ILC overview

S. Michizono and A. Yamamoto

(LCC/ILC/KEK)

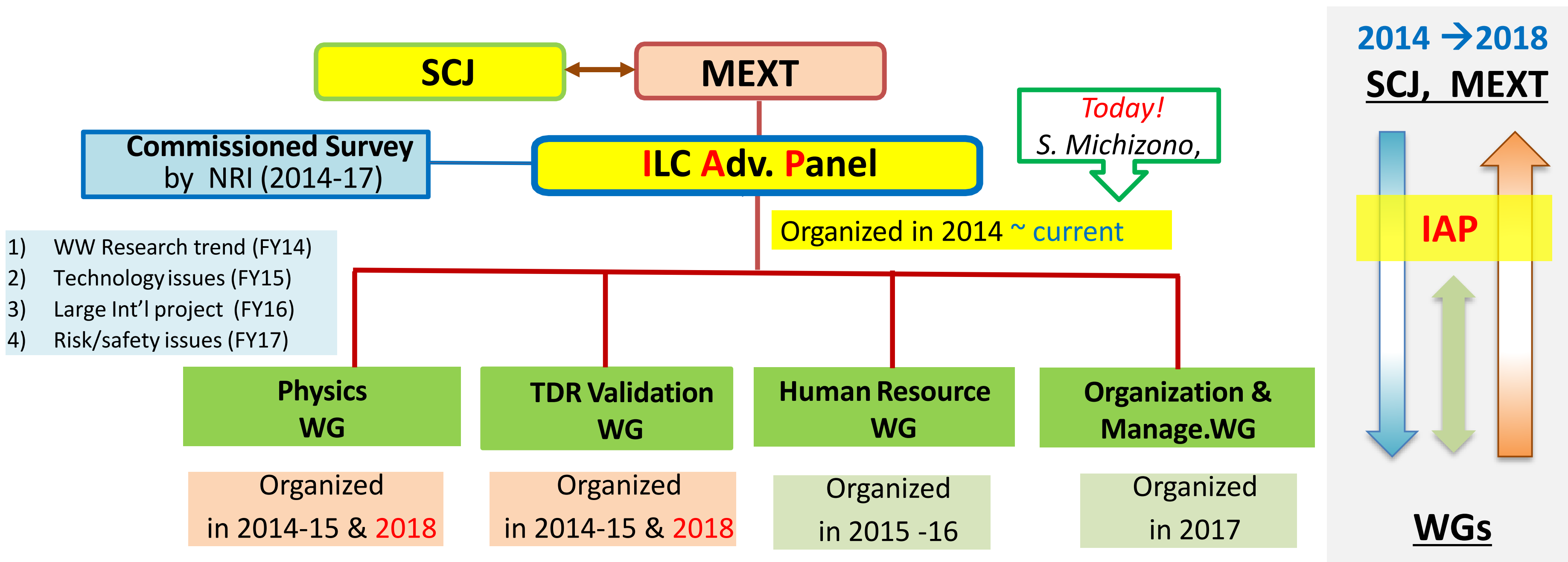
ALCW-2018, Plenary
2018-5-31b

Outline

- *Introduction*
- *ILC-250 overview*
- *Nano-beam and SRF technologies advanced*
- *Progress in cost-reduction R&D*
- *Summary*

- *The progress in ALCW-2018 to be summarized by B. List, in the plenary, tomorrow.*

ILC Study Coordination by MEXT



- Physics WG, and TDR Validation WG re-organized to evaluate ILC-250GeV.

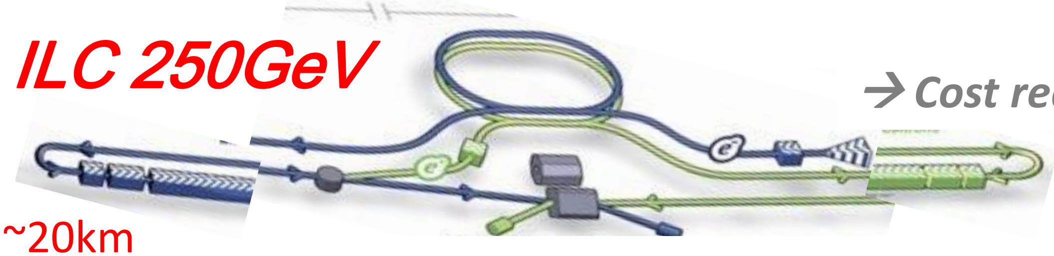
ILC500 (TDR) →ILC250

Item	Parameters
C.M. Energy	250 GeV
Length	20.5 km
Luminosity	1.35 $\times 10^{34}$ $cm^{-2}s^{-1}$
Repetition	5 Hz
Beam Pulse Period	0.73 ms
Beam Current	5.8 mA (in pulse)
Beam size (y) at FF	7.7 nm
SRF Cavity G. Q_0	31.5~35 MV/m Q_0 = 1 ~1.6x10^{10}

ILC 500GeV

~31km

ILC 250GeV



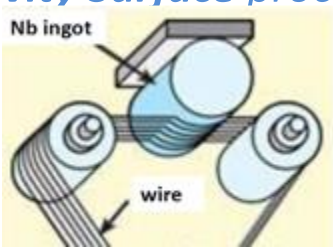
→ *Cost reduction*

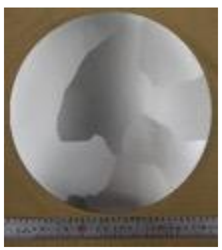
~20km

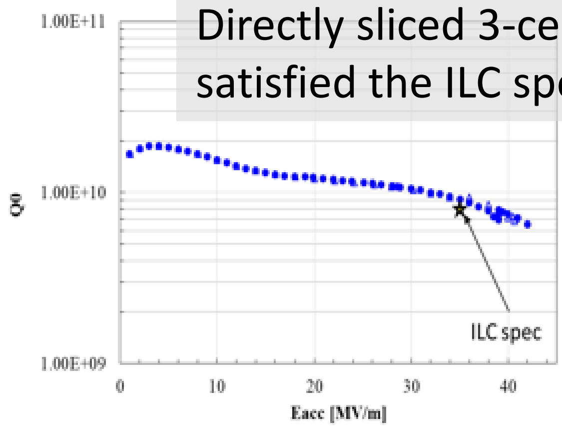
SRF Cost-reduction R&D

Cost reduction by techn. innovation

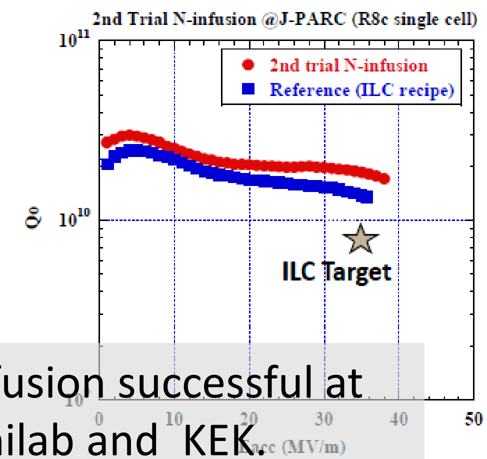
- ***Nb material** process → reduce material cost*
- ***Cavity Surface** process with N-infusion (High-G and –Q): reduce # cavities and cost*







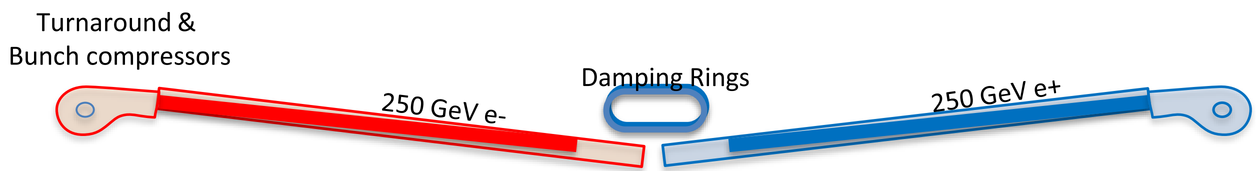
Directly sliced 3-cell cavity satisfied the ILC spec.



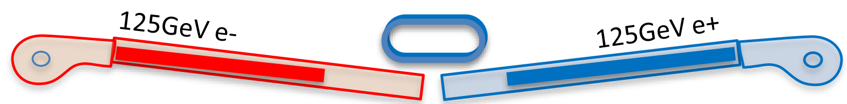
N-infusion successful at Fermilab and KEK.

ILC-500 (TDR) → ILC250

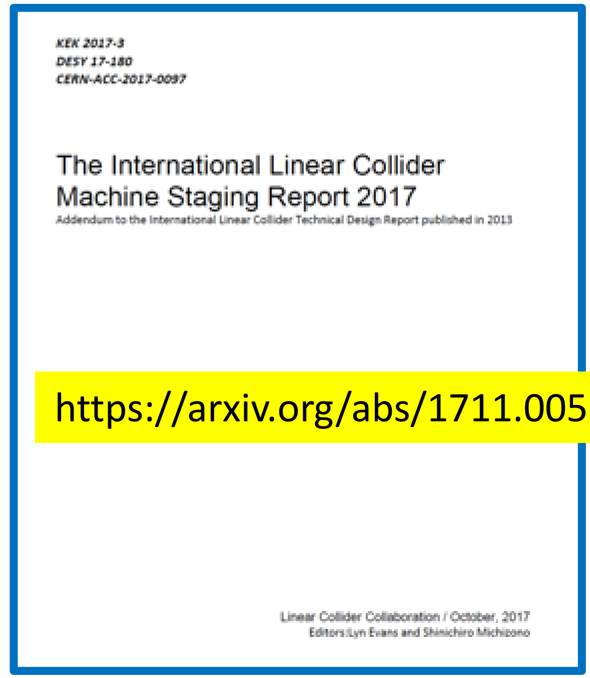
TDR update:



Options A, A': 250 GeV



	Collision E. [GeV]	Tunnel Space [GeV]	Value Total (MILCU in 2012)	Reduction [%]
TDR	250/250	500	7,980	0
TDR update	250/250	500	7,950	-0.4
Option A	125/125	250	5,260	-34
Option A' (w/ R&D)	125/125	250	4,780 w/ R&D success	-40

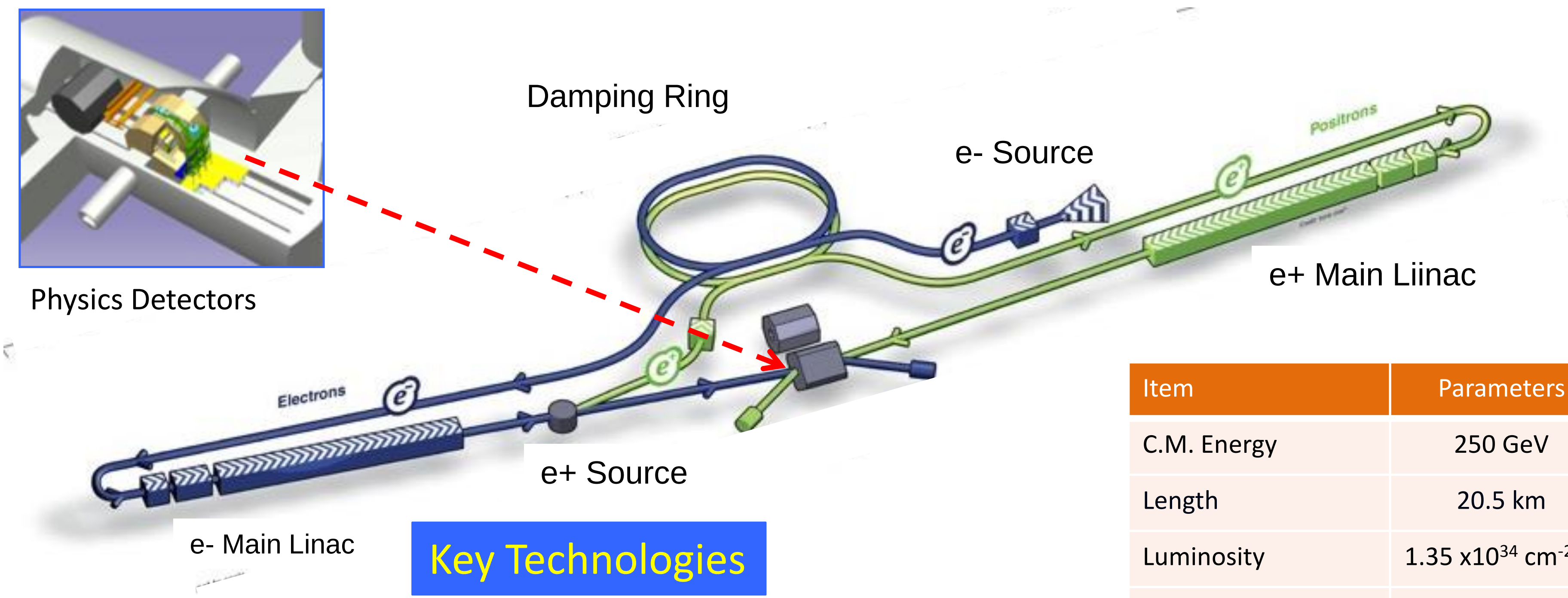

KEK 2017-3
DESY 17-180
CERN-ACC-2017-0097

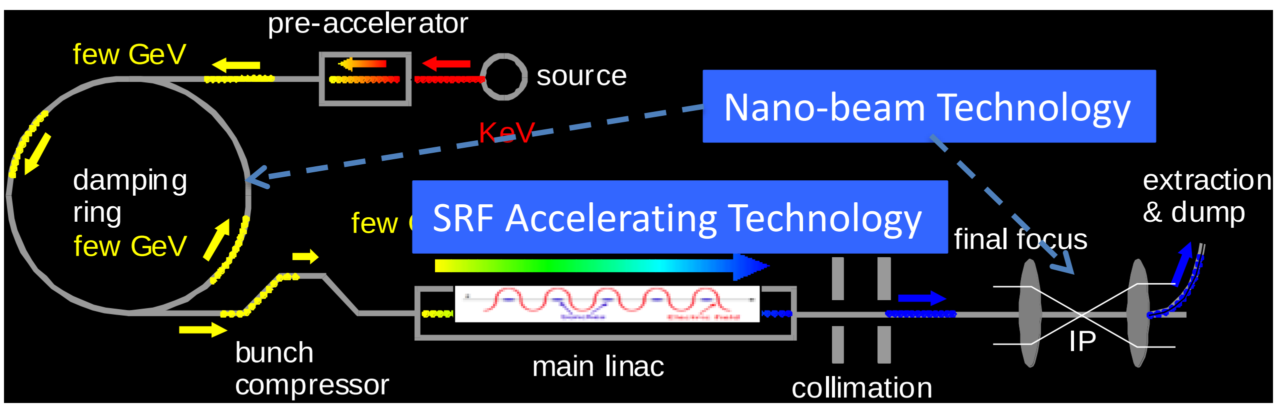
The International Linear Collider Machine Staging Report 2017
Addendum to the International Linear Collider Technical Design Report published in 2013

Linear Collider Collaboration / October, 2017
Editors:Lyn Evans and Shinichiro Michizono

https://arxiv.org/abs/1711.00568

ILC250 Acc. Design Overview





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Technical Status in 2018

•***Key Technologies advanced!***

- Nano-beam Technology :

  KEK-ATF2: FF **beam size (v)**: 41 nm at 1.3 GeV (equiv. to 7 nm at ILC)

- SRF Technology :

  European XFEL completed: <G = ~ 30 MV/m> achieved with 800 cavities and accelerator commissioning/operation reaching > 90 % design energy.

  LCLS-II: construction in progress

  H-FEL (Shinghai): construction approved

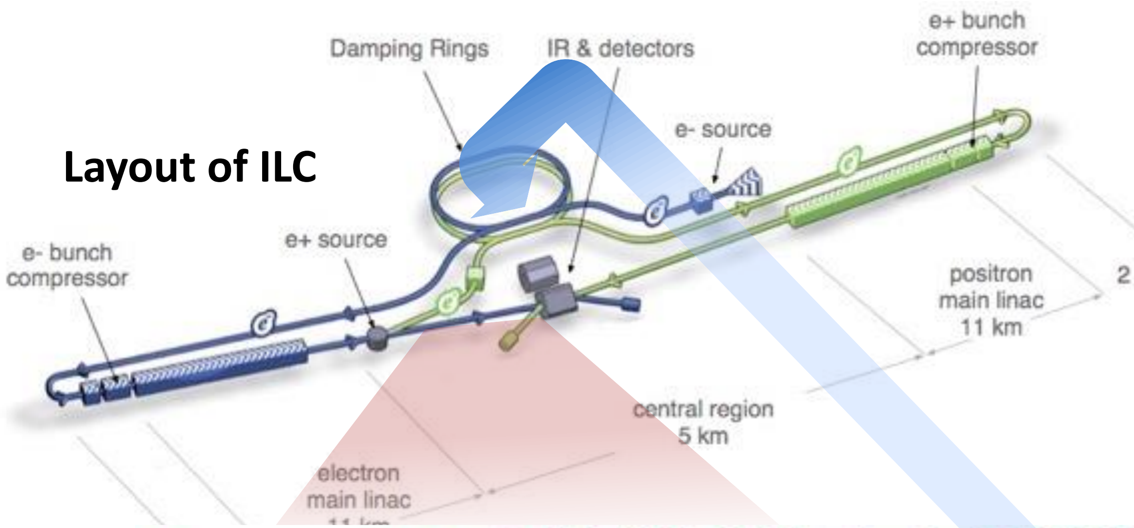
  US-Japan: Cost Reduction R&Ds in progress, focusing on "**N Infusion**" **process** demonstrated, at Fermilab, **for High-Q and High-G**

General design updated:

– **ILC** 250 GeV proposal has been authorized by ICFA/LCB

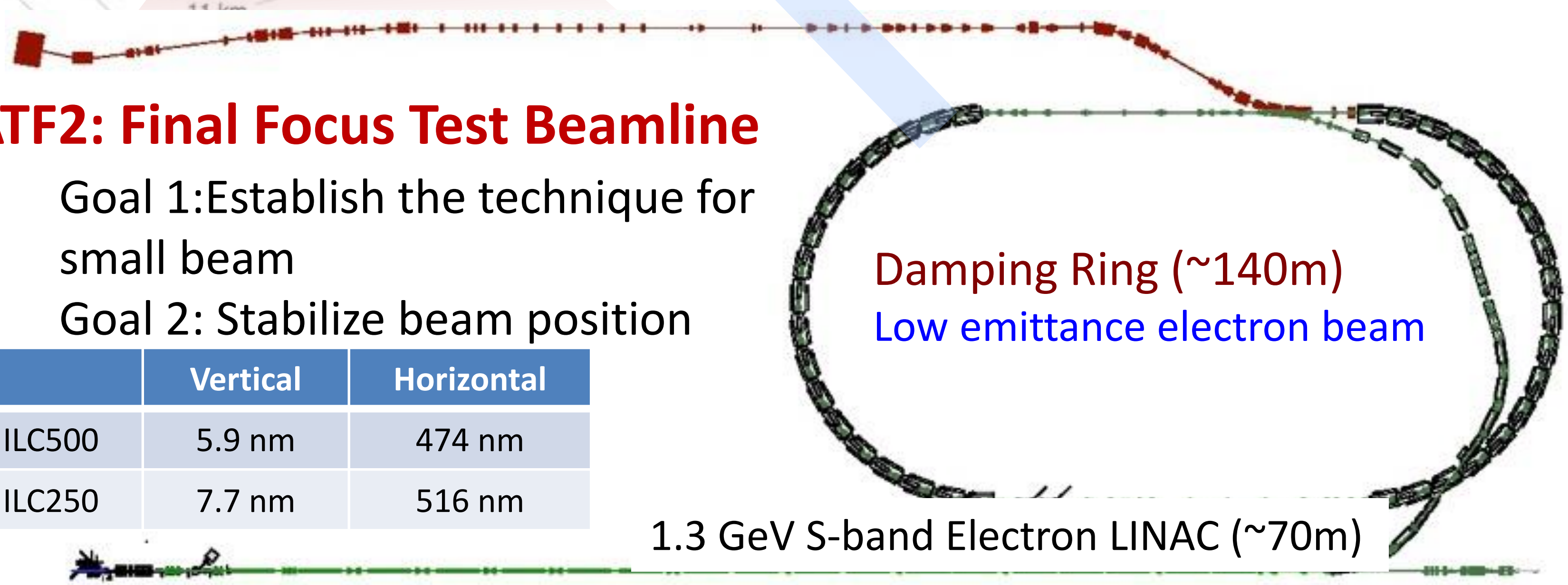
ATF/ATF2: Accelerator Test Facility

Layout of ILC



Develop the nanometer beam technologies for ILC

- Key of the luminosity maintenance
- 7.7 nm beam at IP (ILC250)



ATF2: Final Focus Test Beamline

Goal 1:Establish the technique for small beam

Goal 2: Stabilize beam position

	Vertical	Horizontal
ILC500	5.9 nm	474 nm
ILC250	7.7 nm	516 nm

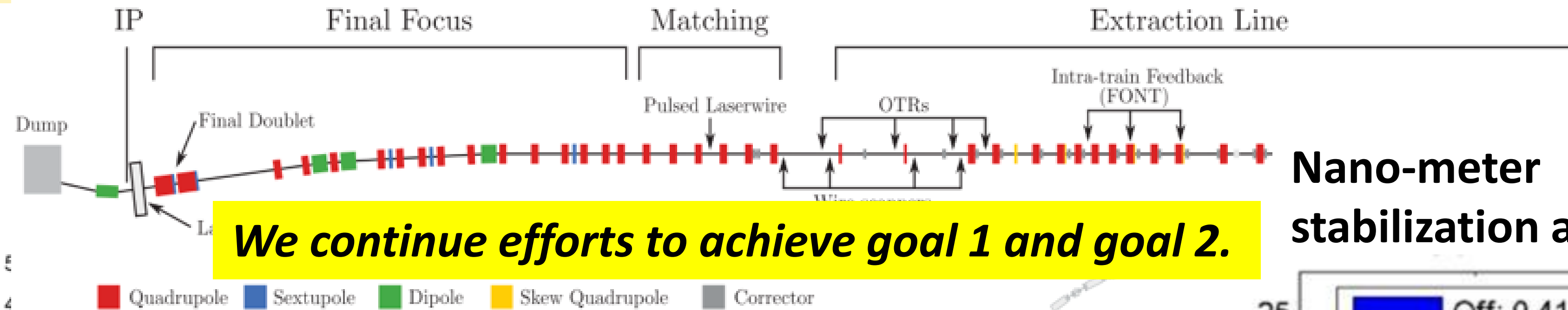
Progress in FF Beam Size and Stability at ATF2

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

- ATF2 Goal : 37 nm → 6nm @ILC500GeV
  7.7nm@ILC250GeV
  - Achieved **41 nm** (2016)

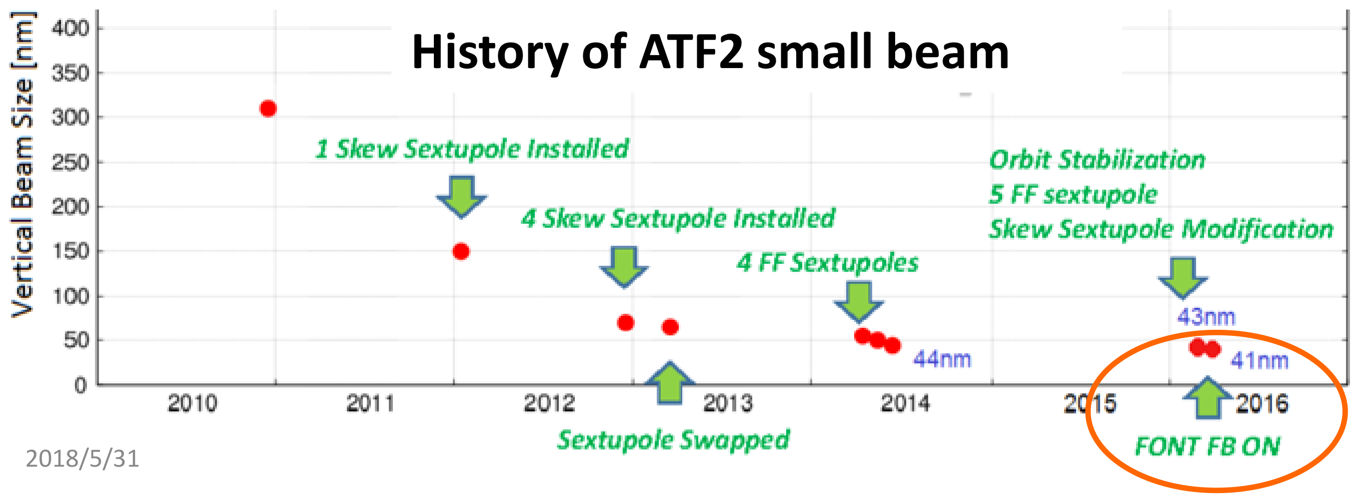
Goal 2: Develop a few nm position stabilization for the ILC collision

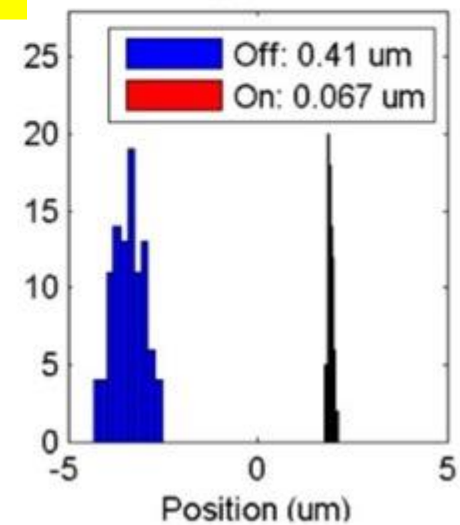
- **FB latency 133 nsec achieved**
  (target: < 300 nsec)
- **positon jitter at IP: 410 → 67 nm (2015)** (limited by the BPM resolution)



We continue efforts to achieve goal 1 and goal 2.

Nano-meter stabilization at IP





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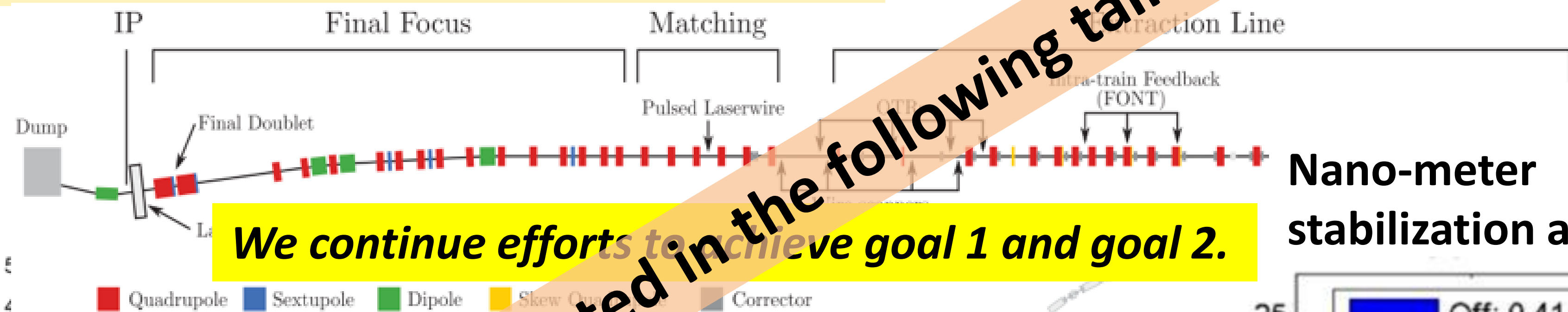
More to be reported in the following talk, by K. Kubo,



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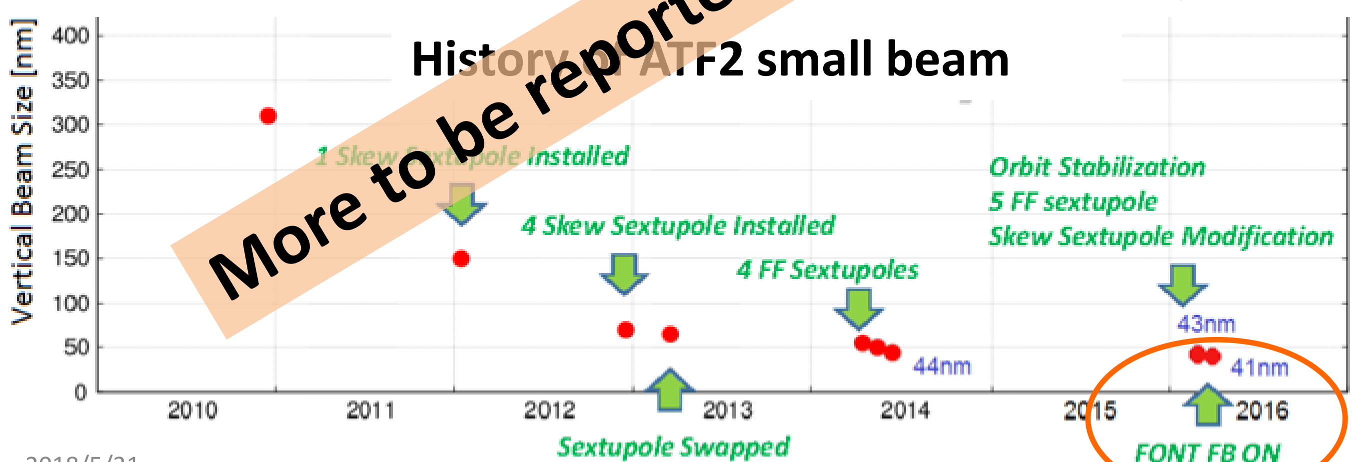

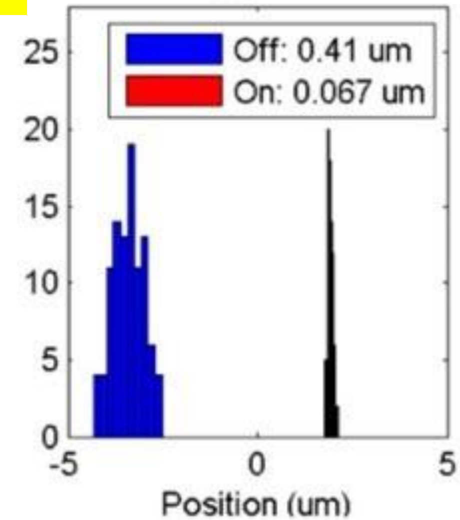

Progress in Positron Source Study

A comprehensive Study Report Published

http://lcdev.kek.jp/~yokoya/temp/PositronReport/v7.zip

Report on the ILC Positron Source

Positron Working Group

May 23, 2018

Summary

The present report have described the present status and scope of the two schemes of positron production, putting emphasis on the contraversy and/or urgent issues.

The technology status of the undulator and e-driven schemes were summarized in the AWLC2017 at SLAC[63]. It was a result of the discussion within the positron working group. The present status is essentially the same as at AWLC2017. Here, the summary table is reproduced (Table 6.1) with a few updates. (See the reference for the details of the individual components.)

Table 6.1: Summary of the technology status of the two schemes

	Undulator Scheme		e-Driven Scheme	
Target	Further consideration on wheel design, cooling calculation, mechanical performance (magnetic bearing), and Ti-Cu contact needed. Prototype shoud be built.	C	Further test of vacuum seal needed. W-Cu contact must be studied.	B
Matching device	FC has the problems of time-dependent field and PEDD.	D	Improvement from superKEKB and BINP. Design of cooling needed.	B
	QWT: yield marginal. Hardware design still required.	B		
Capture cavity	TDR design almost sufficient	A	Further consideration on thermal deformation and cavity cooling design needed	B
Beam dump	Photon dump still requires detailed design.	C	Beam dump is not an issue but radiation shielding must be studied instead.	B

B Basic partial tests done or known to work. No whole prototype.

C Calculation study only. But no show stopper seen yet.

D Break through needed.

E There is a fatal problem.

A few comments on this table:

- Here, driver beam, booster linac and yield simulation are omitted. These are more or less in the state B or better for both schemes.
- The flux concentrator for the undulator scheme is assigned D. However, as explained in Sec.2.1, the positron yield with QWT is nearly enough, though marginal. Thus, we can eliminate the row for FC of undulator scheme.

Note, however, this table does not mean that every member agrees on the status evaluation of individual items. Some of them suggest to assign severer scores for some items. Re-evaluation of the table is inevitable in the near future by the time to down-select the scheme. But it is more important to make a complete "ToDoList" for each item as stated above.

As shown in the previous section

- The cost of the accelerator components for the two schemes are almost the same.
- The CFS cost of the undulator scheme is higher due to the tunnel longer by ~2 km.
- The power consumption of the e-driven scheme is larger by ~4 MW.

But these are not a decisive factor in the choice.

As the table shows, the technology for neither scheme is ready now. Among the two the e-driven scheme seems to be closer to realization, judging from the present status of prototype development. On the otherhand, the baseline scheme, i.e., the undulator scheme, if feasible, has an advantage of the positron polarization. Therefore, the primary question for the choice of the scheme is

- Is the undulator scheme feasible?
- If so, can the feasibility be firmly verified by the time of design finalization?

We do not know clearly when is the deadline for the decision, but it is not too far, within a couple of years. In this respect of the project schedule we need a guidance from TCMB or LCC.

The working group hope that this report gives useful information for the decision in the near future.

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Summary

- The choice, undulator or e-driven, is very important but the deadline is not now. A couple of years later.
- Before this choice we need CFS studies in somewhat in detail. Should be done in parallel.
- Must think of the scenario
  - undulator only, or
  - e-driven → undulator
- The former is simple, but many questions must be answered for the latter
- Laser-straight issue can be managed anyway

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Summary

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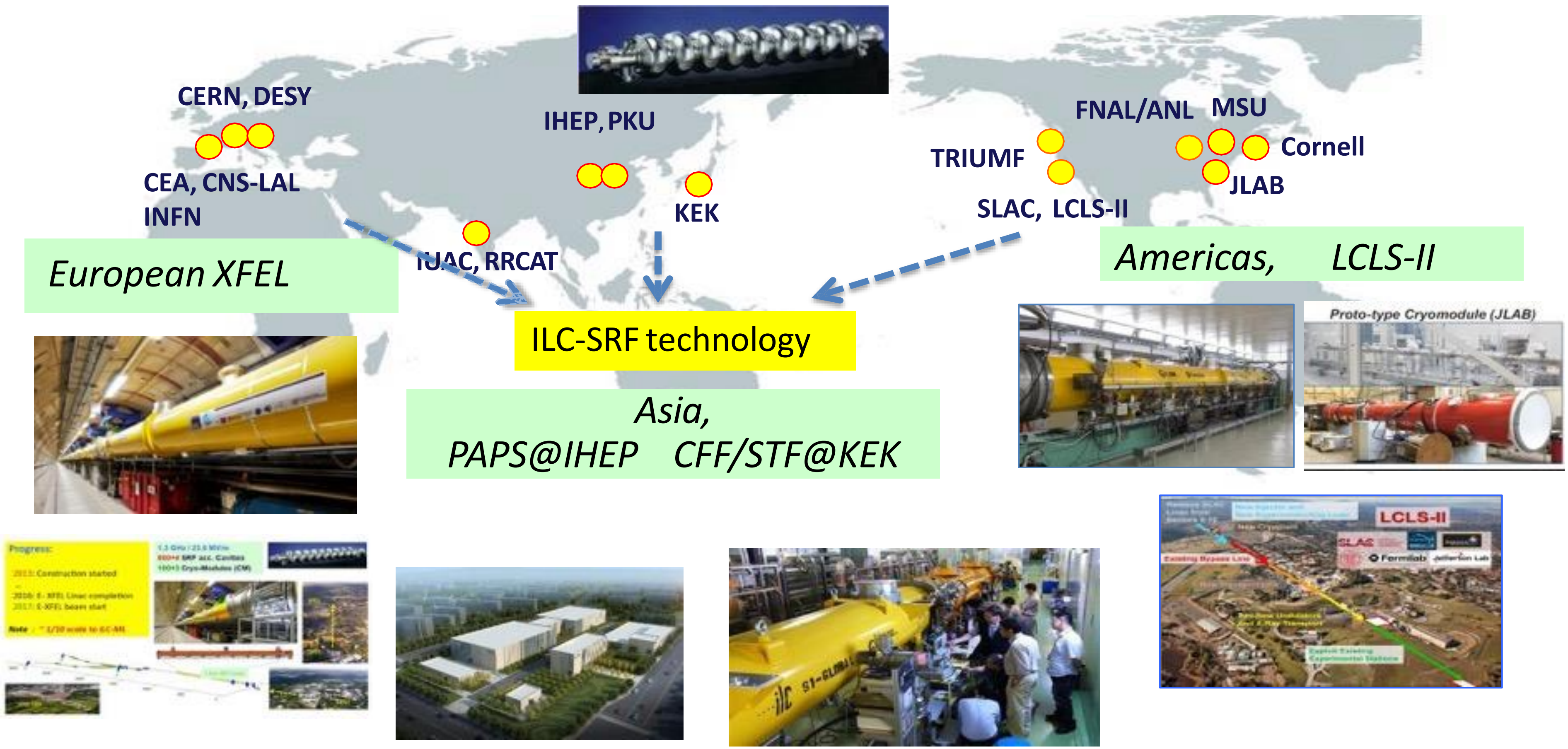
Summary

- The choice, undulator o… …mportant but the deadline is… …of years later.
- Before this … …studies in somew… …ld be done in parallel.
- … …scenario
  - … …only, or
  - …ven → undulator
  - The former is simple, but many questions must be answered for the latter
- Laser-straight issue can be managed anyway

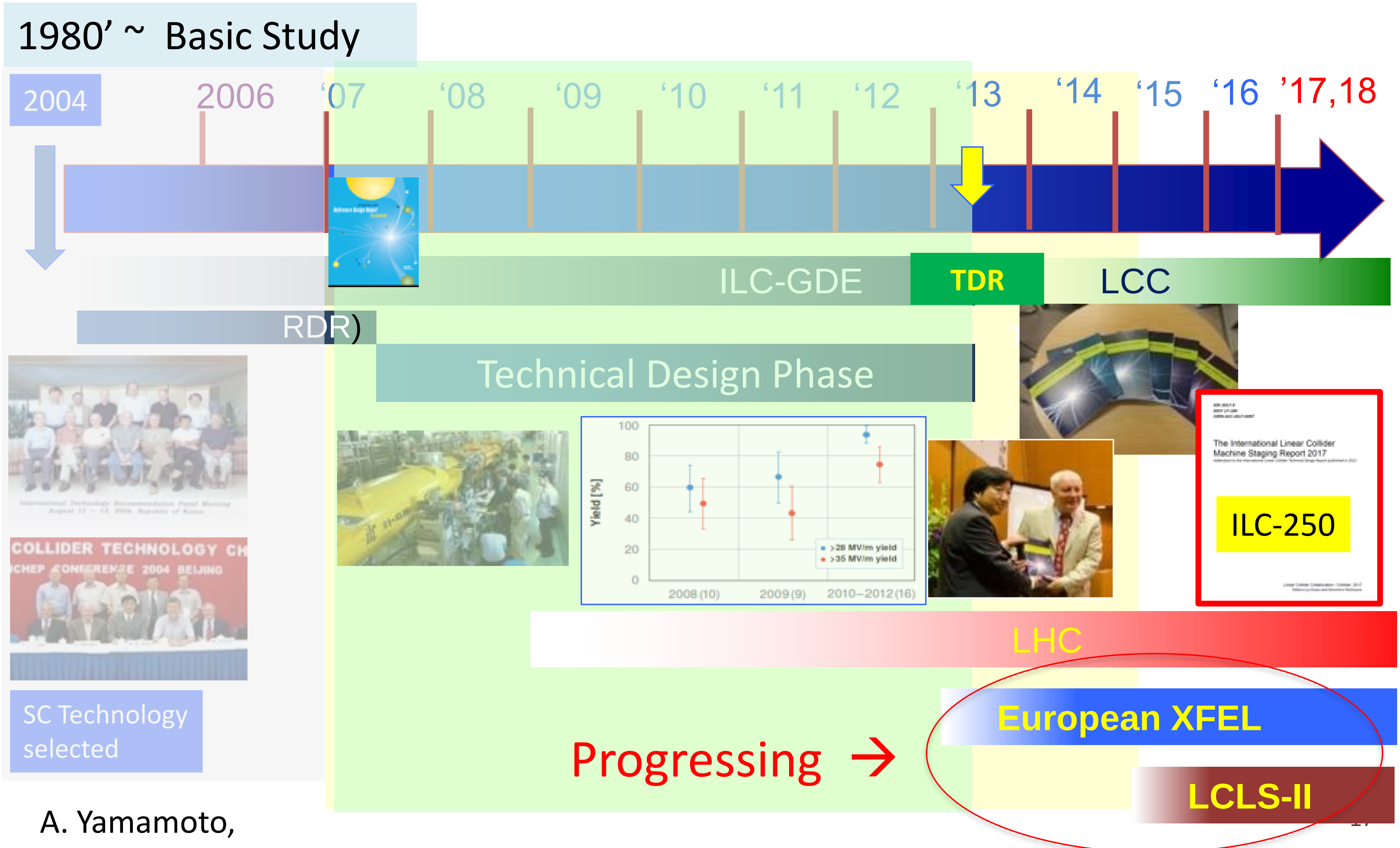
Undulator and e-driven sources comprehensively discussed.

More to be reported by B. List, tomorrow!

SRF Progress with Worldwide Collaboration



ILC-GDE to LCC



A. Yamamoto, 171106

Courtesy, H. Weise

European XFEL, SRF Linac Completed

Progress:

2013: Construction started

…

2016: E- XFEL Linac completion

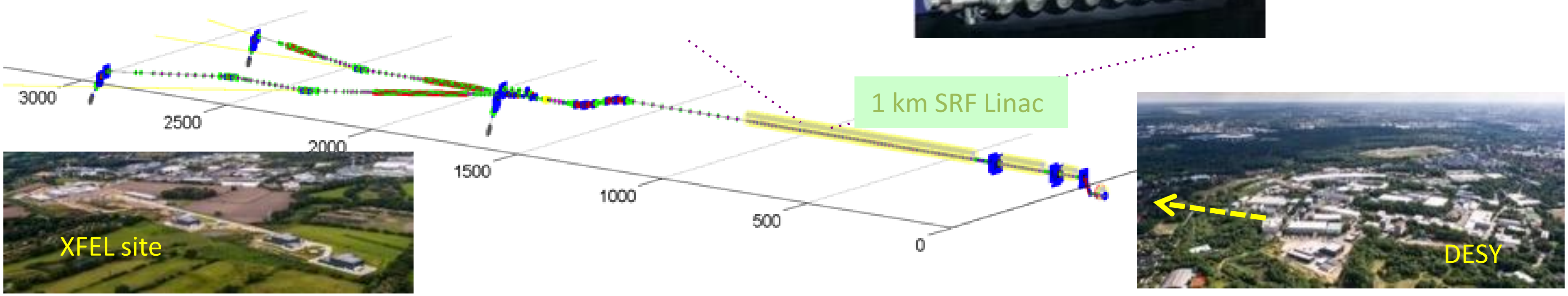
2017: E-XFEL beam start

1.3 GHz / 23.6 MV/m

800+4 SRF acc. Cavities

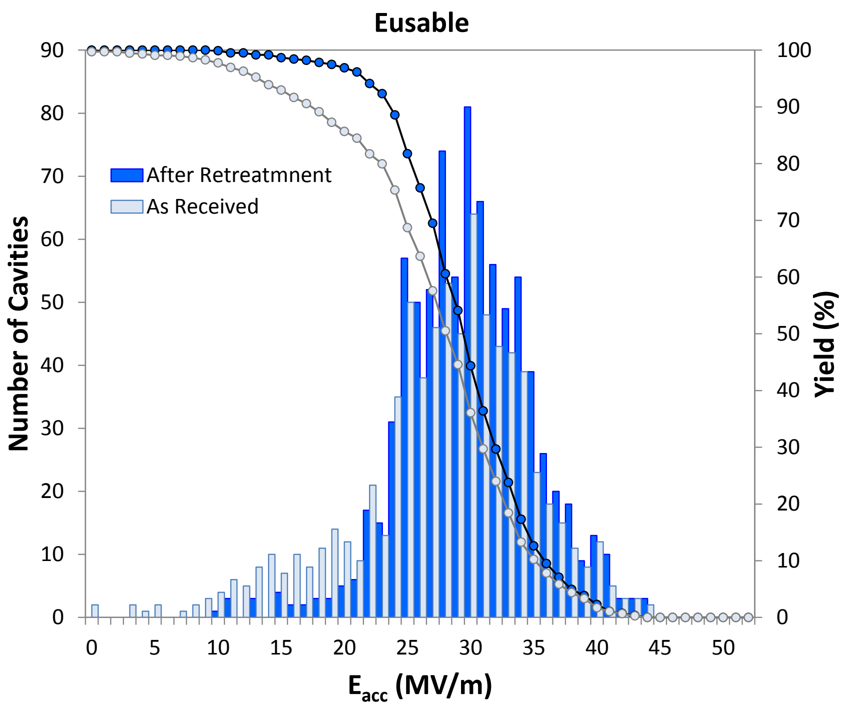
100+3 Cryo-Modules (CM)

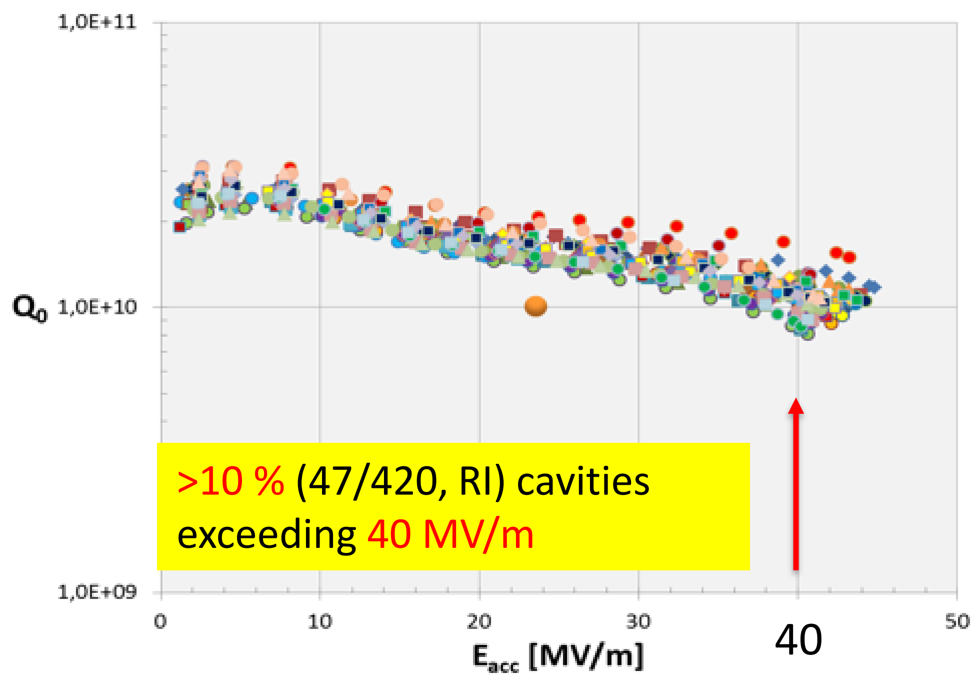
: ~ 1/10 scale to ILC-ML



Courtesy, D. Reschke , N. Walker, C. Pagani

European XFEL: SRF Cavity Performance



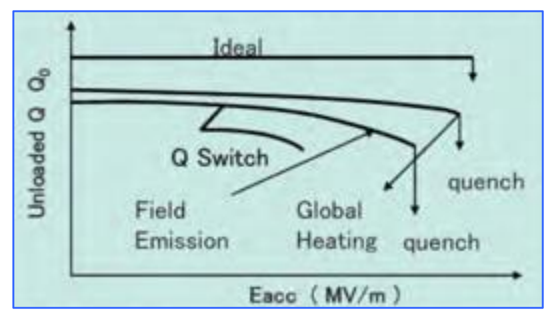


After Retreatment:

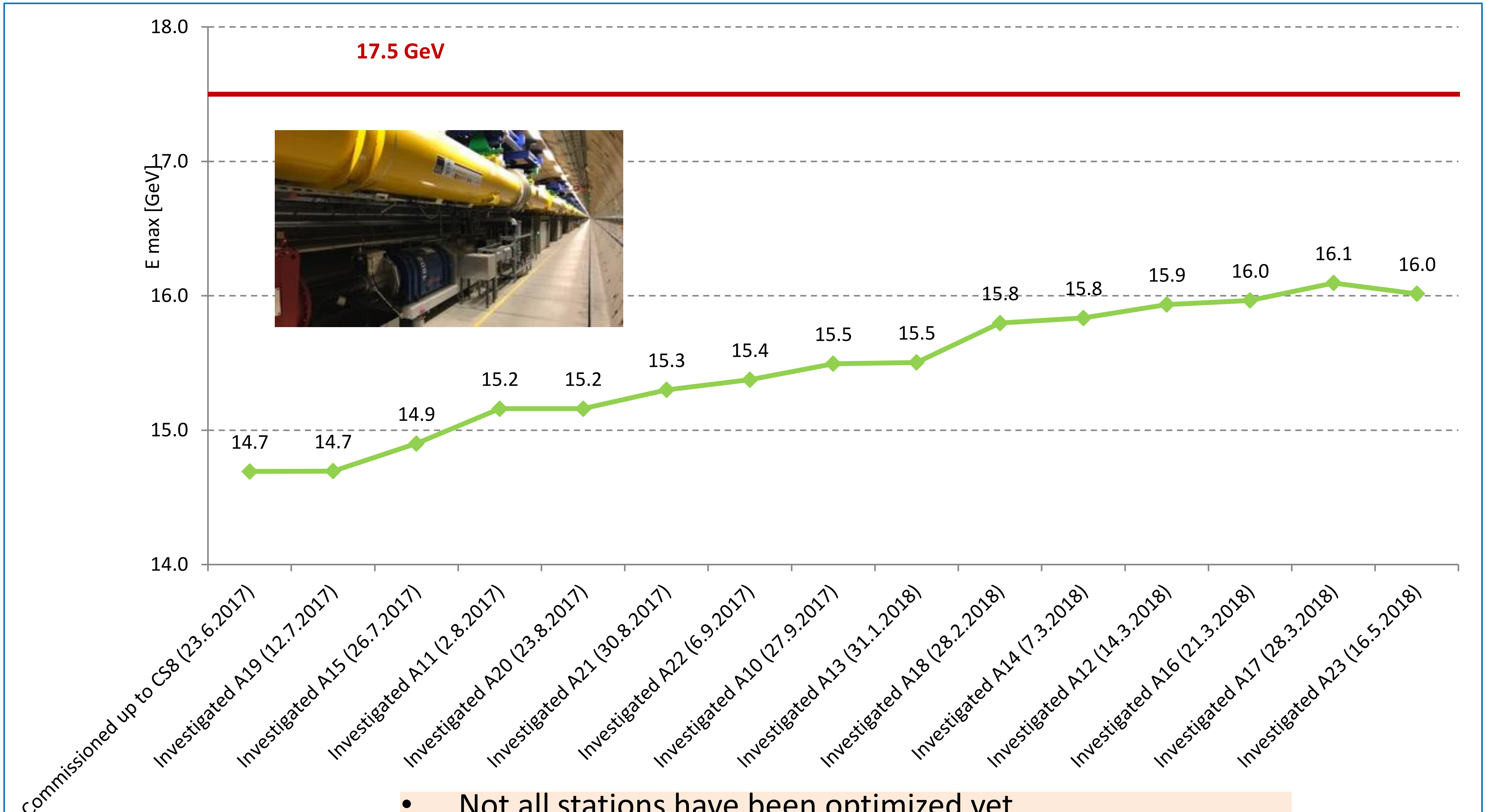
E-usable: 29.8 ± 5.1 [MV/m]

(RI): E usable 31.2 ± 5.2 [MV/m]), w/ 2nd EP

(EZ): E usable 28.6 ± 4.8 [MV/m]) , w/ BCP (instead of 2nd EP)



European XFEL: Emax Development as of 16th of May 2018

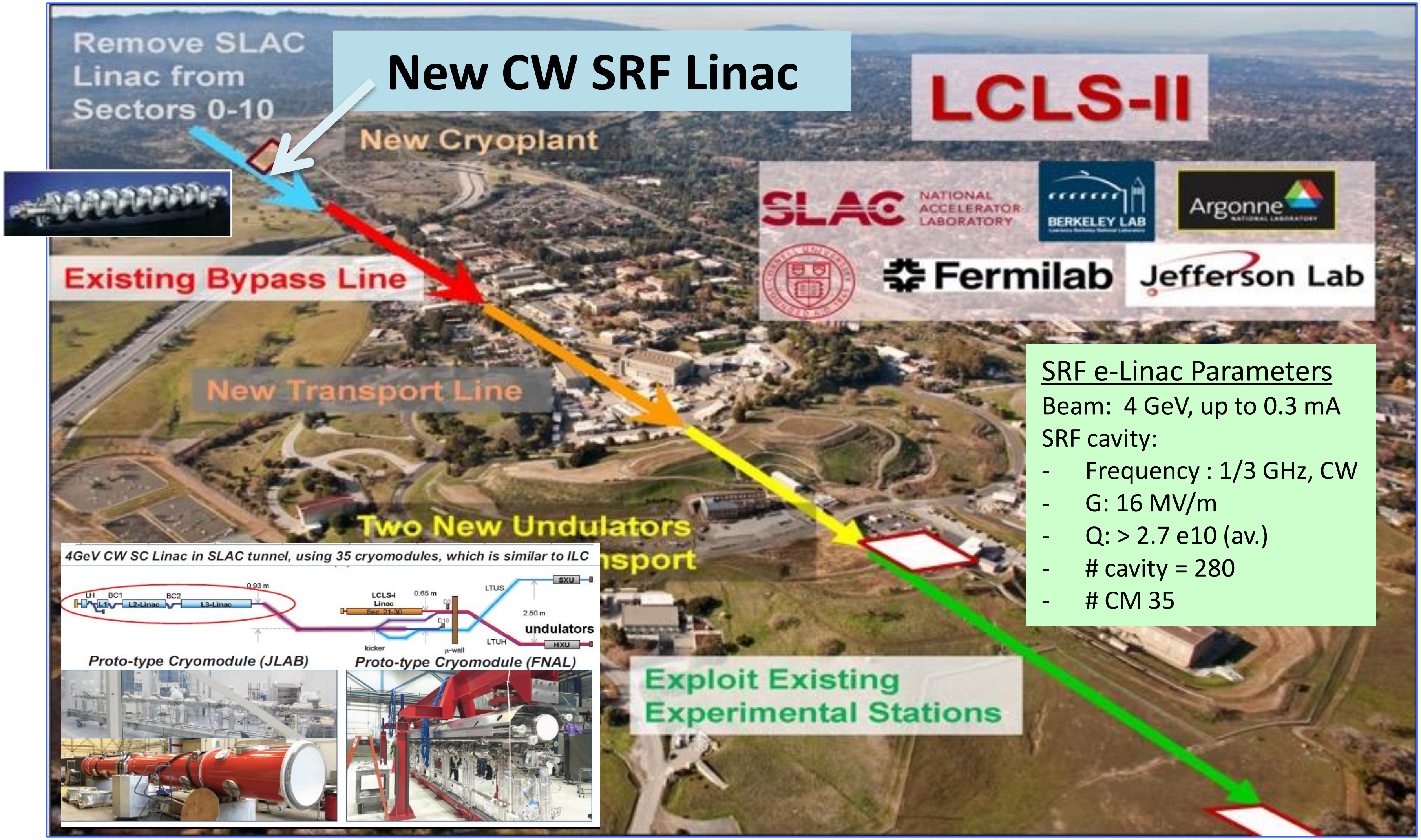


- Not all stations have been optimized yet
- CS9 commissioning nearly done
  – 1.3 GeV additional energy gain expected
- Continued effort necessary to reach and exceed 17.5 GeV
  – Expected latest by end of summer 2018

Courtesy, M. Ross

LCLS-II Concept

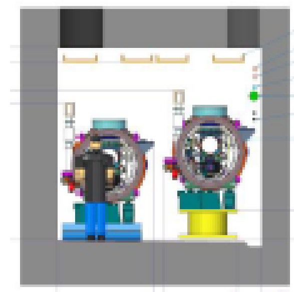
Use 1st km of SLAC Linac for CW SCRF Linac



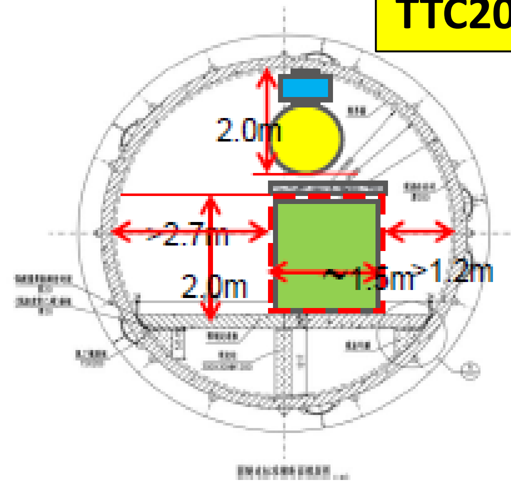
EXFEL , LCLS-II(HE) and Shanghai XFEL

TTC2018 D.Wang

European XFEL



LCLS-II



	EuropeanXFEL	LCLS-II（HE）	Shanghai XFEL
RF mode	Pulsed	CW	CW
Power source	Klystron	SSA	SSA
Install	Single ac Tunnel	Tunnel + Gallery	Single ac Tunnel
2K heat load/CM	~20w/CM	~80w/CM	~80w/CM
Tunnel slope	~	0.5%	~
N of modules	~100	~35（+19）	~75
2K capability	~3kW	~ 2 x 4kw	~ 3x4 or 4x3 kw

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US-Japan Discussion Group on ILC

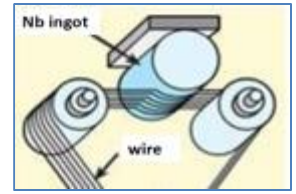
- First meeting on **May 25, 2016** at Washington D.C
  - Attended by Deputy Director-General, Research Promotion Bureau, MEXT, and Director, Office of Science, DOE.
  - Agreed on item of discussion
- Working level meeting on August 8, 2016 at ICHEP venue in Chicago
  - Attended by Director, Basic Research Promotion Div., MEXT, and Associate Director for HEP, DOE.
  - Heard from KEK and FNAL on the proposal of the joint R&D for cost reduction.
- Second meeting on **October 18**, 2016 by video
  - Attended by Deputy Director-General, Research Promotion Bureau, MEXT, and Director, Office of Science, DOE.
  - Agreed to begin the joint R&D from April 2017.
- Discussion group activity continues. The report on ILC Organization and Management is an input to this activity.

- R&D **program started** in **2017**

S. Michizono, S. Belomestnykh

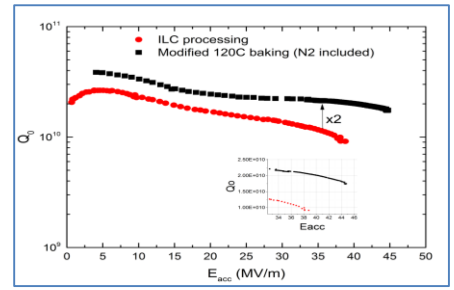
ILC Cost-Reduction R&D in US-Japan Cooperation on SRF Technology, for ~3 years

Based on recent advances in technologies;



- Nb materia/sheet preparation

  - w/ optimum RRR and clean surface



- SRF cavity fabrication for high-Q and high-G

  -w/ a new “N Infusion” recipe demonstrated by **Fermilab**

- Power input coupler fabrication

  - w/ new (low Second. e- emission) ceramic without TiN coating

- Cavity chemical process

  - w/ vertical EP and new chemical (non HF) solution

- Others

US-Japan cost reduction R&D

Evaluate the cavity performance from vertical test to horizontal test

Cavity fabrication

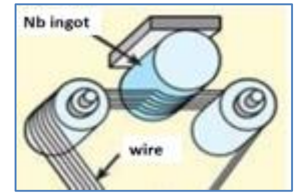
Heat treatment

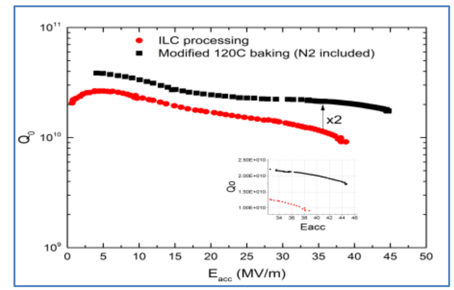
Vertical test

	Standard Fabrication/Process
Fabrication	Nb-sheet purchasing
	Component Fabrication
	Cavity assembly with EBW
Surface Process	EP-1 (~150um)
	Ultrasonic degreasing with detergent, or ethanol rinse
	High-pressure pure-water rinsing
	Hydrogen degassing at ~~> 600 C~~ → 800 C
	Field flatness tuning
	~~EP-2 (~20um)~~
	~~Ultrasonic degreasing or ethanol~~ ~~(or EP 5 um with fresh acid)~~
	High-pressure pure-water rinsing
	Antenna Assembly
	Baking at 120 C (+ N2 infusion)
Cold Test (vertical test)	Performance Test with temperature and mode measurement
Cryomodule	Installation to the cryomodule

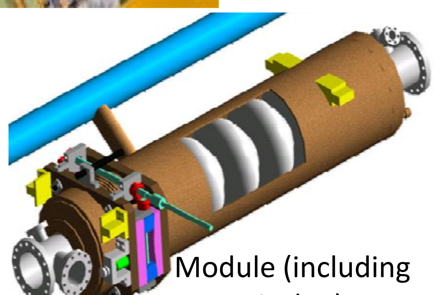
N-Infusion

New Nb material/process





Degradation-free environment



Module (including tuner, jacket)

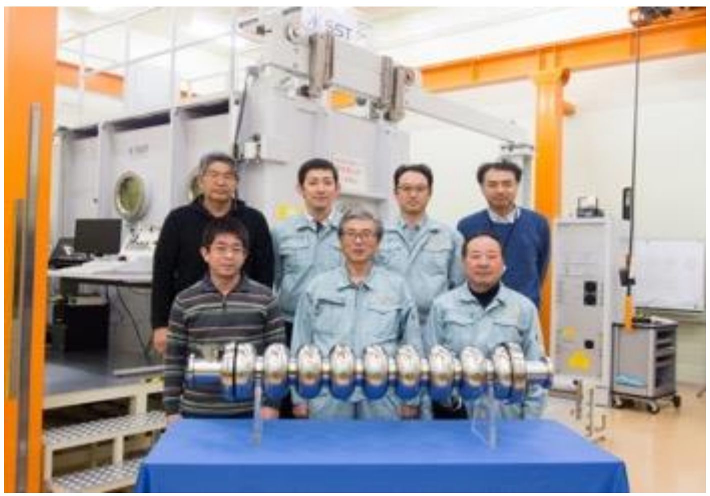
Horizontal test

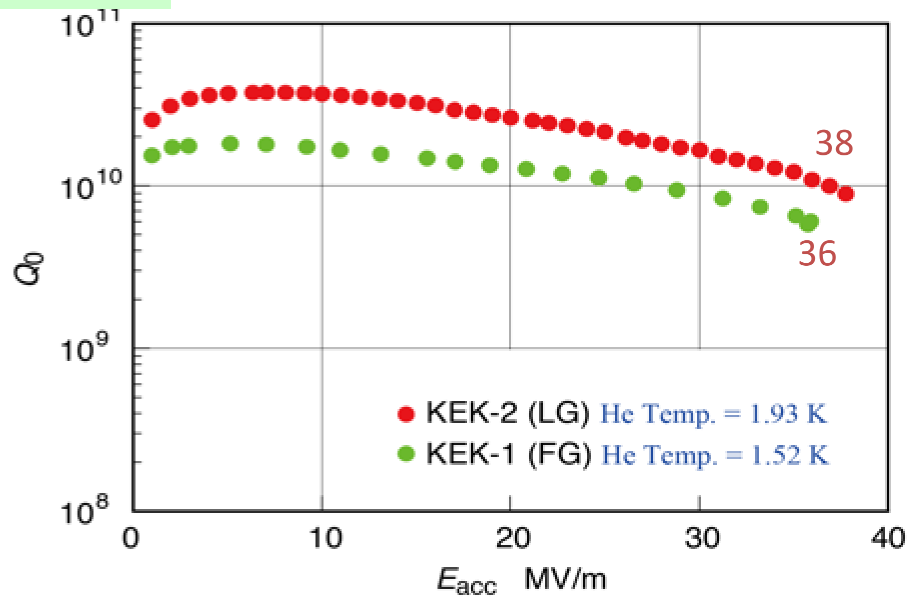
Module test at stF-2

Nb-ingot sliced, LG Cavity at KEK

1.3 GHz TESLA-like SRF cavity, using Nb directly sliced demonstrated:

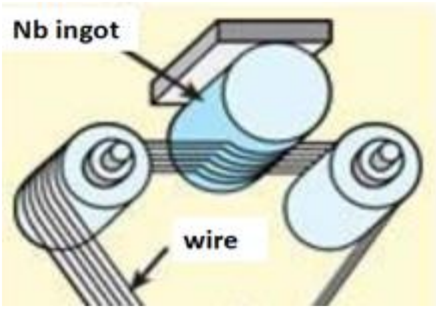
Ingot sliced Niobium (**Tokyo Denkai**)
(Dia : 260 mm)

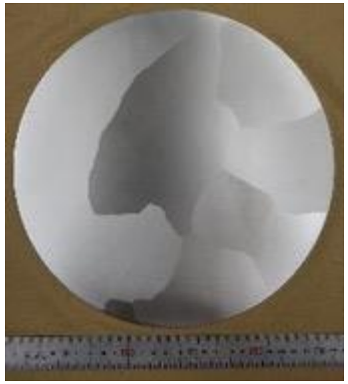




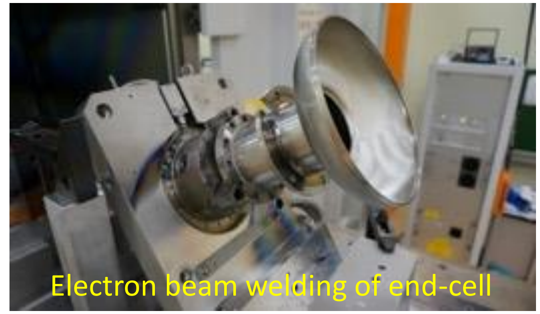
Direct sliced Nb material performance

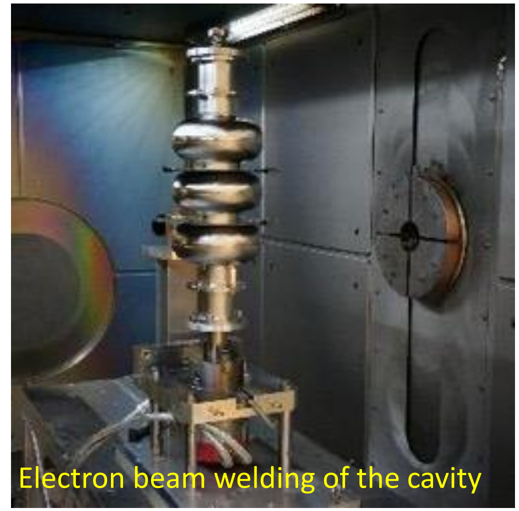
Made from large grain Nb disks;
medium RRR Nb with high Ta content (**CBMM**)

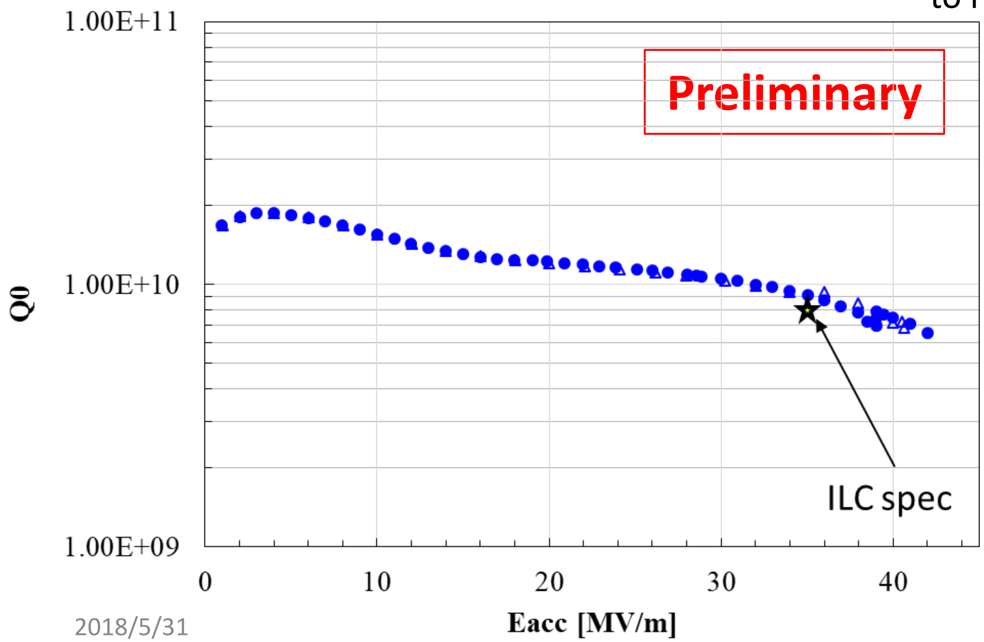




Annealed for
800°C × 3hrs
to remove stresses.







- The 3-cell cavity achieved very high gradient **(> 40 MV/m)** and satisfies ILC spec.

Standard Procedure Established

	Standard Fabrication/Process
Fabrication	Nb-sheet purchasing
	Component Fabrication
	Cavity assembly with EBW
Process	EP-1 (~150um)
	Ultrasonic degreasing with detergent, or ethanol rinse
	High-pressure pure-water rinsing
	Hydrogen degassing at > 800 C
	Field flatness tuning
	EP-2 (~20um)
	Ultrasonic degreasing or ethanol (or EP 5 um with fresh acid)
	High-pressure pure-water rinsing
	Antenna Assembly
	Baking at 120 C
Cold Test (vertical test)	Performance Test with temperature and mode measurement

Key Process

Fabrication

- Material
- EBW
- Shape

Process

- Electro-Polishing
- Ethanol Rinsing or
- Ultra sonic. + Detergent Rins.
- High Pr. Pure Water cleaning

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	Field flatness tuning
	[illegible]
	[illegible]
	[illegible]
	[illegible]
	Baking at 120 C
Cold Test (vertical test)	Performance Test with temperature and mode measurement

- N2 infusion at 120 C directly after heat treatment at 800 C

Key Process

Fabrication

- Material
- EBW
- Shape

Process

- Electro-Polishing
- Ethanol Rinsing or
- Ultra sonic. + Detergent Rins.
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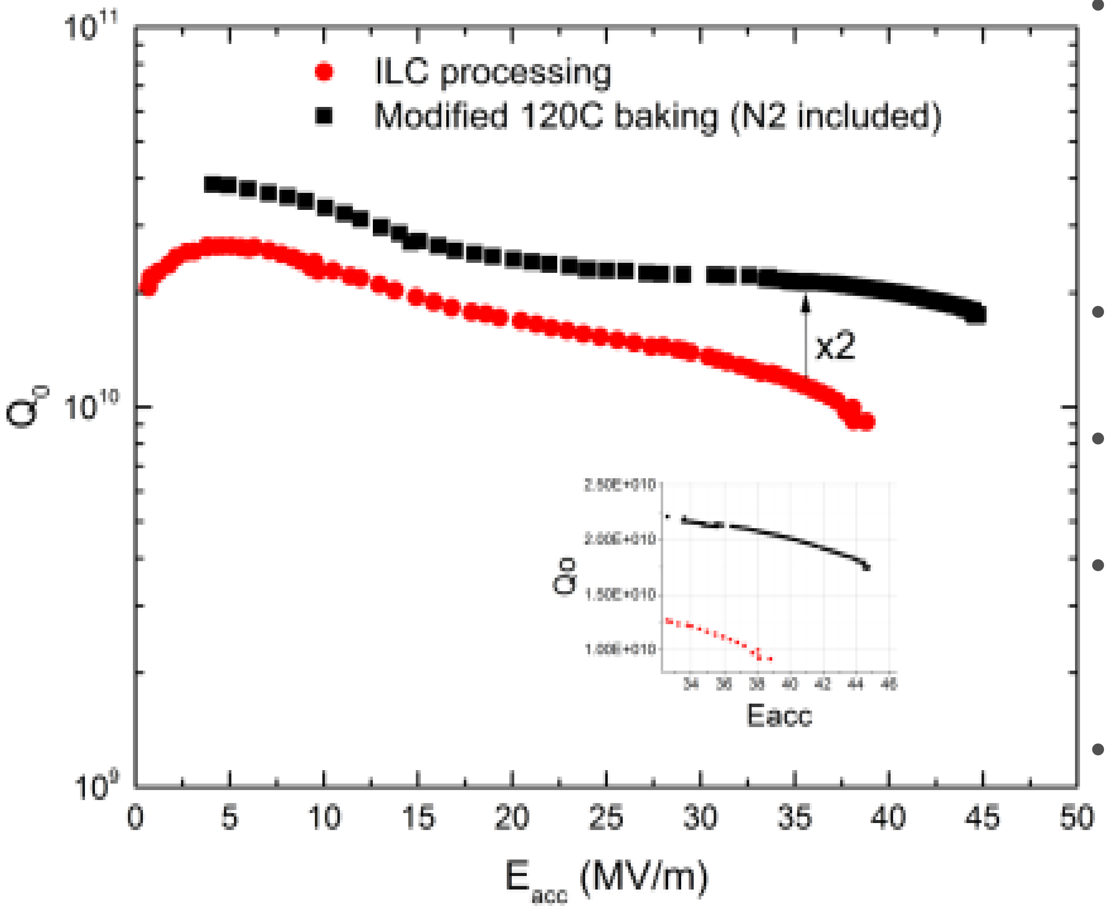
Cavity performance progress at FNAL: "standard" vs "N infused" cavity surface treatment

A. Grassellino



Increase in Q by > a factor of two
Increase in gradient ~15%

- FNAL recently demonstrated a new treatment, which utilizes "nitrogen infusion", achieving

  45.6 MV/m → 194 mT

  with Q ~ 2×10^{10}
- Systematic effect observed on several single cell cavities
- FNAL has now successfully applied it on three nine cell cavities
- Jlab, KEK have reproduced similar results on single cell cavities with Q >2e10 at 35 MV/m
- R&D work towards:
  - Best recipe for higher Q at high gradient
  - Robustness of process

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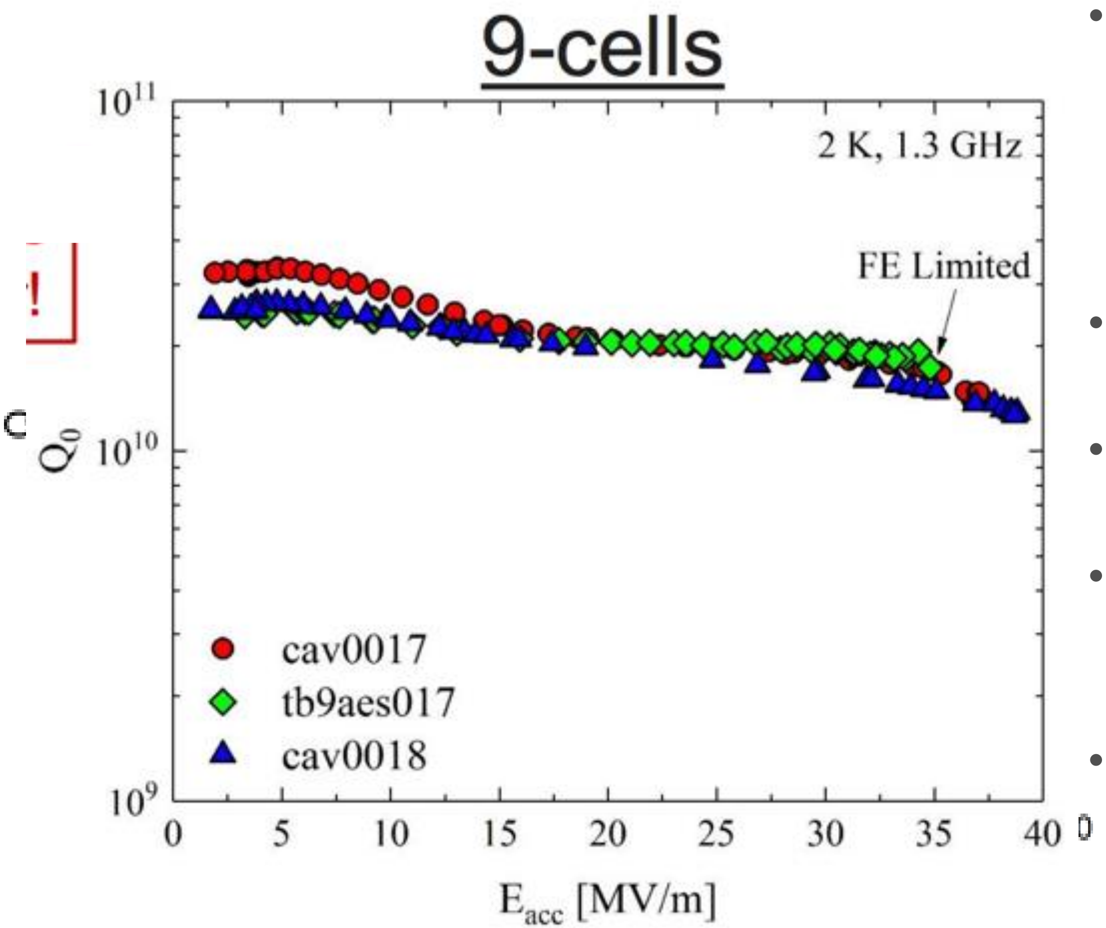
Fermilab

Cavity performance progress at FNAL: "standard" vs "N infused" cavity surface treatment

A. Grassellino



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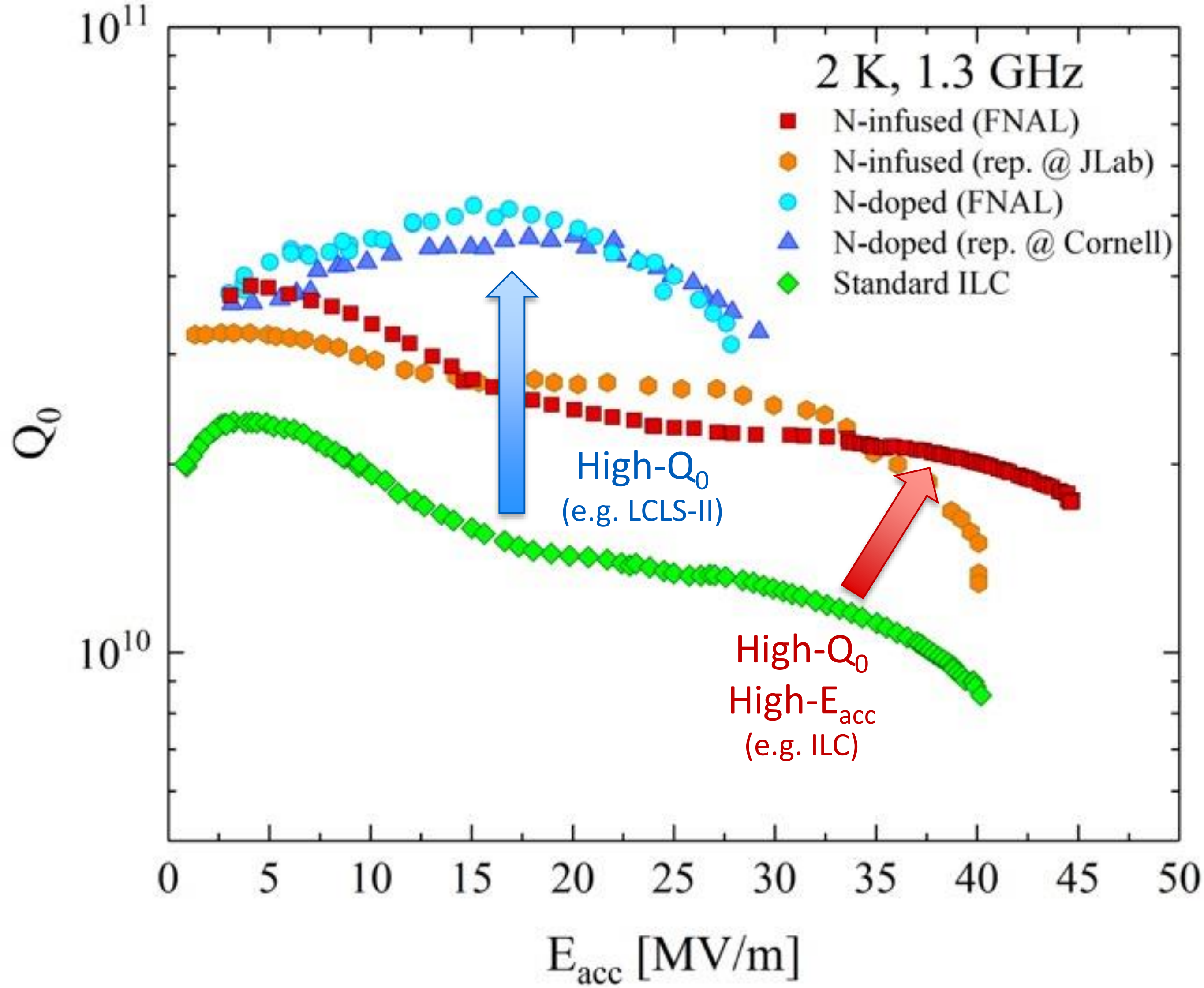
A. Grassellino

Potential for very high Q at very high gradients



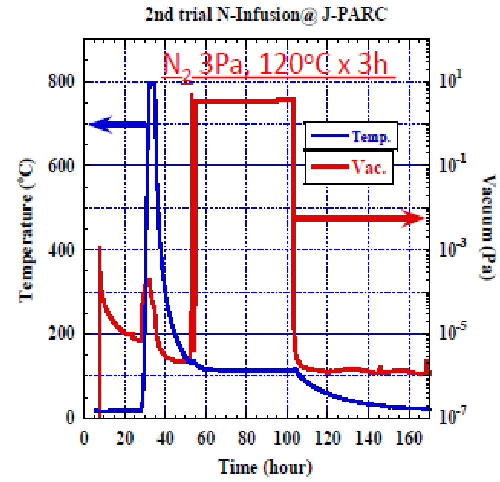
ILC Cost Reduction R&D global effort will explore doping parameter space to extend high Q at the highest gradients

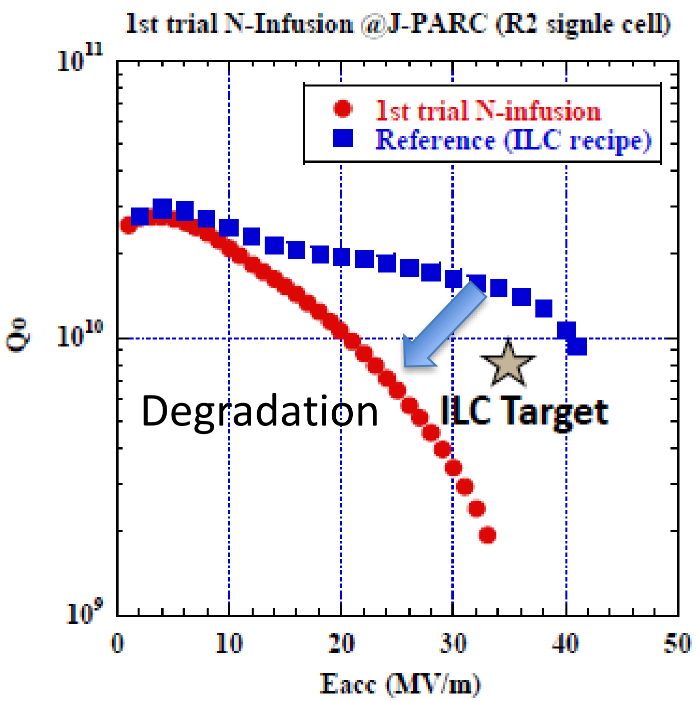
Currently working on this R&D direction: FNAL, KEK, Jlab, Cornell, DESY

Fermilab

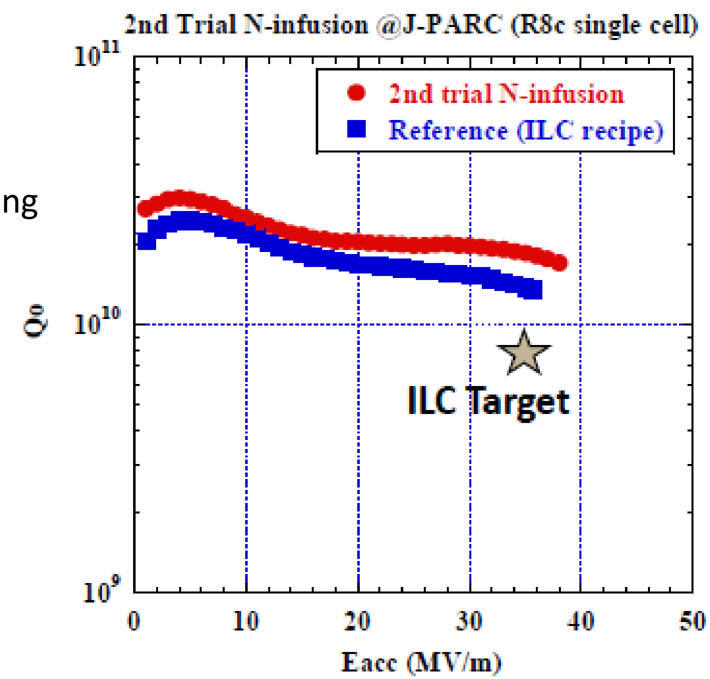
Recent N-Infusion result at KEK

- First trial of N-infusion showed degradation occurred at >5MV/m.
- Degradation seems to come from background vacuum during 120deg. N-Infusion.
- Background vacuum during N-Infusion was improved from 1.7e-2Pa to 1e-5Pa using larger turbo-molecular pump with reduced rotation speed.
- Second trial of N-Infusion was done with improved background vacuum during N-Infusion (120 deg.)
- It showed successful N-Infusion result (Q value +35% gradient +5%).





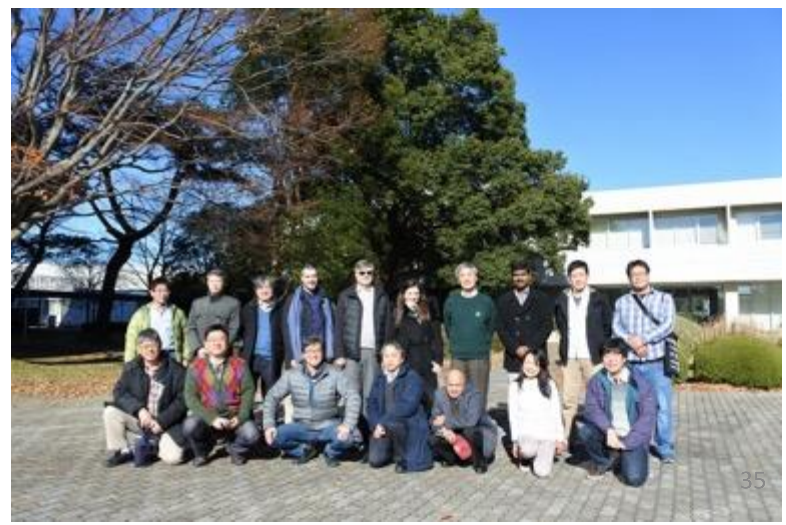
After the vacuum pumping system improvement



Workshop on US-Japan ILC cost reduction R&D @KEK

Wednesday Dec.6 presentation
10:00~11:00 N-Infusion Martina Martinello
11:00~12:00 N-Infusion KEK status Kensei UMEMORI
13:30~14:30 N-Infusion surface analysis Taro KONOMI
14:30~15:30 Vacuum oven specification & operation Saravan Chandrasekaran
16:00~17:00 Input coupler Yasuchika YAMAMOTO
Thursday Dec.7
CFF/STF tour
13:00~14:00 Status and results of the LCLS-II cryomodule production Genfa Wu
14:00~15:00 Nb material Takeshi DOMAE
15:30~16:30 degradation Hiroshi SAKAI
16:30~17:30 recent ILC cost reduction analysis Mattia Checcin
Friday Dec.8
9:00~10:00 US-JAPAN Hitoshi HAYANO
10:00~11:00 Future SRF R&D plan Sergey Belomestnykh
11:00~11:30 discussion

https://kds.kek.jp/indico/event/26400/



An International Symposium

http://www-conf.kek.jp/SRF_for_ILC/index.html

High Energy Accelerator Research Organization (KEK),
Linear Collider Collaboration (LCC) and
International Center for Elementary Particle Physics (ICEPP)
cordially invite you to the symposium on:

The Superconducting RF technology for the International Linear Collider

Monday, June 25th, 2018, at 10:00
Fukutake Learning Theater, The University of Tokyo

Program International Linear Collider symposium 2018

General overview

10:00	**Opening address** Masanori YAMAUCHI (KEK, Japan)
10:10	**Physics at the ILC and international collaboration** Sachio KOMAMIYA (Waseda University, Japan)
10:35	**Accelerator technologies of ILC and their applications** Shinichiro MICHIZONO (KEK, Japan)
11:00	**A global collaboration for the ILC** Lyn EVANS (Linear Collider Collaboration, UK)
11:10	**US SRF R&D status** Sergey BELOMESTNYKH (Fermilab, U.S.A.)
11:35	**European XFEL experiences demonstrating the SRF technology for the ILC** Hans WEISE (DESY, Germany)
12:00	**Advances in SRF technology and future prospects in China** Jie GAO (IHEP, China)
12:25	*Lunch/Media briefing*

Further discussion to be extended in the afternoon

Outline

- *Introduction*
- *ILC-250 overview*
- *Nano-beam and SRF technologies advanced*
- *Progress in cost-reduction R&D*
- *Summary*

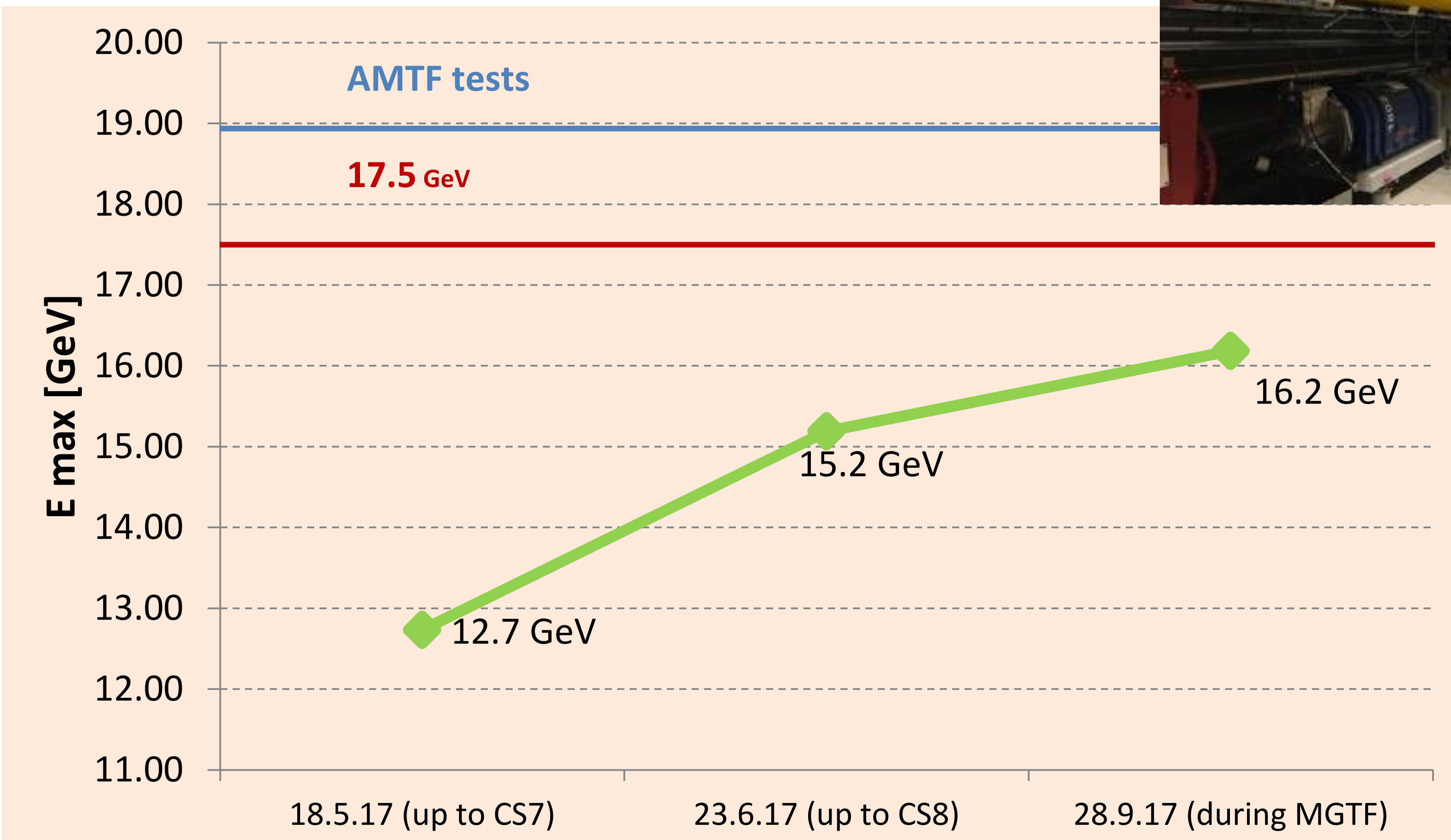
Summary

- ILC collision energy, 250 GeV, for starting well established. The accelerator construction cost well estimated with a meaning cost reduction,
- Key technologies of "Nano-beam" and "SRF" matured. Thanks for worldwide efforts for SRT technology, with European XFEL, LILS-II, and further.
- Positron source study reached a comprehensive report, to be prepared for timely decision after a green-light given.
- The US-Japan, SRF cost-reduction R&D program in progress with encouraging results.
- Our best effort has been made to provide comprehensive information to official WGs and IAP at MEXT is reaching a very critical stage to evaluate the ILC 250 GeV proposal.

backup

Courtesy, M. Omet

E-XFEL SRF Acc. Commisioning in progress



A-2. SRF cavity fabrication for high gradient and high Q (N-Infusion) (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.
- We will demonstrate N-Infusion (High-gradient and High-Q) technology with 9-cell-cavities.

Preparation of clean-vacuum-furnace
+ N2dope

By A. Grassellino (FNAL)