IR Vacuum Chamber and Assembly

The 17th KEKB Accelerator Review Committee
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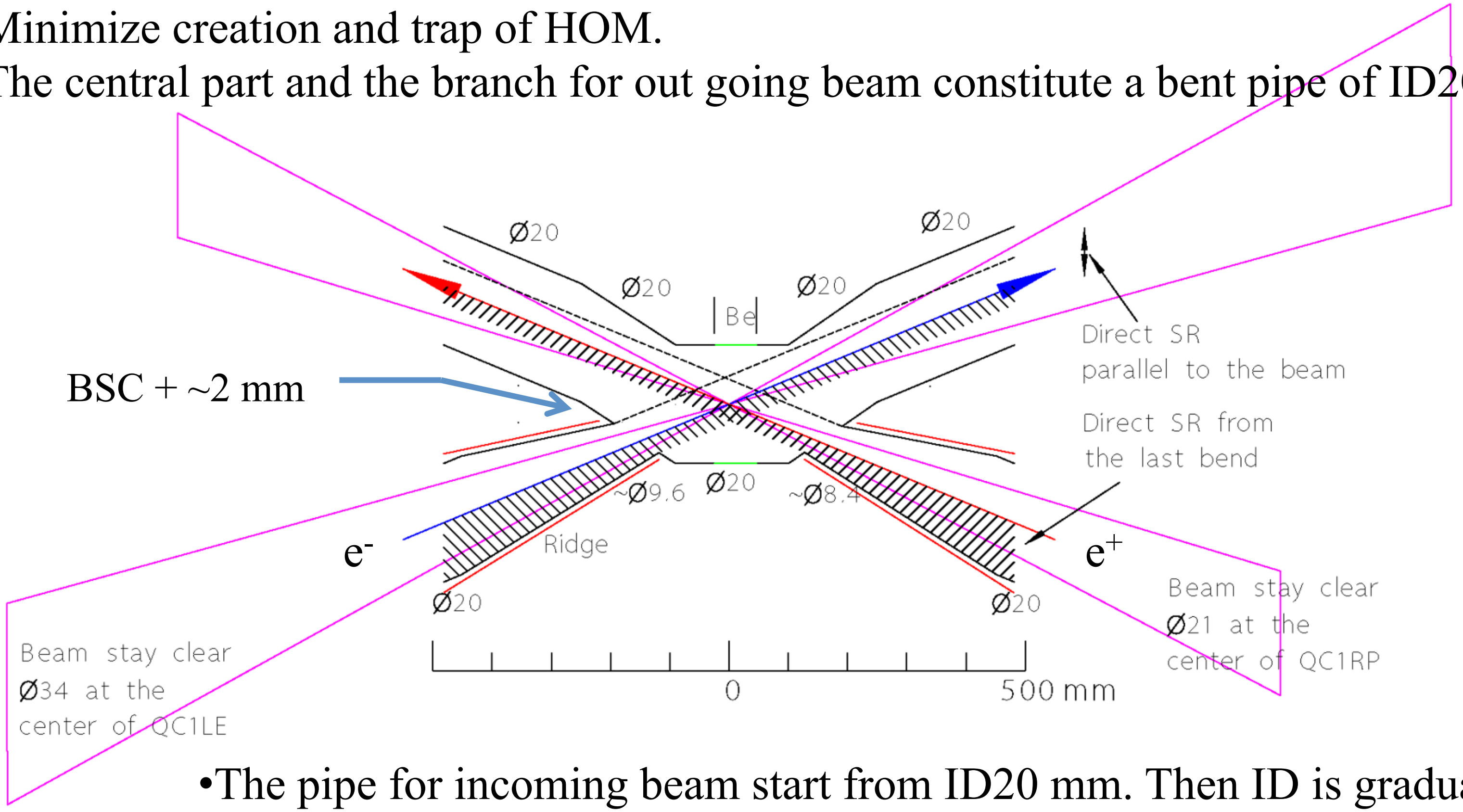
for
KEKB Vacuum Group
IR Technical Meeting Member
IR Installation Meeting Member
SVD/IR Mechanics Meeting Member

Contents

1. IP Chamber
Design features

•Minimize creation and trap of HOM.

•The central part and the branch for out going beam constitute a bent pipe of ID20mm.

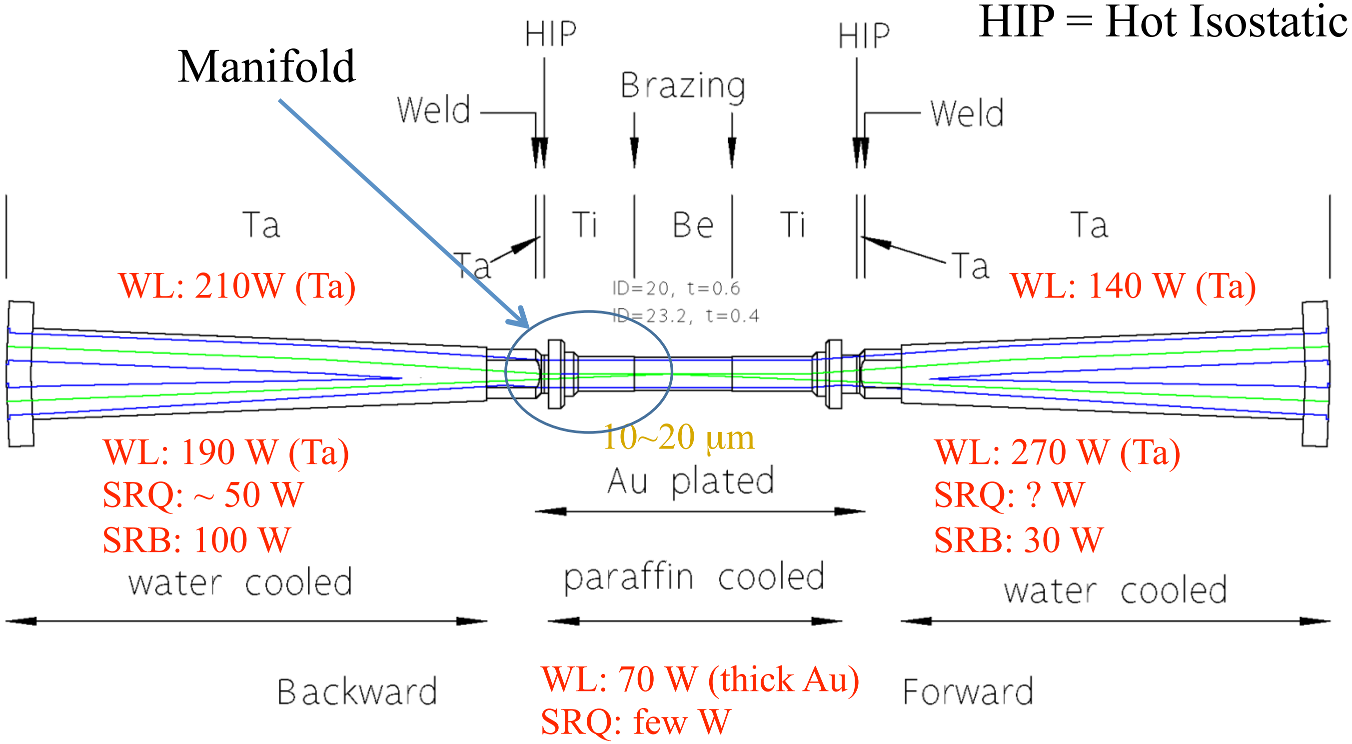


•The pipe for incoming beam start from ID20 mm. Then ID is gradually reduced to about 9 mm to stop direct SR. Now the taper is longer than before.

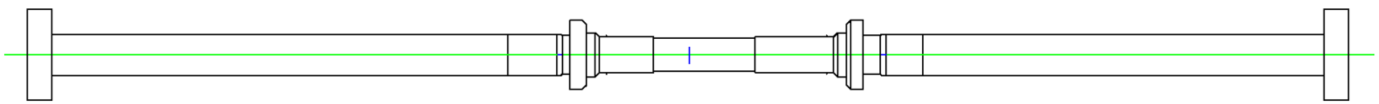
•The inner surface of a pipe for incoming beam has ridges to prevent scattered light from hitting the central Be part.

1. IP Chamber
Fabrication issues

HIP = Hot Isostatic Pressing



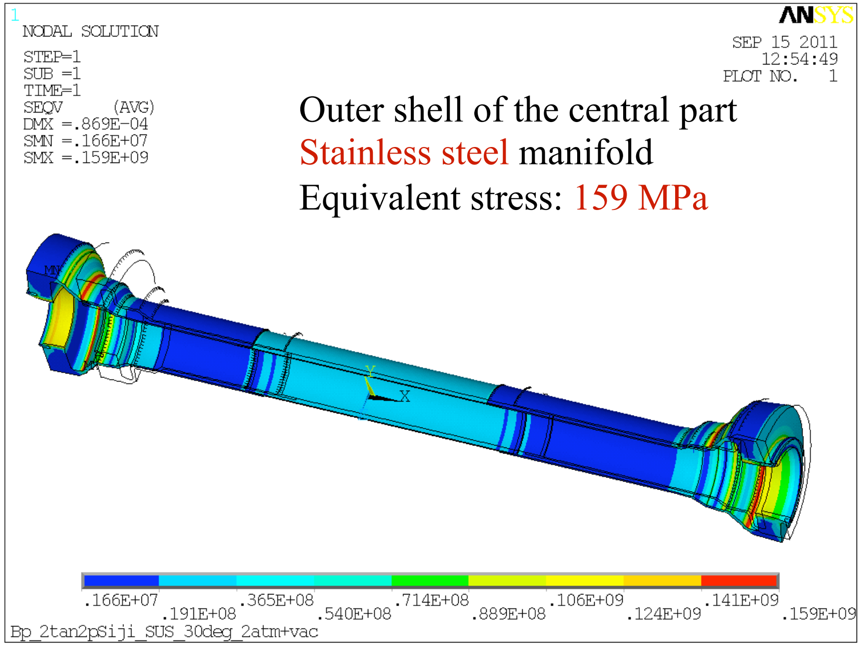
- A test for Be-Ti brazing and Ti-Ta HIP is now undergoing.
- Ti is adopted for the manifold instead of stainless steel to reduce the stress (the following slides).

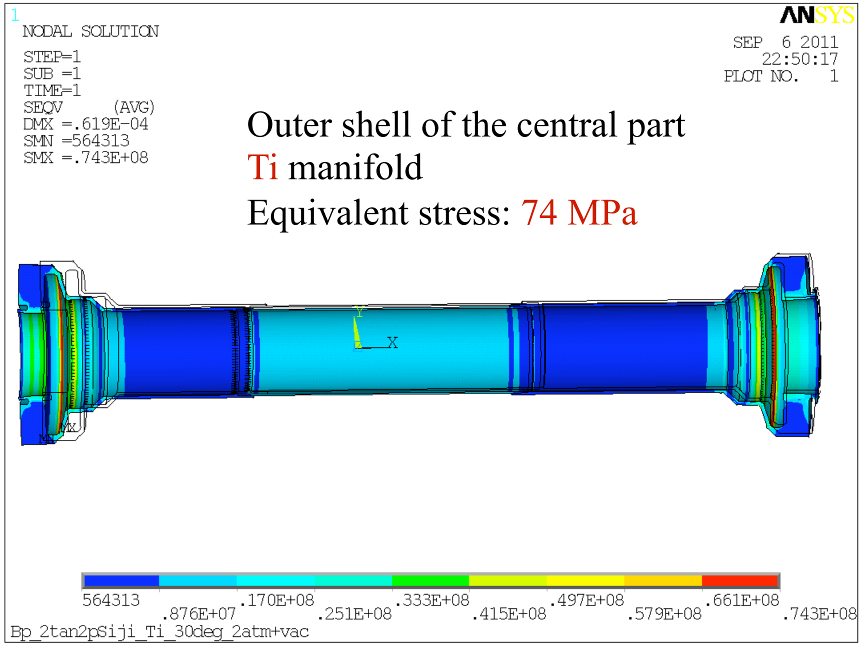


Thin (1~2 mm) Au coat to reduce ohmic power loss on Ti and Ta is an option.

1. IP Chamber
Stress analysis

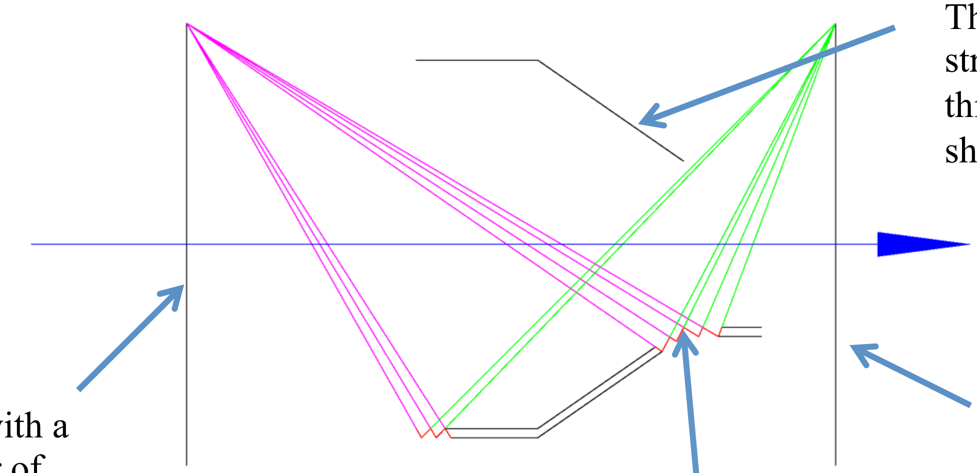
(Koike)





- Under the temperature difference of 30°C between the inner and the outer Be pipe causes an equivalent stress of 159 MPa in a stainless steel manifold, which is about 80% of the yield strength of stainless steel (206 MPa).
- Therefore Ti is adopted instead of stainless steel for the manifold. The equivalent stress for Ti under the same condition is 74 MPa while the yield strength of Ti is 170 MPa.

1. IP Chamber
Ridge shape (original idea)



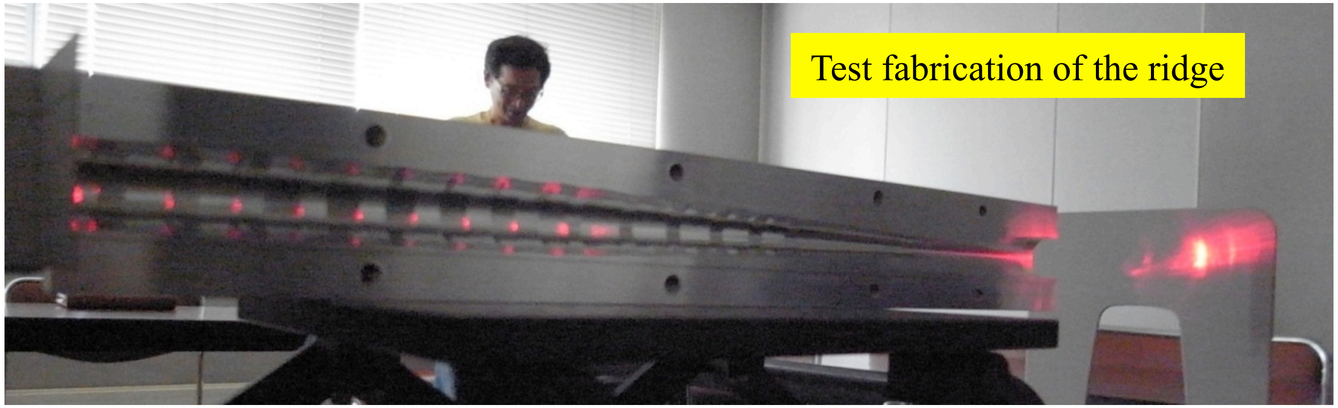
Thin wall around here cannot has a ridge structure. However, scattered photons from this part enter the central pipe with a shallow angle and give no serious effect.

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

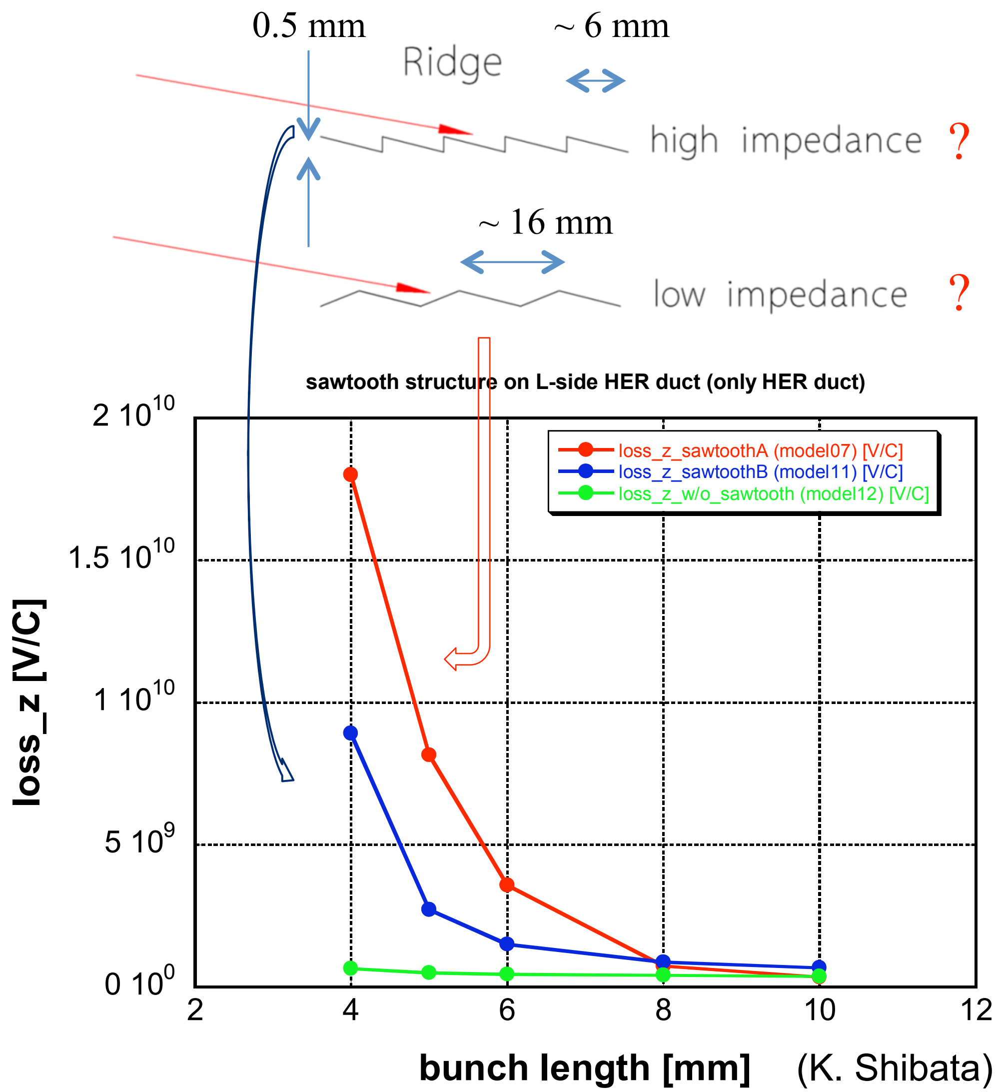
A disk with a diameter of 24mm. The position is the nearest end of a photon production region.

The narrowest aperture must be a ridge, of course.

Only single scattering is taken into account.



1. IP Chamber
Consideration on ridge shape



Low risk for multiply scattered photon to escape forward

Risk for multiply scattered photon to escape forward

Against intuition, the loss factor of the shape with a vertical face is lower. The shape of ridges will be changed to similar one shown in the upper figure.

The contribution of the tip scattering on the top of a ridge is experimentally studied by Z. Murakami and S. Tanaka. Its effect in SR shielding is not serious.

1. IP Chamber
Connection to the QCS cryostat

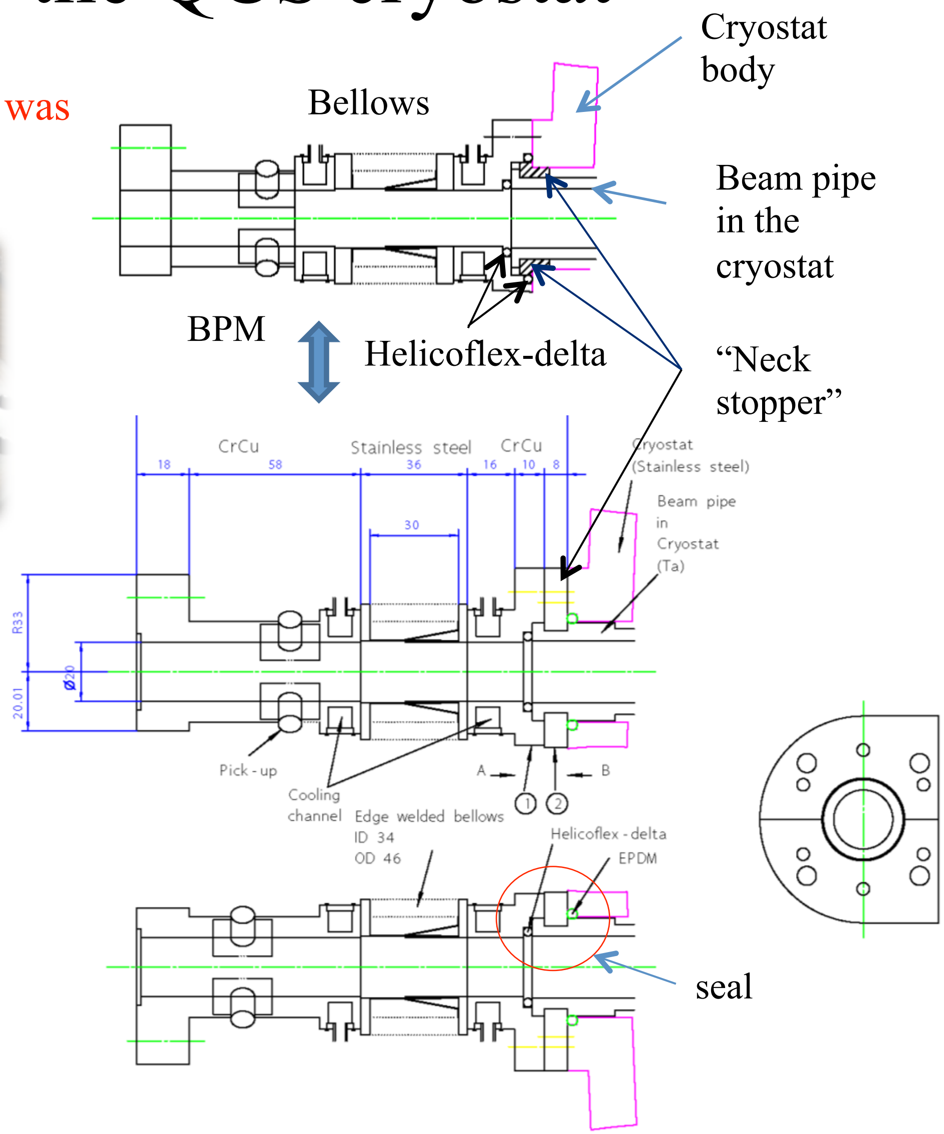
•A model test of the original sealing mechanism was successfully done.

(Photo by Tanaka)

•The use of radiation hard elastomer (EPDM) is investigated as a seal for the insulation vacuum of the cryostat.

•This make it possible to keep the insulation vacuum of the cryostat in exchanging this connection pipe.

•This will be judged based on the estimation of radiation level at the seal.



1. IP Chamber
Summary of new issues

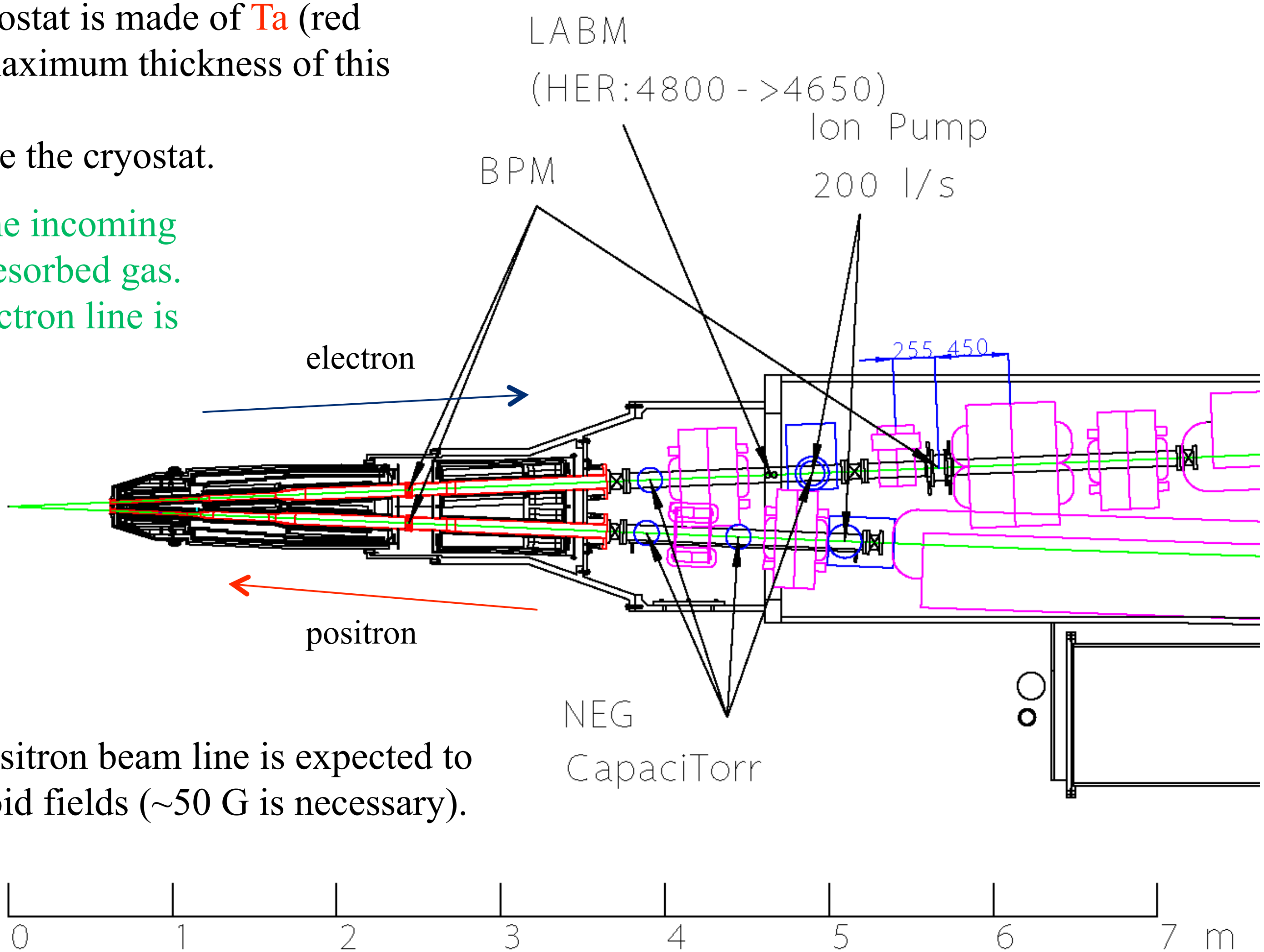
- The taper part for incoming beam is elongated.
- The material of the cooling manifold brazed to a Be pipe is changed from stainless steel to Ti.
- The shape of ridges are reconsidered. More effective form seems adoptable.
- In a connecting pipe to the QCS cryostat, the use of EPDM seal is examined to increase a tolerance for double sealing and to make beam vacuum independent of cryostat vacuum.

2. Vacuum around IR
Layout of vacuum components in the R side

The beam pipe in the cryostat is made of Ta (red part in the figure). The maximum thickness of this pipe is 4 mm.
Pumps are located outside the cryostat.

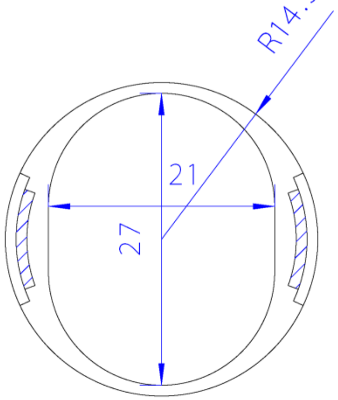
The major gas load for the incoming positron line is photon-desorbed gas. That for the outgoing electron line is thermal outgassing.

Ta beam pipes are Au coated to reduce photon desorption and ohmic power loss.

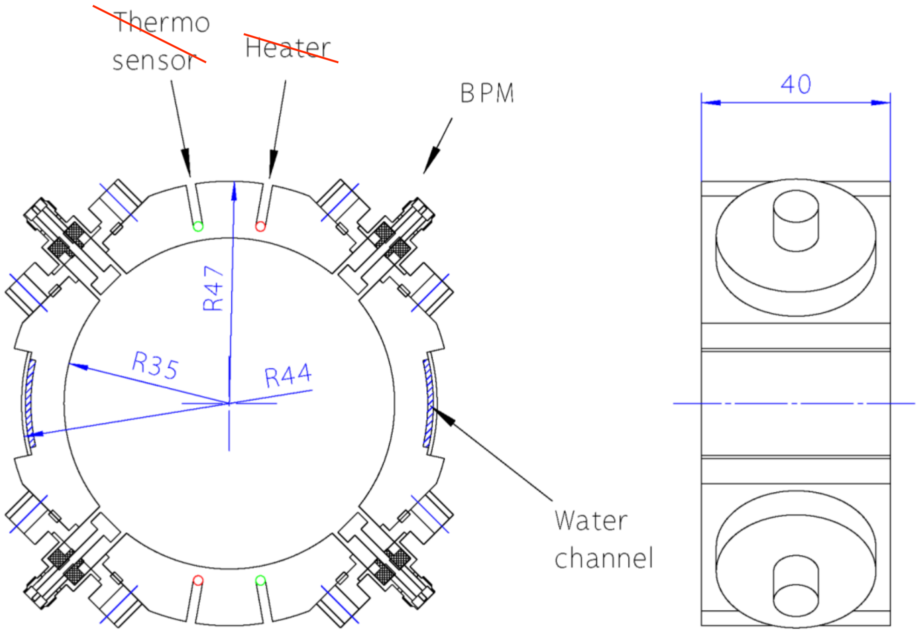


Electron cloud in the positron beam line is expected to be suppressed by solenoid fields (~50 G is necessary).

2. Vacuum around IR
Typical cross section of Ta beam pipe

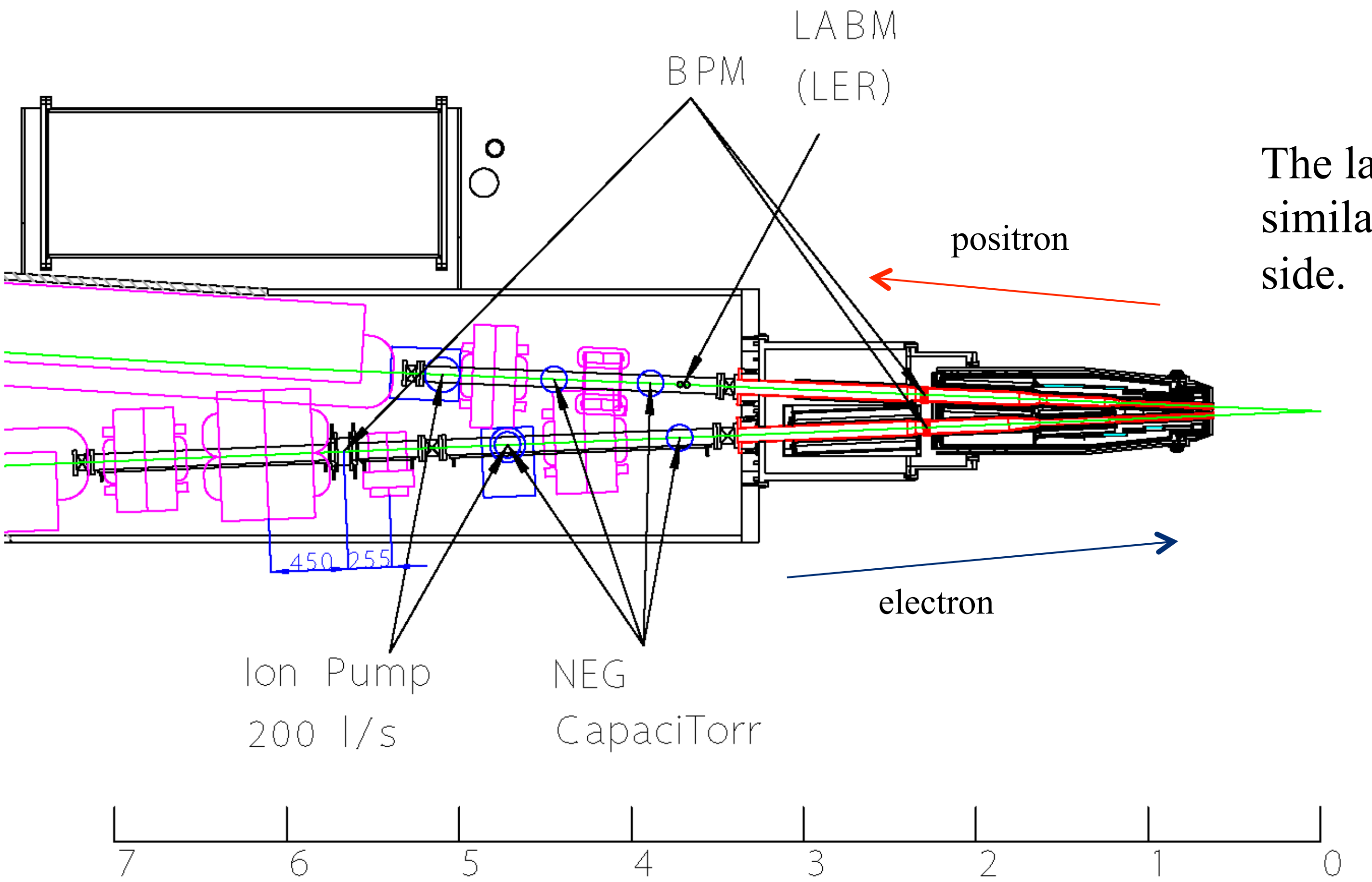


Vertically elongated aperture in QC1P
(Larger aperture is preferable but it is not available in the present design.)



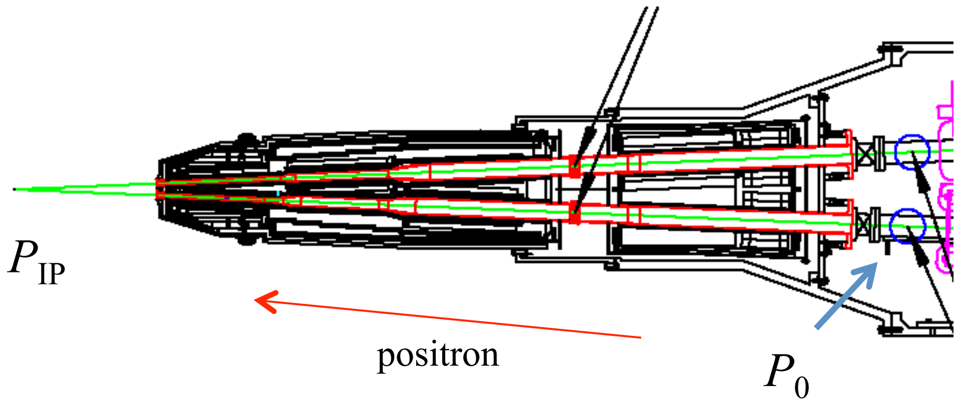
BPM

2. Vacuum around IR
Layout of vacuum components in the L side



The layout is similar to the R side.

2. Vacuum around IR
Rough estimation of pressure



Thermal only

$P_0 = 2\times10^{-7}$ Pa

$P_{IP} = 8\times10^{-7}$ Pa

Photon - desorption dominant

$P_0 = 2\times\eta$ Pa

$P_{IP} = 11\times\eta$ Pa

η : photo - desorption coefficient

Example: Incoming positron line

Assumptions:

- The equation for a long tube gives good estimation for a short tube
- At IP pressure is maximum
- P_0 is determined by the total outgassing of the cryostat beam pipe and the pumping speed there (50 l/s).
- The thermal outgassing rate is 1×10^{-11} Torr*l*/s/cm^2 (1.33$\times10^{-8}$ Pa m^3/s/m^2).

The difference between P_0 and P_{IP} is determined by the local outgassing and the conductance of the beam pipe. It doesn't depend on the pumping speed outside the cryostat.

2. Vacuum around IR
Consideration on IR pressure

•At least, the pressure around the IP (±5m) must not affect the overall average design pressure of the ring (1×10^{-7} Pa). Therefore the target pressure in this region must be less than $1 \times 10^{-7} \times 3000/10 = 3 \times 10^{-5}$ Pa. A consideration on the beam-gas Rutherford scattering requires much lower pressure in the QC magnets where β is large.

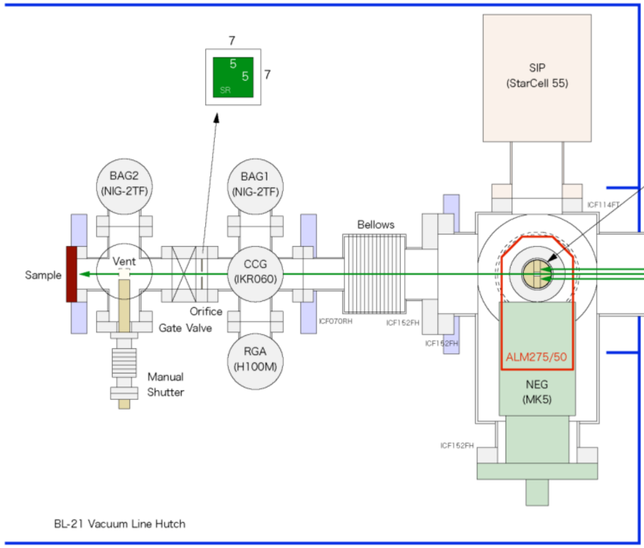
• The main gas source in this region is photon-desorbed gas due to the direct SR from the last bend. If a photo-desorption coefficient η is assumed to be 1×10^{-6} molecules/photon, The average pressure of this region will be a few $\times 10^{-6}$ Pa.

•To realize this low photo-desorption coefficient, it is investigated to use Au coat for a Ta beam pipe in the cryostat, which is expected to show a lower photo-desorption coefficient compared to other metals with a surface oxide layer.

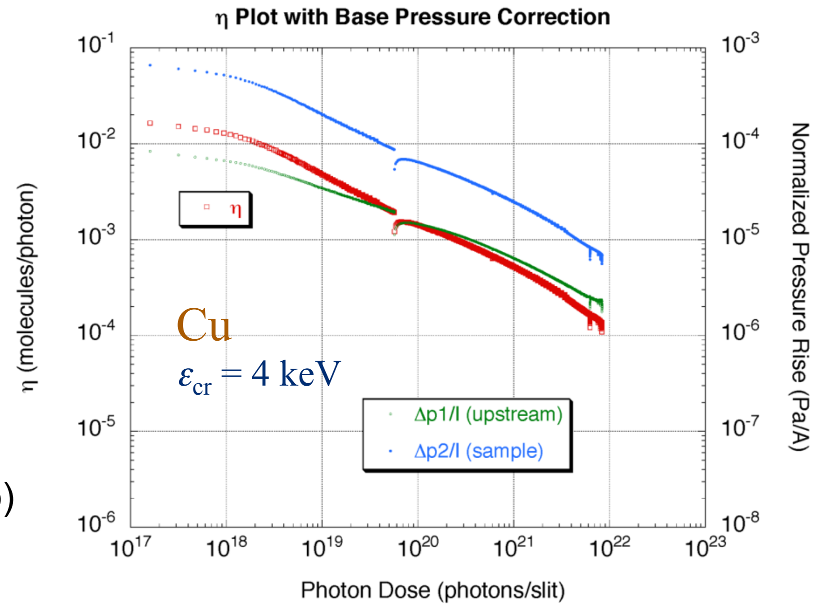
•Au will also work to reduce ohmic power loss on a wall.

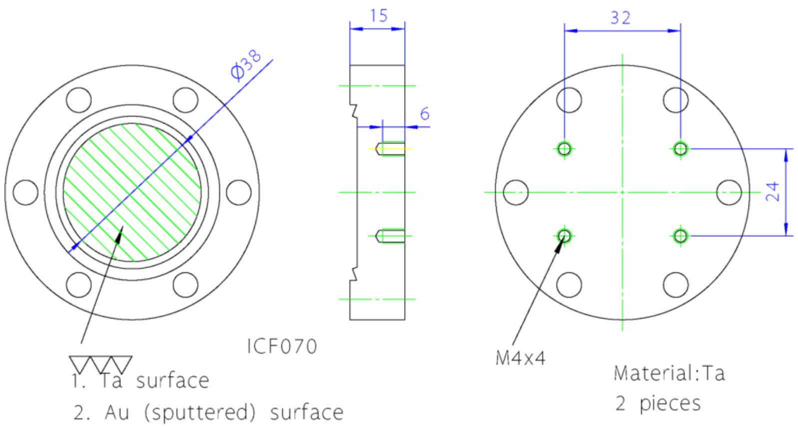
•To check this idea, the photo-desorption coefficient of Au coating and Ta will be measured at PF (Photon Factory) of KEK.

2. Vacuum around IR
PID measurement at PF BL21



(Y. Tanimoto)





Measurement of the photo-desorption coefficient of Cu, Ta, Au plated Ta is now underway at PF BL21 with a cooperation of Dr. Y. Tanimoto.

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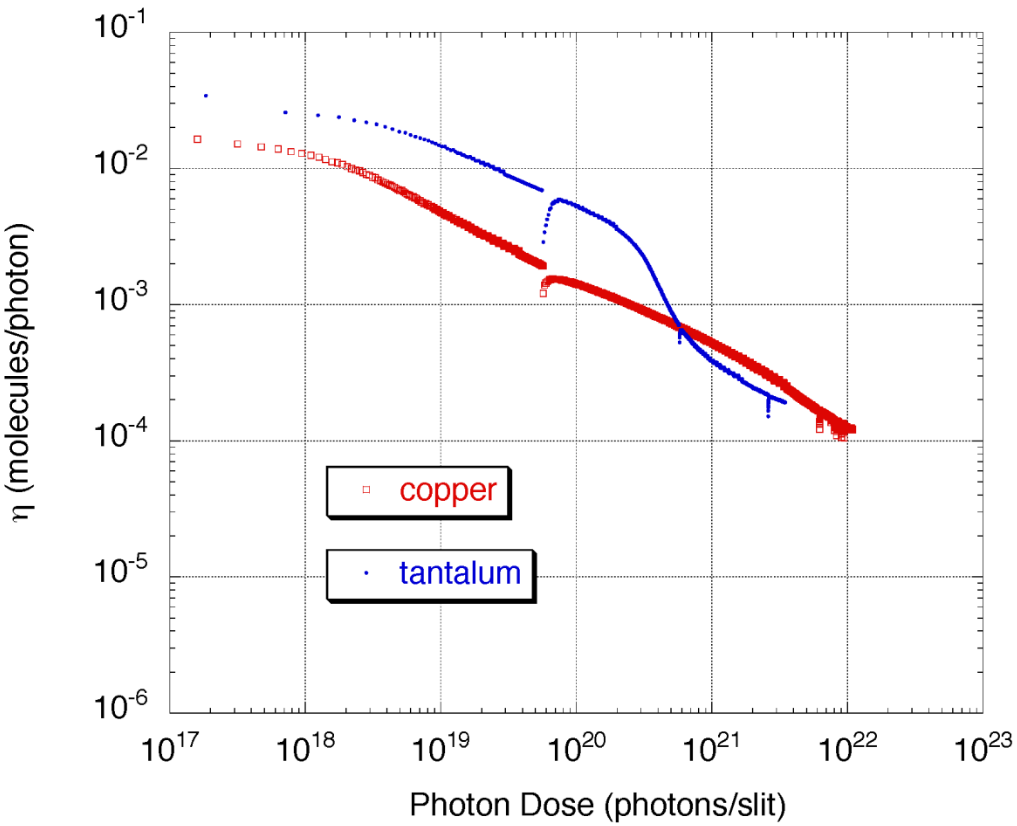
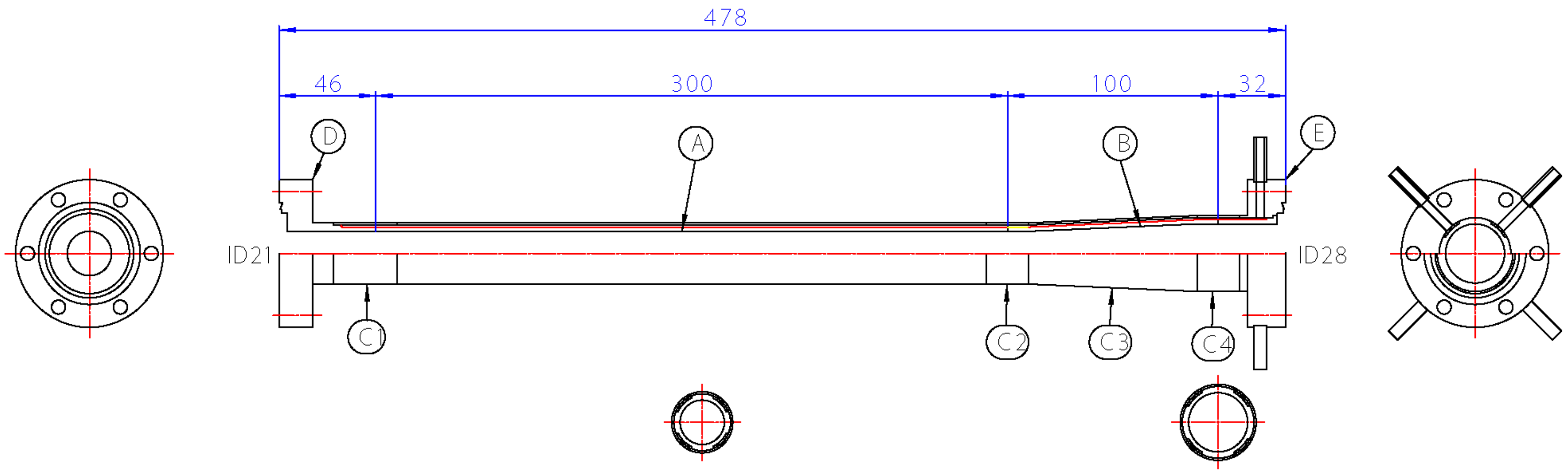
20 Feb 2012



Y. Tanimoto

2. Vacuum around IR
Test Ta beam pipe



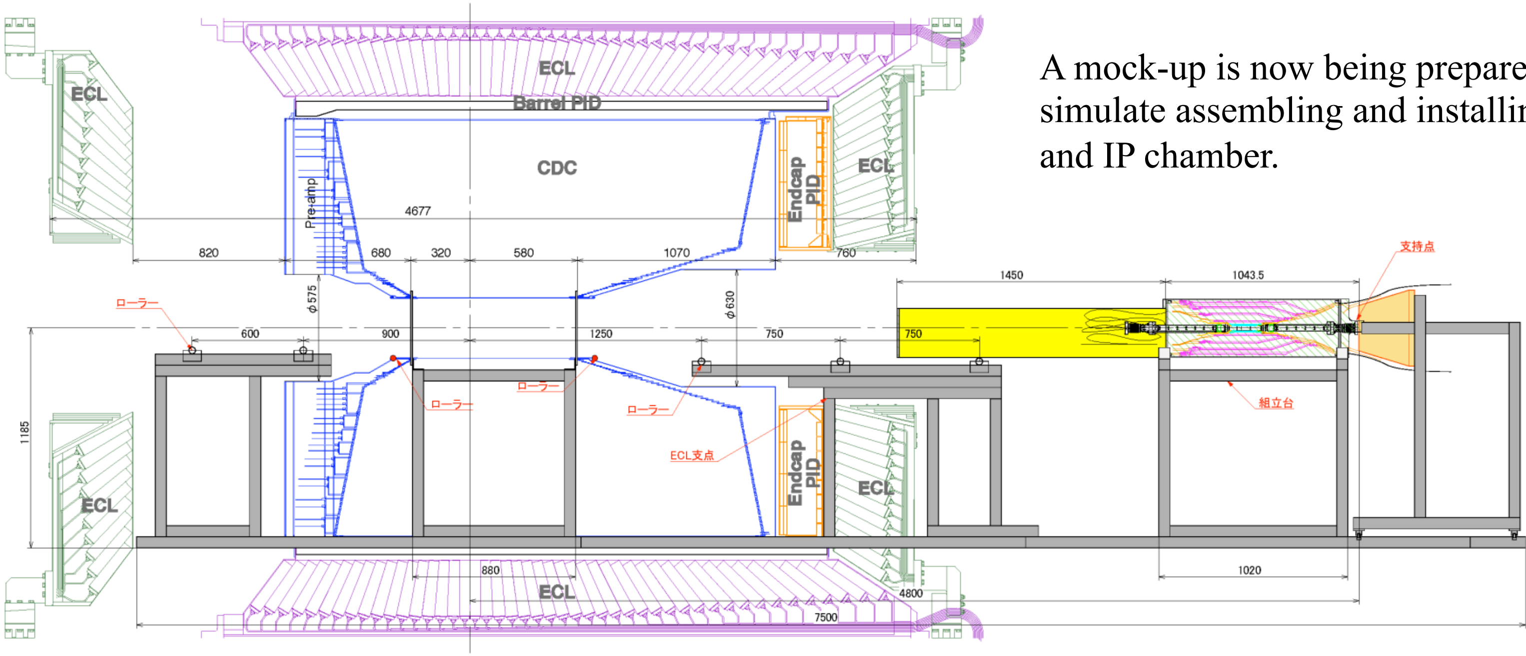
A test Ta beam pipe with cooling channels, a taper, and conflat flanges are now in fabrication.

From the impression on the preparation of Ta flanges for PID experiment, the technology to produce XHV Ta beam pipe seems to be not established yet.

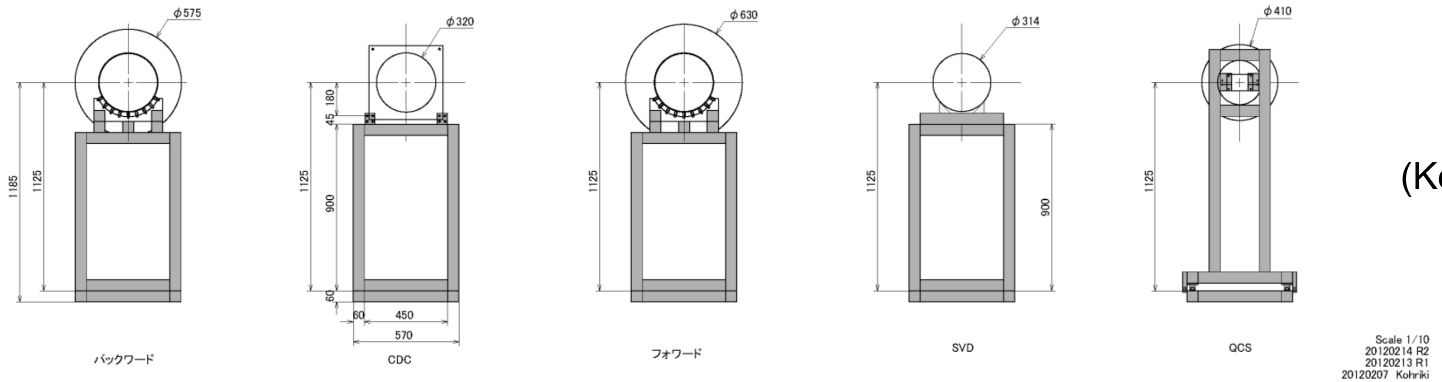
2. Vacuum around IR
Summary of issues

- Adopt a 1 ~ 2 μm thick Au plating for the Ta pipe in the cryostat to obtain a low photo-desorption coefficient ($\eta \sim 10^{-6}$ molecules/photon) and to reduce the ohmic power loss.
- A test model of Ta beam pipe is now under fabrication. At present the technology to produce an XHV beam pipe seems unsatisfactory.

3. Other issues
Mock-up for assembly simulation



A mock-up is now being prepared to simulate assembling and installing of SVD and IP chamber.

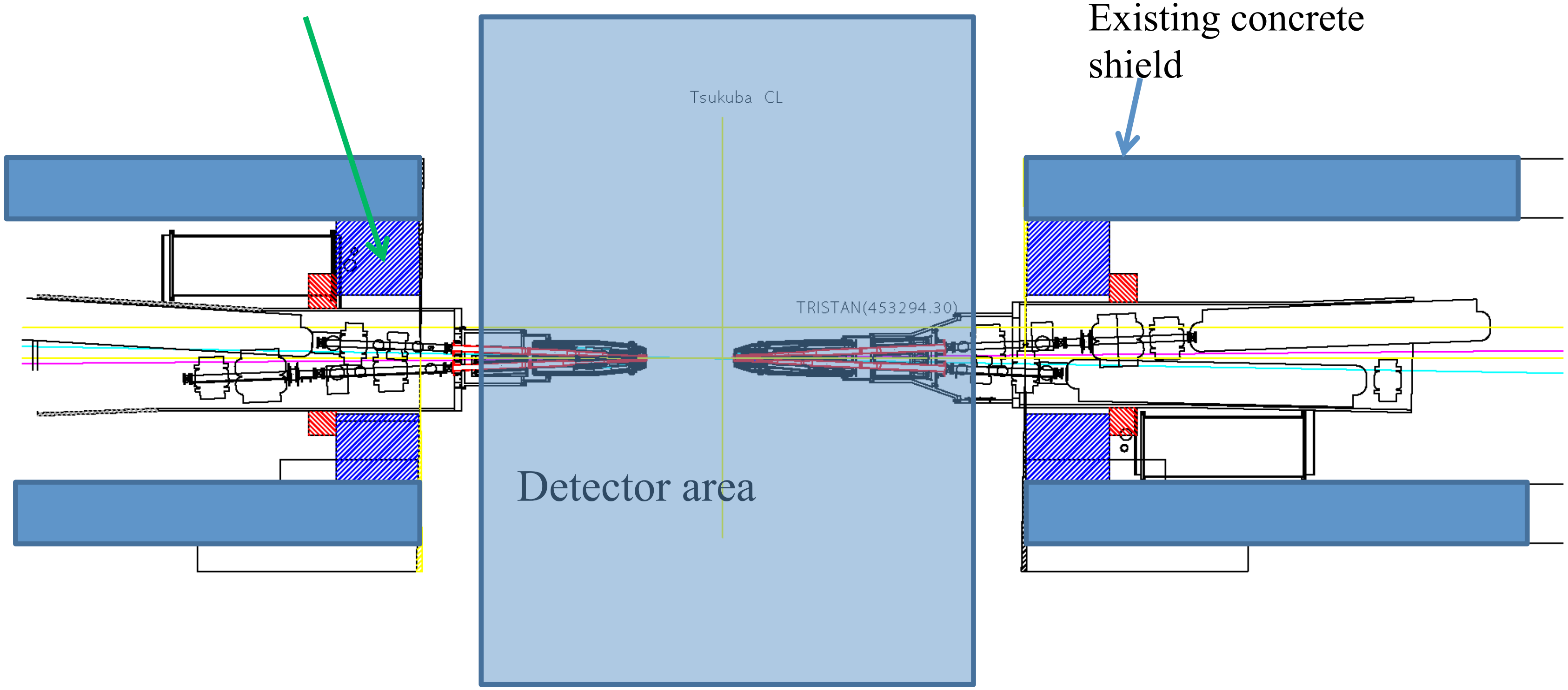


(Kohriki)

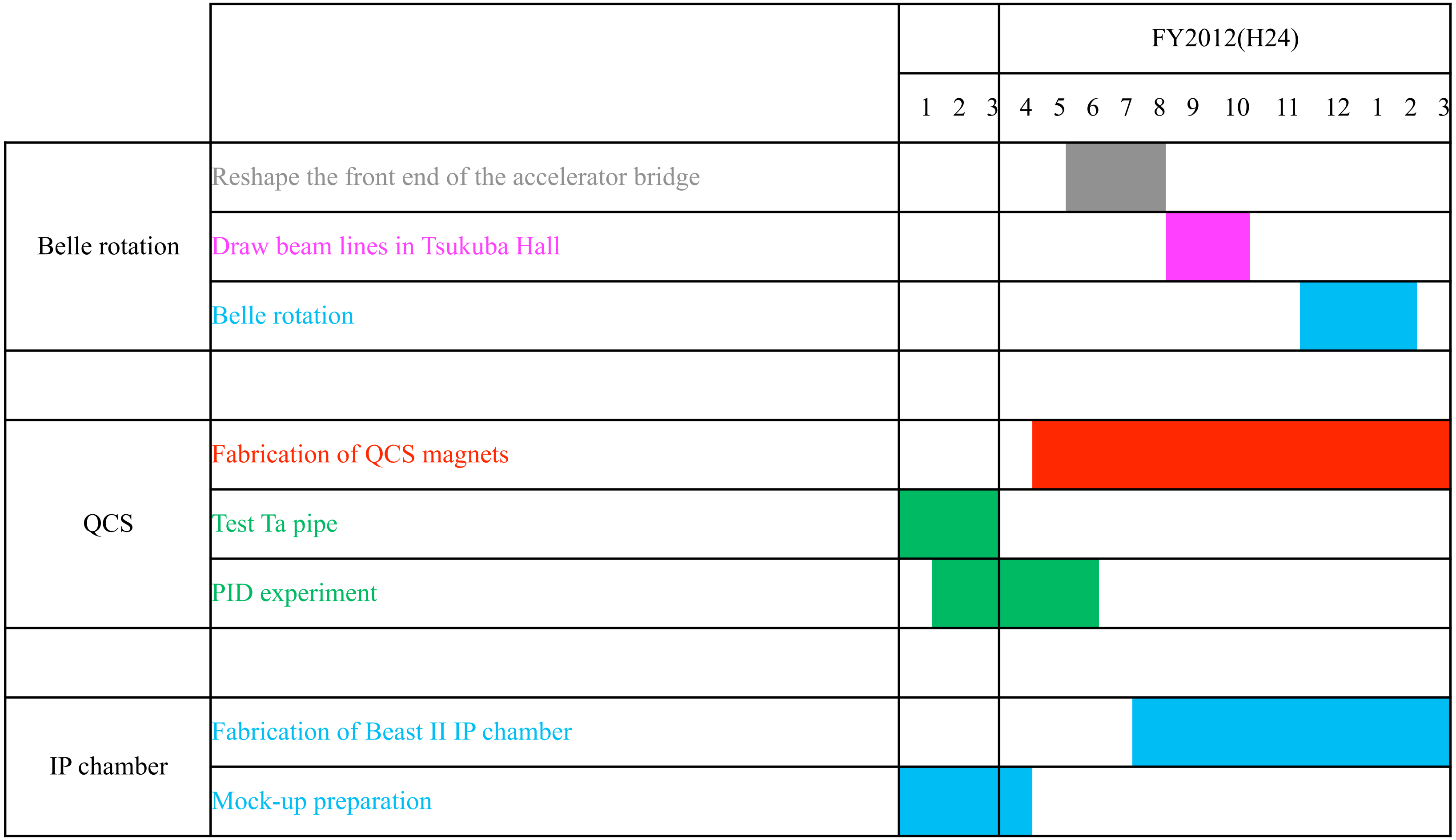
3. Other issues
Radiation shield

Allover radiation shield for detector components, electronics, and human must be considered in detail.
The discussion starts soon.

Example of one of additional shield (blue shaded part)



3. Other issues
Schedule in 2012



(Not a complete list)

4. Summary

- The design of the IP chamber is now in the almost final stage.
- Within ±3.8 m around IP, the major outgassing is due to photo-desorption process by the direct SR from the last bend, an idea to reduce the photo-desorption coefficient using Au coating is now investigated.
- Mock-up to simulate assembling IR components is being prepared.
- Radiation shield is now an important issue to require the discussion on overall structure around IR.