33rd Meeting of SRF Group in IDT/WG2

- ✓ Possibility of supply of Nb material (Kirk)
- ✓ Renewed CM design to be produced (Kirk)
- ✓ Others (if any)

Attendees: K. Umemori, S. Posen, L. Monaco, E. Cenni, R. Geng, S. Belomestnykh, B. Laxdal, B. List, D. Delikaris, S. Stapnes, P. Burrows, Kirk

https://agenda.linearcollider.org/category/256/

Kirk

Possibility of supply of Nb material

At KEK, we are thinking of a possibility to supply Nb material to EU and US.
On early next year, we will start to make a document to purchase them.

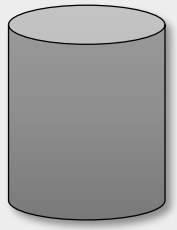
If you have an interest in use of MG, we can provide more information.

	# of cavities to be produced in each region				
	1-cell cavity		9-cell cavity		Crab cavity
	FG	MG	FG	MG	?
Japan	3	3	10	10	0
Europe	?	?	?	?	2 (x 2)
Americas	?	?	?	?	

Manufacture methods of Large-Grain / Medium-Grain Nb discs

Presented by Saeki-san

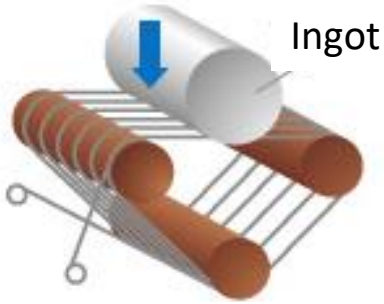
Nb melting



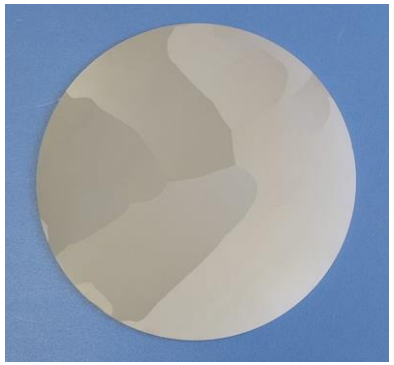
Niobium ingot
(Raw material)

Direct slice of LG ingot

Ingot, as it is



Slicing image
by wire-saw



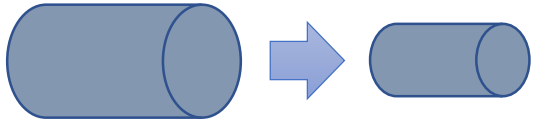
LG Nb

Large Grain (LG) Disc

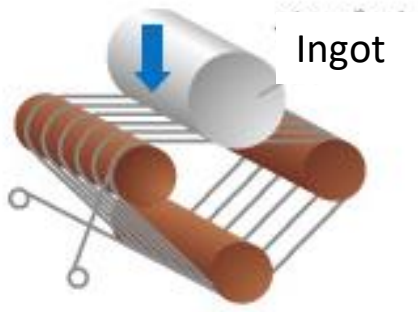
Grain Size >> 1 cm

- Aiming for clean, mechanically stable, and cost-effective SRF cavity production.

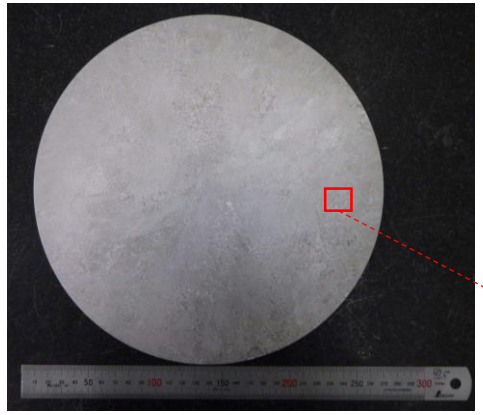
Direct slice of MG ingot

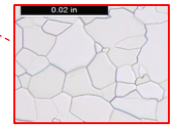


Ingot, forged
and annealed



Slicing image
by wire-saw





MG Nb

A New Approach:

Medium Grain (MG) Disc

Grain Size **< 1 mm**

* The “Nb forged ingot” technology originated by **ATI**, and SRF (GHz) cavities planned to be fabricated and RF tested by **KEK** and **JLab**, to qualify this approach, in collaboration of **ATI, ODU/BSCE, JLab, and KEK.**

MG-Nb demonstration by 1.3 GHz SRF Cavity at KEK

Presented by Saeki-san

Courtesy: **ATI**

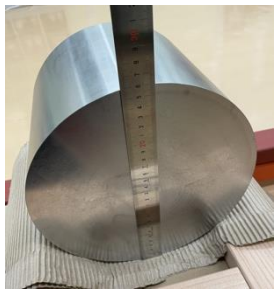
"**Nb RRR**" Billet, annealed

Sample location from forged ingot

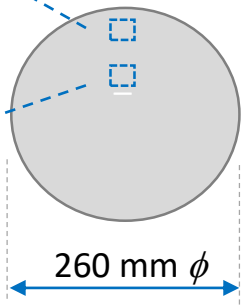
Parameters	Nb sheet (FG) (Spec. Eu-XFEL as Reference)	Nb forged ingot (MG) Measured
RRR	$R_{RT}/R_{4.2K}$ ≥ 300	R_{RT}/R_{TC} 450 523
Re-crystallization	100 %	100 %
Grain size (ASTM) Edge, Mid., Center	4 ~ 6	2 , 1, 1.5
Grain size (mm) Edge, Mid., Center	< 0.05	0.2, 0.25, 0.21
Y.S.-0.2% (RT)	≥ 50 MPa	61 MPa
T.S. (RT)	≥ 140 MPa	141 MPa

MG-Nb: Good mechanical uniformity

0.02 inch (50 μm)



ATI



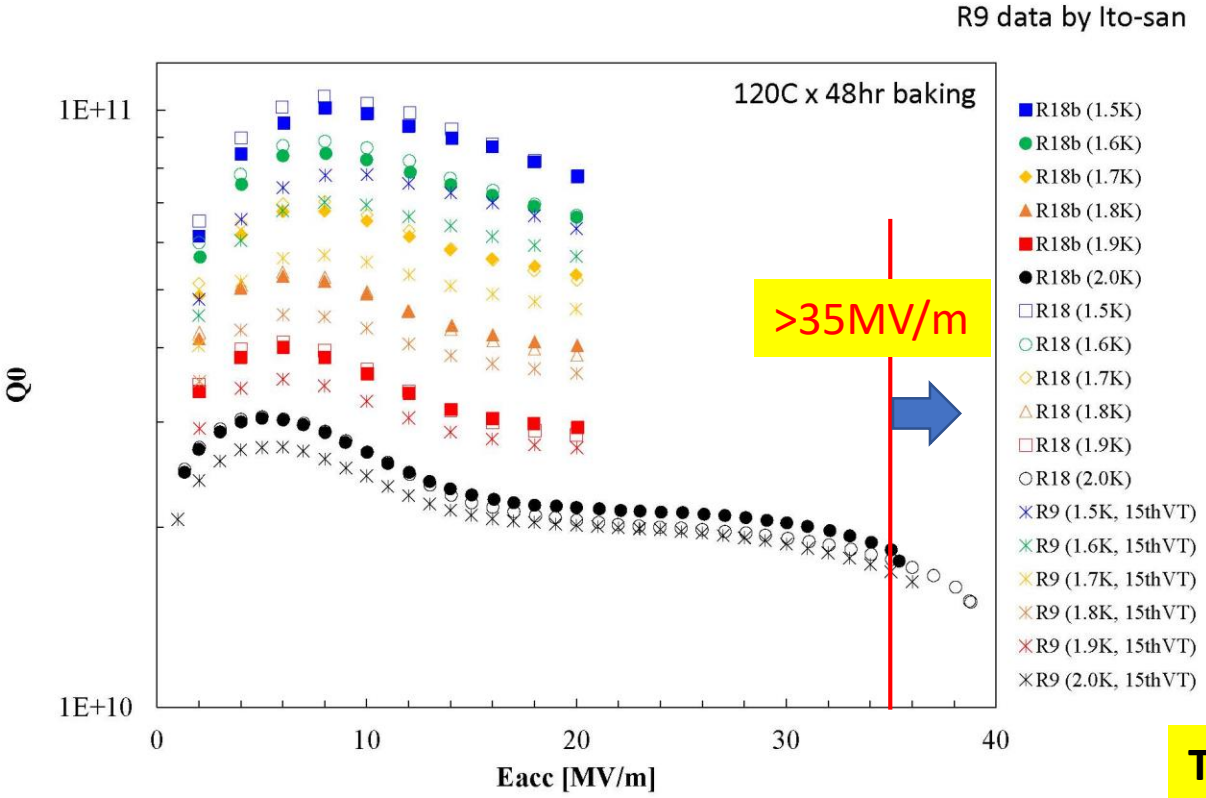
Grain Size: 0.2 ~ 0.3 mm
Mechanical stability may be expected

Presented by Saeki-san

MG-Nb material （High-RRR, Low-Ta）

Results of MG single-cell cavities.
R18, R18b (vs. R9 / FG single-cell cavity).

R18 vs R18b vs R9



- R18, R18b were fabricated using MG discs
- Inner surface of R18 was mechanically polished during fabrication (R18b was not)
- VT of R18: 38.8 MV/m with $Q_0=1.5\times10^{10}$
- VT of R18b: 35.4MV/m with $Q_0=1.76\times10^{10}$

Two MG-Nb single-cell cavities have reached > 35 MV/m

Preparation for SRF Five-year plan at KEK

Michizono-san, Akira Yamamoto-san and Kirk have discussed internally the SRF five-year plan at KEK.
This plan follows the time-critical WPs discussed with the WG2/SRF group.
In WP-prime 2, we will produce **first** CM for ILC.
Also, we will construct the infrastructure related to helium refrigerator, CM assembly/test area, etc.

SRF Five-year plan at KEK (currently prospect)					
	F.Y.2023	F.Y.2024	F.Y.2025	F.Y.2026	F.Y.2027
Infrastructure @COI					
Infrastructure @CFF					
Cavity production	Nb material	Production			
Cavity test	R&D	R&D			
CM production/assembly					
CM test					

Meeting schedule and recent progress

Meeting #	Date	Contents
33	06/Dec	Possibility of supply of Nb material, “Renewed” CM design
?	20/Dec	
	End of Dec	Budget plan will be fixed
	15~19/May/2023	LCWS2023 @SLAC
	25~30/Jun	SRF2023 @Grand Rapids, MI, US

Questions/Suggestions/Comments

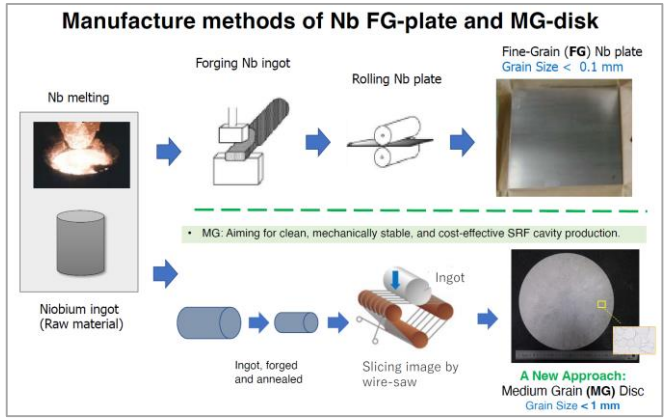
- MG material is available for HPGS?
  - At KEK, we have done some tests related to mechanical property at low temperature. Then, we think it's available, but we need more tests to pass our HPGS.

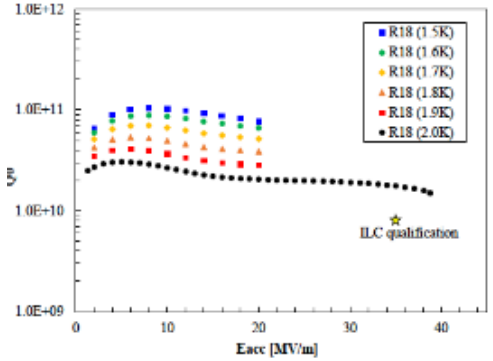
Backup slides

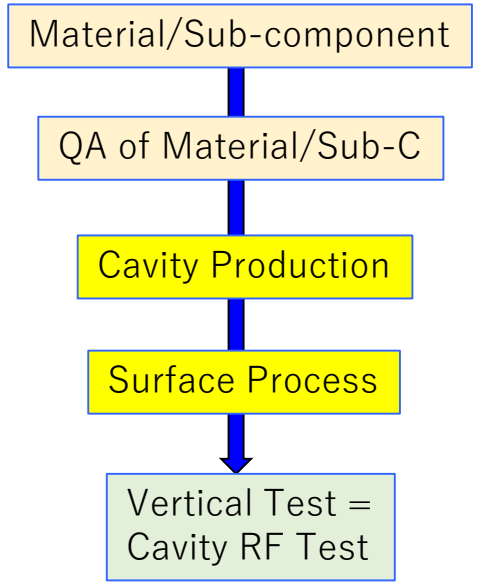
WP-prime 1: SRF Cavity
(Scoping the Industrial-Production Readiness)

- Research with single-cell cavities to establish the best production process
  - Advanced Nb sheet production method
  - Advanced surface treatment recipe
- Globally common design compatible with High Pressure Gas Safety (HPGS) regulation
- 24 nine-cell cavities are to be developed for industrial-production readiness
  - 8 cavities (4 / batch) in each region
  - Production process optimized in each region encouraged
- RF performance/success yield to be examined (at least including 2nd pass)
  - 3rd pass to be examined if effective

	# of cavities to be produced		
	Americas	Europe	JP/Asia
single-cell	2	2	2
nine-cell	8	8	8 (+ 12)





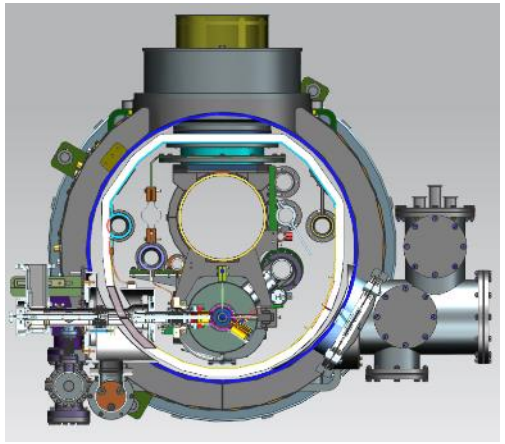


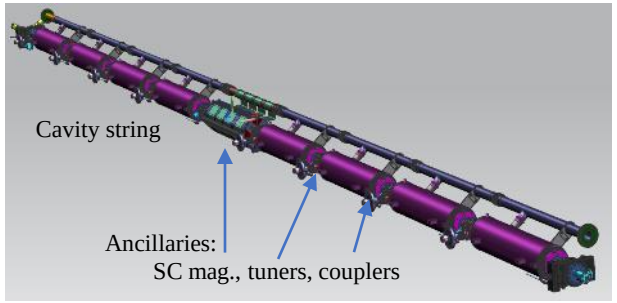
Production process

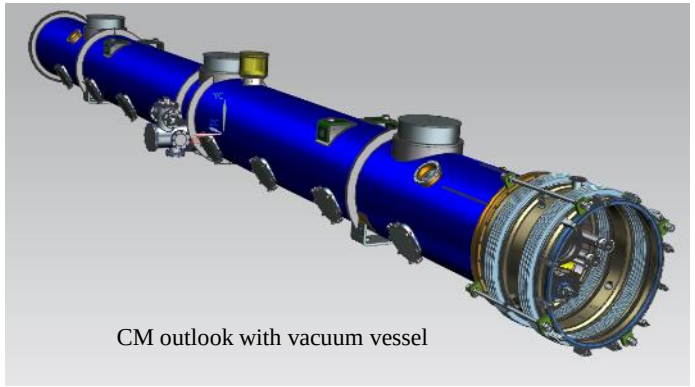
WP-prime 2: Cryomodule (CM) design
(Scoping the CM Global Transfer and Performance Assurance)

We will produce first CM!

- Unify cryomodule (CM) design with ancillaries, based on globally common drawings and data-base
- Establish globally compatible safety design to be approved by HPGS regulations individually authorized in each region.





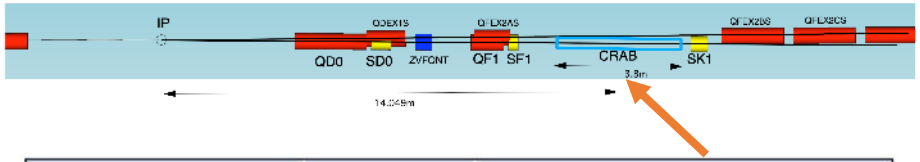


	Americas	Europe	Japan/Asia
CM tech. design base	LELS-II	Euro-XFEL	ILC-TDR
HPGS regulation base	ASME	TÜV and EN	JP-HPGS act
ILC CM design	Common CM design globally adaptable to HPGS regulation in any regions		

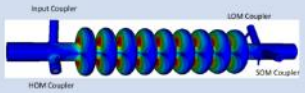
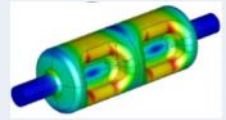
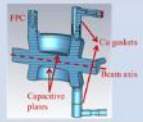
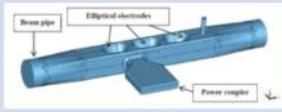
WP-prime 3: Crab Cavity Development with down-selection

- RF property simulation to optimize cavity design
- Pre-down-selection to choose two primary candidates
- Development and evaluation of two prototype cavities
- Demonstration of synchronized operation with two prototypes
- Down-selection to choose final cavity design
- Cryomodule design based on final cavity design

two beamline distance
14.049m x 0.014rad = **197mm**



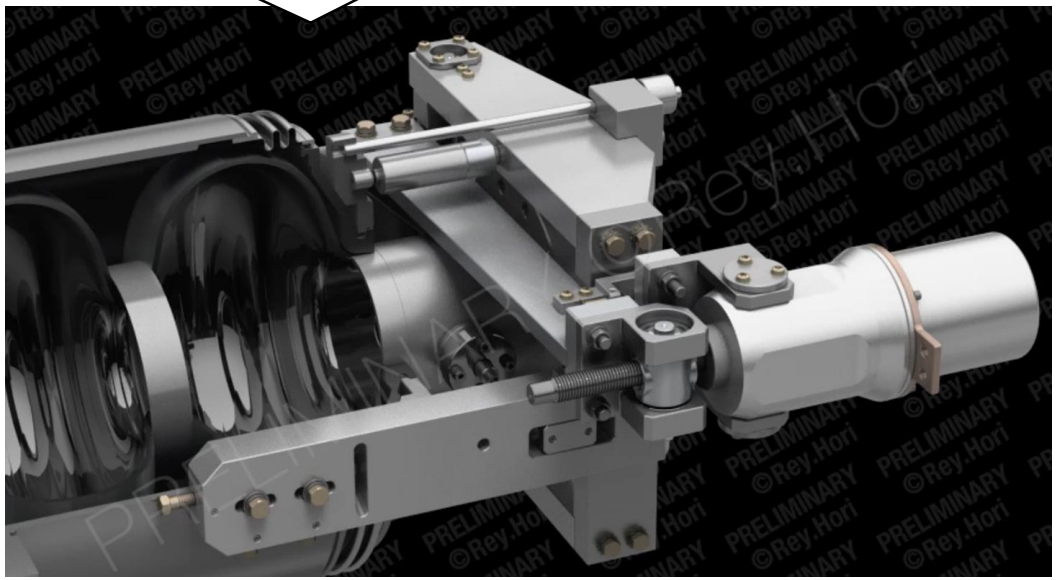
Item	Recent specification (after TDR)
Beam energy	125 GeV (e^-)
Crossing angle	**14 mrad**
Installation site	14 m from IP
RF repetition rate	5 Hz
Bunch train length	727 μsec
Bunch spacing	554 nsec
Operational temperature	2.0 K (?)
Cavity frequency	1.3/3.9 GHz
Total kick voltage	1.845/0.615 MV
Relative RF phase jitter	0.023/0.069 deg rms (49 fs rms)

Elliptical/Racetrack (3.9 GHz)	Lanc. Univ.	
RF Dipole (RFD)	ODU	
Double Quarter Wave (DQW)	CERN	
Wide Open Waveguide (WOW)	BNL	
Quasi-waveguide MultIcell Resonator (QMIR)	FNAL	

Change requests related to SRF

If KEK has enough budget from next FY, we'd like to start cavity/CM production as soon as possible.
Then, we have to decide the design of cavity/CM including tuner/coupler/magnet.
Currently, we have two change requests related to tuner/helium tank and position of current lead box for Q-mag.

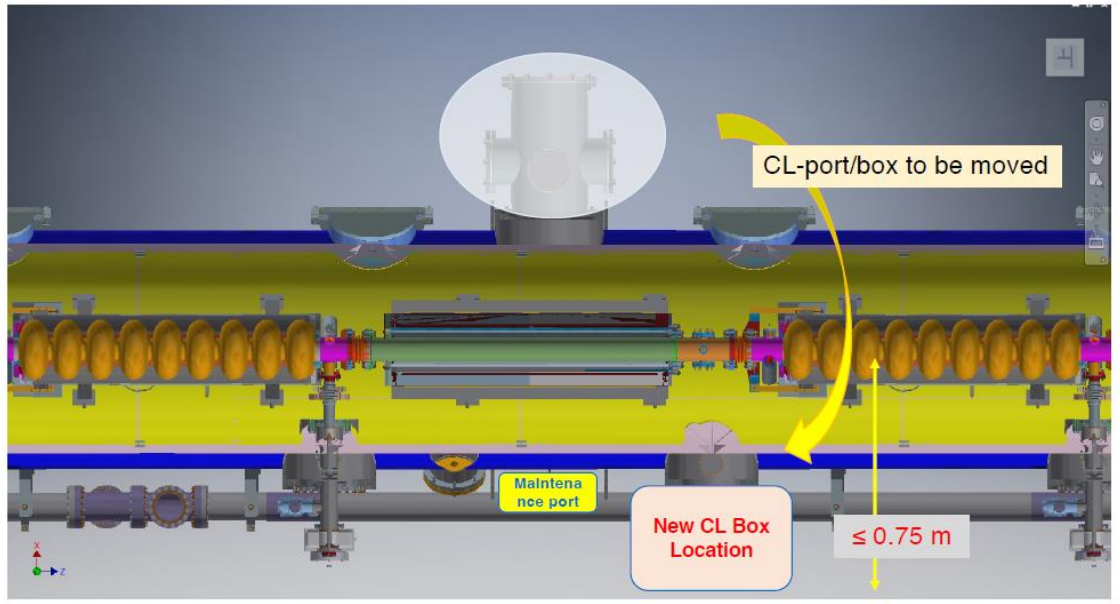
LCLS-II tuner has worked with high reliability,
but there is no experience in pulsed mode operation.
We need to check this with **first** CM.



LCLS II (HE)/FNAL's
N=320 units+ 180units

CM design is already completed, but we have to design outside components, that is, waveguide system, pumping system for power coupler, current lead box, etc.
We need more detailed drawing.

Proposal for the CL box to be moved to the Coupler Port Side



Conclusion/Suggestion

Currently, it's difficult to submit these change requests before cavity/CM production.

After CM test and more detailed drawing completed, we will/can submit the change request.

I'd like to obtain your agreement on this policy including the cavity/CM design within this year.
If you like to check the 3D model developed by FNAL/KEK, I can provide to the SRF group.