KAGRA Cryogenics

Cryostat, 4K Cryocooler Unit, Shield Duct
and
Cryopayload

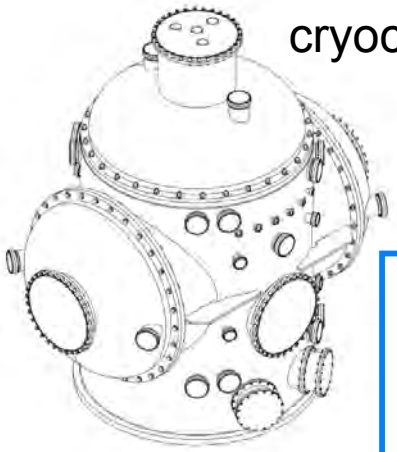
2012.04.18

Overview Definition and scope of the subsystem

Cryostat	4 sets
4K Cryocooler unit	16 sets (4 for each cryostat)
Shield duct with 80K PTC units	8 sets
Cryogenic payload	4 sets
Monitoring cryogenic equipments	

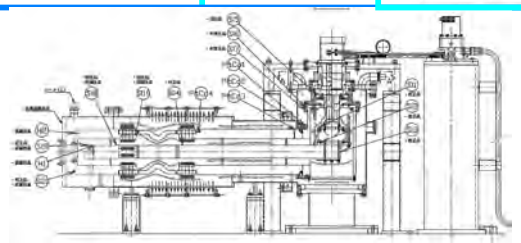
In charge of
- Design
- Prototype test (if possible)
- Manufacture
- Inspection
- Storage and Transportation
- Installation

Details of cryogenic payload will be given by K. Yamamoto.

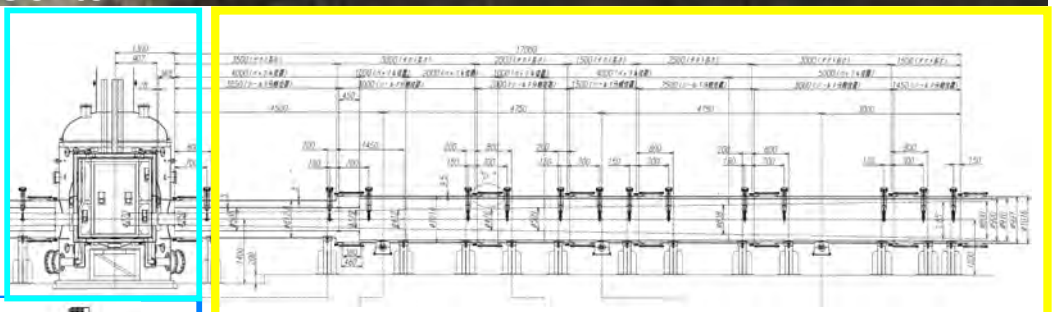


cryochamber
ϕ2600
H4300

Toshiba



4K Cryoooler unit J Torisha



Shield duct v.0 o.d. ϕ1000/800 L17m

Overview Important interfaces (1)

Vacuum space	Low outgassing	Materials: vespel, thin SI, Coating: DLC on baffle, shield Polishing: inner wall of chamber, duct, shield
	Leakage, accumulation of condensable gas	
SAS	Chamber connection at the top flange of cryostat 300K part to cryopayload	
Layout	Distance to gate valve flange Anchor against atmospheric pressure	
Tunnel	Transport through arm tunnel. Layout in laboratory, pit, gas piping, target position of installation Crane or machine for loading/unloading of heavy components. Waste heat from compressors Soundproofing area for compressors Space for storage	
Mirror	Scattering Absorption	

Overview Important interfaces (2)

Aux. Optics	View port, optical lever, CCD camera(?), fiber scope(?), actuator, cryo baffle with vibration isolation		
Interferometer	Aperture of thermal radiation baffle Edge scattering		
Analog electronics	Thermometer monitor Drive signal of rotary valve Gas piping		
Measurement Instrum. Digital system	Thermometer	/Cryostat	Si diode 28 PtCo 26 Heater 2 Spare wirering 6
		/Cryocooler unit	Si diode 11 PtCo 4 Heater 2
		/Compressor ext. control	6 channel
	Pressure monitor	Vacuum He gas supply/return	

Overview Important interfaces (3)

Data acquisition	Regular maintenance	Compressor Cryocooler
Clean environment	Assembling in JIS class 7 (US 10000) Cryostat Cryocooler unit Shield duct Assembling/Installation in JIS class *** Cryopayload	

Overview Design phase

Cryostat (Cryochamber + Thermal shields) : Almost fix.
4K cryocooler unit : Almost fix.
Shield duct : Continue.
Monitor of cryogenic equipments : Continue.

Status of manufacturing

iKAGRA Target specifications

Two cryostats in center room : Same as 300K vacuum chamber
(Another two in end rooms : separated by gate valves)

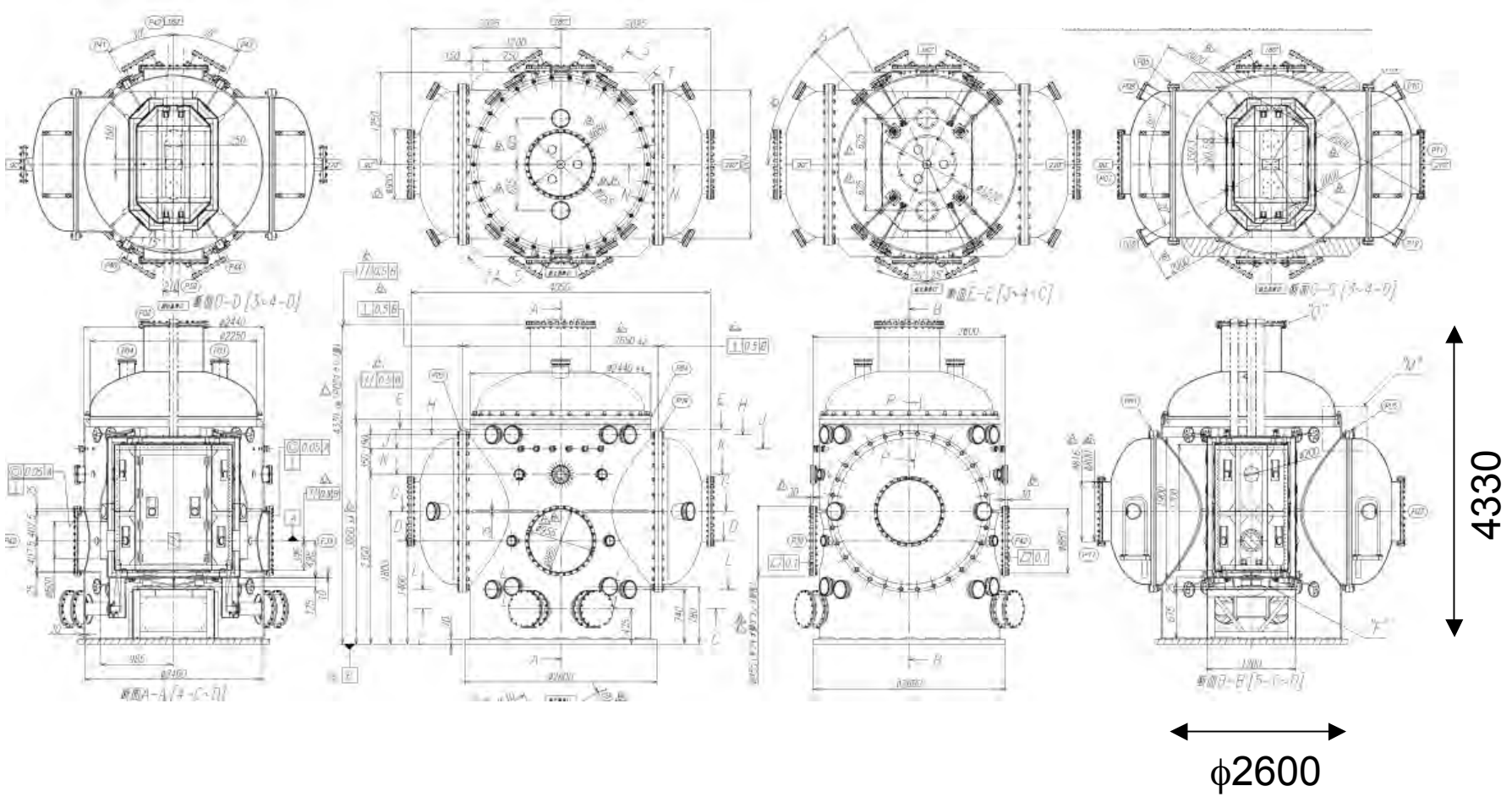
4K cryocooler units in center room : stop in iKAGRA operation

Shield duct : not equipped
(a prototype is equipped at one end room)

Cryopayload : not equipped

iKAGRA Final design (1)

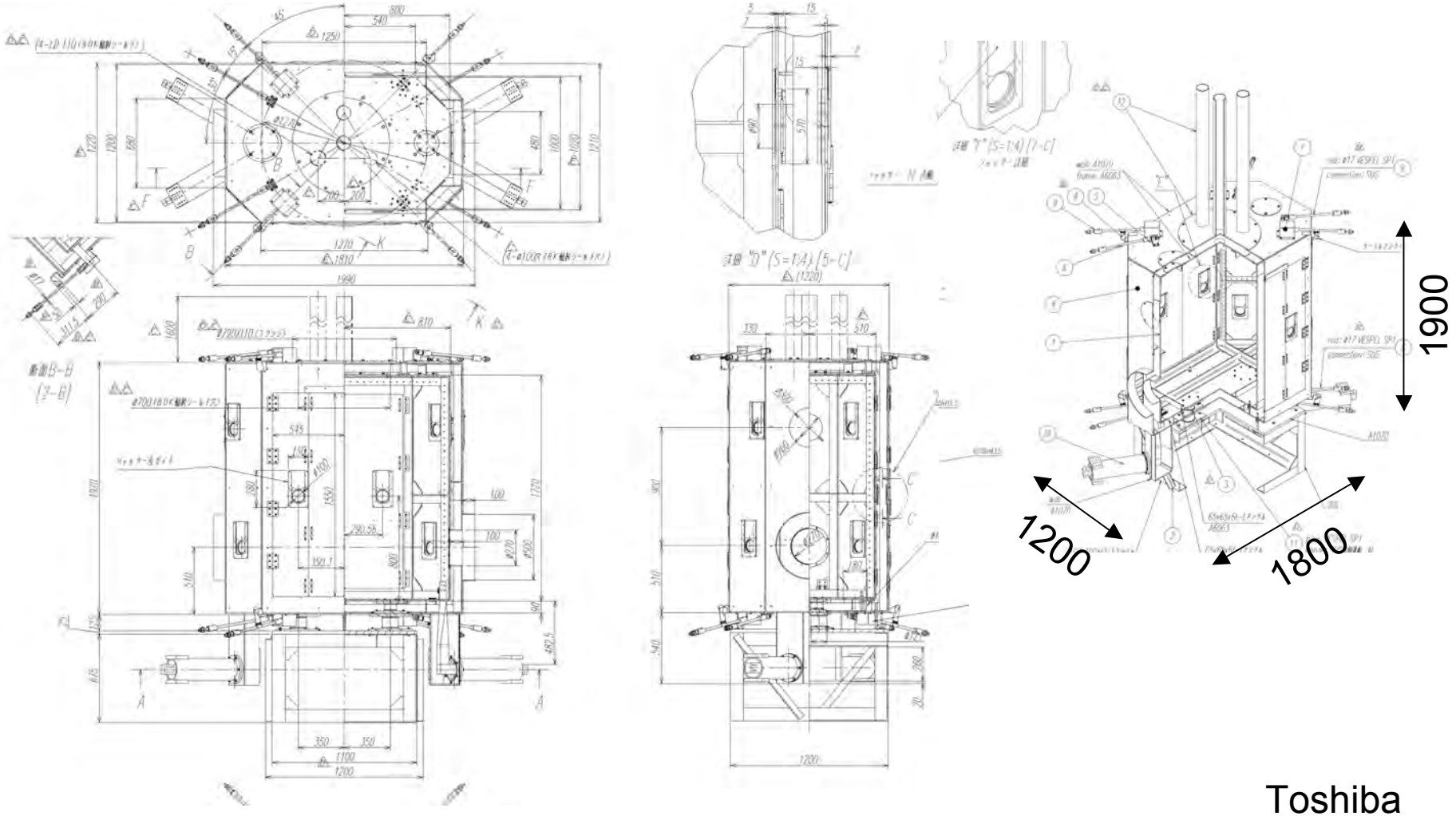
Cryostat (cryochamber)



Toshiba

iKAGRA Final design (2)

Cryostat (thermal shields)



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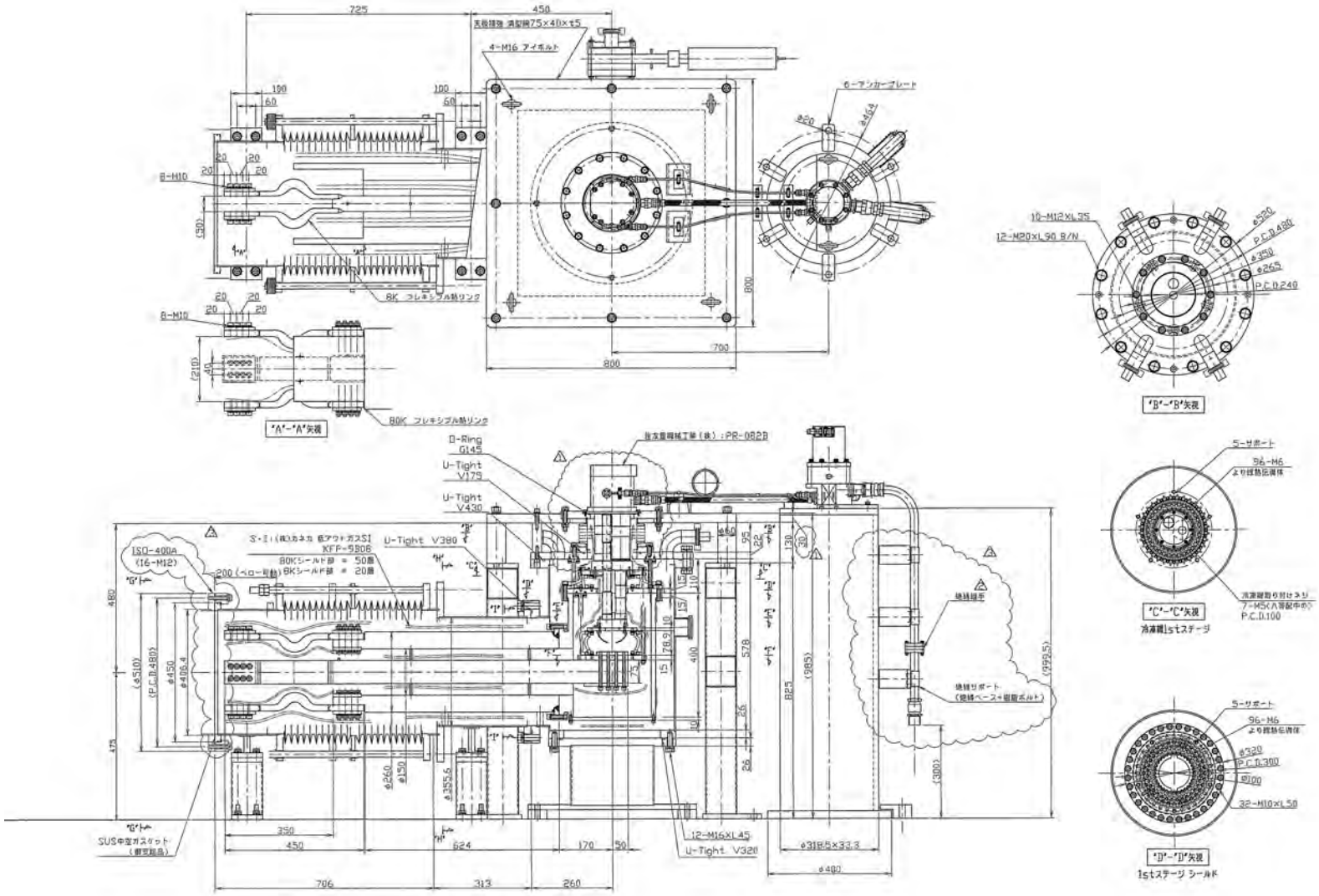
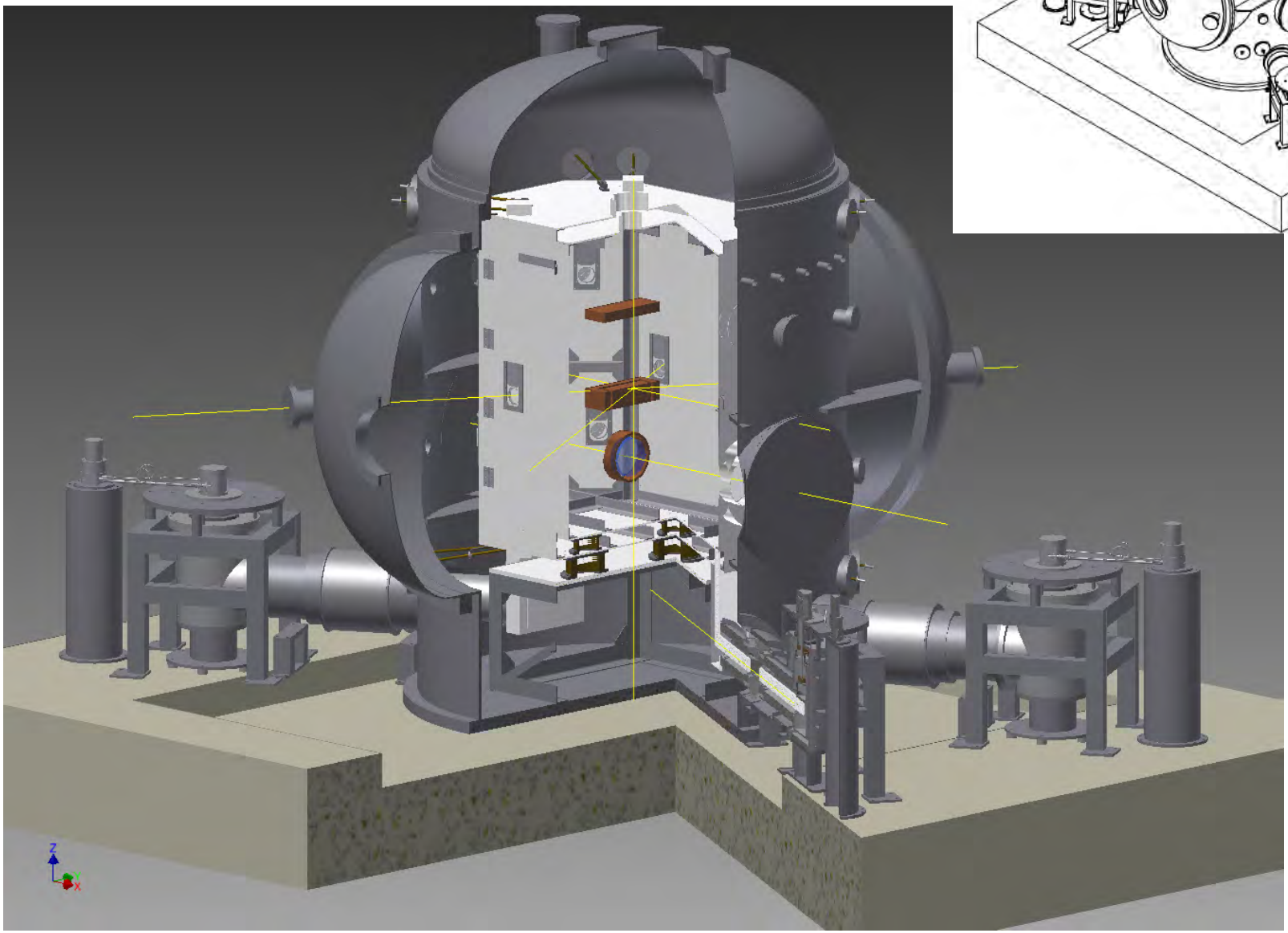
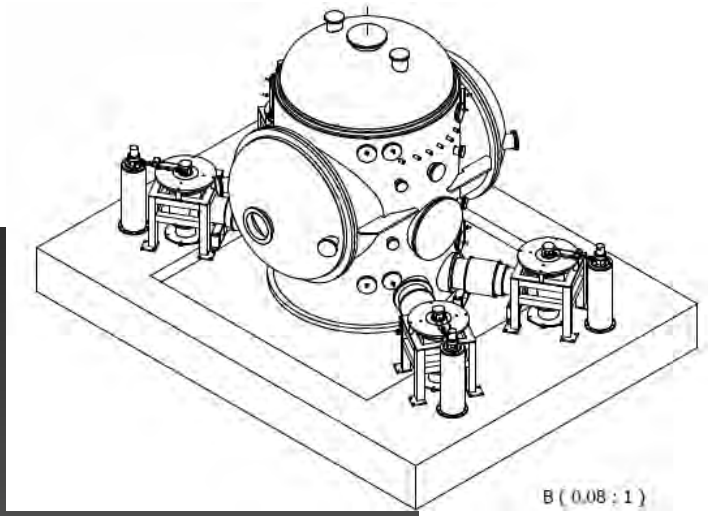
iKAGRA Final design (3)

4K Cryocooler unit



JECC Torishsa


Z
Y
X


B (0.08 : 1)

iKAGRA Schedule

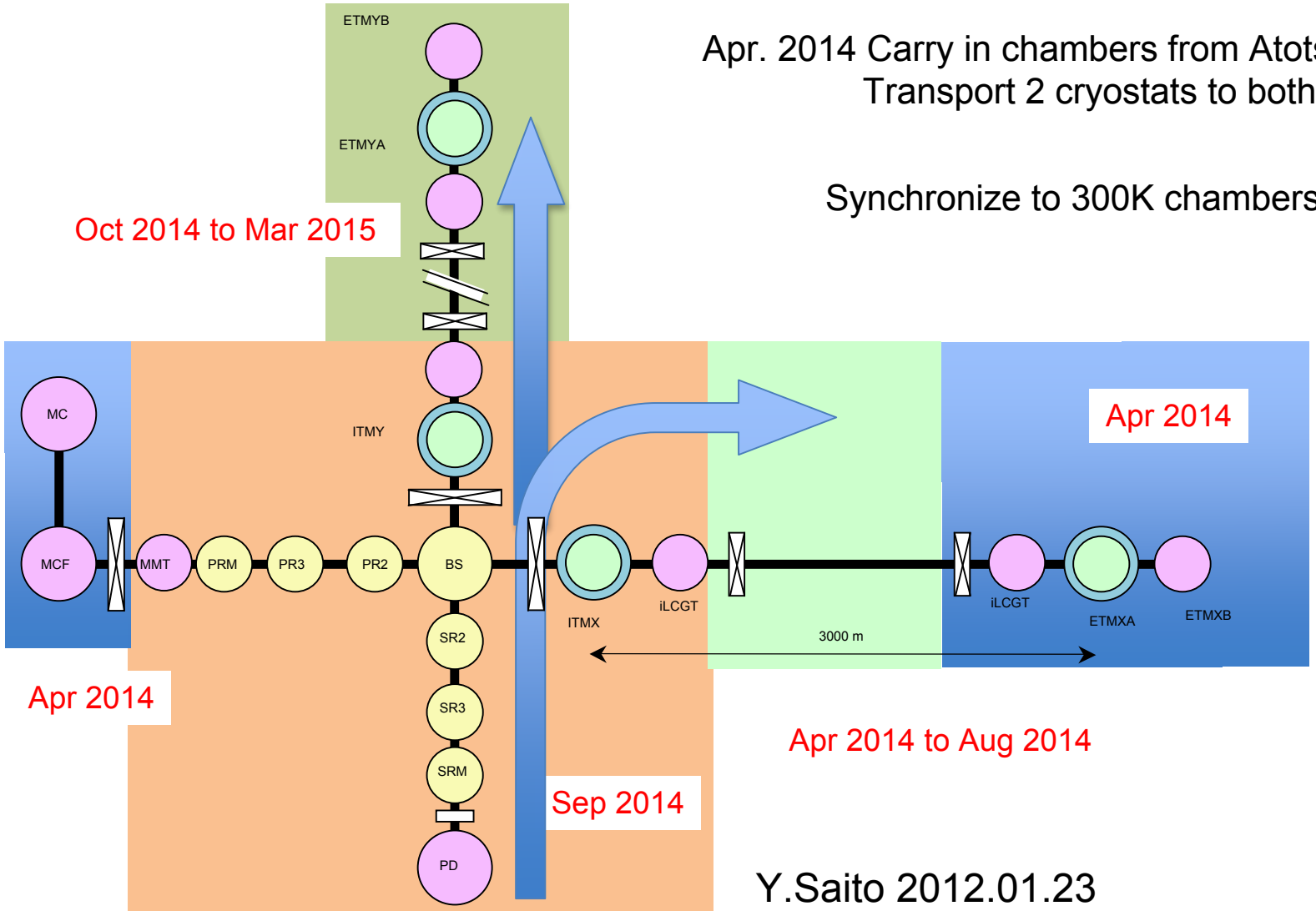
2011fy Cryostat : Purchase and machining of components.
Assembling 4K Cryocooler unit (7)
2012fy Assembling Cryostat (4) and 4K Cryocooler unit (9)
Performance test
2013fy Storage
2014fy Start carry in and installation.

iKAGRA Quality assurance

Cryostat : Vacuum leak test at the manufacturer (2012fy)

4K Cryocooler : Vacuum leak test at the manufacturer (2011fy and 2012fy)

iKAGRA Installation scenario



Apr. 2014 Carry in chambers from Atotsu entrance
Transport 2 cryostats to both ends

Synchronize to 300K chambers and ducts.

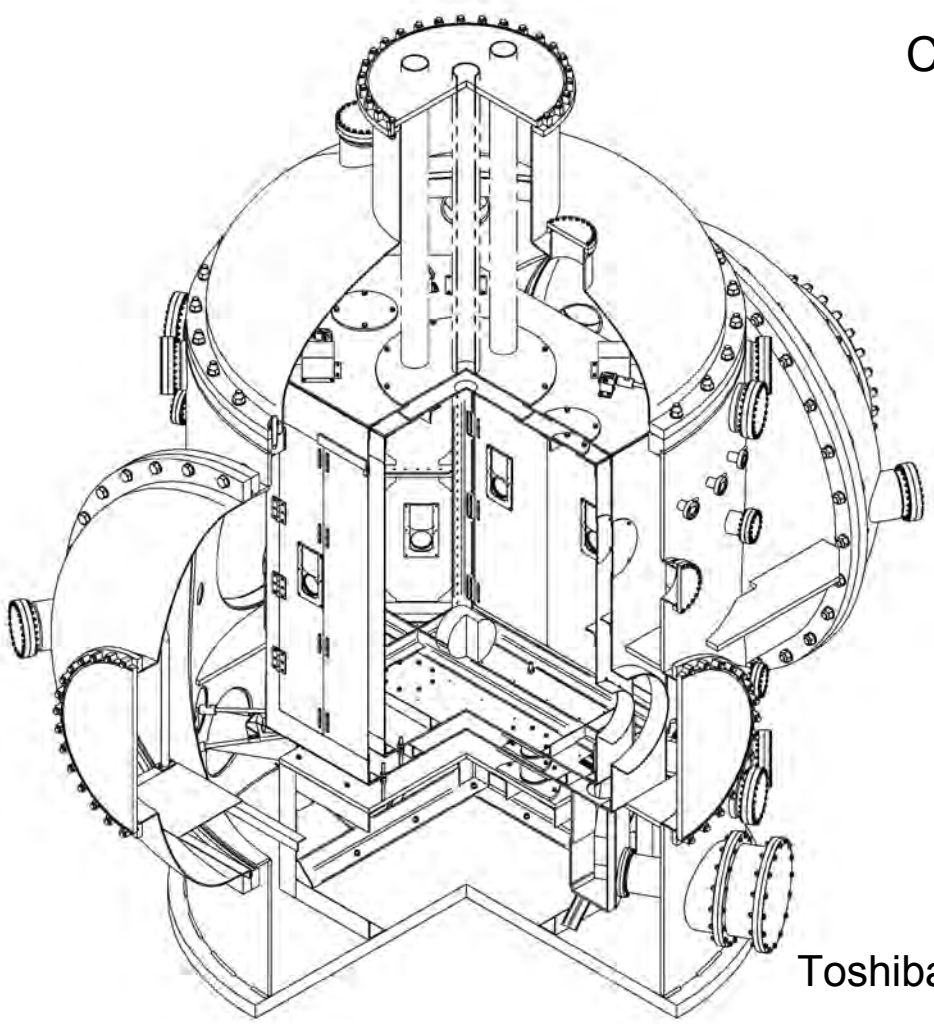
Y.Saito 2012.01.23

iKAGRA Risk management

Transportation through arm tunnel	Passing test by dummy model with same size. Correct the narrow path . (Require to be a part of tunnel construction.)
Leakage	Same as 300K vacuum chamber/components

bKAGRA Requirements

Cool test mass down to 20K and keep the temperature.



Toshiba

Cryostat

View ports with shutter
ϕ900 connection flange to SAS-A
ϕ800 service port
Hinged door on radiation shields
Two way 8K cooling path
2 of 5N8 Al bars -> inner shield
other 2 -> cryopayload

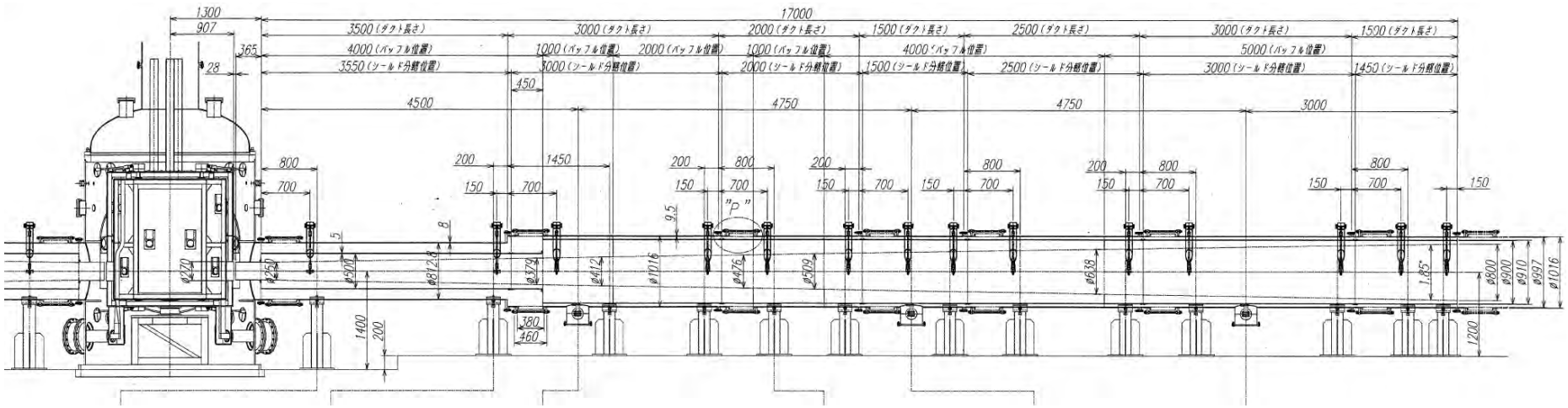
4K Cryocooler unit

Cooling power on the connection.
8K path: 2.5W or more at 9K
80K path: 35W or more at 70K
Vibration amplitude at the connection.
8K path: 100nm or less
80K path: 100nm or less

bKAGRA preliminary design

Cryostat
4K Cryocooler → Same design as iKAGRA
+ Extend 8K conduction bar
Two way of 8K path
+ Heat link to Cryopayload

Shield duct



Length 17m
Vacuum duct o.d. ϕ1000 / ϕ800
Baffles stop 300K radiation from the arm

bKAGRA Schedule

2011fy Cryostat : Purchase and machining of components.
Assembling 4K Cryocooler unit (7)
Performance test of Cryocooler units.

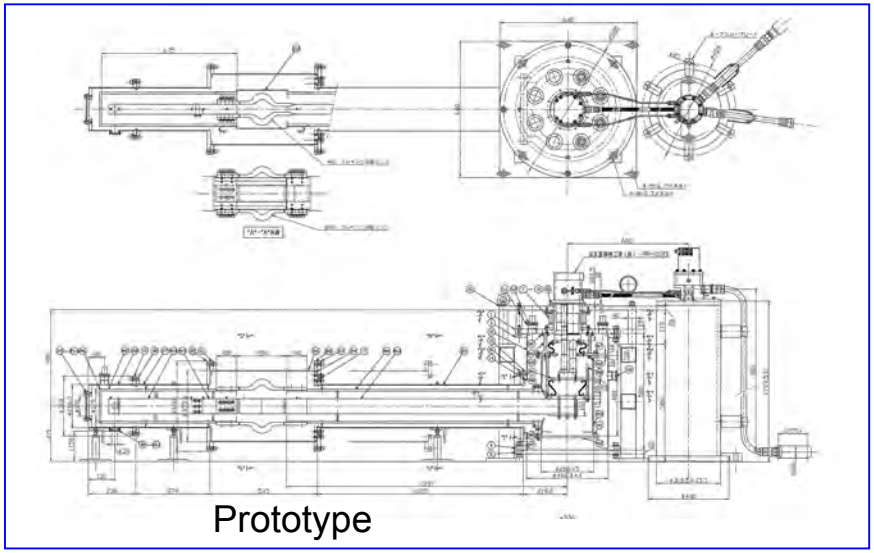
2012fy Assembling Cryostat (4) and 4K Cryocooler unit (9)
Performance test of Cryostats and Cryocooler units.
Design and trial manufacture a prototype shield duct.

2013fy Storage Cryostats and 4K cryocooler units.
Manufacture shield ducts.

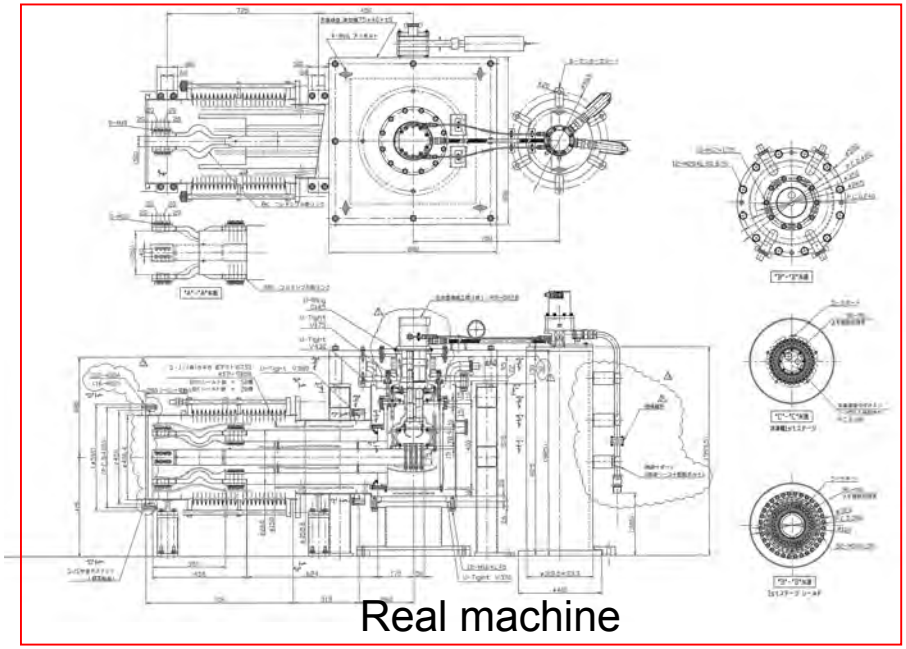
2014fy Start carry in and installation.
Two Cryostats install to the center room.
Other two install to each end.

bKAGRA Prototype test

4K Cryocooler unit



Prototype



Real machine

- Performance test
  - Load map
  - Vibration measurement

- Thicker 80K conductor.
- Fix connection hoses.
- Thicker upper plate.
- Increase number of bolt. for conductor connection.
- Shorter conduction paths.
- Strengthen support posts.

bKAGRA Quality assurance

Kashiwa 1/4 cryosystem

Scale model experiment of shield duct.
Dummy test mass cooling.

Cryostat in a end room with a prototype shield duct
+ SAS type-A
+ Clean area

Installation test
Performance test of cooling.

bKAGRA Installation scenario

Cryostat
4K Cryocooler unit → Carry in schedule is same as iKAGRA

Floor works/sole plate installation
~ 1 month, 5 workers
~ 2 weeks for curing
Assembling in end room
~ 1 month, 5 workers, 1 inspector

Shield duct

Depends on budget and manufacturing.

bKAGRA Risk management

Budgetary request
Maintenance expenses
Operation expenses

Business withdrawal by the company that produces necessary component

Excess heat load	Remove origin(s) Decrease heat into 8K cooling line
Excess vibration on inner shield	Put vibration Isolator

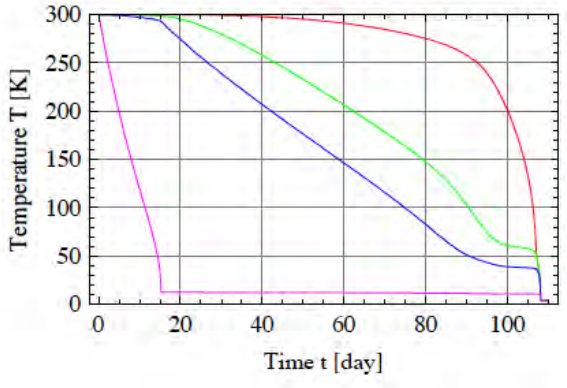
Dust control failure
Time constant of large cryogenic system
Leakage in cryogenic operation

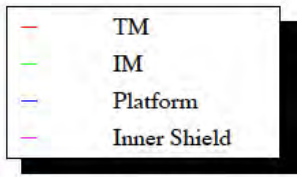
Life/maintenance period shortening in humid environment

Appendix A. Design changes that have been made with the suggestions in the 1st external review

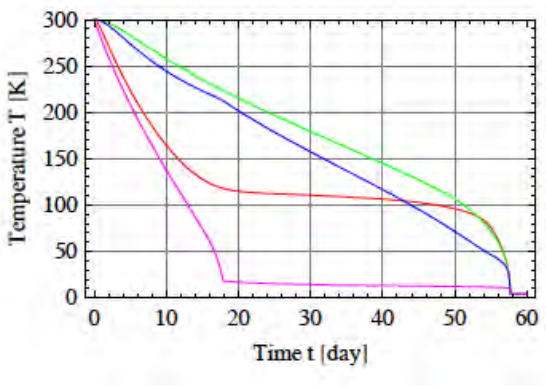
Boost initial cooling by radiation heat transfer

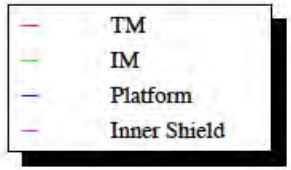
Y.Sakakibara Jul. 2011





Conduction





Conduction + Radiation

Status of manufacturing Cryostat

Four Cryochambers with shields

Contract with Toshiba in FY. 2011.

Mechanical analysis done.
Thermal analysis done.
Machining for components.
Partially assembling.

FY. 2012 Successful bidder : Toshiba

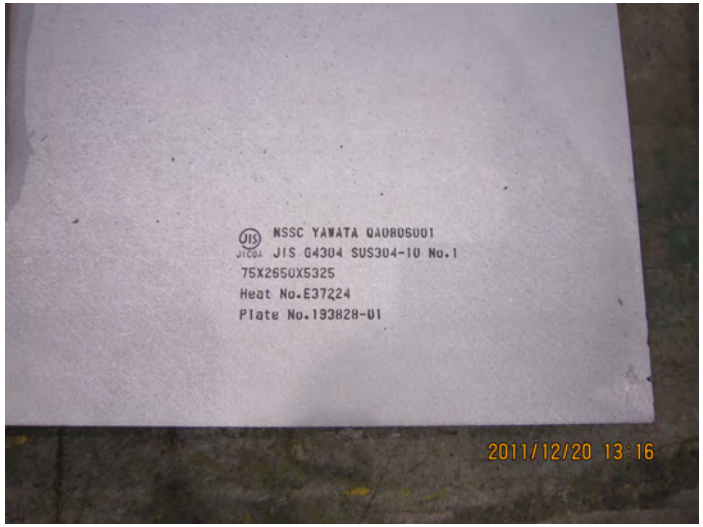
Assembling of cryostats.
Test of cooling performance.
Manufacture a shield duct by way of experiment.

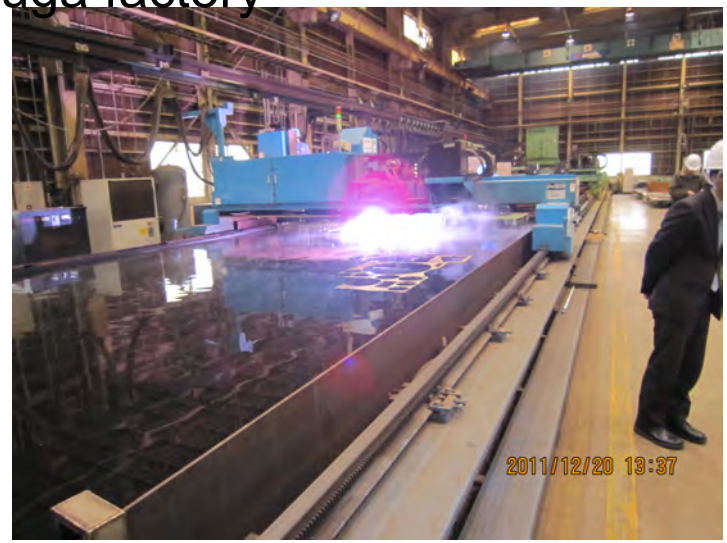
Issues

Selection of material for view port windows.
Fix a specification number of wiring in the cryostat.

SUS304 t70 plate for sole of cryostat inspection/receiving/transfer

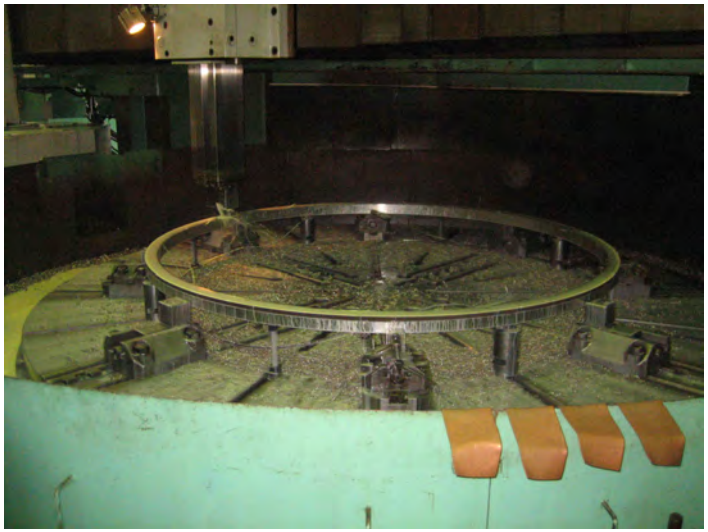
Daiwa shearing Kasuga factory

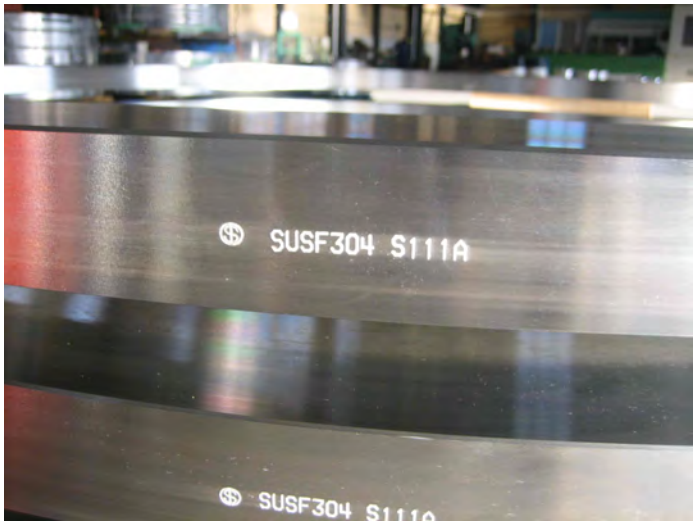




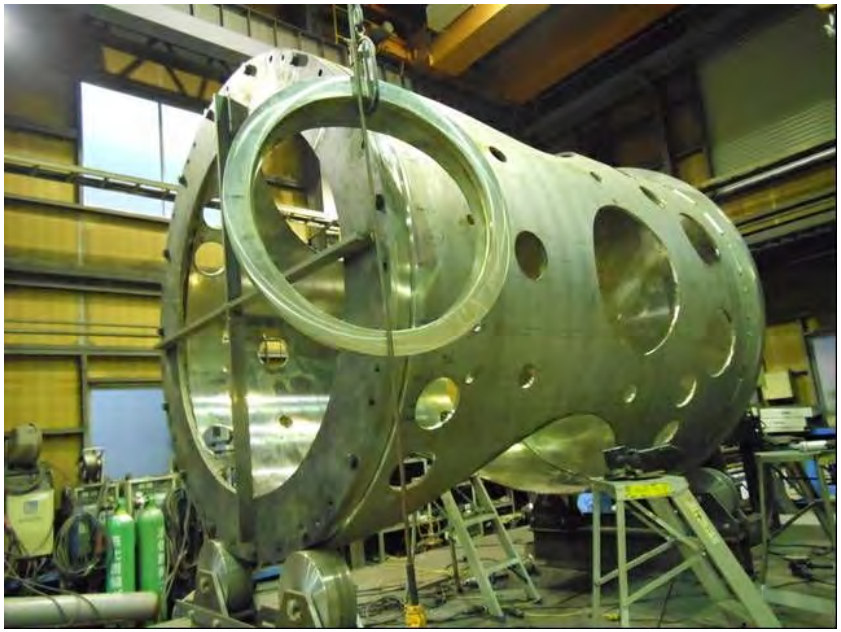
SUS304 large flange

Shimoda Flange Aioi factory



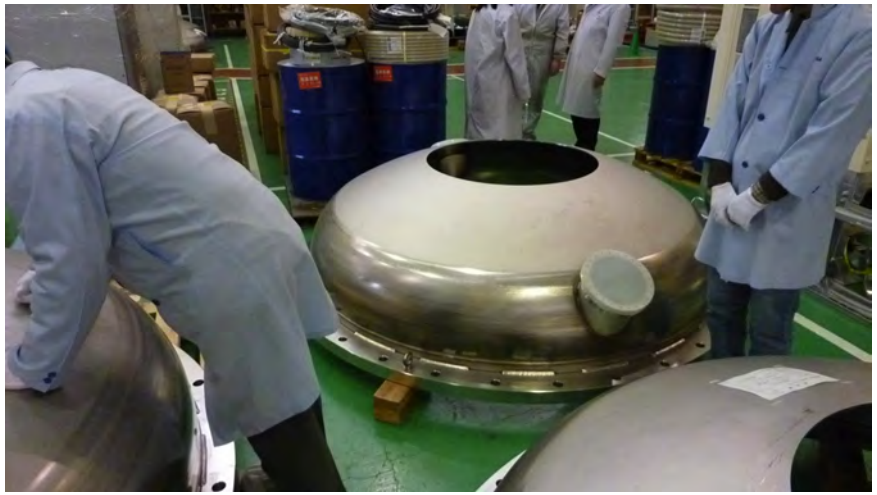


Machining parts at Toshiba Keihin Factory



Inspection and receiving at Toshiba Keihin Factory

2012.03.30



Status of manufacturing

Pulse Tube Cryocoolers

2012 Mar.

Inspection and receiving

9 sets of 4K pulse tube cryocoolers from SHI.
2 sets of 50K pulse tube cryocoolers from JAW.

Storage : ICRR Kashiwa Lab.

2012 June ~

It will carry to the factory for assembling low vibration units.

Issues

Measure cooling power under certain heat loads and make load maps.

Status of manufacturing

4K Cryocooler Unit

Manufacture 7 units in FY. 2011 and 9 units in FY. 2012.

Contract with JECC Torisha in FY. 2011.

Prototype test finished.
Design for production done.
Assembled 7 units.

2012 Mar. Inspection and receiving.

FY. 2012 Successful bidder : JECCTorisha

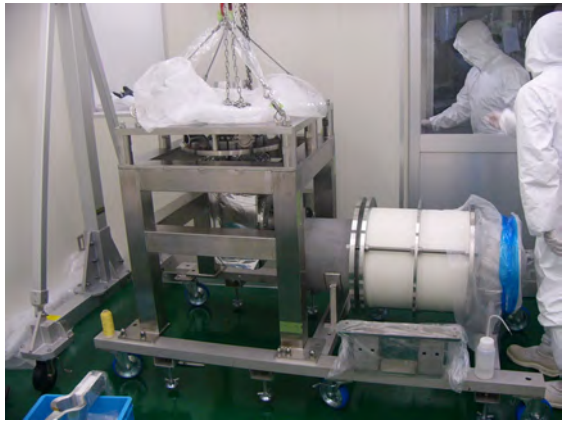
Manufacture 9 units.
Performance test.
Lend 8 units to Toshiba for test of cryostats.

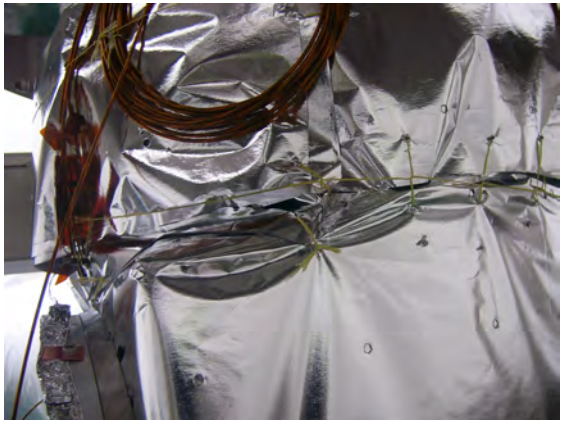
Issues

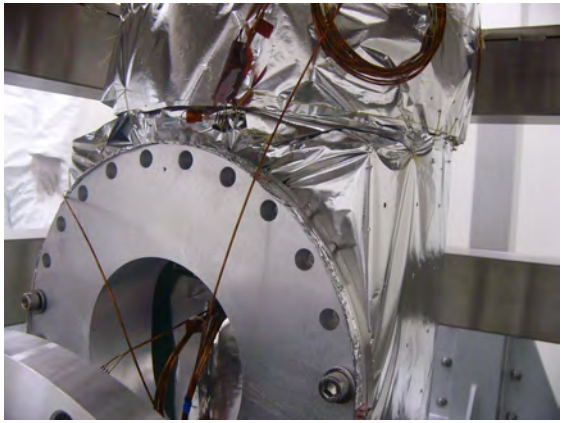
Establish a tight anchoring method to the ground.
Reinforcement of VRS and supporting post of cooling paths.

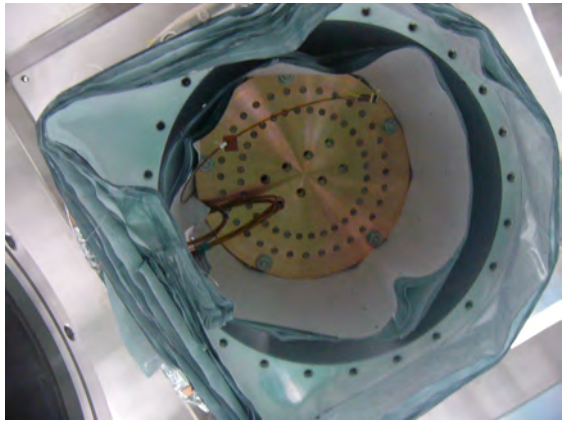
Assembling 4K cooler unit

JECC Torisha Kawagoe factory



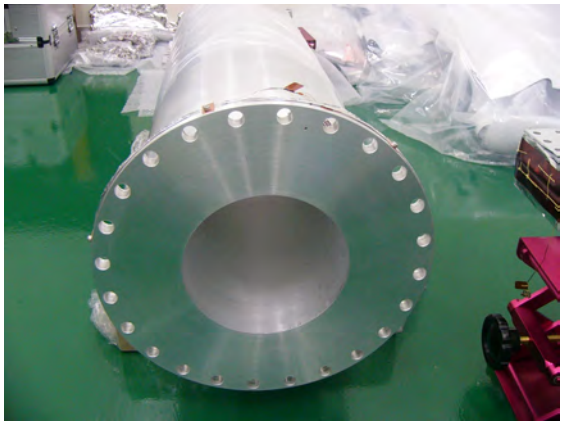


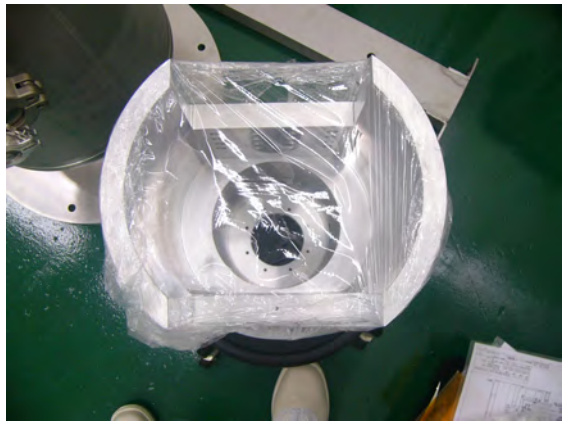




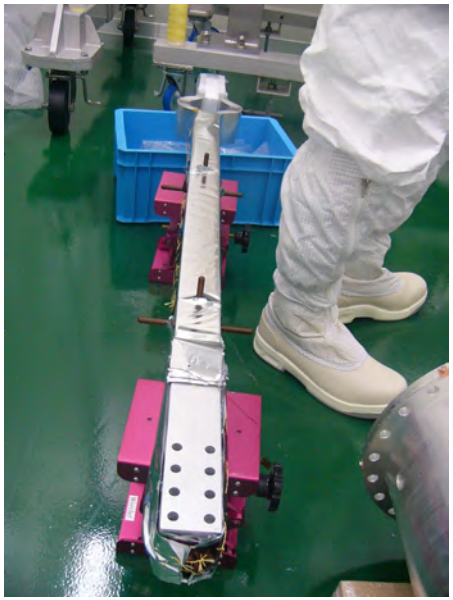
Assembling 4K cooler unit

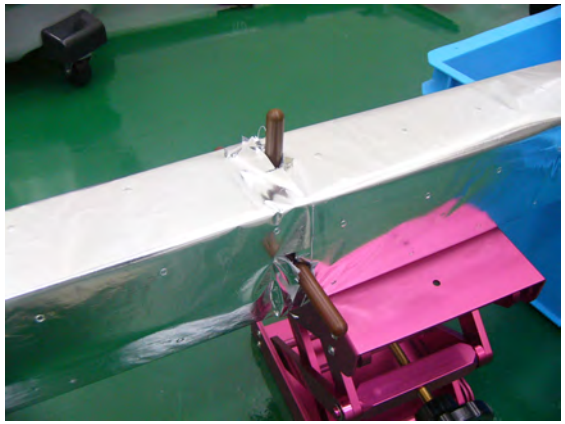
JECC Torisha Kawagoe factory





80K thermal conductor

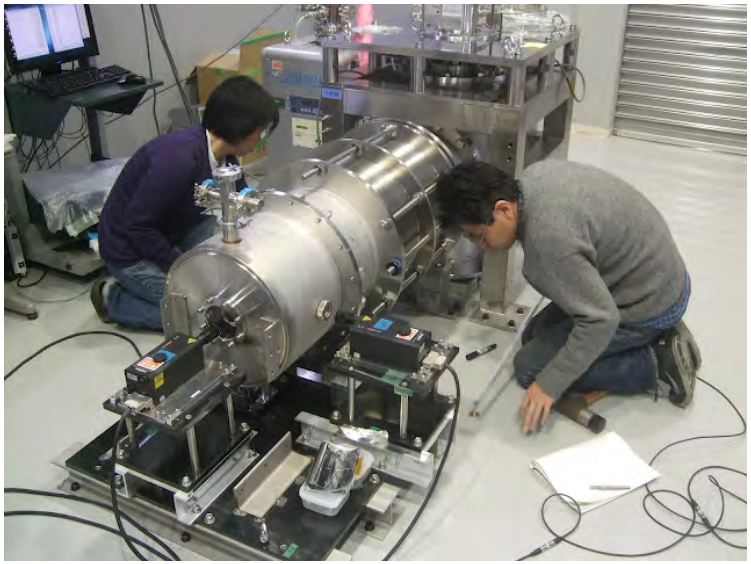


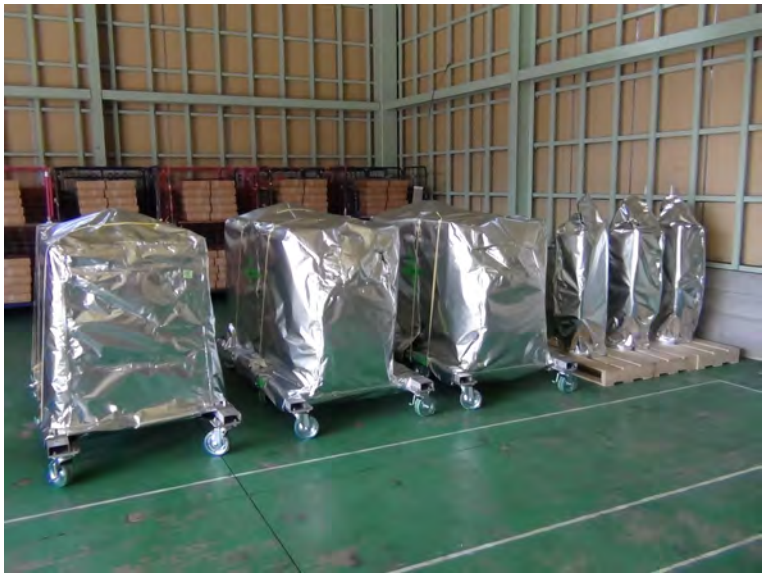


8K thermal conductor

Vespel support rod

Inspection and storage





Status of manufacturing Shield Duct

FY. 2011 Basic studies for thermal radiation protection.
Designing thermal radiation baffle configuration.
Prototype design in progress.

FY. 2012 Design continuation with Toshiba.
Manufacture one set with single stage PTCs.

Issues. Find a tolerable temperature distribution.
Optimize a thermal resistance distribution and configuration of PTCs.

Completion will depend on a success of Budgetary request.

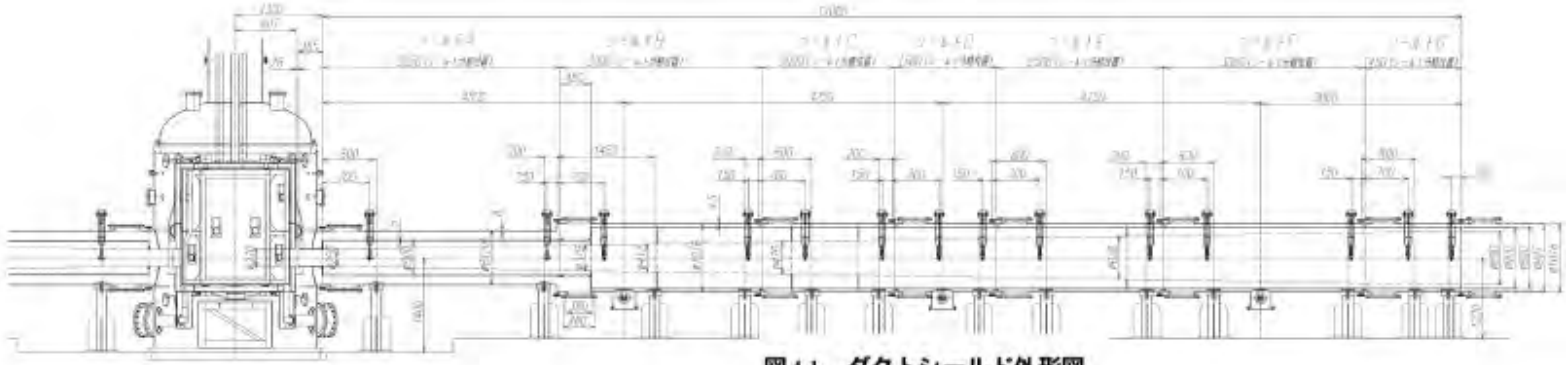


図4.1 ダクトシールド外形図