Report on SRF session at LCWS2023

SRF TG summary

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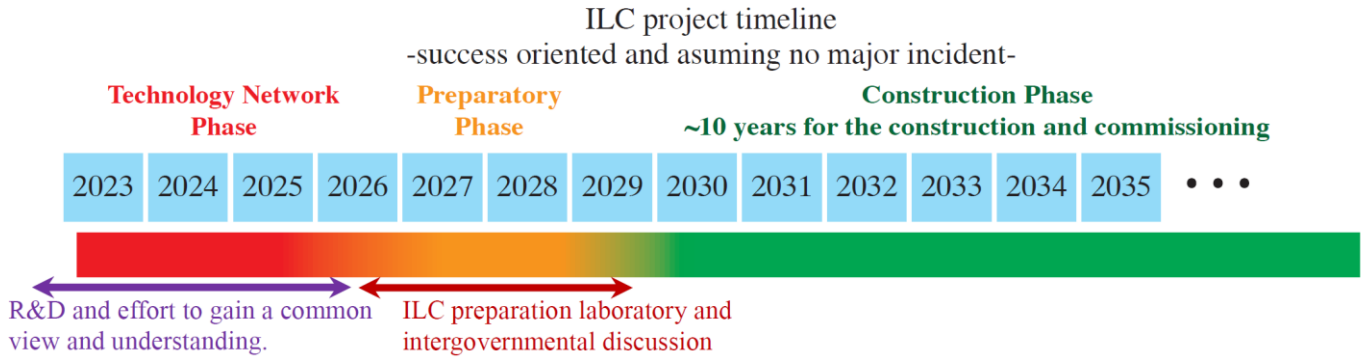
ILC

- ILC is entering an ILC Technology Network (ITN) phase, which will include three major components: SRF, Sources and Nanobeams
- SRF: WP-prime 1, Cavity industrial production readiness; WP-prime 2, Cryomodule design, Global transfer and Performance assurance; WP-prime 3: Crab cavity development
- The 5-year plan in Japan will address the SRF Work Packages. The particular important issues are: Fixing the global cavity design; 2 change requests (tuner and SC magnet current leads box); Some ancillaries to be developed and produced
- KEK has a plan to upgrade SRF infrastructure
- Medium grain Nb material has mechanical properties similar to the fine grain Nb but will be cheaper. Studies of medium grain Nb are in progress
- SRF cavities and cryomodules must satisfy the High Pressure Gas Safety Regulations (HPGR) in Japan. Cavity and cryomodule designs should be fixed and analyzed before an approval can be obtained
- SRF crab cavities are essential for achieving the design luminosity. 2 new designs were down-selected for prototyping: an RF Dipole cavity (ODU/JLAB) and QMiR cavity (FNAL). After the prototypes are tested, one of the designs will be selected for the complete crab cavity system development

S. Michizono (KEK) "ILC Technology Network (ITN)" - Plenary
K. Yamamoto (KEK) "SRF 5-year plan in Japan for ILC"
A. Yamamoto (KEK/CERN) "New Nb material for cost saving"
K. Umemori (KEK) "Current status of high pressure gas regulation for SRF cavity fabricatior
S. De Silva (ODU) "1.3 GHz RF-Dipole crabbing cavity system for International Linear Collic
R. Laxdal (TRIUMF) "ILC crab cavity developments" – Accelerator plenary



SRF R&D

- There have been substantial advances in high gradient / high Q technologies since ILC TDR. R&D results can be applied to ILC and other recent SRF linear collider proposals, some in the ILC-250 and some in the future upgrades
- KEK and CEA Saclay teams continue developing vertical electropolishing (EP), which is likely safer and easier to implement than horizontal EP. The recent results were presented.
- New cavity treatment recipe (cold EP + 2-step low temperature baking) demonstrated higher gradient and Q factor both on single-cell SRF cavities and 9-cell ILC/TESLA cavities with some cavities reaching accelerating gradients of almost 50 MV/m. A High Gradient Cryomodule (HGC) collaboration is working on demonstrating an average accelerating gradient of > 38 MV/m in an ILC-type cryomodule at Fermilab.
- Other surface treatments (e.g., medium temperature baking) are studied for CW accelerators
- Multilayer SRF cavities are being investigated at CEA Saclay with initial promising results. More R&D efforts are needed in this area

S. Belomestnykh (FNAL) "Overview of [SRF] accelerator technology development relevant to ILC and other future lepton linear collider options" - Plenary

T. Goto (KEK) "Development of vertical electropolishing (VEP) for surface treatment of 9-cell Nb cavities at KEK"

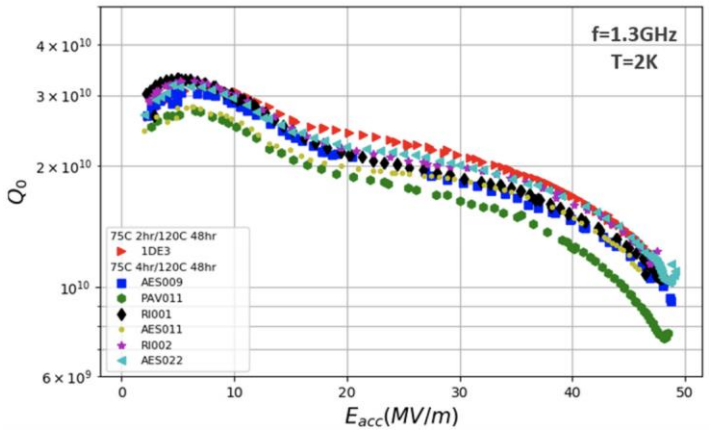
F. Eozenou (CEA Saclay) "SRF activities at CEA Saclay"

S. Belomestnykh (FNAL) "High Gradient Cryomodule (HGC)"

D. Bafia (FNAL) "Surface engineering research for high Q and high gradient CW accelerators"

SRF cavity installed in vertical EP system at KEK

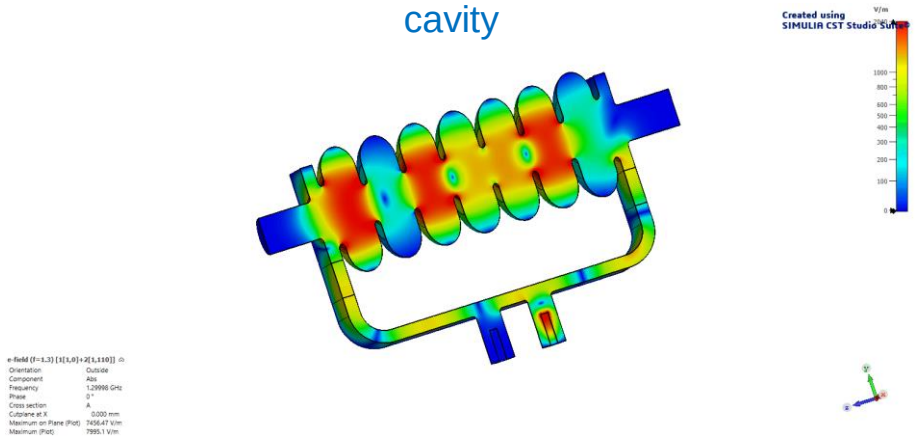
High gradient cavity test results



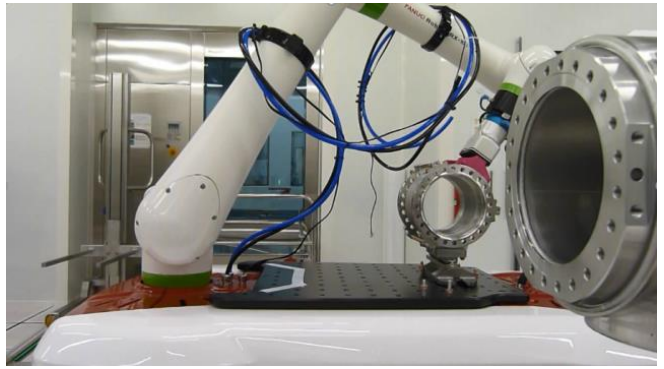
SRF R&D

- Maintaining a particulate-free SRF cavity surface is imperative to avoid field emission (FE). CEA Saclay is developing robotic tools and procedures to assist humans in the clean room. Such methods should help mitigating FE.
- If SRF cavities are affected by FE and/or multipacting in a cryomodule, in-situ methods could be used for mitigation. One of such methods is plasma processing, which was successfully demonstrated on a verification LCLS-II-HE cryomodule at Fermilab. Further R&D is in progress to apply this technique to ILC-type cryomodules
- Developing reliable and inexpensive diagnostic is important to support the SRF cavity development. New sensors include X-ray detectors and magnetic sensors (CEA Saclay)
- Traveling wave (TW) SRF structures have a potential to deliver high gradient (up to ~ 70 MV/m) and higher cryogenic efficiency. A proof-of-principle 3-cell cavity is being prepared for testing at Fermilab

Simulation of traveling wave SRF cavity



Robotic assembly of ESS SRF cavity bellows (under development)



F. Eozenou (CEA Saclay) "SRF activities at CEA Saclay"
V. Yakovlev (FNAL) "Traveling wave SRF cavity status and R&D plan"
B. Giaccone (FNAL) "Progress with plasma processing and plans"

LCLS-II / HE results and lessons learned

LCLS-II SRF linac was successfully cooled down three times and demonstrated expected performance

While this is a CW linac operating at medium accelerating gradients, the experience is very useful for ILC

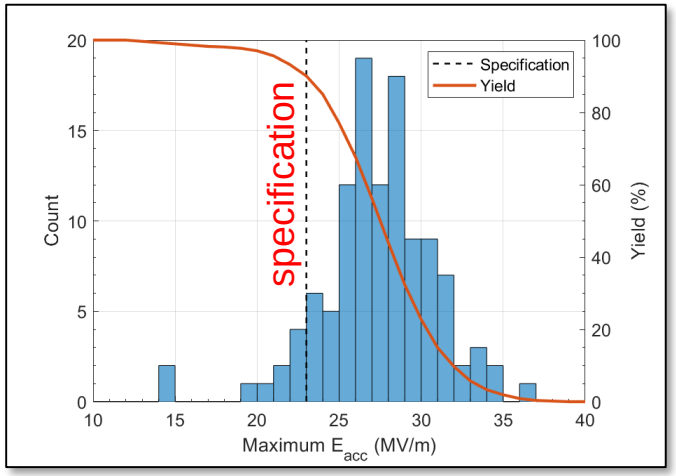
There are several important lessons learned from LCLS-II. A particularly important is to have very good QA/QC processes through strict oversight and statistical analysis

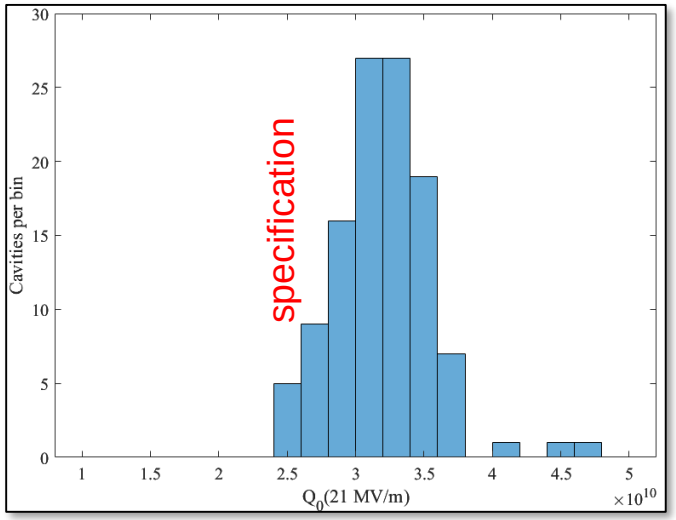
What questions can LCLS-II answer for ILC?

1. Gradient
   - Can we build cavities that achieve gradients required for ILC? **We're getting there**
   - If we achieve those high gradients in vertical test, can they be preserved in the installed linac? **YES**
2. Q0
   - Can we build cavities that achieve high Q0? **YES**
   - Can we achieve the required cool downs to maintain high Q0 in the linac? **YES**

Lessons learned from LCLS-II production and LCLS-II-HE R&D led to significant improvement in gradient performance while maintaining high Q_0

LCLS-II cavity production statistics to date





J. Maniscalco (SLAC) "LCLS-II-HE cavity and cryomodule testing"

D. Gonnella (SLAC) "Leveraging experience from production, commissioning, & early operations of LCLS-II and HE for ILC" – Accelerator plenary

Production Schedule of Cavity and Ancillaries for 5-year Plan (FY starts from April in Japan)

		FY2023				FY2024				FY2025				FY2026				FY2027			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Japan/Asia	1-cell FG	4																			
	1-cell MG	2																			
	9-cell FG	1				5															
	9-cell MG	1 (test)				1				4				1							
	Power coupler					2 (test)				8											
	Frequency tuner					1 (test)				8											
	SCQ magnet+BPM					1 (test)				1											
	Magnetic shield					1 (test)				8											
	Cavity string																				
	CM production																				
	CM assembly																				
	CM test																				
Americas	1-cell FG																				
	1-cell MG																				
	9-cell FG							4													
	9-cell MG			1				3													
Europe	1-cell FG			1																	
	1-cell MG			1																	
	9-cell FG							4													
	9-cell MG			1				3													

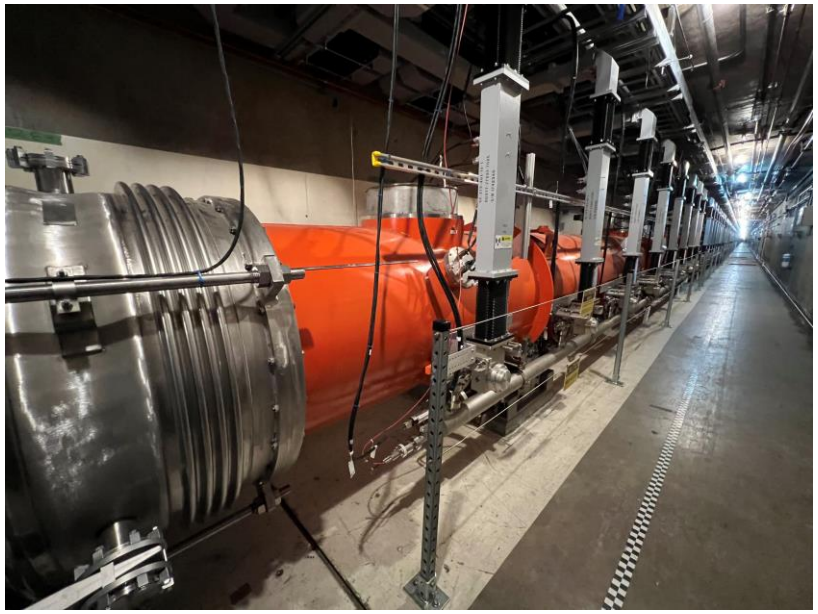
Deadline:
Delivery of all cavities with helium tank @Sep/2026
(should be satisfied with HPGS of Japan)
CM construction @Sep/2027
First cooldown test completed @Mar/2028

Necessary infrastructure will be also constructed for CM assembly and test at COI.

Meeting/Discussion for Global Collaboration

- Americas
  - US has done many collaborative works about CM design and HPGS, High-Q/High-G R&D with Japan
    - Especially, SCQ, Magnetic shield, Frequency tuner, Power coupler, Clean work are main tasks
    - Of course, cavity production is also included
- Asia
  - Korea has an interest in production and test of 1-cell/9-cell cavity and development of cold BPM
- Europe
  - France and Italy have a plan to produce and test 1-cell/9-cell cavities, join CM design and HPGS
    - An expert from CEA will stay at KEK to discuss these items
  - Spain has an interest in development of SCQ magnet and cold BPM systems

Japan hopes more countries and regions will join for this project!
Face-to-face meeting is very important for global collaboration.



Thank you very much!