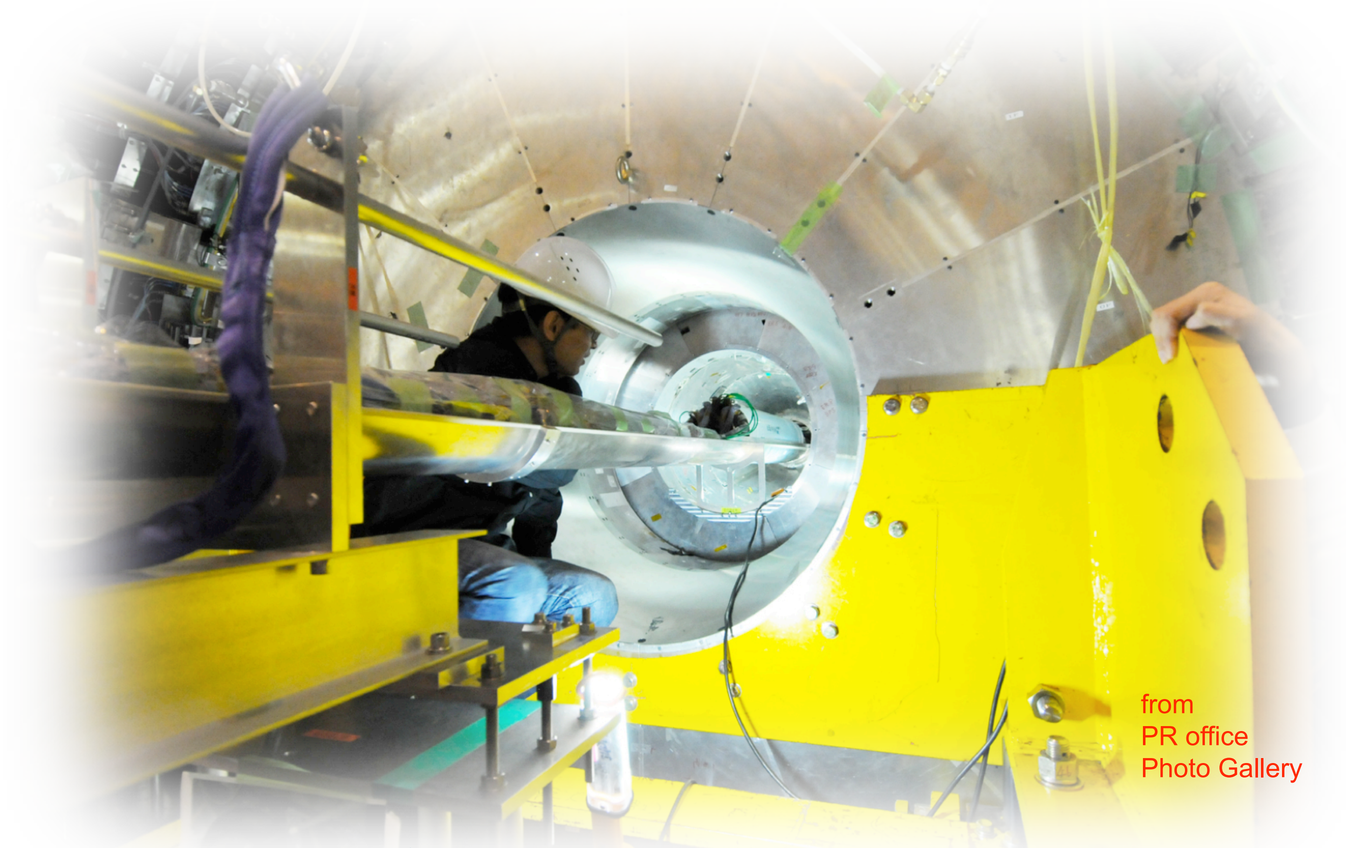
IR Vacuum Chamber and Assembly



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IR Technical Meeting Member
IR Installation Meeting Member
SVD/IR Mechanics Meeting Member

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1. Beam Pipes in the Cryostat Overview

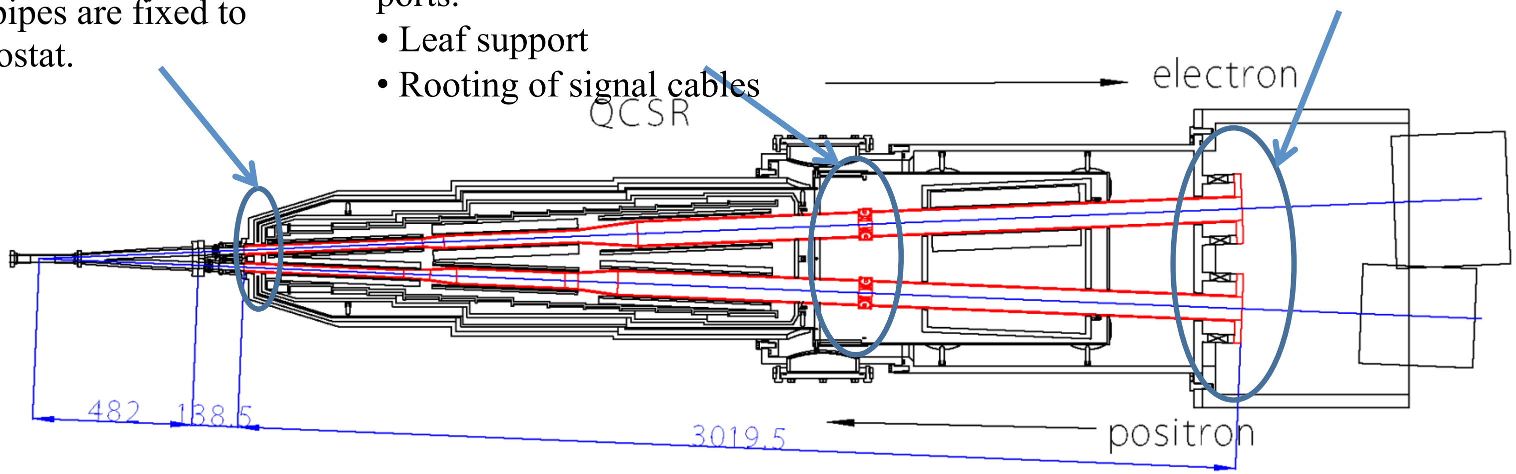
Beam pipes are part of the cryostat.
Two kinds of beam pope will be manufactured.

- Dummy beam pipe for the magnetic field measurement：Stainless steel, 2-3 mm thick.
- Beam pipe for machine operation: Ta is suggested, 4mm thick except BPM
    - NEG coating (Inside, Ti-Zr-V, Thickness: 1μm, Activation temperature: 150-180℃)
    - BPM
    - Cooling channel, heater (for NEG activation), thermosensor.

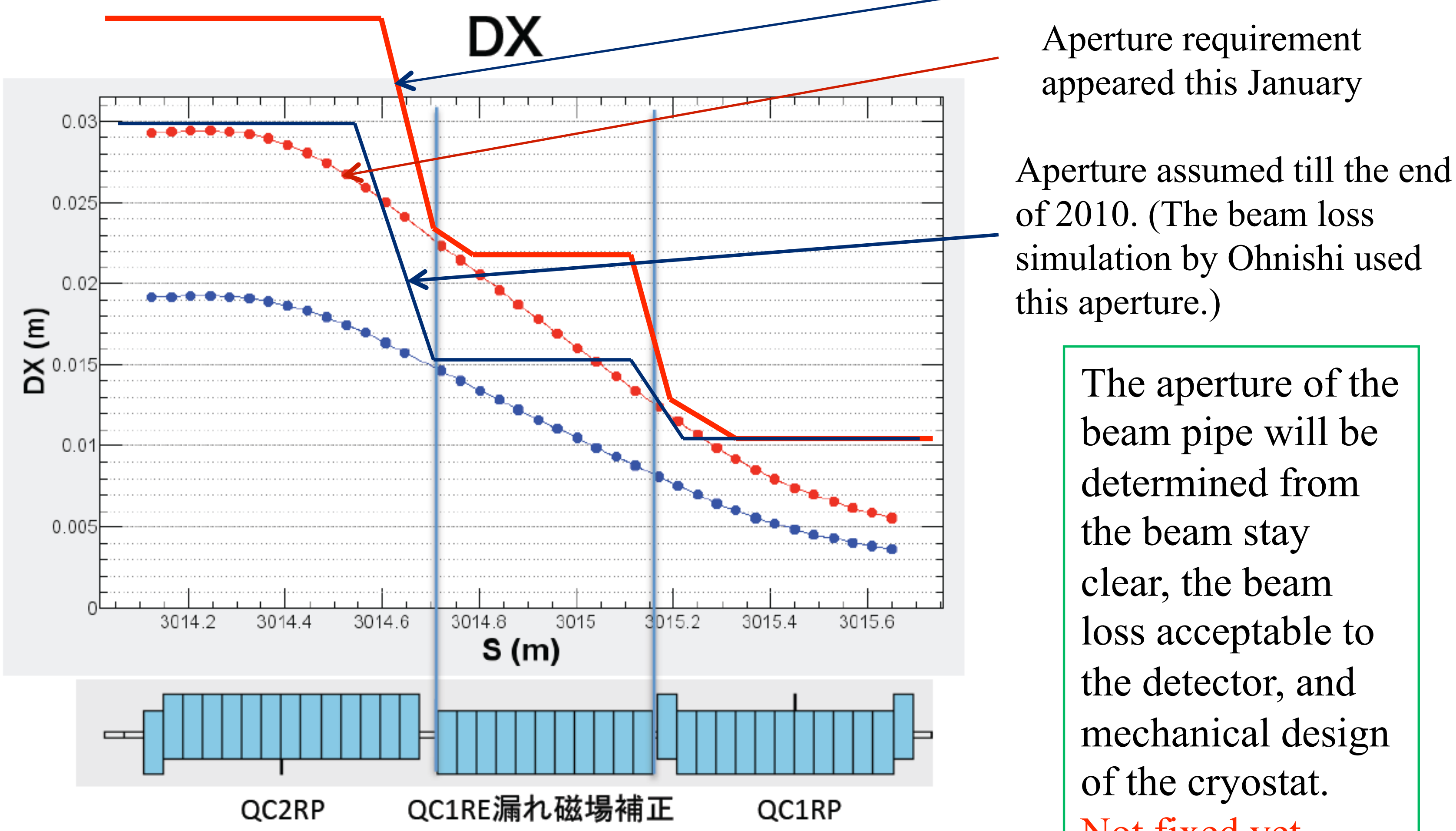
Beam pipes are fixed to the cryostat.

- Pick-ups for BPM are screwed after the beam pipes are inserted into the cryostat using service ports.
- Leaf support
- Rooting of signal cables

- Beam pipes and the cryostat body is intervened with bellows.
- Cooling pipes, heater, thermosensor will be fed through the end flange.



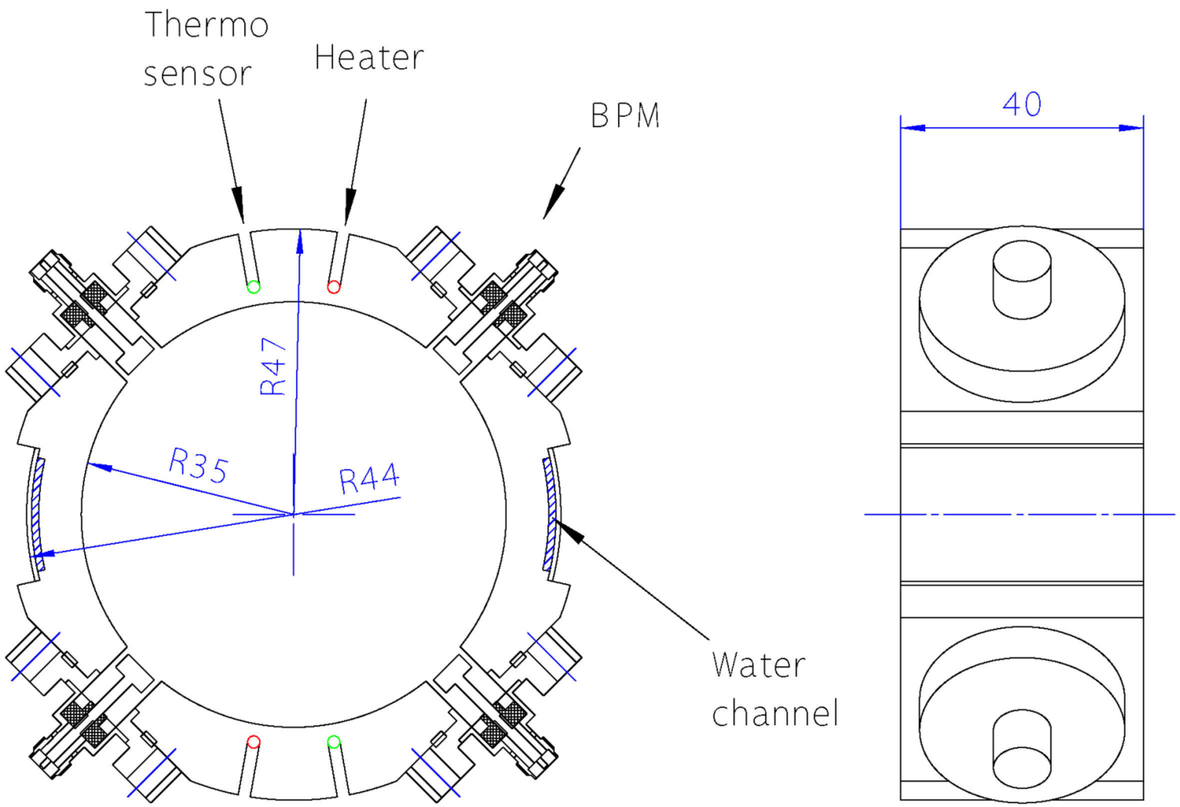
1. Beam Pipes in the Cryostat Aperture



The aperture of the beam pipe will be determined from the beam stay clear, the beam loss acceptable to the detector, and mechanical design of the cryostat. Not fixed yet.

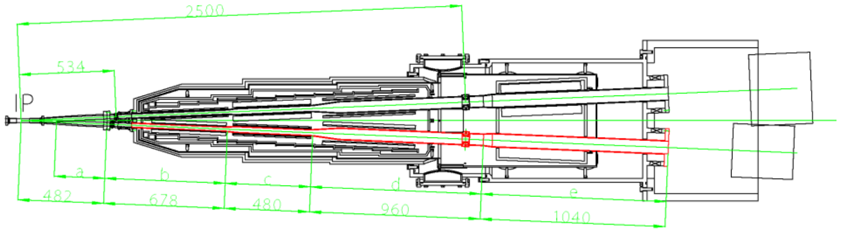
1. Beam Pipes in the Cryostat
BPM

• The thick part of the beam pipe to screw BPM pick-ups is available by making use of the aperture difference before and behind BPM.
• This part will be supported by a leaf support.
Whether QCS design allows these issues or not is still under consideration.



1. Beam Pipes in the Cryostat Pumping and Cooling

Example: QCSR



Beam pipe	In-coming positron	Out-going electron	
Major heat source	Direct SR from BL0RP: 1.4 Wall loss [a]: 0.8	Wall loss [a]: 0.4	kW
Temperature rise of water [b]	12	2	℃
Major gas source	Photo-desorption: 0.13η	Thermal desorption	Pa m^3
Pressure [c]	~10^{-6}	<10^{-7}	Pa

[a] For Ta

[b] ~2.6 l min^{-1} with the velocity of 2 m sec^{-1}

[c] Pumping speed of NEG ~ 10^{-4} Pa m^3 ($1cm^2$) and $\eta = 10^{-5}$

At a pressure of 10^{-6} Pa, NEG will saturate within one day. High capacity coating must be studied.

1. Beam Pipes in the Cryostat
Connection to IP Chamber

• IP chamber and the cryostat is connected with bellows chamber to absorb a possible motion of the cryostat after exciting magnetic fields.

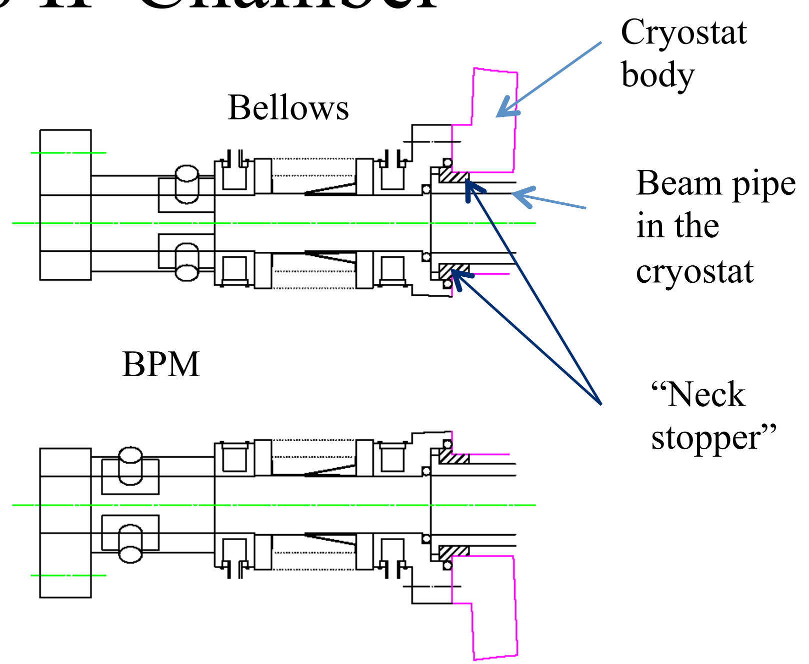
• The bellows has a finger type rf-bridge to ensure flexibility.

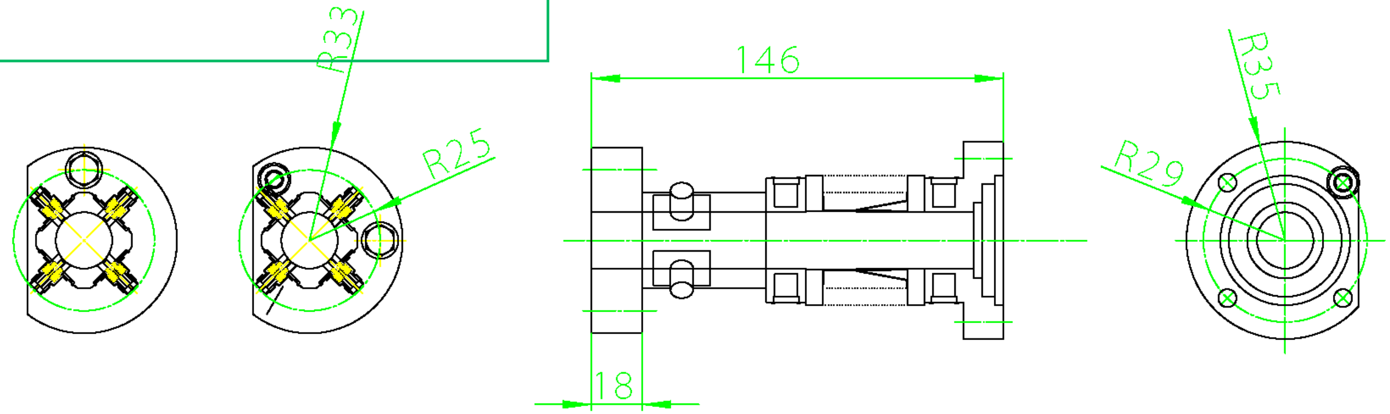
• The bellows is water-cooled on both ends.

• The bellows and BPM is integrated into a short pipe. This makes it easy to replace them.

• The position of bellows is fixed to IP chamber.

The sealing mechanism on both ends of the pipe is designed using reduced number of screws. A model chamber to test the sealing mechanism is now being prepared.



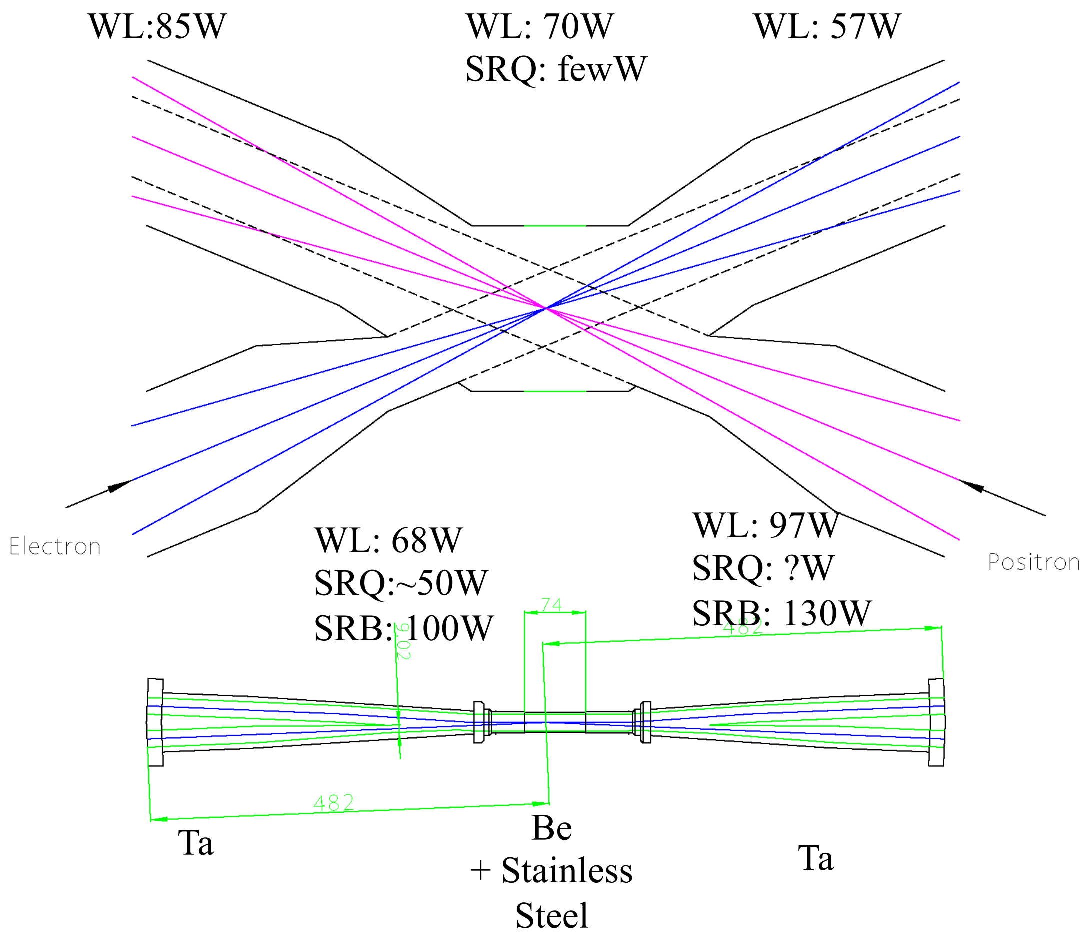


Summary for the Beam Pipes in the Cryostat

- As material for the beam pipe, Ta is suggested at present from the view point of detector back ground.
- The basic connecting structure to the cryostat on the IP side is fixed.
- For the other side, a bellows is necessary. And feedthroughs for water, heater, and thermo-sensor must be incorporated. The design for this part will be proposed till the end of this fiscal year.
- To install pick-ups of BPM, accessibility from outside of the cryostat is necessary.
- The possibility of leaf support and of increasing the bore of beam duct at the position of QC2E must be feed backed from the cryostat design.
- The manufacturing of Ta pipe and its high capacity NEG coating will be tested in FY 2011.
- The connecting structure between the cryostat and IP chamber will be tested within this fiscal year.

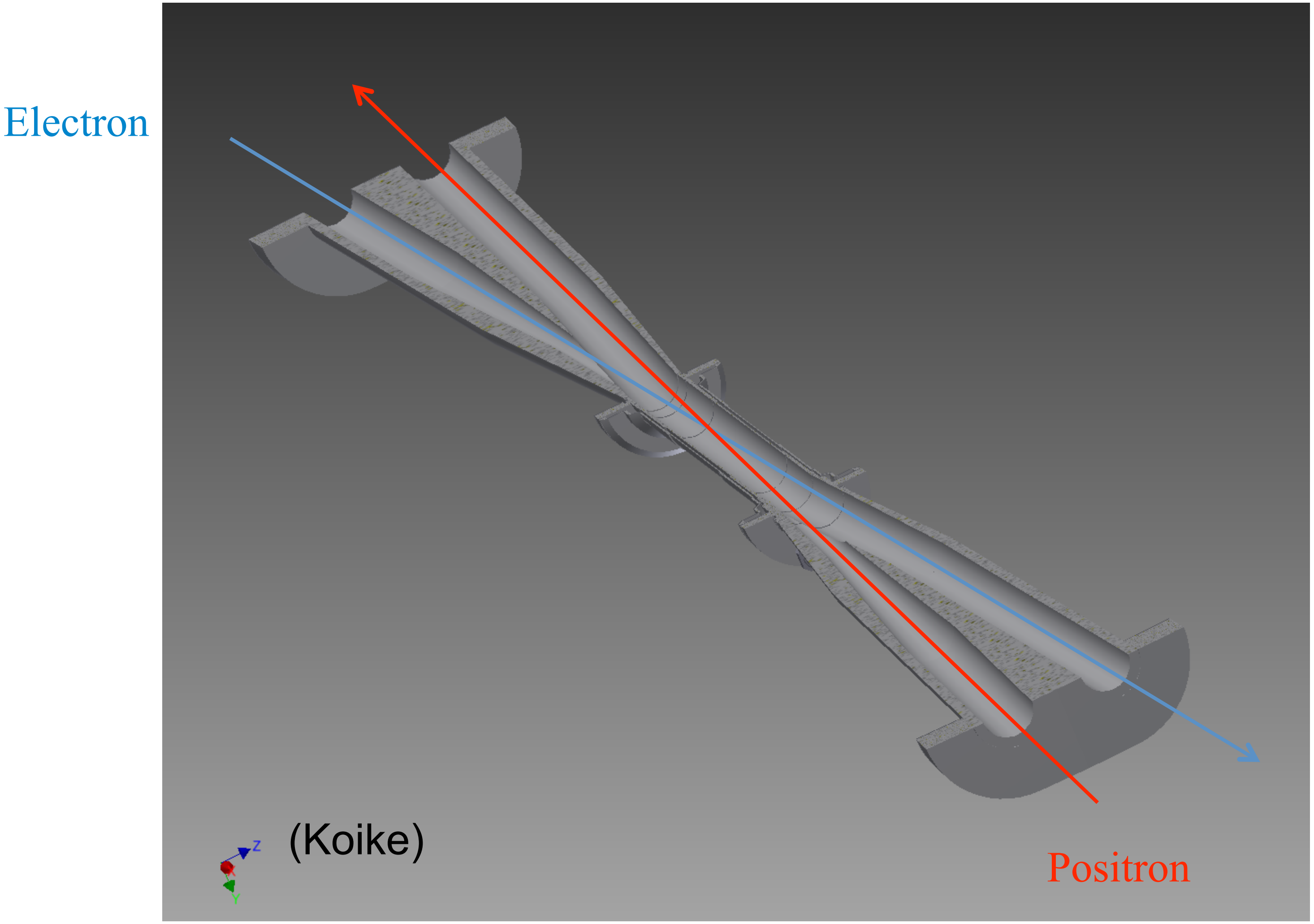
The application of NEG coating is criticized in the Domestic Review last month, because it is not a perfect solution. Recent studies require a larger aperture than before for the beam pipe. This may change the condition for the design of pumping scheme.

2. IP Chamber
Design features of the inner shape



- Minimize the creation and the trap of HOM.
- The pipe for incoming beam start from ID20 mm. Then ID is gradually reduced to about 9 mm to mask SR.
- The central part is a ID20mm straight pipe.
- The central part and the branch for out going beam constitute a bent pipe of ID20mm.
- The inner surface of a pipe for incoming beam has ridges to prevent scattered light from hitting the central part.
- All inner surface will be coated by 10~100mm thick Au.

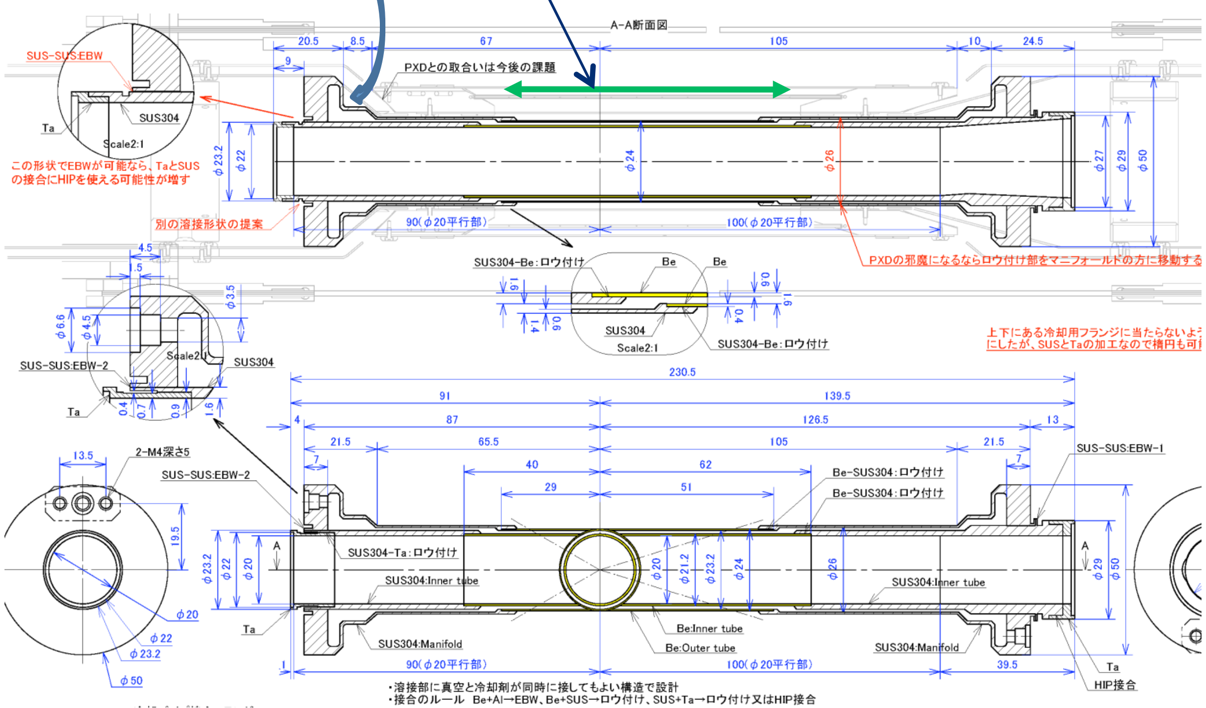
2. IP Chamber
Cut View



2. IP Chamber Central Part

Diaphragm to absorb the change of the length of Be pipes.

Be double tube



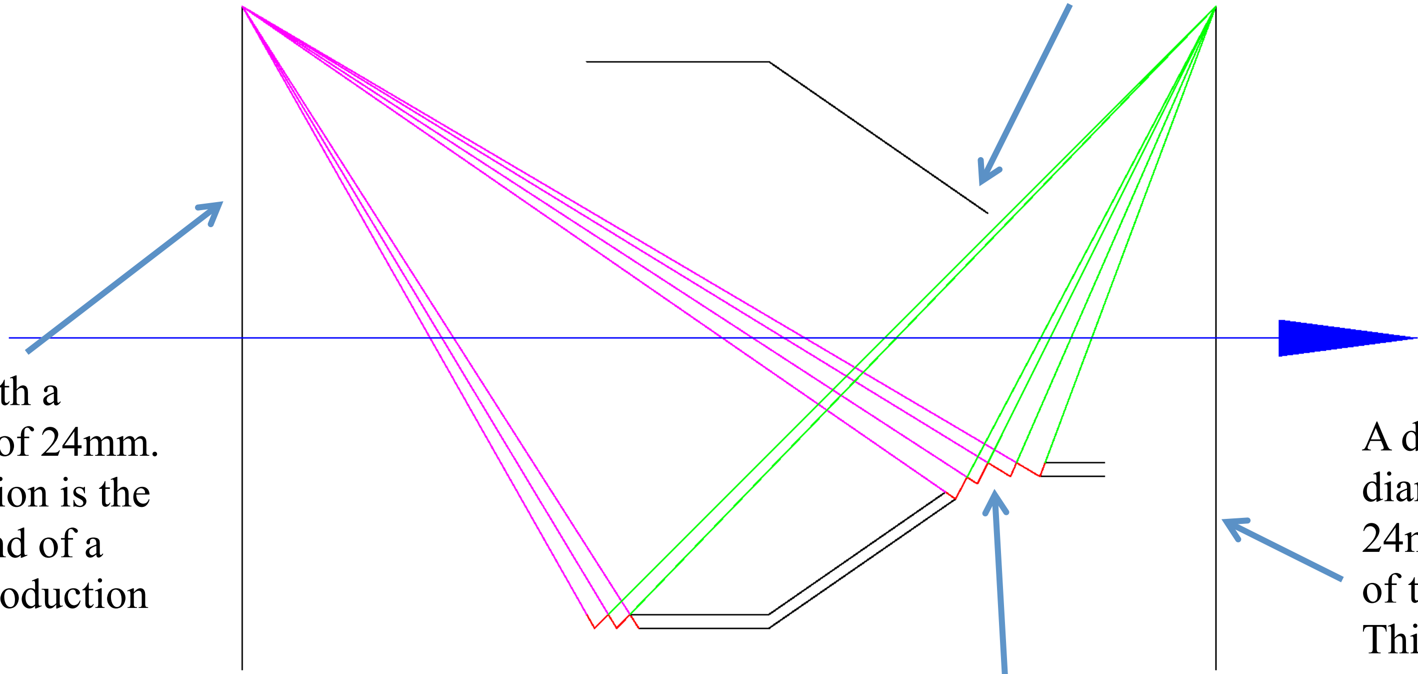
(Kohriki)

- The central part of the central part is a Be double tube. The gap is a space for a coolant.
- The coolant is paraffin. The flow of paraffin can absorb a heat of ~270W for a temperature rise of 10℃. (Estimated heat load from the beam is less than 100W.)
- Both ends of be double tube are manifolds made of stainless steal. Ta is attached to stainless steal by HIP to connect a branched part by EBW.
- In this design, it is permitted to put a weld seam between paraffin and vacuum.

Mock-up model for cooling test

2. IP Chamber Ridge

Thin wall around here cannot has a ridge structure. However, scattered photons from this part enter the central pipe with a shallow angle and give no serious effect.



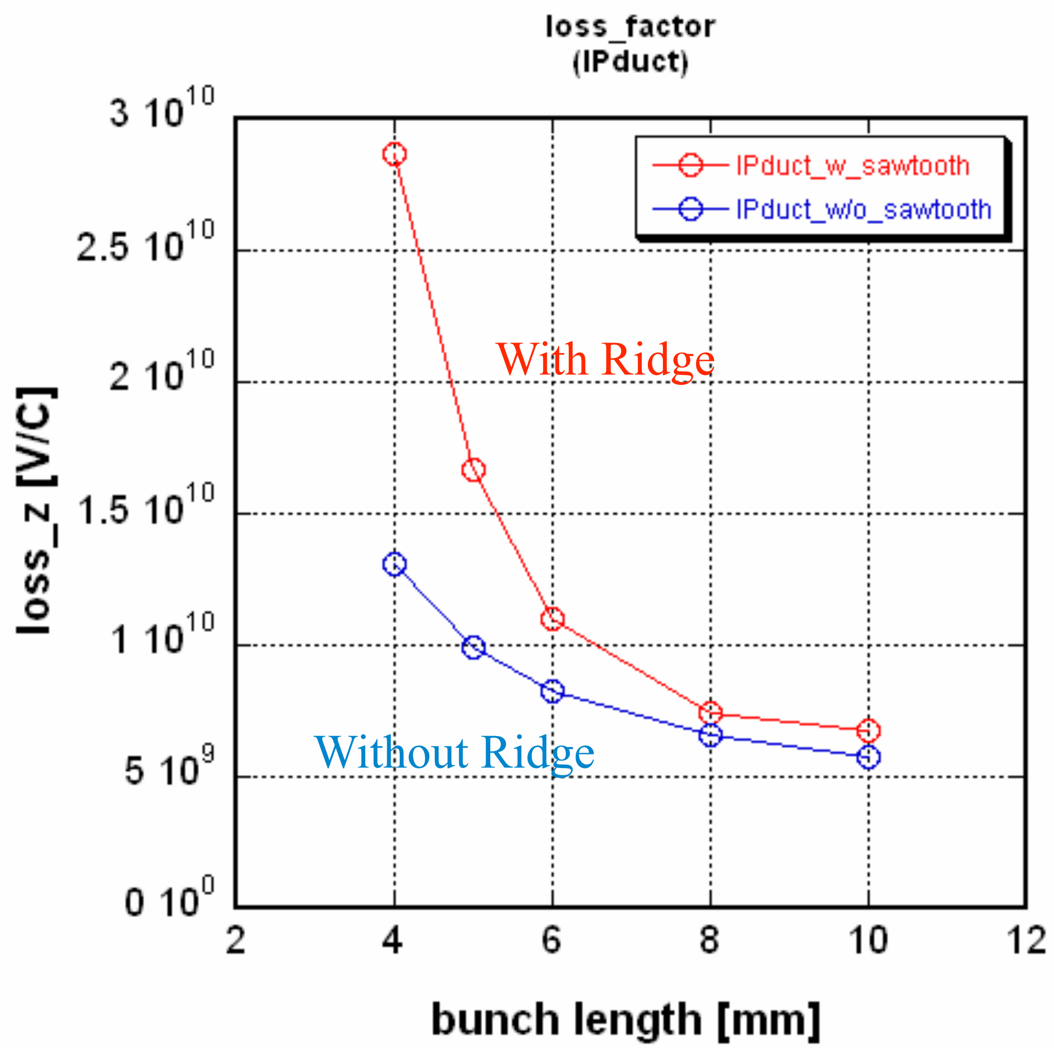
A disk with a diameter of 24mm. The position is the nearest end of a photon production region.

A disk with a diameter of 24mm in front of the Be pipe. This disk should be free from scattered photons.

The narrowest aperture must be a ridge, of course.

Only single scattering is taken into account. Test machining is in progress.

2. IP Chamber
Loss Factor (of HER beam)



(Shibata)

Loss factor [V/C]

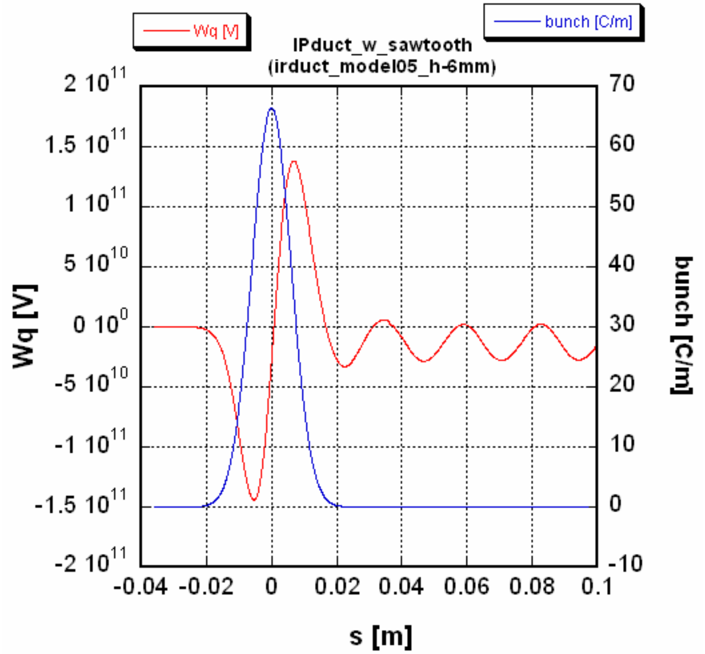
Bunch length [mm]	With Ridge	Without Ridge
3		
4	2.87E+10	1.31E+10
5	1.67E+10	9.92E+09
6	1.10E+10	8.28E+09
8	7.38E+09	6.62E+09
10	6.73E+09	5.78E+09

Power loss [W]
(current : 2.62 A, bunch spacing:4 ns)

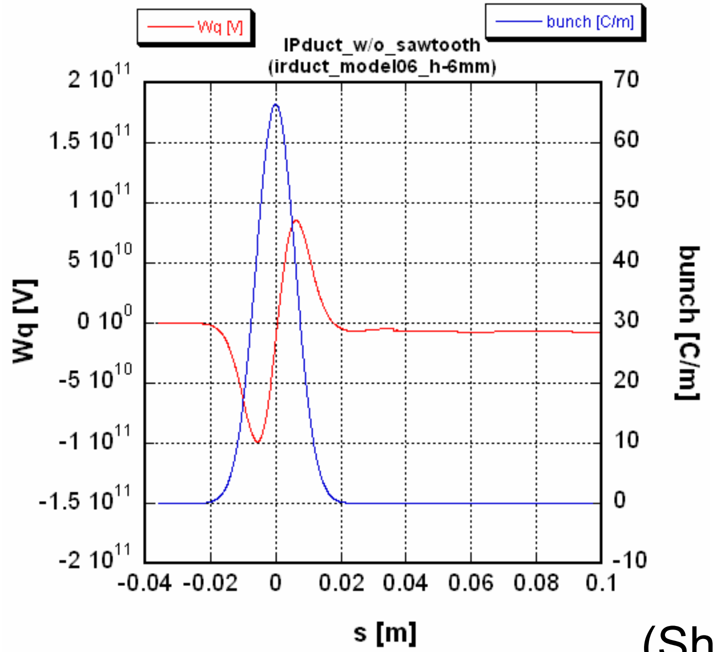
Bunch length [mm]	With Ridge	Without Ridge
3		
4	7.88E+02	3.60E+02
5	4.58E+02	2.72E+02
6	3.03E+02	2.27E+02
8	2.03E+02	1.82E+02
10	1.85E+02	1.59E+02

2. IP Chamber
Longitudinal Wake Potential (of HER beam)

With Ridges



No Ridges Bunch length = 6 mm

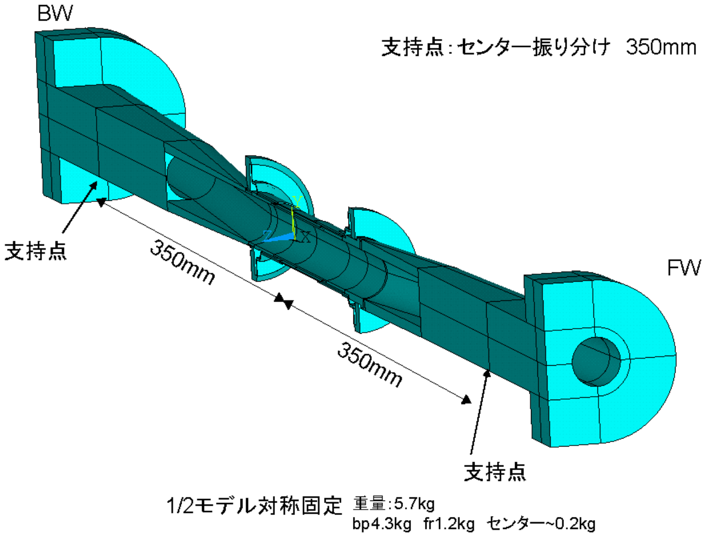


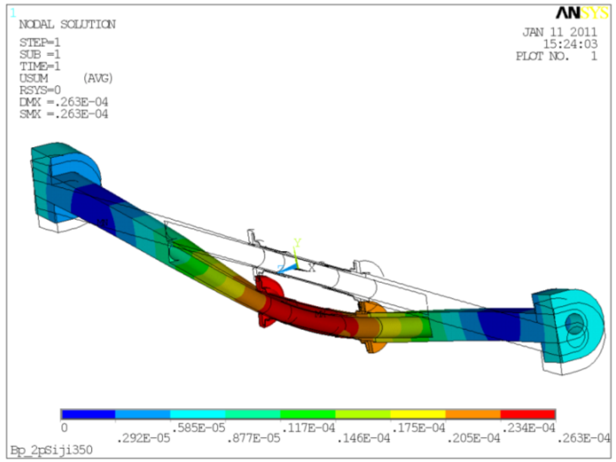
(Shibata)

With a ridge structure, a long oscillating wake appears. The effect of this wake is now under study.
The estimation of the transverse impedance is also to be done.

2. IP Chamber Stress Analysis

(Koike)





変位：Max 0.026mm

Results of stress analysis of the IP chamber

- Even if the chamber is horizontally supported at one end , the maximum stress in the Be part (157 MPa) is less than its yield strength (245 MPa). (It doesn't break!)
- If the chamber is supported at both ends, the central part bend down 0.44 mm, and the stress in the Be tube is 39 MPa.
- If the chamber is supported at the proper position of the Y-shaped part, the central part bend down only 0.026 mm (above picture), and the stress of Be pipe becomes as small as 3.5 MPa.

Therefore, though IP chamber has a delicate built structure, it is not so weak as to require a help of a special supporting tool in handling.

Summary for IP chamber

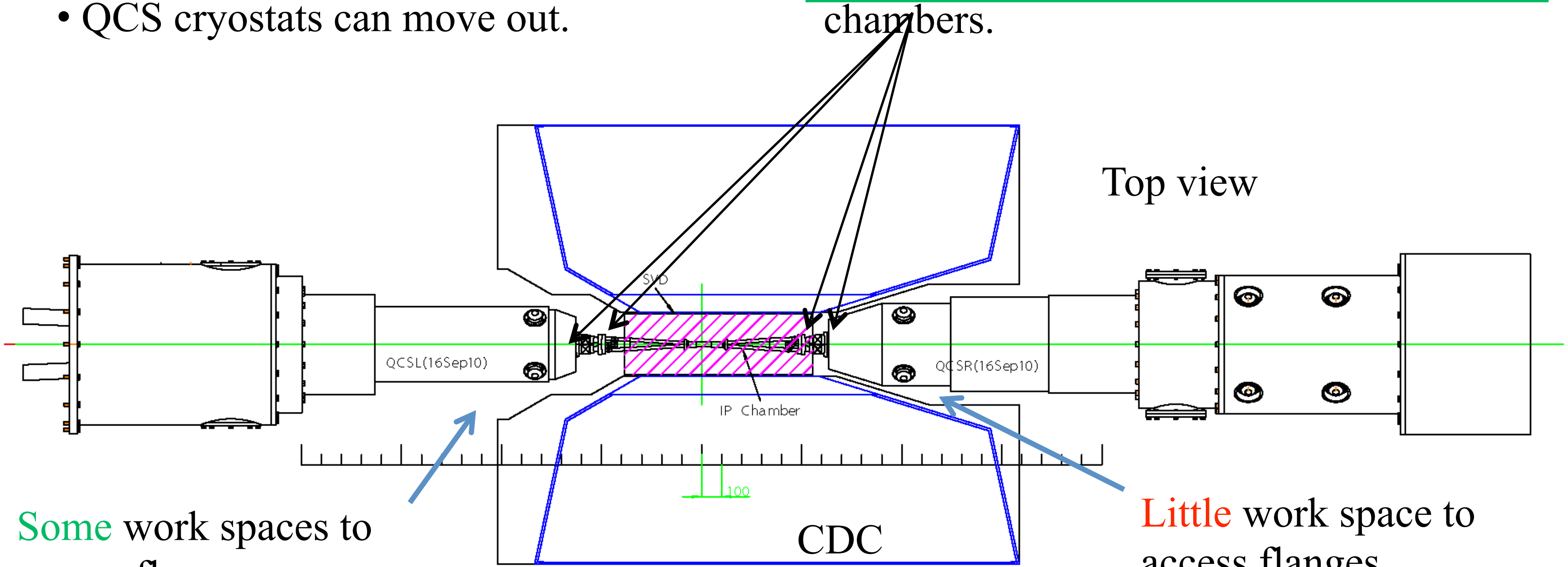
- A basic design of the IP chamber has been proposed.
- In FY 2011, the test of most of technical issues will be over and the final design will appear.
- The ridges in a beam pipe induces a long standing wake. The effect will be studied.
- According to stress analysis, IP chamber is not so weak as to need a help of a special supporting tool in handling.

3. Installation Overview

Find a solution for installing this IR structure.
~ Establish a reasonable procedure to connect vacuum chamber flanges.

- IP chamber is supported by SVD frame.
- SVD is supported by CDC.
- QCS cryostats can move out.

Connection flanges for vacuum chambers.

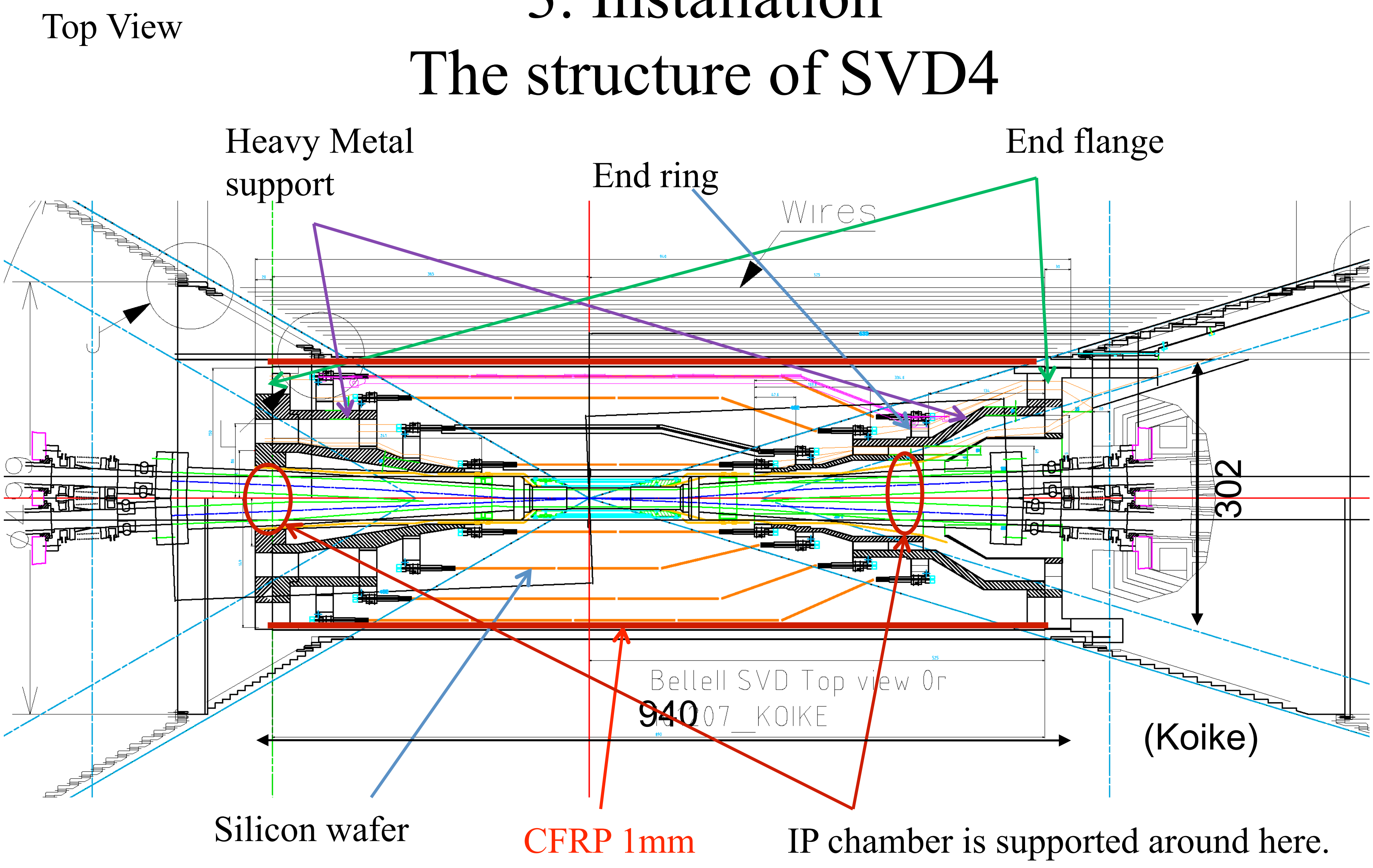


Top view

Some work spaces to access flanges.
It will be possible to make use of these spaces.

Little work space to access flanges.
It is impossible to connect flanges in this configuration.

3. Installation
The structure of SVD4

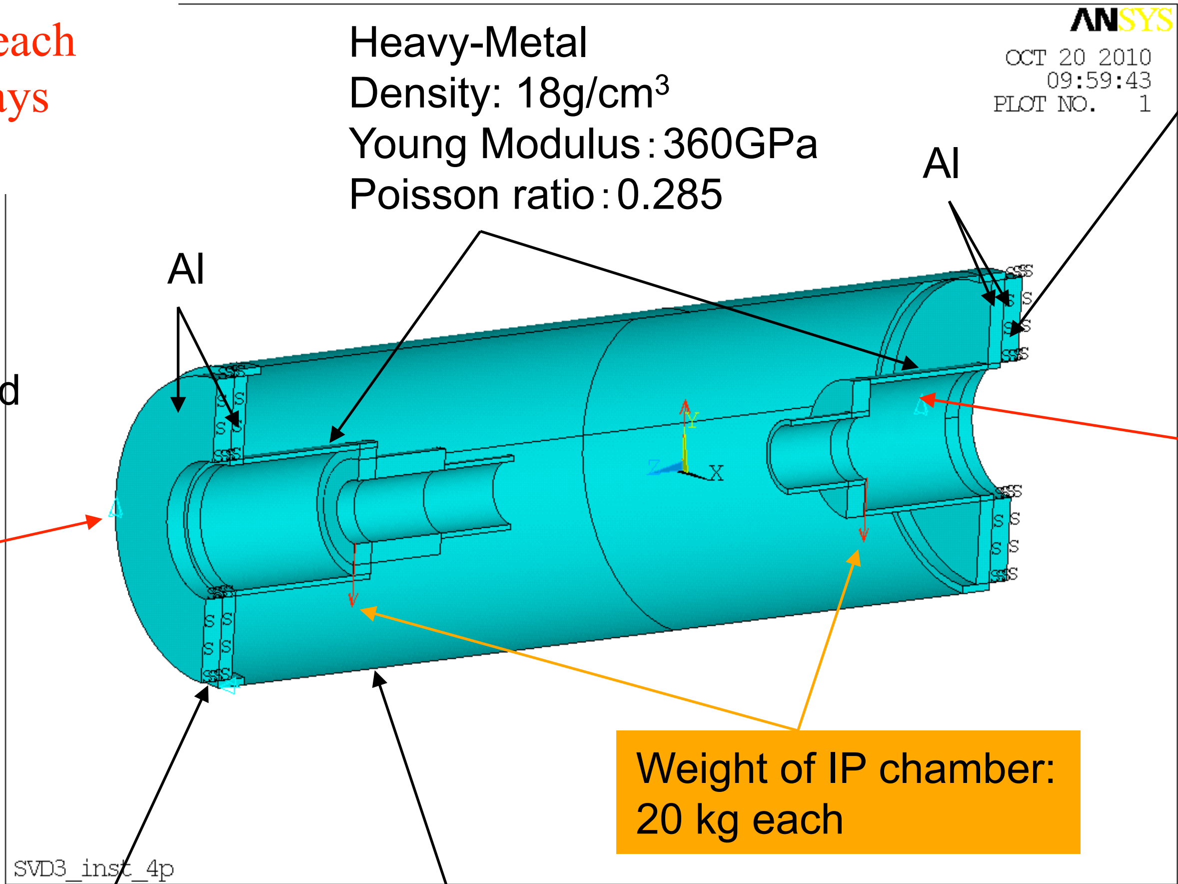


The total amount of Heavy Metal is not fixed yet.
The total weight of SVD4 unit will be close to 100 kg.

3. Installation
Stress Analysis of SVD4

(Koike)

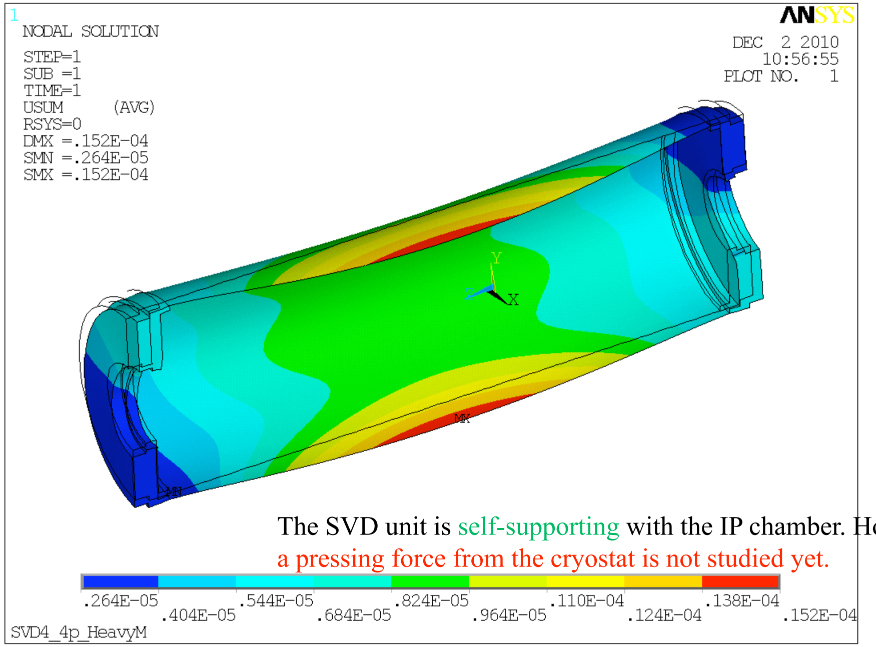
The outside CFRP and heavy-metal structure in each half are always separated.



Total weight ~78 kg

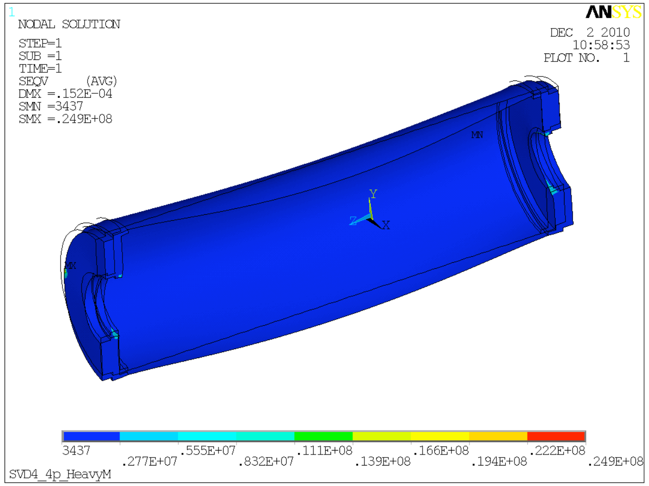
3. Installation
Stress Analysis of SVD4 - Results

(Koike)

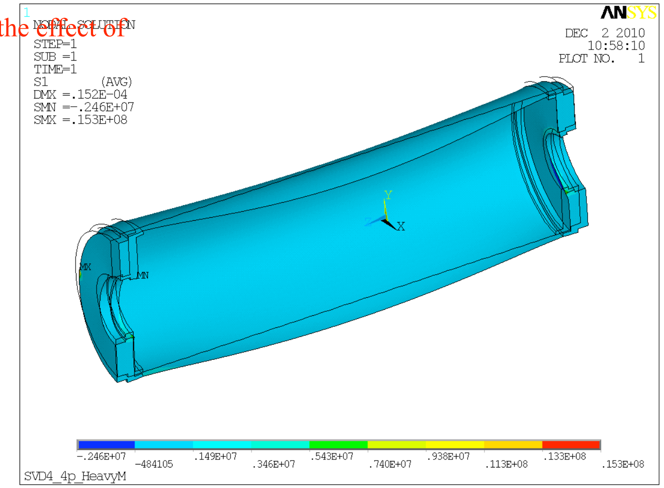


The SVD unit is self-supporting with the IP chamber. However, the effect of a pressing force from the cryostat is not studied yet.

Maximum displacement: 0.015mm



Equivalent stress : Max 25MPa



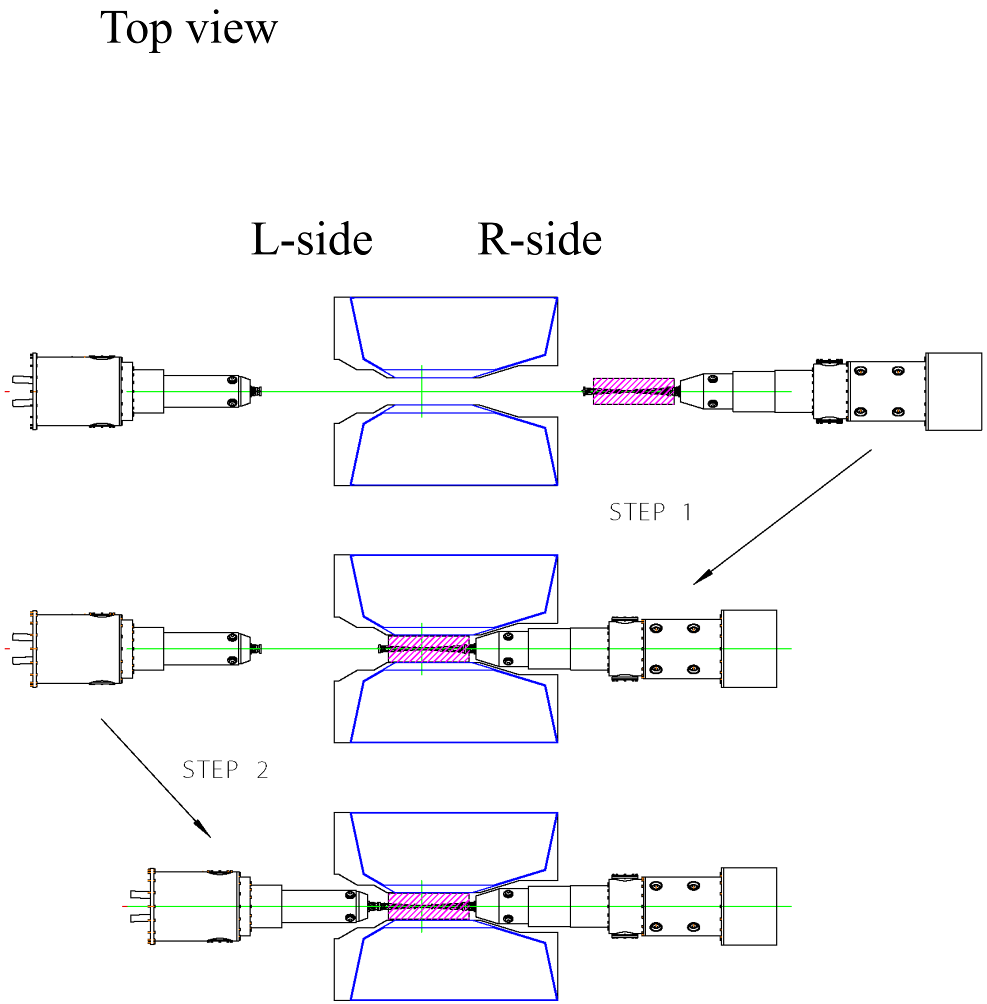
Principal stress : Max 15MPa

The results for CFRP are shown.

- Deformation is very small.
- Stress is much less than the tensile strength.

SVD4 keeps its shape when supported at both ends.

3. Installation
Basic Steps



1. Connect IP chamber with SVD4 to the QCSR cryostat.
2. The QCSR cryostat moves in.
3. The QCSL cryostat moves in.
4. Connect the flanges in front of the QCSL cryostat.

To support SVD4, a gutter is used.

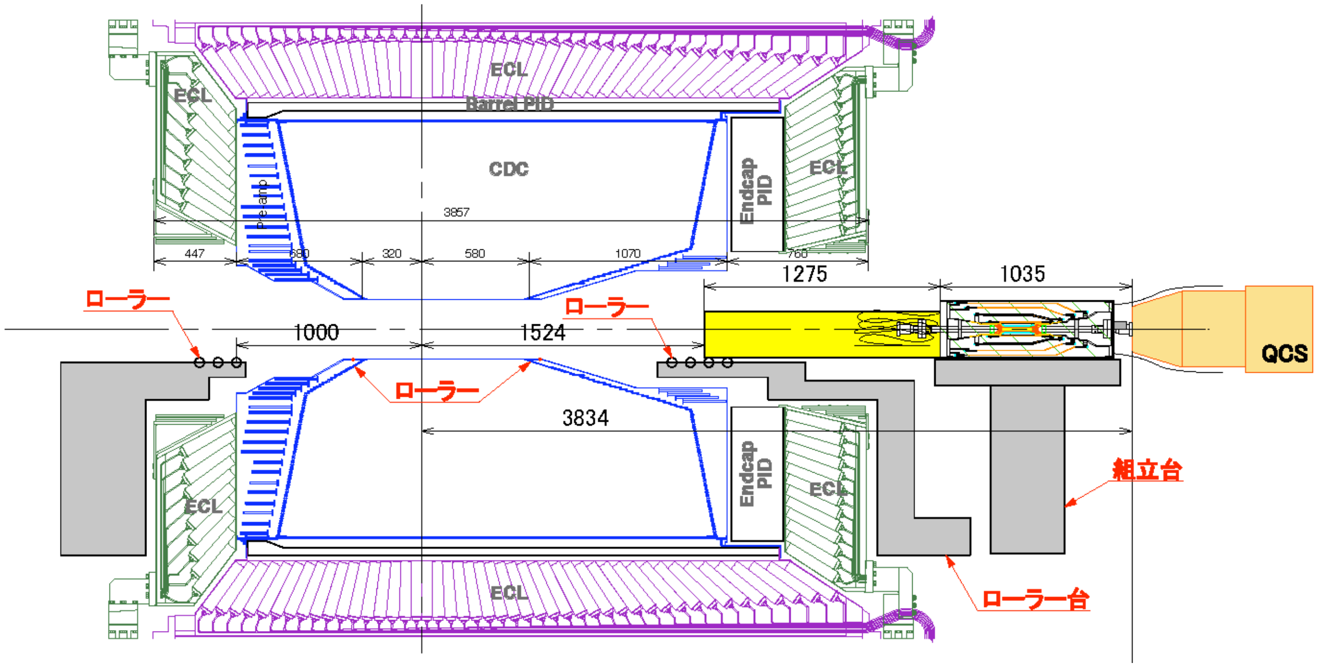
Both sides of IP chamber are fixed to the SVD4 frame transversally and are free longitudinally.

The R-side of SVD4 is aligned transversally and is free longitudinally.
The L-side of SVD4 is fixed to CDC.

3. Installation
Step 1 – Ready to go

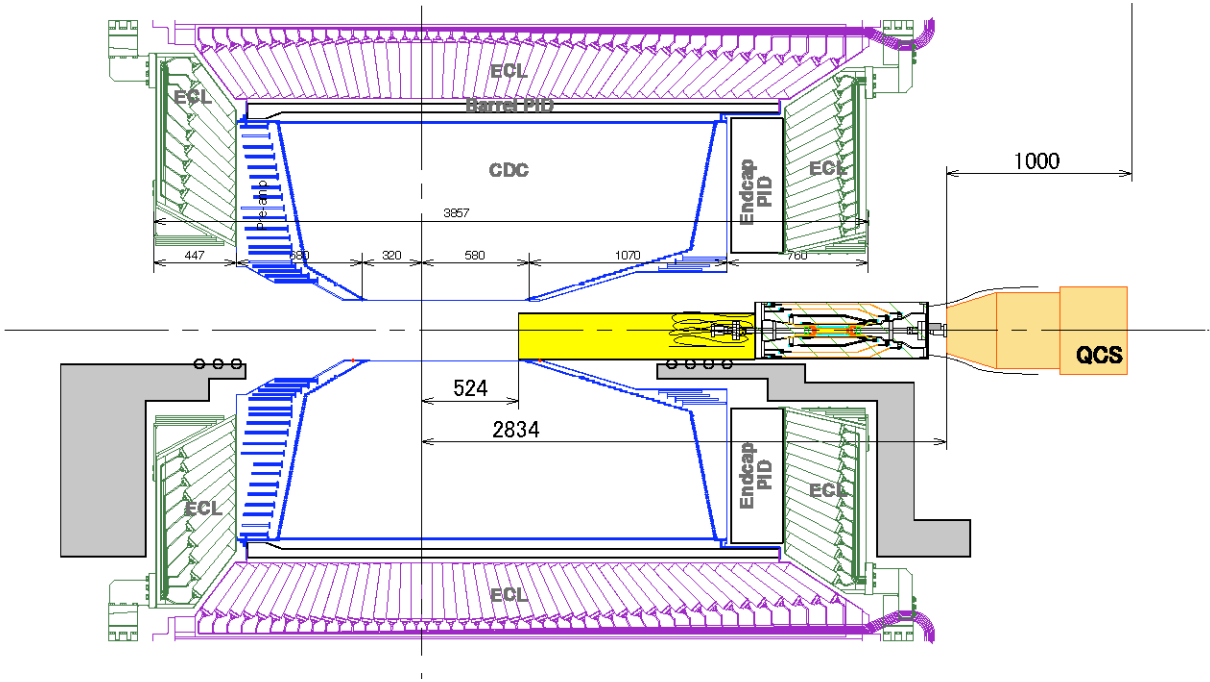
•The gutter is attached to SVD4. The other side of SVD4 is supported by the QCSR cryostat.

•SVD4 must hold by itself. During move-in of the QCSR cryostat, SVD4 is pushed by the cryostat.



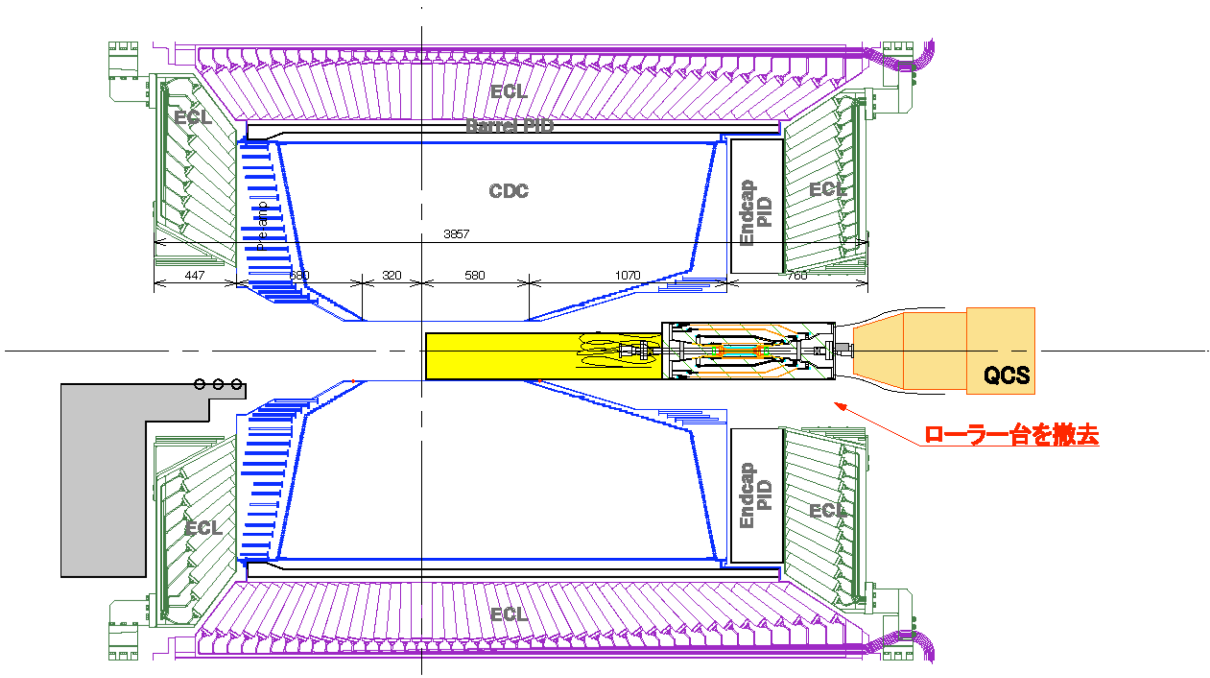
(Kohriki)

3. Installation
Step 1- ongoing



(Kohriki)

3. Installation
Step 1 - ongoing



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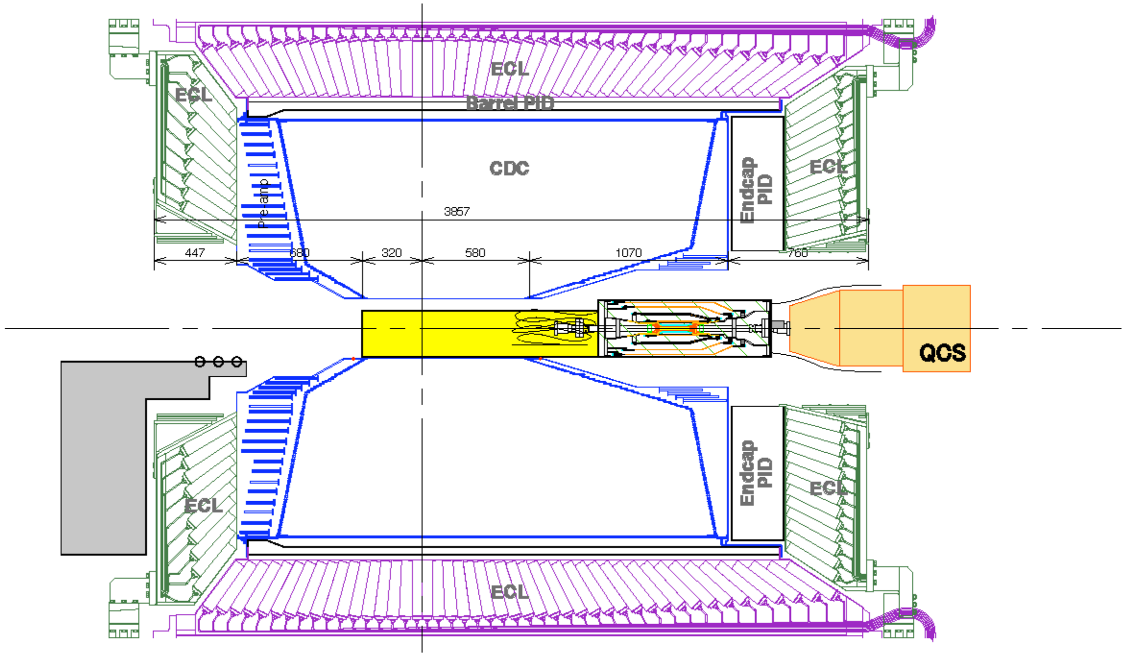
3. Installation
Step 1 - ongoing



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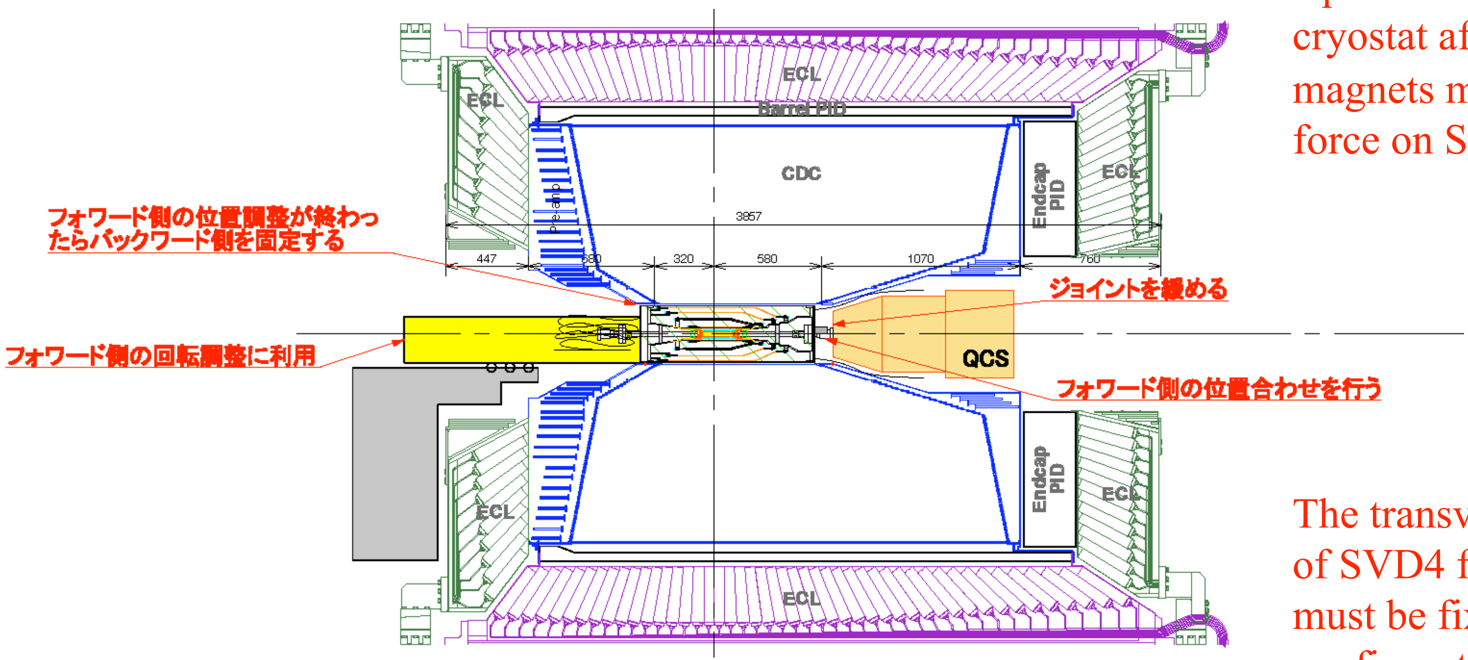
3. Installation
Step 1 – SVD4 arrives at the goal position

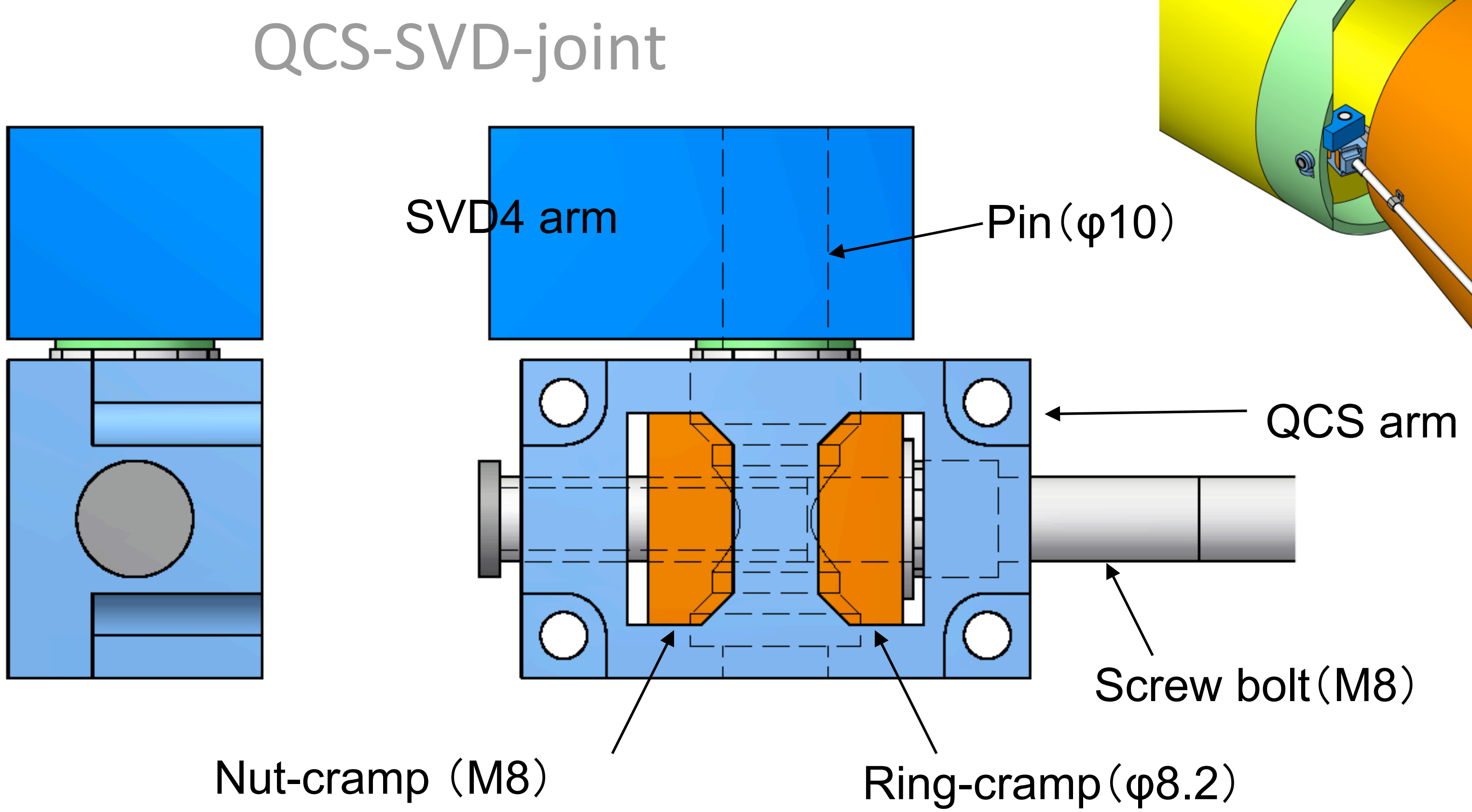


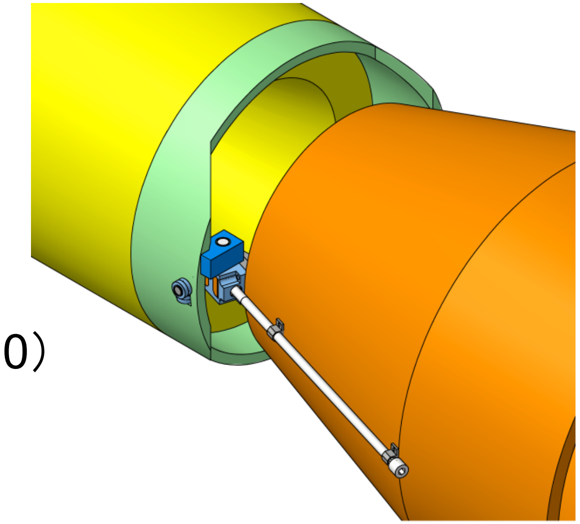
The junction between SVD4 and the cryostat must be loosened so that a possible motion of the cryostat after exciting magnets may not exert a force on SVD4.

The transverse position of SVD4 forward end must be fixed in this configuration.

(Kohriki)

3. Installation
Step 1 – Loosen the junction between SVD4 and QCSR





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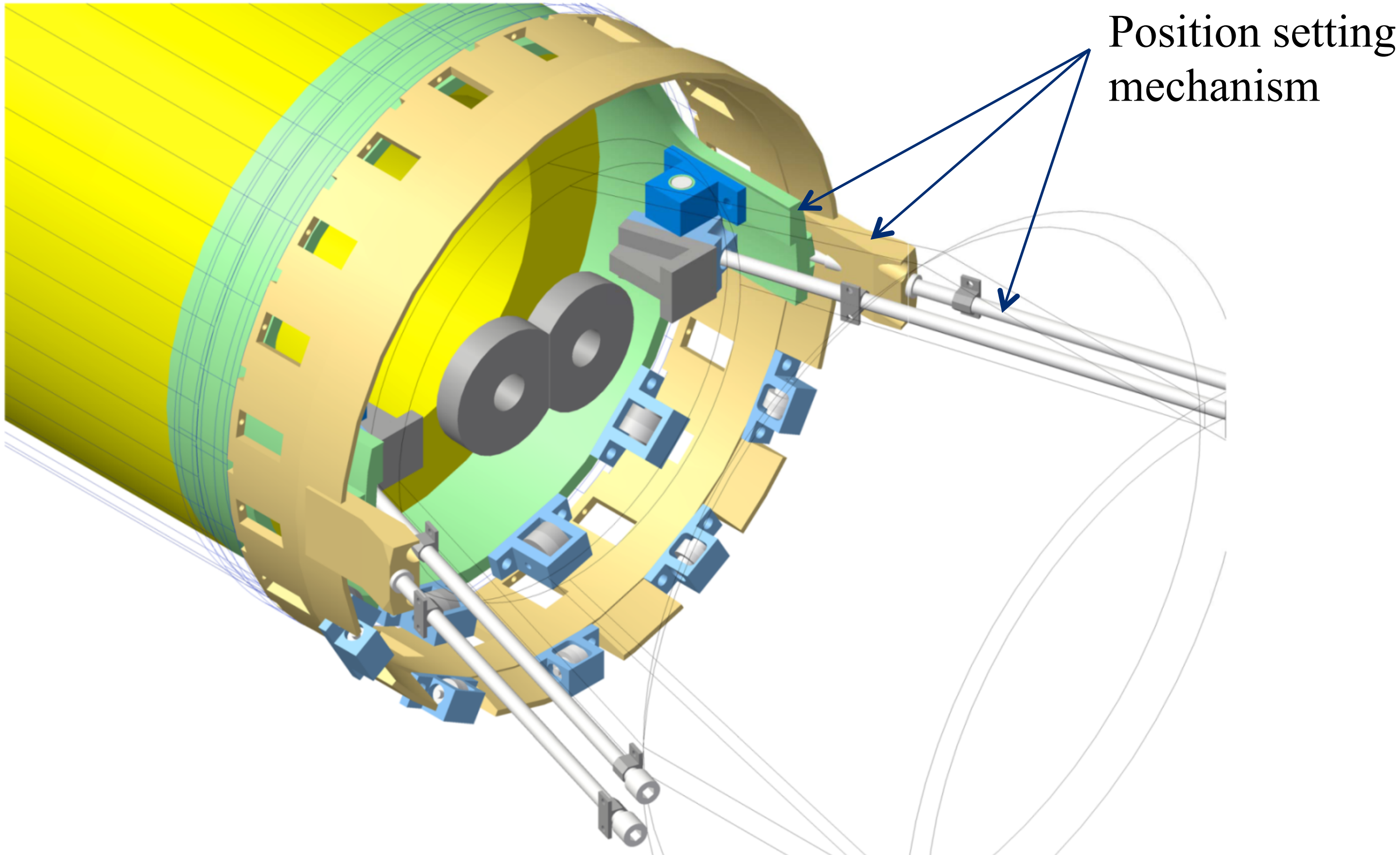
3. Installation
Step 1 – Fix the forward end of SVD4 transversally



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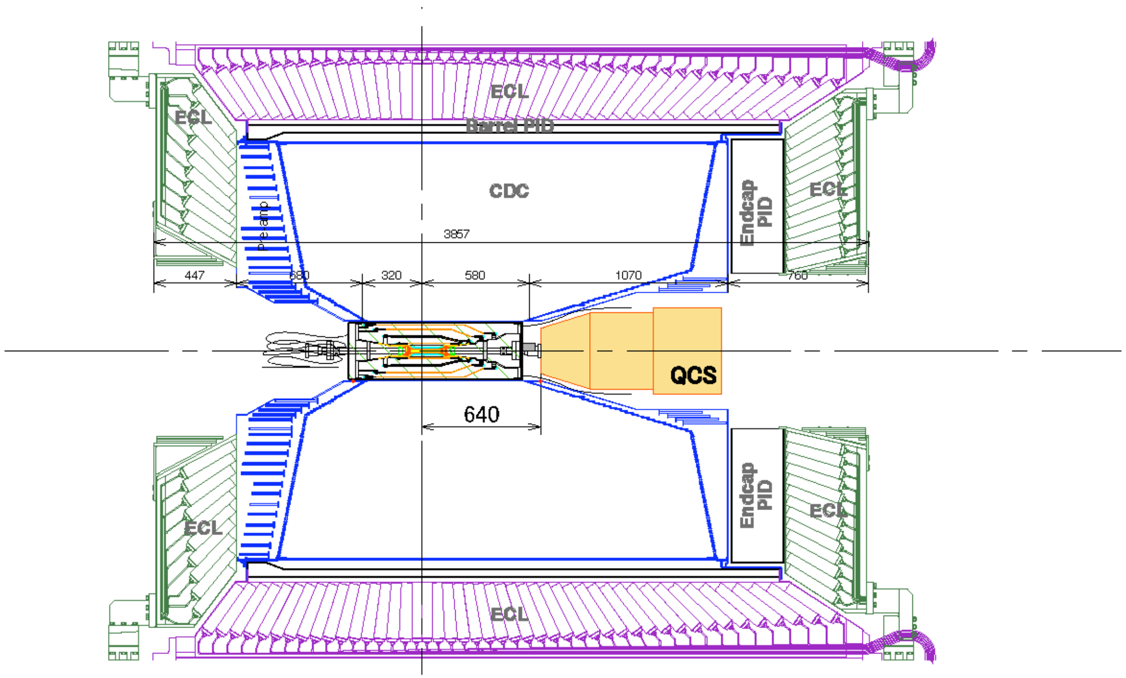
3. Installation
Step 1 - Complete



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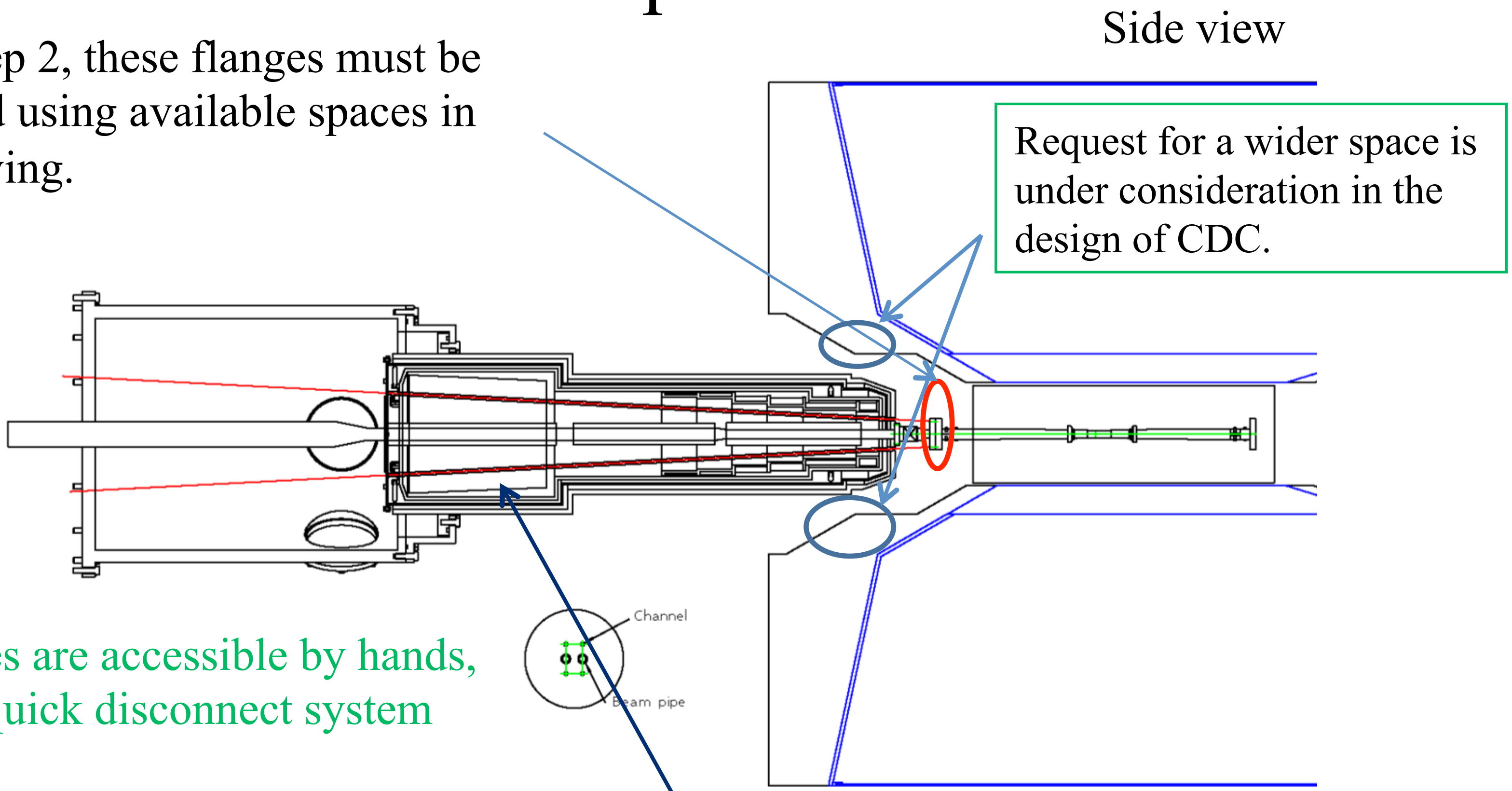
3. Installation
Step 2

In the step 2, these flanges must be tightened using available spaces in this drawing.



- If the flanges are accessible by hands, screws or a quick disconnect system can be used.
- As an option in case the flanges cannot be accessible by hands, an idea to provide the cryostat with channels (along the red line in the figure) for a tightening rod is proposed.

The use of ion yoke for QC2E made this option practically impossible.

Summary for Installation

- In the R-side of Belle II detector, there are no spaces available for connecting vacuum chamber flanges after the QCSR cryostat moves in. On the other hand, some working space seems to be available for the L-side after the QCSL cryostat moves in.
- An IR installation procedure adopted in our working group consists of two steps.
  - Step 1: IP chamber with SVD4 is connected to the QCSR cryostat. Then QCSR cryostat moves in.
  - Step 2: The QCSL cryostat moves in. Then the flanges in front of the QCSL cryostat are tighten up.
- For the step 1, a gutter is attached to the SVD4 unit. A mechanical strength more than self-supporting one is required for the SVD4 unit.
- For the step 2, negotiation on the work space is still going on.
- The final scenario will appear before the end of March 2011.