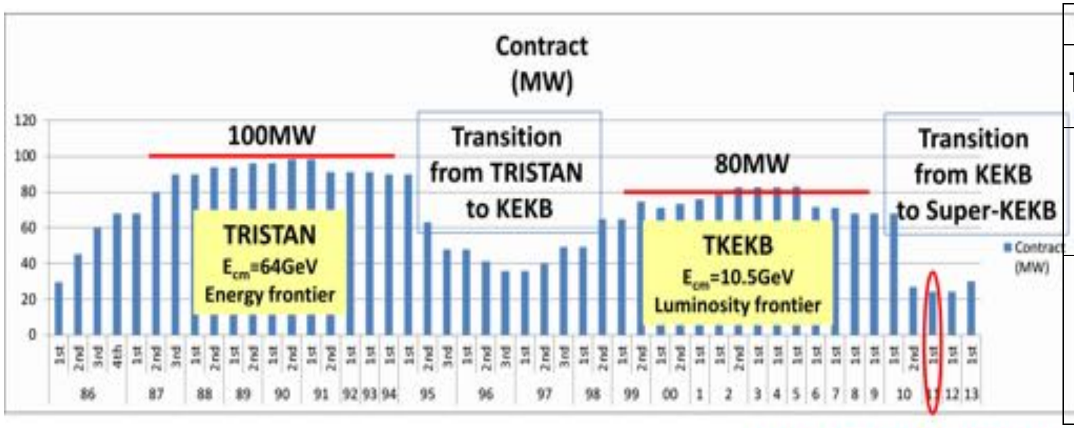
Breakdown of Global GHG Emissions.
This data shows that it is necessary to evaluate CO_2 emissions over the life cycle of an accelerator facility, not just over its operational period.

Our World in Data based on Climate Analysis Indicators Tool (CAIT) 2019 (Adapted)

Presentation by Suzanne Evans of ARUP, WSFA2023 in Morioka

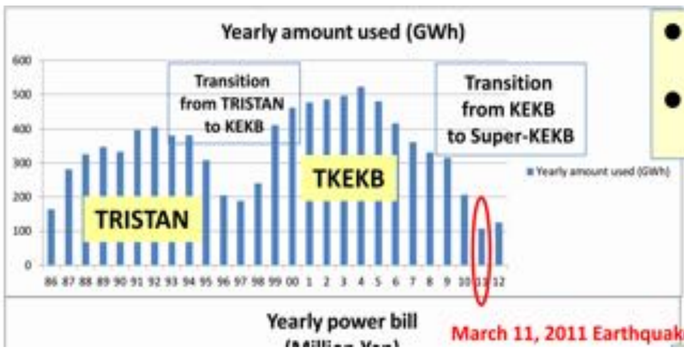


- Accelerators are electric power-loading facilities and their construction uses a lot of concrete and steal.
- Reducing life-cycle global GHG emissions from construction to decommissioning of accelerator facilities is an important issue.



	Peak (MW)	TWh/year	Feature
TRISTAN	100MW	0.4	Energy Frontier 64 GeV in 1986
KEKB	80MW	0.5	Luminosity Frontier (Factory Machine at 10.5 GeV) 2.11 E34 /cm ^{2}/s in 2009
ILC	130MW	0.7	Energy and Luminosity Frontier 250 GeV (Higgs Factory) 2.7 E34 /cm 2/s with 5 Hz operation and pol. e^-

March 11, 2011 Earthquake



- Contract (Peak Power Demand): TRISTAN = 1.15 KEKB
- Yearly amount usage: TRISTAN = 0.8 KEKB

- The table above shows how energy-efficient the ILC is.
- Super-KEKB, currently in operation at KEK, is also an eco-friendly design (nanobeam scheme) and achieves twice the luminosity at half the current of KEKB.

- These figures show data from when I was in charge of power contracts at KEK during TRISTAN and KEKB operation.
- In a large accelerator facility, the contracted power is in the 100MW class, and the annual power consumption exceeds 0.5TWh/year.
- In the case of the ILC, the contracted power is approximately 130 MW, and the annual power consumption is expected to be about 0.7 TWh, depending on the operating hours.

Accelerator researchers are making following four efforts to achieve sustainable accelerator facilities (In case of Japan for 3 and 4).
All efforts are made in collaboration with industry and will eventually have to be returned to society.

① Increasing the power efficiency and performance of accelerator components.

② Electricity used by accelerators should be provided by sustainable power sources instead of fossil fuels, and effective local use of the waste heat energy emitted from the accelerator.

③ To this end, we will help to increase the amount of sustainable electricity in the region and create regional energy management business using waste heat.

④ Cooperate to increase Green Carbon (from forests), Blue Carbon (from seaweed), and White Carbon (CO_2 fixation by increasing wooden buildings) in the region to increase CO_2 absorption.

1. Prologue: Global Warming, ILC Timeline & Features, Sustainable Accelerator Facility

2. The International Workshop on Sustainability in Future Accelerators in Morioka, Iwate

3. Epilogue: ILC and GX create new technologies and give back to society

- Green ILC work should be conducted under international collaboration.
- A compact international workshop with 57 participants (35 from Japan and 22 from overseas) held in Morioka, Japan, for three days from September 25, 2023, played an important role in understanding the current situation and creating a vision for the future.
- I will show here some of the highlights of this workshop and a few of Japan's policies and contributions.

Workshop Highlights

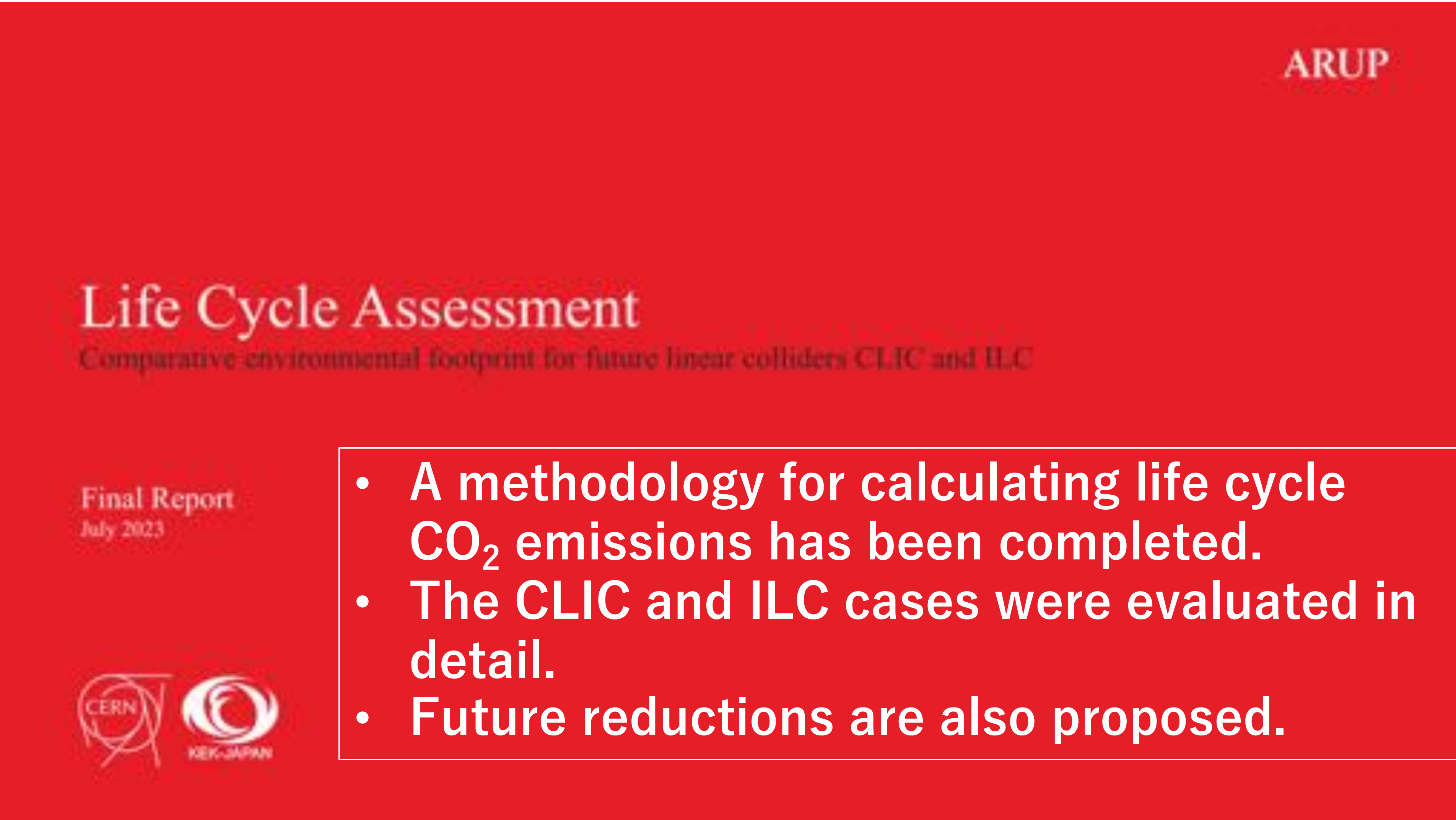
1. According to Suzanne Evans of ARUP, CO_2 emissions during ILC construction will be 250 kilotons.

2. According to Steiner Stapnes of CERN, the CERN electricity future plan in 2050 is 50% nuclear (5 g/kWh CO_2 emissions) and 50% renewable (20 g/kWh CO_2 emissions) => total: 12.5 g/kWh => 1 TWh/year = 12.5 kilotons of CO_2 emissions.

3. I could get global perspectives inspired by Anders Sunesson (ESS) and Steiner Stapnes (CERN)
   1. Nordic countries already meet 2050 EU Targets
   2. Electricity and CO_2 emissions around the world

5. Japan is an island nation, so it is necessary to create its own closed scenario. Therefore, Japan and EU have very different scenarios for achieving carbon neutrality.
   - ➢ Japan reduces fossil fuel use but cannot reduce to zero, so it offsets by increasing CO_2 absorption by forests (Green Carbon) and seaweed (Blue Carbon) and CO_2 fixation by constructing wooden buildings (White Carbon)
   - ➢ Japan is blessed with renewable biomass and also is working on low-carbon technologies in concrete and steel making by indistries.

According to Suzanne Evans of ARUP, CO_2 emissions during ILC construction will be 250 kilotons.



- **A methodology for calculating life cycle CO_2 emissions has been completed.**
- **The CLIC and ILC cases were evaluated in detail.**
- **Future reductions are also proposed.**

Contents

Authors: Suzanne Evans, Ben Castle
Contributors: Yung Loo, Heleni Pantelidou, Jin Sasaki, Fragkoulis Kanavaris

ARUP

Executive summary

Approach

This report evaluates the Life Cycle Assessment (LCA) of the construction of the Compact Linear Collider (CLIC) and the International Linear Collider (ILC). This study has considered the underground facilities construction, covering tunnels, caverns and access shafts only, for the following configuration options:

1. **CLIC Drive Beam**, 5.6m internal diameter, Geneva (380GeV, 1.5TeV and 3TeV)
2. **CLIC Klystron**, 10m internal diameter, Geneva (380GeV)
3. **ILC**, arched 9.5m span, Tohoku Region Japan (250GeV)

The LCA follows the ISO 14040/44 methodology and was carried out using Simapro 9.4.0.2. The ReCiPe Midpoint (H) 2016 method was used to estimate the environmental impacts across 18 impact categories.

A1-A5 Global Warming Potential (GWP) hotspots have been evaluated and possible reduction opportunities have been identified.

The approach and evaluation has been undertaken in close collaboration with CLIC and ILC teams from CERN and KEK.

A1-A5 Outcomes

A1-A5 considers material, transport and construction environmental impacts only. The A1-A5 GWP (tCO_2e) values are detailed below and constitute a baseline GWP for the current design of the CLIC and ILC.

CLIC Klystron 380GeV and ILC 250GeV have similar A1-A5 GWP of approximately 0.3 $MtCO_2e$. The CLIC Klystron 380GeV has approximately 2 times the A1-A5 GWP than CLIC Drive Beam 380GeV which is due to the increase in cross section of the main linear accelerator tunnel and the shielding wall. The increase in GWP across the 3 CLIC Drive Beam build stages is a direct function of the increase in tunnel length per increased energy levels.

The options have been evaluated as tunnels, shafts and caverns. The tunnels is the largest A1-A5 GWP contributor across all CLIC and ILC options.

Recommendations

There is an opportunity for material and design optimisation; this includes but is not limited to:

- Consider the use of low carbon concrete technologies
- Reduce the precast concrete segmental lining thickness for CLIC Drive Beam and Klystron options as this can have a significant impact on embodied carbon reduction of the tunnels.
- Replace the shielding wall in CLIC Klystron and ILC with concrete casing and earthworks fill, repurposed from tunnel excavation. This is to be confirmed with CERN and KEK upon shielding wall requirements for experiments.

These reduction opportunities demonstrate a possible **40% embodied carbon reduction for CLIC and ILC, in line with the** UN Breakthrough Outcomes for 2030.

In addition, consider the steel manufacturing process as well as SFRC alternatives such as plant fibres and recycled tyre steel fibres that are lower cost and environmental impact. More generally, consider partnering with suppliers that are committed to low carbon solutions.

It is recommended to adopt carbon management principles in accordance with PAS2080:2023 to maximise the carbon reduction potential in the development of these projects and integrate carbon reduction into decision-making driving design, construction and operation of the colliders.

Linear colliders

Sustainability studies for LCs
Life Cycle Assessments

Steinar Stapnes

EAJADE WP4: Morioka 27.9.2023

Sustainability during operation

- Operation costs dominated by energy (and personnel, not discussed in the following)
- Reducing power use, and costs of power, will be crucial. Other consumables (gas, liquids, travels …) during operation need to be well justified. Align to future energy markets, green and more renewables, make sure we can be flexible customer and deal with grid stability/quality.
- Carbon footprint related to energy source, relatively low already for CERN (helped by nuclear power), expected to become significantly lower towards 2050 when future accelerators are foreseen to become operational (in Europe, US and Japan).
- Provided we can run on green mixtures (PPA example at CERN, also (hopefully) built fully into the green ILC concept) we can also contractually chose green options. LCs are very suited for this (variable power load).

A rough estimate, assuming ~50% nuclear and ~50% renewables (as wind/sun/hydro):

1 TWh annually equals ~12.5 ktons CO2 equiv. annually

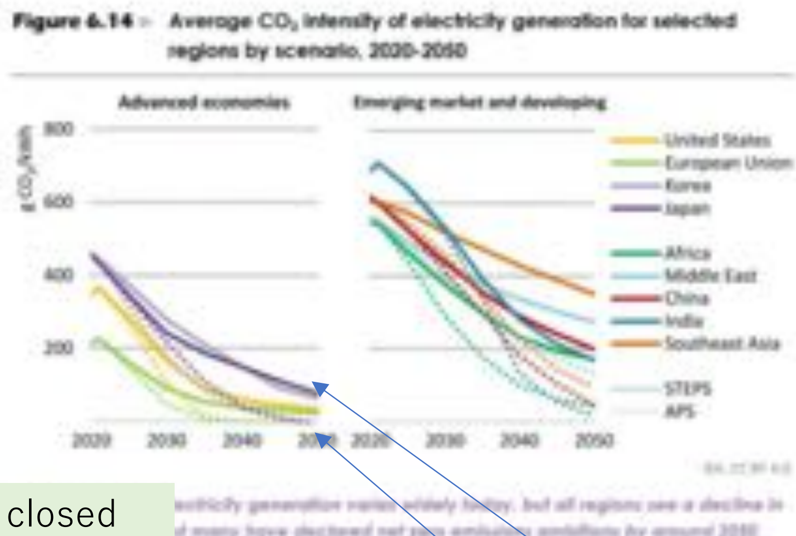
(note: this is factor ~3 below the current French summer month average)

ACCELERATOR

From energy to CO2 – in 2040-50

From: https://app.electricitymaps.com/zone/FR

Contains also g/kWh per source



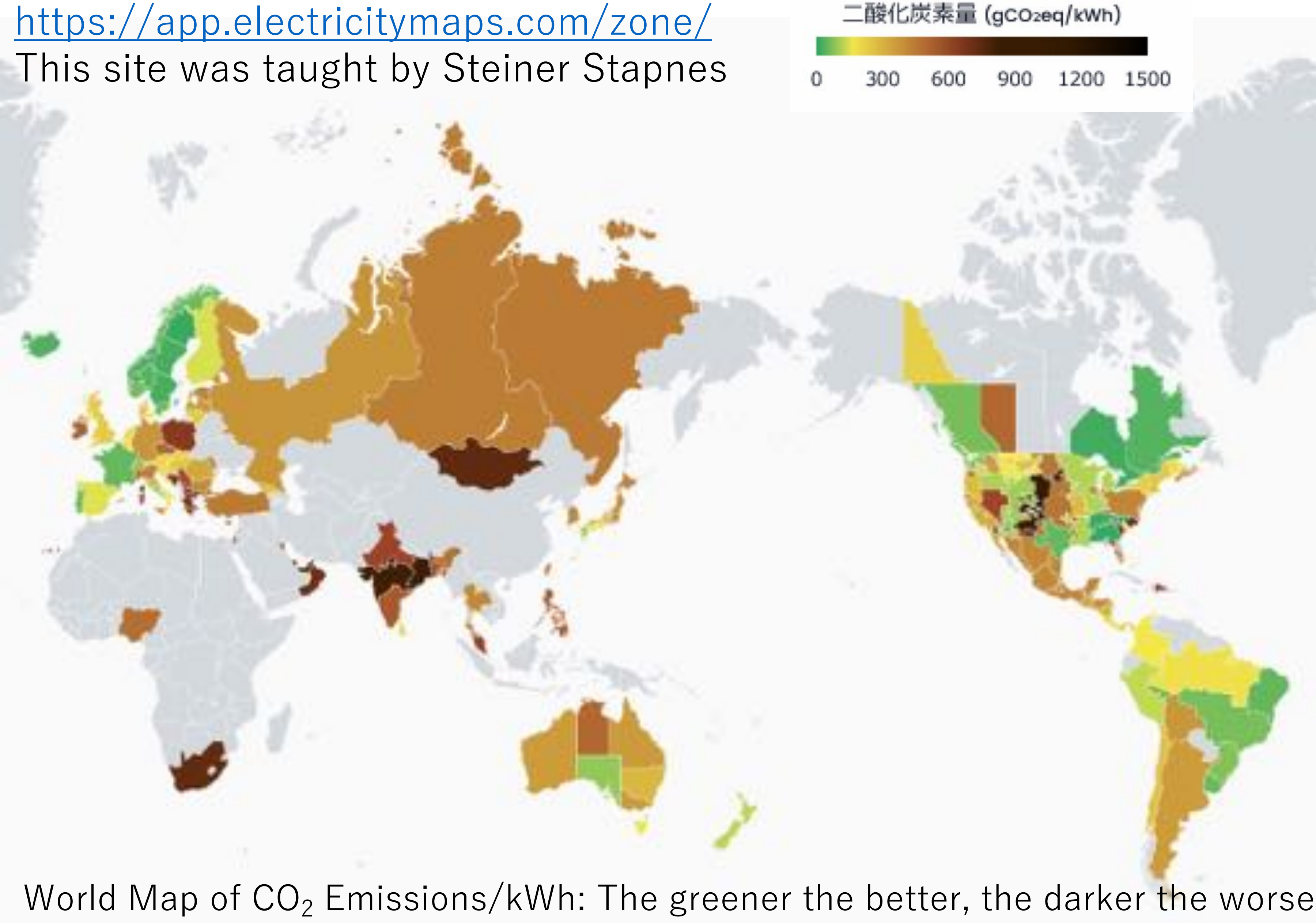
- Japan is an island nation and must be a closed scenario in one country.
- Offset" scenario is reasonable because Japan cannot go fossil fuel free by 2050 and is rich in renewable biomass.

Steinar Stapnes 18

By 2050
Japan: 480g ⇒ 100g
EU: 220g ⇒ almost zero

https://app.electricitymaps.com/zone/

This site was taught by Steiner Stapnes

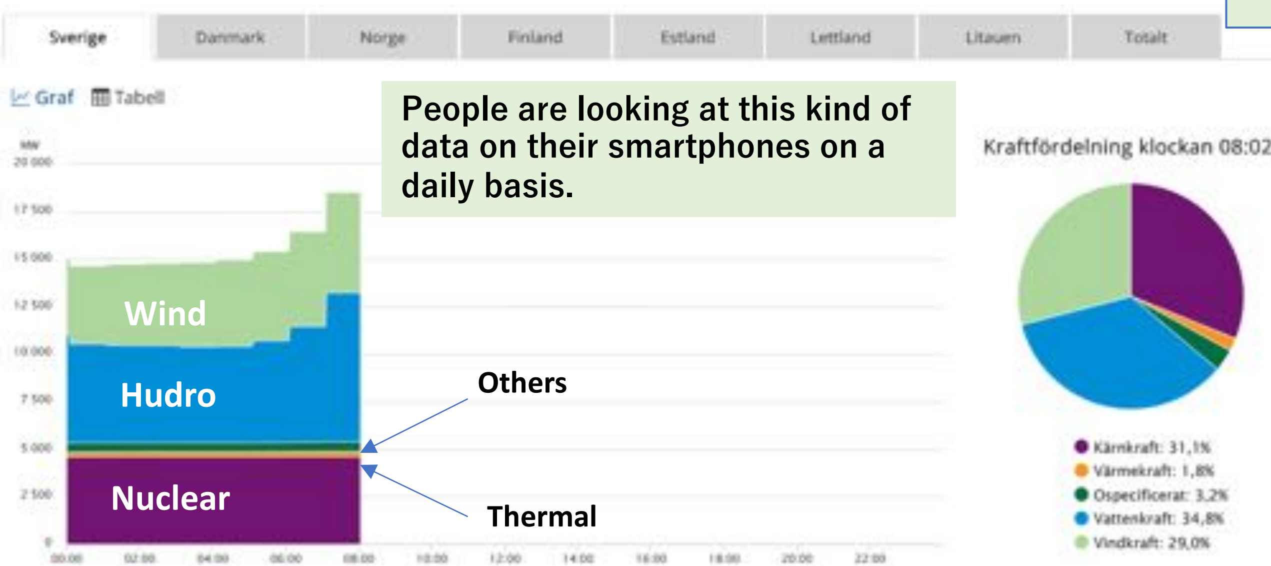


World Map of CO_2 Emissions/kWh: The greener the better, the darker the worse
Data not AVAILABLE for gray countries or regions

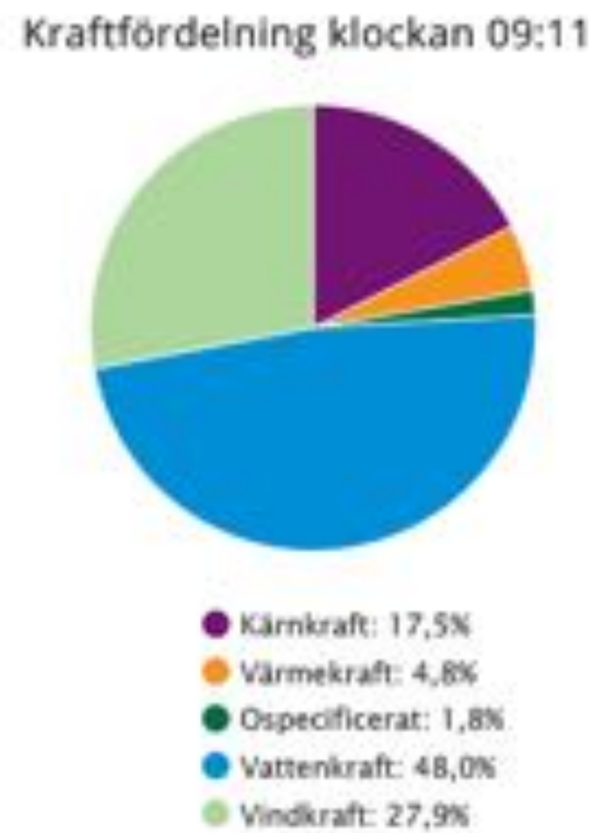
- I spoke with Anders Sunesson (ESS Institute) from Sweden.
- Sweden and Europe have liberalized their electricity markets and electricity is traded under free competition.
- Electricity networks are interconnected and power is transmitted and distributed across borders.
- The objective of the electricity market is to use integrated resources as efficiently as possible to meet the demands of electricity users.
- The public can view the following electricity statuses at any time in real time (https://www.svk.se/om-kraftsystemet/kontrollrummet/)

- This screenshot shows the situation in Sweden at 8:02, October 4. You can switch between the 7 countries.
- The lower figure shows the power flow in the seven countries.
- In Sweden, nuclear power is the base power source, hydro and wind power fluctuate according to demand.
- Hydro and thermal power adjust the overall power balance.
- Denmark: 90% wind power.
- Norway : 90% hydro.
- Finland: 51% nuclear.
- Electricity mix varies by country

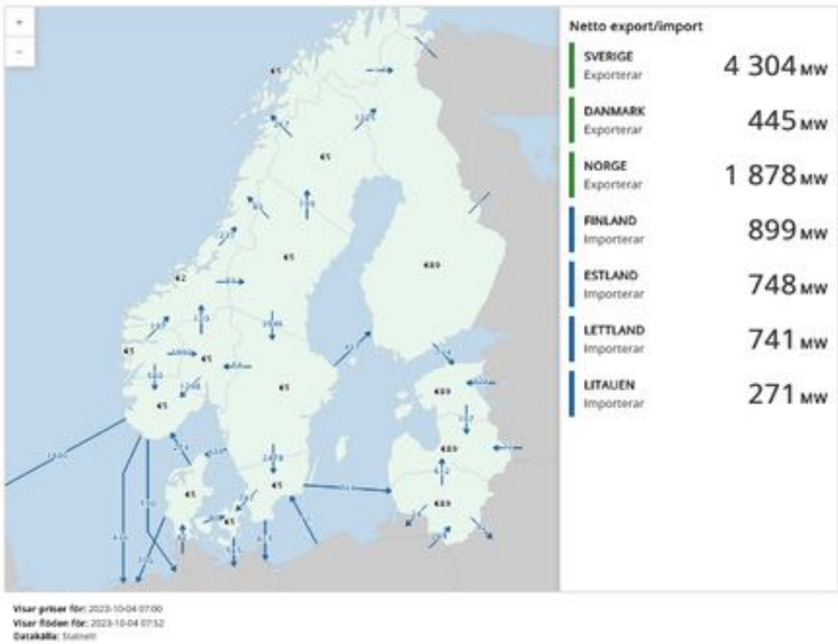
As demand for electricity increases in the morning, wind and hydroelectric power generation is increased.



People are looking at this kind of data on their smartphones on a daily basis.

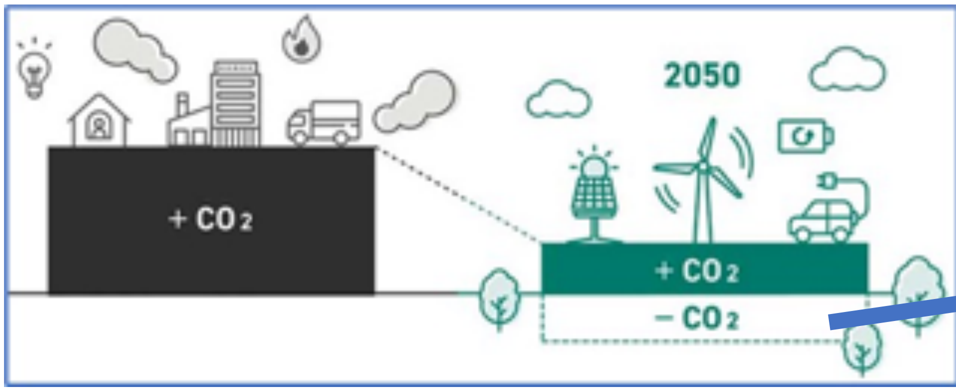


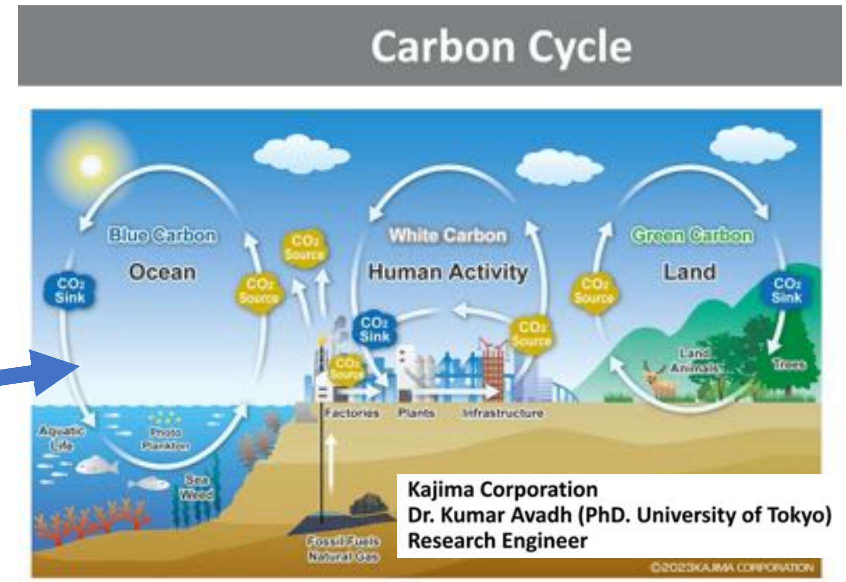
- The total for the seven countries (left graph) is
  (1) hydro,
  (2) wind,
  (3) nuclear,
  (4) thermal, and
  (5) other, in descending order.
- Thermal power is less than 5%.
- Renewable energy 75.9%, nuclear 17.5
- **Nordic countries are a good model for achieving carbon neutrality in 2050**



Finally, here are some contributions of Japanese companies to the Green ILC

Again, Japan's strategy is to reduce CO_2 emissions while simultaneously increasing and ultimately offsetting CO_2 absorption



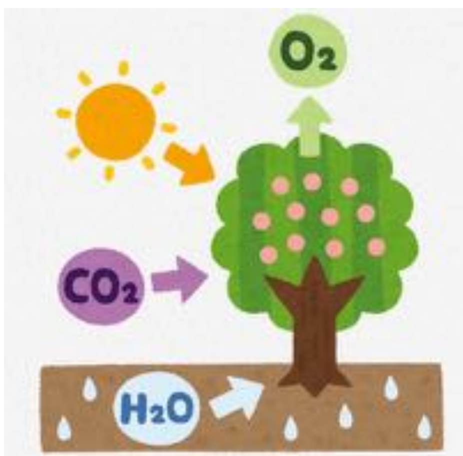


Contributions

- Green Carbon
  - ✓ H. Kikuchi, Ichinoseki City: Estimation of CO_2 absorption by forest
  - ✓ Shibata Sangyo Inc.: Sustainable forestry
- Blue Carbon: Yoshioka, Experience by Hirono-town
- White Carbon: Shelter Inc.: Large scale wooden buildings
- Negative CO_2 emission cement development: Kajima Corporation
- Waste heat utilization business using HASClay: HKK Inc.

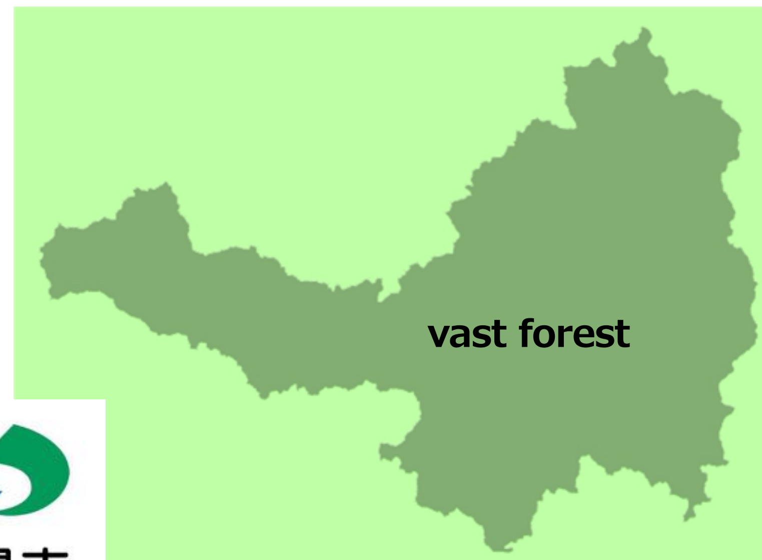
Ichinoseki City Regional Forest Policy Advisor
HIROSHI　KIKUCHI

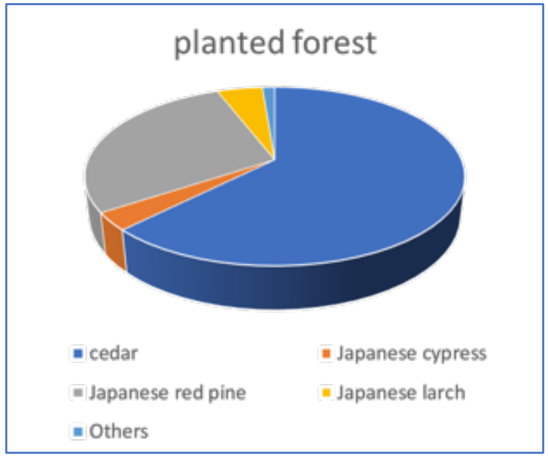
About CO_2 absorption in Ichinoseki City’s forest resources

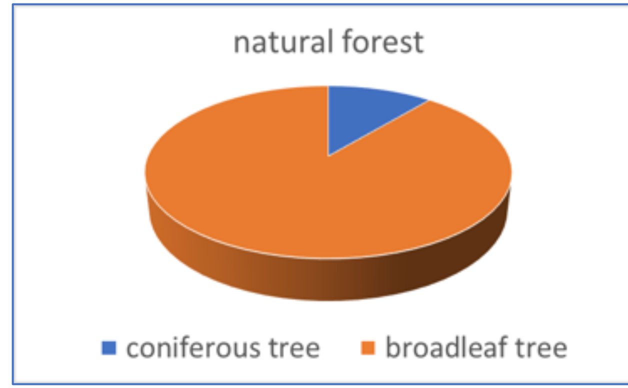


Forests are CO_2 sinks

一関市







47% Planted Forest: 31465 ha
53% Natural Forest: 34895 ha
Total 66363 ha

In planted forests, cedar is the most abundant species, followed by red pine.

Natural forests are mostly broadleaf tree.

Estimation by Hiroshi Kikuchi-san, advisor to the Ichinoseki City Agricultural Land and Forestry Department:

- The entire Ichinoseki forest absorbs 303.53 kilotons of CO_2 per year.
- The average annual CO_2 absorption per unit area is 4.57 t/year/ha.
- Japan's Forestry Agency estimates that an ideally managed artificial cedar forest can absorb 8.8 t CO_2 per hectare each year. Ichinoseki forest management has room for improvement.

- This amount, 303.53 kilotons of CO_2 per year is already sufficient to cover the total emissions of the ILC by the CO_2 emission factor, which should be so around 2040.
- Of course, it is necessary to consider the CO_2 balance of Ichinoseki City as a whole.
- Therefore, it is important to try to further reduce emissions and increase absorption.

Sustainable Forestry in the Tohoku region

~GREEN ILC IWATE~

September 26, 2023
WSFA2023@Morioka

Our Business

Tree planting Logging	Transportation	Wood fuel production	Sawing processing	construction
				

Kimiya Shibata
SHIBATA INDUSTRY CO., Ltd.
Ichinohe Town in northern Iwate Prefecture

President Shibata is on a business trip to Austria, so I will make the presentation on his behalf.

Action goals of our Shibata Sangyo members

- Utilize the latest forestry technology
- Making this region thrive with the power of the forestry industry
- Let's create fun and happiness together!

Blue Carbon (CO_2 absorption by seaweed in coastal areas in the town of Hirono, northern Iwate Prefecture)

CO_2 absorption by seaweed is very promising because it is slightly better than that of forests.

- Creating artificial tidal pools (4m wide and 1m deep ditches, total length 17.5 km) to create a flow of fresh seawater due to the difference in tidal range, which encourages the growth of wakame (seaweed) and kelp.
- Seaweed is eventually anchored to the seafloor as flow algae.
- 3106.5 t (CO2 equivalent) certified as J Blue Credit.
- Sea urchins (very tasty) are now abundant as a byproduct.
- J Blue Credits are blue carbon credits issued and sold by JBE (Japan Business and Economy Technology Research Association).
- JBE is composed of the National Maritime, Port and Aviation Research Institute, the Sasakawa Peace Foundation, and individual university professors.

Wooden Large-scale construction for a Greener Future: Shelter Inc.'s Initiative

Shelter®

09/26/2023
Yuka Shibuya

The Challenges of Timber City

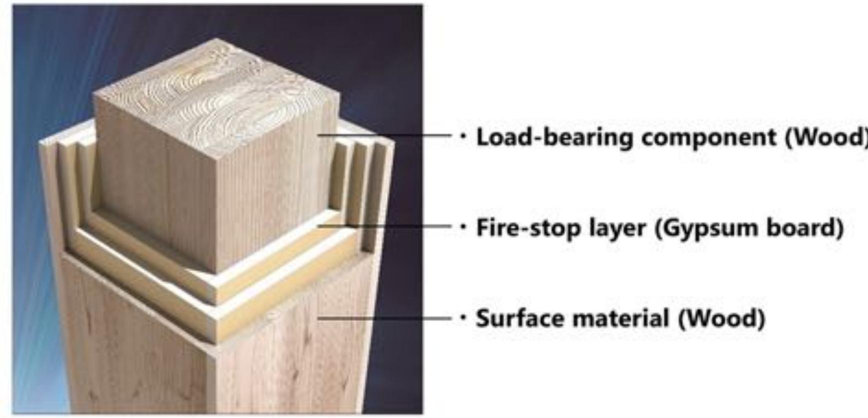
① **Seismic resistance and durability**

② **Fire resistance**

Metal Hardware Joining Method "KES System"

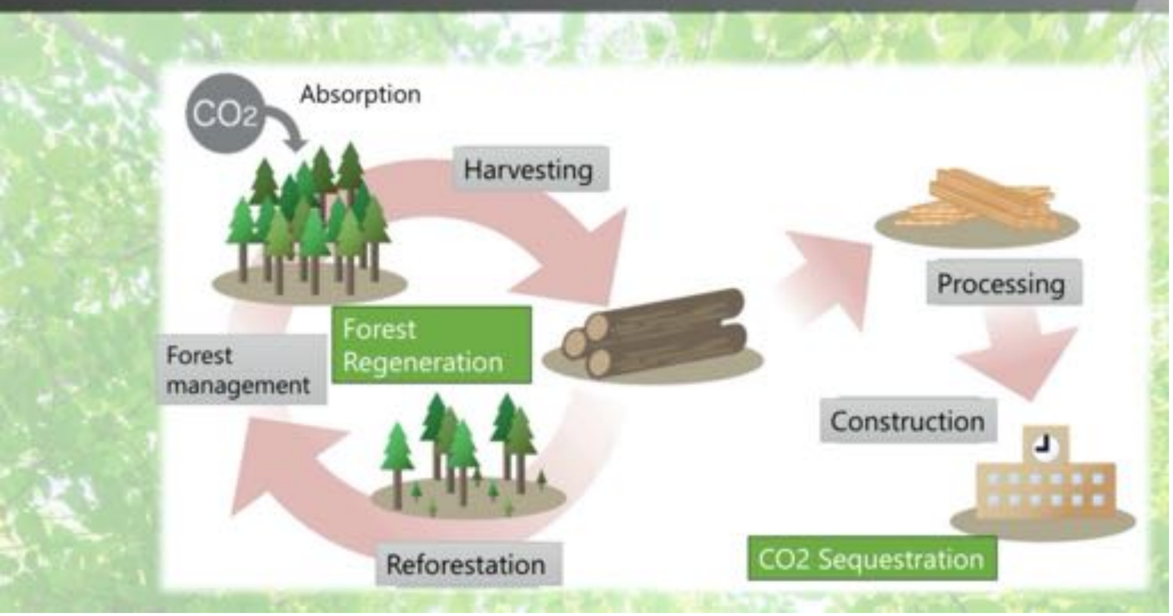
- Use of metal hardware in in the joints and connections of wooden components
- Drastic improvement in the performance of timber construction, including seismic resistance, durability, insulation, airtightness, and ease of construction.

Wooden Fireproof Components "COOL WOOD"



1-hour Fireproof COOL WOOD (Column)

Creating a Forest in the City



EAJADE Workshop on Sustainability in Future Accelerators (WSFA2023)

The Future of Construction: Carbon-Negative Concrete for a Greener Tomorrow

Kajima Corporation
Dr. Kumar Avadh (PhD. University of Tokyo)
Research Engineer

KAJIMA CORPORATION

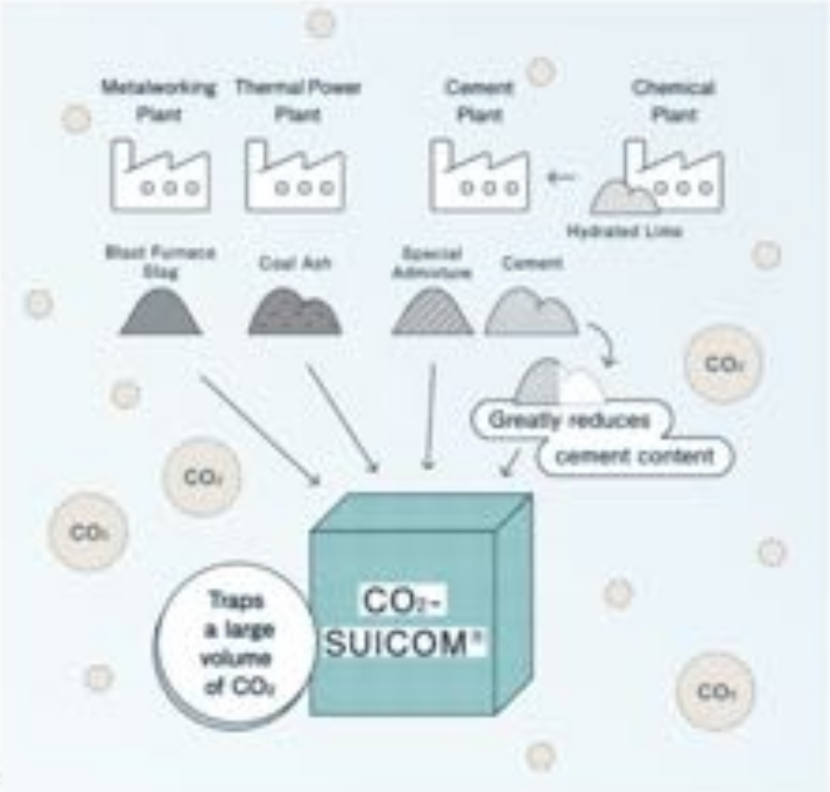
2023/9/26


Concrete: CO2 Emissions
9
Naturally Sourced
Cement
Gravel
Sand
Water
CO2 Emissions
288 kg/m3
0 kg/m3
0 kg/m3
0 kg/m3
Cement Production:
Limestone
CaCO3
Burning
1400°C
Cement
CaO + CO2
CO2= 288kg/m3
CO2 per 1m3 of concrete

CO_2-SUICOM

Storage Utilization Infrastructure by COncrete Materials

- Concrete with negative CO_2 emission in its manufacturing process
- Development started in 2008 by Kajima and 3 companies of Chugoku Electric Power, Denka, and Landes
- Available for commercial use



WSFA2023
Sustainability Session Ⅱ : Green ILC & Japanese Industry

Commercialization of Low-Grade waste heat recovery

Higashi-nihon **K**iden**K**aihatsu Co.,Ltd.(**HKK**)
Yuichi Kouno

What's HASClay ?

HASClay® is an inorganic adsorbent material composed of a composite of amorphous hydroxyl aluminum silicate (HAS) and low-crystallinity clay.

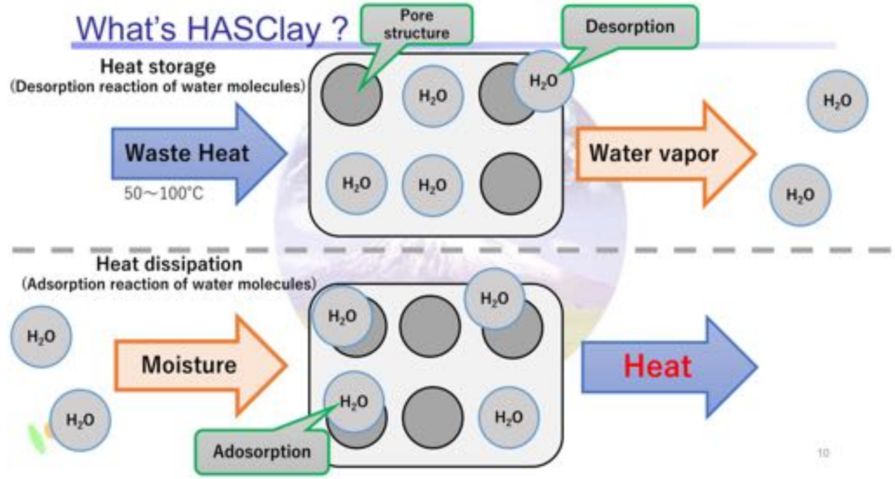
HASClay® has the ability to store heat with the principle of energy transfer by water vapor desorption.

- In particular, it has an excellent storage capacity for low-grade heat (<100 ˚C).
- It is capable of repeating the heat storage and dissipation cycle over and over again.
- By sealing the container and blocking moisture, the heat energy can be stored semi-permanently and will not ignite or deteriorate, making it safe to store.
- Off-line transport allows exhaust heat from ILC and factories to be used effectively in a wide range of fields.

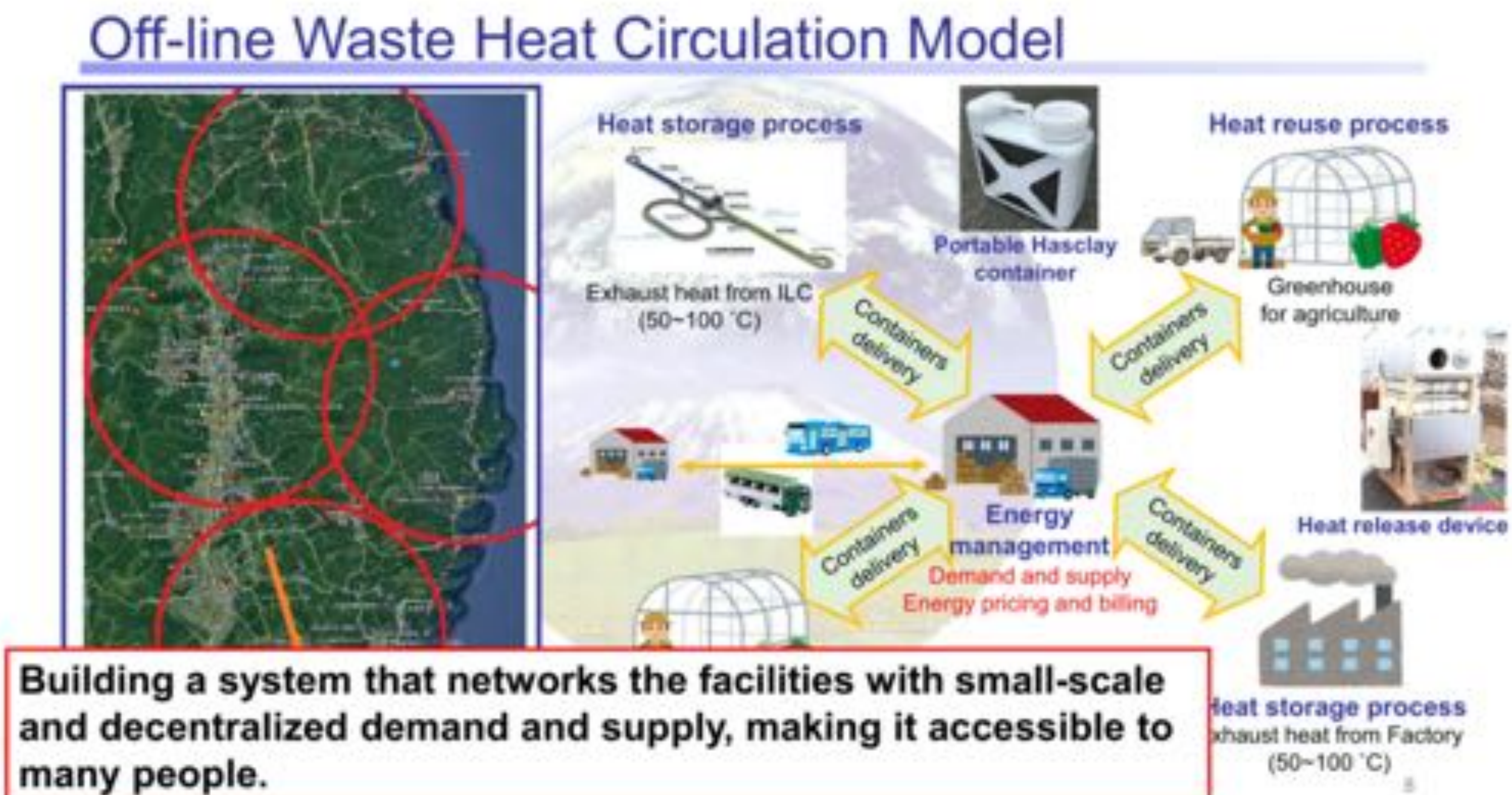
The appearance of HASClay®

Performance of various adsorbents

Adsorbent	Heat storage ability	Heat storage capacity(kJ/L)
HASclay	**40 ˚C or more**	**567**
Modified zeolite	80 ˚C or more	439

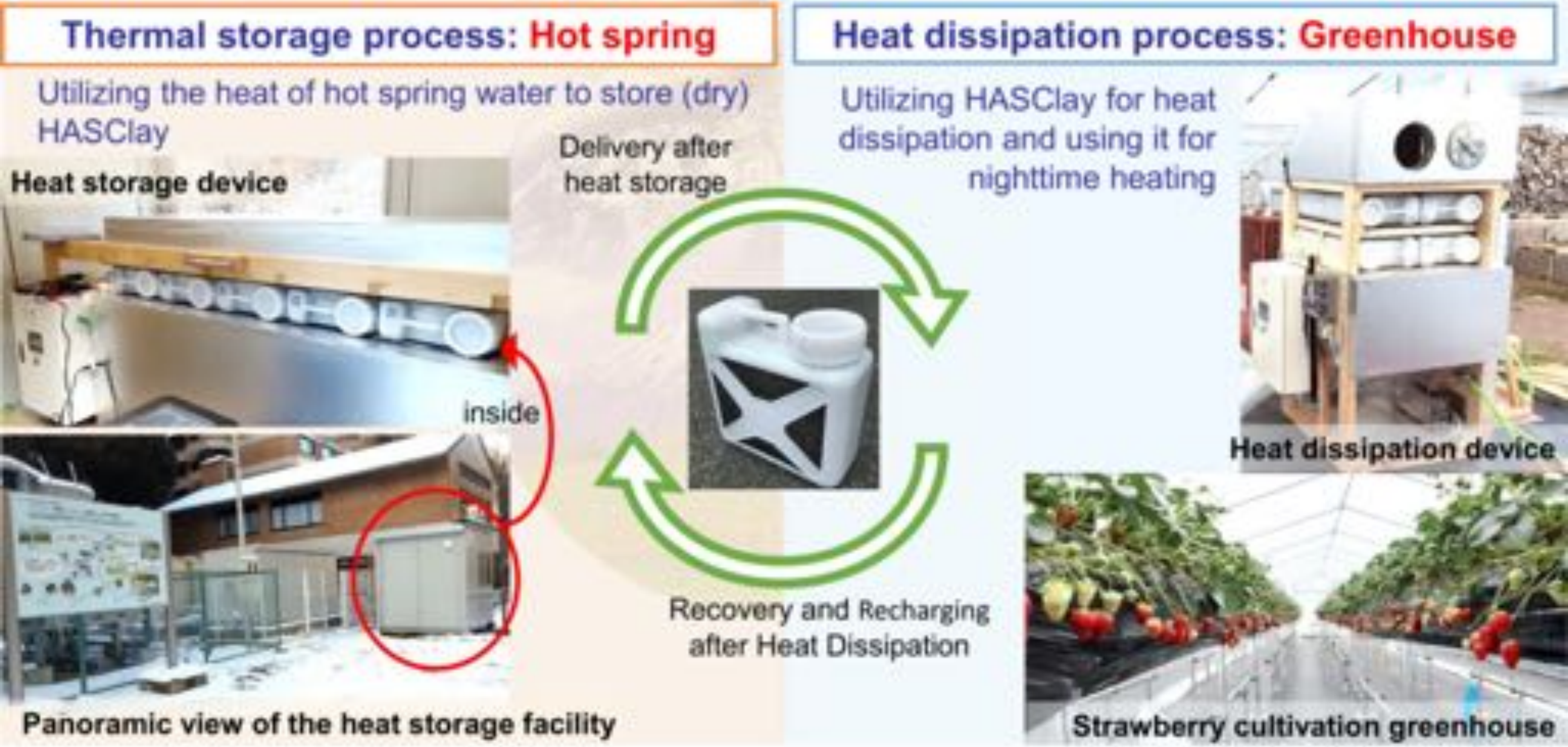


What's HASClay ?
Pore structure
Desorption
Heat storage
(Desorption reaction of water molecules)
Waste Heat
50～100°C
Water vapor
Heat dissipation
(Adsorption reaction of water molecules)
Moisture
Heat
Adosorption



Off-line Waste Heat Circulation Model
Heat storage process
Exhaust heat from ILC
(50~100 °C)
Portable Hasclay container
Heat reuse process
Greenhouse for agriculture
Containers delivery
Containers delivery
Energy management
Demand and supply
Energy pricing and billing
Containers delivery
Containers delivery
Heat release device
Heat storage process
Exhaust heat from Factory
(50~100 °C)
Building a system that networks the facilities with small-scale and decentralized demand and supply, making it accessible to many people.

Demonstration tests to achieve commercialization



Green ILC Summary

- ILC Lab (will be established in near future, hopefully) should make further effort to advance energy-saving technologies.
- On the other hand, as a region with a candidate site, we will continue our efforts to realize a sustainable society by the time construction of the "ILC in Japan" begins.
- To this end, we will make efforts to deepen cooperation between the ILC and local primary industries (agriculture, forestry, and fisheries).
- Furthermore, we will use the technology of the ILC waste heat recovery project to build a regional thermal energy circulation system.

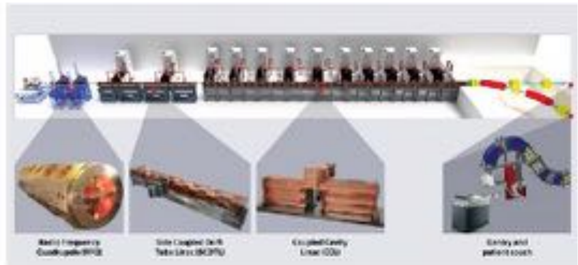
1. Prologue: Global Warming, ILC Timeline & Features, Sustainable Accelerator Facility

2. The International Workshop on Sustainability in Future Accelerators in Morioka, Iwate

3. **Epilogue: ILC and GX create new technologies and give back to society**

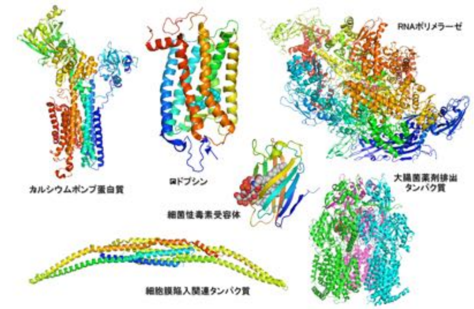
- Accelerators are the product of the synthesis of a wide field of science and technology.
- Conversely, advances in accelerator science have led to innovations in a wide range of fields of science and technology.　Followings are past examples.

Information Management Innovation WWW CERN



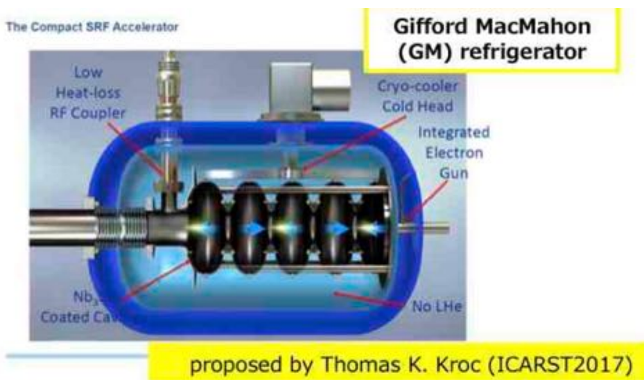
Innovative Cancer Therapy System with Linear Accelerator, CERN/ADAMS

Japan's newest synchrotron radiation facility, Nanoterasu, expected to play an active role in drug design.



Innovations in Structural Biology at Spring-8

ILC ✕ GX ⇒ Create new technologies and industries



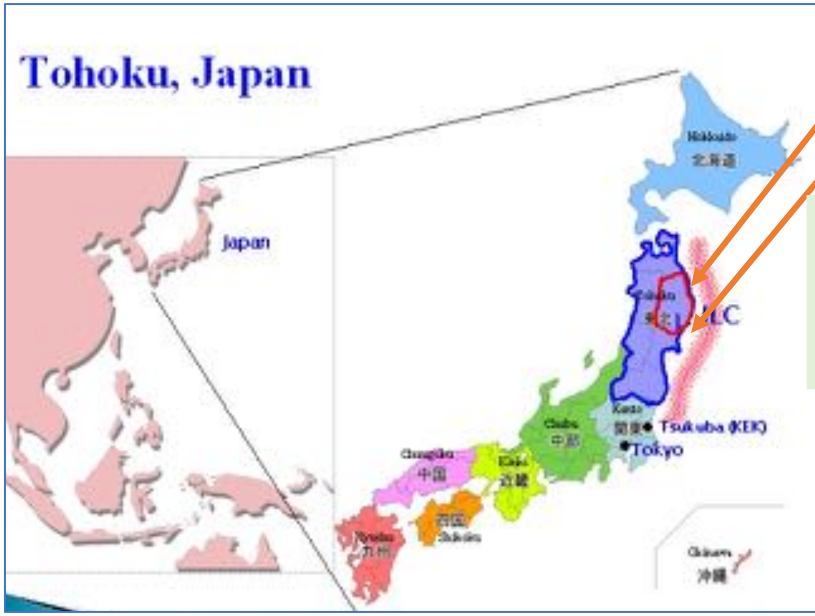
Let me give you just one example of the impact of **ILC x GX** on society.

- ILC researchers are studying the use of Nb_3Sn alloys to further improve the performance of superconducting accelerator cavities in order to improve energy efficiency at the ILC.
- If successful, a high-power compact electron linac could be realized, which would have applications in many fields such as drug discovery, environmental pollution control, and shortening the life of nuclear waste.

Overview of the ILC, its significance and impact on the region and sustainability considerations

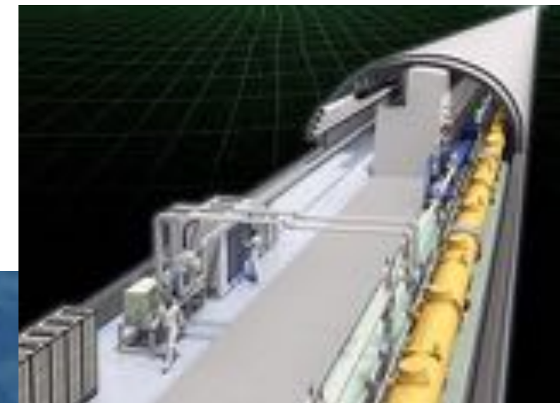
- Accelerator science is the culmination of a wide range of science and technology and is a very interesting field!
- It requires knowledge of a very broad range of fields, and I am sure that everyone's strengths can be utilized in the field of accelerator science.
- Moreover, there are many opportunities not only in high-energy physics, but also in synchrotron radiation, neutrons, medical applications, industry, and many other fields.
- In other words, it is a field where science and society are deeply connected.
- **Come and join us in the accelerator field!**

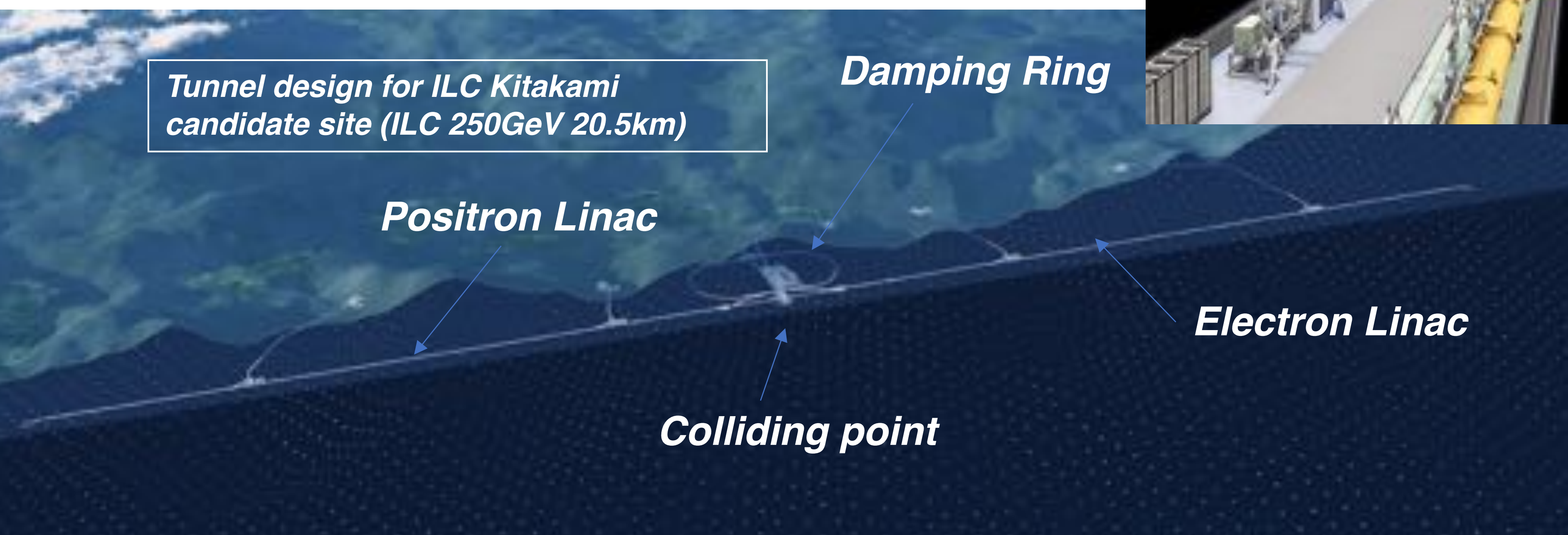
Backup



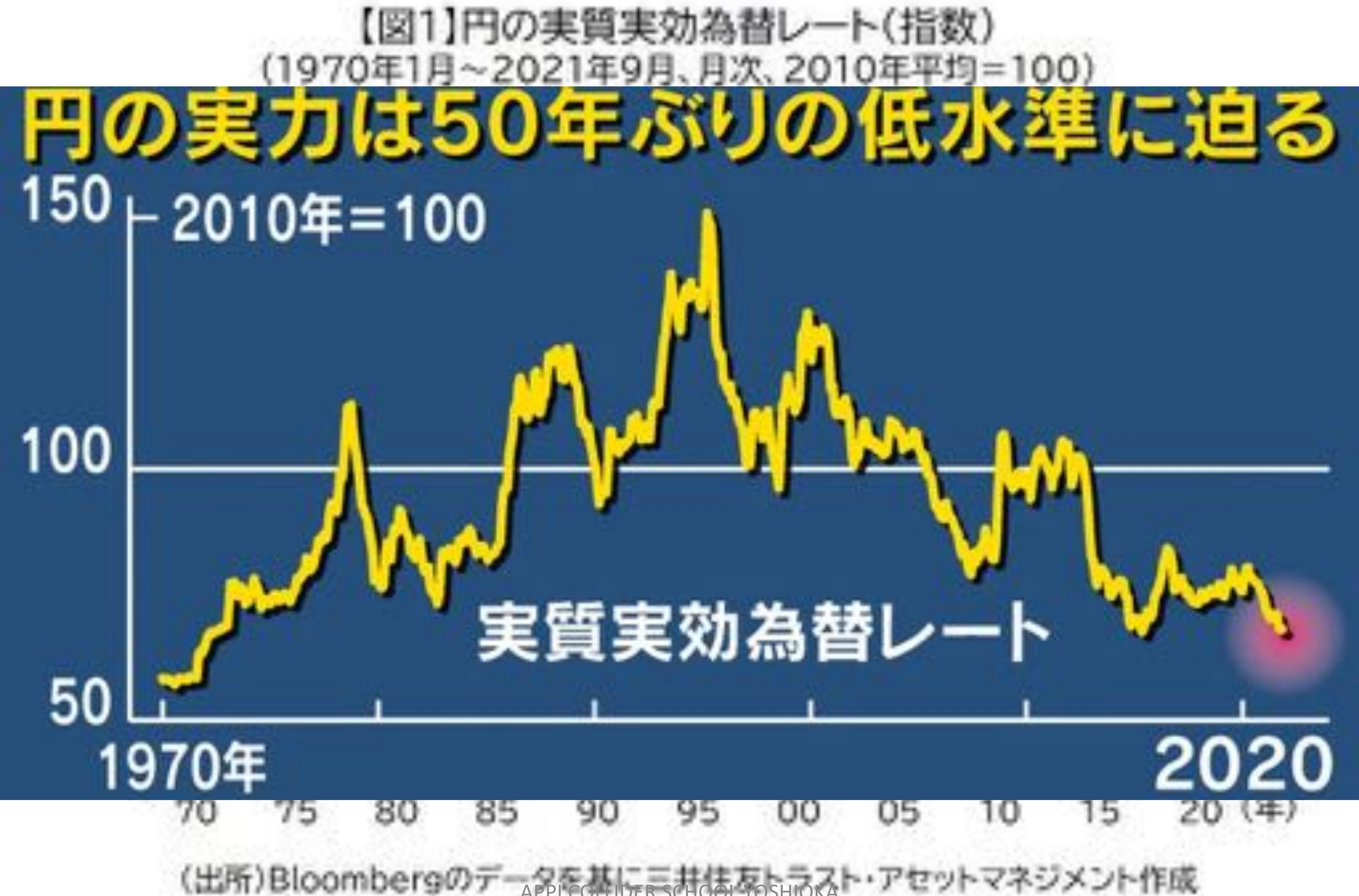
- Where is Iwate Prefecture
- Where is ILC candidate site
- What is ILC?

The ILC is an eco-friendly accelerator based on a superconducting RF technology that is power efficient and sustainable






【図1】円の実質実効為替レート（指数）
（1970年1月～2021年9月、月次、2010年平均＝100）
150
140
130
120
110
100
90
80
70
60
50
70
75
80
85
90
95
00
05
10
15
20
（年）
1973年2月
変動相場制移行
2015年6月
変動相場制移行後最安値
（出所）Bloombergのデータを基に三井住友トラスト・アセットマネジメント作成

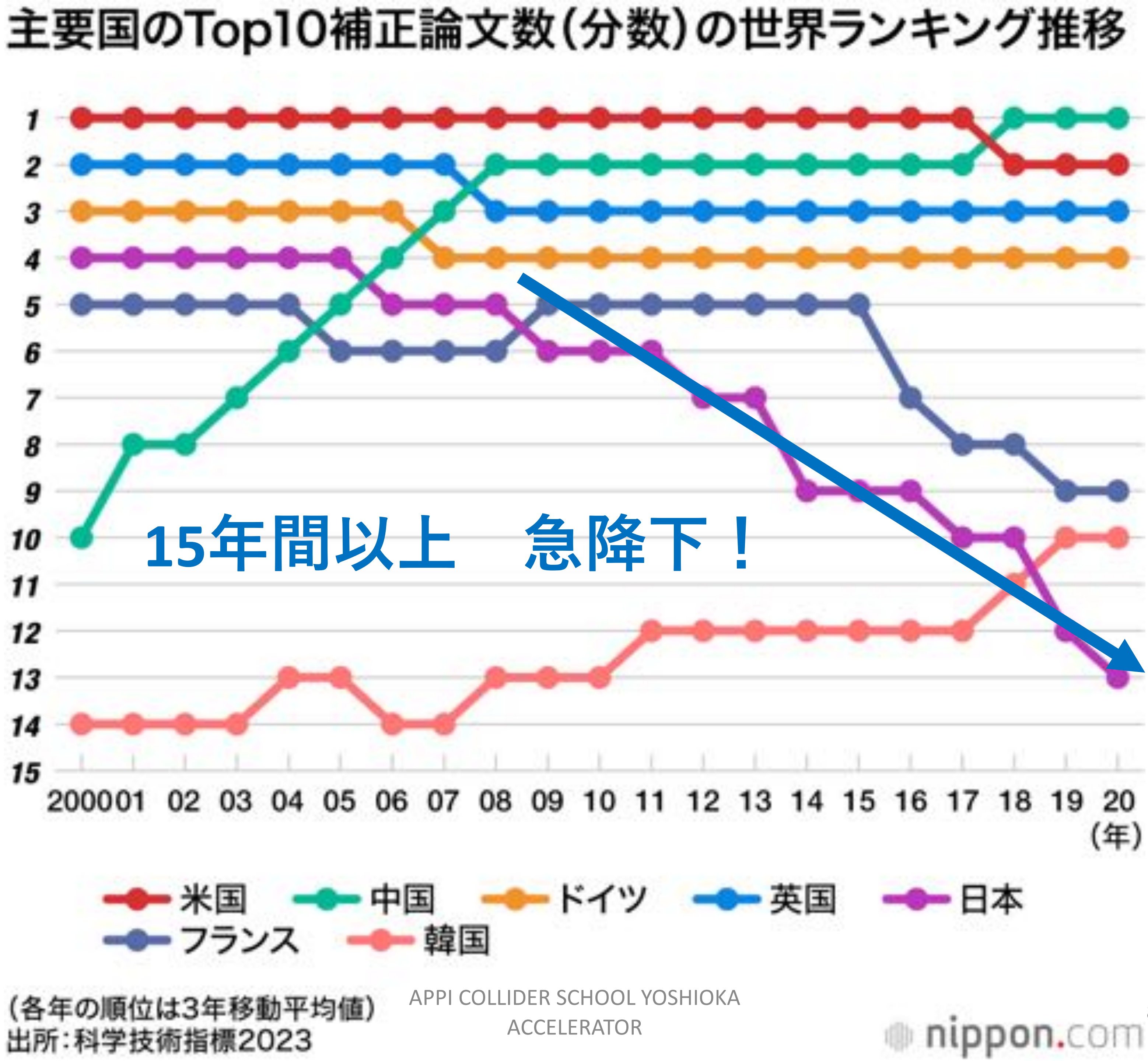


【図1】円の実質実効為替レート（指数）
（1970年1月～2021年9月、月次、2010年平均＝100）
円の実力は50年ぶりの低水準に迫る
150
2010年＝100
100
50
実質実効為替レート
1970年
2020
70
75
80
85
90
95
00
05
10
15
20（年）
（出所）Bloombergのデータを基に三井住友トラスト・アセットマネジメント作成

【図2】日米独の物価と平均賃金の推移
（1991年～2020年、年次、1991年=100として指数化）

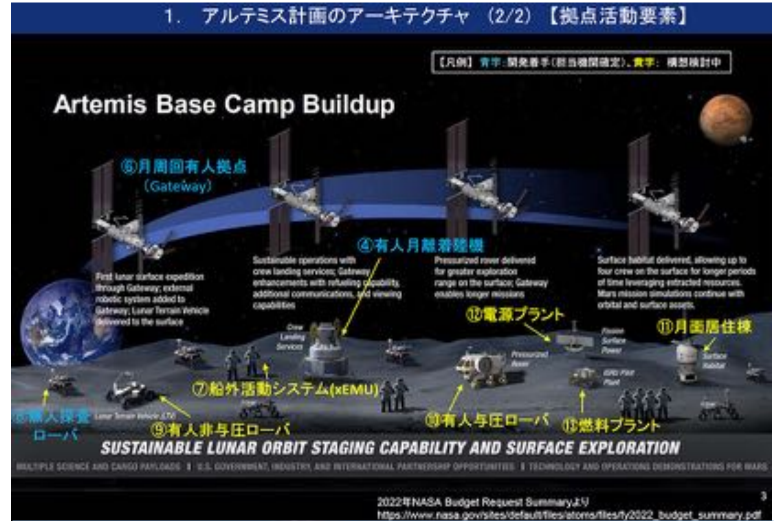
30年間！

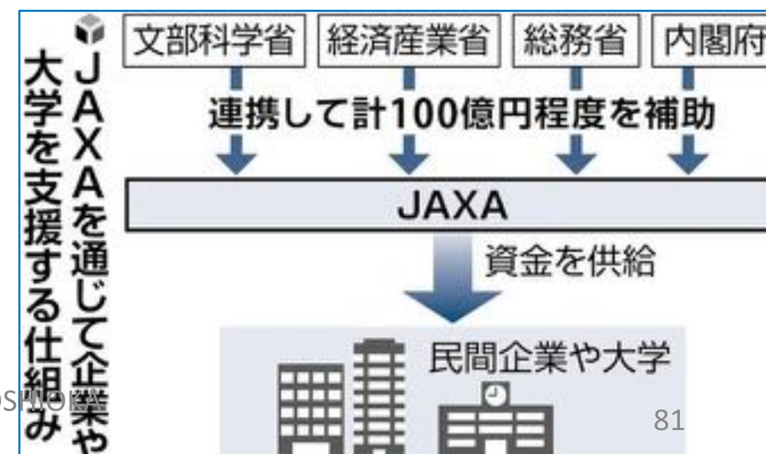
※物価：日本消費者物価指数（全国：2015年基準：年平均）、米国消費者物価指数（総合：季調済：年平均）、ドイツ消費者物価指数（2015年基準：季調前：年平均）
※平均賃金：名目平均賃金（米ドルベース：購買力平価換算：年次）
（出所）総務省、OECD、Bloombergのデータを基に三井住友トラスト・アセットマネジメント作成


主要国のTop10補正論文数(分数)の世界ランキング推移
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
200001 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20
(年)
15年間以上　急降下！
米国
中国
ドイツ
英国
日本
フランス
韓国
(各年の順位は3年移動平均値)
出所：科学技術指標2023
nippon.com

経済も学術も低迷するニッポンの基礎体力を復活しなければならない

最近の政府の梃入れ
- アルテミス計画への参入
- 半導体産業への投資
- 大学ファンド
- JAXAへの1兆円ファンド



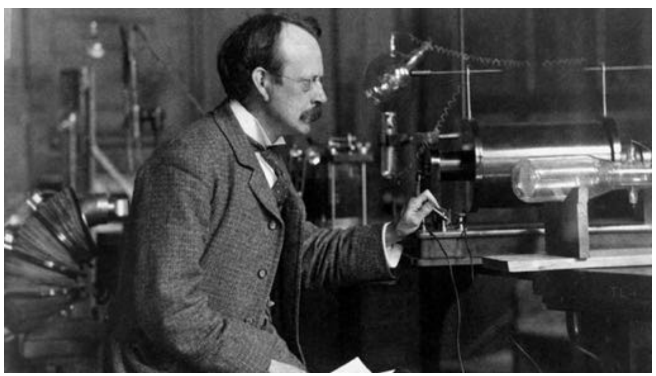


ここまでがプロローグ、これから本題

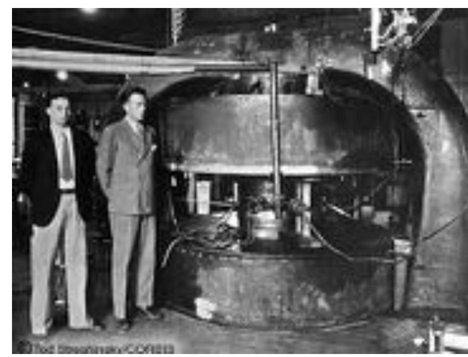
1. **少し加速器の歴史と医療応用**
2. ILCのこと
3. 大型国際研究機関の意義（CERNに学ぶ）
4. 地域はILCをどのように活かすべきか
5. グリーンILC
6. エピローグ




1895年　加速器の祖先はウイルヘルム・C・レントゲンのX線管の発明
直ちに、医療応用が世界に広がる、つまり加速器は医療応用から始まった



2年後の1897年にJ.J.トムソンが電子を発見する。
これが人類が最初に発見した「素粒子」なのです。


1931年にローレンスとリビングストンがロルフ・ビデレの線形高周波加速装置に触発されサイクロトロンを発明

75年間で4インチから27キロメートルまで進化

1931年
4 inches
ローレンス

LHC(Large Hadron Collider, 陽子・陽子衝突）
2012年にヒッグス粒子を発見
陽子は複合粒子のため、詳細スタディに向かない
電子・陽電子衝突のILCが必要

2つの大発明。
① 固定ターゲット実験から衝突型ビーム実験へ
② 超伝導技術の応用（ビーム収束、ビーム加速）

国立がん研究センター東病院の治療装置紹介

Varian Medical Systems社製 TrueBeam
主に頭頸部・前立腺の高精度照射(IMRT)と定位照射

Varian Medical Systems社製 Clinac iX
主に頭頸部・前立腺の高精度照射(IMRT)と食道・肺を治療

SIEMENS社製 ONCOR
主に乳腺を治療

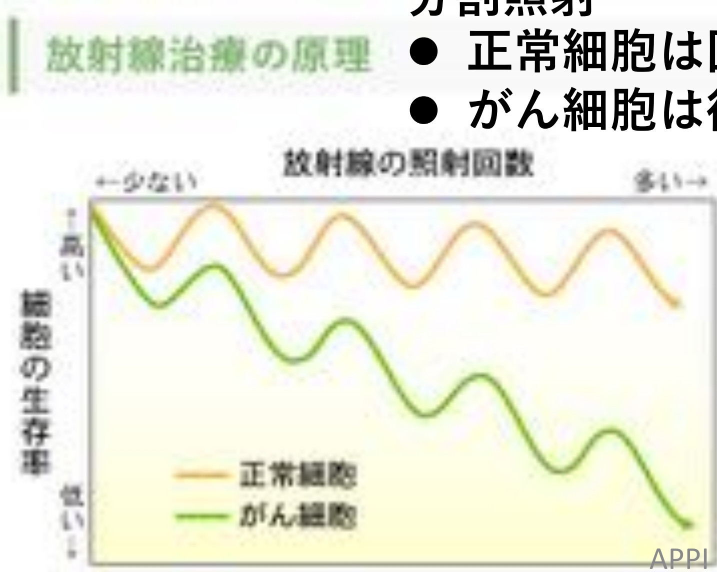
Varian Medical Systems社製 Halcyon
主に前立腺の高精度照射(IMRT)と緩和照射

がん3大治療法
① 外科
② 抗がん剤
③ 加速器
1. X線
2. 陽子線
3. 重粒子
4. 中性子

がん診断法
① CT
② MRI
③ 骨シンチグラフィ
④ PET
⑤ X線透視

- 日本人は何故か放射線治療を選択したがらない
- レントゲン写真やCTは良く受ける

分割照射
- 正常細胞は回復
- がん細胞は徐々に死



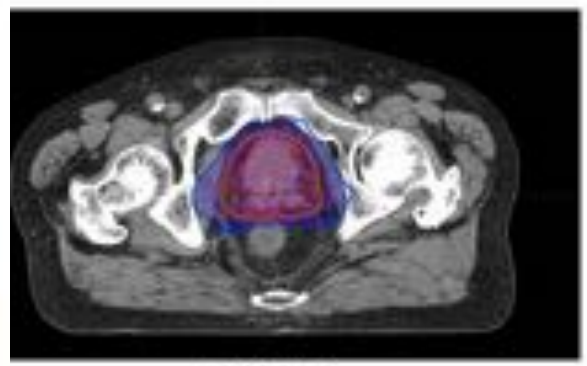
私は現在、初期の前立腺がんで内分泌療法中ですが、来春にIMRTを受ける予定です

強度変調放射線治療：IMRT（Intensity Modulated Radio Therapy）

IMRTとは、多方向から放射線の当たる量(強度)を変化をさせながら照射することで、適切な放射線の線量分布を達成することが可能となる照射方法です。これによって、標的（がん）とリスク臓器（守る必要がある臓器）が近接している症例に対し、標的への線量を担保しながらリスク臓器への線量を低減することを可能にします。

国立がん研究センター東病院では、診療放射線技師が放射線治療医とともにIMRTの治療計画を行っております。

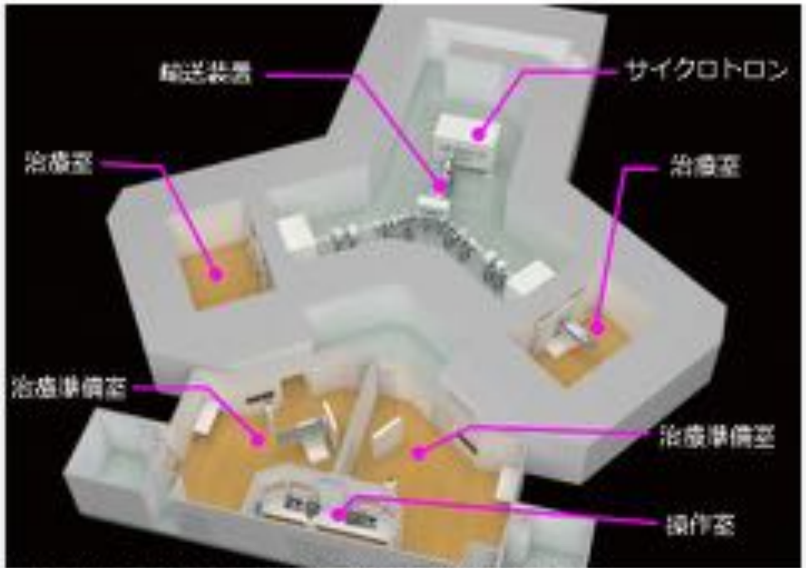
病巣の広がりに合わせた線量分布を作成することが可能



前立腺IMRT
高線量域を病巣部に集中させることが可能

郡山の総合南東北病院
陽子線がん治療施設

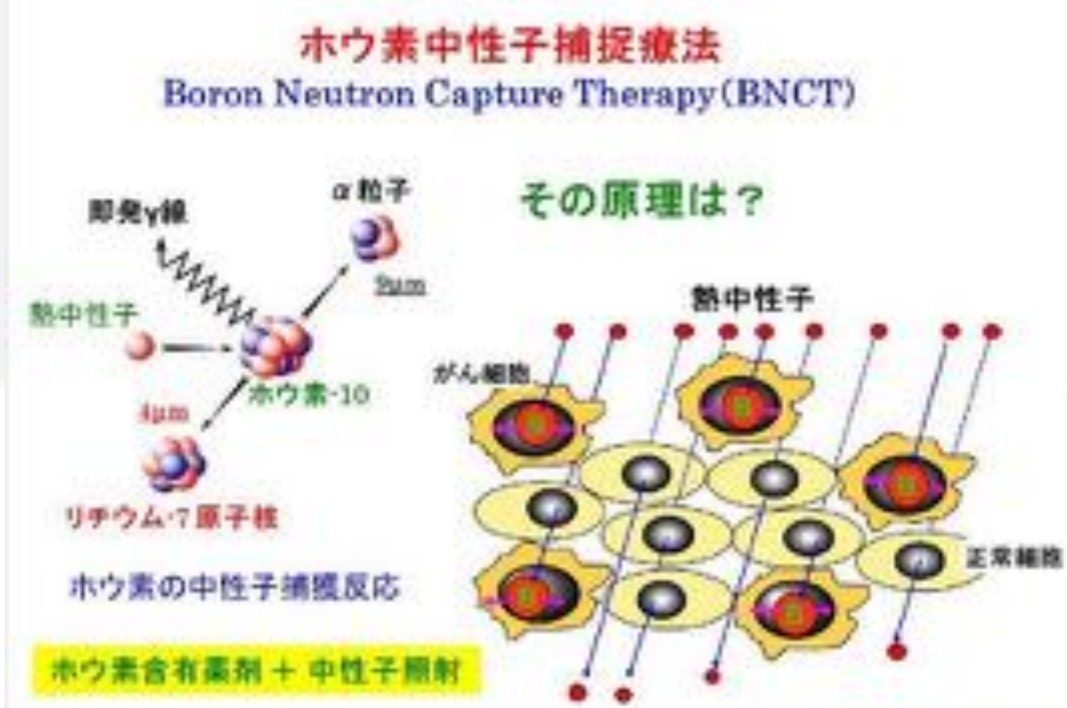
一般財団法人 脳神経疾患研究所 総合南...



南東北BNCT研究センターの地下1階治療フロアの鳥瞰3Dパース

南東北 BNCT 研究センター 陽子ビーム加速器と輸送装置

郡山の総合南東北病院
中性子線を使った新療法
BNCT（ボロン・中性子捕獲療法）



放射線療法
①X線
②陽子線
③重粒子線
④BNCT

自分がガンになったら、お医者様と相談し、症状に合わせて最適な方法を選びましょう

1. 少し加速器の歴史と医療応用
2. **ILCのこと**
3. 大型国際研究機関の意義（CERNに学ぶ）
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6. エピローグ

宇宙の誕生

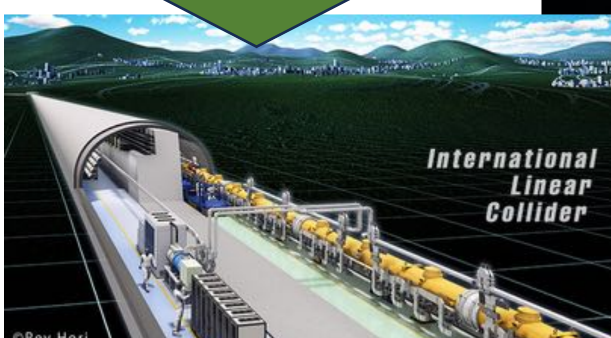
138億年前の量子揺らぎ⇒インフレーション⇒ビッグバン⇒宇宙の晴れ上がり

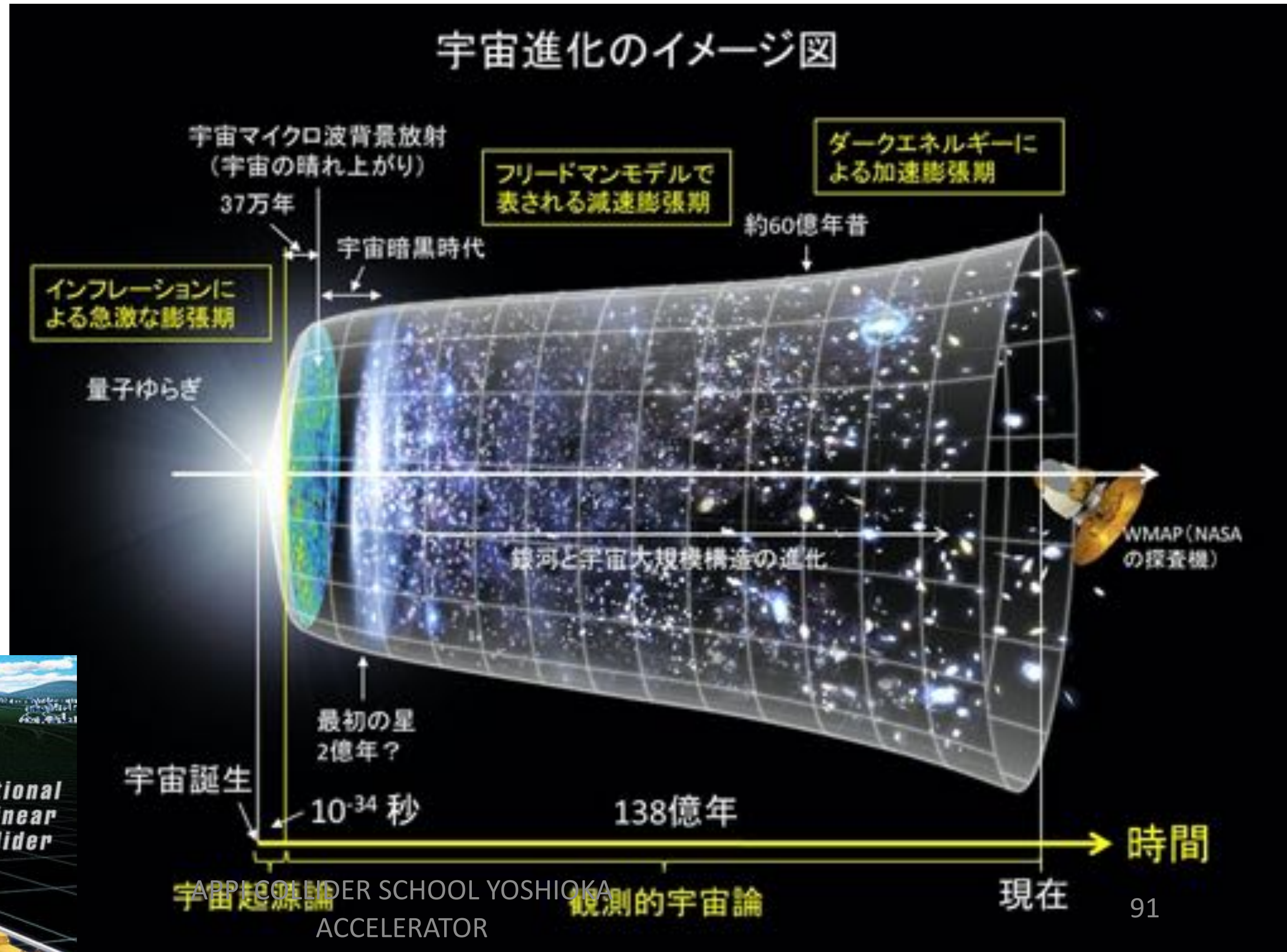
誕生から10^{-36}〜10^{-34}秒後の急膨張

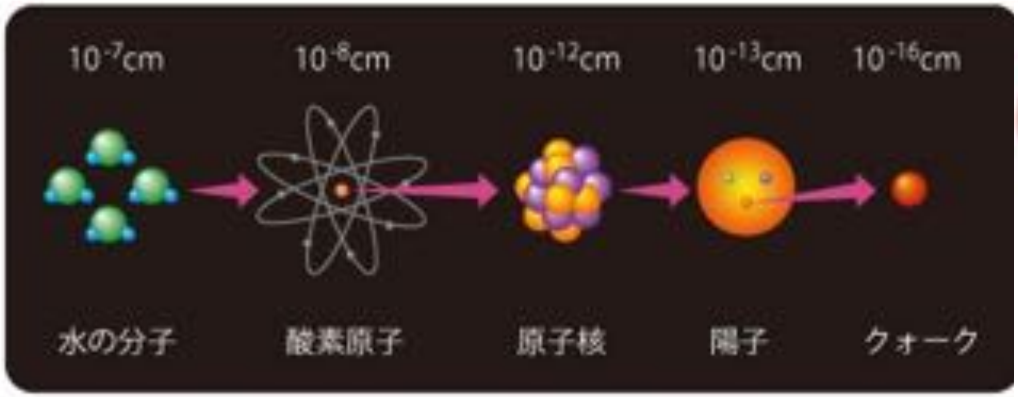
10^{-27}秒後、ビッグバンのはじまり

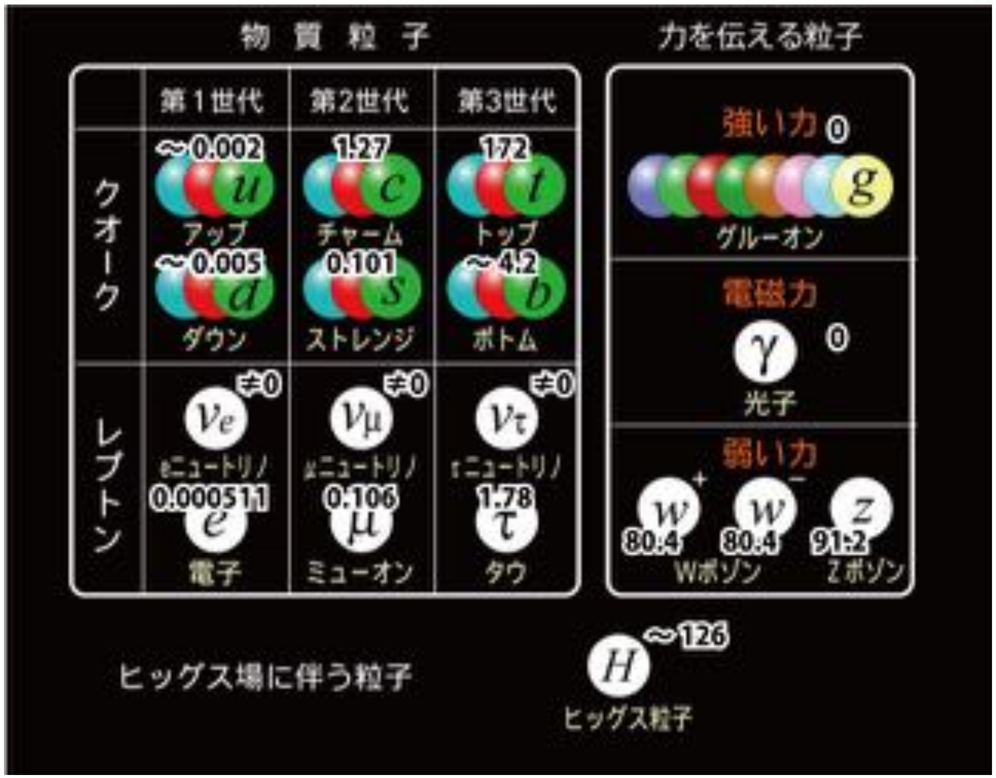
38万年後に光が直進

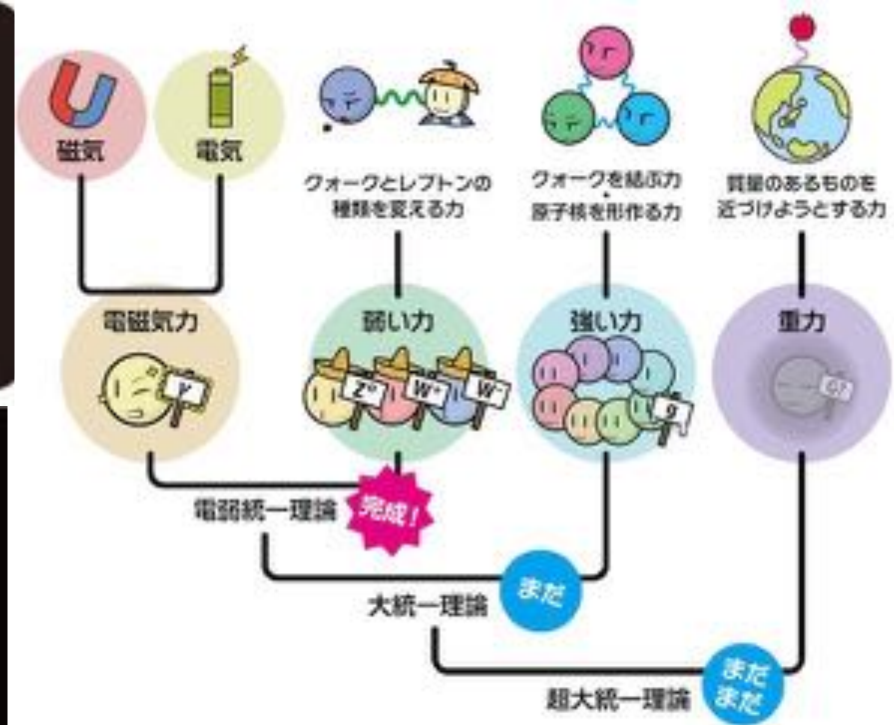
加速器による実験

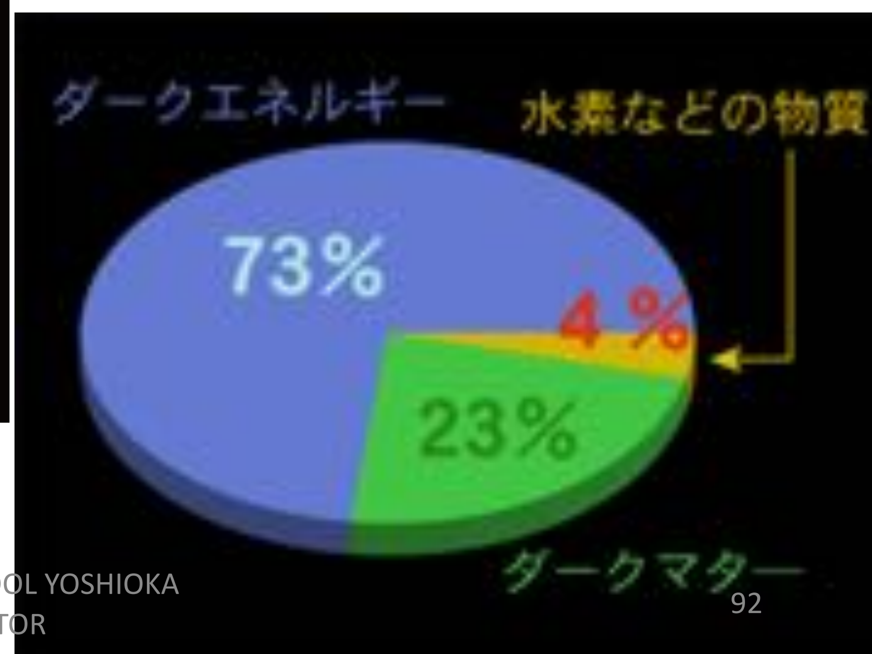




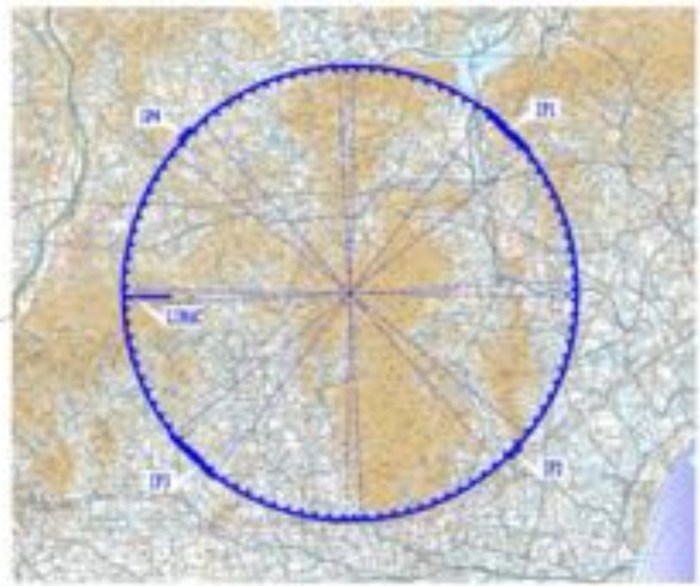

10-7cm
10-8cm
10-12cm
10-13cm
10-16cm
水の分子
酸素原子
原子核
陽子
クォーク


物質粒子
力を伝える粒子
第1世代
第2世代
第3世代
クォーク
~0.002
u
アップ
1.27
c
チャーム
172
t
トップ
~0.005
d
ダウン
0.101
s
ストレンジ
~4.2
b
ボトム
レプトン
≠0
νe
eニュートリノ
≠0
νμ
μニュートリノ
≠0
ντ
τニュートリノ
0.000511
e
電子
0.106
μ
ミューオン
1.78
τ
タウ
強い力
0
g
グルーオン
電磁力
γ
0
光子
弱い力
w+
w−
z
80.4
80.4
91.2
Wボゾン
Zボゾン
ヒッグス場に伴う粒子
~126
H
ヒッグス粒子

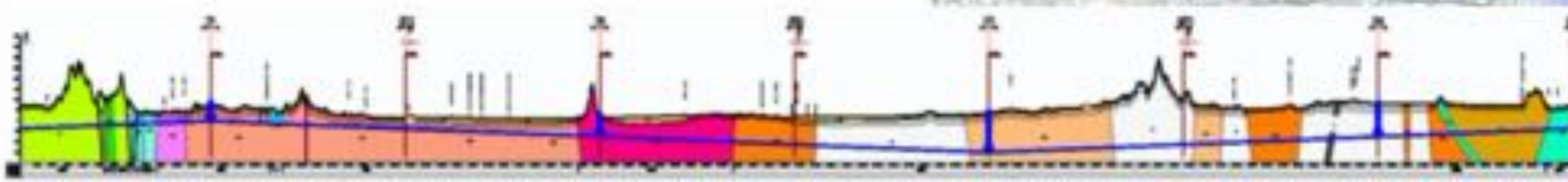

磁気
電気
クォークとレプトンの種類を変える力
クォークを結ぶ力・原子核を形作る力
質量のあるものを近づけようとする力
電磁気力
弱い力
強い力
重力
電弱統一理論
完成!
大統一理論
まだ
超大統一理論
まだまだ


ダークエネルギー
水素などの物質
73%
4%
23%
ダークマター

CEPC Civil Enginnering Design (Funing 100km, example)



2027～2028年の着工を目指しています



中國科學院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences

CEPC

11月28日～12月1日
ICFAセミナー@DESYハンブルク

CEPC and SppC Proposals

Jie Gao

IHEP

- 2023年6月
技術設計書・国際レビュー
- 2023年9月
同・国際コストレビュー
- 2024～2027年
EDR作成（工学設計）
- 2027年
建設開始
- 2035年
建設完了

Summary

- The CEPC TDR parameter and design optimizations with high luminosities (**30MW and 50MW**) operations, for all four energies (**Higgs, W/Z and ttbar**) have been studied. The results demonstrate that the accelerator design satisfies the scientific goals.
- A comprehensive key technology R&D program has been carried out in TDR with CEPC key technplogies in hands ready for industrialization preparation in EDR.
- CEPC accelerator **TDR international review and cost review** were held from **June 12-16, 2023 and Sept. 11-15, 2023**, respectively, and endorsed by **IAC meeting** held from **Oct. 30-31, 2023**. **TDR will be released formally soon at the end of December of 2023.**
- Detailed preparation of **CEPC EDR** phase (**2024-2027**) before construction working plan and beyond have been established (preliminary), with the aim for **CEPC PROPOSAL** to be presented to and selected by Chinese government around **2025** for the construction start during the "**15th five year plan** **(2026-2030)**" (for example, around **2027**) and completion around **2035** (the end of the 16th five year plan).
- **International collaboration and participation are warmly welcome.**

CEPC-SppC Proposals-J. Gao ICFA Seminar 2023, Nov. 30, 2023, DESY 24

1. 少し加速器の歴史と医療応用
2. ILCのこと
3. **大型国際研究機関の意義（CERNに学ぶ）**
4. 地域はILCをどのように活かすべきか
5. グリーンILC
6. エピローグ

- CERNは　1954年、ヨーロッパの12カ国によって「Science for Peace(平和のための科学)」を掲げ、設立された。
- CERNという名前は、前身組織名(仏)(設立検討組織)である
  Conseil Europ e en pour la Recherche Nucl e aire
  の略称
- 現在の加盟国は23カ国

（メンバー国）
ドイツ、フランス、イギリス、イタリア、スペイン、オランダ、ベルギー、ノルウェー、ポーランド、スイス、スウェーデン、オーストリア、ギリシャ、デンマーク、フィンランド、ポルトガル、チェコ、ハンガリー、スロバキア、ブルガリア、イスラエル、ルーマニア、セルビア
（加盟手続き中）
キプロス、スロベニア
（アソシエイト国）
トルコ、パキスタン、ウクライナ、インド、リトアニア、クロアチア
（オブザーバー国）
日本、ロシア、アメリカ、EU、JINR（ドゥブナ合同原子核研究所）、UNESCO

※年間予算約1,200MCHF（各国の出資額は国民純所得NNIに比例する）
※職員数　約2,600人＋約1,400人（other paid personnel）
※ユーザー数　13,000人
※2019年現在

- ユーザーの30％が長期滞在と仮定すると7900人が滞在
- 個々人が年間500万円支出すると~400億円がインバウンド効果
- 1200MCHF＝1700億円
- スイス分担金は4.12％なので70億円

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平井貞義氏のスライド
NTTファシリティーズ

ILCから始まる、新しいまちづくり

復興から、世界最先端へ
世界に誇る、未来都市“Tohoku”へ

(一社)先端加速器科学技術推進協議会（AAA)
プロジェクト推進部会　地方創生・まちづくりWG

2023.05.30.

日本らしい、地方ならではの新しいコンセプトの未来型田園都市
“ Tohoku”

Global Innovation Field
世界中から多様な人々が集い、
人類の課題　解決に向けて挑戦する場所

ILC誘致に伴う
高度人材・世界先端企業の集積

✕

世界的視野を持つ高度人材やイノベーターを
生み出すシステム

社会実証先端フィールドの提供
(国家戦略特区)

ILCサマリー

- 技術よし
- サイトよし
- 欧米もよし
- 経済性よし（経済・技術波及効果）
- 多文化共生よし（文化波及効果）
- 地元地域受け入れよし（まちづくり）
- 中国がヒタヒタと迫ってきている
- ILC2029年建設開始が研究者の目標
- 日本の国際的信用を保とう！

1. 少し加速器の歴史と医療応用
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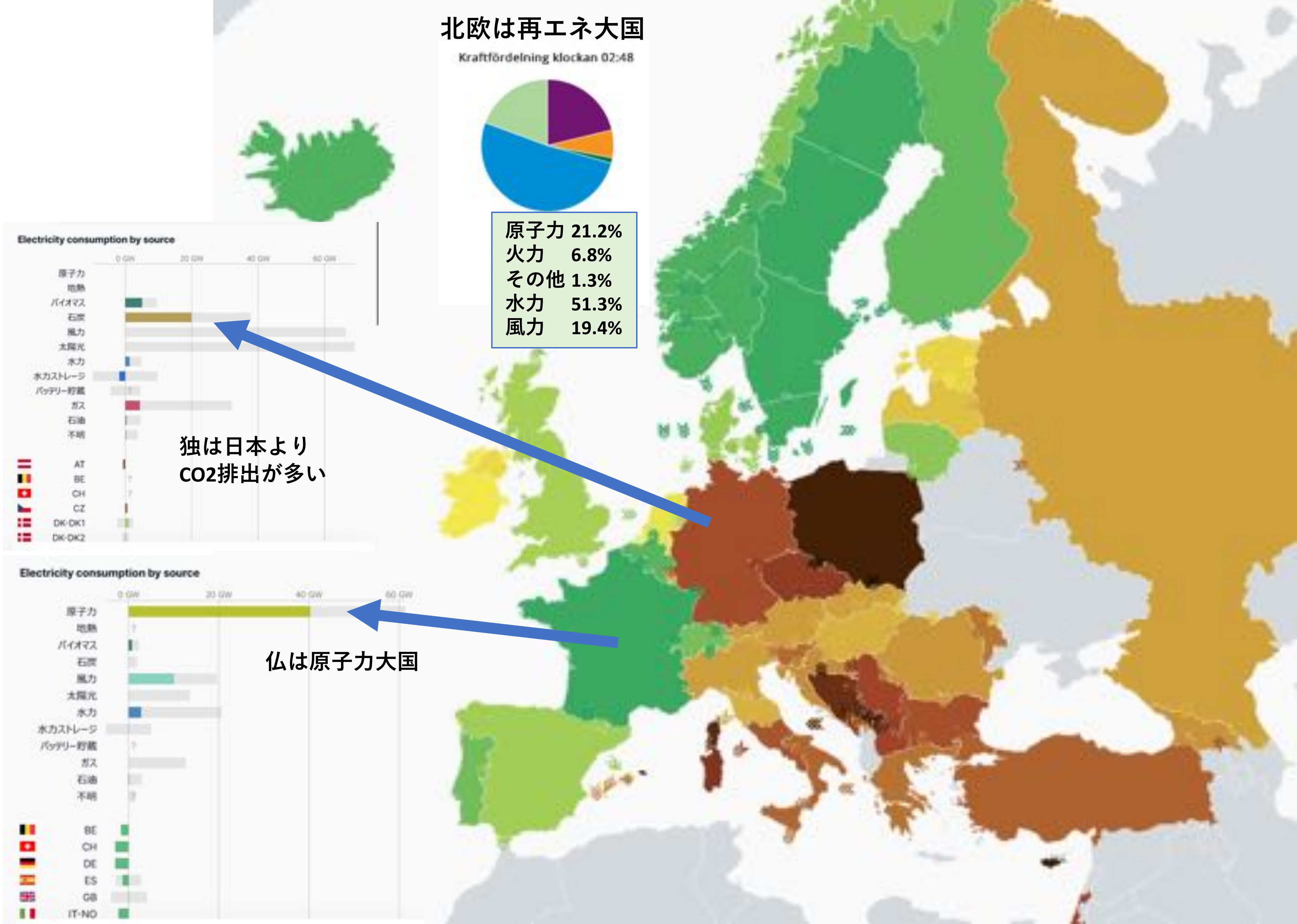
https://app.electricitymaps.com/zone/



https://app.electricitymaps.com/zone/

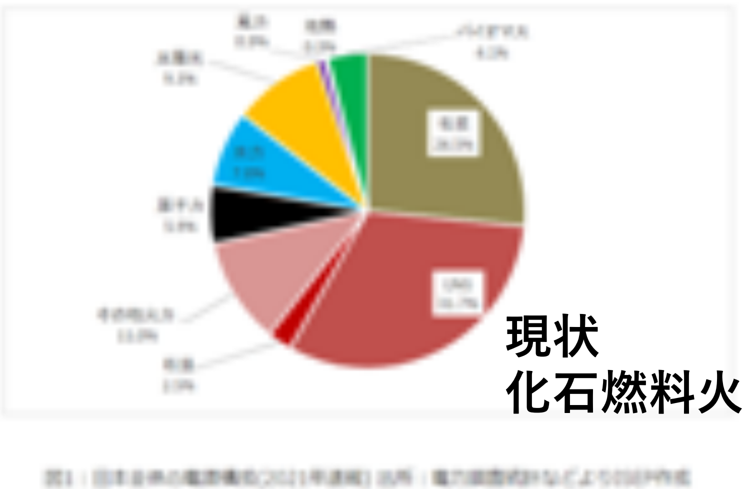
東北電力は石炭・ガスと太陽光・水力

九州電力は原子力と太陽光

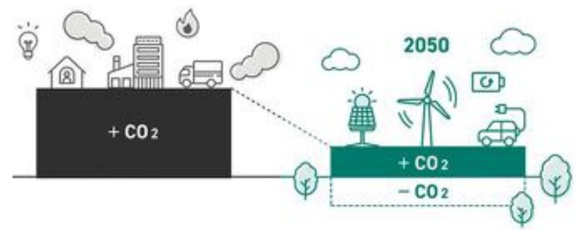
日本の戦略私見

- 再エネを増加すべき
  - 陸上、洋上風力
  - 未利用バイオマス、新バイオマス
- CO_2吸収量を増加すべき
  - グリーンカーボン（森林）
  - ブルーカーボン（沿岸・藻）
  - ホワイトカーボン（木造建築）

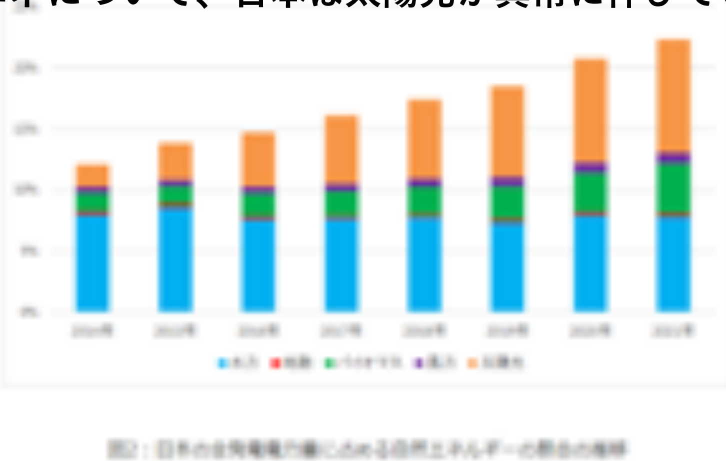
https://gurilabo.igrid.co.jp/article/3329/

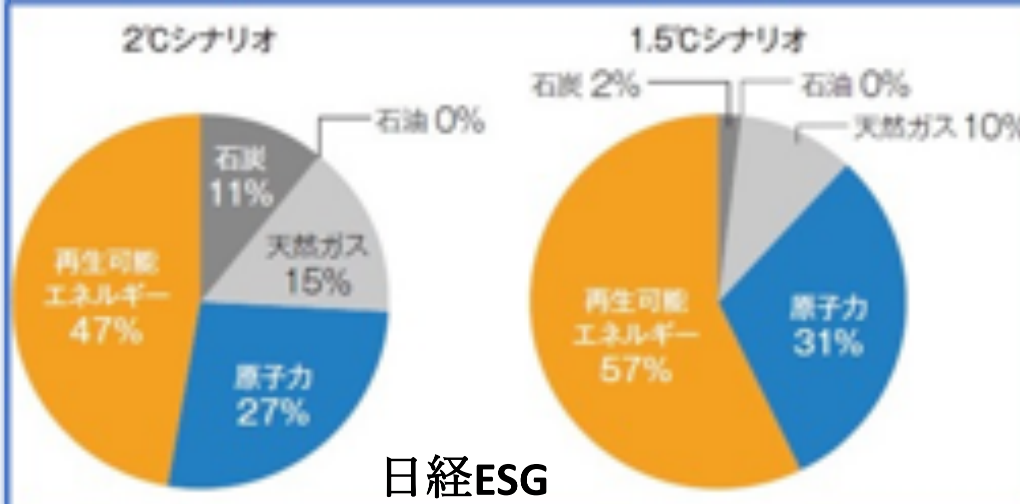


現状
化石燃料火力が72%



再エネについて、日本は太陽光が異常に伸びている

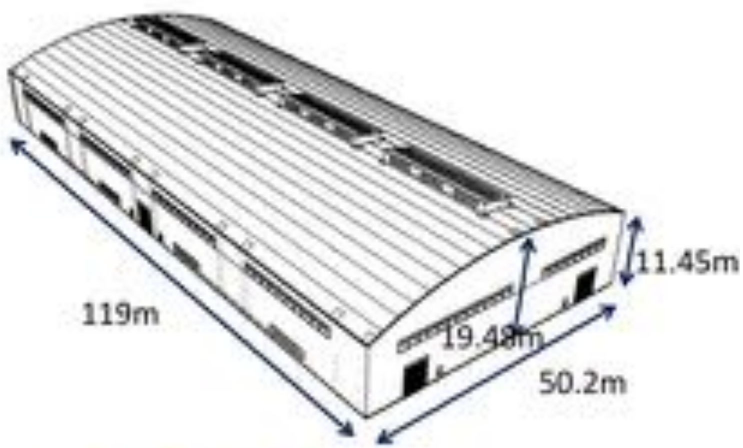


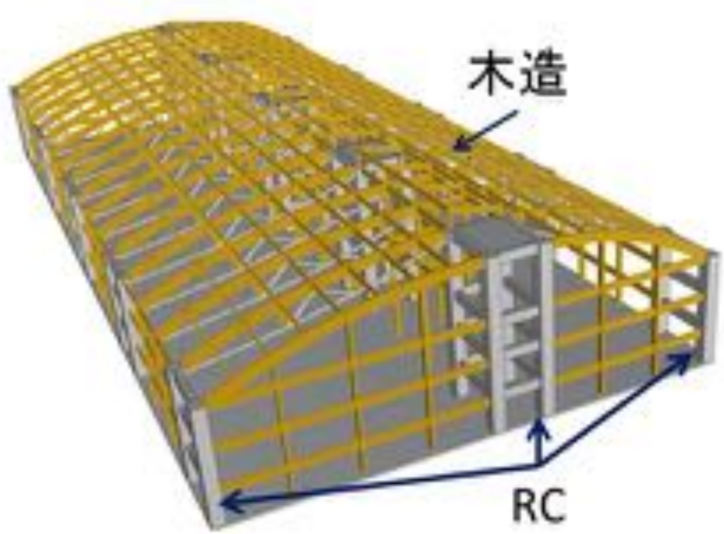


日経ESG

ホワイトカーボン（大型木造建築によるＣＯ２の固定）

弊社は大規模木造建築にこだわり、多くの経験を積んでまいりました。本講演では、地球温暖化防止のソリューションとして木材を活用することの意義について述べるとともに、ILCの大型実験室を例に、木造建築とCO_2吸収の相関関係を明らかにする。





シェルター社が設計・施工した純木造、7階建ての「高惣木工ビル」（仙台駅東）

グリーンILCまとめ

- ILCグループは省エネ技術の高度化にたゆまぬ努力をはらっています
  - 超伝導加速空洞のさらなる性能増強
  - クライストロンや電源の電力効率アップ
  - その他
- 一方、候補地を持つ地域としては、「ILC in Japan」の着工までに、持続可能な社会を実現するための努力を続けていかねばなりません
  - 持続可能なまちづくり
  - 再生可能エネルギーの増強（風力、水力、未利用バイオマス・・・）
  - ILCの排熱回収プロジェクトの技術を活用し、地域の熱エネルギー循環システムの構築（今日は触れませんでしたが）
  - ILCと地域の一次産業（農林水産業）との連携を深める

1. 少し加速器の歴史と医療応用
2. ILCのこと
3. 大型国際研究機関の意義（CERNに学ぶ）
4. 地域はILCをどのように活かすべきか
5. グリーンILC
6. エピローグ

全体サマリー

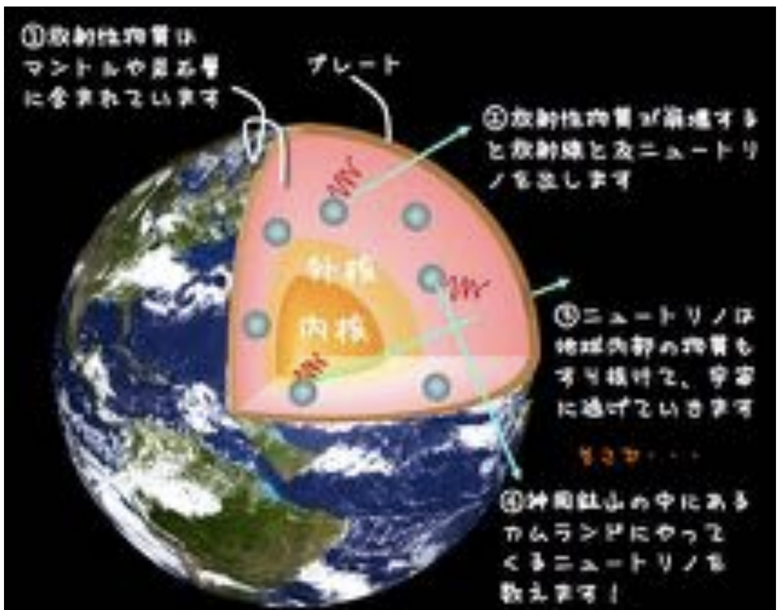
- 日本はもはや先進国ではない
- 学術・技術とも長期低落傾向にある
- 挽回するには基礎体力増強を要する
- それがＩＬＣ大型国際研究機関立地
- 国際機関立地は平和の象徴
- 技術・経済・文化の波及効果は計り知れない
- 実現には持続可能性を満たさねばならぬ

謝辞：
東北ILC事業推進センターのメンバー
岩手県ILC推進協議会のサポート
AAA先端加速器科学技術推進協議会メンバー
岩手県草の根勉強会メンバー

ご清聴ありがとうございました

Last week, Professor Atsuto Suzuki asked me to give a lecture at this school !

Suzuki-sensei is a great physicist.
As far as I know, he has made many achievements in neutrino physics and trained many students.
I am sure you are well aware of his achievements at Kamiokande, Super-Kamiokande, and KamLAND.
Among them, my personal favorite achievement is that he opened the door to Earth neutrino science.



By detecting unti-neutrino from the earth at KamLAND, it was clarified that the reason why the Earth's interior is still hot today is that the energy of radiation emitted from unstable nuclear species is converted into heat.

He was recently honored as a Person of Cultural Merit and was also appointed as a member of the Japan Academy of Sciences.