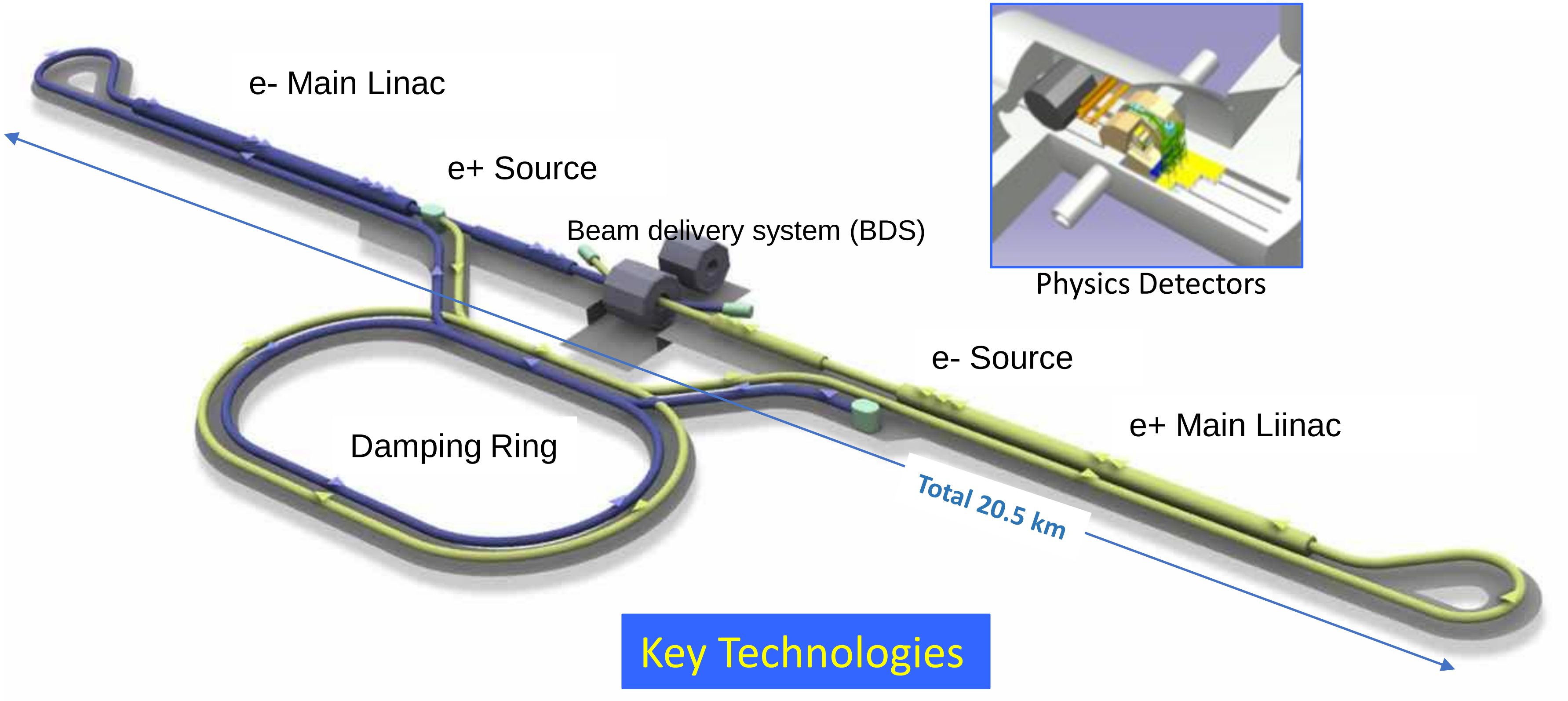
The International Linear Collider

Shin MICHIZONO

International Development Team (IDT) WG2/ KEK

- *ILC250 accelerator overview*
- *ILC area systems*
    - *Sources*
    - *Nano-beam*
    - *SRF*
- *Civil engineering*
- *International Development Team (IDT)*
- *Global situation*
- *Summary*

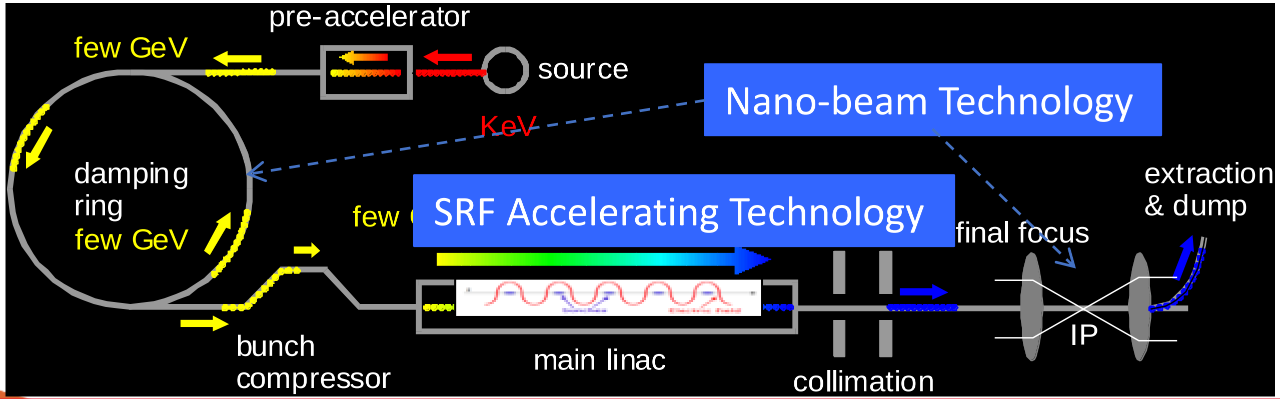
ILC250 accelerator facility



Physics Detectors

Item	Parameters
C.M. Energy	250 GeV
Length	20km
Luminosity	1.35 x10^{34} $cm^{-2}s^{-1}$
Repetition	5 Hz
Beam Pulse Period	0.73 ms
Beam Current	5.8 mA (in pulse)
Beam size (y) at FF	7.7 nm@250GeV
SRF Cavity G. Q_0	31.5 MV/m (35 MV/m) Q_0 = 1x10^{10}

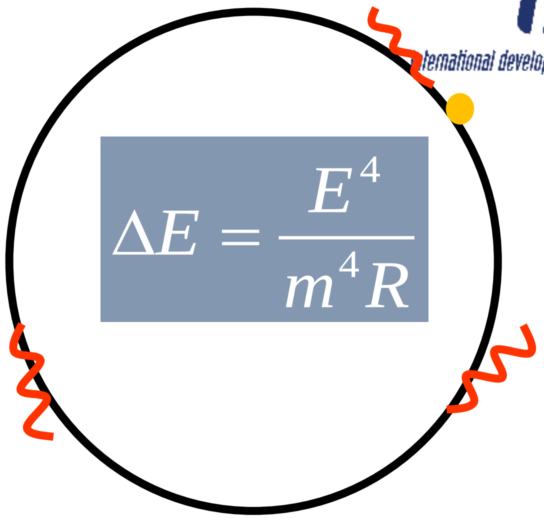
Key Technologies



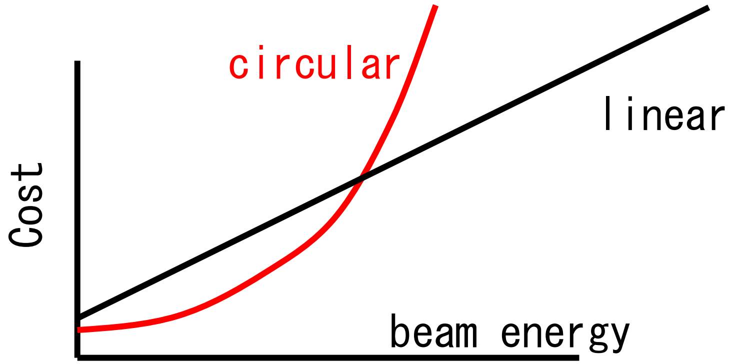
8,000 SRF cavities will be used.

Main advantages

- A linear accelerator is more advantageous for accelerating electron and/or positron beams to higher energies.
- The spin of the electron and/or positron beam can be maintained during the acceleration and collision. This can help significantly improve measurement precision.
- The small surface resistance of the SRF accelerating structure (cavity) made of Nb enables the efficient power transfer from the AC power source to the beam.
- Further energy efficiency improvements are considered as part of the of Green ILC concept, which aims to establish a sustainable laboratory.



Circulating beam loses energy by synchrotron radiation.
Linear collider can extend its collision energy by longer tunnel/ higher gradient.



Technical Maturity

- ILC based on superconducting radiofrequency (SRF) technology started its R&D from 2005 (GDE). Reference Design Report (RDR) was published in 2007 and TDR was published in 2013.
- More than 2,400 researchers contributed to the TDR.

- The SRF technology's maturity was proven by the operation of the European X-ray Free Electron Laser (X-FEL) in Hamburg, where 800 superconducting cavities (1/10 of ILC SRF cavities) were installed.
- In addition to European XFEL, LCLS-II at SLAC, SHINE in Shanghai are under construction.

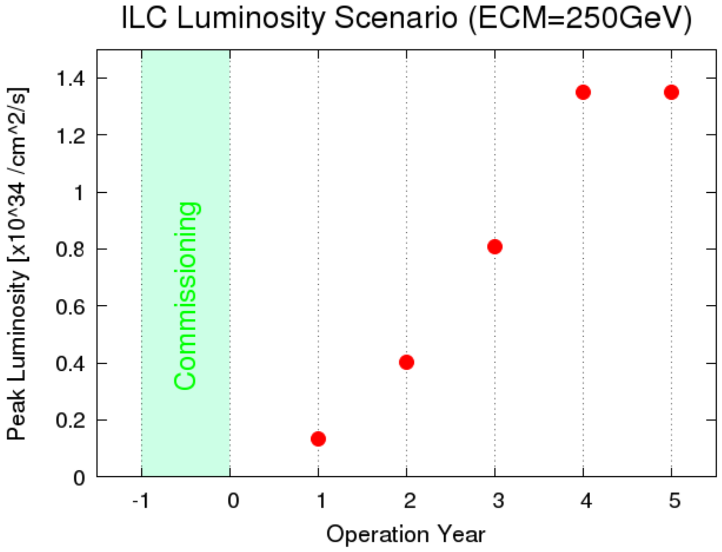
- Nano-beam technology has been demonstrated at ATF hosted in KEK under international collaboration and almost satisfied the requirements of the ILC.

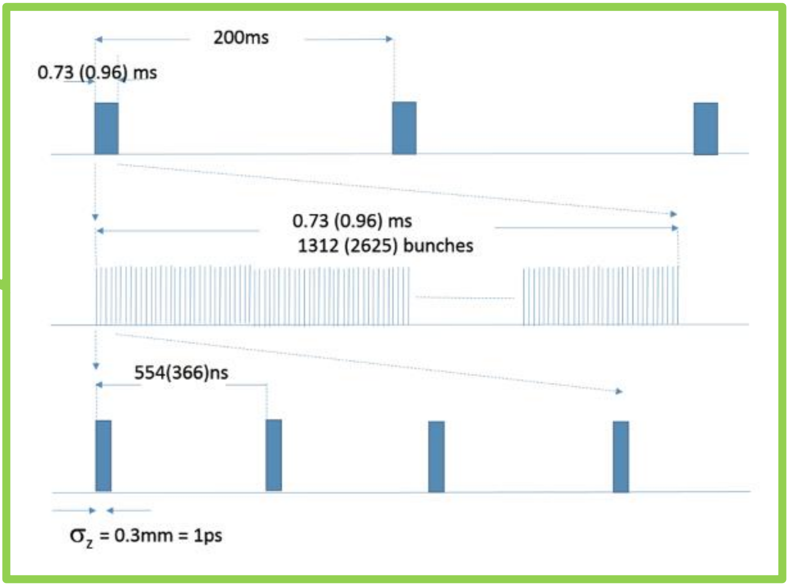
- Remaining technical preparation (such as mass-production of SRF cavities, positron source, beam dump) can be carried out during the preparation phase at Pre-lab before ILC construction. These are listed in "Recommendations on ILC Project Implementation".

ILC machine parameters

ILC	electron/positron	ILC250
Beam Energy	GeV	125 (e-) and 125 (e+)
Peak Luminosity (10^34)	cm-2 s-1	1.35
Int. Luminosity	ab-1/yr	0.24*
Beam dE/E at IP		0.188% (e-), 0.150% (e+)
Transv. Beam sizes at IP x/y	nm	515/7.66
Rms bunch length /	cm	0.03 (σ_z)
beta*	mm	bx*=13mm, by*=0.41mm
Crossing angle	mrad	14
Rep./Rev. frequency	Hz	5
Bunch spacing	ns	554
# of bunches		1,312
Length/Circumference	km	20.5
Facility site power	MW	111
Cost (value) range	$B US	~5 (tunnel and accelerator)
Timescale till operations	years	(~1) + 4(prep.) + 9(construction)

** 5,000-hour operation at peak luminosity*





Potential for upgrades

The ILC can be upgraded to higher energy and luminosity.

			Z-Pole [4]		Higgs [2,5]			500GeV [1*]		TeV [1*]
			Baseline	Lum. Up	Baseline	Lum. Up	L Up.10Hz	Baseline	Lum. Up	case B
Center-of-Mass Energy	E_{CM}	GeV	91.2	91.2	250	250	250	500	500	1000
Beam Energy	E_{beam}	GeV	45.6	45.6	125	125	125	250	250	500
Collision rate	f_{col}	Hz	3.7	3.7	5	5	10	5	5	4
Pluse interval in electron main linac		ms	135	135	200	200	100	200	200	200
Number of bunches	n_b		1312	2625	1312	2625	2625	1312	2625	2450
Bunch population	N	10^{10}	2	2	2	2	2	2	2	1.737
Bunch separation	Δt_b	ns	554	554	554	366	366	554	366	366
Beam current		mA	5.79	5.79	5.79	8.75	8.75	5.79	8.75	7.60
Average beam power at IP (2 beams)	P_B	MW	1.42	2.84	5.26	10.5	21.0	10.5	21.0	27.3
RMS bunch length at ML & IP	σ_z	mm	0.41	0.41	0.30	0.30	0.30	0.30	0.30	0.225
Emittance at IP (x)	γe^*_x	µm	6.2	6.2	5.0	5.0	5.0	10.0	10.0	10.0
Emittance at IP (y)	γe^*_y	nm	48.5	48.5	35.0	35.0	35.0	35.0	35.0	30.0
Beam size at IP (x)	σ^*_x	µm	1.118	1.118	0.515	0.515	0.515	0.474	0.474	0.335
Beam size at IP (y)	σ^*_y	nm	14.56	14.56	7.66	7.66	7.66	5.86	5.86	2.66
Luminosity	L	$10^{34}/cm^2/s$	0.205	0.410	1.35	2.70	5.40	1.79	3.60	5.11
Luminosity enhancement factor	H_D		2.16	2.16	2.55	2.55	2.55	2.38	2.39	1.93
Luminosity at top 1%	$L_{0.01}/L$	%	99.0	99.0	74	74	74	58	58	45
Number of beamstrahlung photons	n_g		0.841	0.841	1.91	1.91	1.91	1.82	1.82	2.05
Beamstrahlung energy loss	δ_{BS}	%	0.157	0.157	2.62	2.62	2.62	4.5	4.5	10.5
AC power [6]	Psite	MW			111	138	198	173	215	300
Site length	Lsite	km	20.5	20.5	20.5	20.5	20.5	31	31	40

Energy

Lumi.

Construction cost

ILC accelerator (including tunnel) construction cost is ~5 B$.

	TDR: ILC500 [B ILCU] (Estimated by GDE)	ILC250 [B ILCU]* (Estimated by LCC)	Conversion to: [B JPY] (Reported to MEXT/SCJ)
Accelerator Construction: sum	**n/a**	**n/a**	**635.0 ~ 702.8**
Value: sub-sum	7.98	4.78 ~ 5.26	515.2 ~ 583.0
Tunnel & building	1.46	1.01	111.0 ~ 129.0
Accelerator & utility	6.52	3.77 ~ 4.24	404.2 ~ 454.0
Labor: Human Resource	22.9 M person-hours (13.5 K person-years)	17.2 M person-hours (10.1 K person-years)	119.8
Detector Construction: sum	**n/a**	**n/a**	**100.5**
Value: Detectors (SiD+ILD)	0.315+0.392	0.315+0.392	76.6
Labor: Human Resource (SiD + ILD)	748+1,400 person-years	748+1,400 person-years	23.9
Operation/year (Acc.) : sum	**n/a**	**n/a**	**36.6 ~ 39.2**
Value: Utilities/Maintenance	0.390	0.290 ~ 0.316	29.0 ~ 31.6
Labor: Human Resource	850 FTE	638 FTE	7.6
Others (Acc. Preparation)	**n/a**	**n/a**	**23.3**
Uncertainty	**25%**	**25%**	**25%**
Contingency	**10%**	**10%**	**10%**
Decommission	**n/a**	**n/a**	**Equiv. to 2-year op. cost**

*1 ILCU= 1 US$ in 2012 prices

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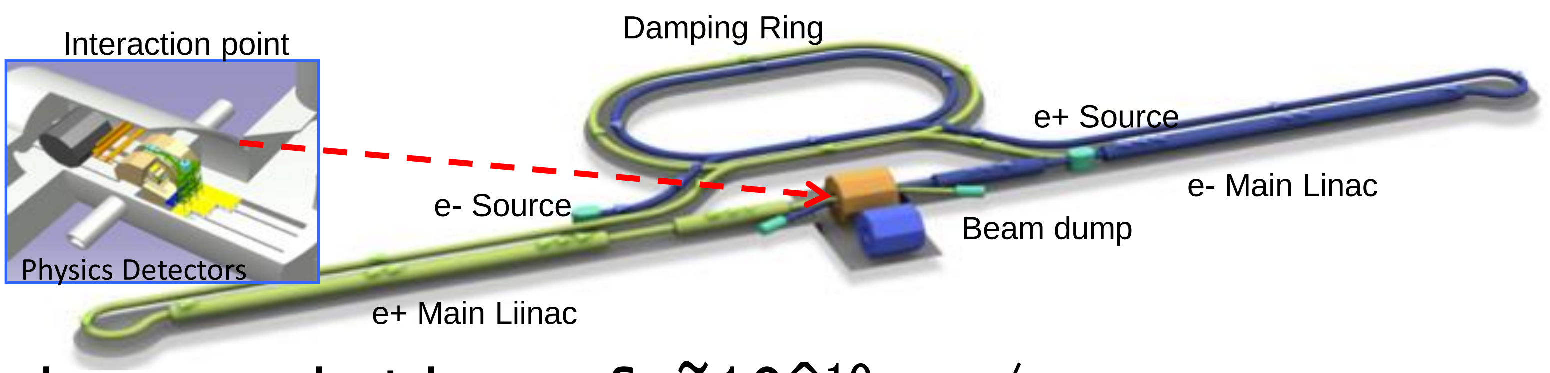
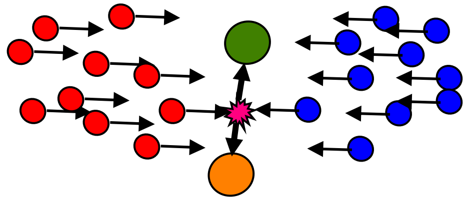
Area systems of the ILC

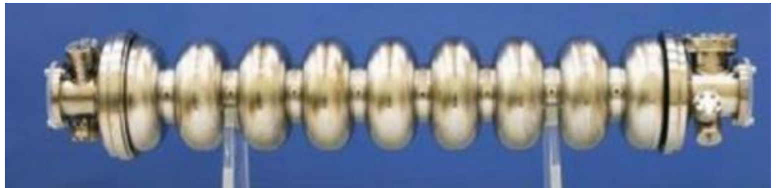


bunch, consisting of ~10^10 e+/e−

- Creating particles *Sources*
  - polarized elections/positrons



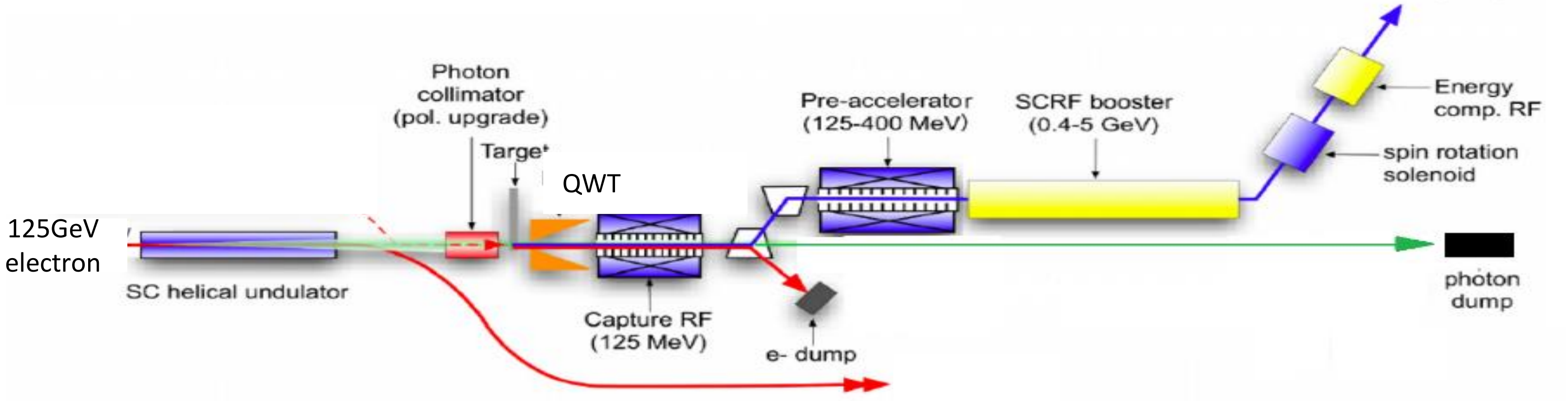
- High quality beams *Damping ring*
  - Low emittance beams
    - Small beam size (small beam spread)
    - Parallel beam (small momentum spread)
- Acceleration *Main linac*
  - superconducting radio frequency (SRF)

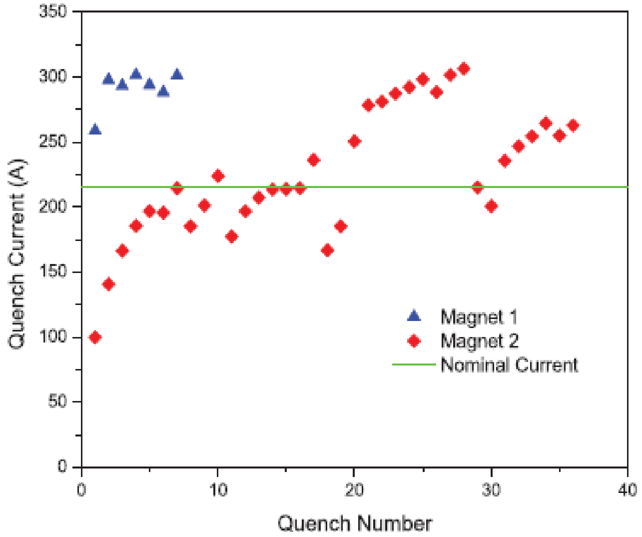


- Getting them collided *Final focus*
  - nano-meter beams
- Go to *Beam dumps*

Positron Source (Undulator)

125 GeV electrons are injected to the helical undulator. The photons produced at the undulator is used for the electron/positron pair creation at the rotating target. Polarized positrons can be generated.





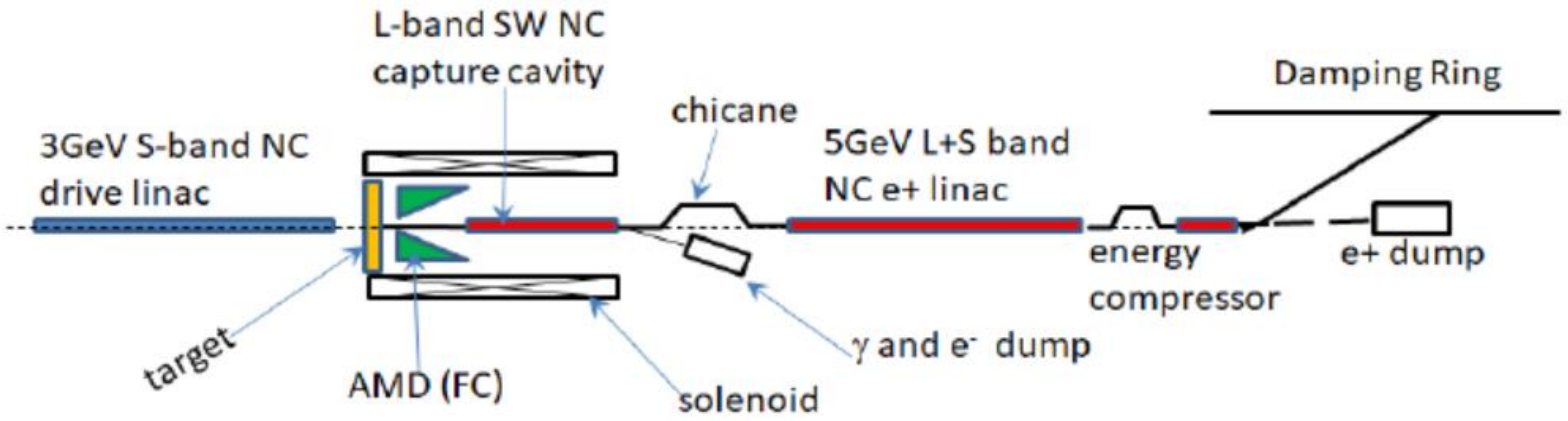
test at Daresbury

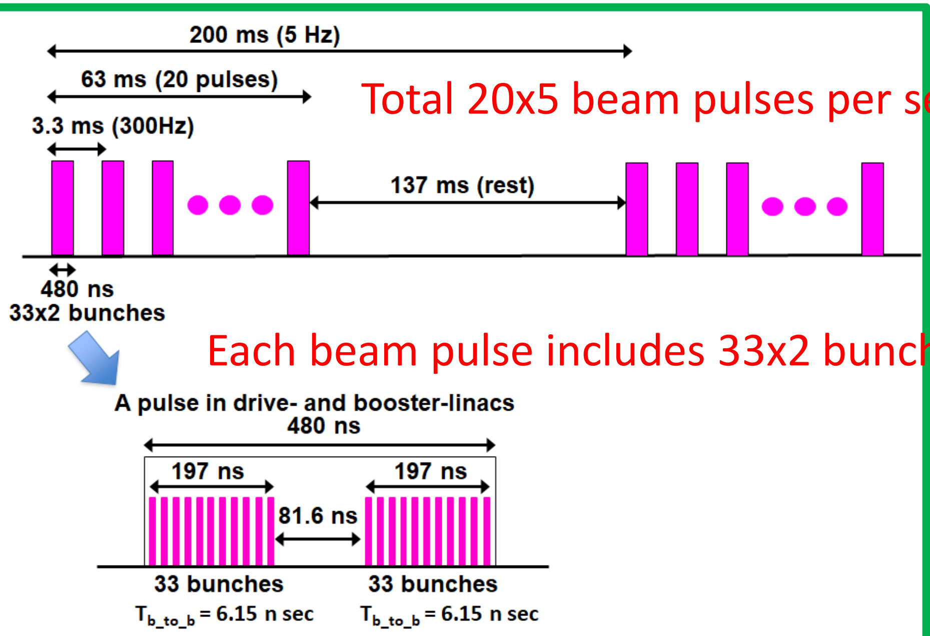
PHYSICAL REVIEW LETTERS 107 (2011) 174803

Two undulators in one cryomodule were tested. Both achieved nominal magnetic fields.

Positron Source (e-Driven)

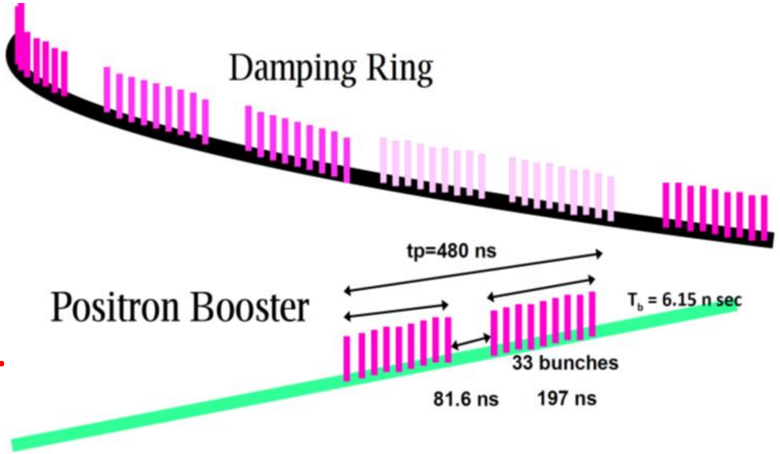
Extra 3GeV linac is used for the positron generation. High energy electrons are not necessary. (Electron independent commissioning is possible. However, polarization is not available.)



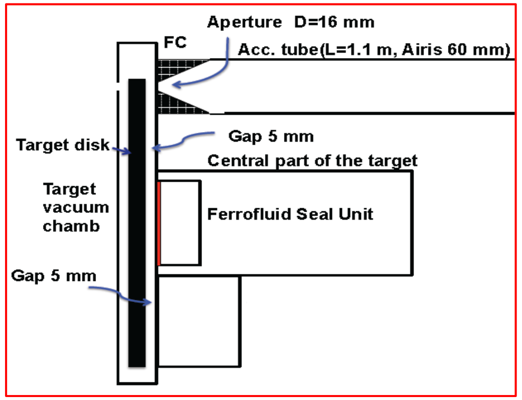


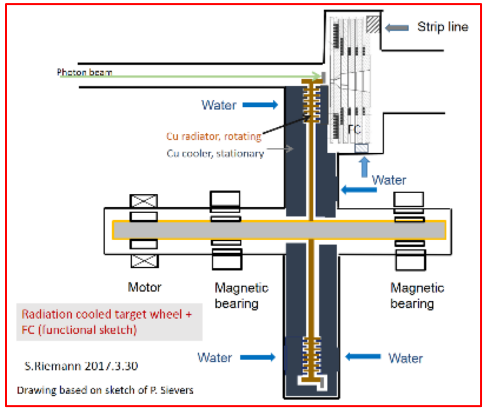
Total 20x5 beam pulses per sec.

Each beam pulse includes 33x2 bunches.



Positron rotating target





	undulator	E-Driven	Existing X-ray generator
Cooling/Seal	Radiation/ magnetic levitation	water/magnetic fluid	water/magnetic fluid
radius（ｍｍ）	500	250	160
weight（kg)	50*	65*	17
Tangential velocity（m/s)	100	5	160
rotation (rpm)	2,000	200	10,000
Beam heat load(kW)	2	20	90
Vacuum pressure（Pa)	10^{-6}	10^{-6}	10^{-4}

*The weight depends on the design of the disk part and the material

- Reliable rotating target
- Replacement of rotating target

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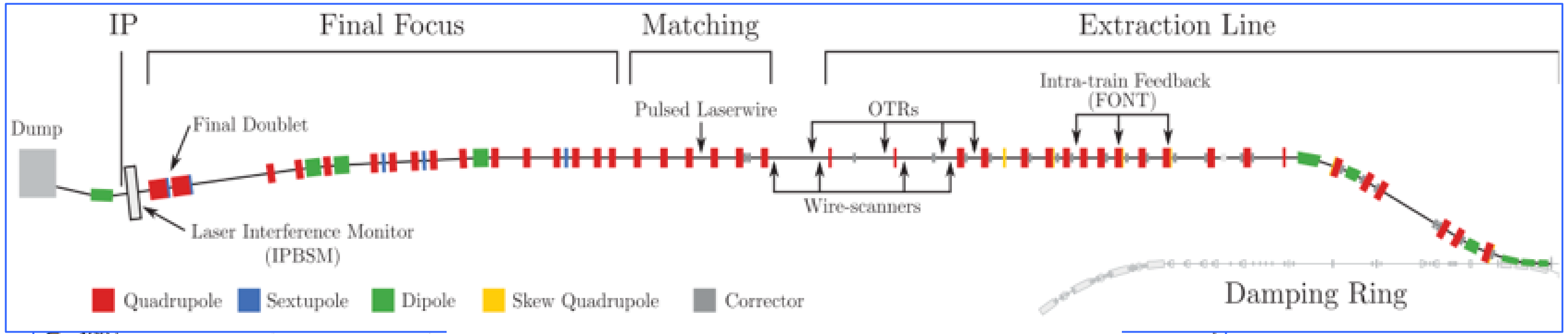
Nano-beam R&D at ATF2

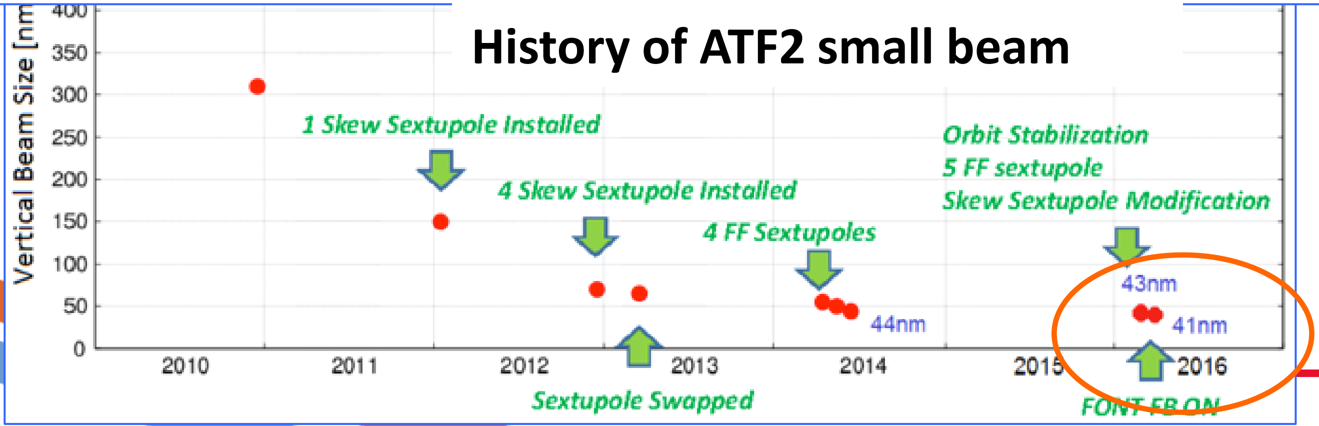
Goal 1: Establish the ILC final focus method with same optics and comparable beamline tolerances

ATF2 Goal : **37** nm → ILC **7.7** nm (ILC250); achieved **41 nm** (2016)

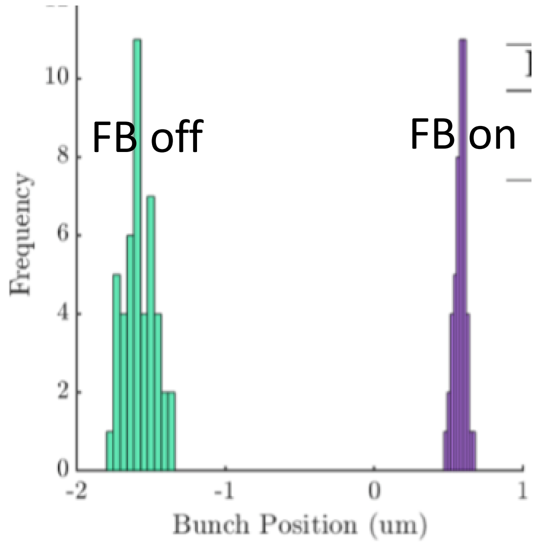
Goal 2: Develop the position stabilization for the ILC collision

- **FB latency 133 nsec achieved** (target: < 366 nsec)
- **positon jitter at IP: 106 → 41 nm (2018)** (limited by the BPM resolution)





Nano-meter stabilization at IP (2018)

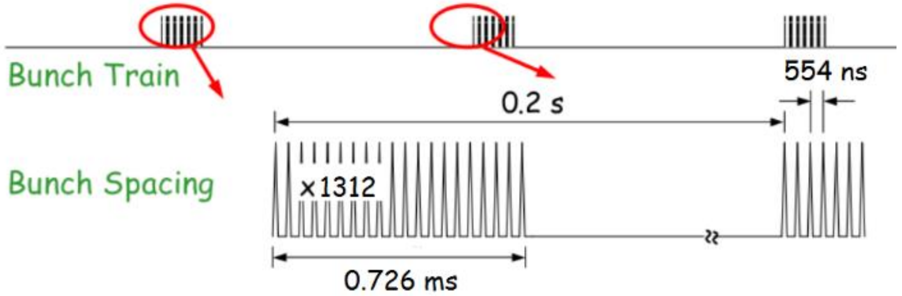


FONT* Bunch train feedback at final focus

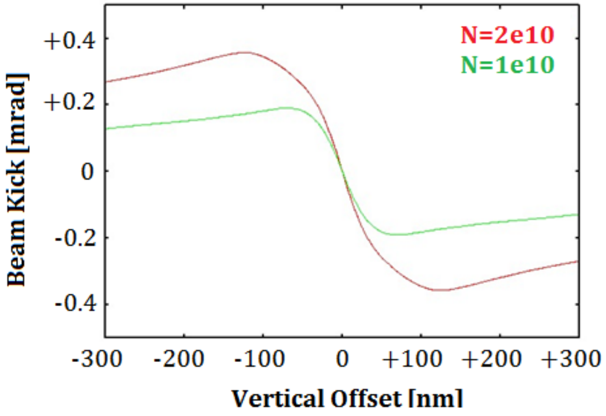
*Feedback On Nanosecond Timescales by Oxford University

https://journals.aps.org/prab/abstract/10.1103/PhysRevAccelBeams.21.122802

ILC bunch structure

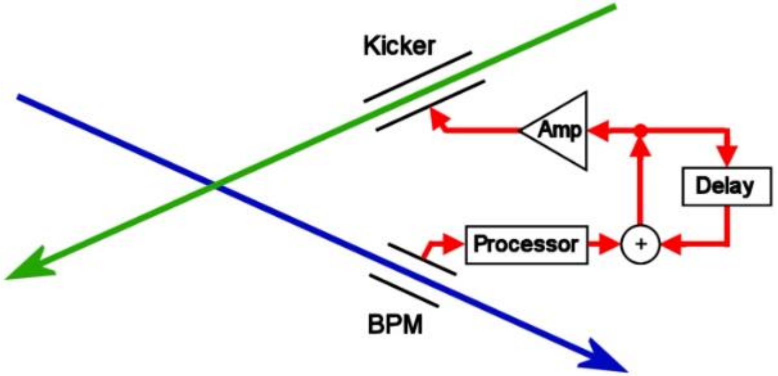


CAIN simulation

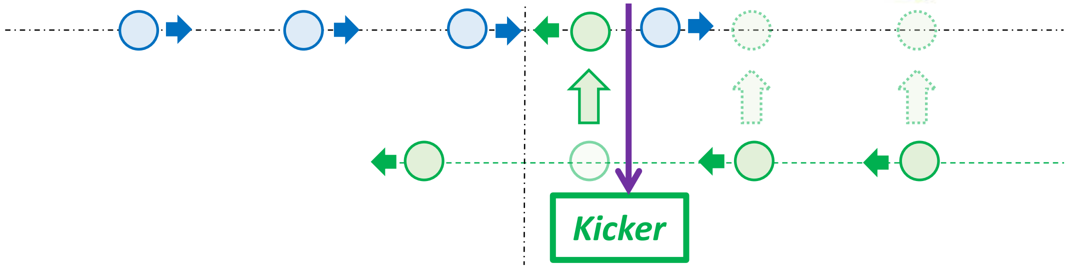


Depending on the relative position of the beam, beams are greatly scattered by the beam-beam effect.

The position of the beam between pulses shifts due to ground vibrations and equipment noise.
On the other hand, the position of the beam does not change significantly inside the bunch train.



Efficient beam collision can be achieved with high-speed feedback that measures the initial beam position of the bunch train and corrects the position of subsequent bunches in the train.
Feedback latency should be less than bunch space.



The first bunch does not collide, but the second and subsequent bunches will collide.

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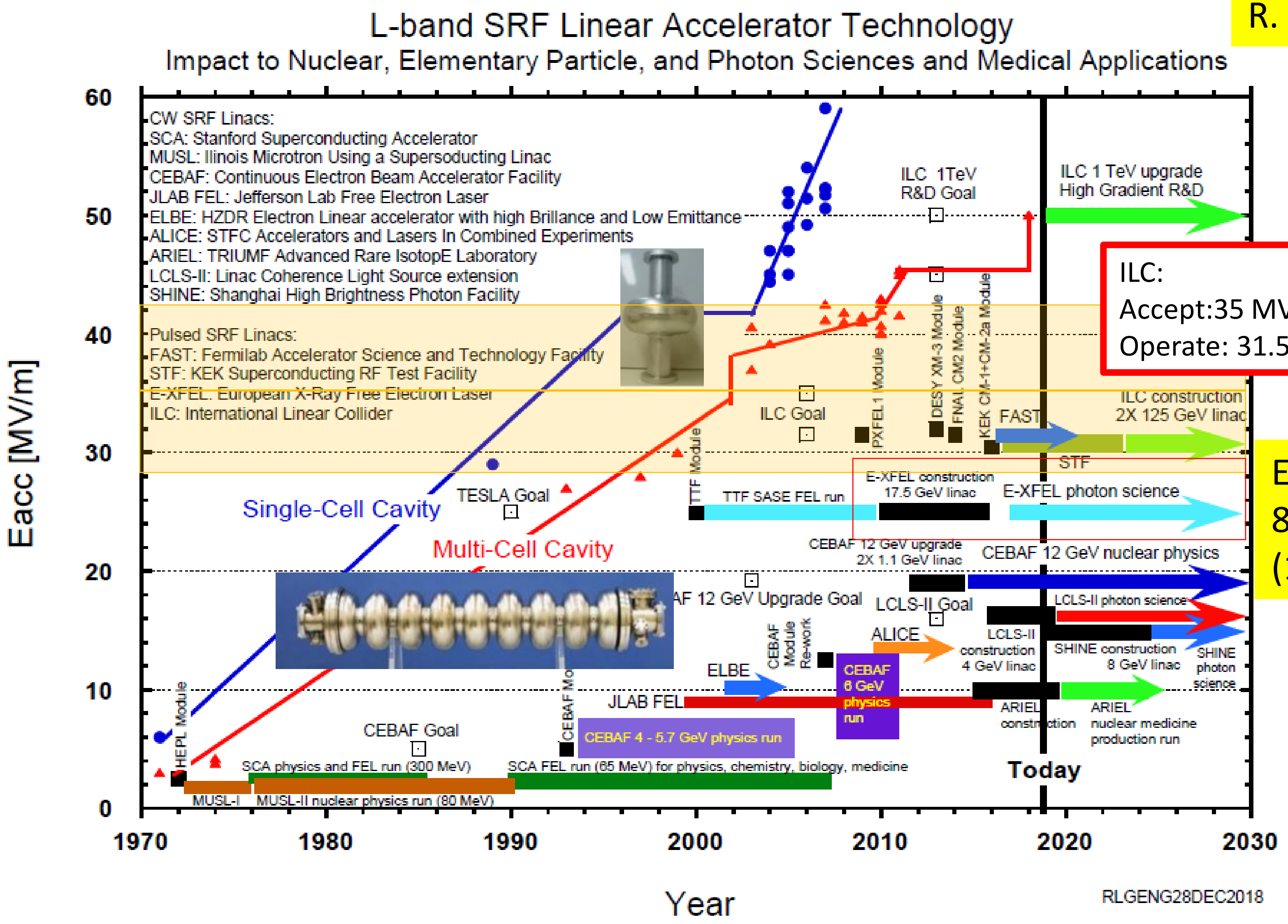
Matured SRF technologies

R. Geng (JLAB)



ILC:
Accept:35 MV/m +/-20%
Operate: 31.5MV/m +/-20%

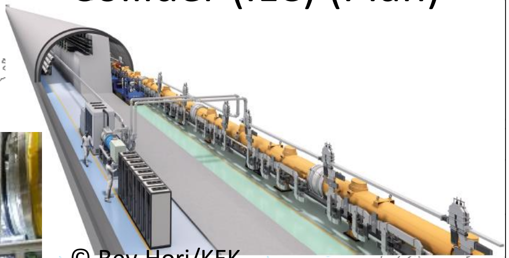
European XFEL
800 cavities
(10% of ILC ML)

Worldwide large scale SRF accelerators

Euro-XFEL
Operation started from 2017
- -100 cyromodules
- -800 cavities
- -17.5 GeV (Pulsed)

DESY

International Linear Collider (ILC) (Plan)



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ILC
- -900 cyromodules
- -8,000 cavities
- -250 GeV (Pulsed)

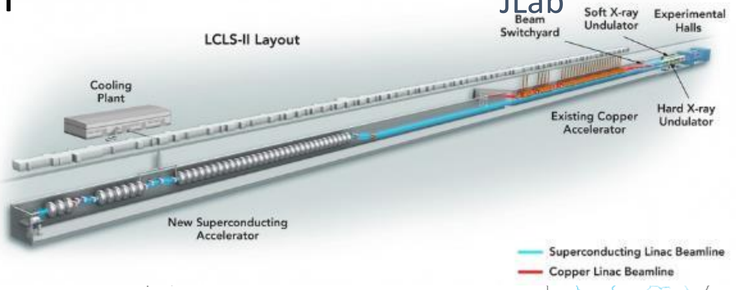
KEK

LCLS-II + HE (under construction)
- -35 + 20 cyromodules
- -280 + 160 cavities
- - 4 + 4 GeV (CW)

SLAC FNAL Cornell JLab

LAL/Sacray INFN

LCLS-II



SINAP

SHINE (under construction)
- -75 cyromodules
- -~600 cavities
- - 8 GeV (CW)

1.3GHz 9 cell cavity

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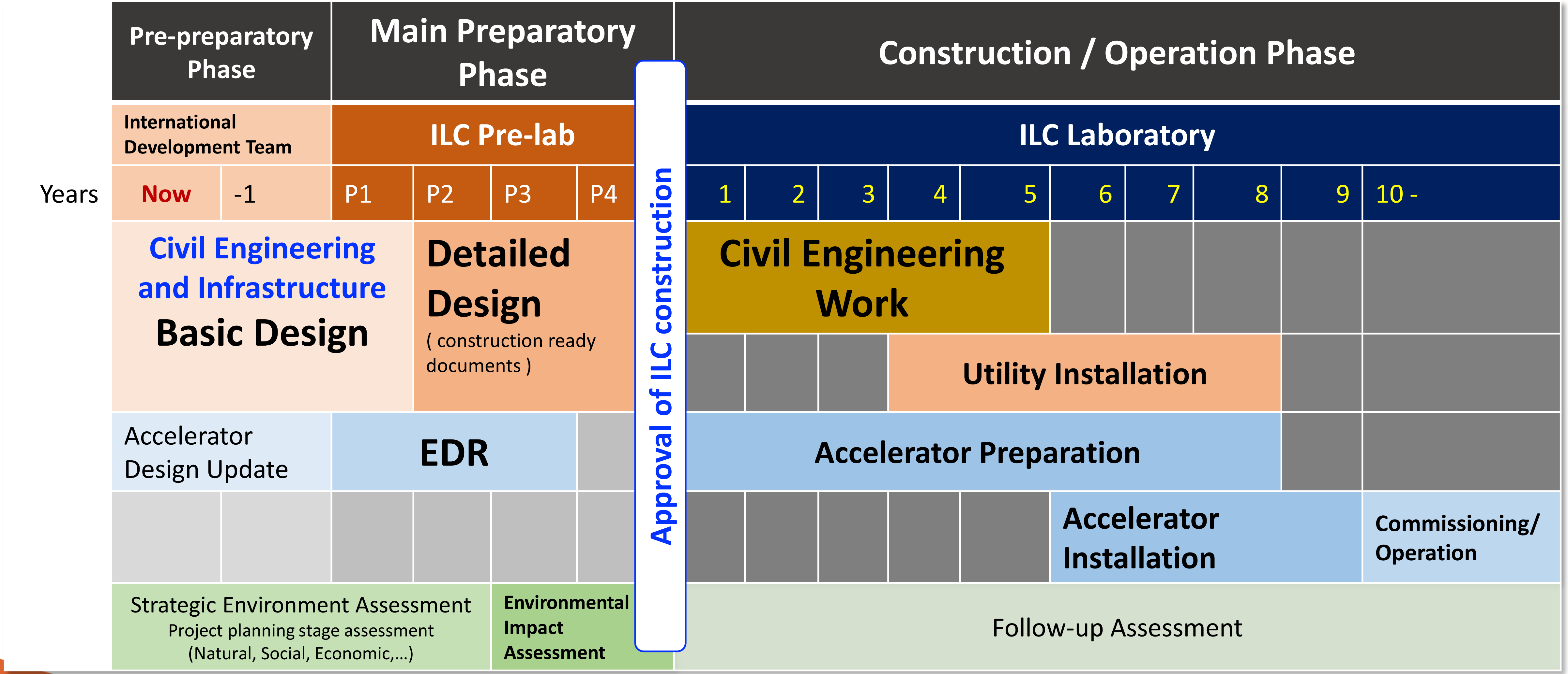
Civil Engineering related Schedule for ILC-250GeV

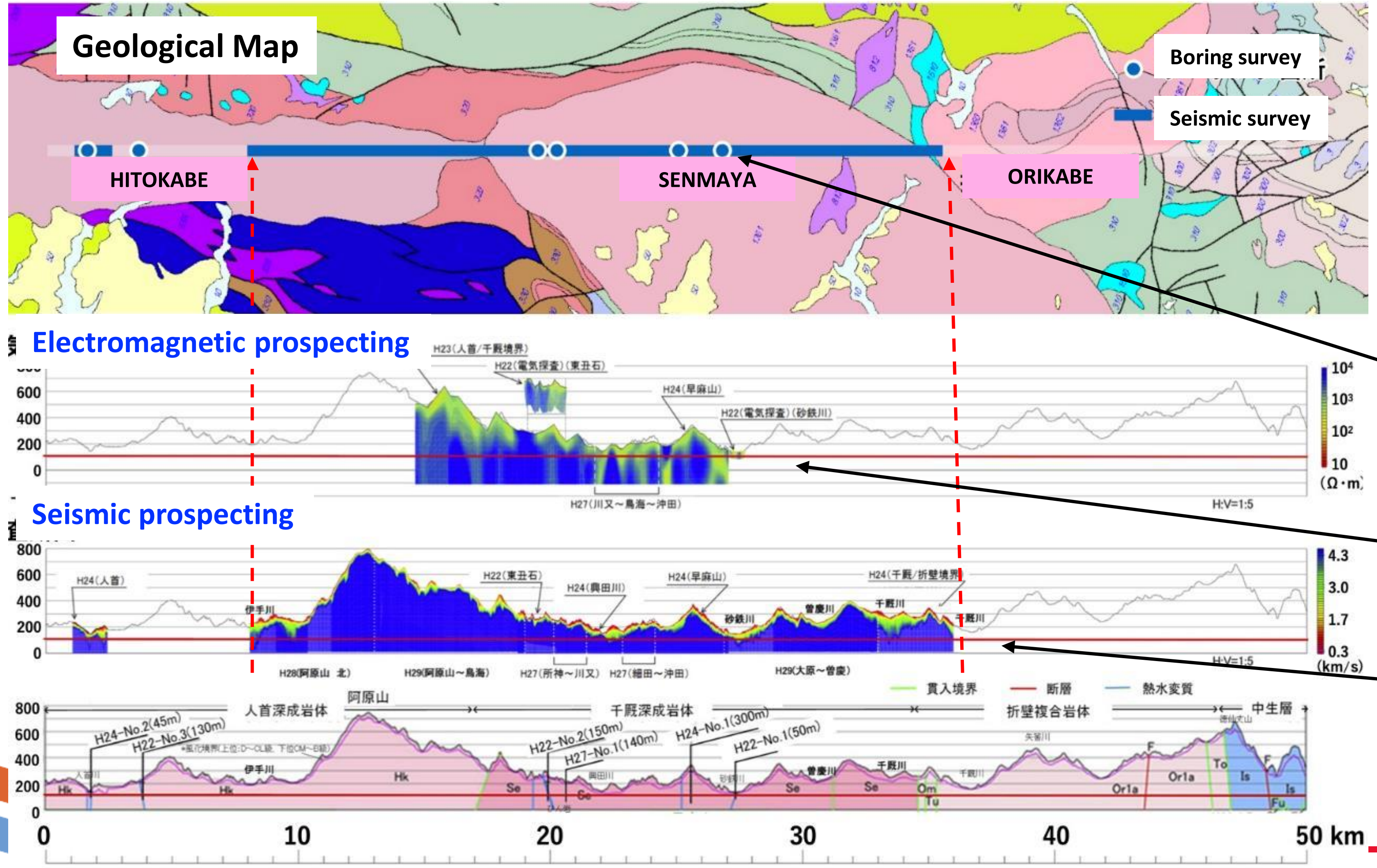
N.Terunuma, AWLC2020



References; (1) TDR, (2) Recommendations on ILC Project Implementation, 2019.

Geological Surveys for ILC: Kitakami Mountains

ILC-250 (20.5 km)



- Continuous **granite region**

  HITOKABE, **SENMAYA** and **ORIKABE** bedrock

- **Have capability to extend the ILC up to 50 km in future**

- **Boring geological survey**

  → Direct sampling down to the accelerator depth

- **Electromagnetic prospecting**

  → Cracks in the rock

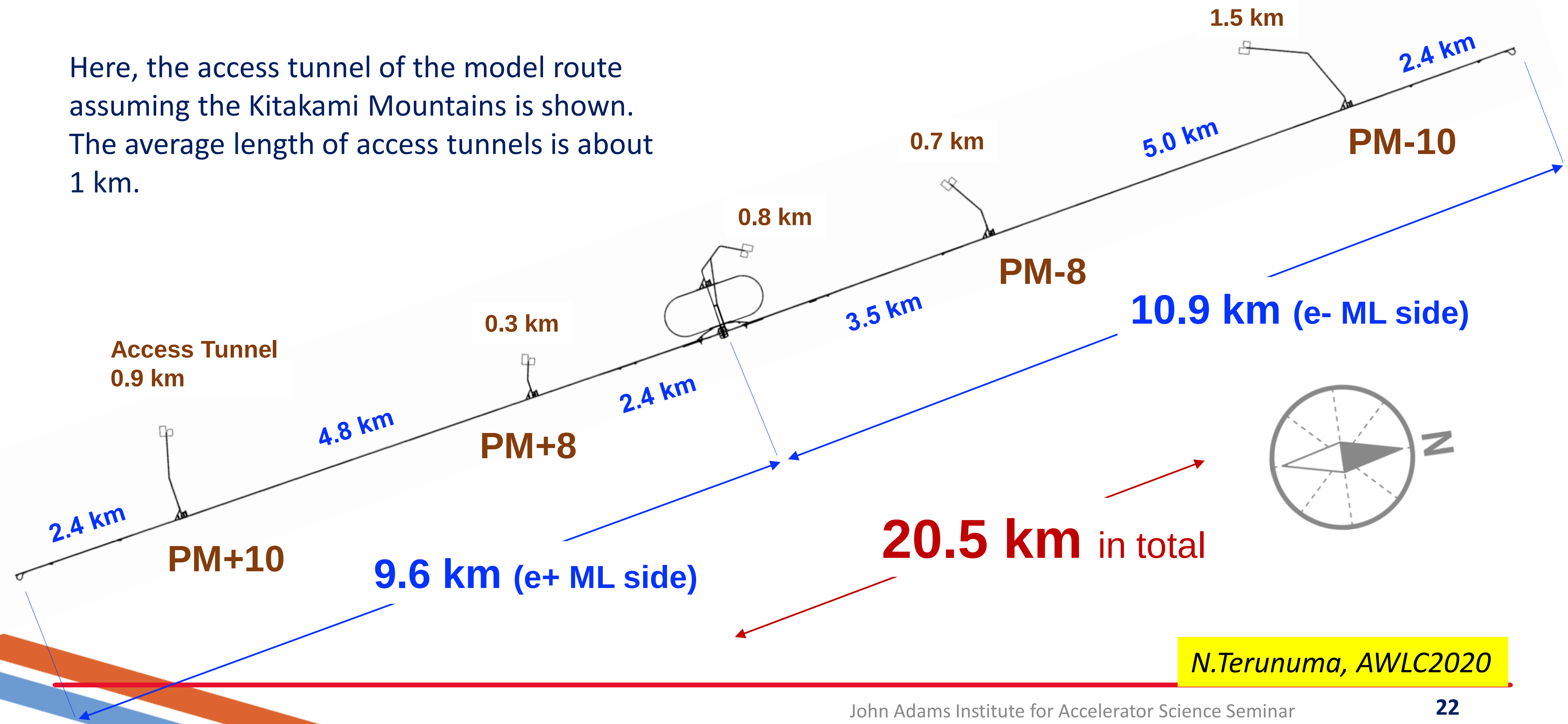
- **Seismic prospecting**

  → Rock hardness

N.Terunuma, AWLC2020

Scale of the ILC-250GeV

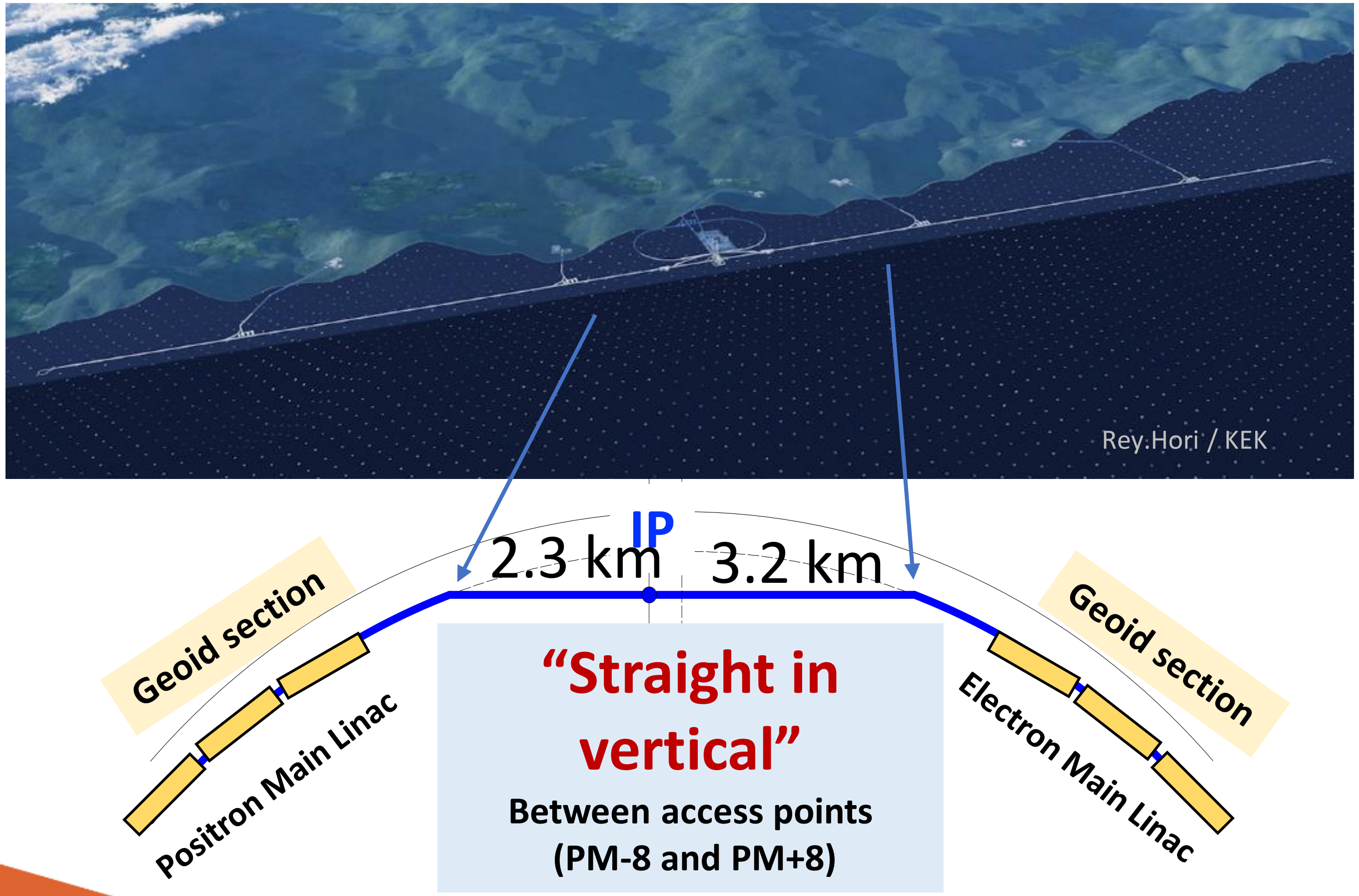
Here, the access tunnel of the model route assuming the Kitakami Mountains is shown. The average length of access tunnels is about 1 km.



N.Terunuma, AWLC2020

Laser Straight Section

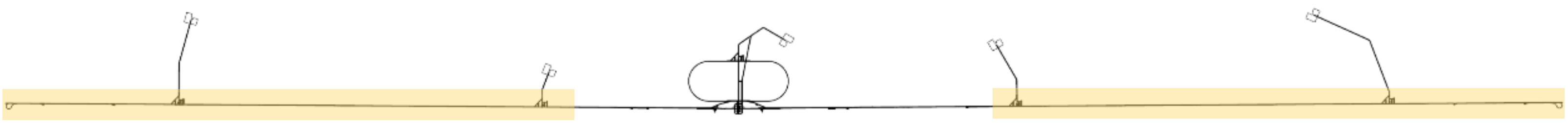
- BDS: “laser straight” in vertical
- ML: Cryomodule will be aligned to the geoid.

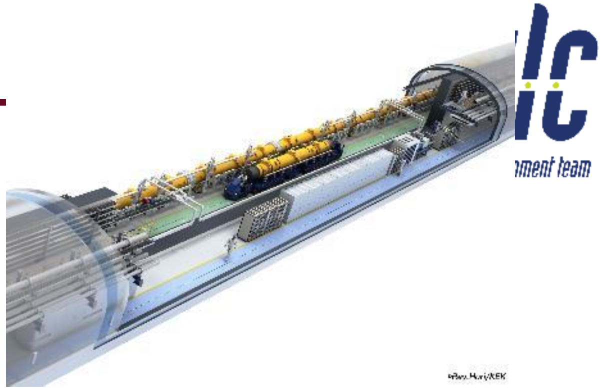


- ILC optics DECK has been updated to incorporate corrections for **geoid** and **straight sections** around the IP.
- Asymmetric straight sections
  - The e- side is longer to include undulator and dog-leg.
  - If e+ and e- MLs are at the same altitude, the IP is tilted by 0.1 mrad.
  - If e- ML is placed 0.6 m higher than e+, the IP has no tilt and BDSs are symmetrically sloped to the IP.

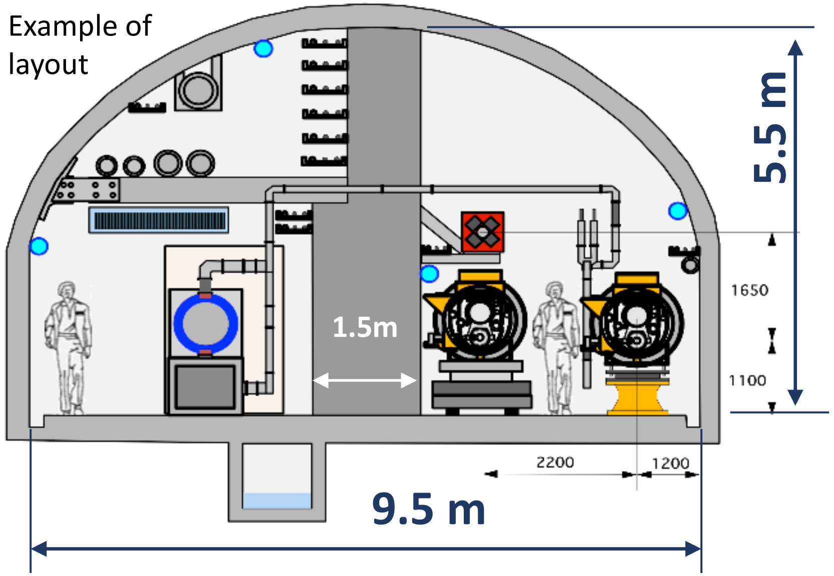
N.Terunuma, AWLC2020

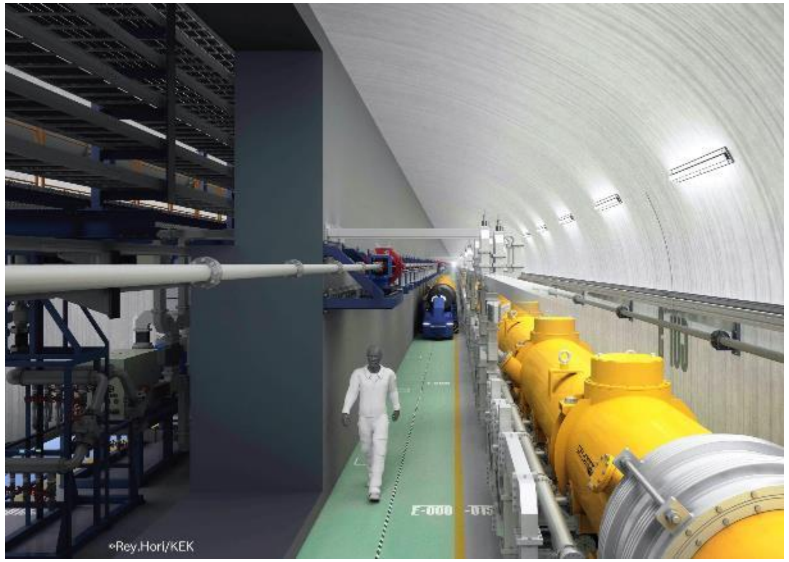
Main Linac (ML) tunnel





- 15 km in (e+e-) total
- follow the geoid in vertical
- **Kamaboko 9.5m X 5.5m**
- **1.5m central radiation shield**
- Further optimization will be done.





- **66 kV distribution cables**
- **Colling water pipes**
- Fan Coil Units
- Low power and signal cables
- **RF klystrons and modulators**
- **Electric Power Stations**

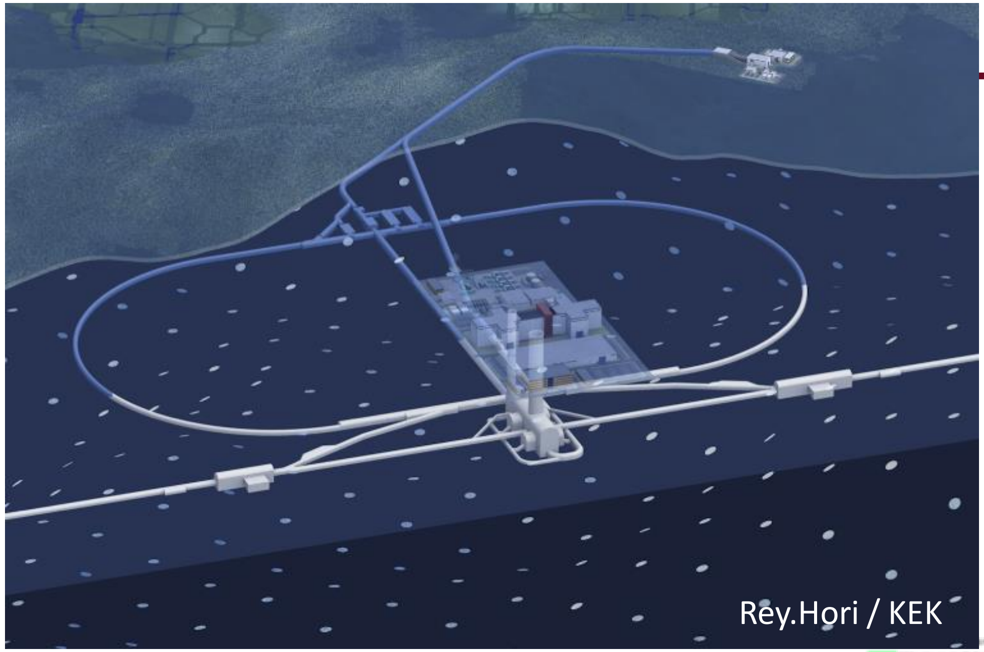
- **ML Cryomodules**
- **RTML**
- Low power and signal cables

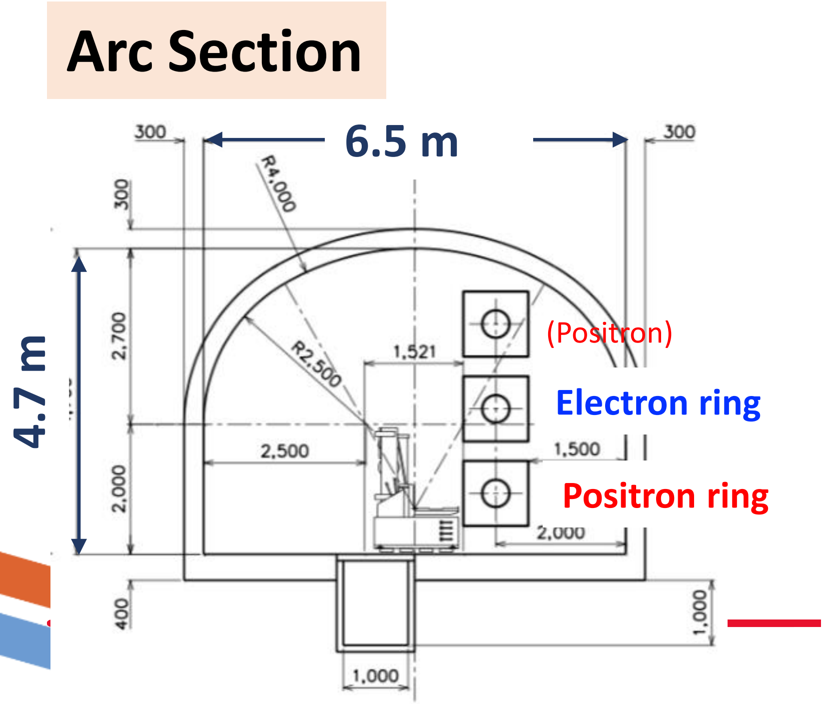
N.Terunuma, AWLC2020

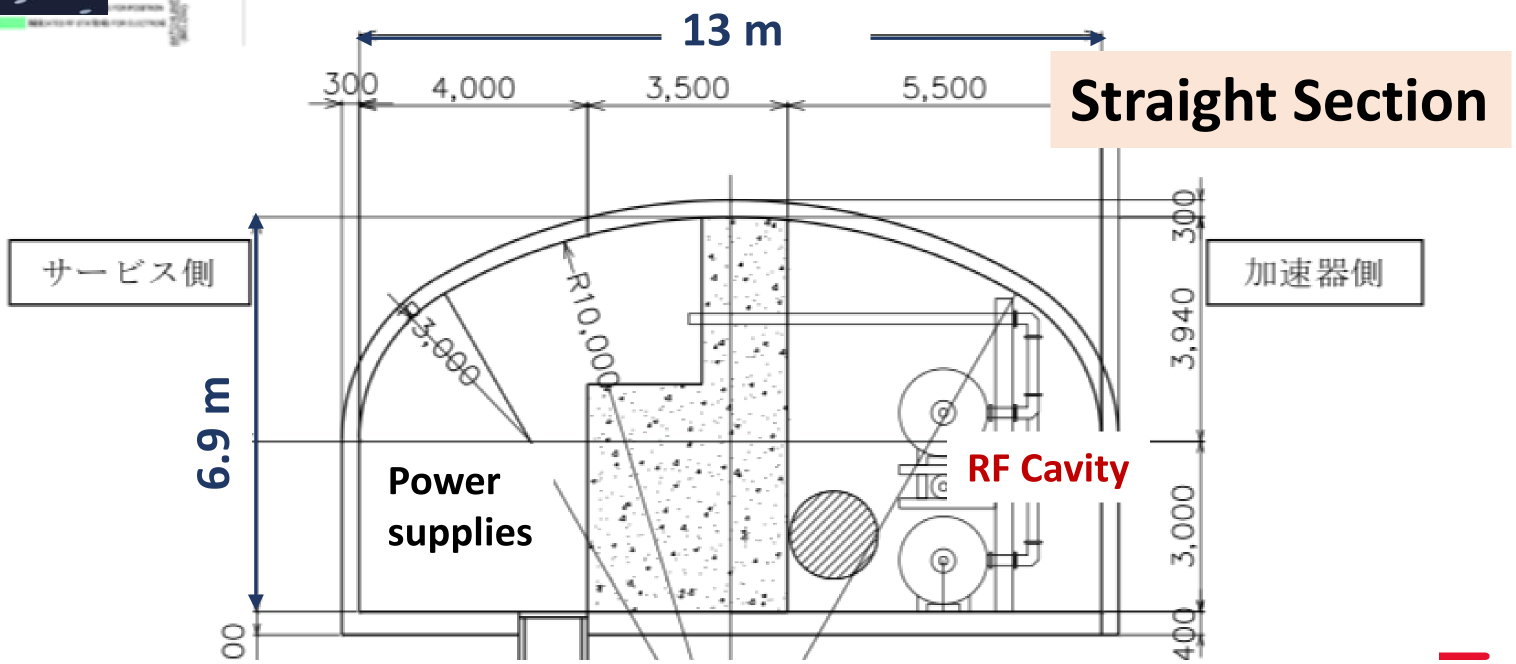
Damping Ring

N.Terunuma, AWLC2020

- Circumference: 3.2km
- Start with two rings
- Arc section: **single tunnel, no central shield.**
- Straight section: **Kamaboko with a central shield** (3.5m in TDR).





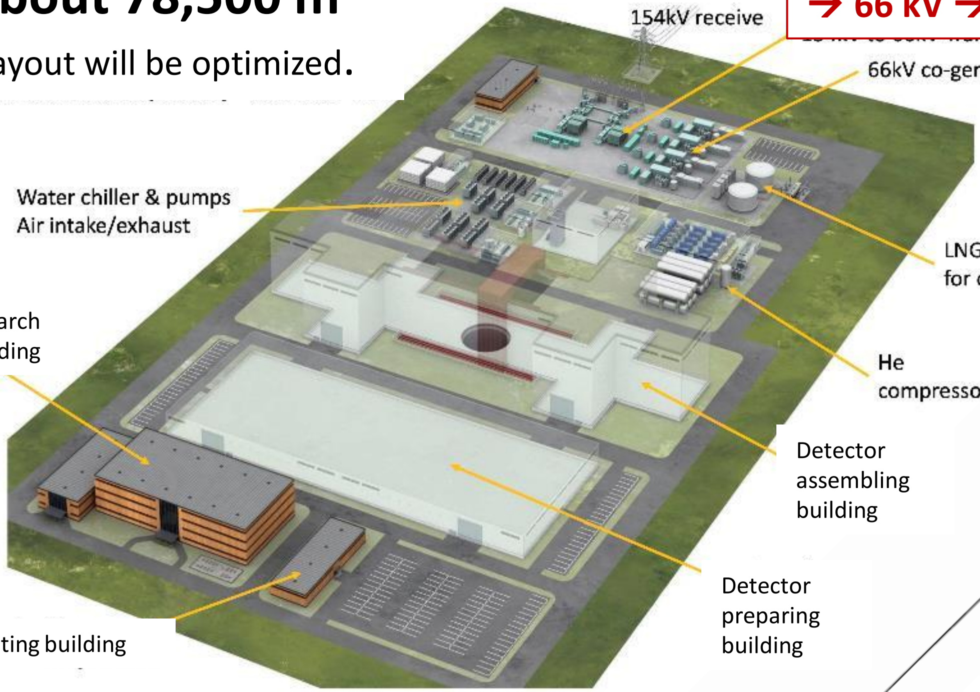


Interaction Point (IP)

N.Terunuma, AWLC2020

IP surface area
about 78,500 m^2

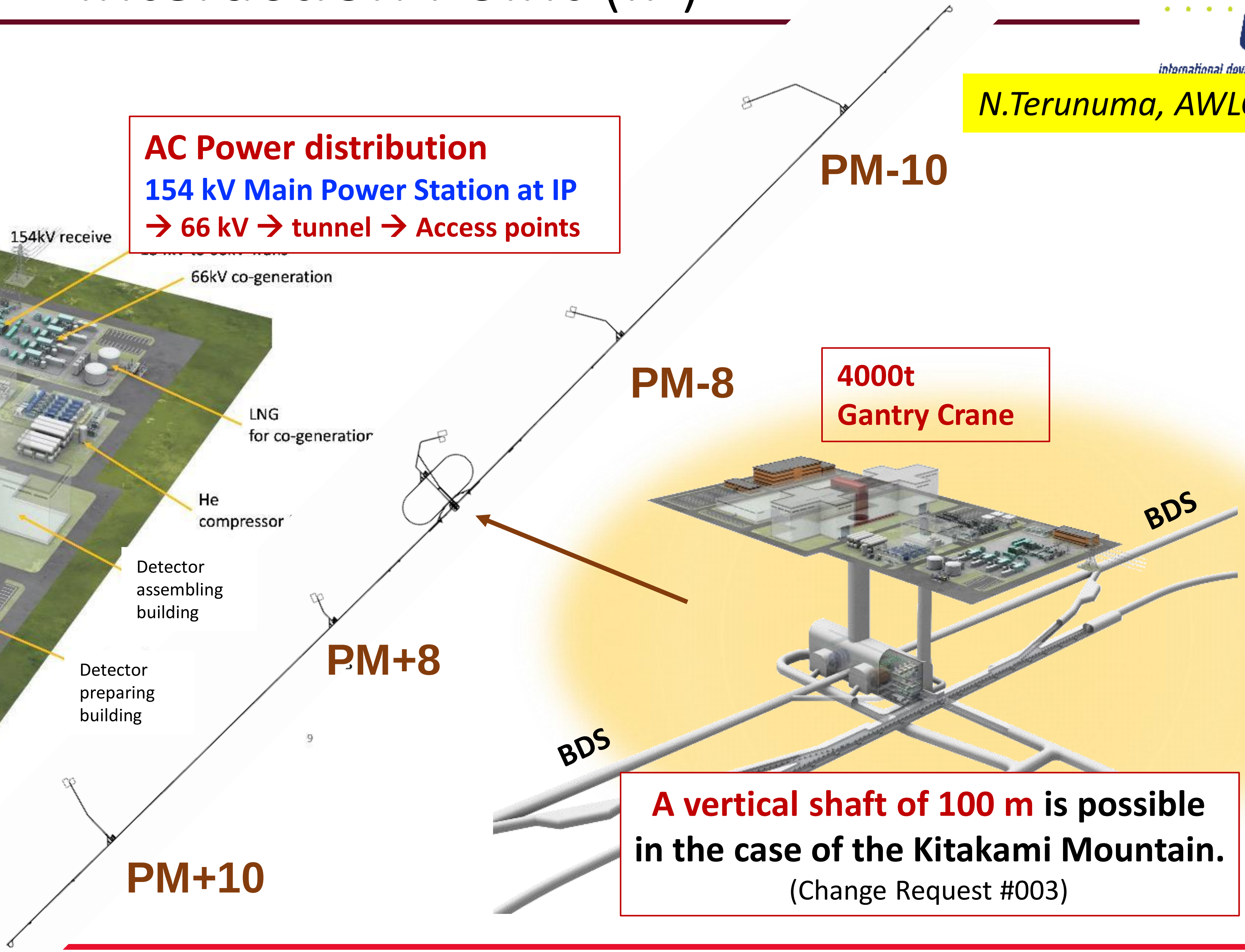
Layout will be optimized.



AC Power distribution

154 kV Main Power Station at IP

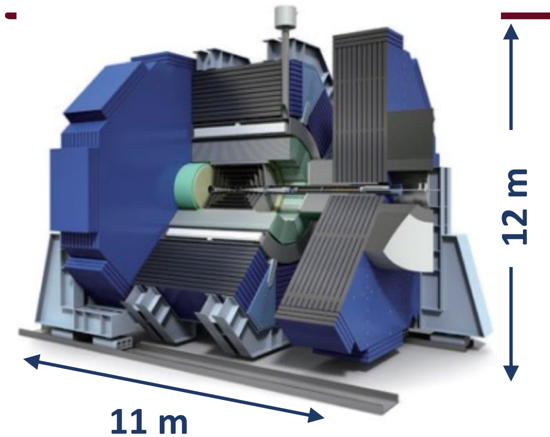
→ 66 kV → tunnel → Access points



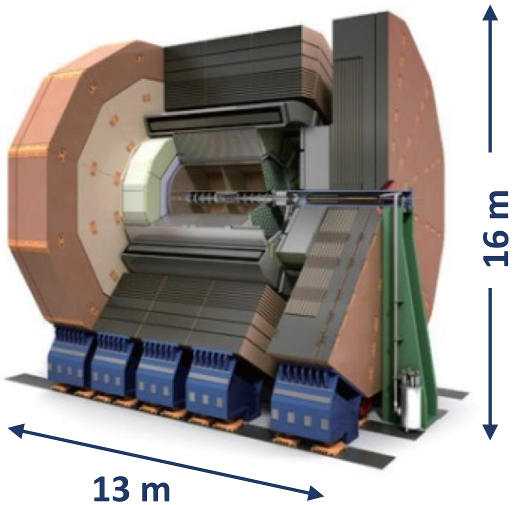
4000t
Gantry Crane

A vertical shaft of 100 m is possible in the case of the Kitakami Mountain.
(Change Request #003)

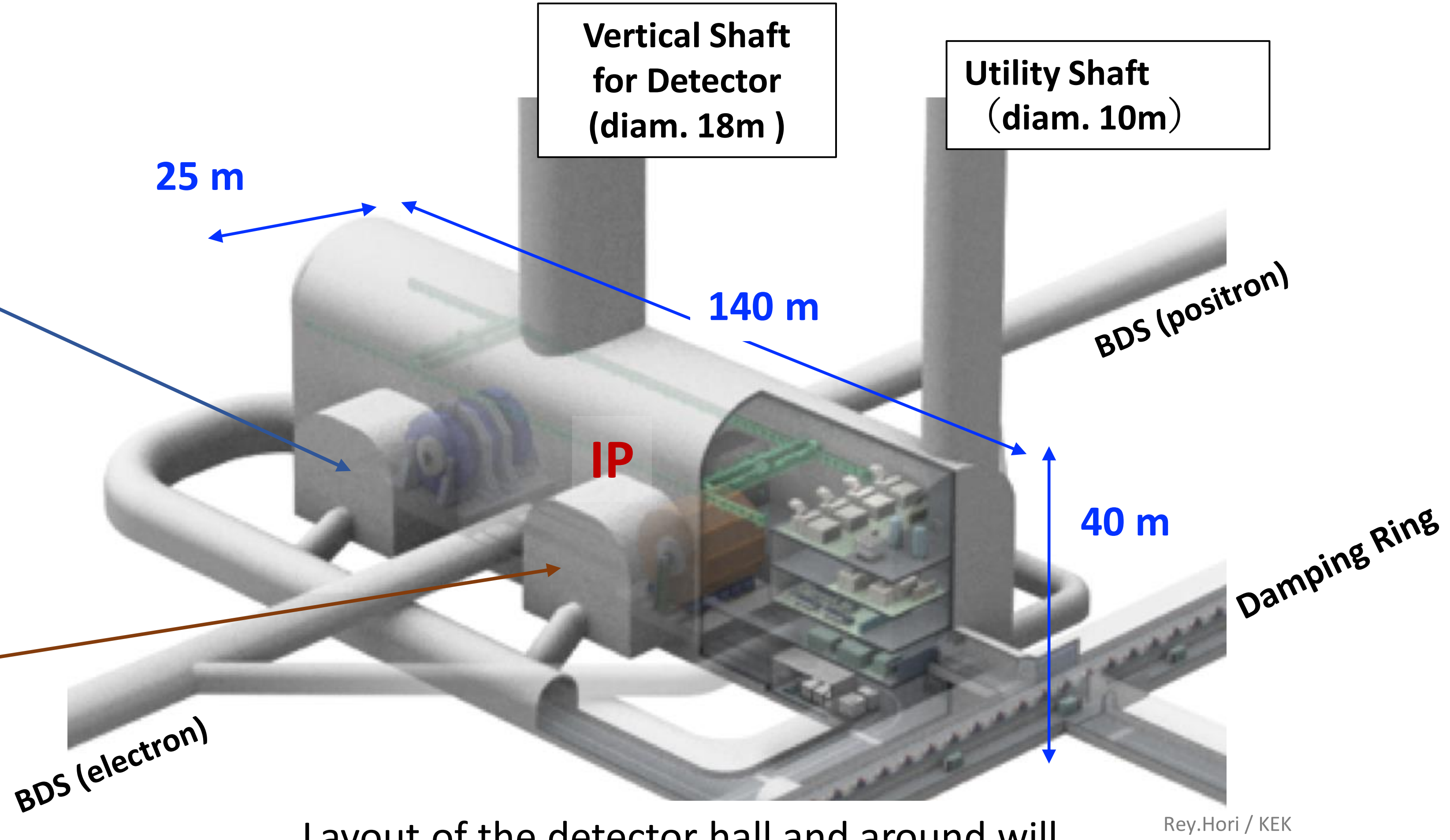
Detector Hall



SiD, 8,000 t



ILD, 15,000 t



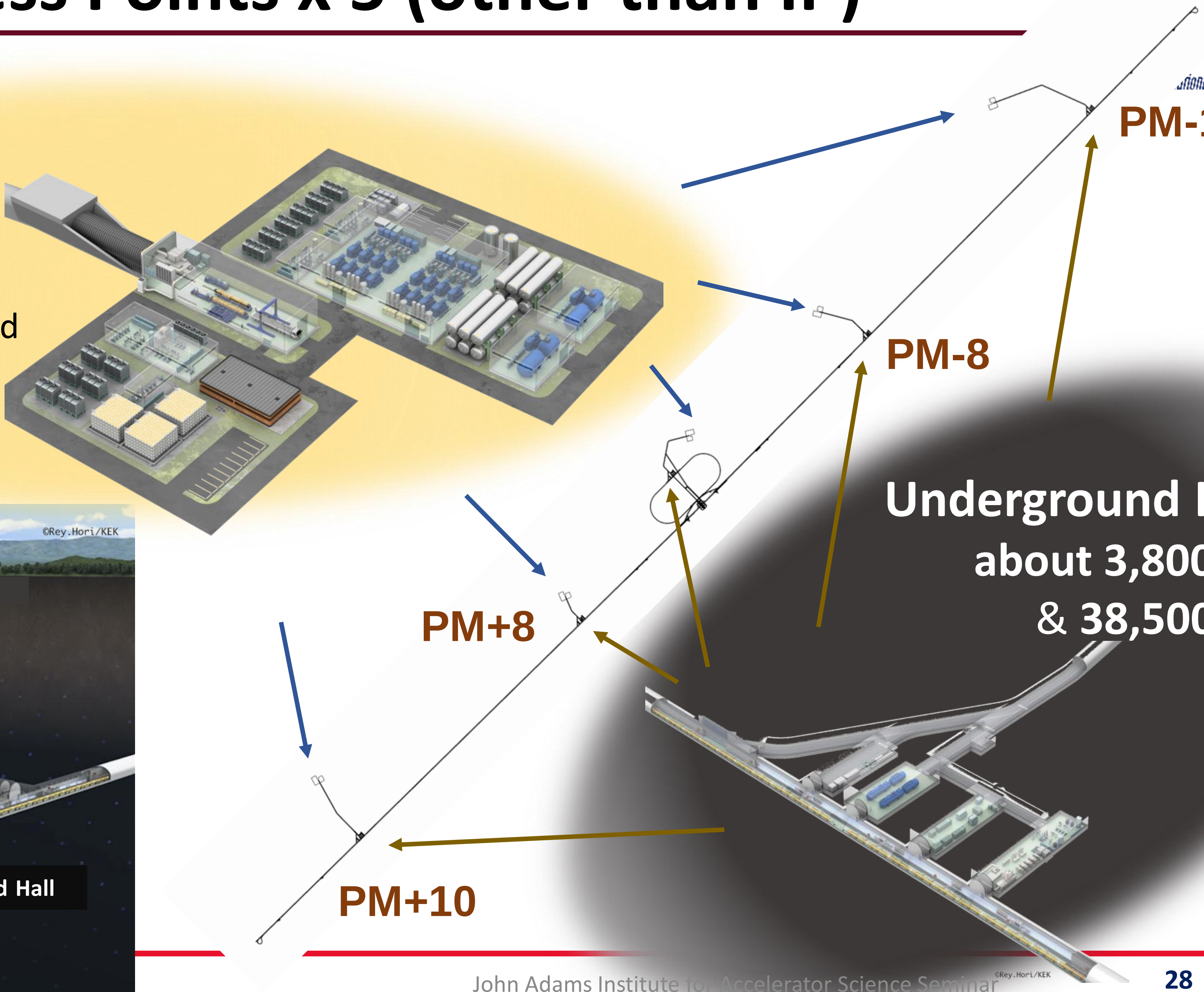
Layout of the detector hall and around will be optimized with detector groups.

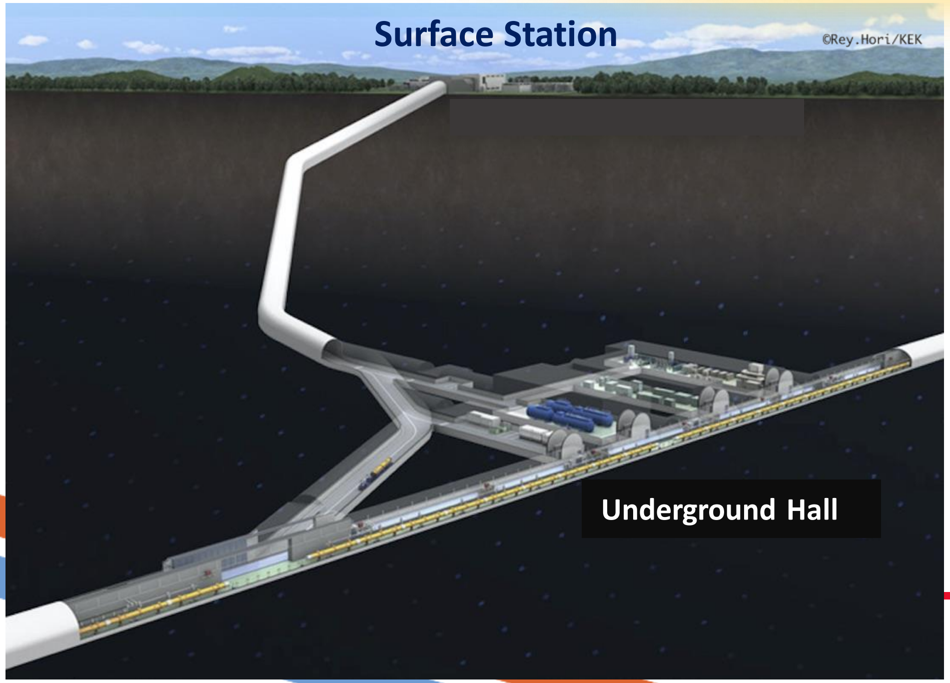
Access Points x 5 (other than IP)

Surface Station

about 16,600 m²

The ground layout is optimized by the station.



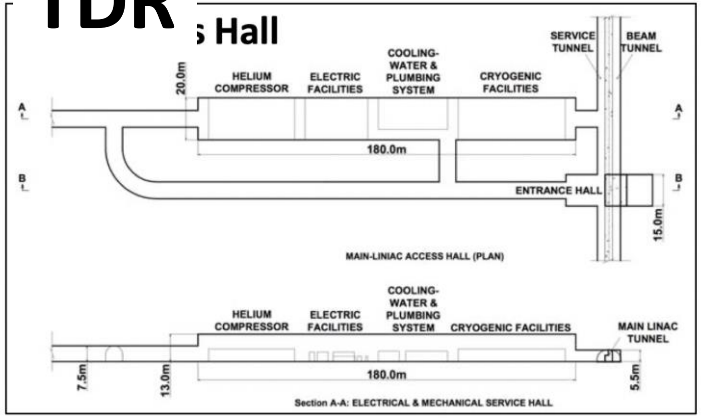


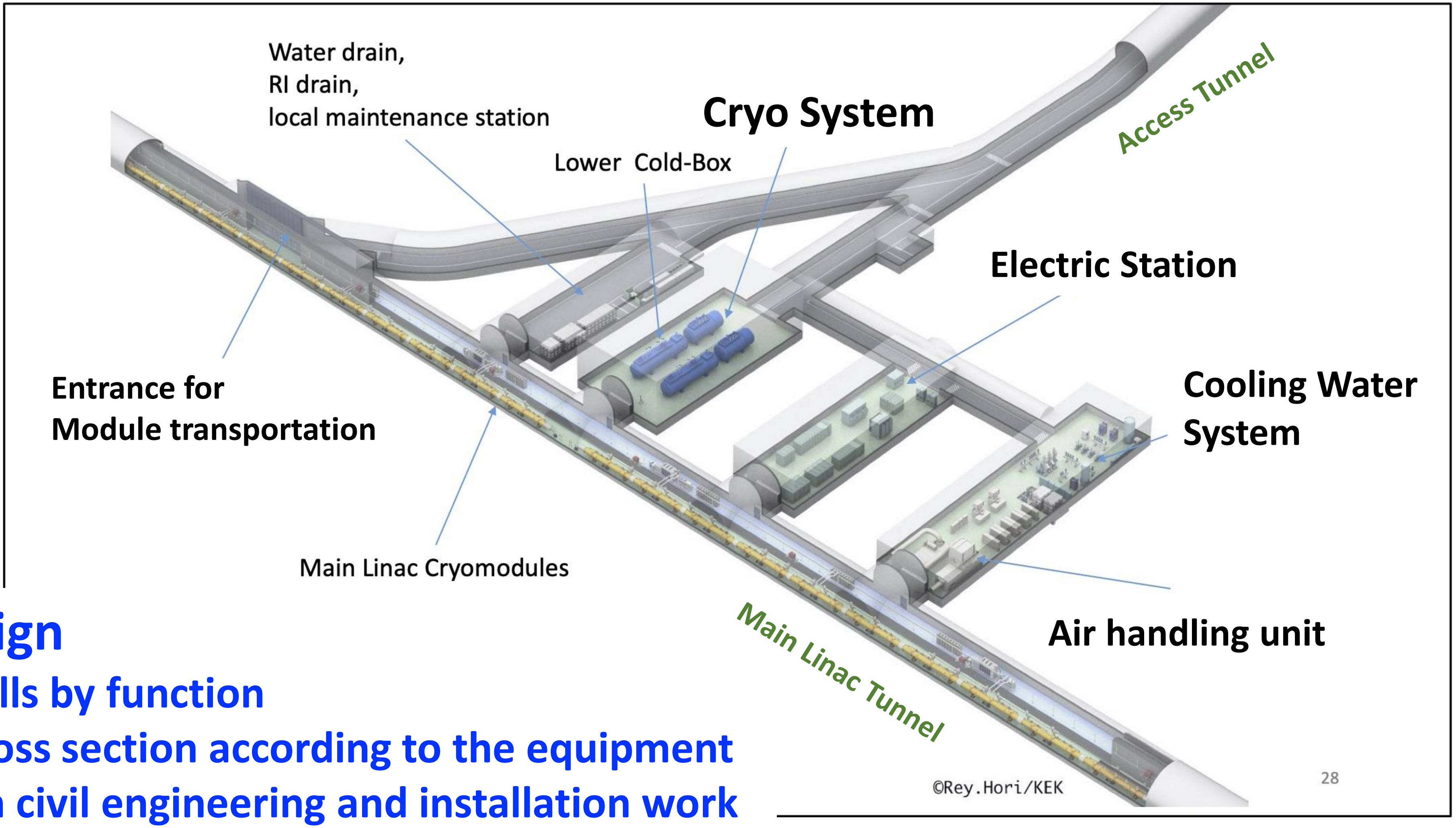
Underground Hall

about 3,800 m² & 38,500 m³

Underground Access/utility Halls

TDR

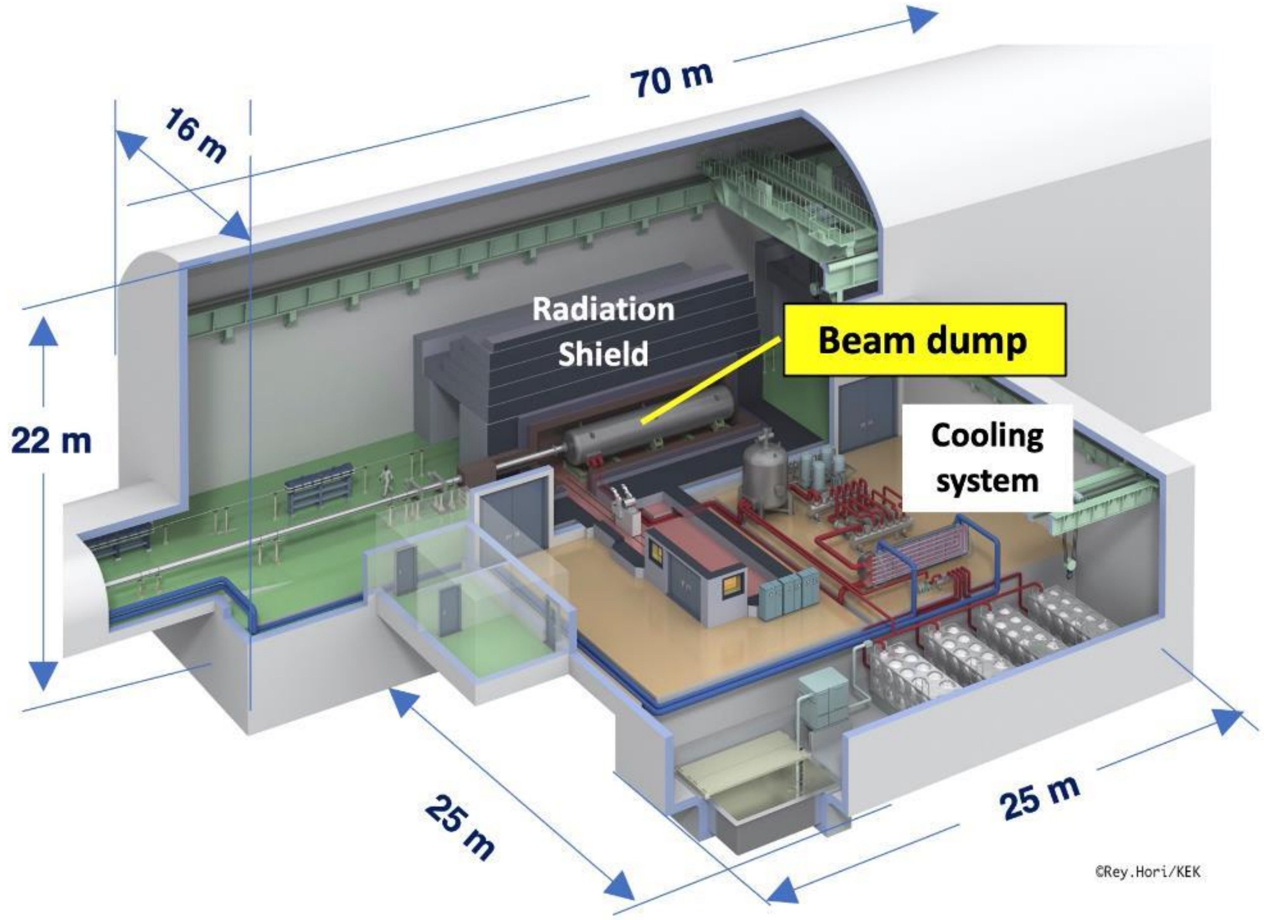




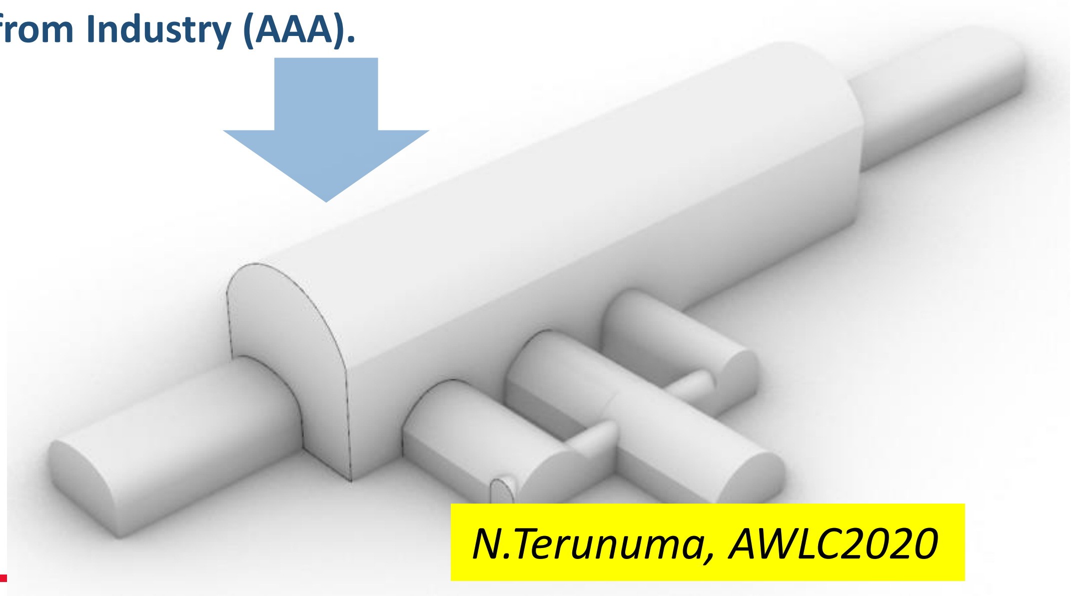
Updated Design

- Separated halls by function
- Optimized cross section according to the equipment
- advantage on civil engineering and installation work

Cavern for Main Beam Dump



- **Three big caverns**
  - Two main beam dumps
  - e- dump for undulator, low energy collision (5 x 5 Hz)
- The main beam dump has been designed for **1 TeV collisions.**
  - **5 m thick concrete shield in all directions**
  - **17 MW power cooling (wider utility hall)**
  - **¼ volume of detector hall**
- **The civil engineering design is updating with experts from Industry (AAA).**



N.Terunuma, AWLC2020

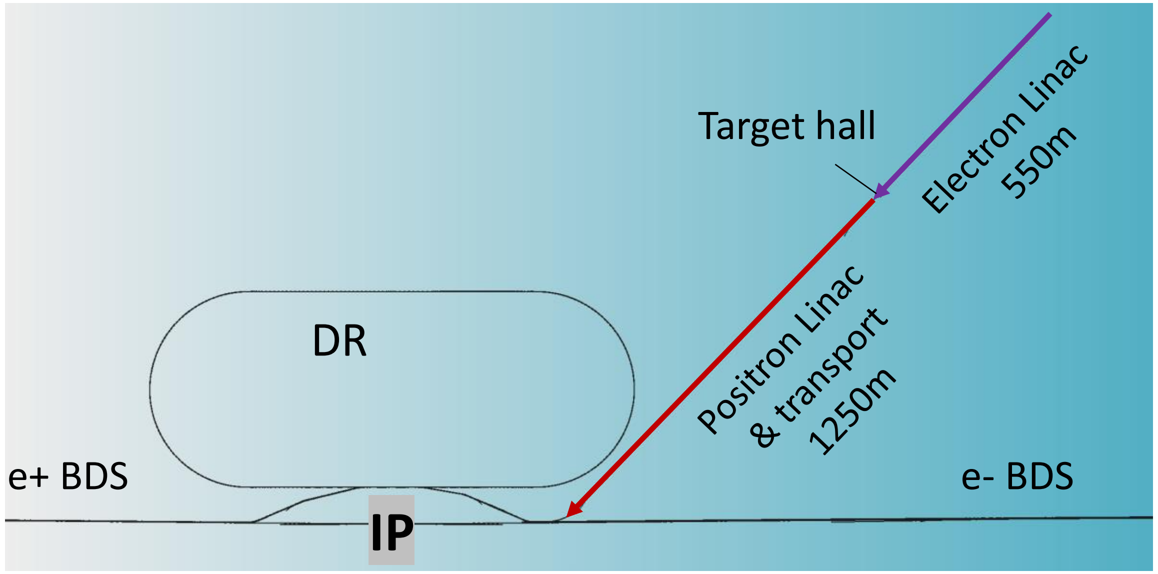
Civil Engineering Design for Positron Source

Since civil engineering (CE) work will start immediately after the preparation period, a lot of detailed design work is expected during the preparation period, so the CFS Group will proceed with the basic design of the CE for the positron source in advance.

- Have the CE design to **include the undulator scheme in any scenarios.**
  - **TDR based layout**
  - and have **Photon dump line** in the BDS tunnel
- **E-driven source** will be in **separated dedicated tunnel.**
  - **add on to the TDR based design**
  - From the CE view, sharing of BDS tunnel is not realistic.
  - e-driven study group is developing this design.
  - Access tunnel should be considered.

Design study for e-driven positron source

- Figure shows the length of the linac, taking into account the size and placement of devices.
- Positron injection into the DR uses RTL.
- Joint angle to the BDS tunnel will be optimized for local conditions.



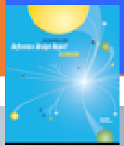
Shin MICHIZONO

International Development Team (IDT) WG2/ KEK

Brief History of ILC Collaboration

2004

2006 '07 '08 '09 '10 '11 '12 '13 '14 '15 '16 '17 '18 '19 '20



SC Technology selected

ILC-GDE

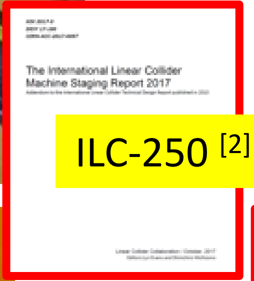
TDR

LCC

RDR)

Technical Design Phase

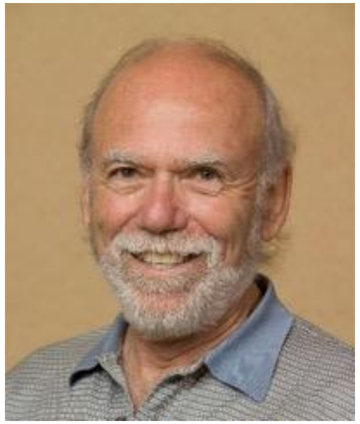
TDR [1] :
49 countries
392 institutions
>2400 researchers



ILC-250 [2]

*I*nternational *D*evelopment *T*eam

Recommendations on ILC Project Implementation [3]



Barry Barish
GDE director
(the Nobel Prize winner for physics in 2017)

Lyn Evans
LCC director
(former LHC project manager)

LHC

European XFEL

LCLS-II

From IDT to Pre-Lab, ILC construction phase

IDT is formed under ICFA. KEK serves as its host.

Stage 1 International Development Team (~1.5 years)

ILC Pre-Lab. is established by MOU's among the laboratories.

Stage 2 ILC Pre-Laboratory (4 years)

ILC Lab. is established by governmental agreement.

Stage 3 ILC Laboratory (10 years for construction)

Stage 4 Experiment at ILC!

International Development Team (IDT)

Pre-preparatory Phase | Main Preparatory Phase | Construction Phase

2020.8 (2022) About 4 years (2026) About 9 years (2035)

LCB/LCC | International Development Team | ILC Pre-Lab | ILC Laboratory

ICFA

ILC International Development Team

Executive Board

Americas Liaison	Andrew Lankford (UC Irvine)
Working Group 2 Chair	Shinichiro Michizono (KEK)
Working Group 3 Chair	Hitoshi Murayama (UC Berkeley/U. Tokyo)
Executive Board Chair and Working Group 1 Chair	Tatsuya Nakada (EPFL)
KEK Liaison	Yasuhiro Okada (KEK)
Europe Liaison	Steinar Stapnes (CERN)
Asia-Pacific Liaison	Geoffrey Taylor (U. Melbourne)

Working Group 1
Pre-Lab Setup

Working Group 2
Accelerator

Working Group 3
Physics & Detectors

IDT: to prepare for smooth transition to the ILC Pre-lab

- Prepare a proposal for the organization and governance of the ILC Pre-Lab
- Prepare the work and deliverables of the ILC Pre-laboratory and workout a scenario for contributions with national and regional partners

KEK's role at IDT and beyond

- The next focus will be when ILC Pre-Lab can be started following the IDT.

- The function of the ILC Pre-lab is to do the remaining works in four years.
    - Solve remaining technical issues of the accelerator.
    - Design of the organization and functions of the ILC laboratory
    - and launch the ILC laboratory

- Since the start of the ILC Laboratory is the official start of the ILC project, it is necessary to reach an international agreement including cost sharing before its start. The ILC Pre-Lab also plays an important role in supporting such international negotiations

- KEK is making every possible effort to start the ILC Pre-Lab soon after the IDT completes its mandate, and to realize the ILC together with the Japanese physics community and supporting groups in the political sector, industrial sector and Tohoku region.

M. Yamauchi, AWLC2020

Accelerator activities at ILC Pre-lab phase

- *Technical preparations & SRF R&D for cost reduction (Solve the technical concerns by international cooperation)* → Have been discussed at IDT-WG2
- *Final technical design and documentation (Engineering Design Report, Cost confirmation)*
- *Preparation and planning of mass production*
- *Civil engineering, local infrastructure and site*

	IDT	ILC Pre-Lab				ILC Lab.										
	PP	P1	P2	P3	P4	1	2	3	4	5	6	7	8	9	10	Phys. Exp.
Preparation CE/Utility, Survey, Design Acc. Industrialization prep.																
Construction																
Civil Eng.																
Building, Utilities																
Acc. Systems																
Installation																
Commissioning																
Physics Exp.																

IDT-WG2 organization

IDT EB

IDT WG2
Shin Michizono (Chair)
Benno List (Deputy)

Charges of Sub-groups

- Discuss and coordinate the topics for
  - technical preparation (remaining topics) at Pre-lab
  - preparation for mass production at Pre-lab
  - possible schedule at Pre-lab
  - international sharing candidates of these activities
  - final technical design and documentation
- Report to the IDT-WG2

SRF

Yasuchika Yamamoto	***KEK***
Sergey Belomestnykh	FNAL
Nuria Catalan	CERN
Enrico Cenni	CEA
Dimitri Delikaris	CERN
Rongli Geng	JLAB
Hitoshi Hayano	KEK
Bob Laxdal	Triumf
Matthias Liepe	Cornell
Peter McIntosh	STFC
Laura Monaco	INFN Milano
Olivier Napoly	CEA
Sam Posen	FNAL
Robert Rimmer	JLAB
Marc C. Ross	SLAC
Luis Garcia Tabares	CIEMAT
Kensei Umemori	KEK
Hans Weise	DESY
Akira Yamamoto	KEK

DR/BDS/Dump

Toshiyuki Okugi	***KEK***
Karsten Buesser	DESY
Philip Burrows	U. Oxford
Angeles Faus-Golfe	LAL
Andrea Latina	CERN
Kiyoshi Kubo	KEK
Jenny List	DESY
Thomas Markiewicz	SLAC
Brett Parker	BNL
Ivan Podadera	CIEMAT
David L. Rubin	Cornell
Nikolay Solyak	FNAL
Nobuhiro Terunuma	KEK
Glen White	SLAC
Kaoru Yokoya	KEK
Mikhail Zobov	INFN LNF

CRAB

Dump

Nobuhiro Terunuma	***KEK***
Toshiyuki Okugi	KEK

Chris Densham(STFC)
Marco Calviani (CERN)
Yu Morikawa (KEK)
Fernadno Sordo (ESS Bilbao)
Peter Sievers (CERN)

Sources

Kaoru Yokoya	***KEK***
Jim Clarke	STFC
Steffen Doebert	CERN
Joe Grames	JLAB
Hitoshi Hayano	KEK
Masao Kuriki	U. Hiroshima
Benno List	DESY
Gudrid Moortgat-Pick	U. Hamburg

Peter Sievers (CERN)
Sabine Riemann (DESY)

Civil engineering

Nobuhiro Terunuma	***KEK***
John Andrew Osborne	CERN
Tomoyuki Sanuki	U. Tohoku

ILC Pre-Lab

Real cavity and cryomodule production

ML&SRF

- WP-1 Cavity production
- WP-2 Cryomodule transfer
- WP-3 Crab cavity

Sources

Electron source

- WP-4 Electron source

Positron sources

Undulator scheme

- WP-5 Undulator
- WP-6 Rotating target
- WP-7 Magnetic focusing

E-driven scheme

- WP-8 Rotating target
- WP-9 Magnetic focusing
- WP-10 Capture cavity
- WP-11 Target replacement

DR

- WP-12 System design
- WP-13 Collective effect
- WP-14 Injection/extraction

BDS

- WP-15 Final focus
- WP-16 Final doublet

Dump

- WP-17 Main dump
- WP-18 Photon dump

Technical preparation (total 18 WPs)
Total ˜57 MILCU ˜360 FTE-yr + infrastructure at each region
Internal review is scheduled on end of Feb.

The International Linear Collider

Shin MICHIZONO

International Development Team (IDT) WG2/ KEK

- *ILC250 accelerator overview*
- *ILC area systems*
  - *Sources*
  - *Nano-beam*
  - *SRF*
- *Civil engineering*
- *International Development Team (IDT)*
- *Global situation*
- *Summary*

JAHEP ILC Steering Panel

- In October 2020, the Japan High Energy Physics Committee (HEPC) that represents the Japanese high energy physics community (Japan Association of High Energy Physics – JAHEP) established the ILC Steering Panel to accelerate community-wide efforts to realize the ILC.
- The ILC Steering Panel, chaired by Satoru Yamashita, is charged to lead the community to advance the ILC project and actively cooperate with other scientific communities, government authorities, legislators, corporate leaders, regional governments, and media, as well as international communities and authorities, toward timely realization of the ILC in Japan.
- The Panel is expected to work closely with the ILC International Development Team and KEK.

ILC Steering Panel Members :

Shoji Asai (University of Tokyo)
Kazunori Hanagaki (KEK)
Toru Iijima (Nagoya University)
Kiyotomo Kawagoe (Kyushu University)
Sachio Komamiya (Waseda University)
Shinichiro Michizono (KEK)
Toshinori Mori (University of Tokyo)
Hitoshi Murayama (UC Berkeley/University of Tokyo)
Yutaka Ushiroda (KEK)
Hitoshi Yamamoto (Tohoku University/IFIC Valencia)
Satoru Yamashita (University of Tokyo) – Chair

US – Japan on ILC

U.S. Deputy Secretary of State Stephen Biegun sent a letter to Japan's Foreign Minister Motegi in February 2020.
It is necessary to take decisive action to ensure that Japan and the United States continue to be at the forefront in particle physics, and I strongly support the progress of the International Linear Collider Program. (Article in the Yomiuri newspaper on May 13, 2020, translation by MY)

Workshop pages (link)

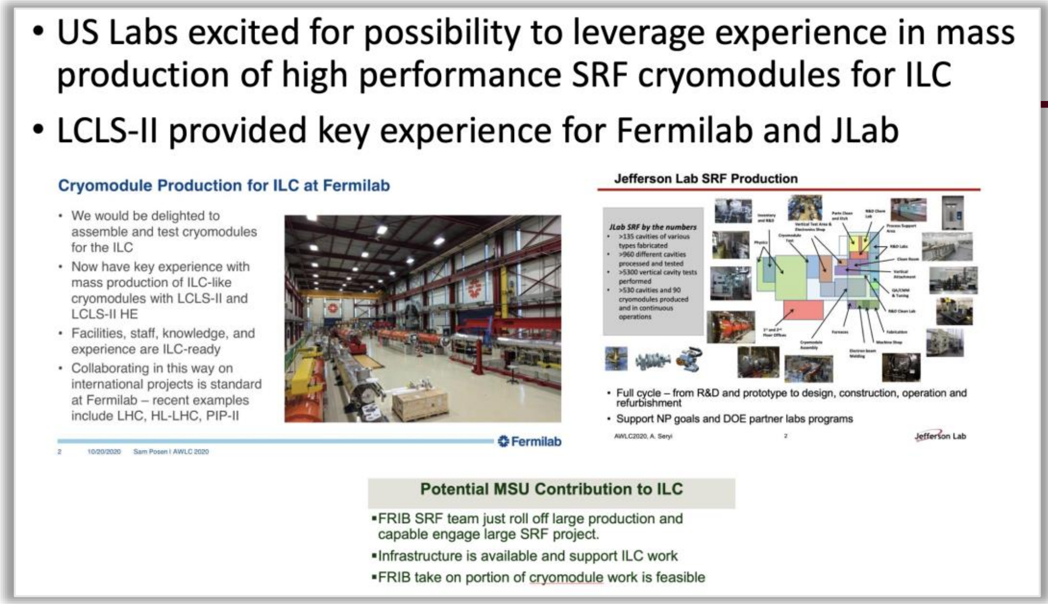
US government views of the ILC - DOE — *Dr Chris Fall*
Zoom 15:10 - 15:20

US government views of the ILC - NSF — *Dr Saul Gonzalez*
Zoom 15:20 - 15:30

US government views of the ILC - State Department — *L. Reece Smyth*
Zoom 15:30 - 15:40

- As I have expressed before, there is strong interest in participation by the United States in the ILC program.
- Earlier this year in February, the Secretary of Energy Brouillette also expressed these same thoughts when he wrote to Japan's Cabinet Minister of State for Science and Technology Policy, Mr. Takemoto.
- We plan to continue discussions both bilaterally with MEXT and other officials in the Government of Japan, and multilaterally with the governments of other global regions to not only have a dialogue on the sharing of costs and resources, but also in understanding organizational and governance models for such a largescale research facility as the ILC.

We support the decision to move the ILC efforts forward through the ILC International Development Team, and will continue to work to help educate partner governments about the value of this facility. We also look forward to coordinating with the Government of Japan to advance the facility.



Please see details from parallel session of the Americas Workshop on Linear Colliders (pictures extracted from summary by S.Posen): [link]

Americas– summary

- Strong push in the US (all the examples above) at all levels, many labs interested and well aligned towards ILC, and in many cases using significant resources in developments directly relevant for ILC
- Snowmass process important: in addition to collider experiments at ILC also other possibilities, as for example Dark Sector physics at ILC, etc.
- Focus on young/next generation in many sessions (Americas workshop on LC and Snowmass)
- Interests and capabilities in Canada (talks by A.Bellerive and O.Kester) and Latin America (talk by M.Losada)

ILC Pre-Lab US SRF Program Draft

Version: November 9. 2020

Task	Notes	Goal	US Labs	Year 1	Year 2	Year 3	Year 4
Field emission and cavity cleaning R&D, e.g. HPP and plasma processing on cavities, development of robotics during cavity assembly, and LN cleaning		(1) Perf	Cornell, FNAL, JLAB, others?				
Yield study (1) with 30 new 9-cell cavities; cold EP + 2-step bake	use new cavities from established vendor	(2) Yield	FNAL, JLAB				
Single cell and 9-cell R&D program to further optimize cavity preparation protocol		(1) Perf	Cornell, FNAL, JLAB, others?				
Yield study (2) with 30 new 9-cell cavities; optimized preparation protocol		(2) Yield	FNAL, JLAB				
Module transport engineering design and studies, including dummy module transport		(3) CM	FNAL, JLAB, SLAC				
Cryomodule optimization for transport		(3) CM	FNAL, JLAB, SLAC				
Cavity accessory components R&D (e.g., tuner, coupler…), e.g. for higher gradients		(3) CM	Cornell, FNAL, JLAB, others?				
Order/fab components for 4 prototype cryomodules		(3) CM	FNAL, JLAB				
Assembly and testing of two prototype cryomodules, with cavities from yield study (1)		(3) CM	FNAL, JLAB				
Field emission studies, including HPP and plasma processing on cryomodules		(3) CM	FNAL, JLAB				
Cryomodule transportation testing (US roundtrips)		(3) CM	FNAL, JLAB				
Cryomodule transportation testing (ship to Japan)	cavities used from yield study (1) would have to be compliant with Japanese HPG regulation	(3) CM	FNAL, JLAB				
Assembly and testing of two prototype cryomodules, with cavities from yield study (2); implement field emission prevention methods during assembly, e.g. robotics in collaboration with CEA		(3) CM	FNAL, JLAB				
Engineering Design Report (SRF part)		EDR	All				
Preparation for mass production / module assembly		Planning and preparation	FNAL, JLAB, others?				
US supply chain development		Planning and preparation	FNAL, JLAB, others?				

LASF4RI

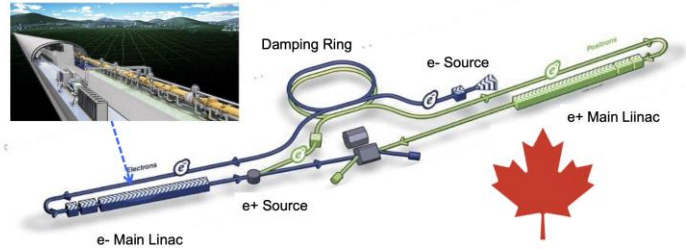
Latin American Strategy Forum for Research Infrastructure

Developing a strategy to strengthen Latin American Scientific Collaborations and their impact.

Potential areas of Canadian Contribution to ILC via TRIUMF

- SRF/RF (crab (or other) cavities, cryomodules, rf ancillaries)
  SRF research on break-down fields and effect of doping
- HV kickers, beam painting magnets and Rf bunch deflectors
- Beam physics (space charge dominated beam, Hamiltonian based fast envelope code, machine learning)
- High brightness electron gun
- e-beam diagnostics
- Normal conducting magnets (also permanent magnet optics for e-beam lines)

24



Europe and ILC

Homework done in 2018: European planning document 2018 – presented to CERN Council in June 2018
(slightly more was done than showed in the document concerning in-kind and resource profiles)

Focus on European capabilities for ILC (e.g. SFR on the right)

July 2, 2018

Preparation Plan for European Participation in the International Linear Collider

Towards a European Contribution to the ILC

Authors: Philip Bambade (LAL Orsay)
Philip Burrows (Oxford)
Angeles Faus-Golfe (IFIC-Valencia and LAL)
Brian Foster (DESY)
Andrea Jeremie (LAPP Annecy)
Benno List (DESY)
Olivier Napoly (CEA-Saclay)
Thomas Schörner-Sadenius (DESY)
Marcel Stanitzki (DESY)
Steinar Stapnes (CERN)
Nick Walker (DESY)
Hans Weise (DESY)

Content

	Germany	France		Italy	Poland			Russia	Spain
	DESY	CEA Saclay	LAL	INFN Milan	IFJ PAN	WUT	NCBJ	BINP	CIEMAT
Linac									
Cryomodules	✓	✓		✓					
SCRF Cavities	✓			✓					
Power Couplers	✓		✓						
HOM Couplers							✓		
Frequency Tuners	✓								
Cold Vacuum	✓							✓	
Cavity String Assembly	✓	✓							
SC Magnets	✓				✓				✓
Infrastructure									
AMTF	✓				✓	✓		✓	
Cryogenics	✓								
Sites & Buildings									
AMTF hall	✓								

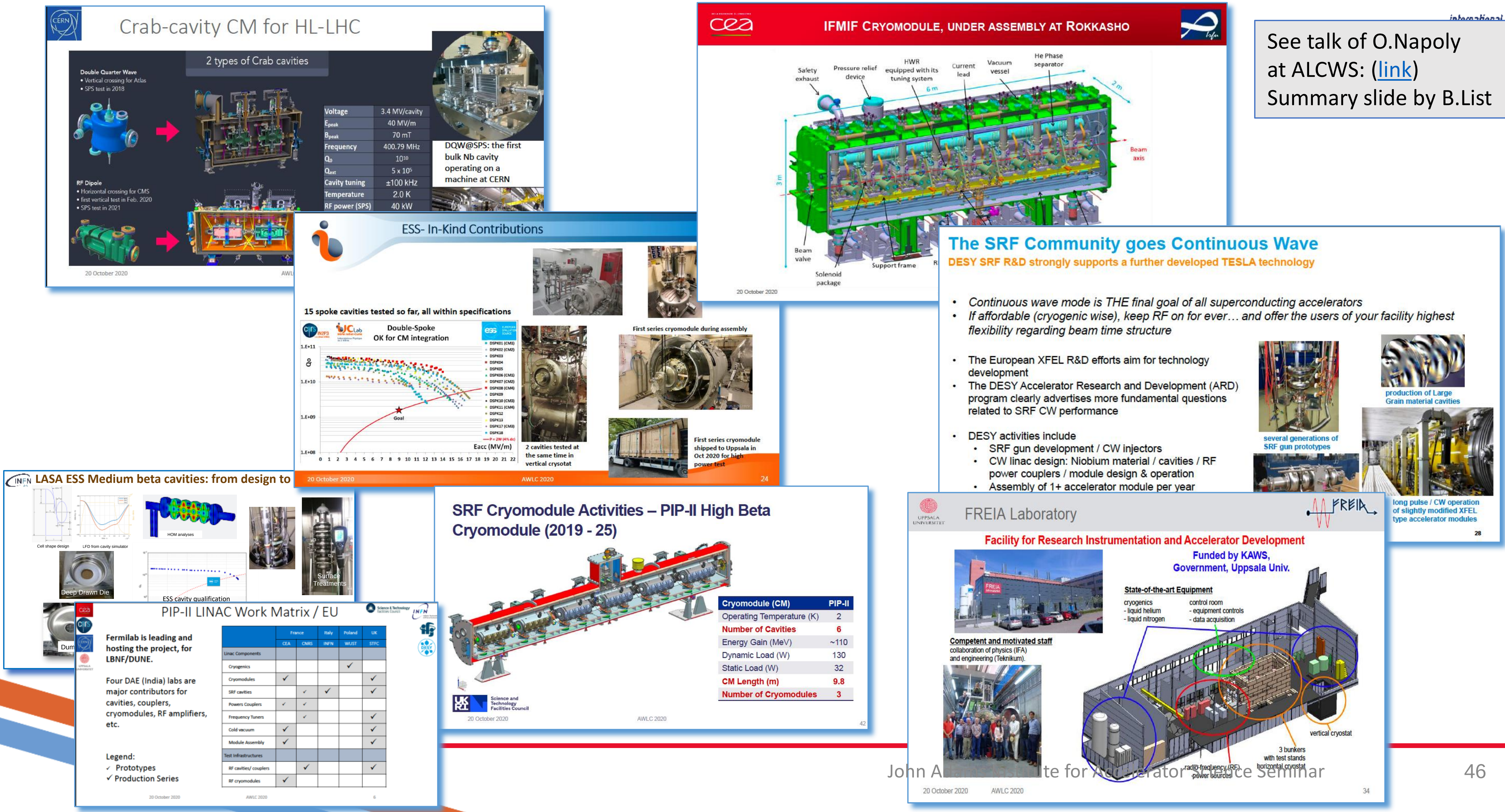
Table 2: Responsibility matrix for cryomodule production and testing for the European XFEL.

	Germany	France		Italy		Poland	Spain	Sweden		UK
	DESY	CEA	IPNO	Elettra	INFN-LASA	IFJ-PAN	ESS Bilbao	ESS	Uppsala	STFC
RF systems				✓			✓	✓		
LLRF									✓	
Cryomodules		✓	✓							
SCRF Cavities		✓	✓		✓					✓
Power Couplers		✓	✓							
HOM couplers										
Frequency Tuners		✓	✓							
Cold Vacuum		✓	✓					✓		
Cavity String Assembly		✓	✓							
RF Tests (Cavites)	✓									✓
RF Tests (Cryomodules)		✓	✓			✓		✓	✓	

Table 3: Responsibility matrix for the cryomodule production and testing for the ESS.

A broad SRF technology base

See talk of O.Napoly
at ALCWS: (link)
Summary slide by B.List



UK – renewed engagement in view of Pre-lab planning

Linear Collider UK (LCUK) Collaboration

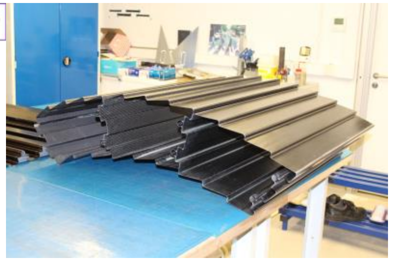
Contacts: Philip Burrows, Aidan Robson

Long standing Consortium of UK particle physics experiment, theory and accelerator groups with interests in a linear collider.

- Previous strong UK research council support for ILC R&D projects, but only very modest support since 2013
- Strong joint CERN/UK CLIC programme 2011-20 (‘CLIC-UK’)
- Detector R&D largely pursued via CALICE, AIDA2020 … main UK technical interests in silicon vertex/tracking, calorimetry, DAQ/trigger
- Synergies with CLIC, FCCee, CEPC in both detector + accelerator systems remain important

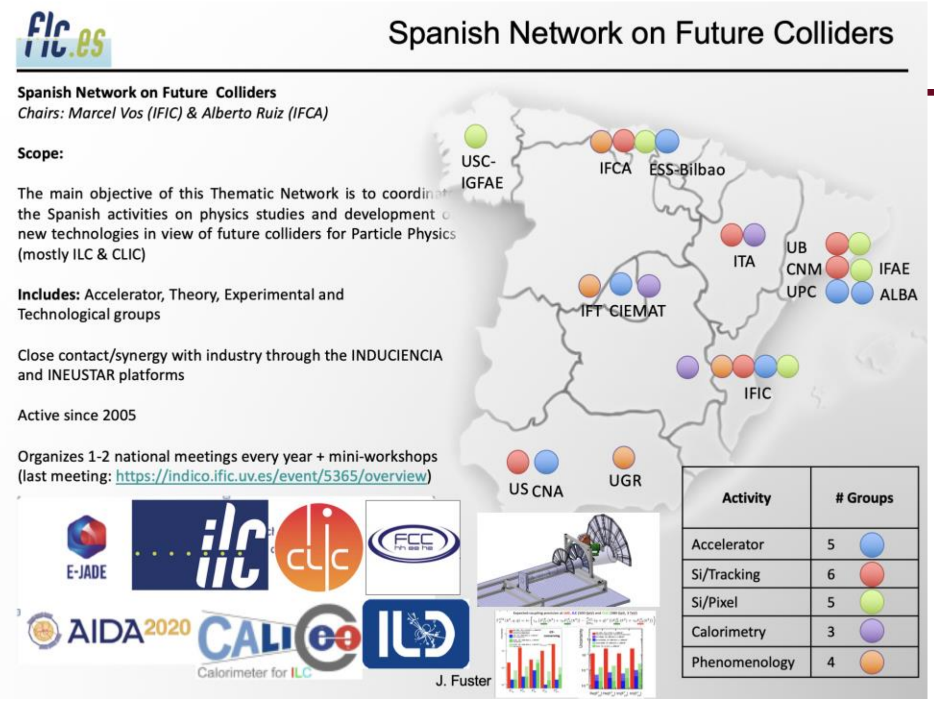
Updates:

- STFC engaged and informed on ILC, UK Tokyo Embassy following ILC developments closely
- LCUK community planning meeting on ILC 18/9/20: https://indico.cern.ch/event/943948/
- UK physicists are engaging with IDT WGs
- UK PP roadmap update (in light of EPPSU) → Spring 2021
  - LCUK input (16/10/20): ‘UK participation in the International Linear Collider’
  - Outline case made for UK contributions to Pre-lab + Construction phases (see matrix on the right of key “capabilities”)
- Engagement with UK industry ongoing → ‘in-kind’ contributions essential



Institute \ Technical system	Accelerator					Detector			Physics
	BDS/MDI	DR	Beam dumps	e+ source	RF	Si tracker	Calorimetry	DAQ	
Birmingham	X					X	X		X
Bristol						X		X	X
Brunel						X		X	X
Cambridge							X		X
STFC – Daresbury Laboratory	X			X	X				
Durham IPPP									X
Edinburgh						X			X
Glasgow						X			X
Imperial College							X	X	X
Lancaster				X	X	X			X
Liverpool		X				X			X
Manchester	X				X	X			X
Open University						X			
Oxford	X	X			X	X		X	X
QMUL						X			X
STFC – RAL			X			X	X	X	X
RHUL	X							X	X
Sheffield						X			X
Southampton									X
Sussex							X	X	X
UCL	X						X	X	X
Warwick						X			X

Spain – consider deliverables from labs and industry, linking to industrial programmes



Japanese-Spanish regular meetings for ILC planning and possible contributions

- Documentation of Scientific and Technology case of the ILC, as well as Industrial Opportunities
- On-going discussion on possible Spanish technological/industrial interests to the ILC accelerator.

CIEMAT/IFIC: exploring a possible contribution to the splitable, super-conducting magnets of the main LINAC
ALBA-synchrotron: interest in the design of parts of the ILC damping ring,
ESS-Bilbao: interest expressed in the beam dump system of the ILC

INDUCIENCIA/INEUSTAR: identifying companies with interest/capacity to contribute to the construction and matching with scientific and technological interest of the public institutes

Network meetings being followed by: Steinar Stapnes (CERN), Nobuhiro Terunuma (KEK), Akira Yamamoto (CERN/KEK), Hitoshi Yamamoto (Tohoku University /IFIC)

CERN – KEK agreement for the ILC IDT

- CERN will facilitate the European participation in the work during the transition to the Pre-Lab Phase; including working groups on Pre-Lab preparation, accelerator and facility, and physics and detectors.
- CERN will coordinate the European contributions to the IDT's common fund, as well as the in-kind contributions to the tasks supported by the common fund during the preparation of the Pre-Lab Phase. The CERN office at KEK (set up under Appendix 10) will, as one of its tasks, provide administrative support to the European efforts related to transition to the Pre-Lab Phase.
- The Parties will continue, or, as the case may be, undertake, collaborative work in studies related to:
  - the accelerator's beam-delivery system and the Accelerator Test Facility 2 (ATF2) (as set out in the 2009 Agreement on Collaborative Work and Appendix 13);
  - high gradient acceleration for linear colliders;
  - high efficiency klystrons (as set out in Appendix 23);
  - detector, physics and software (as set out in Appendix 8);
  - cryogenics systems, beam-dumps, superconducting radiofrequency (SC RF) module components and technologies, civil engineering (all areas where CERN has provided technical advice as part of the LCC collaboration); and
  - other areas of common interest (e.g.: positron production and beam-dynamics) and/or information exchange related to common challenges (e.g.: costing methodology and power reduction studies).
- Any existing collaborative work referred to above will continue to be executed under its relevant Appendix.

APPENDIX 24

to

The Agreement on Collaborative Work (ICA-JP-0103)

between

THE HIGH-ENERGY ACCELERATOR RESEARCH ORGANIZATION (KEK)

and

THE EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

concerning

The work of the ILC International Development Team to facilitate the transition into the "Pre-Lab Phase"

2020

Shin MICHIZONO

International Development Team (IDT) WG2/ KEK

- *ILC250 accelerator overview*
- *ILC area systems*
  - *Sources*
  - *Nano-beam*
  - *SRF*
- *Civil engineering*
- *International Development Team (IDT)*
- *Global situation*
- *Summary*

Summary

- *ILC250 accelerator is 20 km long e-/e+ collider for the Higgs factory.*
- *The ILC is upgradable in energy and luminosity.*
- *Key technologies at the ILC are superconducting rf (SRF) and nano-beam.*
  - *SRF technology has been widely adopted at XFELs such as European XFEL.*
  - *Nano-beam technology has been demonstrated at ATF hosted by KEK*
- *Tunnel design and civil overview are shown.*
- *We assume 4-year preparation and 9-year construction.(now we are at pre-preparation phase (IDT))*
- *Preparation phase activities are*
  - *Technical preparation*
  - *Final engineering design*
  - *Planning and preparation of Hub lab.*
  - *Human resources for ILC construction …*
- *Global collaboration started.*

Thank you for your attention