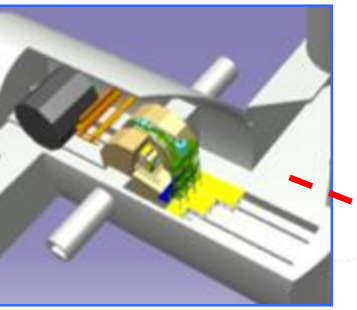
Superconducting RF accelerator

KEK

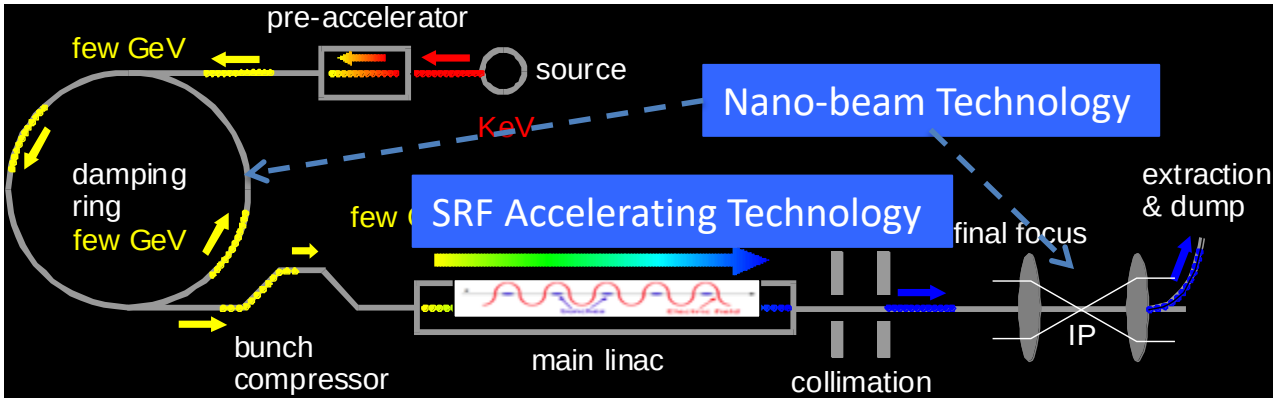
Shin MICHIZONO

- *The ILC*
- *Cavity fabrication facility CFF*
- *Superconducting RF R&D at STF*
- *ILC cost reduction SRF R&D*
- *Low- beta SRF activities*

ILC Acc. Design Overview (in TDR)

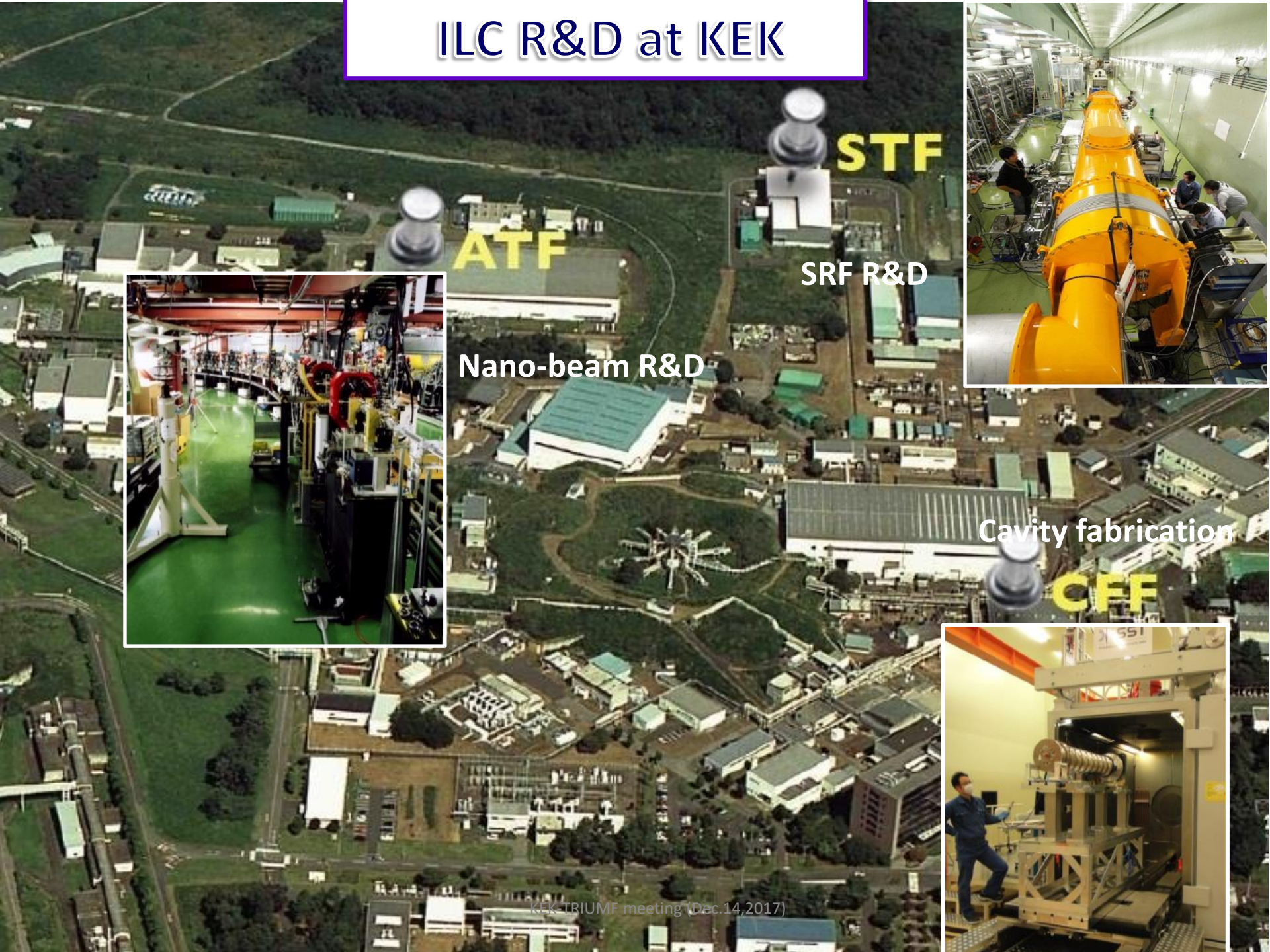


Key Technologies



Item	Parameters
C.M. Energy	500 GeV
Length	31 km
Luminosity	1.8 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	**5.9** nm
SRF Cavity G. Q_0	**31.5** MV/m Q_0 = 1x10 ^{10}

ILC R&D at KEK

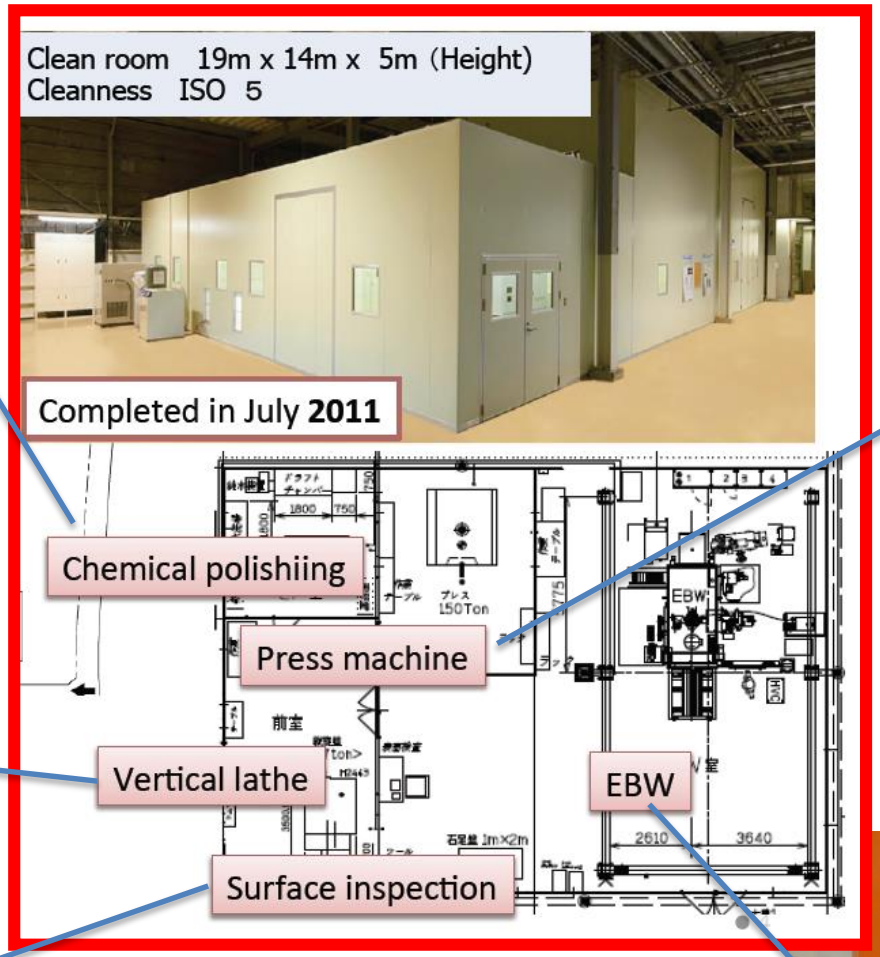


Main equipments in CFF

Chemical polishiing

CNC vertical lathe
(Moriseiki, Japan)

Microscope
(Surface inspection)



Servo press machine
(AMADA, Japan)
Max. applying force:1500 kN

EB welding machine
（SST, Germany）
Max. beam voltage: 150 kV

Present status of production

July 2011 Construction of Cavity Fabrication Facility (CFF) is finished.
Feb. 2012 The first cavity named KEK-0 was fabricated in CFF, and its acceleration gradient attained 29 MV/m.
Mar. 2014 The second cavity named KEK-1 was finished, and its acceleration gradient attained **36** MV/m.
April 2014 5 R&D cavities (1-cell & 3-cell) were fabricated, to June 2015
Feb. 2016 The third cavity named KEK-2 was finished, and its acceleration gradient attained **38** MV/m.
April 2016 Fabrication of new R&D cavities and the fourth cavity named KEK-3 are ongoing.

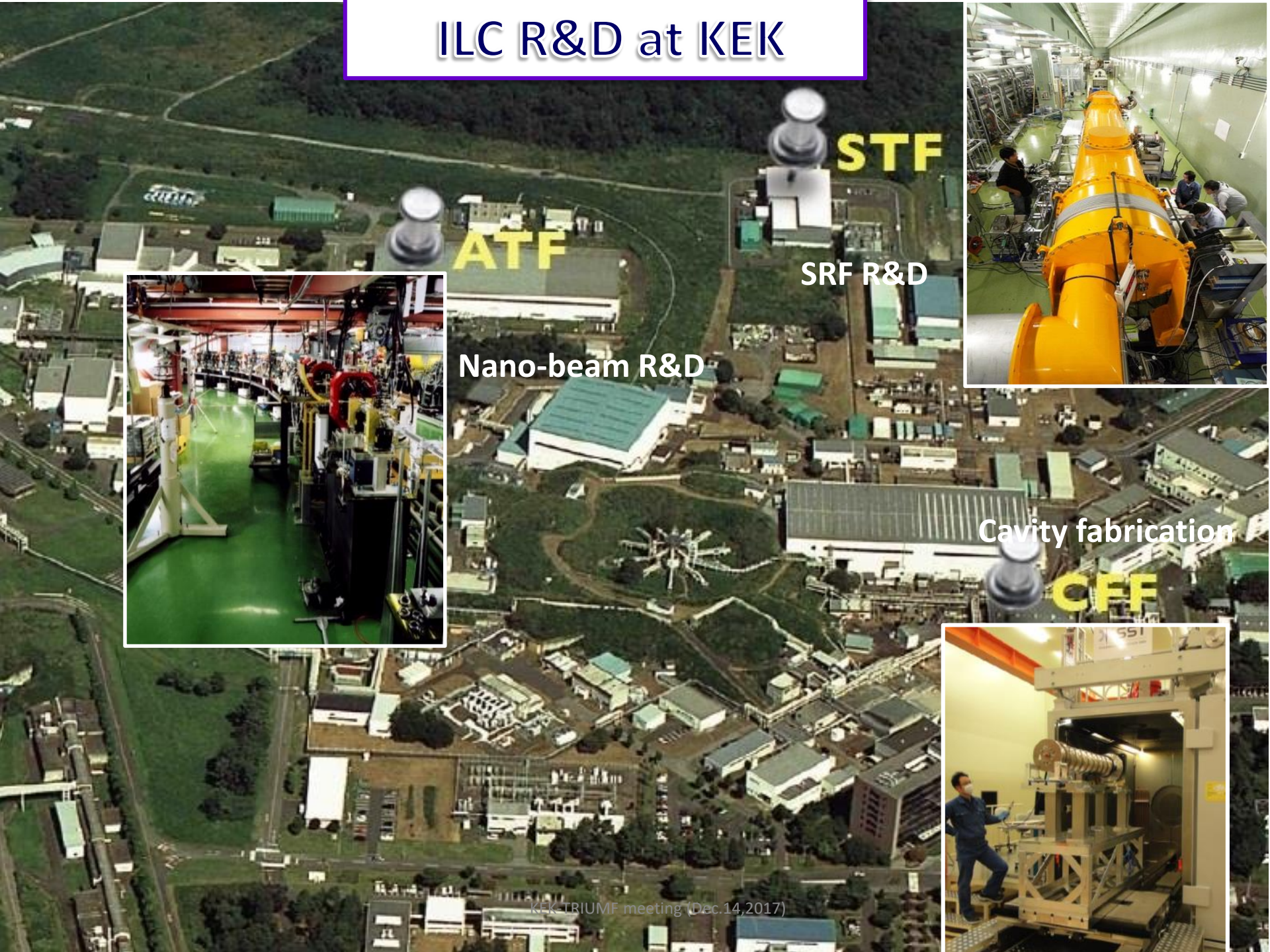
Opening of CFF

KEK-0

KEK-1

KEK-2

ILC R&D at KEK



Construction of STF cryomodules

STF-1 Cryomodule
Four 9-cell cavities (2008')

S1- Global Cryomodule
Four (+4) 9-cell cavities (2010')

STF tunnel (2011')

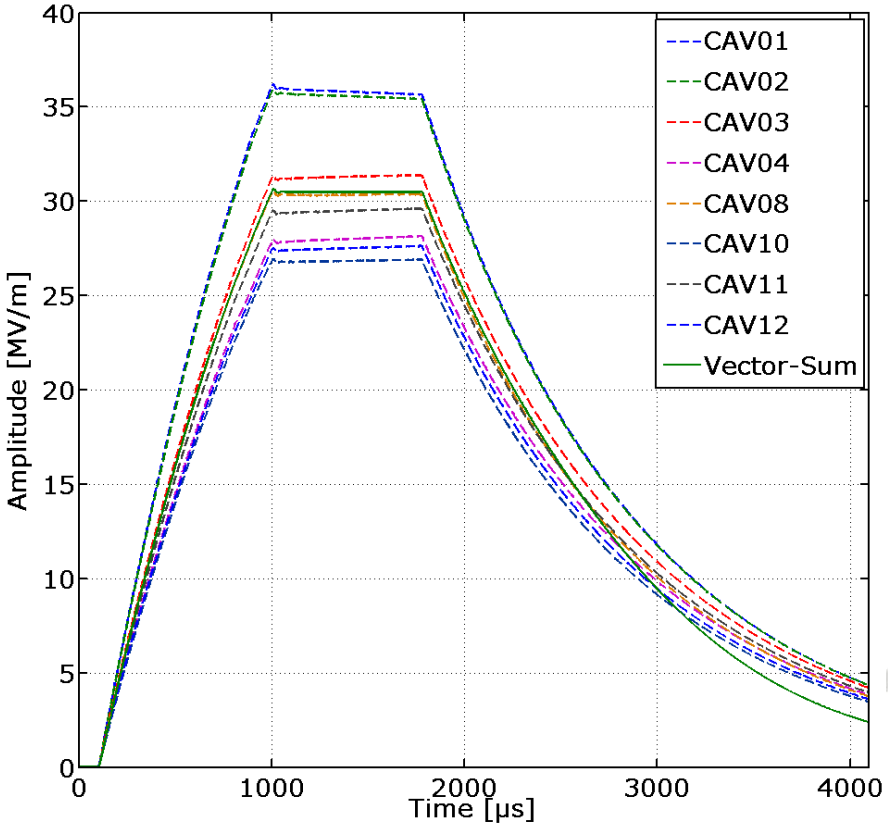
STF-2 - Capture Cryomodule
Two 9-cell cavities (2012')

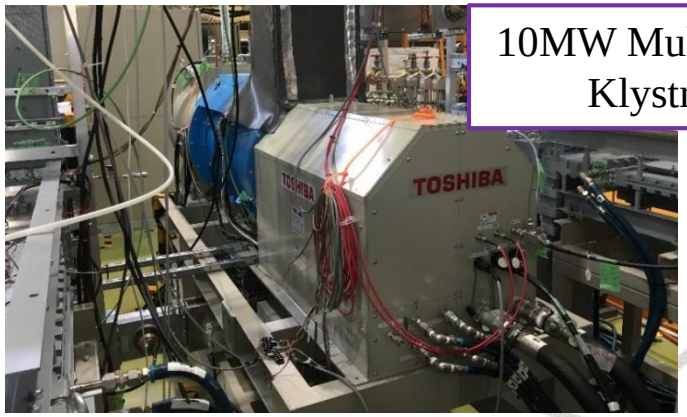
Beam operation

HPG regulation

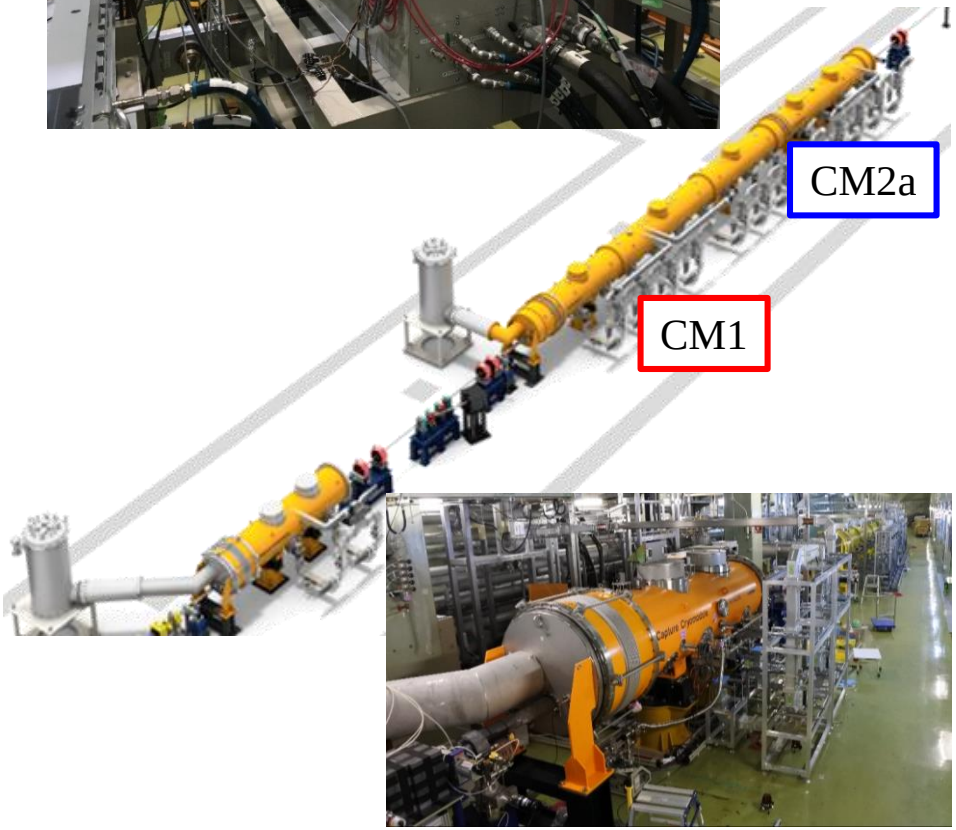
STF-2 - CM1+CM2a Cryomodule
Eight + Four 9-cell cavities (2014')

8 Cavities Operation by Vector-Sum @STF





10MW Multi-beam Klystron



CM2a

CM1

8 Cavities were tuned on resonance by piezo, and vector-sum operation was done at 31MV/m.

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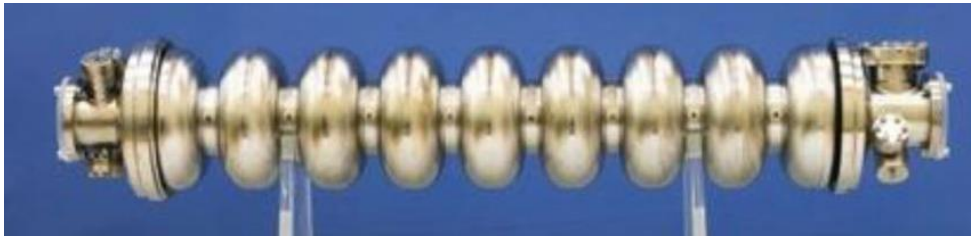
- *Low- beta SRF activities*

US-Japan cost reduction R&D

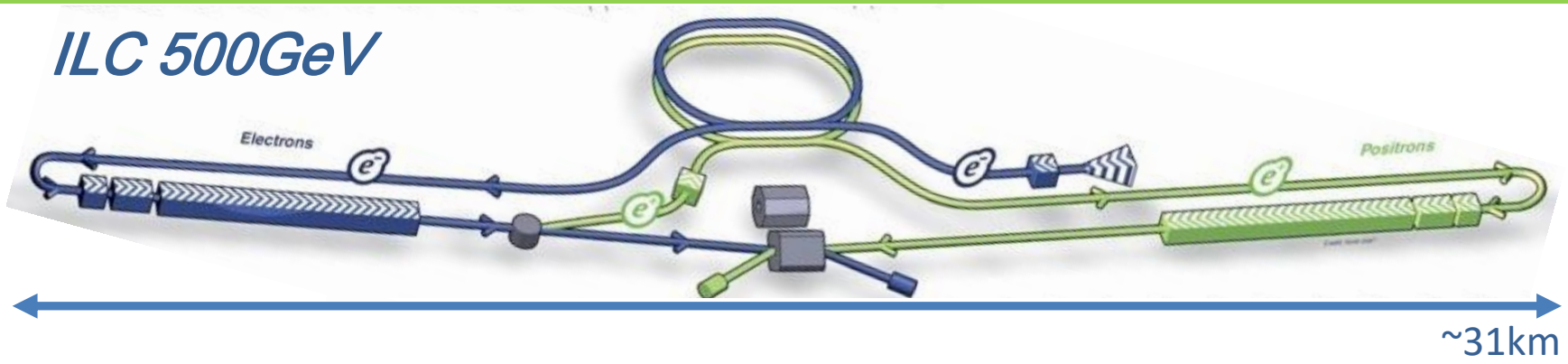


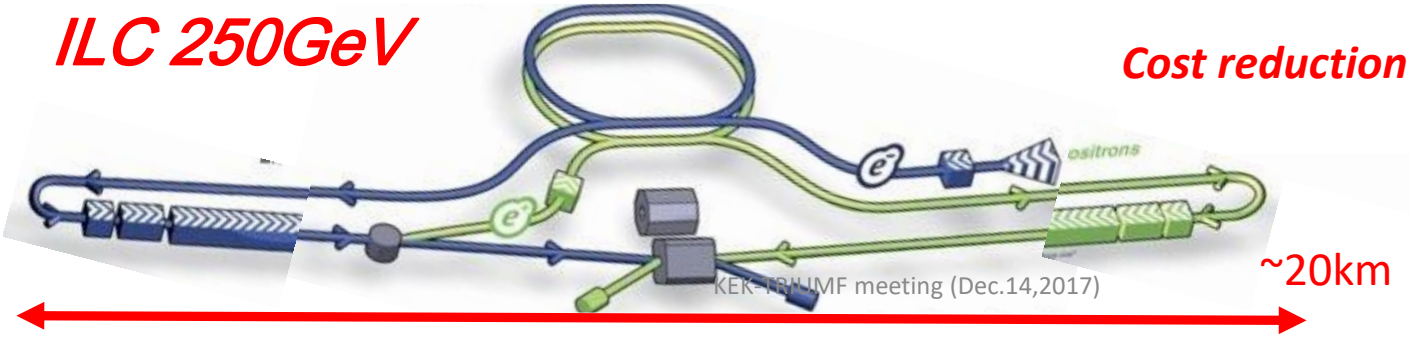
Cost reduction by technological innovation

Innovation of Nb (superconducting) material process: decrease in material cost

Innovative surface process for high efficiency cavity (N-infusion): decrease in number of cavities

Staging





ILC cost reduction R&D

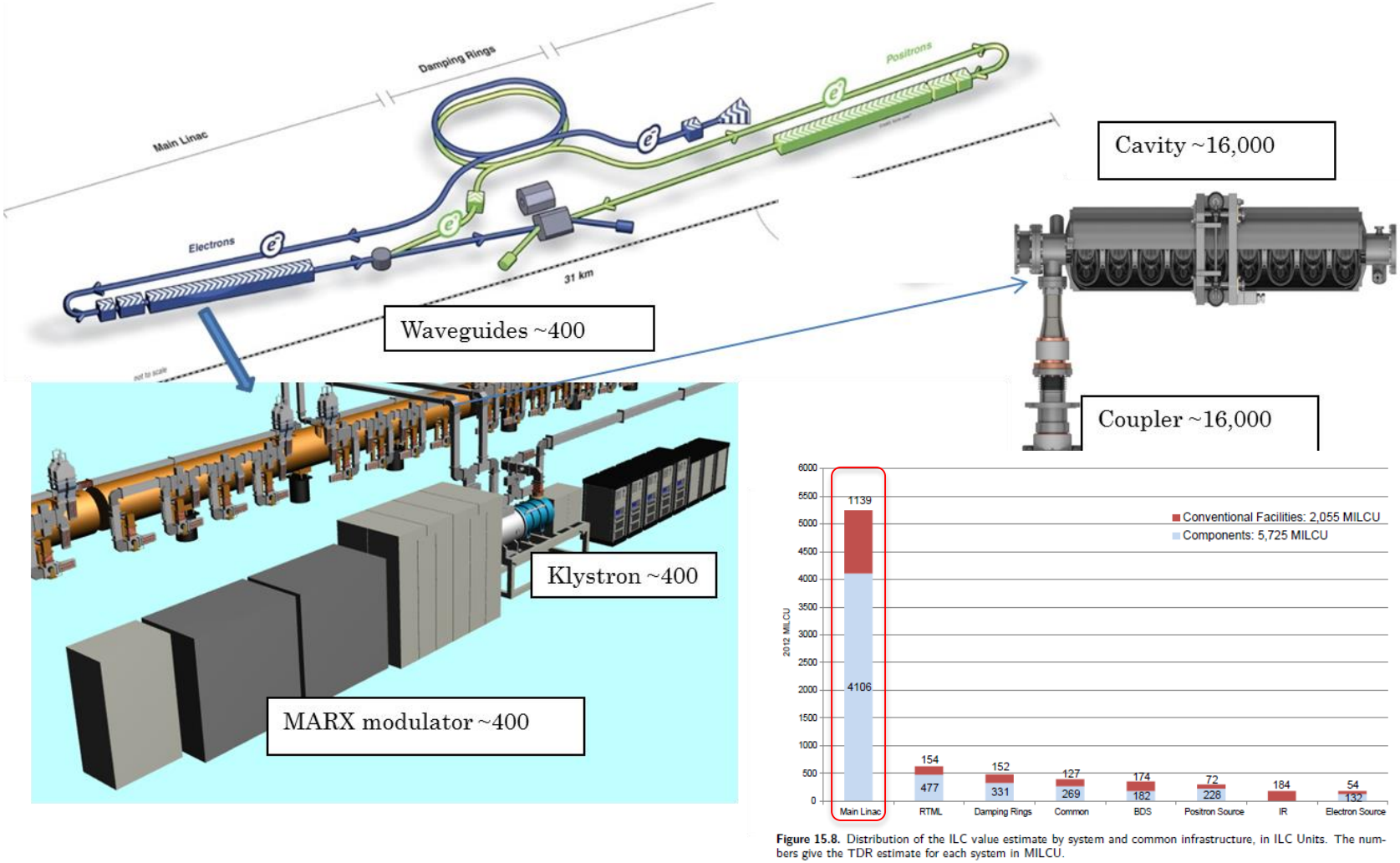


Figure 15.8. Distribution of the ILC value estimate by system and common infrastructure, in ILC Units. The numbers give the TDR estimate for each system in MILCU.

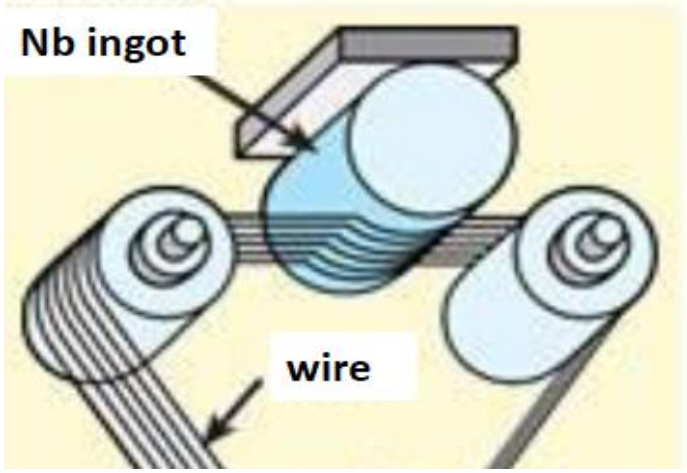
The main fraction of the construction cost is coming from main linac (ML).
Thus we focused our cost reduction R&D into ML (superconducting RF technology)

A-1. Niobium material preparation (with new processing for sheeting and piping)

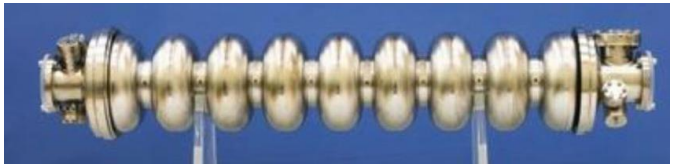
Motivation

- Niobium material cost for fabricating SRF cavity cell and end-groups is relatively high.
- If we can accept lower residual resistivity ratio (RRR) material, the ingot cost becomes cheaper.
- We will try to simplify the manufacturing process (like direct slicing from the ingot).

Niobium ingot



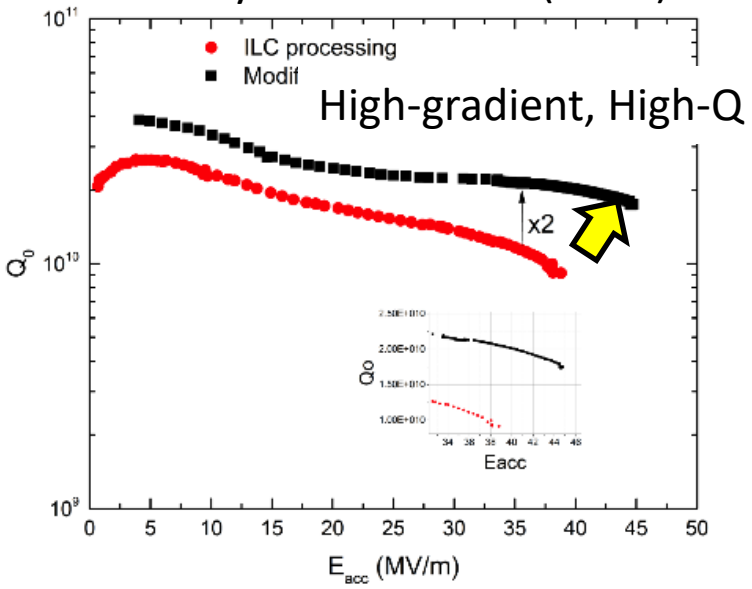
Cavities are under fabrication.
Three cell cavity will be evaluated in this month



A-2. SRF cavity fabrication for high gradient and high Q (with a new surface process provided by Fermilab)

- High Q cavity enables the decrease in number of cryogenics leading to the cost reduction.
- FNAL researcher (A. Grassellino) found the new cavity preparation recipe having high Q and high gradient.
- Demonstrate N2-infusion (High-gradient and High-Q) technology with 9-cell-cavities.

By A. Grassellino (FNAL)



Recently, successful N-infusion (+35% in Q, +5% in gradient) was obtained at single cell cavity. Second cavity will be treated on January and we will confirm reproducibility.

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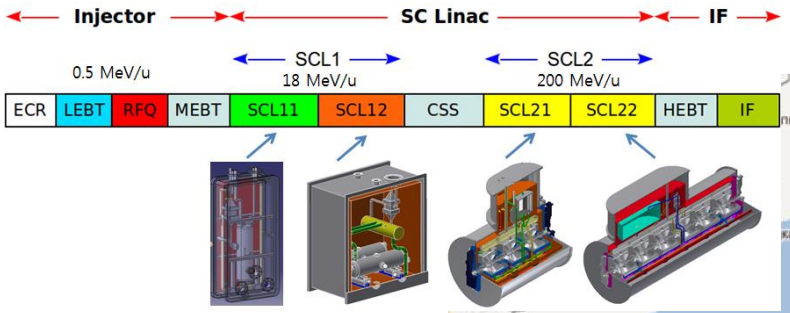
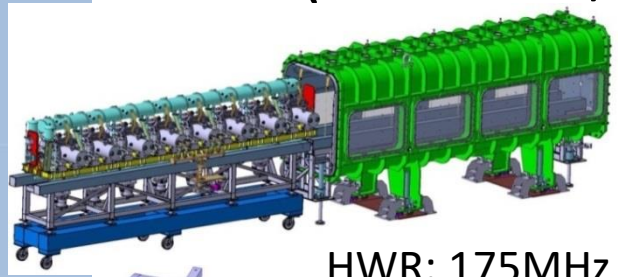
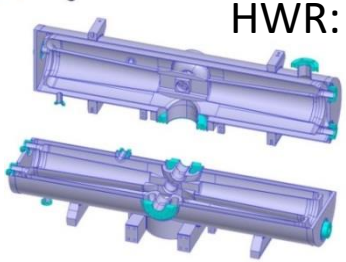
Superconducting Ions Accelerators in Japan/Korea



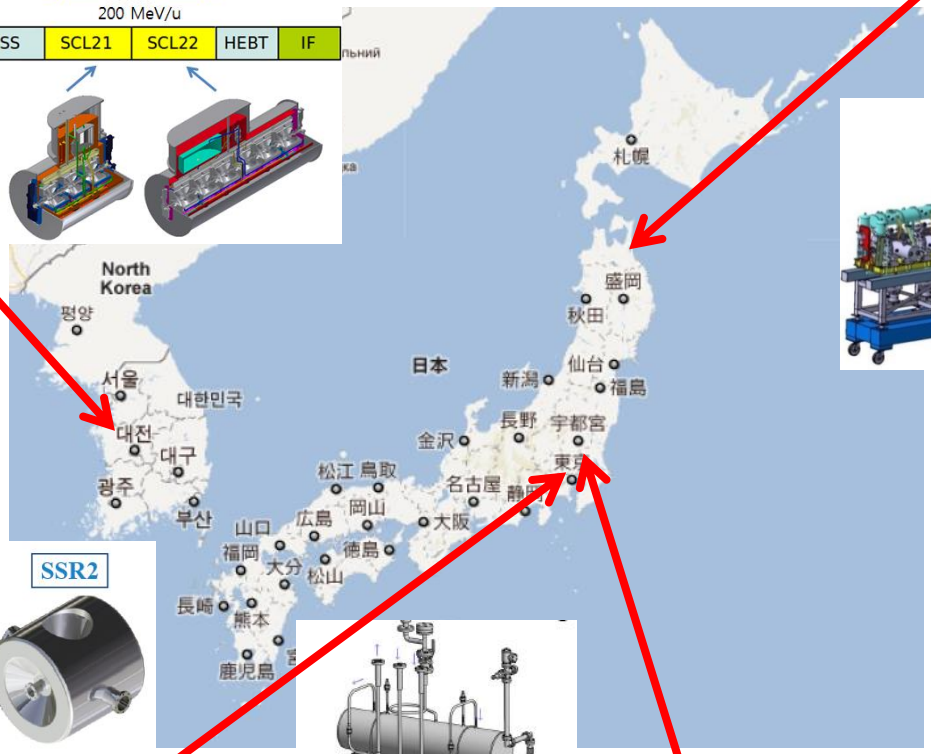
QST/Rokkasho
IFMIF (deuterons)

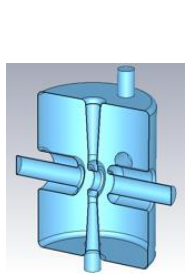


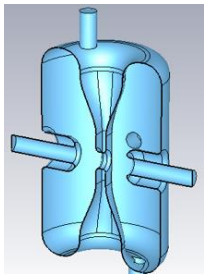
HWR: 175MHz



IBS/Daejeon
RISP-RAON
(heavy ions)

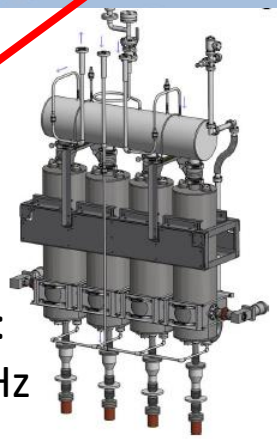






HWR: 325MHz

RIKEN/Wako
SC-Linac
(heavy ions)

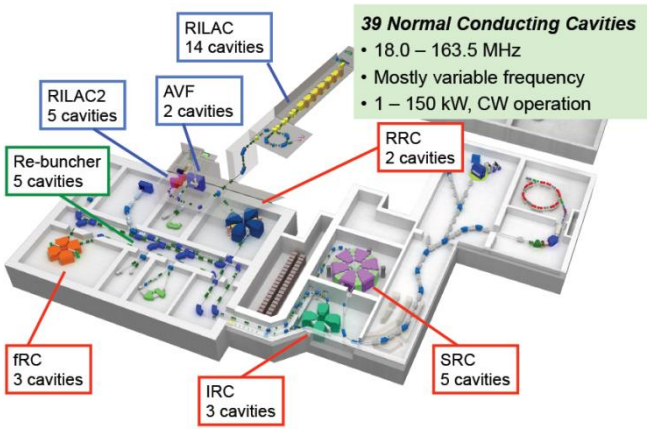


QWR:
75MHz

KEK/Tsukuba
SC Proton Driver
(protons)

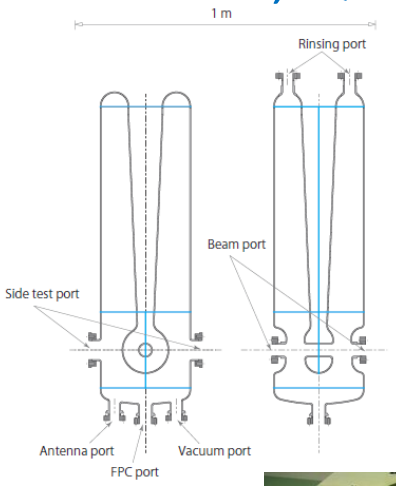
From Eiji KAKO (KEK)

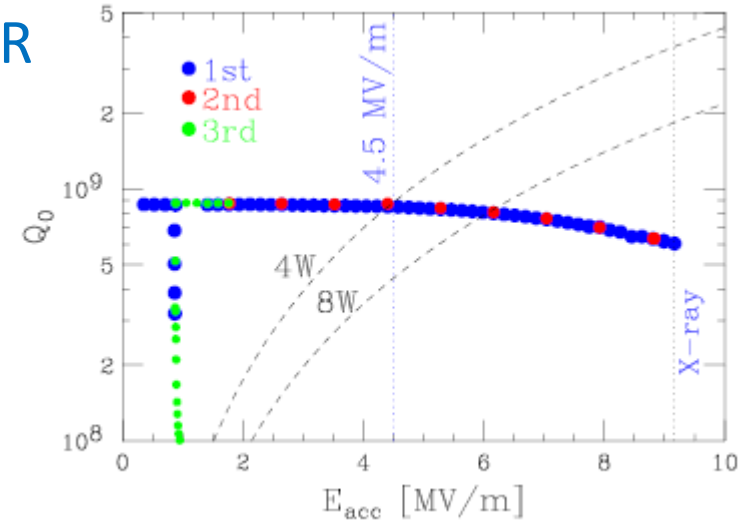
KEK SRF Activities (1) : RIKEN-QWR Cavity

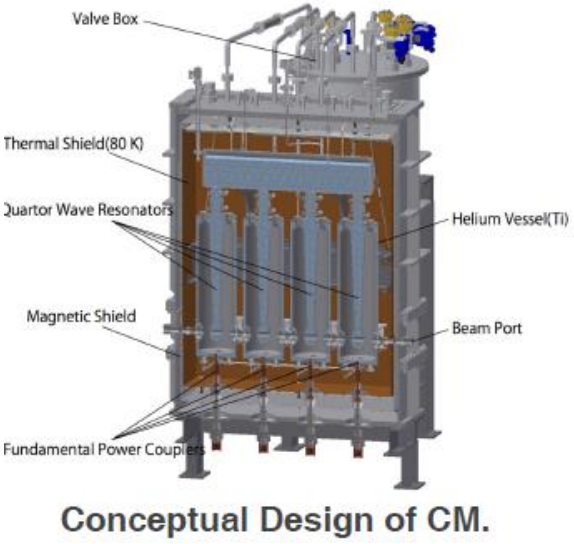


RIKEN-RIBF accelerators

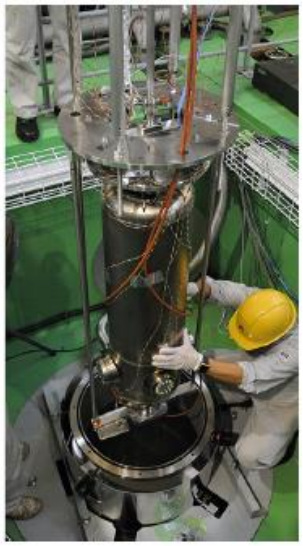
75.5 MHz, QWR

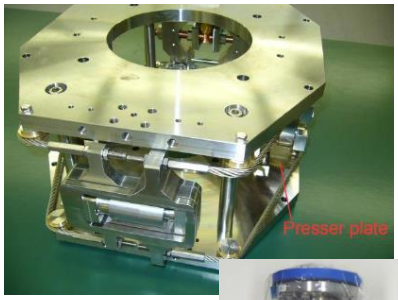






Conceptual Design of CM.



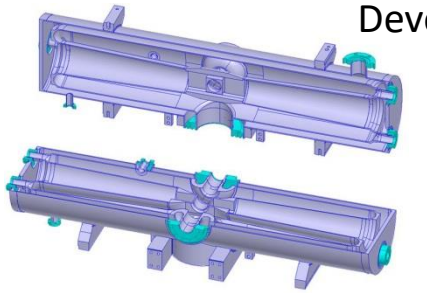


[by K. Ozeki, (RIKEN)]

From Eiji KAKO (KEK)

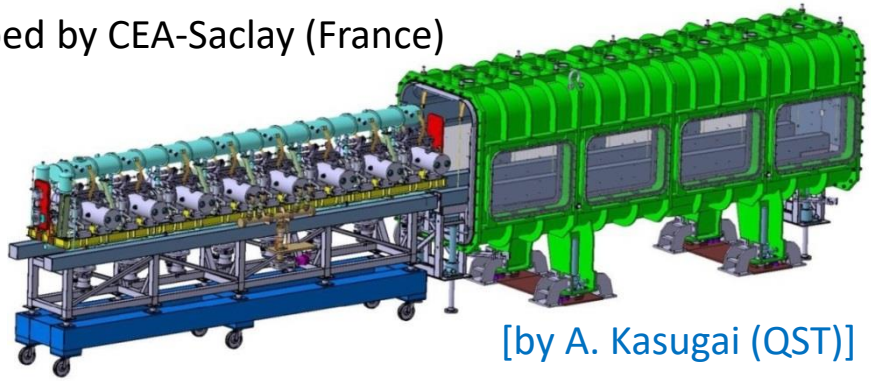
KEK SRF Activities (2) : IFMIF-HWR Cavity

IFMIF; International Fusion Material Irradiation Facility (Deuteron accelerator to produce high intensity neutron flux)

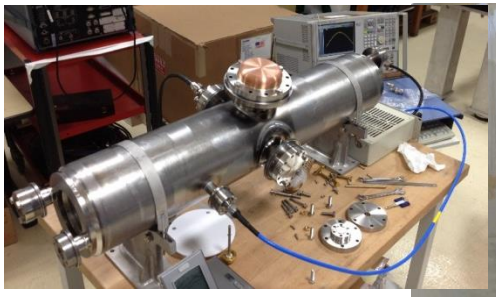


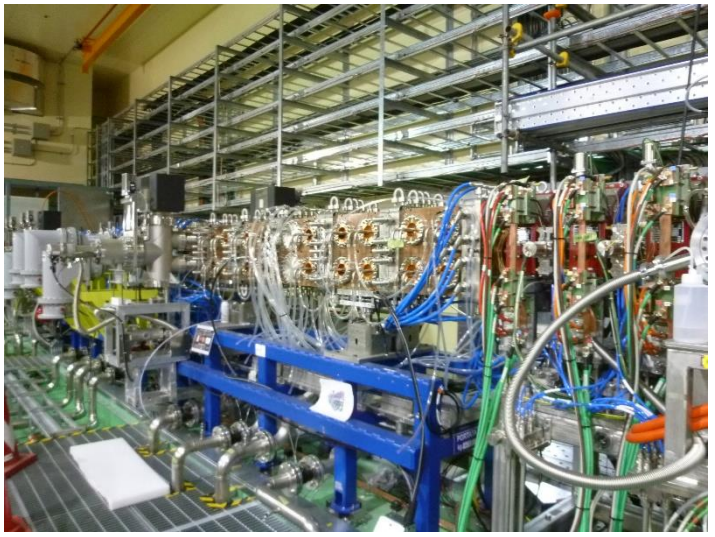
175 MHz, HWR

Developed by CEA-Saclay (France)



[by A. Kasugai (QST)]





From Eiji KAKO (KEK)

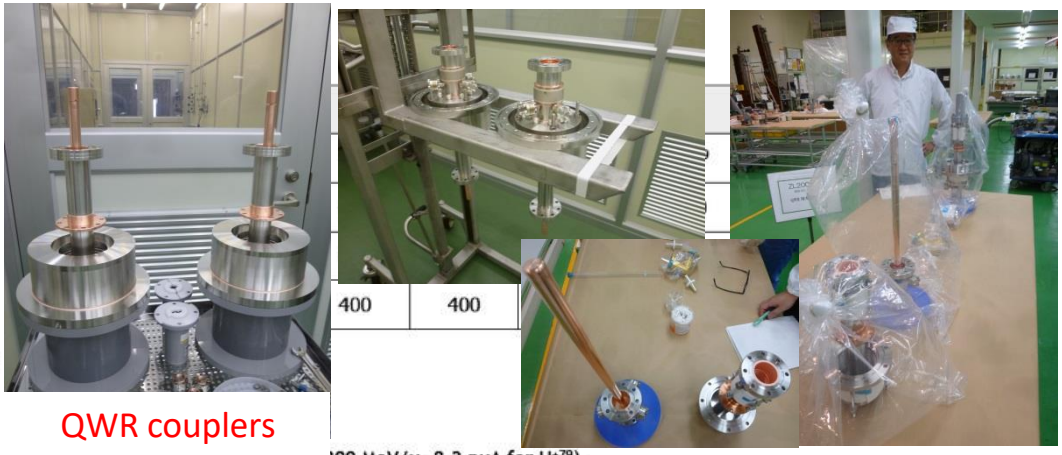
KEK SRF Activities (3) : RAON/RISP at IBS

IBS; Institute for Basic Science (Korea)

RISP; Rare Isotope Science Project

RAON; Heavy ion accelerator

QWR couplers (MHI-MS)

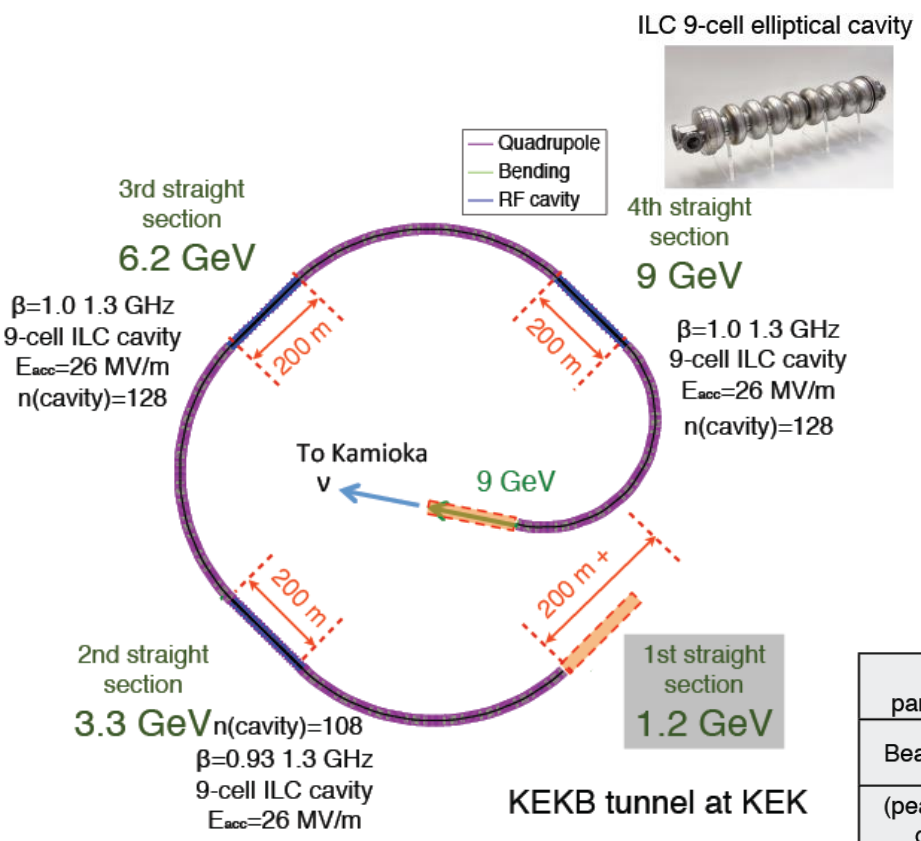


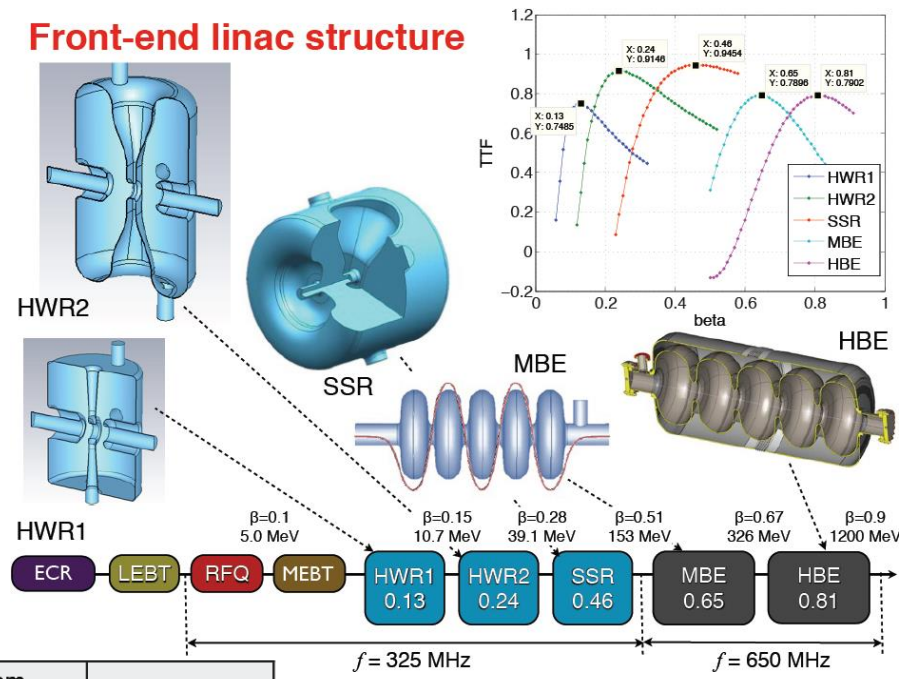
QWR couplers (Toshiba)

parameters	QWR	HWR	SSR1	SSR2
f (MHz)	81.25	162.5	325	325
β_g	0.047	0.12	0.3	0.53
Aperture (mm)	20	20	25	25
Epeak (MV/m)	35	35	35	35
Temp. (K)	4	2	2	2

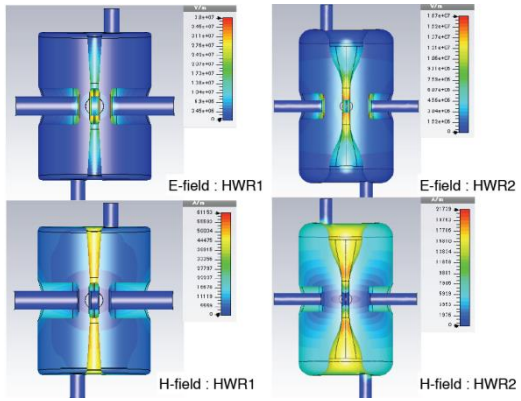
[by I. Shin (IBS)]

KEK SRF Activities (4) : Proton Driver LINAC





Beam parameters	Value
Beam energy	9 GeV
(peak) Beam current	100 mA
Repetition rate	10 Hz
Pulse length	1 ms
Average beam current	1mA
Beam power	9 MW



Purpose:
Multi-MW proton driver Linac with high intensity beam current for neutron oscillation physics

From Eiji KAKO (KEK)

Summary

- *Cavity fabrication facility (CFF) has fabricated various SRF cavities for the ILC.*
- *Superconducting RF R&D has been carried out at STF and 8 cavity vector sum worked well.*
- *ILC cost reduction SRF R&D started from 2016. New Nb material and HighQ-HighG processing (N-infusion) R&Ds are ongoing.*
- *Low- beta SRF design, fabrication and evaluation works have been carried out with RIKEN, IFMIF and RISP (Korea).*

Thank you for your attention