Green-ILC Overview

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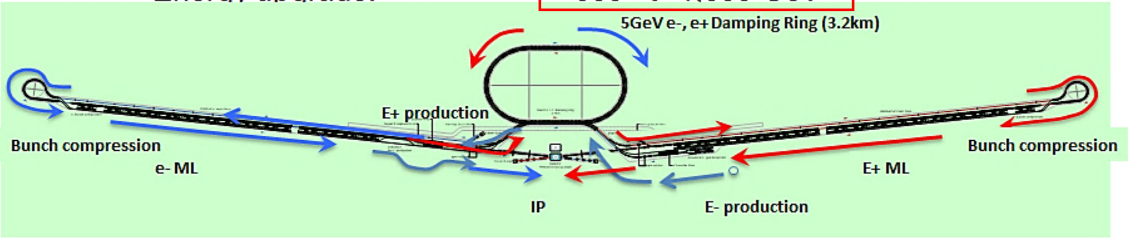
ALCW2018

28 May 2018, Fukuoka, Japan

Power Consumption of ILC

Requirements from Physics Exp.

- Basic requirements :
  - Luminosity : $\int Ldt$ = 500 fb^{-1} in 4 years
  - E_{cm} : 200 – 500 GeV and the ability to scan
  - E stability and precision: < 0.1%
  - Electron polarization: > 80%
- Extension capability :
  - Energy upgrade: 500 → 1,000 GeV



ILC (500 GeV)
Total Power
～164 MW

The cost of energy consumption (electricity) is serious issue for the realization of ILC.

Accelerator section	RF Power	Racks	NC magnets	Cryo	Conventional		Total
					Normal	Emergency	
e^- sources	1.28	0.09	0.73	0.80	1.47	0.50	4.87
e^+ sources	1.39	0.09	4.94	0.59	1.83	0.48	9.32
DR	8.67		2.97	1.45	1.93	0.70	15.72
RTML	4.76	0.32	1.26		1.19	0.87	8.40
Main Linac	52.13	4.66	0.91	32.00	12.10	4.30	106.10
BDS			10.43	0.41	1.34	0.20	12.38
Dumps					0.00	1.21	1.21
IR			1.16	2.65	0.90	0.96	5.67
TOTALS	68.2	5.2	22.4	37.9	20.8	9.2	164 MW

Efficiency from wall-plug to beam-power is ~10 %

We are challenging for higher efficiency

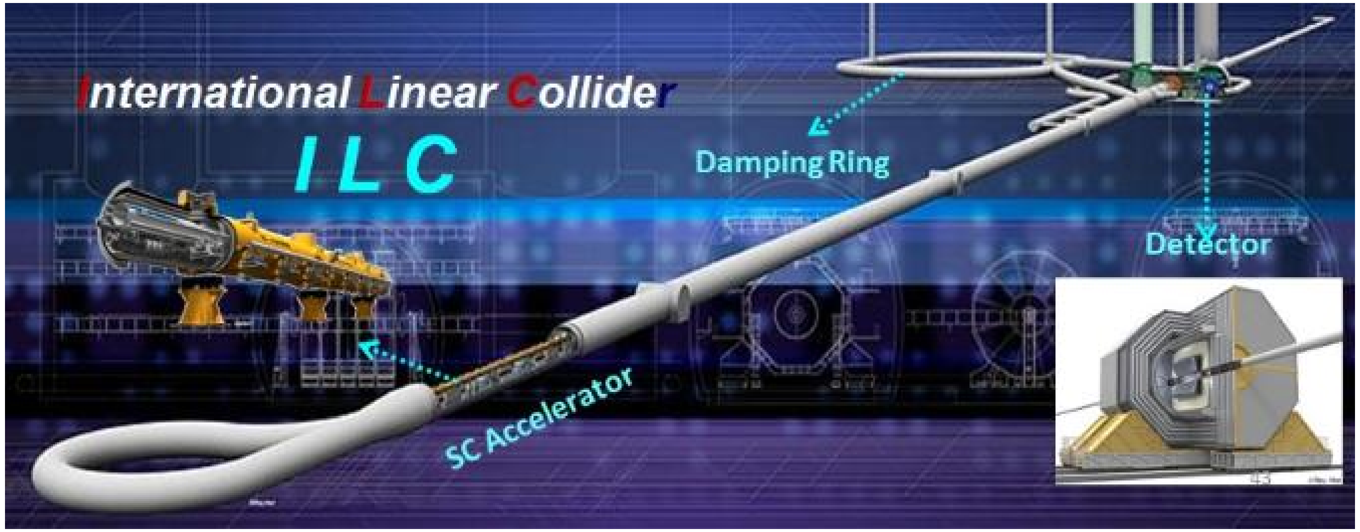
Introduction

ILC design for more efficient energy consumption (in accelerator operation)

We need Green ILC

to have the green sign for ILC !

Serious issue for the realization of ILC



2^{nd} ESS WS (Oct. 2013) triggered our activities !

2nd Workshop
Energy for Sustainable Science
at Research Infrastructures

CERN, GENEVA, SWITZERLAND, 23-25 OCTOBER 2013

Energy Management in Japan, Consequences for Research Infrastructures

Masakazu Yoshioka (KEK)

1. Electric power supply in Japan, before and after March 11, 2011 earthquake
   - High efficiency and "almost" environmental pollution-free electricity generators can save Japan, and contribute to reduce global CO_2 problem
2. KEK Electricity contract as an example of large-scale RIs
3. Accelerator design by considering optimization of luminosity/electricity demand
   - Example: Super-KEKB
   - ILC
4. Accelerator component design by considering high power-efficiency
   - Klystron
   - Availability based on MTBF and MTTR
5. Summary

ILC: an amazing energy transformer

FROM eV TO TeV:

THE GREEN ILC

2nd Energy for Sustainable Sciences, CERN Oct 2013

Denis Perret-Gallix LAPP/IN2P3.CNRS (France)

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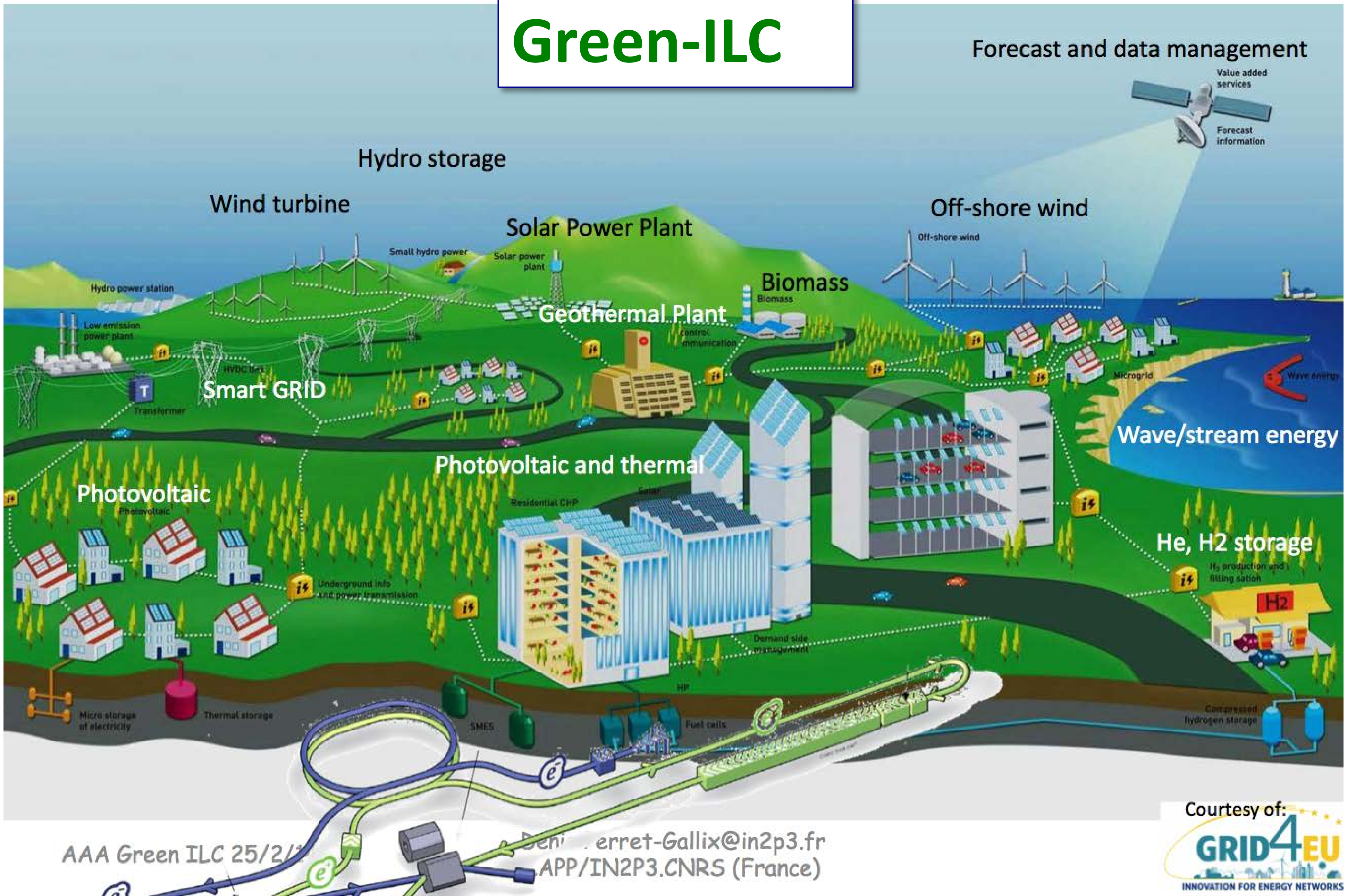
Energy Management at KEK, Strategy on Energy Management, Efficiency, Sustainability

Atsuto Suzuki (KEK)

INTER-UNIVERSITY RESEARCH INSTITUTE CORPORATION
HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION

ILC center futuristic view



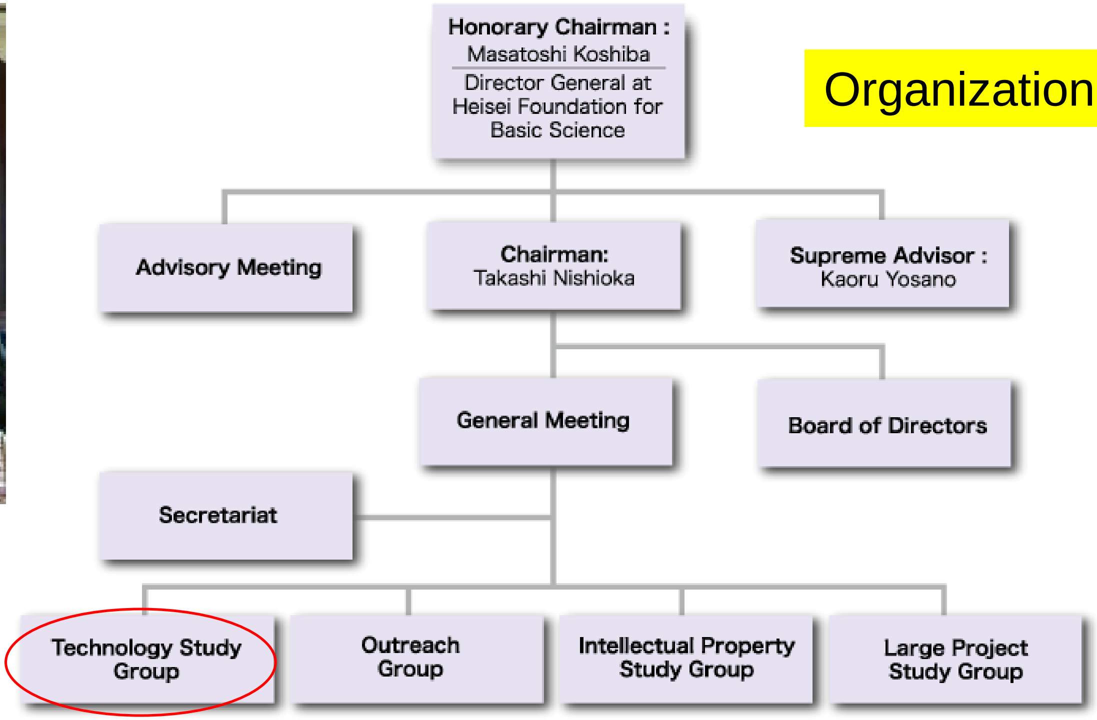
Courtesy of:

Deni· ·erret-Gallix@in2p3.fr
APP/IN2P3.CNRS (France)

Advanced Accelerator Association promoting science & technology (AAA) in Japan

Association by industries and scientists established in 2008

- 112 corporate organizations involved from industries（MHI, Toshiba, Hitachi, Mitsubishi Electric, etc.) as of Nov. 2017.
- 42 institutional organizations involved from universities and laboratories（KEK, Univ. of Tokyo, Univ. of Tohoku, Univ. of Kyoto, Riken, etc.) as of Nov. 2017.



Organization of AAA

Green-ILC WG started in Technology Study Group on 25th Feb. 2014.

Activities for Green ILC

- Three presentations were given (by A. Suzuki, D. Perret-Gallix, and M. Yoshioka) in 2nd WS "Energy for Sustainable Science at Research Infrastructure" at CERN in Oct. 2013.
- A session (four presentations) was organized for Green-ILC activities in LCWS 2013 at Tokyo in Nov. 2013. A. Suzuki also presented Green-ILC activities in the plenary session in LCWS 2013.
- Green-ILC Working Group was organized in "Advanced Accelerator Association promoting science & technology (AAA) in Tokyo/Japan. The 1st meeting for the Green-ILC WG of AAA was held on 25th February 2014. (AAA home page = https://aaa-sentan.org/en/about_us.html)
- 2nd – 15th Green-ILC WG meetings were held on May 2014 – until now in Tokyo/Japan.
- Various realistic technologies of energy-saving for ILC were proposed and discussed by industries and scientists.
- D. Perret-Gallix, T. Saeki, and H. Hayano opened the interactive home page for Green-ILC activities. Please visit http://green-ilc.in2p3.fr/ and http://green-ilc.in2p3.fr/documents/ .

Green ILC

Energy for Innovation, Innovation in Energy

http://green-ILC.in2p3.fr

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The Green ILC Project

ILC, the International Linear Collider, is the next fundamental science project in high energy physics and the first ever true global basic science center.

What CERN did for the European HEP community, ILC will do for the world. But the e+e- ILC project may go even beyond mere fundamental science and contribute to one of the world most pregnant issue: Energy, not merely high-energy but, more generally: energy for the society.

Artistic view of the ILC center in Kitakami (Japan) ILC-Iwate

The ILC scientific goal is simple: high precision study of the Higgs particle recently discovered at LHC (CERN) and other signals LHC could possibly single out. New effects will also be searched for, effects which could have been missed by the LHC due to the heavy background. Higher precision here concerns, more particularly, the various Higgs couplings, limited at LHC, in part, by the complex structure of the interacting particles, the protons compared to the elementary electrons.

Recent Posts

- Green-ILC in LC Newsline
- New Hydraulic Wind Turbine
- Green Session at LCWS 2014
- EUCARD2 EnEfficient
- Liquid Air in the Energy and Transport Systems

Links

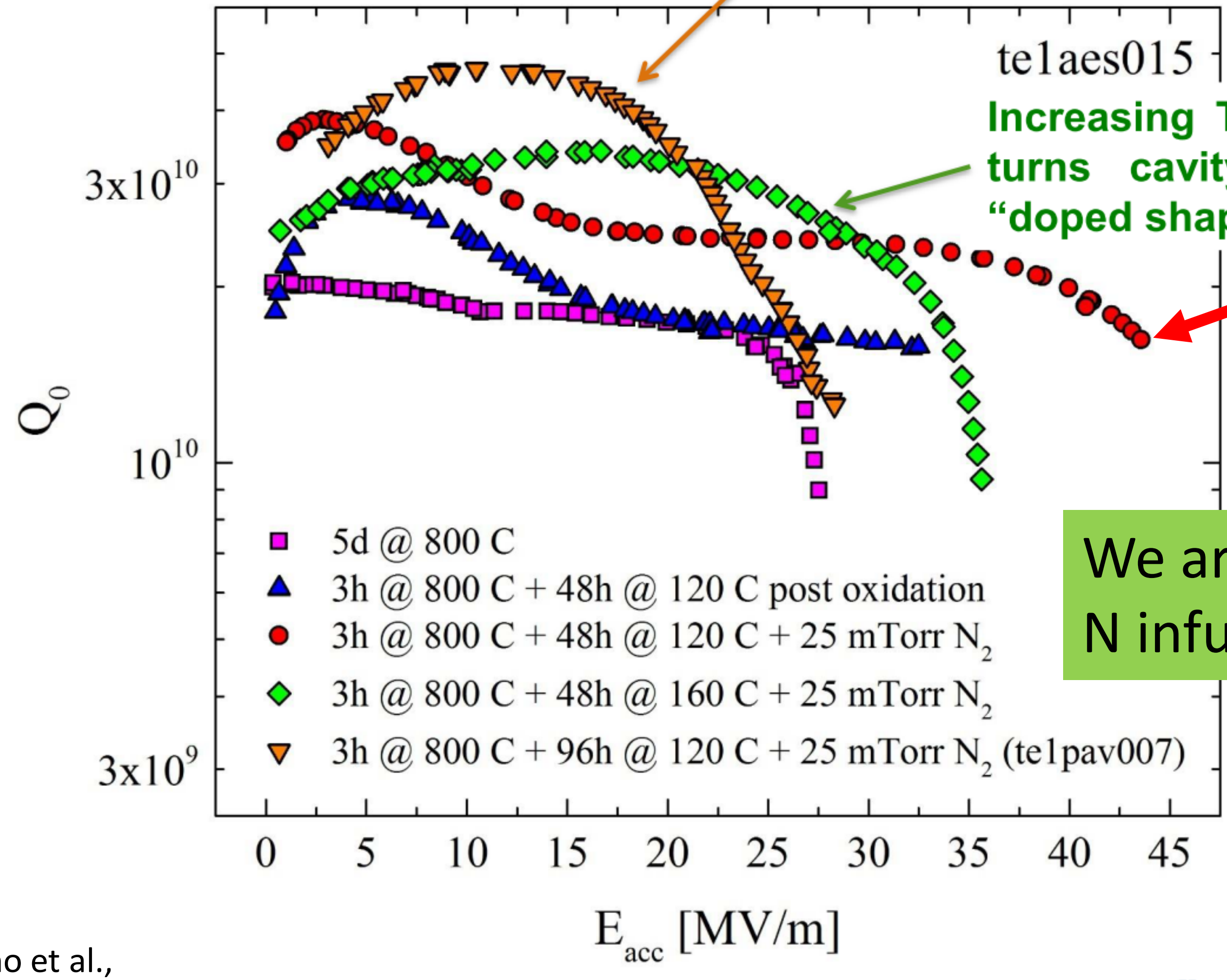
- email: green.accelerators@gmail.com
- Green-ILC wiki
- Green-ILC group discussion

Green-ILC WG (AAA) report-2016 in English and all presentations related to Green-ILC are found on http://green-ILC.in2p3.fr/documents/.

Then "high-Q & high gradient" are realized

Cavity evolution

Increasing duration x 2 turns cavity into "doped shape", even higher Q!



N infusion

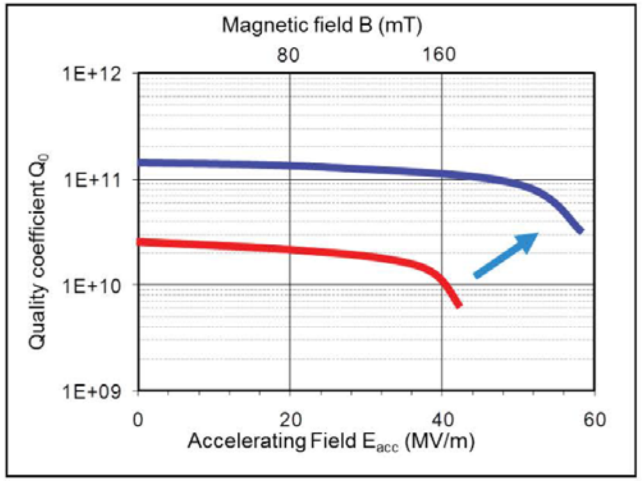
We are trying to involve N infusion in ILC recipe.

A. Grassellino et al., arXiv:1701.06077 to be published in Supercond. Sci. Technol.

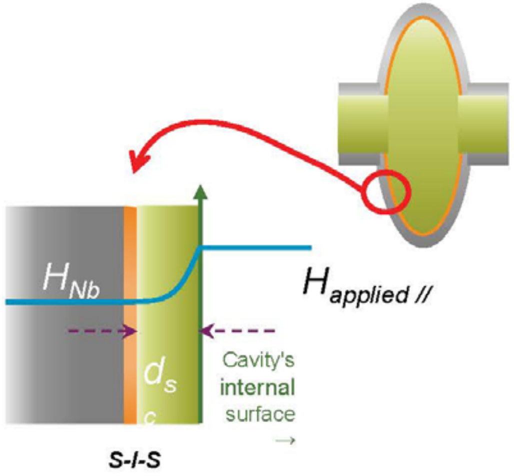
More efforts for higher Q and higher G. Thin-Film Coating Technology.

AFTER NIOBIUM : NANOCOMPOSITES MULTILAYERS

Structures proposed by A. Gurevich in 2006, SRF tailored



- **Dielectric layer**
  - Small ⊥ vortex (short -> low dissipation)
  - Quickly coalesce (w. RF)
  - Blocks avalanche penetration
  - => **Multilayer** concept for RF application
- **Nanometric I/S/I/ layers deposited on Nb**
  - SC nanometric layers (≤ 100 nm) => $H_{C1}\uparrow$ => Vortex enter at higher field
  - Nb surface screening => allows high magnetic field inside the cavity => higher E_{acc}
  - SC w. high T_C than Nb (e.g. NbN): $R_s^{NbN} \approx \frac{1}{10} R_s^{Nb}$ => $Q_0^{multi} >> Q_0^{Nb}$



Slide by C.Z.Antoine (CEA/Saclay)

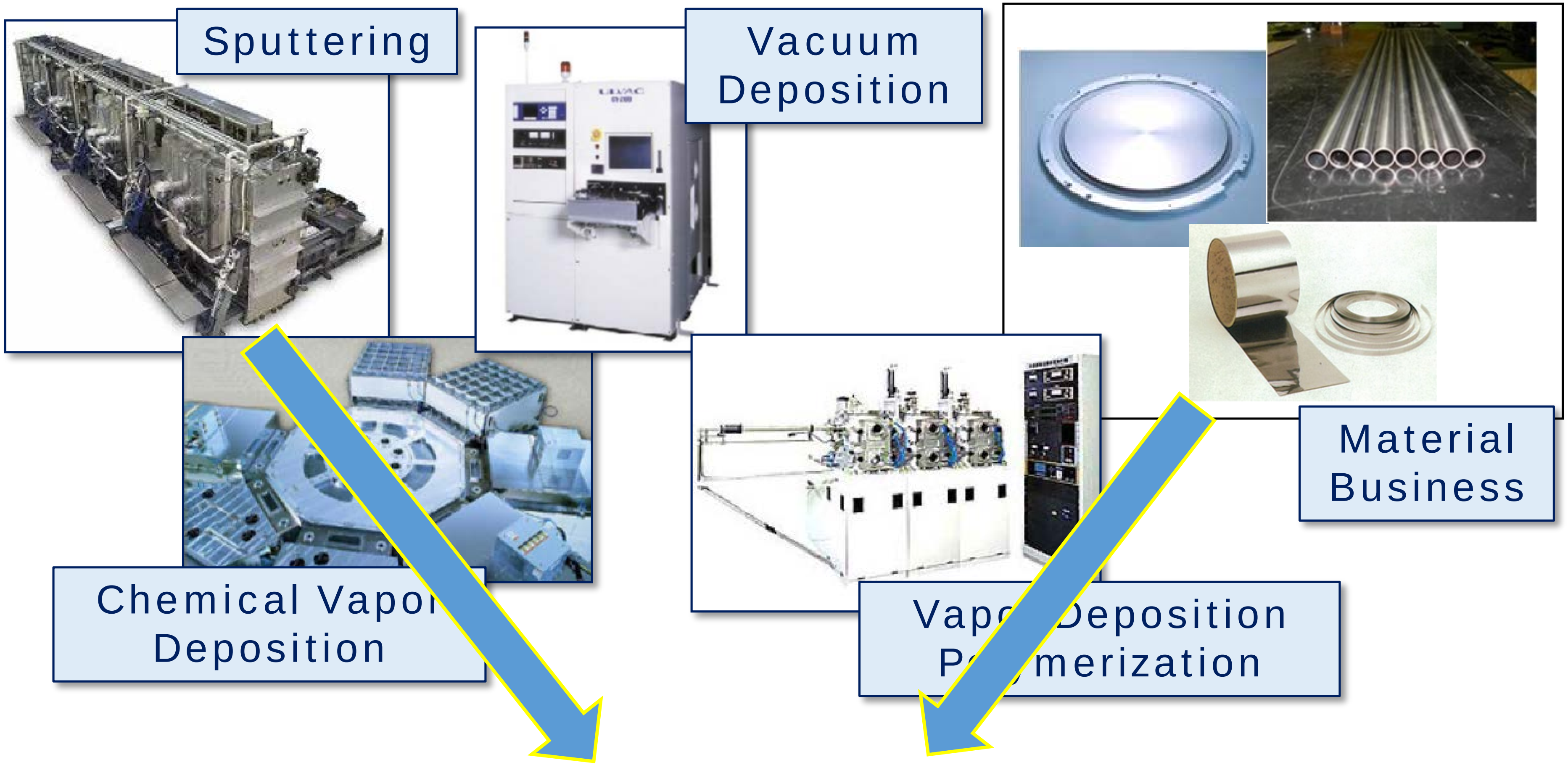
Thin Film R&D

- Thin-Film creation is ongoing in the collaboration among ULVAC, KEK, and Kyoto University.
- Measurements of SRF characteristics on Thin-Film samples by CEA/Saclay, KEK and Kyoto University.
- Plan for SRF cavity experiments:

KEK and JLab will provide SRF Nb single-cell cavities to ULVAC to create various thin-film structures on the inner surface of cavities.

Collaboration with ULVAC Corporate (Industry) for thin-film creation

We have various vacuum related technologies.

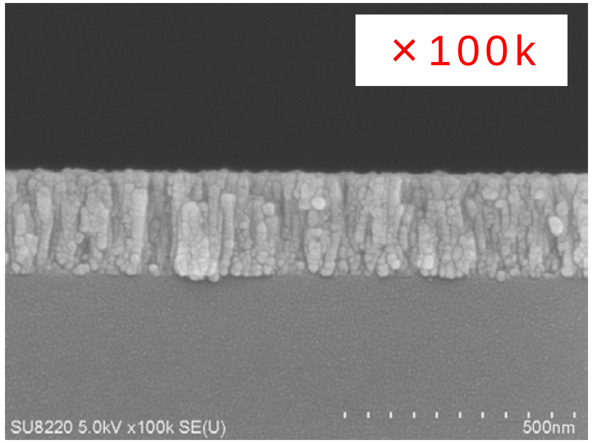


We can create high purity and quality thin-film!

Collaboration with ULVAC (Industry) for thin-film creation

– Optimizing coating condition

We have coated NbN thin-films with an atomic ratio of 1 part N to 1 part Nb.

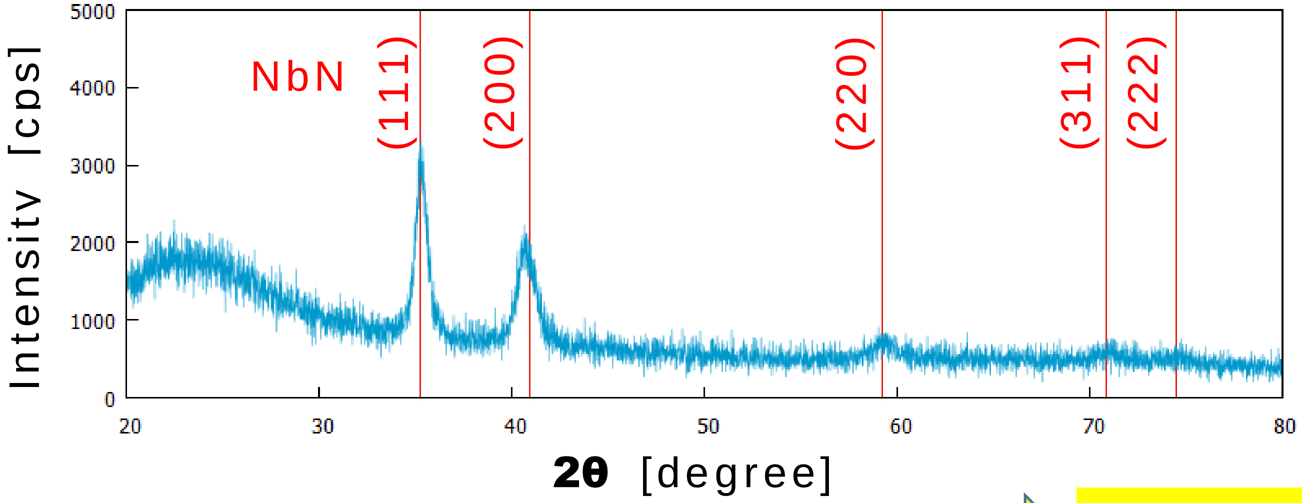


SEM Cross-section
NbN 200nm / Si

・Strong crystalline orientation

・High film density

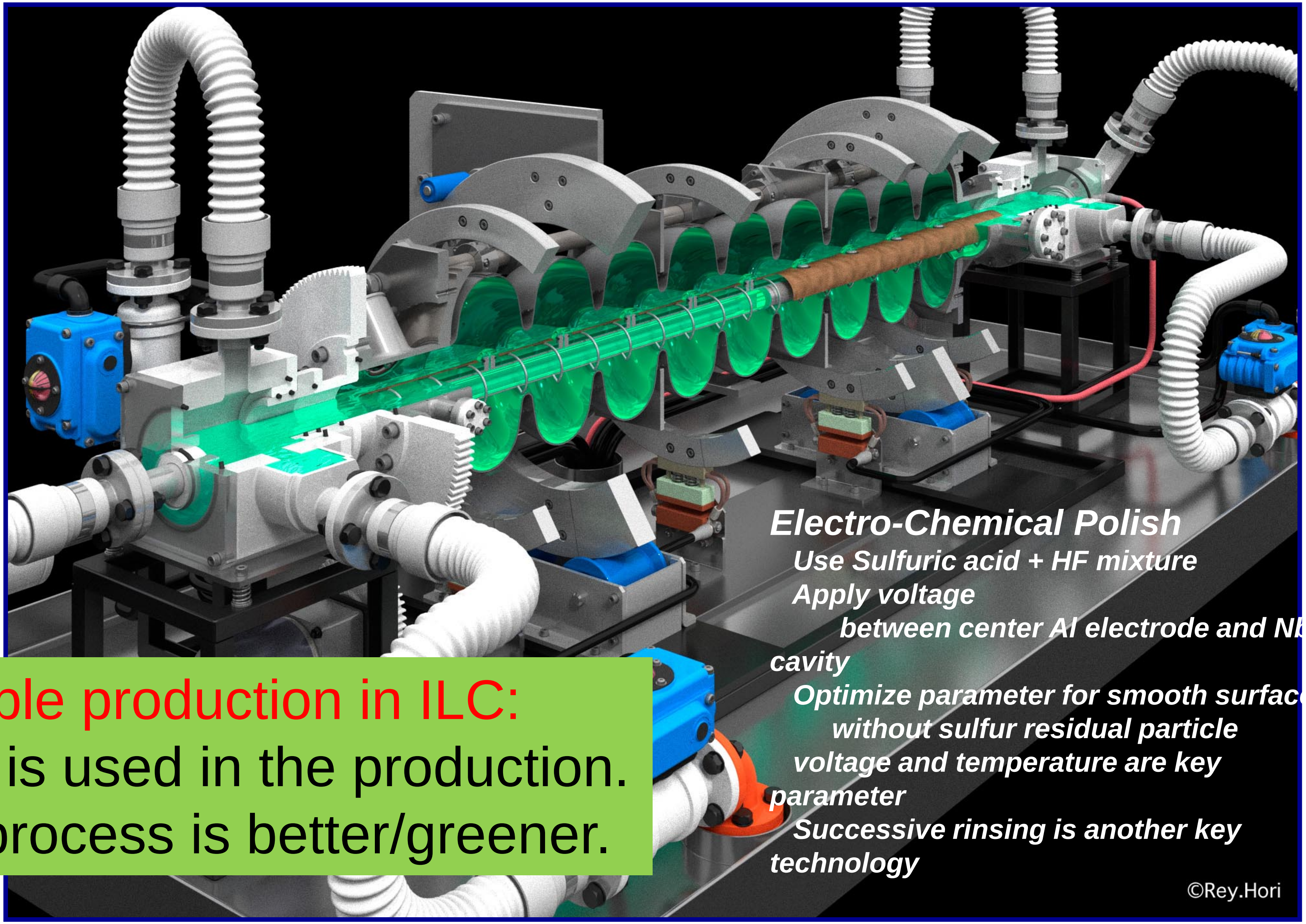
X-ray diffraction 2θ-θ
NbN 200nm / glass



This sample's T_c is about 14K!

See presentation by R. Katayama

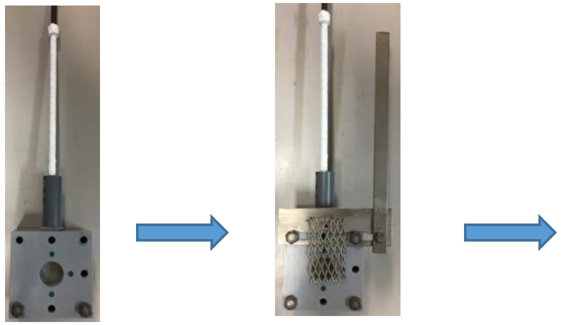
Electro-chemical Polishing (EP) inside SCRF 9-cell cavity



Sustainable production in ILC:
Toxic HF is used in the production.
HF-free process is better/greener.

R&D on EP process with NaCl water (salt water), instead of HF mixture.

setting



Experimental setup

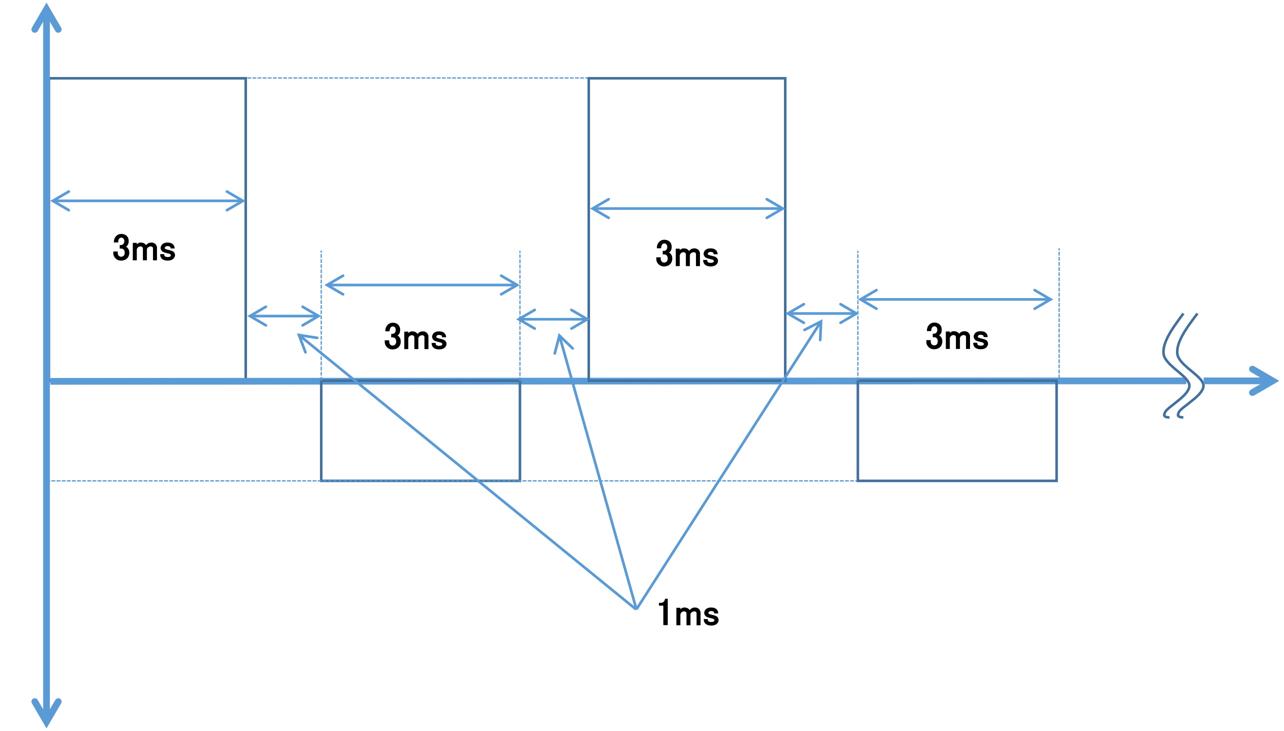
Experimental Voltage and pulls condition

Negative 9V for 3.0ms

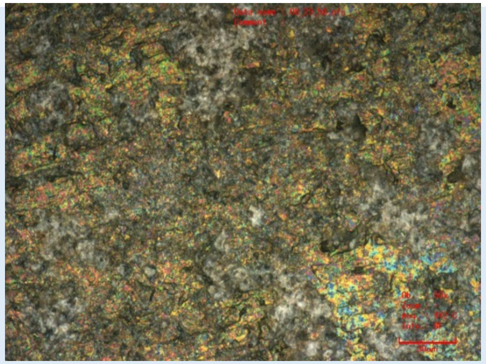
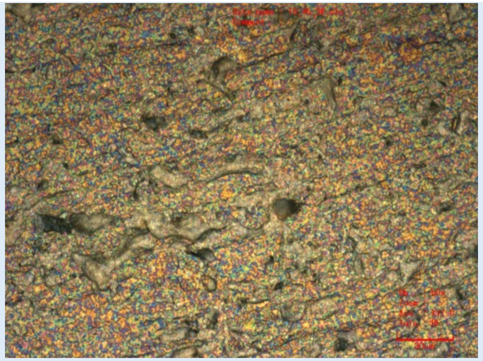
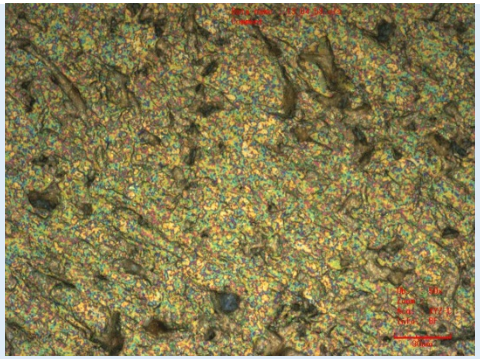
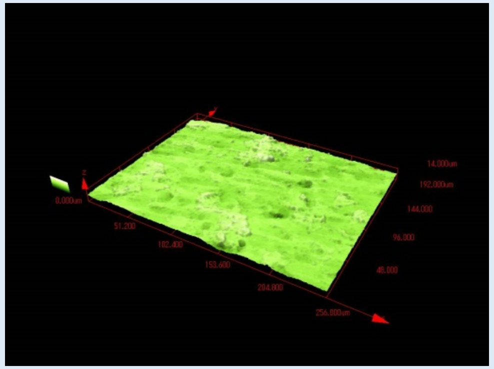
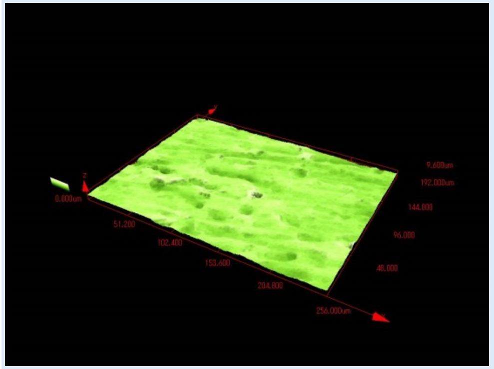
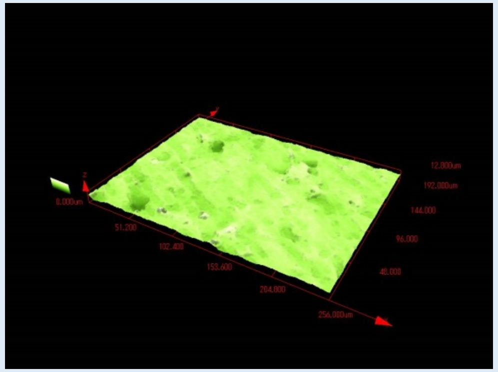
Positive 3V for 3.0ms

Turn off : 1ms

Reaction Time : 10min



(1) The result of surface after EP, when the wave condition was changed.
Results of surface after electro-polishing processes with various pulse-shapes for the concentration of electrolyte of 50 g/L.

	Negative 9V for 3.0ms Positive 9V for 3.0ms	Negative 9V for 3.0ms Positive 9V for 9.0ms	Negative 9V for 3.0ms Positive 9V for 12.0ms
Observation of microscopy			
			

The removal speed , when the wave condition was changed.

Negative Positive	9V3ms 9V3ms	9V3ms 9V9ms	9V3ms 9V12ms	3V3ms 3V3ms	3V3ms 6V3ms	3V3ms 9V3ms	3V3ms 9V9ms	3V3ms 9V12ms
Dissolved amount (mg)	4.6	4.5	4.4	3.7	4.5	4.5	4.2	4.7
Removal speed (μm/分)	0.171	0.167	0.164	0.137	0.167	0.167	0.156	0.175

The change of roughness(Ra) before EP and after EP

Negative	9V3ms	9V3ms	9V3ms	3V3ms	3V3ms	3V3ms	3V3ms	3V3ms
Positive	9V3ms	9V9ms	9V12ms	3V3ms	6V3ms	9V3ms	9V9ms	9V12ms
Before	0.524	0.455	0.598	0.677	0.684	0.602	0.658	0.515
After	0.456	0.424	0.521	0.470	0.385	0.636	0.446	0.388
R*1	13.06	6.86	12.87	30.62	43.68	-5.68	32.24	24.66

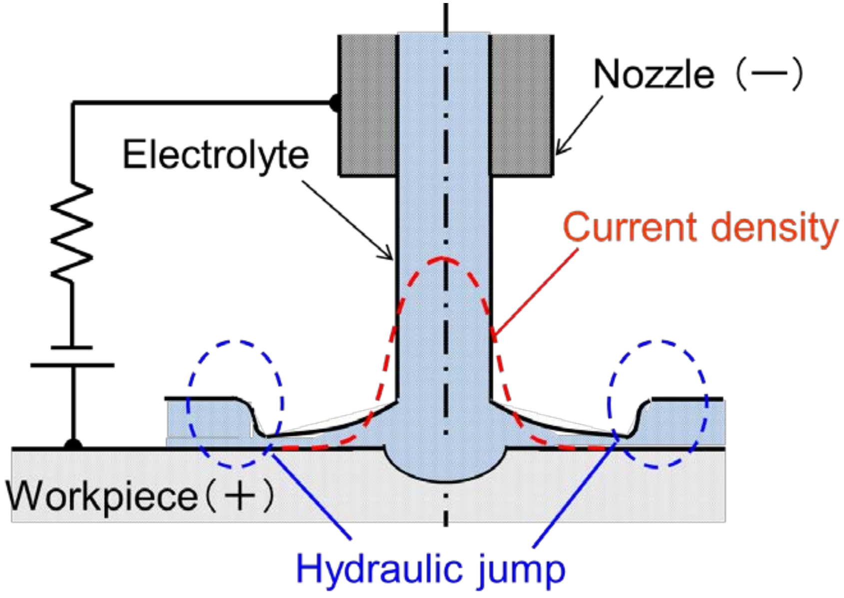
*1 R=(Before roughness − After roughness)/ Before roughness × 100

This was the best condition.

R&D on EP process with NaCl water (salt water), instead of HF mixture.

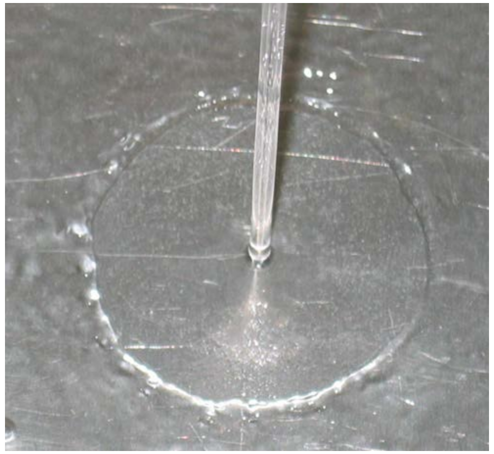
Collaboration of Nomura plating (industry) and KEK.
Sample test seems OK.

Idea on the application of the electrolyte jet machining to the SRF Nb cavity



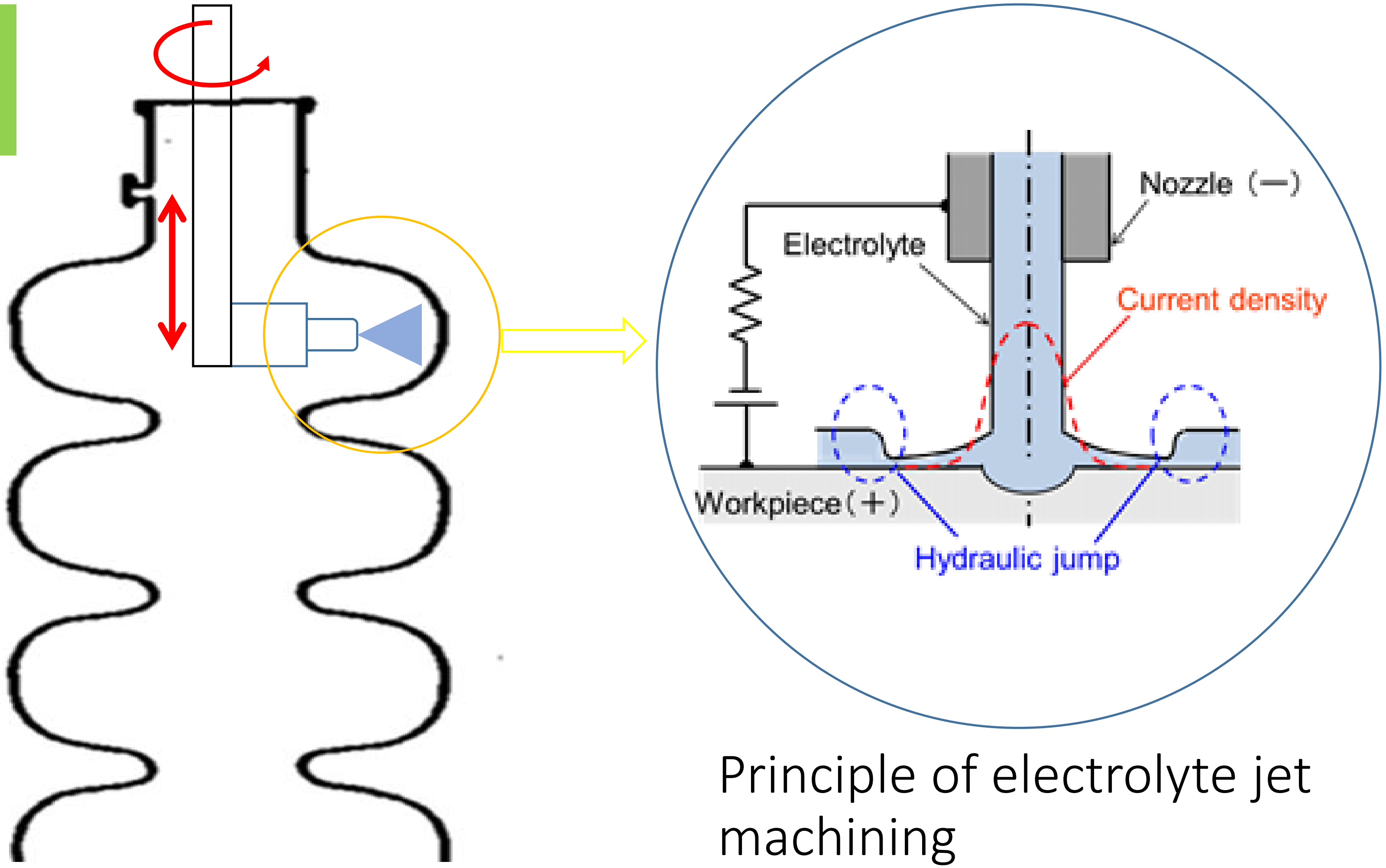
Principle of electrolyte jet machining

The technology from the university of Tokyo. Professor M. Kunieda.



Idea on the application of the electrolyte jet machining to the SRF Nb cavity

Possible application on the local grinding process.



Principle of electrolyte jet machining

Green Technologies in ILC design.

- If we get a green sign from Japanese government, we will soon start fixing the ILC-design for the real construction of ILC.
- The green technologies should be embedded into the ILC design for construction.

High-Q/High-G N-infusion technology, HF-free EP process, thin-film technology, and so on.

- Absolutely, enormous efforts will be required. We should work together for the realization of Green-ILC.

Summary

- HF-free EP process is studied in collaboration between Nomura plating and KEK. Neutral electrolyte of NaCl (salt water) is used in the study and sample test was successful.
- Thin-film studies are done in collaboration among ULVAC, CEA/Saclay, Jlab, KEK and Kyoto University. ULVAC creates thin-film structures, KEK and Kyoto University measure the SRF characteristics of thin-film samples. Plan is to fabricate SRF cavities for thin-film coating.
- Green-ILC activity is very important for the realization of ILC. The activity started in 2013 and so far many green technologies have been considered for ILC. But still we need enormous efforts to embed the green technologies into the real design of ILC.