

S1-G cryomodule assembly status

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S1-Global cryomodule

The main target of the S1-Global;

Operating a cryomodule with an average accelerating gradient of 31.5 MV/m

Included research subjects;

1. Experience the design, assembly and the alignment procedures for cavity packages from participating parties.
2. Measure the heat loads for the cavity packages and the cryomodule for the static and the 31.5 MV/m dynamic conditions.
3. Conduct the comparative studies of performance of cavities from the participating institutes.
4. Attempt to attain an average accelerating gradient of 31.5 MV/m in a pulsed RF operation at 5Hz with 1ms flat-top length, 0.07% rms amplitude variation and 0.35 degree rms phase variation.
5. Advance implementation of the 'plug-compatibility concept'

S1-Global collaborative profile

INFN: Design and construction of the 6m Module-C for DESY and FNAL cavities

DESY: Two TESLA type cavities with Saclay tuner

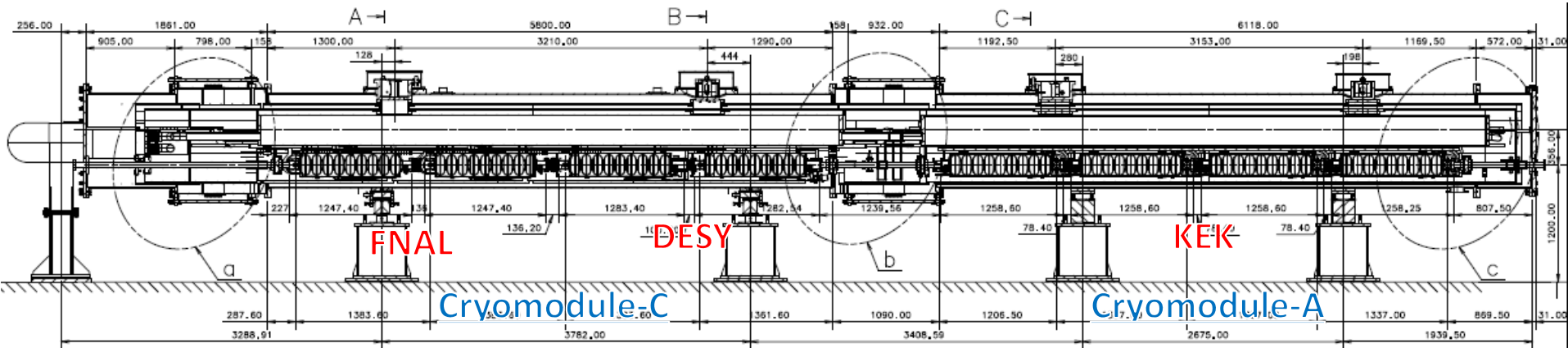
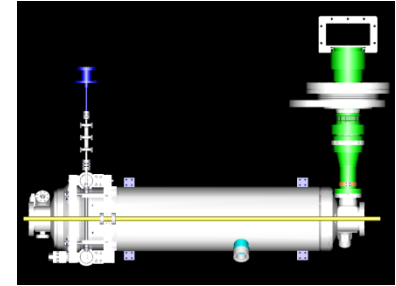
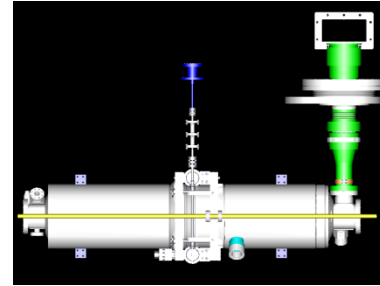
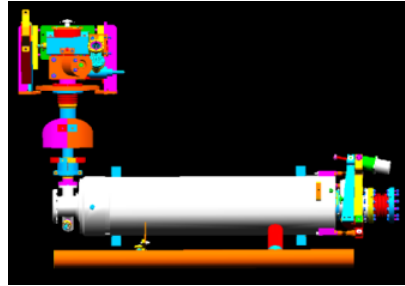
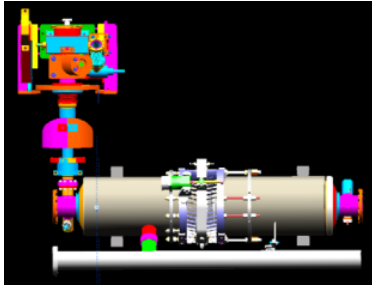
FNAL: Two TESLA type cavities with blade tuner

SLAC: Power distribution system for Module-C

KEK: 6m Module-A for KEK cavities, four TESLA-like cavities and infrastructure for completing the module tests

IHEP and RRCAT: Participation in discussion of the design and tests

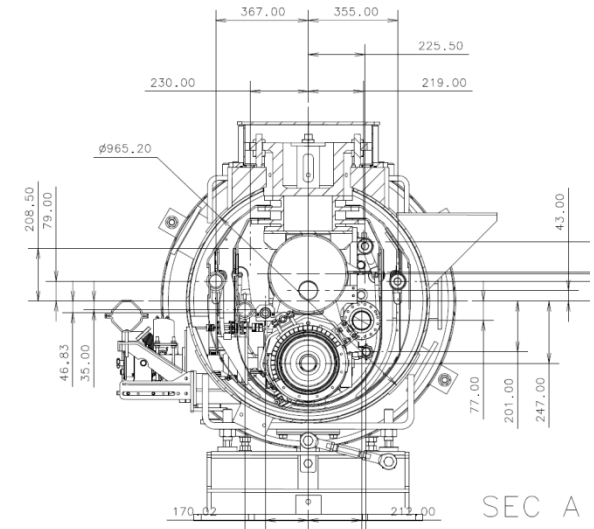
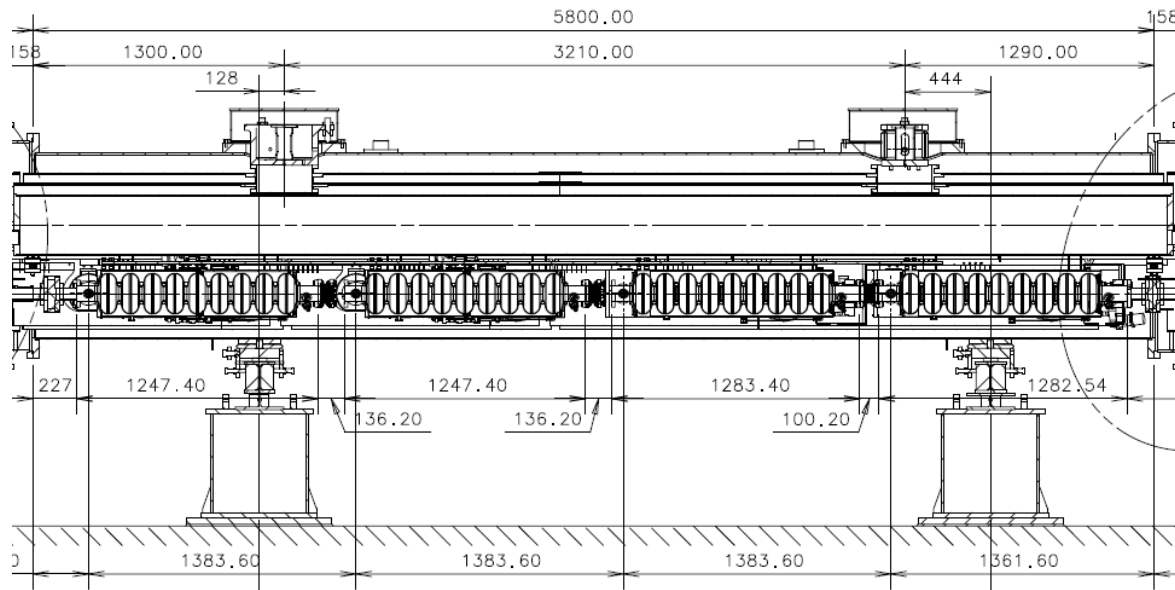
Design of S1-G cryomodules



1. Design of the Module-C and -A for S1-G started at May 2008.
2. Module-C has two FNAL cavities and two DESY cavities, and Module-A has four KEK cavities.
3. Two vacuum vessels are connected with a vacuum bellows.
4. The total length of the S1-G modules including end cans is designed to be 14900 mm.

Design parameters of S1-G cryomodules-C

Module-C

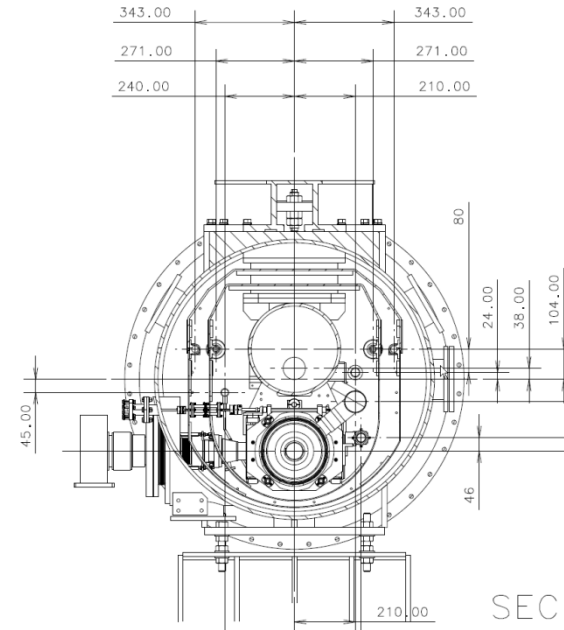
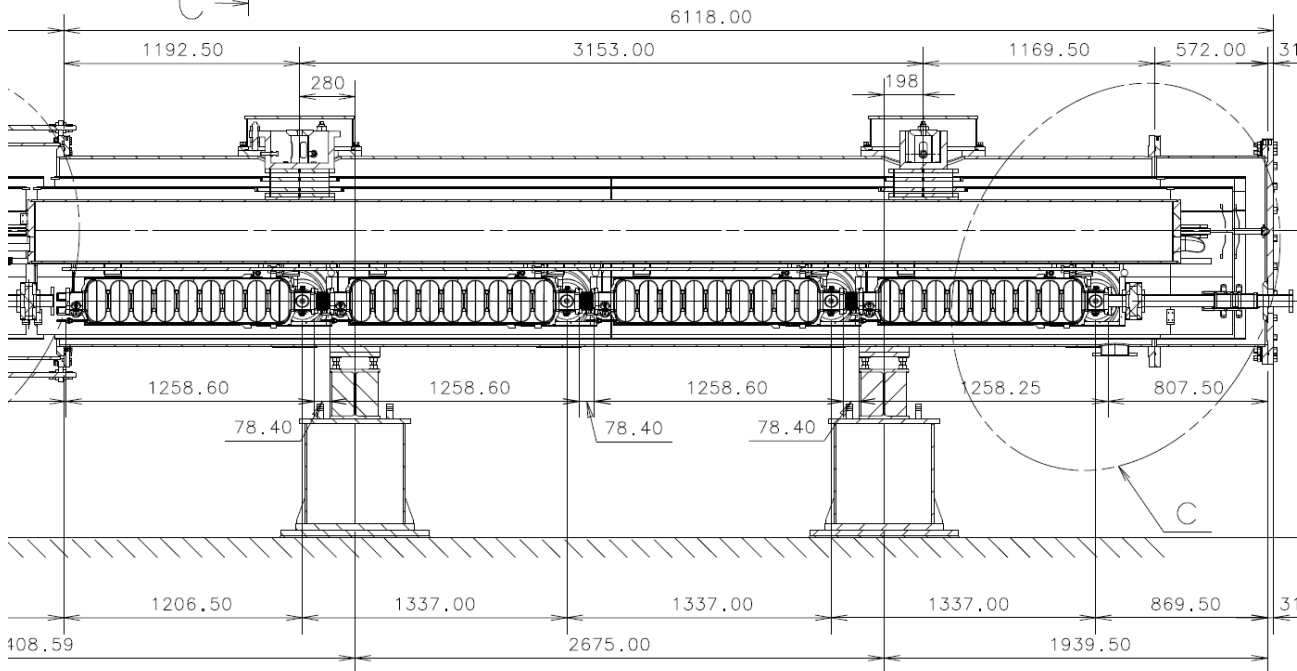


Cross section of Module-C

1. Main parameters of the Module-C were confirmed at January 2009.
2. CAD-work and construction process of the Module-C by Zanon were controlled by INFN.
3. Design features of Module-C:
 - Design is based on the TTF Type-III cryomodule.
 - The cold mass is designed to be supported with two support posts from the vacuum vessel.
 - Design difference of cavity packages are included;
DESY cavity: Saclay tuner, outer magnetic shield and package length=1283.4mm
FNAL cavity: Blade tuner, outer magnetic shield and package length=1247.6mm

Design parameters of S1-G cryomodules-A

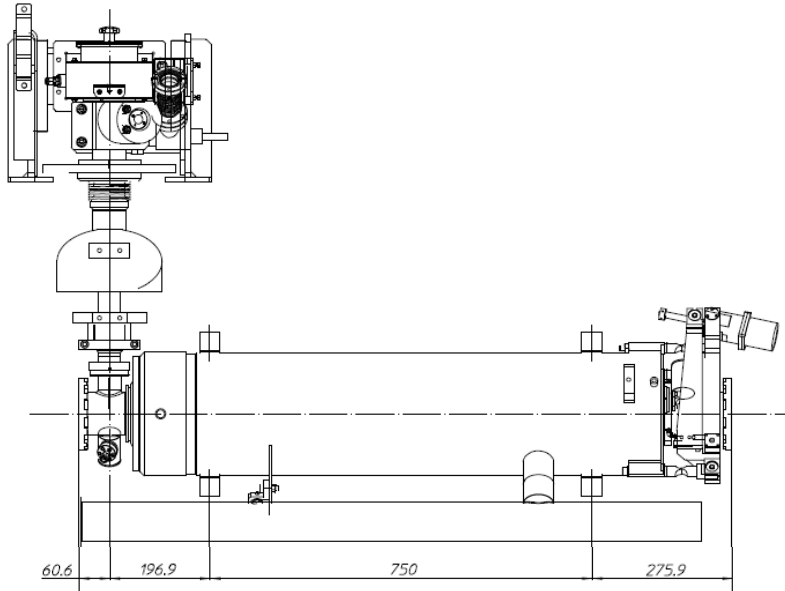
Module-A



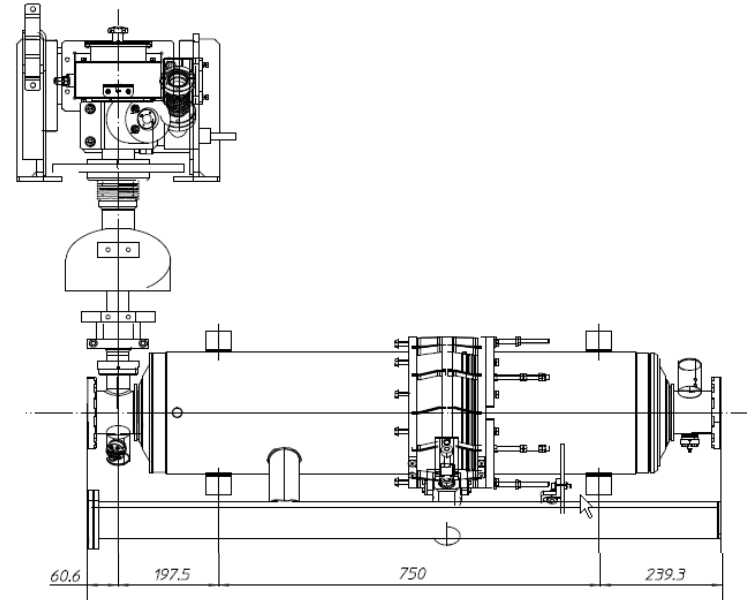
Cross section of Module-A

1. Module-A cryostat and cold mass components are those for STF Tesla-like cavities; re-used.
2. Design features of Module-A;
 - Thermal and mechanical designs are based on the TTF Type-III cryomodule.
 - Module-A is connected to Module-C with a big vacuum bellows and reduced cooling pipes.
 - Cooling pipe sizes are different from those of Module-C.

FNAL/DESY cavities of Cryomodule-C



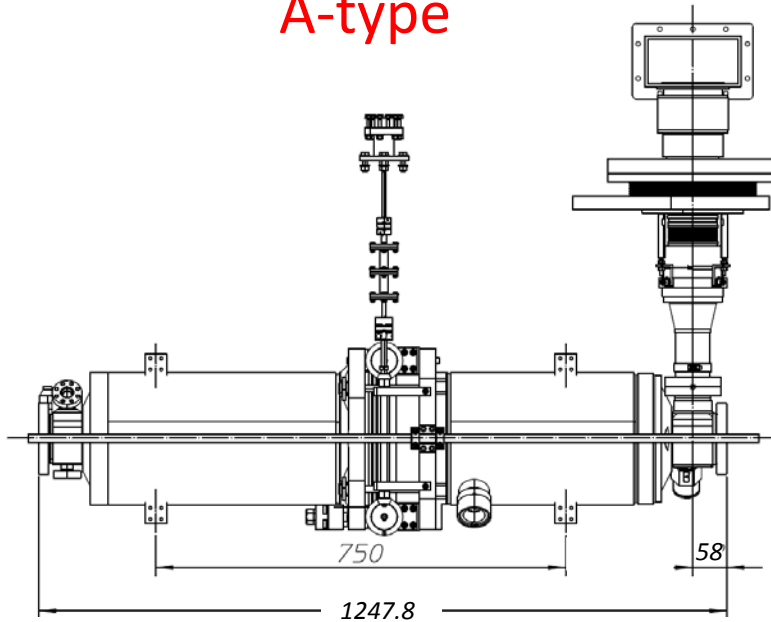
- Two DESY cavities have Saclay tuners.
- The cavity identifications are Z108 and Z109.
- The distance between cavity flanges is 1283.4mm.
- The distance between support lugs is 750mm.



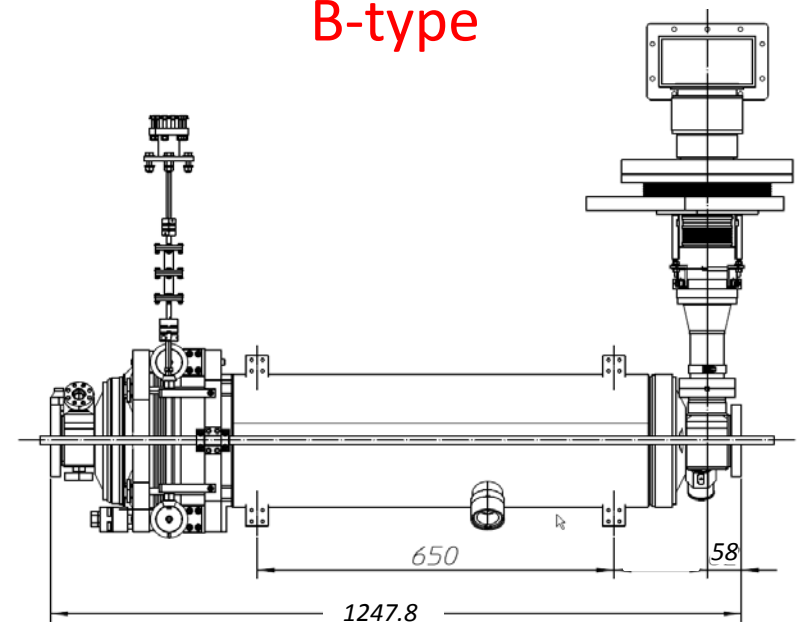
- Two FNAL cavities have the blade tuners which were developed by INFN.
- The cavity identifications are AES004 and ACC011.
- The distance between cavity flanges is 1247.4mm.
- The distance between support lugs is 750mm.

KEK cavities of Cryomodule-A

A-type



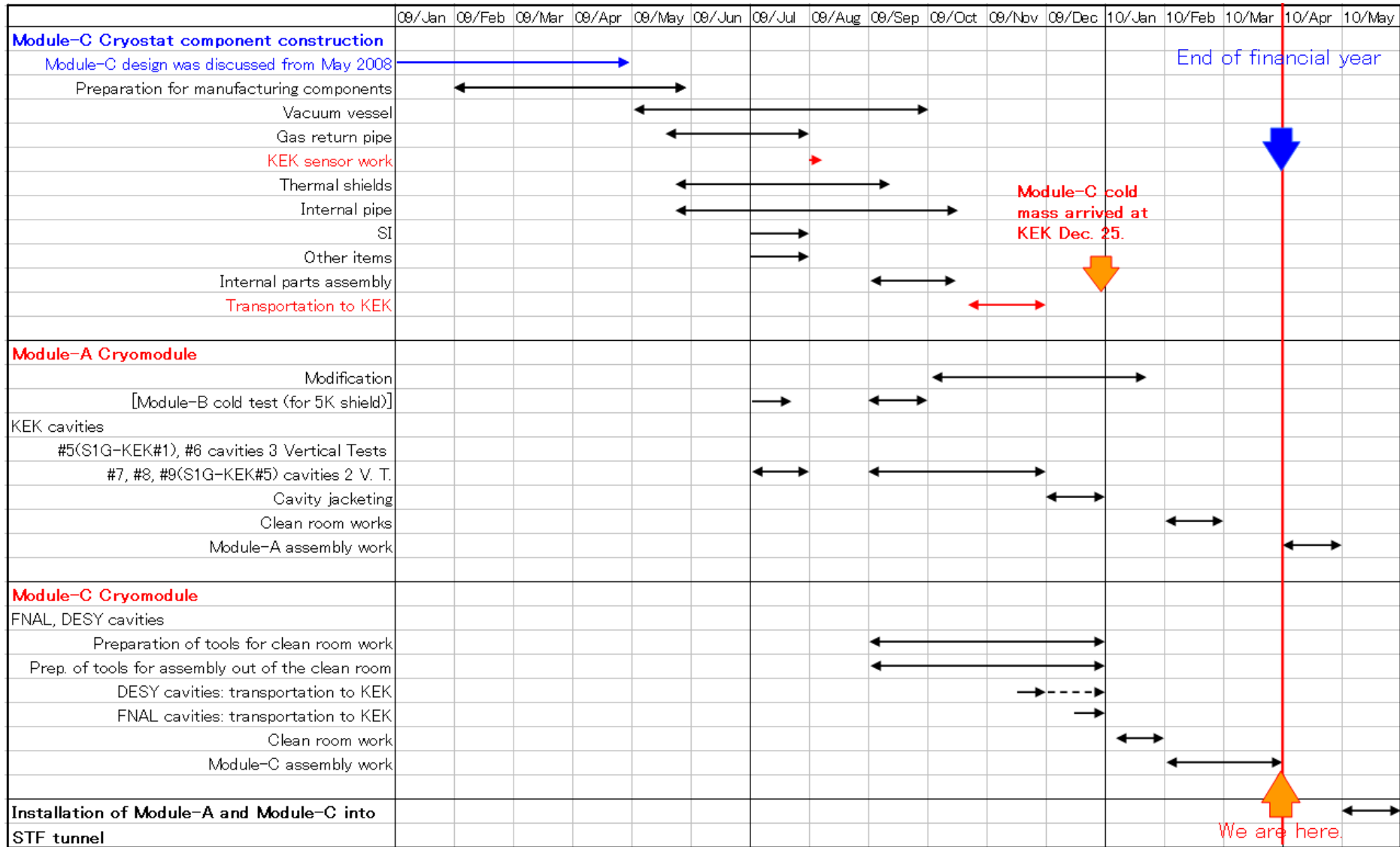
B-type



- The tuner is located in the middle of He jacket.
- The distance between cavity flanges is designed to be 1247.8 mm.
- The support lug distance is 750 mm.
- **The plug compatible standard design**

- The tuner is located out side of support lugs and on the opposite side of input coupler.
- The distance between cavity flanges is designed to be 1247.8 mm.
- The support lug distance is 650 mm.

General construction schedule of S1-Global Cryomodule



Construction of Module-C cold mass at Zanon (2008 May- Oct.)

Helium gas return pipe



80K and 5K thermal radiation shields



Vacuum vessel



Support fixtures

Mounting sensors on the Module-C GRP at Zanon (2008 July 27-30)



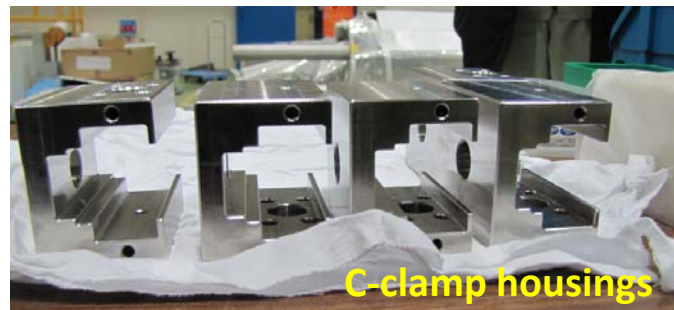
- Mounting sensors:
- 12 PtCo resistance probes
 - 4 CC thermocouples
 - 24 strain gauges
 - 5 WPMs



Module-C cold mass arrived at KEK Dec. 25 2009.



Vacuum vessel



C-clamp housings



Small parts



Assembled GRP, cooling pipes and upper shields



Lower shields

S1-G Cryomodule assembly schedule

Module-C

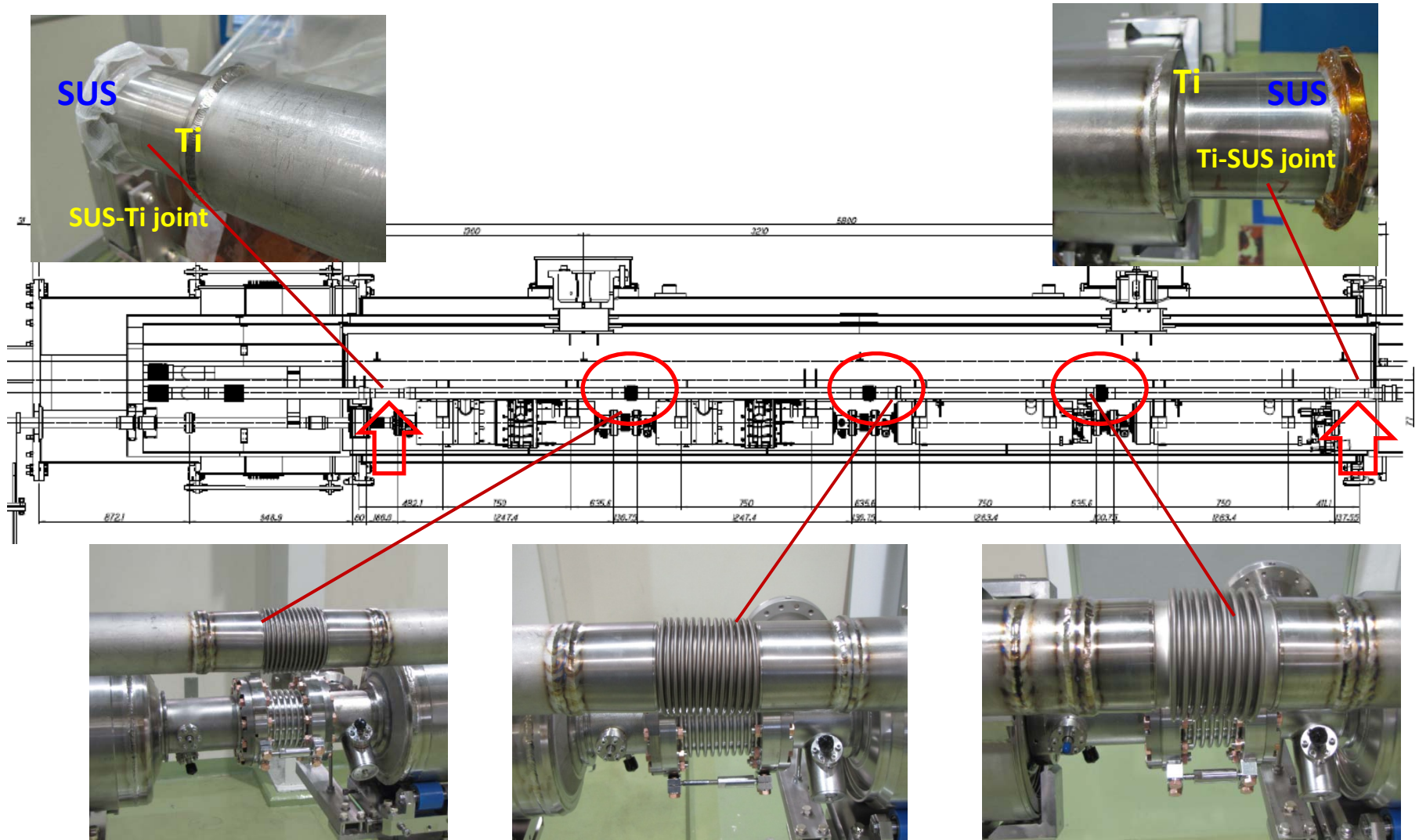
	2010				January				Feb				March				
	4	11	18	25	1	8	15	22	1	8	15	22	29				
FNAL/DESY cavity string in the clean room	←→																
Preparation	←→																
Class 10/1000 assembly work		←→															
FNAL/DESY cavity string outside of the clean room				←→													
KEK cavity string in the clean room								←→									
Preparation								←→									
Class 10/1000 assembly work								←→		←→							
KEK cavity string outside of the clean room and assembling tuners												←→					
Module-C assembly	←→																
Checking the item and number of assembly components by the company personnel		←→															
Placing the GRP cold mass under assembly stand																	
Preparation for welding liquid helium supply pipe				←→													
Verifying the distance between couplers and cavities																	
Welding liquid helium supply pipe and LT																	
Clamping 4 Cu straps on the liquid helium supply pipe for one cavity							←→										
Mounting T-sensors on the cavity jackets																	
Wrapping SI on the cavity jackets																	
Assembling magnetic shieldings and tuner components							←→										
Checking and tuning RF characteristics of cavities and HOM couplers																	
Mounting the cavity-string to GRP with C cramps and roller bearing																	
Connecting Cu straps to HOM couplers and HOM antenna																	
Mounting T-sensors on HOM couplers and Pin-diode																	
Connecting RF cables and signal cables to cavities																	
Welding flanges to GRP ends																	
Wrapping SI on LHe supply pipe																	
Installing the cool down and warm up pipe and connecting flanges to jackets																	
Assembling temporary support brackets for cold couplers																	
Alignment of cavities (measurement of cavity location)																	
Locking cavity jackets to Invar rod																	
Assembling thermal shield for cold couplers																	
Assembling the magnetic shields at the cavity-ends																	
Routing the cables and wires from cavities																	
Assembly of 5K shields (welding work)																	
Connecting heat intercepts of input coupler to 5K shield																	
Sensors and wirings on 5K shield																	
Checking sensors and wiring, and mounting SI on 5K shield																	
Assembly of 80K shields (welding work)																	
Sensors and wirings on 80K shields																	
Checking sensors and wiring, and mounting SI on 80K shields																	
Connecting wires to feed-throughs																	
Inserting the cold mass into vacuum vessel																	
Fixing the cavity-string axis on the vacuum vessel																	
Installing the Module-C in the tunnel																	
Connecting cooling pipes of Module-C and 2K Cold Box																	
PT and LT of Module-C cooling pipes																	
TTF-3 warm coupler installation												←→					

- Module-C assembly works from Jan. 25 – Feb. 6.
 - Jan. 25 ~ Feb. 2 : Welding the liquid helium supply pipe.
 - Alignment of the four cavity jackets on the rail for welding bellows between cavities.
 - Welding bellows and LHe supply pipes
 - Welding SUS-Ti joints to the FNAL and DESY cavities.
 - Feb. 3 : Leak test of the liquid helium supply pipe.
 - Feb.4 ~ Feb. 6: Assembling Cu straps to the 2K helium supply pipe, and mounting thermal sensors on the cavities.
 - Feb. 10: Attaching the cavity string to GRP with the C-clamps.

- Module-C assembly works from Feb. 8 – Feb. 13.
 - Blade tuner, Saclay tuner and magnetic shield assembly by INFN and FNAL.
 - INFN : Carlo Pagani, Angelo Bosotti and Rocco Pararella
 - FNAL : Serena Barbanotti

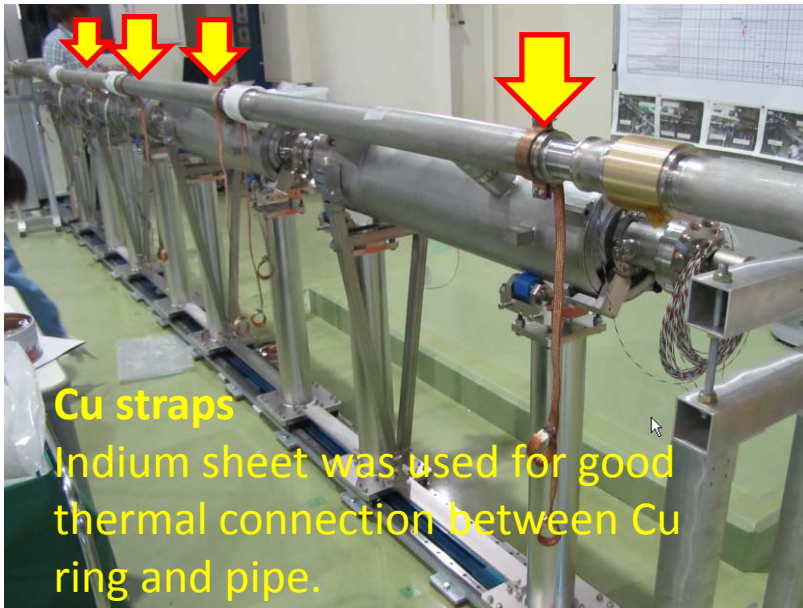
(Details will be reported by Eiji Kako.)

Welding the liquid helium supply pipe (Jan.28~Feb.2)



Ti sleeves which were machined from Ti-plate were used for welding Ti bellows and pipes, not butt welding.

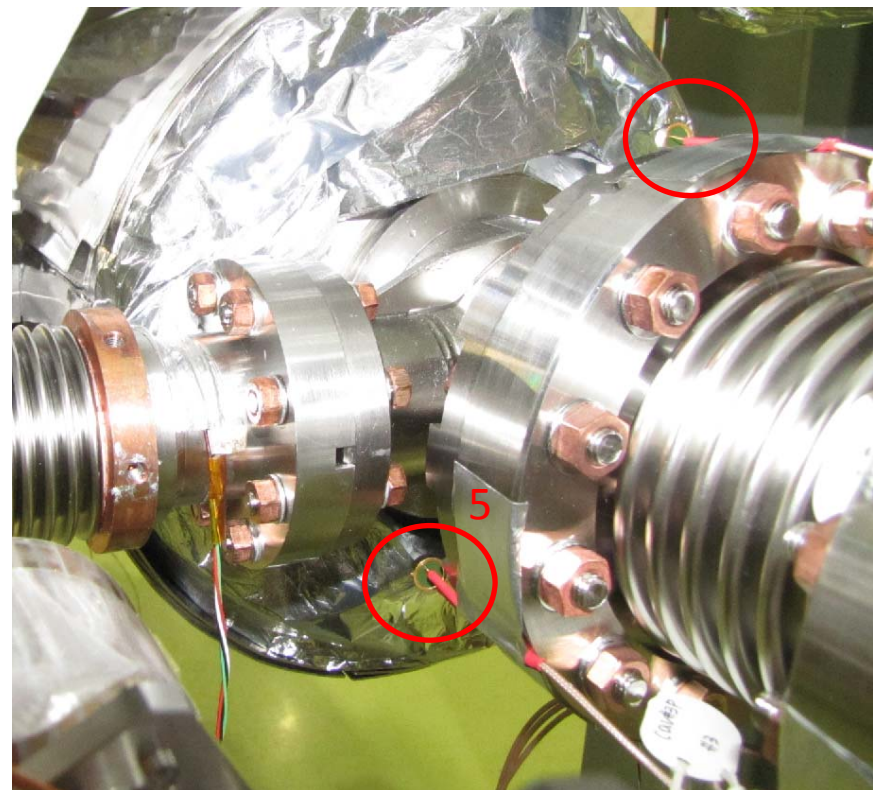
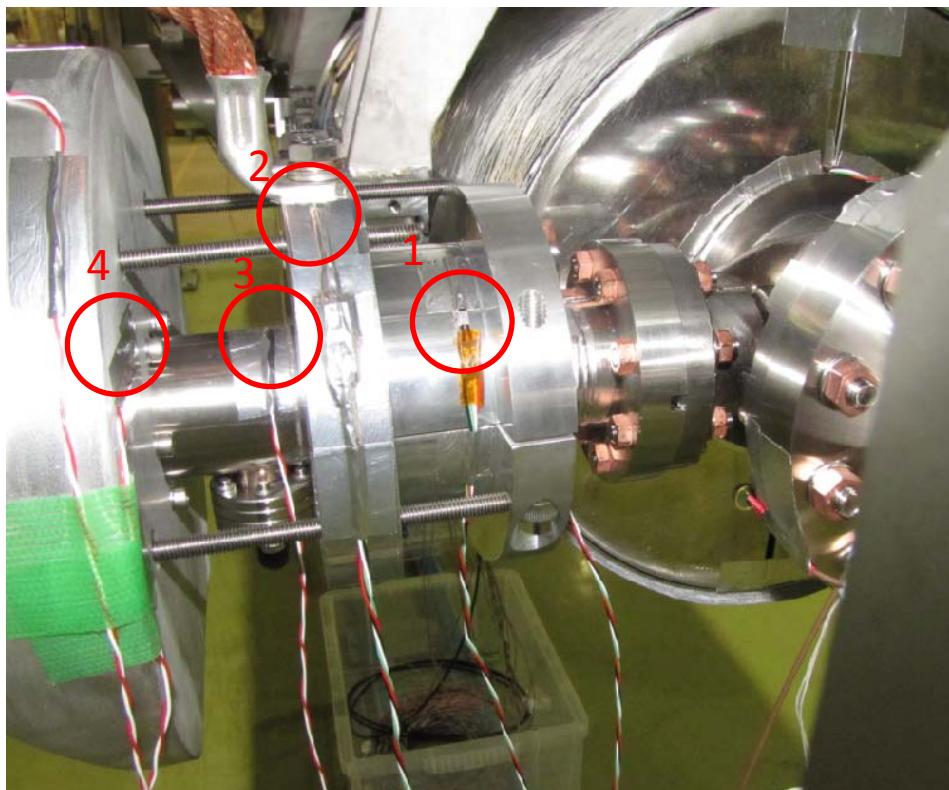
Mounting Cu straps on the 2K He supply pipe and the thermal sensors on cavities (Feb.4~Feb.6)



Cernox sensor: cavity jacket, beam pipe
Calibrated carbon resistor: HOM coupler

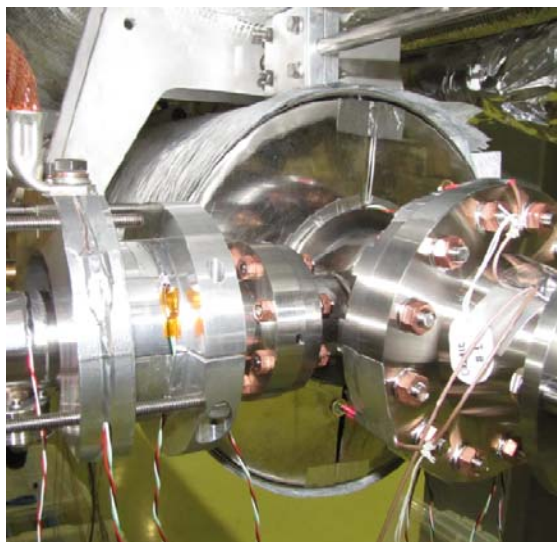
- Module-C assembly works from Feb. 15 – Feb. 26.
 - Feb. 15 -19
 - Alignment of four cavities.
 - Locking the cavity jackets to Invar rod
 - Attaching temperature sensors and pin diodes
 - Assembling 5K thermal intercepts on the input couplers
 - Connecting RF cables, and assembling magnetic shields at the string end of FNAL side, and between FNAL and FNAL cavities, and FNAL and DESY cavities
 - Feb. 22-26
 - Assembling magnetic shields between DESY and DESY cavities, and at the string end of DESY side
 - Setting cool-down/warm-up pipe and He leak test
 - Checking the signal wires of T-sensors for FNAL/DESY cavities

Attaching temperature sensors and pin diodes, and assembling 5K thermal intercepts on the input couplers



1. 5K thermal intercept of input coupler (body): Cernox
2. 5K thermal intercept of input coupler (intercept side): Cernox
3. 80K thermal intercept of input coupler (beam pipe side): CC
4. 80K thermal intercept of input coupler (body): CC
5. 6 Pin diodes for one cavity (3 diodes for each side)

Assembly of magnetic shields between cavities, and 5K thermal intercepts for input coupler.

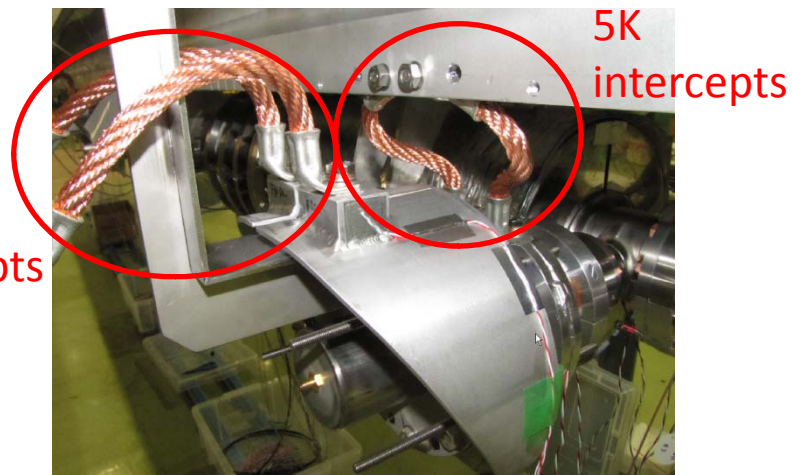


Magnetic shield for the end of the FNAL cavity, AES004

Magnetic shield between the AES004 and ACC011



Magnetic shields between DESY cavities.



80K intercepts

5K intercepts

5K thermal intercepts

- **Module-C assembly works from March 1 – March 13**
 - **March 1 -6**
 - Assembling 5K shield and welding
 - Setting T-sensors on the 5K shield and 5K thermal anchoring of input couplers
 - Thermal anchoring RF cables on the 5K shield
 - Setting SI on the 5K shield
 - Assembling 80K shield and welding
 - Setting T-sensors on the 80K shield and 80K thermal anchoring of input couples
 - **March 8-13**
 - Checking the signal wires of T sensors on the 5K and 80K shields
 - Setting SI on the 80K shields
 - Checking the signal wires of T-sensors for FNAL/DESY cavities
 - Inserting the cold mass into the vacuum
 - Checking the signal wires vessel
 - Moving the Module-C into the STF tunnel and setting the Module-C on the stand

Assembling 5K shield and welding and setting T-sensors on the 5K shield
Thermal anchoring RF cables on the 5K shield and setting SI on the 5K shield



Assembling 5K shield



Welding of 5K shield.



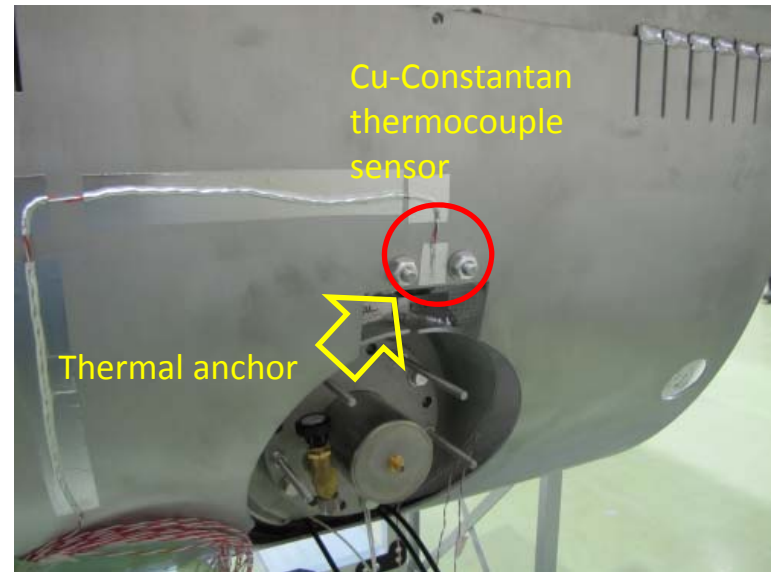
Thermal anchoring RF cables on the 5K shield



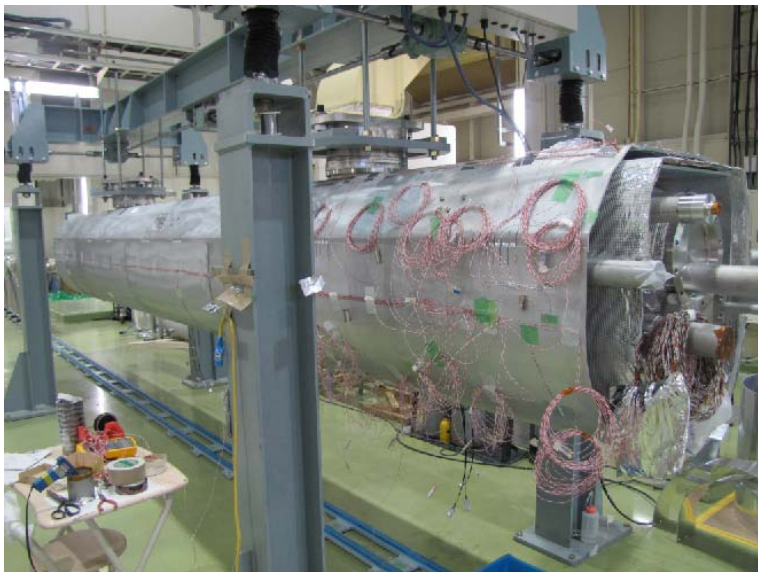
Setting SI on the 5K shield



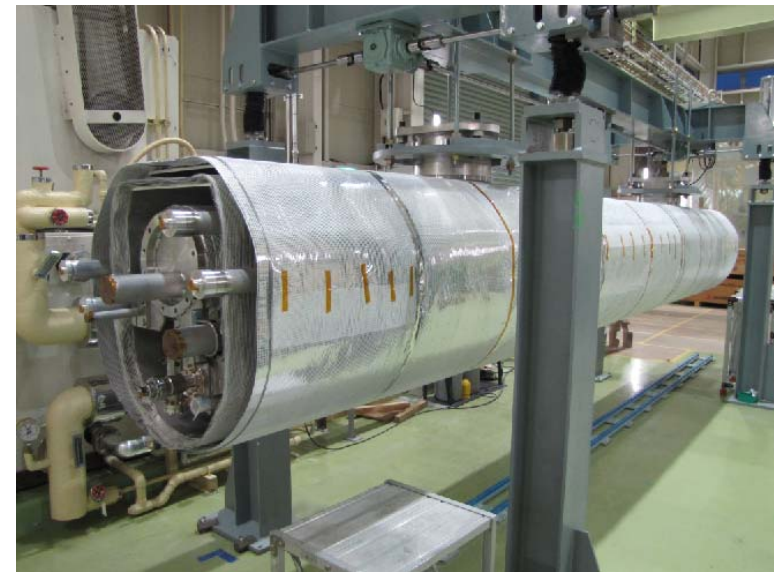
Assembling 80 K shields



Setting T-sensors on the 80K shield and 80K thermal anchoring of input couple



Thermal sensors on the 80K shield
(Cu-Constantan thermo-couples)



Mounting SI on the 80L shield



Moving the cold mass to the insertion area



Setting the cold mass on the equipment



Inserting the cold mass into the vacuum vessel



Assembled Module-C



Moving the Module-C into the STF tunnel



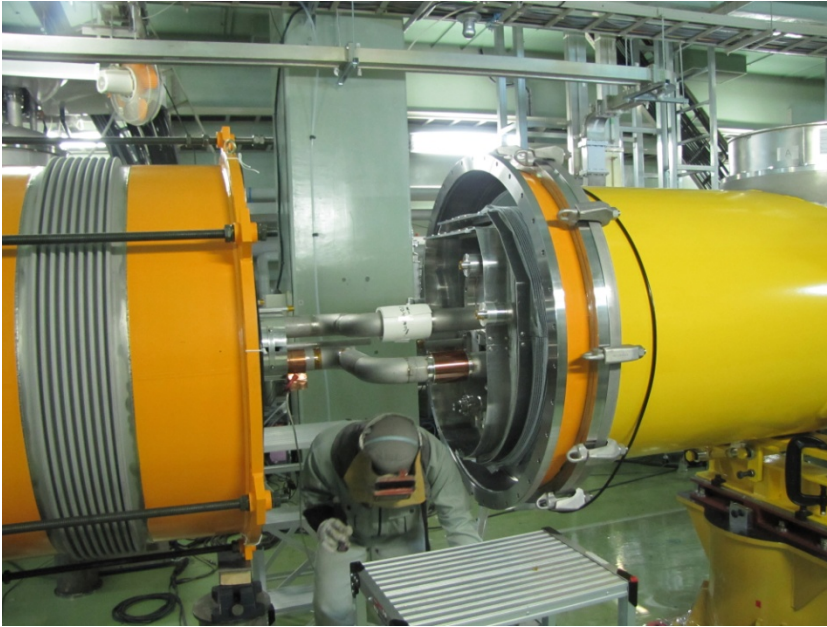
Moving the Module-C into the STF tunnel



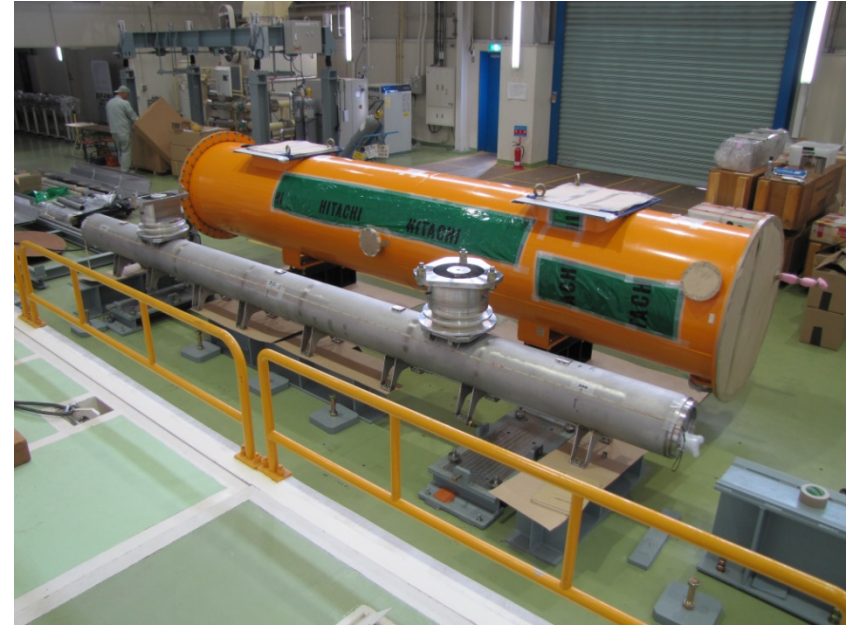
Setting the Module-C on the support stand in the STF tunnel.

- **Module assembly work in March 15~20**

1. Welding the cooling pipes between the 2K cold box and the Module-C
2. Pre-assembly of the thermal shields between the 2K cold box and the Module-C
3. Making the terminals of signal wires for the feed-throughs
4. Preparation of Module-A assembly



Welding the cooling pipes between the 2K cold box and the Module-C



Cryostat of Module-A and the gas return pipe

In this week, the warm couplers for DESY and FNAL cavities were assembled by Denis Kostin from DESY. This assembly will be reported by Eiji Kako in detail.

Module-C assembly was successfully completed under the collaborative works with INFN, FNAL, DESY and KEK on schedule.

Thanks for all S1-G cryomodule members!!

Module-A assembly schedule

	2010	March					April				May				
		1	8	15	22	29	5	12	19	26	3	10	17	24	
KEK cavity string in the clean room		←→													
Preparation Class 10/1000 assembly work		←→													
KEK cavity string outside of the clean room and assembling tuners			←→												
Module-A assembly						←→									
Attaching T-sensors and Pin-diodes on the cavity string						←→									
Mounting the KEK cavity-string to GRP						←→									
Welding LHe supply pipe and cool-down pipes PT and LT of cooling pipes							←→								
Mounting sensors on pipes and wiring for sensors on cavity string and pipes SI on LHe supply pipe and GRP								←→							
Assembling 5K shield															
Attaching and wiring sensors on the 5K shield SI on 5K shield									←→						
Assembling 80K shield															
Attaching and wiring sensors on the 80K shield SI on 80K shield															
Checking sensors										←→					
Inserting the cold mass into V.V. Installing Module-A in the tunnel															
Intermediate area between Modules and 2K cold box															
Welding pipes between Module-C and Module-A											←→				
Welding pipes in the Module-A end and PT, LT of cooling pipes Assembling thermal shields/SI/Wiring												←→			
STF-2 warm coupler installation													←→		
Closing Modules/Vacuum pumping Modules/Final vacuum LT														←→	

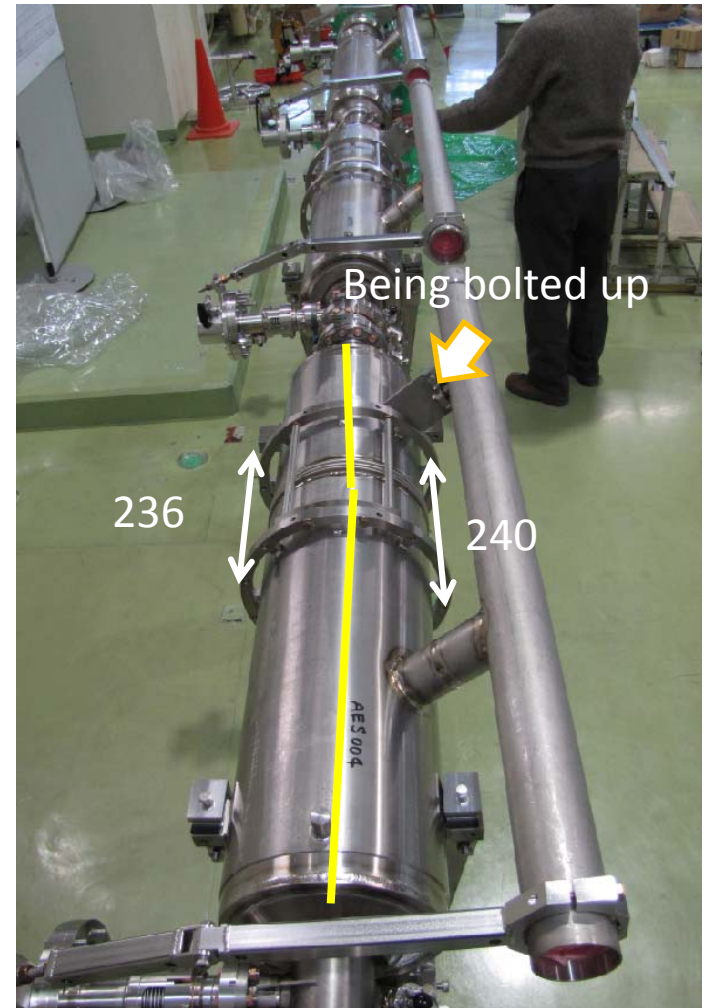
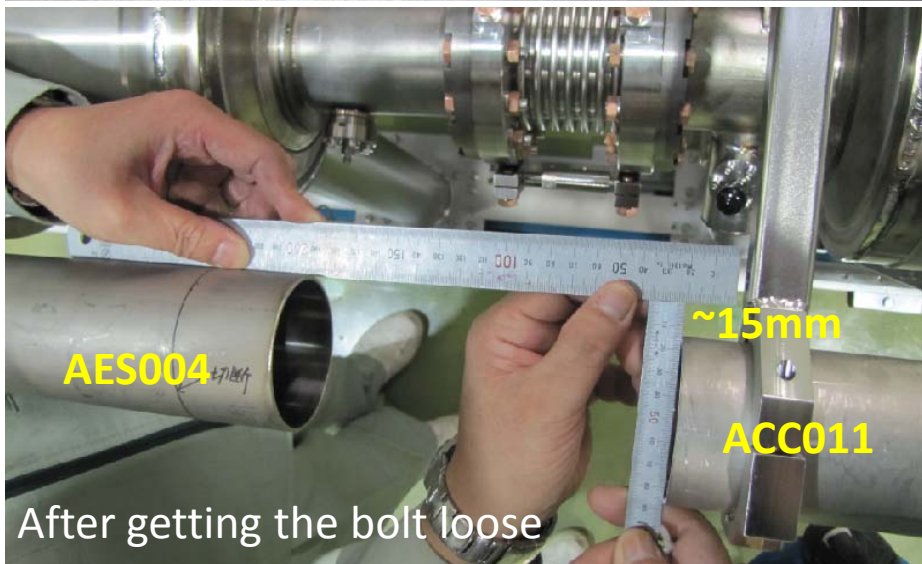
Module-A assembly starts from March 29, today.

The KEK cavity string will be supported from the GRP at April 1.

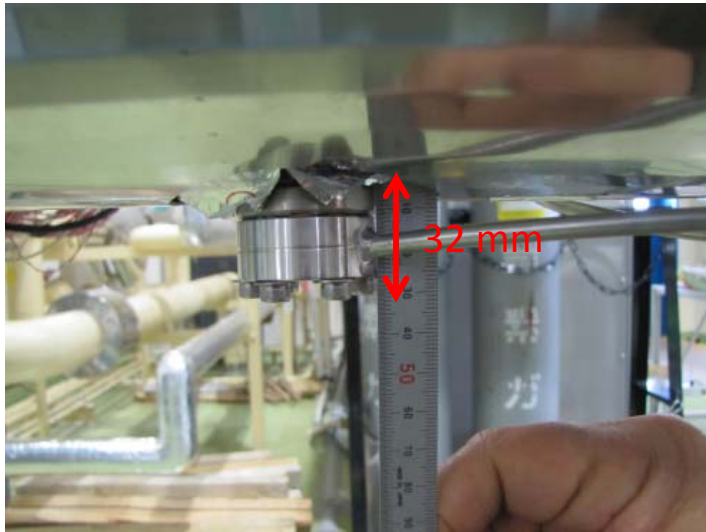
Summary

- Cryomodule-C assembly work including the clean room work started from January 12, and completed March 19.
 - Man-hours of company personnel : 1192 hours
 - The man-hours do not include the time for the clean room work and assembling tuners and input couplers.
 - Welding of Ti-pipes were performed manually. By introducing auto welding and cutting machines, 30 man-hours would be reduced.
- Some troubles
 - Deformation of cavity jacket of AES004
 - Connection flange of cool-down pipe for FNAL cavities.
- Cryomodule-A assembly start on March 29, and the cool-down of S1-G cryomodule will start in June.

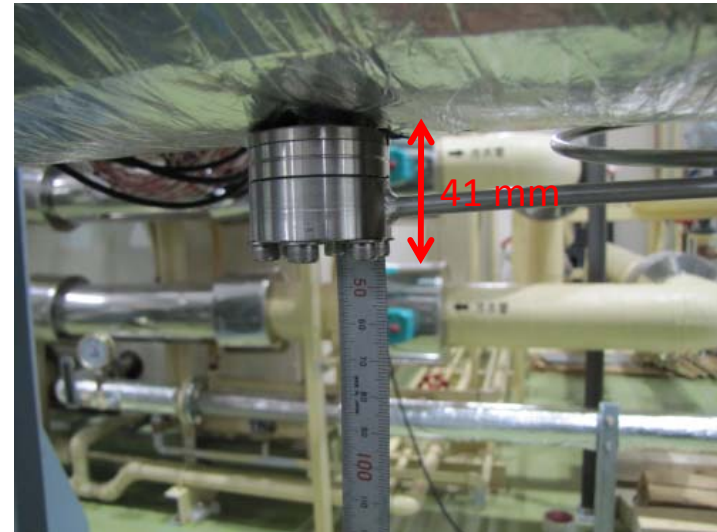
Deformation of cavity jacket of AES004



Connection flange size problem between FNAL and DESY cavities



Connection flanges for DESY cavities



Connection flanges for FNAL cavities

The INFN/Zanon 5K shield had interference with the FNAL flanges. Then the holes on the 5K shield were processed.



Making holes for FNAL cool-down pipe connection