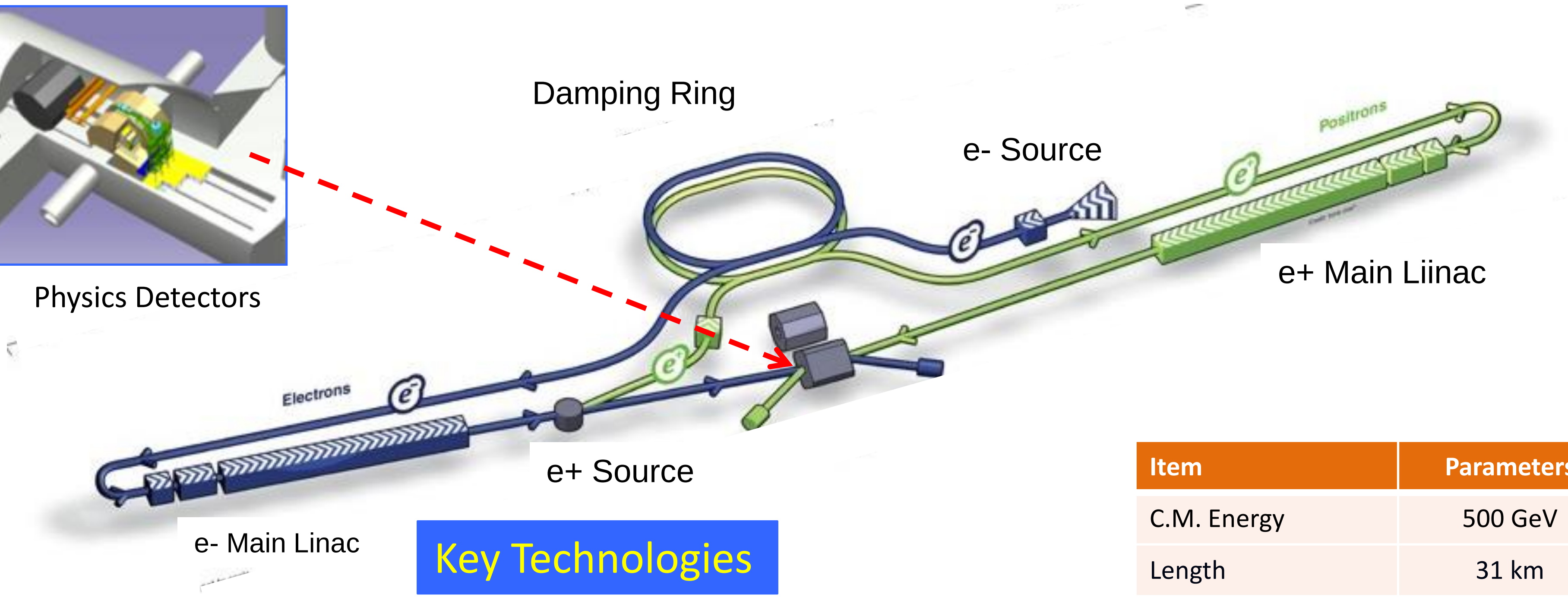
ILC status

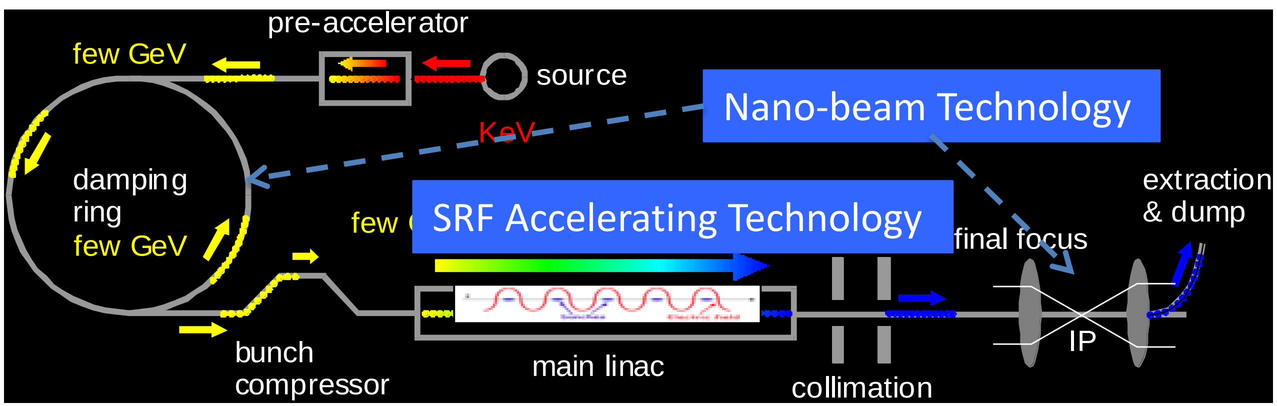
KEK/LCC

Shin MICHIZONO

- *The ILC*
- *KEK's activities*
- *ILC cost reduction R&D*
- *World-wide R&D for high-Q and high-G*
- *staging*

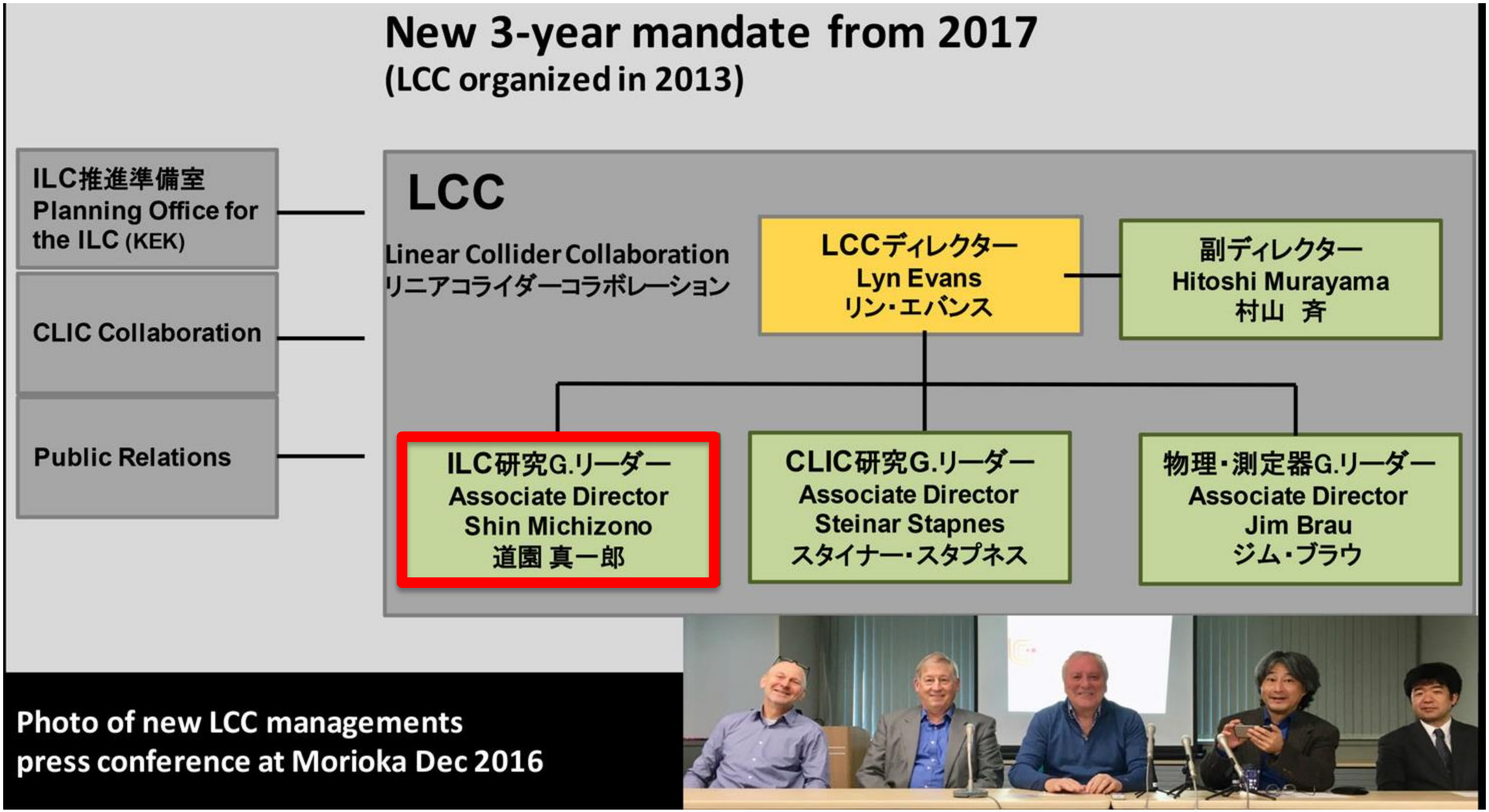
ILC Acc. Design Overview (in TDR)





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}

LCC international structure



ILC Advisory Panel in MEXT

1st survey of technological spin-offs and Research trends (FY2014)
2nd survey of technology issues (FY2015)

Research contract

MEXT

Under ILC TF headed by State Minister of MEXT

ILC Advisory Panel

Established in May 2014

Particle and Nuclear Physics Working Group
Established in June 2014

TDR Validation Working Group
Established in June 2014

Human Resources Working Group
Established in Nov. 2015

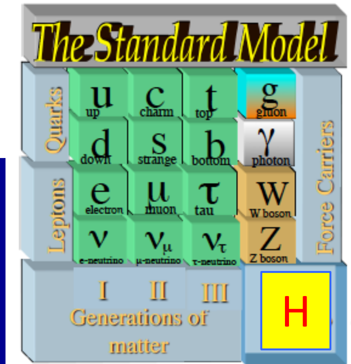
Organization and management Working Group
Established in Feb 2017

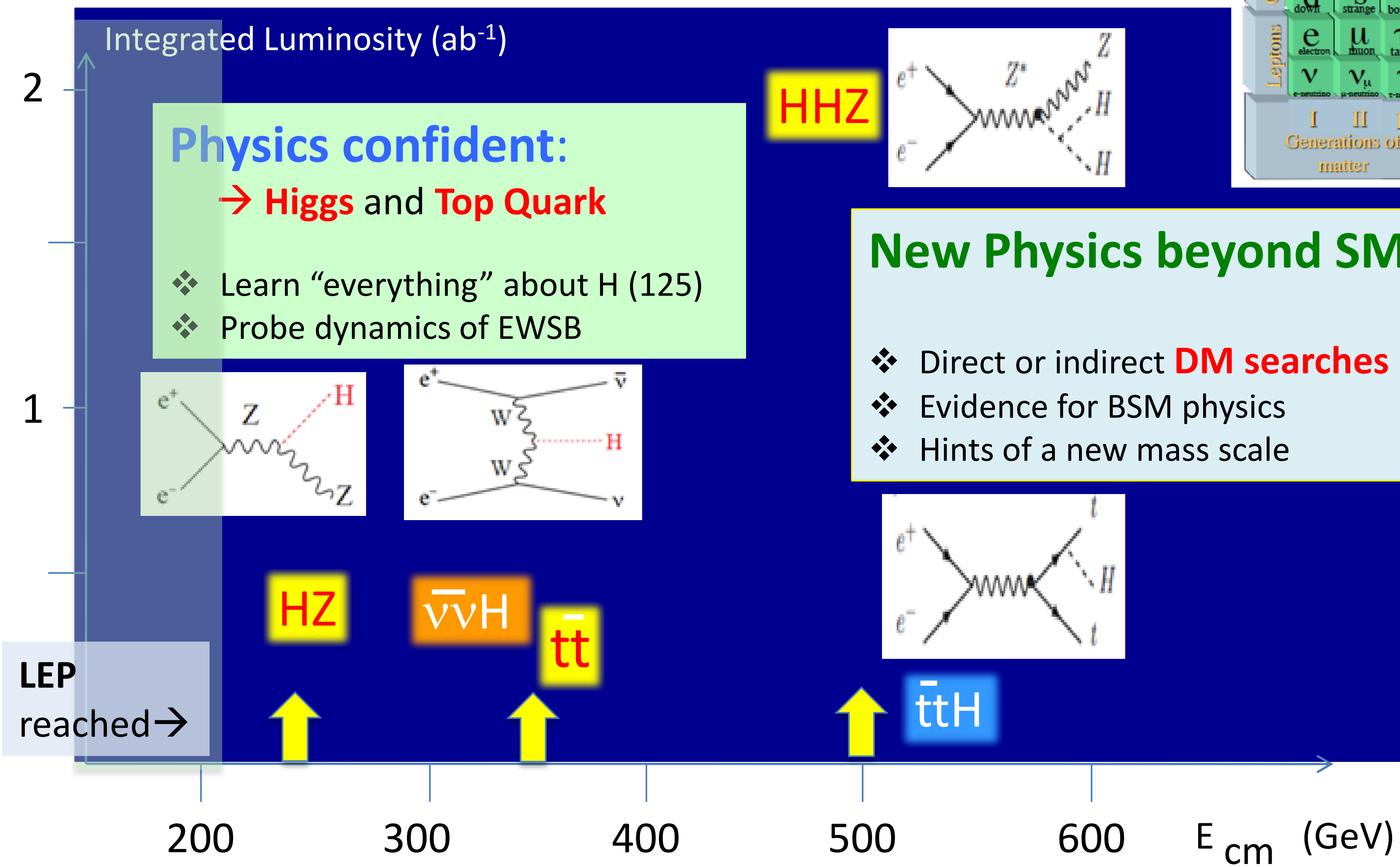
On July 7,2016

- -Cost reduction study with new technology → cost-reduction R&D
- -Feasibility study with current technology

Important Energies in ILC

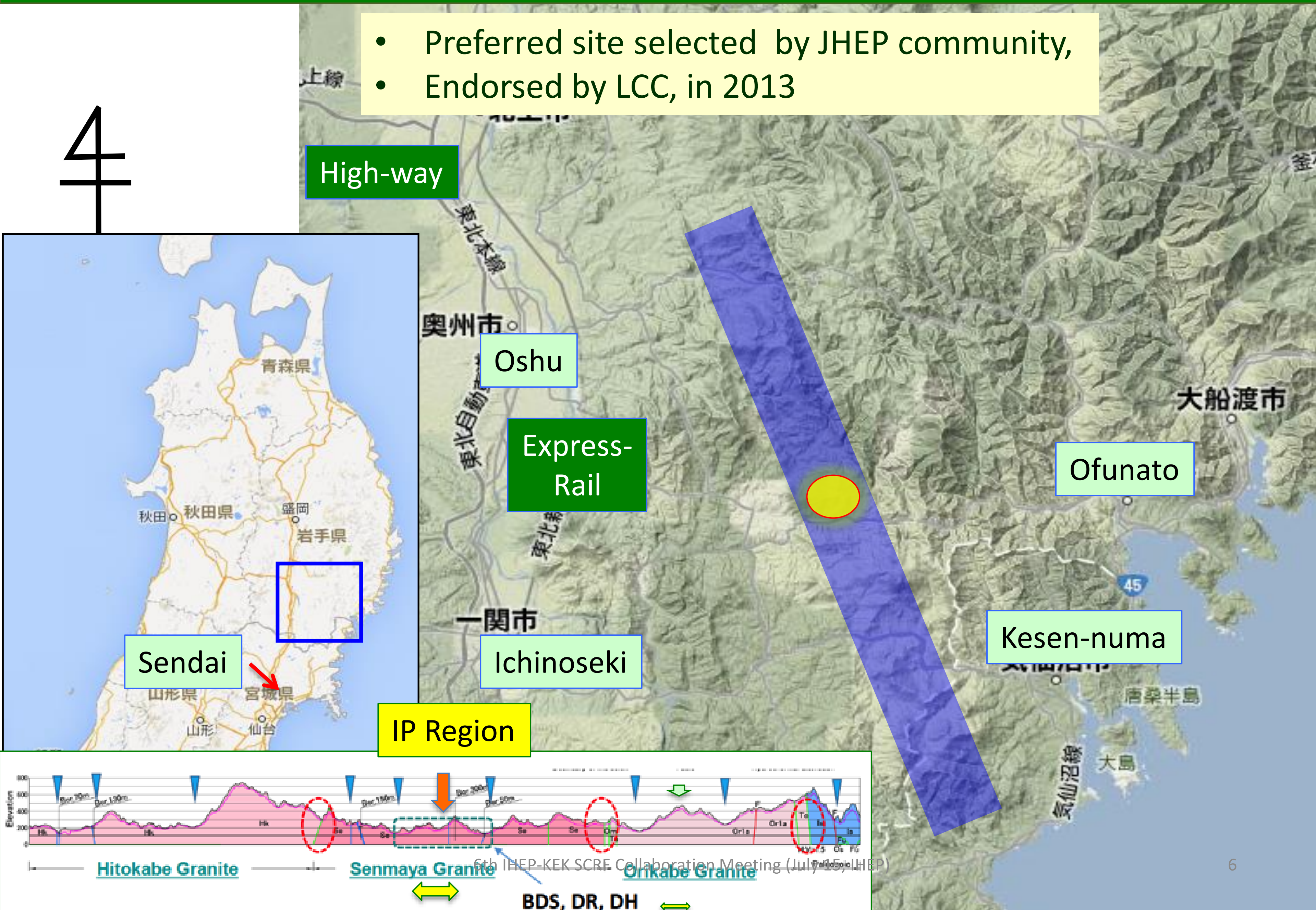
125 GeV Higgs discovery reinforcing the ILC importance



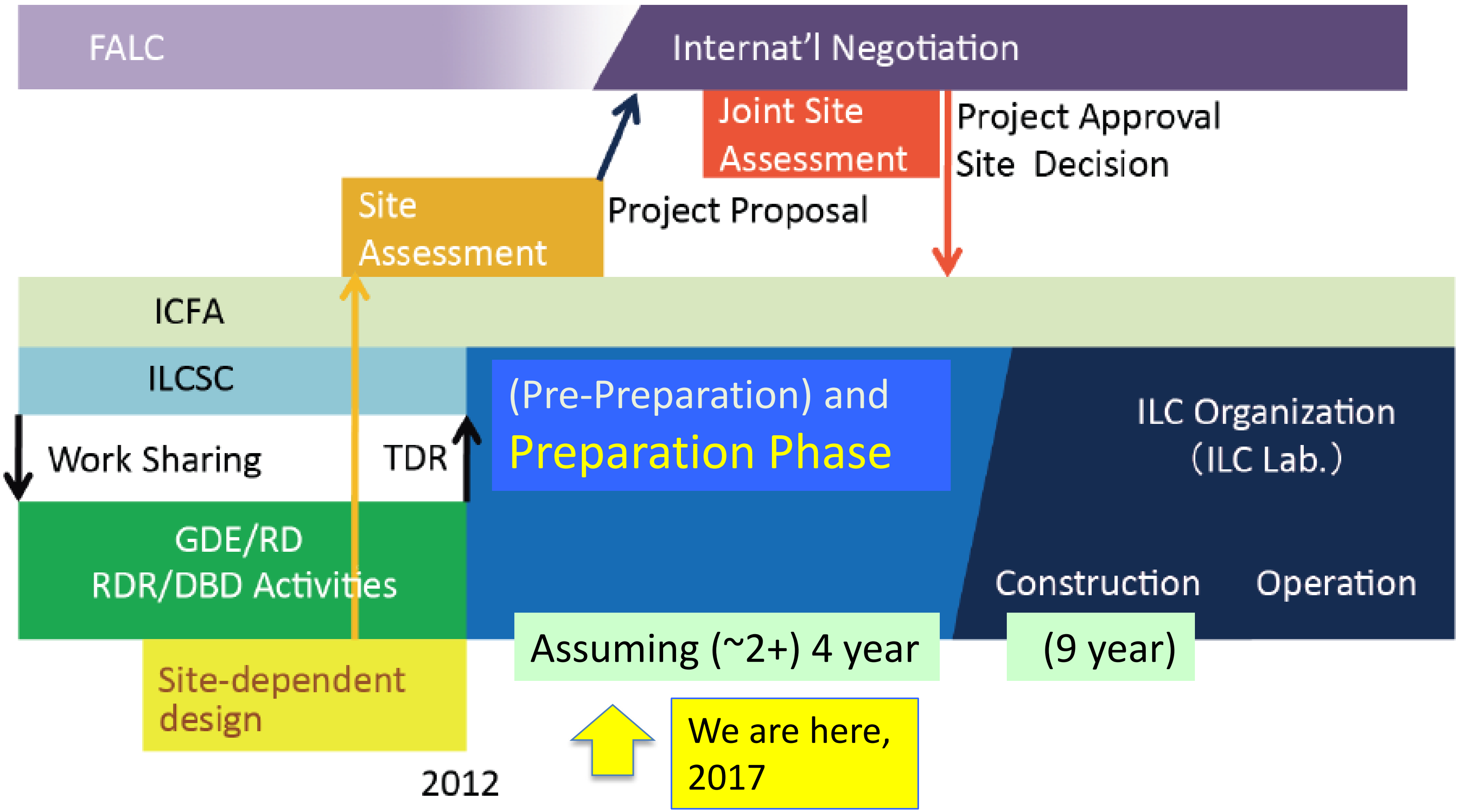


ILC Site Candidate Location in Japan: Kitakami

- Preferred site selected by JHEP community,
- Endorsed by LCC, in 2013



ILC Time Line: Progress and Prospect



ILC status

KEK/LCC

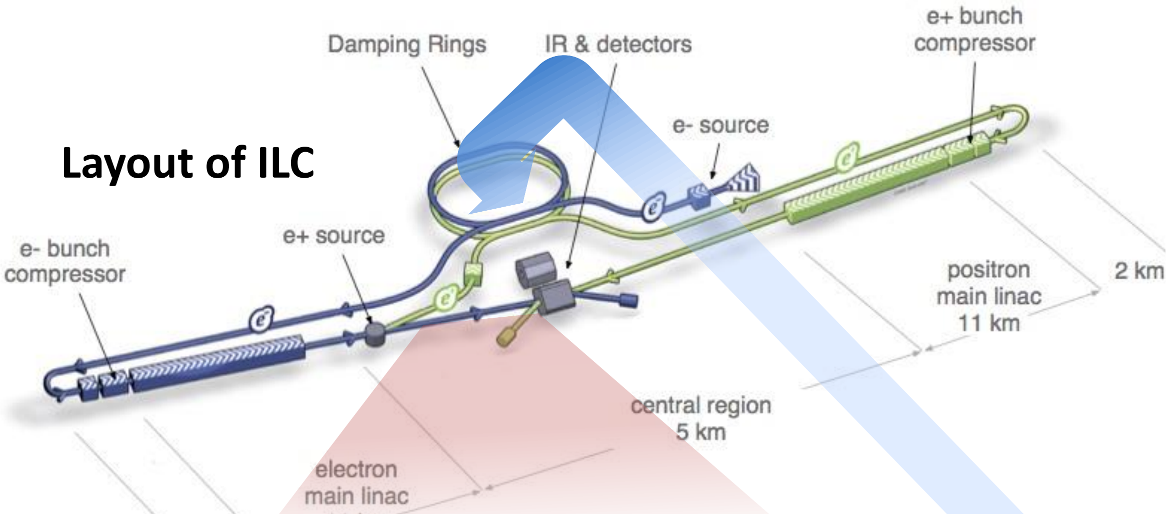
Shin MICHIZONO

- *The ILC*
- *KEK's activities*
- *ILC cost reduction R&D*
- *World-wide R&D for high-Q and high-G*
- *staging*

ILC R&D at KEK

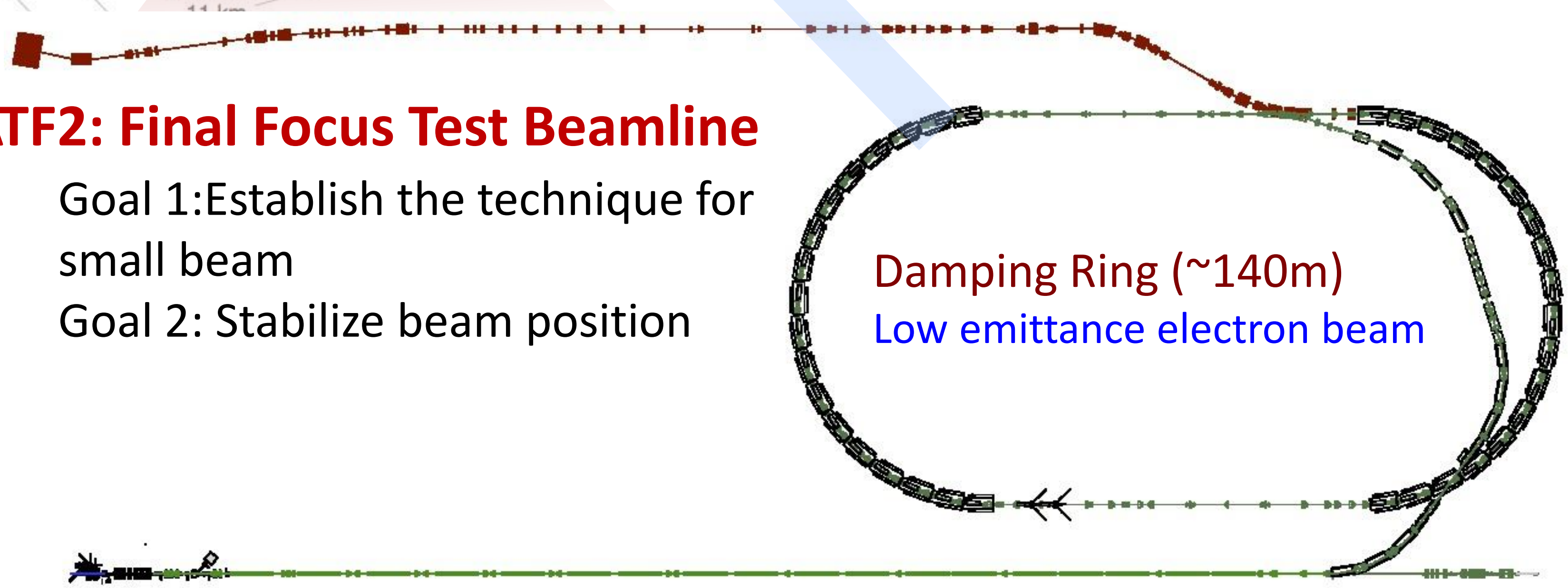
ATF/ATF2: Accelerator Test Facility

Layout of ILC



Develop the nanometer beam technologies for ILC

- Key of the luminosity maintenance
- 6 nm beam at IP (ILC)



ATF2: Final Focus Test Beamline

Goal 1:Establish the technique for small beam

Goal 2: Stabilize beam position

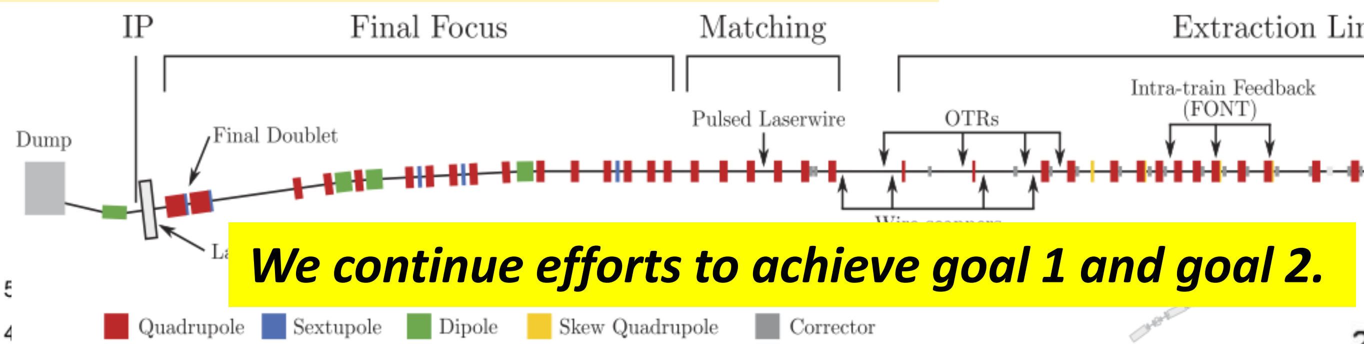
Progress in FF Beam Size and Stability at ATF2

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

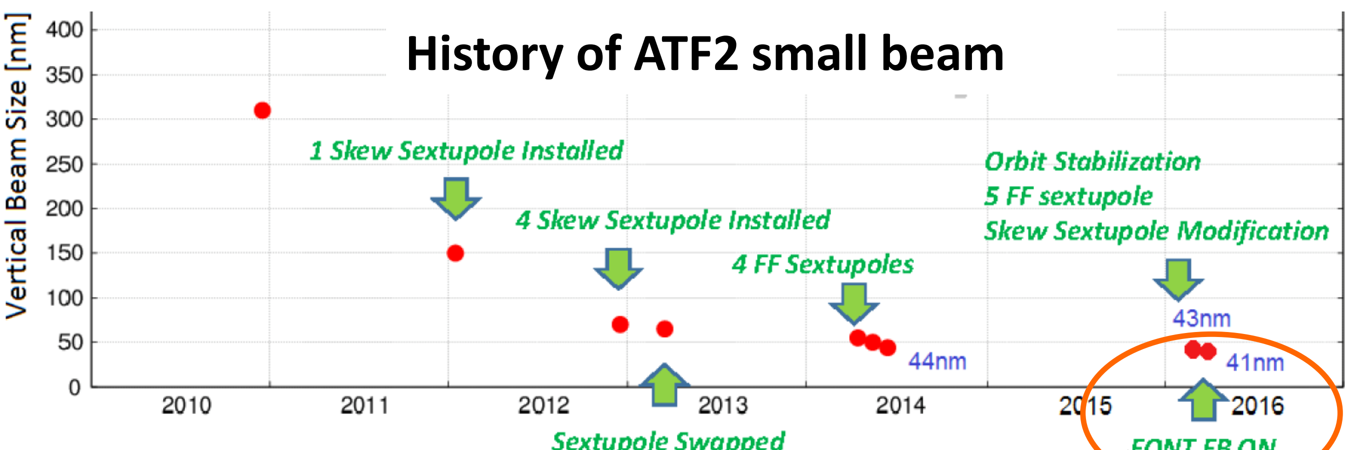
- ATF2 Goal : **37** nm → ILC **6** nm
  - Achieved **41 nm** (2016)

Goal 2: Develop a few nm position stabilization for the ILC collision

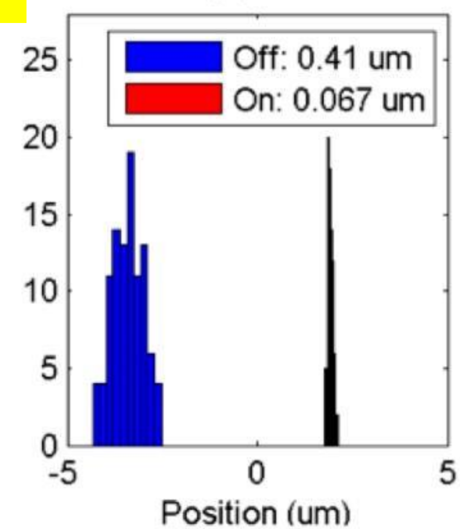
- **FB latency 133 nsec achieved** (target: < 300 nsec)
- **positon jitter at IP: 410 → 67 nm (2015)** (limited by the BPM resolution)



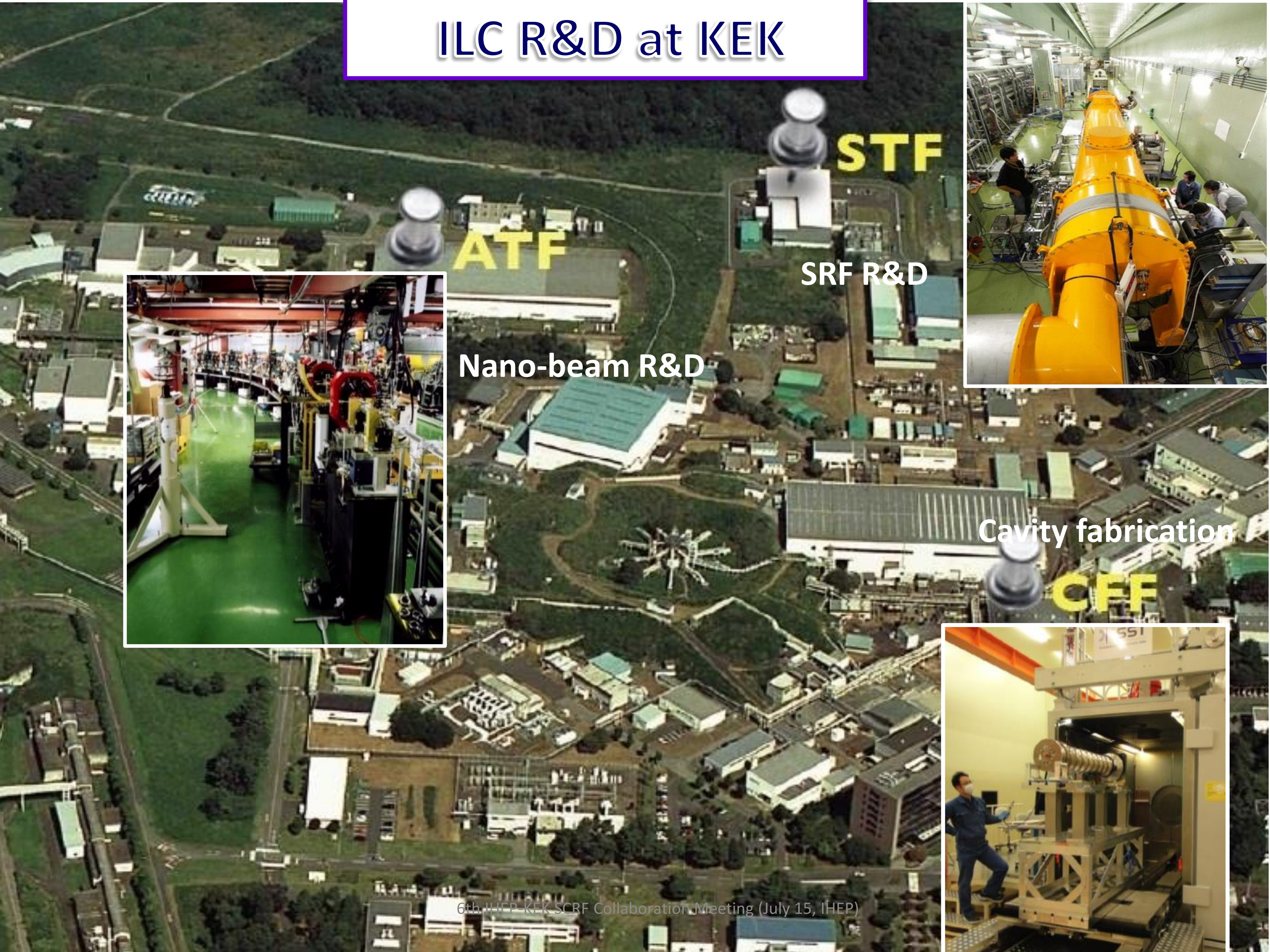
We continue efforts to achieve goal 1 and goal 2.



Nano-meter stabilization at IP



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')

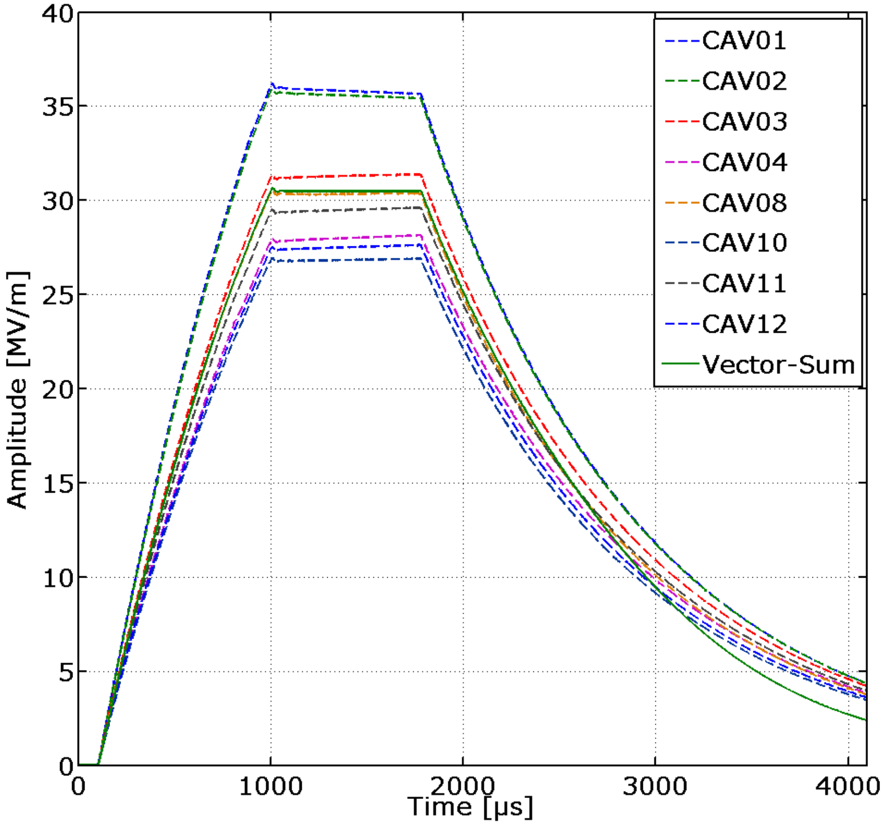
Beam operation

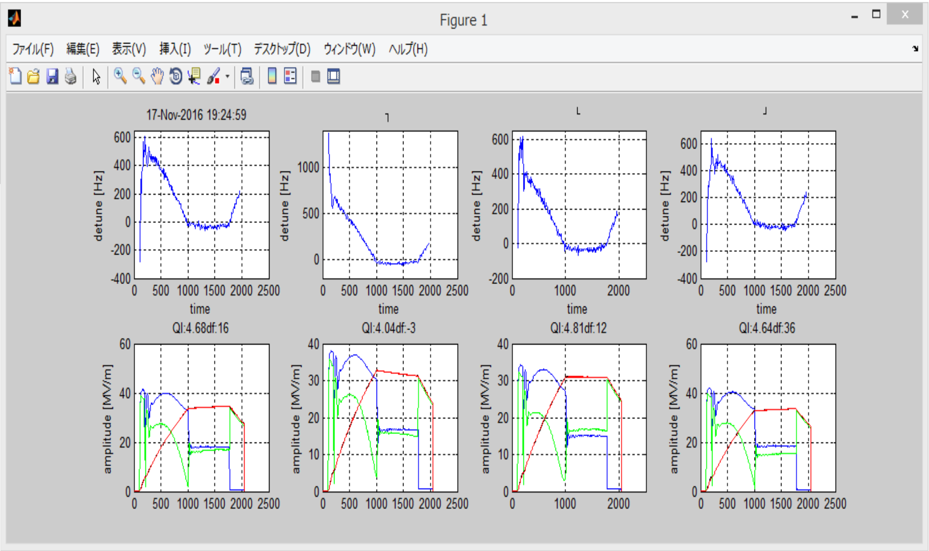
HPG regulation

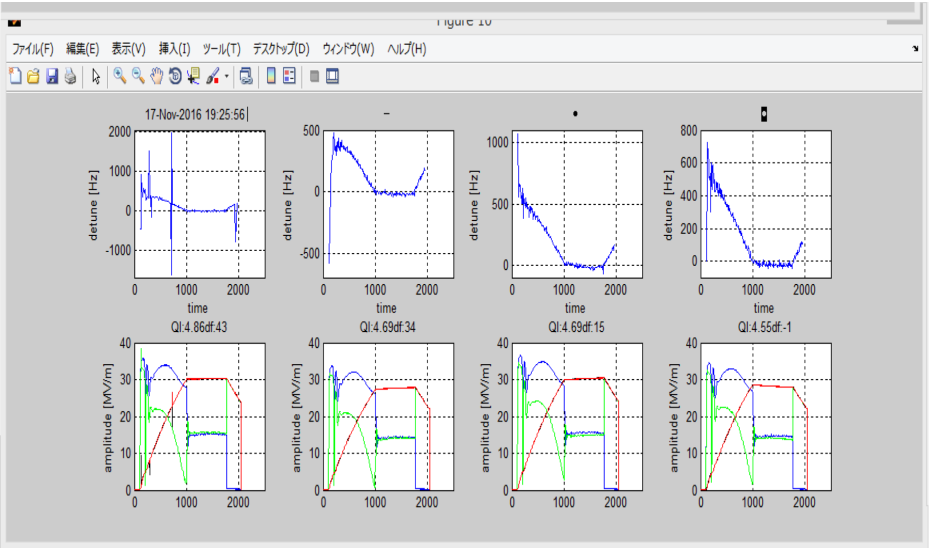
STF-2 - CM1+CM2a Cryomodule
Eight + Four 9-cell cavities (2014')

8 Cavities Operation by Vector-Sum @31MV/m

Preliminary result

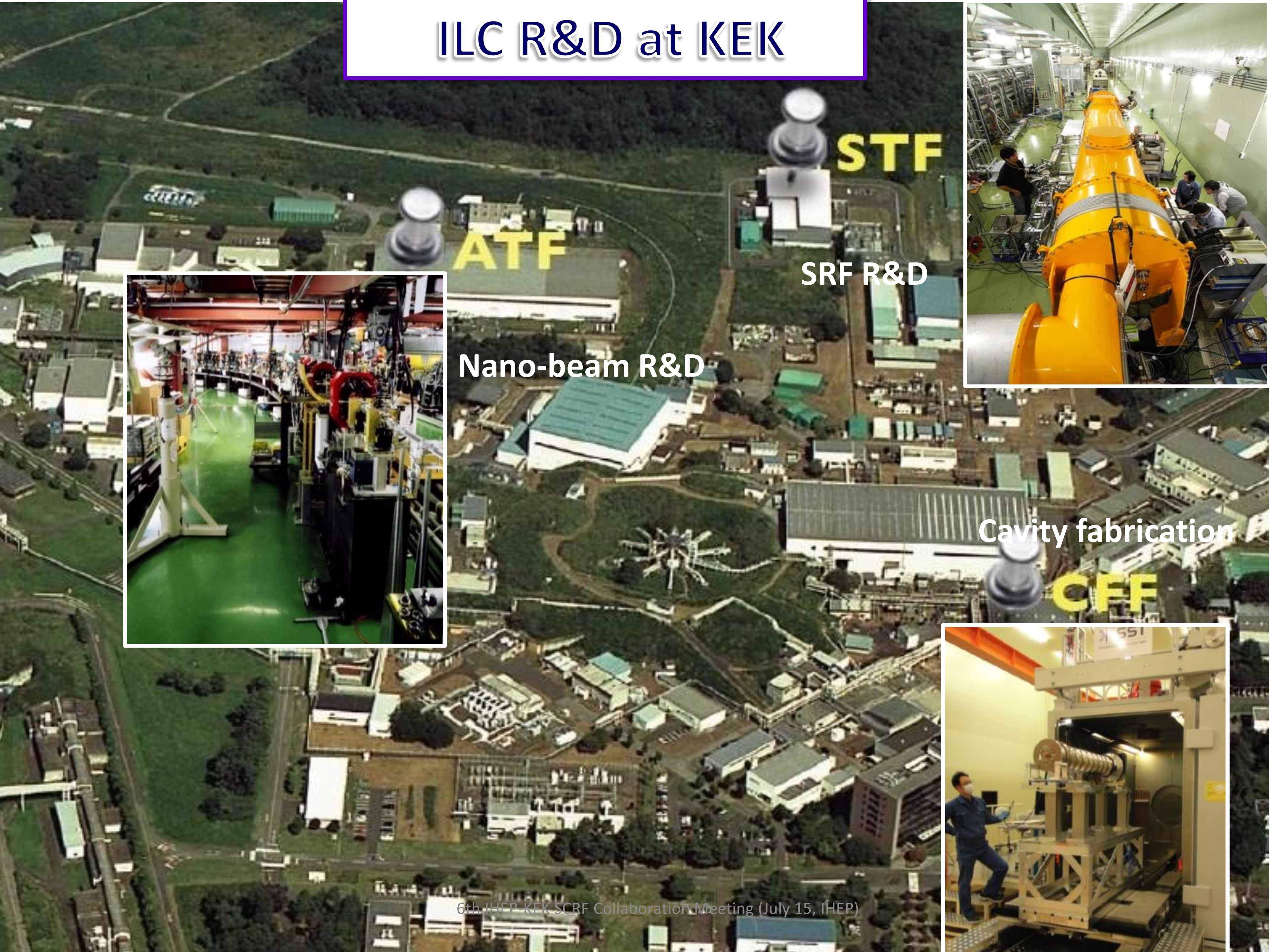






8 Cavities were tuned on resonance by piezo, and vector-sum operation was done at 31MV/m.

ILC R&D at KEK



Main equipments in CFF

Chemical polishiing

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

CNC vertical lathe
(Moriseiki, Japan)

Microscope
(Surface inspection)

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 to June 2015 5 R&D cavities (1-cell & 3-cell) were fabricated,

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

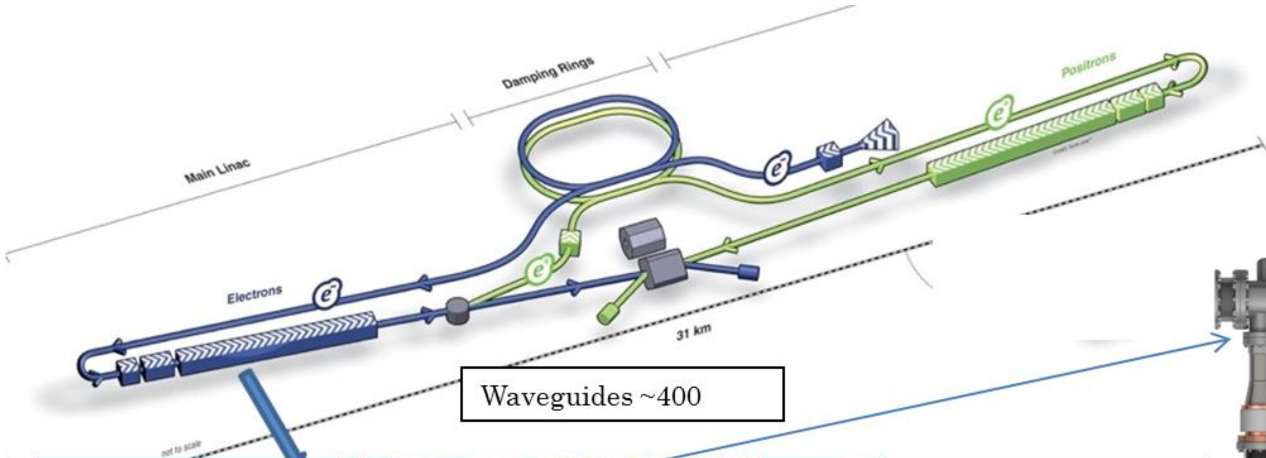
ILC status

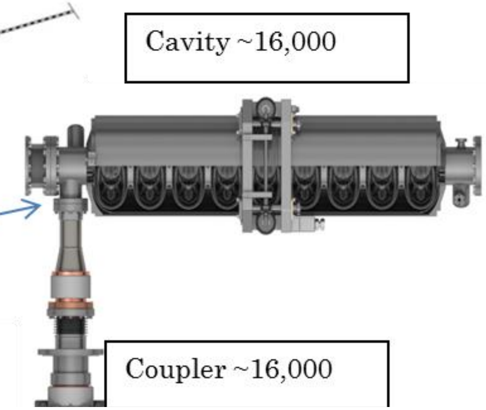
KEK/LCC

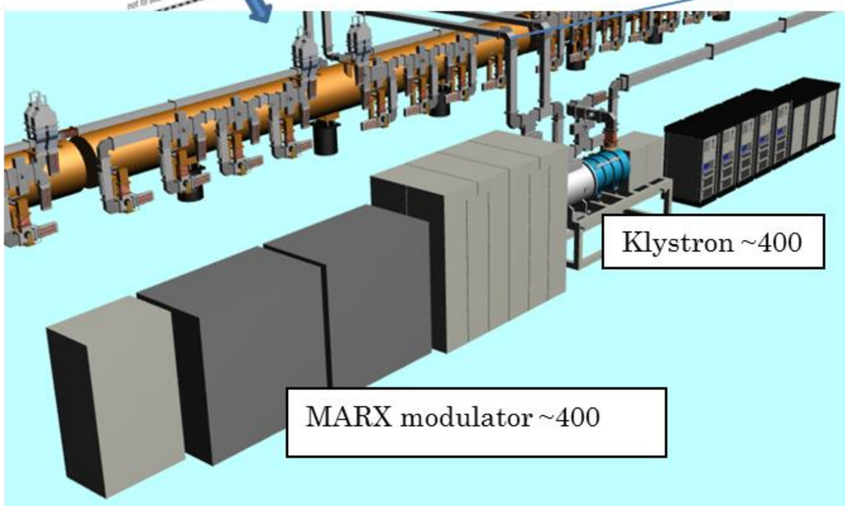
Shin MICHIZONO

- *The ILC*
- *KEK's activities*
- *ILC cost reduction R&D*
- *World-wide R&D for high-Q and high-G*
- *staging*

ILC cost reduction R&D







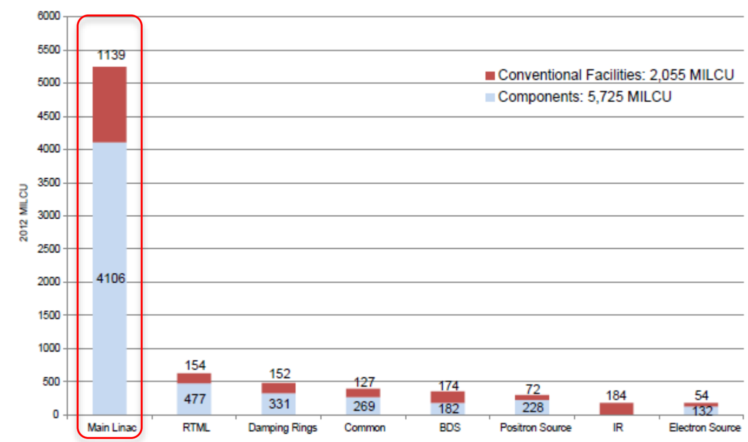


Figure 15.8. Distribution of the ILC value estimate by system and common infrastructure, in ILC Units. The numbers give the TDR estimate for each system in MILCU.

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)

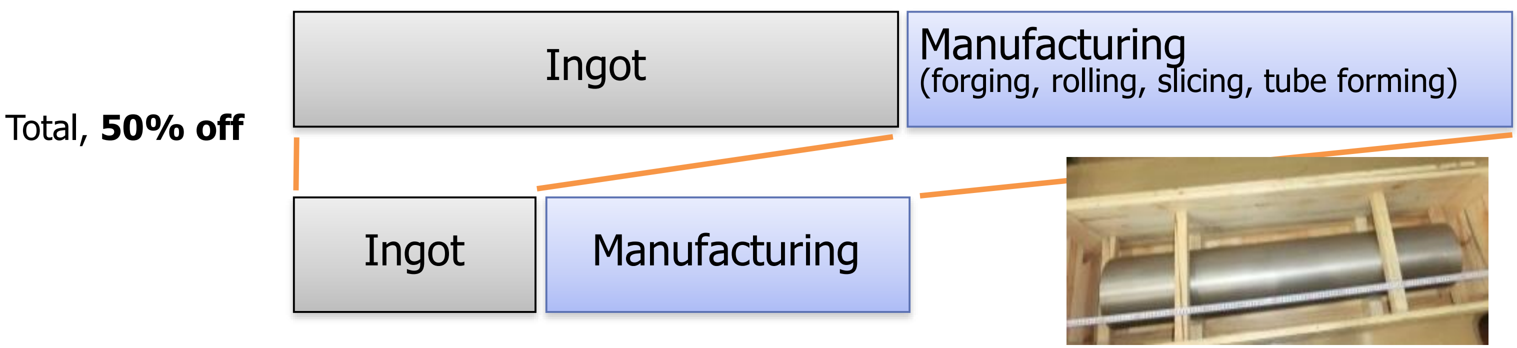
A-1. Niobium material preparation (with new processing for sheeting and piping)

Motivation

Niobium material cost for fabricating SRF cavity cell and end-groups is relatively high. There are 20 kinds of mechanical parts in 9-cell cavity, which shape and the requirement of performance are different, respectively. If the ingot purity and manufacturing method for each part is optimized precisely as well as satisfying the ILC specification shown in the TDR, the cost will be reduced significantly.

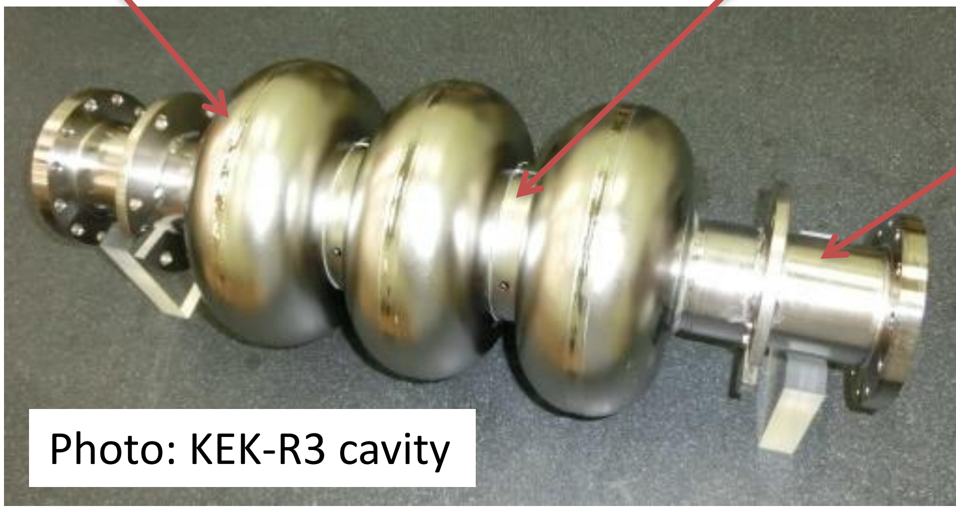
Approach

- Optimize the ingot purity with a lower residual resistivity ratio (RRR) with accepting specific residual content.
- Simplify the manufacturing method such as forging, rolling, slicing and tube forming with small loss.



Niobium ingot

Fabrication of test cavity



●High Ta & Medium or High RRR sheet
●High Ta & Low RRR sheet
●High Ta & Low RRR tube

- 3-cell cavity
- TESLA-like shape
- Both ends are end-cell shape （All center-cell shape in R3）
- Beam tube ID: 80 mm

Start material : Nb ingot from CBMM, Commercial Grade（Ta: 2000 ppm Max., RRR: not specified

●High Ta & Medium or High RRR sheet: for cells

●High Ta & Low RRR sheet: for stiffener

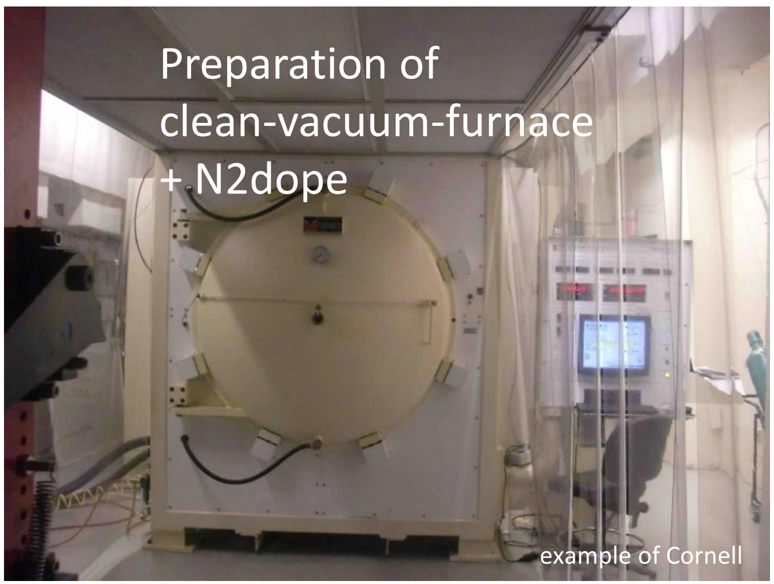
Forging and rolling to sheet from the start material

●High Ta & Low RRR tube: for beam tube

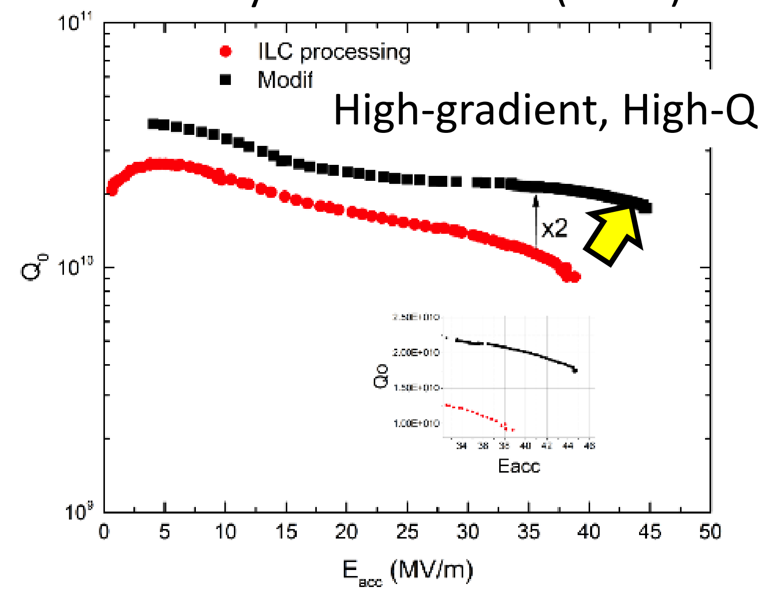
Forging and manufacture of seamless tube with good formability for burring from the start material

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

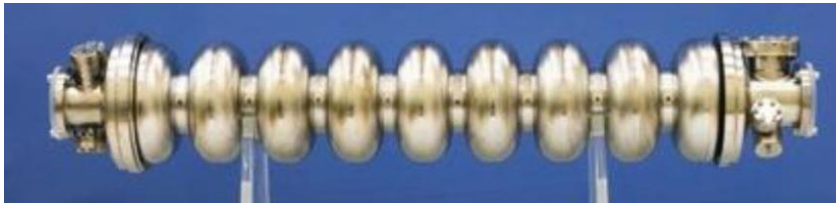
- High Q cavity enables the decrease in number of cryogenics leading to the cost reduction.
- FNAL researcher (A. Grassellino) found the new cavity preparation recipe having high Q and high gradient.
- Demonstrate N2-infusion (High-gradient and High-Q) technology with 9-cell-cavities.



By A. Grassellino (FNAL)

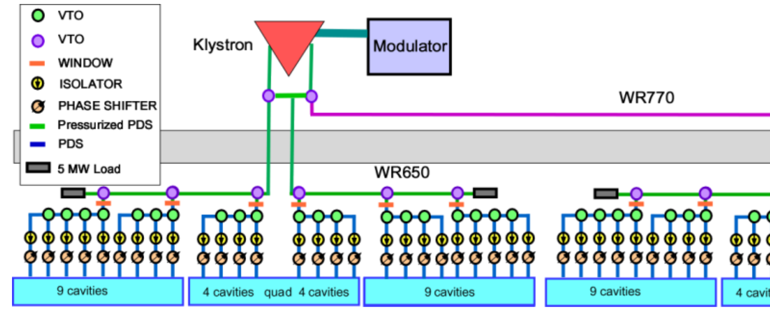


Design optimization for High Q and High Gradient op.



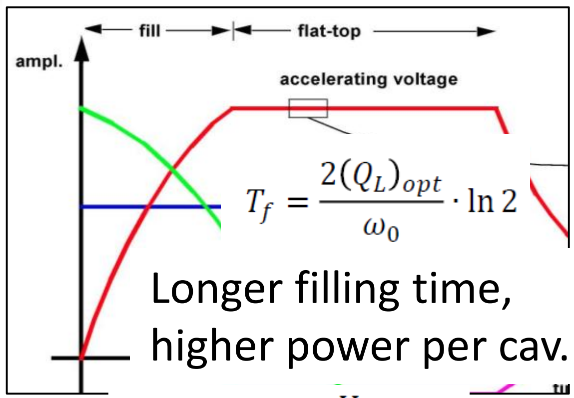
High Q

High Gradient (31.5 MV/m→35 MV/m)



Optimization of rf distribution

Smaller Cryo.



$$T_f = \frac{2(Q_L)_{opt}}{\omega_0} \cdot \ln 2$$

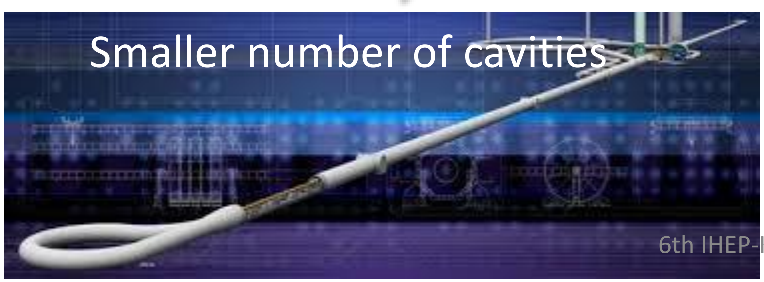
Longer filling time, higher power per cav.

$$(Q_L)_{opt} = \frac{V_{cav}}{\left(\frac{r}{Q}\right) I_{b0} \cos\phi_b}$$

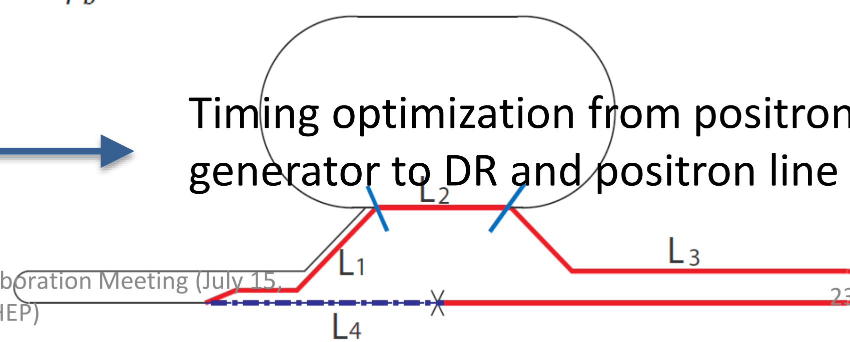
Higher efficiency kly.

Tuning control (for higher Q_L)

$$(L_1 + L_2 + L_3) - L_4 = n \times C_{DR}$$



Timing optimization from positron generator to DR and positron line



ILC status

KEK/LCC

Shin MICHIZONO

- *The ILC*
- *KEK's activities*
- *ILC cost reduction R&D*
- *World-wide R&D for high-Q and high-G*
- *staging*

R&D Plans at worldwide Labs

	On-going	R&D: ML Cavity	Assoc. System	Cryomodule	RF
Fermilab	LCLS-II	N_2-infusion (HQ-HG)	Coupler		
JLab	LCLS-II	Nb-LG/FG (Ingot-sliced/rolled) , LSF cavity, N_2-infusion			
DESY	EXFEL	N_2-infusion Nano-Lab study		High-performance CM	
INFN-LASA	ESS	Nb-LG/FG systematic study for ESS			
CEA/ CNRS-LAL	IFMIF ESS, SARAF	Vertical EP (VEP), N_2-Infusion	Magnetic shield Coupler	Assembly robotizing	
KEK	STF	Nb-LG/FG N_2-infusion	Coupler, Tuner Crab. C.		Marx M.
IHEP	ADS	N_2-infusion, Industrialization		Industrialization	Marx M. h.e. Klystron
CERN	HL-LHC Hi-Isolde	Thin-film (Nb on Cu)	Coupler		h.e. Klystron
TRIUMF	ISAS-II, ARIEL	VEP, muSR			
Cornell		N_2-infusion, VEP			

Exploring Phase Space of Nitrogen Treatment

"2/6" Nitrogen "Doping"

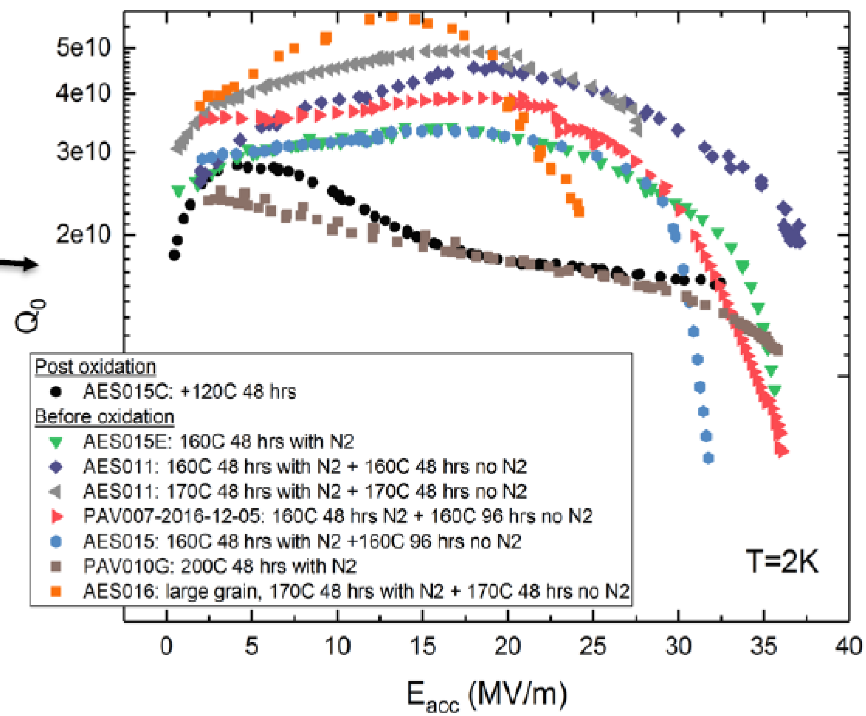
800C UHV, 3 hours → 800C N_2 p = 25 mTorr 2 minutes → 800C UHV, 6 minutes → UHV cooling → 5 um EP

120 C Nitrogen "Infusion"

800C UHV, 3 hours → 120C N_2 p = 25 mTorr 48 hours → UHV cooling

S. Posen (FNAL) at AWLC17

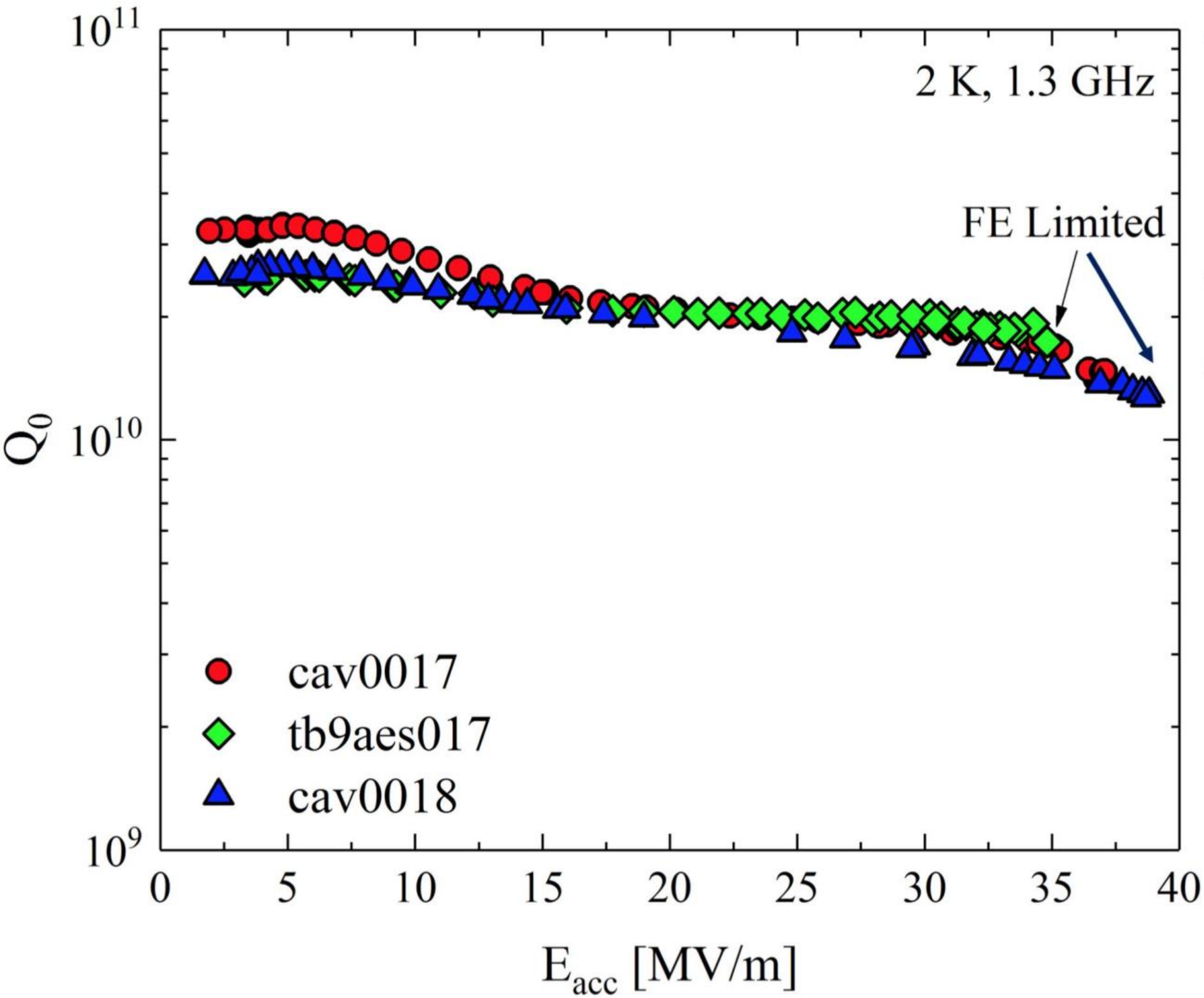
Can tailor treatment to application (optimize for Q_0 at a given E_{acc})



A. Grassellino et al. arXiv:1701.06077

9-cell cavity results, 120C infusion

S. Aderhold (FNAL) at AWLC17

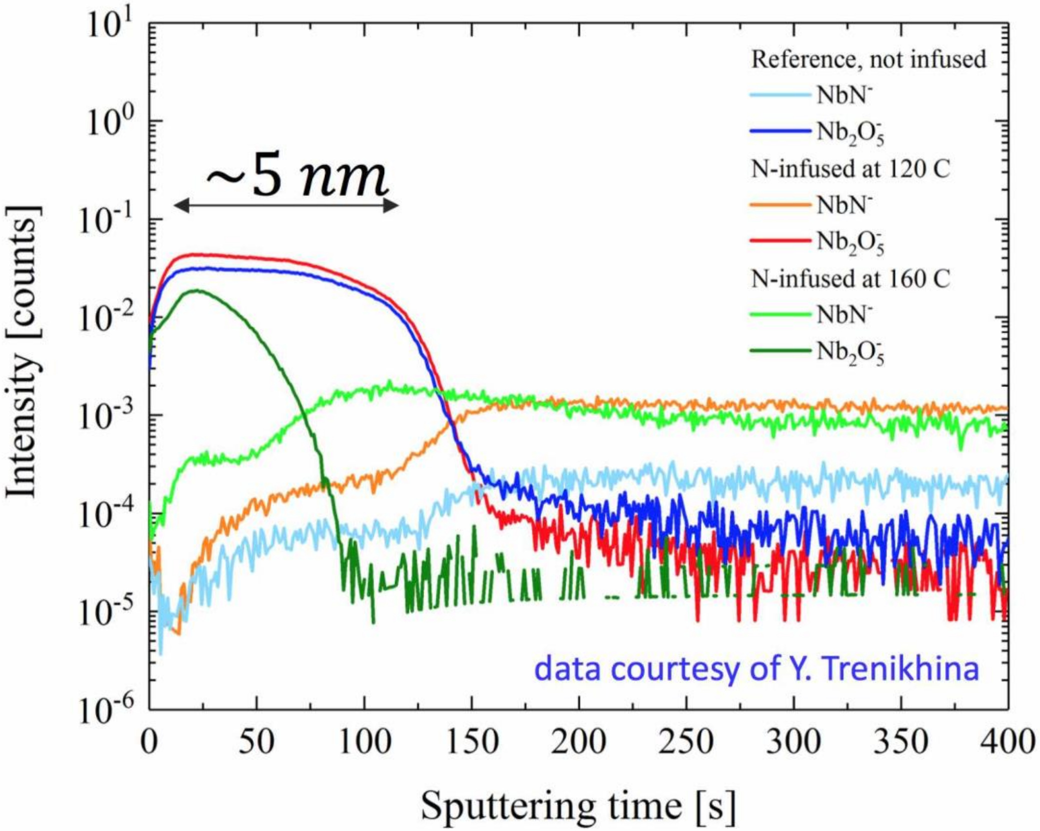


- Same extraodinarily high Q as single cells
- Highly reproducible
- CAV0018 limited by FE -> might have gone even higher in gradient

1.3 GHz cavities, tested at 2K

S. Aderhold (FNAL)

Nitrogen role in N-infusion



- Higher N_2 background compared to non-infused samples
- N_2 enriched layer below native oxide
- SIMS data suggests that performance is related to the first nm from the RF surface

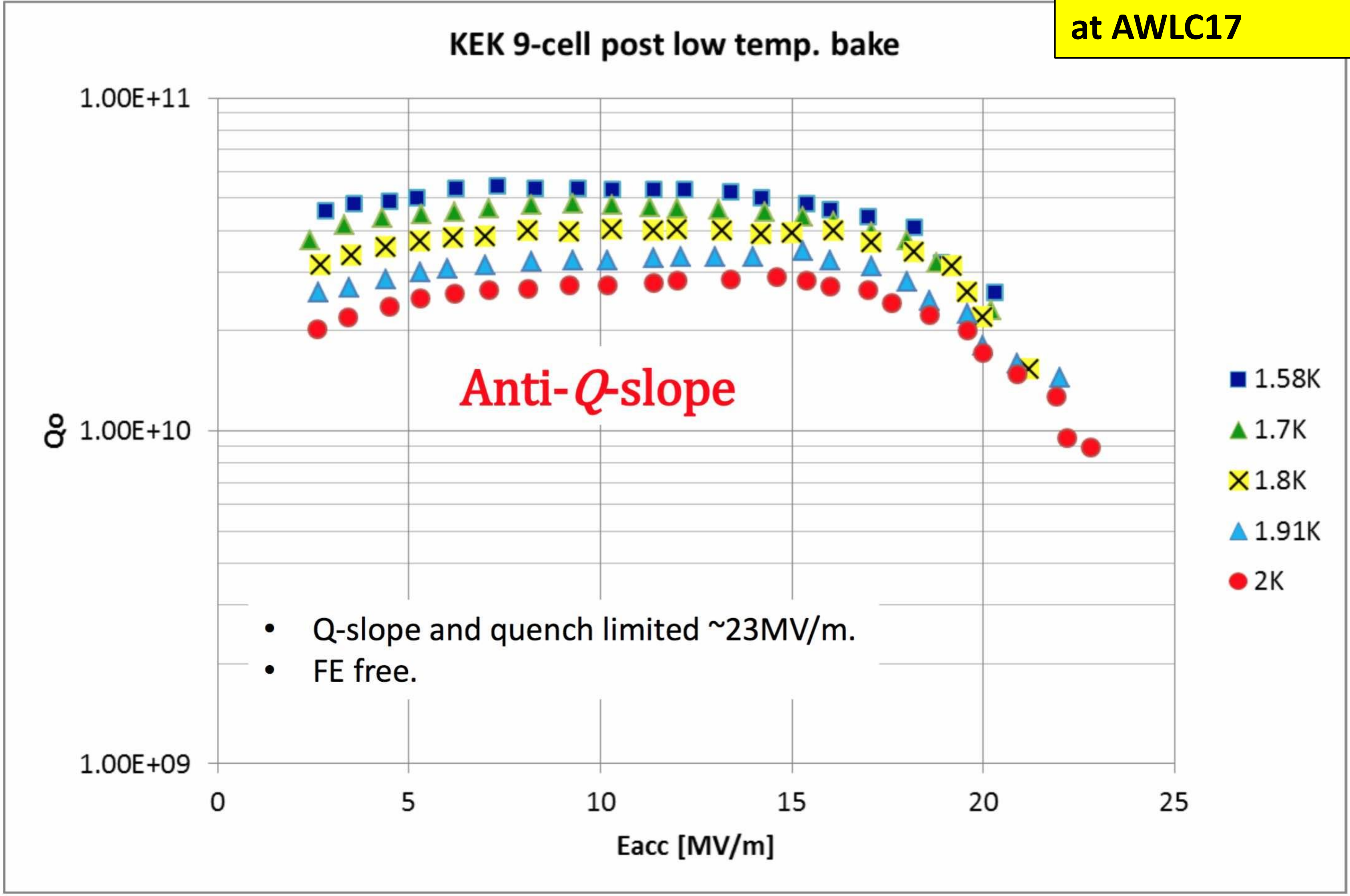
No nitride formation at the RF surface

A. Grasselino *et al.*, **arXiv:1701.06077** (accepted for publication by SUST)

N-infusion at Cornell, 9-cell

Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE)

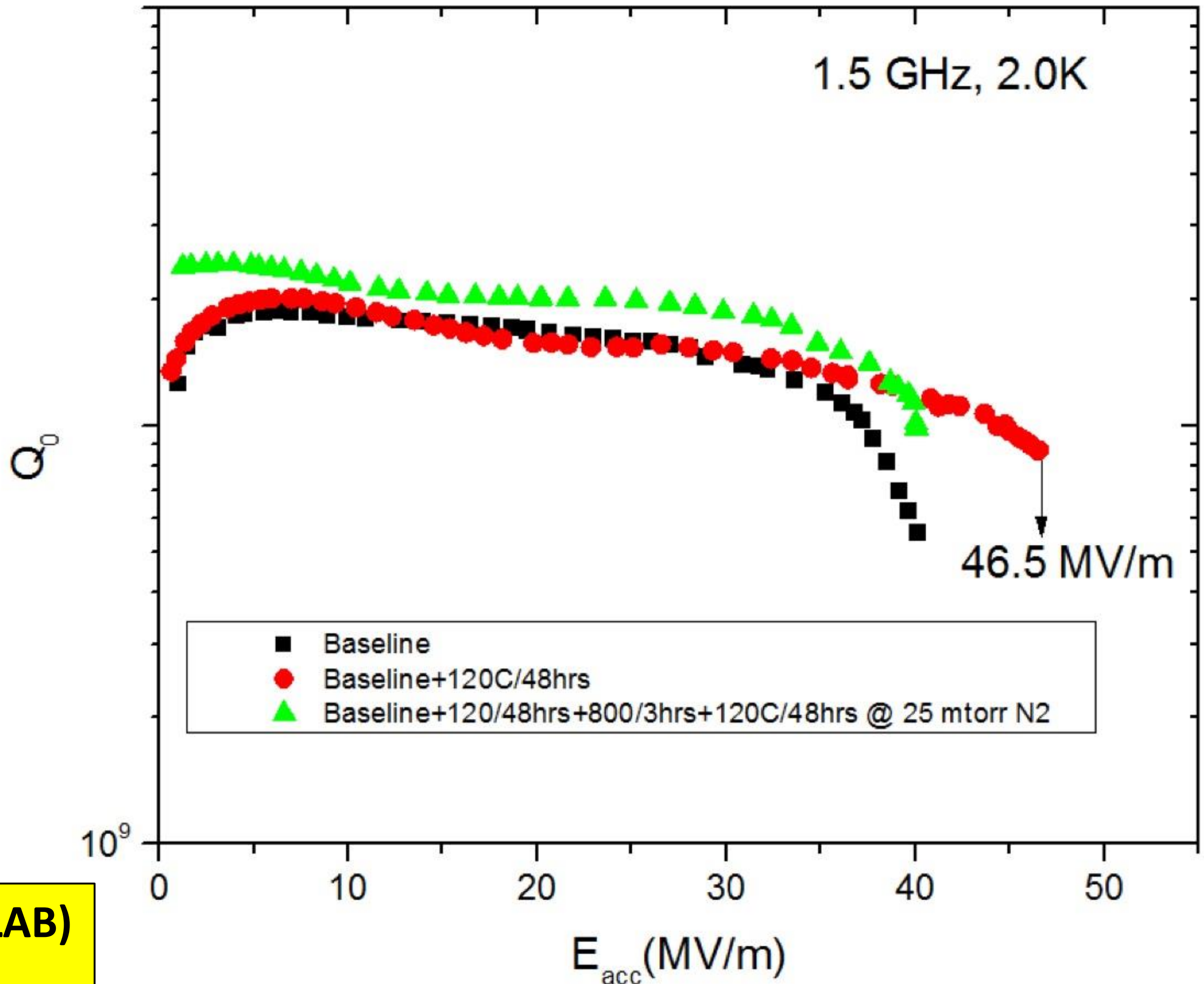
F. Furuta (Cornell) at AWLC17



- Q-slope and quench limited ~23MV/m.
- FE free.

Will be analyzed,,,

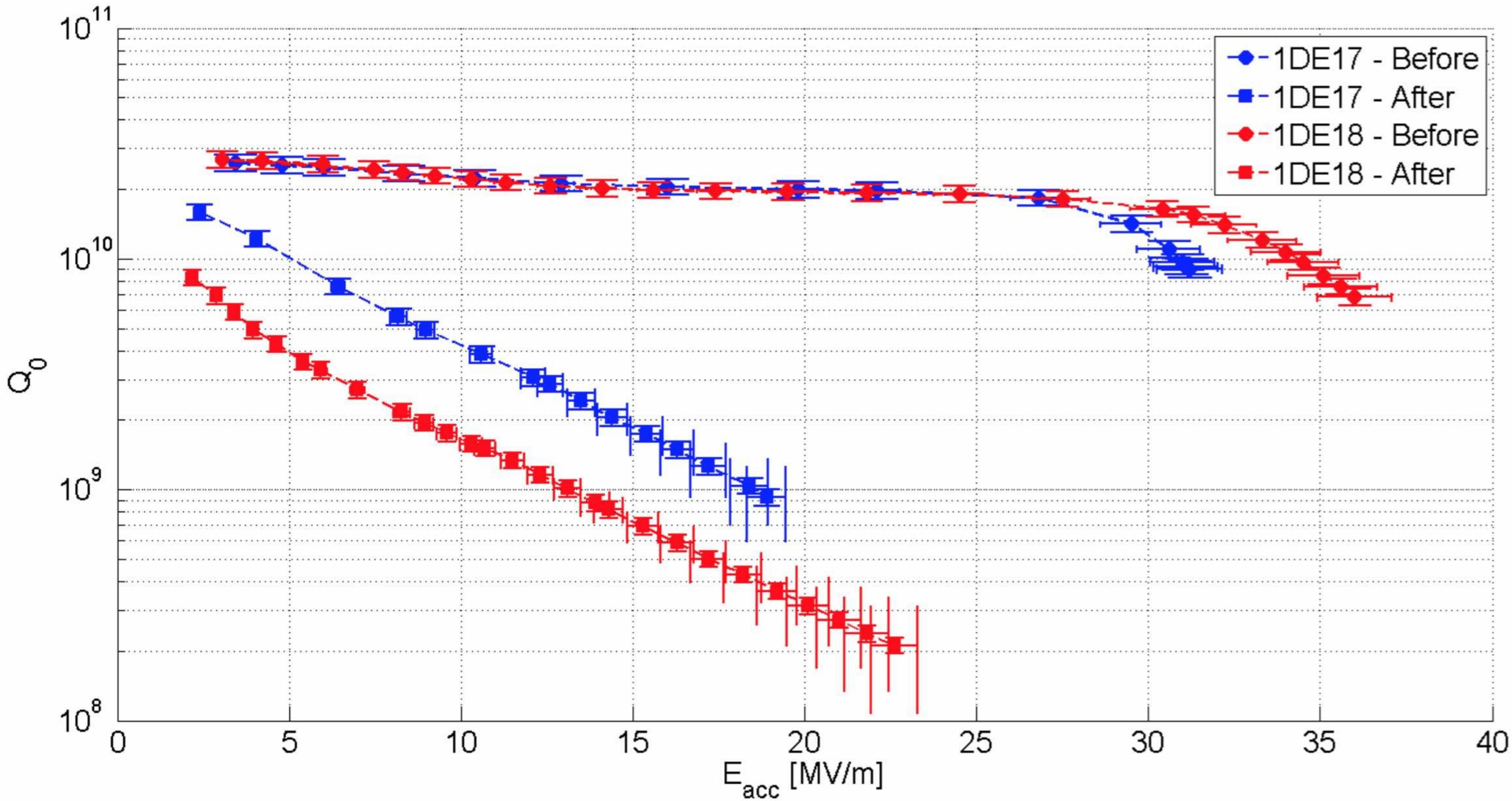
RECENT WORK AT JLAB



P. Dhakal (JLAB) at AWLC17

Comparison of tests before/after treatment

M. Wenskat (DESY) at AWLC17

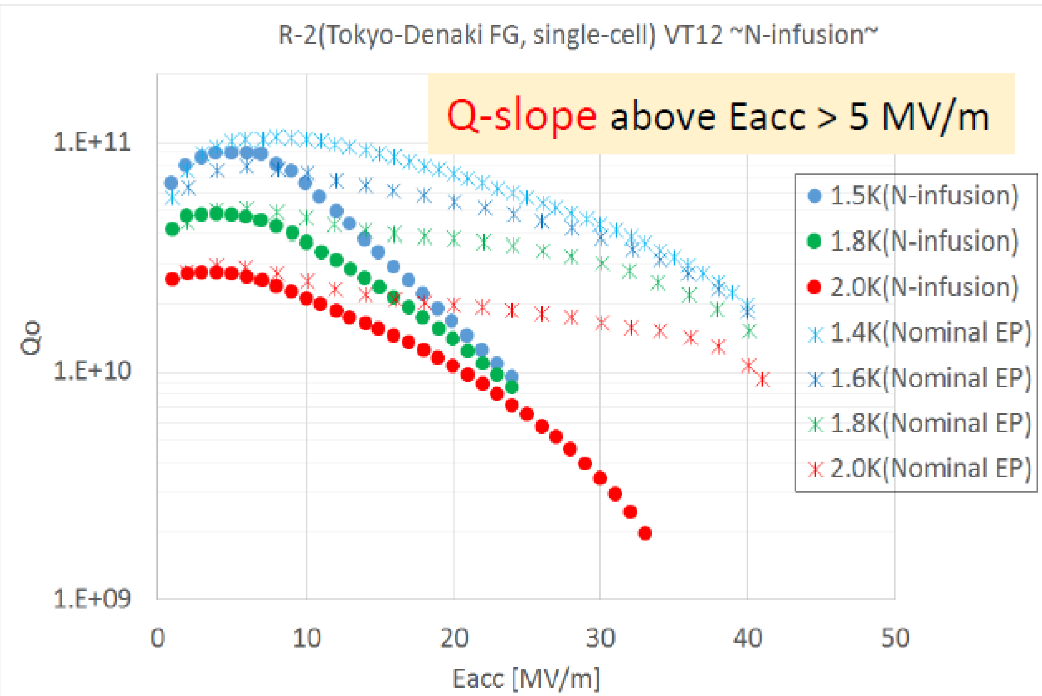


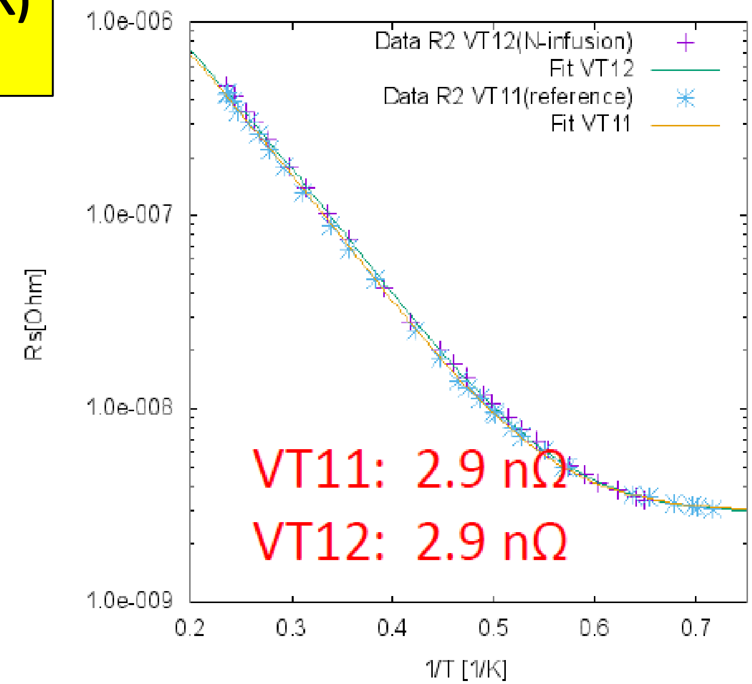
VT results for N-infusion

E.Kako (KEK) at AWLC17

- Transfer to KEK
- HPR (No EP applied)
- Assembly

- Magnetic field canceled. (< 1mG)
- Cooled down with thermal gradient





- Degradation was observed for > 5 MV/m
- Eacc was limited at 33MV/m by quench at 225 degree equator
- No field emission

ILC status

KEK/LCC

Shin MICHIZONO

- *The ILC*
- *KEK's activities*
- *ILC cost reduction R&D*
- *World-wide R&D for high-Q and high-G*
- *staging*

staging option name

500GeV **TDR:**

250 GeV **Option C:**

Option D:

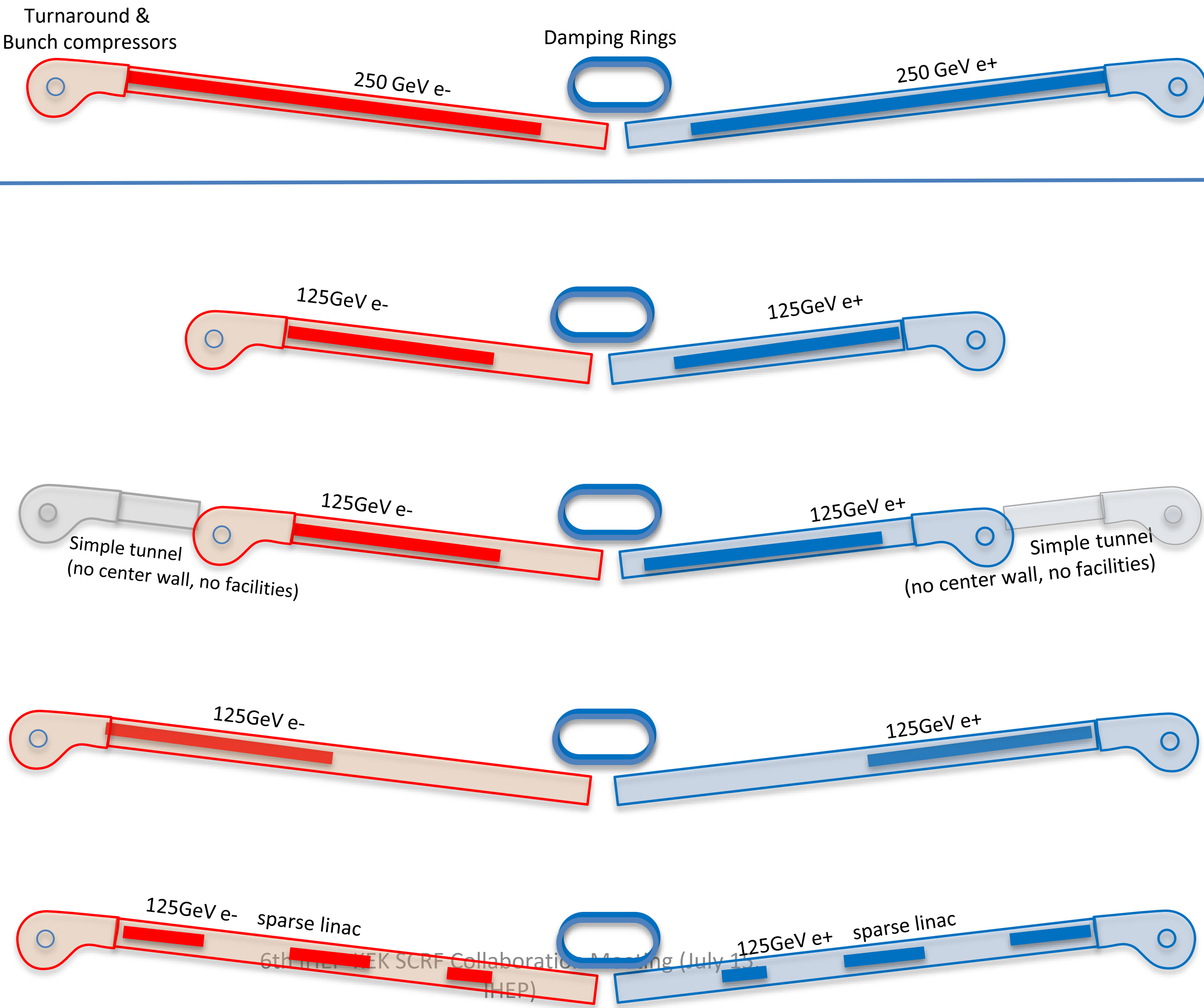
350GeV Option D':

Option E:

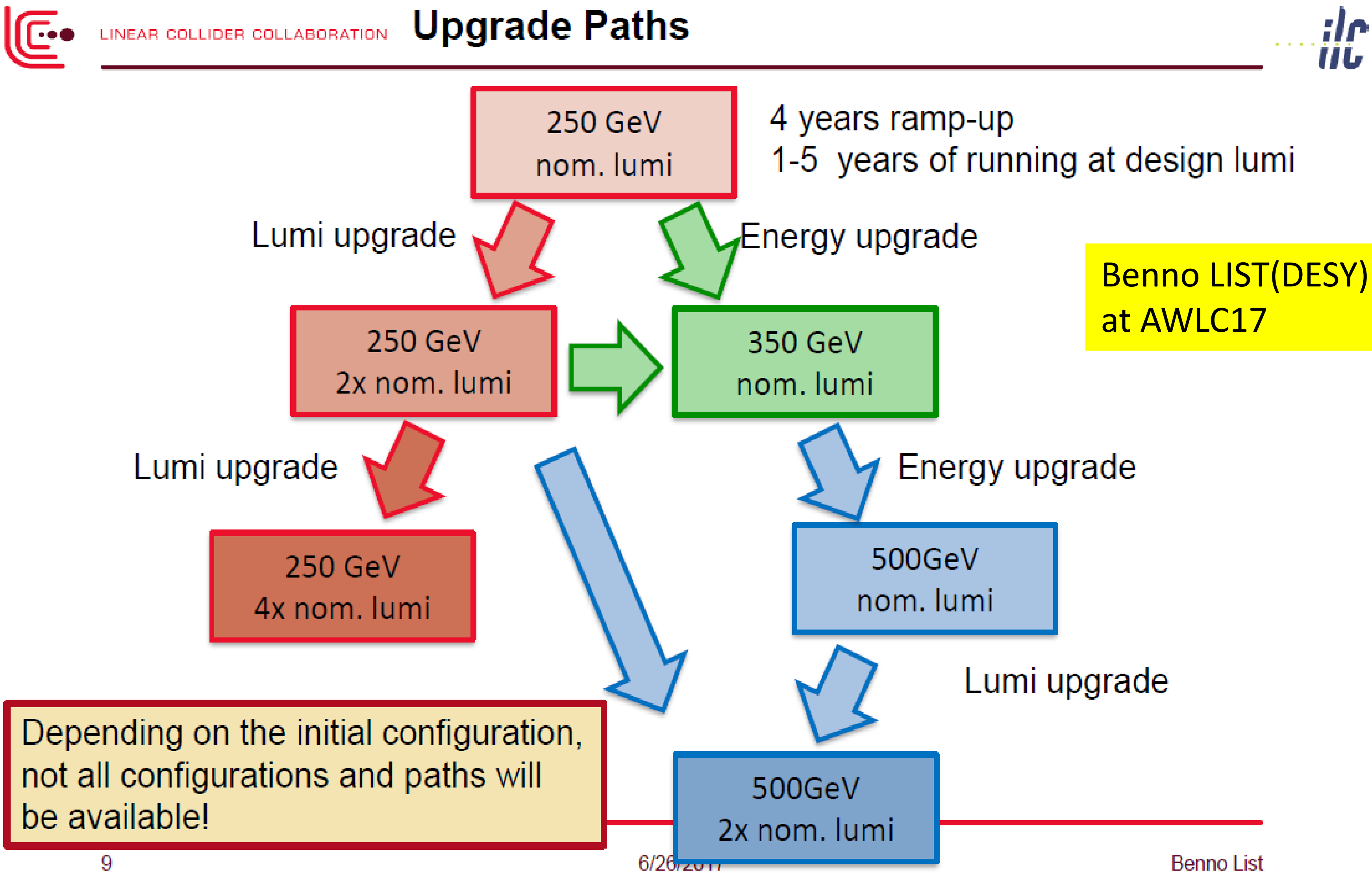
350GeV Option E':

TDR staged: **Option F:**

350GeV Option F':



Example of staging plan



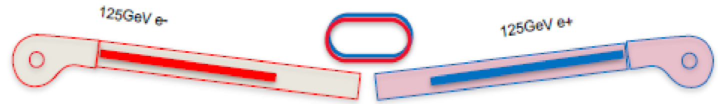
Benno LIST(DESY) at AWLC17

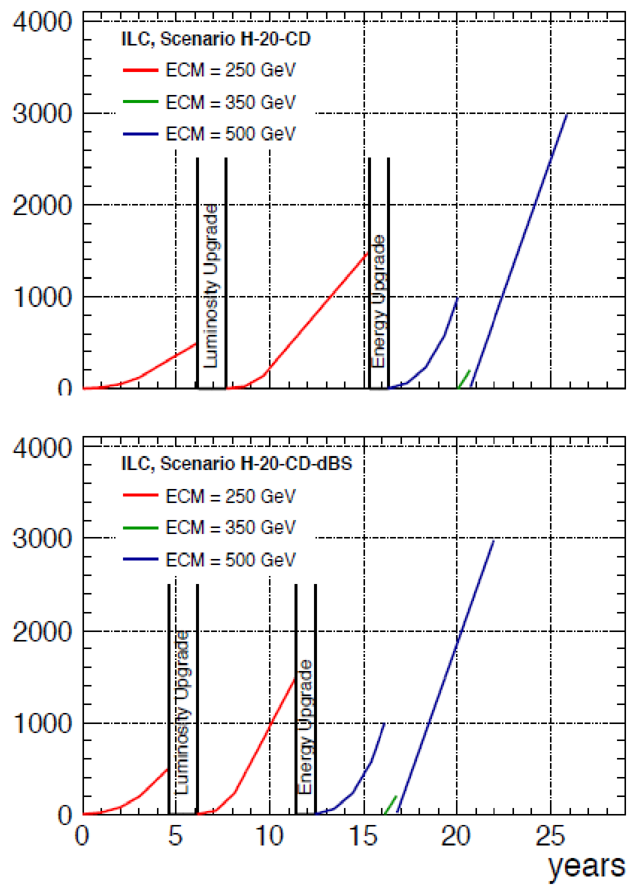
Example of luminosity and energy evolution

new scenarios: H-20-CD (-δ_{BS})

Option C:

(same scenario for option D)





lumi upgrade after
$\int Ldt \sim 500\ fb^{-1}$
(double bunches)

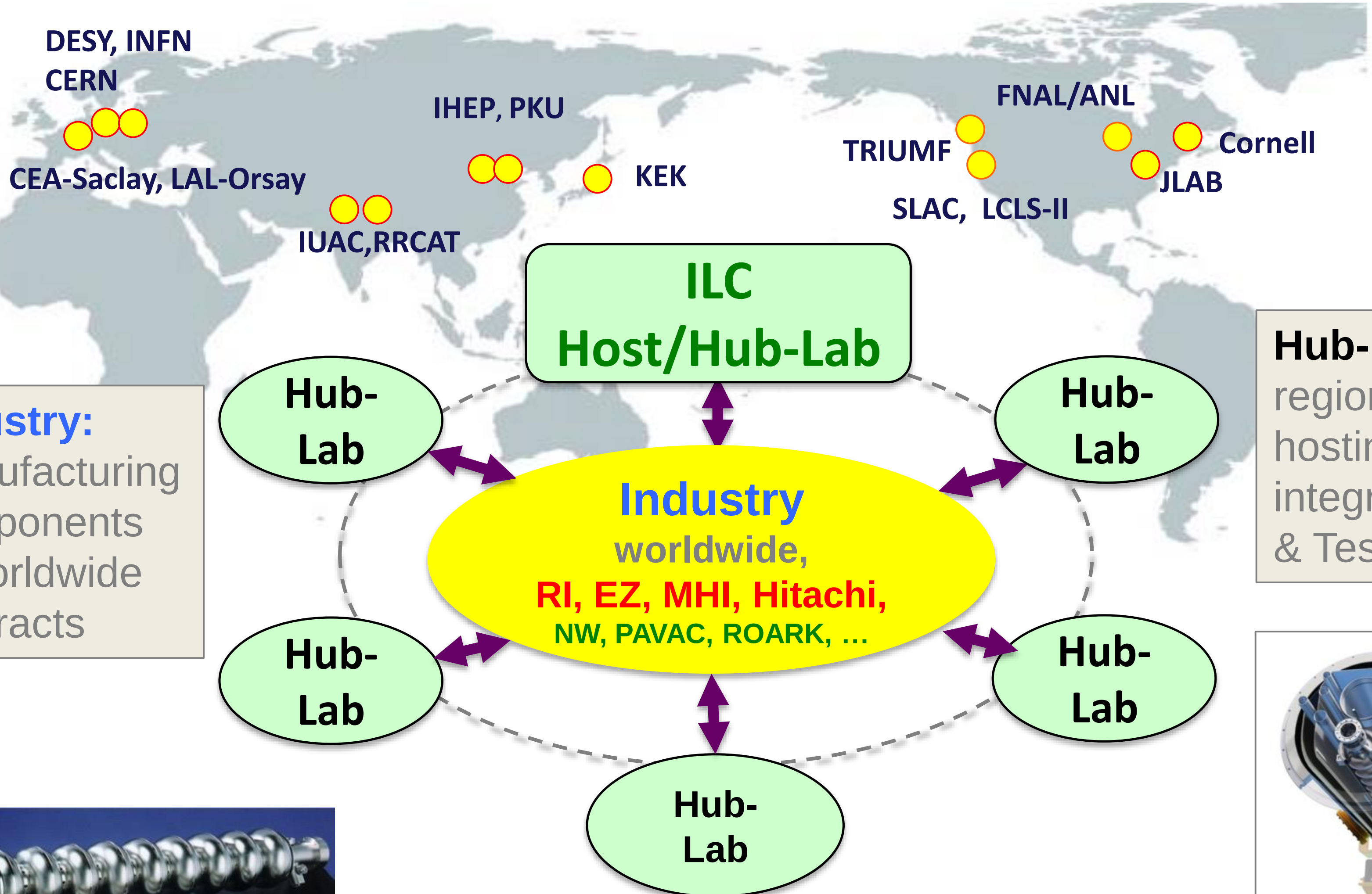
energy upgrade after
$\int Ldt \sim 2\ ab^{-1}$ at 250
GeV in ~15 (11)y

ILC500 starts with x2
bunches directly

save ~4y with δ_{BS}

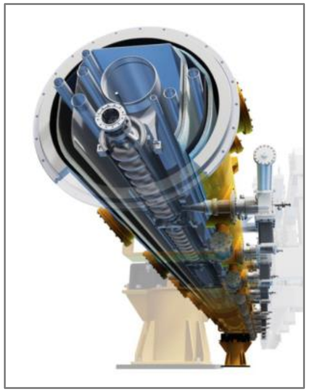
Junpin Tian (U.Tokyo)
at AWLC17

ILC SRF Global Manufacture/Integration Model



Industry: manufacturing components w/worldwide contracts

Hub-lab: regionally hosting integration & Test



Thank you for your attention