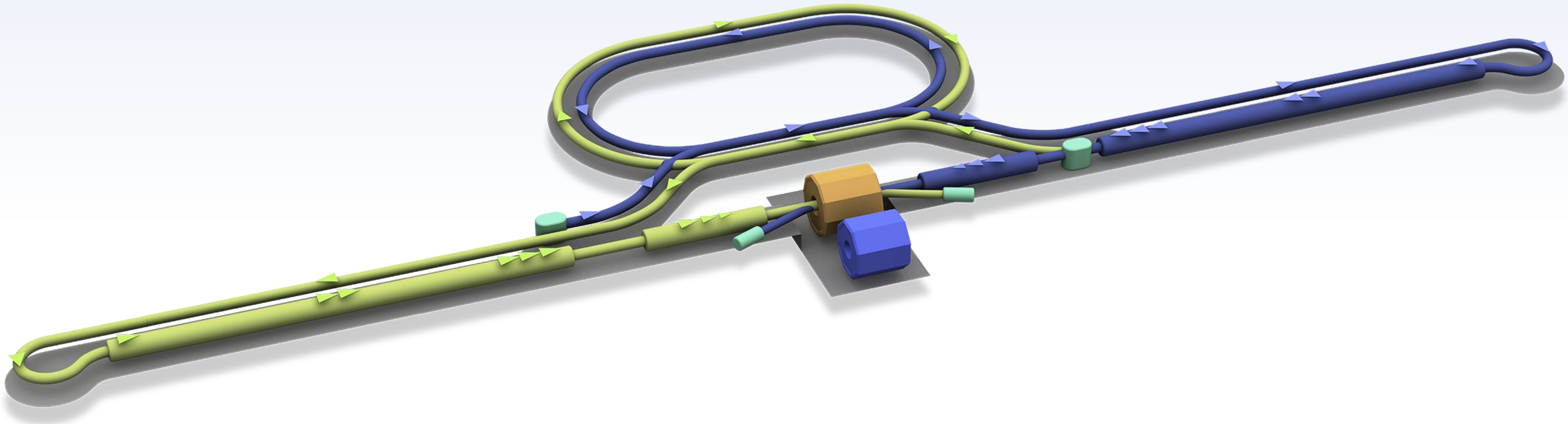


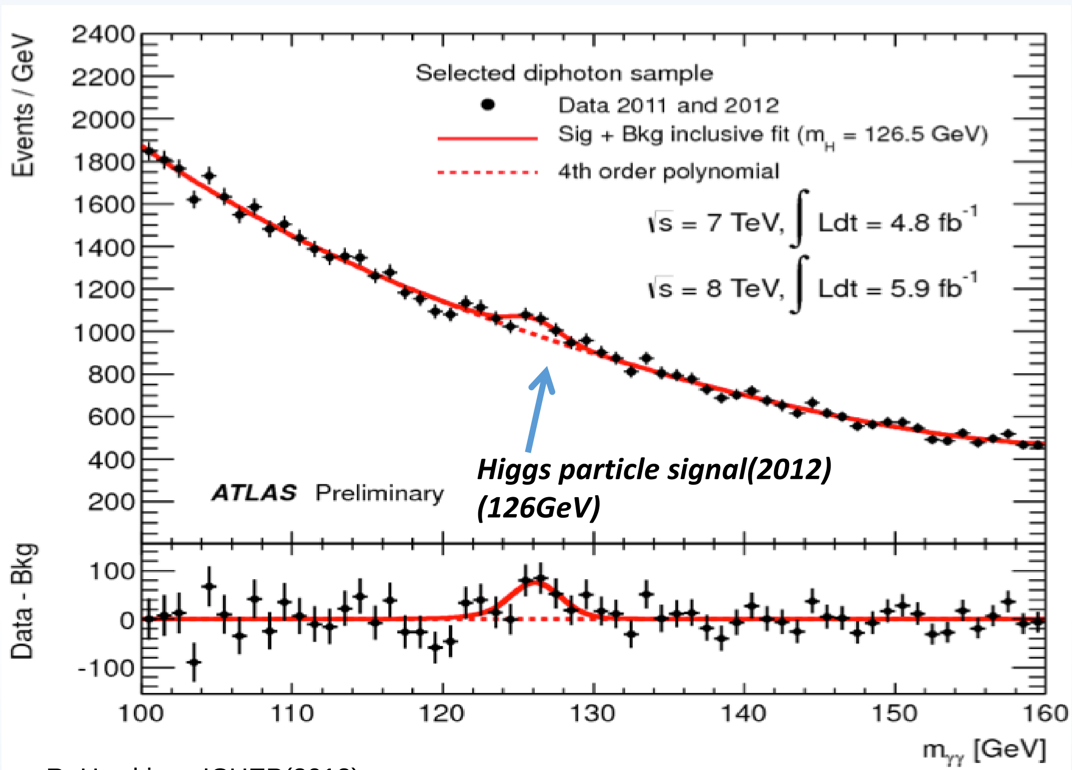
Status of ILC Accelerator

Hitoshi Hayano, KEK   07082019

LHC run-II results and ILC250GeV

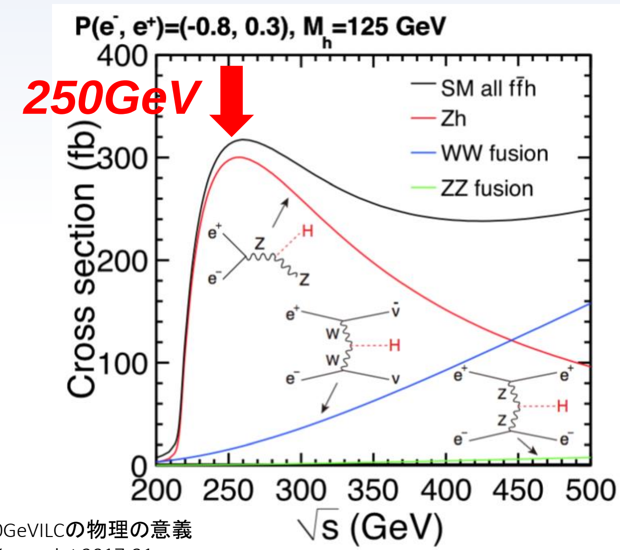
Higgs particle was found, but no other particle was found upto 1TeV region.

—> ***Study of Higgs particle (coupling to other particles) is urgent.***
ILC has an ablities of precise measurements of Higgs.



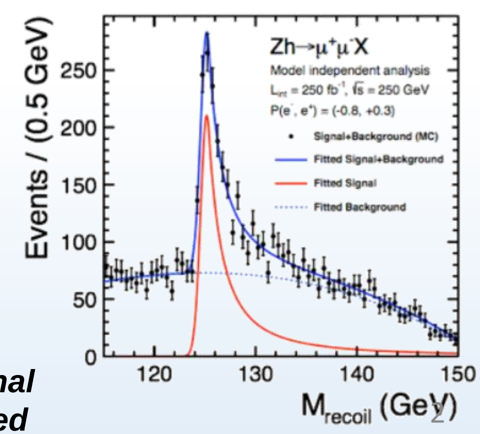
R. Hawkings ICHEP(2012)

ATLAS higgs signal



250GeVILCの物理の意義
KEK preprint 2017-31

ILC Higgs Generation simulation



Clear signal Is expected

[Li et.al. (ILD Collaboration)]

ILC Accelerator Staging Plan

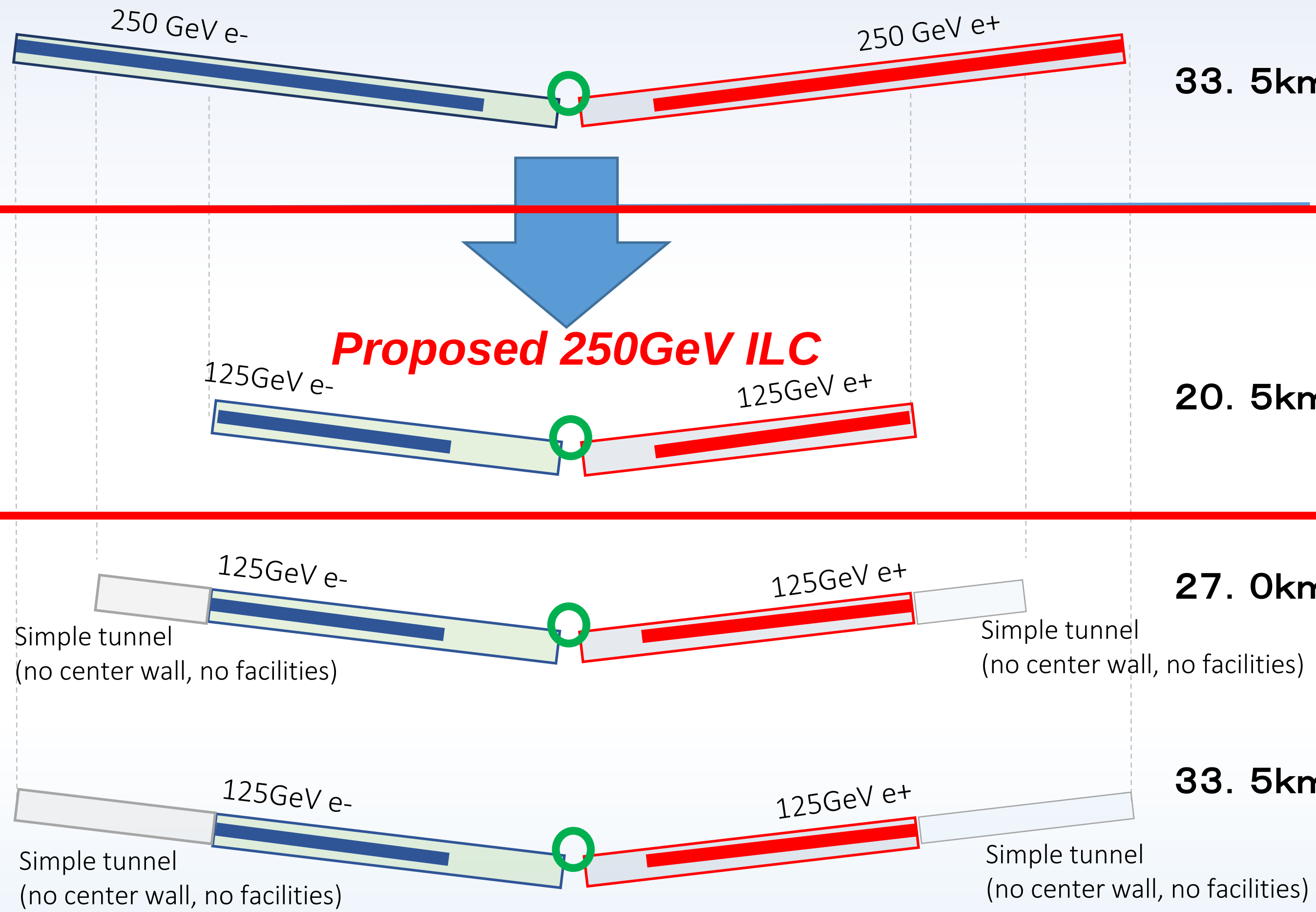
Step-wise construction and experiment (staging) was proposed, and plan of the accelerator at the beginning is 250GeV.

500GeV TDR: 31.5MV/m — **33. 5km**

250GeV tunnel
250GeV accelerator
Option A:
(Option A' 35MV/m) — **20. 5km**

Option B:
(Option B' 35MV/m) — **27. 0km**
350GeV tunnel
250GeV accelerator

Option C:
(option C' 35MV/m) — **33. 5km**
500GeV tunnel
250GeV accelerator



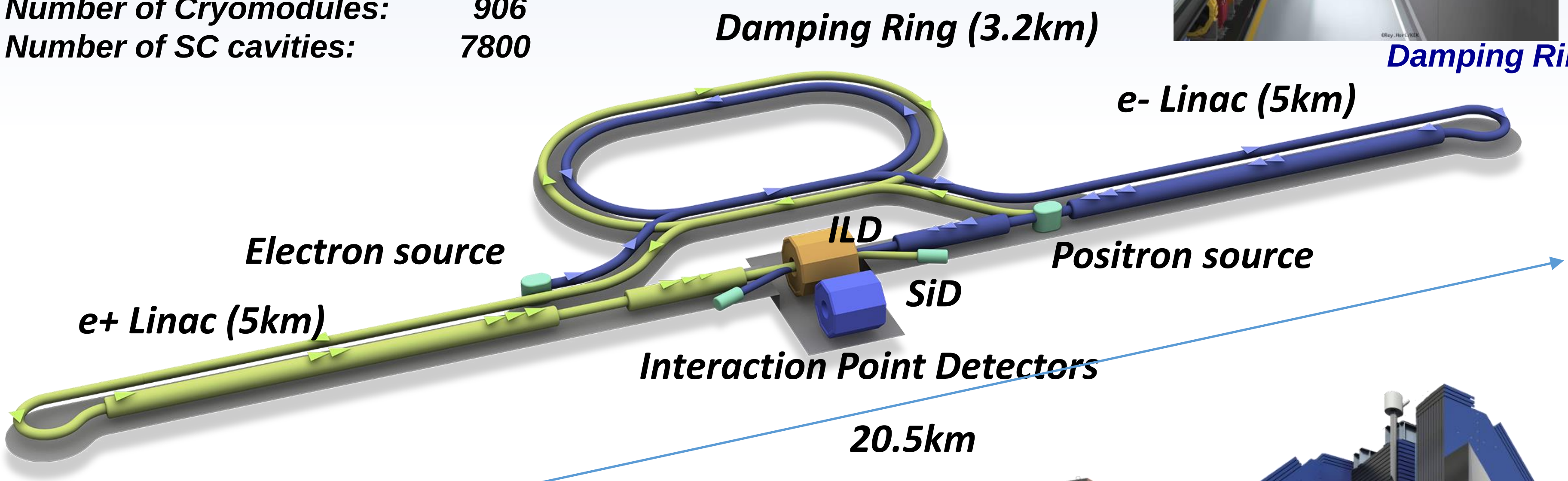
In case success of cost-down R&D, 35MV/m、Q_0=1.6x10^{10} is assumed.

Configulation of ILC Accelerator

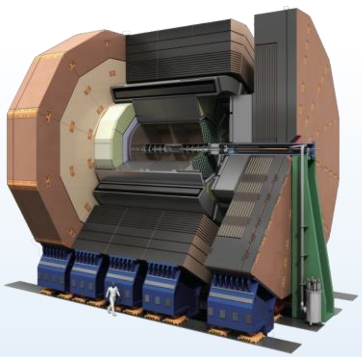
e+, e- Main Linac

Beam Energy : 125GeV + 125GeV = 250 GeV
Total accelerator: 20.5km
SRF Accelerator: 5km + 5km
Number of Klystrons: 218
Number of Cryomodules: 906
Number of SC cavities: 7800

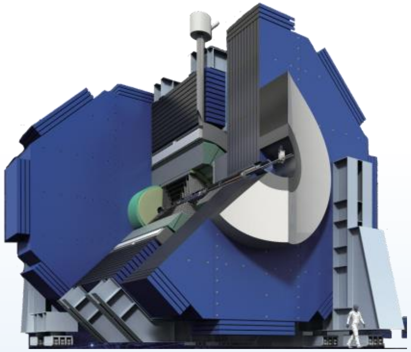
Damping Ring



Main Linac Accelerator

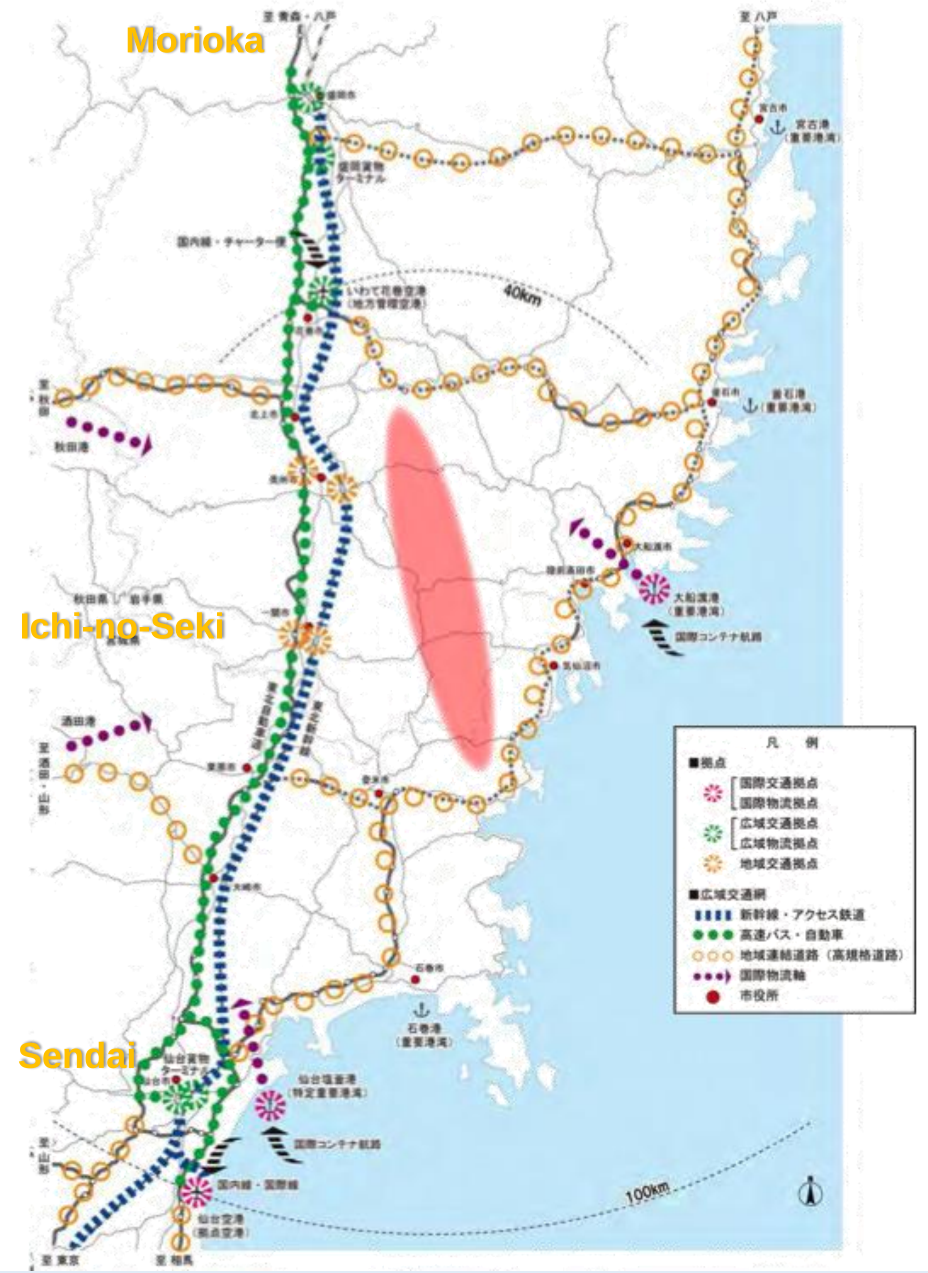


ILD Detector

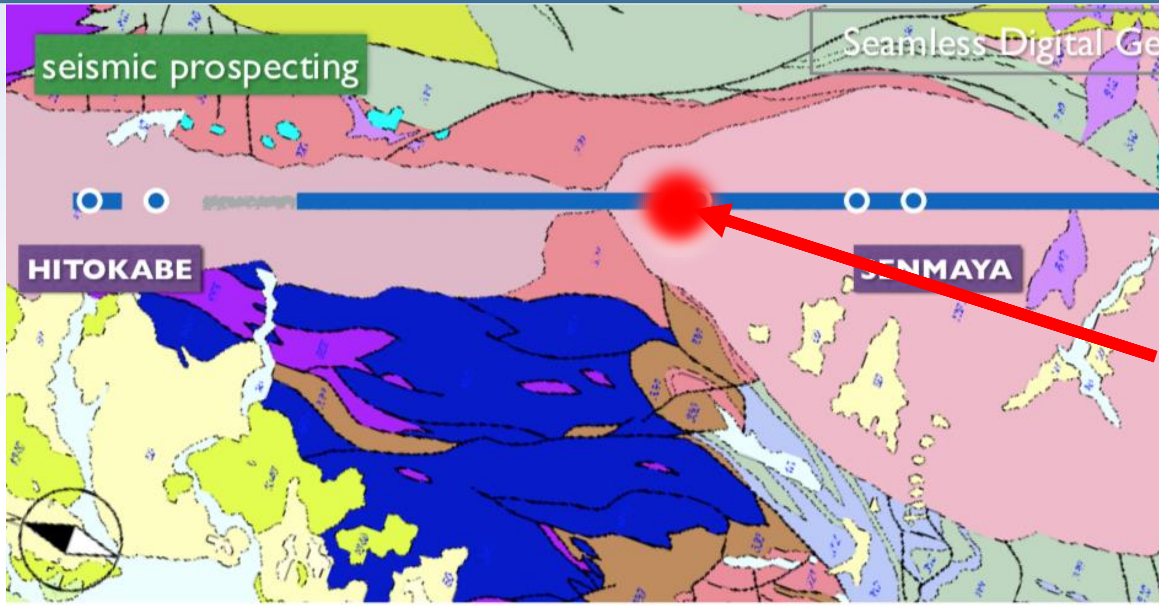


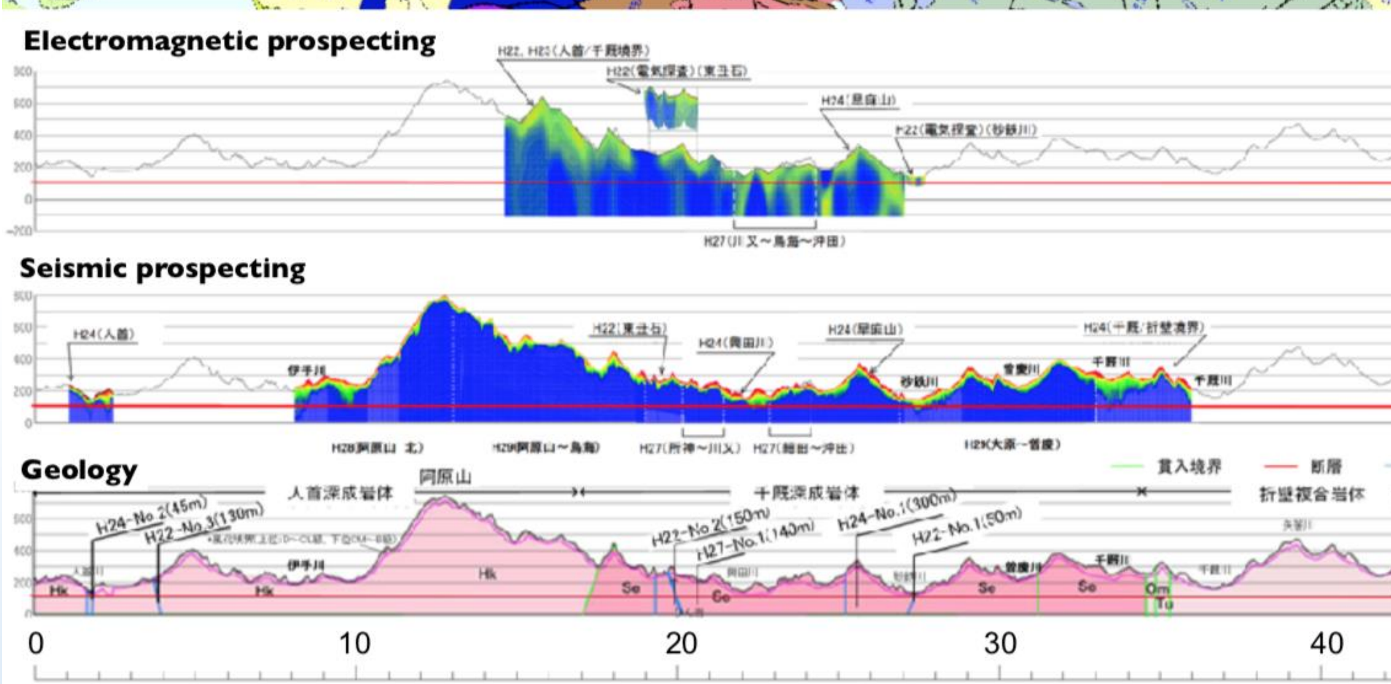
SiD Detector

Kitakami Candidate Site



Kitakami Candidate Site

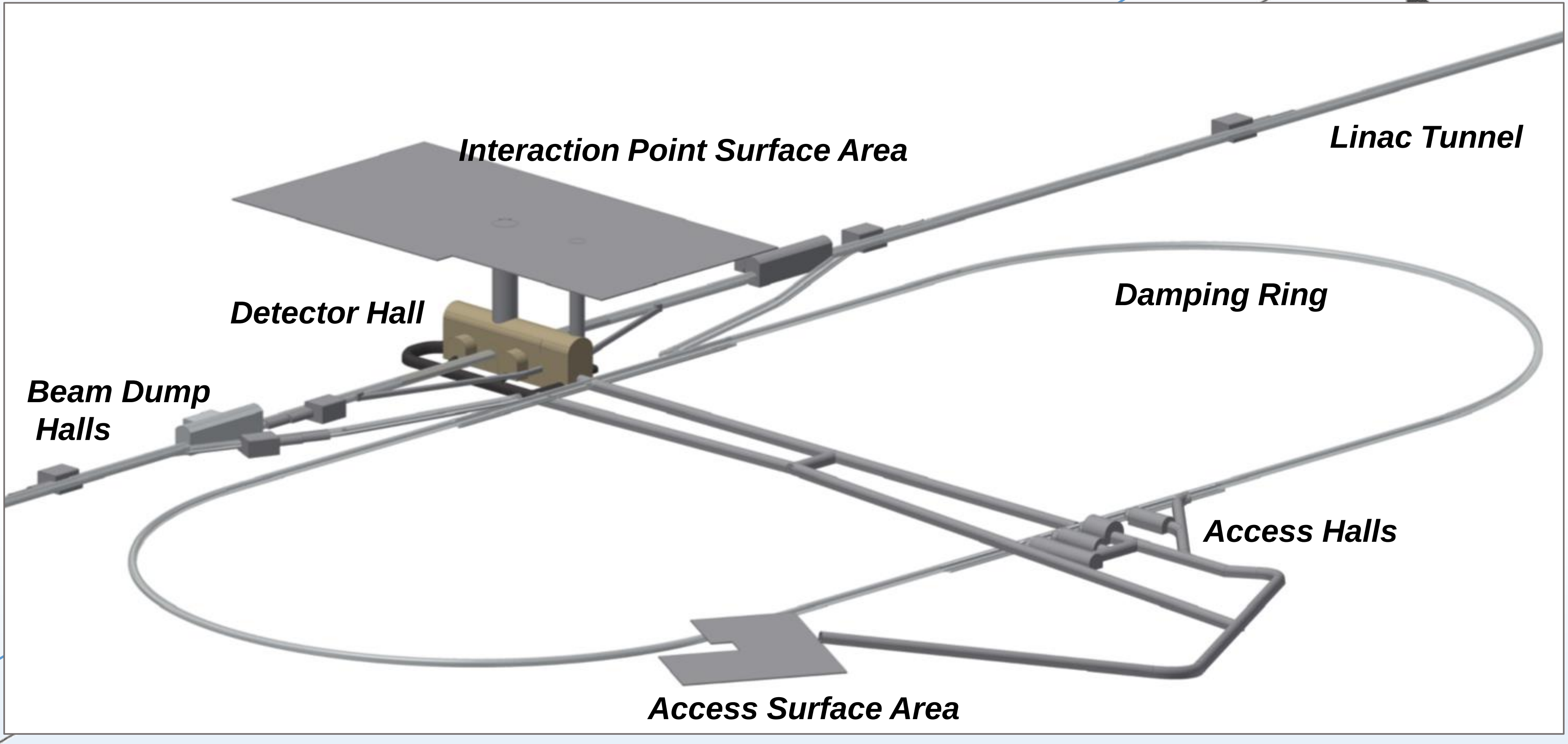


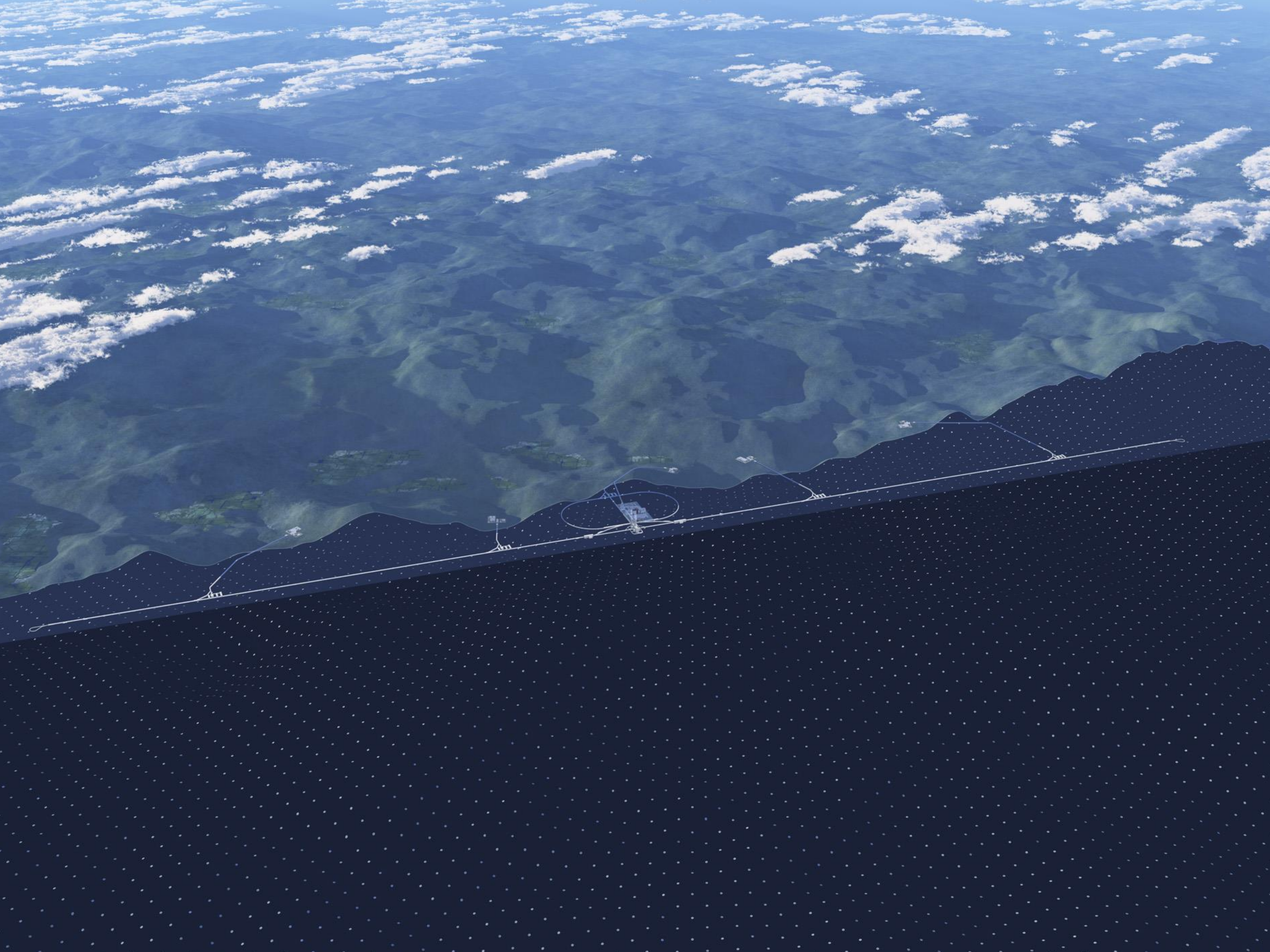


ILC Accelerator: Lattice design and tunnel design

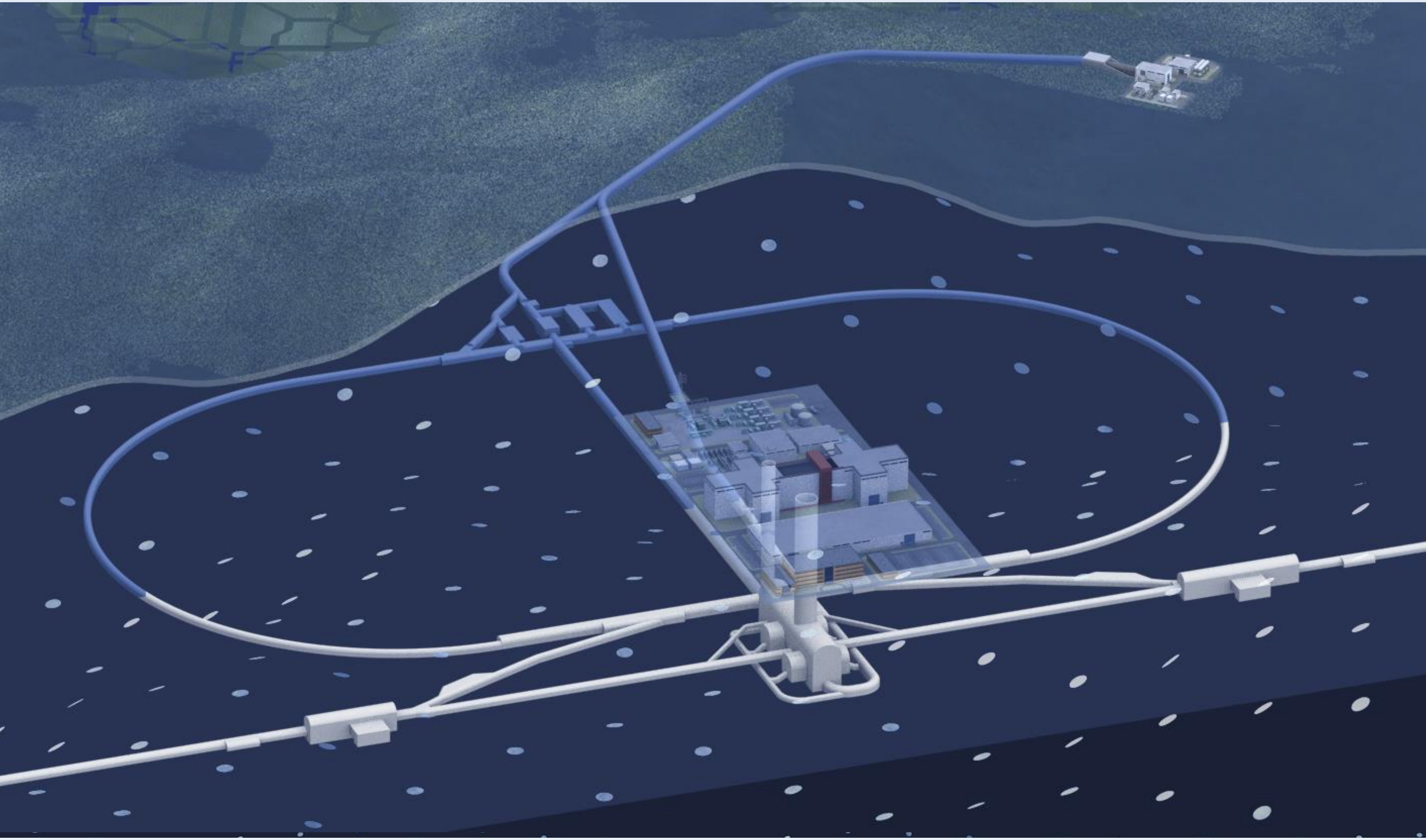
ILC250 Lattice design was fixed, Accelerator tunnel design is on-going

Total Accelerator tunnel length = 20,549.5m (20.5km)



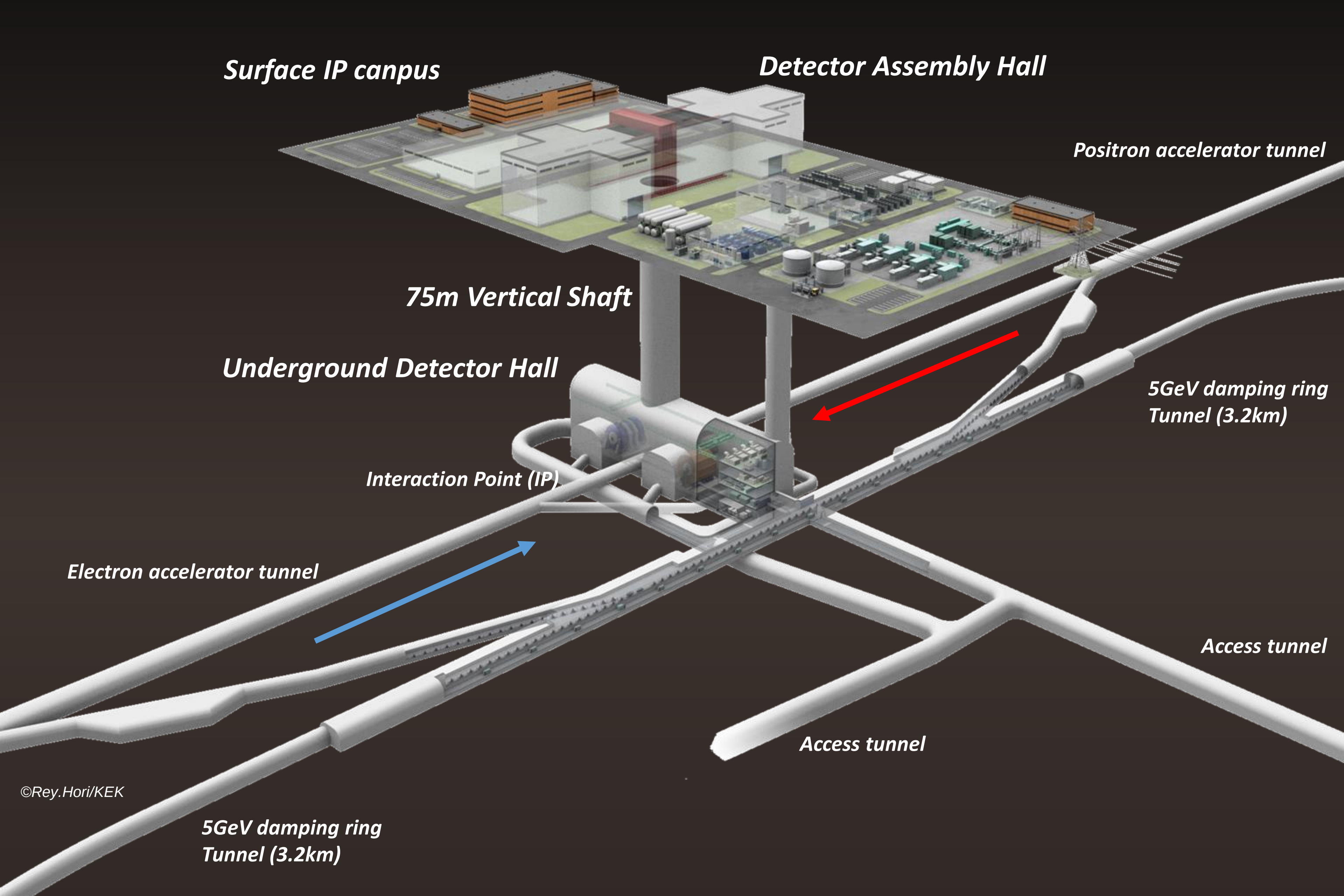


Bird's eye view of ILC in Kitakami candidate site

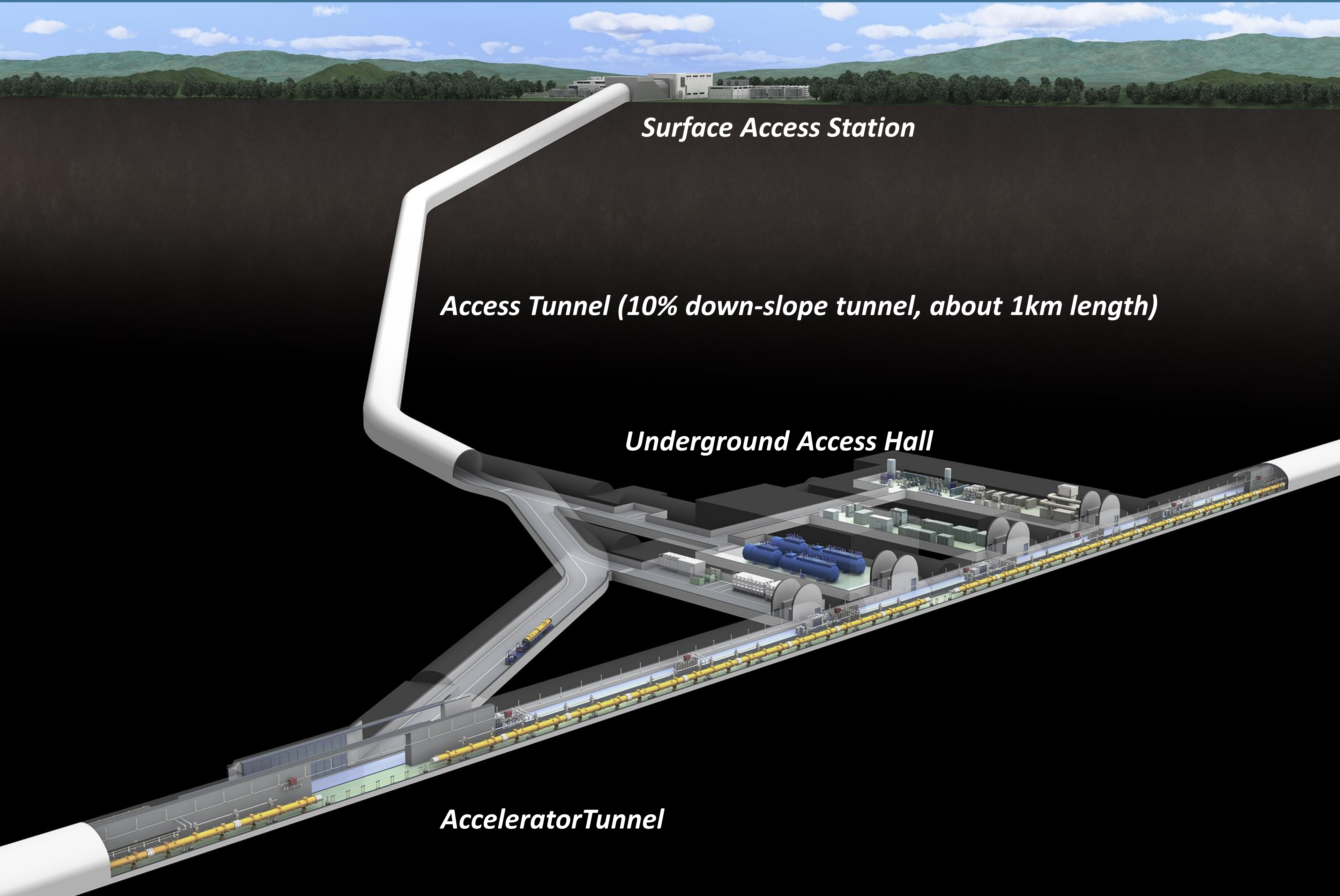


Tunnel design for Kitakami Candidate Site (ILC250GeV 20.5km)

Plan of Interaction point



Surface-to-Underground access-tunnel



ILC political Status of Japan

SCJ committee Discussion about ILC250

MEXT → SCJ: July, 2018
SCJ → MEXT: Dec., 2018

SCJ

half years discussion about ILC250

Review committee for ILC250

Tasks of the committee

- The academic significance of the ILC, importance of the ILC in the elementary particle physics
- Importance of the ILC in the whole academic research
- Significance of the ILC in Japan
- Preparation status for the ILC, budget and human resources necessary for construction and operation

Sub-committee

Tasks of the subcommittee

1 Technical feasibility of large facilities
2 Cost evaluation
3 Economic ripple effect
4 Environmental assessment

MEXT

ht

ILC advisory panel report (in English) is available from http://www.mext.go.jp/component/b_menu/shingi/toushin/__icsFiles/afieldfile/2018/09/20/1409220_2_1.pdf

Commissioned Survey by NRI (2014-17)

1) WW Research trend (FY14)
2) Technology issues (FY15)
3) Large Int'l project (FY16)
4) Risk/safety issues (FY17)

ILC Adv. Panel

Organized from 2014 to 2018

4 years discussion about ILC500(TDR)

Physics WG	TDR Validation WG	Human Resource WG	Organization & Manage.WG
Organized in 2014-15 & 2018	Organized in 2014-15 & 2018	Organized in 2015 -16	Organized in 2017

SCJ : Science Council of Japan
日本学術会議
MEXT : Minister of Education, cluture and sports, Science and Technology Japan
文部科学省

SCJ report to MEXT: Executive summary

http://www.scj.go.jp/ja/info/kohyo/pdf/kohyo-24-k273-en.pdf

Dec. 19, 2018

- The SCJ recognizes the importance of the Higgs physics. "It is agreed upon Japanese high energy physics community that the precision measurement of the Higgs coupling is an important one".
- *"Judging from the plan and preparatory status of the project presented at the moment, the Science Council of Japan does not reach a consensus to support hosting the 250GeV ILC project in Japan."*

Their main concerns are *"Japan's large share of the overall cost required for the project implementation"*, *"matter of concern for the implementation of the project* (for technical issues)", and *"the uncertainty surrounding proper international cost-sharing with respect to the long-term commitment to large budget allocation "*

ICFA/LCB meeting at Tokyo (Mar. 07,2019)

MEXT's view in regard to the ILC project

MEXT announcement at ICFA/LCB meeting

MEXT's view in regard to the ILC project
Executive Summary

March 7, 2019
Research Promotion Bureau, MEXT

- Following the opinion of the SCJ, MEXT has not yet reached declaration for hosting the ILC in Japan at this moment. The ILC project requires further discussion in formal academic decision-making processes such as the SCJ Master Plan, where it has to be clarified whether the ILC project can gain understanding and support from the domestic academic community.

- MEXT will pay close attention to the progress of the discussions at the European Strategy for Particle Physics Update.

- The ILC project has certain scientific significance in particle physics particularly in the precision measurements of the Higgs boson, and also has possibility in the technological advancement and in its effect on the local community, although the SCJ pointed out some concerns with the ILC project. Therefore, considering the above points, MEXT will continue to discuss the ILC project with other governments while having an interest in the ILC project.

SCJ Master Plan

Have interest in the ILC project

Continue to discuss ILC project

This is the first official announcement of MEXT about ILC

KEK create International cost-share WG

ILC International Working Group Established -- First Meeting Held in Granada

2019/05/21 Topics

https://www.kek.jp/en/newsroom/2019/5/21/1900/

KEK established the International Working Group on the International Linear Collider (ILC) project to discuss issues such as international cost sharing. The First Meeting of the Working Group was held on Friday, 17 May, in Granada, Spain.

WG discuss Cost-share, organization

will report to MEXT in September 2019

Schedule

Sep. 2019 : Cost-Share WG will report to KEK, then to MEXT.

Sep. 2019 : SCJ will start hearing of Big-Science-Project of Master Plan Candidates.

Oct. 28, 2019 : LCWS2019 at Sendai, Japan (close to candidate site)

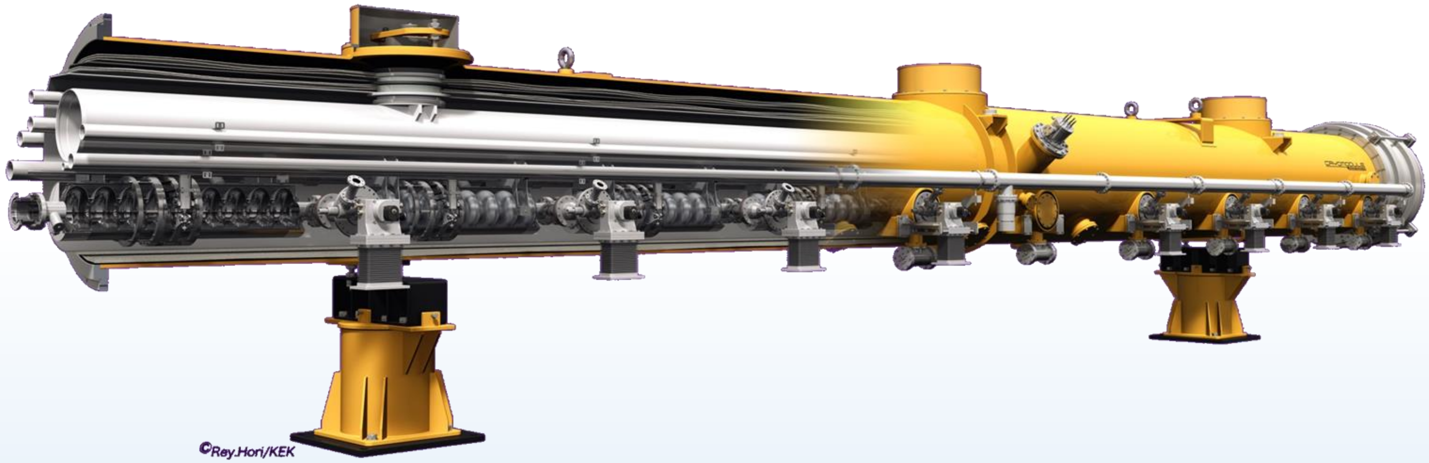
Jan. 2020 : SCJ will decide Master Plan of Big-Science-Project.

May 2020 : Europe next-5-years strategy will be decided.

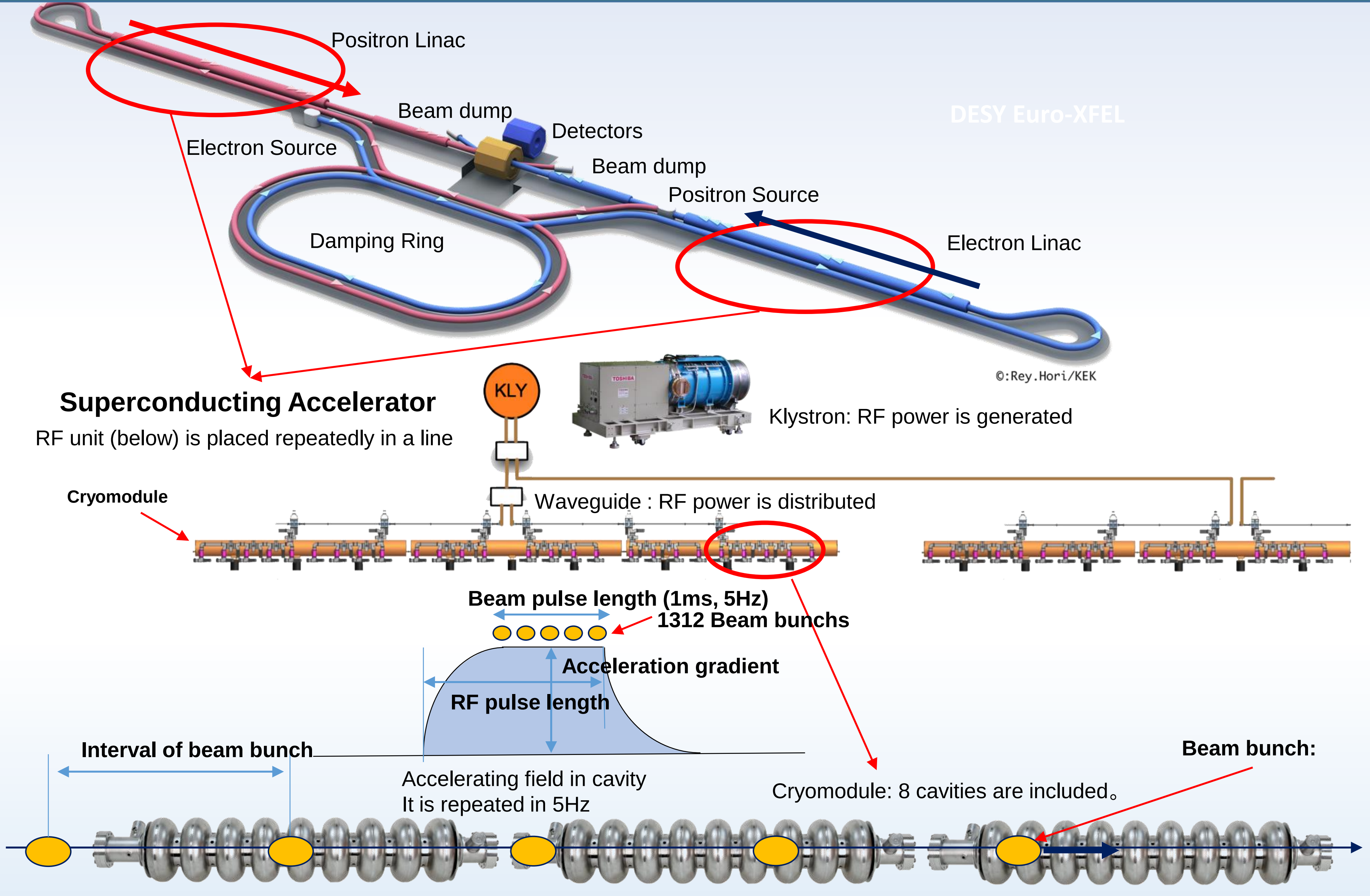
Summer 2020 : ILC will be included clearly in the 6-th Science and Technology Basic Plan of Japanese goverment.

Then, ILC construction preparation will be started.

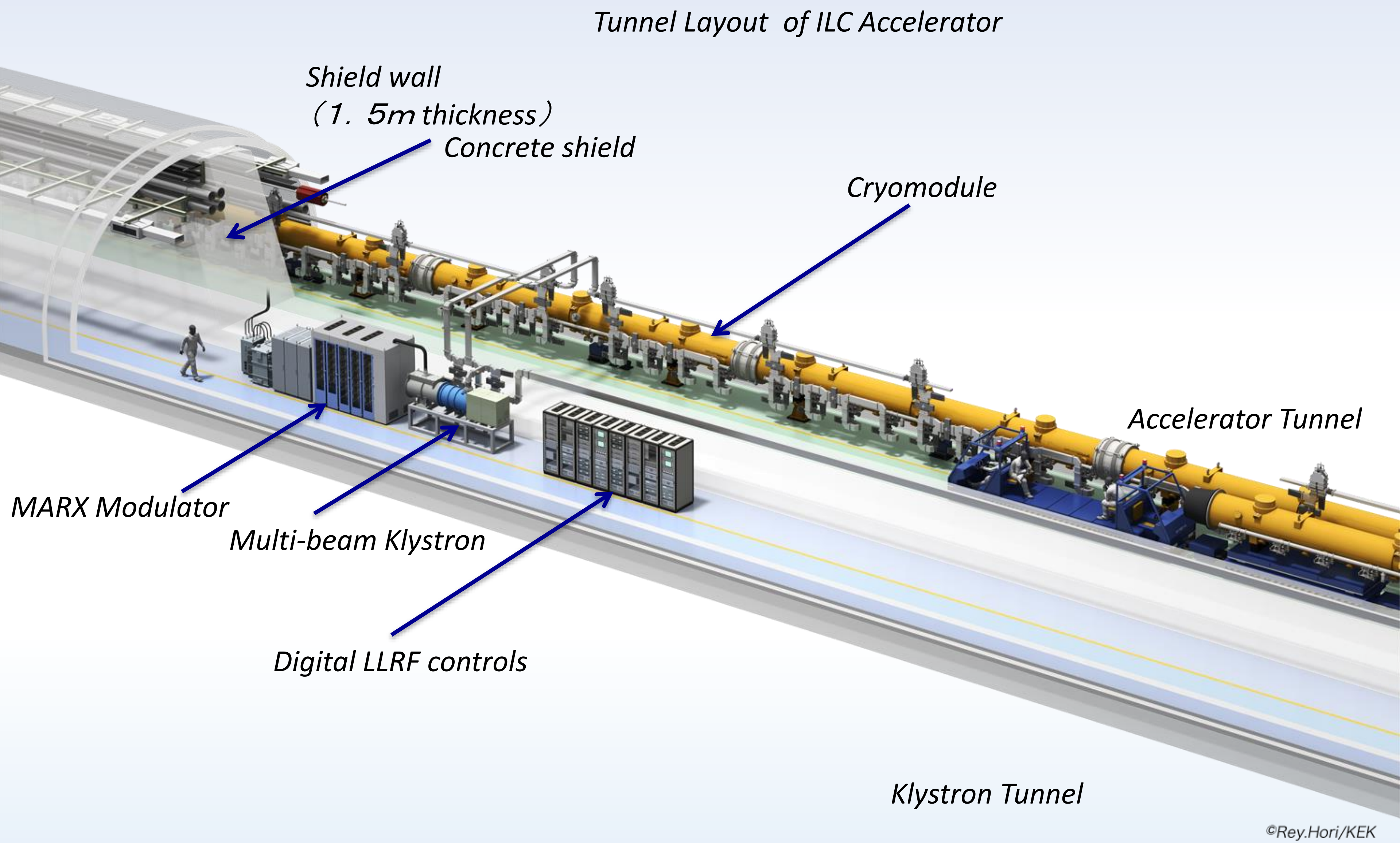
Superconducting Cavity: High Technology Part



Beam Acceleration in Main Linac

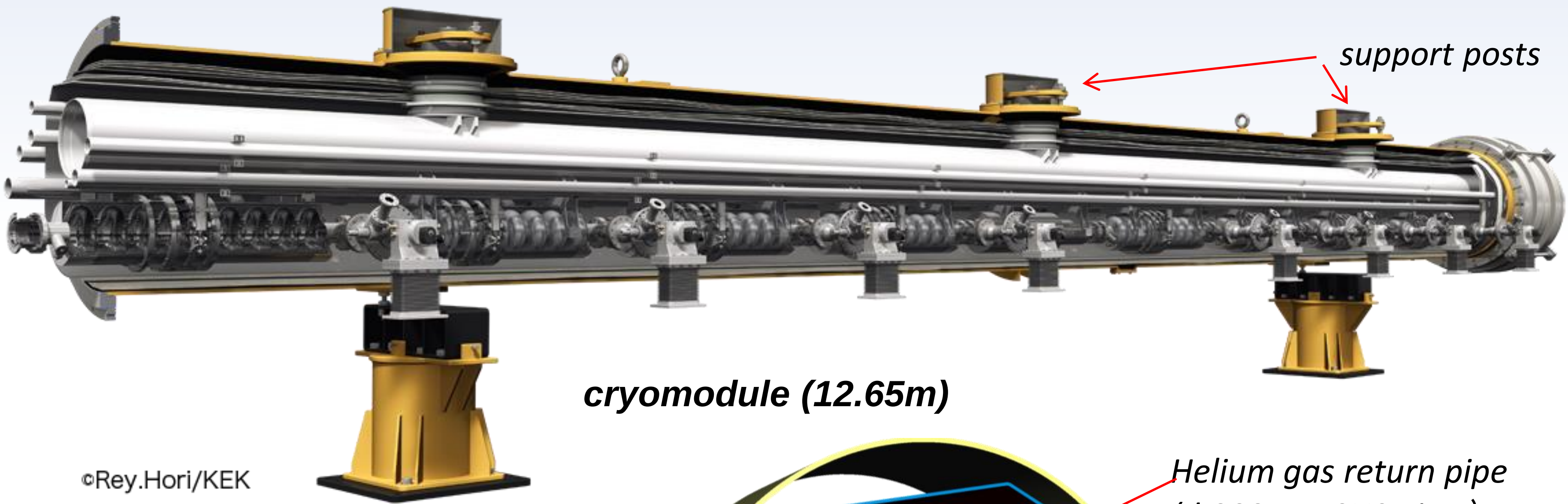


Tunnel layout of ILC Main Linac

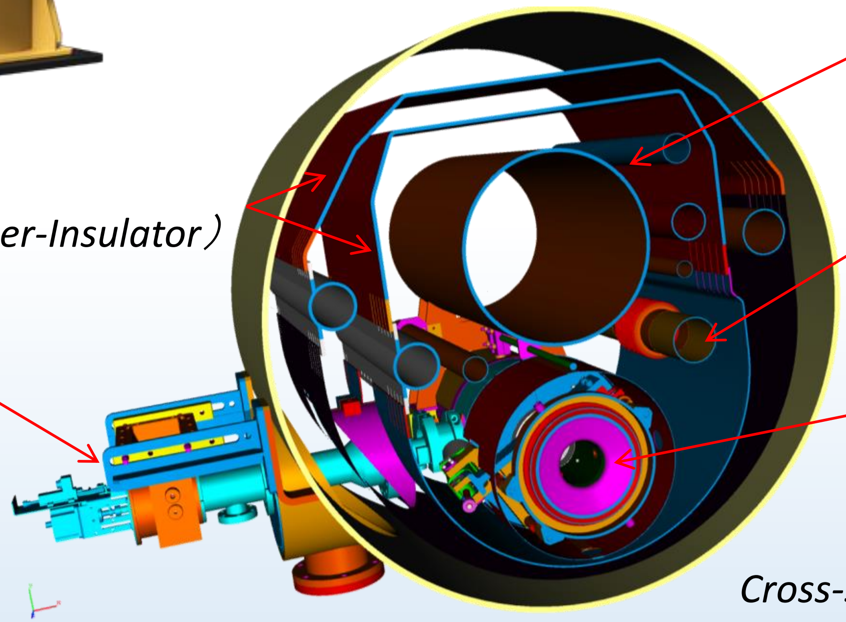


Cryomodule

Type-A (9cavities)	604	**Number of Cryomodules: 906**
Type-B(8cavities+SC-Q magnet)	302	



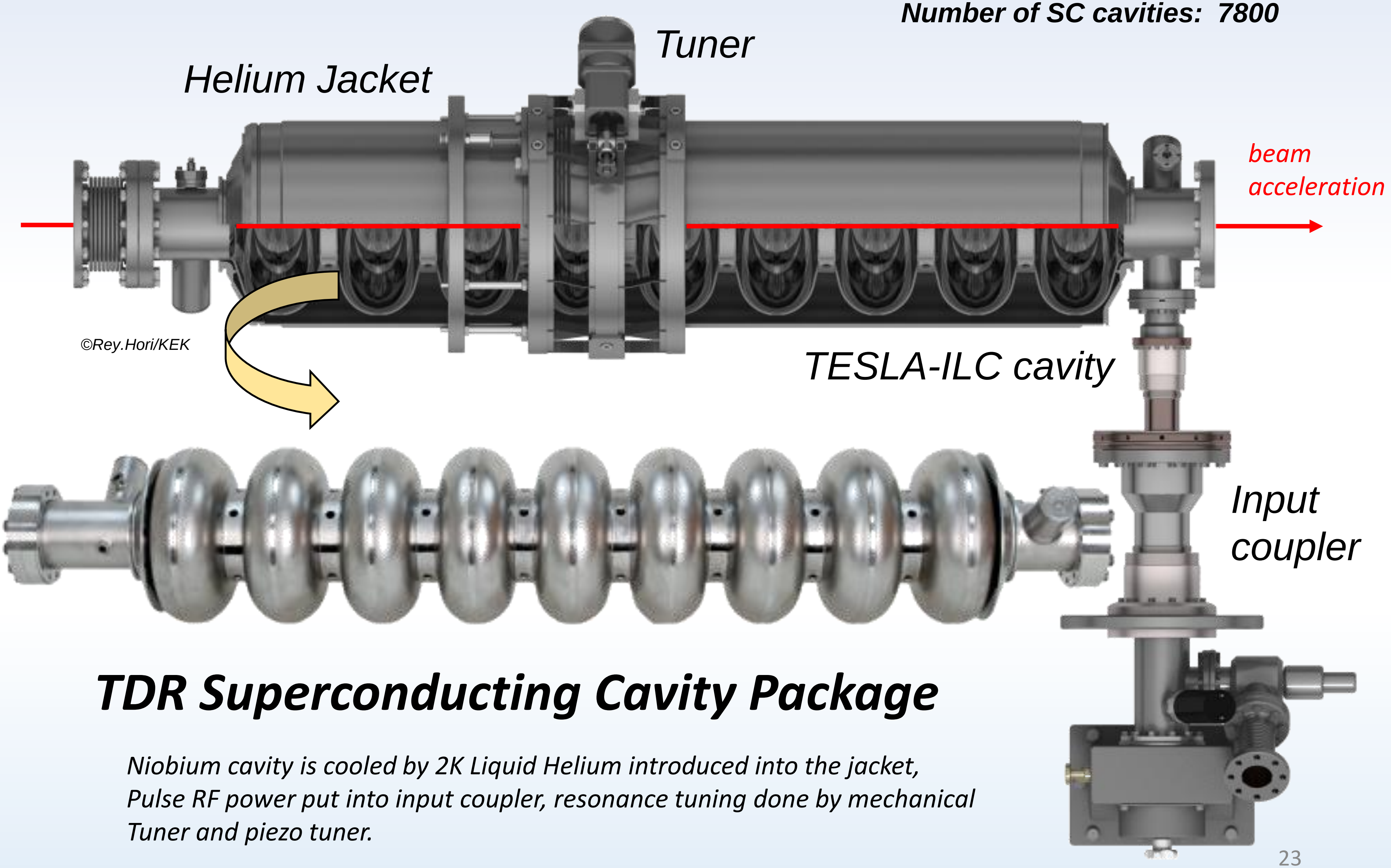
cryomodule (12.65m)



Cross-section from D. Kostin

1.3GHz Superconducting Cavity Package

Number of SC cavities: 7800



TDR Superconducting Cavity Package

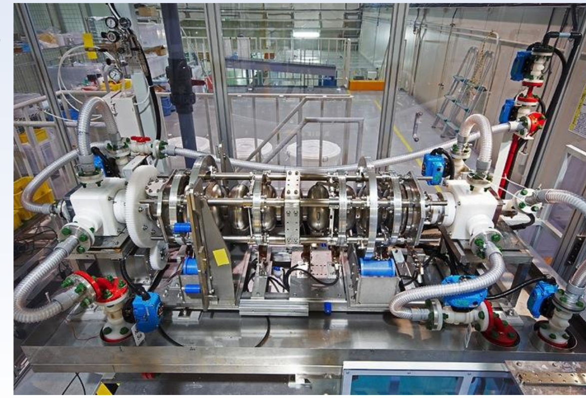
Niobium cavity is cooled by 2K Liquid Helium introduced into the jacket, Pulse RF power put into input coupler, resonance tuning done by mechanical Tuner and piezo tuner.

Technologies for high performance SRF cavity

Press

EBW

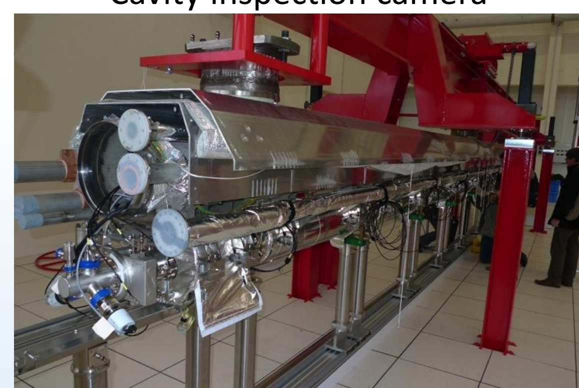
EP



Cavity inspection camera

Clean Room

Cavity frequency tuning



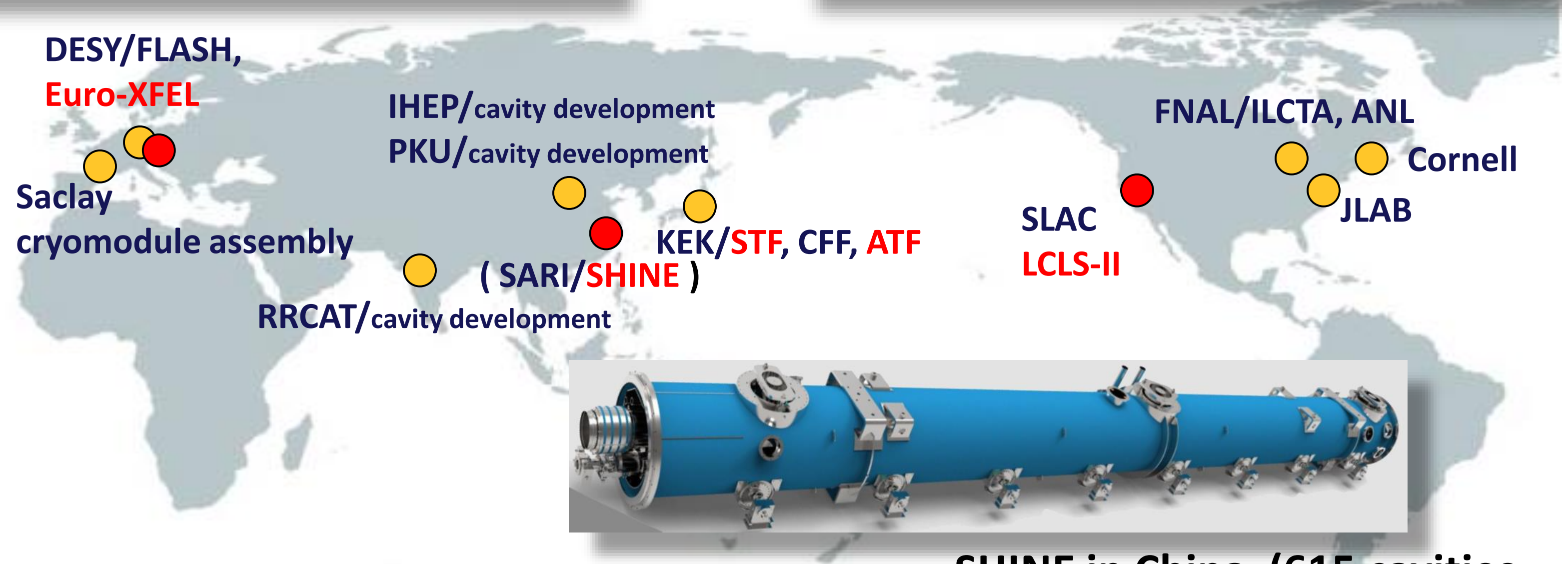
Cryomodule assembly

ILC SRF accelerator development

Number of SC cavities in ILC: 7800

Euro-XFEL in Germany (800 cavities)

LCLS-II in US (280 cavities) under fabrication

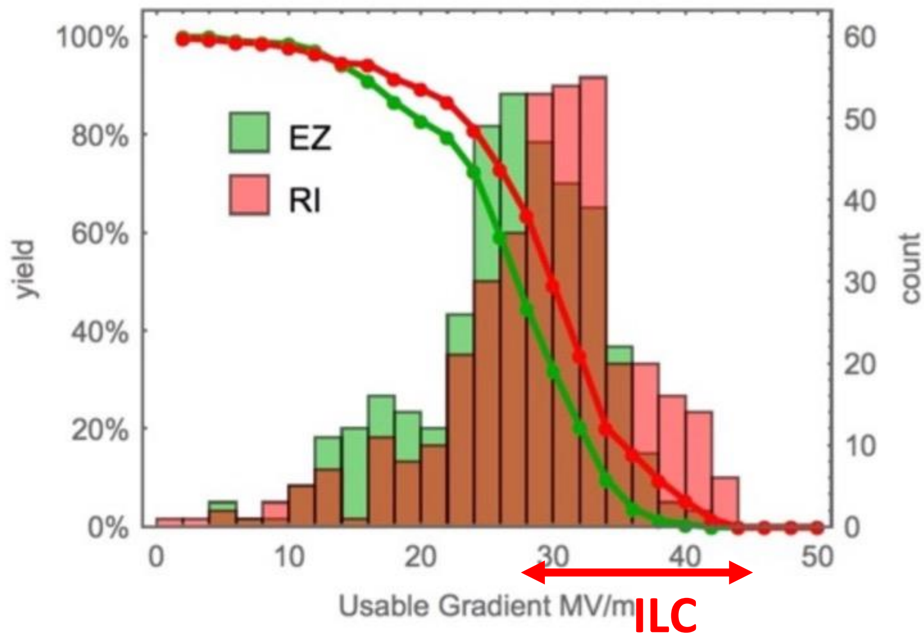


SHINE in China (615 cavities to be fabricated**)**

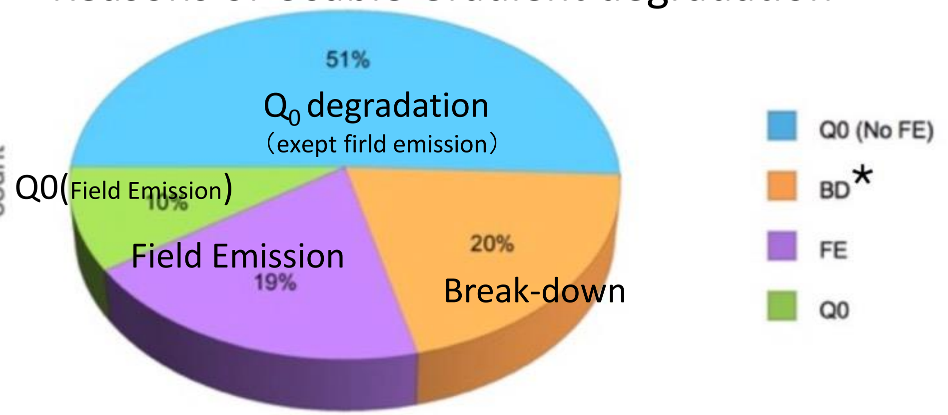
ILC accelerator/SRF technologies development by International Collaboration

Test results: USABLE GRADIENT

"As received" test



Reasons of Usable Gradient degradation

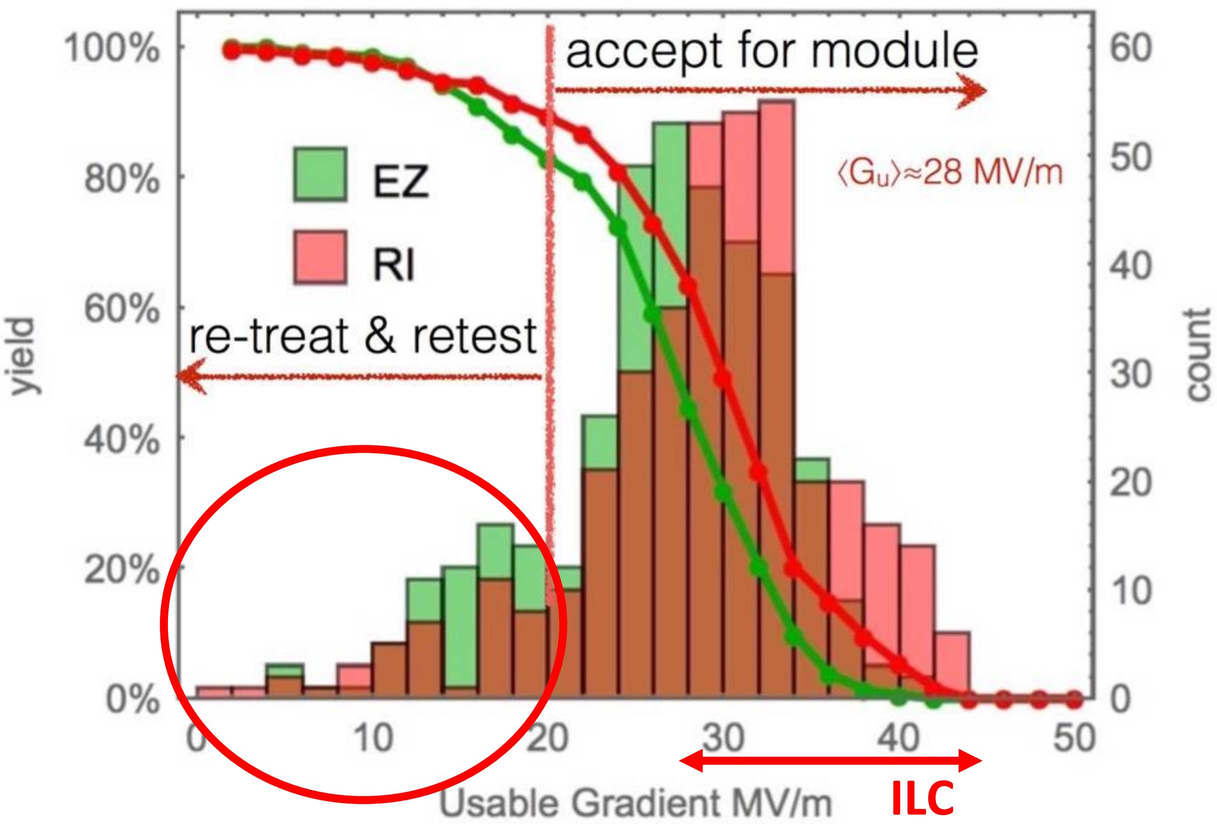


* few cases of power limitation, HOM coupler heating etc.

	RI	EZ	Total
Tests	375	367	742
G_{AVG} (MV/m)	29.1	26.4	27.8
G_{RMS} (MV/m)	7.4	6.6	7.1
yield @ 20MV/m	89%	83%	86%
yield @ 26MV/m	73%	59%	66%
yield @ 28MV/m	63%	45%	54%

Average loss from max: ~4 MV/m

Test results: Re-treatment



"As received" test

In general, first re-treatment is a standard High-Pressure Rinse (HPR)

Second (if required) is BCP

HPR treatment for <20MV/m cavities in XFEL

Extrapolation to ILC - VT

- ILC TDR assumed VT acceptance > 28MV/m (XFEL >20 MV/m)
  - Average of 35 MV/m (XFEL 26 MV/m)
  - Assumed first-pass yield: 75%
  - 25% cavities retreated to give final yield of 90% >28 MV/m (35 MV/m average)
    - ➡ 10% over-production assumed in value estimate

ILC specification : >=90% yield

RI results only (ILC recipe)		ILC TDR (assumed)	XFEL max	XFEL usable
First-pass	Yield >28 MV/m	75%	85%	63%
	Average >28 MV/m	35 MV/m	35.2 MV/m	33.5 MV/m
First+Second pass	Yield >28 MV/m	90%	94%	82%
	Average >28 MV/m	35 MV/m	35.0 MV/m	33.4 MV/m
First+Second+third pass	Yield >28 MV/m	-		91%
	Average >28 MV/m	-		33.4 MV/m

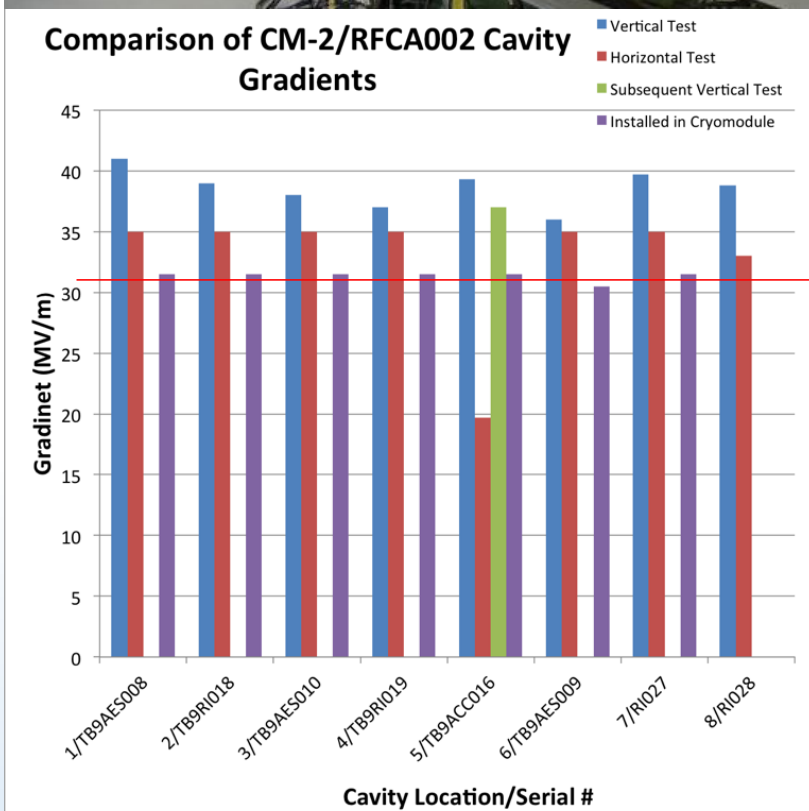
but close!

More re-treatments - but mostly only HPR
Number of average tests/cavity increases from 1.25 to 1.55 (1st+2nd) or 20% over-production or additional re-treat/test cycles

➡ $$$

Nicholas Walker ● DESY ● nicholas.walker@desy.de

FNAL :Test Cryomodule Performance



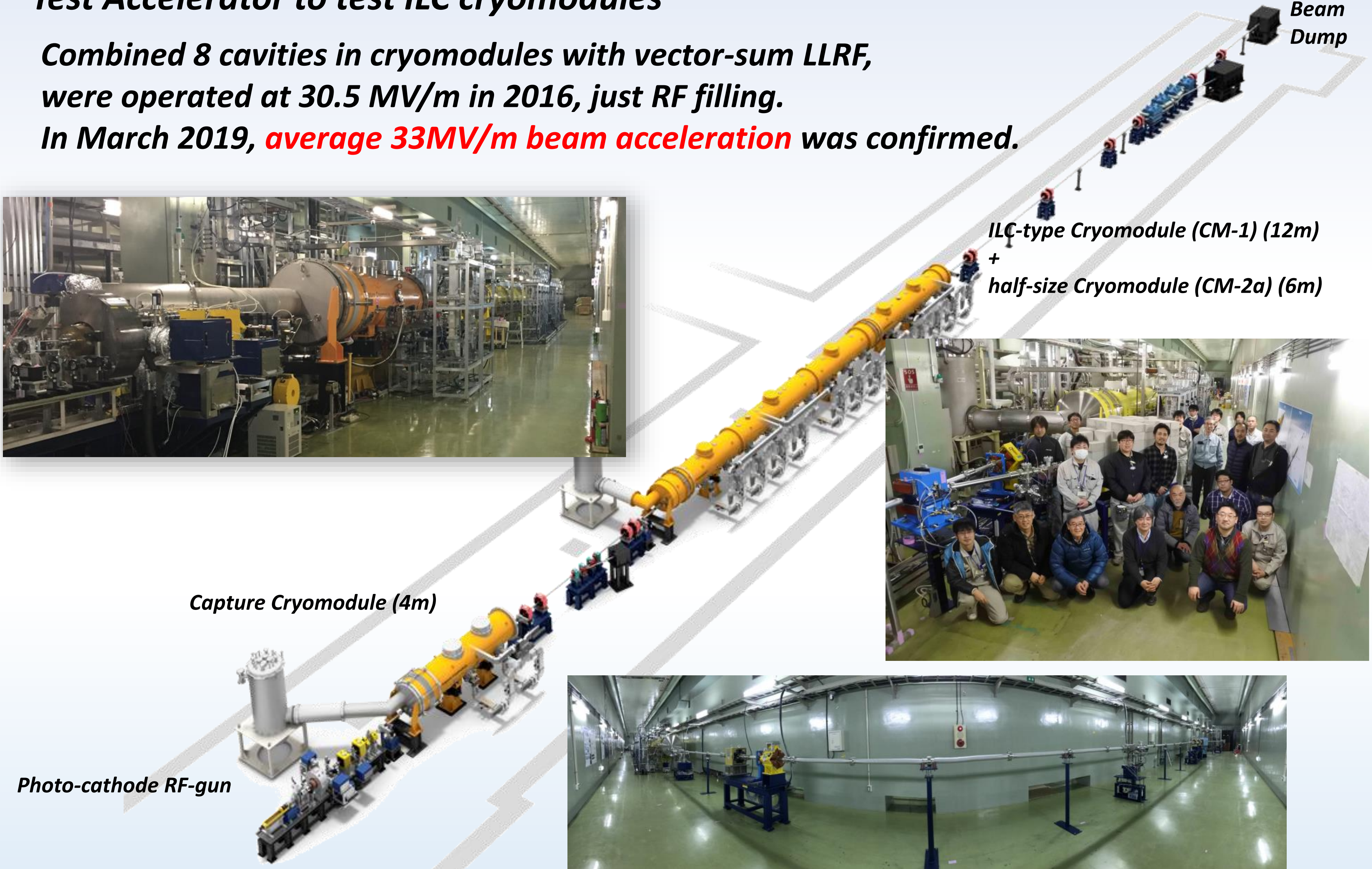
ILC Milestone
31.5MV/m

FNAL CM-2 has achieved the average cavity gradient of 31.5 MV/m

KEK-STF :Superconducting RF Test Facility

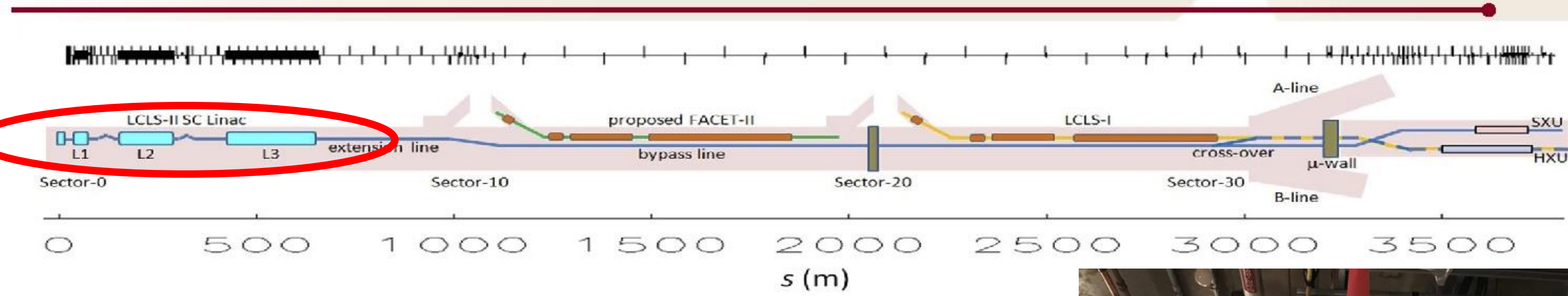
Test Accelerator to test ILC cryomodules

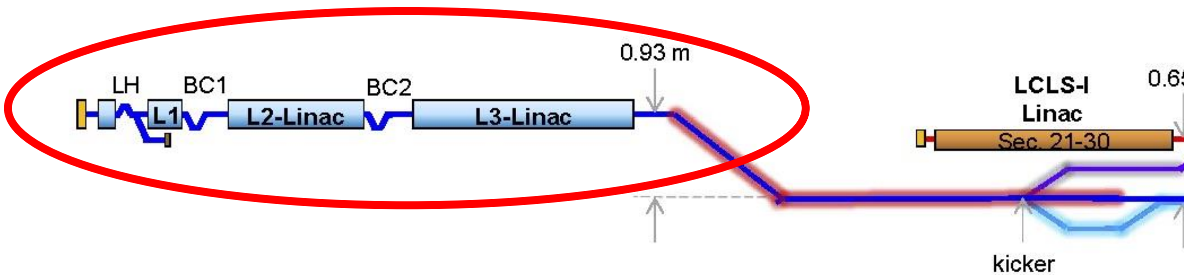
Combined 8 cavities in cryomodules with vector-sum LLRF, were operated at 30.5 MV/m in 2016, just RF filling.
In March 2019, average 33MV/m beam acceleration was confirmed.



LCLS-II superconducting accelerator in SLAC tunnel

LCLS-II linac will occupy 700m of 3 km linac tunnel





The 1,000m "copper" linac in Sectors 0-10 will be replaced by a superconducting linac, occupying 700m(room to grow)

The SC linac will provide electrons to either or both undulators

The existing linac in "middle" 1,000m of the tunnel will be left Intact (likely use: R&D on plasma wake field acceleration). Electrons from SC linac transported past this linac in a separate channel

The LC 30 will with SC electron

"glowing" sections indicate these are not in the vertical pla

BESAC July 7, 2015 LCLS-II Status

LCLS-II Cryomodule production at JLAB, FNAL

LCLS-II (FNAL, JLAB) will fabricate 35 cryomodule (280 cavities)

JLAB Production Line

FNAL Production Line

Preparation at KEK, XFEL project in Shanghai

KEK/COI Cryomodule Production preparation

New Building (80m x 30m) for cryomodule assembly

SHINE Production Line preparation

Cryomodule assembly facility is under construction in the SSRL existing building.

Summary

ILC tunnel design and installation plan into Tohoku-area Japan are presented.

On March 7, MEXT did not say hosting ILC,
but express their interest to ILC.
International cost share discussion WG has been started,
Listing ILC on "master plan of SCJ", is expected in the next Jan. .

High-tech accelerator part (SRF) mass-production is matured in Europe, US, and is developing in Asia.

ILC is very close to go.

END

Thanks for your attention

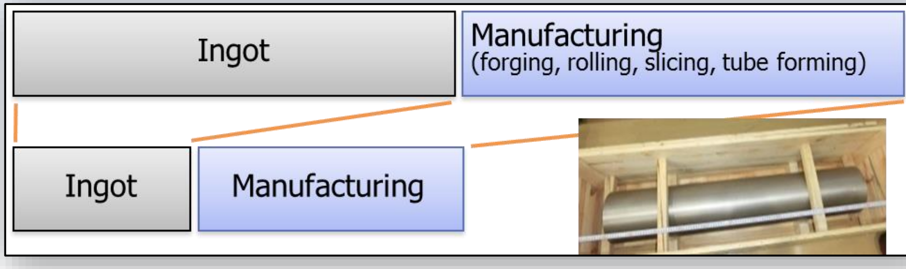
Cost-down of Main Linac

US-Japan cost down R&D

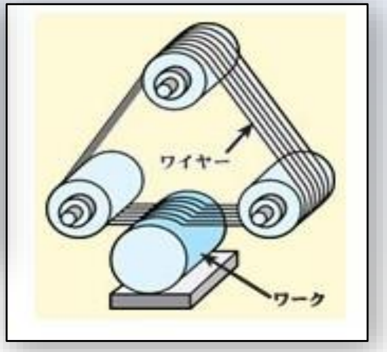
In 2016, MEXT(Japanese government) and US-DOE agreed to have cost-down R&D by US-Japan collaboration, to make ILC realize

ILC 250GeV Cavity Package ***7800 unit***

(A-1) Nb material cost-down by Ingod-slicing



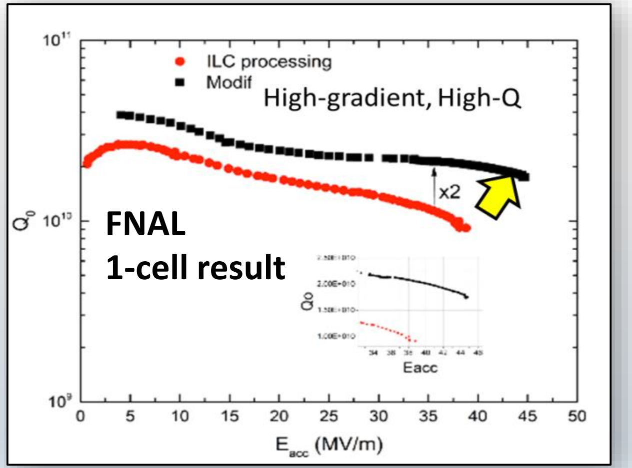
Cost down by Mid-RRR-ingod material + slicing to sheet

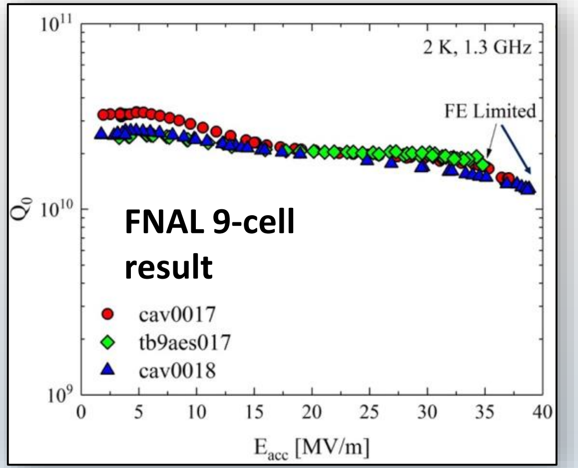


LG cell-material

Development of gradient performance and ensureing Nb sheet strength and press-forming availability

(A-2) High-Q High-G of cavity by N-infusion





ILC operation specification

31.5MV/m $1x10^{10}$

35MV/m $1.6x10^{10}$

Introduction of clean furnace for N-infusion, search of infusion parameter range

N-dope(2013) and N-infusion(2013) were developed

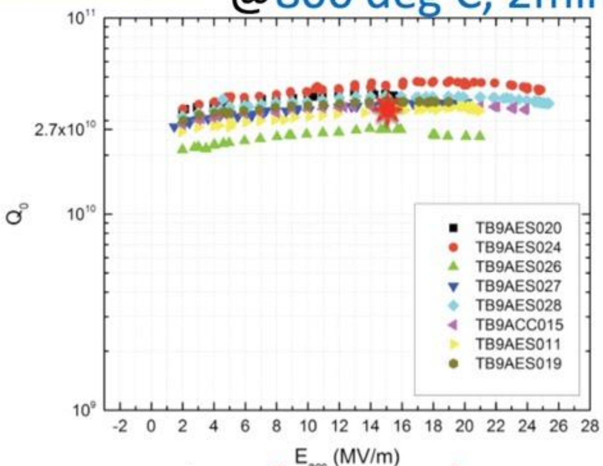
A. Grassellino et al.,2013 Supercond. Sci. Technol. 26 102001

A. Grassellino et al., arXiv:1305.2182, 1701.06077

N-dope

25mTorr N2

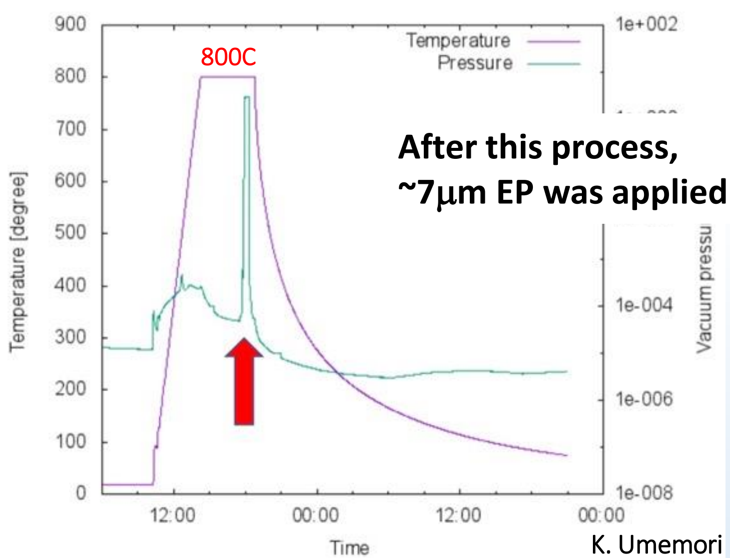
@800 deg C, 2min



High-Q

低損失

TTC meeting（2014/Dec） A. Melnychuk
「Update on N doping at Fermilab」



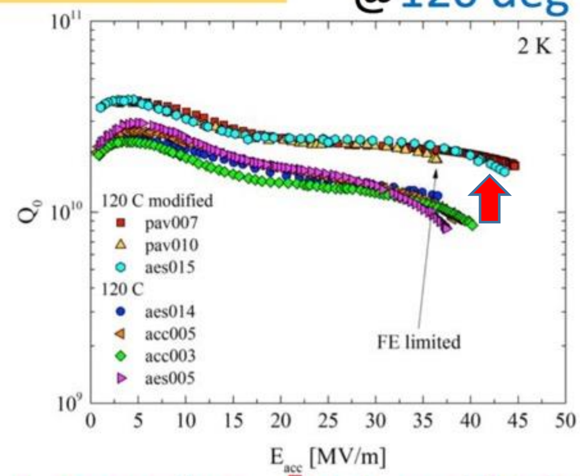
After this process, ~7μm EP was applied

K. Umemori

N-infusion

25mTorr N2

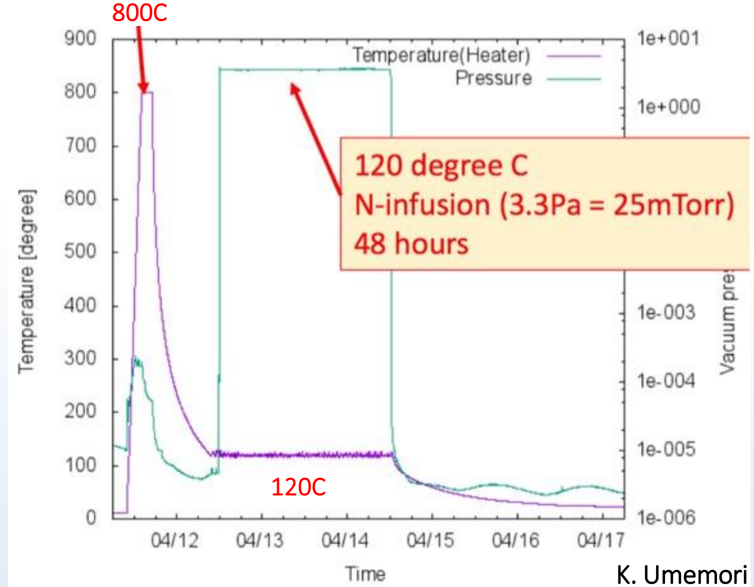
@120 deg C, 48hours



High-Q & High-G

低損失
高電界

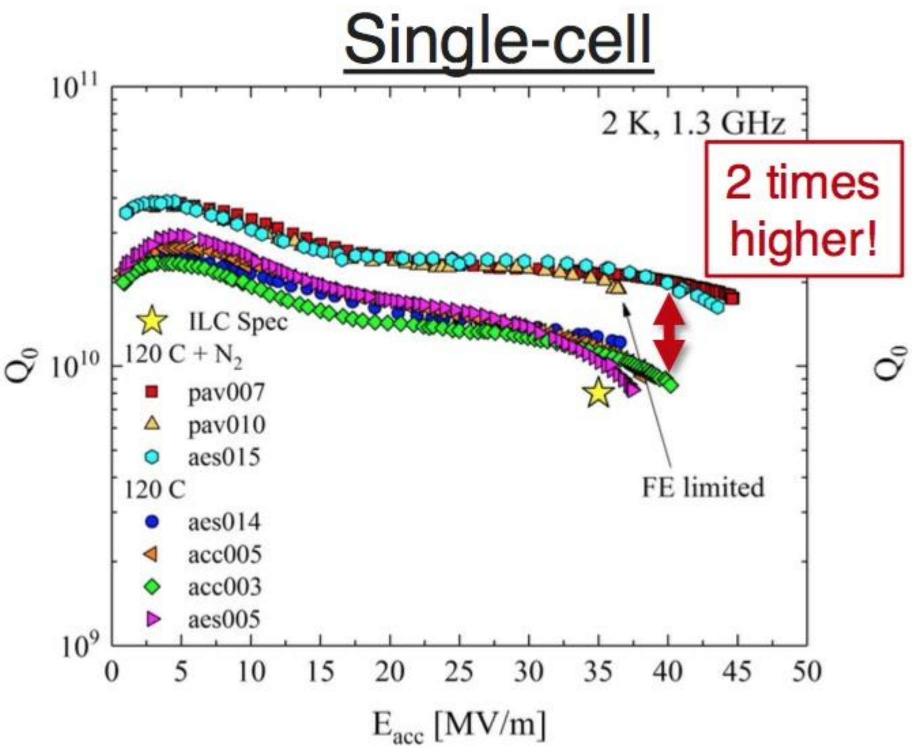
A. Grassellino 「High grad/high Q via N infusion」(LCWS2016)

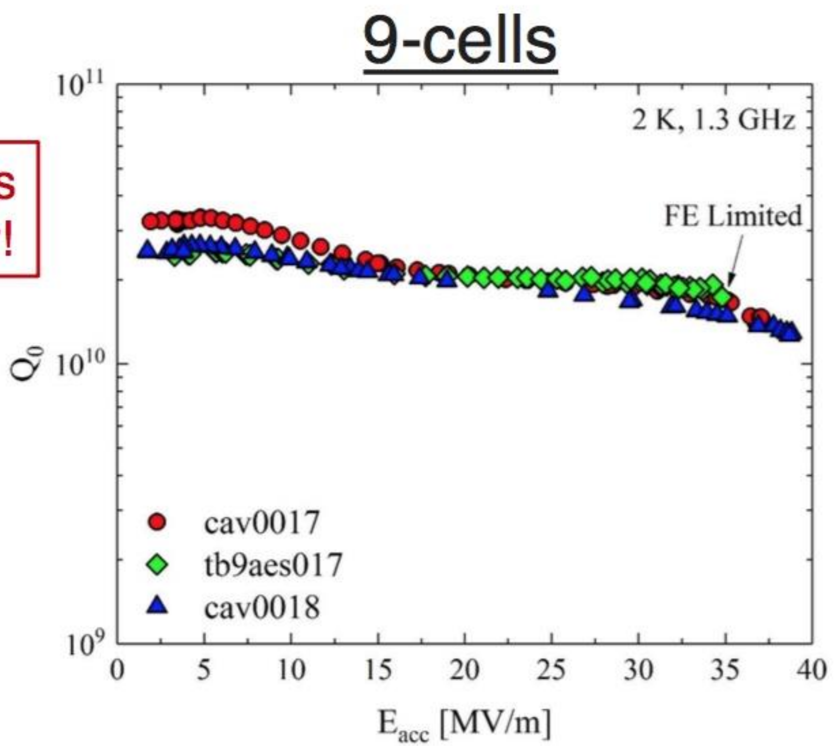


K. Umemori

N-infusion was applied both 1-cell and 9-cell cavities

120 C N-infusion: high Q_0 at high gradients





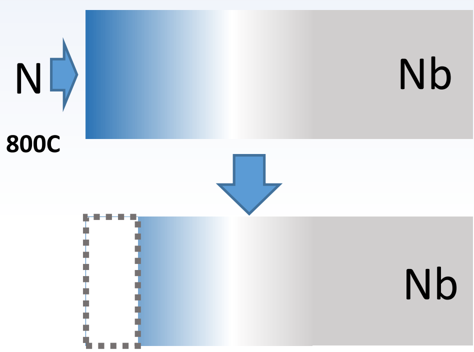
Higher Q-factor at higher field may allow for higher duty-cycles and therefore higher luminosity!

A. Grassellino *et al.*, **arXiv:1701.06077** (in publication to SUST)

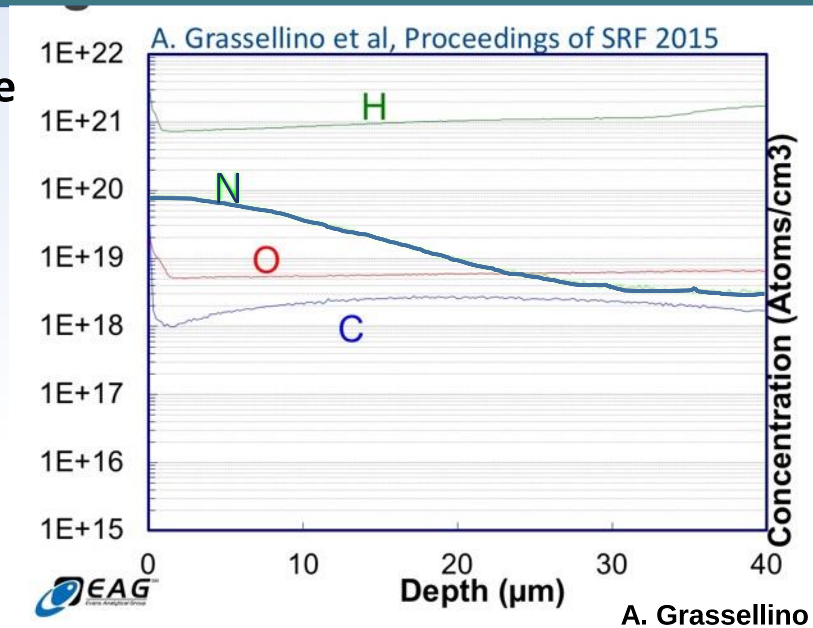
Surface structure of N-dope and N-infusion

Diffusion of N into Nb surface

N-dope



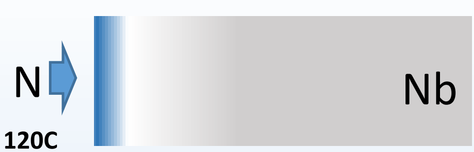
Removal by EP

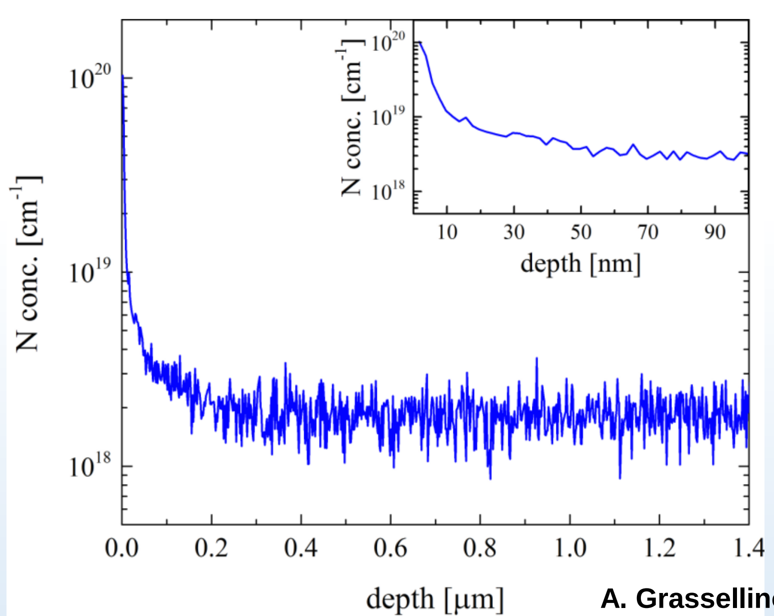


A. Grassellino ALCW2016

Diffusion of N into Nb surface 20 – 30 μm

N-infusion



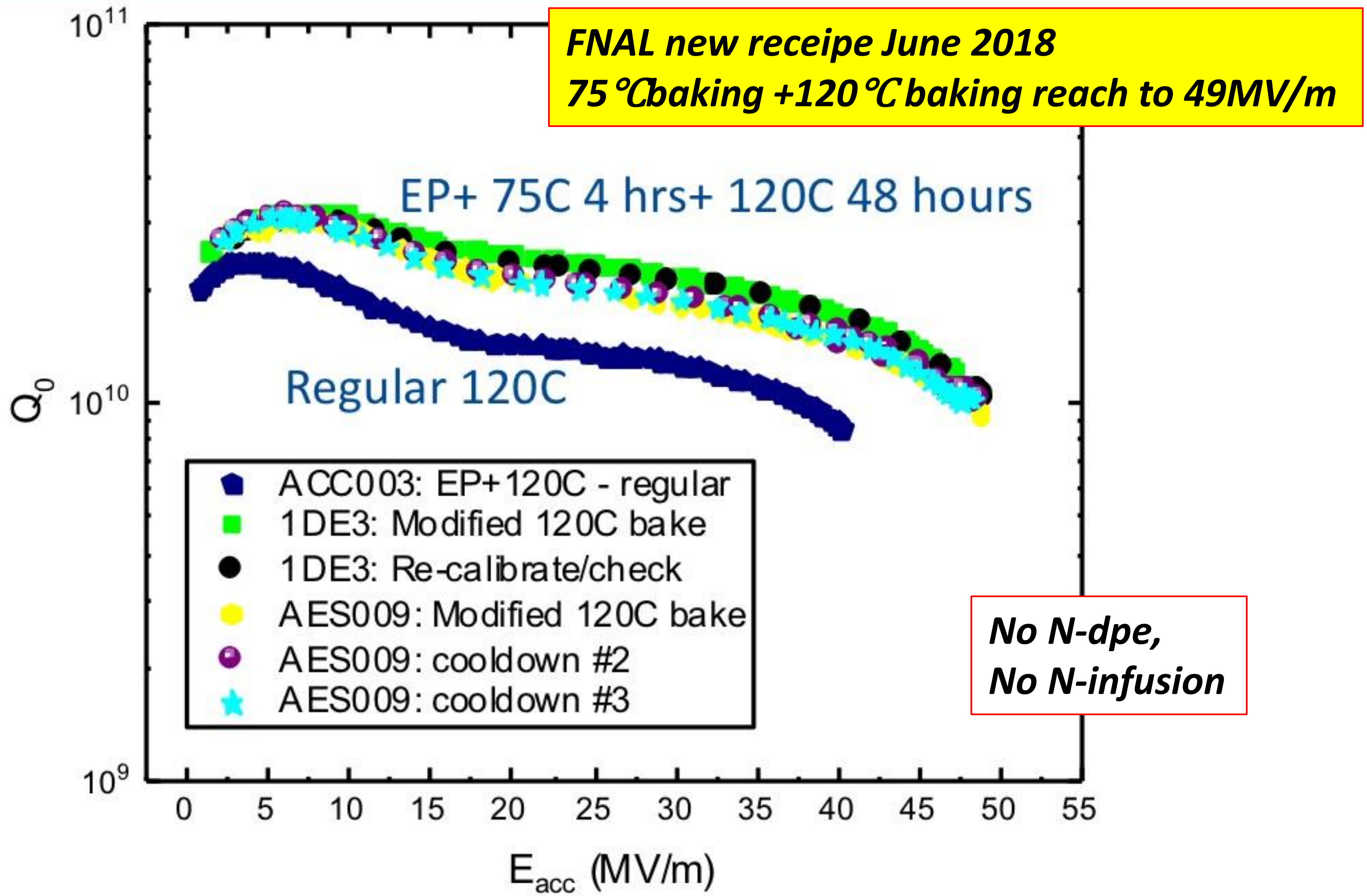


A. Grassellino ALCW2016

Diffusion of N into Nb surface around 200 nm

High-Q/High-G surface only by baking!!

Repeated on second cavity TE1AES009 (fine grain, AES, WC)

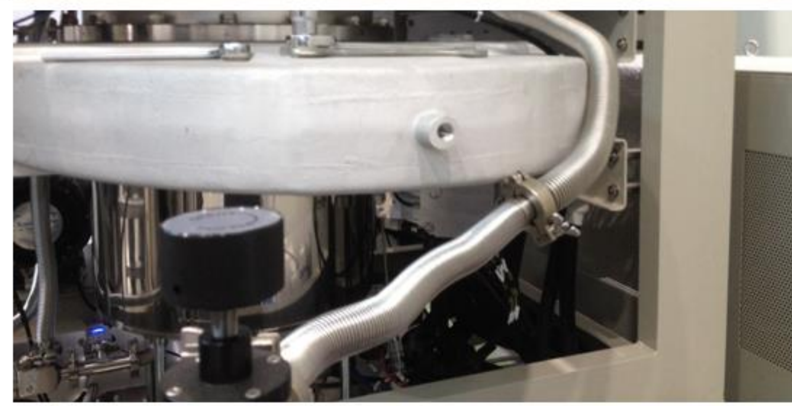


A. Grassellino et al, https://arxiv.org/abs/1806.09824

New Furnace for N-infusion R&D at KEK

KEK new furnace(located at COI)

- Completed at the end of FY2017
- Cryopump for main pump, oil-free pumping system.
- Molybdenum is used for heater, reflector, table etc.
- TMP is used during N-injection, can reach ~2e-5Pa.
- Clean-booth surround entrance door.



K. Umemori

Summary of KEK N-infusion

Summary of N-infusion @KEK new furnace

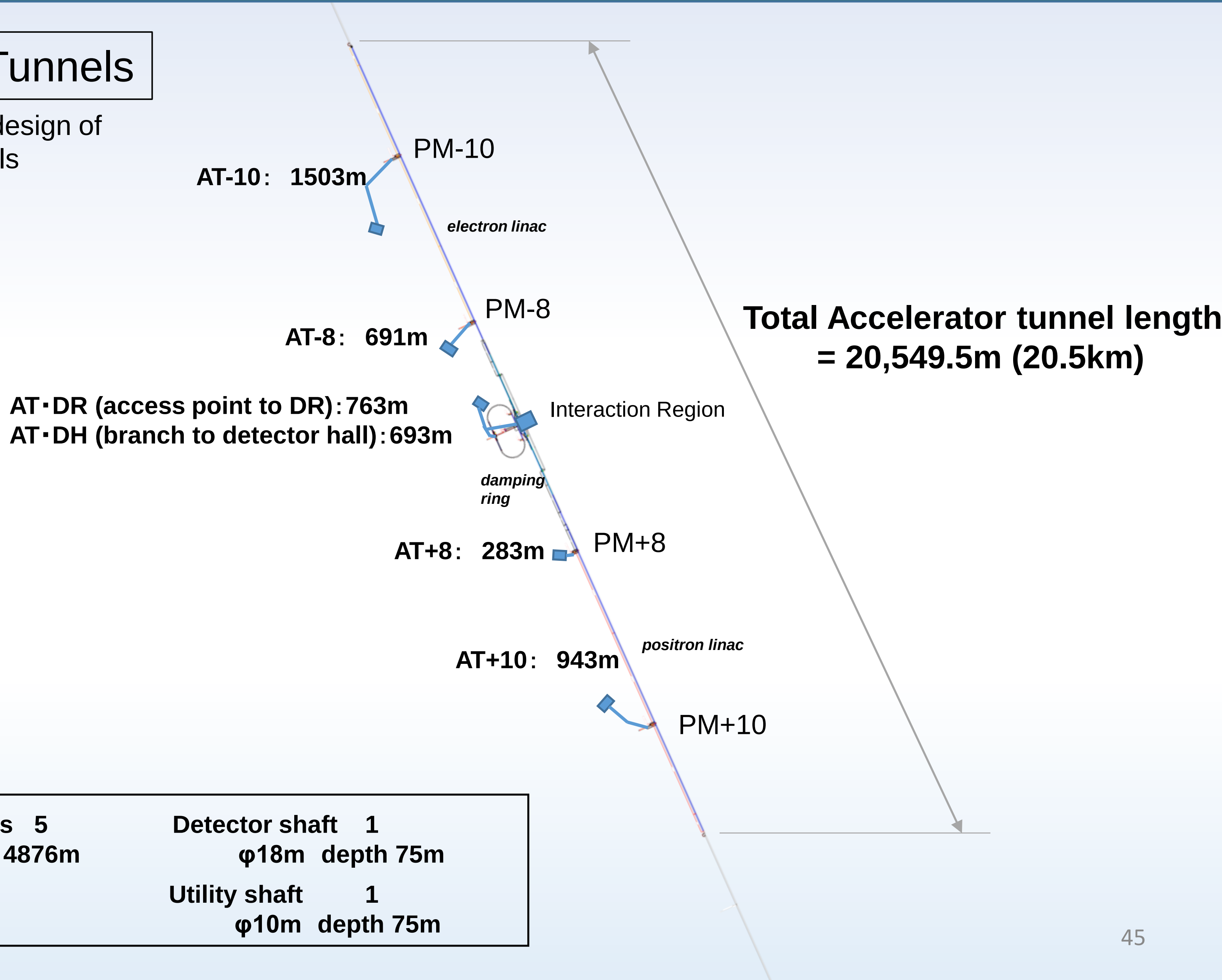
#	Day (N-inf / VT)	Cavity name	# of cell	Nb	Treatment	Results	Eacc (MV/m)	Comment
1	Jun-6 / Jun-21	R-6	1	FG	800C, 3h + 120C, 48h, 3.3Pa N2	No Q-degradation	35	
2	Jun-13 / Jul-2	R-9b	1	FG	800C, 3h + 120C, 48h, 3.3Pa N2	No Q-degradation	26	Quench due to defect
3	Jun-20? / Jul-5	R-10	3	LG	800C, 3h + 120C, 48h, 3.3Pa N2	No Q-degradation	27	F.E. limited
Summer shutdown								
4	Sep-9 / Oct-5	R-2	1	FG	800C, 3h + 160C, 48h, 3.3Pa N2	Strong Q-degradation	19	No defects found
5	Oct-6 / Oct-18	R-6	1	FG	800C, 3h + 120C, 48h (without N2)	Q-degradation (like J-PARC)	32	
6	Nov-23 / Dec-5	R-8	1	FG	800C, 3h + 120C, 48h, 3.3Pa N2	Better Q than reference	36	
7	Dec-21 / Jan-23	R-9b	1	FG	800C, 3h + 160C, 48h, 3.3Pa N2	Q-degradation (like J-PARC)	24	Quench due to defect
8	Jan-31 / Feb-14	AES018	1	FG	800C, 3h + 120C, 48h, 3.3Pa N2	No Q-degradation	38	No reference data at KEK

K. Umemori

Overall siting plan to fit Kitakami Candidate Site

Access Tunnels

Site-specific design of
Access tunnels

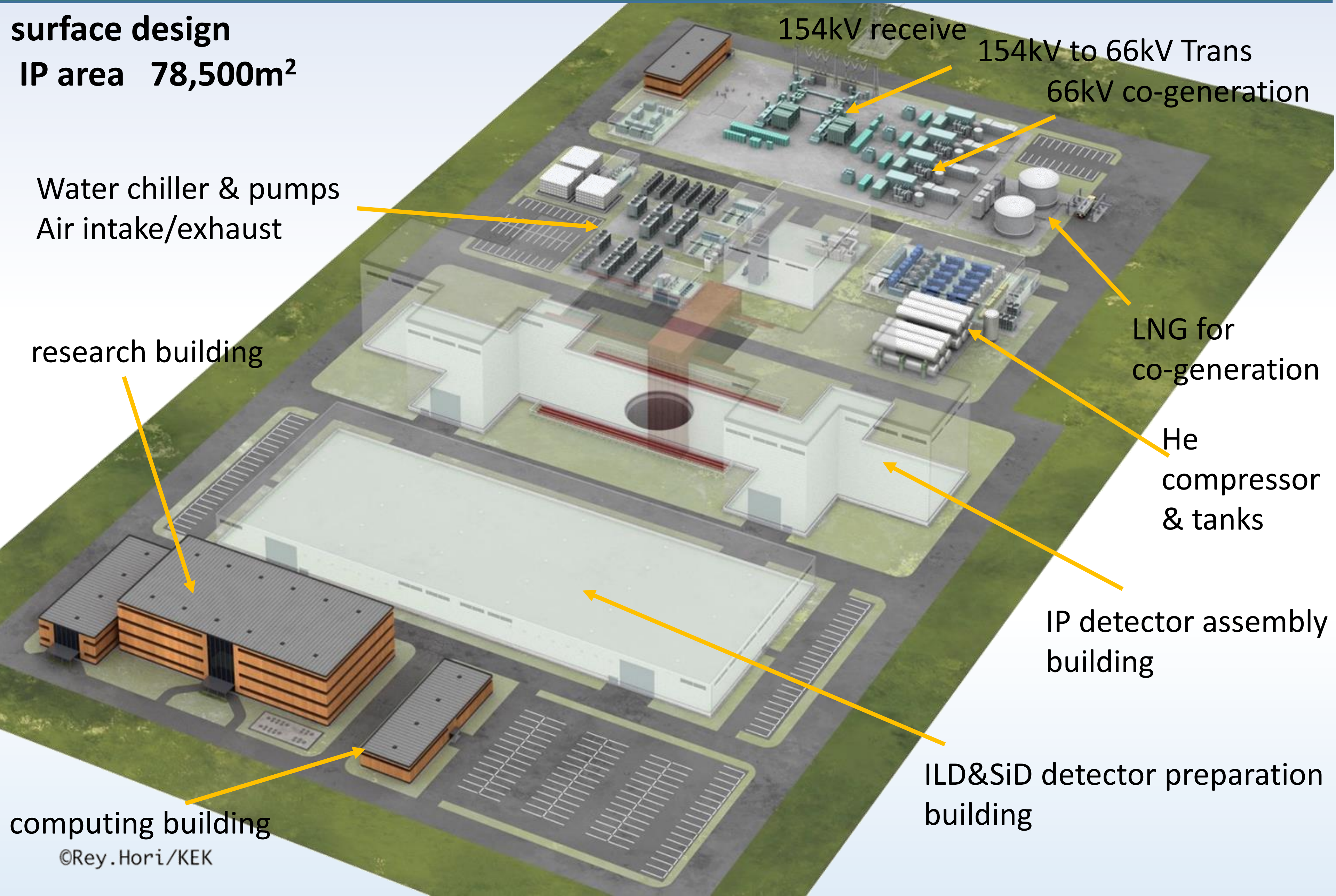


access tunnels 5
total length 4876m

Detector shaft 1
φ18m depth 75m

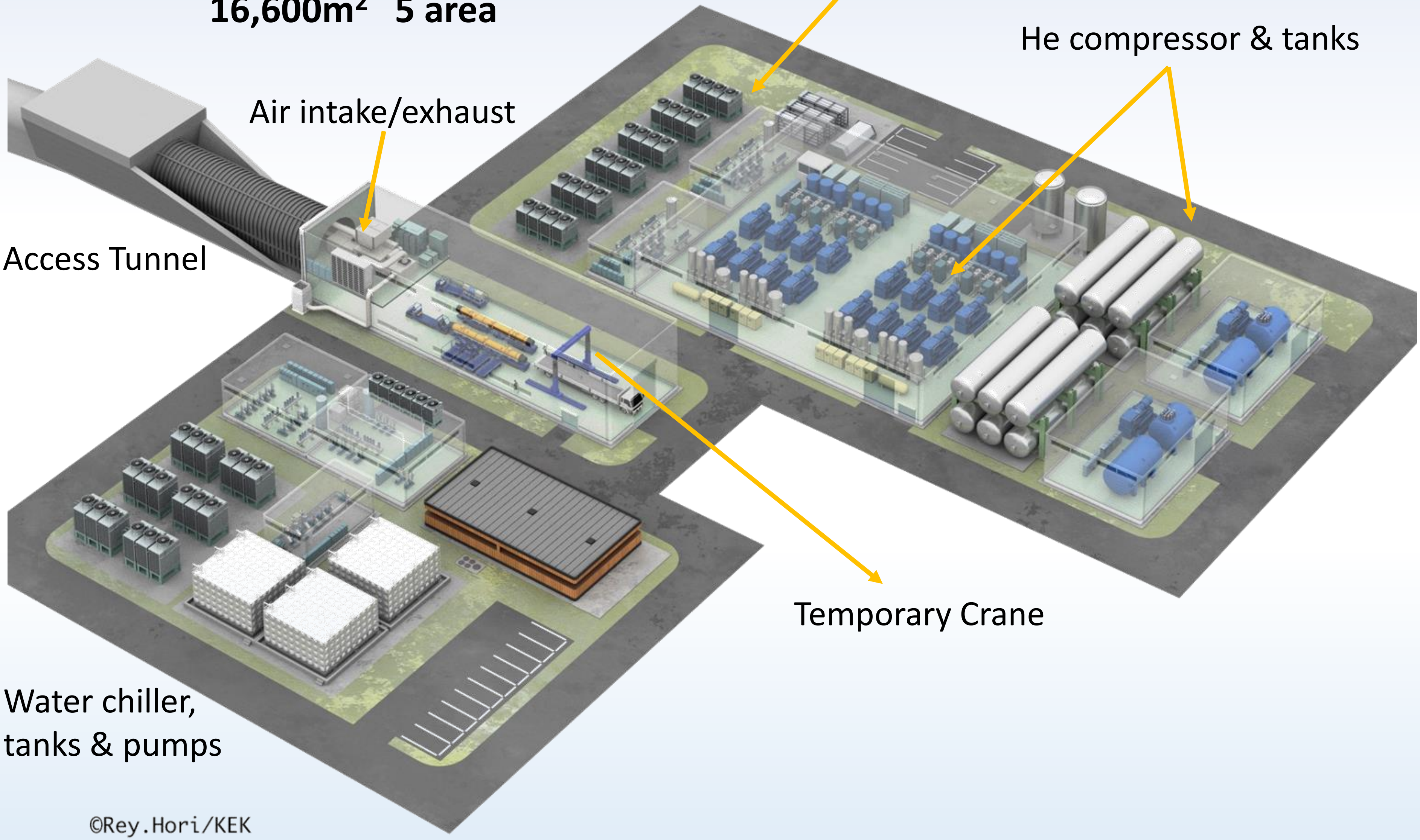
Utility shaft 1
φ10m depth 75m

Interaction Point Campus at Surface

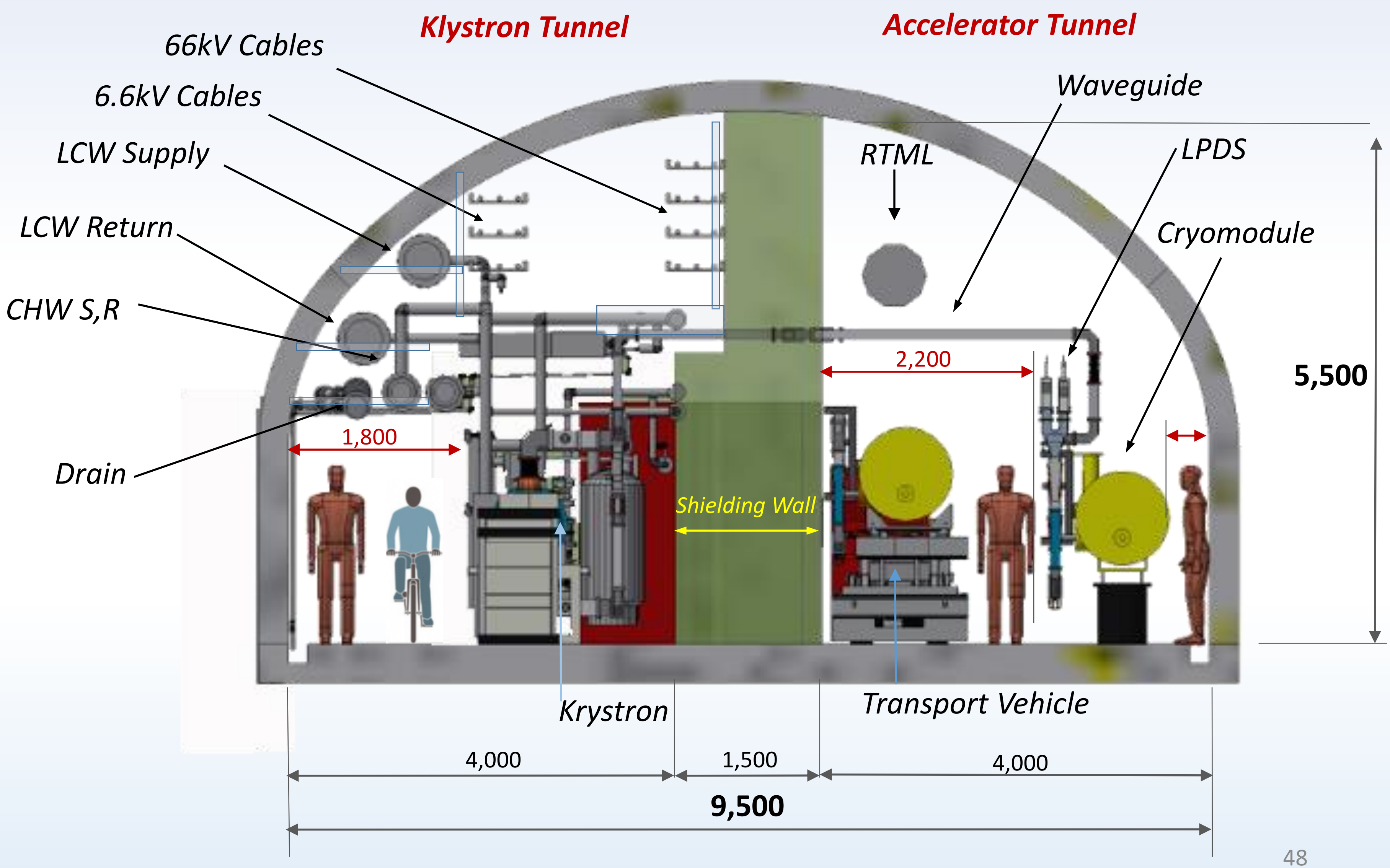


Access-station at Surface

surface design
access stations
16,600m^2 5 area



Cross-section of ILC Main Linac Tunnel



Beam Acceleration Sequence