Current status of high-pressure gas regulation for SRF cavity fabrication in Japan

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KEK-iCASA Kensei Umemori

Note

- Today I will show current status of our preparation for HPGR documents, which are under preparation.
- Most of the data shown in this slide is preliminary results. (Please do not consider as final one.)

On-going issues for HPGR

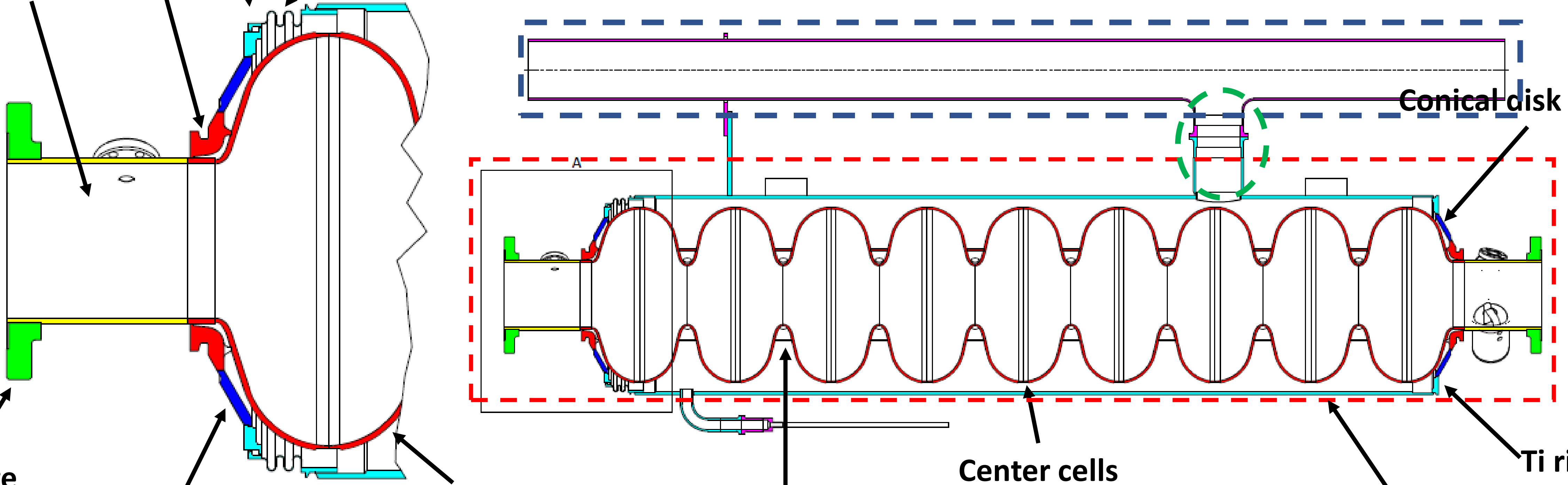
- Prepare documents for KHK (The High Pressure Gas Institute of Japan)
- Mechanical test for all materials (Nb, NbTi, Ti and welding sample)
- Stress analysis of the cavity with He tank

We are now preparing document for

- First cavity which will be fabricated at KEK-CFF
- FG cavity
- 900C heat treatment
- ILC cavity (TESLA shape + short & short beam tubes) design
- Apply for refrigerator safety regulation

Red ：Cavity(Nb)
Yellow ：Beamtube (Nb), out of HPGR
Blueが ：Conical disk (NbTi)
Green ：Flange (NbTi), out of HPGR
Light blue ：He jacket (Ti)
Purple ：Pipe (SUS316L)

Inside Red box: Cavity + He jacket
Inside Green circle: Chimney
Inside Purple box: 2-phase pipe



Our strategy on HPGR application to KHK

- We prepare following 3 applications separately to KHK
  - Cavity & He jacket
  - Chimney (Ti/SUS clad material) ⇒ clad material might have another difficulty
  - 2-phase pipe (SUS)

- Now we mostly concentrate on the application of “cavity + He jacket”.

  ⇒ Today’s presentation

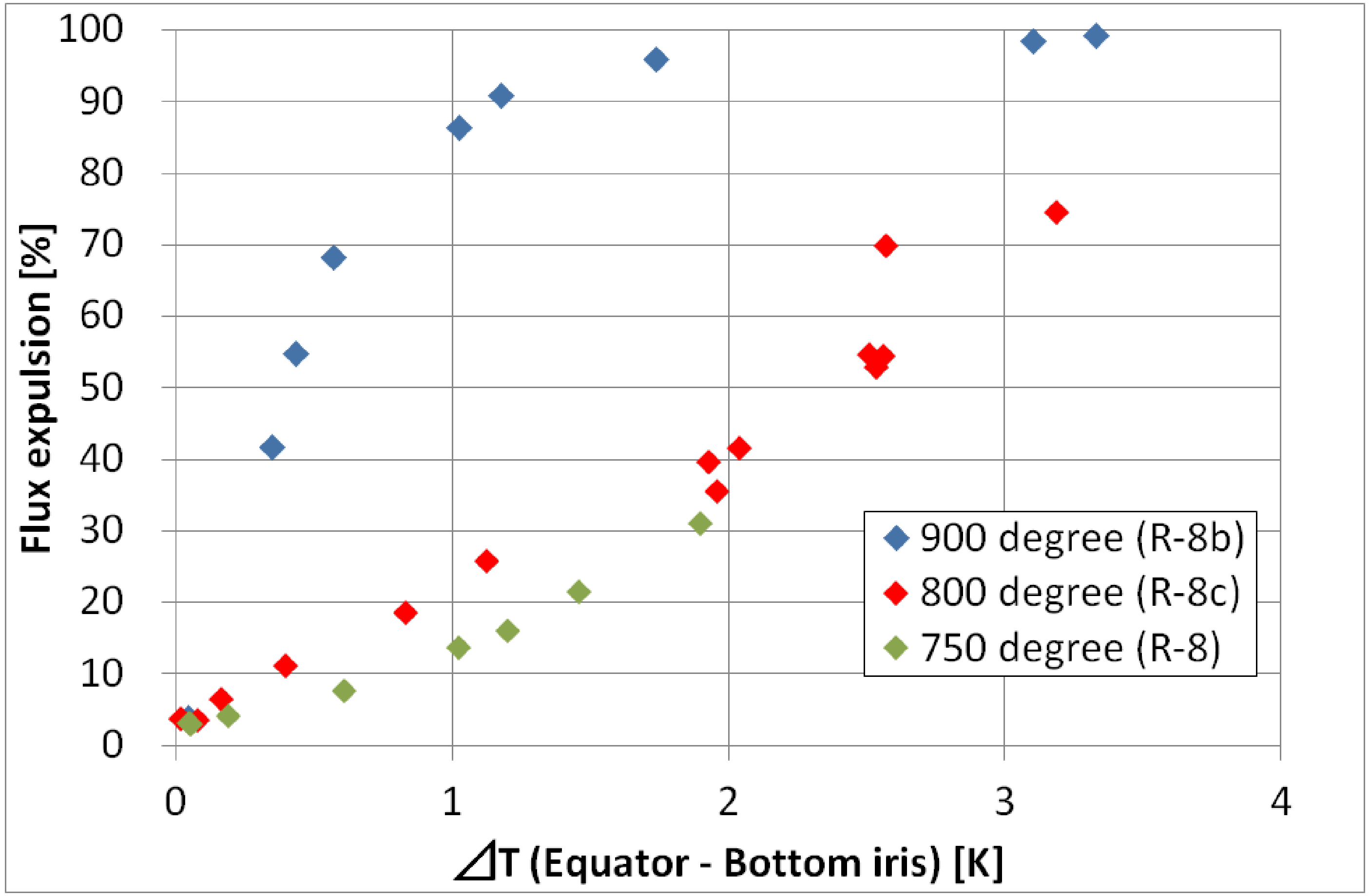
Later, we will combine these 3 components. And also joint the pipes for CM/cryogenic connection.

Assumed condition for the cavity

- Surface treatment
  - 900C heat treatment for better flux expulsion (better Qo)
  - Standard recipe (EP +120C baking) or 2-step baking
  - Ti ring will be welded before surface treatment
- Tuner
  - +2mm stroke (from TDR)
  - Stopper against 0.65mm extension at room temperature

900C heat treatment

Flux expulsion for Tokyo Denkai FG Nb cavity (TTC2018)



- Cooldown scheme is not optimized to ILC CM.
- But still high temperature heat treatment have benefit for effective flux expulsion.
- Probably ~50% more flux can be expelled.
- Reducing residual resistance → High Q (low He loss) → reduce operation cost.

Frequency tuner

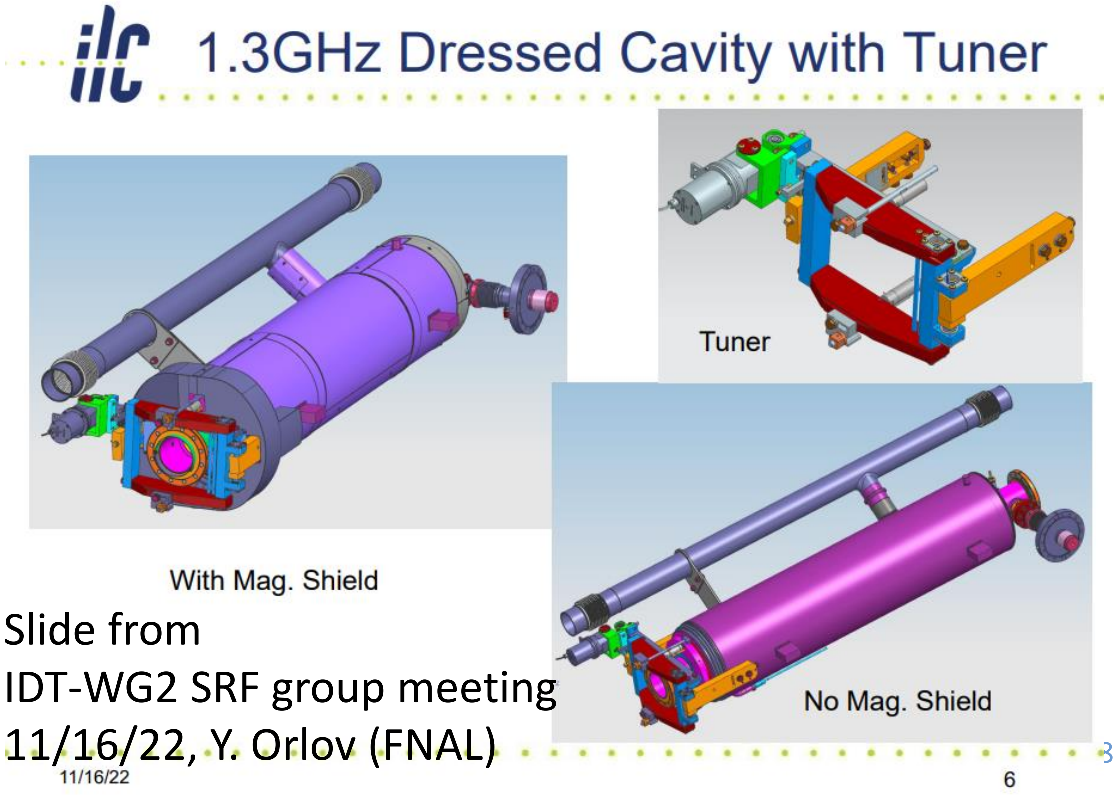
- The frequency tuner make the boundary condition for the high-pressure gas issue.
- Actual function of tuner should be fixed/understood before HPGR application.

The basic tuner design and function which currently considering for HPGR application.

- Current design is based on LCLS-II tuner, with slight modification(?)
- Stopper at +0.65mm at RT.
- Tuner stroke 2.0mm (from TDR)

Need to know details mechanism of tuner.

- How the stopper works?
- Is the tuner stroke mechanically limited by 2.0mm?
- Is the tuner used as compression or extension?



Slide from
IDT-WG2 SRF group meeting
11/16/22, Y. Orlov (FNAL)

List of mechanical test

○ : test was done
△ : sample is under preparation
(empty) : will be prepared and tested

	RT	80K	4.2K
High RRR Nb (RRR > 270)	○	○	○
Low RRR Nb (40 < RRR < 150)	○	○	○
NbTi (Nb45%, Ti55%)	○	○	○
Ti type-2 (Japanese standard)			
H-RRR Nb & H-RRR Nb EBW	△	△	△
H-RRR Nb & L-RRR Nb EBW	○	○	○
L-RRR Nb & NbTi EBW	△	△	△
NbTi & Ti type-2 EBW			
Ti type-2 & Ti type-2 TIG			

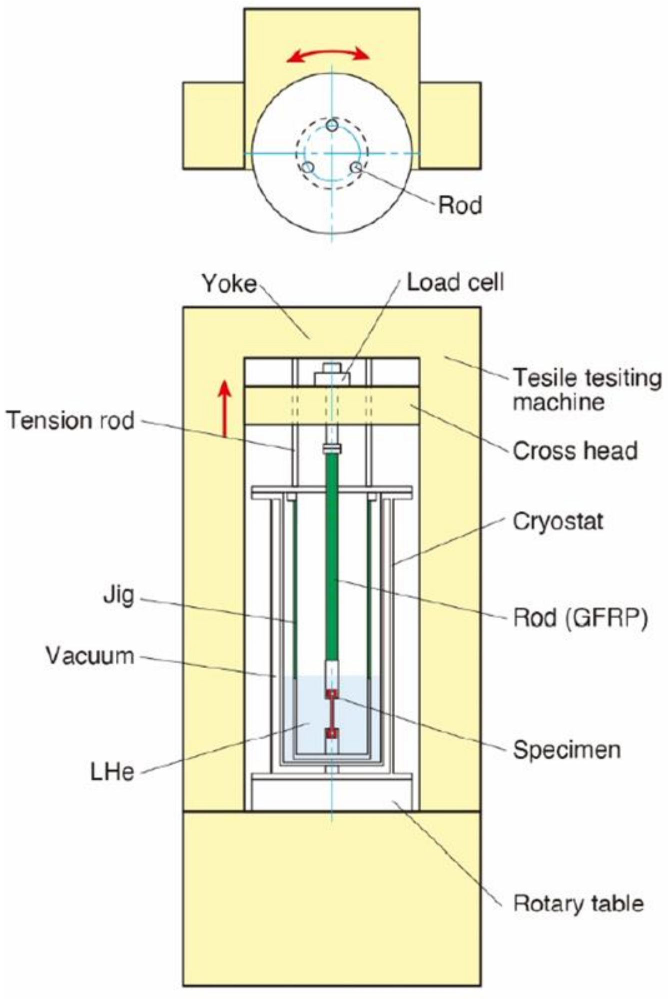
KEK-CFF group working hard for sample preparation and mechanical test.

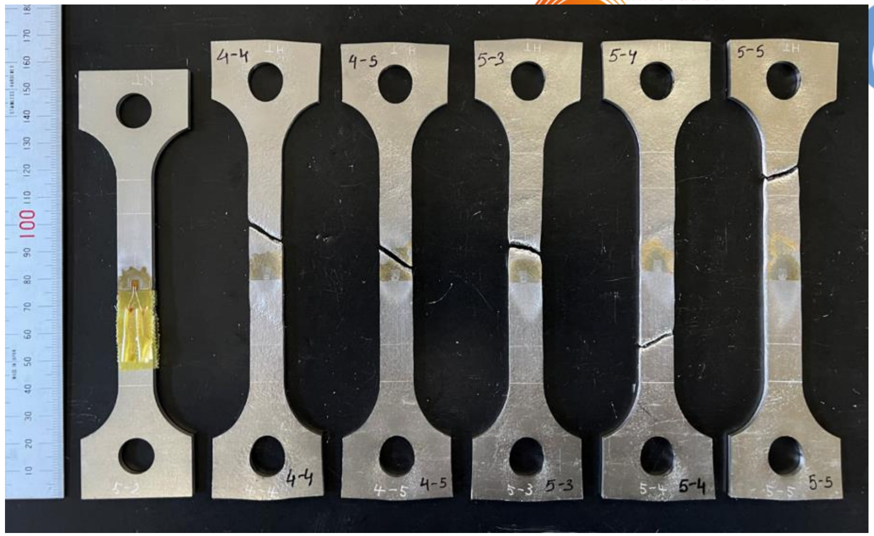
⇒ Allowable stress is estimated from the mechanical test results.

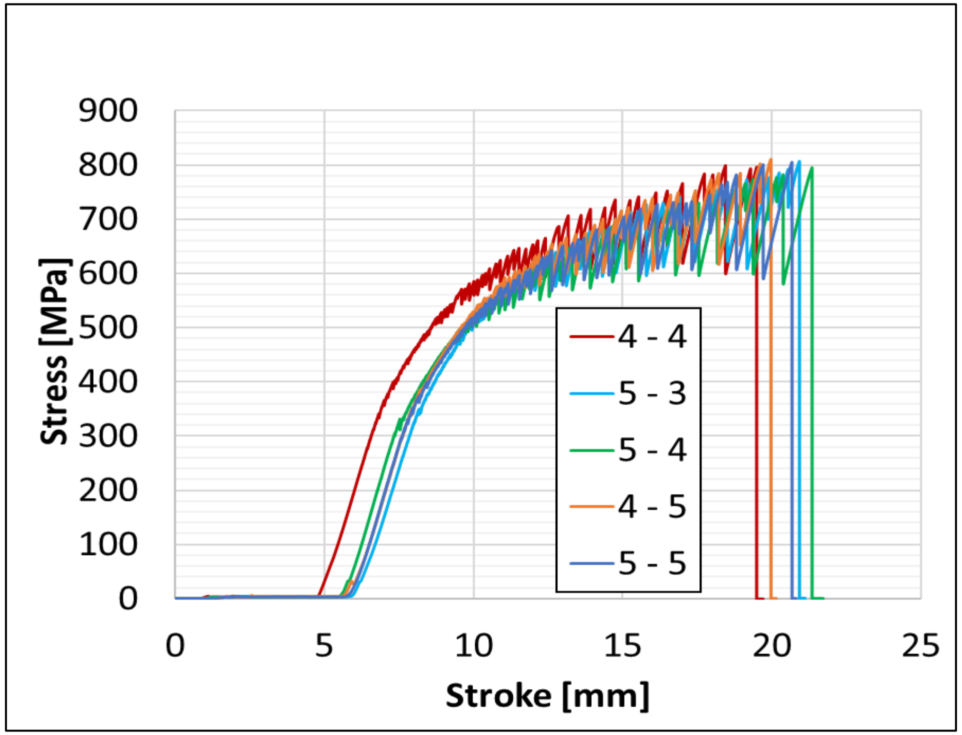
All test samples were/will be heat treated at 900 C.

Mechanical test at KEK

Mechanical test setup under Liquid Helium







Stress analysis

- Stress simulation was carried out by using ANSYS.
- Simulation was done for the following 3 cases.

	Pressure [MPa]			Temperature (degree)	Tuner external load or allowable extension
	Inside Cavity	Between cavity and jacket	Outside jacket		
CASE-A	0	0.2	0	40	0.65 mm
CASE-B	0	0.2	0	40 to -271.4	0.65 mm
CASE-C	0	0.2	0	-271.4	2.0 mm

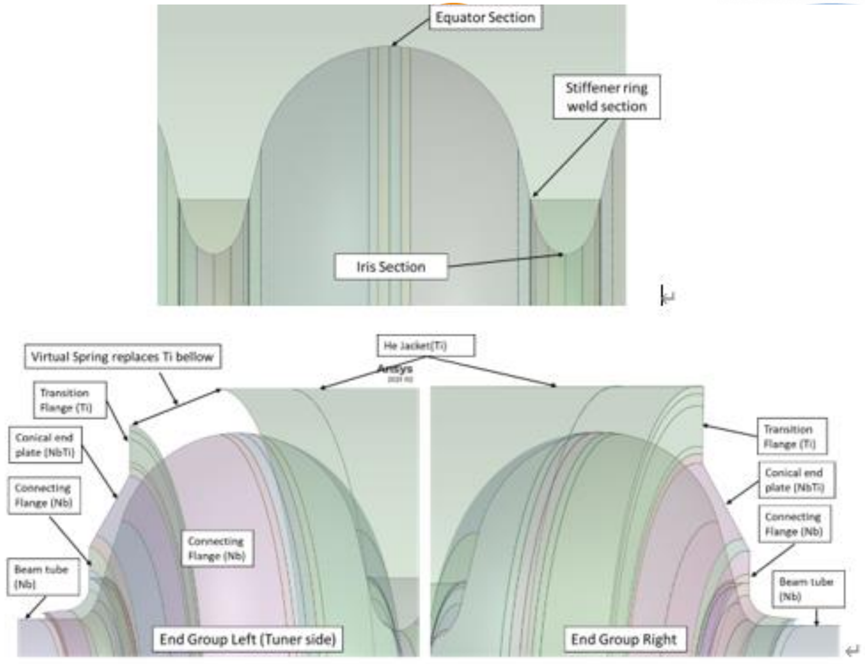
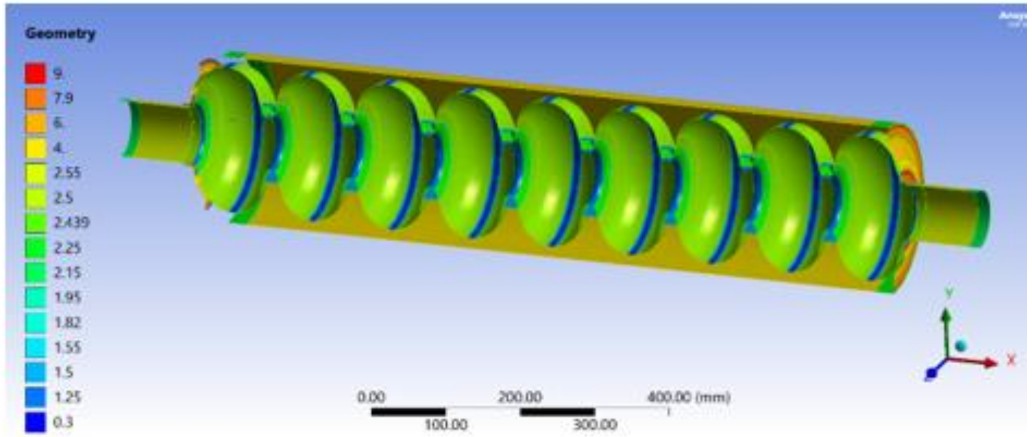


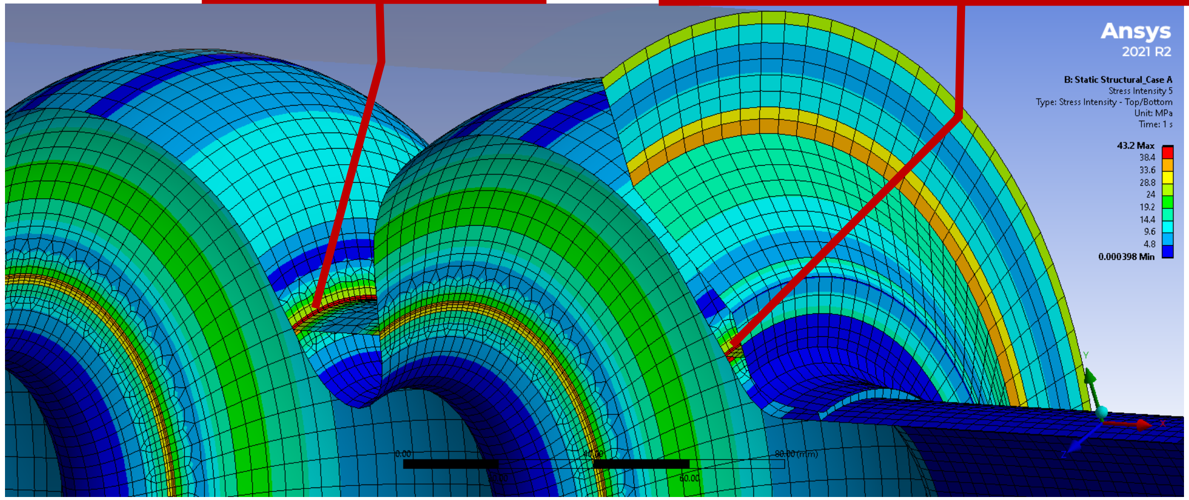
Figure 1: SRF cavity assembly shell model.



High stress region for ILC cavity

Stiffener ring weld
45 MPa

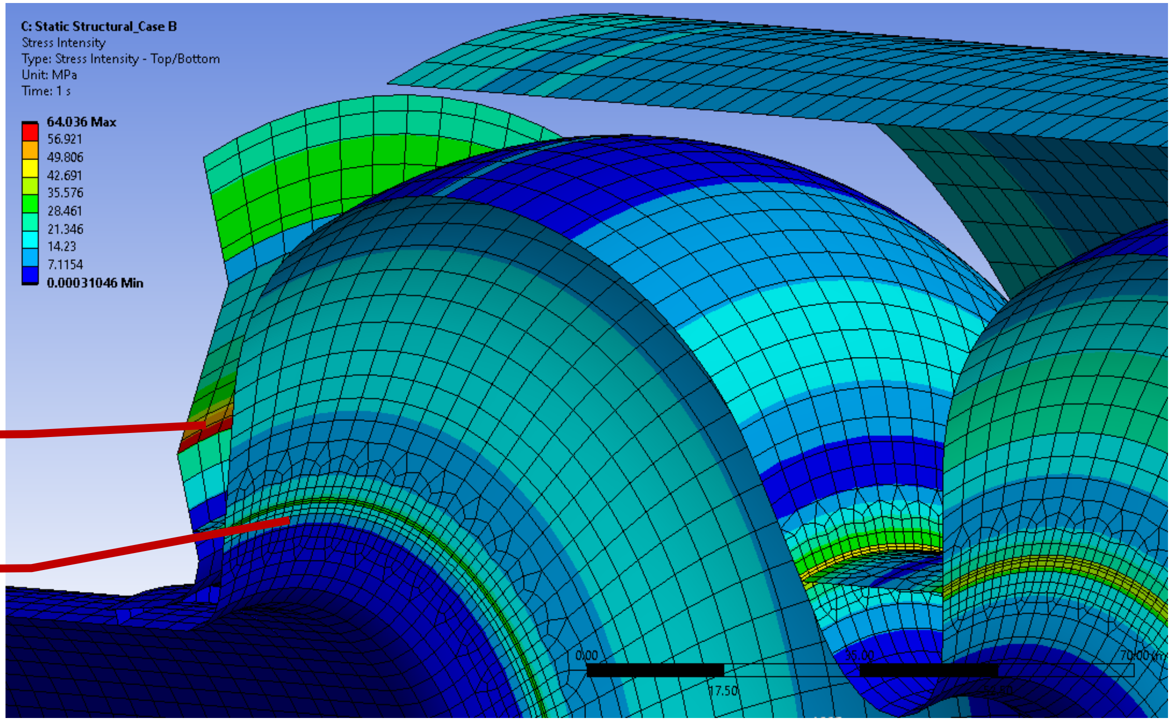
End Cell – Connecting Flange Weld
51 MPa



Case A – Critical Region is End Cell- C.F Weld

Some region show relatively higher stress, which might be close to (or bit over?) the allowable stress.

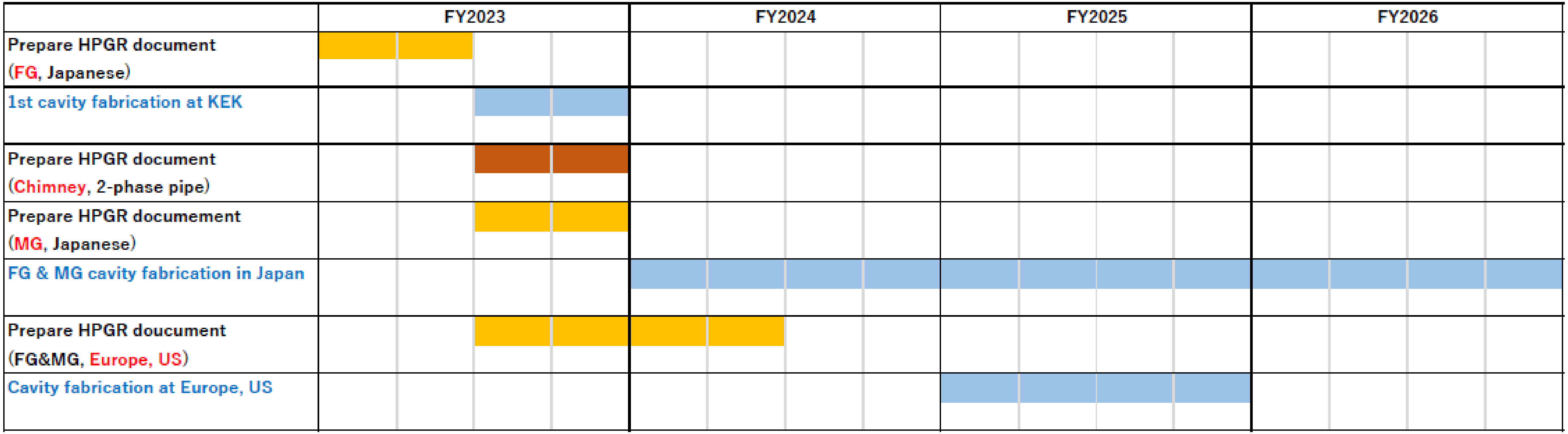
Case B - Critical Region is End Cell- C.F Weld and C.F and Conical Disc Weld



Connecting Flange – Conical Plate Weld
51.2 MPa

End Cell – Connecting Flange Weld
75 MPa

Schedule(HPGR & cavity fabrication)



- Above is current rough schedule for ILC-TN
- HPGR document

  FG ⇒ MG ⇒ Europe, US

Summary

- KEK is preparing the documents for HPGR application.
- Currently, we are preparing the document for first ILC-TD FG cavity with helium tank, which will be fabricated at KEK-CFF.
- Many mechanical tests have been performed and currently on-going. Heat treatment of 900C is assumed.
- Allowable stress is to be decided from the results of mechanical tests.
- Stress analysis has been also carried out.
- Checking the consistency between the simulated stress intensity and allowable stress estimated from the mechanical test.